SA85 Modbus Plus Host Interface Adapter

Device Driver for OpenVMS/AXP

Release: 3.0

IPACT
Integrated Process Automation &
Control Technologies

ModConnect®

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This document is also a condensation and merging of the following two documents: Modicon DEC Host Based Devices User's Guide and Modicon IBM Host Based Devices User's Guide. Published by Modicon, Inc. Industrial Automation Systems.

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This document was created using Microsoft Word for Windows, version 6.0

File ref: \\ipcmv3\pccommon\mbplus\user_doc\mpdriver.v29

Table Of Contents

Table Of Contents

Table Of Contents

Table Of Contents

Modbus Plus Device Driver

1. Introduction

Some of Digital Equipment Corporation's Alpha (AXP) processors are equipped with the personal computer standard EISA (Extended Industry Standard Architecture) or ISA (Industry Standard Architecture) buses. The SA85-002 ISA card manufactured by Modicon which was previously used to connect a personal computer to the Modbus Plus network can now be used to connect an AXP processor with an EISA or ISA bus running OpenVMS/AXP. Previously, only the SQ85 was available to communicate with the Modbus Plus network and only available on OpenVMS/VAX systems with a Q-Bus. The SA85-000 interface card cannot be used as it does not have interrupt support.

This document explains the device driver, utilities, and installation procedure for SA85 Host Interface Adapter for Modbus Plus. This driver is a migration and rewrite of the existing SQ85 device driver for OpenVMS/VAX.

SQ85 and SA85 Software Driver Comparison

2. SQ85 and SA85 Software Driver Comparison

The QIO interface was maintained between both of these drivers. The user only needs to recompile and link existing applications that made calls to the Modbus Plus device driver (MPDRIVER) for OpenVMS/VAX. The mechanism used to load the device driver (SYSMAN is used for OpenVMS/AXP), and some of the error log support has been changed. These particular items should not effect any user written applications. The user should reference the Modicon document: "DEC Host Based Devices User's Guide" for a description of the QIO interface. The user should use the symbolic codes for the I/O function codes which are defined in the include file: "MP_FUNCS" contained in the MBP_C.TLB (C users) or MBP_FOR.TLB (FORTRAN users text libraries). This driver does not support Modbus Function codes that are not documented in the appendix of this document.

The VMS error code message definition file has been renamed to MPDRIVER_MSG.OBJ and is included in the MBP.OLB object library. This file may be included to translate the I/O status returned from the driver via the sys$getmsg or sys$exit VMS system service calls. To include this module in the user's application, add the following linker option:

mbplus_:mbp.olb/include=(mpdriver_msg)

The standard VMS method of testing for success or failure should be used (odd status is successful). Additional error codes were added to further enumerate possible driver errors. The include files: MPDRIVER_MSG in the text libraries: MBP_FOR.TLB and MBP_C.TLB define all of the error codes.

Utilities

3. Utilities

The NDU utility has been migrated to the OpenVMS/AXP platform. Additionally, the MBP_ERRFMT utility has been provided that will format any error log packets generated by the MPDRIVER. DEVDMP, (diagnostic utility designed for the developers) is also provided which will extract information from the driver database for bug reporting. The INSTALL_CK.COM command file is obsolete because the driver software is now installed with VMSINSTAL and loaded with SYSMAN.

3.1 Modbus Plus Message Routing

Each device establishes its host as a node on the Modbus Plus network. Up to 64 nodes can be present on a single network, each with an unique address between 1 and 64. Multiple networks can be joined through Bridge Plus devices.

3.2 Modbus Plus Routing Paths

Nodes address each other using a routing path field of five bytes. The path is imbedded in the Modbus Plus message frame as sent from the originating node. The five bytes of routing allow destination nodes to be addressed up to four networks away from the originating node. The routing bytes are used by each type of device in a specific way, as illustrated below and on the next page.

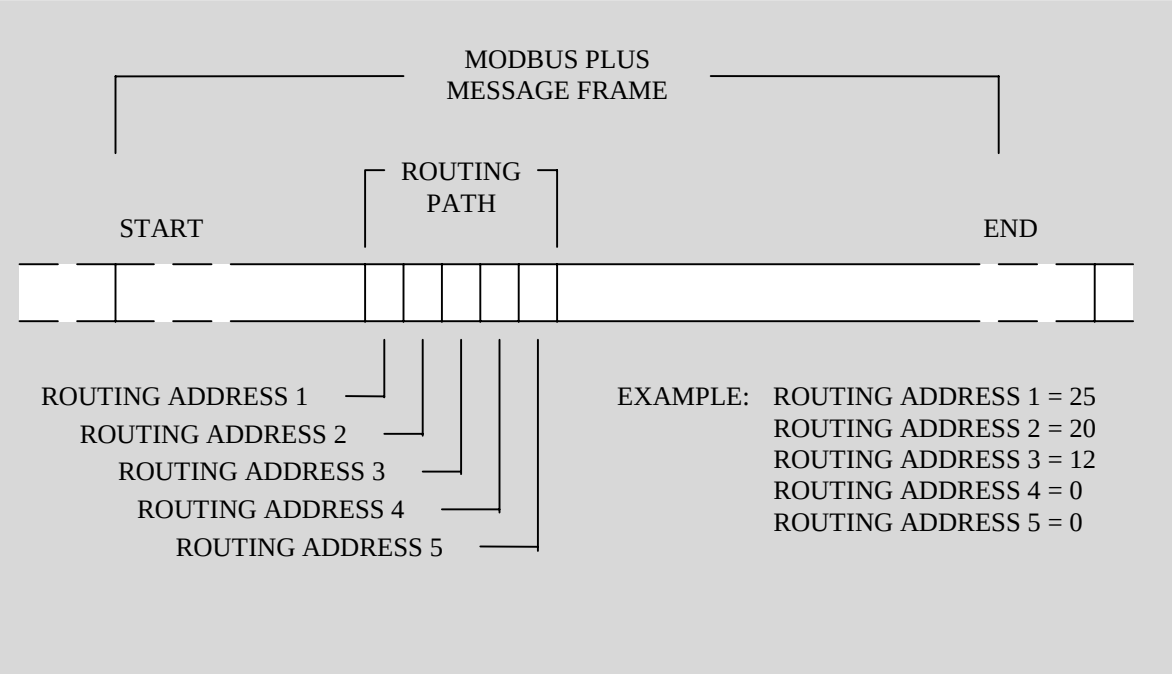


Figure 1 - Message Frame Routing Path

The example in Figure 1 shows routing to a controller through three networks that are joined by a pair of Bridge Plus devices. Using the routing bytes in the example, the message will be sent first to node 25, a Bridge Plus on the local network. That bridge forwards the message to a second Bridge Plus at node address 20 on the second network. The second bridge forwards the message to its final destination, a controller at node address 12 on the third network. The zero contents of bytes 4 and 5 specify that no further routing will occur.

The routing path contents are specific to the type of device at the destination. Routing path methods for various networked devices are outlined below. For further details about message routing paths, see your ***Modbus Planning and Installation Guide*** (GM-MBPL-001).

3.2.1 Routing to Programmable Controllers

For 984 programmable controllers, including the AT-984 and MC-984, the last nonzero byte in the routing specifies the network node address of the controller (range: 1...64). For example, the path 5.0.0.0.0 specifies a controller node at address 5 on the local network (the network to which the host is attached).

3.2.2 Routing to Network Adapters

For host based network adapters such as the SA85 and SM85, the next to last nonzero byte specifies the adapter's network node address (range: 1...64). The last nonzero byte specifies an internal path (range: 1...8) to which the message is to be assigned. For example, if an adapter is at node address 35 on the local network, the path 35.8.0.0.0 specifies routing to path 8 in that adapter. This last routing byte is the data slave path for the OpenVMS SA85 Modbus Plus device driver. Modbus Plus Master nodes need to set this byte to the slave path that the OpenVMS user process is reading. This requires coordination between the PLC programmer and the OpenVMS programmer.

3.2.3 Routing to Bridge Multiplexers

For BM85 bridge multiplexers, the routing field contents are specific to the slave device configuration at the multiplexer's Modbus port. Either a single slave device or a network of slave devices can be connected at the port.

A single slave device at a multiplexer's Modbus port is addressed using two bytes. The next to last nonzero byte addresses the multiplexer node (range: 1...64). The last nonzero byte specifies the port (range: 1...4) to which the slave device is attached. Specifying the port automatically addresses the device at that port. For example, if a BM85 is at node address 25 on the local network, 25.1.0.0.0 routes a message to the single slave device at the multiplexer's port 1.

A networked slave device at the multiplexer's port is addressed using three bytes. The third from last nonzero byte addresses the multiplexer node (range: 1...64). The next to last nonzero byte specifies the port (range: 1...4) to which the network is attached. The last nonzero byte specifies the Modbus address of the slave device (range: 1...247). For example, 25.2.200.0.0 routes a message to multiplexer node address 25, port 2, slave device 200.

3.3 Modbus Plus Transactions

With multiple node devices processing messages asynchronously on the network, an individual device might have several concurrent transactions in process. Each device has multiple internal paths of various types to allow concurrent processing of transactions. It opens a path when a transaction begins, keep it open during processing of the transaction, and closes it when the transaction terminates. When the path is closed, it becomes available to another transaction.

Both the originating and destination devices open paths for a mutual transaction, and maintain the paths until the transaction completes. If the transaction passes through Bridge Plus devices to a destination on another network, each bridge opens and maintains a path at each of its two network ports. Thus, a logical path is established between the originating and destination devices, and maintained until the transaction is finished. When the transaction is completed, all of the paths it has used will be freed.

3.4 Path Types

Each Modbus Plus device contains the following types of paths:

Data Master (DM) Path This type of path is opened for data reads and writes, and forget and clear remote statistics, as they are originated in the device.

Data Slave (DS) Path This type of path is opened for data reads and writes as they are received by the device.

Program Master (PM) Path This type of path is opened for programming commands as they are originated in the device.

Program Slave (PS) Path This type of path is opened for programming commands as they are received by the device.

Each path is independent of the others. Activity in one path does not affect the performance of the other paths.

3.4.1 Path Quantities

The following path quantities are available in the Modbus Plus devices:

Path	Host Based 984s	BM85	BP85	SA85/SM85/SQ85
Data Master	8*	4	8	8
Data Slave	4	4	8	8
Program Master	8*	4	8	8
Program Slave	1	4	8	8

* Because the host based controllers have a *virtual network adapter* capability link built in, their path quantities are different from other types of 984 controllers.

3.5 Queuing

If all DS paths are active in a device, new incoming transactions will be queued. Transactions will remain queued until a path is available, and will then be removed from the queue and given the path. A final data response will not be returned to the originating application until a full path is available from origin to destination.

When the destination node removes a transaction from its queue, it will wait for the network token and then will request the command again from the originating node. The originator will retransmit the command while the destination retains the token. This process occurs transparently, eliminating the need for polling between the origin and destination devices in the application.

BP85 Bridge Plus Queuing Messages which must pass through multiple bridges will be queued (if necessary) within the first bridge, but will not be queued within any subsequent bridges. An attempt to queue in a second bridge will return an error code, which can be tested by the application program in the originating node. This prevents unpredictable delays from queuing across several networks. The originating application can determine how to proceed with outstanding tasks, rather than having to wait through multiple levels of queuing. Tasks that are currently in progress can be allowed to continue, or can be aborted in favor of a higher priority task.

3.6 Modbus Data Access Commands

Transactions to or from programmable controller nodes are based on Modbus data access commands that are imbedded into Modbus Plus frames. These commands are recognized by controllers for reading and writing coils and registers, and for reporting status. The following Modbus commands are used:

Table 3 Modbus Data Access Commands

Function Code (Decimal)	Command Name
1	Read Discrete Output Status (0*xxxx*)
2	Read Discrete Input Status (1*xxxx*)
3	Read Output Register (4*xxxx*)
4	Read Input Register (3*xxxx*)
5	Force Single Coil (0*xxxx*)
6	Preset Single Register (4*xxxx*)
7	Read Exception Status
8*	Get/Clear Network Statistics (Subfunction 21)
15	Force Multiple Coils (0*xxxx*)
16	Preset Multiple Registers (4*xxxx*)
17	Report Slave ID

* Use only subfunction 21 of function 8 for Modbus Plus networking data.

Path Requirements: All of the Modbus data access commands require a Data Master path in the initiating node.

Installation

4. INSTALLATION

The existing documentation in the Modicon "DEC Host Based Devices User's Guide" is obsolete with regard to the installation of the OpenVMS software device driver. The IRQ strapping for the SA85 is shown on the SA85 itself. Place a jumper selecting the desired IRQ level. To install the software, the installer must know the following:

- Serial number of the first SA85 (SA85 with the lowest base address)
- License number from IPACT Inc.
- IRQ for each SA85
- Base Address of each SA85 (Each SA85 must be 800 hex greater than each preceding SA85)
- ALPHA Computer model
- Release of OpenVMS

To install the software, mount the distribution media and execute VMSINSTAL. When prompted for the distribution device, select the distribution device. When prompted for the product, type: "MBP019" or the product listed on the distribution kit. An example VMS install procedure is listed in the appendix. The installation procedure provides a start up command file in the product directory :

SYS$COMMON:[MBPrrv]MBP_STARTUP.COM (Where: rr= release, v= version)

The system manager may execute this command file upon system startup to install the SA85 device driver and define system wide logical names. In particular, the command file will define the system wide logical name: "MBPLUS_:" to point to the product directory. Foreign DCL command symbols may be defined by executing the MBP_SYMBOLS.COM command file in the product directory.

If your distribution is a combination distribution (includes Modbus Plus Interface Library), then you will also be prompted for the optional installation of the Modbus Plus Process I/O Scanner and Interface Library.

Prior to actually installing the software, the user must configure the ISA cards using the ECU utility or the or the ISA configuration utility (ISACFG) provided with your Alpha system. If the ECU or ISACFG utilities are not run, the driver will load with only one unit available, and a **device off line** console message will be logged indicating that the device driver could not acquire any EISA/ISA configuration information for the SA85. If EISA/ISA configuration information is found for the SA85, two devices will be brought on line, and a **device on line** console message will be printed. However, the device will not be made available until the SA85 is successfully initialized. The system manager can use the DCL command "SHOW DEVICE" or the DEVDMP utility provided with this product to determine if the device was successfully brought on line. **Incorrect EISA configuration, SA85 hardware configuration, or incorrect information given during kit installation may result in system crashes or system instability.** The device driver logs a single errorlog log buffer when the device is attempted to be placed on line. The SHOW DEVICE should show a count of one. If the number of errors increases, then suspect configuration problems or inconsistent configuration information between the information entered during VMSINSTAL and the configuration.

The user should execute the NDU utility to do simple tests to determine if the Alpha node is successfully integrated with the Modbus Plus network. Some of the NDU commands do not require a connection to a Modbus Network. Without a network connection, testing of the SA85 and the device driver can still be accomplished with the commands that request information from the SA85 itself.

4.1 SA85 Hardware Installation

The SA85 must be configured with an EISA/ISA IRQ and EISA/ISA Bus memory that do not conflict with other devices installed in the EISA/ISA bus. **The SA85 must also be strapped to interrupt** instead of simply being polled. If two SA85s are installed, only the first needs be assigned the address space with the EISA Configuration Utility (ECU). Sufficient address space should be acquired to contiguously map all of the SA85s that the user intends to install (2K bytes per SA85). Each subsequent SA85 should be assigned a different IRQ and the SA85 should be strapped with a base address 800 Hex larger than the previous SA85 (e.g. C0000, C0800, C1000, etc.). The SA85 itself has the IRQ jumpers silk screened on the card adjacent to the jumpers. By default, the card is strapped in polled mode from the factory. Move the jumper from the polled mode position to the desired IRQ position.

Assuming that the SA85 was strapped as follows:

Base Memory Address	C0000
IRQ	4
Polled Mode Jumper	Removed
Slot	4
ALPHA Model	AXP150

4.2 Software Driver Load

The following command to the SYSMAN utility could be used to load the device driver. This command to load the driver is contained in the MBP_STARTUP.COM command file that is built for the user by the VMSINSTAL kit procedure. It is shown here for custom installations and for understanding. The current release of OpenVMS does not support the unloading of a device driver. Errors in configuration require a reboot of the system to reload the driver.

$mcr sysman -
io connect jpa0/driver=sys$mpdriver-
/vector=16-
/ADAPTER=2-
/node=%x00040004-
/csr=%xFFFFFFFF85960000-
/NUM_UNITS=2-
/MAX_UNITS=34-
/LOG=ALL

The CSR is the CSR of the EISA adapter and may be different on other AXP processors. The maximum number of units is selectable, but selects the maximum number of UCBs that will be cloned for the particular SA85 device. The value of 34 allows all paths plus two additional UCBs for the internal use by the driver (UCB is an internal data structure, each device in OpenVMS has a UCB that describes the device). The “/node” specifies both the IRQ and the Slot of the SA85. The Vector is the IRQ times four.

The adapter number (EISA TR# from below) and the CSR of the EISA adapter (Base CSR) can be acquired by using SYSMAN as follows:

```
$MCR SYSMAN IO SHOW BUS
_Bus__________Node_TR#__Name___________Base CSR_________
  EISA          2    2   Lance NI Adapt  FFFFFFFF85A60000
    AHA_1742A   6    4   SCSI Adapter    FFFFFFFF85C60000
    AHA_1742A   6    4   Floppy          FFFFFFFF85960000
  VTI_COMBO     0    3   Parallel Port   FFFFFFFF863CC000
```

4.3 Using EISA Configuration Utility (ECU)

Since the SA85 is an ISA card and not an EISA card, the product id and other configuration registers are not present. This prevents the ECU utility from being able to auto configure the SA85. A configuration file is provided to you that will allow you to configure a single SA85-02 host adapter into your EISA bus. After invoking ECU and during the “add” phase, select the file “!MOD8502.cfg” from the ECU floppy supplied with your distribution kit. This file may be copied to your normal ECU system floppy using a normal Personal Computer (the ECU floppy is a DOS readable floppy).

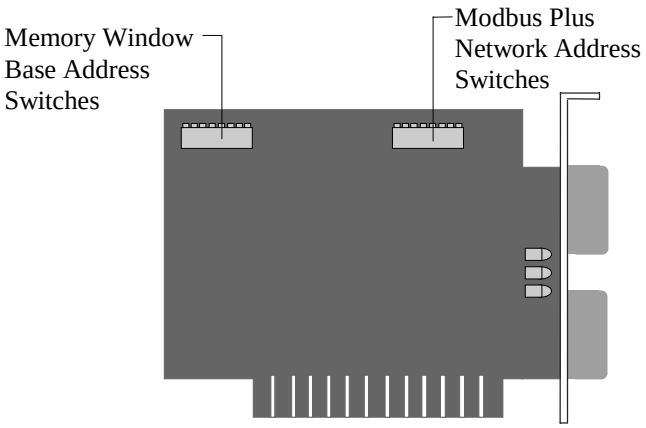
4.4 Using ISACFG

You must manually allocate the memory and the IRQ for the SA85 after you install it in the ISA bus using the ISACFG (see your computer manuals for instructions on using the ISACFG software shipped with you system). All of the SA85 is mapped using bus memory and not I/O space.

4.5 Setting the Modbus Plus Address

Set Modbus Plus node address switches 1-6 to the address in your application. Switches 7 and 8 are not used. Each node must have an unique address. Note that the address will be one higher than the binary value you set into the switches.

It is recommended that you reserve address 64 for future network maintenance. It is also recommended that you do not use address 1, to avoid possible confusion when using a local default address of 1 at a controller node's programming panel.



MODBUS PLUS ADDRESS	SWITCH POSITION 1	2	3	4	5	6	MODBUS PLUS ADDRESS	SWITCH POSITION 1	2	3	4	5	6
1	0	0	0	0	0	0	33	0	0	0	0	0	1
2	1	0	0	0	0	0	34	1	0	0	0	0	1
3	0	1	0	0	0	0	35	0	1	0	0	0	1
4	1	1	0	0	0	0	36	1	1	0	0	0	1
5	0	0	1	0	0	0	37	0	0	1	0	0	1
6	1	0	1	0	0	0	38	1	0	1	0	0	1
7	0	1	1	0	0	0	39	0	1	1	0	0	1
8	1	1	1	0	0	0	40	1	1	1	0	0	1
9	0	0	0	1	0	0	41	0	0	0	1	0	1
10	1	0	0	1	0	0	42	1	0	0	1	0	1
11	0	1	0	1	0	0	43	0	1	0	1	0	1
12	1	1	0	1	0	0	44	1	1	0	1	0	1
13	0	0	1	1	0	0	45	0	0	1	1	0	1
14	1	0	1	1	0	0	46	1	0	1	1	0	1
15	0	1	1	1	0	0	47	0	1	1	1	0	1
16	1	1	1	1	0	0	48	1	1	1	1	0	1
17	0	0	0	0	1	0	49	0	0	0	0	1	1
18	1	0	0	0	1	0	50	1	0	0	0	1	1
19	0	1	0	0	1	0	51	0	1	0	0	1	1
20	1	1	0	0	1	0	52	1	1	0	0	1	1
21	0	0	1	0	1	0	53	0	0	1	0	1	1
22	1	0	1	0	1	0	54	1	0	1	0	1	1
23	0	1	1	0	1	0	55	0	1	1	0	1	1
24	1	1	1	0	1	0	56	1	1	1	0	1	1
25	0	0	0	1	1	0	57	0	0	0	1	1	1
26	1	0	0	1	1	0	58	1	0	0	1	1	1
27	0	1	0	1	1	0	59	0	1	0	1	1	1
28	1	1	0	1	1	0	60	1	1	0	1	1	1
29	0	0	1	1	1	0	61	0	0	1	1	1	1
30	1	0	1	1	1	0	62	1	0	1	1	1	1
31	0	1	1	1	1	0	63	0	1	1	1	1	1
32	1	1	1	1	1	0	64	1	1	1	1	1	1

4.6 Setting the Memory

The SA85 board uses a memory area in your computer as a buffer for the board's status and message transactions. You must define a base address for this memory area that prevents conflict with other option boards in your computer.

Valid base address settings range from C0000...EF800 hexadecimal. The area used in memory is a 2K bytes (800 hex) portion starting at the base address. Refer to your computer's manual to determine available areas of free memory. Select an area that will not be overwritten by your application or by other options and record the address. You will need it later when you setup your CONFIG.SYS file.

