

Hardware

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| COLLABORATORS |
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| | <i>TITLE :</i> Hardware | | |
| <i>ACTION</i> | <i>NAME</i> | <i>DATE</i> | <i>SIGNATURE</i> |
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Chapter 1

Hardware

1.1 Amiga® Hardware Reference Manual: E I/O Connectors And Interfaces

This appendix consists of four distinct parts, related to the way in which the Amiga talks to the outside world.

The first part specifies the pinouts of the externally accessible connectors and the power available at each connector. It does not, however, provide timing or loading information.

The second part briefly describes the functions of those pins whose purpose may not be evident.

The third part contains a list of the connections for certain internal connectors, notably the disk.

The fourth part specifies how various signals relate to the available ports of the 8520. This information enables the programmer to relate the port addresses to the outside-world items (or internal control signals) that are to be affected.

The third and fourth parts are primarily for the use of the systems programmer and should generally not be utilized by applications programmers.

Systems software normally is configured to handle the setting of particular signals, no matter how the physical connections may change. In other words, if you have a version of the system software that matches the revision level of the machine (normally a true condition), when you ask that a particular bit be set, you don't care which port that bit is connected to. Thus, applications programmers should rely on system documentation rather than going directly to the ports.

Warning:

In a multitasking operating system, many different tasks may be competing for the use of the system resources. Application programmers should follow the established rules for resource access in order to assure compatibility of their software with the system. Don't just hit the hardware registers directly, ask the system for exclusive control first.

Part 1 - Amiga I/O Connector Pins
 Part 2 - Explanation of Amiga I/O Connectors
 Part 3 - Internal Connectors
 Part 4 - Port Signal Assignments for 8520 CIAS

1.2 E I/O Connectors And Interfaces / Part 1 - Amiga I/O Connector Pins

This is a list of the I/O connections to the outside world on the Amiga.

| | |
|------------------------|--------------------|
| RS232 and MIDI Port | External Disk |
| Parallel Port | External SCSI Disk |
| Keyboard | RAMEX |
| Video | Expansion |
| Video Display Enhancer | Joy Sticks |
| RF Monitor | |

1.3 E / Amiga I/O Connector Pins / RS232 and MIDI Port

RS232 and MIDI Port

| PIN | RS232 | A1000 | A500/ A2000/ | CBM A3000 | PCs | HAYES | DESCRIPTION |
|-----|-------|--------|-----------------|--------------|-----|-------|--|
| | | | | | | | |
| 1 | GND | GND | GND | GND | GND | GND | FRAME GROUND |
| 2 | TXD | RXD | RXD | RXD | RXD | RXD | TRANSMIT DATA |
| 3 | RXD | RXD | RXD | RXD | RXD | RXD | RECEIVE DATA |
| 4 | RTS | RTS | RTS | RTS | - | - | REQUEST TO SEND |
| 5 | CTS | CTS | CTS | CTS | CTS | CTS | CLEAR TO SEND |
| 6 | DSR | DSR | DSR | DSR | DSR | DSR | DATA SET READY |
| 7 | GND | GND | GND | GND | GND | GND | SYSTEM GROUND |
| 8 | CD | CD | CD | DCD | DCD | DCD | CARRIER DETECT |
| 9 | - | - | +12v | +12v | - | - | + 12 VOLT POWER |
| 10 | - | - | -12v | -12v | - | - | - 12 VOLT POWER |
| 11 | - | - | AUDO | - | - | - | AUDIO OUTPUT (A500, A2000, A3000) |
| 12 | S.SD | - | - | - | SI | SI | SPEED INDICATE |
| 13 | S.CTS | - | - | - | - | - | |
| 14 | S.TXD | -5Vdc | - | - | - | - | - 5 VOLT POWER |
| 15 | TXC | AUDO | - | - | - | - | AUDIO OUTPUT (A1000) |
| 16 | S.RXD | AUDI | - | - | - | - | AUDIO INPUT (A1000) |
| 17 | RXC | EB | - | - | - | - | BUFFERED PORT CLOCK 716kHz |
| 18 | - | INT2* | AUDI | - | - | - | INTERRUPT LINE A1000/AUDIO INPUT (A500, 2000, 3000) |
| 19 | S.RTS | - | - | - | - | - | |
| 20 | DTR | DTR | DTR | DTR | DTR | DTR | DATA TERMINAL READY |
| 21 | SQD | +5 | - | - | - | - | + 5 VOLT POWER |
| 22 | RI | - | RI | RI | RI | RI | RING INDICATOR |
| 23 | SS | +12Vdc | - | - | - | - | +12 VOLT POWER |
| 24 | TXC1 | C2* | - | - | - | - | 3.58 MHZ CLOCK |
| 25 | - | RESB* | - | - | - | - | BUFFERED SYSTEM RESET |

1.4 E / Amiga I/O Connector Pins / Parallel Port

Parallel (Centronics) Port

| PIN | A1000 | A500/A2000/A3000 | Commodore PCs |
|-------|-------------|------------------|---------------|
| --- | ----- | ----- | ----- |
| 1 | DRDY* | STROBE* | STROBE* |
| 2 | Data 0 | Data 0 | Data 0 |
| 3 | Data 1 | Data 1 | Data 1 |
| 4 | Data 2 | Data 2 | Data 2 |
| 5 | Data 3 | Data 3 | Data 3 |
| 6 | Data 4 | Data 4 | Data 4 |
| 7 | Data 5 | Data 5 | Data 5 |
| 8 | Data 6 | Data 6 | Data 6 |
| 9 | Data 7 | Data 7 | Data 7 |
| 10 | ACK* | ACK* | ACK* |
| 11 | BUSY (data) | BUSY | BUSY |
| 12 | POUT (clk) | POUT | POUT |
| 13 | SEL | SEL | SEL |
| 14 | GND | +5v pullup | AUTOFDXT |
| 15 | GND | NC | ERROR* |
| 16 | GND | RESET* | INIT* |
| 17 | GND | GND | SLCT IN* |
| 18-22 | GND | GND | GND |
| 23 | + 5 | GND | GND |
| 24 | NC | GND | GND |
| 25 | Reset* | GND | GND |

1.5 E / Amiga I/O Connector Pins / Keyboard

KEYBOARD ...RJ11 (Not Applicable to the A500)

| | A1000 | A2000/A3000 |
|---|----------|-------------|
| | ----- | ----- |
| 1 | +5 Volts | KCLK |
| 2 | CLOCK | KDAT |
| 3 | DATA | NC |
| 4 | GND | GND |
| 5 | | +5 Volts |

1.6 E / Amiga I/O Connector Pins / Video

Video ...DB23 MALE

For A500, A1000, A2000 and A3000 unless otherwise stated

| | | | |
|---|---------|----|-----------------------------|
| 1 | XCLK* | 13 | GNDRTN (Return for XCLKEN*) |
| 2 | XCLKEN* | 14 | ZD* |
| 3 | RED | 15 | C1* |
| 4 | GREEN | 16 | GND |

| | | | |
|----|--------|----|-----------------------------------|
| 5 | BLUE | 17 | GND |
| 6 | DI | 18 | GND |
| 7 | DB | 19 | GND |
| 8 | DG | 20 | GND |
| 9 | DR | 21 | -5 VOLT POWER (A1000,A2000,A3000) |
| 10 | CSYNC* | | -12 VOLT POWER (A500) |
| 11 | HSYNC* | 22 | +12 VOLT POWER |
| 12 | VSNC* | 23 | +5 VOLT POWER |

