

FDD 3000

SI-VARAN

User Guide

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Original Language

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For the purposes of compliance with the EU Machinery Directive 2006/42/EC, the English version of this manual is the Original Instructions. Manuals in other languages are Translations of the Original Instructions.



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1 Safety Information

1.1 Warnings, Cautions and Notes



A **Warning** contains information, which is essential for avoiding a safety hazard.



A **Caution** contains information, which is necessary for avoiding a risk of damage to the product or other equipment.

NOTE

A **Note** contains information, which helps to ensure correct operation of the product.

1.2 Installation and use

The information given in this publication is derived from tests and calculations on sample products. It is provided to assist in the correct application of the product and is believed to correctly reflect the behaviour of the product when operated in accordance with the instructions. The provision of this data does not form part of any contract or undertaking. Where a statement of conformity is made with a specific standard, the manufacturer takes all reasonable measures to ensure that its products are in conformance. Where specific values are given these are subject to normal engineering variations between samples of the same product. They may also be affected by the operating environment and details of the installation arrangement.

The manufacturer accepts no liability for any consequences resulting from inappropriate, negligent or incorrect installation of the equipment.



WARNING - This warning applies to products intended to be used with variable speed drives.

The adjustable speed drive uses high voltages and currents, carries a high level of stored electrical energy, and is used to control mechanical plant which can cause injury. Close attention is required to the electrical installation and the system design to avoid hazards either in normal operation or in the event of equipment malfunction.

System design, installation, commissioning and maintenance must be carried out by personnel who have the necessary training and experience. They must read this safety information and the instruction manual carefully.

Failure to observe the following instructions can cause physical injury or death, or damage to the equipment.

1.3 Enclosure

The drive is intended to be mounted in an enclosure which prevents access except by trained and authorized personnel, and which prevents the ingress of contamination.

It is designed for use in an environment classified as pollution degree 2 in accordance with IEC 60664-1. This means that only dry, non-conducting contamination is acceptable.

1.4 Competence of the installer

The drive must be installed by professional installers who are familiar with the requirements for safety and EMC. The installer is responsible for ensuring that the end product or system complies with all the relevant laws in the country where it is to be used.

1.5 Repairs

Users must not attempt to repair a drive if it is faulty. It must be returned to the supplier of the drive.

1.6 Electric Shock and Fire Hazards



WARNING - Dangerous voltage

Where products are supplied by or connected to mains voltages, the voltages used can cause severe electrical shock and/or burns, and could be lethal. Extreme care is necessary at all times when working with or adjacent to the equipment. Refer to the relevant documentation.

1.6.1 AC supply

The AC supply must be isolated before any servicing work is performed, other than adjustments to the settings or parameters specified in the manual.

1.6.2 Live terminals

Some types of signal and control lines carry hazardous voltages (120/ 240 V) and can cause severe electric shock and may be lethal.

1.6.3 Isolation device

The AC supply must be removed from the drive using an approved isolation device before any servicing work is performed, other than adjustments to the settings or parameters specified in the manual.

1.6.4 Stored charge

The drive contains capacitors that remain charged to a potentially lethal voltage after the power supply has been disconnected. If the drive has been energized, the power supply must be isolated at least ten minutes before work may continue.

1.7 Electrical installation

1.7.1 Protective Ground (Earth) connection

The ground loop impedance must conform to the requirements of local safety regulations. The drive must be grounded by a connection capable of carrying the prospective fault current until the protective device (fuse or circuit breaker) disconnects the supply. The ground connections must be inspected and tested at appropriate intervals.

1.7.2 Fuses

The supply to the drive must be installed with suitable protection against overload and short-circuits. The tables in the relevant documentation show recommended fuse ratings. Failure to observe these installation instructions could result in fire.

1.7.3 Cables

The cable sizes in the relevant documentation are only a guide. The mounting and grouping of cables affects their current-carrying capacity, in some cases smaller cables may be acceptable but in other cases a larger cable is required to avoid excessive temperature or voltage drop. Refer to local wiring regulations for the correct size of cables. Failure to observe these installation instructions could result in fire.

1.7.4 Terminal connections and torque settings

Loose power connections can be a fire risk. Always ensure that terminals are tightened to the specified torques. Refer to the tables in the relevant documentation.



WARNING - Fire Risk

Braking resistors operate at very high temperatures for short periods. The following precautions are essential to avoid the risk of fire in the event of unexpectedly high braking energy or loss of control of the braking circuit.

- Locate the braking resistor so that inadvertent personal contact with hot surfaces is not possible.
- Do not mount braking resistors on a combustible surface.
- Provide adequate ventilation.
- Mount the braking resistor or reactor in the orientation specified in the data sheet.
- The metal case of the braking resistor must be grounded.
- Use cable with insulation that is capable of withstanding high temperatures.
- Provide independent protection against a loss of control by the braking control system in the drive - refer to the relevant documentation.

1.7.5 High voltage insulation (flash) testing

High voltage insulation (flash) testing should not be carried out on the drive.

1.7.6 ELV terminals

The control terminals are only single insulated from the mains supply, and hence must be prevented from human contact by an additional isolation barrier, for example a terminal cover.

1.7.7 SELV terminals

Drive terminals that are SELV can be safely connected to other SELV equipment.

ELV terminals require an additional insulation barrier between them and other SELV equipment if it is unacceptable to compromise the SELV classification of the SELV equipment.

1.7.8 Products connected by plug and socket

An electric shock hazard exists if the drive is supplied via a plug and socket. When unplugged, the pins of the plug may carry a potentially lethal voltage until the internal capacitors have discharged. This can take up to 10 minutes.

It is recommended that a shrouded plug is used that complies with IEC 60309. If the use of a shrouded plug is not possible, then to avoid any possibility of electric shock from the pins, a means must be provided for automatically isolating the plug from the drive (for example a latching relay).

1.8 Setting up, commissioning and maintenance



It is essential that changes to the drive settings are given careful consideration. Depending on the application, a change could have an impact on safety. Appropriate precautions must be taken against inadvertent changes or tampering. Some specific settings which require particular care are listed below. This is not an exclusive list. Other settings may have an impact on safety in specific applications.

1.8.1 Lifting and handling

Many of the drives weigh in excess of 15 kg (33 lb). Use appropriate safeguards when lifting these models. A full list of drive weights can be found in the installation instructions.

1.8.2 Output circuit and motor protection

The Motor Rated Current parameter must be set correctly to avoid a risk of overheating and fire in the event of motor overload. In some applications motor temperature protection may also be required.

1.8.3 STOP, Enable and Safe Torque Off functions (where applicable)

These functions do not remove dangerous voltages from the equipment or any external option unit, nor do they isolate the motor from dangerous voltages.

Automatic start

Some parameter settings may cause the motor to start unexpectedly.

Restore default parameter set

Depending on the application, this may cause unpredictable or hazardous operation.

1.9 Safety of machinery, safety-critical applications

Within the European Union all machinery in which this product is used must comply with Machinery Directive 2006/42/EC.

The design of safety-related control systems must only be done by personnel with the required training and experience. The Safe Torque Off function will only ensure the safety of a machine if it is correctly incorporated into a complete safety system. The system must be subject to a risk assessment to confirm that the residual risk of an unsafe event is at an acceptable level for the application.

1.10 Electromagnetic compatibility (EMC)

The product is designed to comply with international standards in a typical installation. Installation instructions are provided in the *Power Installation Guide* and EMC data sheet. If the installation is poorly designed or other equipment does not comply with international standards for EMC, the product might cause or suffer from disturbance due to electromagnetic interaction with other equipment. It is the responsibility of the installer to ensure that the equipment or system into which the product is incorporated complies with the relevant EMC legislation in the country of use.

Within the European Union, equipment into which this product is incorporated must comply with the Electromagnetic Compatibility Directive 2014/30/EU.

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2 Introduction

2.1 Products covered by this User Guide

This User Guide covers the SI-VARAN option module.

The SI-VARAN is an option module that provides VARAN connectivity and can be installed on the following drives:

- FDD 3000

2.2 Firmware Statement

This product is supplied with the latest firmware version. When retro-fitting to an existing system, all firmware versions should be verified to confirm the same functionality as products of the same type already present. This also applies to products returned from a SIGMATEK Service Centre or Repair Centre. If there is any doubt, please contact the supplier of the product.

The firmware version of the product can be identified by looking at Pr **MM.002** where MM is the relevant menu number for the module slot being used.

2.3 About SI-VARAN

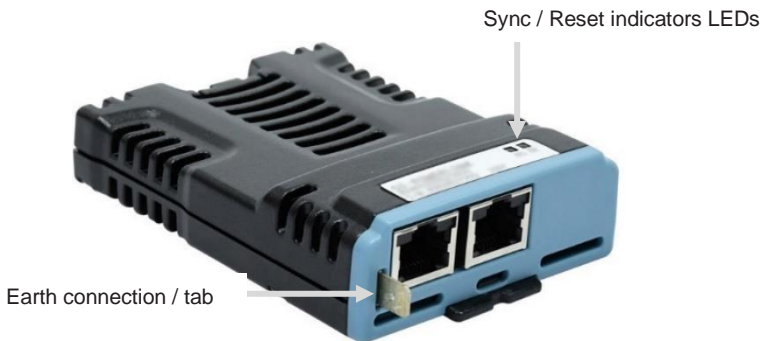
SI-VARAN is an option module that enables the Sigmatek FDD 3000 drives to be connected to a VARAN network as a Controlled Node (Client). It can be used in a variety of applications, to those where ease of use and open loop control are appropriate.

2.4 Features

- Standard RJ45 with support for shielded twisted pair, half-duplex 100 Mbs connectivity
- Dual VARAN interfaces for use in line topologies
- Supports the FDD 3000
- Support of CANopen CiA402
- SDO access to all profile objects and drive parameters
- vl velocity mode

2.5 Option module identification

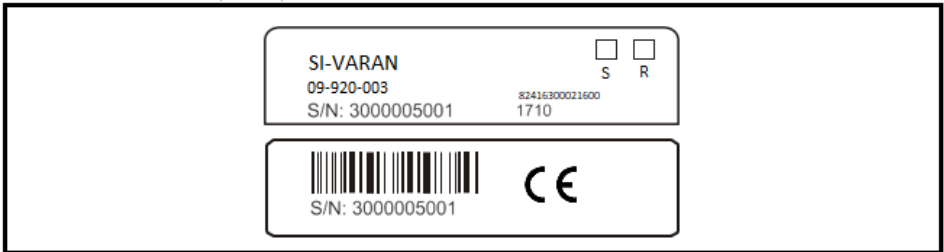
Figure 2-1 SI-VARAN



The SI-VARAN module can be identified by:

- The label located on the underside of the option module.

Figure 2-2 SI-VARAN labels



2.5.1 Date code format

The date code is four numbers. The first two numbers indicate the year and the remaining numbers indicate the week of the year in which the drive was built.

Example:

A date code of **1710** would correspond to week 10 of year 2017.

2.6 Conventions used in this guide

The configuration of the host drive and option module is done using menus and parameters. A menu is a logical collection of parameters that have similar functionality.

In the case of an option module, the option module set-up parameters in menu 0 will appear in drive menu 15, 16 or 17 depending on which slot the module is installed in.

The setting of the Option Slot Identifiers (Pr 11.056) may change the slot numbering from those described above.

NOTE For FDD 3000 drives, the option module set-up parameters will appear in menu 15.

The method used to determine the menu or parameter is as follows:

- Pr **S.mm.ppp** - Where **S** signifies the option module slot number and **mm.ppp** signifies the menu and parameter number respectively.
If the option module slot number is not specified then the parameter reference will be a drive parameter.
- Pr **MM.ppp** - Where **MM** signifies the menu allocated to the option module setup menu and **ppp** signifies the parameter number within the set-up menu.
- Pr **mm.000** - Signifies parameter number 000 in any drive menu.

3 Mechanical Installation

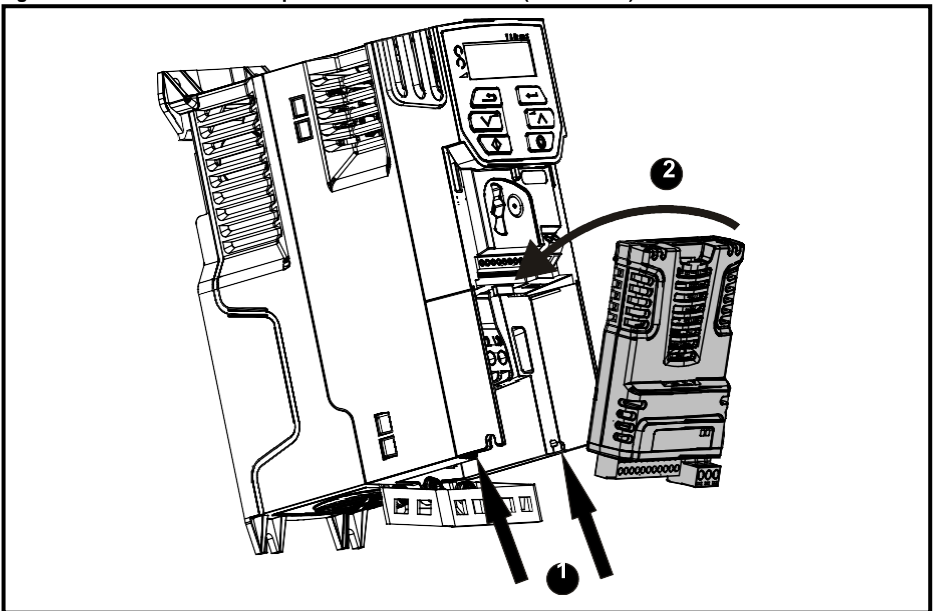


Before installing or removing an option module in any drive, ensure the AC supply has been disconnected for at least 10 minutes and refer to Chapter 1 *Safety information* on page 6. If using a DC bus supply ensure this is fully discharged before working on any drive or option module.

