SYS68K/CPU-44

USER'S MANUAL

EDITION 1

Part Number 049-13856-101 Rev A1

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Photograph of the CPU-44

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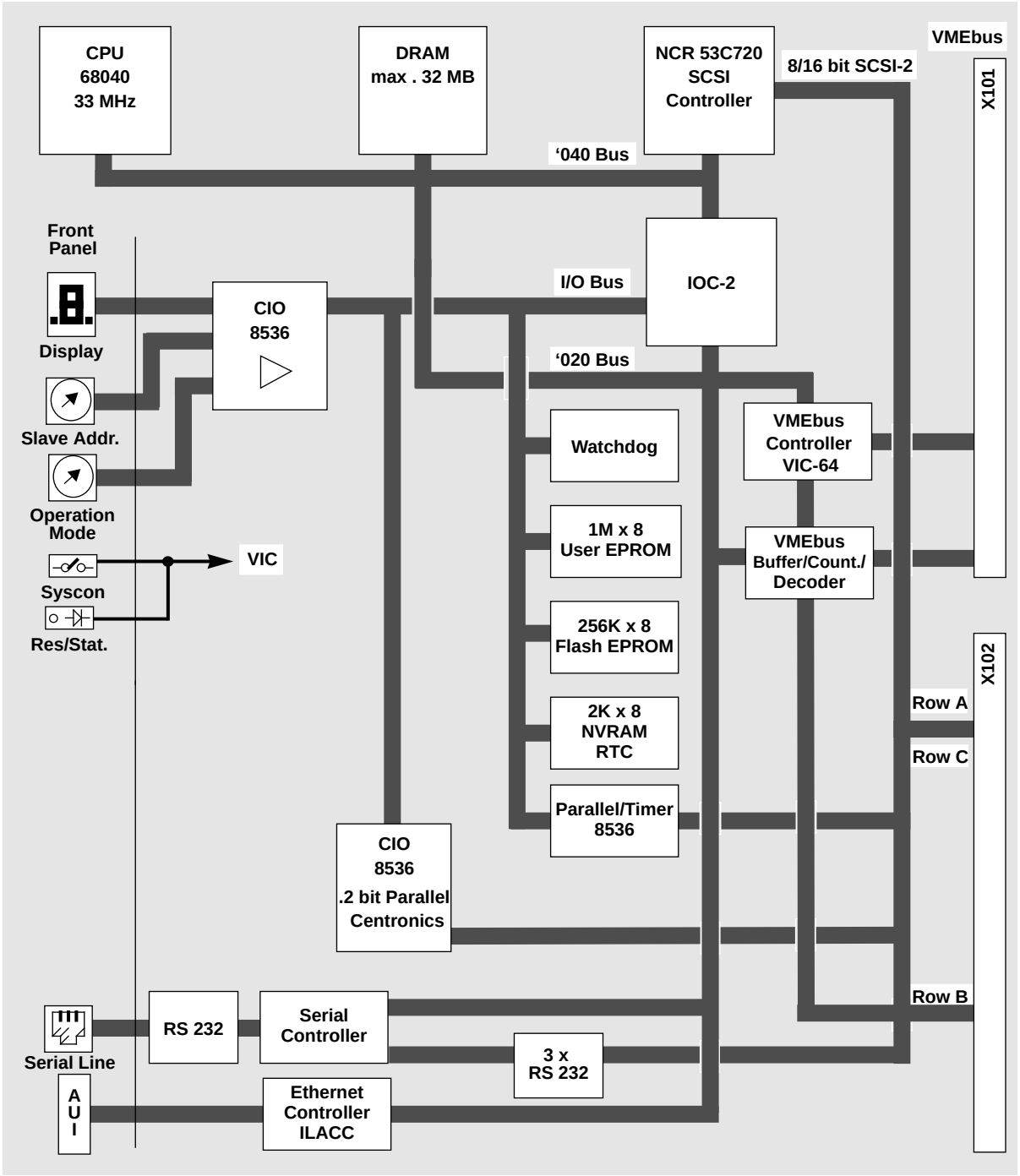
1 Introduction

1.1 Distinguishing Features

- 68040 CPU at 25 MHz or 33 MHz
- Memory
  - Up to 32 MB RAM for data/program storage (79 MB/s)
  - 8 KB SRAM and RTC for storage of variable system parameters (MK48T18)
  - Up to 1 MB user EPROM
  - 256 KB basic Flash EPROM for firmware
- Ethernet interface (32-bit ILACC)
- VMEbus interface controller:
  - System controller and arbiter
  - VMEbus interrupter and interrupt handler
  - Master/slave write posting
  - 64-bit MBLT 35 MB/s
- IOC-2 gate array:
  - 68040 to 68020 bus converter
  - Dynamic bus sizing for VMEbus
  - Translation of BLT into bursts on '040 bus to allow snooping of BLT cycles
  - Separate arbitration on '040 and '020 bus
  - I/O bus interface
  - Support for VMEbus UATs to allow snooping
  - Interface for a single bytewide EPROM
- Parallel I/O or Centronics port
- Six 16-bit timer/counters
- Four serial ports (RS 232, RS 422, RS 485)
- Smart SCSI-2 (NCR 53C720) interface with burst capability (max. transfer capacity 20 MB/s) and single-ended 8/16-bit SCSI data bus
- Two rotary switches on front panel for selection of operation modes and base address
- Status display on front panel
- Watchdog timer with watchdog indicator on front panel

1.2 General Description

Figure 1.1 Block Diagram



The CPU-44 is a highly integrated high-performance single-board VMEbus computer with graphics display. It is designed to offer as many features as possible on a single slot VMEbus board. Suitable intelligent or high integrated components are used to achieve this density of computing power.

The on-board 68040 CPU is clocked at 25 or 33MHz. On-chip caches for program and data (4 KB capacity each) and the on-chip floating-point unit allows 35 MIPS/ 5.6 MFLOPS for the CPU. Additionally, backward compatibility with existing 68000-family software is guaranteed.

The main memory is organized in two banks of interleaved DRAM. Therefore, burst mode transfers allow 70 MB/s on reads. Due to a buffered write mechanism, the transfer rate for writes is even bigger (79 MB/s). This is useful during cache flushes where the CPU may write large amounts of data.

The major drawback of the 68040 is the deletion of dynamic bus sizing. This requires 68020/30 applications to be modified if they access word devices with longword instructions. The longword accesses have to be split by software into two word accesses. This slows down the performance. Instead of this, the IOC-2 hardware generates the needed bus cycles if the addressed device acknowledges a smaller data size than the CPU requested.

One of the main design goals of the CPU-44 is efficient use of the CPU's high speed bus. Thus, the following design rules are established:

- Use of intelligent peripheral devices which are able to perform tasks independent from the main CPU (NCR 53C720, CL-CD2401, ILACC).
- Independent 68020-like bus for VMEbus, Ethernet with separate arbitration.
- Minimum interference between CPU bus, ‘020 bus and I/O bus.
- Decoupling of VMEbus and CPU bus via FIFO for BLT. On traditional designs there could only be one bus master on the whole board at a time. For example, if a BLT was in progress, the CPU was blocked for the duration of the BLT. On the CPU-44 the CPU bus is decoupled from the I/O bus.

In order to enhance system security, the CPU-44 incorporates a watchdog timer. It must be retriggered periodically otherwise the watchdog generates a reset. After watchdog reset, the watchdog reset LED on the front panel signals this condition. The watchdog indicator is cleared only by power-on reset or by triggering the watchdog.

Four serial ports are located on the CPU-44. One, using a 6-pin RJ11 jack on the front panel, is intended for connection of a terminal or a mouse. The other three are fed to rows A and C of the VMEbus P2 connector (X102). They can be connected via ADAP-220/200 and CONV-300 to three 9-pin D-Sub connectors. Two of the serial lines can be configured to support either RS 232 or RS 422/485 standard via SILCs (Serial Interface Level Converters).

Twelve parallel I/O-lines (X102) can be used either as centronics printer port or as TTL-level interface (CONV-300).

The integrated real-time clock allows the operating system to provide date and time for revision control. The clock is powered by an internal lithium battery. (8)KB of battery-backed RAM is used for storage of system dependent parameters.

Status displays a reset switch, and two hex-code switches are located on the front panel. The status display indicates the condition of the processor and watchdog timer. The hexadecimal display is an error status display. The hex-code switches (software readable) are used by the firmware to set up the operating mode and the VMEbus base address of the board.

The VMEbus interface of the CPU-44 uses the VIC-64 VMEbus Interface Controller gate array. The VIC-64 supports D64 multiplexed block transfer according to IEEE 1014 Rev. D.

A 256 K x 8 Flash EPROM holds the firmware. It is on-board reprogrammable to allow reconfiguration.

Up to 1M x 8 of EPROM can be added to the board to hold user firmware.

The onboard Ethernet interface provides connection to most popular local area networks (LAN).

A sophisticated SCSI-2 (wide) interface is also located on the CPU-44. The controller chip is very fast and intelligent so that it forms a very efficient SCSI interface with a maximum transfer rate of 20 MB/s.

1.3 Technical Details

The CPU-44 consists of the following main blocks:

- CPU
- RAM
- Basic Flash EPROM
- User EPROM
- Ethernet Interface
- SCSI Interface
- Serial I/0
- Parallel I/O
- CIO Counters/Timers
- Parameter RAM and Real-Time Clock
- VIC Timer
- Watchdog Timer
- Status Display
- Reset
- VMEbus Interface
- Interrupt Sources
- Software
- Connectors

1.3.1 CPU

The 68040 CPU is clocked with 25 or 33 MHz. All internal bus operations are synchronous to this clock. The CPU uses burst mode only to access main memory.

The CPU handles all interrupts generated by the VIC. CPU IACK cycles are always routed to the VIC.

Non-interruptable read-modify-write cycles (TAS commands) are supported between VMEbus and the CPU. RMC cycles from the VMEbus to the local RAM are only indivisible when they are byte size. CAS2 instructions have limited support As shown in Table 1.1.

Table 1.1 CAS2 Operations on the Various Busses

1st op	2nd op	indivisible
local RAM	local RAM	yes
VMEbus	local RAM	yes
local RAM	VMEbus	no
VMEbus	VMEbus	yes

1.3.2 RAM

The DRAM maybe accessed from the following sources:

- CPU
- SCSI Controller
- Ethernet Controller
- VMEbus

Burst mode is supported for accesses from:

- CPU
- SCSI Controller
- VMEbus BLT

The base address of the DRAM seen from the CPU is fixed to $0000.0000. To avoid programming the MMU, the DRAM and VRAM are mirrored as non-cacheable RAM.

The base address for accessing the RAM from the VMEbus, as well as the window size, is programmable. The on-board firmware uses hex switch S901 to program the VMEbus address decoder and mask registers.

When using A24 addressing, to access the CPU-44 RAM the address translation logic must be programmed to supply local addresses A(24) to A(26). In this case, the DRAM can be reached from VMEbus (including A32 addressing).

The following table summarizes the usable bandwidth of the RAM including precharge and refresh.

Table 1.2: Usable Bandwidth of the RAM

	33 MHz: (MB/s)	25 MHz: (MB/s)
DRAM read	58	50
DRAM write	66	50

RAM Performance- *The CPU-44C/16 has only one RAM bank and therefore can't use interleaving. This reduces memory performance a little. On reads a 5/2/2/2 burst and on writes a 3/2/2/1 burst is done. Including precharge delays and refresh, the usable bandwidth is 48 MB/s for reads and writes.*

1.3.3 Basic Flash EPROM

After reset, the basic Flash EPROM is mapped to $0000.0000 so the initial stack pointer and reset vector can be read. During initialization, it is mapped to its normal address ($FE80.0000) and the DRAM is located at address $0000.0000.

The software in the basic Flash EPROM (RMon) initializes all hardware according to the parameters in the basic Flash EPROM or the NVRAM ($FEC2.0000).

Reprogramming is possible when the appropriate jumpers are set. This should only be done during a firmware update. Reprogramming the basic Flash EPROM with code other than RMon will cause board initialization failures.

The EPROMs are the slowest devices on the '040 bus. Reading a cache line (16 bytes) out of the EPROMs last about 4 us. This is very poor for other bus participants. Especially the following can happen: the ILACC performs a DMA of four accesses to the RAM. Between each access there is a EPROM read. Since this last more than 16 us the VMEbus may get a buserror when it wants to access the board in that situation. Work-around: The EPROMs are only intended for configuration and booting of the CPU-44. The EPROMs should not be used after the boot. If it is necessary to execute code out of the EPROM it should be copied to the RAM before.

1.3.4 User EPROM

The pin assignment of the 32-pin socket corresponds to the JEDEC standard. The socket is designed for use with 32-pin EPROMs only. These EPROM types range from 1 Mb up to 8 Mb (27C010 to 27C080).

The EPROM access time is programmable via an IOC-2 register from 4 to 36 wait-states (60 ns to 810 ns maximum access time).

1.3.5 Ethernet Interface

The Ethernet interface is based on the Integrated Local Area Communications Controller (ILACC - AM79C900).

A main feature of the ILACC and its on-chip DMA channel is the flexibility and speed of communication. The internal Manchester Encoder/Decoder of the ILACC is compatible with the IEEE-802.3 specification.

The CPU-44 is attached to Ethernet (Cheapernet, or 10BaseT) networks via the AUI connector on the front panel .

1.3.6 SCSI Interface

Single-ended 8/16 bit SCSI-2 signals are fed into rows A and C of the VMEbus P2 connector (X102). An ADAP-220 is plugged onto the rear side of the backplane to interface to standard 8/16-bit SCSI connectors: a 50-pin flat cable connector, and a 68-pin, high density, half pitch connector (SCSI-2 P cable). The ADAP-220 is also used to interface between these types of cables, allowing different types of connectors to be mixed in the system.

The ADAP-200 can be used for 8-bit SCSI devices.

The NCR53C720 SCSI controller uses its own code fetching and SCSI data transfer from the onboard DRAM. The processor executes SCSI SCRIPTS to control the actions on the SCSI and the CPU bus. SCRIPTS is a specially designed language for easy SCSI protocol handling. It dramatically reduces the CPU activities. The SCRIPTS processor starts SCSI I/O operations in approximately 500 ns where traditional intelligent host adapters require 2-8 ms.

1.3.7 Serial I/O

The CPU-44 offers four serial I/O lines, implemented by one CL-CD2401 Multi Protocol Controller. CHAN.1 and CHAN.2 are RS 232 two-wire handshake interfaces. CHAN.3 and CHAN.4 use removable Serial Interface Level Converters (SILC). As shipped, two RS 232 level converter SILCs are installed, featuring hardware handshake as well as the XON / XOFF protocol. Additional level converter plug-ins for RS 422 and RS 485 are available.

The baud rate generator is driven by a 20 MHz clock, allowing baud rates from 50 b/s to 64 kb/s.

1.3.8 Parallel I/O

There is one 8-bit parallel port with handshake signals on the CPU-44. This parallel port is based on a Zilog Z8536 device (user CIO). The port signals are routed via the VMEbus P2 connector and the ADAP-220/200 to the CONV-300 board. Three 9-pin D-Sub serial plugs, a 25-pin D-Sub parallel connector (Centronics printer interface), and a 26-pin connector for direct access to the CIO pins are installed on the CONV-300.

The I/O ports of the user CIO feature programmable polarity, programmable direction (bit mode), pulse generators, and programmable open drain outputs. Four handshake modes, including 3-wire (like IEEE-488), are selectable. The CIO is also programmable as a 16-vector interrupt controller.

1.3.9 CIO Counters/ Timers

The CPU-44 offers three independent, programmable 16-bit counters/timers integrated in the user CIO. They can be used as general-purpose devices with up to four external access lines per counter / timer (count input, output, gate, and trigger). Port A and port C lines of the user CIO are routed to a 26-pin I/O connector on the CONV-300 for user applications.

1.3.10 Parameter RAM and Real-Time Clock

The real-time clock is designed with the MK48T18 timekeeper RAM. It combines a 8Kx8 CMOS SRAM (parameter RAM), a bytewide accessible real-time clock, a crystal, and a long-life lithium battery, all in one package.

1.3.11 VIC Timer

The VIC contains a timer that can be programmed to output a periodic wave form on LIRQ2. The available frequencies are 50 Hz, 100 Hz, and 1000 Hz. The VIC timer is typically used as a tick timer for multi-tasking operating systems.

1.3.12 Watchdog Timer

The watchdog timer monitors the activity of the microprocessor. If the microprocessor does not access the watchdog timer within the time-out period of 100 ms or 1.6 s, a reset pulse is generated. After reset, the watchdog timer is disabled. The normal time-out period of 100 ms/1.6 s becomes effective after the first access to the watchdog timer.

The left decimal point of the hex display located at the front panel is illuminated to indicate a watchdog reset. This watchdog indicator is only cleared by power-up reset, the reset switch, a VMEbus SYSRESET, or a VIC remote reset.

The state of the watchdog indicator can be read by software using bit PA7 of the system control register located in the system CIO.

1.3.13 Status Display

The CPU-44 features a seven-segment display on the front panel and displays hexadecimal values from 0 - F.

This status display ($FEC3.0000) is designed as a read / write register and uses the least significant nibble of the byte.

The right decimal point of the hex display is controlled by PA0 of the system control register. The right decimal point is used as an initialization status by the monitor program. After reset the right decimal point is illuminated. RMon switches the decimal point off before the user program in the user EPROM is called.

The LED next to the reset button shows the status of the CPU. It is illuminated when the CPU is running and it is off when the CPU is halted.

1.3.14 Reset

Reset may be initiated by six sources:

- supply voltage drop below 4.75 V or power-up
- reset switch on the front panel
- VMEbus SYSRESET

- VIC remote control reset register
- Watchdog
- CPU RESET instruction

1.3.15 VMEbus Interface

Each CPU-44 board offers VMEbus master and slave interfaces. Additionally, VMEbus system controller functions are available via the VMEbus gate array (VIC).

1.3.15.1 System Controller

The CPU-44 features a full slot-one system controller, including SYSCLK, SYSRESET, bus time-out, IACK daisy chain driver, and a four level arbitration circuit. System controller capabilities are enabled by setting switch S3 to position 'SC' on the front panel.

1.3.15.2 VMEbus Master Interface

The master interface of the CPU-44 board supports 8, 16, and 32-bit data transfer cycles in A32, A24, and A16 addressing modes.

A special feature is provided to support longword accesses from the local CPU to D16 VMEbus boards (dynamic bus sizing). Two control lines of the System Control Register (SCR) enable longword breaking for the A32 and A24 area.

The VIC chip supplies the VMEbus address modifier signals. This is done by either routing the FC0..2 lines to AM0..2, or by driving these signals by the internal address modifier source register of the VIC ($FEC0.10B7). The AM3..5 lines are driven depending on the actual data size, or by the address modifier source register. One output signal of the system control register is used to control this option.

The CPU-44 supports master/slave block transfer cycles. Several options within the VIC chip allow the user to generate different block transfer cycle types.

The overall transfer rate from one CPU-44 to another CPU-44 is approximately 35 MB/s using D64 block transfer.

1.3.15.3 VMEbus Slave Interface

The CPU-44 supports A32 and A24 slave access to the DRAM and an A16 slave interface to access the interprocessor communication registers. The addresses of all of the slave interfaces are separately programmable.

For full support of the interprocessor features, the CPU-44 has two A16 slave decoders: one for individual addressing and one for broadcast addressing of the VIC.

1.3.16 Interrupt Sources

Interrupt sources include VMEIRQ local devices and mailbox interrupts. Interrupts can be reprioritized to any local level using the control registers of the VIC device.

1.3.17 Software

The local CPU-44 firmware (RMon) is stored in the on-board Flash EPROM (FEPROM). RMon provides the basic software layer of the board. Any operating system or application software is based on the RMon and uses its functionality:

- Power-On Initialization
- Configuration
- Various Bootstraps
- External Callable I/O Functions
- Application Hooks

1.3.17.1 Power-On Initialization

After reset or power-on, the local hardware (VIC, serial I/O, CIO, video, keyboard interface, etc.) must be initialized by the CPU. The initialization is affected by certain parameters taken either from the on-board NVRAM or from the Flash EPROM (default values). Hex switch S902 on the front panel selects whether the NVRAM or the default values are to be used.

The NVRAM parameters are certified by a checksum. If the checksum test fails, the default parameters are used independent of the switch setting.

After reset or power-on, an automatic selftest routine checks the functionality of the board and displays the results.

1.3.17.2 Configuration

The configuration program is completely menu driven. The program interactively shows the configuration parameters and allows their modification:

- I/O Configuration, e.g.: serial I/O, baud rate, etc.
- Bootstrap configuration
- Internet address of ILACC
- VMEbus Interface Configuration (VIC Programming)

1.3.17.3 External Callable I/O Functions

These Functions include:

- Enable/Disable IRQs
- Get device status
- Set device mode
- Character raw I/O
- C-like functions **such as `getchar`**, **`putchar`**, **`printf`**

1.3.17.4 Application Hooks

Application programs may freely use the external callable I/O functions and other information provided in the ‘RMon Fixed Public Location.’

Furthermore, a ROMed application can very easily be started interactively or automatically after reset or power-on from RMon. The application autostart mechanism can be installed simply by setting the boot-strap configuration parameters.

