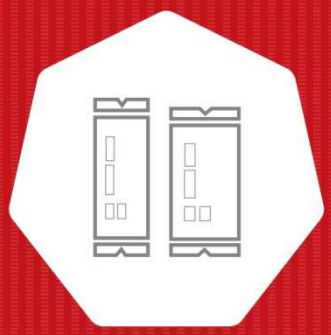
Look Ahead!

CSD MT



Stepping Motor Drives
Instruction Manual

INDEX

TERMS AND USE

For the purposes of this manual the terms used assume the meaning below described:

- **DRIVE**: electronic part of an electromechanical motion system, which receives some digital or analog input signals from an external control system and gives to the stepping motor the suitable phase excitation sequences, in order to obtain the mechanical movements required by the control system. The drive can also communicate its status to the control system through some logic signals.

In this manual, with term “drive” we consider a BDM module (following the standard EN 61800-3, chap.3, Fig.1).

- **Control system**: part of the machine which decides and controls all machine functions and gives to the drive all the execution commands. It could be a numerical or programmable control, a personal computer, a PLC or a specific control card. In the simplest machines it could also be a group of sensors and electromechanical switches.

- **Power Supply**: all machine parts suitable to supply the drive in a correct way; EMI filter, switches, protection systems and in some cases transformer or Switching power supply.

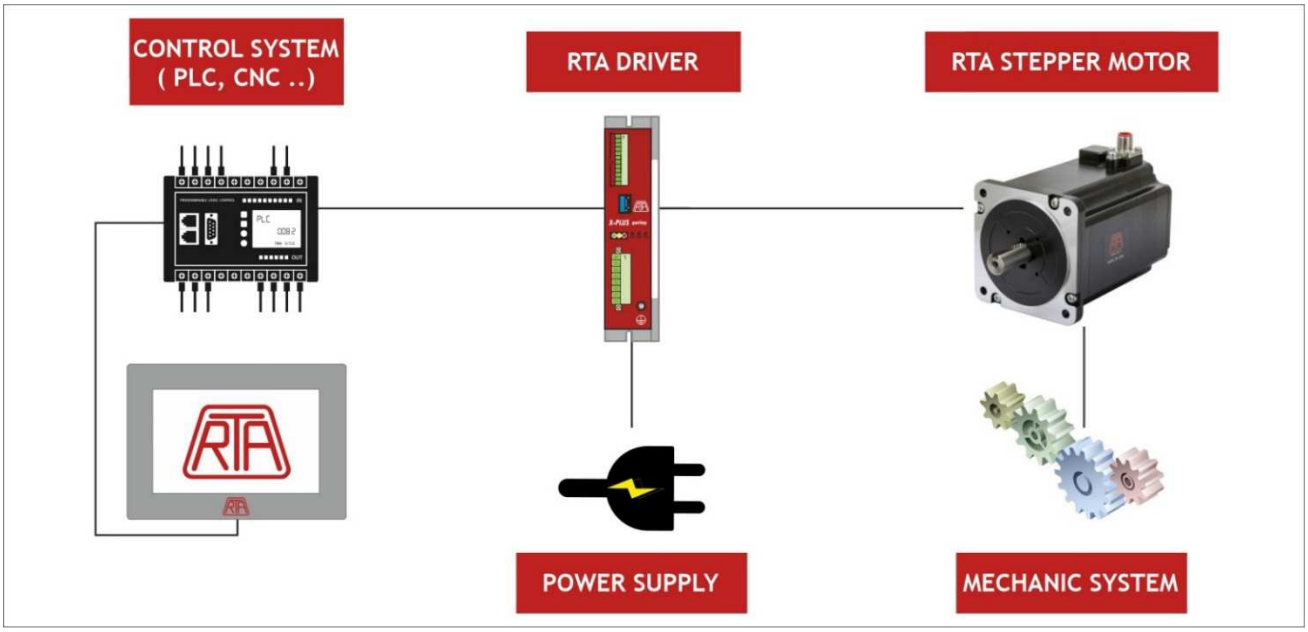


Figure 1: Basic scheme of a control system

This manual covers the following items:

- **CSD MT 94/S4** series stepping motor drives in all their standard versions starting from firmware version **KC03NC33** and **KC04NC34**.

- Standard characteristics of special versions of **CSD MT 94/S4** series stepping motor drives (see chap. 5, pg.11).

Standard drives are all models (see chap. 5, pg.11 for complete identification) whose characteristics comply completely with those described in this manual. For standard drives, this manual gives a complete characterization of all the features.

Special versions are all models in which some characteristics differ from the description given in this manual. For these models, some part of the manual does not apply and, in these cases, you must have the specific "variation sheet" which becomes an integral part of the manual itself.

1. WARNINGS

This manual is conceived in a way to offer to the personnel involved in project and safety verification of a machine all information concerning characteristics, working conditions, application limits hazards and cautions about CSD MT 94/S4 series stepping motor drives. The knowledge of this information is essential for a correct project of machines, apparatus and systems in which the drives are used; it is strongly recommended not to start any operation with the drives before you have completely read and understood the content of this manual; if you find some part of this manual not completely understandable or lacking regarding your particular application, do not hesitate to contact directly R.T.A. that can provide, if necessary, further information in order to make the user able to design his machine and the related safety systems in the best way.

Take into account that an incorrect use or installation, a wrong dimensioning of external safety elements related with the drive could bring to economical damages and also to hazards for human life.

Consider the fact that these are products with a very wide range of possible applications in many different working and environment conditions. For this reason this manual can only fix limits and general rules but cannot take in consideration every single possible application condition.

It is the user's responsibility to check the validity of this manual with respect to the model and version of the product for which it is intended to be used.

If you have problems to understand some part of this manual or to meet its indications with your specific application, do not hesitate to contact R.T.A. for further information. Take into account that R.T.A. has over forty years of experience in any kind of applications, which cannot be condensed in a manual but can always be at customer disposal.

The terms "user" and "customer" often used in this manual always indicate a skilled person.

This manual is considered valid at the moment of the selling of the product. It cannot be considered inadequate as a consequence of product or manual changes or improvements after the selling.

R.T.A. reserves the right of products and manual revisions without notice neither obligation of previous products and manuals revision.

2. HAZARDS AND PRECAUTIONS

Symbol Meaning	
⚠ **WARNING!**	The section marked with this symbol contains warnings regarding safety problems. If the directions indicated in these sections are not fulfilled, it could arise hazardous situations for human life.
⊘ **CAUTION!**	The section marked with this symbol contains information regarding operations which are strictly forbidden.
🕮 **INFORMATION**	The section marked with this symbol contains important information s to avoid not compliant installations.
[...] **UL**	Some parts of the text between square brackets are the original definition of UL standard rules. These requirements are mandatory for the models of this manual that are UL compliant. These models can be identified by UL mark in the identification label on the specific model. In any case, we advise to comply with these requirements even for non-UL certified models.

🕮 INFORMATION

CSD MT 94/S4 series drives are suitable to drive two phases stepping motors with 4, 6 or 8 terminals. The use of stepping motors with 5 terminals is not allowed.

Their use for different purposes is not allowed.

⚠ WARNING!

CSD MT 94/S4 series drives [UL category: Open Type Motor Drive] have the following features:

- IP 20 protection degree (EN60529);
- designed for use in pollution degree 2 environment;
- working temperature range between 5°C (41° F) and 40° C (104° F).

they must be located within a protective enclosure suitable to maintain the above mentioned conditions. The position inside the enclosure must be chosen in a way to avoid that small tools or particles of material can drop inside the drive through the ventilation holes. **Avoid absolutely to install in explosive or flammable environments. Avoid also to install near easily flammable materials and components**; we recommend to verify that all the components located in the enclosure are realized using self-extinguishing materials.

⚠ WARNING!

CSD MT 94/S4 series drives are designed for use in general industrial equipments. Do not use in installations in which an utilization mistake or a malfunction or a failure of the drive could cause:

- Injuries or hazards for human life

- Property damages
- Risks of social and public upsets

In these cases, the person responsible of the installation must design and provide specific equipments or safety techniques, external and independent from the drive, suitable to prevent all dangerous consequences.

Use in conditions not complying with one or more specific limitations or prescriptions stated in this manual regarding electrical, mechanical and environmental specifications or characteristics is strictly forbidden.

CAUTION!

All products considered in this manual are sub-assemblies without a direct function, foreseen to be integrated in a more complex machine. Only a professional assembler, expert in the field of motor drives and in their related problems, can install and put in service this component**. It is exclusive responsibility of the designer of the complete machine or installation in which this component is used to take care of the safety and reliability of his project.** It is forbidden to use this material in application covered from one or more EEC directives (for instance 2014/30/CE, 2006/42/CE, etc.) before the conformity to those directives has been declared. Regarding 2014/30/CE directive (see chap. 4, pg.10).

CAUTION!

The drive is suitable for use on a circuit capable of delivering not more than 5000 A rms symmetrical amperes, 48 V_{DC}; overvoltage category II.

CAUTION!

Remote overload protection is required. Integral solid state short circuit protection does not provide branch circuit protection. Branch circuit protection must be externally provided (see Figure 5, pg. 19). [Integral solid state short circuit protection does not provide branch circuit protection. Branch circuit protection must be provided in accordance with the Manufacturer Instructions, National Electrical Code and any additional local codes].

The drive does not provide Motor Overload protection. External or remote Motor Overload protection shall be provided in the end-use applications. The drive does not provide motor over-temperature sensing. It shall be provided in the end-use applications.

It is exclusive responsibility of the designer of the complete machine or installation in which this component is used to take care of the safety and reliability of his project.

CAUTION!

The drive and related motor have a protective earth terminal which must be connected to earth, in order to prevent risk of electric shock.

With the drive switched on, do not perform any wiring, maintenance, inspection; in particular, do not perform the setting of the dip-switches. After switching the power off, wait at least 10 minutes before to fulfill these tasks.

Do not touch the inside of the drive and do not get close to connection terminals while the device is powered on.

Do not plug or unplug the connectors while the device is powered on. These operations cause some underhand damages of the contact surface which could bring to a subsequent risk of overheating and fire.

Do not try to repair a faulty device. Only R.T.A. service department is authorized to repair the drives.

CAUTION!

During normal working conditions, the heatsink can reach temperatures until 80°C (176 °F). Do not touch this component for some minutes, after switching off, in order to avoid scald hazard.

Modbus commands used to switch off the drive output power and internal electronic functional protections use semiconductor devices; they cannot be used to interrupt power in emergency stop function or in any function involving personnel safety.

R.T.A. cannot be considered liable for property losses, equipment damages and personnel injuries arising from use or installation not fully compliant with specifications contained.

To correctly using of STO inputs and monitor output (in CSD MT S4) please see chapter **Errore. L'origine riferimento non è stata trovata.**, pg. **Errore. Il segnalibro non è definito.**.

3. MAINTENANCE

INFORMATION

BASIC MAINTENANCE

Periodically check the status and installation conditions of the drive:

- Tightening the screws (recommended torque 0.22-0.25 Nm) and correct insertion of the power input and output terminals.
- Correct insertion of the extractable terminal board relating to the logic signals.
- Tightening of the earth connections.
- Cleaning the ventilation slots.

CAUTION!

FAILURES

in case of failure, the drive must be sent for repair to R.T.A.

In any cases, never try to repair the faulty device. Only R.T.A. is authorized for repairs.

4. DIRECTIVES

INFORMATION

The products described in this manual comply with the following **directives**:

- low voltage (2014/35/CE)

- EMC, electromagnetic compatibility (2014/30/CE)

The specific product **standard** are:

- UL 61800-5-1 1st Edition – Power Conversion Equipment

- CSA C22.2 No.274 - Industrial control equipment

Remember that, as stated in all regulations, compliance exists only when a product is installed and used in accordance with its destination and following manufacturer prescriptions.

Thereby, all relevant indications about use, cautions, installation and limitations here described must be followed by user in order to stay within safety and compliance limits: from this point of view, chapter 2, 6 and 7 are particularly important, but the entire content of this manual has to be carefully read and considered in order to obtain the information necessary for a correct use.

Conformity declaration regarding above mentioned products is kept by R.T.A. (as manufacturer residing in EEC country) together with technical construction file and are available on request.

5. BEFORE USE

IDENTIFICATION LABEL

Figure 2 - Identification label

NOMENCLATURE

The identification of the specific drive models belonging to this series is accomplished by means of the following coding:

CSD MT x4.y

Where the character:

x may be:

- **9**, for the standard version
- **S**, for the STO safety function version.

.y is not present in standard models. If present y can be a number or an alphanumeric character identifying a special version with some variations with respect to standard models.

The identification is completed by a progressive serial number that identifies each sample.

DEVICE ASPECT AND DIMENSIONS

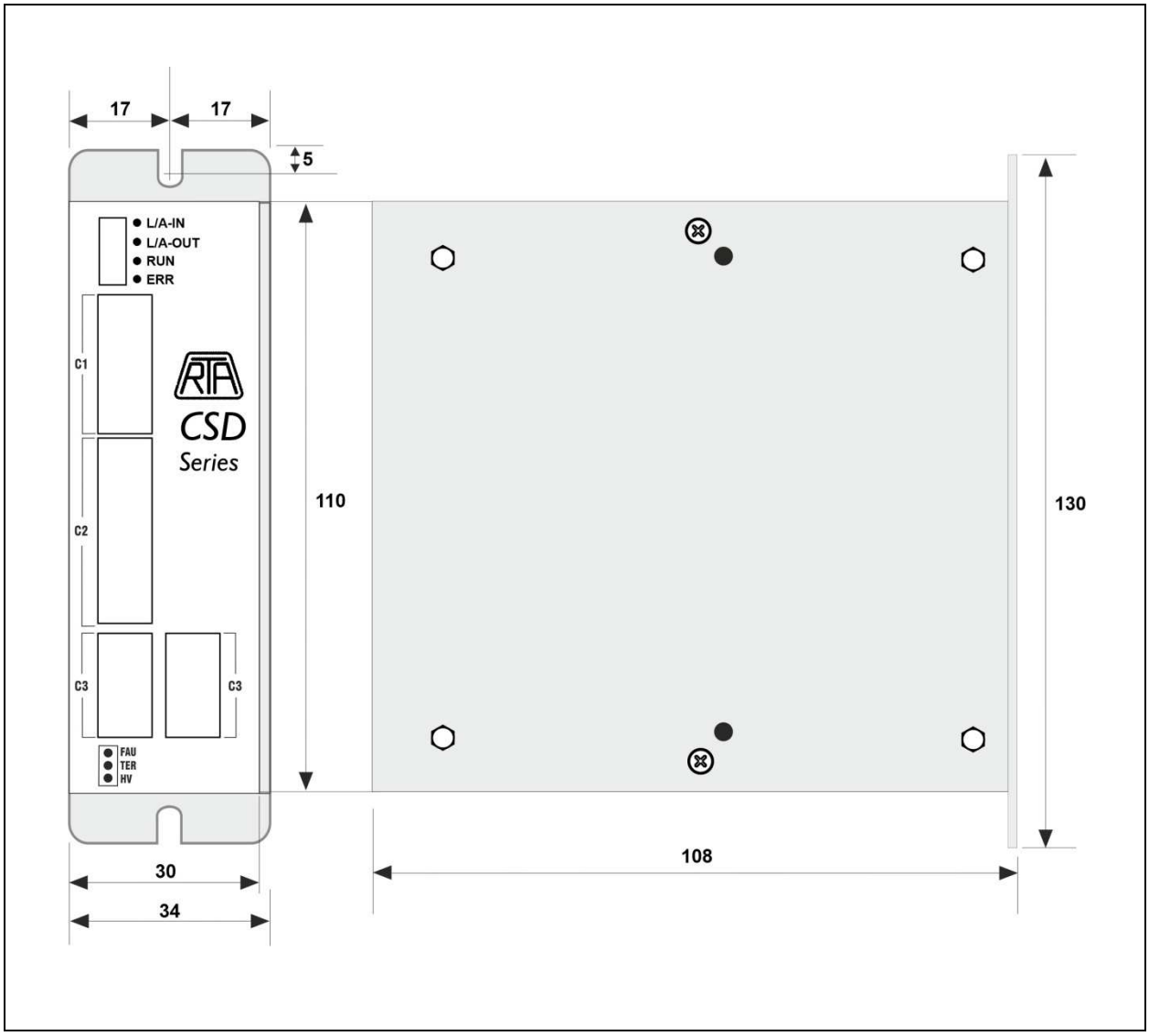


Figure 3 – External view of the drive (dimensions in mm).

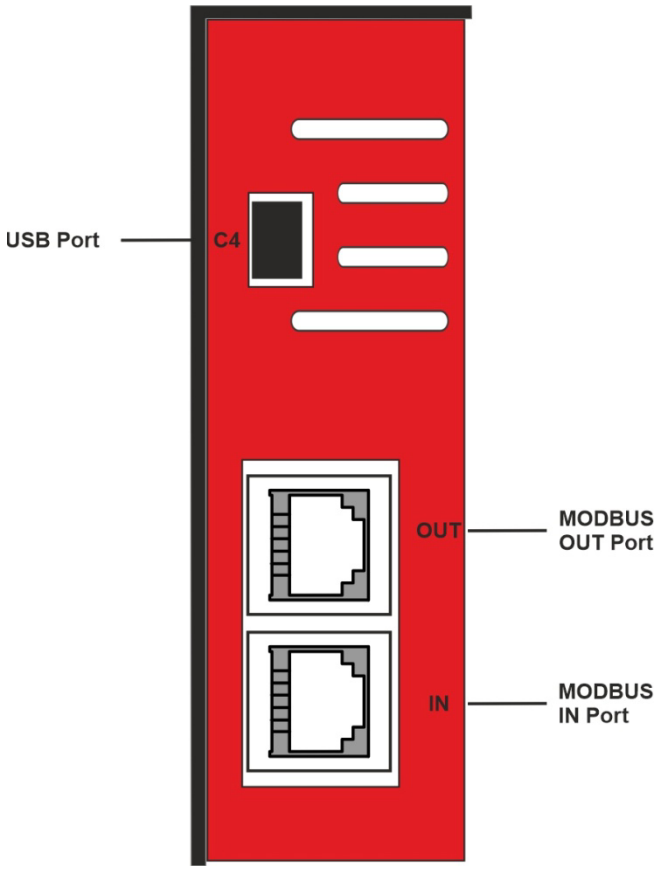


Figure 4-Modbus and USB connectors (Top view of CSD MT 94/S4 drive).

ELECTRICAL CONNECTION

- **C1**: encoder connector
- **C2**: **logic power supply** $24V_{DC}$, **power supply**, PE and motor power outputs connector
- **C3a**: **logic input** connector: general purpose inputs (and STO inputs in CSD ET S4)
- **C3b**: **logic outputs** connector
- **C4**: configuration input connector (**USB** port)
- **IN-OUT**: bus Modbus communication connectors (RJ45 port)

6. INSTALLATION

INSTALLATION CONDITIONS

All products considered in this manual have the following common characteristics:

IP20 protection degree: it is user responsibility to provide an adequate protection enclosure suitable to meet the standards regarding the specific application in which the products are used.

CAUTION!

Installation and work environment. Installation is allowed in a micro-environment with:

- **Environment conditions class 3K3** (IEC 721-3-3): that implies, among other things, a working temperature from +5°C to +40°C and relative humidity from 5% to 85% non condensing.
- **Pollution degree 2**: that implies, among other things, that installation in environments in which explosive and/or flammable and/or chemically aggressive and/or electrically conductive gas, vapor or dust could be present is strictly forbidden.
- **Mechanical conditions class 3M1** (IEC 721-3-3).
- **Maximum operation altitude:** 2000 m.
- If the environment in which the machine is used does not satisfy these conditions, suitable conditioning systems have to be provided for the enclosure.
- Storage environment in original enclosure:
  Temperature: from -25°C to +55°C. Relative humidity: from 5% to 95%.
  Environment condition class 1K3 (IEC 721-3-1). Pollution degree 2.

THERMAL DISSIPATION

The drives generate some amount of heat. Take care of this in considering the total amount of heat generated in the enclosure in which the drives are located.

In order to make easier air circulation in the drive, install the drive vertically (not turned upside down) with at least 5 cm of free space over and under the drive and 1 cm to the left and the right of the drive.

Do not obstruct the air vent.

7. CONNECTIONS

WIRING WARNINGS

For external connections we advise to use copper wire certified to work at 60/75 °C.

The cross-sectional area of conductors used in power supply circuit must be chosen according with dimensioning power. The cross-sectional area of the four shielded conductors between motor and drive must be chosen in accordance with nominal current which has been set in the drive.

POWER SUPPLY SIZING

CAUTION!

Power: the basis to calculate power for filter, switching and protection system and possible transformer is the total power required from drive and motor. It is the sum of the following terms:

- Mechanical power delivered to load: mainly depending on application characteristics like friction, inertia, efficiency of mechanical transmission etc.
- Motor losses: mainly depending on motor type, drive voltage, speed and duty cycle.
- Drive losses: mainly depending on drive model, current setting and duty cycle; according with these parameters these losses can approximately vary between 60 and 130 Watt. It is often very hard to do an exact forecast of drive and motor losses; in these cases a safety over-dimensioning of the supply elements proportional to the uncertainty of the data is recommended. To get more accurate information, please contact R.T.A. describing all the data of the particular application.

Power supply: it can be made of a voltage transformer followed by a single phase rectifier bridge (see Figure 5 and **Errore. L'origine riferimento non è stata trovata.**) or by 3-phase transformer and a 3-phase rectifier bridge.

The value of capacitor C must be adequate to ensure a low level of voltage ripple; in any case, the filter capacitor C1 must be at least not lower than ($\sqrt{n}$ x 4700) µF, where n = number of drives connected to the same power supply. The working voltage of the capacitor C must be at least equal to the drive nominal voltage. The capacitor must shows low values for the high frequency impedance.

The 3-phase solution is better than the single phase when more than 3 drives are connected to the same power supply.

Furthermore the power supply solution must also meet the following conditions:

- Separation from the mains: galvanic separation from the mains must be guaranteed so that, downstream of the power supply, the overvoltage category is equal to II
- The nominal power of the power supply must be equal to the sum of the nominal powers of the drives connected to it.

- The short circuit current value must be not greater than 1000 A.

⚠ **WARNING!**

The **protection systems** indicated in Figure 5 must include:

- residual current protective device with operating residual current of 30 mA.
- branch circuit protection fuses (F3): UL Type JDDZ, class CC, 600 VAC, 8 A (Cooper Bussman model KTK-R-8 or equivalent).
- slow fuse (F1 e F2) with nominal current value related to the power of the voltage transformer

ELECTROMAGNETIC INTERFERENCE AND IMMUNITY

INFORMATION

CSD MT 94/S4 series drives are BDM (Basic Drive Module), as defined in the EN 61800-3. Only a professional assembler, expert in the field of motor drives and in their EMC aspects, can install and put in service this component. R.T.A. has the responsibility to verify the products compatibility in some typical way of use in order to give correct installation information. In any cases, it is responsibility of the professional assembler, who installs this product, to verify the compatibility of the complete machine or system.

Pay attention: the set consisting of drive, motor, transformer and all related cablings are source of electromagnetic interferences. The assembler of installation must consider these problems during the project of the plant where the drive (or drives) will be installed in order to shield and/or reduce these interferences.

Tests performed by R.T.A. show that the most effective measures able to reduce these interferences are the following:

- **Shielding** of cables for the connection between motor and drive. The shield of this cable has to be directly connected to CSD MT 94/S4 series drive terminal 3. The shield of encoder cable, if it is available, has to be directly connected to the earth. This shielding can be avoided only in case of very small and compact machine where motor, drive and related connections are located in the same enclosure, showing adequate shield performance.
- It is suggested not to exceed the maximum length of 10 meters for the wiring between motor and drive. In case of application requires the exceeding of this limit, please contact RTA.
- Connect **earth line** to motor chassis. To reduce the radio-frequency emissions, the mechanical connection of motor to machine chassis (by means of mounting flanges and screws), is typically simple and effective solution. In this case, both screws and chassis must be of conductor material and the chassis must be connected to earth (see Figure 5). All the ground connections must be made in such a way as to have the least possible inductance.
- Mount the drive in a cabinet shielded from electromagnetic interferences.
- Interpose an **EMI filter** in AC power input line (see Figure 5).) in order to reduce conducted electromagnetic interferences. Filter characteristics in a specific installation depend on the following factors:
  - Strictness degree of the specific standard regarding the machine on which drive is used.
  - Power level of the applicaton (nominal voltage and current setting on the drive).
  - Presence of other filtering systems in the machine installation.

  In any case we advise to use the following type of filter: CORCOM SK series. Different models inside these series differ for current rating; thereby choose the specific model according to power level of your installation. All earth connections mentioned above have to be realized with the less possible inductance.

To improve the drive logic input/output signals immunity from external noise the following well known procedures, to manage the relatively fast signals treatment must be considered:

- Use shielded cables.
- Keep signal cables separate from power cables. In particular keep signal cables separate from motor output cables.
- Carefully verify level compatibility when interfacing drive with control system.

Following these procedures is essential to realize an installation which complies with the requirements of 2014/30/CE directive. The real specific standard compliance have to be proved in the complete installation. In fact the effectiveness of the suggested application notes depends also on machine topology and on the measurement setup. Test performed by R.T.A. simulating typical installations and following the mentioned above indications show that EN61800-3 standard compliance applications can be achieved.

In some cases, due to the characteristics of particular installations, conflicts between ground connections necessary for shielding purposes and ground connections necessary for safety reasons could arise. Remember that, in such cases, prescriptions regarding safety take priority, but remember also that, in almost all of the cases it is possible to find a solution meeting both prescriptions; R.T.A. is available for further information about these problems.

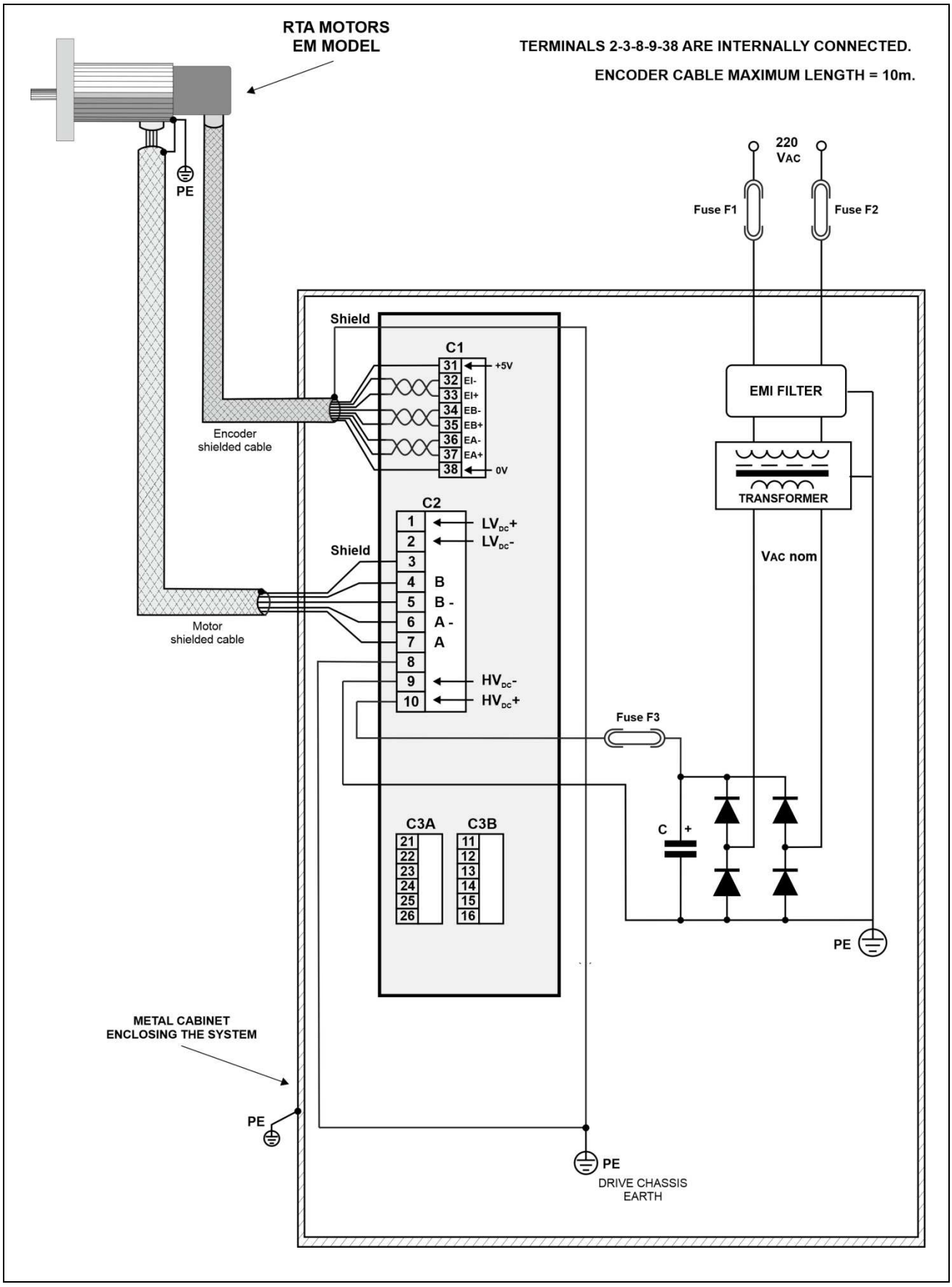


Figure 5 - Wiring diagram.

GROUNDING CONNECTION

CAUTION!

The terminal 8 of C2 connector is the points of motor-drive system that have to be connected to earth (PE terminal). No other point at a different potential power circuit has to be connected to earth. The terminal 3 of C2 connector (motor cable shield) is internally connected to terminal 8 and 9 of C2 connector. Other points at the same potential of GND could be connected to earth using the cautions suggested by classical techniques to obtain a correct location of multiple earth connections. Shielded cables of motor outputs must be connected to points at the same potential. See the connection scheme in Figure 5, Figure 6 e Figure 7.

