HPPC MODBUS USER'S GUIDE

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TABLE OF CONTENTS

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I.0 GENERAL DESCRIPTION

An Intel 86/05 processor resides on the Multibus in the HPPC chassis and handles all MODBUS communications via the onboard RS232C serial port.

The HPPC 1500/1700 works as a slave to the MODBUS system. After all the hardware is installed, refer to this user's guide for a description of how to set up the HPPC to interface to the MODBUS system.

A set of three holding registers in the HPPC is dedicated to the MODBUS slave function as follows:

* The first HR of the set contains the slave address.

* The second HR of the set is a counter for the number of MODBUS queries processed, and it indicates that the 86/05 is operational.

* The third HR of the set contains the serial port configuration. It also indicates the validity of all three values.

Two MODBUS Modules may reside in the same HPPC chassis. The first module uses the holding register set HR15, HR16, and HR17. The second module uses the set HR18, HR19, and HR20. Note that the HPPC should be configured so that the highest holding register used is at least 17 (or 20 for the second module).

After the HPPC is powered up and running, use an APL (Advanced Programmable Loader) in Monitor mode to set the holding registers to the desired values. Only HR15 and HR17 (or HR18 and HR20 for the second module) need to be initialized. See Section II.2. for details about initializing these two registers.

These registers must be set to appropriate values in order for MODBUS communications to occur. In addition, the HPPC must not be in fault and must be properly configured.

The user may change the values of HR15 and HR17 (or HR18 and HR20 for the second module) at any time during MODBUS communications. The MODBUS interface continually scans these registers so that the new holding register values are effective when the next message is processed.

II.0 HARDWARE & SOFTWARE (SET UP) DESCRIPTION

II.1. HARDWARE DESCRIPTION

The HPPC MODBUS adds the capability to an HPPC-1500/1700 to be interfaced to a PC master on the MODBUS system. The interface is accomplished with a Multibus Type Single Board Processor plugged into the HPPC Chassis. The processor is connected to the MODBUS through the onboard RS232 serial port over an adapter cable (Westinghouse Part Number: 45A617G01). See Section VI.0 for a description of the pinouts on this cable. Install the cable so that Pin 2 of the cable lines up with Pin 1 of the card edge connector.

II.2. SOFTWARE DESCRIPTION (SET UP)

II.2.1. SET UP SLAVE ADDRESS

The HPPC works as a slave for the MODBUS system. The address assigned to the slave HPPC is set in holding register 15 (or holding register 18 for the second module). Valid addresses are 1 - 255.

II.2.2. SET UP COMMUNICATION MODE

The HPPC MODBUS supports two different transmitting modes: ASCII and RTU (American Standard Code for Information Interchange and Remote Terminal Unit). ASCII mode uses approximately twice as many characters as RTU mode. Also, transmission in RTU mode must be in a continuous stream; whereas, there can be a delay of up to one second between characters in ASCII mode. Refer to the MODICON MODBUS SYSTEM USER'S MANUAL for more information about ASCII and RTU modes.

The transmitting mode is selected by the user, but it must be the same as the transmitting mode of the MODBUS system. The mode is determined by bit 8 of HR17 (or HR20 for the second module). See Figure 1.

II.2.3. SET UP COMMUNICATION BAUD RATE

The HPPC MODBUS transmits data at the following baud rates: 300, 600, 1200, 2400, 4800, 9600, and 19200. The baud rate is specified in bits 3-5 of HR17 (or HR20 for the second module). See Figure 1.

II.2.4. SET UP COMMUNICATION DATA FRAME

The format of the data frame is determined by the following parameters:

