SOFTWARE MANUAL

SOFTWARE PROGRAMMING, COMMISSIONING AND TOOLS DESCRIPTION MANUAL

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About this Manual

The whole chapter explain all about the low voltage SECOM DRIVE control software and programming.
After a brief safety prescription in the first section, it will follow the programming rules for drive configuration, details about logic and details about each control types. Moreover some example will be provided regarding quick start up and commissioning and interfacing some commercial PLC.
To do so, some tools are provided and they will be described too.
Each chapter is been wrote thinking to a specific target audience.

SAFETY INSTRUCTIONS

1

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Contents

This chapter contains important safety instructions that users must obey when installing, using or maintaining any of the SECOM DRIVE products covered by this manual. Ignoring these rules could lead to physical injury and/or death of those in the near vicinity of the drive; additionally, the drive and/or driven equipment such as an attached motor may be damaged.
This chapter also contains definitions and symbols used throughout this manual.

Chapter Target Audience

This chapter is intended for all personnel who use or work with the SECOM DRIVE products covered by this manual.

1.1 WARNINGS AND SYMBOLS

Due caution to the usage warnings provided in this manual must be followed by all users of applicable SECOM DRIVE equipment; failure to do so could result in serious or injury or death, and/or damage to the equipment.
For the convenience of the reader the hazard symbols in Tab. 1-1 have been used throughout this manual to highlight risks and recommended practices when maneuvering, installing, maintaining or operating the equipment covered by this manual.

Symbol	Description
⚡	**Electrical Warning**: lethal voltage electrical discharge hazard, which may result in serious or deadly injuries and/or damage to the equipment.
⚠	**Generic Warning**: generic hazard, not limited to electrical phenomena, which may cause serious or deadly injuries and/or damage the equipment.
⚠	**Electrostatic Discharge** or **Sensitive Devices**: risk of electrostatic discharge, which can injure the operator or damage the equipment. It is mandatory any personnel handling electronic devices use PPE (such as grounding wrist bands)
⚠	**Hot Surface**: It is recommended that personnel work a safe distance away from any equipment covered by the *Hot Surface hazard*; if any personnel are required to operate near the equipment it is mandatory they wear appropriate PPE (such as protective gloves, shoes, etc).
ℹ	**Info, Note** or **Notice**: additional useful information the user should pay attention to.

Tab. 1-1: Symbols

1.2 TERMS AND ACRONYMS

Tab. 1-2 summarizes all the terms used in the manual.

Term	Meaning	Description
AC	**Alternating Current**:	Components or parts working with alternating current
AFE	**Active Front End**:	a type of line interface converter able to regulate DC bus voltage and AC current
ALI_LEM	**Voltage Sensor** manufactured by SECOM	normally used to sense the DC Voltage
CW	**Command Word**	Command bitword (16 bit) usually used as surfix. Example: *DCBusCW* is DC Bus Command Word. Even called Control Word.
DC	**Direct Current**.	Components or parts working with direct current
DC bus	-	Used as a collective term to indicate all power components used in the common DC section of the drive.
DCS	**Distributed Control System**	External automation wich controls and/or monitors the drive: the level 1 automation
DC/AC Drive, AC/DC Drive, AC/AC Drive	**Input and output of the drive**	*X/Y* refer to the *input/output* of the drive. DC/AC means DC is the input and AC is the output and AC/DC is vice versa. AC/AC indicates the AC input (R, S, T) connected to the grid and the AC output (U, V, W) connected to the load. DC/AC
DPM	**Drive Power Module**:	Indicates the power module (converter) including all printed circuit boards (PCBs)
EMC	**Electromagnetic Compatibility**	Electromagnetic Compatibility
EMI	**Electromagnetic Interference**	Electromagnetic interference
F3E	**Fundamental Frequency Front End**:	A type of line interface converter like the AFE, but does not regulate neither the DC bus voltage nor the AC current
Frame		Mechanical structure that make up the DPM
FSM	**Finite State Machine**	All control state of the drive, based on *PROFIDrive* standards

Term	Meaning	Description
FW	Firmware	Binary code for FPGA
HW	Hardware	Supply, control and interface boards.
I/O	Input/Output	Input/Output
IGBT	Electronic switch	*Insulated Gate Bipolar Transistor*: power semiconductor for switching control.
IQ14	14bit signed fixed point vale	16 bit signed integer where 1 pu = 16384 = 2^{14}; -1 pu = -16384
Line Side, Grid Side	Drive Power Grid Front End	It refers to the AC side of the inverter connected to the power grid. For grid application, this is the output side
MCB	Main Circuit Breaker	Main circuit Braked
MCW	Main Command Word	ProfiDrive standard command word, used by FSM
Motor Side	Drive Motor Front End	It refers to the AC side of the inverter where motor is connected. For motor application, this is the output side
MSW	Main Status Word	ProfiDrive standard status word, generated by FSM
Multi Drive	DC/AC Drive, AC/DC Drive	It's an inverter with a DC input and AC output and the DC side could be common with many other drives and front ends. For SECOM DRIVE, the modules which compose a *Multi Drive* are DPM which can be connected in parallel to the AC side.
OFF1	Ramp Stop	The drive stops the motor with a selected ramp and at the end oper the Main Circuit Breaker (MCB)
OFF2	Coast Stop	The drive cut off the fire pulses to the power module. The motor will stop itself within a time function of the total inertia or the plant
OFF3	Quick Stop	The drive stop the motor with the quick stop ramp. Usually is the fastest ramp possible, compatibly with the brake functions (such as *Vdc Rollback*)
Parallel DPM	Many DPMs	Multiple DPM connected in parallel (could be SDI, SDA or SDF)
PCB	Printed Circuit Board	
PE	Protective Earth	Protective Earth contactor
PPE	Personal Protective Equipment	Personal Protective Equipment
Prc Prc Cmd Prc Fdb	Precharge Precharge Command Precharge Contactor Feedback	Precharge abbreviation Command for starting precharge or activating precharge circuit (SD-MCU digital output) A feedback signal from the precharge device (SD-MCU digital input if configured)
Precharge		The sequence used to charge the DC bus capacitors before the main breaker is closed.
R, S, T	**Inverter Input Phases** for AC/AC drives	Inverter Input Phases for AC/AC drives
Safe Working Voltage	**Less than 50V** unless otherwise stated	The safe working voltage is defined as the maximum voltage for live working as defined in by local safety regulations, however is it is recommended that a safe working voltage close to 0 volts is used.
SD-	SECOM DRIVE Component:	this prefix is used to indicate when a component (or components) is strictly related to SECOM DRIVE, such as electronic board SD-RMU, SD-MCU, etc.
SDA	SECOM DRIVE AFE	Regenerative Active Front End drive with low harmonics: AC/DC Drive kind
SDF	SECOM DRIVE F3E	Regenerative Fundamental Frequency Front End: AC/DC Drive kind
SDI	SECOM DRIVE Inverter	Inverter for motor control or generic load control: DC/AC Drive kind
SDM	SECOM DRIVE Manager:	Coftware configuration tool for drive configuration and monitoring.
SD-MCU	SD Master Control Unit	It is the main control board and is housed externally to the DPM. For more information about the control system, refer to SOFTWARE MANUAL too.
SDRIVE SECOM DRIVE	SECOM DRIVE	indicates everything concerning the drive, in the context of this manual it is particularly used in reference to the drive power components and electronics.
SD-RMU	SD Remote Modulator Unit:	is the interface board for the control unit SD-MCU
SDS	SECOM DRIVE: Single Drive	Motor (or load) control with internal rectifier: AC/AC Drive kind
SD-SU	SD Supply Unit:	this board provides the supply for all the electronic devices in the DPM. It is also the first stage analog interface

Term	Meaning	Description
SD-SYNC	SD Synchronization Board	used to sense the line-to-line voltage and allow the SD-MCU synchronize the converter with the line.
Single DPM	One DPM	Single power module (could be SDS, SDI, SDA or SDF)
Single Drive	AC/AC Drive	It's a stand alone drive with AC input and output. A rectifier bridge is internal to the module. For SECOM DRIVE, the bridge is a semi-controlled bridge; this drive can't be parallelized, so it consists of a single DPM.
SRP	Software Release Package	The SRP is in the form SDrive-*X.Y.Z.J*. The file has the *.pkg* extension
STO	Safe Torque Off	used to describe STO as a function, circuitry or cabling
SW	Status Word	Status bitword (16 bit) usually used as surfix. Example: *DCBusSW* is DC Bus Status Word
U, V, W	**Inverter Output Phases** for DC/AC drives	Inverter Output Phases for DC/AC drives
VDC+, VDC–	Terminals of the DC bus	The positive and negative terminals of the DC bus
Xxx[(+)] [xxxx][(+)]	Addressable variable Addressable parameter	The variable can be connected to other parameters by using *[IPA.bit]* rules The parameter can be connected to other parameters by using *[IPA.bit]* rules

Tab. 1-2: Terms and Acronyms

1.3 STANDARDS

The design, manufacturing and testing of each low voltage converter is performed according to following IEC/EN standards where applicable:

IEC 50178	IEC 50178 Electronic equipment for use in power installations
IEC 60146	Semiconductor converters - General requirements and line commutated converters
IEC 60204–1	Safety of machinery – Electrical equipment of machines.
IEC 60364	Low voltage electrical installations
IEC 60664–1	Insulation coordination for equipment within low-voltage system
EN 61439–1	Low voltage switchgear and control-gear assemblies – Part 1: General rules
EN 61439–2	Low voltage switchgear and control-gear assemblies – Part 2: Power switchgear and control-gear assemblies
IEC 61800–2	Adjustable speed electrical power drive systems – Part 2: General requirements – Rating specifications for low voltage adjustable frequency AC power drive systems
IEC 61800–3	Adjustable speed electrical power drive systems – Part 3: EMC requirements and specific test methods
IEC 61800–5	Adjustable speed electrical power drive systems – Part 5: Safety requirements

1.4 SAFETY OPERATIONS

The following paragraphs describe an overview of safe working practices. Software Manual explain mainly the configuration procedure; seldom it will describe how to manage some electrical board or working in the vicinity of high voltage equipment. So all the prescription for electrical safety must be followed by technician when installing, operating or maintaining the products. Where required further information is provided in the associated chapters.

So for all about mechanical and electrical installation of power parts, please refer to HARDWARE MANUAL.

1.4.1 Mechanical and Handling Safety

Handling the power parts (DPM) is not matter of this manual. Please refer to HARDWARE MANUAL for these kind of information.

 WARNING! Ignoring the instructions reported in HARDWARE MANUAL could lead to physical injury or death and additionally damage the drive and/or equipment.

1.4.2 Installation and Maintenance Safety

These instructions are intended for all personnel who perform installation and maintenance of electronic equipment intro the drive and/or the interface and control board out of the power module.

WARNING! Ignoring the following instruction could lead to serious physical injury or death, damage to the drive and/or equipment. For more safety information regarding power parts please refer to HARDWARE MANUAL.

➢ Only qualified technicians can be allowed to install and maintain the drive (control and power parts).
➢ Ensure that debris from any drilling/boring or grinding do not enter the drive when installing. Electrically conductive debris inside the unit may cause damage or the drive to malfunction.
➢ Do not attach the external board (such as SD-MCU or SD-SYNC) to the drive or into the cubicle using rivets or by welding.
➢ Pay attention to any components with hot surfaces, particularly after operation. Normally the hottest parts of the drive are the component heatsinks and the power stage. However even some board with power supply can be hot.
➢ Perform all operation with the main circuit breaker and switch open, and follow the electrical safety rules listed in HARDWARE MANUAL. Pay attention to some board such as ALI_LEM or ALIDAN2 which are connected to the DC bus (high voltage): always measure the voltage and verify the value is lower than the safety threshold before touching or handling boards inside the power module.

WARNING! Each PCB require protective gloves or IP to avoid damaging due to electric discharge. Pay attention even if the PCB is enclosed into a metal case.

1.4.3   Electrical Safety

These instructions are intended for any personnel who work with the electrical and/or electronic parts of the product, such as the drive, motor cables or electronic circuit boards. In addition to the instructions provided, the relevant local safety standards must also be adhered to.

WARNING! Ignoring the following instruction could lead to serious physical injury or even death. Failure to follow the instructions could also damage the drive and/or equipment and increase electromagnetic interference.

➢ Only qualified technicians should be permitted to install and maintain the drive.
➢ Never work on the drive, cables or motor while the main supply is applied; always disconnect the input supply and after waiting five minutes verify that the voltage on the following terminals is less than the safe working voltage:
  o Between the AC phases (U-V, V-W, W-U)
  o Between the positive and negative terminal of DC bus
  Perform this measurements with a multimeter with an impedance of at least 1 MΩ.
➢ Do not make any insulation or voltage withstand tests on the drive. Only SECOM personnel or personnel trained and authorized by SECOM are permitted to do this and in very rare cases.
➢ Do not connect the drive to a voltage higher than the over voltage trip threshold: this typically results in damage to the drive or where applicable the dynamic brake resistor.
➢ Do not connect the drive to a voltage higher than *VdcRollback* threshold: this can disable some control functionality during braking the motor.
➢ For the safety of personnel ground the drive, motor and adjoining equipment in all circumstances; additionally this reduces the electromagnetic emission and interference.
➢ Make sure that grounding conductors are adequately sized according to local safety regulations.

General safety information

➢ It is vital, after switching off the drive and disconnecting the main power, verify the motor is at stand still; if the motor is not at stand still it is possible that a dangerous residual voltage remains on the cable or at the drive termination. This is a good procedure for all motor types, but particular attention should payed when working with synchronous motors or permanent magnet motors.
➢ When the drive is connected to the main supply the drive motor cable terminals are at a dangerously high voltage regardless of whether the motor is rotating or not.
➢ The *Safe Torque Off* function (STO) does not remove the voltage from the main and auxiliary circuits; in addition, the motor could have voltage applied without generating electromagnetic torque. Furthermore, the function is ineffective against deliberate sabotage or misuse.

Electronical board safety

WARNING! Ignoring the following instruction could result in damage to the printed circuit boards housed in the product.

➢ The printed circuit boards contain components sensitive to electrostatic discharge. Wear a grounding wrist band when handling the boards. Do not touch the boards unnecessarily.

1.4.4   Starting Up Safety

These instructions are intended for personnel who have to operate, commission or use the drive.

WARNING! Ignoring the following instruction could lead to physical injury or death, damage the drive and/or equipment.

➢ Before powering up the drive, all drive covers must be on and in the closed position if applicable. All covers must be kept on during operation.
➢ Some functionality, such as Grid Waiting, can restart the drive automatically. Users must ensure that functions that perform automatic startup can only be performed in safe situations.
➢ The maximum power-ups that can be performed in a given period depends on the precharge circuitry. Usually for frame types which have an external precharge circuit, one power up may be performed per minute, but for AC/AC drives with semi-controlled diode bridges, this number of power ups per minute is not restricted.
➢ Any safety circuits (such as STO) must be connected properly. This is the responsibility of the customer.
➢ Users must pay attention to the starting sequence while configuring the drive. The Drive is compliant to PROFIDRIVE State Machine; however, the user can modify the start sequence by changing the source command or SW configuration. In the following some particular cases are summarized, but for further information about this logic please refer to the SOFTWARE MANUAL:
   o The drive can be configured to start immediately after the SWITCH ON command, or more precisely when the main breaker is closed and the precharge phase is finished.
   o If the SD-OP unit is the main command source (*Local commands*), the drive is automatically configured as above.
   o The drive can start after the ENABLE OPERATION command when the drive is precharged. In this configuration The SWITCH ON command only precharges the drive.

1.5 SOFTWARE RELEASE IDENTIFICATION

This manual refers only to the software release package (SRP) SDrive-1.0.0.x developed from SECOM DRIVE. For the other SRP version please refers only to the related software manual.
To identify the SRP installed in the SECOM DRIVE target please see section 6.3.2.

PROGRAMMING RULES

2

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Contents

This chapter describes how the parameters are organized, the visibility rules to show each parameters and the rules to addressing the I/O, command or status word, fieldbus, etc.
The purpose of this chapter is to explain the logic which aims the parameter organization and helps the customer to configure the drive.

Chapter Target Audience

This chapter is intended for all personnel who has to control and interface the SECOM DRIVE.

2.1 FAMILIES AND PARAMETERS DESCRIPTION

The parameters are always composed by 4 digits in the following representation *[xxyy]*:
- *xx*: it identify the family of the parameter
- *yy*: it identity the parameter in the family

This representation assures that parameter has a unique number. There are also GROUP and SUB-GROUP used only to simplify the access and make easier reading a specific set of parameters. They are not related to the numeration. The parameter number is also called IPA (index parameter).
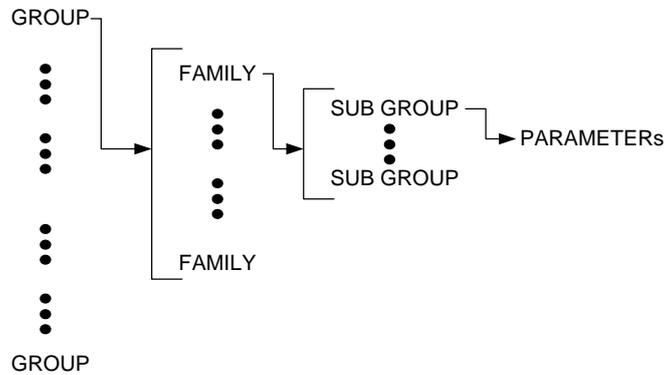
Fig. 2-1: Parameter Grouping

Example

The parameter *[0302]* is the Class Overload and it belongs to [03] INVERTER family.

■

Example

The parameter *[6620]* is the maximum instantaneous current allowed and it belongs to [66] REFERENCES family.

■

2.1.1 Visibility Rules

Visibility rules define the parameter visibility dependency. Each parameter can be shown as function of a value of another parameter.
For example, in the SDM if the operator choses "GRID" as type of load, the family "[05] GRID" will appear, instead of "[05] MOTOR" which will be shown if "MOTOR" load is selected.
The parameters visibility can also be modified depending on the access level:
- Base
- Advanced
- Expert

The Expert is the higher level and allows a complete visibility of all parameters.

2.2 ADDRESSING RULES

SECOM DRIVE Control is able to address almost every word that user can see into the SDM configurator.
There are two methods for addressing parameter, depending on the kind of parameter itself:

Address	Explanation	Normally usage
[IPA]	Decimal number which represent the IPA that must be connected to.	Normally used for fieldbus configuration (output word)
[IPA.bit]	Like IPA, but used to address a specific bit	Normally used to address I/O to a function

Normally the IPA value is picked up from Monitoring group parameter, such as command or status word, but it is possible select every word in the system.
Special value of this parameter are:
- *Negative*: negate the value of the pointed bit. For example, if the value is *[-6506.10]*, the value of the parameter is 1 when bit 10 of parameter 6506 is 0.
- *0.xx* normally the parameter point to a "Zero" word: value of this parameter is always 0
- *1.xx* at the contrary of 0.xx, the parameter which has this value point to a "One" word: value of this parameter is always 1 (High) whatever be the decimal value.
- *-1.00* it is the same as 1.00; minus sign is neglected.

Note: 0.00 could be the default value. Few parameter could have some special default value, different from "Zero word"

SYSTEM DESCRIPTION

3

Chapter Table of Contents

Contents

This chapter describes how the system is composed, starting from a top level description and going through a deeper and deeper explanation.

Chapter Target Audience

This chapter is intended for all personnel who needs to know the architecture of the SECOM DRIVE and an overview of all the components.

3.1 CONTROL SYSTEM STRUCTURE

The SECOM DRIVE Control system is a powerful state of the art firmware/hardware which is composed by several tasks connected to each other.
The complete control system is composed by:

- SD-MCU: the heart of the system where it is located all the control loops and the interface with other devices.
- SD-RMU: this board is located inside the power part (DPM) and represent the interface of the power part (DPM)
- Optional Boards (i.e. SD-IENC, SD-PROFI-COMX, Remote IO) plugged on the SD-MCU or connected through CANOpen or Modbus-TCP protocols

The system processor is located on the SD-MCU, a dual core high speed CPU with an ARM architecture (Avnet MicroZed).
The first core (Core0) is related to customer interface (communication protocols, Operator Panel, SDM) while the second core (core1) is related real time load control (motor, grid, etc.).
In the Core0 is instantiated Linux OS to allow simple and fast communication with the other HMI interfaces whilst in the core1 is instantiated a real time operating system.
The Core0 and Core1 shares a PLC application that can be personalized for customer purposes.
The Core1 communicates with FPGAs. Those are the interface between SD-MCU and the power part modules.
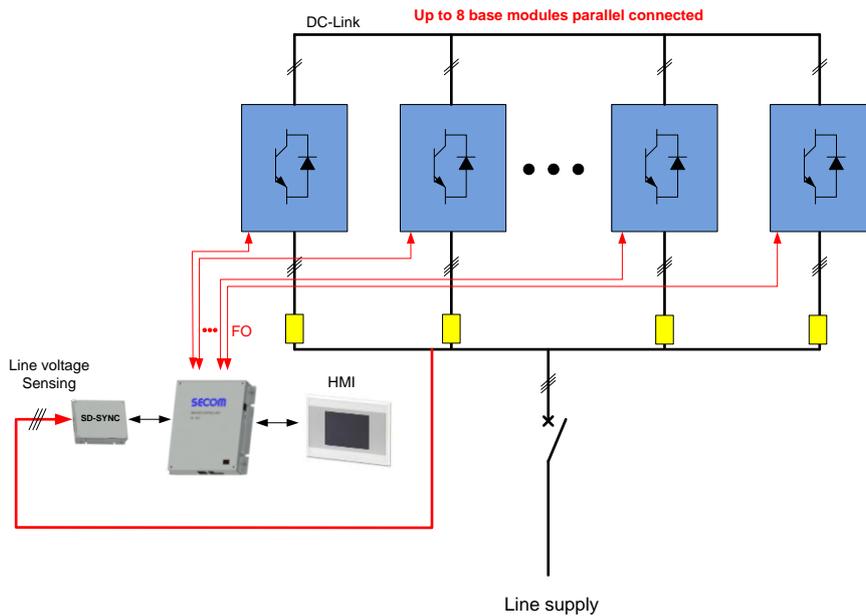
Fig. 3-1: Connection between SD-MCU and power part in case of parallel power part
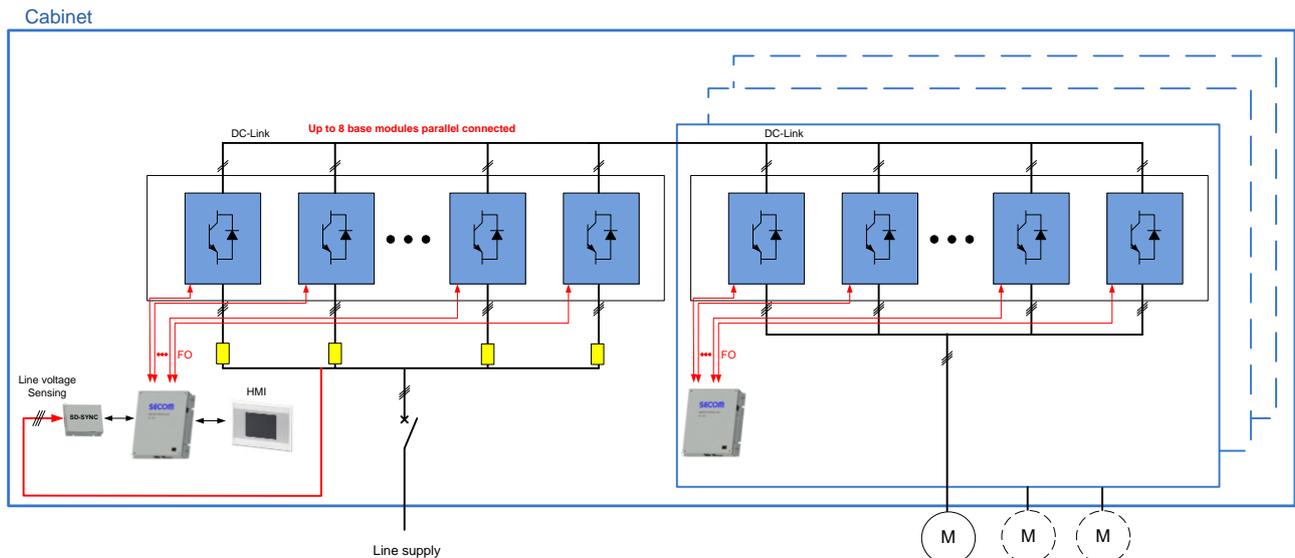
Fig. 3-2: Connection between SD-MCU and power part (general view)

SD-MCU communicates with the SD-RMU by means a fiber optic couple (TX and RX) and not drive directly the IGBT commands.
The analog and digital signals inside the power module is collected from SD-RMU and sent after to the SD-MCU.
The analog input directly connected to SD-MCU are used only for voltage synchronization, auxiliary currents measurement. The SD-MCU allows to read up to 16 digital inputs on board and commands 10 digital output (6 relays and 4 open collector).
As mentioned previously, the system is composed of 5 important tasks spread in the two cores:

	Task name	Real time	Period time	Editable by customer	Utilizable to PLC Programs
Higher Priority	**Main**	Yes	1 ms	No	No
	Control / Critical	Yes	200µs or more, depending on switching frequency	No	Yes
	Fast	Yes	1 ms, 2 ms, 5 ms, 10 ms	yes	Yes
	Automation	No	10 ms, 20 ms, 50 ms, 100 ms	yes	Yes

Tab. 3-1: Tasks Information
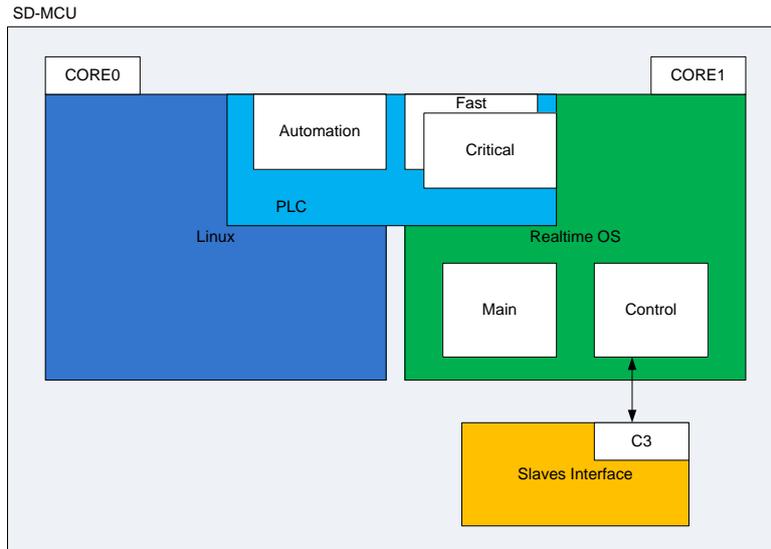
Fig. 3-3: Tasks and OS locations in the control system

The Main Task is used for monitoring purposes, drive state machine and fieldbus communication while in the control task implements the control routines. The control task execution frequency is depending of the selected switching frequency.
PLC tasks can be used to implement customer control routines as example below:

- Torque control (Fast or Critical)
- Complex speed control (Fast or Critical)
- Switchboard logic (Automation)
- Process control (Fast or Critical)

The system architecture is showed in Fig. 3-4 below and it is control depending.
In case of F3E of AFE control, the architecture can be the following:

- SD-MCU
- SD-SYNC
- SD-OP or commercial HMI (both optrional)
- Profibus slave module (option)
- Remote I/O (option)
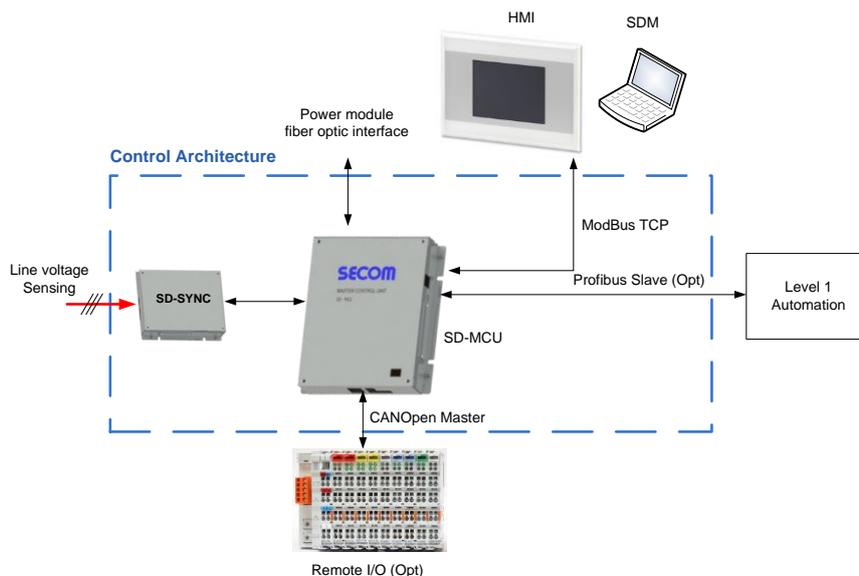
Fig. 3-4: Example of System Architecture for grid control

In case of motor control, the architecture is the following (Fig. 3-5):
- SD-MCU
- Encoder Module (option)
- SD-OP or commercial HMI (both optrional)
- SD-COMX10 (Profibus slave module) of SD-COMX51 (Profinet slave module), both optional
- Remote I/O (option)
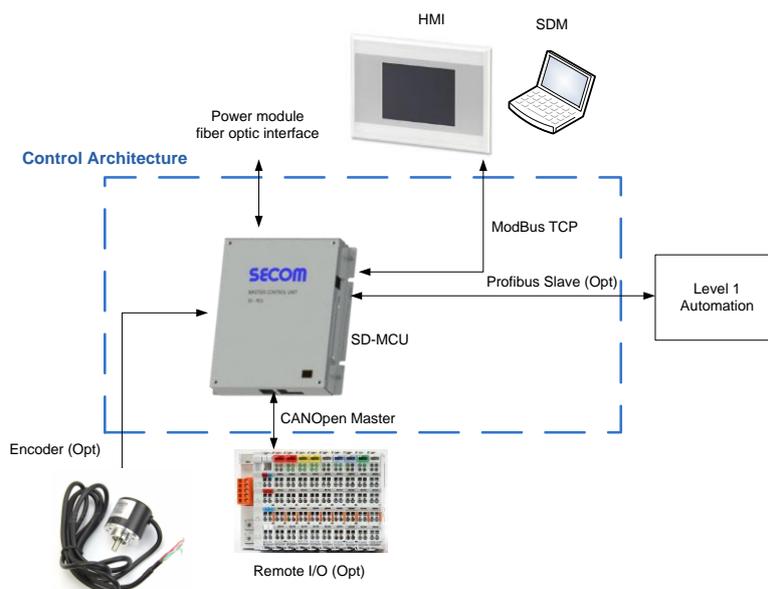
Fig. 3-5: Example of System Architecture for motor control

3.2 DRIVE STRUCTURE DESCRIPTION

The aim of this paragraph is to give a general information about the entire system having a focus on the various sections. The detailed description of the sub-systems will be provided in the later chapters.

3.2.1 Control Boards

In this chapter will be showed the main features and the principal connection of the control boards. The control boards are:
- SD-MCU
- SD-ENC
- SD-COMX

- SD-SYNC

3.2.1.1   SD-MCU

The SD-MCU has the following characteristics:
- Power supply: 24V
- Power consumption: 9 W
- 16 digital inputs
- 6 relays outputs
- 4 open collector outputs
- 8 analog input (±5.5 V)
- Can Open master and slave
- Modbus TCP master and slave
- Profibus DP slave (optional with SD-COMX10) or ProfiNet slave (optional with SD-COMX51)
- Incremental encoder interface (optional with SD-ENC)
- Fiber optic interface to DPM

Fig. 3-6 show the dimensions of the SD-MCU. To mount this board use the four eyelets on left and right side of the case. It is recommended that a spacer is used to separate the bottom of the case from the mounting surface.

> The SD-MCU case is made of anodized aluminum, this means it is insulated (unless the cover is damaged or scratched); to ground the case (and the electronics inside) there is a specific GND connector (see Fig. 3-8).
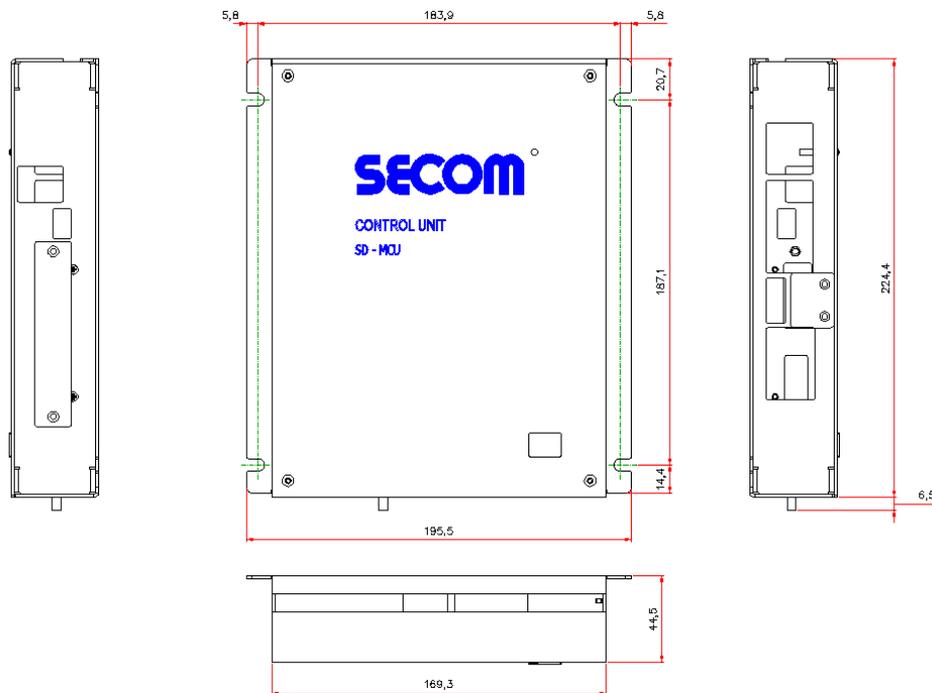
Fig. 3-6: SD-MCU mechanical drawings

A 3D drawing of the SD-MCU is shown in Fig. 3-7; each side is labeled with a letter, these letters are used in conjugation with Fig. 3-8, Fig. 3-9, Fig. 3-10, Fig. 3-11 to illustrate the connections of the SD-MCU. A detailed description of the pin outs of each SD-MCU connector is listed in Tab. 3-2.
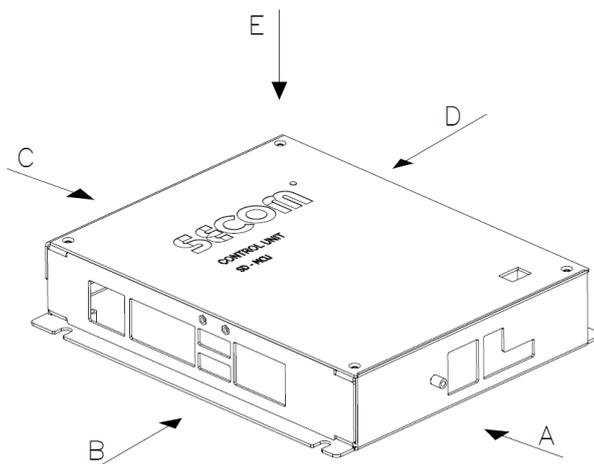
Fig. 3-7: SD-MCU overall drawing, each side is labeled with a reference letter

⊥ :   GND
-X5:   Power Supply
-JP9:   CAN Open Master & Slave
-X6:   Fast Link
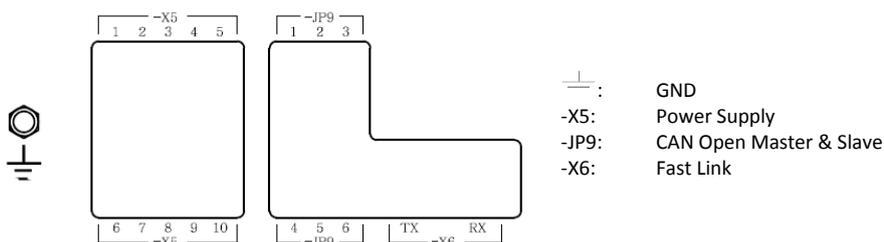
Fig. 3-8: Side A of Fig. 3-7 – grounding, power supply, CAN Open and Fast Link

-X1:   Digital Input
-JP3:   Analog Input (±15V fed form external supply)
-X2:   Analog Input (±15V fed form SD-MCU supply with low power)

-JP20:   Incremental Encoder
-X3:   Digital Output (open collector)
-JP2:   Digital Output (relays)
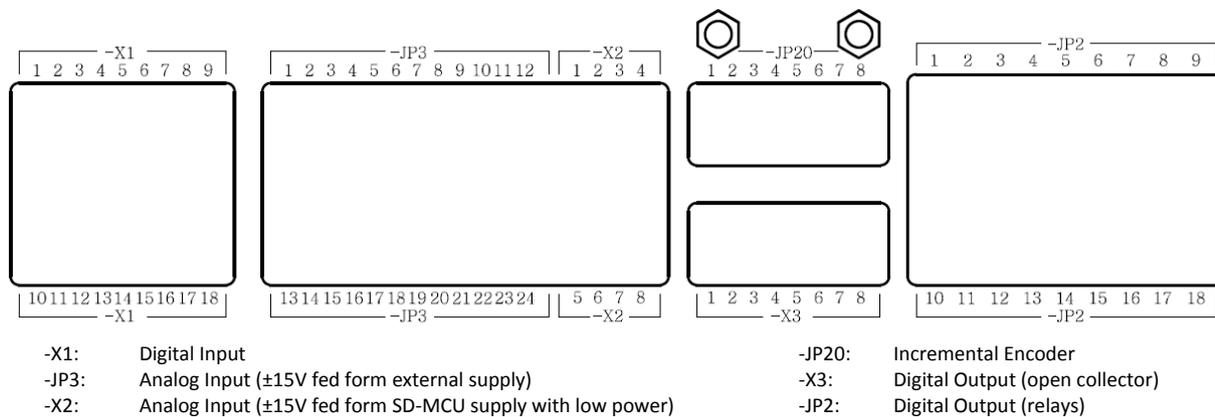
Fig. 3-9: Side B of Fig. 3-7 – digital input, analog input, incremental encoder, digital output, relays output
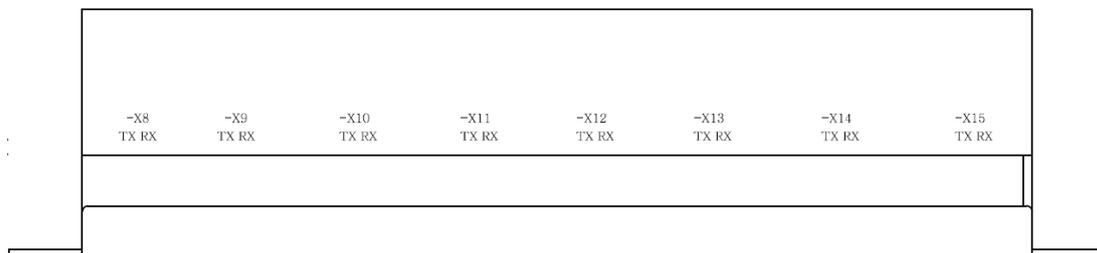
Fig. 3-10: Side C of Fig. 3-7 – fiber optics interface to DPMs

-X30:   Profibus or ProfiNet option
Mini USB
SD-Card slot
ETH0:   Ethernet (ModbusTCP, HMI, SDM, SDScope, etc)
USB0:   for SD-OP, saving logs, updating system, etc
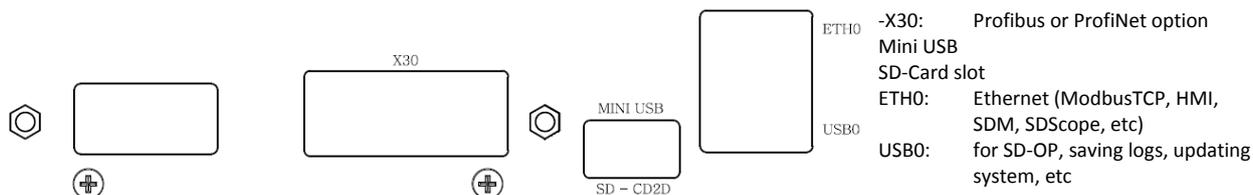
Fig. 3-11: Side D of Fig. 3-7 – SD-COMX (10 or 51), mini USB, SD card, Ethernet and USB
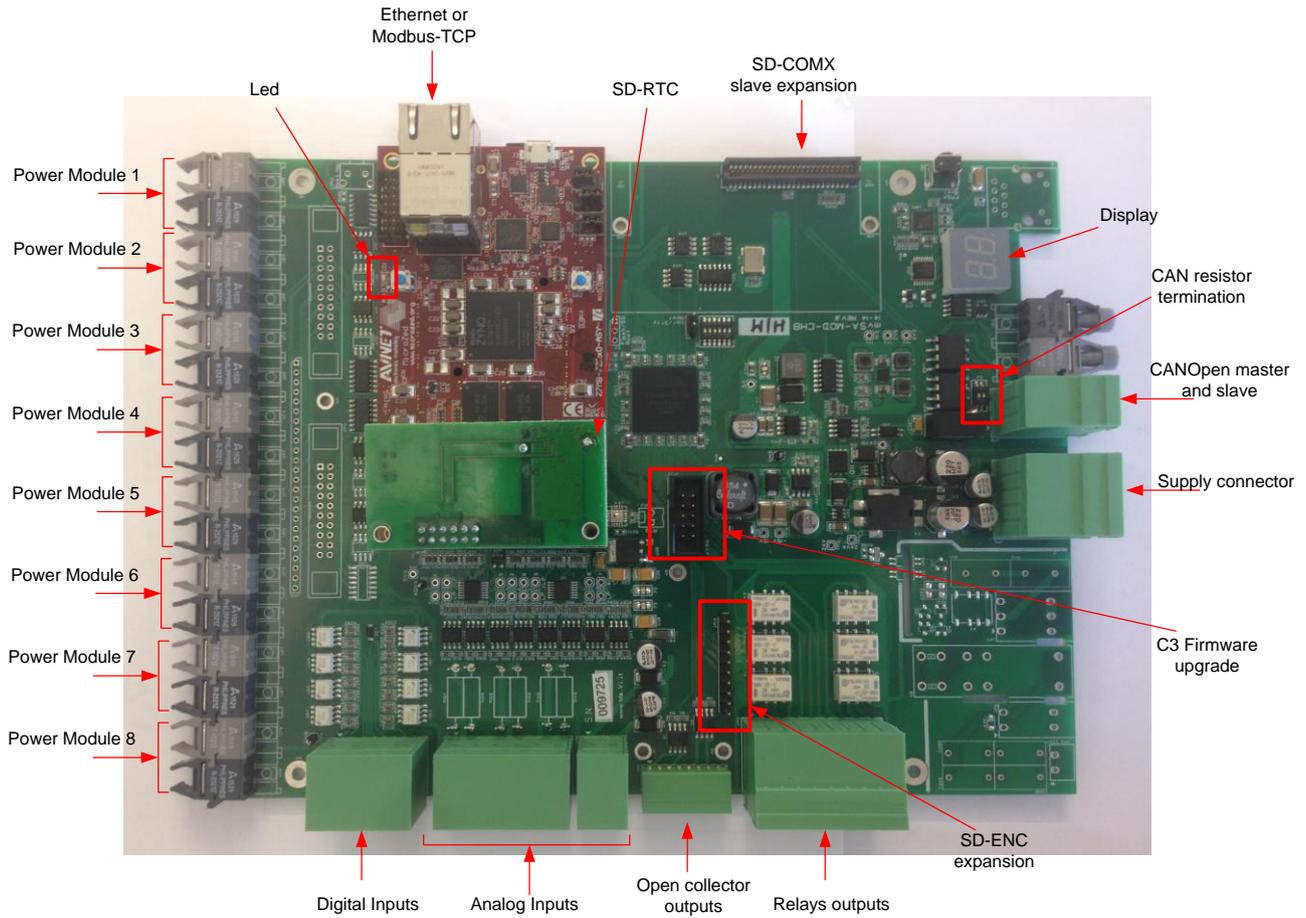
Fig. 3-12: SD-MCU Internal View

Side	Type	Connector	Description	Cable
A	Supply	X5-1	Not connect / *External supply +15V*	Ø 1,5 mm² Pitch 3.5 mm
		X5-2	Not connect / *External supply 0V (same as X5-4)*	
		X5-3	Not connect / *External supply -15V*	
		X5-4	Not connect / *External supply 0V (same as X5-2)*	
		X5-5	Not connect	
		X5-6	Not connect	
		X5-7	**0V** supply	
		X5-8	**24V** supply ± 10 %	
		X5-9	Not connect	
		X5-10	Not connect	
	CAN Open fieldbus	JP9-1	CAN Open Slave – GND	Ø 1,5 mm² Pitch 3.5 mm
		JP9-2	CAN Open Slave – CAN -	
		JP9-3	CAN Open Slave – CAN +	
		JP9-4	CAN Open Master – GND	
		JP9-5	CAN Open Master – CAN -	
		JP9-6	CAN Open Master – CAN +	
		X6-TX	TX cable for fiber optic connection (fast link)	Fiber optics
		X6-RX	RX cable for fiber optic connection (fast link)	
		⏚	Ground connection (for shielding)	
B	Digital Inputs	X1-1	Digital input 1 (24 V) see note e	Ø 0,5 mm² Pitch 2.5 mm
		X1-2	Digital input 2 (24 V) see note e	
		X1-3	Digital input 3 (24 V) see note e	
		X1-4	Digital input 4 (24 V) see note e	
		X1-5	Digital input 5 (24 V) see note e	
		X1-6	Digital input 6 (24 V) see note e	
		X1-7	Digital input 7 (24 V) see note e	
		X1-8	Digital input 8 (24 V) see note e	
		X1-9	Ground (0V) – Common ground only for digital inputs from 1 to 8	
		X1-10	Digital input 9 (24 V) see note e	
		X1-11	Digital input 10 (24 V) see note e	
		X1-12	Digital input 11 (24 V) see note e	
		X1-13	Digital input 12 (24 V) see note e	
		X1-14	Digital input 13 (24 V) – Fault Acknowledge see note c	
		X1-15	Digital input 14 (24 V) – Enable Operation see note c	
		X1-16	Digital input 15 (24 V) – Switch ON see note c	
		X1-17	Digital input 16 (24 V) – Pulse Enable see note d	
		X1-18	Ground (0V) – Common ground only for digital inputs from 9 to 16	

Side	Type	Connector	Description	Cable
	Analog Inputs	JP3-1	Not connect / *External +15V (same as X5-1)*	Ø 0,5 mm² Pitch 2.5 mm
		JP3-2	Auxiliary 0V analog inputs (common with all the analog inputs 0V)	
		JP3-3	Auxiliary Analog input 1 (voltage range ±5.5 V)	
		JP3-4	Not connect / *External +15V (same as X5-3)*	
		JP3-5	Not connect / *External +15V (same as X5-1)*	
		JP3-6	Auxiliary 0V analog inputs (common with all the analog inputs 0V)	
		JP3-7	Auxiliary Analog input 2 (voltage range ±5.5 V)	
		JP3-8	Not connect / *External +15V (same as X5-3)*	
		JP3-9	Not connect / *External +15V (same as X5-1)*	
		JP3-10	Auxiliary 0V analog inputs (common with all the analog inputs 0V)	
		JP3-11	Auxiliary Analog input 3 (voltage range ±5.5 V)	
		JP3-12	Not connect / *External +15V (same as X5-3)*	
		JP3-13	Not connect / *External +15V (same as X5-1)*	
		JP3-14	0V analog inputs (common with all the analog inputs 0V)	
		JP3-15	Analog input 1 (voltage range ±5.5 V): SD-SYNC TV1 (V12)	
		JP3-16	Not connect / *External +15V (same as X5-3)*	
		JP3-17	Not connect / *External +15V (same as X5-1)*	
		JP3-18	0V analog inputs (common with all the analog inputs 0V)	
		JP3-19	Analog input 2 (voltage range ±5.5 V)	
		JP3-20	Not connect / *External +15V (same as X5-3)*	
		JP3-21	Not connect / *External +15V (same as X5-1)*	
		JP3-22	0V analog inputs (common with all the analog inputs 0V)	
		JP3-23	Analog input 3 (voltage range ±5.5 V) SD-SYNC TV2 (V31)	
		JP3-24	Not connect / *External +15V (same as X5-3)*	
		X2-1	Auxiliary +15V for SD-SYNC supply	Ø 0,5 mm² Pitch 2.5 mm
		X2-2	Auxiliary 0V for SD-SYNC supply or for analog inputs (common with all the analog inputs 0V)	
		X2-3	Auxiliary Analog input 4 (voltage range ±5.5 V)	
		X2-4	Auxiliary -15V for SD-SYNC supply	
		X2-5	Auxiliary +15V – Not connect	
		X2-6	Auxiliary 0V analog inputs (common with all the analog inputs 0V)	
		X2-7	Auxiliary Analog input 5 (voltage range ±5.5 V)	
		X2-8	Auxiliary -15V – Not connect	
	SD-ENC Encoder board (optional)	JP20-1	Encoder supply 24V/5V (it is an output for SD-MCU). The supply value depends on the encoder board type.	Ø 0,5 mm² Pitch 2.5 mm
		JP20-2	Encoder channel A+	
		JP20-3	Encoder channel A-	
		JP20-4	Encoder channel B+	
		JP20-5	Encoder channel B-	
		JP20-6	Encoder channel Z+	
		JP20-7	Encoder channel Z-	
		JP20-8	Encoder 0V	
	Digital outputs	X3-1	open collector output 1[see note a, e]	Ø 0,5 mm² Pitch 2.5 mm
		X3-2	0V output 1	
		X3-3	open collector output 2[see note a, e]	
		X3-4	0V output 2	
		X3-5	open collector output 3[see note a, e]	
		X3-6	0V output 3	
		X3-7	open collector output 4[see note a, e]	
		X3-8	0V output 4	
		JP2-1	Digital output 1 – NO contact relay [see note b, e] default: MCB Close Command	Ø 1,5 mm² Pitch 3.5 mm
		JP2-2	Digital output 1 – C contact relay	
		JP2-3	Digital output 1 – NC contact relay [see note b, e]	
		JP2-4	Digital output 2 – NO contact relay [see note b, e] default: Precharge Close Command	
		JP2-5	Digital output 2 – C contact relay	
		JP2-6	Digital output 2 – NC contact relay [see note b, e]	
		JP2-7	Digital output 3 – NO contact relay [see note b, e]	
		JP2-8	Digital output 3 – C contact relay	
		JP2-9	Digital output 3 – NC contact relay [see note b, e]	
		JP2-10	Digital output 4 – NO contact relay [see note b, e]	
		JP2-11	Digital output 4 – C contact relay	
		JP2-12	Digital output 4 – NC contact relay [see note b, e]	
		JP2-13	Digital output 5 – NO contact relay [see note b, e] default: Fan ON command	
		JP2-14	Digital output 5 – C contact relay	
		JP2-15	Digital output 5 – NC contact relay [see note b, e]	
		JP2-16	Digital output 6 – NO contact relay [see note b] Fault relay (fixed function)	
		JP2-17	Digital output 6 – C contact relay Fault relay (fixed function)	
		JP2-18	Digital output 6 – NC contact relay [see note b] Fault relay (fixed function)	
C	DPM interface	X8-TX	TX fiber optic communication cable for DPM1	Fiber optic
		X8-RX	RX fiber optic communication cable for DPM1	
		X9-TX	TX fiber optic communication cable for DPM2	
		X9-RX	RX fiber optic communication cable for DPM2	
		X10-TX	TX fiber optic communication cable for DPM3	
		X10-RX	RX fiber optic communication cable for DPM3	
		X11-TX	TX fiber optic communication cable for DPM4	
		X11-RX	RX fiber optic communication cable for DPM4	
		X12-TX	TX fiber optic communication cable for DPM5	
		X12-RX	RX fiber optic communication cable for DPM5	
		X13-TX	TX fiber optic communication cable for DPM6	
		X13-RX	RX fiber optic communication cable for DPM6	
		X14-TX	TX fiber optic communication cable for DPM7	
		X14-RX	RX fiber optic communication cable for DPM7	

Side	Type	Connector	Description		Cable
		X15-TX	TX fiber optic communication cable for DPM8		
		X15-RX	RX fiber optic communication cable for DPM8		
D	SD-COMX10 SD-COMX51 (optional)	X30	SD-COMX10:	Profibus DP slave Optional fieldbus board (if mounted)	9 pin Profibus D-Sub
			SD-COMX51:	ProfiNet slave Optional fieldbus board (if mounted)	Cat5 / 5e / 6
		Eth0	Ethernet connection (i.e. for SDM, Modbus) 10/100/1000 Mbit/s		Cat5 / 5e / 6
		USB0	Usb device for memory stick or SD-OP		Up to 5m
		SD-CD2D	Micro SD card slot		
E		Display	It provides some information about the MCU FSM (number). See SOFTWARE MANUAL		
		Status led	It provides further information about the drive status (blinking code). See SOFTWARE MANUAL		

Note a: open collector contact type Voltage: Up to 24 VDC, On-state resistance: 200 mΩ, Nominal load current: 1.3 A, Clamping energy: 150 mJ
Note b: relay contact type: bifurcated crossbar, Rated load: 0.3 A at 125 VAC, 1 A at 30 VDC, Rated carry current: 2 A, Max switching voltage: 125 VAC, 60 VDC, Max switching current: 1 A
Note c: these functions are mandatory only if the main command word comes from Terminal Board (see SOFTWARE MANUAL)
Note d: Pulse Enable must be always at 24V whatever it is the command source. If this signal is low, the drive can't switch on and all IGBTs aren't pulsed
Note e: Configurable I/O

<div align="center">Tab. 3-2: SD-MCU Connectors detailed description</div>

3.2.1.2 SD-ENC

The encoder board (SD-ENC, Fig. 3-13) represents an optional board that must be mounted on the SD-MCU in case of encoder feedback. SD-ENC allows to connect incremental encoder to the SD-MCU. SD-ENC supplies the encoder with stabilized 24V and read signals A, B and Z in differential mode from 5V to 24V.
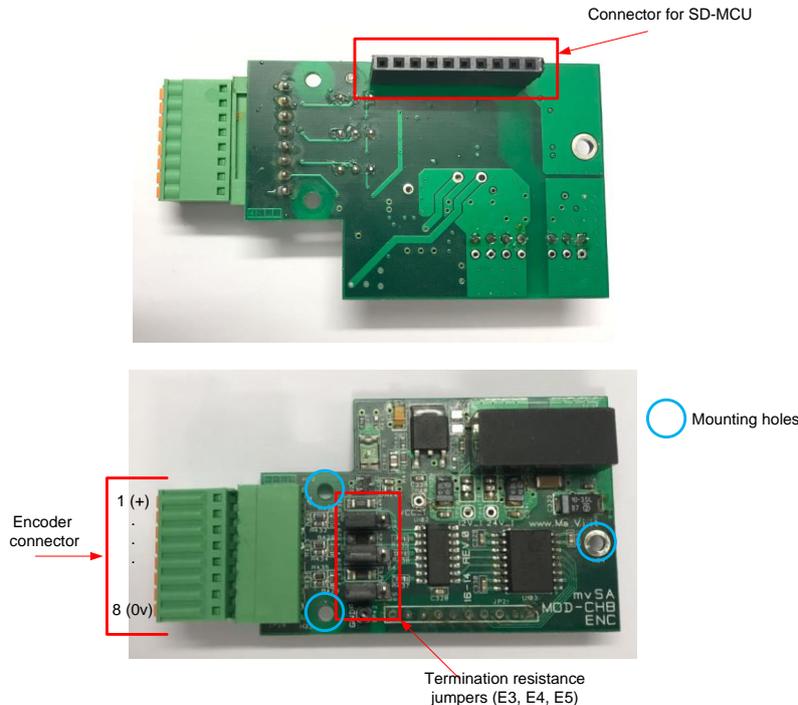
<div align="center">Fig. 3-13: SD-ENC Board description</div>

Normally it is recommended to insert a termination resistance (100 Ω) by setting the dip switches E3, E4 and E5 as terminateon ON. The dip switches configuration is showed in the table below.

E3, E4 and E5 dip switches position	Meaning	E3, E4 and E5 dip switches position	Meaning
	Termination ON (recommended configuration)		Termination OFF
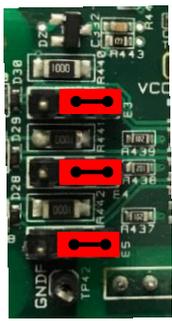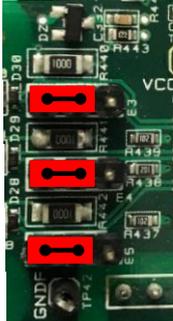
In case of other devices connected to the encoder (for example encoder repeater), it is necessary to check the encoder maximum power consumption before inserting termination resistances.

When at least one of the six encoder signals (A+, A-, B+, B-, Z+, Z-) is not connected to the SD-ENC when a FOC control is selected an alarm is generated (Encoder feedback lost).

3.2.1.3 Profibus Interface SD-COMX10

The SD-COMX10 is an optional board that must be mounted on the SD-MCU and it allows a profibus slave interface. To enable Profibus DP slave functionalities it is necessary to add to the SD-MCU the Hilscher Profibus module (*COMX-10CA-DPS*) as described in the HARDWARE MANUAL.
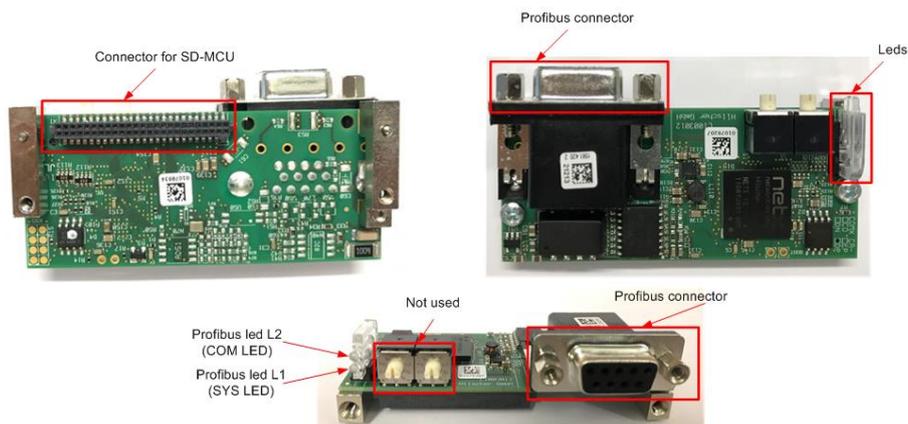
Fig. 3-14: SD-COMX10 board description

3.2.1.4 ProfiNet Interface SD-COMX51

The SD-COMX51 is an optional board that must be mounted on the SD-MCU and it allows a ProfiNet slave interface. To enable ProfiNet slave functionalities it is necessary to add to the SD-MCU the Hilscher ProfiNet module (*COMX-51CA-RE* with ProfiNet firmware[1]) as described in the HARDWARE MANUAL.
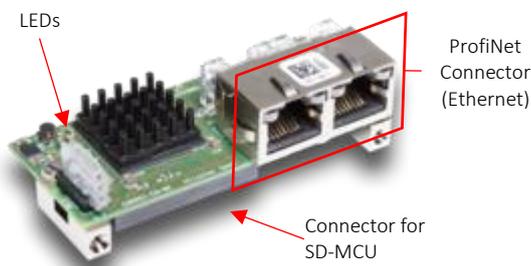
Fig. 3-15: SD-COMX51 board description

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[1] Pay attention that Hilsher COMX-51 can support other protocols, but SECOM Drive can manage only ProfiNet

3.2.2   Inverter Power Part

The size selection is the first step for SECOM DRIVE configuration; all the selectable size typologies (all the size name and rating are showed in the HARDWARE MANUAL) are composed as 1 or up to 8 drive base size(also called DPM drive power module). In every DPM are defined the properties of the base power module.
The DPM has these properties:

Name	Description
DPM base size	It uniquely identifies the drive root. The sample code is the follow: **SD**X.Y.H.ZZZZ.JJJ.QQQQ.(SK) The red part is the same described in the hardware manual. Summarizing, this part identifies the power module hardware version, the input voltage and the output power. the blue part QQQQ identifies the power part topology: LV2L - Low Voltage 2 Level LV3L – Low Voltage 3 Level ML2L – Multilevel 2 Level ML3L – Multilevel 3 Level MVCT – Medium Voltage IGCT MVGT - Medium Voltage IGBT While K identifies special configurations. *Example* SDX.2.A.290K.690.LV2L Secom Drive 290kVA @ 690 V, air coled, Low voltage and two levels inverter type
Working Switching Frequencies $(f_{sw1}, f_{sw2}, f_{sw3}, f_{sw4})$	Each drive root has four switching frequencies. Depending on the drive root some switching frequencies may not be selectable. If F3E is selected the switching frequencies are not used.
Nominal current (I_{cl0}, I_{cl1}, I_{cl2}) @ (f_{sw1}, f_{sw2}, f_{sw3}, f_{sw4}) @ four working classes	Each drive root has the inverter nominal current depending on the switching frequency and the working class[2]. The working class 1 is not allowed in F3E drive root.
Nominal AC input voltage and allowed input bandwidth	The nominal input voltage at the inverter AC input allowed and its relative bandwidth (e.g. 690 ± 10%).

Tab. 3-3: Drive Root parameter description

The main rule is that a Drive Size is composed from 1 up to 8 DPM of the same typology. The general configuration is showed in Fig. 3-16. The standard code is *n* x DPM code (ZZZZ) where *n* is the number of DPM parallel connected to obtain the selected drive size and ZZZZ is the total power (e.g. 6 x SDI.2.A.1M00.690- LV2L (6M00).
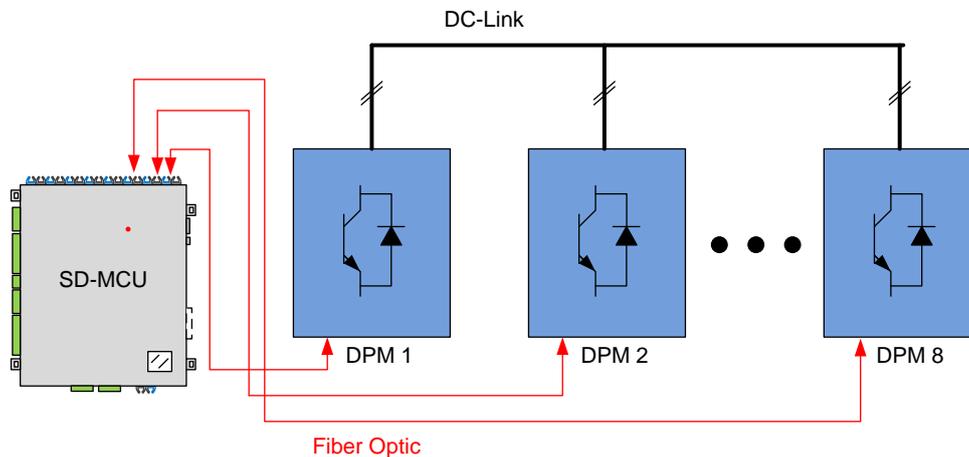
Fig. 3-16: Drive Size general configuration

In the two figures below are showed some configuration example:

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[2] The working classes are defined in the Hardware manual
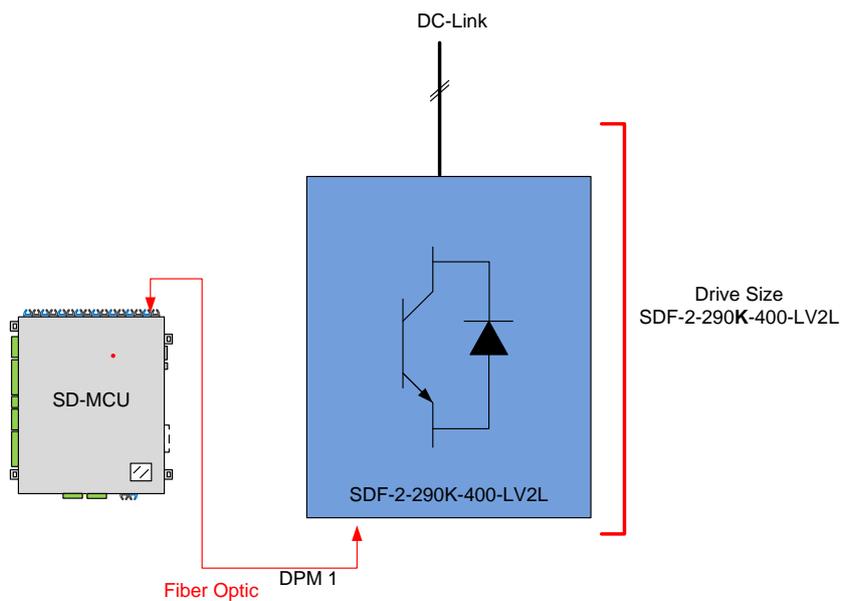
Fig. 3-17: Drive size example with only one DPM
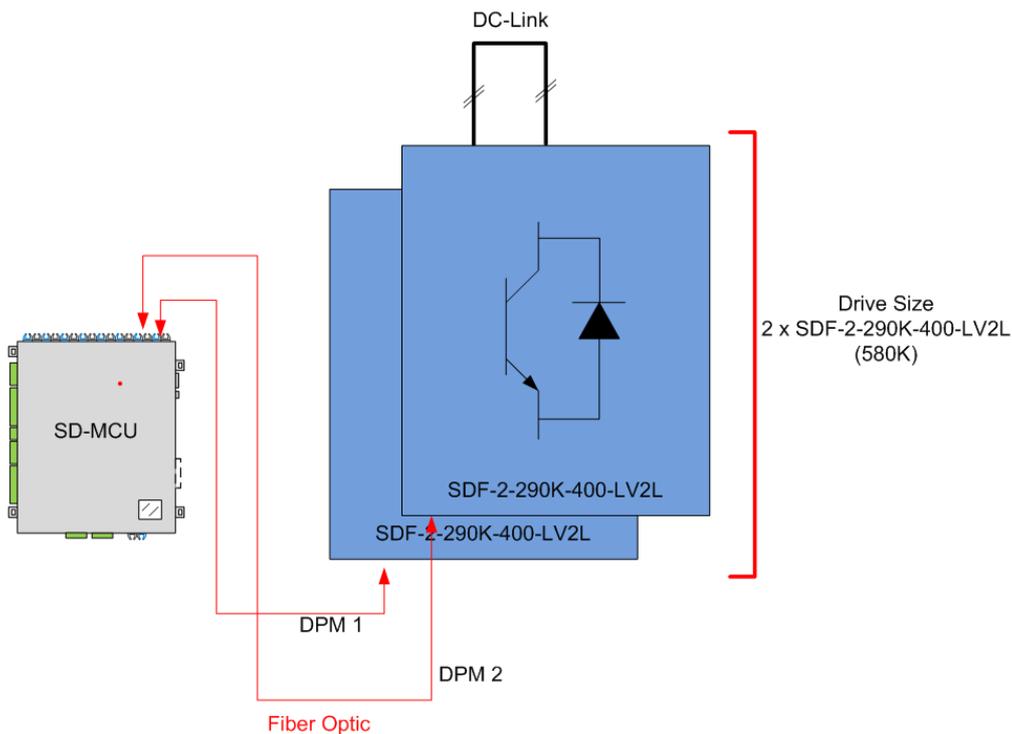
Fig. 3-18: Drive Size with several DPM parallel connected (two in this example)

According to the number of drive root in the drive size (number of DPM) it is necessary to follow the fiber connections as in the figure below:
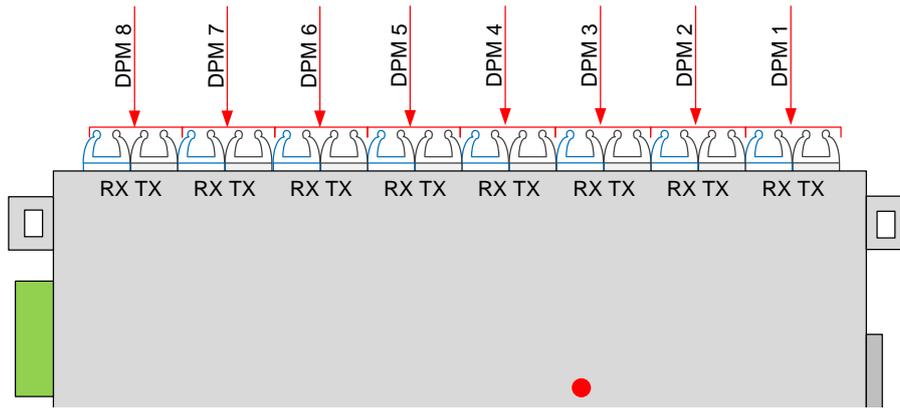
Fig. 3-19: Optical connection for each DPMs

WARNING! Users had better not mix fiber optic from/to the DPMs to avoid alarms and commands misinterpretation

As told before, the Drive size defines the power and physical characteristics of the system. The drive size selection allows to choose different parameters:

- *Switching frequency* (f_{sw}): number of IGBT turn-on/turn-off in one second. For each drive size are defined at most 4 switching frequencies. The switching frequencies affects the inverter rated current.
- *Class overload* (I_{clx}): defines the rated current for each overload class. In the hardware manual are defined all of the parameters that characterize each overload class shown in Fig. 3-16. X defines the class number from 0 to 2.
- *Ambient temperature* (T_{amb}): ambient temperature is used for thermal monitoring (it affects the inverter thermal current)
- *AC Input voltage* (V_{input}): it is the input voltage that supplies the power module. The admissible range is defined for each Drive Size as shown in the hardware manual. This parameter defines the DCBus nominal values as follow:

$$V_{dcNom} = \sqrt{2}V_{input}$$

For Motor application (the load description will be explained further), if the precharge is not controlled by inverter could be necessary to set indirectly V_{dcNom}. This parameter cannot be set directly because it is a read only type. To overcome this problem it is necessary to set

$$V_{input} = \frac{V_{dcNom}}{\sqrt{2}}$$

Or it is possible to set the voltage at the input of the line converter.
This value can be different from the load nominal voltage (e.g. if a transformer is inserted between the line and the inverter in case).

The final rated inverter current is defined as follow:

$$I_{inv} = f(I_{cl}, f_{sw})$$
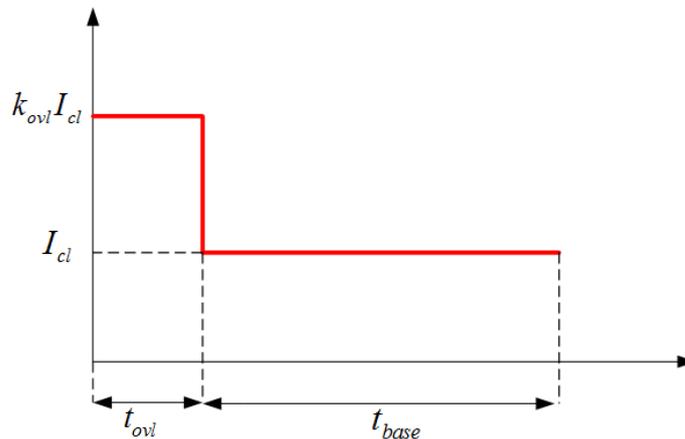
Fig. 3-20: Class overload current parameters definition

The inverter current is used to define the working cycle (in this case the overload current for the selected working cycle type is $k_{ovl}I_{inv}$).
The I_{inv} can be also different from the load nominal current.
There are three overload duty (class) defined as follow:

- Class0: the current I_{cl0} can be maintained indefinitely. No overload is allowed.
- Class1: the current I_{cl1} can follow a working cycle as $1.1I_{cl1}$ for 60 s and I_{cl1} for 240 s.
- Class2: the current I_{cl2} can follow a working cycle as $1.5I_{cl2}$ for 60 s and I_{cl2} for 240 s.

