9000X

Modbus RTU OPTE2/E8

Fieldbus Manual

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Original operating manual
The German-language edition of this document is the original operating manual.

Translation of the original operating manual
All editions of this document other than those in German language are translations of the original German manual.

1. Edition 2023, publication date 12/23

Danger!
Dangerous electrical voltage!

Before commencing the installation

- Disconnect the power supply of the device.
- Ensure that devices cannot be accidentally retriggered.
- Verify isolation from the supply.
- Ground and short-circuit.
- Cover or enclose neighbouring units that are live.
- Follow the engineering instructions (IL) of the device concerned.
- Only suitably qualified personnel in accordance with EN 50110-1/-2 (VDE 0105 Part 100) may work on this device/system.
- Before installation and before touching the device ensure that you are free of electrostatic charge.
- The functional earth (FE) must be connected to the protective earth (PE) or to the potential equalizing. The system installer is responsible for implementing this connection.
- Connecting cables and signal lines should be installed so that inductive or capacitive interference do not impair the automation functions.
- Install automation devices and related operating elements in such a way that they are well protected against unintentional operation.
- Suitable safety hardware and software measures should be implemented for the I/O connection so that a cable or wire breakage on the signal side does not result in undefined states in the automation device.
- Ensure a reliable electrical isolation of the low voltage for the 24 V supply. Only use power supply units complying with IEC 60364-4-41 or HD 384.4.41 S2 (VDE 0100 part 410).
- Deviations of the mains voltage from the nominal value must not exceed the tolerance limits given in the technical data, otherwise this may cause malfunction and dangerous operation.
- Emergency-Stop devices complying with IEC/EN 60204-1 must be effective in all operating modes of the automation devices. Unlatching the emergency switching off devices must not cause restart.
- Built-in devices for enclosures or cabinets must only be run and operated in an installed state, desk-top devices or portable devices only when the housing is closed.
- Measures should be taken to ensure the proper restart of programs interrupted after a voltage dip or failure. This should not cause dangerous operating states even for a short time. If necessary, emergency switching off devices should be implemented.
- Wherever faults in the automation system may cause damage to persons or property, external measures must be implemented to ensure a safe operating state in the event of a fault or malfunction (for example, by means of separate limit switches, mechanical interlocks, etc.).
- During operation, and depending on their degree of protection, variable frequency drives may have live, uninsulated, moving, and/or rotating parts, as well as hot surfaces.
- The impermissible removal of the required cover, improper installation or incorrect operation of the motor or variable frequency drive can cause the failure of the device and serious injury and/or material damage.
- Comply with all applicable national accident prevention regulations (e.g. BGV A3) when working with energized variable frequency drives.
- The electrical installation must be carried out in accordance with the relevant regulations (e.g. with regard to cable cross sections, fuses, PE).
- All transport, installation, commissioning and maintenance work must only be carried out by trained personnel (observe IEC 60364, HD 384 or DIN VDE 0100 and national accident prevention regulations).
- If applicable, systems in which variable frequency drives are installed must be equipped with additional monitoring and protective devices in accordance with the applicable safety regulations, e.g., the German Equipment and Product Safety Act, accident prevention regulations, etc. Making changes to the variable frequency drives by using the operating software is allowed.
- Keep all covers and doors closed during operation.
- When designing the machine, the user must incorporate mechanisms and measures that limit the consequences of a drive controller malfunction or failure (an increase in motor speed or the motors sudden stop) so as to prevent hazards to people and property, e.g.:
  - Additional stand-alone devices for monitoring parameters that are relevant to safety (speed, travel, end positions, etc.)
  - Electrical and non-electrical safety devices (interlocks or mechanical locks) for mechanisms that protect the entire system
  - Due to the possibility of there being capacitors that are still holding a charge, do not touch live device parts or terminals immediately after disconnecting the variable frequency drives from the supply voltage. Heed the corresponding labels on the variable frequency drives

Contents

1 About this manual

OPTE2/E8 RS-485 multiple protocols field option board supports both Modbus RTU and Metasys N2 protocols. With these fieldbuses, the AC drives can then be controlled and monitored from the master. OPTE2/E8 RS485 can be installed to the following Eaton AC drives:

- Eaton SPX
- Eaton SVX

1.1 Target audience

This manual is intended for engineers and electricians. Electrical engineering and practical knowledge and skills will be required in order to be able to commission these devices. We assume that you have a basic knowledge of handling electrical systems and machines, as well as reading technical drawings.

CAUTION

Installation requires qualified electrician

1.2 Change protocol

Publication date	Page	Description	new	modified	deleted
12/23		First edition	√		

1.3 Writing conventions

Symbols with the following meaning are used in this manual:

▶ indicates actions to be taken.

1.3.1 Safety warning concerning property damage

WARNING

Indicates a potentially hazardous situation that may result in property damage.

1.3.2 Safety warning concerning personal injury hazards

CAUTION

Warns of hazardous situations that may cause

WARNING

Warns of hazardous situations that could result in serious injury or death.

DANGER

Warns of hazardous situations that result in serious injury or death.

1.3.3 Hints

⟶ Indicates useful tips.

⟶ All the specifications in this manual refer to the hardware and software versions documented in it

⟶More information on the devices described here can be found on the internet

Eaton.com

1.4 Abbreviations

The following abbreviations are used in this manual:

CW	Control word
DP	Distributed periphery
DU	Data unit
EEPROM	Electrical erasable programmable read-only memory
EMC	Electromagnetic compatibility
FB	Fieldbus
FDT	Field device tool
GSD	Generic Station Description
HMI	Human machine interface
IND	Sub index
LED	Light emitting diode
PC	Personal computer
PDI	Process Data In
PDO	Process Data Out
PLC	Programmable logic controller
PNU	Parameter number
PPO	Process parameter object
SW	Status word

1.5 Mains supply voltages

The rated operating voltages stated in the following table are based on the standard values for star networks with a grounded central point.
In ring networks (as found in Europe) the rated operating voltage at the transfer point of the power supply companies is the same as the value in the consumer networks (e.g. 230V, 400V).
In star networks (as found in North America), the rated operating voltage at the transfer point of the utility companies is higher than in the consumer network.
Example: 120 V → 115 V, 240 V → 230 V, 480 V → 460 V.
The rated mains voltage data is always based on mains frequencies of 50/60 Hz within a range of 48 to 62 Hz.

1.6 Units of measurement

Every physical dimension included in this manual uses international metric system units, otherwise known as SI (Système International d'Unités) units. For the purpose of the equipment's UL certification, some of these dimensions are accompanied by their equivalents in imperial units.

Table 1: Unit conversion examples

Designation	US-American Designation	Anglo American value	SI value	Conversion value
Length	inch	1 in (")	25.4 mm	0.0394
Output	horsepower	1 HP = 1.014 PS	0.7457 kW	1.341
Torque	pound-force inches	1 lbf in	0.113 Nm	8.851
Temperature	Fahrenheit	1 °F (T_F)	-17.222 °C (T_C)	$T_F = T_C \times 9/5 + 32$
Speed	revolutions per minute	1 rpm	1 min^{-1}	1
Weight	pound	1 lb	0.4536 kg	2.205
Flow rate	cubic feed per minute	1 cfm	1.698 m^3/min	0.5889

2 Option board techincal data

2.1 General

Table 1: Technical data

Protocols	**Modbus RTU / Metasys N2**	
Communications	Interface	OPTE2: 5-pin pluggable connector OPTE8: 9-pin D-SUB connector (female)
	Data transfer method	RS-485, half-duplex
	Transfer cable	Shielded Twisted Pair
	Electrical isolation	500 VDC
Environment	Ambient operating temperature	-10°C–50°C
	Storing temperature	-40°C–70°C
	Humidity	<95%, no condensation allowed
	Altitude	Max. 1,000 m
	Vibration	0.5 G at 9–200 Hz
Safety	Fulfills EN50178 standard	

2.2 New features

Table 2: OPTE2/E8 RS485 firmware versions

New Features	**Firmware version**
• Support for Eaton SPX and Eaton SVX AC drives. See control firmware requirements in Chapter 6 "Installation". • Support for 16 Modbus RTU process data items in Eaton SPX AC drive. See details in Chapter 7.3 "Modbus data mapping" and Chapter 11 "Appendix C - Fieldbus option board communication". • Support for OPTC2/OPTC8 backward compatibility mode in Eaton SPX/SVX AC drives. See Chapter "OPTC2/OPTC8 RS485 compatibility mode".	V003
• Initial version	V001

3 Layout and connections

The difference between OPTE2 option board and OPTE8 option board is bus connector. OPTE2 option board has a 5-pin pluggable bus connector, and OPTE8 option board has a 9-pin female D-SUB connector. Except that, they have the same LED indications, jumpers and interface board connector.

3.1 OPTE2 (screw plug) option board layout

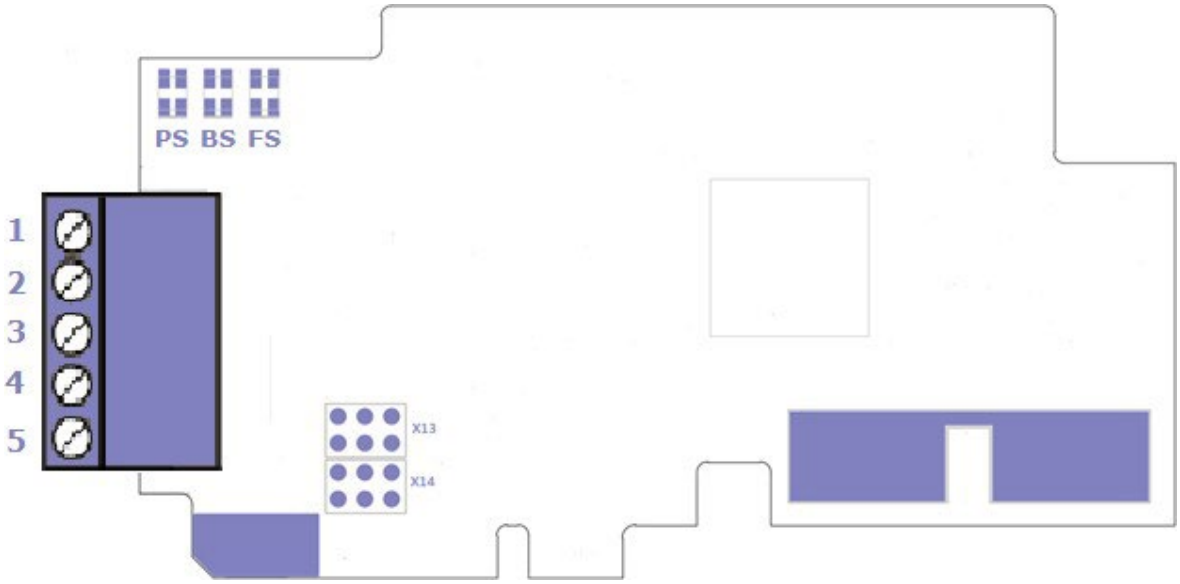


Figure 1: OPTE2 (screw plug) option board layout Table

Table 3: OPTE2 (screw plug) connector pinout

Signal	Pin	Description
Shield	1	Cable Shield
VP	2	Supply voltage - plus (5V)
RxD / TxD-P	3	Receive/Transmit data - plus(B)
RxD / TxD-N	4	Receive/Transmit data - minus(A)
DGND	5	Data ground (reference potential for VP)

NOTE! When replacing the OPTC2 option board with the OPTE2 option board, note that Receive/Transmit data - plus (B) and Receive/Transmit data - minus (A) pins have switched places. In OPTC2, the pin 1 is not connected to the cable shield.

Table 4: OPTC2 (screw plug) connector pinout

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

3.2 OPTE8 (Sub-D9) option board layout

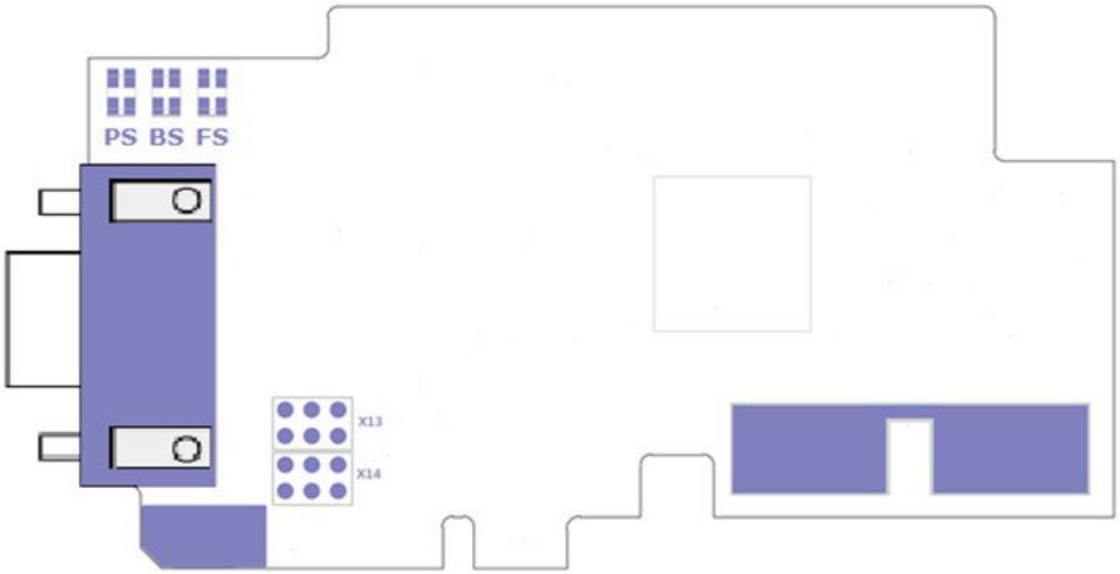


Figure 2: OPTE8 (Sub-D9) option board layout

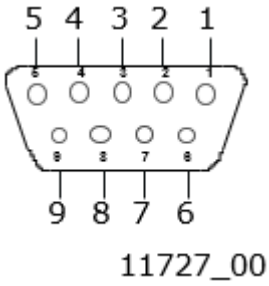


Figure 3: 9-pin female sub-D connector pinout

Table 5: OPTE8 (9-pin female sub-D) connector pinout

Signal	Pin	Description
Shield	1	Cable Shield
VP	2	Supply voltage - plus (5V)
RxD / TxD-P	3	Receive/Transmit data - plus (B)
RxD / TxD-N	4	Receive/Transmit data - minus (A)
DGND	5	Data ground (reference potential for VP)

When replacing the OPTC8 option board with the OPTE8 option board, note that Receive/Transmit data - plus (B) and Receive/Transmit data - minus (A) pins have switched places.