1.4 Definition of Board Parameters

1.4.1 VMEbus

- **VMEbus interface according to specification ANSI/IEEE STD 1014-1987 (Rev. D1.4)**
- **VMEbus Master Capabilities**
  - MD64
  - MRMW8
  - MBLT
- **VMEbus Slave Capabilities:**
  - SADO32
  - SRMW32
  - UAT
  - MBLT
- **Arbiter Options**
  - PRI, RRS
  - BTO 4 µs to 480 µs
  - SYSCLOCK generation
  - BBSY filter
- **Requester Options**
  - Any one of BR(0), BR(1), BR(2) or BR(3)
  - Programmable release when done (RWD)
  - Release-on-request (ROR)
  - Release-on-bus-clear (ROC)
  - Bus capture and hold (BCAP)
  - Programmable fair request timer 2 µs ... 30 µs.
- **Interrupt Handler and Generator Capabilities**
  - Interrupt handler and generator on IRQ1 to IRQ7.

- **Interrupter Options**
  - Any one of I(n) where $1 \leq n \leq 7$.
- **Address Range**
  - Programmable extended/standard/short I/O
    extended access (A31-A24 and mask)
    standard access (A23-A16 and mask)
    short I/O (A15 -A8)
  - Default: extended access 64 MB, short I/O 256 B

1.4.2 Ethernet

- **AUI interface according to 802.3**

1.4.3 SCSI

- **SCSI-2 wide (8/16 bit single ended)**
- **Transfer Speed**
  - asynchronous transfer 5 MB/s (8-bit) 10 MB/s (16-bit)
  - synchronous transfer 10 MB/s (8-bit) 20 MB/s (16-bit)

1.4.4 Serial I/O

- **4 channels (50 b/s - 64 kb/s)**
- **Keyboard:**
  - MF2/AT mode

1.4.5 Parallel I/O

- **12-bit unbuffered TTL**
- **CONV-300:**
  - 12-bit buffered TTL
  - Centronics unidirectional

1.4.6 MTBF Values

- **6857 h (computed from MTL HDBK-217E)**
- **91883.8 h (realistic value from industry standard experience)**

1.4.7 Environmental Conditions

- **Storage Temperature:**

  -35°C to +85°C

- **Operating Temperature:**

  0°C to +50°C (non condensing)

- **Maximum Operating Humidity:**

  85% relative

- **Air temperature with forced air cooling of approx. 1 m/sec.**

1.4.8 Power Requirements

Approximate, with all options:

- 7.0 A max.	5.0 A typ.	+5 VDC	±5 %
- 0.2 A max.	0.1 A typ.	+12 VDC	±10 %
- 0.2 A max.	0.1 A typ.	-12 VDC	±10 %

2 Installation

2.1 Introduction

- Carefully remove the board from the shipping carton. Save the original shipping container and packing material for storing or reshipping the board.

Avoid touching integrated circuits except in an electrostatic free environment. Electrostatic discharge can damage circuits or shorten their lifetime.

- Inspect the board for any shipping damage. If undamaged, the module can be prepared for system installation.

When unplugging boards from the rack or otherwise handling boards, do always observe precautions for handling electrostatic devices.

2.1.1 Board Installation

The installation of the CPU-44 is not complicated, requiring only a terminal, a power supply, and a suitable terminated VMEbus backplane. The power supply must meet the specifications described in Section 1.4 ‘Definition of Board Parameters’. The processor board requires a +5 V supply voltage; ±12 V are needed for the RS 232 serial interface and the Ethernet interface.

2.1.2 Serial Interface Level Converter (SILC)

The Serial Interface Level Converter (SILC) modules generally convert TTL-level signals generated or accepted by the SCC-2 to the appropriate signal levels for external transmission lines. SILC modules for RS 232C, RS 422 and RS 485 are available.

The mechanical outline of the SILC modules allows the changeability of the different SILC modules on the CPU-44:

- SILC-200 for RS 232
- SILC-300 for RS 422
- SILC-400 for RS 485

The mechanical part of the installation is very easy. First switch off the VMEbus system and pull the board out of the rack. If a SILC module is already placed in the connector, remove it carefully. Now plug the new SILC module into the corresponding connector on the CPU or I/O board. Consider the polarization of the SILC module; to avoid damage, check that the pin 1 marked on the back of the SILC corresponds to pin 1 marked on the board.

2.1.3 Installation Parallel I/O

An 8-bit parallel port with handshake signals is available on the CPU-44. The port signals are connected via connector X102 and the ADAP-200/220 to the CONV-300 board. The three 9-pin Sub-D serial plugs, a 25-pin Sub-D parallel connector to support Centronics printer interface, and a 26-pin connector for direct access to the CIO pins for user applications are installed on the CONV-300.

The printer port has to be enabled by jumper J1 on the CONV-300 board. A general 25-pin Sub-D to Centronics printer port cable is used to connect a parallel printer to the CPU-44. The printer port supports the following buffered hardware lines: D(1:8), /STROBE, /ACK, BUSY, and PE.

For user-defined usage of the CIO parallel ports, the printer port has to be disabled with jumper J1 located on the CONV-300. After that, the 26-pin parallel I/O port supports two CIO parallel ports. For more information about the CIO, refer to the Z8536 data sheet and the CONV-300 Hardware Manual.

2.1.4 Ethernet Installation

A standard Ethernet/Cheapernet MAU can be connected via AUI cable to the 15-pin AUI connector on the front panel of the CPU-44. The length of the AUI cable is limited to 50 m.

2.1.5 Pure 8-bit SCSI Installation

A 8-bit SCSI bus can be connected to X103 of ADAP-200/220. If the CPU-44 is located at either end of the SCSI bus, RN601-604 must be installed for signal termination, otherwise RN601-604 must be removed.

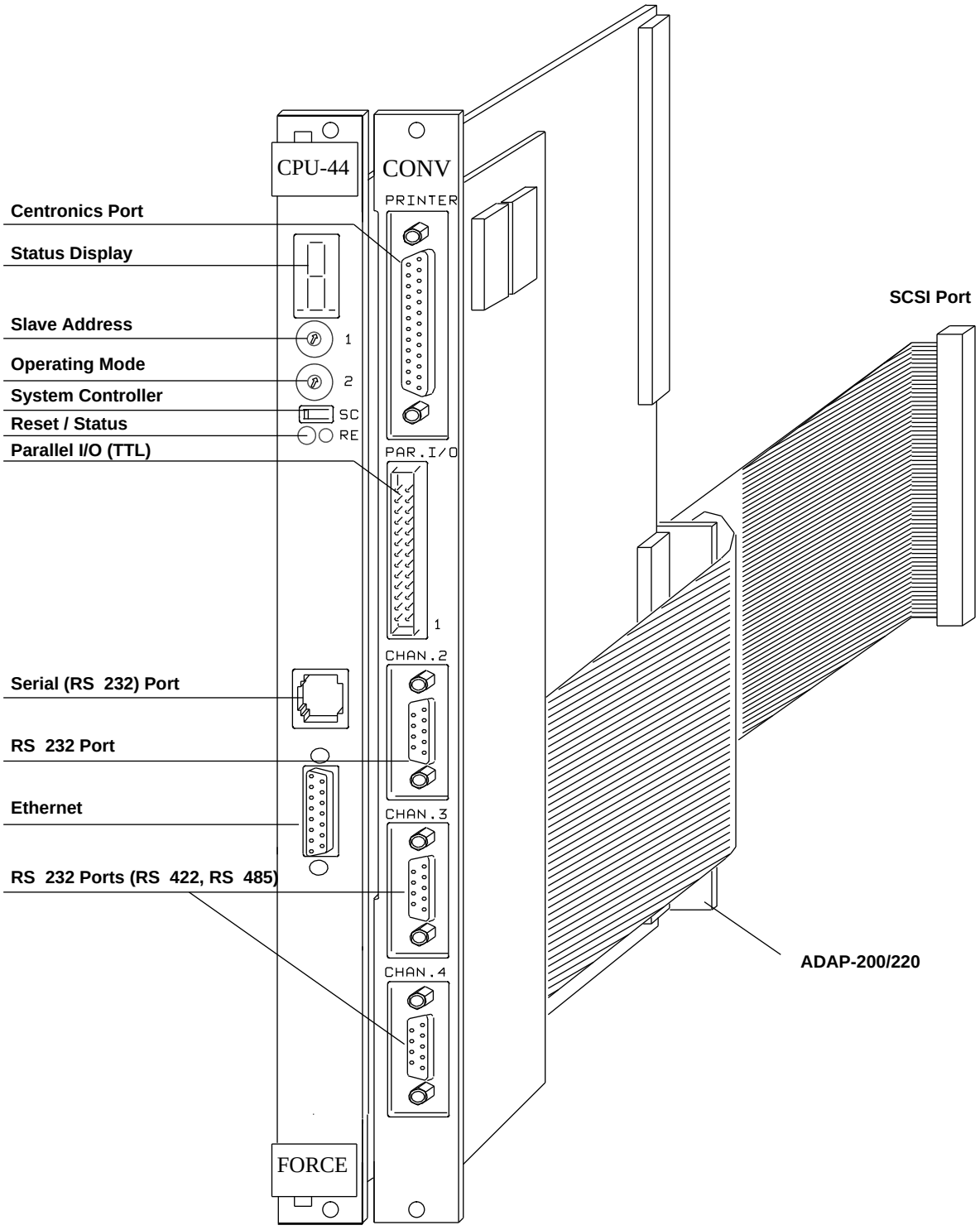
2.1.6 Pure 16-bit SCSI Installation

A 16-bit SCSI bus can be connected to X107 of ADAP-220. If the CPU-44 is located at either end of the SCSI bus, RN601-604 must be installed for signal termination, otherwise RN601-604 must be removed.

2.1.7 Mixed 8/16 bit SCSI Installation

ADAP-220 can be used to build mixed 8/16 bit SCSI bus systems. In this case X103 and X107 are used. RN601-604 must be removed from the CPU-44 and two of the resistor networks must be plugged into RN101-102 sockets of the ADAP-220 (note pin 1 marking of the networks and the sockets).

Figure 2.1 Installation Diagram



2.2 Default Board Setting

Table 2.1 Default Settings

Jumpers/Switches	Position	Description
J1401	closed	Watchdog period 100 ms, see Section 2.3.1 ‘Watchdog Period (J1401)’
J1601	open	No programming voltage for Flash EPROM, see Section 2.3.2 ‘Flash EPROM Programming Voltage (J1601)’
J1605	1 - 2	See Section 2.3.3 ‘Pin 1 Connection of EPROM (J1605)’
J1802	1 - 2	Reserved
S901	0	VMEbus slave address at $8000.0000, see Section 2.3.5.1 ‘VMEbus Slave Address (S901)’
S902	0	Default initialization values, see Section 2.3.5.2 ‘Hardware Configuration (S902)’
S3	SC	System controller enabled, see Section 2.3.5.3 ‘System Controller Switch (S3)’

Figure 2.2 Location of Jumper (Circuit Side)

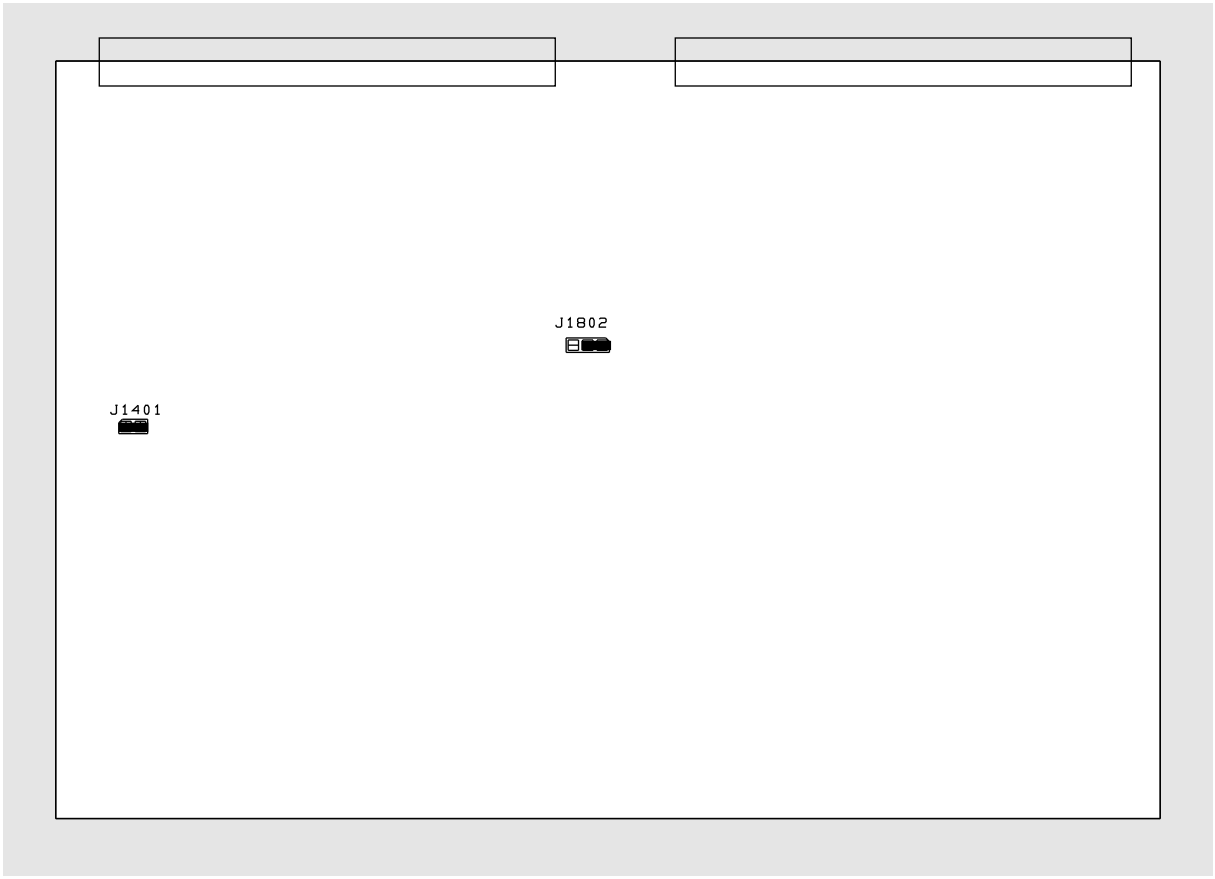
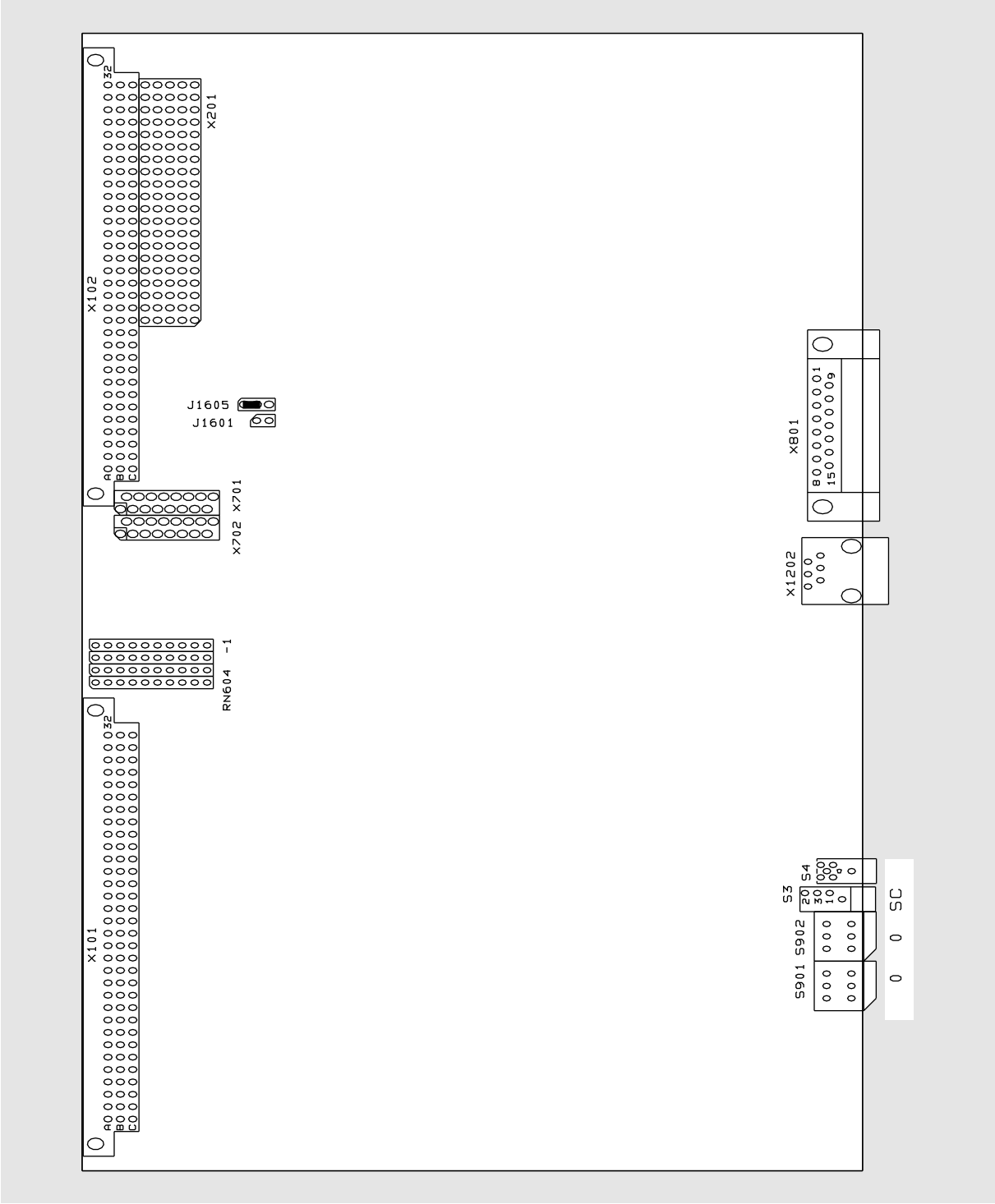


Figure 2.3 Location of Jumpers, Interface Connectors and Switches



2.3 Jumpers and Switches

This section lists all features that are user-selectable by jumpers and switches. For details, refer to the appropriate descriptions identified in parentheses.

All settings on a dark grey background ( ) indicate default settings. The CPU-44 operates as single board computer in this configuration.

There are only a few jumpers on the CPU-44 that typically need changes after shipping. All other parameters are software programmable. Since the jumper connections are not changed easily, it is strongly recommended that these changes are performed by qualified personal only.

The user should refer to the silkscreen print on the component side of the CPU-44 for guidance on jumper area pin identification. Pin 1 of every jumper area is marked by a beveled corner on the silkscreen outline of the jumper. If you see this corner at the left upper side of the jumper area, then pin 2 is on the right-hand side of pin 1. Pin 3 can be found on the right of pin 2, and so on. Reaching the end of the row, counting must be continued beginning on the left-hand side of the next row.

2.3.1 Watchdog Period (J1401)

J1401 Selects between 100 ms and 1.6 s watchdog periods. J1401 is a soldered jumper.

Table 2.2 J1401 (Watchdog Period)

Jumper J1401	Function
open	Watchdog period 1.6 s
closed	**Watchdog period 100 ms**

2.3.2 Flash EPROM Programming Voltage (J1601)

Table 2.3 J1601 (Flash EPROM Programming Voltage)

Jumper J1601	Function
open	**No programming voltage on Flash EPROM**
closed	Apply +12 V to Flash EPROM for programming

2.3.3 Pin 1 Connection of EPROM (J1605)

This jumper allows to select between EPROMs up to 4 Mbit and 8 Mbit.

Table 2.4 J1605 (Pin 1 Connection of EPROM)

Jumper J1605	Function
1 - 2	**Pin 1 connected to +5 V (< 8 Mbit)**
2 - 3	Pin 1 connected to A19 (8 Mbit)

2.3.4 Reserved Jumper (J1802)

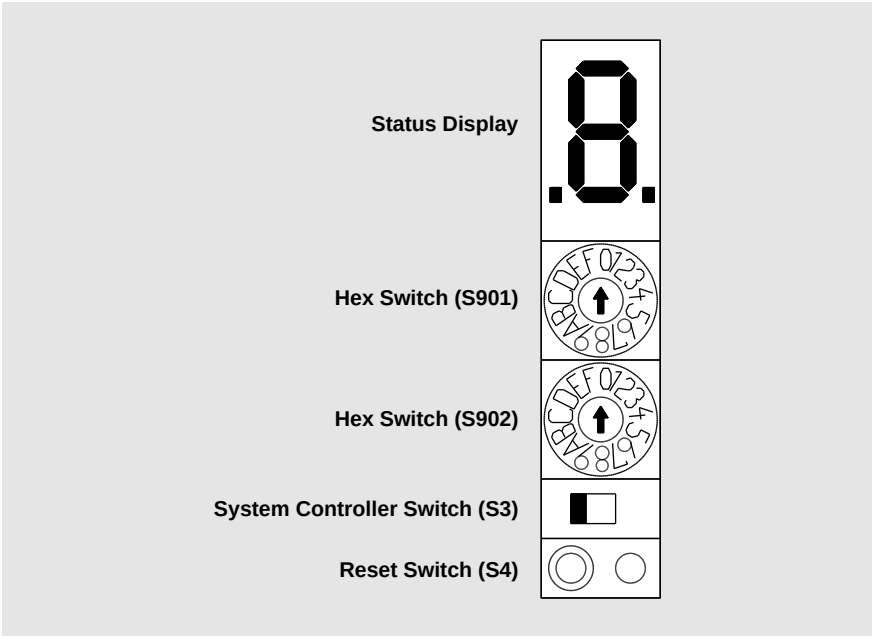
Table 2.5 J1802 (Reserved)

Jumper J1802	Function
1 - 2	**Default**
2 - 3	Prohibited

2.3.5 Switches

Two rotary hex switches (S901 and S902), the system controller switch (S3) and the reset switch (S4) are all located on the front panel. If the system controller switch (S3) is switched to the 'SC' position, the board acts as VMEbus system controller.