It is possible to choose the working cycle by selecting parameter *[0302]*.
With the F3E control is not possible to choose class1 overload.

3.2.3   DC-BUS

Another fundamental part of the power part is the DC-Bus. The DC-Bus defined the connection between the AC and DC part. Inside the DC-Bus section can be connected auxiliary devices as:
- Precharge Unit
- Chopper

As mentioned before the precharge circuit is another the power system. The purpose of this circuit is to charge the DC-Bus capacitors without damaging the hardware components.

⚠️ Connect directly the dc-bus capacitor to the line without a precharge circuit can damage irredeemably the inverter.
Verify all the cabling between control circuitry and precharge circuit before starting the drive.
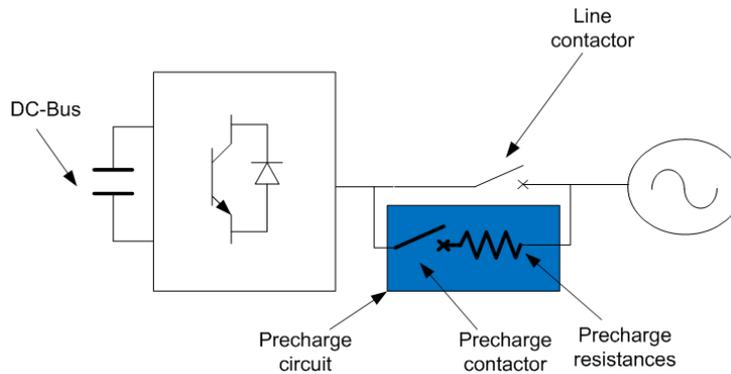
Fig. 3-21: Precharge circuit Example

This procedure is usually made by using an additional contactor and a set of resistance. The line voltage (AC) is converted into DC one by using the internal three-phase diode bridge (Fig. 3-21). If the precharge circuit is "drive controlled" it is called *internal precharge* otherwise *external precharge*. The detailed description about the precharge system will be explained later.

In the DC-Bus section are defined some important parameters as:
- *Vdc Min Threshold*: it is referred to V_{dcNom} and defines the minimum allowed voltage before a fault. This fault can be maked only if grid waiting function is enabled and the precharge type is internal. The minimum value depends on the load type. If it is GRID the minimum value is 0.75 otherwise is 0.7.
- Precharge Ok threshold: it is referred to V_{dcNom} and Precharge Ok threshold: it is referred to V_{dcNom} and It defines the minimum voltage at which it is assumed that DC-Bus is charged
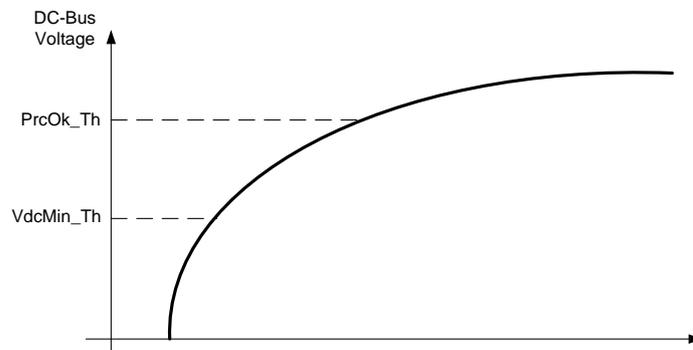
Fig. 3-22: DC-Bus threshold

More the inverter are parallel connected more the dc-link capacitance is high and the resistance seen from the line is low. For this reason it is necessary to check the precharge items (contactor, fuses and resistances) before start the drive.

3.2.4   Inverter Load Type

Once the power part is chosen it is necessary to select which type of load will be connected to it.
The possible choices are:

- **GRID** (the power part is connected to the grid or it can generate a proper net)
  - F3E (**F**undamental **F**requency **F**ront **E**nd)
    - Low switching frequency (6 times the line frequency)
    - Regenerative feedback
    - Unregulated dc-bus voltage (dc-bus voltage depends on the voltage line fluctuations)
  - AFE (**A**ctive **F**ront **E**nd)
    - Low line harmonic content
    - Regulated dc-bus (dc-bus voltage is independent on the voltage line fluctuations)

- ▪ Controlled reactive current
- ▪ Unitary power factor (with reactive current reference set to zero)
- ▪ Sinusoidal output current
  - o Vac Generator (independent line generator)
    - ▪ Independent voltage and frequency setpoint
    - ▪ Current short-circuit detection and control
- **MOTOR**
  - o IM (**I**nduction **M**otor)
    - ▪ Speed control
    - ▪ Torque control
    - ▪ Current control

The load defines the point at which the system refers its control values, configures the regulating loop and calculates the per-unit base values. Because of the different nature of the types of loads it's impossible to make a general discussion but will be examined different cases.

In case of **GRID** the main load parameters are:

- Load rated voltage (V_{sn}): it defines the per-unit base of the voltage quantities
- Load rated current (I_{sn})
- Load current overload (k_{lovl}) compared to nominal current : $k_{lovl}I_{sn}$ defines the per-unit base of the current quantities
- Load rated frequency (f_n): it defines the per-unit base of the frequency quantities
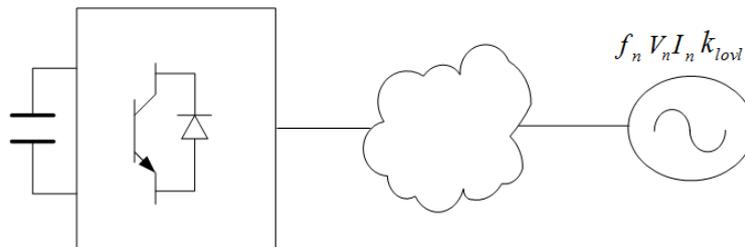
Fig. 3-23: Grid Load Configuration parameter

In case of **Motor** the main load parameters are:

- Load rated voltage (V_{sn}): it defines the per-unit base of the voltage quantities
- Load rated current (I_{sn})
- Load current overload (k_{lovl}) compared to nominal current : $k_{lovl}I_{sn}$ defines the per-unit base of the current quantities
- Load maximum frequency (f_{max}) : it defines the per-unit base of the frequency quantities
- The per-unit base power is calculated as $\sqrt{3}V_{sn}I_{sn}$
- Other values used to calculate motor parameters:
  - o Load rated power (P_n): mechanical power used for parameter calculation
  - o Load rated frequency (f_n)
  - o Rated speed (n_m): rated mechanical speed

3.2.4.1 Transformer

Secom Drive can be manage also load with a transformer part. In this case it is necessary to explain the various parameters used in the control software.
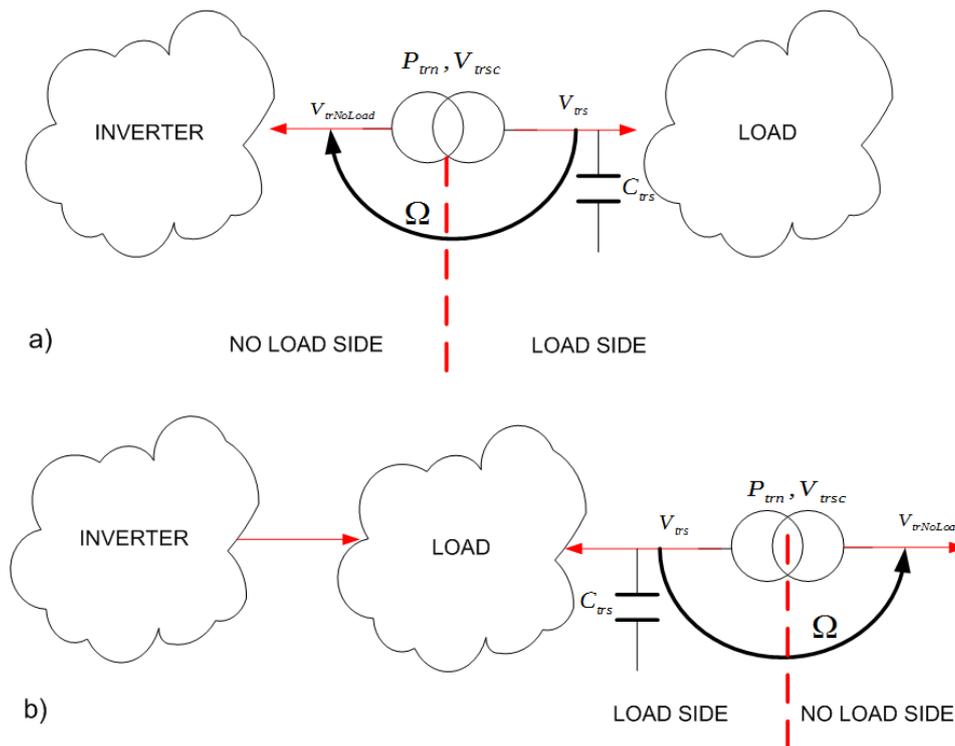
Fig. 3-24: Transformer disposition between inverter and load (a) and after inverter and load (b)

The transformer can be situated in two different position as shown in Fig. 3-24:
- The transformer is inserted between the power module (inverter) and the load. In this case transformer parameters affects the load / inverter parameter (e.g. voltage ratio, phase shift, etc.)
- The transformer is inserted after both load and inverter. In this case the transformer parameters do not affect the load / inverter parameters but only the transformer thermal monitoring (if it is activated).

These two transformer configurations can be selected using the synchronization point that will be explained later. Furthermore the b) configuration can be used only in GRID to monitor transformer thermal current.

The main transformer parameters are described below:
- Rated Apparent Power (P_{tr}): name plate apparent power
- Rated voltage at the load side(V_{trs}): name plate voltage of the windings connected to the load side
- Rated voltage at the no load side($V_{trNoLoad}$): name plate voltage of the windings connected to the other windings
- Short Circuit voltage (V_{trsc}): short circuit transformer voltage in percentage of the nominal voltage
- Phase shift(Ω): phase shift angle between load side and no load side winding

With this parameters it is possible to calculate:
- Transformer ratio(k_{tr}): load side to no load side voltage ratio. This ratio is used to scale the load quantities to the inverter quantities (only if the transformer is in *a)* configuration).
- Rated current at load side(I_{trs}): calculated as $I_{tr} = \dfrac{P_{tr}}{\left(\sqrt{3}V_{trs}\right)}$
- Rated current at no load side($I_{trNoLoad}$): calculated as $I_{trNoLoad} = \dfrac{P_{tr}}{\left(\sqrt{3}V_{trNoLoad}\right)}$
- Transformer inductance(L_{tr}): this inductance is used to load model estimation. The value is calculated as follow: $L_{tr} = \dfrac{(V_{trs}V_{trsc})}{\left(\sqrt{3}2\pi f_n I_{trs}\right)}$

3.2.5   Feedbacks

In the feedback section is defined the connection of external sensors to the inverter and its behavior.
First of all it is necessary to explain the synchronization point that is the base of the calculation made before.

3.2.5.1   Synchronization point (SP)

For proper operation of the inverter control it is necessary to define the point where the load is located respect to the inverter output. The quantities referred to the load side have the subscript **load** or **s** (synchronous) while the others ones referred to the inverter side have the subscript **inv** (e.g. *Iinv magnitude* and *Is magnitude*).
This point is called synchronization points (SP). The SP not only defines the references quantities of the load and thus its PU bases, but also what other components are between the inverter output and the load (filters, transformer).
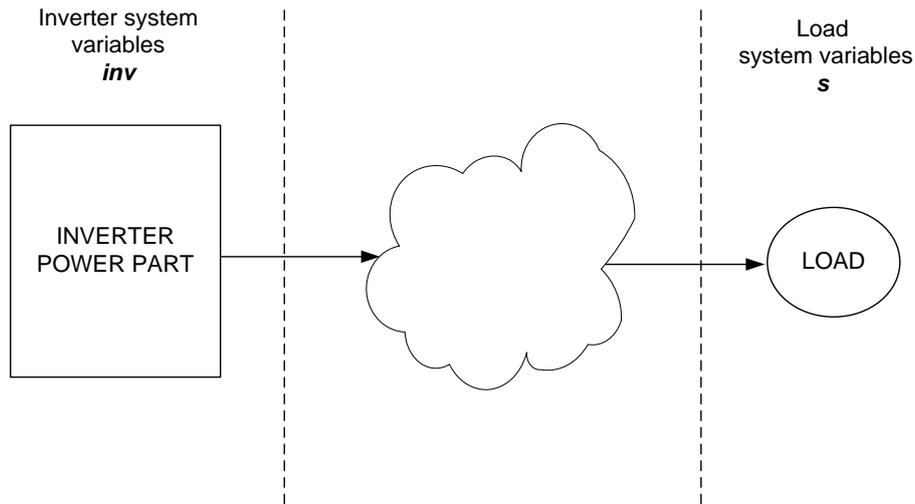
Fig. 3-25: Principle diagram of synchronization point (SP)

There are three SP available:
- Inverter
- Filter
- Transformer
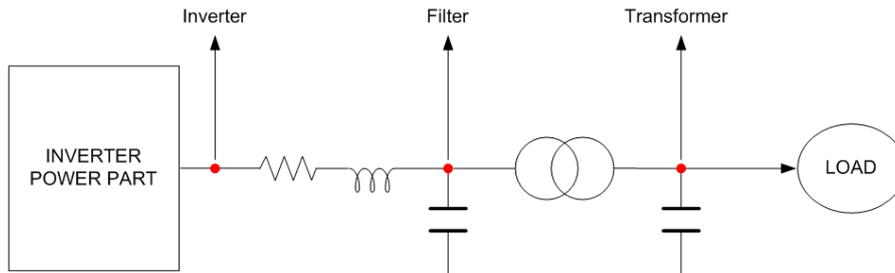
Fig. 3-26: Selectable synchronization point

Inverter: the load parameter are defined directly to the inverter output and will not be taken into account either the filter parameters and or transformer ones (and any scaling due to the transformation ratio).
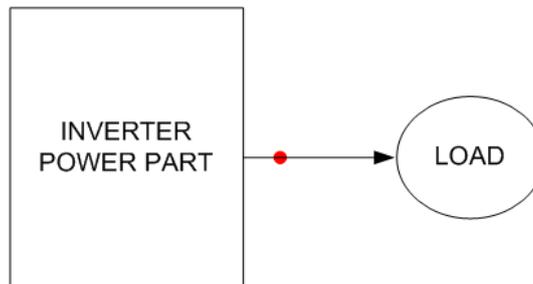
Fig. 3-27: Synchronization point (SP) configuration: inverter

The transformer can be enabled only in GRID mode and only for the purpose of thermal current monitoring (transformer Fig. 3-24.*b* configuration). In this case the transformer parameters do not affect the scaling of the load parameters.

Filter: this option allows the integration of a RLC filter into the system. Of course if you want to disable the parameter you need to set it to zero.
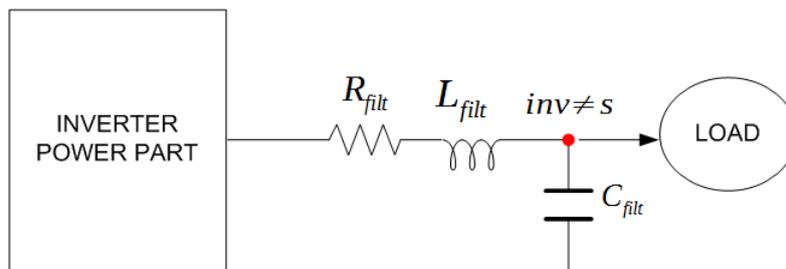
Fig. 3-28: Synchronization point (SP) configuration: filter

By setting to zero one of these three parameter ($R_{filt}, L_{filt}, C_{filt}$) is possible to obtain different filter typologies.

You can also integrate the cable resistance using R_{filt}. In case you want to integrate only the output inductance is possible to set the other two parameters (R_{filt}, C_{filt}) to zero.

As in the previous configuration, in case of GRID mode you can enable the transformer only for thermal current monitoring. The parameters of the transformer does not affect the scaling of the quantities of load.

In the following paragraphs we will be described the operation of the SP with the various types of LOAD and CONTROL.

Transformer: this option allows the integration into the system, in addition to the parameters set up to now, also a transformer. The transformer, in addition to introducing into the system a reactance (modeling of the transformer), it also introduces transformation ratio and a phase shift between the load side end no load side windings.

The parameters of the system that are not used (capacitors, reactors and resistors) may be eliminated from the calculation by setting the value zero. In this case, the transformer is forcedly enabled and cannot be disabled unless you change the SP.
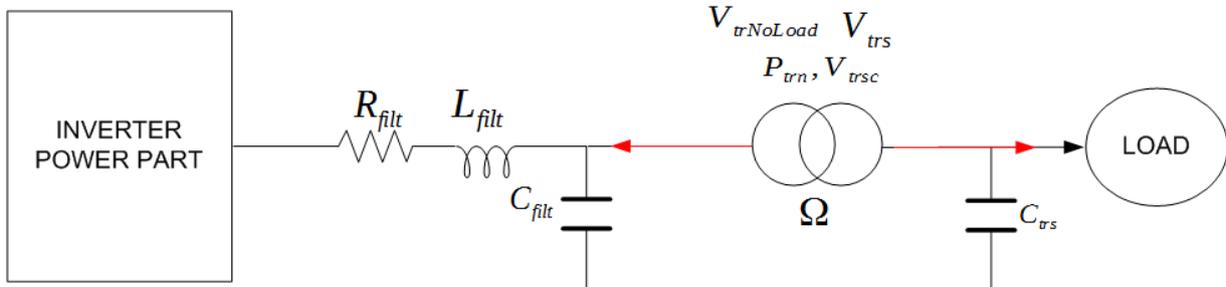
Fig. 3-29: Synchronization point (SP) configuration: transformer

Moreover, not all types of load and control admit all SP configuration. In the following table is shown the various configurations.

SP	GRID				MOTOR	
	F3E	*AFE*	*Vac Gen*	*Transformer Enable*	*All Control*	*Transformer Enable*
Inverter	x		x	optionally	x	
Filter	x	x	x	optionally	x	
Transformer		x	x	x	x	x

Tab. 3-4: SP configuration for all the controls and loads. The symbol (x) means that

The SP represents also the point where the auxiliary voltage and current transducer are located. The auxiliary voltage transducers are usually used to measure AC voltages (e.g. line voltages, output voltages). The transducers are located inside the SD-SYNC board. The output of the SD-SYNC is connected to a terminal board on the SD-MCU.

The auxiliary current transducer are used for special applications like AC generator or when it needed a high dynamic control with LCL filters. Tab. 3-5 below shows the various configurations:

Sensors	GRID			Motor
	F3E	*AFE*	*Vac Gen*	*All Control*
Aux Voltage	x	x	x	(x)
Aux Current		(x)	(x)	(x)

Tab. 3-5: Aux sensors configuration

Aux Voltage sensors: as it told before, this sensor is used for AC voltage measuring. There are two fundamental parameters:
- *Transducer scale*: define the input/output SD-SYNC conversion ratio (for SD-SYNC is 227). The output is defined connected to SD-MCU (low voltage side)
- *Transducer mode*: define which type of connection is made at the input of SD-SYNC: line to line (line) or phase to neutral point.

Aux Current sensor: there is only one parameter for the scaling called "current transducer scale". It defines the input current vs the output voltage ratio. The output voltage is defined at the input of the SD-MCU.

3.2.6 Per-unit

The system quantities can be expressed in two different manners: engineering or per-unit. The first one is useful to define the outline value of the system like line and motor parameters. The second one it is the expression of system quantities as fraction of a defined base unit quantity and it is useful to compare different type of inverters and loads.

The per-unit base quantities are showed in the table below:

Block name	Formula	Parameter formula
DCBus	$\sqrt{2}V_{input}$	$\sqrt{2}$ * **[0303]**
Load current	$I_{sn}k_{lovl}$	**[0503]*[0504]**
Load voltage	V_{sn}	**[0502]**
Load frequency	f_{smax} in case of MOTOR f_{sn} in case of GRID	**[0506]** in case of MOTOR **[0505]** in case of GRID

Block name	Formula	Parameter formula
Load speed	$60f_{smax}/P^3$	Integer value of *[0506]*[0507]/[0505]*
Load power	$\sqrt{3}V_{sn}I_{sn}k_{lovl}$	$\sqrt{3}$*[0502]* [0503]*[0504]*
Inverter current	$I_{sn}k_{lovl}/k_{tr}$	*[0503]* [0504]*[0704]/[0703]*
Inverter voltage	$V_{sn}k_{tr}$	*[0502]* [0703]/ [0704]*
Torque	$\frac{\sqrt{3}V_{sn}I_{sn}k_{lovl}}{2\pi f_{sn}}P$ *in case of VHz control or if parameters are not calculated otherwise the value is calculated by using the internal model*	$\sqrt{3}$*[0502]* [0503]*[0504]*P/(2*π [0505])*

Tab. 3-6: Per-unit value explanation

In this case to converter a per-unit value to engineer value is necessary to determine the block dependence and multiply the value for the per-unit base block name.

Example 1:

It is supposed to determine the engineer value of the parameter [6202] (Vinv Magnitude) and its value is 0.6.
For this parameter the block dependence is inverter voltage (it is supposed that the per-unit value is 400 V). The calculation is the follow:
0.6 * 400 = 240 V
The engineering equivalence is 240 V.
∎

Example 2:

It is supposed to determine the engineer value of the parameter [6341] (Is ph phase 1) and its value is 1. For this parameter the block dependence is load current (it is supposed that the per-unit value is 300 A). The calculation is the follow:
1 * 300 = 300 A
The engineering equivalence is 300 A.
∎

3.3 DETAILED FUNCTIONAL DESCRIPTION

The control software is entirely divided in many sub-systems that cooperate with each other. The interface to the customer is realized through commands (CW) and status words (SW).

Short Name	Description	Input/output
FSM	Finite State machine of the system	MCW, MSW
DC-Bus	DC-Bus system	DC-Bus CW DC-Bus SW
Reference	Speed, Torque and electrical References	Reference CW Speed Reference SW
DiPo	Digital Potentiometer	DiPo SW DiPo CW
Custom	Custom Word	PLC User Defined CW Profibus User Defined CW ModbusTCP User Defined CW CAN User Defined CW Custom SW
Overload	Overload monitoring	Overload SW
Digital	Digital input / output	Digital Input W Digital Output W
RMU interface	RMU Interface in the SD-MCU	Modulator SW Modulator CW
Voltage Drop	Voltage Drop	Voltage Drop SW
Regulator	Regulator	Regulators SW Regulators CW
Fluxing	Motor Fluxing	Fluxing SW
JOG	JOG	JOG SW
Fieldbus	Fieldbus (Modbus TCP slave, CANopen slave, Profibus Slave)	Fieldbus SW
Brake Mode	Motor braking functionalities	Brake Mode SW Brake Mode CW
STO	Safe torque OFF	STO SW

---

[3] Motor pole pairs calculated as $60f_{sn}/n_m$ where n_m is the nominal motor mechanical speed *[0507]*

Short Name	Description	Input/output
Drive Config Info	Drive configuration information	Drive Config Info
Synchronization	Synchronization system (Grid or Motor)	Synchronization SW
Fan	Inverter Fan information	Fan SW
Mod Option	Modulator option information	Mod Option SW
Trace	Trace information	Trace SW
PLC	SDLE system	PLC SW
Commissioning	Drive commissioning	ID Test State, ID Test result

Tab. 3-7: Software control modules

In the following sections will be described the behavior of these sub-systems.

3.3.1 Finite State Machine (FSM)

The finite state machine defines the layer between customer and the controls system algorithms/diagnostic. Each states defines a particular behavior and the state transition is well defined by particular conditions that will be described in the following section. In general the states sequence is a function of the inputs and the actual state. The transition point is defined from the inputs. These ones can be divided in two typologies:
- External input
- Internal Input

External inputs are represented by signals from the fieldbus (Profibus, CAN, PLC ...) and from the terminal board. The internal ones are represented by the signals generated by the firmware among which there are faults and sub-system signals (e.g. synchronization ok).
The customer can check the actual state by reading the MSW (quick description) and the drive state word (detailed description).
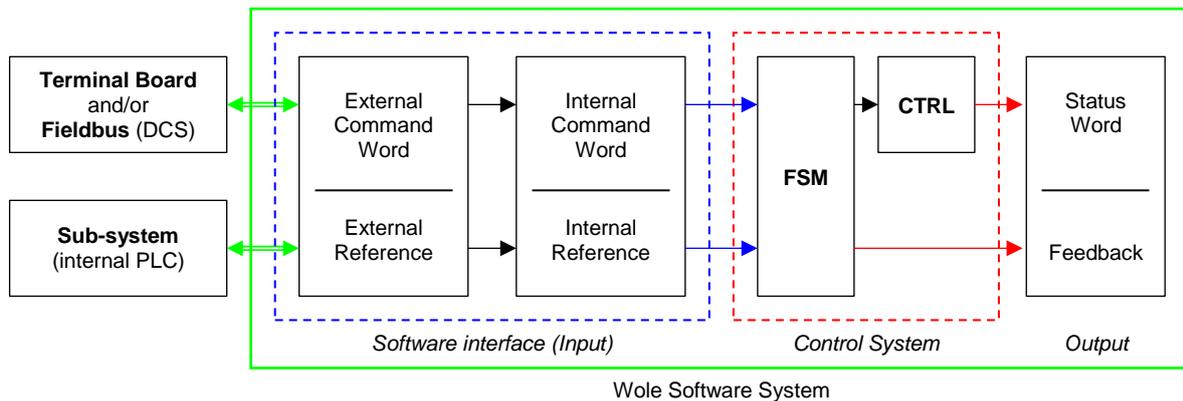
Fig. 3-30: Finite State machine interconnection

To control the FSM it is necessary at least 5 commands:
- ON
- Enable Operation
- Not OFF2
- Not OFF3
- Acknowledge fault

These signals are mapped in the MCW that will be described further.
The FSM is composed by 17 states defined in Tab. 3-8 (detailed description).

State number	Description
0	Start-up
1	Initialization
2	Switch On Inhibited
3	Not Ready to Switch On
4	Ready to Switch On
5	Precharging
6	Wait For Sync
7	Ready to Operate
8	Operation Inhibited
9	Magnetization
10	Running
11	Grid Waiting
12	Ramp Stop

State number	Description
13	OFF1 - Ramp Stop
14	OFF3 - Quick Stop
15	OFF2 - Coast Stop
16	Fault

Tab. 3-8: FSM State number and description

To simplify the customer interface, the most of the states shown in Tab. 3-8 are grouped into 3 main states called:
- READY TO SWITCH ON (always known as READY ON)
- READY TO OPERATE
- OPERATING ENABLE

These main states are mapped in the MSW.
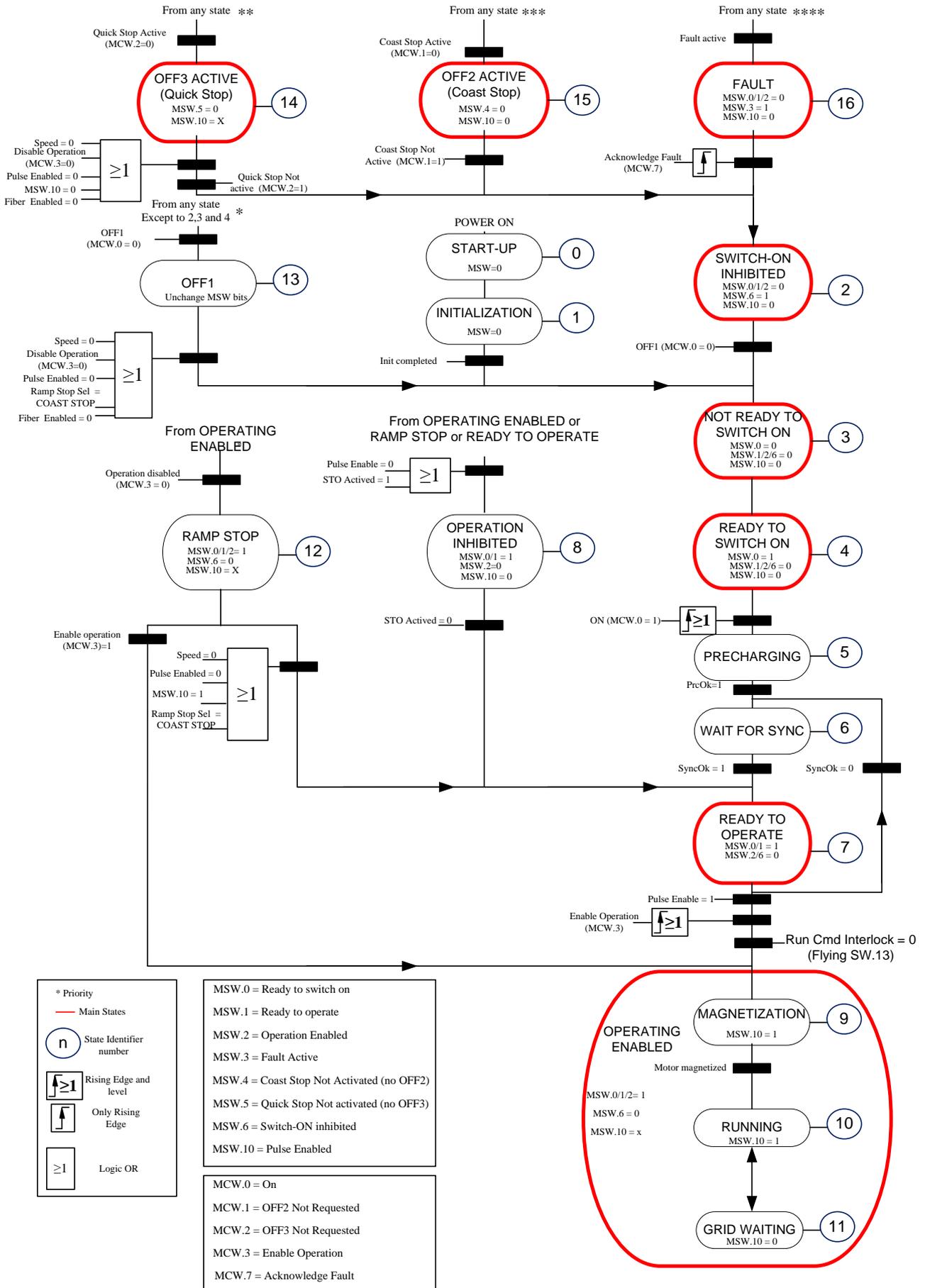
Fig. 3-31: Finite State Machine state flow

START-UP (0): This state is reached when the SD-MCU is switched-on, after the Linux OS is started. The following state is INITIALIZATION.

INITIALIZATION (1): It completes the initialization of variables from last saved parameters. If there are not errors the system proceeds to the next state.

SWITCH-ON INHIBITED (2): the transition to this state is allowed only if the number of the previous one is above 13. In this state the pulses are removed and the line contactor is opened (if precharge circuit is controlled). The state transition to NOT READY TO SWITCH ON is allowed only if ON is set to zero.

NOT READY TO SWITCH-ON (3): This state is maintained for only one main task cycle (1 ms).
This state is a required step before moving to the state READY TO SWITCH ON. In the state NOT READY TO SWICH-ON even if the ON signal is active it is set to zero in such a way that must be provided a new rising edge. If there are not fault active and there are not OFF requests the system proceeds to the next state.

READY TO SWITCH-ON (4): As soon as there is a rising edge of the ON command there is a state transition to PRECHARGING.

PRECHARGING (5): In this state the Precharge Start command is set to high. In this state the precharge sequence is activated and the Dc-Bus voltages is monitored. When the precharge sequence is accomplished there is a state transition to WAIT FOR SYNC.

WAIT FOR SYNC (6): This state has two different mode of operation depending on the load selected:
- *GRID*: the system checks if the line voltages are within the threshold value. If everything is ok there is a state transition to READY TO OPERATE.
- *MOTOR*: the system goes directly to READY TO OPERATE without any checks.

READY TO OPERATE (7): This state indicates that the dc-bus has reached the operation voltage and the system is ready to supply the load. If the digital input pulse enable is closed and the Enable Operation has a rising edge it is possible to have a state transition to READY TO RUN.

OPERATION INHIBITED (8): this state disable the operation of the system due to a STO or Pulse enable from states number 7, 9, 10, 11 and 12. This state transition is activated when pulse enable is set low or STO Actived is high in the previous state. The next transition (to READY TO OPERATE) is allowed only if STO Active is low.

MAGNETIZATION (9): This status updates signal operating enable (MSW.2 = 1) and the pulses are activated (MSW.10 = 1).
This state has two different mode of operation depending on the load selected:
- GRID: The transition to RUNNING is immediately activated
- MOTOR: The motor is magnetized. When the magnetization flux reaches the threshold value the state transition is actived.

RUNNING (10): In this state the load (motor or grid) is fully controlled (speed control, torque control, dc-bus regulation, etc.).
If the Pulse Enable is removed the system returns to OPERATION INHIBITED and then to READY TO OPERATE.

GRID WAITING (11): the transition to this state is allowed only from RUNNING. When the system is in RUNNING state and there is a Line Synchronization loss or the dc-bus is less than a threshold (bus drop) there is a state transition to GRID WAITING. In this case the pulses are removed. This state transition can be configurable. If there is a ramp stop request in this state the system goes directly to READY TO OPERATE.

RAMP STOP (12): This state can be used to stop the motor without removing incoming line power (where there is a precharge control) from the OPERATING ENABLE state. The stop ramp is the same of the ramp used before enabling the RAMP STOP.
This function can be activated by removing *Enable Operation* signal. In this case, the speed setpoint is set to zero using the current ramp time.
When the motor reaches the zero speed there is a state transition to READY TO OPERATE (pulses are removed). To control the motor speed before reaching the zero speed it is necessary to set Enable Operation again.
This feature is disabled in GRID mode and the transition to READY TO OPERATE is immediate.
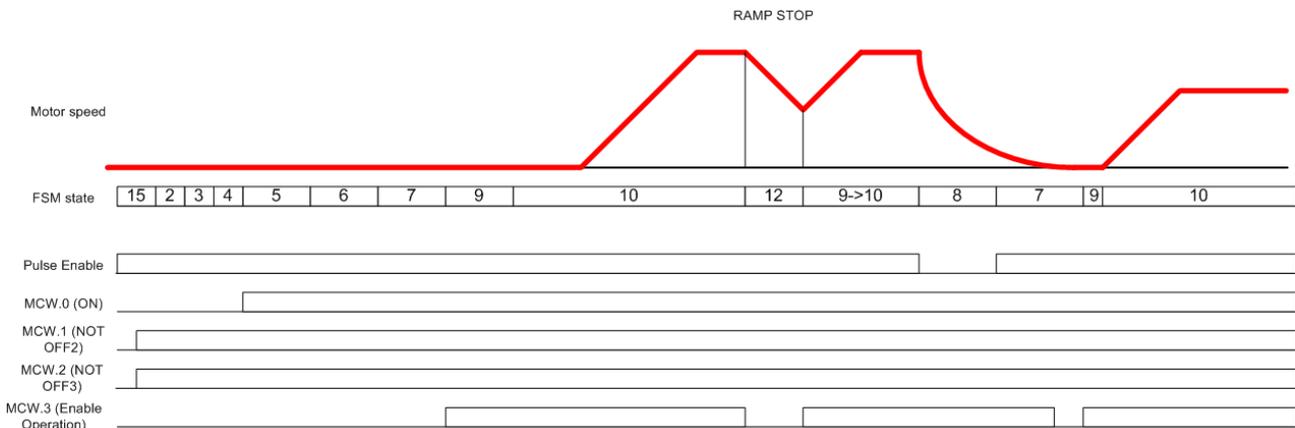
Fig. 3-32: Time diagram of the commands sequence to start the motor

OFF1 ACTIVE (13): the transition to this state is allowed only if the number of the previous one is above 4. This state can be used to stop the motor by using an OFF1 ramp. When the motor reaches the zero speed there is a state transition to NOT READY TO SWITCH-ON.
This state transition can be activated without reaching zero speed if Pulse Enable or Enable operation are withdrawn.
At the end of this routine the pulses are removed and the line contactor is opened (in the case the precharge is managed internally).
This feature is disabled in GRID mode and the transition to NOT READY TO SWITCH-ON is immediate.
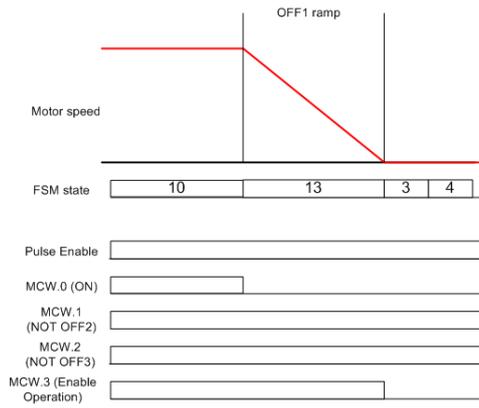
Fig. 3-33: Time diagram of the commands sequence to achieve OFF1 ACTIVE state

OFF3 ACTIVE (14): the transition to this state is allowed only if the number of the previous one is less than 14. This state can be used to stop the motor using an OFF2 ramp. When the motor reaches the zero speed there is a state transition to SWITCHON-INHIBITED. The state transition can be activated without reaching zero speed if Pulse Enable or Enable operation are withdrawn or if NOT OFF3 is set high again.
At the end of this routine the pulses are removed and the line contactor is opened (in the case the precharge is managed internally).
This feature is disabled in GRID mode and the transition to SWITCH-ON-INHIBITED is immediate.
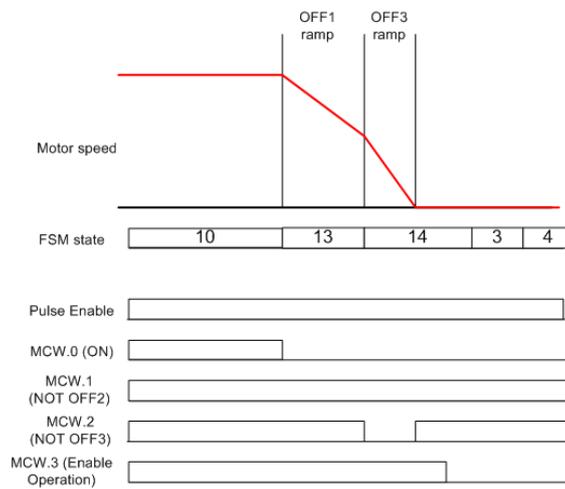
Fig. 3-34: Time diagram of the commands sequence to achieve OFF3 ACTIVE state

OFF2 ACTIVE (15): the transition to this state is allowed only if the previous one is less than 15. In this state the pulses are immediately removed and the motor is stopped by its own inertia. The line contactor is also immediately opened. The state is maintained until NOT OFF2 is set high again. In this case there is a state transition to SWITCHON-INHIBITED.
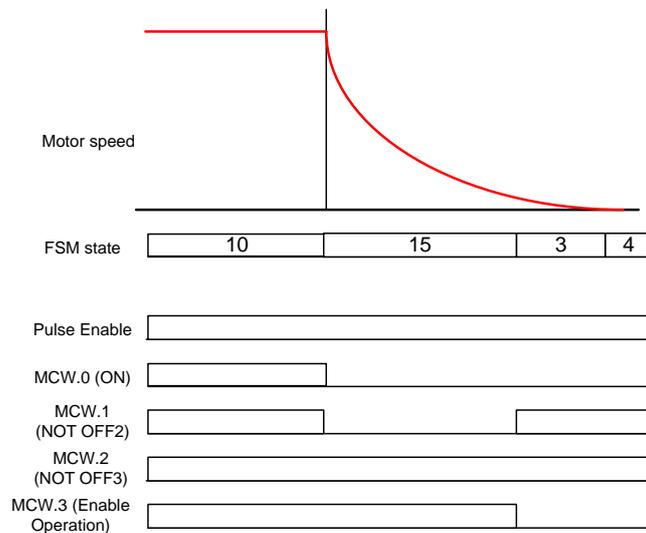
Fig. 3-35: Time diagram of the commands sequence to achieve OFF2 ACTIVE state

FAULT (16): the transition to this state is allowed only if the previous one is above 1. This transition state is activated if a fault event occurs. Some fault event can be customized (by using SDM or OP) to activate the states OFF1 ACTIVE, OFF2 ACTIVE and OFF3 ACTIVE before the state transition to FAULT.

It is possible a state transition from FAULT state only if there are two condition present:
- The fault cause is still not present
- A rising edge on the Acknowledge fault is set

To control the FSM is necessary to use the Main Command Word (MCW). The bits used for this purpose are highlighted in the Tab. 3-9.
To monitor the FSM state it is necessary to read the Main Status Word (MSW). The bits used for this purpose are highlighted in Tab. 3-10.

BIT	MainCW - Description
BIT 0	1↑ = ON 0 = OFF
BIT 1	1 = Operating Condition, no coast stop (OFF2 inactive) 0 = OFF2 active
BIT 2	1 = Operating Condition, no quick stop (OFF3 inactive) 0 = OFF3 active
BIT 3	1↑ = Enable Operation 0 = Disable Operation
BIT 4	1 = Enable ramp function generator 0 = Reset ramp generator
BIT 5	1 = Start ramp function generator 0 = freeze ramp function generator
BIT 6	1 = Enable Setpoit 0 = Disable Setpoint
BIT 7	1↑ = Acknowledge fault 0 = No Effect
BIT 8	1 = JOG1 ON 0 = JOG1 OFF
BIT 9	1 = JOG2 ON 0 = JOG2 OFF
BIT 10	PLC Control
BIT 11	User defined function
BIT 12	User defined function
BIT 13	User defined function
BIT 14	User defined function
BIT 15	User defined function

↑: positive edge

Tab. 3-9: MCW bits disposition related to FSM

BIT	MainSW - Description
BIT 0	Ready To Switch ON
BIT 1	Ready to Operate
BIT 2	Operating Enabled
BIT 3	Fault Active
BIT 4	Coast Stop Not Activated (no OFF2)
BIT 5	Quick Stop Not Activated (no OFF3)
BIT 6	Switch-On Inhibited
BIT 7	Warning
BIT 8	Feedback equal to ref
BIT 9	Control Requested
BIT 10	Pulse Enabled
BIT 11	User defined function [4551]
BIT 12	User defined function [4552]
BIT 13	User defined function [4553]
BIT 14	User defined function [4554]
BIT 15	User defined function [4555]

Tab. 3-10: MSW bit disposition related to FSM

The Led located on the front of the SD-MCU (side E according to the 3.2.1) give some information about the drive state (FSM state).

LED behavior	State
2 fast blinking in 1 second	MAGNETIZATION, RUNNING, GRID WAITING
3 fast blinking in 1 second	FAULT, OFF1, OFF2,OFF3
Fast blinking	STARTUP, INITIALIZATION
Blinking 1 second ON and 1 second OFF	Other FSM states

Tab. 3-11: MCU LED blinks meaning

3.3.2   DC-BUS System

The DC-Bus is the part where can be connected the precharge unit. The control software allows to configure two different typologies of precharge unit:
- Internal (the precharge sequence is completely managed by control software)
- External (the precharge sequence is managed by external system)

The precharge behavior can be configured in the DC-Bus section by using configuration parameters.

Fig. 3-36: Principle scheme of the Precharge management

The FSM controls enable the Precharge start command and waits the Precharge Ok to enable the state transition from PRECHARGING to WAIT FOR SYNC.

3.3.2.1 Internal Precharge

In this case control software can be used to command directly the outputs required for the precharge unit. The precharge unit is always composed by:
1. N° 1 MCB Close command (output for control software)
2. N° 1 MCB Closed Feedback (input for control software)
3. N° 1 Precharge Close Command (output for SD)
4. N° 1 Precharge Closed Feedback (input for SD)
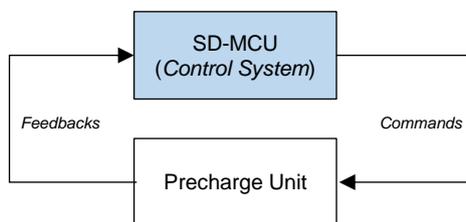
Fig. 3-37: Internal Precharge

Once the hardware interface is defined it is possible to explain the complete precharge sequence:

When the FSM is in PRECHARGING State the precharge start command *StartPrc* (DCBusSW.13) is set high and the precharge sequence can start.

- The precharge contactor close command (*PrcCloseCmd*) is set high. In this case if everything is well connected, the DC-Bus voltage starts to increase (capacitors loading).
- When the *measured DC-Bus voltage [6276]* is more than *Precharge Ok Threshold [0203]* for more than *Precharge Ok delay [0205]* the *PrcCloseCmd* is set to low (DCBusSW.05).
- After a time defined in *Main Contactor delay interlock [0210]* the signal *Precharge Ok (PrcOk)* is set high.

When *StartPrc* is set low every commands variable is set to low.
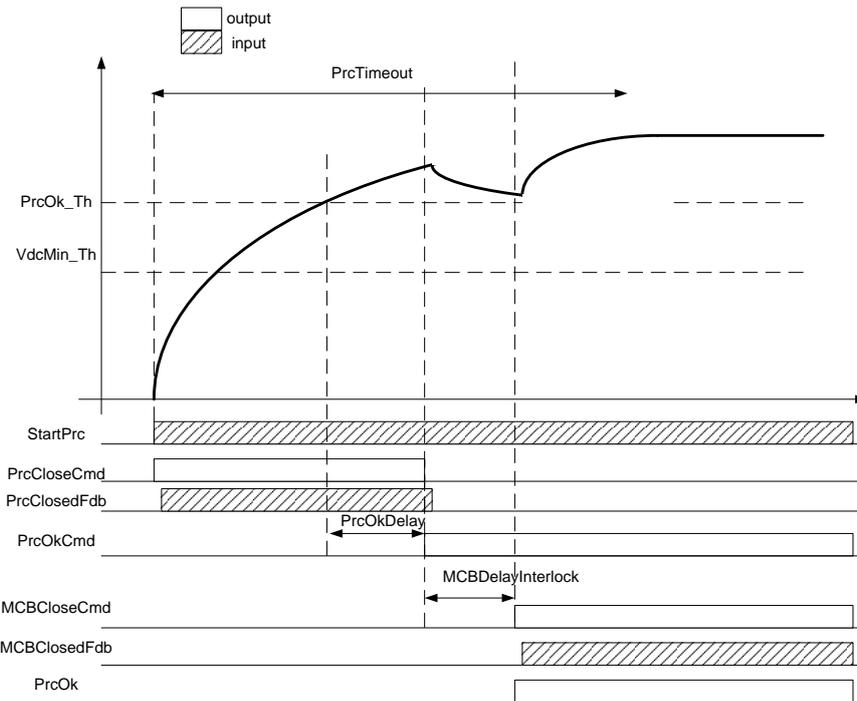
Fig. 3-38: Time diagram of the internal precharge sequence
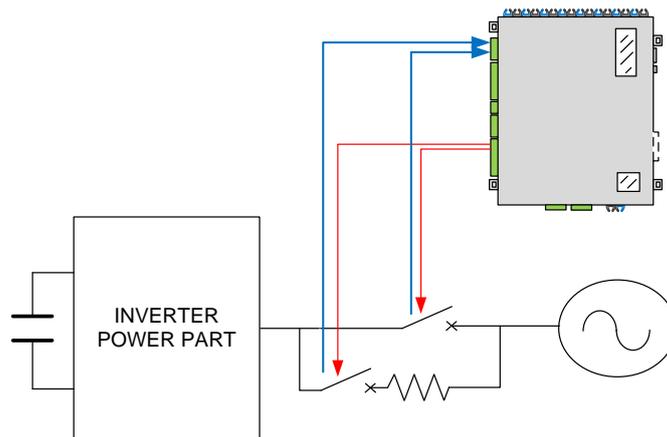
Fig. 3-39: internal precharge wiring example for line converter: commands (red) and feedbacks (blue)

In the Fig. 3-39 is shown an example of internal precharge wiring. The digital output 1 commands the MCB while the digital output 2 the precharge contactor. In the same way, the digital input 1 reads the MCB closed feedback and the digital input 2 reads the precharge contactor feedback.
To achieve this configuration, it is necessary to configure the control software in this manner:
- Select internal precharge (*[0201]*)
- Connect the digital input 1 to the MCB feedback variable (set *[0208]*=7030.00[4])
- Connect the digital input 2 to precharge feedback variable (set **[0206]**=7030.01[5])
- Connect the digital output 1 to the MCB command (**[4556]**=7007.04[6])
- Connect the digital output 2 to the precharge contactor command (**[4557]**=7007.05[7])

3.3.2.2   External Precharge

The "External" precharge configuration allows to interface the control software to a precharge unit externally controlled. In this case the control software read an input called External Precharge Ok. This signals comes from the external precharge unit and must be set to high when the external precharge sequence is completed.
- The On command is set to high and so the precharge routine is started (*StartPrc*=1)
- When the *measured DC-Bus voltage [6276]* is more than *Precharge Ok Threshold [0203]* for more than *Precharge Ok delay [0205]* and *External Precharge Ok* is true then the *Precharge Ok* is set to high.
- Only in this case there is a state transition from PRECHARGING

---

[4] Digital input word

[5] Digital input word

[6] DCBus SW (PrcOk/MCB close command)

[7] DCBus SW (Precharge close command)
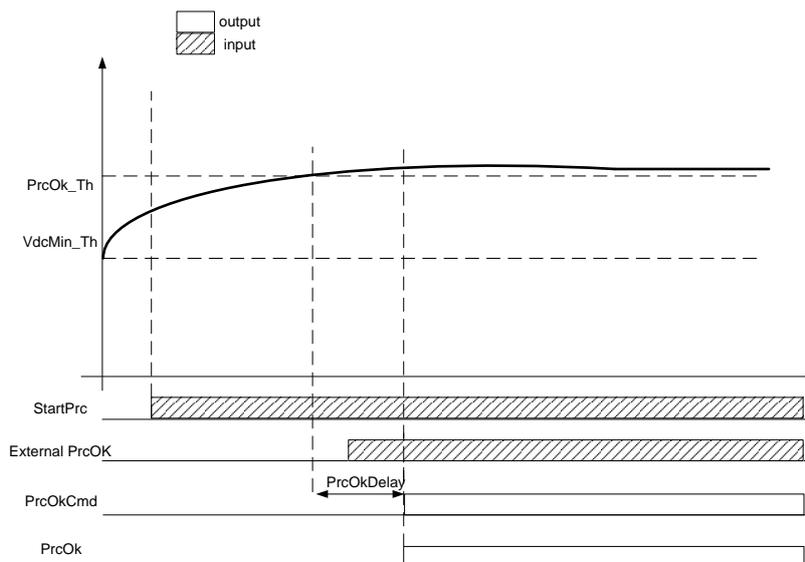
Fig. 3-40: Time diagram example 1 of the external precharge sequence
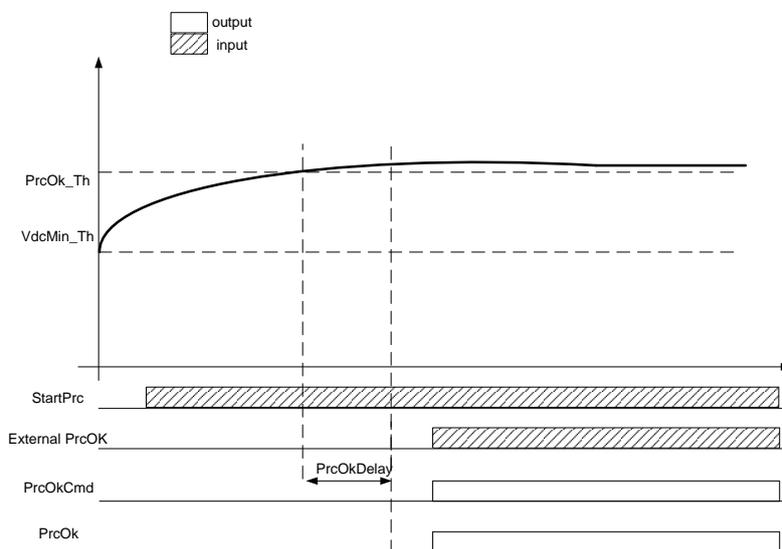
Fig. 3-41: Time diagram example 2 of the external precharge sequence

In the Fig. 3-42 is shown an example of external precharge wiring. In this case the external precharge system provides only the Precharge ok signal. In this example the Precharge ok signal will be wired in the digital input 1.
To achieve this configuration, it is necessary to configure the control software in this manner:
- Select esternal precharge (*[0201]*)
- Connect the digital input 1 to the external precharge ok signal (set *[0202]*=7030.00[8])

---

[8] Digital input word (digital input 1)
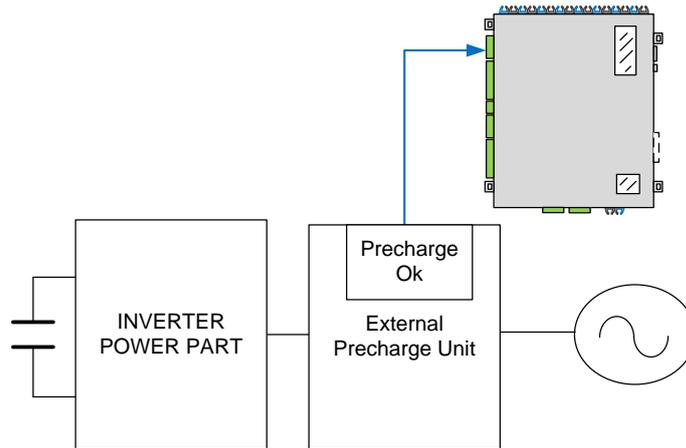
Fig. 3-42: External precharge wiring example

In the following two figures there are described the bit composition of the DCBus status (Tab. 3-12) and command (Tab. 3-13) words.

BIT	DCBusSW - Description
BIT 0	*Precharge configuration. 0 Internal / 1 external*
BIT 1	*Vdc > PrcOk_Th*
BIT 2	*Vdc < VdcMin_th*
BIT 3	*PrcOkCmd*
BIT 4	*PrcOk / MCB close command*
BIT 5	*PrcCloseCmd*
BIT 6	*Precharge Timeout*
BIT 7	*reserved*
BIT 8	*reserved*
BIT 9	*reserved*
BIT 10	*reserved*
BIT 11	*reserved*
BIT 12	*DcBusCW.00(ExtPrcOk)*
BIT 13	*DcBusCW.01(StartPrc)*
BIT 14	*DcBusCW.02(PrcClosedFdb)*
BIT 15	*DcBusCW.03(MCBClosedFdb)*

Tab. 3-12: DC-Bus Status word bit description

BIT	DCBusCW - Description
BIT 0	*External Precharge Ok Feedback*
BIT 1	*Start Precharge command*
BIT 2	*Precharge contactor feedback*
BIT 3	*main circuit breaker feedback*
BIT 4	*reserved*
BIT 5	*reserved*
BIT 6	*reserved*
BIT 7	*reserved*
BIT 8	*reserved*
BIT 9	*reserved*
BIT 10	*reserved*
BIT 11	*reserved*
BIT 12	*reserved*
BIT 13	*reserved*
BIT 14	*reserved*
BIT 15	*reserved*

Tab. 3-13: DC-Bus Command Word bit description

3.3.3   Reference

The section Reference creates analog references in order to control certain GRID/Motor quantities. The Reference section is divided into two other sub-section:

- Mechanical Reference
  - Speed
  - Torque
- Electrical Reference
  - DC-Bus voltage
  - AC-Voltage
  - AC-Current
  - Active Current
  - Active Power
  - Reactive Current
  - Reactive Power
  - Frequency

3.3.3.1   Mechanical Reference

The mechanical reference is used to set the speed or torque reference to the control system. The electrical reference is used to send analog[9] references from different channels. There only one mechanical reference and it can be used to control the torque and speed setpoints.

3.3.3.1.1   Speed Reference

It is possible to connect two sources called Primary and Secondary reference. It is also possible to switch between the two references by using *Primary/Secondary Selection[10]* parameter. These channels can be connected to this signals:

---

[9] Analog is used to identify signal different from boolean values
[10] This parameter are located in *[4703]⁽⁺⁾*

- Fixed
- PLC
- Profibus
- ModbusTCP
- CAN
- OP
- DiPo (1)
- DiPo (2)

Fixed: It is possible to set four difference constant value defined in *Fixed speed Setpoint 1/4*[11]. The value it is defined in per-unit value.
It is also possible to switch between four values by using *Fixed Ref selection bit 0/1*[12].
PLC: From PLC it is possible to send references by using *SetSpeedRef* function. This value is shown in *[7401]*.
Profibus: it can be indexed by using configuration parameter from *[5121]* to *[5152]* according with PPO type
ModbusTCP: it can be indexed by using configuration parameter from *[5021]* to *[5036]*
CAN: it can be indexed by using configuration parameter from *[5221]* to *[5252]*
DiPo(1): It is possible to connect the reference to the DiPo(1) output
DiPo(2): It is possible to connect the reference to the DiPo(2) output
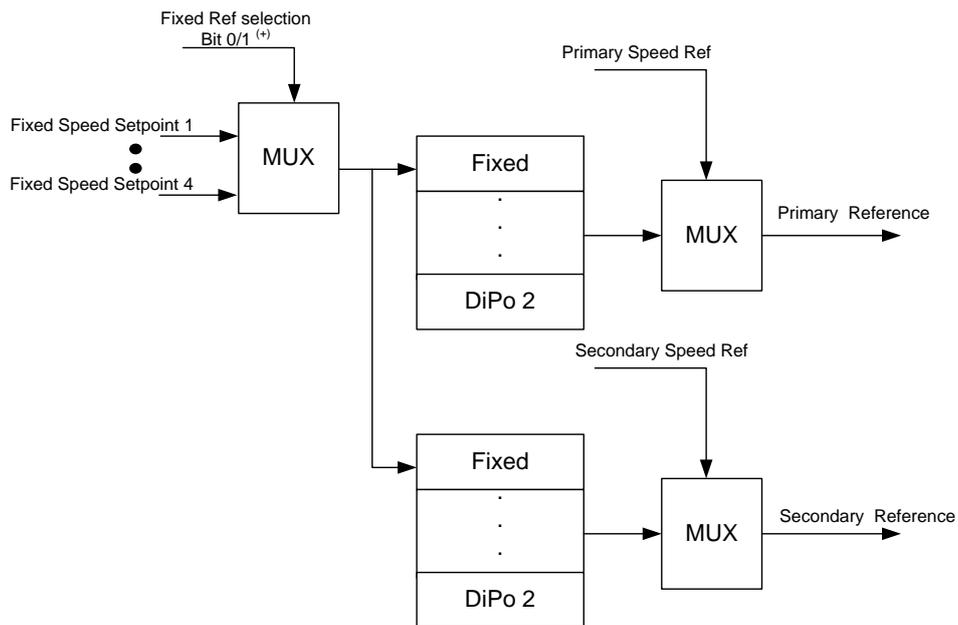
Fig. 3-43: Mechanical reference block diagram (part1)

Once the primary and (if needed) the secondary speed reference are configured, it is necessary to set the other function before configure the ramp builder. The selection between the two channels is possible by using Primary/Secondary Selection[13].
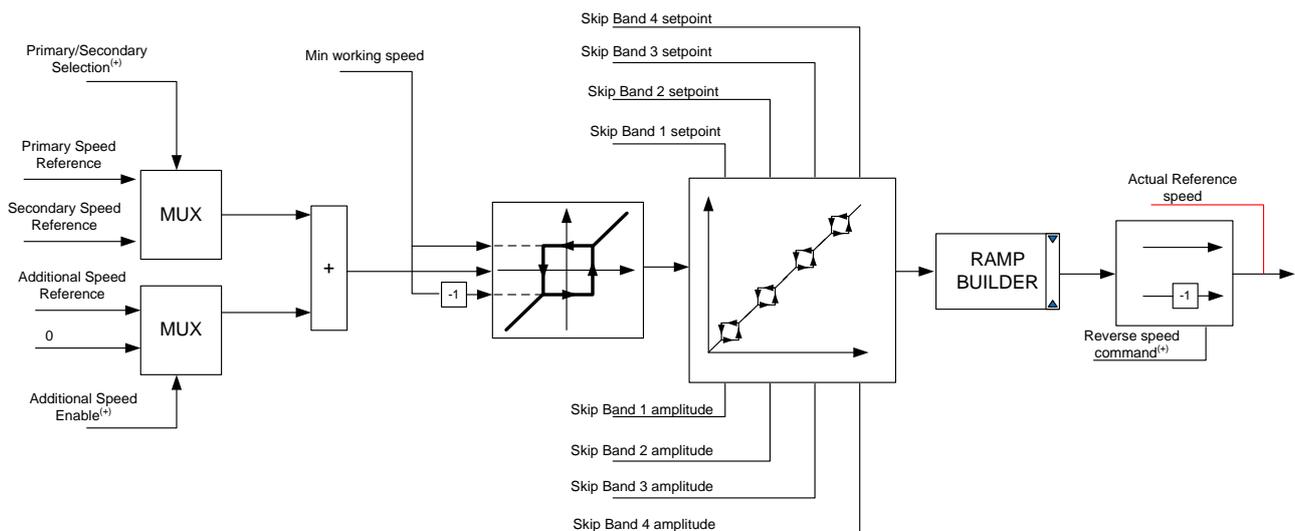
Fig. 3-44: Mechanical reference block diagram (part 2)

---

[11] Fixed Speed Ref1/4 are located in the parameter *[4705]* ,*[4706]*, *[4707]* and *[4708]*
[12] This parameter is located in *[4709]*(+) and *[4710]* (+)
[13] These parameters are located in *[4703]*(+)

As shown in Fig. 3-44 it is possible to add further reference to the primary or secondary reference called additional speed reference. This parameter can be enabled by Enable additional speed parameter *[4713]*[(+)].

In the same manner for primary or secondary reference, it is possible to choose the input channel by mean of Additional speed Ref *[4711]*. The selection possibilities are:

Fixed: It is possible to set four difference constant value defined in *Fixed speed Setpoint 1/4*[14]. The value it is defined in per-unit value. It is also possible to switch between the four values by using *Fixed Ref selection bit 0/1*[15].

PLC: From PLC it is possible to send references by using *SetAddSpeed* function. This value is shown in *[7402]*.

Profibus: it can be indexed by using configuration parameter from *[5121]* to *[5152]* according with PPO type

ModbusTCP: it can be indexed by using configuration parameter from *[5021]* to *[5036]*

CAN: it can be indexed by using configuration parameter from *[5221]* to *[5252]*

DiPo(1): It is possible to connect the reference to the DiPo(1) output

DiPo(2): It is possible to connect the reference to the DiPo(2) output

After these variables there are three blocks before ramp function generator: Minimum working speed, Skip bands and reverse speed.

After these references, it is possible to set a minimum working speed by mean of *[4732]*. This values limits (absolute value) the minimum speed reference[16].

Sometimes, to avoid mechanical resonance in the load could be necessary to avoid the speed reference remains steady at certain frequencies.

In this case it is possible to set up to 4 skip frequencies.
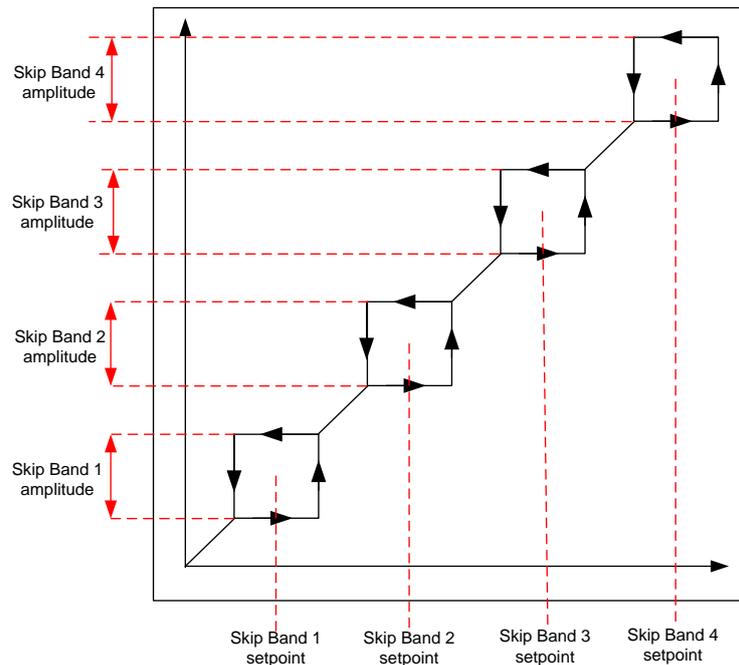
Fig. 3-45: Skip frequency block description

The output value of the Skip frequency block can be inverted by mean of Reverse speed command *[4728]*[(+)]. The output of this calculation is sent to the ramp builder block.

---

[14] Fixed Speed Ref1/4 are located in the parameter *[4705]* ,*[4706]*, *[4707]* and *[4708]*

[15] This parameter is located in *[4709]*[(+)] and *[4710]* [(+)]

[16] i.e. let suppose to set the value of *[4732]*=0.2. It means that even if the speed reference is positive or equal to zero and it is lower 0.2 pu the output of minimum working speed block is set to 0.2. If the speed reference is negative and it is lower 0.2 (absolute value) the output of minimum working speed block is set to -0.2 pu.
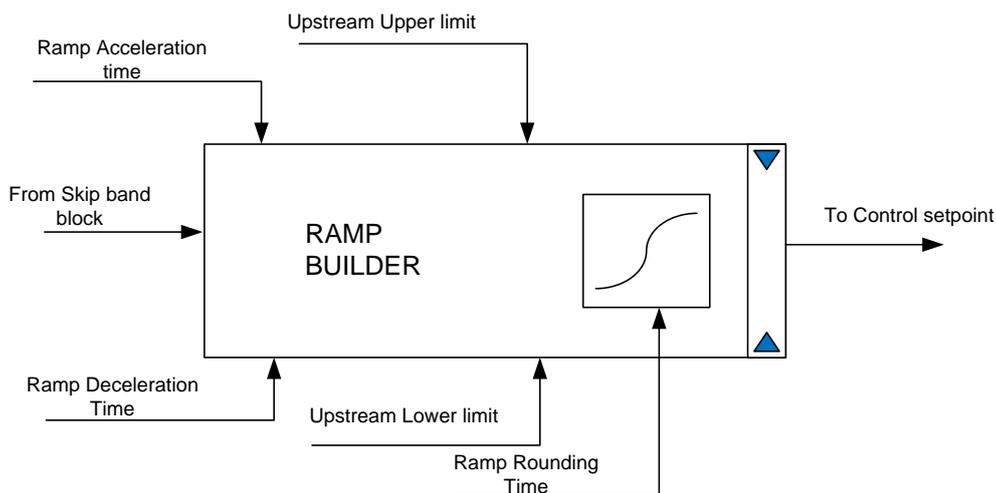
Fig. 3-46: Speed reference Ramp builder – general view

The ramp builder block uses the ramp acceleration time and ramp deceleration time to calculate the slope of the output reference[17].
There is also an output limitation set by *upstream Upper limit [4730]* and *upstream lower limit [4731]*. It also possible to smooth the output ramp by using *ramp rounding time [4729]*.
It is possible to set different types of acceleration/deceleration ramps (up to 4).
The selection of these ramps it is possible with *ramp bit selector* or depending on speed ramp output.
Depending on the value of *Ramp Selection bit 0 [4723]*[(+)] and *Ramp selection bit 1 [4724]*[(+)] it is possible to choose among the 4 ramp values as shown in Tab. 3-14.

Ramp selection bit 1	Ramp selection bit 0	Ramp selection
0	0	Acceleration/Deceleration ramp 1
0	1	Acceleration/Deceleration ramp 2
1	0	Acceleration/Deceleration ramp 3
1	1	Acceleration/Deceleration ramp 4

Tab. 3-14: Ramp bit selection table

It is possible to set the ramp time as function of the actual output speed. In this case the acceleration/deceleration ramps as set according *change ramp speed threshold[18]* parameters.

Change ramp 1-2 speed thresh	Change ramp 2-3 speed thresh	Change ramp 3-4 speed thresh	Ramp selection
<			Acceleration/Deceleration ramp 1
>=	<		Acceleration/Deceleration ramp 2
>	>=	<	Acceleration/Deceleration ramp 3
>	>	>=	Acceleration/Deceleration ramp 4

Tab. 3-15: Ramp selection as function of the actual output speed

It is possible to choose between bit selection mode and speed selection mode by mean of *change ramp mode [4722]*.

