EATON | Cutler-Hammer

MODBUS and N2 Communication Kit

User Manual

Supersedes January 2004
March 2004

March 2004

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Cover Photo: Cutler-Hammer® 9000X Drive

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Safety

Definitions and Symbols

WARNING

This symbol indicates high voltage. It calls your attention to items or operations that could be dangerous to you and other persons operating this equipment. Read the message and follow the instructions carefully.

This symbol is the "Safety Alert Symbol." It occurs with either of two signal words: CAUTION or WARNING, as described below.

WARNING

Indicates a potentially hazardous situation which, if not avoided, can result in serious injury or death.

CAUTION

Indicates a potentially hazardous situation which, if not avoided, can result in minor to moderate injury, or serious damage to the product. The situation described in the CAUTION may, if not avoided, lead to serious results. Important safety measures are described in CAUTION (as well as WARNING).

Hazardous High Voltage

WARNING

Motor control equipment and electronic controllers are connected to hazardous line voltages. When servicing drives and electronic controllers, there may be exposed components with housings or protrusions at or above line potential. Extreme care should be taken to protect against shock.

Stand on an insulating pad and make it a habit to use only one hand when checking components. Always work with another person in case an emergency occurs. Disconnect power before checking controllers or performing maintenance. Be sure equipment is properly grounded. Wear safety glasses whenever working on electronic controllers or rotating machinery.

Chapter 1 — Overview

Introduction

The Cutler-Hammer® HVX9000 from Eaton Electrical® can be controlled, monitored and programmed from a host system via MODBUS RTU or Johnson Controls N2 communication protocols with the addition of the OPTC2 RS-485 Communication Option Board kit.

The SVX9000 can be controlled via MODBUS RTU.

If you purchase your Communication Board Kit separate from the drive, please note that it must be installed in slot E on the control board of the HVX9000 or SVX9000 drive.

Specifications

Table 1-1: Specifications

Item	Specification
Communication Board Connections	
Interface	NXOPTC2: Pluggable connector (5.08 mm) NXOPTC8: 9-pin DSUB connector (female)
Data Transfer Method	RS-485, half-duplex
Transfer Cable	Twisted pair (1 pair and shield)
Electrical Isolation	500V DC
Communications	
Modbus RTU	As described in "Modicon Modbus Protocol Reference Guide" found at: http://public.modicon.com/
Johnson Controls N2	As described in Metasys N2 System Protocol Specification
Baud Rate	300, 600, 1200, 2400, 4800, 9600, 19200 and 38400 Kbaud
Addresses	1 to 247
Environment	
Ambient Operating Temperature	14 to 131°F (-10 to 55°C)
Storage Temperature	-40 to 140°F (-40 to 60°C)
Humidity	<95%, non-condensing
Altitude	Max. 3280 ft. (1000m)
Vibration	0.5G at 9 to 200 Hz
Safety	
Standards	Fulfils EN 50178 standard
Certification	CE, UL

Chapter 2 — Board Layout and Connections

The RS-485 Communication Board is connected to the communications bus through either a 5-pin pluggable bus connector (board OPTC2) or a 9-pin female D-sub connector (board OPTC8).

Communication with the control board of the drive takes place through the standard Interface Board Connector (see **Figures 2-1** and **2-2**).

OPTC2 Communication Board

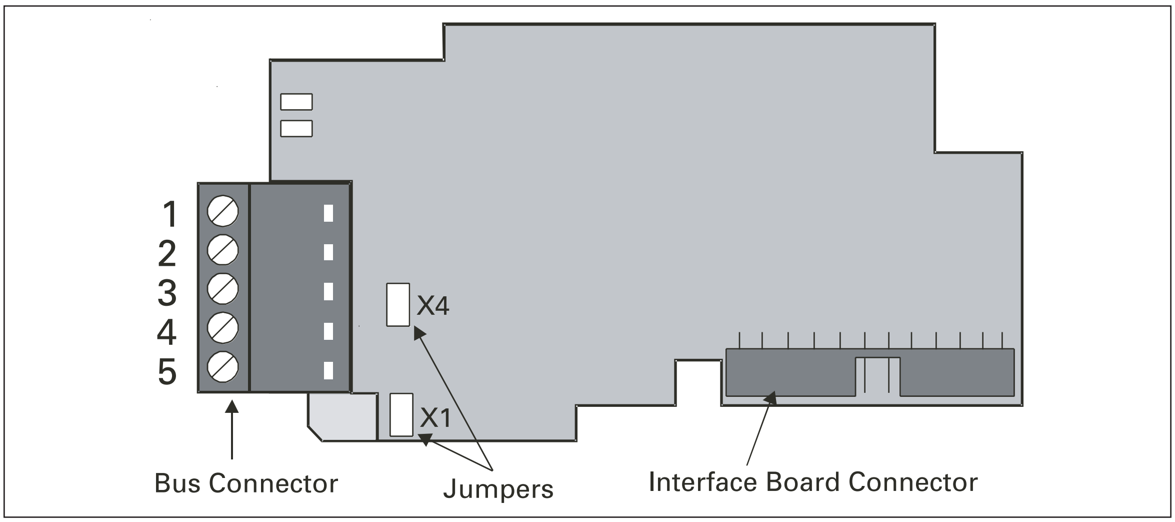
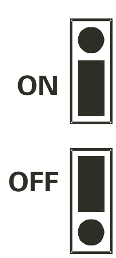


Figure 2-1: Option Board OPTC2 Communication Board

Table 2-1: OPTC2 Bus Connector Signals

Signal	Connector	Description
NC ①	1 ①	No connection
VP	2	Supply voltage – plus (5V)
R_xD/T_xD –N	3	Receive/Transmit data – minus (A)
R_xD/T_xD –P	4	Receive/Transmit data – plus (B)
DGND	5	Data ground (reference potential for VP)

① This pin (1) can be used to bypass the cable shield to the next slave.



X4 jumper is the 120Ω termination resistor. Set X4 jumper to ON only if the Cutler-Hammer drive is the last device on the network.

X1 jumper has no effect on OPTC2 board. It is used on the OPTC8 board on the following page.

OPTC8 Communication Board with D-Sub Connector

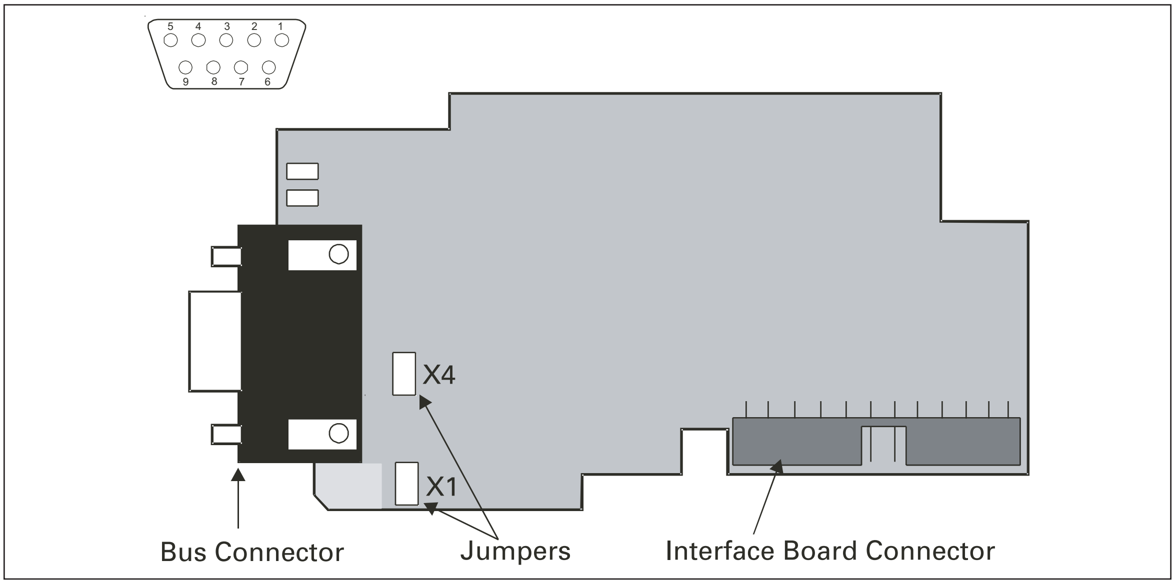
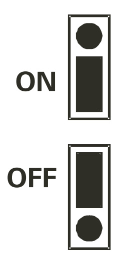


Figure 2-2: Option Board OPTC8 Communication Board with D-Sub Connector

Table 2-2: OPTC8 Bus Connector Signals

Signal	Connector	Description
Shield	1	Cable shield
R_xD/T_xD –N	3	Receive/Transmit data – minus (A)
DGND	5	Data ground (reference potential for VP)
VP	6	Supply voltage – (+5V)
R_xD/T_xD –P	8	Receive/Transmit data – plus (B)



X4 jumper is the 120Ω termination resistor. Set X4 jumper to ON only if the Cutler-Hammer drive is the last device on the network.