The top part of Figure 2 shows the address bus range from all 0 to all 1, with the portion seen by the board's switches. The bottom part of the figure shows the lowest and highest base addresses in binary and hexadecimal.

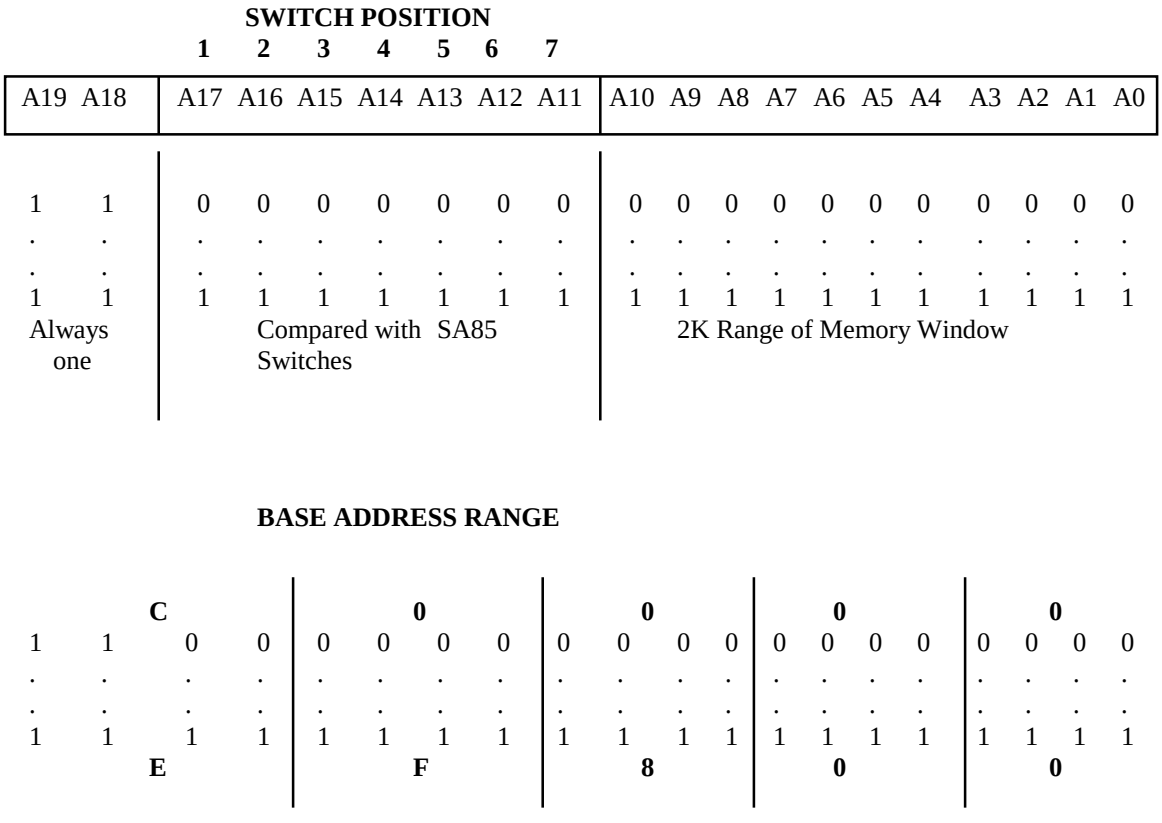
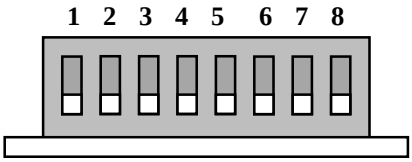


Figure 2 - SA85 Memory Window Addressing Method

To decode a memory address, the SA85 compares the computer's address bus bits A19 and A18 with logic 1's. Bits A17...A11 are compared with the SA85 switch settings. The board is selected when an address matches bits A19...A11. Bits A19...A11 thus define the base address to be accessed by the application software. Locations within the 2K range are addressed by bits A10...A0.

Set the memory base address switches (located on the board shown below) to define the base address. Switch 8 is not used.



SWITCHES SHOWN IN '0' POSITION (TOWARD CIRCUIT BOARD)

BASE ADDRESS	SWITCH POSITION 1	2	3	4	5	6	7	BASE ADDRESS	SWITCH POSITION 1	2	3	4	5	6	7
C0000	0	0	0	0	0	0	0	D2800	0	1	0	0	1	0	1
C0800	0	0	0	0	0	0	1	D3000	0	1	0	0	1	1	0
C1000	0	0	0	0	0	1	0	D3800	0	1	0	0	1	1	1
C1800	0	0	0	0	0	1	1	D4000	0	1	0	1	0	0	0
C2000	0	0	0	0	1	0	0	D4800	0	1	0	1	0	0	1
C2800	0	0	0	0	1	0	1	D5000	0	1	0	1	0	1	0
C3000	0	0	0	0	1	1	0	D5800	0	1	0	1	0	1	1
C3800	0	0	0	0	1	1	1	D6000	0	1	0	1	1	0	0
C4000	0	0	0	1	0	0	0	D6800	0	1	0	1	1	0	1
C4800	0	0	0	1	0	0	1	D7000	0	1	0	1	1	1	0
C5000	0	0	0	1	0	1	1	D7800	0	1	0	1	1	1	1
C5800	0	0	0	1	0	1	1	D8000	0	1	1	0	0	0	0
C6000	0	0	0	1	1	0	0	D8800	0	1	1	0	0	0	1
C6800	0	0	0	1	1	0	1	D9000	0	1	1	0	0	1	0
C7000	0	0	0	1	1	1	0	D9800	0	1	1	0	0	1	1
C7800	0	0	0	1	1	1	1	DA000	0	1	1	0	1	0	0
C8000	0	0	1	0	0	0	0	DA800	0	1	1	0	1	0	1
C8800	0	0	1	0	0	0	1	DB000	0	1	1	0	1	1	0
C9000	0	0	1	0	0	1	0	DB880	0	1	1	0	1	1	1
C9800	0	0	1	0	0	1	1	DC000	0	1	1	1	0	0	0
CA000	0	0	1	0	1	0	0	DC800	0	1	1	1	0	0	1
CA800	0	0	1	0	1	0	1	DD000	0	1	1	1	0	1	0
CB000	0	0	1	0	1	1	0	DD800	0	1	1	1	0	1	1
CB800	0	0	1	0	1	1	1	DE000	0	1	1	1	1	0	0
CC000	0	0	1	1	0	0	0	DE800	0	1	1	1	1	0	1
CC800	0	0	1	1	0	0	1	DF000	0	1	1	1	1	1	0
CD000	0	0	1	1	0	1	0	DF800	0	1	1	1	1	1	1
CD800	0	0	1	1	0	1	1	E0000	1	0	0	0	0	0	0
CE000	0	0	1	1	1	0	0	E0800	1	0	0	0	0	0	1
CE800	0	0	1	1	1	0	1	E1000	1	0	0	0	0	1	0
CF000	0	0	1	1	1	1	0	E1800	1	0	0	0	0	1	1
CF800	0	0	1	1	1	1	1	. . .	.	.	.	.	.	.	.
D0000	0	1	0	0	0	0	0	. . .	.	.	.	.	.	.	.
D0800	0	1	0	0	0	0	1	EE000	1	0	1	1	1	0	0
D1000	0	1	0	0	0	1	0	EE800	1	0	1	1	1	0	1
D1800	0	1	0	0	0	1	1	EF000	1	0	1	1	1	1	0
D2000	0	1	0	0	1	0	0	EF800	1	0	1	1	1	1	1

4.7 Verifying the Jumpers

4.7.1 Polled Mode Jumper

Before installing the SA85 you must verify its IRQ jumper setting. Eight rows of jumper pins and two pins/row are provided on the SA85 board for IRQ and Poll Mode settings.

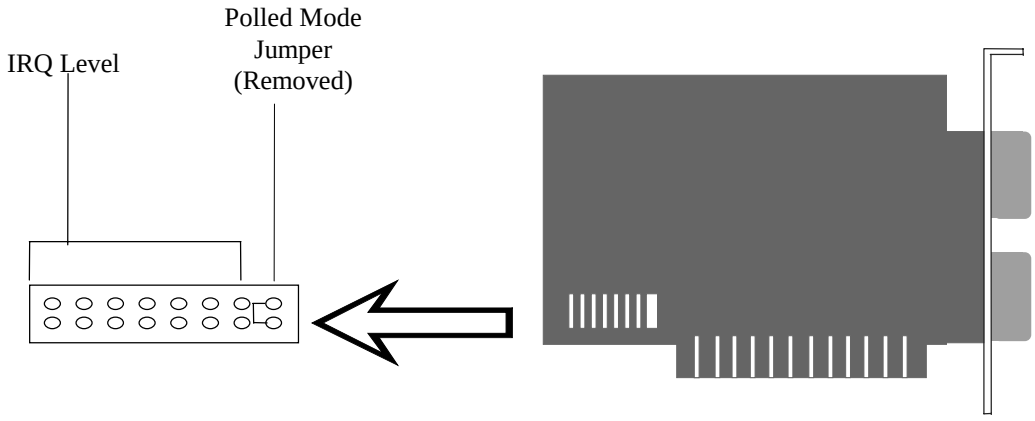


Figure 3 - AM-SA85-002 Jumper Settings

The factory jumper position is as shown in the figure showing Polled Mode. Move this jumper to the IRQ specified with the ECU or ISACFG.

4.8 Installing the SA85 Board

Use these guidelines to install the SA85 board and connect it to the network cable:

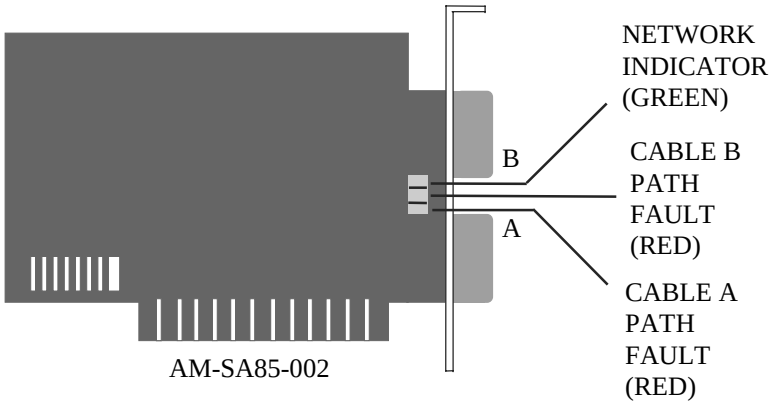
Step 1	Run ECU or ISACFG to determine a valid IRQ, memory base address, and ISA or EISA slot for the SA85
Step 2	If you have not set and verified the SA85 network address, memory base address, and jumper, do so now. Refer to the procedures earlier in this chapter to set them.
Step 3	Referring to your computer's product documentation, set the computer power switch to OFF and unplug its power cable from the power source.
Step 4	Remove the computer cover. Retain the bolts and other hardware for later reassembly.
Step 5	Locate the selected expansion slot connector on the computer motherboard that matches your selection in step one. Remove the bolt securing the blank rear faceplate for this slot position and remove the faceplate. Retain the bolt for later reassembly.
Step 6	Insert the SA85 board into the expansion slot connector. Make sure the board is firmly seated in the connector.
Step 7	Install the bolt to secure the board's rear faceplate to the computer frame.
NOTE:	This bolt is required for proper grounding of the board.
Step 8	Reinstall the computer cover.
Step 9	Plug the Modbus Plus network cable connector(s) into the board's connector(s). If you have a dual-cable network, your two cables should be labeled A and B. Make sure to connect the cables into the proper connectors (A and B). Secure each connector by tightening its two screws.
Step 10	Reconnect the computer power cable and power up the computer. Verify normal operation with the board installed.
Step 11	Execute the VMSINSTAL from the system account from sys$update.

Note: If new ALPHA firmware upgrade is done, the ECU configuration is erased. The ECU utility must be reloaded after a firmware upgrade.

Reading the Network Indicator

AM-SA85-002: This board has three indicators. A green indicator shows the overall communication status at the SA85 node. Two red indicators identify faults on the two cable paths.

If a red indicator blinks momentarily, it indicates that a message error was detected on the cable path. A steady ON state indicates a hard fault either in the cable or in a node device connected to the cable. If communication is lost on one cable path, the other path continues normally.



Figre 4 - SA85 Network Indicators

Network Communication Status (Green Indicator)
Modbus Plus status is shown by flashing a repetitive pattern on the green indicator. The patterns are:

Six flashes per second
The node's normal operating state. The node is successfully receiving and passing the token. All nodes on the network should be flashing this pattern.

One flash per second
The node is offline after just being powered up, or after exiting the four flashes per second mode. In this state, the node monitors the network and builds a table of active nodes and token-holding nodes. It remains in this state for five seconds, then attempts to go to its normal operating state.

Two flashes, then OFF for two second
The node is hearing the token being passed among other nodes, but is never receiving the token. Check the network for an open circuit or defective termination.

Three flashes, then OFF for 1.7 seconds
The node is not hearing any other nodes. It is periodically claiming the token, but finding no other node to which to pass it. Check the network for an open circuit or defective termination.

Four flashes, then OFF for 1.4 seconds
The node has heard a valid message from another node that is using the same address as this node. The node remains in this state as long as it continues to hear the duplicate address. If the duplicate address is not heard for five seconds the node then changes to the pattern of one flash every second.

4.9 Labeling the Modbus Plus Port

Two sets of labels are provided with the SA85 to identify its Modbus Plus network and node address. One label should be attached to the unit when you complete the connection to the network. The other set is a spare.

Enter onto the label the Modbus Plus network number and node address you have assigned to the SA85. Place the label on the unit so that it can easily be seen. Figure 5 shows an example of the completed label. The user should also document the IRQ and Base address of the SA85 for future use.

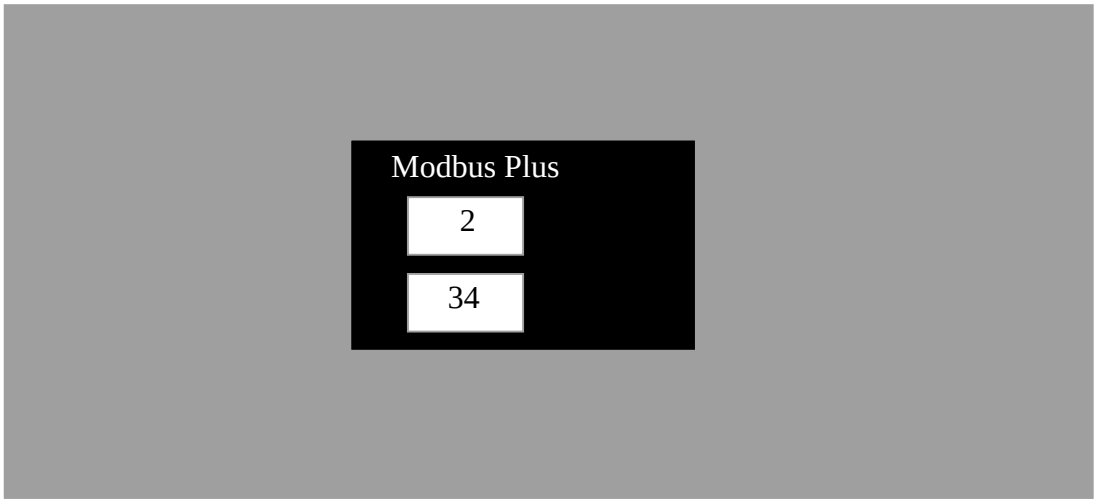


Figure 5 - SA85 Modbus Plus Port Label

Device Driver Functionality

5. Using the Device Driver

◊ Device Driver Overview

◊ Device Names in VMS Requests

◊ Modbus Plus Paths in VMS Processes

◊ Summary of $QIO/$QIOW Requests

◊ Handling Errors

◊ Error Logging

5.1 Device Driver Overview

The OpenVMS device driver, MPDRIVER, is a kernel loadable software module that handles calls from VMS processes for transacting messages with a selected host-based Modbus Plus network device controller. The driver functions as an integral part of the OpenVMS executive. The driver provides user processes access to data and statistics on Modbus Plus network nodes through a standard set of VMS system services.

Devices in the local host processor or at remote sites across the Modbus Plus network are accessed in the same manner. Messages use the Modbus Plus five-byte routing path and node addresses to specify the source and destination nodes. For messages originated in the process, the user supplies the routing information as a portion of the message header that is stored in an outgoing buffer. For device responses, the routing is returned along with the response message contents to the incoming buffer.

The driver performs buffered I/O operations in which data passes through an intermediate buffer in system address space. Direct Memory Access operations are not supported by the Modbus Plus network devices.

VMS processes access device drivers through the following OpenVMS system services:

◊ $ALLOC and $DALLOC - to reserve a device for exclusive use

◊ $ASSIGN and $DASSGN - to establish a channel to a device

◊ $QIO and $QIOW - to communicate with a device across an assigned channel.

The general use and application of these services are described in detail in the *VMS Programming Manual, Volume 4B - System Services*. Their use with the host-based devices is outlined below.

5.1.1 $ALLOC and $DALLOC

VMS provides the $ALLOC service to grant an user process exclusive access to a device, and the $DALLOC to remove the exclusive access. However, because the Modbus Plus devices are of a special type (they use 'cloned' Unit Control Blocks), they cannot be allocated for exclusive use.

An error will be returned from a $ALLOC request if your application attempts to issue it for one of these devices.

5.1.2 $ASSIGN and $DASSGN

A process that wishes to issue $QIO or $QIOW service requests to a device must assign a channel to the device before the $QIO or $QIOW call can be issued. The process does this through the $ASSIGN service request with a parameter that specifies the target device. VMS returns a condition value indicating the success or failure of the request.

If the request is successful, VMS returns a channel number. The requesting process can then make $QIO and $QIOW service requests to the device by specifying the assigned channel number in those requests.

When a process has completed its operations across a channel, it should invoke the $DASSGN system service to deassign the channel. If a process exits, VMS issues $DASSGN requests for any channels that are still assigned. The user only assigns a channel to unit number one for each controller (e.g. JPA1:). The actual unit created may be any unit number as the device is cloned similar to OpenVMS mailboxes.

Each Modbus Plus device maintains multiple internal paths for handling concurrent transactions. A process can assign multiple channels to access the multiple paths in a device, but this is generally not necessary. Typically a single channel would be assigned to the device for each type of access (data master, data slave, program master, or program slave) with all of the $QIO/$QIOW requests issued over that channel. Modbus Plus device paths are described in Chapter 1. Their use in processes that employ various types of networked devices and network topologies is described in the *Modbus Plus Network Planning and Installation Guide*.

5.1.3 $QIO and $QIOW

After a channel has been assigned to a particular device, a process can issue $QIO and $QIOW system service calls across the channel. These calls request VMS to place the specified type of I/O request into the input queue of the driver for the targeted device.

$QIO is an asynchronous request that is queued to the device driver and handled by it while the process continues. $QIOW is a synchronous request that queues to the driver and blocks the process while waiting for the response from the device.

$QIO/$QIOW calls are available for controlling device paths, issuing data and program commands, issuing responses, sending and receiving global data, and getting device configuration and statistics information. Descriptions of the syntax, parameters, and returned values for the calls are contained in Chapter 5.

VMS returns a condition value indicating the success or failure of the attempt to queue the I/O request. The outcome of the requested I/O action is stored in a quadword status block that is specified in the $QIO/$QIOW request. The block is accessible to the process for monitoring the device. The Modicon device status block format differs from the typical block format. A description of the block is provided in the next chapter. The status codes returned by the driver are documented in the appendix. If the user links with the MPDRIVER OpenVMS message file, the status code may be translated with the OpenVMS SYS$GETMSG and SYS$EXIT system services.

5.2 Device Names in VMS Requests

Up to four Modbus Plus devices can be installed on a OpenVMS/AXP host with an ISA or EISA bus. The number of SA85s it typically limited by the IRQs and available slots on the EISA or ISA bus. Each of the SA85 devices are referred to as devices A, B, C, and D. Device names used in VMS requests to the devices have four parts:

◊ The prefix: JP

◊ The device identifies: A, B, C, or D

◊ The unit number: 1

◊ A trailing colon.

For example, if one device is installed it will be referred to as device JPA1:. The allowable range of device names is JPA1:, JPB1:, JPC1:, and JPD1:.

Note: There are two unit numbers created for each installed SA85 device during the loading of the device driver. For example, if one device was installed it was configured as both JPA0 and JPA1 (see the CONNECT statement examples in each device's installation chapter). The unit 0 reference is reserved for the driver program's internal use. It must be not used in your application program. VMS service requests to the unit 0 reference will return an error MP$_WRONGUCB. The unit 1 (JPA1:) reference is for your use in the service requests for user applications.

5.2.1 Using $ASSIGN

The format of the $ASSIGN request is:

SYS$ASSIGN *devnam, chan, [acmode], [mbxnam]*

where:

devnam	is the address of a character string descriptor pointing to the device name string. The string contents are the device name, e.g., “JPA1:’.
chan	is the address of a work into which $ASSIGN will write the VMS I/O channel number if the request is successful.

acmode and *mbxnam* are optional arguments defining the access mode and mailbox name to be associated with the device. Refer to the *VMS Programming Manual, Volume 4B - System Services* for descriptions of these arguments.

The following C code fragment illustrates a call to the $ASSIGN request:

```
unsigned short channel ;
unsigned long status ;
$DESCRIPTOR (device, “JPA1:”) ;

status = SYS$ASSIGN (&device &channel,,) ;
```

5.2.2 Using $DASSGN

The format for the $DASSGN request is:

SYSDASSGN *chan*

where:

chan	is a word containing the number of the I/O channel to be deassigned.

The following C code fragment illustrates a call to the $DASSGN request:

```
unsigned short channel ;
unsigned long status ;

status = SYS$DASSGN(channel) ;
```

Typical condition values returned by VMS to the $DASSGN request include:

SS$_NORMAL	the service was completed successfully
SS$_IVCHAN	an invalid channel number was specified
SS$_NOPRIV	the specified channel is not assigned or was assigned from a more privileged access mode

5.3 Modbus Plus Paths in VMS Processes

Modbus Plus device paths are separate entities from VMS I/O channels. The VMS requests $ASSIGN and $DASSGN handle the assignment of VMS I/O channels. After an I/O channel has been assigned, internal Modbus Plus paths in the host's local device are allocated by $QIO/$QIOW requests. Paths in remote networked devices are not allocated by the local process, but are handled by their respective processes as required by the types and quantities of transactions at those nodes.

