
**Pulse Width Modulated
4-Quadrant Servo Controller**

Series TBF-R Installation Manual
For electronic commutated servo motors

0199

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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!
- Trained personnel who are knowledgeable of the safety instructions must carry out installation, connection and set-up.
- 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.

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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 automatization technique 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/plant is used only when in a safe and reliable state.
- the machine is used in accordance with instructions set out 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 an information, important with regard to the use of the machine. Non-observance may lead to troubles.

1.5 Safety Notes



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

Only qualified personnel, who knows the contents of these start-up instructions, must execute any work on these subassemblies. 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 is 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 measuring or test work on any live device, please observe the relevant accident prevention regulations. The work must be done only with 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 main 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 Information

The series R amplifiers (= resolver) are servo amplifiers for speed control of brushless servo motors. They extract the information for the sine commutation of the motor and for the speed feedback from the signals of the resolver, attached to the motor. In addition to that, incremental encoder signals are simulated by these signals. This allows the realization of favorable solutions for a large range of applications with low and medium power levels.

The amplifiers work with a pulse-width modulated power amplifier in MOSFET technique. The design is a 3 HE (Euroformat) for 19" slide-in racks. These devices have an integrated power supply unit. The electronics is supplied internally from the intermediate circuit voltage, which also allows a battery-powered operation.

The main characteristics are:

- Sine commutation
- Hybrid technique/ SMD technology
- 19 inch/3HE slide-in technique
- Internal power supply unit
- High dynamics
- High efficiency
- Almost no clock noise by doubling of the current frequency
- Short-circuit proof and ground contact proof
- Protective circuit: Undervoltage, overvoltage, overcurrent, overheating
- I^2t current limiting
- Differential amplifier input
- Enable input
- External current limiting
- Limit switch inputs
- PLC compatible inputs
- Incremental encoder simulation

Type code:

TBF

Series

60

Nominal voltage

/ 5

Nominal current

R

Feedback with: R = Resolver
(Optional T = Tachometer generator and
I = Incremental encoder is
separated define.

2.2 Technical Data

Series	TBF60/5R	TBF60/10R	TBF120/7R
Nominal voltage	60V	60V	120V
Nominal current (peak value)	5A	10A	7A
Pulse current (peak value)	15A	25A	18A
Intermediate circuit voltage	max. 85VDC	85VDC	170VDC
	min. 25VDC	25VDC	70VDC
Recommended transformer voltage	54 AC	54VAC	95VAC
Ballast circuit	–	–	internal
Electronic supply		internal	
Efficiency		93%	
Residual voltage drop (nominal current)		1.5V	
Clock frequency		9.5kHz	
Frequency of the current ripple		19kHz	
Current regulator bandwidth		1kHz	
Minimum load inductance (nominal current)	1.2mH	0.8mH	1.6mH
Auxiliary voltage for external consumers	±15V/10mA +5V/10mA		
Set value input (differential amplifier)	±10V		
Internal resistance	20kOhm		
Control inputs Enable, Pos.-, Neg.- Stop, Integral-off	"Off"<4V "On">30V< >12V		
Internal resistance	3.9kOhm		
Input Ext. Current limit.. 0-10V for	0-15A	0-25A	0-18A
Internal resistance	20	kOhm	
Incremental encoder outputs A+, A-, B+, B-, I+, I-	RS422		
Electronic commutation	Resolver		
Resolver	2 Pole, Primary : Rotor transformation Ratio 0.5 input voltage 7V rms; 10kHz		
Output conditioned tachometer voltage	operation amplifier output external load >10kOhm! Only short shielded lines!		
Scaling	10V/6000 rpm		
I ² t message output	≥ 12V with ≤ 20mA		
Operational output	potential free relay contact max. 10W for 100V, 100mA		
Connections	1x plug-type connector DIN 41612-F48 1x D-SUB 9-pole socket		
Dimensions	160x100x40.3 mm	160x100x55.5mm mm	160x100x80.8 mm
Weight	0.5kg	0.8kg	1.0kg

*= external ventilation with $I_{eff} > 4A$ additional filtering with $I_{eff} > 4A$ or $IIMP > 12A$.
 $I_{eff} = 4A$ and $IIMP = 12A$ is adjustment ex factory

2.3 Principle of the Amplifier

The three-phase servo amplifiers of Series TBF are based on the principle of the speed control with secondary current control loop. In addition to that the current-mode logic controls the commutation of the electronically commutated servo amplifier (brushless). The signal flow of this functional group is shown in the following figure.

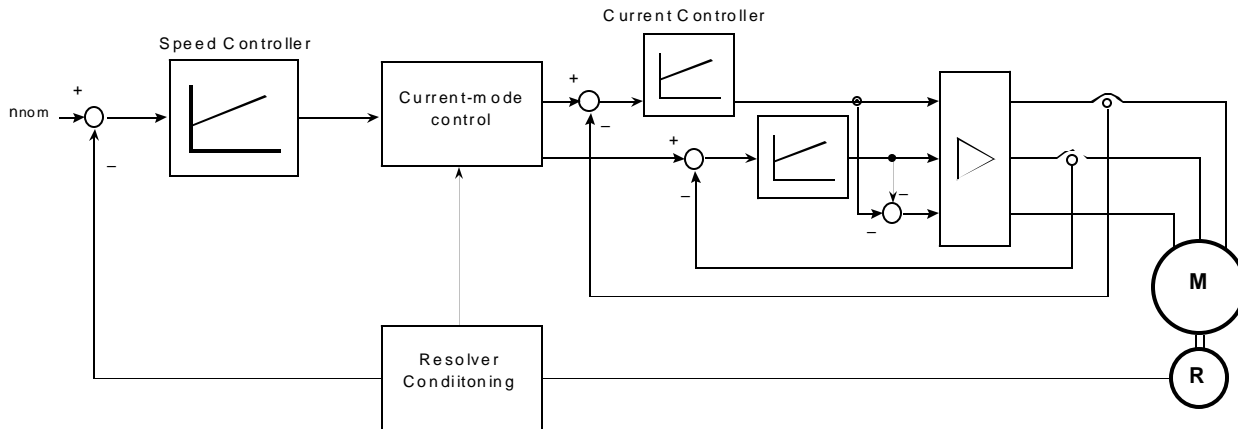


Figure 1: Principle of the Amplifier

The speed control loop consists of speed controller, circuit, motor and speed measurement. The nominal speed value is externally given, e.g. through potentiometer, NC control or something similar. The actual speed value is determined at the motor shaft by a resolver. The difference between nominal value and actual value is formed at the summing point and transmitted to the speed controller. The speed controller then defines the required current set value.

The current control loop consists of the current controllers, the amplifier stage, the current measurement and the motor windings. The current set values available at the output of the current controller, control the six power switches of the inverter through a pulse-width modulator. With a PWM frequency of 9.5kHz this leads, due to the special activation, to a current ripple of 19kHz and consequently to a merely audible clock noise.

This secondary control loop (current) under another one (speed) guarantees a stable control with good dynamics and high rigidity of the drive. This even allows the easy realization of current limitations, necessary to protect the motor and the amplifier, just by limiting the output voltage of the speed controller (current set value).

2.4 Block diagram

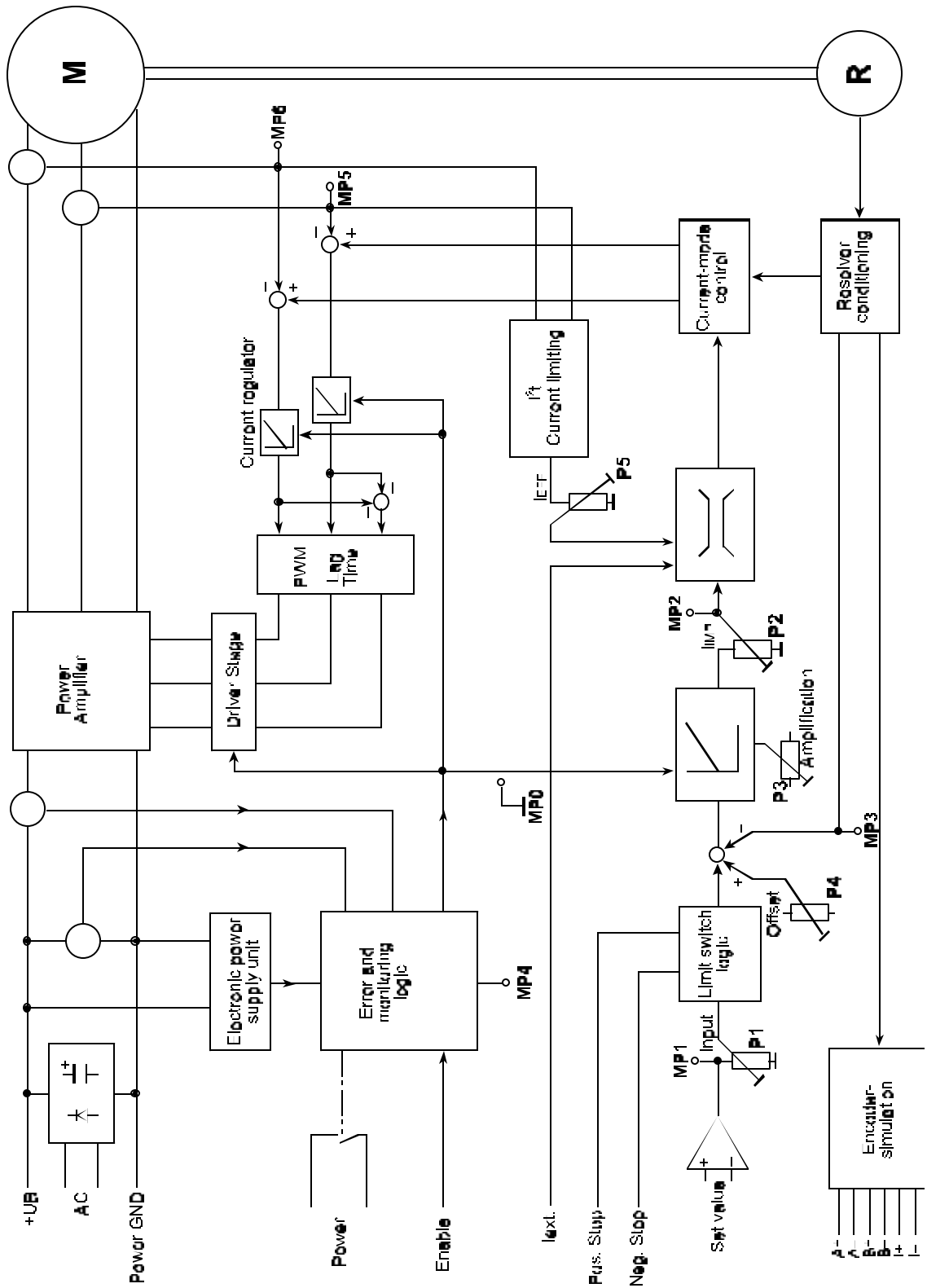


Figure 2: Block Diagram

2.5 Function Description

The function of the amplifier is described by means of the block diagram shown in Figure 2.

