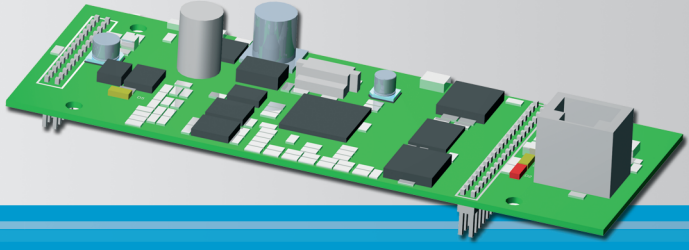
SD 700
Series

VARIABLE SPEED DRIVE



Communication Network

Ethernet Communication

POWER ELECTRONICS®

SD700 Series

VARIABLE SPEED DRIVE

Communication Network

Ethernet Communication

Edition: October 2008

SD70BC02CI Rev. C

SAFETY SYMBOLS

Always follow safety instructions to prevent accidents and potential hazards from occurring.

	This symbol means improper operation may results in serious personal injury or death.
	Identifies shock hazards under certain conditions. Particular attention should be given because dangerous voltage may be present. Maintenance operation should be done by qualified personnel.

Edition October 2008

This publication could present technical imprecision or misprints. The information here included will be periodically modified and updated, and all those modifications will be incorporated in later editions.
To consult the most updated information of this product you might access through our website www.power-electronics.com where the latest version of this manual can be downloaded.

Revisions

Date	Revision	Description
20 / 11 / 2007	A	First edition
11 / 03 / 2008	B	Logotype Adaptation
14 / 10 / 2008	C	Ethernet/IP available. New documentation

INDEX

ENGLISH

PART III – ETHERNET/IP PROTOCOL

SAFETY INSTRUCTIONS

IMPORTANT!

- Safety instructions showed in this manual are useful to teach user how to use the product in a correct and safety way with the purpose of preventing possible personal injuries or property damages.
- Safety messages included here are classified as it follows:

WARNING

Be sure to take ESD (Electrostatic Discharge) protection measures when you touch the board.
Otherwise, the optional board may get damaged due to static charges.

Implement wiring change on the optional board after checking that the power supply is off.
Otherwise, there is a danger of connecting error and damage to the board.

Be sure to connect correctly the optional board to the inverter.
Otherwise, there is a danger of connecting error and damage to the board.

Do not remove the cover while the power is applied or the unit is in operation.
Otherwise, electric shock could occur.

Do not run the inverter with the front cover removed.
Otherwise, you may get an electric shock due to the high voltage terminals or exposure of charged capacitors.

Do not remove the cover except for periodic inspections or wiring, even if the input power is not applied.
Otherwise, you may access the charged circuits and get an electric shock.

Wiring and periodic inspections should be performed at least 10 minutes after disconnecting the input power and after checking the DC Link voltage is discharged with a meter (below 30VDC).
Otherwise, you may get an electric shock.

Operate the switches with dry hands.
Otherwise, you may get an electric shock.

Do not use cables with damaged insulation.
Otherwise, you may get an electric shock.

Do not subject the cables to the abrasions, excessive stress, heavy loads or pinching.
Otherwise, you may get an electric shock.

CAUTION

Install the inverter on a non-flammable surface. Do not place flammable material nearby.
Otherwise, fire could occur.

Disconnect the input power if the inverter gets damaged.
Otherwise, it could result in a secondary accident or fire.

After the input power is applied or removed, the inverter will remain hot for a couple of minutes.
Touching hot parts may result in skin burns.

Do not apply power to a damaged inverter or to an inverter with parts missing even if the installation is complete.
Otherwise, fire or accident could occur.

Do not allow lint, paper, wood chips, dust, metallic chips or other foreign matter into the board or drive.
Otherwise, fire or accident could occur.

WARNINGS

RECEPTION

- Material of Power Electronics is carefully tested and perfectly packed before leaving the factory.
- In the even of transport damage, please ensure that you notify the transport agency and POWER ELECTRONICS: 902 40 20 70 (International +34 96 136 65 57) or your nearest agent, within 24hrs from receipt of the goods.

UNPACKING

- Make sure received merchandise corresponds with delivery note, models and serial numbers.
- Each board is supplied with a technical manual.

RECYCLING

- The packing of the drives must be recycled. For this reason it is necessary to separate different materials (plastics, paper, cardboard, wood, …) and settle them in corresponding containers.
- The residual parts of electrical devices must be collected in a selective manner in order to warranty the correct environmental treatment.

SAFETY

- Before operating the inverter, read this manual thoroughly to gain and understanding of the unit. If any doubt exists then please contact POWER ELECTRONICS, (902 40 20 70 / +34 96 136 65 57) or your nearest agent.
- Wear safety glasses when operating the inverter with power applied and the front cover is removed.
- Handle the inverter with care according to its weight.
- Install the inverter according to the instructions within this manual.
- Do not place heavy objects on the inverter.
- Ensure that the mounting orientation is correct.
- Do not drop the inverter or subject it to impact.
- The SD700 drives contain static sensitive printed circuits boards. Use static safety procedures when handling these boards.

CONNECTION PRECAUTIONS

- To ensure correct operation of the inverter it is recommended to use a SCREENED CABLE for the control wiring.
- For EMERGENCY STOP, make sure supply circuitry is open.
- Do not disconnect motor cables if input power supply remains connected. The internal circuits of the drive will be damaged if the incoming power is connected and applied to output terminals (U, V, W).
- It is not recommended to use a 3-wire cable for long distances. Due to increased leakage capacitance between conductors, over-current protective feature may operate malfunction.
- Do not use power factor correction capacitors, surge suppressors, or RFI filters on the output side of the inverter. Doing so may damage these components.
- Always check whether the DC Link LED is OFF before wiring terminals. The charge capacitors may hold high-voltage even after the input power is disconnected. Use caution to prevent the possibility of personal injury.

COMMISSIONING

- Follow the steps described in this manual.
- Always apply voltage and current signals to each terminal that are within levels indicated within this manual. Otherwise, damage to the optional board may result.

OPERATION PRECAUTIONS

- When the Auto Restart function is enabled, keep clear of driven equipment, as the motor will restart suddenly after a fault is reset.
- The “STOP / RESET” key on the keypad is active only if the appropriate function setting has been made. For this reason, install a separate EMERGENCY STOP push button that can be operated at the equipment.
- If a fault reset is made with the reference signal still present then a restart will occur. Verify that it is permissible for this to happen, otherwise an accident may occur.
- Do not modify or alter anything within the drive.
- Before programming or operating the SD700 Series, initialise all parameters back to factory default values.

EARTH CONNECTION

- The inverter is a high frequency switching device, and leakage current may flow. Ground the inverter to avoid electrical shock. Use caution to prevent the possibility of personal injury.
- Connect only to the dedicated ground terminal of the inverter. Do not use the case or the chassis screw for grounding.
- When installing, grounding wire should be connected first and removed last.
- The earth cable must have a minimal cross sectional area that meets local country electrical regulations.
- Motor ground must be connected to the drive ground terminal and not to the installation’s ground. We recommend that the section of the ground connection cable should be equal or higher than the active conductor.
- Installation ground must be connected to the inverter ground terminal.

PART I

ETHERNET BOARD

1. INTRODUCTION

1.1. Ethernet Network

1.1.1. Introduction

Ethernet is used to designate a family of frame-based computer networking technologies for local area networks (LANs) which is commonly used nowadays. It was mainly developed by Xerox Corporation, Intel Corporation and Digital Equipment Corporation (DEC) companies in 1980, and it continued evolving then.

Ethernet defines a number of wiring and signalling standards for the physical layer and the frame formats of the data link layer of the OSI model (Open System Interconnection) launched on 1984 and created by ISO (International Organization for Standardization).

Ethernet is the most commonly used LAN technology because allows a good balance between speed, cost and installation easiness. Additionally, it is very accepted in the market and supports all popular network protocols virtually.

The advantages of Ethernet networks are the following ones:

- Easy installation and maintenance, together with their low cost.
- Flexibility for interconnecting different topologies.
- Stable standard that allows interconnecting devices from different manufacturers.

For this, Ethernet is the ideal technology for the network of the most of the present computer users.

1.1.2. Types of Ethernet Networks

There are different implementations for Ethernet network, according to the physical environment referred. The existing Ethernet technologies differ in the following concepts:

- **Transmission speed:** Transmission capacity of the environment in Mbps.
- **Cable type:** Used technology of the physical layer.
- **Maximum length:** Maximum allowed distance between two adjacent nodes (without repeaters).
- **Typology:** It defines the performance of the central linking points.

Technology	Transmiss. speed	Cable type	Maximum distance	Typology
10Base2	10 Mbps	Coaxial	185m	Connector T
10BaseT	10 Mbps	Twisted Pair	100m	Hub or Switch
10BaseF	10 Mbps	Fibre Optics	2000m	Hub or Switch
100BaseTX	100 Mbps	Twisted Pair (5UTP category)	100m	Half Duplex (Hub) and Full Duplex (Switch)
100BaseT4	100 Mbps	Twisted Pair (3UTP category)	100m	Half Duplex (Hub) and Full Duplex (Switch)
100BaseFX	100 Mbps	Fibre Optics	2000m	Hubs use is not allowed
1000BaseSX	1000 Mbps	Fibre Optics (multi-mode)	550m	Full Duplex (Switch)
1000BaseLX	1000 Mbps	Fibre Optics (single-mode)	5000m	Full Duplex (Switch)
1000BaseT	1000 Mbps	Twisted Pair	100m	Full Duplex (Switch)

1.2. Description of Ethernet Board

The Ethernet board for SD700 drive allows it to connect to an Ethernet network (LAN – Local Area Net). It supports the standard TCP/IP communication protocol and the industrial application layer protocol Ethernet/IP for industrial automation applications.

Thanks to this board, the drive can be controlled and monitored by the user or through PLC sequence program or any master device (client).

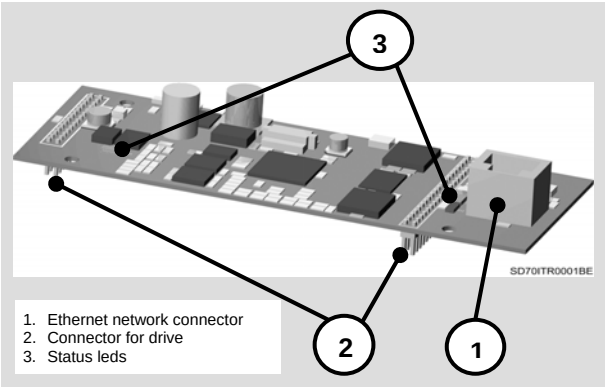


Figure PI-1.1 Description for Ethernet Board

2. TECHNICAL CHARACTERISTICS

2.1. General Information

2.1.1. Contents of Ethernet Board Kit

The kit of the Ethernet board contents:

- 1 Ethernet Board.
- 4 Plastic hexagonal spacers M3, male-female, 12mm, ref. M0191.
- 4 Plastic screws M3x10, ref. M0063.
- 4 Plastics nuts M3, ref. M0127.
- 1 Technical Manual.
- 1 CD with EDS file.

