SCM-301
SCSI - CAMAC
CRATE CONTROLLER
(301-2 Fast CAMAC)

7th Edition (05/01/08)

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1.0 GENERAL INFORMATION

1.1 INTRODUCTION

This manual describes the installation, operation, and programming of SPARROW's SCM-301-2 CAMAC SCSI Bus crate controllers. It is assumed that the user is familiar with the CAMAC system, as described in IEEE Standards 583 and 675. Knowledge of the SCSI-2 specification, ANSI Standard X3.131, while not required, will be helpful, especially in writing software using the SCSI message system, and interpreting the controller's replies to various SCSI commands.

1.2 UNPACKING

Please inspect the shipment thoroughly upon delivery. Check the contents against the enclosed Shipping List to insure that the delivery is complete. If the shipment is damaged, please notify SPARROW. If the damage is due to mishandling during shipment, you may be requested to assist in contacting the carrier and filing a damage claim.

1.3 WARRANTY

SPARROW warrants its products to operate within specifications under normal use and service for a period of one year (12 months) from the date of shipment. Products not manufactured by SPARROW are covered by the original equipment manufacturer's warranty only.

In exercising this warranty, SPARROW will repair or, at its option, replace any product returned, provided that the warrantor's examination discloses that the product is defective due to workmanship or materials and has not been caused by misuse, neglect, accident or abnormal conditions or operations. SPARROW does not warrant that the operation of the software and/or hardware shall be uninterrupted or error free.

The purchaser is responsible for the transportation and insurance charges arising from the return of products to the servicing facility. SPARROW will return all in-warranty products with transportation prepaid.

This warranty is in lieu of all other warranties, express or implied, including but not limited to any implied warranty of merchantability, fitness, or adequacy for any particular purpose or use. SPARROW shall not be liable for any special, incidental, or consequential damages, whether in contract, or otherwise.

1.4 CANCELLATION OF ORDERS/RETURN OF PRODUCTS

If an order with SPARROW is canceled before products are shipped, there is no cancellation charge. In order to return unwanted products that have been ordered from SPARROW, they must be returned within 30 days of receipt by the customer. A restocking fee of 15% is applied to all returns of unwanted products. Before returning a product to SPARROW, please obtain a Return Authorization Number (RAN).

1.5 REPAIR SERVICE

If it becomes necessary to return a product for repair, the following steps should be taken before returning any product:

1. Contact SPARROW to discuss the problem with Technical Support Staff
2. Obtain a Return Authorization Number (RAN)
3. Initiate a Purchase Order for estimated repair charge if the product is out of warranty
4. Include a description of the problem with the product
5. Ship the product with the RAN marked on the outside of the package to SPARROW

Failure to follow these steps may cause unnecessary delays in getting the product repaired.

1.6 ASSISTANCE

Technical assistance in the proper installation, and operation of the SCM-301 CAMAC crate controller is available from SPARROW.

Please e-mail your questions to: <support@sparrowcorp.com>.
You can also contact SPARROW via fax at (386) 845-9352 or you may call SPARROW offices during regular business hours M-F, 8am -5pm EST at (800) 792-1452.

Supplemental services such as installation, training, integration, and custom modifications are available through specific agreements. Please contact SPARROW for details.

IMPORTANT NOTICE:

All users should confirm that the SCM-301 is configured for their specific application. Configuration includes:

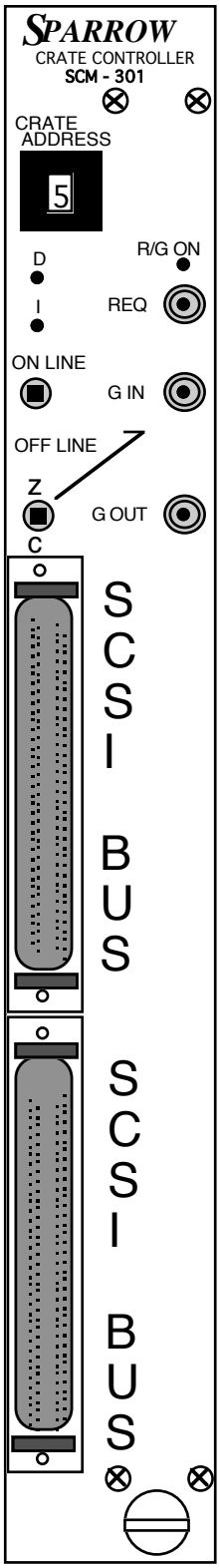
1. Setting the piano switch which is accessible from the top of a module (see section 3.8)

2. Setting the byte order switch under the side cover (see section 3 1. and figure 1)

3. Setting the SCSI address on the front panel.

When using the SCM-301 with Kmax, do not enable demands:
(F = 26, N = 30, A = 10).
This controller mode is incompatible with the software.

2.0 GENERAL DESCRIPTION



The SCM-301 crate controller is a double-width CAMAC module that interfaces a CAMAC crate to any computer supporting the ANSI standard Small Computer System Interface (SCSI) Bus. Several CAMAC crates with SCM-301 controllers can be intermixed with other SCSI devices on a single SCSI port, which can support up to 7 devices. The single-ended SCSI bus is employed, allowing a maximum bus length of six meters. The controller has two SCSI-2 high-density shielded connectors, allowing devices to be daisy-chained.

The SCM-301 obeys all mandatory requirements in the SCSI-2 specification. All types of CAMAC operations are permitted, including high-speed Block transfers under hardware control. Any of three ESONE standard modes can be selected, Address Scan, Q-Stop, or Q-Repeat. During block transfers, only data is transferred on the SCSI Bus. For any transfer, the user can elect to transfer either two or three data bytes for each CAMAC cycle. In the latter case, an additional null byte is inserted in the data stream so that 24 bit data is aligned on 32 bit memory boundaries. The order of byte transmission is user selectable as high order first or low order first. The SCM-301 can operate in synchronous as well as asynchronous SCSI mode. In synchronous mode, data us FIFO buffered within the SCM-301, allowing transfers to take place at close to the full speed of the CAMAC Dataway.