* number of bits per character.
* number of stop bits.
* parity of data sent

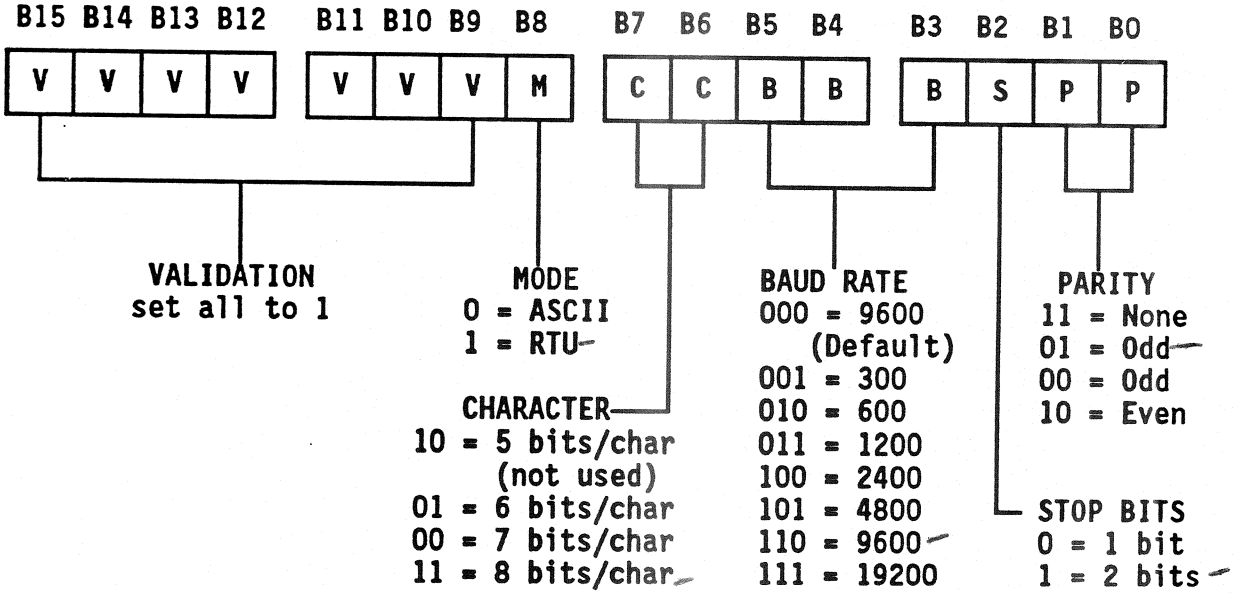
These parameters are set in HR17 (or HR20 for the second module). The number of bits per character is set in bits 6-7. Note that in RTU mode, there must be 8 bits per character. ASCII mode may use 6, 7, or 8 bits per character. Bit 2 determines the number of stop bits, and the parity is defined by bits 0-1. See Figure 1.

II.2.5. VALIDATION OF SERIAL PORT CONFIGURATION

Bits 9-15 of HR17 (or HR20 for the second module) must be set to '1' for the configuration to be valid. See Figure 1.

FIGURE 1 - SERIAL PORT CONFIGURATION

Holding Register 17 (or 20 for the second module):



III.0 SUPPORTED FUNCTIONS

Two MODBUS links or modules are supported. Each module provides the following nine MODBUS functions:

FUNCTION	FUNCTION CODE
Read Output Status	01
Read Input Status	02
Read Output Registers	03
Read Input Registers	04
Force Single Coil	05
Preset Single Register	06
Loopback Test	08
Force Multiple Coils	15
Preset Multiple Registers	16

The MODBUS master sends a query message by the appropriate interface unit or modem to a single HPPC slave. Each message includes an address field, a function field, a data field, and an error check field. Assuming error free reception, the slave interface will transfer the message to its HPPC. After the required action is completed, a response to the message is processed back through the slave interface and sent to the master.

If an error is detected in the reception of a message, such as an invalid error check value or an invalid message length, the message is not processed, and a response message is not sent back to the master.

The address field contains the address of the slave to which the message is being sent. An address of 00 specifies broadcast mode.

In broadcast mode, all of the attached slaves in the system will receive and process the query sent by the MODBUS master. No responses from the slaves are sent back to the master in this mode. Only the following functions are valid in broadcast mode: Force Coil, Load Register, Force Multiple Coils, and Load Multiple Registers. All other functions are ignored by the slaves.

The function code is specified in the function field of the message. Valid function codes are 01-06, 08, 15, and 16. If any other code is used, the slave interface will return an exception response with exception code 01 to the master. See Section V.0 for exception responses.

The data field contains information, such as addresses and values, which is necessary for the slave HPPC to execute the specified function. Invalid data will cause the slave interface to return an exception response. See Section V.0 for exception responses.

The error check field enables the master and the slave to check for errors in the transmission of a message. ASCII mode uses the longitudinal redundancy check (LRC), and RTU mode uses the cyclic redundancy check (CRC-16). The error check field has a length of one byte in ASCII mode and two bytes in RTU mode. For information on the implementation of these checks, refer to the MODICON MODBUS SYSTEM USER'S MANUAL.