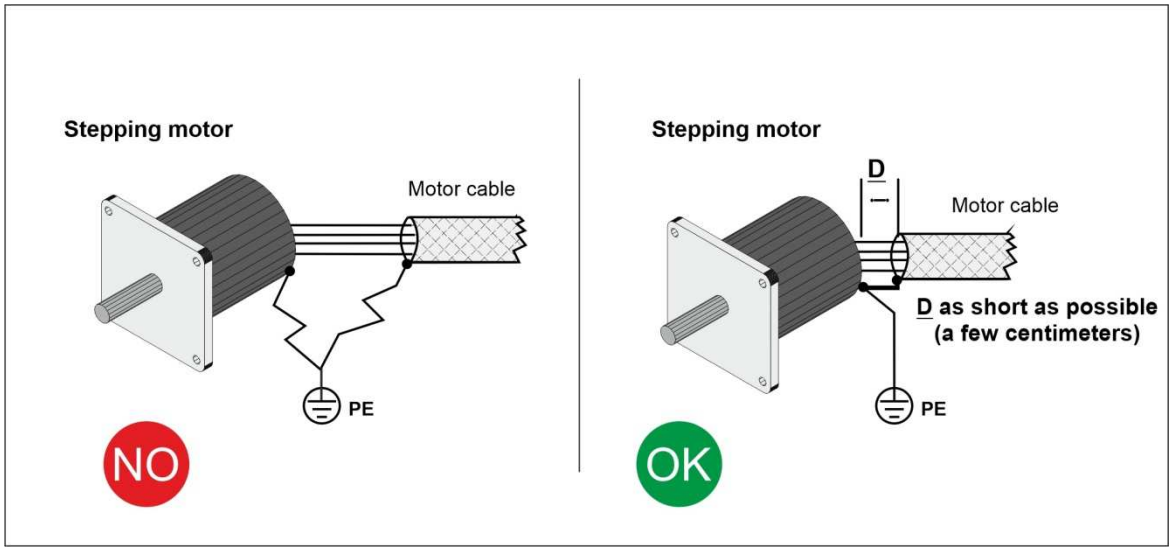


Figure 6- Shielded connection at the stepping motor side.

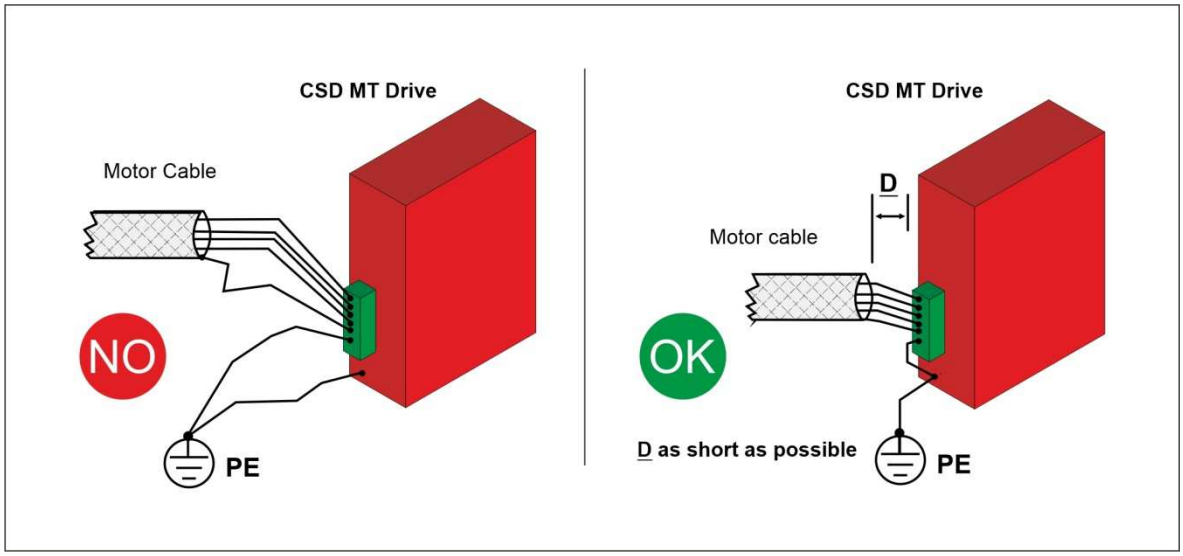


Figure 7 – Shielded connection at the drive side.

CONNECTORS WIRING

RJ-45 CONNECTORS (Modbus)

For the Modbus communication, 2 connectors type Ethernet RJ-45 are provided. For both connectors, the same pin corresponds to the same signal. The Figure 8 shows the RJ-45 connector used for connecting drive to the control system.

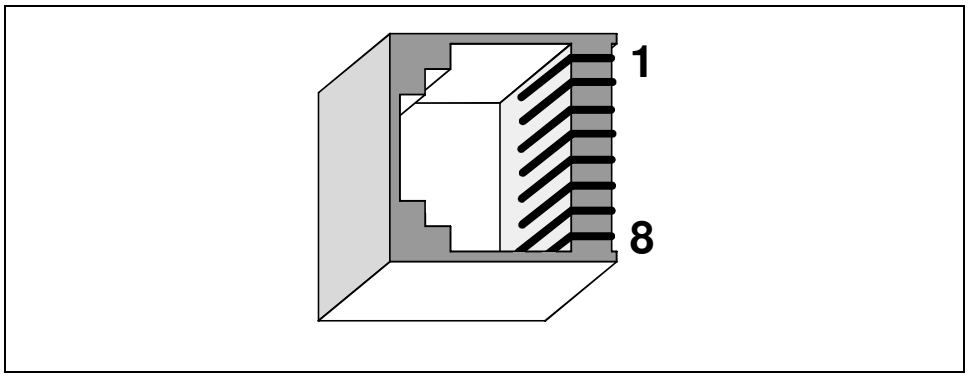


Figure 8 – Modbus connector

Terminal Number	Signal (Ethernet Connection)	Description
1	TX+	Transmitting signals +
2	TX-	Transmitting signals -
3	RX+	Receiving signals +
4	--	75 Ω Connection
5	--	75 Ω Connection
6	RX-	Receiving signals-
7	--	75 Ω Connection
8	--	75 Ω Connection

Table 1

Use twisted-pair cables that satisfy at least “Category 5e” to connect the cable.

When you make cables using exclusive tools, use STP (Shielded twisted pair cable) and RJ-45 modular plug with shield.

SCREW CONNECTORS (motor output lines and power supply wiring)

Use a torque to tighten the screws of the power connector C1 equal to 2,2 - 2,5 Nm.

SPRING CONNECTORS (Encoder and logic I/O wiring)

For connection drive-encoder use only twisted-pair shielded cable (I- twisted with I+; B- twisted with B+; A- twisted with A+).

8. GENERAL CHARACTERISTICS

LOGIC INPUTS AND OUTPUTS

ENCODER INPUTS AND POWER SUPPLY (ConneCtor C1)

The encoder signals and their correspondence with the numbering on the connector are shown in the table below:

Pin number	Function	Note
31	**VCC:** terminal + encoder power supply (+5 $V_{DC,}$ Imax=150 mA)	
32	**I-.** INDEX, input -	
33	**I+.** INDEX, input +	
34	**B-.** fase B encoder, input -	
35	**B+.** fase B encoder, input +	
36	**A-.** fase A encoder, input -	
37	**A+.** fase A encoder, input +	
38	**GND**: terminal - of the encoder power supply	

Table 2

Note1: Negative encoder power supply terminal (pin 38). Inside the drive it is shorted to the terminals 2, 3, 8 and 9 of C2.

Note2: Connect to connector C1 only the encoder mounted on RTA motors of EM or RM series. Please see the section "REGISTER" of this manual for the best settings of drive and motor. In particular, see the setting description of registers 1090-1091.

If different motors with encoders are used, please contact RTA technical assistance.

DIGITAL INPUTS for CSD MT 94 (connector C3a)

The available signals and their correspondence with the numbering on the connector C3a are shown in the table below:

Pin number	Function	Note
21	**I4 INPUT**. Auxiliary input	
22	**I3 INPUT**. Auxiliary input / Touch Probe	
23	**I2 INPUT**. Auxiliary input / Limit Switch	
24	**I1 INPUT**. Auxiliary input / Limit Switch	
25	**I0 INPUT**. Auxiliary input / Proximity	
26	**INPUTS common terminal**	

Table 3

DIGITAL INPUTS for CSD MT S4 (connector C3a)

The available signals and their correspondence with the numbering on the connector C3a are shown in the table below:

Pin number	Function	Note
21	**STO1+**. positive input STO1	
22	**STO2+**. positive input STO2	
23	**STO_COM**. Common terminal STO inputs	
24	**I1 INPUT**. Auxiliary input / Limit Switch+/Touch Probe	
25	**I0 INPUT**. Auxiliary input / Limit Switch- /Proximity	
26	**IN_COM.** inputs common terminal	

Table 4

DIGITAL OUTPUTS for CSD MT 94(connector C3b)

The available signals and their correspondence with the numbering on the connector C3b are shown in the table below:

Pin number	Function	Note
11	**O4 OUTPUT** Auxiliary output	50 mA max
12	**O3 OUTPUT** Auxiliary output	50 mA max
13	**O2 OUTPUT** Auxiliary output / Fault output	50 mA max
14	**O1 OUTPUT** Auxiliary output / Brake output	50 mA max
15	**O0 OUTPUT** Auxiliary output	5 mA max
16	**OUT_COM** OUTPUTS common terminal	

Table 5

DIGITAL OUTPUTS for CSD MT S4 (connector C3b)

The available signals and their correspondence with the numbering on the connector C3b are shown in the table below:

Pin number	Function	Note
11	**EDM OUTPUT+** Error Detection Monitor output	50 mA max
12	**EDM OUTPUT-** Error Detection Monitor output	50 mA max
13	**O2 OUTPUT** Auxiliary output / Fault output	50 mA max
14	**O1 OUTPUT** Auxiliary output / Brake output	50 mA max
15	**O0 OUTPUT** Auxiliary output	5 mA max
16	**OUT_COM** OUTPUTS common terminal	

Table 6

O2 OUTPUT: if it is set as **Driver FAULT** output, the output is ON when the drive is active; it is OFF when the drive operation is inhibited due to any protection circuit.

O1 OUTPUT: if it is set as **BRAKE** (see the software section) the output is ON when the drive is in Operation Enable state. To control the brake it is recommended to use a relay with flyback diode on the coil.

The outputs are ON when they are shorted with respect to the output common terminal (pin 16).

Note: The output values can be set by the user by following the setting of the Output Config register (see chap 12, pg. 50).

All inputs and outputs are opto-isolated from each other and from the internal power circuits.

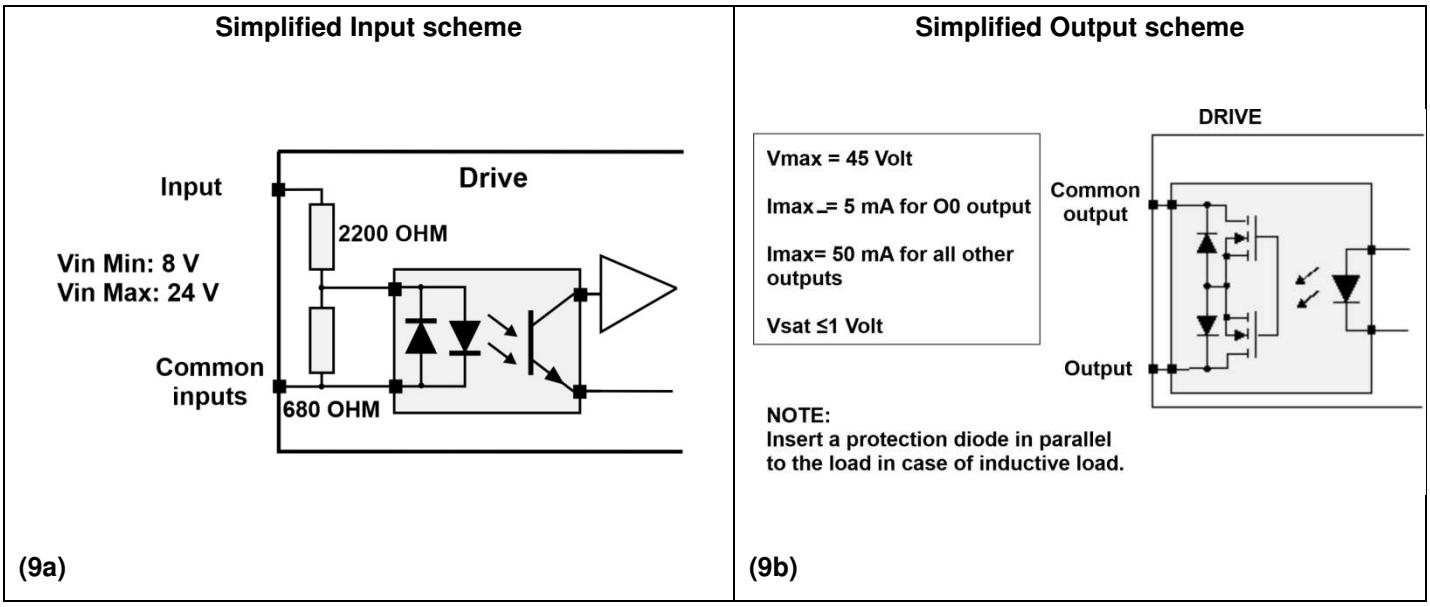


Figure 9 - Simplified input and output scheme

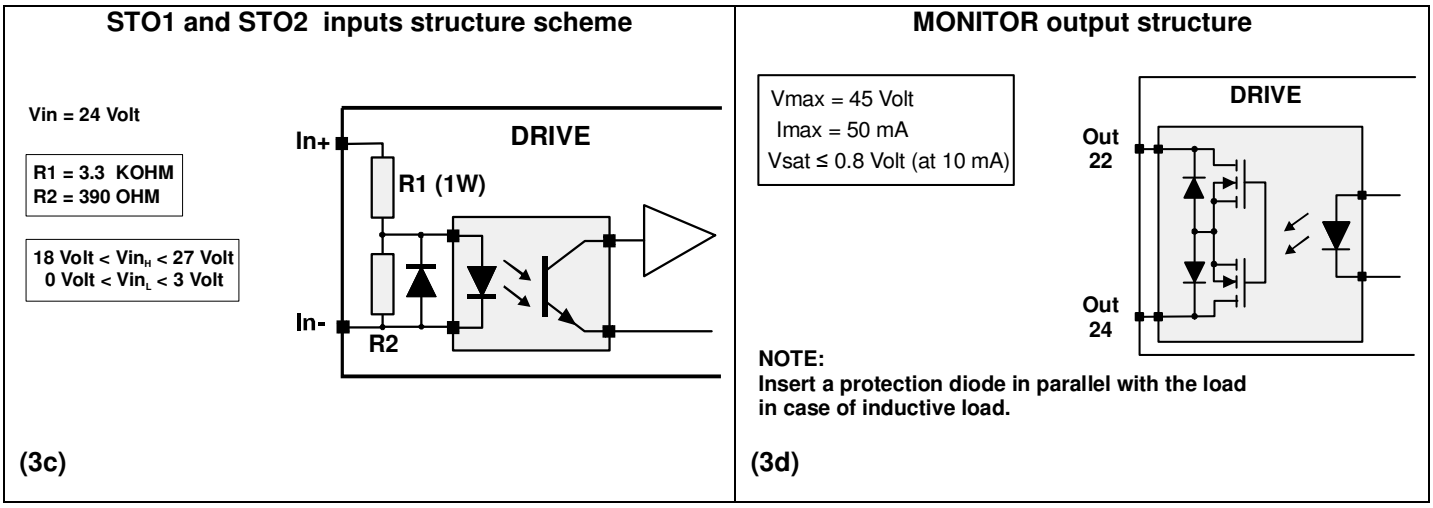


Figure 10 - Simplified STO input and EDM output scheme

CONFIGURATION INPUT (connector C4)

Figure 11 shows the position of the Modbus connectors and the position of the window giving access to the mini-USB port for configuring the drive communication parameters (refer to chapter 12, pg.50) located in the upper part of the CSD MT 94/S4 series drives.

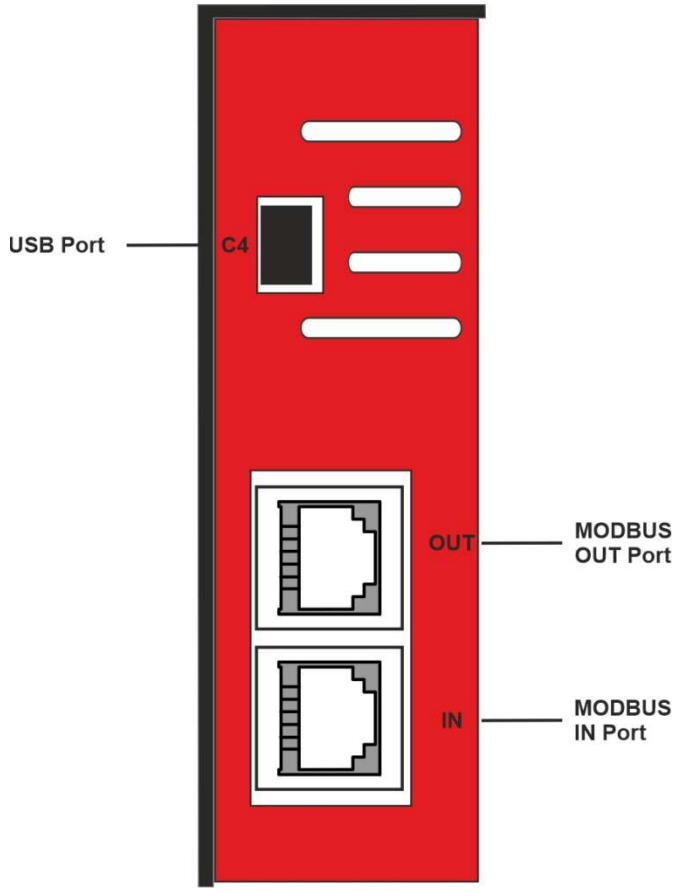


Figure 11- Connectors for the communication on the bus Modbus and USB (Top view of CSD MT 94/S4 drive).

EXAMPLE OF LOGICAL SIGNAL INTERFACING

In this chapter some interfacing techniques are shown. They have to be considered only as examples. The best way to interface the drive with the control system can be chosen only with a complete knowledge of control system and application needs.

Note: The following interfacing examples MUST NOT be used with STO1 and STO2 inputs and MONITOR output.

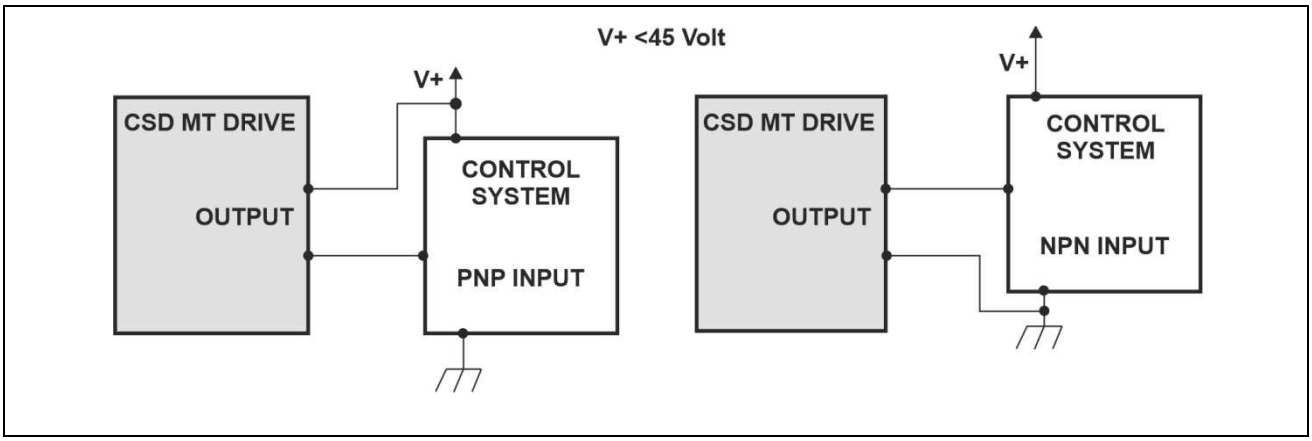


Figure 12- Interfacing between an output of a CSD MT 94/S4 series drive and an input of an external system operating at voltage V +.

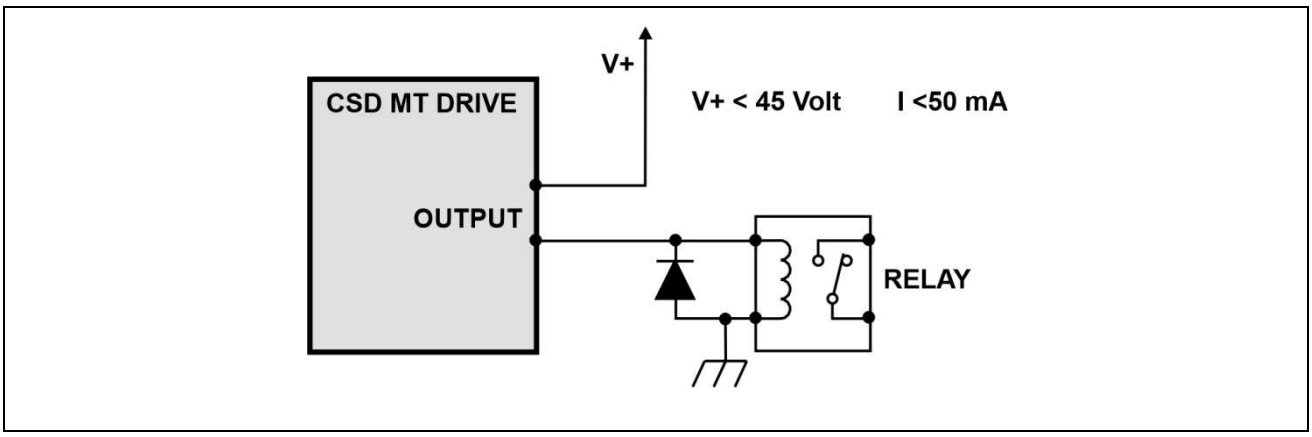


Figure 13 - Connection of an output of a CSD MT 94/S4 series drive to an external microrelay.

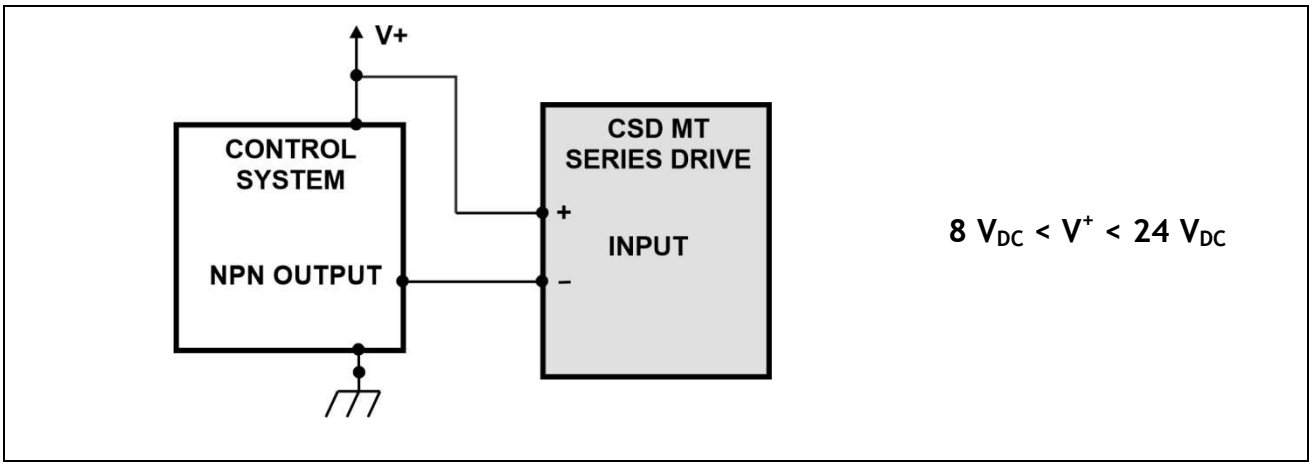


Figure 14 – Interface between an external control system equipped with an NPN type open collector output and a logic input of a CSD MT 94/S4 series drive.

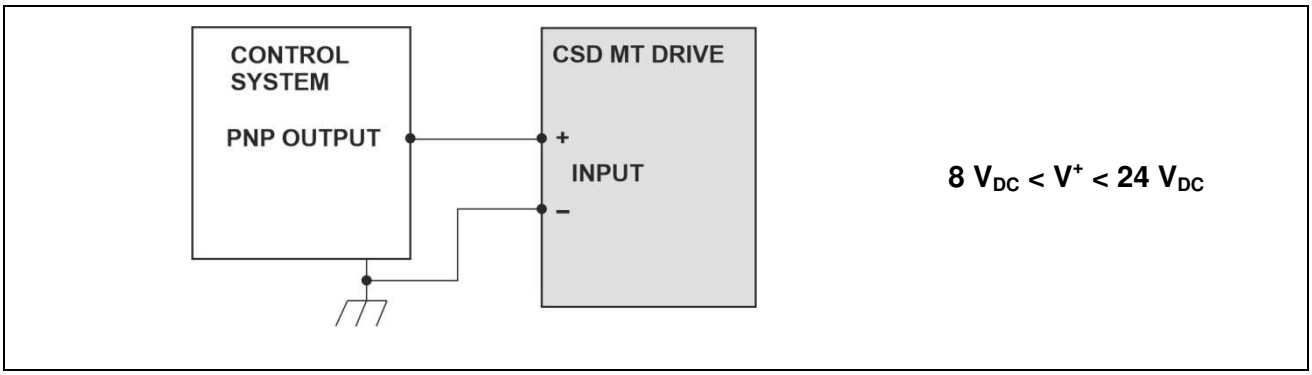


Figure 15 – Interfacing between an external control system equipped with a PNP type output and a logic input of a CSD MT 94/S4 series drive.

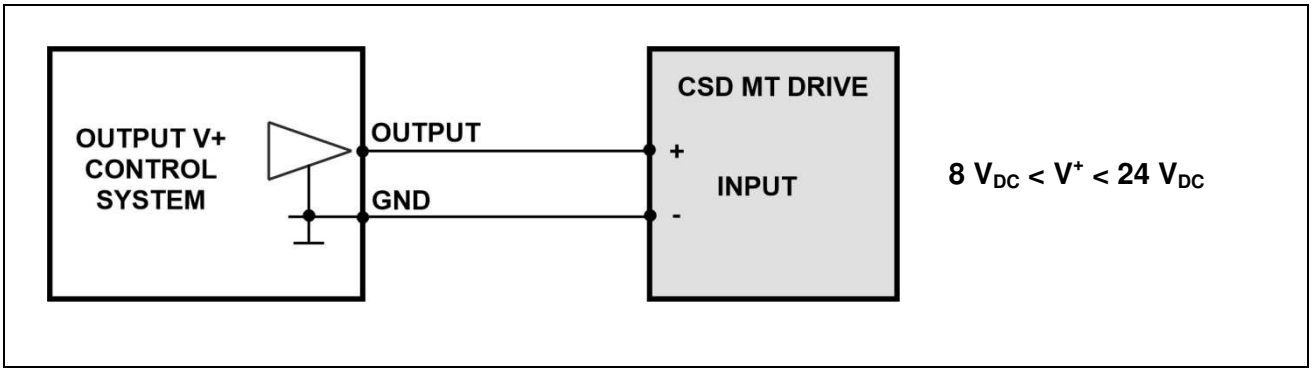


Figure 16 – Connection with a control system with TOTEM-POLE (PUSH-PULL) output.

OUTPUTS AND POWER SUPPLY (connector C2)

⚠ WARNING!

The power outputs are those intended for connecting the stepper motor.

The power input can be connected to a traditional V_{DC} power supply with isolation transformer or to a switching power supply.

The terminals of power supply, the motor outputs and the corresponding number on the connector C1 are shown in the table below:

Pin number	Function	Note
1	Logic power supply, Positive Terminal (LV_{DC})	**24 V_{DC}**
2	Logic power supply, Negative Terminal (LV_{DC})	**0 V_{DC}**
3	GND	
4	Terminal B motor winding	
5	Terminal B- motor winding	
6	Terminal A- motor winding	
7	Terminal A motor winding	
8	GND	
9	Power supply Terminal (HV_{DC}). N (Neutral)	**0 V_{DC}**
10	Power supply Terminal (HV_{DC}). L (Line)	**24 - 48 V_{DC}**

Table 7

The characteristics of motor outputs and power supply lines are shown in the following Table 8 and Table 9:

Function		Value	Note
HV_{DC}	**(V)**	24 - 48	Nominal Value
LV_{DC}	**(V)**	24	Nominal Value
V_{AC} Tolerance	**(%)**	+/- 10	Nominal Value
Max input current	**(A)**	4	
Max input power	**(VA)**	100 - 210	
Dimensions	**(mm)**	110 × 108 × 34	

Table 8

Motor output characteristic		Value	Note
V_{PH} min	**(V)**	0	
V_{PH} max	**(V)**	+/- V_{DC}	
I_{NF} min	**(A)**	0	
I_{NF} max	**(A)**	4	

Table 9

Definition of terms used in Table 8 and Table 9:

HV_{DC} nominal:	nominal value of the continuous voltage that can be used to supply the drive with not stabilized voltage. For voltage value higher or lower than the nominal value, the min/max protection circuit can block the normal operation of the drive in order to avoid damage.
LV_{DC} nominal:	value of the DC power supply voltage of the logic at which the drive can be powered.
Max input current:	maximum allowed input current in continuous operation.
Max input power:	maximum allowed input power in continuous operation.
V_{PH} min:	minimum motor output voltage value.
V_{PH} max:	maximum motor output voltage value.
I_{NF}:	is the maximum rated phase current flowing in each of the motor windings with the motor running at **low speed**. The drive is equipped with automatic current reduction when the motor is stopped

REVERSE ENERGY MANAGEMENT

During the deceleration of a high inertia load, a certain amount of energy can flow from the motor to the drive. In case of excessive reverse energy, the switch-on of the overvoltage protection could inhibit the drive making application impossible. When testing a new application where there are decelerations starting from high speeds, with high inertia load, always carefully check the operating conditions during decelerations.

MOTOR LOSSES AND HEATING

During the design and testing of a new application, from the point of view of the motor heating, it is necessary to be very careful in the choice of following parameters:

- Drive voltage
- Motor inductance
- Operating speed
- Duty cycle
- Current setting of the drive

The combination of these parameters settles motor losses and, if wrong, could bring to the overheating and, as a consequence, to a loss of reliability or damage of the motor.

Following general rules should be taken in consideration:

- Motor heating strongly increases with the **voltage/inductance** ratio and is proportional to duty cycle and to current setting
- Motor heating is much lower at standstill than during the movements
- As far as regarding operating speed, there is always a certain speed at which the heating is maximum; below and above this speed, the heating decreases. The value of this speed can be established only when all other parameters (motor type, voltage, current setting) are known. As a very coarse indication, for the more common combinations of drive and motor type, it could be in the range of 500 – 1500 RPM.

When all operating conditions of a new application are defined, it is strongly recommended to measure motor body temperature: this measurement should be made in the real final working conditions of the machine (motor mounted in its mounting flange and working with the effective machine cycle). Checking the temperature value, after a steady state condition is reached, you can have a very important indication about the long term reliability of your application.

9. SIGNALLING

INFORMATION

CSD MT 94/S4 series drives are general purpose products which can be used to drive many different motor models in different kind of applications. For this reason they can be set with proper commands (see programmer's manual) suitable to adapt drive characteristics to the specific motor and/or application. **Do not forget to do these settings: wrong setting could get application errors and also motor damages and hazard conditions.** Three led indicate the drive status.