1.7 E / Amiga I/O Connector Pins / Video Display Enhancer

Video Display Enhancer - DB 15 Female (A3000 ONLY)

| | |
|----|-----------------------------|
| 1 | RED VIDEO |
| 2 | GREEN VIDEO |
| 3 | BLUE VIDEO |
| 4 | MONITOR ID BIT 2 (NOT USED) |
| 5 | GROUND |
| 6 | RED RETURN (GROUND) |
| 7 | GREEN RETURN (GROUND) |
| 8 | BLUE RETURN (GROUND) |
| 9 | KEY (NO PIN) |
| 10 | SYNC RETURN (GROUND) |
| 11 | MONITOR ID BIT 0 (NOT USED) |
| 12 | MONITOR ID BIT 1 (NOT USED) |
| 13 | HORIZONTAL SYNC |
| 14 | VERTICAL SYNC |
| 15 | NOT USED |

1.8 E / Amiga I/O Connector Pins / RF Monitor

RF Monitor ...8 PIN DIN (J2) (A1000 Only)

| | |
|---|----------------|
| 1 | N.C. |
| 2 | GND |
| 3 | AUDIO LEFT |
| 4 | COMP VIDEO |
| 5 | GND |
| 6 | N.C. |
| 7 | +12 VOLT POWER |
| 8 | AUDIO RIGHT |

1.9 E / Amiga I/O Connector Pins / External Disk

EXTERNAL DISK ...DB23 FEMALE

For A1000, A500, A2000 and A3000 with A2000 and A3000 differences noted.

| | | | |
|----|---------------------------------|----|-----------------------------------|
| 1 | RDY* | 13 | SIDEB* |
| 2 | DKRD* | 14 | WPRO* |
| 3 | GND | 15 | TK0* |
| 4 | GND | 16 | DKWEB* |
| 5 | GND | 17 | DKWDB* |
| 6 | GND | 18 | STEPB* |
| 7 | GND | 19 | DIRB |
| 8 | MTRXD* | 20 | SEL3B* (A2000/A3000 not used (1)) |
| 9 | SEL2B* (A2000/A3000 SEL3B* (1)) | 21 | SEL1B* (A2000/A3000 SEL2B* (1)) |
| 10 | DRESB* | 22 | INDEX* |
| 11 | CHNG* | 23 | +12 |
| 12 | +5 | | |

(1) SEL1B* is not drive 1, but rather the first external drive. Not all select lines may be implemented.

1.10 E / Amiga I/O Connector Pins / External SCSI Disk

EXTERNAL SCSI DISK DB25 FEMALE (A3000 ONLY)

| | | | |
|----|--------|----|-------------------|
| 1 | REQ | 14 | GROUND |
| 2 | MSG* | 15 | C/D |
| 3 | I/O | 16 | GROUND |
| 4 | RST* | 17 | ATN* |
| 5 | ACK* | 18 | GROUND |
| 6 | BSY* | 19 | SEL* |
| 7 | GROUND | 20 | PARITY |
| 8 | DATA0 | 21 | DATA1 |
| 9 | GROUND | 22 | DATA2 |
| 10 | DATA3 | 23 | DATA4 |
| 11 | DATA5 | 24 | GROUND |
| 12 | DATA6 | 25 | TERMINATION POWER |
| 13 | DATA7 | | |

See the ANSI (American National Standard Institute) standard SCSI (Small Computer Standard Interface) Specification for more information.

1.11 E / Amiga I/O Connector Pins / RAMEX

RAMEX ...60 PIN EDGE (.156) (P1) (A1000 only)

| | | | |
|---|-----|---|-----|
| 1 | gnd | A | gnd |
| 2 | D15 | B | D14 |
| 3 | +5 | C | +5 |
| 4 | D12 | D | D13 |
| 5 | gnd | E | gnd |
| 6 | D11 | F | D10 |
| 7 | +5 | H | +5 |
| 8 | D8 | J | D9 |

| | | | |
|----|--------|----|--------|
| 9 | gnd | K | gnd |
| 10 | D7 | L | D6 |
| 11 | +5 | M | +5 |
| 12 | D4 | N | D5 |
| 13 | gnd | P | gnd |
| 14 | D3 | R | D2 |
| 15 | +5 | S | +5 |
| 16 | D0 | T | D1 |
| 17 | gnd | U | gnd |
| 18 | DRA4 | V | DRA3 |
| 19 | DRA5 | W | DRA2 |
| 20 | DRA6 | X | DRA1 |
| 21 | DRA7 | Y | DRA0 |
| 22 | gnd | Z | gnd |
| 23 | RAS* | AA | RRW* |
| 24 | gnd | BB | gnd |
| 25 | gnd | CC | gnd |
| 26 | CASU0* | DD | CASU1* |
| 27 | gnd | EE | gnd |
| 28 | CASL0* | FF | CASL1* |
| 29 | +5 | HH | +5 |
| 30 | +5 | JJ | +5 |

1.12 E / Amiga I/O Connector Pins / Expansion

EXPANSION ...86 PIN EDGE (.1) (P2)

See Appendix K for the 100 pin Zorro II and Zorro III bus connector

| PIN | A500 | A1000 | A2000 | A2000b | FUNCTION |
|-----|------|-------|-------|--------|-----------------------------|
| --- | ---- | ----- | ----- | ----- | ----- |
| 1 | x | x | x | x | ground |
| 2 | x | x | x | x | ground |
| 3 | x | x | x | x | ground |
| 4 | x | x | x | x | ground |
| 5 | x | x | x | x | +5VDC |
| 6 | x | x | x | x | +5VDC |
| 7 | x | x | x | x | No Connect |
| 8 | x | x | x | x | -5VDC |
| 9 | x | x | | | No Connect |
| | | | x | x | 28MHz Clock |
| 10 | x | x | x | x | +12VDC |
| 11 | x | x | x | | No Connect |
| | | | | x | /COPCFG (Configuration Out) |
| 12 | x | x | x | x | CONFIG IN, Grounded |
| 13 | x | x | x | x | Ground |
| 14 | x | x | x | x | /C3 Clock |
| 15 | x | x | x | x | CDAC Clock |
| 16 | x | x | x | x | /C1 Clock |
| 17 | x | x | x | x | /OVR |
| 18 | x | x | x | x | RDY |
| 19 | x | x | x | x | /INT2 |
| 20 | | x | | | /PALOPE |
| | x | | x | | No Connect |