A VMS process wanting to issue a series of commands and responses with a remote Modbus Plus device must allocate a path within the host's local device. Of the available $QIO/$QIOW commands, only four require prior allocation of a path. Those are listed on the opposite page.

When the path has been allocated, the process can then issue commands and responses through the local device to the remote device. It can issue the required sequence of $QIO/$QIOW requests to complete the type of transaction intended.

A typical sequence of operations in two processes handling communication between a Master and Slave device would be:

In the Master Process:	$ASSIGN	Assign I/O Channel
	$QIO	Allocate Master Path
	$QIO	Write Master Command
	. . .	
	$QIO	Write Master Command
	$QIO	Read Master Response
	$QIO	Deallocate Master Path
	$DASSGN	Deassign I/O Channel
In the Slave Process:	$ASSIGN	Assign I/O Channel
	$QIO	Allocate Slave Path
	$QIO	Read Slave Path
	$QIO	Write Slave Response
	. . .	
	$QIO	Read Slave Command
	$QIO	Write Slave Response
	$QIO	Deallocate Slave Path
	$DASSGN	Deassign I/O Channel

You will notice that these Modbus Plus transactions occur in pairs. Typically the matching transaction must be responded to in a timely manner (typically two seconds). The driver ensures that the matching transaction is processed next by rejecting any other requests. Failure to respond promptly may result in controller crashes, path aborts, or path down status.

5.3.1 Requests That Require Paths

Only VMS processes that wish to process master or slave commands need to allocate a Modbus Plus path. These $QIO/$QIOW requests require a path:

IO$_WRITE_MC	Write Master command
IO$_READ_MR	Read Master response
IO$_READ_SC	Read Slave command
IO$_WRITE_SR	Write Slave response

Other requests, such as for handling global data or statistics, can be issued without first allocating a path.

5.3.2 Servicing Slave Paths

When a process communicates with a remote node that is running as a slave (either a data slave or a program slave), the originating process expects the slave process to be ready and awaiting incoming commands. The application serving the slave device must ensure that a slave path has been allocated and that an IO$_READ_SC Read Slave Command has been posted before the incoming command is received on that path. If either of these conditions has not been satisfied, an incoming command is returned to its originating node with a routing error specifying a failure code of 6 - Slave Device Down. To help ensure that data is promptly handled, the MPDRIVER has a single message queue for each slave path being serviced. This one message queue is enabled as soon as the process allocates a slave data path.

Not only must the first Read Slave Command be posted correctly, but subsequent ones must also be posted prior to the receipt of subsequent slave commands. Besides the status that might be returned by the MPDRIVER, or the SA85, the user may also return its own status to the remote Master Modbus node. The master nodes may be Personal Computers, other OpenVMS nodes, or programmable controllers.

The MPDRIVER uses the last route parameter to direct the message to the process that has allocated a slave path.

5.3.3 Path States and Transitions

Paths are assigned a state by the driver. The three possible states are:

Available:	ready to be allocated
Allocated:	allocated but not processing a command
Busy:	allocated and currently processing a command

Paths transition from one state to another as a result of $QIO/$QIOW requests. A summary of these requests and the path transitions caused by them is provided later in this chapter. The driver returns an error value for unsuccessful attempts to use paths:

◊ An attempt to allocate a path that is not Available results in a path unavailable error (MP$_PATHUNAVL).

◊ An attempt to issue a Write Master Command on a path that is Busy results in a path state error (MP$_PATHSTAT).

◊ An attempt to issue a Read Master Response on a path that is not Busy results in a path state error (MP$_PATHSTAT).

◊ An attempt to issue a Read Slave Command on a path that is not Busy results in a path state error (MP$_PATHSTAT).

◊ An attempt to issue a Write Slave Response on a path that is not Busy results in a path state error (MP$_PATHSTAT).

5.3.4 Deallocating Paths

A process should deallocate a path when it is no longer needed. This is done by issuing an explicit IO$_DEALLOC $QIO/$QIOW request. Note also that deassigning a channel through $DASSGN will cause a path allocated to the channel to be deallocated. If a process exits the system, VMS issues a $DASSGN call for any assigned channels with the same effect. Deallocated paths transition to Available.

5.3.5 Aborting a Path

The IO$_ABORT Abort Transaction $QIO/$QIOW request transitions a path state from Busy to Allocated without completing the transaction in progress. It also causes the peer processor in the device to complete its cleanup of the transaction.

Note that the Abort Transaction request is queued in an I/O channel's queue and is not processed until all other requests issued before it on the channel are complete. It does not affect any $QIO/$QIOW requests previously queued.

5.3.6 Canceling a Path

VMS provides a $CANCEL system service that automatically dequeues all queued I/O requests for the channel, cancels them, and returns an $SS_ABORT Condition code to each $QIO/$QIOW request that queued to the channel.

The use of the $CANCEL service id described in detail in the *VMS Programming Manual, Volume 4B - System Services*.

5.4 Summary of QIO and QIOW Requests

The driver supports the following $QIO/$QIOW service requests:

IO$_ALLOC	Allocate a Modbus Plus path in the local device
IO$_DEALLOC	Deallocate a Modbus Plus path in the local device
IO$_WRITE_MC	Write Master command
IO$_READ_MR	Read Master response
IO$_READ_SC	Read Slave command
IO$_WRITE_SR	Write Slave response
IO$_GET_GD	Get global data
IO$_PUT_GD	Put global data
IO$_GET_CS	Get configuration status information
IO$_GET_SR	Get service request
IO$_GET_SS	Get driver status and statistics
IO$_ABORT	Abort transaction

Here is a summary of the requested action and path transition (if any) for each type of request. The syntax, parameters, and returned values are detailed in Chapter 5.

IO$_ALLOC specifies a path type (Data/Program and Master/Slave) and allocates it to the device (JPA1:, JPB1:, JPC1:, or JPD1:) for which a VMS I/O channel has been previously assigned by $ASSIGN. The path state is transitioned to Allocated.

IO$_DEALLOC deallocates a previously allocated path, setting the path state to Available.

IO$_WRITE_MC writes a Master command to a previously allocated Master path. The path state is transitioned from Allocated to Busy.

IO$_READ_MR reads a response on a previously allocated Master path. The response is returned as a result of an IO$_WRITE_MC command sent on the path. The path state is transitioned from Busy to Allocated.

IO$_READ_SC reads a Slave command received on a previously allocated Slave path. The path state is transitioned from Allocated to Busy.

IO$_WRITE_SR writes a response to a previously allocated Slave path. The response is sent as a result of an IO$_READ_SC command received on the path. The path state is transitioned from Busy to Allocated.

IO$_GET_GD retrieves global data for a specified node and places it into an user buffer.

IO$_PUT_GD replaces the local device's global data with the new data specified in an user buffer.

IO$_GET_CS retrieves the current configuration status from a specified node and places it into an user buffer. An optional function modifier causes the node's error counters to be cleared after they are read.

IO$_GET_SR retrieves the current service request information from a specified node and places it into an user buffer.

IO$_GET_SS retrieves the current driver status and statistics for a specified device and places it into a user buffer. Information includes: the driver version, device type, and node address; the latest VMS command to the driver, the driver response, and any crash code; the current state of the Program Master path for the device; and statistics pertaining to the controlling of paths, interrupts, timeouts, and other driver parameters.

IO$_ABORT transitions the path state from Busy to Allocated. A typical use for a Master path would be to abort a transaction in progress after previously sending a Write Master Command (instead of issuing a Read Master Response). A typical use for a Slave path would be to abort a transaction upon receipt of a Read Slave Command (instead of issuing a Write Slave Response).

5.5 Handling Errors

If a device error occurs as a result of a specified $QIO/$QIOW request, the process can recognize the error by examining the condition code returned in the I/O status block specified in the $QIO/$QIOW request. The device error conditions are:

◊ Controller timeouts - when a device does not respond to a command

◊ Controller errors - when a device responds to a command with invalid data

◊ Controller crashes - when a device experiences a logic or hardware fault

5.5.1 Device Errors

All commands issued by the driver require a response from the device. These responses are generated internally by the device and do not require that any network traffic occur.

The drive maintains a timeout timer on each command to ensure that it completes. A failure to complete a command in time causes the driver to complete the current $QIO/$QIOW request (if any) and to return a Controller Timeout condition code (MP$_CTRLTMO) to the request. If a data error has occurred as a result of the $QIO/$QIOW request, a Controller Error code (MP$_CTRLERR) will be returned. If a logic or hardware error occurs, the driver returns a controller Crash (MP$_CTRLCRASH) code.

5.5.2 Process Recovery From a Device Error

In addition to the returned code, the driver takes these steps to reset the device:

◊ The device is marked offline during the reset operation.

◊ The error is logged, using the standard VMS error logging facility.

◊ Any $QIO/$QIOW requests already queued to the device, and any new requests to it during the reset operation, are completed with a device error indicating that the controller is being reset or that a particular path is being aborted.

◊ All of the device paths that were in the Busy state are transitioned to Allocated. No allocated Paths are deallocated.

◊ The device is initialized, and if this is successful, it is returned to online.

If an MP$_CTRLTMO, MP$_CTRLERR, or MP$_CTRLTMO condition code is received in response to a $QIO/$QIOW request, these steps should be taken by the application:

◊ The affected program should reset its own context: no logins or transactions are active following the error.

◊ Any channels and paths in use before the error are still available to the process: the channels are still assigned, and the paths are in the Allocated state. Any $QIO/$QIO requests that were active on those channels have been aborted.

◊ The VMS system administrator should be requested to print the VMS error log when it is convenient to do so.

5.5.3 Process Recovery From a Powerfail

VMS system with battery backup memory can continue running after a brief power failure without a reboot. VMS notifies the driver of a powerfail recovery event. At that time, any $QIO/$QIOW requests in process at the time of the powerfail will be completed with a Powerfail Occurred code (SS$_POWERFAIL).

Systems without battery backup will be rebooted, at which time the driver will be reloaded. If the device looses power, but the driver continues to operate, the driver will detect either a device timeout or device crash. The process should then recover as for a device error.

5.6 Error Logging

The driver supports VMS error logging and uses it to report device errors. The VMS system administrator should periodically format and print the error log report.

Error conditions reported are controller timeout, controller error, and controller crash. The device-specific information included with each error is:

◊ The MPDRIVER version number

◊ The device type: SA85

◊ The error condition code that occurred

◊ The last command sent to the device

◊ The last response received from the device

◊ The device crash code (if any)

Error information is logged in the file:

SYS$ERROR:ERRORLOG.SYS

and can be viewed by the command:

ANALYZE/ERROR SYS$ERRORLOG:ERRORLOG.SYS

Refer to your VMS manuals for further information about this command. Included with the SA85 OpenVMS device driver is an utility that will format the Modbus Plus device errors. MBP_ERRFMT will read the system error log file and print the results in a symbolic form.

5.7 The Error Log File Format

Each entry from the Modbus Plus device driver in the log file appears as 'UNKNOWN DEVICE'. Other non-VMS drivers, if present, will also appear in the file with this identification so you must interpret the rest of the fields in each entry to determine which entries are from the Modbus Plus driver.

Each entry contains fields of information that were written by VMS, plus additional fields written by the driver. The driver logs seven longwords of information.

Not all of the information may be valid for every error. For example, in the case of a controller timeout, the response field has no meaning and should be ignored.

5.8 Error Log Example

The following is an example output from MBP_ERRFMT.

```
MODBUS Error File Formatter v1.0       printed:11-AUG-1995 10:55:53.62
Page:2
Error Log:sys$errorlog:errlog.sys         Entry #4
From 10-AUG-1995 10:55:53.21 to 11-AUG-1995 10:55:53.21
***************** MODBUS ERROR: Sequence #119 *****************

Systemid: 415
Header rev level: fff9
Cpu id: 2
Device class: ff
Device type: ff
Logging Operating System id: 3
Other type of packet
Time of error: 11-AUG-1995 07:11:17.69
Error Sequence number: 119
Name of system (marketing): DEC 2000 Model 300S
Unit number: 0
Unit operation count: 780948
I/O function code: 0  allocate path
Device name length: 10 string: IPCALP$JPA
Number of Longwords: 11c
Driver Version: 1008D
Device Type: 55
Condition code: cc6813b
%MP_-I-SOFTRESET, SA85 softreset
Fault Command: 0  GSR
Response from SA85: 0  GSR
Last Crash Code: d7  fatal -- SA85 timed out doing a controller function
Processing Flag:  0
Current service path:  2
Last service path:  2
Last master path:   2
Last service bits:       18 ABORTS SOFT_RESET
Now service bits:        18 ABORTS SOFT_RESET
SA85 Status: 7f
Number Weird ints: 0
Suspended UCB: 0
Suspended func: 0
Interrupts after 5 microseconds: 0
Peer Locked flag: 0
  Interrupt Stack:
        Host     Host       Peer      Path
       unit      to peer   to host    number
      number     v2p      read SA85

        00        04 GMRESP  00        07
        00        00 GSR     80        02
        00        00 GSR     ff        02
        00        00 GSR     80        02
        05        01 COUT    fe        02
        0f        03 WSLAVE  80        42
        0f        03 WSLAVE  fc        42
        00        00 GSR     ff        00
        00        04 GMRESP  fb        02
        00        00 GSR     80        02
```

```
00        00 GSR     ff        02
00        01 COUT    80        01
02        01 COUT    fe        01
03        0a RGLOBAL f5        3f
05        01 COUT    fe        02
00        00 GSR     ff        00
00        04 GMRESP  fb        02
00        00 GSR     80        02
00        00 GSR     ff        02
00        04 GMRESP  80        01
00        04 GMRESP  fb        01
00        00 GSR     ff        01
05        01 COUT    80        02
05        01 COUT    fe        02
02        01 COUT    80        01
02        01 COUT    fe        01
00        00 GSR     ff        00
00        04 GMRESP  fb        02
00        00 GSR     80        02
00        00 GSR     ff        02
00        04 GMRESP  fb        01
00        00 GSR     80        03
00        00 GSR     ff        03
0e        03 WSLAVE  80        41
0e        03 WSLAVE  fc        41
05        01 COUT    fe        02
02        01 COUT    fe        01
00        00 GSR     ff        00
00        04 GMRESP  fb        02
00        00 GSR     80        02
00        00 GSR     ff        02
00        04 GMRESP  80        01
00        04 GMRESP  fb        01
00        00 GSR     80        03
00        00 GSR     ff        03
00        01 COUT    80        02
05        01 COUT    fe        02
02        01 COUT    fe        01
00        00 GSR     ff        00
00        04 GMRESP  fb        02
00        00 GSR     80        02
00        00 GSR     ff        02
00        04 GMRESP  80        01
00        04 GMRESP  fb        01
00        00 GSR     80        03
00        00 GSR     ff        03
00        02 GSLAVE  fd        41
00        00 GSR     80        00
00        00 GSR     ff        00
00        00 GSR     80        00
00        00 GSR     ff        00
00        02 GSLAVE  fd        42
00        00 GSR     80        00
00        00 GSR     ff        00
00        01 COUT    80        02
05        01 COUT    fe        02
02        01 COUT    fe        01
00        00 GSR     ff        00
00        04 GMRESP  fb        02
00        00 GSR     80        02
00        00 GSR     ff        02
```

```
00         04 GMRESP  80         01
00         04 GMRESP  fb         01
00         00 GSR     80         03
00         00 GSR     ff         03
00         01 COUT    80         02
05         01 COUT    fe         02
02         01 COUT    fe         01
00         00 GSR     ff         00
00         04 GMRESP  fb         02
00         00 GSR     80         02
00         00 GSR     ff         02
00         04 GMRESP  80         01
00         04 GMRESP  fb         01
00         00 GSR     80         03
00         00 GSR     ff         03
00         01 COUT    80         02
05         01 COUT    fe         02
02         01 COUT    fe         01
00         00 GSR     ff         00
00         04 GMRESP  fb         02
00         00 GSR     80         02
00         00 GSR     ff         02
00         04 GMRESP  80         01
00         04 GMRESP  fb         01
00         00 GSR     80         03
00         00 GSR     ff         03
00         01 COUT    80         02
05         01 COUT    fe         02
02         01 COUT    fe         01
00         00 GSR     ff         00
00         04 GMRESP  fb         02
00         00 GSR     80         02
00         00 GSR     ff         02
00         04 GMRESP  80         01
00         04 GMRESP  fb         01
00         00 GSR     80         03
00         00 GSR     ff         03
00         01 COUT    80         02
05         01 COUT    fe         02
02         01 COUT    fe         01
00         00 GSR     ff         00
00         04 GMRESP  fb         02
00         00 GSR     80         02
00         00 GSR     ff         02
00         04 GMRESP  80         01
00         04 GMRESP  fb         01
00         00 GSR     80         03
00         00 GSR     ff         03
00         01 COUT    80         02
05         01 COUT    fe         02
02         01 COUT    fe         01
00         00 GSR     ff         00
00         04 GMRESP  fb         02
00         00 GSR     80         02
00         00 GSR     ff         02
00         04 GMRESP  80         01
00         04 GMRESP  fb         01
```

```
gsr_b_dm_paths:  0,  2
gsr_b_ds_paths:  0,  0
gsr_b_pm_paths:  0,  0
gsr_b_ps_paths:  0,  0
  GSR Map of global data present:
  01 02 03 04 05 06 07 08
  XX XX    XX
  09 10 11 12 13 14 15 16

  17 18 19 20 21 22 23 24

  25 26 27 28 29 30 31 32
           XX
  33 34 35 36 37 38 39 40

  41 42 43 44 45 46 47 48

  49 50 51 52 53 54 55 56

  57 58 59 60 61 62 63 64
                     XX

 LAST COMMAND TO SA85 INFORMATION:

Master Path #1: 2
Broadcast Address: ffffffff
Destination Address: 3c
Source Address: 3f
MAC Function: 11
Transfer Size (Lo): d
Transfer Size (Hi): 0
Master Path #2: 2
RTR Fail Index: 0
Sequence Number: 0
MODBUS Function: 8
Routing bytes: 3c 00 00 00 00

 READ OF SA85 SHARED MEMORY:

Master Path #1: 7
Broadcast Address: 4d
Destination Address: 4f
Source Address: 44
MAC Function: 49
Transfer Size (Lo): 43
Transfer Size (Hi): 4f
Master Path #2: 4e
RTR Fail Index: 2c
Sequence Number: 20
MODBUS Function: 49
Routing bytes: 43 4f 50 59 52

DUMP: Last Command to SA85

  (0000) 3f3cff02 02000d11 003c0000 08000000 03001500 00000004

DUMP: SA85 Shared Memory
```

```
 (0000) 444f4d07 4e4f4349 4f43202c 49525950 20544847 20294328
Data Master Path table
Path Entry: 0
  Path:                   1
  Path UCB owner:  80A2F780
  Path Status:            C
     PT_ABORTING
     PT_BUSY
Path Entry: 1
  Path:                   2
  Path UCB owner:  80A4AF00
  Path Status:            C
     PT_ABORTING
     PT_BUSY
Path Entry: 2
  Path:                   3
  Path UCB owner:  80A6C680
  Path Status:            C
     PT_ABORTING
     PT_BUSY
Path Entry: 3
  Path:                   4
  Path UCB owner:  80A6CEC0
  Path Status:            C
     PT_ABORTING
     PT_BUSY
Path Entry: 4
  Path:                   5
  Path UCB owner:         0
  Path Status:            5
     PT_AVAILABLE
     PT_ABORTING
Path Entry: 5
  Path:                   6
  Path UCB owner:         0
  Path Status:            5
     PT_AVAILABLE
     PT_ABORTING
Path Entry: 6
  Path:                   7
  Path UCB owner:         0
  Path Status:            5
     PT_AVAILABLE
     PT_ABORTING
Path Entry: 7
  Path:                   8
  Path UCB owner:         0
  Path Status:            5
     PT_AVAILABLE
     PT_ABORTING

Data Slave Path table
Path Entry: 0
  Path:                  41
  Path UCB owner:  80A63F40
  Path Status:            8
     PT_BUSY
Path Entry: 1
  Path:                  42
  Path UCB owner:  80A66EC0
  Path Status:            C
```

```
     PT_ABORTING
     PT_BUSY
Path Entry: 2
  Path:                  43
  Path UCB owner:  80A68400
  Path Status:            8
     PT_BUSY
Path Entry: 3
  Path:                  44
  Path UCB owner:         0
  Path Status:            5
     PT_AVAILABLE
     PT_ABORTING
Path Entry: 4
  Path:                  45
  Path UCB owner:         0
  Path Status:            5
     PT_AVAILABLE
     PT_ABORTING
Path Entry: 5
  Path:                  46
  Path UCB owner:         0
  Path Status:            5
     PT_AVAILABLE
     PT_ABORTING
Path Entry: 6
  Path:                  47
  Path UCB owner:         0
  Path Status:            5
     PT_AVAILABLE
     PT_ABORTING
Path Entry: 7
  Path:                  48
  Path UCB owner:         0
  Path Status:            5
     PT_AVAILABLE
     PT_ABORTING

Program Master Path table
Path Entry: 0
  Path:                  81
  Path UCB owner:         0
  Path Status:            5
     PT_AVAILABLE
     PT_ABORTING
Path Entry: 1
  Path:                  82
  Path UCB owner:         0
  Path Status:            5
     PT_AVAILABLE
     PT_ABORTING
Path Entry: 2
  Path:                  83
  Path UCB owner:         0
  Path Status:            5
     PT_AVAILABLE
     PT_ABORTING
Path Entry: 3
  Path:                  84
  Path UCB owner:         0
  Path Status:            5
```

```
     PT_AVAILABLE
     PT_ABORTING
Path Entry: 4
  Path:                  85
  Path UCB owner:         0
  Path Status:            5
     PT_AVAILABLE
     PT_ABORTING
Path Entry: 5
  Path:                  86
  Path UCB owner:         0
  Path Status:            5
     PT_AVAILABLE
     PT_ABORTING
Path Entry: 6
  Path:                  87
  Path UCB owner:         0
  Path Status:            5
     PT_AVAILABLE
     PT_ABORTING
Path Entry: 7
  Path:                  88
  Path UCB owner:         0
  Path Status:            5
     PT_AVAILABLE
     PT_ABORTING

Program Slave Path table
Path Entry: 0
  Path:                  C1
  Path UCB owner:         0
  Path Status:            5
     PT_AVAILABLE
     PT_ABORTING
Path Entry: 1
  Path:                  C2
  Path UCB owner:         0
  Path Status:            5
     PT_AVAILABLE
     PT_ABORTING
Path Entry: 2
  Path:                  C3
  Path UCB owner:         0
  Path Status:            5
     PT_AVAILABLE
     PT_ABORTING
Path Entry: 3
  Path:                  C4
  Path UCB owner:         0
  Path Status:            5
     PT_AVAILABLE
     PT_ABORTING
Path Entry: 4
  Path:                  C5
  Path UCB owner:         0
  Path Status:            5
     PT_AVAILABLE
     PT_ABORTING
Path Entry: 5
  Path:                  C6
  Path UCB owner:         0
```

```
   Path Status:            5
      PT_AVAILABLE
      PT_ABORTING
 Path Entry: 6
   Path:                  C7
   Path UCB owner:         0
   Path Status:            5
      PT_AVAILABLE
      PT_ABORTING
 Path Entry: 7
   Path:                  C8
   Path UCB owner:         0
   Path Status:            5
      PT_AVAILABLE
      PT_ABORTING
```

$QIO Requests

6. $QIO/$QIOW Requests

- Using $QIO/$QIOW Requests
- User Buffers
- IO$_ALLOC Allocate Path
- IO$_DEALLOC Deallocate Path
- IO$_WRITE_MC Write Master Command
- IO$_READ_MR Read Master Response
- IO$_READ_SC Read Slave Command
- IO$_WRITE_SR Write Slave Response
- IO$_GET_GD Get Global Data
- IO$_PUT_GD Put Global Data
- IO$_GET_CS Get Configuration Status Information
- IO$_GET_SR Get Service Request Information
- IO$_GET_SS Get Driver Status/Statistics
- IO$_ABORT Abort Transaction

6.1 Using $QIO/$QIOW Requests

Both the $QIO and $QIOW calls request that VMS place a specified I/O request on the targeted device driver's input queue. A successful $QIO call queues the request to the driver and allows the application process to continue while the I/O action progresses. A successful $QIOW call queues the request to the driver and blocks the process until the I/O action completes.