Figure 17 shows the position of signalling LEDs, connectors and labels in CSD MT 94/S4 series drives

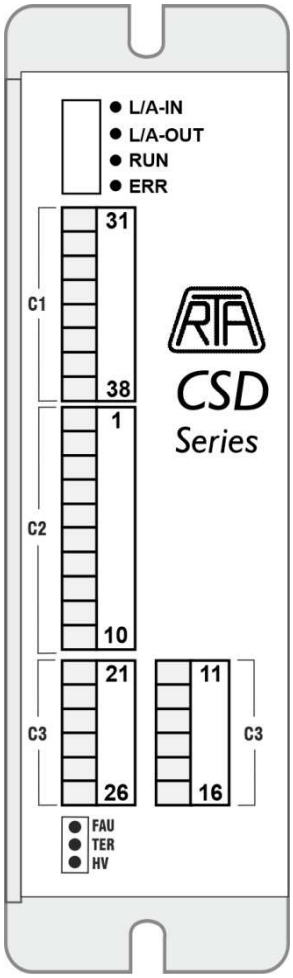


Figure 17 - CSD MT 94/S4 Led and connector

The information provided by the group of 3 LED (HV, FAU, TER) on the front panel of the drive (low side), are listed below:

LED HV (green): ON = supply voltage is in the correct operating range.

OFF = drive is not supplied or supply voltage is out of the correct range (in the second case also LED FAU is ON).

LED FAU (red): ON = drive is in no-working state due to one of the following protection:

- Thermal protection (if LED TER is ON).

- Max or Min supply voltage (if LED HV is OFF).

- Short circuit or wrong motor connection (if LED HV is ON and LED TER is OFF).

OFF = drive is in working state if LED HV is ON.

LED TER (yellow): ON = drive is in no-working state by thermal protection (in this case LED FAU is ON).

OFF = heatsink temperature is lower than the limiting value.

When one of the above-written protections occur, the drive goes in Fault state (see chapter 14, pg. 120).

The following list shows the meaning of the alert LEDs provided for the Modbus communication:

PORT0 Link: led L/A – IN (green)

PORT1 Link: led L/A – OUT (green)

Communication: led RUN (yellow)

Error: led ERR (red)

10. COMMUNICATION INTERFACE

INTRODUCTION TO MODBUS

Modbus is a communication protocol of the 7th level of OSI model (application level) that allows client/server communication between devices connected each other by means of different types of bus or network.

The Modbus protocol is conceived for connection of control devices, for example human machine interfaces (HMI), PLC, industrial automation systems to a variety of slaves.

RTA drive works with the Modbus TCP protocol. It make use of a standard Modbus for the data rendering, implemented on a message support based on TCP/IP standard (transportation level in the OSI model) and a Ethernet physical network.

The use of Modbus TCP makes very easy the connection and data transfer from devices like HMI and PLC to RTA drives and vice versa.

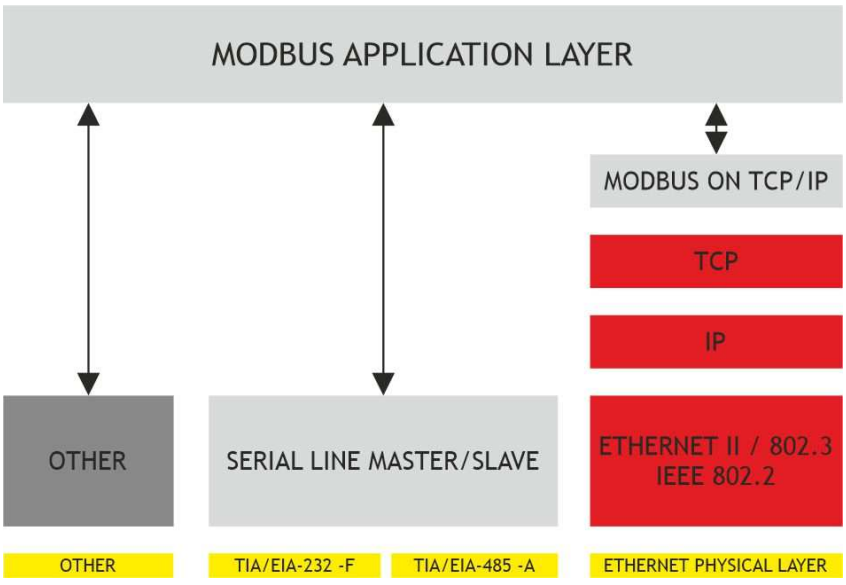


Figure 18 - Modbus Application Layer

NETWORK

A typical application consist of a network including a master and one or more slave devices. In details, a professional Modbus network includes complex devices such as HMI, PLC, and drives, and basic components like barcode scanner and I/O logic signal devices. A typical application is represented in Figure 19 and Figure 20.

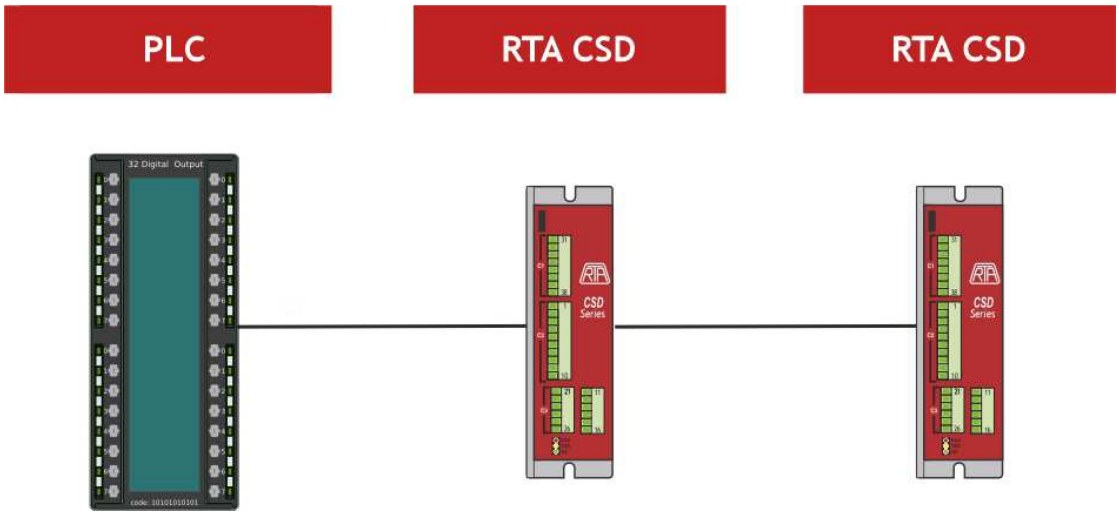


Figure 19 - Typical Modbus TCP network

DEFINITIONS

Master – a Modbus Master (Client) is a control device that receive services from a Modbus Slave (Server) to perform different kind of task. The Modbus Master is also the network element where requests start from. The requests produce reactions or response in the Modbus Slave (Server). For example, HMI and PLC are master in a Modbus network.

Slave – a Modbus Slave (Server) is a device that makes execution of tasks requested by a Modbus Master. A Modbus Slave spend a lot of time waiting requests from Modbus Master. An RTA drive belongs to the category of slave devices.

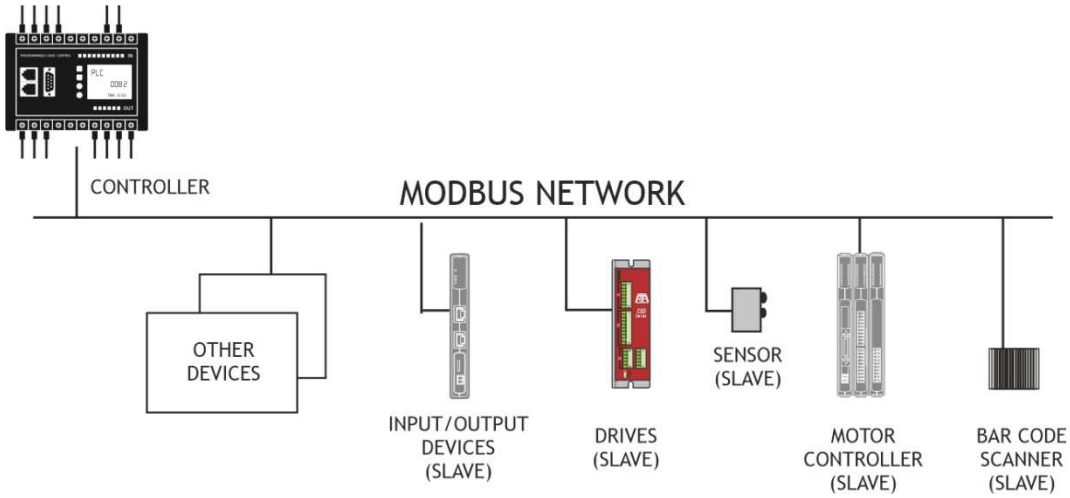


Figure 20 - RTA drive connected as a slave

- Discrete Input – "*Discrete Input*" is used to indicate a single data bit (type Read Only, RO) generated from a I/O device.

- Coils – "*Coils*" is used to indicate a single data bit (type Read and Write, RW) that can be modified by means of a software routine.

- Input Registers – an "*Input Registers*" is a 16-bit RO data that can be generated from an I/O device.

- Holding Registers – an "*Holding Registers*" is a 16-bit R/W data that can be modified by means of a software routine.

TCP PORT

The overall Application Data Unit of the Modbus TCP/IP is included in the field "Data" of a TCP standard frame, and is sent by TCP to the port number 502. This port is exclusively reserved to Modbus applications.

The Modbus TCP/IP server listen and receive Modbus data through the port number 502.

SETTING THE DRIVE IP ADDRESS

To set the IP address, the drive must be connected to a Personal Computer, using a mini-USB plug cable inserted in the drive C4 connector (see hardware section of the manual) and the RTA software "MT Series Setup" supplied with the drive or available in section "download" of RTA web site.

SETTING USING RTA MT SERIES SETUP

Install and run the "MT Series Setup" supplied with the drive. On your monitor will be open a window as shown in Figure 21. Then, by click on "**Find RTA drive by scan of USB port**", the application will scan the USB ports and highlight the USB port connected to the drive, as shown in Figure 22.

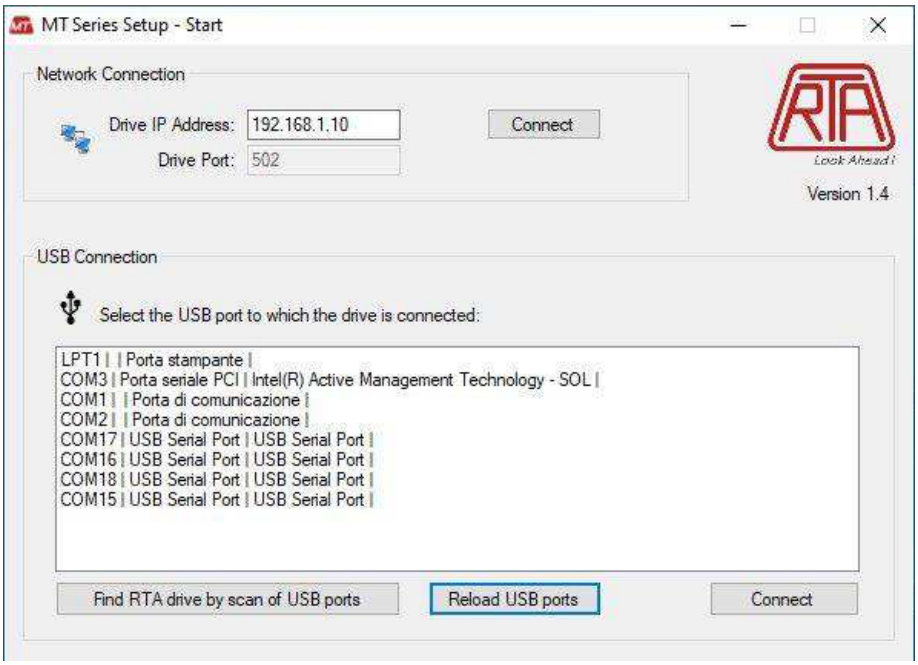


Figure 21- Start window of MT Series Setup

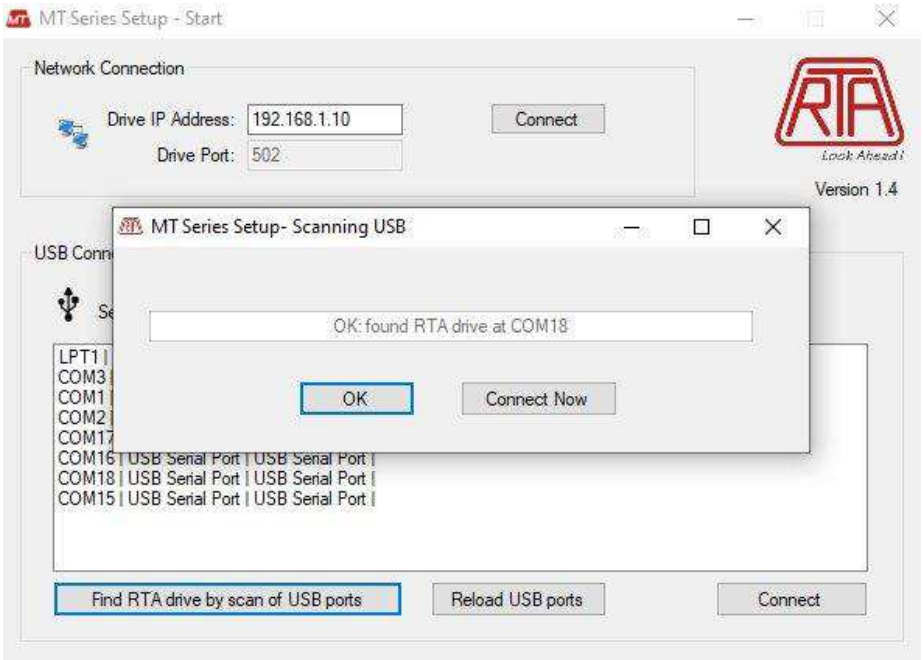


Figure 22 - USB port scan window

Once the device is recognized, by click on the button "**Connect Now**" a new window will be open, as shown in Figure 23.

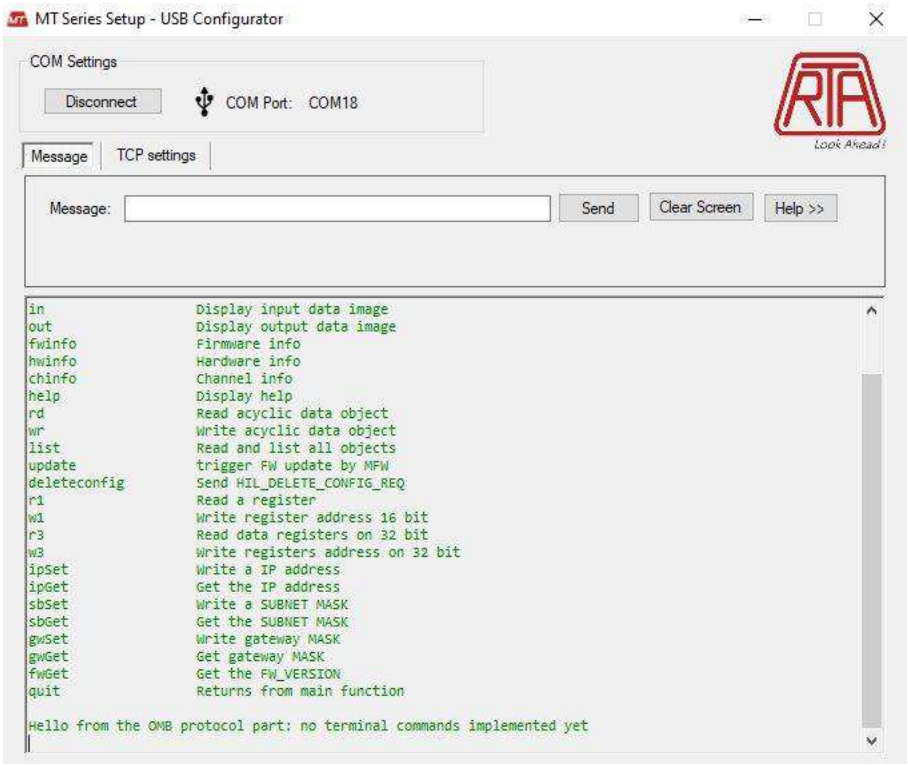


Figure 23 – Command window

To set the desired IP address, for example 192.168.1.5, it is necessary to click on the TAB “TCP Settings” and then write the following value in the IP address text boxes:

192 168 1 5

Click on button “**Set IP**” to set the IP address.

To configure a subnet mask, for example 255.255.0.0, write the following values in the Subnet Mask text boxes:

255 255 0 0

Then click on button “**Set Subnet Mask**”.

Switch OFF and then switch ON the drive.

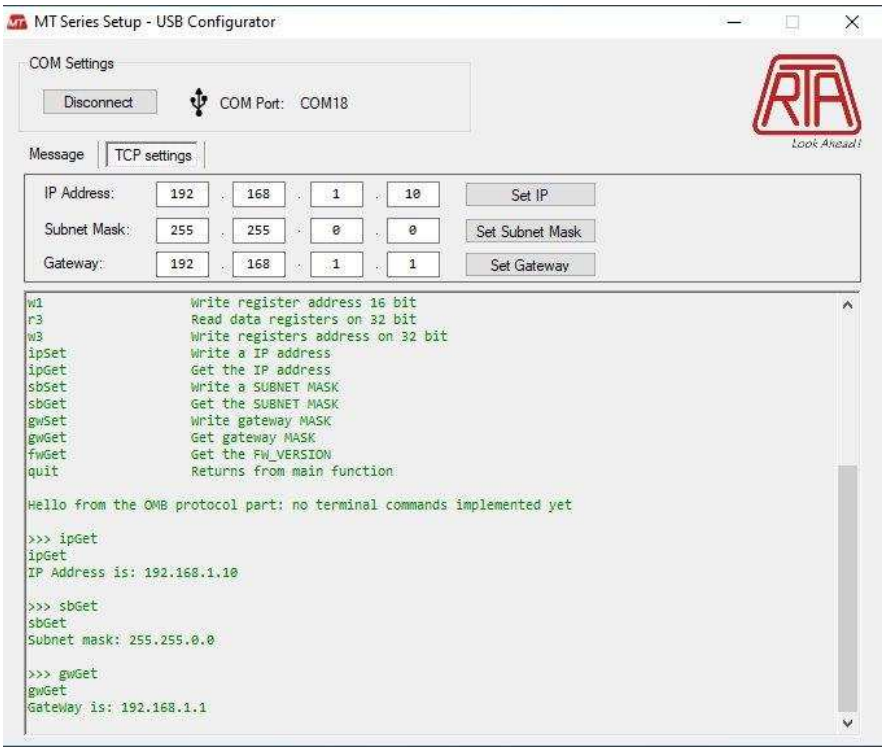


Figure 24 -TCP / IP configuration window

To verify the correct saving in the non volatile memory of the TCP settings mentioned above, switch-OFF and then switch-ON the 24 V_{DC} logic power supply. Select the TAB “TCP Settings” and verify the values in the text boxes.

Another option is to select the TAB “Message” and write the following instructions:

ipGet

sbGet

gwGet

The drive will send back the values stored in the non volatile memory.

Following similar sequence of instructions it is possible to set also the desired Gateway value.

⚠ **WARNING!** For a correct operation, please follow the recommendations:

- Set on the drive a Gateway value included in the range of the subnet mask.
- When Gateway is not used or when the Gateway address is unknown, please set the PLC master IP address.

SETTING USING HyperTerminal

Install and then run the software HyperTerminal.

When the window shown in Figure 25 opens, do not change the default settings. Configure then a new connection writing the connection name, for example: “drive_rta”.

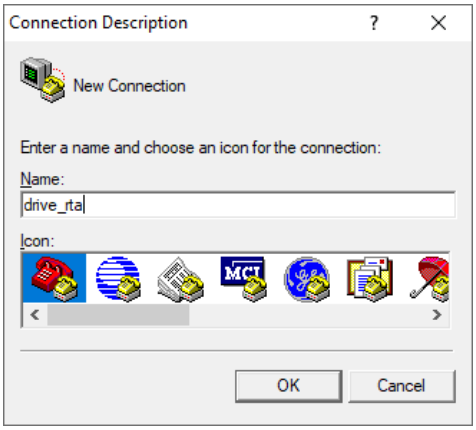


Figure 25 - Network setting window

Click on the button “**OK**”.

In the drop down menu “**Connect using**” select the desired serial port, and then click on button “**Configure…**” in order to set the connection parameters.

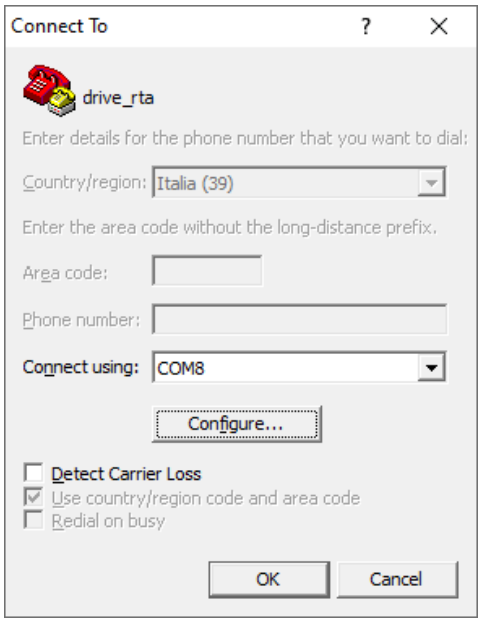


Figure 26 - COM port selection windows

Configure the connection as shown in the following Figure:

- Bit per second: 115200
- BData bit: 8
- Parity: Nothing
- Stop bit: 1
- Flow Control: Nothing

Select and click on “**Applica**” and then “**OK**”.

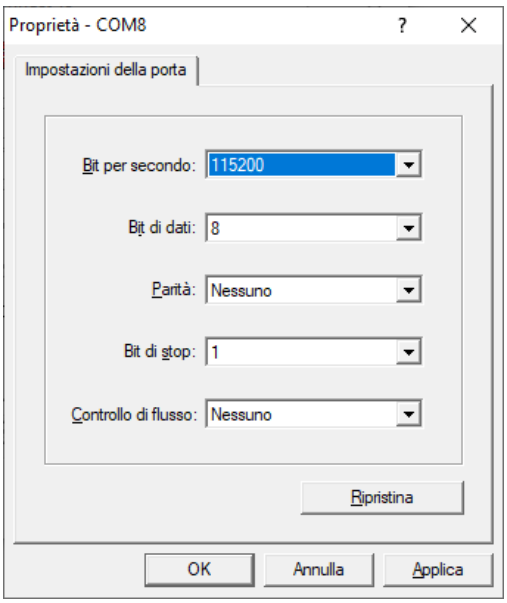


Figure 27 – Connection parameters setting window

To set an IP address, for example 192.168.1.5, write from the terminal the following instruction:

`ipSet 192.168.1.5`

then push the “Return” key.

To set a subnet mask, such as 255.255.0.0, digit the following instruction:

`sbSet 255.255.0.0`

and then push the “Return” key.

Swich OFF and ON the drive.

To verify the correct saving of the TCP settings mentioned above in the non volatile memory, write the following instructions:

ipGet

sbGet

gwGet

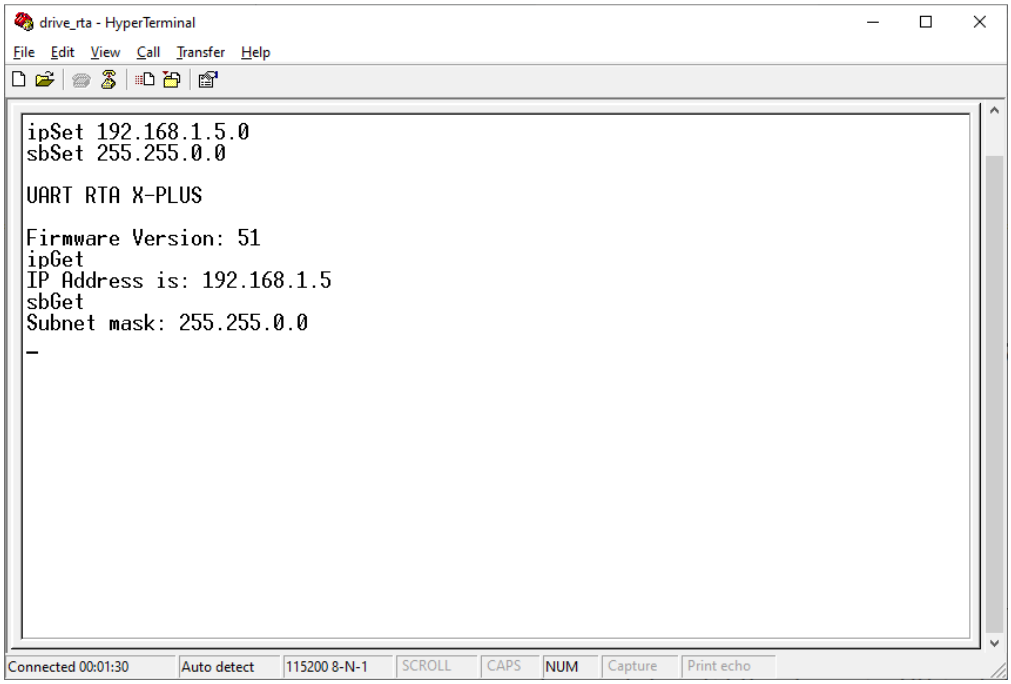


Figure 28 -HyperTerminal window

WHICH ADDRESS MUST BE USED TO READ/WRITE THE MODBUS TCP/IP REGISTERS?

To address the holding registers many Modbus master, for example PLC Siemens S7-1200, do not address registers directly, but make use of Entity Number (see [1]) as a reference policy.

This rule define a 6 digit referencing where the MSB is equal to **4** in case of holding registers.

In particular, the holding registers 0 -> 65535 are then named as 4 00001 -> 4 65536.

In case of use Siemens device, such as S7-1200, see the document "*Modbus/TCP with instructions MB_SERVER and MB_CLIENT*", paragraph 4.2 [2].

Modicon documentation (Modicon is the company who defined the standard Modbus) do not clearly indicates which is the location of the first register, i.e. the number 0000 or the number 0001. Some device start from address 0000, while others such as Siemens S7-1200 starts from address 0001.

For this reason, **in case of use devices such as Siemens S7-1200, it is mandatory to sum +1 to the addresses indicated in the following pages of this document.**

In this manual and in the following summary tables, the address corresponding to each variable are indicated (Entity Address).

The Entity Number is achieved by sum 1 to the Entity Address and then placing the digit “4” as MSB.

For example, in the case of Status Word (Entity Address 1001), the corresponding Entity Number is 41002 or 401002 for the extended 6 digit representation.

Reference:

[1] https://en.wikipedia.org/wiki/Modbus#Coil,_discrete_input,_input_register,_holding_register_numbers_and_addresses

[2] https://support.industry.siemens.com/cs/attachments/109759862/s71200_system_manual_it-IT_it-IT.pdf

DATA FORMAT

The Modbus standard define the master-slave data transfer based on 16 bit word-length data, therefore, to perform a read or write access to any data greater than a word, it is necessary to execute more than one access (2 in case of 32 bit data).

The memory of the RTA Modbus drives is partitioned in 16 bit data register (the type of data for each register is indicated in chapter 3). As a consequence, in order to write 32-bit hex values (for example: 0x12345687) the PLC must perform 2 sequential 16-bit writing operations: (for example: 0x5678 0x1234).

In case of multiple reading or writing, i.e. for data lenght greater than 16 bit, become very important to define the correct sequence of data frames. If data lenght is 32 bit, the access can be made in 2 different way:

- first to the most significant word and then to the least significant word (access type Little-Endian);

- first to the least significative word and then to the most signicative word (access type Big-Endian). For example Siemens adopt this solution.

The desired access type can be set on the drive through a dedicated register.

RTA drives are Little-Endian mode as a default.

Writing of a 32 bit data is succesfully completed only when the writing of the least part of data is terminated. The 32 bit register (16 + 16 bit) is physically updated in the drive memory when the writing of the second part of it is concluded.

If the 2 writing operations are not completed, data in the registers can be incorrect.

MEMORY ORGANIZATION

Data stored in Modbus slave device, are partitioned in 4 main memory sections.

Each of that partitions is dedicated to a particular use and must be addressed by means of specific *function code*.

Name	Section	Type	Access Type	Note
Coils	0	Bit	Read / Write	Data that can be modified by applications
Discrete Inputs	1	Bit	Read	Data supplied from I/O systems
Input Registers	3	Word (16bit)	Read	Data supplied from I/O systems
Holding Registers	4	Word (16bit)	Read / Write	Data that can be modified by applications

Table 10

The internal resource, registers and variables of the RTA Modbus drive are mapped in section 4 (Holding Registers).

SUPPORTED FUNCTION CODE

RTA drive support the following function code:

0x**03** Read Holding Registers

0x**04** Read Input Registers

0x**06** Write Single Register

0x**10** Write Multiple Registers

REFERENCE

[1] Modbus Application Protocol Specifications V.1.1.6 by Modbus - IDA

[2] Modbus Messaging on TCP Implementation Guide, Rev. 1.0b by Modus - IDA

[3] Modbus over Serial Line Specifications and Implementation Guide, V.1.02

11. DRIVE DESCRIPTION

The main characteristics of CSD MT 94/S4 drives are the following:

- Modbus on TCP/IP communications protocol.
- Identification of stall and position error through encoder. Runs with or without encoder. Auto-recovery function in case of synloss, with encoder (Auto-Syncronization function).
- Digital I/O and proximity hardware input for zero search procedure.
- Setting of coordinates system: relative coordinates mode, absolute coordinates mode

Proximity input allows the execution of zero procedure (HOMING).

By using an encoder it is possible to make a mechanical impact homing operation.

DRIVE SUB-STATES

In accordance with standard CiA DSP 402, the drive can be described as a state machine, as shown in Figure 29.

State transitions take place after the following events:

- internal events;

- special commands sent from master to drive by a particular word named CONTROL WORD.

Note: When the logic circuit of the drive is power supplied ($24V_{DC}$), it automatically goes into the SWITCH ON DISABLED status.