Figure 2.4 Switches S901 to S4



Both hex switches (S901, S902) are used by RMon for the configuration setup (see RMon manual).

2.3.5.1 VMEbus Slave Address (S901)

The upper hex switch (S901) selects the CPU-44 slave window address. The size of the A32 slave window is normally 64 MB. This can be changed by the RMon setup menu. The size of the A16 slave window (used for VIC access) is 256 bytes.

Table 2.6 Hex Switch S901 (VMEbus Slave Address)

Hex Switch S901	VMEbus Base Address		
	A32	A24	A16
F	$F000.0000	disabled	$F000
E	$E000.0000	disabled	$E000
D	$D000.0000	disabled	$D000
.	.	.	.
1	$1000.0000	disabled	$1000
0	Use configuration value		

A24 access must be enabled separately.
For a detailed description, see Section 3.2.3 'Address Translation'.

2.3.5.2 Hardware Configuration (S902)

The lower switch (S902) defines the configuration source and the operation mode. For switch position 0 to 2, RMon enters an interactive mode. If switch S902 is in position 8 to F, the program located in the user EPROM is called.

Table 2.7 Hex Switch S902 (Hardware Configuration)

Hex Switch S902	Function
0	Hardware configuration from basic EPROM
1	Hardware configuration from SRAM
2	Hardware configuration from DRAM
3 - 7	Reserved for FORCE COMPUTER
8 - F	Hardware configuration from SRAM and start program in user EPROM.

S901and S902 have no immediate effect. A changed position only becomes effective after the next reset (i.e. the software reads the switches and programs the appropriate registers).

2.3.5.3 System Controller Switch (S3)

Table 2.8 Switch S3 (System Controller Switch)

Hex Switch S3	Function
left	System controller disabled
right 'SC'	**System controller enabled**

3 Hardware User's Manual

3.1 Address Map

The CPU-44 is designed to utilize the entire 4 GB address range of the 68040 chip. Using the address modifier of the VMEbus, the address range may be enlarged by subdivision into data and program areas and/or user and supervisor areas. The CPU-44 recognizes two address areas: the local address space and the global VMEbus address space. The following tables summarize the address space of the CPU-44.

Table 3.1 Address Assignment of CPU-44

Address Range	Device	VMEbus Address Modifier	Cache[a]	Burst[b]	Access Width [b]
$0000.0000 - $01FF. FFFF	Local RAM	local	Y	Y	32
$0200.0000 - $03FF.FFFF	Reserved	-	-	-	-
$0400.0000 - $05FF.FFFF	Local RAM (mirrored)	local	N	Y	32
$0610.0000 - $07FF.FFFF	Reserved	-	-	-	-
$0800.0000 - $FE3F.FFFF	VMEbus Extended I/O	A32	N[c]	N	32/16/8
$FE80.0000 - $FE9F.FFFF	Flash EPROM	local	Y	N	8
$FEA0.0000 - $FEBF.FFFF	User EPROM	local	Y	N	8
$FEC0.0000 - $FECF.FFFF	Local I/O	local	N	N	32/16/8
$FED0.0000 - $FEFF.FFFF	Reserved	-	-	-	-
$FF00.0000 - $FFFE.FFFF	VMEbus Standard I/O	A24	N	N	32/16/8
$FFFF.0000 - $FFFF.FFFF	VMEbus Short I/O	A16	N	N	16/8

a. Y = /TCI driven high, N = /TCI driven low.

b. Y = /TBI driven high, N = /TBI driven low.

c. Caching may be enabled via System Control Register (SCR).

Table 3.2 Local I/O Address Assignment

Address	Device	Size	Access
$FEC0.0000 - $FEC0.7FFF	VIC (D0..7)	byte	read/write
$FEC0.8000 - $FEC0.FFFF	VMEbus Decoder (D0..31) see Section 3.2.2 'RAM Access from the VMEbus'	lword	write
$FEC1.0000 - $FEC1.FFFF	User CIO	byte	read/write
$FEC2.0000 - $FEC2.FFFF	NVRAM/RTC	byte	read/write
$FEC3.0000 - $FEC3.FFFF	System CIO	byte	read/write
$FEC4.0000 - $FEC4.FFFF	Reserved		
$FEC5.0000 - $FEC5.3FFF	Watchdog	byte	read/write
$FEC5.4000 - $FEC5.7FFF	Revision Register Extension	byte	read
$FEC5.C000 - $FEC5.DFFF	Enable slave select (ESR) see Section 3.2.2 'RAM Access from the VMEbus'	byte	write
$FEC5.E000 - $FEC5.FFFF	Snoop Control Register	byte	write
$FEC6.0000 - $FEC6.FFFF	Reserved		
$FEC6.4000 - $FEC6.7FFF	Serial I/O	byte	read/write
$FEC6.8000 - $FEC6.BFFF	ILACC	lword	read/write
$FEC6.C000 - $FEC6.FFFF	SCSI Controller	lword	read/write
$FEC7.0000 - $FEC7.FFFF	IOC-2	lword	read/write
$FEC8.0000 - $FECF.FFFF	Reserved	-	-

The address lines A0 and A1 connected to the user CIO (external parallel port) are reversed. This will never be changed in the future.

3.2 DRAM

3.2.1 RAM Access From the Local CPU

The base address of the DRAM is fixed to $0000.0000.

After reset, the basic EPROM is mapped to address $0000.0000. After some initialization the firmware enables the DRAM at $0000.0000 via PA5 of the system CIO.

3.2.2 RAM Access from the VMEbus

The base address and window size for VMEbus access are specified by the slave base address register (SBR), the slave mask register (SMR), and the enable slave select register (ESR) of the CPU-44. The SBR and the SMR are only accessible by the local CPU by longword write cycles. They are undefined after reset and must be written before the CPU-44 can be accessed from the VMEbus. The ESR is cleared (disabling all slave accesses) by power-on reset and the reset switch. The ESR can only be accessed by byte write cycles. The following table describes the contents of the SMR and SBR:

Table 3.3 SMR and SBR Layout

Reg.	Address	31 24	23 16	15 8	7 0
SMR	$FEC0.80F0	A32 Mask	A24 Mask	ICF1 Mask	ICF2 Decoder
SBR	$FEC0.80F4	A32 Decoder ext. access	A24 Decoder std. access	ICF1 Decoder short I/O	ICF2 Decoder short I/O

Do not use other addresses for the SMR and SBR registers.

The A32 decoder compares A31 to A24 of the VMEbus with the SBR bits 32 to 24 for VMEbus extended access. The A24 decoder compares A23 to A16 of the VMEbus with the SBR bits 23 to 16 for VMEbus standard access.

The ICF1 decoder compares A15 to A8 of the VMEbus with the SBR bits 15 to 8. If a SMR mask bit is set, then the corresponding VMEbus address bit is ‘don’t care.’ For full support of the VIC’s interprocessor communication features, the CPU-44 has a second A16 decoder called the ICF2 decoder. The ESR register allows separate enabling of the four comparators as shown in the following table:

Table 3.4 Enable Slave Register Layout

Reg.	Address	7 ... 4	3	2	1	0
ESR	$FEC5.C000	unused	ICF2 (A16)	ICF1 (A16)	VSTD (A24)	VEXT (A32)

1 = Decoder enabled
0 = Decoder disabled

Writing the SBR clears all mask bits of the SMR, so that the SBR must be written before the SMR. Writing the SMR also writes the IFC2 decoder.

3.2.3 Address Translation

The address presented by the VMEbus or the ILACC is translated from the '020 bus (A_{020}) to the '040 bus (A_{040}) with the help of the MBAR (memory base address register) and ASR (address substitution register) of the IOC-2. The address on the '040 bus is calculated using the following formula:

$A_{040} = (MBAR \& ASR) + (A_{020} \& /ASR)$
'&' logical AND operation,
'+' logical OR operation,
'/' logical complement.

The translation is necessary for snooping of the CPU to keep its caches consistent with the memory.

The translated address must always be in the DRAM. If not, the computer crashes in most cases. Accessing mirrored DRAM locations has to be avoided because this causes inconsistencies between the memory and the caches of the CPU. For all address lines not driven by the source the corresponding bit position in the ASR must be 1 so that the invalid bits are substituted.

Unfortunately the address translation exists only once for the two address sources (VMEbus, ILACC). This leads to some restrictions when the DRAM is accessed by A24 addressing from the VMEbus. In this case only parts of the DRAM can be reached by VMEbus A32 addressing or the ILACC.

Example:

1 MB slave window size for VMEbus A24 addressing at $C0.0000 to the first MB of the DRAM:

MBAR = $0000.0000
ASR = $FFF0.0000
SBR = $xxC0.xxxx
SMR = $xx0F.xxxx

In this case, VMEbus A32 addressing or the ILACC reach only the local address range $0000.0000 to $000F.FFFF, (i.e. the first MB of the DRAM).

To avoid problems, FORCE COMPUTERS recommends that VMEbus A24 slave access only be used when absolutely necessary and with extreme care. If the local RAM/VRAM should be accessed by A24 addressing by the VMEbus, the MBAR and ASR registers of the IOC-2 must be programmed to deliver A24-A26 to the local bus. Doing so has impact on VME A32 addressing and RAM access of the ILACC.

3.2.4 RAM Mirror

When the CPU uses copyback or writethrough cache mode for the DRAM and snooping is disabled, the DRAM can become inconsistent with the cache of the CPU. This can cause problems when the data is accessed by another device (VMEbus, ILACC).

To avoid this problem the CPU can use the cache inhibited RAM mirror ($0400.0000 - $060F.FFFF) for global data. The other devices must also use the mirrored RAM to avoid accessing data cached in the CPU.

3.2.5 RAM Access from ILACC

The AM79C900 Ethernet Controller uses DMA transfer cycles to transfer commands, data and status information to and from the DRAM.

3.3 VMEbus Interface

Each CPU-44 board has a VMEbus master and a VMEbus slave interface. Additionally, VMEbus system controller functions are available via the VMEbus gate array (VIC) used on the CPU-44 board.

3.3.1 System Controller

The CPU-44 features a full slot-one system controller, including SYSCLK, SYSRESET, bus time-out, IACK daisy chain driver, and a four level arbitration circuit. System controller capabilities are enabled by moving switch S3 to the 'SC' position on the front panel.

SYSCLK The SYSCLK is always driven if the system controller is enabled.

SYSRESET A low level on this signal resets the internal logic and asserts the local reset for a minimum of 200 ms. If the VIC is configured as system controller, the reset switch on the front panel (S3) asserts the SYSRESET for a minimum of 200 ms.

Writing a $F0 to the system reset register of the VIC at address $FEC0.10E3 resets all registers of the VIC and asserts the SYSRESET output for a minimum of 200 ms.

BTO The VIC includes two independent bus time-out modules (BTO) for local cycles and for VMEbus cycles. The VMEbus time-out is only enabled when the VIC is configured as system controller. On VIC reset, the VMEbus time-out period is set to 64 µs and the local bus time-out period to 32 µs. This can be altered by programming the transfer time-out register of the VIC at address $FEC0.10A3. Use the RMon setup menu to change this value.

Four Level Arbiter If the VIC is configured as system controller, the four level arbiter is enabled and programmed by writing into the arbiter/requester configuration register at address $FEC0.10B3. Use the RMon setup menu to change this value.

3.3.2 VMEbus Master Interface

The master interface of the CPU-44 board supports 8, 16, and 32-bit data transfer cycles in A32, A24, and A16 addressing modes. For a short overview, see Section 1.4 ‘Definition of Board Parameters’.

3.3.2.1 Longword Access to Wordwide Slaves

Two different control lines of the system CIO enable longword breaking for the A32 and A24/A16 area:

PA3: * 0 : forces A24(A16)/D16 data size on VMEbus
1 : allows A24(A16)/D32 data size on VMEbus

PA4: * 0 : allows A32/D32 data size on VMEbus
1 : forces A32/D16 data size on VMEbus

* specifies the default values set by RMon.
Use the RMon setup menu for changes.

3.3.2.2 Address Modifier Source

The VIC chip supplies the VMEbus address modifier signals. This is done by either routing FC0..2 lines to AM0..2, or by driving these signals by an internal address modifier source register of the VIC ($FEC0.10B7). The AM3..5 lines are driven depending on the actual data size, or by the address modifier source register. One CIO output signal is used to control this option:

PA2: * 0 : uses CPU and address size dependent modifiers
1 : uses VIC’s address modifier source register

* specifies the default values set by RMon.
Use the RMon setup menu for changes.

For a detailed description of the address modifier values, see Section 4.5 ‘Address Modifiers on VMEbus’.

3.3.2.3 Read-Modify-Write Cycles

Read-modify-write cycles like TAS or CAS2 are supported by the CPU-44 board.

The CAS2 instruction has only limited support (see Table 1.1 ‘CAS2 Operations on the Various Busses’). The easiest way to ensure that CAS2 instructions are indivisible is to have both operands of the CAS2 instruction within the same memory area (local RAM, VMEbus).

3.3.2.4 VMEbus Block Transfer Option

The CPU-44 board supports master/slave block transfer cycles. This is done by the **MOVEM.L** operation of the CPU, or by the local DMA device in the VIC. The data size is restricted to D32 and may cross 256 byte boundaries if the slave is also capable of boundary crossing.

Several options within the VIC chip allow it to generate different block transfer cycle types. The following code initializes a DMA write block transfer of two times 256 bytes (write block):

```
        MOVE.L   #$4000,d0        local source address
        MOVE.L   #$80002000,A1    VMEbus target address
        MOVE.B   #$20,$FEC010D3   32 byte blocks
        MOVE.B   #$01,$FEC010DB   256 byte total
*  disable interrupts which may use VIC or VMEbus
        MOVE.B   #$00,$FEC010BF   clear DMA status
        MOVE.B   #$40,$FEC010D7   enables DMA block transfer
                                  mode
        MOVE.L   D0,(A0)          start DMA block transfer
        NOP
LOOP1   BTST     #0,$FEC010BF     wait for BLT finished
        BNE      LOOP1
        MOVE.B   #$00,$FEC010BF   clear DMA status
        ADD.L    #$100,D0         next block
        ADD.L    #$100,A0
        MOVE.L   D0,(A0)          start DMA block transfer
        NOP
LOOP2   BTST     #0,$FEC010BF     wait for BLT finished
        BNE      LOOP2
        MOVE.B   #$00,$FEC010D7   terminate block transfer
*  Interrupts may be enabled
        ...
```

During transfer, the user has to check the DMA status register ($FEC0.01BF) and the bus error register of the VIC ($FEC0.10BB) to see if a VMEbus error condition has occurred. To speed up block transfer cycles, set bit 1 of the interface configuration register of the VIC ($FEC0.10AF). This may violate the VMEbus specification, but is guaranteed to operate with any CPU-44 board.

Block transfer with byte or word size is impossible. Also, the start address and the transfer length must be multiples of 16 bytes.

If the VIC is programmed to transfer exactly 256 bytes starting at a 256 byte boundary, the VIC will set the boundary crossing flags in the DMA status register ($B3). If an interrupt acknowledge occurs between a BLT initiation cycle and the first transfer, the BLT will malfunction. Work-around: Disable all interrupts during BLT.

3.3.2.5 A16 Slave Interface (ICMS, ICGS)

A very useful feature of the VIC is a set of registers and switches for message passing or event signaling.

There are eight bytewide general-purpose interprocessor communication registers accessible from the VMEbus or the local bus (CPU).

- Registers 0 to 4 are general-purpose dual-port registers.

- Register 5 is a dual-port read-only ID register to identify the VIC and its revision level.
- Register 6 is a module status register that is read-only from the VMEbus.
- Register 7 provides semaphores for registers 0-4 and several system control functions like a remote reset function.

Four ‘Interprocessor Communication Module Switches’ (ICMS) and four ‘Interprocessor Communication Global Switches’ (ICGS) are provided by the VIC. These are bytewide mailbox switches to signal events by generating an interrupt to the local CPU if accessed from the VMEbus. To signal dedicated events/ messages the ICMS locate a unique set of addresses. To support this feature, two separate ICF address decoders are installed on the CPU-44 board. The ICF1 decoder for dedicated board specific messages and the ICF2 decoder to feature global messages. Each decoder is enabled separately.

The intercommunication registers within the VIC chip are accessible in A16 VMEbus address space only.

To program the ICF decoder registers, refer to the description of the slave base address register, slave mask register, and enable slave select register in Section 3.2.2 ‘RAM Access from the VMEbus’.

Use the RMon setup menu to change the register values. Within the 256-byte space the VIC chip locates several intercommunication registers as shown in the following table.

Table 3.5 Intercommunication Register Location on VMEbus

Register Type	A07	06	05	04	03	02	01	AM5..0
Interprocessor Communication Registers	X	X	0	0	#	#	#	$2D
Interprocessor Communication Global Switches	X	X	0	1	0	#	#	$2D
Interprocessor Communication Module Switches	X	X	1	0	0	#	#	$2D or $29

X : don’t care.
: selects register/switch number.

For further information, refer to section 5 ‘Copies of Data Sheets’ for the VIC-64 data sheet.

3.4 Ethernet Interface (802.3/10base5)

The ILACC’s internal registers are selected by writing a specific register number to address $FEC6.8006 and accessing the data at address $FEC6.8002 (see Table 3.6 ‘ILACC Registers’). Both addresses must be accessed with word-size instructions.

After initialization and starting, the ILACC operates without any CPU interaction. It transfers prepared data, receives incoming packets, and stores them into reserved memory locations. To signal service requests, the ILACC interrupt signal is connected to the VIC’s LIRQ7 input. The VIC must be programmed to level-sensitive and has to supply the vector because the ILACC has no provision to do so.

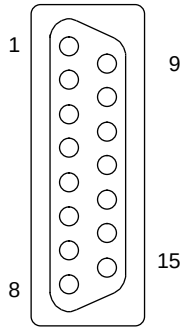
Table 3.6 ILACC Registers

Address	Description
$FEC6.8002	Register Data Port (RDP)
$FEC6.8006	Register Address Port (RAP)

A detailed description of the AM79C900 can be found in the data sheet.

Table 3.7 15-Pin AUI Connector (ETHERNET X801)

Pin	Signal	Description
1	CI-S	Control In circuit Shield
2	CI-A	Control In circuit A
3	DO-A	Data Out circuit A
4	DI-S	Data In circuit Shield
5	DI-A	Data In circuit A
6	VC	Voltage Common
7	CO-A	Control Out circuit A
8	CO-S	Control Out circuit Shield
9	CI-B	Control Out circuit B
10	DO-B	Data Out circuit B
11	DO-S	Data Out circuit Shield
12	DI-B	Data In circuit B
13	VP	Voltage Plus
14	VS	Voltage Shield
15	CO-B	Control Out circuit B



3.5 CIO Counter / Timers

The CPU-44 offers six independent, programmable 16-bit counter/timers integrated in two CIOs. Three of these counters, located in the user CIO ($FEC1.0000), can be used as general-purpose devices with up to four external access lines per counter/timer (count input, output, gate, and trigger). Port A and C of this CIO are connected to X102 for user application. Refer to 4.6 ‘Connectors’. See Section 5 ‘Copies of Data Sheets’ for a more detailed description of the CIO.

The three counters located in the system CIO are used for internal control tasks. A summary of the CIO requester is shown in Table 3.8 ‘CIO Counter/Timer Registers’.

Table 3.8 CIO Counter/Timer Registers

Address	Description
$FEC3.0000	Port C Data Register System CIO
$FEC3.0001	Port B Data Register System CIO
$FEC3.0002	Port A Data Register System CIO
$FEC3.0003	Control Register System CIO
$FEC1.0000	Port C Data Register User CIO
$FEC1.0001	Port A Data Register User CIO
$FEC1.0002	Port B Data Register User CIO
$FEC1.0003	Control Register User CIO

The peripheral clock of both CIOs is connected to a 5 MHz source. The interrupt request outputs of both CIOs tied together and connected to the LIRQ6 input of the VIC. The system CIO has the higher interrupt priority in the daisy chain. Local interrupt control register 6 (LIRQ6) of the VIC must be programmed for an active low, level-sensitive input. The vectors are supplied by the CIOs. The VIC must be programmed to generate interrupts on level 5 to the CPU. Only CPU IACK level 5 cycles are routed to the CIO devices.

The address assignments of the two CIOs are different. The base address of the user CIO is at address $FEC1.0000.

3.6 Serial I/O

The CPU-44 offers four serial I/O lines, implemented by a CL-CD2401 Multi-Protocol Controller (MPC). C1 and C2 are hardwired for RS 232 two-wire (C1) and four-wire (C2) hardware handshake mode, while C3 and C4 use removable serial interface level converters (SILC). As shipped, two RS 232 level converter SILCs are installed featuring hardware handshake as well as XON/XOFF protocol. Different level converter plug-ins, such as RS 422 and RS 485, are available. See Section 5 ‘Copies of Data Sheets’ for more detailed MPC information.

3.6.1 Serial Port Multi-Protocol Controller (MPC)

The operating mode and data format of each channel is programmed independently.