2.1.2. Specifications of Ethernet Board

- Device Type: Network adapter.
- Shape Factor: Inserted board.
- Wiring Type: Ethernet 10Base-T, Ethernet 100Base-TX.
- Data Exchange Protocol: Modbus TCP/IP, Ethernet/IP.
- Auto-addressing Protocol DHCP supported.
- Data Transmission Speed: 10Mbps, 100Mbps, Auto-negotiation 10 / 100.
- Standards: IEEE 802.3, IEEE 802.3u (only for 100Base-TX).
- Cable Lengths: Maximum 100m per network segment.

2.1.3. Local Indications

The Ethernet board includes 3 leds (D2, D3 and D5) that supplies information about the power supply of the board, network detection and communication status. To obtain more detailed information about leds, please, see section *'3.2.1. Description of Connectors and Leds'* .

2.1.4. Requirements

To establish communication with drives of SD700 Series via Modbus TCP/IP, the user should have one Modbus TCP/IP client. For example:

- PLC + Ethernet board for PLC + Client software Modbus TCP/IP
- PC + Ethernet board + Client application Modbus TCP/IP

To establish communication with drives of SD700 Series via Ethernet/IP, the user should have one client which supports Ethernet/IP protocol that supports at the same time:

- Explicit Connected Messaging: not-temporal information data (configuration, diagnosis, data collection).
- Connected I/O Messaging: I/O data online, functional safety data, motion control data.
- Unconnected Messaging: accessing to data without establishing connection.

3. INSTALLATION AND CONNECTION

3.1. Installation of Ethernet Board

The Ethernet board is directly connected to the drive of the SD700 Series from Power Electronics (through two connectors) with the purpose of integrating the equipment in an Ethernet local area network (LAN) with TCP/IP or Ethernet/IP as network protocol. Therefore, it will be necessary one Ethernet board for each equipment which is going to be connected to this network.

CAUTION

Motor controllers of Power Electronics operate with a high electric energy.
Make sure the power supply has been disconnected and wait for at least 10 minutes to guarantee that DC Link voltage is discharged, before installing the Ethernet board. Otherwise, you may get personal injuries or an accident could occur.

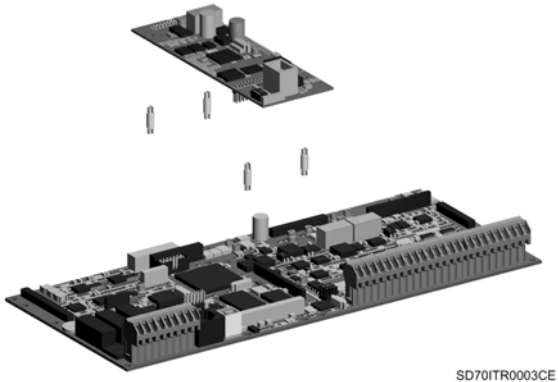


Figure PI-3.1 Installation of Ethernet Board in the drive

3.2. Connections for Ethernet Board

3.2.1. Description of Connectors and Leds

There are connectors and three leds on Ethernet board. Two connectors are used to connect the board to the SD700 drive. The other connector (RJ45) is used for the connection to the Ethernet network. On the other hand, the leds supply information about the input power of the board, network detection and communication status

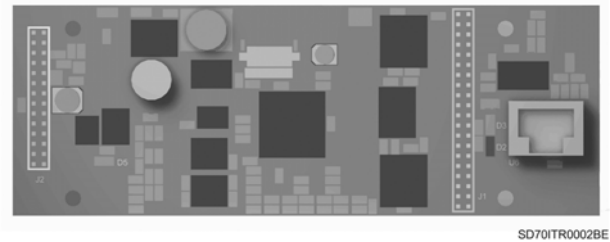


Figure PI-3.2 Location of connectors and leds on Ethernet Board

CONNECTOR / LED	DESCRIPTION
Drive Connector 1 (J1)	Through these connectors, the Ethernet board is connected to the SD700 drive.
Drive Connector 2 (J2)	
Connector for Ethernet Network (U6)	Connector RJ45 used for the connection of Ethernet network.
Led for Network Detection (D2 – Green)	Active when detecting a network of 10Mbps or 100Mbps. Deactivated if no network is detected.
Led for Data Transmission / Reception (D3 – Red)	Blinking when it is transmitting or receiving data. Deactivated if there is not data transmission or reception.
Led for Power Supply (D5 – Green)	Active when Ethernet board is powered on.

4. ETHERNET BOARD CONFIGURATION

After connecting the Ethernet board to the drive, a new parameter group called 'G21 NETWORKS', with the corresponding parameter subgroups, is available. The drive is configured to operate in an Ethernet network by means of this parameters setting.

4.1. Subgroup 21.1 – S21.1: ETHERNET

This parameter subgroup is used to configure the identification parameters of the drive in the Ethernet network (IP, Subnet Mask, Gateway), and the MAC address.

Parameter	Description	Range	Default value	Function	Set on RUN
1 AUTOMATIC IP=Y	G21.1.1 / To enable automatic assignation of parameters	N Y	Y	It allows the possibility of assigning the parameters automatically. OPT. – FUNCTION N=NO – The drive will take IP, Subnet Mask and Gateway addresses set by user from subgroup S21.1. Y=YES – The drive request and receives the parameters of the IP, Subnet Mask and Gateway addresses from the Network Server. To achieve this, it is used DHCP protocol.	YES
Ixxx.yyy.zzz.hhh	Present IP address of the drive	-	-	It shows the IP address assigned to the drive automatically or set by the user from the parameters G21.1.2, G21.1.3, G21.1.4 and G21.1.5.	-
Sxxx.yyy.zzz.hhh	Present Subnet Mask of the drive	-	-	It shows the Subnet Mask address assigned to the drive automatically or set by the user from parameters G21.1.6, G21.1.7, G21.1.8 and G21.1.9.	-

Parameter	Description	Range	Default value	Function	Set on RUN
Gxxx.yyy.zzz.hhh	Present Gateway of the drive	-	-	It shows de Gateway address assigned to the drive automatically or set by the user from parameters G21.1.10, G21.1.11, G21.1.12 and G21.1.13.	-
2 IP MANU. A=192[1]	G21.1.2 / IP address (A)	0 to 255	192	Setting of the IP address assigned to the equipment in the local network of the user. This address must be provided by the network administrator of the own user. The format of the IP address is the following one: A.B.C.D. Therefore, the setting of this address is realized by introducing a value in each parameter that configures the complete address, this is, by assigning a value to each one of the 4 parameters (from parameter G21.1.2 to the parameter G21.1.5).	YES
3 IP MANU. B=168[1]	G21.1.3 / IP address (B)	0 to 255	168		YES
4 IP MANU. C=1[1]	G21.1.4 / IP address (C)	0 to 255	1		YES
5 IP MANU. D=143[1]	G21.1.5 / IP address (D)	0 to 255	143		YES
6 SUBNET A=255[1]	G21.1.6 / Subnet Mask address (A)	0 to 255	255	Setting of the Subnet Mask address of the local network of the user. This address must be provided by the network administrator of the own user. The format of the Subnet Mask address is the following one: A.B.C.D. Therefore, the setting of this address is realized by introducing a value in each parameter that configures the complete address, this is, by assigning a value to each one of the 4 parameters (from parameter G21.1.6 to the parameter G21.1.9).	YES
7 SUBNET B=255[1]	G21.1.7 / Subnet Mask address (B)	0 to 255	255		YES
8 SUBNET C=255[1]	G21.1.8 / Subnet Mask address (C)	0 to 255	255		YES
9 SUBNET D=0[1]	G21.1.9 / Subnet Mask address (D)	0 to 255	0		YES

[1] This parameters will be only available if 'G21.1.1 AUTOMATIC IP = N'.

Parameter	Description	Range	Default value	Function	Set on RUN
10 GATEWAY A=0[1]	G21.1.10 / Gateway address (A)	0 to 255	0	Setting of the Gateway address of the local network of the user. This address is needed to the drive access to an external network. This address must be provided by the network administrator of the own user. The format of the Gateway address is the following one: A.B.C.D. Therefore, the setting of this address is realized by introducing a value in each parameter that configures the complete address, this is, by assigning a value to each one of the 4 parameters (from parameter G21.1.10 to the parameter G21.1.13).	YES
11 GATEWAY B=0[1]	G21.1.11 / Gateway address (B)	0 to 255	0		YES
12 GATEWAY C=0[1]	G21.1.12 / Gateway address (C)	0 to 255	0		YES
13 GATEWAY D=0[1]	G21.1.13 / Gateway address (D)	0 to 255	0		YES
14 MAC A=0	G21.1.14 / MAC address (A)	0 to 255	0	Setting of the MAC address. This address is unique and exclusive, and is associated to the LAN board / drive. It must be provided by Power Electronics. The format of the MAC address is the following one: A.B.C.D.E.F. This address should be unique and is assigned by the manufacturer. In case of Power Electronics: MAC A = 0 MAC B = 80 MAC C = 194 MAC D = 114 MAC E = X (any value from 0 to 255) MAC F = Y (any value from 0 to 255) Note: Check this during the trial run. If any part of the address does not match with the values above indicated, contact with Technical Department from Power Electronics which provides you with a MAC address and indicates you how to introduce it, in order to assure the correct operation.	YES
15 MAC B=80	G21.1.15 / MAC address (B)	0 to 255	80		YES
16 MAC C=194	G21.1.16 / MAC address (C)	0 to 255	194		YES
17 MAC D=114	G21.1.17 / MAC address (D)	0 to 255	114		YES
18 MAC E=X	G21.1.18 / MAC address (E)	0 to 255	X		YES
19 MAC F=Y	G21.1.19 / MAC address (F)	0 to 255	Y		YES

Note: Parameter subgroups 'S21.2 MODBUS TCP' and 'S21.3 ETHER./IP' are detailed in their corresponding section:
S21.2 ➔ 'PART II – 2. MODBUS TCP PARAMETERS SETTING'
S21.3 ➔ 'PART III – 6. ETHERNET/IP PARAMETERS SETTING'

[1] This parameters will be only available if 'G21.1.1 AUTOMATIC IP = N'.

PART II

TCP/IP PROTOCOL

5. INTRODUCTION

5.1. TCP/IP Protocol

TCP/IP (Transmission Control Protocol/ Internet Protocol) is a set of protocols which define a group of rules and premises that allow the interchange of information between heterogeneous systems by means of use of local area nets (LAN), wide area nets (WAN), telephonic public nets, etc. For example, Internet is really built over TCP/IP protocol. This protocol provides a safe connection that allows delivering bytes flow from one machine system to another without errors. The information to be sent will be divided in data strings, forming separate package that will be assembled in destination, managing at same time the control of flow.

5.1.1. Protocol TCP/IP Architecture

The TCP/IP protocol will be distributed in several lays or levels.