2.5.1 Power Supply

- Power amplifier:

Rectification and filtering form the direct voltage (intermediate circuit voltage UB), necessary to operate the power amplifier, from the AC power supply. This intermediate circuit voltage can also be fed directly as d.c. voltage.

- Electronic supply

The electronic supply takes place internally through a switched-mode power supply from the intermediate circuit voltage.

2.5.2 Control System

- Speed controller and current limiting

The nominal speed value can be fed through the input differential amplifier. In the stage connected on load side the positive and negative set values are suppressed separately (limit switch logic). The speed set value, conditioned by this way, is then injected to the speed controller. The inverted tachometer voltage, injected to the speed controller, in this device, is gained from the resolver signals, by means of a corresponding procedure. The current set value is then available at the output of the speed controller.

There are different possibilities to limit the nominal current:

The I^2t current limiting reduces the current set value, using the following procedure: The actual current values are rectified, quadrated and run to a low pass. The circuit limits the current to the continuous current value, which corresponds to the position of the potentiometer P5, when the output voltage of the low pass reaches the voltage, adjusted at this potentiometer. Furthermore, the maximum possible nominal current can be adjusted to 0...15A, 0...25A or 0...18A with an externally fed voltage of 0...10V at the input I_{ext} .

The maximum pulse current, deliverable by the device can be adjusted with the potentiometer P2 of the internal current limiting. This current limiting is connected on load side of the previously mentioned current limitations - this guarantees that the current adjusted here, can never be exceeded.

- Current-mode control and current controller

As shown in the block diagram, the current-mode control must be passed through first, to form the actual current set value for the current controller of the U-conductor current and of the V-conductor current. The nominal current of the speed controller output (conductor current) is converted, depending on signals of the resolver, in two current set values with an offset of 120° and fed to the current controllers for the phases U and V. The nominal current of the third phase W is imitated by subtraction at the outputs of the current controller. This guarantees, that the sum of the currents is always zero.

The pulse-width modulator generates from the three d.c. voltage signals for the conductor currents six PWM signals, which serve for activating the driver stage after the creation of the lag time.

2.5.3 Driver stage and power amplifier

The driver stage amplifies the signals, coming from the pulse-width modulator and by this activates the power transistors. MOSFET transistors are used in the power amplifier, which allows short switching intervals and low residual voltage drop and ensures a good efficiency.

2.5.4 Monitoring and Fault Logic, Enable

The intermediate circuit voltage and the current in the intermediate circuit are permanently monitored by the error detection. The device switches off the motor through the error logic when these values exceed certain quantities. The error logic also reacts when the device temperature exceeds the allowed values because of insufficient air circulation or a too high ambient temperature. Restart is possible only after switch-off and switch-on of the supply voltage.

Now the power amplifier can be enabled at the enable input with an external voltage, the motor turns.



For safety reasons enable is possible only when the device is ready for operation! This avoids that the motor starts running in an uncontrolled manner when applying the operating voltage while the enable signal is already applied.

That means a permanent wired connection of e.g. +24V after the enable input ensures that the motor will not start running when switching on the operating voltage.

The logic also switches off in case of undervoltage in the intermediate circuit and undervoltage of the electronic voltages. The device changes to readiness only when the minimum voltages, necessary for a safe operation, are available.

The motor slows down and enable is disabled if an undervoltage of the electronic supply occurs during the operation. If there is an undervoltage in the intermediate circuit the motor slows down and starts running when the minimum voltage is exceeded.

2.6 Function as Current Controller

In the case the device was not ordered as current controller, the adjustment ex factory is "Speed control".

In some applications it may be useful to operate the TBF amplifier as a pure current controller, because a torque control is desired or the speed controller in the master control is already realized.

To set the amplifier to current control or speed control set the three soldering jumpers JP9, JP10 and JP11 (see figure) as follows:

	JP9.1 to JP9.2	JP10.1 to JP10.2	JP11.1 to JP11.2
Speed control	closed	closed	open
Current control	open	open	closed

Numbering of the soldering jumpers is as follows: e.g. for JP9: JP9.1= right field of the soldering jumper, JP9.2= left field of the soldering jumper.

Speed control Current control

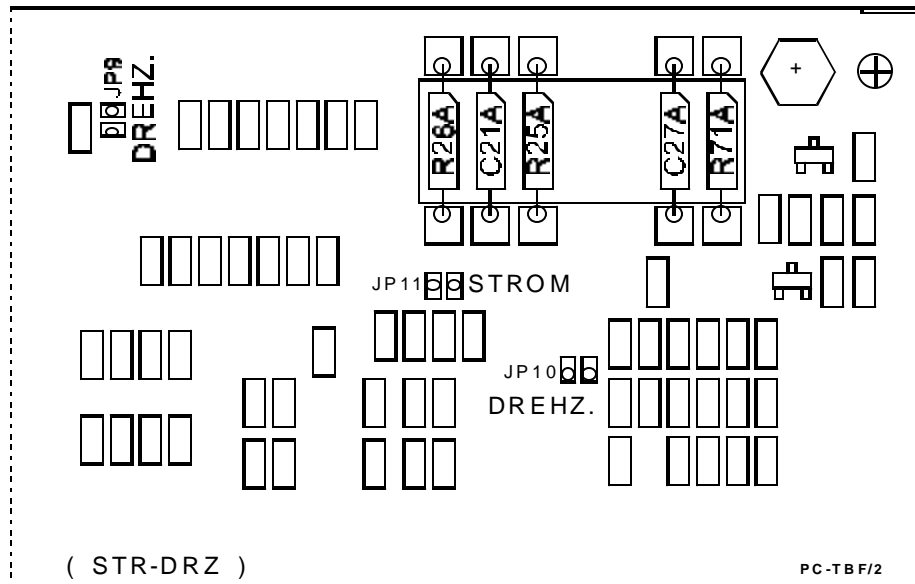


Figure 3: Jumper Settings

2.7 List of Possible Adjustments and Indicators

2.7.1 The LEDs

LED1 (green)	Indicates readiness of the device; lights also when the amplifier is not enabled.
LED2 (yellow)	I ² t- current limiting is active
LED3 (red)	Fault (overcurrent, overvoltage, overtemperature).
LED4 (yellow)	Ballast circuit operates (only for 120V devices).

2.7.2 The Potentiometers

Potentiometer 1	Signal Potentiometer scales the nominal speed input to match the maximum velocity feedback used for adjusting the maximum motor speed (10 to 100%).
Potentiometer 2	Pulse current limiting; range from 10 to 100% of the rated peak current.
Potentiometer 3	Adjustment of the amplification of the speed controller.
Potentiometer 4	Offset adjustment of the speed controller.
Potentiometer 5	Continuous current limit; range from 0 to 100% of rated peak current.

2.7.3 The Test Points

MP0	Ground reference 0V	
MP1	Nominal voltage	Voltage at the differential - nominal speed input (referred to ground)
MP2	Output of the speed controller (set value):	10V ≈ 15A (TBF60/5R) ≈ 25A (TBF60/10R) ≈ 18A (TBF120/7R)
MP3	Tachometer voltage:	10V ≈ 6000 rpm
MP4	Fault diagnosis	9V ±0.4V ≈ Overcurrent 8V ±0.4V ≈ Overvoltage 7V ±0.4V ≈ Overtemperature
MP5	Current monitor Phase V:	10V ≈ 15A (TBF60/5R) ≈ 25A (TBF60/10R) ≈ 18A (TBF120/7R)
MP6	Current monitor Phase U:	10V ≈ 15A (TBF60/5R) ≈ 25A (TBF60/10R) ≈ 18A (TBF120/7R)

2.7.4 The Soldering Jumpers

JP1 to JP8	Adjustment only for devices without resolver.
JP9	Closed when operating the device as speed controller, open for current control.
JP10	As JP9
JP11	Open when operating the device as speed controller, closed for current control
JP12	Only for adjustment by factory
JP13	Only for adjustment by factory

2.7.5 The Internal Potentiometers

P6	Only for adjustment by factory
P7	Only for adjustment by factory
P8	For special requirements to clock frequency of the power amplifier a potentiometer can be used here (normally no components inserted)
P9	Only for adjustment by factory
P10	Only for adjustment by factory

2.7.6 The DIP switches

S1 Adjustment to pole number of the motor

1	2	Poles	Comment
on	on	8	
off	on	6	Delivery condition
on	off	4	
off	off	2	

S2 Adjustment of the number of pulses per rotation from incremental encoder simulation

1	2	Pulse number	Comment
off	off	128	
off	on	256	
on	off	512	Delivery condition
on	on	1024	

2.8 Front view

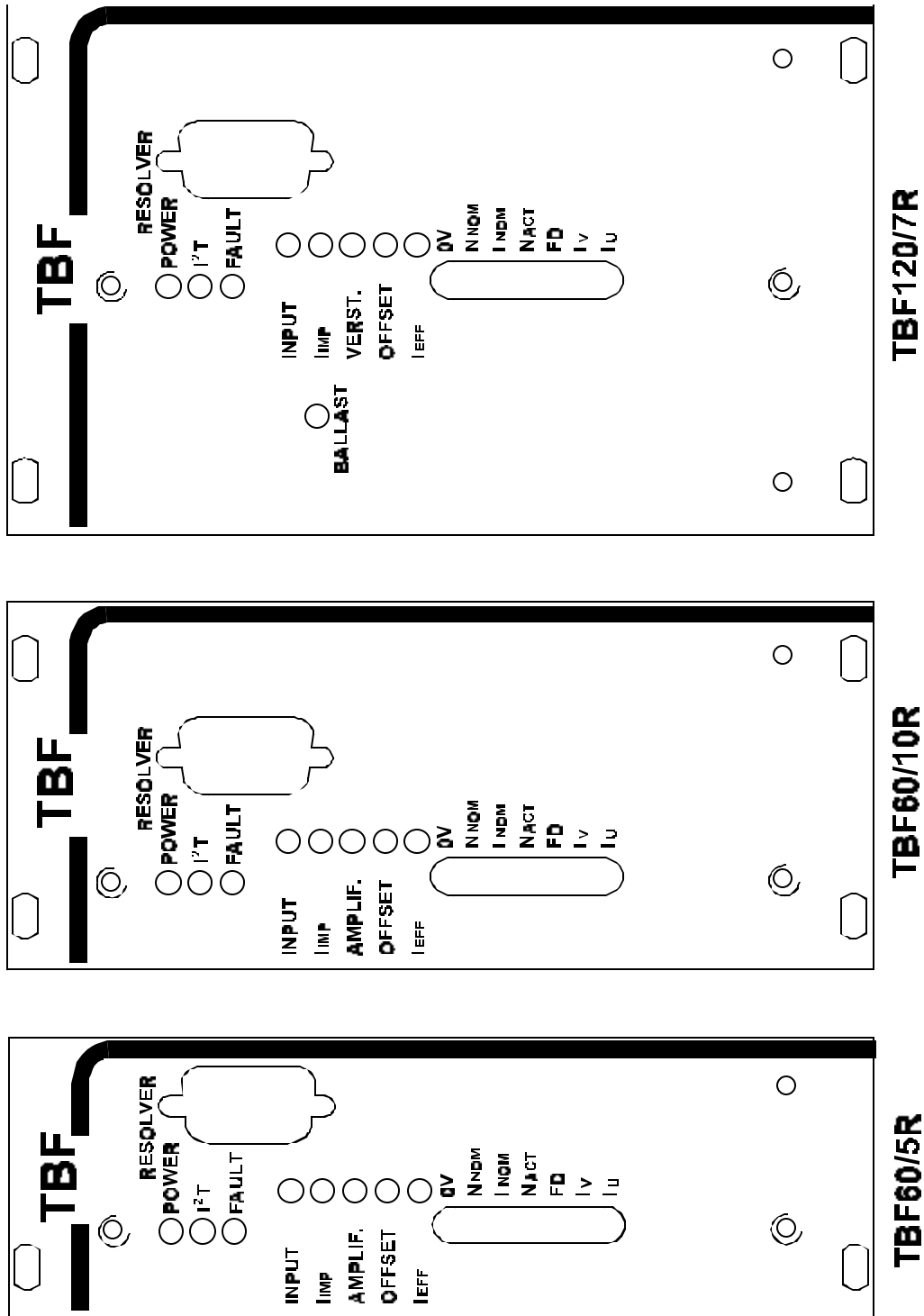


Figure 4: Front Views

3 Connection of the device

3.1 Pin Assignment

Conn. 1 (F48)