The baud rate generator is driven by 20 MHz. The time constant values in the following table are based on that frequency.

Table 3.9 MPC Baud Rate

Bit Rate	Divisor	Clock	Error (%)
50	$C2	clk4	-0.16
110	$58	clk4	-0.25
150	$40	clk4	+0.16
300	$81	clk3	+0.16
600	$40	clk3	+0.16
1200	$81	clk2	+0.16
2400	$40	clk2	+0.16
3600	$AD	clk1	-0.22
4800	$81	clk1	+0.16
7200	$56	clk1	-0.23
9600	$40	clk1	+0.16
19200	$81	clk0	+0.16
38400	$40	clk0	+0.16
56000	$2C	clk0	-0.79
64000	$26	clk0	+0.16

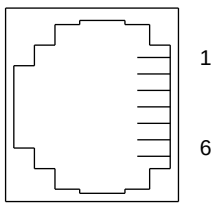
The interrupt request of the MPC is connected to the LIRQ6 input of the VIC. The MPC has higher priority than the CIOs in the daisy chain.

The local interrupt control register 6 (LIRQ6) of the VIC must be programmed for an active low, level-sensitive input. The vectors are supplied by the MPC. The VIC must be programmed to generate an interrupt on level 5 to the CPU. Only CPU IACK level 5 cycles are routed to the MPC.

For polled operation, the MPC can be switched to IACK context by reading address $FEC6.6000 - $FEC6.7FFF. A0-A6 must match one of the priority interrupt level registers of the MPC.

Table 3.10: 6-Pin Telephone Jack Connector CHAN.1 (Serial RS 232 PORT X1202)

Pin	Signal	Description
1	RTS	Request to Send
2	TxD	Transmit Data
3	GND	Signal Ground
4	GND	Signal Ground
5	RxD	Receive Data
6	CTS	Clear to Send



3.7 Watchdog Timer

The watchdog timer installed on the CPU-44 monitors the activity of the microprocessor. If the microprocessor does not write location $FEC5.0000 within the time-out period of 100 ms (min. 70 ms; max. 140 ms) or 1.6 s (±30%), a reset pulse is generated. After reset, the watchdog timer is disabled. The normal time-out period of 100 ms becomes effective after the first write access to address $FEC5.0000.

If the watchdog timer generates a reset pulse, the left decimal point of the hex display located at the front panel is illuminated to indicate a watchdog reset. This watchdog indicator is cleared by power-up reset, the reset switch, a VMEbus SYSRESET, a VIC remote reset, or by a write access to address $FEC5.0000.

The state of the watchdog indicator can be read by software using port A of the system CIO ($FEC3.0002). If the left decimal point of the hex display is illuminated, PA7 of the system CIO is read as '0'. This allows software to distinguish between a watchdog reset and a reset generated by the another source. A summary of the watchdog timer requester is shown in the following table.

Table 3.11 Watchdog Timer Registers

Address	Description	Access Direction
$FEC3.0002	Port A Data Register System CIO	read PA7
$FEC5.0000	Watchdog trigger	write

If the watchdog timer function is enabled at the first access to $FEC5.0000, $FEC5.0000 must be accessed within the time-out period of 100 ms.

3.8 IOC-2

The Input/Output Controller (IOC-2) is an ASIC intended to maximize the performance of FORCE COMPUTER's CPU boards. The IOC-2 is a specially designed data/address bridge between the 68040-type local bus and the VIC-64 that supports fast VMEbus master/slave block transfers. A second main function is a universal programmable I/O bus interface with an address decoder. A complete IOC-2 manual is included in the Data Sheet reprint section.

3.8.1 Register Set

All 25 IOC-2 registers are read/write accessible using longword transfer cycles only. The internal address decoder reserves an IOC-2 address space of 64 KB. The following register map shows all internal registers and their corresponding register offset address. The complete CPU register address is calculated by:

IOALR value* + Register offset address (*Default register value: $FEC0.0000)

Table 3.12 IOC-2 Register Map

Offset Addr.	Symbol	Name	Reset Value
I/O Bus Interface Registers:			
$70000	IOALR	I/O Address Location Register	$FEC0.0000
$70004	IODCR0	I/O Device Control Register 0	$0000.0000
$70008	IODCR1	I/O Device Control Register 1	$0000.0000
$7000C	IODCR2	I/O Device Control Register 2	$0000.0000
$70010	IODCR3	I/O Device Control Register 3	$0000.0000
$70014	IODCR4	I/O Device Control Register 4	$0000.0000
$70018	IODCR5	I/O Device Control Register 5	$0000.0000
$7001C	IODCR6	I/O Device Control Register 6	$0000.0000
$70020	IODCR7	I/O Device Control Register 7	$0000.0000
$70024	IODCR8	I/O Device Control Register 8	$0000.0000
$70028	IODCR9	I/O Device Control Register 9	$0000.0000
$7002C	IODCR10	I/O Device Control Register 10	$0000.0000
$70030	IODCR11	I/O Device Control Register 11	$0000.0000
$70034	IODCR12	I/O Device Control Register 12	$0000.0000
$70038	IOIACR	I/O IACK Control Register	$0000.0000
$7003C	--	reserved	
$70040	EBAR0	EPROM Begin Address Register 0	$0000.0000
$70044	EMAR0	EPROM Mask Register 0	$0000.0000
$70048	EDCR0	EPROM Device Control Register 0	$0000.020F $0000.0A0F
$7004C	- -	reserved	
$70050	EBAR01	EPROM Begin Address Register 1	$0000.0000
$70054	EMAR01	EPROM Mask Register 1	$0000.0000
$70058	EDCR1	EPROM Device Control Register 1	$0000.020F $0000.0A0F
$7005C - $7009C	- -	reserved	
Address Bus Interface Registers:			
$700A0	MBAR	Memory Base Address Register	$0000.0000
$700A4	ASR	Address Substitution Register	$FF80.0000
General Control Registers:			
$700A8	ICR	IOC-2 Control Register	$0000.22xx[a]
$700AC	ITR	IOC-2 Test Register	$0000.0000

a. xx => IOD(7:0) during reset
1. Default register value: $FEC0.0000

3.9 SCSI Interface

A Small Computer System Interface (SCSI) controller is built around a NCR53C720 chip. The full specification (ANSI K3T 9.2) is implemented, supporting all standard SCSI features including arbitration, disconnect, reconnect, and parity. For programming details refer to Section 5 ‘Copies of Data Sheets’ for the NCR53C720 Manual.

3.9.1 SCSI Controller

The interrupt request line (IRQ) of the SCSI controller is connected to the LIRQ3 input of the VIC. The NCR53C720 cannot supply its own vector, so the VIC has to be programmed to supply a vector for the SCSI controller. The VIC LICR3 must be programmed to level-sensitive and must supply the IRQ vector.

The CPU-44 uses Big Endian Bus Mode 2 of the NCR53C720.

According to the SCSI specification, the interconnecting flat cable must be terminated at both ends. On the CPU-44 this is done through removable resistor networks (R601 - R604) between connector X101 and X102. If the CPU-44 board is not located at either end of the cable, these resistors must be removed.

A detailed description of the NCR53C720 controller chip can be found in the data sheet.

The first access to the NCR53C720 must set the EA bit in the DCNTL register of the NCR53C720. Accessing the NCR53C720 without the EA bit set will lock the CPU bus.

3.10 Front Panel Status Display

The CPU-44 features a seven-segment display on the front panel and displays hexadecimal values from 0 to F. This status display is designed as read/write register and uses the least significant nibble of the byte. As an example, the following sequence moves a 'D' in the hex display:

```
move.b #$0D,$FEC30000
```

The left decimal point of the hex display is used as watchdog indicator. The watchdog indicator is illuminated if the watchdog timer has generated a reset pulse.

The right decimal point of the hex display is controlled by the PA0 output of the system CIO. After reset the right decimal point is illuminated. RMon switches the decimal point off before the user program in the user EPROMs is called.

The upper four bits of the display are write-enable bits for the lower four bits. Only those bits of the lower nibble are changed where the corresponding bit in the upper nibble is ’0’.

The display is only enabled when PA6 of the system CIO is ’0’.

3.11 Battery-Backed Parameter RAM and Real-Time Clock

The real-time clock is designed with the MK 48T18 timekeeper RAM from Mostek. The chip combines a 8Kx8 CMOS SRAM (parameter RAM) a bytewide accessible real-time clock, a crystal, and a long life lithium battery, all in one package.

3.11.1 Parameter RAM

The address area of the SRAM is divided into two main partitions as shown in Table 3.13 ‘NVRAM RTC Registers’.

- system dependent parameter data structure, defined by FORCE COMPUTERS to store setup parameters for hardware initialization and boot information for operating systems,
- eight bytes of the SRAM for the registers of the real-time clock.

Table 3.13 NVRAM RTC Registers

MK 48T18 Address	Description
$FEC2.0000 - $FEC2.07F7	Reserved for system configuration values. The structure of the system configuration values is defined in the RMon manual.
$FEC2.07F8 - $FEC2.1FF7	Free for user.
$FEC2.1FF8 - $FEC2.1FFF	Real-time clock registers. See Section 3.11.1.1 ‘Real-Time Clock’ for more information.

The front panel hex switch position '00' uses the configuration values stored in the basic EPROM rather than values defined in the SRAM. For more details, refer to the RMon description.

With a MK 48T18 is installed, J1602 must be position 2-3, which is the default.

3.11.1.1 Real-Time Clock

The clock features BCD-coded year, month, day, hours, minutes, and seconds as well as a software controlled calibration. For lifetime calculations of the battery, please refer to the data sheet.

Access to the clock is as simple as a conventional bytewide RAM access because the RAM and the clock are combined in the same chipThe following table shows the real time registers.

Table 3.14 Real Time Clock Registers

MK 48T18 Address	Description
$FEC2.1F7F8	RTC Control Register
$FEC2.1FF9	Seconds
$FEC2.1FFA	Minutes
$FEC2.1FFB	Hour
$FEC2.1FFC	Day
$FEC2.1FFD	Date
$FEC2.1FFE	Month
$FEC2.1FFF	Year

For further details, see the MK 48T18 data sheet.

The SRAM/RTC can only be accessed with byte instructions.

3.12 VIC Timer

The VIC contains a timer that can be programmed to output a periodic waveform on LIRQ2. The frequencies available are 50 Hz, 100 Hz, and 1000 Hz. The timer is enabled and controlled by writing slave select control register 0. The interrupt is enabled and controlled by writing local interrupt control register 2.

The clock tick timer is typically used as a time base for multi-tasking operating systems, such as OS-9 or VxWorks.

If other frequencies are needed, one of the six counter/timers that are included in the two CIOs may be used. For more details about the timer, refer to the VIC data sheet.

3.13 Reset

During power-up or after actuation of the reset switch (S4), /RESET is held low for approximately 1 s. If the system controller switch (S3) is in the 'SC' position, the VMEbus is also reset because the VIC is configured as the VMEbus system controller. Otherwise SYSRESET from the VMEbus is an input.

The reset switch or power-up reset affects all modules and chips on the CPU-44 board, and also the VMEbus SYSRESET line if switch S3 is in the 'SC' position. The LED included in the reset logic shows the status of the RESET line. RESET inactive means LED is illuminated.

If the reset is generated by the watchdog, the left decimal point of the hex display (watchdog indicator) is active and stays illuminated until it is reset by a voltage drop < 4.75 V, power-up, reset switch, SYSRESET, or VIC remote control reset. The state of the watchdog indicator can be read at port PA7 of the system CIO.

A remote reset via VIC's reset register or a VMEbus SYSRESET behaves the same way as a power-up reset, except that the VMEbus configuration (VIC register and master/slave address) is not changed.

Table 3.15 Reset Conditions

Reset Source	Affected Device
Voltage Drop < 4.75 V or Power-up or Reset Switch S3	CPU, CL-CD2401, CIOs, Keyboard Controller, SCSI Controller, ILACC, VMEbus SYSRESET (if system controller), Watchdog Indicator, VMEbus Slave Decoder
VIC Remote Control Reset or SYSRESET	CPU, CL-CD2401, CIOs, SCSI Controller, ILACC, Watchdog Indicator
Watchdog Reset	CPU, CL-CD2401, CIOs, Keyboard Controller, SCSI Controller, ILACC,
CPU	SCSI Controller, ILACC

3.14 Bus Time-Out

The CPU-44 features two independent, software-programmable bus time-out modules; one for the local time-out and one for the VMEbus time-out.

Both time-out modules are located in the VIC and are programmed by writing the transfer time-out register ($FEC0.10A3). The time-out period is programmable from 4 µs to 480 µs. Local time-out is not generated when waiting for VMEbus mastership. This is programmable within the VIC chip.

Local time-out is set to 32 µs and the VMEbus time-out is set to 16 µs by RMon. Use the RMon setup menu to change these values.

The VMEbus time-out is generated by the system controller, and therefore is only used if the VIC is being used as the system controller. Switch S3 is used to enable/disable the board's system controller.

3.15 System Control Register (SCR)

The CPU-44 features several status and control bits to monitor and change the system control signals. These are implemented using port lines of the system CIO. Reset initializes all ports as input. The default values are set during the RMon initialization routine.

Table 3.16 System Control Register

Bit No.	Type	Name	Description
PA7	Input	WDS	Watchdog Status 0 = Watchdog Reset 1 = Normal Reset
PA6	Output	BLK	Blank Display 0 = Display enabled 1 = Display disabled
PA5	Output	RESCYC	Reset Cycle 0 = Address Decoder normal operation (default) 1 = Address Decoder reset operation (reset condition)
PA4	Output	DSCTRL0	VMEbus A32 Data Size Control 0 = normal longword operation for A32 (default) 1 = breaks longword cycles into two word cycles
PA3	Output	DSCTRL1	VMEbus A24 Data Size Control 0 = normal longword operation for A24 1 = breaks longword cycles into two word cycles (default)
PA2	Output	ASCTRL	VMEbus Address Modifier Source Control 0 = normal operation FC0..2 -> AM3..5 1 = VMEbus Address Modifier from VICs Address Modifier Source Register
PA1	Output	CACTRL	VMEbus Cache Control 0 = disables caching of VMEbus data (default) 1 = enables caching of VMEbus data
PA0	Output	INIT	Initialization Indicator on Front Panel 0 = on 1 = off
PB7..0	Input	HEXSW	Read Hex Switch on Front Panel
PC3..0	Output	DISPLAY	Write Hex Display on Front Panel

All outputs of the CIO are pulled high to ensure a valid logic level after reset.

3.16 Interrupt Sources

All seven priority levels of the VMEbus are implemented. The local modules can be served by interrupts without restricting the VMEbus interrupt capacity.

The interrupt handler is a part of the VIC gate array. This device contains seven registers to handle seven VMEbus interrupt sources. Each IRQ line on the VMEbus is enabled and disabled separately. Additionally, the level passed to the CPU can be changed for each of these lines through the control registers of the VIC.

The VIC also supports seven local interrupt request inputs, called LIRQ1 to LIRQ7. These lines are connected to several local devices generating an IRQ (referenced by Table 3.17 ‘VIC Interrupt Priority Scheme’). Additionally, the VIC can generate local interrupts from eight interprocessor communication registers, ACFAIL, SYSFAIL, arbitration time-out, posted write cycles, and DMA completion.

To change the IRQ values in the VIC registers, use the RMon setup menu. Refer to the VIC068/VIC064 data sheets for more information.

Table 3.17 VIC Interrupt Priority Scheme

IRQ	Source	Generated CPU Level	Vector supplied by
LIRQ7	ILACC	3	VIC
Error Group IRQ	ACFAIL from VMEbus	7	VIC
	Write Post Fail	7	VIC
	Arbitration Time-out	7	VIC
	SYSFAIL from VMEbus	7	VIC
LIRQ6	CL-CD2401 higher priority	5 [a]	CL-CD2401
	System CIO medium priority	5 [1)]	System CIO
	User CIO lower priority	5 [1)]	User CIO
LIRQ4	Video Frame Inactive	5	VIC
LIRQ3	SCSI Controller	2	VIC
LIRQ2	Clock Tick Timer of VIC	6	VIC
LIRQ1	Keyboard Controller	1	VIC
ICGS Group IRQ	Interprocessor Communication	6	VIC
	Global Switches of VIC	6	VIC
ICMS Group IRQ	Interprocessor Communication	7	VIC
	Module Switches of VIC	7	VIC
IRQ7	VMEbus	7	VMEbus
IRQ6	VMEbus	6	VMEbus
IRQ5	VMEbus	5	VMEbus
IRQ4	VMEbus	4	VMEbus
IRQ3	VMEbus	3	VMEbus
IRQ2	VMEbus	2	VMEbus
IRQ1	VMEbus	1	VMEbus
DMA Status IRQ	VIC DMA Controller	1	VIC
VMEbus Interrupt Acknowledged	VIC Interrupter	1	VIC

a. The IRQ levels inside the VIC **have to** be programmed with the level mentioned in the column. All other IRQ levels are example values of the operating system’s initialization, they may be changed by the user.

3.16.1 Local Interrupt Sources

The CPU-44 has eight local interrupt sources connected to six VIC inputs (LIRQ1, LIRQ3 to LIRQ7).

Table 3.18 Local Interrupt Sources

Device	VIC Input	Level	Vector	Supplied by
ILACC	LIRQ7	3	$47	VIC
System CIO	LIRQ6	5 [a]	$xx	CIO
User CIO	LIRQ6	5 [a]	$xx	CIO
Serial I/O	LIRQ6	5 [a]	$xx	CL-CD2401
SCSI Controller	LIRQ3	2	$43	VIC
VIC Timer	LIRQ2	6	$42	VIC
VIC ACFAIL	-	7	$48	VIC
VIC Failed Write Post	-	7	$49	VIC
VIC Arbitration Time-out	-	7	$4A	VIC
VIC SYSFAIL	-	7	$4B	VIC
VIC Interrupter IACK	-	1	$4C	VIC
VIC DMA	-	1	$4D	VIC
VIC ICMS0..ICMS3	-	5	$1C - $1F	VIC
VIC ICGS0..ICGS3	-	7	$10 - $13	VIC

a. These levels are not changeable (i.e. fixed in hardware), all other levels are programmable via VIC register. Also all vectors delivered by the VIC are programmable.

3.16.2 VMEbus Interrupt Sources

Individual interrupt levels are masked dynamically under software control by programming the appropriate VMEbus interrupt control register (ICR1 to ICR7) of the VIC. This feature allows easy implementation of multi-processor systems. The VMEbus interrupt requests are always active low and level-sensitive.

All VMEbus IRQs are disabled after the initialization of RMon. To change this, use the RMon setup menu. For further details, see the data sheet VIC-64.

When the CPU-44 performs VMEbus IACK cycles, it drives only A1-A3 with valid information (this is allowed by the VMEbus specification). It is known that some interrupters deliver the wrong interrupt vector when the undefined address bits A4-A31 match the board's address (these interrupters do not conform to the VMEbus specification). This may lead to a system crash. Since there is no work-around for this problem, VMEbus compliant interrupters should be used when the CPU-44 handles VMEbus interrupts.

3.16.3 Cache Coherency and Snooping

To maintain cache coherency in a multi-master system, the ‘040 has the capability of snooping. Snooping can be enabled via the snoop control register at $FEC5.E000 (write only).

Table 3.19 Snoop Control Register Layout

Register	Address	7 - 4	3	2	1	0
SNCR	$FEC5.E000	unused	unused	unused	SC1 for CPU	SC0 for CPU

Table 3.20 Snoop Control Encoding

SC1	SC0	Requested Snoop Operation	
		Alternate Bus Master Read Access	Alternate Bus Master Write Access
0	0	Inhibit Snooping	Inhibit Snooping
0	1	Supply Dirty Data and Leave Dirty	Sink Byte/Word/Longword
1	0	Supply Dirty Data and Mark Line Invalid	Invalidate Line
1	1	Reserved (Snoop Inhibited)	Reserved (Snoop Inhibited)

After reset, snooping of the CPU is disabled. Normally, the CPU should use SC1=0 and SC0=1 snoop mode. This ensures cache coherency with all non-caching alternate bus masters.

The Snoop Control Register is write only.

J1802 should be set to position 1-2 because this gives better memory performance.

3.17 Revision Information

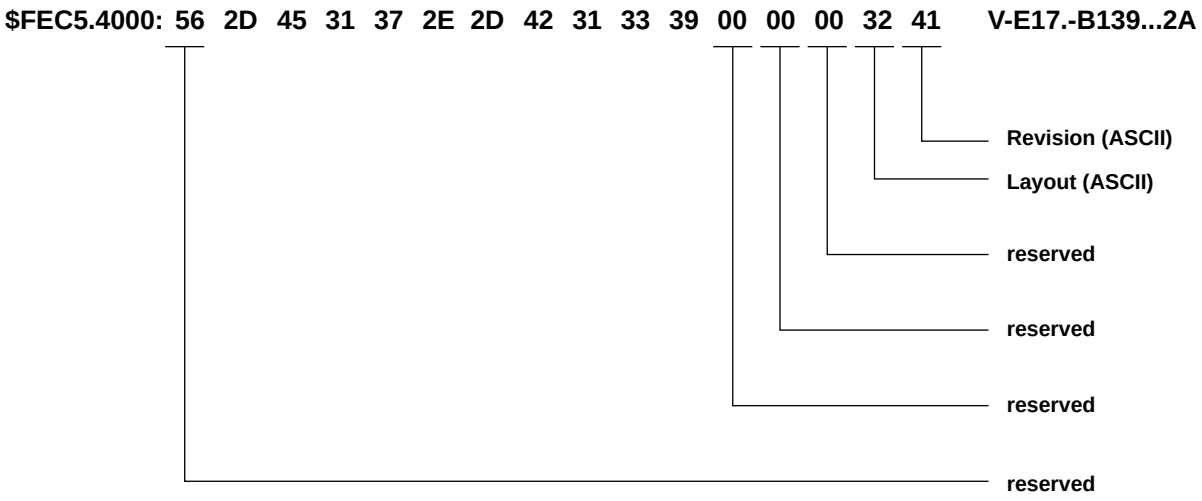
To allow software to distinguish between different versions and derivatives of the CPU-44, there is revision information stored on the board. It may consist of two parts. First, there are bits 3-7 of the IOC-2’s control register at $FEC7.00A8.

