



It is user **RESPONSIBILITY** to check that this manual (in PDF format) refers to product model and version that will be used.

In any case, regarding installation, use and maintenance, the paper-made manual given together with the product **TAKES PRIORITY.**

R.T.A. srl



MOTION CONTROL SYSTEMS

X-MIND K SERIES

STEPPING MOTOR DRIVES

INSTRUCTION MANUAL



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Symbol meaning

 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 .

 The section marked with this symbol contains information regarding operations which are strictly forbidden.



1 - NOTICES AND MANUAL STRUCTURE

1.1 - This manual covers the following items:

- X-MIND K series stepping motor drives in all their standard versions.
- Standard characteristics of special versions of X-MIND K series stepping motor drives (see chapter 1.2).
- For models and versions identification see also chapter 3.

1.2 - For the purposes of this manual the terms used assume the meaning below described (see Fig. 1).

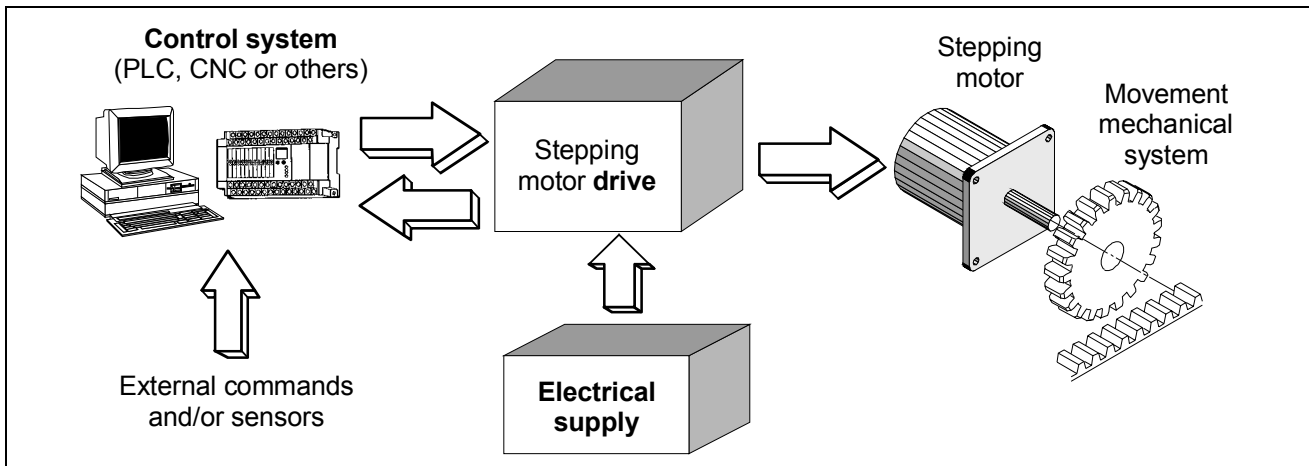


Fig. 1

- 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 we consider the drive as a BDM (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 execution commands. It could be a numerical or programmable control, a personal computer or a specific control card. In the simplest machines it could also be a group of sensors and electromechanical switches.
- Electrical supply: all machine parts suitable to supply the drive in a correct way; anti-interference filter, switches, protection systems and in some cases transformer.
- Standard drives are all models (see chapter 3 for identification) whose characteristics comply completely with those described in this manual. 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.

1.3 - Products described in this manual (see list in chapter 1.1 and identification code in chapter 3) are CE marked and comply with the following directives:

- 1) Low Voltage (73/23/EEC and further modification).
- 2) Electromagnetic Compatibility (89/336/EEC and further modification).

1.4 - Remember that, as stated in all directives, compliance exists only when a product is 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 compliance limits: from this point of view, chapter 2, 8 and 10 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.

1.5 - Conformity declaration regarding above mentioned products is kept by R.T.A. (as manufacturer residing in EEC country) together with technical construction file at authority disposal.



- 1.6 - 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 and cautions about X-MIND K 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.
- 1.7 - 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. 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 twenty years of experience in any kind of applications, which cannot be condensed in a manual but can always be at customer disposal.
- 1.8 - The terms "user and customer" often used in this manual always indicate a skilled person as defined in chapter 2.8.
- 1.9 - 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 - LIMITATIONS, HAZARDS AND CAUTIONS

- 2.1 - X-MIND K series drives are suitable to drive two phases stepping motors with 4, 6 or 8 terminals (see section 10.2 for more detailed indications about motor limits). Their use for different purposes is not allowed.
- 2.2 - It is not allowed the use of these drives for any purpose different from the one above indicated.
- 2.3 - It is also not allowed the use in any condition not complying with one or more specific limitations stated in this manual for electrical, mechanical and environmental quantity or characteristics.
- 2.4 - X-MIND K series drives are classified as protection degree IP20 (EN60529). This means that they must be located inside a protective enclosure meeting requirements of standards applicable in the specific application in which they are used.
- 2.5 - X-MIND K series drives contain capacitors able to store a certain amount of electrical energy. As a consequence, in some cases, according with application conditions and supply dimensioning, a dangerous voltage could remain on the drive, after switching off, for a time greater than 5 seconds. So it is recommended to wait an adequate time before working on the drive.
- 2.6 - The heatsink can reach high temperatures during normal working conditions (for example about 80 °C). Do not touch this component for some minutes, after switching off, in order to avoid scald hazard.
- 2.7 - After a failure due to connection mistakes or others, in the drives could arise a temporary hot spot. For this reason 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.



- 2.8** - All products considered in this manual are sub-assemblies without a direct function, foreseen to be integrated in a more complex machine or installation by a professional assembler. X-MIND K series drives are conceived for restricted distribution (EN 61800-3 Ch. 3.2). Direct use of these products by a final user is not allowed. The professional assembler using this material has to be a skilled person, adequately qualified both in the generic field of electrical and electronic systems and in the specific field of stepping motor systems. 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 89/336/EEC, 89/392/EEC, etc.) before the conformity to those directives has been declared. Regarding 89/336/EEC directive, see chapter 10.
- 2.9** - Use for safety related functions is forbidden (EN 60204-1). Moreover, when the application arrangement is in such way that a drive fault or failure could generate a dangerous condition, external independent safety protection system must be provided in the machine.
- 2.10** - Both CURRENT OFF command (see programmer's manual) and internal electronic functional protections switch off the drive output power by means of semiconductor devices. They cannot be used to interrupt power in emergency stop function or in any function involving personnel safety.



