Important!

Reading these instructions prior to start-up is absolutely necessary.

Dear customer,

The following items and the “Safety Instructions” are for your benefit and are designed to protect the amplifier from damage caused by incorrect use. According to the product liability law, everyone who puts a product which constitutes a risk for life and limb into circulation is obligated to provide safety instructions. These instructions should be clearly defined and should have an informative nature.

To assist you during installation, consider the following points:

- Protect the amplifier from aggressive and electrically conductive media. These may lead to a malfunction or destruction of the amplifier!
- Do not touch live parts. There is a risk of fatal injury!
- Installation, connection and set-up must be carried out by trained personnel who are knowledgeable of the safety instructions.
- Performance and capabilities of the drive can only be guaranteed under proper use.
- Modifications, which are not authorized by MTS Automation - Custom Servo Motors, as well as operation of the amplifier in a manner other than its intended use will void any warranty or liability.
- Our "Terms and Conditions" are the basis for all legal transactions.

Table of Contents

List of Figures

1 Safety Instructions

1.1 General Notes

This start-up manual describes functions and gives all necessary information for the designated use of the subassemblies produced by Custom Servo Motors. The manufacturer is responsible for the preparation of an instruction manual in the national language of the end user. The preparation of machine-specific risk analyses is also the manufacturer's duty.

Observance and understanding of the safety instructions and warnings stated in this document is the condition for the riskless transport, installation and set-up of the components by qualified personnel.

1.2 Qualified Personnel

Must be able to correctly interpret and realize the safety instructions and warnings. Furthermore, the personnel entrusted must be familiar with the safety concepts of the automation technology and must be trained accordingly. Unqualified actions at the subassemblies or the non-observance of the warnings stated in this document or attached to the subassemblies constitute a risk to life and limb of the user, or cause damage to the machine or other material property.

1.3 Designated Use

is given when:

- any work on equipment of the machine/plant is carried out by a skilled electrician or by instructed persons under the supervision and guidance of a skilled electrician.
- the machine is used only when in a safe and reliable state.
- the machine is used in accordance with instructions given in the operating manual.

1.4 Description of Symbols and Signal Words

DANGER!
Warning against risk of serious injuries. Observance is absolutely necessary.

ATTENTION!
Information, the non-observance of which may lead to substantial damage to material property. Observance of these safety instructions is absolutely necessary.

IMPORTANT!
This symbol refers to important information regarding the use of the machine. Non-observance may lead to problems in operation.

1.5 Safety Notes

Because the subassemblies are intended for installation in machines, freely accessible parts may carry dangerous voltage. The manufacturer must ensure adequate protection against contact.

Any work on these subassemblies must be executed only by qualified personnel, who knows the contents of these start-up instructions.
The instructions contained in this manual have to be observed strictly, as a wrong handling causes additional risks.

A correct transport, storage, set-up and assembly of the machine as well as careful operation and maintenance are an important condition for the correct and safe operation of these products.

1.6 Set-up

The relevant safety and accident prevention regulations for the individual case are to be considered.

Devices, intended for installation in cabinets and housings must be operated only in built-in state.

Prior to setting up the devices, which are operated with line voltage, please check that the adjusted nominal voltage range is identical to the local line voltage.

For supply with 24V ensure that the low voltage is mechanically separated from the mains.

Deviations in the line voltage, exceeding the tolerances stated in the technical data for these devices, are not allowed, as this may lead to dangerous conditions.

Voltage dip or voltage failure requires precautions for restoring an interrupted program. Arising of dangerous operational states must be avoided.

EMERGENCY-STOP equipment must not effect an uncontrolled or undefined restart after unlocking. They must remain effective in all modes of operation.

1.7 Maintenance / Service

For any measuring or test work on the alive device, please observe the relevant accident prevention regulations. The work must be done only with admitted and suitable measuring instruments and tools.

Service work on subassemblies is done exclusively by Custom Servo Motors staff.

Incorrect repair work by unqualified persons may lead to damage to material property, and bears a risk of injuries or mortal injuries. Open the main switches or unplug the mains plug before opening the device or pulling it out of the sub-rack. When replacing defective fuses, please observe the stated electrical values. Incorrect modifications and work on the subassemblies lead to a loss of warranty claims and involves unpredictable risks.

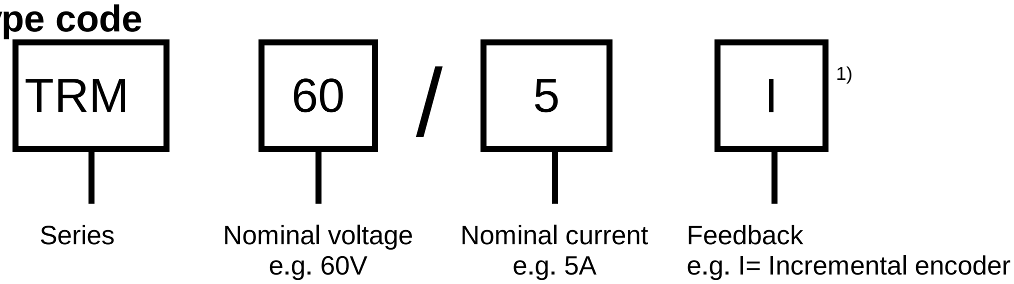
2 Technical Description

2.1 General Description

The series TRM amplifiers are four-quadrant power amplifiers for permanent-field DC motors, that means that acceleration and braking is possible in both directions. To enable this, a 2.2-fold or triple continuous current is available for a certain time (about 2.5 seconds) depending on the version. For the speed control, the simplest version requires a tacho-generator for the feedback of the speed, but can also be realized by an incremental encoder (version ìIì) or by a regenerative motor voltage (version ìEì), the so-called electromotive force (EMF) control. In case of EMF control an additional IxR compensation can be done. The amplifiers are provided with a pulse-width modulated output in MOSFET technique which results in a high power density and a high efficiency. The design is a 3HE eurocard format (160x100mm) for 19 inch slide-in racks. The devices have protective measures against electronic undervoltage, under- and overvoltage of the power supply, short-circuit and ground contact of the motor lines, as well as against excess temperature. The main characteristics are:

- High dynamics
- High efficiency
- Considerable use of SMD technology
- 19 inch/3HE slide-in technique
- Almost no clock noise by special modulation principle
- Short-circuit proof and ground contact proof
- Protective circuit for undervoltage, overvoltage, overcurrent, overheating
- ±10V differential amplifier input
- PLC compatible inputs for enable
- I^2t current limiting
- Outputs for ready, I^2t message and armature current monitor

Type code



[1] Devices that need a tachogenerator for speed feedback have only three letters

2.2 List of Types

Device name	Nominal output voltage	Nominal current	Power pulse current	Fuse protection	Connector DIN41612
TRM24/7 (I, E)	24V	7A	15A	10A	D32
TRM60/5 (I, E)	60V	5A	15A	10A	D32
TRM60/8 (I, E)	60V	8A	20A	16A	D32

2.3 Technical Data

Device name	**TRM24/7**	**TRM60/5**	**TRM60/8**
Nominal voltage	**24V**	**60V**	**60V**
Nom.current (only $T_U$max=45∞C)	**7A**	**5A**	**8A** (only with forced cooling)
Pulse power current	**15A**	**15A**	**20A**
Interm. circuit voltage: min. / max.	19VDC / 42VDC	19VDC / 85VDC	19VDC / 85VDC
Recomm. transformer voltage	24VAC/9A	52VAC/7A	52VAC/10A [2]
Load inductivity min.	0.4mH	0.8mH	0.5mH
Arm. Current monitor (output)	1V equal to 1.6A		1V equal to 2.1A
Efficiency	93%		95%
Output current form factor (with minimum load inductivity for nominal current and nominal voltage)	<1.01		
Clock frequency	9kHz		
Current ripple	18Hz		
Current regulator bandwidth	1kHz		
Set value default	±10V		
Ri set value input	20kΩ		
Max. input drift	±21µV/C		
Input attenuation (through fixed resistor R_E)	0 - 100%		
Voltage range of the tachometer input (for U_{nom} = ±10V and nom. Speed)			
for RE = ∝	12 to 72V		
for RE = 10kΩ	6 to 36V		
for RE = 3,3kΩ	3 to 18V		
Enable (input) active with: / inactive with:	>12V/ >3mA / <4V/ <1mA		
I≤t message (open collector-output switching after +15V)	+13V/10mA		
Contact rating of ready relay	max. 100V/100mA total of max. 10W		
Connections	DIN 41617 -D32		
Dimensions	160 x 100 x 36		
Weight	0.36 kg		

[2] The version TRM60/8 has no internal rectifier and must be provided externally.

2.4 Principle of the Amplifier

The servo amplifiers are based on the principle of the speed control with secondary current control loop. The following illustration shows the signal flow of this controller principle:

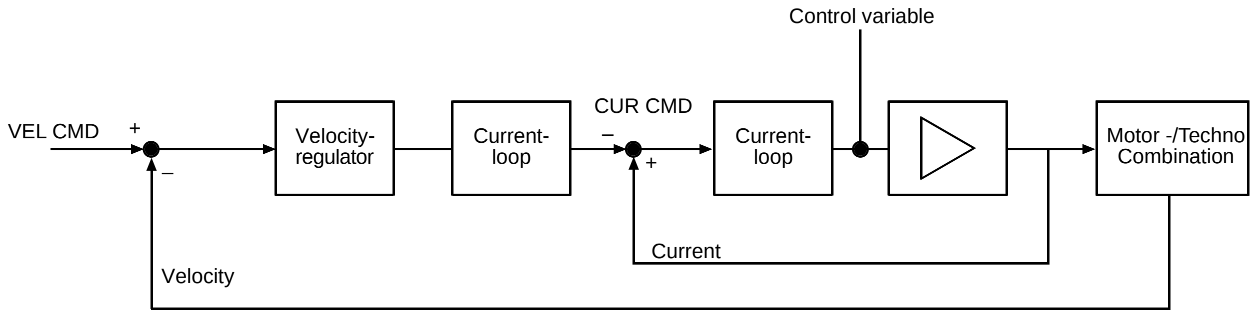


Figure 1: Controller Principle

The current control loop consists of the current controller and the amplifier output. The respective actual current value is determined at the amplifier output and fed back to the summing point. The speed controller[3] delivers the nominal current value. Nominal value and actual value are compared and the difference is transmitted to the current controller.

The higher-ranking speed control loop consists of speed controller, current loop circuit and motor/tachometer combination. The nominal speed value is externally defined by the user, e.g. by potentiometers or NC control systems. The actual speed value is determined directly at the motor shaft, e.g. by means of a tachogenerator, and compared at the summing point with the nominal speed value. The resulting difference is the input value of the speed controller. It generates the necessary nominal current value from the difference.

The advantage of this principle is a very stable controller response, as the secondary current controller quickly responds to interferences and consequently reduces the load on the speed controller. Apart from that, current limits necessary to protect motor and amplifier can be easily achieved by limiting the output voltage of the speed controller (nominal current value).

[3] In some applications the speed control is already taken over by a higher-ranking position control loop. The TRM can also be used as current controller by closing a soldering jumper (see chapter TRM as Current Controller).

2.5 Functional Description with Block Diagram

2.5.1 Voltage Supply

The functions of the amplifier are shown with a block diagram. The first block shows the rectification and filtering. In this part of the circuit the intermediate circuit voltage Ucc, necessary to operate the device, is generated from the AC voltage supply (except TRM60/8).

The output stage is supplied with this voltage and, at the same time, it is used to generate an auxiliary voltage of ±15 Volt, required to supply the control system.

2.5.2 Control System

The nominal speed value is transmitted to the differential input and can be preset in different ranges using a reducing resistor $\mathbf{R_E}$. There are three possibilities for gaining the actual speed value:

- By means of a tachogenerator

The output voltage of the tachogenerator is fed to a RC element (smoothing of the tachometer voltage). Tachogenerators with different EMF are adapted with the fixed-value resistor to the control system.

- With the booster circuit IGT/K (version “I” with incremental encoder feedback)

Here the digital signals of an incremental encoder are converted in a speed-proportional analog voltage, which is treated like the signal of a DC tachometer. Depending on the number of pulses of the incremental encoder, or the required speed of the motor, the corresponding maximum operating frequency is programmed with the soldering jumpers J1, J3, J5 and J7. A maximum operating frequency of 30 kHz for the devices is set at the factory.

- With the "EMF" and IxR compensation (option “E” with regenerative motor voltage)

In this case, a part of the armature voltage of the motor measured with the EMF Measuring circuit, is used as actual speed value. In addition to that, the current-proportional voltage drop at the motor internal resistance can be compensated with the IxR compensation.

☞ If the device is ordered with one of the mentioned options, the corresponding soldering jumpers are already set.

At the summing point SP1, the nominal speed value is compared with the actual speed value. The PI speed controller, which includes the negative feedback system amplifies the resulting control difference and the deviation is regulated to 0. The output variable of the speed controller is the nominal current value. Here the current limiting becomes active:

- **Effective current limiting**

- The actual armature current value is transmitted to this circuit, where it is squared and filtered with a following low pass, the time constant T= 8.2s. The actual effective current value gained by this is compared to an adjustable nominal value. When approximating this value, the circuit reduces the nominal current value requested by the controller, so that the actual effective current value will not increase.

- **Internal nominal current value limiting with R_I**

- This current limiting is connected on the load side of all limiters. That means that the power pulse current adjusted at R_I cannot be exceeded.