3.1 General installation

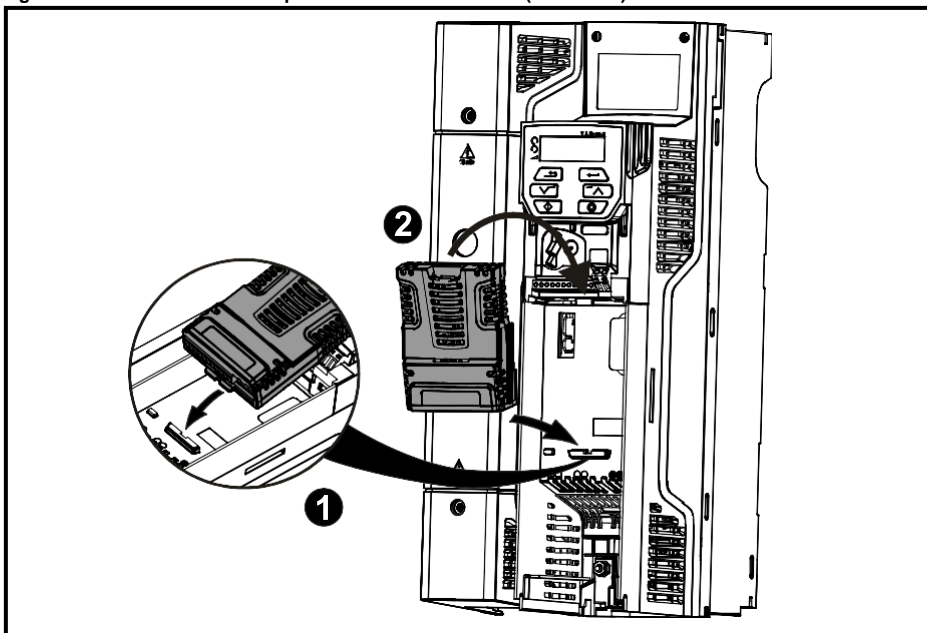
The installation of an option module is illustrated in Figure 3-1.

Figure 3-1 Installation of an SI option module on FDD 3000 (sizes 2 to 4)



- With the option module tilted slightly backwards, align and locate the two holes in the rear of the option module onto the two tabs (1) on the drive.
- Place the option module onto the drive as shown in (2) until the module clicks into place. The terminal cover on the drive holds the option module in place, so this must be put back on.

Figure 3-1 Installation of an SI option module on FDD 3000 (size 5 to 9)



- Place the option module onto the drive as shown in (2) until the module clicks into place. The terminal cover on the drive holds the option module in place, so this must be put back on.

4 Electrical Installation

4.1 SI-VARAN module information

4.1.1 Bus media

The SI-VARAN option module incorporates two 100 BASE-TX RJ45 interfaces.

4.1.2 Cabling considerations

To ensure long-term reliability it is recommended that any cables used to connect a system together be tested using a suitable Ethernet cable tester, this is of particular importance when cables are constructed on site.

4.1.3 Cabling and connections

Cables should be shielded and as a minimum, meet TIA Cat 5e requirements. Please refer to IEC 61918 and IEC 61784-5-13.

SI-VARAN supports Auto-MDIX (automatic medium-dependent interface crossover).

4.1.4 Maximum network length

The maximum cable length (100 meters) predefined by Ethernet 100 Base-TX shall apply. This means that the maximum cable length which can be used between one SI-VARAN port and another VARAN port is 100 m.

4.2 SI-VARAN terminal descriptions

The SI-VARAN module has two RJ45 Ethernet ports for the VARAN network.

Figure 4-3 SI-VARAN connections

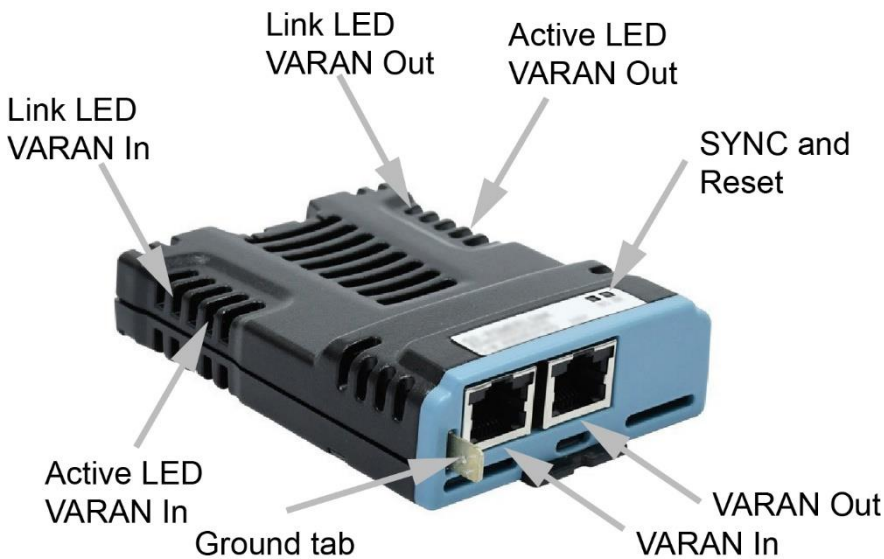


Table 4-1 SI-VARAN terminal descriptions

Pin	VARAN IN	Pin	VARAN OUT
1	Tx+/Rx+	1	Tx+/Rx+
2	Tx-/Rx-	2	Tx-/Rx-
3	Rx+/Tx+	3	Rx+/Tx+
4	-	4	-
5	-	5	-
6	Rx-/Tx-	6	Rx-/Tx-
7	-	7	-
8	-	8	-

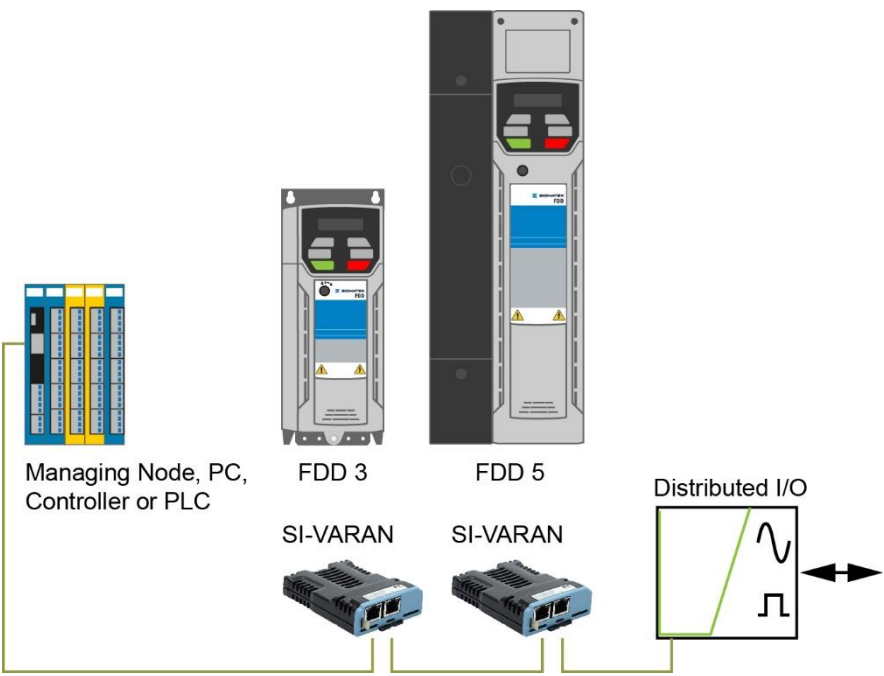
4.3 Module grounding and EMC

SI-VARAN is supplied with a grounding tab on the module that should be connected to the closest possible grounding point using the minimum length of cable. This will greatly improve the noise immunity of the module.

4.4 Network topology

Example for implementing a daisy chaining VARAN topology (see Figure 4-4).

Figure 4-4 SI-VARAN daisy chain network topology



4.5 Indicator LEDs

Figure 4-3 shows the locations of the LEDs

Sync	green	ON	The module is synchronized with the VARAN manager.
Reset	red	ON	The module is in Reset.
VARAN In Link	green	ON	The connection between the two PHYs is established.
		BLINKS	The VARAN in of the primary client does not have a link.
VARAN In Active	yellow	ON	Data is exchanged over the VARAN bus.
VARAN Out Link	green	ON	The connection between the two PHYs is established.
		BLINKS	There is no connection between VARAN In and the primary client.
VARAN Out Active	yellow	ON	Data is exchanged over the VARAN bus.

5 Supported Objects

5.1 Supported objects

Table 6-1 lists the objects currently supported by SI-VARAN

Table 6-1 SI-VARAN Object Dictionary

Object ref. (0x)	Description	Data Type		Access	VL Velocity
		Sub-index	Type		
1000	Device type	0	UDINT	RO	Y
1001	Error register	0	USINT	RO	Y
1006	Communication cycle period	0	UDINT	RW	Y
1018	Identity object (Number of last sub-index)	0	USINT	RO	Y
	Identity object (Vendor ID)	1	UDINT	RO	Y
	Identity object (Product Code)	2	UDINT	RO	Y
	Identity object (Software Version)	3	UDINT	RO	Y
	Identity object (Serial number: lower part)	4	UDINT	RO	Y
	Identity object (Serial number: higher part)	5	UDINT	RO	Y
1600	Receive PDO mapping 1 (Number of objects)	0	USINT	RW	Y
	Receive PDO mapping 1 (Mapped object 1 to si0)	1 to si0	UDINT	RW	Y
1A00	Transmit PDO mapping 1 (Number of objects)	0	USINT	RW	Y
	Transmit PDO mapping 1 (Mapped object 1 to si0)	1 to si0	UDINT	RW	Y
2smm	Drive parameter access (s = slot 0x0 to 0xF, mm=menu 0x00 to 0xFF)	pp (pp=par 0x00 to 0xFF)	[var]	[var]	Y
3001	PDO loss error counter (Number of last sub-index)	0	USINT	RO	Y
	PDO loss error counter (Error reaction)	1	USINT	RW	Y
	PDO loss error counter (Cumulative counter)	2	UDINT	RW	Y
	PDO loss error counter (Threshold counter)	3	UDINT	RO	Y
	PDO loss error counter (Threshold level)	4	UDINT	RW	Y
3002	Network timing monitor (Number of last sub-index)	0	USINT	RO	Y
	Network timing monitor (Error reaction)	1	USINT	RW	Y
	Network timing monitor (Cumulative counter)	2	UDINT	RW	Y
	Network timing monitor (Threshold counter)	3	UDINT	RO	Y
	Network timing monitor (Threshold level)	4	UDINT	RW	Y
	Network timing monitor (Max sync error %)	5	USINT	RW	Y
6007	Abort connection option code	0	INT	RW	Y

Object ref. (0x)	Description	Data Type		Access	VL Velocity
		Sub-index	Type		
603F	Error code	0	UINT	RO	Y
6040	Control word	0	UINT	RW	Y
6041	Status word	0	UINT	RO	Y
6042	vl_target_velocity	0	INT	RW	Y
6043	vl_velocity_demand	0	INT	RO	Y
6044	vl_velocity_actual_value	0	INT	RO	Y
6046	vl_velocity_min_max_amount (Number of last sub-index)	0	USINT	RO	Y
	vl_velocity_min_max_amount (Minimum velocity (rpm))	1	UDINT	RW	Y
	vl_velocity_min_max_amount (Maximum velocity (rpm))	2	UDINT	RW	Y
6048	vl_velocity_acceleration (Number of last sub-index)	0	USINT	RO	Y
	vl_velocity_acceleration (Delta speed value (rpm))	1	UDINT	RW	Y
	vl_velocity_acceleration (Delta time value (s))	2	UINT	RW	Y
6049	vl_velocity_deceleration (Number of last sub-index)	0	USINT	RO	Y
	vl_velocity_deceleration (Delta speed value (rpm))	1	UDINT	RW	Y
	vl_velocity_deceleration (Delta time value (s))	2	UINT	RW	Y
604A	vl_velocity_quick_stop (Number of last sub-index)	0	USINT	RO	Y
	vl_velocity_quick_stop (Delta speed value (rpm))	1	UDINT	RW	Y
	vl_velocity_quick_stop (Delta time value (s))	2	UINT	RW	Y
604B	vl_setpoint_factor (Number of last sub-index)	0	USINT	RO	Y
	vl_setpoint_factor (Numera- tor)	1	INT	RW	Y
	vl_setpoint_factor (Denomi- nator)	2	INT	RW	Y
604C	vl_dimension_factor (Num- ber of last sub-index)	0	USINT	RO	Y
	vl_dimension_factor (Numer- ator)	1	INT	RW	Y
	vl_dimension_factor (De- nominator)	2	INT	RW	Y
605A	Quick stop option code	0	INT	RW	Y
605B	Shutdown option code	0	INT	RW	Y
605C	Disable operation option code	0	INT	RW	Y
605D	Halt option code	0	INT	RW	Y
605E	Fault reaction option code	0	INT	RW	Y
6060	Modes of operation	0	SINT	RW	Y
6061	Modes of operation display	0	SINT	RO	Y
6073	Max current	0	UINT	RW	Y
6075	Motor rated current	0	UDINT	RW	Y
6077	Torque actual value	0	INT	RO	Y
6078	Current actual value	0	INT	RO	Y
6080	Max motor speed	0	UDINT	RW	Y
6502	Supported drive modes	0	UDINT	RO	Y
67FE	Profile version	0	UDINT	RO	Y

6 NMT State machine

The NMT state machine allows the PLC to monitor and control the state of the option module networking handling. The state transitions are directly managed by the Hardware-Class; some transitions, related to the option module initialization or reset, are however self-triggered by the option module (see Figure 3 1).

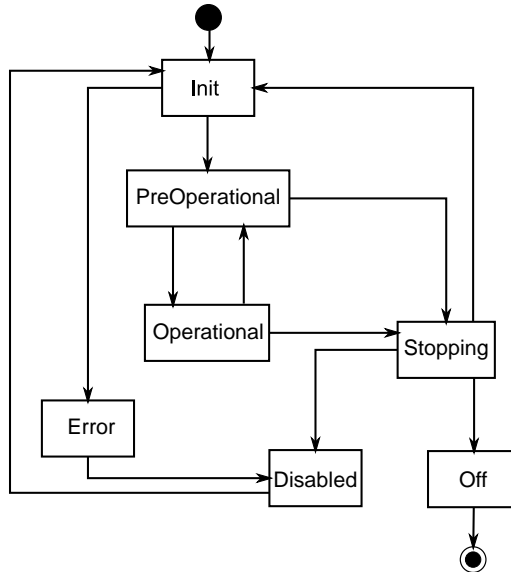


Figure 6-1 NMT State machine

Value	NMT State
0x00	Init
0x01	PreOperational
0x02	Operational
0x80	Stopping
0x81	Disabled
0xFE	Error
0xFF	Off

Table 6-1 NMT state coding

6.1 INIT state

The Init state is automatically activated after a cold or warm reset, or at the end of the FPGA update. All objects (excluding the 0x2000-0x21FF range) are reset to their default values; the FPGA is also reconfigured, causing a network link loss for a short period.

The option module autonomously switches to the PREOP state if all initialization steps succeed, else the STOPPED state is activated.

6.2 PreOperational state (PREOP)

The PLC can read and write all supported objects (5) via SDO (7.2). The PDO mappings configuration shall be defined in this state, but the PDO cyclic handling is disabled.

The mappings configuration is fully validated during the transition to the OP state: the transition is blocked if the configuration is invalid.