3 - GENERAL CHARACTERISTICS AND IDENTIFICATION

3.1 - DIMENSIONS

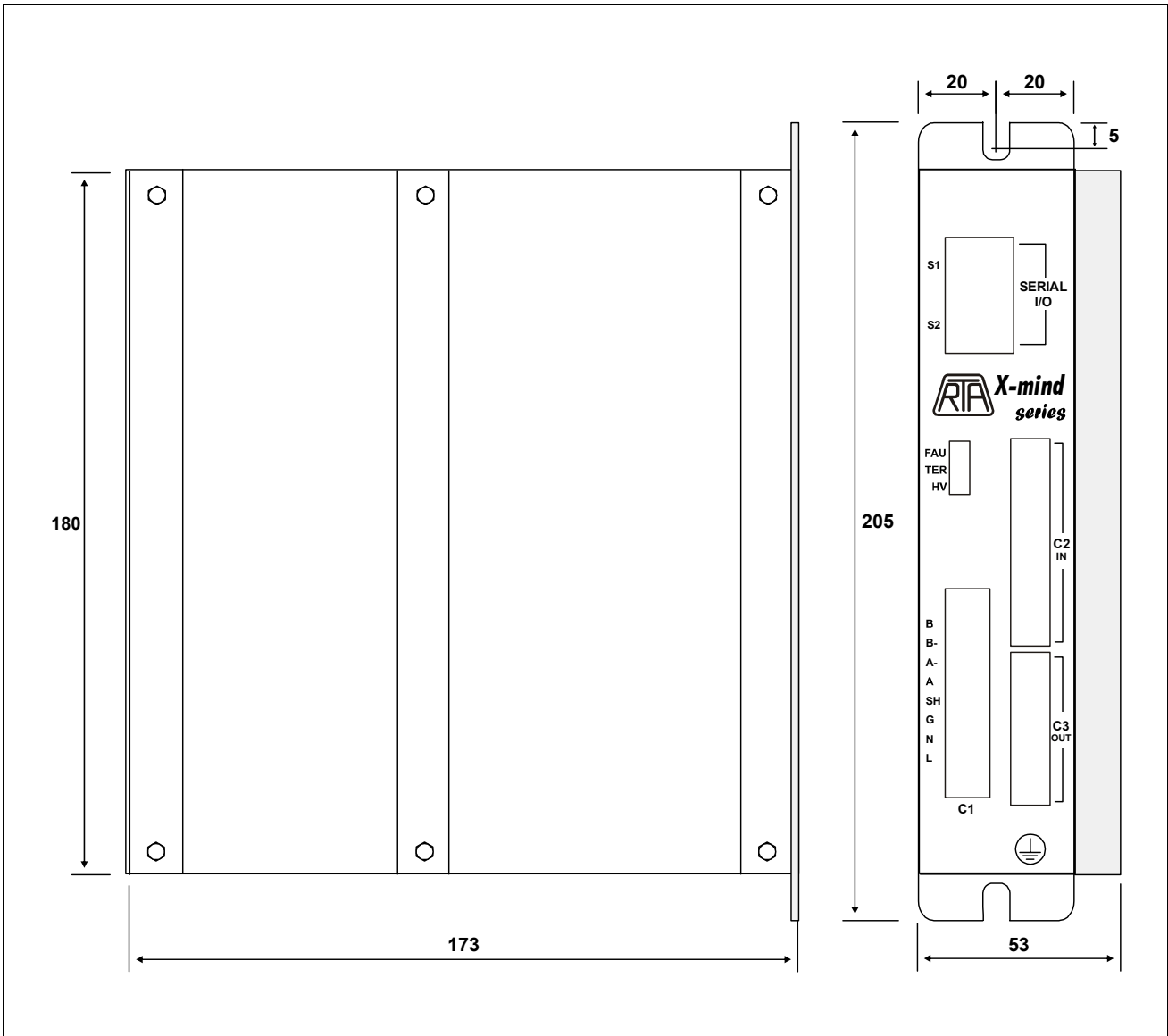


Fig. 2 – Dimensions: all measures in mm.

3.2 - IDENTIFICATION

The models identification of X-MIND K series drives is as follows:

X-MIND KX.Y

where:

X can be: **4** or **6** and identifies a standard model

.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.

Each sample is also identified with a serial number.



4 - INPUT AND OUTPUT LOGIC SIGNALS

All input and output logic signals are optically insulated among them and from internal power circuits. See also programmer's manual about hardware inputs and outputs use.

4.1 - INPUTS

An input is ON when at its terminals is present a voltage within the following limits:

$$V_{in_{MIN}} = 5 \text{ Volt}, V_{in_{MAX}} = 24 \text{ Volt}$$

For each input signal correspondent terminals numbers of connector C2 are indicated.

- 11:** **COMMON OF INPUTS.**
- 12, 13, 14, 15:** (**SEL0, SEL1, SEL2, SEL3**): selection of one of the 16 programs that can be activated through the hardware input ST.
- 16 (ST):** **START:** start of previously stored programs. The program starts on OFF-ON transition of this input at these conditions:
- Start command is rejected when EE is ON
 - Start command can be rejected or not accordingly to setting of "PRESET OF ES PRIORITY" when ES is ON (see chap. 4 of programmer's manual).
- 17 (EE):** **EMERGENCY STOP.** Stop of the execution of any instruction or command, immediate block of any program running.
- 18 (ES):** **FREE RUN STOP.** Stop of the execution of a free run instruction (both with and without ramp).
- 19 (I0):** **I0 INPUT.** Input terminal whose status can be read by a command or instruction.
- 20 (I1):** **I1 INPUT.** Input terminal whose status can be read by a command or instruction.
- 21 (PX):** **PROXIMITY input.** Used for zero research procedure.
- 22 (I2):** **I2 INPUT.** Input terminal whose status can be read by a command or instruction.
- 23:** **Drive GND.** PAY ATTENTION: this terminal is internally connected to 6 terminal of C1 connector (see chap. 5) and insulated from input terminals. It can be used when shield of input signals has to be connected to the earth.