The limited nominal current value is transmitted to the summing point SP2. The armature current measuring circuit determines the actual current value, still unknown for the nominal/actual comparison and it is also transmitted to the summing point SP2.

The current controller determines the manipulated variable for the four-quadrant output resulting from the comparison of nominal and actual current value. The current controller is a PI controller with a proportional amplification KP = 3.03 and an integral-action time (reset time) TN = 1ms. As it is a pulsed controller, the continuous manipulated variable has to be converted into a pulse-width modulated signal. This happens in the pulse-width modulator, by modulating the manipulated variable with a delta voltage of a frequency of 9kHz, which then forms the signals for the driver stage.

Duplicating of the current flow frequency (18kHz), which guarantees a low-noise operation, is achieved with a special modulation principle.

The quicker switch-on than switch-off of transistors makes a delay of the switch-on signal necessary, in order to prevent two quadrants of the power stage being simultaneously conductive. This signal delay is realized in the dead time.

2.5.3 Driver Stage and Power Amplifier

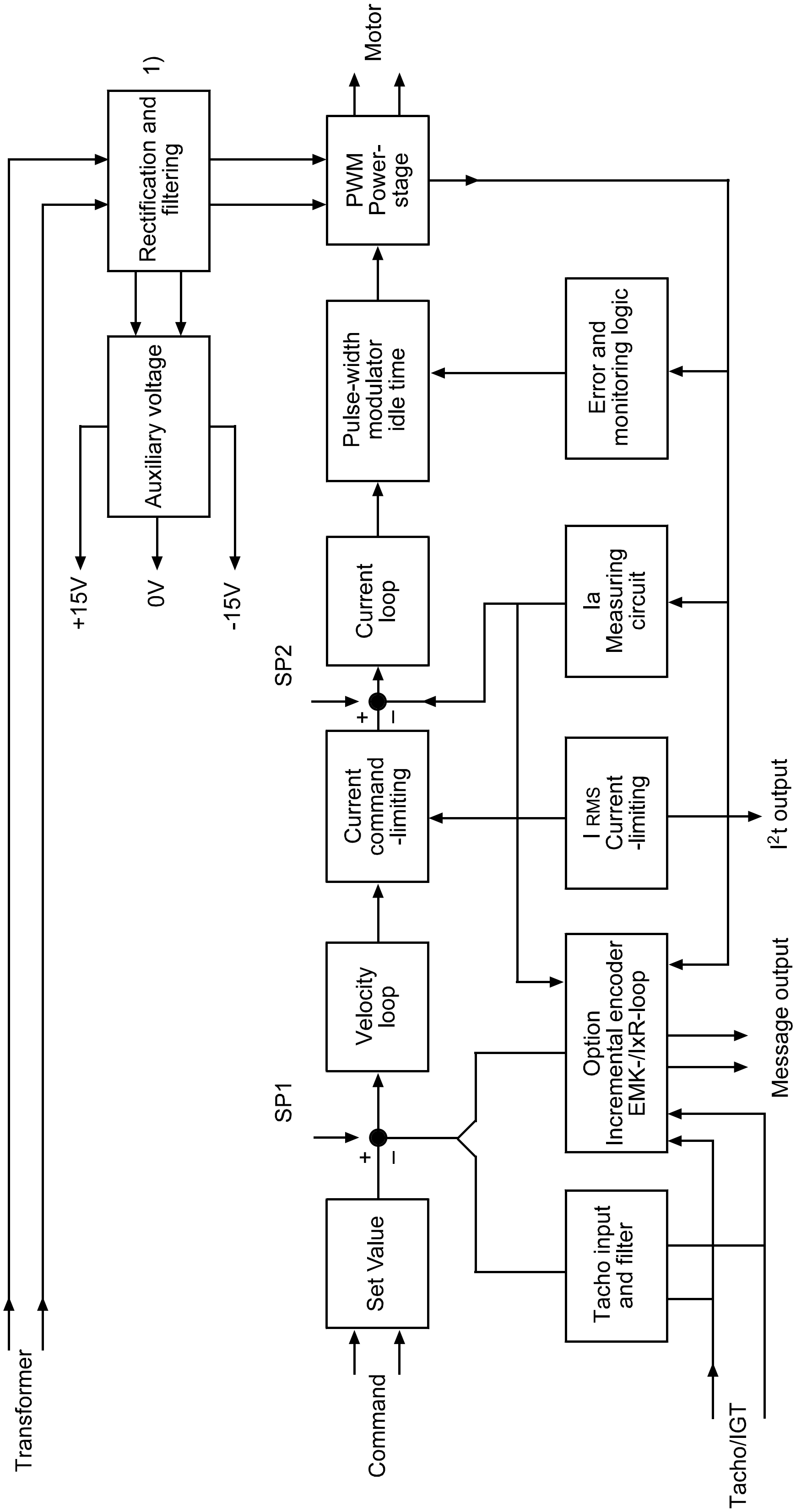
The driver stage amplifies the signals, coming from the pulse-width modulator. The design guarantees the optimum activation of the power amplifier. This allows low-loss and reliable operation of the power amplifier in any situation. The power amplifier converts the signals transmitted by the driver stage into power. It consists of MOS-FETs to allow a quick and consequently low-loss switching.

2.5.4 Safety and Monitoring Circuits

The intermediate circuit voltage (ZwSp) and the current in the intermediate circuit (ZwSt) are permanently monitored. If the ZwSp exceeds a certain value, the power amplifier and the motor are switched off by the safety function "Overvoltage monitoring". If the ZwSt exceeds a certain value, the device is switched off by the safety function "Short-circuit and ground contact monitoring". If the device temperature exceeds a value of 80°C, the power amplifier is switched off by the function "Excess temperature monitoring".

The red LED (LED2) lights and the green LEDs (LED1 and LED3) go off if one of the safety circuits responds. To reset the error, switch off and on the power supply.
For indication of the ready status there is a ready signal available, which is achieved by a potential-free reed contact. The ready status is indicated with the LED1 (green), and the outputs 8a,c and 10c are connected with each other through the reed contact.

2.6 Block Diagram



1) On TRM/60/8, the rectification is not on the board.

Figure 2: Block Diagram

2.7 Indicators, Possible Adjustments, Test Points, Soldering Jumpers

2.7.1 Indicators

LED1 (green)	Indicates the amplifier is ready for use; lights also when the amplifier is not activated by the enable input.
LED2 (red)	Indicates a fault, (overvoltage, overcurrent and excess temperature); Re-activation of the amplifier after lighting of this LED is possible only by switching off and on the amplifier.
LED3 (green)	Indicates that the controller is enabled, that means the amplifier is enabled.
LED4 (yellow)	Effective current limiting, lights after run-down of the power pulse current phase.

2.7.2 Adjustments

Potentiometer 1	Tacho-potentiometer for speed adjustment
Potentiometer 2	Offset adjustment of the speed loop
Potentiometer 3	AC voltage gain (P component) of the speed loop
Potentiometer 4	Effective current limit, adjustment range 0 to 100% of the device-specific effective current
Potentiometer 5	For factory internal adjustment only (current offset)
Potentiometer 6	For factory internal adjustment only (low voltage)

2.7.3 Test Points

MP1: Nominal speed value “N-nom”	Scaling: 10V equal to n_{max}
MP2: Actual speed value “N-act”	For the tachometer version, the tachometer voltage can be tapped off on MP2, for incremental encoder version 10V equals to the currently programmed limit frequency. For EMF controller, the voltage at this test point is not scaled, as it depends on the adjustments on the EMF.
MP3: Actual current value “I-act”	Scaling: 10V equal to device-typical power pulse current.

MP4: Reference potential “0V”

MP4 (0V) must be used only if no ground loops are built by the measuring instrument connected. They will be easily generated e.g. by an oscilloscope, which is connected to ground, or if the probes are applied to different 0V potentials (control/servo controller).

2.7.4 Soldering Jumpers

For a detailed description of the soldering jumpers consult the corresponding chapters. At this point, you will only find general information.

Of course the jumpers are set according to the operating mode you ordered before leaving the factory. This explanation only serves for a possible later conversion (e.g. to current control), or if other maximum operating frequencies have to be programmed for incremental encoder operation.

The jumpers necessary for adjusting the different operating modes are soldering jumpers to save space and costs - as they normally will be set only once. These soldering jumpers are located on the bottom of the printed circuit board (SMD side) near the connecting strip (except JP16) and consist of three copper fields each. The central contact is the common contact. Refer to the table below to connect the outer fields and the inner fields with tin-lead solder.

The soldering jumper for converting the device to current control (JP16) is located on the SMD-side near the board segment for the bonded components. (See also chapter ìTRM as current controllerì)

When using our hybrid component **IGT/K** instead of a DC tachometer, special attention must be given to jumpers J1, J3, J5 and J7. (See also chapter ìStart-up with increment encoder as tachometerì)

Meaning of the individual jumpers:

Jumper	1	2	3	4	5	6	7	8	9	10	11	12	16
Tachometer operation									X		X		
Version EMF/IxR								X		X		X	
Version IGT (10kHz)							X						
Version IGT (20kHz)					X								
Version IGT (40kHz)			X										
Version IGT (80kHz)	X												
Current control													X

The two soldering jumpers JP13 and JP15, located beneath the switched-mode power supply transformer, are for factory-internal adjustments only and must not be resoldered by the user.

2.7.5 Front View of the TRM

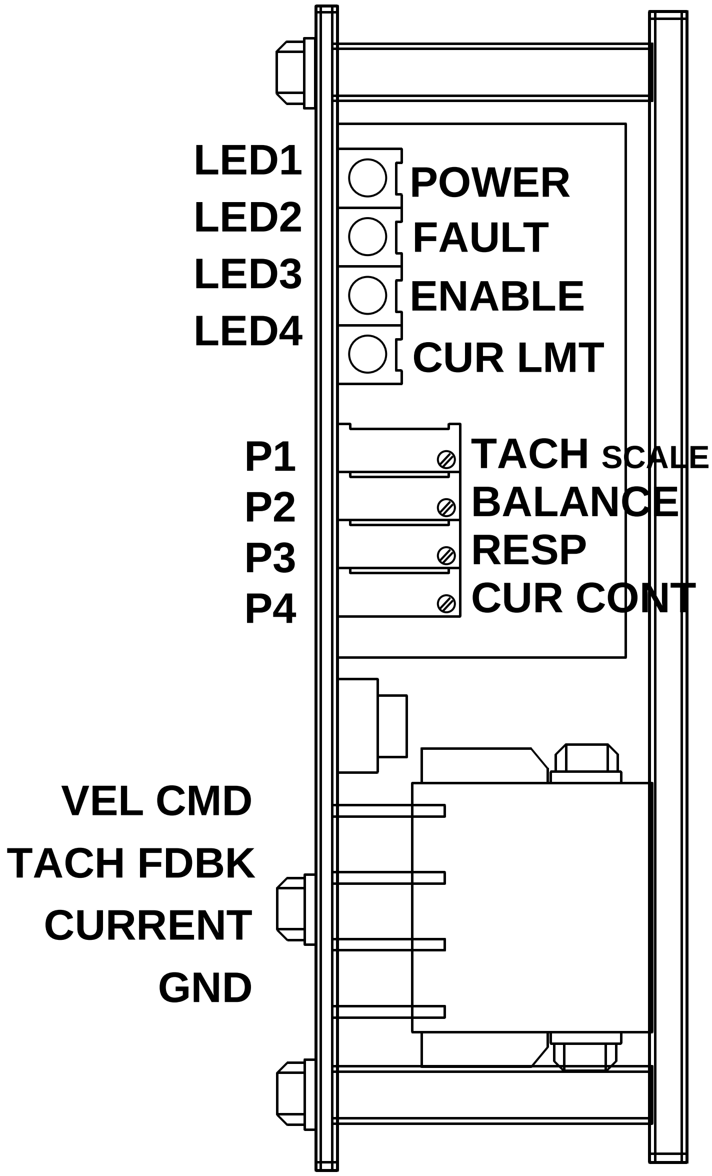


Figure 3: Front View

3 Connection of the Device

3.1 Pin Assignment

2a	+15 Volt (output)
2c	-15 Volt (output)
4a, c	Tacho+ / Encoder track B
6a	I^2t message
6c	Tacho- / Encoder track A
8a, c	Ready message
10a	not connected
10c	Ready message
12a, c	Setpoint input+
14a	not connected
14c	Setpoint input-
16a, c	Enable (enable input)
18a	not connected
18c	Armature current monitor (output)
20a, c	GND electronic
22a, c	Motor+
24a, c	Motor-
26a, c	+UB (intermediate circuit)
28a, c	0 Volt (ground)
30a, c	Transformer (AC1)
32a, c	Transformer (AC2)

3.1.1 Explanation of the Pin Assignment

2a **2c**	**+15Volt (output)** **-15Volt (output)**	An auxiliary voltage of +15 volt on terminal 2a and of -15 volt on terminal 2c are available (max. 10mA). The voltage source is suitable for supplying an external electronic system.
4a, c **6c**	**Tacho+** **Tacho-**	Inputs for connecting a DC tacho-generator for speed feedback. For nominal speed with a set value of 10 Volt, the tachometer voltage should be 3 Volt minimum and 72 Volt maximum. The range is to be fixed with the fixed resistor $\mathbf{R_E}$ (see chapter “Tachometer Adjustment”)
	Ensure correct polarity.	(See chapter “Correct Motor and Tachometer Polarity”)
4a, c **6c**	**Encoder track B** **Encoder track A**	For versions with incremental encoder feedback (version “I”), the tachometer inputs are used for connecting the incremental encoder, where track A has to be connected with 6c and track B with 4a, c. Only use a type with 5V TTL outputs. The track signals are pulled with 2.2 kOhm pull-up resistors to +5V in the device. Supply of the incremental encoder with +5V has to take place with an external voltage. The 0V of the external voltage source have to be connected with 0V of the amplifier (20a, c).
	Ensure correct polarity.	(See chapter “Correct Motor and Incremental Encoder Polarity”)
6a	**I^2t message**	After run-down of the power pulse current phase, the amplifier activates the I^2t current limiting and then supplies only rated current (LED4 lights). In this mode of operation, this output delivers about 13V (max. 10mA), otherwise it is high-resistive.
8a, c **10c**	**Ready message**	Potential-free relay contact which indicates the ready-for-operation status of the device. This contact is closed when the device is ready for operation and will not be effected by the disable function. The contact is open in case of a fault (LED2 lights).
10a	**not connected**	Internal signals are applied to these connections and therefore they must not be used.
12a, c **14c**	**Setpoint input+** **Setpoint input-**	Inputs of the differential amplifier for definition of the nominal speed value. The maximum difference voltage can be ±10 Volt. The terminal 12a, c acts positive against terminal 14c. Both inputs must be wired, e.g. setpoint+ at the output of the D/A converters and setpoint- at analog GND of the NC control system.