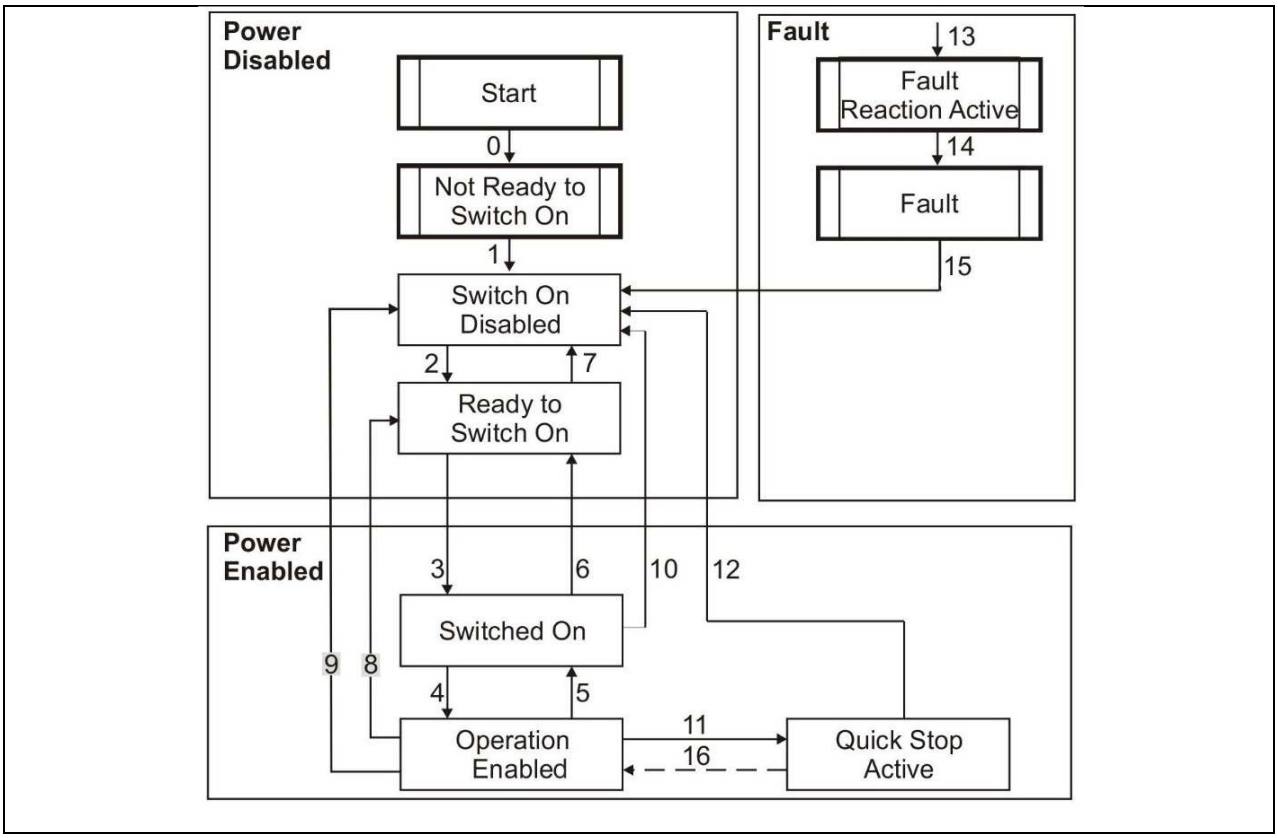


Figure 29 – Drive Sub-States

The available state transition are the following:

Transition 3: READY TO SWITCH ON => SWITCHED ON

'Switch On' command received from master.

This transition is possible when drive power section is supplied (between HVDC+ and HVDC-) at least 500ms before the transition itself; otherwise drive remains in "READY TO SWITCH ON" state.

Transition 4: SWITCHED ON => OPERATION ENABLED

'Enable Operation' command received from master.

After this transition current in stepping motor windings is enabled.

With reference to the drive power supply 24Vdc, the first time that this transition is executed, there is a simultaneous reset of Position Actual Value register (1004-1005) if the register 1114 is set to 1.

Transition 5: OPERATION ENABLED => SWITCHED ON

'Disable Operation' command received from master.

After this transition current in stepping motor windings is disabled (CURRENT OFF).

Transition 6: SWITCHED ON => READY TO SWITCH ON

'Shutdown' command received from master.

After this transition drive power supply can be disconnected.

Transition 8: OPERATION ENABLED => READY TO SWITCH ON

'Shutdown' command received from master.

After this transition current in stepping motor windings is disabled (CURRENT OFF); after this transition drive power supply can be disconnected.

Transition 9: OPERATION ENABLED => SWITCH ON DISABLED

'Disable Voltage' command received from master.

After this transition current in stepping motor windings is disabled (CURRENT OFF); after this transition drive power supply can be disconnected.

Transition 10: SWITCHED ON => SWITCH ON DISABLED

'Disable Voltage' o 'Quick Stop' command received from master.

After this transition drive power supply can be disconnected.

Transition 11: OPERATION ENABLED => QUICK STOP ACTIVE

'Quick Stop' command received from master.

Drive automatically goes into the quick stop status and, if the motor is running, bit 10 (target reached) of Status Word is 0 until the motor is stopped (in this case bit 10 = high and **that means that the motor stopped, it does NOT mean that the motor reached the target position**). Current is not disabled in stepping motor windings (motor torque is maintained).

Transition 12: QUICK STOP ACTIVE => SWITCH ON DISABLED

'Disable Voltage' command received from master.

The drive does not execute this transition automatically, this transition is possible by means of 'Disable Voltage' command only. In this case current is disabled in stepping motor windings (CURRENT OFF).

Transitions 13-14: => FAULT

This transition is caused by drive internal faults only (thermal protection, no power supply, etc.); current in stepping motor windings is disabled (CURRENT OFF). In Fault state drive power supply can be disconnected.

Transition 15: FAULT => SWITCH ON DISABLED

'Fault Reset' command received from master.

This transition is allowed when the fault of the drive is solved.

Transition 16: QUICK STOP ACTIVE => OPERATION ENABLED

'Enable Operation' command received from master.

This transition is allowed because Quick-Stop-Option-Code = 5. Current is kept into the motor windings (motor torque is kept).

Note: because of electro-mechanical interactions in stepping motors, when current in motor windings is enabled or disabled (for example Transition 4), it is required to wait for a settling time of the motor of ~ 50-200ms before the motor is stabilized from the mechanical point of view. Therefore, Status Word indicating the transition to Operation Enabled **means only the acknowledge of the transition, it does not mean that the drive is already stabilized. Any New Set Point commands sent before the stabilization of the drive can cause a loss of synchronism of the run in execution sent into execution.**

The above-mentioned commands are achieved setting the CONTROL WORD as in Table 11.

Command	Bit of the CONTROL WORD					Transitions
	Fault Reset Bit 7	Enable Operation Bit 3	Quick Stop Bit 2	Enable Voltage Bit 1	Switch On Bit 0	
Shutdown	0	X	1	1	0	2,6,8
Switch on	0	X	1	1	1	3
Disable voltage	0	X	X	0	X	7,9,10,12
Quick stop	0	X	0	1	X	7,10,11
Disable operation	0	0	1	1	1	5
Enable operation	0	1	1	1	1	4,16
Fault reset	Trans. L/H	X	X	X	X	15

Table 11 - Bit of the Control Word

Drive status can be read by means bit of STATUS WORD as in Table 12.

Status	Bit of the STATUS WORD					
	Switch On Disabled Bit 6	Quick Stop Bit 5	Fault Bit 3	Op. Enable Bit 2	Switched On Bit 1	Ready to Switch ON Bit 0
Switch on disabled	1	1	0	0	0	0
Ready to switch on	0	1	0	0	0	1
Switched on	0	1	0	0	1	1
Operation enabled	0	1	0	1	1	1
Quick stop active	0	0	0	1	1	1
Fault	0	x	1	0	0	0

Table 12 - Bit of the Status Word

Basically:

from Switch On Disabled state, in order to enable motor Current-ON and then start the motion (relating to the previously set parameters), the **requested Control Word (CW) command sequence** is the following:

CW = **0x0006** -> (Drive goes in Ready to Switch-ON state, Status Word = 0x0221 or 0x1221 if High Voltage is not available, StatusWord = 0x0231 or 0x1231 if High Voltage is available)

CW = **0x0007** -> (Drive goes in Switched-ON state, Status Word = 0x0233 or 0x1233 only if High Voltage is available, in other cases, the transition cannot be completed)

CW = **0x000F** -> (Drive goes in Operation Enabled state, Status Word = 0x0637 or 0x1637 or 0x1237, regarded to the value of Mode of Operation)

CW = **0x001F** or CW = **0x005F** (Motor starts to move following absolute or relative coordinate system, respectively. Relative coordinate are available only if the set value of Mode of Operation enables them)

Note:

Current ON is equal to: Operation Enable.

Current OFF is equal to: Switched ON or Ready to Switch ON

The direct sequence from CW = 0x0006 to CW = 0x000F can be done. Pay attention to the High Voltage restrictions

MODE OF OPERATION

According to the value written in register 1041 (Mode Of Operation), 3 different modes of operation can be set:

1: **Profile Position** mode of operation

3: **Profile Velocity** mode of operation

6: **Homing** mode of operation

12. REGISTERS

Memory partition, registers and their specific functions are described in the following paragraphs.

By writing particular values in that registers, it is possible to make execution of specific functions, related to the corresponding type of register.

The 32-bit length variables need to be stored in 2 16-bit register. In this case, Modbus standard define the read/write access mode to this kind of variables to be done in sequential mode.

CONFIGURATION, IDENTIFICATION AND SERVICE REGISTERS

Modbus Address Little Endian	Modbus Address Big Endian	Data type	Access Type	Function	Default Value	Minimum value	Maximum value
Configuration Registers							
1130	1130	U16	RW	IP Address first octet	192	0	255
1131	1131	U16	RW	IP Address second octet	168	0	255
1132	1132	U16	RW	IP Address third octet	1	0	255
1133	1133	U16	RW	IP Address fourth octet	10	0	255
1134	1134	U16	RW	Subnet Mask first octet	255	0	255
1135	1135	U16	RW	Subnet Mask second octet	255	0	255
1136	1136	U16	RW	Subnet Mask third octet	0	0	255
1137	1137	U16	RW	Subnet Mask fourth octet	0	0	255
1138	1138	U16	RW	Gateway first octet	192	0	255
1139	1139	U16	RW	Gateway second octet	168	0	255
1140	1140	U16	RW	Gateway third octet	1	0	255
1141	1141	U16	RW	Gateway fourth octet	1	0	255
Identification Registers							
1152	1153	U32	RO	Software Version_LSB	51	0x0000 0000	0xFFFF FFFF
1153	1152			Software Version_MSB			
1154	1155	U32	RO	Product Code_LSB	--	0x0000 0000	0xFFFF FFFF
1155	1154			Product Code_MSB			
1156	1157	U32	RO	Hardware Version_LSB		0x0000 0000	0xFFFF FFFF
1157	1156			Hardware Version_MSB			
1158	1159	U32	RO	Serial Number_L	--	0x0000 0000	0xFFFF FFFF
1159	1158			Serial Number_H			
1162	1162	U16	RW	Little Endian / big Endian	1	0	1
Service Regisers							
1006	1006	U16	RO	Error Register	0000	0x0000	0x8611
1007	1007	U16	RO	Error Code	0000	0x0000	0x8611
1122	1122	U16	RW	User Data RAM			
1123	1123	U16	RW	Read Temperature	0	0	1
1124	1124	U16	RO	Drive Temperature	25	22	125

1125	1125	U16	RW	Warning Temperature	85	50	85
1126	1126	U16	RW	Drive Fault Temperature	98	50	105
1220	1220	U16	RO	Drive Alarm Time n°0	0	0	0xFFFF
1221	1221	U16	RO	Drive Alarm Code n°0	0000	0000	8611
1222	1222	U16	RO	Drive Alarm Time n°1	0	0	0xFFFF
1223	1223	U16	RO	Drive Alarm Code n°1	0000	0000	8611
1224	1224	U16	RO	Drive Alarm Time n°2	0	0	0xFFFF
1225	1225	U16	RO	Drive Alarm Code n°2	0000	0000	8611
1226	1226	U16	RO	Drive Alarm Time n°3	0	0	0xFFFF
1227	1227	U16	RO	Drive Alarm Code n°3	0000	0000	8611
1228	1228	U16	RO	Drive Alarm Time n°4	0	0	0xFFFF
1229	1229	U16	RO	Drive Alarm Code n°4	0000	0000	8611
1230	1230	U16	RO	Drive Alarm Time n°5	0	0	0xFFFF
1231	1231	U16	RO	Drive Alarm Code n°5	0000	0000	8611
1232	1232	U16	RO	Drive Alarm Time n°6	0	0	0xFFFF
1233	1233	U16	RO	Drive Alarm Code n°6	0000	0000	8611
1234	1234	U16	RO	Drive Alarm Time n°7	0	0	0xFFFF
1235	1235	U16	RO	Drive Alarm Code n°7	0000	0000	8611
1236	1236	U16	RO	Drive Alarm Time n°8	0	0	0xFFFF
1237	1237	U16	RO	Drive Alarm Code n°8	0000	0000	8611
1238	1238	U16	RO	Drive Alarm Time n°9	0	0	0xFFFF
1239	1239	U16	RO	Drive Alarm Code n°9	0000	0000	8611
1240	1240	U16	RW	Reset Error Logs	0	0	1
1250	1250	U16	RO	Read MAC Address			
1251	1251	U16	RO	Read MAC Address			
1252	1252	U16	RO	Read MAC Address			
1260	1260	U16	RW	Save All Parameters	0000	0x1111	0x6173
1261	1261	U16	RW	Restore All Default Parameters	0000	0x6F6C	0x6F6C

Table 13 – Configuration Registers

Register 1162: Little Endian / Big Endian

This register allow setting the read and write sequence for 32-bit registers as follows:

- Little Endian if the access is before to the least significative data and then to the most significative data

- Big Endian if the access is before to the most significative data and then to the least significative data

Available Values:

- **"0"**: for Big Endian

- **"1"**: for Little Endian

RTA drives are Little-Endian mode as a default.

Register 1006: Error Register

Valid values for this register are 0 or 1:

- **"0"**: normal working condition; no error occurs.
- **"1"**: error occurs; the reason of the error can be read in register 1007 (Error Code). The timeline sequence in Registers 1220…1239 has been updated.

Register 1007: Error Code

This register allow to read the Error Codes

The available codes are:

0x8611: "Motor following error"

0x8400: "Axis speed too high"

0x5100: "Error power supply out of range"

0x4310: "Error drive excessive temperature"

0x2130: "Error short circuit" (or overcurrent on motor phase)

0x0000: "Emergency end"

After an error, the drive goes in Fault state and current in the motor windings is disabled (current off).

Register 1122: User Data RAM

The value of this register at the power-On is equal to 0. The register is reset when the logic power supply (24 V_{DC}) is switched-Off.

This register is a free use register.

Register 1123: Read Temperature

By writing in this register the value "1", the internal drive temperature value (shown in the register 1124) is up to date. In any way, the drive cyclically read the temperature value, independently of the master request.

Default value = 0.

Register 1124: Drive Temperature

This Register is used to view the read temperature value. The value is in °C.

Range = [22 °C, 125 °C].

Default value = 25°C.

Register 1125: Warning Temperature

This Register allow to set the warning threshold temperature value (in °C). If the temperature become greater of the threshold, the bit 7 of the Status Word (Warning) switch to 1.

If the drive is in temperature fault state and then the temperature become lower than the threshold value, the drive exit from the fault state and the drive can switch to a current ON state.

Setting range = [65 °C, 85 °C]

Default value = 85 °C.

Register 1126: Fault Temperature

The value of this Register is the temperature (in °C) limit for the normal drive operation. If the temperature overcome this value, the overheating protection switch the drive state to the fault state.

The default value is 96 °C.

Note: Reserved parameter. Do not modify this value.

Registers 1220 ÷ 1239: Drive Alarm Register

10 events Alarm Register.

For each event the following values are logged:

- Event delay since the last power-ON of the drive (s)
- Alarm code

The available values in **"Alarm Code"** are the ones indicated in the 1007 Register description (Error Code).

Register 1240: Reset Error Logs

This register allows to reset Alarm Memory

Write "**1**" to reset the Drive Alarm Register (Registers 1220… …1239).

Register 1260: Store all parameters

The register is used to save parameters.

In order to avoid storage of parameters by mistate, storage is only executed when a specific signature is written to the register. The available codes are:

Value	Function
0x6173	Store parameters
0x1111	Store IP, subnet Mask and Gateway

Note1: Keep the control power ($24V_{DC}$) ON more than 5 seconds, after sent the command.

Note2: See the appendix 1 for storable parameters

Register 1261: Restore all default parameters

The register is used to restore the default parameters.

In order to avoid the restoring of default parameters by mistate, restoring is only executed when the specific code is written:

0x6F6C

Note1: Keep the control power ($24V_{DC}$) ON more than 5 seconds, after sent the command.

Note2: See the appendix 1 for storable parameters

MOTION REGISTERS

Modbus Address Little Endian	Modbus Address Big Endian	Data type	Access Type	Function	Default Value	Minimum value	Maximum value
1001	1001	U16	RO	Status Word	--	0x0000	0xFFFF
1002	1002	I16	RO	Mode of Operation Display	0	1	6
1004	1005	I32	RO	Position Actual Value_L	0	-2147483648	2147483647
1005	1004			Position Actual Value_H			
1020	1021	I32	RO	Velocity Actual Value_L	0	0	800 000
1021	1020			Velocity Actual Value_H			
1040	1040	U16	RW	Control Word	0x0000	0x0000	0xFFFF
1041	1041	I16	RW	Mode of Operation	0	1	6
1042	1043	I32	RW	Target Position_L	0	-2147483648	2147483647
1043	1042			Target Position_H			
1044	1045	I32	RW	Profile Velocity_L	24 000	0	800 000
1045	1044			Profile Velocity_H			
1046	1047	I32	RW	Profile Acceleration_L	640 000	2000	10 000 000
1047	1046			Profile Acceleration_H			
1048	1049	I32	RW	Target Velocity_L	0	0	800 000
1049	1048			Target velocity_H			
1062	1062	U16	RW	Velocity Window	21300	0	65535
1063	1063	U16	RW	Velocity Window Time	50	0	65535
1064	1064	U16	RW	Velocity Threshold	21300	0	65535
1065	1065	U16	RW	Velocity Threshold Time	50	0	65535
1067	1067	U16	RW	Control Word from I/O	0x0000	0x0000	0xFFFF
1068	1069			Not Used			
1069	1068			Not Used			
1070	1071			Not Used			
1071	1070			Not Used			
1072	1073	I32	RW	Profile Deceleration_L	640 000	2000	10 000 000
1073	1072			Profile Deceleration_H			
1074	1075	I32	RO	Max Motor Speed_L	0	0	400 000
1075	1074			Max Motor Speed_H			

Table 14 - Motion Registers

Register 1001: Status Word

The STATUS WORD corresponds to a string of 16 bit used to communicate the device condition.

Profile Position mode of operaion															
Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Profile Ramp	Closed Loop Active	Following Error	Set Point Acknowledge	Int. Limit Active	Target Reached	Remote	Manufact Spec	Warning	Switch ON Disabled	Quick Stop	Voltage Enabled	Fault	Oper. Enabled	Switched On	Ready To Switch ON
0	0	S	S	S	S	S	0	0	S	S	S	S	S	S	S

Homing mode of operaion															
Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Profile Ramp	Closed Loop Active	Following Error	Homing Completed	Int. Limit Active	Target Reached	Remote	Manufact Spec	Warning	Switch ON Disabled	Quick Stop	Voltage Enabled	Fault	Oper. Enabled	Switched On	Ready To Switch ON
0	0	S	S	0	S	S	0	0	S	S	S	S	S	S	S

Profile Velocity mode of operaion															
Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
User specific	Closed Loop Active	Reserved	Zero Speed Status	Int. Limit Active	Target Velocity Reached	Remote	Manufact Spec	Warning	Switch ON Disabled	Quick Stop	Voltage Enabled	Fault	Oper. Enabled	Switched On	Ready To Switch ON
0	0	S	S	0	S	S	0	0	S	S	S	S	S	S	S

Legenda:

Key: S: managed. 0: always = 0. 1: always = 1.

Managed bits of the STATUS WORD have the following meaning:

Bit 2: Operation Enabled
1 = Drive is in CURRENT ON status and the current flows in each motor winding.

Bit 3: Fault
Usually is 0, when it is 1 the drive is in Fault condition.

Bit 4: Voltage Enabled
0 = The power supply is higher than maximum allowed voltage or lower than minimum allowed voltage.

Bit 5: Quick Stop
Usually 1, when it is 0 drive is in QUICK STOP status.

Bit 9: Remote
Drive can receive and execute command through communication bus when it is 1.

Receive and execute command through PDO is not allowed when it is 0.

Bit 10: Target reached
Usually it is 0, it is 1 when a run or an homing procedure or a quick stop or halt command is successfully executed.
In Profile Velocity Mode, bit 10 becomes equal to 1 when the motor speed is equal to Target Velocity (or 0 after an Halt command) with a tolerance range defined by the register 1064 "Velocity Threshold" and for a time interval defined in the register 1063 "Velocity Threshold Time".

Bit 11: Internal limit active
It is 1 when the motor position exceeded the limit switch (if limit switch function is active).
Note: see the register 1088.

Bit 12: Zero speed status
In Profile Velocity mode, the bit 12 is equal to 1 when motor speed is 0 with a tolerance range defined in register index 1064, for a time interval defined in register 1065.

Bit 13: Following Error / Max Slippage Error
It indicates the Position Error for motor stall, read by the drive through encoder.
0: No Position Error
1: Position Error

Bit 14: Closed Loop Active
Become active by means of register Enable StatusWord bit 14 (1106).
1: show that the drive auto-syncronization function (see registers 1108-1111 Auto-Synchronization Parameters) is working in order to modify the motion;
0: show that the drive is in standstill state or the execution movements are Open Loop type.

Bit 15: Profile Ramp
Become active by means of register Enable StatusWord bit 15 (1107).
1: show that the actual movement is an acceleration or deceleration ramp;
0: show that the motor is standstill or the velocity is constant.
This bit is active only in Profile Position or Homing mode of operation.

Note: Control Word/Status Word timing on a Master state Machine

When designing a state machine on a Modbus Master, and starting from the Control Word sending moment, we suggest to wait at least 12ms in addition to one cycle time before verify (read) the effects on the Status word. In case of Control Word command that produce COFF-CON state transition, the Status Word bit switch with a time delay greater than that mentioned above.

- **Register 1002: Mode of Operation Display**

In this register it is possible to read the mode of operation set in the drive through the register 1041 "Mode of Operation".

Registers 1004 - 1005: Position Actual Value

In this couple of registers it is possible to read the motor shaft actual position sent from the encoder (number of step).

In case of use a Following Error Reaction Code suitable for motors without encoder (register 1085 = 17), the position stored in this registers is the drive commanded position.

Register 1020-1021: Velocity Actual Value

In this registers it is possible to read the velocity actual value of the motor shaft (Hz).

In case of use a Following Error Reaction Code suitable for motors without encoder (register 1085 = 17), the velocity stored in this registers is the drive commanded velocity.

Register 1040: Control Word

The CONTROL WORD corresponds to a string of 16 bit. Through the control word the user can control the condition of the device.

In the following table the meaning of control word bits is shown.

Profile Position mode of operation															
Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
User specific					Reserved		Halt	Fault Reset	Abs (0)/ Rel (1)	Change Set Immed	New Set Point	Enable Operat	Quick Stop	Enable Voltage	Switch ON
0	*0*	*0*	*0*	*0*	*0*	*0*	S	S	S	0	S	S	S	S	S

Homing mode of operation															
Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
User specific					Reserved		Halt	Fault Reset	Riserv	Riserv	New Set Point	Enable Operat	Quick Stop	Enable Voltage	Switch ON
0	*0*	*0*	*0*	*0*	*0*	*0*	S	S	0	0	S	S	S	S	S

Profile Velocity mode of operation															
Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
User specific					Reserved		Halt	Fault Reset	Riserv	Riserv	Riserv	Enable Operat	Quick Stop	Enable Voltage	Switch ON
0	*0*	*0*	*0*	*0*	*0*	*0*	S	S	S	0	S	S	S	S	S

Legend:

Key: S: managed. **0**: Not managed; set always bit = 0

To have a correct transition between OPERATIONAL MODE status, refer to Tab 4.

Bit 2: Quick Stop

1 = no Quick Stop execution; 0 = Quick Stop execution.

Bit 3: Enable Operation

1 = normal working drive (CURRENT ON); 0 = drive in CURRENT OFF state

Bit 4: New Set Point

If set to 1 by master it modifies bit 12 of the STATUS WORD (Set Point Acknowledge) and executes a run depending on Target Position sent to the drive.

Bit 5: Change Set Point Immediately

0 = Target Position and/or Profile Velocity can be modified only after the target was reached or after an Halt command;

1 = Target Position and/or Profile Velocity can be modified.

Bit 6: Rel/Abs

0 = absolute coordinates system; 1 = relative coordinates system

In CSP mode of operation, the bit 6 is always equal to 0; depending on the specific case, the master can emulate a relative coordinate system , but it must always send to the drive the absolute coordinates.

Bit 7: Fault Reset

If set to 1, Fault condition is reset, if the problem is finished (that means that the value of register 1007 “Error Code” is 0x0000). After this bit 7 has to be set to 0.

Bit 8: Halt

0 = normal working condition; 1 = Halt execution and request stop to the motor.

At motor standstill, after Halt execution, Target Reached = 1 (bit 10 of STATUS WORD). If Halt is then set to 0, Target Reached is automatically set to 0 and the interrupted movement is not completed.

Register 1041: Mode of Operation

The available modes of operation are the following:

1: **Profile Position** mode of operation

3: **Profile Velocity** mode of operation

6: **Homing** mode of operation

PROFILE POSITION MODE

In mode of operation Profile Position the coordinate system depends from bit 6 of the CONTROL WORD.

bit 6 = **1** relative coordinates system

bit 6 = **0** absolute coordinates system

- RELATIVE COORDINATE SYSTEM

Using this operation mode, the number of steps of the movement does not depend on the starting position of the motor. For example, executing the run corresponding to the storage shown in Table 15, motor covers 240000 steps in the positive direction; the starting position of the motor has no influence on the number of covered steps.

The operation range is between $[-2^{31}; 2^{31}-1]$. The maximum number of steps that can be executed with one instruction is equal to 2^{31}.

Modbus Address Little Endian	Modbus Address Big Endian	Data type	Access Type	Function	Setting example
1042	1043	I32	RW	Target Position_L	**240000**
1043	1042			Target Position_H	
1044	1045	U32	RW	Profile Velocity_L	**100000 [Hz]**
1045	1044			Profile Velocity_H	
1046	1047	U32	RW	Profile Acceleration_L	**80000 [Hz/sec]**
1047	1046			Profile Acceleration_H	
1072	1073	U32	RW	Profile Deceleration_L	**80000 [Hz/sec]**
1073	1072			Profile Deceleration_H	

Table 15 - Motion Parameters Registers

- ABSOLUTE COORDINATE SYSTEM

Using this operation mode, the number of executed motor steps depends on the position of the motor shaft before the movement starting position (shown in registers 1004-1005, "Position Actual Value"). The value written in "Target Position" will be equal to the final position after the movement. Supposing to execute the same run described in the example of Table 6, the motor shift is in positive direction if the motor is in a position lower than +240000 steps, or in

negative direction if the position before the start of the movement is higher than +240000. The borderline case is when the starting position is +240000, in this case then motor doesn't move.

Working with absolute coordinates operation mode requires the definition of an origin corresponding to coordinate 0. Usually coordinate 0 can be defined through the execution of an HOMING procedure.

The operation range is between [-2^{31}; $2^{31}-1$]. The maximum number of steps that can be executed with one instruction is equal to 2^{31}.

In Profile Position, Mode Of Operation can be switched from the following sub-states: Switched On, Ready to Switch ON, Switch On Disabled, Operation Enabled.

- MOTION PROFILES

The “0” to “1“ transition of the 4th bit of the Control Word determines the start of a movement. The motion profile depends on the setting values of Profile Velocity (PV), Profile Acceleration (PA) and from the steps difference between start position and target position (ΔS). In relative coordinates system, this difference is equal to the absolute value of the Target Position, whereas in absolute coordinates system, this difference is equal to the absolute value of the difference from Target Position and the Actual Position of the shaft before moving starts.

Motion profiles can be of three type:

- START-STOP, if PV is minor or equal to 16000 Hz (12800 step/rev)
- TRAPEZOIDAL, if the relation $PV^2 < PA * \Delta S$ is valid
- TRIANGULAR, in all the other cases

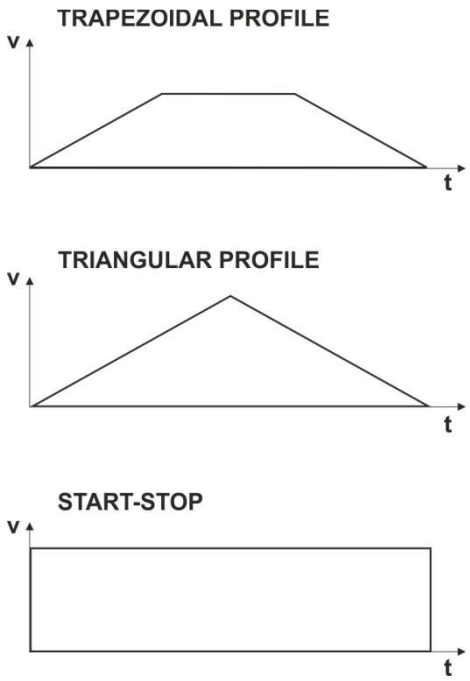


Figure 30 - Motor frequency related to motor position during a generic motion execution. Acceleration profiles are only an example.

MULTI-SET-POINT MODE

To enable this function, the bit 5 (Change Set Point Immediately) of Control Word must be set.

- bit 5 = “**0**”, function Disable:

motion parameters cannot be modified when motor is running until the target position is reached or before sending a HALT (bit 8 of Control Word) or QUICK STOP (bit 2 of Control Word) command.

- bit 5 = “**1**”: function Enable:

Target Position and/or Profile Velocity parameter can be modified when motor is running. In any case, the Profile Acceleration cannot be modified; a new value is loaded only when the movement gets the final target position.

MULTI SET POINT FUNCTION LIMITS:

- bit 6 of the Control Word (enable absolute/relative coordinates) should not be changed: if it is changed, the new value is ignored. A relative movement has the overall starting point as a reference.

- The Profile Velocity value is changed immediately after a new value is received, even during a motion execution, independently of the New Set Point bit status.

- It is not possible to set Profile Velocity = 0 when motor is running (in this case the previous value of Profile Velocity remains be valid). To stop a movement the commands HALT or QUICK STOP can be used.

- The drive acquires a new value of Target Position and changes the final position of the movement only if the new target position is followed by a New Set Point command (i.e. a low->high transition of bit 4 of the Control Word).

- To execute a movement without intermediate stops, the movement must be monotonous, i.e. the new Target Position must be greater or equal to the previous one for positive direction, or lower (or equal) to the previous one for negative direction.

A not monotonous new Set Point is executed with the stop of the movement with a deceleration ramp, the calculation of the new motion profile (during motor stop) and then the restart of the motion to the new Target Position.