4.2 - OUTPUTS

The outputs are considered ON when they are closed as regards to common outputs (31 and 36). For each signal the correspondent terminals numbers of connector C3 are indicated.

- 31, 36:** **COMMON OF OUTPUTS.**
- 32 (FA):** **FAULT.** FA output is ON when drive is working correctly, OFF when it is blocked by a protection.
- 33 (BS):** **BUSY.** BS output is ON when drive is executing an instruction, OFF when drive is waiting or ready to receive a command.
- 34 (O0):** **O0 OUTPUT.** Hardware output whose status can be set by the user using a command or an instruction.
- 35 (O1):** **O1 OUTPUT.** Hardware output whose status can be set by the user using a command or an instruction.
- 37 (O2):** **O2 OUTPUT.** Hardware output whose status can be set by the user using a command or an instruction.
- 38 (O3):** **O3 OUTPUT.** Hardware output whose status can be set by the user using a command or an instruction.
- 39:** **Drive GND.** PAY ATTENTION: this terminal is internally connected to 6 terminal of C1 connector (see chap. 5) and insulated from input terminals. It can be used when shield of output signals has to be connected to the earth.

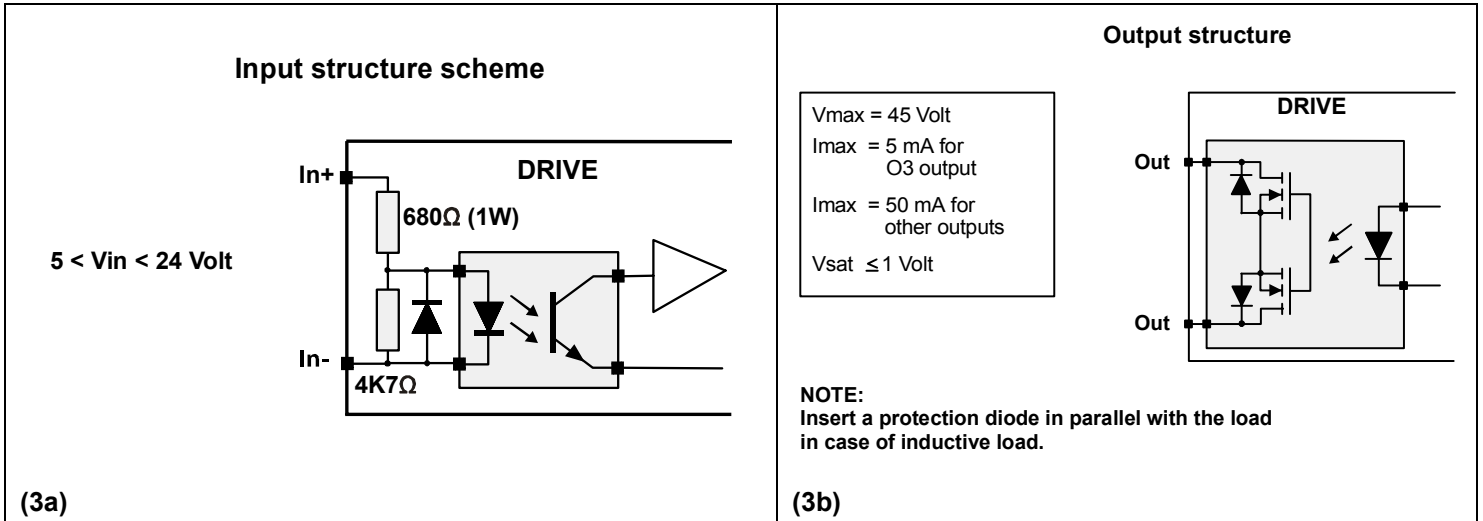


Fig. 3 – Inputs and outputs scheme.

4.3 - CONNETTORI RJ-12 (serial line RS485)

Figure 4 shows connectors RJ-12 S1 and S2 used for connection between the drive and the control system through the serial line.

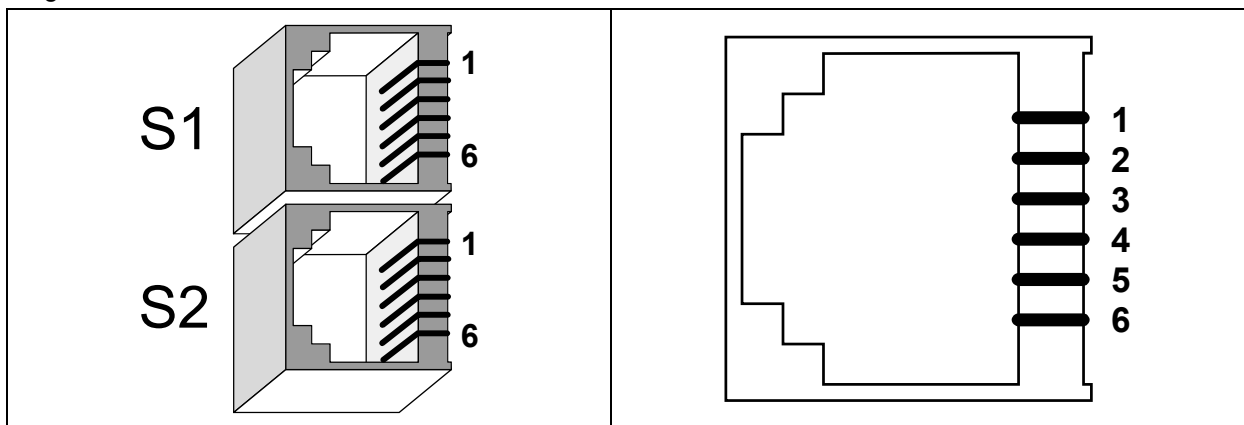


Fig. 4 – S1 and S2 connectors

Connectors S1 and S2 are identical and in parallel in order to allow the connection of more than one drive (daisy-chain, see programmer's manual). In the following are indicated pins functions in dependence on the use of RS485 protocol.

1, 6 (Internally connected): COMMON OF SERIAL LINE.

2, 5 (Internally connected): DATA +. Serial line 485 +.

3, 4 (Internally connected): DATA -. Serial line 485 -.