14a	**not connected**	Internal signals are applied to these connections and must not be used.
16a, c	**“Enable”** **(Enable input)**	For normal operation this connection has to be supplied with a voltage between 12 and 35 volts. A voltage below 4 volts and an open input "disables" the amplifier and the motor is dead.

The enable function is designed so that when switching on the operating voltage while the enable signal is already assigned, the motor starts running when a setpoint is applied or when the speed feedback shows a polarity reversal.

18a	**not connected**	Internal signals are applied to these connections and must not be used.
18c	**Armature current monitor (output)**	A current-proportional analog signal is available at this output, which can be evaluated by an external device. The maximum voltage is ±9.5 volt with device-typical power pulse current.
20a, c	**GND electronic**	0V reference potential of all inputs and outputs. Internally these terminals are also connected with power GND (18a,c).

For the power connections described below, make sure that both contacts (a <u>and</u> c) are always connected with the mating connector.

22a, c **24a, c**	**Motor+** **Motor-**	These are the output terminals of the amplifier which are connected to the motor. The plus pole of the motor is connected to terminal 22a, c and the minus pole to terminals 24a, c.
26a, c; **28a, c**	**+UB (interm. circuit)** **0Volt (ground)**	These connections are either used for an external ballast circuit (see chapter “Connection Diagrams”), or when a d.c. voltage supply is required. A d.c. voltage supply (battery-operated), requires the external protection of the device.

For the version TRM60/8 these connections are used in principle for supplying the DC supply voltage, as this device has no rectifier. The rectifier has to be provided externally.

30a, c **32a, c**	**Transformer (AC1)** **Transformer (AC2)**	The secondary terminals of the transformer are connected to these contacts. When using an extremely low-resistance transformer (e.g. in case of parallel switching of several axes) an inrush current limiter may be necessary, in order to protect the rectifier diodes.

3.2 Wiring

Careful wiring is absolutely necessary to guarantee troublefree operation of the servo amplifier!

Both the control system and amplifier must have the same potential (normally ground potential). Equalized potential must be achieved by only one connection between control system and amplifier (28a, c). This connection has to be a sufficiently strong line. The line cross section should be at least the same as the motor line cross section and not smaller than 1.5mm^2. As 0 volt intermediate circuit (28a, c) in the amplifier are connected with GND electronic (20a, c), no other terminals should be connected with control GND, in order to avoid ground loops.

The control lines, the tachometer lines of the motor, and the motor lines are to be wired separately. The lines for the setpoint and the tachometer lines of the motor have to be shielded. The motor lines should be shielded as well to guarantee a low-interference operation in compliance with the EMC directives, especially in cases with high demands on interference immunity. The shield of the setpoint lines is to be connected to GND, while the shield of the tachometer lines is to be connected to the amplifier (20a, c). The shield of the motor lines must be connected to earth which is the source of the motor currents (28a, c).

To guarantee the reliable operation of the amplifier's safety function "Short-circuit strength", a low-resistance connection of the motor case with 0 volt intermediate circuit (28a, c) has to be made. This can be achieved with a delta PE wiring, which is Power GND. Motor ground and control ground must be connected as close as possible with an equipotential bonding strip.

The lines nominal speed value (12a, c and 14c) have to run to the control system in a shielded cable. The shield has to be connected to earth of the control. In the control systems the setpoint signal is normally available with ground reference or with reference to the voltage. Even in case of connection to ground, both setpoint values have to run to the control system and have to be connected to ground.

3.3 Measures for an Installation in Compliance with the EMC Directives

Because of the compact design of servo amplifiers, no complete noise suppression measures are possible without modifying the design. Therefore the proposed measures will comply with the EMC directive for the total system. These measures are necessary only for the used inputs and outputs. In addition to that, a single total interference suppression of the mains lead of all electronic subassemblies installed in the system, is possible. This would lead to a cost reduction compared to single interference suppression.

In order to simplify the installation work, there are a number of backplanes available with integrated interference suppression elements. Also available are connection boards for ring toridal-core transformers with interference suppression elements too.

- Motor lines and control lines have to be wired as shielded lines in principle. Avoid interferences and loops.
- All lines shall run in one direction only, that means no wye connection, from the servo amplifier via the mounting plate of the switch cabinet.
- The clearance between motor line, mains lead, and control lines should be at least 20mm. Otherwise there is a risk of interference coupling.
- The shield of each cable has to be connected close to the servo amplifier with a fastening clamp to the mounting plate of the switch cabinet. A large blank metallic contact surface must be provided. The shield of the motor line has to be connected on both sides (the resolver line or the tachometer line only at one side) to the servo amplifier.
- The mains transformer has to be installed close to the servo amplifier. The secondary line length of the transformer has to be as short as possible. Run the primary line of the transformer twisted with a clearance of at least 50mm to all other lines.
- The slide-in rack of the servo amplifier has to show a good HF contact to the mounting plate of the switch cabinet, provide for sufficient earthing of the switch cabinet.
- To earth the shieldings, the metallic armored screw joints must be used. Run them through the switch cabinet wall with a good metallic contact.
- For EMC reasons, the shields of one connection line must always have contact on both sides. Low-frequency circulating currents, however, may occur. These so-called hum pick-ups are created by earthing on both sides. This can be eliminated with a capacitive coupling of the shield, which allows high frequency efficiency.

It is useful to carry out an EMC examination for the complete system, consisting of many single components such as motor, servo amplifier, set value resolver, EMC filter, to guarantee a troublefree operation in compliance with the CE directive.

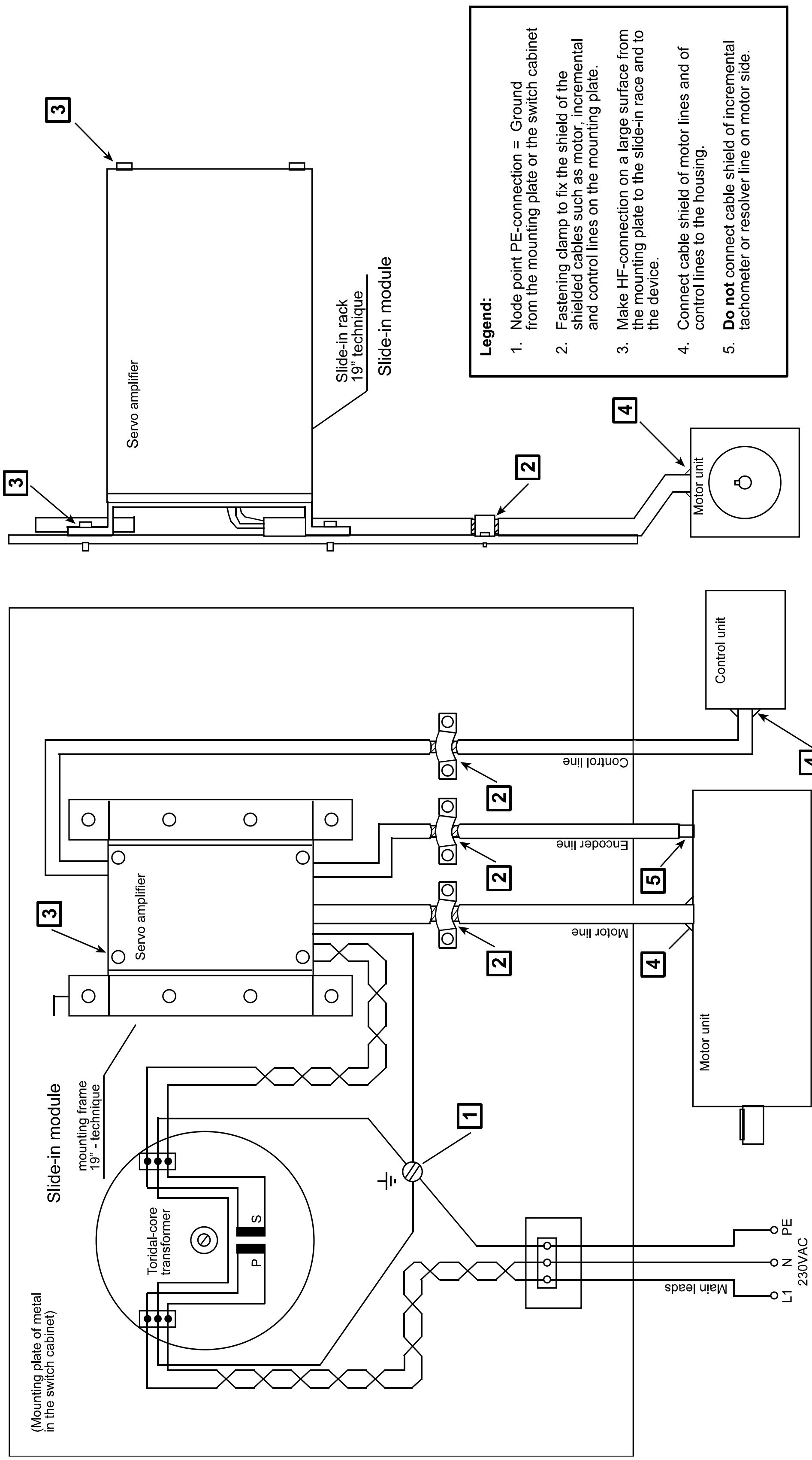


Figure 4: Installation in Compliance with the EMC Directive

3.4 Correct Motor and Tachometer Polarity

If you do the wiring of the motor shaft manually in the positive direction, while the device is switched off, a positive voltage against the terminals (24a,c) must be measurable at the terminals (22a,c). The tachometer voltage at the terminals (4a,c) must also be positive against terminal (6c). In case of an incorrect motor or tachometer polarity, the corresponding connection lines have to be exchanged. If the motor is controlled but runs in the wrong direction, you have to change the polarity for the motor lines as well as for the tachometer lines. A correction by changing the setpoint lines is also possible (see chapter “Explanation of the Pin Assignment”).

In case of an incorrect motor or tachometer polarity, the motor starts running with maximum speed and completely uncontrolled. This could result in serious damage to motor and machine.

3.5 Correct Motor and Incremental Encoder Polarity

Version “I” feedback with incremental encoder.

If you do the wiring of the motor shaft manually in the positive direction, while the device is switched off, a positive voltage against the terminals (24a,c) must be measurable at the terminals (22a,c). The tracks A and B of the incremental encoder then must have the correct phase position to each other. The track signal A at terminal 6c has to lead by 90 degrees as against track signal B (terminal 4a,c). In case of an incorrect motor or incremental encoder polarity, the corresponding connection lines have to be exchanged. If the motor is controlled but runs in the wrong direction, you have to change the polarity for the motor lines as well as for the incremental encoder lines. A correction by changing the setpoint lines is also possible (see chapter ”Explanation of the Pin Assignment”).

In case of an incorrect motor or incremental encoder polarity, the motor starts running with maximum speed and completely uncontrolled. This may result in serious damage to motor and machine.