- The motion cannot be changed when a HALT or QUICK STOP command is sent or in case of a stop and restart operation.

- The Set Point can be changed in any position of the run, even during acceleration or deceleration ramps.

- When motor is running, the Set Point value can be changed many times.

PROFILE VELOCITY MODE

In Profile Velocity mode of operation, any movement, when started, will produce a shaft rotation with the velocity set before in the registers “Target Velocity” (1048-1049).

For example, if we desire to execute the motion profile shown in Table 7, the motor shaft will start to rotate in the positive direction with a target velocity of 140000 Hz (about 656 RPM) and with an acceleration ramp of 80000 Hz/s.

The actual velocity can be read in real time in registers “Velocity Actual Value” (1020-1021).

The max velocity error is equal to: ±0.24% ± 1.5 RPM

Modbus Address Little Endian	Modbus Address Big Endian	Data type	Access Type	Function	Setting example
1048	1049	U32	RW	Target Velocity_L	**140000 [Hz]**
1049	1048			Target Velocity_H	
1046	1047	U32	RW	Profile Acceleration_L	**80000 [Hz/sec]**
1047	1046			Profile Acceleration_H	

Table 16 – Profile Velocity motion parameters registers

During a motion, it is possible to change the velocity value without stopping the motion. In this case, the motor will change the velocity and even the direction of the motion, following the new setting values of velocity, direction and acceleration.

In Profile Velocity, the Mode Of Operation can be changed from the following sub-states: Switched On, Ready to Switch ON, Switch On Disabled, Operation Enabled.

HOMING MODE

With **Homing** mode of operation, the encoder position can be reset depending on a proximity sensor connected to the hardware **I0** input (proximity input, if it is set in register 1088).

Available Homing Method are: 3, 4, 5, 6, 19, 20, 21, 22, 35, 37, .

An example of valid parameters setting can be:

Modbus Address Little Endian	Modbus Address Big Endian	Data type	Access Type	Function	Setting example
1058	1059	I32	RW	Home Offset_L	**0**
1059	1058			Home Offset_H	
1050	1050	I8	RW	Homing Method	**19**
1052	1053	U32	RW	Homing Speeds during Search for Switch_L	**40000** [Hz]
1053	1052			Homing Speeds during Search for Switch_H	
1054	1055	U32	RW	Homing Speeds during Search for Zero_L	**3200** [Hz]
1055	1054			Homing Speeds during Search for Zero_H	
1056	1057	U32	RW	Homing Acceleration_L	**100000** [Hz/sec]
1057	1056			Homing Acceleration_H	

Table 17 – Homing motion parameters registers

As example, the setting showed in Table 17, corresponds to a zero search procedure with 12800 step/rev, maximum frequency of 40 KHz, acceleration of 100 KHz/sec, slow approaching frequency at 3200 Hz and with homing method 19 (DSP 402 V.2.0).

The following figure motor frequency VS time during a zero search procedure execution are shown.

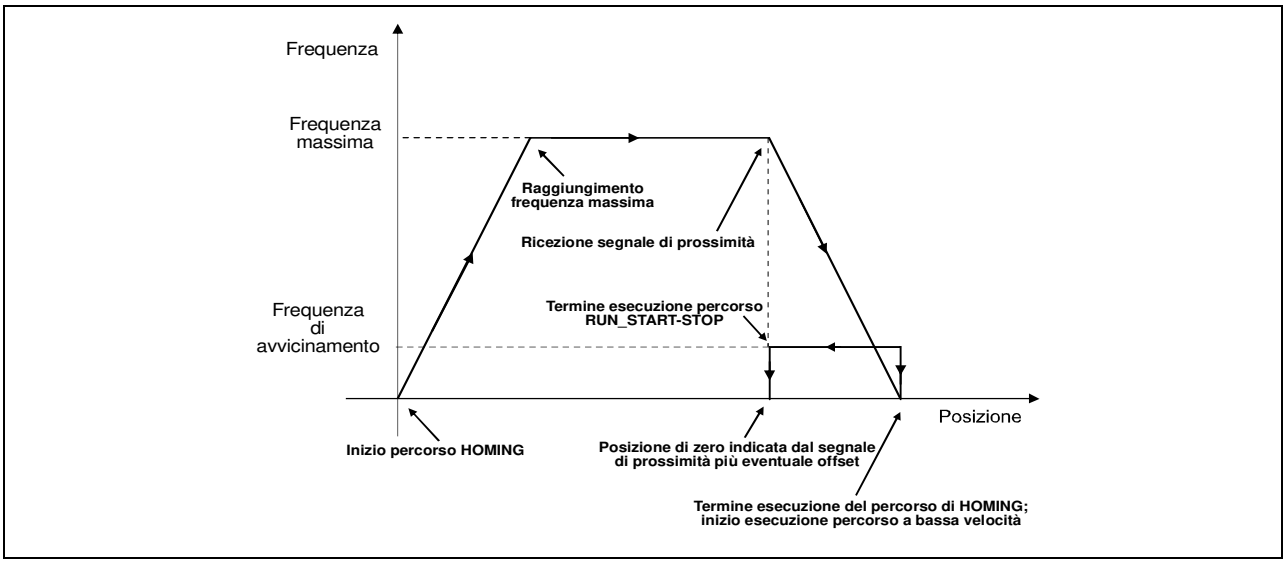


Figure 31 - Motor frequency VS time during a zero search procedure execution. Acceleration ramps are only an example.

If, for example, the *Home offset* is ±1000, after having reached the proximity sensor, this is the position indicated as ±1000.

Note: In HOMING parameters setting and with reference to Figure 31, , it is suggested to set maximum speed higher than frequency value corresponding to 75 rpm (registri 1052 e 1053) and approaching speed lower than frequency value corresponding to 75 rpm (registri 1054 e 1055).

In Profile Homing, Mode Of Operation can be changed from the following sub-states: Switched On, Ready to Switch ON, Switch On Disabled, Operation Enabled.

Registers 1042-1043: Target Position

In this registers it is possible to set

- the number of steps to be executed after receiving a “New Set Point” (bit 4 of CONTROL WORD) in **RELATIVE** coordinate system **(**bit 6 of CONTROL WORD equal to 1)

- the position (indicated in number of steps) to be reached after receiving a “New set Point” if the coordinate system is **ABSOLUTE** (bit 6 of CONTROL WORD equal to 0)

Registers 1044-1045: Profile Velocity

Object active in Profile Position mode of operation only.

This couple of registers allows to set the maximum speed for a **Profile Position Mode** movement.

The measure unit is Hz corresponding to number of steps for second.

Registers 1046-1047: Profile Acceleration

Object active in Profile Position or Profile Velocity mode of operation only.

This registers allow to set the value of acceleration/deceleration used to reach the maximum/zero speed of a positioning movemement in Profile Position mode.

The unit of measure is Hz/s which corresponds to number of steps / s^2.

The minimum setting value is 2000 steps / s^2.

If a movement is running, a new value write in this register become active when the actual movement is completed.

Registers 1048-1049: Target Velocity

Object active in Profile Velocity mode of operation only.

This registers are reserved to set the desired speed value for movements in **Profile Velocity Mode**.

Register 1062: Velocity Window

In Profile Velocity mode, this register allows the setting of a threshold speed value (in steps/s).

When Actual Velocity become greater than the set value, after the delay written in register "Velocity Window Time" (1063), the bit 10 of Status Word "Target Velocity Reached" switch to the value "1".

Register 1063: Velocity Window Time

In Profile Velocity mode, this register allows to set a time threshold.

When Actual Velocity become greater than the velocity threshold set in register "Velocity Window" (1062), the bit 10 of Status Word "Target Velocity Reached" switch to "**1**" after a time delay equal to the value set in this register (in ms).

Register 1064: Velocity Threshold

In Profile Velocity mode, this register allows to set a velocity threshold (in steps/s).

When Actual Velocity become lower than the velocity threshold, after a time delay equal to the value set in register “Velocity Threshold Time” (1065), il bit 12 della Status Word “Zero Speed Status” switch to value “**1**”.

Register 1065: Velocity Threshold Time

In Profile Velocity mode, this register allows to set a time threshold.

When Actual Velocity become lower than the velocity threshold set in register “Velocity Threshold” (1064), the bit 12 of Status Word “Zero Speed Status” switch to “**0**” after a time delay equal to the value set in this register (in ms).

Register 1067: CtrlW_from_IO

In This register allows to enable a special function for digital inputs. The function make possible the execution of a movement (in Profile Position or Profile Velocity operation mode) as follows:

Value of *M*	**“CtrlW_from_IO” value (= 0x*NM*)**	**Mode of operation**
0	0x*N*0	Start Function disabled
1	0x*N*1	Start from I0 input in ABSOLUTE coordinates
2	0x*N*2	Start from I0 input in RELATIVE coordinates
3	0x*N*3	Start from I1 input in ABSOLUTE coordinates
4	0x*N*4	Start from I1 input in RELATIVE coordinates
5	0x*N*5	Start from I2 input in ABSOLUTE coordinates
6	0x*N*6	Start from I2 input in RELATIVE coordinates
7	0x*N*7	Start from I3 input in ABSOLUTE coordinates
8	0x*N*8	Start from I3 input in RELATIVE coordinates
Value of *N*		
0	0x0*M*	Halt Function Disabled
1	0x1*M*	Halt from I0
3	0x3*M*	Halt from I1
5	0x5*M*	Halt from I2
7	0x7*M*	Halt from I3

- In Profile Position mode, the setting value for the register “CtrlW from IO” can be obtained by sum the enable value for the desired Start input (less significant byte) and the possible enabling value for Halt input (more significant byte). For example, by writing in the register the value 0x31 (0x01 + 0x30) will be enabled the Start function in absolute coordinate mode on I0 input and the function Halt on the I1 input. In particular:

- A positive transition applied to the selected input starts a motion in absolute or relative coordinates. The status of the drive can be read by the StatusWord, as usual.
- To start a new motion it is necessary to execute a new low to high transition of the signal applied to the selected input.

- The motion parameters must be pre-set before the off-on transition on the selected input.

- In Profile Velocity mode the more significant byte must be always set to 0. By using only the desired Start input, it is possible to enable or disable the movement of the motor. In particular:

- An high logic level applied to the input enable the motor motion following the pre-set Target Velocity.
- A low logic level applied to the input stop the motion execution. The value in the Target Velocity register is not changed.

The motion status can be read by means of the Busy output (cfr. register 1089, Output Config): ON indicates a running state, OFF indicates that motor is in steady state.

By means of register 1104 (Busy Delay) it is possible to set the time delay value from the motion end and the Busy output switch off.

Note: the ControlWord must be set to 0x0F when using this function, in any motion profile. The Halt command can be used and must be provided by means of the ControlWord, as usual.

Registers 1072-1073: Profile Deceleration

The register is active only in Profile Velocity mode of operation.

In this couple of registers it is possible to set the deceleration value used to get the zero velocity in Profile Velocity mode.

The unit of measure is Hz/s which corresponds to number of steps / s^2.

The minimum setting value is 2000 steps / s^2.

Registers 1074-1075: Max Motor Speed

This Register is active only in Profile Velocity mode of operation.

In this couple of Registers it is possible to set the maximum value (absolute value) of the velocity sent from drive to the motor in Profile Velocity mode of operation. This value limits the maximum teoric value of Target Velocity.

DRIVE SETTING PARAMETERS REGISTERS

Modbus Address Little Endian	Modbus Address Big Endian	Data type	Access Type	Function	Default Value	Minimum value	Maximum value
1080	1080	U8	RW	Current Ratio	70	0	120
1081	1081	U16	RW	Step Revolution	12800	12800	12800
1082	1082	U8	RW	Current Equalization	0	0	0
1083	1083	U8	RW	Current Reduction	1	1	1
1084	1084	U8	RW	Encoder Window	3	1	5
1085	1085	U8	RW	Following Error Reaction Code	0	0	17
1086	1086	U8	RW	Position Error Reset	0	0	2
1087	1087	U8	RW	Set Output	0	0	15
1088	1088	U8	RW	Input Config	31	0	31
1089	1089	U8	RW	Output Config	27	0	39
1090	1091	U32	RW	Motor Code_L	712617	000000	999999
1091	1090			Motor Code_H			
1092	1092	U8	RW	Revolution direction	0	0	1
1093	1093	U16	RW	Brake Delay Lock	100	0	1000
1094	1094	U16	RW	Brake Delay Unlock	100	0	1000
1095	1095	U16	RW	Brake Delay Current ON	0	0	1000
1096	1096	U16	RW	Brake Delay Azio Ready	230	0	1000
1097	1097	U16	RW	Counter Watchdog	0	0	1
1104	1104	U16	RW	Busy Delay	80	10	1000
1106	1106	U16	RW	Enable SW bit 14	0	0	1
1107	1107	U16	RW	Enable SW bit 15	0	0	1
1108	1108	U16	RW	Auto Sync Enable	0	0	1
1109	1109	U16	RW	Auto Sync Kv	100	0	300
1110	1111	U32	RW	Auto Sync Window LSB	32000	1	64000
1111	1110			Auto Sync Window MSB			
1112	1112	U16	RW	Current Reduction Ratio	50	0	100
1113	1113	U16	RW	Velocity Total Sample	100	1	200
1114	1114	U16	RW	Reset Encoder On First Power Up	0	0	1
1115	1115	U16	RW	Hard Stop Homing Disengaging Steps	64	0	255
1116	1116	U16	RW	Power Up Speed Limit	0	0	32000
1117	1117	U16	RO	Motor Current Limit	--	1	4
1118	1118	U16	RO	Motor Proportional Gain	--	100	400
1119	1119	U16	RO	Motor Dynamic Balancing	--	0	500
1120	1120	U16	RO	Motor Current Recycling Enable	--	0	1
1121	1121	U16	RW	Encoder Count Per Revolution	400	400	4000

Table 18

Register 1080: Current Ratio

Allow to set the desired drive current (peak value supplied to the motor) related to the nominal full scale drive current.

Valid values are in the range 0 - 120% and corresponds to nominal current percentage set as regards to full-scale current of the drive (register 1117) and depends also from the motor used. The drive current can be calculated by the following expression (in square brackets, the objects are indicated as [register number]):

$$I_N = [reg.1117] * [reg.1080/100]$$

The current can be automatically reduced in case of motor standstill (see registers 1083, 1112 and 1108)

Default value is 70. The value is the percent ratio with respect to the nominal current and must be set taking into account motor performance and working conditions (i.e. duty cycle).

Motor model must be set in registers 1090-1091 (Motor Code).

To avoid motor and drive overheating, do not keep current values greater than 100% for long period.

Change this value when motor is in stop condition.

Register 1081: Step Revolution

Valid setting value is:

- 12800: correspond to 12800 step/revolution.

Register 1082: Current Equalization

Valid setting values are:

- 0: equalization EXCLUDED

Register 1083: Current Reduction

Valid setting values are:

- 1: automatic reduction active

If automatic reduction is active the current is reduced with respect to the nominal current following the ratio set in the register 1112 (Current Reduction Ratio) about 80ms after the end of the run, when motor is in standstill condition. The drive current is equal to the following expression (in square brackets, the objects are indicated as [register number]):

$$I_{SS} = [reg.1117] * [reg.1080/100] * [reg.1112/100]$$

Note: when Auto Sync function is enabled, the Current Reduction setting could be ignored: the current reduction is set by the register 1108.

Register 1084: Encoder Window

Valid setting values are:

- **0**: position error of **0.9**° compared with the theoretical position
- **1**: position error of **1.8**° compared with the theoretical position
- **2**: position error of **3.6**° compared with the theoretical position
- **3**: position error of **5.4**° compared with the theoretical position
- **4**: position error of **7.2**° compared with the theoretical position
- **5**: position error of **9.0**° compared with the theoretical position

The value of the encoder window corresponds to the limit of the angular error that causes the raising of the synchronism motor loss error with Auto Sync disabled (see note2) (the drive synloss reaction can be set by register 1085 Following Error Reaction Code).

Suggested value: 3.

The value can also be modified when the motor is running.

Note1: if the encoder reading is disabled (register 1085 set to 17), the synloss cannot be sensed and the Encoder Window setting is ignored).

Note2: if the Auto Sync function is enabled, the Encoder Window setting is ignored: the error window become equal to the value set by the value in the registers 1110-1111.

Register 1085: Following Error Reaction Code

Following Error Reaction Code allows to set different possible drive reactions to maximum error, set by means of register 1084 if Auto Sync function is disabled or by means of registers 1110-1111 if the Auto Sync function is enabled. In every Operation Modes, the Alarm of Following Error causes the setting of bit 13 (Following Error) of Status Word at 1.

In case of use of a motor without encoder, this register must be set to 17, see also details about registers 1090-1091.

- "0x0**0**": when a Following Error is raised during the execution of run with ramp, the drive executes the deceleration ramp and stops. When a Following Error is raised during the execution of run without ramp, the drive immediately stops.

Bit 10 (Target Reached) of Status Word is set to 1 when the motor stops, not when the target position is reached.

Bit 13 of Status Word remains high until a following run execution.

-"0x0**1**": when a Following Error is raised, running motor is not stopped*; bit 10 (Target Reached) of Status Word is set to 1 when all steps required by the execution of the run are completed; not when the set position is reached.*

Bit 13 of Status Word remains high also during the following runs, as long as register 1086 is set to 1 or 2 (or the drive executes transition that causes the disabling of the current in motor windings, for example: Ready to Switch On).

Bit 13 of Status Word must be reset to run in Absolute Coordinate System.

⚠ WARNING!

When the **Auto Sync** function is enabled, (value of register 1108 greater than 0), the setting Following Error Reaction Code = 0x01 (which is only a software monitor and does not produce an automatic transition to the Fault state in case of following error) can result in a potentially dangerous situation if it's not correctly managed, because the drive will not automatically go into a Fault status in case of loss of synchronism.

It is recommended not to use the above settings; if the setting is used, the customer is the only responsible to ensure the required safe operation of the system.

Note: When Auto Sync function is enabled with optional setting Following Error Reaction Code = 0x01, the *bit 13 of Status Word* becomes equal to 0 when the synchronization between motor command position and actual position is recovered.

-"0x0**2**": when a Following Error is raised, the drive goes in Fault state and current in the motor windings is disabled (current off).

In Profile Velocity mode of operation: when the Following Error exceeds the value set in Encoder Window register (1084) and the Auto Sync function is disabled or by registers 1110-1111

with Auto Sync function enabled, the drive automatically is inhibited and current in the motor windings is disabled. In this condition, the drive works in this way:

A – The drive goes in Current Off state with a motor deceleration (the drive doesn't keep torque in the motor during deceleration).

1) – Status Word indicates the transition from "Operation Enabled" (0x1237 and 0x1637) to "Fault Reaction Active" (0xXXXF).
2) – Setting of bit 12 and 13 of Status Word are the following: bit 13 = 1, bit 12 = 0.
3) – Status Word is 0x201F (bit Remote and Quick Stop are set = 0).
4) – The drive ignores the new target sent from the master.

C – When the motor stops:

1) – The drive goes in "Fault" state (0x1218).
2) – Bit 12 and 13 of Status Word values are the following: bit 13 = 0, bit 12 = 1.
3) – Bit Remote = 1 (bit 9 of SW) means that the drive can receive new commands (by means Control Word).

D – To reset error and set the drive in Operation Enabled state:

1) – Master must send a Control Word of "Fault Reset" (0x0080)
2) – Master must reset the drive in "Operation Enabled" by means CoE commands.

-"0x**11**": It is the value to set if motor is without encoder. This is a preliminary setting of the drive, the value must be written in a state lower than Operation Enabled. In this case, the drive cannot read the encoder position and so cannot activate any kind of Following Error alarm. The Position Actual Value sent to the Master corresponds to the command position sent from the drive to the motor. The bit 13 of the Status Word is always equal to "0".

Register 1086: Position Error Reset

Allows user to reset a position error.

Write “1” to reset bit 13 (Following Error) of Status Word.

- In case of Auto Sync function disabled (register 1108 = 0), writing 1 in this object also produces the reset of the offset between encoder position and command position.

This object can also be used to fix starting offset between Position Actual Value and Target Position, for example due to an excessive load inertia on the motor shaft.

- In case of Following Error Reaction Code = “1”, this is the only method allowing the Status Word bit 13 reset.

- In case of Following Error Reaction Code = 0 or 2, the Status Word bit 13 reset automatically when drive state switch to a current OFF state or when a new Profile Position or Homing movement start.

It is not possible to use the reset command when the drive state is different from Operation Enabled.

By writing Following Error Reset = 2, the reset of following error is obtained by loading the drive internal value of the logic step counter into encoder position register (Position Actual Value). The command Following Error Reset = 2 is available only if register 1121 CPR (Encoder Counts per Revolution) is set to 400.

We suggest to use this command only when the standard procedure cannot be used. For further information please contact RTA.

Note1: the command is executed immediately. It is mandatory to switch back to 0 the value of Following Error reset after the operation.

Note2: Following Error Reset commands are ignored when encoder is not active (Following Error Reaction Code = 0x11) or when motor is not in current ON state (Operation Enabled).

Register 1087: Set Output

By means of this register it is possible to set the logic state of programmable outputs (O0, O1, O2, O3 and O4 for CSD MT 94 and O0, O1, O2 for CSD MT S4), following the binary code shown in the following tables.

For **CSD MT 94**:

Register VAlue 1087	O0	O1	O2	O3	O4
0	0	0	0	0	0
1	1	0	0	0	0
2	0	1	0	0	0
3	1	1	0	0	0
4	0	0	1	0	0
5	1	0	1	0	0
6	0	1	1	0	0
7	1	1	1	0	0
8	0	0	0	1	0
9	1	0	0	1	0
10	0	1	0	1	0
11	1	1	0	1	0
12	0	0	1	1	0
13	1	0	1	1	0
14	0	1	1	1	0
15	1	1	1	1	0
16	0	0	0	0	1
17	1	0	0	0	1
18	0	1	0	0	1
19	1	1	0	0	1
20	0	0	1	0	1
21	1	0	1	0	1
22	0	1	1	0	1
23	1	1	1	0	1
24	0	0	0	1	1
25	1	0	0	1	1
26	0	1	0	1	1
27	1	1	0	1	1
28	0	0	1	1	1
29	1	0	1	1	1
30	0	1	1	1	1
31	1	1	1	1	1

Table 19 - Set Output

For **CSD MT S4:**

1087 Register Value	O0	O1	O2
0	0	0	0
1	1	0	0
2	0	1	0
3	1	1	0
4	0	0	1
5	1	0	1
6	0	1	1
7	1	1	1

Table 20 - Set Output

In the tables, 0 corresponds to OFF output and 1 corresponds to ON output.

The outputs are considered ON when they are closed as regards to common of outputs (see hardware instruction manual).

Note: In the tables, the outputs are set as "general-purpose" by means of register 1089 (Output Config).

Register 1088: Input Config

Input Config allows to set the operation mode of hardware inputs (see Register Digital Inputs 1008-1009 description) as shown in the following tables

For **CSD MT 94:**

CONTROLLED INPUT	INPUT CONFIG BIT	VALUE	OPERATION MODE
I0	IC0	0	PROXIMITY INPUT
		1	GENERAL-PURPOSE INPUT
I1	IC1	0	NEGATIVE LIMIT SWITCH INPUT
		1	GENERAL-PURPOSE INPUT
I2	IC2	0	POSITIVE LIMIT SWITCH INPUT
		1	GENERAL-PURPOSE INPUT
I3	IC3	0	TOUCH PROBE INPUT
		1	GENERAL-PURPOSE INPUT
I4	IC4	0	GENERAL-PURPOSE INPUT
		1	GENERAL-PURPOSE INPUT

The value of Input Config is equal to the binary coding of the inputs.

For **CSD MT S4:**

INPUT CONFIG VALUE	MODE OF OPERATION
0x05	**I0** NEGATIVE LIMIT SWITCH
	I1 TOUCH PROBE
0x06	**I0** PROXIMITY
	I1 TOUCH PROBE
0x07	**I0** GENERAL-PURPOSE INPUT
	I1 TOUCH PROBE
0x09	**I0** NEGATIVE LIMIT SWITCH
	I1 POSITIVE LIMIT SWITCH
0x0A	**I0** PROXIMITY
	I1 POSITIVE LIMIT SWITCH
0x0B	**I0** GENERAL-PURPOSE INPUT
	I1 POSITIVE LIMIT SWITCH
0x0D	**I0** NEGATIVE LIMIT SWITCH
	I1 GENERAL-PURPOSE INPUT
0x0E	**I0** PROXIMITY
	I1 GENERAL-PURPOSE INPUT
0x0F	**I0** GENERAL-PURPOSE INPUT
	I1 GENERAL-PURPOSE INPUT

Table 21 - Input Config

Note: I1 / I2 for CSD MT 94 and I0 / I1 for CSD MT S4 inputs can be set as limit switch independently from each other.

Register 1089: Output Config

Output Config allows to set the operation mode of hardware outputs (see hardware manual) as shown in the following tables.

For **CSD MT 94**:

OUTPUT CONFIG VALUE	OPERATION MODE
0x1B	**O0**, **O1**, **O3**, **O4**: GENERAL-PURPOSE OUTPUT **O2**: DRIVE FAULT OUTPUT
0x1F	**O0**, **O1**, **O2**, **O3**, **O4**: GENERAL-PURPOSE OUTPUT
0x23	**O0**, **O3**, **O4**: GENERAL-PURPOSE OUTPUT **O1**: BRAKE OUTPUT **O2**: DRIVE FAULT OUTPUT
0x27	**O0**, **O2**, **O3**, **O4**: GENERAL-PURPOSE OUTPUT **O1**: BRAKE OUTPUT

Table 22 - Output Config

For **CSD MT S4**:

OUTPUT CONFIG VALUE	OPERATION MODE
0x1B	**O0**, **O1**: GENERAL-PURPOSE OUTPUT **O2**: DRIVE FAULT OUTPUT
0x1F	**O0**, **O1**, **O2**: GENERAL-PURPOSE OUTPUT
0x23	**O0**: GENERAL-PURPOSE OUTPUT **O1**: BRAKE OUTPUT **O2**: DRIVE FAULT OUTPUT
0x27	**O0**, **O2**: GENERAL-PURPOSE OUTPUT **O1**: BRAKE OUTPUT

Table 23 - Output Config

Busy Output: The Output O0, if it is set as "Busy Output", indicates the state of running or steady of the motor. In particolar, Busy Output = 1 indicate motor running.

Brake Output: In the case of output O1 set as "Brake Output", it can be used to drive holding brake only. It cannot be set by the user, but it is controlled by the drive.

The output is ON if the drive is in Operation Enabled state only.

Note 1: The setting of Output Config object must be made at the beginning, before the transition to OPERATION ENABLED and after this transition, it cannot be changed. In particular, when the drive is in OPERATION ENABLED or during the execution of movements, it is not allowed to modify the Output config register to enable or disable the "Brake Output".

Note 2: The value set in object Output Config vanish when the 24 V_{DC} logic supply voltage is switched OFF. As a consequence, the value of Output Config must be write again after the next logic supply switch ON. Alternatively, and in particular when the output is used as "Brake Output", we advise to store in the non volatile memory the desired value of Output Config by means of Save Parameter command (see register. 1260).

⚠ WARNING!

Use for safety related functions is forbidden (EN 60204-1). Moreover, when the application arrangement is in such way that a motor fault or failure could generate a risk for property or human life, external independent safety protection system must be provided in the machine.

Registers 1090-1091: Motor Code

By these registers it is possible to auto-configure some drive parameters setting the code of motor to be used.

Each motor code corresponds to the code of R.T.A. motors with or without encoder, as shown in the following table:

MOTORS FOR CSD MT						
Motor model	**Resistance (Ohm)**	**Inductance (mH)**	**Nominal Current (A)**	**Register Value 24V**	**Register Value 48V**	**Note**
RH 1S0M	3.6	7	1	0x1591	0x1561	
RH 1S1M	4.6	9.6	1	0x15B1	0x1581	
RH 1S1H	1.1	2.4	2	0x1552	0x1532	
RH 1S2M	5.3	12.5	1	0x15C1	0x1591	
RH 1S2H	0.93	2.2	2.3	0x1042	0x1032	Set Current Ratio = 115%
RH 1S3M	6.5	16	1	0x15E1	0x15A1	
RH 1S3H	1.2	3	2.3	0x1042	0x1032	Set Current Ratio = 115%
RH 2S1M	0.37	1.5	4	0x1534	0x1524	Only for MSE-408
RH 2S2M	0.52	2.4	4	0x1554	0x1544	Only for MSE-408 Set Current Ratio ≤ 80% @ 48V without encoder
SH2141-5541	21	4.2	0.3	0x1551	0x1531	Set Current Ratio = 30
SH2281-5271 (5231)	2.85	1.0	0.7 (bipolar)	0x15A1	0x1561	Set Current Ratio = 70% 4 terminals bipolar config
SH2285-5271 (5231)	4.1	1.9	0.7 (bipolar)	0x15B1	0x15A1	Set Current Ratio = 70% 4 terminals bipolar config
EM 1H2H 103-H5210-4512 (4541)	1.25	2.4	2	0x1542	0x1532	
EM 2H1M 103-H7123-1711 (1749)	0.41	1.6	4	0x1554	0x1544	Only for MSE-408
EM 2H2M 103-H7126-1710 (1740)	0.48	2.2	4	0x1554	0x1544	Only for MSE-408
EM 6H2M 103-H7823-1714 (1740)	0.65	2.4	4	0x1554	0x1544	Only for MSE-408

Table 24 -Motor Codes

In the table above, xxxx can assume the following values:

- “04D0” = motor with 400 CPR encoder, no zero index;

- “04E0” = motor with 400 CPR encoder, and zero index;

- “0HE0” = motor with 4000 CPR encoder, and zero index.

*** = Default value:** is 712617 (0x000ADFA9) which is equal tothe setting 5444 (0x001544).

- Setting of a Custom Motor

It is possible to set a 4 digit exadecimal motor code, for example 0x**ABCD** (with 0xABCD less than 0x8000), to configure some internal drive parameters and maximize drive performance in case of use of a specific motor, different from what showed in the above list.

In detail:

- **A** set the current recirculation (**0**: recirculation disable; **1**: recirculation enabled)

- **B** set the dynamic compensation value (**7**: 700%; **0**: 0%)

- **C** set the current proportional gain (setting values are from **1** to **F**, where 1 = 100%, F = 1500%)

- **D** set the value of nominal current in Ampere (setting values are **1**,**2**,**3**,**4**).

It is recommended to use the setting of a custom motor only in cases of not adequate performances (such as excessive noise, etc.) when using RTA reference motor. Please contact RTA technical service before setting any custom motor parameters.

Note: In case of use a motor without encoder, please consider that:

- Register 1085 (Following Error Reaction Code) should be set to “17”. In this case, a possible loss of synchronism cannot be detected.

- The bit 13 of Status Word is always = 0 and register 1004-1005 (Position Actual Value) will show the commanded position sent from the drive to the motor

Register 1092: Revolution Direction

This parameter is conceived to be set at the machine start-up and cannot be changed later.