Table 6: OPTC8 (9-pin female sub-D) connector pinout

Signal	Pin	Description
Shield	1	Cable Shield
VP	2	Supply voltage - plus (5V)
RxD / TxD-N	3	Receive/Transmit data - plus (A)
RxD / TxD-P	4	Receive/Transmit data - minus (B)
DGND	5	Data ground (reference potential for VP)

3.3 LED indications

There are three LEDs on OPTE2/E8 option board to indicate board and communication status. This table describes their indications.

Table 7: LED indications

Signal	Pin
PS	• Green ON when protocol is communicating • Yellow blinking (1s ON / 1s OFF) when protocol is ready for external communication • OFF when protocol is not ready for communications • Green blinking (fast) when firmware is corrupted or missing
BS	• Green ON when board is operational. • Red blinking (1s ON / 1s OFF) when protocol is in fault state
FS	• Green ON when protocol is communicating. • OFF when protocol is not communicating.

Figure below lists possible LED indication combinations.

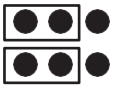
Table 8: LED combinations

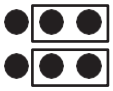
LED combinations			Description
PS	BS	FS	
Dim	Dim	Dim	No power. All LEDs are OFF
Green	Dim	Dim	Option board firmware is corrupted or missing. PS is blinking fast
Dim	Green	Dim	Option board is operational
Yellow	Green	Dim	Protocol is ready for communications. PS is blinking (1s ON / 1s OFF)
Green	Green	Green	Protocol is communicating. The option board is receiving requests from the PLC master and sending responses to the requests.
Yellow	Red	Dim	Protocol communication fault. BS is blinking to indicate a fault. PS is blinking to indicate that protocol is ready for communications.

3.4 Jumpers

Setting of termination resistance and cable shield grounding options is described in Chapter 5.

Jumper X13, termination resistor

Bus termination ON 

Bus termination OFF  Factory default setting

Jumper X14, upper row

GND connected to cable shield 

GND not connected to cable shield  Factory default setting

Jumper X14, lower row

Cable shield is connected to PE through RC 

Cable shield is connected directly to PE 

Cable shield is not connected ● ● ● Factory default setting

Figure 4: Position definition of jumpers

3.5 Bus terminal and bias resistors

If Eaton AC drive is the last device of RS-485 line, the bus termination must be set. Use jumper X13 (ON position) or external termination resistors.

Bus biasing is required to ensure faultless communication between devices at RS-485 bus. Bus biasing makes sure that the bus state is at proper potential when no device is transmitting. Without biasing, faulty messages can be detected when the bus is in idle state. RS-485 bus state should be neither +0.200...+7 V or -0.200...-7 V. Illegal bus state is <200 mV...-200 mV.

The resistance of internal termination and biasing are 120 Ω and 560 Ω.

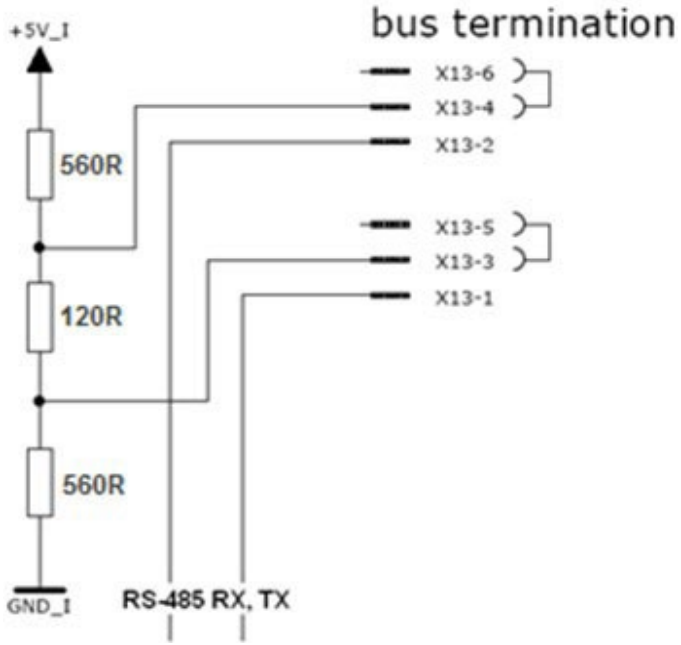


Figure 5: Bus termination

If necessary, external termination and biasing can be added depending on number of nodes and total length of cable.

Table 9: Bias resistance and termination resistance

Number of nodes	Bias resistance	Termination resistance
2-5	1.8 kΩ	120 Ω
5-10	2.7 kΩ	
11-20	12 kΩ	
21-30	18 kΩ	
31-40	27 kΩ	

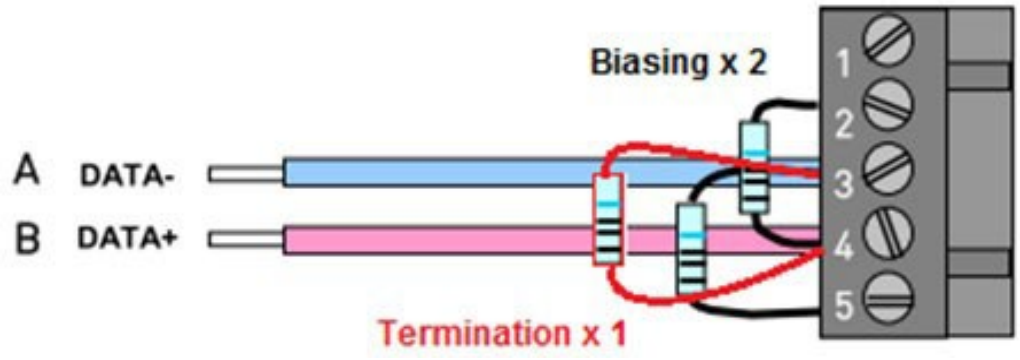


Figure 6

4 Cabling instructions

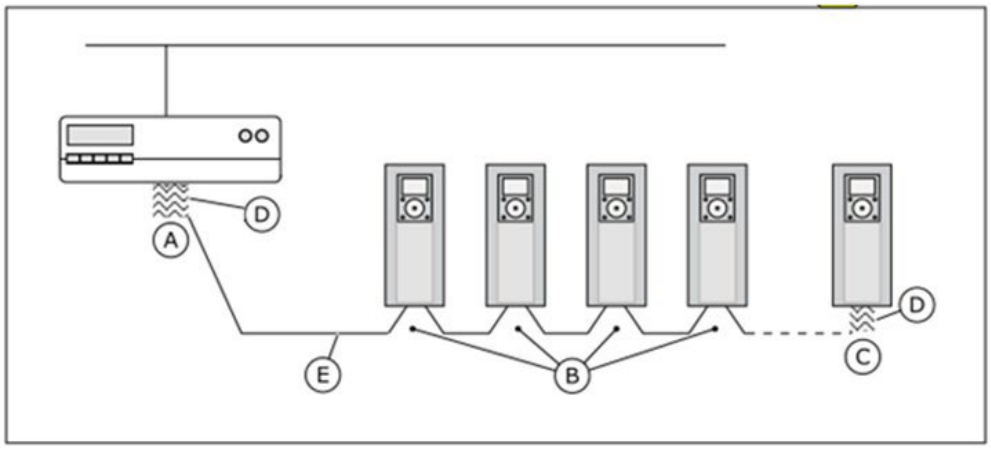
4.1 Selecting cable

In EIA-485 systems, use only shielded cables with twisted-pair signal wires. With EIA-485 protocols, use for example:

- Lapp Kabel UNITRONICR BUS LD FD P A, part number 2170813 or 2170814

4.2 Setting the termination resistance

Install termination resistors at or near both ends of the EIA-485 segment. The typically termination resistor for EIA-485 is 120 Ω.



A. The termination is activated
B. The termination is deactivated
C. The termination is activated with a jumper
D. The bus termination
E. The fieldbus cable

Figure 7: Setting the termination resistance

4.3 Shield grounding options

The equipotential bonding system in an installation refers to metalwork that is used to bring earth potential everywhere in the installation to a common level, the system earth. The purpose is that the earth potential for all devices and equipment would be the same, avoiding undesirable current flow through paths not normally designed to carry current, and to allow efficient shielding of cables.

4.3.1 Shield grounding when equipotential bonding is good

When the equipotential bonding is good, the fieldbus cable shield can be grounded at each AC drive. The grounding can be done by connecting the shield to the drive frame directly, or it can be done through the fieldbus connector and the grounding tab in the option board.

Jumper X14, lower row

Cable shield is connected directly to PE

Figure 8: Jumper X14 setting (all points in system)

If the fieldbus cable is subjected to tensile load, it is recommended to do this grounding via the fieldbus board connector and grounding tab. The strain relief of the cable is then done without exposing the cable shield, which reduces the risk of mechanical wear on the cable.

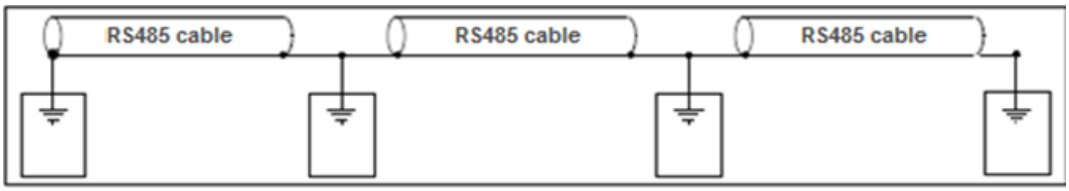


Figure 9: Grounding by clambing the cable to the AC drive frame

4.3.2 Shield grounding when equipotential bonding is poor

In a situation where the equipotential bonding is poor, the fieldbus cable should be grounded directly only at one point in the system. This can be at the Eaton AC drive but can also be some other point in the system. The fieldbus cable should not be directly grounded elsewhere in the system, because difference in electrical potential can cause equalization currents to appear in the shield, causing unnecessary disturbances.

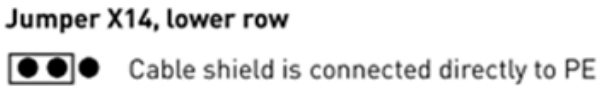


Figure 10: Jumper X14 setting (cable grounding to drive)

Figure 11: Jumper X14 setting (cable shield to RC filter)

In Eaton AC drives, the fieldbus cable can, in these cases, be connected to ground through an RC filter, which helps filter out disturbances in the shield without directly connecting it to the earth. In this case, the shield is connected to the option board connector and through an RC filter to the grounding tab in the option board. The strain relief is done without exposing the cable shield.

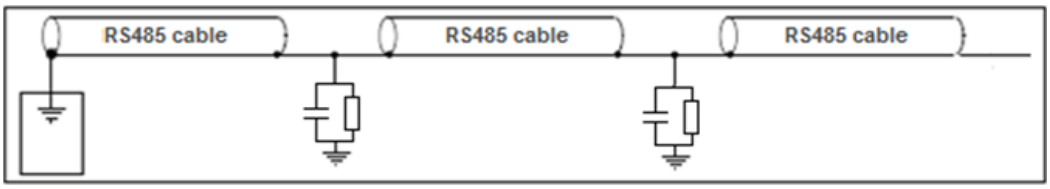


Figure 12: Grounding with RC filter

5 Installation

Following table shows which drives support OPTE2/E8 option board.