3.6 Connection diagrams

3.6.1 Input Test Circuits for TRM24/7 and TRM60/5 - Tachometer Version -

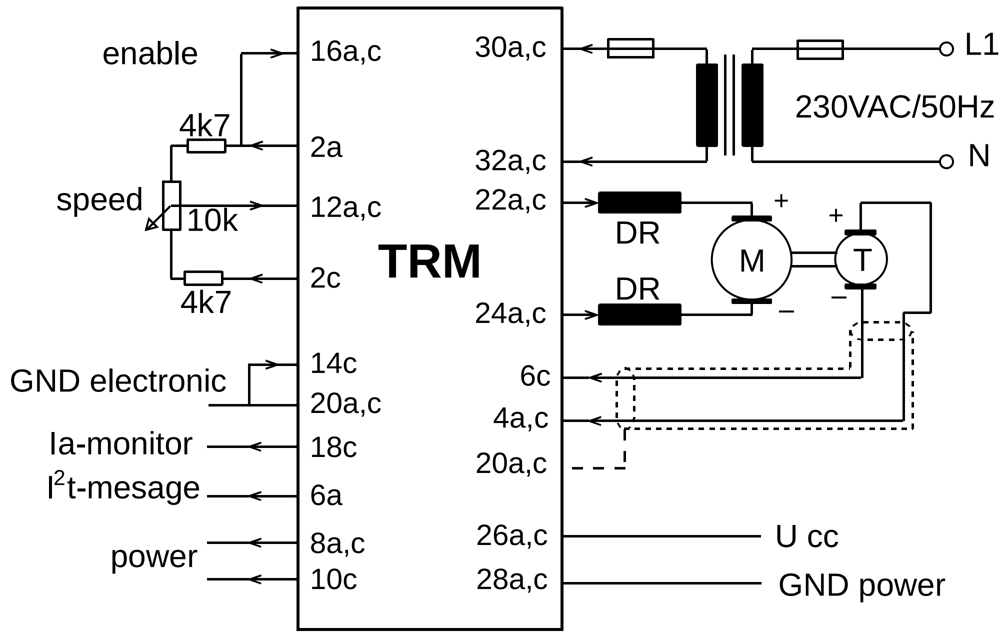


Figure 5: Input Test Circuit TRM24/7 and TRM60/5 with Tachometer

3.6.2 Input Test Circuit for TRM24/7I and TRM60/5I - IGT Version -

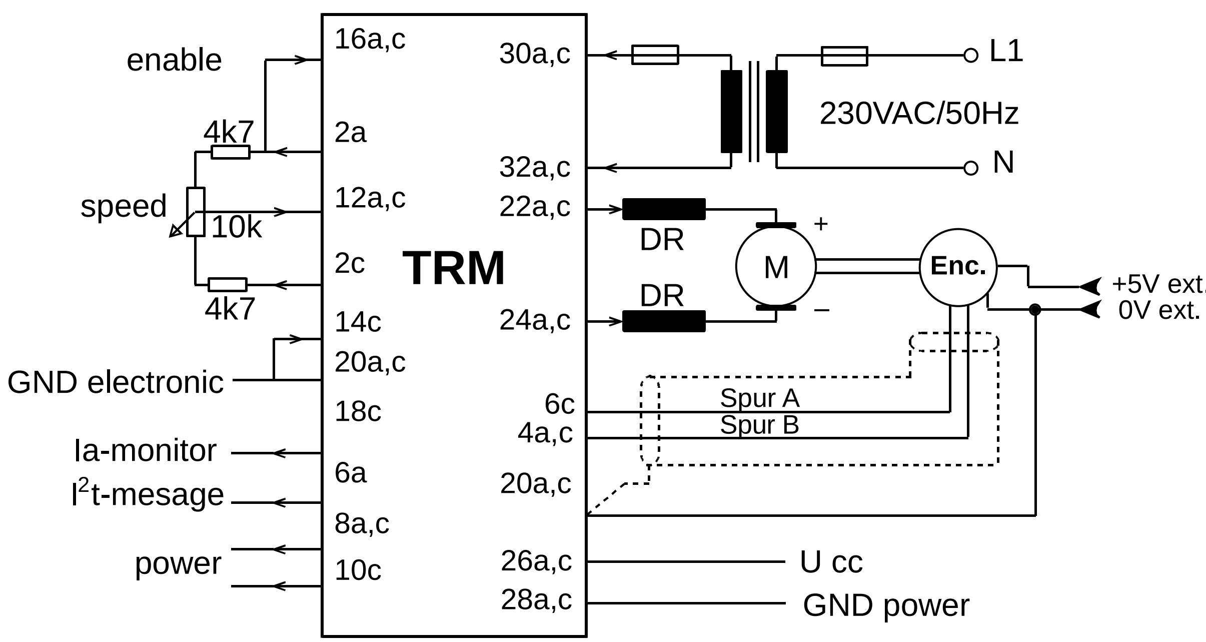


Figure 6: Input Test Circuit TRM24/7I and TRM60/5I with IGT

3.6.3 Input Test Circuit for TRM60/8 - Tachometer Version -

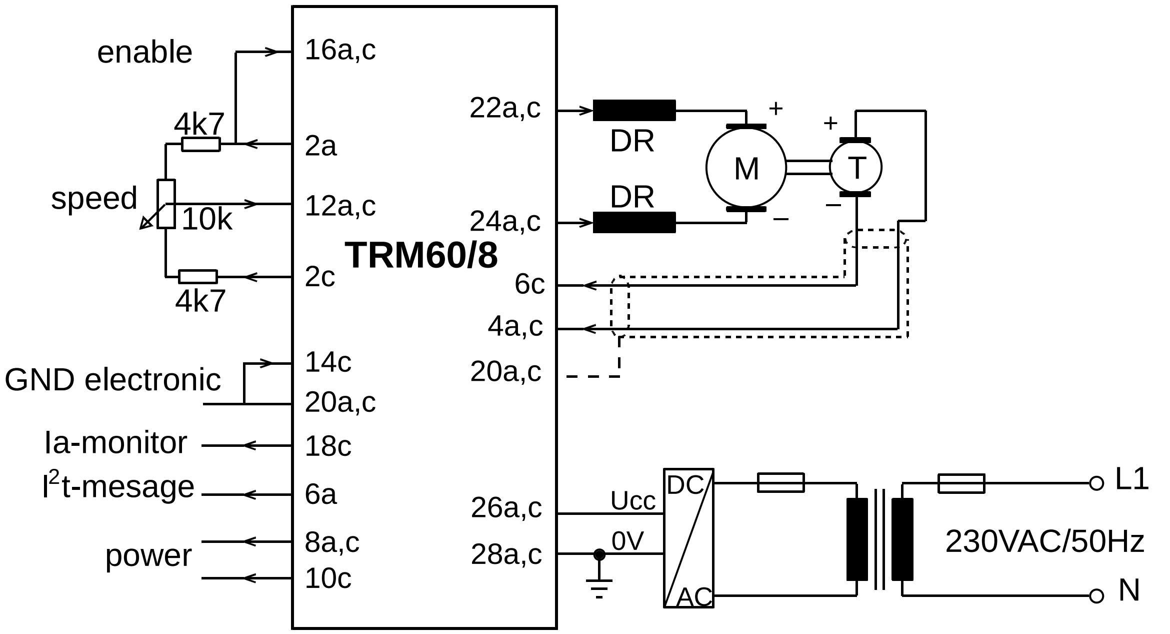


Figure 7: Input Test Circuit TRM60/8 with Tachometer

3.6.4 Input Test Circuit for TRM60/8I - IGT Version -

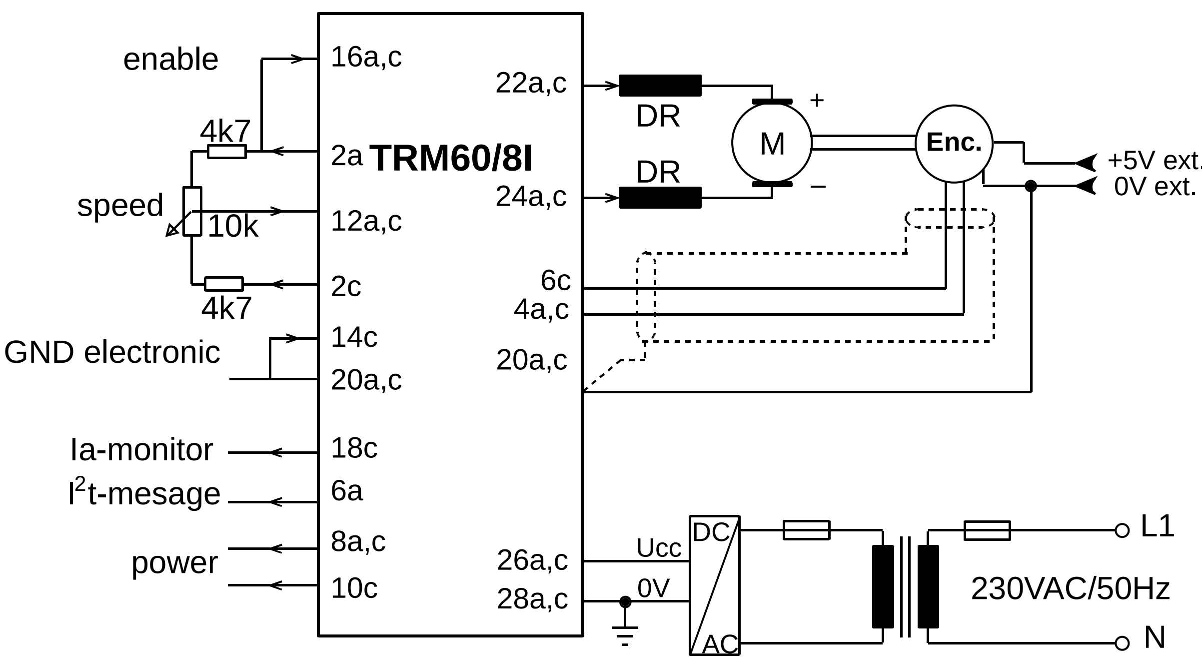


Figure 8: Input Test Ccircuit TRM60/8I with IGT

3.6.5 Wiring Example for TRM24/7 and TRM60/5 - Tachometer Version -

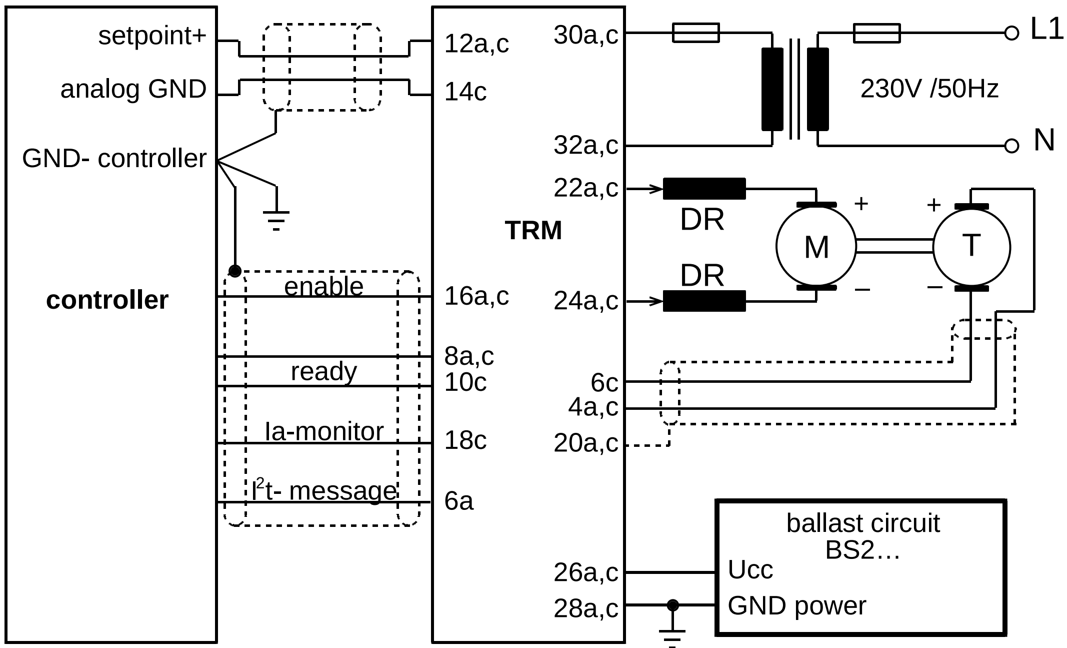


Figure 9: Wiring Example TRM/7 and TRM60/5 - Tachometer Version

3.6.6 Wiring Example TRM24/7 and TRM60/5 - IGT Version

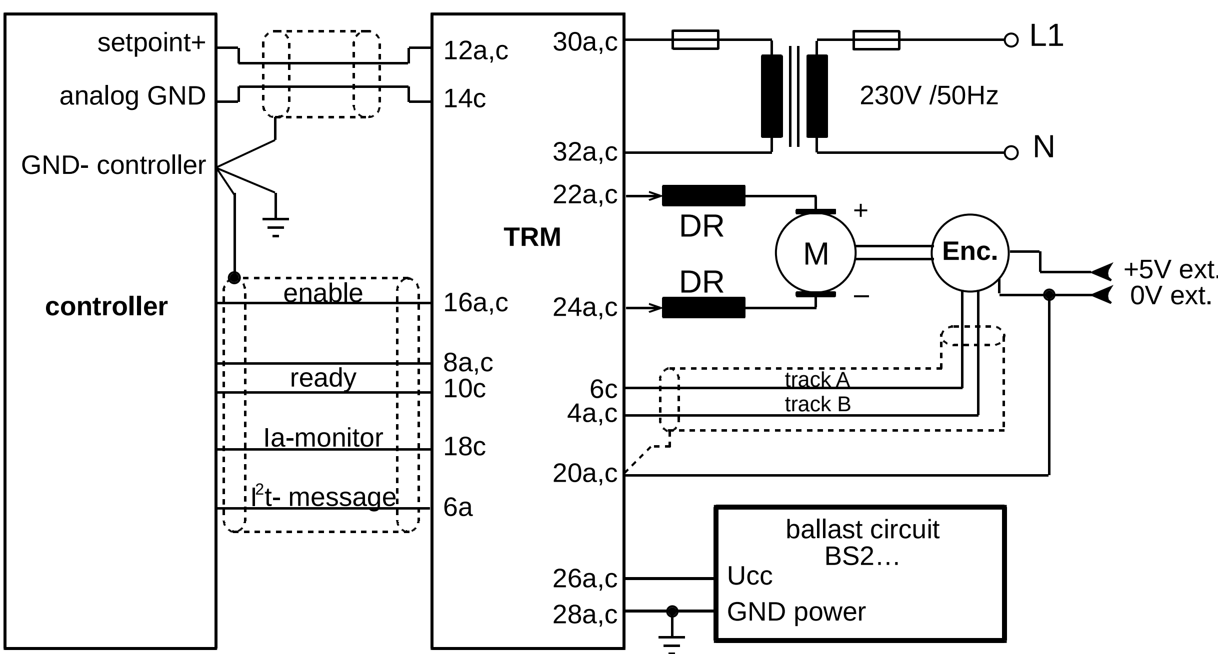


Figure 10: Wiring Example TRM24/7 and TRM60/5 - IGT Version

3.6.7 Wiring Example for TRM60/8 - Tachometer Version -

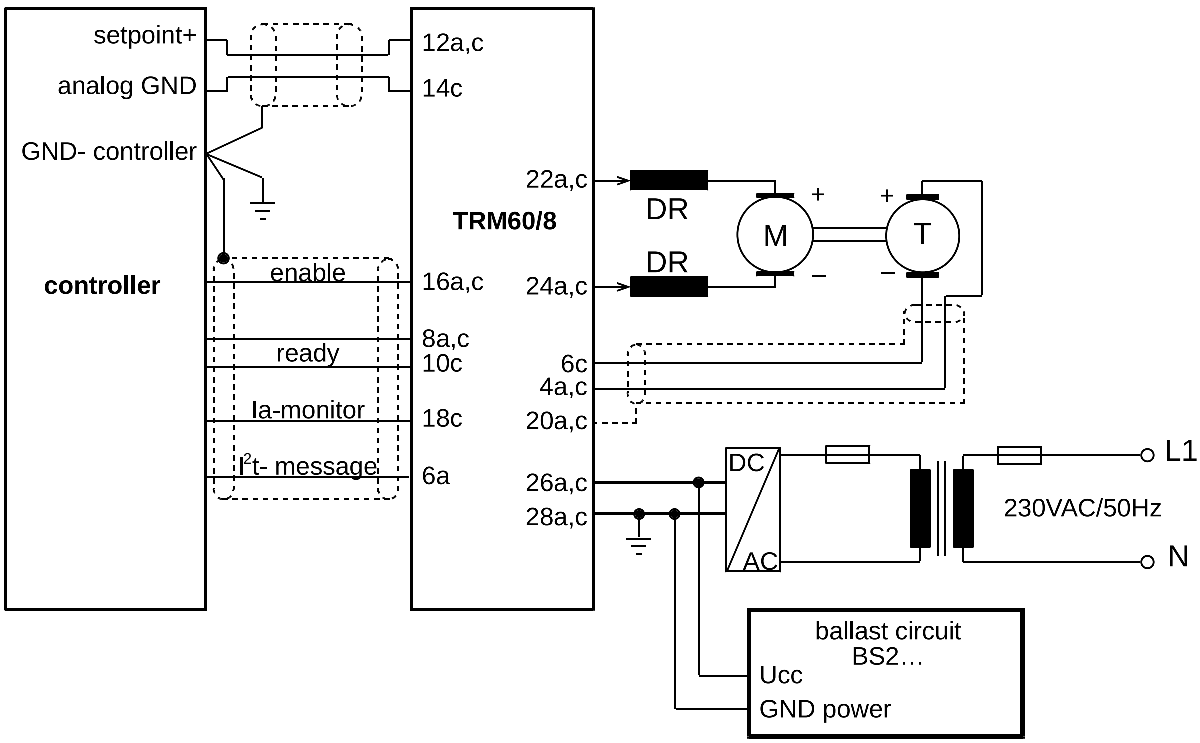


Figure 11: Wiring Example TRM60/8 Tachometer Version

3.6.8 Wiring Example TRM60/8I - IGT Version -

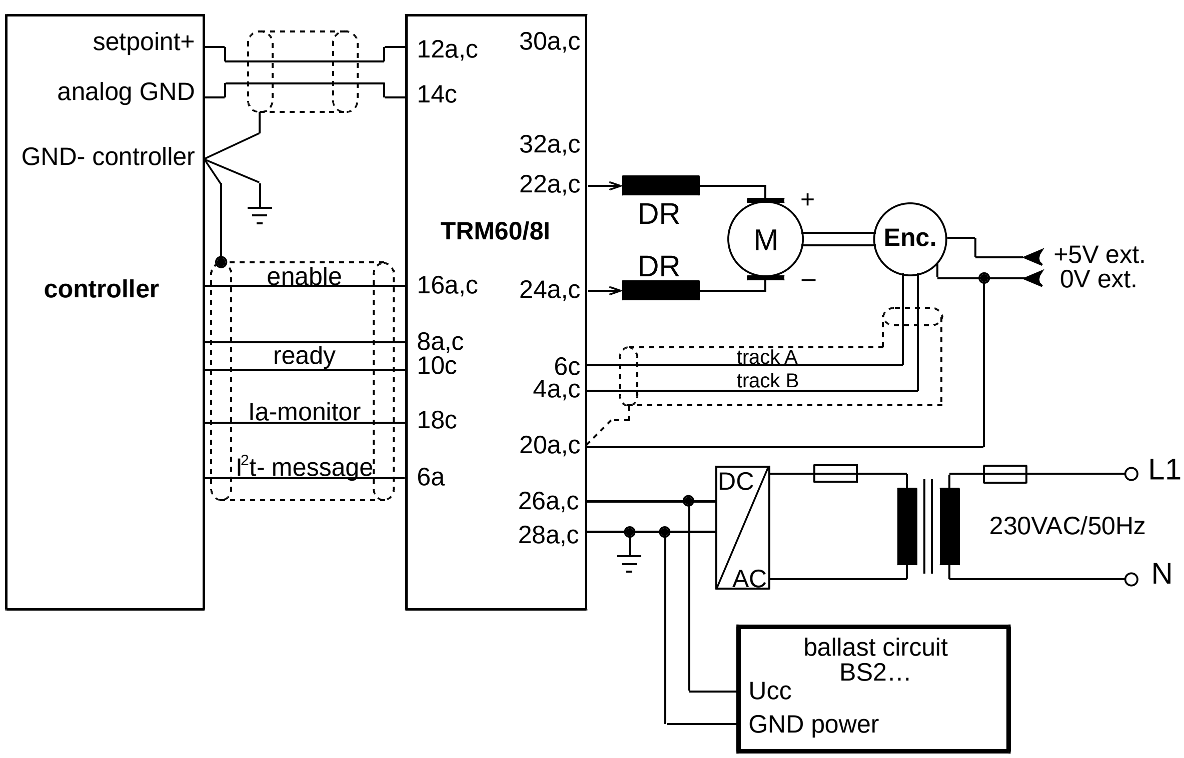


Figure 12: Wiring Example TRM/60/8I IGT Version

4 Set-up

Prior to set-up, read the chapter “Safety Instructions”, as well as all previous chapters.

4.1 Preparation

Make sure to check the wiring thoroughly and compare all connections with the pin assignment in chapter “Pin Assignment”. All devices are individually tested and adjusted with rated values and axis-specific data before delivery.

If incorrect connection cannot be completely avoided, proceed as follows to avoid damage to motor and machine:

- Switch off the operating voltage
- Turn tacho-potentiometer P1 to the left as far as possible
- Turn gain potentiometer P3 to the left as far as possible
- Turn effective current potentiometer P4 to a triple from the left stop position
- The offset potentiometer P2 may remain in the position set in factory
- Check all soldering jumpers for correct adjustment

4.2 Procedure

- Switch on the operating voltage

  If possible, do not apply the full operating voltage, but choose a voltage (e.g. through regulating transformer or transformer tap), with which the motor may only reach small speeds. This is to guarantee a considerably safer start-up.

- If the motor is provided with a brake, de-rate it.

- Activate the enable input (“1”)

  The motor has to stop with holding torque and must drift only slightly unless no nominal speed values are given. If the motor runs in an uncontrolled manner, switch it off immediately and check the tachometer circuit again for incorrect polarity, short-circuit, or line interruption. If you use an incremental encoder, please check the supply voltage and the existence of corresponding pulses, by turning the motor shaft manually. If the controller is operated as current controller (jumper 16 closed), the motor must not show a holding torque, unless there is a voltage at the setpoint input.