| | | | | | |
|----|---|---|---|---|---------|
| | | | | x | /BOSS |
| 21 | x | x | x | x | A5 |
| 22 | x | x | x | x | /INT6 |
| 23 | x | x | x | x | A6 |
| 24 | x | x | x | x | A4 |
| 25 | x | x | x | x | ground |
| 26 | x | x | x | x | A3 |
| 27 | x | x | x | x | A2 |
| 28 | x | x | x | x | A7 |
| 29 | x | x | x | x | A1 |
| 30 | x | x | x | x | A8 |
| 31 | x | x | x | x | FC0 |
| 32 | x | x | x | x | A9 |
| 33 | x | x | x | x | FC1 |
| 34 | x | x | x | x | A10 |
| 35 | x | x | x | x | FC2 |
| 36 | x | x | x | x | A11 |
| 37 | x | x | x | x | Ground |
| 38 | x | x | x | x | A12 |
| 39 | x | x | x | x | A13 |
| 40 | x | x | x | x | /IPL0 |
| 41 | x | x | x | x | A14 |
| 42 | x | x | x | x | /IPL1 |
| 43 | x | x | x | x | A15 |
| 44 | x | x | x | x | /IPL2 |
| 45 | x | x | x | x | A16 |
| 46 | x | x | x | x | BEER* |
| 47 | x | x | x | x | A17 |
| 48 | x | x | x | x | /VPA |
| 49 | x | x | x | x | Ground |
| 50 | x | x | x | x | E Clock |
| 51 | x | x | x | x | /VMA |
| 52 | x | x | x | x | A18 |
| 53 | x | x | x | x | RST |
| 54 | x | x | x | x | A19 |
| 55 | x | x | x | x | /HLT |
| 56 | x | x | x | x | A20 |
| 57 | x | x | x | x | A22 |
| 58 | x | x | x | x | A21 |
| 59 | x | x | x | x | A23 |
| 60 | x | x | x | x | /BR |
| | | | | x | /CBR |
| 61 | x | x | x | x | Ground |
| 62 | x | x | x | x | /BGACK |
| 63 | x | x | x | x | D15 |
| 64 | x | x | x | x | /BG |
| | | | | x | /CBG |
| 65 | x | x | x | x | D14 |
| 66 | x | x | x | x | /DTACK |
| 67 | x | x | x | x | D13 |
| 68 | x | x | x | x | R/W |
| 69 | x | x | x | x | D12 |
| 70 | x | x | x | x | /LDS |
| 71 | x | x | x | x | D11 |
| 72 | x | x | x | x | /UDS |
| 73 | x | x | x | x | Ground |
| 74 | x | x | x | x | /AS |

| | | | | | |
|----|---|---|---|---|--------|
| 75 | x | x | x | x | D0 |
| 76 | x | x | x | x | D10 |
| 77 | x | x | x | x | D1 |
| 78 | x | x | x | x | D9 |
| 79 | x | x | x | x | D2 |
| 80 | x | x | x | x | D8 |
| 81 | x | x | x | x | D3 |
| 82 | x | x | x | x | D7 |
| 83 | x | x | x | x | D4 |
| 84 | x | x | x | x | D6 |
| 85 | x | x | x | x | Ground |
| 86 | x | x | x | x | D5 |

1.13 E / Amiga I/O Connector Pins / Joy Sticks

JOY STICKS ...DB9 male

| USAGE | JOYSTICK | MOUSE |
|-------|----------|----------------------------|
| ----- | ----- | ----- |
| 1 | FORWARD* | (MOUSE V) |
| 2 | BACK* | (MOUSE H) |
| 3 | LEFT* | (MOUSE VQ) |
| 4 | RIGHT* | (MOUSE HQ) |
| 5 | POT X | (or button 3 ... if used) |
| 6 | FIRE* | (or button 1) |
| 7 | +5 | |
| 8 | GND | |
| 9 | POT Y | (or button 2) |

1.14 E I/O Connectors And Interfaces / Explanation of Amiga I/O Connectors

- Parallel Connector Interface Specification
- Serial Interface Connector Specification
- Game Controller Connector Interface Specification
- External Disk Interface Connector Specification

1.15 E / Explanation of I/O Connectors / Parallel Interface Specification

The 25-pin D-type connector with pins (DB25P=male for the A1000, female for A500/A2000 and IBM compatibles) at the rear of the Amiga is nominally used to interface to parallel printers. In this capacity, data flows from the Amiga to the printer. This interface may also be used for input or bidirectional data transfers. The implementation is similar to Centronics, but the pin assignment and drive characteristics vary significantly from that specification (see Pin Assignment). Signal names correspond to those used in the other places in this appendix, when possible.

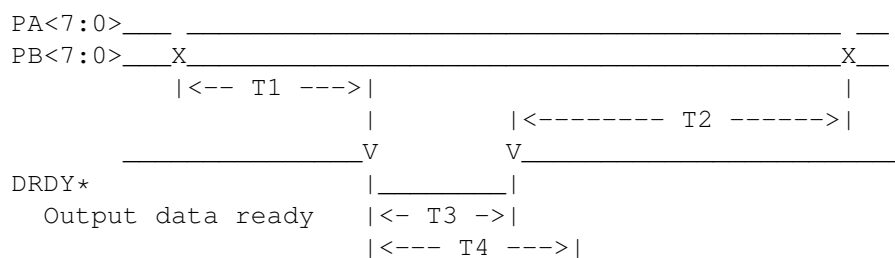
Pin Assignment (J8)

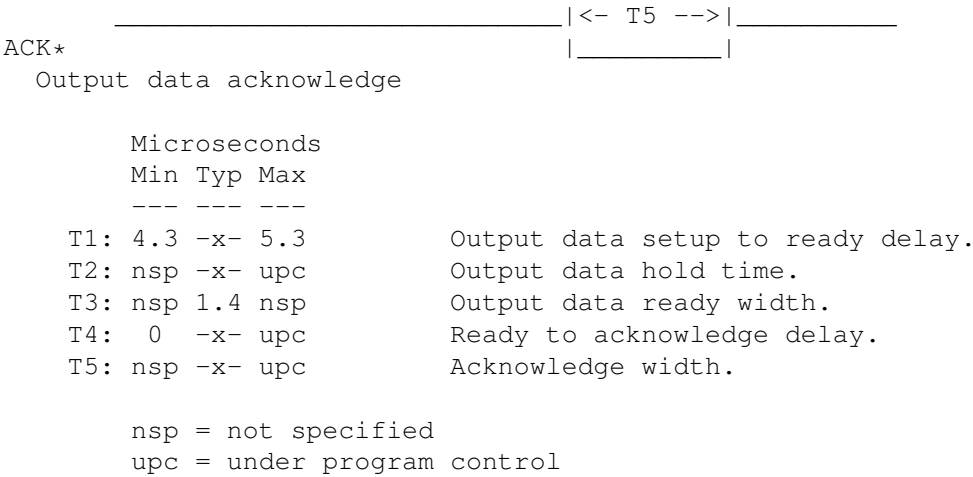
Interface Timing, Output Cycle
Interface Timing, Input Cycle

