ATARI-ST SERIES

Series Editor: Robin Bradbeer
Foreword by Jack Tramiel

THE CONCISE ATARI ST 68000 PROGRAMMER'S REFERENCE GUIDE

Fully updated and revised to cover Megas, Blitters TOS in ROM, etc

Katherine Peel

GLENTOP

The Concise Atari ST Reference Guide

THE CONCISE ATARI ST REFERENCE GUIDE

by

K.D. Peel

Glentop Press Ltd

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All programs in this book have been written expressly to illustrate specific teaching points. They are not warranted as being suitable for any particular application. Every care has been taken in the writing and presentation of this book but no responsibility is assumed by the author or publishers for any errors or omissions contained herein.

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PREFACE

This book is intended as a compact reference guide to the Atari ST range of computers, it provides detailed information on the Atari ST hardware, an overview of the operating systems and the operating system calls. It also covers all types of machine including the Megas and blitters as well as the three generations of operating system used in the ST's todate:

a) OS supplied on disk
b) TOS in ROM
c) 'New TOS' in ROM

The majority of the book has been prepared in both decimal and hexadecimal notation to make reading and data entry less complicated for the beginner, and those who wish to use the VDI and AES tables from BASIC. I hope the use of decimal will not be too distressful to the purists, but most assemblers will accept either format as an input. The diagramatic presentation of data in memory and of stacks follows the Motorola MC68000 user's manual format of low memory towards the top of the page; presentation of memory maps follows the convention of high memory towards the top of the page. All memory representations are annotated to avoid confusion.

The Atari ST range of computers contain one of the largest ROM's (192K) of the current range of home/low cost business computers available. This offers an enormous wealth of data and routines that the user may wish to access; about six times that of most computers. This information is presented in a condensed group tabular form to provide association between the different types of calls available, and to get it all in. General descriptions of all the facilities available (disk, file, interfaces etc) are provided to present the reader with at least an outline understanding of their operation.

The book covers the programming of the Atari ST in three parts:

Chapter 1 gives an overview of the Atari ST hardware and expansion ports, also included is a short description of the peripheral interface circuits.

Chapter 2 presents an overview of the operating systems, the management of memory and resources, control of serial I/O, screen functions and file handling.

The following chapters provide the operating system calls for the Atari OS, GEM, the line-A graphic functions, the intelligent keyboard command instructions and the blitter.

The Appendices contain the system variables, configuration registers and a summary of the MC68000 instruction set.

Acknowledgements

The author wishes to thank Atari Corp. (UK) Limited for its assistance in the preparation of this book by providing much of the technical data, which is reproduced with the kind permission of Atari Corp. (UK) Limited.

Disclaimer

Foreword
by Jack Tramiel

When we introduced the ST series of computers at Atari, we coined the phrase 'Power without the Price'. This sums up all that had been in our minds when we decided to design a range of powerful but low-cost machines that could be used for all applications ranging from sophisticated games to complex business and scientific uses.

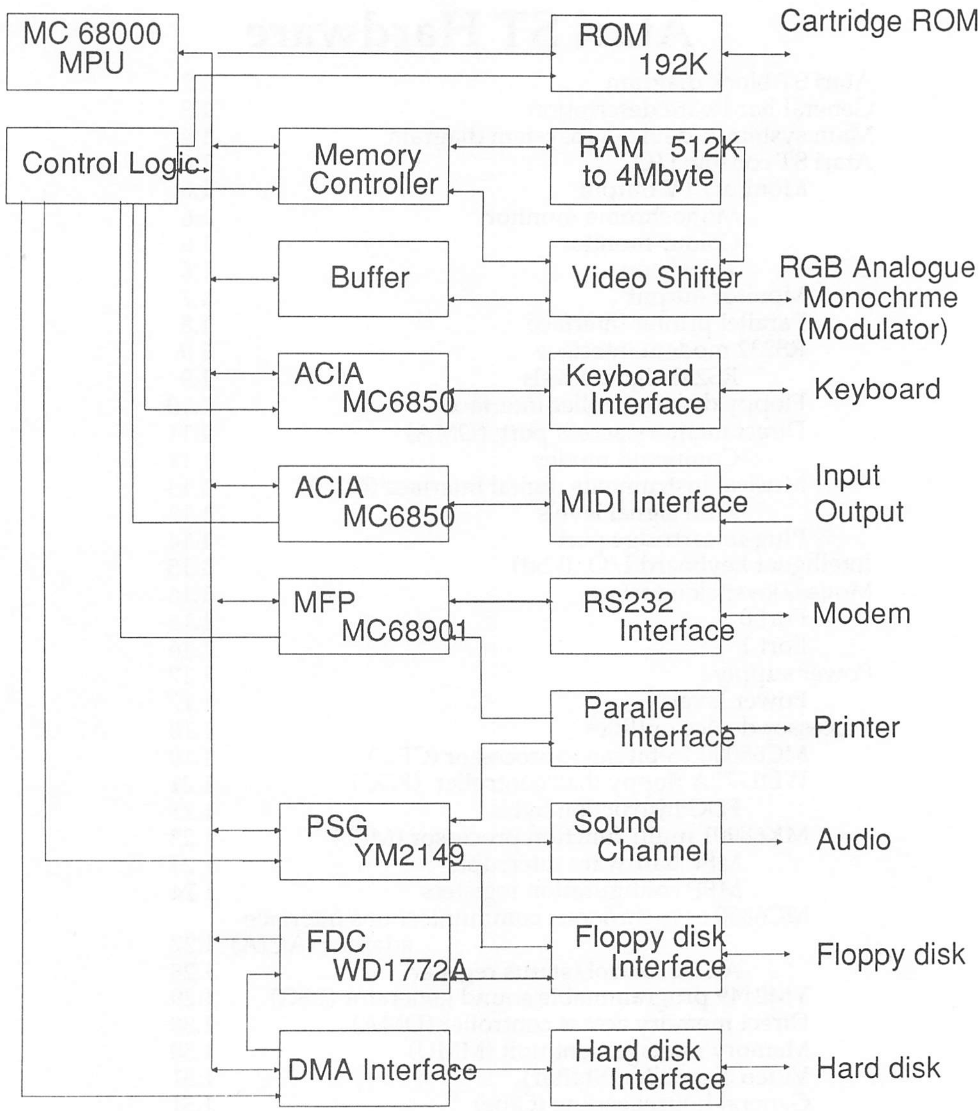
During the past few years, ever since I was responsible for bringing the first mass-produced electronic calculators and then the first true computers to the public at an affordable price, my whole aim has been to bring the benefits of technology to those of average income. We have to get high technology out of the hands of the few into the hands of the many. As I have said before we want 'classes for the masses'. If you give somebody some sophisticated machinery then you'll be surprised what they can do with it. Time and again we have been amazed at what users have done with the technology when it is made freely available at an affordable price.

And that brings me on to this series of books, edited by my old acquaintance Robin Bradbeer. It is impossible to give all the information necessary to completely cover all the uses of a computer in the instruction manual. Also, if more than one person explains something they bring out differing strengths of the system. This series of books should help all users of the ST to get to know the machine better and therefore use it more productively. Who knows, we at Atari may yet again be surprised by what you, the user, can do with the affordable technology that we have provided.

Jack Tramiel
1986

Chapter 1
Atari ST Hardware

Atari ST Block Diagram



General Hardware Description

The Atari ST computer system consists of a console unit featuring an integral keyboard, a display screen, sound subsystem, peripheral input/output and an operating system. Expansion ports are provided for the connection of a variety of peripheral devices i.e. a mouse, joystick, printer, modem, external floppy disk, ROM cartridge application program etc.

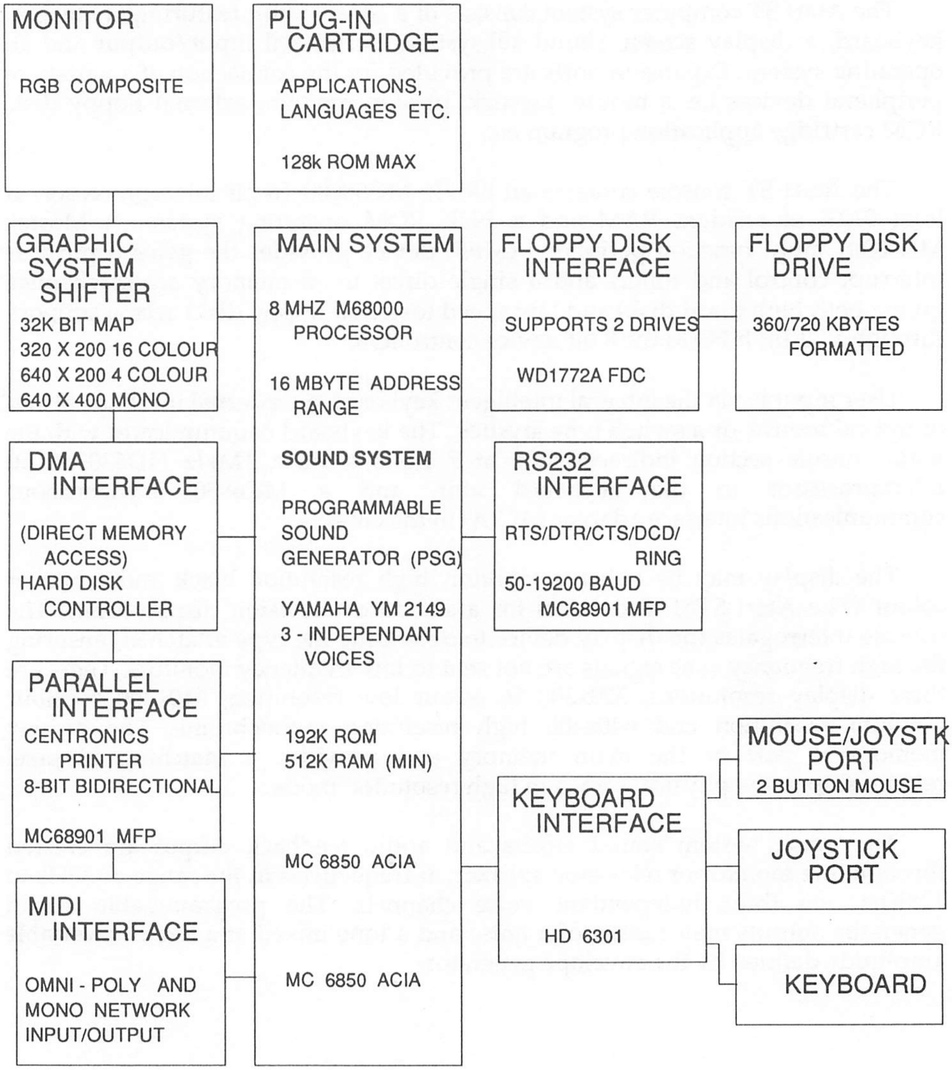
The Atari ST console contains an 8MHz MC68000 16 bit microprocessor, at least 512K of resident RAM and a 192K ROM operating system. A Mostek MK68901 multi function peripheral (MFP) device provides the general purpose interrupt control and timers and a single direct main memory access channel, giving both high (hard disk) and low speed (external floppy disk) access support, through a 32-bit FIFO to the 8 bit device controllers.

User input is via the integral intelligent keyboard, an external mechanical and or optical mouse, or a switch type joystick. The keyboard communicates with the main console section bidirectionally at 7 Kbits/s via a 1MHz HD6301 8 bit microprocessor in the keyboard unit, and a MC6850 asynchronous communications interface adapter (ACIA) in the console.

The display may be either a monitor, high resolution black and white or colour (The Atari STM also caters for a standard television display unit). The console interrogates the display device to determine the type attatched, ensuring the high frequency sync signals are not sent to low frequency monitors. There are three display resolutions, 320x200 16 colour low resolution, 640x200 4 colour medium resolution and 640x400 high resolution monochrome. The display memory is part of the main memory and provides a matching bit-pixel relationship to the physical screen in high resolution mode.

The music system sound effects and audio feedback output are created through the monitor or television speaker, at frequencies in the range of 30Hz to 128Khz, via three independant voice channels. The programmable sound generator outputs may consist of a noise and a tone mixed at a fixed or variable amplitude defined by the envelope generator.

Main System and Device Subsystems



The musical instruments digital interface (MIDI) enables the ST to integrate with music synthesisers, sequencers, drum boxes etc. which incorporate the MIDI interface; enabling OMNI, POLY and MONO networking.

Printer output is achieved via the parallel and RS232 interfaces, the latter also being available for modem and general communication.

The floppy and hard disk interfaces provide the off-line data and program mass storage facilities. The hard disk drive interface is accessed through the DMA controller but the hard disk controller itself is off board. An on-board Western Digital WD1772A interfaces the floppy disk drive, which may be either integral or the Atari ST 3 1/2" disk drives SF 354 or SF 314.

The operating system may be either in 192K of ROM, or an image file on disk, loaded by the disks boot sector, featuring the GEM operating environment of windows, icons, pull down menus. The ST is also supplied with two language implementations, an interpreted BASIC and Atari LOGO.

The ST can accept other operating systems loaded via the boot sector or brought up by a driver in an 'AUTO' folder.

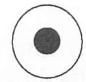
Atari ST Console I/O

MONITOR/TV OUTPUT

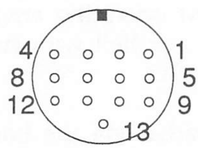
Monochrome Monitor
Atari SM124
71.25 Hz scan rate

Colour Monitor
Atari SC1224 RGB
50/60 Hz scan rate

Television
(where fitted)



RCA pin jack
Core : RF modulated video
Shield: Ground



13 way DIN 13S socket

Sync 5V active low 3.3Kohm
Audio 1V pk-pk 10Kohm
Video 1V pk-pk 75ohm

	Pin	Function	ST signal processing device
	1	Audio out	
	2	Composite video	*(Reserved in older models)*
	3	General purpose output	TTL PSG I/O A
	4	Monochrome detect	TTL MFP active low, 1K pull up to 5V
	5	Audio in	
	6	Green	
	7	Red	
**	8	Ground	(+12V, 10mA shell for SCART connector)
	10	Blue	
	11	Monochrome	
	12	Vertical sync	
	13	Ground	

** Note: Older versions of the ST reserved pin 2 and pin 8, this could be a source of trouble with some peripherals. Always use pin 13 for ground if possible

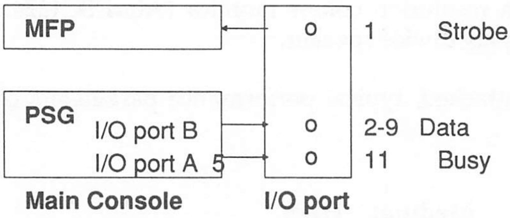
MONITOR OUTPUT

The monitor output supports either a high resolution black and white monitor (Atari SM124) or a medium resolution colour monitor (Atari SC1224). Sound is reproduced through the display device speaker.

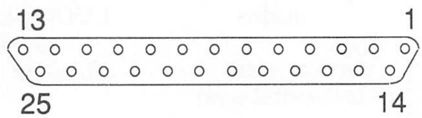
Any suitable monitor may be attached, typical performance parameters of such monitors are as follows:

Resolution	**Low**	**Medium**	**High**
	452x585	653x585	895x585 pixels
Video Bandwidth	10Mhz	18Mhz	18Mhz
Slot pitch (typ)	0.64mm	0.41mm	0.31mm
Input video	1 VDC pk-pk		
audio	1 VDC pk-pk		
Sync	5 VDC active low		
Vertical scan	50/60Hz	50/60Hz	71.2Hz
Horizontal scan		15.7Khz	35.7Khz

PARALLEL PRINTER INTERFACE



The parallel port interface provides an 8-bit data communication channel controlled by a strobe signal generated by the ST, indicating that data bits are available on the data lines for transfer to the peripheral, and a busy signal generated by the peripheral (usually a printer) indicating either that it is busy, has a fault or possibly out of paper if a printer.



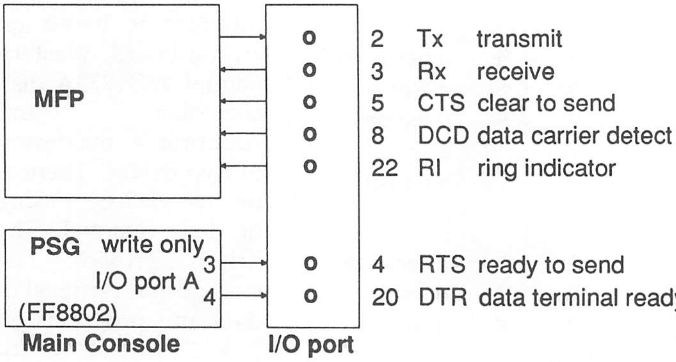
25 way DB 25S socket

Pin	Function		
1	Strobe		
2	Data 1	\	
3	Data 2	|	Data generated at a
4	Data 3	|	typical rate of 4kbytes/s
5	Data 4	|	by the PSG I/O port B
6	Data 5	|	
7	Data 6	|	
8	Data 7	|	
9	Data 8	/	
10	n.c		Acknowledge is not supported
11	Busy		
12-17	n.c		
18-25	Ground		

The parallel port strobe signal generated by the PSG I/O port A (pin 1), supplies the data transfer synchronization. The busy signal (pin 11) is read by the console MFP and provides the handshake control.

The strobe signal is active low, the busy signal active high, with a 1Kohm pull up resistor to +5V. All signals are at TTL levels.

RS232/MODEM INTERFACE



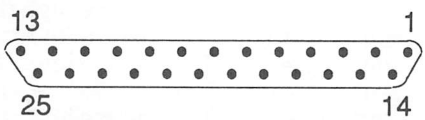
The RS232 interface is controlled via the PSG I/O port A (RTS and DTR) and the MFP (CTS, DCD and RI) transmitting and receiving data within the range 50 to 192K baud, the timing synchronization is generated by the multi-function processor (MFP) timer D. (Only the 'New TOS' supports RTS/CTS handshaking.)

The interface supports hardware handshake control:

RTS \	Transmit	CTS \	Receive
DTR /	PSG I/O port A	DCD I	MFP inputs
		Ring /	

and software control through Xon/Xoff protocol.

Pin	Function	
1	Grd	Protective ground
2	Tx	Transmit data
3	Rx	Receive data
4	RTS	Ready to send
5	CTS	Clear to send
6	n.c	
7	Gnd	Signal ground
8	DCD	Data carrier detect
9-19	n.c	
20	DTR	Data terminal ready
21	n.c	
22	Ri	Ring indicator
23-25	n.c	

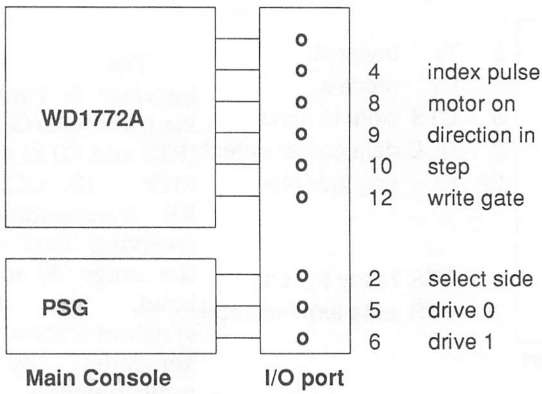


25 way DB 25P plug

RS232 Signal Levels

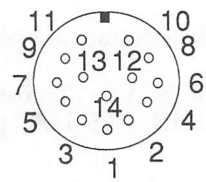
Zero	+3v	to +12v
One	-3v	to -12v

FLOPPY DISK INTERFACE



The floppy disk interface is based on an on-board Western Digital WD1772A disk controller and supports a maximum of two drives. There is no hardware sensing of disk removal. The drives provide fast storage and retrieval of data and programs on 3 1/2" flexible micro disks.

Note that the DIN socket shield must not be connected on the ST side



14 way DIN 14S socket

Pin	Function		
1	read data	TTL	active low, 1K pull up
2	select side 0	TTL	active high (high sys reset)
3	logic ground		pair with read data
4	index pulse	TTL	active low, 1K pull up
5	select drive 0	TTL	active low (high sys reset)
6	select drive 1	TTL	active low (high sys reset)
7	logic ground		pair with write data
8	motor on	TTL	active low \
9	direction in	TTL	active low |
10	step	TTL	active low |- (inverted)
11	write data	TTL	active low |
12	write gate	TTL	active low /
13	track 00	TTL	active low, 1K pull up
14	write protect	TTL	active low, 1K pull up

Data is written to 512 byte sectors.

DIRECT MEMORY ACCESS PORT

This port can be used to provide access to a hard disk or a compact disk. The hard disk controller (target), not supplied with the basic ST system, is communicated with by a sequence of six bytes (from initiator system) which provides format, read and write facilities etc. in one direction only. The command protocol used is referred to as ANSI X3T9.2, a SCSI-like small computer systems interface, of which the ST supports a small subset.

The Atari hard disk descriptor block consists of a six byte command packet conforming to the following:

Six byte command packet

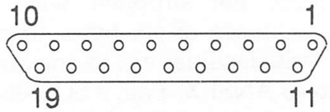
Byte no.	Bit no.	Function	range
0	0-4	Operation code	0-31
	5-7	Controller number	0-7
1	0-4	Head number	0-31
	5-7	Drive number	0-7
2	0-5	Sector number	0-63
	6-7	Cylinder number high	
3	0-7	Cylinder number low	
4	0-7	Sector count	
5	0-7	Control byte	

Hard disk command code summary

Op code Dec	Hex	Command	
5	05	Verify track	\ Multi-sector
6	06	Format track	|_ transfer
8	08	Read sector	|‾ with
10	0A	Write sector	/ implied seek
11	0B	Seek	
13	0D	Correction pattern	
26	1A	Mode sense	

There is only one DMA channel, it is shared by both high speed (upto 8Mbit/s) and low speed (250 to 500Kbit/s) 8-bit device controllers.

DMA interface port socket

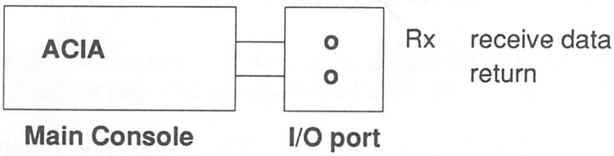


19 way DB 19S socket

Pin	Function	Signal type
1	data 0 \	
2	data 1 |	
3	data 2 |	
4	data 3 |_	TTL
5	data 4 |	
6	data 5 |	
7	data 6 |	
8	data 7 /	
9	chip select	TTL active low
10	interrupt request	TTL active low, 1K pull up
11	ground	
12	reset	TTL active low (system reset)
13	ground	
14	acknowledge	TTL active low
15	ground	
16	A1	TTL
17	ground	
18	read/write	TTL
19	data request	TTL active low, 1K pull up

The 'New TOS' supports more than one device attatched to the DMA port, without the need for special software, on power up.

MUSICAL INSTRUMENT INTERFACE (MIDI)



The MIDI interface functions through an MC6850 asynchronous communications interface adaptor (ACIA) whose control/status register is located at $FFFC04 (16776196); data is passed in the register at offset 2 from the control/status register.

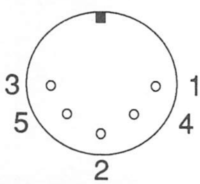
Data is transmitted serially via the MIDI ports through two pins asynchronously using the protocol:

One start bit, 8 data bits, One stop bit and no parity at 31.25 Kbaud.

The MIDI OUT port also supports the optional through port which merely provides the MIDI IN signals through an opto-coupled isolator at the MIDI OUT connector.

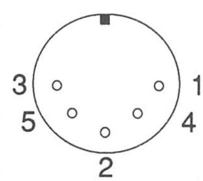
Control of the port is available through the ST's extended BIOS.

MIDI in



5 way DIN 5S socket

MIDI out



5 way DIN 5S socket

Pin	Function
1	n.c
2	n.c
3	n.c
4	In rx data
5	In loop return

Pin	Function
1	Thru tx data
2	Shield ground
3	Thru loop return
4	Out tx data
5	Out loop return

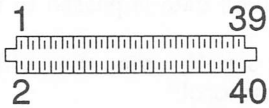
The Midi ports may be used to network data between connected computers, they operate in RS232 current loop mode. That is;

Signal levels	**zero**	5ma
	one	zero current

PLUG-IN CARTRIDGE PORT

This port provides a plug-in cartridge facility that does not sense in hardware the presence of a cartridge. The cartridge ROM occupies addresses in the range:

$FA0000 (16384000) to $FBFFFF (16515071) - 128 Kbyte, Bank switching provides a means of accessing even more.



40 way socket

Pin	Function	Pin	Function
1	power +5 Vdc	21	address 8
2	power +5 Vdc	22	address 14
3	data 14	23	address 7
4	data 15	24	address 9
5	data 12	25	address 6
6	data 13	26	address 10
7	data 10	27	address 5
8	data 11	28	address 12
9	data 8	29	address 11
10	data 9	30	address 4
11	data 6	31	ROM3 select
12	data 7	32	address 3
13	data 4	33	ROM4 select
14	data 5	34	address 2
15	data 2	35	upper data strobe
16	data 3	36	address 1
17	data 0	37	lower data strobe
18	data 1	38	ground
19	address 13	39	ground
20	address 15	40	ground

Only the lower 15 address lines are available to the ROM cartridge which does not provide a 'write' line.

INTELLIGENT KEYBOARD (ikbd) INTERFACE

The Atari intelligent keyboard performs a variety of functions that include the decoding of the key switch matrix, decoding mouse, trackerball and joystick data and providing the time of day. It communicates with the main processor over a high speed bi-directional serial link providing a convenient mouse/joystick interface.

The keyboard consists of a series of make/break key switches for which the ikbd generates keyboard scan codes for each key press and release, chosen mainly for compatibility with the Digital Research graphic system (GSX). The key codes, table Appx D.4, are defined for the whole range of international keyboards such that each code has a predefined key press meaning, irrespective of the presence of the key switch. The break code for each key is signified by bit 7 of the corresponding make code for the key being set; the codes #$F6 to #$FF are reserved for keyboard system functions.

The keyboard controller contains a 1 MHz HD6301 8-bit microprocessor that communicates with the ST's MC6850 asynchronous communications interface adaptor (ACIA) at a fixed 7.8 Kbit/s. The keyboard not only transmits the encoded key scan codes (with a two key rollover), it also enables the programmer to interrogate the status, define the read rates and sensitivity of the mouse and joysticks under software control.

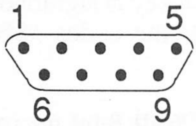
The time-of-day clock incorporated in the keyboard controller is held to a resolution of 1 second and may be read and set from software. The keyboard may be reset, without affecting the time held by the clock, to its power-up parameters.

When reset, the keyboard controller performs a simple ROM (checksum), RAM and key (stuck) series of checks, correct operation is indicated by the return of the version/release number of the ikbd controller.

MOUSE/JOYSTICK INTERFACE

The mouse and joysticks work on the basic unit of an 'event', this is defined as either the opening or closing of a switch, or of motion beyond a predefined programmable threshold level. The mouse is capable of a resolution of 200 events per inch (4 events/mm) and is scanned at such a rate as to permit tracking velocities of up to 10 in/s (250mm/s).

Motion, which produces make then break cursor keycodes, can be reported in three different ways; relative, absolute and cursor key motion (motion per keystroke is independently programmable in both axes). The mouse buttons can also be treated as part of the mouse or as additional keyboard keys.



9 way DB 9P plug

Port 0 is configured for mouse operation

Port 1 is the second joystick interface

Pin	Joystick Function	Mouse/Jstk 0 Function
1	Up	XB/Up
2	Down	XA/Down
3	Left	YA/Left
4	Right	YB/Right
5	reserved	n.c
6	Fire	left button/Fire
7	Power	+5v
8	Gnd	Gnd
9	n.c	right button/Joy 1 fire

The mouse unit provides interactive input to programs like the desktop applications, permitting a convenient method of selecting from a menu of facilities shown symbolically as icons or simply as text. Port zero is configured for the mouse, but may also be connected to a joystick.

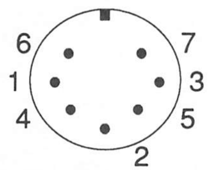
The joystick is invariably used in games applications; but may also be used instead of the cursor keys, for fine control of the screen cursor position (one pixel movement).

The joystick fire and mouse buttons close to ground.

POWER SUPPLY

The seperate power supply provides power for the main system board, the keyboard controller, any connected expansion ROM and expansion RAM.

The supply is fused, the levels are regulated for over-voltage and incorporate over-current protection.



7 way DIN 7P plug

Pin	
1	+5 VDC
2	n.c
3	Ground
4	+12 VDC
5	-12 VDC
6	+5 VDC
7	Ground

The power levels are:

5VDC @ 3A 5%
+12VDC @ 0.03A 10%
-12VDC @ 0.03A 10%

The power supply may be integral with the main unit (1040ST, Mega ST).

PROCESSOR DEVICE OUTLINES

MC68000 8 MHz microprocessor
WD1772A floppy disk controller
MK68901 multi-function processor
MC6850 asynchronous communications interface adaptor
YM2149 programmable sound generator

CUSTOM DESIGNED DEVICES (ULAS)

Direct memory access controller (DMA)
Memory management unit (MMU)
Video controller (Shifter)
General housekeeping (Glue)
Blitter

There have been three generations of operating system for the Atari ST todate:

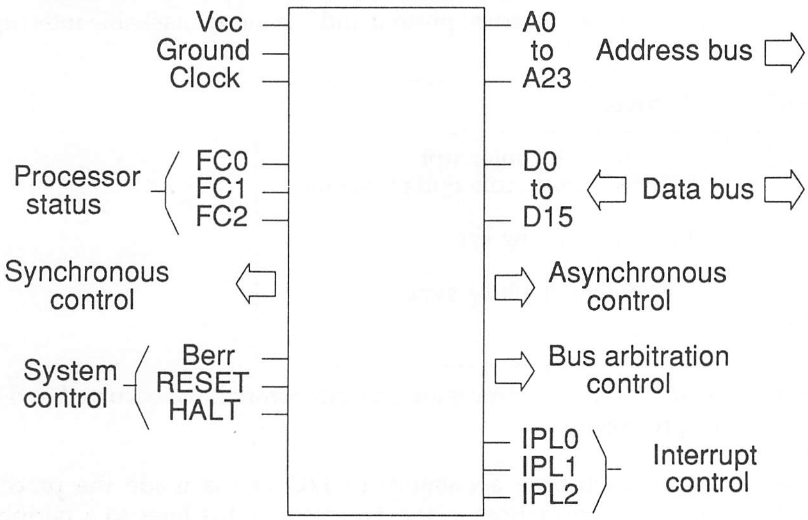
a) OS supplied on disk
b) TOS in ROM
c) 'New TOS' in ROM

The blitter chip requires the 'New TOS', but the 'New TOS' does not necessarily require the blitter chip.

MOTOROLA MC68000 MICROPROCESSOR

Signal I/O

The following is a very brief description of the signal I/O of the Motorola MC68000.



A high-density, N-channel, silicon-gate depletion load 16-bit Microprocessor in a 64 pin DIL package.

The ***Address bus*** (A0 - A23) enables the MC68000 to address 16 megabyte of data or 8 Megaword of instructions. The address bus provides the level being serviced, during an interrupt, on address lines A0 to A3 while A4 to A23 are held high.

The ***Data bus*** (D0 - D15) enables the transfer of word and byte-sized chunks of data. During an interrupt acknowlege, a vector number may be placed on lines D0 to D7 by a peripheral device.

Bus arbitration control allows a peripheral device to control the MC68000 bus (bus master); any external request will be granted on a priority basis between the competing devices.

Interrupt control provides a priority level from peripherals requesting processor control enabling selection of multiple interrupts on a priority basis. Zero implies that there is no interrupt present and 7 is a non maskable interrupt.

Level	Autovector
7 high	Non maskable interrupt
6	MC68901 multi function processor
5	-
4	Vertical blanking sync
3	-
2	Horizontal blanking sync.
1 low	

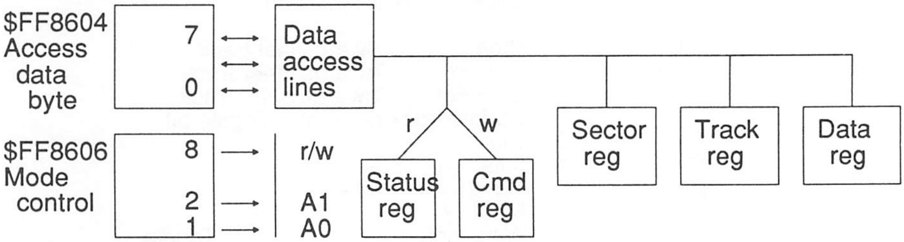
System control informs the processor that bus errors have occurred and also resets or halts the processor.

Processor status: each time a memory or I/O call is made the processor provides the following information on the processor status lines to a peripheral device: whether the processor is accessing data or program memory space or servicing an interrupt; and whether the processor is in user or supervisor mode.

The Motorola MC68000's separate parallel address and data buses are used to transfer data using an asynchronous bus structure controlled by the processor, internal or external, which has current bus control.

Interfacing with the 8-bit M6800 and 6500 family of synchronous peripheral devices is catered for through the use of memory-mapped I/O and a modified bus cycle.

WD1772A FLOPPY DISK CONTROLLER



Commands are passed to the FDC (and an external HDC), by selecting the appropriate FDC or HDC function (Read status/write command, sector, track or data) through the configuration register ($FF8606) and sending instructions or data via the access byte ($FF8604).

MODE BYTE ($FF8606)

Bits	Register	
7 . . . . . 1 0	Read	Write
0 0	Status	Command
0 1	Track	Track
1 0	Sector	Sector
1 1	Data	Data

Bit 7 selects Write (1) or Read (0)

The WD1772A floppy disk controller supports eleven instructions, these should only be loaded into the data byte register when the status bit (bit 5, $FFFA01) is off. The instructions enable head location, reading and writing sectors, tracks and the forced interrupt of a disk operation:

INSTRUCTION BYTE ($FF8604)

Type 1 command

```
0000 ....   Restore \  To track 0 position
0001 ....   Seek    /  Track position

001. ....   Step          Towards last track
010. ....   Step in       Towards inner track
011. ....   Step out      Towards outer track
   1 ....   Update track register   Toggle bit
0    ..00   2ms   \
0    ..01   3ms    |  Step
0    ..10   12ms   |   rate
0    ..11   6ms   /
0    .1..   With verify                \  Toggle
0    1...   Without Spin-up disable    /   bits
```

Type 2 command

```
100. ....   Read Sector
101. ....   Write Sector

     ...1   write 'deleted data' mark       \
     ..1.   precompensation enabled          |  Toggle
     .1..   30ms delay                       |   bits
     1...   without 'spin-up' delay          |
...1 ....   multiple sector read/write      /
```

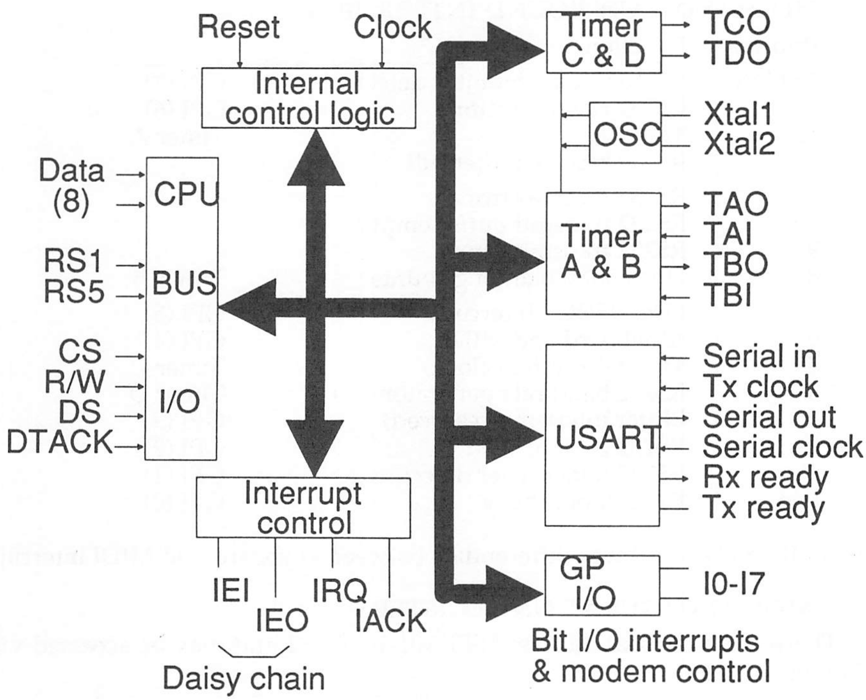
Type 3 command

```
110. ..00   Read address        Read diskette ID
111. ..00   Read track
1111    0   Write track

     ...1   write 'deleted data' mark      \
     ..1.   precompensation enabled         |  Toggle
     .1..   30ms delay                      |   bits
     1...   without 'spin-up' disable      /
```

Type 4 command

```
1101 ..00   Force interrupt

     00..   end with no interrupt
     01..   interrupt on index pulse
     10..   immediate interrupt
```

MC68901 MULTI-FUNCTION PROCESSOR



The MC68901 contains a single channel USART capable of operating in full duplex, at a rate of 62.5Kb/s asynchronous, 1Mb/s synchronous from an internal or external Baud rate generator. The USART also supports DMA handshake signals and modem control.

There are four timers with independant operation and vectored interrupts, the timers have the following preferred timer uses:

Timer A: Stand alone applications and independent software vendor.
B: Primarily Screen Graphics (hblank, sync etc.)
C: System timing (GSX, GEM, Desktop, etc). Suitable for delays and general timing applications (200Hz).
D: RS 232 port baud rate control.

Eight individually programmable I/O pins with interrupt capabilities are also available.

MC68901 INTERRUPT CONTROL

MFP HARDWARE BOUND INTERRUPTS

Priority	Function	
15 high	Monochrome monitor detect	GPI (7)
14	RS232 ring indicator	GPI (6)
13	Timer A	Timer A
12	RS232 receive buffer full	
11	RS232 receive error	
10	RS232 transmit buffer empty	
9	RS232 transmit error	
8	Horizontal blanking counter	Timer B
7	FDC/HDC - Interrupt	GPI (5)
6	*Keyboard and MIDI	GPI (4)
5	Timer C (system clock)	Timer C
4	RS232 baud rata generator	Timer D
3	Blitter interrupt (reserved)	GPI (3)
2	RS232 clear to send	GPI (2)
1	RS232 data carrier detect	GPI (1)
0 low	Parallel port busy	GPI (0)

* Test MC6850 status bit to differentiate between keyboard and MIDI interrupts.

MFP CONFIGURATION REGISTERS

These are located at address $FFFA01-16775681 and may be accessed via the following offsets:

Offset Dec	Hex	Function	Offset Dec	Hex	Function
1	01	Gen purpose I/O	25	19	Timer A control
3	03	Active edge	27	1B	Timer B control
5	05	Data direction	29	1D	Timer C & D control
7	07	Interrupt enable A	31	1F	Timer A data
9	09	Interrupt enable B	33	21	Timer B data
11	0B	Interrupt pending A	35	23	Timer C data
13	0D	Interrupt pending B	37	25	Timer D data
15	0F	Interrupt in-serv A	39	27	Sync character
17	11	Interrupt in-serv B	41	29	Usart control
19	13	Interrupt mask A	43	2B	Receiver status
21	15	Interrupt mask B	45	2D	Transmitter status
23	17	Vector base address	47	2F	Usart data

The MC68901 usart registers are accessible from Extended BIOS (XBIOS)

SYNCHRONOUS CHARACTER REGISTER

7	6	5	4	3	2	1	0

SCR = $FFFA27

Used to synchronize incoming received data acting as the matching character

USART CONTROL REGISTER

7	6	5	4	3	2	1	0

UCR = $FFFA29

Bit 1: 0 = odd, 1 = even

Bit 2: 0 = off, 1 = enable

Bits 4, 3:

4	3		Start and stop bits	
1	1	- async	1 2	
1	0	- async	1 1/2	used by div by 16
0	1	- async	1 1	
0	0	- sync	0 0	

Bits 6, 5:

6	5	
0	0	- 8 bits per word
0	1	- 7 bits per word
1	0	- 6 bits per word
1	1	- 5 bits per word

Bit 7: 0 = normal, 1 = Divide by 16

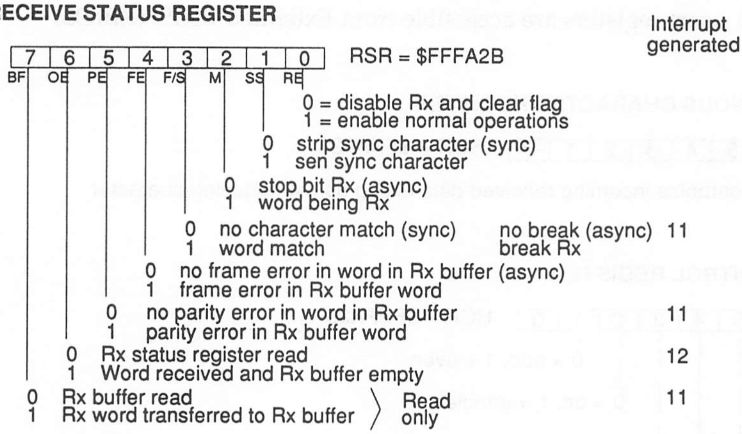
TRANSMIT STATUS REGISTER

7	6	5	4	3	2	1	0
BE	UE	AT	END	B	H	L	TE

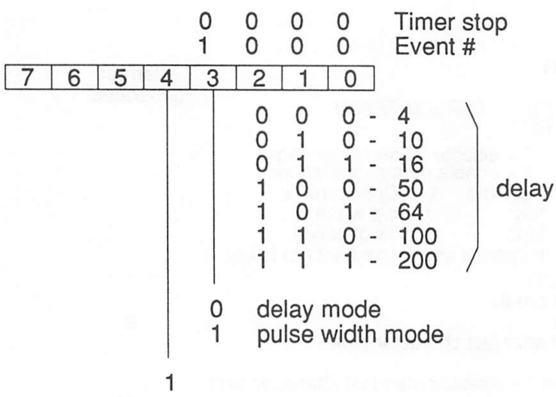
TSR = $FFFA2D

Bit	Value	Meaning	Interrupt generated
0 (TE)	0	= disable Tx and clear flag	
	1	= enable normal operations	
2, 1 (H, L)	0 0	high imp (Configure Tx o/p when Tx disabled)	
	0 1	low (Configure Tx o/p when Tx disabled)	
	1 0	high (Configure Tx o/p when Tx disabled)	
	1 1	loopback async (connect o/p to i/p)	
3 (B)	0	Normal Tx	
	1	Send a break	
4 (END)	0	Tx enabled	9
	1	Tx disabled after last character sent	
5 (AT)	0	Disable Tx	
	1	Enable Rx when Tx disabled after last character sent	
6 (UE)	0	Tx status register read	10
	1	Word transmitted and Tx buffer empty	
7 (BE)	0	Tx buffer read	9
	1	Tx word transferred to Tx shift register	

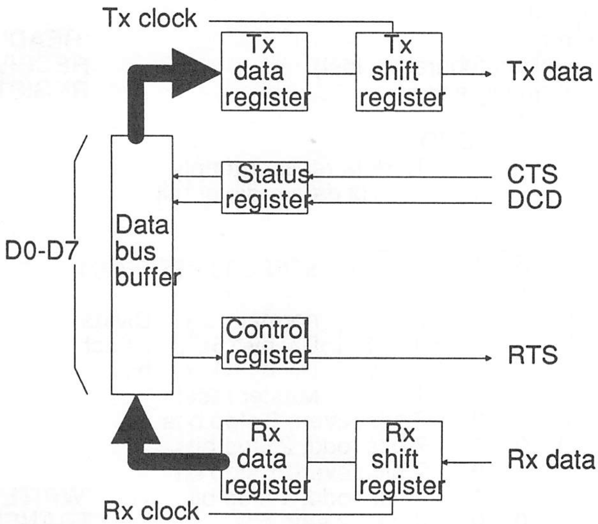
RECEIVE STATUS REGISTER



Timer A uses register B ($FFFA19), timer B register 14 ($FFFA1B), timers C and D both use register 15 ($FFFA1D). Timer C bits 4 to 6 and timer D bits 0 to 2, both operate delay mode only.



MC6850 ASYNCHRONOUS COMMUNICATIONS INTERFACE ADAPTOR



The MC6850 ACIA provides data formatting and control of a serial interface to an 8-bit bidirectional data bus. At the bus interface, the four ACIA registers, the status and receive data -read only and the control and transmit data-write only registers, appear as two addressable memory locations.

The programmable ACIA control register, which sets the format of the serial link, is located at $FFFC00 (16776192) for the intelligent keyboard serial communications link, and at $FFFC04 (16776196) for the MIDI interface.

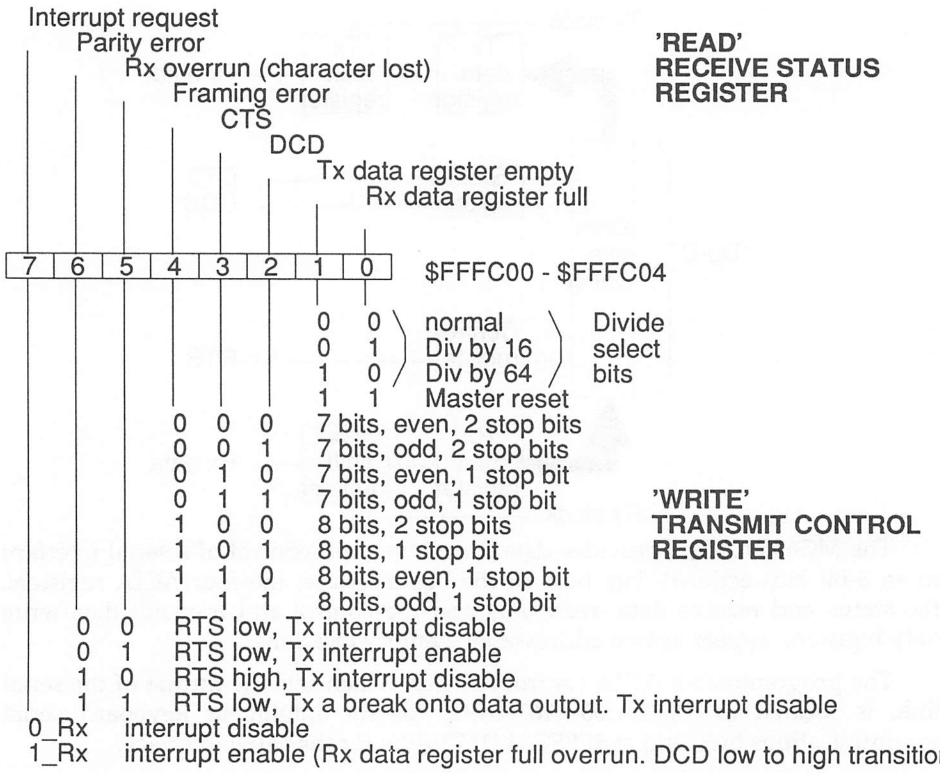
The ACIA supports peripheral/modem control through:

RTS request to send,
CTS clear to send
and DCD data carrier detect.

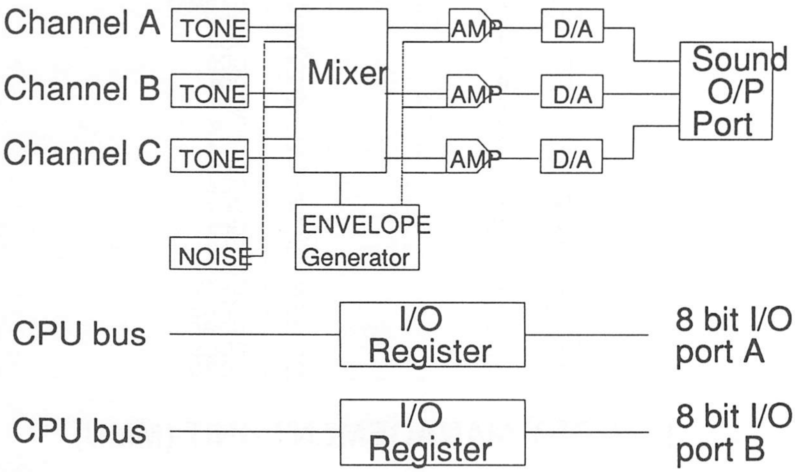
Protocols for 8 and 9 bit transmission using an optional odd or even parity, and one or two stop bits, are available through the programmable control register.

The MIDI port may be configured as a second serial port (for networking) but the intelligent keyboard interface is not accessible.

ACIA CONTROL/STATUS REGISTER



YAMAHA YM2149 PROGRAMMABLE SOUND GENERATOR



The programmable sound generator control registers are located as follows:

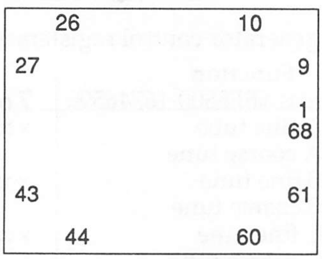
RAM offset reg	addr	Function Base address $FF8800-16746596	Bits used 7 6 5 4	 3 2 1 0
0	0	Channel A fine tune	x x x x	x x x x
1	1	Channel A coarse tune		x x x x
2	2	Channel B fine tune	x x x x	x x x x
3	3	Channel B coarse tune		x x x x
4	4	Channel C fine tune	x x x x	x x x x
5	5	Channel C coarse tune		x x x x
6	6	Noise period	x	x x x x
7	7	Mixer cntrl-I/O enable	I/O noise tone	
		Fixed amplitude		
8	8	Channel A amplitude	M	x x x x
9	9	Channel B amplitude	M	x x x x
10	A	Channel C amplitude	M	x x x x
		Variable amplitude		
11	B	Envelope period fine	x x x x	x x x x
12	C	Envelope period coarse	x x x x	x x x x
13	D	Envelope shape		C R A H
14	E	I/O port A (output only)		
15	F	I/O port B (centronics)	data	

M=mode fixed/variable C=cycle A=alternate x=bits used R=ramp H=hold

DIRECT MEMORY ACCESS CONTROLLER (DMA)

R/W	1	40	+5v
A1	2	39	clk 8Mhz
FCS	3	38	RDY
D0	4	37	ACK
D1	5	36	CD0
D2	6	35	CD1
D3	7	34	CD2
D4	8	33	CD3
D5	9	32	CD4
D6	10	31	CD5
D7	11	30	CD6
D8	12	29	CD7
D9	13	28	Gnd
D10	14	27	CA2
D11	15	26	CA1
D12	16	25	CR/W
D13	17	24	HDCS
D14	18	23	HDRQ
D15	19	22	FDCS
Gnd	20	21	FDRQ

MEMORY MANAGEMENT UNIT (MMU)

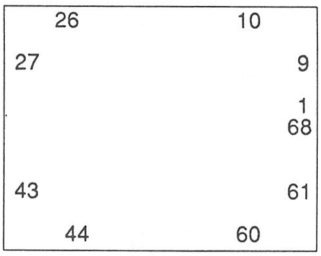


1	D4	18	RAS1	35	A15	52	DE
2	D5	19	4Mhz Out	36	A14	53	DTACK*
3	D6	20	8Mhz Out	37	A13	54	MAD5
4	D7	21	CAS1L	38	A12	55	MAD4
5	16Mhz IN	22	CAS1H	39	A11	56	MAD3
6	CAS0H	23	WE*	40	A10	57	MAD2
7	CAS0L	24	DMA	41	A9	58	MAD1
8	RAS0	25	WDAT*	42	A8	59	MAD0
9	LATCH	26	UDS*	43	A7	60	MAD6
10	VCCA	27	Gnd	44	+5v VCCB	61	Gnd
11	A16	28	CMPCS*	45	A6	62	MAD7
12	A17	29	DCYC*	46	A5	63	MAD8
13	A18	30	RDAT*	47	A4	64	MAD9
14	A19	31	DEV*	48	A3	65	D0
15	A20	32	AS*	49	A2	66	D1
16	A21	33	RAM*	50	A1	67	D2
17	LDS*	34	R/W*	51	VSYNC	68	D3

VIDEO CONTROLLER (SHIFTER)

XTL0	1	40	+5v
32Mhz XTL1	2	39	16Mhz clk
D0	3	38	CS
D1	4	37	DE
D2	5	36	A1
D3	6	35	A2
D4	7	34	A3
D5	8	33	A4
D6	9	32	A5
D7	10	31	R/W
load	11	30	Mono
D8	12	29	R0
D9	13	28	R1
D10	14	27	R2
D11	15	26	G0
D12	16	25	G1
D13	17	24	G2
D14	18	23	B0
D15	19	22	B1
Gnd	20	21	B2

GENERAL HOUSEKEEPING (GLUE)



1	+5v Vcc	18	ROM3	35	Gnd	52	Gnd
2	A14	19	ROM2	36	BLANK*	53	SNDCS*
3	A15	20	ROM1	37	HSYNC	54	2Mhz out
4	A16	21	ROM0	38	VSYNC	55	R/W*
5	A17	22	RESET*	39	DE	56	A1
6	A18	23	RAM*	40	BR*	57	A2
7	A19	24	DMA*	41	BGACK*	58	A3
8	A20	25	DEV*	42	6850CS*	59	A4
9	A21	26	FCS*	43	500Khz out	60	A5
10	A22	27	BGI*	44	MFPINT*	61	A6
11	A23	28	RDY	45	BGO*	62	A7
12	AS*	29	VPA*	46	LDS*	63	A8
13	FC2	30	BERR*	47	UDS*	64	A9
14	FC1	31	DTACK*	48	D0	65	A10
15	FC0	32	IPL1*	49	D1	66	A11
16	VMA*	33	IPL2*	50	IACK*	67	A12
17	ROM4	34	8Mhz In	51	MFPCS*	68	A13

Chapter 2

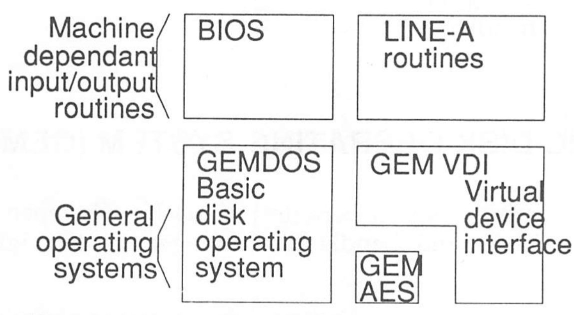
The operating system (TOS) overview

Operating system overview

The Atari ST operating system is in many ways functionally similar to MS-DOS, with extensions for handling a mouse, sound, the midi interface, an intelligent keyboard and joysticks. The source is based on a CP/M 68K related operating system referred to as the TOS (Tramiel Operating System). A graphics environment manager (GEM) provides additional single-user support for windows and communications via VDI and AES extensions, which support graphics and an applications environment. Program transportability is maintained by splitting the operating systems into machine independant (BDOS, VDI and AES) and machine dependant basic input/output utilities (BIOS and line-A routines).

The ST programmer is given access to the VDI primitives via the line-A routines for much greater graphic application speed.

The disk operating system (DOS) contains routines that provide access to the disc drives and support existing single user programs, file locking to ensure safe updating, unlock and read only facilities. Disk operation errors are trapped (where possible) and corrected.



Programmable segments of TOS

The application environment (AES) multitasks using a timeslicing technique and supports a database file management system, real time data aquisition, communications and process control.

The virtual device interface (VDI) allows the use of peripheral independant device drivers and provides a high degree of support for advanced user interfaces.

BASIC INPUT/OUTPUT SYSTEM (BIOS)

The BIOS consists of all the machine dependent I/O routines of Digital Research's GEM and additionally provides access to the line-A routines for fast graphics. The I/O functions can be categorized as follows:

GEM BIOS:

System I/O:	Parameter block initialization
Console I/O:	Data I/O & query
Disk I/O:	Memory/disk transfers

ST XBIOS:

Port I/O:	Configure RS232, mouse, midi & sound port
Screen I/O:	Get screen parameters
Disk I/O:	Memory/disk transfers
Keyboard I/O:	Keyboard communications

Line-A routines:

Pixel graphics
Line graphics
Sprite graphics
Bit block transfer
Mouse handler

BASIC DISK OPERATING SYSTEM (GEMDOS)

The disk operating systems permits the machine independent routines to access the disk drives and handle file management through the following functions:

Set/get time and date
Tree directory management
File attribute management
Create/open/close files and disk transfers.

Current versions of GEMDOS impose a limit of 40 folders>

Virtual device interface (VDI)

The VDI provides a set of graphic function calls that allow portability across physical hardware. Not all the standard VDI calls are implemented on all the operating systems available for the ST, the VDI tables Chapter 3 are annotated to show those that are missing from the various systems.

Control I/O:	Initialize graphics & set defaults.
Graphics I/O:	Primitives, lines, polygons, bars, arcs & pies.
Attribute I/O:	Set colour and style.
Raster I/O:	Bit block transfers, fill, font and cursor forms.
Input I/O:	Keyboard/mouse interaction with console.
Inquire I/O:	Get attributes, resolution, style etc.
Special I/O:	Permits specialized functions to be performed.

Application Environment Services (AES)

The AES (application environment services) are a series of utilities that handle graphic based inputs to the user application. For example, instead of asking for INPUT - the screen displays graphically a menu of options which may include a clock, a file and perhaps a disk, these items being given a pictorial representation that is called generically an 'Icon'. To select one, the user simply moves the cursor, which may look remarkably like an arrow, and places it on the required icon by moving the mouse and pressing a trigger button on the mouse.

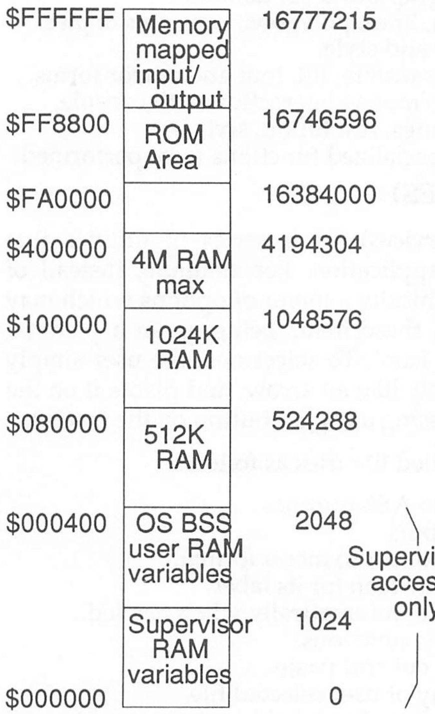
The AES routines are put into groups called libraries as follows:

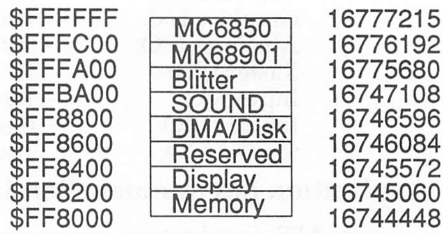
Application:	Provide access to AES routines.
Event:	React to user inputs
Menu:	Translate defined text to menu format.
Object:	Substitute graphic-icon for its label
Form:	Handle text input automatically when needed.
Graphic:	Primitive graphic functions.
Scrap:	Management of cut and paste.
File Selector:	Creation/display of user selected file.
Window:	Handle windowing of queried input responses.
Resource:	Interface device dependant drivers to applications.
Shell:	Enable one program to call another.

Application programs

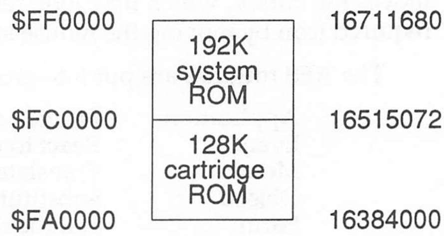
The desktop application is part of the operating system and is the base user interface when other application programs are not running. It provides a calculator, alarm and clock; and through manipulation of icons via the mouse, disk directories, disk and file copy and deletions, disk formatting, as well as other activities such as communications, data output and window control

MEMORY ALLOCATIONS





MEMORY MAPPED I/O CONFIGURATION REGISTERS



ROM CONFIGURATION IN MEMORY

References to the bottom 2K of memory and the I/O space are classed as supervisor references and attempted access from user mode will cause an error exception trap.

SYSTEM TABLES

			Operating system block storage segment
$800			
			System parameters and variables
$400		1024	
$200		512	Reserved for OEMs
$100		256	MFP vectored interrupts
$0BC	Trap #15 vector	188	
$0B8	Trap #14 vector	184	XBIOS (ST extended BIOS)
$0B4	Trap #13 vector	180	BIOS
$0B0	Trap #12 vector	176	
		172	
$08C	Trap #3 vector	140	
$088	Trap #2 vector	136	BDOS
$084	Trap #1 vector	132	GEMDOS interface
$080	Trap #0 vector	128	
$07C	Interrupt level 7	124	Non maskable interrupt
$078	Interrupt level 6	120	68901 MFP
$074	Interrupt level 5	116	
$070	Interrupt level 4	112	Vertical blank sync
$06C	Interrupt level 3	108	Normal interrupt level
$068	Interrupt level 2	104	Horizontal blank sync
$064	Interrupt level 1	100	
$060	Spurious intrpt	96	
			Unused vectors point to the system critical error handler
$03C	Uninit int vector	60	
		48	
$02C	Emulation 1111	44	Used by some AES functions
$028	Emulation 1010	40	Line-A routines entry
$024	Trace	36	
$020	Privilege violation	32	
$01C	Trap instruction	28	
$018	CHK instruction	24	
$014	Divide by zero	20	
$010	Illegal instruction	16	
$00C	Address error	12	
$008	Bus error	8	
	Initialise PC		
$000	Reset init SSP	0	

Supervisor space (from $000 up to $800)

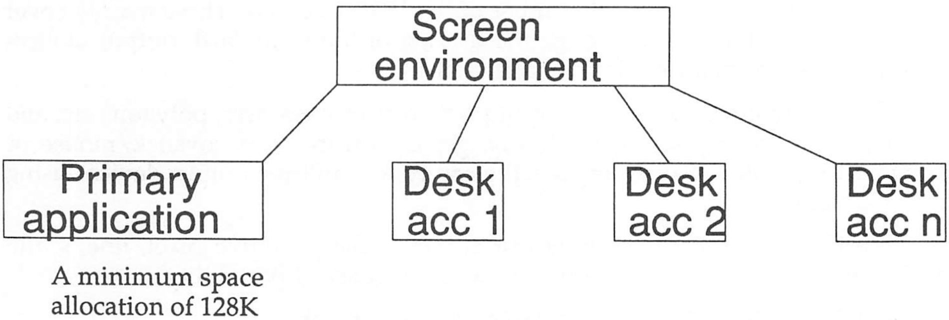
The system variables are in the supervisor space and can be accessed only in supervisor mode

CONFIGURATION REGISTERS

			Functions controlled
$FFFC00	ACIA	16777215	Keyboard and MIDI I/O
$FFFA00	MFP	16776192	System checks, system interrupts
	Blitter	16747108	
$FF8800	Sound	16746596	PSG 3 channel sound, noise, tone, amplitude and envelope
$FF8600	DMA/Disk	16746084	Floppy/hard disk, DMA
$FF8400	Reserved	16745572	
$FF8200	Display	16745060	Video address, field rate, video made and palette
$FF8000	Memory	16744448	Memory size

Resource management overview

The pseudo multitasking kernal can support one primary application and one of a number of desk accessory programs. The main application may be GEM or DOS such as GEM desktop application or a word processing package etc.



A desk accessory is an application that does not take over the entire display screen, running in a specially designed window. The calculator is a typical accessory.

Only one desk accessory program may be active at a time, and will only load if at least 128K of RAM is left for the primary application.

CPU resources

The dispatcher divides CPU time between primary applications and background processes. These jobs are put into lists; 'Ready for processing' and 'Not ready', and are serviced on a round robin schedule with the current process at the head of the list running. Not ready processes may be waiting for a key press, mouse movement or trigger, time lapse etc.

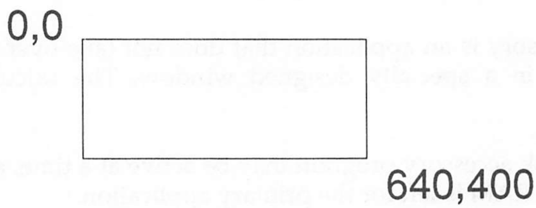
Graphics Concept Overview

The Atari ST graphics is supported at a primitive level through the line-A routines and at a higher level through a limited version of the Digital Research graphic system extension (GSX), which is based on the ANSI virtual device interface (VDI). VDI provides a set of graphic primitives (GDOS) and a library of device drivers (GIOS) for the preparation of transportable software. The whole of GDOS and GIOS are not included in the ROM based ST operating system and there is no support for a small number of the VDI functions. These mainly cover lack of support for multiple fonts, the driving of 'non-standard' output devices and the use of 'normalised device coordinates.

The VDI interface provides output primitives of lines, arcs, polygons etc. and input primitives to point symbolically, get co- ordinates of joystick/mouse or keyboard input etc. It also supports the control of multiple output devices using raster screens.

The line-A routines give very fast access to the primitive pixel, line, sprite and bit block transfer graphic functions at the expense of portability

RASTER COORDINATES are based on screen pixels.



GEM programs are portable but must take into account two possible problem areas:

Screen aspect ratio: Different hardware systems and displays (screen, printer, plotter or another computer) may have different aspect ratios. Producing similar screen designs requires the programmer to scale the data sent to the display device using the aspect ratio returned from the open workstation call.

Language implementations: Different language implementations of a program will require different length text strings to be fitted into windows. The inquire character cell width call in conjunction with the window size returned by the *wind_get* call will enable the programmer to determine the number of characters acceptable.

Alert and Dialog boxes have predetermined responses set up using the resource construction set and therefore do not present a language problem.

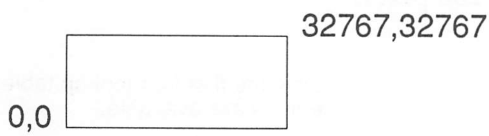
The missing part of GDOS is available as part of the code supplied in certain Digital Research products and may at a later date become more generally available for the ST (as 'AUTO\GDOS.PRG' file). On this premise, the details of the missing parts are given coupled to a rider that they are not available on the basic system.

GEM usually provides two graphic coordinate systems to the programmer, raster and normalized.