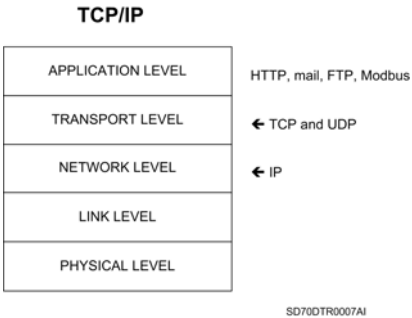


Figure PII-1.1 TCP/IP Protocol levels

These lays or levels are followings:

- **Application Level:** In this level, application that make easy the user life, are assembled. Between them, it is possible to point out some like email, Web navigator, FTP files interchange, Modbus, etc.
- **Transport Level:** This is in fact the level which allows that two TCP/IP connected systems could talk between them. In this level two type of protocols could operate:
  - TCP (Transmission Control Protocol), that provides a safe connection that allow delivering bytes flow from one machine system to another without errors. The global data is divided in separates packages that will be assembled again in destination. It also manages the control of flow.
  - UDP (User Datagram Protocol), this is a protocol not focused to connection, therefore it does not warranty the safe delivery of sent data. Generally, UDP is use when the application installed in the upper lay requires very short response times, and this is more important than the reliability of the delivery.
- **Net Level (IP):** The 'hosts' can enter package in the net which will arrive to destination in a separate way. There is no warranty of delivery or order (IP is not aimed to connection), it just administrates the routes of packages and controls the congestion.
- **Link Level:** Prepares date packages to be sent through the physical mean, solves collisions and it corrects packages errors or requests the resending of them.
- **Physical Level:** Defines the physical media types (pair of cables, coaxial cable, optic fibre cable, etc.) and defines the signal levels that will be entered on them.

The TCP/IP protocol has been designed to transfer huge date quantities between two systems.

5.2. MODBUS TCP/IP

MODBUS TCP/IP is a type or extension of Modbus protocol that allows using it over the transport lay TCP/IP. Therefore, Modbus TCP can be used in Internet.

There are many advantages for people who install lines and automation companies:

- To repair and to provide remote maintenance from the office using a PC, reducing costs and improving the service to customers.
- The user could access to the control system of the plant from any other part, avoiding displacements.
- It allows administrating systems which are distributed in several places by means of using Internet/Intranet technologies, currently available.

MODBUS TCP/IP has change into an industrial standard due to its simplicity , its low cost, its minimum requirements regarding to hardware components but above of this, because it is an open protocol. This protocol it is used for data interchange between devices, and it is used also for monitoring and administration. It also can be used to control peripheral inputs / outputs, being the most popular protocol between manufactures of this kind of components.

The combination of one versatile and scalable physical net as Ethernet, joint to the universal standard of inter-nets TCP/IP and one independent date representation of manufacturer as MODBUS TCP/IP, provide an open net, accessible for interchanging process data.

5.2.1. Modbus TCP/IP Protocol Description

Modbus messenger service provides a Client/Server communication between devices connected in Ethernet TCP/IP network.

This model of Client / Server is based on four types of messages:

- **MODBUS Request**
- **MODBUS Confirmation**
- **MODBUS Indication**
- **MODBUS Response**

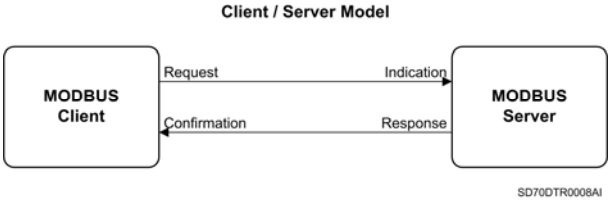


Figure PII-1.2 Modbus TCP/IP. Client / Server model

One MODBUS request is the message sent in the net by the Client to start one transaction.

One MODBUS Indication is the Request message received in the Server side.

One MODBUS Response is the Response message sent by the Server.

One MODBUS Confirmation is the response message received in the Client side.

The messenger services of MODBUS (Client/Server model) are used for the date interchange in real time:

- Between tow device applications.
- Between one device application and one device.
- Between HMI / SCADA applications and devices.
- Between on PC and one device program providing "on line" services.

One communication system over MODBUS TCP/IP can include different devices types:

- Devices of MODBUS TCP/IP Client and Server connected to one TCP/IP network.
- Interconnection devices such us bridges, routers or gateways to connect the TCP/IP network and one sub-net series line where there are MODBUS Client and Server series devices.

5.2.2. Modbus TCP/IP Protocol Architecture

The Modbus TCP protocol just encapsulates one Modbus frame in one TCP segment. TCP provides one service aimed to a reliable connection. That means that each request requires a response.

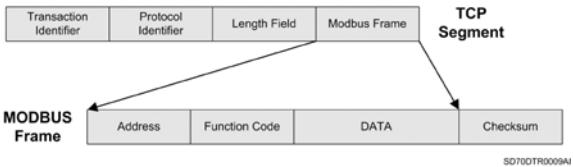


Figure PII-1.3 Modbus frame encapsulated in TCP

6. MODBUS TCP PARAMETERS SETTING

As it has mentioned before, MODBUS TCP/IP is a type or extension of Modbus protocol that allows using it over the transport lay TCP/IP. Therefore, Modbus TCP can be used in Internet.

In the drive SD700, there is a parameter group used to configure the drive to operate with Modbus TCP connected to an Ethernet network with TCP/IP protocol. Concretely, this is the parameter subgroup 'S21.2 MODBUS TCP' which is available when connecting the Ethernet board to the drive, and it is shown below.

6.1. Subgroup 21.2 – S21.2: MODBUS TCP

Note: Configure the Ethernet board before, by means of the parameters setting of subgroup '21.1 ETHERNET' (See section 'PART I – 4. ETHERNET BOARD CONFIGURATION').

See Modbus address list of the parameters of the drive in *'Getting Started Manual'* of the SD700 drive.

Parameter	Description	Range	Default value	Function	Set on RUN
1 MIPtout=OFF MODBUS TCP TOUT	G21.2.1 / Communication timeout	OFF=0 to 600s	OFF	When the equipment is powered, if this parameter is set to OFF (this means, set to some value), the drive will wait for the first communication frame during one minute without considering the set value. If during this minute a Modbus request is produced by the Master, the equipment will response, and from this moment on, the time without communication will be the value set in this parameter, but if during the first minute the equipment does not receive any correct Modbus frame, the drive will trip because of communication fault. Note: Do not modify the value of this parameter if it is not necessary.	YES

PART III

ETHERNET/IP PROTOCOL

1. INTRODUCTION

1.1. Ethernet/IP Protocol

Ethernet/IP is an industrial application layer protocol for industrial automation applications. This is built on the standard TCP/IP protocols and uses Ethernet hardware and software to define an application layer protocol to configure, to access and control industrial automation devices.

The Ethernet/IP application layer protocol is based on the Control and Information Protocol (CIP) layer used in DeviceNet and ControlNet. Ethernet/IP provides a total integrated system from the industrial floor to the company network.

On the factory floor, controllers must access to data from drive systems, workstations, and I/O devices. In normal operation, software makes the user wait while a task is being performed. On the other hand, factory floor data is time sensitive and requires real-time communications.

Ethernet/IP is an application layer protocol that was designed for the industrial environment. It is the finished product from four groups that have joined forces to develop and promote for industrial automation applications: The Open Device Vendor Association (ODVA), the Industrial Automation Open Networking Alliance (IOANA), Control Net International (CI) and the Industrial Ethernet Association (IEA).

1.1.1. Ethernet/IP Technology

It is introduced at the beginning of 2000, Ethernet/IP is one of the pioneers in Ethernet solutions for industrial environment. The main reason for this it is based on open technology, using the same application layer than DeviceNet and ControlNet, and it is called Common Industrial Protocol (CIP). This offers many advantages to users and automation manufacturers, such as a low cost product development, easy to use, simple integration of devices and networks and interoperability among suppliers.

As it has been mentioned before, Ethernet/IP uses an open protocol as application layer (CIP). Therefore, Ethernet/IP network can be defined as the application protocol CIP implemented in an Ethernet TCP/IP. For example, DeviceNet is CIP implemented in a CAN network (Controller Area Network).

Regarding the operation, Ethernet/IP use TCP/IP to send explicit messages, where each package has application data and includes the data meaning and the service to be executed over data. With explicit messages the nodes have to interpret each message, execute the request task and generate responses. This type of messages is variable in size and frequency, and they are used to configure devices and make diagnosis.

Ethernet/IP also uses the standard transport service User Datagram Protocol/Internet Protocol (UDP/IP, part of TCP/IP), which provides high performance and functionality of multicast messaging in real time, also known as I/O messaging.

With I/O messages, the application data field only contents input/output data in real time. The meaning of data is linked to an identifier defined at the beginning when establishing the connection, reducing the processing time in the node at execution time. This type of messages has a high efficiency, is short and provides the needed performance to do a real-time control.

As both protocols are used, TCP/IP and UDP/IP, to encapsulate the messages, Ethernet/IP can be used in control and information applications.

1.2. CIP Protocol

The basis of the integration of real business networks lies in the application layer. The CIP protocol (Common Industrial Protocol) has been designed for this purpose. It is based on a single platform independent of communications means and protocols. It allows reducing the costs of engineering and installation optimizing profits.

This protocol covers a broad range of messages and services for many manufacturing applications (control, safety, synchronization, motion, configuration and verification). The CIP protocol allows users to integrate these manufacturing applications with business networks and Internet. This means that unified communications architecture can be used in the companies, benefiting them by using open networks.

The CIP standard organizes devices in network as objects collection (or elements) and defines the accesses, attributes and extensions, with which it can be access to a broad range of mechanisms by means of the utilization of a protocol in common.

The CIP model is, on the upper layers, a model only focused to objects. Each object has attributes (data), services (instructions), connections and behaviours (relations between the values of the attributes and the services). In the objects, it is introduced the basic functions of:

- Communications
- Files transference
- Devices control

Many broad libraries of commonly used objects which can be set in several devices allow them to operate together. The group of objects set in a device is known as the 'model' of the device. This model is the basis for the direct communication between the devices that generate signals and the devices which are receivers, without the need to do repeated sendings from one origin to several destinations.

When using devices from different suppliers, the devices profiles are employed. These profiles are specific objects collections. In this way, all devices with the same profile operate in the same way. The profiles content besides objects, the configuration options and the input/output formats.

The layers of this model are:

- Devices profiles
- Objects library
- Data services
- Router functions for packages

As this model is independent of the communication means, it allows selecting the required network type, being possible to operate jointly and exchange different network types such as Ethernet/IP or ControlNet or DeviceNet.

1.2.1. CIP Protocol to Ethernet/IP

The advantages of the CIP protocol layer over Ethernet/IP are abundant. Offering consistent device access means that one configuration tool can be used to configure CIP devices on different networks from one access point without proprietary software. Classifying all devices as objects decreases the training and start-up costs required when new devices are incorporated into the network.

Ethernet/IP reduces response times and increases the capacity to transfer data regarding DeviceNet or ControlNet networks. Ethernet/IP links different industrial devices from bus level, to the control level, and to the enterprise level with a consistent application interface.

2. CIP OBJECTS

Next, the different objects implemented by the drive are listed. In order to obtain detailed information about these objects and attribute, refer to the CIP specifications.