SCM-301 modules asserting LAM's can interrupt the computer using the SCSI Asynchronous Event Notification (AEN) protocol. In the course of this protocol, the complete pattern of asserted LAM's from a single crate is transferred to the host, which can determine the crate ID during the selection process. Note that the host computer must be capable of operating in Target mode to use this protocol. In other respects, the SCM-301 provides the same functionality as the Type A CAMAC controller, including the Station Number Register, and uses the same codes for commands addressed to the controller itself. Therefore, the Read-L command can be used to poll for LAMs. In addition, the SCM-301 incorporates a LAM mask register.

The SCM-301 contains a 24 bit mailbox register with flags to facilitate interprocessor communication. The controller functions only as a master controller, but does support the Auxiliary Control Bus. Therefore, the SCM-301 must reside in the rightmost station of a crate, but other auxiliary controllers may also be present, and use either the Request/Grant or AC Lockout protocol.

The SCM-301 with option 1 (SCM-301-1), can function as either a master or auxiliary crate controller. Changing from one role to the other is accomplished by setting DIP switches. The SCM-301-2 provides a level-1, FASTCAMAC read mode (F= 5). To use the FASTCAMAC option, you must have a target CAMAC module which is FASTCAMAC capable and recognizes the F5 for readout.

2.1 SOFTWARE SUPPORT

CAMAC data acquisition with the SCM-301 is supported by the Kmax environment on the Macintosh, Linux, and Windows platforms. This program is also available from SPARROW. The Kmax software features event-by-event or singles data recording with advanced tools for replay, sorting, 2-D and 3-D visualization, and data analysis. Custom instrument panels and toolsheets may be built for process control applications using standard OS mechanisms. Alarms, dials and digital panel meters may be included on the panel. No formal programming experience is required to setup and execute a data-acquisition/process-control task.

A built-in scripting language, Command Sequence Language, provides a complete set of English-like commands which may be grouped into command sequences to perform any necessary function including CAMAC and/or VME module I/O. Command Sequence Language may be extended by the user via an external command interface. External commands and functions may be written in any high level programming language and are compiled and installed into Kmax using standard programming tools. Special "Module Description Resources" contain detailed information about individual CAMAC modules and are used to aid the user in setting up a particular application.

3.0 INSTALLATION

The following sections contain information pertinent to the SCM-301-2, except where differences are specifically noted. In order to communicate with SCSI devices, a SCSI host adapter will have to be installed. In addition, the correct drivers must also be installed.

3.1 BYTE TRANSMISSION MODE

The order of byte significance is determined by a 2-position strap located on the printed circuit board between U29 and Q3 (Figure 1). Some computers expect the most significant byte of a longword to reside at the highest memory address. For these, the least significant byte of each CAMAC word must be transmitted first. This is sometimes referred to as the "little endian" byte order. Other computers are "big endian", i.e., the most significant byte must be transmitted first. If the strap spans X1 and X2, the big endian byte order results. Otherwise, the strap should span X2 and X3. Computers from DEC, and 80x86 based PC's are little endian. Machines based on 680x0 processors, such as Macintosh, are big endian, as are HP, Sun, and IBM RS/6000 workstations. VME processors are also generally big endian. Note that the byte order for commands described in the SCSI standard are not affected by jumper placement.

3.2 HOST ID

Before the controller is installed in the crate, the SCSI ID of the host must be determined and straps inside the controller set accordingly. This setting is used by the controller when selecting the host for LAM notification and is not required only if AEN LAMs are going to be used. The possible host IDs are 0, 1, 6 or 7. It is set at 6 prior to delivery to the customer. The top cover must be removed to change this setting, which will be done rarely. Figure 1 shows the strap locations for the different choices. If a host ID different from the above choices is required, the factory should be contacted.

3.3 INTERNAL SWITCHES, SCM-301

The standard SCM-301 has a 4-position piano switch accessible at the top edge of the module. Only positions 1, 3 and 4 are used. Switch 1 determines whether the SCM-301 maintains continuous control of the CAMAC Dataway during a block transfer. If this switch is ON, the SCM-301 releases the Dataway after each CAMAC cycle, and must re-arbitrate with other controllers before starting another cycle. If switch 1 is OFF, the SCM-301 does not arbitrate after the first cycle, and therefore runs somewhat faster. However, other controllers are prevented from doing cycles until the block is completed. The switch should be OFF if there are no other controllers in the crate.

If switch 3 is OFF, the controller will operate in ACL (Auxiliary Controller Lockout) mode. When instructed to perform a Dataway cycle, it will assert the ACL signal on the Auxiliary Control Bus, and proceed to perform a Dataway cycle as soon as it detects that the Dataway is not busy. The ACL signal assures that the bus will be available within 600 nanoseconds, by forcing active controllers to abort their cycles if they are in early stages. There can only be one controller in a crate operating in ACL mode, but it need not be the master controller (i.e. occupy the rightmost position). CAMAC Serial crate controllers normally operate in ACL mode.

Request/Grant is the preferred method of operating multiple controllers in a crate. If switch 3 is ON, the Request LEMO connector must be patched to the Grant-In Lemo of the highest priority controller. This controller's Grant-Out must be connected to the Grant-In of the next highest priority controller, and so on. The Request LEMO of all controllers carry the same signal. Only one is used. If there is an ACL mode controller in the crate, it does not participate in the grant chain, as it will preempt all other controllers as noted above. If there is only one controller in a crate (occupying the rightmost position), it can operate in either mode. If it is in the R/G mode, Grant-In must be patched to Request.