1.16 E // Parallel Interface Specification / Pin Assignment (J8)

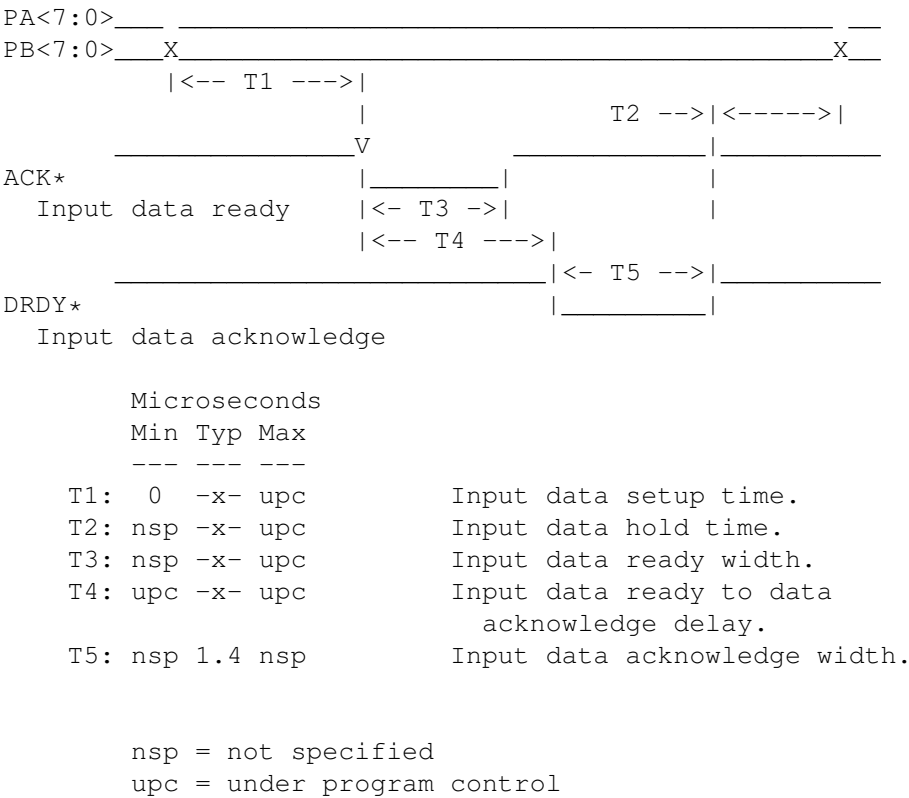
| NAME | DIR | NOTES |
|--------|------|---|
| ----- | ---- | ----- |
| DRDY* | O | Output-data-ready signal to parallel device in output mode, used in conjunction with ACK* (pin 10) for a two-line asynchronous handshake. Functions as input data accepted from Amiga in input mode (similar to ACK* in output mode). See timing diagrams in the following section. |
| D0 | I/O | + |
| D1 | I/O | |
| D2 | I/O | |
| D3 | I/O | D0-D7 comprise an eight-bit bidirectional bus |
| D4 | I/O | for communication with parallel devices, |
| D5 | I/O | nominally, a printer. |
| D6 | I/O | |
| D7 | I/O | + |
| ACK* | I | Output-data-acknowledge from parallel device in output mode, used in conjunction with DRDY* (pin 1) for a two-line asynchronous handshake. Functions as input-data-ready from parallel device in input mode (similar to DRDY* in output mode). See timing diagrams . The 8520 can be programmed to conditionally generate a level 2 interrupt to the 680x0 whenever the ACK* input goes active. |
| BUSY | I/O | This is a general purpose I/O pin also connected to a serial data I/O pin (serial clock on pin 12). Note: Nominally used to indicate printer buffer full. |
| POUT | I/O | This is a general purpose I/O pin to a serial clock I/O pin (serial data on pin 11). Note: Nominally used to indicate printer paper out. |
| SEL | I/O | This is a general purpose I/O pin. Note: nominally a select output from the parallel device to the Amiga. On the A500/A2000 also shared with RS232 "ring indicator" signal. |
| RESET* | O | Amiga system reset |

1.17 E // Parallel Interface Specification / Interface Timing Output Cycle





1.18 E // Parallel Interface Specification / Interface Timing, Input Cycle



1.19 E / Explanation of I/O Connectors / Serial Interface Specification

This 25-pin D-type connector with sockets (DB25S=female) is used to interface to RS-232-C standard signals. Signal names correspond to those used in other places in this appendix, when possible.

WARNING:

Pins on the RS232 connector other than these standard ones described below may be connected to power or other non-RS232 standard signals. When making up RS232 cables, connect only those pins actually used for a particular application. Avoid generic 25-connector "straight-thru" cables.

Pin Assignment (J6)

Timing

Electrical Characteristics

1.20 E // Serial Interface Specification / Pin Assignment (J6)

RS-232-C

| NAME | DIR | STD | NOTES |
|-------|-----|-----|---|
| ---- | --- | --- | ----- |
| FGND | | y | Frame ground -- do not tie to signal ground |
| TXD | O | y | Transmit data |
| RXD | I | y | Receive data |
| RTS | O | y | Request to send |
| CTS | I | y | Clear to send |
| DSR | I | y | Data set ready |
| GND | | y | Signal ground -- do not tie to frame ground |
| CD | I | y | Carrier detect |
| -5V | | n* | 50 ma maximum *** WARNING -5V *** |
| AUDO | O | n* | Audio output from left (channels 0, 3) port, intended to send audio to the modem. |
| AUDI | I | n* | Audio input to right (channels 1, 2) port, intended to receive audio from the modem; this input is mixed with the analog output of the right (channels 1, 2). It is not digitized or used by the computer in any way. |
| DTR | O | y | Data terminal ready. |
| RI | I | y | Ring Indicator (A500/A2000 only) shared with printer "select" signal. |
| RESB* | O | n* | Amiga system reset. |

NOTES:

n*: See warning above

See part 1 of this appendix for pin numbers .

1.21 E // Serial Interface Specification / Timing

Maximum operating frequency is 19.2 KHz. Refer to EIA standard RS-232-C for operating and installation specifications. A rate of 31.25 KHz will be supported through the use of a MIDI adapter.

Modem control signals (CTS, RTS, DTR, DSR, CD) are completely under software control. The modem control lines have no hardware affect on and are completely asynchronous to TXD and RXD .

1.22 E // Serial Interface Specification / Electrical Characteristics

| OUTPUTS | MIN | TYP | MAX | | |
|---------|-------|-----|------|----|-------------------------------|
| ----- | --- | --- | --- | | |
| Vo (-): | -13.2 | -x- | -2.5 | V | Negative output voltage range |
| Vo (+): | 8.0 | -x- | 13.2 | V | Positive output voltage range |
| Io: | -x- | -x- | 10.0 | ma | Output current |
| | | | | | |
| INPUTS | MIN | TYP | MAX | | |
| ----- | --- | --- | --- | | |
| Vi (+): | 3.0 | -x- | 25.0 | V | Positive input voltage range |
| Vi (-): | -25.0 | -x- | 0.5 | V | Negative input voltage range |
| Vhys: | -x- | 1.0 | -x- | V | Input hysteresis voltage |
| Ii: | 0.3 | -x- | 10.0 | ma | Input current |

Unconnected inputs are interpreted the same as positive input voltages.