Table 1: Supported Objects

S. No	Name	Class ID
1.	Identity Object	0x01
2.	Message Router Object	0x02
3.	Assembly Object	0x04
4.	Connection Manager Object	0x06
5.	Parameter Object	0x0F
6.	Parameter Group Object	0x10
7.	Motor Data Object	0x28
8.	Control Supervisor Object	0x29
9.	AC Drive Object	0x2A
10.	PE Status Object (Power Electronics)	0x65
11.	TCP/IP Object	0xF5
12.	Ethernet Link Object	0xF6

The objects and the implemented attributes are listed below.

2.1. Identity Object

Instance number 1 is implemented for this standard object and the following attributes are supported.

Table 2: Identity Objects Attributes

Attribute	Description	Type	GET/SET	Value
1	Vendor ID	UINT	Get	1104: Power Electronics
2	Device Type	UINT	Get	2: AC Drive
3	Product Code	UINT	Get	700
4	Revision	STRUCT of:	Get	
	Revision (High Byte)	UINT		1
	Revision (Low Byte)	UINT		1
5	Status	WORD	Get	Drive Status
6	Serial Number	UDINT	Get	0x12345678
7	Product Name	SHORT_STRING	Get	PESD700Drive

2.2. Message Router Object

This object is implemented.

2.3. Assembly Object

This is the only object that can support the I/O connection. The following instances are supported by the drive.

Table 3: Supported Assembly Objects Instances

Instance Number		Type	Size	Name
Decimal	Hex.	Input / Output	(bytes)	
20	14	Output	4	Basic Speed Control
21	15	Output	4	Extended Speed Control
70	46	Input	4	Basic Speed Control Status
71	47	Input	4	Extended Speed Control Status
100	64	Input	8	PE SD700 Basic Status
101	65	Output	8	PE SD700 Basic Control
150	96	Input	40	PE SD700 Extended Status

The format of the attributes is given below:

Table 4: Assembly Object Instances Format

Instance	Bit / Byte	7	6	5	4	3	2	1	0
20	0						Fault Reset		Run Fwd
	1								
	2	Speed Reference (Low Byte) – RPM							
	3	Speed Reference (High Byte) – RPM							
21	0		NetRef	NetCtrl			Fault Reset	Run Rev	Run Fwd
	1								
	2	Speed Reference (Low Byte) – RPM							
	3	Speed Reference (High Byte) – RPM							
70	0						Running 1 (Fwd)		Faulted
	1								
	2	Actual Speed (Low Byte) – RPM							
	3	Actual Speed (High Byte) – RPM							

Instance	Bit / Byte	7	6	5	4	3	2	1	0
71	0	At Ref	Ref from Net	Ctrl from Net	Ready	Running 2 (Rev)	Running 1 (Fwd)	Warning	Faulted
	1	Drive Status							
	2	Actual Speed (Low Byte) – RPM							
	3	Actual Speed (High Byte) – RPM							
100	0	Fault	Alarm	Ready	At Ref	Reset Active	Running 2 (Rev)		Running 1 (Fwd)
	1	Hi Bus Voltage	Drive Over Cur	Relay 3	Relay 2	Relay 1	Local / Remote	Motor Over-load	Drive Over-load
	2	Actual Speed (Low Byte) – RPM							
	3	Actual Speed (High Byte) – RPM							
	4	Actual Torque (Low Byte) – Nm							
	5	Actual Torque (High Byte) – Nm							
	6	Output Current (Low Byte) – in 100mA							
	7	Output Current (High Byte) – in 100mA							
101	0							Run Rev	Run Fwd
	1								
	2	Speed Reference (Low Byte) – RPM							
	3	Speed Reference (High Byte) – RPM							
	4								
	5								
	6								
	7								

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Instance	Bit / Byte	7	6	5	4	3	2	1	0
150	0	Fault	Alarm	Ready	At Ref	Reset Active	Running 2 (Rev)		Running 1 (Fwd)
	1	Hi Bus Voltage	Drive Over Cur	Relay 3	Relay 2	Relay 1	Local / Remote	Motor Over-load	Drive Over-load
	2	Fault Code (Low Byte) – (Vendor Specific)							
	3	Fault Code (High Byte) – (Vendor Specific)							
	4	Actual Speed (Low Byte) – RPM							
	5	Actual Speed (High Byte) – RPM							
	6	Output Voltage (Low Byte) – V							
	7	Output Voltage (High Byte) – V							
	8	Output Power (Low Byte) – in 0.1kW							
	9	Output Power (High Byte) – in 0.1kW							
	10	Partial Counter – Operation Time in days (Low Byte)							
	11	Partial Counter – Operation Time in days (High Byte)							
	12	Partial Counter – Operation Time in hours							
	13	Reserved							
	14	Output Current (Low Byte) – in 100mA							
	15	Output Current (High Byte) – in 100mA							
	16	Actual Torque (Low Byte) – Nm							
	17	Actual Torque (High Byte) – Nm							
	18	DC Bus Voltage (Low Byte) – V							
	19	DC Bus Voltage (High Byte) – V							
	20	Cos Phi (Low Byte)							
	21	Cos Phi (High Byte)							
	22	Motor Temperature (Low Byte) – in %							
	23	Motor Temperature (High Byte) – in %							
	24	L1 Input Voltage (Low Byte) – V							
	25	L1 Input Voltage (High Byte) – V							

Instance	Bit / Byte	7	6	5	4	3	2	1	0
150	26	L2 Input Voltage (Low Byte) – V							
	27	L2 Input Voltage (High Byte) – V							
	28	L3 Input Voltage (Low Byte) – V							
	29	L3 Input Voltage (High Byte) – V							
	30	L1 Input Frequency (Low Byte) – Hz							
	31	L1 Input Frequency (High Byte) – Hz							
	32	L2 Input Frequency (Low Byte) – Hz							
	33	L2 Input Frequency (High Byte) – Hz							
	34	L3 Input Frequency (Low Byte) – Hz							
	35	L3 Input Frequency (High Byte) – Hz							
	36	IGBT Temperature (Low Byte) – Cº							
	37	IGBT Temperature (High Byte) – Cº							
	38	Internal Temperature (Low Byte) – in 0.01ºC							
	39	Internal Temperature (High Byte) – in 0.01ºC							

2.4. Connection Manager Object

This object is implemented and is responsible for establishing Explicit and I/O connections with the drive.

2.5. Parameter Object

The object model has all the non-debug MODBUS register mapped as parameter instances. All the instances are either of type UINT or INT and of type GET/SET depending up on the MODBUS registers parameters.

The following attributes are supported for every instance.

Table 5: Supported Parameter Object Attributes

Attribute Number	Access	Data Type	Description
1	Set (only if it is a Read / Write parameter)	Depends on Attributes 4, 5, 6	Actual value of the parameter
2	Get	USINT	Link Path Size
3	Get	Packed EPATH	Link Path
4	Get	WORD	Descriptor
5	Get	EPATH	Data Type
6	Get	USINT	Data Size

Note: See section '5.1 Parameter Object Instances' for further information about the supported instances.

2.6. Parameter Group Object

All the parameter instances are grouped as parameter groups. Only Attribute 1 (Group Name String) and Attribute 2 (Number of Members in group) are supported apart from the Parameter Instance numbers starting from Attribute ID 16.

Table 6: Supported Parameter Group Instances

Instance No.	Parameter Group	Number of Parameter Objects
1.	Motor Control Registers	20
2.	DC Brake Registers	6
3.	Digital Input Registers	10
4.	Multi-reference Setpoints Registers	7
5.	Inch Speed Registers	3
6.	Limit Registers	9
7.	Speed Reference Registers	3
8.	Skip Speed Registers	3
9.	PID control Registers	8
10.	Motor / Drive Status Registers	84
11.	Analogue Input Registers	34
12.	Nameplate Registers	10
13.	Comparator Registers	27
14.	Active Algorithm Registers	10
15.	Analogue Output Registers	10
16.	Digital Output Registers	12
17.	Ethernet TCP IP Registers	18
18.	Acc/Dec Rates Registers	12
19.	Communication Registers	6
20.	Fault Registers	7
21.	Protection Registers	12
22.	Encoder Registers	2
23.	Motor Parameters Registers	11
24.	Load Parameters Registers	9
25.	Control Type Registers	4

Instance No.	Parameter Group	Number of Parameter Objects
26.	Options Registers	14
27.	Miscellaneous Registers	9
28.	Auto Reset Registers	8
29.	Pulse Input Registers	8
30.	Tuning Registers	7
31.	Profibus CAN Interface Registers	3
32.	Ethernet Control and Status Registers	18
33.	MODBUS TCP/IP Registers	1
34.	CIP Registers	3

For example, the MODBUS register of parameter 'G.9.1.1 ➔ Source selection for Comparator 1' in address 40302 is mapped to Parameter Instance 225, and it is the first placed in the Parameter Group 'Comparator Registers' numbered 13.

In the same way, the MODBUS register of parameter 'G4.1.5 ➔ Multi-function Digital Input 1 configuration' is placed fifth in the Parameter Group numbered 3 and called 'Input Digital Registers'.

2.7. Motor Data Object

Instance number 1 is implemented for this standard object and the following attributes are supported.

Table 7: Motor Data Object Instances

Attribute	Description	Type	GET / SET	Value
3	Motor Type	USINT	Get	0: Non Standard
6	Rated Current	UINT	Set	Rated Stator Current Units: 100mA
7	Rated Voltage	UINT	Set	Rated Base Voltage Units: V

2.8. Control Supervisor Object

Instance number 1 is implemented for this standard object and the following attributes are supported.

Table 8: Control Supervisor Object Instances

Attribute	Description	Type	GET / SET	Value
3	Run1	BOOL	Set	RUN_FWD Command
4	Run2	BOOL	Set	RUN_REV Command
5	NetCtrl	BOOL	Set	RUN/STOP Control 0: Local Control 1: Network Control
6	Status	USINT	Get	Drive Status. 0: Vendor Specific 1: Start-up 2: Not Ready 3: Ready 4: Enabled 5: Stopping 6: Fault Stop 7: Faulted
7	Running1	BOOL	Get	Drive Running RUN_FWD
8	Running2	BOOL	Get	Drive Running RUN_REV
9	Ready	BOOL	Get	1: Ready or Enabled or Stopping 0: Other Status
10	Faulted	BOOL	Get	1: Fault (latched) 0: No Faults Present
11	Warning	BOOL	Get	1: Warning (not latched) 0: No Warnings Present
12	FaultRst	BOOL	Set	0 → 1: Fault Reset 0: No action
13	Fault Code	UINT	Get	Currently Active Fault Code. See section '5.2 PE – CIP Fault Code Mapping.

Attribute	Description	Type	GET / SET	Value
14	WarnCode	UINT	Get	Currently Active Warning Code. See section '5.3 PE – CIP Warning Code Mapping.
15	CtrlFromNet	BOOL	Get	Status of RUN/STOP Control Source. 0: Control is Local 1: Control is from Network
17	Force Fault	BOOL	Set	0 → 1: Fault F41 forced
18	Force Status	BOOL	Get	Status of the forced fault. 0: Not Forced 1: Forced

2.9. AC Drive Object

Instance number 1 is implemented for this standard object and the following attributes are supported.