Setting values: 0, 1.

Register 1093: Brake Delay Lock

For Output Config values which include the setting of output O2 as Brake Output, the register allows to set the delay between disable of the brake output (BRAKE LOCKED) and next transition Current-ON -> Current-OFF: 5,8 e 9 (See Figure 32).

This parameter can be set in a range of values between 0 and 1000 ms.

The default value is 0 ms.

Register 1094: Brake Delay Unock

For Output Config values which include the setting of output O2 as Brake Output, the register allows to set the delay to enable brake output (BRAKE UNLOCKED) in the transitions Current-OFF -> Current-ON.

These parameters can be set in a range of values between 0 and 1000 ms.

The default value is 0 ms.

Pay Attention: in case of a mechanical system made of vertical loads blocked by a brake, the motor torque and the brake torque must be correctly calculated with regard to the value of the vertical load.

If the sum of the holding torque of the brake and the torque generated by the load is close to the nominal torque of the motor, during the start-up phase of the motor, serious malfunctions such as stall (without encoder) or conditions of loss of torque or Fault in motion (with incremental encoder) can be occurred.

Register 1095: Brake Delay Current-ON

This register allow to set the delay from the switching command to the real switch from Current-OFF to Current-ON condition.

These parameters can be set in a range of values between 0 and 1000 ms.

The default value is 0 ms.

Register 1096: Brake Delay Azio Ready

In all the state transitions where switching from a Current-OFF to Current-ON condition take place, this register allow to set the time delay of: “state transition done and drive ready to receive a new motion command”.

These parameters can be set in a range of values between 0 and 1000 ms.

The default value is 30 ms.

In Figure 32 the time delay signal switching, setting by registers 1093, 1094, 1095 and 1096 are shown.

For further information about different settings, please contact R.T.A.

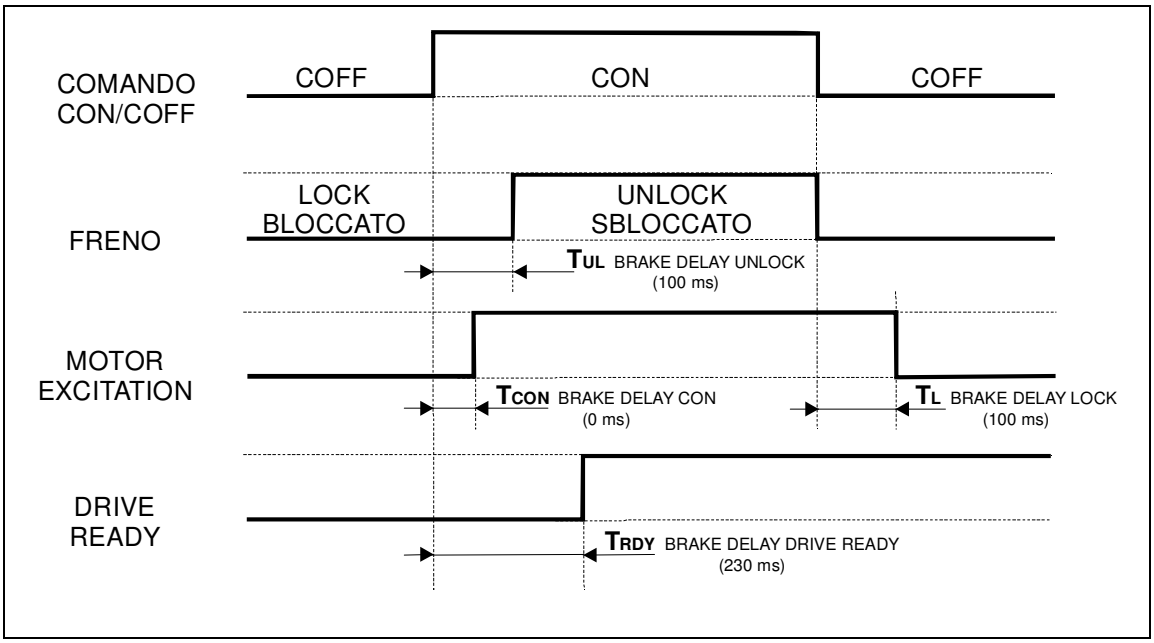


Figure 32 - Timeline sequence

Register 1097: Counter Watchdog

If this register is set to a value different from 0, the function "Watchdog" becomes active and the timeout is set to the value stored in the register. In this case, if drive does not receive any read or write message before the timeout set in the register, goes to the Fault state.

Available values are in the range: 100÷32000 [ms].

Register 1104: Busy Delay

This register allows to set the switch-off time delay of Busy output (cfr. register 1089 for output setting) starting from the end of the executing motion.

Default value is 80 ms.

Setting values are: 10÷1000 [ms].

Register 1105: Enable Status Word bit 7

This register allow to set the function of bit 7 of the Status Word. This bit can be used to alert that the internal drive temperature value (see Register 1124) is over the warning threshold value indicated in Register 1125 (default: 85 °C).

Setting values are:

- **"0"**: bit 7 not used
- **"1"**: bit 7 switch to "1" when the drive temperature exceed the threshold value

Note: if Register 1107 is set to "1" (Enable Status Word bit 15), it is not possible to set "1" in Register 1105 (Enable Status Word bit 7).

Register 1106: Enable Status Word bit 14

This register allows to set the function of Status Word bit 14 (and bit 23 of register Digital Input, 1008-1009). This bit is used to show the state of the Auto Sync function when motor is running.

Setting values are:

- **"0"**: bit 14 not used
- **"1"**: bit 14 switch to "1" when the Auto Sync function acts to modify a potential synloss condition.

Register 1107: Enable Status Word bit 15

This register allows to set the function of bit 15 of Status Word. This bit can be used to show the acceleration state of a movement. This feature is available inly for Profile Position and Homing mode of operation.

Setting values are:

- **"0"**: bit 15 not used
- **"1"**: bit 15 switch to "1" when an acceleration or deceleration ramp occur.

Note: if the Register 1105 is set to "1" (Enable Status Word bit 7), it is not possible to set to "1" the Register 1107 (Enable Status Word bit 15).

Register 1108: Auto Sync Enable

This register allows to enable the **Auto Synchronization** function.

Auto Synchronization allows the drive to recover – within specific range limits – possible gaps between rotor position and drive command that can be result in a loss of syncronism.

If rotor is stopped, the range limits are equal to 1 full step (±1.8°).

If rotor is moving, the range limits corresponds to 2 full steps (3.6°).

In practice, the Auto-Sync function enable a sort of hybrid control system similar to a Closed Loop system: when the gap between rotor position and drive command is lower than 1 full step, the drive works in Open Loop mode (micro-stepping); when the gap between rotor position and drive command is greater than 1 full step, the drive works in Closed Loop mode up to the complete recovery of motor synchronism, then the drive turn to work in Open Loop mode. When

operating in Closed Loop mode, the drive operates to provides the maximum torque at the motor depending on nominal current and speed.

The Auto-Sync function cannot be enabled when object Following Error Reaction Code (1085) is set to 17 (0x11), i.e. when drive is working without encoder. In this case drive is always working in open loop mode.

Auto Synchronization function can also be used to:

- Mechanical impact position search: the bit 23 of Digital Inputs (registers 1008-1009) switch to 1 when the gap between rotor position and drive command overcome the internal limit (window). This condition can also be indicated by bit 14 of Status Word (see description of register 1001)

- Movements with speed, acceleration/deceleration greater than the maximum allowable in Open Loop mode.

The Auto Sync function can be enabled and disabled at any time, also when motor is in Current ON.

Setting values are:

- **"0"** = function disabled (default value)

- **"1"** = function enabled, current reduction disabled

- **"2"** = function enabled, current reduction enabled when motor standstill and the Auto Sync function is not working to recover an excessive position gap (shown by bit 23 of the registers 1008-1009, Digital Inputs)

- **"3"** = function enabled, current reduction enabled when motor is standstill

Note1: it is recommended to enable Auto Sync after having carefully verified the encoder connections, ground connection of both drive and motor and after basic test of movements in Open Loop mode.

Note2: it is advised to enable Auto Sync function in mode 2. Use mode 1 only when the Auto Sync function become active frequently. Use 3 only for cases when is not possible to reach a safe thermal working conditions by simply set the suitable drive nominal current (register 1080, Current Ratio).

Register 1109: Auto Sync Reactivity [Kv Gain]

This register allows to set the reactivity of the Auto Sync function.

Available setting values are: 0, 50, 100 (default), 150, 200, 250, 300.

Greater is the setting value and greater is the precision of the movements in Closed Loop when recover synchronism and greater is the maximum motor velocity limit.

Values greater than the default value can be set only in case of low load inertia, low acceleration/deceleration ramp. In other cases, back-EMF can generate overvoltages which can produce unwanted turn ON of the overvoltage protection system of the drive (Error Code 0x5100).

High values of Reactivity (250 and 300) could generate in particular conditions, a loss of smoothness of motion profiles.

Registers 1110-1111: Auto Sync Error Window

This register allows to set the threshold of the angular position error which is the limit of the activation of synloss alarm. When this limit is overcome, drive raised the alarm.

With Auto-Sync function enabled, this object substitutes the Encoder Window (register 1084). The drive read the correct parameter (in register 1084 or registers 1110-1111) with respect to the function mode (Open Loop or Closed Loop).

The available settings values are in the range: 1 ÷ 64000 (number of step). Default value: 32000.

If the object Following Error Reaction Code is set to 0x01, the following error alarm is automatically reset when the cause vanish. In standard mode of operation, the alert is not automatically reset (see the description of 1086 register).

All the above parameters can be set in any drive state.

Register 1112: Current Reduction Ratio

Allows to set the ratio (as a percentage) of the standstill current with respect to the nominal current when the current reduction function is enabled (by means of object 1083 or register 1108).

Setting values are in the range: **0** ÷ **100** (%).

Default value is 50.

The standstill current value can be calculated as follows (by using parameters in registers 1117, 1080 and 1112):

I_{SS} = [reg.1117] * [reg.1080/100] * [reg.1112/100]

Register 1113: Velocity total sample

Through this register it is possible to set a parameter regarding rotor position and velocity sensing.
In particular, allows to set the number of samples of Position Actual Value (registers 1004-1005) used to calculate the actual velocity, Velocity Actual Value (registers 1020-1021). The calculation time (in ms), is equal to the number of setting samples.

Setting values are: 1,2,4,5,8,10,20,25,40,50,100,200.

Default value is 100.

Register 1114: Reset Encoder On First Power Up

It allows to set the automatic encoder position reset function when the drive switch to current ON the first time from the $24V_{DC}$ power ON (see paragraph 2.2, transition 4: SWITCHED ON => OPERATION ENABLED) or when writing the following objects: CPR (register 1121) or Step Resolution (register 1081) or Revolution Direction (register 1092).

Setting values are:

- **"0"** = nessun reset (default)

- **"1"** = reset encoder abilitato

Register 1115: Hard Stop Disengaging Steps

It allows to set the number of steps executed in the opposite direction respect to the main movement at the end of the homing sequence in mechanical impact position search (Homing Method -1 e -2).

Setting values are in the range from 0 to 255. The default value is 64.

Register 1116: Power Up Speed Limit

By writing a value > 0, the motor state monitor function is enabled.

In particular, if the motor is running before the transition Current OFF->Current ON with a speed greater than the value set in this subindex (indicated in steps/s), the current in motor windings is limited to zero. The drive do not swich to Current ON state, but goes to the Fault.

This feature is useful to prevent potential dangerous conditions in case of vertical load axis.

The setting values are in the range 0÷32000. The default value is 0 (function disabled)

Register 1117: Motor Current Limit

Allows to view the parameters related to the motor drive that can be configured by registers 1090-1091 (Motor Code).

In particular shows the maximum current value (peak value) that drive can supply to the motor in the actual configuration (A).

Register 1118: Motor Proportional Gain

Allows to view the parameters related to the motor drive that can be configured by registers 1090-1091 (Motor Code).

In particular shows the proportional gain value of the current regulation circuit. It is expressed as a percentage ratio (%)

Register 1119: Motor Dynamic Balancing

Allows to view the parameters related to the motor drive that can be configured by registers 1090-1091 (Motor Code).

In particular shows the dynamic compensation parameter. It is expressed as a percentage fraction (%).

Register 1120: Motor Current Recycling Enable

Allows to view the parameters related to the motor drive that can be configured by registers 1090-1091 (Motor Code).

In particular shows the status of the current recirculation (enable or disable).

Register 1121: CPR

Allows to set the corresponding CPR (counts per revolution) of the motor encoder.

For RTA motors, the default value is suitable for motor series EM xxxx-04D0 or EM xxxx-04E0 and it must not be changed.

For RTA motors series xxxx-0HE0, the object value must be set to “4000” (see registers 1090-1091).

For other motor models with encoder, it would be necessary set a value different from the default one.

Verify the encoder motor features before changing the default value. In any case, it is always possible to contact RTA.

Writing this object when state machine is different from Operation Enabled or Quick Stop Active, produce the reset of the encoder position (Position Actual Value).

Writing this object when state machine is Operation Enabled or Quick Stop Active, produce the reset of the encoder position only after the following transition Current ON -> Current OFF.

Note1: the output signals of the encoder are 90 degrees out of phase each other, as a consequence, the real encoder resolution is 4 times the value indicate in CPR index.

Note2: the unit of measure for the encoder position shown in object Position Actual Value (registers 1004-1005) is "number of steps", in accordance with the step/revolution value indicated in register 1081.

I/O SETTING REGISTERS

Modbus Address Little Endian	Modbus Address Big Endian	Data type	Access Type	Function	Default Value	Minimum value	Maximum value
1008	1009	U32	RO	Digital Input_L	0	0	0xFFFF FFFF
1009	1008			Digital Input_H			
1010	1011	U32	RO	Digital Output_L	0	0	0x01F0 0001
1011	1010			Digital Output_H			
1014	1015	I32	RO	Touch Probe Neg Value_L	0	-2147483648	2147483647
1015	1014			Touch Probe Neg Value_H			
1016	1017	I32	RO	Touch Probe Pos Value_L	0	-2147483648	2147483647
1017	1016			Touch Probe Pos Value_H			
1018	1018	U16	RO	Touch Probe Status	0	0	0x0087
1066	1066	U16	RW	Touch Probe Function	0	0	37

Table 25 -I/O parameters registers

Registers 1008-1009: Digital Input

This register shall monitor the status of general-purpose input and the status of special function inputs as shown in the following table:

Bit 22…20	Bit 19	Bit 18	Bit 17	Bit 16	Bit 15…3	Bit 2	Bit 1	Bit 0
Reserved	I3	I2	I1	I0	Reserved	PX	Positive Limit	Negative Limit

Bit 31	Bit 30	Bit 29	Bit 28	Bit 27	Bit 26	Bit 25	Bit 24	Bit23
Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	STO	CL Active

Note: Available/Setting inputs are described in register 1088.

When Inputs I1 / I2 for CSD MT 94 and I0 / I1 for CSD MT S4 are set as limit switch:

1) When limit switch inputs are ON, the motor is free to move.
2) When a limit switch input is OFF, the following behaviors are possible:

- Bit 11 of Status Word goes to 1 (Internal Limit Active)
- The motor begins to stop like it has received Halt command by means of Control Word.
- After a motor stop depending on Internal Limit Active, the motor can run only in the opposite direction. Movements in previous direction are inhibited until limit switch is ON.

(*) For **CSD MT S4:**

If bit 7 of Input Config (register 1088) is set to 1, the bit 24 become equal to 1 in case of drive is in Safe Torque Off state.

Registers 1010-1011: Digital Output

This object shall monitor the status of general-purpose output and the status of special function output (O2 Brake Out) as shown in the following table:

Bit 31…21	Bit 20	Bit 19	Bit 18	Bit 17	Bit 16	Bit 15…3	Bit 0
Reserved	O4	O3	O2	O1	O0	Reserved	Brake Out

Note: Available/Setting outputs are described in register 1089 (Output Config).

Registers 1014-1015: Touch Probe Negative Value

In this couple of registers, the negative edge sample position of Touch Probe trigger signal can be read. The Touch Probe function can be enabled by register 1066.

Registers 1016-1017: Touch Probe Positive Value

In this couple of registers, the positive edge sample position of Touch Probe trigger signal can be read. The Touch Probe function can be enabled by register 1066.

Register 1018: Touch Probe Status

This register show the state of function Touch Probe, in particular:

- Bit 0 indicates Touch Probe Function is active.
- Bit 1 indicates that a position has been sampled on positive edge of sampling signal.
- Bit 2 indicates that a position has been sampled on negative edge of sampling signal.
- Bit 6 indicates the set sampling operation mode: 0=Touch Probe input; 1=index pulse.
- Bit 7 indicates current logic state of sampling signal.

Register 1066: Touch Probe Function

This register allows to activate and configure the Touch Probe function, in particular:

Bit 0 enables Touch Probe Function. Disable and enable Touch Probe Function to reset stored position.

Bit 2 enables position sampling on encoder index

Bit 4 enables position sampling on positive edge of the signal on:

- I3 input, when Bit2 = 0

- encoder index pulse, when Bit2 = 1

Bit 5 enables position sampling on negative edge of the signal on:

- I3 input, when Bit2 = 0

- encoder index pulse, when Bit2 = 1

Note1: The sampling of the position can be affected by a maximum delay of 300us, compared to the switching of the TOUCH PROBE INPUT.

Note2: The sampling of the Touch Probe Function cannot be enabled simultaneously on positive and negative edge trigger. The desired sampling edge (positive or negative) must be chosen when function is enabled.

HOMING REGISTERS

Modbus Address Little Endian	Modbus Address Big Endian	Data type	Access Type	Function	Default Value	Minimum value	Maximum value
1050	1050	U16	RW	Homing Method	0	0	37
1052	1053	U32	RW	Homing Speed Search for Switch_L	16 001	16 001	400 000
1053	1052			Homing Speed Search for Switch _H			
1054	1055	U32	RW	Homing Speed Search for Zero _L	0	0	16 000
1055	1054			Homing Speed Search for Zero _H			
1056	1057	U32	RW	Homing Acceleration_L	2 000	2 000	10 000 000
1057	1056			Homing Acceleration_H			
1058	1059	I32	RW	Homing Offset_L	0	-2147483648	2147483647
1059	1058			Homing Offset_H			

Table 26 -Homing Registers

Register 1050: Homing Method

The register allows to set the desired homing mode.

Available homing modes are:

- **3** homing on home switch (OFF->ON transition) and index pulse, negative direction
- **4** homing on home switch (OFF->ON transition) and index pulse, positive direction
- **5** homing on home switch (ON->OFF transition) and index pulse, positive direction
- **6** homing on home switch (ON->OFF transition) and index pulse, negative direction
- **19** homing on home switch (OFF->ON transition), negative direction
- **20** homing on home switch (OFF->ON transition), positive direction
- **21** homing on home switch (ON->OFF transition), positive direction
- **22** homing on home switch (ON->OFF transition), negative direction
- **35** homing on current position
- **37** homing on current position

Note: If motor has no encoder, homing mode 3, 4, 5 and 6 must not be used.

Registers 1052 - 1053: Homing Speed During Search for Switch

In these registers, the homing speed during search for switch (high speed) can be set.

The measure unit (Hz) corresponds to step/s.

Note: for the execution of a correct homing procedure, the Homing Speed and Homing parameters must be chosen in such a way that, during the deceleration ramp after reaching the

proximity, the motor exceeds the position range of the sensor. Therefore, the setting values for this object must be greater than 75 RPM (16001 step/s with resolution factor of 12800 step/rev)

Registers 1054 - 1055: Homing Speed During Search for Zero

In these registers, the speed during zero final approach in homing procedure can be set.

The measure unit (Hz) corresponds to step/s.

Note: for the execution of a correct homing procedure, it is recommended speed setting < 75 rpm

Registers 1056 - 1057: Homing Acceleration

These registers allow to set the value of acceleration/deceleration to reach the maximum speed during homing procedure.

Hz / sec corresponds to number of step/s^2.

The minimum setting value is equal to 2000 step/s^2.

Registers 1058 - 1059: Homing Offset

In this memory area, it is possible to set a value (number of steps) corresponding to the offset between the proximity sensor and the desired home position.

13. SAFE TORQUE OFF FUNCTION

Safety function (Safe Torque Off, STO) is available only for model CSD MT S4.

INTRODUCTION

This chapter is the **"SIL/PL Safety Manual"** of the device to which this manual refers.

This manual contains information for the use of the device in circuits related to functional safety.

This manual must be carefully read and fully understood before the installation of the equipment.

A copy of this manual shall be retained and used in conjunction with the equipment for the lifetime of the equipment.

The relevant documents, including data sheets, installation, operation and maintenance instructions, the EU/EC declaration of conformity and all the applicable certificates/reports shall be used together with this document.

These documents are always available from RTA srl.

Only properly trained and qualified operators shall be involved in the assembly, commissioning, operation, maintenance and disassembly of any device that may be included in the functional safety circuit.

The solution of installation defects is allowed by acting on the external characteristics of the equipment; if the attempt fails, the devices must be taken out of service and measures must be taken to protect against accidental use.

Defective devices must be delivered to the manufacturer and can only be repaired by the manufacturer.

The deactivation or bypass of the safety functions that affect the safety functions can cause damage to things, environment or people for whom RTA srl will not be held responsible.

Failure to apply the advice provided in this manual that affect the safety functions may cause damage to things, the environment or people for whom RTA srl will not be held responsible.

INTENDED USE

The equipment shall only be used for the applications described in the instructions and environmental conditions specified in this manual and only in combination with approved external devices.

The device referred to in this manual is a stepper motor drive with step/dir controls powered at the rated voltage of 48 V_{DC} with 24 V_{DC} STO digital inputs.

The Safe Torque Off (STO) function reduces the risk of damage and safeguards operator safety.

The device has shutdown functions associated with external TRIP commands.

According to EN61800-5-2 paragraph 4.2.3.2 the safety function is defined as: "STO - torque cannot be transmitted to the motor in case any of the two digital inputs indicated as -*STO digital inputs*- is LOW (less than 3.0V in an operating range of 24V)".

The STO function interrupts the control signals of the final power drivers inside the drive. The two signals STO1 and STO2 act respectively and independently on the control signals of the upper and lower drivers (hardware protection) with the effect of motor current inhibition. Thanks to the particular architecture of these inputs, any failure of one channel does not affect the operation of the other channel and the inhibition of the passage of current in the motor phases.

During a detectable hazardous error or during a safe error condition the motor output is de-energized (fail-safe).

In case of power failure the motor output is de-energized (fail-safe).

Unless otherwise provided, all components of the chain involved in the integrated safety system shall be fail-safe.

The single module that includes an CSD MT is suitable for use in safety-related control circuits with systematic "SC3" capacity and integrity level **up to "SIL3"** depending on the arrangement of STO inputs.

The single module that includes an CSD MT is suitable for use in safety-related control circuits of "category 4" and integrity level **up to "PL e**" depending on the arrangement of STO inputs.

DIRECTIVES AND STANDARDS

The devices are developed, manufactured and tested according to the relevant safety standards and applicable Directives:

STANDARDS:

- "Low Voltage Directive": EN 61800-5-1:2007+A11:2021 - Variable speed electric drives Safety requirements. Electric, thermal and energy.
- "Machinery Directive": EN 61800-5-2:2017 - Variable speed electric drive systems Functional safety requirements.
- "Electromagnetic compatibility directive": EN 61800-3:2018 - Variable speed electric drives - Part 3: EMC requirements and specific test methods.
- "Machinery Directive": EN ISO 13849-1: 2015 - Safety of machinery - Parts of safety-related control systems - Part 1: General principles for design.
- "Machinery Directive": EN ISO 13849-2: 2012 - Safety of machinery - Parts of safety-related control systems - Part 2: Validation.
- "Machinery Directive": EN 62061:2005/A2:2015 Safety of machinery - Functional safety of electrical, electronic and programmable electronic control systems related to safety.
- Functional safety IEC 61508 part 1,2,4,5,6,7 edition 2010: Standard for the functional safety of programmable electrical/electronic/electronic systems related to safety (product manufacturer).

DIRECTIVES:

Low voltage Directive	2014/35/EU
Electro Magnetic Compatibility	2014/30/EU
Machinery Directive	2006/42/EC
ROHS	2011/65/UE

DESIGN: SYSTEM CONSTRAINTS AND DETERMINATION OF SIL AND PL VALUES

The use of both the STO1 and STO2 channels and the Error Detection Monitor output is mandatory to reach the SIL3, PL e.

Demand Mode

It is assumed that the demand rate for the safety circuit that includes the Safe Torque Off Drive to put the EUC (stepper motor) into a specified safety state is rare, with a frequency not exceeding one intervention per year, (LOW DEMAND MODE) or with a frequency higher than one intervention per year (HIGH DEMAND MODE).

Safety parameters and the probability of failure will not change in low-demand mode or high-demand mode.

Calculation of SIL value (according to: EN62061, EN61508-1,2,6)

The main safety parameters to be verified are:

- **PFDavg** (Low demand Mode – Average probability of failure) o **PFH** (High demand Mode – failure rate per hour)
- **Tproof** (test interval that has a direct effect on PFDavg - Low Demand Mode)
- **SFF** (value of Safe Failure Fraction)
- **HFT** (Hardware Fault Tolerance of architecture considered)

Calculation of the value of PL (ACCORDING TO: EN13849-1)

The main safety parameters to be verified are:

- **PL** (Device Performance Level)
- Category of the Equipment

Special consideration about Safe Failure Fraction (according to: EN62061, EN61508-1,2,6)

The safe failure fraction is the measurement of total safe failures relative to the total amount of failure rate.

SFF = (λs +λdd) / λtot = 1 - λdu / λtot

The safety failure fraction is only relevant if determined for elements or (under)systems in a complete safety circuit.

The device under consideration is intended to be a part of the safety circuit and, depending on the safety chain chosen, may be a complete element or a subsystem, depending on the (sub)system in which it is included.

Please contact RTA in case of doubts about the calculation constraints of SFF.

SIL1 / PL c CONFIGURATION, 1001 ARCHITECTURE, WITHOUT MONITOR

The following assumptions were considered during the FMEDA analysis:

- The input is generated by one single channel (STO1 input connected to safety PLC digital output, STO2 input connected to 24V).

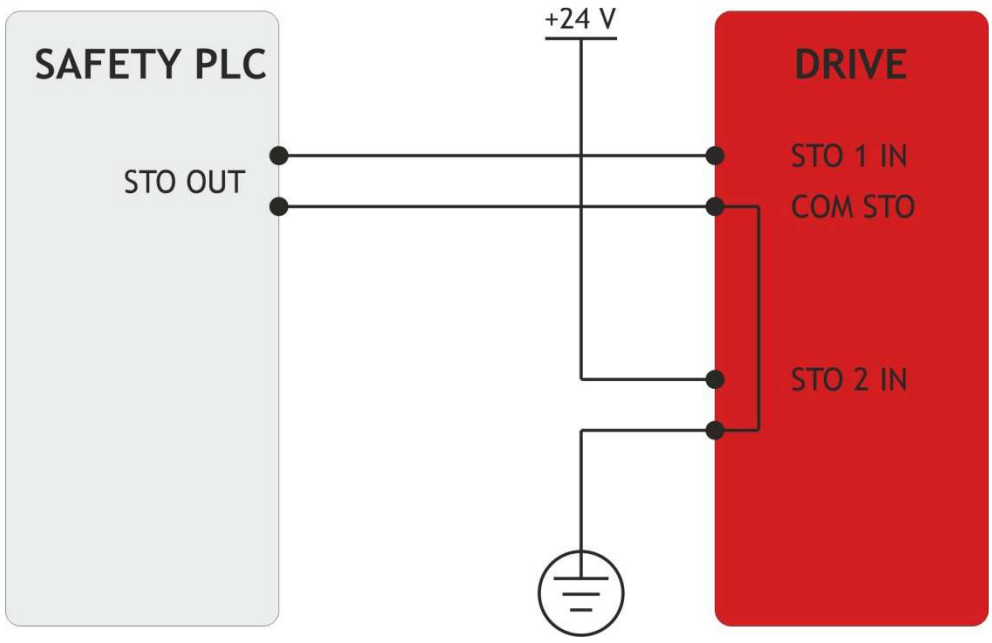


Figure 33 – connection diagram SIL1/PLc, 1001 architecture, without monitor

- The output safety function includes the safe activation of the internal bridge.
- The safe state of the EUC is chosen considering the safe state for the STO drive "non-excited motor outputs".
- The device requires less than 50% of the total failure budget for a SIL1/plc safety loop.
- The component failure rate is based on the Siemens SN29500 database.
- Failure rates are considered constant, wear out mechanisms are not included.
- The failure rates of the external power supply are not included; however, the STO drive is a "fail safe" device leading to a safe state of the motor outputs (de-energized) when a loss of power is handled.

- The safety-related device couple is considered to be of type A components with a Hardware Fault Tolerance of 0.
- It is assumed that the appearance of an error (output in safe state) would be repaired within 4 hours (e. g. swap entire equipment with a ready available and equivalent spare part).
- It is assumed that the indication of an error (output in safe state) would be detected in a negligible time (when compared with the process conditions) by the logic solver.
- Stress levels are average for an industrial environment and can be compared with the Ground Fixed classification of MIL-HNBK-217F.
- The expected installation environment must be comparable to IEC 60654-1 Class C (sheltered location) with temperature limits within the manufacturer's rating and an average temperature over a long period of time of 60 °C. Please contact RTA in case of use in heavy environment.
- During removal of the device for maintenance or repairing, the safety function is assumed to be guaranteed by the substitution with an identical device.

SIL1 / PL c CONFIGURATION, 1002 ARCHITECTURE, WITHOUT MONITOR

The following assumptions were considered during the FMEDA analysis:

- The input is generated by one single channel (STO1 and STO2 inputs are parallel connected and controlled by the series of two independent digital outputs of the safety PLC FAIL TO OPEN / NORMALLY OPEN contacts).