X1 jumper is used for grounding selection on the OPTC8 board only. ON position means that D-sub connector PIN 1 is connected directly to ground. OFF position means that PIN 1 is connected via RC filter to ground.

Chapter 3 — Installation

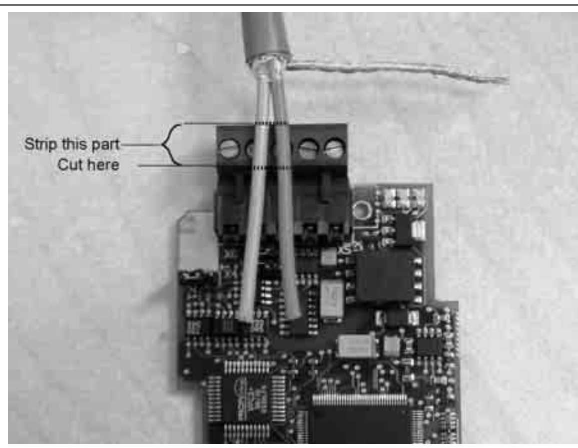
Making the Ground Connection

Grounding by Clamping the Cable to the Converter Frame

This method of grounding is the most effective, and especially recommended when the distances between the devices are relatively short or if the device is the last device on the network.

Note: Normally, the option board has already been installed in slot E of the control board. It is not necessary to detach the whole board to ground the bus cable shield. Just detach the terminal block.

1. Strip about 2 in. (5 cm) of the communication cable and cut off the gray cable shield. Remember to do this for both bus cables (except for the last device). See **Figure 3-1.**
2. Leave no more than 1/4 in. (1 cm) of the cable outside the terminal block and strip the data cables at about 0.2 in (0.5 cm) to fit in the terminals. See **Figure 3-1. Note**: Do this for both bus cables.



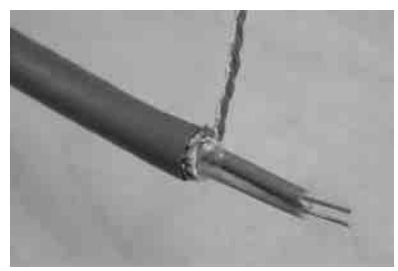


Figure 3-1: Cable Stripping

3. Insert the data cables into terminals #3 (Line A) and #4 (Line B).

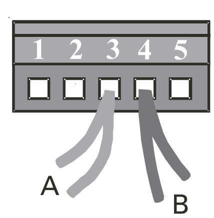


Figure 3-2: Inserting the Data Cables

4. Strip the communication cable so that it can be secured to the drive frame with the grounding clamp.

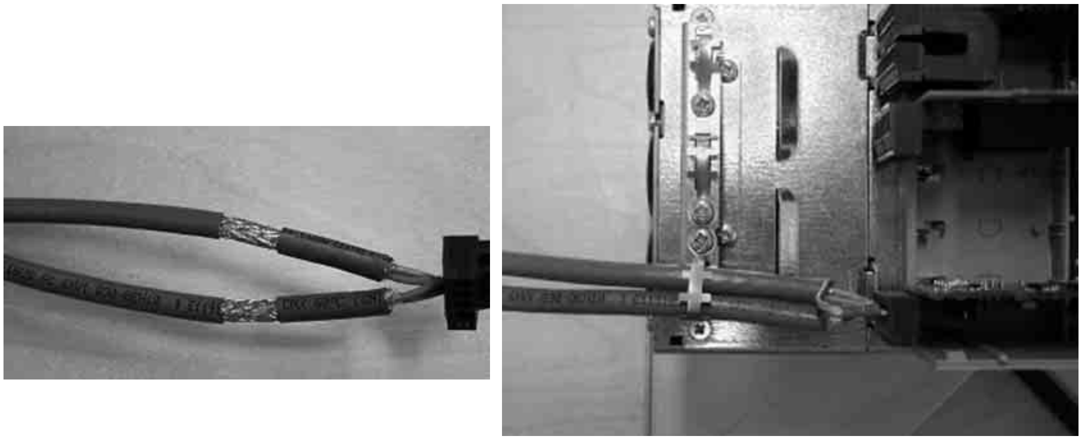


Figure 3-3: Grounding the Communication Cable

Grounding Only One Point on the Net

In this method of grounding, the shield is connected to ground only at the last device on the network. Other devices on the network just bypass the shield.

We recommend you to use an Abico connector to fit the shields into the terminal.

1. Strip about 2 in. (5 cm) of the communication cable and cut off the gray cable shield. Remember to do this for both bus cables (except for the last device).
2. Leave no more than 1/4 in. (1 cm) of the cable outside the terminal block and strip the data cables at about 0.5 cm to fit in the terminals. See **Figure 3-4**. **Note**: Do this for both bus cables.

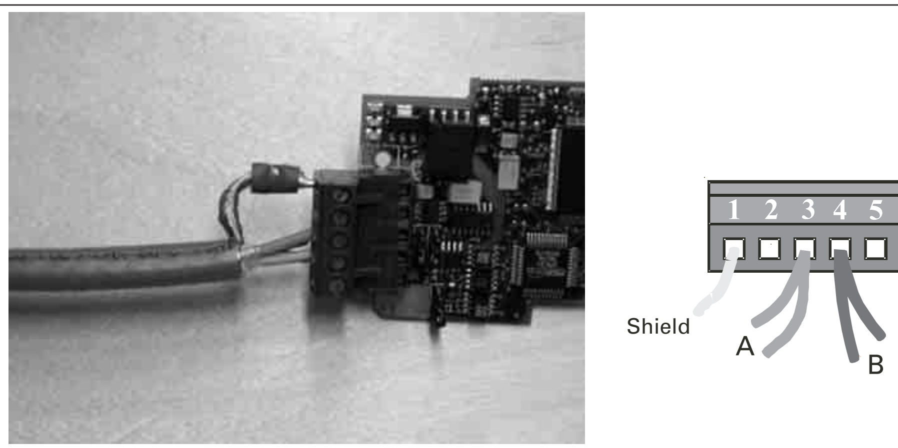


Figure 3-4: Stripping the Communication Cables

3. Secure the communication cable to the drive frame with the grounding clamp as shown in **Figure 3-5**.

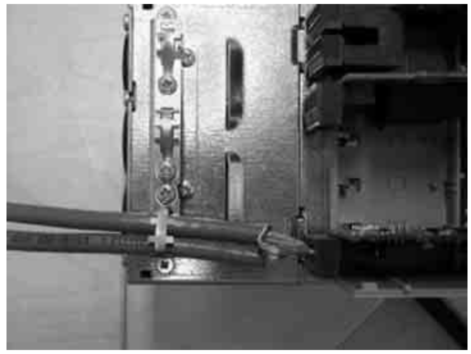


Figure 3-5: Grounding the Communication Cable

Bus Terminal Resistors

If the C2 or C8 Option Card is the last device on the network, the bus termination must be set to ON. Use jumper X4 (set to the ON position for termination). See **Figure 3-6**.