Table 9: AC Drive Object Instances

Attribute	Description	Type	GET / SET	Value
3	AtReference	BOOL	Get	1: Drive at actual reference
4	NetRef	BOOL	Set	Configuration of torque or speed reference mode setting (local or from Network). 0: Reference setting not from Network 1: Reference setting from Network
6	Drive Mode	USINT	Get	0: Vendor specific mode

Attribute	Description	Type	GET / SET	Value
7	SpeedActual	UINT	Get	Actual drive speed
8	SpeedRef	UINT	Set	Speed Reference (RPM)
9	CurrentActual	INT	Get	Actual phase current in 100mA
10	CurrentLimit	INT	Set	Current limit in 100mA
11	TorqueActual	INT	Get	Actual torque in Nm
15	PowerActual	INT	Get	Actual output power in W (scaling used – see Attribute 26)
16	InputVoltage	INT	Get	Input voltage in V
17	OutputVoltage	INT	Get	Output voltage in V
18	AccelTime	UINT	Set	Time for 0 to max. speed in ms
19	DecelTime	UINT	Set	Time from max. speed to 0 in ms
20	LowSpdLimit	UINT	Get	Minimum speed in RPM
21	HighSpdLimit	UINT	Get	Maximum speed in RPM
26	PowerScale	SINT	Get	Fixed to -6. Power = PowerActual/$2^{(-6)}$ = PowerActual · 64
29	RefFromNet	BOOL	Get	Status of torque / speed reference. 0: Local torque / speed reference 1: Network torque / speed reference

2.10. PE Status Object (Power Electronics)

Instance number 1 is implemented for this vendor specific object with class code 0x65 and the following attributes are supported.

Table 10: PE Status Object Instances

Attribute	Description	Type	GET / SET	Value
1	DriveStatus	WORD	Get	Status of the Drive (see Table 11: Drive Status Field Description).
2	SpeedFeedback	INT	Get	Feedback Speed in RPM
3	TorqueFeedback	INT	Get	Torque Feedback in Nm
5	SpeedReference	INT	Get	Reference Speed in RPM
6	OutputFrequency	INT	Get	Actual Speed in RPM
7	OutputCurrent	INT	Get	Output Current in 100mA
8	OutputPower	INT	Get	Actual Output Power in W
9	DCBusVoltage	UINT	Get	DC Bus Voltage in V
10	FaultCode	UINT	Get	PE Fault Code
11	WarnCode	UINT	Get	PE Warning Code
12	DigitalInputStatus	WORD	Get	Status of the Digital Inputs
13	AnalogInput1Status	INT	Get	AIN1 Channel Value in 8192 base
14	AnalogInput2Status	INT	Get	AIN2 Channel Value in 8192 base

Description of the Drive Status byte is given in the table below.

Table 11: Drive Status Byte Description

Bit	Name	Description
0	RunFwd	Activated when the drive is running forward.
1	Reserved	Always 0.
2	RunRev	Activated when the drive is running reverse.
3	Reseting	Activated when a reset command is active.
4	AtSetSpeed	Activated when the drive is running at the reference speed.
5	InverterReady	Activated when the drive is ready to run.
6	Alarm	Activated when any of the warning conditions is active.
7	Fault	Activated when any fault is active.
8	Reserved	Always 0.
9	PowerLost	Activated when the power to the motor is removed.
10	Local/Remote	Activated when the control mode is Remote.
11	Relay 1	Status of Relay 1.
12	Relay 2	Status of Relay 2.
13	Relay 3	Status of Relay 3.
14	PTC	PTC Status.
15	Reserved	Always 0.

2.11. TCP/IP Object

Instance number 1 is implemented for this standard object and the following attributes are supported.

Table 12: TCP/IP Object Instances

Attribute	Description	Type	GET / SET	Value
1	Status	DWORD	Get	Bit 0: Not configured Bit 1: Configured
2	Configuration	DWORD	Get	Bit 1: DHCP Client Bit 4: Settable Configuration
3	Capability	DWORD	Set	Bit 0 – 3: Start-up Configuration
4	Physical Link	STRUCT	Get	Path (Word): EPATH
5	Interface Configuration	STRUCT	Get	IP address

2.12. Ethernet Link Object

Instance number 1 is implemented for this standard object and the following attributes are supported.

Table 13: Ethernet Link Object Instances

Attribute	Description	Type	GET / SET	Value
1	Interface Speed	UINT	Get	10/100
2	Interface Flags	UINT	Get	Bit 0: Link Status Bit 1: 0: Half Duplex 1: Full Duplex
3	Physical Address	ARRAY of 6 USINTs	Get	Assigned MAC address

3. ACCESSING TO CIP OBJECTS

To the implemented CIP objects can be accessed by using the *'Unconnected Messaging Manager'* (UCMM). Also they can be accessed by using the Explicit connection and I/O connection.

3.1. Communication Timeout

Once the connection is established to the drive, the CIP stack continuously monitors the connection for activity. If there is no data received for the time specified in the Inactivity Timer and that the connection is not re-established with in about 3 seconds, the stack stops the drive and trips on fault 'F60 ETH.IP T.OUT' (Ethernet/IP communication). This behaviour reflects the requirement when the NetFaultAttribute of the Control Supervisor objects not implemented. The Inactivity Timer is initialized to a value 'Expected Packed Rate' multiplied by the 'Connection Timeout Multiplied' during the establishment of the connection.

The following sections describe the access to the CIP objects using the Windows based EIPScan application.

3.2. Communication Settings

The following steps explain the procedure to prepare the setup for running the Ethernet/IP stack.

- Load the software with Ethernet/IP support to the drive and connect the Ethernet board.
- The RED LED on the network board indicates the Ethernet link status and the GREEN LED indicates activity.
- Configure the IP address using DHCP protocol or manual assignment.
- *'Ping on'* to the device to make sure it is in the network.
- Open the EIPScan application and add the device using the *'Add Device'* option. The device name should be displayed as 'PESD700Drive'.

3.3. Unconnected Messaging

The CIP protocol allows accessing to CIP object without establishing the connection. This can be done using the *'Unconnected Messaging Manager'* (UCMM) as follows:

- In the UCMM tab, introduce the code of the service to be executed.
- Introduce the other service specific data and press the *'Send Request'* icon to execute the service.

For example, in order to read the actual speed of the drive, the Attribute 7 of the AC drive object is to be read. The steps to be followed are:

- Set the service code to 0xE for *'Get Single Service'*.
- Set the class code as 0x2A for the AC Drive object.
- Set the Instance to 1.
- Set the Attribute value to 7.
- Press the *'Send Request'* button.

The attribute value is displayed in the *'Response'* field.

To set the reference speed of the drive, the Attribute 8 of the AC Drive object should be written. The steps involved are:

- Set the service code to 0x10 for *'Set Single Service'*.
- Set the class code as 0x2A for the AC Drive object.
- Set the Instance to 1.
- Set the Attribute value to 8.
- Introduce the Speed in RPM, swapped and separated by blank, in the *'Request Data'* field.

  For example, introduce 0x500 ➔ 00 05 to set the RPM as 1280.
- Press the *'Send Request'* button.

The attribute value is updated to the introduced data.

3.4. Explicit Connected Messaging

The drive supports Class 3 connection for explicit connected communication. Follow the next steps:

- Right click on the added device and add Class 3 connection.
- Introduce a suitable name.
- Introduce the service to be executed and the parameters in the *'Message Parameters'* tab.
- Press OK to finish the configuration of the connection.

The EIPScan establishes the Class 3 connection and continually send the configured message over the connection.
The response is displayed in the *'named'* tab after the connection.

3.5. Connected IO Messaging

The drive supports Class 1 connection for I/O communication. Currently, only the Assembly Instances described before (20, 21, 70, 71, 100, 101 y 150) can be accessed over the connection.

The steps to be followed are:

- Right click on the added device and add Class 1 connection.
- Configure the Transport Types as *'Point to Point'* or *'Multicast'* for both O ➔ T and T ➔ O connections.
- Set the data size properly. The size can be obtained from the '*Table 3: Supported Assembly Object Instances'* (for example, configure size as 4 for 20 and 70). RUN/IDLE header must be set for O ➔ T and cleared for T ➔ O.
- Only *'Cyclic Trigger'* is supported.
- In the *'Destination'* tab, clear the entry corresponding to the Configuration Connection Instance as the drive does not support any.
- Set the O ➔ T connection point with the Input Instance number (either as 20, 21 or 101) depending on the requirement.
- Set the T ➔ O connection point (either as 70, 71 100 or 150) depending on the requirement.
- Press OK to establish the connection.

Once the connection is established, the data read from the drive is shown in the blue font.

Data to be sent to the drive is given in green font. This data can be modified and the drive will operate according to the new changes.

3.6. Controlling RUN/STOP and Speed Reference

The MODBUS registers CIP_NET_CTRL and CIP_NET_REF can be used to configure the control mode of the drive.

The possible values of the CIP_NET_CTRL register (address 1400) are:

Value	Description
0	The RUN/STOP control resides in the drive.
1	The CIP protocol controls the drive.
2	The NETCtrl bit in the Control Supervisor object determines the control mode.

The possible values of the CIP_NET_REF register (address 1401) are:

Value	Description
0	The Speed Reference is determined by the drive.
1	The CIP protocol controls the Speed Reference.
2	The NETRef bit in the AC Drive object determines the Speed Reference.

4. COMMISSIONING OF THE SD700 IN AN ETHERNET/IP NETWORK

4.1. Introduction

This chapter tries to help the user for configuring the Allen Bradley PLC family to control and monitor a drive of SD700 Series.

4.2. Using the Tools RSLINX, RSLOGIX 5000

RSLINX

Open the RSLINX application and configure the necessary driver, let it run.

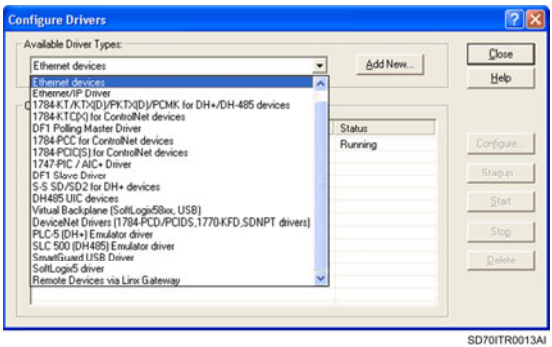

Figure PIII-4.1 Driver configuration screen

Browse the Network (Local), to find the rest of the Network components.

RSLOGIX 5000

Open the RSLOGIX application and create a new project from the menu bar, then choose the appropriated controller. Then click OK.