---

[17] i.e. if the acceleration ramp is set to 5s means that if at the input of the ramp there is a step from 0 to 1 pu, the output reaches the 1 pu value after 5s.
[18] These parameters are *[4725]*, *[4726]* and *[4727]*.
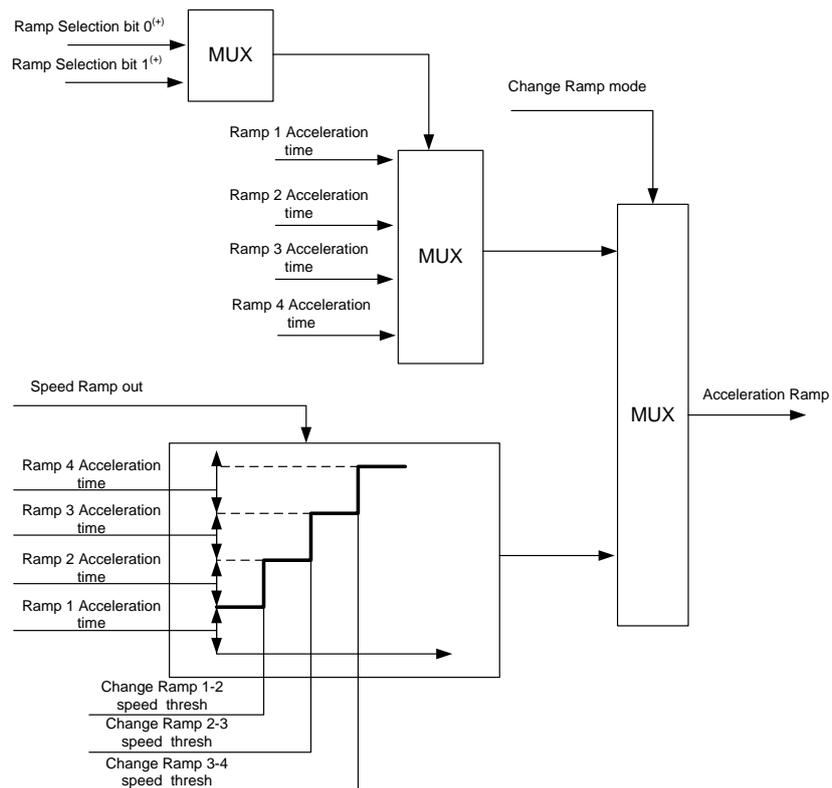
Fig. 3-47: Acceleration ramp calculation as function of actual reference speed

The deceleration ramp can be changed also for the following actions:

- OFF3 is active (*Quick stop time* ramp **[4745]** is set)
- OFF2 is active[19]
- Ramp stop is active[20]

---

[19] In this case there is not ramp change because the pulses are immediately removed
[20] It is possible to select the ramp time during the Ramp stop by mean of *Ramp stop selection* **[4743]**
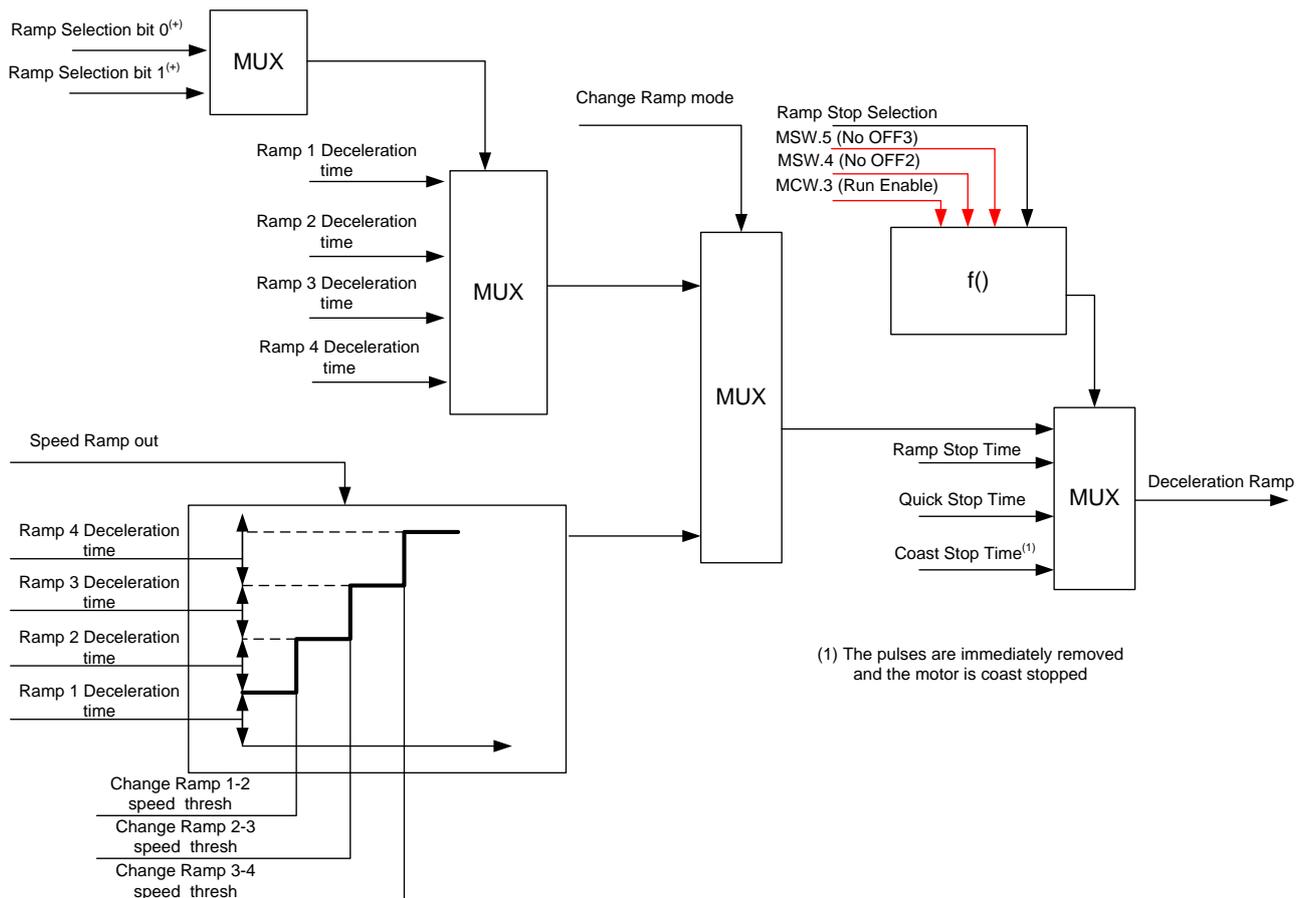
Fig. 3-48: Deceleration ramp calculation as function of actual reference speed

3.3.3.1.2 Torque Reference

It is also possible to control the motor by using torque reference by mean of *Torque Ref Selector* **[4772]**. There are two different possibilities to enable torque control:

- *Ctrl+FFwd*: in this case the speed closed loop is enabled and it is possible to add torque reference after the speed controller
- *Only FFwd*: in this case the speed closed loop is disabled and the torque FFwd reference must assure the speed control

The FFwd source can be selected by using *Torque FFwd source* **[4770]**. The possible choices are:

Fixed: It is possible to set a fixed reference by using *Fixed torque FFwd* **[4771]**. The value it is defined in per-unit value.

PLC: From PLC it is possible to send references by using *SetTorqueRef* function. This value is shown in **[7403]**.

Profibus: it can be indexed by using configuration parameter from **[5121]** to **[5152]** according with PPO type

ModbusTCP: it can be indexed by using configuration parameter from **[5021]** to **[5036]**

CAN: it can be indexed by using configuration parameter from **[5221]** to **[5252]**

DiPo(1): It is possible to connect the reference to the DiPo(1) output

DiPo(2): It is possible to connect the reference to the DiPo(2) output
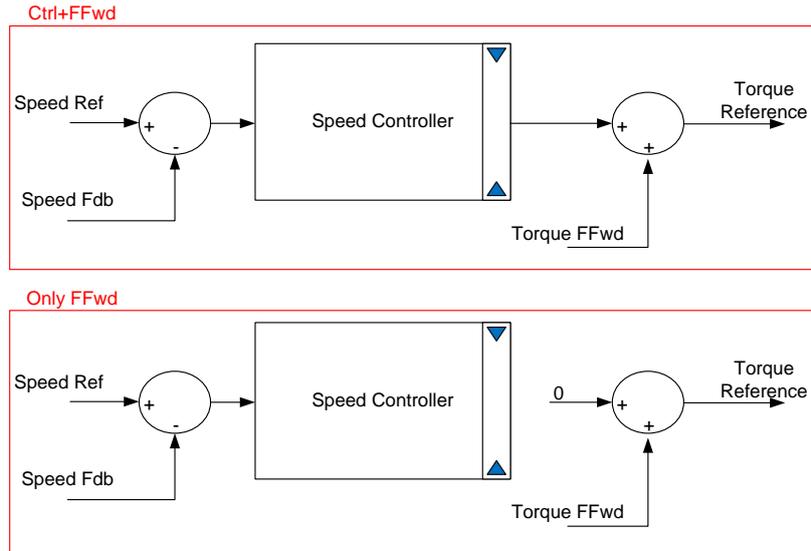
Fig. 3-49: Torque Feedforward selection

3.3.3.2 Electrical Reference

The electrical reference is used to send analog references from different channels. There are two independent electrical references and they can be used to control the following setpoints:

- Reference 1
    - DC-Bus voltage (V_{DC}^{Ref})
    - AC-Voltage (V_{AC}^{Ref})
    - AC-Current (I_{AC}^{Ref})
    - Active Current (I_d^{Ref})
- Reference 2
    - Active Power (P^{Ref})
    - Reactive Current (I_q^{Ref})
    - Reactive Power (Q^{Ref})
    - Frequency (f^{Ref})

These setpoints are depending the control and load typologies as shown in the table below:

		GRID			Motor
		F3E	AFE	Vac Gen	All Control
Reference 1	DC-Bus Voltage		x		
	AC-Voltage			x	
	AC-Current				
	Active Current		x		
Reference 2	Reactive Current		x		
	Active Power				
	Reactive Power		x		
	Frequency			x	

Tab. 3-16: Electrical reference table

For each reference there are two sources called Primary and Secondary reference. These channels can be connected to these signals:

- Fixed
- PLC
- Profibus
- ModbusTCP
- CAN
- OP
- DiPo (1)
- DiPo (2)
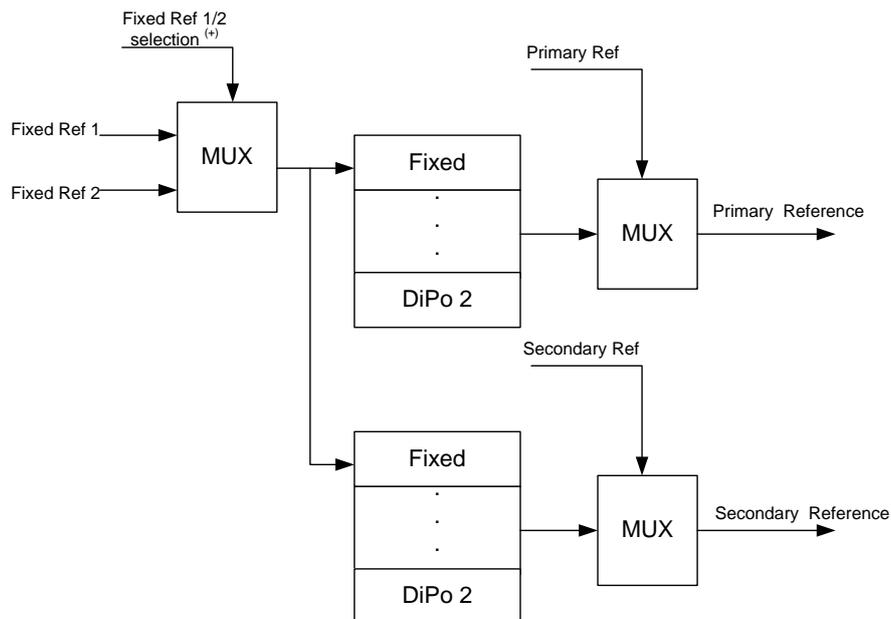
Fig. 3-50: Electrical reference block diagram (part 1)

The selection possibilities are:

Fixed: It is possible to set two difference constant value defined in *Fixed Ref 1/2*[21]. The value it is defined in per-unit value.
It is also possible to switch between the four values by using *Fixed Ref selection bit 0/1*[22].
PLC: From PLC it is possible to send references by using *SetRef1/2* functions. This value is shown in *[7406]* and *[7407]*.
Profibus: it can be indexed by using configuration parameter from *[5121]* to *[5152]* according with PPO type
ModbusTCP: it can be indexed by using configuration parameter from *[5021]* to *[5036]*
CAN: it can be indexed by using configuration parameter from *[5221]* to *[5252]*
DiPo(1): It is possible to connect the reference to the DiPo(1) output
DiPo(2): It is possible to connect the reference to the DiPo(2) output
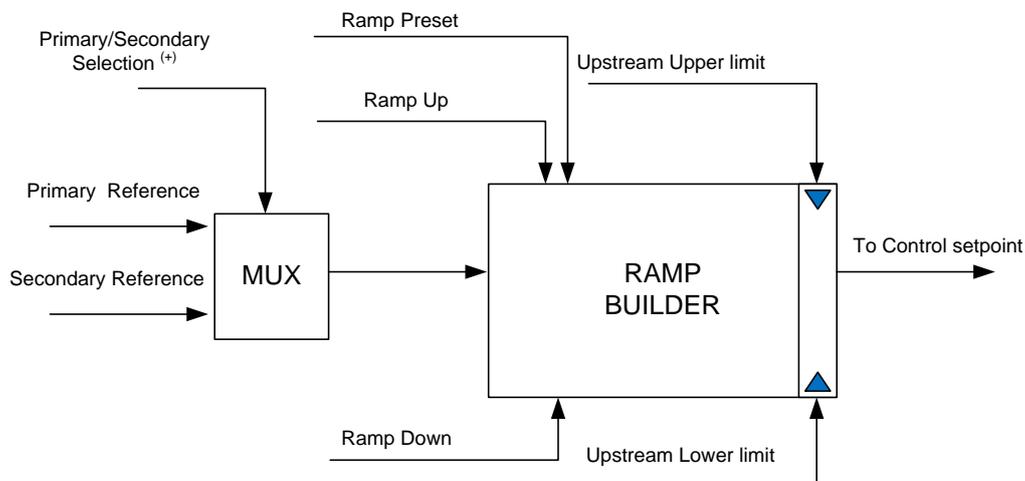
Fig. 3-51: Electrical reference block diagram (part 2)

Once the primary and (if needed) the secondary reference are configured, it is necessary to set the ramp builder input. The selection between the two channels is possible by using Primary/Secondary Selection[23].
It is also possible to set some ramp builder parameters like:

- **Ramp up**: time to reach 1pu of reference starting from zero
- **Ramp down**: time to reach 0pu of reference starting from 1pu
- **Upstream upper limit**: maximum value for positive ramp values
- **Upstream lower limit**: minimum value for negative ramp values
- **Ramp Preset**: it defines the starting value of the ramp (when the FSM enters in the RUNNING State)

Bit	ReferenceCW
BIT 0	*Speed Source Reference Selection*
BIT 1	*Fixed Reference Selection Bit 0*

---

[21] Fixed Ref 1/2 are located in the parameter *[4805]* ,*[4806]*, *[4825]* and *[4826]*

[22] This parameter is located in *[4807]*[(+)] and *[4827]* [(+)]

[23] These parameters are located in *[4804]*[(+)] for Reference 1 and *[4824]*[(+)] for Reference 2.

Bit	ReferenceCW
BIT 2	*Fixed Reference Selection Bit 1*
BIT 3	*Ramp selection Bit 0*
BIT 4	*Ramp selection Bit 1*
BIT 5	*Additional Speed Enable*
BIT 6	*Reverse Speed Enable*
BIT 7	*Torque Reference Selection*
BIT 8	*Torque Fixed Limit Selection Set*
BIT 9	*reserved*
BIT 10	*reserved*
BIT 11	*reserved*
BIT 12	*Source Reference 1 Selection*
BIT 13	*Source Reference 2 Selection*
BIT 14	*Fixed Reference Selection Ref 1*
BIT 15	*Fixed Reference Selection Ref 2*

Tab. 3-17: Reference CW (the red border are related to the electrical references)

3.3.4   DiPo (Digital Potentiometer) macro function

The DiPo function is used to mimic the analog functions of a potentiometer. The control software implements two independent DiPo called (1) and (2). The output of each DiPo can be connected to the mechanical or electrical references. In details:
- Primary speed reference *[4701]*
- Secondary speed reference *[4702]*
- Additional speed reference *[4711]*
- Torque FFwd source *[4770]*
- Additional flux *[2032]*
- Electrical 1 Primary Ref *[4802]*
- Electrical 1 Secondary Ref *[4803]*
- Electrical 2 Primary Ref *[4822]*
- Electrical2 Secondary Ref *[4823]*

It is possible to increase/decrease DiPo output by means of two bits (up/down) that can be connected to different sources. If there is a rising edge on the *step up command* the output is increased of *step up* parameter quantity (according with the *Upper Limit* parameter). If the *step up command* is maintained for at least *time to ramp* parameter the output start to increase with a ramp value set with *ramp time parameter*.
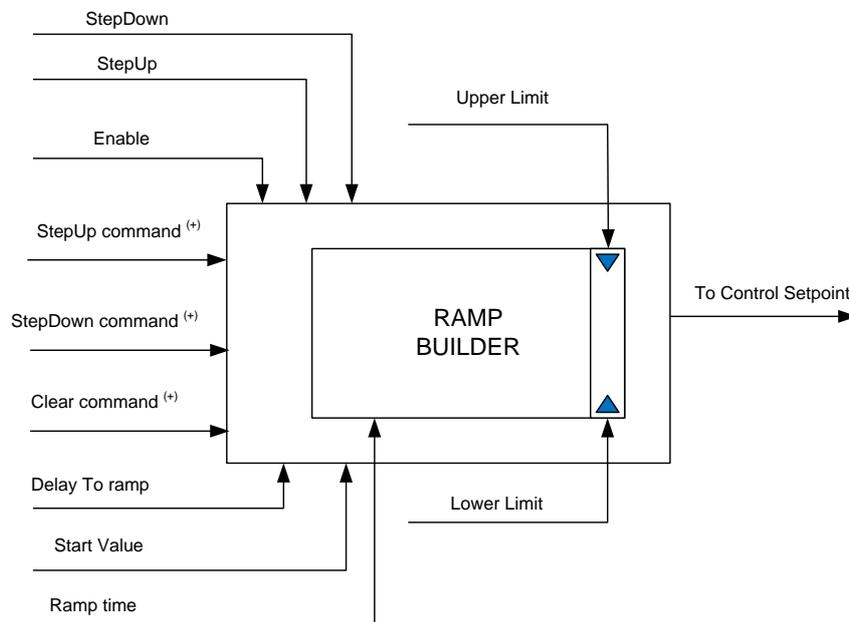
Fig. 3-52: DiPo reference block diagram

If there is a rising edge on the *step down command* the output is decreased of *step down* parameter quantity (according with the *lower Limit* parameter). If the *step down command* is maintained for at least *time to ramp* parameter the output start to decrease with a ramp value set with *ramp time parameter*.

While the ramp is running and or step up or step down command is maintained for long time even if the opposite command step is activated, no changes are made.
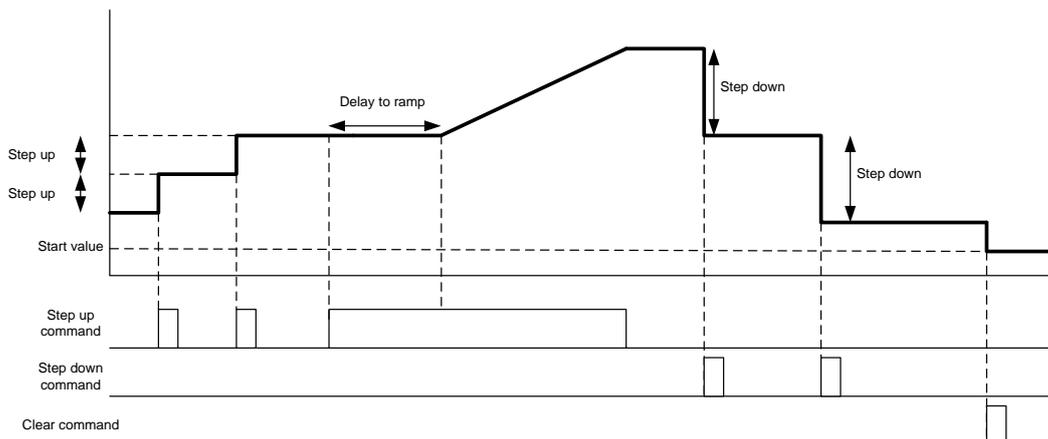
Fig. 3-53: DiPo input/output behavior

If the clear command is active the output is immediately set to the start value parameter. The output is set to the start value parameter also when there is a transition of FSM from Ready to Operating enabled.

Reference tracking parameter can be used when primary and secondary references are used. If the DiPo is connected to one of these two references, when there is a switch from the other reference to the DiPo, the starting value is set to the previous reference value. In the figure below is showed the example with the speed references.
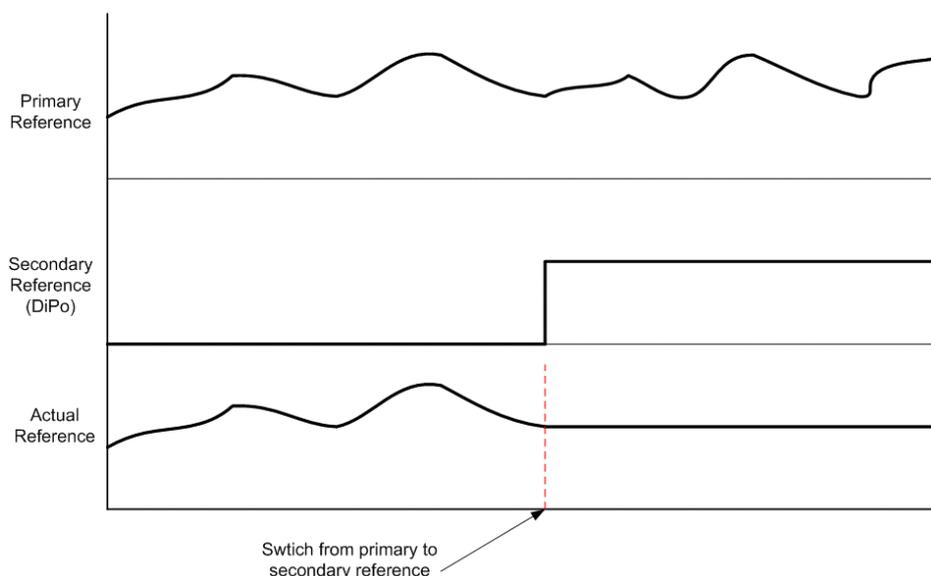
Fig. 3-54: DiPo reference tracking example

In the tables below are showed the DiPo SW (Tab. 3-18) and CW (Tab. 3-19).

BIT	DiPoSW - Description
BIT 0	DiPo 1 Enabled
BIT 1	DiPo 1 Ramp Mode On
BIT 2	DiPo 1 Upper Limit Reached
BIT 3	DiPo 1 Lower Limit Reached
BIT 4	DiPo 1 Tracking Ref Enabled
BIT 5	DiPo 1 Output equal to Ref
BIT 6	Reserved
BIT 7	Reserved
BIT 8	DiPo 2 Enabled
BIT 9	DiPo 2 Ramp Mode On
BIT 10	DiPo 2 Upper Limit Reached
BIT 11	DiPo 2 Lower Limit Reached
BIT 12	DiPo 2 Tracking Ref Enabled
BIT 13	DiPo 2 Output equal to Ref
BIT 14	Reserved
BIT 15	Reserved

Tab. 3-18: DiPo Status word bit description

BIT	DiPoCW - Description
BIT 0	Dipo 1 Step-Up
BIT 1	DiPo 1 Step-Down
BIT 2	DiPo 1 Clear
BIT 3	Reserved
BIT 4	Reserved
BIT 5	Reserved
BIT 6	Reserved
BIT 7	Reserved
BIT 8	Dipo 2 Step-Up
BIT 9	DiPo 2 Step-Down
BIT 10	DiPo 2 Clear
BIT 11	Reserved
BIT 12	Reserved
BIT 13	Reserved
BIT 14	Reserved
BIT 15	Reserved

Tab. 3-19: DiPo Command Word bit description

3.3.5   RMU Interface (Modulator)

The power part is connected to the SD-MCU through optic fiber. The SD-MCU controls all the DPMs by mean of a Modulator SW. <u>The following explanation must be considered only for expert users</u>.
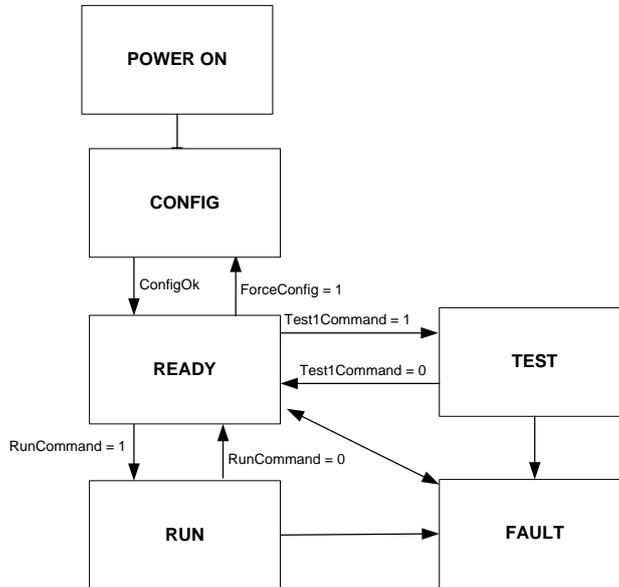
Fig. 3-55: RMU Finite State Machine

POWER ON: this state is active only at the switch-on of the board
CONFIG: SD-MCU or DPM configuration (e.g. switching frequency change). If the selected slaves are not yet configured the Modulator SW remains in this state.
READY: this state is the standard transition from *CONFIG* state. If there is a fault condition (i.e. overcurrent, overvoltage, fiber feedback missing, DPM faults, ect) there is a state transition to FAULT.
RUN: in this state the DPMs IGBT commands can be enabled and the power starts to flow to the load.
FAULT: the transition to this state is achieved if there is a fault condition active.
All of these features are located in the Modulator SW and in the RMU CW.

BIT	ModulatorSW - Description
BIT 0	Power ON
BIT 1	Config
BIT 2	Ready
BIT 3	RUN
BIT 4	FAULT
BIT 5	Test 1 (fiber optic manual test or module identification)
BIT 6	Test 2
BIT 7	Slave Error Timeout
BIT 8	Config OK
BIT 9	Fiber Enabled
BIT 10	Short Circuit Detected
BIT 11	Zbus Checksum Error
BIT 12	Checksum Master Receiver Error
BIT 13	Checksum Slave Error
BIT 14	Watchdog bit 0
BIT 15	Watchdog bit 1

Tab. 3-20: Modulator Status Word bit description (advanced status in grey boxes)

BIT	ModulatorCW - Description
BIT 0	Force Configuration
BIT 1	Run Command
BIT 2	Reset Command
BIT 3	Test 1 Command (fiber optic manual test or module identification)
BIT 4	Test 2 Command
BIT 5	Fiber On
BIT 6	Watchdog Bit 0
BIT 7	Watchdog Bit 1
BIT 8	Write SPI
BIT 9	PS Ready
BIT 10	Reserved
BIT 11	Reserved
BIT 12	Reserved
BIT 13	Reserved
BIT 14	Reserved
BIT 15	Reserved

Tab. 3-21: Modulator Command Word bit description (advanced status in grey boxes)

The display on top of the SD-MCU is showed in the figure below:

Display left part   Display right part

Fig. 3-56: SD-MCU display description

The two parts of the display are used to gives information about the modulator states (see Tab. 3-20 and Tab. 3-21). In Tab. 3-22 are listed the display codification.

Left part	Right part	Meaning
0	x	Power on
1	x	Config
2	-	Ready
3	-	Run (fiber disabled)
3	⟳	Run (fiber enabled)
4	⟳	Fiber optic test or DPM identification
F	-	Fault

Tab. 3-22: 7-segments display codification

3.3.6 Synchronization

For GRID control types, it is necessary to know line voltage amplitude and phase. Due to line harmonic content it is necessary to estimate the real voltage amplitude and phase by using the real measured voltages.
The PLL (Phase locked loop) is used for this purpose and the information is showed in the Synchronization Status word.
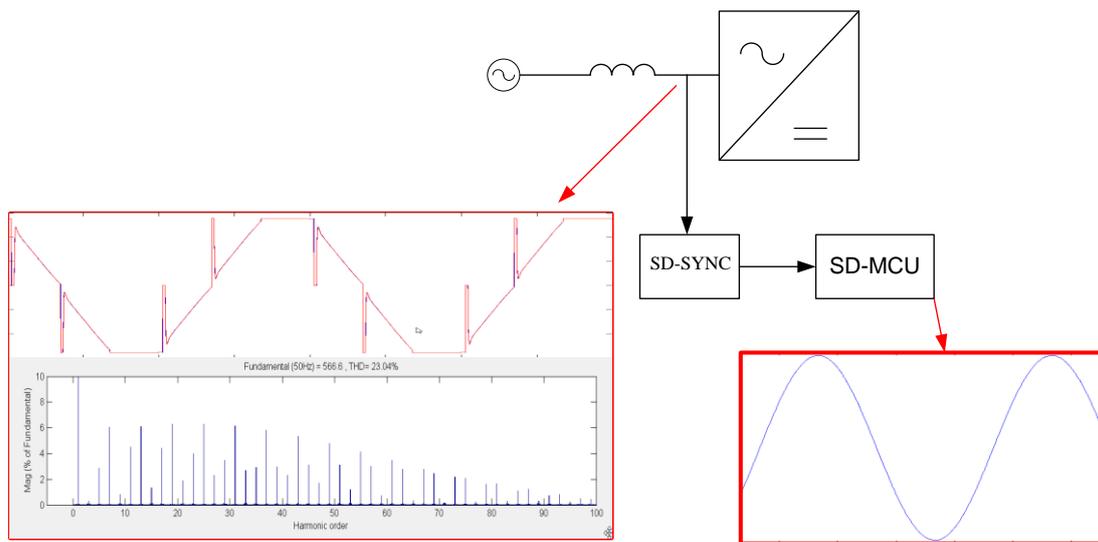
Fig. 3-57: PLL voltage estimation example in the F3E application

The Synchronization system checks:
- Phase sequence (clockwise, counterclockwise)
- Frequency value (ω)
- Phase value (θ)
- Voltage amplitude ($|V|$)

If the FSM is in the state of WAIT FOR SYNC or GRID WAITING checks the phase sequence.
This calculation applies very strong filtering to the line voltage to be sure to detect the real phase sequence even if there is high measure noise. In this case the line control is not yet started and it doesn't need very high dynamic response.
The line sequence (ω_{sign}) is calculated as follow:

- $\omega_{sign} = 1$ se la $\omega > 0.25pu$
- $\omega_{sign} = -1$ se la $\omega < -0.25pu$
- $\omega_{sign} = 0$ otherwise (undetected)

The ω_{sign} is sent to PLL status word at the last two bits:

	clockwise	Counter-clock wise	Phase sequence undetected
Phase sequence bit 0	1	0	0
Phase sequence bit 1	0	1	0

Fig. 3-58: phase sequence bit description

If the estimated frequency is more than 10% or less than 10% of the nominal frequency, there is the information *frequency out of range*.
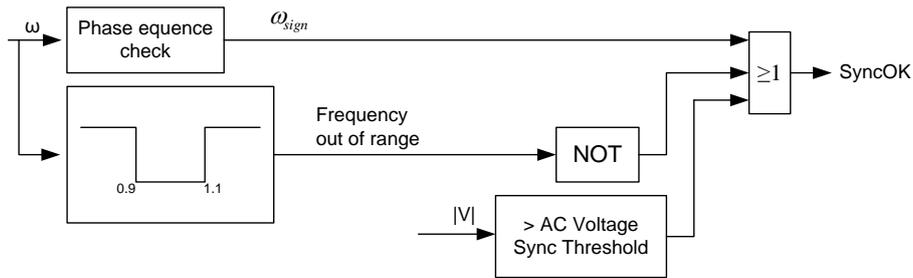
Fig. 3-59: PLL SyncOK behavior

Another important signal is Synchronization OK (or SyncOK). This signal is used to go out from WAIT FOR SYNC. If the phase sequence is detected, the frequency is between the correct bandwidth and the voltage amplitude is more than AC Voltage Sync Threshold **[1102]** for at least 200 ms the SyncOK value is high.

Another information is showed in the PLL status word: *ACOvervoltage* and *ACUndervoltage*.
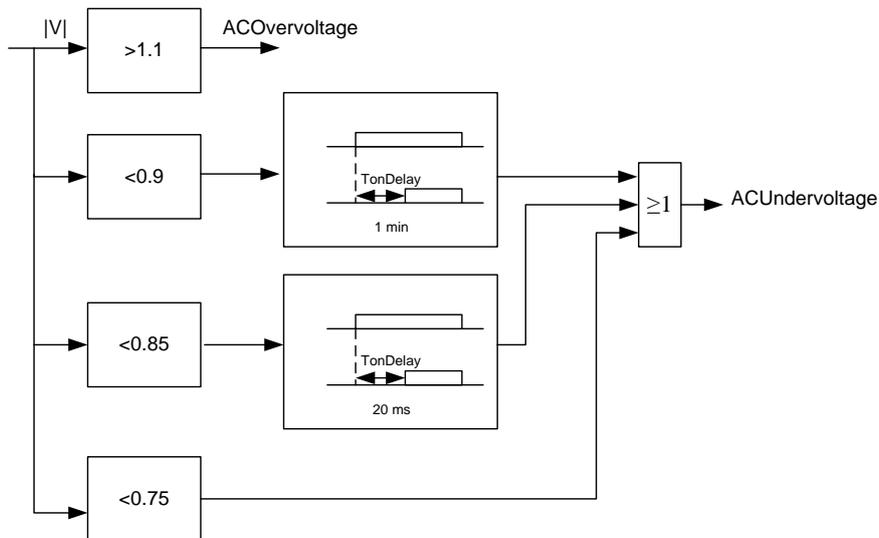
Fig. 3-60: AC Overvoltage and AC Undervoltage calculation method

After phase sequence detection, the Synchronization function is upgraded in order to achieve the high filtering effort with the less filtering delay by using the line phase detected before.

BIT	SyncSW - Description
BIT 0	Synchronization OK
BIT 1	Frequency Out of Range
BIT 2	AC Voltage Drop (for Sync)
BIT 3	Vac Over Voltage
BIT 4	Vac Under Voltage
BIT 5	reserved
BIT 6	reserved
BIT 7	reserved
BIT 8	reserved
BIT 9	reserved
BIT 10	reserved
BIT 11	reserved
BIT 12	reserved
BIT 13	reserved
BIT 14	Phase Sequence bit 0
BIT 15	Phase Sequence bit 1

Tab. 3-23: Synchronization Status Word

The SyncOK is also used to enter to GRID WAITING FSM state.

3.3.7   Inverter Fan

The SECOM DRIVE inverters have an auxiliary supply for their internal fan. The auxiliary supply voltage is dependent on the inverter type (see hardware manual for further description).

It is necessary to insert between the auxiliary supply and the fan connector a contactor and a breaker to switch-on and switch-off the fan.
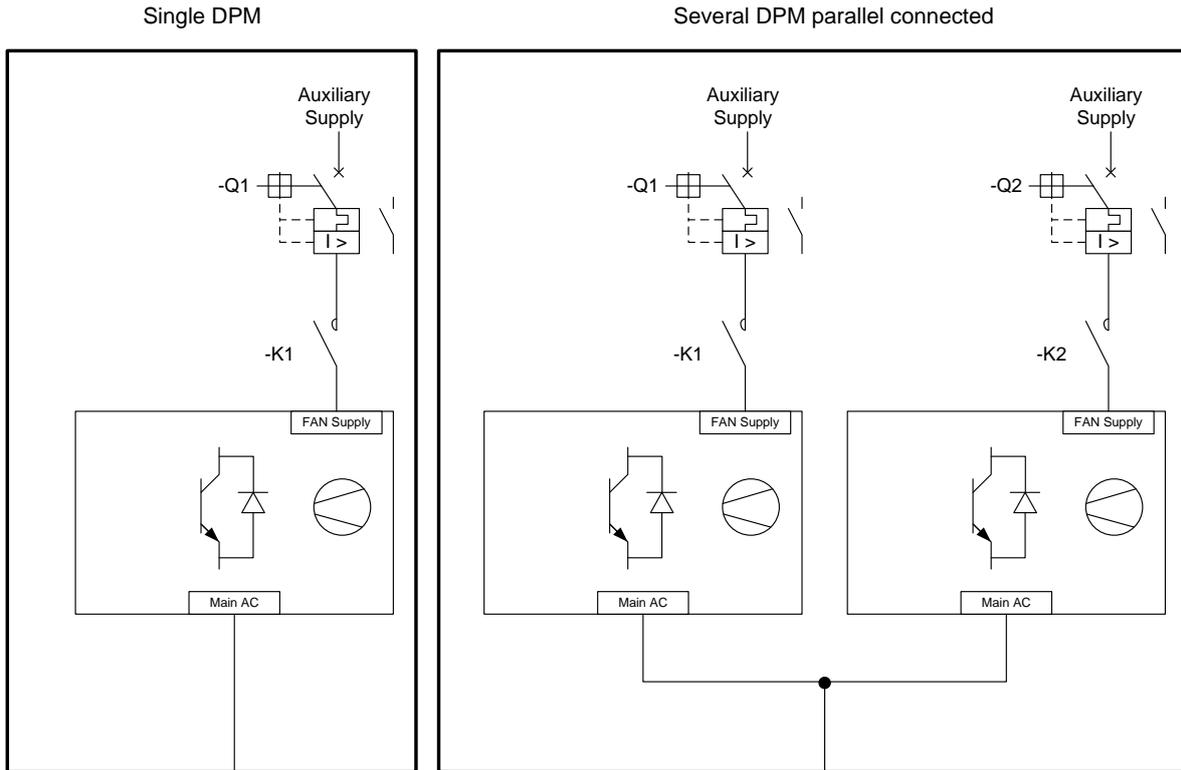
Fig. 3-61: Fan supply connection

In the Fig. 3-61 above is showed the fan connection in case of single DPM [24]or several DPM parallel connected (in this case 2 DPM) while in the Fig. 3-62 below is showed the suggested fan command/feedback connection to SD-MCU (the dashed line are in case of several DPM parallel connected).
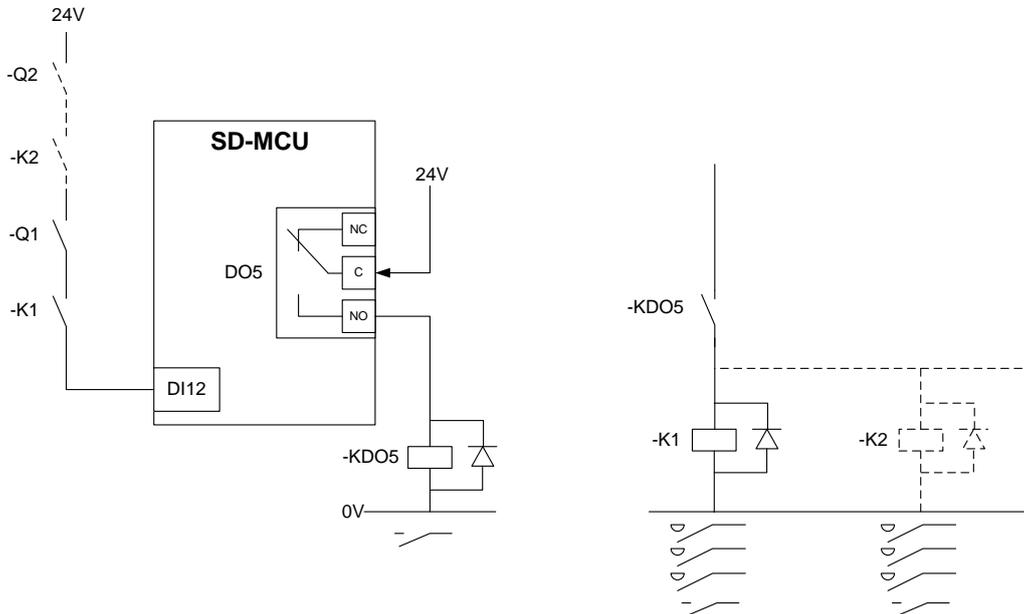
Fig. 3-62: Suggested Fan command/feedback connected to SD-MCU

The fan is started (Fan start command is on) when there is no fault active and the On command (MCW.00) is set true. When the ON command is set false or there is a fault the fan start command is set false (stop fan). It is possible to delay the stop command by using parameter *Fan stop delay [0333]*.
The control software also check if fan feedback (set to DI12 as default) is true when the Fan start command is risen. If this value is not correct, fan alarm is set true. It is possible to mask this alarm by acting to the parameter *fan feedback delay [0332]* (i.e. to correct the delay between fan command and fan feedback).
It is possible to set this alarm as warning, OFF1, OFF2 or OFF3 by mean of parameter *Fan alarm [5532]*.

---

[24] Drive power module

BIT	FanSW - Description
BIT 0	Fan Feedback
BIT 1	reserved
BIT 2	reserved
BIT 3	reserved
BIT 4	reserved
BIT 5	reserved
BIT 6	reserved
BIT 7	reserved
BIT 8	reserved
BIT 9	reserved
BIT 10	reserved
BIT 11	reserved
BIT 12	Start
BIT 13	ONCmd
BIT 14	Alarm
BIT 15	Local/Remote Management

Tab. 3-24: Fan Status Word

3.3.8   Digital (Input/Output)

In this section will be explained the digital input/output configuration.

3.3.8.1   Digital Input

This connection regards the digital input connection of the SD-MCU.

-X1 DI	name	Default function	position
1	DI1		
2	DI2		
3	DI3		
4	DI4		
5	DI5		Bottom terminal block
6	DI6		
7	DI7		
8	DI8		
G	GND (DI1 to DI8)		
9	DI9		
10	DI10		
11	DI11		
12	DI12	Inverter fan feedback	
13	DI13	Acknowledge fault[25]	Top terminal block
14	DI14	Enable operation	
15	DI15	ON command[26]	
16	DI16	Pulse enable[27]	
G	GND (DI9 to DI16)		

Tab. 3-25: Digital Input description

As showed in the Tab. 3-25 the digital input from 1 to 8 are completely customizable as shown in the Fig. 3-63. In this example the precharge feedback signal and the MCB feedback signal are wired on the SD-MCU digital inputs.

---

[25] Acknowledge fault utilized in the MCW.7 if *MCW source* (*[4501]*) is set to *terminal board.*

[26] On Command utilized in the MCW.0 if the *MCW source* (*[4501]*) is set to *terminal board.*

[27] Always used. If this signal is low the fiber connected to the power part are not enabled. The system remains to READY TO OPERATE state. If the FSM remains more than *Pulse Enable timeout* (*[5704]*) an alarm is generated. For further information see 3.3.1.
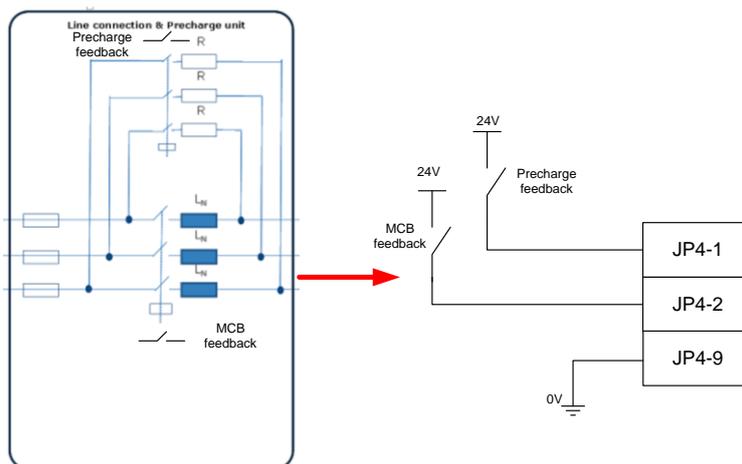
Fig. 3-63: Digital input customization example

The digital input from 9 to 16 are related to control software. All of these digital input are grouped in the Digital Input word:

BIT	Digital Input - Description
BIT 0	-X1 - 1 - Terminal
BIT 1	-X1 - 2 - Terminal
BIT 2	-X1 - 3 - Terminal
BIT 3	-X1 - 4 - Terminal
BIT 4	-X1 - 5 - Terminal
BIT 5	-X1 - 6 - Terminal
BIT 6	-X1 - 7 - Terminal
BIT 7	-X1 - 8 - Terminal
BIT 8	-X1 - 9 - Terminal
BIT 9	-X1 - 10 - Terminal
BIT 10	-X1 - 11 - Terminal
BIT 11	-X1 - 12 - Terminal
BIT 12	-X1 - 13 - Terminal (ACK)
BIT 13	-X1 - 14 - Terminal (En. Op.)
BIT 14	-X1 - 15 - Terminal (Switch ON)
BIT 15	-X1 - 16 - Terminal (Pulse Enable)

Tab. 3-26: Digital Input word

The bit value is true if the input is 24V otherwise is false. The terminal board –X1 indicated in Tab. 3-26 is the name reported on the case envelop of the SD-MCU.

3.3.8.2   Digital Output

The SD-MCU can control up to 6 relay outputs with the following characteristics:
- Contact type: bifurcated crossbar
- Rated load: 0.3 A at 125 VAC, 1 A at 30 VDC
- Rated carry current: 2 A
- Max switching voltage: 125 VAC, 60 VDC
- Max switching current: 1 A

and 4 open collector outputs with the two characteristics:
- Voltage: Up to 24 VDC
- On-state resistance: 200 mΩ
- Nominal load current: 1.3 A
- Clamping energy: 150 mJ

−JP2		Name	Default function (NO position)
NO1	DO1	NO	MCB close command
C1		Common	
NC1		NC	
NO2	DO2	NO	Precharge close command
C2		Common	
NC2		NC	
NO3	DO3	NO	
C3		Common	
NC3		NC	
NO4	DO4	NO	
C4		Common	
NC4		NC	
N5	DO5	NO	Inverter fan start command
C5		Common	
NC5		NC	
NO6	DO6[28]	NO (FAULT ACTIVE)	Fault active
C6		Common	
NC6		NC (NO FAULT ACTIVE)	

Tab. 3-27: Relay digital output description

−X3		Name
1	DO7	NO
G		Common
2	DO8	NO
G		Common
3	DO9	NO
G		Common
4	DO10	NO
G		Common

Tab. 3-28: Open collector output description

The Open collector outputs can be used for example to switch-on/off lamps as showed in Fig. 3-64.
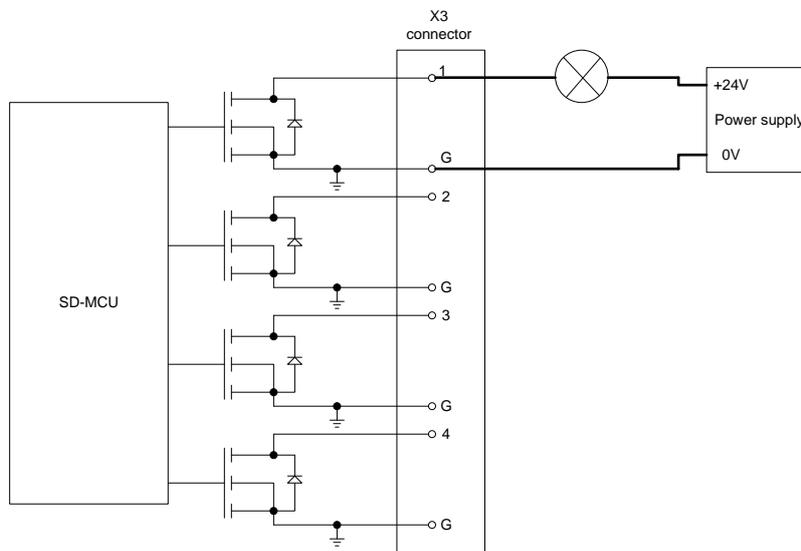
Fig. 3-64: Open collector output schematics (lamp connection example)

3.3.9   STO

STO function allows to obtain safety system type 1oo2D (1 output and two inputs with diagnostic). The system presents two redundant channels that cut-off the voltage of the fiber optic transmitters inside the power part.
The SD-RMU board gives diagnostic functionality for STO function and blocks the system (fault) in case of malfunction. The diagnostic information are sent to the SD-MCU through the standard fiber optic couple. The STO SW provides the information about STO for all the DPM connected as showed in the table below:

---

[28] Not customizable.

BIT	STO SW - Description
BIT 0	STO Actived (cumulative)
BIT 1	STO Actived DPM 1
BIT 2	STO Actived DPM 2
BIT 3	STO Actived DPM 3
BIT 4	STO Actived DPM 4
BIT 5	STO Actived DPM 5
BIT 6	STO Actived DPM 6
BIT 7	STO Actived DPM 7
BIT 8	STO Actived DPM 8
BIT 9	reserved
BIT 10	reserved
BIT 11	reserved
BIT 12	reserved
BIT 13	reserved
BIT 14	reserved
BIT 15	reserved

Tab. 3-29: STO Status Word

In case of STO malfunction (e.g. only one channel is supplied) is generated a DPM X STO fault where X is the DPM with the malfunction. In this case it is possible to find uniquely the problem.
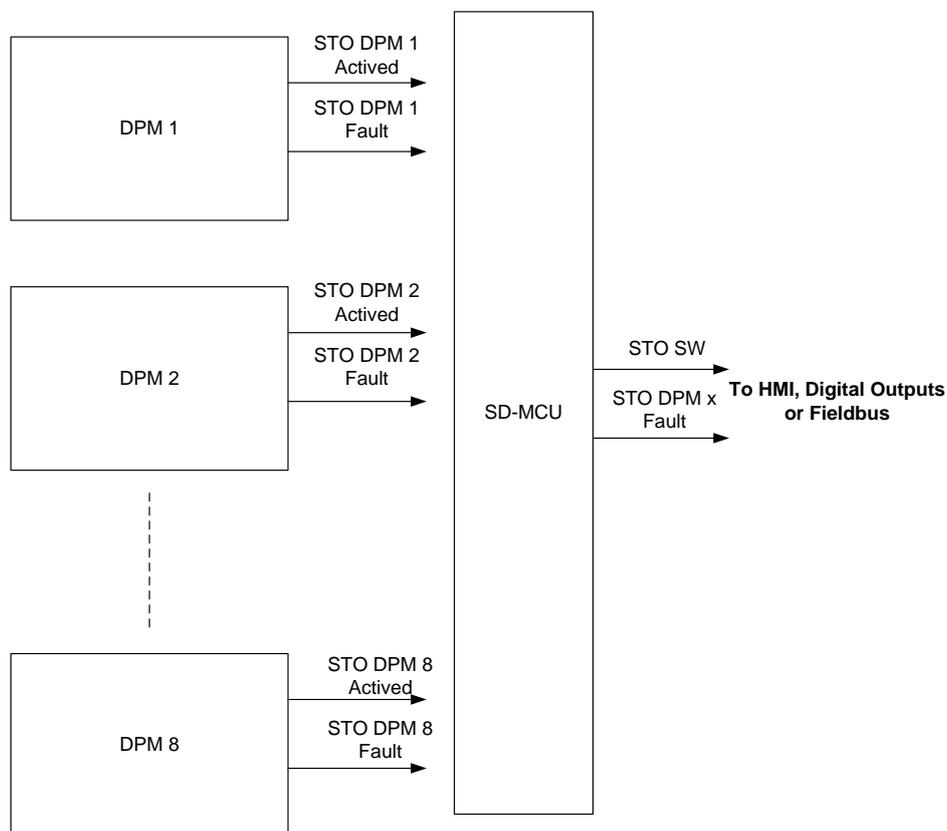
Fig. 3-65: STO functional diagram

STO Active behavior can be customized as disable, warning or Fault OFF2 by mean of parameter *STO active [5532]*. Instead the STO malfunction fault is not customizable and it generated a fault by removing pulses.

3.3.10 Overload Monitoring

The overload monitoring is used to avoid overheating of the inverter power part and additionally of the motor/transformer part. There are three monitored system:
- Inverter
- Motor
- Transformer

For each of these systems there is the parameter to enable the current reduction function. The current reduction function allows to maximize the output power according to the inverter and load thermal limitations.

The limit current setpoint coming from every system is calculate with different formulas and the actuated current limit is set as the smallest value of the subsystems.

BIT	OverloadSW - Description	
BIT 0	Inverter - Overload	Inverter
BIT 1	Inverter - Thermal Fault	
BIT 2	Inverter - Thermal Current	
BIT 3	Inverter - Oveload Current	
BIT 4	Inverter - Rated Current	
BIT 5	Inverter - Enabled Current Reduction	
BIT 6	Reserved	
BIT 7	Reserved	
BIT 8	Motor - Thermal Overload	Motor
BIT 9	Motor - Thermal Warning	
BIT 10	Motor - Thermal Current	
BIT 11	Motor - Overload Current	
BIT 12	Transformer - Thermal Overload	Transformer
BIT 13	Transformer - Thermal Warning	
BIT 14	Transformer - Thermal Current	
BIT 15	Transformer - Overload Current	

Tab. 3-30: Overload Status Word

3.3.10.1 Inverter Overload

For every Drive size (and Drive Root) is calculated a thermal model that defines the current operating range of the inverter. The thermal model takes as input several variables defined below:

- Nominal current at working class 0 (fixed with the drive size and switching frequency)
- Derating factor depending on output frequency (variable with the output frequency).
- Altitude (*[0310]*)

Once this parameters has been loaded, a thermal model is used to <u>estimate</u> the junction temperature ϑ_j of the power part. If this temperature is more than the warning threshold a current reduction (if it enabled by parameter *[5701]*) can be activated otherwise if the temperature is more than the fault threshold a fault is generated.
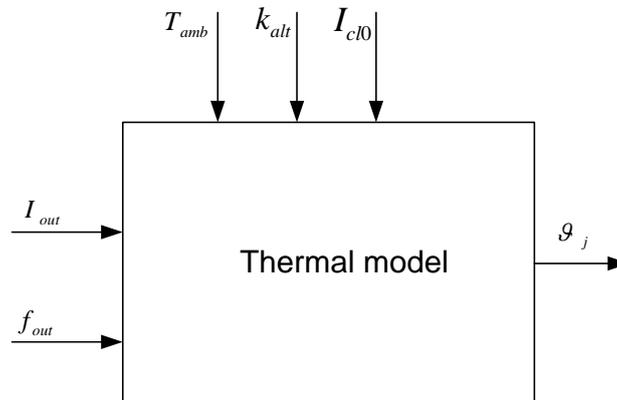
Fig. 3-66: Inverter thermal model

The current reduction function allows to optimize the maximum power of the inverter to avoid overheating. When a drive size, switching frequency and working class are chosen (with the parameter of temperature and altitude), the control software calculated automatically the nominal current *[3116]* (I_n), the overload current *[3117]* (I_{ovl})and the junction temperature at which it is associated (ϑ_n). If the current reduction is not active the maximum allowed current is defined by Inverter Max Current *[0318]*.

The thermal model calculated continuously the junction temperature and when it reaches the critical temperature ϑ_c (this value is defined for each drive root) the current reduction is activated and reduces the inverter current limit to I_n.
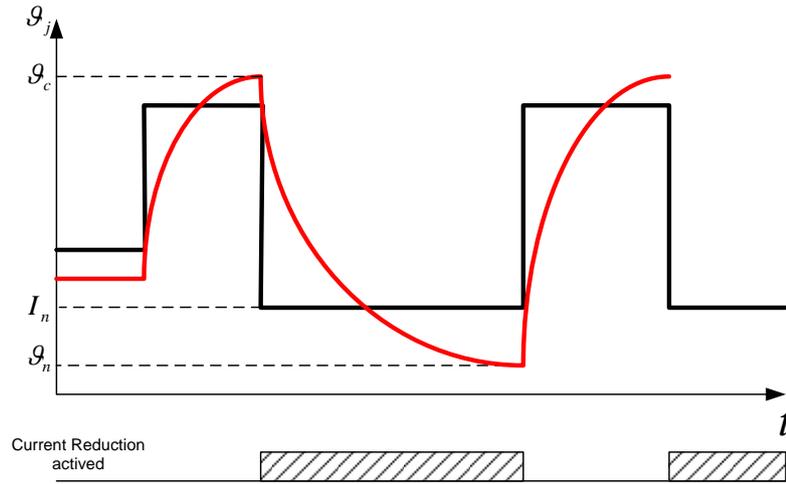
Fig. 3-67: Current reduction behavior when $\vartheta_j < \vartheta_n$

When the junction temperature reaches ϑ_n, the current reduction function sets again the current limit to the previous value (Fig. 3-67). The current reduction function can be also set the previous limit if the current reduction has been active for 9 minutes (for class0, 1 and 2) or 4 minutes (only class 3). This last behavior is showed in Fig. 3-68.
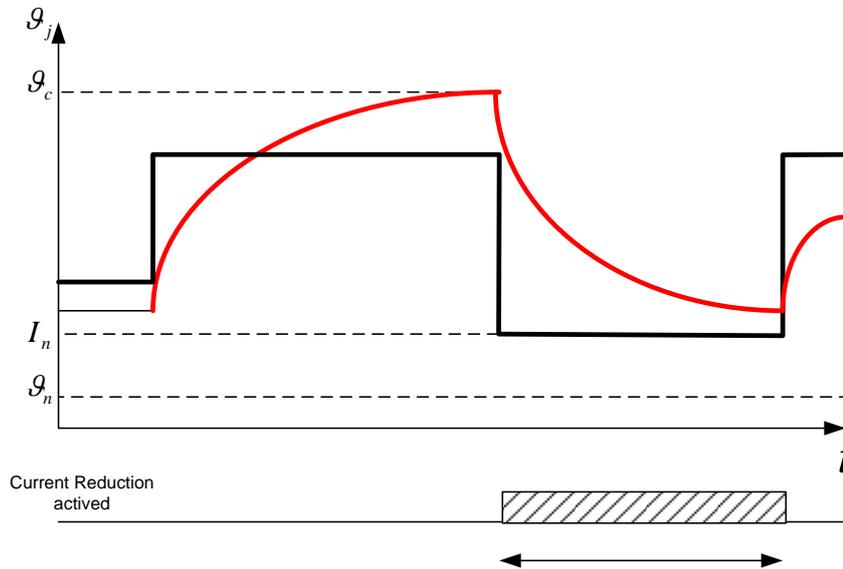
Fig. 3-68: Current reduction behavior when $t > t_{max}$

The information about the inverter overload status is showed in the Overload SW from bit 0 to bit 6.
It is possible to check the inverter limits in the *[03] INVERTER* from parameter *[0315]* to *[0323]* as inverter switching frequency, inverter rated current, inverter overload current.

3.3.10.2 Motor Overload

It is also possible to select the thermal protection for the motor (if the load type is different from GRID). In this case there are not working classes but there are three parameters that define the motor overload k_{ovl} *[5802]*, overload time T_{ovl} *[5803]* and overall time T_{tot} *[5804]*. The motor overload is defined on motor rated current I_{sn} *[0503]*.
Once these parameters are defined, it is possible to calculate the nominal thermal current of the motor as:

$$I_{mot\_rms} = \sqrt{\frac{T_{ovl}(I_{sn}\,k_{ovl})^2 + (T_{tot} - T_{ovl})I_{sn}^2}{T_{tot}}}$$

If the actual thermal current calculated (with a time window long T_{tot}) is high than I_{mot_rms} an alarm is generated. If the current reduction for the motor is enabled *[5701]* the current limit is set to the motor nomnal current.

> **Note**: the control system tries to control the per-unit current; this current is the motor rated current *[0503]* by Max Overload Current *[0504]*/100. To overload the motor is mandatory set the parameter *[0504]* > 100%. So, user has to remember the *[5802]* is only a parameter useful to configure the motor thermal protection.

> **Note**: if the motor overload current is higher than the max inverter current, the output current will be limited to the max inverter current or inverter nominal current if the inverter is overloaded.

Example 1 – run the motor with the same declared overload

The user have a motor of 100A of rated current with an overload of 110% for 1 minute every 10 minutes and he want to configure the thermal protection. The configuration is the following:

- [0503]   Rated Current   100 A
- [0504]   Max Operative Current   110%
- [5802]   Motor Overload   110%   (declared by motor manufacturer)
- [5803]   Overload Time   60 s   (1 minute)
- [5803]   Overload Time   600 s   (10 minutes)

In this case, per-unit current will be 110A.

■

Example 2 – run the motor with higher overload the declared one

The user have a motor of 100A of rated current with an overload of 110%. However, user wants to overload the motor with a current of 125% of the nominal current as long as possible.

- [0503]   Rated Current   100 A
- [0504]   Max Operative Current   125%
- [5802]   Motor Overload   110%   (declared by motor manufacturer)
- [5803]   Overload Time   60 s   (1 minute)
- [5803]   Overload Time   600 s   (10 minutes)

In this case, per-unit current will be 125A, and with this transient current, the motor can be overloaded for less than 60s. To know how much time the motor can be overloaded, it must be apply the following inverse formula:

$$t_{ovl} = \frac{T \cdot I^2_{mot\_rms@110\%} - I^2_n \cdot (T - t_1)}{I^2_{ovl@125\%}} = \frac{600 \cdot 10210 - 100^2 \cdot 540}{125^2} \cong 46.5s$$

After this time, an alarm can be generated or the current reduction function will be activated (depending on configuration).

■

3.3.10.3   Transformer Overload

In case of transformer configuration (*[0701]* = YES) it is possible to monitor its thermal protection (the possible configurations are showed in Tab. 3-4).

In this case there are not working classes but there are three parameters that define the transformer overload k_{ovl} **[5902]**, overload time T_{ovl} **[5903]** and overall time T_{tot} **[5904]**. The transformer overload is defined on transformer rated current I_{trsn} (*[0705]* or *[0706]*).

Once these parameters are defined, it is possible to calculate the nominal thermal current of the transformer as:

$$I_{tr\_rms} = \sqrt{\frac{T_{ovl}(I_{trsn} k_{ovl})^2 + (T_{tot} - T_{ovl})I^2_{trsn}}{T_{tot}}}$$

If the actual thermal current calculated (with a window time long T_{tot}) is high than I_{tr_rms} an alarm is generated. If the current reduction for the transformer is enabled *[5901]* the current limit is set to the transformer nominal current.

3.3.11   Voltage Drop

Voltage drop system (macro function) is used to overcome input power lack and to allow an uninterruptible working sequence.

The voltage drop system has two main functions selectable by mean of parameter *[2701]*:

- Grid waiting
- Ride through

The status word of voltage drop wraps both the mentioned function (Tab. 3-31).

BIT	VoltageDropSW - Description
BIT 0	Grid Waiting Enabled
BIT 1	Ride Trough Enabled
BIT 2	reserved
BIT 3	Under Voltage Trip disabled
BIT 4	Under Voltage Trip temporary disabled
BIT 5	reserved
BIT 6	reserved
BIT 7	reserved
BIT 8	Grid Waiting ON
BIT 9	Grid Waiting Timeout
BIT 10	Ride Through ON
BIT 11	Restart Precharge
BIT 12	Activation threshold reached
BIT 13	Deactivation threshold reached
BIT 14	Minimum Speed Reached
BIT 15	reserved

Tab. 3-31: Voltage Drop Status word (blue for bits only for Grid Waiting, red only for Ride Through)

3.3.11.1 Grid Waiting

The grid waiting function is used when it is necessary to disable the inverter in case of lack of incoming line voltage or dc-bus too low and restart it automatically in case of the quantities described before are above a certain thresholds.
The grid waiting FSM state (and then its related function) is activated only if the previous FSM state was RUN.
It is possible to enable Grid Waiting function by setting *Voltage Drop Management **[2701]*** = *Grid Waiting*.
The conditions to enter in GRID WAITING state are:
- DCBus voltage is lower than $V_{dc\,GW\,ON}$ (**[2703]**)
- SyncOK is false then the line voltage is lower than Voltage Sync Threshold (**[1102]**). SyncOK[29] is used only for GRID configurations.
- If Ride Through is activated and the motor speed is below *Ride Through Disable Thresh* **[2718]**

The conditions to exit from GRID WAITING state are:
- DCBus voltage is higher than $V_{dc\,GW\,OFF}$ (**[2704]**)
- The precharge Ok (PrcOk) signal is true[30]
- The two previous conditions must be true for at least *voltage drop quit delay* (**[2705]**) $T_{VDQ\,delay}$
- SyncOK is true (SyncOK is used only for load of GRID kind)

The control system checks continuously if the DCBus voltage is higher than *Vdc min Threshold **[0204]*** V_{dcmin} otherwise a fault is generated (if the FSM state is higher than READY TO SWITCH ON).
Even if the DCBus voltage is lower than **[0204]** and the GRID WAITING state is active, a fault is generated. To avoid this and to allow to remain in GRID WAITING state overcoming this fault, it is necessary to disable the Vdc min threshold by mean of parameter *Minimum Vdc protection **[2702]***.
The *Vdc min threshold* can be disabled only if the precharge system is configured *Internal* (**[0201]**). In the Fig. 3-69 is showed the grid waiting behavior when the DCBus voltage remains above V_{dcmin}.
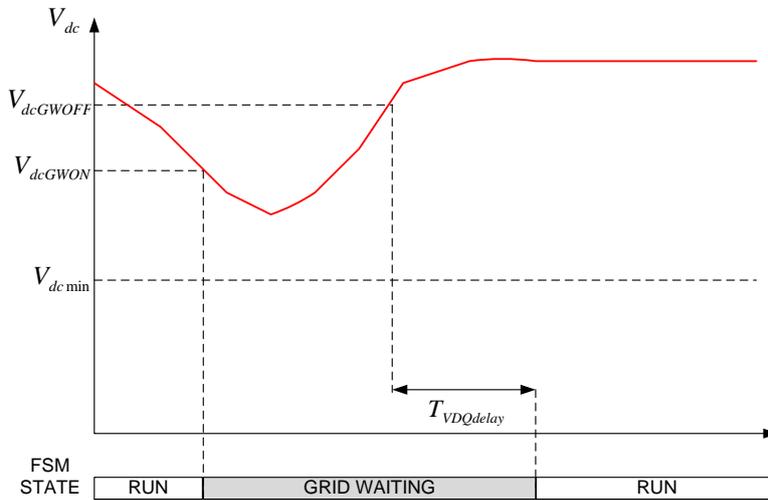
Fig. 3-69: Grid waiting behavior time diagram (case 1)

In the Fig. 3-70 is showed the case in which the DCBus voltage reaches V_{dcmin} and the threshold is not disabled. In this case a fault is generated.
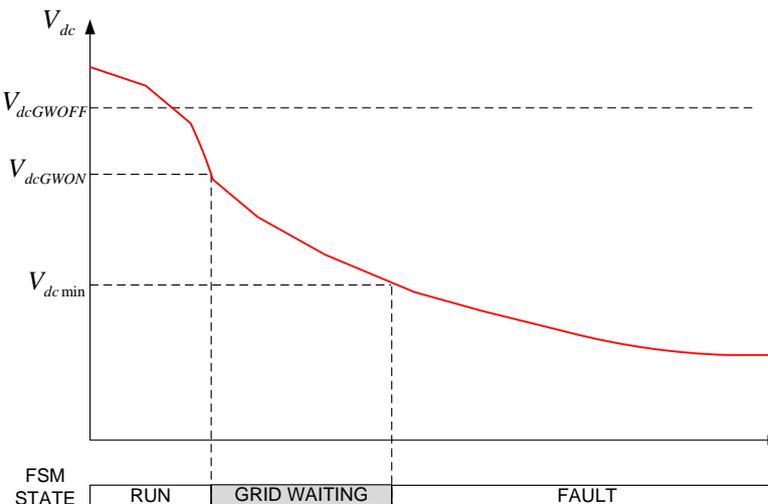
Fig. 3-70: Grid waiting behavior time diagram (case 2)

---

[29] SyncOK is located on PLLSW.00
[30] PrcOK is located on DCBusSW.04

In the Fig. 3-71 is showed the case in which the internal precharge is selected, the Vdc min threshold is disabled. In this case even if the DCBus voltage is lower than the V_{dcmin} a fault is not generated.

When the DCBus voltage is lower than the V_{dcmin} the precharge sequence is activated as well (MCB is opened and precharge contactor is closed). This routine is utilized to avoid that a sudden voltage increase could damage the power part. When the DCBus voltage is higher than the *PrcOk_th* (as described in DcBus section), after *Precharge Ok Delay* (**[0205]**) and *MCBDelayInterlock* (**[0210]**), the MCB is closed again and the PrcOK is restored. Only when the DCBus voltage is higher than $V_{dc\,GW\,OFF}$ and PrcOK is true at least for $T_{VDQ\,delay}$ the FSM goes out from GRID WAITING state and enters to RUN.
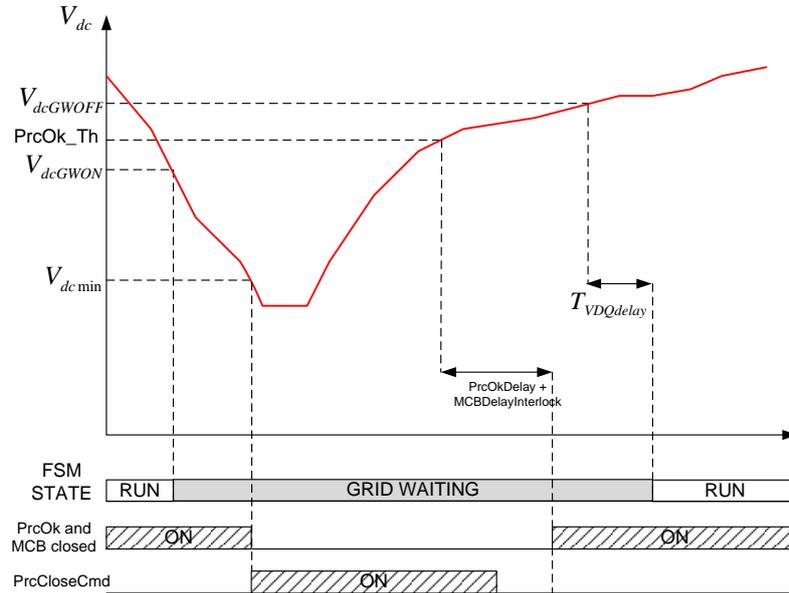
Fig. 3-71: Grid waiting behavior time diagram (case 3)

The three cases mentioned before can be used also with an additional signal if the GRID load is selected: SyncOk.

3.3.11.2   Ride Through

The ride through function is used when it is necessary to maintain the Dc-Bus voltage above a certain value even if the main supply voltage is not present. This function is allowed by using the kinetic energy stored in the motor/load while it is running.
The kinetic energy stored in the motor/load is proportional to speed and regenerating torque and it is used to charge the capacitor located in the dc-bus.

$$P_{kin}(t) = T(t)\omega(t)$$

Where $T(t)$ is the motor torque and $\omega(t)$ is the motor speed.
Thanks to this function it is possible to fast restart the motor if there is a limited Dc-bus voltage drop.
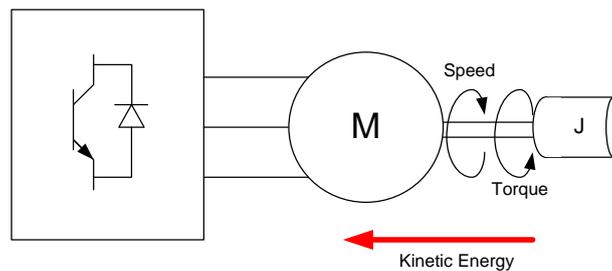
Fig. 3-72: Kinetic energy flow during Ride Through function activated

The ride through function is activated by setting *Voltage Drop Management* **[2701]** = *Ride Through*.
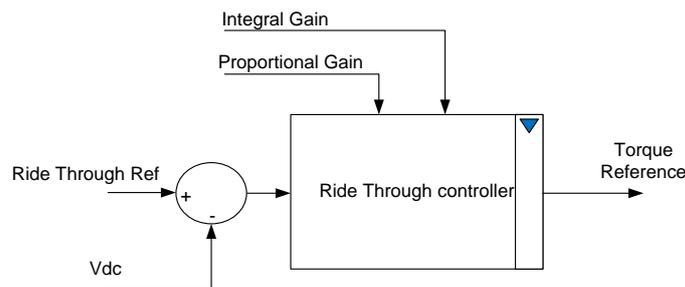
Fig. 3-73: Ride through controller

The ride through controller can be activated (Ride Through ON = True in the status word) when Vdc voltage is lower than the *Vdc Drop Enable Threshold* **[2704]**.

When the DC-Bus voltage is lower than the *Vdc Drop Enable Threshold [2704]* the ride through controller is activated (SW.Ride Through ON) and the DC-Bus voltage is regulated to the *Ride Through reference [2714]* (according to the kinetic energy available in the motor). The Ride Through controller is deactivated only if:

- the Vdc is higher than Vdc Drop Disable Threshold and after *Ride Through ON Timeout[31] [2717]* is elapsed
- the motor torque and speed have the same sign
- the absolute motor speed is below *Ride Through Disable Thresh[32] [2718]*
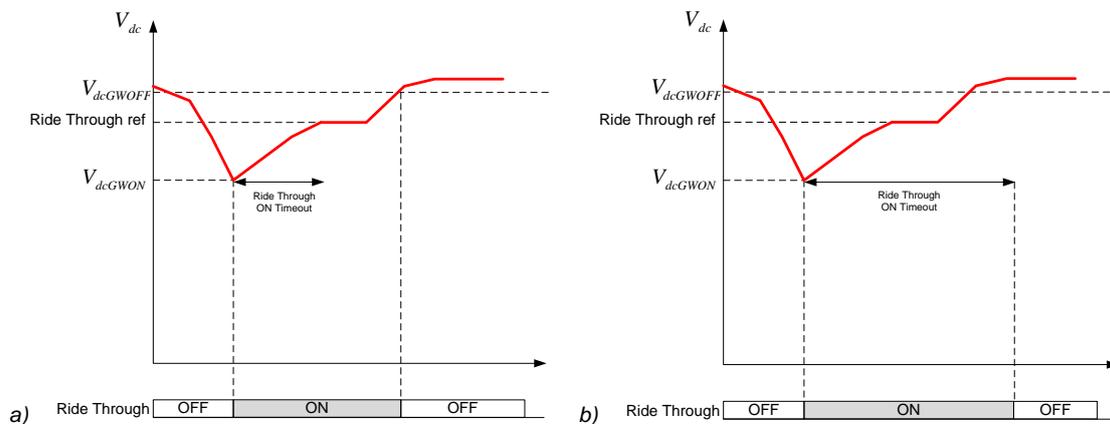
Fig. 3-74: Ride Through behavior in two difference cases

The ride through controller can be tuned by using two parameter *Ride Through P gain [2710]* and *Ride Through I gain [2711]*.