The user configures the number of input groups, output groups, and input registers that are present in the HPPC. The highest holding register used is determined by the highest holding register used in the ladder logic of the HPPC. The ranges of these parameters are shown in the following table.

PARAMETER TYPE	RANGE
Inputs Groups Configured (IGC)	0-512
Output Groups Configured (OGC)	0-512
Input Registers Configured (IRC)	0-512
Highest Holding Register Used (HRU)	1-65535

The limits on the addresses used in the MODBUS functions are determined by the user configuration of the above parameters. The following table summarizes the ranges of the MODBUS address types based on these user configured parameters; the maximum number of each type that may be operated upon at one time in each MODBUS function is also shown. Note that the address ranges are for the MODBUS system which starts numbering from zero. However, the HPPC addresses from one; ie., MODBUS address = HPPC address - 1. The MODBUS address is the address which is used in the messages.

ADDRESS TYPE	ADDRESS RANGE	MAX. NO.
Coils	0 - ((OGC*16)-1)	2000
Inputs	0 - ((IGC*16)-1)	2000
Input Registers	0 - (IRC-1)	125
Holding Registers	0 - (HRU-1)	125

The correspondence between MODBUS terminology and addressing and HPPC terminology and addressing is summarized in the following table.

MODBUS TERM	HPPC TERM	MODBUS ADDRESS	HPPC ADDRESS
Coils or Outputs	Coils	0 - 8191	CR0001 - CR8192
Inputs	Inputs	0 - 8191	IN0001 - IN8192
Input Registers	Input Registers	0 - 511	IR0001 - IR0512
Output Registers	Holding Registers	0 - 65534	R00001 - R65535

MODBUS communications occur in all keyswitch modes: Stop, Run/Protect, Run/Modify, and Run/Outputs Disabled. However, in Stop mode, MODBUS functions are not processed by the slave HPPC. The slave interface returns an exception response with exception code 06 for every message sent to it. Also, in Run/Protect mode, the following functions are not valid: Force Single Coil, Preset Single Register, Force Multiple Coils, and Preset Multiple Registers - an exception response with exception code 04 will be returned if messages of these types are sent. See Section V.0 for exception responses.

When the slave HPPC is in fault, every message causes an exception response with exception code 06. The HPPC must be cleared of all faults before normal communications can resume.

However, when the HPPC is powered up in fault, the above statement does not apply. In this case, no communications occur between the master and the slave, and the slave interface does not return any exception responses. The fault in the HPPC must be cleared before communications can begin.

IV.0 MODBUS FUNCTIONS

This section describes the nine supported functions in more detail.

IV.1 READ OUTPUT STATUS (Function Code 01)

Description: This function allows the user to obtain the ON/OFF status of logic coils used to control discrete outputs from the addressed slave HPPC. Data may be read at any time during the slave HPPC's scan; data reads are not synchronized to the end of the scan.

Message Format:

SLAVE ADDR	FUNC CODE	START ADDR HI	START ADDR LO	# OF COILS HI	# OF COILS LO	ERROR CHECK FIELD

Response Format:

SLAVE ADDR	FUNC CODE	BYTE COUNT N	COIL STATUS 1	- - -	COIL STATUS N	ERROR CHECK FIELD

Slave Addr: 1 - 255; address of slave to receive message

Func Code: 01; function code of Read Output Status function

Start Addr: 0 - ((OGC*16)-1) (corresponds to 1 - (OGC*16) in HPPC); initial coil to be read; OGC is the Output Groups Configured

# of Coils: 1 - 2000; number of consecutive coils, starting from the start address, to be read;

Byte Count: if (# of Coils) is evenly divisible by 8 then,
(Byte Count) = (# of Coils) / 8; otherwise,
(Byte Count) = Trunc((# of Coils) / 8) + 1

Coil Status: 1 = ON, 0 = OFF; The status is packed with one bit for each coil. The low order bit of the first status byte contains the status of the first coil; the remaining coil statuses follow going from low order bit to high order bit and from 1st status byte to Nth status byte. For coil quantities that are not even multiples of eight, the remaining bits in the last status byte are filled with zeroes.

Restrictions: Broadcast mode is not supported by this function.
(Start Addr) + (# of Coils) - 1 < (OGC * 16).