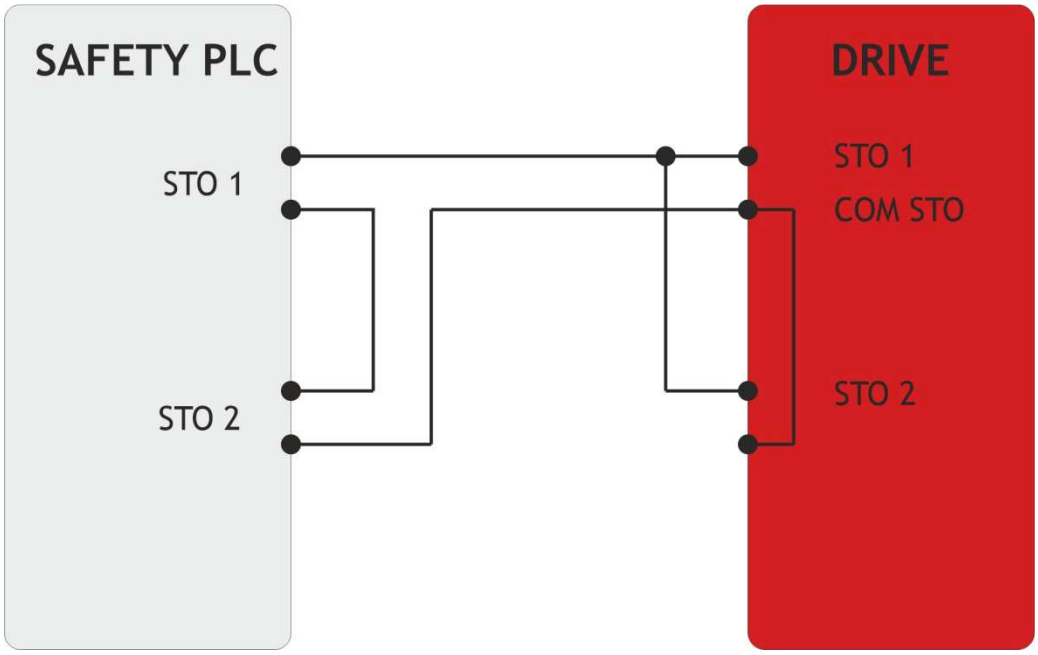


Figure 34 - SIL1 / PL c configuration, 1002 architecture, without monitor

- The output safety function includes the safe activation of the internal bridge.
- The safe state of the EUC is chosen considering the safe state for the STO drive "de-energized motor outputs".
- The device requires less than 50% of the total failure budget for a SIL1/PL c safety loop.
- The component failure rate is based on the Siemens SN29500 database.
- Failure rates are constant, wear out mechanisms are not included.
- The failure rates of the external power supply are not included; the STO drive is nevertheless a "fail safe" device leading to a safe state of the motor outputs (de-energized) when a power loss is handled.

- The safety-related device couple is considered to be of type A components with a Hardware Fault Tolerance of 0.
- It is assumed that the appearance of an error (output in safe state) would be repaired within 4 hours (e.g. swap entire equipment with a ready available and equivalent spare).
- It is assumed that the indication of an error (output in safe state) would be detected in a negligible time (when compared with the process conditions) by the logic solver.
- The stress levels are average for an industrial environment and can be compared with the Ground Fixed classification of MIL-HNBK-217F.
- The expected installation environment must be comparable to IEC 60654-1 Class C (sheltered location) with temperature limits within the manufacturer's rating and an average temperature over a long period of time of 60 °C. Contact RTA in case of installation in heavy environments.
- During removal of the device for maintenance or repairing, the safety function is assumed to be guaranteed by the substitution with an identical device.

SIL2 / PL d CONFIGURATION, 1002 ARCHITECTURE, WITH MONITOR

The following assumptions were considered during the FMEDA analysis:

- The input is generated by on single channel (STO1 and STO2 inputs parallel connected and controlled by the series of two independent digital outputs of the safety PLC, FAIL TO OPEN / NORMALLY OPEN contacts).

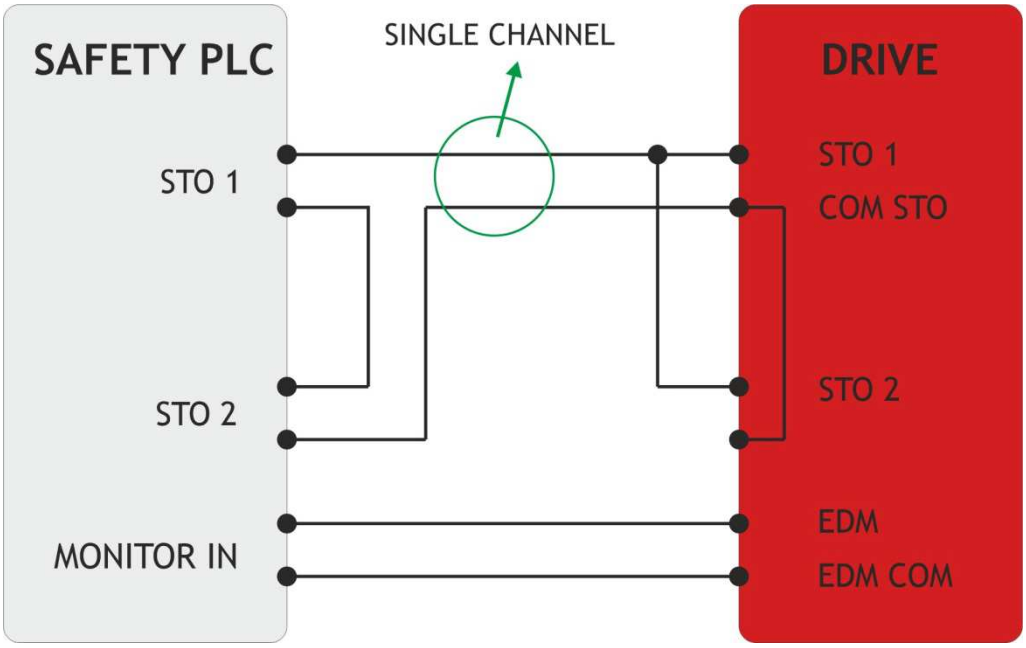


Figure 35 - SIL2/PLd connection scheme, 1002 architecture, with monitor

- The EDM (Error Detection Monitor) output is assumed to be connected and to managed by the user logic solver (safety PLC). The monitor is an open/closed passive output (working range: 5 ÷ 45V) based on photomos and operating according to the following truth table:

Input STO1	Input STO2	Monitor Output EDM	Drive Status
OFF (low/absent voltage)	**OFF** (low/absent voltage)	**ON** (closed-circuit)	**Current OFF** (inhibited current)
OFF (low/absent voltage)	**ON** (high voltage)	**OFF** (opened-circuit)	**Current OFF** (inhibited current)
ON (high voltage)	**OFF** (low/absent voltage)	**OFF** (opened-circuit)	**Current OFF** (inhibited current)
ON (high voltage)	**ON** (high voltage)	**OFF** (opened-circuit)	**READY** (allowable current)

Table 27 - Logic Matching STO Inputs/EDM State/Drive State

The monitor output alerts the user's logical solver (safety PLC) on incoherent status of the drive when compared to the expected status of the STO1 and STO2 inputs. The user shall manage the monitor through the logic solver in order to activate alternative safety functions or alarms in case of incorrect status reported by the monitor.

Once the voltage range of the passive diagnostic line has been chosen, the digital levels "Low" (OFF) and "High" (ON), depending on the configuration of the Logic Solver, must be based on the following considerations:

- The logic state "High" is equal to the maximum voltage of the working voltage range.
- The logic state "Low" is based on the ratio between the maximum output current (depending on the pull-up resistance installed in the logical digital input) and the maximum sink capacity of the digital output of the photomos:

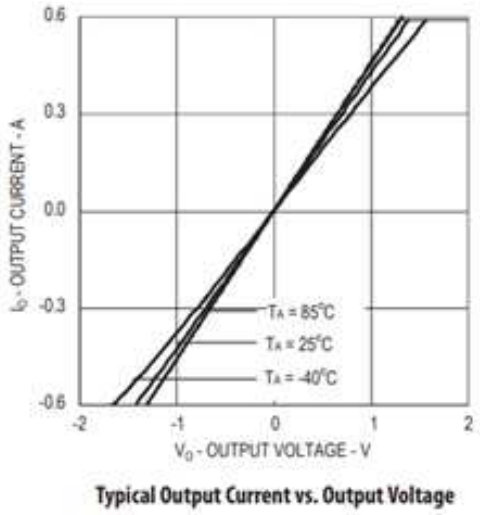


Figure 36 **- voltage/current characteristic of the digital output photoMOS**

- The output safety function includes the safe activation of the internal bridge.
- The safe state of the EUC is chosen considering the safe state for the STO drive "de-energized motor outputs".
- The device requires less than 50% of the total failure budget for a SIL2 / PL d safety loop.
- The component failure rate is based on the Siemens SN29500 database.
- Failure rates are constant, wear out mechanisms are not included.
- The failure rates of the external power supply are not included; the STO drive is nevertheless a "fail safe" device that leads to a safe state of the motor outputs (de-energized) when a loss of power is handled.

- The safety function input pair is considered with Type A components and with a hardware fault tolerance of 0.
- It is assumed that a fault (output in safe state) would be repaired within 4 hours (e.g. replace the entire equipment with a ready available and equivalent spare part).
- It is assumed that the indication of a fault (output in safe state) would be detected in a negligible time (when compared with process conditions) by the logic solver.
- The stress levels are average for an industrial environment and can be compared to the Ground Fixed classification of MIL-HNBK-217F.
- The required installation environment is assumed to be comparable to IEC 60654-1 Class C (sheltered location) with temperature limits within the manufacturer's rating and a maximum average temperature value over a long period of time of 60 °C. Contact RTA in case of installation in heavy environments.
- During removal of the device for maintenance or repairing, the safety function is assumed to be guaranteed by the substitution with an identical device.

SIL3 / PL e CONFIGURATION, 1002 ARCHITECTURE, WITH MONITOR

The following assumptions were considered during the FMEDA analysis:

- The input is generated by two isolated and independent channels (STO1 input connected to a safety PLC output and STO2 input connected to a second safety PLC output).

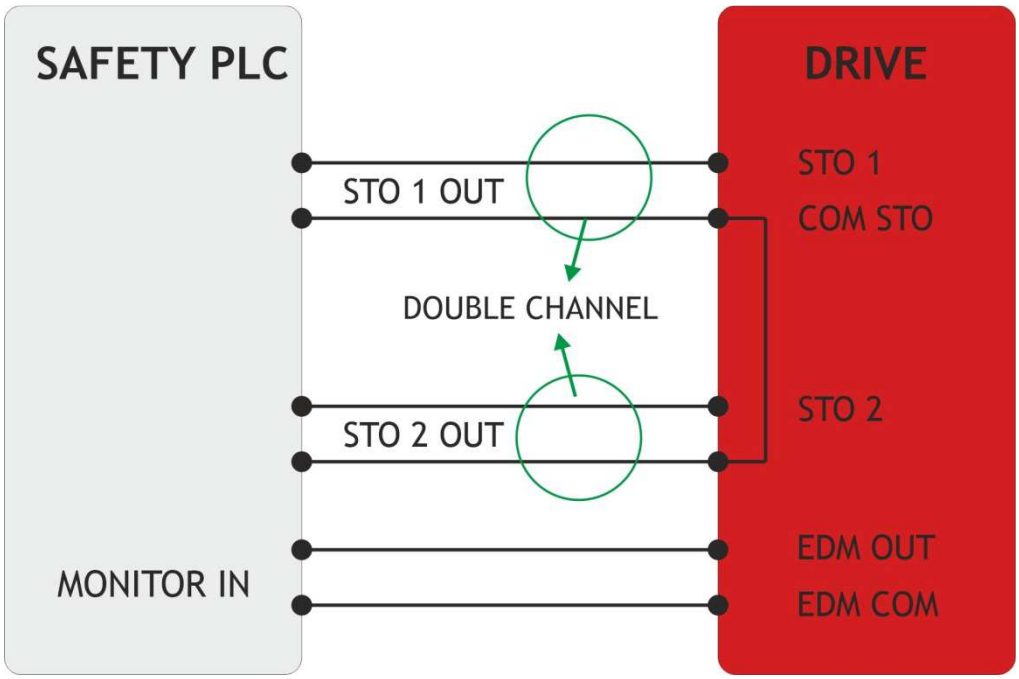


Figure 37 - SIL3/PLe connection diagram, 1002 architecture, with monitor

- The EDM (Error Detection Monitor) output is assumed to be connected and managed by the user logic solver (safety PLC). The monitor is an open/closed passive output (working range: 5÷45V) based on photomos and operating according to the following logic truth table:

Input STO1	Input STO2	Monitor Output EDM	Drive Status
OFF (low/absent voltage)	**OFF** (low/absent voltage)	**ON** (closed-circuit)	**Current OFF** (inhibited current)
OFF (low/absent voltage)	**ON** (high voltage)	**OFF** (opened-circuit)	**Current OFF** (inhibited current)
ON (high voltage)	**OFF** (low/absent voltage)	**OFF** (opened-circuit)	**Current OFF** (inhibited current)
ON (high voltage)	**ON** (high voltage)	**OFF** (opened-circuit)	**READY** (allowable current)

Table 28 - Truth table STO Inputs/EDM State/Drive State

The monitor output alerts the user's logic solver on incoherent status of the drive when compared to the expected status of the STO1 and STO2 inputs. The user shall manage the monitor through the logic solver in order to activate alternative safety functions or alarms in case of an incorrect status reported by the monitor.

- The output safety function includes the safe activation of the internal bridge.
- The safe state of the EUC is chosen considering the safe state for the STO drive "de-energized motor outputs".
- The device requires less than 50% of the total failure budget for a SIL3/PLe safety loop.
- The component failure rate is based on the Siemens SN29500 database.
- Failure rates are constant, wear out mechanisms are not included.
- The failure rates of the external power supply are not included; the STO drive is nevertheless a "fail safe" device that leads to a safe state of the motor outputs (de-energized) when a power loss is handled.
- The safety function input pair is considered to be of Type A components with a Hardware Fault Tolerance of 1.
- It is assumed that a fault (output in safe state) would be repaired within 4 hours (e.g. replace the entire equipment with a readily available and equivalent spare part).
- It is assumed that the indication of a fault (safe state output) is detected in a negligible time (when compared with process conditions) by the logic solver.
- The stress levels are average for an industrial environment and can be compared with the Ground Fixed classification of MIL-HNBK-217F.
- The required installation environment shall be comparable to IEC 60654-1 Class C (fixed position) with temperature limits within the manufacturer's nominal values and a maximum average temperature value over a long period of time of 60 °C. Contact RTA in case of installation in heavy environments.
- During removal of the device for maintenance or repairing, the safety function is assumed to be guaranteed by the substitution with an identical device.

STO TIMING

The correct and stable enabling of STO function is effective after a maximum time of 20 ms after STO1 and STO2 switching off.

Monitor Output indicates that STO function is active with a maximum delay of 20 ms from STO1 and STO2 input signals switch off (see Figure 38).

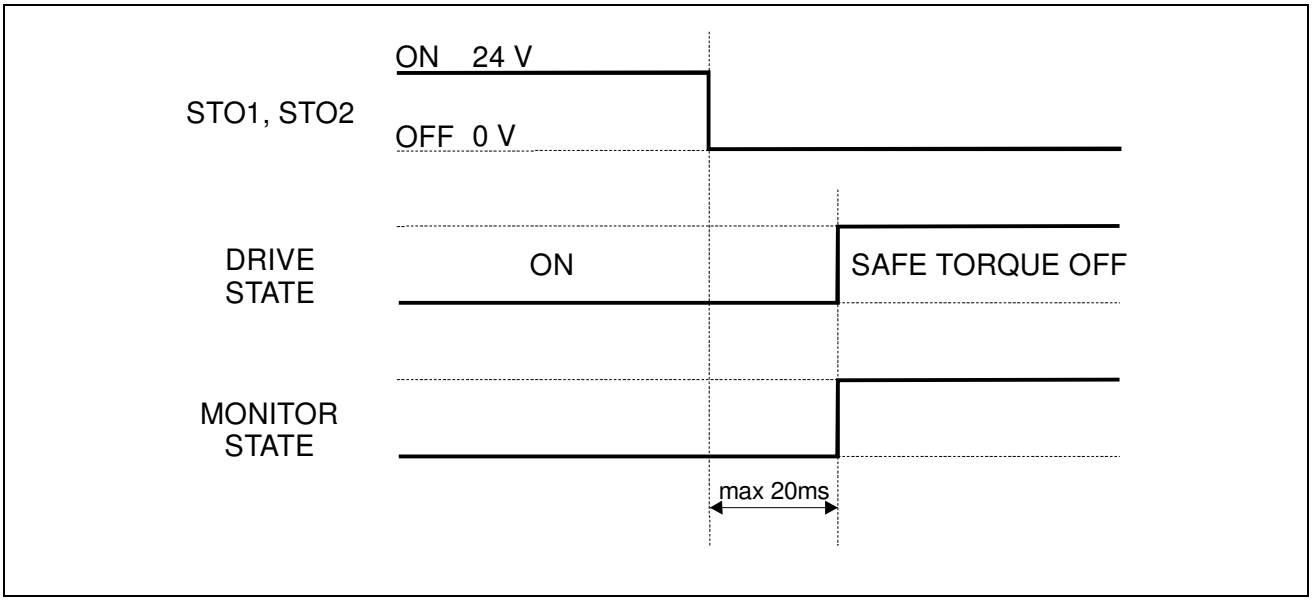


Figure 38 - STO function timing diagram.

The following should also be taken into consideration:

- In addition to the above delay time, an additional time interval to complete the stop of the motor shaft, which is affected by the specific mechanical load applied to the shaft, shall be added. When the safety function is activated while the motor is in motion, the current in the motor is switched to zero and the motor is free to move by inertia. It is necessary to design the safety system in such a way to ensure no risk until the motor shaft is completely stop.

- When the motor is used to handle vertical loads, the motor can move by gravity. External tool (e.g. brakes) must be provided to ensure that the motor stops within the desired limits.

- There is always the possibility, as part of the residual risk, that, in case of malfunction of the final stage of the drive, the motor can make an uncontrolled movement up to 180 electric degrees (corresponding to 1/50 revolution of the motor, or 256 steps at a resolution of 12800 step/rev) to reach a steady state. It is necessary to verify that a movement of this magnitude does not produce a risk condition.

INDICAZIONI SU DURATA IMPULSI DI AUTODIAGNOSTICA SU INGRESSI STO

If a safety PLC, which generates self-diagnostic impulses (i.e. voltage drop on STO1 and STO2 signals) is used, these must have a maximum duration of 1 ms (see Figure 39).

The STO function is not activated when the duration of the negative pulses on the STO1 and STO2 inputs last less than 1ms.

To ensure the correct activation of the STO function, the STO1 and STO2 signals must be switched off for at least 20 ms (see Figure 39).

INFORMATION

The STO1 and STO2 signals with time-delay between two following transitions between approximately 1 ms and 20 ms may result in loss of motor position and/or incorrect signalling.

The maximum allowed frequency for diagnostic pulses is 25 Hz.

In the case of negative pulses less than 1 ms, the maximum possible frequency increases - in any case, it is the exclusive care of the user to verify the correct operation outside the indicated range.

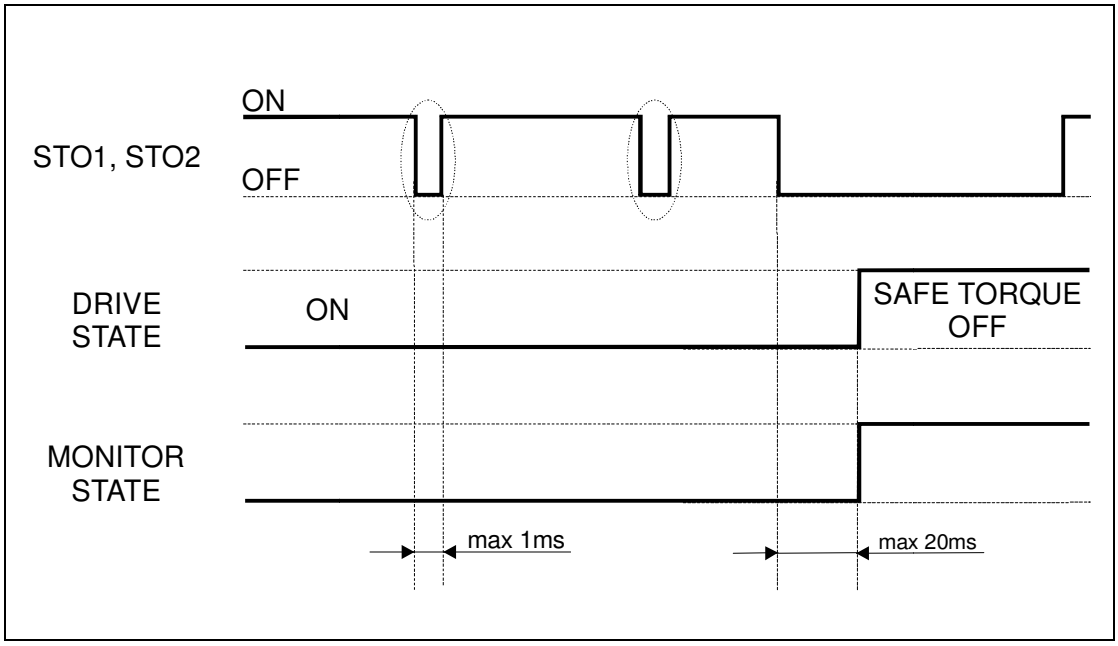


Figure 39 – STO Self-diagnosis.

PARAMETERS RELATING TO THE INTEGRITY OF THE SAFETY FUNCTION

SIL1/PLc Configuretion, 1oo1 Architecture, without monitor

Safety Integrity Related parameter	Value / Description
Assessment type (EN62061, EN61508-2)	FMEDA Assessment / Route 1H
Device type (EN62061, EN61508-2)	Simplex, A
Operation mode (EN62061, EN61508-1)	Low Demand Mode / High Demand Mode
Hardware fault Tolerance (HFT) (EN62061, EN61508-2)	0
Architecture	1oo1
Systematic Capability (EN61508-3)	3
SIL eligibility (EN62061, EN61508-1,2,6)	SIL 1 (up to 5 Years Proof Test in case of Low Demand Mode) SIL 1 in High Demand Mode
PL eligibility (EN13849-1)	PL c
PFD Budget	Up to 50% of the SIS budget
Safety function	STO according to EN61800-5-2 clause 4.2.3.2 – torque is prevented to be driven to the motor in case any of the two digital inputs indicated as -STO digital inputs- is LOW (below 3.0V maximum in a range of 24V)
MTTR (EN62061, EN61508-6)	4 Hours (including alarm detection and restoration)
PFHd = (EN62061, EN61508-1)	3,98 x 10^{-8} [1/h] (SIL1)
PFDavg, Tproof = 5 Year (43800 Hours) (EN62061, EN61508-1)	8,72 x 10^{-4} (SIL1)
SFF (EN62061, EN61508-2)	67,4%
Category (EN13849-1)	1 
Response Time	< 20 x 10^{-3} Sec
Lifetime	20 Years

Table 29

Note:
Wear and tear failures are not counted in the FMEDA and therefore do not contribute to the determination of safety integrity according to IEC61508:2010. Such failures shall not affect the reliability or safety of the system and shall not be included in the calculation of the failure rate.
The failure rates listed in this report do not include failures due to wear of any component.
The safe failure rate shall be calculated at the (sub)system level.
FIT = time failure -> FIT x (1x10-9) = Number of failures per hour

SIL1/PLc configuration, 1002 Architecture, without monitor

Safety Integrity Related parameter	Value / Description
Assessment type (EN62061, EN61508-2)	FMEDA Assessment / Route 1H
Device type (EN62061, EN61508-2)	Simplex, A
Operation mode (EN62061, EN61508-1)	Low Demand Mode / High Demand Mode
Hardware fault Tolerance (HFT) (EN62061, EN61508-2)	0
Architecture	1oo1
Systematic Capability (EN61508-3)	3
SIL eligibility (EN62061, EN61508-1,2,6)	SIL 1 (up to 5 Years Proof Test in case of Low Demand Mode) SIL 1 in High Demand Mode
PL eligibility (EN13849-1)	PL c
PFD Budget	Up to 50% of the SIS budget
Safety function	STO according to EN61800-5-2 clause 4.2.3.2 – torque is prevented to be driven to the motor in case any of the two digital inputs indicated as -STO digital inputs- is LOW (below 3.0V maximum in a range of 24V)
MTTR (EN62061, EN61508-6)	4 Hours (including alarm detection and restoration)
PFHd = (EN62061, EN61508-1)	3,98 x 10^{-8} [1/h] (SIL1)
PFDavg, Tproof = 5 Year (43800 Hours) (EN62061, EN61508-1)	8,72 x 10^{-4} (SIL1)
SFF (EN62061, EN61508-2)	67,4%
Category (EN13849-1)	1 
Response Time	< 20 x 10^{-3} Sec
Lifetime	20 Years

Table 30

Note:
Wear and tear failures are not counted in the FMEDA and therefore do not contribute to the determination of safety integrity according to IEC61508:2010. Such failures shall not affect the reliability or safety of the system and shall not be included in the calculation of the failure rate.
The failure rates listed in this report do not include failures due to wear of any component.
The safe failure rate shall be calculated at the (sub)system level.
FIT = time failure -> FIT x (1x10-9) = Number of failures per hour

SIL2/PLd Configuretion, 1002 Architecture, with monitor

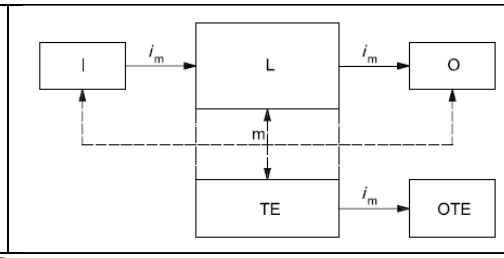
Safety Integrity Related parameter	Value / Description
Assessment type (EN62061, EN61508-2)	FMEDA Assessment / Route 1H
Device type (EN62061, EN61508-2)	Simplex, A
Operation mode (EN62061, EN61508-1)	Low Demand Mode / High Demand Mode
Hardware fault Tolerance (HFT) (EN62061, EN61508-2)	0
Architecture	1oo2 internal
Systematic Capability (EN61508-3)	3
SIL eligibility (EN62061, EN61508-1,2,6)	SIL 2 (up to 5 Years Proof Test in case of Low Demand Mode) SIL 2 in High Demand Mode
PL eligibility (EN13849-1)	PL d
PFD Budget	Up to 50% of the SIS budget
Safety function	STO according to EN61800-5-2 clause 4.2.3.2 – torque is prevented to be driven to the motor in case any of the two digital inputs indicated as -STO digital inputs- is LOW (below 3.0V maximum in a range of 24V)
MTTR (EN62061, EN61508-6)	4 Hours (including alarm detection and restoration)
PFHd = (EN62061, EN61508-1)	2,95 x 10^{-9} [1/h] (SIL2)
PFDavg, Tproof = 5 Year (43800 Hours) (EN62061, EN61508-1)	6,47 x 10^{-5} (SIL2)
SFF (EN62061, EN61508-2)	77,0%
Category (EN13849-1)	2 
Response Time	< 20 x 10^{-3} Sec
Lifetime	20 Years

Table 31

Note:
Wear and tear failures are not counted in the FMEDA and therefore do not contribute to the determination of safety integrity according to IEC61508:2010. Such failures shall not affect the reliability or safety of the system and shall not be included in the calculation of the failure rate.
The failure rates listed in this report do not include failures due to wear of any component.
The safe failure rate shall be calculated at the (sub)system level.
FIT = time failure -> FIT x (1x10-9) = Number of failures per hour

SIL3/PLe configuration, 1002 Architecture, with monitor

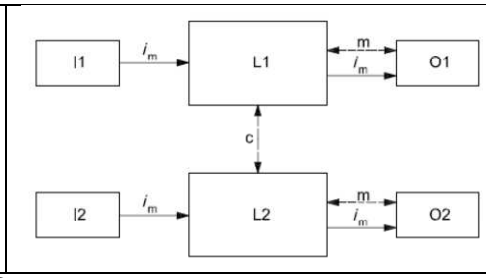
Safety Integrity Related parameter	Value / Description
Assessment type (EN62061, EN61508-2)	FMEDA Assessment / Route 1H
Device type (EN62061, EN61508-2)	Simplex, A
Operation mode (EN62061, EN61508-1)	Low Demand Mode / High Demand Mode
Hardware fault Tolerance (HFT) (EN62061, EN61508-2)	1
Architecture	1oo2 full (internal/external)
Systematic Capability (EN61508-3)	3
SIL eligibility (EN62061, EN61508-1,2,6)	SIL 3 (up to 5 Years Proof Test in case of Low Demand Mode) SIL 3 in High Demand Mode
PL eligibility (EN13849-1)	PL e
PFD Budget	Up to 50% of the SIS budget
Safety function	STO according to EN61800-5-2 clause 4.2.3.2 – torque is prevented to be driven to the motor in case any of the two digital inputs indicated as -STO digital inputs- is LOW (below 3.0V maximum in a range of 24V)
MTTR (EN62061, EN61508-6)	4 Hours (including alarm detection and restoration)
PFHd = (EN62061, EN61508-1)	2,95 x 10^{-9} [1/h] (SIL3)
PFDavg, Tproof = 5 Year (43800 Hours) (EN62061, EN61508-1)	6,47 x 10^{-5} (SIL3)
SFF (EN62061, EN61508-2)	77,0%
Category (EN13849-1)	4 
Response Time	< 20 x 10^{-3} Sec
Lifetime	20 Years

Table 32

Note:
Wear and tear failures are not counted in the FMEDA and therefore do not contribute to the determination of safety integrity according to IEC61508:2010. Such failures shall not affect the reliability or safety of the system and shall not be included in the calculation of the failure rate.
The failure rates listed in this report do not include failures due to wear of any component.
The safe failure rate shall be calculated at the (sub)system level.
FIT = time failure -> FIT x (1x10-9) = Number of failures per hour

ABBREVIATION

β	Beta common cause fraction
βd	Beta common cause fraction of the part of the system covered by the diagnostic
λ_{NE}	Failure rate of no effect failures
λ_{D}	Failure rate of dangerous failures
λ_{DU}	Failure rate of undetected dangerous failures
λ_{DD}	Failure rate of detected dangerous failures
λ_{S}	Failure rate of safe failures
λ_{SU}	Failure rate of undetected safe failures
λ_{SD}	Failure rate of detected safe failures
CL	Confidence Level
DC	Diagnostic Coverage factor
FSMS	Functional Safety Management System
FMEDA	Failure Mode Effect and Diagnostic Analysis
FIT	Failure In Time ($1x10^{-9}$ failures per hour)
HFT	Hardware Fault Tolerance
High demand mode	Mode, where the frequency of demands for operation made on a safety-related system is greater than one per year

Table 33

LIFE TIME

Probabilistic estimation assumes a constant failure rate, provided that the life time of the components is not exceeded.

The assumption of a constant failure rate is based on the bathtub curve, which shows the typical behavior of electronic components.

Early failures are cleaned up by the burn-in procedure implemented by RTA for each produced part and therefore the assumption of a constant failure rate during the life-time is valid if the predefined life-time is not exceeded.

Experience has shown that the life-time often falls within a period of about 20 years with a proper maintenance program.

The STO1 and STO2 inputs and the EDM output are opto-isolated from each other and from the internal power circuits.

To switch the motor to current on state, it is mandatory to provide a rated voltage of +24 V to the STO1 input and a rated voltage of +24 V to the STO2 input, otherwise the current flowing in the motor phases is not allowed.

