*MOTION CONTROL SYSTEMS*

# *PLUS K SERIES*

## *STEPPING MOTOR DRIVES*

# *INSTRUCTION MANUAL*


**R.T.A. s.r.l.**

Via E. Mattei – Frazione DIVISA
27020 MARCIGNAGO (PV)
Tel. +39.0382.929.855 - Fax +39.0382.929.150
Internet: *http://www.rta.it* - e-mail: *info@rta.it*

**R.T.A.**
**DEUTSCHLAND GmbH**

Bublitzer Straße, 34
40599 DÜSSELDORF (Germany)
Tel. +49.211.749.668.60-Fax +49.211.749.668.66
Internet: *http://www.rta-deutschland.de*
e-mail: *info@rta-deutschland.de*

**R.T.A. IBERICA**
**MOTION CONTROL SYSTEMS S.L.**

C/Generalitat 22, 1° 3°
08850 GAVA – BARCELONA (Spain)
Tel. +34.936.388.805-Fax +34.936.334.595
Internet: *http://www.rta-iberica.es*
e-mail: *info@rta-iberica.es*



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# INDEX



**WARNING: it is user RESPONSIBILITY to check that this manual refers to product model and version that will be used**

## 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:

- PLUS K series stepping motor drives in all their standard versions.
- Standard characteristics of special versions of PLUS 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).

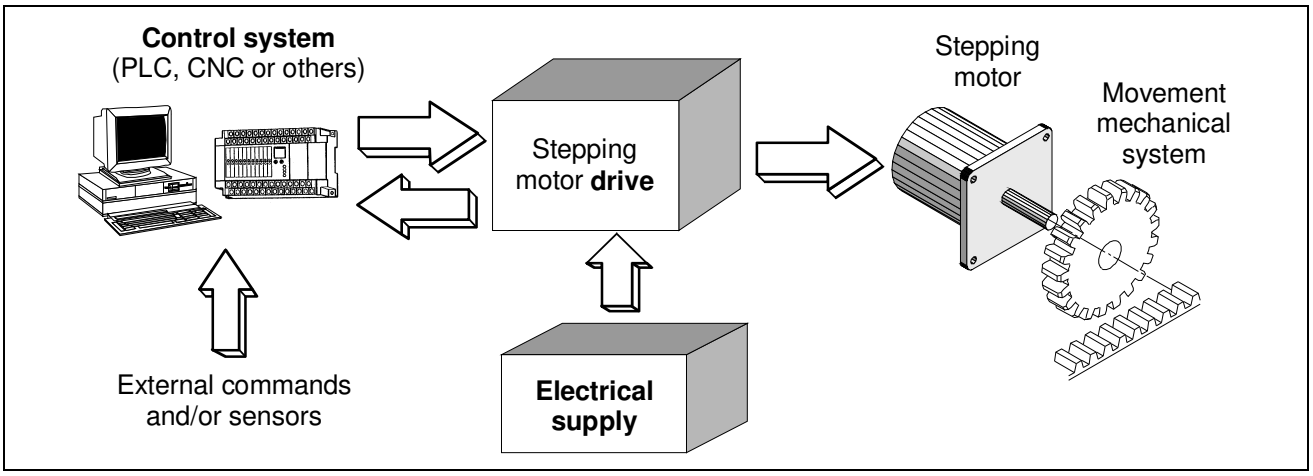


**Fig. 1**

- 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 identification code in chapter 3) are CE marked and comply with the following directives:

1) Low Voltage (2006/95/CE and further modification).
2) Electromagnetic Compatibility (2004/108/CE 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 PLUS 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 -** PLUS K series drives are suitable to drive two phases stepping motors with 4, 6 or 8 terminals. 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 -** PLUS K series drives are classified as protection degree IP20. 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 -** PLUS 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. 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 responsability 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 2004/108/CE, 2006/42/CE, etc.) before the conformity to those directives has been declared. Regarding 2004/108/CE 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 (see chap. 6) 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.

**2.11 -** In some case of drive failure, dangerous high voltage could appear at logic low voltage input and output terminals, even if this event is extremely rare. For this reason, from the point of view of evaluation of the machine safety during a single fault condition, the external control system, connected to these inputs, has to be considered potentially subjected to high voltage, unless an external separation is provided.

