

MDL Users Manual

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MDL

A Linear Four Quadrant Motor Drive



USERS MANUAL

Adress
Knipplagatan 6
414 74 GÖTEBORG
Sweden

Telefon
Nat 031 - 12 17 30
Int +46 31 12 17 30
e-mail info@punos.se

Fax
Nat 031 - 12 58 46
Int +46 31 12 58 46

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Photo: MDL 2 DE

1 Introduction

MDL is a linear four quadrant motor drive, designed for use with PM-servomotors in qualified applications. MDL is linear in contradiction to switch mode drives. This gives the motor a low noise level and avoids problems at other interference sensitive equipment such as microcomputers and similar.

MDL has in the standard version solder lugs where adjustment components are fitted. Through a suitable selection of components the following functions can be achieved or adjusted: tacho interfacing, armature feedback, RxI compensation, variable control of motor current/torque, current limit etc. As an option these adjustment components can be fitted on a plug-in "personality module" to make interchangeability and service easier.

The Set Speed input is designed as a differential input, which gives less wiring interference problems.

The current limit can be set locally on the board or externally. Accordingly it is possible not only to control the speed with a set current limit but also to control the motor torque with a set speed limit. The current limit makes the MDL short circuit protected against shorts across motor terminals and either one of the motor terminals to the +supply line. Shorts between the -supply line and motor terminals are not allowed!

There are two board versions of MDL. The MDL 2 DC (half euro board size) is intended for minimum space requirements and the necessary heat sinks of the power transistors has then to be taken care of by mounting the unit on a suitable metal surface.

MDL 2 DB is a standard Euro board and has necessary heatsinks fitted.

MDL 2 DE and MDL 2 AE are encapsulated plug in units which can be used as stand alone units. MDL 2 AE has built in power supply for connection to 230V 50 Hz mains.

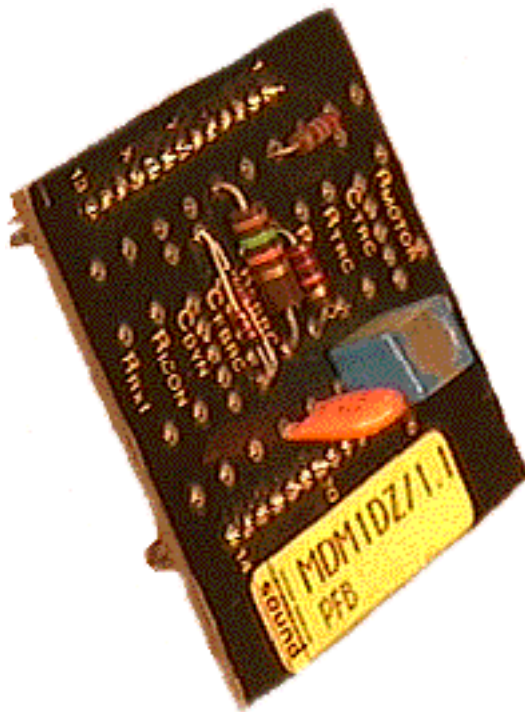


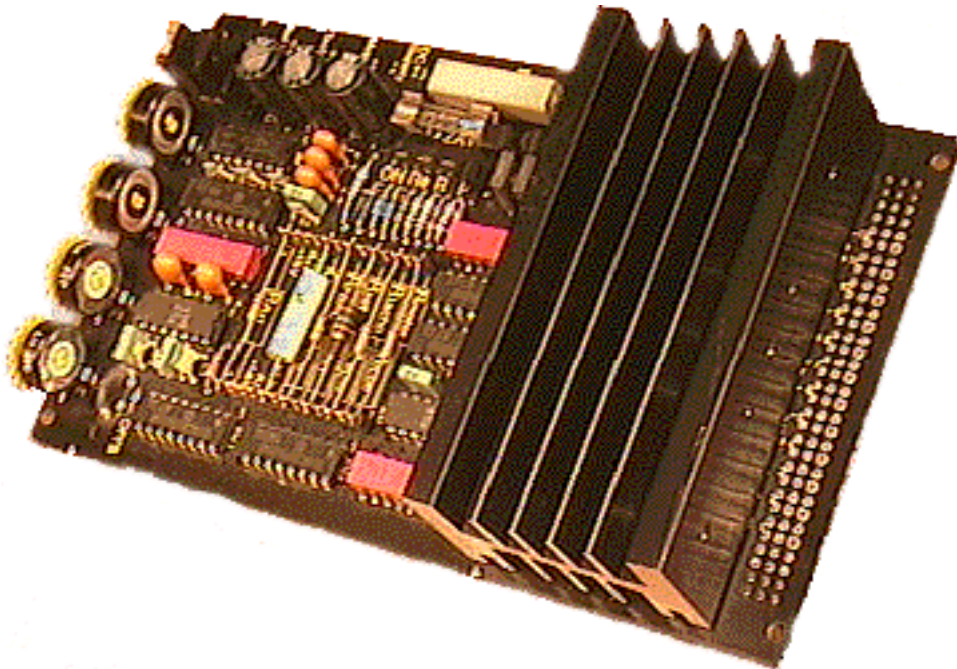
Photo: MDM

1.2 Features

- I_{\max} 2 A with optional dynamic current limit up to 4 A.
- Supply voltage range 10 V to 30 V.
- Tacho or armature feed back.
- Linear four quadrant drive - no interference to adjacent circuits - no chopper sound.
- Differential Set Speed input.
- Optional plug in "personality module" which can contain dynamic current limits, compensation filters, time constants etc.

The MDL is designed for use with most types of PM-DC-motors with a maximum voltage of 24 V and continuous current to 2 A. To obtain good dynamic properties the drive must be trimmed to each application through changing some resistors and capacitors on the PC-board.

Photo: MDL 2 DB



2. How to get running

This example is given for one only of the different available MDL types. It should be easy to apply also for other types.

Supposition: You have a MDL 2 DB which you intend to connect to a 12 V 1 A PM-DC-motor. You want to use armature feedback and not tacho feedback.

- 1 Set the trim-potentiometers according to fig 1.1.

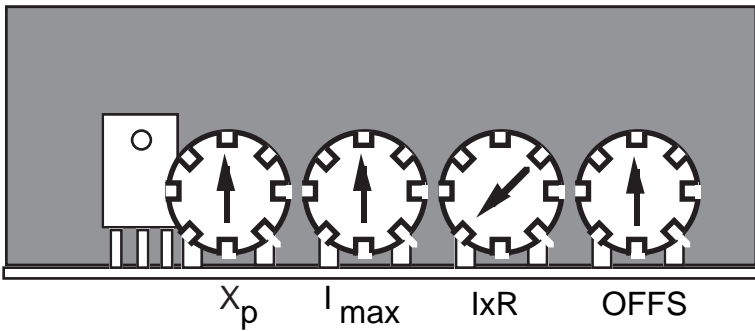


Fig 1.1

- 2 Connect your motor, power supply and set the Speed pot according to fig 1.2 on the following page. Connect also the two 10 k Ω resistors shown.

- 3 Switch on your power supply. Direction and speed depending on the speed pot.

- 4 Adjustments.

Adjust X_p . CCW setting gives slow response and CW causes hunting.

Adjust I_{max} . Fig 1.3 shows roughly the I_{max} pot scale in A.

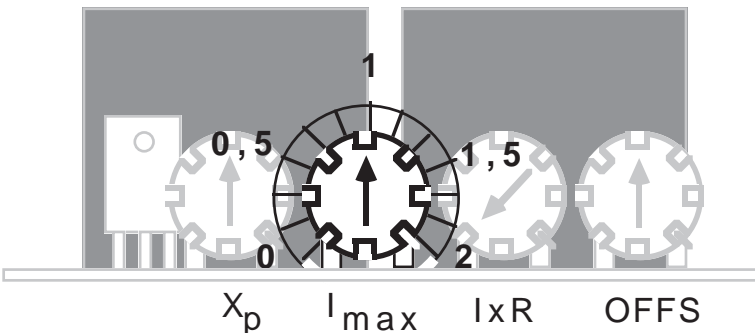


Fig 1.3 I_{max} pot scale.