1.23 E / Explanation of I/O Connectors / Game Controller Interface Spec

The two 9-pin D-type connectors with pins (male) are used to interface to four types of devices:

1. Mouse or trackball, 3 buttons max.
2. Digital joystick, 2 buttons max.
3. Proportional (pot or proportional joystick), 2 buttons max.
4. Light pen, including pen-pressed-to-screen button.

The connector pin assignments are discussed in sections organized by similar hardware and/or software operating requirements as shown in the previous list. Signal names follow those used elsewhere in this appendix, when possible.

J11 is the right controller port connector (JOY1DAT , POT1DAT).
J12 is the left controller port connector (JOY0DAT , POT0DAT).

NOTE:

While most of the hardware discussed below is directly accessible, hardware should be accessed through ROM kernel software. This will keep future hardware changes transparent to the user.

| | |
|-------------------|--------------------------|
| Mouse/Trackball | Proportional Controllers |
| Digital Joysticks | Light Pen |
| Fire Buttons | |

1.24 E // Game Controller Interface Specification / Mouse/Trackball

A mouse or trackball is a device that translates planar motion into pulse trains. Quadrature techniques are employed to preserve the direction as well as magnitude of displacement. The registers JOY0DAT and JOY1DAT become counter registers, with y displacement in the high byte and x in the low byte. Movement causes the following action:

Up: y decrements
 Down: y increments
 Right: x increments
 Left: x decrements

To determine displacement, JOYxDAT is read twice with corresponding x and y values subtracted (careful, modulo 128 arithmetic). Note that if either count changes by more than 127, both distance and direction become ambiguous. There is a relationship between the sampling interval and the maximum speed (that is, change in distance) that can be resolved as follows:

$$\text{Velocity} < \text{Distance(max)} / \text{SampleTime}$$

$$\text{Velocity} < \text{SQRT}(\text{DeltaX}^2 + \text{DeltaY}^2) / \text{SampleTime}$$

For an Amiga with a 200 count-per-inch mouse sampling during each vertical blanking interval, the maximum velocity in either the X or Y direction becomes:

$$\text{Velocity} < (128 \text{ Counts} * 1 \text{ inch}/200 \text{ Counts}) / .017 \text{ sec} = 38 \text{ in/sec}$$

which should be sufficient for most users.

NOTE:

The Amiga software is designed to do mouse update cycles during vertical blanking. The horizontal and vertical counters are always valid and may be read at any time.

CONNECTOR PIN USAGE FOR MOUSE/TRACKBALL QUADRATURE INPUTS

| PIN | MNEMONIC | DESCRIPTION | HARDWARE REGISTER/NOTES |
|-----|----------|------------------------------|---------------------------|
| --- | ----- | ----- | ----- |
| 1 | V | Vertical pulses | JOY[0/1]DAT<15:8> |
| 2 | H | Horizontal pulses | JOY[0/1]DAT<7:0> |
| 3 | VQ | Vertical quadrature pulses | JOY[0/1]DAT<15:8> |
| 4 | HQ | Horizontal quadrature pulses | JOY[0/1]DAT<7:0> |
| 5 | UBUT* | Unused mouse button | See Proportional Inputs . |
| 6 | LBUT* | Left mouse button | See Fire Button . |
| 7 | +5V | +5V, current limited | |
| 8 | Ground | | |
| 9 | RBUT* | Right mouse button | See Proportional Inputs . |

1.25 E // Game Controller Interface Specification / Digital Joysticks

A joystick is a device with four normally opened switches arranged 90 degrees apart. The JOY[0/1]DAT registers become encoded switch input ports as follows:

Forward: bit#9 xor bit#8
 Left: bit#9

Back: bit#1 xor bit#0
Right: bit#1

Data is encoded to facilitate the mouse/trackball operating mode.

NOTE:

The right and left direction inputs are also designed to be right and left buttons, respectively, for use with proportional inputs. In this case, the forward and back inputs are not used, while right and left become button inputs rather than joystick inputs.

The JOY[0/1]DAT registers are always valid and may be read at any time.

CONNECTOR PIN USAGE FOR DIGITAL JOYSTICK INPUTS

| PIN | MNEMONIC | DESCRIPTION | HARDWARE REGISTER/NOTES |
|-----|----------|-------------------------|-------------------------|
| 1 | FORWARD* | Forward joystick switch | JOY[0/1]DAT<9 xor 8> |
| 2 | BACK* | Back joystick switch | JOY[0/1]DAT(1 xor 0> |
| 3 | LEFT* | Left joystick switch | JOY[0/1]DAT<9> |
| 4 | RIGHT* | Right joystick switch | JOY[0/1]DAT<1> |
| 5 | Unused | | |
| 6 | FIRE* | Left mouse button | See Fire Button . |
| 7 | +5V | 125ma max, 200ma surge | Total both ports. |
| 8 | Ground | | |
| 9 | Unused | | |

1.26 E // Game Controller Interface Specification / Fire Buttons

The fire buttons are normally opened switches routed to the 8520 adapter PRA0 as follows:

PRA0 bit 7 = Fire* left controller port
PRA0 bit 6 = Fire* right controller port

Before reading this register, the corresponding bits of the data direction register must be cleared to define input mode:

DDRA0<7:6> cleared as appropriate

NOTE:

Do not disturb the settings of other bits in DDRA0 (Use of ROM kernel calls is recommended).

Fire buttons are always valid and may be read at any time.