6.3 Operational state (OP)

When the Operational state activates, the PDO handling is enabled: the option module moves the cyclic data between the input and output process images, and the PDO mapped objects (see 8.1.4, 8.1.5). The PDO configuration cannot be changed: an explicit request from the PLC to switch to the PREOP state, is required to allow the change of the mapping configuration.

6.4 STOPPING state

The option module autonomously switches from the PREOP or OP to the STOPPING state in the following cases:

- The application reset is requested (e.g.: by Pr.S.00.007)
- The FPGA update, using a PC tool, is requested
- The PLC requests the switch to the INIT state (e.g.: because it restarted or it remotely updated the option module FPGA)

The PDO handling is disabled in the STOPPING state but the objects can be still accessed via SDO.

If the CiA402 drive control is not disabled by Pr.S.00.033, the CiA402 fault reaction is triggered, allowing a graceful motor stop depending on the value of the object 0x605E (9.2.8). After the fault reaction completes or if the fault reaction is not required, the state switches to the INIT, DISABLED or OFF states depending on the cause that triggered the activation of the STOPPING state as shown in Figure 3 1.

Please note that if Pr.S.00.033 is set to "On", the option module doesn't command the motor to stop: the user is in this case responsible to ensure the drive is in the correct state before the reset is requested, to avoid the motor keeps running without the PLC can control it.

6.5 DISABLED state

The DISABLED state activates after the STOPPING state if the stop was caused by the request to start the FPGA update using the drive serial communication. The network link is interrupted and all application VARAN functionalities are disabled.

When the update completes, the state automatically switches to INIT; if the update was successfully, the network link is reestablished and the state automatically switches to PREOP, else the ERROR state is activated.

6.6 NMT OFF state

The OFF state activates after the STOPPING state if the stop was caused by the reset request using Pr.S.00.007 or a request over the drive serial port. All VARAN functionalities are stopped but they will restart when the application restarts, provided that the FPGA configuration succeeds.

During the reset the FPGA is disabled so the option module is not be reachable from the network.

6.7 NMT ERROR state

The ERROR state activates if the FPGA configuration fails. The interaction with the drive is possible but no VARAN functionalities are available; it's possible to attempt to recover from the error transferring a valid FPGA valid update file over the drive serial port.

7 PDO, SDO

7.1 Process Data Objects (PDOs)

Cyclic data is implemented on VARAN networks by using "Process Data Objects" or PDOs. Separate data objects are used for transmitting (TPDO) and receiving (RPDO) data. PDO configuration objects are usually pre-configured in the VARAN PLC Managing Node controller and downloaded to the SI-VARAN at network Initialization using SDOs (the user does not manually configure these SDOs, they are created and downloaded by the Hardware-Class).

Max bytes per PDO	24
Max mappings per PDO	6
Max bytes per mapping	4
Overall maximum PDO bandwidth (bytes per second)	800
Minimum cycle time	20 ms

Table 7-1 Cyclic data exchange constraints

7.1.1 PDO mapping configuration

The RPDO and TPDO mapping configurations are defined by the objects 0x1600 and 0x1A00 respectively.

The configuration can be changed by SDO requests only if the active NMT state is PREOP: the configuration objects can be always read but if a write request is issued in the OP state, the option module returns the abort code 0x06010000 (Unsupported access to an object).

The RPDO and TPDO configurations are validated during the PREOP to OP transition: if the configuration is valid the transition is confirmed and the handling of the cyclic data exchange is started, else the option module remains in the PREOP state. The configurations are also independently validated when the RPDO or the TPDO are enabled in the PREOP state: in this case the cyclic data exchange doesn't start in any case, but a SDO abort code is returned if the validation fails, indicating the first reason of the failure (Table 7-2).

Most of the supported objects can be mapped in PDOs, please refer to the sections 8 and 9 for detailed information about the allowed mapping modes for specific objects.

All drive and option module parameters can be cyclically transferred mapping the objects in the 0x2000-0x2FFF range, using the following correspondence between the object and the parameters:

- Index: $0x2000 + (0x100 \times \text{Slot}) + \text{menu}$
- Sub-index: parameter number

For example, **Pr 20.021** would be index 0x2014 and the sub-index would be 0x15. The values are usually expressed in base 16 (hexadecimal), so care must be taken to enter the correct parameter number.

NOTE Sub-index 0 for any menu is reserved for the highest parameter number and it cannot be mapped.

NOTE The mapping in the RPDO is allowed only for user writable parameters

Error	SDO Abort codes
The number and length of the objects to be mapped would exceed maximum PDO length (24 bytes)	0x06040042
Number of mappings, or mapping entry changed while the NMT state is not PreOperational	0x06010000
Mapping entry changed while the PDO is enabled.	
The mapped object doesn't exist	0x06020000
Object cannot be mapped to the PDO	0x06040041
The mapping data length is larger than the object size	0x08000000

Table 7-2 Mapping error codes

Please refer to the description of the RPDO and TPDO configuration objects (8.1.4 and 8.1.5), for more detailed information about the object structure and usage.

7.1.2 PDO data handling

The option module cyclically exchanges the data between the network process images and the configured mappings when the OP state is active.

The start of the network cycle triggers the data exchange; the RPDO is handled first.

Because of the limited bandwidth of the option module interface on Commander drives, to ensure enough processing resources remain to execute the lower priority tasks, the PDO handling is suspended for 10ms after the TPDO process image is updated. The cyclic data exchange task is triggered again on the first network cycle start after the 10ms delay.

The PDO bandwidth will so depend on the number and size of the mappings and it will be lower if the drive parameters are mapped. Because the parameter size has not a significant impact on the time required for the access, the worst case is represented by mapping 6 parameters per direction.

7.1.3 RPDO data loss monitor

When the OP state is active, the option module verifies if the receive buffer contains new data from the PLC on the network cycle start.

If the NMT state is OP, the option module checks if new data are received; two counters keep track of missing data:

- a cumulative error counter is incremented by one every time an error is detected, and it has only diagnostic purposes: it doesn't control the error reaction. The cumulative counter can be cleared by the user.
- a threshold counter is incremented by 8 every time an error is detected, and it's decremented by one if new data are detected, unless it's already equal to zero. If the value of the threshold counter is greater than a configurable threshold value, the option module can be setup to trigger a fault reaction. The threshold counter is not clearable by the user, but it's automatically reset during the OP to PREOP transition.

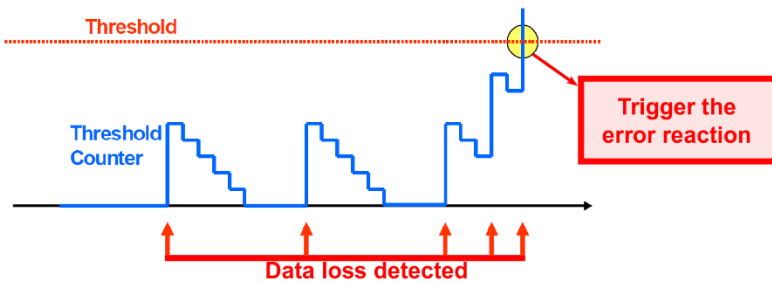


Figure 7-1 RPDO data loss threshold counter

The cumulative and threshold counters, the threshold value and the fault reaction configuration are accessible by the manufacture specific object 0x3001: please refer to 8.2.2 for more detailed information. The cumulative error can be also monitored and cleared using the parameters Pr.S.09.001 and Pr.S.09.009.

7.1.4 PDO general diagnostics

The state of the mapping configuration can be monitored using Pr.S.01.003 and Pr.S.01.004

The number of the handled PDO (in both directions) per second is reported by Pr.S.01.002.

7.2 Service Data Object (SDO)

The service data object (SDO) provides a lower priority asynchronous access to all supported objects, including the drive and option module parameters using the object index range from 0x2000 to 0x2FFF (see 8.2.1).

NOTE

Sub-index 0 for any menu is always read only and it will return the highest parameter number).

8 Object Descriptions

The object dictionary is a collection of logic entities (the objects) that can be used by the PLC to configure, control, and monitor the option module and the drive over the network, using the SDO or PDO functionalities.

The objects are identified by a 16 bit index and 8 bits subindex.

Three object types are defined:

- Simple (VAR): it contains a single value and only the subindex 0 is defined
- Complex:
 - Array: it contains multiple values of the same type. The sub index 0 defines the number of items in the array; the number may be fixed or variable by the user. The sub index numbers greater than zero are used to access the array items
 - Record: it contains multiple values also of different data types. The sub index 0 cannot be altered and it represents the latest accessible subindex. Some sub-indexes may be not defined.

Additional attributes are also assigned to each object:

- Access: it defines if the object is writable by the PLC
 - RO. Read only: it cannot be written from the network
 - RW: the object can be read and write by the PLC
 - Const: As RO but the value is statically defined, and it will be always the same
- PDO: it indicates if the object can be mapped in the RPDO, TPDO or both, to be cyclically transferred
- Allowed data range: an error is returned if a value outside the allowed range is written using the SDO functionality.
- Data type: it indicates the data storage size in bytes and, for numeric types, if the data is signed.

The dictionary is divided in three blocks (Table 8-1); please refer to the following subsections for more details.

Index range	Description
0x1000 – 0x1FFF	Communication parameter objects (8.1)
0x2000 – 0x3FFF	Manufacturer specific objects (8.2)
0x6000 – 0x9FFF	CiA 402 specific objects (9.2, 9.3)

Table 8-1 Object dictionary structure

The object description format describes object related information such as size, range and descriptions and is detailed in the tables below.

Table 8-2 Object description format

<index>		<object name>	
Sub-index 0			
Access: <access>		Range: <range>	Size: <size> Unit: <unit>
Default: <default>		Type: <type>	
Description: <description>			

For entries having sub-indices

Table 8-3 Object description format with sub-indices

<index>	<object name>			
Sub-index 0				
Access: <access>	Range: <range>	Size: <size>	Unit: <unit>	
Default: <default>			Type: <type>	
Description: <description>				
Sub-index 1				
Access: <access>	Range: <range>	Size: <size>	Unit: <unit>	
Default: <default>			Type: <type>	
Description: <description>				
Sub-index ...				

<index>	<object name>		
Sub-index 0			
Access: <access>	Range: <range>	Size: <size>	Unit: <unit>
Default: <default>	Type: <type>		
Description: <description>			
Sub-index n-1			
Access: <access>	Range: <range>	Size: <size>	Unit: <unit>
Default: <default>	Type: <type>		
Description: <description>			
Sub-index n			
Access: <access>	Range: <range>	Size: <size>	Unit: <unit>
Default: <default>	Type: <type>		
Description: <description>			

Definitions:

- <index>: A signed 16-bit number. This is the index of the object dictionary entry specified in four hexadecimal characters.
- <access>: A value describing how the object may be accessed (RW = read/write, RO = read-only and WO = write-only).
- <size>: The size of the object/sub-index in bytes.
- <unit>: The physical unit (e.g. ms, counts per second etc.).
- <type>: Data type:-

Data type	Size (bytes)	Range	Description
USINT	1	0 to 255	Unsigned short integer
SINT	1	-128 to 127	Signed short integer
UINT	2	0 to 65535	Unsigned integer
INT	2	-32768 to 32767	Signed integer
UDINT	4	0 to 2 ³²	Unsigned double integer
DINT	4	-2 ³¹ to 2 ³¹ -1	Signed double integer

8.1 Communication parameter objects

The communication parameter objects have the index between 0x1000 and 0x1FFF: they are an adapted subset of the same range defined by the CiA301 specifications.

The purpose of the communication parameter objects is to provide an interface closer as possible to existing standards, to identify the option module (and the drive where it is fitted) and to configure or monitor, the fieldbus protocol specific functionalities.

8.1.1 0x1000 Device Type

0x1000	DeviceType		Object type: VAR
Sub-index 0		Range: 0...2 ³² -1	
Access: RO	PDO Map: No	Data type: UDINT	Unit: N/A
		Handling rate: N/A	Default: Drive type/mode de-pendant
Description:	Defines the device type, the device's functionality, and the mapping variant		

The lowest significant 16 bits of the object 0x1000 describe the device profile that is used (CiA 402); the most significant bits give instead additional information about optional functionality of the device as it is specified by Table 8-4, according to the IEC 61800-7-201 specifications.

Additional information		Device profile number (hex) Bits 15-0
Mode (hex) Bits 31-24	Type (hex) Bits 23-16	
00 (unused)	01 (frequency converter)	0192 (CiA 402)

Table 8-4 Device type values

If the drive is in the boot state, the drive mode is not available: in this case the object is set equal to zero, the CiA402 functionalities are not available and the relative objects have no effect.

8.1.2 0x1006 Communication cycle period

0x1001	ErrorRegister		Object type: VAR
Sub-index 0	Range: 0... 32000		
Access: RO	PDO Map: No	Data type: UDINT	Unit: µs
		Handling rate: PREOP to OP	Default: 0
Description:	Expected network cycle period		

If an action is required on violations of the network timings (8.2.3), the object 0x1006 shall be set with the network cycle time configured in the VARAN manager, prior to the PREOP to OP transition; the timing monitor service will be disabled if the cycle period is set to zero (default setting), regardless to the object 0x3002 settings.

The object 0x1006 can be written anytime in both the PREOP and OP NMT states but the new value will have effect only after the next PREOP to OP transition.

8.1.3 0x1018 Identity Object

0x1018	IdentityObject		Object type: RECORD
Sub-index 0	Name: NumberOfEntries		
Access: Const	PDO Map: No	Range: 1 to 4	Unit: N/A
		Data type: USINT	Default: 5
Description:	Highest sub-index supported		
Sub-index 1	Name: VendorId_U32		
Access: Const	PDO Map: No	Range: 0...2 ³² -1	Unit: N/A
		Data type: UDINT	Default: 0xF9
Description:	Vendor ID code		
Sub-index 2	Name: ProductCode		
Access: Const	PDO Map: No	Range: 0...2 ³² -1	Unit: N/A
		Data type: UDINT	Default: Drive type/mode dependant (see notes)
Description:	Product code		
Sub-index 3	Name: RevisionNo		
Access: RO	PDO Map: No	Range: 0...2 ³² -1	Unit: N/A
		Data type: UDINT	Default: XX.YY.ZZ.BB
Description:	Application software version		
Sub-index 4	Name: SerialNum_LSW		
Access: RO	PDO Map: No	Range: 0...2 ³² -1	Unit: N/A
		Data type: UDINT	Default: N/A
Description:	Least significant 4 bytes of the serial number		
Sub-index 5	Name: SerialNum_MSW		

Access: RO	PDO Map: No	Range: 0...2 ³² -1	Unit: N/A
		Data type: UDINT	Default: N/A
Description:	Most significant 4 bytes of the serial number		

The product code reported in the sub index 2 identifies the type and the mode of the drive where the option module is fitted. It follows the common format for CANopen like devices adopted by SIGMATEK and represented in Table 8-5.