Figure 5 shows the example of the correct connection between control system and the drive in case of RS485.

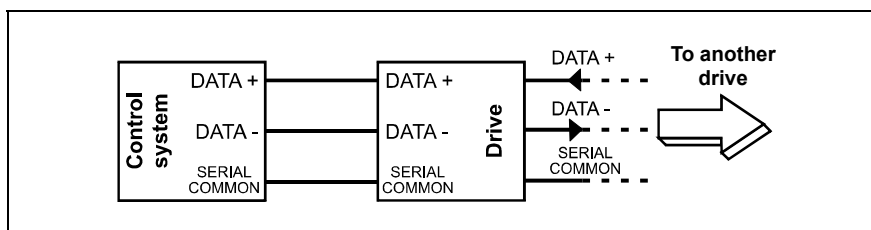


Fig. 5 – Example of connection between control system and drive.

Maximum allowed length up to 1 km as long as adequate cables and right connections modality are applied (Fig. 5).

NOTE: The ground signals of the control system of serial communication must be to the same voltage of the ground signals of the control system of serial communication of the drive. Otherwise the danger to cause damages to both devices is very high.



5 - ⚠ POWER INPUTS AND OUTPUTS

In this chapter drive power input and output and the necessary power supply for drive working are described.

- 5.1- Drive power outputs are the four connections to stepping motor. Drive power inputs can be connected to the main or to an insulation transformer. All connector C1 terminals are listed in the following Table 1.

CONNECTOR C1	DESCRIPTION
1	Motor winding terminal B
2	Motor winding terminal B-
3	Motor winding terminal A-
4	Motor winding terminal A
5	SHIELD
6	GROUND
7	AC power supply. N (Neutral).
8	AC power supply. L (Line).

- 5.2- Earth terminal – Earth terminal is in frontal panel inferior part and has to be electrically connected to earth (PE terminal of the machine in which the drive is installed). The terminal 6 of C1 connector has to be connected to earth too.
- 5.3- The terminal 6 of C1 connector is the point of motor-drive system that has to be connected to earth (PE terminal). No other point at a different potential power circuit has to be connected to earth. The terminal 5 of C1 connector (SHIELD) is internally connected to terminal 6 of C1 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.



5.4- Table 2 and Table 3 show power inputs and outputs characteristics:

TABLE 2			
AC input		X-MIND K4	X-MIND K6
$V_{AC\ nom}$	(VOLT)	110 - 230	110 - 230
Tolerance $V_{AC\ nom}$	(%)	15	15
Max input current	(AMP)	4	6
Max input power	(VA)	440 - 920	660 - 1380
Dimensions	(mm)	180 × 53 × 173	

TABLE 3			
Motor phase outputs		X-MIND K4	X-MIND K6
$V_{PH\ min}$	(VOLT)	0	0
$V_{PH\ max}$	(VOLT)	+/- 1.41 × V_{AC}	+/- 1.41 × V_{AC}
$I_{NP\ min}$	(AMP)	2.27	3.42
$I_{NP\ max}$	(AMP)	4	6
$I_{NP\ step}$	(AMP)	0.58	0.86

5.5- Definition of terms used in Table 2 and in Table 3:

$V_{AC\ nom}$: indicates nominal alternating voltage for drive operation with not stabilized power supply.

Max input current: maximum input current allowed for continuous operations.

Max input power : maximum input power allowed for continuous operations.

$V_{PH\ min}$: minimum value of the voltage at each motor phase output.

$V_{PH\ max}$: maximum value of the voltage at each motor phase output.

I_{NP} : indicates nominal phase current, which flows in each motor winding, measurable with motor turning at **low speed**. The drive is equipped with automatic current reduction with motor at standstill. Phase current is calibrated at final test moment and can be set from the customer, choosing among four different values, by means of "current preset command" (see programmer's manual). This value is the peak value of the sinusoidal approximation of the phase current.

$I_{NP\ min\ and\ max}$: minimum and maximum nominal phase current value which can be set by means of "current preset command" (see programmer's manual).

$I_{NP\ step}$: spacing of the possible current values.

NOTE: The value of the maximum continuous input current can be exceeded of 25% for a short period of time (1 minute).



6 - ⚠️ SETTING AND SIGNALLING

- 6.1- X-MIND K 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 serial commands (see programmer's manual) suitable to adapt drive characteristics to the specific motor and/or application. Led signalling drive status are also present.
- 6.2- Fig. 6 shows the position of signalling LEDs, connectors and labels in X-MIND K series drives.