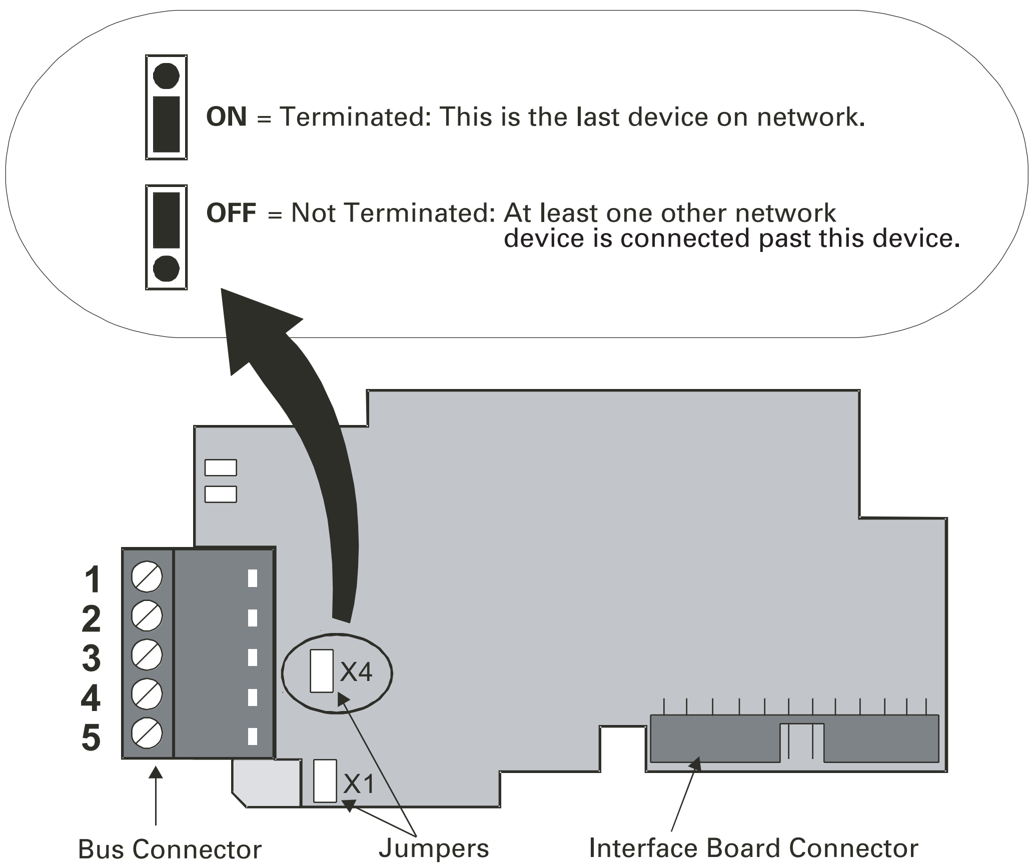


Figure 3-6: Using Jumper X4 to Set the Bus Termination

Bus Biasing

Bus biasing is required to ensure faultless communication between devices at RS-485 bus. Bus biasing makes sure that the bus state has proper potential when no one is transmitting. Without biasing faulty messages can be detected when the bus is in idle state. RS-485 bus state should be from +0.200 to +7V or -0.200 to -7V. Illegal bus state is from -0.200 to 0.200V.

Table 3-1: Bias Resistor Size vs. Number of Nodes

Number of Nodes	Bias Resistance
2 – 5	1.8k ohm
5 – 10	2.7k ohm
11 – 20	12k ohm
21 – 30	18k ohm
31 – 40	27k ohm

Failsafe Biasing in OPTC2 Option Board

Connect resistor biasing resistors between PIN 2 – PIN 4 and PIN 3 – PIN 5. See **Figure 3-7.**

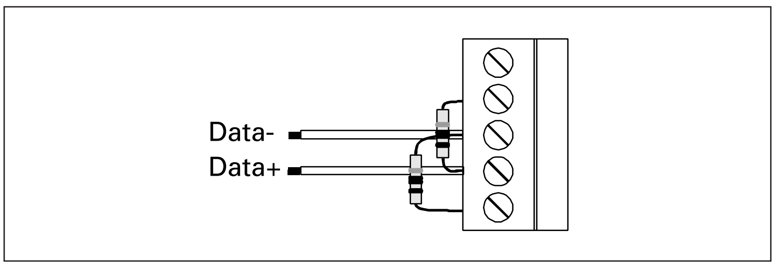


Figure 3-7: Connecting Resistor Biasing

National Semiconductor (www.national.com) has a very good application note concerning this problem. It is *Failsafe Biasing of Differential Buses* (AN-847.PDF).

LED Indications

The two LED indicators next to the connector show the present status of the Communication Board (yellow) and the Fieldbus Module (green).

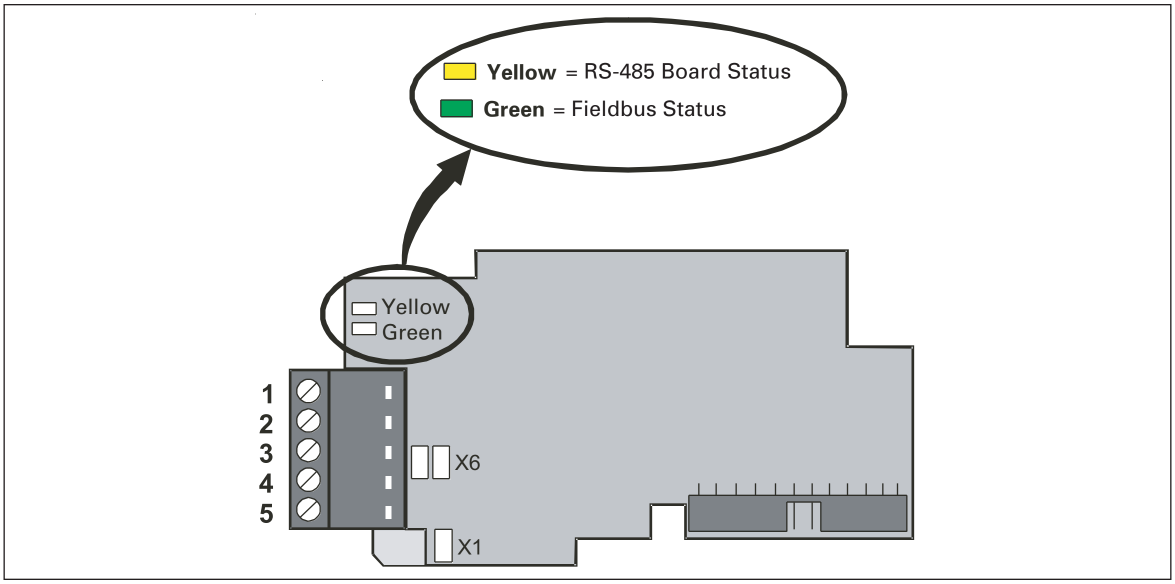


Figure 3-8: LED Indications on the Communication Board

Table 3-2: Communication Board Status LED (BS) — YELLOW

LED is:	Meaning:
OFF	Option board not activated
ON	Option board in initialization state waiting for activation command from the Adjustable Frequency Drive (AFD)
Blinking fast (once/sec)	Option board is activated and in RUN state Option board is ready for external communication
Blinking slow (once/5 secs)	Option board is activated and in FAULT state Internal fault of option board

Table 3-3: Fieldbus Status LED (FS) — GREEN

LED is:	Meaning:
OFF	Fieldbus module is waiting for parameters from the AFD No external communication
ON	Fieldbus module is activated Parameters received and module activated Module is waiting for messages from the bus
Blinking fast (once/sec)	Module is activated and receiving messages from the bus
Blinking slow (once/5 secs)	Module is in FAULT state No messages from Master within the watchdog time Bus broken, cable loose or Master off-line