Byte 3 (MSB)	Byte 2	Byte 1	Byte 0 (LSB)
Generation (always 0x01)	Drive mode	Drive derivative	Drive type

Table 8-5 Product code format

8.1.4 0x1600 RPDO Mapping Parameters

0x1600	RPDOMappingParam		Object type: AR-RAY
			Data type: UDINT
Sub-index 0	Name: Number of mappings		
Access: RW	PDO Map: No	Range: 0...6	Unit: N/A
		Data type: USINT	Default: 0
Description:	The number of the configured mappings		
Sub-index 1...6	Name: ObjectMapping		
Access: RW	PDO Map: No	Range: 0 to 2 ³² -1	Unit: N/A
		Data type: UDINT	Default: 0
Description:	Mapping configuration (see Table 8-6)		

This object shall be used to configure the RPDO mappings (isochronous data from the PLC). The change of the RPDO mappings configuration is allowed only if the NMT state is PREOP, else the SDO write fails with the abort code 0x08000000 (General Error).

The subindex 0 is used to enable the RPDO indicating how many mappings are configured; the RPDO is disabled if it is set to zero. Please note that the enabled condition indicates only that the RPDO configuration is ready, but the data exchange is active only if the OP state is active.

When the subindex 0 is set to enable the RPDO, the configuration is validated: the write fails returning an error as defined by Table 8-7 in case of failure.

The sub-indexes from 1 up to 6 shall be set to describe the mappings following the order in the process image, using the encoding described in Table 8-6. The subindexes 1 to 6 cannot be written if the RPDO is enabled, else an error is returned.

Byte		Name	Description
0	LSB	Length	Length of the mapped object (Bit count, it shall be multiple of 8 except if the data type is BOOLEAN, in this case the length shall be set to 1)
1		Subindex	Sub-index of the object to be mapped
2-3	MSB	Index	Index of the object to be mapped

Table 8-6 Structure of PDO Mapping Entry

The length field shall match the size of the mapped object: partial mappings are not supported.

Error	SDO Abort codes
The number and length of the objects to be mapped would exceed maximum PDO length (24 bytes)	0x06040042
The mapped object doesn't exist	0x06020000
Object cannot be mapped to the PDO	0x06040041
The mapping data length is larger than the object size	0x08000000
Mapping entry changed while the PDO is enabled.	
Number of mappings, or mapping entry changed while the NMT state is not PreOperational	

Table 8-7 Mapping error codes

8.1.5 0x1A00 TPDO Mapping Parameters

0x1600	TPDOMappingParam			Object type: ARRAY
				Data type: UDINT
Sub-index 0	Name: Number of mappings			
Access: RW	PDO Map: No	Range: 0...6	Unit: N/A	
		Data type: USINT	Default: 0	
Description:	The number of the configured mappings			
Sub-index 1...6	Name: ObjectMapping			
Access: RW	PDO Map: No	Range: 0 to 2 ³² -1	Unit: N/A	
		Data type: UDINT	Default: 0	
Description:	Mapping configuration (see Table 8-6)			

This object shall be used to configure the TPDO mappings (isochronous data to the PLC). The functionality is equivalent to the object 0x1600 except that for the different data direction.

8.2 Manufacturer specific objects

The manufacturer specific section of the object dictionary includes Sigmatek specific objects, that extend the product capabilities beyond the features provided by the supported standards.

8.2.1 Parameters Area (0x2000 – 0x21FF)

The objects 0x2000 to 0x20FF in this area are mapped to drive menus 00 to 255 respectively. The sub-indices of each object correspond the parameters of the associated menu. For example, to write a value to parameter Pr.18.011 (Application Menu 1-Integer 11), the value must be written to object 0x2012, sub-index 11.

The sub-index 0, however, contains the number of sub-index entries in the object (the maximum parameter number in the menu); the access to Pr.mm.000 would be thus not possible using the objects. A special option module parameter (Pr.S.01.005; see 10.3.2) is however provided to mirror Pr.mm.000, allowing it to be accessed via the object dictionary.

The objects in the 0x2100 to 0x21FF range are mapped to the menu 00 to 255 of the fitted option module.

The objects corresponding to a not existing parameter, or that correspond to an empty slot are not neither accessible via SDO requests nor mappable.

It will be possible to map all drive parameters in PDOs, although they are still handled to their specific update rate, so the cyclic transfer of some parameters may be pointless.

8.2.2 0x3001 PDO loss error counter

0x3001 PDOLossErrCounter		Object type: RECORD	
Sub-index 0		Name: NumberOfEntries	
Access: Const	PDO Map: No	Range: N/A	Unit: N/A
		Data type: USINT	Default: 4
Description:	Highest sub-index supported		
Sub-index 1		Name: Error reaction	
Access: RW	PDO Map: No	Range: 0 to 3	Unit: N/A
		Data type: USINT	Default: 0
Description:	PDO loss error reaction mode		
Sub-index 2		Name: PDOCumulativeCnt	
Access: RW	PDO Map: No	Range: 0 to 2 ³² -1	Unit: N/A
		Data type: UDINT	Default: 0
Description:	PDO loss error cumulative counter		
Sub-index 3		Name: PDOLossThresholdCnt	
Access: RO	PDO Map: No	Range: 0 to 2 ³² -1	Unit: N/A
		Data type: UDINT	Default: 0
Description:	PDO loss error threshold counter		
Sub-index 4		Name: PDOLossThreshold	
Access: RW	PDO Map: No	Range: 1 to 2 ³² -1	Unit: N/A
		Data type: UDINT	Default: 15
Description:	PDO loss threshold error level		

This object allows to monitor PDO loss event and setup the error reaction.

When the NMT state is OP, the option module verifies on every network cycle start, that the RPDO buffer contains new data.

The cumulative error counter (sub index 2) increments every time a data loss is detected but it has no effect on the error reaction: it has only monitoring purposes. The counter can be reset via a SDO write request, setting it to zero; if any other value is written the SDO abort error code 0x06090030 (Invalid value) is returned.

The threshold counter (sub index 3) is incremented by 8 every time no new PDO data is ready, and it is decremented by 1 every cycle without reoccurrence of the error. The threshold counter self-resets during the PREOP to OP NMT state transition.

The action configured by sub index 1 (Table 8-8) is triggered when the threshold counter is greater than the threshold level (sub index 4). If the mode 0 is selected, the fault reaction code (object 0x605E) shall be set too; this mode is equivalent to mode 2 if the drive control by the CiA402 profile is disabled by Pr.S.00.033.

The NMT state always switches to PREOP after the error reaction is completed: if the no action mode is configured, the drive enable state will be unchanged, continuing to run the motor, but the NMT state will change anyway.

If the threshold level is set equal to zero, the counters are handled but the error reaction is never triggered and the NMT state is not affected by this object.

The cumulative error counter is also written in background to Pr.S.09.001 (11.1.1).

Mode	Description
0	Trigger the CiA402 fault reaction, then trip the drive
1	Reserved (no action)
2	No action
3	Trip the drive immediately: if the motor was running, it will coast.

Table 8-8 Error reaction modes

8.2.3 0x3002 Network timing monitor

0x3001	PDOLossErrCounter			Object type: RECORD
Sub-index 0	Name: Number of entries			
Access: Const	PDO Map: No	Range: N/A	Unit: N/A	
		Data type: USINT	Default: 4	
Description:	Highest sub-index supported			
Sub-index 1	Name: Error reaction			
Access: RW	PDO Map: No	Range: 0 to 3	Unit: N/A	
		Data type: USINT	Default: 0	
Description:	PDO loss error reaction mode			
Sub-index 2	Name: Cumulative counter			
Access: RW	PDO Map: No	Range: 0 to 2 ³² -1	Unit: N/A	
		Data type: UDINT	Default: 0	
Description:	PDO loss error cumulative counter			
Sub-index 3	Name: Threshold counter			
Access: RO	PDO Map: No	Range: 0 to 2 ³² -1	Unit: N/A	
		Data type: UDINT	Default: 0	
Description:	PDO loss error threshold counter			
Sub-index 4	Name: Threshold level			
Access: RW	PDO Map: No	Range: 0 to 2 ³² -1	Unit: N/A	
		Data type: UDINT	Default: 15	
Description:	PDO loss threshold error level			
Sub-index 5	Name: Max sync error percentage			
Access: RW	PDO Map: No	Range: 0 to 50	Unit: %	
		Data type: USINT	Default: 2	
Description:	PDO loss threshold error level			

This object is similar to 0x3001 (8.2.2) but it monitors for timing errors of the SYNC signal reconstructed from the network.

When the NMT OP mode is active, the option module verifies a new SYNC signal is received within the timing window defined by the nominative network cycle period, configured by the object 0x1006 (8.1.2), and the maximum allowed relative percentage error configurable by the sub index 5. Please note that the functionality is disabled if the object 0x1006 is set equal to zero (default setting).

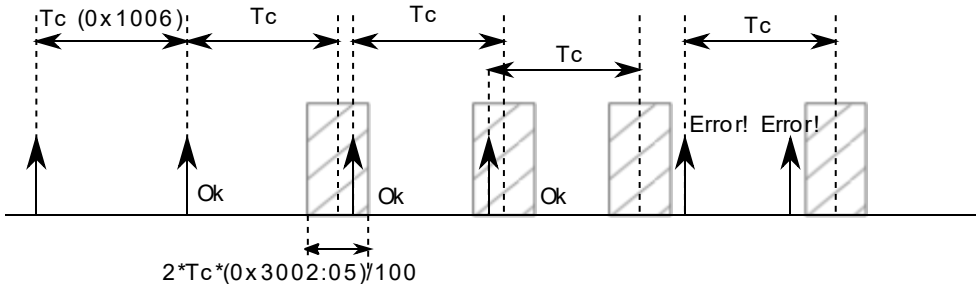


Figure 8-1 Network timing monitoring example

The object 0x3002 can be also used to monitor for physical network link losses, as in this case the option module will not receive SYNC messages anymore.

The cumulative error counter (sub index 2) increments every time a timing violation is detected but it has no effect on the error reaction: it has only monitoring purposes. The counter can be reset via a SDO write request, setting it to zero; if any other value is written the SDO abort error code 0x06090030 (Invalid value) is returned. The cumulative error counter is also written in background to Pr.S.09.002.

The threshold counter (sub index 3) is incremented by 8 every time a timing error occurs, and it is decremented by 1 every cycle without reoccurrence of the error. The threshold counter self-resets during the PREOP to OP NMT state transition.

The action configured by sub index 1 is triggered when the threshold counter is greater than the threshold level (sub index 4).

The action configured by sub index 1 (Table 8-9) is triggered when the threshold counter is greater than the threshold level (sub index 4). If the mode 0 is selected, the abort connection option code (object 0x6007) shall be set too; this mode is equivalent to mode 2 if the drive control by the CiA402 profile is disabled by Pr.S.00.033.

Mode	Description
0	Trigger the action defined by the abort connection option code (object 0x6007)
1	Reserved (no action)
2	No action
3	Trip the drive immediately: if the motor was running, it will coast.

Table 8-9 Network timing error reaction modes

The NMT state always switches to PREOP when the configured reaction is triggered. If a new request to switch to OP is received while the error reaction is still active, it remains pending until the reaction is completed.

If the threshold level is set equal to zero, the counters are handled but the error reaction is never triggered and the NMT state is not affected by this object.

9 Drive Profile Modes

9.1 CiA402 profiles

The CiA402 profiles are defined by the IEC 61800-7-201 specifications, providing standardized motion capabilities to ensure the device interoperability. The motion profiles can be directly controlled by the PLC using the objects described in the sections 9.2 and 9.3. The objects data can be transferred cyclically or by SDO requests depending on the user needs; generally, all objects can be mapped for cyclic transfers, but some restrictions may apply: please refer to the description of each object to check the mappings constraints.

9.1.1 Parameters usage

The CiA402 implementation interfaces with the drive primarily using drive parameters: to avoid malfunctions the parameters listed in Table 9-1 should be not touched by the user when the motion profiles are enabled.

Parameter	Description
0.01.006	Maximum Reference Clamp
0.01.008	Negative Reference Clamp Enable
0.01.010	Bipolar Reference Enable
0.01.014	Reference Selector
0.01.015	Preset Selector
0.01.021	Preset Reference 1
0.02.001	Post Ramp Reference
0.02.002	Ramp Enable
0.02.005	Disable Ramp Output
0.02.010	Acceleration Rate Selector
0.02.020	Deceleration Rate Selector
0.02.021	Deceleration Rate 1
0.02.022	Deceleration Rate 2
0.04.007	Symmetrical Current Limit
0.05.007	Motor Rated Current
0.06.042	Control Word

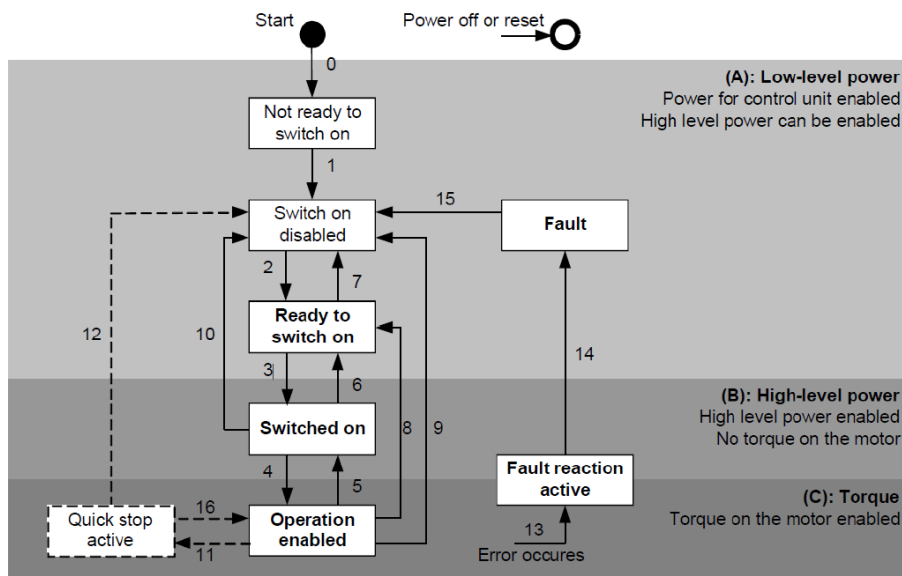
Table 9-1 Parameters written by the CiA402 implementation

9.1.2 CiA402 state machine

The CiA402 state machine is represented in Figure 9-1; the transitions and the relative descriptions are listed in Table 9-2; most of the transitions are triggered by a command specified by the control word object (see 9.2.2) but some can occur spontaneously.