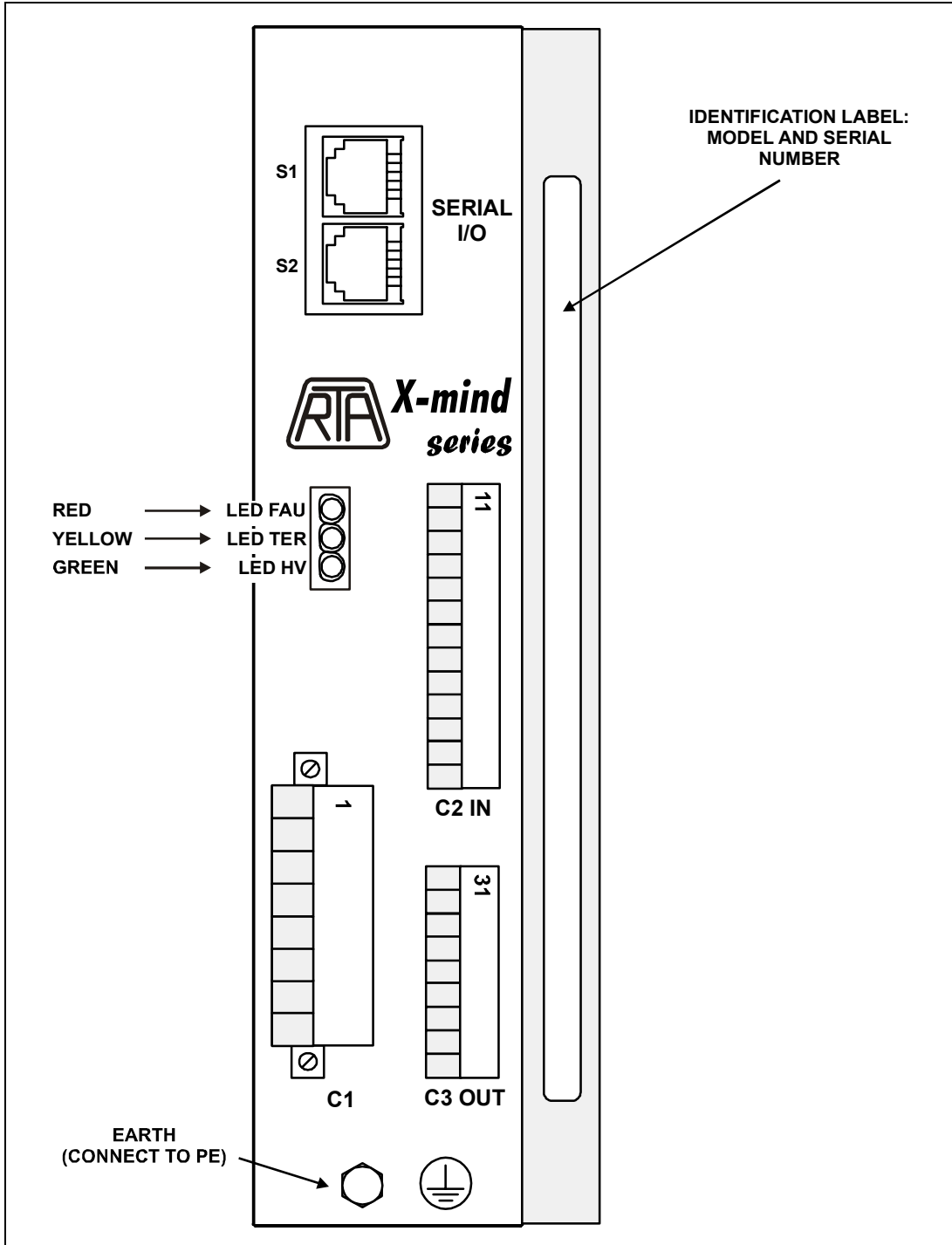


Fig. 6 – Led and connectors.



6.3- The following list shows the meaning of the signalling LEDs existing on the drive.

LED HV : ON = supply voltage inside correct operating range.
OFF = drive not supplied or supply voltage out of the correct range.

LED TER : ON = drive placed in no-working state by thermal protection.
OFF = heatsink temperature in working range.

LED FAU : ON = drive placed in no-working state by one of the following protection:
a- Thermal protection if LED TER is ON.
b- Max or Min supply voltage if LED HV is OFF.
c- Motor output short circuit or wrong motor connection.

NOTE: OFF = LED switched off ;
ON = LED switched on.

All protections are self-resetting, when the intervention causes disappear.



7 - ⚠️ DRIVE EXTERNAL CONNECTIONS

7.1- Dimensioning power for filter, switching and protection system and possible transformer. The basis to calculate this power 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, contact R.T.A. describing all the data of the particular application.

7.2- Protection systems indicated in Fig. 7 must include:

- Residual current protective device with operating residual current of 30 mA.
- Branch circuit protection fuses: UL Type JDDZ, class CC, 600 VAC, 10 Amp (Cooper Bussman model KTK-R-10).

7.3- The cross-sectional area of conductors used in power supply circuit must be chosen according with dimensioning power (see 7.1). 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.