CONNECTOR PIN USAGE FOR FIRE BUTTON INPUTS

| PIN | MNEMONIC | DESCRIPTION |
|-----|----------|-------------|
|-----|----------|-------------|

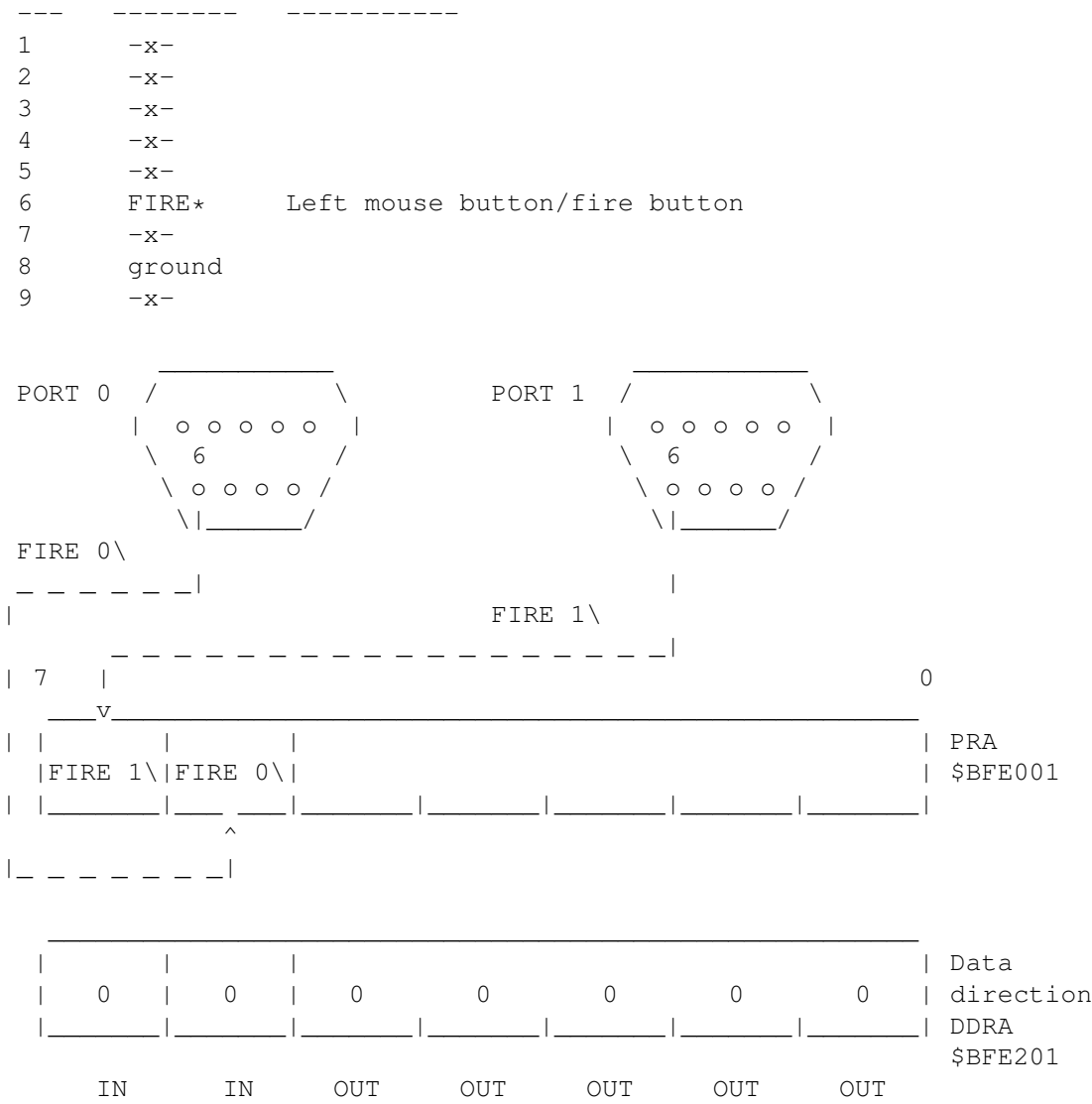


Figure E-1: Reading Fire Buttons

1.27 E // Game Controller Interface Spec / Proportional Controllers

Resistive (potentiometer) element linear taper proportional controllers are supported up to 528k Ohms max (470k +/- 10% recommended). The JOY[0/1]DAT registers contain digital translation values for y in the high byte and x in the low byte. A higher count value indicates a higher external resistance. The Amiga performs an integrating analog-to-digital conversion as follows:

1. For the first 7 (NTSC) or 8 (PAL) horizontal display lines, the analog input capacitors are discharged and the positions counters reflected in the POT[0/1]DAT registers are held reset.

For the remainder of the display field, the input capacitors are allowed to recharge through the resistive element in the external control device.

- 2. The gradually increasing voltage is continuously compared to an internal reference level while counter keeps track of the number of lines since the end of the reset interval.
- 3. When the input voltage finally exceeds the internal threshold for a given input channel, the current counter value is latched into the POT[0/1]DAT register corresponding to that channel.
- 4. During the vertical blanking interval, the software examines the resulting POT[0/1]DAT register values and interprets the counts in terms of joystick position.

NOTE:

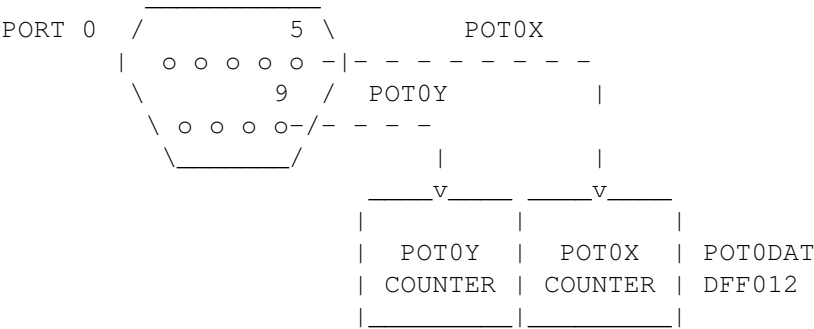
The POTY and POTX inputs are designated as "right mouse button" and "unused mouse button" respectively. An opened switch corresponds to high resistance, a closed switch to a low resistance. The buttons are also available in POTGO and POTGOR registers. It is recommended that ROM kernel calls be used for future hardware compatibility.

It is important to realize that the proportional controller is more of a "pointing" device than an absolute position input. It is up to the software to provide the calibration, range limiting and averaging functions needed to support the application's control requirements.

The POT[0/1]DAT registers are typically read during video blanking, but MAY be available prior to that.

CONNECTOR PIN USAGE FOR PROPORTIONAL INPUTS

| PIN | MNEMONIC | DESCRIPTION | HARDWARE REGISTER/NOTES |
|-----|----------|-------------------------|----------------------------------|
| 1 | XBUT | Extra Button | |
| 2 | Unused | | |
| 3 | LBUT* | Left button | See Digital Joystick |
| 4 | RBUT* | Right button | See Digital Joystick |
| 5 | POTX | X analog in | POT[0/1]DAT<7:0>, POTGO, POTGOR |
| 6 | Unused | | |
| 7 | +5V | 125ma max, 200 ma surge | |
| 8 | Ground | | |
| 9 | POTY | Y analog in | POT[0,1]DAT<15:8>, POTGO, POTGOR |