# 3 - GENERAL CHARACTERISTICS AND IDENTIFICATION

## 3.1 - DIMENSIONS

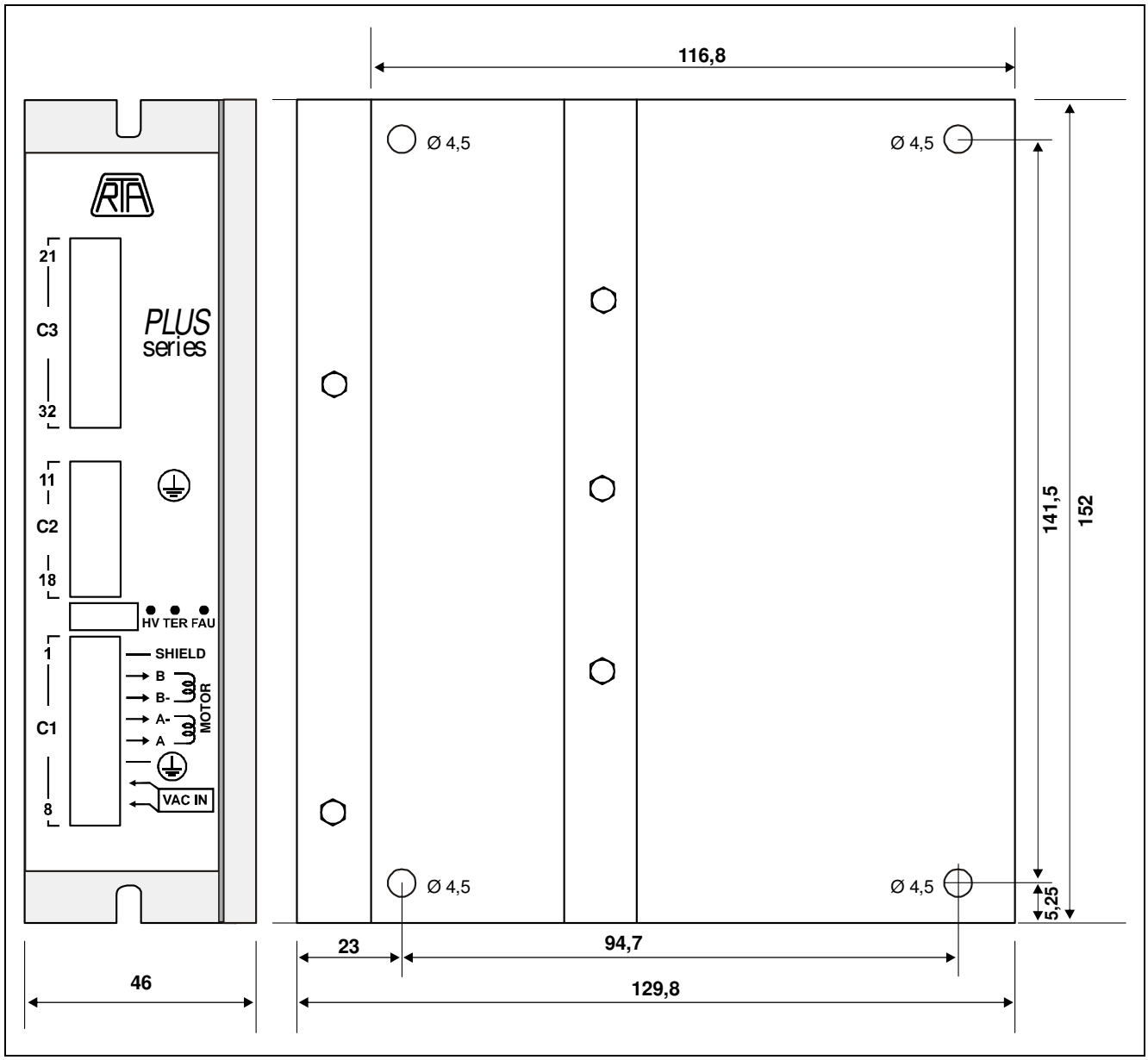


**Fig. 2 – Dimensions: all measures in mm.**

## 3.2 - IDENTIFICATION

The models identification of PLUS K series drives is as follows:

PLUS KX.Y

where:

X is **3, 4 or 5** 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:

$Vin_{MIN}$ = 5 Volt, $Vin_{MAX}$ = 24 Volt

For each input signal correspondent terminals numbers of connector C3 are indicated.

**32:** **COMMON OF INPUTS.**

**28, 29, 30, 31:** **SEL3, SEL2, SEL1, SEL0:** selection of one of the 16 programs that can be activated through the hardware input ST.

**27 (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).

**26 (EE):** **EMERGENCY STOP.** Stop of the execution of any instruction or command: immediate block of any program running.

**25 (ES):** **FREE RUN STOP.** Stop of the execution of a free run instruction (both with and without ramp).

**24 (I0):** **I0 INPUT.** Input terminal whose status can be read by a command or instruction.

**23 (I1):** **I1 INPUT.** Input terminal whose status can be read by a command or instruction.

**22 (PX):** **PROXIMITY input.** Used for zero research procedure.

**21 (I2):** **I2 INPUT.** Input terminal whose status can be read by a command or instruction.

### 4.2 - OUTPUTS

The outputs are considered ON when they are closed as regards to common of outputs (11 and 16). For each signal the correspondent terminals numbers of connector C2 are indicated.

**11, 16:** **COMMON OF OUTPUTS.**

**12 (FA):** **FAULT.** FA output is ON when drive is working correctly, OFF when it is blocked by a protection.

**13 (BS):** **BUSY.** BS output is ON when drive is executing an instruction, OFF when drive is waiting and ready to receive a command.