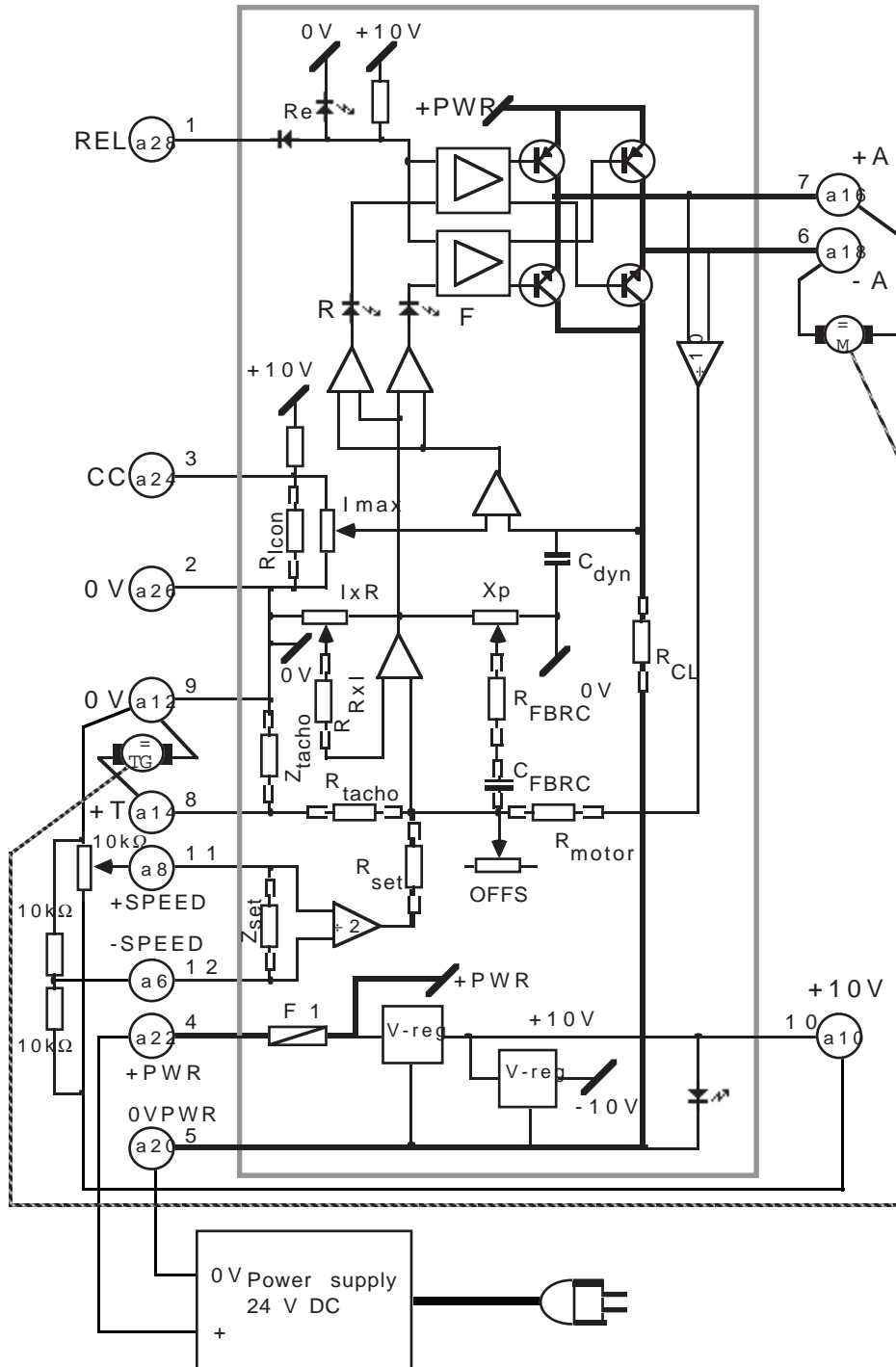
A better method to adjust the motor current is to connect a A-meter in series with the motor and adjust I_{max} .

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Adjust RxI. CCW setting gives poor load regulation. CW causes instability and hunting.

Adjust Offset to give zero speed when the speed input is zero.

5 Your motor is now running but its performance under different conditions can considerably be improved by correctly adjusting the MDL drive so please read the following pages.



3 Electrical

The MDL is designed to operate according to the following basic principles.

The Set Speed input is compared with the speed feedback being either the motor EMF or the tacho generator of the motor. The difference (speed error) is amplified and results in a Set Current signal. The actual momentaneous motor current which is monitored with a resistor is compared with the Set Current Limit signal (I_{max} pot.) giving an Actual Current signal. This is then compared with the Set Current signal thus controlling the output H-bridge. The lower branches of the H-bridge are used to control the value of the motor current by burning the surplus power. The MDL is equipped with four LEDs which gives following information:

- Green **ON** Power on
- Yellow **RE** Release. Motor current off.
- Red **F** Forward. Current limit in forward direction.
- Red **R** Reverse. Current limit in reverse direction.

3.1 Input circuits

The Set Speed input is designed as a differential input in order to give a great freedom of choice of input signals and to give a good interference immunity. If you connect the -SPEED input to the 0V of your signal you can control the speed in the forward direction by varying the +SPEED input from 0V to e.g. +10V. By connecting the input the other way round i. e. +SPEED to 0V and -SPEED to a 0 to +10V signal the motor runs in the reverse direction. If the -SPEED is connected to 0V of a signal and +SPEED is connected to the same signal which is varied between +10V and -10V the motor speed can be controlled in both directions. Fig 3.1 shows a number of possibilities to connect the SET SPEED input.

Fig 3.1 Set Speed input connections.

	External Current Limit	Speed Control + Direction	Speed Control - Direction	Speed Control ± Direction
Potentiometer				
Voltage				
Current				

A current limit input gives the user a possibility to set the current limit with an external signal. The I_{max} potentiometer is then used to set an upper limit and the external signal allows control of the range 0 to I_{max} . As can be seen in figure 3.2 the signal can be an external potentiometer, voltage 0 to 10 V or current 0 to 20 mA.

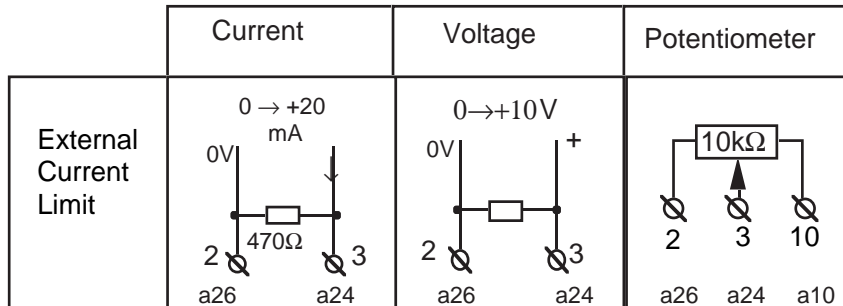


Figure 3.2 CURRENT LIMIT input.

In order to run the motor the REL input must be linked to 0V. When the REL input is open the motor current is disabled and the motor shaft is no longer controlled by the MDL. The REL input can be used with either a simple SPST switch or a transistor controlled by some other system.

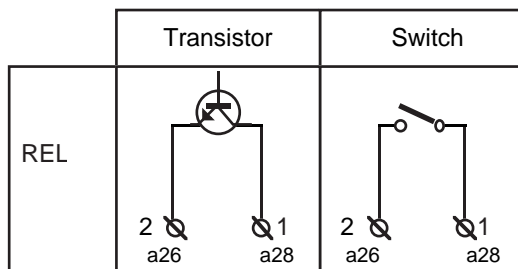


Figure 3.3 The REL input.

3.2 Output circuit

The output circuitry of the MDL is a complete H-bridge where the lower branches of the bridge are used to control the value of the motor current by burning the surplus power. The motor current is monitored by a current measuring resistor connected between the lower end of the bridge and the 0 V supply. As long as all current is flowing through the current resistor the MDL is short circuit protected. But a short between any motor terminal and 0V bypasses the resistor and thus omitting current control. Such a short might therefore cause damage to the MDL. Though the used output transistors have high current capacity (8 - 12 A) the linear design of the MDL limits the allowed currents to values which are determined by the temperature rise in the heat sink.

3.3 Adjustments

The MDL is equipped with following potentiometers:

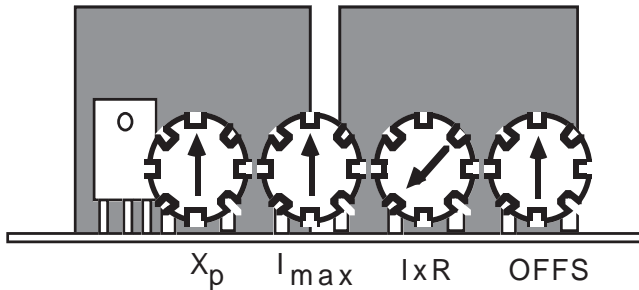


Figure 3.4 Adjustment potentiometers.

X_p

Feedback stiffness, is adjusted as a compromise between fast and soft response, upon load- or setpoint changes. A too high setting causes hunting and a too low results in a slow response. Changing of the adjustment range is achieved by altering R_{fbrc} and C_{fbrc} . For details see the following.

I_{max}

Current limit. When the motor current is limited by the I_{max} setting one of the red LEDs goes on. There are two red current limit LEDs, one for each direction. They are marked **F**, forward and **R**, reverse. The basic method to adjust the I_{max} is to load the MDL output so that the desired current flows and then adjust the I_{max} potentiometer until the red LED indicates current limit. In practice an easy way to adjust I_{max} is to connect an A-meter across the motor terminals, thus shorting the output, and adjust the I_{max} potentiometer until the desired current is read on the A-meter. As can be seen below the current limit is depending on the values of R_{CL} and R_{ICON} .