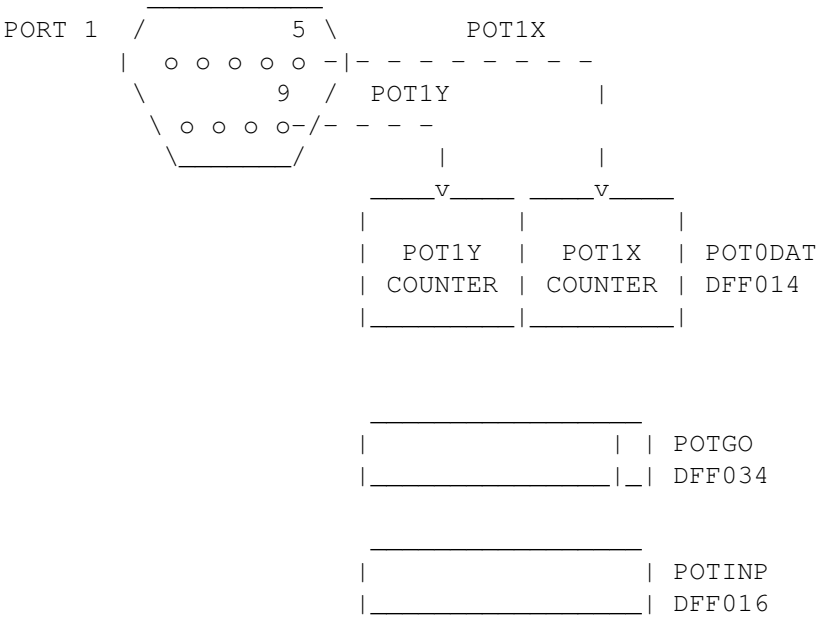


Figure E-2: Pot Counters

1.28 E // Game Controller Interface Specification / Light Pen

A light pen is an optoelectronic device whose light-sensitive portion is placed in proximity to a CRT. As the electron beam sweeps past the light pen, a trigger pulse is generated which can be enabled to latch the horizontal and vertical beam positions. There is no hardware bit to indicate this trigger, but this can be determined in the two ways as shown in chapter 8, "Interface Hardware."

Light pen position is usually read during blanking, but MAY be available prior to that.

CONNECTOR PIN USAGE FOR LIGHT PEN INPUTS

| PIN | MNEMONIC | DESCRIPTION | HARDWARE REGISTER/NOTES |
|-----|----------|-------------------------|-------------------------|
| --- | ----- | ----- | ----- |
| 1 | Unused | | |
| 2 | Unused | | |
| 3 | Unused | | |
| 4 | Unused | | |
| 5 | LPENPR* | Light pen pressed | See Proportional Inputs |
| 6 | LPENTG* | Light pen trigger | VPOSR, VHPOSR |
| 7 | +5V | 125ma max, 200 ma surge | Both ports |
| 8 | Ground | | |
| 9 | Unused | | |

* Note: depending on the maker, the light pen input may be either.

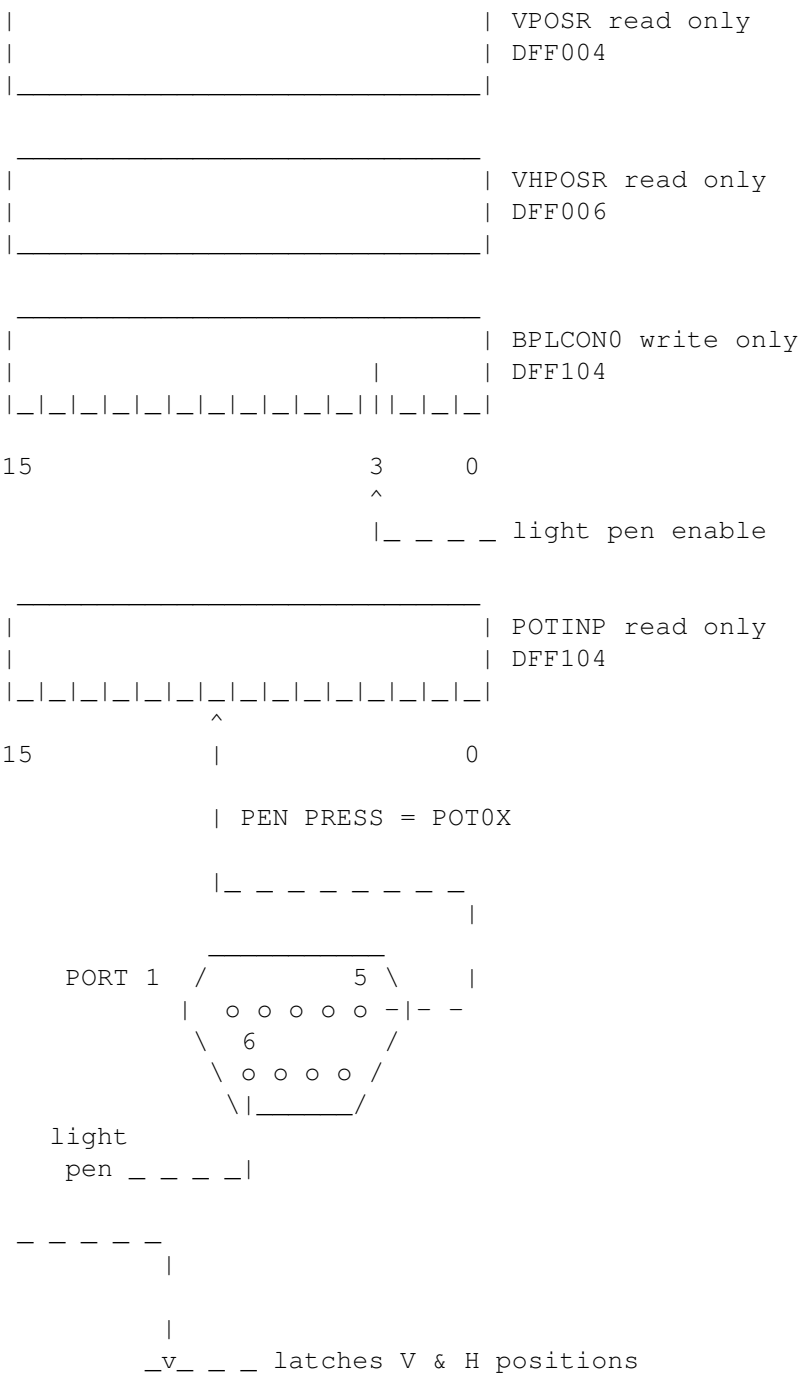


Figure E-3: Light Pen

1.29 E / Explanation of Connectors / External Disk Interface Specification

The 23-pin D-type connector with sockets (DB23S) at the rear of the Amiga is nominally used to interface to MFM devices.