6.1.1 If the Queue Attempt is Successful

If the queue attempt is successful, the driver will process the request until some form of I/O action is completed. An event flag can be specified as a parameter in the request. The flag will be set when the I/O action actually completes.

The address of a VMS AST service routine, and a parameter to be passed to the routine can also be specified as parameters. Upon successful completion of the I/O action, the service routine executes.

6.1.2 Completion of the Request

The final result of completion of the I/O Action will be a condition code value returned in an I/O Status Block, indicating the action that was taken by the driver. The address of the status block is a parameter specified in the $QIO/$QIOW. The application process can examine the condition code to determine whether the I/O action was as requested. The condition value SS$_NORMAL is returned for successful completion. Other values are returned for unsuccessful completion, such as for the target device being offline, or due to a timeout, powerfail, or similar condition. Condition codes are listed for each type of request in this chapter.

Some requests also transfer information to or from a buffer. The buffer address and length are parameters that are specified in the request.

6.1.3 If the Queue Attempt is Unsuccessful

If an error occurs in processing a $QIO/$QIOW request before it is queued to the driver, VMS returns an error condition code as listed in the *VMS Programming Manual, Volume 4B - System Services*.

If an event flag was specified in the request, it will be set to show the termination of the request, but the I/O Status Block will not be filled and any specified service routine will not execute.

6.1.4 Call Format

The format and arguments for the $QIO and $QIOW system services are as follows. Arguments in brackets [ ] are optional:

```
$Q I O [W] [efn],chan,        func     [,iosb]        [,astadr]      [,astprm]
           [,p1]    [,p2]    [,p3]    [,p4]    [,p5]    [,p6]
```

The arguments are outlined below. For a more detailed description refer to your *VMS Programming Manual, Volume 4B - System Services*.

efn — An event flag number specified by the user. The event flag will be set when the I/O operation actually completes.

The event flag will also be set if the $QIO service terminates before queuing the I/O request (for example, if an illegal argument is specified in the request).

chan — The I/O channel number previously assigned to the device by $ASSIGN.

func — The I/O function code and modifier specifying the operation to be performed. A symbolic list of codes and modifiers is contained in this chapter. Their values are listed in Appendix C.

iosb — The address of the I/O status block to receive the final completion status of the I/O operation.

If an error occurs in attempting to queue the request to the device driver, the IOSB fields will not be filled.

astadr — The address of the entry mask of the service routine to be executed when the I/O operation completes.

If the $QIO service terminates before queuing the I/O request, the service routine will not execute.

astprm — The parameter to be passed to the specified service routine.

p1 - p6 — Device and I/O function dependent parameters. Parameters that are buffer pointers are standard VAX 32-bit virtual addresses. All other parameters are 16-bit unsigned integers.

6.1.5 Physical I/O Access Privilege

All of the function codes used with the host-based devices are in the VMS physical I/O range of values, requiring the issuing process to have physical I/O privilege (PHY_IO). This allows the VMS system administrator some control over which users can access the device driver and Modbus Plus network.

If a user without physical I/O privilege issues a $QIO to the driver, the I/O operation is rejected by the $QIO system service, which returns a condition value of SS$_NOPRIV. This prevents a process lacking the physical I/O privilege from communicating with a Modbus Plus device.

6.1.6 $QIO/$QIOW Function Codes and Modifiers

All VMS function codes begin with the characters IO$_ to which is appended a suffix describing the specific type of I/O request intended by the function. All of the $QIO/$QIOW functions recognized by the device driver use this format. They are contained in the C header file mp_funcs.h. Their values are listed in Appendix C.

Function modifiers are values which can be ORed together with the function code to request an operational feature of the function. All VMS function modifiers begin with the characters IO$M_ to which is appended a suffix that describes the modifier. For example, the modifier IO$M_ERASE specifies that the statistics counters are to be zeroed after being returned from the request. Modifiers, if used, are listed in the detailed description of each call in this chapter.

6.1.7 The IOSB Argument

One of the arguments you can specify is the address of an I/O Status Block (IOSB) to receive the driver's completion code and other information about the completed request. It is strongly recommended that you include this argument and check the IOSB upon completion of the request. Otherwise, errors occurring in the I/O operation can go undetected. Also note that the path number returned in the IOSB can be helpful for program debugging. The IOSB is described on the next page.

6.1.8 The P1-P6 Parameters

The $QIO/$QIOW call can include up to six device-dependent parameters, called P1 through P6. The use of these parameters differs for the specific $QIO/$QIOW and is shown in the detailed description of each call in this chapter.

6.1.9 The I/O Status Block (IOSB)

The I/O Status Block is an optional argument [iosb] that you can include in $QIO/$QIOW calls in order to receive detailed information on the status of the request to the device driver. Modicon devices use a differ IOSB format from that used by typical $QIO/$QIOW calls. The IOSB format is shown in Figure 6.

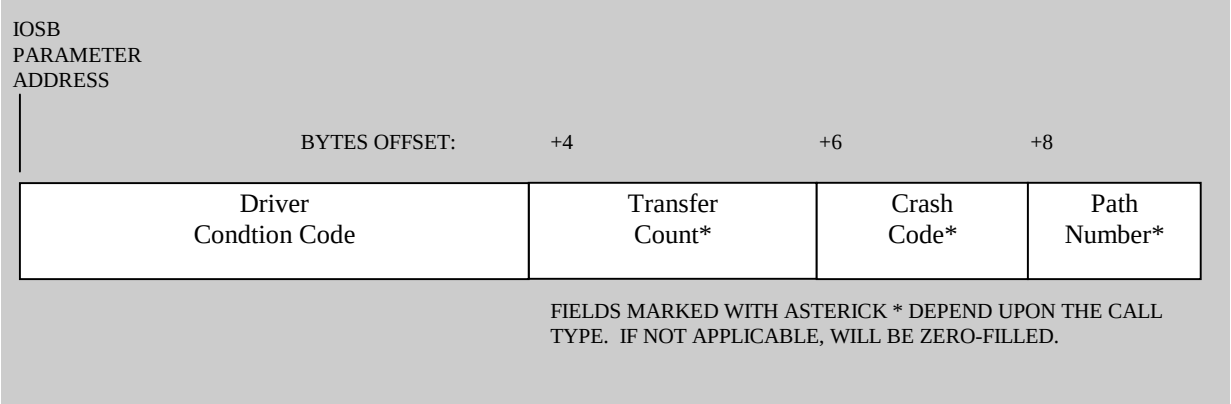


Figure 6 - I/O Status Block (IOSB) Format

VMS clears the IOSB during initial processing of the call, and the device driver fills the appropriate fields when it completes the request. If the call fails before it is queued to the driver, the IOSB will not be filled and the condition code value returned by VMS will indicate the error.

If the queuing succeeds, SS$_NORMAL is returned to the request. At that time the driver will process the request and will return its own condition code in the IOSB indicating the completion status of the I/O operation. SS$_NORMAL is returned as the IOSB condition code if the I/O operation is completed normally.

The IOSB condition code if the I/O operation is completed normally.

The IOSB condition code is returned for all requests completed by the driver. Linking the message file MP_MESSAGE.OBJ (on your TK50 tape) with your application allows error reporting using standard VMS facilities. A listing of condition codes is provided in Appendix C.

Use of the other three IOSB fields is dependent upon the specific $QIO/$QIOW:

◊ Transfer Count (IOSB bytes 4 and 5) is filled by a data input or output request, indicating the quantity of bytes transferred to or from the user buffer.

◊ Crash Code (IOSB byte 6) can only be returned by a request to a controller. If a controller crash occurs, the code MP$_CTRLCRASH is returned in the first word of the IOSB, and the specific crash code is placed in this field. A listing of crash codes is provided in Appendix C.

◊ Path Number (IOSB byte 7) returns the path number currently assigned to the I/O channel (if any) at the time the request completes.

6.1.10 Device Command Timeouts

Command timeouts are automatically used with each device request issued by the driver to ensure that the device makes a timely response to the command. The driver runs an internal timer to monitor completion of each request to the device. This timer does not require that network activity occurs. Your application has no direct control over this type of timer.

A failure to complete a command within the expected time is considered a fatal error. If this occurs, the $QIO/$QIOW is completed with a condition code of MP$_CTRLTMO. Error handling for this condition is described in Chapter 4.

6.1.11 User Timeouts

A user timeout is an argument specified in P5 of certain $QIO/$QIOW requests. It specifies the maximum amount of time, in seconds, that can elapse between the driver initiating an I/O operation and its completion. Only I/O read requests use this timeout parameter.

Any $QIO/$QIOW function that can immediately be completed by the driver (such as IO$_GET_SS - Get Driver Status/Statistics) does not require a user timer. Any function that can immediately be completed by the device (such as $IO_GET_GD - Get Global Data) also does not require a user timer. In such cases the device command timeout used by the device driver ensures that the command completes. User timeouts apply only to requests that require a response from a remote node in order to complete (such as IO$_READ_MR - Read Master Response, and similar requests).

The timing interval starts when the driver actually begins executing the request. While a request remains queued to the driver, the timing interval is not started for that request. Thus the interval reflects the actual execution time to be allowed for the I/O transaction.

Using the Timing Interval: User timeouts are driven by an asynchronous timer with a timing interval of one second. To ensure achieving at least one full timer interval, the specified timing value should be one second more than the desired timeout. The specified value is therefore a maximum value with a tolerance of ‘plus zero, minus one’ second.

For example, to have a timeout of at least one second, a value of two should be used in the argument. A value of one would cause the timeout to occur at any time from zero to one second, because timing starts asynchronously at any point in the timer’s current cycle and the timeout would occur at the end of that cycle. A value of two causes the timeout to occur at a point between one and two seconds. If you specify a value of one, the driver will change it to two.

If you specify a value of zero, the user timeout function will be disabled for that $QIO/$QIOW request. The implication of a zero timeout value is that the request will remain pending until it completes. Meaning that an uncompleted request would remain pending indefinitely and potentially cause the application to hang.

A sufficiently large value can be specified for the timeout argument to effectively disable the user timeout. The argument is a 16-bit unsigned value, allowing a maximum user timeout period of 65,535 seconds (18.2 hours).

If a user timeout occurs the request is completed with a returned condition code of SS$_TIMEOUT. A timed-out operation is not retried by the driver.

6.1.12 Using Global Data

Global data is accessed using the Get Global Data and put Global Data $QIO/$QIOW requests.

Getting Global Data from a Remote Node

When a process issues a Get Global Data request for a node other than the local node is the Modbus Plus device that is processing the request), the data is read from a global data image area that is maintained in the local node. This area contains a copy of the most recent global data received from the other network nodes.

The act of reading the data from the local node's image area destroys the copy of the data stored in the local node. The data is destroyed only for the specific node for which global data was accessed. The data image stored for the other nodes is not affected. The specific node's global data image will be refreshed when that node transmits a new token contained a new copy of its global data, and that data is received by the local node. The new data can be read by issuing another Get Global Data $QIO/$QIOW.

When the local device's copy of a remote node's global data is read, the remote node's data then becomes unavailable until a new token with global data is received from that node. Get Global Data calls for the same node during this interim will return MP$_NOGLOBAL (data for the other nodes is still available). This sequence assures that the call receives the most recent data.

The MP$_NOGLOBAL status would also returned if the remote node were not communicating at all. Thus a process may want to retry the Get Global Data request if the MP$_NOGLOBAL status is returned.

Getting Global Data from the Local Node

When the local device's own global data is read by the request, the global data then becomes unavailable for a subsequent Get Global Data call until the local device next passes the network token. MP$_NOGLOBAL is returned until the token pass occurs.

Putting Global Data

The only node to which the Put Global Data request can be issued is the local node (the local node is the Modbus plus device that is processing the request). When a process wishes to change the local node's global data, it supplies a pointer to the new data and a parameter for its length. The new data overwrites and replaces the old data, if any.

The size is specified in bytes and must be an even quantity since the Modbus Plus peer processor in the device only deals with words of global data. A size of zero is valid and does not return an error.

The local node continues to send its global data with each token pass on the network until it is specifically stopped from doing so by the application. To stop sending global data, the application should issue another Put Global Data request with a size parameter of zero.

6.1.13 Configuration Status Information

The $QIO/$QIOW function, Get Configuration Status Information, retrieves the current configuration status from a selected device and places it into an user buffer. The information returned includes the device type, its peer processor software version, its communication status and active station table, and information pertaining to token counts and rotation time. Also included are counters that report successful message packets, retries, and errors.

The request uses an optional function modifier that will clear the counters after retrieving their information to the user buffer.

The device driver automatically issues this command to each local device approximately every two seconds to serve as a watchdog function. A device not receiving the command within this time will set a crash error and will report it for subsequent requests to the device. This process is independent of any $QIO/$QIOW requests (including Get Configuration Status) issued in the application.

6.2 User Buffers

$QIO/$QIOW requests that transfer input or output data require the specification of user buffer address and length parameters. The descriptions in this chapter show the layout of the required user buffer. 'Input' requests show the purpose of each field contained in the buffer. 'Output' requests show the purpose of each field and identify those which the driver will fill, and those which the user must fill with data.

The length of the buffer must include the entire information packet that is to be transferred. Note that this length must be large enough to include information that is supplied automatically by the device driver as well as by the user. The minimum size is 16 bytes and the maximum is 270. Data input requests with a length below the minimum required will be rejected with a condition code of MP$_BADSIZE. Data output requests that are either below the minimum or above the maximum required will likewise be rejected with a condition code of MP$_BADSIZE.

Note that an input buffer that meets the driver's minimum requirements may still prove to be too small for the size of the received message. Programmers must ensure that an input buffer specified in a request is large enough to hold the expected contents of the input operation. If the buffer will not hold the actual input, the driver will fill the buffer, truncate any input that would otherwise overflow it, and return the condition code MP$_BUFFEROVF. The transfer count returned in the IOSB will always reflect the actual quantity of bytes transferred to the input buffer.

6.2.1 The User Buffer Format for a Normal Transaction

The user buffer for Global Data calls contain the data bytes as read or written. The buffer for Configuration Status and Service Request Information calls is specific to those calls and is shown in detail in the individual call descriptions.

The user buffer format for the $QIO/$QIOW requests IO$_WRITE_MC, IO$_READ_MR, IO$_READ_SC, and IO$WRITE_SR is similar for all of these requests. It consists of two parts: a 15-byte header portion, which contains Modbus Plus packet information, followed by the Modbus message portion.

Some of the header fields will be filled automatically by the driver, while others must be filled by the user application. The individual descriptions of these calls show the purpose of each byte in the header and the source of its contents. The message portion is filled or read entirely by the user application.

The header portion: This is the format of the 15-byte header portion of the buffer for Master or Slave path transactions:

Bytes	Contents
1	For WRITE_MC and READ_MR calls: the master output path. For READ_SC and WRITE_SR calls: the slave input path. The byte contains the path type combined with the path number, in the form 'tn' where 't' is the path and 'n' the path number. The path types are (in hex): DM=0n, DS=4n, PM=8n, PS=Cn. Path numbers are 1 to 8. For example, 01 specifies Data Master path 1;42 specifies Data Slave path 2.
2	Broadcast address: the field is always hex FF.
3	Destination address: the Modbus Plus address of the destination node.
4	Source address: the Modbus Plus address of the source node.
5	MAC function code: the Modbus Plus MAC layer function code.
6	Message data byte count: low-order byte.
7	Message data byte count: high-order byte. When combined with the low-order byte, the resulting value is 7 less than the number of bytes in the user buffer.
8	Master path: the source node's master path type and number used in the transaction.
9	For WRITE_MC and READ_SC calls: reserved, always 0. For READ_MR and WRITE_SR calls: the slave path login status: 1 if the master path used in the transaction has login privilege on the slave node, 0 if it does not.
10	Modbus Plus transaction sequence number. The exception is for station management transactions in which this byte contains a retry count used to complete the transaction.
11-15	Routing bytes 1 through 5 of the Modbus Plus routing path.

The message portion: The Modbus message portion of the buffer begins with the Modbus function code, contained in the first byte of the message. Any data which follows the function code must be encoded in the Modbus RTU format of two hexadecimal characters per eight-bit byte. Up to 255 bytes can be contained in the message portion, including the command byte.

Note that the first byte of the message is *not* the 'slave address' as used in the standard Modbus protocol. For further information about the message contents used for each type of Modbus command, refer to Appendix B of this guide.

6.2.2 The User Buffer Format for a Routing Failure

If a routing failure occurs in a remote node, the header and message contents returned to the user buffer will differ slightly from the expected data contents. The differences are listed below.

Differences in the header portion:

Byte	Contents
4	This byte contains the MAC function code for 'routing-failed'. The least significant five bits of the code will be 10011.
8	Instead of the slave login status, this byte contains the routing failure index. This index value is 1 to 5, indicating the Modbus Plus routing path byte (1 to 5) in the original request at which the routing error occurred.
15	Instead of the first byte of the message, this byte contains the device type of the failed node. It identifies the type of device that generated the routing failure message. The device types are: 0 Unknown device type 1 Programmable Controller 2 Bridge Multiplexer 3 Network Adapter 4 Bridge Plus 5 Peer I/O
16	Instead of the second byte of the message, this byte contains the routing failure error condition. This value is the specific condition that caused the routing failure. The error conditions are (in hex): 01 No response received 02 Program access denied 03 Node offline 04 Exception response received 05 Bridge Plus paths busy 06 Slave device down 07 Bad destination address 08 Invalid route 10 Slave rejected message 20 Forgotten transaction 40 Invalid path 80 Unsupported MAC function

6.3 IO$_ALLOC Allocate Path

This request allocates an available path to this channel and device, setting the path state to Allocated. The request specifies two characteristics of the requested path: Data or Program, and Master or Slave. For Master path requests, you can request a specific path or have the driver search for and supply an available path. For Slave path requests, you must request a specific path, which must be currently Available (not already Allocated or Busy).

During processing of the request, an Abort Transaction command is sent to the device to ensure that the path is clear at the device level.

The path number of the allocated path is returned to the IOSB.

Restrictions

If a specific path is requested, the targeted device must support the requested path number or a bad path error will be returned (MP$_BADPATH).

A path of the type requested (or the specific path requested) must be Available or a path not available error will be returned (MP$_PATHUNAVL).

The I/O channel must not have another path allocated, or a path allocation error will be returned (MP$_PATHALLOC).

Function Modifiers

None.

Parameters

P1 The requested path number, where:

Bit 1 -6: Path number. Zero if the driver is to locate and supply an available Master path.

Bit 7: 0 = Master, 1 = Slave.

Bit 8: 0 = Data, 1 = Program.

Device Commands Issued

Abort Transaction

Valid IOSB Fields

Driver Condition Code
Device Crash Code
Path Number

Condition Codes Returned From the Driver

SS$_NORMAL	Success
SS$_POWERFAIL	Powerfail occurred
SS$_ABORT	Request canceled
SS$_DEVOFFLINE	Device Offline
MP$_CTRLCRASH	Device crash occurred - check IOSB field
MP$_CTRLTMO	Device timeout occurred
MP$_BADPATH	Invalid path number
MP$_PATHUNAVL	Path not available
MP$_PATHALLOC	Path already allocated to this channel

6.4 IO$_DEALLOC Deallocate Path

This request deallocates a previously allocated path to the specified channel and device, setting the path state to Available.

During processing of the request, an Abort Transaction command is sent to the device to ensure that the path is clear at the device level.

Restrictions

A path must already be allocated to the current I/O channel or a path error will be returned (MP$_NOPATH).

Function Modifiers

None.

Parameters

None.

Device Commands Issued

Abort Transaction

Valid IOSB Fields

Driver Condition Code
Device Crash Code

Condition Codes Returned From the Driver

SS$_NORMAL	Success
SS$_ABORT	Request canceled
SS$_DEVOFFLINE	Device offline
MP$_CTRLCRASH	Device crash occurred - check IOSB field
MP$_CTRLTMO	Device timeout occurred
MP$_NOPATH	No path allocated

6.5 IO$_WRITE_MC Write Master Command

This request writes a Master command to the specified device Master path, which must have been previously Allocated. This transitions the path state from Allocated to Busy.

Restrictions

A path must already be allocated to the current I/O channel or path error will be returned (MP$_NOPATH).

The path must be in the Allocated state or a path state error will be returned (MP$_PATHSTAT).

The path must be a Master path or a path type error will be returned (MP$_PATHTYP).

The user output buffer (P1) must not be less than the minimum size or greater than the maximum size requirements of the Modbus Plus protocol or a size error will be returned (MP$_BADSIZE).

Function Modifiers

None.

Parameters

P1 The VAX starting address of the output buffer that contains the master command and header information required by the device.