Table 3.21 IOC-2 Internal Control Register

Register	Address	31 - 8	7 - 5		4	3		2 - 0
ICR	$FEC7.00A8	used for IOC-2 internal purposes	0 0 0	initial version	0	0	25 MHz	used for IOC-2 internal purposes
			0 0 1	extended revision info	0	1	33 MHz	
			other	reserved				
					1	1	reserved	

Second, if bits 5-7 of the ICR are 001, sixteen bytes of extended revision information are available at $FEC5.4000 as shown in Table 3.22 ‘Extended Revision Information Example (Hexdump)’.

Table 3.22 Extended Revision Information Example (Hexdump)



Extended revision information can only be read with byte instructions.

3.18 Indivisible Cycle Operation

3.18.1 Deadlock Resolution

When a CPU performs a locked cycle to the '020 bus (e.g. TAS to the VMEbus) and another device wants to access the '040 bus from the '020 bus (e.g. slave access from VMEbus to the local RAM), there is a deadlock situation. On normal reads or writes such a deadlock is resolved by sending a retry acknowledge to the CPU. On locked cycles this does not work because the arbiter does not grant the bus from the current

bus master as long as /LOCK is active. Such deadlocks are resolved by sending a error acknowledge to the CPU. Then there must be a bus error trap handler that inspects the stack frame whether there was a locked cycle or not. If not, normal bus-error handling is continued; else the locked cycle is retried by simply performing a RTE instruction. The trap handler also should inspect the VIC's bus error status register bits 5 and 6 to determin whether there was a bus error. If so, normal bus error handling should be done to prevent the trap handler from retring the locked cycle.

3.18.2 TAS Violation

If a semaphore resides in a region that can be cached in the '040 in copyback mode, a TAS violation can occur if:

- the semaphore resides in a dirty cache line in the cache of the '040, and the semaphore is set,
- an alternate master performs the read of a TAS,
- the '040 snoops the read and supplies that the semaphore is set,
- the '040 clears the semaphore (in the cache),
- the alternate master performs the write of the TAS,
- the '040 snoops the write so that the semaphore is set again.

As a result of this, the clearing of the semaphore is lost. This can be avoided by using the CAS instruction to clear the semaphore.

4 Appendicies to the Hardware User's Manual

4.1 Mnemonics Chart

This is the same mnemonics chart that can be found in the VMEbus Specification.

4.2 Addressing Capabilities

When the following mnemonic is applied to a board ...	It includes the following addressing capabilities:			
	A16	A24	A32	ADO
MASTER				
MA16	X			
MADO16	X			X
MA24	X	X		
MADO24	X	X		X
MA32	X	X	X	
MADO32	X	X	X	X
SLAVE				
SADO16	X			X
SADO24	X	X		X
SADO32	X	X	X	X
LOCATION MONITORS				
LMA16	X			
LMA24	X	X		
LMA32	X	X	X	

4.3 Data Transfer Capabilities

4.3.1 Master Data Transfer

When the following mnemonic is applied to a board ...	It means that the MASTER has the following data transfer capabilities:							
	D08(EO)	D16	D32	D64	UAT	MBLT	BLT	RMW
MD8	X							
MBLT8	X						X	
MRMW8	X							X
MALL8	X						X	X
MD16	X	X						
BMBLT16	X	X					X	
MRMW16	X	X						X
MALL16	X	X					X	X
MD32	X	X	X					
MBLT32	X	X	X				X	
MBLT64	X	X	X	x		x	X	
MRMW32	X	X	X					X
MALL32	X	X	X				X	X
MD32+UAT	X	X	X		X			
MRMW32+UAT	X	X	X		X			X

4.3.2 Slave Data Transfer

When the following mnemonic is applied to a board ...	It means that the SLAVE has the following data transfer capabilities:							
	D08(O)	D16	D32	D64	UAT	MBLT	BLT	RMW
SD8(O)	X							
SRMW(O)	X							X
SD8	X							
SBLT8	X						X	
SRMW8	X							X
SALL8	X						X	X
SD16	X	X						
SBLT16	X	X					X	
SRMW16	X	X						X
SALL16	X	X					X	X
SD32	X	X	X		X			
SBLT32	X	X	X				X	
SRMW32	X	X	X		X			X
SALL32	X	X	X				X	X
SBLT64	X	X	X	X	X	X	X	

4.3.3 Location Monitor Data Transfer

When the following mnemonic is applied to a board ...	It means that its LOCATION MONITOR has the following capabilities:					
	D08(O)	D16	D32	UAT	BLT	RMW
LMBLT32	X	X	X		X	
LMRMW32	X	X	X	X		X
LMALL32+UAT	X	X	X		X	X

4.4 Glossary

ADO Address Only
UAT Unaligned Transfer
BLT Block Transfer
RMW Read/Modify/Write
EO Both Even and Odd Addresses
O Odd Addresses Only

4.5 Address Modifiers on VMEbus

Hex Code	Address Modifier 5 4 3 2 1 0	Access	Note
3F	H H H H H H	Standard Supervisory Ascending	1
3E	H H H H H L	Standard Supervisory Program	1
3D	H H H H L H	Standard Supervisory Data	1
3C	H H H H L L	Undefined	2
3B	H H H L H H	Standard Non-Privileged Ascend	1
3A	H H H L H L	Standard Non-Privileged Program	1
39	H H H L L H	Standard Non-Privileged Data	1
38	H H H L L L	Undefined	2
30-37	H H L x x x	Undefined	2
2F	H L H H H H	Undefined	2
2E	H L H H H L	Undefined	2
2D	H L H H L H	Short Supervisory I/O	1
2C	H L H H L L	Undefined	2
2B	H L H L H H	Undefined	2
2A	H L H L H L	Undefined	2
29	H L H L L H	Short Non-Privileged I/O	1
28	H L H L L L	Undefined	2
20-27	H L L x x x	Undefined	2
10-1F	L H x x x x	Undefined	3
0F	L L H H H H	Extended Supervisory Ascending	1
0E	L L H H H L	Extended Supervisory Program	1
0D	L L H H L H	Extended Supervisory Data	1
0C	L L H H L L	Undefined	2
0B	L L H L H H	Extended Non-Privileged Ascend	1
0A	L L H L H L	Extended Non-Privileged Program	1
09	L L H L L H	Extended Non-Privileged Data	1
08	L L H L L L	Undefined	2
00-07	L L L x x x	Undefined	2

Notes:
1 Defined by VMEbus Specification
2 Defined reserved
3 Defined by use

4.6 Connectors

Table 4.1 6-Pin Telephone Jack Connector CHAN.1 (Serial RS 232 PORT X1202)

Pin	Signal	Description
1	RTS	Request to Send
2	TxD	Transmit Data
3	GND	Signal Ground
4	GND	Signal Ground
5	RxD	Receive Data
6	CTS	Clear to Send

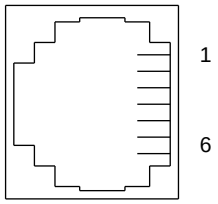


Table 4.2 15-Pin AUI Connector (ETHERNET X801)

Pin	Signal	Description
1	CI-S	Control In circuit Shield
2	CI-A	Control In circuit A
3	DO-A	Data Out circuit A
4	DI-S	Data In circuit Shield
5	DI-A	Data In circuit A
6	VC	Voltage Common
7	CO-A	Control Out circuit A
8	CO-S	Control Out circuit Shield
9	CI-B	Control Out circuit B
10	DO-B	Data Out circuit B
11	DO-S	Data Out circuit Shield
12	DI-B	Data In circuit B
13	VP	Voltage Plus
14	VS	Voltage Shield
15	CO-B	Control Out circuit B

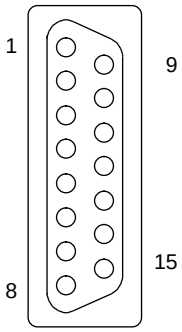


Table 4.3 Pin Assignment of VMEbus P1 Connector (X101)

Pin	Row A	Row B	Row C
1	D00	/BBSY	D08
2	D01	/BCLR	D09
3	D02	/ACFAIL	D10
4	D03	/BG0IN	D11
5	D04	/BG0OUT	D12
6	D05	/BG1IN	D13
7	D06	/BG1OUT	D14
8	D07	/BG2IN	D15
9	GND	/BG2OUT	GND
10	SYSCLK	/BG3IN	/SYSFAIL
11	GND	/BG3OUT	/BERR
12	/DS1	/BR0	/SYSRESET
13	/DS0	/BR1	/LWORD
14	/WRITE	/BR2	AM5
15	GND	/BR3	A23
16	/DTACK	AM0	A22
17	GND	AM1	A21
18	/AS	AM2	A20
19	GND	AM3	A19
20	/IACK	GND	A18
21	/IACKIN	(SERCLK)	A17
22	/IACKOUT	(SERDAT)	A16
23	AM4	GND	A15
24	A07	/IRQ7	A14
25	A06	/IRQ6	A13
26	A05	/IRQ5	A12
27	A04	/IRQ4	A11
28	A03	/IRQ3	A10
29	A02	/IRQ2	A09
30	A01	/IRQ1	A08
31	-12 V	(+5STDBY)	+12 V
32	+ 5 V	+ 5 V	+ 5 V

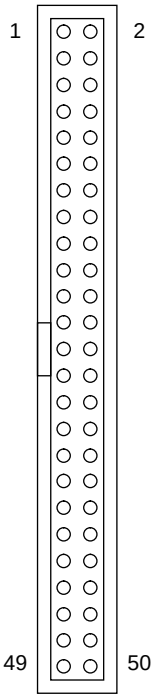
Signals in parentheses are not connected.

Table 4.4 Pin Assignment of P2 Connector X102

Pin	Signal Row A	Signal Row B	Signal Row C
1	SCSIDBP1	+ 5 V	SCSIDB1
2	SCSIDB0	GND	SCSIDB3
3	SCSIDB2	Reserved	SCSIDB5
4	SCSIDB4	A24	SCSIDB7
5	SCSIDB6	A25	SCSIDB9
6	SCSIDBP0	A26	SCSIDB11
7	SCSIDB8	A27	SCSIDB13
8	SCSIDB10	A28	SCSIDB15
9	SCSIDB12	A29	CIOPC3
10	SCSIDB14	A30	CIOPC1
11	CIOPC2	A31	CIOPA6
12	CIOPC0	GND	CIOPA4
13	CIOPA7	+ 5 V	CIOPA2
14	CIOPA5	D16	CIOPA0
15	CIOPA3	D17	/SCSIATN
16	CIOPA1	D18	GND
17	GND	D19	/SCSIBSY
18	/SCSIACK	D20	/SCSIRST
19	/SCSIMSG	D21	/SCSISEL
20	/SCSIC/D	D22	/SCSIREQ
21	/SCSII/O	D23	C4GND4
22	C4GND1	GND	C4DTR
23	C4CTS	D24	C4TxD
24	C4RTS	D25	C4RxD
25	C4DCD	D26	C3GND4
26	C3GND1	D27	C3DTR
27	C3CTS	D28	C3TxD
28	C3RTS	D29	C3RxD
29	C3DCD	D30	+ 5 V
30	C2DTR	D31	C2TxD
31	C2CTS	GND	C2RxD
32	C2RTS	+ 5 V	C2DCD

Lines on rows A and C are TTL-level, except Cx signals which have RS 232C level (SILC-200 used). Pin assignment changes for RS 422/485 configuration. Row B is reserved for 32-bit VMEbus extension.

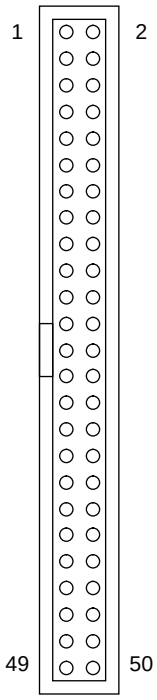
Table 4.5 50-Pin I/O Connector X102 (on ADAP-200 and ADAP-220)



Pin	Dir	Description	Remark	
1 8	I/O	Not connected on ADAP-220, SCSIDB8 - SCSIDB15 on ADAP-200		SCSIDB8 - 15 must be left open on ADAP-200
9	-	GND		
10 13	I/O	CIO Port C 3 - CIO Port C 0		
14	-	GND		
15 22	I/O	CIO Port A 7 - CIO Port A 0		
23	-	+5 V		
24	-	Serial Channel 4	GND2	(may be changed if a non standard level-converter board SILC is installed)
25	-	Serial Channel 4	GND1	
26	-	Serial Channel 4	not connected	
27	I	Serial Channel 4	CTS	
28	O	Serial Channel 4	TXD	
29	O	Serial Channel 4	RTS	
30	I	Serial Channel 4	RXD	
31	-	not connected		
32	-	not connected		
33	-	Serial Channel 3	GND2	(may be changed if a non standard level-converter board SILC is installed)
34	-	Serial Channel 3	GND1	
35	-	Serial Channel 3	not connected	
36	I	Serial Channel 3	CTS	
37	O	Serial Channel 3	TXD	
38	O	Serial Channel 3	RTS	
39	I	Serial Channel 3	RXD	
40	-	not connected		
41	-	not connected		
42	-	Serial Channel 2	GND	
43	-	Serial Channel 2	+5 V	fused (300 mA max.)
44	O	Serial Channel 2	DTR	
45	I	Serial Channel 2	CTS	
46	O	Serial Channel 2	TXD	
47	O	Serial Channel 2	RTS	
48	I	Serial Channel 2	RXD	
49	-	not connected		
50	I	Serial Channel 2	DCD	

Table 4.6 SCSI Connector 8-bit X103 (on ADAP-200 and ADAP-220)

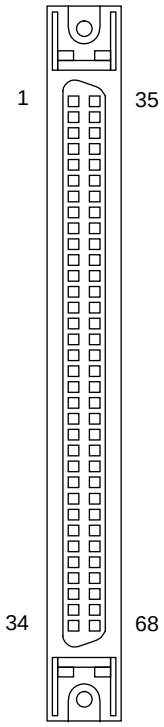
Pin	Description	Pin	Description
2	DB0	28	GND
4	DB1	30	GND
6	DB2	32	ATN
8	DB3	34	GND
10	DB4	36	BSY
12	DB5	38	ACK
14	DB6	40	RST
16	DB7	42	MSG
18	DB8	44	SEL
20	GND	46	CIO
22	GND	48	REQ
24	GND	50	I/O
26	TERM-PWR		



All odd pins of the 50-pin SCSI connector except pin 25 are connected to ground. Pin 25 is left open. Pin 26 is connected to +5 V via a Shottky diode to supply power to an external SCSI terminator.

Table 4.7 SCSI Connector 16-bit X107 (on ADAP-220)

Pin	Description	Pin	Description
1 - 16	GND	50	GND
17	TERM	51	TERM
18	TERM	52	TERM
19	NC	53	NC
20 - 34	GND	54	GND
35	SCSIDB12	55	/SCSIATN
36	SCSIDB13	56	GND
37	SCSIDB14	57	/SCSIBSY
38	SCSIDB15	58	/SCSIACK
39	SCSIDP1	59	/SCSIRST
40	SCSIDB0	60	/SCSIMSG
41	SCSIDB1	61	/SCSISEL
42	SCSIDB2	62	/SCSIC/D
43	SCSIDB3	63	/SCSIREQ
44	SCSIDB4	64	/SCSII/O
45	SCSIDB5	65	SCSIDB8
46	SCSIDB6	66	SCSIDB9
47	SCSIDB7	67	SCSIDB10
48	SCSIDP0	68	SCSIDB11
49	GND		



4.7 References

For more information, we recommend the following additional literature:

MC68(EC/LC)040 M68040UM/AD
Microprocessors User’s Manual
Motorola Lititure Distribution; P.O. Box 20912; Phoenix, Arizona 85036

VMEBus Specification

Vita International Trade Association
10229 N. Scottsdale Road, Suite B
Scottsdale, AZ 85253 USA

5 Copies of Data Sheets

MC68040 Data Sheet and Errata

CIO Z8536

IOC-2

VIC 68 User’s Guide

VIC 64 Design Notes

NCR 53C720 Data Sheet

53C720 Programmers Guide

CL-CD2400/CD2401

ILACC Am79C900 Data Sheet

FORCE COMPUTERS Product Error Report

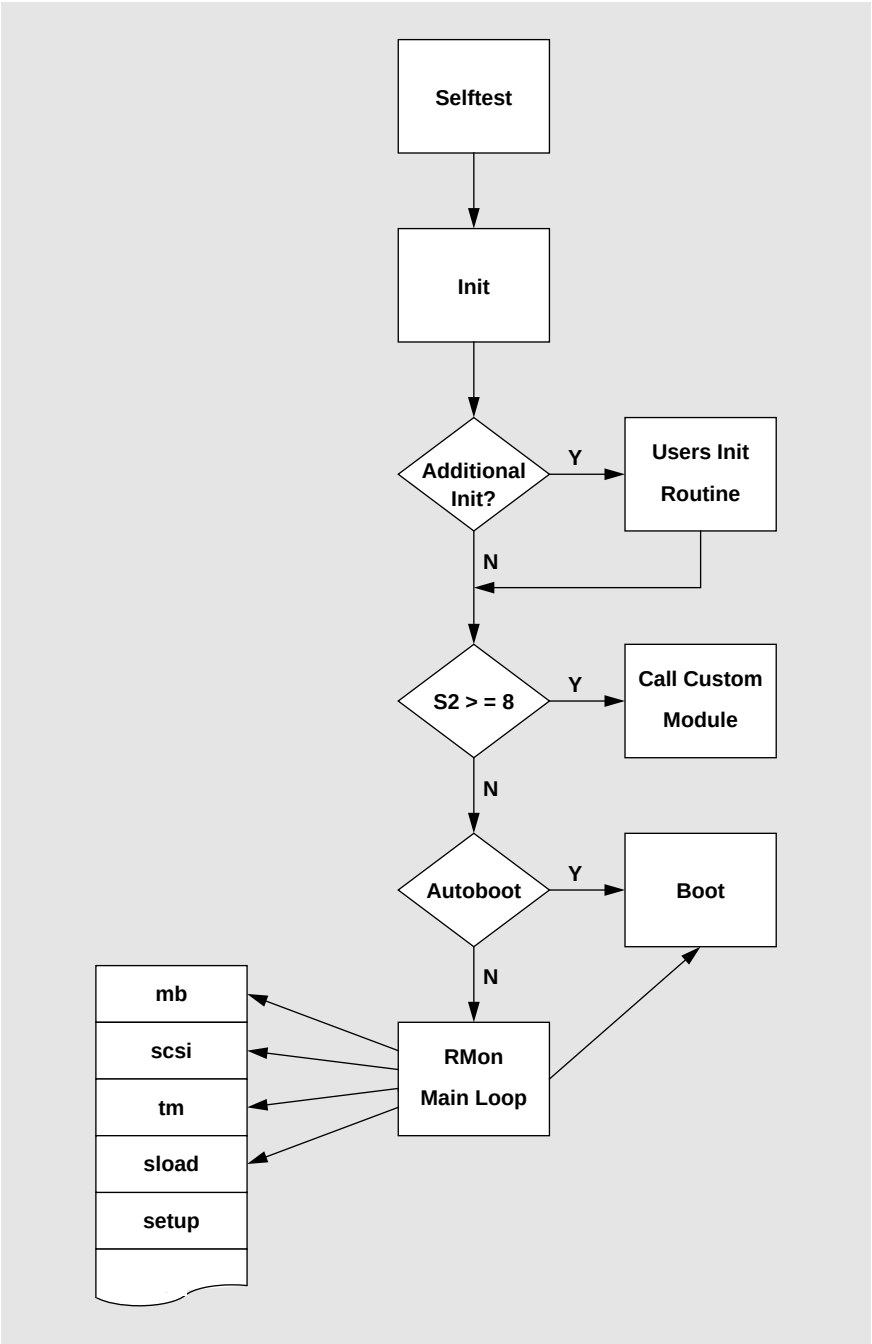
6 Firmware User's Manual

6.1 Distinguishing Features

- Hardware test after cold boot.
- Hardware initialization, depending on the selected configuration parameters.
- Easy to change configuration parameters using a setup menu.
- Bootstrap loader for OS-9 and LynxOS. Boot from Ethernet.
- Commands for memory change and inspection.
- S-record download from host and transparent mode.
- User-applicable routines for character I/O and SCSI.

6.2 General Description

Figure 6.1 Block Diagram



RMon is a product especially designed to meet new demands. Most of the source code has been written in the programming language C to ensure maximum portability. Furthermore, the usage of a high level language facilitates further extensions and maintenance.

On reset, the RMon always performs a hardware test. Each step of the test is indicated by a unique number on the board's status display. If one of these steps fails due to a hardware error, it is easy to ascertain the defective hardware function.