Installing the C2 Communication Board

Table 3-4: Installing the C2 Communication Board

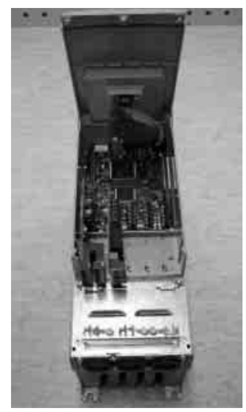
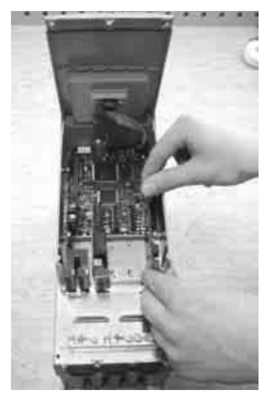
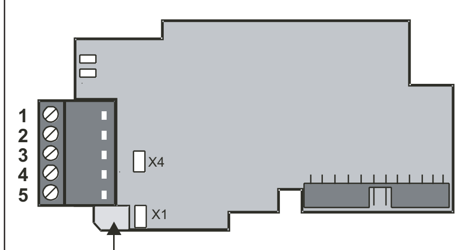
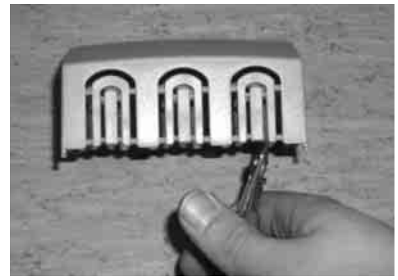
Procedure	Illustration
1. Remove the cable cover.	
2. Open the cover of the control unit.	
3. Install the C2 option board in slot E on the control board of the AFD. Make sure that the grounding plate (see below) fits tightly in the clamp.	  Grounding Plate

Table 3-4: Installing the C2 Communication Board, continued

Procedure	Illustration
4. Make a sufficiently wide opening for your cable by cutting the cover grid as wide as necessary.	
5. Close the cover of the control unit and the cable cover.	

Chapter 4 — Commissioning

Fieldbus Board Parameters

The RS-485 Communication boards (OPTC2 and OPTC8) are commissioned with the control keypad by giving values to appropriate parameters in the Expander board menu M5.

Expander Board Menu (M5) or (M4, HVX)

The Expander board menu makes it possible for the user, (1) to see what expander boards are connected to the control board and (2) to view and edit the parameters associated with the expander board.

Enter the following menu level **(G#)** with the menu button Right. At this level, you can browse through slots A to E with the Browser buttons to see which expander boards are installed. On the bottom line of the display, you also see the number of parameter groups associated with the board.

If you still press the menu button Right once you will reach the parameter group level where there are two groups: Editable parameters and Monitored values. A further press on the menu button Right takes you to either of these groups.

RS-485 Communication Parameters

To commission the RS-485 communication board, enter the level P5.5.1.# from the Parameters group (G7.5.1).

Table 4-1: Changing the Modbus Board Commissioning Parameter Values

#	Name	Default	Range	Description
1	Communication Protocol	1	1 – Modbus RTU 2 – N2	
2	Slave Address	1	1…247	
3	BAUD Rate	6	1 – 300 baud 2 – 600 baud 3 – 1200 baud 4 – 2400 baud 5 – 4800 baud 6 – 9600 baud 7 – 19200 baud 8 – 38400 baud	Communication speed **Note**: When the N2 protocol is used, the Baud Rate Setting must be: ***6 – 9600 baud***
4	Parity Type	0	0 – None 1 – Even 2 – Odd	Describes what kind of parity checking is used.
5	Communication Timeout	10	0 – OFF 1 – 300 s	See ***Communication Timeout*** on **Page 4-2**
6	Operate Mode	1	1 – Normal	Reserved for later use

The parameters of every device must be set before connecting to the bus. Especially the parameters "SLAVE ADDRESS" and "BAUD RATE" must be the same as in the master configuration.

Communication Timeout

The RS-485 communication board initiates a communication error if communication is broken for as long as defined by Communication Timeout. Communication Timeout is disabled when given the value **0.**

Communication Status

To see the present status of the communication board, enter the Communication status page from the Monitor menu (G7.5.2). See **Figure 4-1** and **Table 4-2.**

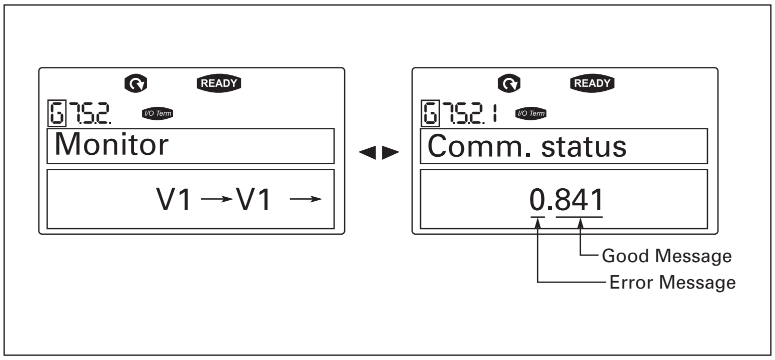


Figure 4-1: Communication Status

Table 4-2: Communication Message Indications

Messages	Indications
Good messages	
0 – 999	Number of messages received without communication errors
Error messages	
0 – 64	Number of messages received with CRC or parity errors

Chapter 5 — Modbus

MODBUS RTU Protocol

The MODBUS protocol is an industrial communications and distributed control system to integrate PLCs, computers, terminals, and other monitoring, sensing and control devices. MODBUS is a Master-Slave communications protocol. The Master controls all serial activity by selectively polling one or more slave devices. The protocol provides for one master device and up to 247 slave devices on a common line. Each device is assigned an address to distinguish it from all other connected devices.

The MODBUS protocol uses the master-slave technique, in which only one device (the master) can initiate a transaction. The other devices (the slaves) respond by supplying the requested data to the master, or by taking the action requested in the query. The master can address individual slaves or initiate a broadcast message to all slaves. Slaves return a message ("response") to queries that are addressed to them individually. Responses are not returned to broadcast queries from the master.

A transaction comprises a single query and single response frame or a single broadcast frame. The transaction frames are defined below.

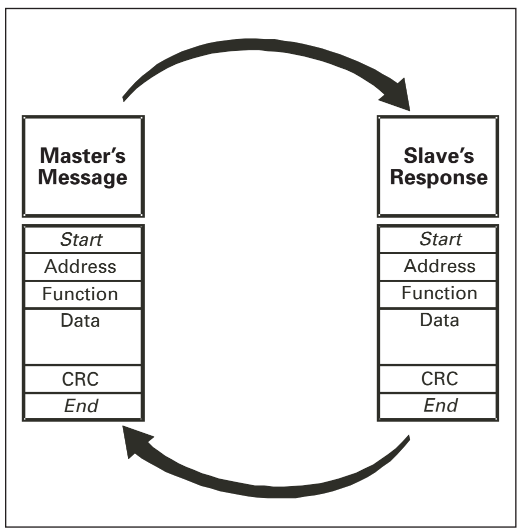


Figure 5-1: The Basic Structure of a Modbus Frame

Valid slave device addresses are in the range of 0 – 247 decimal. The individual slave devices are assigned addresses in the range of 1 – 247. A master addresses a slave by placing the slave address in the address field of the message. When the slave sends its response, it places its own address in this address field of the response to let the master know which slave is responding.

The function code field of a message frame contains two characters (ASCII) or eight bits (RTU). Valid codes are in the range of 1 – 255 decimal. When a message is sent from a master to a slave device, the function code field tells the slave what kind of action to perform. Examples are to read the ON/OFF states of a group of discrete coils or inputs; to read the data contents of a group of registers; to read the diagnostic status of the slave; to write to designated coils or registers; or to allow loading, recording or verifying the program within the slave.

When the slave responds to the master, it uses the function code field to indicate either a normal (error-free) response or that some kind of error occurred (called an exception response). For a normal response, the slave simply echoes the original function code. For an exception response, the slave returns a code that is equivalent to the original function code with its most significant bit set to a logic state of 1.