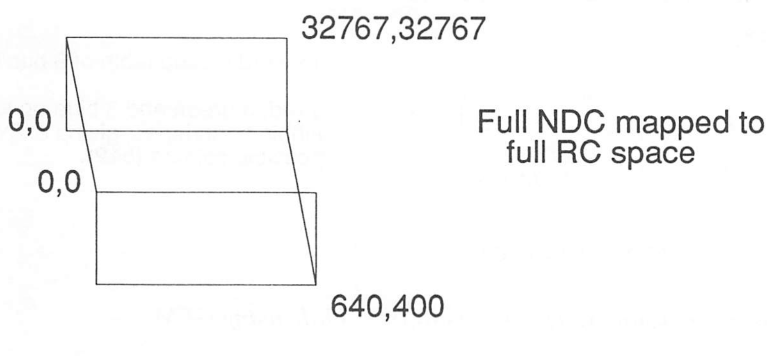
Raster is based on the computers screen resolution, in the case of the Atari ST 600 x 400 pixels (monochrome).

NDC (not implemented) is based on a notional screen of 32767 x 32767 points, the points being translated to the actual screen of the target system by one of the GIOS device drivers. The idea behind this is to write software independant of specific screen resolutions.

NORMALIZED DEVICE COORDINATES are based on a screen of 32767x32767 pixel dimensions.



Graphic Coordinate Computation

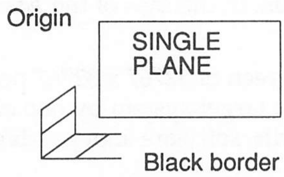


Overview of screens

The Atari ST screen may be operated in three different resolution modes, the colours may be chosen from a palette of 512 colours:

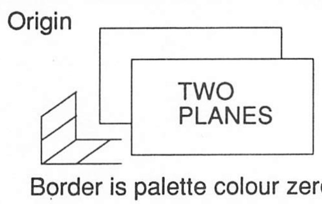
High:	640 x 400 pixel, black and white display
Medium:	640 x 200 pixel, 4 colour display
Low:	320 x 200 pixel, 16 colour display

High Resolution 640 x 400 pixels



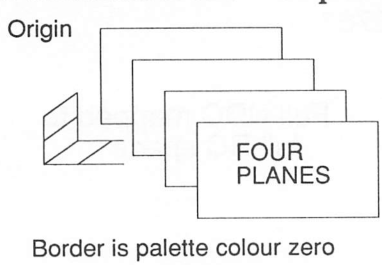
No colour but inverse video is available determined by the condition of bit zero of palette colour zero

Medium Resolution 640 x 200 pixels



Only the first four lookup table entries are available.

Low Resolution 320 x 200 pixels

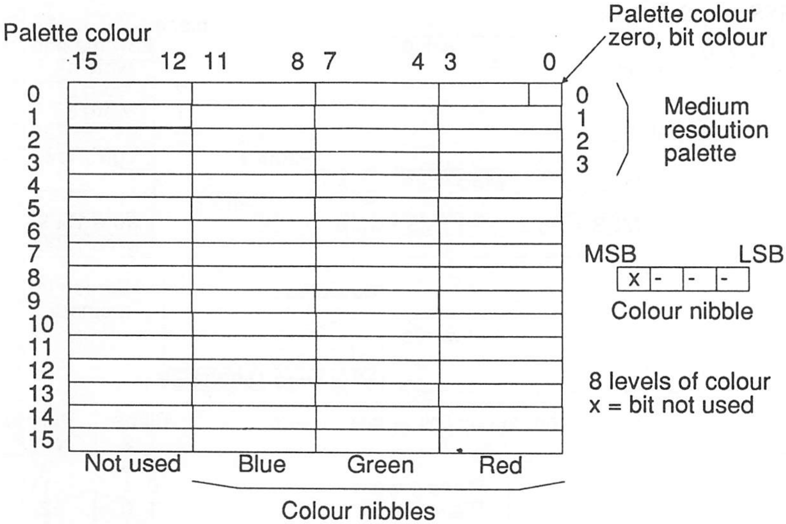


16 word lookup table of 9 bits/entry

3 red, 3 green and 3 blue on low nibble boundaries, giving 8x8x8 possible colours (512).

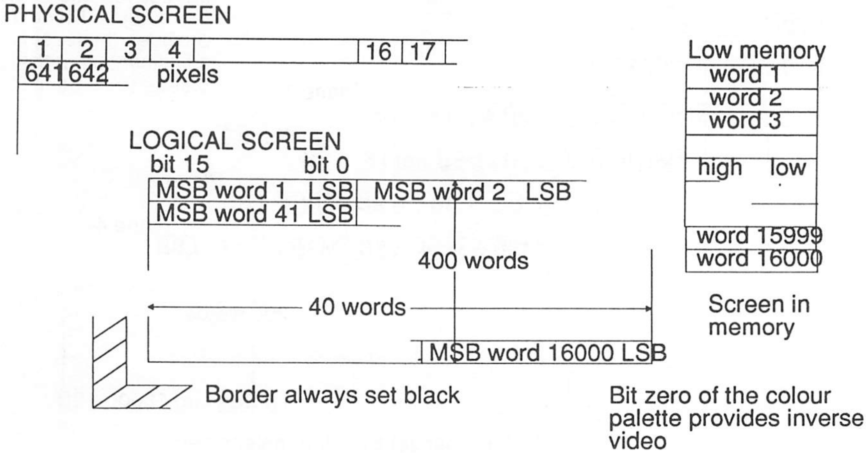
It is not possible to change resolution while using GEM

Colour Palette Table

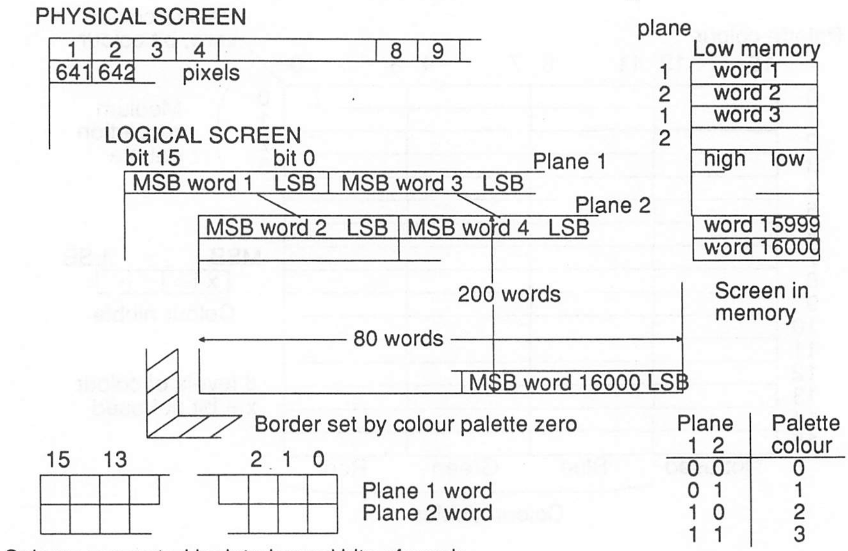


Physical to logical screen transposition

High resolution mode 640 x 400

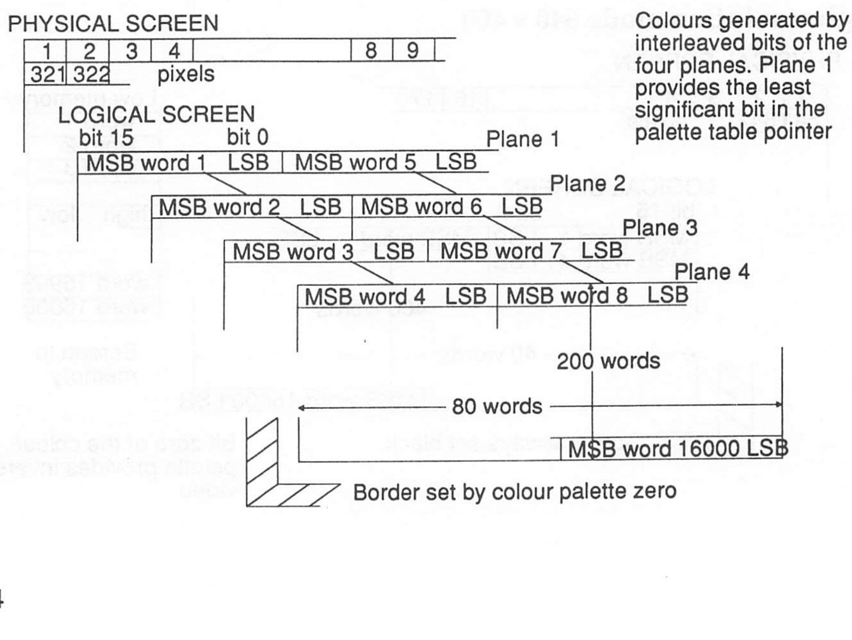


Medium resolution mode 640 x 200



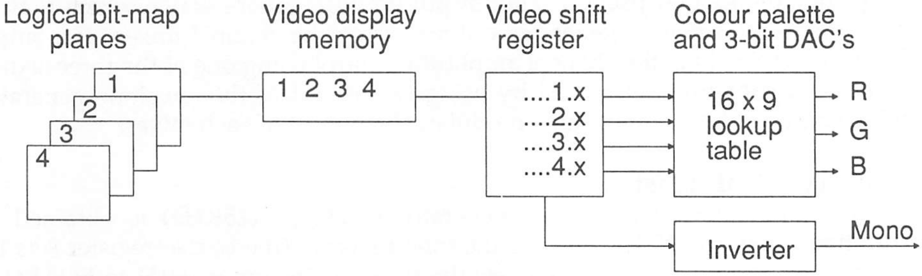
Colours generated by interleaved bits of words

Low resolution mode 320 x 200



Color generation

A word from each plane is taken from the video display file and placed in the video shift register from where the bits are collectively used to index into the colour palette table. The colour code generated is supplied to a 3-bit digital to analogue convertor to produce the RGB signals.



In high resolution monochrome mode, the video shift register passes its data to the inverter and not the palette lookup table.

Colour changing

To prevent jitter when changing colors using the Hblank ($068) and Hsync ($120) interrupt vectors, programmers should use the following procedure:

1) Revector keyboard/MIDI interrupt to a routine that lowers the IPL to 5 and then jumps through the original vector.

2) During the critical section of screen, revector the system 200Hz clock interrupt vector to a routine that increments a counter and then RTEs.

3) After the critical section, block interrupts (at IPL 6) and call a system clock handler that jumps through the interrupt vector with a fake SR and return address on the stack, the number of times indicated by the counter.

Animation

Animation is most easily achieved by switching alternately between two screens; one on display, the other being updated in the background. Initially write two identical screens and display one while modifying the other, swap the screens over and display the modified screen while updating the one previously on display. The technique will produce a very stable display with quite slow switching rates.

Sound concept overview

Sound is generated via a Yamaha YM2149 programmable sound generator. The PSG contains three tone generators that produce the basic square wave tone frequencies for the A, B and C channels and a noise generator, that produces a frequency modulated pseudo random pulse width square wave, which may be combined with the tone generator outputs using the channel mixer. The output level can be fixed via the channel amplitude control using one of the three sixteen level D/A converters or varied by using the output of the envelope generator, which may be used to amplitude modulate the output of each mixer.

Sound control registers

The frequency of each tone generator (30Hz to 125KHz) is obtained by counting-down the 12-bit value of the tone registers (the coarse register sets the upper 4 bits and the fine register sets the lower 8 bits, range 001H to FFFH (1 to 4095). The standard PSG format is to produce a lower note for a higher count whenever a register count-down is performed.

The noise generator frequency is controlled by a 5-bit noise period register, value 01H to 1FH (1 to 31), producing a frequency range of 4Khz to 125Khz.

The mixer control register is a multi-function register that mixes the noise channels (defined by bits 3 to 5) and the tone channels (defined by bits 0 to 2) in all possible combinations to the input/output ports (bit 6 I/O, bit 7 port A or B).

The amplitude of a channel is controlled to one of sixteen fixed levels by the channel D/A converter register (lower 4 bits of the register) and only by setting the register to zero can the channel be turned off. The fifth bit of the amplitude control register is set to select the variable level output defined by the envelope generator.

The envelope generator comprises of three registers, two provide the frequency variation and the third the format of the envelope. The frequency is determined by counting down the 16-bit value of the coarse and fine envelope registers range 0001H to FFFFH (1 to 65535). The shape and cyclic pattern of the envelope is defined by the lower 4 bits of the shape register (the amplitude register setting the level), the four bits provide for combinations of hold/cycle, reverse cycle on/off, ramp up/down and cycle hold pattern/reset to zero.

Parallel data I/O

The I/O register in the PSG is not associated with sound production, it provides a register to transfer 8-bit parallel data to and from the CPU bus to the I/O port A, there is no affect on any of the PSG's other functions.

Port A is controlled through functions 'ONGBIT' and 'OFFGBIT' (See page B.4 for bit functions and 3.12 for calls).

Port B read/write is controlled through BIOS functions BCONOUT and BCONIN (See page 3.4 for calls)

Data is written to a peripheral device from the bus using the following steps:

Select enable register (mixer register)
Set bit 6 to '1' (set I/O port A to output)
Select I/O port A data store (I/O port A register)
Write data to PSG (write data to I/O port A register)

Once data has been loaded into the register, the data remains until further data is loaded, the system is reset, or

the register is switched to input mode.

Data is read from a peripheral device to the bus with the following steps:

Select enable register (mixer register)
Set bit 6 to '0' (set I/O port A to input)
Select I/O port A data store (I/O port A register)
Read data from PSG (read data in I/O port A register)

The register follows signals applied to the port, only by reading will the data be transferred to the bus.

Sound configuration registers

Access to the PSG should be in supervisor mode as the SR register is modified. The PSG registers are located for write at address ($FF8800-16746596) as follows:

offset			
0	$0	Channel A fine tune	(8 bit)
1	$1	Channel A coarse tune	(4 bit)
2	$2	Channel B fine tune	(8 bit)
3	$3	Channel B coarse tune	(4 bit)
4	$4	Channel C fine tune	(8 bit)
5	$5	Channel C coarse tune	(4 bit)
6	$6	Noise generator control	(5 bit)
7	$7	Mixer control, I/O enable	(8 bit)
8	$8	Channel A amplitude	(5 bit)
9	$9	Channel B amplitude	(5 bit)
10	$A	Channel C amplitude	(5 bit)
11	$B	Envelope period fine tune	(8 bit)
12	$C	Envelope period coarse tune	(8 bit)
13	$D	Envelope shape	(4 bit)
14	$E	I/O port A	

Tone frequency calculations (registers 0 to 5)

The tone frequency is in the range 30.5Hz to 125Khz and may be calculated from the formula:

$$f = \frac{2 * 10^6}{16*(256 * CT + FT)}$$

where CT=coarse tone period
FT=fine tone period

Noise frequency calculations (register 6)

The noise frequency is in the range 4Khz to 125Khz and may be calculated from the formula:

$$f = \frac{2 * 10^6}{16 * Np}$$

where Np=noise period

The mixer control I/O enable (register 7) bit functions take the following format:

0 1 2	3 4 5	6 7
Tone channels	Noise channels	I/O port
A B C	A B C	A B
If the bit is zero the channel is on		If bit 0 port i/p

The channel amplitude (registers 8-11) bits have the following function:

-	-	-	M	x	x	x	x

M = 0 Fixed amplitude level
0-low to 15-high (xxxx)

M = 1 Amplitude determined
by envelope shape

Envelope calculations

Period

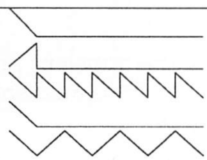
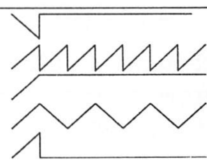
The envelope period *(registers 11 & 12)* of the shape is based on the 16-bit register value:

$$fe = \frac{fclock}{256 * Ep}$$

where Ep =envelope period
fclock =i/p clock frequency

Shape/cycle

The envelope shape/cycle control *(register 13)* bit settings produce the following range of sound envelopes:

Bits 3 2 1 0	Function	Bits 3 2 1 0	Function
0 0 x x 0 1 x x 1 0 0 0 1 0 0 1 1 0 1 0		1 0 1 1 1 1 0 0 1 1 0 1 1 1 1 0 1 1 1 1	

Bit 0 = Hold/_cycle
Bit 1 = Reverse on/_off

Bit 2 = Ramp up/_down
Bit 3 = Cycle hold/_reset zero

1 bit set
0 bit clear
x don't care

GEM disk operating system GEMDOS

Overview

For those systems supplied with the operating system on disk; the system disk contains on the first two tracks, a cold start loader that loads the operating system image file (TOS,IMG) into high memory and then block loads it down into RAM memory at address $5000.

The TOS image file contains both the GEM and Atari ST extended operating systems, including:

BDOS Basic disk operating system Access functions to the file system
BIOS Basic I/O system -Functions that interface peripheral device drivers

The operating system is always in memory above $400 and all modules reside permanently in memory, even those of disk based systems (unless the power is removed). After TOS is loaded, the remaining contiguous address space is called the transient program area (TPA) where TOS loads executable (command) files. The command files (programs) should not access absolute addresses or default TOS variables but use the BIOS and GEMDOS function calls, except those system variables documented in Appendix A (upto address $04xx).

Each transient program loaded into memory consists of the program segments (Text, Data and BSS), a user stack and a Base Page. The 256 byte Base Page contains the direct memory address (DMA) buffer, at base page offset $80; the buffer contains the command tail, typically the input typed to an application installed as a TOS Takes Parameters program. Before the loaded program takes control, the address of the transient programs base page and a return address are pushed onto the user stack, 4(A7) and (A7) respectively.

Although the OS can only load one program; the transient program itself can load further programs using GEMDOS function $4B, but must specifically supply the base page and return address if they are required.

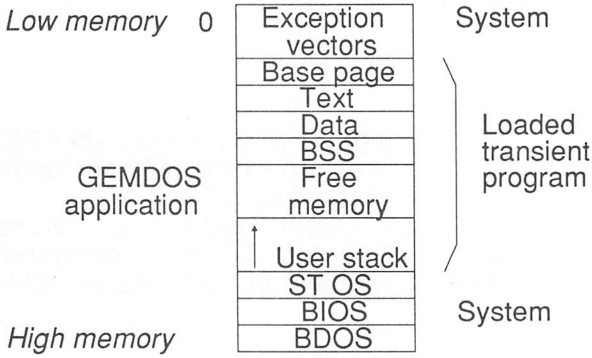
A return from a transient program may be achieved by:

An RTS as the last statement, returning via the return pushed onto the stac the load function.

Execute warm boot by calling extended BDOS function 0.

Type Control_C from the console during the execution of console output, printing a string or reading from the console buffer (functions 2, 9 and 10)

GEMDOS Memory model



Command file

The format of a command file is that of a header, two program segments (text and initialized data segments) and optionally a symbol table and relocation information. After the program is linked and loaded into memory, it contains additionally a zeroed uninitialized data (BSS) program segment and starts execution at the beginning of the text segment.

Not all assemblers provide for an uninitialised data section within the source code, this results in executable GEM based program files on disk that are much larger than necessary.

The operating system holds information on the data segments in a descriptor block (256 byte base page data structure) at the bottom of the TPA. The base page does not reside at a fixed address, its position is determined when it is created by the load a process function (GEMDOS function #$4B) and held in register D0.L.

The base page contents are initialized by the GEMDOS load function:

Base page format initialized by GEMDOS

$00	0	Base address of TPA
$04	4	End address of TPA + 1
$08	8	Base address of text (code)
$0C	12	Length of text (code)
$10	16	Base address of initialised data
$14	20	Length of data
$18	24	Base address of BSS uninitialised data
$1C	28	Length of BSS uninitialised data

There are slight differences between small sections of the original CP/M 68K and GEMDOS base page formats as follows:

CP/M 68K format

Offset	Decimal	Contents	
$20	32	Length of free memory after BSS	
$24	36	Drive from which program loaded	
$25	37	Reserved by BDOS	
$38	56	2nd parsed FCB from command line	Set by OS
$5C	92	1st parsed FCB from command line	Set by OS
$80	128	Command tail and default DMA buffer	Set by OS

GEMDOS format

Offset	Decimal	Contents
$20	32	DTA address pointer
$24	36	Parent's base page pointer
$28	40	Reserved
$2C	44	Pointer to environmental string
$80	128	Command line image (typically the entry to a dialog box for a TTP application)

File header format

GEMDOS file header and program segments take the format:

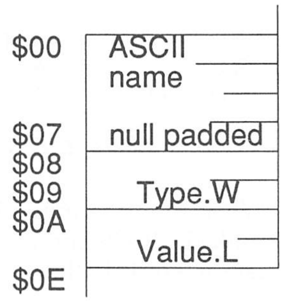
Offset	Decimal	Contents
$00	0	Data and BSS contiguous 601AH
$02	2	Number of bytes in text segment
$06	6	Number of bytes in data segment
$0A	10	Number of bytes in BSS
$0E	14	Number of bytes in symbol table
$12	18	Reserved
$16	22	Reserved
$1A	26	Reserved
$1C	28	Beginning of text segment

NOTE that 601AH is a BRA.S instruction that bypasses the file header data segment. The Atari OS does not support segmented files.

Symbol table

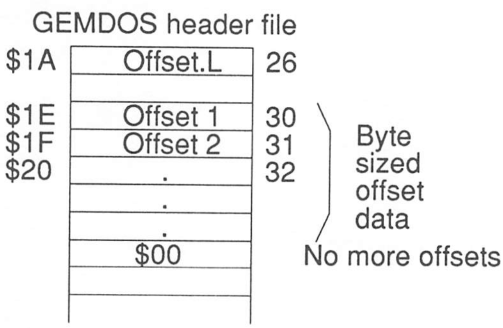
The symbol table consists of fourteen bytes that specify a null padded 8 character name, the type of symbol and the symbol value (address etc).

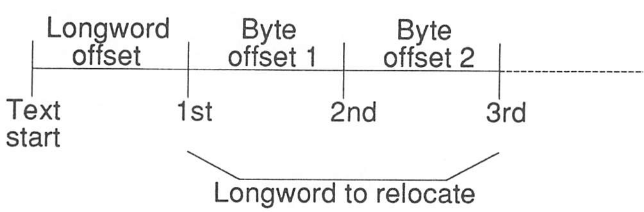
hex	Symbol type
$100	BSS
$200	Text relocatable
$400	Data
$800	External reference
$1000	Equated register
$2000	Global
$4000	Equated
$8000	Defined



Relocation table

The linker optionally produces a relocatable executable file and places the relocation information in the GEM file header.





If the offset byte is 1, then a multiple byte offset based on the following table is used to determine the actual offset.

Offset byte value	Relocation data
$00	End of relocation data
$01	Add 254 from current location and decode next byte
$02....$FE	Add byte value from current location

Other odd numbers are not used (reserved)

When the program is loaded into memory at a location other than where it was linked, BDOS computes an offset and adds the offset to the address of the relocation words in the text and or data segments.

GEMDOS function $4B (75 decimal) loads or executes a program.

Atari ST file system

GEM contains a fairly comprehensive sets of file manipulation facilities, they enable the programmer to write software that provides multiple access file sharing and file protection, periodic file updates and selective backups. The file facilities are:

Code Dec	Hex	GEMDOS function	
60	3C	Create file	
61	3D	Open file	Invoked by filling a
62	3E	Close file	parameter block with the
63	3F	Read a file	number of the function,
64	40	Write a file	the parameters and any
65	41	Delete file	other relevant data.
66	42	Seek file pointer	
67	43	Get/set attributes	Returns are in D0.L
			Zero indicates o'k
69	45	Duplicate file handle	Where data is returned,
70	46	Force file handle	D0 contains the address
			of the data return block
78	4E	Search for first	
79	4F	Search for next	
			GEM uses the stack as
96	56	Rename file	the parameter block.
97	57	Get/set	date/timestamp

Atari ST disk system

The Atari ST 3 1/2" disk uses soft sectored disks of the following format:

Bytes/sector	512		
Sectors/track	9		
Tracks/side	80		
Sides/media	1	2	
Unformatted	360K	720K	Kbytes

The GEM BIOS interfaces (Basic input/output systems) make the hardware dependent interface to the floppy disk drives. These communicate with the drives as follows:

Select the drive, the side, the track and then the number of sectors from the track that will be read to a buffer or written from the buffer to the disk.

GEMDOS is fairly basic in terms of disk operations but has extensions to handle tree type directories.

Code Dec	Hex	GEMDOS function
14	0E	Set default drive
25	19	Get default drive
54	36	Get drive free space
57	39	Create a subdirectory
58	3A	Delete a subdirectory
59	3B	Set current directory
71	47	Get current directory

A file does not use consecutive disk sectors as there is insufficient time to identify, read and or write a record via software, and to locate a specific track via hardware. The record spacing (skew) is usually 6 sectors between adjacent file segments.

Atari ST BIOS comparisons

The ST contains device dependant input/output utilities that handle the interface between the device independant routines and the hardware, the ST BIOS and GEM BIOS utilities are supplemented by the line-A primitives which provide rapid screen control.

The GEM type BIOS handles the input/output to the peripheral devices: parallel port, RS232 port, console, midi interface and intelligent keyboard. There is also a basic disk read/write to sector and a facility to check that the disk has not been removed or replaced.

The ST extended BIOS also controls the input/output to the midi interface, intelligent keyboard, console and disk read/write, but additionally includes the control of a mouse, joysticks, sound and of the screen colours.

The line-A routines are the VDI graphic primitives which are not program transportable and therefore included here, they enable control of the mouse and pixel-line-sprite-screen graphics.

Interrupt handler overview

The operating system provides the machine code programmer with access to the interrupt handler.

Every 1/50th of a second control is transferred from the operating system to a routine at the address designated in the system variables at $68 (104 decimal), the system interrupt handler (vertical blank interrupts). The handler provides a timing facility, sets the screen parameters and current device driver installation and entry points.

System Initialisation

The ST in general follows a predefined initialization sequence on power-up, with variations for the different operating systems, typically:

System reset

ssp-->	$60xxxxxx	The supervisor stack pointer (SSP) and program counter (PC) are set from $0 and $4 respectively, the SSP is garbage until the system is sized. The
pc--->	$00FC0020	
move.w	#$2700,SR	Interrupt priority level (IPL) is set to seven and a hardware reset executed
reset		
cmpi.l	#$FA52235F,$FA0000	A check is made for a diagnostic cartridge, which if present will cause a return address to be set in A6 and execution of the diagnostic routines commenced.
bne	cmpi_nxt	
lea	$8(PC),A6	
jmp	$FA0004	
cmpi.l	#$31415926,$426	A check is made to see if memory has previously been sized (warmstart). If not jump past memory sizing routine.
bne	psgset	
move.l	$42A,D0	If this is a soft reset, the bailout vector may be valid. First check that the MSB is zero, secondly that the vector is to an even address, if not, jump past the reset handler.
tst.b	$42A	
bne	psgset	
btst	#$0,D0	
bne	psgset	
movea.l	D0,A0	Set A0 to point to the reset handler, set A6 to the return address and jump to reset handler.
lea	$4(PC),A6	
jmp	(A0)	
lea	$FFFF8800,A0	Set A0 to PSG configuration register base and set port A & port B to output, activate general purpose output and through output port A deselect the disks.
move.b	#$7,(A0)	
move.b	#$C0,$2(A0)	
move.b	#$E,(A0)	
move.b	#$7,$2(A0)	
move.b	#$0,$FFFF820A	Set sync mode to external 50/60Hz and A1 to base of pallette table.
lea	$FFFF8240,A1	
move.w	#$F,D0	Set up a count in D0 to shift the default hardware palette colors to A0 which points to the default color table.
lea	$28A(PC),A0	
move.w	(A0)+,(A1)+	
dbf	D0,loop	

```
                                  Size both memory banks and perform a
move.l    #$752019F3,$420         memory test. Set 'memory sized' and
move.l    #$237698AA,$43A         'memory tested' flags in the system
                                  variables table. Set up screen, vblank
move.l    #$8900,$432(A5)         queue entries, BIOS entry point and
lea       $D50,A7                 supervisor stack.
                                  Run type '0' cartridge applications.
                                  Point A3 and A4 at RTE and RTS resply
                                  Test diagnostic cartridge.
                                  Initialise exception vectors to
                                  terminate process handler except for
move.l    rte,$14                 divide by zero which is RTE'd.
move.l    #$FC0324,$70(A5)        Set vblank handler entry address.
move.l    rte,$68(A5)             Kill hblank handler entry address.
move.l    rte,$88(A5)             Initially empty trap#2 handler.
move.l    #$FC03C0,$B4(A5)        Set up trap#13 handler address.
move.l    #$FC03BA,$B8(A5)        Set up trap#14 handler address.
move.l    rts, $400(A5)           Default timer tick vector to RTS.
move.l    #$FC03B6,$404(A5)       Set up the critical error handler
move.l    rts,$408(A5)            and default the terminate vector.
move.l    #$550,$4A2(A5)          Set up BIOS register save area pntr
suba.l    A5,A5                   Zero page pointer.

suba.l    A5,A5                   Intialize vblank vector list.
move.w    $454(A5),D0             8 nvbls into D0
lsl.w     #2,D0                   multiply by four to
move.w    D0,D1                   create queue length in D1.
bsr       make_spc                Routine to create a space of
and.l     #$FFFF,D0               8 longwords in high memory.
btst      #$0,D0                  \make
beq       jump1                   |address
ddq.w     #$1,D0                  /even
movea.l   $436,A0                 current memory top
suba.l    D0,A0                   'come on down'
move.l    A0,$436                 reset memory top
move.l    A0,D0                   and put in D0
rts
move.l    A0,$456(A5)             vblqueue start address
subq      #$1,D1                  \
clr.b     (A0)+                   | zero the queue
dbf       D1,clr_byte             /
```

Initialize screen resolution.

```
move.w    #$F8FF,SR        Enable all interrupts except Hblank
                           by setting IPL to 3.
                           Run type '1' cartridge applications
                           Initialize GEMDOS- set up a DOS
                           disk buffer chain & memory manager.
                           Run type '3' cartridge applications
                           Attempt to boot from floppy and
                           execute if successful, if not poll
                           devices on DMA bus for logical boot
                           sector zero, execute if successful.
                           (checksum $1234). Any 'returns'
                           continue polling the devices in sequence.
                           Turn on the cursor.
                           Execute file COMMAND.PRG? otherwise
                           construct a default environment and
                           execute AES.
                           Initiate a RESET on a return.
```

Cartridge Software

There are two types of cartridge which may be plugged into the ST; diagnostic and program cartridges. The cartridge program header format is as follows:

	c_flag	-4	Only the first header contains a flag which denotes the presence of a cartridge. *Flag: #$FA52255F=diagnostics* *#$ABCDEF42=program/data*
$00	c_next	0	Pointer to next application header, a null indicates no additional applications
$04	c_init	4	Pointer to application initialisation code, if zero there is no initialisation code. The longword high byte is unused in the 24-bit address and starts applications as follows: bit 0-set, run before interrupt vectors & memory initialised bit 1-set, run before GEMDOS initialised bit 2-unused bit 3-set, run before disk boot bit 4-unused bit 5-set, application is a desk accessory bit 6-set, not a GEM application (no AES calls) bit 7-set, needs command line parameters before execution
$08	c_run	8	Pointer to application entry point
$0C	c_time	12	Time } DOS format time and date stamps
$0E	c_date	14	Date } DOS format time and date stamps
$10	c_bsiz	16	The size of the application BSS segment allocation. The OS must allocate the BSS before invoking any run code. Set to zero if not applicable.
$14	c_name	20	The ASCII name (max 12 characters) terminated by a zero nnnnnnnn.eee

Diagnostic cartridge: The ST hardware will not be initialised and a return address is held in A6, the stack pointer is trashed. The cartridge software is responsible for sizing memory and setting the hardware registers as required.

Cartridge software: Application headers are strung together in a linked list, so there may be any number of applications on one cartridge.

Boot Sectors

To write software that will auto run from disk, the programmer must produce a boot sector that contains a loader program which transfers the program from disk to memory before bringing up GEM.

The boot sector follows IBM PC format and contains:

The volume serial number

- 24 bit number generated when the media is formatted

BIOS parameter block (BPB)

- Sector size in bytes
- Number of sectors/cluster
- Cluster size in bytes
- Length of root directory in sectors
- Size of a File Allocation Table (FAT-in sectors)
- Sector# of start of second FAT
- Sector# of first data sector
- Number of data clusters on disk
- Flags

Optional boot code and boot parameters

During initialization the boot sector is loaded into a buffer and the executable boot sector code tested for a word checksum of #$1234. If satisfactory a subroutine jump is made to the beginning of the position- independent code in the buffer.

When a 'get BIOS parameter block' call is made, the BIOS reads the boot sector (normally created when the volume is formatted), and returns an error indication if any critical parameter fields are zero.

The 24-bit volume serial number, written when the media is formatted, is used to determine whether or not a disk has been changed.

The 'protobt' extended BIOS call (dec 18) is used to create the boot sector (pg 3.8), which is written to track_0 side_0 sector_1.

BIOS boot parameter block

Normally written when the volume is formatted.

Hex offset	Field	Offset	Description
$00	bra.s	0	Branch to boot code
$02	oem_space	2	Space reserved for OEMs use
$08	Vol serial# #$000000	8	24-bit volume serial number. *(used to determine disk changes)*
$0B	BPS #$00 #$02	11	Number of bytes/sector
$0D	SPC #$02	13	Number of sectors/cluster
$0E	RES #$01 #$00	14	Number of reserved sectors *(at start of media including boot)*
$10	NFATS #$02	16	Number of file allocation tables on media
$11	NDIRS #$70 #$00	17	Number of directory entries
$13	NSECTS #$D0 #$02	19	Number of sectors on media *(including reserved)*
$15	MEDIA #$F8	21	Media descriptor *(not used by ST)*
$16	SPF #$05 #$00	22	Number of sectors/FAT
$18	SPT #$09 #$00	24	Number of sectors/track
$1A	NSIDES #$01 #$00	26	Number of sides on media
$1C	NHID #$00 #$00	28	Number of hidden sectors *(not used)*
$1E	boot code	30	Start of code, if any
$1FE	last word	510	Checksum
$200		512	

Note: Word storage is low byte at the low address (even) as per Intel 8088 format and not the usual 68000 mode.

The BIOS parameter block is compatible with MS-DOS versions of the BPB, but will only read and write sectors written by another WD1772A disk controller.

Boot loader

The boot loader resides in the boot sector and is used during system initialization to load an image file or a contiguous set of sectors; it is also used to load GEM from disk on early ST models. The format of the loader is:

$00	boot sector	0	The standard BIOS parameter block
$1E	execflg	30	The word copied to 'cmd_load' flag
$20	ldmode	32	If lmode=0 load file
$22	ssect	34	If lmode<>0 load from here
$24	sectcnt	36	If lmode<>0 load 'sectcnt' sectors
$26	ldaddr	38	Load address of file or sectors
$2A	fatbuf	42	Address for FAT and DIR sectors
$2E	fname	46	Filename: 8 Character name. 3 Character extension *(valid if 'lmode' is zero)*
$39	reserved	57	Reserved
$3A	boot code	58	The executable code

Some software tools require the six bytes reserved for OEMs at offset $2 to contain the ASCII text 'loader'.

The loader can load any file from disk regardless of where it appears in the directory or whether it has the form of contiguous sectors or not.

An image file contains no header or relocation information and is an exact copy of the program to be executed.

Boot ROM

The initialization of the system from the boot ROM follows the predefined pattern of a RESET with some system variables installed and pretty color screen graphics to keep the operator from getting bored.

The boot directory and second FAT buffer are read into memory starting at membot. TOS.IMG is loaded starting at $40000 and an error code produced if the file is not found. The memory $10000 to $20000 is used for screen buffers and should not be used initially for any code or data.

The first ST's sold contained a small 32K boot ROM that loaded the operating system from disk. The boot ROM contains a small sub-set of the BIOS, just sufficient to read an 80 track, BPB floppy disk boot sector from either drive into memory and then execute it.

Trap 13 GEM BIOS functions implemented

code		function
4	rwabs	Read/write sectors (read only)
7	getbpb	Get BIOS parameter block

Trap 14 extended functions implemented

code		function
1	ssbrk	Reserve x bytes from top of memory
8	floprd	Read sectors from floppy disk

All other BIOS facilities are not loaded into the system until a later stage. The first 100 bytes of disk TOS relocate TOS.IMG at $5000 from where it takes control.

The first TOS implementation uses the following disk parameters:

80 track, single sided BIOS parameter block

Bytes/sector	512	#sides/media	1
Sectors/cluster	2	#hiddensectocrs	0
Reserved sectors	1	Load address	$40000
# of FATs	2	FAT/directory buffer	$8000
# of root dir entries	7	Volume serial number	0
# of sectors on media	720	Media descriptor byte	F8H
# sectors/FAT	5	Filename	TOS.IMG
# sectors/track	9		

Atari ST peripheral device communications

Communications overview

The ST supports serial and parallel communications through dedicated RS232 and parallel ports, and permits two further communicaton channels to be opened through the MIDI and DMA ports.

The serial RS232 communication port accomodates hardware data control based on the PSG I/O port A, RTS and DTR outputs, and the MFP MK68901, CTS, DCD and RI inputs, and Xon/Xoff software data protocol at transmit and receive baud rates in the range 50 to 19200 baud. The port is generally used to interface with a printer, modem or another computer. The MFP is located at $FFFA00 (16775680) and the $PSG at $FF8814 (16746610).

The general purpose parallel port interface provides bi-directional 8 bit communications for printer operation. The port is based on the MFP MK68901 (busy control), the PSG I/O port A bit 5 (strobe control) and the PSG I/O port B (data transfer). The control is limited to a busy signal, acknowledge is not supported and data transfer is at a typical rate of 4000 bytes/s.

The MIDI interface provides an asynchronous, current loop, serial data (one start bit, eight data bits and one stop bit) communications channel at 31.25Kbaud. The MC6850 port controller may be reconfigured for most forms of RS232 interface via the control/status register situated at address $FFFC04 (16776196).

The intelligent keyboard interface is also controlled by an MC6850 ACIA, but there is no external access provided to the port, which is of limited use other than accessing the ikbd command set; for reading and or writing to the clock, joysticks, mouse and perhaps reconfiguring the keyboard. The transfer rate is fixed at 7812.5 baud.

The floppy disk interface is based on the Western Digital WD1772A disk controller and is limited to supporting two drives.

The DMA interface is provided by a ULA device, access is through the control/status configuration registers at $FF8600 (16746084) et seq. The DMA or Hard disk port uses an Atari version of the SCSI interface and can support a maximum of 8 peripheral devices. Theoretically data may pass either way through the interface so it should be possible to use it for high speed networking, remembering that the DMA controller also supports the Floppy Disk Controller.

RS232 interface

General

Data is transmitted and received via an RS232 interface as a sequence of ones and zeroes (bits) along a three wire link, one wire being ground, one for transmitted data and the other for the received data. Information is sent as 'characters' and each character is prefixed by a start bit (a one) and terminated with either one or two stop bits (zeroes). Providing the sending and receiving devices are set to the same speed (baud), then the stop and start bits act as a timing signal to each 'character' sent. Occassionally error detection is incorporated in the form of a parity bit. If the count of ones in the character is even, then the eighth bit is set to a one (even parity), an alternative process is odd parity where if the one count is odd, the eighth bit is set to a one. Personal computers work without parity which is used in general as a warning of data errors in the transmission. Providing the transmitting and receiving station agree on the protocol used, then communications will be reasonably straight forward !!!

The port is reconfigured using the sequence:

a) Save current MK68901 register contents
b) Disable Rx and Tx enable bits
c) Set flow control mode
d) Set baud rate
e) Set RS232 registers
f) Re-enable Rx and Tx enable bits

The extended BIOS call #$0F (15) enables selective reconfiguration of the RS232 port according to a block of parameters pushed onto the stack:

```
move.w   sync_char,-(SP)     * Pushing          \
move.w   tx_status,-(SP)     * -1               | (page
move.w   rx_status,-(SP)     * leaves           |  3.10)
move.w   usrt_cntl,-(SP)     * parameter        |
move.w   flow_cntl,-(SP)     * unchanged        /
move.w   baud_rate,-(SP)     * Set timer D
move.w   #15,-(SP)           * push RS232 config
trap     #14                 * call function
add.w    #14,SP              * tidy stack, jump 7 words
tst.w    D0                  * test for error
rts                          *
```

Data is passed through the interface using the extended BDOS calls to the auxiliary device (RS232 port). Only the 'New TOS' supports RTS/CTS handshaking.

Parallel port interface

General

Data is transmitted and received via a parallel port interface in blocks of 8 (sometimes 7) data bits, set either as ones or zeroes to form a character byte. The character is 'framed' by a strobe signal enabling the receiving device to read the character transmitted, which may be printed immediately or saved in a buffer for subsequent printing. At some stage the printer will not be able to accept further input and will send a 'busy' signal to stop the transmitter from sending additional data. The acknowledge signal is sometimes used to indicate that the printer is no longer busy, occasionally this signal line is omitted and the busy line also provides the 'not busy' signal.

Data is passed to and from the interface using the following procedures:

Write data

a) Check the busy line for high
   If line low, monitor until high
   or time out set CPU D0 register to 0

When high

b) Set PSG I/O B port to output, use IPL 7
c) Place data into the PSG's B output register 15
d) Switch strobe line on, Port A bit 5
e) Switch strobe line off, set CPU D0 register to -1

Read data

a) Set PSG I/O B port to input
b) Switch strobe line off
c) Check busy line for high loop till high
d) Switch strobe on
e) Get data from PSG's B output register

As the status register is affected, the above procedures should be performed in supervisor mode.

MIDI interface

General

The MIDI (musical instument digital interface) sequential circuits provide for integrated operation of music synthesizers, sequencers, drum boxes etc. which have the MIDI interface. The ST operates as a data store for a large number of notes/voices which may be sent to different instruments (channels), and played together in sequence and time as music. The data may be 'recorded' from a tune previously played, edited and/or synthesized by entering new data in step-time-note format into the store for later retrieval.

The MIDI bus provides 16 channels in one of three networking modes. OMNI, the default where all units are addressed together and transmit and receive on all channels. POLY where all the units are individually addressed and receive on one channel only, data assigned to non-existant channels is ignored. MONO where the voice of each unit is addressed seperately, providing different channels for individual voices within one synthesizer.

The information transmitted is priortised and sent as bytes, the most significant bit signifying either status (1) or data (0). The priority order is:

System reset	Set defaults
System exclusive	Manufacturers unique data
Sequential circuits	Roland, Yamaha etc.
System real time	Synchronization
System common	Broadcast
Channel	Note selection, prog data etc.

The MIDI port supports the optional through port which merely provides the MIDI in signals at the MIDI out port.

The MIDI interface operate in RS232 current loop mode at 31.25K baud. It may be reconfigured by resetting the control/status registers.

The Atari ST's extended BIOS enables the programmer to reconfigure the MIDI port.

MIDI control/status register functions

Controlregister functions (write only) $FFFC04

Bit	Divide select	Bit	Data format			Bit	RTS format		Bit	Interrupt
0 1		2 3 4	#bit	Parity	Stop	5 6	Tx on/off		7	enable
0 0	by 1	0 0 0	7	even	2	0 0	off	RTS=		Interrupts
0 1	by 16	0 0 1	7	odd	2	0 1	on	low		enabled by
1 0	by 64	0 1 0	7	even	1	1 0	off	RTS=		bit 7 = 1.
		0 1 1	7	odd	1			high		Rx data
1 1	master	1 0 0	8	-	2	1 1	off	RTS=		register full,
	reset	1 0 1	8	-	1			low		Overrun,
		1 1 0	8	even	1	Tx break level				DCD low to
		1 1 1	8	odd	1	on Tx data o/p				high step.

Status register functions (read only) $FFFC06

Bit	Name and function
0	Rx data register full Rx data in register ready for CPU read
1	Tx data register empty Transmitted data sent, load with next character to transmit
2	Data carrier detect Indicates modem state, carrier present
3	Clear to send Indicates modem state, Master reset - no change.
4	Frame error Character synchronisation error
5	Rx over-run Characters have been lost from stream
6	Parity error Only active if parity selected
7	Interrupt request Read received data register or write to transmit data register.

Intelligent keyboard interface (IKBD)

The intelligent keyboard functions through a MC6850 ACIA device whose control/status register is located at address $FFFC00 (16776192), and functions like the MIDI interface. There is no external access to this port so there is little point in reconfiguring, but it can be used to transmit and receive data or commands from the keyboard, mouse, joystick and clock using the following facilities:

Keyboard

Return keycodes

Mouse

Set mouse button action (keys, on press/on release)
Set mouse position relative (default)
Set threshold level per 'click'
Set mouse position absolute
Set scale ('clicks' per movement)
Read/write mouse position
Set mouse to simulate cursor motion codes
Set Y origin top/bottom
Disable/pause/resume mouse operation

Joystick

Enable joystick (default)
Disable, act on request only
Interrogate joystick
Set monitoring (serial line, joystick and clock)
(serial line, button 1 and clock)
Set keycode mode (variable 'click' rate)
Disable joystick

Clock

Set date and time
Read date and time

Program control

Load data into ikbd memory
Read data from ikbd memory
Execute ikbd program

A status inquiry command returns a null padded 8-byte packet detailing the current mode and parameters of a specific function, the packet may be stored and later used to restore the status of the keyboard by modifying the header byte and returning the data as a command.

The keyboard scancodes do not maintain complete compatibility with IBM PC key scancodes. Appendix D.6 provides the major differences due to the non-availability of certain keys on the ST keyboard. The additional ST keys are mapped into unused CTL_ and ALT_ function scancodes.

To detect ALT_ and CTL_ function key combinations, execute a BDOS or BIOS 'getchar' call followed by a BIOS 'kbshft' call (#$0B).

Floppy disk interface

The floppy disk interface is based on an on-board Western Digital WD1772A disk controller and can support a maximum of two drives.

The floppy disk read/write sequence of events is:

a) select floppy drive 0 or 1 (PSG I/O port A)
b) select floppy side 0 or 1 (PSG I/O port A)
c) load DMA base address and counter register
d) toggle read/write to clear status (DMA mode control reg)
e) select DMA read or write (DMA mode control register)
f) select DMA sector count register (DMA mode control reg)
g) select FDC internal command reg (DMA mode control reg)
h) issue FDC read or write command (Disk controller reg)
i) DMA active until sector count zero (DMA status reg)
do NOT poll during DMA active.
j) issue FDC interrupt command after sector data transfers,
except at track boundaries (Disk ctrl reg)
k) Check MFP bit 5 ($FFFA01) for interrupt
l) check DMA error status, non destructive (DMA stat reg)

The DMA configuration registers are at the base address $FF8600 (16746084) and the following offsets:

4	$4	Disk controller data access	
6	$6	DMA read_mode control, write_FIFO	
9	$9	DMA base high	\ set last
11	$B	DMA base medium	|
13	$D	DMA base low	/ set first

The PSG configuration registers are at base address $FF8800 (16746596) and the following offset:

2	$2	PSG write port Bit 0 floppy side Bit 1 floppy drive 0 Bit 2 floppy drive 1

There is no hardware support for sensing disk removal, therefore this facility must be performed in software.

Formatting a floppy disk

The following procedure illustrates the technique used in formatting a floppy disk:

flopfmt $A	Sides: 1 or 2 Sectors/track: 9 Tracks: 80 No interleave and the first two tracks zeroed (to 0 FAT and directory sectors), either sector bad and the media is unusable
protobt $12	Use disk type parameter 2 or 3 Serial number parameter, random or #$1000000 Execute flag usually zero, non zero if it contains loader code etc. that is to execute when the disk is booted.
flopwr $9	Write boot sector (prototyped in buffer to track 0, side 0, sector 1 of disk Do not use 'rwabs' call

XBIOS calls

The WD1772 'write track' codes used to format a track are:

Double density format: issue a write track command and load the following values into the data register. There is a data request for every byte written.

ID field

#bytes	60	12	3	ID	Trck	Side	Sect	Len	CRC	CRC
data	#$4E	#$00	#$F5	#$FE	#	#	#	#	1	2
					0-$4F	0-1	1-9	*		

#bytes	22	12	3	ID	512	CRC	CRC	40		1401
data	#$4E	#$00	#$F5	#$FB	data	1	2	#$4E		#$4E
										End of track

Data field

* length = #512 bytes/sector (usually 2)

CRC's written $F7

Note that early versions of TOS do not report CRC errors in all cases causing reduced reliability of the disk system.

WD1772 DMA channel interface

The WD1772 is interfaced through the DMA channel via the following procedure:

To initialize the WD1772:

```
move.w   #$190,$FF8606       Clear the fifo by toggling r/w
move.w   #$90,$FF8606        and leave in the write state.
move.b   #xx,dmalow          Set up dma address pointer in
move.b   #xx,dmamid          low to high order
move.b   #xx,dmahigh         $FF860D, $FF860B & $FF8609 resply
```

The following addresses are used by the WD1772

$80	128	command/status register
$82	130	track register
$84	132	sector register
$86	134	data register

To address the WD1772:

```
move.w   #$yy,$FF8606        The FDC rquires two writes to
move.w   #$zz,D7             access the registers, the first
delay                        write selects the FDC register
rts                          and the second write modifies
                             the register
```

To transfer from memory to floppy the values must be ORed with #$100 and #$FF written to $43E to prevent TOS from changing the value in address $FF8606. When the operation is complete the byte in $43E, the floppy lock variable, must immediately be zeroed.

To seek to a track:

```
move.w   #$86,$FF8606        Select the data register
move.w   #$4F,$FF8604        Write seek track ($4F last track)
move.w   #$80,$FF8606        Select command register
delay                        Wait for drives
move.w   #$17,$FF8604        Seek with verify (pg 1.23 Type 1 command)
```

The FDC will generate an interrupt when the seek is finished, it can be polled at $FFFA01 where bit 5 is zeroed. Errors are read from $FF8604, the read clearing the interrupt bit.

To transfer data:

```
move.b    #$xx,dma           set up dma address, clear fifo
move.w    #$190,$FF8606
move.w    #$1,$FF8604        512byte size limit of transfer write sector# (1..9)

                             write track# (#$00.#$27)     use #$A6
                             write track# (#$28.#$4F)     use #$A4
                             read track#,                 use #$84
```

Do not use read/write multiple sector commands as they require a force interrupt command which is slower than re-executing a read or write.

To format a track

```
                             write track# (#$00,#$27)     use #$F6
                             write track# (#$28,#$4F)     use #$F4
```

Write data to the drive beginning and ending with the index pulse. It takes about #$1A00 bytes to fill a drive running at 3%.

The existing format command produces 9 sectors per track.

Do not change the id-field, the fourth byte is used to count the number of bytes to transfer, and to locate the CRC data field. It may produce incompatibilities with TOS if changed.

To write an entire track:

The entire track can be written as one long sector and then read back, without any error checking, using the read track command if the following format is used:

Index pulse followed by

#$00	a minimum of 12 bytes for lock-on
#$F5	3 bytes for synchronization

DMA interface

There is only one direct memory access (DMA) channel which is shared by both low and high speed 8 bit device controllers. The configuration registers hold the 3 register MMU base address of the DMA operation which is performed through a 32 bit FIFO programmed by the DMA mode control register.

The hard disk read/write sequence of events is:

a) load DMA base address
b) toggle read/write to clear status (DMA mode ctrl reg)
c) select DMA read or write (DMA mode control register)
d) select DMA sector count register (DMA mode cntrol reg)
e) load DMA sector count register (DMA mode trigger)
f) select HDC internal command reg (DMA mode control reg)
g) issue HDC read or write command (Disk controller reg)
    1st cmd A0 set to 0, set to 1 for remaining commands
    Each byte command is acknowledged with an interrupt
    After last cmd byte set hard disk sector count bit 1
h) DMA active until sector count zero (DMA status reg)
    do NOT poll during DMA active.
i) check DMA error status, non destructive (DMA stat reg)
j) check HDC status byte and if necessary perform an ECC
    correction following a verify track or read sector command.

The DMA configuration registers are at the base address $FF8600 (16746084) and the following offsets:

4	$4	Disk controller data access
6	$6	DMA read_mode control, write_FIFO
9	$9	DMA base high
11	$B	DMA base medium
13	$D	DMA base low

The DMA registers are used to perform the floppy disk data transfers but may also be used for hard disk and other high speed data interfaces, bearing in mind the restriction of one DMA operation at a time.

Any modification of the DMA base address or counter register requires that they be set in low-mid-high order.

DMA bus boot code

The following code, which is typical of the ST's BIOS, attempts to load boot sectors from devices on the DMA bus. The code shows typically how the DMA bus is used and provides the timeout and the command characteristics expected from bootable DMA bus devices.

```
gpip      equ     $FFFFFA01    * .B  68901 input register
dskctl    equ     $FFFF8604    * .W  controller data access
fifo      equ     $FFFF8606    * .W  DMA mode control
dmahigh   equ     $FFFF8609    * .B  DMA base high
dmamid    equ     $FFFF860B    * .B  DMA base mid
dmalow    equ     $FFFF860D    * .B  DMA base low
flock     equ     $43E         * .W  DMA chip lock variable
dskbuf    equ     $4C6         * .L  1K disk buffer
Hz_200    equ     $4BA         * .L  200 Hz counter
bootmg    equ     #$1234       * .W  boot checksum
```

Try to boot from DMA device

```
dmaboot  moveq    #0,D7          * # devices to try (eight)
dmb_1    bsr      dmaread        * try to read boot sector
         bne      dmb_2          * failed -- next device
         move.l   dskbuf,A0      * disk buffer pointer in A0
         move.w   #$00FF,D1      * checksum #$100 words
         moveq    #0,D0          * initialize checksum
dmb_3    add.w    (A0)+,D0       * add a word
         dbra     D1,dmb_3       *  until #$100 counted
         cmp.w    #bootmg,D0     * Is it a boot sector
         bne      dmb_2          * No -- next device
         move.l   dskbuf,A0      * disk buffer pointer in A0
         jsr      (A0)           * run the code.
dmb_2    add.b    #$20,D7        * next device
         bne      dmb_1          *
         rts
```

Try to read DMA bus device boot sector

```
dmaread  lea      fifo,A6        * DMA control register
         lea      dskctl,A5      * DMA data register
         st       flock          * DMA lock against vblank
         move.l   dskbuf,-(SP)   *
         move.b   3(SP),dmalow   * set up DMA pointer
         move.b   2(SP),dmamid   *
         move.b   1(SP),dmahigh  *
```

```
         addq      #4,sp            *
         move.w    #$098,(A6)       * toggle r/w, leave at read
         move.w    #$198,(A6)       *
         move.w    #$098,(A6)       *
         move.w    #1,(A5)          * write sector count reg = 1
         move.w    #$088,(A6)       * DMA bus select (not SCR ?)
         move.b    D7,D0            * D0.l to device# + command
         or.b      #$08,D0          *
         swap      D0               * D0.l=xxxxxxxxDDD01000
         move.w    #$088,D0         *       xxxxxxxx010001010
         bsr       wcbyte           * write cmd and wait for IRQ
         bne       dmr_q            * error exit on timeout
         moveq     #3,D6            * write cmd  $00
         move.l    #$00008A,D0      *     cntl $8A
dmr_1p   bsr       wcbyte           *    four times
         bne       dmr_q            * error exit on timeout
         dbra      D6,dmr_1p        *
         move.l    #$00000A,(A5)    * write final byte
         move.w    #400,D1          * 2s timeout limit
         bsr       wwait            *
         bne       dmr_q            * error exit on timeout
         move.w    #$08A,(A6)       * select status register
         move.w    (A5),D0          * get DMA return code
         and.w     #$00FF,D0        * mask for error code only
         beq       dmr_r            * return if o'k
dmr_q    moveq     #-1,D0           * set error return (-1)
dmr_r    move.w    #$080,(A6)       * reset DMA chip for drivr
         tst.b     D0               * test for error return
         sf        flock            * unlock DMA chip
         rts                        *
```

Write ASCII command byte and wait for IRQ

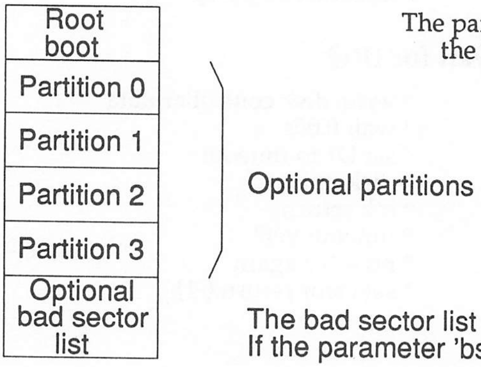
```
wcbyte   move.l    D0,(A5)          * write disk controller data
         moveq     #10,D1           * wait 0.05s
wwait    add.l     Hz_200,D1        * set D1 to timeout
ww_1     btst.b    #5,gpip          * disk finished
         beq       ww_w             * o'k return
         cmp.l     Hz_200,D1        * timeout yet?
         bne       ww_1             * no -- try again
         moveq     #-1,D1           * set error return (-1)
ww_w     rts
```

Hard disk partitioning

Logical sector #0 contains information on the four possible hard disk partitions:

	offset			
hd_siz	$1C2	Total size of the disk in sectors		
p0_flg	$1C6	Non zero to show partition exists, bit_7 set for BIOS boot partition		
p0_st.	$1C7	Partition start logical sector number		
p0_siz	$1CE	Size of partition in logical sectors		
		Three further optional partitions		
px_flg	$1D2 \	$1DE \	$1EA \	
px-id	$1D3 I 2nd	$1DF I 3rd	$1EB I 4th	
px_st	$1D6 I	$1E2 I	$1EE I	
px_siz	$1DA/	$1E6 /	$1F2 /	
bsl_st	$1F6	Staring sector of the bad sector list		
bsl_cnt	$1FA	Number of bad sectors		
	$200	reserved		

An ST disk may contain up to four partitions, the first sector of each partition is a boot sector and contains a BIOS parameter block.



The partitions are described by the 12 byte structure above.

The bad sector list is usually held at the end of the device. If the parameter 'bsl_cnt' is zero, there are no bad sectors.

Chapter 3

The Atari Operating System

GENERAL

The operating system (TOS) is a mixture of GEM and an Atari OS (GEMDOS, BIOS and XBIOS as well as the line-A routines). Any of the OS's can completely control the system and although calls to the various types of utilities can be mixed without restriction, the programmer is advised to use a consistent set of calls. There are many reasons for using a consistent set of calls, not the least being that the programmer can write programs which are portable to other computers that contain the same operating systems. Although the writers present intention may not be to provide the program on an alternative computer system, it is wise to adhere preferably to the basic OS or GEM calls if possible. Those who have programs generated on older 8-bit machines, and now find that they cannot be translated easily, will understand the need for portability.

The line-A routines provide access to the graphic primitives; they will not produce portable code but will give very rapid execution of graphic functions.

Register usage

The BIOS, XBIOS and GEMDOS routines use and preserve registers in a specific manner; d0, d1, d2, a0, a1 and a2 must always be considered trashed and should never be used even though a particular version of TOS does not change them, the next version probably will.

$13 BIOS calls	
$14 XBIOS calls	preserve d3 to d7 / a3 to a7
$1 GEMDOS calls	

Replies are normally held in register D0 on return.

A word of warning. GEM was developed for use on the IBM PC, and as such was designed to run the Intel 8088 processor, which stores addresses in memory low word first. 68000 GEM uses the same convention in some of the tables and parameter blocks, it is a point programmers should be aware of, as a mixture of conventions of this kind is likely to cause problems.

Note that Appendix E provides a list of all the functions and may be used as an index to the calls in this and the following chapters.

Traps

BIOS calls (trap #13)

Trap #13 access

To access the BIOS functions, push the parameters in the order given onto the stack and then call trap#13. Reply or status is returned in register D0 and the data placed on the stack trashed.

Typical use might be:

```
move.w    driveA,-(sp)      * push device code
move.w    record,-(sp)      * push record to start
move.w    count, -(sp)      * push number of sectors
move.l    addrss,-(sp)      * push buffer address
move.w    #0, -(sp)         * push read data
move.w    #4, -(sp)         * push rwabs function call
trap      #13               * call the function
add.w     #14,sp            * tidy the stack
tst.w     D0                * test for error
rts                         *
```

It is the programmers responsibility to tidy the stack after the call. The BIOS, accessible from user mode, is re-entrant to three levels of calls, users are advised that this non-standard feature should be used wisely where program portability is required.

BIOS calls (Trap #13)

Param.Size	Description of parameter to push			Notes
pmpb.L:	Pointer to empty memory parameter block to be filled [See Appendix F.7]	MPB structure:		Initial values:
		Memory_free_list	-->	MD in BSS
		Memory_alloc_list	-->	0
		Roving_pointer	-->	MD in BSS
		MD structure:		
		Next_link_MD	-->	0
(MD=memory descriptor)		*Start_addr_block*	-->	mbottom
		No._bytes_block	-->	mtop-mbot
		Owner_description	-->	0

getmpb 0 Get/fill a memory parameter block
(#$00) (Tidy #6) (No return)
Use this function BEFORE initialising GEMDOS and only with ROM based systems.

Param.Size	Description			Notes
dev.W:	device code range	0 printer	parallel port	Operations
		1 aux	RS232 port	0 and 4 are
(No range error checking)		2 console	screen	illegal in
		3 midi		this mode.
		4 keyboard		Return D0.L

bconstat 1 Return character_device input status — 0 no character
(#$01) (Tidy #4) (Return D0.L) — -1 Char_ready

---

dev.W: device code 0 to 3 *If dev 2, also return IBM-PC compatible code hi_word lo_byte* — WAIT for a character D0.L reply.

bconin 2 Input character from device
(#$02) (Tidy #4) (Return Ascii D0.W)
If conterm.b ($484) bit 3 set, also returns the keyboard shift status (kbshift_BIOS #11) in highest byte (See Appendix A.5 for meaning).

---

char.W: character to be sent *(Appendix C.4 for escape codes)* — WAIT until character sent.
dev.W: device code 0 to 4

bconout 3 Output character to device
(#$03) (Tidy #6) (Return none)
dev.w may also use code 5 which outputs to a screen without control characters.

BIOS calls (trap #13) cont.

	Param.Size	Description of parameter to push		Notes
	driv.W:	device code	0 floppy drive A 1 floppy drive B 2+ disks, networks etc.	0 return o'k negative error
	recn.W:	logical sector number to start at		read/write mode
	secn.W:	number of sectors to transfer		2 & 3 allow
	buf.L:	buffer address (very slow if odd)		formatter
	rwfl.W:	read/write flag	0 read 1 write 2 read \ do not affect 3 write /media-change	to read & write and allow BIOS to recognize
rwabs (#$04)	**4**	**Read/write logical sectors on a device** (Tidy #14)	(Return D0.L)	formatted_disk mediachange
	vec.L:	vector slot address (-1L no change)		0 to FF system
	vecn.W:	vector number to set/get		to $1FF GEM
setexc (#$05)	**5**	**Set exception vector** (see below) (Tidy #8)	(Return D0.L)	to $FFFF OEMs (not with GEM)
tickcal (#$06)	**6**	**Return system elapsed time mS** (Tidy #2)	(Return D0.L)	
	driv.W:	device code (0 to 2+, as per rwabs)		Boot on $446
getbpb (#$07)	**7**	**Get BIOS parameter block pointer** (Tidy #4)	(Return D0.L)	D0.L=address 0=not found
	dev.W:	device code_as per bconstat 0 to 4		0=not ready
bcostat (#$08)	**8**	**Return device char output status** (Tidy #4)	(Return D0.L)	-1=ready to send
	driv.W:	device code (0 to 2+, as per rwabs)		GEMDOS will
mediach (#$09)	**9**	**Get media status**	0_Media no change 1_Media maybe changed 2_Media has changed	try to read media with a status value of 1
		(Tidy #4)	(Return (D0.L)	

BIOS level character output is much faster when implemented through the 'NEW TOS' ROM's.

BIOS calls (trap #13) cont.

	Param.Size	Description of parameter to push	Notes
		must be updated by installable disk drives	Bits 0 - 31 ($4C2)
drvmap (#$0A)	**10**	**Get bitmap of drives** (Tidy #2) (Return D0.L)	1=drive in 0=drive out
Note: Not all GEMs will read bits 5 & 6	mode.W:	Mode bits 7 reserved (zero) 6 ALT - Insert 5 ALT - Clr/home 4 CAPS-lock 3 ALT key 2 CONTROL key 1 left shift key 0 right shift key	If mode negative get IBM-PC state of shift keys as bit vector in D0.L low byte. Critical code for portability
kbshift (#$0B)	**11**	**Set keyboard shift bits** (Tidy #4) (Return old shift bits D0.L)	

Critical interrupt handlers

The extended GEMDOS vectors (Appendix A.4) may be employed by user programs but should take note of the following:

$100 etv_timer: Word value on stack is number of millisecs since last tick.
Save all registers

$101 etv_critic: Stack word value is error number, save registers used.
To ignore an error set D0.L=0
To retry an error set D0.L=$10000
To abort an error set D0.L=sign extend stack parameter.

$102 etv_term: Abort termination by a longword jump back to the top of the calling application or terminate via an RTS

XBIOS calls (Trap #14)

Trap #14 access

To access the extended BIOS functions, push the parameters in the order given onto the stack and then call trap#14 from user or supervisor mode. Reply or status is returned in register D0.

Typical use might be:

```
move.l   vector,-(sp)    * push vector address
move.l   parblk,-(sp)    * push parameter block addr
move.w   type, -(sp)     * push type of mouse action
move.w   #0, -(sp)       * push initmouse call
trap     #14             * call the function
add.w    #12,sp          * tidy the stack
tst.w    D0              * test for error
rts
```

Param.Size	Description of parameter to push		Notes
vect.L:	vector address (mouse interrupt handler)		If mode = 2
para.L:	parameter 1_y=0 top, 0_y=0 bottom		then extra
(Block	block	Mouse button command (6.3_#7)	word sized
contains	address	x parameter thresh/scale/delta	parameters
4 bytes)		y parameter thresh/scale/delta	required in
type.W:	mode 0 disable mouse		parameter block
		1 enable relative mouse	*xmax*
		2 enable absolute mouse	*ymax*
		3 unused	*xinitial*
		4 enable keycode mouse	*yinitial*
initmous 0	**Initialize mouse packet handler**		See call #34
(#$00)	(Tidy #12)	(No return)	re vector address
numb.W:	Bytes from memory top to be saved		MUST call
ssbrk 1	**Reserve block of memory at high RAM**		before OS
(#$01)	(Tidy #4)	(Return D0.L)	initialized
_physbase 2	**Get screen physical base address**		At next
(#$02)	(Tidy #2)	(Return D0.L)	vblank

XBIOS calls (Trap #14) cont.