2z	Integral off	26z	Power GND
2b	Pos. Stop	26b	Power GND
2d	Neg. Stop	26d	Power GND
4z	GND Ref.	28z	Motor W
4b	Nominal speed input (-)	28b	Motor W
4d	Nominal speed input (+)	28d	Motor W
6z	+ 5V	30z	Motor V
6b	Ready	30b	Motor V
6d	Ready	30d	Motor V
8z	+ 15V	32z	Motor U
8b	Enable input	32b	Motor U
8d	Tachometer output	32d	Motor U
10z	N.C.		
10b	Track I+		
10d	Track I-		
12z	N.C.		
12b	Track A+		
12d	Track A-		
14z	N.C.		
14b	Track B+		
14d	Track B-		
16z	GND		
16b	I ² t-message		
16d	lxt.		
18z	GND		
18b	ñ 15V		
18d	+ 15V		
20z	+ UB		
20b	+ UB		
20d	+ UB		
22z	AC 2		
22b	AC 2		
22d	AC 2		
24z	AC 1		
24b	AC 1		
24d	AC 1		

Connector 2 (D-SUB/9-pole/socket)

1	S4-Resolver
2	S2-Resolver
3	S3-Resolver
4	S1-Resolver
5	R1-Resolver
6	Shield
7	Shield
8	Shield
9	R2-Resolver

3.2 Explanation of the pin assignment

3.2.1 Connector 1 (F48)

2z **Integral switch-off** The integral-action component of the speed controller can be switched off at this input by injecting a high signal (15 to 30V). This may be useful, e.g. for positioning tasks. The motor does not drift slowly, but has a lower holding moment.



During the normal operation, this input is inactive. The input is not to be wired for this case or is to be connected to ground.

2b, **Positive Stop,**
2d **Negative Stop** A limit switch logic can be realized with these inputs. For a running of the motor in positive direction the input Pos.Stop is to be connected to +15V ... +30V. When the connection is interrupted, e.g. by a limit switch (normally closed contact), the positive set values will be suppressed and the motor is therefore braked with the maximum adjusted pulse current. Negative speeds are still possible. Simultaneously with the active stop function the integral-action component is being switched off. The same applies for the Neg.Stop input, but for the negative rotational direction.



When these inputs are not used, they have to be connected to +15V.

4z **GND-REF** Reference ground for measuring the conditioned tachometer voltage. Avoid external connection with GND or Power-GND of the device, not via protective earth terminal either (ground loops).

4b, **Set value+;**
4d **Set value-** Inputs of a differential amplifier to define the speed set value. Terminal 4d has a positive effect against 4b. The maximum differential voltage must not exceed $\pm 10V$. Always both inputs have to be wired, e.g. set value + at the output of the D/A converter and set value- at the output of the analogue GND of the D/A converter.

6z **+5V** Output of a +5V power supply, carrying capacity +10mA.

6b **Ready for operation**
6d **Ready for operation** Potential-free Reed contact to indicate the ready-for-operation status of the device. The contact is closed when the device is ready for operation. Maximum voltage 100V for 100mA.

8z	+15V	Output of the +15V electronic voltage for supply of the limit switch inputs Pos.Stop, Neg.Stop. Carrying capacity together with 18d: 10mA.
8b	Enable input	This connection is to be applied for enable input to a voltage of +15V to +30V, after the ready contact is closed. The motor is disabled with the input open.



As in chapter 2.5 the following applies: Enable of the motor is possible only when the device is ready for operation (green LED lights). This prevents the motor from running in an uncontrolled manner when the operating voltage is applied to the amplifier while the enable signal is active.

8d	Output Tachometer	Output of the conditioned tachometer signal. A signal with a carrying capacity of 1mA is available, which corresponds to a DC tachometer. Use a short, shielded cable for the wiring. The reference point is 4z (GND-REF). Scaling is 10V _r - 6000 rpm.
10z, 12z, 14z	NC, NC, NC	These connections are not used (not connected), but they must not be applied with a voltage.
10b, 12b, 14b	Track I, Track A, Track B	Together with 10d, 12d, 14d (track I-, track A-, track B-) these contacts form the outputs of the simulated incremental encoder signals. These outputs are designed as differential output drivers for each track. The output levels are >2,5V for high and <0,5V for low according to RS422, with a maximum carrying capacity of 20mA per channel. By this the TTL specification >2,4V for high and <0,8V for low is fulfilled
10d, 12d, 14d 16z	Track I-, Track A-, Track B- GND	Together with 10b, 12b, 14b (track I+, track A+, track B+) these contacts form the outputs of the simulated incremental encoder signals (see above). 0V reference potential for +5V, +15V and -15V.
16b	I²t-message	This output has a low-impedance connection to +15V when the I ² t current limiting is active, otherwise it has a high impedance.
16d	I external	Current limiting input, at which the pulse current, set at P2 can be limited from 0...100% by an external voltage from 0...10V. About 0A correspond to a voltage of 0V, and the pulse current set at P2 corresponds to a voltage of 10V.



Normally no external current limiting is used. In this case the input can be switched to +15V.

18z	GND	0V reference potential for +5V, +15V, and -15V.
18b	-15 V	15V supply for external use. Carrying capacity -10mA.
18d	+15 V	-15V supply for external use. Carrying capacity together with 8z= 10mA.
20z,b,d	+UB	Plus pole of the d.c. intermediate circuit. Here the plus pole of a probably existing external d.c. voltage can be supplied by circumventing the internal rectifier. If an additional filtering of the intermediate circuit voltage is necessary, the plus pole of the external electrolyte capacitor is connected here. An external ballast circuit can be connected here with the plus pole.



These three contacts have to be connected parallel, as the carrying capacity of one contact should not exceed 5A for 45°C.

22z,b,d	AC2	Supply inputs of the device. Here all secondary connections of a transformer are connected. For protection a fuse has to be built in the supply line.
24z,b,d	AC1,	



In no mode of operation and under consideration of all winding tolerances and line voltage variations, the transformer voltage must never exceed 60VAC (for 60 devices) and 120VAC (for 120V devices)! These three contacts have to be connected parallel.

26z,b,d	Power GND	GND of the d.c. intermediate voltage circuit. GND connection of a probably existing external direct voltage. The minus pole of the external electrolyte capacitors has to be connected to 26z,b,d when an additional filtering of the intermediate circuit voltage is necessary. An external ballast circuit can be connected here with your minus pole. The housing of the motor is to be connected here too.
----------------	------------------	--



Power GND is the point, the protective earth terminal has to be connected to. These three contacts have to be connected parallel.

28z,b,d	Motor W	Output terminals of the power amplifier, to which the motor will be connected. 32z,b,d to line U, 30z,b,d to line V and 28z,b,d to line W. Please consider, that when connecting the motor lines, all three contacts
30z,b,d	Motor V	
32z,b,d	Motor U	

each have to be connected parallel.

3.2.2 Connector 2 (D-SUB/9-pins/socket)

Connector 2 is intended for connecting a resolver. A two-pole transmitter with a transformation ratio of 0.5 is required as resolver. The input voltage of the rotor should be suitable for $7V_{\text{rms}}$ with 10kHz.

1	S4-Resolver	Input for the stator signal S4 of a two-pole resolver.
2	S2-Resolver	Input for the stator signal S2 of a two-pole resolver.
3	S3-Resolver	Input for the stator signal S3 of a two-pole resolver.
4	S1-Resolver	Input for the stator signal S1 of a two-pole resolver.
5	R1-Resolver	Output of the $7V_{\text{rms}}/10\text{kHz}$ reference signal for the rotor connection R1 of the resolver.
6	Shield	Contact to connect the shielding of the resolver line, e.g. common shield S4/S2 and common shield S1/S3.
7	Shield	Contact to connect the shielding of the resolver line, e.g. common shield R1/R2.
8	Shield	Contact to connect the shielding of the resolver line, e.g. total shielding.
9	R2-Resolver	Connection for the resolver R2. This connection is internally connected to GND.

3.3 Wiring

A careful wiring is absolutely necessary to guarantee a troublefree operation of the servo amplifier!

The control line for the servo amplifier, the signal lines of the motor and the motor lines are to be wired separately.

See also \tilde{N} Measures for an installation in conformity to the EMC directive.

3.3.1 Protective Earth Terminal

Power GND (ST1 26z,b,d) must be connected with the protective earth terminal. Control unit and amplifier must have an equal potential. The equalized potential must be realized by a single connection between control unit and amplifier (ST1 26z,b,d). This connection should be a sufficiently strong line. The conductor cross section should at least correspond to that of the motor line, however, should not be smaller than 1.5mm^2 . As in the amplifier Power GND (ST1 26z,b,d), GND (ST1 18z and ST1 16z) and GND-REF (ST1 4z) are connected, no further terminal must be connected with control GND, to avoid ground loops.

3.3.2 Resolver Cable

The resolver cable must be shielded. The pairs S1/S3, S2/S4 and R1/R2 must be twisted. The shorter the twist, the better it is. Each pair has to be shielded separately within the total shield (see 3.5). The internal shields are to be connected to connector ST2 with ST2.6, ST2.7, ST2.8, the external shield is to be connected to the connector housing. Connection of the shields on the side of the motor is not allowed, and not to the connector housing either, as otherwise interference currents of the motor winding may be discharged through this shield, which would partly wreck the shielding effect (ground loops).

3.3.3 The Line Cable of the Motor

The power supply of the motor, that means the actual motor cable, has to consist of four stranded cores (U^1, V^1, W^1, PE). The shorter the twist, the better it is. In order to minimize interference emission, you have to use a shielded cable. The shield must be connected with a low inductance to POWER GND (26z,b,d). On the motor side the shield has to be connected to the motor housing via the metallic connector housing. To guarantee a reliable functioning of the protective function ground contact resistance (safety against contact of the winding with the housing), the motor housing has to be connected with POWER GND (26z,b,d).