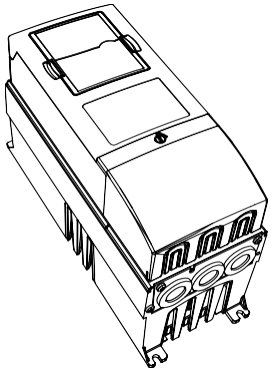
Table 10: OPTE2/E8 option board support

Drive	Slot	Since drive firmware version	Since OPTE2/E8 firmware version
Eaton SPX	D, E	SPXV027	FW0204V003
Eaton SVX	D, E	SVXV032	FW0204V003

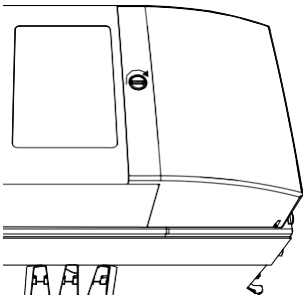
5.1 Installation in Eaton SPX/SVX

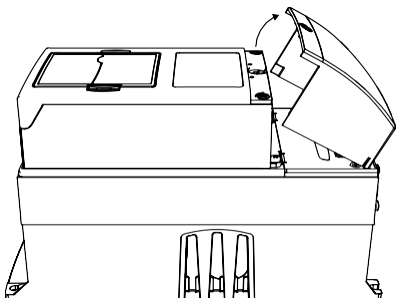
Make sure that the AC drive is switched off before an option or fieldbus board is changed or added!

1. Eaton SPX/SVX AC drive.

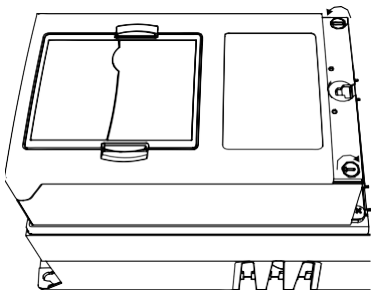


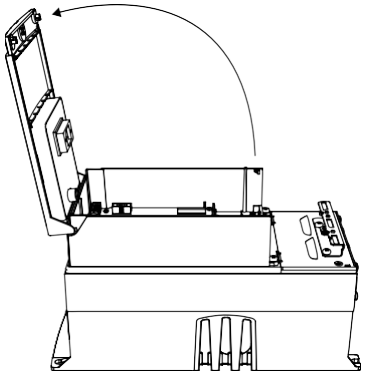
2. Remove the cable cover



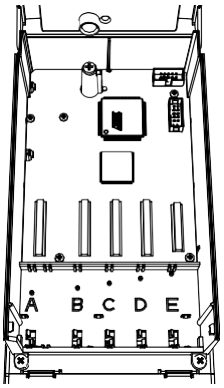


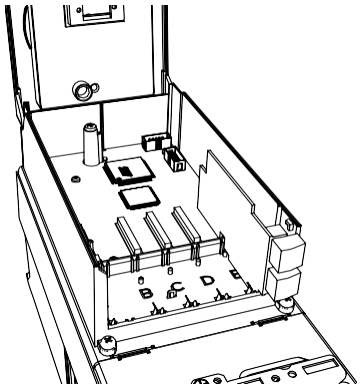
3. Open the cover of the control unit.



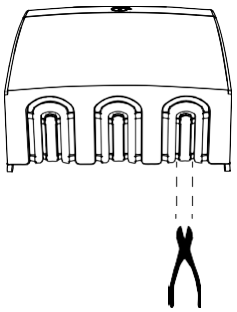


4. Install the OPTE2/E8 RS485 option board in slot D or E on the control board of the AC drive. Make sure that the grounding plate fits tightly in the clamp.





5. Make a sufficiently wide opening for your cable by cutting the grid as wide as necessary.



6. Close the cover of the control unit and the cable cover.

6 Commissioning

OPTE2/E8 is commissioned with Eaton SPX/SVX family panel by setting appropriate parameters in the option board menu.

Keypad/Panel commissioning and location of parameters are different between these two types of drives.

Table 11: Parameter location for commissioning

Drive	Slot
Eaton SPX/SVX family	Expander boards menu (M7) → Slot D' or 'Slot E'

NOTE! The AC drive application must be parametrized to enable motor controlling from the fieldbus. For application parametrization instructions, see Chapter 9 "Appendix A - Fieldbus parametrization".

6.1 Option board menu

The keypad/panel makes it possible for users to see which option board is connected to drive, and to reach and edit the parameters associated with option board.

6.1.1 Option board monitor menu

Table 12: Option board monitor menu

Monitor	Range	Description
Fieldbus protocol status	1 = Initializing, 3 = Operational, 4 = Faulted	
Communication Status	X.Y 0.0 … 64.999	X = Number of messages with errors Y = Number of messages without communication errors
Protocol/fieldbus control word	-	Control word received from RS-485
Protocol/fieldbus status word	-	Status word in drive format

Communication status

The number of messages with errors counter is increased when OPTE2/E8 receives a corrupted frame from the bus. The content of the corrupted message cannot be parsed.

The number of messages without communication errors counter is increased when OPTE2/E8 receives a valid Modbus RTU or N2 frame from the bus. Also the frame that is addressed to some other slave device increases the counter.

6.1.2 Option board parameter menu

Table 13: Option board parameter menu

Parameter	Range	Description
Communication protocol	1 = Modbus RTU 2 = N2	Current active fieldbus protocol. Default communication protocol is Modbus RTU
Slave address	1 … 247	Slave address
Baud rate	1 = 300 bps 2 = 600 3 = 1200 4 = 2400 5 = 4800 6 = 9600 7 = 19200 8 = 38400 9 = 57600 10 = 76800 11 = 115200 12 = 230400	Baud rate. Default baud rate is 9600 bps. When N2 protocol is used baud rate must be set to 9600.
Parity	0 = None 1 = Even 2 = Odd 3 = None Stopbits1	Modbus RTU: Parity None 2 stop bit Parity Even 1 stop bit Parity Odd 1 stop bit Parity None Stopbits1 1 stop bit N2 always uses 1 stop bit.
Communication timeout	0 = Disable 1 … 65535 s	Protocol communication timeout
Mode	1 = Normal 2 = NX mode	NX mode enables OPTC2/OPTC8 RS485 emulation. See Chapter "OPTC2/OPTC8 RS485 compatibility mode".

Communication timeout

The OPTE2/E8 RS485 option board reports communication timeout fault to the AC drive if the option board cannot receive Modbus RTU or Metasys N2 request during a communication timeout time. For more information on the fault, see Chapter 13.3 "Fieldbus timeout fault (F53)".

Only Modbus RTU or Metasys N2 requests that are pointed to the option board are taken into account in the communication timeout calculation. Requests that are pointed to other devices do not affect the timeout calculation.

Timeout monitoring starts after one valid request is received from the master.

The OPTE2/E8 RS485 does not create communication timeout fault to the drive when the timeout value is set to zero. This is useful for example when Modbus RTU or N2 is used only for monitoring the AC drive.

OPTC2/OPTC8 RS485 compatibility mode

OPTE2/OPTE8 firmware V003 and newer support the NX mode which enables emulation of the old OPTC2/OPTC8 RS485 option board.

- In case of Eaton SPX or Eaton SVX AC drive the emulation mode is enabled automatically.
  - See also the related system parameter “Show to Application as” in Chapter 6.1.3 "System Parameter menu".

The OPTC2/OPTC8 compatibility mode causes the following functionality changes in OPTE2/OPTE8 RS485 option board:

- N2 Binary input (BI) mapping is different. See Chapter 8.2.2 "Binary Input (BI)".
- N2 Binary output (BO) mapping is different. See Chapter 8.2.4 "Binary Output (BO)".
- Modbus RTU reading/writing of multiple Eaton application ID’s succeeds when reading/ writing of at least one ID succeeds. Normally OPTE2/8 returns "Illegal Data Address" (2) Modbus error when access to one ID fails.
- Modbus RTU Holding/input register 98 reads the first active fault code.

6.1.3 System Parameter menu

Parameter	Range	Description
Show to Application As*	0 = Default 17202 = OPTC2 17208 = OPTC8	Application sees the OPTE2/OPTE8 option board as OPTC2 or OPTC8 option board if “OPTC2” and “OPTC8” is selected.

*Available in Eaton SPX

Show to Application As

Some Eaton SPX applications assume that a certain fieldbus option board is used together with the application. In such cases, the application may refuse to go to the run state if a wrong type of fieldbus option is installed to the drive.

With the Show to Application As parameter it is possible to modify the option board type information that is fed to the application. For example, if an OPTC2 option board is replaced with an OPTE2 option board, with the Show to Application As parameter it is possible to lie to the application that an OPTC2 board is installed to the drive.

With the default setting the application normally sees the OPTE2/OPTE8 option board as OPTE2 or OPTE8 option board.

The Show to Application As parameter is available in Eaton SPX control firmware version SPXV027 and newer.

7 Modbus RTU

7.1 Overview

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 request 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.

7.2 Modbus RTU communications

Features of the Modbus-Eaton interface:

- Acts as a Modbus slave
- Direct control of Eaton AC drive (e.g. Run, Stop, Direction, Speed reference, Fault reset)
- Full access to all Eaton parameters
- Monitor the status of the Eaton AC drive (e.g. Output frequency, Output current, Fault code)

7.2.1 Data addresses in Modbus message

All data addresses in Modbus messages are referenced to zero. The first occurrence of a data item is addressed as item number zero. For example:

- Holding register 40001 is addressed as register 0000 in the data address field of the message. The function code field already specifies a 'holding register' operation. Therefore the '4XXXX' reference is implicit.
- Holding register 40108 is addressed as register 006B hex (107 decimal).

7.2.2 Modbus memory map

The Eaton 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 has been given an ID number in the application. The ID numbering of the parameters as well as the parameter ranges and steps can be found in the application manual in question. The parameter value is given without decimals. If several parameters/actual values are read with one message, the addresses of the parameters/actual values must be consecutive.

Table 14: Modbus memory map

Function code	Current terminology	Access type	Address range (hex)
3 (0x03)	Read holding registers	16bit	40000-4FFFF
4 (0x04)	Read input registers	16bit	30000-3FFFF
6 (0x06)	Write single register	16bit	40000-4FFFF
16 (0x10)	Write multiple registers	16bit	40000-4FFFF
23 (0x17)	Read/Write multiple registers	16bit	40000-4FFFF

7.2.3 Modbus exception responses

Table 15: Modbus exception responses

Code	Function	Description
01	ILLEGAL FUNCTION	The function code received in the query is not an allowable action for the slave
02	ILLEGAL DATA ADDRESS	The data address received in the query is not an allowable address for the slave
03	ILLEGAL DATA VALUE	A value contained in the query data field is not an allowable value for the slave
04	SLAVE DEVICE FAILURE	An unrecoverable error occurred while slave was attempting to perform the requested action.
06	SLAVE DEVICE BUSY	The slave is engaged in processing a long-duration program command.
08	MEMORY PARITY ERROR	The slave attempted to read record file, but detected a parity error in memory.

7.3 Modbus data mapping

7.3.1 Holding and input registers

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

Table 16: Modbus register mapping to drive IDs

Address range	Purpose	Access type
0001 - 2000	Eaton Application IDs	16bit
98	If "NX mode" is enabled: Read active fault code	16bit
2001 - 2050	FBProcessDataIN	16bit
2051 - 2099	FBProcessDataIN	32bit
2101 - 2150	FBProcessDataOUT	16bit
2151 - 2199	FBProcessDataOUT	32bit
2200 - 10000	Eaton Application IDs	16bit
10501 - 10530	IDMap	16bit
10601 - 10630	IDMap Read/Write	16bit
10701 - 10760	IDMap Read/Write	32bit
20001 - 40000	Eaton Application IDs	32bit
25101 - 25102	Drive system time	32bit
40001 - 40005	Operation day counter	16bit
40011 - 40012	Operation day counter	32bit
40201 - 40203	Energy counter	16bit
40211 - 40212	Energy counter	32bit
40301 - 40303	Resettable energy counter	16bit
40311 - 40312	Resettable energy counter	32bit
40401 - 40430	Fault history	16bit
40501	Communication timeout	16bit

7.3.1.1 Eaton application IDs

Application IDs are parameters that depend on the drive's application. These parameters can be read and written by pointing the corresponding memory range directly or by using the so-called ID map (more information below). It is easiest to use a straight address if you want to read a single parameter value or parameters with consecutive ID numbers. It is possible to read 12 consecutive ID addresses.

Table 17: Eaton application IDs

Address range	Purpose	ID
0001-2000	Application parameters (16bit)	1-2000
2200-10000	Application parameters (16bit)	2200-10000
20001 - 40000	Application parameters (32bit)	1-10000

Read register/registers can fail with Modbus error "ILLEGAL DATA ADDRESS" in the following cases:

- Reading of a single application ID fails if the ID does not exist.
- In "NX mode" OPTE2/E8 tries to read all registers. The read request succeeds if reading of one application ID succeeds. The failed application IDs are set to zero in the Modbus response data. If OPTE2/8 is used in Eaton SPX/SVX AC drives, this mode is enabled automatically.
- In case of 32-bit address space the read operation fails if only half of the 32-bit value is read. The read request must read complete 32-bit values.

Write register/registers can fail with Modbus error "ILLEGAL DATA ADDRESS" in the following cases:

- Writing of a single application ID fails if the ID does not exist.
- In case of Eaton SPX/SVX AC drives writing of 32-bit value fails if the application ID is not 32-bit.
- In "NX mode" OPTE2/8 tries to write all registers. The write request succeeds if writing of one application ID succeeds. If OPTE2/8 is used in Eaton SPX/SVX drives, this mode is enabled automatically.
- In case of 32-bit address space the write operation fails if only half of the 32-bit value is written. The write request must write complete 32-bit values.