Pin Assignment (J7)
Identification Mode

Limitations

1.30 E // External Disk Interface Specification / Pin Assignment (J7)

| PIN | NAME | DIR | NOTES |
|------|--------|------|---|
| ---- | ----- | ---- | ----- |
| 1 | RDY* | I/O | If motor on, indicates disk installed and up to speed. If motor not on, identification mode. See below. |
| 2 | DKRD* | I | MFM input data to Amiga. |
| 3 | GND | | |
| 4 | GND | | |
| 5 | GND | | |
| 6 | GND | | |
| 7 | GND | | |
| 8 | MTRXD* | OC | Motor on data, clocked into drive's motor-on flip-flop by the active transition of SELxB*. Guaranteed setup time is 1.4 usec. Guaranteed hold time is 1.4 usec. |
| 9 | SEL2B* | OC | Select drive 2.* |
| 10 | DRESB* | OC | Amiga system reset. Drives should reset their motor-on flip-flops and set their write-protect flip-flops. |
| 11 | CHNG* | I/O | Note: Nominally used as an open collector input. Drive's change flop is set at power up or when no disk is not installed. Flop is reset when drive is selected and the head stepped, but only if a disk is installed. |
| 12 | +5V | | 270 ma maximum; 410 ma surge When below 3.75V, drives are required to reset their motor-on flops, and set their write-protect flops. |
| 13 | SIDEB* | O | Side 1 if active, side 0 if inactive |
| 14 | WPRO* | I/O | Asserted by selected, write-protected disk. |
| 15 | TK0* | I/O | Asserted by selected drive when read/write head is positioned over track 0. |
| 16 | DKWEB* | OC | Write gate (enable) to drive. |
| 17 | DKWDB* | OC | MFM output data from Amiga. |
| 18 | STEPB* | OC | Selected drive steps one cylinder in the direction indicated by DIRB. |
| 19 | DIRB | OC | Direction to step the head. Inactive to step towards center of disk (higher-numbered tracks). |
| 20 | SEL3B* | OC | Select drive 3. * |
| 21 | SEL1B* | OC | Select drive 1. * |
| 22 | INDEX* | I/O | Index is a pulse generated once per disk revolution, between the end and beginning of cylinders. The 8520 can be programmed to conditionally generate a level 6 interrupt to the 680x0 whenever the INDEX* input goes active. |
| 23 | +12V | | 160 ma maximum; 540 ma surge. |

* Note: the drive select lines are shifted as they pass through a string of daisy chained devices. Thus the signal that appears as drive 2 select at the first drive shows up as drive 1 select

at the second drive and so on...

1.31 E // External Disk Interface Specification / Identification Mode

An identification mode is provided for reading a 32-bit serial identification data stream from an external device. To initialize this mode, the motor must be turned on, then off. See pin 8, MTRXD* for a discussion of how to turn the motor on and off. The transition from motor on to motor off reinitializes the serial shift register. After initialization, the SELxB* signal should be left in the inactive state. Now enter a loop where SELxB* is driven active, read serial input data on RDY* (pin 1), and drive SELxB* inactive. Repeat this loop a total of 32 times to read in 32 bits of data. The most significant bit is received first.

DEFINED IDENTIFICATIONS

\$0000 0000 - no drive present.
\$FFFF FFFF - Amiga standard 3.25 diskette.
\$5555 5555 - 48 TPI double-density, double-sided.

As with other peripheral ID's, users should contact Commodore-Amiga for ID assignment.

The serial input data is active low and must therefore be inverted to be consistent with the above table.

1.32 E // External Disk Interface Specification / Limitations

1. The total cable length, including daisy chaining, must not exceed 1 meter.
2. A maximum of 3 external devices may reside on this interface, but specific implementations may support fewer external devices.
3. Each device must provide a 1000-Ohm pull-up resistor on those outputs driven by an open-collector device on the Amiga (pins 8-10, 16-21).
4. The system provides power for only the first external device in the daisy chains.

1.33 E I/O Connectors And Interfaces / Part 3 - Internal Connectors

Internal Disk
Internal Disk Power
Internal SCSI Disk

1.34 E / Internal Connectors / Internal Disk

INTERNAL DISK ...34 PIN RIBBON (J10)

| | | | |
|----|-------------|----|--------|
| 1 | GND | 18 | DIRB |
| 2 | CHNG* | 19 | GND |
| 3 | GND | 20 | STEPB* |
| 4 | MTR0D*(led) | 21 | GND |
| 5 | GND | 22 | DKWDB* |
| 6 | N.C. | 23 | GND |
| 7 | GND | 24 | DKWEB* |
| 8 | INDEX* | 25 | GND |
| 9 | GND | 26 | TK0* |
| 10 | SEL0B* | 27 | GND |
| 11 | GND | 28 | WPRO* |
| 12 | N.C. | 29 | GND |
| 13 | GND | 30 | DKRD* |
| 14 | N.C. | 31 | GND |
| 15 | GND | 32 | SIDEB* |
| 16 | MTR0D* | 33 | GND |
| 17 | GND | 34 | RDY* |

1.35 E / Internal Connectors / Internal Disk Power

INTERNAL DISK POWER ...4 PIN STRAIGHT (J13)

| | |
|---|-------------------------------|
| 1 | +12 (some drives are +5 only) |
| 2 | GND |
| 3 | GND |
| 4 | +5 |

1.36 E / Internal Connectors / Internal SCSI Disk

INTERNAL SCSI DISK ...50 PIN CONNECTOR (A3000 MOTHERBOARD)

| | | | |
|----|--------|----|-------------------|
| 2 | DATA 0 | 26 | TERMINATION POWER |
| 4 | DATA 1 | 28 | GROUND |
| 6 | DATA 2 | 30 | GROUND |
| 8 | DATA 3 | 32 | ATN* |
| 10 | DATA 4 | 34 | N.C. |
| 12 | DATA 5 | 36 | BSY |
| 14 | DATA 6 | 38 | ACK* |
| 16 | DATA 7 | 40 | RST* |
| 18 | PARITY | 42 | MSG* |
| 20 | GROUND | 44 | SEL* |
| 22 | GROUND | 46 | C/D |
| 24 | GROUND | 48 | REQ* |
| | | 50 | I/O |

(ALL ODD-NUMBERED PINS, EXCEPT PIN 25, ARE CONNECTED TO GROUND. PIN 25 IS OPEN)

See the ANSI standard SCSI (Small Computer Standard Interface) Specification for more information.

1.37 E Connectors And Interfaces / Port Signal Assignments for 8520 CIAS

CIA-A Address BFE_x01 data bits 7-0 (A12*) (int2)

```

PA7..game port 1, pin 6 (fire button*)
PA6..game port 0, pin 6 (fire button*)
PA5.. RDY*      disk ready*
PA4.. TK0*      disk track 00*
PA3.. WPRO*     write protect*
PA2.. CHNG*     disk change*
PA1..LED*       led light (0=bright)/audio filter control (A500 & A2000)
PA0..OVL        ROM/RAM overlay bit

SP... KDAT      keyboard data
CNT.. KCLK      keyboard clock
PB7..P7         data 7
PB6..P6         data 6
PB5..P5         data 5      Centronics parallel interface
PB4..P4         data 4      data
PB3..P3         data 3
PB2..P2         data 2
PB1..P1         data 1
PB0..P0 data 0

PC... drdy*          Centronics control
F.... ack*
```

CIA-B Address BFD_x00 data bits 15-8 (A13*) (int6)

```

PA7..com line DTR* , driven output
PA6..com line RTS* , driven output
PA5..com line carrier detect*
PA4..com line CTS*
PA3..com line DSR*
PA2.. SEL      Centronics control
PA1.. POUT +--- paper out -----+
PA0.. BUSY | +--busy -----+ |
          | |                      | |
SP... BUSY | +- commodore serial bus + |
CNT.. POUT +----commodore serial bus --+

PB7.. MTR*      motor
PB6.. SEL3*     select external 3rd drive
PB5.. SEL2*     select external 2nd drive
PB4.. SEL1*     select external 1st drive
PB3.. SEL0*     select internal drive
```

PB2.. SIDE* side select*
PB1.. DIR direction
PB0.. STEP* step*

PC...not used
F.... INDEX* disk index pulse*