**14 (O0):** **O0 OUTPUT.** Hardware output whose status can be set by the user using a command or an instruction.

**15 (O1):** **O1 OUTPUT.** Hardware output whose status can be set by the user using a command or an instruction.

**17 (O2):** **O2 OUTPUT.** Hardware output whose status can be set by the user using a command or an instruction.

**18 (O3):** **O3 OUTPUT.** Hardware output whose status can be set by the user using a command or an instruction.

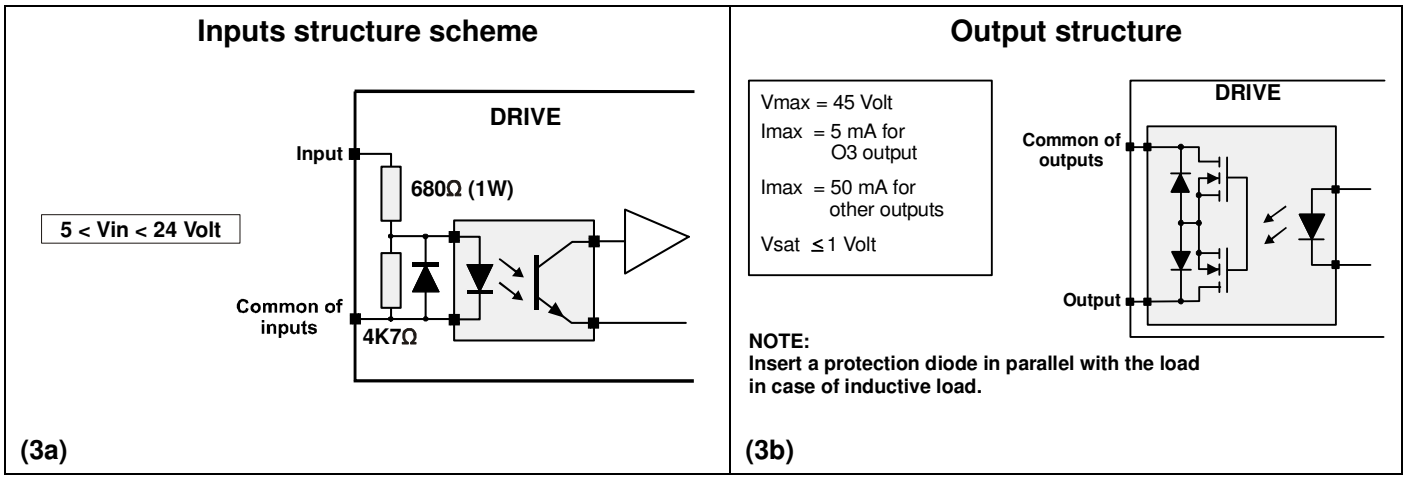


**Fig. 3 – Inputs and outputs scheme.**

### 4.3 - CONNETTORI RJ-12 (serial line RS485)

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

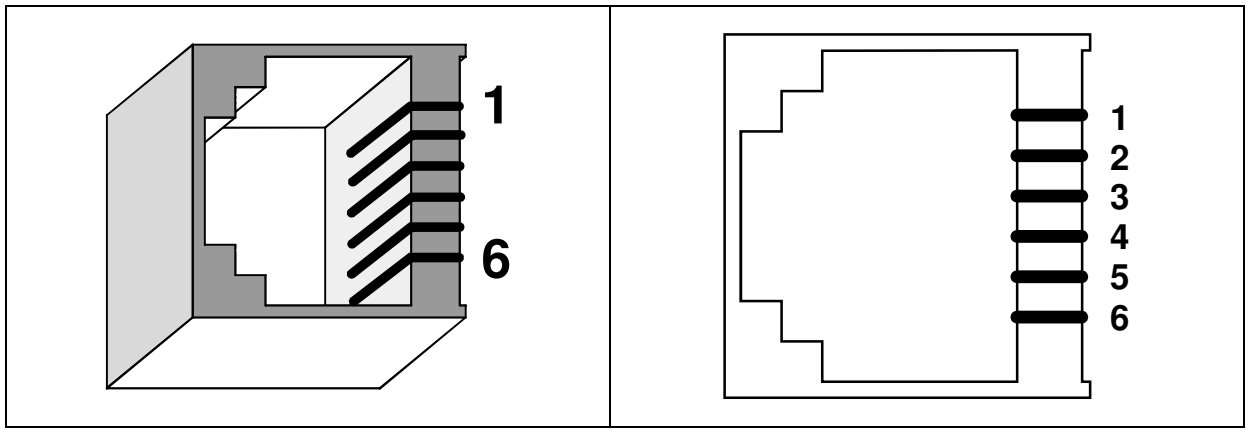


**Fig. 4 –Serial connector**

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.

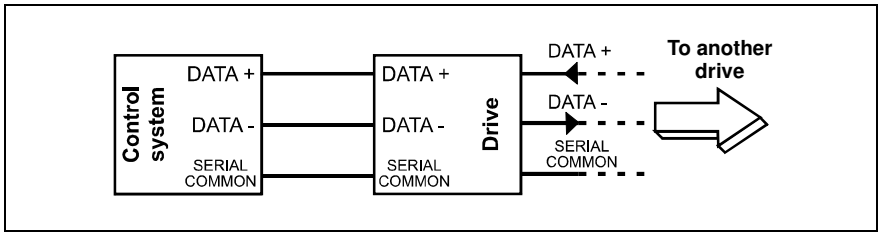


**Fig. 5 – Example of connection between control system and drive.**

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 phase lines driving the stepping motor winding. Drive power inputs are the two connection lines to $V_{AC}$**nom**. All connector C1 terminals are listed in the following Table 1.

| **TABLE 1** | |
|---|---|
| **CONNECTOR C1** | **DESCRIPTION** |
| 1 | SHIELD |
| 2 | Motor winding terminal B |
| 3 | Motor winding terminal B- |
| 4 | Motor winding terminal A- |
| 5 | Motor winding terminal A |
| 6 | GND |
| 7,8 | Power supply |

**5.2-** Earth terminal – Earth terminal is on the frontal panel in the middle of it and has to be electrically connected to earth (PE terminal of the machine in which the drive is installed).

**5.3-** The terminal indicated as GND is the point of motor-drive system that has to be connected to earth (PE terminal) in order to guarantee the correct operation of some drive protection systems. No other point at a different potential of logic circuit and of power circuit has to be connected to earth; in particular has not to be connected to earth transformer secondary winding. Shield of shielded cables of motor outputs must be connected to terminal 1 of C1 connector and shield of shielded cables of signal outputs mus be connected to PE with connection with the less possible length. Furthermore it is important to note that GND terminal is internally connected to terminal 1 of C1. See connection schemes of Fig. 8, 15 and 16.

**5.4-** Table 2 shows power inputs and outputs characteristics:

| **TABLE 2** | | **PLUS K3** | **PLUS K4** | **PLUS K5** |
|---|---|---|---|---|
| **$V_{AC}$ nom** | **(VOLT)** | from 28 to 62 | from 55 to 100 | from 28 to 62 |
| **$I_{NP}$ min** | **(AMP)** | 3.4 | 3.4 | 4.4 |
| **$I_{NP}$ max** | **(AMP)** | 6 | 6 | 8 |
| **Phase inductance** | **(mH)** | from 0.8 to 12 | from 1.2 to 12 | from 0.8 to 12 |
| **Dimensions** | **(mm)** | 152 × 129 × 46 | | |
| **Operating temperature** | | from +5°C to +40°C (see chap. 8.3) | | |

**5.5-** Definition of terms used in Table 2:

**$V_{AC}$ nom:** RMS value of alternate voltage at which the drive can be supplied.

**$I_{NP}$:** indicates nominal phase current (peak value), which flows in each motor winding, it can be measurable with motor turning at **low speed**. The drive provides an automatic current reduction when the motor is in hold condition (the reduction rate is equal to 50% for PLUS K3 and PLUS K4, the reduction rate is equal to 66% for PLUS K5). Phase current is calibrated during the test phase and can be set by the customer, choosing between four different values, by means of “current preset command” (see programmer’s manual).