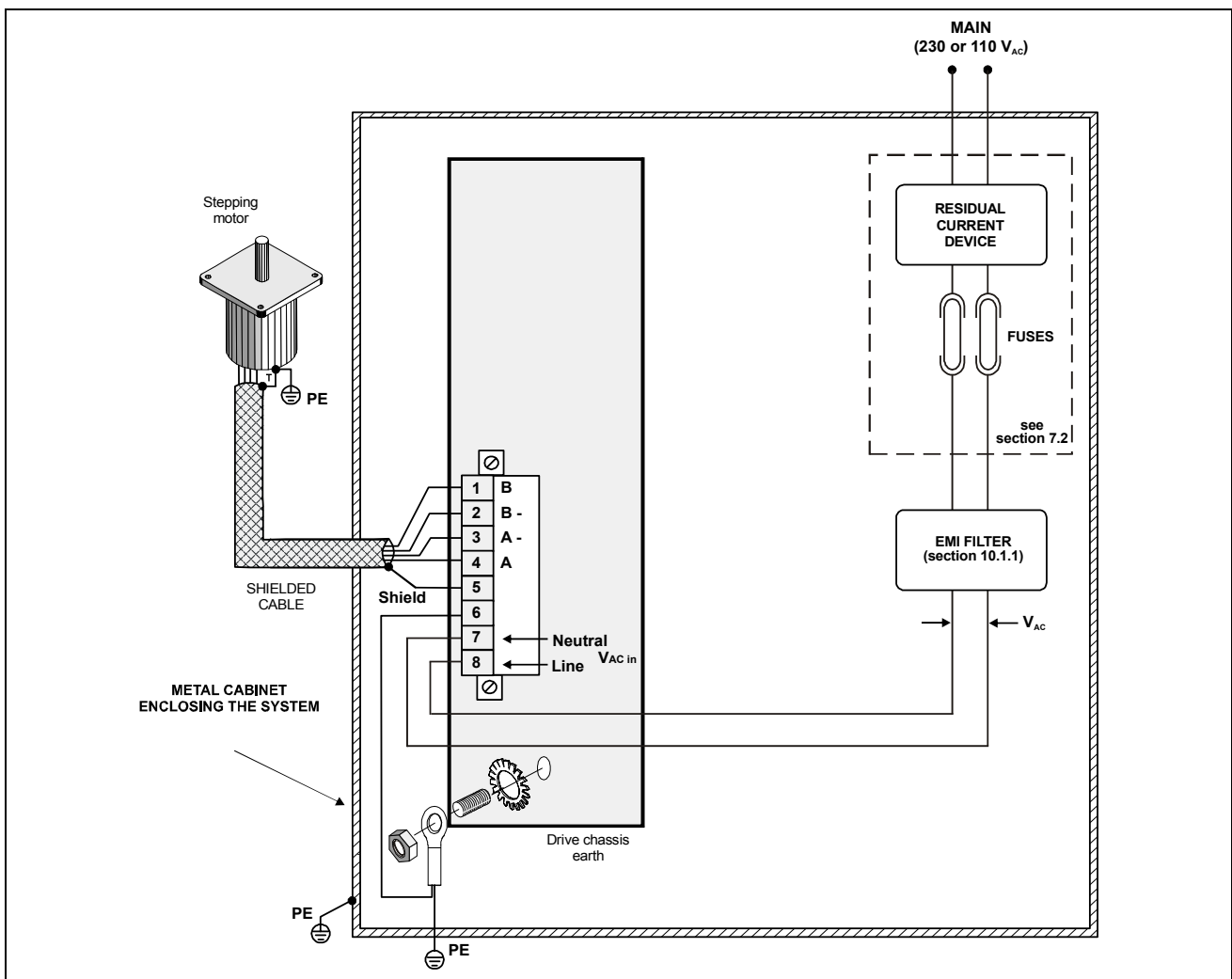


Fig. 7 – Drive external connections scheme.



8 - ⚠️🚫 INSTALLATION AND ENVIRONMENT

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

8.1 - Protection degree IP20 (EN 60529): 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.

8.2 - 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 (IEC 664-1):** 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).**

If the environment in which the machine is used does not satisfy these conditions, suitable conditioning systems have to be provided for the enclosure.

8.3 - Storage environment in original enclosure:

- Temperature: from -25°C to +55°C. Relative humidity: from 5% to 95%.
- Environment conditions class 1K3 (IEC 721-3-1). Pollution degree 2.

8.4 - The drives generate some amount of heat (see chap. 7.1). 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 air gratings.

9 - LOGIC INTERFACING EXAMPLES

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.

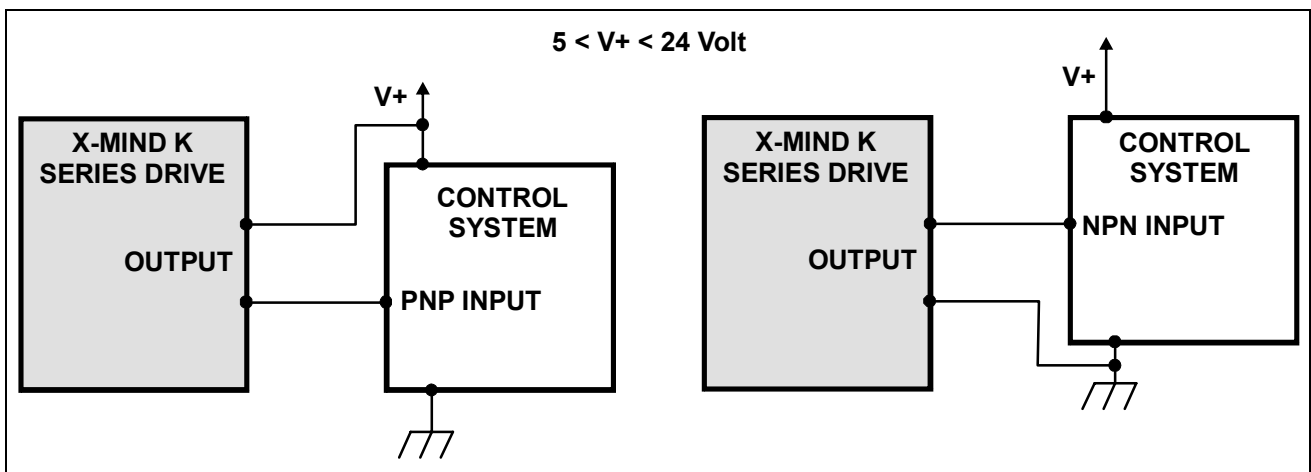


Fig. 8 – Interfacing a X-MIND K logic output and an input of a control system operating at $V+$ voltage.

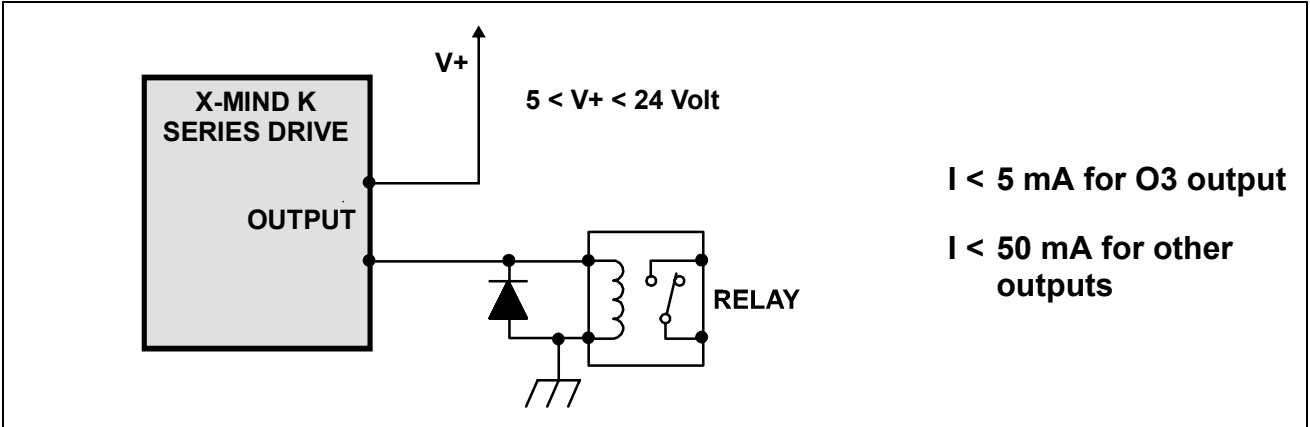


Fig. 9 – Driving a micro-relay by means of a X-MIND K logic output.