Switch 4 enables a 24-bit LAM mask register, that can be overwritten by the CAMAC command (F16)N(30)A(0). If the mask register is enabled, only LAMS from stations corresponding to a set mask bit will be returned by a read-L command or generate an interrupt. If switch 4 is off, all LAMs will be recognized.

3.4 BUS TERMINATION

Multiple SCSI controllers can be daisy-chained on a single SCSI bus, by interconnecting the SCSI-2 high density connectors on the front panel. The connectors are identical; either can serve as input or output. Up to seven SCSI devices may reside on the bus, but one of these is normally the host. The total bus length is limited to six meters by the SCSI standard.

The SCSI bus must be terminated at each end with resistor networks or their equivalents, which require power. A wire in the cable is dedicated to this purpose. The SCSI Standard states that this line must be powered by all SCSI "Initiators". The Host interface normally serves this function, as well as providing back termination of the Bus. In accordance with the Standard, the SCM-301 does not provide continuity between connectors for terminator power from the host.

The SCSI bus is internally terminated within the SCM-301 by resistor networks in sockets at locations shown in Figure 1. These resistors are powered by the Crate, and do not use the TERTMPWR line in the SCSI bus. The unit is normally shipped with these networks in place, and they should be removed from all but the last controller in a multi-crate system. Alternatively, all terminators can be removed, and a SCSI terminator plug inserted in the unused bus connector of the last device. If it is required that the SCM-301 power the bus terminator line in the cable, the factory should be contacted.

NOTE

Some commercially available SCSI terminators do not include filtering on the incoming power line. This together the reactance of the single wire providing the power, could result in spurious signal transitions (glitches) if many lines switch at once. Some computers (such as the IBM RS/6000 and the MAC IIFX) employ special terminators to reduce these effects. However, the internal terminations in the SCM-301 have proved satisfactory in all cases tested.

3.5 SCSI ID

The SCSI ID of the controller is set by a front panel thumbwheel switch. An ID from 0 to 7 must be selected that differs from all other devices on the bus (including the host). If LAMs are expected from several different crates, the higher IDs should be assigned to crates with the higher priority LAM sources, since the bus arbitration protocol favors higher device IDs. Note that if the SCSI ID of the controller is changed while the crate is powered, a reset is necessary before the changed ID is recognized.

3.6 STATION

The standard SCM-301 (master only) must be installed in the rightmost two CAMAC stations. The SCM-301-2 may be installed in any stations, but a master controller or equivalent must reside in the rightmost position.

The SCM-301-2 has three multi-pole piano switches at the rear, between the finger areas of the circuit boards. For master controller operation, all switches must be ON, and the module must be placed in the rightmost two stations of the crate. For operation as an auxiliary controller, the switches must be "OFF". In this case the controller can reside in any stations except the rightmost (control) station.

3.7 AUXILIARY CONTROL BUS

If more than one controller resides in a crate, all must be interconnected by the Auxiliary Control Bus. This is a 40-conductor ribbon cable that interconnects the auxiliary bus connectors found on the rear of all controllers above the Dataway edge connectors. If the SCM-301-2 is to be used as an auxiliary controller in conjunction with a serial crate controller, a modified auxiliary control bus is used. Refer to the appropriate manual for the connections.

3.8 INTERNAL SWITCHES, SCM-301-2

The SCM-301-2 has an eight-pole piano switch in place of the four-pole switch on the standard model. The function of these switches is as follows:

SWITCH	LABEL	FUNCTION
1	Re Arb	Arbitrate Each Cycle
2	none	Not used. Should be OFF
3	R/G	Selects Request/Grant mode
4	LAM Mask	Enables the LAM Mask Register
5	Mailbox	Enables the Mailbox Register
6	GL24	LAM asserted as internal L24
7	L24	LAM asserted on Dataway L24
8	L23	LAM asserted on Dataway L23

Switches 1, 3, and 4 are the same as on the standard model, described above. Switch 5 enables a 24-bit mailbox, with associated LAM source. This register can be accessed via the SCSI Bus, or by another controller via the Dataway, and the LAM source can be set or cleared by CAMAC commands, detailed in section 6. The LAM signal is asserted on the normal Dataway L contact at the higher numbered of the two slots occupied by the controller. There is, however, no provision for an L25 signal, so that if the SCM-301 is in the master position, it's LAM cannot be recognized normally. If switch 6 is set, the LAM signal will be returned as bit 24 of a SCSI bus READ-L command and can generate an interrupt if unmasked. If switch 7 is set, the LAM signal will be asserted on an auxiliary control bus L24 line, and can be recognized by an auxiliary controller. If switch 8 is set, the LAM will be asserted on the L23 line. Note that if switches 7 and 8 are both set, a direct connection exists between L23 & L24 on the dataway and the ACB.

4.0 INDICATORS

There are three indicators on the front panel of either model. The D light will be on if there is any unmasked LAM asserted in the Crate. If the LAM Mask is disabled, the D light will be illuminated if there is a LAM from any station.

The I light will be on if the Dataway Inhibit line is asserted, either by the SCM-301 or another controller. The user should be aware that the effect of Inhibit depends only on the specific CAMAC module in use. No features of the Crate controller are affected by Inhibit.

The R/G ON light tells the operator the position of the internal switch selecting the Request/Grant or ACL arbitration mode.

5.0 OPERATION

The only operator controls on SCM 301-2 are the ON/OFF line switch, and a two-position momentary switch that generates the Dataway Initialize (Z) or Clear (C) CAMAC cycles. In the Off-Line state, the controller responds appropriately to SCSI protocol commands, but will not perform CAMAC cycles. Instead, an error status is returned. The Z/C switch is only active in the Off-Line state. Manual C affects only CAMAC modules, and does not change the internal state of the controller. Manual Z initializes all CAMAC modules as well as the controller. It is equivalent to power-on reset. It sets Dataway Inhibit, disables LAMs, and establishes the SCSI UNIT ATTENTION condition. The controller can be switched off line, and the manual Z switch actuated at any time, without causing SCSI protocol errors, as the action is delayed until the SCSI bus is not busy. Manual Z should be used if the controller's SCSI ID has been changed while the crate is powered, so that the new ID is recognized. Manual Z does not affect other devices on the SCSI bus.