	Param.Size	Description of parameter to push	Notes
_logbase 3 (#$03)		**Get screen logical base address now** (Tidy #2) (Return D0.L)	Used by GSX on screen
_getRez 4 (#$04)		**Get screen resolution** (Tidy #2) (Return D0.W)	Ret 0_320x200 1_640x200 2_640x400
	rez.W:	Set screen resolution (0, 1 or 2) clear screen, home cursor, reset VT52	Negative parameters
	ploc.L:	Set screen physical location (next vblnk)	are ignored
	lloc.L:	Set screen logical location (now)	so a single
_setScreen 5 (#$05)		**Set screen parameters** (Tidy #12) (No return)	parameter can be set
	palp.L:	Set palette pointer (word boundary)	At next
_setPalette 6 (#$06)		**Set palette hardware register contents** (Tidy #6) (No return)	vblank, all change.
	colr.W:	Set colour format - *16 bit colour word*	If colour
	coln.W:	Set colour number (0 to 15)	negative
_setColor 7 (#$07)		**Set a colour in hardware palette** (Tidy #6) Return old colour D0.W (with $777 mask)	ignore.
	secn.W:	number of sectors to be read	Return D0.W=0
	sidn.W:	side number selected (0 or 1)	for o'k
	trkn.W:	track number to seek to	else failed
	stsc.W:	sector to start reading from (1 to 9)	error number
	devn.W:	floppy device number (0 or 1)	
	scrt.L:	#0, not used at present.	
	buff.L:	word aligned sized buffer address -->	must be big
_floprd 8 (#$08)		**Read sectors from a floppy drive** (Tidy #20)	enough

XBIOS calls (Trap #14) cont.

	Param.Size	Description of parameter to push	Notes
	secn.W:	number of sectors to write (<=sectors/track)	Return D0.W=0
	sidn.W:	side number selected	for o'k
	trk.nW:	track number to seek to	else failed
	stsc.W:	sector to start writing to (1 to 9)	error number
	devn.W:	floppy device number (0 or 1)	
	scrt.L:	#0, not used at present.	Writing to
	buff.L:	word aligned buffer address	boot 1,0,0
_flopwr	**9**	**Write sectors to a floppy drive**	sets 'maybe'
(#$09)		(Tidy #20) (Return D0.W)	mediachange (1)

	Param.Size	Description of parameter to push	Notes
	fcod.W:	$E5E5 format code (not 0 or FxFx)	Return D0.W=0
	magc.L:	$87654321	for o'k
	intl.W:	Sector interleave factor (say 1)	else failed
	sidn.W:	side number to format (0 or 1)	error number.
	trkn.W:	track number to format (0 to 79)	Buffer holds
	sptk.W:	number sectors/track to format (say 9)	Zero terminated
	devn.W:	floppy device number (0 or 1)	list of bad
	scrt.L:	#0, not used at present.	sectors.
	buff.L:	word aligned buffer address (8K-9track)	Formatting
_flopfmt	**10**	**Format a floppy disk**	sets
(#$0A)		(Tidy #26)	mediachange (2)

The 'NEW TOS' formats a floppy disk with track skew (-1) and a longword pointer to a one word per sector skew table in the previously unused scrt.L parameter

	Param.Size	Description of parameter to push	Notes
getdsb	**11**	**Get device status block pointer**	Obsolete
(#$0B)		(Tidy #2) (RTS call only)	function.

	Param.Size	Description of parameter to push	Notes
	ptr.L:	Pointer to character vector	
	cnt.W:	number characters to write less one.	
midiws	**12**	**Write a string to midi port**	
(#$0C)		(Tidy #8) (No return)	

	Param.Size	Description of parameter to push	Notes
	vect.L:	Address of interrupt routine	Old vector
	intn.W:	Interrupt number (0 to 15)	is lost.
_mfpint	**13**	**Set MFP interrupt**	
(#$0D)		(Tidy #8) (No return)	

XBIOS calls (Trap #14) cont.

Param.Size	Description of parameter to push			Notes
devn.W:	Serial device	0: RS232 1: Keyboard 2: Midi		For RS232 identical o/p buffer follows i/p
Return a pointer .L to a serial device's input buffer record parameter block (brpb)		(L.pntr to device buffer (W.size of buffer (W.head index (W.tail index (W.low-water mark (W.high-water mark		High & low water start RS232 Xon/Xoff if flow control enabled.
iorec 14 (#$0E)	**Get pointer to serial device i/p brpb** (Tidy #4)	(Return D0.L)		
scr.W: tsr.W: rsr.W: usr.W:	Sync character \\ Tx status | Rx status | Usart control /	68901 MFP register settings (page 1.25)		-1 parameters do not change registers
flow.W:	0 No flow control (default) 1 Xon/Xoff 2 RTS/CTS 3 Xon/Xoff & RTS/CTS	(^S/^Q)		
baud.W:	0=19200 1=9600 2=4800 3=3600 (3840) 4=2400	5=2000 (1920) 6=1800 (1745) 7=1200 8=600 9=300	10=200 11=150 12=134 13=110 14=75 (120) 15=50 (80)	*Actual baud in brackets*
rsconf 15 (#$0F)	**Configure RS232 port** (Tidy #14)	(No return)		
capl.L: shft.L: unsh.L:	Caps lock \\ Shift | Unshifted /	Set pointers to 128 byte Keyboard translation tables.		Return pointer to structure: *Unshft_tab* *Shift_tabl* *Capslk_tab*
keytbl 16 (#$10)	**Set/get keyboard translation table pointer** (Tidy #14)	(Return D0.L)	-1 not to change characters	
	Bit zero poor distribution			
_random 17 (#$11)	**Get 24-bit pseudo random number** (Tidy #2)	(Return D0.L)		Bits 24-31 are zero

XBIOS calls (Trap #14) cont.

	Param.Size	Description of parameter to push	Notes
	exfl.W:	1 = boot sector executable	-1 retains
		0 = non-executable boot sector	old values.
	dskt.W:	0=40 track SS 2=80 track SS	
		1=40 track DS 3=80 track DS	Image is
	sern.L:	random boot serial no. if=#$1000000	written
	buf.L:	pointer to any 512-byte buffer	to volumes
_protobt	**18**	**Prototype a boot sector image**	boot sector
(#$12)		(Tidy #14) (No return)	
	secn.W:	number sectors to verify (<=sectors/track)	Return D0.W=0
	sidn.W:	side number selected	for o'k
	trkn.W:	track number to seek to	else failed
	stsc.W:	sector to start reading from (1 to 9)	error number
	devn.W:	floppy device number (0 or 1)	
	scrt.L:	#0, not used at present.	Buffer holds
	buff.L:	word aligned 1024 byte buffer address	0 terminated
_flopver	**19**	**Verify sectors from a floppy drive**	list of bad
(#$13)		(Tidy #20)	sectors.W
scrdmp	**20**	**Dump screen to printer**	At present
(#$14)		(Tidy #2) (No return)	mono only.
	rate.W:	Rate = 1/2 cycle time	-1 retains
		60/50 Hz color 70 Hz monochrome	old values.
	attr.W:	0_Hide cursor 4_Set rate	
		1_Show cursor 5_Get rate	Returns
		2_Blink cursor 6_unused	old rate High
		3_Noblink cursor 7_unused	old attribute low
cursconf	**21**	**Set/get cursor blink rate & attribs**	word byte.
(#$15)		(Tidy #6) (Return D0.W)	
	date.L:	32-bit DOS format date and time	Date Hiword
settime	**22**	**Set ikbd time and date**	Time Loword
(#$16)		(Tidy #6) (No return)	(See page 3.22
			for the format.
gettime	**23**	**Get ikbd 32-bit format date & time**	*These functions use*
(#$17)		(Tidy #2) (Return D0.L)	*the real time clock*

XBIOS calls (Trap #14) cont.

Name	Param.Size	Description of parameter to push	Notes
bioskey (#$18)	**24**	**Restore power up keyboard setting** (Tidy #2) (No return)	Reset translation tabs
	pntr.L: nch.W:	Pointer to character string vector Count of characters to send -1	Send command to ikbd
ikbdws (#$19)	**25**	**Write a string to intelligent kybd** (Tidy #8) (No return)	
	intn.W:	MK68901 interrupt number	
jdisint (#$1A)	**26**	**Disable a MK68901 interrupt** (Tidy #4) (No return)	
	intn.W:	MK68901 interrupt number	
jenabint (#$1B)	**27**	**Enable a MK68901 interrupt** (Tidy #4) (No return)	
	regn.W: data.B:	PSG register number (00 to 0FH) Byte to write to register	Register ORed #$00 read
giaccess (#$1C)	**28**	**Read/write a sound chip register** Atomic access only (Return D0.B)	#$80 write
	bitn.W:	Bit number to be set (Mask AND)	
offgibit (#$1D)	**29**	**Atomically set PORT A bit to zero** (Tidy #4) (No return)	
	bitn.W:	Bit number to be set (Mask OR)	
ongibit (#$1E)	**30**	**Atomically set PORT A bit to one** (Tidy #4) (No return)	
	vec.L: data.W: cntl.W: timr.W:	Pointer to an interrupt handler Byte placed in timer's data register Timers control register setting Timer number allocations are: 0_A Reserved for end-users & applications 1_B Reserved for graphics primarily 2_C System timer (GEM, DESKTOP etc) 3_D RS232 baud rate and mere users	
xbtimer (#$1F)	**31**	**Provide control timing facility** (Tidy #12) (No return)	

XBIOS calls (Trap #14) cont.

	Param.Size	Description of parameter to push	Notes
	ptr.L:	Pointer to table of bytes (command-data)	
		cmd 0 to 15 load register 0 to 15 with data	0 xx
		cmd 128 load tempreg with databyte	128 xx
		cmd 129 reg # contents to load into tempreg (rr)	129 rr cc ee dd
		two's c value to add to tempreg (cc)	
		time delay between steps (dd/50)	
		terminate on value (ee)	
		cmd 130-255 set delay data (ticks) [0=stop]	130 xx
dosound	**32**	**Produce a sound**	(See Appendix
(#$20)		(Tidy #6)	L.22 et seq.)
	conf.W:	Bit 0 0=dot matrix, 1=daisy wheel	-1 returns
		1 0=colour device 1=monochrome	configuration
		2 0=1280.dots/line 1=960.dots/line	byte else
		3 0=draft, 1=NLQ	change and
		4 0=parallel, 1=RS232 port	return the
		5 0=formfeed, 1=single sheet	old value.
		6-14 reserved	
		15 must be zero	
setprt	**33**	**Get/set printer configuration byte**	
(#$21)		(Tidy #4) (Return D0.W)	
Structure		MIDI_input (BIOS buffer routine) -->	D0.B character
longword		keybrd_err \ Called when - \	68901
format		MIDI_err / overrun detected /	or 6850's
	ikbd_stat \	Pointer to packet	
	mous_pack |	handlers (pointer to	(mouse vector
	clock_pack |	packet received in	used by
	joyst_pack /	A0 & on stack.L)	GEM & GSX)
	MIDI_vec \	Call when character	
	ikbd_vec /	available on 6850	Handlers to
kbdvbase	**34**	**Return pointer to structure base**	return by RTS
(#$22)		(Tidy #2) (Return D0.L)	within 1ms
	rept.W:	Rate of key-repeats (System ticks)	-1 parameters
	init.W:	Delay before key-repeat starts	no change.
kbrate	**35**	**Get/set keyboard repeat rate**	Delay high byte
(#$23)		(Tidy #6) (Return D0.W)	repeat low byte

XBIOS calls (Trap #14) cont.

Param.Size		Description of parameter to push	Notes
prt.L:		Pointer to parameter block	
_prtblk	**36**	**Hard copy routine**	
(#$24)		(Tidy #6) (No return)	
vsync	**37**	**Wait till next vblank and return**	Graphics
(#$25)		(Tidy #2) (No return)	synchronize
code.L:		Pointer to code ending with RTS	Must not
		Hackers access to hardware & protected locations	call BIOS
superx	**38**	**Execute code in supervisor mode**	or GEMDOS
(#$26)		(Tidy #6)	functions
puntaes	**39**	**Switch off AES,** when not in ROM	
(#$27)		(Tidy #2) otherwise perform a RESET.	
flag.W:		Blitter status word	Automatic
		bit 0- set to enable blitter	operation
		1-14 reserved	through line-A
		15 0_clear	and VDI calls.
		or -1_Get blitter status	Return D0
blitmode	**64**	**Get/set blitter status** bit	0_set (blit on)
(#$40)		(Tidy #4) (Return D0.W)	1_set (if blit there)
The reserved fields are for future blitter capabilities			2-14 reserved
and will be used in future.			15_clear

GEMDOS calls (Trap #1)

Trap #1 access

To access GEM BDOS functions, push the parameters in the order given onto the current stack and then call trap#1. Any byte, word or longword reply or the address of a parameter block will be returned in register D0.

```
move.W    driveB,-(SP)    * push drive number (2)
move.W    #13,-(SP)       * push setdrv function call
trap      #1              * call the function
add.W     #4, SP          * tidy stack
rts                       * return with bitmap in D0
```

It is the programmers responsibility to maintain the stack integrity (tidy) after the call.

Function	Param.Size	Description of parameter to push	Notes
p_term_o 0 (#$00)		**End process and return to parent.** (Tidy #2) (use $4c)	Return code zero.
c_conin 1 (#$01)		**Read character from standard i/p & echo** (Tidy #2) (Return D0.L)	The console scan code (Appendix page d.3) is returned in the low byte of the high word. The upper byte of the word sent MUST be 0 for future compatibility
c_conout 2 (#$02)	char.W:	Character to be printed **Write character to standard output** (Tidy #4) (No return)	
c_auxin 3 (#$03)		**Read character from auxiliary port** (Tidy #2) (Return D0.L) *(RS232)*	
c_auxout 4 (#$04)	char.W:	Character to be printed **Write character to standard aux device** (Tidy #4) (No return) *(RS232)*	
c_prnout 5 (#$05)	char.W:	Character to be printed **Write character to standard print device** (Tidy #4) (Return -1_o'k, 0_after 30ms time out)	

GEMDOS calls (Trap #1) cont.

Name	Param.Size	Description of parameter to push	Notes
	parm.W:	If parm.W=255 ($00FF) then read else parmeter is character to be written	If no character then D0.L=0
c_rawio (#$06)	**6**	**Raw I/O to standard input/output** (Tidy #4) (Return D0.L)	Character as per c_conin
c_rawcin (#$07)	**7**	**Raw input from standard input** (Tidy #2) (Return D0.L)	No echo to screen Pass controls
c_necin (#$08)	**8**	**Read a character from standard input** (Tidy #2) (No return)	No echo. ^C ^Q & ^S active
	addr.L:	Address of null terminated string	Character bytes terminated by a zero.
c_conws (#$09)	**9**	**Write string to standard output** (Tidy #6) (Return D0.L=# char sent)	
	addr.L:	Address of input buffer (First byte data portion length)	<u>On return</u> 2nd length read 3-n characters n+1 zero
c_conrs (#$0A)	**10**	**Read edited string from standard input** (Tidy #6) (Buffer returns) *^C,^H,^I,^J,^M,^R,^U,and^X have their normal 'edit' meaning. Terminate edit using : RETURN, ^J or ^M*	
c_conis (#$0B)	**11**	**Check status of standard input** (Tidy #2) (Return D0.L)	character ready -1_yes,0_no
	driv.W:	Drive number: 0=A, 1=B....15=P	Return bitmap of drives present
d_setdrv (#$0E)	**14**	**Set default drive** (Tidy #4) (Return D0.L)	
c_conos (#$10)	**16**	**Check status of standard output** (Tidy #2) (Return D0.L)	-1 ready 0 not ready
c_prnos (#$11)	**17**	**Check status of standard print device** (Tidy #2) (Return D0.L)	-1 ready 0 not ready
c_auxis (#$12)	**18**	**Check status of standard aux device i/p** (Tidy #2) (Return D0.L)	-1 char received 0 no characters

GEMDOS calls (Trap #1) cont.

	Param.Size	Description of parameter to push		Notes
c_auxos (#$13)	**19**	**Check status of standard aux device o/p** (Tidy #2)	(Return D0.L)	-1 ready 0 not ready
d_getdrv (#$19)	**25**	**Get current drive** (Tidy #2)	(Return D0.L)	drive A=0 B=1...etc.
	addr.L:	Disk transfer address		Address
f_setdta (#$1A)	**26**	**Set disk transfer address** (Tidy #6)	(No return)	used by sfirst (#78)
t_getdate * (#$2A)	**42**	**Get date** (Tidy #2)	(as per set date format) (Return D0.L)	Date return in low word
	date.W:	Date format	date: bits 0-4, 1 to 31	Error return
t_setdate * (#$2B)	**43**	**Set date** (Tidy #4)	mnth bits 5-8, 1 to 12 year: bits 9-15, 1980 - 2100	if date not valid
t_gettime * (#$2C)	**44**	**Get time** (Tidy #2)	(as per set time format) (Return D0.L)	Time return in low word
	time.W:	Time format	secs: bits 0-4, step 2s	Error return
t_settime * (#$2D)	**45**	**Set date** (Tidy #4)	mins: bits 5-10 hour: bits 11-15	if date not (D0.L) valid
f_getdta (#$2F)	**47**	**Get disk transfer address** (Tidy #2)	(Return D0.L)	
s_version (#$30)	**48**	**Get version no.** (1.00 lo- hi byte) (Tidy #2)	(Return D0.W)	0001H for first release
	exit.W:	Exit code (process return code)		May cause
	keep.L:	# bytes to keep in process description		problems
p_termres (#$31)	**49**	**Terminate and stay resident** (Tidy #8)	(No return)	for future conversions

* Updated from RTC on the termination of every process

GEMDOS calls (Trap #1) cont.

Call	Param.Size	Description of parameter to push	Notes
	driv.W:	Drive number: 0=current, 1=A, 2=B..	Buffer pb.L
	info.L:	Address of drive information buffer	*#free clusters*
d_free 54		**Get drive free space** (data in buffer 4 x longwords)	*#clusters total*
(#$36)			*#bytes/sector*
		(Tidy #8) (Return D0=0_o'k else error)	*#sectors/cluster*
	path.L:	Address of string containing pathname	Pathname is
d_create 57		**Create a subdirectory**	terminated
(#$39)		(Tidy #6) (Return D0.L)	in a null.
	path.L:	Address of string containing pathname	
d_delete 58		**Delete a subdirectory**	0 ret o'k
(#$3A)		(Tidy #6) (Return D0.L)	negative error
	path.L:	Address of string containing pathname	
d_setpath 59		**Set current directory**	
(#$3B)		(Tidy #6) (Return D0.L)	
	attr.W:	File attributes: 01H read only	Return file
		02H hidden file	handle if o'k,
		04H hidden system file	negative error
		08H File, vol label in first 11 bytes	
	path.L:	Address of string containing pathname	
f_create 60		**Create a file**	Pathname
(#$3C)		(Tidy #8) (Return D0.L)	ends in a zero
	attr.W:	File read-write mode	Return file
		0=file open for read only	handle if o'k,
		1=file open for write only	negative if
		2=file open read and write	error.
	path.L:	Address of string containing pathname	
f_open 61		**Open file**	Pathname
(#$3D)		(Tidy #8) (Return D0.L)	ends in a zero
	hndl.W:	File handle	0 ret o'k
f_close 62		**Close file** *-errors may crash system*	negative error.
(#$3E)		(Tidy #4) (Return D0.L)	

GEMDOS calls (Trap #1) cont.

Call	Param.Size	Description of parameter to push	Notes
	buff.L:	Address of buffer to store bytes	D0 contains the number of bytes read.
	byts.L:	Number of bytes to read *(never 0)*	
	hndl.W:	File handle	
f_read 63		**Read file**	Negative on error.
(#$3F)		(Tidy #12) (Return D0.L)	
	buff.L:	Address of buffer storing bytes	D0 contains the number of bytes written. Negative on error. i.e disk full.
	byts.L:	Number of bytes to write *(never 0)*	
	hndl.W:	File handle *(errors may crash the system)*	
f_write 64		**Write file**	
(#$40)		(Tidy #12) (Return D0.L)	
	path.L:	Address of string containing pathname	0 return o'k negative on error.
f_delete 65		**Delete file**	
(#$41)		(Tidy #6) (Return D0.L)	
	fmod.W:	0: move n bytes from beginning 1: move n bytes from current position 2: move n bytes from end of file	Positive moves to end of file, negative to beginning
	hndl.W:	File handle	
	nbyt.L:	Signed number of bytes argument	
f_seek 66		**Seek file pointer**	D0=Absolute file pointer location
(#$42)		(Tidy #10) (Return D0.L)	
	attr.W:	File attributes: #$01 read only #$02 hidden file #$04 hidden system file #$08 File, vol label in 1st 11 bytes #$10 File is a subdirectory #$20 File has been written & closed	Return file handle if o'k, negative if error Pathname is terminated in a null.
	wrt.W:	0_get/1_set file attributes	
	path.L:	Address of string containing pathname	
f_attrib 67		**Get/set file attributes**	
(#$43)		(Tidy #10) (Return D0.L)	Get in D0.L
	shnd.W:	Standard file handle to duplicate	Error return page I.3
f_dup 69		**Duplicate file handle**	
(#$45)		(Tidy #4) (Return D0.L)	

GEMDOS calls (Trap #1) cont.

	Param.Size	Description of parameter to push	Notes
	shnd.W:	Standard file handle to force	0 console i/p
	nhnd.w:	Non-standard file handle	-1 console o/p
f_force	**70**	**Force point file handle** to non-standard	-2 serial
(#$46)		(Tidy #6) handle file or device	-3 parallel
	driv.W:	Drive number: 0=default, 1=A...etc.	Buffer minimum
	path.L:	Address of 64 byte buffer for pathname	64 bytes.
d_getpath	**71**	**Get current directory**	
(#$47)		(Tidy #8) (Return D0.L)	Return 0_o'k
		Allocated block may not be on a word boundary	
	nbyt.L:	Bytes to allocate or -1 return maximum available	D0.L=0 if
m_alloc	**72**	**Allocate memory** (D0.L start pointer)	allocation fails
* (#$48)	or	Read free memory (D0.L bytes available)	or pointer to
		(Tidy #6) (Return D0.L)	block.
	frad.L:	Address of memory to free	0 return o'k
m_free	**73**	**Free allocated memory**	negative on error
* (#$49)		(Tidy #6) (Return D0.L)	
	rmem.L:	Length of retained memory	Reallocates
	mmem.L:	Start of memory space to modify	unused memory
	zero.W:	zero (reserved)	for GEMDOS.
m_shrink	**74**	**Shrink size of allocated memory**	0 return o'k
* (#$4A)		(Tidy #12) (No return)	negative on error
	penv.L:	Pointer to environmental string, 0 for parent	Mode 3 is
	pcmd.L:	Pointer to command tail including redirection	used for
	path.L:	Address of string containing pathname	overlays,
	mode.W:	0=load & execute. return terminal child code	
		3=load only. return D0.L base page address	
		4=create basepage, 5=execute only	Return D0.L
p_exec	**75**	**Load or execute a process**	error if
(#$4B)		(Tidy #16) (Return D0.L)	load fails.
		Insufficient memory error returned as $000000D9.	

* These functions are unreliable in early versions of TOS.

GEMDOS calls (Trap #1) cont.

Param.Size		Description of parameter to push	Notes
stat.W:		Interrogation code for parent	0 Return o'k
p_term	**76**	**Terminate process,** control to parent	non-zero error
(#$4C)		(Tidy #4) (Return D0.L)	
satt.W:		Search attributes	Filename
		#$00 normal files: #$01 read only	may include
		#$02 hidden files: #$04 hidden system file	'*' or '?'
		#$08 volume label file #$10 subdirectory files	wildcards.
		#$20 File has been written & closed	
path.L:		Address of string containing pathname	If file not
f_sfirst	**78**	**Search for 1st occurence filespec**	found return
(#$4E)		44-byte DTA buffer created if found	-33 code
		0-20 OS reserved: 21 file attributes	in D0.L
		22-23 Time stamp: 24-25 Date stamp	(file not found)
		26-29 Filesize.L (Lo-Hi): 30-43 Name.extension	
		(Tidy #8) (Return D0.L)	
f_snext	**79**	**Search for next occurence filespec**	First 20bytes
(#$4F)		(Uses first 20 bytes of DTA buffer,	DTA buffer
		name.extension updated on success)	must not be
		(Tidy #2) (Return D0.L)	altered.
pth2.L:		Pointer to 'new' file string	Rename a
pth1.L:		Pointer to 'old' file string	file
zero.W:		zero	Return D0
f_rename	**86**	**Rename a file**	error number
(#$56)		(Tidy #12) (Return D0.L)	or 0=o'k

GEMDOS calls (Trap #1) cont.

Function	Param.Size	Description of parameter to push	Notes
	info.W:	0_set/1_get date and time	
	hndl.W:	File handle	
	buff.L:	Time and date buffer pointer	
f_datime 87		**Get/set file date and time stamp**	
(#$57)		*Buffer first word*	
		Bit format days 0-4 1 to 31	
		mnth 5-8 1 to 12	
		year 9-15, 1980 to 2100	
		Buffer second word	
		Bit format secs 0-4 in 2 sec steps	
		mins 5-10	
		hour 11-15	
		(Tidy #10) (No return)	

Offset	Dec	Contents
$00	0	OS reserved
$15	21	File attributes
$16	22	File time stamp
$18	24	File date stamp
$1A	26	Longword file size
$1E	30	Name and ext. of file found (7 words)

DTA buffer

Use function #$1A (dec 26) to set DTA buffer address and functions #$2F (dec 47) to get DTA address.

Supervisor/User toggle

This special function allows users to get in and out of supervisor mode from GEMDOS.

	Param.Size	Description of parameter to push	Notes
	stck.L:	-1_get mode: Return (D0.L) 0_user, 1_supervisor	
		<>-1 switch mode a) User to supervisor mode 0_set supervisor stack equal to user stack before call <>0_set supervisor stack equal to stck.L	Return value of old super stack in D0.L
		b) Supervisor to user mode set supervisor stack from stck.L which must be the first SMODE function call or the system will crash.	The old value of super stack MUST be restored on process termination
smode (#$20)	32	**Set/get supervisor/user mode** (Tidy #6) (Return D0.L)	

Test for mode

```
move.L   #$1,-(sp)      * Returns DO.L
move.W   #32,-(sp)      *     $0= user mode
trap     #1             *     $FF=supervisor mode
addq     #6,sp          *
```

User to supervisor mode

```
clr.L    -(sp)          *  Set supervisor stack equal to
move.W   #32,-(sp)      * user stack before this call,
trap     #1             *
addq     #6,sp          *
move.L   D0,save_stk    *  Save old supervisor stack value
```

Supervisor to user mode

```
move.L   save_stk,-(sp) *  Recover old supervisor stack
move.w   #32,-(sp)      *
trap     #1             * and back into user mode.
addq     #6,sp          *
```

Extended BDOS calls (Trap #2)

To access the extended BDOS functions, the D0.W register is loaded with the function code, an address pointer is placed in D1.L and trap #2 called. A return, if any, is placed in D0.W.

GEM VDI and AES may be accessed by loading the relevant parameter block address into D1, the function number into d0 and making an extended BDOS call:

GEM VDI access

```
move.l    #contrl, pblock
move.l    #pblock,d1          * address of VDI param block
move.w    #$73,d0             * set d0 equal to 115 and
trap      #2                  * execute an extended BDOS call
```

GEM AES access

```
move.l    #control,_c
move.l    #_c,d1              * address of AES param block
move.w    #$c8,d0             * set d0 equal to 200 and
trap      #2                  * execute an extended BDOS call
```

Extended BDOS calls (Trap #2) cont.

Code#	Hex Dec	Function	Notes
D0.W :	#$00 0	Terminate current program and return to CP level	The function does not return to calling program.
Trap #2		**RESET**	
D1.L :	#pblock	VDI parameter block pointer	
D0.W :	#$73 115	VDI function number	
Trap #2:		**GEM VDI access**	
D1.L :	#control	AES param block pointer	
D0.W :	#$c8 200	AES function number	
Trap #2:		**GEM AES access**	
D0.W :	#$c9 201		
Trap #2			
D0.W :	#$fe -2		Return D0.W=-2 if GDOS not installed.
Trap #2		**Test for GDOS version**	

The trap #2 RESET call simply calls the GEMDOS trap #1 process terminate function #$4C.

* Test for GDOS, looks for Atari GDOS version 1.0 which does not contain all the VDI functions.

Interrupt Handler

The standard system interrupt is level 2, vector $68 (104) and takes the following sequence every interrupt:

Vertical blank interrupt (VBI)

Order	Function	System variable	
1	Increment the frame counter	FRCLOCK.L	$466
2	Test for mutual exclusion	VBSLEM.W	$452
	if = 0 return		
3	Save all the registers on stack		
4	Increment 'Vblank counter'	VBCLOCK.L	$462
5	Test for high resolution mode	SHFTMD.W	$44C
	if shftmd<2 then goto 6,		
	test for low resolution monitor attatched		
	if yes set mode to zero	DEFSHFTMD.B	$44A
6	Call cursor blink routine		
7	Test for new colour pallette	COLORPTR.L	$45A
	if colorptr=0 then goto 8		
	Load pallette with 16 words pointed to by colorptr and then zero it.		
8	Test for new screen	SCREENPTR.L	$45E
	if screenptr=0 then goto 9		
	Set screen physical base to screen pointer and then zero pointer.		
9	Run deferred VBI vectors		
	\# of deferred VBI vectors	nvbls.W	$454
	Pointer to VBI vector array	vblqueue.L	$456
10	Return		

There are eight VBI vectors available in the default array, the first is reserved for GEM's VBI code. Pointers to new handlers are placed in the spare slots. Handler code ends in RTS and may use any register except the user stack pointer. Larger arrays can be allocated by redefining nvbls and vblqueue, copying the current vectors to the new array. An application that returns, should tidy up the VBI queue.

Do not make VDI or Line-A calls via an Interrupt as the results are unpredictable if the ST has a blitter chip installed.

Chapter 4

GEM VDI

GEM VDI function calls

Digital Research's GEM VDI (Virtual Device Interface) provides graphic capabilities and a device independent operating environment for the development of programs that are transportable to other operating systems. It is therefore a pity that the initial ROM implementations of the Atari ST did not include that portion of code which provided the transportability.

The VDI comprises GDOS, the Graphics Device Operating System and GIOS, the Graphics Input/Output System.

GDOS consists of the basic and device independent graphic functions that are called by applications and functions without reference to any specific hardware in a manner similar to the disk operating system. The GIOS consists of the device specific code that is needed to interface to each specific graphic device (device drivers). The OS needs a device driver for every different graphics device attatched to the system, unfortunately only one is supplied - for the screen. This limitation, the drivers restriction of only two fonts per screen resolution and the absence of support for the normalised device coordinate system means that the ST does not have a device independent capability.

Appendix E lists all the GEM VDI functions. As a general rule, only those functions associated with the screen are implemented (virtually all are), those associated with either a printer, plotter or meta-file are not implemented.

It may be possible to obtain the file GDOS.PRG which when placed in an AUTO folder, provides the ST with the missing facilities of GDOS. Atari have made the file available to registered software developers for a nominal sum but the code (and that means small parts of it as well) is subject to a single fixed licence fee if used in commercial programs.

GEM VDI function calls

The VDI functions are accessed through an extended BDOS call and the VDI parameter block (five longword pointers to the word tables; *cntrl, input attribute and points, output attribute and points*). The parameter and array blocks, which are usually initialized by an AES call to APPL_INIT, have the following formats:

VDI parameter block

$00	Control pointer table	control
$04	Input attribute table pointer	intin
$08	Input points table pointer	ptsin
$0C	Output attribute table pointer	intout
$10	Output points table pointer	ptsout

Control table

$00	Opcode	
$02	Length of input coordinate table	Length in word pairs
$04	Length of output coordinate table	Length in word pairs
$06	Length of input attribute table	Length in words
$08	Length of output attribute table	Length in words
$0A	Subfunction ident number	
$0C	Device handle	Zero if can not be opened
$0E	Opcode depend information	

It is the programmers responsibility to define the correct number of arguments to be passed and the array size (1 to n) required by the function on return.

Attribute table

intin / intout	Typical usage
$00	device ID (handle)
$02	line type
$04	line colour
$06	mark type
$08	mark colour
$0A	font

Note: These parameters are held in word sized tables. Assembler and BASIC use the actual offset whereas 'C', Pascal and GFA Basic etc. use word sized offsets. i.e half the actual value I have used in this book.

Points table

ptsin / ptsout	Typical usage	
$00	x coordinate	word pair
$02	y coordinate	
$04		
$06		
$08	width	word pair
$0A	height	

A minimum application stack space of 128 bytes is required, plus space for the GEM arrays. The VDI function calls have been detailed in groups as follows:

Workstation control functions:

Define the workstation parameters and defaults; these govern the font and the window size to be used and the generation of virtual screens.

Output functions:

These functions draw the graphic primitive on the specified output device.

General drawing primitive functions:

Contain the basic graphic primitives of line, arc, filled and unfilled ellipse and rectangle, and of justified text.

Attribute functions:

Define the output style of the graphic primitives; the line, marker, text cell and polygon for colour, size and fill.

Raster operations:

Provide the ability to transpose a source block of pixels to a destination location on the basis of a logical operation between the bits comprising the source and destination.

Input functions:

Enable the programmer to provide the user with both a 'request and wait on event' and a 'request, sample and return' mode of inquiry.

Inquire functions:

Return the status or attributes of a specific device

Escape functions:

Enable the application to access special features applicable to certain graphic devices.

VDI Parameter block sizes

The numbers of parameters required by the various functions are detailed in the tabular format:

Control table

Function	Op	Pointpair in	Pointpair out	Integers in	Integers out	GDP	Device name	Comments
	$0	$2	$4	$6	$8	$A	$C	

The table contains details of the parameter input and output word sizes; note that the points value is *half* the table size (a point is defined by a pair of x and y word-sized coordinates - a longword). All data is assumed to be 2 byte integer including string characters.

Open workstation function v_opnwk

The major VDI function in terms of size is the 'open workstation function', which sets up a named screen, (device handle) the desktop window, identified as device name zero. The new screen is initialized to graphics mode, cleared and the parameter table outputs initialized. The *v_opnwk* (op_1) function is **not available** on the Atari ST (only with GDOS.PRG), programmers should use the virtual workstation function *v_opnvwk* (op_100).

The control table

Control offset		*Data entered*	*Array size.B*	*Function*	
$0	0	1		Opcode for 'open workstation'	
$2	2	0	0	# of i/p point pairs	ptsin
$4	4	6	24	# of o/p point pairs	ptsout
$6	6	11	22	Length of i/p attribute table	intin
$8	8	45	90	Length of o/p attribute table	intout
$A	10			Not used	
$C	12	x		Handle for this device	(out)

Attribute input table (intin)

Intin Offset		*Initial defaults (style, colour etc.)*		*VDI Op code*
$0	0	Device driver	(screen = 1)	
$2	2	Linetype	(solid = 1)	15
$4	4	Polyline colour index		-
$6	6	Marker type	(dot = 1)	18
$8	8	Polymarker colour index		20
$A	10	Text face		21
$C	12	Text colour index		
$E	14	Fill interior style		23
$10	16	Fill style index		24
$12	18	Fill colour index		
$14	20	NDC to RDC transform flag (2 only) 0 map full NDC to full RC 1 reserved 2 Raster coordinates		

The input ranges required to open a workstation with a specific attribute can be found, in the table box for that attribute, later in this chapter.

The procedure names are limited to the maximum of eight unique characters supported by the most C compilers. Note that C external names are prefixed by a '_' which reduces the uniqueness to seven characters.

Attribute output table (intout)

Intout Offset		*Default output parameters*		*Typical b&w values*		
$0	0	Maximum pixel width		$27f		639
$2	2	Maximum pixel height		$18f		399
$4	4	Device coordinate flag (0=fine, 1=coarse)		always 0		
$6	6	Pixel height, microns	mm/1000			372
$8	8	Pixel width, microns	mm/1000			372
$A	10	# character heights (0=continuous)			3	
$C	12	# linetypes			7	
$E	14	# line widths (0=continuous)			0	
$10	16	# marker types			6	
$12	18	# marker sizes (0=continuous)			8	
$14	20	# faces supported (fonts)			1	
$16	22	# patterns		$18		24
$18	24	# hatch styles		$c		12
$1A	26	# simultaneous colours (2=mono)			2	
$1C	28	# generalized drawing primitives		$a		10
		List of the first 10 GDP's (-1 ends list)				
$1E-$30		1=Bar	6=Elliptical arc			
		2=Arc	7=Elliptical pie		1 to 10	
	30-48	3=Pie slice	8=Rounded rectangle			
		4=Circle	9=Filled rounded rectangle		3 0 3	
		5=Ellipse	10=Justified graphic text		3 3 0	
		Attribute list for GDP's			3 0 3	
$32-$44		0=Polyline	1=Polymarker		2	
	50-68	2=Text	3=Fill araea 4=None			
$46	70	Colour	\ 0=no, 1=yes		0	
$48	72	Text rotation	| Capability		1	
$4A	74	Fill area	| flags		1	
$4C	76	Cell array operation	/		0	
$4E	78	# colours (2=mono, 4, 16)			2	
$50	80	# locator devices	1=keyboard only		2	
			2=keyboard + i/p (mouse)			
$52	82	# valuator devices	1=keyboard		1	
$54	84	# choice devices	1=function keys		1	
			2=button device			
$56	86	# string devices	1=keyboard		1	
$58	88	# Workstation type	0=output only		2	
		1=i/p only,	2=input/output			
		3=reserved,	4=metafile output			

Output points table (ptsout)

Ptsout Offset		*Output points table*		*Typical values*
$0	0	Minimum character width		5
$2	2	Minimum character height		4
$4	4	Maximum character width		7
$6	6	Maximum character height	$d	13
$8	8	Minimum line width		1
$A	10	Zero		0
$C	12	Maximum line width	$28	40
$E	14	Zero		0
$10	16	Minimum marker width	$f	15
$12	18	Minimum marker height	$b	11
$14	20	Maximum marker width	$78	120
$16	22	Maximum marker height	$58	88

The GEM VDI calls

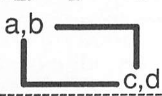
Workstation control functions

The following functions set the workstation parameters and defaults for use by the application:

Function	Op $0	Pointpair in $2	Pointpair out $4	Integers in $6	Integers out $8	GDP $A	Device name $C	Comments
Open workstation * *v_opnwk*	1	0	6	11	45		zero	Set up desktop window (device zero) to graphics mode & initialise tables
		Call only with GDOS.PRG installed						

* Not implemented on the Atari ST

Workstation control functions cont.

Function	Op $0	Pointpair in $2	Pointpair out $4	Integers in $6	Integers out $8	GDP $A	Device name $C	Comments
Close workstation * *v_clswk*	2	0 Call only with GDOS.PRG installed	0	0	0		-	Return to alpha mode Close device and flush buffers.
Open virtual screen *v_opnvwk*	100	0	6	11 parameters as opcode 1 (pg 4.6 Intin)	45		i/p screen o/p new window	Permits multiple windows based on one screen with different attributes
Close virtual screen *v_clsvwk*	101	0	0	0	0		-	Close virtual screens first to stop further output to screen.
Clear workstation *v_clrwk*	3	0	0	0	0		-	Clear the screen. New page if possible. Delete buffer data
Update workstation *v_updwk*	4	0	0	0	0		-	Execute graphic commands waiting. No effect on screen. Use to print data
Load font * *vst_load_fonts*	119	0 intin (0)=0, reserved intout(0)=# fonts loaded	0	1	1		-	Load additional fonts. intin(0) reserved for future use.
Unload font * *vst_unload_fonts*	120	0 intin (0)=0, reserved	0	1	0		-	Unload font from memory if no other live users. intin(0) reserved
Set clipping rectangle *vs_clip*	129	2 	0	1 intin(0)=0_off (default) <>0_on	0		-	Disable/enable clipping of output primitive. ptsin a,b,c,d

* Not implemented on the Atari ST

Output Functions

The following functions draw the graphic primitives (lines, arc etc.) on the current device using the current attributes.

Function	Op $0	Pointpair in $2	 out $4	Integers in $6	 out $8	 GDP $A	Device name $C	Comments
Polyline *v_pline*	6 min of 2 coord pairs	n	0	0	0 x1,y1 x2,y2.....etc .		-	Draw line between n pairs of points
Poly-marker *v_pmarker*	7	n	0 x1,y1 x2,y2.....etc.	0	0		-	Draw marker at each of n pairs of points.
Text *v_gtext*	8	1 intin (0)=text string (n=string length) ptsin (0)=lower left corner ptsin (2)=upper right corner	0	n	0		-	Write character string to device. 0-255 Intin word LSByte contains character.
Filled area *v_fillarea*	9	n n* x,y points as per polyline Uses Op #25 *vsf_color* for fill colour	0	0	0		-	Outline if device can not fill. Close area if open.
Fill rectangle *vr_recfl*	114	2 a,b (upper left) ... c,d (lower right)	0	0	0 ptsin (0)=a ptsin (4)=c ptsin (2)=b ptsin (6)=d Uses Op #25 *vsf_color* for fill colour		-	Rectangular area fill ptsin a,b,c,d
Cell array Rect array Row length Xc #Words/row # Rows Xc Writing mode *v_cellarray*	10	2 c,d (upper right) ... a,b (lower left) Cntrl $E Cntrl $10 Cntrl $12 Cntrl $14	0 Not implemented in all systems	n n=length of colour index Colour index array: Xc ... Yc (Intin 0 . . .n)	0		-	Draw rectangular cell array. ptsin a,b,c,d based on colour cells Xc * Yc Writing mode see Op #32
Contour fill *v_contour*	103	1 intin (0)=colour index ptsin (0)=x coordinate] Starting ptsin (2)=y coordinate] point	0	1	0		-	Flood fill area bound by edge or colour. There must not be a gap

General drawing primitive functions (GDP's)

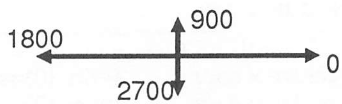
The GDP's provide the basic graphic primitives of line, arc, ellipse etc.

Function	Op $0	Pointpair in $2	Pointpair out $4	Integers in $6	Integers out $8	GDP $A	Device name $C	Comments
GDP (General format)	11	n	-	-	-	x	-	
Bar	11	2	0	0	0	1	-	Area attributes
	ptsin (0)=corner x coordinate ptsin (2)=corner y coordinate ptsin (4)=diagonally opposite x coordinate ptsin (6)=diagonally opposite y coordinate							Uses Op #25 *vsf_color* attributes
v_bar								
Arc	11	4	0	2	0	2	-	Line attributes
	ptsin (0)=centre x coordinate ptsin (2)=centre y coordinate ptsin (4)=0 ptsin (6)=0			ptsin (8)=0 ptsin (A)=0			ptsin (C)=radius ptsin (E)=0 intin (0)=start angle intin (2)=end angle	] 0 to 3600
v_arc	*'New TOS' clears reliability problems of small angles.*							
Pie	11	4	0	2	0	3	-	Area attributes
v_pieslice		Parameters as per arc above						
Circle	11	3	0	0	0	4	-	Area attributes
		ptsin (0)=centre x coordinate ptsin (2)=centre y coordinate ptsin (4)=0					ptsin (6)=0 ptsin (8)=radius ptsin (A)=0	
v_circle								
Ellipse	11	2	0	0	0	5	-	Area attributes
		ptsin (0)=centre x coordinate ptsin (2)=centre y coordinate ptsin (4)=radius x axis ptsin (6)=radius y axis						
v_ellipse								
Elliptic arc	11	2	0	2	0	6	-	Line attributes
		ptsin (0)=centre x coor ptsin (2)=centre y coor ptsin (4)=radius x axis ptsin (6)=radius y axis					intin (0)=start angle intin (2)=end angle	] 0 to 3600
v_ellarc								

GDP's cont.

Function	Op $0	Pointpair in $2	Pointpair out $4	Integers in $6	Integers out $8	GDP $A	Device name $C	Comments
GDP (General format)	11	n	-	-	-	x	-	
Elliptic pie *v_ellpie*	11	2	0	2	0	7	-	Area attributes
		Parameters as per elliptic arc above						
Rounded rectangle *v_rbox*	11	2	0	0	0	8	-	Line attributes
		ptsin (0)=corner x coordinate ptsin (2)=corner y coordinate ptsin (4)=diagonally opposite x coordinate ptsin (6)=diagonally opposite y coordinate						
Filled rounded rectangle *v_rfbox*	11	2	0	0	0	9	-	Area attributes
			Parameters as per rounded rectangle					
Justified graphics text *v_justified*	11	2	0	2+n	0	10	-	Text attributes
		intin (0)=interword space flag] zero to intin (2)=intercharacter space flag] keep as is intin (4)=first character] Null terminated intin (4+n)=last character] string ptsin (0)= x alignment ptsin (2)= y alignment ptsin (4)= string length ptsin (6)= zero						
			Intin uses least significant byte of word for character					

Notation used for angular specification



Attribute functions

The attribute functions determine the output style of all the graphic primitives; that is colour, line style, character size etc.

Function	Op $0	Pointpair in $2	Pointpair out $4	Integers in $6	Integers out $8	GDP $A	Device name $C	Comments
Set	32	0	0	1	1*		-	Out of range uses
writing		intin(0)=1,replace						replace mode
mode			=2,transparent (mask 1's)					Modes 2, 3 and 4
			=3,XOR					based on line or
vswr_mode			=4,reverse transparent (mask 0's)					fill pattern mask
Set a	14	0	0	4	0		-	Redefine a colour.
colour		*v_opnvwk (intout $1A) gives # colours*						No action if lookup
		intin (0)=colour index					In mono	table is not available
		intin (2)=red			\ Colour		any colour	or 'out of range'
		intin (4)=green			I intensity		is set to	The number of colours
vs_color		intin (6)=blue			/ 0 to 1000		white	is device dependent.
Set	15	0	0	1	1*		-	Most devices support
polyline		*v_opnvwk (intout $C) gives # linetypes*						at least six line styles
line type		intin (0)=line style						
		1=solid		2=long dash			3=dot	4=dash-dot
vsl_type		5=dash		6=dash-dot-dot			7=user defined.	
Set user	113	0	0	1	0		-	User defined pattern
defined			*Sets linetype #7*					for line,
polyline		intin (0)=line pattern (16 bits)						MSB is first pixel.
vsl_udsty								
Set	16	1	1	0	0		-	On error width is set
polyline								to the nearest below
width		ptsin (0)=line width				ptsout(0)=width		Use odd numbers
vsl_width		ptsin (2)=zero				ptsout(2)=zero		>= three.
Set polyline	17	0	0	1	1*		-	Set colour for polyline
colour								operations
vsl_color		intin (0)=colour index						
Set	108	0	0	2	0		-	0=square (default)
polyline								1=arrow
end style		intin (0)=start			intin (2)=end			2=rounded
vsl_ends								

* denotes intout() is actual value of intin() used.

Attribute functions cont.

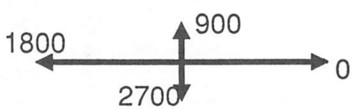
Function	Op $0	Pointpair in $2	Pointpair out $4	Integers in $6	Integers out $8	GDP $A	Device name $C	Comments
Set polymarker type *vsm_type*	18	0	0	1	1*	-		All devices support at least six markers Defaults on error to asterisk.
		intin (0)=marker type 1=dot 2=plus 3=asterisk 4=square 5=cross 6=diamond						
Set polymarker height *vsm_height*	19	1	1	0	0	-		Height set is nearest below on error.
		ptsin (0)=zero ptsin (2)=y-axis height					ptsout(0)=x-axis width ptsout(2)=y-axis height	
Set poly-marker colour *vsm_color*	20	0	0	1	1*	-		Set colour for polymarker operations.
		intin (0)=colour index						
Set character height *vst_height*	12	1	2	0	0	-		Size of character V character *All i/p's in raster units*
		ptsin (0)=zero ptsin (2)=height			ptsout(0)=character width ptsout(2)=character height ptsout(4)=cell width ptsout(6)=cell height			
Set character cell height *vst_point*	107	0	2	1	1*	-		Size of cell V cell *Ptsout in raster units*
		intin (0)=cell ht in point size *(1 point=1/72 inch)*			ptsout(0)=character width ptsout(2)=character height ptsout(4)=cell width ptsout(6)=cell height			
Set char baseline vector *vst_rotation*	13	0	0	1	1*	-		Angular range 0 to 3600 Not supported by all devices.
		v_opnvwk (intout $48) gives capability intin (0)=angle requested						
Set text face *vst_font*	21	0	0	1	1*	-		Face 1 is built-in (System face)
		intin (0)=face selection						
Set graph text colour *vst_color*	22	0	0	1	1*	-		Set colour for next text. default 1
		intin (0)=text colour index						

* denotes intout() is actual value of intin() used.

Attribute functions cont.

Function	Op $0	Pointpair in $2	Pointpair out $4	Integers in $6	Integers out $8	GDP $A	Device name $C	Comments
Set text	106	0	0	1	1*		-	Default to standard
special								text
effect		intin (0):bits 0 to 5 set effects						Effect 'on' if bit = 1
vst_effects		*Thick, light, skew, underline, outline, shadow respectively*						
Set	39	0	0	2	2*		-	Left/right/centre
graphic text		intin (0)=0,left 1,centre 2,right						justify. Vertical position
position		intin (2)=3,4,0,1,2,5 respectively						defaults to base (zero)
vst_alignment		*bottom, descent, base, half, ascent, top*						*See pg 4.26*
Set fill	23	0	0	1	1*		-	Set future polygon
interior style		intin (0)=0 to 4 respectively						fill style
vsf_interior		*Hollow, solid, pattern, hatch, user-defined*						
Set fill	24	0	0	1	1*		-	Set pattern or hatch
style		intin (0)=0 solid colour					\	type. No effect if
index			2,1 to 24 patterns				*See pg 4.26*	interior hollow, solid
vsf_style			3,1 to 12 hatch				/	or user defined.
Set fill	25	0	0	1	1*		-	Set future polygon
colour index								fill colour
vsf_color		intin (0)=colour index						
Set fill	104	0	0	1	1*		-	Set on/off
peri visible								fill outline
vsf_perimeter		intin (0)=0_invisible, <>0_visible						
Set user	112	0	0	16*n	0		-	Pattern 16 words/plane
-defined								Bit 15 of word_1 upper
fill pattern		intin (0-15)=1st plane						left bit, Bit 0 last_word
vsf_udpat		intin (16-31)=2nd plane etc.						lower right bit

Notation used for angular specification



* denotes intout() is actual value of intin() used.

Raster operations

Raster operations are the manipuation of rectangular blocks of bits in memory or pixels on screen, the area is defined in memory form definition blocks (MFDB) that consists of:

Offset	Field	Description
$00	Memory pointer	32-bit address of pixel 0,0
$04	Width in pixels	Raster area dimensions
$06	Height in pixels	
$08	Word width	Pixel width/word size
$0A	Format flag	1=standard, 0=device specific
$0C	Memory planes	#planes in raster area
$0E	Reserved	3 reserved words

The raster planes word-bit-pixel relationship follows the format shown in the TOS overview 2.13, the top left hand corner pixel address being 0,0

Colour index table

Pixel	Index	Colour	Pixel	Index	Colour
0000	0	white	1000	9	grey
0001	2	red	1001	10	light red
0010	3	green	1010	11	light green
0011	6	yellow	1011	14	light yellow
0100	4	blue	1100	12	light blue
0101	7	magenta	1101	15	light magenta
0110	5	cyan	1110	13	light cyan
0111	8	low white	1111	1	black

Raster operations perform logical translations of the source to the destination over the original destination pixel area. The required logic operation is passed as an argument in intin(0) as follows:

Mode	Function	Mode	Function
0	D'=0 (all white)	8	D'=NOT [S OR D]
1	D'=S AND D	9	D'=NOT [S XOR D]
2	D'=S AND [NOT D]	10	D'=D INVERT
3	D'=S	11	D'=NOT D
4	D'=[NOT S] AND D	12	D'=S OR [NOT D]
5	D'=D	13	D'=[NOT S] OR D
6	D'=S XOR D	14	D'=NOT [S AND D]
7	D'=S OR D	15	D'=1 (all black)

S=Source
D=Destination
D'=Destination pixel final state

Mode 3=replace
Mode 4=erase
Mode 6=XOR

Raster operations

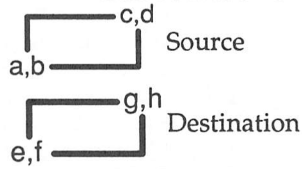
Function	Op $0	Pointpair in $2	Pointpair out $4	Integers in $6	Integers out $8	GDP $A	Device name $C	Comments
Copy raster opaque	109	4	0	1	0		-	Copy rectangular block from source to destination. If source <> dest then source size used
Copy raster transparent	121	4	0	3	0		-	Copy mono block from source to destination If source <> dest then source size used
Transform form	110	0	0	0	0		-	Toggle raster area from standard to device-specific form.
Get pixel	105	1	0	0	2		-	Return pixel value and colour index

Copy raster opaque (*vro_cpyfm*)

ptsin ()=a,b,c,d,e,f,g,h order
intin (0)=logic operation

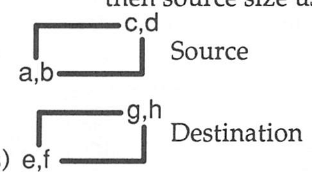
cntrl $E=Address.L of source MFDB

cntrl $12=Address.L of destination MFDB



Copy raster transparent (*vrt_cpyfm*)

ptsin ()=a,b,c,d,e,f,g,h order
intin (0)=write mode
intin (2)=colour for 1's
intin (4)=colour for 0's
cntrl $E=Address.L of source MFDB
cntrl $12=Address.L of destination MFDB
write_mode a replace
b transparent (mask 1's)
c XOR mode
d reverse transparent (mask 0's)



Transform form (*vr_trnfm*)

cntrl $E=Address.L of source MFDB
cntrl $12=Address.L of destination MFDB
The destination block must be verified

Get pixel (*v_get_pixel*)

ptsin (0)=x coordinate intout(0)=pixel value (0 or 1)
ptsin (2)=y coordinate intout(2)=colour index
Background colour is accessible on only some devices.

Input functions

There are two types of input function generally provided by GEM:

'Request and wait' for reply
and 'Request and sample' current status.

Function	Op $0	Pointpair in $2	Pointpair out $4	Integers in $6	Integers out $8	GDP $A	Device name $C	Comments
Set	111	0	0	37	0		-	Redefine cursor pattern
mouse	intin (0)=x coordinate							Bit 15 of word_1 upper
form	intin (2)=y coordinate							left bit of pattern.
	intin (4)=1, reserved							
	intin (6)=mask colour							
	intin (8)=data colour (usually 1)							
	intin ($A-$28)=16 word mask bits pixel.							Data under mask is
vsc_form	intin ($2A-$48)=16 word data bits							saved.
Exchange	118	0	0	0	1		-	Goto user-written
timer interrupt	cntrl $E=Address.L of new routine							interrupt routine
vector	return cntrl $12=Address.L of old routine							on timer tick.
vex_timv	intout(0)=milliseconds per tick							Disable interrupts
Show	122	0	0	1	0		-	Show cursor if
cursor	intin (0)=0, show cursor							'show'='hide' or
	<> 0, show if # of							intin(0)=zero
v_show_c	show calls = # hide calls							
Hide cursor	123	0	0	0	0		-	Hide cursor (default)
v_hide_c	Operates as per 'show cursor'							
Sample	124	0	1	0	1		-	Return button state
mouse	ptsout(0)=x coor \ cursor							0=none 1=left key
button state	ptsout(2)=y coor /							2=right key 3=both keys
vq_mouse	intout(0)=return button state							
Exchange	125	0	0	0	0		-	Go to routine on
button	cntrl $E=Address.L user routine							button state change
change return	cntrl $12=Address.L old routine							Uses D0.W for button
vector								keys as above.
vex_butv	(Save and restore registers)							Disable interrupts

Input functions cont.

Function	Op $0	Pointpair in $2	Pointpair out $4	Integers in $6	Integers out $8	GDP $A	Device name $C	Comments
Exchange mouse movement vector *vex_motv*	126	0	0	0	0		-	Goto routine on mouse movement. Uses D0.W & D1.W to store x & y. Disable interrupts
	cntrl return		$E=Addr.L user routine $12=Addr.L old routine *x an y coords may be changed after being stored in hardware register*					
Exchange cursor change vector *vex_curv*	127	0	0	0	0		-	Goto routine on cursor state change Uses D0.W & D1.W to store x & y. Disable interrupts
	cntrl return		$E=Addr.L user routine $12=Addr.L old routine *routine can be used to draw special cursor.*					
Sample keyboard state information *vq_key_s*	128	0	0	0	1		-	Return current state of Keyboard shift-alt - control keys. Zero bit key up One bit key down.
		intout(0), bit			0, right shift 1, left shift 2, Control 3, Alternate			

Functions calling user written code should not enable interrupts
Registers may need to be restored.

The following GEM VDI functions are not implemented in the Atari ST ROM, but are included for completeness:

Input functions (Not implemented)

Function	Op $0	Pointpair in $2	Pointpair out $4	Integers in $6	Integers out $8	GDP $A	Device name $C	Comments
Set input mode *vsin_mode*	33	0 intin (0)=Logical input device 1=locator, 2=valuator 3=choice, 4=string intin (2)=input mode (1=req, 2=sample)	0	2	1	-		Set i/p mode for device to request or sample. (locator is mouse or cursor keys) Intout shows mode selected.
Input locator, request mode *vrq_locator*	28	1 ptsin (0)=initial x coor ptsin (2)=initial y coor ptsout(0)=final x coor ptsout(2)=final y coor	1	0	1	-	intout(0)= terminate character (LSByte)	Return position of locator device. Screen tracks cursor till terminated by key/button press
Input locator, sample mode (cursor change/ event) *vsm_locator*	28	1 ptsin (0)=init x coor ptsin (2)=init y coor ptsout(0)=new x coor ptsout(2)=new y coor (A tablet or a mouse terminate characters begin at 20H, 32dec) If 2 locators, either may input	1/0	0	0/1	-	intout(0)= terminate character (LSByte)	Return position (NDC) of locator device If set — o/p's new coor — 1 0 key press — 0 1 no i/p — 0 0 key press & new coor — 1 1
Input valuator, request mode *vrq_valuator*	29	0 intin (0)=initial value intout(0)=output value intout(2)=terminator	0	1	2	-		Return value of valuator device. arrow keys, range 1 to 100.
Input valuator, sample mode *vsm_valuator*	29	0 intin (0)=initial value intout(0)=new valuator value intout(2)=keypress, if event occured	0	1	0/2	-		Return value of valuator device. cntrl $8 — event 0 — nothing 1 — val change 2 — key press

Input functions (Not implemented) cont.

Function	Op $0	Pointpair in $2	out $4	Integers in $6	out $8	GDP $A	Device name $C	Comments
Input choice, request mode	30	0	0	1	1		-	Return choice status of device chosen. If invalid return choice number
vrq_choice		intin (0)=Initial choice number (range 1 to device - Atrari ST 10 - dependent maximum) intout(0)=terminator key (1-10) or ASCII code						
Input choice, sample mode	30	0	0	0	1		-	Return choice status of device chosen. intout(0)=0 if unsuccessful.
vsm_choice		intout(0)=0, choice number (1 to 10) cntrl $8=0, nothing occured =1, sampled o'k						
Input string, request mode	31	1	0	2	L		-	Return a string from specified device. Terminate on CR or intout full. If intin(0) is negative pg D4 defines keyboard
vrq_string		ptsin (0)=screen x coor ptsin (2)=screen y coor intin (0)=maximum string length intin (2)=0, no echo 1, echo at ptsin					L=array length	
Input string sample mode	31	1	0	2	0/0		-	Return a string from specified device. Terminate on CR, intout full or no more data. If intin(0) is negative pg D.4 defines keyboard.
vsm_string		ptsin (0)=screen x coordinate ptsin (2)=screen y coordinate intin (0)=max string length (absolute) intin (2)=0, no echo 1, echo at ptsin cntrl(8)=0, no characters returned						

Inquire functions

The inquire functions return the current attribute settings of a specific device.

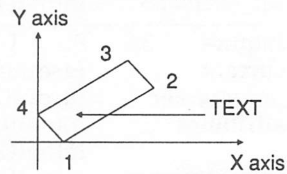
Function	Op	Pointpair in	Pointpair out	Integers in	Integers out	GDP	Device name	Comments
	$0	$2	$4	$6	$8	$A	$C	
Extended inquire function	102	0	6	1	45		-	Return extra device information not in the open workstation call or return open workstation values.

intin (0) =0 open workstation values
=1 extended inquire
intout(0) =0 not screen
=1 separate screen \ Alpha &
=2 common screen / graphics
=3 separate image mem \Common alpha &
=4 common image mem /graphic controller
intout(2) =# pallette background colours (may not be same as $4E(78) v_opnwk
intout(4) =Text effects supported (op 106)
intout(6) =Scaling 0=no 1= yes
intout(8) =Number of planes
intout($A) =Support lookup table 0=no 1=yes
intout($C) =# 16x16 pixel raster operations/sec (Speed factor)
intout($E) =Contour fill capability 0=no 1=yes
intout($10) =Character rotate 0=no, 1=90' steps only, 2=cont.
intout($12) =# writing modes available
intout($14) =Input mode 0=none, 1=request, 2=sample
intout($16) =Text alignment 0=no, 1=yes
intout($18) =Inking ability 0=no, 1=yes (Plotter - colour pen)
intout($1A) =Rubberbanding 0=no, 1=lines, 2=lines & rectangles (Printer - colour ribbon)
intout($1C)=Maximum ptsin -1=no max
intout($1E) =Maximum intin -1=no max
intout($20) =Number of keys on mouse
intout($22) =Styles for wide lines 0=no, 1=yes
intout($24) =Writing modes for wide lines
intout($26-$58) reserved, contains zero words
vq_extnd ptsout(0-$16) reserved, contains zero words

Inquire function cont.

Function	Op $0	Pointpair in $2	Pointpair out $4	Integers in $6	Integers out $8	GDP $A	Device name $C	Comments
Inquire colour representation *vq_color*	26	0	0	2	4		-	Return value of colour index in RGB units Intout(0)=-1 'out of range'
		intin (0)=request colour index intin (2)=0_return colour value request 1_return colour values available intout(0)=colour index intout(2)=red intensity (0-1000) intout(4)=green intensity (0-1000) intout(6)=blue intensity (0-1000)						
Inquire current polyline attributes *vql_attributes*	35	0	1	0	5		-	Return all attributes that affect polylines
		ptsout(0)=line width ptsout(2)=zero intout(0)=line type intout(2)=line colour intout(4)=write mode				intout(6)=Start end style intout(8)=Finish end style		
Inquire current polymarker attributes *vqm_attributes*	36	0	1	0	3		-	Return all attributes that affect polymarkers
		ptsout(0)=width ptsout(2)=height intout(0)=marker type intout(2)=marker colour intout(4)=writing mode						
Inquire current fill area attributes *vqf_attributes*	37	0	0	0	5		-	Return all attributes that affect fill areas
		intout(0)=interior style (Op #23) intout(2)=colour intout(4)=fill style (Op #24) intout(6)=writing mode (Pg 4.13) intout(8)=fill perimeter status						

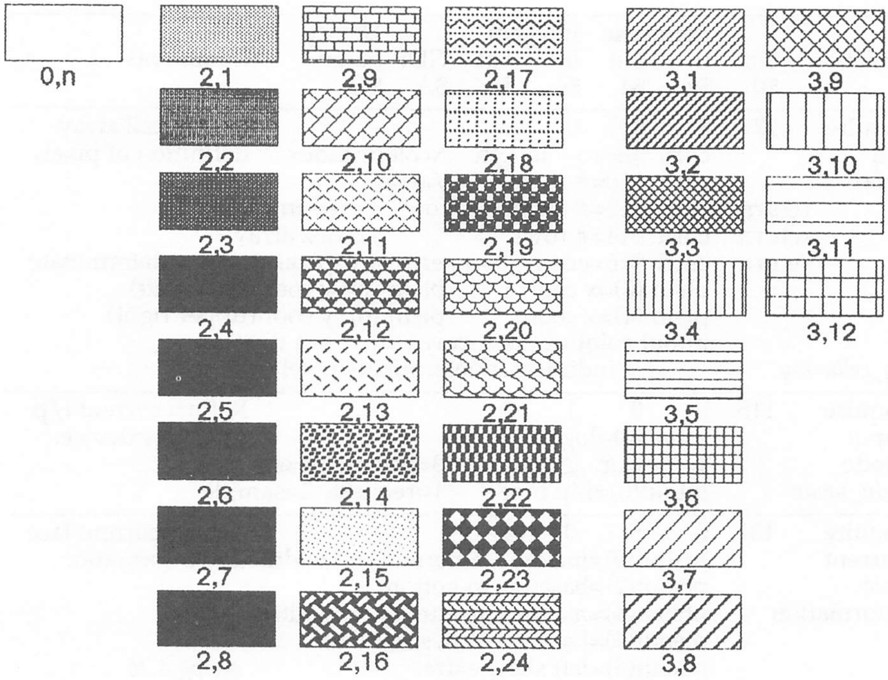
Inquire function cont.

Function	Op $0	Pointpair in $2	Pointpair out $4	Integers in $6	Integers out $8	GDP $A	Device name $C	Comments
Inquire current graphic text attributes	38	0	2	0	6		-	Return all attributes that affect graphic text.
vqt_attributes		ptsout(0)=character width ptsout(2)=character height ptsout(4)=cell width ptsout(6)=cell height intout(0)=current graphic text face intout(2)=current graphic text colour intout(4)=baseline angular rotation (0-3600) intout(6)=horizontal alignment intout(8)=vertical alignment intout($A)=writing mode (op #32 Pg 4.13)						
Inquire text extent	116	0	4	n	0		-	Return a rectangle that encloses the specified string.
vqt_extent		intin() = # words in text (low bytes) ptsout(0)=x coordinate \ bottom ptsout(2)=y coordinate / left ptsout(4)=x coordinate \ bottom ptsout(6)=y coordinate / right ptsout(8)=x coordinate \ top ptsout($A)=y coordinate / right ptsout($C)=x coordinate \ top ptsout($E)=y coordinate / left						
Inquire character cell width	117	0	3	1	1		-	Return the character cell width for specified character in current text face. Rotation and special affects ignored.
vqt_width		intin (0)=character value in ADE form ptsout(0)=cell width ptsout(2)=0 ptsout(4)=left char delta ptsout(6)=0 ptsout(8)=right char delta ptsout($A)=0 intout(0)=ADE of inquire value -1 if invalid character						
Inquire face name and index	130	0	0	1	33		-	Return 32 character face descriptor (text).
vqt_name		intin (0)=element number intout(0)=ID number intout(2-$40) 32 ADE code (lowbytes)					First 16 characters face Second 16 style and weight	

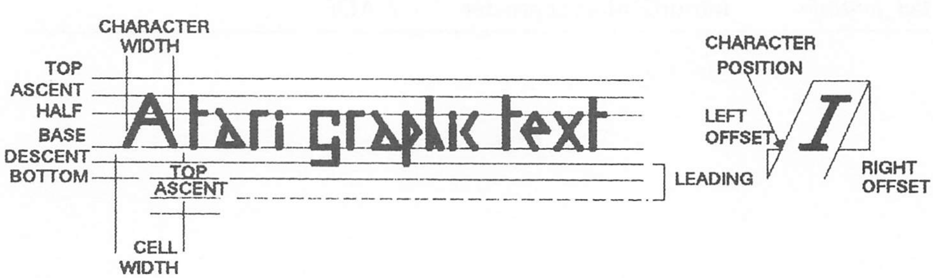
Inquire function cont.