The initial state of the CiA402 state machine is “NOT READY TO SWITCH ON”. The module must be in the network operating state before any further state transitions can happen. If the option module goes back to a pre-operational network state when the CiA402 state machine is in the “SWITCH ON DISABLED”, “READY TO SWITCH ON”, “SWITCHED ON”, “OPERATION ENABLE” or “QUICK STOP ACTIVE” states, the transition to the “NOT READY TO SWITCH ON” state is forced. This implies that the motor will stop according to the configured stopping method and the drive will be inhibited after the motor has stopped.

In the state “QUICK STOP ACTIVE”, the currently selected mode of operation indicates how a quick stop should be handled. When the drive is stopped (using the ramp defined in the 0x605A object), and the Quick stop option code doesn't indicate that the state should remain at “QUICK STOP ACTIVE”, the state moves to “SWITCH ON DISABLED”.



- | | |
|---------|--|
| [state] | Optional state |
| state | State can be changed manually by the slave |
| state | State is checked by master |

Figure 9-1 CiA 402 state machine

Transition	Event(s)	Action(s)
0	Automatic transition after the device reset, or if the drive hardware is disabled (Pr.06.029 = 0), or the CiA402 profiles are disabled (Pr.SS.00.033 = 1)	On device reset only: device initialization.
1	The drive inverter is not active (Pr.10.002 = 0) and the drive hardware is enabled (Pr.06.029 = 1) and the CiA402 profiles are enabled (Pr.SS.00.033 = 0)	The handling of the CiA402 objects is enabled
2	Shutdown command from control device and the drive is not in the undervoltage state	The drive is forced in the inhibit state
3	Switch on command received from control device	The drive is forced in the inhibit state
4	Enable operation command received from control device and the drive hardware is enabled (Pr.06.029 = 1)	The drive is set in the "Run" state and the torque zero All internal set-points are cleared.
5	Disable operation command received from control device	Execute the action specified by the disable operation option code, then the drive is forced in the inhibit state
6	Shutdown command received from control device	The drive is set in the "Inhibit" state
7	Quick stop or disable voltage command from control device or the drive undervoltage state is active	None
8	Shutdown command from control device or the drive inverter is not active (Pr.10.002 = 0)	Execute the action specified by the shutdown option code, then set the drive is set in the "Inhibit" state.
9	Disable voltage command from control device or the drive undervoltage state is active	Set the drive in the "Inhibit" state immediately: the motor is free to rotate if not braked
10	Disable voltage or quick stop command from control device or the drive undervoltage state is active	
11	Quick stop command from control device	The quick stop function is started

Transition	Event(s)	Action(s)
12	Automatic transition when the quick stop function is completed and quick stop option code 1, 2, 3 or 4 disable voltage command received from control device (dependent on the quick stop option code), or the drive undervoltage state is active	The drive is set in the "Inhibit" state
13	Fault signal	The configured fault reaction function is executed
14	Automatic transition when the fault reaction is completed, or a trip is signalled	The drive is set in the "Inhibit" state The objects 0x1001 and 0x603F are set.
15	Fault reset command from control device	Clear the fault condition resetting the drive trip. The objects 0x1001 and 0x603F are reset.

Table 9-2 CiA 402 state transitions

The transition 16 ("Quick stop active" to "Operation enabled") is not supported.

9.1.3 Common feedback values

The objects relative to the velocity, torque and current feedbacks are shared by multiple operating modes.

9.1.4 Velocity feedback

The actual velocity object (index 0x6044) is updated independently to the active operating mode. The object value is derived from Pr.03.002 (Estimated frequency) or Pr.05.004 (Motor RPM), depending on the drive mode (see Figure 9-2).

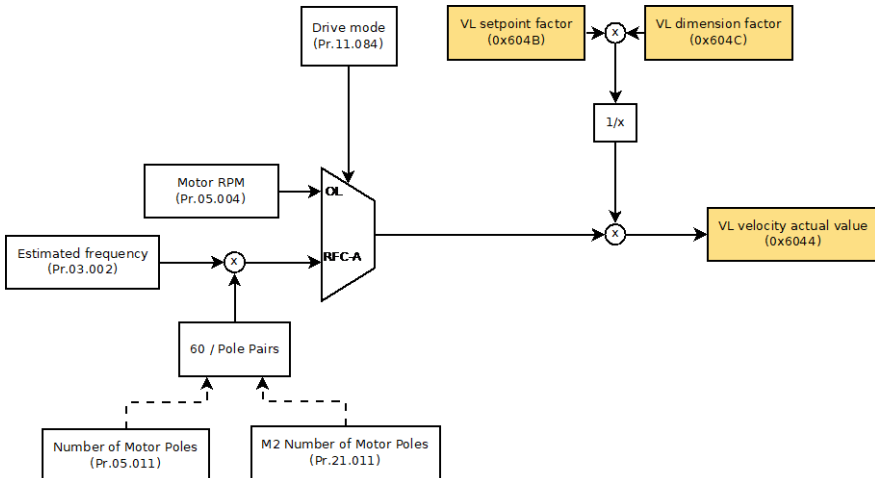


Figure 9-2 Velocity feedback dataflow

9.1.5 Torque and current feedback

The object 0x6077 reports the actual torque; the drive estimates the torque on the motor only if the Open Loop mode is selected: in this case the object is set with the value from Pr.04.026 (Percentage torque) else the Pr.04.003 (Final torque reference) is used.

The actual current reported by the object 0x6078, is instead derived from Pr.04.001 (Current Magnitude) and Pr.05.007 (Motor rated current).

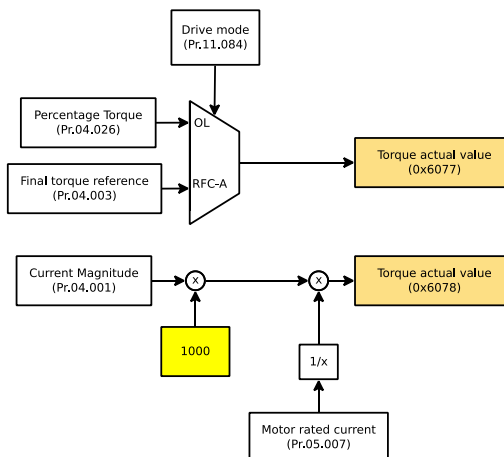


Figure 9-3 Torque and current feedback

9.1.6 Halt and Stop deceleration

If the motion profiles are enabled, the motor is stopped if any of the events listed in Table 9-3 occurs.

Event	Configuration object
The network timing error threshold counter reached the configured threshold level.	0x6007 (9.2.1)
The quick stop function is activated	0x605A (9.2.5)
The state changes from "Operation enabled" to "Ready to switch on"	0x605B (9.2.10)
The state changes from "Operation enabled" to "Switched on"	0x605C (9.2.6)
The halt bit in the control word is set	0x605D (9.2.7)
The fault reaction activates	0x605E (9.2.8)
The network state machine leaves OPERATIONAL state	

Table 9-3 Motion stop events

For each event, the behaviour can be selected using the associated object. In general, the configuration objects allow to select three main behaviours: disable immediately the drive output or decelerate using a normal or a quick ramp. Depending on the event however, not all selections may be available, or they can be extended to disable the drive with or without enabling the break after the motor has stopped; please refer to the documentation of the objects for the details.

The deceleration rate is always copied in background, after the appropriate scaling is applied, from the objects 0x6049 or 0x604A to Pr.2.021 (Deceleration rate 1) or Pr.2.022 (Deceleration rate 2), if a normal or a quick stop is respectively required.

The appropriate deceleration rate is selected setting Pr.S.02.020 (Deceleration Rate Selector), depending on the stop type. The deceleration rate 1 is used during the normal operations (9.3), so the parameter changes only if a quick stop is requested.

The motor stop is finally triggered forcing Pr.34.006 (Preset Reference 1) to zero; the parameter is linked to the target velocity objects 0x6042 or 0x60FF in normal operations.

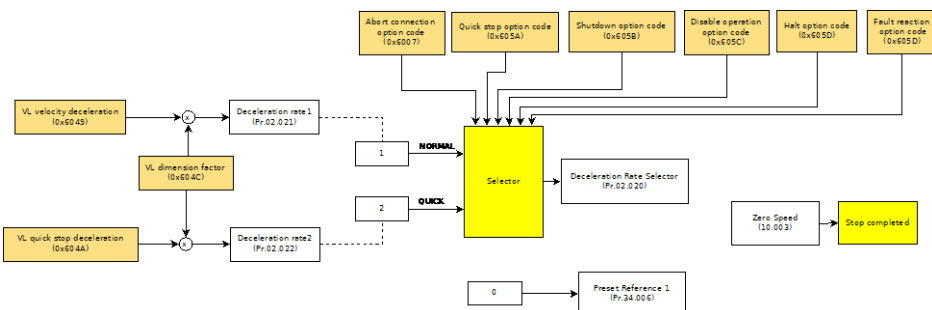


Figure 9-4 Stop: VL mode

9.2 Common profile features

9.2.1 0x6007 Abort connection option code

0x6007	AbortConnectionOptionCode			Object type: VAR
Sub-index 0	Range: 0...3			
Access: RW	PDO Map: No	Data type: INT	Unit: N/A	
		Handling rate: 40 ms	Default: 1	
Description:	Configure the CiA 402 behavior on NMT state changes			

The user can use the object 0x6007 to configure behaviour of the CiA402 state machine when the network error timing error threshold counter reaches the configured threshold and the object 0x3002:01 (8.2.3) is set equal to zero.

Value	Definition
-3	Execute the quick stop according to the quick stop option code (object 0x605A), then raise the drive trip
-2	Immediate drive disable (disable voltage command) and raise the drive trip
-1	Perform the fault reaction configured by object 0x605E, then raise the drive trip
0	No action
1	Perform the fault reaction configured by object 0x605E
2	Immediate drive disable (disable voltage command)
3	Quick stop according to the quick stop option code (object 0x605A)

Table 9-4 Abort connection option code value definition

9.2.2 0x6040 Control word

0x6040	ControlWord			Object type: VAR
Sub-index 0	Range: 0...65535			
Access: RW	PDO Map: RPDO	Data type: UINT	Unit: N/A	
		Handling rate: 40 ms	Default: N/A	
Description:	Control of the CiA 402 state machine and of the motor movements			

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
ms					r	oms	h	fr	oms			eo	qs	ev	so

Table 9-5 Controlword structure

LEGEND: ms = manufacturer-specific; r = reserved; oms = operation mode specific; h = halt; fr = fault reset; eo = enable operation; qs = quick stop; ev = enable voltage; so = switch on.

Bit	Name	Description
7, 3, 2, 1, 0	Command	These bits encode the commands used to sequence the drive through the CiA 402 state machine.
4, 5, 6, 9	Operating mode specific	Please refer to the operating modes description.
8	Halt	If this bit is set, the motion in progress is interrupted according to the behaviour specified by the halt option code (object 0x605D). If the pp or pv profiles are active, the interrupted movement is resumed after the releasing the halt function.
10	Reserved	These bits are ignored: they may be used for future development and they should be always set to zero.
11 to 15	Manufacturer specific	

Table 9-6 Controlword bits description


Command	Bits of the Controlword				
	Bit 7	Bit 3	Bit 2	Bit 1	Bit 0
Shutdown	0	X	1	1	0
Switch on	0	0	1	1	1
Switch on + enable operation	0	1	1	1	1
Disable voltage	0	X	X	0	X
Quick stop	0	X	0	1	X
Disable operation	0	0	1	1	1
Enable operation	0	1	1	1	1
Fault reset		X	X	X	X

Table 9-7 CiA 402 command coding

9.2.3 0x6041 Status word

0x6041	StatusWord	Object type: VAR
Sub-index 0	Range: 0...65535	
Access: RO	PDO Map: TPDO	Unit: N/A
	Update rate: 40 ms	Default: N/A
Description:	Feedback about the current operating state of the drive	

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
ms		oms		ila	tr	rm	ms	w	sod	qs	ve	f	oe	so	rtso

Table 9-8 Statusword structure

LEGEND: ms = manufacturer-specific; oms = operation mode specific; ila = internal limit active; tr = target reached; rm = remote; w = warning; sod = switch on disabled; qs = quick stop; ve = voltage enabled; f = fault; oe = operation enabled; so = switched on; rtso = ready to switch on

Bit	Name	Description
0, 1, 2, 3, 5, 6	State	The current CiA 402 state is encoded in these bits according to the definitions in Table 9-10
4	Voltage enabled	The main voltage is present
7	Warning	A drive warning is active; the error cause can be obtained reading the object 0x603F.
9	Remote	This bit is cleared when the control word is not processed (the CiA402 profiles are disabled by Pr.S.00.034)
10	Target reached	Not used (always zero)
11	Internal limit reached	Not used (always zero)
12, 13	Operation mode specific	Please refer to the operating modes description.
8, 15, 14	Manufacturer specific	All manufacturer specific bits are always set to zero.

Table 9-9 Status word bits description

Statusword	State
xxxx xxxx x0xx 0000b	Not ready to switch on
xxxx xxxx x1xx 0000b	Switch on disabled
xxxx xxxx x01x 0001b	Ready to switch on
xxxx xxxx x01x 0011b	Switched on
xxxx xxxx x01x 0111b	Operation enabled
xxxx xxxx x00x 0111b	Quick stop active
xxxx xxxx x0xx 1111b	Fault reaction active
xxxx xxxx x0xx 1000b	Fault

Table 9-10 CiA 402 state coding

9.2.4 0x6044 VL Velocity actual value

0x6044	VIVelocity actual value		Object type: VAR
Sub-index 0		Range: -2^{15} to $2^{15} - 1$	
Access: RO	PDO Map: TPDO	Data type: UINT	Unit: UU
		Update rate: 40 ms	Default: 0
Description:	Actual velocity feedback		

The object 0x6044 is defined by the EN61800 specifications only in the velocity mode; the option module however updates it independently to the active operating mode. The object value is calculated from a parameter dependent on the drive type and mode: please refer to the section 9.1.4 for a detailed description.