6.0 PROGRAMMING

In order to issue a command to the SCM-301, the host interface must perform the following tasks, in the appropriate SCSI Bus phase. Many of these tasks are automatically performed, in a fashion transparent to the user, by the SCSI driver provided by many host processor vendors.

1. Bus Arbitration
2. Select the controller
3. Send the Identify message
4. Send the Command Descriptor Block
5. Send or Receive Data
6. Receive the Status Byte
7. Receive the Command Complete Message

Bus Arbitration is only required if there are devices on the bus, other than the host interface, that might become SCSI Initiators. Note that the SCM-301 controller can become a (temporary) Initiator for the purpose of transmitting a LAM message. Therefore, arbitration by the host is required if LAM's are enabled. The hardware of the host SCSI interface normally performs the Arbitration procedure, but this can be skipped if there are no other potential Initiators.

The controller is selected by asserting the SCSI Data line corresponding to the controller ID, together with the SCSI SEL signal. The line associated with the host ID may optionally be included. The selected controller will respond by asserting the SCSI BSY signal, and the enter target mode. The SCSI target determines the type and direction of data transfer on the bus by controlling the signals C/D, I/O, and MSG. These signals determine the bus "Phase", in accordance with the following table:

Phase	C/D	I/O	MSG
Command	1	0	0
Data Out	0	0	0
Data In0	1	0	
Status	1	1	0
Message Out	1	0	1
Message In	1	1	1

The "In" direction indicates a transfer from the target to the Initiator (controller to host). The host interface, acting as Initiator, should monitor the bus phase, and send or receive the type of data requested by the target. Since the sequence of bus phases is normally known to the host, an anomalous phase is indicative of an error condition. The Message Phases are used for physical path management, and to recover from error conditions.

In accordance with the SCSI-2 specification, the host should select the SCM-301 with the ATN signal asserted, causing the controller to enter the Message Out phase initially. The controller then expects the host to send a one byte IDENTIFY message that selects the logical unit within the target. This message is described in section 7. If the host continues to assert ATN, the controller will remain in Message Out phase, and the host may send another message such as a SYNCHRONOUS DATA TRANSFER REQUEST. When ATN is no longer asserted, the controller enters Command Phase, and expects the host to send a Command Descriptor Block. The following commands are accepted by the SCM-301.

1. INQUIRY
2. TEST UNIT READY
3. REQUEST SENSE
4. CAMAC Commands

The Command Descriptor Blocks accepted by the SCM-301 are either 6 or 10 bytes long, and will be described in the next section. Following the Command Phase, the controller will enter Data Phase if the command involves a data transfer, is valid, and contains no errors. Following this, the controller will enter Status Phase, and send one byte of status. If the command is invalid, does not involve a data transfer, or for some reason cannot be performed, the controller will proceed directly from Command Phase to Status Phase. Only three possible status bytes are generated by the SCM-301:

Value	Status
0	GOOD
2	CHECK CONDITION
4	CONDITION MET

CHECK CONDITION status indicates an error. The REQUEST SENSE command may be used to determine the cause. CONDITION MET status is used to return the value of the CAMAC Q signal during a CAMAC non-data command. A status of 4 indicates Q=1, 0 indicates Q=0. Data transfer commands will not return CONDITION MET status. Following the Status Phase, the controller will enter Message In phase, and send a single null byte as required by the standard. It will then cause the bus to go free. Linked commands are not presently supported by the SCM-301.

6.1 INQUIRY COMMAND

The INQUIRY command may be issued at any time to determine the characteristics of any logical unit on any target. 36 bytes of information are returned indicating the type of device attached, the manufacturer, model number, and revision level. The command is generally issued by an operating system at start-up, but may be issued by a user. The Command Descriptor Block is as follows:

INQUIRY Command

Bit Byte	7	6	5	4	3	2	1	0
0	Operation Code (12h)							
1	Logical Unit Number			Reserved				EVPD
2	Page Code							
3	Reserved							
4	Allocation Length							
5	Vendor Specific		Reserved				Flag	Link

All reserved fields in all SCSI commands must be zero. In accordance with the Standard, the SCM-301 will reject any command violating this rule. The only valid Logical Unit Number for the SCM-301 is 0. The EVPD, Page Code, Vendor Specific, Flag, and Link fields must also be 0. The Allocation Length is the number of data bytes that the host expects the controller to return, and is typically 36 (decimal), but may be less (in which case the returned data will be truncated).

The data returned by the SCM-301 conforms to Table 7-15 of the SCSI Standard. Prior to Serial Number 354, the device type returned was 1Fh. This was incompatible with the Windows 95 boot sequence. Controllers with Serial Number 354 and above report SCSI device type 3 in response to the SCSI inquiry command. The Peripheral Qualifier will be 000b if the controller is on-line, or 001b if off-line. If a non-zero logical unit is specified (in the preceding IDENTIFY message), the Peripheral Qualifier will be 011b. The INQUIRY command will return GOOD Status unless an improper bit is detected in the Command Descriptor Block.