The status of STO signals can be seen by the EDM (Error Detection Monitor) output: the output is active (closed contact between EDM± and EDM∓) when the drive read low voltage level on both the STO1 and STO2 inputs. The EDM output is bidirectional.

The STO1 and STO2 inputs are mono-directional, OFF in the range [0 V, +3 V] and ON in the range [+18 V, +27 V].

In typical conditions, by pressing the emergency button, both STO1 and STO2 signals go OFF and the EDM output, as a result, goes to ON state (closed). Once the emergency button is released, if the feedback circuit of the Safety Unit resets and the two safety inputs switch to ON, the EDM output opens, goes OFF. This allows the machine to go to normal operation.

Figure 40 shows an example of a connection diagram for activate the safety function Safe Torque Off by means of a Safety Unit with emergency button.

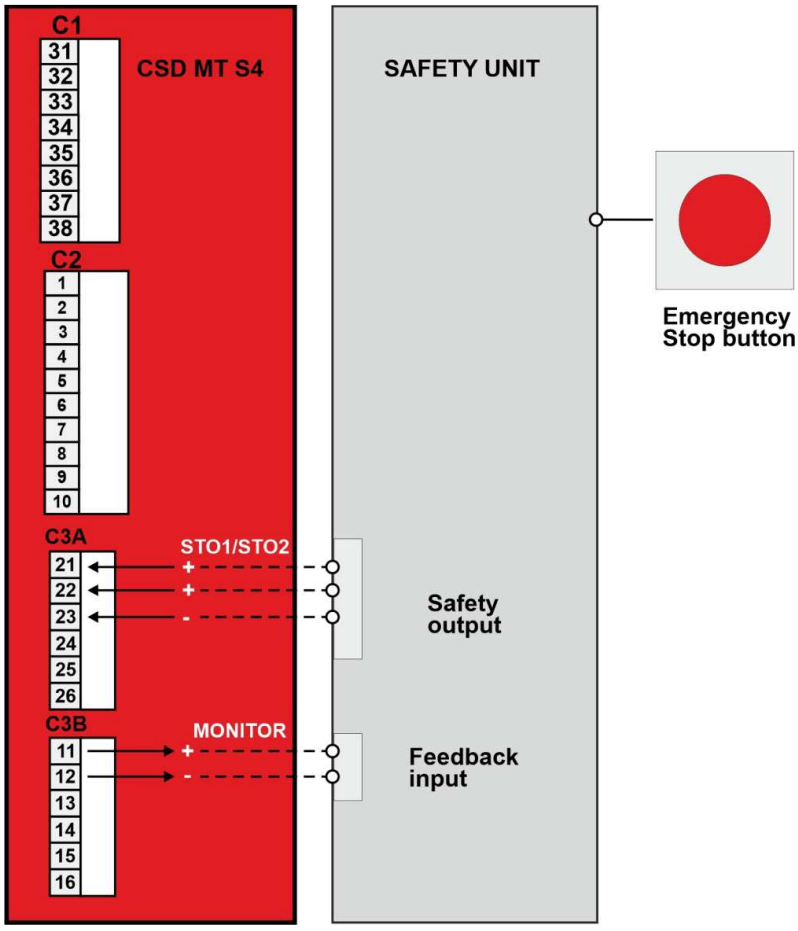


Figure 40 - Connection diagram to a Safety Unit

STO INPUTS (connector C3a)

The available terminals for STO function and the corresponding numbers on the connector C3a are listed below:

PIN Numbers	Function	Note
21	**STO1+** Positive Input STO1	
22	**STO2+** Positive Input STO2	
23	**STO_COM** STO common terminal	
24		
25		
26		

Table 34- STO Pin/Input

EDM OUTPUT (connector C3b)

All outputs are opto-isolated from each other and from the internal power circuits.

The available terminals for STO function and the corresponding numbers on the connector C3b are listed below:

PIN Numbers	Function	Note
11	**EDM OUTPUT+** Error Detection monitor Output	50 mA max
12	**EDM OUTPUT-** Error Detection monitor Output	
13		
14		
15		
16		

Table 35- EDM PIN/Outputs

The EDM (Error Detection Monitor) is not an output with safety functions. The EDM should not be used for any purpose other than simply reporting system malfunctions, as indicated in this chapter.

The presence of the EDM output is however a necessary condition to achieve a risk reduction level equal to SIL3 / PL e.

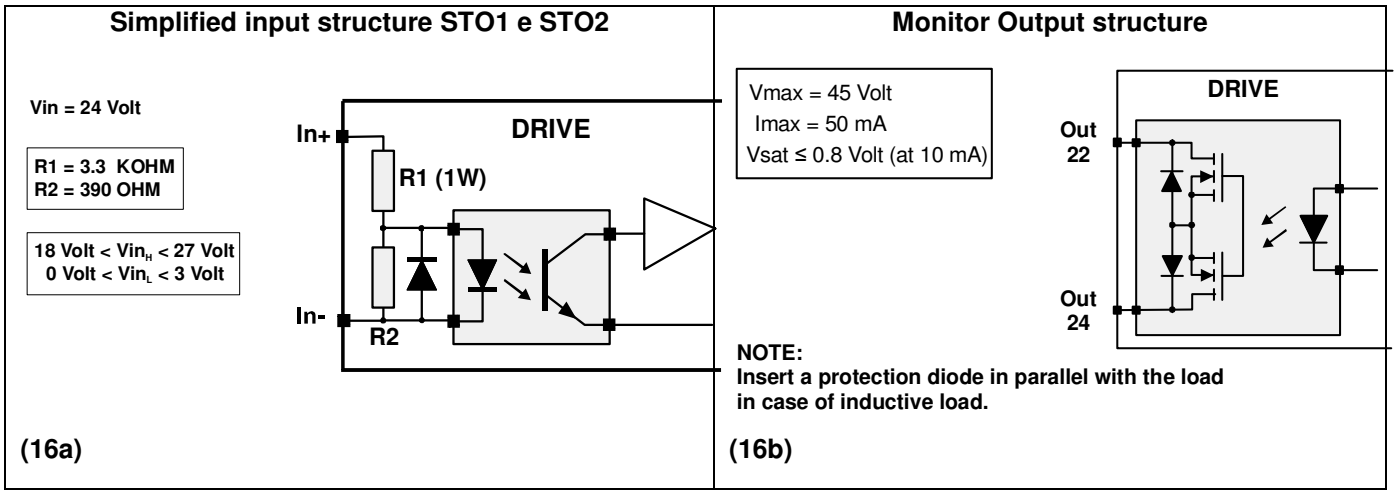


Figure 41- STO Outputs scheme

TIMING OF INPUT-OFF SHOT PULSE FOR SAFETY DEVICE SELF-DIAGNOSIS

In case of the safety device perform self-diagnosis through input-off shot pulses, the input-off shot pulse must have a maximum duration of 1 ms. (Figure 42).

STO function is not activated when the period of STO inputs signal STO1 / STO2 - OFF is 1 ms or less.

To surely grant the activation of the Safe Torque Off function, it is necessary that STO1 and STO2 input signals are turned off for 20 ms or more (Figure 42).

Note: When STO1 and STO2 input signals switch ON and OFF in a range of 1-20 ms, motor loss of synchronism and/or wrong signaling can occur.

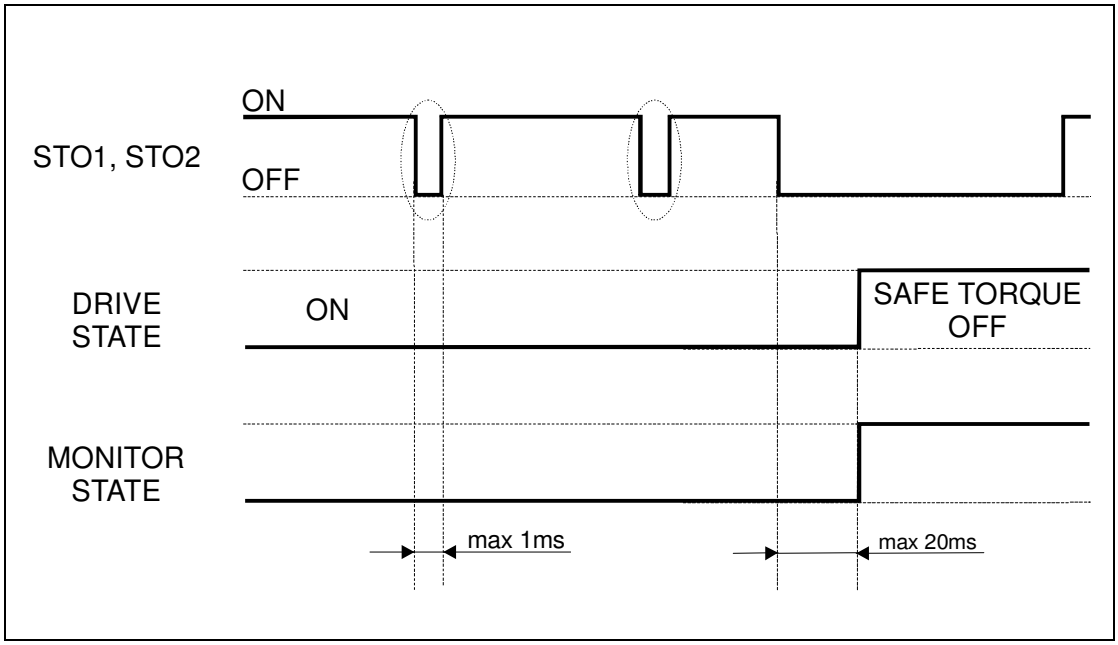


Figure 42- STO self-diagnosis timing.

INFORMATION

The installation must be carried out by qualified personnel and must preserve the SIL level of the loop.

During installation or replacement of the device, the entire safety chain must be switched off.

Devices must be replaced with devices of the same type.

WARNING!

TEST MODE

According to IEC 61508-2, a recurring proof test must be performed to reveal potential dangerous failures that are otherwise not detected by the diagnostic test.

The functionality of the subsystem must be verified at periodic intervals depending on the applied PFDavg (5 Years) in accordance with the data provided in this manual. See the relevant paragraphs in this safety manual according to the expected configuration.

It is under the responsibility of the operator to define the type of proof test and the interval time period (not exceeding the required intervals). The correct operation of the SAFE TORQUE OFF function must always be carried out at the first put in service and at each change of the drive.

The full functionalities of the device must be tested:

- Device intervention shall be simulated to verify the STO to commutate and the output changes status to zero torque when either STO1 or STO2 or both are forced below the lower threshold level.
- The intervention of the device must be simulated to verify that STO commutates to zero torque generating a dummy short circuit only on STO1, only on STO2, both on STO1 and on STO2.
- Simulate device intervention to verify that STO commutates to zero torque by extracting connectors STO1 only, STO2 only, STO1 and STO2.

It is under the responsibility of the operator to put the plant in a safe state before performing the functional test.

WARNING!

VERIFICATION TEST INSTRUCTION

Please verify that SAFE TORQUE OFF function properly works at every first machine start-up and at every drive replacement.

Before check the correct working of SAFE TORQUE OFF function, please verify that every drive connections properly operate. Incorrect wiring of I/O signals may lead to incorrect operation of the safety function and to risk conditions.

To complete the Verification Test, you must perform the following steps in sequence:

- Enable LV_{DC} logic power supply HV_{DC} drive power supply
- Bring STO1 and STO2 inputs ON
- Activate the CURR_ON signal, wait 1 s and check the motor excitation
- Check the corresponding EDM monitor output status (if used)
- Bring STO1 and STO2 inputs OFF
- Check that the motor can rotate freely and is free from coil excitation
- Check the corresponding EDM monitor output status (if used)
- Repeat steps 5 to 7 by turning the STO1 and STO2 inputs separately OFF.

⚠ WARNING!

RISK ASSESSMENT

The drive complies with the above standards.

In any case, before activating the safety feature, it is important to ensure that you have assessed the risk associated with the entire installation to ensure the necessary safety.

⚠ WARNING!

RESIDUAL RISK

Even if the STO safety function is activated, the following risks remain. It is necessary to ensure the safety of the installation even in the event of the following situations, through an appropriate risk assessment:

- The activation of the STO function with the motor in motion produce the elimination of the current flowing in the motor. The motor will continue to move by inertia. It is necessary to ensure safe conditions of the system to prevent any dangerous situations until the time when the motor has completely stopped its movement.
- When the motor is used to control vertical axes, it is possible that in the absence of holding torque, the axis rotates by force of gravity. In such cases, it is necessary to provide external tools for stop the movement, such as electromagnetic brakes.
- In the event of a short circuit or in general in case of failure of the transistors of the final stage of the drive, the motor may perform an uncontrolled movement of limited amplitude but always in a maximum range of 180 degrees electric (corresponding to 1/50 revolution of the motor, or 256 steps at a resolution of 12800 steps per revolution).
- It is always necessary to check the correct operation of the safety function at the first installation and in case of replacement of the drive. In case of incorrect connection of the input and output signals, the safety function may not work properly, with dangerous consequences.
- Please note that even when the safety function is active, the power supply of the drive is not interrupted. When operating the drive for maintenance or verification, the power supply must be switched off to avoid potential exposure to electric shock.

14. ALARM GUIDE

The drive provide with some logic protection circuits in order to prevent and / or avoid, as far as possible, any problem that can result for the most common installation errors or for the use of the drive outside its application limits.

In particular on the drive there are the following protections against failures:

- short-circuit between the motor and ground outputs
- supply voltage out of the range
- overheating

CAUTION!

The following error cases related to drive signals, can help the user to understand the occurred problem in case of electronic protection / alarm signal:

- **Error code 0x2130, (led HV ON, led "F" ON)** 

Corresponding state:

- Short circuit between motor and ground outputs
- Drive goes in Fault state and motor current is turned to zero

Possible cause:

- Cabling error
- Power stage failure

Try this:

Turn off power voltage supply of the drive, check supply connections and motor output before turning on again.

Please contact R.T.A. if the alarm is back again

- **Error code 0x5100, (led "HV" OFF, led "F" ON)** 

Corresponding state:

- Power supply out of range
- Drive goes in Fault state and motor current is turned to zero.

Possible cause:

- Power supply is out of the correct range (lower or greater)
- Switching power supply with too low output capacity value

Try this:

Check that power supply value is between 24 and 48 V_{DC} (±10%)

Check that output capacity of the power supply is correctly designed (see hardware manual).

Please contact R.T.A. if the alarm is back again.

Error code 0x4310, (Led “T” ON, led “F” ON) 

Corresponding state:

- Overheating

- Drive goes in Fault state and motor current is turned to zero. The drive remains in the Fault state as long as the temperature has not reached the allowed limits.

Possible cause:

- Too hot environment conditions
- Too high duty-cycle workload
- Obstructed air gratings
- Drive not vertically installed

Azioni da intraprendere:

Improve heating flow from drive to the surrounding environment.

Check that the full scale current value is not set to a value higher than the actual performance needs (see register 1080).

Error code 0x8611, (led “HV” ON) 

Corresponding state:

- Drive following error

Possible cause:

- Motion parameters too high related to mechanical load and system inertia
- Parameters not correct in registers: 1080 “Current Ratio”, 1084 “Encoder window”, 1085 “Following Error Reaction Code”.

Try this:

- Check if the values in objects listed above are appropriate with respect to motor and encoder ratings
- Check if the motion parameters are appropriate with respect to system mechanical feature

15. REGISTERS COMPLETE TABLE

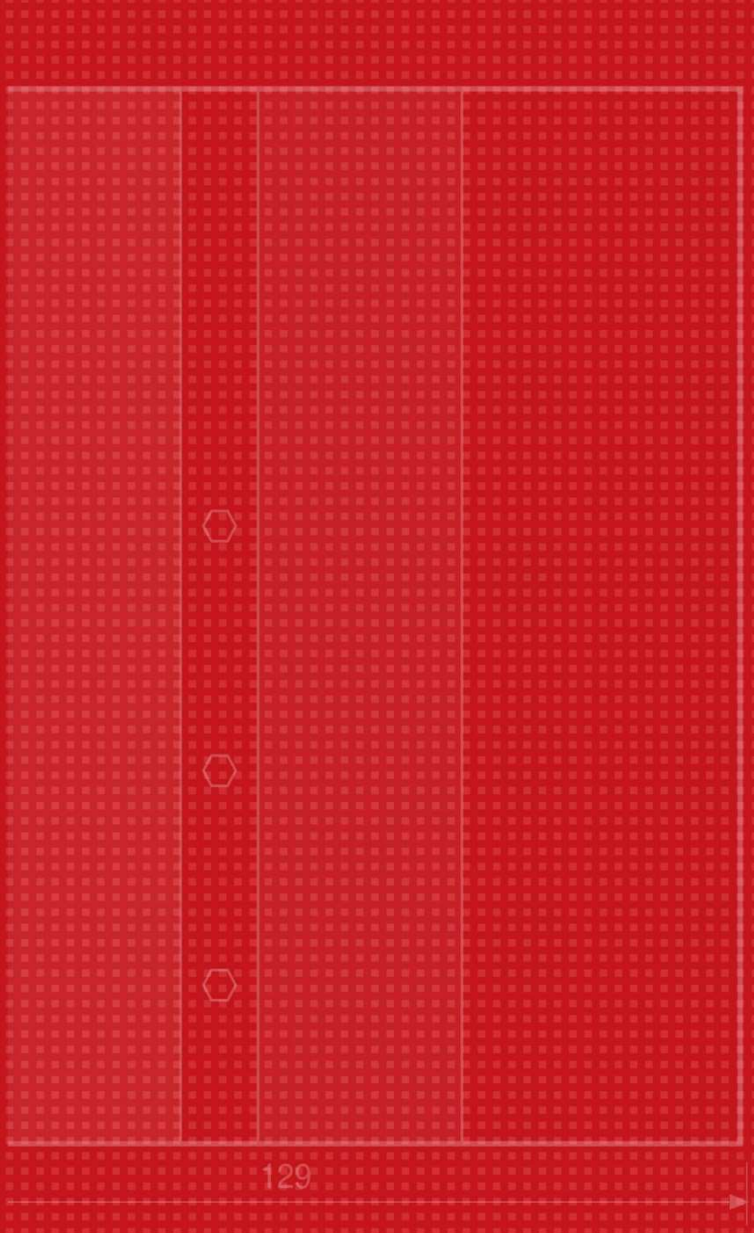
Modbus Address Little Endian	Modbus Address Big Endian	Data type	Access Type	Function	Default Value	Minimum value	Maximum value
1001	1001	U16	RO	Status Word	--	0x0000	0xFFFF
1002	1002	I16	RO	Mode of Operation Display	0	0	6
1004	1005	I32	RO	Position Actual Value_L	0	-2147483648	2147483647
1005	1004			Position Actual Value_H			
1006	1006	U16	RO	Error Register	0000	0000	8611
1007	1007	U16	RO	Error Code	0000	0000	8611
1008	1009	I32	RO	Digital Input_L	0	0	0xFFFF FFFF
1009	1008			Digital Input_H			
1010	1011	I32	RO	Digital Output_L	0	0	0x01F0 0001
1011	1010			Digital Output_H			
1014	1015	I32	RO	Touch Probe Neg Value_L	0	-2147483648	2147483647
1015	1014			Touch Probe Neg Value_H			
1016	1017	I32	RO	Touch Probe Pos Value_L	0	-2147483648	2147483647
1017	1016			Touch Probe Pos Value_H			
1018	1018	U16	RO	Touch Probe Status	0	0x0087	0
1020	1021	I32	RO	Velocity Actual Value_L	0	0	800 000
1021	1020			Velocity Actual Value_H			
1040	1040	U16	RW	Control Word	0x0000	0x0000	0xFFFF
1041	1041	U16	RW	Mode of Operation	0	0	6
1042	1043	I32	RW	Target Position_L	0	-2147483648	2147483647
1043	1042			Target Position_H			
1044	1045	I32	RW	Profile Velocity_L	24 000	0	800 000
1045	1044			Profile Velocity_H			
1046	1047	I32	RW	Profile Acceleration_L	640 000	2000	10 000 000
1047	1046			Profile Acceleration_H			
1048	1049	I32	RW	Target Velocity_L	0	0	800 000
1049	1048			Target velocity_H			
1050	1050	U16	RW	Homing Method	0	37	0
1052	1053	U32	RW	Homing Speed During Search Switch_L	16 001	16 001	400 000
1053	1052			Homing Speed During Search Switch _H			
1054	1055	U32	RW	Homing Speed During Search Zero _L	0	0	16000
1055	1054			Homing Speed During Search Zero _H			
1056	1057	U32	RW	Homing Acceleration_L	2 000	2 000	10 000 000
1057	1056			Homing Acceleration_H			

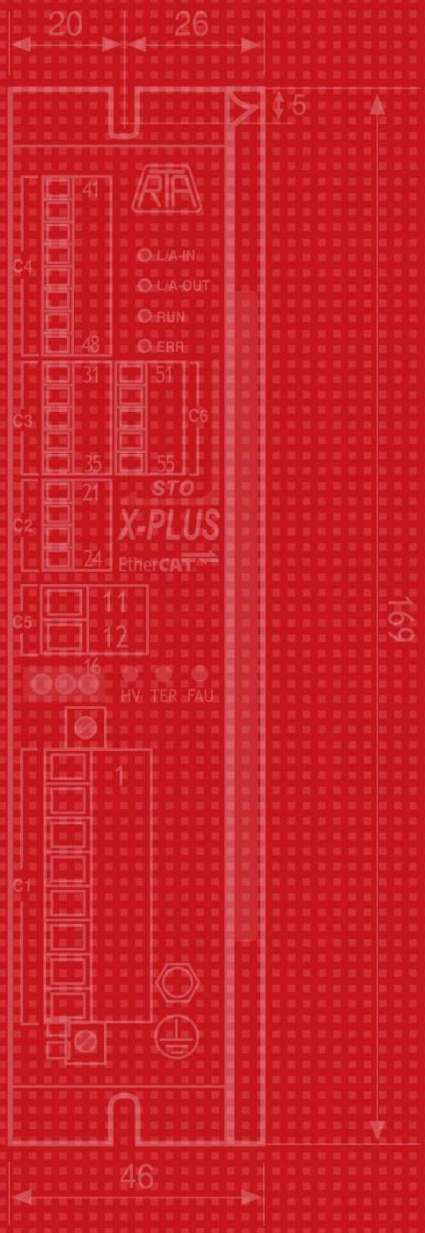
Modbus Address Little Endian	Modbus Address Big Endian	Data type	Access Type	Function		Default Value	Minimum value	Maximum value
1058	1059	I32	RW	Homing Offset_L		0	-2147483647	2147483648
1059	1058			Homing Offset_H				
1066	1066	U16	RW	Touch Probe Function		0	37	40060
1062	1062	U16	RW	Velocity Window		21300	0	65535
1063	1063	U16	RW	Velocity Window Time		50	0	65535
1064	1064	U16	RW	Velocity Threshold		21300	0	65535
1065	1065	U16	RW	Velocity Threshold Time		50	0	65535
1067	1067	U16	RW	Control Word from I/O		0x0000	0x0000	0xFFFF
1068	1069	I32	RW	Minimum Position Range Limit_L		0	-2147483648	2147483647
1069	1068			Minimum Position Range Limit_H				
1070	1071	I32	RW	Maximum Position Range Limit_L		0	-2147483648	2147483647
1071	1070			Maximum Position Range Limit_H				
1072	1073	I32	RW	Profile Deceleration_L		640 000	2000	10 000 000
1073	1072			Profile Deceleration_H				
1074	1075	I32	RW	Max Motor Speed_L		0	0	400 000
1075	1074			Max Motor Speed_H				
1080	1080	U8	RW	Current Ratio	**	70	0	120
1081	1081	U16	RW	Step Revolution	**	12800	12800	12800
1082	1082	U8	RW	Current Equalization	**	0	0	1
1083	1083	U8	RW	Current Reduction	**	1	1	1
1084	1084	U8	RW	Encoder Window	**	3	1	5
1085	1085	U8	RW	Following Error Reaction Code	**	0	0	17
1086	1086	U8	RW	Position Error Reset		0	0	2
1087	1087	U8	RW	Set Output		0	0	15
1088	1088	U8	RW	Input Config	**	31	0	31
1089	1089	U8	RW	Output Config	**	27	0	39
1090	1091	U32	RW	Motor Code_L	**	286151	286151	782317
1091	1090			Motor Code_H	**			
1092	1092	U8	RW	Revolution direction	**	0	0	1
1093	1093	U16	RW	Brake Delay Lock	**	100	0	1000
1094	1094	U16	RW RW	Brake Delay Unlock	**	100	0	1000
1095	1095	U16	RW	Brake Delay Current ON	**	0	0	1000
1096	1096	U16	RW	Brake Delay Azio Ready	**	230	0	1000
1097	1097	U16	RW	Counter Watchdog	**	0	0	1

Modbus Address Little Endian	Modbus Address Big Endian	Data type	Access Type	Function		Default Value	Minimum value	Maximum value
1104	1104	U16	RW	Busy Delay		80	0	0xFFFF
1105	1105	U16	RW	Enable SW bit 7		0	0	1
1106	1106	U16	RW	Enable SW bit 14		0	0	1
1107	1107	U16	RW	Enable SW bit 15		0	0	1
1108	1108	U16	RW	Auto Sync Enable	**	0	0	1
1109	1109	U16	RW	Auto Sync Kv	**	100	0	300
1110	1111	U32	RW	Auto Sync Window LSB	**	32000	1	64000
1111	1110			Auto Sync Window MSB	**			
1112	1112	U16	RW	Current Reduction Ratio	**	50	0	100
1113	1113	U16	RW	Velocity Total Sample		100	1	200
1114	1114	U16	RW	Reset Encoder On First Power Up		0	0	1
1115	1115	U16	RW	Hard Stop Homing Disengaging Steps		64	0	255
1116	1116	U16	RW	Power Up Speed Limit		0	0	32000
1117	1117	U16	RO	Motor Current Limit		--	1	4
1118	1118	U16	RO	Motor Proportional Gain		--	100	400
1119	1119	U16	RO	Motor Dynamic Balancing		--	0	500
1120	1120	U16	RO	Motor Current Recycling Enable		--	0	1
1121	1121	U16	RW	Encoder Count Per Revolution	**	400	400	4000
1122	1122	U16	RW	User Data RAM				
1123	1123	U16	RW	Read Temperature		0	0	1
1125	1125	U16	RW	Warning Temperature	**	85	50	85
1126	1126	U16	RW	Drive Fault Temperature	**	98	50	105
1130	1130	U16	RW	IP Address first octet		192	0	255
1131	1131	U16	RW	IP Address second octet		168	0	255
1132	1132	U16	RW	IP Address third octet		1	0	255
1133	1133	U16	RW	IP Address fourth octet		10	0	255
1134	1134	U16	RW	Subnet Mask first octet		255	0	255
1135	1135	U16	RW	Subnet Mask second octet		255	0	255
1136	1136	U16	RW	Subnet Mask third octet		0	0	255
1137	1137	U16	RW	Subnet Mask fourth octet		0	0	255
1138	1138	U16	RW	Gateway first octet		192	0	255
1139	1139	U16	RW	Gateway second octet		168	0	255
1140	1140	U16	RW	Gateway third octet		1	0	255
1141	1141	U16	RW	Gateway fourth octet		1	0	255
1152	1153	U32	RO	Software Version_LSB		51	0x0000 0000	0xFFFF FFFF
1153	1152			Software Version_MSB				
1154	1155	U32	RO	Product Code_LSB		--	0x0000 0000	0xFFFF FFFF
1155	1154			Product Code_MSB				
1156	1157	U32	RO	Hardware Version_LSB			0x0000 0000	0xFFFF FFFF
1157	1156			Hardware Version_MSB				

Modbus Address Little Endian	Modbus Address Big Endian	Data type	Access Type	Function	Default Value	Minimum value	Maximum value
1158	1159	U32	RO	Serial Number_L	--	0x0000 0000	0xFFFF FFFF
1159	1158			Serial Number_H			
1162	1162	U16	RW	Little Endian / big Endian	1	0	1
1220	1220	U16	RO	Drive Alarm Time n°0	0	0	0xFFFF
1221	1221	U16	RO	Drive Alarm Code n°0	0000	0000	8611
1222	1222	U16	RO	Drive Alarm Time n°1	0	0	0xFFFF
1223	1223	U16	RO	Drive Alarm Code n°1	0000	0000	8611
1224	1224	U16	RO	Drive Alarm Time n°2	0	0	0xFFFF
1225	1225	U16	RO	Drive Alarm Code n°2	0000	0000	8611
1226	1226	U16	RO	Drive Alarm Time n°3	0	0	0xFFFF
1227	1227	U16	RO	Drive Alarm Code n°3	0000	0000	8611
1228	1228	U16	RO	Drive Alarm Time n°4	0	0	0xFFFF
1229	1229	U16	RO	Drive Alarm Code n°4	0000	0000	8611
1230	1230	U16	RO	Drive Alarm Time n°5	0	0	0xFFFF
1231	1231	U16	RO	Drive Alarm Code n°5	0000	0000	8611
1232	1232	U16	RO	Drive Alarm Time n°6	0	0	0xFFFF
1233	1233	U16	RO	Drive Alarm Code n°6	0000	0000	8611
1234	1234	U16	RO	Drive Alarm Time n°7	0	0	0xFFFF
1235	1235	U16	RO	Drive Alarm Code n°7	0000	0000	8611
1236	1236	U16	RO	Drive Alarm Time n°8	0	0	0xFFFF
1237	1237	U16	RO	Drive Alarm Code n°8	0000	0000	8611
1238	1238	U16	RO	Drive Alarm Time n°9	0	0	0xFFFF
1239	1239	U16	RO	Drive Alarm Code n°9	0000	0000	8611
1240	1240	U16	RW	Reset Error Logs	0	0	1
1260	1260	U16	RW	Save All Parameters	0000	0x6173	0x6173
1261	1261	U16	RW	Restore All Default Parameters	0000	0x6F6C	0x6F6C

******: means that the value of Register can be stored in the non volatile memory and the default value can recovered by writing Registers 1260 -1261





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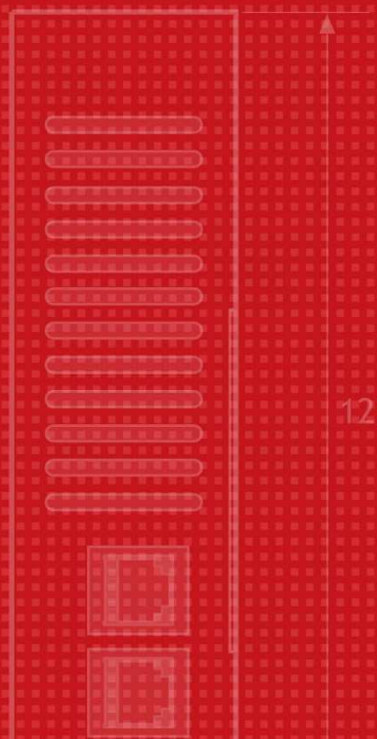

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