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

# 6 - ⚠ SETTING AND SIGNALLING

**6.1-** PLUS 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 alert LED, connectors and labels on the case.

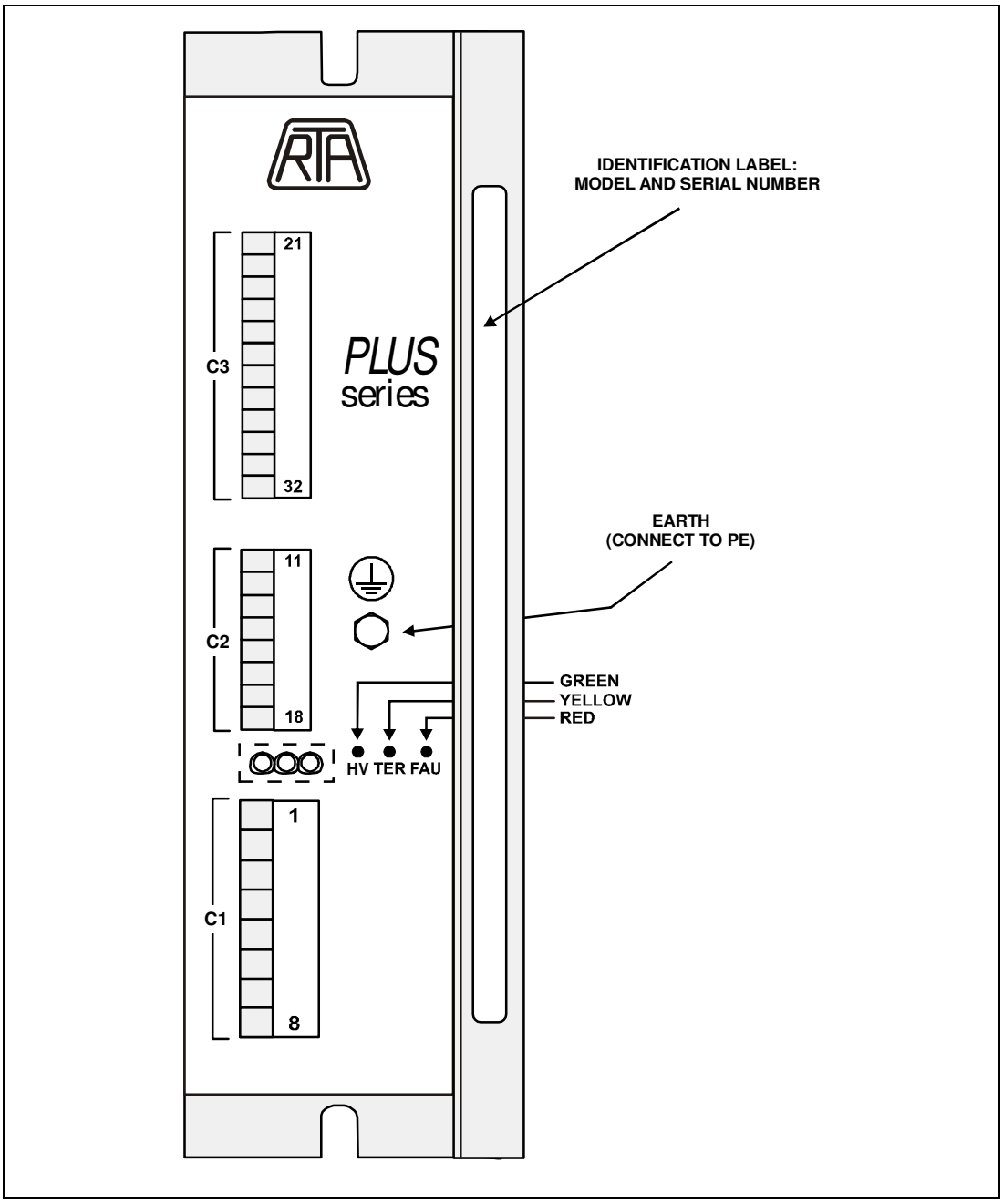


**Fig. 6 – Alert led and connectors.**

**6.3-** Fig. 7 shows the position of DIP-SWITCH located on the high side of PLUS K series drives.

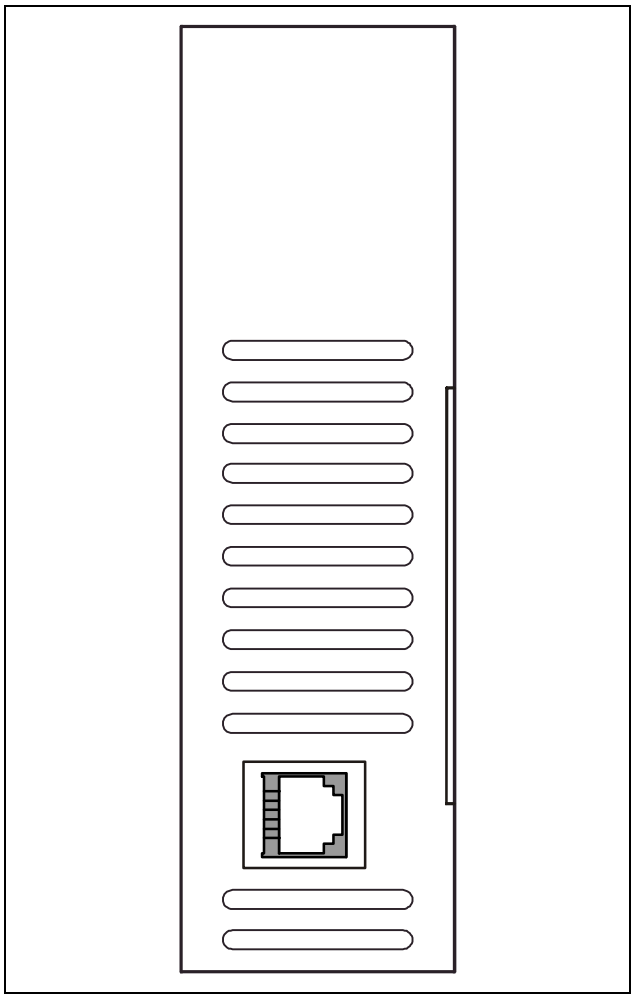

**Fig. 7 – Serial connector (PLUS K series drives high side view).**

**6.4-** The following list shows the meaning of the alert LEDs.

**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:

a-Thermal protection (if LED TER is ON).
b-Max or Min supply voltage (if LED HV is OFF).
c-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.

BLINKING:

- 1 FLASH = Min/max voltage protection memory
- 2 FLASHES = Thermal protection memory
- 3 FLASHES = Short circuit protection memory
- 4 FLASHES = Motor cable not connected (active with motor in stop state only)

All protection circuit and alarm reset itself when the alarm source vanish. Memory must be reset by removing power supply voltage.