The data field is constructed using sets of two hexadecimal digits, in the range of 00 to FF hexadecimal. These can be made from a pair of ASCII characters, or from one RTU character, according to the network's serial transmission mode.

The data field of messages sent from a master to slave devices contains additional information that the slave must use to take the action defined by the function code. This can include items like discrete and register addresses, the quantity of items to be handled, and the count of actual data bytes in the field.

If no error occurs, the data field of a response from a slave to a master contains the data requested. If an error occurs, the field contains an exception code that the master application can use to determine the next action to be taken.

Two kinds of checksum are used for standard Modbus networks. The error checking field contents depend upon the transmission method that is being used.

Supported Functions

Table 5-1: Supported Messages

Function Code	Description	Address Range	Maximum Read/Write
03	Read Holding Registers	Applies to all addresses ①	20/20
04	Read Input Registers	Applies to all addresses ①	20/20
06	Write Single Register	Applies to all addresses	20/20
16	Write Multiple Registers	Applies to all addresses ①	20/20

① Parameters can read or write only once within query.

Note: Broadcasting can be used with codes 06 and 16.

Read Holding Registers

The query message specifies the starting register and the quantity of registers to be read. Registers are addressed starting with zero: registers 1 – 16 are addressed as 0 – 15.

Example of a request to read registers 42001 – 42003 from Slave device 1:

ADDRESS	01 hex	Slave address 01 hex (= 1)
FUNCTION	03 hex	Function 03 hex (= 3)
DATA		
Starting address HI	07 hex	Starting address 07d0 hex (= 2000)
Starting address LO	D0 hex	
No. of points HI	00 hex	Number of registers 0003 hex (= 3)
No. of points LO	03 hex	
ERROR CHECK		
CRC HI	05 hex	CRC field 0546 hex (= 1350)
CRC LO	46 hex	

Read Input Registers

The query message specifies the starting register and the quantity of registers to be read. Registers are addressed starting with zero: registers 1 – 16 are addressed as 0 – 15.

Example of a request to read registers 32001 from Slave device 1:

ADDRESS	01 hex	Slave address 01 hex (= 1)
FUNCTION	04 hex	Function 04 hex (= 4)
DATA		
Starting address HI	07 hex	Starting address 07d0 hex (= 2000)
Starting address LO	D0 hex	
No. of points HI	00 hex	Number of registers 0001 hex (= 1)
No. of points LO	01 hex	
ERROR CHECK		
CRC HI	31 hex	CRC field 3147 hex (= 1350)
CRC LO	47 hex	

Preset Single Register

The query message specifies the register reference to be preset. Registers are addressed starting with zero: Register 1 is addressed as 0.

Example of a request to preset register 42101 to 00001 hex in Slave device 1:

ADDRESS	01 hex	Slave address 01 hex (= 1)
FUNCTION	06 hex	Function 06 hex (= 6)
DATA		
Starting address HI	07 hex	Starting address 07d0 hex (= 2000)
Starting address LO	D0 hex	
No. of points HI	00 hex	Number of registers 0001 hex (= 3)
No. of points LO	01 hex	
Data HI	00 hex	Data = 0001 hex (= 1)
Data LO	01 hex	
ERROR CHECK		
CRC HI	B7 hex	CRC field B7A2 hex (= 47010)
CRC LO	A2 hex	

Preset Multiple Registers

The query message specifies the register references to be preset. Registers are addressed starting with zero: register 1 is addressed as 0.

Example of a request to preset two registers starting at 42001 to 0001 hex and 0010 hex in Slave device 1:

ADDRESS	01 hex	Slave address 01 hex (= 1)
FUNCTION	10 hex	Function 10 hex (= 16)
DATA		
Starting address HI	07 hex	Starting address 07d0 hex (= 2000)
Starting address LO	D0 hex	
No. of registers HI	00 hex	Number of registers 0002 hex (= 2)
No. of registers LO	02 hex	
Byte Count	04 hex	Byte count 04 hex (= 4)
Data HI	00 hex	Data 1 = 0001 hex (= 1)
Data LO	01 hex	
Data HI	00 hex	Data 2 = 0010 hex (= 16)
Data LO	10 hex	
ERROR CHECK		
CRC HI	88 hex	CRC field 88CF hex (= 35023)
CRC LO	CF hex	

Exception Responses

Error response is given when Slave receives message without communication errors, but cannot handle it. Examples of such messages are an incorrect register address, data value or unsupported message. No answer is given if a CRC or parity error occurs or the message is a broadcast message.

Table 5-2: Exception Response Codes

Code	Function	Description
01	ILLEGAL FUNCTION	The message function requested is not recognized by the slave.
02	ILLEGAL DATA ADDRESS	The received data address is not an allowable address for the slave.
03	ILLEGAL DATA VALUE	The received data value is not an allowable value for the slave.
06	SLAVE DEVICE BUSY	The message was received without error but the slave was engaged in processing a long duration program command.

Example of an exception response:

In an exception response, the slave sets the most-significant bit (MSB) of the function code to 1. The slave returns an exception code in the data field.

Command Master → Slave:

ADDRESS	01 hex	Slave address 01 hex (= 1)
FUNCTION	04 hex	Function 04 hex (= 4)
DATA		
Starting address HI	17 hex	Starting address 1770 hex (= 6000)
Starting address LO	70 hex	
No. of registers HI	00 hex	Invalid number of registers 0005 hex (= 5)
No. of registers LO	05 hex	
ERROR CHECK		
CRC HI	34 hex	CRC field 3466 hex (= 13414)
CRC LO	66 hex	

Message Frame:

01	04	17	70	00	05	34	66

Exception Response

Answer Slave → Master:

ADDRESS	01 hex	Slave address 01 hex (= 1)
FUNCTION	14 hex	Most significant bit set to 1
ERROR CODE	02 hex	Error code 02 => Illegal Data Address
CRC HI	AE hex	CRC field AEC1 hex (= 44737)
CRC LO	C1 hex	

Reply Frame:

01	14	02	AE	C1

MODBUS Interface

Features of the Modbus interface:

- Direct control of the drive (e.g. Run, Stop, Direction, Speed reference, Fault reset)
- Full access to drive parameters
- Monitor drive status (e.g. Output frequency, Output current, Fault code)

Modbus Registers

The variables and fault codes as well as the parameters can be read and written from Modbus. The parameter addresses are determined in the application. Every parameter and actual value have been given an ID number in the application. The ID numbering of the parameter as well as the parameter ranges and steps can be found in the application manual in question. The parameter value shall be given without decimals.

All values can be read with function codes 3 and 4 (all registers are 3X and 4X reference). Modbus registers are mapped to drive IDs as follows:

Table 5-3: Index Table

ID	Modbus Register	Group	R/W
1 – 98	40001 – 40098 (30001 – 30098)	Actual Values	1/1
99	40099 (30099)	Fault Code	1/1
101 – 1999	40101 – 41999 (30101 – 31999)	Parameters	1/1
2001 – 2099	42001 – 42099 (32001 – 32099)	Process Data In	20/20
2101 – 2199	42101 – 42199 (32101 – 32199)	Process Data Out	20/20

Process Data

The process data fields are used to control the drive (e.g. Run, Stop, Reference, Fault Reset) and to quickly read actual values (e.g. Output frequency, Output current, Fault code). The fields are structured as follows:

Table 5-4: Process Data Slave → Master — (max. 22 bytes)

ID	Modbus Register	Group	Range/Type
2101	32101, 42101	FB Status Word	Binary coded
2102	32102, 42102	FB General Status Word	Binary coded
2103	32103, 42103	FB Actual Speed	0 – 100.00%
2104	32104, 42104	FB Process Data Out 1	①
2105	32105, 42105	FB Process Data Out 2	①
2106	32106, 42106	FB Process Data Out 3	①
2107	32107, 42107	FB Process Data Out 4	①
2108	32108, 42108	FB Process Data Out 5	①
2109	32109, 42109	FB Process Data Out 6	①
2110	32110, 42110	FB Process Data Out 7	①
2111	32111, 42111	FB Process Data Out 8	①

① See Appendix A.