P2 The size in bytes of the P1 buffer. The minimum size is 16 bytes to accommodate the 15-byte header and one-byte Modbus command. The maximum size is 270 bytes to accommodate the 15-byte header and Modbus message of 255 bytes.

Device Commands Issued

Put Master Command to Output Path

Valid IOSB Fields

Driver Condition Code
Transfer Count
Device Crash Count
Path Number

User Buffer Format

P1 Command Output Buffer (data supplier in parentheses):

Byte 01	Master Path (driver)
Byte 02	Broadcast Address (driver)
Byte 03	Destination Address (driver)
Byte 04	Source Address (driver)
Byte 05	MAC Function (driver)
Byte 06	Data Byte Count, Low (driver)
Byte 07	Data Byte Count, High (driver)
Byte 08	Master Path (driver)
Byte 09	Reserved (driver)
Byte 10	Sequence Number (driver)
Byte 11	Routing Byte 1 (user)
Byte 12	Routing Byte 2 (user)
Byte 13	Routing Byte 3 (user)
Byte 14	Routing Byte 4 (user)
Byte 15	Routing Byte 5 (user)
Byte 16	Modbus Command Byte 1 - the Modbus function code (user)
. . .	
Byte n	Last Modbus Command Byte (user)

Condition Codes Returned From the Driver

SS$_NORMAL	Success
SS$_POWERFAIL	Powerfail occurred
SS$_ABORT	Request canceled
SS$_DEVOFFLINE	Device offline
MP$_BADSIZE	Invalid user buffer size
MP$_CTRLCRASH	Device crash occurred - check IOSB field
MP$_CTRLTMO	Device timeout occurred
MP$_NOPATH	No path allocated
MP$_PATHTYP	Invalid path type for requested operation
MP$_PATHSTAT	Path state error occurred

6.6 IO$_READ_MR Read Master Response

This request reads a Master response from the specified device master path. The user must be reading a response to a Write Master command that was previously written on this path. This transitions the path state from Busy to Allocated.

Restrictions

A path must already be allocated to the current I/O channel or a path error will be returned (MP$_NOPATH).

The path must be in the Busy state or a path state error will be returned (MP$_PATHSTAT).

The path must be a Master path or a path type error will be returned (MP$_PATHTYP).

The user input buffer (P1) must not be less than the minimum size requirements of the Modbus Plus protocol or a size error will be returned (MP$_BADSIZE).

If the input buffer is not large enough to contain the input during processing a buffer overflow error will be returned (MP$_BUFFEROVF).

Function Modifiers

None.

Parameters

P1 The VAX starting address of the input buffer to receive the Master response and header information returned by the device.

P2 The size in bytes of the P1 buffer.

P5 The user timeout value, in seconds, to apply to this request.

Device Commands Issued

Get Service Request
Get Master Response from Output Path

Valid IOSB Fields

Driver Condition Code
Transfer Count
Device Crash Code
Path Number

User Buffer Format

See the description on the following pages for the P1 Response Input Buffer formats for a normal response and for a routing error response.

Condition Codes Returned From the Driver

SS$_NORMAL	Success
SS$_POWERFAIL	Powerfail occurred
SS$_ABORT	Request canceled
SS$_DEVOFFLINE	Device offline
SS$_TIMEOUT	User timeout occurred
MP$_BADSIZE	Invalid user buffer size
MP$_BUFFEROVF	Buffer overflow
MP$_CTRLCRASH	Device crash occurred - check IOSB field
MP$_CTRLTMO	Device timeout occurred
MP$_NOPATH	No path allocated
MP$_PATHTYP	Invalid path type for requested operation
MP$_PATHSTAT	Path state error occurred
MP$_ROUTERR	Modbus Plus routing error occurred

User Buffer Format for a Normal Response

P1 Response Input Buffer:

Byte 01	Master Path, echoed back
Byte 02	Broadcast Address
Byte 03	Destination Address
Byte 04	Source Address
Byte 05	MAC Function
Byte 06	Data Byte Count, Low
Byte 07	Data Byte Count, High
Byte 08	Master Path originally assigned
Byte 09	Slave Device Login Status (1 = logged in, 0 = not)
Byte 10	Sequence Number
Byte 11	Routing Byte 1
Byte 12	Routing Byte 2
Byte 13	Routing Byte 3
Byte 14	Routing Byte 4
Byte 15	Routing Byte 5
Byte 16	Modbus Command Byte 1
Byte 17	Modbus Command Byte 2
. . .	
Byte n	Last Modbus Response Byte (user)

User Buffer Format for a Routing Error Response

P1 Response Input Buffer

Byte 01	Master Path, echoed back		
Byte 02	Broadcast Address		
Byte 03	Destination Address		
Byte 04	Source Address		
Byte 05	MAC Function, set to xxx10011 binary = routing failed		
Byte 06	Data Byte Count, Low		
Byte 07	Data Byte Count, High		
Byte 08	Master Path originally assigned		
Byte 09	Routing Path Failure Index: 1-5, indicating the routing path byte containing node address that returned the error		
Byte 10	Sequence Number		
Byte 11	Routing Byte 1		
Byte 12	Routing Byte 2		
Byte 13	Routing Byte 3		
Byte 14	Routing Byte 4		
Byte 15	Routing Byte 5		
Byte 16	Failed Node Type:	0	Unknown device type
		1	Programmable Controller
		2	Bridge Multiplexer
		3	Network Adapter
		4	Bridge Plus
		5	Peer I/O
Byte 17	Routing Failure Error Condition:		
		01	No response received
		02	Program access denied
		03	Node offline
		04	Exception response received
		05	Bridge Plus paths busy
		06	Slave device down
		07	Bad destination address
		08	Invalid route
		10	Slave rejected message
		20	Forgotten transaction
		40	Invalid path
		80	Unsupported MAC function

6.7 IO$_READ_SC Read Slave Command

This request reads a Slave command from the specified device slave path which must have been previously Allocated. This transitions the path state from Allocated to Busy.

Restrictions

A path must already be allocated to the current I/O channel or a path error will be returned (MP$_NOPATH).

The path must be in the Allocated state or a path state error will be returned (MP$_PATHSTAT).

The path must be a Slave path or a path type error will be returned (MP$_PATHTYP).

The user input buffer (P1) must not be less than the minimum size requirements of the Modbus Plus protocol or a size error will be returned (MP$_BADSIZE).

If the input buffer is not large enough to contain the input during processing a buffer overflow error will be returned (MP$_BUFFEROVF).

Function Modifiers

None.

Parameters

P1 The VAX starting address of the input buffer to receive the Slave command and header information returned by the device.

P2 The size in bytes of the P1 buffer.

P5 The user timeout value, in seconds, apply to this request.

Device Commands Issued

Get Service Request
Get Slave Command from Input Path

Valid IOSB Fields

Driver Condition Code
Transfer Count
Device Crash Code
Path Number

User Buffer Format

P1 Command Input Buffer

Byte 01	Slave Path (Hex: 41, 42,...,48)
Byte 02	Broadcast Address
Byte 03	Destination Address
Byte 04	Source Address
Byte 05	MAC Function
Byte 06	Data Byte Count, Low
Byte 07	Data Byte Count, High
Byte 08	Master Path
Byte 09	Reserved
Byte 10	Sequence Number
Byte 11	Routing Byte 1: your node address
Byte 12	Routing Byte 2: the slave path number
Byte 13	Routing Byte 3: 0
Byte 14	Routing Byte 4: 0
Byte 15	Routing Byte 5: 0
Byte 16	Modbus Command Byte 1
Byte 17	Modbus Command Byte 2
. . .	
Byte n	Last Modbus Response Byte

Condition Codes Returned From the Driver

SS$_NORMAL	Success
SS$_POWERFAIL	Powerfail occurred
SS$_ABORT	Request canceled
SS$_DEVOFFLINE	Device offline
SS$_TIMEOUT	User timeout occurred
MP$_BADSIZE	Invalid user buffer size
MP$_BUFFEROVF	Buffer overflow
MP$_CTRLCRASH	Device crash occurred - check IOSB field
MP$_CTRLTMO	Device timeout occurred
MP$_NOPATH	No path allocated
MP$_PATHTYP	Invalid path type for requested operation
MP$_PATHSTAT	Path state error occurred

6.8 IO$_WRITE_SR Write Slave Response

This request writes a Slave response to the specified device master path, which must have been previously Allocated. The user must be responding to a Slave command that was previously read on this path. This transitions the path state from Busy to Allocated.

Restrictions

A path must already be allocated to the current I/O channel or a path error will be returned (MP$_NOPATH).

The path must be in the Busy state or a path state error will be returned (MP$_PATHSTAT).

The path must be a Slave path or a path type error will be returned (MP$_PATHTYP).

The user output buffer (P1) must not be less than the minimum size or greater than the maximum size requirements of the Modbus Plus protocol or a size error will be returned (MP$_BADSIZE).

Function Modifiers

None.

Parameters

P1 The VAX starting address of the input buffer to receive the Slave command and header information returned by the device.

P2 The size in bytes of the P1 buffer.

Device Commands Issued

Put Slave Response to Input Path.

Valid IOSB Fields

Driver Condition Code
Transfer Count
Device Crash Code
Path Number

User Buffer Format

See the description for the P1 Response Input Buffer formats for sending a normal response and for sending a routing error response.

Condition Codes Returned From the Driver

SS$_NORMAL	Success
SS$_POWERFAIL	Powerfail occurred
SS$_ABORT	Request canceled
SS$_DEVOFFLINE	Device offline
MP$_BADSIZE	Invalid user buffer size
MP$_CTRLCRASH	Device crash occurred - check IOSB field
MP$_CTRLTMO	Device timeout occurred
MP$_NOPATH	No path allocated
MP$_PATHTYP	Invalid path type for requested operation
MP$_PATHSTAT	Path state error occurred

User Buffer Format for a Normal Response

If a process wishes to return a normal response, the following format is used for the P1 Response Input Buffer (data supplier in parentheses):

Byte 01	Master Path (driver)
Byte 02	Broadcast Address (driver)
Byte 03	Destination Address (driver)
Byte 04	Source Address (driver)
Byte 05	MAC Function (driver)
Byte 06	Data Byte Count, Low (driver)
Byte 07	Data Byte Count, High (driver)
Byte 08	Master Path (driver)
Byte 09	Slave Path Login Status: 1 = logged in, 0 = not (user)
Byte 10	Sequence Number (driver)
Byte 11	Routing Byte 1: (driver)
Byte 12	Routing Byte 2: (driver)
Byte 13	Routing Byte 3: (driver)
Byte 14	Routing Byte 4: (driver)
Byte 15	Routing Byte 5: (driver)
Byte 16	Modbus Command Byte 1 (user)
Byte 17	Modbus Command Byte 2 (user)

. . .
Byte n Last Modbus Response Byte (user)

User Buffer Format for a Routing Error Response

If a process wishes to return a Modbus Plus routing error rather than a regular response, an alternative format is used for the P1 Response Input Buffer:

Byte 01	Master Path (driver)
Byte 02	Broadcast Address (driver)
Byte 03	Destination Address (driver)
Byte 04	Source Address (driver)
Byte 05	MAC Function (driver)
Byte 06	Data Byte Count, Low (driver)
Byte 07	Data Byte Count, High (driver)
Byte 08	Master Path (driver)
Byte 09	Routing Path Failure Index: must be set to 2(user)
Byte 10	Sequence Number (driver)
Byte 11	Routing Byte 1: (driver)
Byte 12	Routing Byte 2: (driver)
Byte 13	Routing Byte 3: (driver)
Byte 14	Routing Byte 4: (driver)
Byte 15	Routing Byte 5: (driver)
Byte 16	Failed Node type: must be set to 3 (user)
Byte 17	Routing Failure Error Condition: (user)

01	No response received
02	Program access denied
03	Node offline
04	Exception response received
05	Bridge Plus paths busy
06	Slave device down
07	Bad destination address
08	Invalid route
10	Slave rejected message
20	Forgotten transaction
40	Invalid path
80	Unsupported MAC function

6.9 IO$_GET_GD Get Global Data

This request retrieves the global data for the specified Modbus Plus node and places it in the user buffer.

The format of global data returned from this request is defined by the application. Note that the byte order for global data is different from that for master and slave read/write buffers. Examples are shown later in this section.

When the local device's own global data is read by the request, the global data then becomes unavailable for a subsequent Get Global Data call until the local device passes the network token. When the local copy of a remote node's global data is read, the remote node's data then becomes unavailable until a new token with global data is received from that node. Get Global Data calls for the same node during this interim will return MP$_NOGLOBAL (data for the other nodes is still available). This sequence assures that the call receives the most recent data.

Restrictions

The specified node address must be from 1 to 64 or node address error will be returned (MP$_BADNODE).

The input buffer size is specified as a byte count from 1 to 64. The size must be an event number of bytes or a bad size error will be returned (MP$_BADSIZE).

If the input buffer is not large enough to contain the input during processing a buffer overflow error will be returned (MP$_BUFFEROVF).

The local device must have received global data from the specified node or a no global data error will be returned (MP$_NOGLOBAL).

Function Modifiers

None.

Parameters

P1 The VAX starting address of the input buffer to receive the global data.

P2 The size in bytes of the P1 buffer from 1 to 64.

P3 The Modbus Plus address of the target node.

Device Commands Issued

Get Service Request
Get Global Data

Valid IOSB Fields

Driver Condition Code
Transfer Count
Device Crash Code
Path Number

User Buffer Format

The P1 Global Data Input Buffer format is defined by the user application:

Byte 01	First global data byte (driver)
. . .	
Byte n	Last global data byte (driver)

Example:	**User Buffer**	**Controller Register Global Data**
	Byte 1	1st register, LOW byte
	Byte 2	1st register, HIGH byte
	Byte 3	2nd register, LOW byte
	Byte 4	2nd register, HIGH byte
	. . .	
		(register data layout is: [HIGH byte | LOW byte])

Condition Codes Returned From the Driver

SS$_NORMAL	Success
SS$_POWERFAIL	Powerfail occurred
SS$_ABORT	Request canceled
SS$_DEVOFFLINE	Device offline
MP$_BADNODE	Invalid Modbus Plus node address
MP$_BADSIZE	Invalid user buffer size
MP$_BUFFEROVR	Buffer overflow
MP$_CTRLCRASH	Device crash occurred - check IOSB field
MP$_CTRLTMO	Device timeout occurred
MP$_NOGLOBAL	No global data available

6.10 IO$_PUT_GD Put Global Data

This request replaces the local device's global data with the data specified in the user buffer.

The format of the global data in this request is defined by the application. Note that the byte order for global data is different from that for master and slave read/write buffers. Examples are shown later in this are later in this section.

Restrictions

The output buffer size is specified as a byte count, from 0 to 64. The size must be an even number of bytes or a bad size error will be returned (MP$_BADSIZE). A size of zero is a valid size and is used to terminate the sending of global data.

Function Modifiers

None.

Parameters

P1 The VAX starting address of the output buffer containing the global data.

P2 The size in bytes of the P1 buffer, from 1 to 64.

Device Commands Issued

Put Global Data

Valid IOSB Fields

Driver Condition Code
Transfer Count
Device Crash Code
Path Number

User Buffer Format

The P1 Global Data Input Buffer format is defined by the user application:

Byte 01	First global data byte (user)
. . .	
Byte n	Last global data byte (user)

Example:	**User Buffer**	**Controller Register Global Data**
	Byte 1	1st register, LOW byte
	Byte 2	1st register, HIGH byte
	Byte 3	2nd register, LOW byte
	Byte 4	2nd register, HIGH byte
	. . .	
		(register data layout is: [HIGH byte | LOW byte])

Condition Codes Returned From the Driver

SS$_NORMAL	Success
SS$_POWERFAIL	Powerfail occurred
SS$_ABORT	Request canceled
SS$_DEVOFFLINE	Device offline
MP$_BADSIZE	Invalid user buffer size
MP$_CTRLCRASH	Device crash occurred - check IOSB field
MP$_CTRLTMO	Device timeout occurred

6.11 IO$_GET_CS Get Configuration Status Information

This request retrieves the current configuration status from the peer processor of the specified device and places it in the user buffer. The optional function modifier IO$M_ERASE causes the device's communication error counters to be cleared after they are read.

The buffer format is shown in the description of 'Get/Clear Network Statistics' in Appendix B.

Restrictions

If the input buffer is not large enough to contain the input during processing a bad size error will be returned (MP$_BADSIZE). The minimum buffer size is currently 55 words (110 bytes).

Function Modifiers

IO$M_ERASE Clear the device's error counters after reading them.

Parameters

P1 The VAX starting address of the output buffer to receive the configuration status information.

P2 The size in bytes of the P1 buffer.

Device Commands Issued

Configuration Status

Valid IOSB Fields

Driver Condition Code
Transfer Count
Device Crash Code
Path Number

User Buffer Format

The P1 Configuration Status Information Input Buffer format is shown in the description of ‘Get/Clear Network Statistics’ in Appendix B.

Condition Codes Returned From the Driver

SS$_NORMAL	Success
SS$_POWERFAIL	Powerfail occurred
SS$_ABORT	Request canceled
SS$_DEVOFFLINE	Device offline
MP$_BADSIZE	Invalid user buffer size
MP$_CTRLCRASH	Device crash occurred - check IOSB field
MP$_CTRLTMO	Device timeout occurred
MP$_CTRLERR	Device error occurred

6.12 IO$_GET_SR Get Service Request Information

This request retrieves the service request status information from the specified device and places it in the user buffer.

Note that the device driver issues Get Service Request commands to the devices as part of its processing of other user requests. Because of this, some of the Get Service Request Information received as a result of this $QIO/$QIOW could be invalid by the time it is received. Refer to the Device Commands Issued listing for each request to determine which ones issue this command during processing.

Restrictions

If the input buffer is not large enough to contain the input during processing a bad size error will be returned (MP$_BADSIZE). The minimum buffer size is currently 12 bytes.

Function Modifiers

None.

Parameters

P1 The starting address of the output buffer to receive the configuration status information.

P2 The size in bytes of the P1 buffer.

Device Commands Issued

Get Service Request

Valid IOSB Fields

Driver Condition Code
Transfer Count
Device Crash Code
Path Number

User Buffer Format

Byte 01	Data Master path service request bit-map.
Byte 02	Data Slave path service request bit-map.
Byte 03	Program Master path service request bit-map.
Byte 04	Program Slave path service request bit-map.
Byte 05	Global data present bit-map, nodes 1-8.
Byte 06	Global data present bit-map, nodes 9-16.
Byte 07	Global data present bit-map, nodes 17-24.
Byte 08	Global data present bit-map, nodes 25-32.
Byte 09	Global data present bit-map, nodes 33-40.
Byte 10	Global data present bit-map, nodes 41-48.
Byte 11	Global data present bit-map, nodes 49-56.
Byte 12	Global data present bit-map, nodes 57-64.

Condition Codes Returned From the Driver

SS$_NORMAL	Success
SS$_POWERFAIL	Powerfail occurred
SS$_ABORT	Request canceled
SS$_DEVOFFLINE	Device offline
MP$_BADSIZE	Invalid user buffer size
MP$_CTRLCRASH	Device crash occurred - check IOSB field
MP$_CTRLTMO	Device timeout occurred

6.13 IO$_GET_SS Get Driver Status / Statistics

This request retrieves the current driver status and statistics for the specified device and places it in the user buffer. Most of the information returned by this request concerns driver internal functions which do not affect the user application.

Restrictions

If the input buffer is not large enough to contain the input during processing, a bad size error will be returned (MP$_BADSIZE). The minimum buffer size is 316 bytes.

Function Modifiers

None.

Parameters

P1 The VAX starting address of the input buffer to receive the status and statistics information.

P2 The size in bytes of the P1 buffer.

Device Commands Issued

None.

Valid IOSB Fields

Driver Condition Code
Transfer Count
Path Number

Condition Codes Returned From the Driver

SS$_NORMAL	Success
SS$_POWERFAIL	Powerfail occurred
SS$_ABORT	Request canceled
SS$_DEVOFFLINE	Device offline
MP$_BADSIZE	Invalid user buffer size

User Buffer Format

Byte 001-003	Driver version.
Byte 004	Modbus Plus node address.
Byte 005	Device type.
Byte 006	Device status.
Byte 007	Device needs.
Byte 008	Latest VAX-to-device command.
Byte 009	Latest device-to-VAX response.
Byte 010	Latest device crash code.
Byte 011	Program master path connect status.
Byte 012 - 015	Number of unit Control Blocks cloned.
Byte 016 - 019	Number of paths allocated.
Byte 020 - 023	Number of paths deallocated.
Byte 024 - 027	Number of watchdog timer expirations.
Byte 028 - 031	Number of device service entries.
Byte 032 - 035	Number of device commands issued.
Byte 036 - 039	Number of device soft resets.
Byte 040 - 043	Number of device hard resets.
Byte 044 - 047	Number of interrupts.
Byte 048 - 051	Number of unsolicited interrupts.
Byte 052 - 055	Number of weird interrupts.
Byte 056 - 059	Number of device timeouts.
Byte 060 - 063	Number of user timeouts.
Byte 064 - 067	Number of device errors.
Byte 068 - 071	Number of QIOs canceled.
Byte 072 - 075	Number of cancels causing path deallocations.
Byte 076 - 079	Number of abort request entries.
Byte 080 - 083	Number of get service request entries.
Byte 084 - 087	Number of start I/O entries.
Byte 088 - 091	Number of I/O done entries.
Byte 092 - 095	Number of get service request case #1 entries.
Byte 096 - 099	Number of get service request case #2 entries.
Byte 100 - 103	Number of get service request case #3 entries.
Byte 104 - 107	Virtual address of CSR.
Byte 108 - 111	Virtual address of shared RAM.
Byte 112 - 303	Path table.
Byte 304 - 315	Latest get service request bit-map.

6.14 IO$_ABORT Abort Transaction

This request issues an Abort Transaction command for the specified device and path, cleans up any in-progress transactions on this path, and forces the path state to Allocated.

Restrictions

A path must already be allocated to the current I/O channel or a path error will be returned (MP$_NOPATH).

Function Modifiers

None.

Parameters

None.