3.3.4 Control Lines And Signal Lines Between Master Control Unit And Amplifier

For the definition of the speed reference, the master control unit normally provides an output of a digital/analogue converter. This output signal normally is measured against ground or against reference voltage. The input at the amplifier is a differential input with set value+ at 4d and set value- at 4b. The lines at these inputs have to be run to the control unit in the same cable. This cable has to be shielded, with connection of the shield to the servo amplifier and the control unit. Input+ of the TBF-R is connected to the set value output of the master control unit. Input- of the TBF-R is connected to the reference point for the set value output at the master control unit.

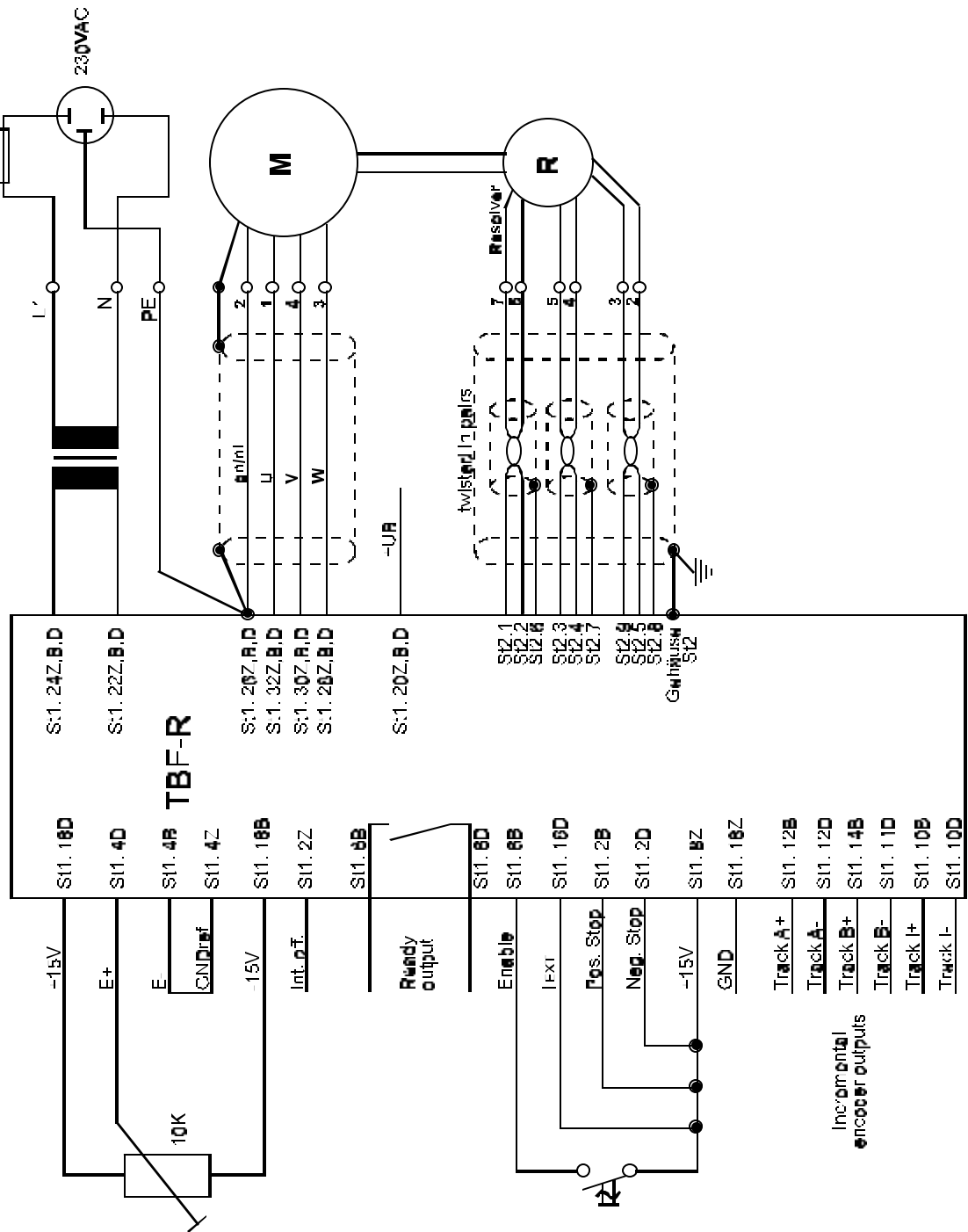
The lines $I_{ext.}$, Int.off, Ready output, Enable and Pos.Stop/Neg.Stop, if used, have to be wired in a shielded cable as well. These lines are measured against ground, that means the connection requested in 0. between TBF and master control unit is sufficient.

3.3.5 The Simulated Incremental Encoder Signals

The connection cable for the incremental encoder signals has to be shielded. The pairs track A+/track A-, track B+/track B- and track I+/track I- have to be twisted, the shorter the twist the better the interference immunity. Each pair is shielded separately within the total shield (see 0). The shield has to be connected on amplifier side and control unit side.

3.4 Connection Diagrams

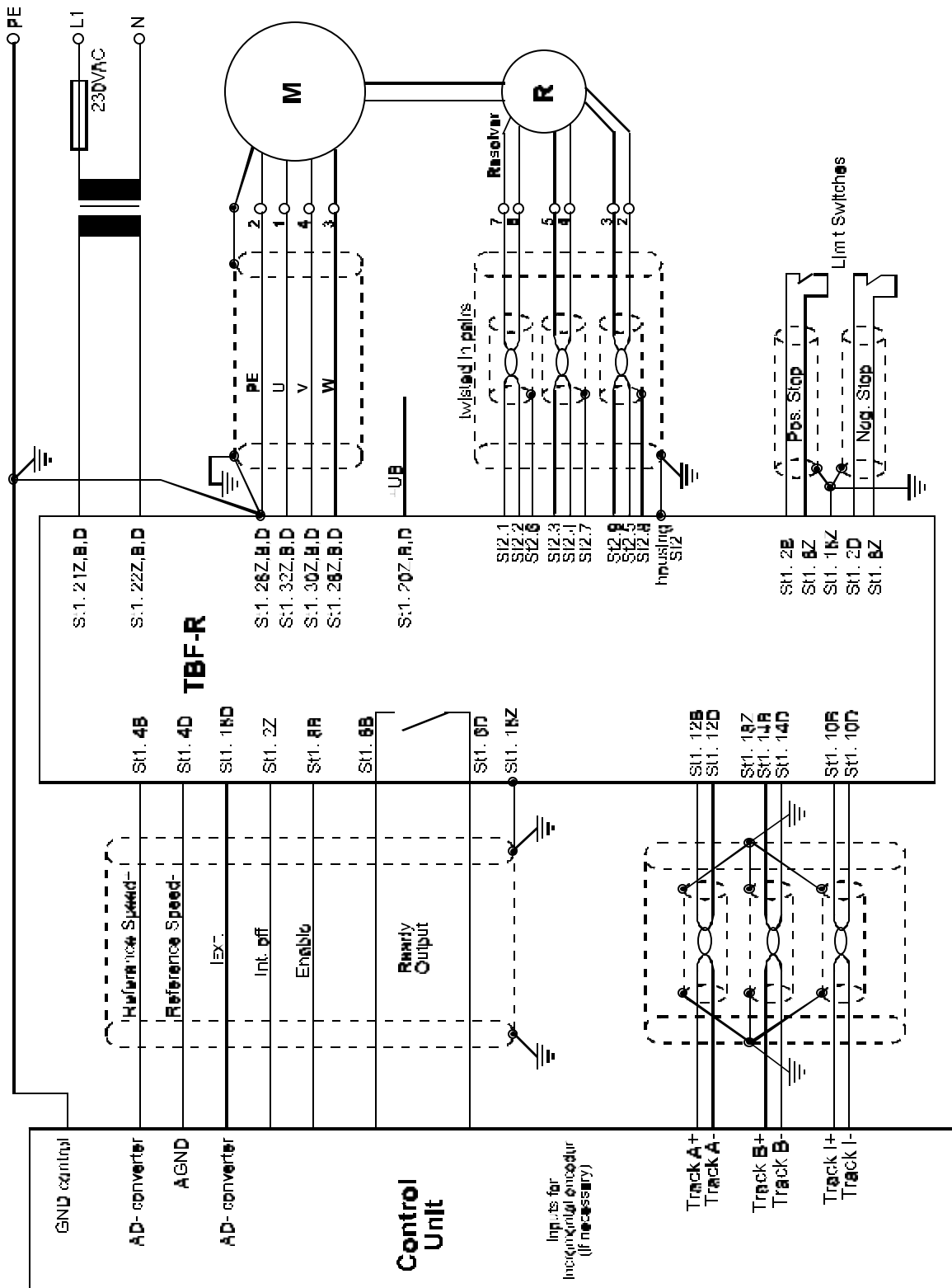
3.4.1 Minimum connection



applies for motors with serial no. ...507 and higher

Figure 5: Connection Diagram (minimum connection)

3.4.2 Connection diagram



applies for motor series "S" with serial no. ...507 and higher

Figure 6: Connection Diagram TBF-R

3.5 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 shall help to keep 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, we offer a number of backplanes with integrated interference suppression elements and connection boards for ring toroidal-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 the risk of interference coupling.
- The shield of each cable has to be connected close by the servo amplifier with a fastening clamp to the mounting plate of the switch cabinet. Please ensure a large blank metallic contact surface. 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 by 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 have to be used. Run them through the switch cabinet wall, with a good metallic contact to the wall.
- 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, for example, created by earthing on both sides and can be eliminated by a capacitiv coupling of the shield, which consequently 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.