Table 5-5: Process Data Master → Slave — (max. 22 bytes)

ID	Modbus Register	Group	Range/Type
2001	32001, 42001	FB Control Word	Binary coded
2002	32002, 42002	FB General Control Word	Binary coded
2003	32003, 42003	FB Speed Reference	0 – 100.00% Hz
2004	32004, 42004	FB Process Data In 1	Integer 16
2005	32005, 42005	FB Process Data In 2	Integer 16
2006	32006, 42006	FB Process Data In 3	Integer 16
2007	32007, 42007	FB Process Data In 4	Integer 16
2008	32008, 42008	FB Process Data In 5	Integer 16
2009	32009, 42009	FB Process Data In 6	Integer 16
2010	32010, 42010	FB Process Data In 7	Integer 16
2011	32011, 42011	FB Process Data In 8	Integer 16

The use of process data depends on the application. In a typical situation, the device is started and stopped with the ControlWord (CW) written by the Master and the Rotating speed is set with Reference (REF). With PD1…PD8 the device can be given other reference values (e.g. Torque reference). With the StatusWord (SW) read by the Master, the status of the device can be seen. Actual Value (ACT) and PD1…PD8 show the other actual values.

Process Data In

This register range is reserved for the control of the AFD. Process Data In is located in range ID 2001 – 2099. The registers are updated every 10 mS. See **Table 5-6**.

Table 5-6: Fieldbus Basic Input Table

ID	Modbus Register	Name	Range/Type
2001	32001, 42001	FB Control Word	Binary coded
2002	32002, 42002	FB General Control Word	Binary coded
2003	32003, 42003	FB Speed Reference	0 – 100.00%
2004	32004, 42004	FB Process Data In 1	Integer 16
2005	32005, 42005	FB Process Data In 2	Integer 16
2006	32006, 42006	FB Process Data In 3	Integer 16
2007	32007, 42007	FB Process Data In 4	Integer 16
2008	32008, 42008	FB Process Data In 5	Integer 16
2009	32009, 42009	FB Process Data In 6	Integer 16
2010	32010, 42010	FB Process Data In 7	Integer 16
2011	32011, 42011	FB Process Data In 8	Integer 16

Control Word

HVX9000 drive uses 16 bits as shown below. SVX9000 drive uses bits 0 – 2. These bits are application specific.

Not In Use	PM Setback	Activate Fire Mode	Pass Through DO1	Pass Through RO2	Pass Through RO1	Not In Use	Not In Use	FB ① DIN 6	FB ① DIN 5	FB ① DIN 4	FB ① DIN 3	Enable Bypass			
15	14	13	12	11	10	9	8	(7)	(6)	(5)	(4)	(3)	2	1	0
—	—	—	—	—	—	—	—	—	—	—	—	—	RST	DIR	RUN

① These control bits (4 – 7) will activate or turn on the function associated with the digital input selections in Parameter Group 2.2 “Input Signals”.

The three first bits of the control word are used to control the AFD.

Table 5-7: Control Word Bit Descriptions

Bit	Description	
	Value = 0	**Value = 1**
0	Stop	Run
1	Clockwise	Counterclockwise
2	Rising edge of this bit will reset active fault	
3	Disable Bypass	Enable Bypass
4	FB DIN3 ① — OFF	ON
5	FB DIN4 ① — OFF	ON
6	FB DIN5 ① — OFF	ON
7	FB DIN6 ① — OFF	ON
8	Not in use	
9	Not in use	
10	Pass Through RO1 — OFF	ON
11	Pass Through RO2 — OFF	ON
12	Pass Through DO1 — OFF	ON
13	Activate Fire Mode — OFF	ON
14	PM Setback — OFF	ON
15	Not in use	Not in use

① These control bits (4 – 7) will activate or turn on the function associated with the digital input selections in Parameter Group 2.2 “Input Signals”.

Speed Reference

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
MSB	—	—	—	—	—	—	—	—	—	—	—	—	—	—	LSB

This is the Reference 1 to the AFD. Used normally as Speed reference.

The allowed scaling is: 0 – 100.00% of maximum freq.

Process Data In 1 to 8

Process Data In values 1 to 8 can be used in applications for various purposes. Update rate is 10 mS for all values. See *HVX9000 Application Manual* for usage of these data values. Refer to Parameter Group G2.13 (Fieldbus).

Process Data Out

This register range is normally used to fast monitoring of the AFD. Process Data Out is located in range ID 2101…2199. See **Table 5-8**.

Table 5-8: Fieldbus Basic Output Table

ID	Modbus Register	Name	Range/Type
2101	32101, 42101	FB Status Word	Binary coded
2102	32102, 42102	FB General Status Word	Binary coded
2103	32103, 42103	FB Actual Speed	0 – 100.00%
2104	32104, 42104	FB Process Data Out1	①
2105	32105, 42105	FB Process Data Out2	①
2106	32106, 42106	FB Process Data Out3	①
2107	32107, 42107	FB Process Data Out4	①
2108	32108, 42108	FB Process Data Out5	①
2109	32109, 42109	FB Process Data Out6	①
2110	32110, 42110	FB Process Data Out7	①
2111	32111, 42111	FB Process Data Out8	①

① See Appendix A.

Status Word

15	14	13	12	11	10	9	8②	7③	6④	5	4	3	2	1	0
—	—	—	—	—	—	—	—	—	—	AREF	W	FLT	DIR	RUN	RDY

② Interlocked.
③ Fire mode activated.
④ Bypass activated.

Information about the status of the device and messages is indicated in the Status Word. The Status Word is composed of 16 bits that have the following meanings:

Table 5-9: Status Word Bit Descriptions

	Bit	Description: Value = 0	Description: Value = 1
HVX & SVX	**0**	Not Ready	Ready
	1	STOP	RUN
	2	Clockwise	Counterclockwise
	3	—	Faulted
	4	—	Warning
	5	Ref. frequency not reached	Ref. frequency reached
HVX Only	**6**	Bypass not activated	Bypass activated
	7	Fire mode not activated	Fire mode activated
	8	Interlocked	Not interlocked
	9 – 15	Not In use	Not In use

Actual Speed

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
MSB	—	—	—	—	—	—	—	—	—	—	—	—	—	—	LSB

This is the reference 1 to the AFD. Used normally as Speed reference.

The allowed scaling is: 0 – 100.00% of maximum frequency.

Process Data Out 1 to 8

Process Data Out values 1 to 8 can be used in application for various purposes. Update rate is 10 mS for all values. See ***Appendix A*** for usage of these values.

Parameters

The parameter addresses are determined in the application. Every parameter has been given an ID number in the application. The ID numbering of the parameter as well as the parameter ranges and steps can be found in the application manual in question. The parameter value shall be given without decimals. The following functions can be activated with parameters:

Table 5-10: Parameters

Function Code	Function	Modbus Address	Parameter IDs
03	Read Holding Registers	30101 – 31999	101 – 1999
04	Read Input Registers	40101 – 41999	101 – 1999
06	Preset Single Register	40101 – 41999	101 – 1999
16	Preset Multiple Registers	40101 – 41999	101 – 1999

Actual Values

The actual values as well as parameter addresses are determined in the application. Every actual value has been given an ID number in the application. The ID numbering of the actual values as well as the value ranges and steps can be found in the application manual in question. The following functions can be activated with parameters:

Table 5-11: Actual Values

Function Code	Function	Actual values
03	Read Holding Registers	30001 – 30098
04	Read Input Registers	40001 – 40098

Example Messages

Example 1

Write the process data 42001 – 42003 with command 16 (Preset Multiple Registers).