3.3.12   Brake Mode

The brake mode system allows to control the braking power or to limit the dc-bus voltage during braking or to speed-up the braking operation (current brake).
The two functions parameters are located in the *BRAKE MODE [28]* family and they are allowed only with MOTOR load.
The brake mode status word wraps all the function (Tab. 3-32).

BIT	BrakeModeSW - Description
BIT 0	Vdc Rollback Enabled
BIT 1	Vdc Rollback ON
BIT 2	Vdc Rollback Aux. Enable
BIT 3	Vdc Rollback Acceleration
BIT 4	Current Brake Enabled
BIT 5	Current Brake ON
BIT 6	Current Brake Aux. Enable
BIT 7	reserved
BIT 8	reserved
BIT 9	reserved
BIT 10	reserved
BIT 11	reserved
BIT 12	reserved
BIT 13	Mirror VdcRollback Cmd
BIT 14	Mirror Current Brake Cmd
BIT 15	reserved

Tab. 3-32: Brake Mode Status Word

3.3.12.1   Vdc Rollback

The Vdc Rollback limits the regenerative power in the DC bus capacitor to avoid overvoltage. The system has a threshold (*Vdc Rollback Reference [2803]*) that activates the regenerative power limiting (a PID controller) when the actual DC bus voltage value is higher than this value.
Depending on the selected control type, the Vdc Rollback controller has different behaviors:

- FOC and V/Hz: The Vdc Rollback control acts directly in the torque loop and speed regulator is disconnected from the control loop. The Vdc rollback control is removed automatically when the desired torque (from the speed regulator) is higher than the Vdc rollback reference torque.
- V/Hz open loop: Vdc Rollback control act as an additional frequency reference. The Vdc rollback control is removed automatically when additional frequency accelerates the motor.

The other parameters are:

- *Vdc Rollback [2801]*: enables the Vdc rollback. If the value is disabled the Vdc Rollback controller does not modify the torque or the output frequency (see also *[2802]*).

---

[31] This timer is started since the ride through controller is actived
[32] In this case the FSM jumps to GRID WAITING state and the ride through is deactivated

- *Vdc Rollback Cmd [2802]*[(+)]: IPA.bit parameters. If the *[2801]* is enabled and the IPA.bit parameter value is 1, then the Vdc rollback controller is enabled.
- *Vdc Rollback gain P [2804]:* proportional gain of the Vdc Rollback controller.
- *Vdc Rollback gain I [2805]:* Integral gain of the Vdc Rollback controller.
- *Speed Dev. during Vdc Rollback [2808]*[(+)]*:* if the IPA.bit parameters value is 1 the speed deviation alarm is masked during Vdc Rollback correction.

3.3.12.2 Barking Current

The braking current tries to increase the power loss of the motor. This function can stop the motor much faster, mainly if it is used in combination with Vdc Rollback.
The parameters are:
- *Bracking Current [2811]*: enable/disable the function
- *Braking Current Cmd [2812]*: auxiliary command to enable the function
- *Braking Current Ref [2813]*: maximum current value for braking
- *Braking Current Threshold [2814]*: the function will be activated only if the spread between reference and speed is higher than this threshold. This avoid the continuous activation/deactivation of the function

3.3.13 Regulators

The control firmware is composed by many regulators used to maintain certain process variable under control. The general regulator is shown in the Fig. 3-75.
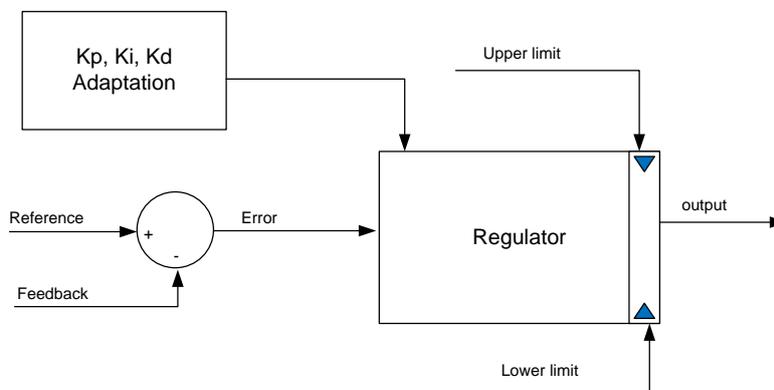
Fig. 3-75: General Regulator representation

The aim of the system is attempt to minimize (or better delete) the error between the reference quantity and the feedback one by adjusting the output value (Fig. 3-76). The physical limitation of the output value is take into account by Upper and lower limit.
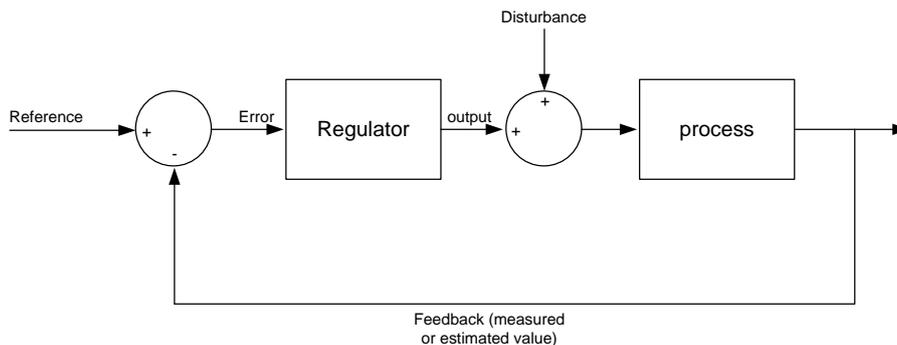
Fig. 3-76: Process regulation scheme

The output value $u(t)$ is determined by a weighted sum:

$$u(t) = K_p input(t) + K_i \int input(t)dt + K_d(1 - e^{-t\omega_d})\frac{dinput(t)}{dt}$$

where $input(t)$ is the error defined as difference between reference and feedback and K_p, K_i and K_d denote the coefficient for the proportional, integral and derivative gain. The ω_d defines the low pass filter pole used in the real derivative term.
The proportional term produces a direct change of the output proportionally with the error variation. If the proportional gain is too high the system can become unstable by mean of increasing overshoot. In contrast, a small gain results in a small output response to a large input error (less sensitive controller).
Proportional-only regulator will leave an offset error in the final steady-state condition. Integral gain is required to eliminate this error.
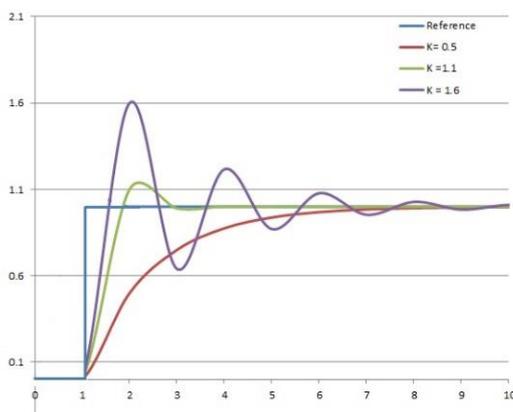
Fig. 3-77: Feedback behavior in case of K_p variation (the other coefficients held constant)

The derivative term is proportional to the slope of the error over time. The derivative term predicts system behavior improving settling time and stability of the system. In the real world system the ideal derivative is always accompanied by a low pass filter to reduce measure noise.
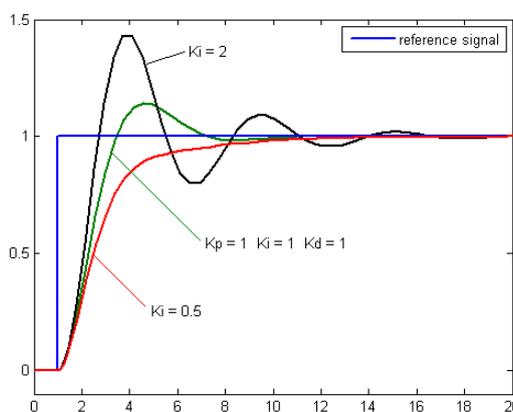
Fig. 3-78: Feedback behavior in case of K_i variation (the other coefficients held constant)

The derivative term is proportional to the slope of the error over time. The derivative term predicts system behavior improving settling time and stability of the system. In the real world system the ideal derivative is always accompanied by a low pass filter to reduce measure noise.
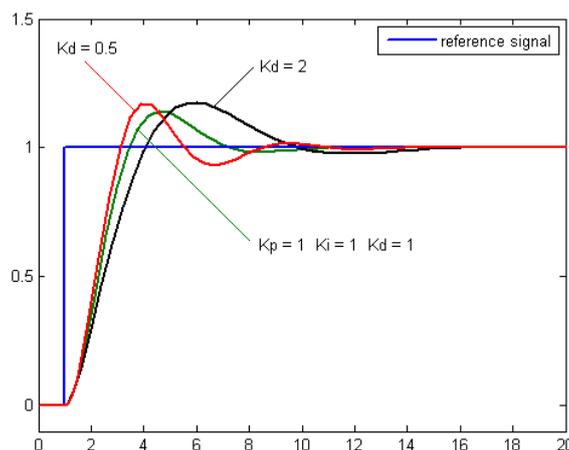
Fig. 3-79: Feedback behavior in case of K_d variation (the other coefficients held constant)

If the derivative gain is too high the system can be unstable. For the most applications the derivative term is not used.
Once the regulator is explained it is possible to look deeply to the regulators system. The regulators are used dependently the load and control type as shown in Tab. 3-33.

	F3E	AFE	Vac Gen	V/Hz	FOC	SLS
D Current		x		x[33]	x	x
Q Current		x			x	x
Vac			x[34]			

[33] Only if *Isd Control Mode [1601]* > 0 (No Load Current)
[34] Only if *Voltage Compensation [1301]* > 0 (Disabled)

	F3E	AFE	Vac Gen	V/Hz	FOC	SLS
Iac			x			
Flux				$\underline{x}^{35}$	$\underline{x}$	$\underline{x}$
Speed					$\underline{x}$	$\underline{x}$
Dc Voltage		x				
Mod Ratio				x^{36}	x^{36}	

Tab. 3-33: Regulators vs control types (x = fixed parameters, $\underline{x}$ = adaptive gain)

The fixed parameters are defined for standard applications while the adaptive gain are used to increase the performance in a wide system operation.
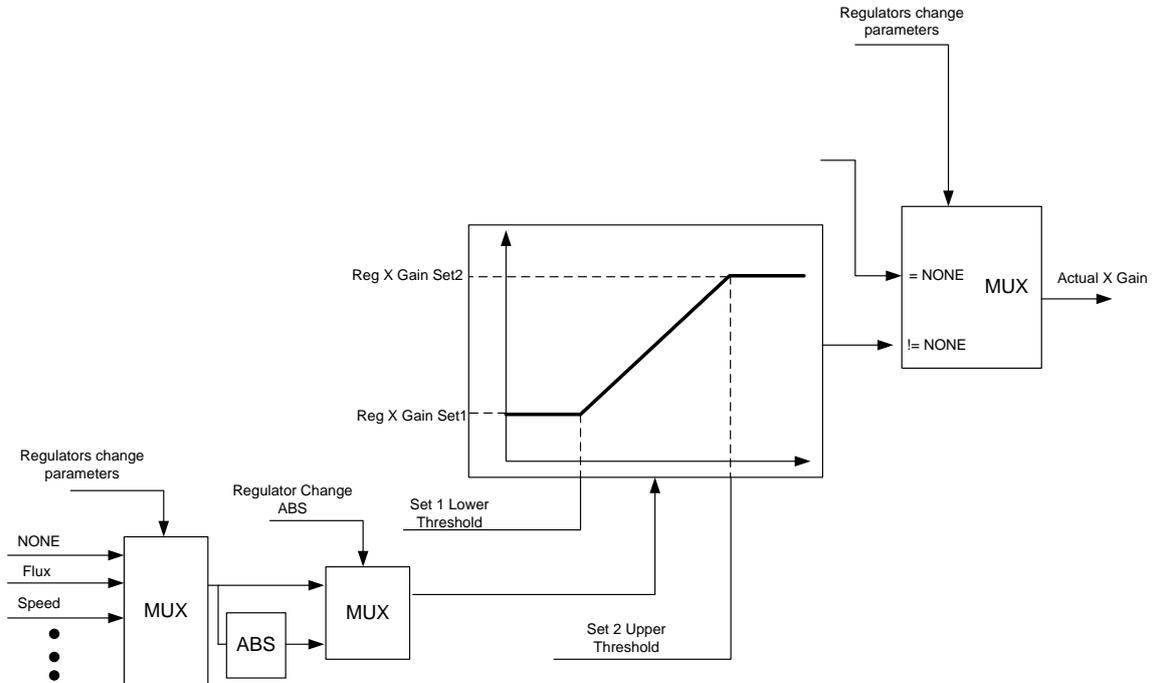
Fig. 3-80: Adaptive gain for regulator parameter where X denotes a generic gain (e.g. K$_p$, K$_i$)

As shown Fig. 3-80 in it is possible to change on-line the gain by using a linear formula by selecting a value different from zero for *regulator change parameters*. The regulator change parameters sets the variable used to change parameters dynamically and defines these rules:

- If this variable is lower than *Set 1 lower threshold* then *Reg X Gain Set 1* is applied
- If this variable is between *Set 1 lower threshold* and *Set 2 upper threshold* then there is a gain set linearly starting from *Reg X Gain Set 1* up to *Reg X Gain Set 2*
- If this variable is higher than *Set 2 upper threshold* then *Reg X Gain Set 2* is applied

	F3E	AFE	Vac Gen	V/Hz	FOC	SLS
Flux				x	x	x
Speed/Freq				x	x	x
Speed Ref				x	x	x
Torque				x	x	x
Inverter Current		x	x	x	x	x
Load Current		x	x	x	x	x

Tab. 3-34: Regulator change parameters vs control types

In Tab. 3-34 is shown the selectable variables used for regulator change parameters.
It also possible to change between two parameters set by using X[37] Regulator Set selection as shown in Fig. 3-74. If the value is 0 the set 1 is used whilst if the value is 1 the set 2 is used. This value can be also connected to every bit addressable by using *[IPA.bit]* rules.

Example 1

Suppose you have two different loads on the motor shaft. These two loads also defines different gains on the speed regulator.

- Set Speed Reg Set selection *[2115]*[(+)] = 0 and tune the speed regulator with the first load by using set 1 parameters[38].
- Set Speed Reg Set selection *[2115]*[(+)] = 1 and tune the speed regulator with the second load by using set 2 parameters[38].
- Set Speed Reg Set selection *[2115]*[(+)] to the desired bit selector (e.g. 7041.02 is the default value and represents the Ext Regulators CW). In this case by setting the bit 02 of this CW it is possible to switch between the two regulator gains set dynamically

---

[35] Only if *Isd Control Mode [1601]* = 2 (Flux Reg)

[36] Only if *ModRatio [2070]* is enabled

[37] X defines the regulator type (e.g. Speed, Current)

[38] In this case the K$_p$, K$_i$, K$_d$ and ω$_d$ are respectively *[2107]*, *[2108]*, *[2109]* and **[2110]**

■

Example 2

Suppose you have a wide speed range and it is necessary to tune the speed regulator for a range at nominal speed and at maximum speed (high flux weakening point). For this example the nominal speed is at 50 Hz whilst the maximum speed is at 200 Hz (it defines that the motor reaches the nominal speed at 0.25 pu).

- Set Speed Reg Set selection *[2115]*[(+)] = 0 and tune the speed regulator at nominal speed by using set 1 parameters.
- After reaching maximum speed with a very low speed ramp time, set Speed Reg Set selection *[2115]*[(+)] = 1 and tune the speed regulator by using set 2 parameters.
- After stopping the motor and releasing the Enable Operation Command (MCW.03) it is necessary to set the following parameters:
  - o Regulators change parameters *[2055]* = Speed/Freq
  - o Regulators change ABS *[2056]* = ON[39]
  - o Set 1 – Lower Threshold *[2057]* = 0.25
  - o Set 2 – Upper Threshold *[2058]* = 1

■

Status and Command Word

The behavior of each regulator can be monitored via the Regulator Status word *[7014]*. The relater command word is used only to choose the parameter set.

BIT	RegulatorsSW - Description
BIT 0	D-Current Reg saturated
BIT 1	Q-Current Reg saturated
BIT 2	Flux Reg saturated
BIT 3	Speed Reg saturated
BIT 4	Vdc Reg saturated
BIT 5	reserved
BIT 6	reserved
BIT 7	D-Current Steady
BIT 8	Q-Current Steady
BIT 9	Flux Steady
BIT 10	Speed Steady
BIT 11	Vdc Steady
BIT 12	reserved
BIT 13	Q-Current Ref Max
BIT 14	Current/Flux Linear K
BIT 15	Speed Linear K

Tab. 3-35: Regulators Status word bit description

BIT	RegulatorsCW - Description
BIT 0	Current Reg Set
BIT 1	Flux Reg Set
BIT 2	Speed Reg Set
BIT 3	Torque Limit Set
BIT 4	reserved
BIT 5	reserved
BIT 6	reserved
BIT 7	reserved
BIT 8	reserved
BIT 9	reserved
BIT 10	reserved
BIT 11	reserved
BIT 12	reserved
BIT 13	reserved
BIT 14	reserved
BIT 15	reserved

Tab. 3-36: Regulators Command Word bit description

3.3.14 Fluxing

The motor flux is an estimated quantity that it is used to perform vector and scalar control. The most of motor parameters are used to estimate it. The behavior of the flux circuit is shown in the following figure.
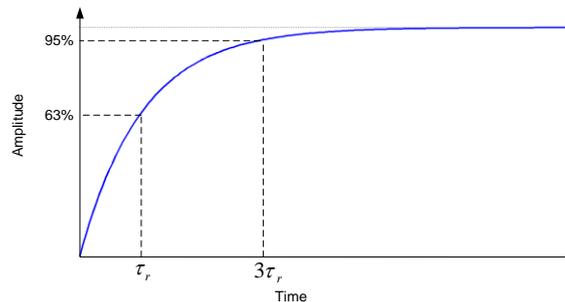
Fig. 3-81: Flux circuit behavior

The flux system is utilized only for two control types i.e. FOC and V/Hz[40]. The motor is magnetized during the MAGNETIZATION state. The transition from MAGNETIZATION to RUNNING is activated when *MagnetizationDone* is activated. In this case the fluxing time counter is expired or if the flux value has reached the Flux ok threshold[41] at least once. The most of the parameters for the fluxing configuration is located in [49] MAGNETIZATION. The fluxing time counter can be set by mean of *Fluxing time calculation [4901]*:

- Auto: the fluxing time will be:
  - o Set to 3s if control is VHz and no motor parameters are provided

---

[39] This parameter enables the absolute value calculation

[40] Only if *Current control Mode [1601]* = 2 (Flux Reg)

[41] The flux ok threshold value is calculated as *Flux Ok Threshold [4905]* * Weakening factor. This value is calculated at run time as *Weakening setpoint [4904]* * rated mechanical frequency / actual mechanical frequency.

    o   Function of motor parameter (rotor constant) and boost current *[1612]* with VHz control and *Magnetization Control Mode [1601] = No-load current*

    o   Function of motor parameters (rotor constant) and Flux regulator output limit (*Flux Reg Limit [2031]*) with FOC or with VHz and *Magnetization Control Mode [1601] = Flux Reg*

•   Manual: the fluxing time is set by user according to *Fluxing Time* parameter *[4902]*

The *FluxOk* is activated if the estimated flux is higher than *Flux Ok Threshold [4905]* and depends also by the actual speed and weakening factor ratio.

If the output voltage is more than 0.2 pu and the inverter current is less than 0.02 pu for more than 5 ms then a configurable alarm (*No Flux*) is activated.
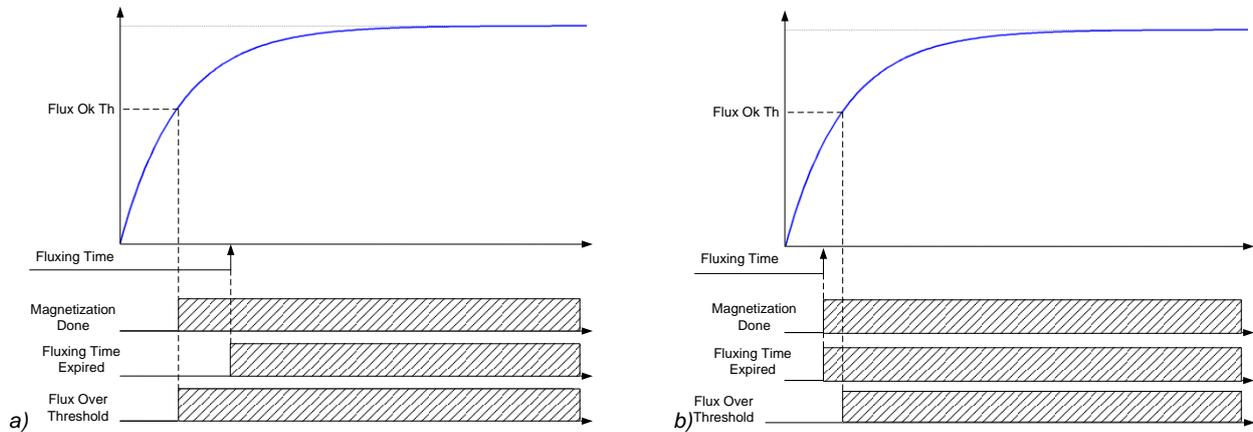
Fig. 3-82: Flux Ok behavior during MAGNETIZATION

If the FSM is in RUNNING state and the flux is lower than Flux Ok Threshold (adapted to the actual motor speed) more than *Fluxing Timeout [4903]* a configurable alarm is activated (Magnetization timeout).

Flux Status word is provided to monitor the fluxing behavior (Tab. 3-37).

BIT	FluxingSW - Description
BIT 0	Auto Set Time
BIT 1	Fluxing Time Expired
BIT 2	Fluxing Timeout
BIT 3	NO Flux
BIT 4	Flux Ok
BIT 5	Magnetization Done
BIT 6	Weakening ON
BIT 7	Modulation Ratio Enabled
BIT 8	Modulation Ratio ON
BIT 9	reserved
BIT 10	reserved
BIT 11	reserved
BIT 12	reserved
BIT 13	reserved
BIT 14	reserved
BIT 15	reserved

Tab. 3-37: Fluxing Status Word

3.3.15   JOG

JOG is located in the group Macro functions, [26] JOG family. It is possible to choose this function only if Motor is selected as load.

This function it used mainly for:

•   Verify the direction of rotation

•   Wind/unwind slowly the band (e.g. paper mill)

This macro can be enabled through an *IPA.bit* parameter *JOG Enable [2601]* *(+)*. The JOG function is disabled temporary when the SDM local commands are taken.
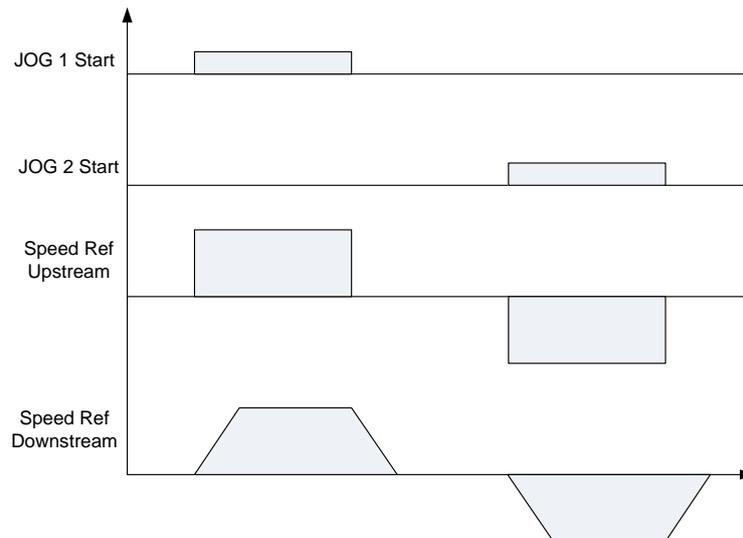
Fig. 3-83: JOG Macro behavior

The parameters related to this function are:
- JOG Enable [2601] (+): Enable the JOG function
- JOG 1 Command [2602] (+): if the Drive status is READY TO OPERATE and there is a rising edge of the value *IPA.bit* addressed the JOG is running.
- JOG 2 Command [2603] (+): if the Drive status is READY TO OPERATE and there is a rising edge of the value *IPA.bit* addressed the JOG is running.
- JOG 1 Reference [2604]: set the speed reference to this value when JOG1 Start is high.
- JOG 2 Reference [2605]: set the speed reference to this value when JOG2 Start is high.

If the Drive Status is READY TO OPERATE:
- When the JOG1 start command is risen (and kept to high steady value) the speed reference goes to the *JOG 1 Reference [2604]* value. If the JOG 1 start command is set to low the speed reference goes to zero.
- When the JOG2 start command is risen (and kept to high steady value) the speed reference goes to the *JOG 2 Reference [2605]* value. If the JOG 2 start command is set to low the speed reference goes to zero.
- If JOG Enable *[2601]*(+) is set low while the JOG is running, the motor will be stopped and it is necessary an Enable Operation rising edge (MCW.04) to start again the motor.
- While the Drive Status is RUNNING (after a rising edge of the Enable Operation) the JOG commands are ignored.
- While JOG is Running the Enable Operation command is ignored.
- If the JOG1 is activated and then it JOG2 Command is activated, only when JOG1 command is low the speed reference will be set to JOG2 reference (Fig. 3-84).
- If the JOG2 is activated and then it JOG1 Command is activated, only when JOG2 command is low the speed reference will be set to JOG1 reference.
- *Force Stop* is high when the JOG is running. It means that it is necessary a rising edge to the Enable operation command to move the FSM to RUNNING after the JOG is stopped.
- *Inhibited* is high when JOG1 or JOG2 command are set true before JOG is enabled. In this case it is necessary to set the two JOG commands low before enabling it.

Tab. 3-38 report the JOG status word. A relative command word for JOG is not needed. The only command are JOG1/2 start command and the default commands in inside the Main Command word (MCW, see Tab. 3-9).

BIT	JOGSW - Description
BIT 0	Auto Set Time
BIT 1	Fluxing Time Expired
BIT 2	Fluxing Timeout
BIT 3	NO Flux
BIT 4	Flux Ok
BIT 5	Magnetization Done
BIT 6	Weakening ON
BIT 7	Modulation Ratio Enabled
BIT 8	Modulation Ratio ON
BIT 9	reserved
BIT 10	reserved
BIT 11	reserved
BIT 12	reserved
BIT 13	reserved
BIT 14	reserved
BIT 15	reserved

Tab. 3-38: JOG Status Word
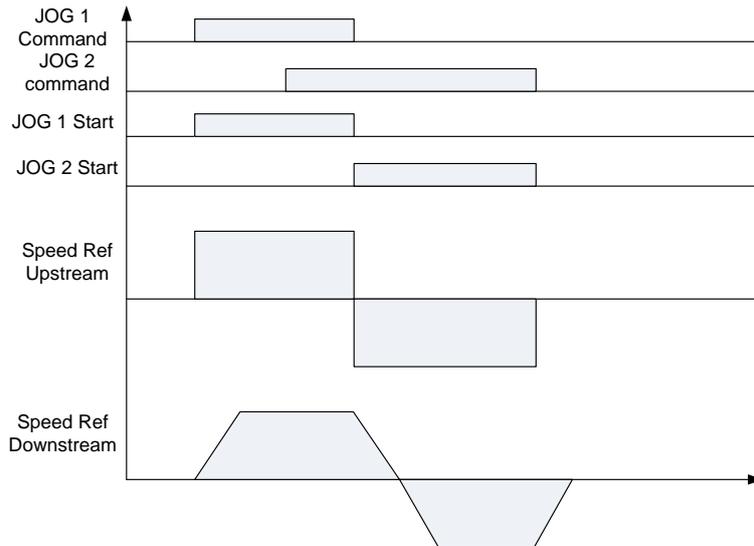
Fig. 3-84: JOG behavior in case of JOG1 e JOG2 commands overlapping

3.3.16   Fieldbus

The Secom Drive has several fieldbus interfaces useful to interconnect many objects in the network.

Fieldbus Name	Equipment	Example use
CAN Open Master	Standard	• Remote I/O expansion • Master/Follower application (Master side)
CAN Open Slave	Standard	• Automation Level 1 Slave
Modbus TCP Master	Standard	• Remote I/O expansion
Modbus TCP Slave	Standard	• Automation Level 1 Slave • SDM interface
Profibus Slave‡	Optional	• Level 1 Slave
ProfiNet Slave‡	Optional	• Level 1 Slave

‡: Exclusive selection: only one option selectable

Tab. 3-39: Available Fieldbus

To monitor the fieldbus behavior, the *Fieldbus Status Word **[7028]*** is provided (Tab. 3-40).

BIT	FieldbusSW - Description
BIT 0	Modbus TCP Action
BIT 1	Mabus TCP Alarm
BIT 2	CANOpen Salve Enabled
BIT 3	CANOpen Action
BIT 4	CANOpen Alarm
BIT 5	Profibus Slave Enabled
BIT 6	Profibus Action
BIT 7	Profibus Alarm
BIT 8	Profibus Swap byte
BIT 9	reserved
BIT 10	reserved
BIT 11	reserved
BIT 12	reserved
BIT 13	Modbus TCP WDog Enabled
BIT 14	CANOpen Wdog Enabled
BIT 15	reserved

Tab. 3-40: Fieldbus Status Word

3.3.16.1   CANOpen

The CANOpen fieldbus is the fieldbus suggested by SECOM to expand I/O and/or connect SD-MCU among each other for the following features:
- CAN is cheaper than other network
- Is deterministic and robust
- Is real-time and quite fast

One Master and one Slave unit is present onboard as shown in Fig. 3-86.a. The CAN module can communicate in the speed range 50 Kb/s to 1Mb/s and usually a resistance of 120Ω is needed on both termination of the CAN network. SD-MCU provide the termination resistance on board (Fig. 3-86.b).
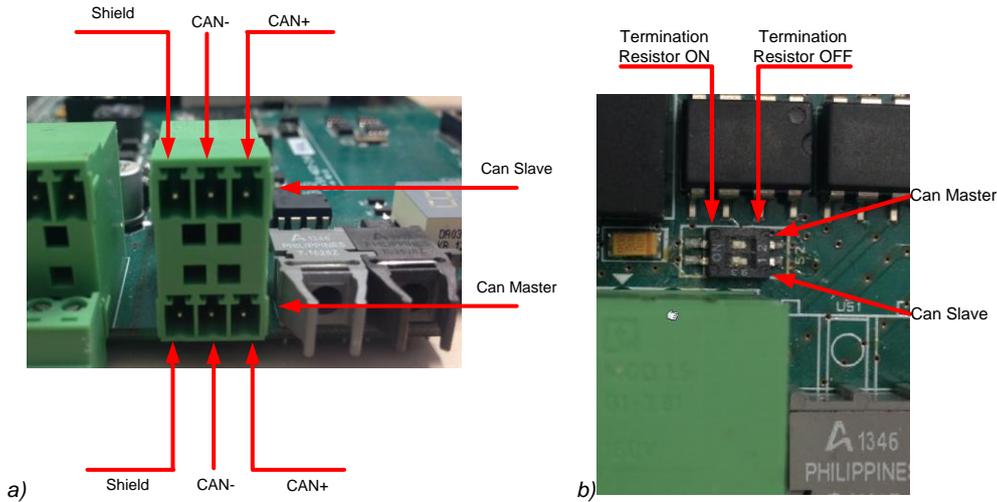
Fig. 3-85: CANOpen connector and equilibration resistance

Addressing

It is possible to write/read parameter by using CANOpen interface. Each parameter is indexed by using the following rules:

CanOpen index = 0x2000 + 2*[IPA]

Example

Suppose to write/read parameter [0309] Ambient temperature. The CanOpen index is 0x2000+2*[0309] = 0x226A.

∎

3.3.16.1.1 CANOpen Master

The CAN open master can be used to connect several devices like digital inputs, digital outputs. It is possible to configure CAN Master only by using SDLE (Secom Drive Logic Environment). The CAN Master speed range is from 50 Kb/s to 1Mb/s.
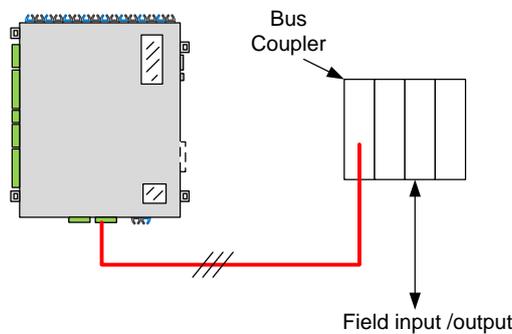
Fig. 3-86: CANOpen Master connection concept

The wire connection is made by using JP9 (bottom part) connector located in SD-MCU (see Fig. 3-85) and the S2-2 dip switch must be set ON (termination resistor enabled). It is possible to connect several devices by selecting among the catalog devices or by importing further devices thanks to EDS import feature.

There is no brand limitation regarding the product that can be connected to the CAN network. In the examples will be reported Beckhoff components without any advertising purpose.

⚠ **WARNING!** It is mandatory to disconnect the power part before changing CAN hardware module dispositions.

⚠ **WARNING!** The CAN hardware network configuration must match with the CAN software network in the SDLE.

It is possible to write/read process image and also set parameters. The CAN Open master can be set only by with SDLE. For further information about how to configure CAN OPEN master please refers to the SDLE paragraph.

3.3.16.1.2 CANOpen Slave

The CANOpen slave is a useful protocol when it is necessary to connect the control system in a deterministic network. All the configuration parameters regarding the CANOpen Slave are located in *Fieldbus/[52] CANOPEN*. To connect the SD-MCU to the network it is necessary to follow these steps:

- Wire the slave to the master by using the JP9 terminal
- If the SD-MCU is the last node of the chain set to ON the termination resistor by setting to "ON" the S2-1 dip switch (it is possible to see this dip-switch by opening SD-MCU case).
- Set the *CANOpen Slave [5201]*=Disable
- Set the *Node ID [5202]* and the *Baud Rate [5203]*[42] according to the Master configuration
- Configure CAN Word IN (these words are inputs for the SECOM control) by selecting among the possible choices[43] (e.g. Speed reference, Torque limits, CWs…). It is possible to watch the connected variables from parameter *[7461]* to *[7474]*.
- Configure CAN Word OUT (These words are outputs for the SECOM control) by using *[IPA]* rules. If the selected IPA has a pu type the value sent to master is IQ14 type whilst if the selected IPA has an engineering type the value sent to master is transformed to INT (e.g. Output Frequency = 43.5 Hz will be sent to master as the value 43).
  The allowed IPA range for this purpose is from *[60]* to *[74]*.
- Set the *CANOpen Slave [5201]*=Enable[44]
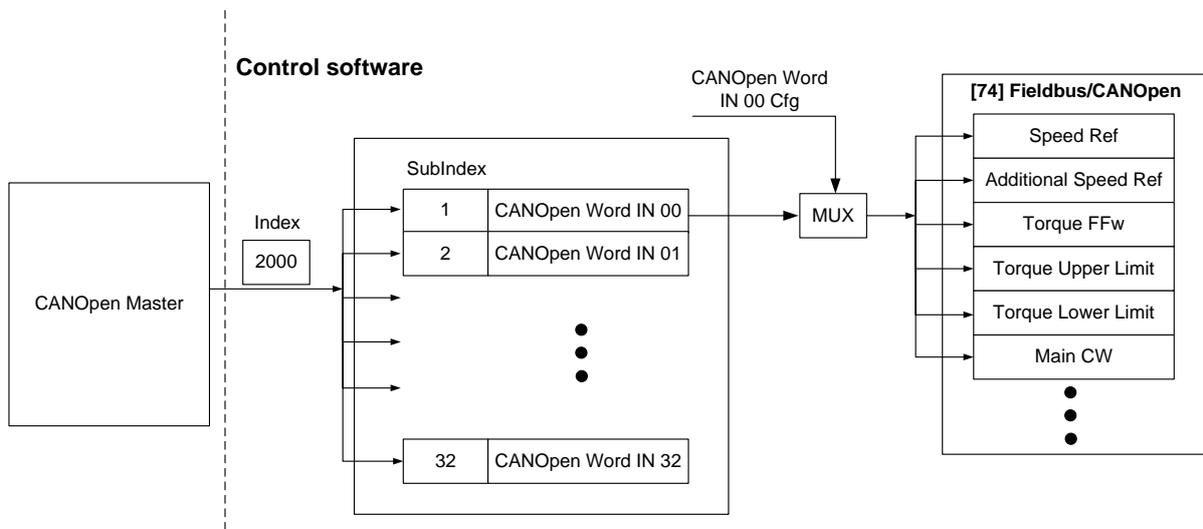
Fig. 3-87: CANOpen Slave Input words configuration
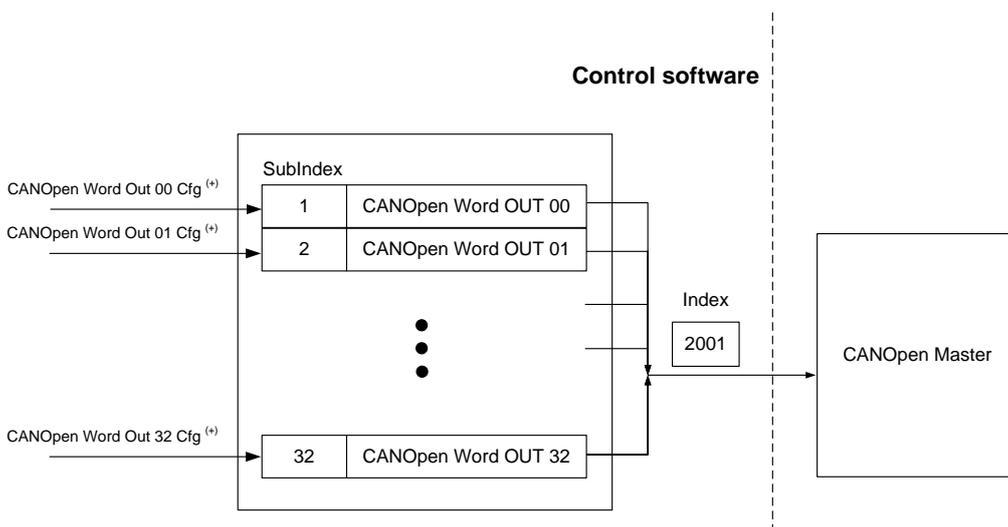
Fig. 3-88: CANOpen Slave Output words configuration

By Master side, it is possible configure easily the network by using the configuration file .EDS. Thanks to this configuration file it is possible to write/read all the parameters of the control software by using SDO/SDI packets and write/read real time value by using PDO/PDI packets.
It is possible to exchange in real-time mode between master and slave up to 32 input words[45] and 32 output words (called also process data). The SDO/SDI (parameters) are exchanged without time requirement whilst PDO/PDO have master cycle time requirement (linked to baud rate).

---

[42] It is possible to configure up to 6 different baud rate: 50, 100, 125, 250, 500 and 1000 Kb/s
[43] If Analog variable is selected, the master must adapt the reference according to IQ14 type (the value 16384 is equivalent to 1 pu)
[44] When the CANOpen slave configuration is changed, it is necessary to force a new reconfiguration to the Master side
[45] It the network total slave nodes are less than 64 otherwise up to 16 words in and 16 words out can be exchanged

Example

Suppose to configure the *CANOpen Word IN 00* as *MCW* and the *CANOpen Word IN 01* as *Speed reference*. To achieve this configuration set the following parameters:

- Set CANOpen Slave **[5201]** = Disable
- Set CANOpen Word IN 00 cfg **[5221]** = Main CW
- Set CANOpen Word IN 01 cfg **[5222]** = Speed Ref
- Set CANOpen Slave **[5201]** = Enable

The CAN Open master will write the MCW on the index 2000.1 whilst the Speed Ref on the index 2000.2. It is possible to watch the value written by master in the variables *CANOpen Main CW* **[7468]** and *CANOpen Speed Reference* **[7461]**.

■

Example

Suppose to send to the master the *Is Magnitude (pu)* **[6331]**, V*inv Magnitude (pu)* **[6202]** and *DC Bus Voltage (V)* **[6101]** in the CAN Word OUT 00, 01 and 02. To achieve this configuration set the following parameters:

- Set CANOpen Slave **[5201]** = Disable
- Set CANOpen Word OUT 00 cfg **[5253]** =6331
- Set CANOpen Word OUT 01 cfg **[5254]** = 6202
- Set CANOpen Word OUT 02 cfg **[5255]** = 6101
- Set CANOpen Slave **[5201]** = Enable

The CAN Open master will read the *Is Magnitude* on the index 2001.1, the *Vinv Magnitude* on the index 2001.2 and *DC-Bus voltage* on the index 2001.3.

In the following table is shown an example of signal conversion from master and slave:

Parameter	Slave side	Master side
Is Magnitude (pu)	0.6	9830
Vinv Magnitude (pu)	1.5	24576
DC Bus Voltage (V)	535.7	535

■

It is possible to monitor the CANOpen Master activity by implementing a counter to the Master side and enabling the watchdog function to the slave side (*CANOpen watchdog* **[5204]**=Enable). The master must write a different value to the CANOpen index 2002.0 CANOpen Watchdog.

It is possible to set two different behaviors in case of watchdog missing:

- Alarm generation
- Action generation

Alarm generation is the standard alarm that can be configured in the Alarm setting as standard (Disabled, Warning, Ramp Stop, Coast Stop, Quick Stop). If SD-MCU CANOpen slave doesn't find a change in the watchdog variable within *CANOpen Alarm Timeout* **[5205]** an alarm is generated.

Action generation can be configured by mean of *CANOpen Action* **[5207]** and allows to create particular actions independently of alarm generation. If SD-MCU CANOpen slave doesn't find a change in the watchdog variable within *CANOpen Action Timeout* **[5206]** an action is generated.

The possible choices are:

- None
- Minimum Speed
- Zero Speed
- Ramp Stop
- Ramp Stop (OFF1)
- Quick Stop (OFF3)

None: the old reference value is maintained.

Minimum speed: reference speed will set to the *minimum working speed* parameter **[4732]** according with the actual ramp time. In this case the action can be reset if the watchdog starts to change.

Zero Speed: reference will set to zero according with the actual ramp time. In this case the action can be reset if the watchdog starts to change.

Ramp stop: reference will set to zero according with the *Ramp Stop Time* **[4744]**. In this case the action can be reset if the watchdog starts to change.

Ramp stop (OFF1): reference will set to zero according with the *Ramp Stop Selection* **[4743]** and OFF1 sequence will be performed.

Quick Stop (OFF3): reference will set to zero according and OFF3 sequence will be performed.

It is possible to monitor PDO/PDI sent/received values by mean of parameters from **[8001]** to **[8019]**. The configuration rules are the following (for the first parameters group):

- Chose the *Fieldbus selection* **[8001]**=CANOpen Slave
- Choose the *Fieldbus In/Out register* **[8002]**[46]
- Select the *Word number* **[8003]**[47]
- Watch the value to *Register Value* **[8004]**

3.3.16.2 ModbusTCP

Modbus/TCP is provided by default via Ethernet interface (Fig. 3-89). Modbus/TCP could be cheaper than CAN or other fieldbus only if an Ethernet switch is already provided. Nonetheless this fieldbus is not real-time and is usually used for HMI or the SECOM Drive Manager (SDM) or automation that has to read (or write) a great amount of data.

---

[46] Choose Input for CANOpen Input Words or Output for CANOpen output Words
[47] From 0 to 31 (depending to the configuration)
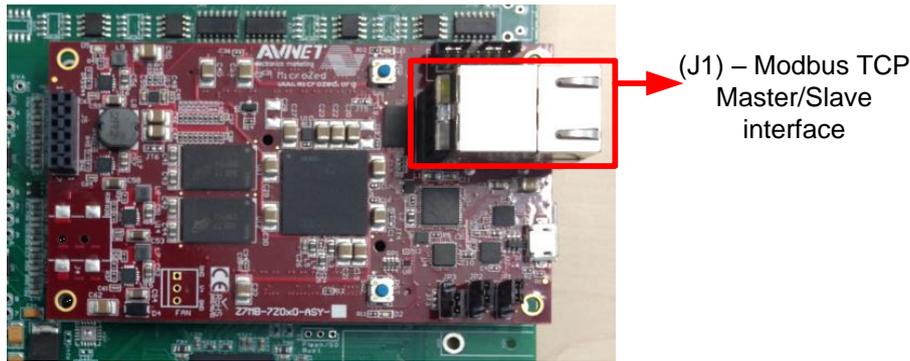
Fig. 3-89: Modbus TCP Master/Slave Interface

Addressing

The standard rule to read/write parameters by using Modbus TCP index is the following:

$$IPA\ Modbus\ TCP\ index = 2*[IPA]$$

Example

Suppose to write/read parameter [0309] Ambient temperature. The CanOpen index is 0x2000+2*[0309] = 0x226A.

■

Example

Suppose to write parameter *Main Contactor delay [0209]* = 120 (type INT); in this case Modbus TCP master must be configured as:
- Address = 255
- Port Number = 502
- Index = 418 (209*2)
- Access Type = INT
- Value = 120

■

Example

Suppose to read parameter I_{inv} Q *[6307]* (Type Real); in this case Modbus TCP master must be configured as:
- Address = 255
- Port Number = 502
- Index = 12614 (6307*2)
- Access Type = REAL

■

3.3.16.2.1   Modbus/TCP Master

The Modbus TCP master can be used to connect several devices like digital inputs, digital outputs. It is possible to configure it only by using SDLE (Secom Drive Logic Enviorment).
Both Modbus TCP master and slave are interfaced with Eth0 (Ethernet) connector[48]. It is possible to add several devices to the Modbus TCP network by configuring SDLE.
It must be reminded that the Modbus TCP address is double respect the parameter number (i.e. *[7006] Main Status Word* has Modbus TCP address 14012).
For further information about how to configure Modbus TCP master please refers to the SDLE paragraph.

3.3.16.2.2   Modbus/TCP Slave

The Modbus TCP is a protocol based on TCP protocol and it needs an IP address. In this case to connect many devices in the same network is necessary to use a switch. It is important that the IP address is different for each device. The hardware connection is made by using Eth0 connector. All the configuration parameters are located in [50] Modbus TCP.
In this case, the Modbus TCP master configuration setting necessary to communicate with SD-MCU (Modbus TCP slave mode) are the following:
- Set the SD-MCU IP address contained in Eth0 – IP Address parameter [8504]
- Set port number 502
- Set Modbus address 255

The external Modbus TCP master connected to SD-MCU Modbus TCP slave can:
- Read/write internal parameters in the SD-MCU start from 200 up to 9200
- Write 16 process data and watchdog
- Read 16/32 process data
- Read PLC custom parameter from 30000 to 34999
- Write PLC custom variables (no persistent value) from 35000 to 39999

Write 16 process data and watchdog

It is possible to write (from Master side) 16 input words (type Word) using index from 10 to 25.

---

[48] In case of multiple connections (SDM, Remote I/O) it is necessary to use an ethernet switch. In this case packets speed can be reduced.

Word IN	Modbus TCP address
00	10
01	11
02	12
03	13
04	14
05	15
06	16
07	17
08	18
09	19
10	20
11	21
12	22
13	23
14	24
15	25

It is possible to assign these words to particular variables by using Modbus TCP word IN Cfg parameters from *[5011]* up to *[5026]*. The behavior described before is shown in Fig. 3-90.
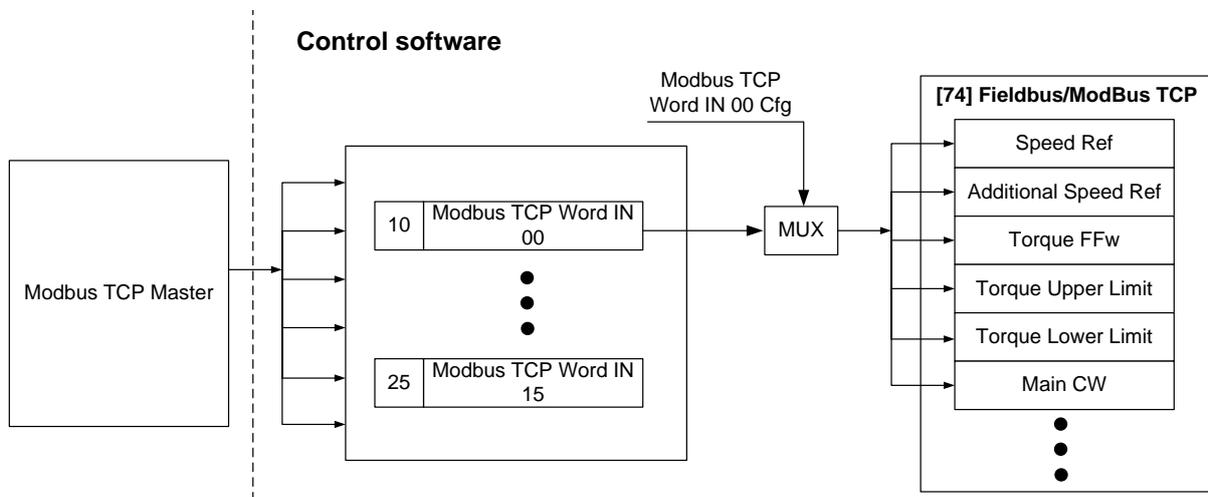
Fig. 3-90: Modbus TCP slave input words configuration

It is possible to monitor sent/received data values by mean of parameters from *[8001]* to *[8019]*. The configuration rules are the following (for the first parameters group):
- Chose the *Fieldbus selection [8001]*=Modbus TCP Slave
- Choose the *Fieldbus In/Out register [8002]*[49]*.* For the MobusTCP Word OUT purpose the allowed IPA range is from [60] to [74].
- Select the *Word number [8003]*[50]
- Watch the value to *Register Value [8004]*

Example

Suppose to write to the Modbus *TCP Word IN 00* the MCW and in the *Modbus TCP Word IN 01* the Speed reference. To achieve this configuration set the following parameters:
- Set Modbus *TCP Word IN 00* cfg *[5011]* = Main CW
- Set Modbus *TCP Word IN 01* cfg *[5012]* = Speed Ref

The Modbus TCP master will write the MCW on the index 10 whilst the Speed Ref on the index 11. It is possible to watch the value written by master in the variables *Modbus TCP Main CW [7428]* and Modbus *TCP Speed Reference [7421]*.

∎
It is possible to monitor the Modbus TCP Master activity by implementing a counter to the Master side and enabling the watchdog function to the slave side (*ModBus TCP watchdog [5001]*=Enable). The master must write a different value to the Modbus TCP slave index 42.
It is possible to set two different behaviors in case of watchdog missing:
- Alarm generation
- Action generation

Alarm generation is the standard alarm that can be configured in the Alarm setting as standard (Disabled, Warning, Ramp Stop, Coast Stop, Quick Stop). If SD-MCU Modbus TCP slave doesn't find a change in the watchdog variable within *Modbus TCP Alarm Timeout [5002]* an alarm is generated.
Action generation can be configured by mean of *Modbus TCP Action [5004]* and allows to create particular actions independently of alarm generation. If SD-MCU Modbus TCP slave doesn't find a change in the watchdog variable within *Modbus TCP Action Timeout [5003]* an action is generated.
The possible choices are:
- Minimum Speed

---
[49] Choose Input for Modbus TCP Input Words or Output for Modbus TCP output Words
[50] From 0 to 31 (depending to the configuration)

- Zero Speed
- Ramp Stop
- Ramp Stop (OFF1)
- Quick Stop (OFF3)

Minimum speed: reference speed will set to the *minimum working speed* parameter *[4732]* according with the actual ramp time. In this case the action can be reset if the watchdog starts to change.

Zero Speed: reference will set to zero according with the actual ramp time. In this case the action can be reset if the watchdog starts to change.

Ramp stop: reference will set to zero according with the *Ramp Stop Time [4744]*. In this case the action can be reset if the watchdog starts to change.

Ramp stop (OFF1): reference will set to zero according with the *Ramp Stop Selection [4743]* and OFF1 sequence will be performed.

Quick Stop (OFF3): reference will set to zero according and OFF3 sequence will be performed.

It is possible to monitor PDO/PDI sent/received values by mean of parameters from *[8001]* to *[8019]*. The configuration rules are the following (for the first parameters group):

- Chose the *Fieldbus selection [8001]*=Modbus TCP Slave
- Choose the *Fieldbus In/Out register [8002]*
- Select the *Word number [8003]*
- Watch the value to *Register Value [8004]*

Read 16/32 process data: It is possible to read up to 32 process data by using a Modbus TCP Master (address from 26 to 41).

Word OUT	Modbus TCP address
00	26
01	27
02	28
03	29
04	30
05	31
06	32
07	33
08	34
09	35
10	36
11	37
12	38
13	39
14	40
15	41

It is necessary to configure Modbus TCP Slave Word OUT (These words are outputs for SD-MCU) by using *[IPA]* rules. If the selected IPA has a *pu* type the value sent to master is IQ14 type whilst if the selected IPA has an engineering type the value sent to master is transformed to INT (e.g. Output Frequency = 43.5 Hz will be sent to master as the value 43).
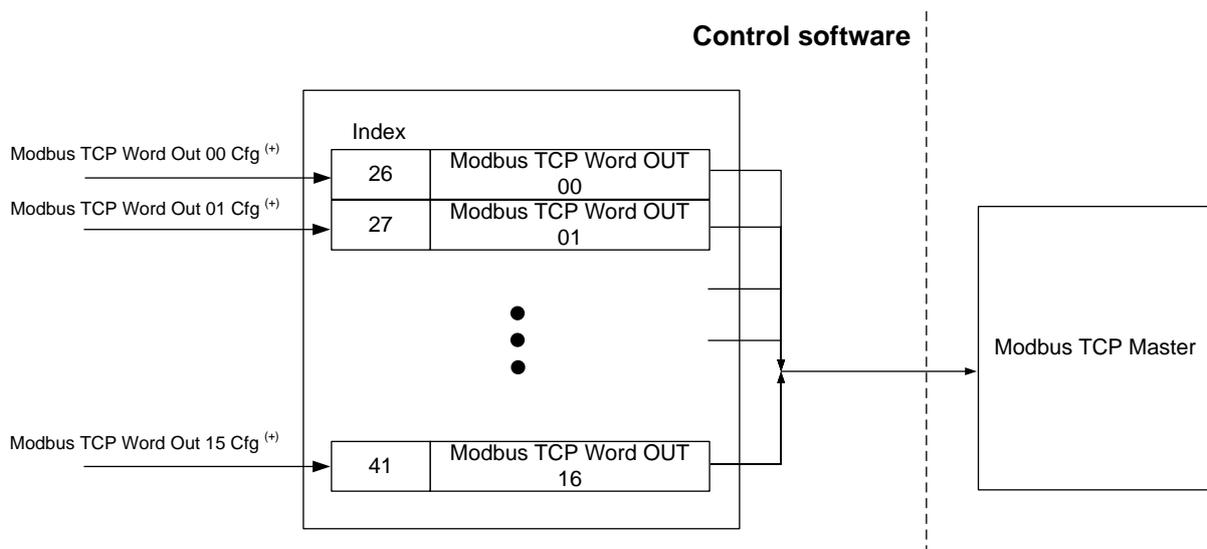
Fig. 3-91: Modbus TCP slave output words configuration

Example

Suppose to want to send to the master side the *Grid voltage (V) [6105]*, *Main Status Word [7006]* and *Torque Ref (pu) [6658]* in the Modbus TCP Word OUT 00, 01 and 02.

In this case it is necessary to configure the following parameters:
* Set Modbus TCP Word OUT cfg **[5043]** = 6105
* Set Modbus TCP Word OUT cfg **[5044]** = 7006
* Set Modbus TCP Word OUT cfg **[5045]** = 6658

In the following table is shown an example of signal conversion from master and slave:

Parameter	Slave Side	Master Side
Grid voltage (V)	401.7 V	401
Main Status Word	0x0157	0x0157
Torque ref (*pu*)	0.5	8192

▪

3.3.16.3 Profibus Slave
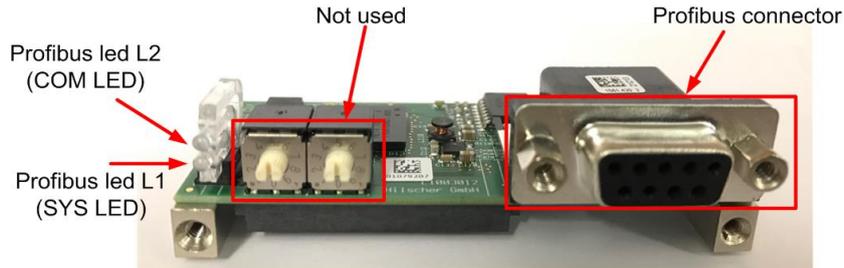
Fig. 3-92: Profibus connector and leds

The Profibus slave is used in the industrial application and allows a parallel connection between master and slaves[51]. The interface rules are the same used in the CANOpen and Modbus TCP slave.
The Profibus profile is used to exchange data between a process master controller (i.e. PLC) and drives. The SecomDrive allows only DP V0 cyclic data transfer and the PPO configuration achieve exchanging of process data and/or drive parameters.
The leds those are visible in the SD-MCU case are the following meaning[52]:

Led name	Led color and behavior	Meaning
LED L1	Green Steady	Operating system running
	Green/yellow blinking	Second stage bootloader is waiting for firmware
	Yellow steady	Second stage bootloader missing. Contact Hilscher support
	Switched off	Power supply is missing or hardware defect
LED L2	Green steady	RUN, cyclic communication
	Red steady	Wrong configuration at profibus DP slave
	Red flashing cyclic	STO, No communication, communication error
	Red flashing acyclic (more time switched on than off)	Not configured

Tab. 3-41: COMX10 led codification
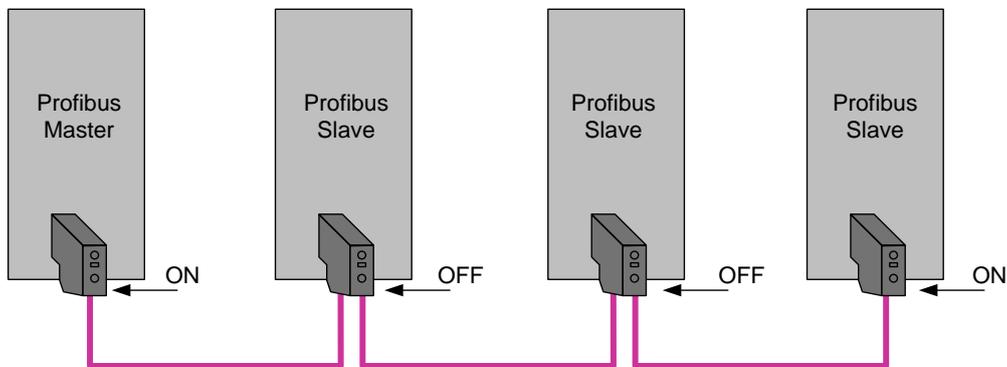
Fig. 3-93: Profibus connector termination example

---

[51] The Profibus cable termination must be selected in order to follow the rule showed in the Fig. 3-93 (only the last Profibus slave must have the termination resistance inserted).
[52]These information have been taken from http://www.hilscher.com/fileadmin/cms_upload/en-US/Resources/pdf/comX_-_Communication_Modules_UM_05_EN.pdf

PPO types 3, 4, 6, 7, 8 and custom 2 are pure process data objects for applications requiring no cyclic parameter access. The PLC sends out process control data, and the adjustable frequency drive then responds with a PPO of the same length, containing process status data.

PPO types 1, 2, 5 and custom 1 consist of a parameter channel and process data. The parameter channel can be used for reading and/or updating of parameters (successively).

To enable Profibus DP slave functionalities it is necessary to add to the SD-MCU the hilscher Profibus module (*COMX-10CA-DPS*) as described in the HW manual.

The choice of PPO type is made in the master configuration, and is then automatically recorded in the adjustable frequency drive.

The Profibus state is showed in *[5199]* *Profibus state* parameter:

In this case, the Profibus slave configuration setting is the follow:

- set the baud rate *[5102]* from 9.6kbps to 12 Mbps
- set the node address *[5103]*
- set the optional features like SYNC[53] support *[5104]* and Freeze[54] support *[5105]*
- set the Profibus cycle time *[5109]* that configure the refresh rate of the exchanged variables
- set the swap bit order *[5110]* if necessary (i.e. 0xABCD is converted into 0xCDAB)
- select the PPO type *[5111]*
- configure the Profibus word IN and OUT according to the PPO type selected before. For Profibus DP Word OUT purpose the allowed IPA range is from *[60]* to *[74]*.
- enable Profibus DP slave *[5101]*

The configuration of PPO is described in the table below. The parameter access via the PCV channel is performed by PROFIBUS DP V0 cyclical data exchange, where the PCV channel is part of the PPO.

	PCV	PD						
Byte number	4	4	4	4	4	4	8	4
PD Words index		0..1	2..3	4-5	6-7	8-9	10..29	30..31
Type 1	■	■						
Type 2	■	■	■					
Type 3		■						
Type 4		■	■					
Type 5	■	■	■	■	■			
Type 6		■	■					
Type 7		■	■	■	■			
Type 8		■	■	■	■			
Custom 1		■	■	■	■	■	■	■
Custom 2	■	■	■	■	■	■	■	

PCV   Parameter characteristic value
PD   Process Data

Tab. 3-42: Supported PPO Type by SECOM Drive

The PCA part of PPO types 1, 2, 5 and Custom 2 can handle several tasks. The master can control and supervise parameters and request a response from the slave, whereas the slave can respond to a request from the master.

Requests and responses is a handshake procedure and cannot be batched, meaning that if the master sends out a read/write request, it has to wait for the response, before it sends a new request. The request or response data value will be limited to maximum 4 bytes, which implies that text strings are not transferable.

The PCV is composed by three parts:
- **PCA**: Parameter characteristic (byte 1 and 2)
- **IND**: Parameter index (byte 3 and 4) – parameter to write/read as IPAnumber * 2
- **PVA**: Parameter value (byte from 4 up to 8) – parameter read value or parameter value to write

The PCA is composed as in the table below:

15..12	11..0
RC	Not used

RC is the request/response characteristic and defines the requests that may be issued from master to the slaves as well as other portions of the PCV.

The RC content is showed in the table below:

Request	Function
0	No request
1	Request parameter value
2	Change parameter value (word)
3	Change parameter value (long word)
4-15	Not used

If the slave rejects a request from the master, the RC word in the PPO-read will indicate this by assuming the value 7. The fault number will be carried by bytes 7 and 8 in the PVA element.

---

[53] The control command SYNC is a broadcast function. It can be used to obtain simultaneous reactions in several slaves. A SYNC command will freeze the process control data and they are stored but not used until a new SYNC command is received.

[54] The FREEZE command is a broadcast function. It can be used to read simultaneous reading of process data. FREEZE command will freeze the actual values and upon request the slave will send back the value that was present when the FREEZE command was received.

Response	Function
0	No response
1	Transfer parameter value (word)
2	Transfer parameter value (long word)
4…6	Not used
7	Request rejected (incl. fault #, see below)
8	Not serviceable by PCV interface
9-15	Not used

If the request is rejected it is possible to see the fault code in the PVA. The faul code is showed in the table below.

Fault no.	Interpretation
0	Illegal parameter number
1	Parameter value cannot be changed
2	Upper or lower limit exceeded
3	Subindex corrupted (not used)
4	No array
5	Data type false
6	Cannot be set by user (reset only)
7	Description element cannot be changed (not used)
8	IR required PPO-write not available
9	Description data not available (not used)
10	Access group (not used)
11	No parameter write access (not used)
12	Key word missing
13	Text in cyclical transmission not readable (not used)
14	Name in cyclical transmission not readable (not used)
15	Text array not available (not used)
16	PPO-write missing
17	Request temporarily rejected
18	Other fault
19	Data in cyclical transmission not readable
130	There is no network access to the parameter called
131	Data change is not possible because factory set-up has been selected

Example

This example shows how to use PPO type 2 to change *[4714] Ramp acceleration time* to 20 s. When the parameter has to be changed, choose value 2 and 3 as RC (depending the parameter type).
In this example value 3 is chosen, because *[4714]* is a long word type (32 bit float). The value to write in the PCV field are:
- PCA = 0x3000
- IND = 0x24D4
- PVA = 0x41A00000 (hexadecimal 32 bit long representation of 20 float type)

It is necessary to read the value of the PCA coming from the SecomDrive in order to check the response code.
■

Example

This example shows how to use PPO type 2 to read *[0502] Rated voltage*. When the parameter has to be read, choose value 1 as RC.
In this example the parameter value is 690.
The value to write in the PCV field are:
- PCA = 0x1000
- IND = 0x03EC
- PVA = 0x442C8000 (hexadecimal 32 bit long representation of 690 float type)

The PVA is correct only if the PCA read value (coming from SecomDrive) is 0x2000 (transfer parameter value long word). Otherwise the PVA value contains the error code.
■

Example

This example shows how to use PPO type 1 to write *MCW* and *Speed Reference* and read *[7006] MSW* and *[6403] Speed Fdb* in the Profibus input words.
The value to write in the PCV field are:
- Set *[5101] Profibus DP slave* = Disabled
- Set *[5102] Baud rate*, *[5103] Bus Address*, *[5104] Sync Supported* according to master configuration
- Set *[5109] Cycle Time* according to the application
- Set *[5111] PPO type* = 1
- Set *[5121] IPZ1* = Main CW [8]
- Set *[5122] IPZ2* = Speed Ref [1]
- Set *[5153] OPZ1* = 7006
- Set *[5154] OPZ2* = 6403

- Set *[5101]* = Enable

■

3.3.16.3.1 Profibus slave configuration example with TIA portal software

This paragraph is used to explain how to configure Siemens PLC with TIA portal software to communicate with SECOM Drive Profibus slave.