6.2 TEST UNIT READY COMMAND

The TEST UNIT READY command is a rapid way to determine if the controller is ready to accept data transfer commands, since there is no associated data phase. The TEST UNIT READY command returns GOOD status if the controller is ready. There are two situations in which it may not be ready, and will return CHECK CONDITION status in response to this command: (a) The controller has been switched off-line, or (b) The UNIT ATTENTION condition exists. THE UNIT ATTENTION condition is established at crate power-up, by SCSI Bus Reset, by receipt of a BUS DEVICE RESET message, or by a manual Dataway reset (manual Z). While the UNIT ATTENTION condition exists, CAMAC commands and the TEST UNIT READY command return CHECK CONDITION status, and CAMAC commands cannot execute. After this status is transmitted, a "Contingent Allegiance" is said to exist, and the UNIT ATTENTION is cleared. A REQUEST SENSE command, if issued at this time, would return a Sense Key indicating UNIT ATTENTION. Note that the sense data is cleared after a REQUEST SENSE command, or if another TEST UNIT READY or CAMAC command is issued.

NOTE

The SCM-301 will be ready to process SCSI commands within 25 microseconds of power-up or reset. It will, however, be in the Unit Attention condition, which must be removed before CAMAC transfers can take place (including CAMAC non-data commands). This can be done by issuing a single TEST UNIT READY command (which will return Check Condition status). It is not necessary to issue a REQUEST SENSE command, but if this is not done an error in the command itself will go undetected. Conservative practice is to issue TEST UNIT READY commands until GOOD STATUS is returned.

The format of the TEST UNIT READY command follows:

TEST UNITY READY Command

Bit Byte	7	6	5	4	3	2	1	0
0	Operation Code (00h)							
1	Logical Unit Number			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							
5	Vendor Specific		Reserved				Flag	Link

The Logical Unit field, Reserved fields, and all fields of byte 5 should be 0. If any are non-zero, CHECK CONDITION status will be returned and a Sense Key of "illegal request" established for a future REQUEST SENSE command. A similar result will be obtained if the preceding IDENTIFY message specified a non-zero logical unit. The two conditions differ in the "Additional Sense Code", as noted later.

6.3 REQUEST SENSE COMMAND

The REQUEST SENSE command is normally issued after a CHECK CONDITION status is returned by any command, to determine the reason. The format of the Command Descriptor Block follows:

REQUEST SENSE Command

Bit Byte	7	6	5	4	3	2	1	0
0	Operation Code (03h)							
1	Logical Unit Number			Reserved				
2	Reserved							
3	Reserved							
4	Allocation Length							
5	Vendor Specific		Reserved				Flag	Link

Bytes 1, 2, 3, and 5 should be 0, or the command itself will return CHECK CONDITION status ("illegal request"). The Allocation Length is the number of bytes the host expects in reply. In accordance with the Standard, the SCM-301 can return 18 (decimal) bytes of sense data, using the format and codes specified in the Standard. The reply format follows. It will be noted that the last 5 bytes of the standard reply convey no useful information in the present context, so that an improvement in throughput could be achieved by lowering the allocation length to 13.

Sense Data Format

Bit Byte	7	6	5	4	3	2	1	0
0	Valid	Error Code (70h)						
1	Segment Number (0)							
2	0	0	0	0	Sense Key			
3	FIFO Status							
4	(MSB)							
5	DMA Byte Count							
6								(LSB)
7	Additional Sense Length (10)							
8								
9	0							
10								
11								
12	Additional Sense Code							
13								
14	0							
15								
16								
17								

The following Sense Keys may be returned by the SCM-301:

Sense Key	Description
0h	NO SENSE - No specific sense key is available. Would be the case if a REQUEST SENSE were issued after a successful command.
2h	NOT READY - controller was off-line
4h	HARDWARE ERROR - Parity error during data transfer or CAMAC module did not return X signal.
5h	ILLEGAL REQUEST - A non-zero logical unit was selected, or a command was issued that is not implemented or contained an improper bit (possibly in IDENTIFY msg.)

6h UNIT ATTENTION - The controller has been reset.

9h SHORT TRANSFER - A stop-mode block transfer did not transfer the expected number of bytes because a CAMAC cycle failed to return the Q signal.

Bh ABORTED Command - The controller aborted the command

In those cases where the sense key leaves some doubt as to the exact cause of an error, the Additional Sense Code (ASC) provides more specifics. The following ASC's from the SCSI-2 Standard may be encountered:

00h	No additional sense information
04h	Controller off-line
20h	Invalid Command Operation Code
24h	Invalid field in CDB
25h	Logical unit not supported
29h	Power on reset of Bus Device Reset occurred
3Dh	Invalid bit in IDENTIFY message
44h	CAMAC Cycle did not return X=1
47h	SCSI Parity error
48h	INITIATOR DETECTED ERROR message received
80h	CAMAC cycle did not return Q=1

Bytes 3 through 6 are the "information" field of the standard sense reply, and pertain to improperly terminated block transfers. They will be described later.

NOTE

While the SCSI Bus will operate properly with a controller off-line, all controllers on the Bus must be powered at all times, regardless of the method used to terminate the Bus.

6.4 CAMAC COMMANDS

The SCSI Standard does not provide for a device like a CAMAC crate. Therefore, non-standard Command Descriptor Blocks are used, following the IDENTIFY message of the SCSI-2 specification. Both 6 and 10 byte commands are used, the latter only for block data transfers of 256 or more bytes in length.

6.4.1 CAMAC NON-DATA COMMANDS

A CAMAC non-data command has a function code between 8 and 15, or between 24 and 31 (the F8 bit set). The Command Descriptor Block for a non-data CAMAC command consists of 6 bytes as follows:

CAMAC Non-Data Command

Bit Byte	7	6	5	4	3	2	1	0
0	Operation Code (01h)							
1	Logical Unit Number			F16	1	F4	F2	F1
2	0	0	0	N16	N8	N4	N2	N1
3	0	0	0	0	A8	A4	A2	A1
4	0							
5	Control Byte (0)							

After the command is executed, the controller proceeds to the Status Phase, and returns one of the following status bytes, and then the Command Complete message (which is null):

Status Byte	Description
0	GOOD Status, Q=0
2	CHECK CONDITION (Error)
4	GOOD Status, Q=1

If CHECK CONDITION status is returned, the REQUEST SENSE command may be issued to determine the reason.