9.2.5 0x605A Quick stop option code

0x605A	QuickStopOptionCode		Object type: VAR
Sub-index 0		Range: 0...2	
Access: RW	PDO Map: No	Data type: INT	Unit: N/A
		Handling rate: 40 ms	Default: 2
Description:	Specifies what action is performed in the event of a quick stop function		

Value	Definition
0	Disable drive function
1	Slow down on slow down ramp and transit into Switch on disabled
2	Slow down on quick stop ramp and transit into Switch on disabled

Table 9-11 Quick stop option codes

9.2.6 0x605C Disable operation option code

0x605C		DisableOperationOptionCode		Object type: VAR
Sub-index 0		Range: 0...1		
Access: RW	PDO Map: No	Data type: INT	Unit: N/A	
		Handling rate: 40 ms	Default: 1	
Description:	Configure the action to be taken if there is a transition from the Operation Enable state to the Switched On state			

Value	Definition
0	Disable drive function (switch off the drive power stage)
1	Slow down with slow down ramp; disable the drive function

Table 9-12 Disable operation option codes

9.2.7 0x605D Halt option code

0x605D	Halt option code			Object type: VAR
Sub-index 0		Range: 0...2		
Access: RW	PDO Map: No	Data type: INT	Unit: N/A	
		Read rate: 40 ms	Default: 1	
Description:	Configure the action executed when a halt is requested by the bit 8 of the controlword			

Value	Definition
0	Reserved (no action)
1	Slow down with slow down ramp; stay in Operation enabled
2	Slow down with quick stop ramp; stay in Operation enabled

Table 9-13 Halt option codes

9.2.8 0x605E Fault reaction option code

0x605E	FaultReactionOptionCode			Object type: VAR
Sub-index 0		Range: 0...2		
Access: RW	PDO Map: No	Data type: INT	Unit: N/A	
		Read rate: 40 ms	Default: N/A	
Description:	Configure the action to be performed when the fault reaction is activated			

Value	Definition
0	Disable drive function, motor is free to rotate
1	Slow down on slow down ramp
2	Slow down on quick stop ramp

Table 9-14 Fault reaction option codes

9.2.9 0x6060 Modes of operation

0x6060	ModesOfOperation			Object type: VAR
Sub-index 0		Range: 0...10		
Access: RW	PDO Map: RPDO	Data type: SINT	Unit: N/A	
		Read rate: 40 ms	Default: 2	
Description:	Select the active operating mode			

As only the Velocity Mode (2) is supported and it is activated by default, it remains active for any valid value written in the object 0x6060.

The user doesn't need to set this object: it is provided only to ensure the compatibility with future version that will support more modes of operation.

9.2.10 0x605B Shutdown option code

0x605B	ShutdownOptionCode		Object type: VAR
Sub-index 0		Range: 0...1	
Access: RW	PDO Map: No	Data type: INT	Unit: N/A
		Handling rate: 40 ms	Default: 0
Description:	Configure the action to be taken if there is a transition from the Operation Enable state to the Ready To Switch On state		

Value	Definition
0	Disable drive function (switch off the drive power stage)
1	Slow down with slow down ramp; disable the drive function

Table 9-15 Shutdown option codes

9.2.11 0x6061 Modes of operation display

0x6061	ModesOfOperationDisplay			Object type: VAR
Sub-index 0		Range: 0...65535		
Access: RO	PDO Map: TPDO	Data type: SINT	Unit: N/A	
		Update rate: 40 ms	Default: N/A	
Description:	Indication of the active operating mode			

The 0x6061 object reports the active operating mode using the same coding as for the 0x6060 object.

As only the Velocity Mode is supported, this object always reports 2, unless the handling of the drive parameters by CiA 402 profiles is disabled by Pr.S.00.033: in this case the object 0x6061 is set equal to zero to indicate that no mode is active.

9.2.12 0x6073 Max current

0x6073		MaxCurrent		Object type: VAR
Sub-index 0		Range: VM_MOTOR1_CURRENT_LIMIT		
Access: RW	PDO Map: RPDO	Data type: UINT	Unit: 0.1 % rated motor current	
		Handling rate: 40 ms	Default: N/A	
Description:	Maximum current value			

This object indicates the maximum output current is limited by the value specified by the 0x6073 object. It is linked to Pr.04.007 parameter (Symmetrical Current Limit): any change to the parameter will be reflected to the object and vice versa; if both values are changed, the parameter value is prioritized.

The object is automatically initialized with the Pr.04.007 value on startup.

9.2.13 0x6075 Motor rated current

0x6075		MotorRatedCurrent		Object type: VAR
Sub-index 0		Range: ±VM_RATED_CURRENT		
Access: RW	PDO Map: No	Data type: UDINT	Unit: mA	
		Update rate: 40 ms	Default: Pr05.007	
Description:	Motor rated current			

This object indicates the configured motor rated current; all relative current data refers to this value, expressed in mA. It is linked to Pr.05.007 parameter (Rated Current Limit): any change to the parameter will be reflected to the object and vice versa; if both values are changed, the parameter value is prioritized.

The object is automatically initialized with the Pr.05.007 value on startup.

9.2.14 0x6077 Torque actual value

0x6077	TorqueActualValue		Object type: VAR
Sub-index 0		Range: 0...999999	
Access: RO	PDO Map: TPDO	Data type: INT	Unit: 0.1 % rated motor torque
		Update rate: 250 µs	Default: N/A
Description:	Torque actual value feedback		

This object reports estimated torque on the shaft, obtained from the torque producing current represented as a percentage of the rated value for the motor. If the drive mode is Open Loop, the value is directly copied from Pr.04.026 (Percentage torque), else from Pr.04.003 (Final torque reference) as the drive doesn't estimate the torque on the motor if the mode is RFC-A.

9.2.15 0x6078 Current actual value

0x6078		CurrentActualValue		Object type: VAR
Sub-index 0		Range: 0...999999		
Access: RO	PDO Map: TPDO	Data type: INT	Unit: 0.1 % rated motor current	
		Update rate: 250 µs	Default: N/A	
Description:	Current actual value feedback			

The current actual value is set from Pr.04.001 (Current magnitude), after it is converted to thousands of the rated current.

9.2.16 0x6080 Max motor speed

0x6080	MaxMotorSpeed			Object type: VAR
Sub-index 0		Range: 0...2 ³² -1		
Access: RW	PDO Map: RPDO	Data type: UDINT	Unit: UU/s	
		Handling rate: 40 ms	Default: N/A	
Description:	Maximum velocity for profiled motion			

This object indicates the configured maximum allowed speed for the motor in either direction, to protect the motor from damages. It is automatically initialized with the value from Pr.01.006 after the proper conversion is applied in the following cases:

- Startup
- The CiA 402 profiles are reenabled
- The operating mode is changed

When the object is written, a copy of the value is converted applying the appropriate scaling, then it is copied to Pr.01.006 (Maximum Reference Clamp), within 40 ms. Please note that except when the object is initialized, any user change to Pr.01.006 have no effect on it: the user should not change the parameter when the CiA402 profiles are enabled.

9.2.17 0x6502 Supported drive modes.

0x6502	SupportedDriveModes		Object type: VAR
Sub-index 0		Range: 0...2 ³² -1	
Access: RO	PDO Map: No	Data type: UDINT	Unit: N/A
		Update rate: Const	Default: 0x00000002
Description:	Information about the supported operating modes		

Each bit of the 0x6502 object represent the support to a specific operating mode: if a bit value is 1 the relative mode is supported. The reserved bits (4 and 11 to 15) and the manufacturer specific bits (16 to 31) are unused and they are always set to zero.

31-16	15-11	10	9	8	7	6	5	4	3	2	1	0
ms	r	cstca	cst	csv	csp	ip	hm	r	tq	pv	vl	pp
0	0	0	0	0	0	0	0	0	0	0	1	0

Table 9-16 Supported drive modes value definition

9.2.18 0x67FE Profile version

0x67FE	ProfileVersion_U32			Object type: VAR
Sub-index 0		Range: N/A		
Access: Const	PDO Map: No	Data type: UDINT	Unit: N/A	
		Handling rate: N/A	Default: 0x03010000	
Description:	Version of the CiA 402 profile			

This object provides the version number of the CiA 402, which is implemented in the device, according to the format described by Table 9-17

Byte		Definition	
MSB	3	0x03	Major version number
	2	0x01	Minor version number
	1	0x00	Minor version number
LSB	0	0x00	Sub version number

Table 9-17 Profile version data format

9.3 vl velocity mode

The velocity mode is supported on both the Open Loop and RFC-A modes. The drive's speed handling and ramps are always used; the data flow partially depends however on the drive type and mode, and the configured position feedback source where available.

Figure 9-2 VL velocity mode (Open loop mode FDD 3000)

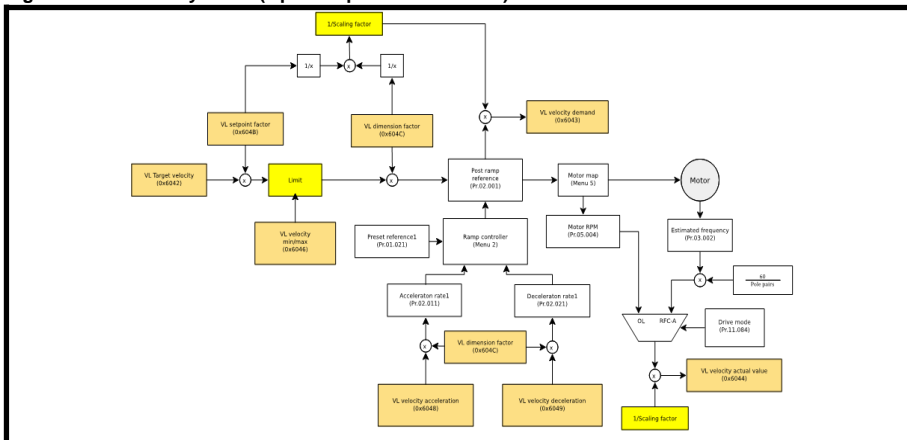


Table 9-31 lists the objects that are supported.

Table 9-31 vl velocity mode supported objects

Index	Name
0x6042	<i>vl_target_velocity</i>
0x6043	<i>vl_velocity_demand</i>
0x6044	<i>vl_velocity_actual_value</i>
0x6046	<i>vl_velocity_min_max_amount</i>
0x6048	<i>vl_velocity_accleration</i>
0x6049	<i>vl_velocity_deceleration</i>
0x604A	<i>vl_velocity_quick_stop</i>
0x604B	<i>vl_setpoint_factor</i>
0x604C	<i>vl_dimension_factor</i>

9.3.1 0x6042 VL Target velocity

0x6042	VLTargetVelocity			Object type: VAR
Sub-index 0		Range: -2 ¹⁵ ...2 ¹⁵ -1		
Access: RW	PDO Map: RPDO	Data type: INT	Unit: UU	
		Handling rate: 40 ms	Default: 0	
Description:	Target velocity used by the velocity mode			

9.3.2 0x6043 VL Velocity demand

0x6043	VLVelocityDemand			Object type: VAR
Sub-index 0		Range: -2 ¹⁵ ...2 ¹⁵ -1		
Access: RO	PDO Map: TPDO	Data type: INT	Unit: UU	
		Update rate: 40 ms	Default: 0	
Description:	Actual velocity demand generated by the ramp function used by the velocity mode)			

9.3.3 0x6044 VL Velocity actual value

0x6044	VLActualValue			Object type: VAR
Sub-index 0		Range: -2 ¹⁵ ...2 ¹⁵ -1		
Access: RO	PDO Map: TPDO	Data type: INT	Unit: UU	
		Update rate: 40 ms	Default: 0	
Description:	Actual velocity feedback			

The object 0x6044 is defined by the EN61800 specifications only in the velocity mode; the option module however updates it independently to the active operating mode. The object value is calculated from a parameter dependent on the drive type and mode: please refer to the section 9.1.4 for a detailed description.

9.3.4 0x6046 VL velocity min max amount

0x6046	VLMinMaxAmount			Object type: ARRAY
				Data type: UDINT
Sub-index 0	Name: NumberOfEntries			
Access: Const	PDO Map: No	Range: N/A	Unit: N/A	
		Data type: USINT	Default: 2	
Description:	Highest sub-index supported			
Sub-index 1	Name: VL_VelocityMinAmount			
Access: RW	PDO Map: RPDO	Range: 0 to 2 ³² -1	Unit: UU	
		Data type: UDINT	Default: 0	
		Read rate: 40 ms		
Description:	Absolute value of the minimum velocity that the system can operate.			
Sub-index 2	Name: VL_VelocityMaxAmount			
Access: RW	PDO Map: RPDO	Range: 0 to 40000	Unit: UU	
		Data type: UDINT	Default: 40000	
		Read rate: 40 ms		
Description:	Absolute value of the maximum velocity that the system can operate.			

This object configures the minimum and maximum values that the system can operate both in the forward and reverse direction. The output speed is automatically clipped to satisfy the configured constraints; the transfer characteristic is shown in Figure 9-5.

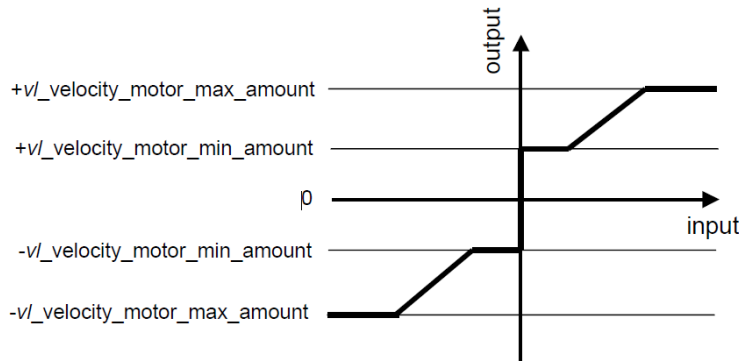


Figure 9-5 Transfer characteristic of vl velocity min max amount

9.3.5 0x6048 VL velocity acceleration

0x6048	VLVelocityAcceleration			Object type: RECORD
Sub-index 0	Name: NumberOfEntries			
Access: Const	PDO Map: No	Range: N/A	Unit: N/A	
		Data type: USINT	Default: 2	
Description:	Highest sub-index supported			
Sub-index 1	Name: DeltaSpeed			
Access: RW	PDO Map: RPDO	Range: 0 to 2 ³² -1	Unit: UU	
		Data type: UDINT	Default: 10000	
		Handling rate: 40 ms		
Description:	Velocity increase in the time specified by the sub index 2			
Sub-index 2	Name: DeltaTime			
Access: RW	PDO Map: RPDO	Range: 0 to 2 ¹⁶ -1	Unit: s	
		Data type: UINT	Default: 2	
		Handling rate: 40 ms		
Description:	The value of delta time is given in seconds.			

This object is linked to Pr.02.011 (Acceleration rate 1): the changes to the objects are reflected to the parameter and vice versa. The parameter value is prioritized if they change at the same time. Even if the object is defined by the EN61800 specifications only in the velocity mode, the link between the object and the parameter is active for any mode of operation.

9.3.6 0x6049 VL velocity deceleration

0x6049	VLVelocityDeceleration			Object type: RECORD
Sub-index 0	Name: NumberOfEntries			
Access: Const	PDO Map: No	Range: N/A	Unit: N/A	
		Data type: USINT	Default: 2	
Description:	Highest sub-index supported			

Sub-index 1	Name: DeltaSpeed		
Access: RW	PDO Map: RPDO	Range: 0 to 2 ³² -1	Unit: UU
		Data type: UDINT	Default: 10000
		Handling rate: 40 ms	
Description:	Velocity reduction in the time specified by the sub index 2		
Sub-index 2	Name: DeltaTime		
Access: RW	PDO Map: RPDO	Range: 0 to 2 ¹⁶ -1	Unit: s
		Data type: UINT	Default: 2
		Handling rate: 40 ms	
Description:	The value of delta time is given in seconds.		