- Click to add new device and select the correct CPU (in this case 6ES7 315-2EH14-0AB0)
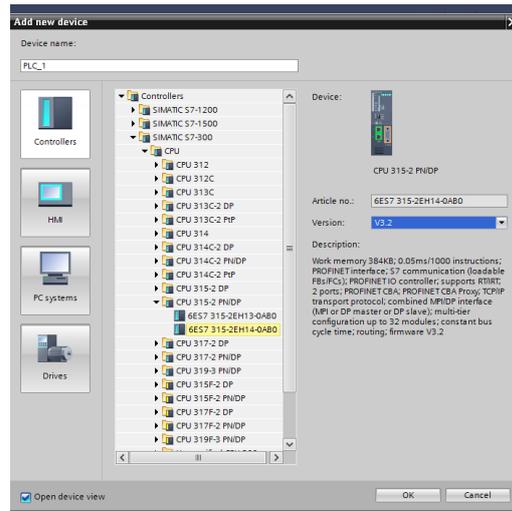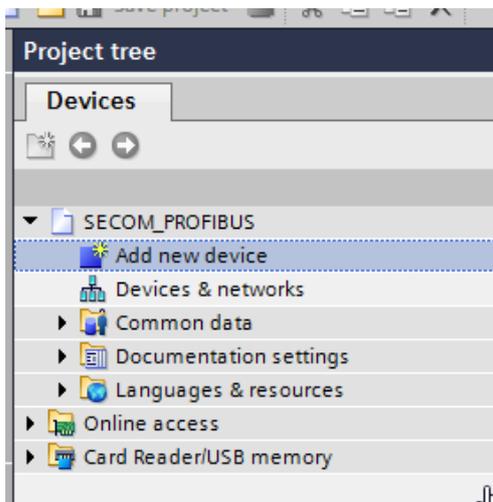
- Double click on PLC_1 and set the ethernet address and click on add new subnet
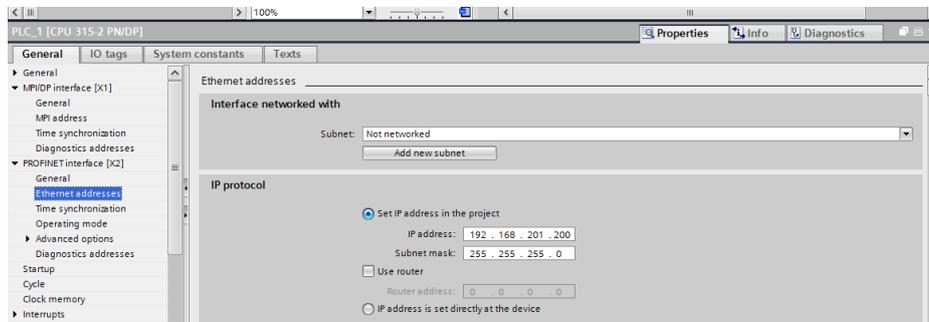
- Click on MPI/DP interface and scroll down up to parameters. Then select PROFIBUS as interface type. Subsequently click on Profibus addresses and click on add new subnet.
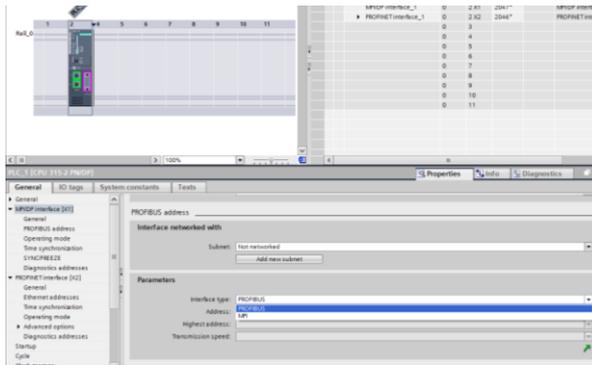
- Then click on Cycle and expand the size of process image to 300 (both input and output). This is useful to access to the memory space that will be utilized by Profibus slave
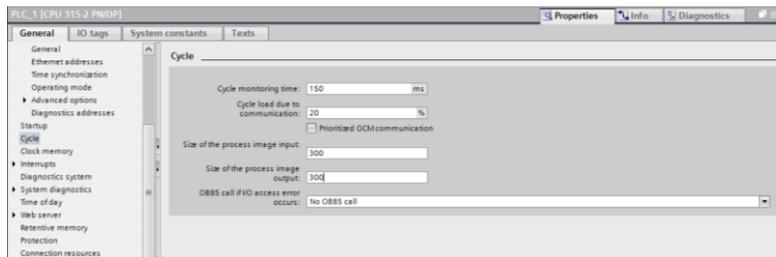
- Install SD_MOD gsd file by clicking on options->manage general station description files
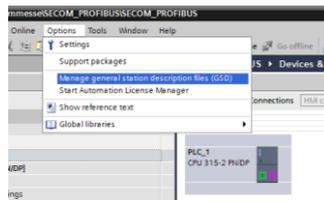
- Click on install button to complete the installation procedure
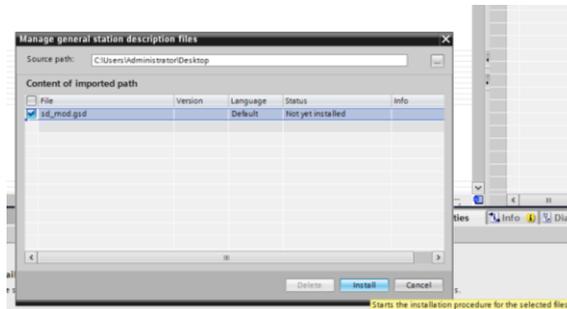
- Click on devices & network on the project tree and on the hardware catalog search for Secom products. Then double click on SD_MOD to add the slave in the project
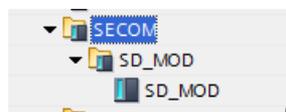
- Connect the two violet squares between master and slave to create a Profibus network
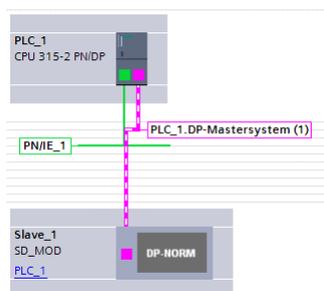
- Click on profibus network (in this case PLC_1.DP-Mastersystem) to modify network parameter (i.e. transmission speed)
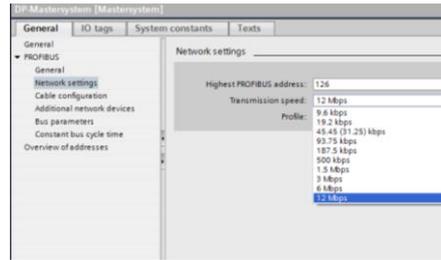
- Double click on the slave and set the parameters (i.e. slave address) and the PPO type (double click on the hardware catalog). Check if the I address and Q address range is below 300 otherwise it is necessary to increase this parameter

Module	Rack	Slot	I address	Q address	Type
Slave_1	0	0	2043*		SD_MOD
PPO Type 5_2_1	0	1	256...263	256...263	PPO Type 5
PPO Type 5_2_2	0	2	264...283	264...283	PPO Type 5
	0	3			
	0	4			

- Then compile all the hardware configuration and download it on the target
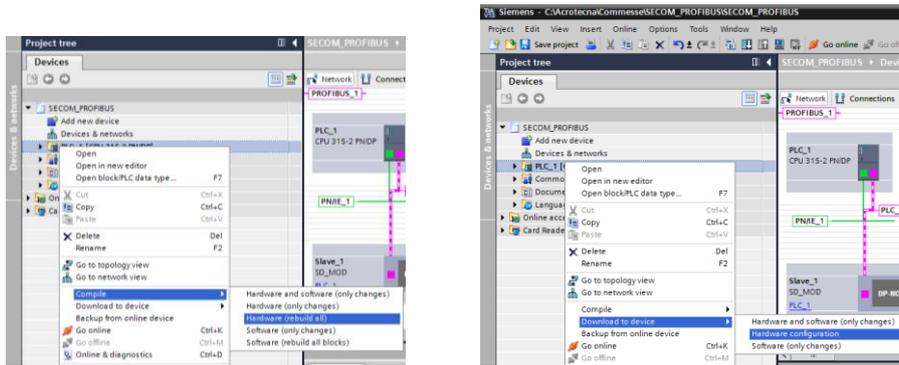
- Extended download device windows will appear and after start search click on load button. In this case the hardware configuration is completed
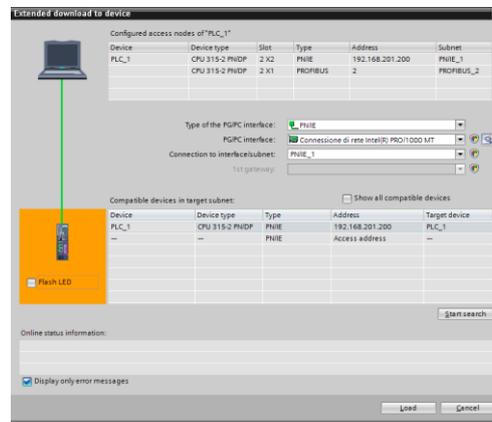
- Now it is necessary to insert all the software interrupt that can block the CPU in order to avoid uncontrolled stop. Then click on program block in the project tree and add all the blocks shown in the picture below
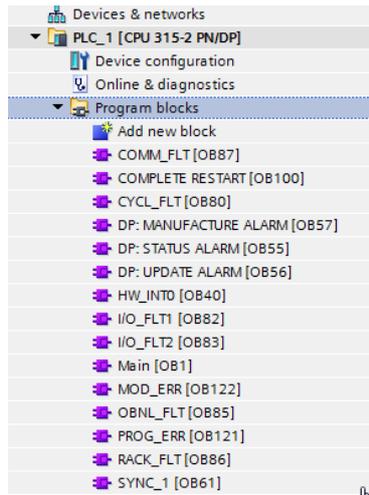
- In the force table add the register that you want to monitor/write, compile and download the software

3.3.17 SW/CW Addressing

Every CW can be customized (entire word or part of it) by using IPA.bit addressing and ExtWord addressing.
The fieldbus types are defined as:
- PLC
- Profibus (slave)
- ModbusTCP (slave)
- CanOpen (slave)

For the MCW (Main Command Word) will be needed advanced considerations.
There are 3 main steps to configure the CW:
1. Fieldbus input word customization (not for PLC).
2. ExtCW source selection
3. CW bit source selection

Fieldbus input word customization

Every input word of every fieldbus channel can be connected or to analog word (Speed Reference, Additional Speed Reference, Torque Upper Limit, etc) or to CW (MCW, Reference CW, DiPO CW, User Defined CW, etc).
This configuration can be done by using Fieldbus Group [50], [51], [52].
Depending on the selection, the value of the input word will replace the selected variable value (e.g. Fieldbus CW) of that fieldbus.
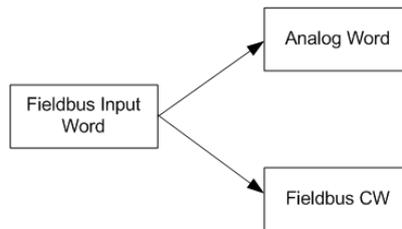
Example

This example shows how to write the Reference CW through the Modbus Input Word 00. It is necessary to customize the input word 00 of the Modbus by selecting "Reference CW" in the parameter *Modbus TCP word IN 00 [5021]* located in the Modbus TCP section [50]. This means that the value written in the input word 00 of the ModbusTCP slave is copied to the *ModbusTCP Reference CW [7430]*. There is a further step to connect the ModbusTCP Reference CW to the Ext Reference CW by choosing the *Reference CW source [4503]* = ModbusTCP.
■
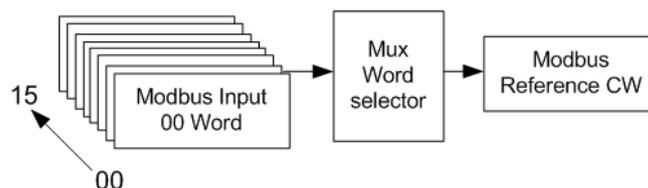
Fig. 3-94: Fieldbus input word customization – example

Example

You suppose to write the DiPo CW through the Profibus input Word 02 (IPZ2). It is necessary to customize the IPZ2 of the Profibus by selecting "DiPo CW" in the Profibus section [51], parameter *[5122]*. This means that the value written in the input word 02 of the Profibus

slave is copied to the Profibus *DiPo CW [7451]*. There is a further step to connect the Profibus DiPo CW to the Ext DiPo CW by choosing *DiPo CW source [4504]*=Profibus.

For each fieldbus topology only one input word can be customized with the same Analog Word or Fieldbus Word.

■

ExtCW Source selection

The external command word (ExtCW) is used only to speed up the CW composition. In fact the default value of CW bit addressing (using IPA.bit) is linked to the respective ExtCW bit. In this case to connect directly the fieldbus word to the CW it is necessary set the IPA.bit default value.

The principle scheme is shown in the figure below where once created the Fieldbus CWs (in this case Reference CW) it is possible to link the value of one of the four fieldbus sources (of the same sub-system) to the ExtCW (in this case Ext Reference CW).
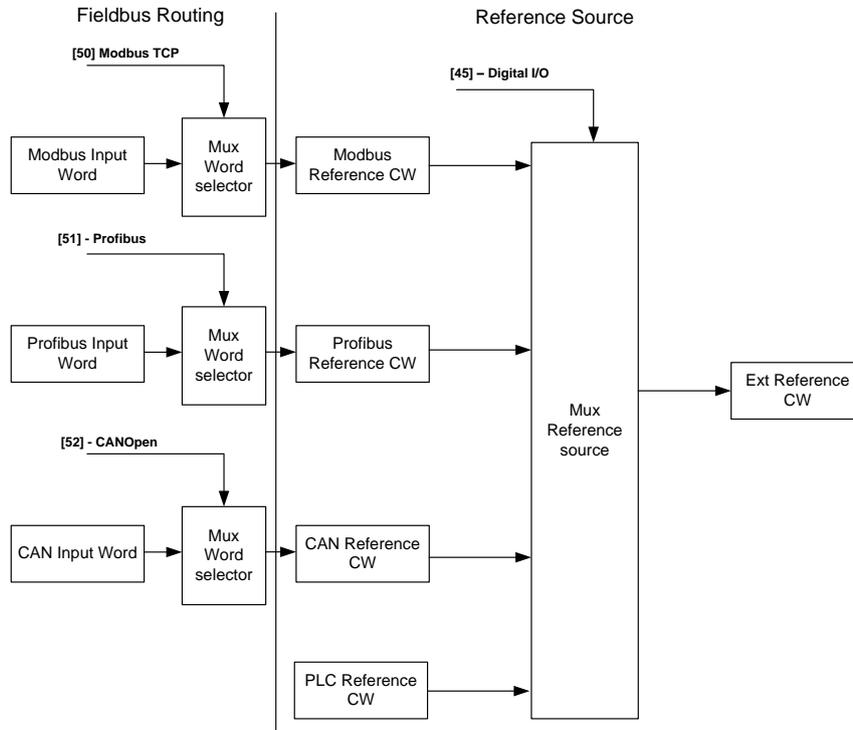
Fig. 3-95: Ext Command Word composition

Example

This example shows how to write to the Ext DiPo CW through the input word 05 of the CANOpen. At first, it is necessary to customize the word 05 by selecting "DiPO CW" in the parameter *[5226]*.

After that it is necessary to choose the fieldbus source of the Ext DiPo CW by selecting "CAN OPEN" in the parameter *[4504]* of the *Digital I/O section [45]*.

Then, if the CAN master writes a value in the word 05, it is possible to see it replaced in:

- Word 05 (CAN Fieldbus)
- CAN DiPo CW (fieldbus source) *[7471]*
- Ext DiPo CW *[7039]*

■

Example

This example shows how to write the Ext Reference CW through PLC. In this case it is impossible to customize the word because the customization is done in the PLC program. The PLC software developer must connect the internal bits that wants to use (in this case is Reference CW) directly to data block[55] (in this case the data block name is SetRefCW). Then it is necessary to choose the fieldbus source of the Ext Reference CW by selecting "PLC" in the parameter *[4503]* of the *Digital I/O section [45]*.

■

---

[55] The data block structure will be explained in the PLC description section
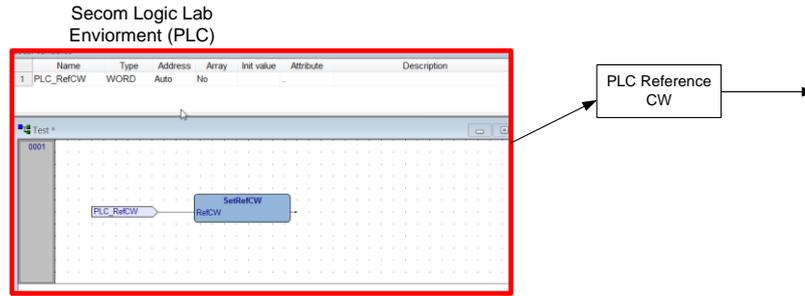
Fig. 3-96: PLC Reference CW example

CW bits source selection

The CW is the real input of the sub-system (Reference, DiPo, etc.). The bit addressing is done by IPA.bit (only for CW and not for references). The default configuration defines that CW value is written from the ExtCW value. It is also possible to address all the variables inside the control software by using IPA.bit.

Example 1

It is supposed to write the entire DiPO CW through IPZ 08 (Profibus slave) but the Clear DiPo2 signal (bit10 of the DiPo CW) must be connected to the Digital Input number 2 (*[7030.01]*). It is necessary to follow the 3 steps mentioned below:
Fieldbus Input word customization: select "DiPo CW" in the parameter *[5128]*. Then, the values written from the Profibus master to profibus input word 08 will be copied to the *Profibus Dipo CW [7451]*.
ExtCW Source Selection: After that it is necessary to choose the fieldbus source of the Ext DiPo CW by selecting "Profibus" in the parameter *[4504]* of the *Digital I/O section [45]*. After that the value written in the Profibus IPZ 08 will be copied to the *ExtDiPo CW [7039]*.
CW bits source selection: in this case the DiPo CW has only six customizable bits (the other ones are not used) as shown in Tab. 3-19.
In the section *[25] DiPo* is possible to define the bit addressing. Set all the parameters that define the IPA.bit to the default value except DiPo 2 Clear that must be set to the digital input 2 by using its IPA.bit value:

- *[2510] DiPo 1 Step-Up* = 7039.00 (default value ExtDiPoCW.00)
- **[2511]** DiPo 1 Step-Down = 7039.01 (default value ExtDiPoCW.01)
- **[2512]** DiPo 1 Clear = 7039.02 (default value ExtDiPoCW.02)
- *[2530] DiPo 2 Step*-Up = 7039.08 (default value ExtDiPoCW.08)
- **[2531]** DiPo 2 Step-Down = 7039.09 (default value ExtDiPoCW.09)
- **[2532]** DiPo 2 Clear = 7030.01 (Digital Input SW)

■
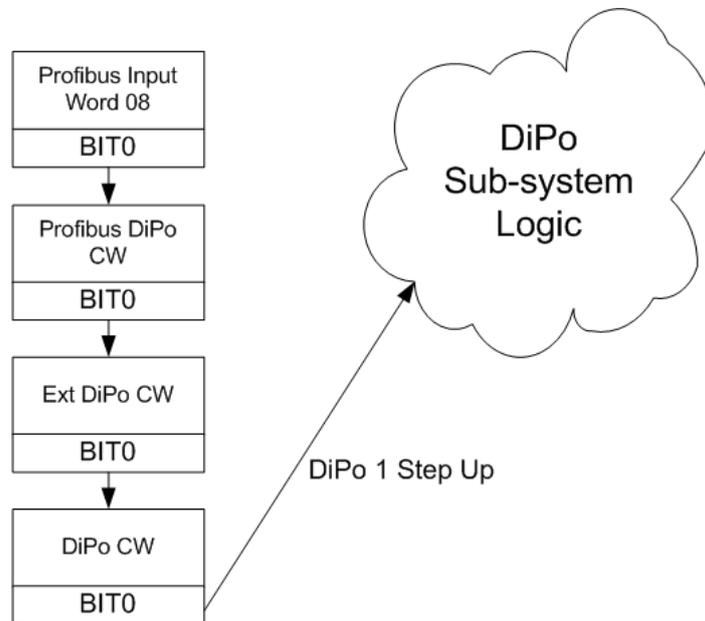
Fig. 3-97: CW bits source selection for DiPo CW example

Example 2 (advanced IPA addressing)

It is supposed to write the DiPo 1 through Profibus input word 09 and DiPo 2 through Digital Input 3, 4 and 5.
Fieldbus Input word customization: select "Dipo CW" in the parameter *[5129]*. Then the values written in the Profibus input word 09 will be copied in the Profibus Dipo CW *[7451]*.
ExtCW Source Selection: After that it is necessary to choose the fieldbus source of the ExtDiPo CW by selecting "Profibus" in the parameter *[4504]* in the *DIGITAL I/O [45]* family Then, the values written from the Profibus master to Profibus input word 09 will be copied to the *Profibus Dipo CW [7451]*.
CW bits source selection: in this case the DiPo CW has the following configuration:

- **[2510]** DiPo 1 Step-Up = 7039.00 (default value ExtDiPoCW.00)
- **[2511]** DiPo 1 Step-Down = 7039.01 (default value ExtDiPoCW.01)

- **[2512]** DiPo 1 Clear = 7039.02 (default value ExtDiPoCW.02)
- **[2530]** DiPo 2 Step-Up = <u>7030.00 (Digital Input SW)</u>
- **[2531]** DiPo 2 Step-Down = <u>7030.01 (Digital Input SW)</u>
- **[2532]** DiPo 2 Clear = 7030.02 (Digital Input SW)

■
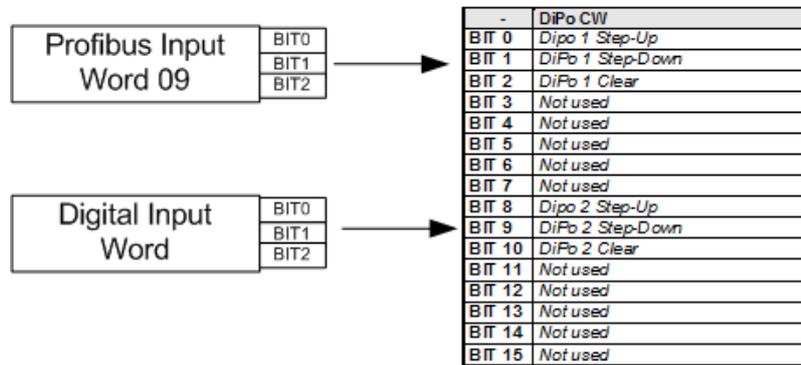
Fig. 3-98: CW bit source selection – advanced IPA addressing

The MCW has an additional layer between the internal MCW and the external command word in order to increase the degree of customization.
This layer regards additional input from:

- External fault
- External fault with delay
- Auxiliary reset
- Auxiliary OFF1
- Auxiliary OFF2
- Auxiliary OFF3
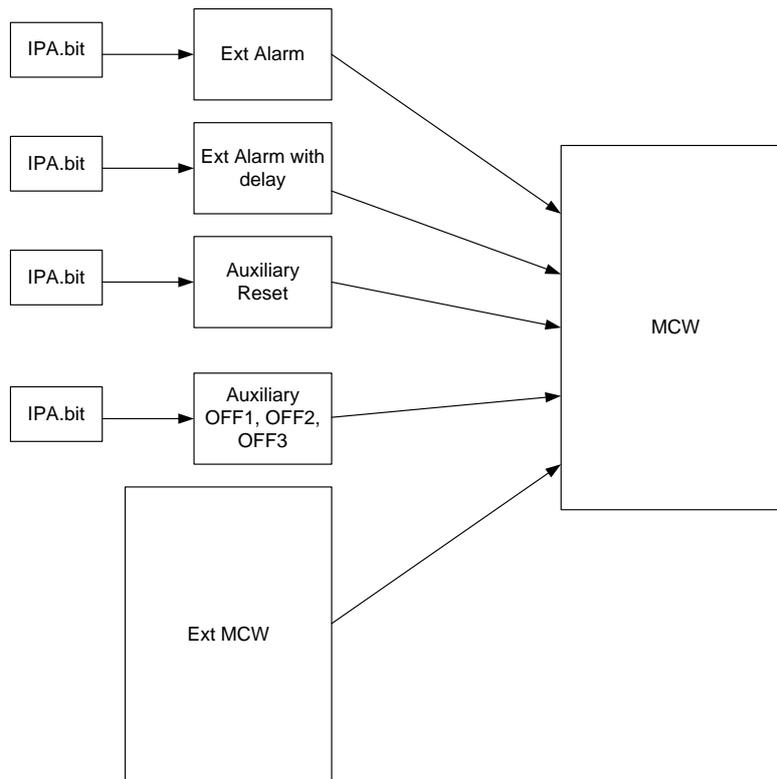
Fig. 3-99: MCW with external input customization

The External Fault can be used to generate an addition alarm signal (warning, OFF1/2/3) by mean of IPA.bit addressing (*[4516]*). If the input signal is different from 1 (high level) an alarm is generated. The alarm type can be configured by using *External Alarm [5507]*. To reverse the value of the input signal can be used the standard IPA.bit negation (-IPA.bit).
The externa fault with delay can be used to generate an additional alarm signal with the following conditions:

- Time delay (Alarm Delay mode [4518] = 0). If the signal has a falling edge an alarm is generated after the time lapse *External alarm delay [4519]* even if it is again to high value. It is necessary a reset command to switch off the alarm.
- Duration (*Alarm Delay mode [4518]* = 1). If the integral value of the input signal lasts for E*xternal alarm delay [4519]* an alarm is generated. It is necessary a reset command to switch off the alarm.
- Instant reset (*Alarm Delay mode [4518]* = 2). If the value of the input signal lasts for E*xternal alarm delay [4519]* an alarm is generated. It is not necessary a reset command to switch off the alarm.

It can be configured (warning, OFF1, OFF2, OFF3) by the parameter *External alarm delayed* ***[5508]***.

The auxiliary reset can be used as an additional reset (acknowledge fault) by the parameter *Auxiliary reset command* ***[4520]***. The reset command coming from the ExtMCW and the auxiliary reset command are logic OR used.

The auxiliary OFF1 can be used as additional OFF1 command by the parameter *Auxiliary OFF1 (Ramp stop)* ***[4521]***. The OFF1 command coming from the ExtMCW and the auxiliary OFF1 command are logic AND used.

The auxiliary OFF2 can be used as additional OFF1 command by the parameter *Auxiliary OFF1 (Coast stop)* ***[4522]***. The OFF2 command coming from the ExtMCW and the auxiliary OFF2 command are logic AND used.

The auxiliary OFF3 can be used as additional OFF3 command by the parameter *Auxiliary OFF2 (Quick stop)* ***[4523]***. The OFF3 command coming from the ExtMCW and the auxiliary OFF3 command are logic AND used.

3.3.18 Commissioning

In this paragraph will be explained the motor parameter identification procedure. The parameters used for this purpose are located in the [08] COMMISSIONING.

This procedure could be used when a new motor is connected and it is necessary a new machine commissioning. The procedure to commission a new motor is the following (Fig. 3-100).
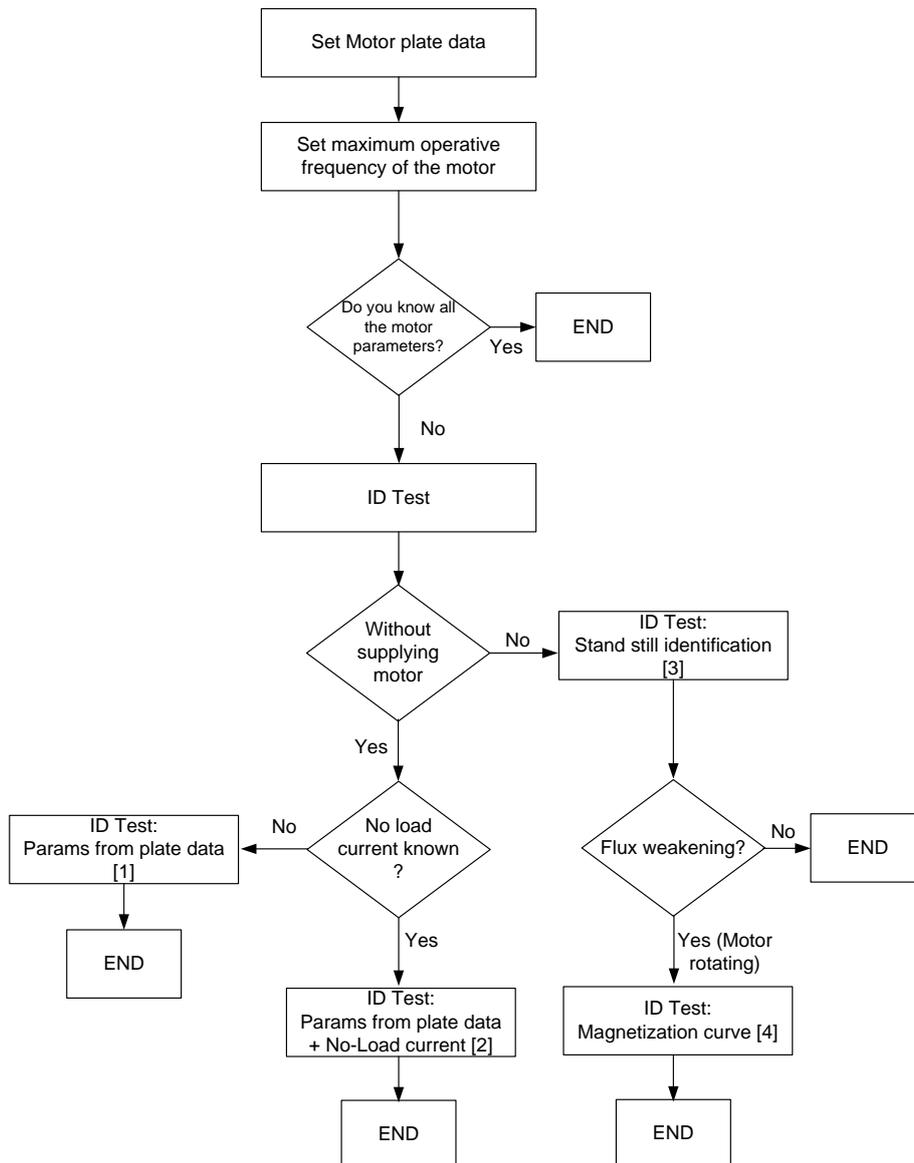
Fig. 3-100: Flow chart for ID test routine

The procedure showed in Fig. 3-100 is used only to found the motor parameters. The regulator tuning must be done only after parameter estimation. The parameters from plate data are:

- *Rated Power* ***[0501]***
- *Rated Voltage* ***[0502]***
- *Rated Current* ***[0503]***
- *Rated Frequency* ***[0505]***
- *Max Operative Frequency* ***[0506]***
- *Rated Speed* ***[0507]***

- *Power factor [0508]*
- *No Load Current [0509]*: usually this parameter is not present on the plate. To find out it, technician can:
  - Run the motor in VHz (scalar control) without mechanical load: the value of the motor current is about the No Load current[56]
  - Run the ID-Test at standstill
  - As last chance, technician can estimate the no load current by himself (depending on speed and power, but usually it is 25%÷35% of rated current)

When all this parameters are inserted it is possible to estimate all the motor parameter by using ID test. There are two modes:
- Parameter estimation from plate data
- Parameter estimation from standstill

The parameter estimation from plate data allows to estimate motor parameters without supplying the motor. If the *no-load current [0509]* is defined it is necessary to set the *ID test type [0801] = Params from Plate Data[1]*.

If otherwise no load current is not known it is necessary to set the *ID test type [0802] = Params from Plate Data + No load current [2]*.

After parameters calculation the *ID test type [0802]* return to value *NONE [0]*.

If it is possible to supply the motor it is necessary use the *ID test type [0802] = stand still identification*.

> **WARNING!** With standstill identification the motor will be supplied. Take attention to the people close to the motor because unexpected motor movement can be generated.

This type of identification allows to increase parameters estimation precision. To enable the stand still identification it is necessary to follow these steps:
- Set plate data parameters
- If there are no-standard requirement it is necessary to set all the parameters in the *[08] COMMISSIONING* family to default value
- Set correctly all the parameters necessary to run the motor
- Take the local control (check for local) from SDM
- Switch-on the drive pressing ON/OFF button in the control panel (SDM) and wait until the drive status is equals to Ready to Operate.
- Set *ID test type [0802] = stand still identification [3]*
- Press Run command and wait the identification end. It is possible the step of procedure with:
  - *ID test state [0820]*
  - *ID test result [0821]*
- If the ID test is completed correctly the drive status return to Ready to Operate and the *ID test type [0802]* return to value *NONE [0]*.
- If the ID test is not completed correctly a fault will be risen. It is possible to see the ID test fault information with *ID test result [0821]*.

If the motor has a high weakening range *([0506]* / *[0505]* > 1.5) it could be necessary to perform the ID test magnetization curve [4]. This identification must be done after one of the three identification described above.

> **WARNING!** With magnetization curve the motor will be supplied and motor rotation is started.

To enable the magnetization curve identification it is necessary to follow these steps:
- Set plate data parameters
- If there are no-standard requirement it is necessary to set all the parameters in the *[08] COMMISSIONING* family to default value
- Set correctly all the parameters necessary to run the motor
- Take the local control (check for local) from SDM
- Switch-on the drive pressing ON/OFF button in the control panel (SDM) and wait until the drive status is equals to Ready to Operate.
- Set *ID test type [0802] = magnetization curve [4]*
- Press Run command and wait the identification end. It is possible the step of procedure with:
  - *ID test state [0820]*
  - *ID test result [0821]*
- If the ID test is completed correctly the drive status return to Ready to Operate and the *ID test type [0802]* return to value *NONE [0]*.
- If the ID test is not completed correctly a fault will be risen. It is possible to see the ID test fault information with *ID test result [0821]*.

3.4   ALARMS SETTINGS

Alarm setting is a group that allow to configure the drive alarms located in the [72] and [73] family. The SecomDrive alarms system generates the alarm event. This event, depending on the drive configuration and the alarm setting parameters, can be configured as:
- *Warning*: there is no action, the warning information appears in the active alarm bar (SDM), CTRL/PLC Warn Word, alarm history log, *Main SW.Warning [7006.07]*. If the cause of the alarm disappears the warning disappears as well (the warning remains only in the alarm history log).
- *Fault*: the fault information appears in the active alarm bar (SDM), CTRL/PLC Fault Word, alarm history log, *Main SW.Fault Active [7006.03]*. If the cause of the alarm disappears the fault doesn't disappear until a acknowledge fault rising edge is given.

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[56] Actually, during this test the no-load current must be set very low, or better, the magnetization control must be disabled before reading the value of the current. Moreover, it had better run the motor at least at half the rated speed.

If the cause of the alarm is not present and a acknowledge fault rising edge is given, the fault disappears (the fault remain logged only in the history log).

When the fault occurs there are three possible action: Coast Stop, Ramp Stop and Quick Stop. For line application the three action are the same (no speed is detected) while for motor application after reaching zero speed a fault is generated and the FSM remain in the FAULT state.

- *Disabled*: the alarm doesn't produce any warning or fault/action. The alarm is not logged in the alarm history log.
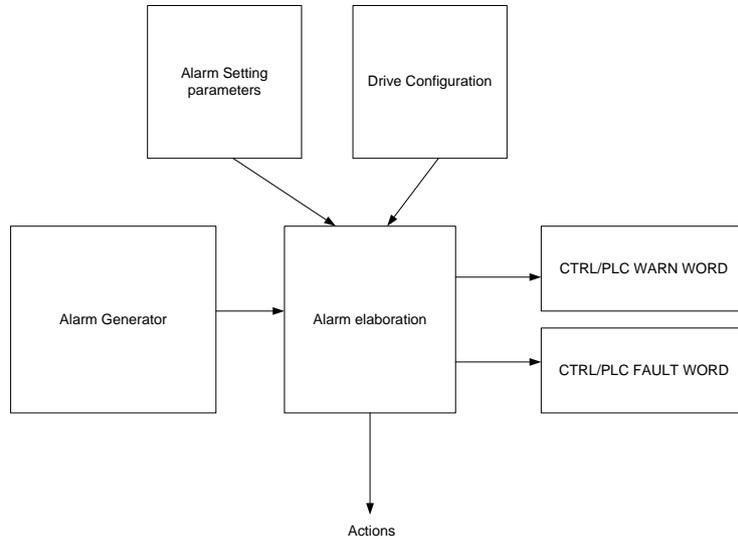
When the alarm generates a warning or a fault, a bit of CTRL/PLC WARN WORD or CTRL/PLC FAULT WORD is activated.

There are 7 Control Alarm Words (alarms coming from the control routine) and 50 PLC alarm word (alarms that can be generated from PLC application). Every bit defines a specific alarm. The value of this alarm word is hidden but it is visible their warning and fault word elaboration (in this case there are 54 Warning words and 54 Fault words).

The CTRL/PLC WARN WORD are located in the family [72] whilst the CTRL/PLC FAULT WORD are located in the family [73].

When a bit of these words are set high an alarm or fault with an ID number appears to alarm windows on SDM. The ID number is related to the word and bit number of the active alarm.

CTRL ALARM WORD	
Name	Bit 0 → Bit 15
Word 1	5008 → 5023
Word 2	5024 → 5039
Word 3	5040 → 5055
Word 4	5056 →5071
Word 5	5072 →5087
Word 6	5088→5103
Word 7	5104→5119

PLC ALARM WORD	
Name	Bit 0 -> Bit 15
Word 1	5120 →5135
Word 2	5136 →5151
…	(319+Word N)*16 → (319+Word N+1)*16-1
Word 50	5904→ 5919

Example

Suppose to configure main contactor error as warning (CTRL warning word 1 bit 03). It is necessary to set in the family *[55] ALARM CONFIG*, *Main contactor Error [5504]* = Warning [1]. If this alarm is generated a warning will be present in the main status word and bit 03 of the CTRL WARN WORD 1 will be high. At the same time in the alarm window (SDM) will be showed a warning with the ID 5011. If the main contactor error is configured as fault (CTRL FAULT word 1 bit 03) with Coast Stop action, it means that parameters *Main contactor Error [5504]* = OFF2 Coast Stop [3]. If this alarm is generated a fault will be present in the main status word and bit 03 of the CTRL FAULT WORD 1 will be high. At the same time in the alarm window (SDM) will be showed a fault with the ID 5011.

■
The Alarm setting group is composed by these families:
- *[55] ALARM CONFIG*: it configure the alarms types
- *[56] INVERTER ALARM*: set some parameters related to the inverter power part (i.e. set the delay time for Pulse enable timeout alarm).
- *[58] MOTOR/GRID ALARM*: set some parameters related to the load MOTOR or GRID (i.e. motor overload management, motor overload set work cycle).
- *[59] TRANSFORMER ALARM*: set some parameters related to the transformer (i.e. transformer overload management, transformer overload set work cycle).

3.5   MONITORING VARIABLES

Monitoring variables are all the variables necessary to watch the entire behavior of the system as control variables, internal system variables, status and command word and others. The monitoring range parameters is from [60] up to [76].

The parameters range from [60] to [74] can be also connected to the fieldbus words (ModBus TCP Word OUT, CAN Word OUT and Profibus DP Word OUT) as shown in the Fieldbus chapter.

The complete list of the families in the Monitoring group is:

- *[60] PER-UNIT BASE*: it shows all the per-unit base of the entire system (current, voltage, frequency). All the pu quantities are reported to these parameters.
- *[61] ENGINEERING*: it shows the load quantities in engineering system (A, V, Hz). This family doesn't contain all the variables contained in the next families.
- *[62] VOLTAGE (pu)*: it shows all the voltage (i.e. Vinv magnitude, Vdc), frequency and flux variables of the system related to the feedback or estimated parts reported to their per-unit base. The reference values are showed in another family.
- *[63] CURRENT (pu)*: it shows all the current variables (i.e. Iinv Magnitude, Is Q) related to the feedback or estimate parts reported to their per-unit base. The reference values are showed in another family.
- *[64] MECHANICAL (pu)*: it shows all the mechanical variables (i.e. Encoder Speed) reported to their per-unit base.
- *[65] POWER (pu)*: it shows all the power calculation variables (i.e. Active power) reported to their per-unit base.
- *[66] REFERENCES (pu)*: it show all the reference variables of the control system (i.e. Is D reference, Torque reference) reported in their per-unit base.
- *[70] CW-SW*: it show all the Commands Word, ExtCW (as explained in 3.3.17), Status words, DPM or Drive configuration info.
- *[71] HW ALARM WORD*: it shows all the fault generated inside or the SD-MCU C3 (FPGA) or in the DPM (SD-RMU boards). It is not possible to mask these fault.
- *[72] CTRL/PLC FAULT WORD*: it shows all the fault generated in the control system and PLC. Some of them is possible to change to warning or disable according to the drive configuration.
- *[73] CTRL/PLC WARN WORD*: it shows all the warning generated in the control system and PLC. Some of them is possible to change to warning or disable according to the drive configuration.
- *[74] FIELDBUS*: it shows all the variable coming from all the fieldbus, internal PLC and reference variable (it is explained in 3.3.16) that can be connected to the references configuration (i.e. *primary speed ref [4701]*) or to the fieldbus WORD IN (i.e. *Profibus DP Word IN IPZ 01 [5121]*).
- *[75] MISCELLANEOUS*: it shows some drive additional information related to expert users like sampling time.
- *[76] INFO*: it shows all the information of the boards connected to the system like SECOM Drive version, expected power module size, DPM size and so on.

3.6   POWER PARTS INFORMATION

The SD-MCU allows to connect up to 8 DPM of the same typology as described in 3.1. This configuration is possible in order to reach full power with several paralleled power modules.

Each fiber optic couple of the SD-MCU must be connected to the DPM according with the drive size selected. Once the fiber optics are connected (check also if the TX and RX fiber are plugged correctly) it is possible to power-up the drive (SD-MCU and DPMs).

If the connection among the SD-MCU and DPMs doesn't work correctly there is a fault C*onfiguration timeout (ID 5090)*. This means there could be something wrong in the DPM configuration.

Regarding the communication, it is possible to check which DPM have the problem by using parameter *DPM configuration INFO [7682]* and *DPM data info [7683]*.

Each bit of these two words corresponds to the DPM (e.g. bit 0 corresponds to the DPM1, bit 1 corresponds to the DPM2).

DPM configuration info checks the DPM communication (e.g. if the fiber optic couple is unplugged, DPM switched power off) whilst the DPM data info checks the data integrity between MCU and DPM (e.g. if the fiber optic is not well connected).

The DPM also monitors the hardware status like the DCbus fuses and the heatsink temperature.
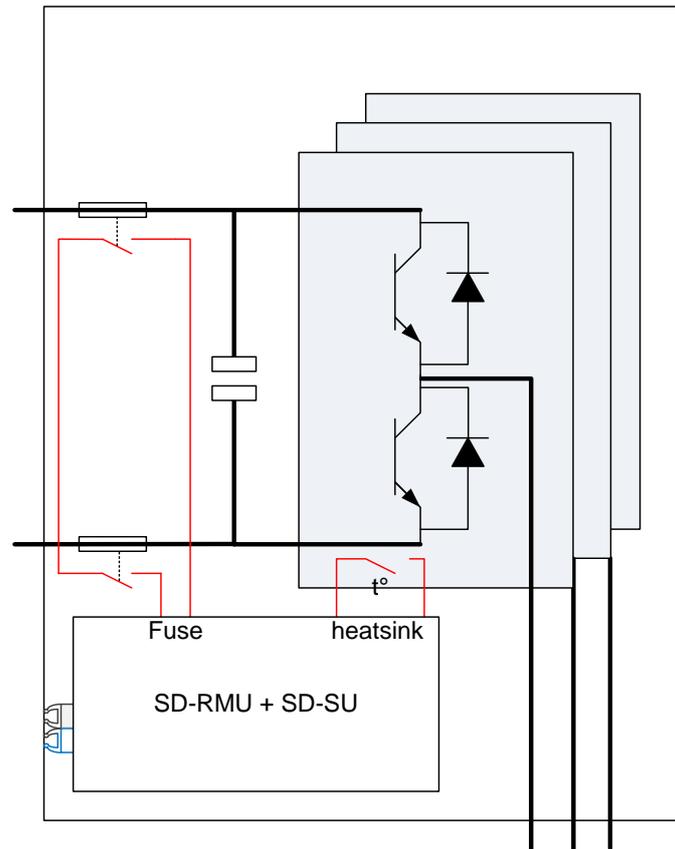
If the fuses are opened is generated a fault "DPM X: DCbus fuse fault" or if the heatsink reaches the threshold temperature is generated a fault "DPM X: Heatisink temp fault". The ""X" letter represents the DPM number.

When a drive size is selected and then a drive root (DPM) is chosen, the control system checks if the connected DPMs has the correct size selected in **[0101]**.

As described in the hardware manual, for every DPM type there is a SD-SU dip-switches configuration.

The expected DPM size is showed in the *Expected DPM Size* **[7630]** in the following format Y.X where Y describes the SD-SU dip-switches configuration (there is only one dip-switches configuration for each drive DPM) and X represents the firmware version inside the SD-SU.

For every DPM connected (and activated) it is possible to read the bit configuration through parameter *DPM X Size* where X is the DPM number from 1 to 8 (parameters number from **[7631]** to **[7638]**).
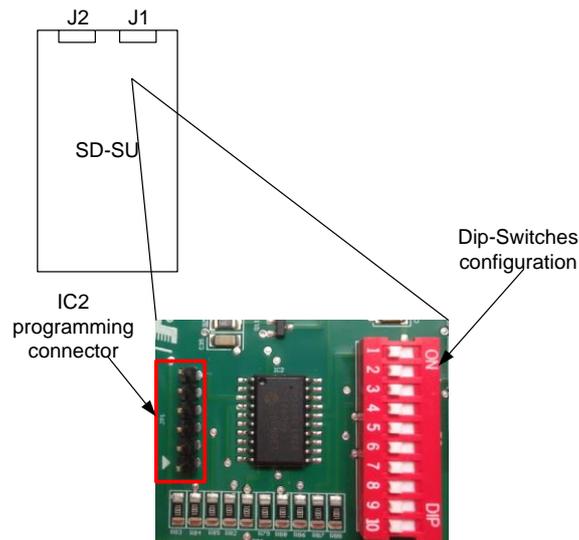
Fig. 3-101: Dip-switches location (S1 on SD-SU board)

The number represents the decimal representation of the SD-SU dip-switches configuration showed in the Fig. 3-101. The rule is the following:

$$DPM\ X\ ID\ Code = S1_1 + 2 \cdot S1_2 + 4 \cdot S1_3 + 8 \cdot S1_4 + 16 \cdot S1_5 + 32 \cdot S1_6 + 64 \cdot S1_7 + 128 \cdot S1_8 + 256 \cdot S1_9 + 512 \cdot S1_{10}$$

Where $S1_n$ represents the i-th dip-switches position (from 1 to 10). If the position is ON the $S1_n$ value is 1 otherwise is 0.

Example

In the SDI.2.540K.400 the bit configuration is showed in the table below:

dsw	ON	Value
1	1	1
2	1	2
3	1	4
4	1	8
5	1	16
6	0	32
7	0	64
8	0	128
9	0	256
10	0	512

If the selected size is *3 x SDI.2.540.400* then it will be possible to see in parameter *[7631]*, *[7632]* and *[7633]* the following value: 5 (1+4).

■

If the value is different from the *Expected DPM ID Code* a Size Mismatch fault (ID 5087) is generated. If the ID code is undetected (e.g. something does not work properly) it is possible to read in the *DPM X ID Code* parameter the string "Error: Undetection".

3.6.1 DPM Visual Identification

It is possible to identify the DPM modules through a visual test procedure by using the interface leds in the SD-RMU showed in the Fig. 3-102.
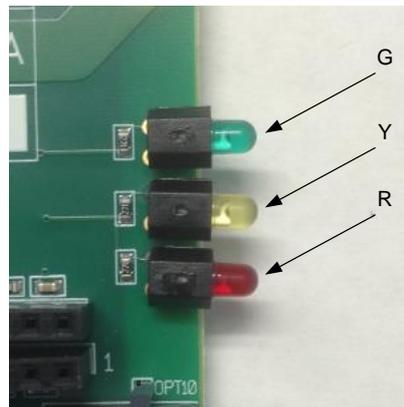
Fig. 3-102: Leds showed (G – Green Led, Y – Yellow Led, R – Red Led)

To activate the test procedure it is necessary to follow these steps:
- Remove switch-ON command (MCW.00)
- Change menu visibility to *Advanced*
- Set *Simulation mode [0110]* = TEST 1 (it is necessary that the faults are not present and the dc-bus voltage is lower than 50 V
- If the Drive status is not fault it is possible to identify the DPM number by watching LEDs behaviors as showed in the table below.

DPM number	G	Y	R	Behavior
1	ON	OFF	OFF	Steady
2	OFF	ON	OFF	Steady
3	ON	ON	OFF	Steady
4	OFF	OFF	ON	Steady
5	ON	OFF	ON	Steady
6	ON	OFF	OFF	Blinking
7	OFF	ON	OFF	Blinking
8	ON	ON	OFF	Blinking

Tab. 3-43: Parallel DPM identification through the LEDs on SD-RMU

3.7 CPU CONFIGURATION

The CPU configuration is allowed in the CPU group. This group contains two families:
- [85] BOARD CONFIG: it allows to configure some parameters related to the board as Ethernet IP, Date, etc.
- [86] DATA-LOGGER: this family allows to log up to 10 analogs and 8 digitals variables triggered by an IPA.bit selectable event. The control system after the trigger event creates a file inside the board that can be uploaded in the PC and read with Softscope.

The two families will be explained more detailed in the following two paragraphs.

3.7.1   Board Config

BOARD CONFIG family allows to modify standard and expert parameters or function related to the board or OS interface. The parameters are described below:

- *Exec Command [8501]*: the meaning of these commands are described below:
    - *Reboot [1]*:   The control system is rebooted. This command can be executed even if the drive is running. When the system is rebooted the SDM/SDLE connection is lost. It is necessary to reconnect when the system is again on line.
    - *Sync Par [2]*:   All the parameters are force to be saved in the flash
    - *DHCP request [3]*:   There is a request for dynamic IP address
    - *Save all Logs [4]*:   Save the system logs (system diagnostic logs for R&D) to USB stick (if connected)
    - *Save Trace [5]*:   Save the Data logs (recorded control data with data logger) to USB stick (if connected)
    - *Delete Logs [6]*:   delete the system logs (system diagnostic logs for R&D) in the target
    - *Delete Trace [7]*:   delete the Data logs (recorded control data with data logger) in the target
    - *USB Detach [8]*:   Safe remove for USB stick connected to the target
    - *Upgrade firmware [9]*:   Upgrade firmware (upgrade firmware package in the file *.pkg)
    - *Restore firmware [10]*:   Restore base firmware contained in the SECOM Drive Image distribution
- *Lock control parameter [8502]*: it is possible to block the write access to the parameters. If you set a value different from zero, the CPU memorizes this value and disables the write access until the same value is set to the Lock control parameter. It is possible to see the locked/unlocked status through the PLCSW bit 10.
- *User Default Parameter Cfg [8503]*: SECOM Drive can work with three different set of parameters (set 1, 2, and 3). It is possible to save the current parameters set to Database set 1,2,3 (save database set X) or load this databases (load database set X) to current parameter set. It is also possible to copy/save the database set to USB memory stick (copy database set X from USB or save Database Set X to USB).
- *Ethernet configuration [8504]*: set the type of IP address in the Ethernet network (DHCP or Static).
- *Eth0 – IP Address [8505]*: set the IP address in case of static configuration.
- *Eth0 – Subnet Mask [8506]*: set the subnet mask of Ethernet network.
- *Board MAC address*: the MAC address is composed by three parameters *Eth0 - MAC address High [8507]*, *Eth0 – MAC Address – Middle [8510]* and *Eth0 – MAC address – Low [8509]*.
- *Date [8510]*: set system date as *YYYY-MM-DD*.
- *Time [8511]*: set system Time as *HH:MM:SS*.

3.7.2   Data Log

The configuration parameters for data logger are located in *Data Log [86]* family. The data logger function allows to record 10 analog variables and 8 digital variables (1 bit long) at every control time execution (this frequency depends on the selected switching frequency). The total amount of recorded data for the analog tracks are 180000. The length of recorded data for each analog track depends on the number of active tracks (the value is different from NONE [0]) and it is the integer part of $18000/N°activeTrack$. For example, if the active track is 7 the recorded data length for each track is 2571 samples. This number is the same of every digital variables recorded.
The configuration parameters are:

- *Trigger channel [8601]*: the available channels for trigger purpose are two: trigger A and trigger B. This parameter allow to select which of these two trigger must be used or a combination of them. (only A, A OR B, A AND B).
- *Trigger event A [8602]*: this parameter selects the type of trigger variable: digital High/Low (only for digital signals one bit long) and greater/less than threshold for analog signal. The type of signal is selected in the following parameter.
- *Trigger signal A [8603]*: by using *IPA* or *IPA.bit* function it is possible to address all the SW/CW and the variable in the Monitoring group (except [75] and [76] families). The choice is made according with the selection in the parameter *trigger event A [8602]*. If in the parameter [8602] is selected greater/less than threshold you must set the threshold value in the parameter *trigger threshold A [8605]*.
- *Trigger event B [8606]*: this parameter selects the type of trigger variable: digital High/Low (only for digital signals one bit long) and great/less than threshold for analog signal. The type of signal is selected in the following parameter.
- *Trigger signal B [8608]*: by using *IPA* or *IPA.bit* function it is possible to address all the SW/CW and the variable in the Monitoring group (except [75] and [76] families). The choice is made according with the selection in the parameter *trigger event A [8606]*. If in the parameter [8602] is selected greater/less than threshold you must set the threshold value in the parameter *trigger threshold B [8609]*.
- *Reset trigger event [8610]*: when the trigger signal is fulfilled, the data logger create a file with the sampled data and it stops to record further data even if the trigger is fulfilled. To start a new recording it is necessary to give a rising edge to the Data logger. The variable that gives the rising edge is addressed through IPA.bit with this parameter.
- *Trigger position [8611]*: this parameter sets the trigger position in percentage of the length of recordable data for each track. In Fig. 3-103 there is an example of trigger configuration "greater than threshold" and trigger position = 40%.
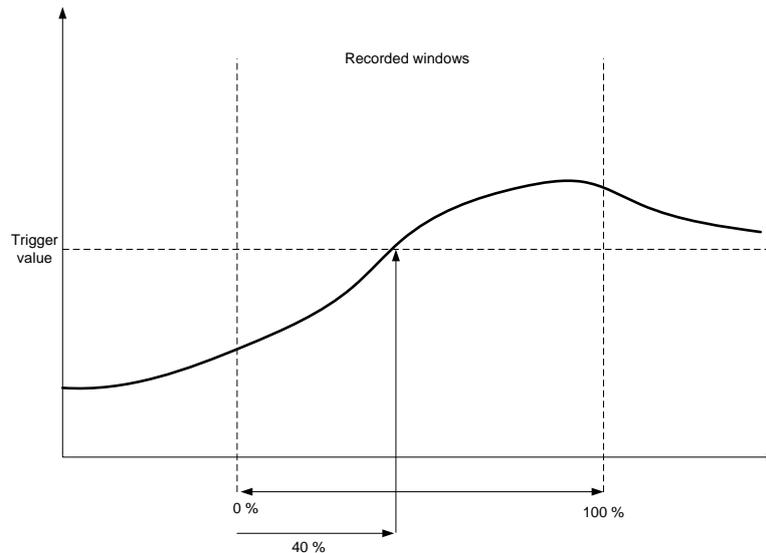
Fig. 3-103: Data log example with trigger "greater than threshold" and 40% of pretrigger

- *Data Log status [8630]*: it shows the status of the Datalogger. The possible values are:
    1. *OFF*: Data logger disabled or not active yet
    2. *ON*: Data logger enabled and activated
    3. *Pre*-trigger: waiting for trigger
    4. *Triggered:* the data is triggered
    5. *Data ready*: recording data completed
    6. *Saving Data:* System is storing data on the SD-Card on board
    7. *Wait for reset event*: waiting for trigger reset event

Once the data is saved on SD-Card, it is possible to collect it in two ways: via USB memory stick or SDM.
USB Memory Stick: plug the USB memory stick in the target and set the parameter *Exec Command [8501]* = Save Trace [5]. The file will be copied in the USB memory stick.
SDM: connect the SDM to the target and click on Target→upload data logger files.
The file with extension OSCX can be opened with Softscope.

3.8 CONTROL TYPE

There are different control type depending on the chosen load. The main control types are showed in the list below:
- Grid load
    1. F3E
    2. Vac Generator
- Motor Load
    1. IM (induction motor)
        ▪ Scalar (V/f)
        ▪ Vector (FOC)
In the following sections will be explained how these control techniques work.

3.8.1 F3E Control

This control is mainly used to avoid DC-bus overvoltage during regenerative working. During motoring working when the DC-bus voltage is lower than line voltage the F3E control commands the IGBTs like a diode bridge while on the contrary, in the regenerative working, the F3E control commands the IGBTs to discharge the dc-bus in the line.
In this control there is not Dc-bus regulation and the Dc-bus voltage is depending to the line voltage fluctuation but the IGBT switching frequency is very low and it is the same of the line frequency.
The switching frequency is very low and in this case a higher current can be achieved than AFE contro.
It is necessary to connect to the SD-MCU the SD-SYNC to monitor the line voltages. This step is fundamental and the F3E control cannot work without line voltages sensing.
It is a very simple and useful control and it has few parameters to configure. The commissioning procedure will be explained afterwards.
In Fig. 3-104 below is showed the behavior of the F3E currents in case of regenerative or motorizing mode.
With SECOM Drive control, the power factor (cosφ) during motorization is not lower than 0.98, while during regeneration is 1.

a)   *b)*
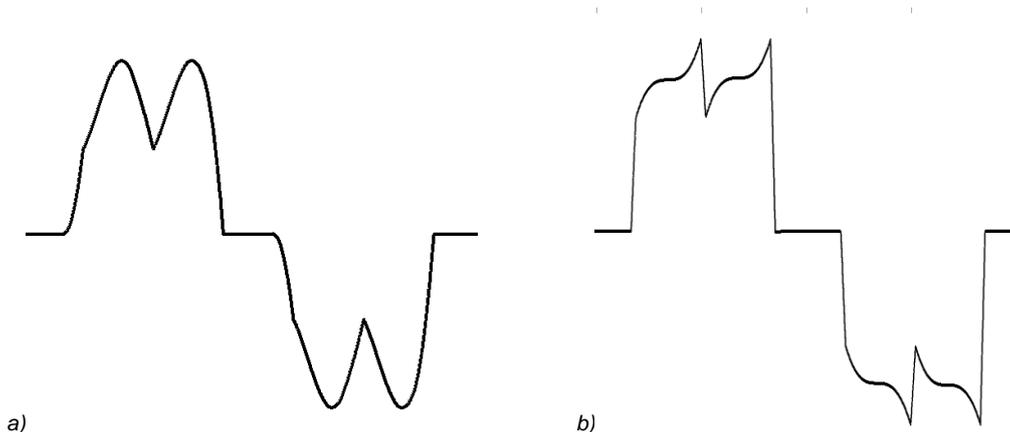
Fig. 3-104: F3E control waveform during motorizing mode (a) and regenerative mode(b)

3.8.2   Vac Generator Control

Vac generator control allows to generate a three-phase output voltage with independent magnitude and frequency references. It is possible also to manage short-circuit in various way, but is not possible to synchronize this control with other active load (such as power grid). Fig. 3-105 represent a general configuration of this kind of control.
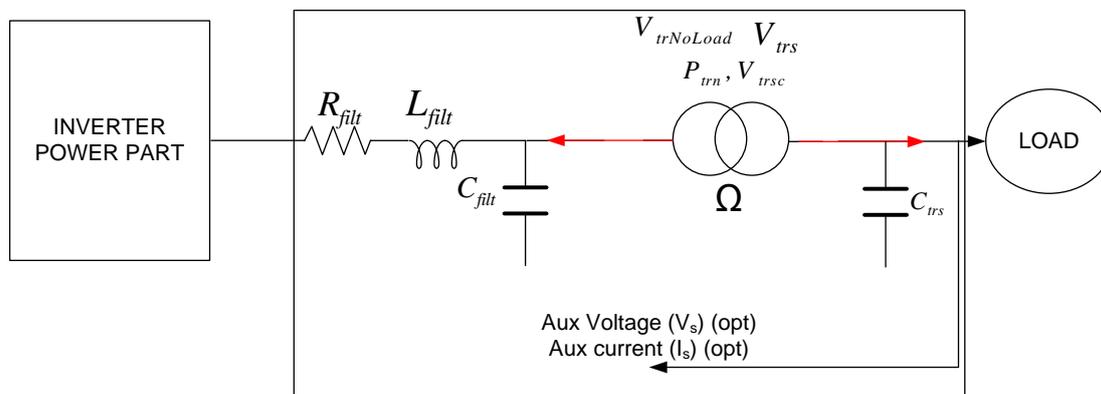
Fig. 3-105: General configuration for Vac generator

This application can be used to:
- Motor and transformer testing
- Independent supply network generation

As shown in Fig. 3-105, it is possible to satisfy very complex configurations and control the output voltage and current (at the load side) by configuring auxiliary voltage and current sensors. The control scheme are shown in Fig. 3-106.
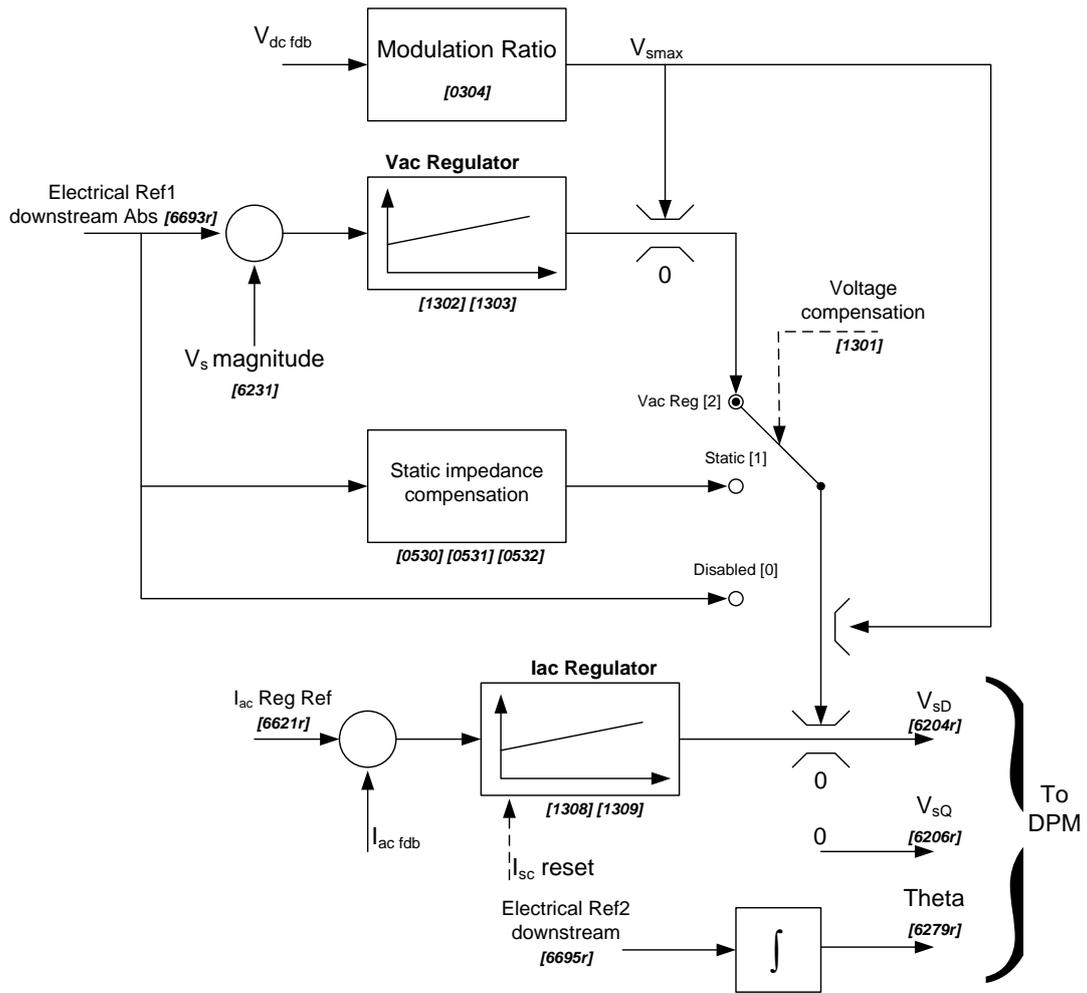
Fig. 3-106: Vac generator control scheme

The *Iac fdb* and *Iac Ref Ref* are calculated as in the Fig. 100.
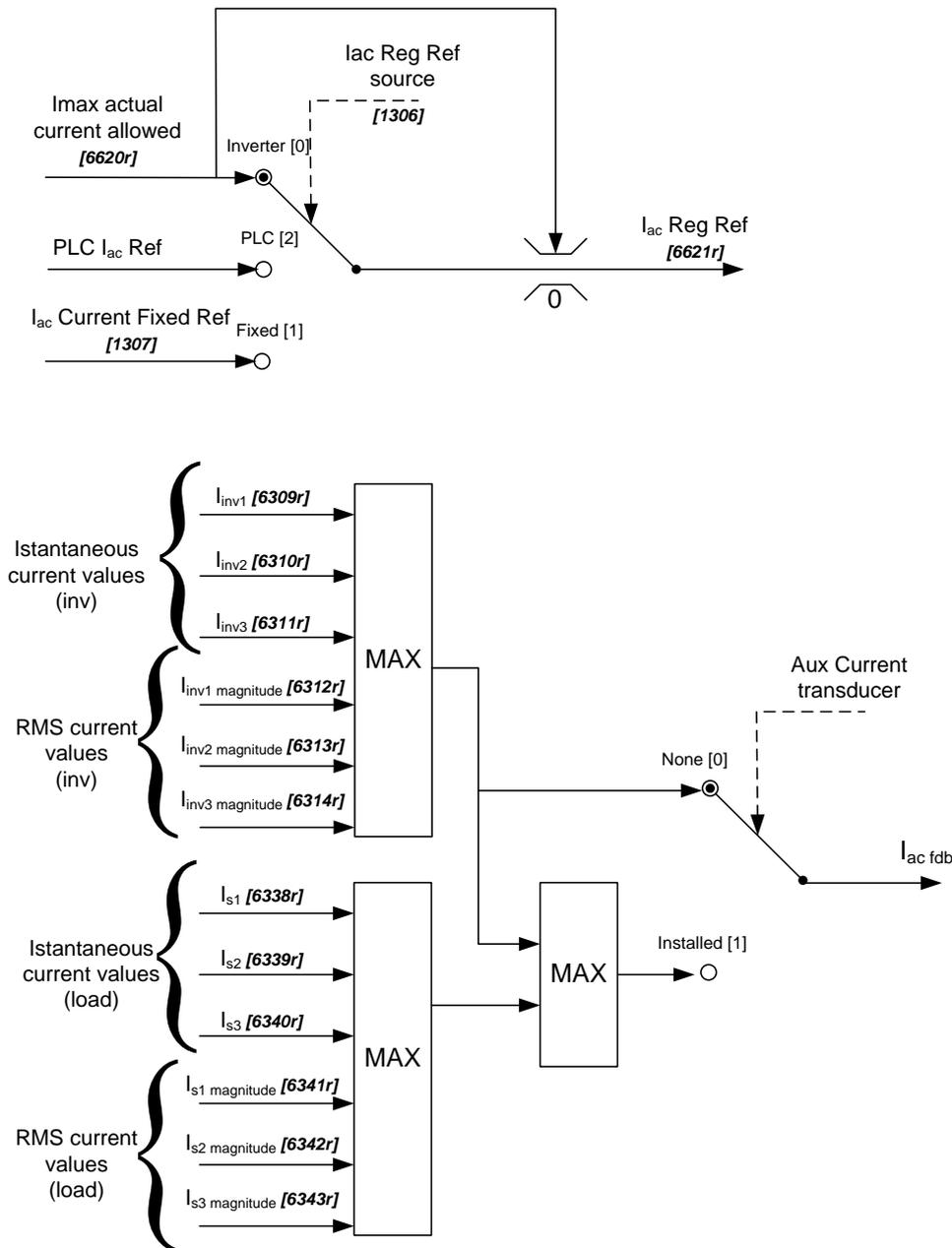
Fig. 3-107: Vac Generator: Current feedback and reference calculation

The parameter *voltage compensation [1301]* allows to select three different modes:
- Disabled: the voltage reference is sent directly to the limit of the current regulator without any voltage feedback or compensation
- Static: the voltage is sent to the limit of the current regulator by adding a voltage drop compensation by mean of line parameters.
- Vac Reg[57]: in this case the voltage reference is sent to the limit of the current regulator in order to regulate the measured voltage (in this case it is necessary to set *Aux AC voltage transducers [0602]* = Installed). In this case the auxiliary voltage sensor must be configured by mean of parameters *voltage transducer scale[58] [0603]* and *voltage transducer mode [0604]*.

The Iac regulator is activated only if the measured current (as shown in Fig. 3-107) is higher than the *Iac Reg Ref*. On the contrary the set voltage is equal to the voltage reference (according to the maximum modulation ratio).

If it is necessary to monitor the load currents and they are different from inverter current (e.g. there is a capacitor between load and inverter) it is possible to add auxiliary current sensor[59] to the system.

In this case the auxiliary current sensor must be configured by mean of parameter *Aux current transducer scale [0605]*.

The parameter *Iac Reg Ref source [1306]* allows to select three different input source:
- Inverter: set the Imax actual current allowed *[6620]* as reference. This parameter take into account the maximum inverter current, the derating factor, the output frequency.
- Fixed: the current reference is set through parameter *Iac current fixed ref [1317]*.
- PLC: the current reference is set through a PLC variable PLCIacRef (library→Secom Interface block)

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[57] Please refer to the hardware manual for the wiring between sensors and SD-MCU.
[58] In case of SD-SYNC the value is 227.27 is calculated as 1250 V /5.5 V (Input/Output)
[59] To enable auxiliary sensor to the SD-MCU, the parameter *synchronization point [0601]* must be different from inverter [0]. Please refer to the hardware manual for the wiring between sensors and SD-MCU.

It is possible to activate the short circuit protection (only at the inverter output *inv*) by mean of parameter *short circuit management [0305]*. The possible selection are the following:

- Disable: the short circuit is not activated. If there is a fast current rise in order to overcome the current trip threshold a fault is generated.
- Instant OFF: when the instantaneous value of the current (I_{inv}) is higher than *short circuit threshold [0306]* the pulses are switched off and they are switched on again after a delay time *short circuit on delay [0307]*. In this case it is applied the reference voltage. If the short circuit happens after 20 ms that the fiber are switched off a counter is incremented. When the counter value reaches the parameter value *consecutive short circuit [5706]* a fault is generated (*[5029] shortcircuit fault*). The counter is reset after 20 ms that the fibers are switched on. The behavior is showed in Fig. 3-108.
- Current limit: when the instantaneous value of the current (I_{inv}) is higher than *short circuit threshold [0306]* the pulses are switched off and when the pulses are switched on again (after a delay time defined in parameter *short circuit on delay [0307]*) the current regulator controls the current value to the Iac Reg Ref setpoint. The behavior is showed in Fig. 3-109.
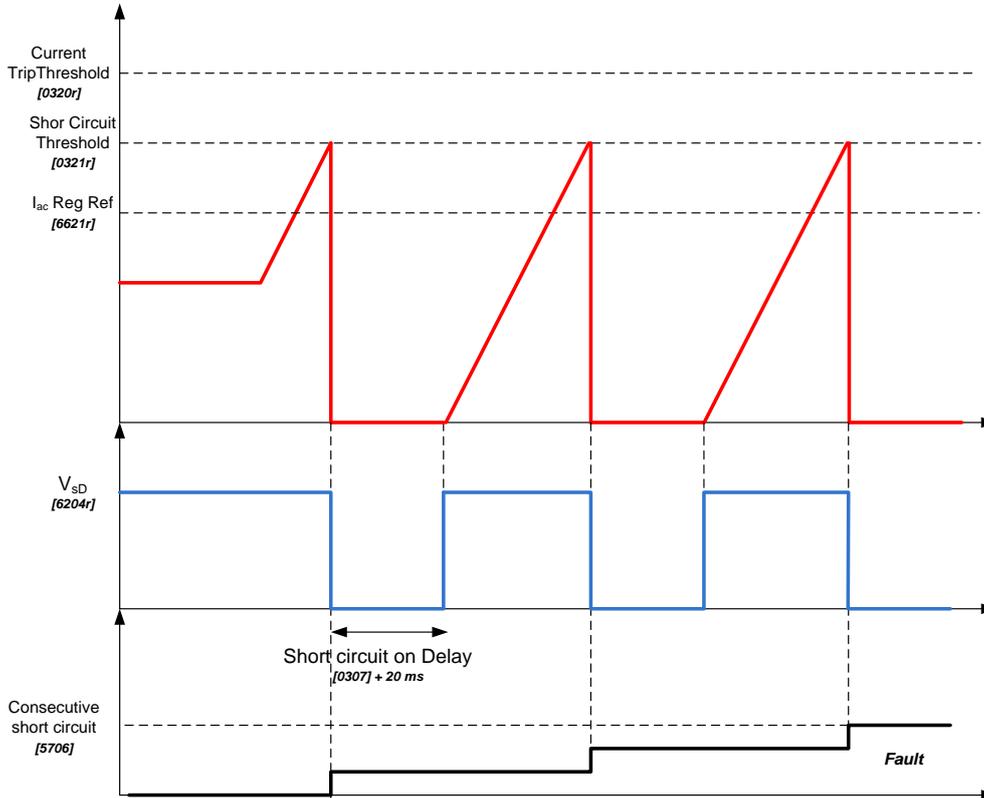
Fig. 3-108: Vac generator: short circuit protection INSTANT OFF mode

All the short circuit type managements have a configurable alarm with parameter *short circuit timeout [5705]*. An alarm is generated (configured warning, OFF2 or disable with parameter *short circuit timeout [5521]*) when the Iac regulator is active (it means that the output voltage is lower than the voltage reference) for a time more than value defined in parameter *[5705]*.
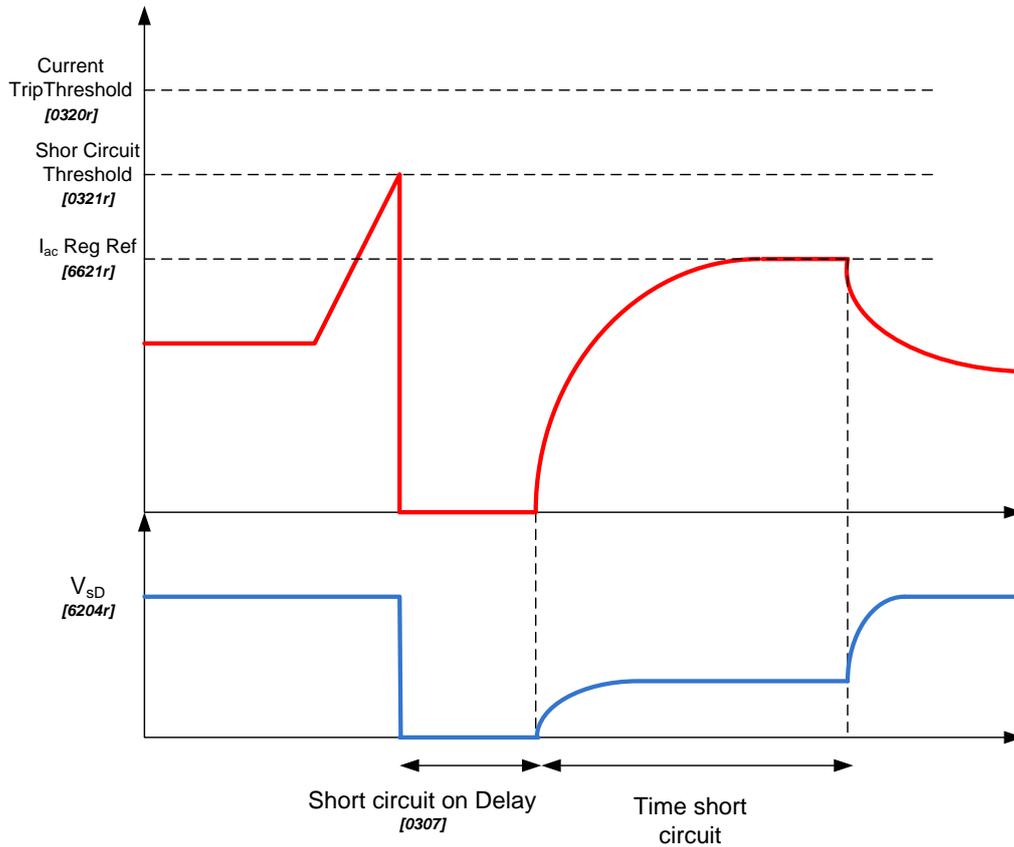
Fig. 3-109: Vac generator: short circuit protection CURRENT LIMIT mode

3.8.3 Motor Control (IM)

Induction motors derive their name from the way the rotor magnetic field is created. The rotating stator magnetic field induces currents in the short circuited rotor. These currents produce the rotor magnetic field, which interacts with the stator magnetic field, and produces torque, which is the useful mechanical output of the machine. The bars forming the conductors along the rotor axis are connected by a thick metal ring at the ends, resulting in a short. The sinusoidal stator phase currents fed in the stator coils create a magnetic field rotating at the speed of the stator frequency (ω_s or synchronous speed). The changing field induces a current in the cage conductors, which results in the creation of a second magnetic field around the rotor wires with frequency ω_r. As a consequence of the forces created by the interaction of these two fields, the rotor experiences a torque and starts rotating in the direction of the stator field. As the rotor begins to speed up and approach the synchronous speed of the stator magnetic field, the relative speed between the rotor and the stator flux decreases, decreasing the induced voltage in the stator and reducing the energy converted to torque. This causes the torque production to drop off, and the motor will reach a steady state at a point where the load torque is matched with the motor torque.
The rotor speed is denoted as ω_m. This point is an equilibrium reached depending on the instantaneous loading of the motor.
The rotor and stator frequency, from an electrical point of view, are linked by a parameter called the slip s, expressed in per unit as $s = \omega_m / \omega_s$. It represents the difference between the synchronous frequency and the actual motor rotation speed.
The motor parameter used in these two control techniques are showed in Fig. 3-110.
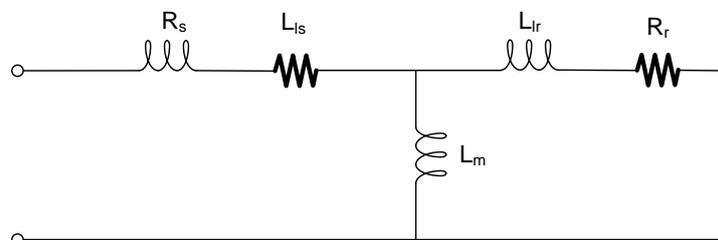
Fig. 3-110: Induction motor parameters model

Where:
- R_s Stator resistance **[0515]**
- L_{ls} Leakage stator inductance **[0518]**
- R_r Rotor resistance **[0516]**
- L_{lr} Leakage rotor inductance **[0519]**
- L_m Magnetization inductance **[0517]** (saturated value)
- I_0 No Load Current **[0509]**

There are three control technique used in the SECOM DRIVE:

- Scalar (V/f)
- Vector (FOC)

In the following sections will be explained what listed above.