IV.2. READ INPUT STATUS (Function Code 02)

Description: This function allows the user to obtain the ON/OFF status of discrete inputs in the addressed slave HPPC. Data may be read at any time during the slave HPPC's scan; data reads are not synchronized to the end of the scan.

Message Format:

SLAVE ADDR	FUNC CODE	START ADDR HI	START ADDR LO	# OF INPUTS HI	# OF INPUTS LO	ERROR CHECK FIELD

Response Format:

SLAVE ADDR	FUNC CODE	BYTE COUNT N	INPUT STATUS 1	- - -	INPUT STATUS N	ERROR CHECK FIELD

Slave Addr: 1 - 255; address of slave to receive message

Func Code: 02; function code of Read Input Status function

Start Addr: 0 - ((IGC*16)-1) (corresponds to 1 - (IGC*16) in HPPC); initial input to be read; IGC is the Input Groups Configured

# of Inputs: 1 - 2000; number of consecutive inputs, starting from the start address, to be read;

Byte Count: if (# of Inputs) is evenly divisible by 8 then, (Byte Count) = (# of Inputs) / 8; otherwise, (Byte Count) = Trunc((# of Inputs) / 8) + 1

Input Status: 1 = ON, 0 = OFF; The status is packed with one bit for each input. The low order bit of the first status byte contains the status of the first input; the remaining input statuses follow going from low order bit to high order bit and from 1st status byte to Nth status byte. For input quantities that are not even multiples of eight, the remaining bits in the last status byte are filled with zeroes.

Restrictions: Broadcast mode is not supported by this function.
(Start Addr) + (# of Inputs) - 1 < (IGC * 16).

IV.3. READ OUTPUT* REGISTERS (Function Code 03)

Description: This function allows the user to obtain the binary contents of holding registers in the addressed slave HPPC. Data may be read at any time during the slave HPPC's scan; data reads are not synchronized to the end of the scan.

*NOTE: In the MODBUS system, output registers refer to holding registers.

Message Format:

SLAVE ADDR	FUNC CODE	START ADDR HI	START ADDR LO	# OF REGS HI	# OF REGS LO	ERROR CHECK FIELD

Response Format:

SLAVE ADDR	FUNC CODE	BYTE COUNT N	OUTPUT REG 1 HI	OUTPUT REG 1 LO	- - -	OUTPUT REG N/2 HI	OUTPUT REG N/2 LO	ERROR CHECK FIELD

Slave Addr: 1 - 255; address of slave to receive message

Func Code: 03; function code of Read Output Registers function

Start Addr: 0 - (HRU-1); (corresponds to 1 - HRU in HPPC); initial register to be read

# of Regs: 1 - 125; number of consecutive registers, starting from the start address, to be read;

Byte Count: (Byte Count) = (# of Regs) * 2

Output Reg: Two bytes of data are returned for each holding register requested. The first byte contains the higher order bits, and the second contains the lower order bits. The first two bytes contain the contents of the holding register specified by the start address; the remaining registers' contents follow in succeeding bytes.

Restrictions: Broadcast mode is not supported by this function.
(Start Addr) + (# of Regs) - 1 < HRU.

IV.4. READ INPUT REGISTERS (Function Code 04)

Description: This function obtains the contents of the slave HPPC's input registers. These locations receive their values from devices connected to the I/O structure. They can only be referenced, not altered, from within the HPPC or via the MODBUS system. Data may be read at any time during the slave HPPC's scan; data reads are not synchronized to the end of the scan.

Message Format:

SLAVE ADDR	FUNC CODE	START ADDR HI	START ADDR LO	# OF REGS HI	# OF REGS LO	ERROR CHECK FIELD

Response Format:

SLAVE ADDR	FUNC CODE	BYTE COUNT N	INPUT REG 1 HI	INPUT REG 1 LO	- - -	INPUT REG N/2 HI	INPUT REG N/2 LO	ERROR CHECK FIELD

Slave Addr: 1 - 255; address of slave to receive message

Func Code: 04; function code of Read Input Registers function

Start Addr: 0 - (IRC-1) (corresponds to 1 - IRC in HPPC); initial register to be read; IRC is the Input Groups Configured

# of Regs: 1 - 125; number of consecutive registers, starting from the start address, to be read;

Byte Count: (Byte Count) = (# of Regs) * 2

Input Reg: Two bytes of data are returned for each input register requested. The first byte contains the higher order bits, and the second contains the lower order bits. The first two bytes contain the contents of the input register specified by the start address, the remaining registers' contents follow in succeeding bytes.