RxI

Compensation of the resistive armature voltage drop. Applicable only when armature feedback is used. When no tacho feedback signal is available and armature feedback is used the resistive voltage drop across the armature causes the speed to be more or less dependent of the load. The RxI compensation is adjusted from the CCW end up until no more change in speed occurs although the load is varied between min. and max. A too high setting causes hunting.

OFFS

Offset. Adjustment to reach zero speed at zero SPEED input. May also be used as on board SET SPEED potentiometer.

As the MDL is intended to be able to handle high demands of dynamic response it is necessary to individually for many applications to adjust more parameters than the above mentioned potentiometers can do. Several components are therefore soldered on standoffs on the board in order to be available for changing. On the board and in diagrams are the below listed abbreviations used for these components. As an option the adjustment components can be fitted on a plug-in personality module.

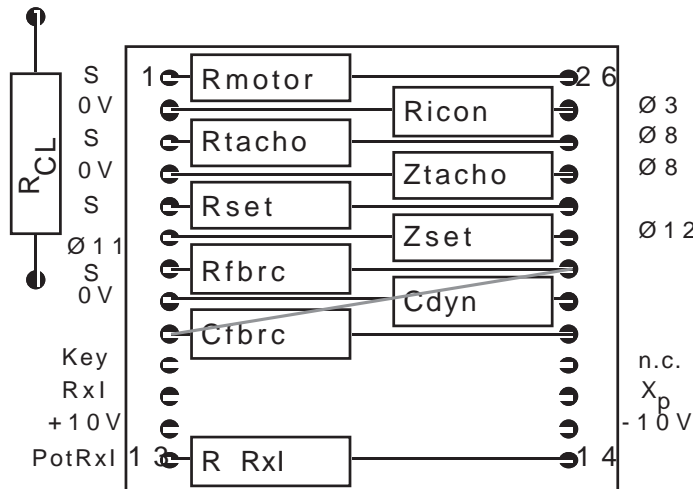


Figure 3.5 Adjustment components.

3.3.1 Current limit

R_{CL} Shipped with $R_{CL} = 0,33 \Omega$. Calculation : $\frac{0,7}{I_{max}} = R_{CL}$

3.3.2 I_{max}

is the current limit when I_{max} potentiometer is max. CW.

MDL 2 DB has an extra input to decrease the current limit. See figure 3.2.

3.3.3 C_{DYN}

Not included when shipped.

C_{DYN} causes the current limit to be delayed, and the current may a short while be 2 times the I_{max} setting. Increased C_{DYN} value lengthen the Extra-Current state. To make C_{DYN} to influence, I_{max} must be reduced by R_{ICON} or by the current control input.

3.3.4 R_{ICON}

Not included when shipped. Determines I_{CL} . See figure below.

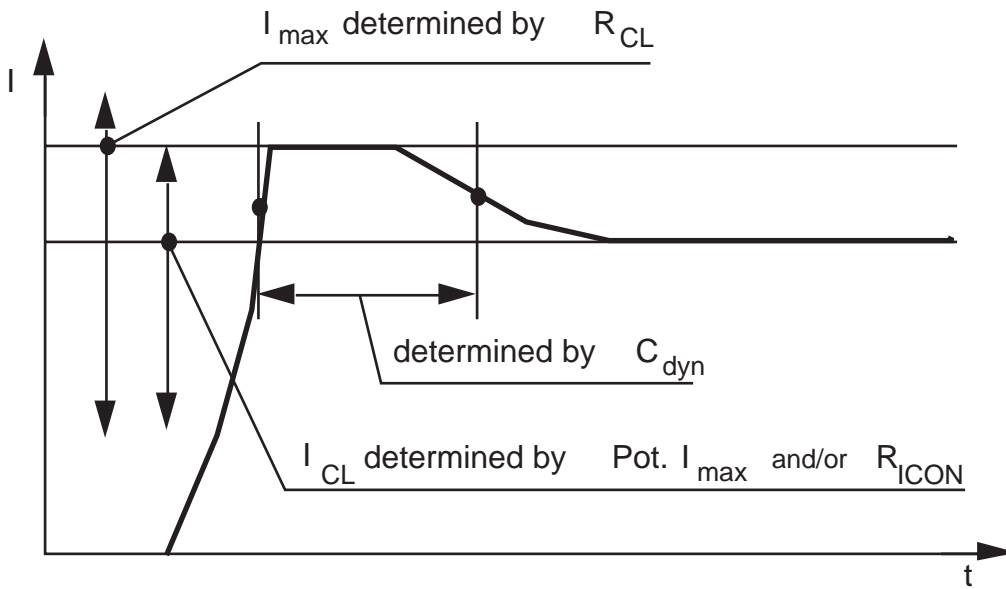


Figure 3.6 Current control.

3.3.5 R_{motor}

Shipped with 2,2 k Ω . Not to be used when tacho feedback is used.

Calculation :
$$\frac{U_{11-12}}{2 \cdot R_{set}} = \frac{U_{motor}}{10 \cdot R_{motor}}$$

where

U_{11-12} is the SET SPEED input voltage across terminals 11 and 12.

U_{motor} is the rated motor voltage or the motor voltage at the highest speed the motor is to be used.

$$1 \text{ k}\Omega < R_{motor} < 100 \text{ k}\Omega$$

Or by inserting values as shipped and SET SPEED input 10 V:

$$\frac{10}{2 \cdot 15 \cdot 10^3} = \frac{U_{motor}}{10 \cdot R_{motor}} ; R_{motor} = 300 \cdot U_{motor}$$

A higher value of R_{motor} will give a higher motor speed.

3.3.6 R_{RI}

Shipped with 12 k Ω . Not to be used when tacho feedback is used.

$$\text{Calculation : } \frac{U_{11-12}}{2 \cdot R_{\text{set}}} = \frac{U_{\text{motor}}}{10 \cdot R_{\text{motor}}}$$

where R_{motor} is internal resistance of the motor and U_{motor} the motor voltage at max. desired SET SPEED.

$$10 \text{ k}\Omega < R_{\text{RI}} < 1 \text{ M}\Omega$$

Or by inserting values as shipped:

3.3.7 R_{imotor}

$$R_{\text{imotor}} = \frac{100 \cdot 0,33 \cdot 2,2 \cdot 10^3}{12 \cdot 10^3} = 8,6 \Omega$$

As shipped the MDL is suitable for motors with R_{imotor} up to 8,6 Ω .

A higher value of R_{RI} will give a lower RI-compensation.

The RxI compensation is set by the trimmer RxI in that way that the speed will be as constant as possible at variable loads. The calculations holds true for a fully CW setting of the RxI potentiometer. However the above calculation has to be true in order to give enough compensation. Replace R_{RI} if necessary.

3.3.8 R_{set}

Shipped with 15 k Ω .

$$\text{Calculation : } \frac{U_{11-12}}{2 \cdot R_{\text{set}}} = \frac{U_{\text{motor}}}{10 \cdot R_{\text{motor}}}$$

10 k Ω < R_{set} < 100 k Ω . Start calculation by setting R_{set} to 2,2 k Ω .

Or by inserting values as shipped and SET SPEED input 10 V:

$$\frac{10}{2 \cdot R_{\text{set}}} = \frac{U_{\text{motor}}}{10 \cdot 2,2 \cdot 10^3} ; R_{\text{set}} = \frac{1,1 \cdot 10^5}{U_{\text{motor}}}$$

A higher value of R_{set} will give a lower motor speed.

3.3.9 R_{tacho}

Shipped with 10 k Ω . Not to be used when armature-feedback is used.

$$\text{Calculation : } \frac{U_{11-12}}{2 \cdot R_{\text{set}}} = \frac{U_{\text{tacho}}}{R_{\text{tacho}}}$$

$$1 \text{ k}\Omega < R_{\text{tacho}} < 100 \text{ k}\Omega$$

Or by inserting values as shipped and SET SPEED input 10 V:

$$\frac{10}{2 \cdot 15 \cdot 10^3} = \frac{U_{\text{tacho}}}{R_{\text{tacho}}} ; R_{\text{tacho}} = 3000 \cdot U_{\text{tacho}}$$

A higher value of R_{tacho} will give a higher motor speed.

U_{tacho} is the tacho voltage at the speed the motor is to have with SET SPEED input at the level it is calculated to have.

3.3.10 R_{FBRC}

Shipped with 100 k Ω .

$$\text{Calculation: } R_{\text{FBRC}} = 5 \cdot R_{\text{RI}}$$

$$10 \text{ k}\Omega < R_{\text{FBRC}} < 1 \text{ M}\Omega$$

The dynamic stability will be trimmed using potentiometer X_p as a compromise between accuracy and reaction time for compensation of disturbances in speed. If the range of the potentiometer is insufficient, R_{FBRC} and C_{FBRC} must be changed. The calculation of R_{FBRC} has to be done together with the calculation of C_{FBRC} .