# 7 - ⚠ DRIVE EXTERNAL CONNECTIONS

**7.1-** Design the power transformer: the power of transformer has to be higher than the sum of the power requested from drive and motor (total power). This one can be calculated as 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 estimate drive and motor losses; in this case an over-dimensioning of the supply elements proportional to the inaccuracy is recommended. To get more accurate information, contact R.T.A. and describe the particular application. Obviously if a single power supply is used for more than one drive, the total power is equal to the sum of the single drive powers

**7.2-** Transformer must meet the following requirements:

- Supply the correct voltage through a transformer secondary winding. The $V_{AC}$ voltage value is intended as measured at secondary terminals in no load condition and with primary voltage equal to the nominal value. Maximum voltage drop at full power load must be less than 5%.
- Ensure the galvanic insulation between the drive circuits and the main. **Remember that direct connection of drive circuits to the main is strictly forbidden. The use of autotransformer is strictly forbidden.**
- Ensure the galvanic insulation between the drive circuits and all other circuits of the same machine. **This means that the drive dedicated transformer secondary has to be used exclusively for the drive.**

**7.3-** The use of one secondary winding for more drives (max 3 drives) is allowed only if the total power required by the drives is less than 600VA. In any case, two fuses (F1 and F2 showed in Figure 8) for each drive must be used.

**7.4- Branch circuit protection fuses F1 and F2 (see Fig. 8) must be 10 Amp, at least 250 Volt with $I^2t$ between 150 $A^2s$ and 400 $A^2s$ (for example Cooper Bussman model KTK-R-10 or Littelfuse 215010.P).**

**7.5-** The cross-section area of conductors used in power supply circuit must be chosen according with power dimensioning (see 7.1). The cross-section area of the four shielded conductors connecting motor to the drive must be chosen with regard to the nominal current which has been set in the drive.

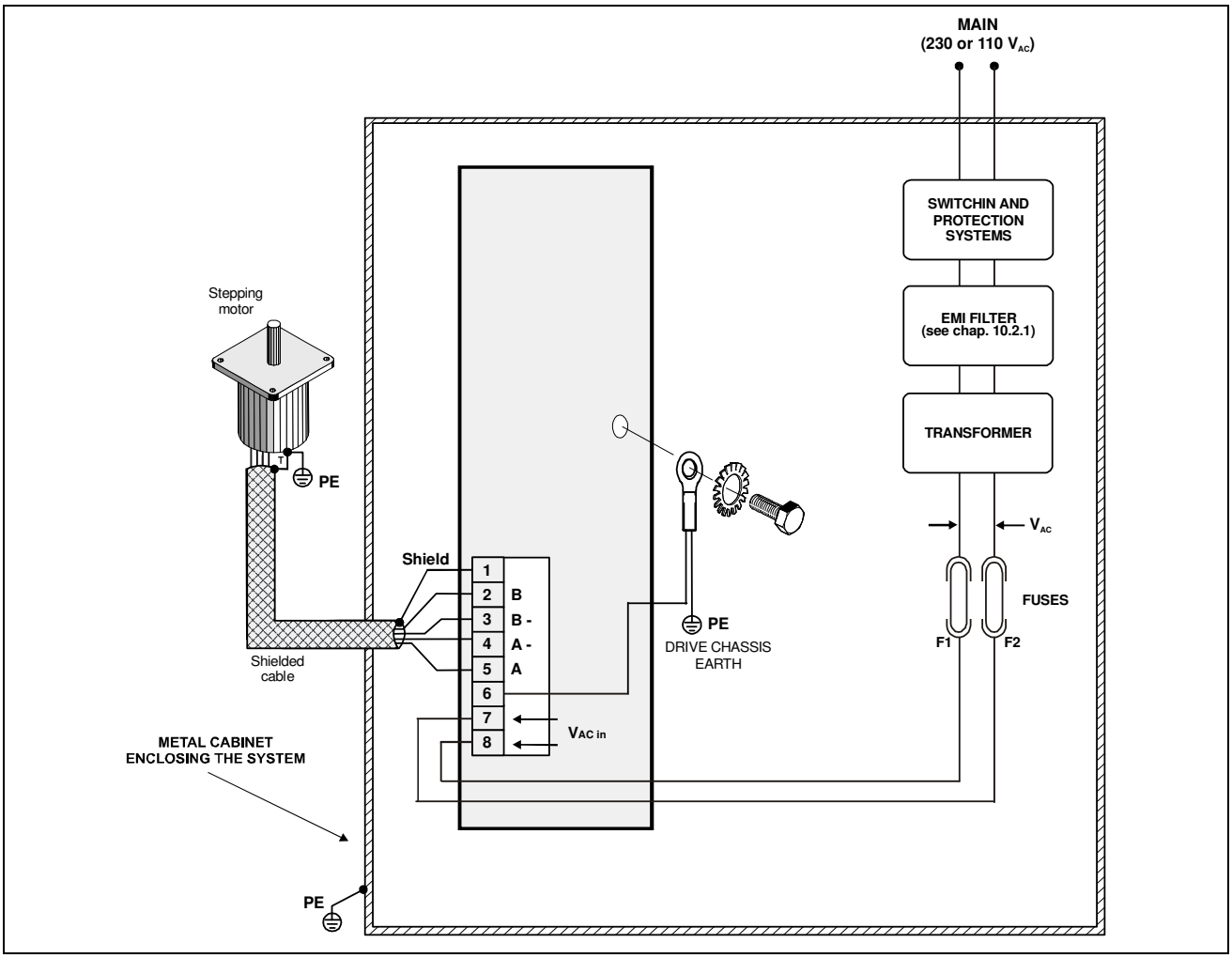


**Fig. 8 – Drive external connections scheme.**

# 8 - ⚠⃠ INSTALLATION AND ENVIRONMENT

All products described in this manual are subjected to the following characteristics:

**8.1-** 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.

**8.2-** Direct connection with the main is not allowed. Transformer separation is mandatory.

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

- **Environment conditions class 3K3** (IEC 721-3-3): it includes a working temperature from +5°C to +40°C and relative humidity from 5% to 85% non condensing.
- **Pollution degree 2**: it includes 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 system or suitable case have to be used.