Restrictions: Broadcast mode is not supported by this function.
(Start Addr) + (# of Regs) - 1 < IRC.

IV.5 FORCE SINGLE COIL (Function Code 05)

Description: This function changes the state of a coil to either ON or OFF. This change is made by writing to the I/O table, not the force table. However, since the controller is actively scanning, it can alter the state of the coil at any time. The coil is modified at the end of the slave HPPC's scan.

Message Format:

SLAVE ADDR	FUNC CODE	COIL ADDR HI	COIL ADDR LO	ON/OFF VALUE HI	ON/OFF VALUE LO	ERROR CHECK FIELD

Response Format:

SLAVE ADDR	FUNC CODE	COIL ADDR HI	COIL ADDR LO	ON/OFF VALUE HI	ON/OFF VALUE LO	ERROR CHECK FIELD

Slave Addr: 0 - 255; address of slave to receive message; slave address 00 (broadcast mode) causes all attached slaves to modify the specified coil

Func Code: 05; function code of Force Single Coil function

Coil Addr: 0 - ((OGC*16)-1) (corresponds to 1 - (OGC*16) in HPPC); coil to be modified; OGC is the Output Groups Configured

On/Off Value: FF00 hex = ON, 0000 = OFF; values that set the coil ON or OFF; any other value will return an exception code 03 in the exception response from the slave interface

Restrictions: This function is not valid when the keyswitch mode of the HPPC is Run/Protect. An exception code 04 is returned in the exception response from the slave interface if this message is sent while the HPPC is in this mode.

IV.6 PRESET SINGLE REGISTER (Function Code 06)

Description: This function allows the user to modify the contents of a holding register. However, since the controller is actively scanning, it can alter the contents of any holding register at any time. The register is modified at the end of the slave HPPC's scan.

Message Format:

SLAVE ADDR	FUNC CODE	REG ADDR HI	REG ADDR LO	REG VALUE HI	REG VALUE LO	ERROR CHECK FIELD

Response Format:

SLAVE ADDR	FUNC CODE	REG ADDR HI	REG ADDR LO	REG VALUE HI	REG VALUE LO	ERROR CHECK FIELD

Slave Addr: 0 - 255; address of slave to receive message; slave address 00 (broadcast mode) causes all attached slaves to modify the specified holding register

Func Code: 06; function code of Preset Single Register function

Reg Addr: 0 - (HRU-1) (corresponds to 1 - HRU in HPPC); register to be modified

Reg Value: value that the content of the specified holding register is modified to

Restrictions: This function is not valid when the keyswitch mode of the HPPC is Run/Protect. An exception code 04 is returned in the exception response from the slave interface if this message is sent while the HPPC is in this mode.

IV.7. LOOPBACK TEST (Function Code 08)

Description: This function allows the user to test the communication system without affecting the contents of the slave HPPC. The slave should return the identical message that was sent to it by the master. If it does not, this may indicate a possible communications problem.

Message Format:

SLAVE ADDR	FUNC CODE	DIAG CODE HI	DIAG CODE LO	DATA VALUE HI	DATA VALUE LO	ERROR CHECK FIELD

Response Format:

SLAVE ADDR	FUNC CODE	DIAG CODE HI	DIAG CODE LO	DATA VALUE HI	DATA VALUE LO	ERROR CHECK FIELD

Slave Addr: 1 - 255; address of slave to receive message;

Func Code: 08; function code of Loopback Test function

Diag Code: 0000; Diagnostic code for Return Query Data; any other diagnostic code will return an exception code 03 in the exception response from the slave interface

Data Value: any value

Restrictions: Broadcast mode is not supported by this function.

IV.8. FORCE MULTIPLE COILS (Function Code 15)

Description: This function changes each coil in a consecutive block of coils to the desired ON/OFF state. These changes are made by writing to the I/O table, not the force table. However, since the controller is actively scanning, it can alter the state of any coil at any time. The coils are modified at the end of the HPPC's scan.