  When small setpoints are given, the motor will follow them

- Now you can apply the full operating voltage, so that the motor has to follow large setpoints as well and so the drive can be checked with full speed.

4.3 Adjusting Power Pulse Current and Effective Current

The maximum power pulse current is given through the resistor **R_I**. It is adjusted to the rated date for the device in factory. If other currents are necessary, use the following table.

I_{MAX} (in % from the device-typical power pulse current)	**R_I**
100%	180K
90%	68K
80%	33K
70%	20K
60%	13K
50%	9.1K
40%	6.2K
30%	3.9K
20%	2.4K
10%	1.2K

After run-down of the power pulse current phase, the current is reduced automatically to the effective current, adjustable with the potentiometer P4. For adjusting the potentiometer P4, turn it infinitely without delay. After a short matching time, during which the current is either 0 or I_{IMP}, the new continuous current flows.

For measuring the adjusted currents, the motor can also be replaced by an ammeter with a suitable measuring range. The necessary minimum load inductivity, however, must be guaranteed, that means this inductivity has to be achieved by means of reactors. Since the motor is not to be blocked here, the adjustment procedure can be simplified considerably by this. The value for the minimum load inductivity does not depend on the version and can be found in the chapter “Technical Data”.

4.4 Tachometer Adjustment

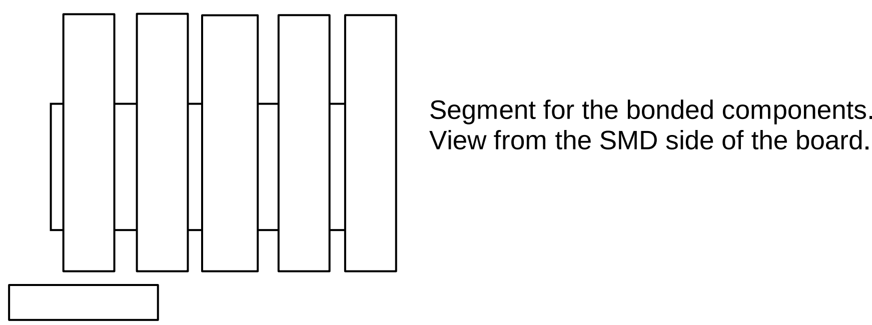
Before leaving the factory, the devices are calibrated to a motor speed of 3000 rpm with a tachometer delivering 6V/1000 rpm.

For adjusting the maximum speed, a set value of 10 volt or a certain percentage of this is applied to the setpoint input. The required final speed, or a percentage of this (as for the setpoint) is then adjusted with the tacho-potentiometer P1. If the speed cannot be adjusted in the desired range in this way, another tachometer voltage range has to be chosen by replacing the resistor $\mathbf{R_E}$.

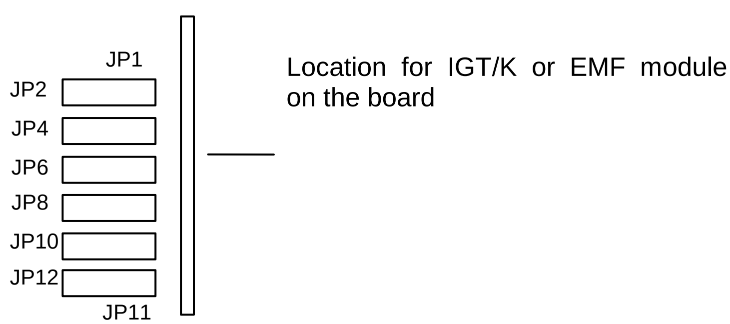
Tachometer voltage range	Values for R_E
12 to 72 Volt	not applicable
6 to 36 Volt	10kOhm
3 to 18 Volt	3.3kOhm

If the speed is too high, please reduce $\mathbf{R_E}$, or increase it if the speed is too low.
For versions with incremental encoder and EMF control, $\mathbf{R_E}$ is inserted in the factory.

- Incremental encoder control: $\mathbf{R_E}$= 20K
- EMF control: $\mathbf{R_E}$= 27K
- Location of $\mathbf{R_E}$ on the board:



4.4.1 Adjusting the Soldering Jumpers for Tachometer Operation



4.5 Offset-Adjustment

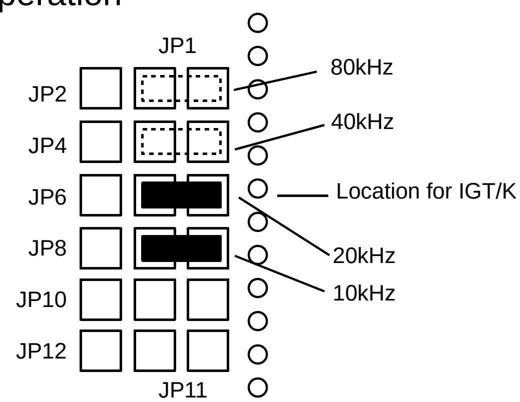
After all previously described adjustments have been made, it may be necessary to carry out an offset adjustment. To do this, a setpoint of 0 volt is once again given and a possible drifting of the motor shaft is eliminated with P2.