6.5 CAMAC DATA TRANSFERS

CAMAC data transfers use the same Operation Code (Byte 0) for reads and writes (unlike other SCSI commands). The distinction is conveyed in the CAMAC Function Code within the Command Descriptor Block. A distinction is made, however, between commands with a transfer length less than 256 bytes, and those with 256 or more. Short transfers use a 6 byte Command Descriptor Block, and long transfers 10. Either type of transfer may be made in either 16 or 24 bit mode. The former only transfers data on the low order 16 data lines of the CAMAC Dataway, and therefore requires only two bytes to transfer a CAMAC word on the SCSI Bus. In 24 bit mode, all Dataway data lines are used, and three bytes are required for each Dataway cycle. In order to align memory data on fullword boundaries in 24 bit mode, a null byte is inserted in the SCSI data stream as the most significant byte of each CAMAC word transferred.

Transfer lengths are always stated in bytes, and therefore will be two or four times the number of CAMAC words involved.

NOTE

Inexperienced CAMAC users are often disturbed to find non-zero bits appearing on the high order eight Dataway write lines (W17-W24) when using 16-bit mode. This is unavoidable, as the Dataway is "hard-wired" to use 24 bits. If it is desired to use 16-bit mode with modules sensitive to all 24 bits, a single 24 bit write command may be issued with a null high order byte. Following this 16 bit mode may be used, and the high order bits will be 0.

6.5.1 SHORT CAMAC TRANSFERS

The Command Descriptor Block for transfers of less than 256 bytes consists of the following 6 bytes:

CAMAC Short Data Transfer Command

Bit Byte	7	6	5	4	3	2	1	0
0	Operation Code (01h)							
1	Logical Unit Number			F16	0	F4	F2	F1
2	M1	M2	S	N16	N8	N4	N2	N1
3	0	0	0	0	A8	A4	A2	A1
4	Transfer Length							
5	Control Byte (0)							

6.5.2 LONG CAMAC TRANSFERS

CAMAC data transfers with a length of 256 or more bytes use a 10 byte Command Descriptor Block as follows:

CAMAC Long Transfer Command

Bit Byte	7	6	5	4	3	2	1	0
0	Operation Code (21h)							
1	Logical Unit Number			Reserved				
2	Reserved			F16	0	F4	F2	F1
3	M1	M2	S	N16	N8	N4	N2	N1
4	0	0	0	0	A8	A4	A2	A1
5	Reserved							
6	(MSB)							
7	Transfer Length							
8								(LSB)
9	Control Byte (0)							

6.5.3 TRANSFER MODES

For either short or long transfers, the M1, M2 and S bits specify the mode of transfer as follows:

M1	M2	S	Transfer Mode
0	0	0	Single Word, 16 bit Mode
0	1	0	Address Scan, 16 bit Mode
1	0	0	Q-Stop, 16 bit Mode
1	1	0	Q-Repeat, 16 bit Mode
0	0	1	Single word, 24 bit Mode
0	1	1	Address Scan, 24 bit mode
1	0	1	Q Stop, 24 bit Mode
1	1	1	Q-Repeat, 24 bit Mode

In Address Scan mode, consecutive Subaddresses are addressed until either Subaddress 16 is finished, or a CAMAC cycle returns Q=0. The Station number is then incremented, and the process continues until the transfer length is satified or N24 is reached. In Q-Stop or Q-Repeat mode, the station and subaddress remain fixed at the initial value. If M2=0, the transfer terminates if Q=0. If M2=1, data is not transferred if Q=0, but CAMAC cycles continue as long as X=1. All transfer modes terminate if the transfer length is satisfied or an error occurs, and the controller proceeds to the Status Phase.

Single word mode is included to permit reading the few CAMAC modules that do not return Q=1 when transferring valid data. Transfers of a single CAMAC word may be made in Q-Stop mode or with M1=M2=0. In the former case, data from a CAMAC read operation will not be transferred to the host if the command returns Q=0, and CHECK CONDITION status will be returned. If M1=M2=0, data will always be transferred to the host, and GOOD status returned even if Q=0. The user cannot tell, on the basis of Q response, if valid data was delivered. Single word mode does not apply to CAMAC write operations, nor can it be used for transfers of longer than one CAMAC word.

NOTE

Early models of the SCM-301 returned CHECK CONDITION status in response to single word mode transfers that detected Q=0, although data was transferred.

CAMAC data transfer commands return only two possible status bytes, GOOD (0) or CHECK CONDITION (2). CHECK CONDITION status will be returned any time the transfer length is not satisfied, or if the transfer terminates with X or Q equal to 0. The REQUEST SENSE command can be issued to determine the cause of termination, and the number of bytes successfully transferred. Byte 3 of the sense data is the number of bytes remaining in the internal FIFO of the controller. Bytes 4 through 6 contain a value that is one less than the number of bytes remaining to be transferred on the SCSI bus. In other words, the value in bytes 4-6 is subtracted from the programmed byte count, and 1 subtracted from the result, to yield the number of bytes transferred on the SCSI bus This value may also be obtained by counting bytes at the host end. In the case of CAMAC reads, this value, plus the number of bytes remaining in the FIFO, yield the number read from CAMAC modules. If the transfer was done in 24 bit mode, this value includes the "filler" bytes, and must be divided by 4 to obtain the number of CAMAC Dataway cycles. In 16 bit mode, it should halved.