7.3.1.2 Drive System time

Eaton SPX/SVX family support reading and setting of drive system time via fieldbus. It is also possible to synchronize time by using SNTP protocol. For details of the functionality, see Ethernet fieldbus manuals.

With OPTE2/E8 Modbus RTU it is possible to read and write drive system time via ID 2551. The time is presented as unsigned 32-bit unix time. For example, unix time 1536315873 (0x5B9251E1) stands for 07-Sep-2018 10:24:33.

Example: Read or write drive system time by using 32-bit application parameter access. Modbus address 25102 (low data) becomes from calculation

"32-bit area start address" + (application ID * 2) = 20000 + (2551 * 2).

Modbus index 25101 value: 23442 (0x5B92)

Modbus index 25102 value: 20961 (0x51E1)

NOTE! Eaton SPX/SVX family AC drives do not have time settings. Therefore the value written to this ID must be local time. Eaton SPX/SVX system time is zero after the drive boots up. The system time is started after writing into ID 2551.

7.3.1.3 FB Process data IN

The process data in fields are used for fast controlling of the AC drive (e.g. Run, Stop, Reference and Fault Reset).

The 32-bit process data can be used with all Eaton AC drives, but only lower 16 bits can ve processed

Table 18: Process Data Master -> Slave (max 22 bytes)

Address		Name	Range/Type
16-bit	32-bit		
2001	2051 = High data 2052 = Low data	FB Control Word	See Chapter 10.2 "Control Word bit support in Eaton AC drives".
2002	-	FB General Control Word	See Chapter 10.2 "Control Word bit support in Eaton AC drives".
2003	2053 = High data 2054 = Low data	FB Speed Reference	-10000...10000d See Chapter 10.6 "Eaton speed reference and actual speed - FBSpeedReference and FBActualSpeed".
2004	2055 = High data 2056 = Low data	FB Process Data In 1	See Chapter 10.7 "Process data".
2005	2057 = High data 2058 = Low data	FB Process Data In 2	See Chapter 10.7 "Process data".
2006	2059 = High data 2060 = Low data	FB Process Data In 3	See Chapter 10.7 "Process data".
2007	2061 = High data 2062 = Low data	FB Process Data In 4	See Chapter 10.7 "Process data".
2008	2063 = High data 2064 = Low data	FB Process Data In 5	See Chapter 10.7 "Process data".
2009	2065 = High data 2066 = Low data	FB Process Data In 6	See Chapter 10.7 "Process data".
2010	2067 = High data 2068 = Low data	FB Process Data In 7	See Chapter 10.7 "Process data".
2011	2069 = High data 2070 = Low data	FB Process Data In 8	See Chapter 10.7 "Process data".
2012**	2071 = High data 2072 = Low data	FB Process Data In 9	See Chapter 10.7 "Process data".
2013**	2073 = High data 2074 = Low data	FB Process Data In 10	See Chapter 10.7 "Process data".
2014**	2075 = High data 2076 = Low data	FB Process Data In 11	See Chapter 10.7 "Process data".
2015**	2077 = High data 2078 = Low data	FB Process Data In 12	See Chapter 10.7 "Process data".
2016**	2079 = High data 2080 = Low data	FB Process Data In 13	See Chapter 10.7 "Process data".
2017**	2081 = High data 2082 = Low data	FB Process Data In 14	See Chapter 10.7 "Process data".
2018**	2083 = High data 2084 = Low data	FB Process Data In 15	See Chapter 10.7 "Process data".
2019**	2085 = High data 2086 = Low data	FB Process Data In 16	See Chapter 10.7 "Process data".

**See requirements for 9–16 process data items in Chapter 12 "Appendix C - Fieldbus option board communication".

Control word bits

See Control word bits definition in Chapter 10.8 "Fieldbus process data mapping and scaling"

7.3.1.4 FB Process data OUT

The process data out fields are used for fast monitoring of the AC drive (e.g. drive status and actual speed).

The 32-bit process data can be used with all Eaton AC drives, but the upper 16 bits are set to zero for transmission.

Table 22. FB Process data OUT

Address		Name	Range/Type
16-bit	32-bit		
2101	2151 = High data 2152 = Low data	FB Status Word	See Chapter 10.3 "Eaton Status Word - FBFixedStatusWord".
2102	-	FB General Status Word	See Chapter 10.3 "Eaton Status Word - FBFixedStatusWord".
2103	2153 = High data 2154 = Low data	FB Actual Speed	-10000...10000d See Chapter 10.6 "Eaton speed reference and actual speed - FBSpeedReference and FBActualSpeed".
2104	2155 = High data 2156 = Low data	FB Process Data Out 1	See Chapter 10.7 "Process data".
2105	2157 = High data 2158 = Low data	FB Process Data Out 2	See Chapter 10.7 "Process data".
2106	2159 = High data 2160 = Low data	FB Process Data Out 3	See Chapter 10.7 "Process data".
2107	2161 = High data 2162 = Low data	FB Process Data Out 4	See Chapter 10.7 "Process data".
2108	2163 = High data 2164 = Low data	FB Process Data Out 5	See Chapter 10.7 "Process data".
2109	2165 = High data 2166 = Low data	FB Process Data Out 6	See Chapter 10.7 "Process data".
2110	2167 = High data 2168 = Low data	FB Process Data Out 7	See Chapter 10.7 "Process data".
2111	2169 = High data 2170 = Low data	FB Process Data Out 8	See Chapter 10.7 "Process data".
2112[2)]	2171 = High data 2172 = Low data	FB Process Data Out 9	See Chapter 10.7 "Process data".
2113**	2173 = High data 2174 = Low data	FB Process Data Out 10	See Chapter 10.7 "Process data".
2114**	2175 = High data 2176 = Low data	FB Process Data Out 11	See Chapter 10.7 "Process data".
2115**	2177 = High data 2178 = Low data	FB Process Data Out 12	See Chapter 10.7 "Process data".
2116**	2179 = High data 2180 = Low data	FB Process Data Out 13	See Chapter 10.7 "Process data".
2117**	2181 = High data 2182 = Low data	FB Process Data Out 14	See Chapter 10.7 "Process data".
2118**	2183 = High data 2184 = Low data	FB Process Data Out 15	See Chapter 10.7 "Process data".
2119**	2185 = High data 2186 = Low data	FB Process Data Out 16	See Chapter 10.7 "Process data".

**See requirements for 9–16 process data items in Chapter 11 "Appendix C - Fieldbus option board communication".

Status word bits

See Status word bits definition in Chapter 10.3 "Eaton Status Word - FBFixedStatusWord".

The use of process data depends on the application. In a typical situation, the device is started and stopped with the Control Word (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 Status Word (SW) read by the Master, the status of the device can be seen. Actual Value (ACT) and PD1…PD8 show the other actual values.

7.3.1.5 ID map

Using the ID map, you can read consecutive memory blocks that contain parameters whose ID's are not in a consecutive order. The address range 10501 - 10530 is called 'IDMap', and it includes an address map in which you can write your parameter IDs in any order. The address range 10601 to 10630 is called 'IDMap Read/Write,' and it includes values for parameters written in the IDMap. As soon as one ID number has been written in the map cell 10501, the corresponding parameter value can be read and written in the address 10601, and so on. The address range 10701 - 10730 contains the ID Map for 32bit values.

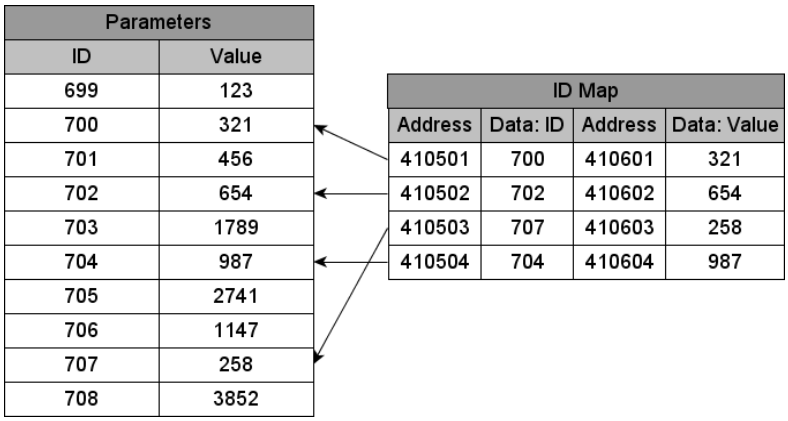


Figure 13

Once the IDMap address range has been initialized with parameter IDs, the parameter values can be read and written in the IDMap Read/Write address range address (IDMap address + 100).

Table 19

Address	Data
410601	Data included in parameter ID700
410602	Data included in parameter ID702
410603	Data included in parameter ID707
410604	Data included in parameter ID704

If the IDMap table has not been initialized, all fields show index as '0'. If it has been initialized, the parameter IDs included in it are stored in the flash memory of the option board.

Table 20: Example of 32bit IDMap

Address	Data
410701	Data High, parameter ID700
410702	Data Low, parameter ID700
410703	Data High, parameter ID702
410704	Data Low, parameter ID702

7.3.1.6 Operation day counter

Control unit operating time counter (total value). This counter cannot be reset.

Operation day counter as seconds

This counter in registers 40011d to 40012d holds the value of operation days as seconds in a 32-bit unsigned integer.

Table 21: Operation day counter as seconds

Address	Register	Description
40011 High data	440011	Holds the counter value as seconds.
40012 Low data	440012	

Operation day counter

This counter in registers 40001d to 40005d holds the value of operation days counter.

For compatibility with V100 internal and OPT-CI option board, this counter is found from two different register areas: holding registers 40001d to 40005d and input registers 1d to 5d.

Table 22: Operation day counter

Holding register address	Input register address	Purpose
40001	1	Years
40002	2	Days
40003	3	Hours
40004	4	Minutes
40005	5	Seconds

7.3.1.7 Resettable operation day counter

This register holds the value for resettable control unit operating time counter (trip value).

Resettable operation day counter as seconds

This counter in registers 40111d to 40112d holds the value of resettable operation days as seconds in a 32-bit unsigned integer.

Table 23: Resettable operation day counter as seconds

Address	Register	Description
40111 High data	440111	Holds the counter value as seconds.
40112 Low data	440112	

Resettable operation day counter

This counter in registers 40101d to 40105d holds the value of operation days counter.

For compatibility, this counter is found from two different register areas: holding registers 40101d to 40105d and input registers 30101d to 30105d.

Table 24: Operation day counter

Holding register address	Input register address	Purpose
40101	101	Years
40102	102	Days
40103	103	Hours
40104	104	Minutes
40105	105	Seconds

7.3.1.8 Energy counter

This counter holds the value of total amount of energy taken from supply network. This counter cannot be reset.

Energy counter as kWh

This counter is in registers 40211d to 40212d and is a 32-bit floating point (IEEE 754) value containing the number of kilowatt-hours (kWh) that is in the drive's energy counter. This value is read-only.

Table 25: Energy counter as kWh

Address	Register	Description
40211 High data	440201	Holds the value of energy counter in kWh. Datatype is 32 bit float IEEE 754
40212 Low data	440202	

Energy counter

These registers hold three values for the energy counter, amount of energy used, format of the energy value and unit of the energy value.

For compatibility, this counter is found from two different register areas: holding registers 40201d to 40203d and input registers 201d to 203d.

Example: If energy = 1200, format = 52, unit = 1, then actual energy is 12.00 kWh.

Table 26: Energy counter

Holding register address	Input register address	Purpose	Description
40201	201	Energy	Amount of energy taken from supply network.
40202	202	Format	The last number of the Format field indicates the decimal point place in the Energy field. Example: 40 = 4 number of digits, 0 fractional digits 41 = 4 number of digits, 1 fractional digit 42 = 4 number of digits, 2 fractional digits
40203	203	Unit 1 = kWh 2 = MWh 3 = GWh 4 = TWh	Unit of the value.

7.3.1.9 Resettable energy counter

This counter holds the value of total amount of energy taken from supply network since the counter was last reset.

Resettable energy counter as kWh

This counter is in registers 40311d to 40312d and is a 32-bit floating point (IEEE 754) value containing the number of kilowatt-hours (kWh) that is in the drive's resettable energy counter.

Table 27: Energy counter as kWh

Address	Register	Description
40311 High data	440311	Holds the value of energy counter in kWh since last counter reset. Datatype is 32 bit float IEEE 754
40312 Low data	440312	

Resettable energy counter

These registers hold three values for the energy counter, amount of energy used, format of the energy value and unit of the energy value.

For compatibility, this counter is found from two different register areas: 40301d to 40303d and 301d to 303d.

Example: If energy = 1200, format = 52, unit = 1, then actual energy is 12.00 kWh.

Table 28: Energy counter

Holding register address	Input register address	Purpose	Description
40301	301	Energy	Amount of energy taken from supply network.
40302	302	Format	The last number of the Format field indicates the decimal point place in the Energy field. Example: 40 = 4 number of digits, 0 fractional digits 41 = 4 number of digits, 1 fractional digit 42 = 4 number of digits, 2 fractional digits
40303	303	Unit 1 = kWh 2 = MWh 3 = GWh 4 = TWh	Unit of the value.

7.3.1.10 Fault history

The fault history can be viewed by reading from address 40401 onward. The faults are listed in chronological order so that the latest fault is mentioned first and the oldest last. The fault history can contain maximum 29 faults at the same time. For compatibility, this counter is also found from input register area: 401d to 403d.