3.8.3.1 Open/Closed Loop Scalar control (V/f)

In the V/Hz control, the speed of induction motor is controlled by the adjustable magnitude of stator voltages and frequency in such a way that the air gap flux is always maintained at the desired value at the steady-state.
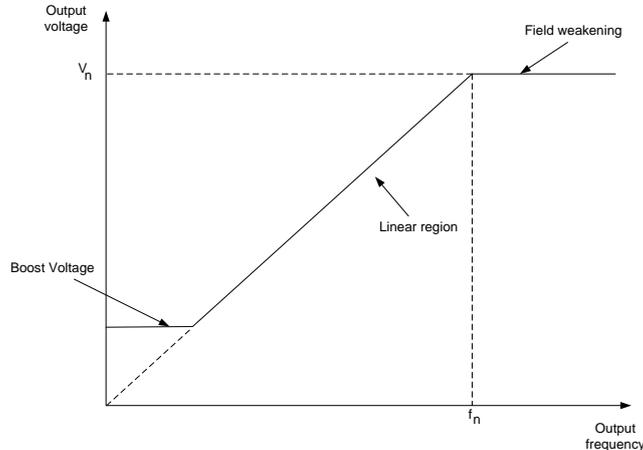
Fig. 3-111: Scalar control characteristic

The aim of the scalar control is to maintain the voltage and frequency ratio constant in the linear region to achieve constant flux.
An additional voltage (boost voltage[60]) is added to compensate the stator resistance voltage drop at lower output frequencies.
After the nominal frequency the output voltage is maintained constant to the nominal motor voltage. It is possible to change the slope of the voltage characteristic by adjusting the *voltage output gain [1608]*.
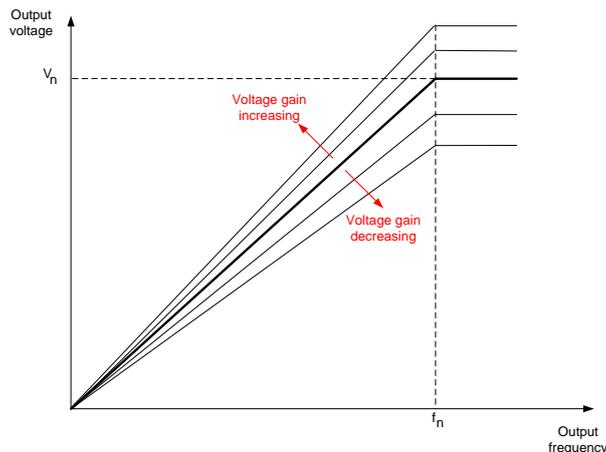
Fig. 3-112: Voltage output gain behavior

The motor slip compensation is also used to achieve best speed precision even in loaded condition. The nominal slip is added or subtracted depending the nominal power sign.
In default conditions, when it is requested the nominal current (motoring working) is added to the reference frequency the nominal slip. It is possible to change the gain of this feature by acting to the *slip compensation* parameter *[1606]*. The default value is 100%.
The current harmonics can creates small oscillations of the motor speed. These oscillation can lead to system instability. For this purpose a damper system is utilized to reject this behavior. The parameters dependencies are:
- *Damping gain [1603]*
- *Damping Frequency [1604]*
- *Damping disable threshold [1605]*

Normally the default values achieve satisfactory results for the most of the applications. Changing these values must be done only from qualified personnel.
As shown above is the base of the scalar control and it can be used to check motor rotation or simple applications. It is possible to improve the scalar control qualities by acting to two different parameters:
- *magnetization control mode [1601]*
  - None (boost only)
  - No load current
  - Flux regulator
- *Speed control mode [1602]*
  - Open loop

---

[60] Boot voltage is parameter *[1607]*

      o   Closed loop

What explained up to now regarding the scalar control is achievable by setting magnetization control mode = None. In this case the machine magnetization is made "open loop" by setting the boost voltage.

In case of *magnetization control mode* = *no load current*, the magnetization current is regulated to *No load current* parameter **[0509]**[61] by using PID regulator. In this case it is not necessary any boost voltage. In this case the motor magnetization current is controlled but it doesn't take into account the magnetization time that must be inserted in the *Magnetization [49]* family.

In case of *magnetization control mode* = *Flux reg*, the motor magnetization is achieved by using the flux estimation and flux regulator. This control mode uses the motor parameter to estimate the motor flux.

In the speed control mode = scalar there is no current limiting in case of torque load step because the output frequency follows the reference frequency. The only manner to limit the motor current is to enable the current rollback controller **[1609]**.

The aim of the current rollback controller is to limit or reduce the current overshoot only if:

- The torque current is higher than the torque limits
- The torque current is higher than the allowed maximum torque current. This one is calculated by the control current functions depending on the drive size, the current reduction, *current overload* **[0504]** and the flux weakening point.

In the *speed control mode* = *closed loop* the frequency is regulated as function of the torque current and in this way it is possible to limit the current by using torque limiter parameters from **[2136]** to **[2140]**. In this case the current rollback function cannot be utilized.
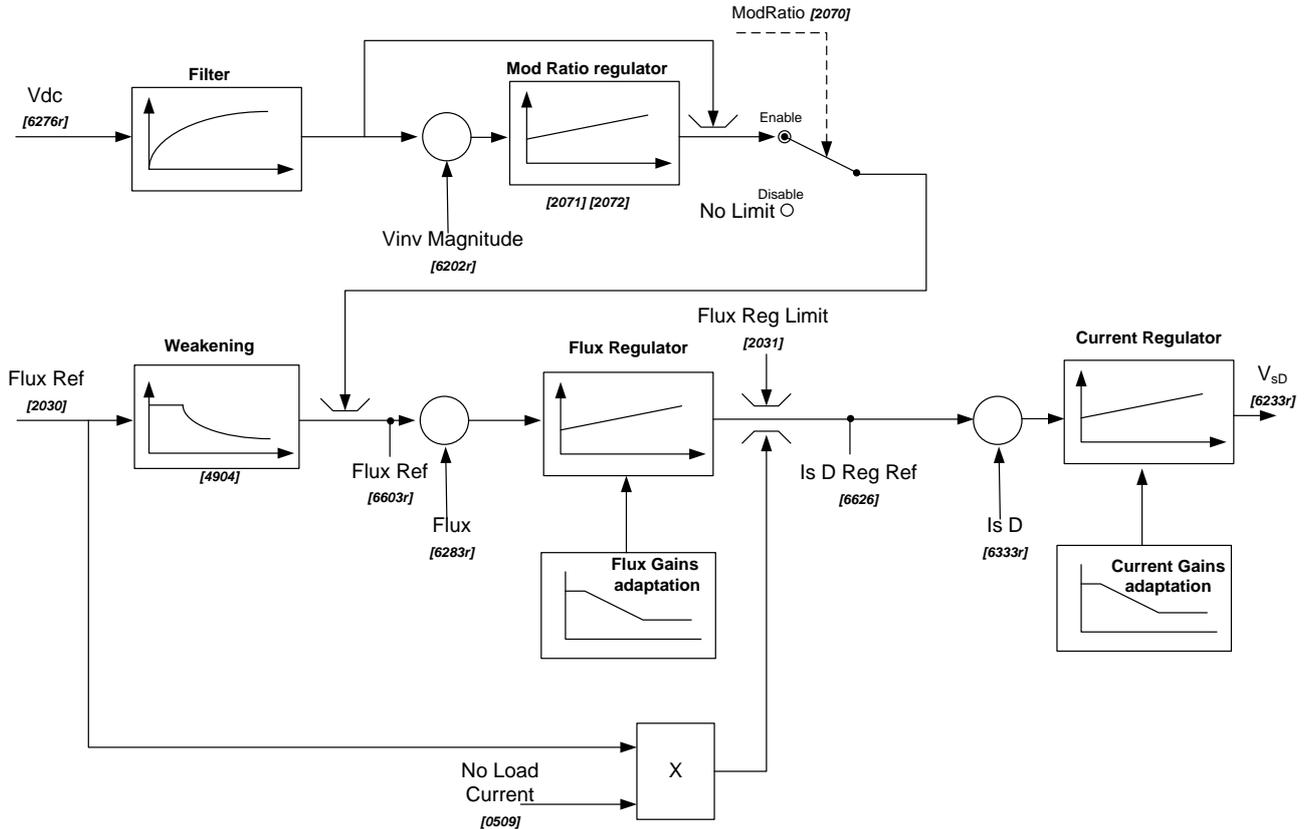
Fig. 3-113: VHz control: magnetization scheme in case of Magnetization control mode = flux reg

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[61] The related configuration parameters are located in *[20] CURRENT/FLUX* Family

210450P004-00-EN
www.secompower.it

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Power Electronic Equipment & Components

SDrive-1.0.0.x
3-91
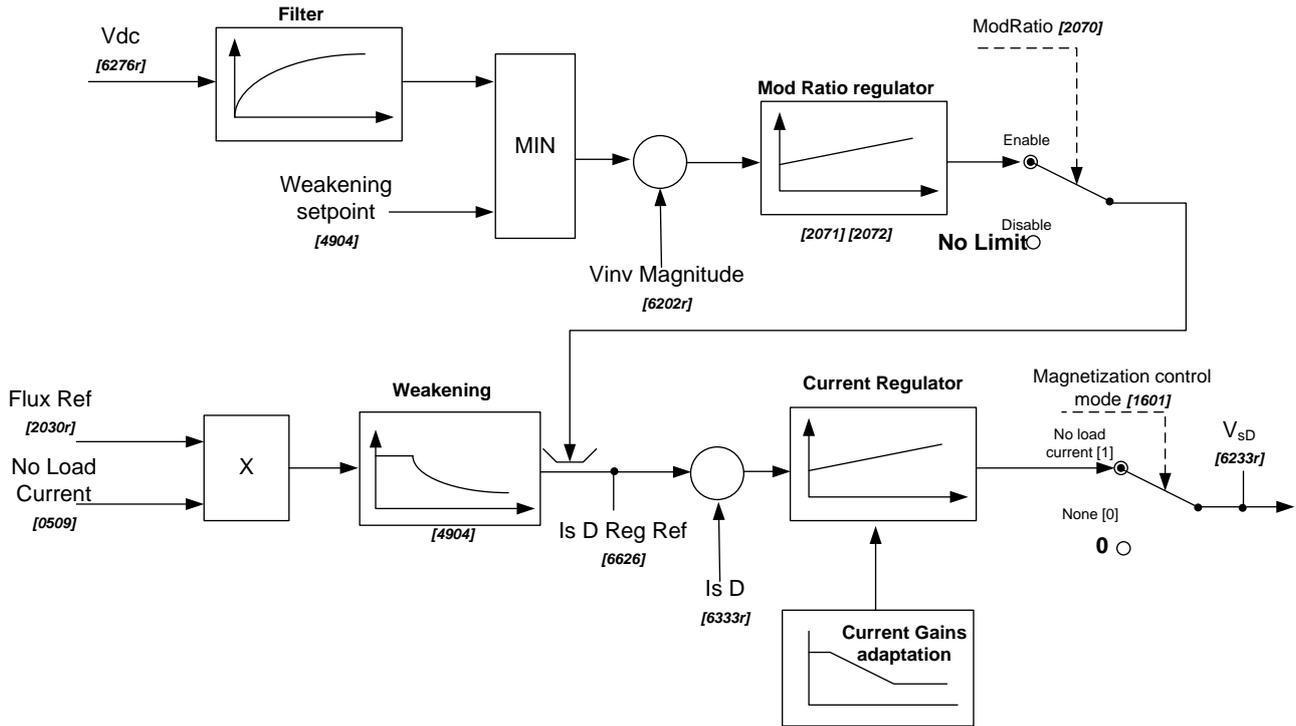
Fig. 3-114: VHz control: magnetization scheme in case of Magnetization control mode = No load current or None
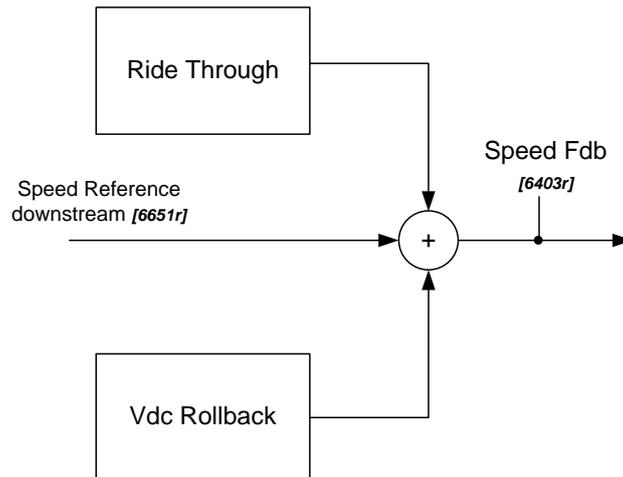
Fig. 3-115: VHz control: speed control scheme in case of speed control mode = open loop
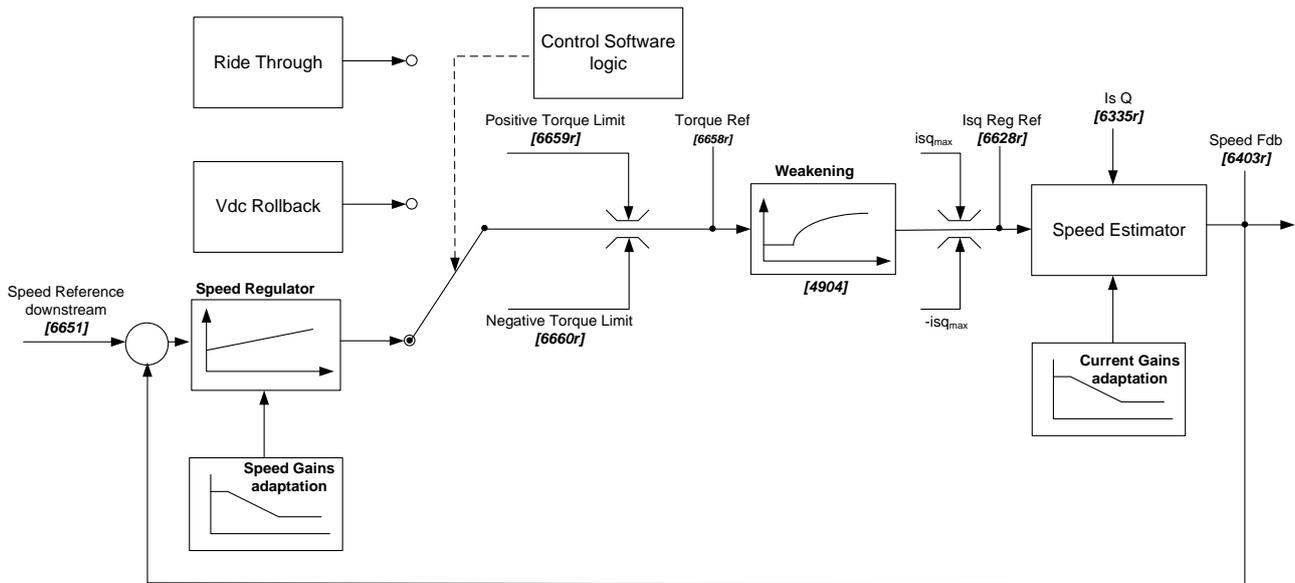
Fig. 3-116: VHz control: speed control scheme in case of speed control mode = closed loop
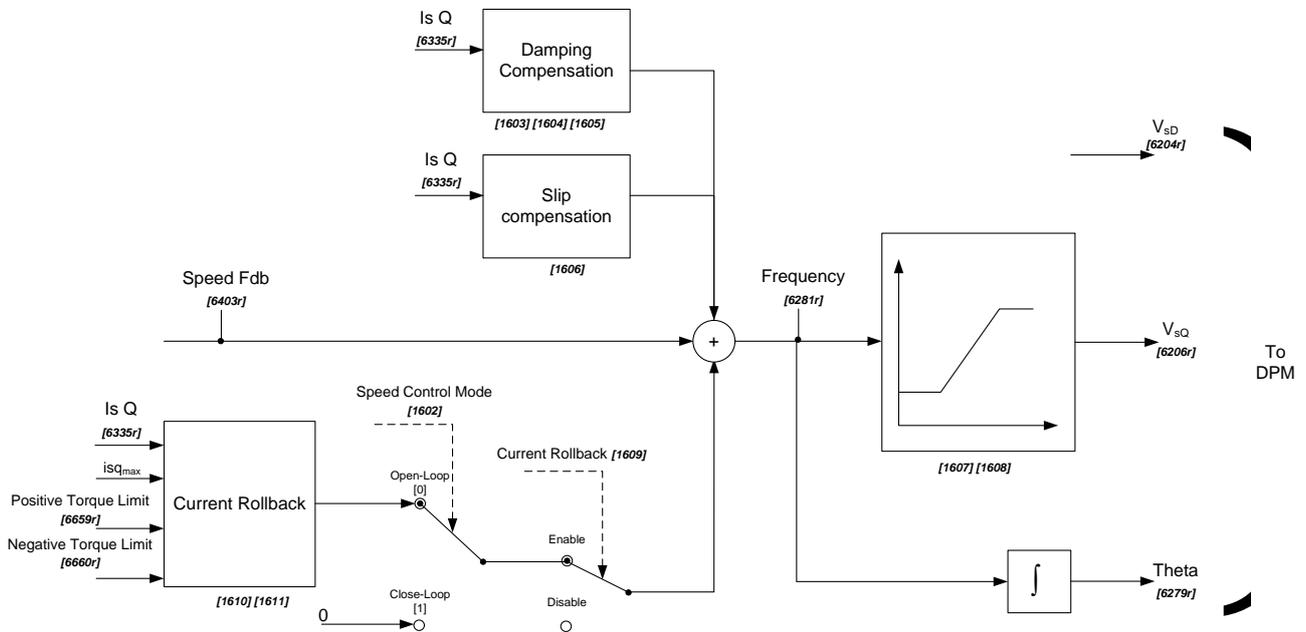
Fig. 3-117: VHz control: DPM references

3.8.3.2   Field Oriented Control (FOC)

Vector control is used when it is necessary an accurate torque, speed and a fast response. The drawback is due to need of the speed encoder (incremental type) to measure the rotor speed.
Respect V/Hz control, the FOC control allows to generate the desired torque to all the speed range.
In the figures below there is showed the block diagram of the FOC control.
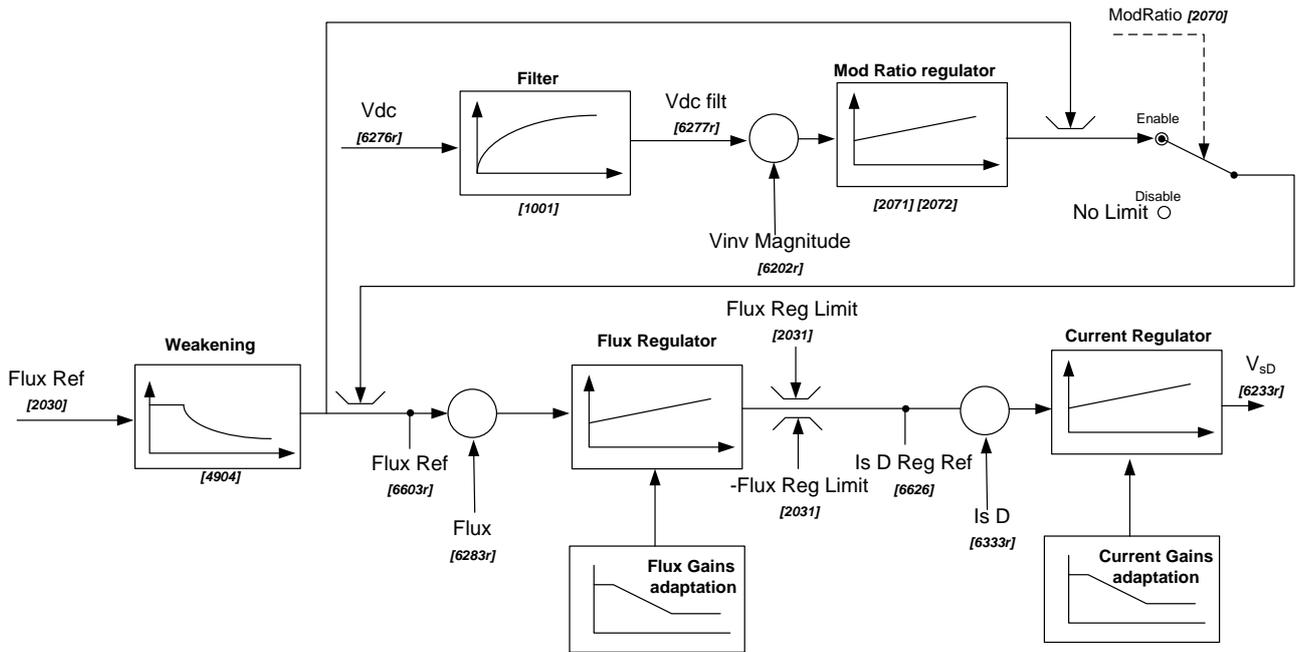
Fig. 3-118: FOC control: D Axis scheme
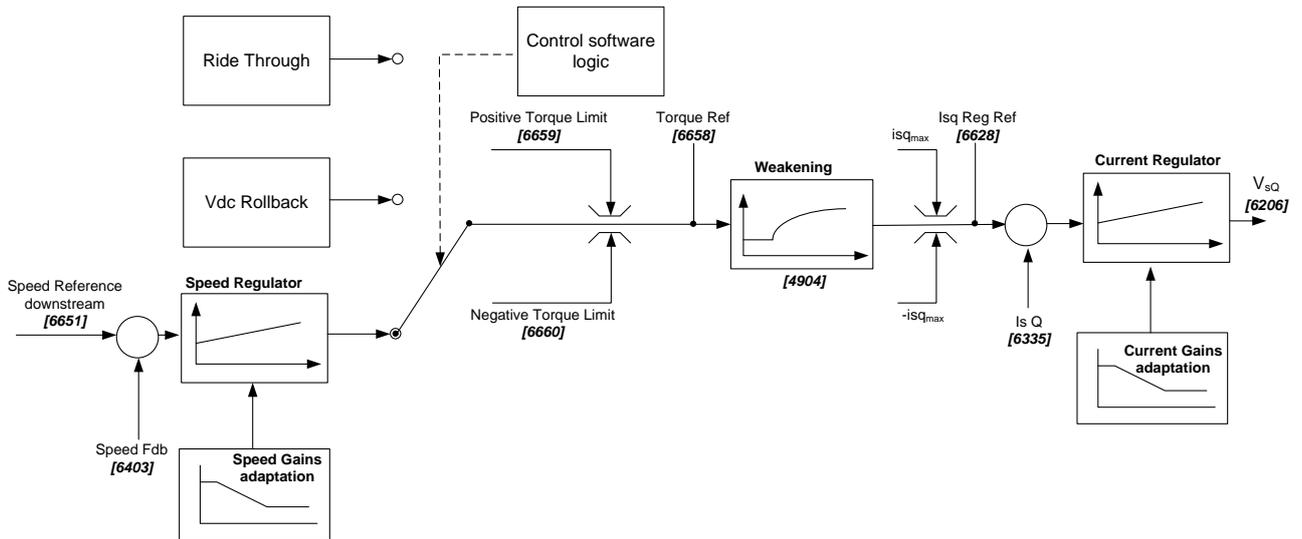
Fig. 3-119: FOC control: Q axis scheme

PROGRAMMING TOOLS

<div style="font-size:large">**4**</div>

Chapter Table of Contents

Contents

This chapter will describe all the tools to configure, program and monitor the drive. They are SDM (Secom Drive Manager), SDLE (Secom Drive Logic Environment) and Soft Scope.

The SDM is a powerful application that could be installed in the PC and it is possible to:

- Configure Drive parameters
- Monitor Drive parameters
- Configure and visualize alarms
- Upgrade Firmware/Software
- Do some additional functions

The SDLE is a powerful and integrated PLC that improve customizability to several applications, and configure the master fieldbuses CANOpen and ModbusTCP.

SoftScope is a SDM plug-in useful when it is necessary to record data with high sampling frequency.

All of these tools can be installed by using Setup_SECOM Drive PC Tools_xxxx.exe where xxxx is the installer version.

Chapter Target Audience

This chapter is aimed at customers who need to know all the software tools and interface to configure, programming, monitoring and commissioning the drive.

4.1 SDM INTERFACE

Configurator project is strictly related to system catalog that provides full description of the features of the available devices. "Device" can be thought as the software object that describes a physical target and that is used to interact with it.

4.1.1 Projects

You can create a new project starting selecting one of the available Catalog devices. The catalog version represents the software package version inside the target where you have to connect. The catalog contains all the parameters list, alarm and PLC configuration and it is mandatory to use catalog and software package of the same versions.
In this chapter will be showed the tools to achieve what has been written before.
A project can be composed by one or more devices of any type and version. User can add or remove devices from an existing project at any time. A project device item can be also updated to new versions. Projects files are saved with *.sdm* extension.
After adding the device to the project as shown in the picture below it is necessary to set the parameters connection.
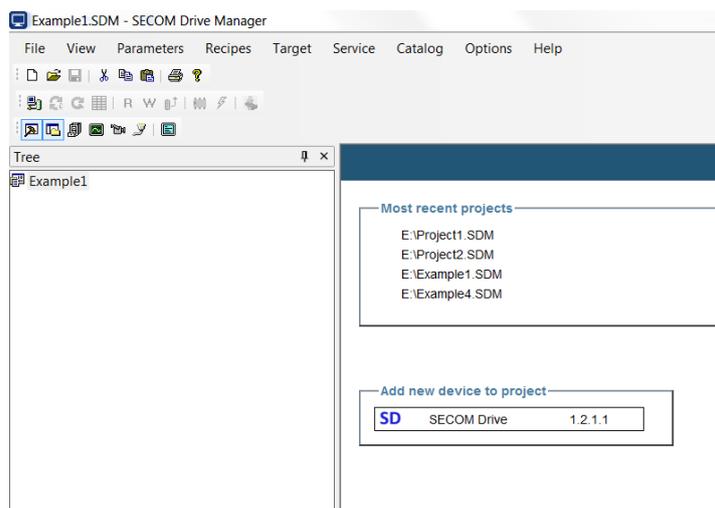
Configurator allows the user to specify for each device its own communication settings to let the Configurator communicate with each of the physical target devices of the project.
The SDM shown (by default) the most recent version catalog. It is possible to see all the catalogs installed in the SDM by clicking on *Catalog→Show all versions* in the catalog.
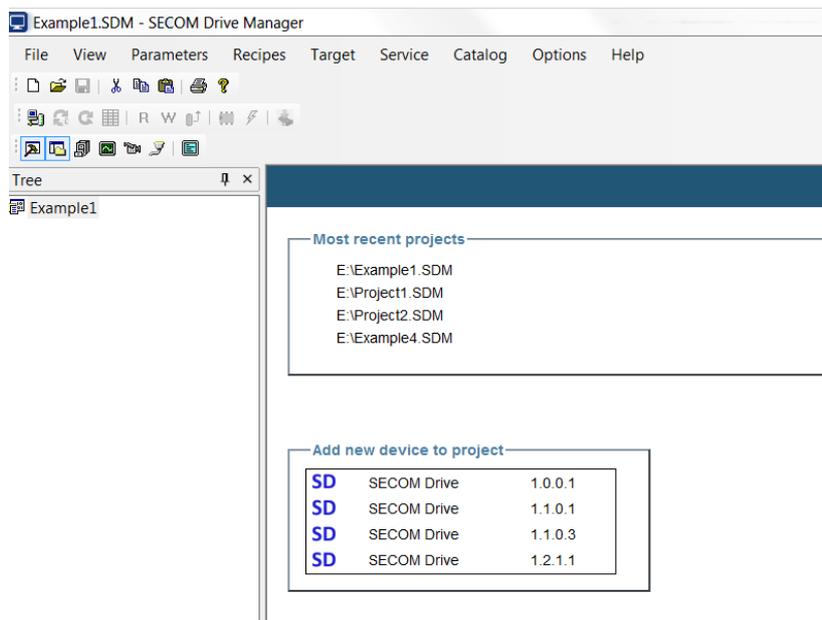
It is possible to connect to physical targets once configured communication settings for each device in the project.

4.1.2   Connect to Target

Once the device is selected it is necessary to set the communication parameters. The standard connection mode is made through Modbus TCP channel (RJ45[62] cable).
Before connecting to the target it is necessary to set PC IP address in the same subnet of which one you want to connect.
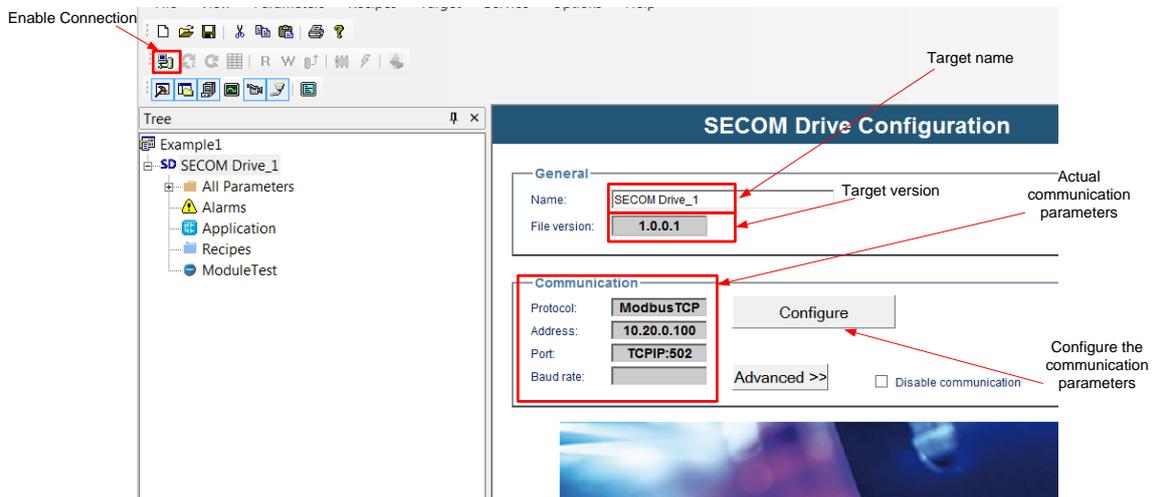
By clicking to configure button it is possible to set the drive IP address. If it is necessary can be set also the name in order to distinguish them in case of multi-drive configuration in the same project.
After connection parameter configuring it is possible to click on enable connection button on top of the SDM. It is possible to see the *connection status* of the drive by clicking on view→connection status.
The SDM checks if the catalog selected has the same version the software package in the target. If the versions are different a message will be displayed:
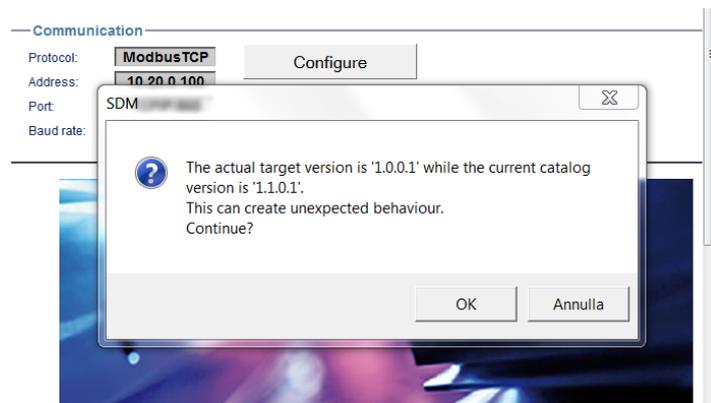
The connection between different catalogs is not recommended except for software download or catalog upload.
For further information about the catalogs and how to install them see the 4.1.8.
A new window will be opened where it is possible to see for each drive in the project the connection status (connected, disconnected, connection error) and the drive status (fault RED, warning YELLOW, ok GREEN).
  • Connected : SDM is connected correctly to the drive
  • Disconnected: SDM is disconnected (enable connection button is released)
  • Connection error: SDM tried to connect to the drive but there is no connection

It is possible also to see the connection status on the right-down corner of the SDM.

---

[62] It is necessary to set the PC ip address in the same network of the target (drive). E.g. if the ip target is 10.20.0.101 it is necessary to set the PC ip address as 10.20.0.x.

It is possible to connect multiple drive to the SDM in the same project. To add a new device to a project right click on the root node (available on the tree panel[63]) then click on Add voice of the popup menu. Available catalog devices will be shown in a window. Select desired device to add. Device will be added to the project as child of the root node.
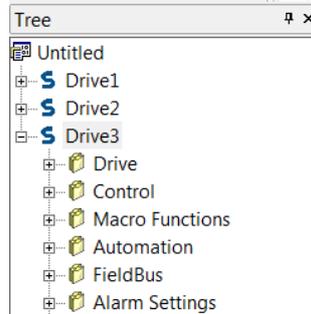
In case of multiple drive in the same SDM project in the connection status on the right-down corner will be shown the drive status with the highest status priority and the highest connection info priority. The drive status priories are:

- Fault
- Warning
- Ok

The drive connection info priorities are:

- Error
- Disconnected
- Connected

Example

If there are two nodes in the same project and one of them has fault status, in the corner status bar will be displayed fault whatever the other drive status.

■

The parameters related to the target (or Drive) connection are located on the "target" menu:

- *Communication settings*: it defines the communication settings where port, address parameters must be kept equal to the image below. The IP or hostname must be set equal to the target one.
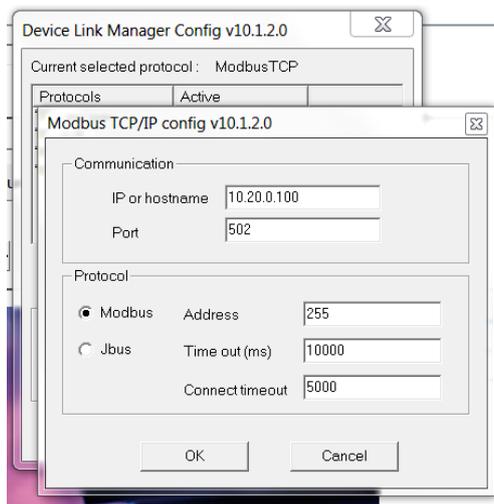
- *Device reboot*: the operating system in the target will be rebooted. All the control routines will be stopped. Special caution must be used to use this command while the drive is running, because the system is stopped immediately!
- *Save Parameters into flash disk*: the parameters values are saved into non-volatile memory when one of them is changed. The value is maintained even if the drive is switched-off. If this option is unchecked, the modified parameters are lost when the drive is switched off.
- *Restore default values*: restore the parameters to the factory settings. If this option is activated, all the parameters values is overwritten to their default values.
- *View parameters log*: shows the list of the modified parameters history with the following formatting:
  Date | time | parameter number | parameter value | channel
  The channel can be Modbus (SDM or others Modbus masters), Profibus or CANOpen.
- *View history log*: shows the list of the last alarms (faults or warnings) with the following formatting:
  Date | time | Type of alarm | alarm number | short description

---

[63] The tree panel can be visible by clicking on view→tree

- *View software upgrade log*: show the history of the software upgrade and eventually the error log. The procedure will be explained in the Firmware Upload paragraph.
- *Software download*: allows to upgrade the software package into drive. The procedure will be explained in the Firmware Upload paragraph.
- *Create Param Backup file*: allows to save in the PC the complete parameter configuration. In this case it can be downloaded to another target.
- *Load parameters backup into target*: allows to download a parameter configuration previously saved
- *Fpga firmware upload*: allows to upload the firmware necessary to upgrade the C3 and the SD-RMU[64]

The tree panel is showed all the components of the drive. The components of the tree are the following:

- parameter groups (as described in the 2.1)
- active alarm
- Recipe
- PLC application
- Smart user interface
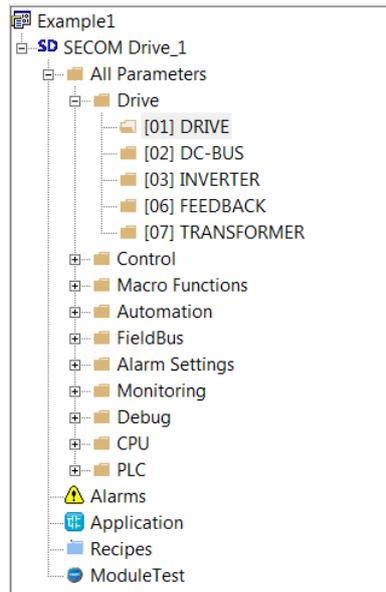
4.1.2.1   Parameter Groups

The parameter tree panel allow to easily access to all the parameters showed for the selected access level (this one will be explained further) and for the selected control/load.

The main folders are the GROUPs, the second layer folders are the FAMILIEs and the third ones (if present) are the SUB-GROUPs. Inside the SUB-GROUP or the FAMILIES are located the parameters.

In the figure above is showed an example of the parameter representation on the SDM.

---

[64] For firmware download (C3 and SD-RMU) it is necessary to use Altera USB blaster and quartus II programmer.

It is possible to expand the folder by left clicking on the "+" symbol.
The parameter grid is composed by the following columns:

- **IPA**: number of the IPA
- **Name**: parameter name
- **Type**: the allowed type are: BOOL, INT, UINT, DINT, WORD, REAL and ENUM (Enumerators). The last one are used to give a short description of the parameter value. The standard formatting is: *Name Enum [equivalent number]* as in the example in the picture below. It is necessary to know the type only if there is a need to write/read the parameter from the fieldbus channel.

- **Um**: unit of measure (e.g. Hz, A). If it is not defined an empty space is present.
- **Default**: it is present only for writable parameter and represents the value that can be written if "Set Default value" command is utilized (parameters -> write default values that sets the default value of the selected parameter or target -> restore the default values that sets the default value of all the parameters).
- **Min**: it is present only for writable parameter and it used to print out an error when the written parameter is lower than this value (in this case the old value is kept).
- **Max**: it is present only for writable parameter and it used to print out an error when the written parameter is lower than this value (in this case the old value is kept).

- **Description**: parameter description

With some parameters (most of all are SW/CW) it is possible to obtain bitword description and status by double left clicking on the parameter name.

The function allowed in the parameter grid are:

- **Selecting rows**:
    1. left click to select a single row
    2. Ctrl + left click to select on another row to add the row to the selection
    3. Shift + left click to select a set of rows
    4. Ctrl + A to select all the row of the active grid
    5. Menu → Parameters → Select all to select all the visible parameters

- **Editing values**:
  - o Editing values causes the value to be modified in the grid but not in the connected device untile the parameter writing take place. Values are aligned with device value when successful Read/Write operation are done. In this case the value of the parameter is black. When a value is differente from the device value (because of editing or because it has not been read yet) is shown in red color. It is shown in red until a write of the parameter on the device is successfully done or the parameter value is restored reading its value from the device. The value shown in the grid will be updated. If the value in the grid is different from the default value, the default value is shown in blue instead of black.

    If a field is editable (value) its value can be changed simply entering cell. Cursor will start blinking and editing will be allowed.

If a parameter is associated to an enum (enumerator) type a combo box to choose the new parameter value is shown.

If a parameter is associated to a free enum type a combo box to suggest new parameter value is shown. It is also possible to insert a value as a standard parameter. In case of this value is inside the suggestion list the string is showed when the value is confirmed.

- **Resizing columns**: it is possible to resize a column left-clicking on the right margin of the header of the comuln to resize and moving the mouse (with the button pressed) on the left or on the right to reduce or to enlarge the comumn.

It is possible to refresh the parameter values (read and write) by clicking on Parameters → Auto refresh mode or in the icon.
The parameter menu has the following fields:

- *Read selected*: Select one or more parameters in a parameters grid then click this button. Selected parameters will be read from connected device. Value shown in the grid will be updated.
- *Write selected*: Select one or more parameters in a parameters grid then click this button. Values set for the selected parameters will be written to connected device.
- *Write default values*: Select one or more parameters in a parameters grid then click this button. Default values of the selected parameters will be written to connected device.
- *Refresh page*: To read from the connected device all the values of the parameters shown in the current parameter grid.
- *Select all*: To select all the parameters of the opened grid.
- *Read all*: To read from connected device all the parameters values.
- *Write all*: To write into connected device all the parameters values.
- *Write all default values*: To restore the default values of all the parameters of the connected device.
- *Connected mode*: To connect/disconnect Configurator to/from devices.
- *Auto refresh mode*: If it is enabled Configurator ciclically read all the parameters of the grid shown in the main window. The refresh interval can be set to Options → Refresh interval.

4.1.2.2   Change Menu Visibility

It is possibile to change menu visibility by clicking on file→Change menu visibility and select the proper access level. The available access levels are:

- Base
- Advanced
- Expert

For advanced and expert access level it is necessary to insert a password. Contact SECOM customer center for further details.
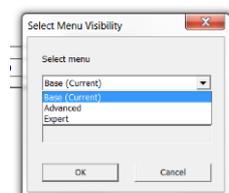
4.1.2.3   Active Allarms

It is possible to access to the Alarm State window by left clicking to the Alarm Icon. The alarms state grid shows the active alarms (Warning or Fault) by describing:

- Type: there are three possibilities:
  1. First Fault: Fault occurred first. The Drive is stopped, the fiber command is disabled and the MCB is opened (if any). Reset command is mandatory. In the history log is written as **!F**.
  2. Fault: fault occurred after the first fault. The Drive is stopped, the fiber command is disabled and the MCB is opened (if any). Reset command is mandatory. In the history log is written as **F**.
  3. Warning: in this case is only an information that doesn't change the drive behavior. If the cause of warning disappear also the warning does the same without any reset command. In the history log is written as **W**.

Alarm description

Alarm icon

Drive Status cumulative
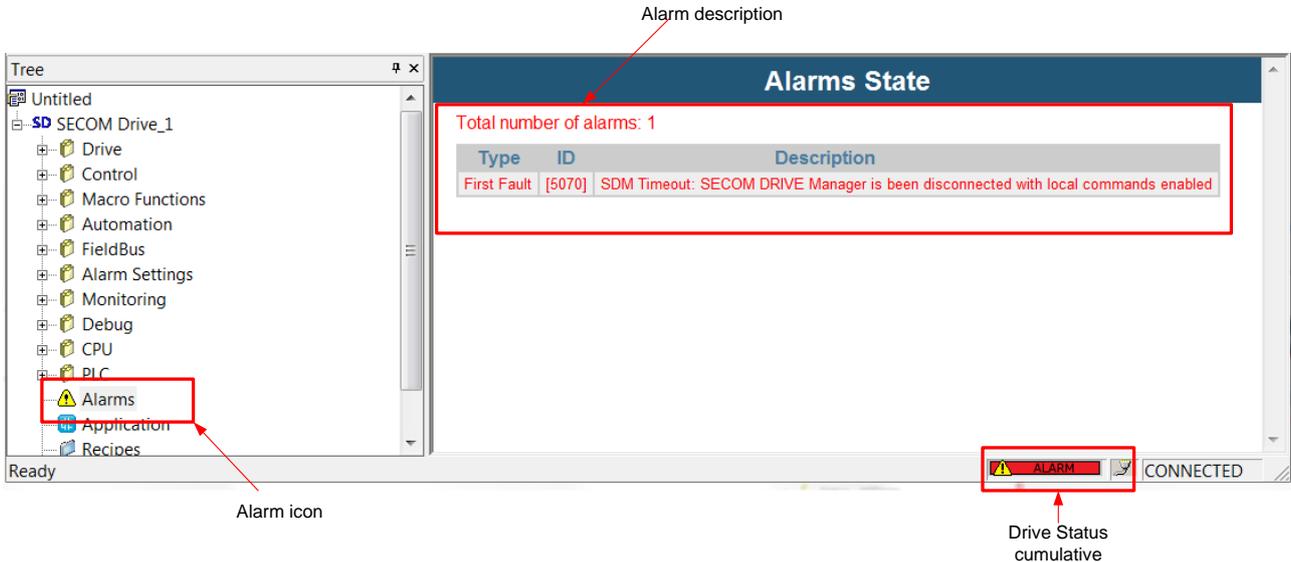
In the Alarm state window is possible to see up to 16 alarms.
The warnings or faults are recorded in the history log into the drive (SD-MCU) with the time when the event occurs. it is possible to upload to PC the history log by clicking on target → view history log.
In the history log the alarm are formatted as follows:

Date and time	type of alarm	[alarm number]	alarm name

4.1.2.4   Recipe

Recipe consists in a set of parameters that user can compose to define specific values of the parameters. User drag & drop parameters onto the recipe node and then you can modifies parameters values of the recipe. Once modified as desired, values can be set as "Recipe value" using specific command Menu → Recipes → Set recipe values.
User can apply a recipe simply choosing the recipe to apply from the tree, selecting all the items of the recipe and finally selecting Recipe → Write Recipe Values. "Recipe value" will be set for the selected parameters.

Recipe node

Actual value

Recipe value
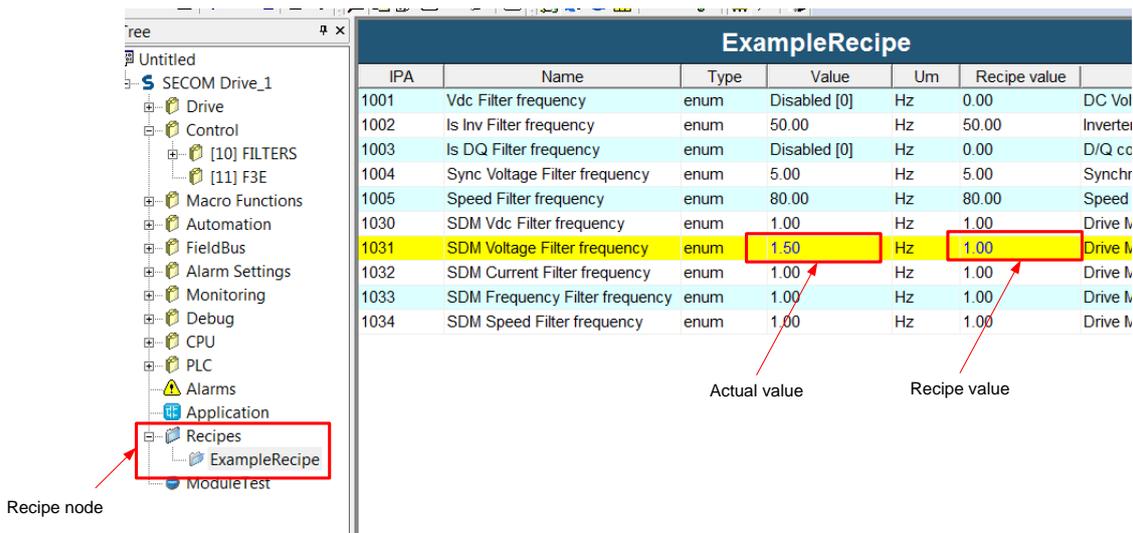
The recipe menu has the following fields:
- Add recipes: Use this command to add a new recipe in project Recipes node. When clicked "New Recipe" node is added as "Recipes" child node. Click on the "New Recipe" node and press F2 to rename it.
- Import recipe: It is possible to add a previously exported recipe in the project. Select "Import recipe" from the menu then select from the open file dialog the .RCP file of the recipe to import. Recipe is added as "Recipes" child node
- Delete recipe: To delete a recipe from project select recipe node in the tree then click "Delete recipe" menu command and answer "OK" to confirm deletion. The same can be done with a right click on the recipe node and selecting "Delete Recipe" from the popup menu.

- Export recipe: Recipes can be exported and saved in .RCP files to be used in other projects. To export a recipe click on the node of the recipe to export then specify the name of the .RCP file in the save dialog box that appears. The same can be done with a right click on the recipe node and selecting "Export Recipe" from the popup menu.
- Copy values to recipe: this command is used to set parameters values shown in the parameters grid of the recipe as the recipe values. Select the recipe node then click on "Copy values to recipe" of the menu.
- Write recipe value: "Write recipe value" command is used to set selected parameter recipe values in the parameter grid e write them.
- Delete parameters from recipe: To delete a parameter from a recipe select the parameter(s) to remove in the grid then click Menu → Delete parameters from recipe command.

4.1.3   Monitor Panel

Monitor panel is useful to continuously monitor a set of parameters (even from different project devices) chosen by user.

Monitor				
Device	Name	Value	Um	Description
Device1	Load Voltage	0.0	V	Load Voltage: RMS value
Device2	Load Voltage	0.0	V	Load Voltage: RMS value

In connection status user can add to monitor panel desired parameters dragging it from one of the parameters grid and dropping it directly into this panel.
Once dropped, the parameter is added to the list of the parameters to monitor and enqueued in the reading list. Each record of the list shows: the device who belongs to, the name of the parameter, the value of the parameter that is cyclically refreshed, the unit of measure of the value and the description of the parameter.
To remove a parameter from the monitor list (and from the queue of the parameters) to read simply select the record of the parameter to delete in the monitor list and press Del button.
The interval between two consecutive readings of the same parameter in the monitor list depends on the number of the parameters to be read by configurator in an entire cycle of readings: if the parameters grid shows 10 parameters and the auto refresh option is enabled, and the monitor panel parameter list has 10 elements, the refresh period of each parameter is equal to the time of 20 readings.

4.1.4   Graph Panel

Graph panel allows you to plot the evolution of the values of a set of variables. Being an asynchronous tool cannot guarantee synchronization of samples.
Graph panel consists of three elements, as shown in the following picture:
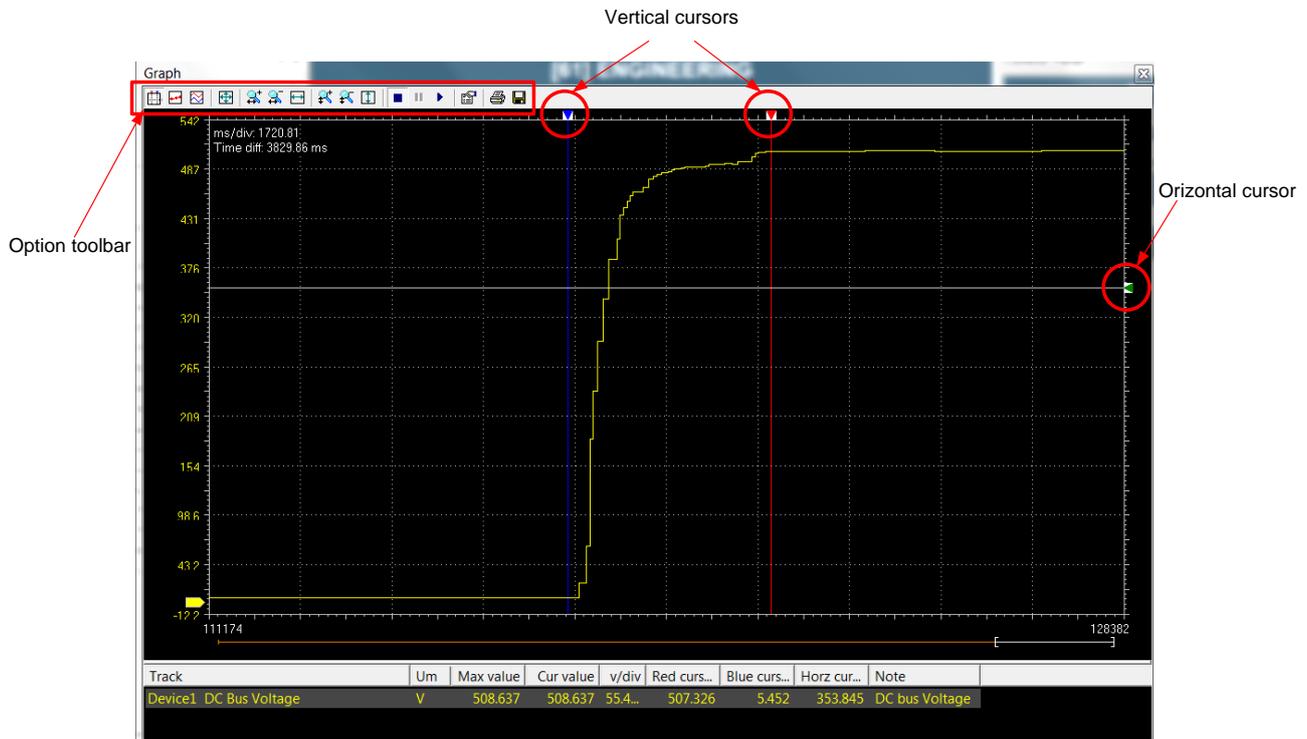
The toolbar allows you to better control the Graph. A detailed description of the function of each control is given later in this chapter.
The chart area includes several items:
- Plot: area containing the curve of the variables

- Vertical cursors: cursors identifying two distinct vertical lines. The values of each variable at the intersection with these lines are reported in the corresponding columns.
- Scroll bar: if the scale of the x-axis is too large to display all the samples in the Plot area, the scroll bar allows you to slide back and forth along the horizontal axis.

The lower section of the Graph is a table consisting of a row for each variable.

4.1.4.1   Add Parameters to Graph

When Configurator is connected user can add to Graph panel desired parameters dragging it from one of the parameters grid and dropping it directly into this panel. Once dropped, the parameter is added to the tracks of the parameters to monitor and queued in the reading list.

4.1.4.2   Remove Parameter from Graphs

To remove a parameter track from Graph (and from the queue of the parameters to read) simply select the track of the parameter to delete in the tracks table and press Del button.

4.1.4.3   Controlling Data Acquisition

The Graph includes a toolbar with several commands, which can be used to control the acquisition process and the way data are displayed. This paragraph focuses on these commands. Note that all the commands in the toolbar are disabled if no variable has been added to the Graph.

4.1.5   Control Panel

The control panel is an interface to control the drive directly from SDM.

WARNING! Ignoring the instructions reported in HARDWARE MANUAL could lead to physical injury or death and additionally damage the drive and/or equipment.
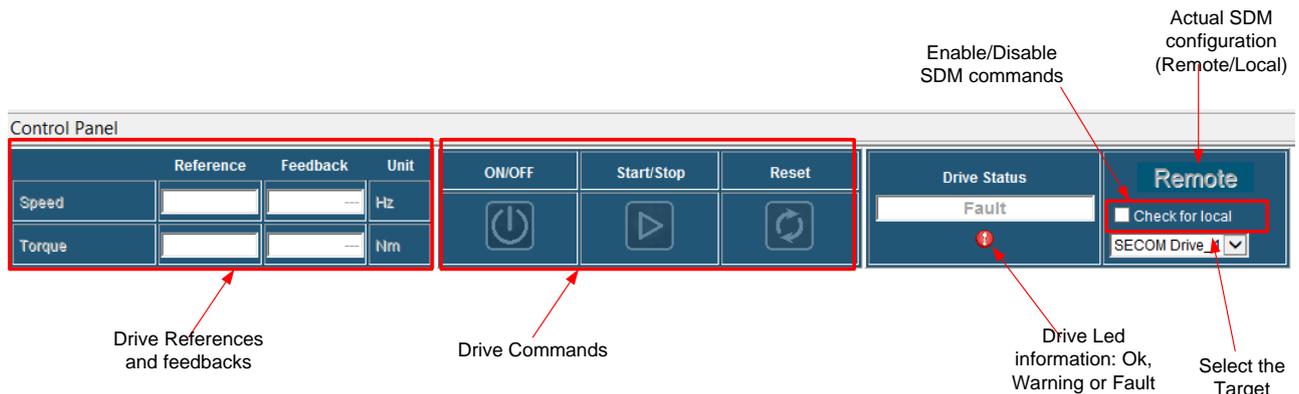
When the check for manual checkbox is checked the other reference commands are overridden from the SDM references. The SDM in this case write the MCW bit in this manner:

MCW Bit number	Button connection
0	SDM ON/OFF button
1	1
2	1
3	SDM Start/Stop button
4	1
5	1
6	1
7	SDM Reset button
8/15	0

The auxiliary Reset, OFF1, OFF2 and OFF3 are still working.
When the SDM control is enable the command buttons became colored (green or red) and it is possible to control the drive directly from control panel.

The reference and feedback signal are depending on the load and the selected control type as shown in the following table:

Load Type	Control Type	Ref 1 / Fdk1	Ref2 / Fdk2
Unknown	---	---	---
IM	FOC or SLS	Speed [rpm]	Torque [Nm]
	V/Hz	Speed [Hz]	---
GRID	AFE	DcBus Voltage [V]	React Current [A] or React Power [kVA] depending on *[4821]*
	F3E	---	---
	Vac Gen	Ac voltage [V]	Frequency [Hz]

Tab. 4-1: reference table variables vs load/control type

To set references values it is necessary to write the number in the white space under "reference" and press Enter.
When the target is disconnected and check for manual is still checked in case of a new connection (Connected mode) without quit the SDM project it is necessary to uncheck manually the "Check for manual" checkbox before other operations.
The control panel can be resized in order to fit to different windows spaces as in the picture below:
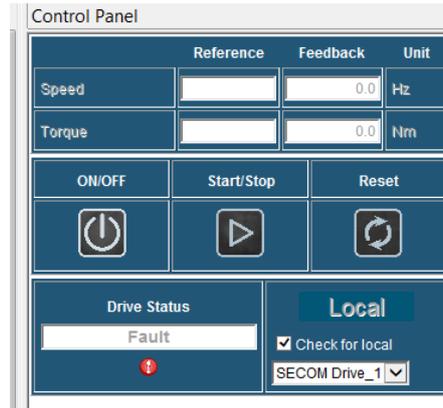
4.1.6 File Comparison

It is possible to compare different target in order to check which parameters has been changed. In this case the procedure is the following:
- Connect to the first target and click on read all parameters then save the SDM project (i.e. Project1.sdm)
- Connect to the second target and click on read all parameters then save the SDM project (i.e. Project2.dsm)
- Open one of the two project (without connecting) and click on service→ file comparison
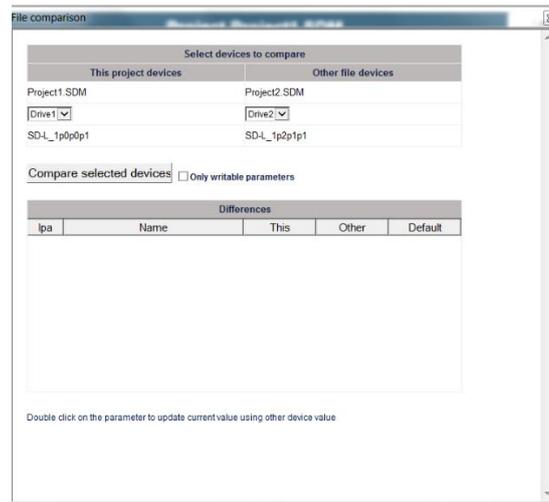
- Check "only writable parameters" if you want only see the writable paramters and than click on comparae selected devices button obtaining the figure below
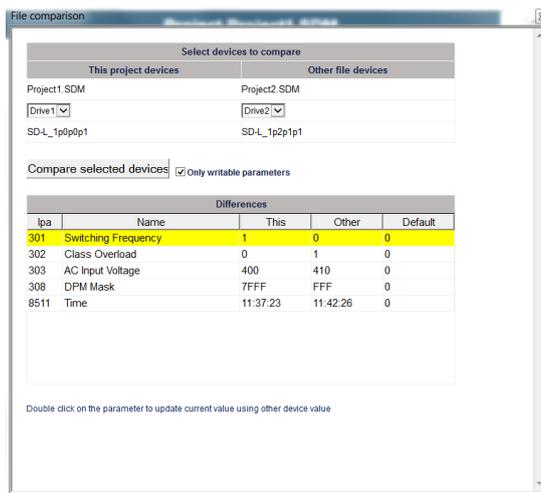
4.1.7 SoftScope

SoftScope is a real time graph that allows you to plot evolution up to 8 variables selected in the drive. The sample time is synchronous to the control routine and related to the switching frequency selected **[0301]**. It is possible also to save and load the evolution of the variables.

The relationship between the switching frequency and the sampling time is $T_s = {^2}/{f_{sw}}$ where T_s is declared in seconds and f_{sw} in Hz.

It is possible to access to softscope in two different ways:

- Directly opening to SoftScope icon on the windows application bar (in this case it is necessary to set the IP address of the target)
- Opening Softscope from SDM by clicking on Service→Open with Softscope. In this case, the Softscope is automatically connected with the same target of SDM is.
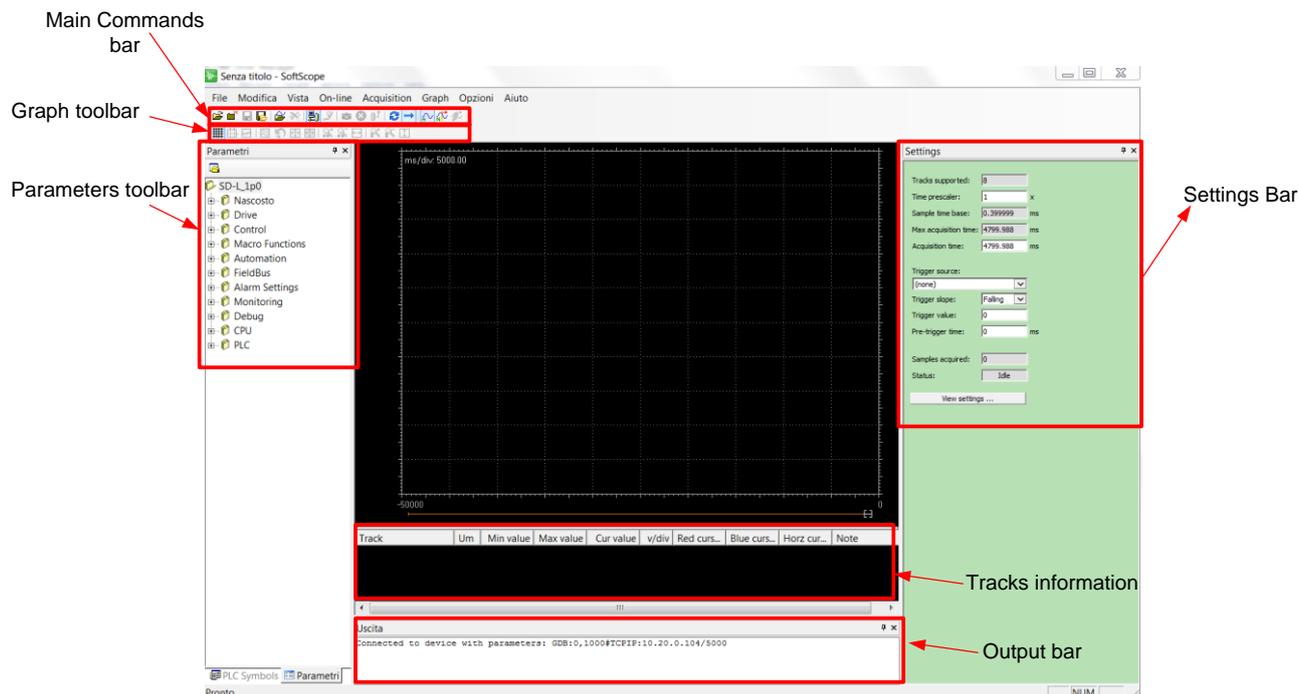
In the picture above it is showed all the components of the SoftScope. The function of these components will be described in the following paragraphs.

4.1.7.1 Parameters Toolbar

The parameters toolbar allows you to drag and drop parameters to the graph.
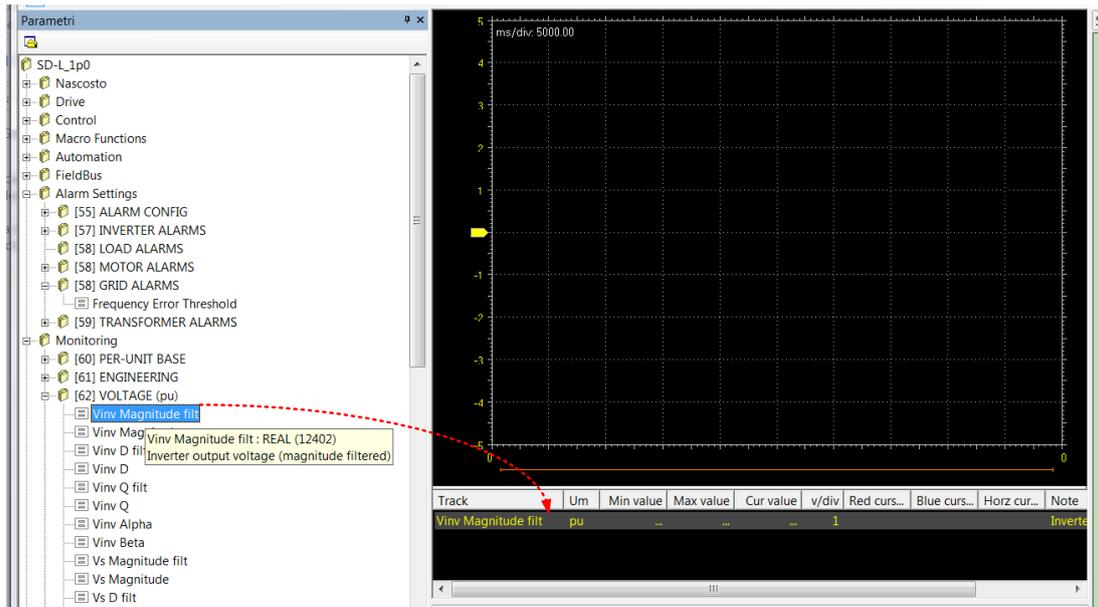
If the mouse pointer is close to the variable it is possible to see advanced information as in the figure above. It is also possible to use the drag and drop function from SDM parameter list to SoftScope.

4.1.7.2 Settings Bar

The setting bar helps the user to customize the sample time and the trigger settings. The total amount of the recordable samples are 12000.
This number is divided by the number of the selected tracks (max 8). The sampling time can be increased by a time prescaler in order to increase the maximum acquisition time. In the picture below is showed an example with 1250Hz of switching frequency ($T_s = 400\mu s$), time prescaler = 2 and three selected tracks.
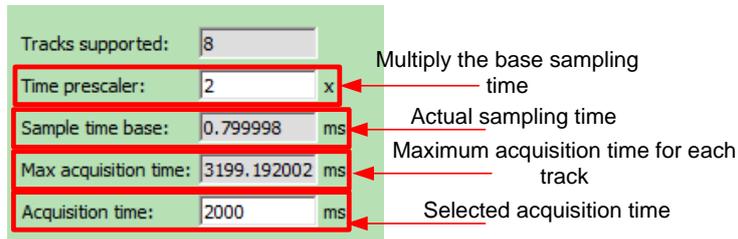
In the second part of the setting bar, there are the trigger settings. The trigger input is selectable among the chosen tracks and it is possible to set also the trigger slope (rising or falling), trigger value and pretrigger-time.
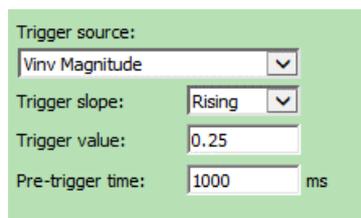
In the third part of the setting bar, there are the view setting (track scaling and color configuration) and the trigger status. The trigger status could be:
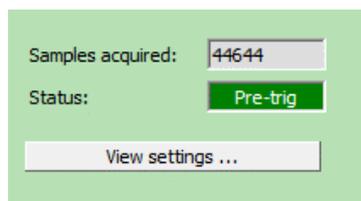
- Pre-trig: SoftScope is waiting for trigger condition
- Triggered: SoftScope is triggered
- Acquiring: SoftScope is acquiring sampled values
- Idle: Softscope acquired sample values
- Stopped: Softscope is stopped

In the picture below is showed an example of triggering.

Track	Um	Min value	Max value	Cur value	v/div	Red curs...	Blue curs...	Horz cur...	Note
Vinv Magnitude	pu	0.678	0.873	0.720	0.2				Inverter output voltage (magnitude not fi...
Iinv Magnitude	pu	0.247	0.426	0.386	0.2				Inverter output current (magnitude not fil...
Speed Fdb	pu	0.370	0.400	0.376	0.2				Speed (or frequency) Feedback extimed ...
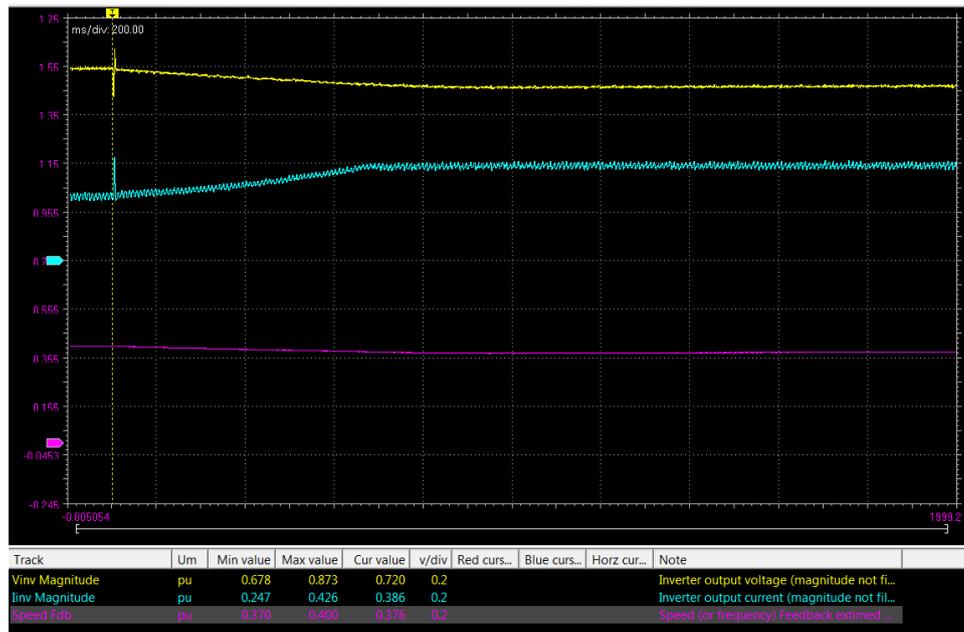
4.1.7.3   Main Commands Bar

The main commands bar allow to connect to the target and to select the type of acquisition mode. After connecting to the target (connect button), it is possible to add the variable to the track list/information.

After choosing the proper trigger setting in the settings bar, it is possible to start the acquisition by clicking on Run acquisition button .