In the case of CAMAC writes, the number of bytes remaining in the FIFO must be subtracted from the number of SCSI transfers to determine the number of Dataway cycles completed. Furthermore, if a Q-Stop write transfer terminates due to (lack of) Q response, the above calculation will produce a value one higher than the actual number of successful (Q=1) Dataway transfers, since the cycle resulting Q=0 is counted. In the case of CAMAC reads, a cycle returning Q=0 does not result in data transfer, except in single-word mode.

6.5.4 CONTROLLER COMMANDS

The controller itself responds to the following CAMAC commands, resulting in the actions indicated. Except for the last one, these are the same commands used with the standard type A crate controller.

ACTION	COMMAND	RESPONSE
Generate Dataway Z	F(26) N(28) A(8)	Q=0
Generate Dataway C	F(26) N(28) A(9)	Q=0
Read LAM Pattern	F(0) N(30) A(0-7)	Q=1
Load Station Number Register	F(16) N(30) A(8)	Q=1
Remove Dataway Inhibit	F(24) N(30) A(9)	Q=0
Set Dataway Inhibit	F(26) N(30) A(9)	Q=0
Disable Demands	F(24) N(30) A(10)	Q=0
Enable Demands	F(26) N(30) A(10)	Q=0
Overwrite LAM Mask	F(16)N(30)A(0)	Q=0
FASTCAMAC Level -1 read	F(5)NA	-

In addition to the above commands, commands addressed to N (24) select all stations stored in the Station Number Register, and N (26) addresses all stations simultaneously.

See section 9.0 for commands related to the "Mail Box" register.

7.0 ASYNCHRONOUS EVENT NOTIFICATION

If LAMs are enabled (F(26)N(30)A(10)), and a LAM arises in an enabled CAMAC module, the SCM-301 will become a temporary Initiator and will inform the host using the SCSI-2 AEN procedure. It will arbitrate for the bus, select the host SCSI adapter, and send the IDENTIFY message followed by the host SCSI SEND command. The host adapter must have been programmed to execute the proper Target mode phases. The SEND command instructs the Target (the host adapter) to transfer data from the Initiator (the crate controller). The SEND command, described in Table 11-3 of the Standard, will have a transfer length of 4 bytes, and an AEN bit of zero. This informs the host that the data format is vendor-specific. During the ensuing data phase, the controller sends 4 bytes that convey the pattern of all LAMs asserted in the crate (not merely the one initiating the request). The byte order is the same as for a CAMAC data transfer in 24-bit mode, including the null filler byte. The least significant bit of the fullword corresponds to the LAM from station number 1, and so on up to station 24.

The host interface must be capable of executing the AEN procedure, or else LAMs should not be enabled. The controller does not check that the host has this capability. However, the controller does clear the UNIT ATTENTION condition in the host interface, using the TEST UNIT READY command prior to sending its first LAM message. The Target (host) is expected to send the status byte and COMMAND COMPLETE message in response to this command, although the contents of these bytes are not checked. It is assumed that the TEST UNIT READY command clears the host UNIT ATTENTION.

8.0 MESSAGES

The SCM-301 responds to the following SCSI messages:

IDENTIFY
ABORT
BUS DEVICE RESET
INITIATOR DETECTED ERROR
MESSAGE PARITY ERROR
MESSAGE REJECT
NO OPERATION
SYNCHRONOUS DATA TRANSFER REQUEST

The IDENTIFY message is the SCSI-2 method of selecting the Logical Unit within a target. If a non-zero Logical Unit is specified in the IDENTIFY MESSAGE, the ensuing command will fail. The IDENTIFY message is one byte long as follows:

IDENTIFY MESSAGE

Bit	7	6	5	4	3	2	1	0
	1	0	0	0	0	Logical Unit Number		

NOTE

It will be noted that there is also a Logical Unit Number field in the Command Descriptor Blocks described earlier. This field has been maintained in the SCSI-2 Specification for compatibility with SCSI-1. If the Logical Unit is conveyed by the IDENTIFY message, this field is not used, and should be set to zero.

The ABORT message interrupts the currently executing command, and the controller enters the BUS FREE phase. The BUS DEVICE RESET message causes a hardware reset of the controller. A Dataway Z is generated, and the UNIT ATTENTION condition is set. LAMs are disabled, and Dataway Inhibit asserted. If synchronous transfers were in effect, the controller reverts to asynchronous mode.

The INITIATOR DETECTED ERROR message causes the controller to terminate the current command, and return CHECK CONDITION status. A subsequent REQUEST SENSE command will return a sense key of OBh, and an ASC of 48h. Note that early versions of the SCM-301 responded to this message by retrying the current command.

The MESSAGE PARITY ERROR message causes the controller to resend the previous message. The MESSAGE REJECT message causes the controller to perform an "unexpected disconnect". This should not occur, due to the limited and well defined message repertoire of the SCM-301.

The SYNCHRONOUS TRANSFER REQUEST message causes the SCM-301 to prepare to use synchronous transfers in future data phases, and to return a similar message confirming the parameters it will use. This message is 5 bytes long as follows:

Byte	Contents
0	1
1	3
2	1
3	Transfer Period
4	REQ/ACK Offset

The Transfer Period is specified in units of 4 nanoseconds. The SCM-301 can transfer at a 5 mbyte/sec. rate, and accordingly returns the value 50 (decimal) in byte 3, or a lower value if proposed by the host. A value of 8 is returned in byte 4 unless the host proposed a smaller offset.

The SCM-301 generates the following SCSI messages under the appropriate circumstances and the host must be prepared to process them:

COMMAND COMPLETE
SYNCHRONOUS DATA TRANSFER REQUEST

The COMMAND COMPLETE message is one byte transmitted in Message IN phase at the completion of every command, after the STATUS Phase. Since the SCM-301 does not support linked commands, this message is always NULL. The SYNCHRONOUS DATA TRANSFER REQUEST message is only generated in response to a similar message from the host. The SCM-301 will not initiate synchronous transfers. ALL AEN transfers use asynchronous mode.