**8.4-** Storage environment limits with drive in its original packaging:

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

**8.5-** The drive generates some amount of heat (see chap. 7.1). This must be considered during the global electrical cabinet design. In order to ease air flowing around 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 on the left and on 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 the control system and application requirements.

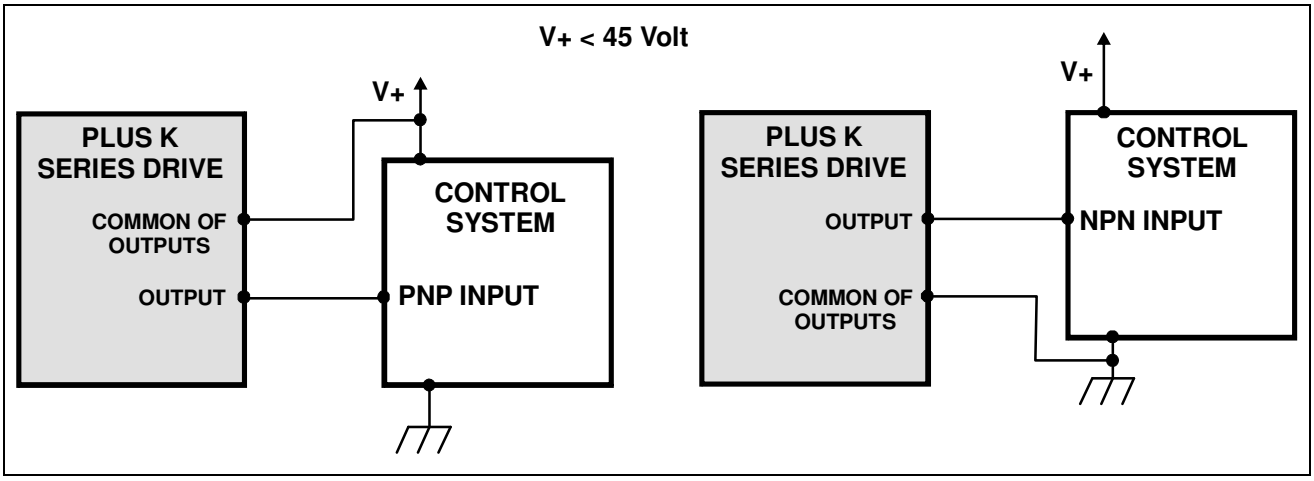


**Fig. 9 – Electric connection between a PLUS K logic output and an input of a control system operating at V+ voltage.**

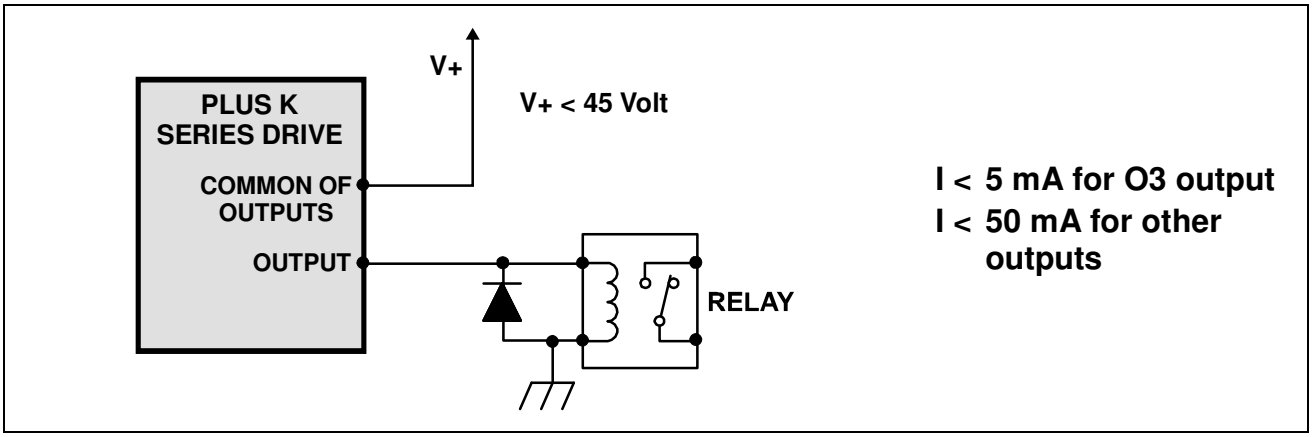


**Fig. 10 - Driving a micro-relay by means of a PLUS K logic output.**

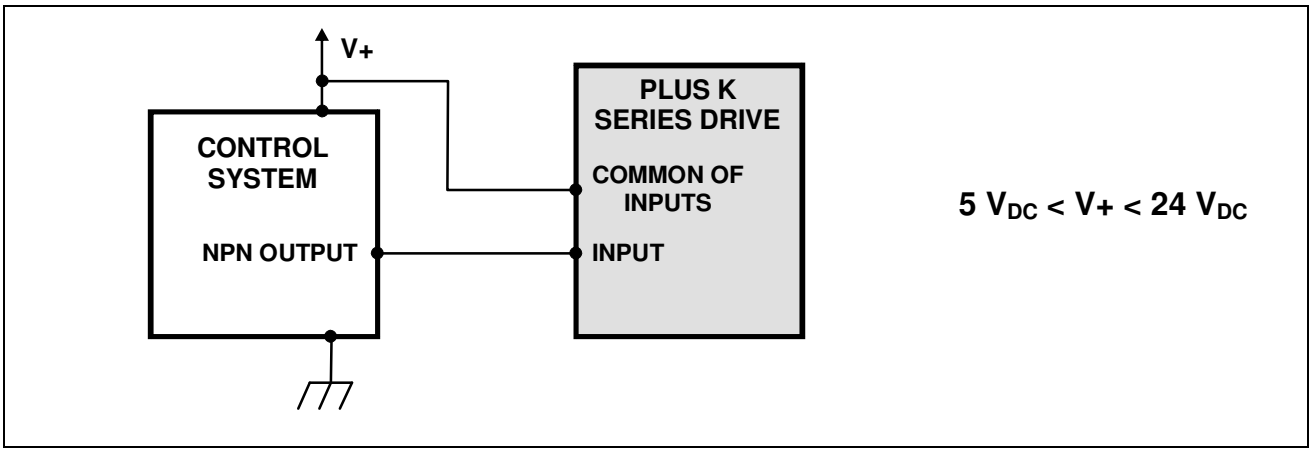