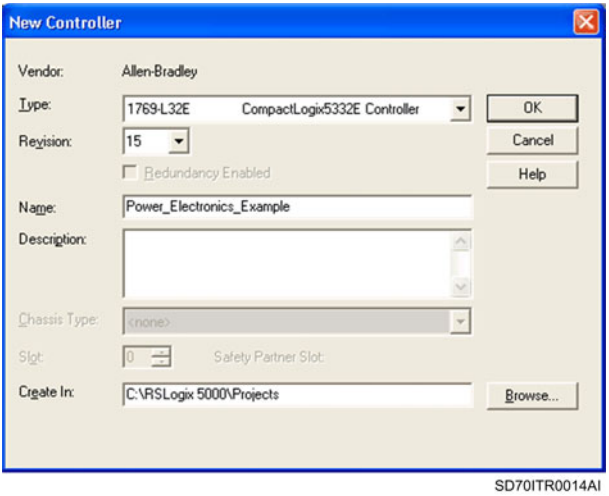

Figure PIII-4.2 Controller selection screen

Next, we will add the SD700 in the I/O configuration.

Use the Ethernet/IP employed in the project. Press right click and enable new module.

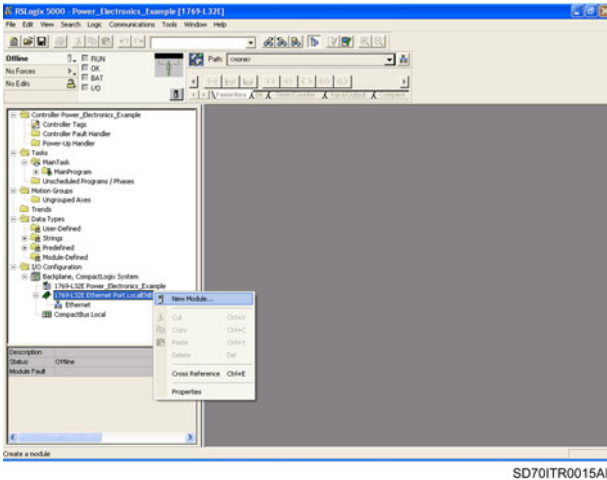

Figure PIII-4.3 Screen for Enabling new module

Then, introduce the associated data to the I/O device, for the SD700 drive select 'ETHERNET-MODULE' and press OK.

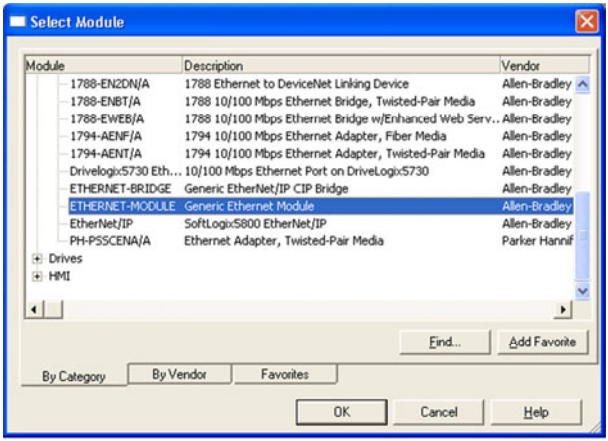

Figure PIII-4.4 Module selection screen

Now, fill up the module properties, name and drive descriptions, the IP address, the assembly instances.

Example for Instances 70, 20.

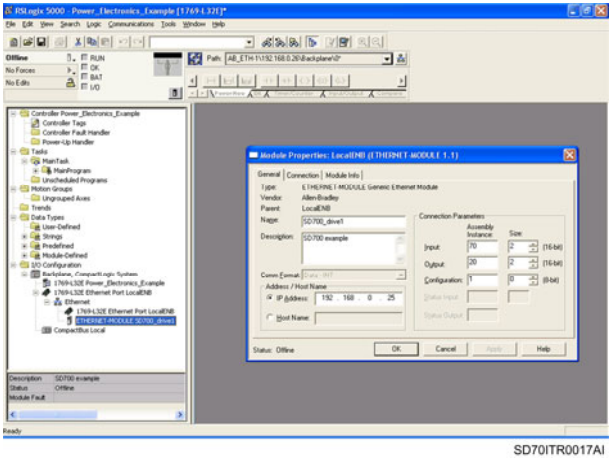

Figure PIII-4.5 Module properties. Screen 1

Example for Instances 71, 21.

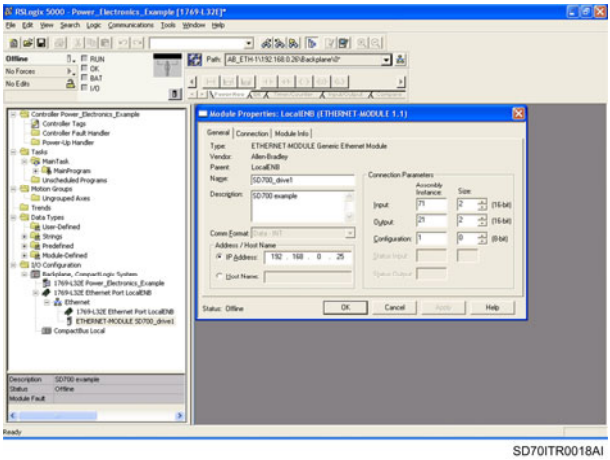

Figure PIII-4.6 Module properties. Screen 2

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Click in the connection tab to configure the *'Requested Packet Interval'*.

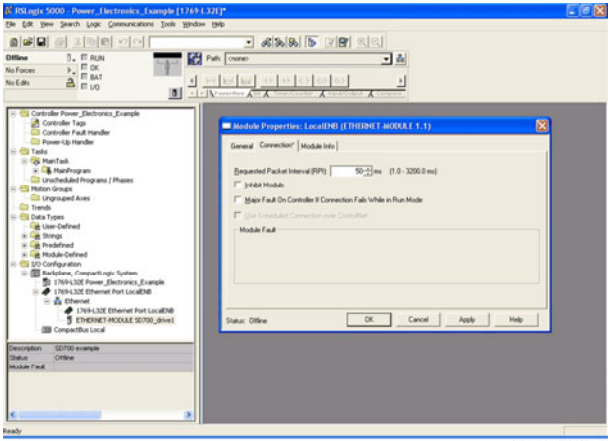

Figure PIII-4.7 Module properties. Screen 3

Next, click on 'OK' and the I/O configuration will be completed.

You should visualize a screen like this:

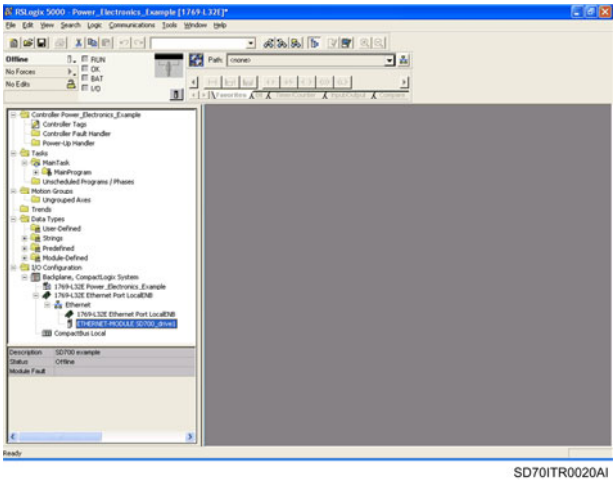

Figure PIII-4.8 Configured module screen

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Then, go online, download the project into the PLC and check that the new module is operating correctly.

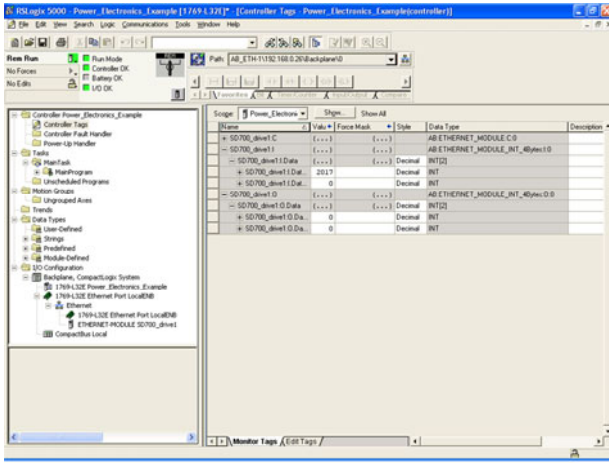

Figure PIII-4.9 Online connection screen. 'Controller tags' using Instances 70, 20 or 71, 21

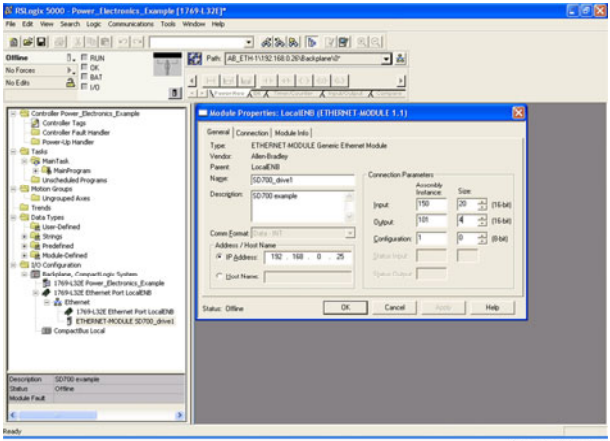

Figure PIII-4.10 Online connection screen. Instances 150, 101

EXPLICIT MESSAGES CONFIGURATION

The user can configure explicit messages to communicate with the SD700.

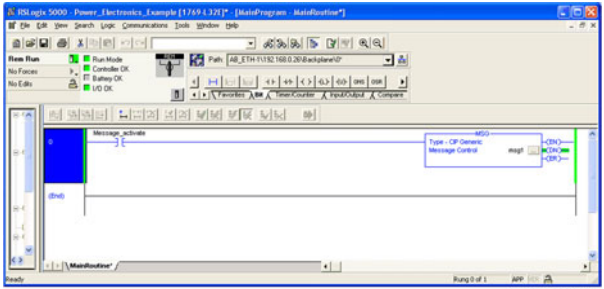

Figure PIII-4.11 Explicit messages configuration

Example: Class 2A, Instance 1, Attribute 8, for reading the speed reference of the drive.