The fault history contents are represented as follows.

Table 29: Fault history

Holding register address	Input register address	Purpose
40401	301	Upper byte is fault code, lower byte is sub code
40402	302	
40403	303	
…	…	
40429	429	

7.3.1.11 Fault history with 16-bit error codes

The fault history can be viewed by reading from address 40511 onward. The faults are listed in chronological order so that the latest fault is mentioned first and the oldest last. These addresses contain fault code and the subcode for the fault. Reading can be started from any address.

Table 30: Fault history with 16-bit error codes

Holding register address	Input register address	Purpose
40511	Fault code 1	16-bit fault code in index 1.
40512	Sub code 1	16-bit sub code for fault in index 1.
40513	Fault code 2	16-bit fault code in index 2.
40514	Sub code 2	16-bit sub code for fault in index 2.
…		
40569	Fault code 30	
40570	Sub code 30	

7.4 Quick setup

Following these instructions, you can easily and fast set up your Modbus for use:

First parametrize AC drive for field bus. See instructions in Chapter 9 "Appendix A - Fieldbus parametrization".

In the Master software:

1. Make these settings in the master software
2. Set Control Word to '**0**' (2001)
3. Set Control Word to '**1**' (2001)
4. Drive's status is RUN
5. Set Reference value to '**5000**' (50.00%) (2003).
6. Actual speed is 5000 (25.00 Hz if MinFreq is 0.00 Hz and MaxFreq is 50.00 Hz)
7. Set Control Word to '**0**' (2001)
8. Drive's status is STOP.

7.5 Example messages

7.5.1 Example 1: Write process data

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

Command Master - Slave:

ADDRESS		01 hex	Slave address 1 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).
	Data LO	00 hex	
	Data HI	13 hex	Data 3 = 1388 hex (= 5000), Speed Reference to 50.00%
	Data LO	88 hex	
ERROR CHECK	Data HI	C8 hex	CRC field C8CB hex (= 51403)
	Data 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 1 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	80 hex	CRC field 8085 hex (= 32901)
	CRC LO	85 hex	

Reply frame:

01	10	07	D0	00	03	80	85

7.5.2 Example 2: Read process data

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

Command Master - Slave:

ADDRESS		01 hex	Slave address 1 hex (= 1)
FUNCTION		04 hex	Function 4 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 1 hex (= 1)
FUNCTION		04 hex	Function 4 hex (= 4)
DATA	Byte count	04 hex	Byte count 4 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 (=2500 =>25.00Hz)
	Data LO	C4 hex	
ERROR CHECK	CRC HI	78 hex	CRC 78E9 hex (= 30953)
	CRC LO	E9 hex	

Reply frame:

01	04	04	13	88	09	C4	78	E9

7.5.3 Example 3: 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 1 hex (= 1)
FUNCTION		04 hex	Function 4 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 3466 hex (= 13414)
	CRC LO	66 hex	

Message frame:

01	04	17	70	00	05	34	55

Exception response.

Answer Slave - Master:

ADDRESS		01 hex	Slave address 1 hex (= 1)
FUNCTION		84 hex	Most significant bit set to 1
DATA	Starting address HI	04 hex	Error code 04 => Slave device failure
ERROR CHECK	CRC HI	42 hex	CRC 3466 hex (= 13414)
	CRC LO	C3 hex	

Reply frame:

01	84	04	42	C3

8 Metasys N2

8.1 Overview

The N2 communications protocol is used by Johnson Controls and others to connect terminal unit controllers to supervisory controllers. It is open to any manufacturer and based upon simple ASCII protocol widely used in the process control industry.

The physical characteristics of the N2 bus are two wires RS-485 with a maximum of 100 devices over a 4000 foot distance running at 9600 bps by default. Logically, the N2 is a master-slave protocol, the supervisory controller normally being the master.

8.2 Metasys N2 communication

Features of the N2 interface:

- Direct control of drive (e.g. Run, Stop, Direction, Speed reference, Fault reset)
- Full access to necessary parameters
- Monitor drive status (e.g. Output frequency, Output current, Fault code)
- In standalone operation, or should the polling stop, the overridden values are released after a specified period.

8.2.1 Analogue Input (AI)

All Analogue 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 an 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.

8.2.2 Binary Input (BI)

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.

8.2.3 Analogue Output (AO)

All Analogue 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 non-volatile 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 with the keypad. To avoid this, 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.

8.2.4 Binary Output (BO)

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

8.2.5 Internal Integer (ADI)

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).

8.3 Metasys N2 point map

8.3.1 Analogue Input (AI)

Table 31: Analogue Input (AI)

NPT	NPA	Description	Units	Note
AI	1	Speed setpoint	Hz	2 decimals
AI	2	Output frequency	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 decimals
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 (trip)	Day	0 decimal
AI	12	Operating hours (trip)	Hour	0 decimal
AI	13	Kilowatt hours (trip)	kWh	Trip counter
AI	14	Torque reference	%	1 decimal
AI	15	Motor temperature rise*	%	1 decimal
AI	16	FBProcessDataOut1	-32768 to +32767	0 decimal
AI	17	FBProcessDataOut2	-32768 to +32767	0 decimal
AI	18	FBProcessDataOut3	-32768 to +32767	0 decimal
AI	19	FBProcessDataOut4	-32768 to +32767	0 decimal
AI	20	FBProcessDataOut5	-32768 to +32767	0 decimal
AI	21	FBProcessDataOut6	-32768 to +32767	0 decimal
AI	22	FBProcessDataOut7	-32768 to +32767	0 decimal
AI	23	FBProcessDataOut8	-32768 to +32767	0 decimal

8.3.2 Binary Input (BI)

Binary Input (BI) functionality depends on the compatibility mode. See Chapter "OPTC2/OPTC8 RS485 compatibility mode".

- In "NX mode" mode OPTE2/E8 emulates the functionality of the OPTC2/C8 RS485 option board. The binary Inputs 8–15 are mapped to application specific FB General Status Word bits.

Table 32: Binary Input (BI) in Normal mode

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	Alarm	Not alarm	Alarm
BI	6	Reference frequency reached	False	True
BI	7	Motor running zero speed	False	True
BI	8	Flux ready	Not ready	Ready

Table 33: Binary Input (BI) in Normal mode

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	Alarm	Not alarm	Alarm
BI	6	Reference frequency reached	False	True
BI	7	Motor running zero speed	False	True
BI	8	FB General Status Word bit 0	0	1
BI	9	FB General Status Word bit 1	0	1
BI	10	FB General Status Word bit 2	0	1
BI	11	FB General Status Word bit 3	0	1
BI	12	FB General Status Word bit 4	0	1
BI	13	FB General Status Word bit 5	0	1
BI	14	FB General Status Word bit 6	0	1
BI	15	FB General Status Word bit 7	0	1

8.3.3 Analogue Output (AO)

Table 34: Analogue Output (AO)

NPT	NPA	Description	Units	Note
AO	1	Common speed	-100.00%–100.00%	2 decimals
AO	2	Current limit	A	2 decimals
AO	3	Minimum speed	Hz	2 decimals
AO	4	Maximum speed	Hz	2 decimals
AO	5	Acceleration time	s	1 decimal
AO	6	Deceleration time	s	1 decimal
AO	7	FBProcessDataIN1	-32768 to +32767	0 decimal
AO	8	FBProcessDataIN2	-32768 to +32767	0 decimal
AO	9	FBProcessDataIN3	-32768 to +32767	0 decimal
AO	10	FBProcessDataIN4	-32768 to +32767	0 decimal
AO	11	FBProcessDataIN5	-32768 to +32767	0 decimal
AO	12	FBProcessDataIN6	-32768 to +32767	0 decimal
AO	13	FBProcessDataIN7	-32768 to +32767	0 decimal
AO	14	FBProcessDataIN8	-32768 to +32767	0 decimal
AO	15	Any parameter read/write	-	Depends on parameter

8.3.4 Binary Output (BO)

Binary Out (BO) functionality depends on the compatibility mode. See Chapter "OPTC2/OPTC8 RS485 compatibility mode".

- In "NX mode" mode OPTE2/E8 emulates the functionality of the OPTC2/C8 RS485 option board. The binary Outputs 4–16 are mapped to Fixed control word bits.

Table 35: Binary Output (BO) in Normal mode

NPT	NPA	Description	0 =	1 =
BO	1	Comms start/stop	Stop	Start
BO	2	Comms forward/reverse	Forward	Reverse
BO	3	Reset fault	N/A	Reset
BO	4	Stop mode information 1	-	-
BO	5	Stop mode information 2	-	-
BO	6	Force ramp to zero	-	-
BO	7	Freeze ramp	-	-
BO	8	Reference to zero	-	-
BO	9	BusCtrl	-	-
BO	10	BusRef	-	-
BO	11	Operation time trip reset	-	Reset AI11 & AI12
BO	12	Energy trip counter reset	-	Reset AI13

Table 36: Binary Output (BO) in NX mode

NPT	NPA	Description	0 =	1 =
BO	1	Comms start/stop	Stop	Start
BO	2	Comms forward/reverse	Forward	Reverse
BO	3	Reset fault	N/A	Reset
BO	4	FB Control Word bit 3	-	-
BO	5	FB Control Word bit 4	-	-
BO	6	FB Control Word bit 5	-	-
BO	7	FB Control Word bit 6	-	-
BO	8	FB Control Word bit 7	-	-
BO	9	FB Control Word bit 8	-	-
BO	10	FB Control Word bit 9	-	-
BO	11	FB Control Word bit 10	-	-
BO	12	FB Control Word bit 11	-	-
BO	13	FB Control Word bit 12	-	-
BO	14	FB Control Word bit 13	-	-
BO	15	FB Control Word bit 14	-	-
BO	16	FB Control Word bit 15	-	-

8.3.5 Internal Integer (ADI)

Table 37: Binary Output (BO) in NX mode

NPT	NPA	Description	Units
ADI	1	Active fault code	-
ADI	2	Control word	-
ADI	3	Status word	-
ADI	4	Any parameter ID	-

N2 Any parameter service

With the Any parameter functionality it is possible to read and write ID's from/to the AC drive. Take into account the application specific limitations and value scaling. For more information, see application manual.

Read ID 102 (Maximum Frequency Reference) parameter value:

7. Write '102' to ADI4: Any parameter ID.

8. Read AO15: Any parameter read/write.

Write value '15' to ID 103 (Acceleration Time 1) parameter:

1. Write '103' to ADI4: Any parameter ID.

2. Write value '15' to AO15: Any parameter read/write.

8.4 Quick setup

Following these instructions, you can easily and fast set up your N2 for use.

First parametrize AC drive for field bus. See instructions in Chapter 9 "Appendix A - Fieldbus parametrization".

Make these settings in the N2 master software:

1. Set Control Word to '0' (ADI2).

2. Set Control Word to '1' (ADI2).

3. AC drive status is RUN.

4. Set Reference value to '50.00%' (AO1).

5. Output Frequency (AI2) is 25.00Hz if MinFreq is 0.00 Hz and MaxFreq is 50.00 Hz.

6. Set Control Word to '0' (ADI2).

7. AC drive status is STOP.

9 Appendix A - Fieldbus parametrization

The following chapter describes briefly how to parametrize the AC drive in order for the motor to be controllable via fieldbus. These instructions are written for some basic applications. For more information, see the application specific manual.

In order for the AC drive to accept commands from the fieldbus network, the control place of the AC drive has to be set to fieldbus. The default value of the parameter "Control Place" is usually I/O. Note that if the control unit firmware is updated, the default settings are restored. In addition, some applications may have the remote speed reference selection set by default to other than fieldbus. In these cases, the speed reference selection must be set to fieldbus, in order for the speed reference to be controlled via fieldbus.

NOTE! The motor control mode should be selected to support the used process and profile.

9.1 Fieldbus control and basic reference selection

The following tables list some of the parameters related to fieldbus control in case of standard applications for Eaton SPX/SVX family AC drives. See the application specific manuals for more detailed information and latest updates.

The parameters can be read and written by using the drive panel, PC tools or fieldbus protocol. The following table contains links to chapters where the ID value reading is described.

Table 38: Parametrization for Eaton SPX/SVX (multipurpose application)

Parameter Name	ID	Value	Default	Panel Tree
Motor control mode	600	0 = Frequency 1 = Speed 2 = Torque 3 = Closed loop speed control* 4 = Closed loop torque control*	0	P2.6.1
Control place selection	125	3 = Fieldbus	1	P3.1
Fieldbus Ctrl ref.	122	9 = Fieldbus	3	P2.1.13

* Available in Eaton SPX/SVX

9.2 Torque control parametrization

Some extra parametrization must be made in order to control the frequency control with torque control. The following instructions are for the Eaton SPX/SVX application. For more information, see the application specific manual.

- Motor control mode (ID 600) must be configured to “Torque control” (2).

To configure the AC drive to use correct torque reference, select the parameter "Torque Reference Selection" to ProcessDataIn1 (9). This can be done with:

- PC tool or panel (Eaton SPX/SVX: P2.10.4) / ID 641
- Vendor Parameter Object

9.3 Response to fieldbus fault

In case of a fieldbus fault (for example, loss of connection), a fieldbus fault is triggered. This fault can be parametrized in application to result in a desired response. Always check the application specific manual for details as responses vary between used applications. For common fault responses used commonly in standard applications, see the table below.