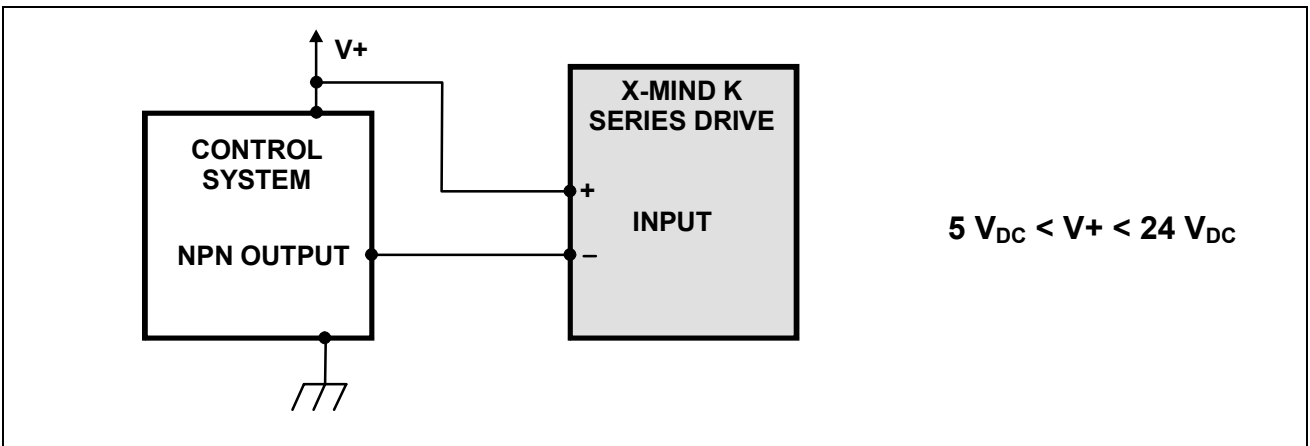


Fig. 10 – Driving a X-MIND K logic input from a control system with a NPN open collector output.

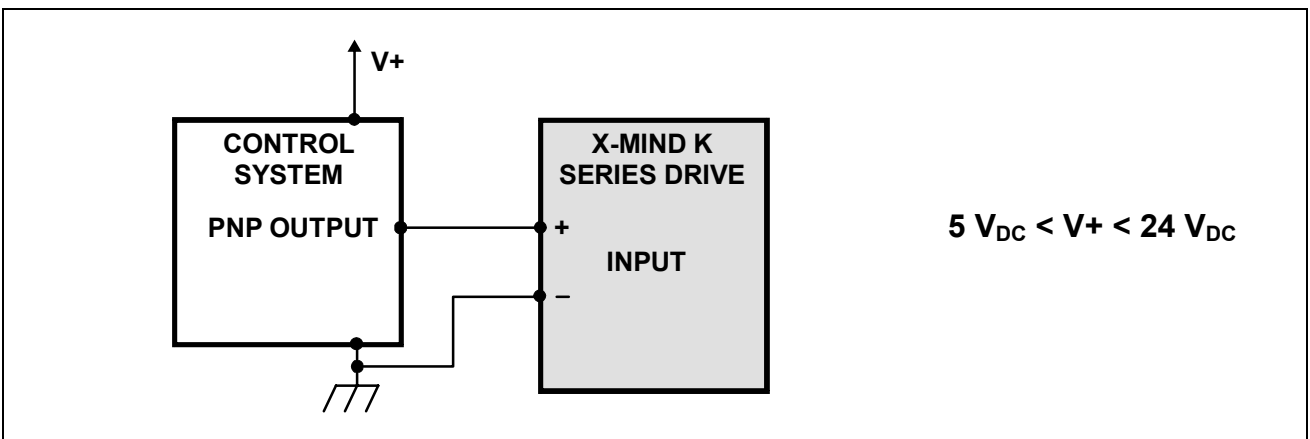


Fig. 11 – Driving a X-MIND K logic input from a control system with a PNP output.



10 - APPLICATION NOTES

10.1 - X-MIND K series drives are BDM (Basic Drive Module) conceived for restricted distribution (EN 61800-3). This means that 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.

10.1.1 - The set consisting of drive, motor 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 X-MIND K series drive terminal 5. 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, equipped with an adequate shield.
- Connect earth line to motor chassis. From the point of view of radio-frequency emissions shielding, it is usually sufficient the connection to machine chassis assured by mounting flanges and screws, as long as both screws and chassis are made of conductor material and the chassis is connected to earth. See Fig. 10.
- Location of drive in a container shielding from electromagnetic interferences.
- Interpose an EMI filter in AC power input line (see Fig. 7) in order to reduce conducted electromagnetic interferences. Filter characteristics in a specific installation depend on following factors:
 - Strictness degree of the specific standard regarding the machine on which drive is used.
 - Power level of application (voltage and current setting of the drive).
 - Presence of other filtering systems in the general electrical machine installation.

In any case, following filter type is recommended:

- CORCOM SK series.

Different models inside these series differ for current rating; thereby choose the specific model according to power level of your installation.

- Consider that the position of the filter in the system is particularly important: no electromagnetic coupling must exist between circuits up the filter and circuits down the filter; if such coupling is present, the effectiveness of filter could be strongly reduced.
- All earth connections above mentioned have to be realized in a way to present the less possible inductance.

10.1.2 - Considering drive logic input signals immunity from external noise present in the environment in which they are most often used, take in account following normal procedures, suggested from the classical techniques relatively fast signals treatment:

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

10.1.3 - A correct accomplishment of these procedures constitutes an essential starting point in order to realize an installation which complies with the requirements of 89/336/EEC directive. The effective compliance with specific standards covering the particular application in which this drive is used will have in any case to be proved in the complete installation, because the effectiveness of suggested actions depends also on machine topology and on their correct fulfilment. Tests performed by R.T.A. simulating typical installations and following above mentioned indications show that it is possible to stay within the limit of EN61800-3 standard.



10.1.4 - 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 the great majority of cases it is possible to find a solution meeting both prescriptions; R.T.A. is at disposal for further information about these problems.