The monitor is equipped with a set of default values for a correct system initialization. These values are stored in the EPROM and thus cannot be modified. Customizing these system configuration values is possible by redirecting the monitor to use configuration values of other sources. There are three different sources to choose from:

- EPROM (default configuration values)
- NVRAM (for long-term configuration changes)
- DRAM (for short-term configuration changes)

The data structure of the system configuration values is divided into five logical groups:

- Group A: **I/O Initialization**

  Used by the monitor during startup for initialization of I/O hardware components.

- Group B: **Address Information**

  Used by the monitor during startup for local and bus slave address determination.

- Group C: **Hooks**

  Used by the monitor during startup for recognition of customer-specific routines. The hooks are provided for special initialization and start-up programs.

- Group D: **Boot Parameters**

  Used by the boot loader(s) of the monitor, described later.

- Group E: **Board Information**

  Used by basic and monitor during startup for identification and start-up state purposes.

During start-up, the system configuration values are copied from the chosen source to the DRAM area and the system is initialized with these values. To modify this image of the system configuration values, the interactive mode of the monitor provides a set-up command to view and change the DRAM memory as well as to transfer the system configuration values between DRAM and NVRAM. The source selection makes it possible to test a system configuration in DRAM without losing a previously saved configuration. The correct configuration then can be saved to the NVRAM to replace the former one.

The monitor program must always be resident in EPROM for service purposes, system initialization and FORCE COMPUTERS-specific parameters. The monitor program starts at EPROM offset $0. User modules should start at offset $0 in the user EPROM.

After system initialization, the monitor starts interactive mode or a custom program (by default at offset $0 in the user EPROM).

In order to ensure system reliability, RMon uses independent checksums for the monitor program and the NVRAM system configuration values. If an error occurs, the user is informed about the data corruption to preserve any damage. See also Section 6.5 ‘Hardware Test’.

The monitor provides a set of user-applicable routines, which include even complex functions such as **`printf()`** and **`gets()`**. The interface to the application routines is built by an address table in the module header of the monitor. These routines are not invoked by means of interrupts, but are called directly

through an assembler interface by any user program. For additional information, see section 7 ‘RMon Programmers Reference’.

6.3 Technical Details

The RMon consists of the following main building blocks:

- Hardware selftest
- Hardware initialization
- Network boot and bootstrap program for OS-9 and LynxOS
- Interactive mode

6.3.1 Hardware Test

After reset (power-on, reset switch, etc.) the RMon checks several parts of the board. Each step of the test is indicated by a unique number on the board's status display.

- **EPROM**
  Part of the RMon EPROM is used for simple calculation of a checksum. The start address, the end address, and the checksum are stored in the RMon module header.
- **System CIO**
  The system CIO is loaded with the correct register values to enable the dynamic RAM, to switch on the hex display, etc.
- **VIC**
  Four VIC registers (SSxCRx) are loaded and checked.
- **RAM**
  After a bit test with longword, byte, and word access to the first longword of the main memory, a 32 KB RAM block starting at address $0000 is tested with a pseudo random pattern. This test destroys the contents of the first 32 KB DRAM.
- **VMEbus Slave Decoder**
  The VMEbus slave address decoder registers are written with test values. The stored data is verified afterwards.
- **SRAM/RTC**
  The battery of the timekeeper RAM MK48T18 is checked and one byte is tested for bit errors. This does not destroy the contents of the timekeeper RAM.

If one of these tests fails due to a hardware error or if an exception occurs, the test will be repeated. This results in an endless loop always performing the same test. For a detailed description, refer to 8.3 Hardware Selftest.

6.3.2 Hardware Initialization

The hardware initialization depends on the system configuration values located at offset $0800 in the main memory. These system configuration values are copied from the EPROM (default configuration values) or from the NVRAM (user-changeable configuration values). Hex switch S2, located on the front panel, is used to select the source of the configuration values.

During the hardware initialization, the board's status display shows the letter 'D'. The hardware initialization consists of:

- Calculate the checksum of the system configuration value located in the timekeeper RAM.
- Copy the system configuration values from EPROM (S2 = '0'), from the NVRAM (S2 = '1', '8'-'F'), or do not change the current system configuration values (S2 = '2').
- Initialize the VIC using the VIC-dependent values within the system configuration values.
- Initialize the VMEbus slave address decoder and enable the VMEbus slave access. The VMEbus slave addresses depend on switch S1 located at the front panel.
- Initialize the character I/O. This part includes the keyboard input and the serial communication controllers.
- Initialize the SCSI controller and generate a SCSI reset if enabled.
- Start the watchdog if enabled by the system configuration values.
- Call any additionally installed user initialization routine.

6.3.3 Network Boot and Bootstrap for OS-9

The RMon is able to load a file from a remote system via TFTP. The first 16 bytes of the file must contain the load address and the start address.

The bootstrap program for OS-9 supports harddisk, floppy, and tape drive. Also a boot from a OS-9 RAM disk is implemented.

6.3.4 Interactive Mode

The command set of the RMon interactive mode includes commands

- for memory change (**`mb`**, **`mw`**, **`ml`**),
- for memory inspection (**`db`**, **`dw`**, **`dl`**),
- for I/O (**`tm`** and **`sload`**),
- to change and copy the system configuration values (**`setup`**, **`re`**, **`we`**),
- to test and help (**`scsi`**, **`help`**),
- to boot the operating system (**`boot`**).

6.4 Default Parameters

Table 6.1 Default RMon Parameters (S1=0, S2=0)

	Default	Description
Extended VMEbus slave address Standard VMEbus slave address Short VMEbus slave address	$8000.0000 $80.0000 $8000	see Section 6.6 ‘Hardware Initialization’
System Configuration Source Startup Program	EPROM RMon (interactive mode)	see Section 6.6 ‘Hardware Initialization’

6.5 Hardware Test

After reset, a hardware test checks the important parts of the board which are necessary for RMon. During this test the status display, located on the front panel, shows the currently running test (EPROM test, RAM test, etc.) or the kind of exception with a unique number.

The status display is updated at the beginning of the test. If the test of one device fails or if an exception occurs, the test of this device is repeated. At the end of each test, a short delay loop is used to display the value on the status display for a while.

On some CPU boards, the status display is not activated after reset and has to be switched on separately. Therefore, it is possible that the status display will start with a value greater than '1.' Also the order of the tests may differ from board to board. For example, the CPU-44 status display is activated by a system CIO output port, so the first displayed value is '3'. Table 6.2 ‘Hardware Test Display Values’ gives an overview of the tests and the corresponding values in the status display. The status display is updated before starting a new function.

Table 6.2 Hardware Test Display Values

Value	Task in Progress
1	First access to the status display
2	Calculate checksum of EPROM part and compare
3	Initialize the system CIO
4	First VIC access; test the SSxCRx registers
5	Test of main memory (32 KB block)
6	Test of VMEbus slave address decoder
7	Test CLUT and video frame buffer (if present)
8	Test timekeeper RAM (if present)
9	Warm boot entry

Table 6.2 Hardware Test Display Values (Continued)

Value	Task in Progress
A	Address error exception
B	Bus error exception
C	Illegal instruction exception
D	Hardware initialization is running
E	All other exceptions
F	RMon is running in interactive mode

6.5.1 Status Display

Before the status display is written the first time, the CPUs vector base register is initialized to point to an exception table located in the EPROM and the stack pointer is initialized to point to a memory area. This allows write accesses without bus error and without memory modification (for example, the user EPROM on the CPU-44).

6.5.2 RMon EPROM

A simple checksum of RMon is built (status display '2'), by adding all bytes to a longword. If the result does not match the saved checksum, or if any exception occurs, this test is started again. The start address, the end address, and the checksum are stored at offset $0014, $0018, and $001C.

6.5.3 System CIO

The initialization of the system CIO (status display '3') includes a software reset, setup of all data direction registers, and the initialization of the output ports to their default values.

6.5.4 VIC Access

If the VMEbus SYSRESET and a VIC access occur at the same time, the VIC cannot be initialized. Therefore, the VIC access results in a bus error. The VIC’s IFCR1 is read until no bus error occurs (status display '4'). When this loop is passed, the VIC’s SSxCRx registers are loaded with test patterns, read back, and compared with the original.

6.5.5 Main Memory

The main memory test (status display '5'), starts with simple longword write and read operations.

After that, the RAM is checked with the following sequence: byte write, longword read and word write, longword read.

The next part of the main memory test is a check of the 32-KB RMon working memory (data and stack). The memory block is completely filled with a pseudo random test pattern and later checked by calculating the same pattern again.

Each single memory test (longword test, byte/word test, random test) is repeated if it fails or if any exception occurs.

6.5.6 VMEbus Slave Address Decoder Register

The on-board VMEbus slave address decoders are checked (status display '6') by writing different test patterns to registers and verifying that they are stored.

6.5.7 Timekeeper RAM

If the board is equipped with a timekeeper RAM, it’s battery is checked (status display '8'). Afterwards, the byte at offset $04 within the timekeeper RAM is tested with test patterns. This test does not destroy the contents of the timekeeper RAM.

6.6 Hardware Initialization

6.6.1 Configuration Switches

After the hardware test is passed, RMon initializes the on-board hardware. The hardware initialization depends on the system configuration values that are located at address $0800 in the main memory. These system configuration values are a copy of the EPROM configuration value (default setting), or they are a copy of the configuration values located in the timekeeper RAM (user setting).

The front panel hex switch S2 (lower switch) setting selects one of the sources or prevents copying of the system configuration values. Hex switch S2 is also used to determine the startup mode of the RMon. The following table shows the usage of this source selection switch.

Table 6.3 System Configuration Values Source

Switch S2	Source	Startup Program
0	EPROM	RMon (interactive mode)
1	NVRAM	RMon (interactive mode)
2	no copy	RMon (interactive mode)
3	EPROM	RMon (interactive mode on Serial Port [a]
4-7		RESERVED
8-F	NVRAM	Custom module [b] located in the user EPROM(s)

a. Since version 2.0 of RMon

b. Module is a program, extended with a module header of the following format:
Offset 0: Stack pointer (longword)
Offset 4: Entry pointer (longword)
...
Program Entry: ... (Beginning of program)

Hex switch S1 (upper switch) is used to configure the VMEbus slave address (15 different values). To select other VMEbus slave addresses, hex switch S1 must be turned to '0' and hex switch S2 to a position

other than '0'. The corresponding slave address must be set in the system configuration values (using the RMon **`setup`** command).

The following table shows how the slave address is built using the position of S1.

Table 6.4 Slave Address Selection

Extended Address Space:	$S0xx.xxxx
Standard Address Space:	$S0.xxxx
Short Address Space (ICF):	$S0xx

S: position of switch S1 for $0 < S1 \leq F$
x: don't care

6.6.1.1 System Configuration Values

The first step of the hardware initialization process is to check the validity of the timekeeper RAM, which holds the user-defined configuration values. If the checksum is not correct or if the battery of the timekeeper RAM is low (tested during hardware test), the system configuration values are copied from EPROM, independent of the position of hex switch S2.

6.6.1.2 VIC

The system configuration values (address $0800) are loaded into the corresponding registers to initialize the VIC registers. The table used to initialize the VIC consists of entries with two bytes. The first byte is the value and the second one is the register number. The end of the table is marked with value and register number set to $FF.

6.6.1.3 Slave Address Decoder

Depending on the position of hex switch S1, the VMEbus slave address is either specified by the position of S1 ($0 < S1 \leq \$F$) or taken from the system configuration values (S1 = 0).

6.6.1.4 Character I/O

The character I/O initialization includes serial devices and the keyboard input device. The initialization values for SCCx are located within the system configuration values at address $890 (serial port 1), $08B0 (serial port 2). The initialization values are organized as pairs of value and register number. The end is marked by the register number $FF.

6.6.1.5 SCSI Controller

The initialization of the SCSI controller includes the setting of the own SCSI ID (address $0950) and the generation of the SCSI reset signal if enabled.

6.6.1.6 Watchdog

If enabled by the system configuration values (address $0C5C), the watchdog timer is started. The watchdog is retriggered by a VIC timer interrupt service routine which runs on interrupt level 7.

6.6.1.7 User Initialization

If enabled by the system configuration values (address $0B48 contains a pointer), an additional user initialization routine is called. This routine is called as subroutine and must not change any CPU registers.

After initialization is complete, the interactive mode is started (S2 <8) or the custom module located in the user EPROM (default) is called (S2 ≥ 8). If hex switch S2 is less than '8,' the autoboot flag within the system configuration values (address $0B70) is checked first. If autoboot is enabled, the corresponding bootstrap loader (Ethernet, OS-9, LynxOS) is called after a delay time that depends on the system configuration values (address $0B7E).

Any exception during the hardware initialization causes the RMon to restart, resulting in a new hardware selftest.

6.6.2 Starting a User Program Module

If hex switch S2 is turned to a position between '8' and 'F', the user program module is started after the hardware initialization. A module is an executable block of code starting with a module header of the following format:

```
Offset 0: Stack pointer (longword)
Offset 4: Entry pointer (longword)
...
Program entry: ... (start of program)
```

The start address of the user program module is specified by the system configuration values (address $0B4C). Start address $FFFF.FFFF selects a user program module in the user EPROM.

The RMon uses the VIC timer interrupt on level 7 (vector $42) to support the watchdog and to handle different timing functions. Within the interrupt service routine, the watchdog must be retriggered. If the user program module builds a new exception table or changes the contents of the vector base register (VBR), this interrupt must be switched off (do not forget the watchdog). Alternatively, an entry in the new exception table must be available (offset $0108).

The timer interrupt can not be switched off by the CPU interrupt mask, because it is a level 7 interrupt. Use the VIC local interrupt control register 2 for this task (LICR2 = $80).

6.6.3 Autoboot

The monitor program supports automatic booting after hardware initialization. Use RMon's **`setup`** command to enable the autoboot.

Hex switch S2 must be turned to a position other than '0' to get the system configuration values from the timekeeper RAM because the autoboot flag and the autoboot delay time are part of the system configuration values.

An autoboot delay can also be enabled using the RMon's **`setup`** command. This delay is necessary to avoid hard disk access during power-on spin-up.

6.7 Interactive Mode

6.7.1 Introduction

After reset, the monitor outputs the display shown in Figure 6.2 ‘RMon Start-up Display’:

Figure 6.2 RMon Start-up Display

```
          **********   RMON   **********

                Version : 1.6 (13) for the CPU-44
          Creation date : 03sept92

Copyright (C) 1991,1992 by FORCE COMPUTERS

              CPU board : CPU-44

         DRAM available : 8 MBytes

Extended slave address : 0x80000000
Standard slave address : 0x800000
           ICF1 address : 0x8000
           ICF2 address : not enabled

       Ethernet address : 00:00:5b:00:06:7b

***>
```

During startup, the monitor performs some hardware tests, sending status information to the front panel display. The status display should show a 'F' digit with neither of the two decimal points switched on. The program’s prompt now appears on the terminal connected to the configured communication port.

6.7.2 General Operation

6.7.2.1 Command Input

Interacting with the monitor program is done by entering a command line. The general format of a command line is:

***> <command> {<arguments>}

The sequence ***> is the monitor prompt. For the syntax description, Refer to Section 6.7.3 ‘Formal Syntax Notation’.

A command may be abbreviated as long as it is still definite. For example, **`help`** may be entered as 'h', 'he', or 'hel', since there is no other command beginning with 'h'.

Commands and arguments may be entered in uppercase letters, lowercase letters or mixed. In quoted arguments (") uppercase and lowercase spelling is distinguished. This is important for initial strings, which are sent (**`sload`** command) to another system.

The keyboard input is software-buffered, i.e. input may be typed ahead even if the program does not prompt for input. All characters remain invisible until the program is in the input state.

The monitor provides no facilities for command editing besides <BS> to erase the character to the left of the cursor.

6.7.2.2 On-line Help

A listing of all valid monitor commands is displayed by pressing the '?' key or entering the monitor command **`help`**. This displays a syntax description, task explanation, and additional information about special features of the command.

Every input line is checked for a valid command and all needed arguments. If an invalid command is entered, the command line is ignored and an error message is printed. In case of missing arguments, help is provided by listing all necessary parameters. Therefore, just typing the command is the fastest way to get helpful information.

6.7.2.3 Special Keys

Besides the <BS> key, there are some keystrokes with a special function.

Table 6.5 RMon Special Keys

Keystroke	Function
<Ctrl>-S	Stop in/output
<Ctrl>-Q	Restart in/output
<DEL>	Abort current task (software equivalent to abort switch)
<Ctrl>-R <Ctrl>-R	Reset board locally (this does not imply a VMEbus reset)

6.7.2.4 Data Input Formats

The monitor program supports the input formats shown in the following table.

Table 6.6 RMon Input Formats

Number System	Input Prefix	Example
Hexadecimal	0x, $	a, 0xa, $a, 0xA, 0x00a, $00A
Decimal	&, +, -	&10, +10
Octal	o	o12, o012, o0012
Binary	%	%1010, %01010, %001010

All signed input values (prefix '+' or '-') must be decimal. By default, input is interpreted as hexadecimal.

6.7.3 Formal Syntax Notation

This section describes each RMon command, including a syntactical description of the command line. The symbolic description showing in the following table:

Table 6.7 RMon Syntax Description

Symbol	Meaning
abcd	exactly 'abcd'
<name>	word or number with the meaning 'name'
[...]	enclosed items are optional
{...}	enclosed items are used 0, 1 or many times
(x | y | z)	Select one of x, y, z

Commands that can effect different types of objects are declared like this:

Syntax: c(x | y | z)

with

'c'	Trunk of command mnemonic
'x', 'y', 'z'	Possible extensions (one char)

Example: m(b|w|l)

with

'm' for modify	
'b' for byte	(-> 'mb'),
'w' for word	(-> 'mw'),
'l' for longword	(-> 'ml')

Common extensions are:

- 'b' for byte (8 bits)	Range: $00 to $FF
- 'w' for word (16 bits)	Range: $00 to $FFFF
- 'l' for longword (32 bits)	Range: $00 to $FFFF.FFFF
- 't' for text (quoted '')	For example: "Hello World"

6.7.4 Command Description

The following table shows a summary of all RMon commands and a short description.

Table 6.8 RMon Commands

Command	Description
boot	Boot operating system
db	Display memory using byte size
dl	Display memory using longword size
dw	Display memory using word size
gm	Start user module
help	Display detailed information about the commands
mb	Modify memory using byte size
ml	Modify memory using longword size
mw	Modify memory using word size
re	Read system configuration values from timekeeper RAM
scsi	Check SCSI bus devices
setup	Display/change system configuration values
sload	S-record download from host system
tm	Transparent mode
we	Write system configuration values to timekeeper RAM

6.7.4.1 Boot

- **Syntax:** `boot`

- **Description:**
  Boot the operating system.

- **Caveats:**
  The operating system and the devices to boot from are configurable by means of the configuration utility. See Section 6.6.1 ‘Configuration Switches’ for detailed information about the boot configuration.

- **Examples:** None

6.7.4.2 Display Memory

- **Syntax:** `d(b | w | l) [<startaddr> {<count>}]`

- **Description:**
  Display memory area.

- **Caveats:**
  The data is displayed in hexadecimal notation and it’s corresponding ASCII characters. Values beyond the printable ASCII range are displayed as a period.

  A period ('.') as start address declaration is a short cut for the current address. By default, address $0 or the address used with the last memory command is used as start address value.

- **Examples:** `db 2000`
  Display contents of memory starting at address $0000.2000 byte by byte.

  `dw &400 20`
  Display contents of the memory area $0000.0190 to $0000.01AF word by word.

6.7.4.3 Run Module

- **Syntax:** `gm [<startaddr>]`

- **Description:**
  Run a module from start address or user EPROM.

- **Caveats:**
  `Gm` takes the following parameters from the module header at the specified address:
  - Stack pointer (offset $0).
  - Entry point (offset $4).

  Monitor control is regained after returning from the user program, when a breakpoint is detected, or when an exception has occurred. By default, the

user program at user EPROM offset $0000 is started. This default address may be changed with the **`setup`** command.

- **Examples:** **`gm 500`**
  Start module located at address $0000.0500.

6.7.4.4 Help

- **Syntax:** **`help [<monitor command>]`**
  or
  `? [<monitor command>]`

- **Description:**
  This on-line help function displays information about a specific monitor command or, without an argument, a list of all valid commands.

- **Caveats:**
  '?' is a short cut and needs no <CR> to accept.

- **Examples:** **`help dw`**
  Get help for RMon command **`dw`**.

6.7.4.5 Modify Memory

- **Syntax:** **`m(b | w | l) [<startaddr> {<value>}]`**

- **Description:**
  Modify memory contents.

- **Caveats:**
  A period ('.') as start address is a short cut for the current address. By default, address $0 or the address used by the last memory command is used as start address value.

  If only the start address is specified, memory modify will start an interactive mode. Besides entering values, in this mode the following keys may be used:

<	go to the previous address,
>, <CR>	go to the next address,
<SP>	re-read from the current address,
!	end the interactive mode.

  Single modified values are written, then read again and displayed.

  If one or more values are given, memory modify will not read the contents of the concerned addresses, but only write to them.

- **Examples:** **`ml 2000 1 2 3 4 5 &10 -1 o1`**`1`
  New memory contents (without prior reading):

```
2000: 00000001
2004: 00000002
2008: 00000003
200c: 00000004
2010: 00000005
2014: 0000000A
2018: ffffffff
201c: 00000009.

mw 2000
```

Modify memory content interactively, starting at address $0000.2000.