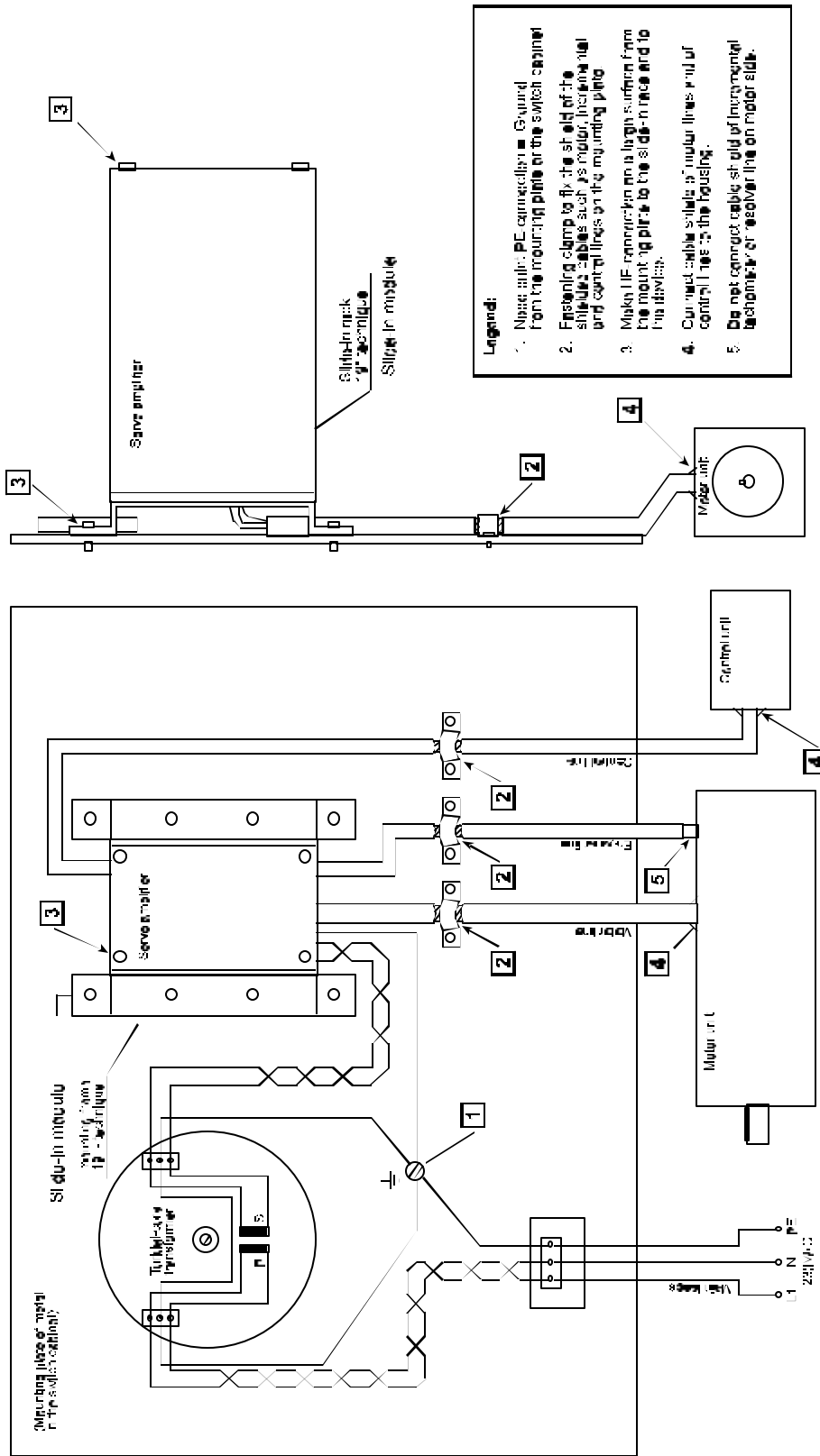


Figure 7: Installation in Compliance with the EMC Directives

4 Set-up

4.1 Connection

When the servo amplifier is used together with one of our motors, the connection does not cause any problems. In 3.4 you will find the connection diagrams. Connect the motor power contacts U, V, W, earth and shield as described there. The resolvers are also connected as described in 3.4.



When using an auxiliary drive together with the servo amplifier TBF, we offer to work out the correct connection diagram for you.

4.2 Presetting



Prior to set-up please read the chapters **1, 2, and 3**.

For connecting the power amplifier and the motor sensors, the specifications given in the connection diagrams 3.40 have to be strictly observed! Connecting the motor "in any way" and to exchange two phase in case of wrong directional run is not useful! We therefore offer to first check the capability of auxiliary drives in-house.

- Connect the power amplifier to the motor (see 3.4 Figure 5/Figure 6)
- Connect the sensors of the motor (resolver) to the servo amplifier (see 3.4 Figure 5/ Figure 6)
- Connect the amplifier with the power supply (see 3.4 Figure 5/Figure 6)
- The factory configures the servo amplifier so our motors will reach 3000 rpm with 10V setpoint default.



If you need other speed values or if this motor/amplifier combination is set up for the first time, please proceed as follows.

Input potentiometer	P1	five turns from left stop
Pulse current potentiometer	P2	five turns from left stop
Amplification	P3	Shipped adjustment by two turns to the left

4.3 Switching On and Configuration

4.3.1 Procedure Until Amplifier is Enabled

Set enable input to logical 0!

Give a speed reference of 0V!

Switch on control unit and amplifier supply!

Release the brake of the motor, if available!

Set enable input to logical 1!

Turn P3 to the left, if the motor vibrates, until the vibration stops

4.3.2 Configuration of the Speed Controller Amplification

For the configuration of the amplification, the motor has to be coupled to load. Turn the potentiometer P3 to the right until vibrations are noticeable, reduce the amplification immediately by turning the potentiometer to the left until the oscillation stops and then turn it tick more to the left.

4.3.3 Configuration of Pulse Current and Continuous Current

For a first set-up, where the currents have been reduced as described under 4.1, or when a pulse current or continuous current, other than the preset values is required (see 2.2), the configuration can be done as follows:

Measure the current at MP2. The scaling is to be found under 2.7.3. Proceed as follows to load the motor in a way that it is operated to the pulse current and continuous current limits:

4.3.3.1 Pulse current

Move the motor with minimum speed to a mechanical stop and leave the set value at the amplifier so that the motor still tries to move towards the stop. Neither limit switch, nor I_{AB} must be active

Turn P5 to the right stop and P2 to the left stop.

Use the potentiometer (P2) to increase the pulse current to the desired value.

Should the device reduce the continuous current before the adjustment is completed, disable the amplifier and wait for a recovery time of 10 to 20 seconds then carry out the configuration once again. Optimum values are often achieved after several repeated adjustments.

4.3.3.2 Continuous Current

Leave P2 in the position determined as described above, adjust P5 with five turns from left stop.

Once again, move the motor with minimum speed to a mechanical stop and leave the set value at the amplifier so that the motor still tries to move towards the stop. Neither limit switch, nor I_{AB} must be active.

After expire of the pulse current phase, the current is automatically reduced to the continuous current, adjustable at P5. For adjusting P5, always turn slowly. After a short time the new continuous current flows.

Adjustment becomes essentially easier when instead of the motor, three wye-connected reactors are connected to the motor connections. The reactors should have a minimum load inductance and a saturation current, that exceeds the maximum current of the amplifier.

4.3.4 Setting the Maximum Motor Speed

The amplifier is set ex factory to a motor speed of max. = 3000 with 10V input voltage for our motors. In order to reduce the maximum motor speed, turn the input potentiometer to the left, to increase the motor speed turn it to the right.

4.3.5 Offset Adjustment of the Speed Regulator

The offset adjustment has to be carried out in a warm operating status of the device. Define the set value zero (short-circuit the input). Adjust motor drift by setting P4 to zero.

5 Optimizing the Controller Response

5.1 Amplification setting of the current regulators

The adjustment a.c. amplification of the current regulators is done with the resistors R25 (standard 4.7kOhm) and R26 (standard 4.7kOhm) (see Figure 16), where each resistor is part of a voltage divider. Smaller resistor values increase the amplification. A response is seldom necessary here. Should, however, motors with higher winding resistors are used, the motor heats up already in idle operation, as the resistor of the winding, together with the inductance of the winding leads to high reactive current.

Remedy is possible by increasing the amplification.

During the test stage, the fixed resistors can be replaced by potentiometers (25kOhm) and in series production the values determined can be realized by fixed resistors.

Both resistors must have the same size. The accuracy must be 1% or higher.

For adjustment, increase the current amplification with low speed until an "oscillation" becomes noticeable (a stronger motor noise starts with approx. 1kHz). Immediately reset the amplification until the oscillation stops and a tick more.

5.2 Alternating Current Amplification of the Speed Controller

To adjust the amplification, couple the motor to load and define a set value of 0V. Turn the potentiometer P3 to the right until the oscillation starts, immediately reset the amplification until the oscillation (amplified motor noise because of rotary oscillation of the motor shaft with approx. 200Hz) stops and a tick more.

5.3 Tachometer Filtering

The capacitor C21 is responsible for the tachometer filtering (see Figure 16). When operating the drive with a three-phase tachometers a standard value of 22nF is enough. It allows a very good dynamic controller response.

5.4 Integral-Action Component of the Speed Controller

The capacitor C27 is responsible for the integral-action component of the speed controller (see Figure 17).

The standard value of C27 is 220nF.

5.5 Direct Voltage Amplification of the Speed Controller

The resistor R71 is intended for modifying the static rigidity (see Figure 17). The rigidity decreases with increasing resistor value. The standard value is 330Ohm.

5.6 Derivative-Action Component in the Tachometer Feedback

By inserting a resistor (R80) normally not provided with components and a capacitor (C25), a differential action can be given for special requests to the control of the tachometer feedback.

6 Troubleshooting

Green LED (POWER.) does not light, axis does not move, no holding torque:

- -15V or +15V or +5V overloaded by external consumers or short-circuited.
- Fuse S1 is defective.
- External fuse to the power amplifier is defective.

Green LED (POWER.) lights, axis does not move, no holding torque:

- Interruption of the motor lines.
- Power amplifier enable is missing.
- Power amplifier enable took place but the device was not ready.
- Input I_{extern} is not wired.
- Input Pos.Stop and Neg.Stop are not wired.

Axis does not move, motor has several positions with holding torque during one turn, with oscillating engagement when the motor is manually displaced:

- Wrong polarity of the motor.
- Wrong setting for number of motor poles
- Motor line interrupted.
- Wrong resolver connection or wrong adjustment of the resolver.

Axis traveling, weakly pronounced holding torque:

- Pulse current potentiometer in I_{mp} left stop position.

No axis traveling, motor has no holding torque:

- No speed reference available.
- Motor shaft blocked.

Yellow LED (I^2t) lights:

- Wrong adjustment of the potentiometer I_{eff} .
- Mechanical friction too large.
- Oscillations approx. 200Hz because of wrong adjustment of the potentiometer (ampl.).
- A hum on the input line.

Red LED (FAULT) lights:

- Operational voltage too high (8V \pm 0.4 at MP4).
- Braking energy too high (8V \pm 0.4 at MP4).
- The thermal switch reacted, as the heat sink temperature is $>80^{\circ}$ (7V \pm 0.4 at MP4).
- Short-circuit in the motor or ground contact of a motor line (9V \pm 0.4 at MP4).

Uncontrolled high motor speed:

- Wrong polarity of the resolver or wrongly adjusted.
- Wrong polarity of the motor.

Motor does not reach the desired speed:

- Speed reference values attenuated too strong by P1.
- Operational voltage too low.
- Driven load set too high or current limiting set too low.

No smooth running of the motor:

- Alternating current amplification too high.
- Insufficient resolver line shielding or shield connected wrongly.
- Interference by wrong input wiring.

Yellow LED (BALLAST) permanently lights:

- Power supply too high.

Motor heats up strongly in idle operation:

- A motor with a high internal resistance is used (see 5.1).

7 Options

7.1 Ballast circuit

A ballast circuit is necessary when the regenerative energy from motor and load is larger than the energy, which can be taken up by the filter electrolytic capacitors, until the maximum voltage is reached.

Because of the relatively large capacitor in the power supply unit: the TBF60/5R normally can do without a ballast circuit.

As for the TBF120/7R, the filter capacitor is only half as large and the voltage as well as the current is higher, this device is normally provided with a ballast circuit of 35W continuous power.

Should a braking causes the yellow LED (BALLAST) to light up and 8V can be measured at MP4, an additional ballast circuit (or a ballast circuit at all) has to be used.