3.3.11 C_{FBRC}

Shipped with 330 nF.

$$\text{Calculation: } R_{\text{FBRC}} \cdot C_{\text{FBRC}} = t_{\text{FBRC}}$$

$$22 \text{ nF} < C_{\text{FBRC}} < 300 \text{ nF}$$

Higher C_{FBRC} , longer t_{FBRC} , gives slower reaction in the control, but a too small C_{FBRC} , shorter t_{FBRC} , may cause the system to start "hunting". A longer time constant is valid for higher load inertias.

t_{FBRC} should be within the following limits

$$33 \text{ ms} < t_{\text{FBRC}} < 10 \text{ s}$$

Inserting values as shipped:

$$100 \cdot 10^3 \cdot 330 \cdot 10^{-9} = 33 \cdot 10^{-3} \text{ s} = 33 \text{ ms}$$

3.3.12 R_{TRC}

Shipped without. Not to be used at armature feedback.

Calculation: R_{TRC} & R_{tacho}

See C_{TRC} .

3.3.13 C_{TRC}

Shipped without. Not to be used at armature feedback.

Calculation: $R_{TRC} \cdot C_{TRC} = t_{TRC}$

$10 \text{ ms} < t_{TRC} < 200 \text{ ms}$

If overshoot needs to be reduced and the step response improved an RC-network parallel to R_{tacho} , consisting of R_{TRC} in series with C_{TRC} can be attached. C_{TRC} is selected for the run condition at normal load - the more load inertia, the bigger capacitance.

3.4 Armature feed back, calculations.

- 1 Calculate R_{CL} .
- 2 Calculate C_{DYN} and R_{ICON} if delayed current limitation is to be used.
- 3 Remove R_{tacho} .
- 4 Calculate R_{motor} .
- 5 Calculate R_{set} .
- 6 Calculate R_{RI} .
- 7 Do test runs. Adjust potentiometers I_{max} , RxI and $OFFS$.
- 8 Adjust X_p . If satisfactory dynamic response not can be achieved calculate C_{FBRC} and R_{FBRC} .

3.5 Tacho feed back, calculations.

- 1 Calculate R_{CL} .
- 2 Calculate C_{DYN} and R_{ICON} if delayed current limitation is to be used.
- 3 Remove R_{motor} and R_{RI} .
- 4 Calculate R_{tacho} .
- 5 Calculate R_{set} .
- 6 Do test runs. Adjust potentiometers I_{max} and OFFS.
- 7 Adjust X_p . If satisfactory dynamic response can not be achieved calculate C_{FBRC} and R_{FBRC} and if further improvements are needed calculate R_{TRC} and C_{TRC} .

4 Data tables

	MDL 2 DC	MDL 2 DB	MDL 2 DE	MDL 2 AE
Supply	10 - 30 V DC	10 - 30 V DC	10 - 30 V DC	230 VAC 50 Hz
I_{max} motor cont	2 A	2 A	2 A	2 A
I_{max} motor peak 10 s	4 A	4 A	4 A	4 A
Recovery time I_{peak}	20 s	20 s	20 s	20 s
$t_{ambient}$ max	40 °C	40 °C	40 °C	40 °C
Δt_{heat} sink typ	90 °C	90 °C	90 °C	90 °C
U_{max} motor	4V below supply	4V below supply	4V below supply	24 V at 2 A
Weight	0,2 kg	0,3 kg	0,9 kg	2,7 kg
Dimensions	100x100x30	100x170x35	170x70x130	170x105x130
Connector	Terminal block	Edge connector	Terminal block	Terminal block

5 Connectors

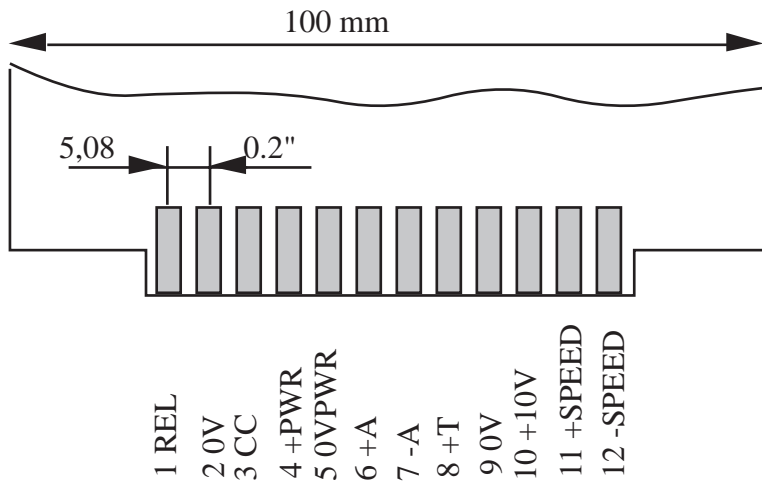


Fig 5.1 MDL 2 DB Edge connector.

The Edge Connector on the MDL 2 DB can be used for several different contacts. Figures 5.3 to 5.6 show four possible types. The Eurocontact in fig 5.5 and the terminal blocks in 5.6 can be soldered into existing holes on the board.

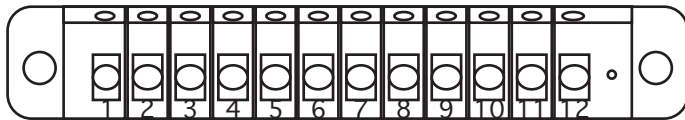


Fig 5.2 Edgeblock EB 12.

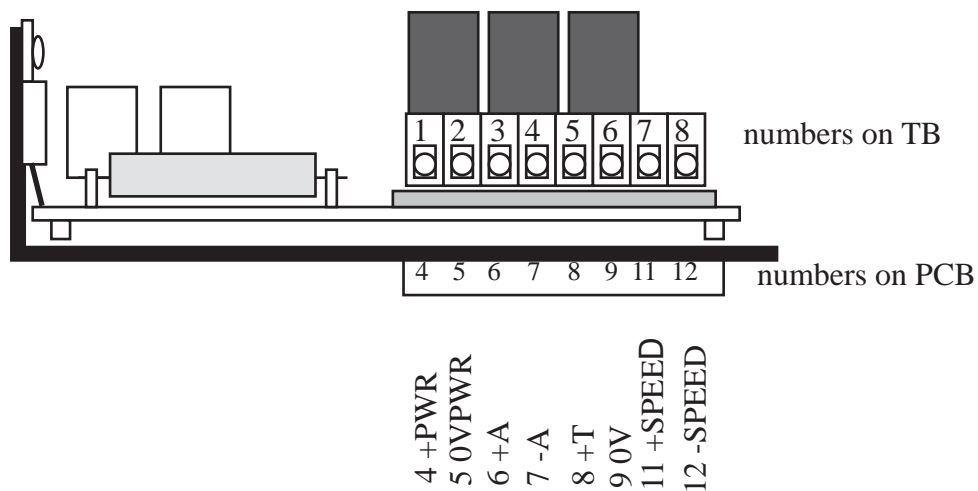
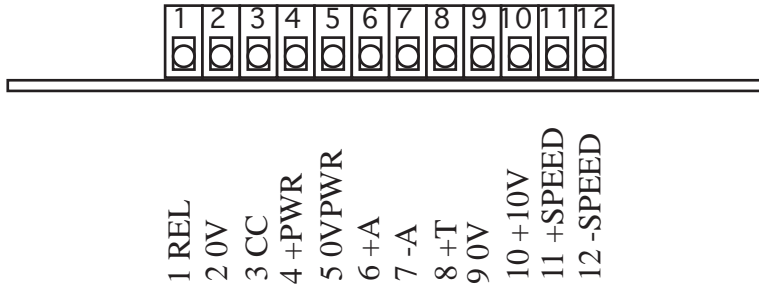


Fig 5.3 MDL 2 DC Terminal Block connector.

Fig 5.4 Terminal blocks



DIN 41612
IEC 603-2
type C 32
outside view

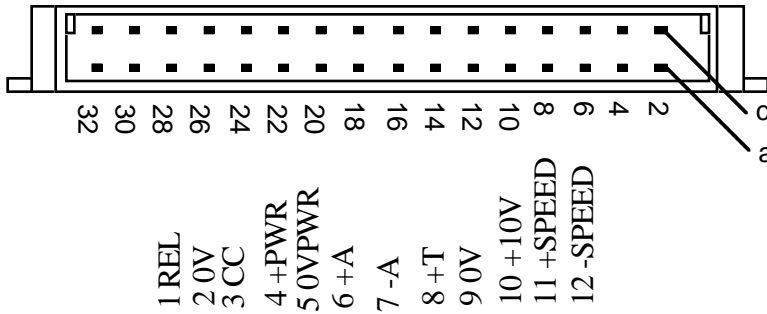


Fig 5.5 Eurocontact

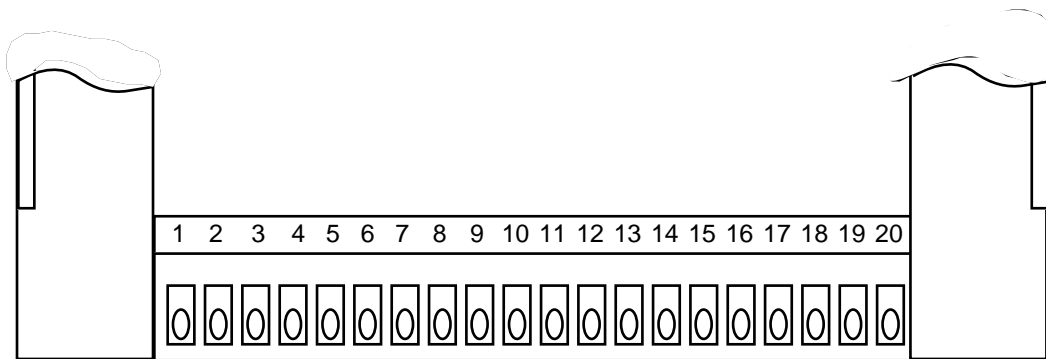
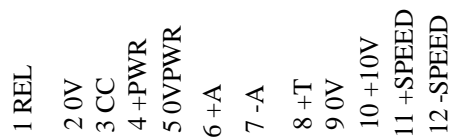