6.7.4.6 Read Parameters from NVRAM

- **Syntax:** `re`

- **Description:**
  Load system configuration values from NVRAM system area to DRAM area at address $0000.0800 to $0000.0CFF.

- **Caveats:**
  The system configuration values in the NVRAM are checksum protected. Do not change these values directly in the NVRAM. Make modifications in the DRAM image area ($0000.0800 to $0000.0CFF) and save these values with the monitor command **`we`**.

  To use NVRAM values, switch S2 must be set to '1' prior to system reset.

  See Section 6.6.1 ‘Configuration Switches’ for detailed information.

- **Examples:** None

- **See also:** `we`

6.7.4.7 SCSI Bus Scan

- **Syntax:** `scsi`

- **Description:**
  Check devices with controller id 0-6, LUN 0-3. The result is printed in a table with the following symbols:

+	LUN is ready
-	LUN is not ready
<SP>	No reply (terminated by time-out)

- **Caveats:**
  Controller number 7 cannot be checked since it is reserved for the SCSI controller chip itself.

- **Examples:** None

6.7.4.8 System Setup

- **Syntax:** `setup`

- **Description:**
  Start interactive menu-driven configuration program.

- **Caveats:**
  The **`setup`** command is used to change the current system configuration values located at $800 in the main memory.

  To save the changes in the NVRAM, the question 'Save parameters (y/n,)?' which appears before leaving the setup menu, must be answered with 'y'.

  Modifications of the system configuration values become active with the next cold boot (power-on reset) or warm boot (<Ctrl>-R, <Ctrl>-R) of RMon if hex switch S2 is set to '1', '8-F' (see also Section 6.6.1 ‘Configuration Switches’).

- **See also:** 8.1 ‘Walkthrough Examples’

6.7.4.9 Load S-Records

- **Syntax:** `sload <portno> [<offset> ["<init string>"]]`

- **Description:**
  Load S1, S2 or S3 record data from specified port.

- **Caveats:**
  An offset is added to the addresses of the incoming data (default: 0). The init string is used to initiate the data transfer.

  The string in quotes distinguishes uppercase and lowercase. Without quotes all characters are converted to lowercase letters and characters beyond the first <SP> in the string are ignored.

  In the current release, the program will not abort automatically in case of no response.

- **Examples:** `sload 2 0 “cat sfile”`
  Load S-record data from port 2, do not add any address offset, initiate data transfer via the (UNIX) command **`cat sfile`**.

6.7.4.10 Transparent Mode

- **Syntax:** `tm [<portno> [<ASCII(break key)>]]`

- **Description:**
  Set the monitor program to terminal emulation mode.

- **Caveats:**
  All input is sent directly to the specified port without any interpretation. That means, <Ctrl>-S, <Ctrl>-Q, the software abort via the <DEL> key and the software reset (<Ctrl>-R <Ctrl>-R) are ignored by the monitor program. The transparent mode is stopped by pressing the specified break key or the abort switch.

  By default, **`<portno>`** is '2' and <Ctrl>-\ ($1C) is the break key.

- **Examples:** `tm 2 1d`
  Emulate terminal at port 2, return to command line with <Ctrl>-].

6.7.4.11 Write Parameters to NVRAM

- **Syntax:** `we`

- **Description:**
  Save system configuration values from the DRAM area ($0000.0800 to $0000.0CFF) to the NVRAM system area.

- **Caveats:**
  To use NVRAM values, hex switch S2 must be set to '1' prior to system reset. See Section 6.6.1 ‘Configuration Switches’ for detailed information.

- **Examples:** None

- **See also:** `re`

7 RMon Programmers Reference

Conventions

Unless otherwise specified, addresses are written in hexadecimal notation and identified by a leading dollar sign ("$").

Signal names preceded by a slash ("/"), indicate that this signal is either active low or that it becomes active on the trailing edge.

b	bit
B	byte
K	kilo, means the factor 400 in hex (1024 decimal)
M	mega, the multiplication with 100 000 in hex (1 048576 decimal)
MHz	1 000 000 Hertz

Software-specific abbreviations:

<BS>	Back Space ($8)
<CAN>	Control-X ($19)
<Ctrl>	Control
<CR>	Carriage Return ($D)
<ESC>	Escape Character ($2B)
<LF>	Line Feed ($A)
<SP>	Space ($20)
NMI	Non-maskable Interrupt

7.1 Programming Interface

7.1.1 Module Header

The RMon consists of a module header and the monitor program. A module header has the following format:

Offset0: Stack pointer (longword)
Offset4: Entry pointer (longword)
...
Program Entry: ... (start of program)

The RMon's module header contains a lot of additional information between the entry pointer and the program entry. Table 7.1 'RMon Module Header' shows a detailed list of the current module headers, that may be extended in future releases.

Table 7.1 RMon Module Header

EPROM Offset	Usage
$00	Cold boot stack pointer
$04	Cold boot entry pointer
$08	Warm boot stack pointer
$0c	Warm boot entry pointer
$10	FORCE COMPUTERS reserved
$14	Start address of EPROM checksum area
$18	End address of EPROM checksum area
$1c	EPROM checksum
$20 to $30	FORCE COMPUTERS reserved
$34	RTO_Base: link to graphics terminal firmware
$38	FORCE COMPUTERS reserved
$3c	Board initialization routine
$40	Initial value of vector base register
$44	Base address of RMon static storage
$48	Free RAM area (end of static storage)
$50	Pointer to 'character in' routine
$54	Pointer to 'character out' routine
$58	Pointer to 'character I/O status read' routine
$5c	Pointer to 'character I/O mode set' routine
$60	Pointer to 'getchar' routine
$64	Pointer to 'putchar' routine
$68	Pointer to 'printf' routine
$6c	Pointer to 'monitor re-entry' routine
$70	Ethernet address of on-board lance
$76	FORCE COMPUTERS reserved
$78	Try to perform raw input from standard input port
$7c	Try to perform raw output to standard output port
$80	Execute SCSI command (version 2.0 and up)

7.1.2 User Applicable Routines

The RMon provides an EPROM jump table with addresses of several procedures that can be called as subroutines from outside the monitor. Parameters are passed through data registers **`d0.l`**, **`d1.l`**, etc. as longword values. Return values are always found in **`d0.l`**. All user applicable routines preserve the contents of all used registers. A complete description of all parameters and return values for each procedure is given below.

Here is a short example using the **getchar** routine:

Input parameter: **d0.l** - port number
Return value: **d0.l** - received character

```
       move.l  #0,d0          Port number 0 means standard
                              input port
       move.l  $c90,a0        Get pointer to jump table (Note)
       cmpa.l  #-1,a0         Pointer defined ?
       bne.s   doit           Yes, call function
       lea     $fe000000,a0   Load address of basic EPROM
                              of E16
doit   jsr     $60(a0)        Call 'getchar()' routine
       cmp.b   d0,$41         Got an 'A' ?
```

For RMon versions below 2.0, location $0C90 does not contain a pointer to the jump table. To make programs run on both versions, check if $0C90 contains $FFFF.FFFF and use the board's basic EPROM address as pointer to the jump table.

7.1.2.1 Character In

- **EPROM Offset:** $50

- **Description:**
  Pointer to low level character input routine. Tries to read a character from the given port, but will not wait for it.

- **Input Parameters:**
  d0.l - Port number, by default 1 - 4 for a specific port or '0' for the currently configured character I/O port.

- **Return Value:**
  d0.l - (0 - 255) received character
  (-1) sequence of character
  (-2) no character available

  a0 - pointer to buffer with sequence of character. The sequence of characters is terminated with $00. The pointer is only valid if **d0.l** contains (-1).

7.1.2.2 Character Out

- **EPROM Offset:** $54

- **Description:**
  Pointer to low level character output routine. Sends a character to the given port.

- **Input Parameters:**
  d0.l - Port number, by default 1 - 4 for a specific port or '0' for the currently configured character I/O port.

  d1.l - Character to be sent

- **Return Value:** None

7.1.2.3 Character I/O Status Read

- **EPROM Offset:** $58

- **Description:**
  Pointer to low level character status routine. Reads the status of the given port.

- **Input Parameters:**
  d0.l - Port number, by default 1 - 4 for a specific port or '0' for the currently configured character I/O port.

- **Return Value:**
  d0.l - Bit 0: receiver ready (input buffer not empty) if set to 1
  Bit 1: transmitter ready if set to 1

7.1.2.4 Character I/O Mode Set

- **EPROM Offset:** $5C

- **Description:**
  Pointer to I/O mode set routine. Modifies enable flags for character I/O.

- **Input Parameters:**
  d0.l - Port number, by default 1 - 4 for a specific port or '0' for the currently configured character I/O port.

  d1.l - Bit 0: enable special key interpretation
  Bit 1: enable software abort

- **Return Value:** None

7.1.2.5 Getchar

- **EPROM Offset:** $60

- **Description:**
  Pointer to high level character input routine with <CR>-<LF> mapping. Reads a character from the configured character I/O port and echoes it.

- **Caveats:**
  `Getchar` calls the **`character in`** function until it returns a value not equal to 0. The local echo feature can be disabled by the **`character I/O mode set`** call.

- **Input Parameters:**
  None, the currently configured character I/O port will always be used (port 0).

- **Return Value:**
  `d0.l` - Received character.

7.1.2.6 Putchar

- **EPROM Offset:** $64

- **Description:**
  Pointer to high level character output routine with <CR>-<LF> mapping. Sends a character to the configured character I/O port.

- **Caveats:**
  `Putchar` calls the **`character out`** function with the port parameter 0.

- **Input Parameters:**
  None. The currently configured character I/O port is always used (port 0).

- **Return Value:** None

7.1.2.7 Printf

- **EPROM Offset:** $68

- **Description:**
  Pointer to standard C **`printf`** function.

- **Caveats:**
  The current implementation does not support floating point output.

- **Input Parameters:**
  `d0.l` - Pointer to descriptor string (e.g. “out:%d %x\n” with '\n' = $A)

  `d1.l` - Pointer to parameter list. Parameter list (longwords): '#values, value1, value2, etc.' (values are numerics or string pointers).

- **Return Value:** None

- **Example:**

```
*
* Call 'printf()' of RMon
*
printf: lea     format(pc),a0 Pointer to format
        move.l  a0,d0
        pea     1234          Second parameter
        pea     $1234         First parameter
        pea     2             Number of parameters
        move.l  a7,d1         Pointer to parameter list
        move.l  $c90,a0       Get pointer to jump table
        cmpa.l  #-1,a0        Pointer defined ?
        bne.s   printf20      Yes, call function
        lea     $fe000000,a0  Load address of basic EPROM
                              of E16
printf20jsr     $68(a0)
.
        addq.l  #3*4, a7      Remove parameter from stack
.

format          dc.b          "Hex: 0x04x  Deci: %d",0
```

7.1.2.8 Monitor Re-Entry

- **EPROM Offset:** $6C

- **Description:**
  Return from user program to monitor.

- **Caveats:**
  `Monitor re-entry` is used to return from a command line call or an automatic call via the user hook.

- **Input Parameters:** None

- **Return Value:** None

7.1.2.9 Raw Input

- **EPROM Offset**: $78

- **Description:**
  Pointer to raw character input routine. **`Raw input`** reads characters from the standard input port.

- **Caveats:**
  `Raw input` calls the **`character in`** routine with the port number of the standard input port number.

- **Input Parameters:** None.
  The currently configured character input port is always used.

- **Return Value:**
  `d0.l` - (0 - 255) received character
  (-1) sequence of character
  (-2) no character available

  `a0` - pointer to buffer with sequence of character. The sequence of characters is terminated with $00.
  The pointer is only valid if **`d0.l`** contains (-1).

7.1.2.10 Raw Output

- **EPROM Offset:** $7C

- **Description:**
  Pointer to raw character output routine. Writes a character to the standard output port.

- **Comments:**
  `Raw output` calls the **`character out`** routine with the port number of the standard output port number.

- **Input Parameters:**
  `d0.b` - character to be sent

- **Return Values:**
  `d0.l` - (0) o.k.
  (-1) device busy

7.1.2.11 Execute SCSI Command

- **EPROM Offset:** $80

- **Description:**
  Pointer to routine that executes a SCSI command. Sends the command to the SCSI device, transfers the data, and returns the SCSI status.

- **Comments:**
  `Execute SCSI command` handles the whole protocol on the SCSI port. It covers the phases ‘select’, ‘command’, ‘data’ (optional), ‘status’ and ‘message’. For command and data phase, parameters must be supplied.

- **Input Parameters:**
  `d0.l` - SCSI controller ID
  `d1.l` - Number of bytes in command block
  `d2.l` - Number of data bytes
  `d3.l` - Data direction
  (-1): input
  (0): no data
  (+1): output
  `a0.l` - Pointer to command block
  `a1.l` - Pointer to data buffer

- **Return Value:**
  `d0.l` - (>0) SCSI status byte
  (-1) Time-out error

7.2 Internals

7.2.1 Memory Map

The monitor program is located in EPROM. Several areas of DRAM are used for data storage.

Table 7.2 RMon Memory Usage

Memory Area	Utilization
$0000.0000 - $0000.07FF	Exception table
$0000.0800 - $0000.0CFF	DRAM image of System Configuration Values
$0000.0D00 - $0000.1FFF	Reserved
$0000.2000 - $0000.7FFF	Monitor data segment and stack

7.2.2 CPU Registers

The monitor keeps an image of

- the user registers, including the general purpose registers,
- all three stack pointers,
- program counter,
- status register,
- vector base register,
- CCR,
- SFC,
- DFC.

These registers are initialized to zero, except the status register, which is set to $2700. By starting a module, all values are copied to the corresponding registers.

7.2.3 Exception Handling

After system reset, the vector base register is set to address $0000.0000. All 256 exception vectors are initialized. If an exception occurs while executing a monitor command, the complete name of the exception and, for some exceptions, the fault address is printed.

7.2.4 Status Indication

The status display on the front panel is used by the RMon to indicate status/error conditions during power-on reset. Table 7.3 ‘RMon Status Display’ shows all display values and the corresponding task that is currently in progress.

Table 7.3 RMon Status Display

Value	Task in progress
0	Test/Initialize I/O controller
1	First access to the status display
2	Calculate checksum of EPROM part and compare it with the stored value
3	Initialize the system CIO
4	First VIC access; test the SSxCRx registers
5	Test main memory (32 KB block)
6	Test/access to VMEbus slave address decoder
7	Test CLUT and video framebuffer (if present)
8	Test timekeeper RAM (if present)
9	Warm boot entry
A	Address error exception
B	Bus error exception
C	Illegal instruction exception
D	Hardware initialization
E	All other exceptions
F	RMon is running in interactive mode

7.2.5 System Configuration Values

The EPROM system configuration values of the RMon are used whenever the board is reset and switch S2 is set to position '0'. See also Software Manual, Section 6.6.1 ‘Configuration Switches’.

After the hardware test phase, these values are copied from the NVRAM system area to the DRAM area from $0000.0800 to $0000.0CFF. Modified values can be saved in the NVRAM with the monitor command **`we`**.

Most of these parameters can be changed with the RMon **`setup`** command.

The factory setting of the parameters may change with different RMon versions and implementations.

For detailed information, please refer to the corresponding hardware manual.

7.3 ANSI Standard Terminal Emulation

The RMon output character functions for the graphic interface - called by the EPROM jump table - emulates a subset of a standard ANSI X3.64 terminal.

The RMon displays 24 lines with 80 ASCII characters per line, with scrolling, (x, y) cursor addressability, and some other control functions. The non-blinking block cursor marks the current line and character position on the screen. When one of the ASCII characters between $20 (space) and $7E (tilde) are written to the screen by calling the RMon function (and the character is not part of an escape sequence), it is displayed at the current cursor position and the cursor moves one position to the right on the current line. If the cursor is already at the right edge of the screen, it moves to the first character position on the next line. If the cursor is already at the right edge of the screen on the bottom line, the screen is scrolls up by one line, before moving the cursor to the first character position on the next line.

7.3.1 Control Sequence Syntax

The RMon output function defines a number of control sequences. When such a sequence is written to the RMon output function, it is not displayed on the screen, but effects some control function as described below.

Some of the control sequences consist of a single character. The notation

"<Ctrl>-x"

for some character x, represents a control character.

Other ANSI control sequences are of the form

"CSI <params> <char>" or "<ESC> [<params> <char>"

Spaces are included only for readability. These characters must occur in the given sequence without the intervening spaces.

<ESC>	represents the ASCII escape character (<ESC>, <Ctrl>-[, $1B).
[	The next character is a left square bracket '[' ($5B).
<params>	are a sequence of zero or more decimal numbers made up of digits between 0 and 9, separated by semicolons.
<char>	represents a function character, which is different for each control sequence.
CSI	represents the ANSI control sequence introducer ($9B).

‘<ESC> [’ and CSI are alternate representations of the ANSI ‘Control Sequence Introducer’ and may replace each other in any situation.

Some examples of syntactically valid escape sequences are:

<ESC> [m	select graphic rendition with default parameter
<ESC> [2 A	moves cursor 2 lines up
<ESC> [10;5 H	set cursor position

7.3.2 Supported Control Codes

- <Ctrl>-H or <BS>

  The cursor moves one position to the left on the current line. If it is already at the left edge of the screen, nothing happens.

- <Ctrl>-J or <LF>

  The cursor moves down one line, remaining at the same character position on the line. If the cursor is already at the bottom line, the screen scrolls up one line.

- <Ctrl>-M or <CR>

  The cursor moves to the leftmost character position on the current line.

7.3.3 Supported ANSI Control Sequences

The syntax of the sequences follows the ANSI terminal standard, i.e. arguments are to be given as readable ASCII strings, using decimal notation, and are to be separated by semicolons. In the following arguments are indicated by short names enclosed in angle brackets.

Printing characters in the range '@'..'~' are regarded as terminating codes. If they are defined in the following, they start processing the respective function. Undefined terminating codes simply abort the sequence without any action taken.

If a syntactical error is found within a sequence, the RMon output function skips all input until a terminating code is encountered, which results in a return to the normal not-in-sequence state.

- **<ESC> [<n> A** Cursor Up (CUU)

Moves the cursor up <n> lines (default 1). If the cursor is fewer than <n> lines from the top of the screen, moves the cursor to the topmost line in the screen. The character position of the cursor on the line is unchanged.

- **<ESC> [<n> B** Cursor Down (CUD)

Moves the cursor down <n> lines (default 1). If the cursor is fewer than <n> lines from the bottom of the screen, moves the cursor to the last line on the screen. The character position of the cursor on the line is unchanged.

- **<ESC> [<n> C** Cursor Forward (CUF)

Moves the cursor right by <n> character positions on the current line (default 1). If the cursor is fewer than <n> positions from the right edge of the screen, moves the cursor to the rightmost position on the current line.

- **<ESC> [<n> D** Cursor Backward (CUB)

Moves the cursor left by <n> character positions on the current line (default 1). If the cursor is fewer than <n> positions from the left edge of the screen, moves the cursor to the leftmost position on the current line.

- **<ESC> [<lin>;<col> H** Cursor Position (CUP)

Moves the cursor to the line <lin> and the character position <col> (default 1, 1). Character positions are numbered from 1 at the left edge of the screen; line positions are numbered from 1 at the top of the screen.

- **<ESC> [J** Erase in Display (ED)

Erases from the current cursor position inclusive to the end of the screen. The cursor position is unchanged.

- **<ESC> [K** Erase in Line (EL)

Erases from the current cursor position inclusive to the end of the current line. The cursor position is unchanged.

- **<ESC> [<sel> m**

Invokes the graphic rendition specified by the parameter (default 0). All following printing characters in the data stream are rendered according to the parameter until the next occurrence of this escape sequence. Only two graphic renditions are defined:

0 Normal rendition
7 Reverse video mode on

- **ESC ? <sel> h**

Turns on private feature specified by the parameter. Only one private feature is defined in RMon:

<sel> = 25 Cursor On (visible)

- **ESC ? <sel> l**

Turn off private feature specified by the parameter. Only one private feature is defined in RMon:

<sel> = 25 Cursor Off (invisible)

8 Appendices to the Firmware Manual

8.1 Walkthrough Examples

The figures on the following pages show most of the RMon 1.6 setup menus implemented on the CPU-44.

The setup menus may be different depending on the RMon version and on the board the RMon is implemented. The CPU-44 does not implement the video interface or the keyboard.

After the **`setup`** command is entered, the main menu is displayed on the screen (Figure 8.1 ‘Main Menu’). Each submenu is called by typing the corresponding letter.

Figure 8.1 Main Menu

```
--------------------------------------------------------------------------------
Main Menu
--------------------------------------------------------------------------------



                        (a)  VME Interface
                        (b)  Serial Interface
                        (c)  Video Interface
                        (d)  SCSI, Keyboard Interface
                        (e)  Boot
                        (f)  Hooks
                        (g)  Special

                        (x)  Exit



--------------------------------------------------------------------------------
Select item:
--------------------------------------------------------------------------------
```

The VMEbus interface submenu, shown in Figure 8.2 ‘VMEbus Interface Menu’, is used to change the VIC initialization parameters, the VMEbus slave addresses and the size of the slave window.