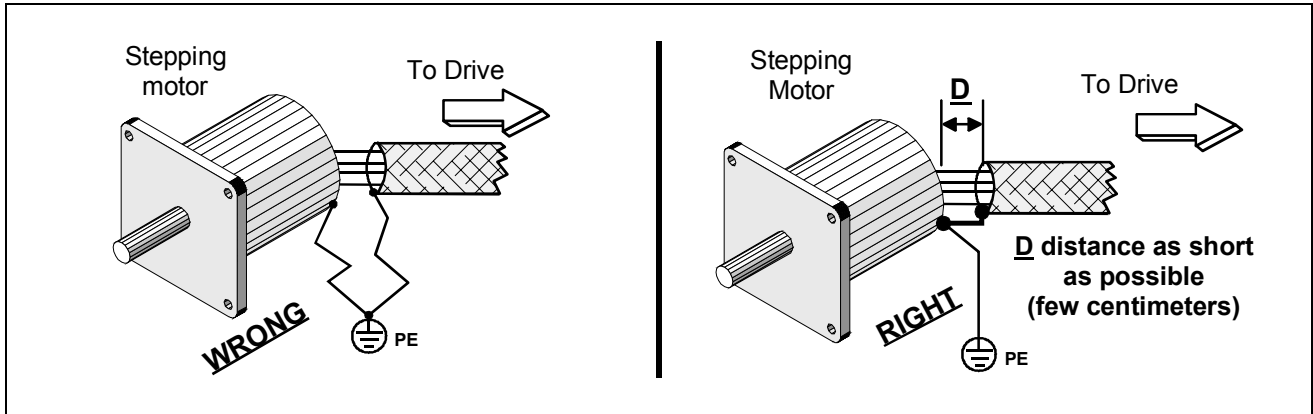


Fig. 12 – Shielded connection at stepping motor side.

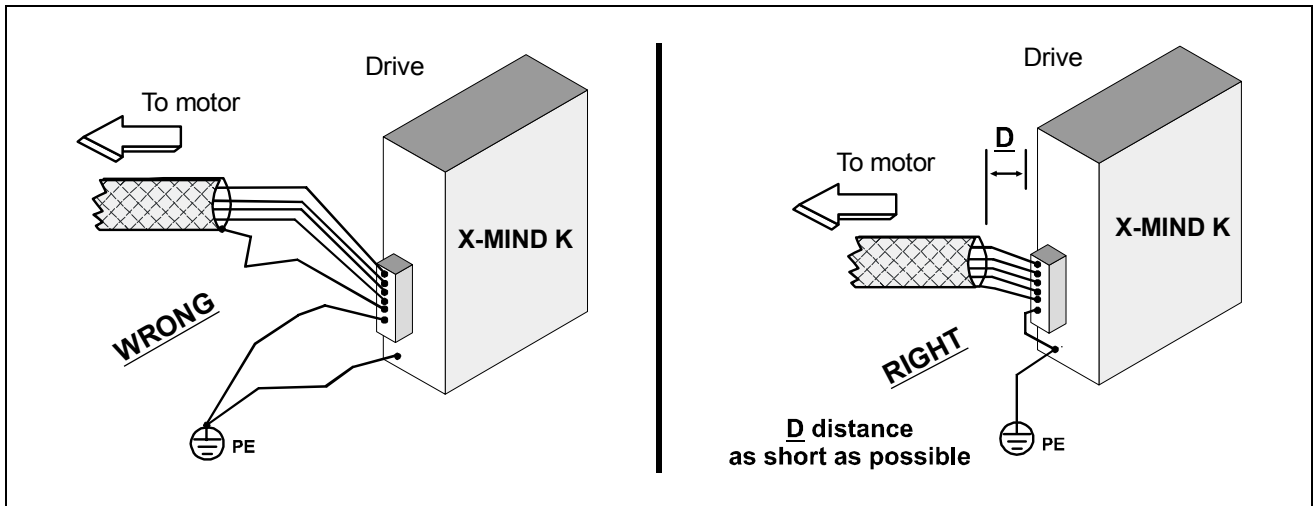


Fig. 13 – Shielded connection at drive side.



10.2 - MOTOR LIMITATIONS.

X-MIND K drives can be used with many different motor types; nevertheless there are some limitations regarding phase inductance, motor nominal current, size and speed. The following tables indicate these limits.

DRIVE TYPE	PHASE INDUCTANCE LIMITS (mH)			
	110 V _{AC}		230 V _{AC}	
	Min	Max	Min	Max
X-MIND K4	1.6	20.0	2.5	25.0
X-MIND K6	1.6	20.0	2.5	25.0

TABLE 6

DRIVE TYPE	MOTOR NOMINAL CURRENT LIMITS (Amp)	
	Minimum	Maximum
X-MIND K4	1.70	4.0
X-MIND K6	2.60	6.0

TABLE 7

MOTOR SIZE	MAX ALLOWABLE SPEED (RPM)	
	X-MIND K4	X-MIND K6
H89223 (4.2 inch, 3 Stacks)	1200	2000
H89222 (4.2 inch, 2 Stacks)	1500	2500
SM 2863 (3.4 inch, 3 Stacks)	2250	3000
SM 2862 (3.4 inch, 2 Stacks)	3000	3500
All other smaller size motors	3500	4000

TABLE 8

The motor must have insulation characteristics foreseen to withstand a direct connection to the main supply (110 or 230 V_{AC}).

All limits above indicated must be observed in order to avoid risks of damages or unreliability both for the motor and for the drive. Furthermore, in order to build up a reliable application, the general rules explained in the following sections 10.3, 10.4, 10.5 has to be taken into account.

10.3 - REVERSE ENERGY MANAGEMENT.

During deceleration of load with high inertia, some amount of energy can flow from motor to drive. In case of excessive reverse energy, an overvoltage protection could inhibit the drive operation making impossible the application. During the test of a new application in which there are decelerations starting from relatively high speed, with high inertial load, always check carefully the operation conditions during the decelerations.



10.4 - EQUALIZATION.

Equalization changes the phase current profile in the medium speed range. If equalization is excluded, current profile approximates sinusoidal shape independently of speed. If equalization is active, current profile is switched to a square shape when speed exceeds a certain threshold: as a consequence, with equalization active, the torque output of the motor will be increased in the medium speed range. Generally speaking, it is helpful to keep equalization active in application with long movement. In application with high rate and very short movement, it is better to exclude equalization, because the continuous changing of the current profile could cause some motor instability.

Consider also the fact that, with equalization active, motor heating during the movements is greater. For this reason, it is suggested to exclude equalization in the following two cases:

- Drive current is set to a value greater than nominal motor current
- Application working conditions are near to the thermal limits of the motor (see sec. 10.5)

10.5 - 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 stand still than during the movements
- As far as regards 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.