Fig 5.6 Contact type SKBD



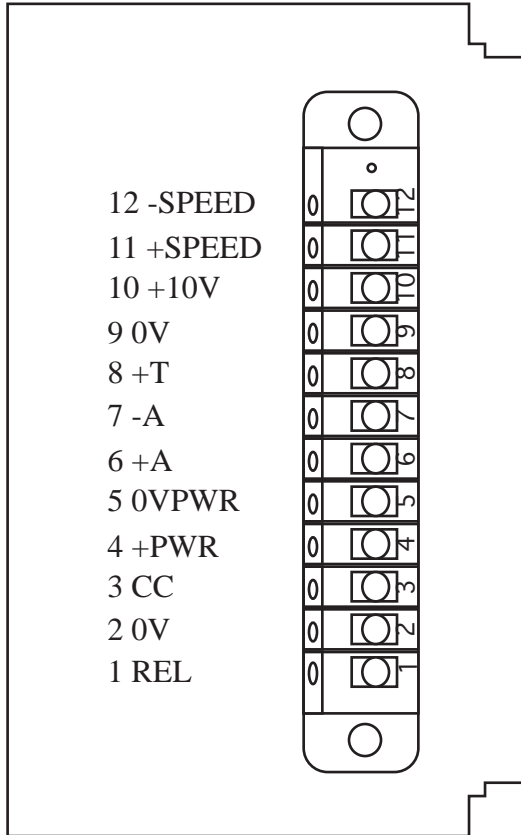


Fig 5.7 MDL 2 DE Connections

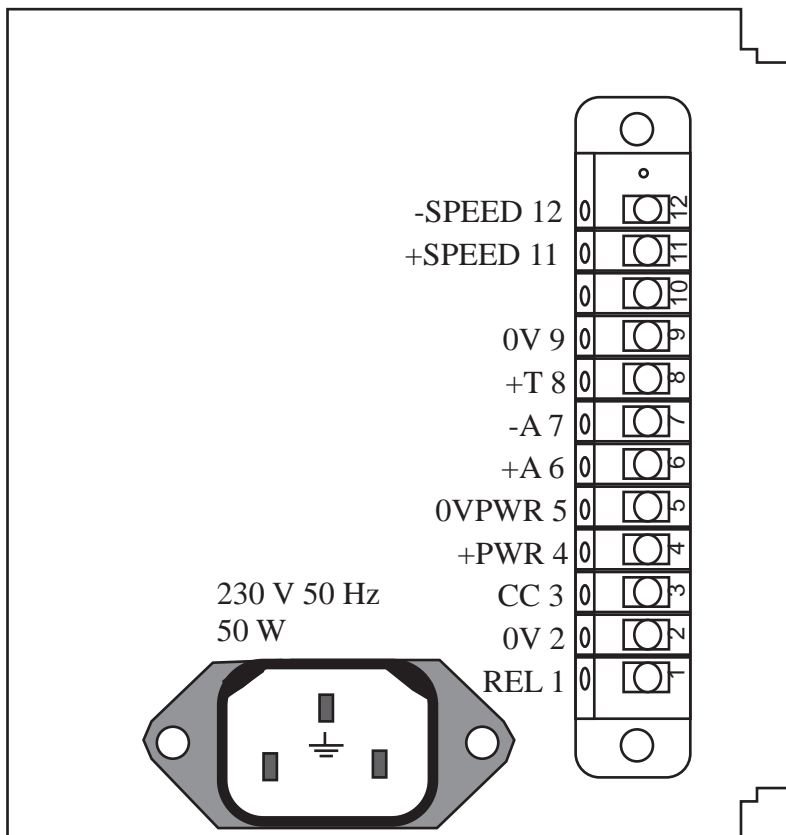


Fig 5.8 MDL 2 AE Connections.

List of connections

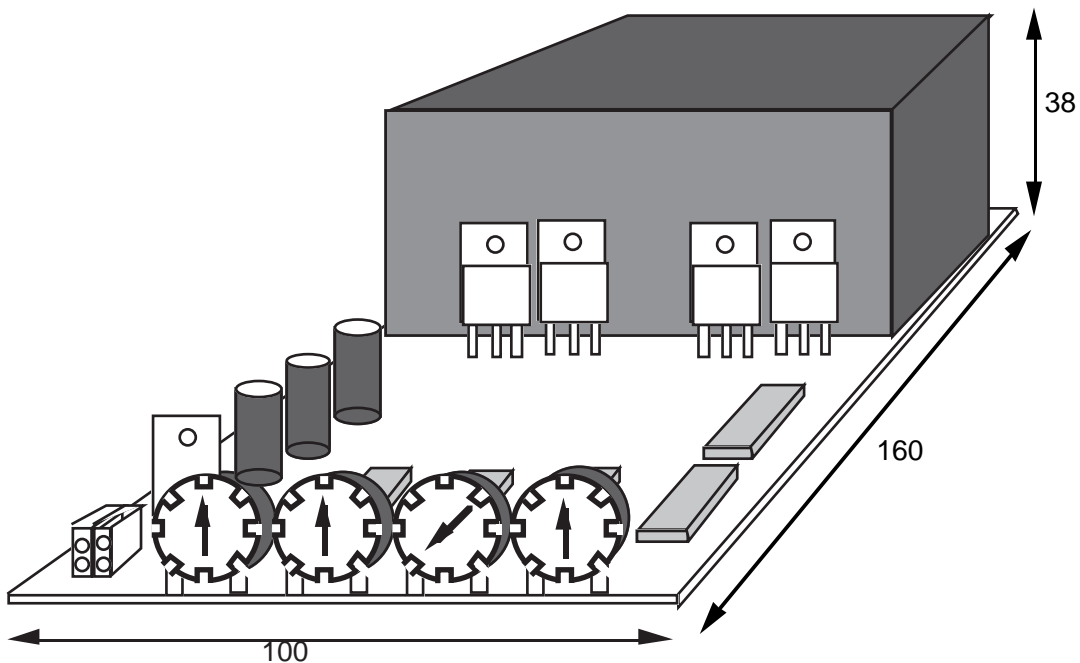
Nr.	Euronumbers	Used abbreviation	Input/Output	Function
1	ac 28	REL	Input	Release
2	ac 26	0V	In/Out	0 V reference
3	ac 24	CC	Input	Current Control
4	ac 22	+PWR	Input	+ Power supply 10 - 30 V
5	ac 20	0VPWR	Input	- of Power Supply; 0 V
6	ac 18	+A	Output	+ side of motor Armature
7	ac 16	-A	Output	- side of motor Armature
8	ac 14	+T	Input	+ side of Tacho generator
9	ac 12	0V	In/Out	0 V reference
10	ac 10	+10V	Output	+ 15 V max. load 1 mA
11	ac 8	+Speed	Input	+ side of Set Speed input
12	ac 6	-Speed	Input	- side of Set Speed input

NB.

Terminals 11 and 12 on MDL 2 AE are internally connected to the front panel SPEED potentiometer. If used externally the front panel potentiometer has to be disconnected.