Function	Op $0	Pointpair in $2	Pointpair out $4	Integers in $6	Integers out $8	GDP $A	Device name $C	Comments
Inquire	27	2	0	0	n		-	Return cell array
cell		cntrl $E=row length \colour index						definition of pixels
array		cntrl $10=# rows /array						
	return	cntrl $12=# elements/row \used in colour						
	return	cntrl $14=# rows /index array						
	return	cntrl $16=errors, 0=no errors, 1=pixel colour indeterminate						
		ptsin (0)=x coor ptsin (2)=y coor (lower left)						
		ptsin (4)=x coor ptsin (6)=y coor (upper right)						
		intout colour index array (1 row at a time)						
vq_cellarray		-1 indicates indeterminate pixel colour						
Inquire	115	0	0	1	1		-	Return current i/p
input		intin (0)=logical device						mode for device.
mode		1=locator 2=valuator 3=choice, 4=string						
vqin_mode		intout(0)=i/p mode 1=request, 2=sample						
Inquire	131	0	5	0	2		-	Return current face
current		ptsout(0)=maximum normal cell width						size information.
face		ptsout(2)=baseline to bottom						
information		ptsout(4)=maximum extra skew width						
		ptsout(6)=baseline to descent line						
		ptsout(8)=left skew extra						*see pg 4.26*
		ptsout($A)=baseline to half distance						
		ptsout($C)=right skew extra						
		ptsout($E)=baseline to ascent						ADE= ASCII
		ptsout($10)=zero						decimal
		ptsout($12)=baseline to top distance						equivalent
		intout(0)=first character \ in face						
vqt_fontinfo		intout(2)=last character / ADE						

VDI Style Index patterns



VDI Text alignment



Escape functions

The escape functions allow the programmer to access special device functions.

Function	Op $0	Pointpair in $2	Pointpair out $4	Integers in $6	Integers out $8	GDP $A	Device name $C	Comments
Escape (General format)	5	-	-	-	-	id	-	
Inquire addressable alpha character cells *vq_chcells*	5	0 intout(0)=# rows intout(2)=# columns	0	0 -1 no cursor addressing	2	1	-	Get number of vertical rows and horizontal columns for alpha cursor.
Exit alpha mode *v_exit_cur*	5	0	0	0	0	2	-	Enter graphics mode and exit alphanumeric mode.
Enter alpha mode *v_enter_cur*	5	0 *cursor set to upper left of character cell*	0	0	0	3	-	Exit graphics mode and enter alphanumeric mode.
Alpha cursor up *v_curup*	5	0 *Do nothing if at top*	0	0	0	4	-	Move alpha cursor up one row.
Alpha cursor down *v_curdown*	5	0 *Do nothing if at bottom*	0	0	0	5	-	Move alpha cursor down one row
Alpha cursor right *v_curright*	5	0 *Do nothing if at right edge*	0	0	0	6	-	Move alpha cursor right one column.
Alpha cursor left *v_curleft*	5	0 *Do nothing if at left edge*	0	0	0	7	-	Move alpha cursor left one column.
Home alpha cursor *v_curhome*	5	0 *Home usually top left*	0	0	0	8	-	Move cursor to home position.

Escape functions cont.

Function	Op $0	Pointpair in $2	Pointpair out $4	Integers in $6	Integers out $8	GDP $A	Device name $C	Comments
Erase to end of alpha screen *v_eeos*	5	0	0	0	0	9	-	Erase from current cursor position to end of screen.
		No cursor position change						
Erase to end of alpha text line *v_eeol*	5	0	0	0	0	10	-	Erase from current cursor position to end of line.
		No cursor position change						
Direct alpha cursor address *vs_curaddress*	5	0	0	2	0	11	-	Place cursor at the specified row and column.
		intin (0)=row (1 to n) intin (2)=column (1 to n)						
Output cursor addressable alpha text *v_curtext*	5	0	0	n	0	12	-	Display a string of alpha text from current cursor position.
		n=number of characters in string intin ()=text string in ADE						
Reverse video on *v_rvon*	5	0	0	0	0	13	-	Display following text in reverse video.
Reverse video off *v_rvoff*	5	0	0	0	0	14	-	Display following text in normal video.
Inquire current alpha cursor address *vq_curaddress*	5	0	0	0	2	15	-	Return current alpha cursor position.
		intout(0)=row# (minimum one) intout(2)=column# (minimum one)						

Escape functions cont.

Function	Op $0	Pointpair in $2	Pointpair out $4	Integers in $6	Integers out $8	GDP $A	Device name $C	Comments
Inquire tablet status *vq_tabstatus*	5	0	0	0	1	16	-	Return availability status of tablet, mouse, joystick etc.
		intout(0)=0, not available -1, available						
Hard copy *v_hardcopy*	5	0	0	0	0	17	-	Copy screen to specific printer.
Place graphic cursor at location *v_dspcursor*	5	2	0	0	0	18	-	Place crosshair on screen.
		ptsin (0)=x coordinate ptsin (2)=y coordinate						
			The positioning function is not accurate					
Remove last graphic cursor *v_rmcursor*	5	0	0	0	0	19	-	

Escape functions (Not implemented)

The following Escape functions are available when loaded via the expanded GDOS file, they are included for completeness; as is a discussion on VDI bit image file format.

Function	Op $0	Pointpair in $2	Pointpair out $4	Integers in $6	Integers out $8	GDP $A	Device name $C	Comments
Form advance *v_form_adv*	5	0	0	0	0	20	-	Pages printer but keeps screen display
Output window	5	2	0	0	0	21	-	Copies specified window to printer Adjacent pictures may not join.
v_output_window		ptsin (0)=x coordinate \window ptsin (2)=y coordinate / corner ptsin (4)=x coordinate \opposite ptsin (6)=y coordinate / corner						
Clear display list *v_clear_disp_lis*	5	0	0	0	0	22	-	Empty the VDI printer buffer
Output bit image file	5	0-2	0	L+2	0	23	-	Enables printer to process bit image file. Page placement by specifying or by default
v_bit_image		cntrl (2) =0, get coordinates from file =1, upper left specified =2, user specified coords ptsin (0)=x upper left \ coordinates ptsin (2)=y upper left I if ptsin (4)=x lower right I specified ptsin (6)=y lower right / intin (0)=Aspect ratio flag 0_ignore, 1_pixel ratio, 2_page ratio intin (2)=Scaling 0_uniform, 1_x and y intin (4)=First character of file name (length L) intin (2n+2)=Last (nth) character file name						Pixel ratio provides for printing circles
Select palette	5	0	0	1	1	60	-	Allows IBM compatable palette selection.
vs_palette		intin (0)=0_use red, green, brown =1, use cyan, magenta, white intout(0)=palette selected						

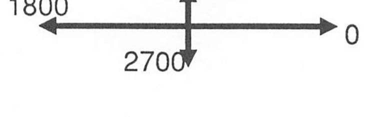
Escape functions (Not implemented)

Function	Op $0	Pointpair in $2	Pointpair out $4	Integers in $6	Integers out $8	GDP $A	Device name $C	Comments
Inquire palette film types *vqp_films*	5	0 intout 5 sets of 25 ADE byte descriptor strings	0	0	125	91	-	Return film driver
Inquire palette driver state *vqp_state*	5	0 intout(0)=port # 0=first comms port intout(2)=film number (0 to s) intout(4)=lightness control(-3 +3) 1/3 f_stop steps intout(6)=0_noninterlace, 1_interlace intout(8)=planes(1 to 4) intout($0A-$28)=colour codes for 16 colours.	0	0	20	92	-	Return film driver status block. (ADE format)
Set palette driver state *vsp_state*	5	0 intout(0)=port # 0=first comms port intout(2)=film number (0 to 4) intout(4)=lightness control(-3 +3) 1/3 f stop steps intout(6)=0_noninterlace, 1_interlace intout($8-$26)=color codes for 16 colors	0	0	20	93	-	Set film driver status block.
Save palette driver state *vsp_save*	5	0	0	0	0	94	-	Save current driver state to disk
Supress palette messages *vsp_message*	5	0	0	0	0	95	-	Supress user prompts and error messages

Escape functions (Not implemented) cont.

Function	Op	Pointpair in	Pointpair out	Integers in	Integers out	GDP	Device name	Comments
	$0	$2	$4	$6	$8	$A	$C	
Palette error inquire	5	0	0	0	1	96	-	Return error code
		intout(0) =0, no error						
		=1, open dark slide for print film						
		=2, no port at specified location						
		=3, palette not found at port specified						
		=4, video cable disconnected						
		=5, OS does not allow memory allocation						
		=6, not enough memory for buffer						
		=7, memory not deallocated						
		=8, driver file not found						
		=9, driver file incorrect type						
vqp_error		=10, prompt user to process print film						
Update metafile extents	5	2	0	0	0	98	-	Update file header enabling application to get indication of a minimum window.
		ptsin (0)=min x value \						
		ptsin (2)=min y value I bounding						
		ptsin (4)=max x value I rectangle						
v_meta_extents		ptsin (6)=max y value /						
Write metafile item	5	n	0	1	0	99	-	Intin and ptsin data written to metafile with a sub opcode >100 see pages 4.35 to 4.36
		ptsin user defined data						
		intin user defined data						
		intin(0)=sub-opcode						
v_write_meta		Sub opcodes 0 to 100 reserved						
Change GEM VDI filename	5	0	0	1	0	100	-	Rename metafile from GEMFILE.GEM to ..... ,GEM
		intin ()=path/filename						
vm_filename		upto 74 characters						

Notation used for angular specification



Bit image file format

Header
raw pixel data

There are two parts to the bit image file, a 16 word header, and a block of codified raw data.

File header

$00	0	upper left x	Bit image	
$02	2	upper left y	Bit image	
$04	4	lower right x	Bit image	
$06	6	lower right y	Bit image	
$08	8	page width		Source device
$0A	10	page height		Source device
$0C	12	pixel width	in microns	Source device
$0E	14	pixel height	in microns	Source device
$10	16	bits per pixel		
$12 to $20	18 to 32	Zero, reserved		

Raw data formats

The four methods of data coding may be mixed in any desired combination within a file.

Run length encoding (default)

$00	<128bytes	Run length
$01	<256	colour index data

Use a two byte subheader to define the data, which must be less than 128. The pixels may line wrap.

Extended run length encoding

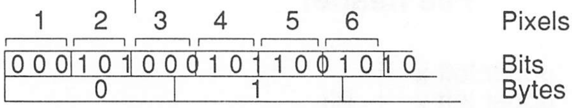
$00	-1	Op code
$01	<128bytes	extended run length
$02	<256	colour index data

To cater for pixel runs >127, the extended run includes a count of 128 providing a range of 128 to 255 pixels. The pixel line may wrap.

Raster encoding

$00	-2	Op code
$01		# pixels in stream
$02		packed colour indices

Raster encoding packs color indices into bytes in the following format:



Use either:

	1	(black and white)
	3	(four colour)
or	4	(sixteen colour)

bits per pixels format (offset $10 in the header).

Raster run encoding

$00	-3	Op code
$01	<256	repeat count
$02		# pixels in stream
$03		packed colour indices

Raster run encoding permits the efficient coding of repeated pixel patterns. It is in the same form as raster encoding but includes a repeat count in the header.

Metafile Sub opcodes

The Metafile functions are not implemented on the Atari ST, but are included for completeness of the GEM operating environment. Installation of the file Meta.sys will provide the functions, if you can get it?

Output page (Not implemented)

There are two reserved GEM output codes for configuring the output page:

Physical page size, which defines the output area and Coordinate window, specifying the coordinate system used in the metafile.

Function	Op $0	Pointpair in $2	Pointpair out $4	Integers in $6	Integers out $8	GDP $A	Device name $C	Comments
Physical page size	5	0	0	3	0	99	-	Sub opcode 0
		intin (0)=sub opcode 0 intin (2)=page width \ tenths of intin (4)=page height / millimeters						
Coordinate window	5	0	0	5	0	99	-	Sub opcode 1
		intin (0)=sub opcode 1 intin (2)=x coordinate \ lower left corner intin (4)=y coordinate / of window intin (6)=x coordinate \ upper right corner intin (8)=y coordinate / of window						

Metafile sub opcodes (Not implemented) cont.

GEM Draw

There are a number of reserved GEM output codes used by GEM draw:

Group: Start and end enclose a set of primitives.

Draw area type primitive: Start and end indicate that enclosed functions are subject to the area type primitive block that follows the start function.

Attribute shadow: On and off indicate enclosed primitives are ignored as they are used to draw a drop shadow for the first primitive following 'off'.

Set no line style: Subsequent area type primitives are not outlined.

Function	Op $0	Pointpair in $2	Pointpair out $4	Integers in $6	Integers out $8	GDP $A	Device name $C	Comments
Start group	5	0	0	1	0	99	-	Bracket a set of primitives as a group for a
		intin (0)=sub opcode 10						
End group	5	0	0	1	0	99	-	GEM DRAW application
		intin (0)=sub opcode 11						
Start draw area type primitive	5	0	0	1	0	99	-	Use the vertices of the first primitive (except text)
		intin (0)=sub opcode 80						
End draw area type primitive	5	0	0	1	0	99	-	to define a GEM DRAW area type primitive.
		intin (0)=sub opcode 81						
Set attribute shadow on	5	0	0	1	0	99	-	Only draw a drop shadow on the first primitive, ignore
		intin (0)=sub opcode 50						
Set attribute shadow off	5	0	0	1	0	99	-	remaining shadow primitives until next off sub-opcode.
		intin (0)=sub opcode 51						
Set no line style	5	0	0	1	0	99	-	Subsequent area type primitives not to be outlined
		intin (0)=sub opcode 49						

Chapter 5

GEM AES

GEM AES function calls

A set of application environment services (AES) function calls are available to the programmer, they consist of routines that make extensive use of the VDI function calls, and a dispatcher that provides a limited multitasking capability. The GEM VDI calls generally manage graphic outputs to peripheral devices, screen, printer etc. whereas GEM AES calls usually handle graphics input. The calls are grouped into eleven libraries that provide a variety of facilities:

Application library: controls the access to the other AES libraries.
Event library: responds to user inputs from mouse, keyboard or elapsed time.
Menu library: text options.
Object library: data collections that describes a displayed object, eg a box, an icon.
Form library: a means of obtaining information by the use of a list of questions.
Graphics library: a set of routines for manipulating the outline of a rectangular box.
Scrap library: routines that allow the interchange of data between applications.
File selector library: user selection of a file from a displayed directory or a file via a filename and path.
Window library: manages up to eight GEM AES windows.
Resource library: provides the interface between the application and its data and files.
Shell library: enables an application to invoke another application and to keep track of the calling command and tail.

Within GEM AES there is a limited multitasking environment created by the dispatcher; a routine that activates processes sequentially simulating a multitasking environment. The dispatcher maintains two process queues, the 'ready' for processing list and the 'not ready' list, where processes are typically waiting for a user input, an input from another process or a specified time delay. Each 'ready' process is allowed a predefined period of CPU time before being returned to the end of the 'ready' queue, the environment is saved, the queues updated and control passed to the next item in the 'ready' queue.

Access to the AES functions is through an extended BDOS call and the AES parameter block (six longword pointers to the tables; cntrl, global array, input and output attributes and input and output addresses). The AES parameter block, control table and global array have the following formats:

AES parameter block

$00	Control table pointer	control
$04	Global array	global
$08	I/P attribute table pointer	int_in
$0C	O/P attribute table pointer	int_out
$10	I/P add1ress table pointer	addr_in
$14	O/P address table pointer	addr_out
$18		

Control table

Offset	Contents	
$00	Op code	
$02	Length of i/p coordinate table	Table length in words
$04	Length of o/p coordinate table	
$06	Length of i/p address table	Table length in longwords
$08	Length of o/p address table	
$0A		

Global array

Offset	Field		Description
$00	version	0	GEM AES version identification word
$02	count	2	Max # concurrent applications supported
$04	id	4	Unique application identifier
$06	private	6	Longword user data as required
$0A	ptree	10	Pointer to resource load address tree, initially zero
$0E	reserved	14	Zero, address of memory allocations
$12	reserved	18	Zero, memory length, screen colours
$16	reserved	22	Zero
$1A	reserved	26	Zero
$1E		30	

The minimum size of an input table is one word, which must contain zero if no parameters are being passed.

Typical AES application call

A typical sequence of calls for an application might be:

a) Initialize and free unused memory, set up GEM parameter blocks and tables APPL_INIT [10] must be called first).

b) Open (virtual) workstation and get the screen resolution, .

c) Load a resource file, applicable to the current screen resolution and number of colours available, into memory.

d) Get the address of specific resource objects and store them in memory.

e) Get the address of the resource menu bar and call 'display menu'.

f) Find the size and location of window WIND_GET, identify window as a desktop (handle=0), get the windows width/height (get_field=4) and draw icons.

g) Wait for a user action, a keystroke, mouse button click or movement, GEM AES message or a specified time delay as either individual occurences or combined events.

h) Select from the menu, normally by moving the mouse to the menu bar. The message buffer is updated automatically and the process waiting for the input is moved to the 'ready list' and progressed to the next stage.

i) Reserve and then box a space to hold the dialog which is tested for an exit. On exit, any highlighting should be deselected.

j) Further user selections, could entail keyboard entries, icon selection etc.

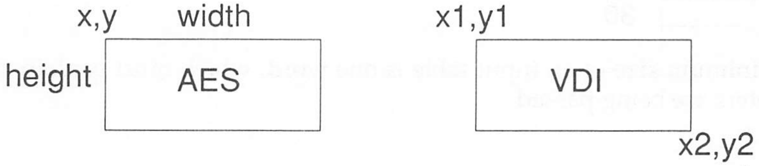
...program...

One of the first operations of an application is to create an active window, which may be sized, redrawn, updated and finally closed.

Handles and coordinates

Note that VDI calls use 'device' handles and AES 'window' handles - further confusion may arise in the use of 'file' handles - they are all different, beware !!!!

The coordinate systems differ also !



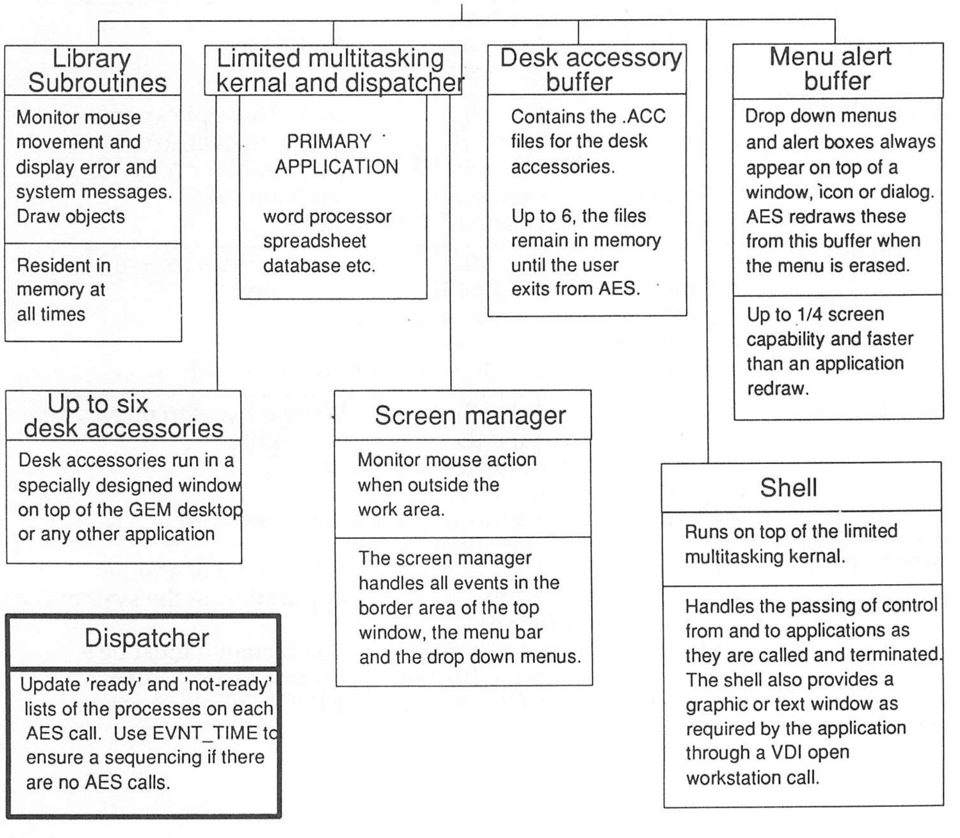
AES Parameter block sizes

The numbers of parameters required by the various functions are detailed in the tabular format:

Function	Op	Integers in	Integers out	Addresses in	Addresses out	Comments
	$0	$2	$4	$6	$8	

The table contains details of the parameter inputs and outputs; note that a zero indicates a block filled with a zero.

GEM AES components



The GEM AES libraries

Application library

The application library functions initialize memory and data structures, terminate processes, communicate with other processes and record/replay user actions.

		Integers		Addresses		
Function	Op	in	out	in	out	Comments
	$0	$2	$4	$6	$8	
APPL_INIT	10	0	1	0	0	Initialize application and generate data structures prior to other AES function calls.
	int_out(0)=application_ID -1 failure, >=0 o'k placed in global array MUST call before any other AES function call					
APPL_READ	11	2	1	1	0	Read n bytes from message pipe.
	int_in(0)=the 'from' pipe ID int_in(2)=number of bytes to read (n) int_out(0)=0_error, >0_o'k addr_in(0)=buffer address of the data to be read					
APPL_WRITE	12	2	1	1	0	Write n bytes to message pipe.
	int_in(0)=the 'to' pipe ID int_in(2)=number of bytes to write (n) int_out(0)=0_error, >0_o'k addr_in(0)=buffer address of the data to be written					
APPL_FIND	13	0	1	1	0	Find the ID of another application in the system.
	int_out(0)=application ID =-1, not found addr_in(0)=address of a null terminated filename Handles SCRENMGR, CONTROL and EMULATOR may exist					The filename must be 8 characters long, blank fill.

Application library cont.

Function	Op $0	Integers in $2	Integers out $4	Addresses in $6	Addresses out $8	Comments
APPL_TPLAY	14	2	1	1	0	Replay a series of user actions.
*	int_in(0)=number of actions int_in(2)=speed(1-10000) int_out(0)=one (always) addr_in(0)=address of memory holding recording					speed 50=half 100=full 200=twice
APPL_TRECORD	15	1	1	1	0	Record a series of actions (see record format below)
* (6 byte record word-longword)	int_in(0)=number of actions int_out(0)=number recorded addr_in(0)=address in memory to store records					
APPL_EXIT	19	0	1	0	0	Let application library clean up environment when the appliction has finshed making calls
	int_out(0)=0_error >0_o'k					

APPL_TRECORD record format:

First word	low longword high
0=timer	elapsed time ms
1=button	0=up,1=down/#clicks
2=mouse	x pixels / y pixels
3=keyboard	char/keyboard_status

It is possible to terminate an application with an illegal call

* Note that functions APPL_TPLAY and APPL_TRECORD do not work on early ST operating systems (pre 'NEW TOS')

Event library

The event library routines monitor multiple and individual user inputs providing efficient polling of the clock, keyboard, mouse and message pipes.

Function	Op $0	Integers in $2	Integers out $4	Addresses in $6	Addresses out $8	Comments
EVNT_KEY	20	0	1	0	0	Return standard keyboard code (Appendix D)
	int_out(0)=keycode press					
EVNT_BUTTON *	21	3	5	0	0	Return mouse status on button event
	int_in(0)=wait a #clicks int_in(2)=buttmask int_in(4)=button state int_out(0)=number clicks >=1 int_out(2)=x coor \ on int_out(4)=y coor / event int_out(6)=button state int_out(8)=keystate					(see mask table below) Button state bits 0=up,1=down

Mask	buttmask	Keystate
bit 0	button left	right_shift
bit 1	2nd button	left_shift
bit 2	3rd button	Ctrl
bit 3	up to 16	Alt

Button state bits 0=up,1=down

Function	Op $0	Integers in $2	Integers out $4	Addresses in $6	Addresses out $8	Comments
EVNT_MOUSE	22	5	5	0	0	Return mouse status on leaving specified area. Return flag =1, on area exit =0, on area entry
	int_in(0)=return flag int_in(2)=x coor \ area int_in(4)=y coor I position int_in(6)=width I pixel int_in(8)=height /coordinate int_out(0)=Reserved (=1) int_out(2)=x coor \ on int_out(4)=y coor / event int_out(6)=button state int_out(8)=keystate					(see mask table below) Button state bits 0=up,1=down

Mask	Buttmask	Keystate
bit 0	button left	right_shift
bit 1	2nd button	left_shift
bit 2	3rd button	Ctrl
bit 3	up to 16	Alt

Button state bits 0=up,1=down

Event library cont.

Function	Op $0	Integers in $2	Integers out $4	Addresses in $6	Addresses out $8	Comments
EVNT_MESAG	23	0	1	1	0	Flag message, up to eight words, in message pipe.
	int_out(0)=Reserved (=1)					
EVNT_TIMER	24	2	1	0	0	Flag application that a specified length of time has past.
	int_in(0)=low \ longword int_in(2)=high / time ms int_out(0)=Reserved (=1)					

EVNT_MESAG:

16 \ addr_in(0)=message type ID →
byte | addr_in(2)=ID of sender
buffer/ addr_in(4)=0 or length of message over 16 bytes
addr_in(6-14)=extra words

ID	extra words	Message function
10	GH	Selected menu
20	ABCDE	Redraw window
21	A	Move work area to top
22	A	Close window
23	A	Toggle full size window
24	AF	Scroll/page window
25	AJ	Move window horizontally
26	AJ	Move window vertically
27	ABCDE	Re-size window
28	ABCDE	Move window
29	A	Set new top window
40	I	Desk_accessory open mess
41	I	Desk_accessory close mess
50		ct_update
51		ct_move
52		ct_newtop

Addr_in() extra word entries

A=windw_handl G=Object index title
B=x coor \ H=Object index item
C=y coor | active I=menu item ID
D=width | area (op#35 call return)
E=height / J=top/left 0-1000
F=Page 0_up 1_down \Mouse
4_left 5_right | arrow
. Row 2_up 3_down | click
. Column 6_left 7_right /message

Messages entered FIFO, where message length >16 byte use APPL_READ.
Reading kills a message.

Event library cont.

Function	Op $0	Integers in $2	Integers out $4	Addresses in $6	Addresses out $8	Comments
EVNT_MULTI *	25	16	7	1	0	Application waiting on one or more events.

int_in(0)=Standard key code
int_in(2)=number of clicks
int_in(4)=buttmask — Button state 0_up, 1_down
int_in(6)=button state
int_in(8)=flags \Mouse
int_in($A)=x coor | 1
int_in($C)=y coor | area
int_in($E)=width | event
int_in($10)=height /
int_in($12)=flags \Mouse
int_in($14)=x coor | 2
int_in($16)=y coor | area
int_in($18)=width | event
int_in($1A)=height /
int_in($1C)=low \ longword
int_in($1E)=high / time ms
int_out(0)=flag
int_out(2)=x coordinate
int_out(4)=y coordinate
int_out(6)=button state
int_out(8)=keystate
int_out($A)=keycode press — Retn standard keyboard code
int_out($C)=number clicks >=1 — # of button events/time
addr_in(0)=16 byte buffer (see EVNT_MESAG op 23)

Mask	buttmask	flags
bit 0	button left	Keyboard
bit 1	2nd button	Button
bit 2	3rd button	Mouse 1
bit 3		Mouse 2
bit 4		Message
bit 5		Timer

Flags show the type of event the application is waiting for or occurred

Keystate	
bit 0	right shift
bit 1	left shift
bit 2	Ctrl
bit 3	Alt

Function	Op $0	Integers in $2	Integers out $4	Addresses in $6	Addresses out $8	Comments
EVNT_DCLICK	26	2	1	0	0	Get/set double click speed

int_in(0)=slow 0 to 4 fast
int_in(2)=0_get, 1_set
int_out(0)=speed 1_new 0_old

* The 'NEW TOS' processes requests for single clicks correctly

Event Library cont.

Most applications will wait for a combination of events using the EVNT_MULTI call. When a required event occurs, the application will be moved from the 'not ready' list to the 'ready' list by the dispatcher, respond to the event and then return to the 'not ready' list to wait for the next event in the EVNT_MULTI sequence.

Be careful in using the right hand Atari mouse button if writing portable code, not all versions of GEM have two buttons.

Keystroke selection

Some menu items support keystoke selection through the EVNT_MULTI call. On receipt of the specified key selection, the application should call MENU_TNORMAL to highlight the title to enable the user to see the selection actually made; deselect highlighting when the application has finished with the menu. The 16-bit keyboard event codes are given in Appendix D; use GRAF_MKSTATE to decode Control, Alternate and left and right Shift keys.

Icon selection

The bits for the required icon selection sequence are set by the application in the EVNT_MULTI call, button up or down state and a predefined number of clicks within a given space of time. On the event taking place, a bit value for the mouse and keyboard state is returned; the application needs to also call GRAF_MKSTATE to obtain the mouse's x and y coordinates and then make an OBJC_FIND call passing the x and y coordinates and the address of the window, desktop or application object tree containing it's icons.

If OBJC_FIND reports the mouse covering an icon, its state should be changed to selected.

If the mouse does not cover an icon, the application should assume the user will select a group of icons by drawing an expanding rectangle around them. Call GRAF_MKSTATE to ensure the button is still depressed and then call GRAF_RUBBERBOX to provide the extent of the box when the button is released. The application should look for icons within the rectangle and change each icon from normal to selected via OBJC_CHANGE calls.

Menu library

The menu library routines provide the user with a textural menu choice from within an application, placing the mouse cursor over an enabled item and clicking the mouse button to make the selection.

Function	Op $0	Integers in $2	Integers out $4	Addresses in $6	Addresses out $8	Comments
MENU_BAR	30	1	1	1	0	Display/erase menu bar
	int_in(0)=menu bar 0_erase, 1_draw int_out(0)=error 0_yes, +ve_no addr_in(0)=Object tree address that forms this menu					
MENU_ICHECK	31	2	1	1	0	Display/erase menu item check mark.
	int_in(0)=menu item ID int_in(2)=0_clear, 1_display (check mark) int_out(0)=error 0_yes, +ve_no addr_in(0)=Object tree address that forms this menu					
MENU_IENABLE	32	2	1	1	0	Disable/enable menu item
	int_in(0)=menu item ID int_in(2)=0_disabled, 1_enabled (light/dark text) int_out(0)=error 0_yes, +ve_no addr_in(0)=Object tree address that forms this menu					
MENU_TNORMAL	33	2	1	1	0	Display menu title in reverse video.
	int_in(0)=menu item ID int_in(2)=0_reverse, 1_normal video int_out(0)=error 0_yes, +ve_no addr_in(0)=Object tree address that forms this menu					
MENU_TEXT	34	1	1	2	0	Change text of menu item. reverse video.
	int_in(0)=menu item ID int_out(0)=error 0_yes, +ve_no addr_in(0)=Address of new text string for this item addr_in(4)=Object tree address that forms this menu					
MENU_REGISTER	35	1	1	1	0	Place desk accessory menu item string on desk menu and return acc's menu ID
	int_in(0)=Desk accessory process ID int_out(0)=menu item ID (0-5) addr_in(0)=address of desk accessory menu text string.					

Menu library cont.

To display a menu bar, call the resource function RSRC_GADDR with the menu bar's (object) details to obtain the long address of the object tree root, call MENU_BAR with the address and set the routine to draw.

Menu bar control

The AES screen manager controls all user interaction with the menu bar in the following manner:

The user touches an item in the menu bar using the mouse cursor

The screen manager receives a message that the cursor has entered the menu bar and enters the 'ready list'. It determines which item in the title bar the cursor touched, saves the screen under and displays the 'titles' menu; highlighting menu items as the cursor passes over them.

The application is held in the 'not ready' list while the screen manager has initiated open menus. When the user clicks the mouse on a menu item, the screen manager sends details of the object tree of the menu selected to the primary application's message buffer.

The dispatcher checks the 'not ready' list for the application process waiting for the message and moves it to the 'ready' list.

The EVNT_MULTI call returns a flag of the events that occurred, which may be read by the application and any action deemed appropriate by the application taken.

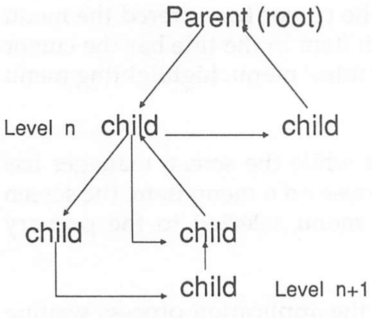
When the action is complete, the menu title is de-highlighted by the application making a MENU_TNORMAL call.

Object library

An object, described by a collection of data in a linked list (object tree), can be created, deleted, edited, drawn on the screen, and the object's position on the screen found, using the object library routines.

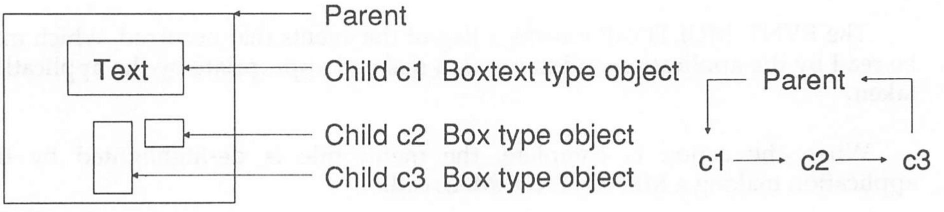
Object tree

An object comprises of a parent and perhaps a number of different levels of children, who always reside within the parents display space. The tree is created by making seperate calls to the OBJC_ADD routine for each child or loaded from disk using RSRC_LOAD.



Each child points to a brother in a chain, if it has one? The last one points back to its parent

Different objects may be created by only using parts of the tree.



The object library uses a number of additional tables, as well as the parameter block, control table and global arrays, to describe objects. The tables are accessed via the resource library routines and are as follows:

Additional object library word tables

(bracketed items are longwords)

offset	Object	Tedinfo	Iconblk	Bitblk	Applblk	Parmblk
(0)	Nextchild	\Text	\Mask	\Image	\Code	\Tree
(2)	Firstchild	/string	/string	/pointer	/pointer	/pointer
(4)	Lastchild	\Template	\Data	W_array	\Loparm	Objindex
(6)	Otype	/string	/string	H_pixel	/Hiparm	Oldst
(8)	Oflag	\Vchar	\Text	x_source	-	Newst
($A)	OState	/pointer	/string	y_source	-	x_coor
($C)	\OSpec	Font	Icon_c	fg_colour	-	y_coor
($D)	/	Reserved	x_cpos	0	-	W_pixel
($10)	x_coor	Justify	y_cpos	-	-	H_pixel
($12)	y_coor	Colour	x_ipos	-	-	x_cpos
($14)	Width	Reserved	y_ipos	-	-	y_cpos
($16)	Height	Borderthk	i_wide	-	-	W_cpxl
($18)		textlength	i_height			H_cpxl
($1A)		tmplength	x_tpos			Loparm
($1C)	(x & y		y_tpos			Hiparm
($1E)	relative to		t_wide			0
($20)	parent		t_height			
($22)	or screen)		0			

Prefixes
O=object
c=character
i=icon -
t=text -

The tables, filled by the object library routines, are used in performing various functions:

Object: Provides data that describes each object, its tree relationship to other objects and its location relative to parent (screen if the root). The predefined object values on next page.
Tedinfo: Allows object types Text (21), Boxtext (22), Ftext (29) and Fboxtext (30) to be edited, using the object table spec pointer to point to the Tedinfo table. The 'NEW TOS' allows the underscore to be used in the text string.
Iconblk: Is used to hold icon (31) data definitions. Object type Icon points here with its spec pointer.
Bitblk: Object type Image (23) uses this to draw bit images like cursors and icons.
Applblk: Is used to locate and call an application defined routine that draws and or changes an object. The object type Progdef (24) spec pointer points here.
Parmblk: Storage of data used by the application defined routine above (applblk) and pointed to by the code pointer.

Object libraries cont.

Routines which edit, create and draw data describing objects that appear on the screen: boxes, characters, icons etc.

There are some predefined values for the table entries:

Graphic types of objects (Otype)	Ospec points to	Object flags (Oflag)	Object colours (color)
20=Box	-	0x0000=none	0=white
21=Text	Tedinfo	0x0001=selectable	1=black
22=Boxtext	Tedinfo	0x0002=default	2=red
23=Image	Bitblk	0x0004=exit	3=green
24=Progdef	Applblk	0x0008=editable	4=blue
25=Invisbox		0x0010=rbutton	5=cyan
26=Button	Nstrg	0x0020=lastobj	6=yellow
27=Boxchar		0x0040=touchexit	7=magenta
28=String	Nstrg	0x0080=hidetree	8=white
29=Ftext	Tedinfo	0x0100=indirect	9=black
30=Fboxtext	Tedinfo		10=lred
31=Icon	Iconblk		11=lgreen
32=Title	Nstrg		12=lblue
			13=lcyan
			14=lyellow
			15=lmagenta

Font types

3=system font
5=small font

Colour fields

15–12	11–8	7	6–4	3–0
border colour	text colour	0_trans 1_replace	fill type	fill colour

Object states (Ostate)

0x0000=normal
0x0001=selected
0x0002=crossed
0x0004=checked
0x0008=disabled
0x0010=outlined
0x0020=shadowed

Ospec 32-bit word/byte values			
	Loword	Highword	
		Lobyte	hibyte
Box	colour	0	0
Invisbox	colour	borderthk	0
Boxchar	colour	0	character

Editable text	
field definitions	justification
0=edstart	(Justfy)
1=edinit	0=left justified
2=edchar	1=right justified
3=edend	2=centered

Borderthk	
0	none
1 to 128	inside
-1 to -127	outside
	(in pixels)

9	only digits 0 to 9	Allowable valid characters (Vchar pointer)
A	only uppercase A to Z and space	
a	upper and lowercase A to Z and space	
N	0 to 9, uppercase A to Z and space	
n	0 to 9, upper and lowercase and space	
F	all valid DOS filename characters, plus ? * :	
P	all valid DOS pathname characters, plus \ : ? *	
p	all valid DOS pathname characters, plus \ :	
X	anything	

Object library cont.

Function	Op $0	Integers in $2	Integers out $4	Addresses in $6	Addresses out $8	Comments
OBJC_ADD	40	2	1	1	0	Add an object to an object tree.
	int_in(0)=Parent ID int_in(2)=Child ID (item to add)					
OBJC_DELETE	41	1	1	1	0	Delete an object from an object tree.
	int_in(0)=Object to delete int_out(0)=error 0_yes, +ve_no addr_in(0)=Object tree address with object in it					
OBJC_DRAW	42	6	1	1	0	Draw an object in an object tree.
	int_in(0)=start object int_in(2)=draw 0_object only, nth_level int_in(4)=x coordinate \\ int_in(6)=y coordinate	Clip int_in(8)=width	rectangle int_in($A)=height / int_out(0)=error 0_yes, +ve_no addr_in(0)=Object tree address with object in it					
OBJC_FIND	43	4	1	1	0	Find an object under the mouse form.
	int_in(0)=search start object int_in(2)=levels of search int_in(4)=x coordinate \\ mouse int_in(6)=y coordinate / location int_out(0)=-1_no object, 0 to n # of object in tree addr_in(0)=Object tree address of search start object					
OBJC_OFFSET	44	1	3	1	0	Find objects screen relative x and y coordinates
	int_in(0)=object to locate int_out(0)=error 0_yes, +ve_no int_out(2)=x coordinate \\ relative int_out(4)=y coordinate / to screen addr_in(0)=Object tree address with int_in(0) in it					

Object library   cont.

Function	Op $0	Integers in $2	Integers out $4	Addresses in $6	Addresses out $8	Comments
OBJC_ORDER	45	2	1	1	0	Reorder an object within a list int_in(0)=Object to be moved int_in(2)=new position (0_bottom level, 1_next etc. to -1 top) int_out(0)=error 0_yes, +ve_no addr_in(0)=Object tree address with int_in(0) in it
OBJC_EDIT	46	4	2	1	0	Edit object text. int_in(0)=text object to be edited int_in(2)=user input character int_in(4)=next character index in text string int_in(6)=0_reserved =1_format string using text and template strings =2_validate against Tedinfo valid_char, update and display. =3_turn off text cursor int_out(0)=error 0_yes, +ve_no int_out(2)=next character index after operation addr_in(0)=Object tree address of object with text in it
OBJC_CHANGE	47	8	1	1	0	Changes an objects state value. int_in(0)=object to be changed int_in(2)=zero, reserved int_in(4)=x coordinate \\ int_in(6)=y coordinate I Clip int_in(8)=width I rectangle int_in($A)=height / int_in($C)=object state new value int_in($E)=redraw 0_no, 1_yes int_out(0)=error 0_yes, +ve_no addr_in(0)=Object tree address

To display an icon, calculate the desktop windows work area using a WIND_GET call and use OBJC_DRAW to draw the icon in the work area. The icons position within the window is held by the 'Iconblk' structure.

Form library

A set of routines that enable the user to reply to a list of questions, either by checking off boxes or entering text.

Function	Op $0	Integers in $2	Integers out $4	Addresses in $6	Addresses out $8	Comments
FORM_DO	50	1	1	1	0	Monitor users interaction with a form.
	int_in(0)=object number int_out(0)=object number that caused the exit addr_in(0)=object tree address					
FORM_DIAL	51	9	1	0	0	Reserve or free dialog box screen area.
	int_in(0)=flag int_in(2)=x coordinate \ int_in(4)=y coordinate I small int_in(6)=width I box int_in(8)=height / int_in($A)=x coordinate \ int_in($C)=y coordinate I large int_in($E)=width I box int_in($10)=height / int_out(0)=error 0_yes, 1_no					Flag: 0=reserve screen space for dialog box 1=draw expanding box 2=draw shrinking box 3=free screen space
FORM_ALERT	52	1	1	1	0	Display an alert.
	int_in(0)=exit button int_out(0)=chosen exit addr_in(0)=address of alert string					0=no default exit 1=first exit button 2=2nd exit button etc.
FORM_ERROR	53	1	1	0	0	Display an error box
	int_in(0)=DOS error code int_out(0)=exit button code (as above)					
FORM_CENTER	54	0	5	1	0	Centre a dialog box on the screen
	int_out(0)=one, reserved int_out(2)=x coordinate \ Of int_out(4)=y coordinate I centered int_out(6)=width I object int_out(8)=height / tree addr_in(0)=dialog object tree address					

The forms library routines enable the user to respond to a typical printed style of form on the screen in a question and answer mode without tying up the applications resources. The forms library also provides a consistent application/user response format. The forms have three optional types of user response, they are:

Check a single box,
Check a combination of boxes,
Provide a typed response;

These may be used any number of times in any combination. Finally the user exits typically via an "o'k" or "cancel" button.

Taking a dialog as an example:

To display a dialog, which will appear in the centre of the screen, call resource function RSRC_GADDR to get the address of the dialogs object tree. Call FORM_DIAL to reserve screen space and then call OBJC_DRAW to draw the dialog.

The application should call FORM_DO to monitor user interaction with the dialog box. Where user changes have been made, the application may use OBJC_CHANGE to reset initial values, in particular dehighlight selected buttons. It may also be necessary to save some changes made to dialogs.

To exit from the dialog, call FORM_DIAL to release the screen space, the application which should be in an EVNT_MULTI wait state can redraw the screen using an OBJC_DRAW call.

A nicer display may be achieved if FORM_DIAL is used to draw expanding and shrinking boxes on start up and finish of the dialog sequence.

Edit keys

Keys have certain specified meanings for editting the text fields of forms and dialog boxes:

Left and right arrow: Move left or right within the field.

Down arrow and tab: Move to first free space of the next field.

Up arrow: Move to first free space of previous field.

Delete: Delete character following cursor without moving cursor.

Backspace: Delete character to the left of the cursor, move cursor and following text one space left.

Return: End edit and terminate if either "o'k" or "cancel" type buttons are default objects, otherwise ignore.

Escape: Clear all characters from the field.

Form library cont.

Alerts

Alerts, which are used by GEM AES to handle error conditions, contain one of three pictorial designs; note icon, wait icon and the stop icon, and up to a maximum of 5 lines of 30 character width text (each line being seperated by the "|" *bar symbol*) and up to 3 exit buttons, each containing up to 20 characters of text.

A special case alert is the error box which reports errors in TOS terminology (appendix I).

A typical set of object structures for an alert box with some textural information and "o'k" and "cancel" buttons might be:

More than 30 characters/line could crash early TOS systems. 'NEW TOS' truncates the line and remains solid.

	Object structure element	Box	"help" Text	"o'k" Boxtext	"cancel" Boxtext	Comments Pntr to next obj.
0	nextchild	-1	2	3	0	<---- -1 root
2	firstchild	1	-1	-1	-1	\ -1 lowest
4	lastchild	3	-1	-1	-1	/ level
6	Otype	20	21	22	22	
8	Oflag	0	0	5	27	See page 5.16
$A	Ostate	0	0	0	0	for details
$C	Ospec	00020007L	0L	0L	0L	
$10	x-coor	90 Relative	86	374	374	
$12	y_coor	150 to	16	18	50	
$14	width	454 screen	272	64	54	
$16	height	98	64	16	16	
			[Relative to parent (Box)]			

The o'k button takes *Oflag* attributes selectable and exit.
The cancel button takes *Oflag* attributes selectable, default, exit and lastobj.

Offset	Tedinfo structure element	Box	"help" Text	"o'k" Boxtext	"cancel" Boxtext
0	Text string	-	help	o'k	cancel
4	Tmplate string	-	0	0	0
8	Vchar pointer	-	0	0	0
$C	Font	-	3	3	3
$D	Reserved	-	0	0	0
$10	Justify	-	0_left	2_center	2_center
$12	Colour	-	00020000L	00020000L	00020000L
$14	Reserved	-	0	0	0
$16	Borderthk	-	0	-2	-2
$18	textlength	-	0	0	0
$1A	tmplength	-	0	0	0

The form library follows the tree from root to children in displaying the form objects.

Graphics library

The graphics library routines enable the programmer to manipulate the rectangular outline of a box.

Function	Op $0	Integers in $2	Integers out $4	Addresses in $6	Addresses out $8	Comments
GRAF_RUBBERBOX	70	4	3	0	0	Draw a box that expands and contracts from a fixed point as the mouse moves.
	int_in(0)=x coordinate \ of					
	int_in(2)=y coordinate / box					
	int_in(4)=minimum pixel width					
	int_in(6)=minimum pixel height					
	int_out(0)=error 0_yes, +ve_no					
	int_out(2)=width \ when button					
	int_out(4)=height / last released					
GRAF_DRAGBOX	71	8	3	0	0	Move a box and keep the mouse pointer at the same position inside the box.
	int_in(0)=width \ Of					
	int_in(2)=height I box					
	int_in(4)=x coordinate I being					
	int_in(6)=y coordinate / dragged					Height and width in pixels
	int_in(8)=x coordinate \ Boundary					
	int_in($A)=y coordinate I rectangle					
	int_in($C)=width I					
	int_in($E)=height /					
	int_out(0)=error 0_yes, +ve_no					
	int_out(2)=x coordinate \ When button					
	int_out(4)=y coordinate / released					
GRAF_MOVEBOX	72	6	1	0	0	Draw a moving box
	int_in(0)=width					
	int_in(2)=height					
	int_in(4)=x coordinate \ Initial					
	int_in(6)=y coordinate / position					Height and width in pixels
	int_in(8)=x coordinate \ Final					
	int_in($A)=y coordinate / position					
	int_out(0)=error 0_yes, +ve_no					

Graphics library cont.

Function	Op $0	Integers in $2	Integers out $4	Addresses in $6	Addresses out $8	Comments
GRAF_GROWBOX	73	8	1	0	0	Draw an expanding box outline
	int_in(0)=x coordinate \					
	int_in(2)=y coordinate I Initial					
	int_in(4)=width I position					
	int_in(6)=height /					
	int_in(8)=x coordinate \					
	int_in($A)=y coordinate I Final					Height and width
	int_in($C)=width I position					in pixels
	int_in($E)=height /					
	int_out(0)=error 0_yes, +ve_no					
GRAF_SHRINKBOX	74	8	1	0	0	Draw a shrinking box outline
	int_in(0)=x coordinate \					
	int_in(2)=y coordinate I Final					
	int_in(4)=width I position					
	int_in(6)=height /					
	int_in(8)=x coordinate \					
	int_in($A)=y coordinate I Initial					Height and width
	int_in($C)=width I position					in pixels
	int_in($E)=height /					
	int_out(0)=error 0_yes, +ve_no					
GRAF_WATCHBOX	75	4	1	1	0	Track the mouse pointer and button inside and outside the box.
	int_in(0)=reserved					
	int_in(2)=object tree index					
	int_in(4)=in the box \ object					
	int_in(6)=out of box / state					
	int_out(0)=0_outside, 1_inside the box					
	addr_in(0)=address object tree containing box					
GRAF_SLIDEBOX	76	3	1	1	0	Keep sliding box inside parent box.
	int_in(0)=parent index					
	int_in(2)=object index (slider)					
	int_in(4)=motion 0_horizontal, 1_vertical					
	int_out(0)=0_left/top to 1000_right/bottom					
	addr_in(0)=Address of object tree containing slider & parent					

Graphics library cont.

Function	Op $0	Integers in $2	Integers out $4	Addresses in $6	Addresses out $8	Comments
GRAF_HANDLE	77	0	5	0	0	Return GEM VDI handle for open screen workstation.
	int_out(0)=VDI handle					
	int_out(2)=width			\ character cell		
	int_out(4)=height			/ system font		
	int_out(6)=width			\ box for		
	int_out(8)=height			/ system font		
GRAF_MOUSE	78	1	1	1	0	Permit application to change predefined mouse.
	int_in(0)	=0_arrow				
		=1_text cursor (vertical bar)				
		=2_bee (hourglass-IBM GEM)				
		=3_hand with pointing finger				
		=4_flat hand, extended fingers				
		=5_thin cross hair				
		=6_thick cross hair				
		=7_outline cross hair				
		=255_mouse form stored in addr_in(0)				
		=256_hide mouse form				
		=257_show mouse form				
	int_out(0)=error 0_yes, +ve_no					(VDI op 111)
	addr_in(0)=35 word buffer for mouse form definition block					
GRAF_MKSTATE	79	0	5	0	0	Return current mouse location button and keyboard state.
	int_out(0)=1, reserved					
	int_out(2)=x coor			\mouse		
	int_out(4)=y coor			/location		
	int_out(6)=Butonstate			\ 0_up		
	int_out(8)=keystate			/1_down		

Mask	Buttonstate	keystate
bit 1	butt left	right_shift
bit 2	2nd button	left_shift
bit 3	3rd button	Ctrl
bit 4		Alt

GEM AES provides the graphic routines to manipulate the rectangular outline of a box which are based on GEM VDI routines. Graphics applications should use GEM VDI directly for graphic output to avoid any loss in performance through the AES overhead.

Scrap library

The scrap library consists of routines that manage the interchange of information between applications. Data is either deleted or copied from the source to the clipboard (disk file named scrap), which only holds one document; and then pasted (copied) from the clipboard (disk) to the target application.

Function	Op $0	Integers in $2	Integers out $4	Addresses in $6	Addresses out $8	Comments
SCRP_READ	80	0	1	1	0	Read the current scrap directory on the clipboard
	int_out(0)=error 0_yes +ve_no addr_in(0)=buffer address into which scrap directory is copied.					
SCRP_WRITE	81	0	1	1	0	Write new scrap directory to clipboard. (Cut & Copy)
	int_out(0)=error 0_yes +ve_no addr_in(0)=buffer address from which scrap directory is copied to clipboard.					

The scrap data is held on disk in a file named scrap, the extension identifies the type of data:

.txt	ASCII text string
.dif	Spreadsheet data
.gem	Metafile - GEM VDI type graphic images
.img	Bit image - GEM VDI standard form

Applications access the data via GEM BDOS file system calls to:

Search
Create a file
Open a file
Read a file
Write a file
Close a file
Delete a file *and*
Get file size.

File selector library

The file selector library routine enables the programmer to select file from a displayed directory or to type in a filename and path.

Function	Op	Integers in	Integers out	Addresses in	Addresses out	Comments
	$0	$2	$4	$6	$8	
FSEL_INPUT	90	0	2	2	0	Display file selector box and monitor user interaction with it.

int_out(0)=error 0_yes
+ve_no
int_out(2)=exit button 0_cancel
1_o'k
addr_in(0)=buffer address of initial directory specification
(If not updated holds last dir spec user selected)
addr_in(4)=buffer address of initial selection displayed
in file selector dialog box.
(If not updated holds last selection)

This routine displays a file directory dialog box, the user either selects a filename directly from the directory list using a mouse or types in a filename to create a new file.

The file directory dialog box displays the name of the current directory path, a selection field, a scrollable directory listing and two buttons to terminate the routine. The user interacts with the dialog box in the standard manner, changing the directory being displayed, selecting an item from the directory list or typing in a user selection and then exiting via the "o'k" or "cancel" button.

The file selector library returns the filename selected or entered, in the buffer at addr_in(4), the directory path of the file in the buffer at addr_in(0) and whether the selection is o'k or to be cancelled. The application acts upon the information as required.

Entering the underscore into the directory string may cause older versions of the TOS to crash the ST.

Window Library

The window library routines permit the creation, opening, closing and deletion of windows to a maximum of eight active windows. The window parameters can be recovered or set, the window under the mouse cursor found, a flag set to indicate that a window is being updated and the size of a window determined.

Function	Op $0	Integers in $2	Integers out $4	Addresses in $6	Addresses out $8	Comments
WIND_CREATE	100	5	1	0	0	Allocate window size including border & return window handle. Window open must set size < = to that
	int_in(0)=window parts int_in(2)=x coordinate \ Of int_in(4)=y coordinate I full int_in(6)=width sizeallocated. int_in(8)=height/window int_out(0)=window handle (-ve, no windows available)					
WIND_OPEN	101	5	1	0	0	Open a window at it's initial size and location, - not necessarily it's full size.
	int_in(0)=window handle int_in(2)=x coor \ int_in(4)=y coor I Window int_in(6)=width I initial int_in(8)=height / size int_out(0)=error 0_yes, +ve_no					
WIND_CLOSE	102	1	1	0	0	Close window, does not deallocate the window or handle.
	int_in(0)=window handle int_out(0)=error 0_yes, +ve_no					
WIND_DELETE	103	1	1	0	0	Free space occupied by window and handle.
	int_in(0)=window handle int_out(0)=error 0_yes, +ve_no					

Window parts (bit representation)

bit 0	Name (name and title bar)
bit 1	Close (close box)
bit 2	Full (full box)
bit 3	Move (move box)
bit 4	Info (information line)
bit 5	Size (size box)
bit 6	Uparrow (up arrow)
bit 7	Dnarrow (down arrow)
bit 8	Vslide (vertical slider)
bit 9	Lfarrow (left arrow)
bit 10	Rtarrow (right arrow)
bit 11	Hslide (horizontal slider)

Window library cont.

Function	Op $0	Integers in $2	Integers out $4	Addresses in $6	Addresses out $8	Comments
WIND_GET	104	2	5	0	0	Get window data specified field
	int_in(0)=window handle int_in(2)=get_field int_out(0)=error 0_yes, +ve_no int_out(2)= \ Data int_out(4)= | specified int_out(6)= | by Get int_out(8)= / field					
WIND_SET	105	6	1	0	0	Set displayed window parameters
	int_in(0)=window handle int_in(2)=set_field int_in(4)= \ Data int_in(6)= | specified int_in(8)= | by Set int_in($A)= / field int_out(0)=error 0_yes, +ve_no					

Get field	(2)	int_out() (4)	(6)	(8)	Associated function
4	x coor	y coor	width	height	Window work area
5	x coor	y coor	width	height	current \ size including
6	x coor	y coor	width	height	previous / border title
7	x coor	y coor	width	height	maximum poss window size
8	1-1000	1 left, 1000 right			relative horiz slider position
9	1-1000	1 top, 1000 bottom			relative vertical slider position
10	handle				top window handle
11	x coor	y coor	width	height	first rectangle in window list
12	x coor	y coor	width	height	next rectangle in window list
13	reserved				
15	1-1000	(-1 default minimum sq box)			relative horizontal slider size
16	1-1000	(-1 default minimum sq box)			relative vertical slider size
17					screen

Set field	(4)	int_in() (6)	(8)	($A)	Associated function
1	Parts		see pg 5.30		window components
2	Name pointer				address of name strng
3	Info pointer				address info line string
5	x coor	y coor	width	height	current window size
8	1-1000	1 left, 1000 right			relative horiz slider position
9	1-1000	1 top, 1000 bottom			relative vertical slider pos
10	handle				top window handle
14	lo-word	hi-word	strtobj		GEM desktop to draw
15	1-1000	(-1 default minimum sq box)			relative horiz slider size
16	1-1000	(-1 default minimum sq box)			relative vert slider size
17					screen

Window library cont.

```
-----------------------------------------------------------------------------------------
                   Integers      Addresses
Function      Op   in    out     in    out       Comments
              $0   $2    $4      $6    $8
-----------------------------------------------------------------------------------------
WIND_FIND     106  2     1       0     0         Find window under mouse
              int_in(0)=x coordinate \ mouse
              int_in(2)=y coordinate / position
              int_out(0)=window handle
-----------------------------------------------------------------------------------------
WIND_UPDATE   107  1     1       0     0         Flag about to update window
              int_in(0)=update 0_end, 1_begin (window locking)
                               2_end, 3_begin (usual mouse control)
              int_out(0)=error 0_yes, +ve_no
                    Do not alter size while update proceeding
-----------------------------------------------------------------------------------------
WIND_CALC     108  6     5       0     0         Ret window bordr/work area
              int_in(0)=area 0_work->-border, 1_border->-work
              int_in(2)=parts   (see pg 5.30 -same as window create)
              int_in(4)=x coordinate \
              int_in(6)=y coordinate | border/work   To calculate work
              int_in(8)=width        | area values   area, input border
              int_in($A)=height      /               area values.
              int_out(0)=error 0_yes, +ve_no         To calculate border
              int_out(2)=x coor      \               area input work
              int_out(4)=y coor      | work/border   area values.
              int_out(6)=width       | area values
              int_out(8)=height      /
-----------------------------------------------------------------------------------------
```

Note that AES windows do not use the same coordinates as VDI

AES x, y, width, height
VDI x1,y1,x2,y2

The desktop window is always present in the AES environment and supports a maximum of eight windows at a time. The AES screen manager handles all the user interaction outside the border area and the sizing, dragging and scrolling actions requested from within the border. The contents of the border area determine which of these functions are available.

Each user action sends a message through the message pipe to the applications 'EVNT_MESAG' buffer where it is stacked on a first in-first out basis. In order to perform the requested function, the message must first be read and then the window management action may be either programmed to be performed or ignored. The assembler GEM program (Appendix L) demonstrates the effect of creating a window with the facilities, but not incorporating any code to handle the screen managers requests. The example also shows the parts handled by the screen manager, moving sliders, rubber boxing windows etc.

The application handles all activities within the window work area.

To create a window, the application calls WIND_CREATE defining the type (only those facilities that the application supports) and position of the window required, returning the window handle to be used in all subsequent actions on the window. An application call to WIND_CALC may be used to return the size of the window work area. A call to WIND_OPEN will get AES to draw the window's border area on the screen and send a message to the application to draw the windows work area.

WIND_SET calls are used to set the size and location of the vertical and horizontal sliders. If the window is resized, the application must decide if the preview rubber box size is valid. If not, the application may resize to the nearest valid size or display a warning dialog message. If valid, the application must issue a WIND_SET call to change the window size. A reduced window size does not require the work area to be redrawn, but if larger, GEM AES will send a message to the application to redraw the windows work area (EVNT_MESAG ID=20).

The application is responsible for redrawing and updating the visible parts of its windows, which it divides into the smallest number of non-overlapping rectangles, found by a series of WIND_GET calls. Initially to the 'first' rectangle in the window list and subsequently to the 'next' rectangle until the returned width and height are both zero. Note that if the window is not covered, say by the control panel, that there will be only one rectangle.

Before updating the window, the application makes a WIND_UPDATE call to freeze all other rectangle lists and to prevent menus and alerts from being displayed during the update. On completion of the update, another WIND_UPDATE call permits further change to the display and rectangle lists.

To redraw the window work area, each rectangle in the rectangle list is compared with the update rectangle in turn, and any common portion redrawn.

To make a window active, the application (which must include an EVNT_MULTI call that includes a mouse button event) will receive a 'button pressed' message from the screen manager - the event occurred outside the active window and is therefore detected by the screen manager. The application calls WIND_FIND using the mouse x and y coordinates to obtain the handle of the window under the mouse. If it is the desktop, handle 0, a rubber box is drawn in expectation of the user selecting desktop icons. If the handle is that of an inactive window, the screen manager sends a message (EVNT_MESAG ID=29) to request the window be brought to the top. The application calls WIND_SET to comply.

To close a window via the windows border or menu command, the screen manager sends a message to the application which should make a WIND_CLOSE call; a WIND_DELETE call will then free the handle.

Resource library

The resource library provides the interface between the application and its file resources, trees, objects, icons and pictures etc. providing the means to port an application to a different environment by simply changing the resource file data.

Function	Op $0	Integers in $2	Integers out $4	Addresses in $6	Addresses out $8	Comments
RSRC_LOAD	110	0	1	1	0	Allocate memory and load a resource file into memory.
	int_out(0)=error 0_yes, +ve_no addr_in(0)=ASCII filename string address					
RSRC_FREE	111	0	1	0	0	Free the memory space allocated by rsrc_load.
	int_out(0)=error 0_yes, +ve_no					
RSRC_GADDR	112	2	1	0	1	Get address of data structure (object) loaded in memory.
	int_in(0)=type int_in(2)=structure index int_out(0)=error 0_yes, +ve_no addr_out(0)=address of specified structure					
Only functions with object types R_TREE and R_FRSTR						
RSRC_SADDR	113	2	1	1	0	Store the address of a data structure in memory.
	int_in(0)=type int_in(2)=structure location index int_out(0)=error 0_yes, +ve_no addr_in(0)=address of the data structure					
RSRC_OBFIX	114	1	1	1	0	Convert objects location and size from character coordinates
	int_in(0)=object index int_out(0)=1, reserved to pixels. addr_in(0)=object tree address					

Type (of data structure)

0	tree	8	text string	(tedinfo)
1	object	9	template string	(tedinfo)
2	tedinfo	10	valid chars	(tedinfo)
3	icon blk	11	mask string	(iconblk)
4	bitblk	12	data string	(iconblk)
5	string	13	text string	(iconblk)
6	imagedata	14	image pointer	(bitblk)
7	obspec	15	pointer address of free string	
		16	pointer address of free image	

To isolate an application from device, user and country specific data and provide program portability; GEM AES supports resource files that contain the variable parts of the application code.

To use a resource file, the application makes a RSRC_LOAD call to find the total file size in bytes, allocate the memory space for the resource file and update the file for screen resolution. The pointers to the object and the tree structures are also updated and the address of the tree array stored in the applications 'Global array'.

Access to the object library table pointers may be through RSRC_GADDR and RSRC_SADDR calls. The tree index may be accessed via FORM_DO and MENU_BAR calls among others.

RSRC_FREE deallocates the resource file memory and zeroes the tree array address in the Global array.

Resource files are generated using the Atari ST icon edit and resource utility program.

Shell library

The shell library routines enable one application to call another and keep track of command and command tails.

Function	Op $0	Integers in $2	Integers out $4	Addresses in $6	Addresses out $8	Comments
SHEL_READ	120	0	1	2	0	Let application identify command that called it in format of GEM BDOS func 75
	int_out(0)=error 0_yes, +ve_no addr_in(0)=buffer address of command string addr_in(4)=buffer address of command tail					
SHEL_WRITE	121	3	1	2	0	Inform GEM which, if any, application to run or exit GEM AES.
	int_in(0)=0_exit, 1_run int_in(2)=graphic 0_no, 1_yes int_in(4)=GEM application 0_no, 1_yes int_out(0)=error 0_yes, +ve_no addr_in(0)=new executable command file address addr_in(4)=command tail address of next program					
SHEL_GET	122	1	1	1	0	Read data from the GEMDOS environmental string buffer
	int_in(0)=length int_out(0)=error code addr_in(0)=buffer address					
SHEL_PUT	123	1	1	1	0	Write data to the GEMDOS environmental string buffer
	int_in(0)=length int_out(0)=error code addr_in(0)=buffer address					
SHEL_FIND	124	0	1	1	0	Search for filename and return full DOS specification
	int_out(0)=error 0_yes, +ve_no addr_in(0)=address 80 character buffer minimum i/p search filename o/p full DOS filename					
SHEL_ENVRN	125	0	1	2	0	Search for environment parameter and store address of following byte
	int_out(0)=1, reserved addr_in(0)=pointer to byte storage address addr_in(4)=search parameter string					

The shell library routines use a single buffer containing the command and command tail that invoked the current application. A typical sequence to call and run another application might be:

Call SHEL_WRITE with a command, command tail and the home directory addresses; also define graphic/character or GEM/Not GEM application. On completion of the current application, the shell library will start the requested application.

Exit from GEM AES by making a SHEL_WRITE call with the int_in(0) parameter set to zero.

Chapter 6

Intelligent keyboard commands

Intelligent keyboard commands

General

The Atari ST keyboard unit contains a 1MHz HD 6301 8-bit microprocessor with some on-board memory storage to maintain the time of day clock etc. The keyboard and its peripheral items, joystick and mouse may be initialized, monitored for position or status and the time of day clock read or set.

The intelligent keyboard (ikbd) communicates with the main processor over a 7.8Kbit/s bidirectional serial link, sending individual keycodes or receiving instructions and returning status codes in packets of data through a pair of addresses, one for transmit and one for receive.

Characters can be read from the keyboard input queue in main system RAM, it is filled by an interrupt routine that transfers data from the ikbd to memory automatically. Characters are written to the keyboard by placing the character code in the keyboard data register after bit 1 of the keyboard command/status register is set.

Keycodes

The keyboard transmits make and break keycodes for each key press and release. Appendix D provides the codes for the individual keys, bit 7 being set for break and cleared for make.