**Fig. 11 - Driving a PLUS K logic input from a control system with a NPN open collector output.**

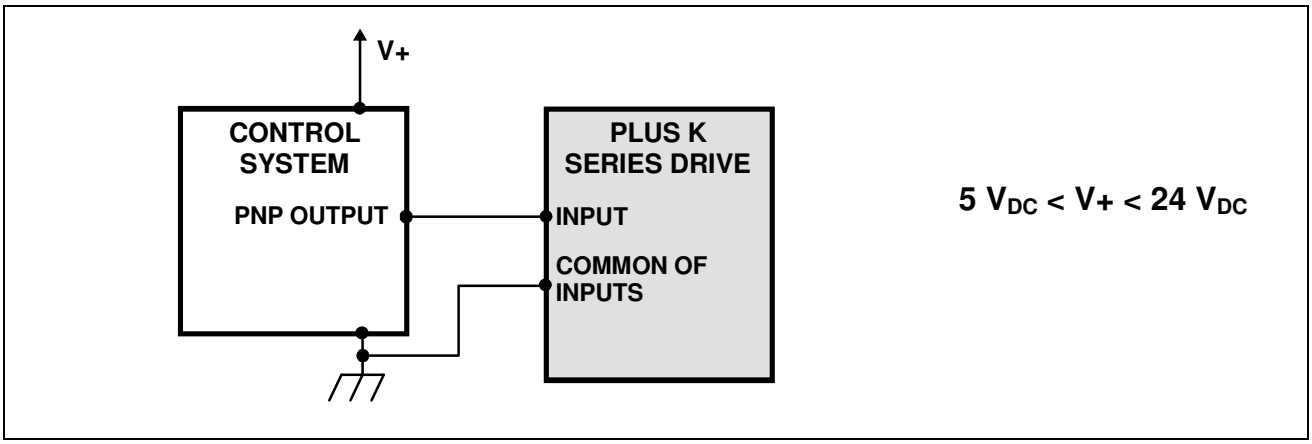


**Fig. 12 - Driving a PLUS K logic input from a control system with a PNP output.**

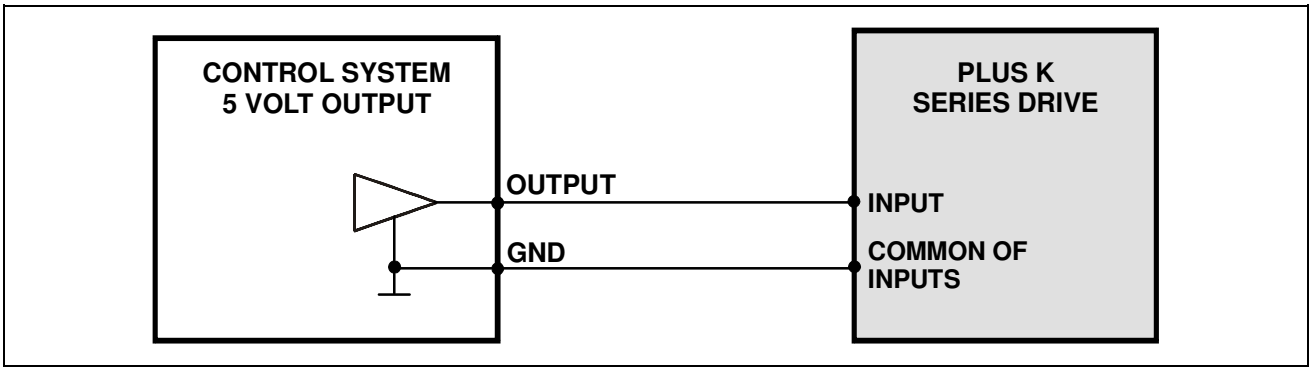


**Fig. 13 - Connection example with control system with 5 Volt TOTEM-POLE (PUSH-PULL) output.**

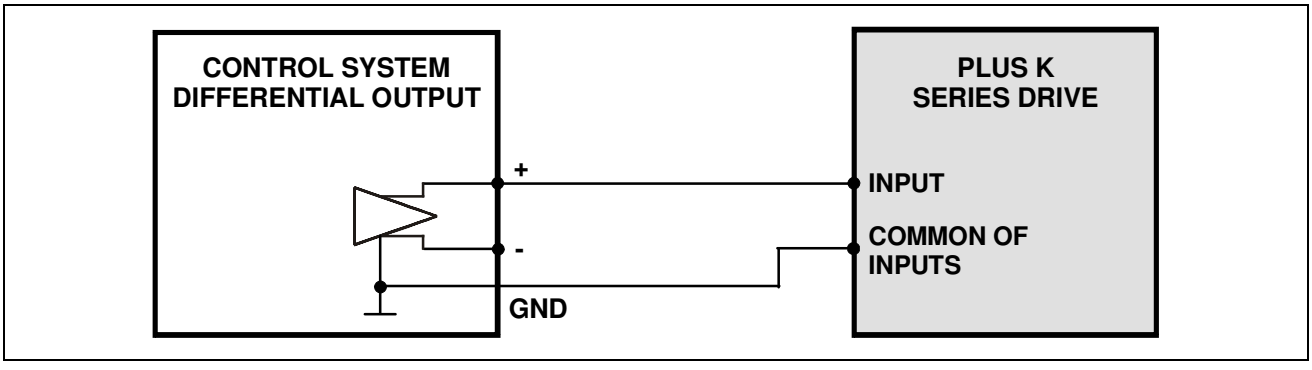


**Fig. 14 - Connection example with control system with DIFFERENTIAL output (or LINE DRIVER or RS422).**

# 10 - ⚠⃠ APPLICATION NOTES AND EMC

**10.1-** Drive (or drives) power supply can not be used to supply other machines.

**10.2-** Electromagnetic compatibility (directive 2004/108/CE). PLUS K 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 with the above and other possible specific directives.