6 Physical properties.

Fig 6.1 Dimensions MDL 2 DB



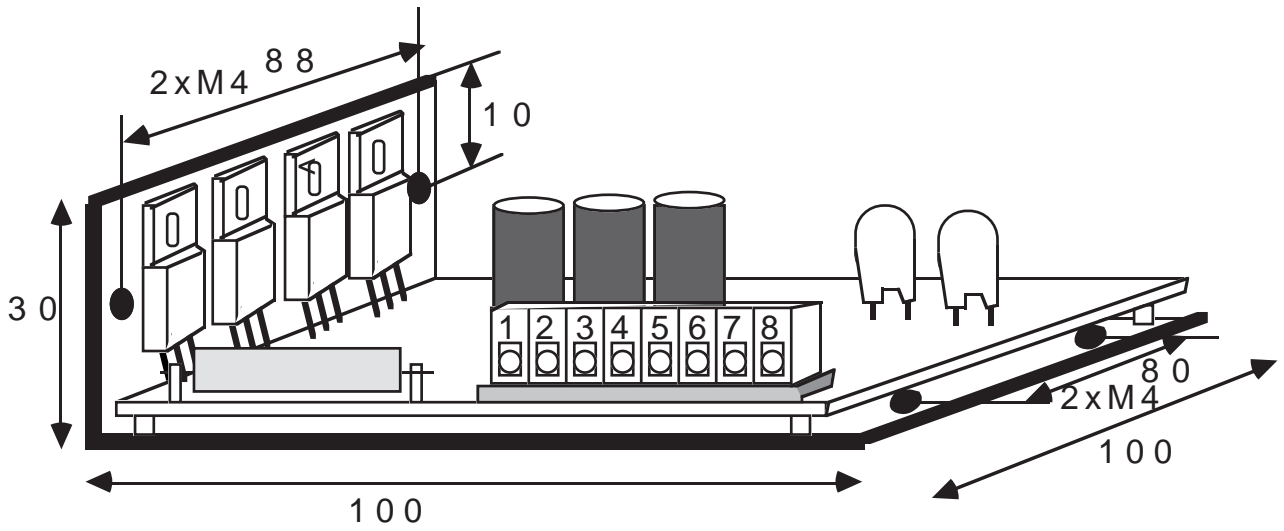


Fig 6.2 Dimensions MDL 2 DC

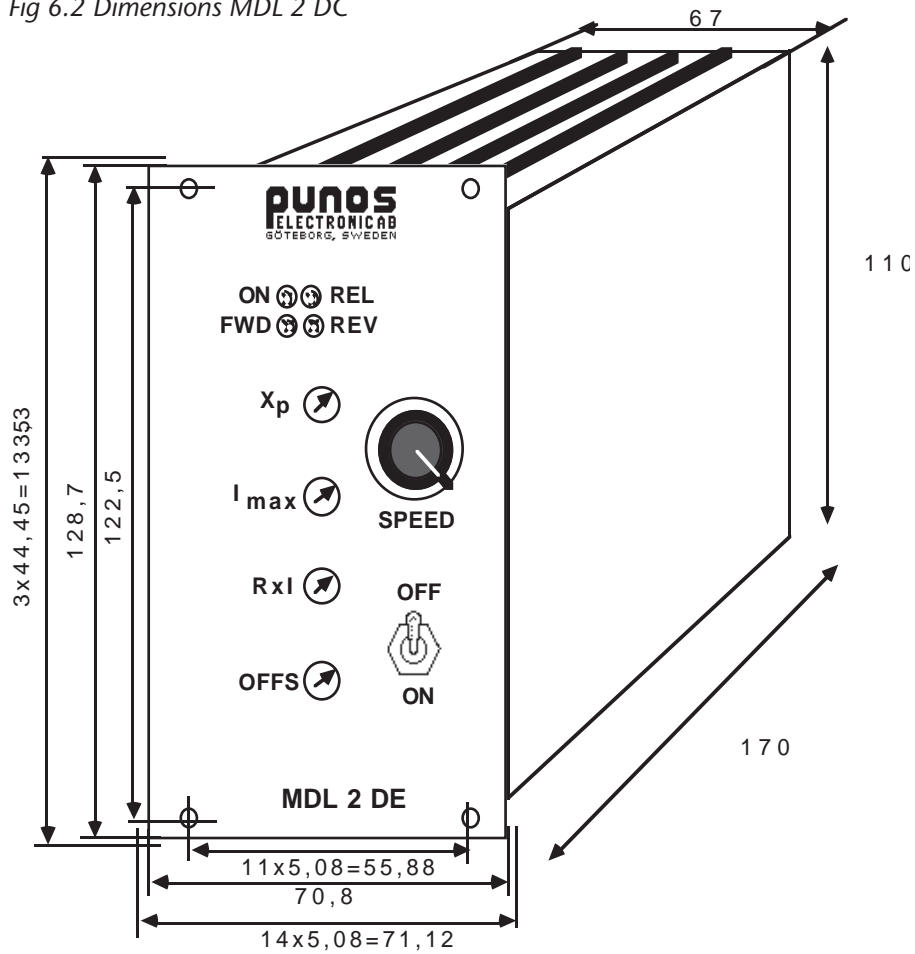


Fig 6.3 Dimensions MDL 2 DE

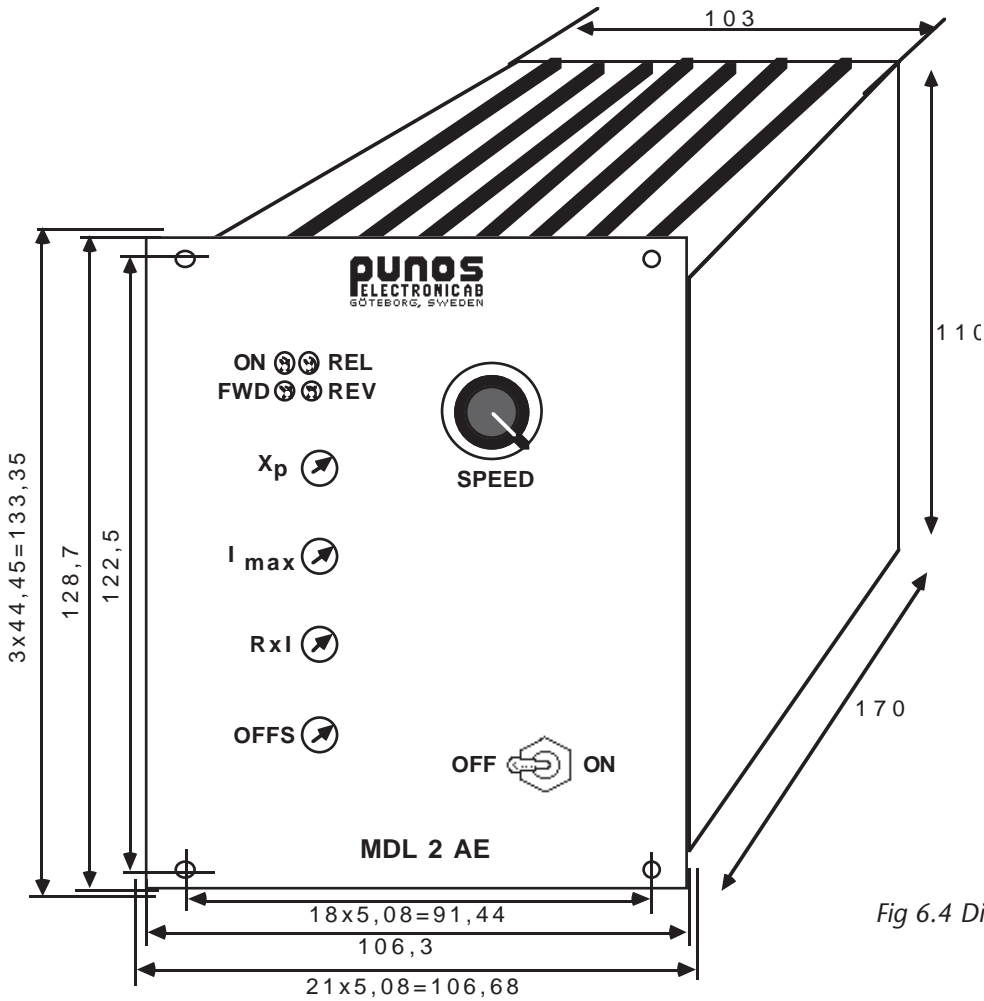


Fig 6.4 Dimensions MDL 2 AE

6.1 Disassembly and assembly

Disassembly of MDL 2 DE and MDL 2 AE

1. Remove the four screws that holds the front panel.
2. Remove the two screws at the left side of the enclosure. They hold the internal heat sink.
3. Pull out the PC-board half way.
4. Disconnect wires to the speed potentiometer and power supply.
5. Remove the PC board.

Assembly of MDL 2 DE and MDL 2 AE.

1. Push the PC board half way in. Take care that all wires are free.
2. Connect wires to the speed potentiometer and the power supply.
3. Push the PC board all the way in until the screw holes in the heat sink are in position.
4. Fasten the two screws at the left side of the enclosure.
5. Attach the front panel. Fasten its four screws.