Since some operating systems are not prepared to accept the MESSAGE REJECT or MESSAGE PARITY ERROR messages, the SCM-301 does not generate either. In the event that it receives corrupted or invalid message, it merely disconnects from the bus. This "unexpected disconnect" informs the host that an error has occurred. However, the response to an invalid IDENTIFY message is sent in Status Phase, as noted earlier.

During Asynchronous Event Notification, the SCM-301 generates the IDENTIFY message to convey the host's Logical Unit Number, which is expected to be zero. It further expects the host to send the COMMAND COMPLETE message after sending the status byte.

9.0 MAILBOX

The SCM-301 incorporates a 24 bit "Mail Box" register to facilitate communication between its SCSI host and another processor connected to (or incorporated in) another controller in the same crate. This register is enabled by "piano" switch 5. The mailbox can be overwritten or read either by the SCSI host, or by another controller using the Dataway. The host accesses the mailbox using CAMAC commands addressed to station 28. Another controller addresses it at the station number corresponding to the right hand slot occupied by the SCM-301 (station 25 if the SCM-301 is in the control station).

Associated with the mail box is a flag that can be used to interlock communication between the controllers using Q response. In addition, a LAM flip-flop is included that can be set by Dataway command. As noted in Section 3, the LAM can be detected by either controller. These features utilize the following commands:

COMMAND	**ACTION**
F(0) A(0)	Read content of mail box
F(0) A(1)	Read contents. Return Q=1 if flag set, else Q=0. Clear flag.
F(16) A(0)	Overwrite mail box
F(16) A(1)	Overwrite if Flag Clear, set flag and return Q=1. If flag is set, return Q=0 but do not overwrite.
F(8) A(0)	Test LAM
F(10) A(0)	Clear LAM source
F(14) A (0)	Set LAM source
F(24) A(0)	Disable LAM
F(26) A(0)	Enable LAM

FIGURE 1

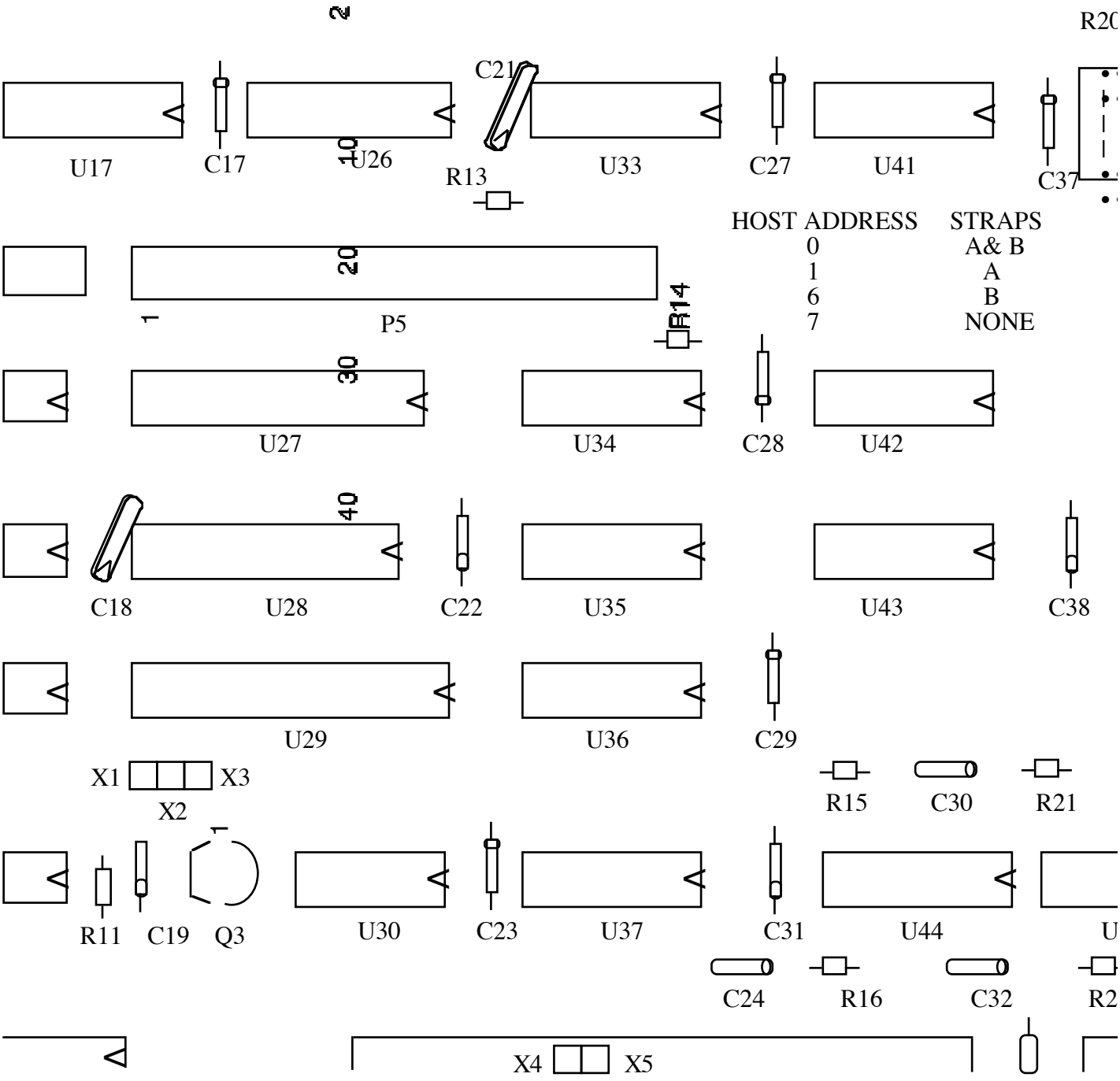


FIGURE 1