This object defines the deceleration used if the target velocity changes or a controlled stop is required using the slow down ramp.

The value is linked to Pr.02.021 (Deceleration rate 1): the changes to the objects are reflected to the parameter and vice versa. The parameter value is prioritized if they change at the same time. Even if the object is defined by the EN61800 specifications only in the velocity mode, the link between the object and the parameter is active for any mode of operation.

9.3.7 0x604A VL Velocity quick stop

0x604A	VLVelocityQuickStop		Object type: REC-ORD
Sub-index 0	Name: NumberOfEntries		
Access: Const	PDO Map: No	Range: N/A	Unit: N/A
		Data type: USINT	Default: 2
Description:	Highest sub-index supported		
Sub-index 1	Name: DeltaSpeed		
Access: RW	PDO Map: RPDO	Range: 0 to 2 ³² -1	Unit: UU
		Data type: UDINT	Default: 10000
		Handling rate: 40 ms	
Description:	Velocity reduction in the time specified by the sub index 2 used when quick stop is requested.		
Sub-index 2	Name: DeltaTime		
Access: RW	PDO Map: RPDO	Range: 0 to 2 ¹⁶ -1	Unit: s
		Data type: UINT	Default: 2
		Handling rate: 40 ms	
Description:	The value of delta time is given in seconds.		

This object defines the deceleration used if the quick stop is activated. The value is linked to Pr.02.022 (Deceleration rate 2): the changes to the objects are reflected to the parameter and vice versa. The parameter value is prioritized if they change at the same time.

Even if the object is defined by the EN61800 specifications only in the velocity mode, the link between the object and the parameter is active for any mode of operation.

9.3.8 0x604B VL set-point factor

0x604B	VLSetPointFactor			Object type: AR-RAY
				Data type: INT
Sub-index 0	Name: NumberOfEntries			
Access: Const	PDO Map: No	Range: N/A	Unit: N/A	
		Data type: USINT	Default: 2	
Description:	Highest sub-index supported			
Sub-index 1	Name: Numerator			
Access: RW	PDO Map: RPDO	Range: -2 ¹⁵ to 2 ¹⁵ -1	Unit: N/A	
		Data type: INT	Default: 1	
		Read rate: 40 ms		
Description:	Numerator			
Sub-index 2	Name: Denominator			
Access: RW	PDO Map: RPDO	Range: -2 ¹⁵ to 2 ¹⁵ -1	Unit: N/A	
		Data type: INT	Default: 1	
		Read rate: 40 ms		
Description:	Denominator			

The VL set-point factor serves to modify the resolution or directing range of the specified set-point. It is also included in calculation of the VL target velocity, and the VL velocity demand values (objects 0x6042 and 0x6043 respectively). It does not influence the velocity limit function and the ramp function. If zero is written in the numerator or the denominator, it is considered equal to 1 in the calculations. Please refer to the sections 9.1.4 and 9.3 for more detailed information about how the object is internally used.

9.3.9 0x604C VL dimension factor

0x604C	VLDimensionFactor			Object type: ARRAY
				Data type: INT
Sub-index 0	Name: NumberOfEntries			
Access: Const	PDO Map: No	Range: N/A	Unit: N/A	
		Data type: USINT	Default: 2	
Description:	Highest sub-index supported			
Sub-index 1	Name: Numerator			
Access: RW	PDO Map: RPDO	Range: -2 ¹⁵ to 2 ¹⁵ -1	Unit: N/A	
		Data type: INT	Default: 1	
		Read rate: 40 ms		
Description:	Numerator			
Sub-index 2	Name: Denominator			
Access: RW	PDO Map: RPDO	Range: -2 ¹⁵ to 2 ¹⁵ -1	Unit: N/A	
		Data type: INT	Default: 1	
		Read rate: 40 ms		
Description:	Denominator			

Every user-specific velocity used by the VL mode consists of specific units referred to specific units of time (e.g. 1/s, bottles/min, m/s, etc.). The purpose of the VL dimension factor is to convert the specific velocity units to rpm. It influences the VL target velocity, VL velocity demand, VL velocity actual value as well as the velocity limit function and the ramp function.

$$Velocity_{uu} \times \frac{VL\ dimension\ factor_{num}}{VL\ dimension\ factor_{denom}} = Velocity_{rpm}$$

If zero is written in the numerator or the denominator, it is considered equal to 1 in the calculations.

9.4 Error Handling

The following objects can be used to indicate the reason of an error condition:

Index	Name
1001	error_register
603F	error_code

9.4.1 0x1001 Error Register

0x1001	ErrorRegister			Object type: VAR
Sub-index 0		Range: 0...255		
Access: RO	PDO Map: TPDO	Data type: USINT	Unit: 0 -> 255	
		Handling rate: 40 ms	Default: N/A	
Description:	Active errors bitmask			

When the CiA402 fault reaction activates, or the CiA402 state immediately switches to FAULT, the user can obtain a general indication of the error cause from the object 0x1001. Each bit indicates a different error cause and it groups a range of errors reported by the object 0x603F (Table 9-19).

Error register		Object 0x603F range
Bit	Description	
0	Generic error	0x0001 – 0x1FFF Or any other value not listed in this table but greater than zero
1	Current	0x2000 – 0x2FFF
2	Voltage	0x3000 – 0x3FFF
3	Temperature	0x4000 – 0x4FFF
4	Communication error	0x8100 – 0x8100
5	Device profile specific (unused)	-
6	Reserved (always 0)	-
7	Manufacturer specific	0xFF00 – 0xFFFF

Table 9-18 0x1001 Error register bits

9.4.2 0x603F Error code

0x603F	Error Code		Object type: VAR
Sub-index 0	Range: 0...65535		
Access: RO	PDO Map: TPDO	Data type: UINT	Unit: N/A
		Update rate: 40 ms	Default: N/A
Description:	Report active error conditions		

The cause that triggered the activation of the fault reaction is reported in the 0x603F object. The fault reaction is usually triggered by a trip but in some cases, it can be activated without a warning or a trip are signalled. The correspondences between the reason that caused the fault reaction and the error codes are listed in Table 9-1. The trip codes indicated as S.nnn refer to an option module trip

The object 0x603F is automatically cleared when the fault condition is reset.

Error category	Error Code	Trip Code or trigger condition	
Error reset / No error	0x0000	0	None
Short circuit/earth leakage (device internal)	0x2230	5	PSU
		92	OI_SNUBBER
Current, device output side	0x2340	3	OI_AC
		228	OUTPUT_PHASE_U
		229	OUTPUT_PHASE_V
		230	OUTPUT_PHASE_W
Phase failure	0x3130	32	PHASE_LOSS
		98	OUT_PHASE_LOSS
DC link over-voltage	0x3210	2	OVER_VOLTS
Excess temperature drive	0x4310	21	OHT_INVERTOR
	0x4311	22	OHT_POWER
	0x4312	219	OHT_CONTROL
	0x4313	24	THERMISTOR
	0x4316	27	OHT_DC_BUS
	0x431F	S.213	OTH_OPTION_MODULE
Control device hardware	0x5200	200	SLOT1_HF
	0x5201	203	SLOT1_NOT_FITTED
	0x5202	204	SLOT1_DIFFERENT
	0x520C	236	NO_POWER_BOARD
Power section	0x5400	220	POWER_DATA
Contacts	0x5440	226	SOFT_START
RAM	0x5510	227	SUB_ARRAY_RAM_ALLOCATION
Data Storage (Non-volatile data memory)	0x5530	31	EEPROM_FAIL
		36	USER_SAVE
		37	POWER_DOWN_SAVE
Software reset (watchdog)	0x6010	30	WATCHDOG
Parameter Error	0x6320	199	DESTINATION
Brake Chopper (Over current brake chop- per)	0x7112	4	OI_BRAKE
		19	BRAKE_R_TOO_HOT
		250	HOT_RECT_BRAKE
Motor	0x7120	11	AUTOTUNE_1
		13	AUTOTUNE_3
Motor error or commutation malfunction	0x7122	20	MOTOR_TOO_HOT
		25	TH_SHORT_CIRCUIT
		33	RESISTANCE
Sensor	0x7300	218	TEMP_FEEDBACK

Error category	Error Code	Trip Code or trigger condition
Speed	0x7310	7 OVER_SPEED
Communication	0x7500	93 POWER_COMMS
	0x7600	175 CARD_PRODUCT
	0x7604	178 CARD_BUSY
	0x7605	179 CARD_DATA_EXISTS
	0x7606	180 CARD_OPTION
	0x7607	181 CARD_READ_ONLY
	0x7608	182 CARD_ERROR
	0x7609	183 CARD_NO_DATA
	0x760A	184 CARD_FULL
	0x760B	185 CARD_FILE_ERROR
	0x760C	186 CARD_RATING
	0x760D	187 CARD_DRIVE_MODE
	0x760E	188 CARD_COMPARE
Protocol error	0x8101	S.103 PDO_LOSS
	0x8102	S.106 NETWORK_CYCLE
	0x8107	Drive control disabled by Pr.S.000.33 (no trip)
Generic trip related error	0xFF01	- Any trip code not listed

Table 9-19 CiA 402 error codes

10 Parameter Descriptions

It is intended that it is not necessary to use many option module parameters for VARAN setup or control of a drive; parameters are mostly provided for status and information. This means that a user will configure the motor and feedback in the usual way, using parameters, install an SI- VARAN option, and use CiA402 objects to control the drive from that point onwards.

Although, with objects which correspond to drive parameters, it should be possible to perform all drive/motor/feedback configuration using the VARAN interface. In the following descriptions, S means the option module slot number.

10.1 Internal menus

SI-VARAN provides parameters for configuration and information, these parameters are grouped into menus as shown in Table 10-1.

Table 10-1 SI-VARAN internal menus

Menu	Name	Description
S.0	Setup	Provides module information such as firmware version and serial number
S.1	VARAN	Provides information about the module's VARAN stack
S.9	Diagnostics	Provides general diagnostic parameters related to the hardware and the internal software status of the option module.

10.2 Parameter type codes

Table 10-2 lists the coding used for the parameter type in the subsequent parameter description tables.

Table 10-2 Parameter type codes

RW	Read / Write	RO	Read-only	Bit	Bit parameter	Txt	Text string	Date	Date parameter	Time	Time parameter
Chr	Character parameter	Bin	Binary parameter	IP	IP address	Mac	MAC address	Ver	Version number	SMP	Slot, menu, parameter
Num	Number parameter	DE	Destination	ND	No default value	RA	Rating dependant	NC	Non-copyable	PT	Protected
FI	Filtered	US	User save	PS	Power-down save	BU	Bit default or unipolar				

10.3 Parameter descriptions

10.3.1 Menu 0 (Setup)

Pr.S.00.001 Module ID

S.00.001	Module ID		
Short Description	Module identification		
Minimum	0	Maximum	65535
Default	438	Units	N/A
Type	16 bits volatile	Update Rate	Once on power up
Display Format	Standard	Decimal Places	0
Coding	BU, PT, NC, ND		

Pr.S.00.002 Application version

S.00.002	Application version		
Short Description	Application firmware version		
Minimum	0	Maximum	99999999
Default	N/A	Units	N/A
Type	32 bits volatile	Update Rate	Once on power up
Display Format	Version	Decimal Places	0
Coding	BU, PT, NC, ND		

Pr.S.00.003 Hardware version

S.00.003	Hardware version		
Short Description	Hardware version		
Minimum	0	Maximum	655.35
Default	N/A	Units	N/A
Type	16 bits volatile	Update Rate	Once on power up
Display Format	Standard	Decimal Places	2
Coding	BU, PT, NC, ND		

Pr.S.00.004 Serial number LS

S.00.004	Serial number LS		
Short Description	Least significant part of the serial number		
Minimum	0	Maximum	99999999
Default	N/A	Units	N/A
Type	32 bits volatile	Update Rate	Once on power up
Display Format	Lead zero pad	Decimal Places	2
Coding	BU, PT, NC, ND		

The module serial number is available as a pair of 32 bits values where Serial Number LS (S.MM.004) provides the least significant 8 decimal digits and Serial Number MS (S.MM.005) provides the most significant 8 decimal digits. The reconstructed serial number is $((\text{MM.005} * 10000000) + \text{MM.004})$. For example, the serial number "0001234567898765" is stored as S.MM.005 = 12345 and S.MM.004 = 67898765.

Pr.S.00.005 Serial number MS

S.00.005	Serial number MS		
Short Description	Most significant part of the serial number		
Minimum	0	Maximum	99999999
Default	N/A	Units	N/A
Type	32 bits volatile	Update Rate	Once on power up
Display Format	Standard	Decimal Places	2
Coding	BU, PT, NC, ND		

Pr.S.00.006 Module status

S.00.006	Module status		
Short Description	Status of the option module		
Minimum	-2	Maximum	3
Default	0	Units	N/A
Type	8 bits volatile	Update Rate	Background
Display Format	Standard	Decimal Places	0
Coding	PT, NC, ND, TE		

Value	Text	Description
-2	Bootldr – Update	The bootloader is updating the flash memory
-1	Bootldr – Idle	The bootloader is waiting for commands
0	Initializing	The firmware is initializing
1	Ok	The firmware initialized, and no errors have been detected
2	Config	Reserved code for future use.
3	Error	An error has occurred preventing the firmware from running correctly, a power cycle or a re-set is required to attempt to restore the normal functionalities.

Pr.S.00.007 Reset

S.00.007	Reset		
Short Description	Perform a warm reset		
Minimum	0	Maximum	1
Default	0	Units	N/A
Type	1 bit volatile	Update Rate	Read in background Written to 0 on start-up
Display Format	Standard	Decimal Places	0
Coding	W, NC		

A warm reset is performed when this parameter is set; it's automatically cleared by the initialization routines executed on reset. The drive, and any other modules fitted to the drive are not be affected by the reset. If Pr.S.00.033 is not set to On (the drive is controlled by the CiA402 profile), the motor may be gracefully stopped before the reset, depending on the object 0x605E value (9.2.8).

Pr.S.00.008 Default

S.00.008	Default		
Short Description	Restore to factory default		
Minimum	0	Maximum	1
Default	0	Units	N/A
Type	1 bit volatile	Update Rate	Read and cleared on reset
Display Format	Standard	Decimal Places	0
Coding	W, NC		

If it is set to "ON" when the module is reset, it causes the option module to return to its "Out of Box configuration" any settings stored on the module will be returned to their default values, including the object dictionary, if it is saved. This parameter is automatically cleared after the reset and the revert to the default values is completed.