The following ballast circuits are available:

- The BS2/60 with 35W for the 60V device
- The BS2/120 with 80W and BS120/V with 125W for the 120V device
- The ballast threshold is 87V for the 60V device and 172V for 120V devices.
- For the determination of the braking power the following formula can be used:

$$P = \frac{0.0055 \times J \times n^2}{T}$$

P= Power in [W]

J= Mass moment of inertia in [kgm²]

n= Speed in [rpm]

T= Period duration in [s] (time from the begin of a braking procedure until the begin of the next braking procedure)

7.2 Bus boards

7.2.1 For 19" sub-racks (article no. TBF/BUS-S)

Pin assignment of the screw-type terminals:

1	Int. Off	22	GND-REF
2	Neg. Stop	23	Set value-
3	Pos. Stop	24	Set value+
4	+5V	25	+15V
5	Ready 13	26	Enable
6	Ready 14	27	Tachometer output
7	Track I-	28	Track I+
8	Track A-	29	Track A+
9	Track B-	30	Track B+
10	NC	31	I ² t-message
11	NC	32	+15V
12	NC	33	+15V
13	I _{ext.}	34	-15V
14	GND	35	GND
15	AC2	36	AC2
16	AC1	37	AC1
17	Power GND	38	Power GND
18	Motor W	39	Power GND
19	Motor V	40	Power GND
20	Motor U	41	Power GND
21	+UB	42	+UB

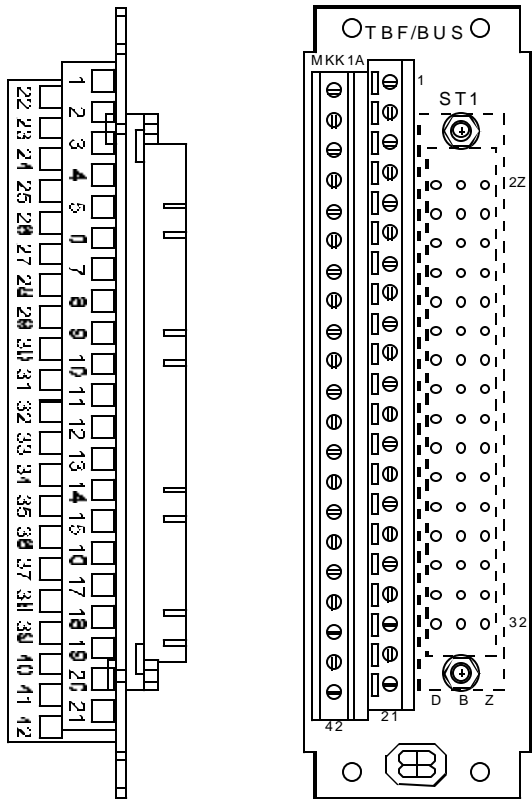
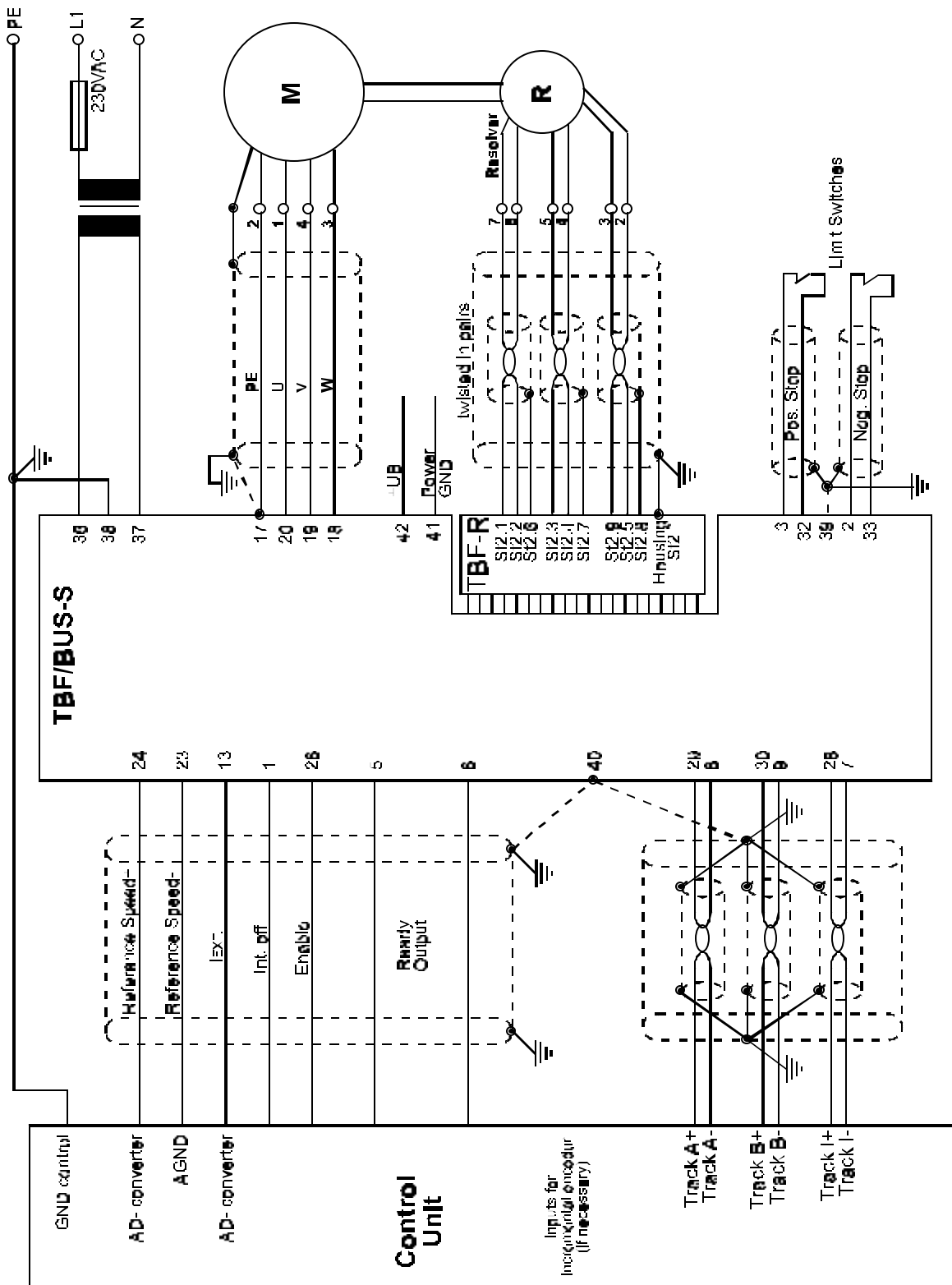


Figure 8: Pin Assignment – 19" sub-rack

7.2.2 Connection diagram TBF-R/BUS-S



applies for motor serial no. ...507 and higher

Figure 9: Connection Diagram TBF-R/BUS-S

7.2.3 Connection diagram TBF-R/BUS-W

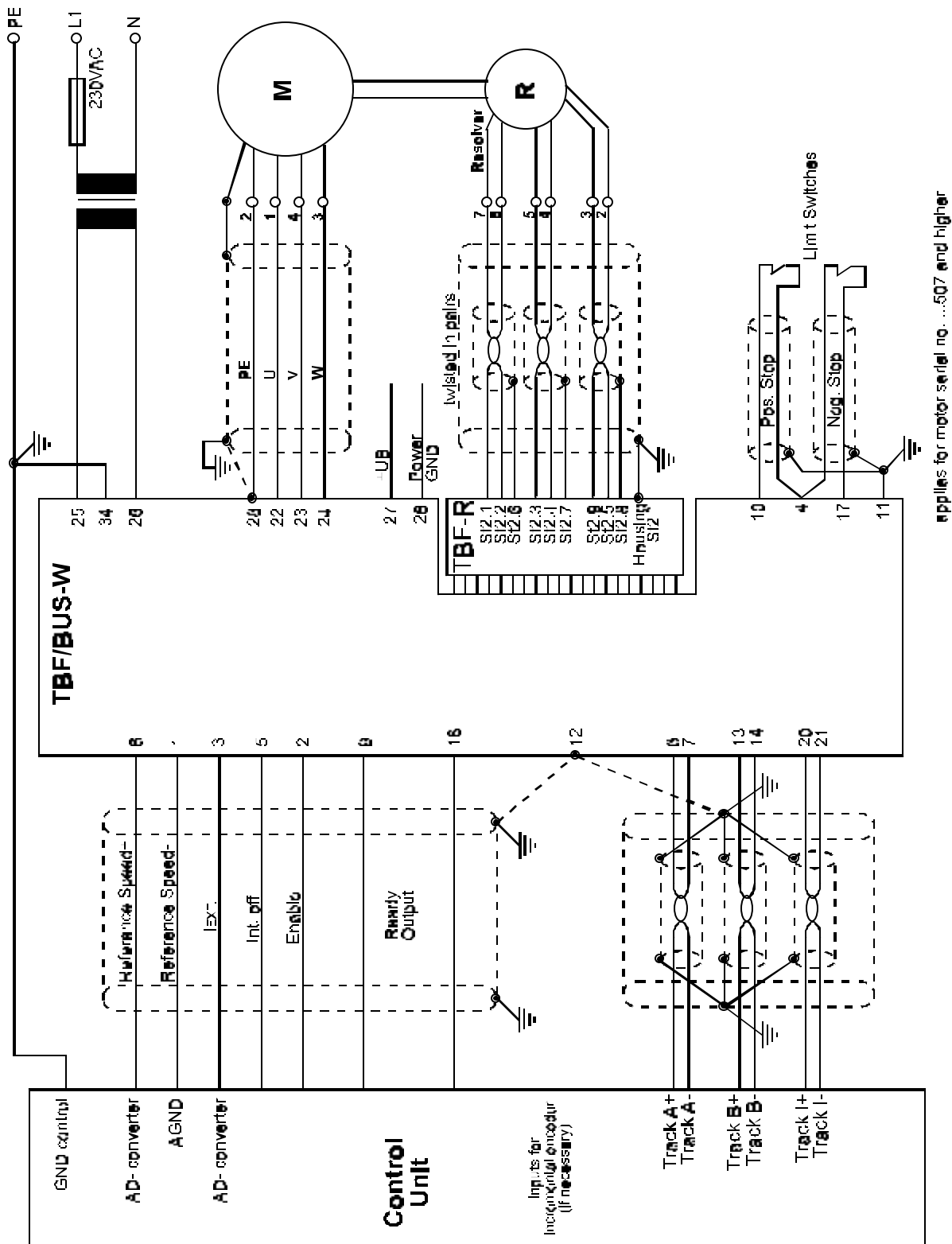


Figure 10: Connection Diagram TBF-R/BUS-W

7.2.4 Pin assignment for wall mounting (article no.: TBF/BUS-W)

Pin assignment of the screw-type terminals:

1	Set value-	8	Set value+	15	Tachometer output
2	Enable	9	Ready 14	16	Ready 13
3	I_{ext}	10	Pos Stop	17	Neg.Stop
4	+15V	11	GND	18	-15V
5	Int.off	12	GND	19	Rot-message
6	Track A+	13	Track B+	20	Track I+
7	Track A-	14	Track B-	21	Track I-