Data packets

To differentiate the keyboard codes from the data packets transmitted to and from the ikbd to the main processor; the codes #$F6 to #$FF precede status information packets. The packets provide reports of mouse position and status, time of day and joystick status. The packets may be stored and used later, with the header byte removed, to restore the condition of the ikbd.

Ikbd commands

Input op code string	Output databyte string	Function
#$80 #$01		**Reset.** Return keyboard to power-up status without affecting clock. A break 200ms also causes a reset
#$07 00000aaa		**Set mouse button action.** default %00000000 bit 0 1_press \ Mouse position report on bit 1 1_release / (only relevant in absolute mode) bit 2 0_button, 1_key type operation.
#$08		**Set mouse relative position reporting (default).** Position packet generated asynchronously when threshold exceeded
#$09 X msb X lsb Y msb Y lsb		**Set mouse absolute positioning.** \ X maximum — Resets ikbd x and y coordinates. / — The x and y values in \ Y maximum — scaled mouse 'clicks' do / — not wrap, ignore <0 & >max
#$0A X step Y step		**Set mouse keycode mode.** Return mouse motion in cursor keycodes instead of relative or absolute motion records.
#$0B X level Y level		**Set mouse threshold.** Before move event is generated Default value 1 (Relative motion only)
#$0C X Y		**Set mouse scale.** Set X and Y scale factors for absolute mouse positioning - 'clicks' per coordinate change.
#$0D	#$F7 0000xxxx X msb X lsb Y msb Y lsb	**Interrogate mouse position** bit 0 right button down since last interrogation bit 1 right button up \ bit 2 left button down | since last bit 3 left button up / report \ X coor / — Only valid in absolute \ Y coor — mode, regardless of mouse / — button action setting.

Ikbd commands cont.

Input op code string	Output databyte string	Function	
#$0E		**Load mouse position.**	
#$00		filler (null)	Enables the user
X msb \		X coor \ in scaled	to preset the
X lsb /		I coordinate	internal absolute
Y msb \		Y coor / system	mouse position
Y lsb /			
#$0F		**Set Y = 0 at bottom**	Set for relative and
#$10		**Set Y = 0 at top (default)**	absolute mouse motions.
#$11		**Resume.**	Resume sending data back.
#$12		**Disable mouse.**	Stop mouse event reports. Resume on any mouse mode command.
#$13		**Pause output.**	Stop sending further reports, queue them in a (short) buffer.
#$14		**Set joystick event reporting (default)**	
#$15		**Set joystick interrogation mode.**	Disable joystick event reporting, use interrogate to sense joystick state.
#$16		**Joystick interrogation.**	Return a record of current joystick state.
#$17		**Set joystick monitoring.**	(sample rate of .01s)
rate	000000ab	[packets of two bytes]	
		bit 0 Joystick 1 \ Fire	Set ikbd to monitor
		bit 1 Joystick 0 / button	serial command line
	aaaabbbb		and joystick, update
		bits 0-3 Joystick 1 \ Position	time of day clock
		bits 4-7 Joystick 0 / only	
#$18	cccccccc packed 8-bits/byte	**Set fire button monitoring**	Set ikbd to monitor serial command line and fire button of joystick 1, update time of day clock.

Ikbd commands cont.

Input op code string	Output databyte string	Function
#$19		**Set joystick keycode mode** (Joystick 0)
Rx		(provides a velocity autorepeat facility)
Ry		initial rate final rate
Tx		Tn Tn Tn Vn Vn — If Rn zero
Ty		|----- |----- |----- |----- |----- |----- |-- — only Vn
Vx		|<-------Rn------> | times in .1s — matters.
Vy		length of time — Directions x & y set individually.
#$1A		**Disable joysticks.** Disable any joystick event generation. Valid joystick commands resumes generation
#$1B		**Set time of day clock**
YY		year \ (86, 87, 88 etc) — An invalid
MM		month | — BCD digit
DD		day | Data sent in packed — does not
hh		hour | BCD format. — alter the
mm		minute | — existing
ss		second / — value.
#$1C	#$FC	**Interrogate time of day clock**
	YY	year \
	MM	month |
	DD	day | Data in returned in
	hh	hour | packed BCD format.
	mm	minute |
	ss	second /
#$20		**Memory load**
Addr msb		\ ikbd controller address
Addr lsb		/ to be loaded.
Numb		Number of data bytes (0-128)
(data)		

Ikbd commands cont.

Input op code string	Output databyte string	Function		
#$21	#$F6	**Memory read**		Status header
Addr msb	#$20	\ ikbd controller		memory access
Addr lsb	data	/ address to be read.	\	
	data		| 6 bytes of	
	data		| data starting	
	data		| at address	
	data		| (addr)	
	data		/	
#$22		**Controller execute**	Allows main system	
Addr msb		\ ikbd controller	to call an ikbd	
Addr lsb		/ subroutine address	subroutine.	

Input op code string	Output databyte string									
OR 80		**Status inquiries.**								Get 8 byte data packet. Strip
with the	#$F6									packet header and return to
set	mode	#$7	#$8	#$9	#$A	#$0B	#$0C			recover
command	param 1	Code	0	Xmaxh	Xstep	Xthresh	Xtick			status
	param 2	0	0	Xmaxl	Ystep	Ythresh	Ytick			
	param 3	0	0	Ymaxh	0	0	0			
	param 4	0	0	Ymaxl	0	0	0			ONLY one
	param 5	0	0	0	0	0	0			inquiry
	param 6	0	0	0	0	0	0			at a
										time.
	#$F6	Packet header								
	mode	#$0F	#$10	#$12	#$14	#$15		#$19	#$1A	
	param 1	_______/		____________/				Rx	on	
	param 2	Inquiry			on			Ry		
	param 3	returns			<--			Tx	#$00	
	param 4	correct			#$00 off			Ty	off	
	param 5	mode						Vx		
	param 6							Vy		

Not valid if in joystick or fire button monitoring mode.

Data packet function

When preceding a data packet returned from the keyboard, the special keycodes #$F6 to #$FF give the following meanings to the data packets:

. Code Dec	Hex	Data packet function		
246	F6	Status report		
247	F7	Absolute mouse position record		
248	F8 to FB	\ Relative mouse position record I 111110xx (xx=left-right button state) I delta x, 2's complement / delta y, 2's complement		
252	FC	Time of day	(resolution of 1 second)	
253	FD	Joystick report header	(both sticks)	
254	FE	x000yyyy	\ x=trigger	Joystick 0 event
255	FF	x000yyyy	/ y=stick position	Joystick 1 event

Chapter 7

The Line-A routines

The Line-A routines

Atari ST programmers have access to the VDI primitives via the line-A exception routines; they provide a faster performance than the VDI routines, additional facilities and use less code to implement. The line-A routines may be mixed with VDI calls or used entirely on their own, but program portability to other systems will not be possible.

Line-A access

The line-A routines operate from a set of variables contained in a data table (Page 7.8 - 7.9). The table is initialized by activating the line-A exception vector in passing the word #$A000. The programmer may then alter or insert variables into the data table and call the required function by passing the appropriate function call word.

```
dc.w      #$A000       ; initialize data table
move.w    #n,d(A0)     ; set function at offset d
                       ; to value n

dc.w      #$A00m       ; call function
```

Initialization pointers

Initialization creates the following pointers:

d0=base address of line-A variables
a0=base address of line-A variables
a1=array of pointers to the 3 system font headers
a2=array of pointers to the 15 line-A routines
(a2 is not returned correctly on disk based versions of TOS)

If VDI and AES are not used, the variables should be fairly static. If they are used, the variables may be changed, registers d0-d2 and a0-a2 will be trashed.

Line-A routines

Function	Op $0	Pointpair in $2	Pointpair out $4	Integers in $6	Integers out $8	Comments
Put pixel	#$A001	1	0	1	0	Plot a pixel at x,y
	ptsin (0)=X_msbyte, Y_lsbyte					
	intin (0)=pixel value					
Get pixel	#$A002	1	0	0	0	Get the pixel at x,y
	ptsin (0)=X_msbyte, Y_lsbyte					Return d0=pixel value

Function	Parameters		Comments
Line	#$A003		Draw a line between
	offset	$26 X1 coordinate	X1,Y1 and X2,Y2
		$28 Y1 coordinate	The line is ALWAYS drawn
		$2A X2 coordinate	from left to right and the
		$2C Y2 coordinate	mask applied left to right
		$18 plane 0 \	also- so watch the phase.
		$1A plane 1 I Bit	
		$1C plane 2 I value	/ Mask is word aligned
		$1E plane 3 /	I pattern for horizontal
		$22 line style mask <----------	I lines. i.e. any bit of
		$24 writing mode	I mask may be used at the
		$20 -1 for XOR mode	\ left-most endpoint.
		else ignore	
	output		Mask is rotated to align
		$22 line style mask	with rightmost endpoint.
Horizontal Line	#$A004		Draw a line between
	offset	$26 X1 coordinate	X1,Y1 and X2,Y1
		$28 Y1 coordinate	The line is ALWAYS drawn
		$2A X2 coordinate	from left to right
		$18 plane 0 \	
		$1A plane 1 I Bit	
		$1C plane 2 I value	
		$1E plane 3 /	
		$24 writing mode	
		$2E Fill pattern pointer	
		$32 Fill pattern mask	
		$34 Multi-plane fill flag	
	output	none	

Line-A routines cont.

Function	Parameters		Comments
Filled rectangle	#$A005		Draw a filled rectangle with upper lefthand corner X1,Y1 and lower righthand corner X2,Y2.
	offset	$26 X1 coordinate $28 Y1 coordinate $2A X2 coordinate $2C Y2 coordinate $18 plane 0 \\ $1A plane 1 | Bit $1C plane 2 | value $1E plane 3 / $24 writing mode $2E Fill pattern pointer $32 Fill pattern mask $34 Multi-plane fill flag $36 Clipping flag $38 minimum X clipping value $3A maximum X clipping value $3C minimum Y clipping value $3E maximum Y clipping value	
	output	none	
Line-by -line filled polygon	#$A006	n - - - ptsin (0)=X,Y array of polygon vertices	Draw one scan-line of a filled polygon.
	offset	$28 Y1 coordinate $18 plane 0 \\ $1A plane 1 | Bit $1C plane 2 | value $1E plane 3 / $24 writing mode $2E Fill pattern pointer $32 Fill pattern mask $34 Multi-plane fill flag $36 Clipping flag $38 minimum X clipping value $3A maximum X clipping value $3C minimum Y clipping value $3E maximum Y clipping value	Polygon X1,Y1...Xn,Yn...X1,Y1 Start point must be repeated at the end of the list. Y1 is the Y coordinate of the line to fill.
	output	none	X1 and X2 trashed on return

Line-A routines cont.

Function	Parameters		Comments
Bitblt	#$A007		Bit block transfer
	input	a6=i/p parameter table pointer	See page 7.10
	output	none	for table entries
Textblt	#$A008		Perform a Text block
	offset	$24=writing mode	transfer of one character.
		$6A=Foreground \ Text	
		$72=Background / colour	
		$54=Pointer \	Writing mode
		$58=Width | Font	0-3 VDI modes
		$48=X coor | form	4-19 Bitblt modes
		$4A=Y coor /	
		$4C=X coor \ Character	
		$4E=Y coor / on screen	
		$50=width \ Character	
		$52=height /	
		$5A=Style flag	
		$5C=Lighten text mask	
		$5E=Skew text mask	
		$60=Thickening text width	
		$62=above \ Character offset	
		$64=below / from baseline	
		$66=Scaling flag (0=none)	
		$40=Accumulator for x dda	
		$42=Textblt scale factor	
		$44=Scale direction (down 0)	
		$68=Character rotation vector	
		$46=Font status	
		$6C=Special effects buffer pointer	
		$70=Scaling buffer offset in above pointer	
	output	none	
Show mouse	#$A009		Show the mouse, if # of
	input	none	'show' calls >= # of
	output	none	'hide' calls.
Hide mouse	#$A00A		Hide the mouse, if # of
	input	none	'hide' calls exceeds #
	output	none	of 'show' calls.

Line-A routines cont.

Function	Parameters		Comments
Trans -form mouse	#$A00B		Transform mouse form
		cntrl $E=Addr.L source MFDB	
		cntrl $12=Addr.L destination MFDB	
	output	none	
Undraw sprite	#$A00C		Undraw previously drawn sprite
	input a2=sprite slave block pointer		The sprite save block saves the screen underneath the sprite and is (10bytes + 648 # planes) bytes in size.
	output	none	*** a6 smashed ***
Draw sprite	#$A00D		Draw a sprite
	input	d0=X hot spot	(Function not available on disk based versions of TOS)
		d1=Y hot spot	
		a0=pointer to sprite definition block	
		a2=pointer to sprite save block	
	output	none	*** a6 smashed ***
Copy raster form	#$A00E		Copy a raster from source to destination.
		cntrl $E=Addr.L source MFDB	
		cntrl $12=Addr.L destination MFDB	
	output	none	
Contour fill	#$A00F		Contour fill
		intin (0)=colour index	input may be +ve or -ve.
	output	none	

Logic table

			fg	bg
10	$0A	Op_0	0	0
11	$0B	Op_1	0	1
12	$0C	Op_2	1	0
13	$0D	Op_3	1	1

The logic operation bytes specify the effect of the foreground and background colour bits on the current plane.

Line-A parameter blocks

Sprite definition block

0	$00	X offset of hot-spot	
2	$02	Y offset of hot-spot	
4	$04	Format flag	
6	$06	Background	\ Colour
8	$08	Foreground	/ table index
10	$0A	Interleaved	\ Background line 0
12	$0C	background/	I Foreground line 0
...	...	foreground	I ...
74	$4A	image (32 words)	/ Foreground line 16
76	$4C		

Format flag

+ve Fg	+ve Bg	-ve Fg	-ve Bg	colour plotted
0	0	0	0	Transparent
0	1	0	1	Background
1	1	1	1	Foreground
1	0			Foreground
		1	0	XOR screen

Memory form definition block (MFDB)

0	$00	Memory pointer to 32-bit address of pixel 0,0	
4	$04	Width \ Raster area	
8	$08	Height / dimensions	
12	$0C	Word width	Pixel width/word size
16	$10	Format flag	1=standard, 0=device specific
20	$14	Memory planes	# planes in raster area
24	$18	\ Three	
28	$1C	I reserved	
32	$20	/ words	
36	$24		

Line-A parameter table

offset		Function
$00	0	Number of video planes \ Can produce special
$02	2	Number of bytes/video line / effects.
$04	4	Pointer to cntrl array
$08	8	Pointer to intin array
$0C	12	Pointer to ptsin array
$10	16	Pointer to intout array
$14	20	Pointer to ptsout array
$18	24	Bit plane_0 \ current
$1A	26	Bit plane_1 I colour
$1C	28	Bit plane_2 I value
$1E	30	Bit plane_3 /
$20	32	-1
$22	34	VDI line style equivalent
$24	36	Writing mode 0_replace 1_transparent
		2_XOR mode 3_inverse transparent
$26	38	X1 coordinate
$28	40	Y1 coordinate
$2A	42	X2 coordinate
$2C	44	Y2 coordinate
$2E	46	Pointer to current fill pattern
$32	50	Fill pattern mask (length of pattern)
$34	52	Multi-plane fill pattern
		0_current fill pattern is single plane
		1_current fill pattern is multi-plane
$36	54	Clipping flag 0_no clipping
$38	56	Minimum x clipping value
$3A	58	Minimum y clipping value
$3C	60	Maximum x clipping value
$3E	62	Maximum y clipping value
$40	64	Accumulator for textblt x dda
		initialize to 8000H before each call
$42	66	Textblt scale factor
$44	68	Scale direction 0_down

Line-A parameter table cont.

offset		Function
$46	70	Font status 1_solid 0_proportional or variable
$48	72	X coordinate of character in font form
$4A	74	Y coordinate of character in font form (typically 0)
$4C	76	X coordinate of character on screen
$4E	78	Y coordinate of character on screen
$50	80	Character width
$52	82	Character height
$54	84	Pointer to start of font data (font form)
$58	88	Width of font form
$5A	90	Style bit 0_Thicken, bit 1_lighten, bit 2_skew bit 3_underline (ignored), bit 4_outline
$5C	92	Lighten text mask
$5E	94	Skew text mask
$60	96	Text thickening additional width
$62	98	Offset above character baseline for skew
$64	100	Offset below character baseline for skew
$66	102	Scaling flag 0_no scaling
$68	104	Character rotation vector 0_horizontal 900_vertically down etc.
$6A	106	Text foreground colour
$6C	108	Special effects buffer pointer
$70	112	Scaling buffer offset in above buffer
$72	114	Text background colour (RAM VDI only)
$74	116	Copy raster form type flag (RAM VDI only) 0_opaque type n-plane source to n-plane destination bitblt write mode <>0_transparent type 1-plane source to n-plane destination VDI write mode
$76	118	Abort fill routine pointer (Function not available on disk based versions of TOS)

BITBLT table used in block transfers (routine $A008)

Parameter block length must be 76 bytes, the first 52 bytes being set by the user and the remainder by the blt. Address register a6 is used as a pointer to the table, a point C programmers should note.

	0	$00	b_width	width \ of block in
	2	$02	b_height	height / pixels
*	4	$04	#planes	# of cosecutive planes to blt
*	6	$06	fg_col	foreground colour - high bit \ logic operation
*	8	$08	bg_col	background colour - low bit / index
	10	$0A	op_table	logic operation-- Table of 4 raster operation code
	11	$0B		bytes, each containing one of sixteen
	12	$0C		logical operations. They are indexed
	13	$0D		by fg*2 + bg for each plane (see pg7.6).
	14	$0E	s_xmin	minimum source x
	16	$10	s_ymin	minimum source y
	18	$12	s_form	source form base address (word boundary)
	22	$16	s_nxwd	# word in line \ next offset (2hi-4med-8low rez)
	24	$18	s_nxln	# lines in plane / in bytes (90hi-160med/low rez)
	26	$1A	s_nxpl	next plane offset from current (always 2)
	28	$1C	d_xmin	minimum destination x
	30	$1E	d_ymin	minimum destination y
	32	$20	d_form	destination form base address (word boundary)
	36	$24	d_nxwd	# word in line \ next offset (2hi-4med-8low rez)
	38	$26	d_nxln	# lines in plane / in bytes (90hi-160med/low rez)
	40	$28	d_nxpl	next plane offset from current (always 2)
*	42	$2A	p_addr	address of pattern buffer (0=no pattern) A word size repetative, word aligned pattern that is ANDed with the source before being logically combined with the destination.
	46	$2D	p_nxln	next line in pattern \ offset (2, 4, 6 etc)
	48	$30	p_nxpl	next plane in pattern / in bytes (0=1 plane)
	50	$32	p_mask	pattern index mask length

* may be altered during bitblt execution

The source bit defined by s_xmin, s_ymin, b_width, b_height is transfered to destination d_xmin, d_ymin by the number of planes iterations (#planes). There is no clipping or check that bit blocks are within the encompassing memory forms.

Chapter 8

The Blitter

The Blitter

General

The New TOS versions of the Atari ST contain a hardware bit block transfer processor (blitter) which operates automatically on certain line-A and VDI functions, providing a considerable increase in the speed at which blocks of memory can be manipulated. The blitter can be switched off, or tested for presence, through the XBIOS $40 blitmode function. An attempt to 'turn on' the blit mode in a system which does not contain a blitter is ignored by the OS. The blitter should not be used from within an interrupt context where multiple blitter operations may conflict and cause unpredictable results.

The blitter device moves bit aligned data in memory using one of sixteen logic operations. It can be used to provide rapid implementation of the following functions:

Area seed fill
Rotation and magnification
Brush line drawing
Text transformations eg. Bold, italic, outline
Text scrolling
Window updating
Pattern filling
Memory to memory block copying

Blitter operation

The blitter operates as follows,: Initially the transfer parameters are calculated before the data is moved, the parameters involved are:

Clipping, sets the source and destination blocks to a predefined clipping rectangle size, the transfer is omitted if the block size is set to zero. Although the blocks are the same 'size', they may have different increments.

Skew, the source to destination horizontal bit offset.

Endmasks, provide start, intermediate and finish word masks to define the portion of the word in each line to be operated on.

Overlap, a check that source data will not be overwritten before the transfer is complete, overlap reverses the default left to right transfer mode if necessary.

The transfer is effected after the parameters have been calculated:

Blitter Control/Status

Two bits in the blitter configuration registers are used to provide the programmer with control and the status of the blitter.

The **HOG** bit when clear gives equal processor/blitter bus access (64 bus cycle segments), when set the processor is stopped until the blitter transfer is complete although other DMA processes can always interrupt the blitter.

The **BUSY** bit is set after the other registers are initialised and is only cleared when the transfer is complete. Bus arbitration can still be used to initiate processor instructions, which means that the next instruction after the transfer is not necessarily that which set the BUSY bit.

The blitter is usually operated with the HOG flag cleared. In this mode the blitter and the ST's CPU share the bus equally, each taking 64 bus cycles while the other is halted. This mode allows interrupts.

Blitter access

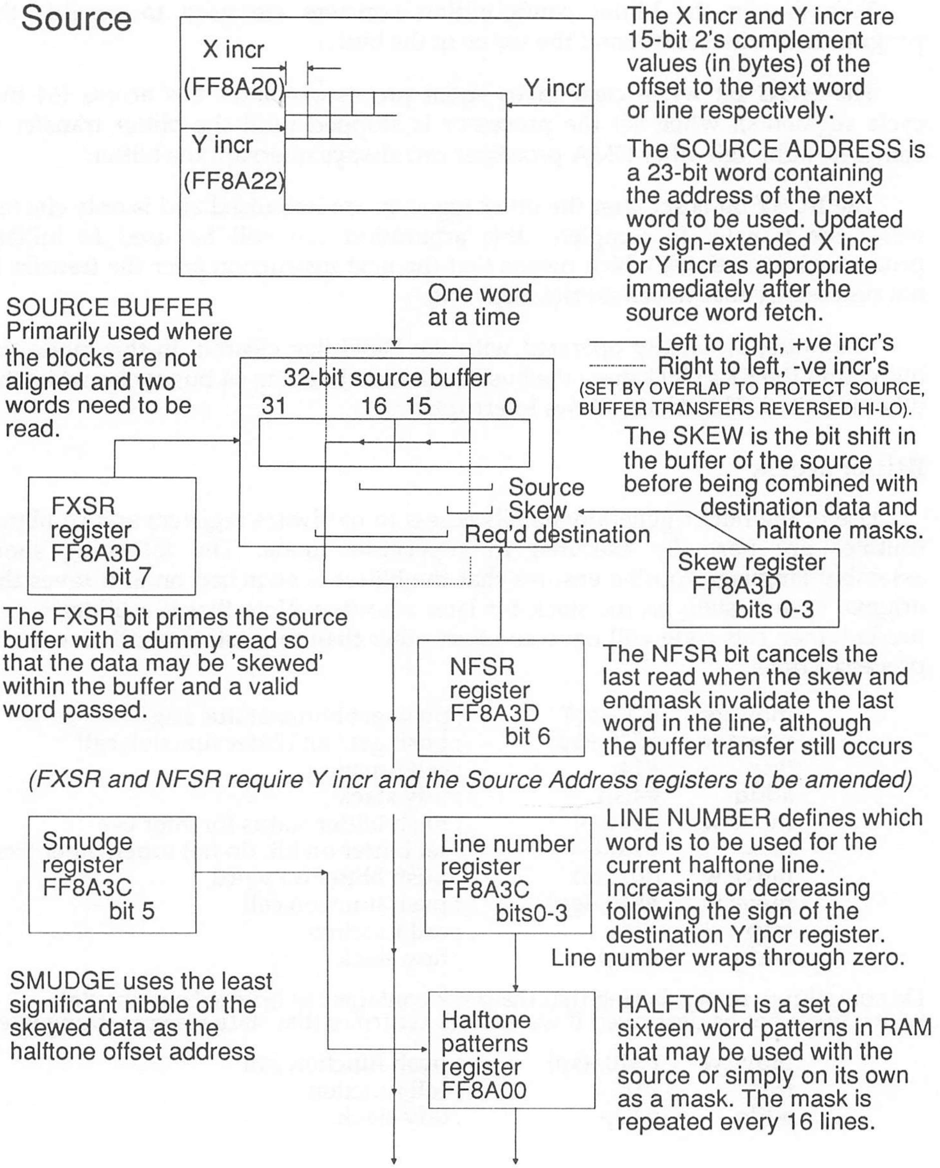
Use of the blitter generally entails access to hardware registers and so blitter routines are normally executed in supervisor mode. The following short assembly language routine ensures that the blitter is switched on and saves the original system state on the stack for later recovery. Note that if a blitter is not present, then this code will have no affect other than to waste a small amount of processor time.

```
move.w   #-1,-(sp)     ; push get blitter status flag
move.w   #$40,-(sp)    ; push get/set blitter function call
trap     #14           ; call function
addq     #4,sp         ; tidy stack
move.w   d0,-(sp)      ; push blitter status for later use
or.w     #1,d0         ; set blitter on bit, do not touch other bits
move.w   d0,-(sp)      ; push blitter on word
move.w   #$40,-(sp)    ; push function call
trap     #14           ; call function
addq     #4,sp         ; tidy stack
```

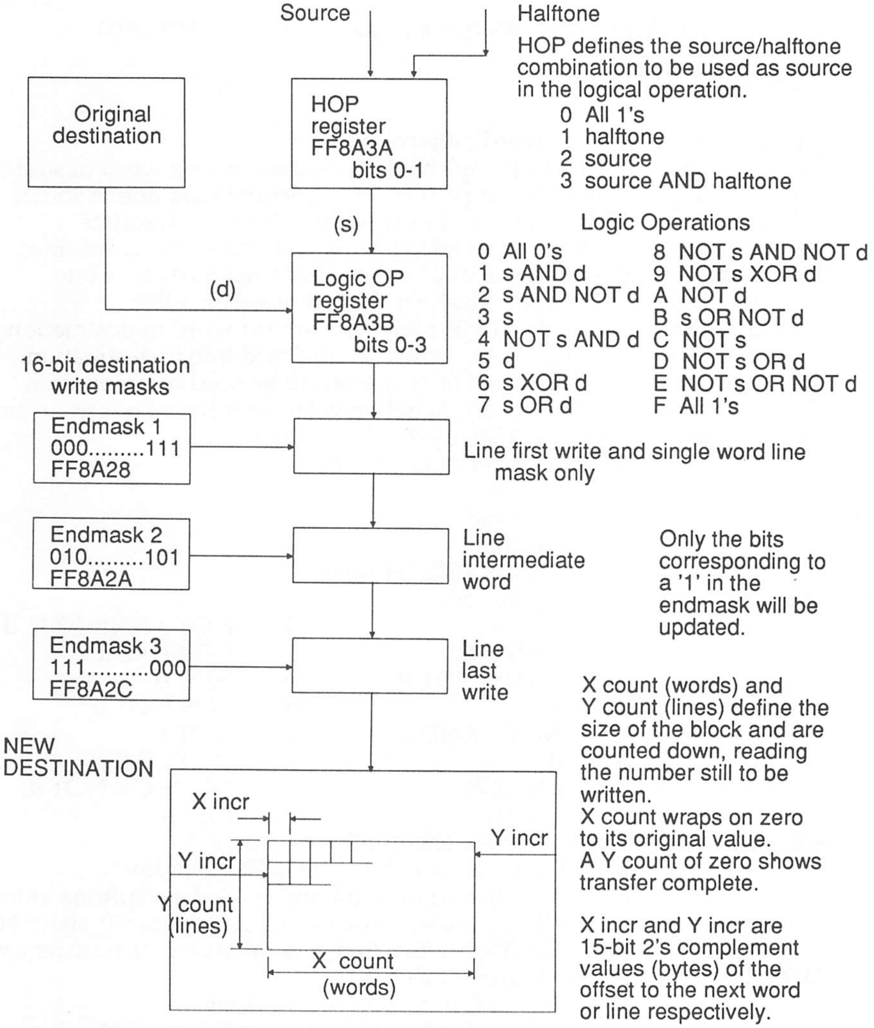
Do something, remembering that the stack contains the original system state which must not be destroyed if we wish to return to that state via something like:

```
move.w   #$40,-(sp)    ; push function call
trap     #14           ; call function
addq     #4,sp         ; tidy stack
```

Blitter flow diagram



Blitter flow diagram cont.



The destination address is a 23-bit word containing the address of the next word to be used. It is automatically updated by sign-extending X incr or Y incr as appropriate (Y incr if X count is one) immediately after the destination write.

Blitter parameter table

The blitter configuration registers are located at address $FF8A00

Blitter offsets

0	$00	halftone	16 x 16 word pattern masks			
32	$20	src_xinc	15-bit 2's complement increment of next word in source			
34	$22	src_yinc	15-bit 2's complement increment of next line in source			
36	$24	src_addr	23-bit address of next word to be used in source			
40	$26	endmask1	destination write mask for first and single word lines			
42	$28	endmask2	destination mask for intermediate words on a line			
44	$2A	endmask3	destination mask for the last word on a line			
46	$2C	dst_xinc	15-bit 2's complement incr of next word in destination			
48	$30	dst_yinc	15-bit 2's complement incr of next line in destination			
50	$32	dst_addr	23-bit address of next word to be used in destination			
54	$36	x_count	number of words in line yet to be written, wraps on zero.			
56	$38	y_count	number of lines yet to be written			
58	$3A	HOP	Halftone operation options			
			0	All 1's		
			1	halftone		
			2	source		
			3	source AND halftone		
59	$3B	OP	Logic operations			
			0	All 0's	8	NOT s AND NOT d
			1	s AND d	9	NOT s XOR d
			2	s AND NOT d	A	NOT d
			3	s	B	s OR NOT d
			4	NOT s AND d	C	NOT s
			5	d	D	NOT s OR d
			6	s XOR d	E	NOT s OR NOT d
			7	s OR d	F	All 1's
60	$3C	line_num	Halftone mask line number			
			bit 0-3 line number (0 to 15) - halftone index			
			bit 5 Smudge - skew data nibble used as halftone index			
			bit 6 HOG - 1_halt processor while transfer. 0_share bus			
			bit 7 BUSY - 1_when registers initialised. 0_transfer over			
61	$3D	skew	Source buffer bit shift			
			bit 0-3 bit shift (0 to 15) - source skew			
			bit 6 NFSR - 1_no final source read. 0_normal			
			bit 7 FXSR - 1_force initial extra source read. 0_normal			

Appendices

Appendix A

System variables

The following tables present the system variables in low supervisor space $0 to $7FF (0 to 2047):

Exception vectors

<table>
<tr><td>0</td><td>$000</td><td>Reset initial SSP value</td><td>(ROM)</td></tr>
<tr><td>4</td><td>$004</td><td>Reset initial PC address</td><td>(ROM)</td></tr>
<tr><td>8</td><td>$008</td><td>Bus error</td><td>\ Dump state</td></tr>
<tr><td>12</td><td>$00C</td><td>Address error</td><td>| and terminate</td></tr>
<tr><td>16</td><td>$010</td><td>Illegal instruction</td><td>/ routine pointer</td></tr>
<tr><td>20</td><td>$014</td><td>Divide by zero</td><td>(Pointer to an RTE)</td></tr>
<tr><td>24</td><td>$018</td><td>Chk instruction</td><td>\ Dump state</td></tr>
<tr><td>28</td><td>$01C</td><td>Trapv instruction</td><td>| and terminate</td></tr>
<tr><td>32</td><td>$020</td><td>Privilege violation</td><td>| routine pointer</td></tr>
<tr><td>36</td><td>$024</td><td>Trace mode</td><td>/</td></tr>
<tr><td>40</td><td>$028</td><td>Line 1010</td><td>line-A routine pointer</td></tr>
<tr><td>44</td><td>$02C</td><td>Line 1111</td><td>Used by AES</td></tr>
<tr><td>48</td><td>$030</td><td>Unassigned</td><td></td></tr>
<tr><td>52</td><td>$034</td><td>Coprocessor protocol violation (MC68020)</td><td></td></tr>
<tr><td>56</td><td>$038</td><td>Format error (MC68020)</td><td></td></tr>
<tr><td>60</td><td>$03C</td><td>Uninitialized interrupt vector</td><td></td></tr>
<tr><td>64</td><td>$040</td><td>Unassigned</td><td>\</td></tr>
<tr><td>.</td><td>.</td><td></td><td>| Reserved</td></tr>
<tr><td>82</td><td>$05C</td><td>Unassigned</td><td>/</td></tr>
<tr><td>96</td><td>$060</td><td>Spurious interrupt (Hacked to level 3)</td><td></td></tr>
<tr><td>100</td><td>$064</td><td>Int level 1</td><td>(Used if user wants Hblanks)</td></tr>
<tr><td>104</td><td>$068</td><td>Int level 2</td><td>Horizontal blank sync (Hblank)</td></tr>
<tr><td>108</td><td>$06C</td><td>Int level 3</td><td>Normal processor interrupt level</td></tr>
<tr><td>112</td><td>$070</td><td>Int level 4</td><td>Vertical blank sync (Vblank)</td></tr>
<tr><td>116</td><td>$074</td><td>Int level 5</td><td></td></tr>
<tr><td>120</td><td>$078</td><td>Int level 6</td><td>MK68901 MFP interrupts</td></tr>
<tr><td>124</td><td>$07C</td><td>Int level 7</td><td>Non maskable interrupt</td></tr>
<tr><td>128</td><td>$080</td><td>Trap #0</td><td></td></tr>
<tr><td>132</td><td>$084</td><td>Trap #1</td><td>GEMDOS interface calls</td></tr>
<tr><td>136</td><td>$088</td><td>Trap #2</td><td>Extended DOS calls (AES, VDI)</td></tr>
<tr><td>140</td><td>$08C</td><td>Trap #3</td><td></td></tr>
<tr><td>.</td><td>.</td><td></td><td></td></tr>
<tr><td>176</td><td>$0B0</td><td>Trap #12</td><td></td></tr>
<tr><td>180</td><td>$0B4</td><td>Trap #13</td><td>GEM BIOS calls</td></tr>
<tr><td>184</td><td>$0B8</td><td>Trap #14</td><td>Atari extended BIOS calls (XBIOS)</td></tr>
<tr><td>188</td><td>$0BC</td><td>Trap #15</td><td></td></tr>
<tr><td>192</td><td>$0C0</td><td>Unassigned</td><td>\</td></tr>
<tr><td>.</td><td>.</td><td></td><td>| Reserved</td></tr>
<tr><td>252</td><td>$0FC</td><td>Unassigned</td><td>/</td></tr>
</table>

MFP hardware bound interrupt vectors

*	256	$100	Parallel port interrupt_0 (Centronics busy)	
*	260	$104	RS232 carrier detect (dcd)	interrupt_1
*	264	$108	RS232 clear to send (cts)	interrupt_2
*	268	$10C	Graphics blt done	interrupt_3
*	272	$110	RS232 baud rate generator	(Timer D)
	276	$114	200Hz system clock	(Timer C)
	280	$118	Keyboard/MIDI (6850)	interrupt_4
*	284	$11C	Polled fdc/_hdc	interrupt_5
*	288	$120	Horizontal blank counter	(Timer B)
	292	$124	RS232 transmit error interrupt	
	296	$128	RS232 transmit buffer empty interrupt	
	300	$12C	RS232 receive error interrupt	
	304	$130	RS232 receive buffer full interrupt	
*	308	$134	User/application	(Timer A)
*	312	$138	RS232 ring indicator	interrupt_6
*	316	$13C	Polled monochrome monitor detect	interrupt_7
	320	$140		
.				
	508	$1FF		Priority levels (7 high)

* Initially disabled
The polled fdc/_hdc interrupt must be disabled on return.

Application interrupts

512	$200	\
		| Reserved for OEMs
892	$37C	/

After an uncaught trap, the processor state is dumped as follows:

Processor state

896	$380	proc_lives	Processor state saved if system variable set to $12345678
900	$384	proc_regs	D0-D7/A0-A6, A7_ssp
964	$3C4	proc_pc	First byte exception number
968	$3C8	proc_usp	USP
972	$3CC	proc_stk	sixteen words of superstack

The above values are not overwritten by a system reset, but are by a further crash.

System variables

Address		Size		Function
1024	$400	L	etv_timer	Timer handoff (logical vector $100)
1028	$404	L	etv_critic	Critical error handoff vector ($101)
1032	$408	L	etv_term	Process terminate handoff vector ($102)
1036	$40C	5xL	etv_xtra	Space for reserved logical vectors ($103-$107)
1056	$420	L	memvalid	#$752019F3 (cold start o'k)
1060	$424	B	memcntlr	memory controller low nibble 0=128K, 4=512K, (0=256K, 5=1MB 2 banks)
1062	$426	L	resvalid	#$31415926 to jump through resvector
1066	$42A	L	resvector	System reset bailout vector
1070	$42E	L	phystop	Physical RAMtop (points to first unusable byte
1074	$432	L	_membot	Available memory bottom (getmpb uses)
1078	$436	L	_memtop	Available memory top (getmpb uses)
1082	$43A	L	memval2	#$237698AA for legal memory configuration.
1086	$43E	W	flock	Floppy FIFO lock variable
1088	$440	W	seekrate	0=6ms, 1=12ms, 2=2ms, 3=3ms default
1090	$442	W	_timr_ms	20 (#$14) system timer calibration
1092	$444	W	_fverify	0=no write-verify else verify (default)
1094	$446	W	_bootdev	System boot device number
1096	$448	W	palmode	0=NTSC, 60Hz else PAL, 50Hz
1098	$44A	B	defshftmd	Default video resolution if monitor changed
1100	$44C	B	sshiftmd	Shadow shiftmd hardware register 0=320x200x4 1=640x200x2 2=640x400x1
1102	$44E	L	_v_bas_ad	Screen memory base pointer (32K contiguous) on a 512 byte boundary
1106	$452	W	vblsem	Vert blank mutual exclusion semaphore 1_vblank enabled
1108	$454	W	nvbls	8 (No. longwords vblqueue points to)
1110	$456	L	_vblqueue	Vblank handler pointer to pointers
1114	$45A	L	colorptr	0 null else pointer to 16 word vector for hardware palette next vblank
1118	$45E	L	screenpt	Pntr to screen base next vblank or 0
1122	$462	L	_vbclock	Vertical blank interrupt count
1126	$466	L	_frclock	Count vblank interrupts not vblsem'd

System variables cont.

Address		Size		Function
1130	$46A	L	hdv_init	Hard disk initialize vector else zero
1134	$46E	L	swv_vec	'Monitor changed' vector to follow
1138	$472	L	hdv_bpb	Hard disk vector to return bpb else 0
1142	$476	L	hdv_rw	Hard disk rd/wr routine vector else 0
1146	$47A	L	hdv_boot	Hard disk boot routine vector else 0
1150	$47E	L	hdv_mediach	Disk media change routine vector else 0
1154	$482	W	_cmdload	<>0 load & exe COMMAND.PRG (boot device)
1156	$484	B	conterm	Attribute bits for console system, bit:
				0_bell on (^G) 1_keyrepeat
				2_keyclick 3_bios conin() function
				kbshft in bits 24 to 31 of D0.L
1157	$485	B		reserved
1158	$486	L	trp14ret	Saved trap 14 return address
1162	$48A	L	criticret	Saved return address for etv_critic
1166	$48E	L	themd	GEMDOS memory descriptors (don't change)
				Structure MD
				m_link Next MD/null
				m_start Start of TPA
				m_length Byte size of TPA
				m_own MD's owner/null
1182	$49E	W	_md	? reserved
1186	$4A2	L	savptr	BIOS register save area pointer
1190	$4A6	W	_nflops	# floppies attached 0, 1 or 2
1192	$4A8	L	con_state	State of conout() parser (VT52 emulation)
1196	$4AC	W	save_row	Save row# for x-y addressing
1198	$4AE	L	sav_contxt	Pointer to saved processor context
1202	$4B2	L	_bufl	GEMDOS two buffer-list pointers
				1st buffers data sectors
				2nd buffers FAT and DIR sectors
				Structure BCB
				b_link Next BCB
				b_bufdrv Drive#/-1
				b_buftyp Buffer type
				b_bufrec Record# cached
				b_dirty Dirty flag
				b_dm Drive media descriptor
				b_bufr Buffer pointer

System variables cont.

Address		Size		Function
1210	$4BA	L	_hz_200	Raw 200Hz timer tick
1214	$4BE	L	the_env	Default environment string $00000000
1218	$4C2	L	_drvbits	32 bit vector of live block devices
1222	$4C6	L	_dskbufp	Pointer to common disk buffer, 1 Kbyte in systems BSS. (Do not use by an interrupt routine)
1226	$4CA	L	autopath	Pointer to autoexec path (or null)
1230	$4CE	8xL	vbl_list	Initial vblqueue
. .				
. .				
1262	$4EE	W	_prt_cnt	Initially set -1, ALT_HELP increments screen-dump flag (0 abort)
1264	$4F0	W	prtabt	Printer abort flag
1266	$4F2	L	_sysbase	Base of OS pointer (RAM or ROM)
1270	$4F6	L	_shell_p	Global shell information pointer
1274	$4FA	L	end_os	Pointer to end of OS memory usage
1278	$4FE	L	exec_os	Pointer to shell address to execute on startup (normally 1st byte of AES text seg).
2048	$800			Start of user RAM

Bomb error codes

# bombs	meaning
2	Bus error
3	Address error (odd address)
4	Illegal instruction
5	Division by zero
6	CHK exception
7	TRAPV exception
8	Privilege violation
9	Trace exception

Appendix B

Configuration registers

Configuration Registers (one/_zero)

MEMORY

16744452	FF8004	r/w	|....xxxx|		**Memory configurations**	
					Bank 0	Bank 1 (not used)
				0	128Kbyte	128Kbyte
				1	128Kbyte	512Kbyte
				2	128Kbyte	2Mbyte
				3	reserved	
				4	512Kbyte	128Kbyte
				5	512Kbyte	512Kbyte
				6	512Kbyte	2Mbyte
				7	reserved	
				8	2Mbyte	128Kbyte
				9	2Mbyte	512Kbyte
				10	2Mbyte	2Mbyte
				11	reserved	
				12+	reserved	

DISPLAY

16745061	FF8201	r/w	|xxxxxxxx|		Video base high
16745063	FF8203	r/w	|xxxxxxxx|		Video base low
16745065	FF8205	r	|xxxxxxxx|		Video address counter high
16745067	FF8207	r	|xxxxxxxx|		Video address counter mid
16745069	FF8209	r	|xxxxxxxx|		Video address counter low
16745071	FF820A	r/w	|............xx|		**Sync mode**
				bit 0	External/_Internal sync
				bit 1	50Hz/_60Hz field rate
16745124	FF8240	r/w	|.....xxx.xxx.xxx|		**Palette colour** 0/0 (border)
				bit 0	Invert/_normal mono
				bit 0-2	Blue
				bit 4-6	Green
				bit 8-10	Red
16745126	FF8242	r/w	|.....xxx.xxx.xxx|		Palette colour 1/1
16745128	FF8244	r/w	|.....xxx.xxx.xxx|		Palette colour 2/2
16745130	FF8246	r/w	|.....xxx.xxx.xxx|		Palette colour 3/3
16745132	FF8248	r/w	|.....xxx.xxx.xxx|		Palette colour 4
16745134	FF824A	r/w	|.....xxx.xxx.xxx|		Palette colour 5
16745136	FF824C	r/w	|.....xxx.xxx.xxx|		Palette colour 6
16745138	FF824E	r/w	|.....xxx.xxx.xxx|		Palette colour 7
16745140	FF8250	r/w	|.....xxx.xxx.xxx|		Palette colour 8

Configuration Registers (one/_zero) cont.

16745142	FF8252	r/w	I.....xxx.xxx.xxx I	Palette colour 9
16745144	FF8254	r/w	I.....xxx.xxx.xxx I	Palette colour 10
16745146	FF8256	r/w	I.....xxx.xxx.xxx I	Palette colour 11
16745148	FF8258	r/w	I.....xxx.xxx.xxx I	Palette colour 12
16745150	FF825A	r/w	I.....xxx.xxx.xxx I	Palette colour 13
16745152	FF825C	r/w	I.....xxx.xxx.xxx I	Palette colour 14
16745154	FF825E	r/w	I.....xxx.xxx.xxx I	Palette colour 15
16745156	FF8260	r/w	I......xx I	*Shift mode*
				0 320x200, 4 plane
				1 640x200, 2 plane
				2 640x400, 1 plane
				3 Reserved

Reserved

16745572	FF8400		I. I	reserved

DMA/Disk

16746084	FF8600		I. I	reserved
16746086	FF8602		I. I	reserved
16746088	FF8604	r/w	I...........xxxxxxxx I	Disk controller data access
16746090	FF8606	r	I....................xxx I	**DMA status** (mode control)
			bit 0	_Error
			bit 1	_Sector count zero
			bit 2	_Data request inactive
	FF8606	w	I.......xxxxxxxx. I	**DMA mode control**
			bit 1	A0) WD1772
			bit 2	A1) registers
			bit 3	HDC/_FDC register select
			bit 4	Sector count register select
			bit 5	0 reserved
			bit 6	Disable/_enable DMA
			bit 7	FDC/_HDC
			bit 8	Write/_read
16746093	FF8609	r/w	I xxxxxxxx I	DMA base and counter high
16746095	FF860B	r/w	I xxxxxxxx I	DMA base and counter mid
16746097	FF860D	r/w	I xxxxxxxx I	DMA base and counter low

Configuration Registers (one/_zero) cont.

SOUND

16746596	FF8800	r	|xxxxxxxx|		**PSG read data**
					I/O port B, Parallel i/f data
		w	|xxxxxxxx|		**PSG register select**
				reg #	
				8 bit 0	Channel A fine tune
				4 bit 1	Channel A coarse tune
				8 bit 2	Channel B fine tune
				4 bit 3	Channel B coarse tune
				8 bit 4	Channel C fine tune
				4 bit 5	Channel C coarse tune
				5 bit 6	Noise generator control
				8 bit 7	Mixer control-I/O enable
				5 bit 8	Channel A amplitude
				5 bit 9	Channel B amplitude
				5 bit 10	Channel C amplitude
				8 bit 11	Envelope period fine tune
				8 bit 12	Envel period coarse tune
				4 bit 13	Envelope shape
				14	I/O port A (output only)
				15	I/O port B (Centronics O/P)
16746598	FF8802	w	|xxxxxxxx|		**PSG write data, I/O port A**
				bit 0	Floppy side 0/_side 1 select
				bit 1	Floppy _drive 0 select
				bit 2	Floppy _drive 1 select
				bit 3	RS232 RTS
				bit 4	RS232 DTR
				bit 5	Centronics STROBE
				bit 6	General purpose output
				bit 7	Reserved
		r/w	|xxxxxxxx|		**I/O port B, Par i/f data**

Configuration Registers (one/_zero) cont.

Blitter

16747108	FF8A00	|xxxxxxxxxxxxxxxx|		Halftone RAM
16747110	FF8A02	|xxxxxxxxxxxxxxxx|		
16747112	FF8A04	|xxxxxxxxxxxxxxxx|		16 x 16 pattern mask
.	.	.		
16747138	FF8A1E	|xxxxxxxxxxxxxxxx|		
16747140	FF8A20	|xxxxxxxxxxxxxxx.|		Source increment X
16747142	FF8A22	|xxxxxxxxxxxxxxx.|		Source increment Y
16747144	FF8A24	|........xxxxxxxx|		\ Source address
16747146	FF8A26	|xxxxxxxxxxxxxxx.|		/
16747148	FF8A28	|xxxxxxxxxxxxxxxx|		Endmask 1
16747150	FF8A2A	|xxxxxxxxxxxxxxxx|		Endmask 2
16747152	FF8A2C	|xxxxxxxxxxxxxxxx|		Endmask 3
16747154	FF8A2E	|xxxxxxxxxxxxxxx.|		Destination increment X
16747156	FF8A30	|xxxxxxxxxxxxxxx.|		Destination increment Y
16747158	FF8A32	|........xxxxxxxx|		\ Destination address
16747160	FF8A34	|xxxxxxxxxxxxxxx.|		/
16747162	FF8A36	|xxxxxxxxxxxxxxxx|		count x (words across)
16747164	FF8A38	|xxxxxxxxxxxxxxxx|		count y (lines down)
16747166	FF8A3A	|..........xx|		HOP halftone operation
16747167	FF8A3B	|.......xxxx|		OP logic operation
16747168	FF8A3C	|xxx.xxxx|		**Halftone mask line #**
			bit 0-3	line number of halftone pattern RAM
			bit 5	Smudge
			bit 6	HOG
			bit 7	Busy
16747169	FF8A3D	|xx...xxxx|		**Source buffer skew**
			bit 0-3	source skew shift
			bit 6	NFSR toggle
			bit 7	FXSR toggle

Configuration Registers (one/_zero) cont.

MK68901

16775681	FFFA01	|xxxxxxxx|		**MFP general purpose I/O**
			bit 0	Parallel port status
			bit 4	WD1772 active
			bit 5	Interrupt
			bit 7	Mono monitor
16775683	FFFA03	|xxxxxxxx|		MFP active edge
16775685	FFFA05	|xxxxxxxx|		MFP data direction
16775687	FFFA07	|xxxxxxxx|		MFP interrupt enable A
16775689	FFFA09	|xxxxxxxx|		MFP interrupt enable B
16775691	FFFA0B	|xxxxxxxx|		MFP interrupt pending A
16775693	FFFA0D	|xxxxxxxx|		MFP interrupt pending B
16775695	FFFA0F	|xxxxxxxx|		MFP intrpt in-service A
16775697	FFFA11	|xxxxxxxx|		MFP intrpt in-service B
16775699	FFFA13	|xxxxxxxx|		MFP interrupt mask A
16775701	FFFA15	|xxxxxxxx|		MFP interrupt mask B
16775703	FFFA17	|xxxxxxxx|		MFP vector base
16775705	FFFA19	|xxxxxxxx|		MFP timer A control
16775707	FFFA1B	|xxxxxxxx|		MFP timer B control
16775709	FFFA1D	|xxxxxxxx|		MFP timers C & D control
16775711	FFFA1F	|xxxxxxxx|		MFP timer A data
16775713	FFFA21	|xxxxxxxx|		MFP timer B data
16775715	FFFA23	|xxxxxxxx|		MFP timer C data
16775717	FFFA25	|xxxxxxxx|		MFP timer D data
16775719	FFFA27	|xxxxxxxx|		MFP sync character
16775721	FFFA29	|xxxxxxxx|		MFP USART control register
16775723	FFFA2B	|xxxxxxxx|		MFP receiver status
16775725	FFFA2D	|xxxxxxxx|		MFP transmitter status
16775727	FFFA2F	|xxxxxxxx|		MFP USART data

MC6850

16776192	FFFC00	|xxxxxxxx|	Keyboard ACIA control
16776194	FFFC02	|xxxxxxxx|	Keyboard data
16776196	FFFC04	|xxxxxxxx|	Midi ACIA control
16776198	FFFC06	|xxxxxxxx|	Midi data

All unused bits read zero.

Appendix C

Printer and terminal escape codes

Typical Epson Printer Codes

Code Dec	Hex	Ascii Mnemo	Function
0	00	NUL	
1	01	SOH	
2	02	STX	* for one
3	03	ETX	line only
4	04	EOT	
5	05	ENQ	
6	06	ACK	
7	07	BEL	Bell
8	08	BS	Backspace
9	09	HT	Tab horizontal
10	0A	LF	Line feed
11	0B	VT	Tab vertical
12	0C	FF	Form feed
13	0D	CR	Carriage Return
14	0E	SO	* Enlarged on
15	0F	SI	Condensed on
16	10	DLE	
17	11	DC1	On-line printer
18	12	DC2	Condensed off
19	13	DC3	Off-line printer
20	14	DC4	* Enlarged off
21	15	NAK	
22	16	SYN	
23	17	ETB	
24	18	CAN	Clear print buffer
25	19	EM	Cut sheet feeder
26	1A	SUB	
27	1B	ESC	
28	1C	FS	
29	1D	GS	
30	1E	RS	
31	1F	US	
32	20		
			Printable ASCII codes
127	7F		

***** ESC code functions *****

Dec	Hex	Ch	Function
32	20		
33	21	!	Combine print modes
34	22	"	
35	23	#	
36	24	$	
37	25	%	Select ROM/user charset
38	26	&	Define user characters
39	27	'	
40	28	(	
41	29	)	
42	2A	*	Select graphics mode
43	2B	+	
44	2C	,	
45	2D	-	Underline on/off
46	2E	.	
47	2F	/	Select vert Tab channel
48	30	0	Set 1/8 inch LF
49	31	1	Set 7/72 inch LF
50	32	2	Set 1/6 inch LF
51	33	3	Set n/216 inch LF
52	34	4	Italic on
53	35	5	Italic off
54	36	6	
55	37	7	
56	38	8	Detect paper-out on
57	39	9	Detect paper-out off
58	3A	:	Copy ROM char to RAM
59	3B	;	
60	3C	<	* Unidirection print
61	3D	=	
62	3E	>	
63	3F	?	Redefine graphic mode
64	40	@	Initialize printer
65	41	A	Set n/72 inch LF
66	42	B	Set vertical Tabs
67	43	C	n Set form length
68	44	D	Set horizontal Tabs
69	45	E	Bold on
70	46	F	Bold off

Typical Epson Printer Codes cont.

***** ESC code functions *****

Dec	Hex	Ch	
71	47	G	Double strike on
72	48	H	Double strike off
73	49	I	
74	4A	J	LF n/216 inch
75	4B	K	60 dpi bitimage
76	4C	L	120 dpi bitimage
77	4D	M	Elite on
78	4E	N	Skip perforation on
79	4F	O	Skip perforation off
80	50	P	Pica on/Elite off
81	51	Q	Set right column
82	52	R	Select character set
83	53	S	Super/subscript on
84	54	T	Super/subscript off
85	55	U	Unidirection on/off
86	56	V	
87	57	W	Enlarged on/off
88	58	X	
89	59	Y	120 dpi bitimage-fast
90	5A	Z	240 dpi bitimage
91	5B	[	
92	5C	\	
93	5D	]	
94	5E	^	Set 9 pin bit image
95	5F	_	
96	60	`	
97	61	a	Set NLQ justify
98	62	b	Set vertical tabs channels
99	63	c	
100	64	d	
101	65	e	Set hor/ver Tab increment
102	66	f	Paperfeed/Tab execute
103	67	g	
104	68	h	
105	69	i	
106	6A	j	
107	6B	k	
108	6C	l	Set left margin
109	6D	m	Special character generator

***** ESC code functions *****

Dec	Hex	Ch	
110	6E	n	
111	6F	o	
112	70	p	Proportional on/off
113	71	q	
114	72	r	
115	73	s	Half speed on/off
116	74	t	
117	75	u	
118	76	v	
119	77	w	
120	78	x	Select draft/NLQ mode
121	79	y	
122	7A	z	
123	7B	{	
124	7C	|	
125	7D	}	
126	7E	~	
127	7F	del	Cancel last character

VT52 terminal escape codes

The following BIOS bconout() functions simulate a VT52 terminal, with extensions for colour, screen wrap etc.

Esc	Function	Comments
A	Cursor up	Up one line, no affect if at top
B	Cursor down	Down one line, no affect if at bottom
C	Cursor right	Right one position, no affect if at edge
D	Cursor left	Left one position, no affect if at edge
E	Clear screen	Clear screen and home cursor to column 0, row 0
H	Home cursor	Home cursor to column 0, row 0
I	Cursor up	Up one line, if at top scroll
J	Erase to eop	Erase to end of page from and including cursor position
K	Clear to eol	Clear to end of line from cursor position
L	Insert line	Insert blank line with cursor at start of line. Move current line down
M	Delete line	Delete cursor line and move remaining lines up one, put blank at bottom.
Y,r,c	Cursor r,c	Position cursor at row r column c
b,f	fgd colour f	Colour is the 4 lsb of colour byte
c,b	bgd colour b	Colour is the 4 lsb of colour byte
d	Erase to start of page	Erase to start of page including the current cursor position
e	Show cursor	Show cursor
f	Hide cursor	Hide cursor
j	Save cursor	Save the cursor position
k	Restore cursor	Restore cursor, home if no saved posn
l	Erase line	Erase line and move cursor left edge
o	Erase to start of line	Erase to start of line from and including the cursor
p	Reverse video	Enter reverse video mode
q	Normal video	Exit reverse video mode
v	Wrap at end of line	Wrap at end of line and scroll up if necessary
w	Discard end of line	Overprint line end character with the next character

Printers

In general an Atari printer that is designed to work with the ST will provide the most suitable path to trouble free computer/printer interfacing and the production of hard copy printout and screen dumps. Where a printer from another manufacturer is to be used, the following may be of use:

If screen dumps are required, the code 1B 4C (27 76 dec) should be recognized as 'double density bit image mode' for printing 960 dots/line at 120 dots/inch on 8" wide paper (the dump is virtually the same size as the monitor screen display) or code 1B 59 (27 89 dec) for the wider paper screen dumps.

It may reasonably be assumed that whatever word processor you employ, it will provide the necessary print configuration file to make available the printers facilities. Double clicking a non-executable file icon to print it's contents should not cause problems as control codes are not sent within the text. The ST does however precede the file with the code to select draft or NLQ (near letter quality) print, i.e ESC,"x",n.

Some serial printers are restricted to 2400 and 600 baud operation, the ST supports neither rate without recource to C or assembly language programming.

Appendix D

Keycode definitions

Note that the keycodes returned do differ for the different international keyboards.

ASCII codes 0 to 127

Dec	Ascii	Dec	Ascii	Dec	Ascii	Dec	Ascii
0	NUL	32	SPACE	64	@	96	’
1	SOH	33	!	65	A	97	a
2	STX	34	"	66	B	98	b
3	ETX	35	#	67	C	99	c
4	EOT	36	$	68	D	100	d
5	ENQ	37	%	69	E	101	e
6	ACK	38	&	70	F	102	f
7	BEL	39	’	71	G	103	g
8	BS	40	(	72	H	104	h
9	HT	41	)	73	I	105	i
10	LF	42	*	74	J	106	j
11	VT	43	+	75	K	107	k
12	FF	44	,	76	L	108	l
13	CR	45	-	77	M	109	m
14	SO	46	.	78	N	110	n
15	SI	47	/	79	O	111	o
16	DLE	48	0	80	P	112	p
17	DC1	49	1	81	Q	113	q
18	DC2	50	2	82	R	114	r
19	DC3	51	3	83	S	115	s
20	DC4	52	4	84	T	116	t
21	NAK	53	5	85	U	117	u
22	SYN	54	6	86	V	118	v
23	ETB	55	7	87	W	119	w
24	CAN	56	8	88	X	120	x
25	EM	57	9	89	Y	121	y
26	SUB	58	:	90	Z	122	z
27	ESC	59	;	91	[	123	{
28	FS	60	<	92	\	124	|
29	GS	61	=	93	]	125	}
30	RS	62	>	94	^	126	~
31	US	63	?	95	_	127	DEL

GSX compatible keyscan codes

. Code Dec	Hex	Keytop
1	01	ESC
2	02	1
3	03	2
4	04	3
5	05	4
6	06	5
7	07	6
8	08	7
9	09	8
10	0A	9
11	0B	0
12	0C	-
13	0D	CR
14	0E	BS
15	0F	TAB
16	10	Q
17	11	W
18	12	E
19	13	R
20	14	T
21	15	Y
22	16	U
23	17	I
24	18	O
25	19	P
26	1A	[
27	1B	]
28	1C	RET
29	1D	CNTL
30	1E	A
31	1F	S
32	20	D
33	21	F
34	22	G
35	23	H
36	24	j
37	25	k

. Code Dec	Hex	Keytop
38	26	L
39	27	;
40	28	'
41	29	`
42	2A	left shift
43	2B	\
44	2C	Z
45	2D	X
46	2E	C
47	2F	V
48	30	B
49	31	N
50	32	M
51	33	,
52	34	.
53	35	/
54	36	right shift
55	37	n.u
56	38	ALT
57	39	space bar
58	3A	caps lock
59	3B	F1
60	3C	F2
61	3D	F3
62	3E	F4
63	3F	F5
64	40	F6
65	41	F7
66	42	F8
67	43	F9
68	44	F10
69	45	n.u
70	46	n.u
71	47	HOME
72	48	up arrow
73	49	n.u
74	4A	kpd -

. Code Dec	Hex	Keytop
75	4B	left arrow
76	4C	n.u
77	4D	right arrow
78	4E	kpd +
79	4F	n.u
80	50	down arrow
81	51	n.u
82	52	INSERT
83	53	DEL
84	54	n.u to
95	5F	n.u
96	60	ISO key
97	61	UNDO
98	62	HELP
99	63	kpd (
100	64	kpd)
101	65	kpd /
102	66	kpd *
103	67	kpd 7
104	68	kpd 8
105	69	kpd 9
106	6A	kpd 4
107	6B	kpd 5
108	6C	kpd 6
109	6D	kpd 1
110	6E	kpd 2
111	6F	kpd 3
112	70	kpd 0
113	71	kpd .
114	72	kpd ENTER
115	73	n.u
116	74	left_m/jstk_0
117	75	rt_m/jstk_1

UK Keyboard

43	2B	#
96	60	\

Returned highword lowbyte from the BDOS c_conin function

n.u = not used   xx_m/jstk_1=mouse/joystick button

GEM VDI standard keyboard codes

High byte	Low byte	Character	High byte	Low byte	Character	High byte	Low byte	Character
03	00	Ctl_2	39	20	space	03	40	@
1E	01	Ctl_A	02	21	!	1E	41	A
30	02	Ctl_B	28	22	"	30	42	B
2E	03	Ctl_C	2B/04	23	#	2E	43	C
20	04	Ctl_D	05	24	$	20	44	D
12	05	Ctl_E	06	25	%	12	45	E
21	06	Ctl_F	08	26	&	21	46	F
22	07	Ctl_G	28	27	'	22	47	G
23	08	Ctl_H	0A	28	(	23	48	H
17	09	Ctl_I	0B	29	)	17	49	I
24	0A	Ctl_J	09	2A	*	24	4A	J
25	0B	Ctl_K	0D	2B	+	25	4B	K
26	0C	Ctl_L	33	2C	,	26	4C	L
32	0D	Ctl_M	0C	2D	-	32	4D	M
31	0E	Ctl_N	34	2E	.	31	4E	N
18	0F	Ctl_O	35	2F	/	18	4F	O
19	10	Ctl_P	0B	30	0	19	50	P
10	11	Ctl_Q	02	31	1	10	51	Q
13	12	Ctl_R	03	32	2	13	52	R
1F	13	Ctl_S	04	33	3	1F	53	S
14	14	Ctl_T	05	34	4	14	54	T
16	15	Ctl_U	06	35	5	16	55	U
2F	16	Ctl_V	07	36	6	2F	56	V
11	17	Ctl_W	08	37	7	11	57	W
2D	18	Ctl_X	09	38	8	2D	58	X
15	19	Ctl_Y	0A	39	9	15	59	Y
2C	1A	Ctl_Z	27	3A	:	2C	5A	Z
1A	1B	Ctl_[	27	3B	;	1A	5B	[
2B	1C	Ctl_\	33	3C	<	2B	5C	\
1B	1D	Ctl_]	0D	3D	=	1B	5D	]
07	1E	Ctl_6	34	3E	>	07	5E	^
0C	1F	Ctl_-	35	3F	?	0C	5F	underscore

GEM VDI standard keyboard codes cont.

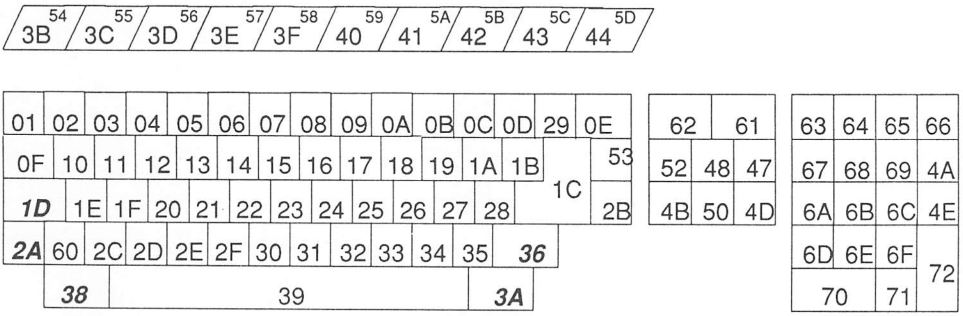
High byte	Low byte	Character	High byte	Low byte	Character	High byte	Low byte	Character
29	60	'	81	00	Alt_0	11	00	Alt_W
1E	61	a	78	00	Alt_1	2D	00	Alt_X
30	62	b	79	00	Alt_2	15	00	Alt_Y
2E	63	c	7A	00	Alt_3	2C	00	Alt_Z
20	64	d	7B	00	Alt_4	3B	00	F1
12	65	e	7C	00	Alt_5	3C	00	F2
21	66	f	7D	00	Alt_6	3D	00	F3
22	67	g	7E	00	Alt_7	3E	00	F4
23	68	h	7F	00	Alt_8	3F	00	F5
17	69	i	80	00	Alt_9	40	00	F6
24	6A	j	1E	00	Alt_A	41	00	F7
25	6B	k	30	00	Alt_B	42	00	F8
26	6C	l	2E	00	Alt_C	43	00	F9
32	6D	m	20	00	Alt_D	44	00	F10
31	6E	n	12	00	Alt_E	54	00	Shf_F1
18	6F	o	21	00	Alt_F	55	00	Shf_F2
19	70	p	22	00	Alt_G	56	00	Shf_F3
10	71	q	23	00	Alt_H	57	00	Shf_F4
13	72	r	17	00	Alt_I	58	00	Shf_F5
1F	73	s	24	00	Alt_J	59	00	Shf_F6
14	74	t	25	00	Alt_K	5A	00	Shf_F7
16	75	u	26	00	Alt_L	5B	00	Shf_F8
2F	76	v	32	00	Alt_M	5C	00	Shf_F9
11	77	w	31	00	Alt_N	5D	00	Shf_F10
2D	78	x	18	00	Alt_O	5E	00	* F21
15	79	y	19	00	Alt_P	5F	00	* F22
2C	7A	z	10	00	Alt_Q	60	00	* F23
1A	7B	{	13	00	Alt_R	61	00	* F24
60/2B	7C	|	1F	00	Alt_S	62	00	* F25
1B	7D	}	14	00	Alt_T	63	00	* F26
29	7E	~	16	00	Alt_U	64	00	* F27
0E	7F	DEL	2F	00	Alt_V	65	00	* F28

* These scan codes are not supported by the Atari ST BIOS

GEM VDI standard keyboard codes cont.