Message Format:

SLAVE ADDR	FUNC CODE	START ADDR HI	START ADDR LO	# OF COILS HI	# OF COILS LO			
						BYTE COUNT N	COIL STATUS 1	... COIL STATUS N	ERROR CHECK FIELD

Response Format:

SLAVE ADDR	FUNC CODE	START ADDR HI	START ADDR LO	# OF COILS HI	# OF COILS LO	00	ERROR CHECK FIELD

Slave Addr: 0 - 255; address of slave to receive message slave address 00 (broadcast mode) causes all attached slaves to modify the specified coils

Func Code: 15; function code of Force Multiple Coils function

Start Addr: 0 - ((OGC*16)-1) (corresponds to 1 - (OGC*16) in HPPC); initial coil to be modified; OGC is the Output Groups Configured

# of Coils: 1 - 2000; number of consecutive coils, starting from the start address, to be modified

Byte Count: if (# of Coils) is evenly divisible by 8 then,
(Byte Count) = (# of Coils) / 8; otherwise,
(Byte Count) = Trunc((# of Coils) / 8) + 1

Coil Status: 1 = ON, 0 = OFF; The status is packed with one bit for each coil. The low order bit of the first status byte contains the desired status of the first coil; the remaining coil statuses follow going from low order to high order bit and from 1st status byte to Nth status byte. For coil quantities that are not even multiples of eight, the remaining bits in the last status byte should be filled with zeroes.

Restrictions: (Start Addr) + (# of Coils) - 1 < (OGC * 16).
This function is not valid when the keyswitch mode of the HPPC is Run/Protect. An exception code 04 is returned in the exception response from the slave interface if this message is sent while the HPPC is in this mode.

IV.9. PRESET MULTIPLE REGISTERS (Function Code 16)

Description: This function modifies each holding register in a consecutive block of registers to the desired values. However, since the controller is actively scanning, it can alter the contents of any holding register at any time. The registers are modified at the end of the HPPC's scan.

Message Format:

SLAVE ADDR	FUNC CODE	START ADDR HI	START ADDR LO	# OF REGS HI	# OF REGS LO

BYTE COUNT N	REG VALUE 1-HI	REG VALUE 1-LO		REG VALUE N/2-HI	REG VALUE N/2-LO	ERROR CHECK FIELD

Response Format:

SLAVE ADDR	FUNC CODE	START ADDR HI	START ADDR LO	# OF REGS HI	# OF REGS LO	00	ERROR CHECK FIELD

Slave Addr: 0 - 255; address of slave to receive message slave address 00 (broadcast mode) causes all attached slaves to modify the specified holding registers

Func Code: 16; function code of Preset Multiple Registers function

Start Addr: 0 - (HRU-1); (corresponds to 1 - HRU in HPPC); initial register to be modified

# of Regs: 1 - 125; number of consecutive registers, starting from the start address, to be modified

Byte Count: (Byte Count) = (# of Regs) * 2

Reg Value: any desired values for the specified holding registers

Restrictions: (Start Addr) + (# of Regs) - 1 < HRU.
This function is not valid when the keyswitch mode of the HPPC is Run/Protect. An exception code 04 is returned in the exception response from the slave interface if this message is sent while the HPPC is in this mode.

V.0 EXCEPTION RESPONSES

Exception responses are sent to the master by the slave interface when errors occur such as illegal data in a message, no response from the slave HPPC, difficulty in communicating with the slave HPPC, and invalid keyswitch mode for the message sent. Exception responses have the following format.

Exception Response Format:

SLAVE ADDR	FUNC CODE + 80H	EXCEP CODE	ERROR CHECK FIELD

Slave Addr: 1 - 255; address of slave that message was sent to

Func Code: function code sent + 80 hex

Exception Code Table:

CODE	NAME	DESCRIPTION
01	Illegal Function	The message received is not an allowable function for the slave HPPC addressed.
02	Illegal Data Address	The address referenced in the message is not valid.
03	Illegal Data Value	The data value referenced in the message is not valid.
04	Failure in Associated Device	The slave PC has failed to respond to a message or an abortive error occurred. Keyswitch in Run/Protect mode for function codes 5, 6, 15, and 16.
06	Busy, Rejected Message	The message was received without error, but the slave HPPC is busy processing another command; or the keyswitch mode is Stop.

V1.0 PINOUTS FOR RS232 ADAPTER CABLE

The adapter cable for the RS232 serial port is configured as DCE. The pins are described in the following table.

PIN	FUNCTION
1	Chassis Ground
2	Receive Data Input
3	Transmit Data Output
4	CTS Input
5	RTS Output
6	DTR Output
7	Ground
20	DSR Input