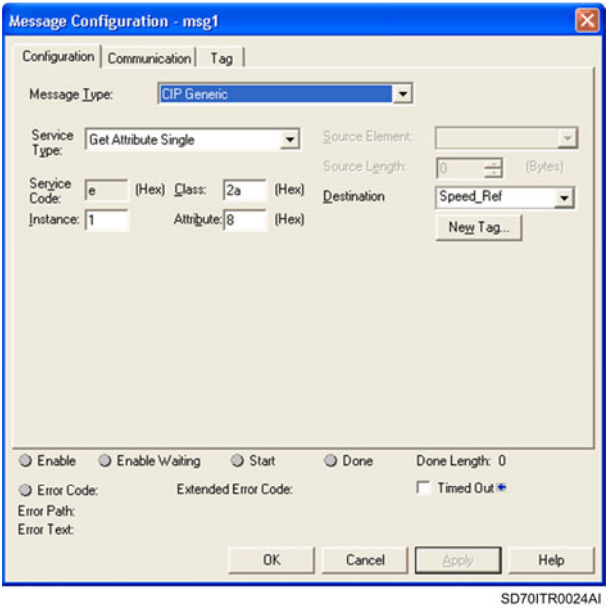

Figure PIII-4.12 Example – Screen 1. Explicit messages configuration

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Now, click on the *'Communication'* tab and indicate the *'Local PLC Destination Tag'*, as the example shows:

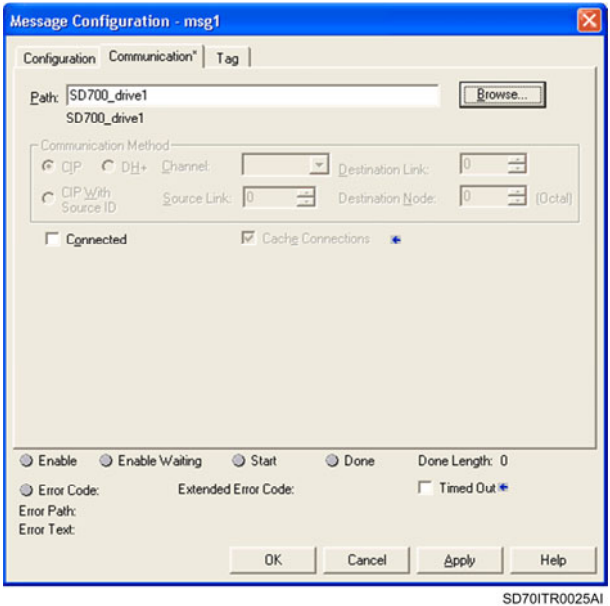

Figure PIII-4.13 Example – Screen 2. Explicit messages configuration

The user can activate the *'Msg_Activation contact'* to check the updating process of the *'Speed Reference Tag'*.

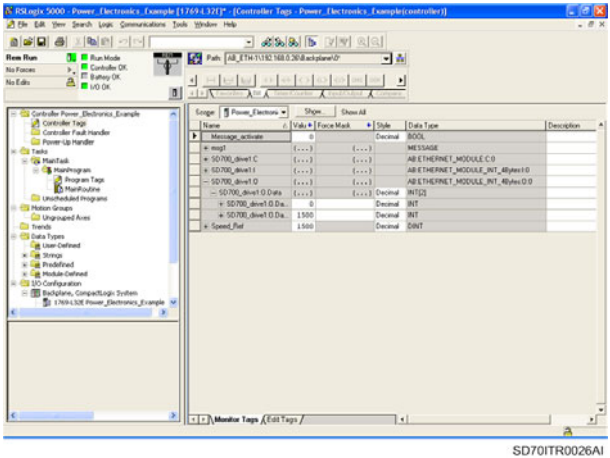

Figure PIII-4.14 Example – Screen 3. Explicit messages configuration

5. ADDITIONAL INFORMATION

5.1. Parameter Object Instances

The following table shows the Parameter object instances supported and their Modbus addresses to access to them.

All the parameters objects are either of type INT or UINT. Each object is either of access type GET or SET. For further details about the individual object instances, like the limits, properties, etc., refer to the drive documentation.

Table 14: Supported Parameter Object Instances

Description	Parameter Instance Number	MODBUS Address
Start mode	1	40002
Stop mode 1	2	40003
Stop mode 2	3	40004
Changing speed for stop mode	4	40005
Start delay time	5	40006
Stop delay time	6	40007
Minimum stop speed	7	40008
Run after occurring power loss	8	40009
Starting after fault reset with start command	9	40010
Delay time between stop and next start	13	40014
Start mode 2	14	40015
Accuracy setting for starting by spin	16	40017
Frequency V/Hz change	17	40018
Regeneration bus voltage	20	40021
Current applied to the brake	21	40022
Voltage applied to the brake	22	40023
Non condensing heating current	23	40024

Description	Parameter Instance Number	MODBUS Address
Time for DC brake activation	24	40025
Use of external brake	25	40026
Delay time for start command after stop	26	40031
Multi-function Digital Input 1 configuration	27	40032
Multi-function Digital Input 2 configuration	28	40033
Multi-function Digital Input 3 configuration	29	40034
Multi-function Digital Input 4 configuration	30	40035
Multi-function Digital Input 5 configuration	31	40036
Multi-function Digital Input 6 configuration	32	40037
Selection of Digital Inputs configuration	33	40038
Reset from keypad	34	40039
Main Control Mode	35	40040
Alternative Control Mode	36	40041
Multi-reference 1	37	40052
Multi-reference 2	38	40053
Multi-reference 3	39	40054
Multi-reference 4	40	40055
Multi-reference 5	41	40056
Multi-reference 6	42	40057
Multi-reference 7	43	40058
Inch speed 1	71	40092
Inch speed 2	72	40093
Inch speed 3	73	40094
Minimum speed limit 1	74	40102
Minimum speed limit 2	75	40103
Maximum speed limit 1	76	40104
Maximum speed limit 2	77	40105

Description	Parameter Instance Number	MODBUS Address
Current limit	78	40106
Torque limit	79	40107
To enable speed inversion	80	40108
Alternative current limit	81	40109
Change speed for Imax 2	82	40110
Reference source 1 of speed	83	40122
Reference source 2 of speed	84	40123
Local Speed Reference	85	40124
Skip frequency 1	86	40132
Skip frequency 2	87	40133
Skip bandwidth	88	40134
Source selection for introducing reference signal	89	40142
Selection of feedback signal source	90	40143
Proportional gain of PID control	91	40144
Integration time of PID control	92	40145
Derivation time of PID control	93	40146
PID output inversion	94	40147
PID control error	95	40148
PID local reference	96	40149
Frequency of input voltage – phases RS	98	40159
Frequency of input voltage – phases ST	99	40160
Frequency of input voltage – phases RT	100	40161
Value of present speed reference	101	40162
Present current of the motor	102	40163
Present torque of the motor	103	40164
Power consumption by the motor	104	40165
Present voltage applied to the motor	105	40166
Motor frequency	106	40167

Description	Parameter Instance Number	MODBUS Address
Power factor of the motor (Cos Phi)	107	40168
Motor speed (rpm)	108	40169
Motor speed (%)	109	40170
DC Link voltage of the drive	110	40171
IGBT temperature	113	40172
Motor temperature	112	40173
Current consumption per phase of the motor (phase U)	116	40177
Current consumption per phase of the motor (phase V)	117	40178
Current consumption per phase of the motor (phase W)	118	40179
Compound Instantaneous voltage (phases UV)	119	40180
Compound Instantaneous voltage (phases VW)	120	40181
Compound Instantaneous voltage (phases UW)	121	40182
Input instantaneous voltage (phases RS)	122	40183
Input instantaneous voltage (phases ST)	123	40184
Input instantaneous voltage (phases RT)	124	40185
Average value of the Analogue Input 1	125	40186
Average value of the Analogue Input 2	126	40187
Analogue Input 1 reference	129	40190
Analogue Input 2 reference	130	40191
Analogue Output 1 value	131	40192
Analogue Output 2 value	132	40193
Value of the magnitude associated to AO1	133	40194
Value of the magnitude associated to AO2	134	40195
Digital Input status	135	40196
Output Relays status	136	40197

Description	Parameter Instance Number	MODBUS Address
PID error value	142	40203
PID setpoint value	143	40204
PID feedback value	144	40205
Software version	145	40206
Hardware version	146	40207
Drive rated current	148	40209
Drive rated voltage	149	40210
Motor PTC connection	157	40218
General status	158	40219
Comparator 1 status	171	40232
Comparator 2 status	172	40233
Comparator 3 status	173	40234
Actual fault	174	40235
Drive temperature	179	40240
Speed for the maximum range Analogue Input 1	181	40242
Speed for the maximum range of Analogue Input 2	182	40243
Maximum range of Analogue Input 1	183	40244
Maximum range of Analogue Input 2	184	40245
Speed for the minimum range of Analogue Input 1	185	40246
Speed for the minimum range of Analogue Input 2	186	40247
Minimum range of Analogue Input 1	187	40248
Minimum range of Analogue Input 2	188	40249
Maximum range of sensor 1	189	40250
Maximum range of sensor 2	190	40251
Minimum range of sensor 1	193	40254
Minimum range of sensor 2	194	40255
Value of sensor 1 associated to AI1	201	40262
Value of sensor 2 associated to AI2	202	40263
Analogue Input 1 format	203	40264
Analogue Input 2 format	204	40265

Description	Parameter Instance Number	MODBUS Address
Protection for AI1 loss	205	40266
Protection for AI2 loss	206	40267
To enable sensor of AI1	207	40268
To enable sensor of AI2	208	40269
Zero band filter for AI1	209	40270
Zero band filter for AI2	210	40271
Selection of sensor 1 units	211	40272
Selection of sensor 2 units	212	40273
Low Pass filter for AI1	213	40274
Low Pass filter for AI2	214	40275
Motor rated current	215	40282
Motor rated voltage	216	40283
Motor rated frequency	217	40284
Motor rated power	218	40285
Motor rpm	219	40286
Motor cooling at zero speed	220	40287
Cosine Phi	221	40288
Pump overload level	222	40289
Filter for pump overload	223	40290
Trip delay time because of pump overload	224	40291
Source selection for Comparator 1	225	40302
Comparator 1 type selection	226	40303
Deactivation value of C1 in Normal mode	227	40304
Limit 1 for Comparator 1 in Window mode		
Activation value of C1 in Normal mode	228	40305
Limit 2 for Comparator 1 in Window mode		
ON delay time for Comparator 1	229	40306
OFF delay time for Comparator 1	230	40307
Selection of output function for Comparator 1	231	40308
Source selection for Comparator 2	234	40311
Comparator 2 type selection	235	40312

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Description	Parameter Instance Number	MODBUS Address
Deactivation value of C2 in Normal mode	236	40313
Limit 1 for Comparator 2 in Window mode		
Activation value of C2 in Normal mode	237	40314
Limit 2 for Comparator 2 in Window mode		
ON delay time for Comparator 2	238	40315
OFF delay time for Comparator 2	239	40316
Selection of output function for Comparator 2	240	40317
Source selection for Comparator 3	243	40320
Comparator 3 type selection	244	40321
Deactivation value of C3 in Normal mode	245	40322
Limit 1 for Comparator 3 in Window mode		
Activation value of C3 in Normal mode	246	40323
Limit 2 for Comparator 3 in Window mode		
ON delay time for Comparator 3	247	40324
OFF delay time for Comparator 3	248	40325
Selection of output function for Comparator 3	249	40326
Mode selection for Analogue Output 1	262	40342
Format selection for Analogue Output 1	263	40343
Low of range selection Analogue Output 1	264	40344
High range selection of Analogue Output 1	265	40345
Filter selection for Analogue Output 1	266	40346
Mode selection Analogue Output 2	267	40347
Format selection for Analogue Output 2	268	40348
Low range selection of Analogue Output 2	269	40349
High range selection of Analogue Output 2	270	40350
Filter selection for Analogue Output 2	271	40351
Selection of Relay 1 control source	272	40362
ON delay time for Relay 1	273	40363
OFF delay time for Relay 1	274	40364
Relay 1 inversion	275	40365