High byte	Low byte	Character
66	00	* F29
67	00	* F30
68	00	* F31
69	00	* F32
6A	00	* F33
6B	00	* F34
6C	00	* F35
6D	00	* F36
6E	00	* F37
6F	00	* F38
70	00	* F39
71	00	* F40
73	00	Ctl_ left arrow
4D	00	Right arrow
4D	36	Shft right arrow
74	00	Ctl_ right arrow
50	00	Down arrow
50	32	Shift down arrow
48	00	up arrow
48	38	Shift up arrow
51	00	* Page down
51	33	* Shift page down
76	00	* Ctl_ page down
49	00	* Page up
49	39	* Shift page up
84	00	* Ctl_ page up
77	00	Ctl_ home
47	00	Home
47	37	Shift home
52	00	Insert
52	30	Shift insert
53	00	Delete
53	2E	Shift delete
72	00	* Ctl_ print screen
37	2A	* Print screen
01	1B	Escape
0E	08	Backspace
82	00	Alt_-
83	00	Alt_=
1C	0D	CR
1C	0A	Ctl_ cr
4C	35	Shift number pad 5
4A	2B	Number pad -
4E	2B	Number pad +
0F	09	Tab
0F	00	* Backtab
4B	00	Left arrow
4B	34	Shift left arrow
4F	00	* End
4F	31	* Shift end
75	00	* Ctl end

* These scan codes are not supported by the Atari ST BIOS


54 55 56 57 58 59 5A 5B 5C 5D
3B 3C 3D 3E 3F 40 41 42 43 44
01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 29 0E
0F 10 11 12 13 14 15 16 17 18 19 1A 1B 1C 53
1D 1E 1F 20 21 22 23 24 25 26 27 28 2B
2A 60 2C 2D 2E 2F 30 31 32 33 34 35 36
38 39 3A
62 61
52 48 47
4B 50 4D
63 64 65 66
67 68 69 4A
6A 6B 6C 4E
6D 6E 6F 72
70 71

Appendix E

List of callable functions

List of callable functions

BIOS calls (Trap #13)

Code Dec	Hex		Function	Pg. #
0	00	getmpb	Get and fill memory parameter block	3.4
1	01	bconstat	Return character-device input status	3.4
2	02	bconin	Input character to device, return when done	3.4
3	03	bconout	Output character to device, return when done	3.4
4	04	rwabs	Read/write logical sectors from/to device	3.5
5	05	setexc	Get or set vector number	3.5
6	06	tickcal	Return system timer value (ms)	3.5
7	07	getbpb	Return pointer to BIOS parameter block	3.5
8	08	bcostat	Return character output device status	3.5
9	09	mediach	Check for media change	3.5
10	0A	drvmap	Get/set bit map and logical drives	3.6
11	0B	kbshft	Set keyboard shift bits	3.6

Callable from user mode, re-entrant to three levels

Device =	0_Printer,	parallel port
	1_Aux,	RS232 port
	2_Con,	screen
	3_Midi	
	4_Keyboard	

XBIOS calls (Trap #14)

Code Dec	Hex		Function	Pg. #
0	00	inimous	Initialize mouse packet handler	3.7
1	01	ssbrk	Reserve X bytes from top memory	3.7
2	02	_physbase	Get screens physical base address	3.7
3	03	_logbase	Get screens logical base	3.8
4	04	_getRez	Get screens current resolution	3.8
5	05	_setScreen	Set screen logical location	3.8
6	06	_setPalette	Set hardware palette registers	3.8
7	07	_setcolor	Set the palette number	3.8
8	08	_floprd	Read sectors from floppy disk	3.8
9	09	_flopwr	Write sectors to floppy disk	3.9

XBIOS calls (Trap #14) cont.

. Code Dec	Hex		Function	Pg. #
10	0A	_flopfmt	Format floppy disk	3.9
11	0B	getdsb	Get device status block pointer	3.9
12	0C	midiws	Write string to MIDI port	3.9
13	0D	_mfpint	Set MFP interrupt number	3.9
14	0E	iorec	Return pointer to serial device buffer record	3.10
15	0F	rsconf	Configure RS232 port	3.10
16	10	keytbl	Set/get pointer to keyboard translation table	3.10
17	11	_random	Return 24 bit pseudo random number	3.10
18	12	_protobt	Prototype image boot sector	3.11
19	13	_flopver	Verify sectors from floppy	3.11
20	14	scrdmp	Dump screen to printer	3.11
21	15	cursconf	Get/set cursor blink/attributes	3.11
22	16	settime	Set keyboard time and date	3.11
23	17	gettime	Get time and date from keyboard	3.11
24	18	bioskeys	Restore keyboard translation tables	3.12
25	19	ikbdws	Write string to interrupt keyboard	3.12
26	1A	jdisint	Disable interrupt # on MK68901	3.12
27	1B	jenabint	Enable interrupt # on MK68901	3.12
28	1C	giaccess	Read/write sound chip register	3.12
29	1D	offgibit	Set port A bit to 0 atomically	3.12
30	1E	ongibit	Set port A bit to 1 atomically	3.12
31	1F	xbtimer	Set MFP timers and control registers	3.12
32	20	dosound	Set pointer to sound command bytes	3.13
33	21	setprt	Set/get printer configuration byte	3.13
34	22	kbdvbase	Return pointer to keyboard structure	3.13
35	23	kbrate	Get/set keyboard repeat rate	3.13
36	24	_prtblk	Hard copy routine	3.14
37	25	vsync	Wait for next vblank	3.14
38	26	supexec	Execute in super mode	3.14
39	27	puntaes	Throw away AES	3.14
64	40	blitmode	Get/set blitter status	3.14

Callable from user mode.

GEMDOS calls (Trap #1)

. Code Dec	Hex		Function	Pg. #
0	00	p_term_o	Terminate process (use $4c)	3.15
1	01	c_conin	Read character from standard input	3.15
2	02	c_conout	Write character to standard output	3.15
3	03	c_auxin	Read character from aux device	3.15
4	04	c_auxout	Write character to aux device	3.15
5	05	c_prnout	Write character to standard print device	3.15
6	06	c_rawio	Raw input to standard input	3.16
7	07	c_rawcin	Raw input from standard input	3.16
8	08	c_necin	Read character from standard input -no echo	3.16
9	09	c_conws	Write null terminated string to standard o/p	3.16
10	0A	c_conrs	Read editted string from standard input	3.16
11	0B	c_conis	Check status of standard input	3.16
14	0E	d_setdrv	Set default drive	3.16
16	10	c_conos	Check status of standard output	3.16
17	11	c_prnos	Check status standard print device	3.16
18	12	c_auxis	Check status standard aux device input	3.16
19	13	c_auxos	Check status standard aux device output	3.17
25	19	d_getdrv	Get current drive	3.17
26	1A	f_setdta	Set disk transfer address	3.17
42	2A	t_getdate	Get date	3.17
43	2B	t_setdate	Set date	3.17
44	2C	t_gettime	Get time	3.17
45	2D	t_settime	Set time	3.17
47	2F	f_getdta	Get disk transfer address	3.17
48	30	s_version	Get version number	3.17
49	31	p_termres	Terminate and stay resident	3.17
54	36	d_free	Get drive free space	3.18
57	39	d_create	Create a subdirectory	3.18
58	3A	d_delete	Delete a subdirectory	3.18
59	3B	d_setpath	Set current directory	3.18
60	3C	f_create	Create a file	3.18
61	3D	f_open	Open file	3.18
62	3E	f_close	Close file	3.18
63	3F	f_read	Read file	3.19
64	40	f_write	Write file	3.19
65	41	f_delete	Delete file	3.19
66	42	f_seek	Seek file pointer	3.19
67	43	f_attrib	Get/Set file attribute	3.19
69	45	f_dup	Duplicate file handle	3.19

GEMDOS calls (Trap #1) cont.

. Code Dec	Hex		Function	Pg. #
70	46	f_force	Force file handle	3.20
71	47	d_getpath	Get current directory	3.20
72	48	m_alloc	Allocate memory	3.20
73	49	m_free	Free allocated memory	3.20
74	4A	m_shrink	Shrink size of allocated memory	3.20
75	4B	p_exec	Load or execute a process	3.20
76	4C	p_term	Terminate process	3.21
78	4E	f_sfirst	Search for first occurrence of filespec	3.21
79	4F	f_snext	Search for next occurrence of filespec	3.21
86	56	f_rename	Rename a file	3.21
87	57	f_datime	Get/set file date and time stamp	3.22
32	20	smode	Set/get supervisor/user mode	3.23

Extended BDOS call (Trap #2)

. Code Dec	Hex		Function	Pg. #
0	00	System reset	System/program control	3.25
115	73		VDI access	3.25
200	c8		AES access	3.25
201	c9			
-2	fe		GDOS version test	3.25

J

GEM VDI functions

Op code	Definition		Screen	Printer	Plotter	Metafile	Pg. #
*1	Open workstation	) Use virtual	x	x	x	x	4.5
*2	Close workstation	) workstation	x	x	x	x	4.9
3	Clear workstation		x	x	x	x	4.9
4	Update workstation		x	x	x	x	4.9
5	Escape code						
	1 Inquire address of character cells		x	x	x	x	4.27
	2 Exit alpha mode		x			x	4.27
	3 Enter alpha mode		x			x	4.27
	4 Cursor up		x				4.27
	5 Cursor down		x				4.27
	6 Cursor right		x				4.27
	7 Cursor left		x				4.27
	8 Home cursor		x				4.27
	9 Erase to screen end		x				4.28
	10 Erase to line end		x				4.28
	11 Direct cursor address		x				4.28
	12 Output cursor addressable text		x				4.28
	13 Reverse video on		x				4.28
	14 Reverse video off		x				4.28
	15 Inquire current alpha cursor address		x				4.28
	16 Inquire tablet status				x		4.29
	17 Hard copy			x			4.29
	18 Place graphic cursor		x				4.29
	19 Remove last graphic cursor		x				4.29
	*20 Form advance			x		x	4.30
	*21 Output window			x		x	4.30
	*22 Clear display list			x		x	4.30
	*23 Output bit image file			x		x	4.30
	*60 Select palette					x	4.30
	*91 Inquire palette film types					x	4.31
	*92 Inquire palette driver state					x	4.31
	*93 Set palette driver state					x	4.31
	*94 Save palette driver state					x	4.31
	*95 Suppress palette messages					x	4.31
	*96 Palette error inquire					x	4.32
	*98 Update metafile extents					x	4.32
	*99 Write metafile item					x	4.32
	*100 Change GEM VDI filename					x	4.32

* Not implemented on the Atari ST

GEM VDI functions cont.

Op code	Definition	Screen	Printer	Plotter	Metafile	Pg. #
6	Polyline	x	x	x	x	4.10
7	Polymarker	x	x	x	x	
8	Text	x	x	x	x	
9	Filled area	x	x	x	x	
10	Cell array	x	x	x	x	
11	Escape code — Generalized drawing primitives (GDP)					
	1 Bar	x	x	x	x	4.11
	2 Arc	x	x	x	x	
	3 Pie	x	x	x	x	
	4 Circle	x	x	x	x	
	5 Ellipse	x	x	x	x	
	6 Elliptical arc	x	x	x	x	
	7 Elliptical pie	x	x	x	x	4.12
	8 Rounded rectangle	x	x	x	x	
	9 Filied rounded rectangle	x	x	x	x	
	10 Justified graphics text	x	x	x	x	
12	Set character height absolute mode	x	x	x	x	4.14
13	Set character baseline vector	x			x	
14	Set colour representation	x			x	4.13
15	Set polyline linetype	x	x	x	x	
16	Set polyline line width	x			x	
17	Set polyline colour index	x	x	x	x	
18	Set polymaker type	x	x	x	x	4.14
19	Set polymarker height	x			x	
20	Set polymarker colour index	x	x	x	x	
21	Set text face	x	x	x	x	
22	Set text colour index	x	x	x	x	
23	Set fill interior style	x	x	x	x	4.15
24	Set fill style index	x	x	x	x	4.15
25	Set fill colour index	x	x	x	x	4.15
26	Inquire colour representation	x	x	x		4.23
27	Inquire cell array	x			x	4.25
* 28	Input locator	x			x	4.20
* 29	Input valuator, request/sample	x			x	4.20
* 30	Input choice, request/sample	x			x	4.21
* 31	Input string	x			x	4.21
32	Set writing mode	x	x		x	4.13
* 33	Set input mode	x			x	4.20

* Not implemented on the Atari ST

GEM VDI functions cont.

Op code	Definition	Screen	Printer	Plotter	Metafile	Pg. #
35	Inquire current polyline attributes	x	x	x	x	4.23
36	Inquire current polymarker attributes	x	x	x	x	4.23
37	Inquire current fill area attributes	x	x	x	x	4.23
38	Inquire current graphic text attributes	x	x	x	x	4.24
39	Set graphic text alignment	x	x	x	x	4.15
100	Open virtual screen workstation	x				4.9
101	Close virtual screen workstation	x				4.9
102	Extended inquire function	x	x	x	x	4.22
103	Contour fill				x	4.10
104	Set fill perimeter visibility	x	x	x	x	4.15
105	Inquire pixel					4.17
106	Set graph text special effects	x	x		x	4.15
107	Set character cell height, points mode	x	x	x	x	4.14
108	Set polyline and styles	x	x	x	x	4.13
109	Copy raster, opaque	x				4.17
110	Transform form	x				4.17
111	Set mouse form	x				4.18
112	Set user-defined fill pattern	x	x		x	4.15
113	Set user-defined linestyle	x			x	4.13
114	Fill rectangle	x			x	4.10
115	Inquire input mode	x				4.25
116	Inquire text extent	x	x	x		4.24
117	Inquire character cell width	x	x	x	x	4.24
118	Exchange timer interrupt vector	x				4.18
119	Load fonts	x				4.9
120	Unload fonts	x				4.9
121	Copy raster, transparent	x				4.17
122	Show cursor	x				4.18
123	Hide cursor	x				4.18
124	Sample mouse button state	x		x		4.18
125	Exchange button change vector	x				4.18
126	Exchange mouse movement vector	x				4.19
127	Exchange cursor change vector	x				4.19
128	Sample keyboard state information	x				4.19
129	Set clipping rectangle	x	x		x	4.9
130	Inquire facename and index	x	x	x		4.24
131	Inquire current face information	x	x	x	x	4.25

The standard range of VDI function output devices include a camera and a tablet as well as the screen, printer, plotter and metafile; Only the screen is implemented in the Atari ST.

GEM AES function calls

Op#	Description		Pg #
Application library routines			
10	Initialise application	APPL_INIT	5.6
11	Read message from pipe	APPL_READ	5.6
12	Write message to pipe	APPL_WRITE	5.6
13	Find another application	APPL_FIND	5.6
14	Playback GEM recording	APPL_TPLAY	5.7
15	Record GEM session	APPL_TRECORD	5.7
19	Cleanup and exit	APPL_EXIT	5.7
Timer event routines			
20	Waiting for keyboard input	EVNT_KEY	5.8
21	Waiting for button input	EVNT_BUTTON	5.8
22	Waiting for mouse input	EVNT_MOUSE	5.8
23	Waiting for message input	EVNT_MESAG	5.9
24	Waiting period	EVNT_TIMER	5.9
25	Waiting for multi-events	EVNT_MULTI	5.10
26	Get/set mouse clickrate	EVNT_DCLICK	5.10
Menu library routines			
30	Toggle applicatn menu bar	MENU_BAR	5.12
31	Toggle menu check mark	MENU_ICHECK	5.12
32	Toggle menu item able	MENU_IENABLE	5.12
33	Toggle display video	MENU_TNORMAL	5.12
34	Change item menu text	MENU_TEXT	5.12
35	Put accessry's menu in desk	MENU_REGISTER	5.12
Object library routines			
40	Add object to tree	OBJC_ADD	5.18
41	Delete object from tree	OBJC_DELETE	5.18
42	Draw an object or tree	OBJC_DRAW	5.18
43	Find object under mouse	OBJC_FIND	5.18
44	Compute object offset	OBJC_OFFSET	5.18
45	Change object tree order	OBJC_ORDER	5.19
46	Edit objects text	OBJC_EDIT	5.19
47	Change objects state	OBJC_CHANGE	5.19

GEM AES function calls cont.

Op#	Description		Pg #
Form library routines			
50	Monitor user/form	FORM_DO	5.20
51	Toggle dialog boxes	FORM_DIAL	5.20
52	Display alert box	FORM_ALERT	5.20
53	Display error box	FORM_ERROR	5.20
54	Centre dialog box	FORM_CENTER	5.20
Graphics library routines			
70	Draw a rubber box	GRAF_RUBBERBOX	5.24
71	Drag a box around	GRAF_DRAGBOX	5.24
72	Draw moving box	GRAF_MOVEBOX	5.24
73	Draw expanding outline	GRAF_GROWBOX	5.25
74	Draw shrinking outline	GRAF_SHRINKBOX	5.25
75	Test for mouse inside	GRAF_WATCHBOX	5.25
76	Slide box in parent	GRAF_SLIDEBOX	5.25
77	Return screen handle	GRAF_HANDLE	5.26
78	Redefine mouse form	GRAF_MOUSE	5.26
79	Return mouse attributes	GRAF_MKSTATE	5.26
Scrap library routines			
80	Read clipboard directory	SCRP_READ	5.27
81	Write directory to clipboard	SCRP_WRITE	5.27
File selector routines			
90	Display file selector box	FSEL_INPUT	5.28
Window library routines			
100	Allocate full window	WIND_CREATE	5.29
101	Open window to size	WIND_OPEN	5.29
102	Close window	WIND_CLOSE	5.29
103	Deallocate window	WIND_DELETE	5.29
104	Get window data	WIND_GET	5.30
105	Set window data	WIND_SET	5.30
106	Find mouse window	WIND_FIND	5.32
107	Update window	WIND_UPDATE	5.32
108	Calculate window data	WIND_CALC	5.32

GEM AES function calls cont.

Op#	Description		Pg #
Resource library routines			
110	Load resource file	RSRC_LOAD	5.35
111	Deallocate resource file	RSRC_FREE	5.35
112	Get structure address	RSRC_GADDR	5.35
113	Save structure index	RSRC_SADDR	5.35
114	Convert charaters to pixels	RSRC_OBFIX	5.35
Shell library routines			
120	Find how created	SHEL_READ	5.37
121	Exit AES or run other	SHEL_WRITE	5.37
122	Get data	SHEL_GET	5.37
123	Put data	SHEL_PUT	5.37
124	Find filename path	SHEL_FIND	5.37
125	Find parameter address	SHEL_ENVRN	5.37

Intelligent keyboard (ikbd) command set

Code Dec	Hex	Command	Function	Pg. #
128	80	Reset	Return keyboard to power-up status	6.3
1	01		without affecting the clock.	
			A break of 200ms also causes a reset	
7	07	Set mouse button action		6.3
8	08	Set mouse relative position reporting		6.3
9	09	Set mouse absolute positioning		6.3
10	0A	Set mouse keycode mode		6.3
11	0B	Set mouse threshold		6.3
12	0C	Set mouse scale		6.3
13	0D	Interrogate mouse position		6.3
14	0E	Load mouse position		6.4
15	0F	Set Y = 0 at bottom		6.4
16	10	Set Y = 0 at top		6.4
17	11	Resume		6.4
18	12	Disable mouse		6.4
19	13	Pause output		6.4
20	14	Set joystick event reporting		6.4
21	15	Set joystick interrogation mode		6.4
22	16	Joystick interrogation		6.4
23	17	Set joystick monitoring		6.4
24	18	Set fire button monitoring		6.4
25	19	Set joystick keycode mode		6.5
26	1A	Disable joysticks		6.5
27	1B	Set time of day clock		6.5
28	1C	Interrogate time of day clock		6.5
32	20	Memory load		6.5
33	21	Memory read		6.6
34	22	Controller execute		6.6
OR 80		Status inquiries	(OR 80H with command)	6.6

The status of the keyboard can be determined by interrogating the status register in the configuration tables.

Line-A routines

Dec	Hex	Line-A function	Pg. #
20480	A000	Initialization	7.3
20481	A001	Put pixel	7.3
20482	A002	Get pixel	7.3
20483	A003	Line	7.3
20484	A004	Horizontal line	7.3
20485	A005	Filled rectangle	7.4
20486	A006	Line_by_line filled polygon	7.4
20487	A007	BitBlt (including half tone source patterns)	7.5
20488	A008	TextBlt (all 16 BitBlt logic operations)	7.5
20489	A009	Show mouse	7.5
20490	A00A	Hide mouse	7.5
20491	A00B	Transform mouse	7.6
20492	A00C	Undraw sprite	7.6
20493	A00D	Draw sprite	7.6
20494	A00E	Copy raster form	7.6
20495	A00F	Contour fill	7.6

Appendix F

Parameter blocks

System

System start-up block

0	$00	*Reseth*	Branch to reset handler	
2	$02	*Vers*	OS version number	
4	$04	*Reseth*	System reset handler	
8	$08	*Ostext*	Base of Operating system	\
12	$0C	*Endos*	End of OS memory used	I Pointers
16	$10	*Reseth*	Default shell	/
20	$14	*Magic*	Verification number or zero	
24	$18	*Date*	System build date	

Boot sector parameter block

0	$00	*BRA.S*	Branch to boot code
2	$02	*OEM's space*	Reserved for OEMs use
8	$08	*Vol ser #*	24 bit volume serial number
11	$0B	*BPS*	Number of bytes/sector
13	$0D	*SPCs*	Number of sectors/cluster
14	$0E	*RES*	Number of reserved sectors
16	$10	*NFATS*	Number of file alocation tables
17	$11	*NDIRS*	Number of directory entries
19	$13	*NSECTS*	Number of sectors on media
21	$15	*MEDIA*	Media descriptor - not used
22	$16	*SPF*	Number of sectors/FAT
24	$18	*SPT*	Number of sectors/track
26	$1A	*NSIDES*	Number of sides on media
28	$1C	*NHID*	Number of hidden sectors-not used
30	$1E	*boot code*	Start of code, if any ?
511	$1FE	*last word*	Used for checksum
512	$200		

Device drivers

Each device has one driver (Device control block-DCB) that contains entry points to routines and constants used by the systems to initialize the device's state during a warm-start. The routines and constants are defined as follows:

Device driver

0	$00	*BREAD*	Read sector
4	$04	*BWRITE*	Write sector
8	$08	*BINIT*	Initialize drive (warm start)
12	$0C	*BFORMAT*	Format drive
16	$10	*BINTR*	Vblank call (time-out homing)
20	$14	*BRDTRK*	Read track
24	$18	*BWRTRK*	Write track
28	$1C	*BXLATE*	Logical to physical translate
32	$20	*BCVSIZ*	CSV size allocation
34	$22	*BALVSIZ*	ALV size allocation
38	$26	*BDEFINFO*	Default information block
42	$2A		

Device drivers are stored in RAM in a device state block (DSB), the DSB contains TOS specific data structures (the DPB and DPH) and device specific information, such as the number of tracks, head seek rate. The DSB is allocated during a warm-start.

Device state block

0	$00	*DDPH*	Device parameter header
26	$1A	*DDPB*	Disk parameter block
42	$2A	*DINFOSIZ*	DSB size (not incl DDPH)
44	$2C	*DPHYSDEV*	Device physical number
46	$2E	*DNTRACKS*	Number of tracks on device
48	$30	*DSPT*	Number of sectors/track
50	$32	*DNSIDES*	Number of sides/device
52	$34	*DSEEKRT*	Floppy seek rate
54	$36		

Floppy parameter block

0	$00	*Flock*	Floppy lock return address
4	$04	*Cret*	Callers return address
8	$08	*Dmapn*	DMA pointer
12	$0C		Obsolete
16	$10	*Devno*	Device number
18	$12	*Secno*	Sector number
20	$14	*Trkno*	Track number
22	$16	*Sidno*	Side number
24	$18	*Secnt*	Sector count
26	$1a		

Sector buffer block

0	$00	*BNEXT*	Next buffer or null
4	$04	*BBUF*	Size of buffer (512 bytes)
8	$08	*BLRU*	LRU replacement value
12	$0C	*BFLAGS*	Valid/dirty flags
14	$0E	*BDEV*	Device number
16	$10	*BTRACK*	Track number
18	$12	*BSIDE*	Side number
20	$14	*BSSECT*	Start sector number
22	$16	*BESECT*	End sector number
24	$18	*BPSECT*	Physical sector number
26	$1A	*BSIZE*	

Program parameter blocks

Transient program area block

	Low TPA	
Base page *Text*		To maintain maximum GEM DOS compatibility, free unused memory and lower top of stack (4A). Determine memory available and allocate it.
Data		
BSS		
Application user area	High TPA	

Load block

0	$00	Opened program file address
4	$04	Base address to load program
8	$08	Program end address +1
12	$0C	Address of Base Page
16	$10	Default user stack pointer
20	$14	Loader control flags 0_load at bottom 1_load at top
22	$16	

Base page format block

0	$00	*Low TPA*	Base address of TPA
4	$04	*Hi TPA*	End of TPA + 1
8	$08	*Tbase*	Base address of text
12	$0C	*Tlen*	Length of text
16	$10	*Dbase*	Base address of initialized data
20	$14	*Dlen*	Length of data
24	$18	*Bbase*	Base address of BSS uninitialized data
28	$1C	*Blen*	Length of BSS uninitialized data

Atari OS specific base page

32	$20		Length free memory after BSS		
36	$24		Drive from which program loaded		
37	$25		Reserved by BDOS		
56	$38		Second parsed FCB	\ Command	\ Set
92	$5C		First parsed FCB	/ line	I by
128	$80		Command tail and default DMA buffer		/ OS
	$FF		end		

GEMDOS specific base page

32	$20		DTA address pointer
36	$24		Parents Base Page pointer
40	$28		Reserved
44	$2C	*Environ*	Environment string pointer
128	$80	*Cmdline*	Command line image

File header

0	$00	*BRA.S flag*	/ 601AH data & BSS contiguous \ else 601BH
2	$02		Bytes in text segment
6	$06		Bytes in data segment
10	$0A		Bytes in BSS
14	$0E		Bytes in symbol table
18	$12		Zero (reserved)
22	$16		Start of text segment & program execution
26	$1A		Zero if no relocation bits

File header extension

(If BSS and data not contiguous:- Not supported by Atari OS)

28	$1C	Start address of data segment
32	$20	Start address of BSS
36	$24	

Memory parameter block

0	$00	Owner description	\
		# bytes in block	I Memory
		Start address of block	I descriptor
		Next link MD	/
		Roving pointer	
		Memory allocation list	
		Memory free list	

GEM parameter blocks

VDI parameter block

Longword addresses

0	$00	*contrl*	Control table pointer
4	$04	*intin*	I/P attribute table pointer
8	$08	*ptsin*	I/P points table pointer
12	$0C	*intout*	O/P attribute table pointer
16	$10	*ptsout*	O/P points table pointer
20	$14		

VDI control table

0	$00	*Op code*	Function op code			
2	$02	*L_ptsin*	I/P coordinate	\ Size in	\	
4	$04	*L_ptsout*	O/P coordinate	/ longwords	|	Table
6	$06	*W_intin*	I/P attribute	\ Size in	|	sizes
8	$08	*W_intout*	O/P attribute	/ words	/	
10	$0A		Subfunction identification number			
12	$0C		Device handle			
14	$0E		Op code dependent information			

AES parameter block

			Longword addresses
0	$00	*cntrl*	Control table pointer
4	$04	*global*	Global array pointer
8	$08	*int_in*	I/P attribute table pointer
12	$0C	*int_out*	I/P points table pointer
16	$10	*addr_in*	O/P attribute table pointer
20	$14	*addr_out*	O/P points table pointer
24	$18		

AES control table

0	$00	*Op code*	Function op code		
2	$02	*W_int_in*	I/P coordinate	\ Size in	\
4	$04	*W_int_out*	O/P coordinate	/ words	| Table
6	$06	*L_addr_in*	I/P attribute	\ Size in	| sizes
8	$08	*L_addr_out*	O/P attribute	/ longwords	/
10	$0A				

AES global array

0	$00	*version*	GEM AES version identification word
2	$02	*count*	Maximum #concurrent applications allowed
4	$04	*id*	Unique application identifier
6	$06	*private*	Longword user data
10	$0A	*ptree*	Resource address tree pointer
14	$0E	*reserved*	\
18	$12	*reserved*	| Zero
22	$16	*reserved*	|
26	$1A	*reserved*	/
30	$1E		

Line-A variables

Line-A parameter table

		Function	
0	$00	Number of video planes	\ Can produce special
2	$02	Number of bytes/video line /	effects.
4	$04	Pointer to Cntrl array	
8	$08	Pointer to Intin array	
12	$0C	Pointer to Ptsin array	
16	$10	Pointer to Intout array	
20	$14	Pointer to Ptsout array	
24	$18	Bit plane_0	\ current
26	$1A	Bit plane_1	I colour
28	$1C	Bit plane_2	I value
30	$1E	Bit plane_3	/
32	$20	-1	
34	$22	VDI line style equivalent	
36	$24	Writing mode 0_replace	1_transparent
		2_XOR mode	3_inverse transparent
38	$26	X1 coordinate	
40	$28	Y1 coordinate	
42	$2A	X2 coordinate	
44	$2C	Y2 coordinate	
46	$2E	Pointer to current fill pattern	
50	$32	Fill pattern mask	
52	$34	Multi-plane fill pattern	
		0_current fill pattern is single plane	
		1_current fill pattern is multi-plane	
$36	54	Clipping flag 0_no clipping	
$38	56	Minimum x clipping value	
$3A	58	Minimum y clipping value	
$3C	60	Maximum x clipping value	
$3E	62	Maximum y clipping value	
$40	64	Accumulator for textblt x dda, initialize to 8000H before each call	
$42	66	Textblt scale factor	
$44	68	Scale direction 0_down	

Line-A parameter table cont.

		Function
70	$46	Font status
		1_solid, 0_proportional or variable
72	$48	X coordinate of character in font form
74	$4A	Y coordinate of character in font form (typically 0)
76	$4C	X coordinate of character on screen
78	$4E	Y coordinate of character on screen
80	$50	Character width
82	$52	Character height
84	$54	Pointer to start of font data (font form)
88	$58	Width of font form
90	$5A	Style bit 0_Thicken, bit 1_lighten, bit 2_skew
		bit 3_underline (ignored), bit 4_outline
92	$5C	Lighten text mask
94	$5E	Skew text mask
96	$60	Text thickening additional width
98	$62	Offset above character baseline for skew
100	$64	Offset below character baseline for skew
102	$66	Scaling flag 0_no scaling
104	$68	Character rotation vector. 0_horizontal 900_vertically down etc.
106	$6A	.Text foreground colour
108	$6C	.Special effects buffer pointer
112	$70	.Scaling buffer offset in above buffer
114	$72	.Text background colour (RAM VDI only)
116	$74	Copy raster form type flag (RAM VDI only)
		0_opaque type, n-plane source to n-plane destination bitblt write mode
		<>0_transparent type single plane source to n-plane dest VDI write mode
118	$76	Abort fill routine pointer (Function not available on disk based versions of TOS)

Undocumented Line-A variables

The Line-A variables table contains other parameters that may be of use to the programmer. I refer to these variables as 'undocumented' although Atari do in fact list the variables in their reference material. These variables may change although it is unlikely.

		Function
-46	$D2	Pixel cell height. (Same as font form's height)
-44	$D4	Maximum number of cells across -1 (X)
-42	$D6	Maximum number of cells high -1 (Y)
-40	$D8	Byte offset next vertical cell. Screen width (byte)*Pixel cell height
-38	$DA	Physical colour index of background color.
-36	$DC	Physical colour index of foreground color.
-34	$DE	Current cursor address
-30	$E2	Byte offset from screen base to top of first cell
-28	$E4	Cursor position: cell x
-26	$E6	Cursor position: cell y
-24	$E8	Cursor flash interval (in frames)
-23	$E9	Cursor countdown timer
-22	$EA	Address of monospace font data. Each cell is 8 pixels wide and byte aligned. The data format is defined in the VDI chapter. The cells may be arbitrarily high.
-18	$EE	Last ascii code in font
-16	$F0	First ascii code in font
-14	$F2	Width of font form in bytes
-12	$F4	Maximum x pixel value
-10	$F6	Address of font offset table (per VDI spec)
-6	$FA	Alpha text status byte bit 0 cursor flash 0:disabled 1:enabled bit 1 flash state 0:off 1:on bit 2 cursor visibility 0:invisible 1:visible bit 3 end of line 0:overwrite 1:wrap bit 4 reverse video 0:on 1:off bit 5 cursor position saved 0:false 1:true
-04	$FC	Maximum y pixel value of the screen

Sprite definition block

0	$00	X offset of hot-spot		
2	$02	Y offset of hot-spot		
4	$04	Format flag		
6	$06	Background	\ Colour	
8	$08	Foreground	/ table index	
10	$0A	Interleaved		\ Background line 0
12	$0C	background/foreground		| Foreground line 0
		image of 32 words		|
74	$4A			/ Foreground line 16
76	$4C			

Format flag

+ve		-ve		Colour plotted
Fg	Bg	Fg	Bg	
0	0	0	0	Transparent
0	1	0	1	Background
1	1	1	1	Foreground
1	0			Foreground
		1	0	XOR screen

Memory form definition block (MFDB)

0	$00	*Memory pointer*	32-bit address of pixel 0,0
4	$04	*Width*	\ Raster area
8	$08	*Height*	/ dimensions
12	$0C	*Word width*	Pixel width/word size
16	$10	*Format flag*	1=standard, 0=device specific
20	$14	*Memory planes*	Number of planes in raster area
24	$18		\ Three
28	$1C		| reserved
32	$20		/ words
36	$24		

Header blocks

Cartridge header block

			Prefix to application header
252	$FC	*Flag*	#$ABCDEF42 program/data
		or	#$FA52255F diagnostic

Application header block

0	$00	*Next*	Link to next application
4	$04	*Flag/ init*	Pointer to initialize code or run flag (MSB)
8	$08	*Run*	Pointer to run code
12	$0C	*Time*	DOS-format \ Time/date
14	$0E	*Date*	DOS-format / application created
16	$10	*Size*	Application size
20	$14	*Name*	Application name (NNNNNNNN.EEE)

Run flag bit set:

0, Run before interrupt vectors and memory initialized
1, Run before GEMDOS initialized
2, unused
3, Run before disk boot
4, unused
5, Application is a desk accessory
6, Not a GEM application. No AES calls
7, Requires command line parameters before execution

Appendix G

MC68000 instruction summary

INSTRUCTION SUMMARY

Each Motorola MC68000 instruction is presented, many in terms of equivalent BASIC Instructions or assembler routines. The similes are for clarification of the use of each instruction; there is no access to the data or address registers (Dn or An respectively) or the condition codes from BASIC and therefore the examples which make use of these registers, and most of the effective address modes (ea), cannot be taken literally.

Instructions

ABCD: Add Binary Coded Decimal with Extend. Add two byte-sized binary coded decimal numbers and the Extend bit; a dollar sign is used to indicate a BCD number. Clear the extend bit and set the zero bit before performing this instruction which is limited to byte-size data register operations; multibyte additions are performed more easily in memory.

BCD addition		*DATA Register Addition Byte only*	*Memory Multibyte Addition*
			MOVE #4,CCR
$7	$27		ABCD -(A0),-(A1)
ABCD $6	ABCD $16	ABCD D0,D1	ABCD -(A0),-(A1)
$13	$43		ABCD -(A0),-(A1)

Note that the z-flag is cleared if the result is non-zero, otherwise it is unchanged and that in memory additions the data must be stored with the most significant digit lower in memory and the address pointers initially set to the byte above the low order BCD digit in memory, as the only available addressing mode is predecrement.

ADD: Add two integers, one of the integers must be the contents of a data register.

LET Dn = Dn + ea	ADD ea,Dn
LET ea = ea + Dn	ADD Dn,ea

Use ADD ea,Dn where the destination is a data register.
Use ADDA where the destination is an address register.
Use ADDI or ADDQ where the source is immediate data.

ADDA: Add the contents of the effective address to the contents of the destination address register.

LET An = An + ea   ADDA ea,An

ADDI: Add a constant value to the contents of the destination effective address. Use ADDQ for speed and small integers.

LET ea = ea + 999   ADDI #999,ea

ADDQ: Add a constant in the range of 1 to 8 to the contents of the effective address. Faster addition than ADDI.

LET ea = ea + 8   ADDQ #8,ea

ADDX: Add either register to register, or predecremented memory to memory, with extend. Use of the extend bit enables multiprecision arithmetic to be performed, the extend bit acting as a carry between successive operations.

Memory additions
ADDX -(Ay),-(Ax)
Where X infers the Extend bit
LET Ay = Ay - 4
LET Ax = Ax - 4
POKE(Ax), PEEK(Ax) +
PEEK(Ay) + X

Data register addition
Add two 64 bit integers
D0_D1 and D2_D3 Lo-Hi resply
ADD.L D0,D2 Low bits
ADDX.L D1,D3 High bits

Memory addition
MOVE #4,CCR
ADDX.L -(A0),-(A1)
ADDX.L -(A0),-(A1) etc.

Note that the z-flag is cleared if the result is non-zero, otherwise it is unchanged. For memory additions first clear the Extend bit and set the Zero flag. The data must be stored with the most significant digit lower in memory and the address pointers initially set the operand size above the low order digit in as the only addressing mode is predecrement.

AND: AND the source operand to the destination operand. The source AND data is normally used either (a) as a mask enabling a portion of the destination operand to be examined (bits are masked by 1's in the source); or (b) to clear bits by setting the corresponding bit in the source to a zero.

LET ea = Dn && ea	AND Dn,ea
LET Dn = src && Dn	AND ea,Dn

If src = 3, then AND src keeps bits 0 and 1 in Dn only, the others are set to zero.

Use AND ea,Dn where the destination is a data register.
Use ANDA where the destination is an address register.
Use ANDI where the source is immediate data.

ANDI: ANDI the immediate data to the destination effective address.

LET ea = data && ea	ANDI.W #512,D0 *Keep bit 9 of word only*

ANDI to CCR: ANDI the data to the condition code register.

LET CCR = 26 && CCR	ANDI #26,CCR

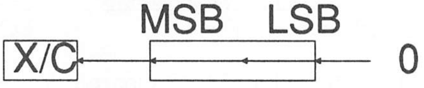
Normally bits can be tested via the condition codes without using the AND function as a mask. Here it is used to zero a bit position where there is a zero in the AND data; that is zero and carry (bits 0 and 2 in the CCR) are cleared.

ANDI to SR: ANDI the data to the status register is a privileged instruction and attempted access while in user mode will trap to the privilege violation exception vector.

LET SR = 63743 && SR	ANDI #63743,SR

Set the interrupt mask level to zero and leave unchanged the condition code and system flags.

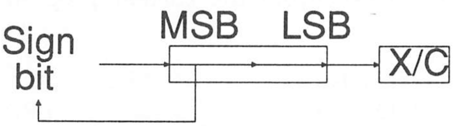
ASL: Arithmetically Shift Left the bits of the operand. The last MSB shifted sets the carry and extend bits; the LSB is set to zero each shift. The overflow bit is set if the sign is changed during the shift and is used to flag a change of sign. The instruction is used for fast multiplication of *2 and *4; other values should use MULS.



LET ea = ea * 2	ASL ea (shift 1)
LET Dy = Dy * (2^Dx)	ASL Dx,Dy (reg modulo 64)
LET Dy = Dy * (2^5)	ASL #5,Dy (shift 1 to 8)

The carry bit is cleared if the shift count is zero.

ASR: Arithmetically Shift Right the bits of the operand. The MSB sign bit is retained; the last LSB shifted is used to set the carry and extend bits. This instruction can be used for rapid integer division by 2, 4, 8 of signed numbers; use DIVS for other divisions.



LET ea = INT(ea/2)	ASR ea (shift 1)
LET Dy = INT(Dy/(2^Dx)	ASR Dx,Dy (reg modulo 64)
LET Dy = INT(Dy/(2^5)	ASR #5,Dy (shift 1 to 8)

The carry bit is cleared if the shift count is zero.

Bcc: Branch on condition a two's complement displacement from the current program counter position (Instruction address + 2) +126 to -128 for a short branch or +32766 to -32768 for a word branch operation, the condition cc may be:

Conditions				*Two's complement arithmetic*	
EQ	Equal To	CS	Carry Set	GT	Greater Than
NE	Not Equal	CC	Carry Clear	LT	Less Than
MI	Minus	VS	Overflow	GE	Greater Than or Equal to
PL	Plus	VC	No Overflow		
HI	Higher Than			LE	Less Than or Equal to
LS	Lower Than or same				

IF Dn = 0 THEN GOTO yy	BEQ #14
IF Dn 0 THEN GOTO label	BGT label

BCHG: A bit is tested and its state reversed. If the bit was zero before the test; that is clear, then the Zero flag is set, otherwise it is cleared.

IF BITn = 0 THEN set_Zflag:	
ELSE clear_Zflag	BCHG #6,ea (data modulo 8)
LET BITn = 1 - BITn	BCHG Dn,ea (reg modulo 32)

BCLR: A bit is tested and then cleared. If the bit was zero before the test; that is clear, then the Zero flag is set, otherwise it is cleared.

IF BITn = 0 THEN set_Zflag:	
ELSE clear_Zflag	BCLR #6,ea (data modulo 8)
LET BITn = 0	BCLR Dn,ea (reg modulo 32)

BRA: BRanch Always, a two's complement displacement branch either of +126 to -128 bytes by a single word instruction or of +32766 to -32768 bytes by a two-word instruction from the current program counter position (instruction address + 2).

GOTO label	BRA label
GOTO 1275	BRA #8

BSET: A bit is tested and then set. If the bit was zero before the test; that is clear, then the Zero flag is set, otherwise it is cleared.

IF BITn = 0 THEN set_Zflag:	
ELSE clear_Zflag	BSET #6,ea (data modulo 8)
LET BITn = 1 BSET	Dn,ea (reg modulo 32)

BSR: Branch to SubRoutine, either a two's complement displacement of +126 to -128 bytes by a single-word instruction, or of +32766 to -32768 bytes by a two-word instruction, from the current program counter position (instruction address +2). Return to the next instruction via an RTS from the subroutine.

GOSUB label	BSR label
GOSUB 1275	BSR #8

BTST: A bit is tested. If the bit was zero; that is clear, then the Zero flag is set, otherwise the Zero flag is cleared.

IF BITn = 0 THEN set_Zflag:	BTST #6,ea (data modulo 8)
ELSE clear_Zflag	BTST Dn,ea (reg modulo 32)

CHK: Check a data register low-order word against the two's complement upper bound of the source operand. If the register value is less than zero or greater than the test value, then jump to the CHK Trap exception vector.

```
IF Dn >  ea OR                      CHK ea,Dn
  Dn < 0 THEN GOSUB chk_trap
```

CLR: Clear an operand sets all or part of a specified address or register to zero.

```
LET ea = 0                          CLR ea
```

MOVEQ #0,Dn is quicker than CLR.L Dn
SUBA.L An,An is quicker for memory applications

CMP: The compare instructions are used exclusively to set the condition code registers for a subsequent conditional operation. The comparison is made by subtracting the source operand from the destination operand and setting the condition codes accordingly; neither operand is altered by the instruction.

```
                                    CMP ea,Dn
IF ea = Dn THEN GOTO loop           BEQ loop
```

Use CMPA when the destination is an address register.
Use CMPI when the source is immediate data.
Use CMPM for memory to memory comparisons.

CMPA: Subtract the source operand from the address register and set the condition code flags accordingly. The comparison is based on a sign-extended source if it is a word operand. The address register is not altered.

```
                                    CMPA ea,Dn
```

CMPI: Subtract the immediate operand from the effective address operand and set the condition code flags accordingly; neither operand is altered. Use TST for comparing with zero as it is much quicker.

```
                                    CMPI #999,ea
```

CMPM: Subtract the contents of the memory address pointed to by the source address register from the contents of the memory address pointed to by the destination register and set the condition code flags accordingly. Increase the value of both address registers by the size of the operand (1, 2 or 4 byte word and longword respectively).

The main use for this instruction is comparing strings

```
LET Dn = length_string - 1
loop                                      loop      CMPM (Ay)+,(Ax)+
IF PEEK (Ay) <> PEEK (Ax) THEN                      BNE not_same
      Ay = Ay + s  : Ax = Ax + s                    DBRA Dn,loop
      GOTO not_same                       same      .
ELSE                                                .
      Ay = Ay + s : Ax = Ax + s                     .
      LET Dn = Dn -1                                .
      IF Dn = -1 THEN GOTO loop                     .
                                                    .
same                                      not_same


not_same                       Dn is the character count, s=operand size
```

DBcc: Test the condition and exit loop to the next instruction if the condition is met. If the condition is not met, then decrement the low order 16 bits of the count data register. If the count becomes -1, then exit loop and carry on with the next instruction, otherwise branch the two's complement displacement of the following word -32766 to +32768 from the current program counter position (instruction address +2). The test may be one of the following:

Conditions				*Two's complement arithmetic*	
EQ	Equal To	CS	Carry Set	GT	Greater Than
NE	Not Equal	CC	Carry Clear	LT	Less Than
MI	Minus	VS	Overflow	GE	Greater Than or Equal to
PL	Plus	VC	No Overflow		
HI	Higher Than			LE	Less Than or Equal to
LS	Lower Than or same				

```
        DBEQ D0,loop                BEQ pass
                                    SUB #1,D0
        (Equivalent)                BPL loop
                               pass .
```

DBT: Always branches and is of little use.

DBRA: Sometimes written DBF, it makes the branch based on the data register count only and branches when the count reaches -1. Therefore the count should be initialised to the required count -1. If the loop is entered via a jump or branch at the DBcc instruction, then the count is the required count and usefully an initial zero count will cause an immediate exit from the loop.

DIVS: Sign Divide a 32-bit data register destination operand by a 16 bit source operand and store the integer result in the lower 16 bits of the destination register, the remainder is stored in the upper 16 bits of the destination and keeps the dividend sign. Division by zero causes a jump to the Divide-by-Zero Trap exception vector. On overflow, the result is larger than 16 bits, the V-flag is set and the operation terminated without affecting either operand.

LET Dn = Dn / ea   DIVS ea,Dn

ASR ea is a fast signed divide by two

MOVEQ #2,D2
ASR D2,Dx is a quicker divide by four

Generally use DIVS and DIVU for division by a prime number, otherwise think of an alternative as the division instruction, because of its general nature, is not quick.

DIVU: Unsigned arithmetic divide of a 32-bit data register destination operand by a 16-bit source operand. The integer result is stored in the lower 16 bits of the destination register and the remainder in the upper 16 bits. Division by zero causes a jump to the Divide-By-Zero exception vector. On overflow the result is larger than 16 bits, the V-flag is set and the operation terminated without affecting either operand.

LET Dn = Dn / ea   DIVU ea,Dn

EOR: EOR the data register source operand to the contents of the destination operand. The source EOR data is normally used to invert the state of a bit or bits.

LET ea = Dn ^^ ea	EOR Dn,ea

If Dn=3, then bits 0 and 1 in the effective address are inverted.

Use EORI where the source is immediate data.
There is no memory to data register operation.

EORI: EORI the immediate data to the destination effective address.

LET ea = data ^^ ea	EORI.B #16,D0 *Invert bit 4 of D0*

EORI to CCR: EORI the immediate data to the condition code register.

LET CCR = 4 ^^ CCR	EORI #4,CCR *Toggle the Zero_flag*

EORI to SR: EORI the immediate data to the status register. This is a privileged instruction and attempted access while in user mode will cause a trap to the privilege violation exception vector.

LET SR = 8192 ^^ SR	EORI #8192,SR *Toggle the supervisor bit*

EXG: Exchange the longword contents of two registers. Referred to in many BASICs as SWAP, which has a different meaning in the MC68000 instruction code.

LET tmp=D0 : D0=D1 : D1=tmp	EXG D0,D1
LET tmp=A0 : A0=A1 : A1=tmp	EXG A0,A1
LET tmp=D0 : D0=A0 : A0=tmp	EXG D0,A0

EXT: Sign-extend a data register contents, a byte to a word or a word to a longword, to permit operations involving mixed size data to take place.

	EXT Dn

ILLEGAL: The illegal instruction causes the processor to jump to the illegal instruction trap exception process subroutine.

GOSUB Ill_Trap	ILLEGAL

JMP_JSR: JMP and JSR are long forms of BRA and BSR, the main difference being the jump instruction's ability to access any part of memory whereas the branch instructions are limited to a relative +/-32K bytes jump.

JMP: Jump to a routine in memory specified by the effective address, either absolute or relative to the current program counter position.

GOTO ea	JMP ea

JSR: Jump to a subroutine in memory specified by the effective address, either absolute or relative to the current program counter position

GOSUB ea	JSR ea

LEA: Load Effective Address loads a calculated effective address into an address register. The calculated address can be the sum of two registers, one must be an address register, and a displacement which provides the addition of two registers and a displacement without affecting either register, in a single instruction.

LET An = Start_of_text_address	LEA text,An
LET An = Start_of_table	LEA tabl,An
LET A0 = A1 + D2 +64	LEA 64(A1.D2),A0

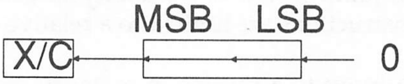
LINK: LINK enables a block of memory, part of the stack, to be temporarily reserved for a specific purpose; that is an index table, a text string, an array etc. and the space recovered when the requirement has passed.

DIM A(64)	LINK An,#-64

Saves a block of 64 bytes in memory. The original value of An is preserved on the stack and will be recovered on UNLK. The current value of An is the start of the data space which may be most easily accessed via indirect with displacement or indirect with index addressing modes.

LSL: Logically Shift Left the bits of the operand. The MSB sets the carry and extend bits, the LSB is set to zero.

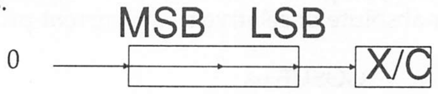
The carry bit is cleared if the shift count is zero.



LET ea = ea * 2	LSL ea (shift 1)
LET Dy = Dy * (2^Dx)	LSL Dx,Dy (reg modulo 64)
LET Dy = Dy * (2^5)	LSL #5,Dy (shift 1 to 8)

LSR: Logically Shift Right the bits of the operand. The MSB is set to zero and the LSB sets the carry and extend bits.

The carry bit is cleared if the shift count is zero



LET ea = INT(ea/2)	LSR ea (shift 1)
LET Dy = INT(Dy/(2^Dx)	LSR Dx,Dy (reg modulo 64)
LET Dy = INT(Dy/(2^5)	LSR #5,Dy (shift 1 to 8)

MOVE: Move the byte, word or longword contents of the source effective address to the destination effective address.

	MOVE ea,ea
LET D1 = D0	MOVE D0,D1
LET SP = SP-4 : POKE(SP),D7	MOVE D7,-(SP)
POKE(SP),D7 : LET SP = SP+4	MOVE (SP)+,D7

Use MOVEA where the destination is an address register.

MOVE from SR: Save the word contents of the status register in the effective address register or memory location. ** Be careful as this instruction is privileged in the MC68010 and MC68020 instruction sets, programers should try not to use it in user state.

	MOVE SR,ea
LET D0 = PEEK_W(SR)	MOVE.W SR,D0

MOVE to CCR: Move the contents of the source operand WORD into the condition code register. Only the low-order byte is used; the upper byte is ignored.

	MOVE ea,CCR
POKE_W(CCR),4	MOVE #4,CCR

Set the Zero flag and clear all others.

MOVE to SR: Move the contents of the source operand into the status register. This is a privileged instruction and attempted access while in user mode will cause a trap to the privilege violation exception vector.

	MOVE ea,SR
POKE_W(SR),1792	MOVE #1792,SR

Clear all flags, set user state, and set interrupt mask to level seven.

MOVE USP: Move the contents of the user stack pointer to or from the specified address register. This is a privileged instruction and attempted access while in user mode will cause a trap to the privilege violation exception vector.

LET A3 = USP	MOVE USP,A3
LET USP = A3	MOVE A3,USP

MOVEA: Move the contents of the source effective address to the destination address register. Byte-sized operations are not permitted.

LET A3 = PEEK_W(192)	MOVEA.W 192,A3
LET A0 = PEEK_L(4)	MOVEA.L 4,A0

MOVEM: Move multiple registers to or from memory which permits the transfer of a block of specified registers to and from memory in a predetermined sequence by one instruction.

LET A7=A7-4 : POKE_L(A7),D0	MOVEM.L #57344,-(A7)
LET A7=A7-4 : POKE_L(A7),D1	
LET A7=A7-4 : POKE_L(A7),D2	
	MOVEM.L (A7)+,#1860

Either of these instructions save registers D0, D1 and D2

MOVEM.L # 7,24(A7)
or MOVEM.L #57344,-(A7) **

and to recover the registers D0, D1 and D2 either
MOVEM.L 24(A7),#7
or MOVEM.L (A7)+,#7

** The predecrement mode of addressing values the registers in reverse order for the register list mask (D0 - bit 15, A7 - bit 0), permitting push-on, pull-off on a last in-first out basis.

MOVEP: Move data to or from a data register and alternate bytes in memory, enabling the MC68000 to interface with 8-bit peripheral devices. The data is transferred on either the high half of the data bus D8-D15, even addresses, or the low half D0-D7, odd addresses, to memory occupying alternate bytes in the processor's memory map. The data is transferred in high-low order.

POKE_W(7+65536),Dn	MOVEP Dn,d(Ay)
LET Dn = PEEK_W(7+65536)	MOVEP 7(Ay),Dn

This is the ONLY instruction that provides word and longword access at odd addresses.

MOVEQ: Move sign-extended 32-bit immediate data in the range of +127 to -128 to a data register. A fast means of loading small positive and negative integers into a data register.

LET D0 = 0	MOVEQ #0,D0

MULS: Multiply two signed 16-bit operands. Only the low-order 16-bits are used from both operands for the multiplication, the result being the 32-bit product in the destination data register.

MULS ea,Dn

ASL ea is a fast signed multiply by two.

MULU: Multiply two unsigned 16-bit operands. Only the low- order 16-bits are used from both operands for the multiplication, the result being the 32-bit product in the destination data register.

MULU ea,Dn

NBCD: Negate Decimal with Extend subtracts the destination byte-sized operand and the extend bit from zero using decimal arithmetic.

NBCD ea

Extend bit clear, the ten's complement is produced.
Extend bit set, the one's complement is produced.

NEG: Negate subtracts the destination operand from zero, producing the two's complement of a byte, word or longword operand.

NEG ea

NEGX: Negate with extend subtracts the destination operand and the extend bit from zero, producing the two's complement of a byte, word or longword operand.

NEGX ea

NOP: No OPeration has no effect other than to increment the program counter by 2. Its use is generally either for creating a space in code which may be used later on for adding a subroutine call, for writing text etc. or for deleting parts of code, especially test routines, without the need for recompiling.

NOP

NOT: Logically complement, producing the one's complement of the operand.

NOT ea

OR: Or the source to the contents of the destination data register. The source OR data is normally used to set specific bits of an operand.

LET Dn = src I I Dn	OR ea,Dn

If src = 3, then OR src sets bits 0 and 1 in Dn; the other bits are left unchanged.

Use OR ea,Dn where the destination is a data register.
Use ORI where the source is immediate data.

ORI: ORI the immediate data to the destination effective address.

LET ea = data I I ea	ORI.W #512,D0 *Set bit 9 of word, others unchanged*

ORI to CCR: ORI the data to the condition code register.

LET CCR = 5 I I CCR	ORI #5,CCR

OR is used to set bit positions; that is Zero and Carry (Bits 0 and 2 in the CCR) are set, the others are unchanged.

ORI to SR: ORI the data to the status register

LET SR = 1792 I I SR	ORI #1792,SR

Set the status register interrupt mask to level seven, all other conditions unchanged. This is a privileged instruction and attempted access from user mode will cause a trap to the privilege violation exception process routine.

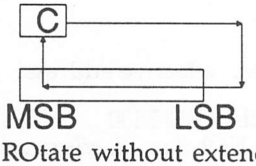
PEA: Push effective address pushes a longword-computed address onto the current stack. It is useful for passing parameters to a subroutine which are accessed via an address register indirect with displacement instruction, the parameter may be removed from the stack prior to return if necessary.

```
                                PEA param
                                JSR sprog

Access parameter        sprog   MOVEA.L 4(SP),A0
Tidy stack                      MOVE.L (SP)+,(SP)
                                .
                                .
                                RTS
```

RESET: Reset external devices by asserting the reset line. There is no affect on the processor other than an increase of two in the value of the program counter. This is a privileged instruction and attempted access while in user mode will cause a trap to the privilege violation exception vector.

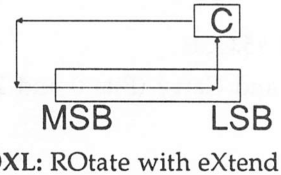
RESET

ROL: ROtate without extend Left. The MSB is rotated to the LSB and the carry; the other bits are shifted up one. The carry bit is set to the extend bit for a shift count of zero



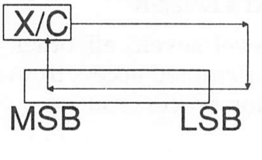
ROL ea (shift 1)
ROL Dx,Dy (reg modulo 64)
ROL #5,Dy (shift 1 to 8)

ROR: ROtate without extend Right. The LSB is rotated to the MSB and the carry; the other bits are shifted down one. The carry bit is set to the extend bit for a shift count of zero.



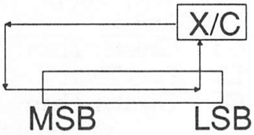
ROR ea (shift 1)
ROR Dx,Dy (reg modulo 64)
ROR #5,Dy (shift 1 to 8)

ROXL: ROtate with eXtend Left. The MSB is rotated to the extend bit and the carry, the extend bit is rotated to the LSB and the other bits are shifted up one. The carry bit is set to the extend bit for a shift count of zero.



ROXL ea (shift 1)
ROXL Dx,Dy (reg modulo 64)
ROXL #5,Dy (shift 1 to 8)

ROXR: ROtate with eXtend Right. The LSB is rotated to the extend bit and the carry, the extend bit is rotated to the MSB and the other bits are shifted down one. The carry bit is set to the extend bit for a shift count of zero.



ROXR ea (shift 1)
ROXR Dx,Dy (reg modulo 64)
ROXR #5,Dy (shift 1 to 8)

RTE: Return from Exception. The status register and the program counter are pulled from the current (supervisor) stack. This instruction is privileged and attempted access while in user mode will cause a trap to the privilege violation exception vector.

(SP)+,SR RTE
(SP)+,PC

RTR: Return and Restore. The condition code and then the program counter are pulled from the current stack.

(SP)+,CCR RTR
(SP)+,PC

RTS: Return from Subroutine. The program counter is pulled from the current stack.

(SP)+,PC RTS

SBCD: Subtract Decimal with Extend. Subtrract a byte-sized binary coded decimal number and the extend bit from the destination operand byte using decimal arithmetic and store the result in the destination location.

BCD subtraction

SBCD	$ 7	SBCD	$27
	<u>$ 6</u>		<u>$16</u>
	$ 1		$11

Memory
Multibyte Subtraction

MOVE #4,CCR
SBCD D0,D1

Note that the z-flag is cleared if the result is non-zero, otherwise it is unchanged. For memory additions the data must be stored with the most significant digit lower in memory and the address register pointers initially set to the byte above the low-order BCD digit. The only memory addressing mode is predecrement.

Scc: Set according to condition. The specified condition is tested and the byte specified set to all ones if true or all zeros if false. The condition may be:

Conditions				*Two's complement arithmetic*	
EQ	Equal To	CS	Carry Set	GT	Greater Than
NE	Not Equal	CC	Carry Clear	LT	Less Than
MI	Minus	VS	Overflow	GE	Greater Than or Equal to
PL	Plus	VC	No Overflow		
HI	Higher Than	T	True	LE	Less Than or Equal to
LS	Lower Than or same	F	False		

Scc ea

STOP: Load the status register and Stop. The immediate operand is put into the status register and the program counter advanced to the next instruction and then stopped. Execution only resumes when a trace, interrupt or reset exception occurs.

STOP #7

SUB: Subtract the source from the destination. One of the integers must be the contents of a data register.

LET Dn = Dn - ea   SUB ea,Dn
LET ea = ea - Dn   SUB Dn,ea

Use SUB ea,Dn where the destination is a data register.
Use SUBA where the destination is an address register.
Use SUBI or SUBQ where the source is immediate data.

SUBA: Subtract the contents of the effective address from the contents of the destination address register.

LET An = An - ea   SUBA ea,An

SUBI: Subtract a constant value from the contents of the destination effective address. Use SUBQ for speed and small integers.

LET ea = ea - 999   SUBI #999,ea

SUBQ: Subtract a constant of from 1 to 8 from the contents of the effective address. Faster subtraction than SUBI.

LET ea = ea - 8   SUBQ #8,ea

SUBX: Subtract either register to register, or predecremented memory from memory, with extend. The extend bit enables multiprecision arithmetic to be performed, acting as a borrow between successive operations.

Memory subtractions
SUBX -(Ay),-(Ax)
where X infers Extend bit
LET Ay = Ay - 4
LET Ax = Ax - 4
POKE(Ax),PEEK(Ax) -
PEEK(Ay) - X

Data register subtractions
Subtract two 64 bit integers
D0_D1 and D2_D3 Lo-Hi resply
SUB.L D0,D2 Low bits
SUBX.L D1,D3 High bits

Memory subtractions
MOVE #4,CCR
SUBX.L -(A0),-(A1)
SUBX.L -(A0),-(A1)

Note that the z-flag is cleared if the result is non-zero, otherwise it is unchanged. For memory additions first clear the Extend bit and set the Zero flag. The data must be stored with the most significant digit lower in memory and the address pointers initially set the operand size above the low order digit. Predecrement is the only memory addressing mode.

SWAP: Swap register halves exchanges the high-order word of a data register with the low-order word. This instruction provides access to the low-order byte of the high word.

Dn 0-15 <----> Dn 16-31

TAS: Test and set an operand, compares the operand byte with zero and sets the condition codes accordingly. If the byte is zero, the Z_flag is set; if the MSB is non-zero, then the N_flag is set. The MSB of the operand is then set.

TAS ea

TRAP: Trap. The processor commences execution at the relevant trap exception vector address.

TRAP #n

TRAPV: Trap on Overflow. The processor commences execution at the trap on overflow exception vector address.

TRAPV

TST: Test an operand. The operand is compared with zero and the condition codes set accordingly.

TST ea

Use in preference to CMPI #0,ea

UNLK: Unlink. The stack pointer is loaded from the specified address register; the address register is then loaded with the longword pulled from the top of the stack and the linked space deallocated.

UNLK An

Key

&&	bitwise	AND
^^	bitwise	EOR
||	bitwise	OR

Address mode

Assembler language and BASIC equivalents

Address Mode	Source	Destination
Data register Dn direct	MOVE.L D2,D0 LET D0 = D2	MOVE.L #999,D0 LET D0 = 999
Address register An direct	MOVE.L A0,D0 LET D0 = A0	MOVEA.L #999,A0 LET A0 = 999
Address register (An) indirect	MOVE.L (A0),D0 LET D0,PEEK_L(A0)	MOVE.L #999,(A0) POKE_L (A0),999
Address register (An)+ indirect with postincrement	MOVE.L (AO)+,D0 LET D0,PEEK_L(A0) LET A0 = A0 + 4	MOVE.L #999,(A0)+ POKE_L (A0),999 LET A0 = A0 + 4
Address register -(An) indirect with predecrement	MOVE.L -(AO),D0 LET A0 = A0 - 4 LET D0,PEEK_L(A0)	MOVE.L #999,-(A0) LET A0 = A0 - 4 POKE_L (A0),999
Address register d(An) indirect with displacement	MOVE.L 9(A0),D0 LET D0 = PEEK_L(9 + A0)	MOVE.L #999,9(A0) POKE_L(A0+9),999
Address register d(An.Ri) indirect with index	MOVE.L 9(A0.D2),D0 LET D0=PEEK_L(9+A0+D2)	MOVE.L #999,9(A0.D0) POKE_L(A0+9+D0),999
Absolute short $xxxx ABS.S	MOVE.L 1024,D0 LET D0 = PEEK_L(1024)	MOVE.L #999,1024 POKE_L(1024),999
Absolute long $xxxxxx ABS.L	MOVE.L 163840,D0 LET DO=PEEK_L(163840)	MOVE.L #999,163840 POKE_L(163840),999
Program counter d(PC) with displacement	MOVE.L 9(PC),D0 LET D0=9 + Contents of Program Counter	Not legal
Program counter d(PC.Ri) with index	MOVE.L 9(PC.D2),D0 LET D0=9+D2+Contents of Program Counter	Not legal
Immediate #$xxx Imm	MOVE.L #65536,D0 LET D0 = 65536	Not legal
Notes	Register D0 is used for the destination as an example; any other valid effective address may be used.	The source is defined as immediate data value 999; any other valid effective address may be used.

All equivalents have been defined as having longword operands, byte and word-sized operands may also be used.

Allowable address mode types

	All	Alt Mem Add	Dat Alt Add		Alt Add Mod	Dat Add Md1	Dat Add Md2	Con Add Md1	Con Alt Add	Con Add Md2
	Srce	Dest	Dest		Dest	Srce	Dest		Dest	Srce
Dn	x		x	x	x	x	x			
An	x				x					
(An)	x	x	x	x	x	x	x	x	x	x
(An)+	x	x	x	x	x	x	x			x
-(An)	x	x	x	x	x	x	x		x	
d(An)	x	x	x	x	x	x	x	x	x	x
d(An.Ri)	x	x	x	x	x	x	x	x	x	x
ABS shrt	x	x	x	x	x	x	x	x	x	x
ABS long	x	x	x	x	x	x	x	x	x	x
d(PC)	x					x	x	x		x
d(PC.Ri)	x					x	x	x		x
Imm	x					x				
	ADD	ADD	ADDI	NBCD	ADDQ	AND	BTST	JMP	MOVEM	
	ADDA	AND	ANDI	NEG	SUBQ	CHK		JSR	reg	MOVEM
	CMP	OR	BCHG	NEGX		DIVS		LEA	to	mem
	CMPA	SUB	BCLR	NOT		DIVU		PEA	mem	to
	MOVE		BSET	ORI						reg
	MOVEA	ASL	CLR			MOVE				
	SUB	ASR	CMPI	Scc		to CCR				
	SUBA	ROXL	EOR			MOVE				
	ROXR	EORI	SUBI			to SR				
	ROL	MOVE	TAS							
	ROR		TST		MULS					
	LSL	MOVE			MULU					
	LSR	fr SR			OR					

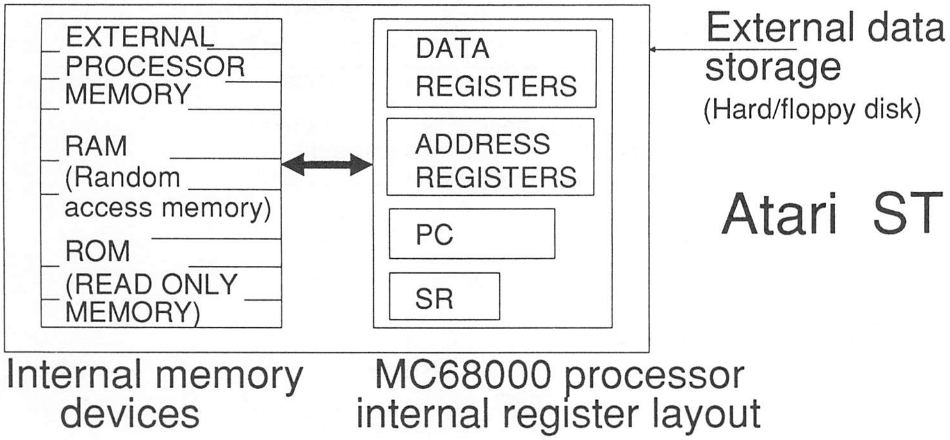
Alt = Alterable Mod = Mode Md1 = Mode1 \ Types of addressing mode
Mem = Memory Dat = Data Md2 = Mode2 | definitions used by Motorola
Add = Address Con = Control / to describe allowable modes.