Device Commands Issued

Abort Transaction

Valid IOSB Fields

Driver Condition Code
Transfer Count
Path Number

Condition Codes Returned From the Driver

SS$_NORMAL	Success
SS$_POWERFAIL	Powerfail occurred
SS$_ABORT	Request canceled
SS$_DEVOFFLINE	Device offline
MP$_CTRLCRASH	Device crash occurred - check IOSB field
MP$_CTRLTMO	Device timeout occurred
MP$_NOPATH	Path error occurred

Driver Utilities

7. Driver Utilities

The following utilities are provided with the SA85 OpenVMS/AXP device driver:

- Devdmp - Formats contents of driver tables. Used for reporting bugs and diagnosing driver faults.
- NDU - Network Diagnostic Utility. This utility was migrated from the existing Modbus driver for OpenVMS/VAX to the OpenVMS/AXP platform. Reference the Modicon: "DEC Host Based Devices User's Guide" for a description of this utility.
- MBP_ERRFMT - This utility will format out the error log packets logged by the MPDRIVER.

The "MBPLUS_" logical name points to the product directory as created by the kit installation. It is assumed the MBP_STARTUP.COM command file contained within the product directory has been executed to define this logical name. The file: MBPLUS_:MBP_SYMBOLS.COM will define the foreign symbols for the SA85 device driver utilities.

7.1 DEVDMP

DEVDMP is a DCL utility that takes a single parameter, the DEVICE name. The user must define the foreign command symbol as follows:

$DEVDMP == "$MBPLUS_:DEVDMP"

This utility does a change mode to Kernel and therefore must have this privilege granted in the user's authorization file. To evoke DEVDMP type the following:

$DEVDMP device name
Examples:

$DEVDMP JPA10:
$DEVDMP JPA1:

The driver maintains two devices per controller, one for servicing the unsolicited interrupts from the SA85 (device zero), and a template device that is copied whenever a user assigns a channel to the device (device one). DEVDMP first formats the UCB for the requested device, the controller dependent structure (CBF), and some fields of UCB zero.

7.2 MBP_ERRFMT

MBP_ERRFMT is a DCL utility that formats VMS error log packets from the MPDRIVER. The user must define the foreign command symbol as follows:

$MBP_ERRFMT == “$MBPLUS_:MBP_ERRFMT”

The syntax of the DCL command line to MBP_ERRFMT is as follows:

$MBP_ERRFMT [/err=filename][/out=filename][/start=vaxtime][/end=vaxtime]

err=
VMS filename of the error log file. The default is SYS$ERRORLOG:ERRLOG.SYS. This switch allows the user to examine alternate error log files, or files that were extracted with "analyze/error_log/binary=filename".

out=
VMS filename or device for formatted listing. Default is sys$output.

start=
VMS timestamp to limit search for entries after the indicated time. Default is all entries that are within the last two days.

end=
VMS timestamp to limit search for entries before the indicated time. Default is current time.

Example:

The following command would examine the current default error log file and format any found MPDRIVER error log entries to the output file: MBP_ERRORS.LIS that have been logged today.

$MBP_ERRFMT/OUT=MPB_ERRORS.LIS/START=TODAY

7.3 DCL_READ_REG

DCL_Read_Reg is a general purpose DCL foreign command. This utility will read up to forty holding registers (40001 to 49999) from any slave Modbus Plus node. This utility allocates a Modbus Plus Program master path to acquire the data. The utility will display data to the user and optionally place the data into DCL symbols. DCL_Read_Reg can be set up as a foreign command as follows. The following line was extracted from the MBP_STARTUP.COM command procedure which defines other foreign command.

$ rr :== "$dcl_readreg"

The DCL syntax for the utility is shown below. This utility also uses the process symbol table to save the route and holding register last read or it may be set by the user prior to executing the command. The two symbols used are: MBP_START_REGISTER and MBP_ROUTE.

$ rr /reg= Starting holding register-
/route=(xx.xx.xx.xx.xx)-
/count=<>-
[/adapter=]-
[/byte]-
[/hex]-
[/ASCII]-
[/symbols]

/reg=
Starting holding register. This may be omitted if the DCL symbol: MBP_START_REGISTER populated with a valid holding register.

/route=
Route path to the PLC. This may be omitted if the DCL symbol: MBP_ROUTE populated with a valid route path.

/adapter=
Modbus Plus adapter to use. By default, it uses JPA1:. The user enters: 0= jpa1:, 1= jpb1:, 2= jbc1: , or 3= jbd1:

/byte=
Byte swap the data before displaying.

/hex=
Display data in hex.

/ASCII=
Display or store data in symbol as ASCII. First null in holding register read will terminate string.

/symbols=
If present, then this utility will populate DCL symbols HR_1 to HR_nn where nn= count if "/ASCII" is not specified. Otherwise, HR_ASCII is set to the ASCII text.

VMSINSTAL
EXAMPLE

8. VMS Installation

The following is an example VMSINSTAL installation procedure. The user input is bolded.

```
$ set def sys$update
$@vmsinstal

OpenVMS AXP Software Product Installation Procedure V6.2

It is 13-NOV-1996 at 09:01.

Enter a question mark (?) at any time for help.
* Are you satisfied with the backup of your system disk [YES]? y
* Where will the distribution volumes be mounted: sys$update:

Enter the products to be processed from the first distribution volume
set.
* Products: mbp019
* Enter installation options you wish to use (none):

The following products will be processed:

  MBP V1.9

Beginning installation of MBP V1.9 at 09:02

%VMSINSTAL-I-RESTORE, Restoring product save set A ...

 MODBUS Plus SA85 Device Driver
           13-Nov-1996

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            260 S. Campbell
            Valparaiso, IN  46383
            Ph: 219-464-7212
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The distribution files have been restored from the
saveset.  The installation procedure is continuing...
Your system or common device/directory: IPCNET$DKA300:[SYS0.SYSCOMMON.]
This product by default creates the directory:

   IPCNET$DKA300:[SYS0.SYSCOMMON.][MBP019]

* Use default directory location [Y]? y


      The following two questions can be acquired by
using sysman and finding the EISA adapter number and the
CSR for the EISA adapter.  For the EISA CSR, enter only
the last eight digits (e.g. do not enter the leading
eight FFFFFFFFs).

      Only the serial number from the first SA85-002
is required along with the IPACT license number.  The
serial number from the card along with the license number are
used to validate a proper license of this software product.
Contact IPACT Inc. at 219-464-7212 if you donot have a license
pack.
```

```
* Enter Serial number of the first SA85-002 [0]: ####

* Enter license number for SA85 Serial number:  10: ####

Validating license for SA85 Serial number: ####
License number: ####

      The following question determines how the IRQ and vector
are mapped for your system.  Depending on the model, the
IRQs from the SA85 may be mapped differently.  Currently,
only the Sable (ALPHA 2100) should be answered with a "2".
All other CPUs should be answered with the default of "1".
      If the wrong option is selected, the SA85 will fail
to interrupt to the correct vector used by the device driver.

* Enter CPU type [ 1 or 2] [1]:


      The EISA adapter or the ISA adapter and the CSR can be
found by using "MCR SYSMAN IO SHOW BUS".  For some CPU's,
it is listed as the XBUS.

* Enter EISA adapter number [2]:

* Enter EISA adapter CSR address (in hex) [8644C000]:

* How many SA85 ISA Modbus Plus devices [1]:

* Enter  IRQ  for SA85 number 1:  [4]:

* Enter  ISA slot for SA85 number 1:  [4]:

* Enter  base address for SA85 number: 1  (in hex):  [000C0000]:

 CPU Type: 1
 Adapter Number: 2
 Adapter CSR: FFFFFFFF8644C000
 SA85 1 IRQ: 4, Slot: 4, Base: 000C0000
 Target Product location: SYS$COMMON:[MBP019]
* Are these correct [Y]? y

MBP_I_COFFEEBREAK answer section complete

MBP_I_COMMAND Building startup command file MBP_STARTUP.COM
MBP_I_DIRECTORY Creating SYS$COMMON:[MBP019]
%VMSINSTAL-I-SYSDIR, This product creates system disk directory
  SYS$COMMON:[MBP019].
%VMSINSTAL-I-SYSDIR, This product creates system disk directory
  SYS$COMMON:[MBP019.EXAMPLES].
MBP_I_MOVING Marking files to move
MBP_I_COMPLETE KITINSTAL.COM complete

      This kit currently is not supplied with an
IVP.  The command file:  MBP_STARTUP.COM has been
placed in the product directory.  Do not run this
file until you are sure that the SA85s have been configured
as you specified earlier, and the ECU has also been
run to configure the IRQs, and the memory mapped by theSA85s.


Your installation is now complete.
%VMSINSTAL-I-MOVEFILES, Files will now be moved to their target
directories...
      Installation of MBP V1.9 completed at 09:06
```

```
    Adding history entry in VMI$ROOT:[SYSUPD]VMSINSTAL.HISTORY

    Creating installation data file: VMI$ROOT:[SYSUPD]MBP019.VMI_DATA

Enter the products to be processed from the next distribution volume
set.
* Products:
      VMSINSTAL procedure done at 09:06
```

8.1 Additional Release Notes

It was found that the equivalence of some of the I/O function codes used by the driver were changed in the current release of OpenVMS. The prior SQ85 device driver QIO function codes were defined using an include file that did not use the definitions defined by the OpenVMS supplied standard definitions. The header file supplied with this SA85 device driver uses the OpenVMS supplied header definition file: **IODEF.H** to define the SA85 device driver's I/O function codes. Any previous users who had been including "v_mpfunc.h" should include from the MBP.TLB text library: "mp_funcs.h" for "C" users or "mp_funcs.txt" for FORTRAN users.

The following files are written to the SYS$COMMON:[MBP019] on the user's system disk.

Directory SYS$COMMON:[MBP019]

DEVDMP.EXE - Developer's driver database display utility
MBP.OLB - Object library containing message definition file for the MPDRIVER.
MBP_C.TLB - C header definitions text library
MBP_ERRFMT.EXE - Formats MPDRIVER error log entries
MBP_FOR.TLB - FORTRAN include files
MBP_STARTUP.COM - Loads device driver
NDU.EXE - Network Diagnostic Utility
SYS$MPDRIVER.EXE - SA85 driver
SYS$MPDRIVER.STB - SA85 driver symbol table

To install the driver, the user needs to execute the following command file:

$@SYS$COMMON:[MBP019]MBP_STARTUP.COM.

The Modicon Modcom III Communications Software Library has not been tested with the device driver as it is not available on the OpenVMS/AXP platform at this time. The IPACT Communications Library was tested and functions with the device driver and if licensed is installed as part of the VMSINSTAL kit.

8.2 Test Environment

This release of the Modbus Plus Device driver for OpenVMS/AXP with the ISA SA85 has been tested on a single processor Alpha with an EISA bus (Alpha DEC 2000 model 150). Due to hardware availability, only a single SA85 was tested, however, the driver was designed to support up to four SA85s installed in the EISA bus. The OpenVMS/AXP device driver MPDRIVER is a STEP 2 device driver and is therefore available on OpenVMS/AXP version 6.1 or later. The AM-SA85-002 SA85 was the only device tested and found to function correctly. An AM-SA85-000 was also tested, but failed to interrupt. The AT-984 was tested, but it also failed to interrupt. Further discussion with Modicon resolved that these other devices do not have interrupt capabilities.

Modbus Commands for Modbus Plus

9. Modbus Commands for Modbus Plus

- Modbus Protocol for Modbus Plus
- The Modbus Transaction
- Modbus Command Summary
- *Read Coil Status* (Function 01)
- *Read Input Status* (Function 02)
- *Read Holding Registers* (Function 03)
- *Read Input Registers* (Function 04)
- *Force Single Coil* (Function 05)
- *Preset Single Register* (Function 06)
- *Read Exception Status* (Function 07)
- *Get/Clear Network Statistics* (Function 08, Subfunction 21)
- *Force Multiple Coils* (Function 0F)
- *Preset Multiple Registers* (Function 10 Hex)
- *Report Slave ID* (Function 11 Hex)
- Exception Responses

9.1.1 Modbus Protocol for Modbus Plus

This appendix describes Modbus commands as they are used in Modbus Plus. This information is intended for programmers who wish to write applications that communicate between the host based devices and Modicon 984 controllers.

Modicon 984 controllers use the Modbus protocol to access data and statistics. Modbus Plus uses a set of Modbus commands to perform data acquisition tasks between your host based device and Modicon 984 controllers across the network.

The Modbus protocol determines how:

◊ The message sender and receiver identify each other

◊ The system maintains network-wide order as messages are exchanged

◊ Errors on the network are detected

9.1.2 The Master-Slave Relationship on Modbus and Modbus Plus

In the original Modbus protocol, only one master device can exist on a single network, originating contacts with multiple slave devices. The Modbus Plus peer-to-peer protocol allows multiple masters to contact multiple slave devices. Concurrent transactions are handled using multiple paths of various types in the devices.

The Modbus protocol uses a query-response cycle between master and slave devices. A complete message transaction consists of a query originated by a Modbus master device and a response sent by the slave back to the master.

9.1.3 Creating Modbus Queries and Responses

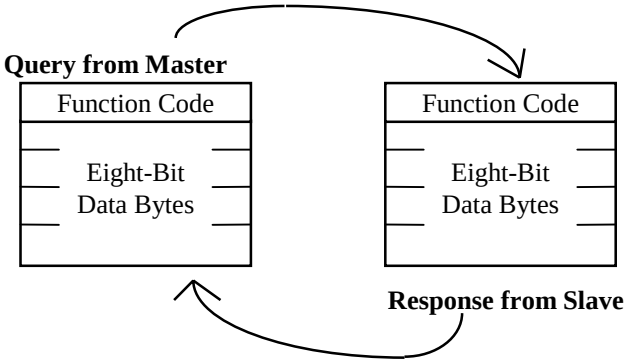
A Modbus query message originated by a host application can be constructed in a data buffer. The message should consist of the Modbus function code and data elements in the formats described in this appendix. To send the message, the buffer can be accessed by the $QIO/$QIOW functions for Modbus Plus.

Similarly, a slave application in the host can receive the query into a buffer using $QIO/$QIOW functions. It can construct the response message in a buffer and send it.

The processes of obtaining a network path, designating a Modbus Plus destination node, and imbedding the Modbus message into a Modbus Plus message packet are handled by the $QIO/$QIOW functions and network hardware.

9.2 The Modbus Transaction

The format for Modbus commands or responses is an eight-bit function code followed by a block of eight-bit bytes (maximum length: 252 bytes).



Master and Slave Query-Response Cycle

The Query: The function code in the query tells the addressed slave device what kind of action to perform. The data bytes contain any additional information that the slave will need to perform the function. For example, if you issue function code 03, querying the slave to read holding registers and respond with their contents, the data field must contain information telling the slave which register to start at and how many registers to read.

The Response: If the slave makes a normal response, the function code in response is an echo of the function code in the query. The data bytes contain the data collected by the slave, such as register values or status. If an error occurs the function code is modified to indicate that the response is an error response, and the data bytes contain a code that describes the error.

The buffer contents of the message as it is used for Modbus Plus are nearly the same as in a standard Modbus message, with two exceptions:

A Modbus message contains the slave device address. This is stripped from the Modbus message contents before transmission over Modbus Plus. It appears instead in the Modbus Plus MAC level destination field.

The Modbus CRC/LRC error check field is stripped from the message contents. Error checking is performed on the entire Modbus Plus message in the HDLC level CRC-16 field.

Code (In Hex)	Meaning	Action
01	*Read Coil Status*	Obtain the current ON/OFF status of a group of logic coils
02	*Read Input Status*	Obtain the current ON/OFF status of a group of discrete inputs
03	*Read Holding Registers*	Obtain the current binary value in one or more holding registers
04	*Read Input Registers*	Obtain the current binary value in one or more input registers
05	*Force Single Coil*	Force a logic coil ON or OFF
06	*Preset Single Register*	Place a specific binary value in a holding register
07	*Read Exception Status*	Obtain the current ON/OFF status of internal coils 00001 ... 00008 in a 984 controller; user logic determines the status of the coils; short message length allows rapid reading
08 (sub 15 hex)	*Get/Clear Network Statistics*	Obtain current network statistics from the host; specify subfunction 21 (15 hex)
09 ... 0E	Reserved	
0F	*Force Multiple Coils*	Force a set of consecutive coils ON or OFF
10	*Preset Multiple Registers*	Place a specific binary values into a series of consecutive holding registers
17	*Report Slave ID*	Lets the master decide the slave type and status of the slave's RUN light
18 ... FF	Reserved	

9.3 Specifying Discrete and Register References

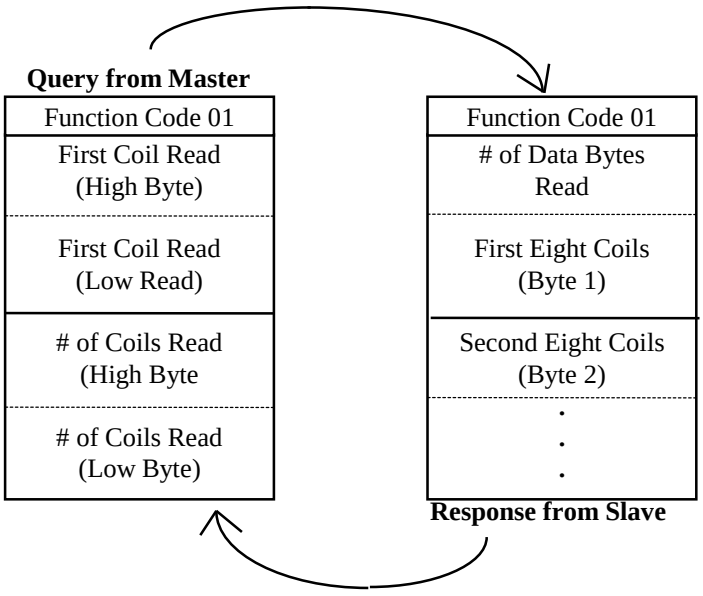
In the Modbus message the type of reference to be accessed (e.g., discrete coil, discrete input, input register, or holding register) is specified in the function code. All discrete or register addresses within the Modbus data portion of the message are in hexadecimal and are numbered relative to a base reference of zero. The address is specified as an offset from the base reference (0000) of that type.

For example, the first holding register in the 984 controller is termed 40001, and is addressed in a Read Holding Registers command as register address 0000. Similarly, the first coil is termed 00001 and is addressed in a Read Coil Status command as 0000. Coil 00127 is addressed as 007E hexadecimal (126 decimal).

> **Note** All numbers in Modbus are in hexadecimal and are referred to in high byte and low byte format. In the above example, coil 00127 (007E hex) is represented with a high byte of 00 and a low byte of 7E.

9.4 *Read Coil Status* (Function 01)

Read Coil Status reads the power bit of 0*xxxx* coils and packs them together eight per byte, starting at the least significant bit of the first byte. Any unused bits in the last byte are padded with zeros at the high order end of the byte. The maximum number of coils that can be read is 2000, returned in up to 250 bytes.

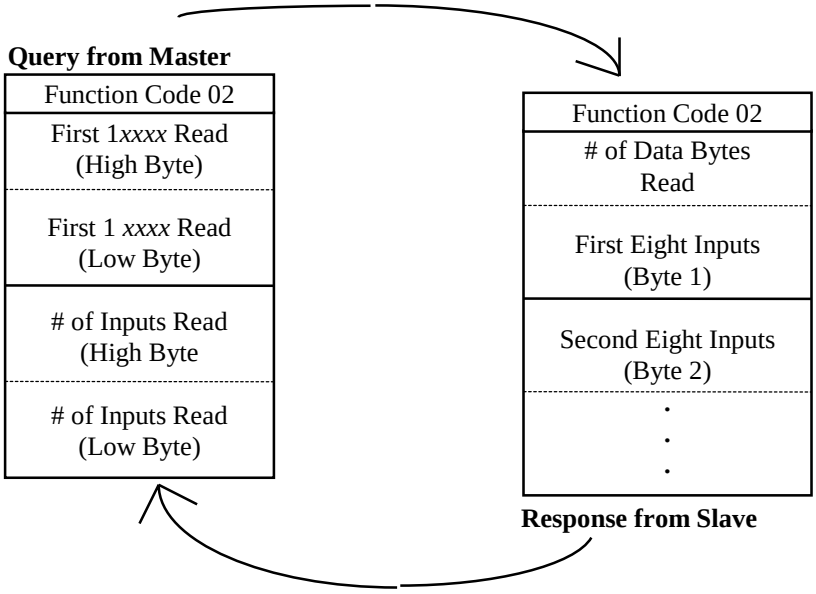


Normal Cycle for Modbus Function 01

> **Note** All 0xxxx coils specified in the query must exist in the 984 for this command to be processed. If not, the slave device will return an exception response.

9.5 *Read Input Status* (Function 02)

Read Input Status reads the power bit of 1*xxxx* discrete inputs and packs them together eight per byte, starting at the least significant bit of the first byte. Any unused bits in the last byte are padded with zeros at the high order end of the byte. The maximum number of discrete inputs that can be read is 2000, returned in up to 250 bytes.

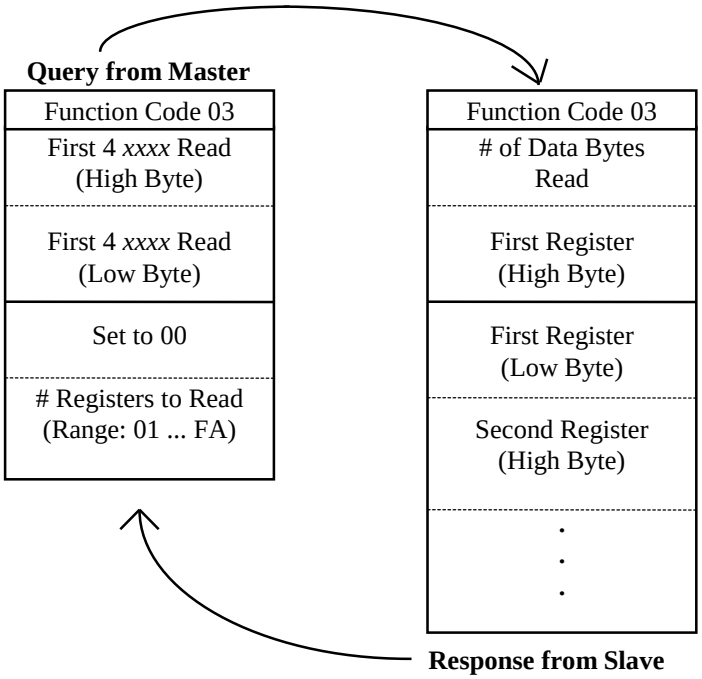


Normal Cycle for Modbus Function 02

Note All 1xxxx inputs specified in the query must exist in the 984 for this command to be processed. If not, the slave device will return an exception response.