7 Schematics

Fig 7.1 MDL 2 DC Block diagram

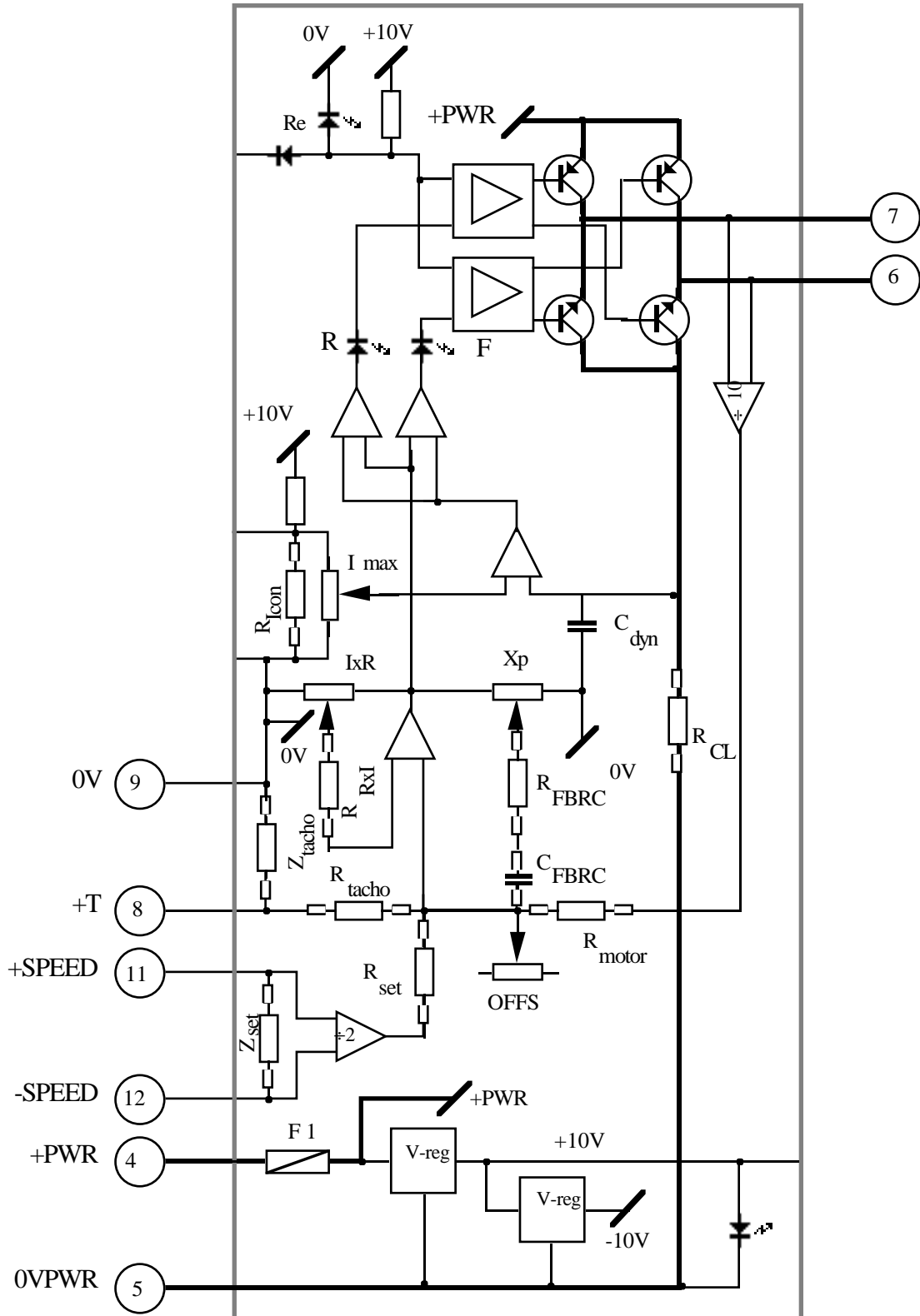


Fig 7.2 MDL 2 DB Block diagram.

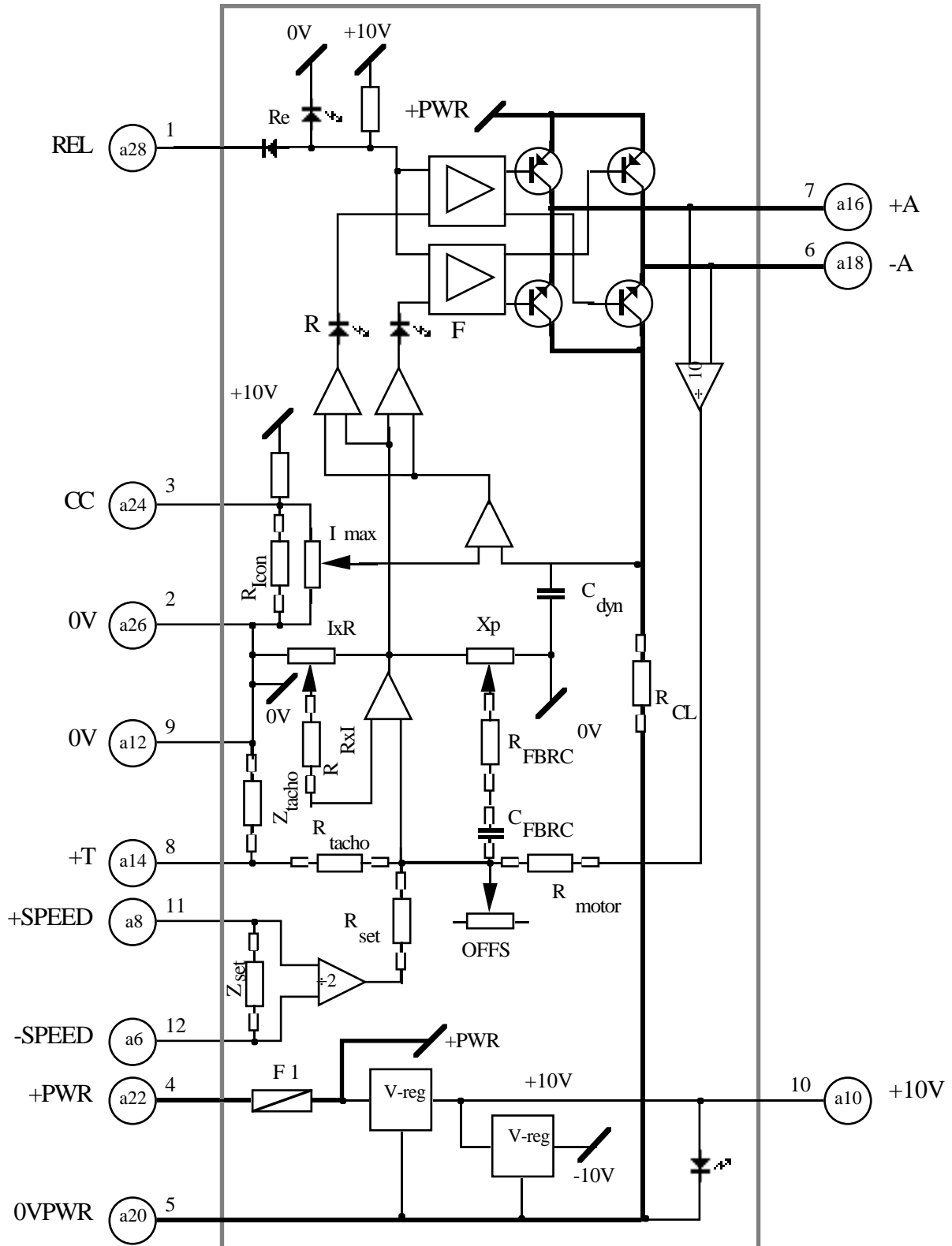
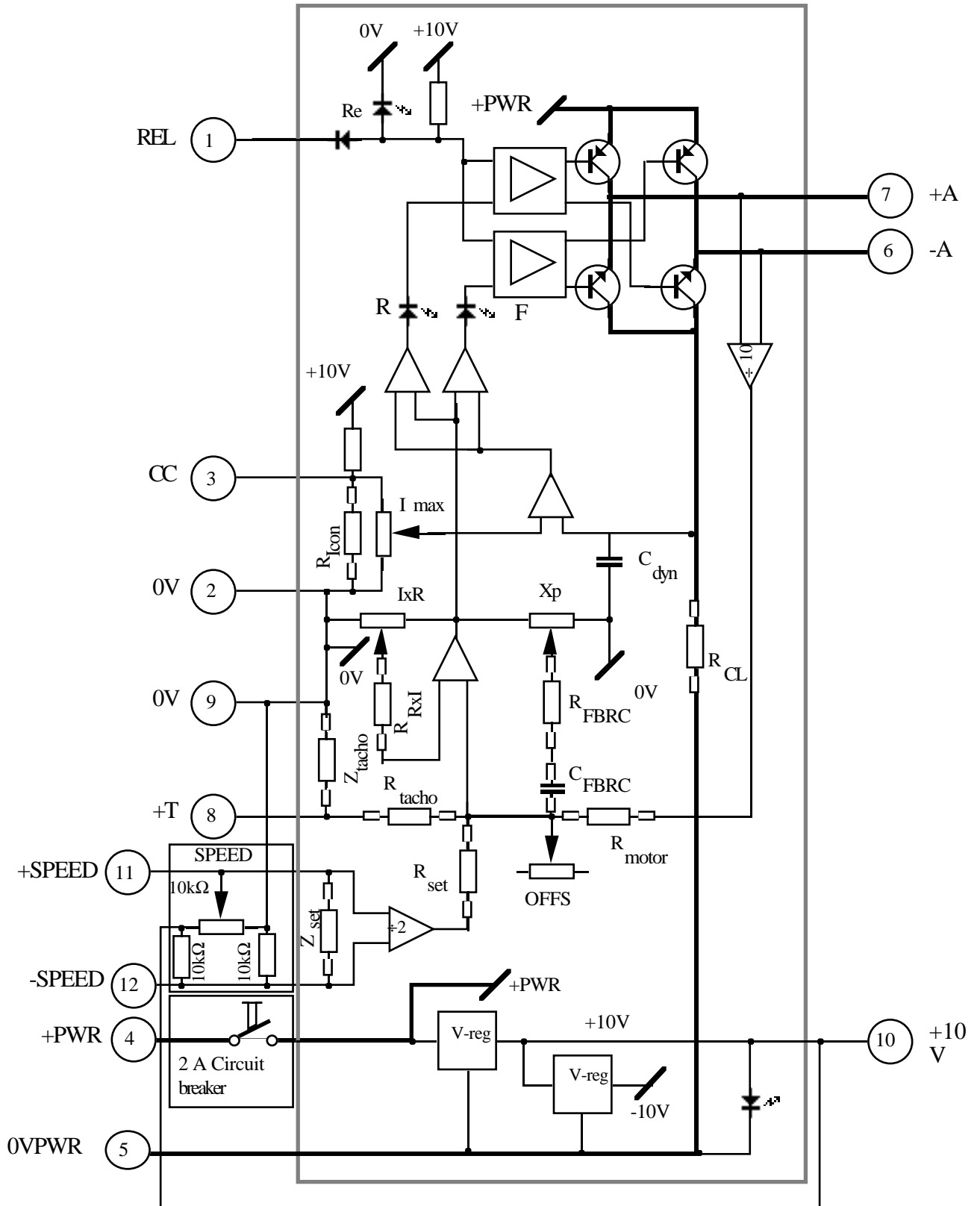