For a more precise offset adjustment, the tachometer voltage can be measured on terminals 4a, c and 6c using a voltmeter (switch to smallest measuring range) and adjusted to 0 volt.

The offset adjustment can also be carried out in other ways when a higher-ranking position controller is used.

4.6 Set-up with Incremental Encoder Feedback

4.6.1 Adjustment of the Soldering Jumpers with Incremental Encoder Operation



Use the jumpers 1, 3, 5 and 7 to program the maximum encoder frequency. Maximum operating frequency between 10 to 150kHz in increments of 10kHz can be adjusted by closing several jumpers. The illustration on the opposite shows the programming of e.g. 30kHz. All other jumpers must be open.

Instead of a speed feedback by d.c. voltage tachometer, the actual value can also be gained from the digital signals of an incremental encoder by means of the booster circuit **IGT/K**. The **IGT/K** is, in principle, an F/U converter, adapted to the special condition, and the speed-proportional output voltage of which is taken for control purpose. Most position feedback loops, which have an incremental encoder for the position identification, will not need an additional DC tachometer.

All devices for incremental encoder control are normally delivered with a maximum encoder operating frequency of 30kHz (JP1 and JP3 closed).

If another maximum encoder operating frequency is required, you may determine it using the following formula:

$$f\ \max = \frac{number\ of\ \ pulses \times \max.speed}{60}$$

Example:

Number of pulses the encoder delivers: 1000 pulses per rotation.
Maximum motor speed: 4000 rpm.

$$\text{operating frequency} = \frac{4000}{60} \times 1000 = 66{,}66kHz$$

The next higher programmable maximum operating frequency is chosen, that means 70kHz. JP3 (40kHz), JP2 (20kHz) and JP1 (10kHz) have to be closed.

4.6.2 Retro-conversion for Incremental Encoder Operation

A retro-fitting of the F/U converter **IGT/K** is possible, but should be done in our factory, because the amplifier has to be dismantled for that. Please let us know, in case of need, how many increments per rotation the used encoder delivers and the maximum motor speed. A special description of this hybrid circuit is available upon request.

When retro-converting the device for incremental encoder operation, verify the correct fitting of the hybrid “IGT/K”. Soldering has to take place in a way that the white point on the module is at PIN1 of the module location (PIN1 and PIN12 are marked on the board). In addition to that, a value of 20kOhm has to be soldered in for the bonded resistor R_E (see “Component Mounting Diagram SMD Page”).

Article number for the F/U converter: **IGT/K**

4.6.3 Set-up with Incremental Encoder Feedback

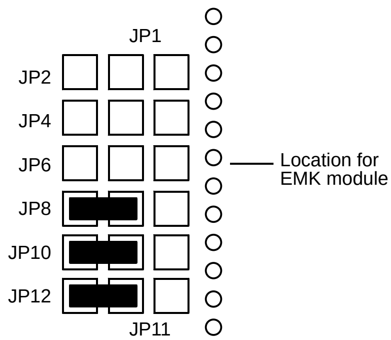
Even in case of a set-up with incremental encoder all previous chapters must have been read, except the chapter “Tachometer Adjustment”.

The procedure for set-up with IGT/K is, in principle, the same as for set-up with tachometer. Just the adjustment of the maximum encoder operating frequency through the soldering jumpers J1, J3, J5 and J7, as well as the existence and the value of the resistor R_E (20kOhm) have to be checked and modified, if necessary (see above).

The fine adjustment of the speed is done here also with the tacho-potentiometer P1.

4.7 Set-up with EMF/IxR Feedback

4.7.1 Adjustment of the Soldering Jumpers for EMF Control with IxR Compensation



If no IxR compensation is required, the jumper JP8 may remain open.

4.7.2 Retro-conversion for EMF/IxR Control

A retro-fitting of the module **“TRM/IxR”** is possible - but must done in our factory, as the amplifier needs to be disassembled..

When retro-converting the device for EMF/IxR operation, verify the correct fitting of the module “TRM/IxR”. It has to be soldered so that the potentiometers can be operated from the front side of the amplifier. In addition to that, a value of 27 kOhm has to be soldered in for the bonded resistor R_E (see “Component Mounting Diagram SMD Page”).

Article number of the EMF module: **TRM/IxR**

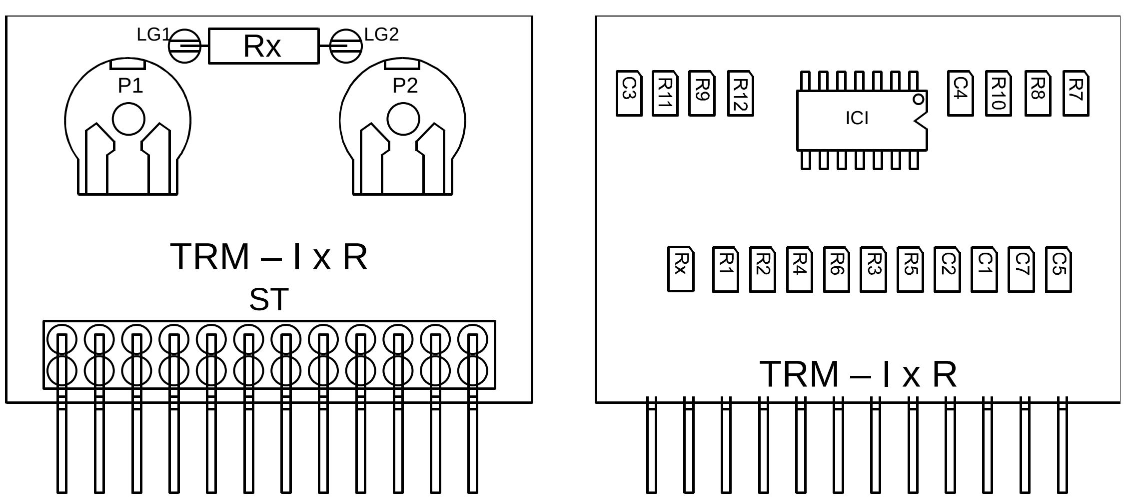


Figure 13: Component Mounting Plan TRM/IxR

4.7.3 Set-up for EMF Control

Even in case of a set-up with EMF control, all previous chapters must have been read, except the chapter “Tachometer Adjustment” and “Set-up with Incremental Encoder”

The procedure for set-up with the module "TRM/IxR" is, in principle, the same as the set-up with tachometer. Only the adjustment of the maximum speed and of the IxR compensation differs.

The complete adjustment should be done while the motor is cold, as motor resistance increases as the temperature rises. A compensation with a warm motor would lead to an over-compensation in cold condition, that means the motor would turn faster under load.

- Turn the tacho-potentiometer P1 to the left as far as possible.
- Turn the gain potentiometer P3 to the center position (approx.).
- When maximum setpoint is reached, turn the EMF potentiometer P1 (on the module “TRM/IxR”) to the right until about 90% of the required speed is reached.
- Do the fine speed adjustment by turning the tacho-potentiometer P1 (on the TRM board) to the right.

The IxR compensation may take place in two ways:

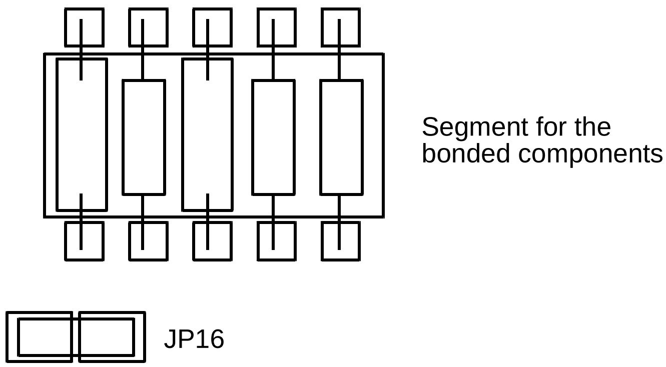
- **IxR compensation with speed counter:** Define a speed of about 10% of the maximum speed and put full load on the motor shaft; the speed will decrease. Turn the IxR potentiometer P2 (on the module “TRM/IxR”) to the right until the speed decrease is nearly compensated. Decreasing the speed by some percentage should be allowed, to avoid that the motor will be over-compensated in case of a possible decrease of the ambient temperature. If the adjustment range of the IxR potentiometer is not large enough, the resistor R_X (on the module ‘TRM/IxR’) has to be increased.

- **IxR compensation with oscilloscope and tachometer:** Define start-stop pulses at the setpoint input and watch the step response at the auxiliary tachometer with the oscilloscope. When operating the brake the motor should reach the new speed (standstill) after one or two overshoots. If no overshoots can be identified, turn the IxR potentiometer P2 (on the module “TRM/IxR”) to the right, in case of too strong overshoots to the left. In case of an insufficient compensation with the potentiometer completely turned to the right, increase the resistor R_X (on the module “TRM/IxR”).

After adjustment of the IxR compensation, a fine speed adjustment with the tacho-potentiometer P1 (on the TRM board) should be repeated.

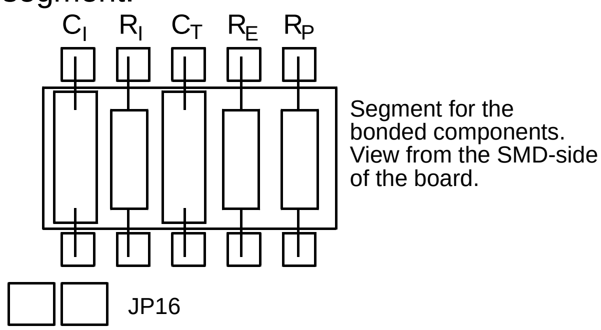
4.8 TRM as Current Controller

If the amplifier was not ordered as current controller, the standard adjustment is “Speed control”. In some applications it may be useful to operate the device as current controller, since a synchro-control is required or the speed controller is already implemented in a higher-ranking position control. The soldering jumper JP16 must be closed to operate the device as current controller. The jumpers JP1 to JP12 then must be open. The setpoint inputs (12a, c) and (14c) are still to be used for current setpoint supply.
Location of jumper JP16:



5 Optimizing the Controller Response

All components (fixed resistors and capacitors) for optimizing the controller response are located in a board segment.



5.1 AC Voltage Gain

For most applications, the optimization is restricted to the adjustment of the AC voltage gain (Gain) at potentiometer P3. To do this, couple the motor with load and define a set value of 0 volt. Turn the potentiometer P3 to the right until the oscillation starts and then determine the point when oscillation stops again by immediately turning the potentiometer to the left.

When using a higher-ranking position controller, the gain adjustment may also be done under consideration of the positioning accuracy.

5.2 DC Voltage Gain of the Speed Controller

Especially in case of a higher-ranking position loop, precise static rigidity is often required. The resistor $\mathbf{R_P}$ is intended for changing the rigidity. The rigidity decreases with increasing resistance. The static rigidity must not be confused with the dynamic rigidity, adjustable at P3 (AC voltage gain). A value of 330Ω is normally inserted for $\mathbf{R_P}$. The location of the resistor is found on the component mounting diagram in chapter “Component Mounting Diagram - Bottom Side”.

5.3 Tachometer Filtering

The capacitor $\mathbf{C_T}$ is intended for filtering the tachometer signal. Nevertheless this capacitor is also responsible for the limitation of the control band width, so that no oscillation because of torsion resonance occurs. A whining noise coming from the motor, which cannot be eliminated with the Gain potentiometer P3, identifies such an oscillation by torsion resonance. For suppressing the oscillation, progressively increase the capacitor $\mathbf{C_T}$, until the motor runs smoothly. A further increase unnecessarily deteriorates the dynamic controller response (overshoots). A value of 47nF is a practice-proven value for $\mathbf{C}_T$.

The location of the component is found on the component mounting diagram in chapter “Component Mounting Diagram - Bottom Side”.

A value of 47nF is normally inserted for C_T.

5.4 Integral-action Component of the Speed Controller

The capacitor **C_I** is responsible for the integral-action component of the speed controller.

The demands on the dynamics of the amplifiers considerably differ from those a higher-ranking position controller requires, when operating it as speed controller.
In the first case, the rigidity has to be generated by the speed controller, which for this reason must have the largest possible integral gain (**C_I** must be small). A short-time overshooting is normally allowed. A value of about 100nF for **C_I** would be ideal here. In case of a higher-ranking position controller, however, the rigidity will be generated by the position controller itself. Here the largest possible band width of the servo amplifier is significant, where the integral gain may be considerably lower than in the first case. The capacitor **C_I** must be increased here. The overshooting of the amplifier without position control becomes less, the braking time until standstill of the motor, however, is a little bit longer. For this kind of speed control, 2µF for **C_I** are usual values. The location of the component is found on the component mounting diagram in chapter "Component Mounting Diagram - Bottom Side".