Table 39: Response to fieldbus fault in Eaton AC drives

ID	AC Drive	Value	Default	Panel Tree
733	Eaton SPX/SVX Family	0 = No action 1 = Warning 2 = Fault: Stop function 3 = Fault: Coast	2	P2.7.22

10 Appendix B - Eaton IO data description

The PLC master typically commands Eaton AC drive by transmitting Control Word, Speed Reference and Process Data In variables to the AC drive application. The AC drive status is typically monitored by receiving Status Word, Actual Speed and Process Data Out variables from the AC drive application.

Control Word, Speed Reference, Status Word and Actual Speed formats depend on the fieldbus and application. This appendix describes the Eaton specific profile. For description of PROFIdrive, CiA-402 CANopen and CIP AC/DC drive profile, see related fieldbus manual.

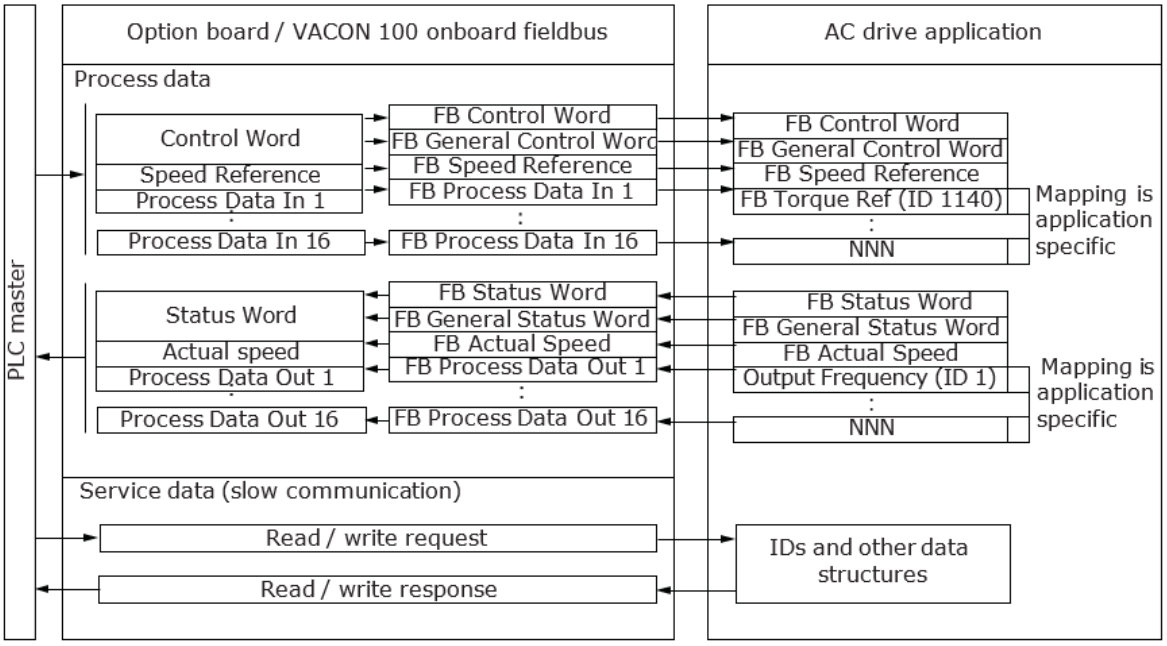


Figure 14: Communication between PLC master and AC drive application

10.1 Eaton profile

Eaton specific control profile is described in the following chapters.

10.1.1 Eaton Control Word – FBFixedControlWord

The Eaton Control Word is composed of 32 bits. This control data is split into two words: FBFixedControlWord consist of the first 16 bits and FBGeneralControlWord consist of the remaining 16 bits.

While the functionality of FBFixedControlWord is fixed in Eaton standard applications, the functionality of FBGeneralControlWord is completely application specific and can vary even in Eaton standard applications.

The FBFixedControlWord bit definitions are described in the following table. Note that there are some control word bit modifications in the Eaton SPX and SVX AC drives. These modifications are described in Table 41. Unused bits must be set to zero.

Table 40: FBFixedControlWord bits

Bit	Function	Value	Description
0	Start/Stop	0	Stop request from fieldbus.
		1	Run request from fieldbus.
1	Direction	0	Requested direction is “FORWARD”.
		1	Requested direction is “REVERSE”.
2	Fault reset	0	No action.
		1	No action when 1 ⍰ 1. Rising edge (0 ⍰ 1) = Active faults, alarms and infos are reset.
3	Stop mode 1	0	Stop mode is unmodified.
		1	Stop mode is overridden to "Coasting".
4	Stop mode 2	0	Stop mode is unmodified.
		1	Stop mode is overridden to "Ramping".
5	Quick ramp time	0	Normal deceleration ramp time.
		1	Deceleration ramp time is switched to shorter than normal.
6	Freeze setpoint	0	Changes in the setpoint value from fieldbus (FBSpeed-Reference) are taken into use by the application.
		1	Changes in the setpoint value from fieldbus (FBSpeed-Reference) are not taken into use by the application.
7	Setpoint to zero	0	The setpoint value from fieldbus is taken from FB Speed Reference.
		1	The setpoint value from fieldbus is changed to 0.
8	Request Fieldbus Control	0	Control Place is as parametrized in the drive (unchanged).
		1	Control Place is overridden to Fieldbus Control.
9	Request Fieldbus Reference	0	Source of the setpoint value is as parametrized in the drive (unchanged).
		1	Source of the setpoint value is overridden to Fieldbus.
10	Jogging 1	0	No action.
		1	Jogging request with jogging reference 1.
11	Jogging 2	0	No action.
		1	Jogging request with jogging reference 2.
12	Quick stop	0	No action.
		1	Drive executes quick stop / emergency stop.
13	Reserved	0	
		1	
14	Reserved	0	
		1	
15	Master connected*	0	Only in certain Eaton SPX/SVX applications. Fieldbus sets this bit to zero when it detects that there is no connection to the master.
		1	Only in certain Eaton SPX/SVX applications. Fieldbus sets this bit to one when it detects valid connection from the master.

*This functionality can be enabled/disabled by application from drive parameters.

Table 41: FBFixedControlWord modifications in Eaton SPX/SVX family

Bit	Function	Value	Description
3	Fieldbus DIN1	0	Fieldbus DIN1 off
		1	Fieldbus DIN1 on
4	Fieldbus DIN2	0	Fieldbus DIN2 off
		1	Fieldbus DIN2 on
5	Fieldbus DIN3	0	Fieldbus DIN3 off
		1	Fieldbus DIN3 on
6	Fieldbus DIN4	0	Fieldbus DIN4 off
		1	Fieldbus DIN4 on
7	Fieldbus DIN5	0	Fieldbus DIN5 off
		1	Fieldbus DIN5 on

10.2 Control Word bit support in Eaton AC drives

The following table describes the control word bit support in different AC drives. Notice that the table is valid only for Eaton standard applications. Always check the application specific manual.

Table 42: FBFixedControlWord bit support in different Eaton AC drives

Bit	Function	Eaton
0	Start/Stop	x
1	Direction	x
2	Fault reset	x
3	Stop mode 1	o
4	Stop mode 2	o
5	Quick ramp time	o
6	Freeze setpoint	o
7	Setpoint to zero	o
8	Request Fieldbus Control	x
9	Request Fieldbus Reference	x
10	Jogging 1	
11	Jogging 2	
12	Quick stop	
13-14	Reserved	
15	Master connected	x

x) Supports standard function
o) FBDIN function instead of standard function

10.3 Eaton Status Word – FBFixedStatusWord

The Eaton Status Word is composed of 32 bits. This status data is split into two words: FBFixedStatusWord consist of the first 16 bits and FBGeneralStatusWord consist of the remaining 16 bits.

While the functionality of FBFixedStatusWord is fixed in Eaton standard applications, the functionality of the FBGeneralStatusWord is totally application specific and can vary even in Eaton standard applications.

The FBFixedStatusWord bit definitions are described in the following table. Unused bits are set to zero. In Eaton SPX/SVX series AC drives FBFixedStatusWord comes from firmware variable "MCStatus".

Table 43: FBFixedStatusWord bits

Bit	Function	Value	Description
0	Ready	0	Drive is not ready.
		1	Drive is ready to run.
1	Run	0	Motor is not running.
		1	Motor is running.
2	Direction	0	Motor is running clockwise.
		1	Motor is running counterclockwise.
3	Fault*	0	No fault active.
		1	Drive has an active fault.
4	Alarm*	0	No alarm active.
		1	Drive has an active alarm.
5	At reference	0	Motor is not running at reference speed.
		1	Motor is running at reference speed.
6	Zero speed	0	Motor is not at zero speed.
		1	Motor is running at zero speed.
7	Flux ready	0	Motor is not magnetized.
		1	Motor is magnetized.
8	Info*	0	No info active.
		1	Drive has an active info.
9 - 15	Reserved	0	-
		1	-

*Drive faults have three levels: Fault, Alarm and info. Bits 3, 4 and 8 are set to 1 if the given fault type is activated.

10.4 Status Word bit support in Eaton AC drives

Table 44: FBFixedStatusWord bit support in different Eaton AC drives

Bit	Function	Eaton SPX/SVX
0	Ready	x
1	Run	x
2	Direction	x
3	Fault	x
4	Alarm	x
5	At reference	x
6	Zero speed	x
7	Flux ready	x
8	Info	
9 - 15	Reserved	

10.5 Monitoring of control and status words in Eaton AC drives

The following table describes from where the control/status words can be read in different AC drives via panel or PC tool.

Table 45: FBFixedStatusWord bit support in different Eaton AC drives

Signal	Eaton SPX/SVX family
FBFixedControlWord	V1.24.3*
FBGeneralControl- Word	-
FBFixedStatusWord	V1.24.16*
FBGeneralStatusWord	V1.24.3*

* Advanced application only

9000XDrive PC tool is used with Eaton SPX/SVX family.

9000XDrive:

- View → Monitoring
- Type: Firmware

Table 46: Signal name in PC tools

Signal	Eaton 9000Xdrive Eaton SPX/SVX
FBFixedControlWord	FBFixedControl- Word
FBGeneralControl- Word	FBGeneralControlWord
FBFixedStatusWord	MCStatus
FBGeneralStatusWord	FBGeneralSta- tusWord

10.6 Eaton speed reference and actual speed - FBSpeedReference and FBActualSpeed

The FBSpeedReference value is signed in the range of -10000...10000d (d8f0...2710h). The given reference is scaled in percentage between the minimum and maximum frequency parameters by application. The value 0 corresponds to minimum frequency and the value 10000d corresponds to maximum frequency. The scale of the value is 0.01%. Negative value indicates direction. If the direction bit in control word is set (means direction should be counterclockwise) and the reference is negative, motor runs clockwise despite the direction bit.

The FBActualSpeed value is signed in the range -10000...10000d (d8f0...2710h). Actual speed is scaled in percentage between the minimum and maximum frequency parameters by application. The value 0 corresponds to minimum frequency and the value 10000d corresponds to maximum frequency. The scale of the value is 0.01%.

Some Eaton applications support speed values over 100%. In these cases, the range is wider than

-10000...10000d (d8f0...2710h). When using control modes that are fieldbus protocol specific, for example PROFIdrive, exceeding the speed value range is not possible.

NOTE! Some Eaton applications do not support negative speed reference. In this case the direction must be controlled with control word's direction bit. Some Eaton applications support negative reference but the actual speed is always positive. In this case the direction status must be read from status word's direction bit.

10.7 Process data

The process data variables are vendor specific variables that can be communicated to and from the AC drive. Eight process data items can be communicated between PLC and the drive. Some drives and firmware versions can support up to sixteen process data items. If the drive does not support 9–16 process data items, then the incoming 9–16 process data items are ignored and outgoing 9–16 process data items are set to zero. For more information, see chapter "11. Appendix C - Fieldbus option board communication" and chapter "12. Appendix D - Parameters for application developers".

Values sent from the drive to the PLC are called ProcessDataOut variables, whereas the values sent from the PLC to the drive are called ProcessDataIn variables. The contents of the ProcessDataOut variables can be parametrized in the AC drive using a feature known as Fieldbus process data mapping. For more information, see the following chapter.

10.8 Fieldbus process data mapping and scaling

This chapter describes how standard applications map process data items by default. For more information, especially when not using a standard application, see the application manual for the AC drive in use.

Table 47: Process data output mapping defaults for Eaton SPX/SVX family (standard applications)

PD out	Mapped application data	ID	Unit	Scale
1	Output frequency	1	Hz	0.01 Hz
2	Motor speed	2	rpm	1 rpm
3	Motor current	45	A	0.1 A
4	Motor torque	4	%	0.1%
5	Motor power	5	%	0.1%
6	Motor voltage	6	V	0.1 V
7	DC link voltage	7	V	1 V
8	Last active fault code	37	-	-

Table 48: FB process data out mapping for Eaton SPX/SVX family

Parameter name	Path	ID
FB DataOut 1 Selection	P2.9.3	852
FB DataOut 2 Selection	P2.9.4	853
...	...	...
FB DataOut 8 Selection	P2.9.10	859
FB DataOut 9 Selection	P2.9.12*	558
FB DataOut 10 Selection	P2.9.13*	559
...	...	...
FB DataOut 16 Selection	P2.9.18*	565

*See firmware requirements for 9–16 process data items in chapter "11. Appendix C - Fieldbus option board communication".