Fig 7.3 MDL 2 DE Block Diagram.



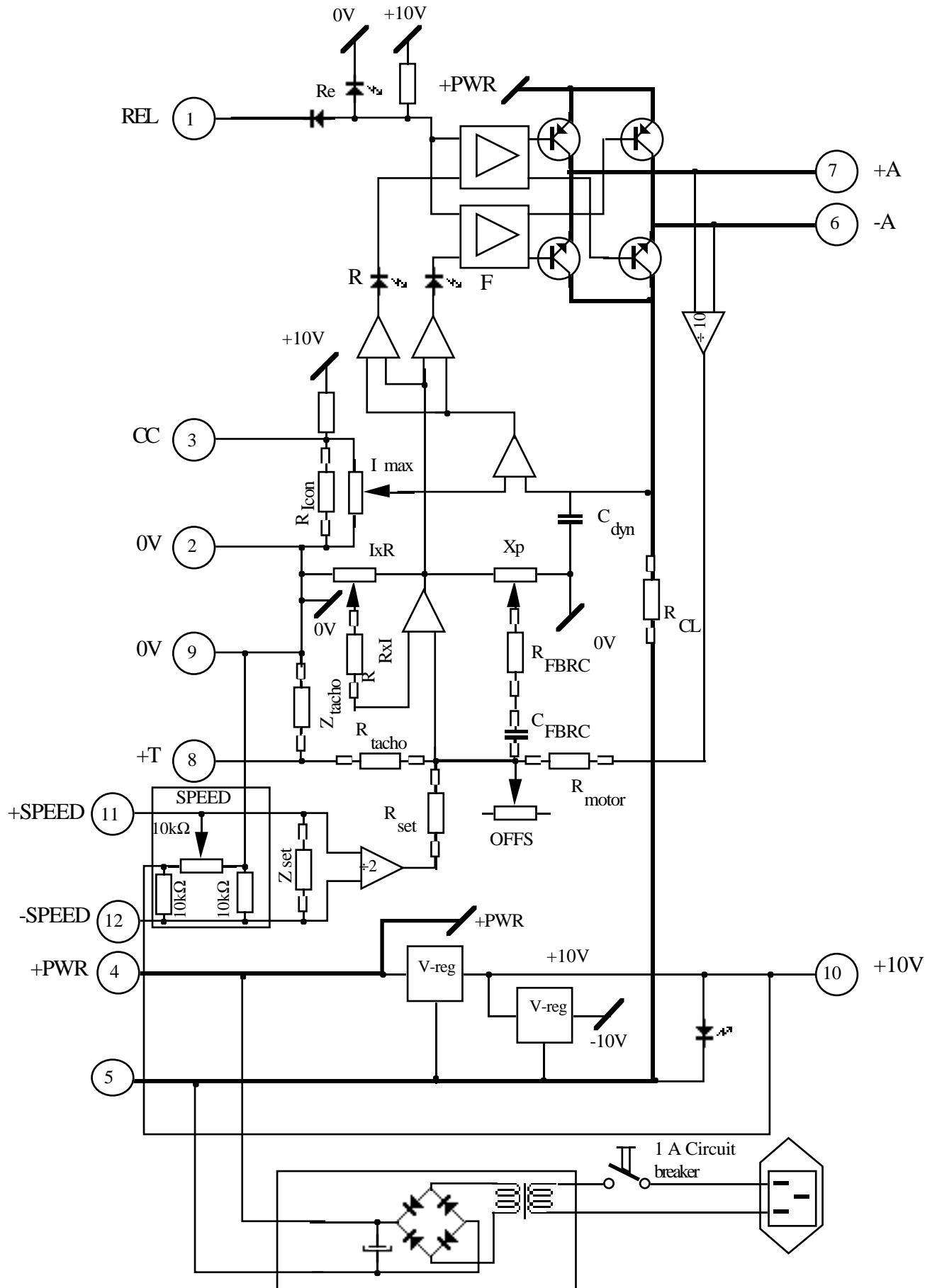
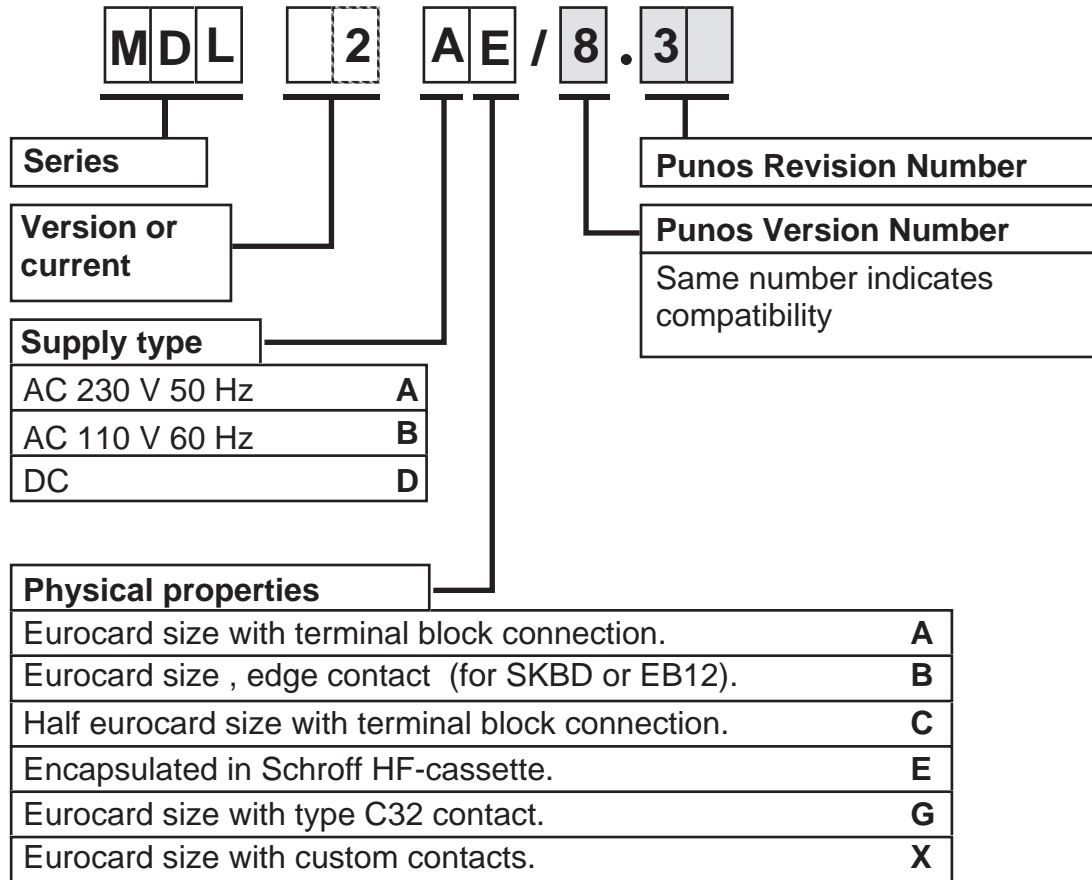


Fig 7.4 MDL 2 AE Block Diagram.

8 Type number designation

Type number designation:



Stock available types

- MDL 2 DB
- MDL 2 DE
- MDL 2 AE
- MDL 2 DG