A value of 100nF is normally inserted for **C_I**

6 Troubleshooting

The following pages show, in short form, the most frequently occurring troubles and their possible causes:

LED1 “Power” does not light, axis does not move, no holding torque:

- No operating voltage
- Device fuse Si.1 is defective
- ±15V auxiliary voltage is defective
- Fuses in the operating voltage supply are defective

LED1 “Power” lights, LED3 “Enable” does not light, axis does not move, no holding torque:

- No amplifier enable

LED1 “Power” lights, LED3 “Enable” lights, axis does not move, no holding torque:

- Interruption of the armature circuit
- Device works as current controller (JP16 closed)
- Too large power pulse current limiting

Axis moves, weakly pronounced holding torque:

- Device works as current controller (JP16 closed)
- Too large power pulse current limiting

Axis does not move, motor has no holding torque:

- No nominal speed value
- Motor shaft blocked

I^2t message LED 4 lights:

- Wrong I^2t limiting adjustment (P4)
- Too large mechanical friction
- Armature short-circuit in the motor
- Field excitation too weak
- Hum noise on the input line
- Oscillations because of incorrect gain adjustment (P3)

Fault LED2 (red) lights:

- Too high operating voltage
- Too high braking energy
- Overcurrent because of short-circuit or flashover in the motor
- Minimum load inductivity not reached
- Short-circuit in the amplifier
- The thermal switch reacted, as the heat sink temperature is >80°

Uncontrolled high motor speed:

- Incorrect polarity of tacho-generator or incremental encoder tracks
- Interruption of tachometer circuit or incremental encoder tracks
- No tachometer voltage or track signals
- Incorrect adjustment of the soldering jumpers JP1 to JP16

Speed too low:

- Incorrect tachometer adjustment or incorrect adjustment of the maximum operating frequency for the incremental encoder (JP1, JP3, JP5 and JP7)
- Nominal speed values too low
- Operating voltage too low
- Driven load too high

Untrue running of the motor:

- Tacho-generator or incremental encoder defective
- Short-circuit in the armature

Irregular running of the motor:

- Too large AC voltage gain
- Too large tachometer voltage ripple
- Number of pulses generated by the incremental encoder too small
- Interferences by incorrect input wiring

7 Options

7.1 Front Panel

A front panel for 19" sub-racks, labelled in German language is available for the devices. The panel has a height of 3HE and a width of 8TE.

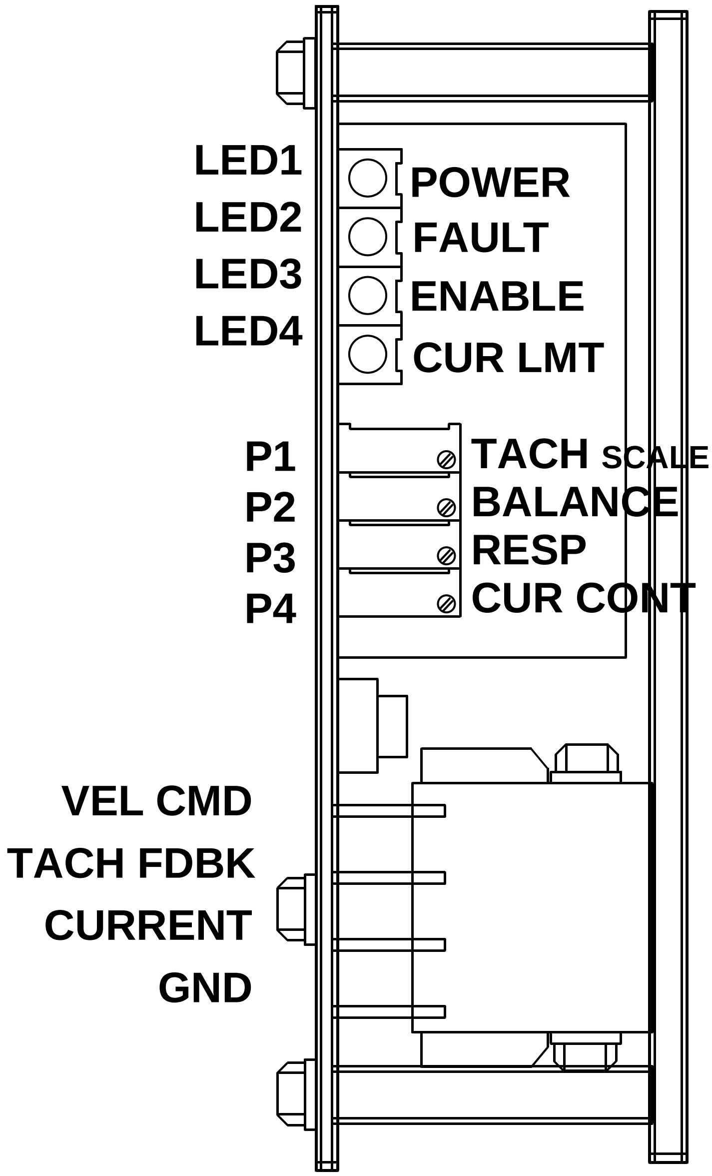


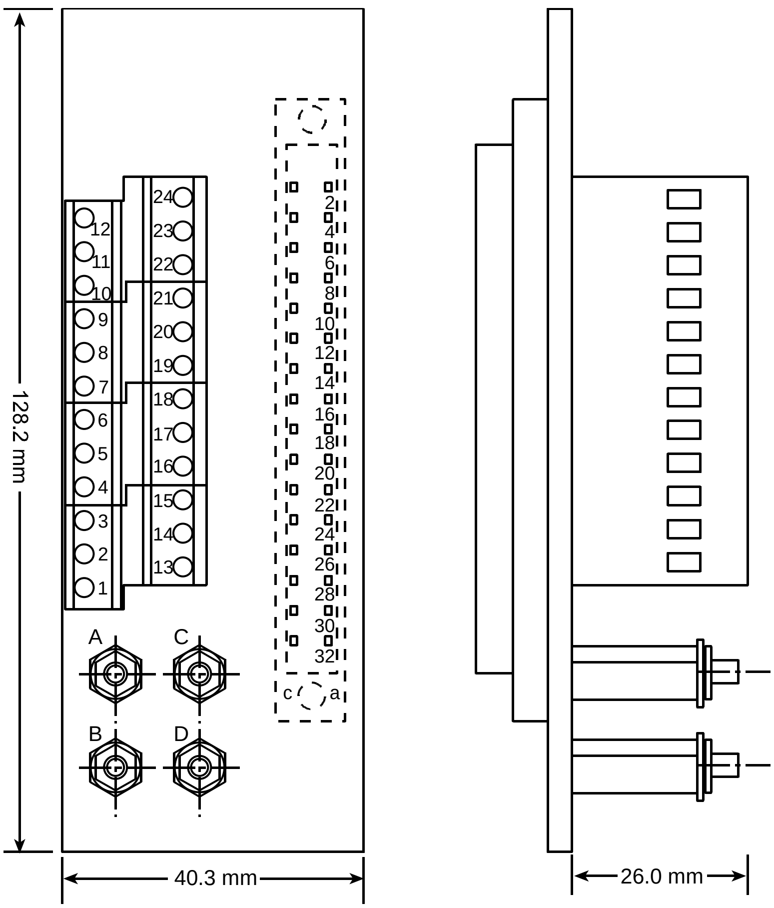
Figure 14: Front View TRM

7.2 Bus Boards

There is a bus board for 19" sub-racks 3HE available, to make the wiring easier. This will save time and increase precision and operating safety.

This bus board (article no: **TRM/BUS-S**) has a 24-pin screw-type terminal strip. With this version it is possible to complete the transformer connections and the connections for the intermediate circuit Ucc (parallel switching of several axes) by means of M3 studs.

7.2.1 Bus Board TRM/BUS-S



Pin assignment

Screw-clip	plug
1 = AC2 (transformer)	(32a,c)
2 = AC1 (transformer)	(30a,c)
3 = NC	
4 = I_A - Monitor	(18c)
5 = NC	
6 = NC	
7 = NC	
8 = for Optionals	(14a)
9 = Ready operational	(10c)
10 = Ready operational	(8a,c)
11 = I^2t - message	(6a)
12 = +15V	(2a)
13 = motor -	(24a,c)
14 = motor +	(22a,c)
15 = GND electronic	(20a,c)
16 = NC	(18a)
17 = GND electronic	(20a,c)
18 = Enable	(16a,c)
19 = Input -	(14c)
20 = Input +	(12a,c)
21 = NC	(10a)
22 = Tacho -	(6c)
23 = Tacho +	(4a,c)
24 = -15V	(2c)

OPTIONAL:

A	+UB (interm, circuit)
B	0V (ground)
C	AC1 (transformer)
D	AC2 (transformer)

Figure 15: TRM/BUS-S Pin Assignment for Screw-type Terminal Strip

8 Additional Boards

8.1 Ballast Circuit (BS2/24, BS2/60)

8.1.1 General

The kinetic energy, stored in motor and load, is recovered through the amplifier into the power supply when braking occurs. However, the energy consumption of the filter capacitor is not sufficient for this energy in case of a large moment of inertia, and an energy recovery into the mains is not possible in case of an uncontrolled rectifier bridge. The increase of the intermediate circuit voltage over a defined value enables the amplifier. This is indicated by “LED2” (red, fault). A ballast circuit has to be connected in this case.

8.1.2 Operating Principle

The ballast circuit (often called brake chopper) mainly consists of a comparator, a power switching transistor and power resistors. If the intermediate circuit voltage exceeds the ballast tolerance voltage because of regenerative motor power (generator operation), the comparator activates the power switching transistor. The transistor then switches the power resistors parallel to the intermediate circuit voltage until the value felt below a certain value. The electronic power limiting by a so-called "soft" ballast threshold is something special. This threshold protects the power resistors against overload, by displacing the ballast threshold upward when the maximum continuous power is reached, until the amplifier gets overvoltage and indicates "Fault". Since the motor cannot be braked down any longer, no more power will be delivered to the ballast circuit. If you notice that the consumption capacity of the ballast circuit is insufficient, a further ballast circuit board (or several boards) can be switched parallel to the first one. The boards will be adapted to each other by the "soft" threshold, described before.

The safety function ”electronic power limiting” only works in case of an overvoltage because of regenerative motor power. A longer exceeding of the operating voltage by the power supply may destroy the ballast board (risk of fire).

For determination of the braking power the following formula can be used

$$P = \frac{0{,}0055 \times J \times n^2}{T}$$

where:

- P = power in [W]
- J = moment of inertia in [kg m≤]
- n = speed in [rpm]
- T = period duration in [sec.]

(Time from the beginning of a braking process until the beginning of the next braking process)

8.1.3 Technical Data

TYPE	BS2/24	BS2/60
max. pulse power	550W	1280W
max. continuous power	35W	35W
Switch-on threshold	43V	87V
Switch-off threshold	40V	83V

8.1.4 Connecting the Ballast Circuit

STOP

The ballast circuit contains live and uncovered parts with up to 100V and power resistors which, depending on the current braking power, may become very hot (risk of burn). Please guarantee protection against contact by adequate installation.

The ballast circuit is connected parallel to the intermediate circuit voltage of the amplifier(s). Use a line cross-section of at least 1.5mm^2.

8.1.5 Pin Assignment

2a...32a	Power GND of intermediate circuit voltage
16c...32c	Power GND of intermediate circuit voltage
2c...14c	+UB of intermediate circuit voltage

At least five contacts have to be switched parallel for the connections +UB and Power GND.