9.6 *Read Holding Registers* (Function 03)

Read Holding Registers reads the contents of 4*xxxx* output registers and returns them two bytes per register. The maximum number of 4*xxxx* registers that can be read in one function 03 operation is 125, returned in up to 250 bytes.

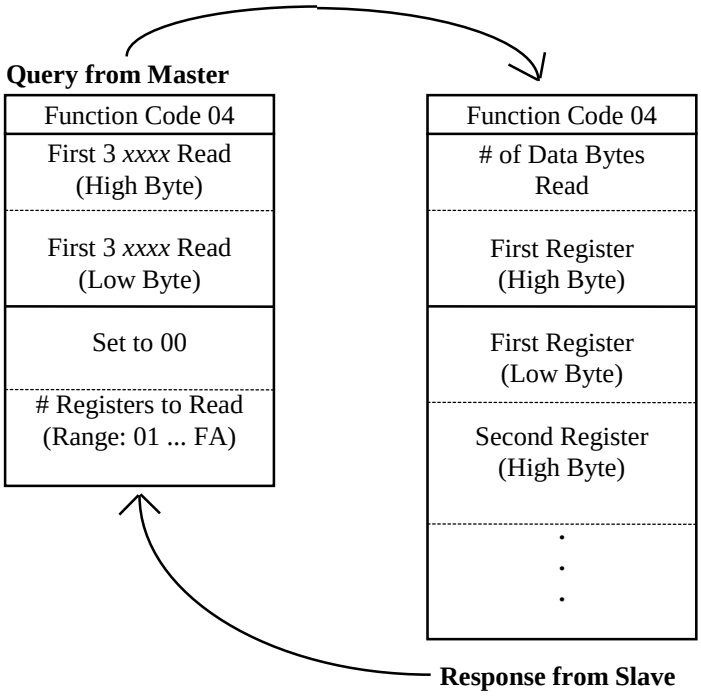


Normal Cycle for Modbus Function 03

Note All 4xxxx registers specified in the query must exist in the 984 for this command to be processed. If not, the slave device will return an exception response.

9.7 *Read Input Registers* (Function 04)

Read Input Registers reads the contents of 3*xxxx* input registers and returns them two bytes per register. The maximum number of 3*xxxx* registers that can be read in one function 04 operation is 125 returned in up to 250 bytes.



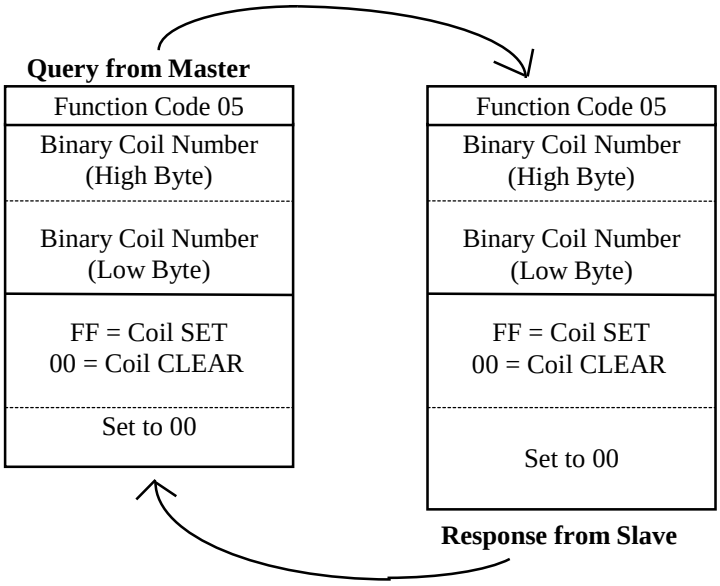
Normal Cycle for Modbus Function 04

Note All 3xxxx registers specified in the query must exist in the 984 for this command to be processed. If not, the slave device will return an exception response.

9.8 *Force Single Coil* (Function 05)

A *Force Single Coil* command sets or clears the current power state of a coil. The history bit associated with the coil is also updated so that transitionals will work correctly. The function uses four bytes for the query and four bytes for the response; the byte implementation is identical in both the query and response.

The first two bytes give you 17 bits with which to specify in binary notation the number of the coil to be forced. To force the coil ON, set all eight bits in the third byte to 1; to force the coil OFF, clear all eight bits in the third byte to 0. The fourth byte must be present, and its eight bits must always be cleared to 0.



Normal Cycle for Modbus Function 05

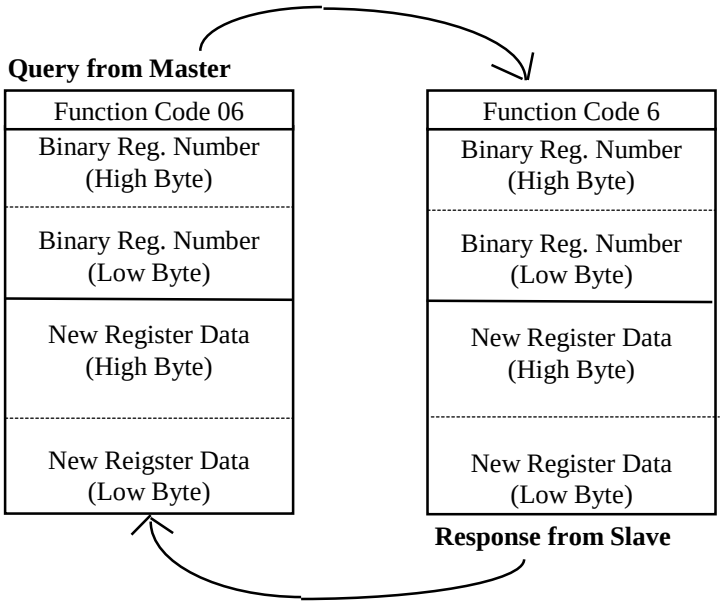
Note Remember when you specify a coil number in bytes 1 and 2 that the binary representation of coil 0 corresponds to reference 00001.

Caution Function 05 will override both the controller's MEMORY PROTECT and the coil DISABLE state.

9.9 *Preset Single Register* (Function 06)

A *Force Single Register* command sets the contents of a 4xxxx register. The function uses four bytes for the query and four bytes for the response; the byte implementation is identical in both the query and response.

The first two bytes give you 17 bits with which to specify in binary notation the number of the register to be set. The last two bytes give you 16 bits with which to specify the new register content.



Normal Cycle for Modbus Function 06

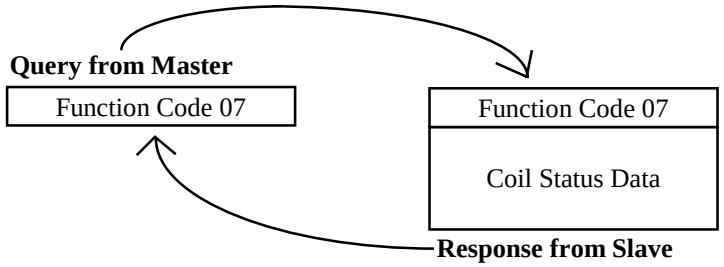
Note Remember when you specify the register number in bytes 1 and 2 that the binary representation of register 0 corresponds to reference 40001.

Caution Function 06 will override the controller's MEMORY PROTECT.

9.10 *Read Exception Status*

(Function 07)

A *Read Exception Status* function requests the current power state of the first eight coils in the 984 controller. The state of these coils is returned in a single data byte in the response - the power state of the first coil is returned in the least significant bit of the data type.

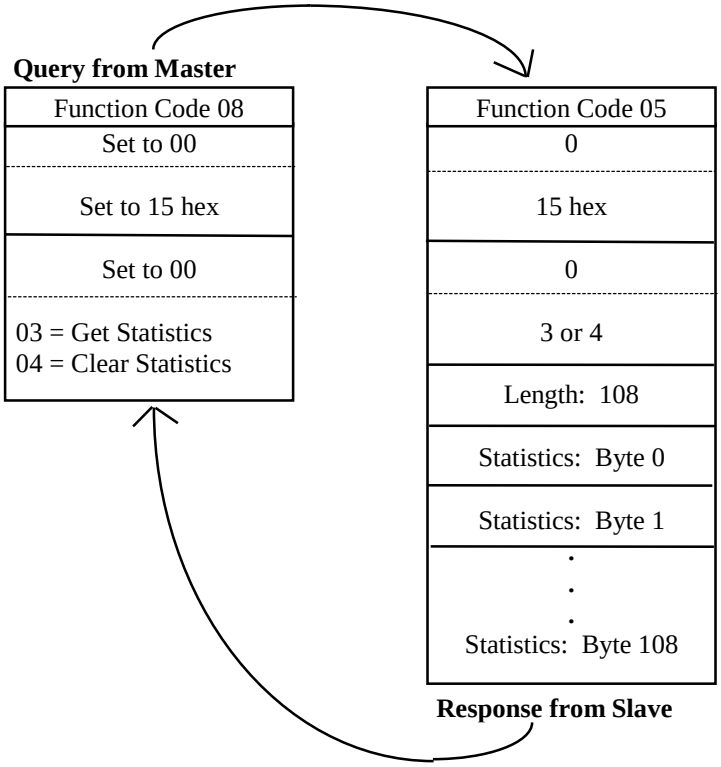


Normal Cycle for Modbus Function 07

9.11 *Get/Clear Network Statistics*

(Function 08, Subfunction 21)

In order to obtain network statistics from a host device, function 8 must be used in conjunction with subfunction code 21 (hex 15), which is specified in the first two bytes following the function code in the query. To *Get Statistics*, specify 03 in the fourth byte following the function code; to *Clear Statistics*, specify 04 in that byte.



Normal Cycle for Modbus Function 08, Subfunction 21

> **Note** Other diagnostic subfunctions accessible through Modbus function 08 are not applicable to Modbus Plus networks.

The Modbus Plus network statistics accessible via this function are described on the next four pages.

Modbus Plus Network Statistics

Bytes	Meaning
2,1 (see note below)	Node type ID: 0 Unknown node type 1 Programmable controller node 2 Modbus bridge node 3 Host computer node 4 Bridge Plus node 5 Peer I/O node
4,3	Most significant bit in byte 3 defines use of error counters in bytes, 30, 31 Least significant half of byte 3, plus byte 2, contain software version. Layout: Byte 3 Byte 2 [ ] [---Software version in hex----] \ Most significant bit defines error counters (see bytes 30, 31)
6,5	Network address for this station
8,7	MAC state variable: 0 Power up state 1 Monitor offline state 2 Duplicate offline state 3 Idle state 4 Use token state 5 Work response state 6 Pass token state 7 Solicit response state 8 Check pass state 9 Claim token state 10 Claim response state
10,9	Peer status (LED code); provides status of this unit relative to the network: 0 Monitor link operation 32 Normal link operation 64 Never getting token 96 Sole station 128 Duplicate station

Note: The notation (1,0) means that the data is formed with byte 1 as the most significant byte, and with byte 0 as the least significant byte.

12.11	Token pass counter; increments each time this station gets the token
14,13	Token rotation time in ms
15	Data master failed during token ownership bit map
16	Program master failed during token ownership bit map
17	Data master token owner work bit map
18	Program master token owner work bit map
19	Data slave token owner work bit map
20	Program slave token owner work bit map
21	Data master/get master response transfer request bit map
22	Data slave/get slave command transfer request bit map
23	Program master/get master response transfer request bit map
24	Program slave/get slave command transfer request bit map
25	Program master connect status bit map
26	Program slave automatic logout request bit map
27	Pre-transmit deferral error counter
28	Receive buffer DMA overrun error counter
29	Repeated command received counter
30	Frame size error counter

If the MSB in byte 4 is *not set*, bytes 31 and 32 have the following meaning:

31	Receiver collision-abort error counter
32	Receiver alignment error counter

If the MSB in byte 4 is *set*, bytes 31 and 32 have the following meaning:

31	Cable A framing error counter
32	Cable B framing error counter
33	Receiver CRC error counter
34	Bad packet-length error counter
35	Bad link-address error counter
36	Transmit buffer DMA-underrun error counter
37	Bad internal packet length error counter
38	Bad MAC function code error counter
39	Communication retry counter
40	Communication failed error counter
41	Good receive packet success counter
42	No response received error counter
43	Exception response received error counter

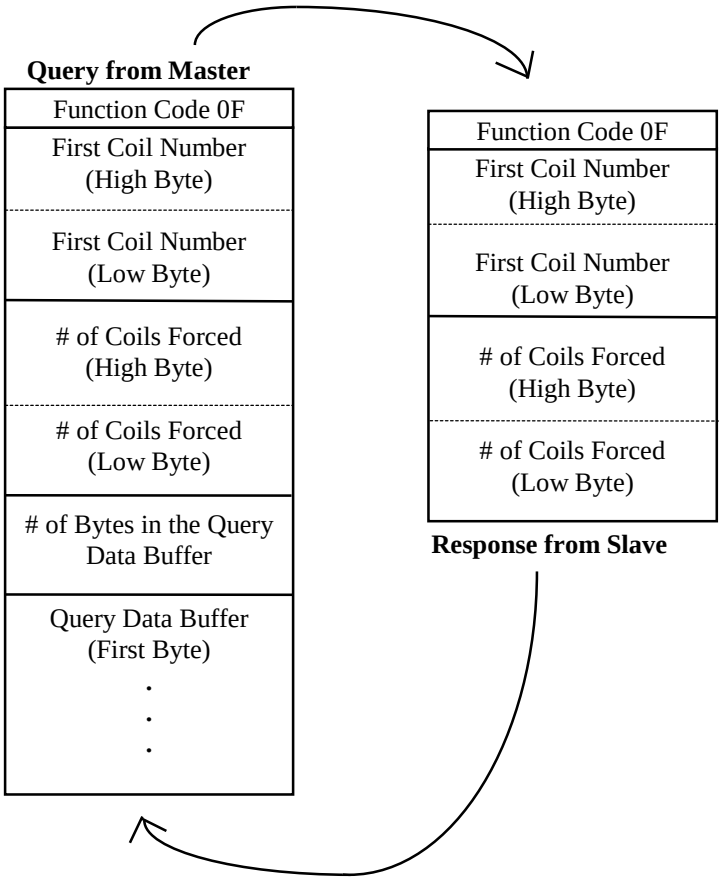
44	Unexpected path error counter
45	Unexpected response error counter
46	Forgotten transaction error counter
47	Active station table bit map, nodes 1...8
48	Active station table bit map, nodes 9...16
49	Active station table bit map, nodes 17...24
50	Active station table bit map, nodes 25...32
51	Active station table bit map, nodes 33...40
52	Active station table bit map, nodes 41...48
53	Active station table bit map, nodes 49...56
54	Active station table bit map, nodes 57...64
55	Token station table bit map, nodes 1...8
56	Token station table bit map, nodes 9...16
57	Token station table bit map, nodes 17...24
58	Token station table bit map, nodes 25...32
59	Token station table bit map, nodes 33...40
60	Token station table bit map, nodes 41...48
61	Token station table bit map, nodes 49...56
62	Token station table bit map, nodes 57...64
63	Global data present table bit map, nodes 1...8
64	Global data present table bit map, nodes 9...16
65	Global data present table bit map, nodes 17...24
66	Global data present table bit map, nodes 25...32
67	Global data present table bit map, nodes 33...40
68	Global data present table bit map, nodes 41...48
69	Global data present table bit map, nodes 49...56
70	Global data present table bit map, nodes 57...64
71	Receive buffer in use bit map, buffer 1...8
72	Receive buffer in use bit map, buffer 9...16
73	Receive buffer in use bit map, buffer 17...24
74	Receive buffer in use bit map, buffer 25...32
75	Receive buffer in use bit map, buffer 33...40
76	Station management command processed initiation counter
77	Data master output path 1 command initiation counter
78	Data master output path 2 command initiation counter
79	Data master output path 3 command initiation counter
80	Data master output path 4 command initiation counter

81	Data master output path 5 command initiation counter
82	Data master output path 6 command initiation counter
83	Data master output path 7 command initiation counter
84	Data master output path 8 command initiation counter
85	Data slave input path 41 command processed counter
86	Data slave input path 42 command processed counter
87	Data slave input path 43 command processed counter
88	Data slave input path 44 command processed counter
89	Data slave input path 45 command processed counter
90	Data slave input path 46 command processed counter
91	Data slave input path 47 command processed counter
92	Data slave input path 48 command processed counter
93	Program master output path 81 command initiation counter
94	Program master output path 82 command initiation counter
95	Program master output path 83 command initiation counter
96	Program master output path 84 command initiation counter
97	Program master command initiation counter
98	Program master output path 86 command initiation counter
99	Program master output path 87 command initiation counter
100	Program master output path 88 command initiation counter
101	Program slave input path C1 command processed counter
102	Program slave input path C2 command processed counter
103	Program slave input path C3 command processed counter
104	Program slave input path C4 command processed counter
105	Program slave input path C5 command processed counter
106	Program slave input path C6 command processed counter
107	Program slave input path C7 command processed counter
108	Program slave input path C8 command processed counter

9.12 *Force Multiple Coils*

(Function 0F)

A *Force Multiple Coils* function sets or clears the current power state of a set of up to 800 consecutive coils. The history bits associated with the coils are also updated so that transitionals will work correctly.



Normal Cycle for Modbus Function 0F

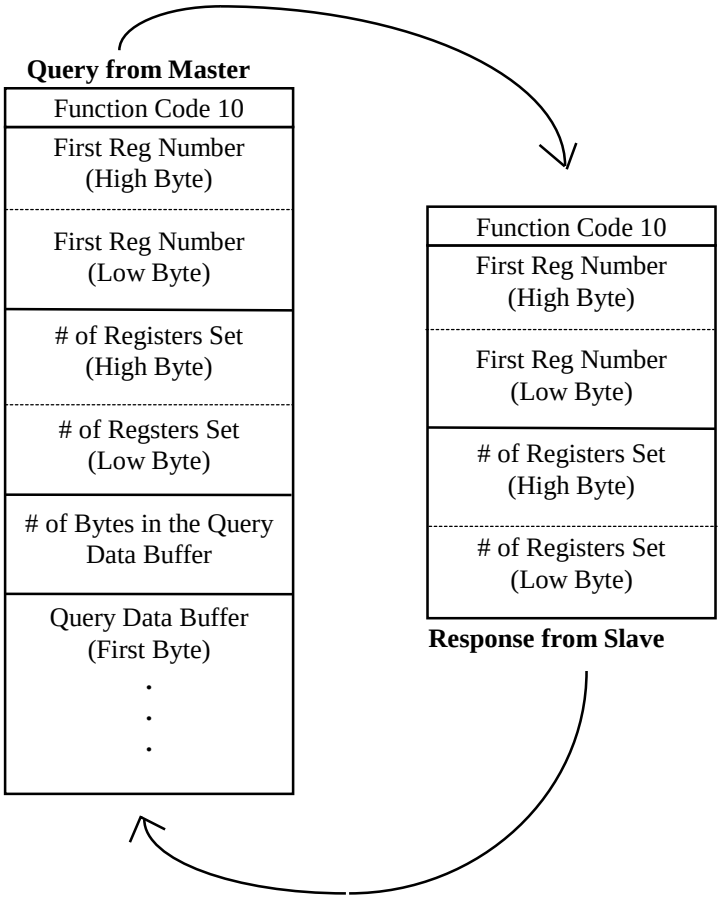
The number of bytes in the query data buffer is the integer part of (# of coils Forced + 7) divided by 8. A byte in this data buffer stores the state of eight consecutive coils - to force a coil ON, set its representative bit to 1; to force the coil OFF, clear the associated bit to 0.

> **NOTE** Remember when you specify coils in the data bytes that the binary representation is 1 less than the coil reference number - e.g., coil 0 corresponds to reference 00001.
>
> **Caution Function 0F will override both the controller's MEMORY PROTECT and the coil DISABLE state.**

9.13 Preset Multiple Registers

(Function 10 Hex)

A *Preset Multiple Registers* function sets the contents of a set of up to 100 consecutive 4xxxx registers, two bytes per register.



Normal Cycle for Modbus Function 10

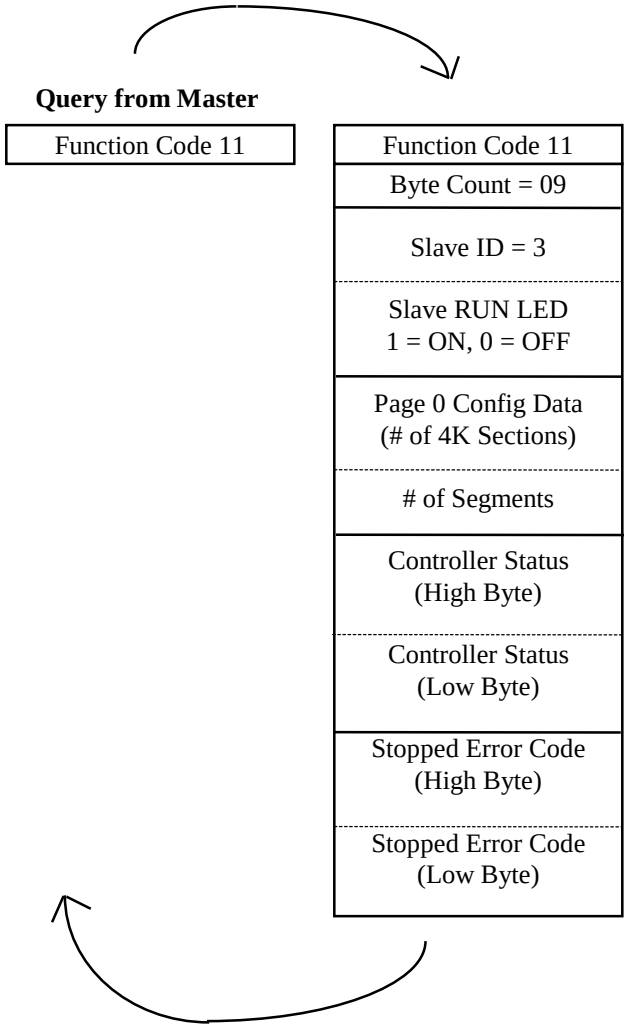
The number of bytes in the query data buffer is the number of 4xxxx registers to be preset x2. The contents of each register are preset with the high and low bits in two consecutive bytes per register.

> **Note** Remember when you specify register content in the data bytes that the binary representation is 1 less than the coil reference number - e.g., register 0 corresponds to reference 40001.
>
> **Caution Function 10 hex will override the controller's MEMORY PROTECT.**

9.14 Report Slave ID

(Function 11 Hex)

Issuing a *Report Slave ID* function lets you obtain in a single response the slave type, its RUN light state, and- for a 984 controller - configuration information, machine status, and any potential stopped error code.