Figure 8.2 VMEbus Interface Menu

```
--------------------------------------------------------------------------------
VME Interface Menu
--------------------------------------------------------------------------------




                        (a)  Slave Access
                        (b)  Master Access
                        (c)  Arbiter/Requester/Timeout
                        (d)  Interrupts

                        (x)  Exit




--------------------------------------------------------------------------------
Select item:
--------------------------------------------------------------------------------
```

The VMEbus slave address changed by the VMEbus slave access parameter menu (Figure 8.3 ‘VMEbus Slave Access Parameters’) is only used if the hex switch S1 is set to position '0'. In all other cases, the VMEbus slave address is selected by the hex switch position.

Figure 8.4 ‘VMEbus Master Access Parameters’ displays the VMEbus master access parameters. The two menu entries define the data size used to transfer a longword within the corresponding VMEbus address range. The default setting for the VMEbus standard address range is to divide a D32 access into two subsequent D16 accesses, to support single eurocard VMEbus boards.

Figure 8.3 VMEbus Slave Access Parameters

```
--------------------------------------------------------------------------------
VME Slave Access Parameters
--------------------------------------------------------------------------------
Parameter Name:              Current Setting:         Factory Setting:

(a)  ICF1                    Enabled                  Enabled
(b)  ICF1 Address            8000                     8000
(c)  ICF2                    Disabled                 Disabled
(d)  Standard Access         Enabled                  Enabled
(e)  Standard Address        80                       80
(f)  Standard Size           1 MByte                  1 MByte
(g)  Extended Access         Enabled                  Enabled
(h)  Extended Address        8000                     8000
(i)  Extended Size           8 MByte                  8 MByte


(w)  Set Parameters to default
(x)  Exit
--------------------------------------------------------------------------------
Select item:
--------------------------------------------------------------------------------
```

Figure 8.4 VMEbus Master Access Parameters

```
--------------------------------------------------------------------------------
VME Master Access Parameters
--------------------------------------------------------------------------------
Parameter Name:               Current Setting:         Factory Setting:


(a)  Std. Access Data Width   32 Bit -> 32 Bit         32 Bit -> 32 Bit
(b)  Ext. Access Data Width   32 Bit -> 32 Bit         32 Bit -> 32 Bit









(w)  Set Parameters to default
(x)  Exit
--------------------------------------------------------------------------------
Select item:
--------------------------------------------------------------------------------
```

The VMEbus arbiter/requester/time-out menu (Figure 8.5 ‘VMEbus Arbiter/Requester/Time-out Parameter’) and the VMEbus interrupt parameter menu (Figure 8.6 ‘VMEbus Interrupt Parameter’) are used to change the parameters used for VIC initialization.

Figure 8.5 VMEbus Arbiter/Requester/Time-out Parameter

```
--------------------------------------------------------------------------------
VME Arbiter/Requester/Timeout Parameters
--------------------------------------------------------------------------------
Parameter Name:               Current Setting:         Factory Setting:

(a)  *System Controller*      Enabled                  Enabled
(b)  Bus Arbitration          Round Robin              Round Robin
(c)  VME Bus Timeout          16us                     16us
(d)  Local Bus Timout Period  64us                     64us
(e)  Include VME Acquis. time No                       No
(f)  Bus Request on level     BR3                      BR3
(g)  Bus Request Fairness     Disabled                 Disabled
(h)  Bus Release Control      Release on request       Release on request



(w)  Set Parameters to default
(x)  Exit
--------------------------------------------------------------------------------
Select item:
--------------------------------------------------------------------------------
```

Figure 8.6 VMEbus Interrupt Parameter

```
--------------------------------------------------------------------------------
VME Interrupt Parameters
--------------------------------------------------------------------------------
Parameter Name:               Current Setting:         Factory Setting:

(a)  *Interrupting ICGS*      ICGS3                    ICGS3
(b)  *Interrupting ICMS*      ICMS3                    ICMS3
(c)  VME IRQ Handler Level 1  Disabled                 Disabled
(d)  VME IRQ Handler Level 2  Disabled                 Disabled
(e)  VME IRQ Handler Level 3  Disabled                 Disabled
(f)  VME IRQ Handler Level 4  Disabled                 Disabled
(g)  VME IRQ Handler Level 5  Disabled                 Disabled
(h)  VME IRQ Handler Level 6  Disabled                 Disabled
(i)  VME IRQ Handler Level 7  Disabled                 Disabled


(w)  Set Parameters to default
(x)  Exit
--------------------------------------------------------------------------------
Select item:
--------------------------------------------------------------------------------
```

The serial interface menu is used to change the parameters of the serial interface channels (Figure 8.7 ‘Serial Interface Menu’). A submenu for each serial channel allows to change the baud rate, bits per character, parity, and the number of stop bits (Figure 8.8 ‘Serial Port 1 Parameters’).

Figure 8.7 Serial Interface Menu

```
--------------------------------------------------------------------------------
Serial Interface Menu
--------------------------------------------------------------------------------




                        (a)  Serial Port 1
                        (b)  Serial Port 2
                        (c)  Serial Port 3
                        (d)  Serial Port 4

                        (x)  Exit




--------------------------------------------------------------------------------
Select item:
--------------------------------------------------------------------------------
```

Figure 8.8 Serial Port 1 Parameters

```
--------------------------------------------------------------------------------
Serial Port 1 Parameters
--------------------------------------------------------------------------------
Parameter Name:               Current Setting:         Factory Setting:


(a)  Baud Rate                9600                     9600
(b)  Bits/Character           8                        8
(c)  Parity                   none                     none
(d)  Stop Bits                1                        1









(w)  Set Parameters to default
(x)  Exit
--------------------------------------------------------------------------------
Select item:
--------------------------------------------------------------------------------
```

The changeable parameters within the interface menu (Figure 8.9 ‘SCSI/Keyboard Interface Menu’) are a pointer to an alternate keyboard set, the own SCSI ID, and the possibility to generate a SCSI reset during startup.

Figure 8.9 SCSI/Keyboard Interface Menu

```
--------------------------------------------------------------------------------
SCSI/Keyboard Interface Menu
--------------------------------------------------------------------------------
Parameter Name:               Current Setting:         Factory Setting:


(a)  Alternate Keyboard Set   ffffffff                 ffffffff
(b)  SCSI Own ID              07                       07
(c)  SCSI Reset on startup    Enabled                  Enabled









(w)  Set Parameters to default
(x)  Exit
--------------------------------------------------------------------------------
Select item:
--------------------------------------------------------------------------------
```

The boot parameter menu (Figure 8.10 ‘Boot Parameters’) specifies the operating system, the boot device, and the boot device specific parameters. Currently (Rmon 1.6), the RMon bootstrap loader supports only the OS-9 operating system and the following boot devices:

Hard disk:	SCSI ID, LUN
Floppy:	SCFL or TEAC, SCSI ID, LUN
Steamer tape:	SCSI ID, LUN
Ethernet:	Local and remote internet address, boot file name
RAM disk:	Base address of RAM disk
ROM kernel:	Base address of operating system
VME download:	Base address of downloaded operating system

If ROM kernel is selected as boot device, the RMon bootstrap loader uses the longword (base address+4) as program counter.

If VMEbus download is selected as the boot device, the bootstrap loader of the RMon enters a waiting loop. The operating system may now be downloaded by any other board on the VMEbus into the dual-ported RAM at the selected base address. After the complete download is done, a local NMI, generated by the VIC Interprocessor Communication Switch Register 3, let the bootstrap loader continue and start the downloaded operating system like a ROM kernel.

The following program lines show a short example how to generate a NMI:

```
1   nmi()
2     {
3        unsigned char  *icms =   0xffffc026   /* VIC in VME short IO for S2 = C */
4
5        *icms++ = 0;   /* Set intercomunication switch */
6        *icms = 0;     /* Clear intercomunication switch */
7     }
```

Figure 8.10 Boot Parameters

```
-------------------------------------------------------------------------------
Boot Parameters
-------------------------------------------------------------------------------
Parameter Name:              Current Setting:        Factory Setting:


(a)  Operating System        OS-9                    OS-9
(b)  Boot Device             Harddisk                Harddisk
(c)  ID                      06                      06
(d)  LUN                     00                      00









(w)  Set Parameters to default
(x)  Exit
-------------------------------------------------------------------------------
Select item:
-------------------------------------------------------------------------------
```

Within the menu shown in Figure 8.11 ‘Hooks’, pointers to;

- an additional initialization routine,
- a different module entry address,
- a company name, and
- a board name may be defined by the user.

The additional initialization routine is called after the local I/O is initialized if a pointer not equal to $FFFF.FFFF is defined. The initialization routine is a subroutine and must not destroy any data or address register.

If defined (pointer not equal to $FFFF.FFFF), the module entry is used as default value for the RMon **gm** command or is used at startup if hex switch S2 is turned to a position between '8' and 'F'. See also Section 6.6.2 ‘Starting a User Program Module’.

If the pointer is not defined, the user EPROM is used as the module entry.

Figure 8.11 Hooks

```
--------------------------------------------------------------------------------
Hooks
--------------------------------------------------------------------------------
Parameter Name:               Current Setting:         Factory Setting:


(a)  Additonal Init           ffffffff                 ffffffff
(b)  Module Entry             ffffffff                 ffffffff
(c)  Company Name             ffffffff                 ffffffff
(d)  Board Name               ffffffff                 ffffffff









(w)  Set Parameters to default
(x)  Exit
--------------------------------------------------------------------------------
Select item:
--------------------------------------------------------------------------------
```

The settings for quiet mode, autoboot, input port, output port, and watchdog may be changed using the special menu (Figure 8.12 ‘Special Menu’). If the watchdog is enabled, it must be retriggered by the user program or the operating system which is called by the RMon **gm** (or S2 ≥ 8) or **boot** command. While the RMon (including bootstrap loader) is running, the enabled watchdog is retriggered by a service routine of a level 7 interrupt generated by the VIC (vector $42).

Figure 8.12 Special Menu

```
--------------------------------------------------------------------------------
Special
--------------------------------------------------------------------------------
Parameter Name:               Current Setting:         Factory Setting:


(a)  Quiet Mode               Disabled                 Disabled
(b)  Autoboot                 Disabled                 Disabled
(c)  Input Port               Serial Port 1            AT-KBD
(d)  Output Port              Serial Port 1            ??
(e)  Watchdog Timer           Disabled                 Disabled
(f)  Reset Watchdog Counter
(g)  Trigger VME Interrupt    00                       00
(h)  Trigger VME Reset


(w)  Set Parameters to default
(x)  Exit
--------------------------------------------------------------------------------
Select item:
--------------------------------------------------------------------------------
```

8.2 S-Record Format

The S-record format has been developed to facilitate the exchange of programs in printable form between different computers. Each record consists of an ASCII character string which is subdivided into five fields:

Field	No. of Characters	Contents
Type	2	S-records -- S0, S1, S2, etc.
Length	2	Number of characters of the string
Address	4, 6, or 8	4-, 6-, or 8-byte wide address on which the data field shall be loaded
Code	0-2*n	0 to n bytes code
Checksum Complement	2	The lower byte of the one's of the sum of all characters in the length, address, and code fields

The record can be optionally closed by <CR>/<LF>.

There are the following types of S-records:

S0 Header record for a block of S-records. The code field may have optional information about the block.

S1 Record with code and a 2-byte address to where the code shall be loaded.

S2 Record with code and a 3-byte address to where the code shall be loaded.

S3 Record with code and a 4-byte address to where the code shall be loaded.

S5 Record indicating the number of S1-records, S2-records, and S3- records of the block. The number of records is stored in the address field. There is no code field. (Not implemented.)

S7 Closing record for a block of S3-records. The address field may have an optional 4-byte address at which the program can be started.

S8 Closing record for a block of S2-records. The address field may have an optional 3-byte address at which the program can be started.

S9 Closing record for a block of S1-records. The address field may have an optional 2-byte address at which the program can be started.

Every block of S-records must not have more than one closing record.

8.3 Hardware Self Test

After reset, a self test checks all vital parts of the CPU-44. The status display on the front panel is used to signal which test is in progress, or what kind of exception occurred, with a unique number. The status display is updated at the beginning of each test (see Table 2: 'Hardware Test Display Values'). If a test fails or if an exception occurs during the test, the test of that device is repeated until it is successful.

This description reflects version 2.2 of the RMon.

While self test is running the right decimal point of the display is on.

Since the system CIO must be initialized before any value can be displayed, the first number that can normally be seen on the display is '2'. Some tests consist of more than one part. In this case the invisible upper nibble of the display value is used to distinguish between these parts. If such a test fails, it is vital to know the invisible part of the display value (subvalue). The easiest way to check this is to connect a storage oscilloscope to /CSSCIO and to inspect the I/O bus data lines ID (0:7).

Table 8.1 Hardware Test Display-Values

Display	Subvalue (1)	Task in Progress
1	0	First access to the hex display
1	1	Initialize Snoop Control Register
2	0	System CIO initialization
3	0	Calculate checksum of EPROM part
4	0	First access to VIC
4	1	VIC initialization
5	0	RAM test: Long Word access to 0
5	1	RAM test Byte write and long read
5	2	RAM test Word write and long read
5	3	RAM test Random test pattern
6	0	VME Address Decoder access
7	0	Graphic: Access to controller
7	1	GraphicTest of CLUT
7	2	Graphic: Word test pattern to Frame Buffer
7	3	Graphic: Random test pattern
8	0	MK48T12/18: Check if battery empty
8	1	MK48T12/18: RAM test
9	1	Test secondary CPU present
9	2	CL-CD2401: Access to GFRCR
9	3	CL-CD2401: Test register access
9	4	NCR53C720: Check if present
9	0	Warm start entry
A	0	Address error exception
B	0	Bus error exception
C	0	Illegal instruction exception
D	0	Any other exception

1. Nibble not visible.

8.3.1 Reset

Display: undefined (disabled)

If the display remains dark after reset, the following things should be checked:

- PCLK, BCLK and /RESET at U501
- BCLK and /RESET at U1301
- about 4 µs after /RESET has gone high /BR1 should go low
- the arbiter U505 drives /BG1 low
- the CPU U501 asserts /BB, /TS, /TIP, ..., and LA(0:31) = $0000.0000
- the IOC-2 generates /CSFEPR (or /CSUEPR if J1301 is closed)
- the EPROM delivers the first byte of the initial stack pointer
- after some 100 ns the IOC-2 increments EPRA(0:1)
- after four bytes have been fetched the IOC-2 asserts the initial stack pointer at LD(0:31) and gives /TA
- the CPU reads the initial program counter
- the CPU reads the location where the initial program counter points to
- the CPU tests ICR and IOALR registers of the IOC-2 for correct values
- the CPU initializes some IOC-2 registers
- the CPU writes 01 to the display
- the CPU writes the Snoop Control Register (only if layout≥ 2)

8.3.2 System CIO Initialization

Display: 2 Subvalue: 0 (disabled or enabled)

At the end of the initialization the display is enabled. The initialization is only repeated if an exception occurs.

8.3.3 EPROM Checksum

Display: 3 Subvalue: 0

If this test fails the address lines IA(0:19) and LA(0:19) should be checked to determin whether there are shortcuts or interruptions (the data lines should be ok).

8.3.4 First Access to VIC

Display: 4 Subvalue: 0

The only way to fail this test is that an exception occurs (normally bus error) or that the computer hangs. This is the first access from the '020 bus to the '040 bus. The following things should be checked:

- the CPU reads ICFRl of the VIC at $FEC0.l0AF
- the IOC-2 generates /GSEL and /IOAS
- Ul302 generates PBMS and IENADR low
- the IOC-2 drives PAB(0:31)
- Ul808generates/CSVlC
- Ul302 generates /PAS and /PDS
- the VIC asserts PDB(0:7) and/DSACK(0:1)
- Ul302 de-asserts /PAS and /PDS
- Ul302 de-asserts PBMS, /ENADR and asserts /TA

8.3.5 Minimum VIC Initialization

Display: 4 Subvalue: l

This test fails if a value can't be stored in the appropriate VIC register (i.e. the value read differs from the value written). Check the PAB(0:7), PDB(0:7 and PBSW(0:4) lines.

8.3.6 RAM Test

Display: 5 Subvalue: 0

Various test pattern are written to $0000.0000 and read back. If they are not the same, the test is repeated. If the test fails, the following should be inspected:

- refresh is running (/RFACK is low for some 100 ns every 16µs, CAS before RAS refresh on DRAM and VRAM)
- the CPU writes to $0000.0000
- U1801 generates /RAS(0) (early cycle start)
- CASADR becomes high about 13 ns after /RAS(0) goes low
- /RAMSEL becomes low
- U1801 drives NVRB(0:3) low and asserts /CAS(0) low
- U1801 drives /TA low
- U1801 de-asserts/RAS(0) and/CAS(0)
- on the read cycle BOD(0:31) have the same data pattern as during the write

The test may hang if the DRAM controller U1801 fails to generate /TA. If the test is successful, the data lines to bank 0 of the DRAM are aright.

Display 5 Subvalue: 1 and 2

If the test fails, there is normally something wrong with the NVRB(0:3) signals.

Display: 5 Subvalue: 3

If this test fails, there is normally something wrong with the addressing of the DRAM. Inspect VRAD(2:8), RA(8:10) and IA(23:24). Also there may be something wrong with bank 1 of the DRAM (if present).

8.3.7 VMEbus Address Decoder

Display: 6 Subvalue: 0

Since the VMEbus decoders can't be read back, this test only fails if an exception occurs.

8.3.8 Access to Video Controller

Display: 7 Subvalue: 0

If the first access to the video controller ends in a bus error, it is assumed that the board has no graphic interface and none of the following graphic tests is performed. The board then uses the serial port for I/O.

8.3.9 Test of CLUT

Display: 7 Subvalue: 1

The CLUT of the video controller is written with random values and then read back. If the values are not the same, the test is repeated. This tests the data and address lines to the video controller MPAD(0:23). Note that the CLUT registers are only 24 bits wide. A microport write cycle roughly runs in the following order:

- the CPU writes to the CLUT
- the IOC-2 generates /GSEL and /IOAS
- address decoder U1808 generates /MPSEL
- the microport arbiter in U1801 generates /BGMICRO when Ul302 has driven PBMS low and no transfer cycle is running or pending
- U1001 and U1003 drive the address to MPAD(2:11)
- U1202 generates/CSVCNTR
- U1201 asserts VIDCWT as long as the write is in progress
- U1001 and U1002 drive the data to MPAD(0:23)
- U1202 asserts NVEVCNTR
- U1201 de-asserts VIDCWT and U1202 asserts /DSACK(0:1)

Read cycles are very similar to write cycles. The main difference is that /OEVCNTR is used instead of N~EVCNTR and that the direction of the data buffers is reversed.

8.3.10 Video RAM Test

Display: 7 Subvalue: 2 and 3

These tests are very similar to the RAM tests described in Section 3.6 'RAM Test'.

8.3.11 MK48T12/18 BatteIg Test

Display: 8 Subvalue: 0

If the battery of the MK48T12/18 is exhausted, the first write operation after power-on fails. If this happens, the RMon uses EPROM initialization values regardless of the setting of the hex switch S902 and a message is printed.

8.3.12 MK48T12/18 RAM Test

Display: 8 Subvalue: 1

One byte of the SRAM is tested with some test pattern.

8.3.13 Secondary CPU

Display: 9 Subvalue: 1

The presence of a secondary CPU is tested by trying to run a small program on it. If the secondary CPU is present, it alters a memory location. This can be detected by the primary CPU.

8.3.14 Serial Controller Access

Display: 9 Subvalue: 2

This test fails if there is a bus error or if the Global Firmware Revision Code Register is zero.

8.3.15 Serial Controller Register Test

Display: 9 Subvalue: 3

Various test patterns are written to the A Receive Buffer Address Lower register of the CL-CD2401. The test fails if the values read are different from written values.

8.3.16 SCSI Controller

Display: 9 Subvalue: 4

The NCR53C720 is reset and two registers are tested to determin whether they have the correct initial values. If not, a flag is set which later prevents initialization of the NCR53C720, leading to a hang-up. If the NCR53C720 is not present, booting and using the RMon SCSI command also causes a hang-up, but at least RMon runs.

8.3.17 Watchdog

During a test, the watchdog may be triggered unintentionally. In this case the board is reset after the watchdog period has expired and the left decimal point on the display is set. Typically this happens periodically. Note that the watchdog input of the MAX695 has a rather high impedance, so that moisture or dirt on the board may trigger the watchdog.

8.3.18 Halt and Hang-up

There are several ways the computer can crash.

The CPU enters the HALT state when nested exceptions occur. In this case the LED near the reset button on the front panel goes off.

The CPU accesses an address where no /TA or /TEA occurs. In this case the LED near the reset button stays on and /BB and /TIP are low all the time. Normally no such holes exist in the address map of the CPU-44, so that this only happens when the addressed device doesn't respond.

The CPU accesses an address where it always gets a retry acknowledge (/TA and /TEA low). This happens if FIRES gets stuck high or /BG20 gets stuck low.

8.3.19 Exceptions

If an exception occurs during self test, the exception handler writes one of the letters 'A', 'B', 'C', or 'D' onto the display (depending on the kind of exception) and enters a delay loop, so that the letter can be recognized. After that the faulty test is repeated. This typically leads to the next exception so that two altering letters can be seen on the display.

There is a little trap in conjunction with the display because the upper nibble of port C of the CIO is used as write enable for the lower nibble (only those bits in the lower nibble are written where the corresponding bit in the upper nibble is clear). Alternating writes of $14 and $0B for example lead to alternating '5' and 'B' on the display.

8.3.20 Untested Peripherals

The User CIO and the Ethernet Controller are not tested because they are not necessary for RMon.