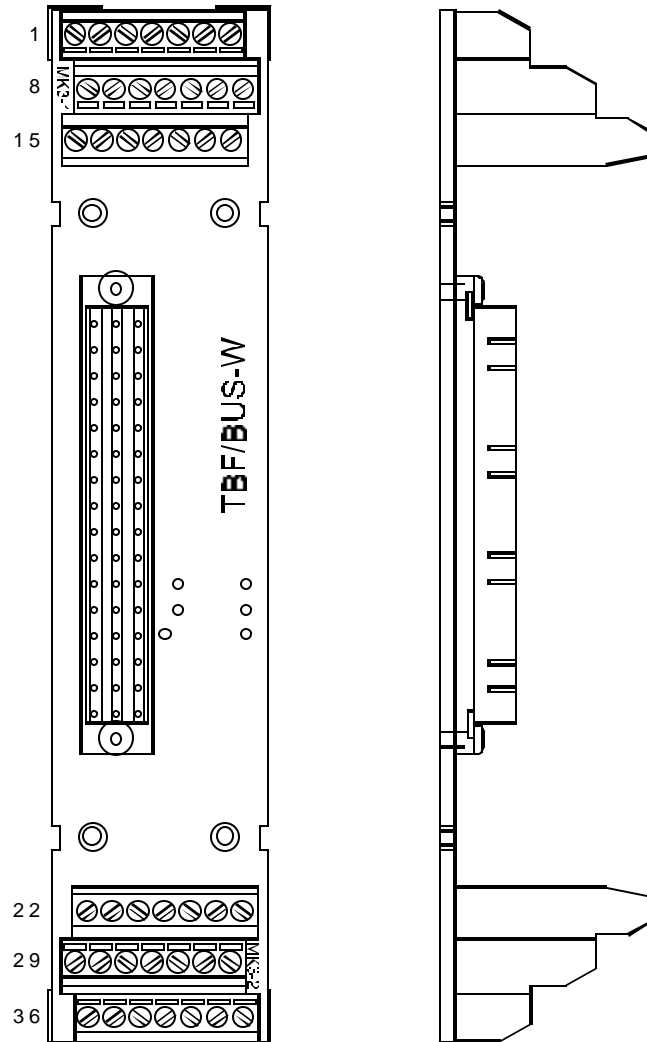


Figure 11: Pin Assignment (wall mounting)

22	Motor U	29	Track I-	36	Track I+
23	Motor V	30	Track B-	37	Track B+
24	Motor W	31	Track A-	38	Track A+
25	AC1	32	Power GND	39	GND-REF
26	AC2	33	+5 Volt	40	NC
27	+ U _B	34	PE	41	NC

28 Power GND

35 GND

42 NC

7.2.5 For Wall Mounting with Higher Demands to EMC (Article No.: TBF/BUS-WE)

Pin assignment of the screw-type terminals:

The bus board TBF/BUS-WE has the same pin assignment for the screw-type terminals as the bus board TBF/BUS-W (see Figure 11).