Description	Parameter Instance Number	MODBUS Address
Selection of Relay 2 control source	276	40366
ON delay time for Relay 2	277	40367
OFF delay time for Relay 2	278	40368
Relay 2 inversion	279	40369
Selection of Relay 3 control source	280	40370
ON delay time for Relay 3	281	40371
OFF delay time for Relay 3	282	40372
Relay 3 inversion	283	40373
IP address (A)	284	40374
IP address (B)	285	40375
IP address (C)	286	40376
IP address (D)	287	40377
Subnet Mask address (A)	288	40378
Subnet Mask address (B)	289	40379
Subnet Mask address (C)	290	40380
Subnet Mask address (D)	291	40381
Gateway address (A)	292	40382
Gateway address (B)	293	40383
Gateway address (C)	294	40384
Gateway address (D)	295	40385
MAC address (A)	296	40386
MAC address (B)	297	40387
MAC address (C)	298	40388
MAC address (D)	299	40389
MAC address (E)	300	40390
MAC address (F)	301	40391
Acceleration ramp 1	302	40392
Acceleration ramp 2	303	40393
Deceleration ramp 1	304	40394
Deceleration ramp 2	305	40395
Speed for acceleration ramp change	306	40396
Speed for deceleration ramp change	307	40397

Description	Parameter Instance Number	MODBUS Address
Ramp 2 of reference increase for motorized potentiometer	308	40398
Ramp 1 of reference decrease for motorized potentiometer	309	40399
Ramp 1 of reference increase for motorized potentiometer	310	40400
Ramp 2 of reference decrease for motorized potentiometer	311	40401
Speed for ramp change with motorized potentiometer	312	40402
Time constant to filter the speed	313	40403
Comunication timeout Modbus RTU	315	40413
Communication address	316	40414
Communication speed	317	40415
Communication parity	318	40416
Register 1 of fault history	320	40432
Register 2 of fault history	321	40433
Register 3 of fault history	322	40434
Register 4 of fault history	323	40435
Register 5 of fault history	324	40436
Register 6 of fault history	325	40437
Erase fault history	326	40438
Trip time because of speed limit	327	40452
Trip time because of current limit	328	40453
Maximum time for stop limit	329	40454
Trip time because of torque limit	330	40455
Ground fault detection	331	40456
Low input voltage level	332	40457
Trip time because of low input voltage	333	40458
High input voltage level	334	40459
Trip time because of high input voltage	335	40460

Description	Parameter Instance Number	MODBUS Address
Performance in case of input power loss	336	40461
PTC motor option	337	40462
Trip delay time due to output voltage imbalance	338	40463
Stator resistance (Rs)	341	40482
Minimum Flux	352	40502
Slip compensation	355	40505
Drive damping	356	40506
Compensating bandwidth of Torque transitory	357	40507
Current limit factor	358	40508
Voltage for activating regeneration control	359	40509
Selection of control type	361	40522
Commutation frequency	362	40523
Pewave control	363	40524
Drive fan control mode	372	40549
Total running time of the drive (Days)	373	40550
Total running time of the drive (Hours)	374	40551
Partial running time of the drive (Days)	375	40552
Partial running time of the drive (Hours)	376	40553
Reset of the partial time counter for running status (RUN)	377	40554
Host Start Control	379	40562
Host Stop Control	380	40563
Host Reset Control	381	40564
Host Trip Control	382	40565
Auto Reset	388	40571
Number of Auto Reset attempts	389	40572

Description	Parameter Instance Number	MODBUS Address
Delay time before Auto Reset	390	40573
Reset time for the counter of Auto Reset attempts	391	40574
Selection of fault 1 to be reset	392	40575
Selection of fault 2 to be reset	393	40576
Selection of fault 3 to be reset	394	40577
Selection of fault 4 to be reset	395	40578
Sensor units of Pulse Input	396	40581
Flowmeter configuration	397	40582
Maximum range of flow meter	398	40583
Initial voltage	404	40592
Torque boost band	405	40593
Initial frequency	406	40594
Speed for disconnecting relay in option Crane	409	40597

5.2. PE – CIP Fault Code Mapping

The mapping from the Power Electronics (PE) Vendor specific fault codes to that of the CIP standard codes is presented in the following table.

Table 15: PE to CIP Fault Code Mapping

PE Fault Code	Description	CIP Code (Hex)
0	F0 NO FAULT	0000
1	F1 I LIM FLT	2300
2	F2 V LIM FLT	3210
3	F3 PDINT FLT	A001
4	F4 U+DESAT	A002
5	F5 U - DESAT	A003
6	F6 V + DESAT	A004
7	F7 V - DESAT	A005
8	F8 W + DESAT	A006
9	F9 W - DESAT	A007
10	F10 NEG IGBT	5410
11	F11 VIN LOSS	3130
12	F12 IMB V IN	3131
13	F13 HI V IN	3110
14	F14 LW V IN	3120
15	F15 CURL Vdc	3221
16	F16 HI Vdc	3211
17	F17 LW Vdc	3220
18	F18 IMB V OUT	3300
19	F19 IMB I OUT	2330
20	F20 GROUND FLT	2230
21	F21 I LIM T/O	A008
22	F22 TQ LIM T/O	8311
25	F25 MTR O/L	4420
27	F27 DL SMTH	3230
28	F28 MICRO FLT	A00B

PE Fault Code	Description	CIP Code (Hex)
29	F29 DSP FLT	A00C
30	F30 WATCHDOG	A00D
31	F31 SCR L1	A00E
32	F32 SCR L2	A00F
33	F33 SCR L3	A010
34	F34 IGBT TEMP	4200
40	F40 EXT / PTC	A100
41	F41 COMMS TRIP	9101
42	F42 AIN1 LOSS	A101
43	F43 AIN2 LOSS	A102
44	F44 CAL FLT	A103
45	F45 STOP T/O	A104
46	F46 EEPROM FLT	A105
47	F47 COMMS T/O	8100
48	F48 SPI COM	A106
49	F49 SPD LIMIT	A107
50	F50 PSU FAULT	A108
51	F51 SCR TEMP	A109
52	F52 SUPPLY FAN	A10A
53	F53 INTRNAL TEMP	4300
54	F54 WATCHDOG TMR	6010
56	F56 EMERGEN.STOP	9100
57	F57 PUMP OVERLOA	A10C
60	F60 ETH.IP T.OUT	A10F

5.3. PE – CIP Warning Code Mapping

The mapping from the Power Electronics (PE) Vendor specific warning codes to that of the CIP standard codes is presented in the following table.

Table 16: PE to CIP Warning Code Mapping

PE Warning Message Codes	Description		CIP Code (Hex)
	Screen	Name	
60		No Warning	0000
61	MOL	Motor Overload	4410
63	MOC	Motor Over-current	2312
64	DOC	Drive Over-current	4320
65	ILT	Current Limitation	B001
66	TLT	Torque Limitation	8302
67	VLT	Voltage Limitation	3212
68	ACO	Asymmetric Current	B002
69	AVO	Output Voltage Imbalance	B003
70	AVI	Input Voltage Imbalance	3132
71	OVV	High Input Voltage	3111
72	UNV	Low Input Voltage	3121
90	S1L	Speed Limit 1 reached	8402
91	S2L	Speed Limit 2 reached	8402

6. ETHERNET/IP PARAMETERS SETTING

In the drive SD700, there is a parameter group used to configure the drive to operate into an Ethernet/IP network. Concretely, this is the parameter subgroup 'S21.3 ETHER./IP' which is available when connecting the Ethernet board to the drive, and it is shown below.

6.1. Subgroup 21.3 – S21.3: ETHER./IP

Note: Configure the Ethernet board before, by means of the parameters setting of subgroup '21.1 ETHERNET' (See section 'PART I – 4. ETHERNET BOARD CONFIGURATION').

<table>
<tr><th>Parameter</th><th>Description</th><th>Range</th><th>Default value</th><th>Function</th><th>Set on RUN</th></tr>
<tr><td>1 CONTROL MODE=0</td><td>G21.3.1 / Control mode of the drive</td><td>0 – 2</td><td>0</td><td>This parameter allows setting how the drive will be controlled.
<table>
<tr><th>OPT</th><th>DESCRIP.</th><th>FUNCTION</th></tr>
<tr><td>0</td><td>LOCAL</td><td>The drive can be started and stopped like the equipment is not connected to the Ethernet network, this means, from the settings in G4.1.1 or G4.1.2 (see 'Getting Started Manual' of SD700).</td></tr>
<tr><td>1</td><td>NETWORK</td><td>The drive can only be controlled through the Ethernet/IP Client by means of the Ethernet board. In this case, the setting of G4.1.1 and G4.1.2 is ignored (see 'Getting Started Manual' of SD700).</td></tr>
<tr><td>2</td><td>NET DECIDES</td><td>In this case, the Ethernet/IP Client, through the Ethernet board, will inform the drive all the time about who is controlling it.</td></tr>
</table></td><td>YES</td></tr>
</table>

<table>
<tr><th>Parameter</th><th>Description</th><th>Range</th><th>Default value</th><th>Function</th><th>Set on RUN</th></tr>
<tr><td>2 REFEREN.MODE=0</td><td>G21.3.2 / Reference mode of the drive</td><td>0 – 2</td><td>0</td><td>This parameter allows setting from where the speed reference is provided to the drive.
<table><tr><th>OPT</th><th>DESCRIP.</th><th>FUNCTION</th></tr><tr><td>0</td><td>LOCAL</td><td>The drive will take the reference from parameters G3.1 or G3.2 (see 'Getting Started Manual' of SD700).</td></tr><tr><td>1</td><td>NETWORK</td><td>The reference will only be taken through the Ethernet/IP Client by means of the Ethernet board. In this case, the setting of G3.1 and G3.2 is ignored (see 'Getting Started Manual' of SD700).</td></tr><tr><td>2</td><td>NET DECIDES</td><td>In this case, the Ethernet/IP Client, through the Ethernet board, will inform the drive all the time about who is providing the speed reference to it.</td></tr></table></td><td>YES</td></tr>
</table>

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HEAD OFFICE	C/ Leonardo da Vinci, 24 - 26, Parque Tecnológico · 46980 · Paterna · VALENCIA Tel. (+34) 96 136 65 57 · Fax. (+34) 96 131 82 01
INTERNATIONAL BRANCHES:	
GERMANY	Power Electronics Deutschland GmbH Conradtystrasse, 41 · D-902441 · NÜRNBERG · GERMANY Tel. (+49) 911 99 43 99 0 · Fax (+49) 911 99 43 99 8
KOREA	Power Electronics Asia HQ Co. Room #305, SK Hub Primo Building 953-1, Dokok-dong, Gangnam-gu · SEOUL · 135-270 KOREA Tel. (+82) 2 3462 4656 · Fax (+82) 2 3462 4657
CHINA	IVEX BEIJING Citic Building · IVEX Beijing Representative Office 9D N.19 Jianguomenwei Dajie 100004 Beijing P.R. CHINA Tel. (+86 10) 65 25 41 47 · Fax (+86 10) 65 25 41 48
AUSTRALIA	Power Electronics Australia Pty Ltd U6, 30-34 Octal St, Yatala, Brisbane, Queensland 4207 · P.O. Box 3166 Browns Plains · Queensland 4118 · AUSTRALIA Tel. (+61) 7 3386 1993 · Fax. (+61) 7 3386 1997

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