Normal Cycle for Modbus Function 11

The number of bytes in the query data buffer is the number of 4*xxxx* registers to be preset x 2. The contents of each register are preset with the high and low bits in two consecutive bytes per register.

Reading the Controller Status

Word 101 in the 984 configuration table (in page 0 of system memory) indicates certain states of the controller. A state may be valid for the life of the controller (for example, the size of the configuration), or may be set conditionally be external events (for example, MEMORY PROTECT currently ON or OFF).

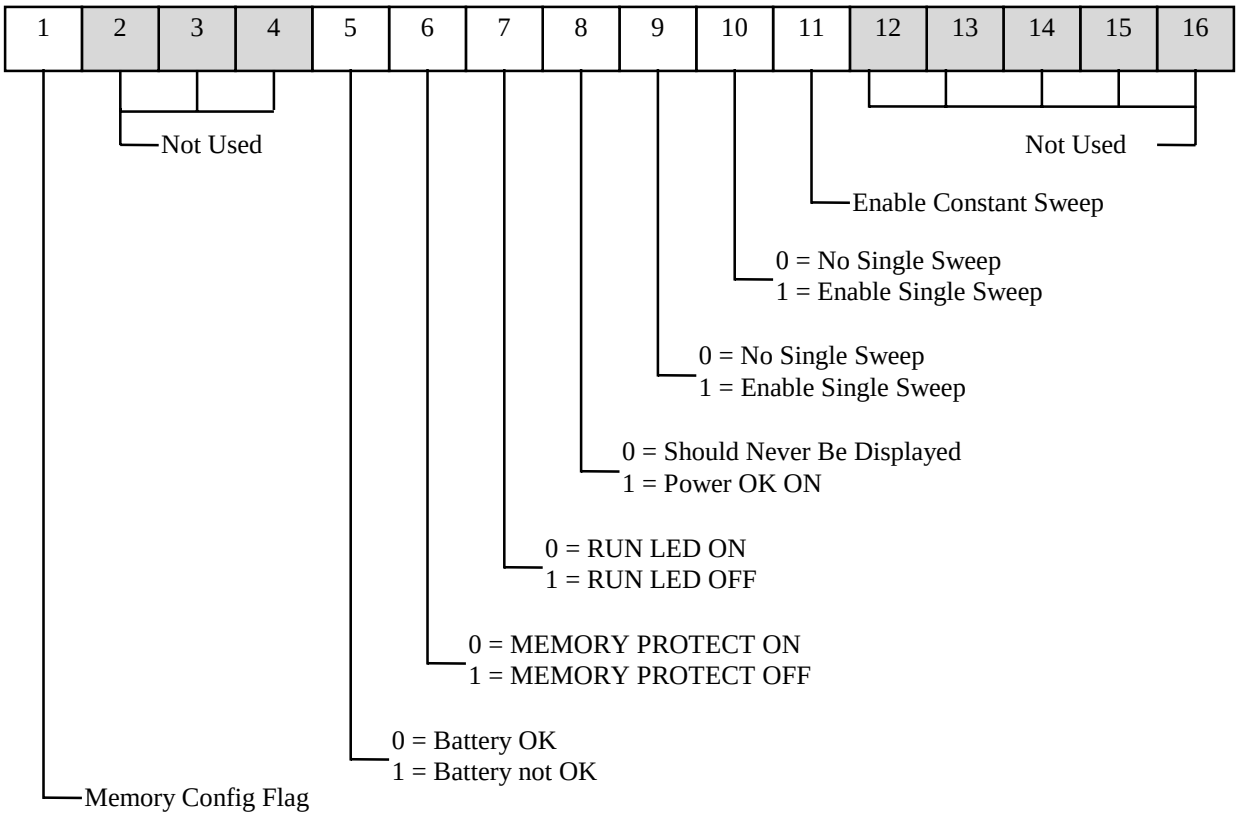


Figure 7 - Machine State Bit Values

Information about 984 controller stopped error codes can also be obtained with this command. The codes are described on the next page.

Function 11 Hex (Continued)

Reading Stopped Error Codes

Stopped error codes for any 984 programmable controller on a Modbus Plus network can be accessed via function 11 hex. The current stopped state condition, if one exists, is stored in word 105 in the 984 configuration table (in page 0 of system memory):

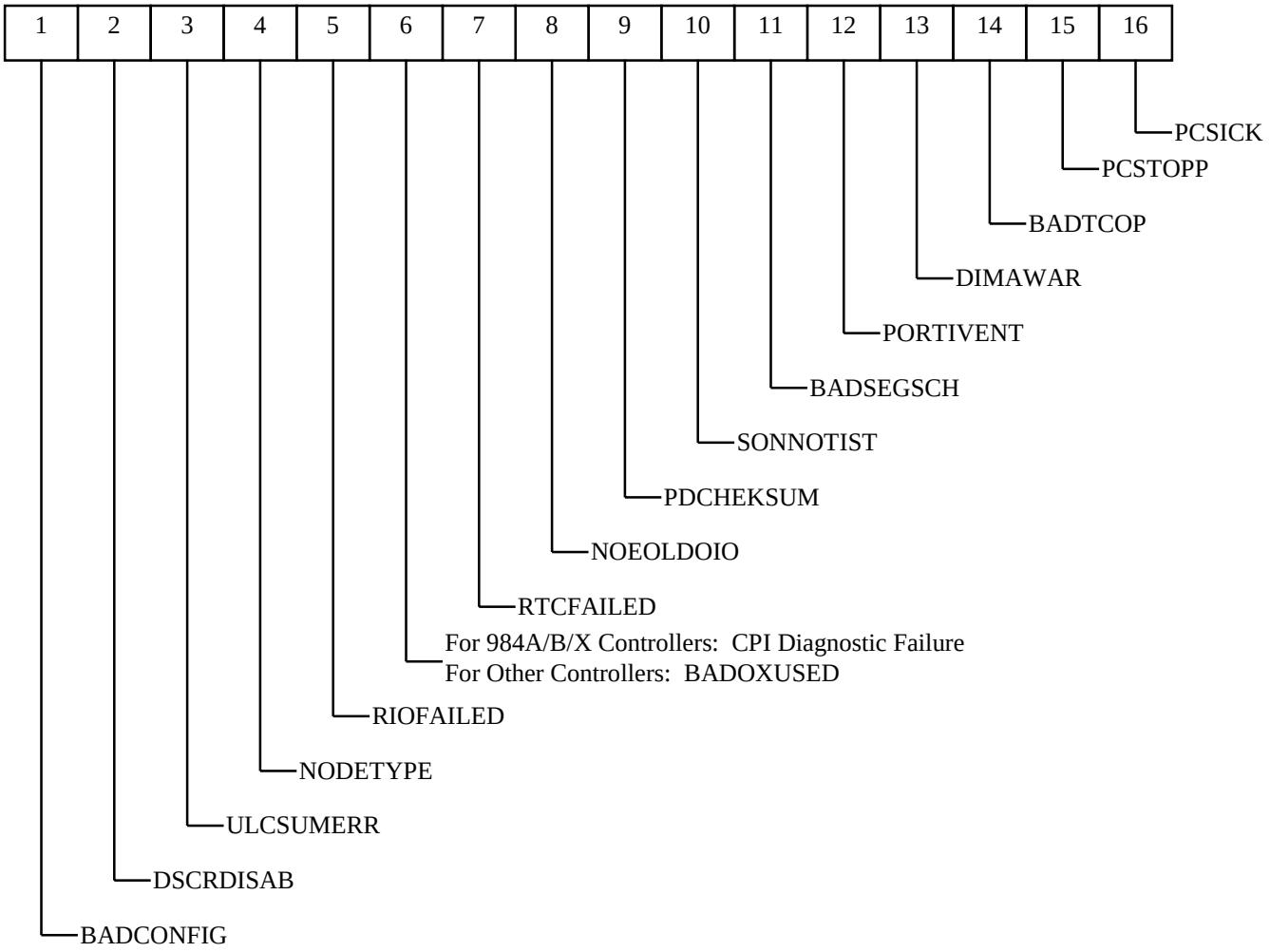


Figure 8 - Stopped Error Bit Values

Legend	Meaning
PCSICK	Controller unhealthy
PCSTOPPED	Controller stopped
BADTCOP	Bad I/O traffic cop table
DIMAWAR	Controller in DIM AWARENESS state
PORTIVENT	Bad port intervention
BADSEGSCH	Bad segment schedule
SONNOTIST	Start of network (SON) did not start segment
PDCHEKSUM	Bad power - down checksum
NOEOLDOIO	Watchdog timer has expired
RTCFAILED	Real time clock failure
BADOXUSED	Bad *coil used* table
RIOFAILED	Remote I/O failure
NODETYPE	Illegal node type used
ULCSUMERR	User logic checksum error
DSCRDISAB	Discrete disable error
BADCONFIG	Bad configuration table

9.15 Exception Responses

When a programming or operation error occurs while issuing any of these Modbus data access commands, the slave responds to the master with an error message in the form of an *exception code*. Typical errors that elicit exception responses include illegal data in a message, a controller's failure to respond to an interface panel, or a difficulty communicating with a slave.

Four exception responses are possible in a Modbus Plus data acquisition operation:

Exception Code	Error Condition
01	Illegal function for the addressed slave
02	Illegal data address within the information field for the addresses slave
03	Illegal data value in the information field for the addressed slave
06	Busy - the function just requested cannot be performed at this time because a long-duration PROGRAM command is being processed; reissue the command later

Exception codes 04, 05, and 07 are not applicable in Modbus Plus applications, and exception codes 08...FF are reserved.

When a slave detects an error, it sends a response message to the master consisting of a function code and one of the above exception codes. The function code associated with an exception response is the original function code + 80 hex - i.e., the high order bit in the function code of the original query is set to 1.

An Example

Here is an example of an incorrect query and the subsequent exception response:

Function	Start Address (High Byte)	Start Address (Low Byte)	# of Coils (High Byte)	# of Coils (Low Byte)
01	04	A1	00	01

Figure 9 - Incorrect Query - Example

The query above is a *Read Coil Status*, requesting the status of coil 1245 decimal. If the controller is a 1 K machine, this is an invalid reference. Consequently, the following exception response is generated:

Function Code	Exception Code
81	02

Figure 10 - Exception Response - Example

The function code is the original query code + 80 (with its high order bit set to 1). Exception code 02 indicates an illegal data address.

Responding as a Slave

A Modbus Plus application that handles Modbus protocol must function as a slave. Other devices on the network will function as masters, sending queries to the application. The application can determine how to respond to those queries.

The application should issue an exception response for all Modbus function codes that it does not recognize. Otherwise, the application should create the correct response message for the selected Modbus function code.

Crash Codes

10. Crash Codes

10.1 SA85 Controller Crash Codes

The following lists the SA85 peer processor crash codes. When the controller crashes, this information is captured by the device driver and stored with the error log.

A non-zero crash code that has bit seven clear, indicates that the interface died when an invalid interface command was given to it by the driver or the Modbus Plus device driver failed to do a configuration status command within the one second time-out. The Modbus Plus device driver will return status to all QIOs that were currently active, generate an error log packet, and reset the SA85.

A non-zero crash code that has bit seven set, indicates that the SA85 peer processor detected some sort of internal hardware or software error. A reset of the ALPHA EISA or ISA bus is required to clear this fault. This is accomplished with a power cycle or by pushing the “init” button on most ALPHAs.

Hex Crash Code	Description
0	Interface operational
1	2.0 Second interface time-out
2	Bad interface opcode
3	Interface data error
4	Interface test error
5	Interface transfer done error
6	Bad interface path
7	Path in wrong state
8	Bad transfer length
9	Global data length error
A	Global data address error
B	Global data not present
81	Prom checksum error
82	Internal RAM data test error
83	External RAM data test error
84	External RAM address test error
85	Bad confidence test
86	External int0 event error
87	External int1 event error
88	DMA int0 event error
89	Comm. int event error

(Continued)

Hex Crash Code	Description
8A	Transmit no good event error
8B	No response time-out MAC state
8C	No response time-out MAC idle
8D	Receive OK MAC state
8E	Transmit OK MAC state
8F	No receive buffer free
90	Bad input transfer length
91	Reserved receive buffer error
92	Bad transfer control state
93	Bad work request bit
94	Node queue overflow
95	Bad data queue error
96	Empty data path error
97	Bad path search index
98	Bad data slave path

Driver Crash and Errorlog Codes

11. Driver Crash and Errorlog Codes

The following are crash codes that are generated by the driver and are not as a result of the SA85. They will show up only in the system error log file. The driver will recover from the error but it indicates that the driver found an abnormal condition. These errors should be directed to IPACT.

Hex Crash Code	Description
C0	This is a driver debug check. The driver logs this error log buffer when the driver was about to do an output but was interrupted by a GSR request from the SA85. The interrupted function is then called back to complete its processing.
C1	This is a driver debug check. The driver logs this when a master write is requested, but the path is in the wrong state. This can occur after a path abort or controller reset.
C2	This is a driver debug check. The driver logs this when a read master response is requested, but the path is in the wrong state. This can occur after a path abort or controller reset.
C3	This is a driver debug check. The driver logs this when a read slave response is requested, but the path is in the wrong state. This can occur after a path abort or controller reset.
C4	This is a driver debug check. The driver logs this when a write slave response is requested, but the path is in the wrong state. This can occur after a path abort or controller reset.
D1	While attempting process a get slave message, the driver path number was invalid for the slave path. This can occur after a path abort or SA85 reset. Otherwise, this is a driver fault. Examine the driver stack to find out what was the slave path that was completing. This test was done after the driver had actually got the slave message response.
D2	The SA85 did not respond with the two's complement of the command that was sent to it. This was detected by the controller servicing code.
D3	While attempting to process a master response, the driver path number was invalid for the master path. This can occur after a path abort or SA85 reset. Otherwise, this is a driver fault. Examine the driver stack to find out what was the slave path that was completing.
D4	While attempting process a get slave message, the driver path number was invalid for the slave path. This can occur after a path abort or SA85 reset. Otherwise, this is a driver fault. Examine the driver stack to find out what was the slave path that was completing. This test is done when the driver has written a slave response such as a routing error to the Modbus master.
D5	A GSR indicated that we needed to read a slave message in. The controller service found the slave path to be invalid.
D6	A GSR indicated that we needed to read a master response message in. The controller service found the master path to be invalid.
D7	The driver was doing a controller function but the SA85 timed out.

(**Continued)**

Hex Crash Code	Description
F9	A master output has timed out.
FA	A master output has timed out.
FC	A non-GSR response came in from the SA85, but there was no fork or I/O waiting for the response for a user UCB (not UCB zero).
FD	A non-GSR response came in from the SA85, but there was no fork or I/O waiting for the response on UCB zero.
FE	A master miscellaneous output has timed out.

Modbus Plus Driver Messages

12. Modbus Plus Driver Messages

The following lists the VMS error codes returned in the I/O status block of the user's QIO request. The Modbus Plus driver follows normal VMS standards for error codes where an odd status is successful.

MBP$_BADSIZE Invalid buffer size

The user passed a buffer that was too small for at least the size of the Modbus header or the size required for the requested function.

MBP$_NOPATH User has requested a function that requires an allocated path

The user has requested a function that requires the user allocate a master data path, slave data path, or a master program path. Call the driver with an allocate function first.

MBP$_BADPATH Invalid path number

The user specified path number in the QIO argument is larger than the number available on the SA85 controller for that type of path.

MBP$_CTRLCRASH Modbus Plus controller crashed

The Modbus Plus SA85 controller has crashed. There should be an error log entry in the system error log file. Use MBP_ERRFMT to extract the error log entry. The driver attempts to protect the SA85 from crashes, but program paths are allowed to perform any function. Consult the crash codes in the appendix and contact IPACT if the problem can not be resolved.

MBP$_CTRLTMO Modbus Plus controller timed out

A function to the controller did not complete within the default two seconds or the user specified time limit. It can also be a SA85 fault. There should be an error log entry in the system error log file. Use MBP_ERRFMT to extract the error log entry.

MBP$_PATHUNAVL Requested path is not available

The user has attempted to allocate the same path or has specified a particular path that has already been allocated by someone else. Use a different path or let the device driver allocate the path. It is also possible that there are no more paths of the type being requested available. The SA85 only supports eight of each of the different types.

MBP$_PATHTYP Invalid path type for requested operation

The user has called the driver with an invalid path number. This occurs when the function code requested does not match the type of path for which the function code is valid for. For example, the device is allocated as a data master but a function requiring a data slave request was requested.

MBP$_PATHSTAT Path in wrong state for requested operation

The user is out of synchronization with the SA85. Typically, this can be caused by the user not correctly detecting an SA85 crash, waiting for I/O completion, or by a general programming fault. The slave and master paths operate in paired request and responses. All master requests are followed by a master response and all slaves reads must be followed by a slave response. If the user application takes too long to respond to a slave message, this may cause path synchronization as the addressed slave may abort the transaction.

MBP$_BUFFEROVF Buffer overflow occurred

The message was received but the user buffer was too small for all of the data. The user must still provide any handshake on a slave path. The user should provide a larger buffer. What was able to fit in the buffer was returned.

MBP$_ROUTERR Modbus Plus routing error occurred

The SA85 controller has indicated that the message could not be routed to the indicated target node as specified by the route path in the message. Use NDU utility to determine if the route path is valid. This may occur if all of the network segments are not operational (such as a bridge) or the addressed node is not on the Modbus network.

MBP$_NOGLOBAL No global data present for requested node

Since the previous call to the driver, no global data was acquired from the requested node. Each token rotation normally provides the global data for each node. Delay and request the global data again.

MBP$_BADNODE Bad node number, valid node numbers are 1-64 inclusive

The user has specified an invalid Modbus plus node. Correct the node number.

MBP$_WRONGUCB Attempt to $ASSIGN to UCB zero, rather than UCB one

The user has attempted to assign a channel to JPA0:, JPB0:, JPC0: or JPD0:. The user should assign channels only to unit one (JPA1:). The actual unit assigned to the user will never be unit zero or one but rather a “cloned” unit created by the OpenVMS executive. This operation is similar to the OpenVMS mailbox device driver.

MBP$_BADROUTE User specified route path invalid

A scan of the user specified route path found an invalid node number. All node numbers must be between 1 and 64 inclusive or zero to terminate the route path.

MBP$_BADMODFUNC User specified MODBUS function code invalid

The user has specified a Modbus function code that is not supported. This test is not made for program master paths. This test is made to help ensure that the SA85 does not crash.

MBP$_UNKNOWNERR Unknown controller error has occurred

The SA85 Modbus plus adapter did not correctly respond to a host request. An error log buffer should have been created. Use MBP_ERRFMT to extract the error log entry. The controller will be reset and all active I/O terminated.

MBP$_PATHABORTING Current path is currently in process of aborting

The user has requested a function to a path that is currently in the process of aborting due to a controller crash, driver initialization, or other error. The user should delay and try again.

MBP$_PATHNOMATCH Path does not match allocated path

The user has tried to pass a path in the Modbus header that does not match the path currently allocated for this device. Correct the message and try again.

MBP$_UNKNOWNFNC Unknown function code

The user has passed an invalid I/O function code in the QIO request. The user should check the MP_FUNC.H and MP_FUNC.TXT files for the valid function codes.

MBP$_PATHSTATSR Read being posted to a slave path that needs an acknowledgment

The user has attempted to post another read to a slave path without first acknowledging the message that was just read by the user. Check for program logic errors.

MBP$_PATHSTATSW Write being posted to a slave path that has no message to ack

The user has attempted to write a response message to a slave path that has no message to be acknowledged. The user should first check for a programming error. This error can occur if the slave node aborts the path or the SA85 Modbus plus adapter was reset after the user read the message.

MBP$_PATHSTATMW Master path in wrong state for requested write

The user has attempted to write a new master request to the path, but the user application has not read the response from the previous master request. Check for program logic errors.

MBP$_PATHSTATMR Master path in wrong state for requested read

The user has attempted to read the response from a previous master request. The user should first check for a programming error. This error can occur if the slave node aborts the path or the SA85 Modbus plus adapter was reset after the user wrote the request.

MBP$_ABCTRLRESET Path aborted because controller was reset

The user's request was terminated because the SA85 was reset. The device driver returns this status to all active processes with I/O when the controller is reset. The user still maintains allocation of the path, but the path should be considered to have been aborted and reset. Any slave messages that require a response or any outstanding master requests are canceled by the driver.

MBP$_NORESPONSE Master path response or slave message timed out

The user specified a time-out value or the default. The addressed slave did not respond within the indicated time-out interval**.**

MBP$_SUCCESS Operation completed successfully

MBP$_SOFTRESET SA85 softreset

The Modbus Plus adapter was reset.

MBP$_SA85DIAG SA85 diagnostic being performed

The user requested function couldn't be performed at the current time, as the SA85 is busy doing a diagnostic. This can occur after a reset of the SA85 or at system initialization.

MBP$_SLVMSGABT Slave message was aborted

A read of slave message was unsuccessful because the path had been aborted. Typically this is caused by a reset of the SA85 or protocol error between the SA85 and the ALPHA.

Modbus Plus Device Driver Console Messages

13. Modbus Plus Device Driver Console Messages

The ability of the driver to identify configuration errors to the user is very difficult, as there is no way to return the status in a meaningful manner. However, the Modbus Plus Device driver uses the standard OpenVMS device messages (exe_std$sndevmsg) to identify the driver's initialization faults. The console messages that can be output by the driver are limited and their meanings are not necessarily those printed. The following documents the meaning of each of these messages with respect to the Modbus Plus device driver.

Device JPA0: is online

The driver successfully initialized itself and is now ready.

Device JPA0: is offline

The driver attempted to allocate non-paged pool for its internal buffers. There was insufficient contiguous non-paged dynamic pool space for the request. Increase sysgen parameter for non-paged dynamic pool by 8K bytes.

Device JPA0: has been write locked. Mount verification is in progress.

The driver requested the ISA IRQ for the indicated slot, but was returned an error code. The most likely fault is that the EISA configuration for the slot does not match the command passed via the SYSMAN command. Verify the slot number in both the ECU or ISACFG and the MBP_STARTUP.COM command file.

Device JPA0: is offline. Mount verification is in progress.

The driver requested the ISA memory base address for the SA85 but was returned an invalid status or the driver was requested to load a second SA85 controller, but the first controller was not successfully configured. Contact IPACT for assistance.

Index