Command Master → Slave:

ADDRESS	01 hex	Slave address 01 hex (= 1)
FUNCTION	10 hex	Function 10 hex (= 16)
DATA		
Starting address HI	07 hex	Starting address 07d0 hex (= 2000)
Starting address LO	D0 hex	
No. of registers HI	00 hex	Number of registers 0003 hex (= 3)
No. of registers LO	03 hex	
Byte count	06 hex	Byte count 06 hex (= 6)
Data HI	00 hex	Data 1 = 0001 hex (= 1). Setting control word run bit to 1.
Data LO	01 hex	
Data HI	00 hex	Data 2 = 0000 hex (= 0). General control word 0.
Data LO	00 hex	
Data HI	13 hex	Data 3 = 1388 hex (= 5000), Speed Reference to 50.00%
Data LO	88 hex	
ERROR CHECK		
CRC HI	C8 hex	CRC field C8CB hex (= 51403)
CRC LO	CB hex	

Message Frame:

01	10	07	D0	00	03	06	00	01	00	00	13	88	C8	CB

The reply to Preset Multiple Registers message is the echo of 6 first bytes.

Answer Slave → Master:

ADDRESS	01 hex	Slave address 01 hex (= 1)
FUNCTION	10 hex	Function 10 hex (= 16)
DATA		
Starting address HI	07 hex	Starting address 07d0 hex (= 2000)
Starting address LO	D0 hex	
No. of registers HI	00 hex	Number of registers 0003 hex (= 3)
No. of registers LO	03 hex	
ERROR CHECK		
CRC HI	F1 hex	CRC F101 hex (= 61697)
CRC LO	01 hex	

Reply Frame:

01	10	07	D0	00	F1	01

Example 2

Read the Process Data 42103…42104 with command 4 (Read Input Registers).

Command Master → Slave:

ADDRESS	01 hex	Slave address 01 hex (= 1)
FUNCTION	04 hex	Function 04 hex (= 4)
DATA		
Starting address HI	08 hex	Starting address 0836 hex (= 2102)
Starting address LO	36 hex	
No. of registers HI	00 hex	Number of registers 0002 hex (= 2)
No. of registers LO	02 hex	
ERROR CHECK		
CRC HI	93 hex	CRC field 93A5 hex (= 37797)
CRC LO	A5 hex	

Message Frame:

01	04	08	36	00	02	93	A5

The reply to the Read Input Registers message contains the values of the read registers.

Answer Slave → Master:

ADDRESS	01 hex	Slave address 01 hex (= 1)
FUNCTION	04 hex	Function 04 hex (= 4)
DATA		
Byte count	04 hex	Byte count 04 hex (= 4)
Data HI	13 hex	Speed reference = 1388 hex (=5000 => 50.00%)
Data LO	88 hex	
Data HI	09 hex	Output Frequency = 09C4 hex (=5000 => 50.00%)
Data LO	C4 hex	
ERROR CHECK		
CRC HI	78 hex	CRC field 78E9 hex (= 30953)
CRC LO	E9 hex	

Reply Frame:

01	04	02	13	88	09	C4	F0	E9

Start-Up Test

Drive Application Software

Choose Fieldbus (Bus/Comm) as the active control place.

Drive Master Software

1. Set FB Control Word (MBaddr 42001) value to **1hex.**
2. AFD status is RUN.
3. Set FB Speed Reference (MBaddr 42003) value to **5000** (=50.00%).
4. The Actual value is 5000 and the AFD output frequency is 50.00%.
5. Set FB Control Word (MBaddr 42001) value to **0hex.**
6. AFD status is STOP.

Note: If FB Status Word (Addr 42101) bit 3 = 1, status of AFD is FAULT.

Chapter 6 — Johnson Controls Metasys N2 Protocol

Overview

The N2 Interface provides:

- Direct control of Drive (e.g. Run, Stop, Direction, Speed reference, Fault reset)
- Full access to necessary parameters
- Monitoring of Drive status (e.g. Output frequency, Output current, Fault code)
- In stand-alone operation, or if the polling is stopped, the overridden values are released after a specified period (about 10 minutes).

Analog Input (AI) Features

All Analog Input (AI) points have the following features:

- Support Change of State (COS) reporting based on high and low warning limits.
- Support Change of State (COS) reporting based on high and low alarm limits.
- Support Change of State (COS) reporting based on override status.
- Always considered reliable and never out of range.
- Writing of alarm and warning limit values beyond the range that can be held by the drive's internal variable will result in having that limit replaced by the "Invalid Float" value even though the message is acknowledged. The net result will be the inactivation of the alarm or warning (the same as if the original out of range value was used).
- Overriding is supported from the standpoint that the "Override Active" bit will be set and the value reported to the N2 network will be the overridden value. However, the value in the drive remains unchanged. Therefore, the N2 system should be set up to disallow overriding AI points or have an alarm condition activated when a AI point is overridden.
- Overriding an AI point with a value beyond the limit allowed by the drive's internal variable will result in an "Invalid Data" error response and the override status and value will remain unchanged.

Binary Input (BI) Features

All Binary Input (BI) points have the following features:

- Support Change of State (COS) reporting based on current state.
- Support Change of State (COS) reporting based on alarm condition.
- Support Change of State (COS) reporting based on override status.
- Always considered reliable.

Overriding is supported from the standpoint that the "Override Active" bit will be set and the value reported to the N2 network will be the overridden value. However, the value in the drive remains unchanged. Therefore, the N2 system should be set up to disallow overriding BI points or have an alarm condition activated when a BI point is overridden.

Analog Output (AO) Features

All Analog Output (AO) points have the following features:

- Support Change of State (COS) reporting based on override status.
- Always considered reliable.
- Overriding of the AO points is the method used to change a value. Overriding an AO point with a value beyond the limit allowed by the drive's internal variable will result in an "Invalid Data" error response and the override status and value will remain unchanged. If the overridden value is beyond the drive's parameter limit but within the range that will fit in the variable, an acknowledge response is given and the value will be internally clamped to its limit.
- An AO point override copies the override value to the corresponding drive parameter. This is the same as changing the value on the keypad. The value is nonvolatile and will remain in effect when the drive is turned off and back on. It also remains at this value when the N2 network "Releases" the point. The N2 system always reads the current parameter value.

Note: On some N2 systems, the system will not poll the AO point when it is being overridden. In this case, the N2 system will not notice a change in value if the change is made via the keypad. To avoid this scenario, set the point up as a "local control" type and release it once it has been overridden. In this way, the N2 system will monitor the value when not being overridden.

Binary Output (BO) Features

All Binary Output (BO) points have the following features:

- Support Change of State (COS) reporting based on override status.
- Always considered reliable.
- Overriding BO points control the drive. These points are inputs commands to the drive.

When released, the drive's internal value remains at its last overridden value.

Internal Integer (ADI) Features

All Internal Integer (ADI) points have the following features:

- Do not support Change of State (COS) reporting.
- Can be overridden and the "Override Active" bit will be set. However, the Internal value is unchanged (Read Only).

N2 Point Map

Analog Input (AI) Point Map

Table 6-1: Analog Inputs (AI)

NPT	NPA	Description	Units	Note
AI	1	Speed Setpoint	Hz	2 decimals
AI	2	Output Speed	Hz	2 decimals
AI	3	Motor Speed	Rpm	0 decimal
AI	4	Load (power)	%	1 decimal
AI	5	Megawatt Hours	MWh	Total Counter
AI	6	Motor Current	A	2 decimal
AI	7	Bus Voltage	V	0 decimal
AI	8	Motor Volts	V	1 decimal
AI	9	Heatsink Temperature	° C	0 decimal
AI	10	Motor Torque	%	1 decimal
AI	11	Operating Days	Day	0 decimal
AI	12	Operating Hours	Hour	0 decimal
AI	13	Kilowatt Hours	kWh	Trip Counter
AI	14	Torque Reference	%	1 decimal
AI	15	Motor Temperature Rise	%	1 decimal
AI	16	FBProcessDataOUT1 ①	—	0 decimal
AI	17	FBProcessDataOUT2 ①	—	0 decimal
AI	18	FBProcessDataOUT3 ①	—	0 decimal
AI	19	FBProcessDataOUT4 ①	—	0 decimal
AI	20	FBProcessDataOUT5 ①	—	0 decimal
AI	21	FBProcessDataOUT6 ①	—	0 decimal
AI	22	FBProcessDataOUT7 ①	—	0 decimal
AI	23	FBProcessDataOUT8 ①	—	0 decimal

① These analog inputs are application specific. No scaling available. These can all be used to read any Parameter or Monitoring Value based on selections made in Parameter Group G2.14 Fieldbus.