Pr.S.00.020 FPGA Version

S.00.020	FPGE version		
Short Description	FPGA version		
Minimum	0	Maximum	255
Default	N/A	Units	N/A
Type	8 bits volatile	Update Rate	Once on power up
Display Format	Standard	Decimal Places	0
Coding	BU, PT, NC, ND		

Pr.S.00.033 Disable drive control

S.00.033	Disable drive control		
Short Description	Prevent the option from controlling the drive motion function		
Minimum	0	Maximum	1
Default	0	Units	N/A
Type	1 bit volatile	Update Rate	Read every 40 ms
Display Format	Standard	Decimal Places	0
Coding	W		

To use the CiA402 motion profiles, this parameter shall be set to "OFF"; in this case the drive controlword and many other drive parameters related to the motor control are controlled by the option module and they should not be touched by the user. If this parameter is set to "ON", all drive parameters can be freely changed but the CiA402 specific objects will not be handled even if they are still mappable and accessible via SDO requests.

If the motor is running when the profiles are disabled, the fault reaction is activated: the profiles will be deactivated as soon the motor stops or immediately if the immediate disable fault reaction is configured.

10.3.2 Menu 1 VARAN

This menu provides information about the VARAN network.

Pr.S.01.001 NMT state

S.01.001	NMT state		
Short Description	Actual NMT state		
Minimum	-2	Maximum	4
Default	0	Units	N/A
Type	8 bits volatile	Update Rate	Background
Display Format	Standard	Decimal Places	0
Coding	PT, NC, TE		

It displays the actual NMT state, also reported to the PLC.

Value	Display text
-2	Error
-1	Off
0	Init
1	PreOperational
2	Operational
3	Stopping
4	Disabled

Table 10-1 NMT State

Pr.S.01.002 PDO accesses per second

S.01.002	PDO access per second		
Short Description	Number of PDO handled per second		
Minimum	0	Maximum	65535
Default	0	Units	N/A
Type	16 bits volatile	Update Rate	Every 2 s in background
Display Format	Standard	Decimal Places	0
Coding	BU, PT, NC		

It counts the average number of the handled PDO per second, in both directions.

Pr.S.01.003 RPDO Mapping status

S.01.003	RPDO Mapping status		
Short Description	Configuration status of the RPDO mappings		
Minimum	-5	Maximum	1
Default	0	Units	N/A
Type	16 bits volatile	Update Rate	On object 0x1600:00 update
Display Format	Standard	Decimal Places	0
Coding	PT, NC, TE		

The Pr.S.01.003 and Pr.S.01.004 report the actual status of the RPDO and TPDO mapping configurations, respectively.

Status		Description
Code	Display text	
-5	Error	Unexpected error (Reserved for debug purpose)
-4	Invalid Map Len	The mapping length of one or more entries in the configuration doesn't match the data size of the mapped object.
-3	Too big	The overall mapping size is higher than the maximum allowed
-2	Not mappable	The mapping configuration refers to a non-mappable object or to a rad only object
-1	Invalid object	A not existing object is mapped
0	Disabled	No mappings are configured or the NMT state is not PreOperational or Operational.
1	Ok	The mappings are valid and enabled: if the NMT Operational state is active, the cyclic data are exchanged with the PLC.

Table 10-2 Mapping status

Pr.S.01.004 TPDO Mapping status

S.01.004	TPDO Mappings status		
Short Description	Configuration status of the TPDO mappings		
Minimum	0	Maximum	
Default	0	Units	N/A
Type	8 bits volatile	Update Rate	Background
Display Format	Standard	Decimal Places	0
Coding	PT, NC, TE		

See Pr.S.01.003.

Pr.S.01.005 Mapped parameter xx.000

S.01.005	Mapped Parameter xx.000		
Short Description	Value which is mapped to parameter mm.000		
Minimum	0	Maximum	65535
Default	0	Units	N/A
Type	16 bits volatile	Update Rate	Background
Display Format	Standard	Decimal Places	0
Coding	BU, PT, NC		

The drive or options parameters can be accessed via the objects in the 0x2000 to 0x24FF range via SDO or PDO mappings. The subindex number normally correspond to a parameter number in a menu; the sub index 0 is however reserved to specify the highest parameter number in the menu (highest subindex number) so the mm.000 would be not accessible. The Pr.S.01.005 mirrors the mm.000 to also allow the parameter 0 to be accessed by the network. The Pr.mm.000 and Pr.S.01.005 are checked in background for changes: if one value is changed, it is copied to the other; the parameter mm.000 is evaluated first to be prioritized over the Pr.01.005 changes.

11 Diagnostics

11.1 Diagnostic parameters

11.1.1 Menu 9 Diagnostics

This menu contains general diagnostic parameters related to the hardware and the internal software status of the option module.

Pr.S.09.001 PDO loss counter

S.09.001	PDO loss counter		
Short Description	PDO loss cumulative error counter		
Minimum	0	Maximum	$2^{32}-1$
Default	0	Units	N/A
Type	32 bits volatile	Update Rate	Background
Display Format	Standard	Decimal Places	0
Coding	BU, PT, NC		

It displays the number of the PDO data loss event occurred, mirroring the value of the object 0x3001:01 (see 8.2.2). The counter can be reset set Pr.S.09.009 to "On" or writing zero in 0x3001:01.

Pr.S.09.002 Network timing errors counter

S.09.001	Network timing errors counter		
Short Description	Network timing errors counter		
Minimum	0	Maximum	$2^{32}-1$
Default	0	Units	N/A
Type	32 bits volatile	Update Rate	Background
Display Format	Standard	Decimal Places	0
Coding	BU, PT, NC		

It displays the number of the detected network timing violations, mirroring the value of the object 0x3002:02 (see 8.2.3). The counter can be reset set Pr.S.09.009 to "On" or writing zero in 0x3002:02.

Pr.S.09.009 Reset error counter

S.09.009	Reset error counters		
Short Description	Reset the PDO loss cumulative error counters		
Minimum	0	Maximum	1
Default	0	Units	
Type	1 bit volatile	Update Rate	Background Auto reset
Display Format	Standard	Decimal Places	0
Coding	BU, PT, NC, W		

The cumulative counters for the detected errors (Pr.S.09.001, Pr.S.09.002, objects 0x3001:02 and 0x3002:02) can be reset setting Pr.S.09.009 to "On".

Pr.S.09.030 PCB temperature

S.09.030	PCB temperature		
Short Description	Measured temperature		
Minimum	-128	Maximum	127
Default	N/A	Units	°C
Type	8 bits volatile	Update Rate	Background
Display Format	Standard	Decimal Places	0
Coding	PT, NC, ND		

It shows the temperature measured on the PCB surface, expressed in Celsius degrees.

11.2 Error handling

The following objects can be used to indicate the reason of an error condition:

Index	Name
1001	error_register
603F	error_code

11.2.1 0x1001 Error Register

0x1001	ErrorRegister			Object type: VAR
Sub-index 0			Range: 0...255	
Access: RO	PDO Map: TPDO		Data type: USINT	Unit: 0 -> 255
			Handling rate: 40 ms	Default: N/A
Description:	Active errors bitmask			

When the CiA402 fault reaction activates, or the CiA402 state immediately switches to FAULT, the user can obtain a general indication of the error cause from the object 0x1001. Each bit indicates a different error cause and it groups a range of errors reported by the object 0x603F.

Error register		Object 0x603F range
Bit	Description	
0	Generic error	0x0001 – 0x1FFF Or any other value not listed in this table but greater than zero
1	Current	0x2000 – 0x2FFF
2	Voltage	0x3000 – 0x3FFF
3	Temperature	0x4000 – 0x4FFF
4	Communication error	0x8100 – 0x8100
5	Device profile specific (unused)	-
6	Reserved (always 0)	-
7	Manufacturer specific	0xFF00 – 0xFFFF

Table 11-1 0x1001 Error register bits

11.2.2 0x603F Error code

0x603F	ErrorCode		Object type: VAR
Sub-index 0	Range: 0...65535		
Access: RO	PDO Map: TPDO	Data type: UINT	Unit: N/A
		Update rate: 40 ms	Default: N/A
Description:	Report active error conditions		

The cause that triggered the activation of the fault reaction is reported in the 0x603F object. The fault reaction is usually triggered by a trip but in some cases, it can be activated without a warning or a trip are signalled. The correspondences between the reason that caused the fault reaction and the error codes are listed in Table 11-2 **Table 9-1**. The trip codes indicated as S.nnn refer to an option module trip.

The object 0x603F is automatically cleared when the fault condition is reset.

Error category	Error Code	Trip Code or trigger condition
Error reset / No error	0x0000	0 None
Short circuit/earth leakage (device internal)	0x2230	5 PSU
		92 OI_SNUBBER
		3 OI_AC
Current, device output side	0x2340	228 OUTPUT_PHASE_U
		229 OUTPUT_PHASE_V
		230 OUTPUT_PHASE_W
		32 PHASE_LOSS
Phase failure	0x3130	98 OUT_PHASE_LOSS
DC link over-voltage	0x3210	2 OVER_VOLTS
Excess temperature drive	0x4310	21 OHT_INVERTOR
	0x4311	22 OHT_POWER
	0x4312	219 OHT_CONTROL
	0x4313	24 THERMISTOR
	0x4316	27 OHT_DC_BUS
	0x431F	S.213 OTH_OPTION_MODULE
Control device hardware	0x5200	200 SLOT1_HF
	0x5201	203 SLOT1_NOT_FITTED
	0x5202	204 SLOT1_DIFFERENT
	0x520C	236 NO_POWER_BOARD
Power section	0x5400	220 POWER_DATA
Contacts	0x5440	226 SOFT_START
RAM	0x5510	227 SUB_ARRAY_RAM_ALLOCATION
Data Storage (Non-volatile data memory)	0x5530	31 EEPROM_FAIL
		36 USER_SAVE
		37 POWER_DOWN_SAVE
Software reset (watchdog)	0x6010	30 WATCHDOG
Parameter Error	0x6320	199 DESTINATION
Brake Chopper (Over current brake chopper)	0x7112	4 OI_BRAKE
		19 BRAKE_R_TOO_HOT
		250 HOT_RECT_BRAKE
Motor	0x7120	11 AUTOTUNE_1
		13 AUTOTUNE_3
Motor error or commutation malfunction	0x7122	20 MOTOR_TOO_HOT
		25 TH_SHORT_CIRCUIT
		33 RESISTANCE
Sensor	0x7300	218 TEMP_FEEDBACK

Error category	Error Code	Trip Code or trigger condition	
Speed	0x7310	7	OVER_SPEED
Communication	0x7500	93	POWER_COMMS
	0x7600	175	CARD_PRODUCT
	0x7604	178	CARD_BUSY
	0x7605	179	CARD_DATA_EXISTS
	0x7606	180	CARD_OPTION
	0x7607	181	CARD_READ_ONLY
	0x7608	182	CARD_ERROR
	0x7609	183	CARD_NO_DATA
	0x760A	184	CARD_FULL
	0x760B	185	CARD_FILE_ERROR
	0x760C	186	CARD_RATING
	0x760D	187	CARD_DRIVE_MODE
	0x760E	188	CARD_COMPARE
Protocol error	0x8101	S.103	PDO_LOSS
	0x8102	S.106	NETWORK_CYCLE
	0x8107	Drive control disabled by Pr.S.000.33 (no trip)	
Generic trip related error	0xFF01	-	Any trip code not listed

Table 11-2 CiA 402 error codes

11.3 Drive trip display codes

Table shows the possible trip codes that will be displayed on the drive when SI-VARAN initiates a drive trip.

Trip codes

Code	Display text	Description
100	FPGA Config	The FPGA configuration image is invalid or unavailable; no VARAN functionalities are available. It should never happen except than during the manufacturing; Connect can be however used to program a new image and recover from the error condition.
101	FPGA update	FPGA update failed; the same behaviour of the option module as for the "FPGA Config" trip applies.
102	Invalid FPGA Ver	The FPGA version is not compatible with the software
103	PDO Loss	Too many PDO data lost
106	Network cycle	Too many network cycle time violations. It might also indicate a network link loss as the sync signalling is interrupted in this case.
200	Software Fault	Internal software fault
204	Drive Unsup-ported	The option module is fitted on an unsupported drive
213	Over Temperature	The device is overheated
221	Factory settings	The factory settings file is missing
224	Pwr on self-test	Power on hardware self-tests failed

Warning codes

Code	Display text	Description
1	Too hot	The temperature is over the warning limit

11.4 SDO abort codes

Abort code	Meaning
0x06010001	Attempt to read a write only object.
0x06010002	Attempt to write a read only object.
0x06020000	Object does not exist in the object dictionary.
0x06040041	Object cannot be mapped to the PDO.
0x06040042	The number and length of the objects to be mapped would exceed PDO length.
0x06070010	Invalid data length
0x06090011	Sub-index does not exist.
0x06090030	Invalid value
0x06090031	Value too high
0x06090032	Value too low
0x08000000	General error

Table 11-3 SDO abort codes

12 Glossary of terms

Address: This is the unique network identification given to a networked device to allow communication on a network. When a device sends or receives data the address is used to determine the source and the destination of the message.

Bit: A binary digit, this may have the value of 1 or 0.

Byte: A collection of eight binary digits that collectively store a value. This may be signed or unsigned.

Control word: A collection of binary digits that are used to control the drive. Features typically include directional controls, run controls and other similar functions.

Cyclic: Data that is transmitted at regular intervals over the network.

Data rate: Determines the communication speed of the network, the higher the value the more data can be sent across the network in the same time period.

Device: A piece of equipment connected to a network, this may be any type of equipment including repeaters, hubs, masters (Managing Node) or slaves (Controlled Nodes).

Double word: A 32-bit word, this may be signed or unsigned.

FPGA: Field Programmable Gate Array. Hardware device on the option module that provides the physical and data link network layers.

Grounding / Earthing: Describes the electrical safety or shielding connections for the module.

LED: Light emitting diode.

Long word: A 32-bit data word that may be signed or unsigned.

LSB: Least significant bit/byte.

MSB: Most significant bit/byte.

Node: A device on the network. This may be either a device such as a drive or part of the network such as a repeater.

Non cyclic data: Data that is requested or sent as required and not on a regular basis.

Octet: A collection of eight binary digits which form a byte.

PC: Personal computer.

PLC: Programmable logic controller.

Poll rate: The rate at which cyclic data is sent and received on the network.

Polled data: See *Cyclic data*.

Scan rate: See *Poll rate*.

Shielding: A connection to provide additional immunity to noise used on a network cable.

Status word: A value that denotes the status of the drive. Each bit within the word will have a specific meaning.

Word: A collection of sixteen binary digits.