Data storage

The MC68000 accesses two internal locations for storage:

Internal registers, of which there are 17, store the data inside the microprocessor itself. They are very limited in the amount of data they can store, but provide extremely fast access.

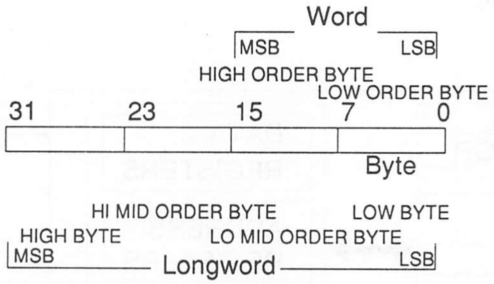
ST RAM/ROM, where data access is still quick, but not as fast as the internal register data access.



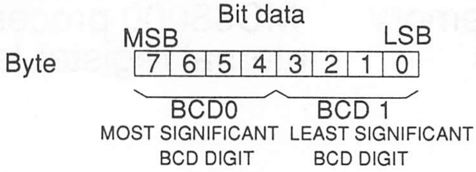
Data types

The MC68000 microprocessor supports five different data types; some instructions are limited to a specific data type, but mostly there is an allowable range with the default of a word. Where choice is not implicit, it is defined in the instruction word extension as either *byte, word or longword.*

Byte, Word and Longword data types



BCD and BIT data types

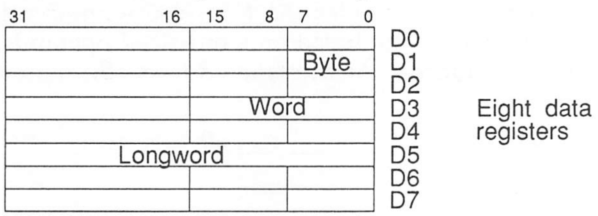


Internal registers

The Motorola 68000 has seventeen 32-bit registers, a 24-bit program counter and a 16-bit status register. Eight of the 32-bit registers (D0 to D7) are used as data registers for operations involving single bit, BCD (4-bit), byte (8-bit), word (16-bit) and longword (32-bit) data. The remaining nine registers are split into two: seven of them (A0 to A6) act as address registers, and two act as stack pointers. Only one stack pointer may be accessed at a time, hence the convention of calling both of them A7. The address register operations are based on words and longwords only.

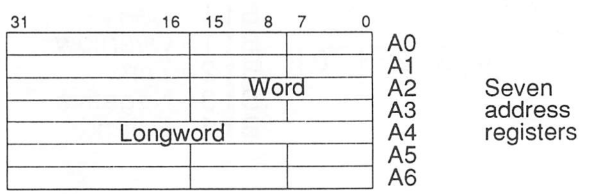
Data registers

Data storage of byte, word and longword is always performed in the part of the data registers shown; unused parts of the register are not altered.



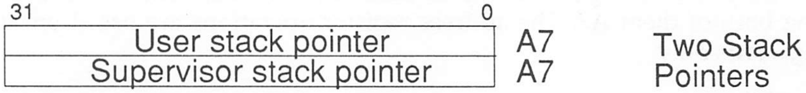
Address registers

The address registers are used as pointers to user stacks, as base address registers and temporary storage for computed addresses that are not to affect the Status Register. Address storage is always performed in the part of the address register shown. When used as a destination operand, the entire address is changed regardless of the operation size. Address registers *do not* support byte-sized operations as either source or destination. Words are sign- extended to longwords before an operation is performed.



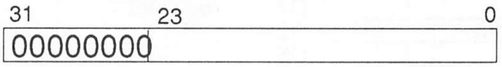
Stack pointer

The user stack pointer typically saves subroutine returns when in user mode. The supervisor stack pointer points to a stack that saves the status register contents during trap and interrupt routines as well as the supervisor subroutine returns. Only one of the stack pointers is addressable at a time, so they are both called A7. Bytes pushed onto a stack are stored in the high order half of the word.

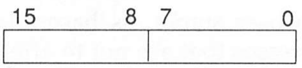


Program counter

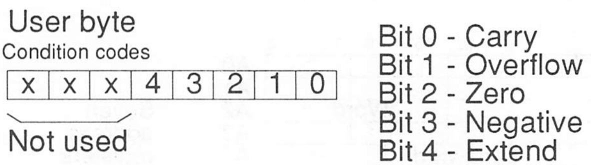
The program counter provides the MC68000 with an address range of 16 Megabytes. As instructions are based on word-sized operands, the counter must always hold an even address. Attempts to address odd-numbered locations will cause an error-trap.



Status register

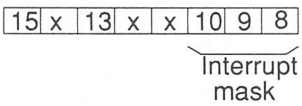


The status register is split into *user* and *system* bytes. The user byte is evaluated for the condition codes used in the branching instructions. The codes are affected by all instructions that alter the contents of the data registers or memory, but not by changes to the address registers.



The unused bits in the status register are read as zero. They are reserved for the MC68020 instruction set.

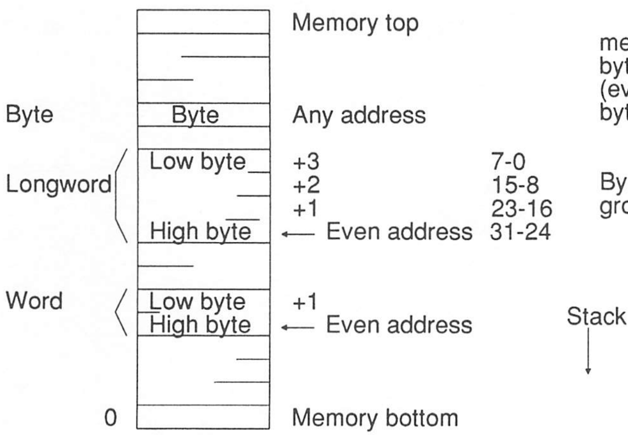
System byte



Bits 8-10 Interrupt mask (0-7)
Bit 13 - Supervisor state
Bit 15 - Trace mode

x = not used

Organization of addresses in memory



For word and longword memory operations, the high byte is on a word boundary (even address), the following bytes are in order higher in memory.

By convention, system stacks grow downwards in memory.

Appendix H

MC68000 instruction codes

Motorola MC68000 Coding

The Motorola MC68000 series of microprocessors rationalize instruction code allocation by segmenting the 16-bit Operation Word into five smaller blocks, each of which has a fairly consistent meaning.

Operation word instruction

15 14 13 12	11 10 9	8 7 6	5 4 3	2 1 0
type	dmod	dreg	smod	sreg

Instruction Word Parsing Analysis

Type

15	14	13	12

The types 0 to 15 instruction codes (16 classes) are allocated as follows:

Type	Instructions Range
0	Bit manipulation, Move Peripheral and Immediate instructions
1	Move byte Instructions
2	Move longword instructions
3	Move word instructions
4	Miscellaneous instructions
5	Add Quick, Subtract Quick, Set conditionally and Decrement instrs.
6	Branch conditionally instructions
7	Move Quick instructions
8	OR, Divide and Subtract decimal instructions.
9	Subtract, Subtract extended instructions.
10	Unassigned
11	Compare, Exclusive OR instructions
12	AND, Multiply, Add decimal and Exchange instructions
13	Add, Add extended instructions
14	Shift and Rotate instructions
15	Unassigned

Dreg

11	10	9

Dreg has three main uses, normally holding the destination address in the general move instruction, one of the two register numbers for use in the specified instruction or embedded data for use in the add and subtract quick instructions.

Dreg only refers to a register in those instances where the instruction has two register operands.

Dmod

8	7	6

Dmod has two main uses, specifying the effective address mode of the destination operand in the general move instruction or, in most other cases it defines the size of the operation to be performed.

Smod

5	4	3

Smod usually defines the effective address mode of the instruction, the source operand for the move instruction.

Sreg

2	1	0

Sreg defines the effective address register, usually the source.

Instruction codes

Bit Manipulation,Move Peripheral and Immediate Instructions - Type 0

Instruction Syntax	Dreg 11-9	Dmod 8-6	Smod 5-3	Sreg 2-0	Address Mode	Condition Codes X N Z V C
BCHG Dn,ea	Dn	5	-ea-		dataltadd	- - A - -
BCHG data,ea	4	1	-ea-		dataltadd	- - A - -
BCLR Dn,ea	Dn	6	-ea-		dataltadd	- - A - -
BCLR data,ea	4	2	-ea-		dataltadd	- - A - -
BSET Dn,ea	Dn	7	-ea-		dataltadd	- - A - -
BSET data,ea	4	3	-ea-		dataltadd	- - A - -
BTST Dn,ea	Dn	4	-ea-		dataddmd2	- - A - -
BTST data,ea	4	0	-ea-		dataddmd2	- - A - -
MOVEP Dx,d(Ay)	Dx	1 1 x	1	Ay	-	- - - - -
MOVEP d(Ay),Dx	Dx	1 0 x	1	Ay	-	- - - - -
ORI data,ea	0	0 s s	-ea-		dataltadd	- A A 0 0
ORI data,CCR	0	0	7	4	-	A A A A A
ORI data,SR	0	1	7	4	-	A A A A A
ANDI data,ea	1	0 s s	-ea-		dataltadd	- A A 0 0
ANDI data,CCR	1	0	7	4	-	A A A A A
ANDI data,SR	1	1	7	4	-	A A A A A
SUBI data,ea	2	0 s s	-ea-		dataltadd	A A A A A
ADDI data,ea	3	0 s s	-ea-		dataltadd	A A A A A
EORI data,ea	5	0 s s	-ea-		dataltadd	- A A 0 0
EORI data,CCR	5	0	7	4	-	A A A A A
EORI data,SR	5	1	7	4	-	A A A A A
CMPI data,ea	6	0 s s	-ea-		dataltadd	- A A A A

Move byte instruction - Type 1

Instruction Syntax	Dreg 11-9	Dmod 8-6	Smod 5-3	Sreg 2-0	Address Mode	Condition Codes X N Z V C
MOVE.B ea,ea						- A A 0 0
source			-ea-		ALL *	
destination	-ea-				dataltadd	

* Address register direct mode is not permitted

Move longword instruction - Type 2

Instruction Syntax	Dreg 11-9	Dmod 8-6	Smod 5-3	Sreg 2-0	Address Mode	Condition Codes X N Z V C
MOVE.L ea,ea						- A A 0 0
source			-ea-		ALL	
destination	-ea-				dataltadd	

Move word instruction - Type 3

Instruction Syntax	Dreg 11-9	Dmod 8-6	Smod 5-3	Sreg 2-0	Address Mode	Condition Codes X N Z V C
MOVE.W ea,ea						- A A 0 0
source			-ea-		ALL	
destination	-ea-				dataltadd	

x Size	*s s Size*	*Condition Codes*
0 = Word	0 0 = Byte	u = Undefined
1 = Longword	0 1 = Word	A = Affected
	1 0 = Longword	- = Unaffected
ea = Effective address		0 = Cleared
CCR = Condition code register		1 = Set
SR = Status register		

Miscellaneous instructions - Type 4

Instruction Syntax	Dreg 11-9	Dmod 8-6	Smod 5-3	Sreg 2-0	Address Mode	X	N	Z	V	C
NEGX ea	0	0 s s	-ea-		dataltadd	A	A	A	A	A
CLR ea	1	0 s s	-ea-		dataltadd	-	0	1	0	0
NEG ea	2	0 s s	-ea-		dataltadd	A	A	A	A	A
NOT ea	3	0 s s	-ea-		dataltadd	-	A	A	0	0
MOVE SR,ea	0	3	-ea-		dataltadd	-	-	-	-	--
MOVE ea,CCR	2	3	-ea-		dataddmd1	A	A	A	A	A
MOVE ea,SR	3	3	-ea-		dataddmd1	A	A	A	A	A
SWAP Dn	4	1	0	Dn	-	-	A	A	0	0
EXT.W Dn	4	2	0	Dn	-	-	A	A	0	0
EXT.L Dn	4	3	0	Dn	-	-	A	A	0	0
NBCD.B ea	4	0	-ea-		dataltadd	A	u	A	u	A
PEA ea	4	1	-ea-		conaddmd1	-	-	-	-	-
MOVEM list,ea	4	0 1 x	-ea-		conaltadd	-	-	-	-	-
MOVEM ea,list	6	0 1 x	-ea-		conaddmd2	-	-	-	-	-
TST ea	5	0 s s	-ea-		dataltadd	-	A	A	0	0
TAS ea	5	3	-ea-		dataltadd	-	A	A	0	0
ILLEGAL	5	3	7	4	-	-	-	-	-	-
TRAP data	7	1	0 0 v v v v		-	-	-	-	-	-
LINK An,data	7	1	2	An	-	-	-	-	-	-
UNLK An	7	1	3	An	-	-	-	-	-	-
MOVE An,USP	7	1	4	An	-	-	-	-	-	-
MOVE USP,An	7	1	5	An	-	-	-	-	-	-

Miscellaneous instructions - Type 4 cont.

Instruction Syntax	Dreg 11-9	Dmod 8-6	Smod 5-3	Sreg 2-0	Address Mode	Condition Codes X N Z V C
RESET	7	1	6	0	-	- - - - -
NOP	7	1	6	1	-	- - - - -
STOP data	7	1	6	2	-	A A A A A
RTE	7	1	6	3	-	A A A A A
RTS	7	1	6	5	-	- - - - -
TRAPV	7	1	6	6	-	- - - - -
RTR	7	1	6	7	-	A A A A A
JSR ea	7	2	-ea-		conaddmd1	- - - - -
JMP ea	7	3	-ea-		conaddmd1	- - - - -
CHK.W ea,Dn	Dn	6	-ea-		dataddmd1	- A u u u
LEA.L ea,An	An	7	-ea-		conaddmd1	- - - - -

Add Quick,Subtract Quick, Set conditionally, Decrement instructions -Type 5

Instruction Syntax	Dreg 11-9	Dmod 8-6	Smod 5-3	Sreg 2-0	Address Mode	Condition Codes X N Z V C
AddQ data,ea	data	0 s s	-ea-		altaddmod	A A A A A
SUBQ data,ea	data	1 s s	-ea-		altaddmod	A A A A A
Scc ea	c c c c 1 1		-ea-		dataltadd	- - - - -
DBcc Dn,data	c c c c 1 1		1	Dn	-	- - - - -

x Size	*s s Size*	*Condition Codes*
0 = Word	0 0 = Byte	u = Undefined
1 = Longword	0 1 = Word	A = Affected
	1 0 = Longword	- = Unaffected
ea = Effective address		0 = Cleared
CCR = Condition code register		1 = Set
SR = Status register		
cccc = 4-bit Condition code		
vvvv = 4-bit Vector address		

Branch conditionally instruction - Type 6

Instruction Syntax	Dreg 11-9	Dmod 8-6	Smod 5-3	Sreg 2-0	Address Mode	Condition Codes X N Z V C
Bcc data	c c c c	displacement (bits 0-7)				- - - - -
BSR data	0	1 displacement (bits 0-7)				- - - - -
BRA data	0	0 displacement (bits 0-7)				- - - - -

Conditional tests for branch instructions

cc	Mnemonic	Condition
0	T	TRUE
1	F	FALSE
2	HI	HIGH
3	LS	LOW or SAME
4	CC	CARRY CLEAR
5	CS	CARRY SET
6	NE	NOT EQUAL
7	EQ	EQUAL
8	VC	OVERFLOW CLEAR
9	VS	OVERFLOW SET
10	PL	PLUS
11	MI	MINUS
12	GE	GREATER or EQUAL
13	LT	LESS THAN
14	GT	GREATER THAN
15	LE	LESS or EQUAL

There is no Branch TRUE BT or Branch FALSE BF, the codes are used by the BSR and BRA instructions

x Size	*s s Size*	*Condition Codes*
0 = Word	0 0 = Byte	u = Undefined
1 = Longword	0 1 = Word	A = Affected
	1 0 = Longword	- = Unaffected

ea = Effective address
CCR = Condition code register
SR = Status register
cccc = 4-bit Condition code

0 = Cleared
1 = Set

Move Quick instruction - Type 7

Instruction Syntax	Dreg 11-9	Dmod 8-6	Smod 5-3	Sreg 2-0	Address Mode	Condition Codes X N Z V C
MOVEQ data,Dn	Dn	0	data (bits 7-0)			- A A 0 0

2's complement data value

Or, Divide, Subtract Decimal instructions - Type 8

Instruction Syntax	Dreg 11-9	Dmod 8-6	Smod 5-3	Sreg 2-0	Address Mode	Condition Codes X N Z V C
OR ea,Dn	Dn	0 s s	-ea-		dataddmd1	- A A 0 0
OR Dn,ea	Dn	1 s s	-ea-		altmemadd	- A A 0 0
DIVU ea,Dn	Dn	3	-ea-		dataddmd1	- A A A 0
DIVS ea,Dn	Dn	7	-ea-		dataddmd1	- A A A 0
SBCD Dy,Dx	Dx	4	0	Dy	-	A u A u A
SBCD -(Ay),-(Ax)	Ax	4	1	Ay	-	A u A u A

Subtract, Subtract Extended instructions - Type 9

Instruction Syntax	Dreg 11-9	Dmod 8-6	Smod 5-3	Sreg 2-0	Address Mode	Condition Codes X N Z V C
SUBA.W ea,An	An	3	-ea-		ALL	- - - - -
SUBA.L ea,An	An	7	-ea-		ALL	- - - - -
SUB ea,Dn	Dn	0 s s	-ea-		ALL	A A A A A
SUB Dn,ea	Dn	1 s s	-ea-		altmemadd	A A A A A
SUBX Dy,Dx	Dx	1 s s	0	Dy	-	A A A A A
SUBX -(Ay),-(Ax)	Ax	1 s s	1	Ay	-	A A A A A

Emulation Instruction - Type 10 (#$A)

Line-A

Normally available for the implementation of user-written routines and entered by ensuring four MSB of the op word or defined word constant are 1010 (10 dec), which will cause a trap to a user routine; other bits of op word may be used for parameter passing. The ST uses this instruction for initializing and operating the line-A functions on which GEM VDI and subsequently GEM AES are based - so use with care.

Compare, Exclusive Or instructions - Type 11 (#$B)

Instruction Syntax	Dreg 11-9	Dmod 8-6	Smod 5-3	Sreg 2-0	Address Mode	Condition Codes X N Z V C
CMPA ea,An	An	x 1 1	-ea-		ALL	- A A A A
CMP ea,Dn	Dn	0 s s	-ea-		ALL	- A A A A
CMPM -(Ay),-(Ax)	Ax	1 s s	1	Ay	-	- A A A A
EOR Dn,ea	Dn	1 s s	-ea-		dataltadd	- A A 0 0

x Size	*s s Size*	*Condition Codes*
0 = Word	0 0 = Byte	u = Undefined
1 = Longword	0 1 = Word	A = Affected
	1 0 = Longword	- = Unaffected
ea = Effective address		0 = Cleared
CCR = Condition code register		1 = Set
SR = Status register		

And, Multiply, Add Decimal, and Exchange instructions - Type 12 (#$C)

Instruction Syntax	Dreg 11-9	Dmod 8-6	Smod 5-3	Sreg 2-0	Address Mode	Condition Codes X N Z V C
AND ea,Dn	Dn	0 s s	-ea-		dataddmd1	- A A 0 0
AND Dn,ea	Dn	1 s s	-ea-		altmemadd	- A A 0 0
MULU ea,Dn	Dn	3	-ea-		dataddmd1	- A A 0 0
MULS ea,Dn	Dn	7	-ea-		dataddmd1	- A A 0 0
ABCD Dy,Dx	Dx	4	0	Dy	-	A u A u A
ABCD -(Ay),-(Ax)	Ax	4	1	Ay	-	A u A u A
EXGD Dx,Dy	Dx	5	0	Dy	-	- - - - -
EXGA Ax,Ay	Ax	5	1	Ay	-	- - - - -
EXGM Dx,Ay	Dx	6	1	Ay	-	- - - - -

Add, and Add Extended instructions - Type 13 (#$D)

Instruction Syntax	Dreg 11-9	Dmod 8-6	Smod 5-3	Sreg 2-0	Address Mode	Condition Codes X N Z V C
ADDA.W ea,An	An	3	-ea-		ALL	- - - - -
ADDA.L ea,An	An	7	-ea-		ALL	- - - - -
ADD ea,Dn	Dn	0 s s	-ea-		ALL	A A A A A
ADD Dn,ea	Dn	1 s s	-ea-		altmemadd	A A A A A
ADDX Dy,Dx	Dx	1 s s	0	Dy	-	A A A A A
ADDX -(Ay),-(Ax)	Ax	1 s s	1	Ay	-	A A A A A

Shift / Rotate instructions - Type 14 (#$E)

Instruction Syntax	Dreg 11-9	Dmod 8-6	Smod 5-3	Sreg 2-0	Address Mode	X	N	Z	V	C
ASL Dx,Dy	Dx	1 s s	4	Dy	-	A	A	A	A	A
ASL data,Dy	count	1 s s	0	Dy	-	A	A	A	A	A
ASL ea	0	7	-ea-		altmemadd	A	A	A	A	A
ASR Dx,Dy	Dx	0 s s	4	Dy	-	A	A	A	A	A
ASR data,Dy	count	0 s s	0	Dy	-	A	A	A	A	A
ASR ea	0	3	-ea-		altmemadd	A	A	A	A	A
LSL Dx,Dy	Dx	1 s s	5	Dy	-	A	A	A	0	A
LSL data,Dy	count	1 s s	1	Dy	-	A	A	A	0	A
LSL ea	1	7	-ea-		altmemadd	A	A	A	0	A
LSR Dx,Dy	Dx	0 s s	5	Dy	-	A	A	A	0	A
LSR data,Dy	count	0 s s	1	Dy	-	A	A	A	0	A
LSR ea	1	7	-ea-		altmemadd	A	A	A	0	A
ROL Dx,Dy	Dx	1 s s	7	Dy	-	-	A	A	0	A
ROL data,Dy	count	1 s s	3	Dy	-	-	A	A	0	A
ROL ea	3	7	-ea-		altmemadd	-	A	A	0	A
ROR Dx,Dy	Dx	0 s s	7	Dy	-	-	A	A	0	A
ROR data,Dy	count	0 s s	3	Dy	-	-	A	A	0	A
ROR ea	3	3	-ea-		altmemadd	-	A	A	0	A
ROXL Dx,Dy	Dx	1 s s	6	Dy	-	A	A	A	0	A
ROXL data,Dy	count	1 s s	2	Dy	-	A	A	A	0	A
ROXL ea	2	7	-ea-		altmemadd	A	A	A	0	A
ROXR Dx,Dy	Dx	1 s s	6	Dy	-	A	A	A	0	A
ROXR data,Dy	count	1 s s	2	Dy	-	A	A	A	0	A
ROXR ea	2	7	-ea-		altmemadd	A	A	A	0	A

Emulation instruction - Type 15 (#$F)

Line-F

Normally available for the implementation of user-written routines, and entered by ensuring four MSB of the op word or defined word constant are 1111 (15 dec), directing the trap service to a user routine. Other bits of op word may be used for parameter passing.

This service trap is used by the MC68020 processor for passing co-processor instructions. The ST uses it in processing the application environment services (AES), so be careful.

. *x Size*	*s s Size*	*Condition Codes*
. 0 = Word	0 0 = Byte	u = Undefined
. 1 = Longword	0 1 = Word	A = Affected
	1 0 = Longword	- = Unaffected
. ea = Effective address		0 = Cleared
CCR = Condition code register		1 = Set
. SR = Status register		

Address modes

Encoding

The range of addressing modes are coded consistently throughout the MC68000 instruction set and may be summarized as follows:

Addressing mode		Syntax	Mode #	Register #	Extension words
Data register direct		Dn	0	n	0
Address register direct		An	1	n	0
Address register indirect		(An)	2	n	0
Address register indirect with postincrement		(An)+	3	n	0
Address register indirect with predecrement		-(An)	4	n	0
Address register indirect with displacement		d(An)	5	n	1
Address register indirect with index		d(An.Ri)	6	n	1
Absolute short	ABS.S	$xxxx	7	0	1
Absolute long	ABS.L	$xxxxxx	7	1	2
Program counter with displacement		d(PC)	7	2	1
Program counter with index		d(PC.Ri)	7	3	1
Immediate	Imm	#$xxx	7	4	1or2

n = Register number 0 to 7

Extension Word = Number of extension words following the op word due to this address mode (source and destination ext. words are cumulative)

Mode # ==Dmod and Smod in instruction code tables

Register # ==Dreg and Sreg in instruction code tables

Appendix I

Error codes

BIOS error codes

Error code	Function	Comments
0	O'K	Successful operation
-1	Error	
-2	Drive not ready	Not ready, not attached or busy
-3	Unknown command	Command not understood by device
-4	CRC error	Soft error while reading sector
-5	Bad request	Bad parameter, Cannot do request
-6	Seek error	Drive could not seek
-7	Unknown media	Foriegn media. Bad zero boot sector
-8	Sector not found	
-9	No paper	
-10	Write fault	
-11	Read fault	
-12	General error	Reserved
-13	Write protect	Read only or protected media
-14	Media change	Media changed since last write or the rd/wr op not done (file error)
-15	Unknown device	BIOS doesn't recognize device
-16	Bad sectors	Format yielded bad sectors
-17	Insert disk	Disk not in drive (shell error)

GEMDOS error codes

Error code	PC DOS equivalent	Function Supported	Function Not supported
-32	1	Invalid function number	
-33	2	File not found	
-34	3	Path not found	
-35	4	No handles left (too many open files)	
-36	5	Access denied	
-37	6		Invalid handle
-38	7		
-39	8	Insufficient memory	
-40	9		Invalid memory block address
-41	10	** Insufficient memory	
-42	11	** Insufficient memory	
-43	12		
-44	13		
-45	14		
-46	15	Invalid drive specified	
-47	16	** Invalid operation	
-48	17		
-49	18	No more files	

The list of PC-DOS equivalent error codes supported may be found by running the GEM demonstration program (Appendix L).

Miscellaneous error codes

Error code	Function
-64	Range error
-65	Internal error
-66	Invalid program load format
-67	Setblock failure due to growth restrictions

Appendix J

BASIC GEM

ST BASIC provides the programmer with direct access to parts of the operating system AES and VDI interface.

GEMSYS

The AES control arrays are accessed through the AES parameter block (GB pointer), the block provides pointers to the other supplementary AES parameter blocks:

```
control table    +$0   \
global array     +$4   | Data input and output
int_in table     +$8   | as specified in the AES
int_out table    +$C   | traps and utility tables.
addr_in table    +$10  | Chapter 5
addr_out table   +$14  /
```

The tables are used by the programmer to input data, call the appropriate GEM AES function, GEMSYS(n), and read any reply from the data placed in the output tables by the function.

VDISYS

The VDI parameter blocks are directly accessible from BASIC:

```
contrl    input    \
ptsin     input    |
ptsout    output   | tables
intin     input    |
intout    output   /
```

The appropriate tables are loaded with data and the function called via VDISYS(1), the (1) being a dummy argument. Any reply is read from the output tables.

```
GEMSYS                                      VDISYS
  |                                           |
  v                                           v
GB ---->   control    \                     contrl
           global     |                     intin
           int_in     | Indirect            intout
           int_out    | access              ptsin
           addr_in    |                     ptsout
           addr_out   /
```

SYSTAB

ST BASIC also provides access to a BASIC system table of the following read only pointers and parameters:

<table>
<tr><td>Graphics resolution</td><td>+$0</td><td>1=high resolution</td><td></td></tr>
<tr><td></td><td></td><td>2=medium resolution</td><td></td></tr>
<tr><td></td><td></td><td>4=low resolution</td><td></td></tr>
<tr><td>Editor ghost line style</td><td>+$2</td><td>0=thickened</td><td></td></tr>
<tr><td>(Read/write)</td><td></td><td>1=intensity</td><td></td></tr>
<tr><td></td><td></td><td>2=skewed</td><td></td></tr>
<tr><td></td><td></td><td>3=underlined</td><td></td></tr>
<tr><td></td><td></td><td>4=outline</td><td></td></tr>
<tr><td></td><td></td><td>5=shadow</td><td></td></tr>
<tr><td>Edit AES handle</td><td>+$4</td><td>1</td><td>\</td></tr>
<tr><td>List AES handle</td><td>+$6</td><td>2</td><td>| default</td></tr>
<tr><td>Output AES handle</td><td>+$8</td><td>3</td><td>|</td></tr>
<tr><td>Command AES handle</td><td>+$A</td><td>4</td><td>/</td></tr>
<tr><td>Edit open flag</td><td>+$C</td><td>\</td><td></td></tr>
<tr><td>List open flag</td><td>+$E</td><td>| 0=closed</td><td></td></tr>
<tr><td>Output open flag</td><td>+$10</td><td>| 1=open</td><td></td></tr>
<tr><td>Command open flag</td><td>+$12</td><td>/</td><td></td></tr>
<tr><td>Graphics buffer</td><td>+$14</td><td>Longword 32K buffer pointer</td><td></td></tr>
<tr><td>GEM flag</td><td>+$18</td><td>0_normal, 1_off</td><td></td></tr>
</table>

The GEM flag is used to turn BASIC I/O off and increase the processing speed of GEM based operations. With BASIC partially off, the I/O functions involving the screen, mouse and keyboard are disabled, although disk I/O is still enabled.

The BASIC functions can be re-enabled after the burst of speed for user input

Not all GEM and VDI functions are available through BASIC, some of the BASIC housekeeping activities negate the effect of the functions.

Cautionary notes:

Ensure that evaluations of the graphic primitives take into account color. Many experiments may appear not to work simply because the writing color is the same as the screen backgound.

Characters are written to the screen starting from the left-hand edge and will probably be obscured by the command screen border unless the programmer moves it out of the way.

BASIC example

Use the mouse and the right button to draw a primitive, use the left button to change the primitive. Note the effect on a primitive of crossing the left hand screen edge.

```
10    start: CLEAR: a#=gb:int_out=PEEK(a#+12)
20    FULLW 2:CLEARW 2
30    INPUT "GDP (1 to 9) ";gdp
40    IF gdp or gdp9 THEN GOTO start
50    POKE systab+24,1:                       REM BASIC I/O off
60    POKE contrl,122:POKE contrl+2,0:POKE contrl+6,1
70    GOSUB curson
80    attribs: GEMSYS(79)
90    x=PEEK(int_out+2) :                     REM x mouse
100   y=PEEK(int_out+4) :                     REM y mouse
110   key=PEEK(int_out+6) :                   REM button state nil_left_right
120   ON key+1 GOSUB showcurs, done, drawprim
130   GOTO attribs
140   done: POKE systab+24,0:GOTO start:      REM nasty return
150   drawprim:                               REM
160   COLOR 1,(RND*15)+1,1,RND*25,2 :         REM random color
170   IF mouse=0 THEN GOTO 210
180   mouse=0
190   POKE contrl,123:POKE contrl+2,0:POKE contrl+6,0
```

```
200 VDISYS(1) :                        REM hide cursor
210 POKE contrl,11:in=0:xop=x+50:yop=y+50:rc=0
220 ptin=2:IF gdp=4 THEN ptin=3:xop=0:yop=0:rc=50
230 IF gdp=2 OR gdp=3 THEN ptin=4:xop=0:yop=0:in=2
240 POKE contrl+2,ptin
250 IF gdp=6 OR gdp=7 THEN xop=50:yop=20:in=2
260 IF gdp=5 THEN xop=60:yop=40
270 IF in0 THEN POKE contrl+6,in
280 POKE contrl+10,gdp
290 POKE ptsin,x
300 POKE ptsin+2,y
310 POKE ptsin+4,xop
320 POKE ptsin+6,yop
330 REM IF ptin=2 THEN GOTO nxtin
340 POKE ptsin+8,rc
350 POKE ptsin+10,0
360 REM IF ptin=3 THEN GOTO nxtin
370 POKE ptsin+12,50
380 POKE ptsin+14,0
390 REM nxtin: IF in=0 THEN GOTO draw
400 POKE intin,(rnd*3600)
410 POKE intin+2,(rnd*3600)
420 draw: VDISYS(1)
430 RETURN
440 showcurs: IF mouse=1 THEN RETURN
450 POKE contrl,122:POKE contrl+2,0:POKE contrl+6,0
460 curson: POKE intin,0: VDISYS(1)
470 mouse=1: RETURN
```

Look at the spelling of the variables, particularly contrl, if the program crashes. Although BASIC access to the processor is normally in user mode, PEEK and POKE instructions are performed in supervisor mode to provide access to all parts of memory.

BASIC ASSEMBLER

There are many ways of producing a combined BASIC/assembler program on the Atari ST computer, the following demonstrates one of them:

First create the assembler subroutine of relocatable 68000 machine code that can be saved using a BASIC program similar to the following.

```
10   RESTORE
20   ZA$="12345678901234567890":     REM \Use either method to
30   ZB$=STRING$(100,"*"):           REM /create space for code
40   y=VARPTR(ZA$):                  REM Somewhere to put code
50   DEF SEG=y:                      REM Set up loop offset
60   FOR a=0 TO n
70   READ x:POKE a,x:                REM Put code into memory
80   NEXT a
90   BSAVE "prog1.asm",y,n:          REM Save code to disk
100  STOP
200  DATA .........                  REM Byte sized data
```

The machine code will probably be loaded into a space created within the main BASIC program by a dummy variable. Obviously, any number of different machine code utilities can be loaded into the same space dependant upon program state, or they may be stored in individual program spaces.

Parameters are passed to the machine code routine on the user stack which contains an integer count of the number of parameters passed on top. The next item on the stack is a longword pointer to the 8-byte per parameter array. String variables use the array parameter as a pointer to the string.

Output can be placed in predefined variables and if correctly formatted, read back by the BASIC program.

```
10   ZB$=STRING$(100,"*"):     REM Space to load code
20   ZR$="12345678":           REM Space for reply
30   y=VARPTR(ZB$):            REM Position for code
40   ans=VARPTR(ZR$):          REM Position of reply
50   BLOAD "prog1.asm",y:      REM Load code from disk
.
100  CALL prog1(x,y,ans):      REM Call program code, passing parameters
                               REM x and y, returning data in the
                               REM variable ans
```

An alternative might be to compile the code within the BASIC program proper if the machine code program length is quite short.

Hand coding

Many programmers had their first contact with assembly language programming through hand coded 8-bit microprocessor routines embedded in short BASIC programs. MC68000 code is slightly more complicated to assemble than 8-bit code, but is still perfectly manageable.

Use tables of instruction types 0 to 15 (Appendix H), to generate the basic code i.e:

4096 * type + 512 * dreg + 64 * dmod + 8 * smod + sreg

and the address mode encoding table (Pg H.14) to determine the effective address (-ea-) values if required.

Example of a hand coded program

Project: MONITOR SCREEN INVERSION Author:
Version #: 2 Date: DEC/85

Label	Syntax	Src Mnm	Dest Mnm	type	dreg	dmod	smod	sreg	Dec value	Notes
00	MOVE.W	N	-(SP)	3	7	4	7	4	16188	GET OLD COLOUR
2			-1						-1	
4	MOVE.W	N	-(SP)	3	7	4	7	4	16188	_SETCOLOR (Pg 3.8)
6			0						0	
8	MOVE.W	N	-(SP)	3	7	4	7	4	16188	
10			7						7	
2	TRAP	14		4	7	1		14	20046	
4	ADDA.W	N	SP	13	7	3	7	4	57084	TIDY STACK
6			6						6	
8	EORI.W	N	D0	0	5	1	0	0	2624	TOGGLE COLOUR BIT 0
20			1						1	
2	MOVE.W	D0	-(SP)	3	7	4	0	0	16128	SET NEW COLOUR
4	MOVE.W	N	-(SP)	3	7	4	7	4	16188	
6			0						0	
8	MOVE.W	N	-(SP)	3	7	4	7	4	16188	
30			7						7	
2	TRAP	14	SP	4	7	1		14	20046	
4	ADDA.W	N	6	13	7	3	7	4	57084	TIDY STACK
6									6	
8	RTS			4	7	1	6	5	20085	RETURN TO BASIC

Use this type of program to load the code into a file on disk:

```
10   restore:n=70
20   zb$=string$(100,"*")
30   y=varptr(zb$)
40   def seg = y
50   for a=0 to n step 2
60   read x:poke a,int(x/256):poke a+1,x mod 256
70   next a
80   bsave "b/w.asm",y,n+2
100  stop
210  data 16188,-1,16188,0,16188,7
220  data 20046,57084,6,2624,1
230  data 16128,16188,0,16188,7
240  data 20046,57084,6
250  data 20085
300  data 0,0,0,0,0,0,0,0,0,0,0,0,0
310  data 0,0,0,0,0,0,0,0,0,0,0,0,0
320  data 0,0,0,0,0,0,0,0,0,0,0,0,0
```

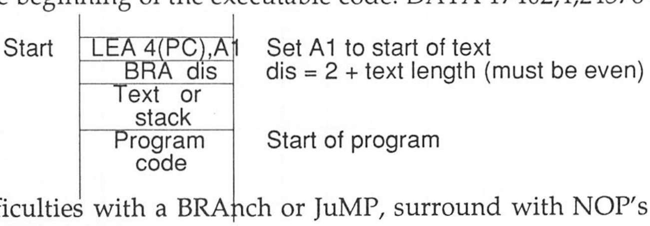
and to toggle the screen or border color, run the following BASIC program which loads the file back from disk and executes it:

```
10   zb$=string$(100,"*")
20   y=varptr(zb$)
30   bload "xb/w.asm",y
40   call y
50   stop
```

The following brief notes may be useful in compiling programs in the above manner:

Entry to machine code level from BASIC is in supervisor mode.

If you drop to user mode, be careful where you place your stack. Perhaps you might like to use the following sequence of instructions that jump over your stack or data to the beginning of the executable code. DATA 17402,4,24576+dis,...



If in difficulties with a BRAnch or JuMP, surround with NOP's to make the jump less sensitive to the count.

Project: Author:
Version #: Date:

Label	Syntax	Src Mnm	Dest Mnm	type	dreg	dmod	smod	sreg	Dec value	Notes
0										
2										
4										
6										
8										
0										
2										
4										
6										
8										
0										
2										
4										
6										
8										
0										
2										
4										
6										
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4										
6										
8										
0										
2										
4										
6										
8										
0										
2										
4										
6										
8										

Appendix K

Program development tools

Atari MC68000 assemblers

There are a number of assemblers available for the Atari ST programmer, they have small discrepancies in the assembly syntax used, no uniformity in the library and utility files supplied or of the method of creating an executable program.

This makes it difficult for the inexperienced programmer to type as source a program listing created for another assembler, and to get it operational. What I have tried to produce is an analysis of each assembler and a conversion chart that may help in isolating fairly straightforward problems.

Where a published program uses a particular assembler specific facility (special macros etc.) then translation will not always be possible by simple substitution and there may be no easy solution. Hopefully the general assembler compatibility chart will indicate whether there is the likelyhood of a conversion.

This guide is very much less than perfect, but it is an attempt at assisting inexperienced programmers in a very difficult field.

The assemblers

Very few of the assemblers provide programming details of the Motorola M68000 processor instruction set, or teach the user basic assembler language programming. If the reader has not written assembly language programs before, the brief overview of the language in Appendices G and H should help.

Seka

The combined editor/assembler/monitor/debugger is held in a very compact 20K of code, this means that parts of the package are a bit weak. Although two editors are supplied, a line editor and a screen editor, neither performs block find and replace function. Use the Atari wordprocessor in non wp mode for major or block changes in large files. What is likely to be more of a significant problem is the limitation to a leading letter for label and symbol names (the use of an underscore is very common in most libraries and the Atari system variables). A possible solution would be to substitute a little used letter for the leading underscore, say 'z'.

On the positive side, the Seka assembler generates absolute or relocatable executable code directly, has limited macro and conditional capability, and is a quick assembler for writing programs if you know what you are doing - some of the runtime error messages are incomprehensible with no guide in the manual as to what they are trying to tell you. It is very convenient having all the facilties in one program, an assembly error leaves the editor at the erroneous line for immediate correction and reassembly or the programmer may trace through the code with the monitor/debugger. The editor also allows the programmer to type the source code in free format; the assembled output listing is automatically tabulated, but there is no way of simply listing the code to a printer in a tabulated form which makes the source difficult to read when trying to debug program logic errors. Source files entered in a tabulated form are occasionally detabulated in parts of the assembly list file. The system for linking files is a bit messy and very non-standard as are some of the assembler directives. The monitor/debugger allows the programmer to single/multiple step through a program, examine registers, set breakpoints and provides all the necessary facilities to aid program debugging. It is important to ensure that program files are of even length; odd file lengths sometimes produce run-time errors not discovered by the debugger, which makes the fault extremely difficult to locate. The assembly syntax is pretty standard; labels must terminate in a colon, 'movea' should be entered as 'move', the assembler correcting the syntax but strangely 'adda' is acceptable.

The 36 page manual limits the two examples to very simple TOS programs, one of which includes macros. The manual has a lot of ground to cover which it manages only at a fairly minimal level. i.e it does not provide enough information regarding the cause of errors - an error in a macro is flagged as an illegal operand in the calling code. The manual contains a very useful single page command summary.

The package is very easy to use, although not as powerful as some of the other packages in this appendix. As an assembler, it is complete with minimal libraries of DOS calls equates and GEM array generators.

Hisoft

A combined editor/assembler with a seperate monitor/debugger. The Hisoft assembler employs include files to ease the access to the GEM and TOS functions and produces machine code directly. The include files require function parameters to be explicitly placed in the parameter arrays as per the assembler GEM example (Appendix L). The assembler does not have a linker facility, which makes that aspect a little unusual, and does not like labels followed only by comments on the same line. The editor is a full feature program with the minor omission of displaying and handling only one file at a time.

The package contains include files of equates for BDOS, BIOS, extended BIOS calls, system variables and a GEM include file that provides program initialisation, VDI and AES constant equates and parameter array initialisation. The package does not provide details of the data (Chapters 3, 4 and 5) to be placed in the arrays.

The monitor/debugger besides supporting the usual step, set breakpoints, examine and modify registers and memory etc. enables the assembled program to be run and debugged using seperate screens for the graphics and the monitor output, a very useful feature.

The documentation is well written and provides a good introduction for the beginner.

A very friendly package that could benefit from the use of a RAM disk to hold all the files in memory at once. In a 512K machine, seperating the program into two components does not appear to provide the optimum 'modus operandi'.

GST

The GST assembler package has a very good GEM based editor that enables up to four files to be worked on at the same time in multiple windows, copying blocks from one to another with ease. The only possible complaint regarding the editor could be the relatively slow loading of program and files and of cursor movement up and down within the file.

The assembler can produce relocatable binary output suitable for the linker or executable code directly from position independant source. The executable code does not contain the standard Atari TOS file header preamble, which must be added by the programmer if the file is to act as a stand alone program. A very useful list of the instruction mnemonics is provided, as is information on the optimisation route taken in compiling code. The use of an underscore for the leading character of a label or symbol is not permitted, which entails a degree of non compatibilty with the standard Atari ST notation for some system variables and extended BIOS calls.

The assembly of source is slow by virtue of the many disc accesses, but the use of RAM disc for compilation and the loading of all modules into memory together will obtain reasonable speed. There is no uninitialised data (BSS) directive which means that GEM program files held on disc are about 1K larger than necessary. If some instruction sizes are not explicitly stated, a liberal supply of warning messages are issued.

The GST linker is also supplied with the Metacomco macro assembler, it enables other high level language modules written in Pascal, Assembler and C to be linked together in a single program.

The library supplied contains macro definitions of conditional structures. GEM and TOS libraries are not supplied.

The documentation consists of seperate index-less assembler, editor and linker manuals, which are very well packaged in a ring binder, the manuals are very detailed, but may be difficult for the inexperienced assembly language programmer to read.

Metacomco

The screen editor is good but does not follow the normal GEM style of access, although the user will very quickly adjust. The global 'find and replace' is comparitively slow as the screen is re-written for each change.

The assembler is slow in comparison with the smaller assemblers evaluated in this appendix and would benefit greatly from the use of RAM disk. Symbols may be of up to thirty significant characters, but tabulated 'dc' data values on one source line seperated by a comma and space are not permitted - the space may be used to introduce a comment.

Metacomco supply the GST linker with their macro assembler which can produce either a binary file suitable for the GST linker or a CP/M 68K object file suitable for the DR link68 linker; which links to the complete DR set of GEM and TOS libraries, but is undocumented.

The Metacomco assembler package is supplied with assembler source to the GEM libraries and a monitor program. The monitor provides breakpoints, a trace mode and register/memory change and examine facilities.

The assembler suite of programs can be batched using the Menu+ program provided, It enables the sequence of edit, assemble, link and run to be controlled by the menu file, which runs and loads each program producing the specified outputs as requested and entering the next stage automatically via a pause, wait or continue programmed instruction.

The documentation is concise and very well laid out, but gives no additional explanation on assembly errors to that displayed on the screen during the assembly phase.

Digital Research

The Digital Research package can use any editor/word processor that is capable of producing an unformatted ASCII text file.

The assembler, which is a reasonable implementation of the Motorola M68000 assembly language, has no macro facilities but optimises instructions and branches to produce efficient code.

The DR LINK68 linker provides access to the DR GEM and TOS libraries that consist of accessory and application header files, GEMDOS, BIOS, XBIOS, VDI, AES and floating point libraries.

Although the assembler, linker and relocator programs can be installed as TTP (TOS Takes Parameters) files, the programs are much easier to run via the Activenture Corp. batch program. The additional use of a RAM disk to hold the files and programs produces a very reasonable response, eliminating much of the disc access.

The development package was intended for software developers and not the general public, as such it is written with a high degree of technical jargon. Complete with no omissions, a veritable 'War and Peace'. It provides information on all of the GEM VDI functions and makes no mention of those not implemented on the ST.

DR C language modules may also be linked with the assembled source and DR libraries to produce executable programs.

The package is supplied with the DR symbolic interactive debugger 'SID' enabling the program writer to test and debug M68000 executable code, either from TOS or GEM, read/write/move blocks of memory, disassemble code or produce a hex dump, examine the CPU state, trace, run or step through the code.

Atari have recently made available a new faster linker ALN to software developers, which replaces both LINK 68 and RELMOD, the linker and relocation package respectively.

Compatibility table

The analysis of each package necessarily concentrates on the flaws, looking for inconsistences and omissions. What may not be apparent is how good in absolute terms the packages are, any purchaser being able to justify the cost on technical excellence alone.

It may be useful to give an indication as to the range of likely purchaser of each package:

K_seka assembler:

Absolute beginner - competent programmer: Very fast program development

Hisoft devpak:

Absolute beginner - competent programmer: Fast program development, with GEM and TOS bindings.

GST macro assembler:

Absolute beginner - expert: Full feature assembler capable of linking with other high level language modules to form executable programs.

Metacomco assembler:

Competent programmer - expert: Full feature assembler with macros. DR's linker may be used to provide access to the complete set of system libraries, and GST's linker to link high level language modules into a combined language program.

Digital Research assembler:

Software developer: Not available to the general public.

General assembler compatibility:

Not exhaustive, merely a guide to what facilities are available.

Function	Hisoft assembler	Digital Research	GST assembler	Metacomco assembler	Kseka assembler
Editor	GENST	-	Edit	Ed	All-in-one package
multifile edit	No	Can use any	Yes (4)	No	No
screen/line	screen	wordprocessr	screen	screen	Line & screen
GEM	Yes	ASCII text.	Yes	No	No
Assembler(i/p)	(.S)	AS68 (.S)	(.ASM)	(.ASM)	(.S)
Output	Executable	Binary file	Binary file	See linker	Executable
-nolink	or binary		or executable		
			(no file header)		
Optimiser	Yes	Yes	Yes	Yes	
Macros	Yes	No	Yes	Yes	Yes
conditional	Yes	Yes	Yes	Yes	Yes
Linker	LINKST	Link68	GST-LINK	Can use either	Relocatable
Input			Binary file	GST-LINK or	mode
Submissions		Batch file	Control file	DR's LINK68	only
Output			File-header	& RELMOD	
			reloc table	programs	(odd format)
			code	(GST-LINK	
			data	is supplied)	
			opt sym table		
Libraries					
GEM	Yes-limited	Yes-complete	No	Yes-source	Yes-minimal
TOS	Yes-limited	Yes-complete	No	No	Yes-minimal
Maths	No	Yes	No	No	No
Monitor	MONST		No	Yes	Yes
Debugger	Yes	SID	Not supplied	Supplied	Yes
		symbolic	Linker can put	as source	
		interactive	debug symb	example	
		debugger	in program	on disk	
Relocator program	No	RELMOD	No	No	No
Symbols	16 signif		8 signif char	Upto 30 char	
Label) column 1	Space	Space or :	Space or :	Space or :	Colon
end) column n	Space or :	Colon	Colon	Colon	Colon
Directives		Optional period			
Comment) col 1	*	*	* or ;	* or ;	* or ;
) col n	space	*	; or space	; or space	;
Case (Symbols)	Selectable	Significant	Not_significant	Selectable	Not significant
Quotes	Sngle/dble	Sngle/dble	Single	Single/double	Single/double

GST assembler executable code must supply a TOS program header and be written in positition-independant code before it can be run. The default file extensions are given in brackets.

Assembler directives compatibility

Directive	Explanation	Hisoft	Digital Research	GST	Metacomco	Kseka
Include(i/p)	Insert external file	Yes (.S)	No	Yes (.IN) (.MAC)	Yes	Abs. code via linker
Text	Relocatable code	No	Yes	Section code	Yes (def)	Code ==
Data	Initialised data	No	Yes		Yes	No
BSS	Uninitialised data	DSBSS==	Yes	No	Yes	Data ==
even	Align to word	Yes ***	Yes	***	***	Yes & odd
ORG <addr>	Absolute section	Yes	Yes	Yes	No	Yes
Common	Common region	No	Yes	Yes	No	No
RORG <addr>	Adjust curr locn	No		Yes	Yes	No
Offset	Define table via a DS directive	No	Yes	Yes	Yes	No
OPT	Select addr mode	Diff meaning	Ignored	PC or Abs	No	No
Globl	External label	Yes	Yes	No	No	Yes
Xref	External name	Yes	Yes	Yes	Yes	No
Xdef	Internal label for external use	Yes	Yes	Yes	Yes	No
Module	Link module name	Yes		Yes		
Comment	Include comments in linker listing			Yes		
Equ	Symbol	Yes	Yes	Yes	Yes	Yes & =
Equr	Register	Yes			Yes	
Reg	Register list		Yes	Yes	Yes	
Set	Temporary value	Yes	Uses Equ		Yes	
DC	Constant	Yes	Yes	Yes	Yes	Yes
DS	Storage	Yes	Yes	Yes	Yes	
DCB	Constant block			Yes	Yes	Blk ==
RS		Yes				No
Conditionals		Yes	Yes	Yes	Yes	Yes
IF eq,ne,gt ge,lt,le		Yes	Yes	No	Yes	If,Else IFB
String c,nc		Yes	Yes	Yes	Yes	No
Symbol d,nd		Yes		Yes	Yes	No
Library Sys		GEM/TOS	GEM/TOS/FP	None	None	Minimal
Macro				If,Else,For While,Until Repeat,Case		
	Sub nth arg	\n	Not	[n]	\n	?n
	Sub unique # nnn	\@	applicable	[.L]	\@	?o
Mask2			Ignored		Ignored	
IDNT			Ignored		Ignored	

*** DS and DC word and longwords automatically align to boundaries

Assembler conversions

There are a number of assemblers available for the ST, each with different characteristics, this ·section is provided as an aid to translation of programs presented from alternative sources.

One of the by-products of the compatibility information is that it provides the opportunity of generating a subset of directives and instructions that are of 4 almost0 universal applicability, but compatibility does tend to look at the lowest common denominator.

All of these programs have other attributes which provide a significant improvement in performance over the base standard, these improvements are not always apparent to the casual user but very handy to have if required.

If you wish to write source for maximum compatibility with other assemblers, the following should minimise the problems:

- Size all instructions (move, clr, lea etc. do not default)
- Size branches (avoids masses of GST warning messages)
- Avoid using reserved words for labels such as text, code etc.
- Use a semicolon for all comments (except Hisoft and DR which should use a '*')
- Do not tabulate DC data, added spaces do not travel well.
- Limit label and symbol lengths to eight characters.
- Use 'EQU' directive, not '='.
- After text and data sections, it is wise to ensure that the PC is on a word boundary. Most programs use 'EVEN', some assemblers use 'DC' and 'DS' with a .W or a .L extension.

Sizing instructions is perhaps the most difficult factor to come to terms with. I find it extremely difficult to ignore and not stop and read any warning messages, and become a little irritated to find that a branch 'might be short' or that LEA has not got a .L extension. All warnings should be significant or else they will 1 all0 be treated as superfluous information.

General conversion chart

FROM	To-Kseka	Hisoft	GST	Metacomco	DR	Comments
Macros **Kseka** comment Opcodes	MACRO ?1 ?2 ?o ; blk	\1 \2 \@ * ds	MACRO A [A] [B] [.L] Size Opcodes & branch ds	\1 \2 \@ Size opcodes ds	n.a. Expand code in full * ds	Program may use many labels that do not appear to have any function. They will probably be breakpoints.
Macros **Hisoft** comment Opcodes	?1 ?2 ?o ; blk	MACRO \1 \2 \@ * ds :	MACRO A [A] [B] [.L] ; Size Opcodes & branch	; Size opcodes	n.a. Expand code in full	Places GEM data directly into VDI and AES arrays. If the source includes GEM calls, follow the example in appendix L
Macros **GST** comment Opcodes	MACRO ?1 ?2 ?o blk	MACRO \1 \2 \@ *	MACRO A [A] [B] [.L] ; ds	MACRO \1 \2 \@	n.a. Expand code in full	Seems to like all instructions sized or issues lots of warning messages. Library of conditional macros will cause problems. Code has to belong to a section.
Macros **Metacomco** comment Opcodes	?1 ?2 ?o blk	* Size branch	MACRO A [A] [B] [.L]	MACRO \1 \2 \@ ; ds	n.a. Expand code in full	GEM library supplied Implementation is standard but translation depends on the availability of the library used, (follow example Appendix L)
Digital Research comment Opcodes	code data zlabel ; (add to all labels) blk		Section C Section D zlabel ;	;	TEXT BSS _label * ds	Delete any period directive prefix. No macro facilities but a full set of GEM libraries. Look at example appx L to see sheer power and how difficult translation will be

The above table will help to eliminate some of the more straight-forward program conversion problems, those that remain are likely to be due to the use of assembler specific directives and or libraries (especially label errors).

If a program is published, one assumes that any include file data will be generally available and can either be appended as an include file or the code integrated with the main program block of code.

If your assembler does not have VDI and AES libraries, then to use GEM you will have to create the arrays and load the addresses as shown in the assembler GEM example appendix L

The chart is limited to simple conversions. Once include files and global label definitions are used, you will need to assemble the program, generate a list of the missing external labels and hopefully find them in the examples Appendix L and or the call listings Appendix E.

Numbers

The following shows the standard presentation of the various numeric types:

Octal	@nnn	n=0 to 7
Binary	%xxxxxxxx	x=0 or 1
Decimal	nnnn	n=0 to 9
Hexadecimal	$nnnn	n=0 to 9, a to f

Basic calling procedures

Basic calling procedures for simple source files assembled (and linked) without libraries.

Kseka

SEKA> r	Instruction to read source file from disc
FILENAME> filename	File to read (default .S extension)
SEKA> a	Instruction to assemble source
OPTIONS> v	Option to view assembly on screen
.	
.	
SEKA> wo	Instruction to write output program
FILENAME> filename	File to write (default .PRG extension)

Hisoft Menu driven, place cursor over instruction and click
Option -------> Assemble
Option dialog box
Binary filename xxxxx.prg
Listing option boxes (none/screen/printer/disc)
Assemble/cancel boxes

GST Menu driven, place cursor over instruction and click, OR double click the TTP program file and enter the filename as the parameter:

ASM.PRG filename	to produce a list file and filename.BIN from a default .ASM extension file
LINK.PRG filename	to produce a .MAP file and filename.PRG from a default .BIN extension file

Metacomco The program files are installed as Tos Takes Parameters (TTP), double click and enter input file:

ASSEM.PRG filename	Assembles filename.asm to produce a GST format output file
LINK.PRG filename	Produces a .MAP file and filename.PRG from a default .BIN extension file

Digital Research The program files are installed as TOS Takes Parameters and the file data entered into the parameter box.

AS68.PRG filename.S	Produce binary file
LINK68.PRG filename.68K = filename.o	Produce relocatable file
RELMOD.PRG filename	Produce absolute file

Executable file sizes (bytes)

Natural compilations with no optimisation extensions called.

Program	Page #	D.R	Seka	Hisoft	GST	Metacomco
GEM error message	L7	777	-	-	-	781
Assembler GEM	L8-17	1651	1734 3170	3170	3016	3170
TOS colour demo	L16	145	162 246	246	235	248
TOS VT52 screen	L18-19	194	202	202	192	202
TOS sound program	L20-22	324	331 591	591	586	591
Line-A sprite program	L25-26	296	314 394	394	374	392

The Metacomco file sizes are for files linked via the GST linker except for the 'GEM error message' which used the DR linker.

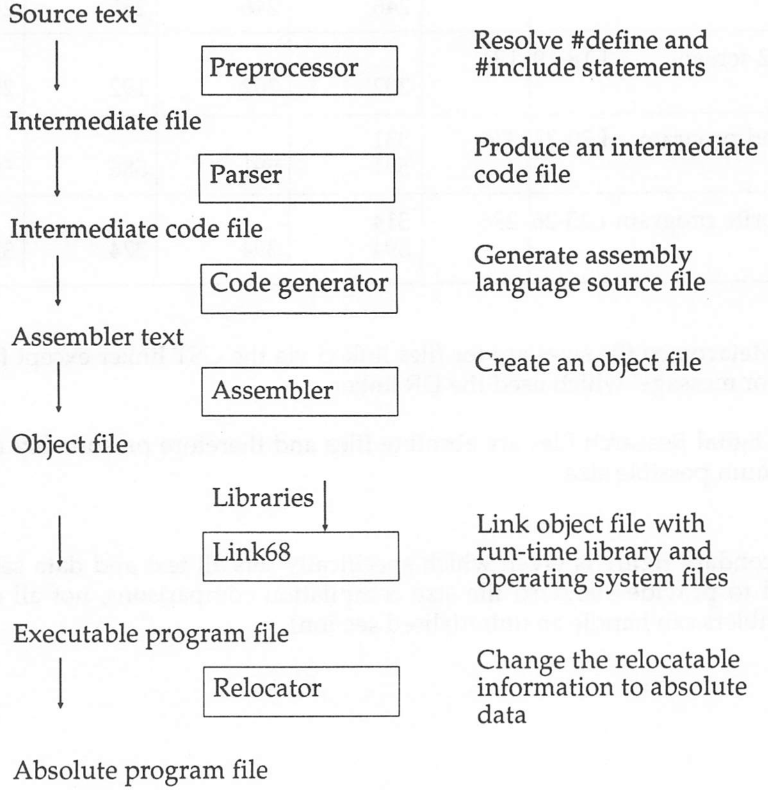
The Digital Research files are absolute files and therefore presumably nearer the minimum possible size.

(a secondary figure is given which specifically sets all text and data sections initialised to provide standard file size compilation comparisons, not all of the test assemblers can handle an uninitialised section)

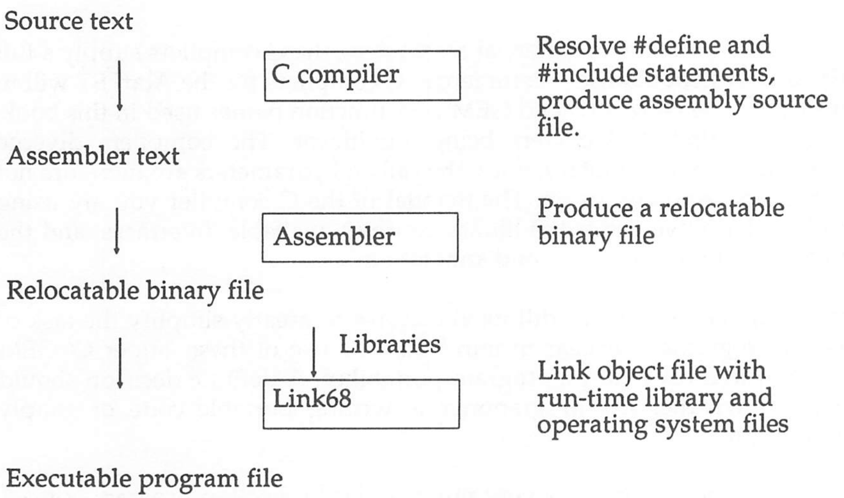
C compilers

Many C compilers have been developed for the ST range of computers, enabling the ST programmer to produce modular, well documented, easily maintained code that may be ported to other C systems with a minimum of effort.

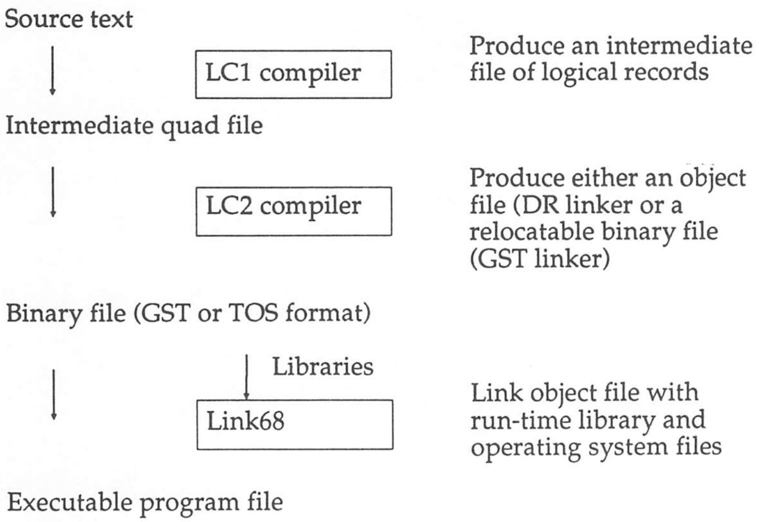
Although achieving the same end result, the C compilers differ considerably in the way that they attain that result. I give three examples of the compilation process:



GSTC compiler



Metacomco Lattice C



Those programmers who wish to program the Atari ST in C may find the following brief notes helpful:

Unlike nearly all of the commercial assemblers, the C compilers supply a full set of GEM and system libraries. Commercial C compilers for the Atari ST will in general adhere to the GEM VDI and GEM AES function names used in this book, usually only the first 8 characters being significant. The compilers diverge considerably in use of parameter names, the call and parameters are therefore not provided here to avoid confusion. The manual of the C compiler you are using will provide a definitive list of the library routines available, interfaces, and the required parameter size, sequence and annotation.

Many compilers will have additional features to greatly simplify the task of writing GEM programs; but bear in mind that the use of these 'super C' GEM functions may put a restraint on program portability. A definite decision should be made as to whether the programmer is writing portable code or simply writing a program.

On a more general note; it is very much easier to develop programs on a 1 Meg disk drive, which makes the larger drive well worth the small additional cost for those machines without the built-in drive.

Appendix L

Example assembler programs

Example programs

General

The programs presented in this section illustrate some of the techniques involved in accessing parts of the Atari ST operating system and also present general purpose header/include files. The programs are written as shells to which the programmer may add his/her own composition.

It is not the intention to provide 'state of the art' programs, merely demonstrate access to the various parts of the operating system. Any attempt at definitive programming would rapidly succumb to the passage of time and tend to produce a book of listings. The main place to find quality programs will be the computer magazines, where programs developed from this and other books will appear as programmers quickly find new, smarter routes to access and use the ROM routines.

Desktop accessories should be compiled as applications for debugging purposes as it is not possible to execute an accessory.

Program conversion key

```
n.a         program not suitable for this assembler.
xxx         delete this line
*           use ; for Kseka, GST and Metacomco comments
```

GEM

GEM application and accessory header file

Digital Research (and Metacomco in CP/M 68K object mode) application and desk accessory files require a similar type of header source file construct to provide access to the GEM VDI and AES libraries, either as the first file in the DR link statement or as the beginning of a single block of assembler code.