It is possible to have continuous capture or single capture . It is also possible to have auto trigger mode (the acquisition start without any trigger) or normal trigger mode (the acquisition starts only if the trigger constrains are fulfilled) .
It is possible to save the current graph with *.SSC extension by clicking on File→Export tracks. The saved graph can be loaded by clicking on File→Load offline tracks.

4.1.7.4   Graph Toolbar

This toolbar is useful to make calculation in the graph windows. It is possible to zoom-in, zoom-out, stretch or compress the plot.
The Graph includes two measure bars, which can be exploited to take some measures on the chart; in order to show and hide them, click on the Show measure bars item in the Graph toolbar.
If you want to measure a time interval between two events, you just have to move one bar to the point in the graph that corresponds to the first event and the other to the point that corresponds to the second one. The time difference is shown on top left corner "time diff".
By moving the red and blue measure bars, it is possible to see the tracks value in the table below the chart (track information).

Track	Um	Min value	Max value	Cur value	v/div	Red curs...	Blue curs...	Horz cur...	Note
Vinv Magnitude	pu	0.677	0.870	0.724	0.02...	0.720	0.725	0.773	Inverter output voltage (magnitude not fi...
Iinv Magnitude	pu	0.247	0.422	0.388	0.02...	0.395	0.388	0.335	Inverter output current (magnitude not fil...
Speed Fdb	pu	0.370	0.400	0.376	0.00...	0.371	0.374	0.385	Speed (or frequency) Feedback extimed ...
Is D	pu	0.247	0.333	0.256	0.25...	0.261	0.255	-3.705	Load current D axis
Is Q	pu	-0.308	0.013	-0.292	0.04...	-0.296	-0.292	-0.147	Load current Q axis

4.1.8   Install a New Catalog in the SDM

The catalog can be installed in two different ways:
- Catalog installation from target (it is necessary the target presence). This features assures that the catalog is correct according to the connected target.
- Catalog installation from an file (it is not necessary the target presence)

4.1.8.1   Catalog installation from target

This feature is possible only if the target is present and switched-on. In this case, the target contains a copy of the catalog of the proper version. To install it in the SDM/SDLE it is necessary to:
- Close SDLE if it is opened
- Open SDM and select an available catalog and connect it to the target
- If the catalog version is different from the target a message window will be showed (it is possible to see the target catalog version)
- Click on Catalog→Install catalog from target and wait the installing procedure
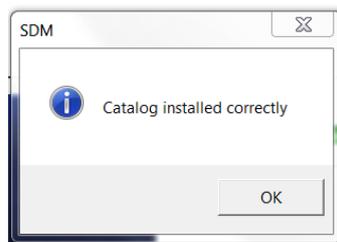
- Then it is possible to see all the catalog installed when a new SDM project is opened by clicking on Catalog→Show all version in catalog

4.1.8.2   Catalog installation from a file

This feature is possible even if the target is not present (i.e. for service/assistance purpose). In this case, it is necessary to have the catalog file (zip archive type).
- Open SDM
- Click on Catalog→Install Catalog from file
- Select the Catalog archive and wait to complete the catalog installation
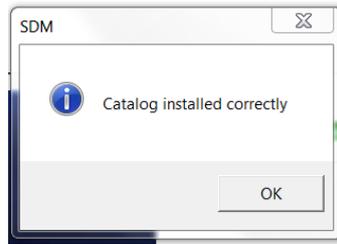
- Then it is possible to see all the catalog installed when a new SDM project is opened by clicking on Catalog→Show all version in catalog

4.2 SDLE

SDLE (SECOM Drive Logic Environment) or LogicLab is an IEC61131-3 Integrated Development Environment supporting the whole range of languages defined in the standard. In order to support the user in all the activities involved in the development of an application, LogicLab includes:

- textual source code editors for the Instruction List (briefly, IL) and Structured Text (briefly, ST) programming languages
- graphical source code editors for the Ladder Diagram (briefly, LD), Function Block Diagram (briefly, FBD), and Sequential Function Chart (briefly, SFC) programming languages
- a compiler, which translates applications written according to the IEC standard directly into machine code, avoiding the need for a run-time interpreter, thus making the program execution as fast as possible
- a communication system which allows the download of the application to the target environment
- a rich set of debugging tools, ranging from an easy-to-use watch window to more powerful tools, which allows the sampling of fast changing data directly on the target environment, ensuring the information is accurate and reliable
- interact with the Control program as described in 4.1.

The complete SDLE description can be found on the SECOM Drive Logic environment help[65]. In this chapter will be showed the special functionalities developed for SECOM Drive.
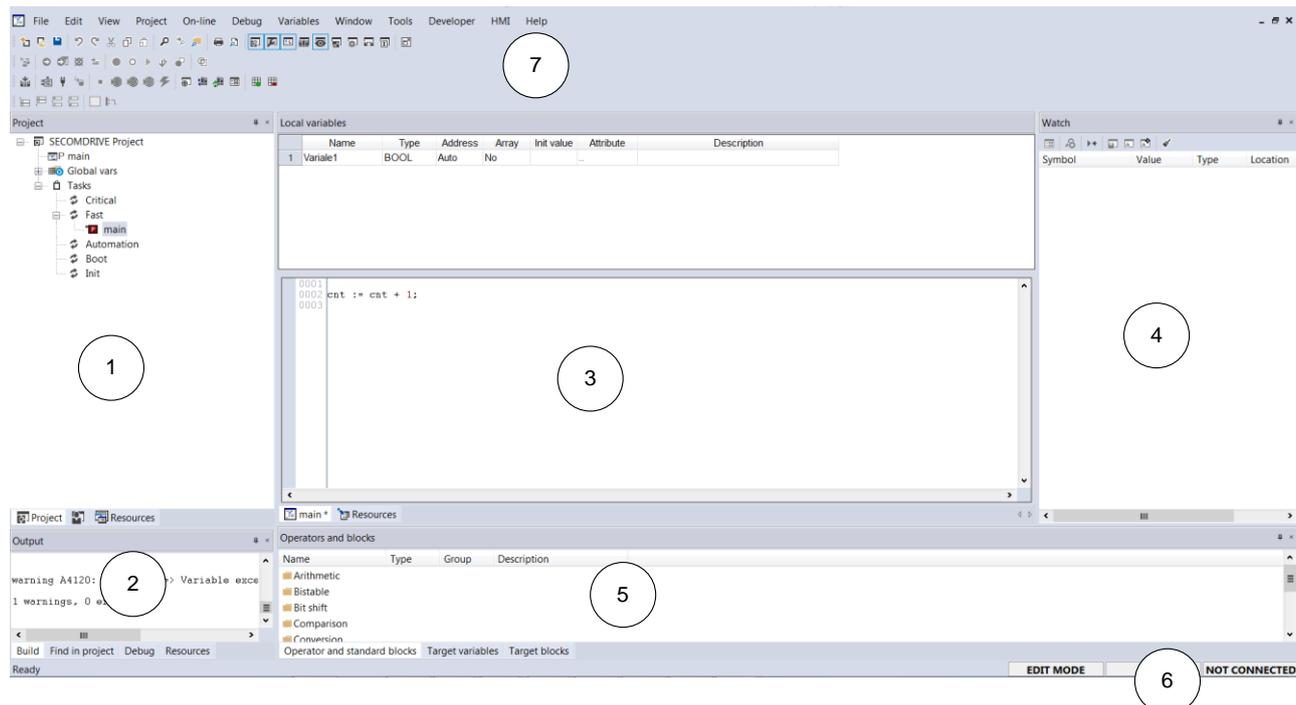
Fig. 4-1: SDLE workspace: 1. Workspace windows 2. Output window 3. Source code editors 4. Watch window 5. Library window 6. Status bar 7. Document bar

4.2.1 Create a Project in SDLE

To open a new project on the SDLE it is necessary to follow these rules:

- Click on new project (as shown in the figure below)

---

[65] Open SDLE click on Help→Index
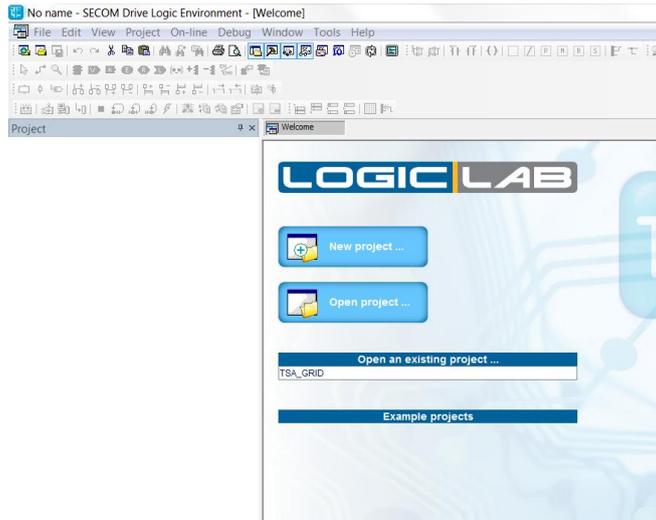
- Fill the black spaces in the new windows and select the catalog version
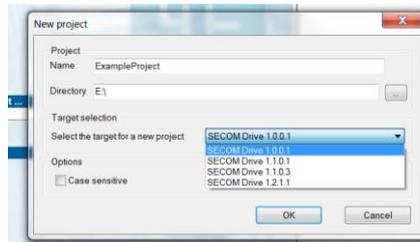
The catalog version must be the same of the package software version in the target. The value is contained in the parameter *SECOMDrive Version **[7601]***. After selecting the version press ok button. The catalog also contains the address mapping between the PLC and the control variables. A different catalog can have different variable address mapping.
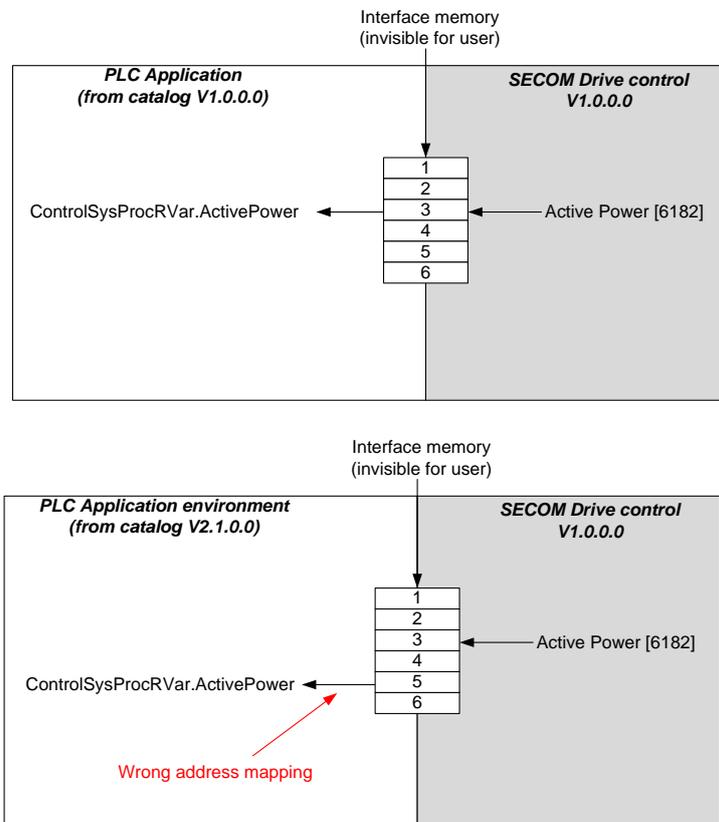
Fig. 4-2: Example of wrong interface by using same PLC Project coming from different Catalog versions

- Connect to the target by clicking on the connection icon. If the project catalog version if different from the target one a message will be showed as in the figure below. In this case press "NO" ad follow the procedure described in 4.2.2.
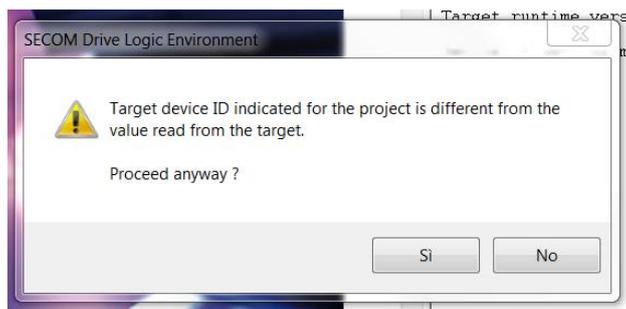
The PLC project created with different catalogs versions must be avoided in order to have unexpected behavior.

4.2.2 Upgrade/Downgrade the PLC Project to another SECOM Drive Version

This feature can be useful when it is necessary to convert a PLC project with a new catalog version. It must be take into consideration that this procedure can be made only if the variable names are maintained.
The procedure is described below:
- Open the PLC project. It is necessary that the catalog version of this project must be present in the catalog folder of SDM.
- Click on Project→Select target and select the new target version in the available version. It is necessary that the desired catalog version must be correctly installed in the SDM.
- In this case the project has been configure to be compatible with the selected target version.

A project cannot be compatible with more than one version at the same time.

4.2.3 Task Description

It is possible to link the program created to one of the task displayed in the workspace window→project. In this case the code of the linked program will be executed at the time period of the task.
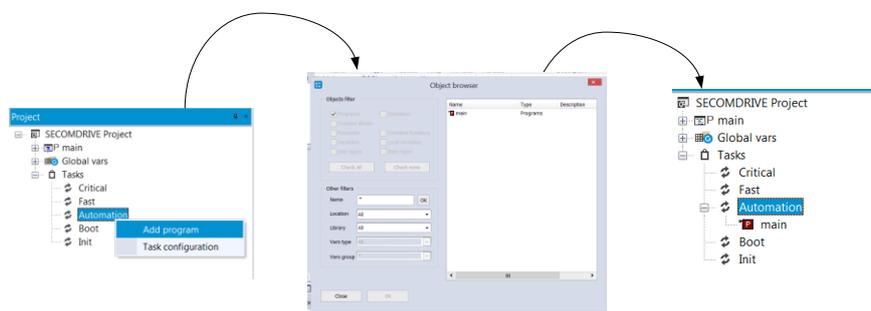
Fig. 4-3: How to link a program to a task

There are 5 task:
- *Critical*: this is the highest priority task (periodic) and it is depending on the switching frequency and it is cyclic
- *Fast*: this is 1 ms periodic task
- *Automation*: this is a 10 ms periodic task
- *Boot*: this task it is executed once at the board switch-on
- *Init*: this task it is executed once at the board switch-on or PLC download

4.2.4 Add/modify PLC parameters database

When a PLC application is developed, it could be useful to define parameters and status variables. The only difference between parameters and status variables is that the second one doesn't maintain the value when the drive is switched off (no retain function).
It is possible to show these parameters in the SDM or in the SD-OP.
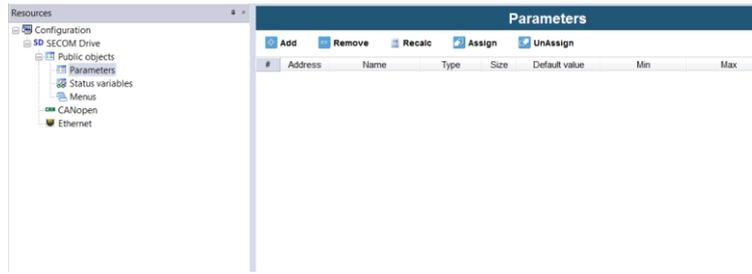
Fig. 4-4: Parameters database creation

In the following paragraph will be described the procedure how to create parameters/status variables in the PLC application.
- Go to resource window
- If you want to add a parameters click on parameter icon and then "add" in the windows on the right (see Fig. 4-4). It is possible to create a new variable or "assign" to an existing one. It is possible to set additional fields as showed in the figure below (default value, min, max, description). These fields will be visible in the SDM or SD-OP.
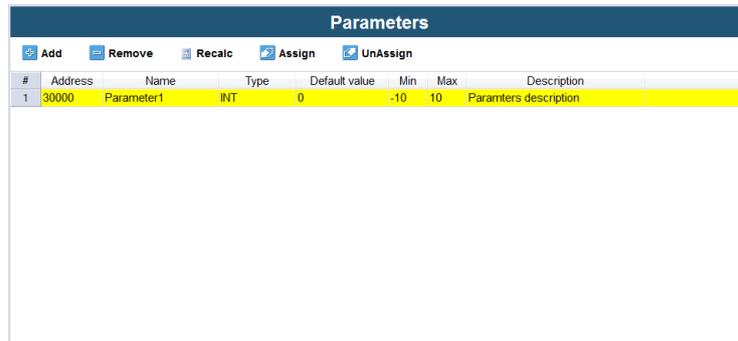
- If you want to add a status variable click on status variable icon and then "add" in the windows on the right. It is possible to create a new variable or "assign" to an existing one. It is possible to set additional fields as showed in the figure below (default value, min, max, description). It is also possible to define this variable as read only or read/write by using Read Only field. These fields will be visible in the SDM or SD-OP.
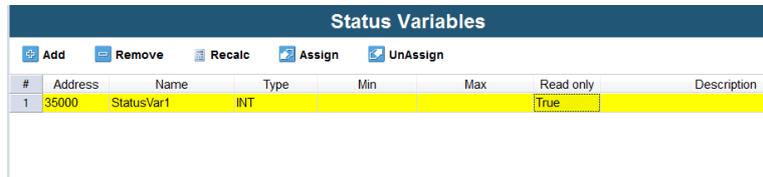
- After creating parameters or status variable list, it is possible to assign them to a menu that can be personalized by adding other branches to the main tree.
- Right click on menu icon to add a new branch (it is possible to change its xname after creating a branch).
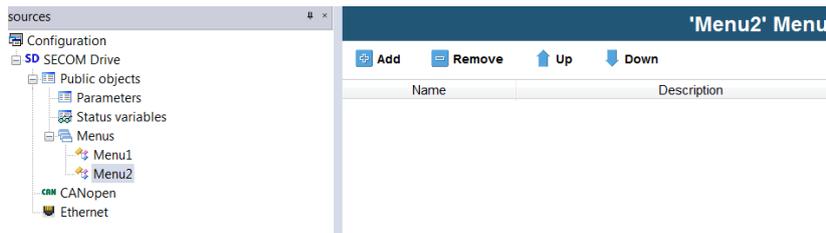
- Then, on the right window click on add and chose the item among the available ones.

- After compiling and downloading the PLC software in the drive, it is possible to see the PLC parameter in the SDM by clicking on Developer→Open with SECOM Drive Manager.
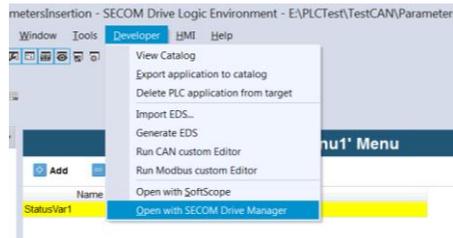
- In the SDM, under the Application icon is possible to see the PLC parameter tree[66]. If you have not access to the SDLE source program, it is necessary to save a SDM project
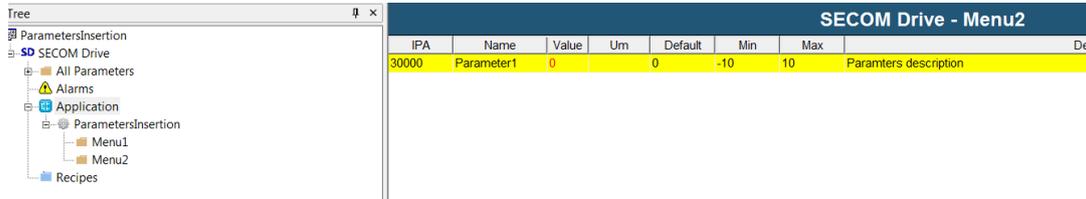
- To see the PLC parameters in the SD-OP it is necessary to connect to the drive and then click on HIM→Download HMI application. Refers to SD-OP paragraph to how to access to these parameters.

4.2.5 Operators and Blocks

SDLE is a powerful PLC that can exchange data at high speed rate. It is possible to see the common variables with the control system by accessing to library window→Secom Interface block and target block.
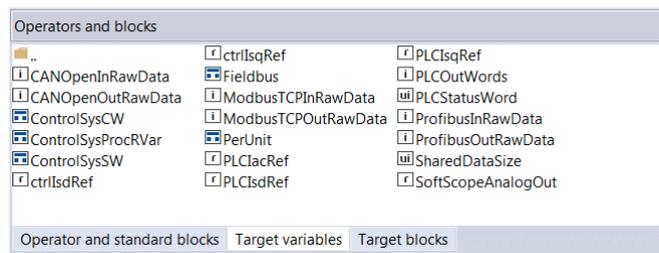
Each task can recall a program written in SDLE in different type of languages (IL, FBD, LD, ST, SFC). The interface between the PLC and the control system is made by using variables, structured variables and functions and they are called *Datablocks*.
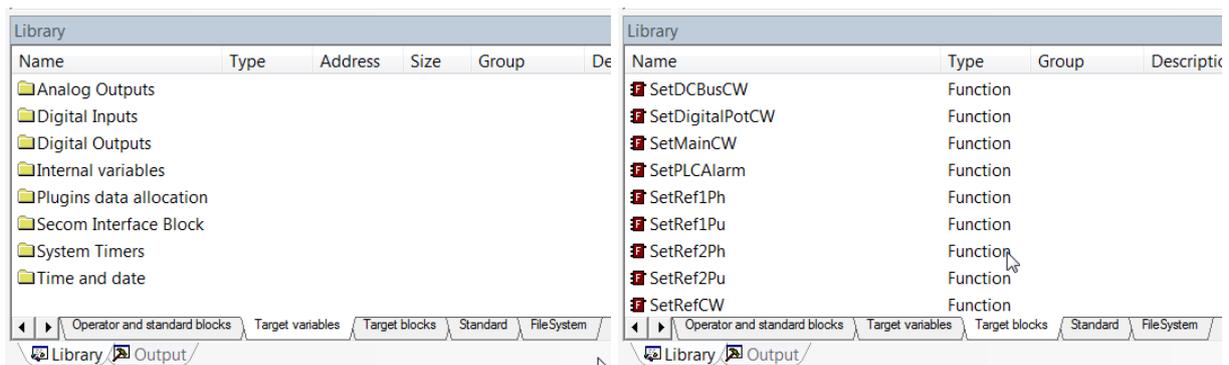
Fig. 4-5: DataBlocks in SDLE

The main structure is described in Tab. 4-2. The variables (read only) are mapped to the PLC memory by using data block. In this case, it is possible to read in real time mode these objects (current, voltage, speed, etc.).

---

[66] To upload/modify the plc parameters it is necessary to download the application
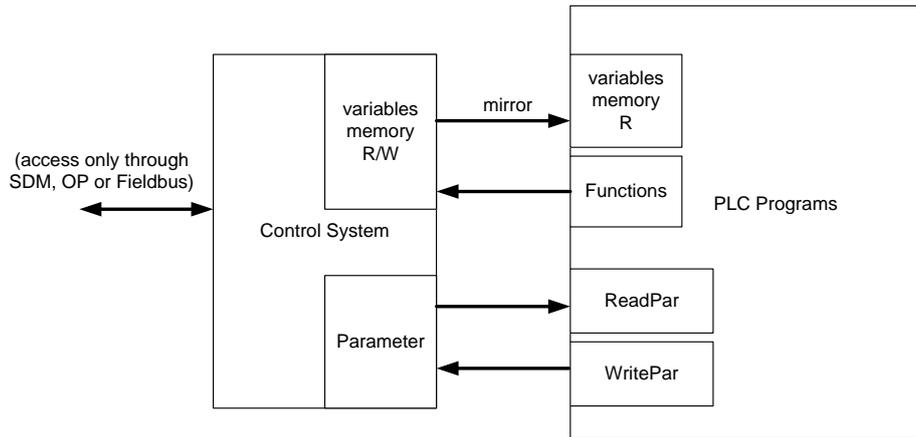
Fig. 4-6: SDLE interface with Control firmware

It is necessary to use functions or dedicated variables (in target block window) to write/read variables in real time mode (torque limits, setpoints, CW, etc.).

The dedicated variable (called datablocks) allow to read/write directly the control system variable without any delay. In the table below is shown the list of them. The datablock can be a simple variable or a complex one like a data structure.

Name	Type
ControlSysProcRVar	Read only structure
ControlSysCW	Read only structure
ControlSysSW	Read only structure
Fieldbus	Read only structure
PerUnit	Read only structure
CANOpenInRawData	Read only array
CANOpenOutRawData	Read only array
ProfibusInRawData	Read only array
ProfibusOutRawData	Read only array
ModbusTCPInRawData	Read only array
ModbusTCPInRawData	Read only array
PLCIacRef	Read/Write float
PLCOutWords	Read/Write array
SoftScopeAnalogOut	Read Array (Reserved)

Tab. 4-2: Datablock Structure

ControlSysProcRVar: it is a complex data structure[67] where are located all the important control variables of the control system. The structure can be shown in target blocks/ControlRead as shown in Fig. 4-7.

Fig. 4-7: SDLE ControlRead structure

In this complex structure there are also different types of structure as:

- **LPf1** (low pass filter structure) where *In* and *Out* rappresent the input/output of the filter. In this case if for example you want to see input and output of the VdcFilt you have to read *ControlSysProcRVar.VdcFilt.In* and *ControlSysProcRVar.VdcFilt.Out*. In the description is also reported the connected parameter in SDM (shown in the figure below).

---

[67] Complex data structure is defined as a nested data structure where can be located different type of variables/structures.

- **PARK** (Park transformation structure) where D and Q represent the components of the Park transformation.
- ***ControlSysCW*** and ***ControlSysSW***: it is a data structure composed by all the CS command and status words[68] like DC-BusCW, ReferenceCW, DC-BusSW.
- ***Fieldbus***: it is a complex nested data structure composed by all the CS variables located in *[74] FIELDBUS*. In the figure below is shown an example of this structure.
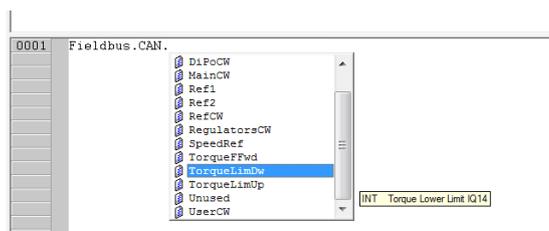
- ***PerUnit***: it is data structure composed all the per-unit reference value of the CS system.
- ***CANOpenInRawData*** and ***CANOpenOutRawData***: these are two arrays of 32 elements each. It is possible to read all the word in input/output of the CANOpen Slave regarding the process image.
- ***ModbusTCPInRawData*** and ***ModbusTCPOutRawData***: these are two arrays of 16 elements each. It is possible to read all the words in input/output of the CANOpen Slave.
- ***ProfibusInRawData*** and ***ProfibusOutRawData***: these are two arrays of 32 element each. It is possibile to read all the words in input/output of the Profibus slave.
- ***PLClacRef***: it is a reference current in case of short circuit control (e.g. Vac generator).
- ***PLCOutWords***: it is a 32 element array used to send data to CS. It is possible to use these elements through *IPA.Bit* addressing.

In the following table are showed all the functions used to send data to CS. The subscript *X* defines as the function send data to CS. *Pu* function sends directly the data directly to the CS (it means that the data is already scaled according to its pu value). *Ph* function sends the send data to the CS after scaling it according to the second input *Base Value*.
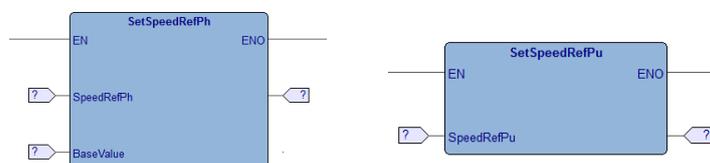
Fig. 4-8: PLC analog reference functions

	Name	Description
	SetSpeedRef*X*	Speed reference
	SetTorqueLimDw*X*	Torque Limit (Down)
	SetTorqueLimUp*X*	Torque Limit (Up)
Analog Reference	SetTorqueRef*X*	Torque Reference
	SetAddSpeed*X*	Additional Speed
	SetRef1*X*	Reference 1 (for electrical ref)
	SetRef2*X*	Reference 2 (for electrical ref)
	SetMainCW	MainCW
	SetDCBusCW	Dc-BusCW
Digital Reference	SetDigitalPotCW	Digital potentiometer CW
	SetUserCW	User CW[69]
	SetPLCAlarm	Used to send alarms (warning, OFF1, OFF2 and OFF3) to CS from PLC

The *SetPLCAlarm* can be used to create warning or fault from PLC. The block function is showed in the figure below.

---

[68] These parameters are located on [70] CW-SW
[69] There is an User CW for each fieldbus (CAN Slave, Modbus TCP Slave, Profibus Slave) and one for PLC. These words can be used for IPA.bit addressing
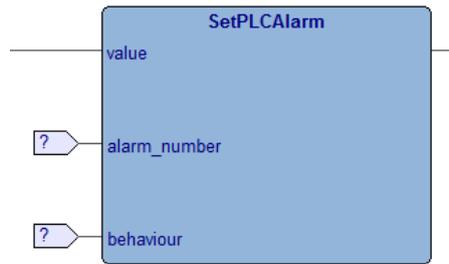
Fig. 4-9: SetPLCAlarm function

It is possible to set up to 4 alarm type by using behavior field:
- Disabled [0]
- Warning [1]
- Fault OFF1 (ramp stop) [2]
- Fault OFF2 (coast stop) [3]
- Fault OFF3 (quick stop) [4]

It is possible to set up to 800 PLC alarms by using alarm number field. This alarm is also showed in SDM as "PLC alarm X: PLC alarm actived" where X is the PLC alarm number. The PLC alarm number it is related to the CTRL/PLC FAULT WORD [72] if the behavior field is higher than warning and CTRL/PLC WARN WORD [73] on the contrary.

If the warning behavior is selected the alarm number follows this rule:

$$PLC\,AlarmWord.bit = integer\,(1 + alarm\,number\,/16).remainder\,(alarm\,number\,/16)$$

Example

You suppose to configure the alarm number 236. The PLC AlarmWord.bit related to this number is AlarmWord11.12.

■

Once the alarm number and behavior fields are configured, when this fault/alarm must be active the value field must be set to true.

In case of warning configuration, when the value field is set to false again the warning disappears, instead if it is configured as fault also when the value field is set to false the fault remains. It is necessary a rising edge in the acknowledge fault signal.

Example

This example shows how to configure the alarm number 400 as Fault OFF1. It is necessary to:
- Set alarm number = 400
- Set behaviour = 2

In this case, when there is a rising edge in the value field a fault is generated through the PLC Fault Word 26.00 [7235.00].

■

Example

This example shows how to configure the alarm number 125 as Warning. It is necessary to:
- Set alarm number = 125
- Set behaviour = 1

In this case, when the value field is true a warning is generated through the PLC Warn Word 8.13 [7317.13].

■

It also possible to write/read all the parameters visible in the SDM. In this case it is necessary to use additional functions called:
- *DatabaseSys_ReadParameter*
- *DatabaseSys_WriteParameter*

WARNING! These two function[70] can be used only in Automation task and it is recommended to avoid continuous reading/writing.

Input / output	Pin name	description
Input (UINT type)	idx	Modbus address of parameter to read/write[71]
Input (UDINT type)	buf	Address of the PLC variable where the value will be stored or where there is the value to write (Variable address can be calculated by using ADR() function). Pay attention when it works with variable address! The software can become unstable because an erroneous address access.
Input (UDINT type)	bufLen	Size in byte of the parameter to read/write (INT = 2 bytes, REAL = 4 bytes, DINT = 4 bytes, UINT = 4 bytes, WORD = 2 bytes, DWORD = 4 bytes)
Output (DBResult Type)	out	Return value of the operation

Tab. 4-3: DatabaseSys_ReadParameter ports

The *DBResult* is an enumerative type and the meaning is described in the table below:

Name	Value	Description
DB_E_OK	0	Parameter read/write correctly

---

[70] These functions can be found in *library/target blocks*

[71] The Modbus address of parameter is described in 3.3.16.2.2

Name	Value	Description
DB_E_NO_IPA	1	IPA not found in the database
DB_E_SYSERR	2	Generic System Error
DB_E_TYPE	3	Invalid type specified or value outside the type
DB_E_READONLY	4	Can not write ready-only parameter
DB_E_NOTWRITENOW	5	Can not write this parameter now (e.g. invalid access mask)
DB_E_MINVAL	6	Value below minimum value
DB_E_MAXVAL	7	Value above maximum value
DB_E_INVALIDBUFFER	10	Specified buffer too small
DB_E_OK_WRITTEN	255	OK, value already written

Tab. 4-4: DBResult enumerator meaning

Example

This example shows how to read parameter *AC Input Voltage [0303]* using PLC function *DatabaseSys_ReadParameter*. AC input voltage is a real type and in this case it is necessary to declare a variable in the PLC of the same type. We call it *ACInVoltPLC*. Insert the *DatabaseSys_ReadParam* in the program linked to Automation Task or Init task and set the following fields:

- Idx = 606 (2*IPA)
- Buf = ADR(ACInVoltPLC)
- BufLen = 4

In ACInVoltPLC will automatically copied the [0303] parameter value

■

Example

This example shows how to write parameter *Ramp 1 acceleration time [4714]* using the PLC function *DatabaseSys_WriteParameter*. *Ramp 1 acceleration time* is a real type and it is necessary to declare a variable in the PLC of the same type. We call it *Ramp1AccTimePLC*. Insert the *DatabaseSys_WriteParam* in the program linked to Automation Task or Init task and set the following fields:

- Idx = 9428 (2*IPA)
- Buf = ADR(Ramp1AccTimePLC)
- BufLen = 4

In this case whatever value will be written in *Ramp1AccTimePLC* will be copied in the parameter *[4714]* (if the writing conditions are fulfilled).
It is also necessary to avoid continue writing and a "single shot" write must be implemented. In the following picture is showed an example by using TP function (Pulse Creator). Every time there is a rising edge on the variable ParameterWriteReq will be only one write on the parameter inside the "if construct".
■

4.2.6   CAN-Open master configuration

In the workspace window→resources left click on "CANopen" and check Modbus TCP master.

Example

It is supposed to expand the I/O of the system by adding 6 remote I/O modules (only digital type).
It is supposed to use these components:

- Bus Coupler Beckhoff LC5110[72]
- Digital Input Beckhoff KL1508 (8 inputs)
- Digital Input Beckhoff KL1508 (8 inputs)
- Relay Output Beckhoff KL2612 (2 outputs)
- Relay Output Beckhoff KL2612 (2 outputs)
- Bus End terminal Beckhoff KL9010[73]

First of all, it is necessary to connect property the hardware components:

- Connect and switch-on all the boards
- Check if the K-bus led is ok in the LC5100 (C must be green and steady). If it is not, check if the modules are properly connected each others and the input supply
- Check if there are no I/O error in the LC5100 (D is switched off and not blinking). If it is not, check if CAN wiring are correct and if all modules are switched on and the bus end terminal is connected. If the bus end terminal is inserted subsequently it is necessary to switch-off and swich-on again the bus coupler module
- If the master is configured correctly the RUN led (A) is switched on and steady. If it is blinking (approx. 200 ms on, 200 ms off) it means that the master must be configured.

Now it is possible to configure the software by using SDLE:

- Open SDLE project or create a new one

---

[72] The Bus coupler can be chosen among different model BK5110, BK5120, BK5150 and LC5100
[73] It is necessary to end the remote I/O block with this module

- In the Resources tab left click on CANopen and select *Mode* = *Master* and *Baud Rate* as it was set in the remote I/O boards
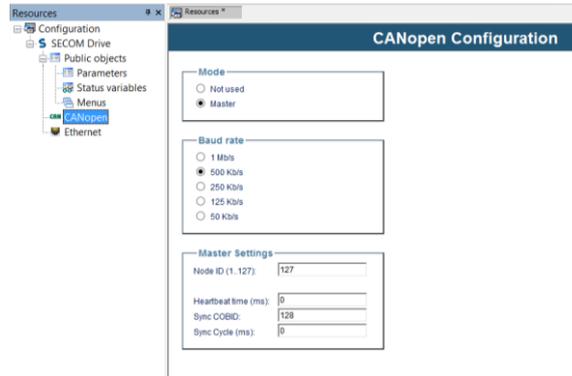
Fig. 4-10: CANOpen node insertion

- Right click again on CANOpen, click on Add and select LC5100 on device catalog . If LC5100 is not present on the Device Catalog, please add this component by using Developer\import EDS (The EDS file can be downloaded from http://www.beckhoff.it/ or can be searched on CAN_EDS folder located on SDM installation path).
- If the device is inserted correctly a new branch (LC5100_1) will appear below CANOpen tree
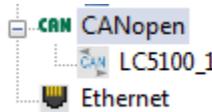
Fig. 4-11: CANOpen node with LC5100

- By clicking on LC5100 a new windows appear called LC5100 Configuration
- Set the node number as it was set in the remote I/O modules
- Uncheck Identity Object Check
- In the PDO Tx-Input windows are shown all the input variables connected to the remote I/O (Digital/Analog Input)
- In the PDO Rx-Output windows are shown all the output variables connected to the remote I/O (Digital/Analog Output)
- The default configuration of LC5100 is composed from 8 digital input and 8 digital output. The object name items are not PLC variables and cannot be written or read. It is necessary to assign them to PLC global variables. As shown in Fig. 4-12 the global variable can be assigned thanks to "*Assign*" button. The window shows all the unassigned global PLC variables.
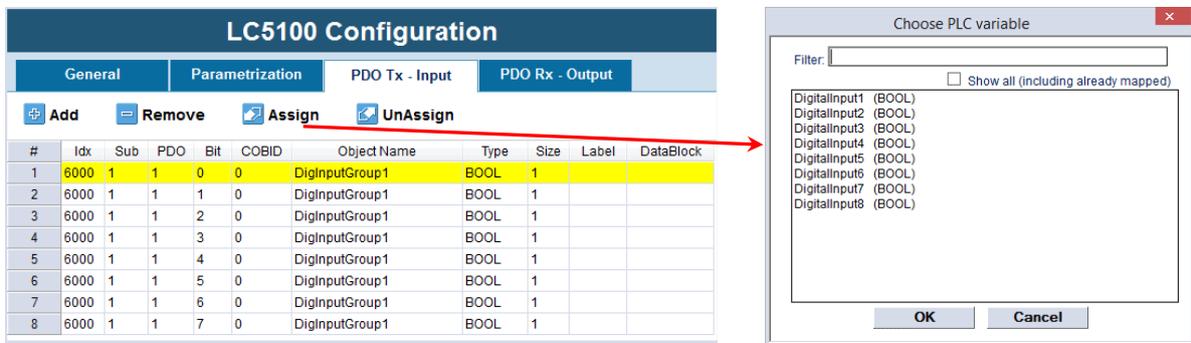
Fig. 4-12: Digital Input variables assign example

- To add further input/outputs according to hardware disposition it is necessary to click to add and select a new object typology (e.g. to add further digital inputs it is necessary to click to "add" button on PDO Tx-input and select from the available digital inputs. The first digital input connected close to bus coupler are 6000.1 and so on).
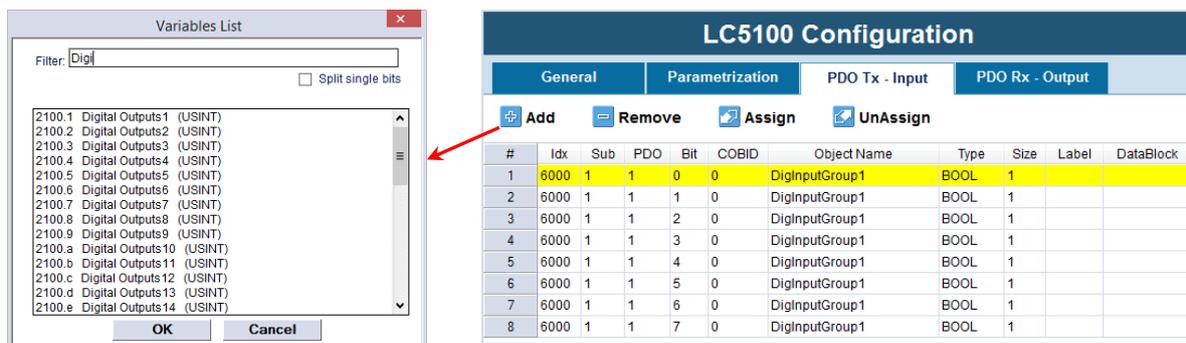
Fig. 4-13: CANOpen Digital Input add window

The same rules described above can be applied to PDO Rx-Output.

- Compile all and download the software.
- If the slave is running the two led A and C are green and steady. It is also possible to check the node status by using COPM library as described in 4.2.6.1 – CANOPen Diagnostic.

■

Example

It is supposed to expand the I/O of the system by adding 6 remote I/O modules (only digital type).
It is supposed to use these components:
- Bus Coupler Beckhoff BK5120
- Digital Input Beckhoff KL1508 (8 inputs)
- Digital Input Beckhoff KL1508 (8 inputs)
- Analog Output Beckhoff KL4002 (2 outputs 0-10V)
- Bus End terminal Beckhoff KL9010

First of all, it is necessary to connect property the hardware components:
- Connect and switch-on all the boards
- Check if the K-bus and power leds are ok in the BK5120 (A and C must be green and steady). If it is not, check if the modules are properly connected and the input supply
- Check if there are no I/O error in the BK5120 (I/O ERR led is off). If it is not, check if CAN wiring are correct, if all modules are switched on and the bus end terminal is connected. If the bus end terminal is inserted subsequently it is necessary to switch-off and swich-on again bus coupler module
- If the master is configured correctly the RUN led is switched on and steady. If it is blinking (approx. 200 ms on, 200 ms off) it means that the master must be configured.

Now it is possible to configure the software by using SDLE:
- Open SDLE project or create a new one (Fig. 4-10)
- In the Resources tab left click on CANopen and select *Mode = Master* and *Baud Rate* as it was set in the remote I/O boards
- Right click again on CANopen, click on Add and select BK5120 on device catalog. If BK5120 is not present on the Device Catalog, please add this component by using Developer\import EDS (The EDS file can be downloaded from http://www.beckhoff.com/ or can be searched on CAN_EDS folder located on SDM installation path).

If the device is inserted correctly a new branch (BK5120_1) will appear below CANopen tree the following icon:

Fig. 4-14: CANopen node with BK5120

- By clicking on BK5120 a new windows appear called BK5120 Configuration
- Set the node number as it was set in the remote I/O modules
- Uncheck Identity Object Check
- In the PDO Tx-Input windows are shown all the input variables connected to the remote I/O (Digital/Analog Input)
- In the PDO Rx-Output windows are shown all the output variables connected to the remote I/O (Digital/Analog Output)
- Add/remove the input/output according to the hardware configuration

■

Special attention must be done when there are:
- Analog inputs/Outputs
- More than 64 digital inputs

Analog inputs (index 6401) must start from PDO 2. When PDO 2 is completed (PDO is composed by 64 bits (4 channel of INT)) it is necessary to use PDO 4 for the others analog inputs. The next will be PDO 6 and so on. The same rule can be utilized for analog outputs. In order to activate the analog input signal it is necessary to set in the parametrization window the "Analogue Input Global interrupt Enable" = TRUE.
The first Digital inputs are located in the PDO 1. If there are more than 64 digital input, it is necessary to use PDO 3. The same rule can be utilized for digital outputs.

Idx	sub	PDO	Bit	Type	Digital Input/Output range
6000/6200	1	1	0	USINT	1-8
	2		8	USINT	9-16
	3		16	USINT	24-17
	4		24	USINT	32-25
	5		32	USINT	40-33
	6		40	USINT	48-41
	7		48	USINT	56-49
	8		56	USINT	64-57
	9	3	0	USINT	72-65
	10		8	USINT	80-73
	11		16	USINT	88-81
	12		24	USINT	96-89
	13		32	USINT	104-97
	14		40	USINT	112-105
	15		48	USINT	120-113
	16		56	USINT	128-121

Tab. 4-5: CANOpen expansion digital I/O

Idx	sub	PDO	Bit	Type	Analog Input/Output
6401/6411	1	2	0	INT	1
	2		16	INT	2
	3		32	INT	3
	4		48	INT	4
	5	4	0	INT	5
	6		16	INT	6
	7		32	INT	7
	8		48	INT	8
	9	6	0	INT	9
	10		16	INT	10
	11		32	INT	11
	12		48	INT	12
	13	8	0	INT	13
	14		16	INT	14
	15		32	INT	15
	16		48	INT	16

Tab. 4-6: CANOpen expansion Analog I/O

4.2.6.1   CANOPen Diagnostic

The diagnostic functions can be loaded into the PLC by adding COPM library in the target (Library manager->add). Once the library is loaded it is necessary to download the PLC software again into target.

After the software is loaded, it is necessary to drag *sysCOPMNodeStatus* in the watch list windows and select the node number. In this case there is only one CANopen node located in 1 position.

Variable name	description	troubleshooting
cfg	Node Configured (True)	
pres	Present and in operation status	If this value is zero the node is not well connected. Check the termination resistance Check the cables
netStat	Status of the node in the network	
	0 → Boot up slave	
	1 → Missing	Check if the node is correct regarding to the hardware configuration or CANopen master configuration Check the cable after checking the points above, if the problem persist reboot PLC by clicking on the flash icon
	4 → Stopped	
	5 → Operational	
	6 → Reset	
	7 → Reset command	
	127 → Pre operation status	
emrgCode	Emergency code	
syncPdoMissCnt	Count of expected sync PDO Tx from node to master missed	
syncPdoMissLast	Last sync PDO Tx expected from node to master missed	

Variable name	description	troubleshooting
BootErr	Boot error code	If it is different from zero check the configuration parameter on general windows (uncheck identity object check)
assigned	Slave node assigned to master network by COPM master configurator	
deviceId	deviceId value read from target	
productCode	Product code value read from target	
revisionNumber	Revision number value read from target	
serialNumber	Serial number value read from target	

Tab. 4-7: CANOpen diagnostic through *sysCOPMNodeStatus* variable

4.2.7 Modbus-TCP master configuration

In the workspace window→resources left click on "Ethernet" and check Modbus TCP master.
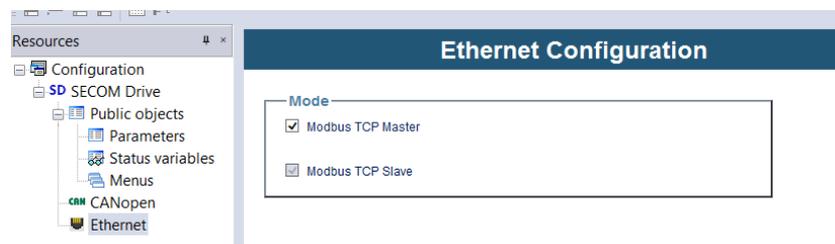
It is possible to add a slave node by right clicking on Ethernet icon and then select generic Modbus item.
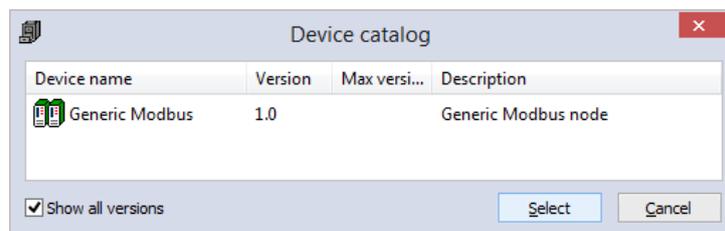
After selecting it, it will be showed a new node on below the Ethernet tree. In this case it is possible to set node parameters in the window as in the example below.
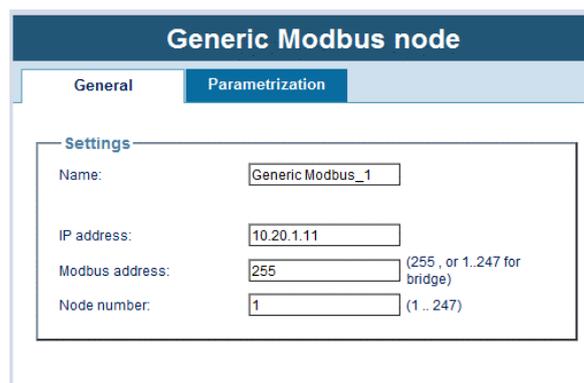
To read or write parameters it is necessary to add respectively **Modbus FC-03** (Read holding registers) or **Modbus FC-16** (write multiple registers). These blocks can be added by right clicking on the generic Modbus node icon.
When Modbus FC-03 is added there are 5 configuration parameters as showed in the figure below.
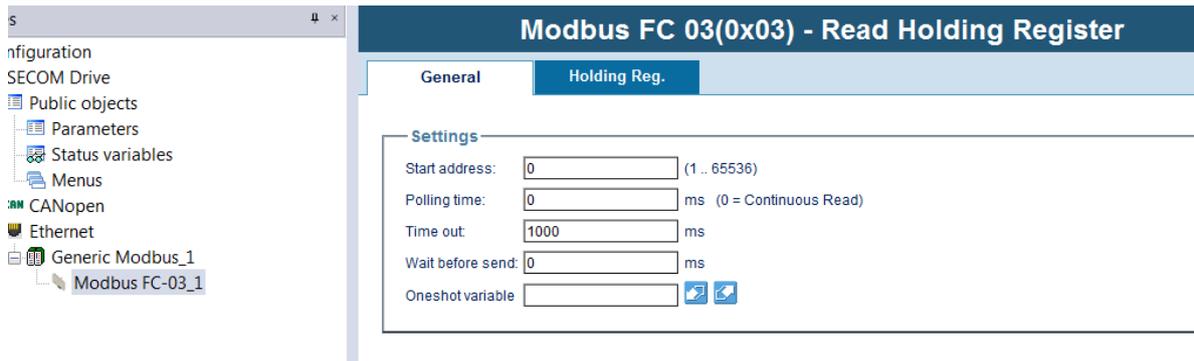
- Start address: Modbus TCP address where you want to start to read the first variable in this block.
- Polling time: if 0 the master reads the slave address at maximum speed otherwise the refresh time is defined (ms)
- Time out: after this time period from the Modbus TCP address request the value is not updated
- Wait before send: not used
- One shot variable: it is possible to link a plc variable. When the variable value is true there is a parameter read. After that, the PLC sets the variable value immediately to false. It is used to read the value by event.

After completing the configuration parameters it is possible to set the registers to read by using the Holding Reg. tab.
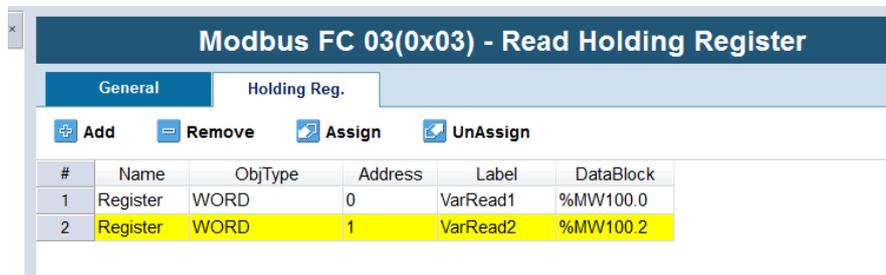
It is possible to add/remove register only if they have consecutives addresses. If the plc variable is already declared it is possible to assign it with the button "assign". It is possible to assign and declare the variable at the same time by writing the variable name in the label column (only for variable undeclared and unassigned).
To read variable with not consecutives addresses it necessary to add several Modbus-FC-03.
When a Modbus FC-16 is added there are 5 configuration parameters as showed in the figure below
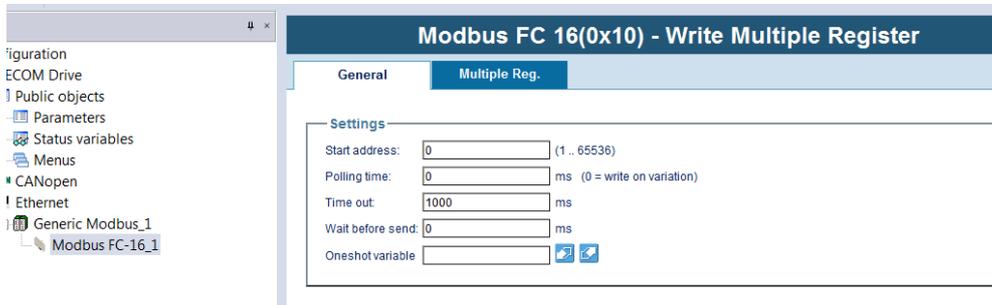
- Start address: Modbus TCP address where you want to start to write the first variable in this block.
- Polling time: if 0 the master writes to the slave address only when a variation in the variable to write is detected. Otherwise refresh time is defined (ms)
- Time out: not used
- Wait before send: not used
- One shot variable: it is possible to link a plc variable. When the variable value is true there is a address write. After that, the PLC sets the variable value immediately to false. It is used to write the value by event.

After completing the configuration parameters it is possible to set the registers to write by using the Multiple Reg. tab.
It is possible to add/remove register only if they have consecutives addresses. If the plc variable is already declared it is possible to assign it with the button "assign". It is possible to assign and declare the variable at the same time by writing the variable name in the label column (only for variable undeclared and unassigned).
To write variable with not consecutives addresses it necessary to add several Modbus-FC-16.

#	Name	ObjType	Address	Label	DataBlock
1	Register	WORD	0	VarWrite1	%MW101.0
2	Register	WORD	1	VarWrite2	%MW101.2
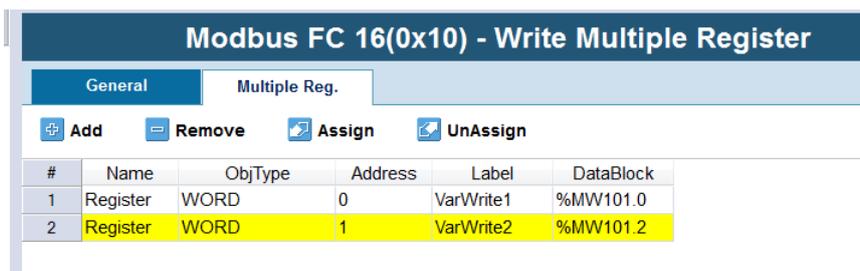
4.2.8   Library Manager

It is possible to increase the PLC functionalities by using library manager tools (project→library manager) including *.lib files.
The library can contain variables, function, structures. It is possible to see what a library contains by view→tool window→library tree.
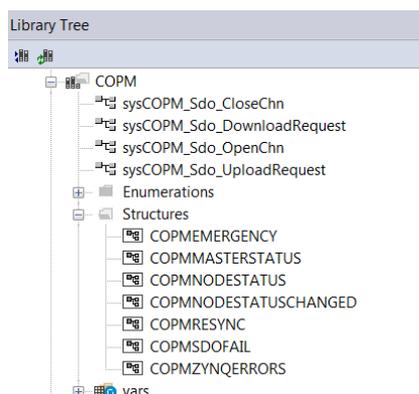
Fig. 4-15: Library tree example

For each library it is possible to explode the tree by clicking on the "+" symbol. For each item it is possible to show the information by right clicking and press "object properties". In the property windows is showed the item description.
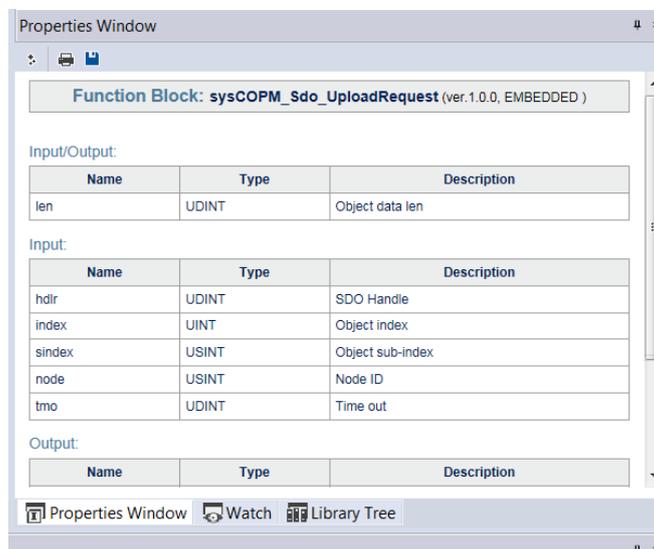
4.3   OPERATOR PANEL (SD-OP)

By using the SD-OP it is possible to do the following operations:
- Visualize/edit all the Drive Parameter (as SDM)
- Start/stop drive
- Backup/Restore drive parameters

SD-OP allows to perform drive commissioning as the SDM.

1. Led Green
2. Led yellow
3. Led Red
4. Display
5. F1
6. F2
7. Loc
8. LSK
9. DSK
10. RSK
11. USK
12. Start
13. Stop
14. USB connector
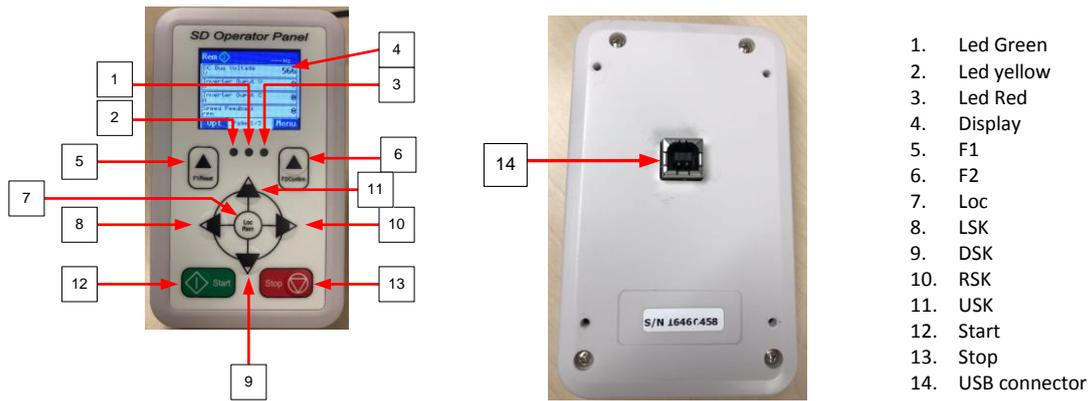
Fig. 4-16: SD-OP front and back view

The SD-MCU supplies the SD-OP by USB2 cable Male-A – Male-B (up to 6m[74]) as showed in Fig. 4-17.
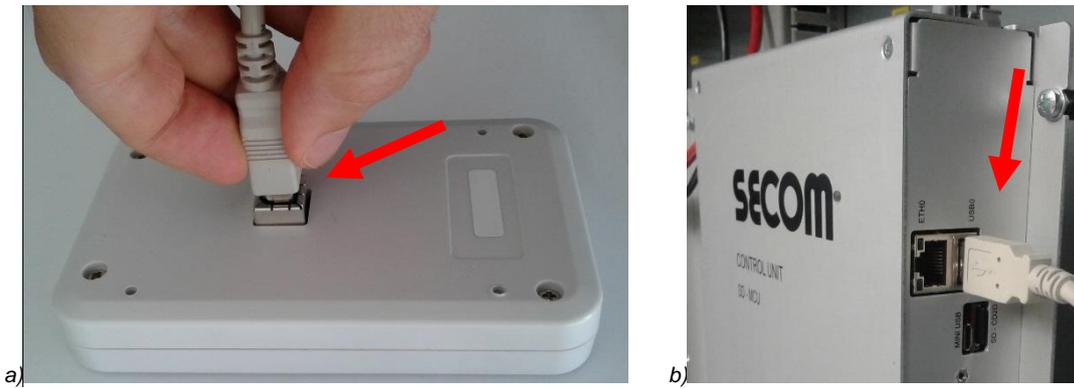
Fig. 4-17: SD-OP cable connection

The SD-OP has no battery inside and then, when the USB cable is unplugged the display is switched off.
Fig. 4-16 describes the SD-OP LEDs and buttons. By using the buttons is possible to access to different pages as showed in Fig. 4-18 below:
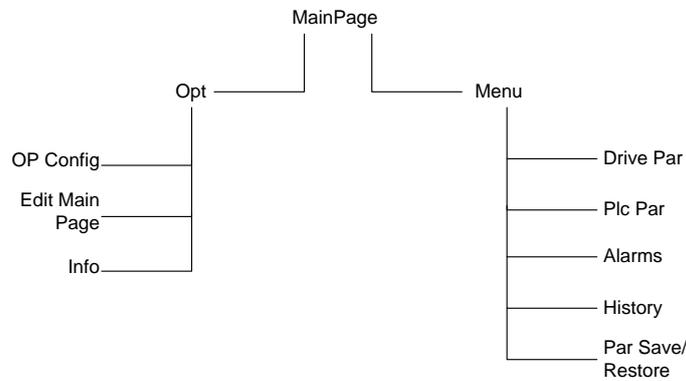
Fig. 4-18: SD-OP pages tree

The environmental limits are:
- Air temperature: -20 °C to +55 °C (operation) and -40 °C to +70°C (Storage).
- Altitude: <4000 m.
- Relative humidity: 95%
- EMC compliance: IEC 61800-3 (Electrostatic discharge phenomenon)

4.3.1   Display

The description of the display function are:

---

[74] For distance more than 5m contact Secom
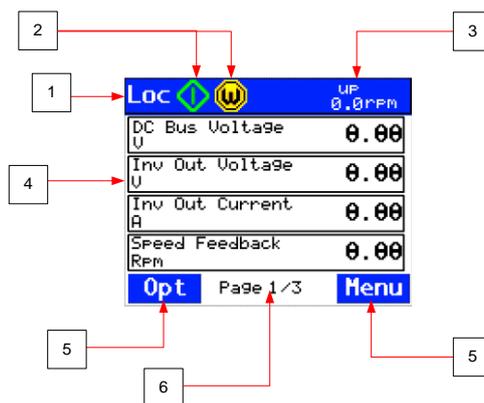
Fig. 4-19: Display description

1 – Control location: Indicates how the drive is controlled:
- LOC: the drive is controlled by SD-OP (local control)
- SDM: the drive is controlled by SDM
- REM: the drive is controlled through digital I/O or fieldbus

2– Drive status: indicates the status of the drive and other information.

Icons	Drive State
	Start-up Initialization Switch On Inhibited Not Ready to Switch On
	Ready to Switch On
	Precharging Wait For Sync
	Ready to Operate
	Operation Inhibited
	Magnetization Running
	Grid Waiting
	Ramp Stop
	OFF1 - Ramp Stop
	OFF3 - Quick Stop
	OFF2 - Coast Stop
	Fault

Tab. 4-8: SD-OP icons description

there is another icon to show warning or other information:

Icons	Meaning
	No additional info
	Warning active

Tab. 4-9: SD-OP warning icon

3 – Reference value: in this part is showed the reference value and it depends on the type of control selected:
- AFE: Vdc [V]
- Vac generator: Vac [V]
- FOC: Speed [rpm]
- V/f : frequency [Hz]

4 – page area: this part is windows depending.
5 – soft key virtual selection: display the function of the softkey F1 and F2.
6 – actual page and total pages

4.3.2　Key

The SD-OP has 9 keys.

- F1/Reset: ▲ (F1/Reset) is used as soft key (the function is defined in the left bottom corner of the display and page dependent). In the main page, it reproduces reset function by holding down. In the edit mode (e.g. parameter editing value), it reproduces "exit without saving value".

- F2/Confirm: ▲ (F2/Confirm) is used as soft key (the function is defined in the right bottom corner of the display and page dependent). In the edit mode it reproduces "confirm value".

- Loc/Rem: (Loc Rem) is used to switch from remote control to SD-Op control (local). It can be used only in the main page.
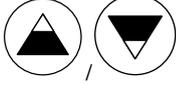
- UpK/DwK: ▲ / ▼ are used to modify references (e.g. speed, frequency) only in the main page. In the other pages are used to move among the selection. In the edit mode are used to change the digit value (0…9 and + and - character).In the main page is used to increase/reduce the value of the reference (visible in the top right corner of the display). Holding down UpK (for 2 seconds) it is possibile to start the increase ramp mode of the reference. Holding down Dwn (for 2 seconds) it is possibile to start the decrease ramp mode of the reference. To stop the ramp mode it is necessary to press one of the 4 arrow keys.

- LK: ◀ is used to move backward in the three pages of the main page. In the parameter pages it is used to previous selection. Holding it down in the main page it is possibile to reset the reference to the "start ramp value" parameter.

- RK: ▶ In the parameters page　it is used to enter in the selected menu.

- Start: ◇ Start : it is used to start the drive when Loc mode is selected

- Stop: ⬭ Stop ⬤ : it is used to stop the drive when Loc mode is selected.

4.3.3　LED

The LEDs are used to inform the user about the drive status.

Led color	behavior	description
Green	Off	No the drive is not precharged
	Blinking	Drive state is Ready to operate/Operation inhibited/Magnetization
	Steady	Drive state is running
Yellow	Off	No warning active
	Blinking	Warning active
Red	Off	No fault active
	Blinking	STO actived
	Steady	Fault active

Tab. 4-10: SD-OP LEDs behaviour

4.3.4　Main Page

The main page is used to show the parameters located in the Monitoring [60-76]. It is composed by three pages of the same structure. In each page there is showed the following structure:
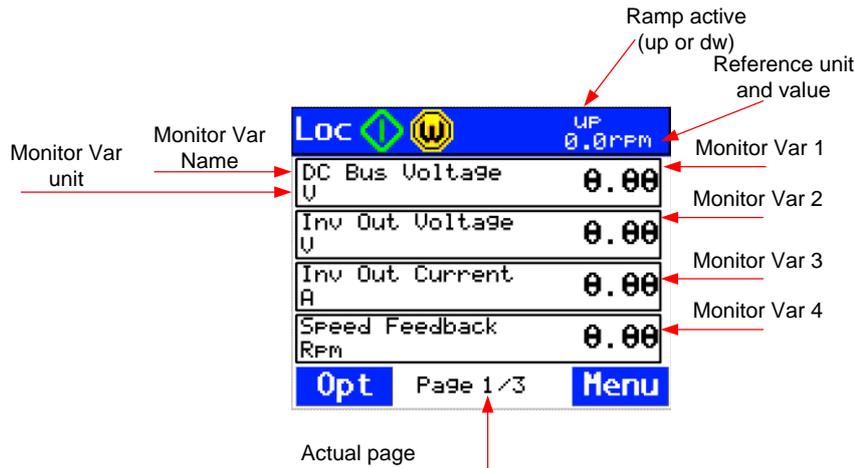
Tab. 4-11: Main Page structure

For each page is possible to show 4 variables. The variables showed in the main page can be configured by Opt→Edit main page.

To move among the three pages it is necessary to press (◀) or (▶).

In the main page it is possible to change the reference value (the reference is control/load dependent). Use (▲) and (▼) to adjust the reference. For further information see 4.3.2.

The reference unit depends on the load and control type as described in Tab. 4-1.

It is possible to see the control location in the left top corner of display. The possibilities are:

- Loc: commands (start/stop/reset) and reference from SD-OP
- SDM: command and reference from SDM
- Rem: commands and reference from DI/O or fieldbus

Loc has the highest priority and Rem the lowest one.

To switch to Loc mode or viceversa it is necessary to be in the main page and press (Loc Rem). You can have two different messages as follow:
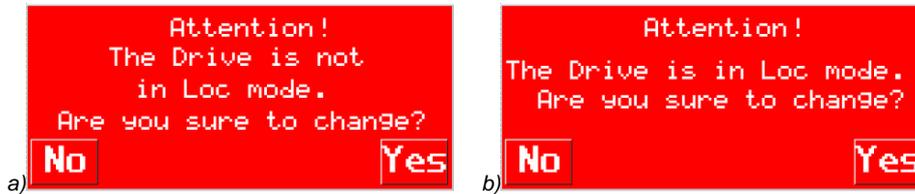
Fig. 4-20: Message in case Loc/Rem button is pressed where previous control location is different from Loc (a) or Rem (b)

As showed in the caption, the message depends on the previous control location. It is possibile to confirm or discard the message by pressing (F1/Reset) (No) or (F2/Confirm) (Yes).

4.3.5   OP Config

It is possible to enter in this page by Opt→OP Config.
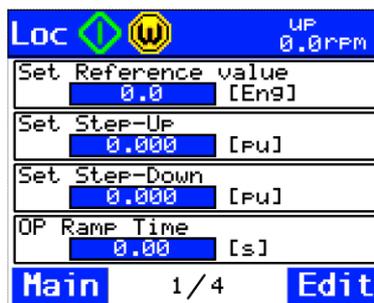
Fig. 4-21: Structure example of OP config page

All the parameter are described in the Parameter manual and they are visible also from SDM as *[86] SD-OP*. It is possible to move among parameters by using (▲) and (▼).

4.3.6   Edit Main Page

It is possible to enter in this page by Opt→OP Config.
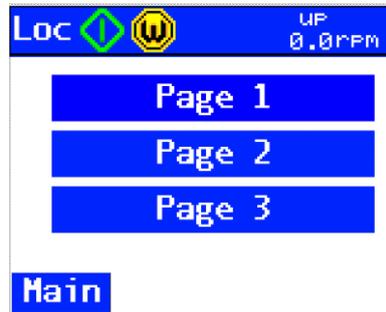
Fig. 4-22: Edit main page configuration

It is possible to select one of three pages to modify by using ⬆ and ⬇. To open the selected page press ▶.
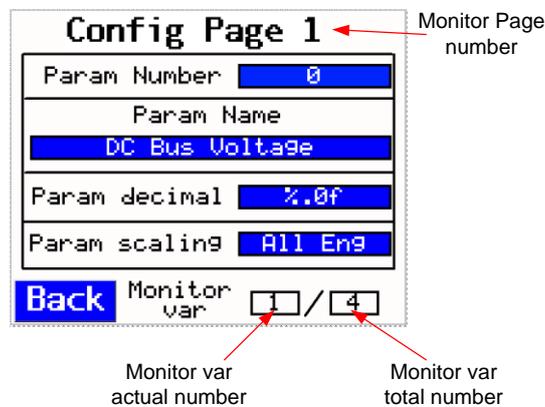
Fig. 4-23: Monitor variables configuration pages

In Fig. 4-23 is showed the configuration page of the monitor var. Each monitor var has 4 configuration parameter:

- Param number: the parameter number that is wanted to be showed
- Param name: it is possibile to choose the variable by the parameter name (to help the configurator to fast selection)
- Param decimal: number of digit displayed after the decimal point
  - %.0f: 0 digits
  - %.1f: 1 digits
  - %.2f: 2 digits
- Param scaling: for some parameters that are expressed in pu it is possible to convert them in their engineering value by setting "All eng". If "default" is selected the parameters are showed with the unit described in the Parameter manual.

4.3.7   Info

It is possible to enter in this page by Opt→Info. This page is used to show all the information about SD-OP and Drive (e.g. software version).

Fig. 4-24: Info page structure

It is possible to move among the pages of info by using ◀ and ▶.
The parameter showed in the info page are:

- SD-OP firmware version
- SD-OP software version

- Information parameters located in the family *Info [76]*

4.3.8 Drive Par

It is possible to enter in this page by menu→Drive Par. This page allow to modify/see all the drive parameters (PLC parameters excluded). The parameter tree is the same showed in the SDM.