Binary Input (BI) Point Map

Table 6-2: Binary Inputs (BI)

NPT	NPA	Description	0 =	1 =
BI	1	Ready	Not Ready	Ready
BI	2	Run	Stop	Run
BI	3	Direction	Clockwise	Counterclockwise
BI	4	Faulted	Not Faulted	Faulted
BI	5	Warning	Not Warning	Warning
BI	6	Ref. Frequency reached	False	True
BI	8	General 0 (Interlocked) ①	No	Yes
BI	9	General 1 (Bypass Active) ①	No	Yes
BI	10	General 2 (Fire Mode Active) ①	No	Yes
BI	11	General 3 HAND/AUTO	Hand	Auto
BI	12	General 4 HOA OFF/ON	OFF	ON

① These binary inputs are application specific. They are read from the drive's General Status Word.

Analog Output (AO) Point Map

Table 6-3: Analog Outputs (AO)

NPT	NPA	Description	Units	Note
AO	1	Comms Speed	%	2 decimal
AO	2	Current Limit	A	2 decimal
AO	3	Minimum Speed	Hz	2 decimal
AO	4	Maximum Speed	Hz	2 decimal
AO	5	Accel Time	s	1 decimal
AO	6	Decel Time	s	1 decimal
AO	7	FB PID Setpoint ②	%	2 decimal
AO	8	FB Sensor Feedback ②	%	2 decimal

② These analog outputs are sent to the drive and require Parameter 1.11.1 (PID Reference) to be set to "Fieldbus" for AO7 and Parameter 1.11.4 (Actual 1 Input) to be set to "Fieldbus" for AO8.

Binary Output (BO) Point Map

Table 6-4: Binary Outputs (BO)

NPT	NPA	Description	0 =	1 =
BO	1	Comms Start/Stop	Stop	Start
BO	2	Comms Forward/Reverse	Forward	Reverse
BO	3	Comms Reset Fault	N/A	Reset
BO	4	Enable Bypass	Disable	Enable
BO	5	Activate FB.DIN3 FBFixedControlWord Bit_4 ①	OFF	ON
BO	6	Activate FB.DIN4 FBFixedControlWord Bit_5 ①	OFF	ON
BO	7	Activate FB.DIN5 FBFixedControlWord Bit_6 ①	OFF	ON
BO	8	Activate FB.DIN6 FBFixedControlWord Bit_7 ①	OFF	ON
BO	11	Pass Through RO1	OFF	ON
BO	12	Pass Through RO2	OFF	ON
BO	13	Pass Through DO1	OFF	ON
BO	14	Activate Fire Mode	OFF	ON
BO	15	Comms PM Setback	OFF	ON

① These binary outputs are application specific. These can be used to override DIN2 through DIN6 to the “ON” or “Activated” position.

Pass Through Digital and Relay Outputs

If DO1, RO1 or RO2 outputs are programmed in Parameter Group “Outputs” for “Pass Through” this allows these “relays” to be forced ON.

Internal Integer (ADI) Point Mapping

Table 6-5: Internal Integers (ADI)

NPT	NPA	Description	Units
ADI	1	Active Fault Code	—

Chapter 7 — Communication Board Fault Tracking

The table below presents the faults related to the Modbus option board. For more fault code information, see also SVX or HVX User Manual (Fault Tracking Section).

Table 7-1: Communication Board Faults

Fault Code	Fault	Possible cause	Possible solutions
37	Device change	Option board changed	Reset
38	Device added	Option board added	Reset
39	Device removed	Option board removed	Reset
40	Device unknown	Unknown option board	Check the installation. If installation is correct contact the nearest Cutler-Hammer distributor.
53	Fieldbus fault	The data connection between the Modbus Master and the Modbus option board is broken	Check the installation. If installation is correct contact the nearest Cutler-Hammer distributor.
54	Slot fault	Defective option board or slot	Check the board and slot. Contact the nearest Cutler-Hammer distributor.

You can define with parameters how the AFD shall react to certain faults:

Table 7-2: AFD Response to Faults

Code	Parameter	Min.	Max	Unit	Step	Default	Note
P2.7.22	Response to fieldbus fault	0	3		1	0	0=No response 1=Warning 2=Fault,stop acc. to 2.4.7 3=Fault,stop by coasting
P2.7.23	Response to slot fault	0	3		1	0	0=No response 1=Warning 2=Fault,stop acc. to 2.4.7 3=Fault,stop by coasting

Appendix A — Process Data

Process Data OUT (Slave → Master)

The fieldbus master can read the AFD's actual values using process data variables.

Basic, Standard, Local/Remote, Multi-Step, PID control and Pump and Fan Control Applications use process data as follows:

Table A-1: Process Data OUT

ID	Data	Value	Unit	Scale
2104	Process Data OUT 1	Output Frequency	Hz	0.1 Hz
2105	Process Data OUT 2	Motor Speed	rpm	1 rpm
2106	Process Data OUT 3	Motor Current	A	0.1A
2107	Process Data OUT 4	Motor Torque	%	0.1 %
2108	Process Data OUT 5	Motor Power	%	0.1 %
2109	Process Data OUT 6	Motor Voltage	V	0.1V
2110	Process Data OUT 7	DC Link Voltage	V	1V
2111	Process Data OUT 8	Active Fault Code	—	—

The Multipurpose and HVX application has a selector parameter for every Process Data. The monitoring values and drive parameters can be selected using the ID number (see HVX or SVX User's Manual, Tables for monitoring values and parameters). Default selections are as in **Table A-1**, except for HVX. Refer to HVX User's Manual for the Default selections.

Process Data IN (Master → Slave)

ControlWord, Reference and Process Data are used with All-in-One applications as follows:

Basic, Standard, Local/Remote, Multi-Step Applications use process data as follows:

Table A-2: Process Data IN — All-In-One Applications

ID	Data	Value	Unit	Scale
2003	Reference	Speed Reference	%	0.01%
2001	Control Word	Start/Stop Command Fault Reset Command	—	—
2004 – 2011	PD1 – PD8	Not Used	—	—

Multipurpose Control Applications use process data as follows:

Table A-3: Process Data IN — Multipurpose Applications

ID	Data	Value	Unit	Scale
2003	Reference	Speed Reference	Hz	0.01 Hz
2001	Control Word	Start/Stop Command Fault Reset Command	—	—
2004	Process Data IN1	Torque Reference	%	0.1%
2005	Process Data IN2	Free Analog INPUT	%	0.01%
2006 – 2011	PD3 – PD8	Not Used	—	—

PID Control and Pump and Fan Control Applications use process data as follows:

Table A-4: Process Data IN — PID and Pump & Fan Applications

ID	Data	Value	Unit	Scale
2003	Reference	Speed Reference	Hz	0.01 Hz
2001	Control Word	Start/Stop Command Fault Reset Command	—	—
2004	Process Data IN1	Reference for PID controller	%	0.01%
2005	Process Data IN2	Actual Value 1 to PID controller	%	0.01%
2006	Process Data IN3	Actual Value 2 to PID controller	%	0.01%
2007 – 2011	PD4 – PD8	Not Used	—	—

HVX/Intellipass Applications use process data as follows:

Table A-5: Process Data IN — HVX Intellipass Applications

ID	Data	Value	Unit	Scale
2003	Reference	Speed Reference	%	0.01%
2001	Control Word	Start/Stop/Fault/Reset/ FBDIN3 – FBDIN6	—	—
2004	Process Data IN1	Reference for PID controller	%	0.01%
2005	Process Data IN2	Actual Value 1 to PID controller	%	0.01%
2006 – 2011	PD3 – PD8	Not used	—	—

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EATON | Cutler-Hammer

Printed in USA
Publication No. MN04003003E/CPG
March 2004