Part of this file determines the size of memory the application requires and returns the remainder to GEMDOS. Some Atari ST assemblers will provide similar code as a header/initialisation file to permit the programmer to access the VDI and AES functions through their own integral libraries.

```
* Digital Research                        *   Hisoft .    GST     Metacomco     Seka  .
*                                         *    n.a   .    n.a   .           .   n.a   .
      text              * Text segment    *          .          .           .         .
*
      globl _main       * Make labels     *          .          . xdef      .         .
      globl _crystal    * accessible to   *          .          . xdef      .         .
      globl _ctrl_cnts  * external files  *          .          . xdef      .         .
*
      move.l a7,a5      * store stack (a5) *         .          .           .         .
      move.l #ustk,a7   * set local stack *          .          .           .         .
*
* Desk accessories do not require the following lines of code
* which size memory and return the unused memory to GEMDOS
*
      move.l 4(a5),a5   * basepage address *         .          .           .         .
      move.l $c(a5),d0  * length of text  *          .          .           .         .
      add.l $14(a5),d0  * length of data  *          .          .           .         .
      add.l $1c(a5),d0  * length of BSS   *          .          .           .         .
      add.l #$100,d0    * basepage size   *          .          .           .         .
      move.l d0,-(sp)   * retained mem len *         .          .           .         .
      move.l a5,-(sp)   * memory to modify *         .          .           .         .
      move d0,-(sp)     * dummy word      *          .          .           .         .
      move #$4a,-(sp)   * reallocate to GEM*         .          .           .         .
      trap #1           * function number *          .          .           .         .
      add.l #12,sp      * tidy stack      *          .          .           .         .
*
* Main program call
*
      jsr _main         * main program code*         .          .           .         .
      move.l #0,-(a7)   * return to GEMDOS *         .          .           .         .
      trap #1           * function call   *          .          .           .         .
```

```
*
* Digital Research                              *  Hisoft .    GST     Metacomco     Seka  .
*
* GEMAES calls link through _crystal
*
_crystal:
      move.l 4(a7),d1    * address of AES pblk*        .        .         .          .
      move.w #200,d0     * GEMAES function #*          .        .         .          .
      trap #2            * function call     *         .        .         .          .
      rts                * return            *         .        .         .          .
      bss                * block storage seg*          .        .         .          .
      even               * force even boundary*        .        . xxx     .          .
*
      ds.l 64                                *         .        .         .          .
ustk: ds.l 1                                 *         .        .         .          .
*
      data                                   *         .        .         .          .
      even                                   *         .        . xxx     .          .
*
_ctrl_cnts
*
* Application manager
*
      dc.b 0,1,0         * APPL_INI.......10*          .        .         .          .
      dc.b 2,1,1         * APPL_READ......11*          .        .         .          .
      dc.b 2,1,1         * APPL_WRIte.....12*          .        .         .          .
      dc.b 0,1,1         * APPL_FINd......13*          .        .         .          .
      dc.b 2,1,1         * APPL_TPLay.....14*          .        .         .          .
      dc.b 1,1,1         * APPL_TRECord...15*          .        .         .          .
      dc.b 0,0,0         *                  *          .        .         .          .
      dc.b 0,0,0         *                  *          .        .         .          .
      dc.b 0,0,0         *                  *          .        .         .          .
      dc.b 0,1,0         * APPL_EXIt......19*          .        .         .          .
*
* Event manager
*
      dc.b 0,1,0         * EVNT_KEY.......20*          .        .         .          .
      dc.b 3,5,0         * EVNT_BUTton....21*          .        .         .          .
      dc.b 5,5,0         * EVNT_MOUse.....22*          .        .         .          .
      dc.b 0,1,1         * EVNT_MESsage...23*          .        .         .          .
      dc.b 2,1,0         * EVNT_TIMe......24*          .        .         .          .
      dc.b 16,7,1        * EVNT_MULti.....25*          .        .         .          .
      dc.b 2,1,0         * EVNT_DCLick....26*          .        .         .          .
      dc.b 0,0,0         *                  *          .        .         .          .
      dc.b 0,0,0         *                  *          .        .         .          .
      dc.b 0,0,0         *                  *          .        .         .          .
```

```
*
* Digital Research                          *  Hisoft .   GST     Metacomco   Seka  .
*
* Menu manager
*
      dc.b 1,1,1         * MENU_BAR.......30*        .        .        .        .
      dc.b 2,1,1         * MENU_ICHeck....31*        .        .        .        .
      dc.b 2,1,1         * MENU_IENable...32*        .        .        .        .
      dc.b 2,1,1         * MENU_TNOrmal...33*        .        .        .        .
      dc.b 1,1,2         * MENU_TEXt......34*        .        .        .        .
      dc.b 1,1,1         * MENU_REGister..35*        .        .        .        .
      dc.b 0,0,0         *                  *        .        .        .        .
      dc.b 0,0,0         *                  *        .        .        .        .
      dc.b 0,0,0         *                  *        .        .        .        .
      dc.b 0,0,0         *                  *        .        .        .        .
*
* Object manager
*
      dc.b 2,1,1         * OBJC_ADD.......40*        .        .        .        .
      dc.b 1,1,1         * OBJC_DELete....41*        .        .        .        .
      dc.b 6,1,1         * OBJC_DRAw......42*        .        .        .        .
      dc.b 4,1,1         * OBJC_FINd......43*        .        .        .        .
      dc.b 1,3,1         * OBJC_OFFset....44*        .        .        .        .
      dc.b 2,1,1         * OBJC_ORDer.....45*        .        .        .        .
      dc.b 4,2,1         * OBJC_EDIt......46*        .        .        .        .
      dc.b 8,1,1         * OBJC_CHAnge....47*        .        .        .        .
      dc.b 0,0,0         *                  *        .        .        .        .
      dc.b 0,0,0         *                  *        .        .        .        .
*
* Form manager
*
      dc.b 1,1,1         * FORM_DO........50*        .        .        .        .
      dc.b 9,1,1         * FORM_DIAlog....51*        .        .        .        .
      dc.b 1,1,1         * FORM_ALErt.....52*        .        .        .        .
      dc.b 1,1,0         * FORM_ERRor.....53*        .        .        .        .
      dc.b 0,5,1         * FORM_CENtre....54*        .        .        .        .
      dc.b 0,0,0         *                  *        .        .        .        .
      dc.b 0,0,0         *                  *        .        .        .        .
      dc.b 0,0,0         *                  *        .        .        .        .
      dc.b 0,0,0         *                  *        .        .        .        .
      dc.b 0,0,0         *                  *        .        .        .        .
*
* Dialog manager
*
      dc.b 0,0,0         *                  *        .        .        .        .
      dc.b 0,0,0         *                  *        .        .        .        .
      dc.b 0,0,0         *                  *        .        .        .        .
      dc.b 0,0,0         *                  *        .        .        .        .
      dc.b 0,0,0         *                  *        .        .        .        .
      dc.b 0,0,0         *                  *        .        .        .        .
      dc.b 0,0,0         *                  *        .        .        .        .
      dc.b 0,0,0         *                  *        .        .        .        .
      dc.b 0,0,0         *                  *        .        .        .        .
      dc.b 0,0,0         *                  *        .        .        .        .
```

```
*
* Digital Research                       *  Hisoft .   GST    Metacomco   Seka .
*
* Graphics manager
*
     dc.b 4,3,0       * GRAF_RUBberbox.70*         .          .         .          .
     dc.b 8,3,0       * GRAF_DRAgbox...71*         .          .         .          .
     dc.b 6,1,0       * GRAF_MOVebox...72*         .          .         .          .
     dc.b 8,1,0       * GRAF_GROwbox...73*         .          .         .          .
     dc.b 8,1,0       * GRAF_SHRinkbox.74*         .          .         .          .
     dc.b 4,1,1       * GRAF_WATchbox..75*         .          .         .          .
     dc.b 3,1,1       * GRAF_SLIdebox..76*         .          .         .          .
     dc.b 0,5,0       * GRAF_HANdle....77*         .          .         .          .
     dc.b 1,1,1       * GRAF_MOUse.....78*         .          .         .          .
     dc.b 0,5,0       * GRAF_MKState...79*         .          .         .          .
*
* Scrap manager
*
     dc.b 0,1,1       * SCRP_REAd......80*         .          .         .          .
     dc.b 0,1,1       * SCRP_WRIte.....81*         .          .         .          .
     dc.b 0,0,0       *                  *         .          .         .          .
     dc.b 0,0,0       *                  *         .          .         .          .
     dc.b 0,0,0       *                  *         .          .         .          .
     dc.b 0,0,0       *                  *         .          .         .          .
     dc.b 0,0,0       *                  *         .          .         .          .
     dc.b 0,0,0       *                  *         .          .         .          .
     dc.b 0,0,0       *                  *         .          .         .          .
     dc.b 0,0,0       *                  *         .          .         .          .
*
* File selector manager
*
     dc.b 0,2,2       * FSEL_INPut.....90*         .          .         .          .
     dc.b 0,0,0       *                  *         .          .         .          .
     dc.b 0,0,0       *                  *         .          .         .          .
     dc.b 0,0,0       *                  *         .          .         .          .
     dc.b 0,0,0       *                  *         .          .         .          .
     dc.b 0,0,0       *                  *         .          .         .          .
     dc.b 0,0,0       *                  *         .          .         .          .
     dc.b 0,0,0       *                  *         .          .         .          .
     dc.b 0,0,0       *                  *         .          .         .          .
     dc.b 0,0,0       *                  *         .          .         .          .
*
* Window manager
*
     dc.b 5,1,0       * WIND_CREate...100*         .          .         .          .
     dc.b 5,1,0       * WIND_OPEn.....101*         .          .         .          .
     dc.b 1,1,0       * WIND_CLOse....102*         .          .         .          .
     dc.b 1,1,0       * WIND_DELete...103*         .          .         .          .
     dc.b 2,5,0       * WIND_GET......104*         .          .         .          .
     dc.b 6,1,0       * WIND_SET......105*         .          .         .          .
     dc.b 2,1,0       * WIND_FINd.....106*         .          .         .          .
     dc.b 1,1,0       * WIND_UPDate...107*         .          .         .          .
     dc.b 6,5,0       * WIND_CALc.....108*         .          .         .          .
     dc.b 0,0,0       *                  *         .          .         .          .
```

```
*
* Digital Research                            *   Hisoft .     GST      Metacomco      Seka  .
*
* Resource manager
*
       dc.b 0,1,1        . * RSRC_LOAd.....110*       .          .           .            .
       dc.b 0,1,0          * RSRC_FREe.....111*       .          .           .            .
       dc.b 2,1,0          * RSRC_GADdress.112*       .          .           .            .
       dc.b 2,1,1          * RSRC_SADdress.113*       .          .           .            .
       dc.b 1,1,1          * RSRC_OBFix....114*       .          .           .            .
       dc.b 0,0,0          *                  *       .          .           .            .
       dc.b 0,0,0          *                  *       .          .           .            .
       dc.b 0,0,0          *                  *       .          .           .            .
       dc.b 0,0,0          *                  *       .          .           .            .
       dc.b 0,0,0          *                  *       .          .           .            .
*
* Shell manager
*
       dc.b 0,1,2          * SHEL_REAd.....120*       .          .           .            .
       dc.b 3,1,2          * SHEL_WRIte....121*       .          .           .            .
       dc.b 1,1,1          *                  *       .          .           .            .
       dc.b 1,1,1          *                  *       .          .           .            .
       dc.b 0,1,1          * SHEL_FINd.....124*       .          .           .            .
       dc.b 0,1,2          * SHEL_ENVrn....125*       .          .           .            .
*      *                   .                  .       .          .
       end
```

The object file is used as the first file in the link to produce an Atari ST program file, say myprog, that accesses the DR GEM libraries i.e:

either **DR**

```
as68 -l -u apstart.s
```

or **Metacomco**

```
assem.prg apstart.asm opt j
```

followed by the linking of the main program file (see following example) to the header and the DR library files.

```
Link68 [u] myprog.68=apstart myprog.o vdibind aesbind

Relmod myprog
```

Delete all temporary files, leaving either an application file myprog.prg (which may be run by double clicking the icon in the directory listing) or an accessory file which must be renamed myprog.acc. Reboot the system and run the file by clicking the icon in the list of 'Desk' accessory files.

Remember to initially compile and run accessories as applications to debug them.

GEM demonstration program

To use GEM directly, push the function parameters onto the stack in the order given by the GEM VDI and GEM AES tables, ensuring that the correct size of parameter is pushed.

The following program, which may be written in either DR or Metacomco macro assembler but must use the DR link68 linker, lists in descending order the TOS error codes in dialog boxes, the user stepping from one code to the next via the mouse or the 'return' key.

```
* Digital Research                         *  Hisoft .   GST    Metacomco    Seka  .
*                                          * n.a     . n.a     .           . n.a   .
* Demo GEM program
*
      globl _main        *                 *         .         . xdef      .       .
      globl _form_err    *                 *         .         . xref      .       .
      globl _appl_ini    *                 *         .         . xref      .       .
      globl _appl_exi    *                 *         .         . xref      .       .
*
      text                                 *         .         . The       .       .
*                                          *         .         Metacomco           .
_main:                                     *         .         .external           .
      jsr _appl_ini                        *         .         .symbol     .       .
*                                          *         .         . names     .       .
      move.w #63,d4      * Error start #   *         .         . are       .       .
loop: move.w d4,temp     * Save it         *         .         .limited    .       .
      move.w d4,-(sp)    * Stack it        *         .         . to 8      .       .
      jsr _form_err      * What is it      *         .         characters          .
      add.w #2,sp        * Tidy it         *         .         . i.e       .       .
      move.w temp,d4     * Recover it      *         .         .           .       .
      dbra d4,loop       * and next        *         .          _form_er           .
      jsr _appl_exi      * Controlled exit *         .         _appl_in            .
      rts                                  *         .         _appl_ex            .
*
      bss                                  *         .         .           .       .
*
temp: ds.w 1                               *         .         .           .       .
*
      end
```

The file may be assembled using either

DR-

```
as68 -l -u -p myprog.s
```

or **Metacomco-**

```
assem myprog.asm opt j
```

Both programs are linked with the Digital Research link68 linker i.e:

```
link68 [s,u] myprog.68k=apstart,myprog.o,aesbind
```

and finally relocated by:

```
relmod myprog
```

GEM demonstration assembly program

It is possible to write assembly language programs that do not use the DR GEM bindings but simply access the functions via the Extended BDOS TRAP #2 calls. The following example shell shows a technique that will enable the programmer to create a window, do some work in it, and then make a controlled exit.

Note: Although the window is created with the sizing diamond and sliders, no code has been written to handle the screen managers requests for change; if these functions are activated they are ignored. If the cursor is active (as in this program) and covers part of the foreground content of the screen when the program is loaded, it will leave a hole when moved.

```
* Digital Research                          *  Hisoft .    GST     Metacomco     Seka  .
*
* Assembler GEM program
*
* Size the job and free back to GEMDOS unused memory
*
*
      text                                 * xxx      section c             . code     .
*
      move.l a7,a5        * curr - a5      *          .       .       .         .
      move.l #ustk,a7     * set local stk  *          .       .       .         .
      move.l 4(a5),a5     * get base page  *          .       .       .         .
      move.l $c(a5),d0    * text segment   *          .       .       .         .
      add.l $14(a5),d0    * data segment   *          .       .       .         .
      add.l $1c(a5),d0    * uninitialized  *          .       .       .         .
      add.l #$100,d0      * basepage size  *          .       .       .         .
      move.l d0,-(sp)     *                *          .       .       .         .
      move.l a5,-(sp)     *                *          .       .       .         .
      move d0,-(sp)       *                *          .       .       .         .
      move #$4a,-(sp)     *free unused mem *          .       .       .         .
      trap #1             *                *          .       .       .         .
      add.l #$c,sp        * tidy stack     *          .       .       .         .
      jsr start           *                *          .       .       .         .
      move.l #$0,-(sp)    * ret to GEMDOS  *          .       .       .         .
      trap #$1            *                *          .       .       .         .
*
* Technique for setting up VDI & AES arrays
*
* Initialize AES arrays
*
start:
*
      jsr ini_aes         *                *          .       .       .         .
*
```

```
* Digital Research                        *  Hisoft .   GST    Metacomco    Seka  .
*
* Call APPL_INI (1st call)                * pg 5.6
*
appl_ini:
     move.w #$a,control                   *       .        .        .        .
     move.w #$0,control+2                 *       .        .        .        .
     move.w #$1,control+4                 *       .        .        .        .
     move.w #$0,control+6                 *       .        .        .        .
     jsr aes                              *       .        .        .        .
     tst.w int_ou                         *       .        .        .        .
     bpl graf_han                         *       .        .        .        .
     rts                                  *       .        .        .        .
*
* Call GRAF_HAN to get name of the currently opened window. pg 5.26
*
graf_han:
     move.w #77,control                   *       .        .        .        .
     move.w #$0,control+2                 *       .        .        .        .
     move.w #$5,control+4                 *       .        .        .        .
     move.w #$0,control+6                 *       .        .        .        .
     jsr aes                              *       .        .        .        .
     move.w int_ou,handle                 *       .        .        .        .
*
* Initialize VDI arrays
*
     jsr ini_vdi                          *       .        .        .        .
*
* Open virtual workstation                * pg 4.9
*
v_opnvwk:
     move.w #100,contrl                   *       .        .        .        .
     move.w #0,contrl+2                   *       .        .        .        .
     move.w #11,contrl+6                  *       .        .        .        .
     move.w handle,contrl+12              *       .        .        .        .
*
* 11 input parameters
*
     move.w #1,intin       *drive id      *       .        .        .        .
     move.w #1,intin+2     *line type     *       .        .        .        .
     move.w #1,intin+4     *line color    *       .        .        .        .
     move.w #1,intin+6     *marker type   *       .        .        .        .
     move.w #1,intin+8     *marker color  *       .        .        .        .
     move.w #1,intin+10    *text face     *       .        .        .        .
     move.w #1,intin+12    *text color    *       .        .        .        .
     move.w #1,intin+14    *interior fill *       .        .        .        .
     move.w #1,intin+16    *fill index    *       .        .        .        .
     move.w #1,intin+18    *fill color    *       .        .        .        .
     move.w #2,intin+20    *NDC/RC        *       .        .        .        .
     jsr vdi                              *       .        .        .        .
*
* Save virtual screen workstation device handle
*
     move.w contrl+12,vhandl              *       .        .        .        .
     tst.w contrl+12                      *       .        .        .        .
     beq appl_exi                         *       .        .        .        .
```

```
* Digital Research                          *  Hisoft .    GST     Metacomco     Seka  .
*
* Test here for screen resolution and number of colors available
* (even in mono). Load appropriate resource file using the AES
* RSRC_LOA call if necessary.
*
* Get max possible size of window
*
max_wind:
      move.w vhandl,int_in                  *         .        .          .         .
      move.w #7,int_in+2      * sizes       *         .        .          .         .
      jsr wind_get                          *         .        .          .         .
      tst.w int_ou                          *         .        .          .         .
      beq appl_exi                          *         .        .          .         .
*
* Calculate work area of window
*
      move.w #0,int_in                      *         .        .          .         .
      jsr wind_cal                          *         .        .          .         .
      tst.w int_ou                          *         .        .          .         .
      beq appl_exi                          *         .        .          .         .
*
* Calc new window bordered area
*
      move.w #1,int_in                      *         .        .          .         .
      jsr wind_cal                          *         .        .          .         .
      tst.w int_ou                          *         .        .          .         .
      beq appl_exi                          *         .        .          .         .
*
* Alloc space for full size window          * pg 5.29
*
wind_cre:
      move.w #100,control                   *         .        .          .         .
      move.w #$5,control+2                  *         .        .          .         .
      move.w #$1,control+4                  *         .        .          .         .
      move.w #$0,control+6                  *         .        .          .         .
*
      move.w #$0fff,int_in     * edges      *         .        .          .         .
      move.w int_ou+2,int_in+2 * x1         *         .        .          .         .
      move.w int_ou+4,int_in+4 * y1         *         .        .          .         .
      move.w int_ou+6,int_in+6 * x2         *         .        .          .         .
      move.w int_ou+8,int_in+8 * y2         *         .        .          .         .
      jsr aes                               *         .        .          .         .
*
      move.w int_ou,whandl                  *         .        .          .         .
      tst.w int_ou                          *         .        .          .         .
      beq appl_exi                          *         .        .          .         .
*
* Open window at last                       * pg 5.29
*
wind_ope:
      move.w #101,control                   *         .        .          .         .
      move.w #$5,control+2                  *         .        .          .         .
      move.w #$1,control+4                  *         .        .          .         .
      move.w #$0,control+6                  *         .        .          .         .
```

```
* Digital Research                          *   Hisoft .    GST     Metacomco     Seka  .
*
* Absolute parameters
*
      move.w whandl,int_in                  *          .        .          .         .
      move.w #0,int_in+2* x1                *          .        .          .         .
      move.w #0,int_in+4* y1                *          .        .          .         .
      move.w #280,int_in+6      * x2        *          .        .          .         .
      move.w #160,int_in+8      * y2        *          .        .          .         .
      jsr aes                               *          .        .          .         .
      tst.w int_ou                          *          .        .          .         .
      beq appl_exi                          *          .        .          .         .
*
* Do something on the screen, this is where your program starts.
*
* Set screen parameters                     * pg 4.15
*
vsf_inte:
      move.w #23,contrl                     *          .        .          .         .
      move.w #0,contrl+2                    *          .        .          .         .
      move.w #1,contrl+6                    *          .        .          .         .
      move.w whandl,contrl+12               *          .        .          .         .
*
      move.w #1,intin          * solid      *          .        .          .         .
      jsr vdi                               *          .        .          .         .
*
* Style                                     * pg 4.15
*
vsf_styl:
      move.w #24,contrl                     *          .        .          .         .
      move.w #0,contrl+2                    *          .        .          .         .
      move.w #1,contrl+6                    *          .        .          .         .
      move.w whandl,contrl+12               *          .        .          .         .
*
      move.w #1,intin          * n.a        *          .        .          .         .
      jsr vdi                               *          .        .          .         .
*
* Colour                                    * pg 4.15
*
vsf_colo:
      move.w #25,contrl                     *          .        .          .         .
      move.w #0,contrl+2                    *          .        .          .         .
      move.w #1,contrl+6                    *          .        .          .         .
      move.w whandl,contrl+12               *          .        .          .         .
*
      move.w #1,intin     * black           *          .        .          .         .
      jsr vdi                               *          .        .          .         .
*
* Set mouse style                           * pg 5.26
*
graf_mou:
      move.w #78,control                    *          .        .          .         .
      move.w #$1,control+2                  *          .        .          .         .
      move.w #$1,control+4                  *          .        .          .         .
      move.w #$1,control+6                  *          .        .          .         .
```

```
* Digital Research                                * Hisoft .   GST      Metacomco     Seka  .
*
       move.w #$0,int_in                          *         .         .          .          .
       jsr aes                                    *         .         .          .          .
       tst.w int_ou                               *         .         .          .          .
       beq appl_exi                               *         .         .          .          .
*
* Get position of window work area
*
where:
       move.w whandl,int_in                       *         .         .          .          .
       move.w #4,int_in+2          * work area    *         .         .          .          .
       jsr wind_get                               *         .         .          .          .
       tst.w int_ou                               *         .         .          .          .
       beq appl_exi                               *         .         .          .          .
*
* Get coordinates within work area
*
       add.w #35,int_ou+2                         *         .         .          .          .
       add.w #35,int_ou+4                         *         .         .          .          .
       sub.w #50,int_ou+6                         *         .         .          .          .
       sub.w #50,int_ou+8                         *         .         .          .          .
*
* Draw a shape from those coords                  * pg 4.12
*
v_rfbox:
       move.w #11,contrl                          *         .         .          .          .
       move.w #2,contrl+2                         *         .         .          .          .
       move.w #0,contrl+6                         *         .         .          .          .
       move.w #9,contrl+10                        *         .         .          .          .
       move.w whandl,contrl+12                    *         .         .          .          .
*
* Absolute coords -- not window the reason for this patch
*
       move.w int_ou+2,ptsin                      *         .         .          .          .
       move.w int_ou+4,ptsin+2                    *         .         .          .          .
       move.w int_ou+6,ptsin+4                    *         .         .          .          .
       move.w int_ou+8,ptsin+6                    *         .         .          .          .
*
       jsr vdi                                    *         .         .          .          .
*
* Wait for a sign - about 1 minute                * pg 5.9
*
evnt_tim:
       move.w #24,control*                        .         .         .          .
       move.w #$2,control+2                       *         .         .          .          .
       move.w #$1,control+4                       *         .         .          .          .
       move.w #$0,control+6                       *         .         .          .          .
*
       move.w #$ffff,int_in        *Lo            *         .         .          .          .
       move.w #$0000,int_in+2      *Hi            *         .         .          .          .
       jsr aes                                    *         .         .          .          .
*
* End of program, shut the window in a controlled manner
```

```
* Digital Research                               *  Hisoft .   GST    Metacomco   Seka  .
*
* Close v_scrn Stop o/p (Shut window down)       * pg 4.9
*
v_clsvwk:
      move.w #101,contrl                         *       .        .        .      .
      move.w #0,contrl+2                         *       .        .        .      .
      move.w #0,contrl+6                         *       .        .        .      .
      move.w vhandl,contrl+12                    *       .        .        .      .
*
* Close window                                   * pg 5.29
*
wind_clo:
      move.w #102,control                        *       .        .        .      .
      move.w #$1,control+2                       *       .        .        .      .
      move.w #$1,control+4                       *       .        .        .      .
      move.w #$0,control+6                       *       .        .        .      .
*
      move.w whandl,int_in                       *       .        .        .      .
      jsr aes                                    *       .        .        .      .
      tst.w int_ou                               *       .        .        .      .
      beq appl_exi                               *       .        .        .      .
*
* Deallocate space and handle                    * pg 5.29
*
wind_del:
      move.w #103,control                        *       .        .        .      .
      move.w #$1,control+2                       *       .        .        .      .
      move.w #$1,control+4                       *       .        .        .      .
      move.w #$0,control+6                       *       .        .        .      .
*
      move.w whandl,int_in                       *       .        .        .      .
      jsr aes                                    *       .        .        .      .
      tst.w int_ou                               *       .        .        .      .
      beq appl_exi                               *       .        .        .      .
*
* Call APPL_EXI (Last call)                      * pg 5.7
*
appl_exi:
      move.w #19,control                         *       .        .        .      .
      move.w #$0,control+2                       *       .        .        .      .
      move.w #$1,control+4                       *       .        .        .      .
      move.w #$0,control+6                       *       .        .        .      .
*
* Subroutines
*
* Get window data                                * pg 5.30
*
wind_get:
      move.w #104,control                        *       .        .        .      .
      move.w #$2,control+2                       *       .        .        .      .
      move.w #$5,control+4                       *       .        .        .      .
      move.w #$0,control+6                       *       .        .        .      .
```

```
* Digital Research                                      *    Hisoft .    GST     Metacomco     Seka  .
*
*      move.w vhandl,int_in      * rem                  *           .          .          .         .
*      move.w #7,int_in+2        * out                  *           .          .          .         .
      jsr aes                                           *           .          .          .         .
      rts                                               *           .          .          .         .
*
* Calculate window work area based on facilities: title,
* scroll bar etc.                                       * pg 5.32
*
wind_cal:
      move.w #108,control                               *           .          .          .         .
      move.w #$6,control+2                              *           .          .          .         .
      move.w #$5,control+4                              *           .          .          .         .
      move.w #$0,control+6                              *           .          .          .         .
*
*      move.w #0,int_in           * rem out             *           .          .          .         .
      move.w #$0fff,int_in+2      * edges               *           .          .          .         .
      move.w int_ou+2,int_in+4    * x1                  *           .          .          .         .
      move.w int_ou+4,int_in+6    * y1                  *           .          .          .         .
      move.w int_ou+6,int_in+8    * x2                  *           .          .          .         .
      move.w int_ou+8,int_in+10   *y2                   *           .          .          .         .
      jsr aes                                           *           .          .          .         .
      rts                                               *           .          .          .         .
*
* VDI parameter block call
*
vdi:
      move.l #contrl,pblock   * reset                   *           .          .          .         .
      move.l #pblock,d1                                 *           .          .          .         .
      move.l #115,d0                                    *           .          .          .         .
      trap #$2                                          *           .          .          .         .
      rts                                               *           .          .          .         .
*
* AES parameter block call
*
aes:
      move.l #control,_c      * reset                   *           . zc       .          . zc      .
      move.l #_c,d1                                     *           . #zc      .          . #zc     .
      move.l #200,d0                                    *           .          .          .         .
      trap #$2                                          *           .          .          .         .
      rts                                               *           .          .          .         .
*
* Set up AES array
*
ini_aes:
      move.l #control,_c                                *           . zc       .          . zc      .
      move.l #global,_c+4                               *           . zc+4     .          . zc+4    .
      move.l #int_in,_c+8                               *           . zc+8     .          . zc+8    .
      move.l #int_ou,_c+12                              *           . zc+12    .          . zc+12   .
      move.l #addr_in,_c+16                             *           . zc+16    .          . zc+16   .
      move.l #addr_ou,_c+20                             *           . zc+20    .          . zc+20   .
      rts                                               *           .          .          .         .
```

```
* Digital Research                          *   Hisoft .    GST     Metacomco    Seka  .
*
* Set up VDI array
*
ini_vdi:
      move.l #contrl,pblock                 *          .         .          .          .
      move.l #intin,pblock+4                *          .         .          .          .
      move.l #ptsin,pblock+8                *          .         .          .          .
      move.l #intout,pblock+12              *          .         .          .          .
      move.l #ptsout,pblock+16              *          .         .          .          .
      rts                                   *          .         .          .          .
*
* Make space for the arrays. You must ensure these are large
* enough to hold the array's data. Be especially careful regarding
* the spelling of the array names. 'New TOS' requires larger VDI
* arrays than previous versions of the OS.
*
      bss                                   * xxx     section d            . data     .
      even                                  * xxx    . xxx     . xxx       . xxx      .
*
          ds.l 256                          *          .         .          . blk.l    .
ustk:     ds.l 1                            *          .         .          . blk.l    .
*
pblock:   ds.l 5                            *          .         .          . blk.l    .
contrl:   ds.w 12                           *          .         .          . blk.w    .
intin:    ds.w 30                           *          .         .          . blk.w    .
ptsin:    ds.w 30                           *          .         .          . blk.w    .
intout:   ds.w 45                           *          .         .          . blk.w    .
ptsout:   ds.w 12                           *          .         .          . blk.w    .
*
handle:   ds.w 1                            *          .         .          . blk.w    .
vhandl:   ds.w 1                            *          .         .          . blk.w    .
whandl:   ds.w 1                            *          .         .          . blk.w    .
*
_c:       ds.l 6                            *          . zc      .          .zc blk.l
control:  ds.w 5                            *          .         .          . blk.w    .
global:   ds.w 16                           *          .         .          . blk.w    .
int_in:   ds.w 16                           *          .         .          . blk.w    .
int_ou:   ds.w 7                            *          .         .          . blk.w    .
addr_in:  ds.l 2                            *          .         .          . blk.l    .
addr_ou:  ds.l 1                            *          .         .          . blk.l    .
*
      end
```

The program may be assembled and linked (if required) using the assembler calling procedures outlined in Appendix_K

TOS

Display demonstration program

The following program shows a typical Atari TOS file, which simply inverts the current mono display color for those programmers who,like myself, prefer white on black or toggles the border of a color display.

```
* Digital Research                             *  Hisoft .    GST      Metacomco    Seka  .
*
* Demo Atari TOS program
*
      text                                     * xxx     section c              . code    .
*
      move.l a7,a5                             *          .          .          .         .
      move.l #ustk,a7     * set - a7           *          .          .          .         .
      move.l 4(a5),a5                          *          .          .          .         .
      move.l $c(a5),d0                         *          .          .          .         .
      add.l $14(a5),d0                         *          .          .          .         .
      add.l $1c(a5),d0                         *          .          .          .         .
      add.l #$100,d0                           *          .          .          .         .
      move.l d0,-(sp)                          *          .          .          .         .
      move.l a5,-(sp)                          *          .          .          .         .
      move d0,-(sp)                            *          .          .          .         .
      move #$4a,-(sp)     * free unused        *          .          .          .         .
      trap #1             * back to GEM        *          .          .          .         .
      add.l #$c,sp                             *          .          .          .         .
      jsr start           * jump to prg        *          .          .          .         .
      move.l #$0,-(sp)    * terminate          *          .          .          .         .
      trap #$1                                 *          .          .          .         .
*
start:
      clr.l -(sp)                              *          .          .          .         .
      move.w #32,-(sp)    * set super          *          .          .          .         .
      trap #1                                  *          .          .          .         .
      move.l d0,a1                             *          .          .          .         .
      move.w #-1,d0       * get/set col        *          .          .          .         .
      jsr newcol                               *          .          .          .         .
      eori #1,d0                               *          .          .          .         .
      jsr newcol                               *          .          .          .         .
exit:
      move.l a1,-(sp)                          *          .          .          .         .
      move.w #32,-(sp)    * set user           *          .          .          .         .
      trap #1                                  *          .          .          .         .
      move.l #0,-(a7)                          *          .          .          .         .
      trap #1                                  *          .          .          .         .
```

```
* Digital Research                                 *   Hisoft .    GST     Metacomco    Seka  .
*
*
newcol:
      move.w d0,-(sp)   * get color                *          .          .           .         .
      move.w #0,-(sp)                              *          .          .           .         .
      move.w #7,-(sp)                              *          .          .           .         .
      trap #14                                     *          .          .           .         .
      add.w #6,sp                                  *          .          .           .         .
      rts                                          *          .          .           .         .
*                                                             .          .           .         .
      bss                                          * xxx      section d              . data    .
      ds.l 20                                      *          .          .           . blk.l   .
ustk: ds.l 1                                       *          .          .           . blk.l   .
*
      end
```

The above program is assembled and linked without any other files.

TOS header file

The following shows a typical Atari TOS header file that may be incorporated in a user-written program to provide access to the base page offset variables.

```
**********************************************************
*
* Base page format initialised by BDOS
*
**********************************************************
*
ltpa            equ 0           * Low TPA address
htpa            equ 4           * High TPA address + 1
lcode           equ 8           * Text segment start
codelen         equ 12          * Length of text segment
ldata           equ 16          * Initialized data segment start
datalen         equ 20          * Length of initialized data
lbss            equ 24          * BSS segment start
bsslen          equ 28          * Length of uninitialized data
*
* either GEMDOS
*
*env            equ 44          * Environment string pntr (GEMDOS)
*
* or Atari OS
*
freelen         equ 32          * Free memory length after BSS
ldriv           equ 36          * Drive from which program loaded
resvd           equ 37          * Reserved
fcb2            equ 56          * 2nd parsed fcb
fcb1            equ 92          * 1st parsed fcb
*
* common tail
*
command         equ 128         * Command tail
```

Although it is good practice to size the memory requirements of you program and return the unused memory to GEMDOS, programs can be writte without if they return to the GEM desktop.

GEM allocates all the memory to the program, only if it multitasks or cal and loads another program is there any real need to return spare memory.

Character printing program

This simple program demonstrates some of the methods available for printing to the VT52 screen. The compiled program may be installed as:

A 'GEM program' - the busy bee cursor will appear in the display and leave a hole when moved.

A 'TOS program' - with flashing cursor, the cursor may be hidden quite easily by incorporating within the 'prdat' string the hide cursor escape code as specified in Appendix C.

```
* Digital Research                          *  Hisoft .   GST     Metacomco    Seka  .
*
* Monochrome TOS VT52 screen print program (0,0 to 24,79)
*------------------------------------------------------------
* (For colour, set max print width in 'prdat' to 39)
*
      text                                  * xxx      section c            . code   .
* GEM BIOS type print
*
      clr.l d4           * Clear d4         *          .         .          .        .
      clr.l d5           * Clear d5         *          .         .          .        .
      lea prdat,a4       * Get data address *          .         .          .        .
      move.b (a4),d4     * Data count-1     *          .         .          .        .
cloop:
      adda.l #1,a4       * Get next         *          .         .          .        .
      move.b (a4),d5     * Getchar byte     *          .         .          .        .
      move.w d5,-(sp)    * Stack char.w     *          .         .          .        .
      move.w #2,-(sp)    * Send to console  *          .         .          .        .
      move.w #3,-(sp)    * Set bconout()    *          .         .          .        .
      trap #13           * Call it          *          .         .          .        .
      add.w #6,sp        * Tidy stack       *          .         .          .        .
      dbra d4,cloop      * loop for next    *          .         .          .        .
*
* GEMDOS type print
*
      lea mess,a0        * GetASCII string  *          .         .          .        .
      move.l a0,-(sp)    * Stack it         *          .         .          .        .
      move.w #9,-(sp)    * set conws()      *          .         .          .        .
      trap #1            * Call it          *          .         .          .        .
      add.w #6,sp        * Tidy stack       *          .         .          .        .
*
      move.l #200,d1     *                  *          .         .          .        .
exlp:
      move.l #-1,d0      * Wait             *          .         .          .        .
dloop:
      dbra d0,dloop      *                  *          .         .          .        .
      dbra d1,exlp       *                  *          .         .          .        .
      move.l #0,-(a7)    * GEM return       *          .         .          .        .
      trap #1            *                  *          .         .          .        .
      rts                * Return           *          .         .          .        .
```

```
* Digital Research                                 *  Hisoft .    GST     Metacomco     Seka  .
*
*
      data                                         * xxx      section d1              . xxx   .
      even                                         * xxx      . xxx       . xxx       . xxx   .
*
* VT52 screen location character equivalents
*
*! " # $ % & ' ( )  * + , - .  / 0 1 2 3 4 5 6
* 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22
*
* 7  8  9  : ;  <  =  > ? @  A  B  C  D  E  F  G  H  I  J
*23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42
*
* K  L  M N  O  P  Q  R  S  T  U  V  W  X  Y  Z  [  \  ]
* 43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61
*
* ^  _  ` a  b  c d  e  f  g  h  i  j  k  l  m  n  o
* 62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79
*
* Data string to print (See Appendix C for codes)
*
*                                                  *          .           .           .       .
*                                                  *          section d2              . even  .
prdat:dc.b 50                                      *          .           .           .       .
      dc.b 27,'E'         * Clear screen
      dc.b 27,'b',0       * foregnd col white
      dc.b 27,'c',1       * backgnd col black
      dc.b 27,'Y 0,0'     * Set cursor at 0,0
      dc.b 27,'Y!!1,1'    * Set cursor at 1,1
      dc.b 27,'b',1       * foregnd col black
      dc.b 27,'c',0       * backgnd col white
      dc.b 27,'Y8f24,69'  * Set curs @ 24,69
      dc.b 27,'p'         * Inverse video
      dc.b 27,'I'         * Up 1 line
      dc.b 'hi !'         * Say something witty
      dc.b 27,'Y,4'       * set cursor at 12,20
      dc.b 27,'q'         * Reset video
*
* Print null terminated string - uses ASCII & control codes
*
*                                                  *          .           .           . even  .
*                                                  *          .           .           .       .
mess: dc.b 'hello'        * Alternative print
      dc.b 10,10,7        * method for screen
      dc.b 'hello'        * printing.
      dc.b 10             * Text
      dc.b 'hello'        * linefeed
      dc.b 10,13          * carriage return
      dc.b 'hello'        * and a bell
      dc.b 0              * End of string
*                                                  *          .           .           . even  .
*                                                  *          .           .           .       .
      end
```

Sound demonstration program

This program provides a basic introduction to 'sound' programming on the Atari ST; where experimentation with each of the sounds provided is perhaps the best approach to understanding the effects of each argument.

Take care of the following general points:

Userstack: Make sure it is large enough. It grows down in memory and it can overwrite the data area.

Timing: It is necessary to provide a delay before an exit back to GEMDOS, TOS could reallocate the sound data bytes space.

```
* Digital Research                          *  Hisoft .   GST    Metacomco    Seka  .
*
* Experimental TOS sounds program
*
      text                                  * xxx     section c          . code   .
*
      move.l a7,a5          * create        *         .         .         .         .
      move.l #ustk,a7       * space for     *         .         .         .         .
      move.l 4(a5),a5       * program       *         .         .         .         .
      move.l $c(a5),d0                      *         .         .         .         .
      add.l $14(a5),d0                      *         .         .         .         .
      add.l $1c(a5),d0                      *         .         .         .         .
      add.l #$100,d0                        *         .         .         .         .
      move.l d0,-(sp)                       *         .         .         .         .
      move.l a5,-(sp)                       *         .         .         .         .
      move d0,-(sp)                         *         .         .         .         .
      move #$4a,-(sp)                       *         .         .         .         .
      trap #1                               *         .         .         .         .
      add.l #$c,sp                          *         .         .         .         .
*
start:
      move.l #sound1,a1     *               *         .         .         .         .
      jsr dosound           *               *         .         .         .         .
*
      move.l #150,d1        * 15 secs       *         .         .         .         .
loopo:
      moveq #-1,d2          * wait for      *         .         .         .         .
loopi:
      dbra d2,loopi         * finish        *         .         .         .         .
      dbra d1,loopo                         *         .         .         .         .
*
exit:
      clr.l -(sp)           * GEMDOS ret    *         .         .         .         .
      trap #$1                              *         .         .         .         .
      rts                                   *         .         .         .         .
```

```
* Digital Research                                    *   Hisoft .    GST     Metacomco    Seka  .
*
dosound:
      move.l a1,-(sp)     * sound pointer     *           .          .           .          .
      move.w #32,-(sp)    *                   *           .          .           .          .
      trap #14            *                   *           .          .           .          .
      add.w #6,sp         *                   *           .          .           .          .
      rts                 *                   *           .          .           .          .
*
      bss                                     * xxx      section d1              . data     .
      even                                    * xxx      . xxx      . xxx        . xxx      .
*
      ds.l 64             * Large enough not  *           .          .           . blk.l    .
ustk: ds.l 1              * to overwrite data*            .          .           . blk.l    .
*
      data                                    * xxx      section d2              . code     .
      even                                    * xxx      . xxx      . xxx        . xxx      .
*     * Bell
sound1:
*
      dc.b 0,$34          *\ chan A           *           .          .           .          .
      dc.b 1,0            */ 2150 hz          *           .          .           .          .
      dc.b 2,0            * \ chan            *           .          .           .          .
      dc.b 3,0            * / B               *           .          .           .          .
      dc.b 4,0            *\ channel          *           .          .           .          .
      dc.b 5,0            */ C                *           .          .           .          .
      dc.b 6,0            * noise             *           .          .           .          .
      dc.b 7,$fe          * enable A only     *           .          .           .          .
      dc.b 8,$10          * enable A envelope*            .          .           .          .
      dc.b 9,0            * B off             *           .          .           .          .
      dc.b 10,0           * C off             *           .          .           .          .
      dc.b 11,0           *\Single attack     *           .          .           .          .
      dc.b 12,$10         **envelope shape    *           .          .           .          .
      dc.b 13,9           */ 1 0 0 1          *           .          .           .          .
      dc.b 130,100        * delay             *           .          .           .          .
*
* sound2:                 * Siren
*
      dc.b 0,$fe          *\ chan A           *           .          .           .          .
      dc.b 1,0            */ 440 hz High note*            .          .           .          .
      dc.b 2,0            * \ chan            *           .          .           .          .
      dc.b 3,0            * / B               *           .          .           .          .
      dc.b 4,0            *\ channel          *           .          .           .          .
      dc.b 5,0            */ C                *           .          .           .          .
      dc.b 6,0            * noise             *           .          .           .          .
      dc.b 7,$fe          * enable A only     *           .          .           .          .
      dc.b 8,11           * A amplitude       *           .          .           .          .
      dc.b 9,0            * B off             *           .          .           .          .
      dc.b 10,0           * C off             *           .          .           .          .
      dc.b 11,0           *\ no               *           .          .           .          .
      dc.b 12,0           * |envelope         *           .          .           .          .
      dc.b 13,0           */ shape            *           .          .           .          .
      dc.b 130,20         *                   *           .          .           .          .
```

```
* Digital Research                          *   Hisoft .     GST     Metacomco     Seka  .
*
       dc.b 0,$56           *\ chan A Low note *          .          .          .          .
       dc.b 1,1             */ 187 hz          *          .          .          .          .
       dc.b 130,20          *                  *          .          .          .          .
*
       dc.b 0,$fe,1,0,130,20     *High note    *          .          .          .          .
       dc.b 0,$56,1,1,130,20     *Low note     *          .          .          .          .
*
* sound                     * silence
*
       dc.b 8,0,9,0         * A & B off        *          .          .          .          .
       dc.b 130,50          *                  *          .          .          .          .
*
* sound3:                   * gunshot
*
       dc.b 0,0,1,0,2,0,3,0,4,0,5,0            *          .          .          .          .
       dc.b 6,15            * medium noise period
       dc.b 7,199           * enable noise chans A,B & C
       dc.b 8,16            * \ using          *          .          .          .          .
       dc.b 9,16            *  |envelope       *          .          .          .          .
       dc.b 10,16           * / control        *          .          .          .          .
       dc.b 11,0            *\ envelope period *          .          .          .          .
       dc.b 12,16           */                 *          .          .          .          .
       dc.b 13,0            * one cycle decay  *          .          .          .          .
       dc.b 130,25          *                  *          .          .          .          .
*
* sound                     * silence
*
       dc.b 8,0,9,0         * A & B off        *          .          .          .          .
       dc.b 130,50          *                  *          .          .          .          .
*
* sound4:                   * explosion
*
       dc.b  0,0,1,0,2,0,3,0,4,0,5,0           *          .          .          .          .
       dc.b 6,10            * noise period     *          .          .          .          .
       dc.b 7,199           * enable noise chans A,B & C
       dc.b 8,16            * \ using          *          .          .          .          .
       dc.b 9,16            *  | envelope      *          .          .          .          .
       dc.b 10,16           * / control        *          .          .          .          .
       dc.b 11,0            *\ envelope period *          .          .          .          .
       dc.b 12,80           */                 *          .          .          .          .
       dc.b 13,0            * one cycle decay  *          .          .          .          .
       dc.b 130,120         *                  *          .          .          .          .
*
* sound                     * silence
*
       dc.b  8,0,9,0,10,0* A B & C off
       dc.b  130,100        *                  *          .          .          .          .
```

```
* Digital Research                               *   Hisoft .     GST       Metacomco     Seka  .
*
* sound5:                  * whistle
*
     dc.b   0,0,1,0,2,0,3,0,4,0,5,0,6,0
     dc.b  7,254         * enable tone A only
     dc.b  8,15          *                  *           .          .          .             .
     dc.b   9,0,10,0,11,0,12,0,13,0         *           .          .          .             .
     dc.b  128,60        * Initial tempreg  *           .          .          .             .
     dc.b  129,0,-2,40   * reg-step-end     *           .          .          .             .
     dc.b  130,2         *                  *           .          .          .             .
*
* exit list
*
     dc.b  7,255,8,0     * off              *           .          .          .             .
     dc.b  255,0         * return           *           .          .          .             .
*                                           *           .          .          . even        .
     end
```

Line-A parameter table

The following is the complete list of the Line-A equates and functions. It may be used as a standard assembler header file to Line-A programs.

```
***********************************************
*
* Line-A parameter table
*
***********************************************
*
V_CEL_HT            equ -46         * .W        Pixel cell height
V_CEL_MX            equ -44         * .W        Max cells across -1
V_CEL_MY            equ -42         * .W        Max cells high -1
V_CEL_WR            equ -40         * .W        Offset to next cell
V_COL_BG            equ -38         * .W        Background index color
V_COL_FG            equ -36         * .W        Foreground index color
V_CUR_AD            equ -34         * .L        Current cursor address
V_CUR_OFF           equ -30         * .W        Offset to 1st cell
V_CUR_CX            equ -28         * .W        X cursor position
V_CUR_CY            equ -26         * .W        Y cursor position
V_CUR_CNT           equ -24         * .B        Cursor flash interval
V_CUR_TIM           equ -23         * .B        Cursor countdown timer
V_FNT_AD            equ -22         * .L        Font address
V_FNT_ND            equ -18         * .W        Last font ASCII code
V_FNT_ST            equ -16         * .W        1st font ASCII code
V_FNT_WR            equ -14         * .W        Font width
V_X_MAX             equ -12         * .W        Max X pixel scrn value
V_OFF_AD            equ -10         * .L        Font offset table addr
V_STATUS            equ -6          * .W        Text status byte
V_Y_MAX             equ -4          * .W        Max Y pixel scrn value
*
VPLANES             equ 0           * .W        # video planes
VWRAP               equ 2           * .W        # bytes/video
CONTRL              equ 4           * .L        \
INTIN               equ 8           * .L        |
PTSIN               equ 12          * .L        | array pntrs
INTOUT              equ 16          * .L        |
PTSOUT              equ 20          * .L        /
COLBIT0             equ 24          * .W        \  1       * )
COLBIT1             equ 26          * .W        |  2       * ) write
COLBIT2             equ 28          * .W        |  4       * ) color
COLBIT3             equ 30          * .W        /  8       * )
LSTLIN              equ 32          * .W        -1
LNMASK              equ 34          * .W        VDI line style
WMODE               equ 36          * .W        Write mode
*
X1                  equ 38          * .W        \
Y1                  equ 40          * .W        | coordinates
X2                  equ 42          * .W        |
Y2                  equ 44          * .W        /
*
PATPTR              equ 46          * .L        Curr fill patt pntr
PATMSK              equ 50          * .W        Len fill patt mask
MFILL               equ 52          * .W        0_single plane
CLIP                equ 54          * .W        0_no clipping
```

```
*
XMINCL          equ 56          * .W      \
YMINCL          equ 58          * .W      |  Clipping
XMAXCL          equ 60          * .W      |  values
YMAXCL          equ 62          * .W      /
XDDA            equ 64          * .W      txtblt x dda accum
DDAINC          equ 66          * .W      txtblt scale factor
SCALDIR         equ 68          * .W      0_down
*
MONO            equ 70          * .W      0_font monospaced
SRCX            equ 72          * .W      \ Coords of char
SRCY            equ 74          * .W      / in font form
DESTX           equ 76          * .W      \ Coords of char
DESTY           equ 78          * .W      / on screen
DELX            equ 80          * .W      Char width
DELY            equ 82          * .W      Char height
*
FBASE           equ 84          * .L      Font form pointer
FWIDTH          equ 88          * .W      width
STYLE           equ 90          * .W      style
LITEMSK         equ 92          * .W      lighten text mask
SKEWMSK         equ 94          * .W      skew text mask
WEIGHT          equ 96          * .W      extra text width
ROFF            equ 98          * .W      high offset skew
LOFF            equ 100         * .W      low offset skew
SCALE           equ 102         * .W      0_no scaling
CHUP            equ 104         * .W      0_horiz orientation
TEXTFG          equ 106         * .W      Text foreground color
SCRTCHP         equ 108         * .L      Text effects buffer
SCRPT2          equ 112         * .W      Offset to scale buffer
TEXTBG          equ 114         * .W      Text background color
COPYTRAN        equ 116         * .W      Copy raster type flag
SEEDABORT       equ 118         * .W      Abort fill routine ptr
*
************************************************
*
* Line-A function calls
*
************************************************
*
init            equ $a000
putpix          equ init+1      * put pixel
getpix          equ init+2      * get pixel
abline          equ init+3      * draw a line
habline         equ init+4      * horizontal line
rectfill        equ init+5      * draw filled rectangle
polyfill        equ init+6      * draw 1 line poly fill
bitblt          equ init+7      * bit block transfer
textblt         equ init+8      * text block transfer
showcur         equ init+9      * show mouse
hidecur         equ init+10     * hide mouse
chgcur          equ init+11     * transform mouse form
unsprite        equ init+12     * undraw previous sprit
drsprite        equ init+13     * draw sprite
copyrstr        equ init+14     * copy raster form
seedfill        equ init+15     * polygon fill
```

Sprite demonstration

The following Line-A program is deliberately compressed to show the small number of lines of assembler used to control sprites. The program produces an alternate black and white sprite crossing a monochrome screen.

```
* Digital Research                              *   Hisoft .   GST     Metacomco    Seka  .
*
init            equ   $a000                     * initialize init: .
unsprite        equ   init+12                   * undraw sprite unsprite:
drsprite        equ   init+13                   * draw sprite drsprite:
*
V_X_MAX         equ   -12                       * Max X pixel scrn val V_X_MAX:
*
      text                                      * xxx      section c            . code   .
*
start: clr.l -(sp)        * Set                 *          .         .          .        .*]
      move.w #$20,-(sp)   * super               *          .         .          .        .*]
      trap #1             * mode                *          .         .          .        .*]
      addq.l #6,sp        *                     *          .         .          .        .*]
      move.l d0,stksv     * save stack          *          .         . .        .        .*]
      move.w #0,olda      * versn flag          *          .         .          .        .*:
      move.l #0,a2        *                     *          .         .          .        .*:
      dc.w init           * Init                *          .         .          .        .
      move.l a2,d2        * aline               *          .         .          .        .*:
      bne a2ok            * registers           *          .         .          .        .*:
      lea #-60(a1),a2     *                     *  <---------------60(a1),a2 ------------> .*:
      move.w #-1,olda     *                     *          .         .          .        .*:
*
a2ok: move.l $34(a2),a3 * draw addr (4*13)                                                 .*:
      move.w #V_X_MAX(a0),a5* get max width <------------ V_X_MAX(a0),a5 ----------> .
      move.w #0,d0        * init x              *          .         .          .        .
      move.w #50,d1       * init y              *          .         .          .        .
      move.w #10,d2       * scan count          *          .         .          .        .
      lea sprit,a0        * sprite add          *          .         .          .        .
      lea save,a2         * bg savearea         *          .         .          .        .
      movea.l a0,a4       * sprite col          *          .         .          .        .
      adda.l #6,a4        * pointer             *          .         .          .        .
*
setcol: move.w (a4),d3    * get color           *          .         .          .        .
      bne white           *                     *          .         .          .        .
      move.l #$00010001,(a4)* black             *          .         .          .        .
      bra loop            * color               *          .         .          .        .
white: move.l #0,(a4)     * set white           *          .         .          .        .
loop: movem.l d0-d2/a0-a4,-(sp)*sav r           *          .         .          .        .
      tst.w olda          * test versn          *          .         .          .        .*:
      beq new             *                     *          .         .          .        .*:
      jsr (a3)            * old versn           *          .         .          .        .*:
      bra cont            *                     *          .         .          .        .*:
new:  dc.w drsprite       * new versn           *          .         .          .        .
cont: move.w #2000,d0     *                     *          .         .          .        .*:
```

```
* Digital Research                                    *   Hisoft .    GST      Metacomco     Seka
*
wait: dbra d0,wait       * delay                      *           .          .          .          .*
      lea save,a2        * bg savarea                 *           .          .          .          .
      dc.w unsprite      *                            *           .          .          .          .
      movem.l (sp)+,d0-d2/a0-a4* unsave r             *           .          .          .          .
      add.w #1,d0        * slide over                 *           .          .          .          .
      cmp.w a5,d0        * screen                     *           .          .          .          .
      ble loop           *                            *           .          .          .          .
      move.w #0,d0       * init x                     *           .          .          .          .
      add.w #10,d1       * drop y                     *           .          .          .          .
*
      sub.w #1,d2        * count down                 *           .          .          .          .
      bne setcol         * and again                  *           .          .          .          .
      move.l stksv,-(sp) * back                       *           .          .          .          .*]
      move.w #$20,-(sp)  * to                         *           .          .          .          .*]
      trap #1            * user                       *           .          .          .          .*]
      addq.l #6,sp       * mode                       *           .          .          .          .*]
      move.w #0,-(sp)    * back                       *           .          .          .          .
      trap #1            * to GEM                     *           .          .          .          .
*
      data                                            * xxx       section d             . xxx      .
      even                                            * xxx       . xxx      . xxx      . xxx      .
*
sprit: dc.w 0,0          * x,y                        *           .          .          .          .
      dc.w -1            * 1_vdi, -1_xor
      dc.w 0             * bg col                     *           .          .          .          .
      dc.w 0             * fg col                     *           .          .          .          .
ghoul: dc.w $ffff                                     *           .          .          .          .
      dc.w $03c0                                      *           .          .          .          .
      dc.w $ffff
      dc.w $0ff0                                      *           .          .          .          .
      dc.w $ffff
      dc.w $1ff8                                      *           .          .          .          .
      dc.w $ffff
      dc.w $3ffc                                      *           .          .          .          .
      dc.w $ffff
      dc.w $73ce                                      *           .          .          .          .
      dc.w $ffff
      dc.w $73ce                                      *           .          .          .          .
      dc.w $ffff
      dc.w $ffff                                      *           .          .          .          .
      dc.w $ffff
      dc.w $ffff                                      *           .          .          .          .
      dc.w $ffff
      dc.w $fbdf                                      *           .          .          .          .
      dc.w $ffff
      dc.w $f81f                                      *           .          .          .          .
      dc.w $ffff
      dc.w $ffff                                      *           .          .          .          .
      dc.w $ffff
      dc.w $67e6                                      *           .          .          .          .
```

```
* Digital Research                        *   Hisoft .    GST     Metacomco     Seka   .
*
      dc.w $ffff                          *          .          .          .          .
      dc.w $300c                          *          .          .          .          .
      dc.w $ffff                          *          .          .          .          .
      dc.w $1ff8                          *          .          .          .          .
      dc.w $ffff                          *          .          .          .          .
      dc.w $0420                          *          .          .          .          .
      dc.w $ffff                          *          .          .          .          .
      dc.w $1818                          *          .          .          .          .
*
      bss                                 * xxx      section d             . data     .
      even                                * xxx      . xxx      . xxx      . xxx      .
*
stksv: ds.l 1                             *          .          .          . blk.l . *1
save: ds.b 74                             *          .          .          . blk.b .
olda: ds.w 1                              *          .          .          . blk.w . *2
*
      end
```

*1 There is no requirement to run this program in supervisor mode, these lines of code may be omitted.

*2 Some versions of the disk based TOS incorrectly return the value of A2. These lines of code are not required by ROM based versions of the ST.

*3 The use of the following code provides more stable sprites:

```
MOVE #37,-(sp)      * wait for vblank
TRAP #14            * XBIOS call
ADDQ #2,sp          * tidy stack
```

The programmer might also contemplate hiding the busy-bee cursor.

Appendix M

Glossary of abbreviations

ADE	ASCII decimal equivalent
AES	Application environment services
ACIA	Asynchronous communications interface adaptor
ANSI	American national standards institute
ASCII	American standard code for information interchange
AUX	Auxilary
BCD	Binary coded decimal
BDOS	Basic disk operating system
BIOS	Basic input/output system
BPB	BIOS parameter block
BSS	Block storage segment
CCP	Console command processor
CCR	Condition code register
CON	Console
CP/M	Control program for microcomputers
CPU	Central processing unit
CRC	Cyclic redundancy check
CTS	Clear to send
DCD	Data carrier detect
DIR	Directory
DMA	Direct memory access
DOS	Disk operating system
DPB	Disk parameter block
DS	Double sided
DTR	Data terminal ready
D/A	Digital to analogue
EPB	Exception parameter block
FAT	File allocation table
FCB	File control block
FDC	Floppy disk controller
FIFO	First in, first out register
GDOS	Graphics device operating system
GEM	Graphics environment manager
GIOS	Graphics input/output system
GP	General purpose
Grd	Ground
GSX	Graphic system extension

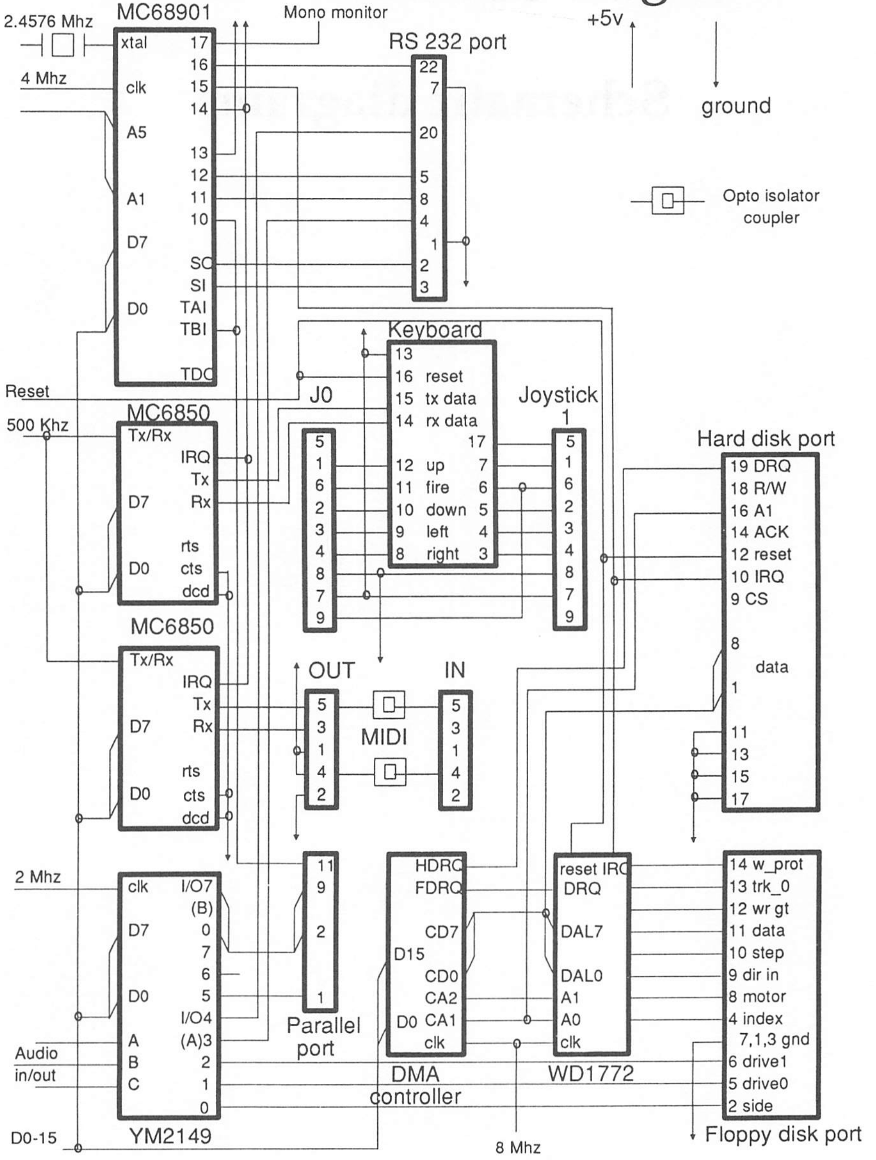
HDC	Hard disk controller
ID	Identification
ikbd	Intelligent keyboard
IPL	Interrupt level
I/O	Input/output
LPB	Load parameter block
LSB	Least significant byte/bit
LST	List
MD	Memory descriptor
MFDB	Memory form definition block
MFP	Multi function peripheral
MIDI	Musical instruments digital interface
MS-DOS	Microsoft disk operating system
MSB	Most significant bit
NDC	Normalized device coordinates
OEM	Other equipment manufacturer
OS	Operating system
OSC	Oscillator
PC	Program counter
PC-DOS	IBM personal computer operating system
pk-pk	Peak to peak
PSG	Programmable sound generator
RAM	Random access memory
RC	Raster coordinate
RF	Radio frequency
RGB	Red-green-blue
Ri	Ring
ROM	Read only memory
RSX	Resident system extension
RTE	Return from exception
RTS	Return from subroutine
Rx	Receive

SASI	Shugart associates standard interface
SCSI	Small computer systems interface
SP	Stack pointer
SR	Status register
SS	Single sided
SSP	Supervisor stack pointer
TOS	The operating system
TPA	Transient program area
TTL	Transistor-transistor logic
Tx	Transmit
ULA	Uncommitted logic array
USART	Universal synchronous/asynchronous receiver-transmitter
USP	User stack pointer
VBI	Vertical blank interrupt
VDI	Virtual device interface
VLSI	Very large scale integration

Appendix N

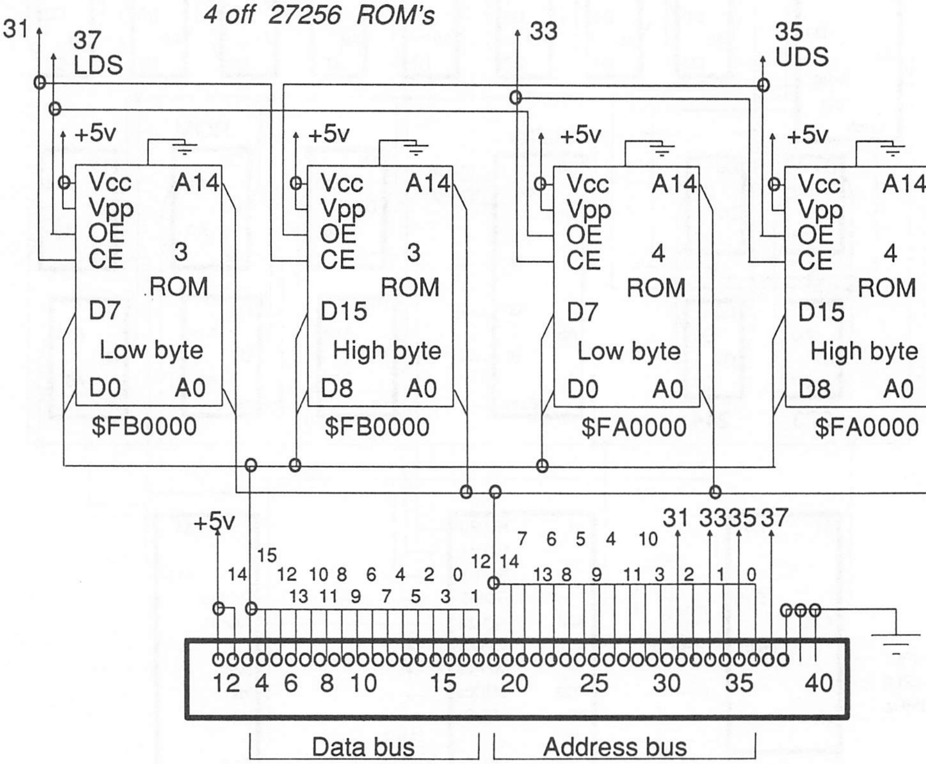
Schematic diagrams

Atari ST schematic diagram




MMU
4M
8M
16Mhz
MAD0
MAD9
A21
D7
D0
A1
wdat
rdat
latch
RAM
A0
D0
A9
D7
Shifter
D0
D15
clk
16MHz
32MHz
R
G
B
A5
A0
Mono
ROM
A12
A14
cs
373
244
MC68000
A1
D0
D15
A23
reset
IPL1
IPL2
8MHz
clk
556
GLUE
ROM0
ROM1
ROM2
ROM3
ROM4
6850cs
MFPcs
SNDcs
FCS
FC2
FC1
FC0
2MHz
500KHz
ROM port
A15
uds
lds

128K ROM cartridge



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THE CONCISE ATARI ST 68000 PROGRAMMER'S REFERENCE GUIDE

Katherine Peel

About the Atari ST Series

The Atari ST is one of the most significant new computers to be launched in recent years. Its performance and technical specifications are outstanding and comparable to machines several times the price. Moreover, it is a machine which appeals to the hobbyist and business user alike and the large amount of software available allows it to be used extensively in the home or office.

This series of books provides Atari ST owners with practical, down-to-earth information about their computers – from the introductory level through to advanced programming techniques and professional business uses.

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The aim of this book is to provide the Atari ST user with a complete reference manual to the machine. It is designed to be used both as a quick reference manual and as a source of detailed technical material. Topics covered include machine code programming, details of GEM and the operating system. Much of the material included in the book has been taken directly from official Atari technical documentation and is unlikely to be found from any other source. The book will be an essential reference manual for every Atari ST owner.

About the author

Katherine Peel was formerly a senior systems analyst in industry, and now works as a freelance author. She has been a major contributor of reviews and technical articles to the "Your Computer" magazine for a number of years, providing in-depth authoritative reviews of the latest hardware.

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PROGRAMMER'S REFERENCE GUIDE

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