To move between menus is necessary to use (▲) and (▼). Use (▶) to enter in the selected menu.
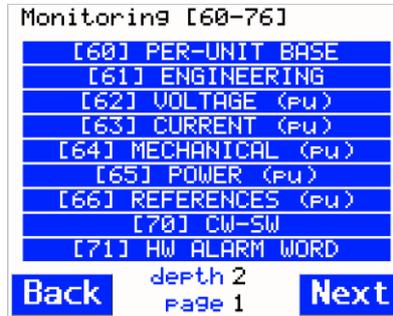
Fig. 4-25: Drive Par menu navigation

It is possible to see the depth and page on the bottom part of the page. In the figure below is showed an example:
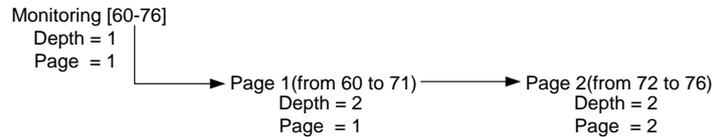
Fig. 4-26: Depth and page in the drive parameter menu

After selecting the menu it is possible to change/see the parameter value.
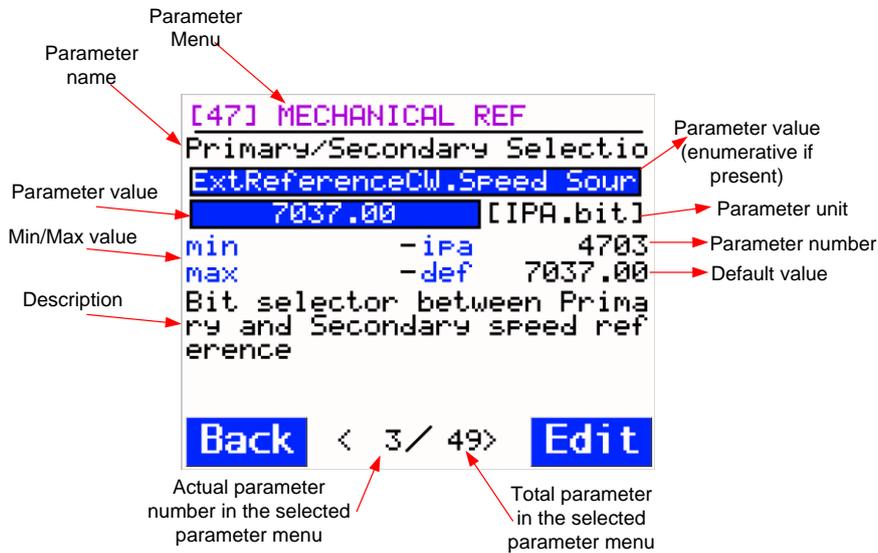
Fig. 4-27: Drive Param page description

It is possible to move to the following/previous parameter in the same menu with (◀) and (▶).

4.3.9 Alarms

It is possible to enter in this page by menu→Drive Par.

210450P004-00-EN
www.secompower.it

SECOM
Power Electronic Equipment & Components

SDrive-1.0.0.x
4-37
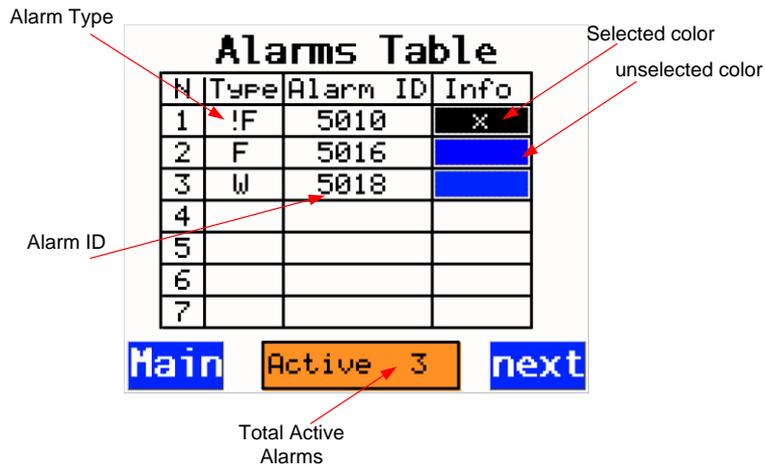
Fig. 4-28: Alarms page

There are two page, each page shows up to 7 alarms. In the Fig. 4-28 is showed an example. It is possible to move on the active alarm with ▲ and ▼. If further information are necessary it is possible, when the active alarm is selected, to press ▶. In this case a pop-up page will be opened and the detailed description will be showed. To exit from the pop-up page press ◀. The alarm will be recorded even if the SD-OP is connected after that the alarm is occurred.

4.3.10   Save and Restore parameters

It is possible to enter in this page by menu→Save/Restore Par. It is possible to save the drive parameters in SD-OP. When the parameters are saved in the SD-OP it is possible to detach it. Then it is possible to connect it to another drive and download the previous parameter saved values.
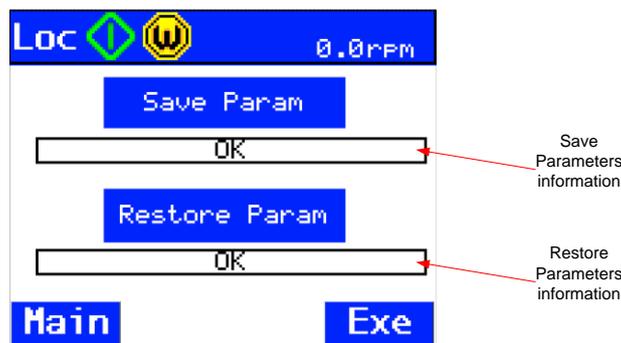
Fig. 4-29: Save/Restore parameters page

By ▲ and ▼ it is possible to select "Save Param" or "Restore Param". If you want to save the drive parameters in the SD-OP it is necessary to execute *Save Param*.
It you want to restore parameters to drive from SD-OP it is necessary to execute *Restore Param*. When Restore Param is executed a pop-up windows will appear.

Fig. 4-30: Restore/Save parameter information

By pressing F1 or F2 is possible to discard/accept the parameters restore. After closing the pop-up window it is possible to see the restore parameter information as showed in Fig. 4-29.

4.3.10.1   PLC parameters page

When a PLC application is created (with SDLE) it is possible to see the PLC parameters (for information how to add PLC parameters see 4.2.4) in the SD-OP.
It is possible to access to the PLC parameter menu by *menu→Plc par*.
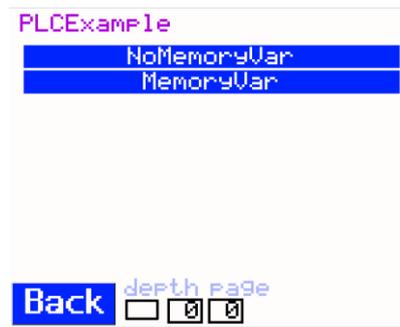
Fig. 4-31: PLC parameters example

COMMISSIONING AND MAINTENANCE

5

Chapter Table of Contents

Contents

In this chapter will be showed how to make drive commissioning regarding line converter and motor converter. For each load and control type will be explained a quick commissioning and a standard commissioning procedure.
The first one is a faster procedure but it gives a low customer/application personalization. The second one is slower than the first one but it allows to access to a wide range of parameters and optimize the drive for the application.

Chapter Target Audience

Commissioning and/or maintenance engineers who have to know the main parameters for programming and monitoring the drive.

5.1 SAFETY

SECOM assume that the wiring of all parts of the drive (control, interfaces and power parts) are just be done by skilled personnel. However all the prescription in the HARDWARE MANUAL must be followed by anyone who has to manage electrical equipment.

In general, always refer to the rules described in chapter *1 – Safety Instructions*, in particular paragraphs 1.4.2 and 1.4.3. However some reminds are reported in the follow.

WARNING! SECOM DRIVE is designed for industrial application. When it is ON (not only RUN), the drive is energized; installing and operating the drive has to be carried out by skilled personnel.

Maintenance of the drive must be performed with no energized power part, which means that technician or skilled personnel has to disconnect the drive from the grid supply and wait at least 5 minutes to allow the voltage be close to zero. After this time, <u>users must measure the residual DC bus voltage</u>, which has to be close to zero before operating on power parts. Moreover, motor must be stand still too, mainly If it is synchronous or permanent magnet motor, to avoid hazardous voltage on both AC and DC side of inverter.

WARNING! Maintaining the drive without a ground connection is not allowed, mainly for safety reasons. Be aware the inverter ground is connected to the earth bar of the plant or the cabinet (PE).

WARNING! Touching, removing or simply manage the PCB has to be done using PPE (such as grounding wrist bands) to avoid electrical discharge which can damage the equipment or injure the technician.

5.2 PRE-COMMISSIONING

It is supposed the pre-commissioning of the drive is already done. As pre-commissioning it is intended that all mechanical and electrical installation explained in HARDWARE MANUAL are performed. So, technician has to be sure about:

- Mechanical installation
- Electrical installation:
    - o Power parts
    - o Sensor (such as SD-SYNC, encoder, etc) and interfaces between SD-MCU and all DPMs
    - o SD-MCU wiring
- Checking the control integrity
- Checking the cooling system
- Do the Reform of DC capacitors if needed (please refer very carefully to HARDWARE MANUAL)
- All regarding safety

After that, software commission and configuration can start.

5.3 F3E QUICK START-UP

This procedure explains how to configure the line converter with a SECOM DRIVE F3E control. This inverter is connected to the AC line through and the precharge system as described in 3.3.2. The SD-MCU connection are standard as described in the HARDWARE MANUAL. Quick start-up doesn't take into account phases wrong connections or SD-SYNC cabling error. There is no fieldbus configuration.
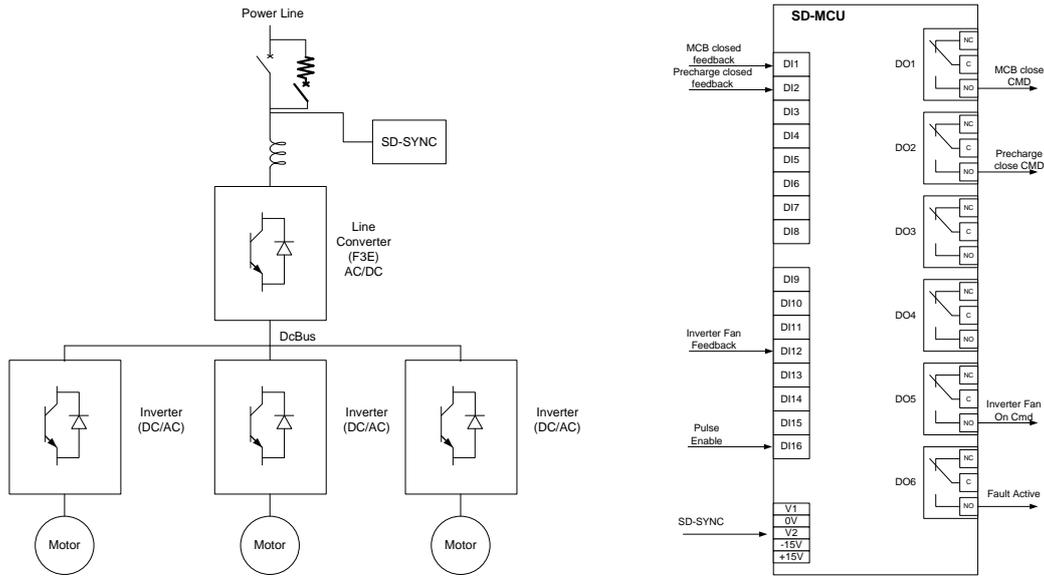
Fig. 5-1: F3E precharge electrical scheme and SD-MCU connection

The main connection are related to the main circuit breaker, precharge contactor, Fans and synchronization board (SD-SD-SYNC).

- Once the cabling is checked it is necessary to set these parameters:
  - *Drive Size [0101]*: set the Drive Size according with the electrical diagram or with the drive root ID and the number of DPM. It is possible to verify this choice by checking the parameter *Drive Root [0102]* and the *DPM Number [0103]*. For example, SDI.1.1M62.400 is composed by number 3 DPM of drive root type SDI.1.540K.400.
  - *Load Type [0104]*: set this parameter as GRID
  - *Control Type [0105]*: set this parameter as F3E
  - Set *Precharge [0201] = internal (default)*. If there is a precharge contactor and a MCB feedback to manage, it is necessary to set *Main contactor feedback [0208]* [+] and *Precharge contactor feedback [0206]* [+] according with the wiring connection. In this case, according to the picture above they must be connected to the digital input 1 (7030.00) and 2 (7030.01).
  - Set *AC input voltage [0303]*
  - Set the grid parameter: *rated voltage [0502]*, *rated current [0503]*, *current overload [0504]*, *Rated frequency [0505]*. The rated current can be set as the nominal current value of the reactance at the inverter output. In case of drive size with parallel configuration (more than one DPM) it is necessary to set the total current.
  - Start the converter

5.3.1   F3E quick start-up with SDM

To start the procedure with the SDM, it is necessary to follow these steps:
- Check the wiring connection according to the schematics
- Connect the RJ45 cable between PC and Drive
- Open SDM and follow the procedure described on 4.1 to connect to the target
- Write the parameters according to the 5.3.
- Take local control by checking to "check for manual" in the control panel in order to obtain "local"

- If there are fault present it is necessary to give a reset command:

- If the fault is still present, check the in the alarm window otherwise press ON/OFF button:

- The fan starts and the drive status is "Ready to Operate"
- Press Start/Stop Button and when the status is "Running" the drive is ready to operate in both direction (regenerative and no-regenerative)

5.4   F3E ADVANCED STRAT-UP

This procedure explains how to configure the line converter with a SECOMDRIVE F3E control. This inverter is connected to the AC line through and the precharge system is as described in 3.3.2. The SD-MCU connection are standard as described in the hardware manual. In this case it is also necessary to use advanced tools and then it is necessary to explain it with the help of SDM/SDLE/SoftScope.
Advanced start-up take into account phases wrong connections or SD-SYNC cabling error with advanced troubleshooting using SoftScope tool. It is showed also a grid waiting and fieldbus configuration (Profibus case).
Once the cabling is checked it is necessary to set these parameters:

- *Drive Size [0101]*: set the Drive Size according with the electrical diagram or with the drive root ID and the number of DPM. It is possible to verify this choice by checking the parameter *Drive Root [0102]* and the *DPM Number [0103]*. For example, SDI.1.1M62.400 is composed by number 3 DPM of drive root type SDI.1.540K.400.
- *Load Type [0104]*: set this parameter as GRID
- *Control Type [0105]*: set this parameter as F3E
- Set *Precharge [0201] = internal (default)*. If there is a precharge contactor and a MCB feedback to manage, it is necessary to set *Main contactor feedback [0208]⁽⁺⁾* and *Precharge contactor feedback [0206]⁽⁺⁾* according with the wiring connection. In this case, according to the picture above they must be connected to the digital input 1 (7030.00) and 2 (7030.01).
- Set *AC input voltage [0303]*
- Set the grid parameter: *rated voltage [0502]*, *rated current [0503]*, *current overload [0504]*, *Rated frequency [0505]*. The rated current can be set as the nominal current value of the reactance at the inverter output. In case of drive size with parallel configuration (more than one DPM) it is necessary to set the total current.
- Take local control by checking to "check for manual" in the control panel in order to obtain "local"

- If there are fault present it is necessary to give a reset command:

- If the fault is still present, check the in the alarm window otherwise press ON/OFF button:

- The fan starts and the drive status is "Ready to Operate" (only if the synchronization is ok) otherwise the drive state is "Wait for sync"
- Now it is necessary to check that the voltage phase sequence is the same of current phase sequence to avoid short circuit / overcurrents. Open Softscope and add to the track list the following parameters: *[6238]*, *[6240]*, *[6309]*, *[6310]*, *[6311]* and click on single sequence capture. Check the *phase sequence [7513]* and then have a look at currents and voltages are similar to the Fig. 5-2 and Fig. 5-3.
- If the Synchronization is not Ok after Precharging is finished, a fault Line Sync Timeout will appear. It is possible to declass this alarm to warning by acting to parameter *Sync timeout [5512] = warning*. In this case it is possible to see the currents and voltages without any fault generation.
- If the currents and voltages phase sequence is correct, it is necessary to restore the Sync timeout parameter to the default value (OFF2). Then it is possible to press START button

Note that is mandatory that the wiring between SD-SYNC and SD-MCU is properly done. A wrong connection can lead to a DC bus overvoltage and/or an over current trip.

black [6241]
blue [6243]
violet [6309]
green [6311]
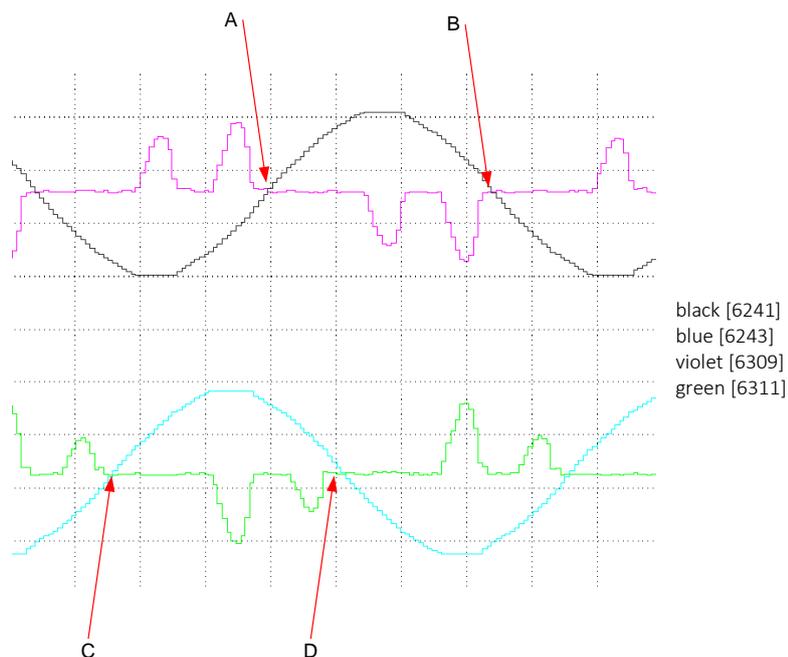
Fig. 5-2: Voltages and currents sequence in case of phase sequence "U-V-W"

black [6241]
blue [6243]
violet [6309]
green [6311]
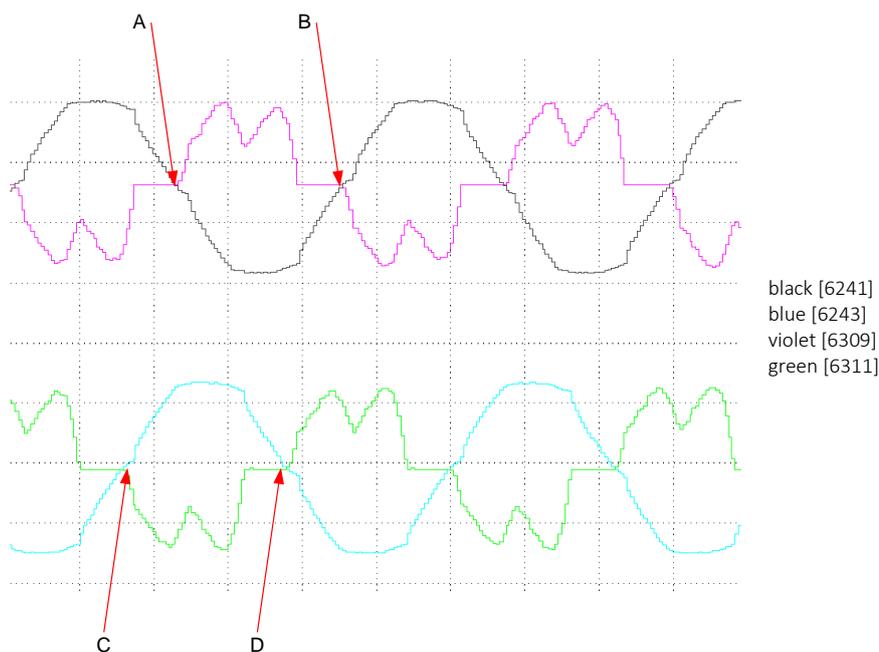
Fig. 5-3: Voltages and currents sequence in case of phase sequence "U-W-V"

5.5 QUICK MOTOR START-UP (V/HZ OR FOC)

This procedure explains how to configure an induction motor with a SECOM DRIVE with scalar control. This inverter is connected to the AC line through an external diode bridge and the precharge system is as described in 3.3.2. The SD-MCU connection are standard as described in the HARDWARE MANUAL. For precharging, many kind of precharge circuit are described in HARDWARE MANUAL depending on the front-end (ie. Semi-controlled diode bridge, external precharge circuit, etc) or the kind of drive (SDS or other SDx). In Fig. 5-4 is proposed a normal precharge resistors.
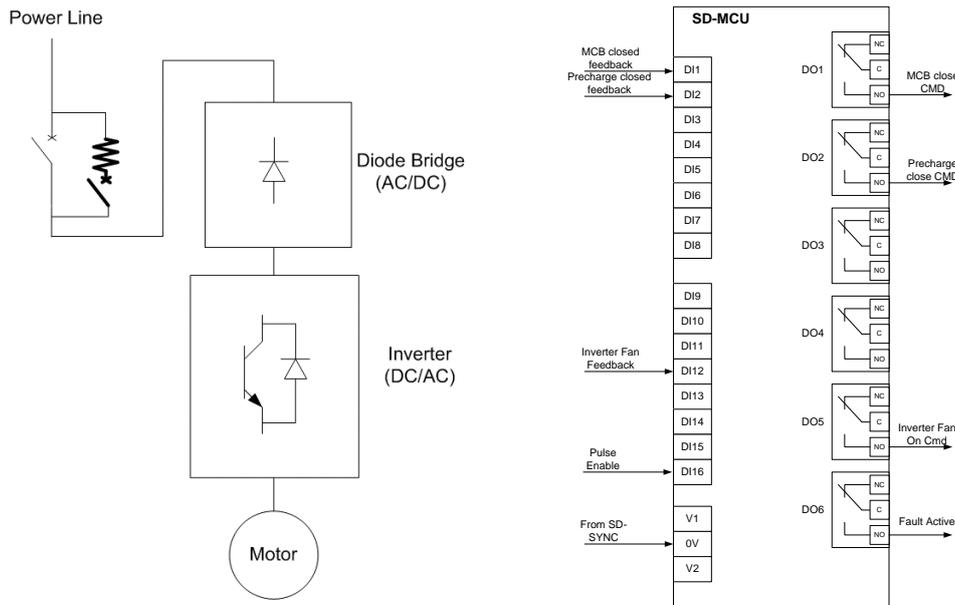
Fig. 5-4: V/Hz precharge electrical scheme and SD-MCU connection

Set the following parameters:
- *Drive Size [0101]*: set the Drive Size according with the electrical diagram or with the drive root ID and the number of DPM. It is possible to verify this choice by checking the parameter *Drive Root [0102]* and the *DPM Number [0103]*. For example, SDI.1.1M62.400 is composed by number 3 DPM of drive root type SDI.1.540K.400.
- *Load Type [0104]*: set this parameter as IM (induction motor)
- *Control Type [0105]*:
  - Scalar (V/f): by default is a closed loop control
  - Vector (FOC): need a complete parametrization of the motor
- If precharge is managed from the line converter, it is possible to set *Precharge [0201] = internal (default)* and jump to the following step. Otherwise if there is a precharge contactor and a MCB to manage, it is necessary to set *Main contactor feedback [0208]* and *Precharge contactor feedback [0206]* according with the wiring connection. In this case, according to the picture above they must be connected to the digital input 1 and 2.
- Set the *Switching Frequency [0301]*
- Set *AC input voltage [0303]*
- Set the motor parameter from or name plate or datasheet (i.e. picture below).
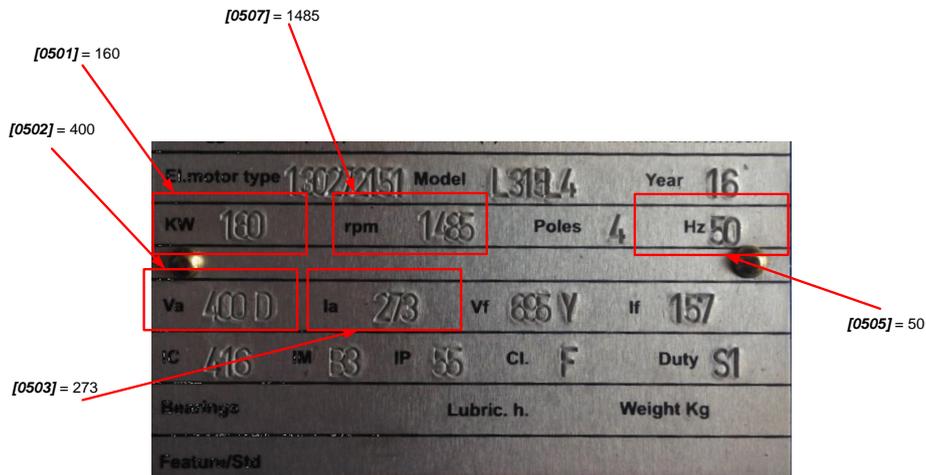
The parameters to insert are:
- *Rated Power [0501]*
- *Rated Voltage [0502]*
- *Rated Current [0503]*
- *Rated Frequency [0505]*
- *Max Operative Frequency [0506]*
- *Rated Speed [0507]*
- *Power factor [0508]*
- *No Load Current [0509]*: if this value is not available it is necessary to estimate it from ID test

For vector control, the motor parameter (R_s, L_m, etc) are needed. If user doesn't know them, the system can calculate all the parameter using *ID Test Type [0801] = Parameter from plate data*.
- *ID Test Type [0801] = Params from name plate data*: this is useful only if the user doesn't know the motor parameters. Note that for vector control (FOC) the parameters are mandatory.
- Only for V/Hz, the following configuration is the default:

      o *Magnetization Control Mode **[1601]** = No Load Current*
      o *Speed Control Mode **[1602]** = Closed Loop*
- *Current/Flux Reg Autotune **[2001]** = ON*
- *ModRatio = Enabled*
- Set *Ramp 1 acceleration time **[4714]*** and *Ramp 1 deceleration time **[4715]*** to high value (i.e. 30 s) to avoid overcurrent if the first step of parametrization. The start to decrease these values in order to reach the value needed

5.5.1   Quick motor start-up with SDM

To start the procedure with the SDM, it is necessary to follow these steps:
- Check the wiring connection according to the schematics
- Connect the RJ45 cable between PC and Drive
- Open SDM and follow the procedure described on 4.1 to connect to the target
- Write the parameters according to the 5.3.
- Take local control by checking to "check for manual" in the control panel in order to obtain "local"

- If there are fault present it is necessary to give a reset command:

- If the fault is still present, check the in the alarm window otherwise press ON/OFF button:

- The fan starts and the drive status is "Ready to Operate"
- Press Start/Stop Button and when the status is "Running" insert a desired output frequency to the Speed reference box

It is possible to check the output values by using Graph and drag and drop the following parameters:
- *Vinv magnitude filt **[6201]***
- *Vdc **[6276]***
- *Iinv magnitude filt **[6301]***
- *Speed fdb **[6404]***

5.6   TROUBLESHOOTING

Usually, alarms can be detected in several way; the majority of the faults regard the DPM. A fault can be detected via:
- SD-RMU: the red LED is on (not blinking)
- SD-MCU: the display indicates **F−**
- SD-OP: show an icon which indicates the fault
- SDM: the drive manager indicate a fault of the module

There are two kind of alarm: hardware and software. The majority of the former's come from the DPM (SD-RMU) and they aren't configurable; on the contrary software alarms are almost all configurable as described in 3.4.

Tab. 5-1 list all the hardware faults and the most common causes and way to troubleshoot them.

HW Fault Code and Name	Description, Causes and Troubleshooting
Over Current DPM *x* – Overcurrent *y*	**DESCRIPTION**: instantaneous current has reached the Overcurrent trip threshold. Each phase of each DPM can indicate this alarm; the "*x*" indicate the number of the DPMs (1÷8), and "*y*" indicate the phase (1÷3).
	CAUSES: • If current is not under control, the load variation has to be not too much faster and/or is such to generate a ripple greater than 15% (while current is next to max allowed current) • If current is under control, the regulator could not be tuned properly or the load is such to generate a ripple greater than 15%(while current is next to max allowed current) • Speed control is not properly tuned or is not coordinated with current control, so the current could be unstable and lead to a fault • A short-circuit with a not so low impedance could be happened to the output AC side of the drive (or DPM) • The analog terminal block of SD-SU is not connected or screws have not enough grip to fasten the cables termination

HW Fault Code and Name	Description, Causes and Troubleshooting
	TROUBLESHOOTS: • If current is under control, tune the current regulator • Avoid too fast load variation
Over Voltage DC DPM *x* – VdcH Max	*DESCRIPTION*: instantaneous DC voltage has reached the Overvoltage trip threshold. "*x*" indicates the DPM number (1÷8).

	CAUSES:
	• With motor control, *Vdc Rollback* macro function is disabled or not tuned properly
	• With AFE:
	  ▪ Vdc regulator is not tuned properly
	  ▪ inverter has reached the current capability while the load is regenerating more than the AFE regenerative power limit
	• With common DC bus, another device is regenerating energy
	• An overvoltage on power grid could be happened
	• The analog terminal block of SD-SU is not connected or screws have not enough grip to fasten the cables termination

	TROUBLESHOOTS: • Enable and ore tune Vdc Rollback macro function • Tune AFE regulators • The analog terminal block of SD-RMU and/or SD-SU is not connected or screws have not enough grip to fasten the cables termination
IGBT Desaturation DPM *x* – Desat IGBT *y*	*DESCRIPTION*: IGBT "*y*"-*th* desaturation of DPM number "*x*". Odd number of IGBT in some frame can be cumulative for the phases.
	CAUSES: • A short circuit with zero impedance on the AC output of the drive is happened • Damage or disturbance on electronic driver board • Serious damage of power parts
	TROUBLESHOOTS: • Check if cable or load are damaged • Check the driver cards and clean them from dust or dirt if needed. Check if the board is visibly damaged too. • Substitute the power module
Earth Protection DPM *x* – Earth Protection	*DESCRIPTION*: SD-RMU detect the current of each DPM flowing toward earth for more than 5 seconds.
	CAUSES: • Current sensor terminals (from each side: sensor and SD-SU) ad not fastened • Current sensor can be damaged or burden resistor on SD-SU are not well welded • Some parts (DC and AC) are lost their insulation between earth • Load insulation can be damaged
	TROUBLESHOOTS: • Check SD-SU terminal block of current sensors • Check the terminals of current sensors • Insulation must be verified: only authorized and skilled personnel can perform this check
Fuse Fault DPM *x* – Fuse Fault	*DESCRIPTION*: one or more internal DC fuses (if they are present) of the DPM number "*x*" are opened. This is a cumulative signal
	CAUSES: • With common DC bus, a short-circuit on the DC bus can be happened • Internal power parts (DC capacitors or IGBT) could be short-circuited • Contact on the fuse striker may have lose grip
	TROUBLESHOOTS: • Check if other equipment connected to the DC bus have caused the fault and replace the fuses • Disconnect the DI5 from SD-SU (see HARDWARE MANUAL) and check the continuity • Check the drive integrity (visually or burning smell) and verify the fuse striker wiring • If DPM is seriously damaged, substitute it, otherwise change only the fuses
Phase Current Unbalance DPM *x* – Phase *y* current unbalance	*DESCRIPTION*: transduced current of the phase "*y*" of DPM number "*x*" is far from average value of the same phase of all the DPMs in parallel.
	CAUSES: • Wiring of the power parts, mainly next to the parallel connection, could unbalance the load • Damage of internal circuits
	TROUBLESHOOTS: • Check the wiring of parallel connection • Check drive integrity
Heatsink Fault	*DESCRIPTION*: heatsink has reached an anomalous temperature

HW Fault Code and Name	Description, Causes and Troubleshooting
DPM *x* – heatsink temp fault	**CAUSES**: • Ambient temperature is very high and the drive is working with high current so that the heatsink has overcome the 90°C • Heatsink is not properly cooled • If current is not too high, probably the cabinet temperature (ambient temperature) is too high • One of the three thermal clip on the heatsink are opened or not connected • Heatsink could be obstructed (usually due to dust or pollution)
	TROUBLESHOOTS: • Check the cooling system of the DPM (for example if fan is running properly which means the correct wise and/or enough pressure) • Check the cooling of the cabinet: no hot air recirculation is allowed • Disconnect the DI4 from SD-SU (see HARDWARE MANUAL) and check the continuity • Clean the heatsink and remove the obstruction if needed.
Size Mismatch Size Mismatch	**DESCRIPTION**: at least one power module size differs from the selected one or it isn't detected. **CAUSES**: • Configured size via software is different with the one selected on SD-SU boars dip switch S1. • Communication between SD-RMU and SD-MCU is wrong, so this alarm may happen • Communication problem between SD-SU and SD-RMU • The cpu on SD-SU is not programmed **TROUBLESHOOTS**: • Check if the size is correctly configured according to the drive size indicated on the plate data and so verify the size codification on the dip switch of SD-SU • Check the optical fiber couple between SD-MCU and SD-RMU • Check the flat connection between SD-RMU and SD-SU • If SD-RMU or SD-SU board are damaged, replace them
STO STO Activated DPMx – STO Fault Red LED blink	**DESCRIPTION**: at least one channel of STO is opened. **CAUSES**: • STO circuit is opened. • If STO is wrongly enabled, the wire of safety circuit could be damaged or terminal connectors are not proper plugged into SD-RMU • STO circuit on SD-RMU could be damaged **TROUBLESHOOTS**: • Check the wiring of safety circuit and the terminals of SD-RMU • Replace DS-RMU

Tab. 5-1: Hardware Fault Troubleshooting

Tab. 5-2 list all the software alarms. As described before (3.4) these alarms can be fault, warning or disabled.

SW Fault Code and Name	Description, Causes and Troubleshooting
Fault Code: 5008 **Pulse Enable Timeout** [7102.00] [7202.00]	**DESCRIPTION**: the input signal PE on the SD-MCU (X1-17, see Tab. 3-2) is low **CAUSES**: • The digital input 16 signal (X1-17) is low or it is wrongly wired • The cable is damaged **TROUBLESHOOTS**: • Check the Digital input 16 wiring on the SD-MCU terminal board
Fault Code: 5009 **Precharge Timeout** [7102.01] [7202.01]	**DESCRIPTION**: Precharge routine last more than the timeout defined by parameter *[0211]* **CAUSES**: • Parameter [0211] is too low • The precharge circuit is not working • AC power supply or voltage on the common DC bus are missing **TROUBLESHOOTS**: • Increase parameter [0211] according to the precharge circuit • Check the precharge circuit • Chek the main voltage supply
Fault Code: 5010 **Precharge Contactor Error** [7102.02] [7202.02]	**DESCRIPTION**: Precharge Contactor feedback is missing (the feedback value is different from the Precharge contactor command) **CAUSES**: • Error in wiring the precharge command (usually SD-MCU DO JP2-4) • Feedback configuration [0206] is wrong or the feedback signal is missing • Precharge contactor damaged **TROUBLESHOOTS**: • Check wiring and configuration of precharge circuit • Check the precharge contactor integrity

SW Fault Code and Name	Description, Causes and Troubleshooting
Fault Code: 5011 **Line Contactor Error** [7102.03] [7202.03]	**DESCRIPTION**: Line Contactor feedback is missing (the feedback value is different from the contactor command)
	CAUSES: • Error in wiring the main command (usually SD-MCU DO JP2-1) • Feedback configuration [0208] is wrong or the feedback signal is missing • Main contactor is damaged or in trip
	TROUBLESHOOTS: • Check wiring and configuration of line contactor • Check the line contactor integrity
Fault Code: 5012 **Earth Current** [7102.04] [7202.04]	**DESCRIPTION**: SD-MCU detect the total current flowing toward earth for more than 5 seconds.
	CAUSES: • Some parts (DC and AC) are lost their insulation between earth • Load insulation can be damaged
	TROUBLESHOOTS: • If *DPM x – Earth Protection* is present, maintainer has to solve this problem before • Insulation must be verified: only authorized and skilled personnel can perform this check
Fault Code: 5013 **Software Overcurrent** [7102.05] [7202.05]	**DESCRIPTION**: The current exceeds the per-unit. value
	CAUSES: • Current is too high • Current has a lot of spike in the vicinity of the per-unit value
	TROUBLESHOOTS: • Disable the protection • Increase the per-unit current
Fault Code: 5014 **External Alarm** [7102.06] [7202.06]	**DESCRIPTION**: External Alarm activated
	CAUSES: • The input signal related to this alarm is low
	TROUBLESHOOTS: • Check the wiring of alarms • Check the configuration of the alarm and the parameter [4516]
Fault Code: 5015 **External Alarm Delayed** [7102.07] [7202.07]	**DESCRIPTION**: External Alarm activated with delay
	CAUSES: • The input signal related to this alarm is low
	TROUBLESHOOTS: • Check the wiring of alarms • Check the configuration of the alarm and the parameter [4517], [4518] and [4519]
Fault Code: 5016 **DcBus Undervoltage** [7102.08] [7202.08]	**DESCRIPTION**: The DcBus voltage is less than the threshold value [0204] after the precharging state
	CAUSES: • The DC voltage is lower than [0204] or the AC input is too low • The real AC input voltage is lower than *[0204]•[0303] AC input voltage* • The input impedance is too high
	TROUBLESHOOTS: • Check the configuration • Check the main supply voltage
Fault Code: 5017 **Line Overvoltage** [7102.09] [7202.09]	**DESCRIPTION**: Line voltage is out of the overvoltage permissible constrains.
	CAUSES: • Grid voltage is too high • Sensors (such as SD-SYNC) could be damaged
	TROUBLESHOOTS: • Check the grid voltage stability • Check the transducer
Fault Code: 5018 **Line Undervoltage** [7102.10] [7202.10]	**DESCRIPTION**: Line voltage is out of the undervoltage permissible constrains.
	CAUSES: • Grid voltage is too low • Sensors (such as SD-SYNC) could be damaged
	TROUBLESHOOTS: • Check the grid voltage stability • Check the transducer
Fault Code: 5019 **Line Sync Timeout**	**DESCRIPTION**: Line Synchronization is missing after precharging routine.
	CAUSES: • Grid voltage has too much noise • Sensors (such as SD-SYNC) could be damaged or wrongly wired

SW Fault Code and Name	Description, Causes and Troubleshooting
[7102.11] [7202.11]	**TROUBLESHOOTS**: • Check the grid voltage stability • Check the transducer
Fault Code: 5020 **Grid Waiting Timeout** [7102.12] [7202.12]	**DESCRIPTION**: Drive Status Grid Waiting is maintained more than the permissible threshold time. **CAUSES**: • The lack of the power grid lasts more than [2706] time • Sensors (such as SD-SYNC) could be damaged and can't sense the voltage **TROUBLESHOOTS**: • Verify the drop voltage duration if it possible • Check the transducer and/or the configuration
Fault Code: 5021 **Inverter Overload** [7102.13] [7202.13]	**DESCRIPTION**: Inverter thermal overload reached. **CAUSES**: • For some reason, the inverter current remains too high for too much time • Current reduction is disabled • Terminal board for current sensors on SD-SU can be disconnected **TROUBLESHOOTS**: • Check the configuration and eventually enable the current reduction function • Check if the filter of the inverter current [1002] is too heavy • Check the wiring of the SD-SU into the each DPM (see HARDWARE MANUAL)
Fault Code: 5022 **Motor Overload** [7102.14] [7202.14]	**DESCRIPTION**: Motor thermal overload reached. **CAUSES**: • The motor current remains too high for too much time • Motor current reduction is disabled and the protection is configured as fault • Motor thermal fault is not properly configured (according to rated value) **TROUBLESHOOTS**: • Check the configuration and eventually enable the current reduction function • Change the configuration of the protection
Fault Code: 5023 **Transformer Overload** [7102.15] [7202.15]	**DESCRIPTION**: Transformer or Choke Thermal overload reached. **CAUSES**: • The transformer current remains too high for too much time • Transformer current reduction is disabled and the protection is configured as fault • Transformer thermal fault is not properly configured (according to rated value) **TROUBLESHOOTS**: • Check the configuration and eventually enable the current reduction function • Change the configuration of the protection
Fault Code: 5023 **Transformer Overload** [7102.15] [7202.15]	**DESCRIPTION**: Line voltage is out of the overvoltage permissible constrains. **CAUSES**: • Grid voltage is too high Sensors (such as SD-SYNC) could be damaged **TROUBLESHOOTS**: • Check the grid voltage stability Check the transducer
Fault Code: 5024 **Load Unbalanced** [7103.00] [7203.00]	**DESCRIPTION**: Current load is not balanced according to unbalance threshold [5708] **CAUSES**: • Connection between inverter and a 3-phase load is not properly fastened or wired • The load is no longer symmetric and probably it is damaged • One or more IGBT are not driven • The threshold [5708] is too low **TROUBLESHOOTS**: • Check the load (wire and integrity) • Check if the internal commands of the DPM drive all the IGBT. With fiber optic connection, verify that the optical connection are fastened • Disable or reconfigure the protection
Fault Code: 5025/5026/5027 **Output Phase*X* Loss** [7103.01]/[7103.02]/[7103.03] [7203.01]/[7203.02]/[7203.03]	**DESCRIPTION**: Phase *X* probably is been opened. *X* could be 1,2,3 **CAUSES**: • The indicated phase is probably disconnected • The protection threshold [5707] is too low **TROUBLESHOOTS**: • Check the load wiring and integrity • Disable or reconfigure the protection

SW Fault Code and Name	Description, Causes and Troubleshooting
Fault Code: 5028 **Shortcircuit Timeout** [7103.04] [7203.04]	**DESCRIPTION**: Shortcircuit current controlled for too much time
	CAUSES: • A shortcircuit is happened and the control has controlled the current for too much time • SD-RMU could be damaged if the shortcircuit happens too often
	TROUBLESHOOTS: • Try to understand the shortcircuit causes • Replace SD-RMU if needed (see HARDWARE MANUAL)
Fault Code: 5029 **Shortcircuit Fault** [7103.05] [7203.05]	**DESCRIPTION**: Too many consecutive shortcircuit.
	CAUSES: • Depending on configuration, a few number of shortcircuits are allowed • The protection is wrongly tuned
	TROUBLESHOOTS: • Try to understand the shortcircuit causes • Tune the shortcircuit protection
Fault Code: 5030 **Power Grid Loss** [7103.06] [7203.06]	**DESCRIPTION**: Power Grid is missing in action (only for GRID load)
	CAUSES: • The main contactor/circuit braker is been opened • The main supply circuit could be damages
	TROUBLESHOOTS: • Check the main line
Fault Code: 5031 **No Flux** [7103.07] [7203.07]	**DESCRIPTION**: Too much voltage and too few current for too much time (for MOTOR load)
	CAUSES: • The circuit between drive and motor is opened • An high impedance is between drive and motor
	TROUBLESHOOTS: • Close the circuit between drive and motor
Fault Code: 5032 **Magnetization Timeout** [7103.08] [7203.08]	**DESCRIPTION**: Flux is too low after magnetization state
	CAUSES: • The motor passes by the magnetization state because of a timeout, but the flux time constant is such as the flux has not reached the [4905] threshold • With motor in run, flux goes lower than [4905] • The flux dynamic is related to the maximum magnetization current ([2031]), especially if the rotor time constant is very high
	TROUBLESHOOTS: • Tune the system or disable the alarm
Fault Code: 5033 **Minimum Speed** [7103.09] [7203.09]	**DESCRIPTION**: Speed value didn't reach the minimum speed threshold before the timeout
	CAUSES: • Torque or current limit are too low • The load is too heavy
	TROUBLESHOOTS: • Change the torque/current limits • Verify the load condition
Fault Code: 5034 **Overspeed** [7103.10] [7203.10]	**DESCRIPTION**: Speed value excided the overspeed threshold
	CAUSES: • An additional torque is provided without sufficient load • The speed regulator is too slow • The overspeed threshold [5805] is too low • The motor is dragged by the load
	TROUBLESHOOTS: • Check the configuration of the protection • Check the configuration of regulators and references
Fault Code: 5035 **Motor Stall** [7103.11] [7203.11]	**DESCRIPTION**: Speed regulator and/or current regulators are saturated and speed feedback is under a certain threshold
	CAUSES: • Too much load • Wrong configuration of regulators, in particular the output limits
	TROUBLESHOOTS: • Verify the load • Check the configuration of regulators
Fault Code: 5036	**DESCRIPTION**: Speed feedback is far from speed reference for too much time

SW Fault Code and Name	Description, Causes and Troubleshooting
Speed Deviation [7103.12] [7203.12]	*CAUSES*: • The protection is not properly configured (threshold and time) • The load is too much and the drive can't speed up it • The current/torque limits are too low
	TROUBLESHOOTS: • Reconfigure the protection and/or the regulators • Check the load
Fault Code: 5037 **Encoder Error** [7103.13] [7203.13]	*DESCRIPTION*: Encoder counter step error
	CAUSES: • Due to much noise, it could happen the encoder loses steps • The ground or the shield is not properly connected • The encoder or the SD-ENC are damaged
	TROUBLESHOOTS: • Check the ground and shield connection according with prescription on HARDWARE MANUAL • Check the encoder and the SD-ENC
Fault Code: 5038 **Encoder Feedback Error** [7103.14] [7203.14]	*DESCRIPTION*: Encoder wire cut off or not present
	CAUSES: • The encoder cable is cut or is not present • The encoder or the SD-ENC are damaged
	TROUBLESHOOTS: • Check the encoder cable and wiring • Check the encoder and the SD-ENC and eventually replace them
Fault Code: 5039 **STO Activated** [7103.15] [7203.15]	*DESCRIPTION*: Safe torque off is activated (this alarm is not related to STO diagnostic system). On SD-OP the yellow led blink. If only one channel of STO is missed, even a hardware fault will be generated.
	CAUSES: • One or two STO channel are opened • The STO circuit is damaged
	TROUBLESHOOTS: • Check the STO wiring • Check the SD-RMU and eventually replace it according with the HARDWARE MANUAL
Fault Code: 5039 **Fan Alarm** [7104.00] [7204.00]	*DESCRIPTION*: Fan Feedback is missing for too much time
	CAUSES: • The configuration of the digital input of the feedback doesn't match the wiring • The cable of the feedback is cut • The contactor which control the fan, is damaged
	TROUBLESHOOTS: • Check configuration and wiring • Check the contactor
Fault Code: 5040 **No Load** [7104.01] [7204.01]	*DESCRIPTION*: Load is too low for too long above a certain speed
	CAUSES: • Configuration of the protection is not tuned • Usually with pumps, this alarm appears when cavitation happens
	TROUBLESHOOTS: • Check the configuration • Check the load and/or the plant
Fault Code: 5041 **Flying Start Timeout** [7104.02] [7204.02]	*DESCRIPTION*: Flying Start lasts too much
	CAUSES: • Flying Start macro is been unable to estimate the speed • Flying Start is wrongly tuned
	TROUBLESHOOTS: • Tune the Flying Start or disable the protection
Fault Code: 5042 **M/F Follower Fault** [7104.03] [7204.03]	*DESCRIPTION*: Too many followers are in FAULT (Master/Follower Macro)
	CAUSES: • Follower could be in fault for any reason
	TROUBLESHOOTS: • Check the follower
Fault Code: 5043 **M/F Mater Timeout** [7104.04]	*DESCRIPTION*: Too many followers are not READY to OPERATE on time (Master/Follower Macro)
	CAUSES: • Master is configured to communicate with more than the actual followers • For some reasons, followers can't switch to READY to OPERATE state • Fieldbus communication could have some problem

SW Fault Code and Name	Description, Causes and Troubleshooting
[7204.04]	**TROUBLESHOOTS**: • Check the M/F (Master) configuration • Check the followers • Check the fieldbus
Fault Code: 5083 **MCU Firmware not supported** [7106.11] [7206.11]	**DESCRIPTION**: MCU Modulator is not supported by this control version
	CAUSES: • The carrier board has incompatible firmware with the main control system
	TROUBLESHOOTS: • Reprogram the board • Upgrade the control software
Fault Code: 5084 **Modulator Option Mismatch** [7106.12] [7206.12]	**DESCRIPTION**: Modulator function or option not supported by remote firmware - check Mod Option Status Word
	CAUSES: • Wrong firmware version on carrier board
	TROUBLESHOOTS: • Reprogram the board • Upgrade/Downgrade the control software
Fault Code: 5085 **MCU-DPM Modulator Mismatch** [7106.13] [7206.13]	**DESCRIPTION**: MCU modulator major version differs from at least one power module major version
	CAUSES: • Wrong firmware version on DPM
	TROUBLESHOOTS: • Reprogram the SD-RMU • Upgrade/Downgrade the control software
Fault Code: 5086 **Remote Modulator Mismatch** [7106.14] [7206.14]	**DESCRIPTION**: At least one remote module has a modulator firmware version different from the others - check INFO menu
	CAUSES: • Wrong firmware version on SD-RMU
	TROUBLESHOOTS: • Reprogram the SD-RMU • Upgrade/Downgrade the control software
Fault Code: 5087 **Size Mismatch** [7106.15] [7206.15]	**DESCRIPTION**: At least one power module size differs from the selected one or it isn't detected - check INFO menu to know which DPM has the problem
	CAUSES: • The size on the DPM is wrongly configured • The DPM is actually different in term of power parts • The size configured in the software is wrong
	TROUBLESHOOTS: • First of all, verify carefully the size of each DPM • Verify the correctness of the size • Verify the deep switch into the DPM and eventually set them properly according to SOFTWARE and HARDWARE MANUAL ⚠️ **WARNING!** Modify the DPM dip switch is an hazardous procedure which can lead to damage the drive or injure or kill people in the vicinity of the machine. This procedure is not protected against sabotage.
Fault Code: 5088 **Heavy Control Routine** [7107.00] [7207.00]	**DESCRIPTION**: System control task execution time exceeded the safe threshold value
	CAUSES: • For some reason the control routine is using too much resources
	TROUBLESHOOTS: • Contact SECOM
Fault Code: 5089 **WatchDog FPGA** [7107.01] [7207.01]	**DESCRIPTION**: Main CPU firmware probably is crashed
	CAUSES:
	TROUBLESHOOTS: • Contact SECOM
Fault Code: 5090 **Configuration Timeout** [7107.02] [7207.02]	**DESCRIPTION**: Modulator board hasn't been configured on time
	CAUSES: • Fiber optic from SD-MCU and SD-RMU can be disconnected • SD-RMU is not supplied
	TROUBLESHOOTS: • Check optical wiring • Check 24V power supply to the DPM
Fault Code: 5091	**DESCRIPTION**: There is something wrong in drive configuration, probably size or control type

SW Fault Code and Name	Description, Causes and Troubleshooting
Drive Configuration Error [7107.03] [7207.03]	*CAUSES*: • Size or control type could be wrong • Some calculation is incompatible<hr>*TROUBLESHOOTS*: • Check the size and SD-MCU configuration
Fault Code: 5092 **Alignment Data Error** [7107.04] [7207.04]	*DESCRIPTION*: CRITICAL ERROR! Exchange data between internal PLC and Control are unaligned<hr>*CAUSES*: • Something goes wrong during software update<hr>*TROUBLESHOOTS*: • Contact SECOM
Fault Code: 5093/5094/5095 **PLC Task*X* Overrun** [7107.05]/[7107.06]/[7107.07] [7207.05]/[7207.06]/[7207.07]	*DESCRIPTION*: PLC control task *X* exceeds the safe threshold value. *X* could be CRITICAL, FAST or AUTOMATION Task<hr>*CAUSES*: • PLC program is using too much resources<hr>*TROUBLESHOOTS*: • Redesign the PLC
Fault Code: 5096 **PLC Datablocks Unaligned** [7107.08] [7207.08]	*DESCRIPTION*: CRITICAL ERROR! PLC data blocks are not aligned with control system<hr>*CAUSES*: • Datablock interface between PLC and control system is unaligned • Something goes wrong during upgrade<hr>*TROUBLESHOOTS*: • Contact SECOM
Fault Code: 5098 **SD-OP Timeout** [7107.10] [7207.10]	*DESCRIPTION*: SD-OP Watchdog hasn't been written within the timeout<hr>*CAUSES*: • SD-OP is not programmed • SD-OP is not connected any more<hr>*TROUBLESHOOTS*: • Replug the USB cable behind the SD-OP • Replace the SD-OP
Fault Code: 5099 **Profibus Error** [7107.11] [7207.11]	*DESCRIPTION*: An error or timeout occurs on Profibus network<hr>*CAUSES*: • Profibus cable is not connected or there are connection problems • The SD-COMX10 could have some problem (ie. The board is not programmed) • Profibus is enabled, but SD-COMX10 is not installed<hr>*TROUBLESHOOTS*: • Check the communication and/or the connection of Profibus • Verify the SD-CAOMX10 is installed and eventually the correct working (see 3.3.16.3)
Fault Code: 5100 **CANOpen Timeout** [7107.12] [7207.12]	*DESCRIPTION*: CANOpen Watchdog hasn't been written within the timeout<hr>*CAUSES*: • CANOpen slave is configured to receive a watchdog (*[5204]*=Enabled), but the master is not programmed to write something into slave address 2002.0 • CANOpen master is not connected • There are communication problem on the fieldbus (this can be monitored via SDLE or by the master)<hr>*TROUBLESHOOTS*: • Configure the CANOpen Master to write into 2002.0 address no longer than [5205] • Increase the timeout value [5205] • Disable CAN watchdog (*[5204]*=Disabled) or the alarm itself
Fault Code: 5101 **Modbus TCP Timeout** [7107.13] [7207.13]	*DESCRIPTION*: Modbus TCP Watchdog hasn't been written within the timeout<hr>*CAUSES*: • ModbusTCP slave is configured to receive a watchdog (*[5001]*=Enabled), but the master is not programmed to write something into slave address 0042 • ModbusTCP master is not connected • There are communication problem on the Ethernet, for example the network is so overloaded that the slave do not receive the watchdog on time<hr>*TROUBLESHOOTS*: • Configure the ModbusTCP master to write into 0042 address no longer than [5002] • Increase the timeout value [5002] • Disable ModbusTCP watchdog (*[5001]*=Disabled) or the alarm itself
Fault Code: 5102 **SDM Timeout**	*DESCRIPTION*: SECOM DRIVE Manager has been disconnected with local commands enabled<hr>*CAUSES*: • Ethernet cable has been disconnected while SDM is taking control of the drive • The Ethernet network is overloaded or too slow

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SW Fault Code and Name	Description, Causes and Troubleshooting
[7107.14] [7207.14]	TROUBLESHOOTS: • Check the network and cable connection
Fault Code: 5103 **Simulation Error** [7107.15] [7207.15]	DESCRIPTION: Simulation Error: real Vdc is present during simulation
	CAUSES: • Simulation is enabled, but for some reason the DC voltage is present
	TROUBLESHOOTS: • Avoid the load of DC bus • Disable the simulation mode

Tab. 5-2: Software Alarms Troubleshooting

FIRMWARE DISTRIBUTION AND UPGRADE

6

Chapter Table of Contents

Contents

In this chapter will be explained how install the SDM (SECOM Drive Manager) and the procedures to upgrade the standard firmware distributed by SECOM.

The chapter reports even all the procedures to reprogram all the PCB with CPU or FPGA on board; these kind of operation are usually done by SECOM on factory and no one have to perform them.

Chapter Target Audience

Commissioning or maintenance engineers who need to know how to install SDM and upgrade the software. Upgrading firmware is usually done by SECOM personnel or customers qualified by SECOM to perform these operations.

6.1 OVERVIEW

As shown at the beginning of this manual, SECOM DRIVE is composed by two main components, the SD-MCU and SD-RMU.
The software release is composed by 5 packages:

- *SD-RMU firmware*: this is file *.jic extension file related to SD-RMU and it must be upgraded <u>only</u> from qualified personnel.
- *SD-MCU firmware*: this is file*.jic extension file related to FPGA on the SD-MCU and it must be upgraded <u>only</u> from qualified personnel.
- *SDrive package*: this is related to MCU control system and it can be upgraded also from standard customer using SDM.
- *SecomDrive PCTools*: this distribution is related to SDM and SDLE
- *Drive Catalog*: it is related to the parameters and PLC interface from SDM to the target. The catalog version is the same of SDrive package.
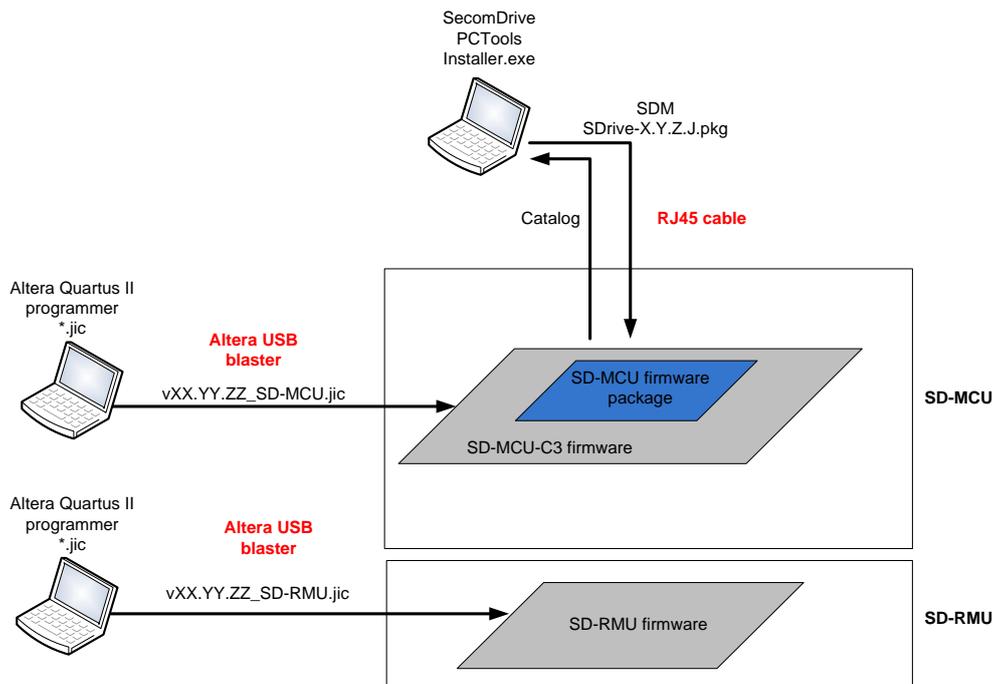
The software upgrade procedure can be made by following these steps:

- Install in your PC the Setup_SECOM Drive PC Tools_xxxx where xxx is the installer version
- Make a backup of control parameters (target →create param backup file)
- Check the actual software package version (*[7601]*) and verify the system change to the new version with the help of the Tab. 6-1
- Apply the upgrade procedure described in 6.4.1
- Check if it is necessary to upgrade also the SD-MCU firmware e SD-RMU firmware (Tab. 6-1). If it is so, please follow the rules described in 6.3
- Install the target catalog as described in 4.1.8.1

6.2 INSTALL SECOM DRIVE PC TOOLS

Secom drive can increase the functionality by the help of the PC tools. The PC tools are the following:

- SDM (Secom Drive Manager)
- SDLE (Secom Drive Logic Environment)
- Soft Scope

To install all these tools is necessary to download the latest version of Setup_SECOM Drive PC Tools_xxxx.exe (where xxxx is the version).

- Double click on Setup_SECOM Drive PC Tools_xxxx.exe
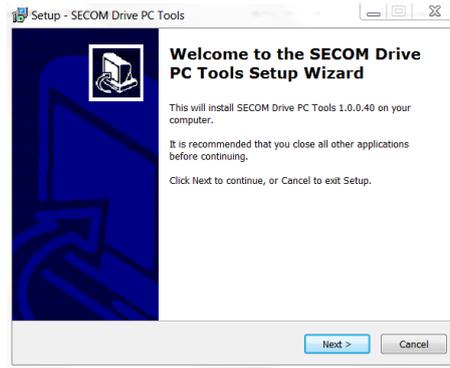
- Follow the instruction to install all of the tools
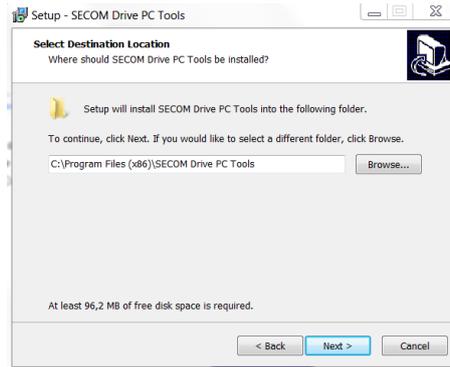
- Wait the installation completion
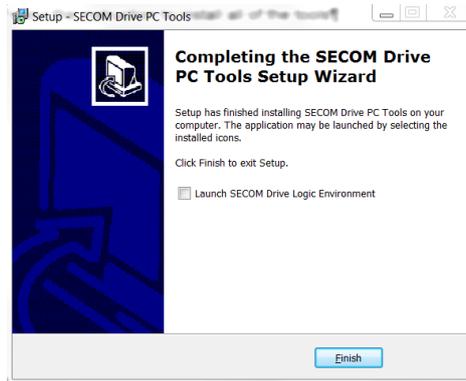
6.3   SD-RMU OR C3 FIRMWARE UPGRADE

The firmware contained to SD-RMU and C3 (FPGA in the SD-MCU) are mutually linked and it is not possible to work with different firmware versions.
The compatibility table is showed in 6.5. The firmware versions are showed in this way: XX.YY.ZZ where XX is the version and YY is the subversion or bugfix (ZZ is an additional information related only to R&D). The SD-MCU check if the version (XX) contained in the SD-RMU connected are the same of the C3. If there is a different version a fault is generated "Master-Remote modulator mismatch".
In this case it is necessary to check in *INFO [76*] to understand which RMU generates the fault.
This kind of fault is not generated if there is only a different subversion among the C3 firmware and SD-RMU firmware.
The control system (that can be upgraded with the SDrive package) provides the SD-MCU C3 compatibility version **[7606]**. For example, if this parameter value is "from 2 to 3" it means that it is possible to use C3 firmware version from 2 to 3. If the version firmware is out of the range a fault is generated "Modulator not supported by this CTRL".
It is possible to upload the firmware to upgrade the C3 and SD-RMU directly from SDM as described in 4.1.2.

6.3.1   SD-MCU C3 Firmware Upgrade Procedure

WARNING! Before firmware upgrade it is necessary to disconnect the drive from the power line to avoid unexpected behaviors.

This procedure requires the following elements:
- Quartus Programmer software
- Altera USB-blaster adapter
- vXX.YY.ZZ_SD-MCU.jic file

To upgrade the firmware inside the SD-MCU (only C3 component) it is necessary to follow this steps:
- Switch-off the board by removing 24V supply
- Open the upper part of the SD-MCU case
- Connect the USB-adapter to the JP22 connector (JTAG) situated in the center of the board as shown in the picture below
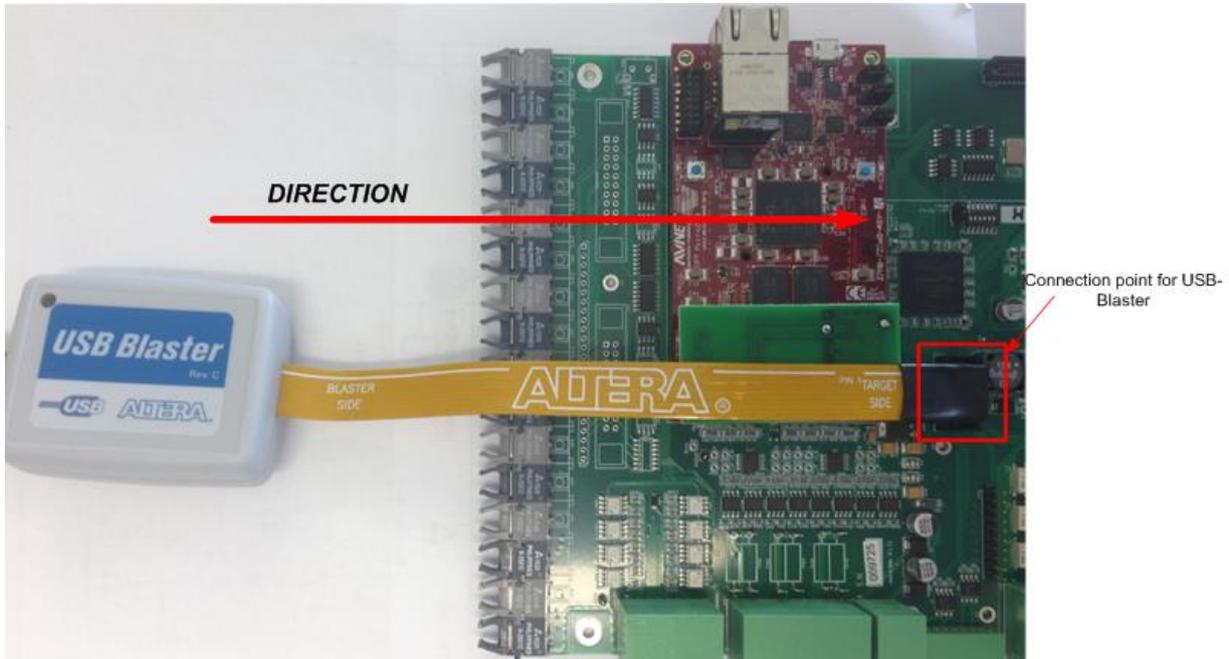
- Switch-on the SD-MCU
- Open Quartus Programmer, click on "add file" and select the file which version you want to upgrade
- Then check on Program/configure as shown in the picture below

File	Device	Checksum	Usercode	Program/ Configure	Verify
Factory default enhanced SFL image	EP3C25	00173917	FFFFFFFF	☑	☐
E:/v03.04.01_SD-MCU.jic	EPCS16	160A31CA		☑	☐

- Click on hardware setup button, select USB blaster and press close
- Select mode→JTAG
- Click on Start button on top left and wait the progress bar on the top right is green and labeled "100% complete"
- Now switch-off the board, remove the USB blaster and switch-on again
- The firmware upgrade is completed

6.3.2 SD-RMU Firmware Upgrade Procedure

⚠ **WARNING!** Before firmware upgrade it is necessary to disconnect the drive from the power line to avoid unexpected behaviors.

This procedure requires the following elements:
- Quartus Programmer software
- Altera USB-blaster adapter
- vXX.YY.ZZ-SD-RMU.jic file

⚠ **WARNING!** It is necessary to avoid to download firmware for SD-MCU version in the SD-RMU.

To upgrade the firmware inside the SD-RMU it is necessary to follow this steps:
- Switch-off the inverter supply by removing 24V supply
- Open the upper part of the inverter
- Connect the USB-adapter to the JTAG connector (JTAG) situated in the center of the board as shown in the picture below
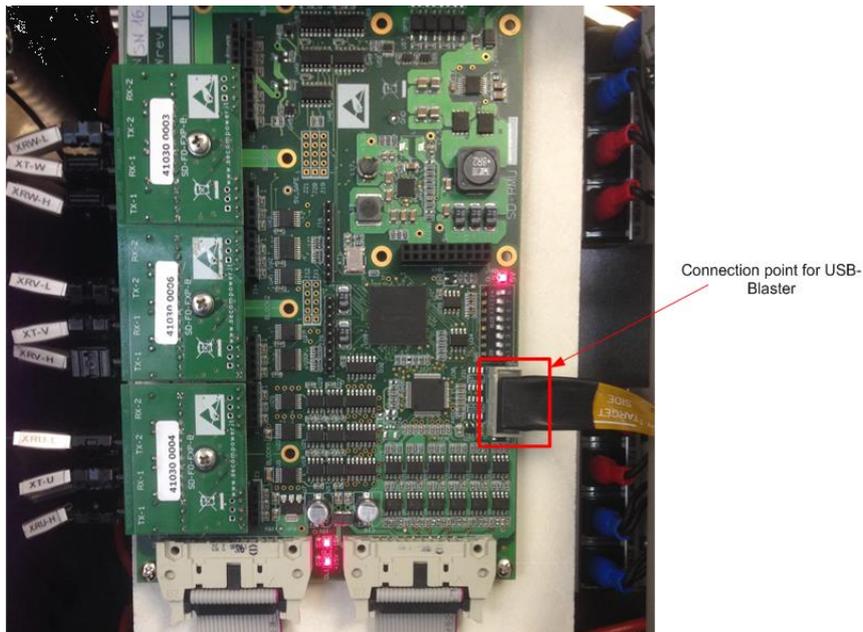
- Switch-on the inverter 24V power supply. The SD-RMU supply led are switched-on.
- Open Quartus Programmer, click on "add file" and select the file which version you want to upgrade
- Then check on Program/configure as shown in the picture below

File	Device	Checksum	Usercode	Program/Configure	Verify
Factory default enhanced SFL image	5CEBA2	0064323C	FFFFFFFF	✓	
E:/v03.04.01_SD-RMU.jic	EPCQ32	1AADFD02		✓	

- Click on hardware setup button, select USB blaster and press close
- Select mode→JTAG
- Click on Start button on top left and wait the progress bar on the top right is green and labeled "100% complete"
- Now switch-off the inverter , remove the USB blaster and switch-on again
- The firmware upgrade is completed

6.4 SD-MCU FIRMWARE PACKAGE UPGRADE

This redistributable firmware is composed by 4 numbers (X.Y.Z.J). The actual version of the installed package is located in the parameter *[7601]*. Depending on the previous package version upgraded and the new package version different actions should be taken into account.

Version main package				
Name field	*Control Interface*	*Control*	*Doc Revision*	*bugfix*
Description	This field is related to all application interfaced with the control system and the PLC. This number is inherited from the main version contained in the parameter *[7623]*. i.e. a new datablock, function.	The part related to motor or grid control. This number is inherited from the main version contained in the parameter *[7602]*. I.e.: a new control function added	If a new parameter is added or if a new utility is implemented. This value is set to zero when the *control* or *control interface* numbers change.	This number change if there is a change in the minor version of the control, control interface or other firmware inside the target.
Action when upgrade if the number is different	Internal PLC parameters are deleted	Default parameter values are restored and the parameters database set 1,2,3 are deleted	-	-

Tab. 6-1: Main package version description

6.4.1   Firmware Upgrade Procedure

⚠️ **WARNING!** Before firmware upgrade it is necessary to disconnect the drive from the power line to avoid unexpected behaviors.

This procedure require the following elements:
- SDM tool
- SDrive-X.J.Z.K.pkg file
- Ethernet cable

To upgrade the firmware inside the SD-MCU (no C3 component) it is necessary to follow this steps:
- Connect the SDM to the drive
- Left click on target→Software download
- Select the file by browsing in the PC folders
- When download is complete, press close button
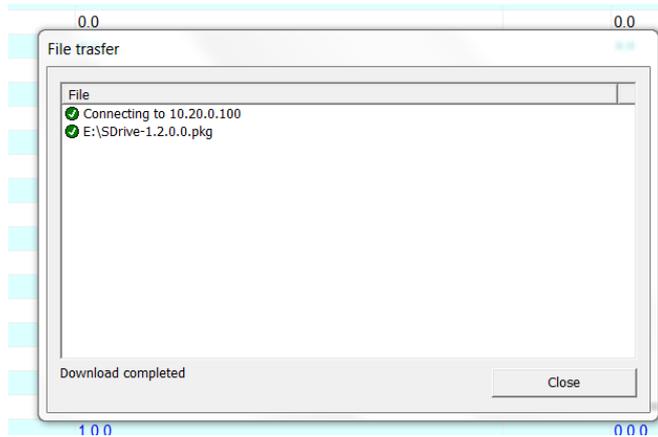
- The firmware upgrade starts automatically and the system will be rebooted.
- After few seconds, it is possible to connect again to the target and see the firmware upgrade log by clicking on *target→view software upgrade log*. In the picture below is showed an example where the control version changed from 1 to 2. In this case the parameters value will be set to default values.

```
==========================
Tue Sep  6 17:54:18 UTC 2016
Detect package: SDrive-1.2.0.0.pkg
WARNING: Control changed from 1 to 2 version
         Control parameters and defaults will be deleted
Copy file... DONE
Clean all... DONE
```

It is possible to check the actual SECOM DRIVE version in the parameter *[7601]*.

6.5   SOFTWARE PACKAGE COMPATIBILITY TABLE

In Tab. 6-2 is showed the firmware compatibility table. It is necessary to use only the version in this table and don't mix them each other.

Package Description						Compatibility range		
Release Version	pkg	MCU fpga ver	RMU fpga vers	Catalog	Installer	Installer	MCU fpga	SD Card Image
171218	1.0.0.11					>= 1.0.0.40	2.x ↔3.x	>=161219
		03.04.01	03.04.01	1.0.0.11				
		03.04.01	03.04.01	1.0.0.11	1.0.0.43			

Tab. 6-2: Software package compatibility table