8.1.6 Top View BS2/24, BS2/60:

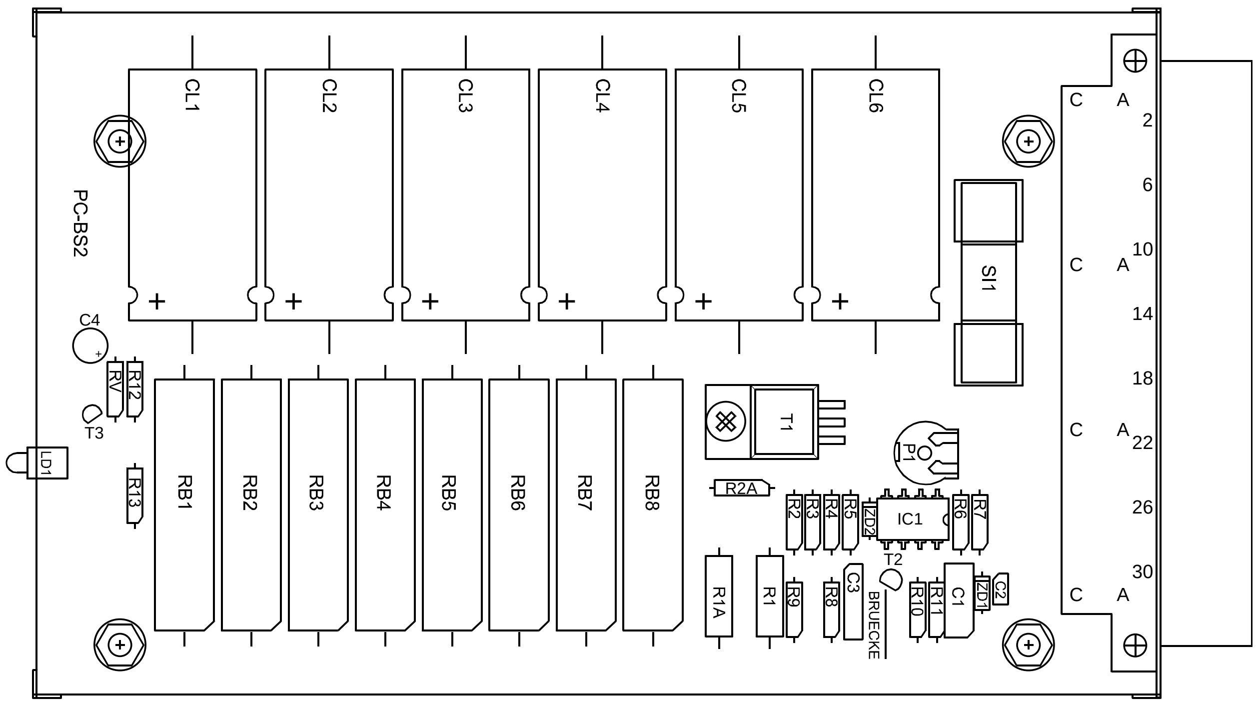


Figure 16: Component Mounting Diagram, Ballast circuit

9 Appendix

9.1 Component Mounting Diagram, Top Side (TRM24/7, TRM60/5)

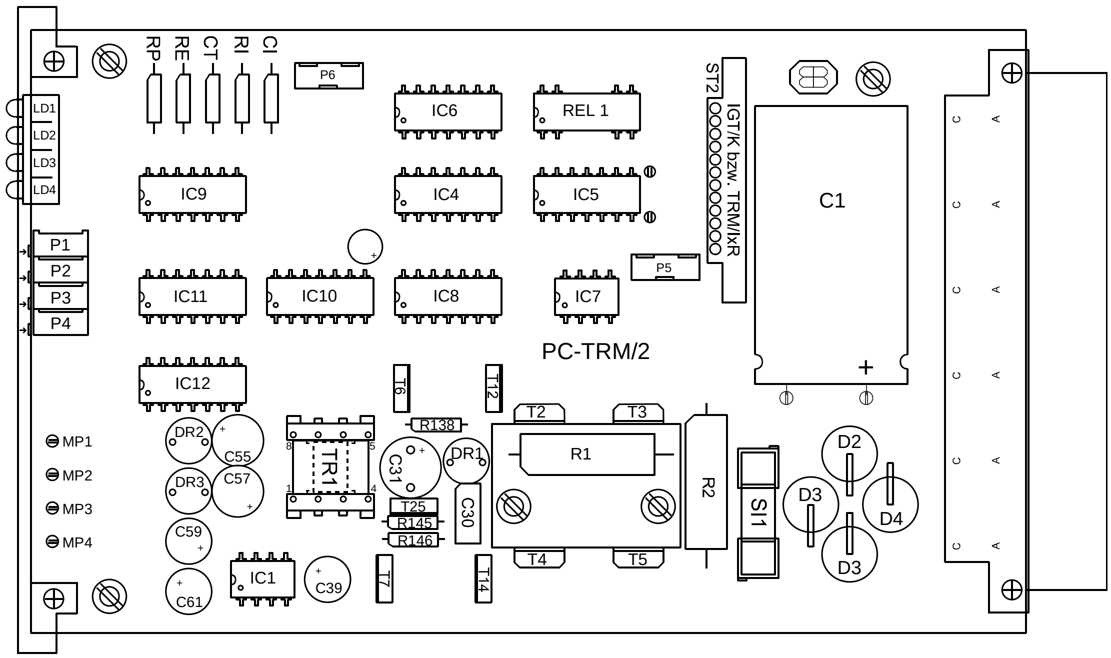


Figure 17: TRM24/7; TRM60/5 Component Mounting Diagram, (top side)

9.2 Component Mounting Diagram, Top Side (TRM60/8)

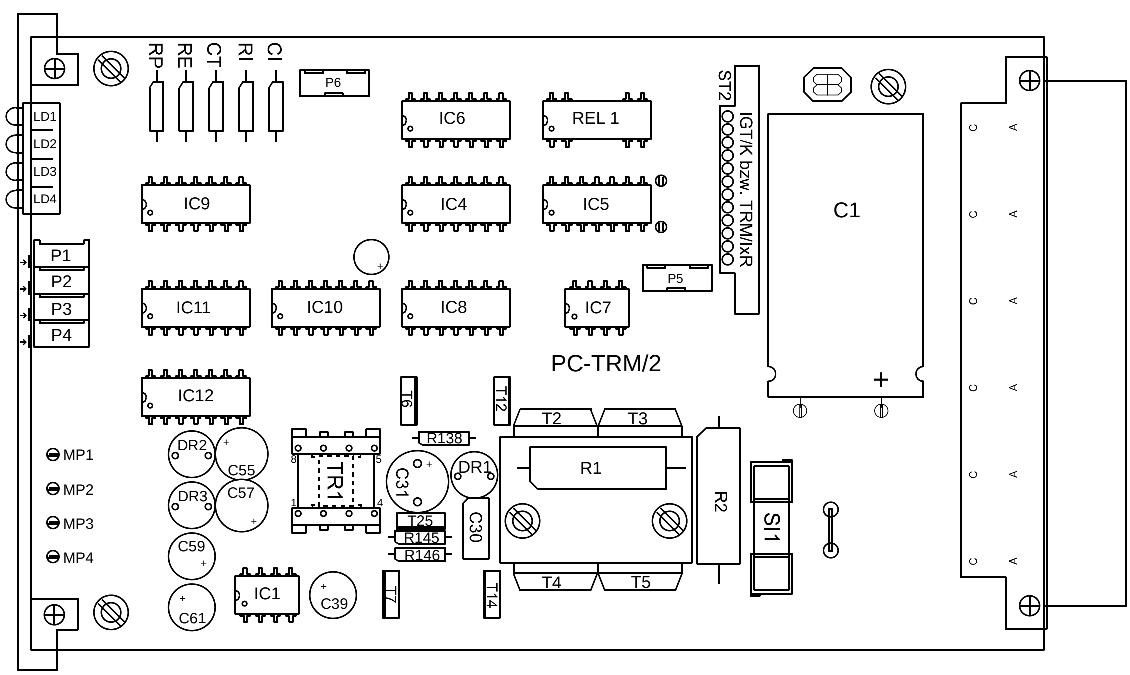


Figure 18: TRM60/8 Component Mounting Diagram, (top side)

9.3 Component Mounting Diagram, Bottom Side (all versions)

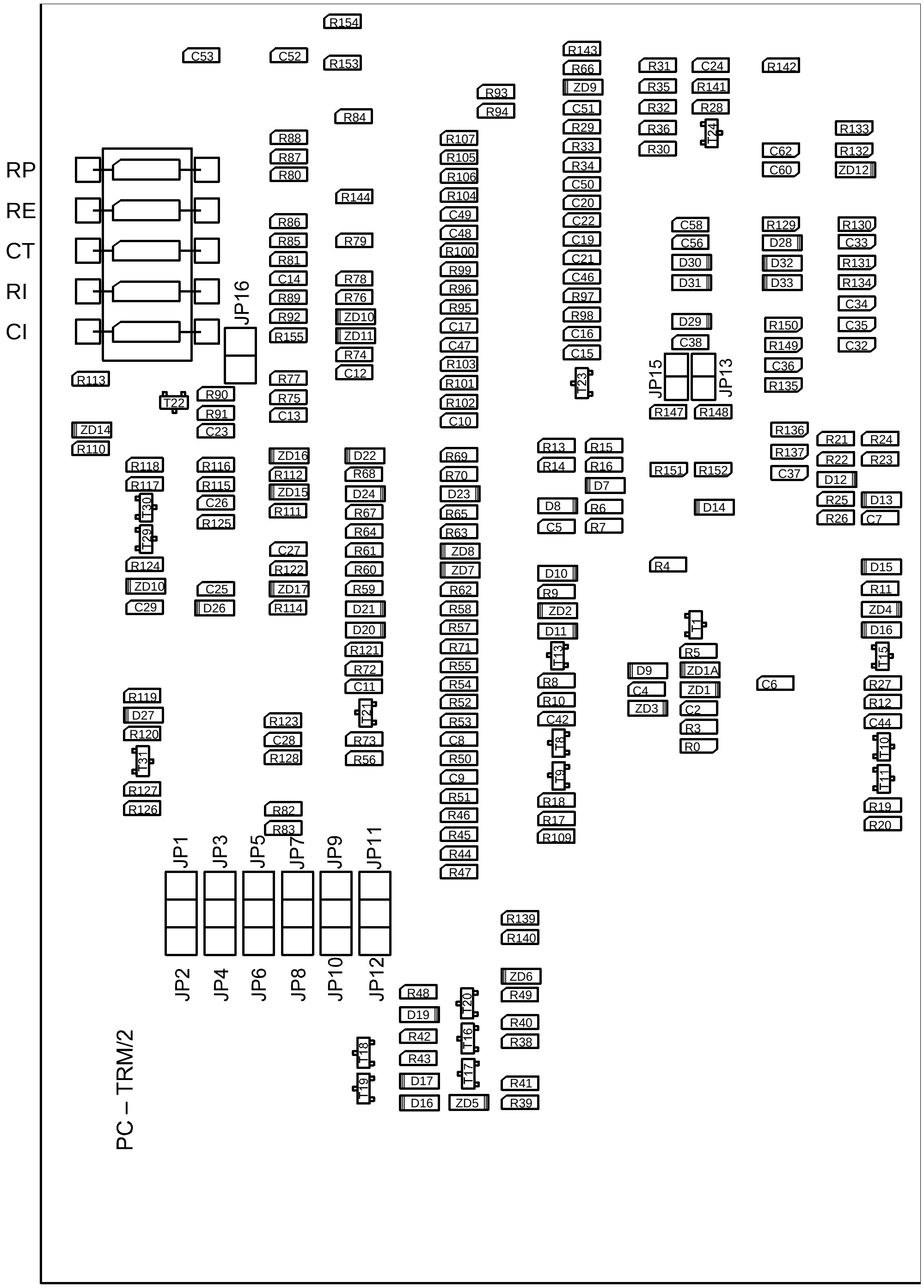


Figure 19: TRM Component Mounting Diagram (bottom side)

9.4 Dimensional Drawing

TRM24/7, TRM60/5, TRM60/8

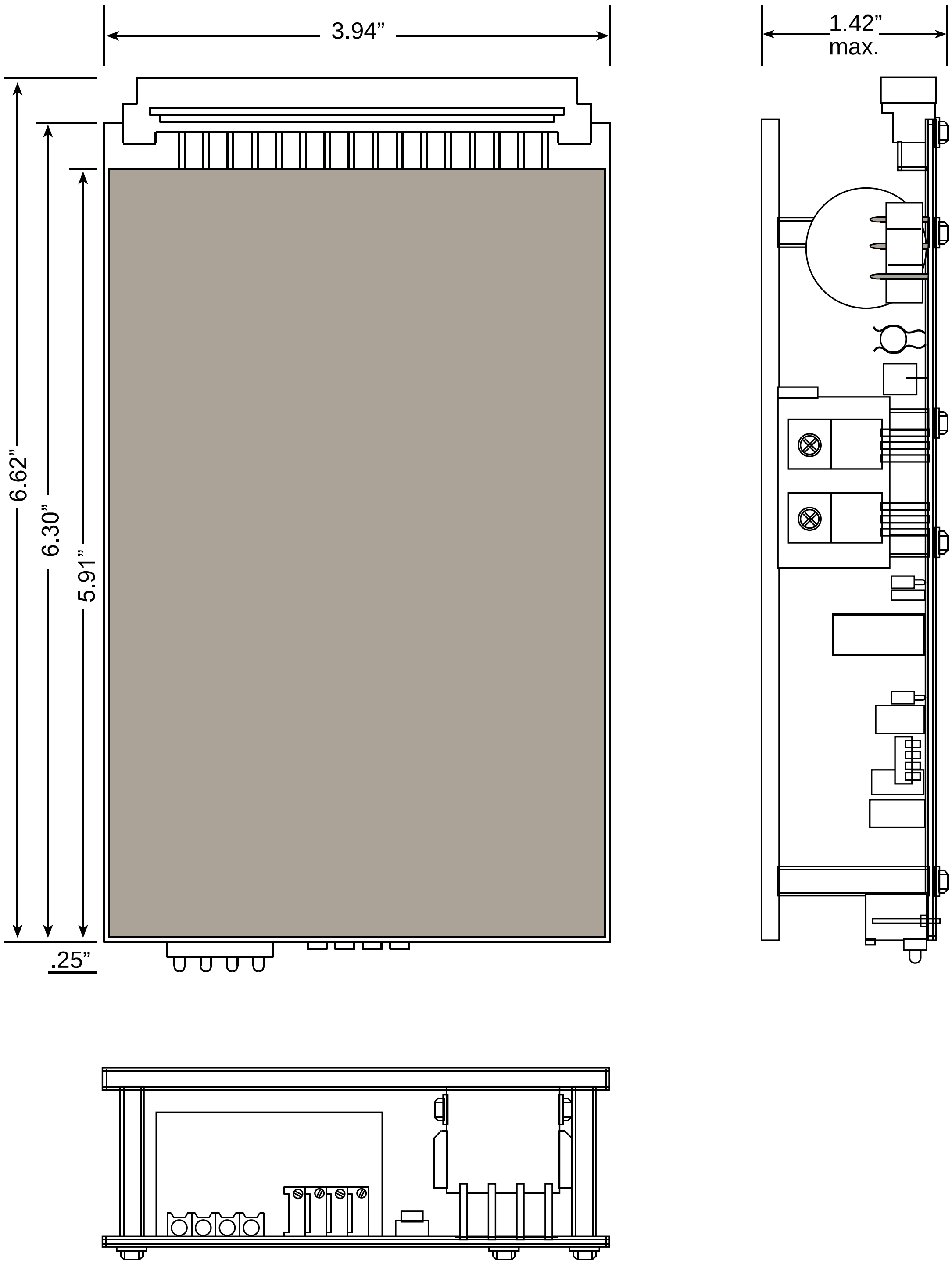


Figure 20: Dimensional Drawing, (TRM)