**10.2.1-** 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 PLUS K series drive terminal 1. 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.
- 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 fig. 11.
- Location of motor-drive set in the same cabinet shielded from electromagnetic interferences.
- Use a power supply transformer with a metallic shield, connected to earth, interposed between primary and secondary winding.
- Interpose a filter between the transformer primary and the main (220 or 380 $V_{AC}$). The filter is used to reduce conducted electromagnetic interferences. Filter characteristics in a specific installation depend on the following factors:
  - The specific standard limits the machine (in which drive is used) is subjected to.
  - Power level of application (voltage and current setting of the drive).
  - Presence of other filtering systems in the general electrical machine connections.

  In any case, the following filter types are recommended:
  - CORCOM VDK series for single-phase power supply.
  - CORCOM FCD10 series for three-phase power supply.

  Different types of these series differ for current rating. Choose the specific model according to the power level of the specific installation.
- Consider that the position of the filter in the system is extremely important: no electromagnetic coupling must take place between electromagnetic source and circuits (and lines). To this end, filter and main must be kept as close as possible.
- All earth connections mentioned above have to be realized with the less possible inductance.

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

- Use shielded cables with shield connected to PE of machine, with connection with the less possible length.
- Keep signal cables separate from power cables. In particular keep signal cables separate from motor output cables.
- Carefully verify logic level compatibility when interfacing drive with control system.

**10.2.3-** Following these procedures is essential to realize an installation which complies with the requirements of 2004/108/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.

**10.2.4-** 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 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.

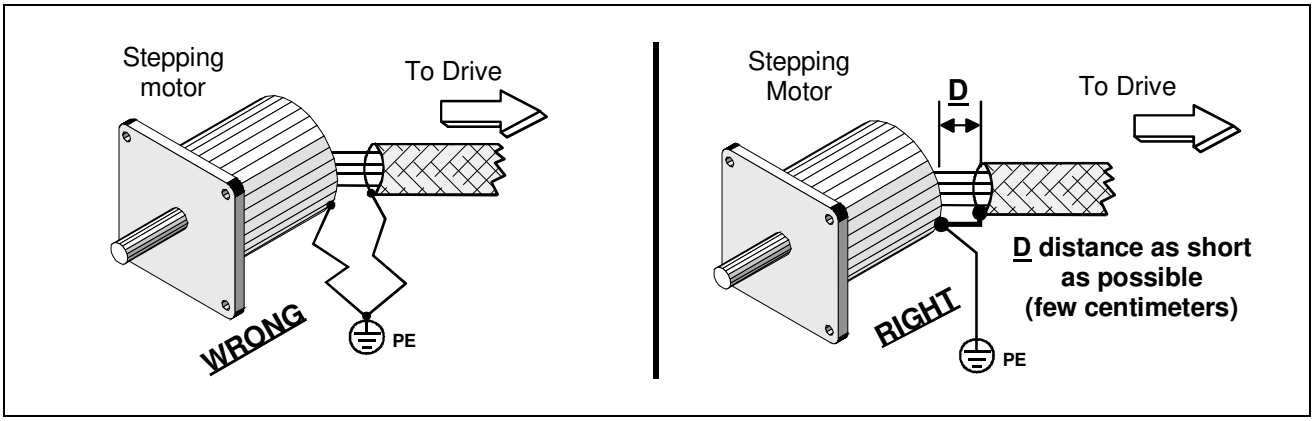


**Fig. 15 – Shielded connection at stepping motor side.**

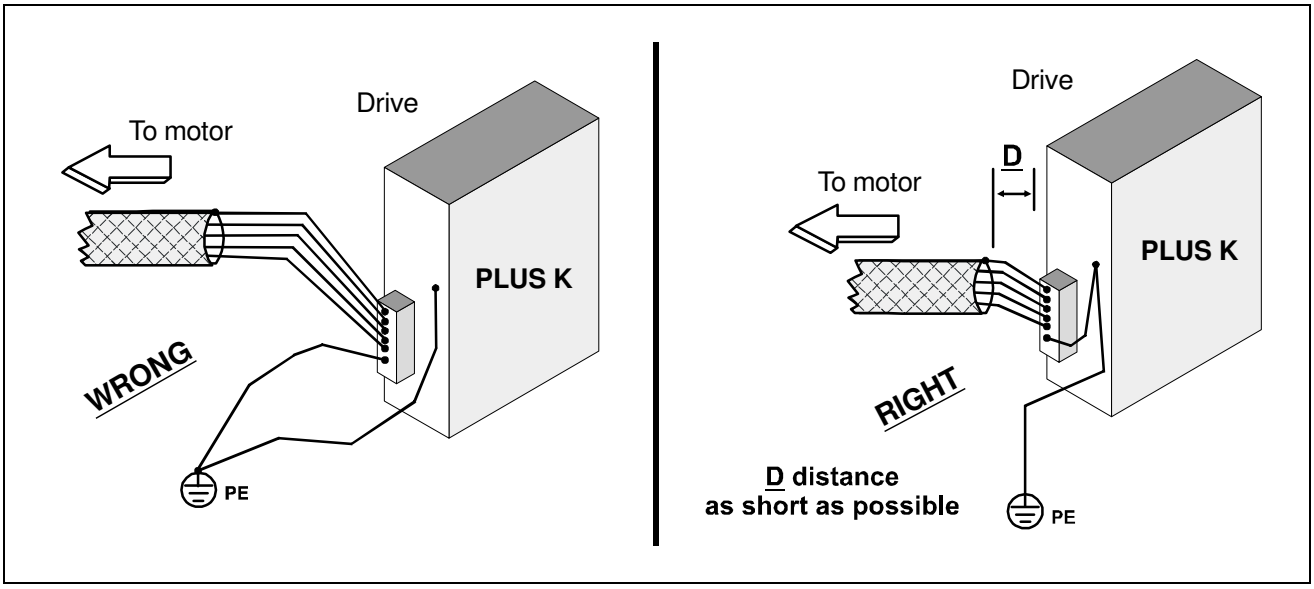


**Fig. 16 – Shielded connection at drive side.**

## 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 (see also chap. 4.2.2.4 of programmer's manual) 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.