Process data in can also be mapped in Eaton SPX AC drives.

Table 49: FB process data in mapping for Eaton SPX/SVX family

Parameter name	Path	ID
FB DataIn 1 Selection	P2.9.3	852
FB DataIn 2 Selection	P2.9.4	853
...	...	...
FB DataIn 8 Selection	P2.9.10	859
FB DataIn 9 Selection	P2.9.12*	558
FB DataIn 10 Selection	P2.9.13*	559
...	...	...
FB DataIn 16 Selection	P2.9.18*	565

*See firmware requirements for 9–16 process data items in chapter "11. Appendix C - Fieldbus option board communication".

10.8.1 Monitoring of process data in Eaton AC drives

This chapter describes how incoming and outgoing process data can be monitored with the standard applications. For more information, especially when not using a standard application, see the application manual for the AC drive in use.

Table 50: FB Process data monitoring in Eaton SPX/SVX drives

Parameter name	Eaton SPX*		Eaton SVX	
	Path	**ID**	**Path**	**ID**
FB DataIn 1	P1.22.16.1*	221		
...	...	...		
FB DataIn 8	P1.22.16.8	228		
FB DataIn 9	P1.22.16.9**	229		
...	...	...		
FB DataIn 16	P1.22.16.16**	236		
FB DataOut 1	P1.22.16.17	237		
...	...	...		
FB DataOut 8	P1.22.16.24	244		
FB DataOut 9	P1.22.16.25**	245		
...	...	...		
FB DataOut 16	P1.22.16.32**	252		

*Multipurpose application

**See firmware requirements for 9–16 process data items in chapter “11. Appendix C - Fieldbus option board communication”.

11 Appendix C - Fieldbus option board communication

Traditionally all Eaton AC drives and fieldbuses support transferring of Control Word/Status Word, speed information and 8 process data values between PLC master and the AC drive application. Typically in this so-called "Normal communication mode" the process data is updated to/from the AC drive application with 10-ms interval.

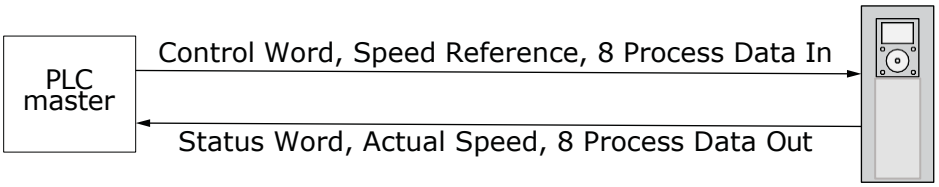


Figure 15: Normal fieldbus communication

With advanced communication modes it is possible to get more process data items, faster update cycle and safety data channel. The functionalities and requirements of the communication modes are described in the following chapters.

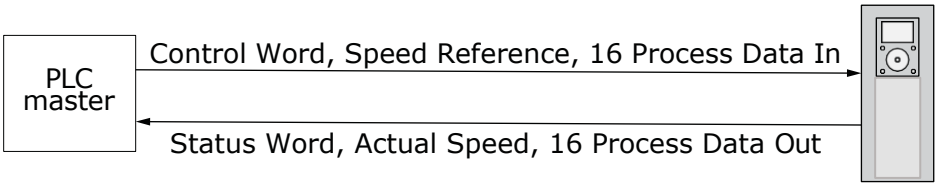


Figure 16: Advanced fieldbus communication Table

Table 51: Communication modes overview

Communication mode	Process Data In	Process Data Out	Update cycle
Normal mode	CW + Speed Reference + 8 Process data	SW + Actual Speed + 8 Process data	~10 ms*
Normal extended mode	CW + Speed Reference + 16 Process data	SW + Actual Speed + 16 Process data	~10 ms*
Fast mode	CW + Speed Reference + 16 Process data	SW + Actual Speed + 16 Process data	1 ms
Fast safety mode	CW + Speed Reference + 16 Process data + Safety data	SW + Actual Speed + 16 Process data + Safety data	1 ms
Fast PROFIBUS mode	CW + Speed Reference + 8 Process data	SW + Speed ref + 8 Process data	1 ms

*Depends on the AC drive application.

Table 52: Communication modes overview

Communication mode	**Eaton SPX**
Normal mode	x
Normal extended mode*	x
Fast mode*	x
Fast safety mode*	x
Fast safety mode*	x
Fast PROFIBUS mode*	x

*For description and requirements, see the following chapters.

11.1 Normal fieldbus communication

The normal fieldbus communication can be used for most commonly used setups.

- Transfers Control/Status Word, speed information and 8 process data values between PLC master and the AC drive application.
- 10 ms update cycle
- Supported in all Eaton AC drives and fieldbuses.
- Can be used simultaneously in option board slots D and E. The AC drive application can select from which slot it receives the process data.
- Normal mode is enabled by default if other communication modes are not possible or available.

The normal fieldbus communication between option board and AC drive application is visible in Figure 17. Maximum data transfer delay for the process data can be calculated by adding all delays together:

$$t = t_{IOdatacycle} + t_{updateinterval} + 2 \cdot t_{communicationdelay} + t_{applicationcycle}$$

Example: With fieldbus cycle time of 4 ms and application cycle of 10 ms, the delay is:

$$t = 4ms + 10ms + (2 \cdot 5)ms + 10ms = 34ms$$

NOTE: This value does not include delays of the fieldbus master, jitter in the process data cycle of the communication protocol or resending due to electronic interference.

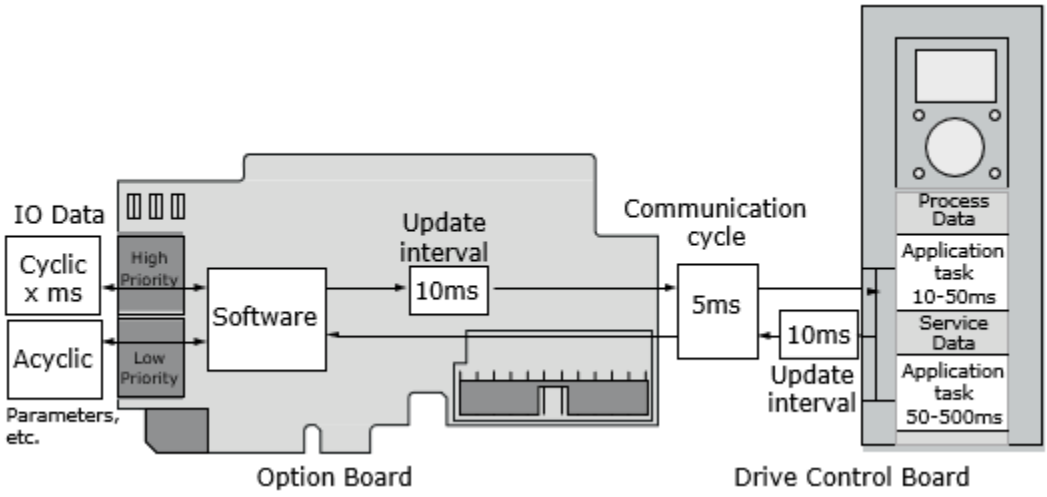


Figure 17: Normal fieldbus communication

11.2 Normal Extended Mode

The normal extended mode like “Normal mode” bit it transfers 16 process data items into both directions.

- Transfers Control/Status Word, speed information and 16 process data values between PLC master and the AC drive application.
- 10 ms update cycle.
- Can be used simultaneously in option board slots D and E. The AC drive application can select from which slot it receives the process data.
- Supported in Eaton SPX. For requirements, see the following tables.

NOTE! Eaton application might enable this mode automatically if the fieldbus supports the normal extended mode.

Table 53: Eaton SPX requirements for Normal Extended Mode

Board	Since firmware version
Eaton SPX	SPXV027
Application	Multipurpose V236
OPTE2/OPTE8 RS485 Modbus RTU	V003
OPTE3/OPTE5 PROFIBUS DP	V006
OPTE6 CANopen	V010
OPTE7 DeviceNet	V006
OPTE9 Dual Port Ethernet	V007
OPTEA Advanced Dual Port Ethernet	V001
OPTEC EtherCAT	V003

11.3 Fast fieldbus communication

The fast mode decreases the communication delay between the PLC and the AC drive application significantly by using two communication channels separately for process and service data.

- Transfers Control/Status Word, speed information and 16 process data values between PLC master and the AC drive application.
- 1 ms update cycle
  - Application can be synchronized to run with the communication cycle.
- Can be used simultaneously in option board slots D and E. The AC drive application can select from which slot it receives the process data.
- Supported in Eaton SPX AC drives. For requirements, see the following table.

Table 54: Eaton SPX requirements for Fast Mode

Board	Since firmware version
Eaton SPX	SPXV027
Application	Multipurpose V236*
OPTE2/OPTE8 RS485 Modbus RTU	V003
OPTE3/OPTE5 PROFIBUS DP	V006
OPTE6 CANopen	V010
OPTE7 DeviceNet	V006
OPTE9 Dual Port Ethernet	V007
OPTEA Advanced Dual Port Ethernet	V001
OPTEC EtherCAT	V003

*In addition to Multipurpose application delivered with SPX firmware as part of the All-in-one application suite, some other applications may include support for use of Fast Mode. See respective application manual.

The fast fieldbus communication between option board and the AC drive application is presented in Figure 18. The maximum communication delay for process data in fast communication mode is (when application task is synchronized with communication):

$$t = t_{IOdata\ cycle} + t_{update\ interval} + t_{application\ cycle}$$

Example: With fieldbus cycle time of 1 ms and application cycle of 1 ms, the delay is:

$$t = 1\ ms + 1\ ms + 1\ ms = 3\ ms$$

NOTE: This value does not include delays of the fieldbus master, jitter in the process data cycle of the communication protocol or resending due to electronic interference.

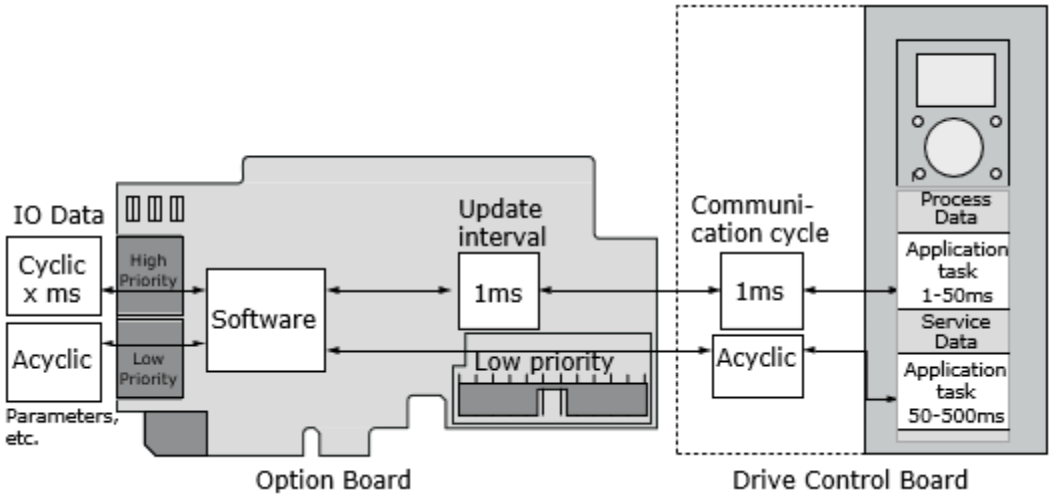


Figure 18: Fast fieldbus communication

11.4 Fast PROFIBUS fieldbus communication

NOTE! This mode is not recommended for new installations.

Fast PROFIBUS mode was originally developed for the OPTC3/C5 PROFIBUS option board. This mode can achieve the same latencies for process data as Fast Mode. However, this mode has significant limitations, and it is not recommended for new installations.

- Transfers Control/Status Word, speed information and 8 process data values between PLC master and the AC drive application.
- 1 ms update cycle.
- No service data is available. Mode transfers only process data.
- Option board panel parameters and monitor values cannot be accessed after the mode is enabled.
- Supported in Eaton SPX AC drives. For requirements, see the following table.

Table 55: Eaton SPX requirements for Fast PROFIBUS Mode

Board	Since firmware version	Other info
Eaton SPX (Control board SN 761)	SPXV027	Only option board slot E
Eaton SPX (Control board SN 561)	SPXV027	Option board slots D and E
Application	System Interface V110 Advanced V085 Marine V107	
OPTC3 PROFIBUS DP (VB00257) OPTC5 PROFIBUS DP (VB00279)	OPTC3_10502V014.vcn	
OPTC3 PROFIBUS DP (70CVB01987) OPTC5 PROFIBUS DP (70CVB01985)	OPTC3-5_FW0232V001.vcx	
OPTEC EtherCAT	V001	

The fast PROFIBUS communication between option board and the AC drive application is visible in Figure 19. The communication delay for process data is the same as in Fast Mode.

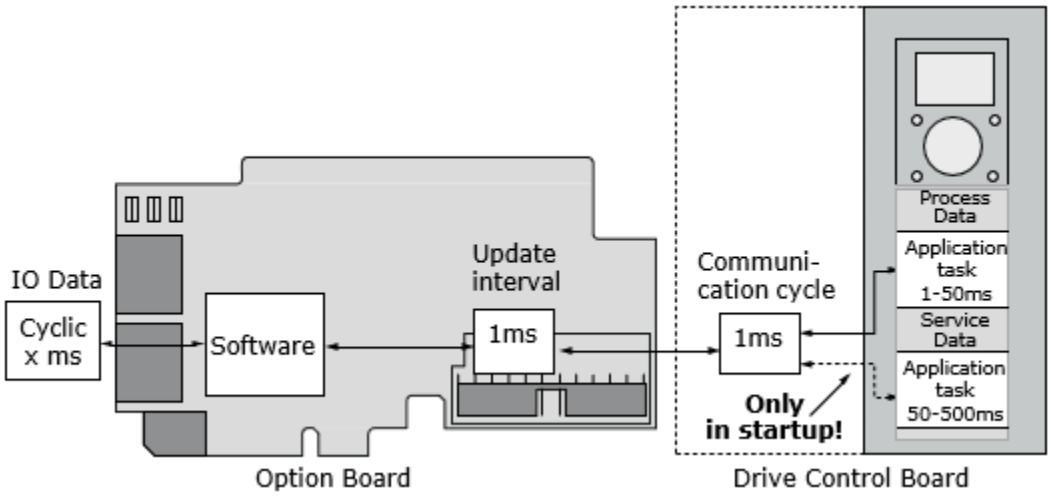


Figure 19: Fast PROFIBUS communication

12 Appendix D - Parameters for application developers

This appendix gives information for the application developers and system integrators on the Eaton SPX system software variables used to activate and control different fieldbus communication modes and features.

For more information on supported modes and required firmware version on given option board and control unit, see Appendix C - Fieldbus option board communication.

NOTE! Changing the mode while the motor is running is not supported because of security reasons.

Table 56: System software variables for selecting communication modes

Parameter	Value	Default info
FBModeSlotD_fwu8	0 = Normal mode 1 = Fast safety mode* 2 = Fast mode 3 = Fast PROFIBUS mode	0
Eaton SPX (Control board SN 561)		0

* Fast safety mode is automatically enabled/disabled by system software. Cannot be set by user.

FBModeSlotX_fwu8 variables are used to select the active fieldbus option board communication mode. If no fieldbus option board is connected to the related slot, the selection of the FBModeSlot parameter is set to 0 = Normal mode.

Table 57: System software variables for monitoring supported communication modes

Parameter	Value	Default info
FBModeSlotDSupModes_fwu16	0x00 = Not yet updated. Read again later. 0x01 = Fieldbus communication not supported 0x02 = Normal mode supported 0x04 = Fast safety mode supported 0x08 = Fast mode supported 0x10 = Fast PROFIBUS mode supported 0x20 = Normal extended mode supported	0
FBModeSlotESupModes_fwu16		0

FBModeSlotXSupModes_fwu16 variables can be used to determine the different supported modes of the fieldbus option boards. All features are set as bit fields as multiple modes can be supported.

Value '0' is returned while the feature set of the option board is not yet retrieved. The value should be asked again. Any option board not supporting fieldbus communication returns value '1'.

Example 1: OPTE9_FW0196V007 Dual Port Ethernet board returns value ‘0x2A’ indicating support for Normal, Fast and Normal extended modes.

Example 2 (PROFIsafe is used): OPTE3-E5_FW0083V006 board returns value ‘0x04’ indicating that only Fast safe mode can be set.

Table 58: System software variables for selecting the input process data slot

Parameter	Value	Default info
FBControlSlotSelector_fwu8	0 = All slots 4 = Slot D only 5 = Slot E only 6 = Fast PROFIBUS D slot 7 = Fast PROFIBUS E slot	0

13 Appendix E - Fault tracing

When the option board or the AC drive control diagnostics detect an unusual operating condition, the drive opens a notification, for example, on the keypad. The keypad shows the ordinal number of the fault, the fault code and a short fault description. You can reset the fault with the Reset button on the control keypad, via the I/O terminal or via the used fieldbus protocol. The faults are stored in the Fault history menu, which can be browsed. The fault table presents only the fault conditions related to the fieldbus in use.

NOTE! When you contact a distributor or a factory because of a fault condition, always write down all texts and codes on the keypad display. Then send the problem description together with the Drive Info File to the local distributor. If possible, also send a fieldbus communication log from the situation if applicable.

Service Info can be read from the drive with PC tool.

- In case of 9000XDrive connect to the drive and select from 9000XDrive menu bar: File → Service Info…

Table 59: Fieldbus communication log tools

Recommended tool	For	Boards
Wireshark	Wireshark	OPTE9 Dual Port Ethernet OPTEA Advanced Dual Port Ethernet OPTEC EtherCAT
ProfiTrace	ProfiTrace	OPTE3/E5 PROFIBUS DP
CANalyzer	CANalyzer	OPTE6 CANopen OPTE7 DeviceNet
RealTerm	RealTerm	OPTE2/E8 RS485

13.1 Diagnostic information

OPTE2/8 RS485 offers the following diagnostic information for problem solving:

- Monitor values. See Chapter 6.1.1 Option board monitor menu.
- Option board LEDs. See Chapter 3.3 LED indications.
- Fieldbus fault diagnostic. See Chapter 13.3 Fieldbus timeout fault (F53) diagnostic info.

13.2 Typical fault conditions

13.2.1 PLC master cannot get response from OPTE2/E8 RS485

Modbus RTU master or N2 master cannot get response from OPTE2/E8 RS485.

1. Check OPTE2/E8 RS485 board's LED status that is described in Chapter 3.3 LED indications.
   - If all three LED's are green, then OPTE2/E8 receives requests from the PLC master with a correct slave address. → Check PLC master status again.
   - If the PS led is flashing yellow and the BS led is flashing red, then OPTE2/E8 RS485 has activated Fieldbus timeout fault (F53). This means that OPTE2/E8 received requests from the PLC master with a correct slave address but that connection to PLC master was lost.
   - In other cases OPTE2/E8 RS485 has not communicated with the PLC master.
2. Check "Communication Status" monitor value that is described in Chapter 6.1.1 Option board monitor menu.
   - If the number of messages without errors increases, then OPTE2/E8 RS485 is successfully receiving frames from the PLC master but probably with a different slave address. → See step 3. Check that the slave address is correct
   - If the number of messages with errors increases, then OPTE2/E8 RS485 is receiving corrupted frames from the bus. → See step 4. Check baud rate and parity settings. → Check cabling and connectivity described in steps 5–11.
   - If "Communication Status" monitor value counters are not increasing, then OPTE2/E8 RS485 is not receiving any data from the bus. → Check cabling and connectivity described in steps 5–11.
3. Check that the slave address is correct.
   - Check that the PLC master sends the frames with the same slave address as configured with Slave Address panel parameter which is described in Chapter 6.1.2 Option board parameter menu.
   - Check that the RS485 bus does not have two slave devices with the same slave address.
4. Check baud rate and parity settings.
   - Check that OPTE2/E8 RS485 uses the same baud rate and parity as used by the PLC master. Baud rate and parity parameters are described in Chapter 6.1.2 Option board parameter menu.
5. Check that the RS485 bus is terminated properly from both ends.
   - RS485 communication might work without termination

with slow baud rates in a short distance. Despite this bus termination is always required.

- If OPTE2/E8 is the last device of a RS485 bus, termination must be set in OPTE2/E8. For instructions, see Chapter 3.4 Jumpers.

6. Check that the RS485 bus is biased properly. Biasing ensures that the bus state is at a proper potential when no device is transmitting.
   - Typically bias voltage is generated from one device in the RS485 bus.
   - Bias voltage can be generated from OPTE2/E8 according instructions in Chapter 3.5 Bus terminal and bias resistors.
7. Check that the RS485 cable is connected correctly to the OPTE2/E8 option board's connector. For pin layout, see Chapter 3. Layout and connections.
8. Check that the RS485 cable is not short-circuited.
9. Check that the supply or motor cable is not located too close to the RS485 cable.
   - The supply or motor cable can cross the RS485 cable in a 90-degree angle. However, it is problematic if the supply or motor cable is placed into the same cable duct with the RS485 cable.
   - If it is possible that the supply or motor cable causes communication problems, the impact of the supply or motor cable can be tested with the following procedure:
     1. Disconnect the main supply from the automation devices.
     2. Power on the control unit of Eaton AC drive with +24 V. For instructions on powering the control unit, see AC drive manual.
     3. Test the communication with the PLC master.
10. Check grounding of the cable shield and the related OPTE2/E8 option board jumper settings.
    - The OPTE2/E8 option board supports different shield grounding options. For for information, see Chapter 4.3 Shield grounding options.
11. Check that the RS485 cable is not too long.
    - If it is possible that RS485 cable it too long, then try to use lower baud rate in communication.

13.2.2 Data corruption in communication

Communication works at some level but the PLC master or OPTE2/E8 option board reports data corruption on bus. The OPTE2/E8 option board's "Communication Status" monitor tells if the option board receives corrupted data from the bus. For information on monitor value, see Chapter 6.1.1 Option board monitor menu.

→ Check steps 5–11 in Chapter 13.2.1 PLC master cannot get response from OPTE2/E8 RS485.

13.2.3 AC drive does not start to run

The PLC master gives a run command to the AC drive via Modbus RTU or N2 but the motor is not started.

1. Check that the AC drive is configured to fieldbus control. See Chapter 9. Appendix A - Fieldbus parametrization.
2. Check that fault is not active in the AC drive. For fault behavior in used AC drive, see AC drive specific manual.
3. Check that the AC drive is in "Ready" state.
   - Eaton SPX/SVX family AC drives show this information in the keypad panel.
4. Check that OPTE2/E8 is in “Operational” state:

"Fieldbus protocol status" monitor value tells the state of the OPTE2/E8 option board. For more information, see Chapter 6.1.1 Option board monitor menu.

- If the status is "Initializing", then OPTE2/E8 is waiting for communication from the PLC master. Follow instructions in Chapter 14.2.1 PLC master cannot get response from OPTE2/ E8 RS485.
- If the status is "Faulted", then communication has been active between the PLC master and OPTE2/E8 but connection to PLC master was lost. Connection should be re-established again, and the possible Field bus timeout fault (F53) should be cleared in the AC drive. For fault behavior, see AC drive specific manual.
- If the status is "Operational", then OPTE2/E8 RS485 is receiving requests from the PLC master with a correct slave address, but probably the format of the commands is incorrect.

5. Check that OPTE2/E8 really receives run command from the PLC master. Control words and status words handled by OPTE2/E8 can be seen from the monitor values. See the following monitor values in Chapter 6.1.1 Option board monitor menu.
   - Protocol/Fieldbus control word
   - Protocol/Fieldbus status word
6. Check that the AC drive application understands the control word given by the PLC master.
   - In most cases Eaton standard applications can be

commanded with a Eaton control word format described in Chapter 10. Appendix B - Eaton IO data description. However, some applications support special command modes. For example, Eaton SPX Advanced application (APFIFF08) supports PROFIdrive mode where the control word must be given in PROFIdrive format. → For control word format, see application manual.

7. Check special requirements of the AC drive application.
   - Some applications have special requirements for motor controlling. For example, Eaton SPX SIAII application (APFIFF40) requires by default that digital inputs DIN4 (Run enable), DIN5 (Switch is closed) and DIN6 (Quick stop active) are connected before running the motor is possible. → For applications specific requirements, see application manual

13.2.4 Drive runs with wrong speed

See Chapter 9. Appendix A - Fieldbus parametrization.

13.2.5 AC drive reports Fieldbus timeout fault (F53)

See Chapter 13.3 Fieldbus timeout fault (F53).

13.2.6 Fieldbus timeout fault (F53) cannot be reset

See Chapter 13.3 Fieldbus timeout fault (F53).

13.3 Fieldbus timeout fault (F53)

Eaton fieldbuses create a fieldbus timeout fault (F53) when a fault occurs in the fieldbus protocol and the AC drive is set to fieldbus control.

NOTE! If the control place is set to e.g. I/O, no fieldbus fault is triggered even if a fault condition is detected. The fault response can also be modified in the AC drive application. For more information, see Chapter 9. Appendix A - Fieldbus parametrization.

NOTE! Some drive applications require that the fieldbus writes non-zero process data before fieldbus fault activation is possible.

13.3.1 OPTE2/E8 RS485 fault conditions

OPTE2/E8 creates a Fieldbus fault F53 in the conditions described in the following table.

NOTE! Connection to the PLC master must be re-established before resetting the F53 Fieldbus fault is possible.

Table 60: OPTE2/E8 RS485 Fieldbus fault trigger conditions

Fault	Description
Too many bad messages (10)	OPTE2/E8 cannot receive a valid request from the PLC master within time defined by the Communication timeout parameter (Chapter 7.1.2 Option board parameter menu). Corrupted data frames are received during the timeout time.
IO watchdog (1)	OPTE2/E8 cannot receive a valid request from the PLC master within time defined by the Communication timeout parameter (Chapter 7.1.2 Option board parameter menu). It is possible that OPTE2/E8 receives requests addressed to some other slave.

14 Index

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