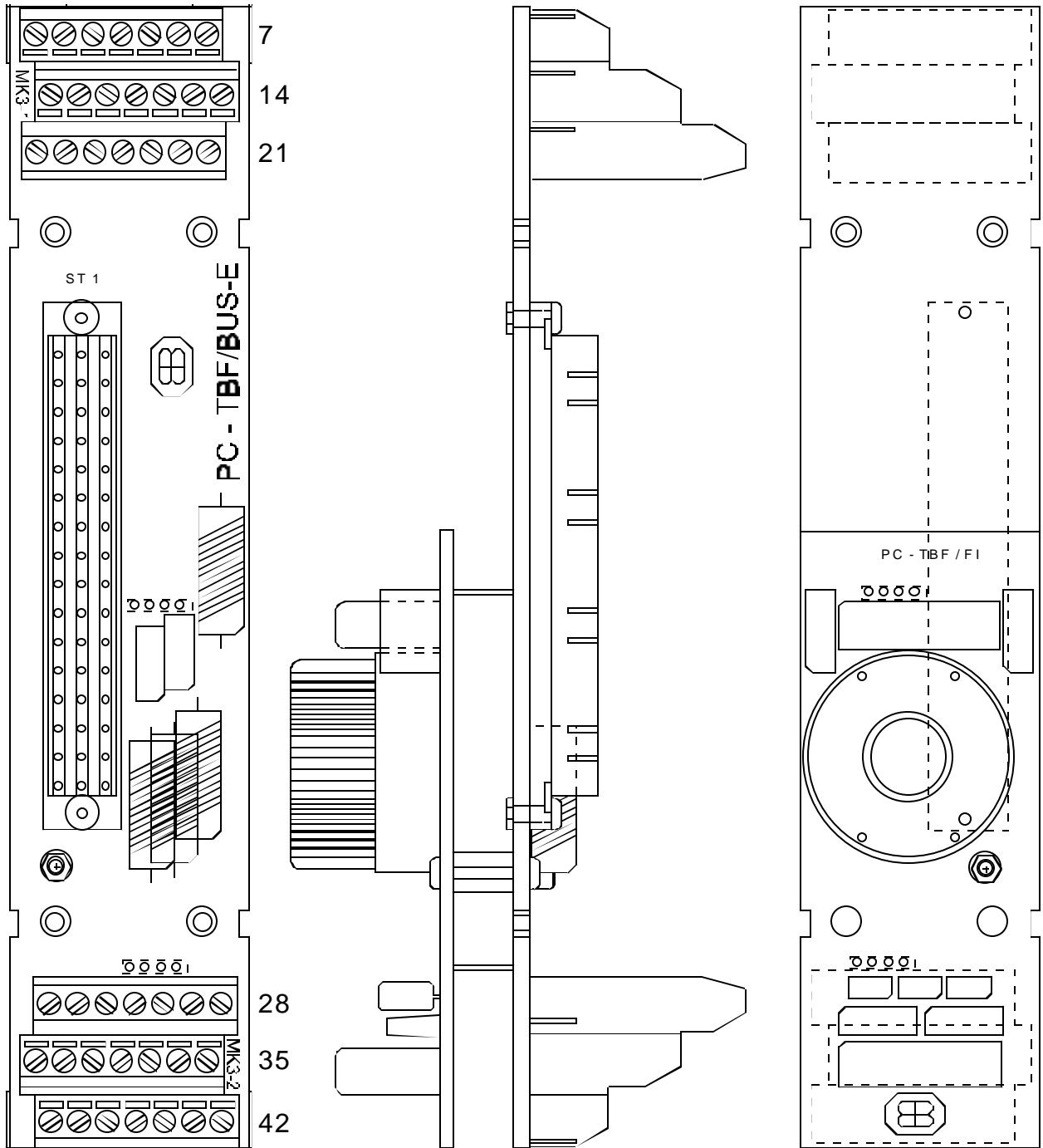


Figure 12: Bus Board TBF/BUS WE

8

APPENDIX

8.1

Dimensional drawing

TBF60/5R

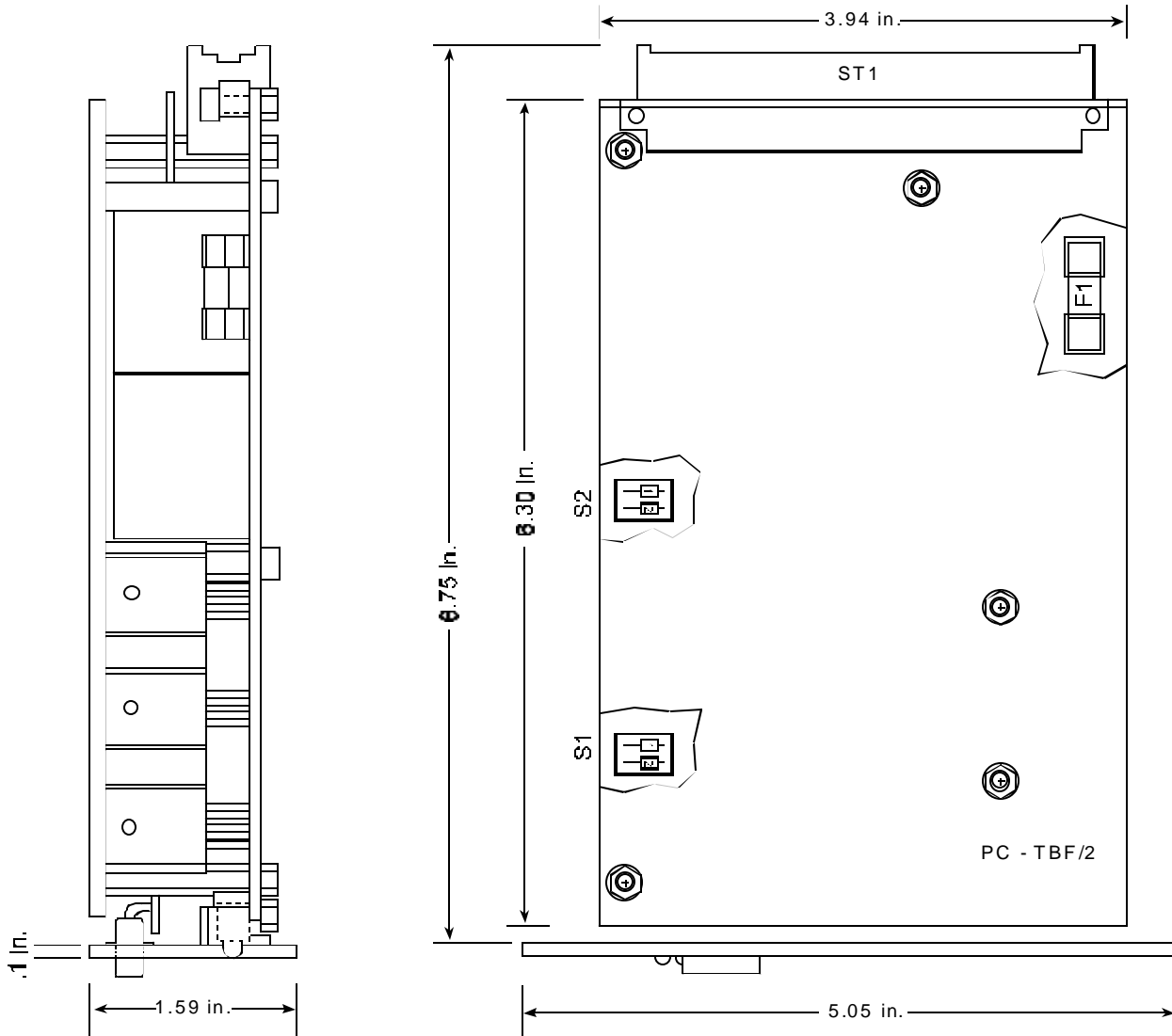


Figure 13: Dimensional Drawing TBF60/5

TBF 60/10R

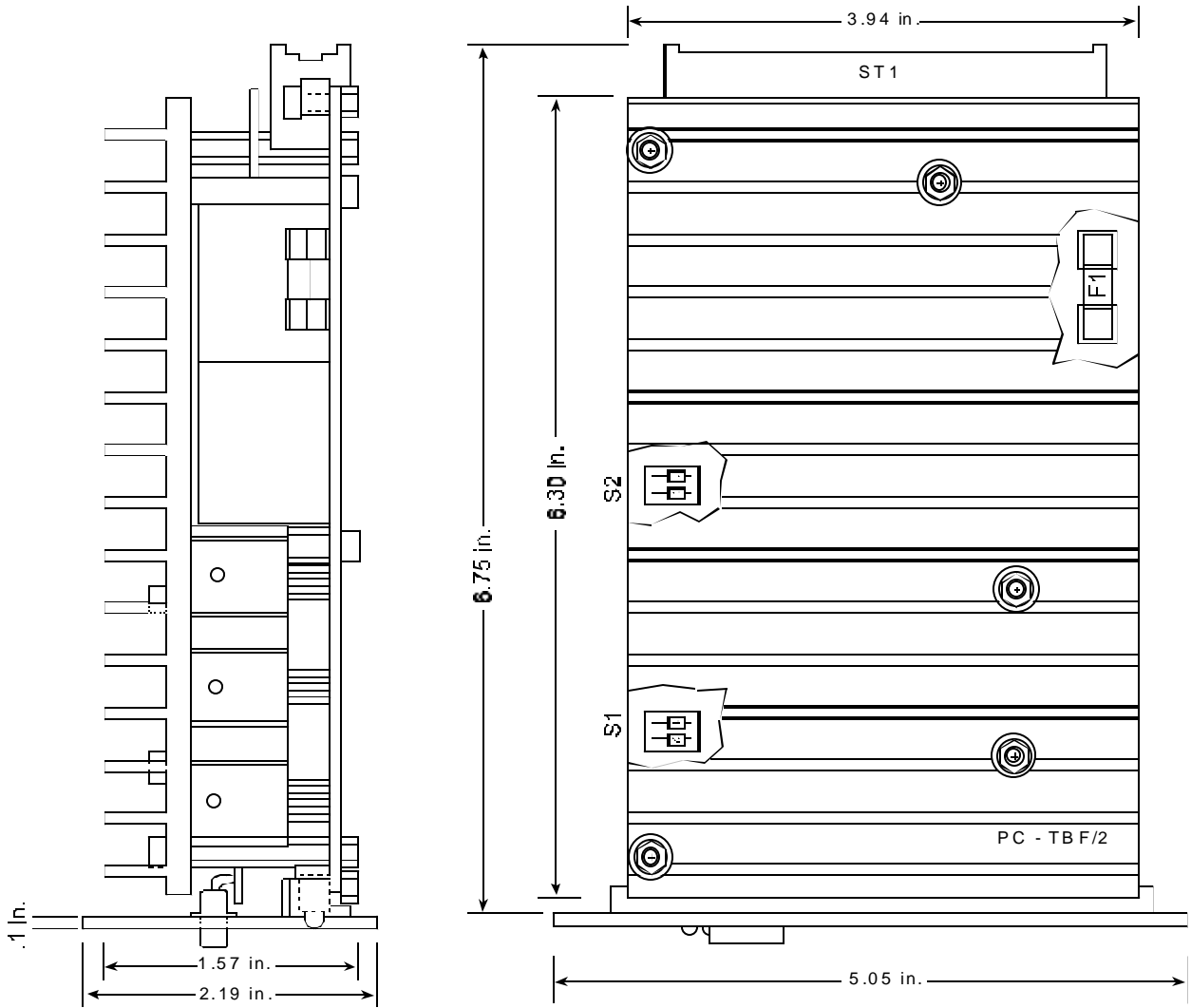


Figure 14: Dimensional Drawing TBF60/10

TBF 120/7R

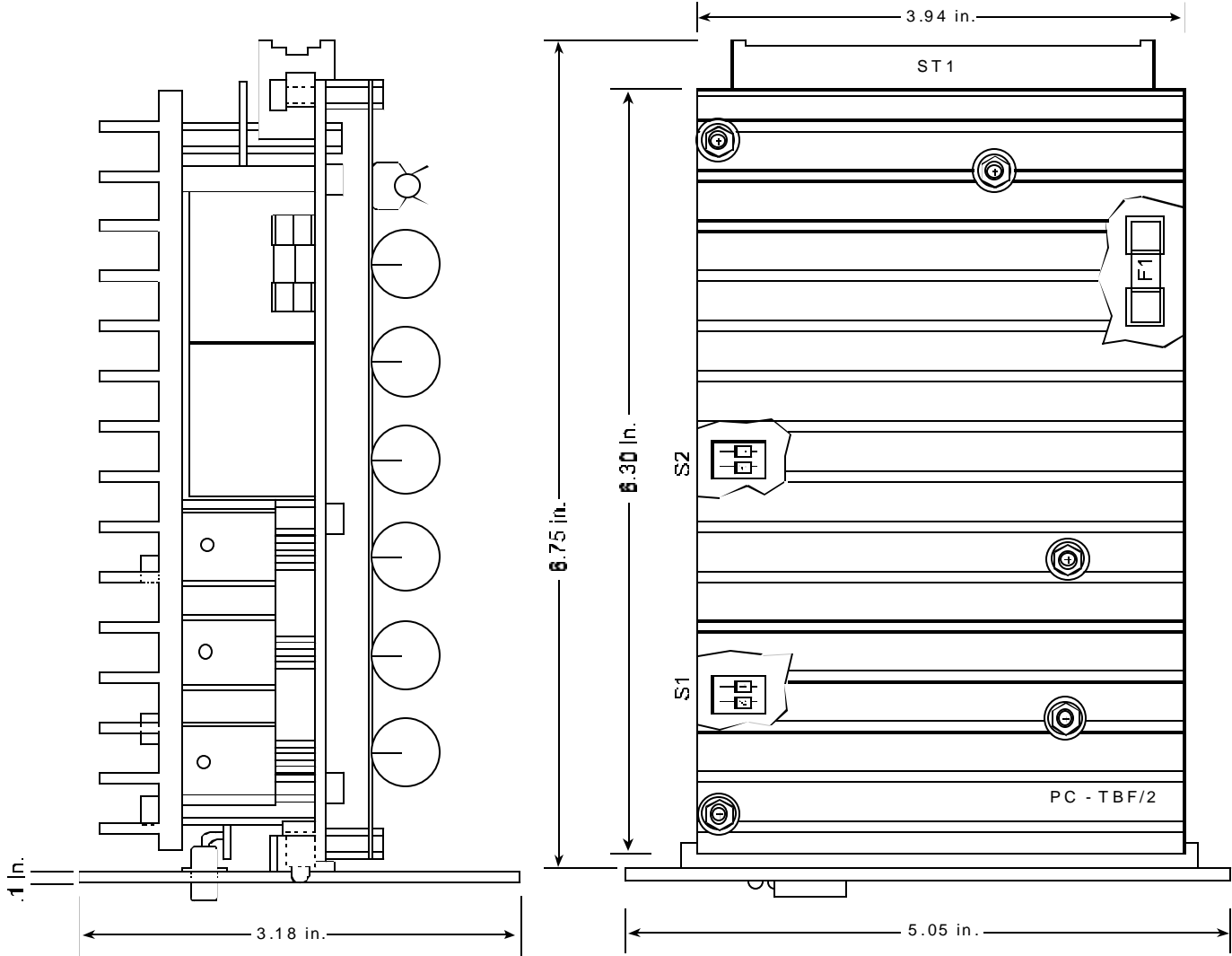


Figure 15: Dimensional Drawing TBF120/7

8.1.1 Component mounting diagram TBF-R (upper side)

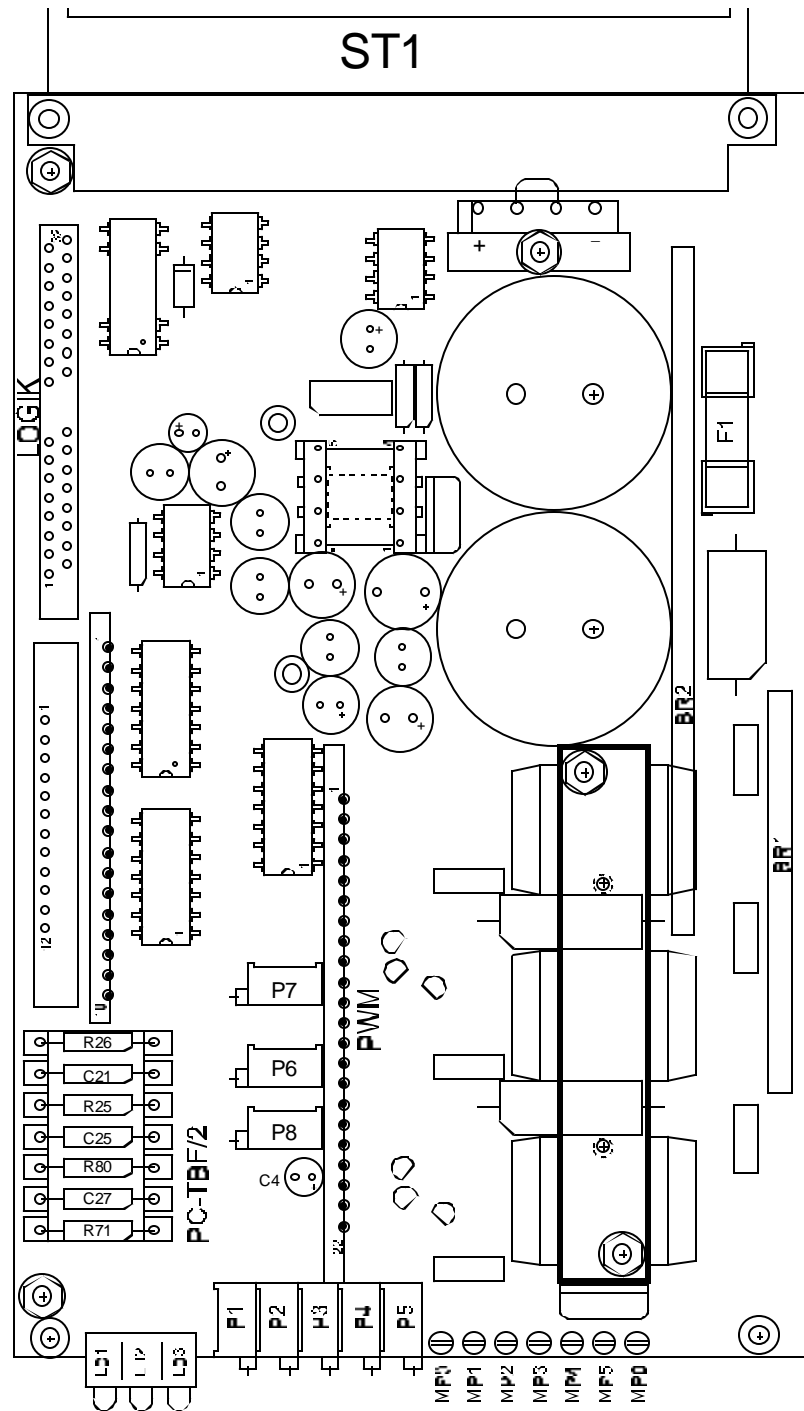


Figure 16: Components Inserted (upper side)

8.1.2 Component mounting diagram (lower side)

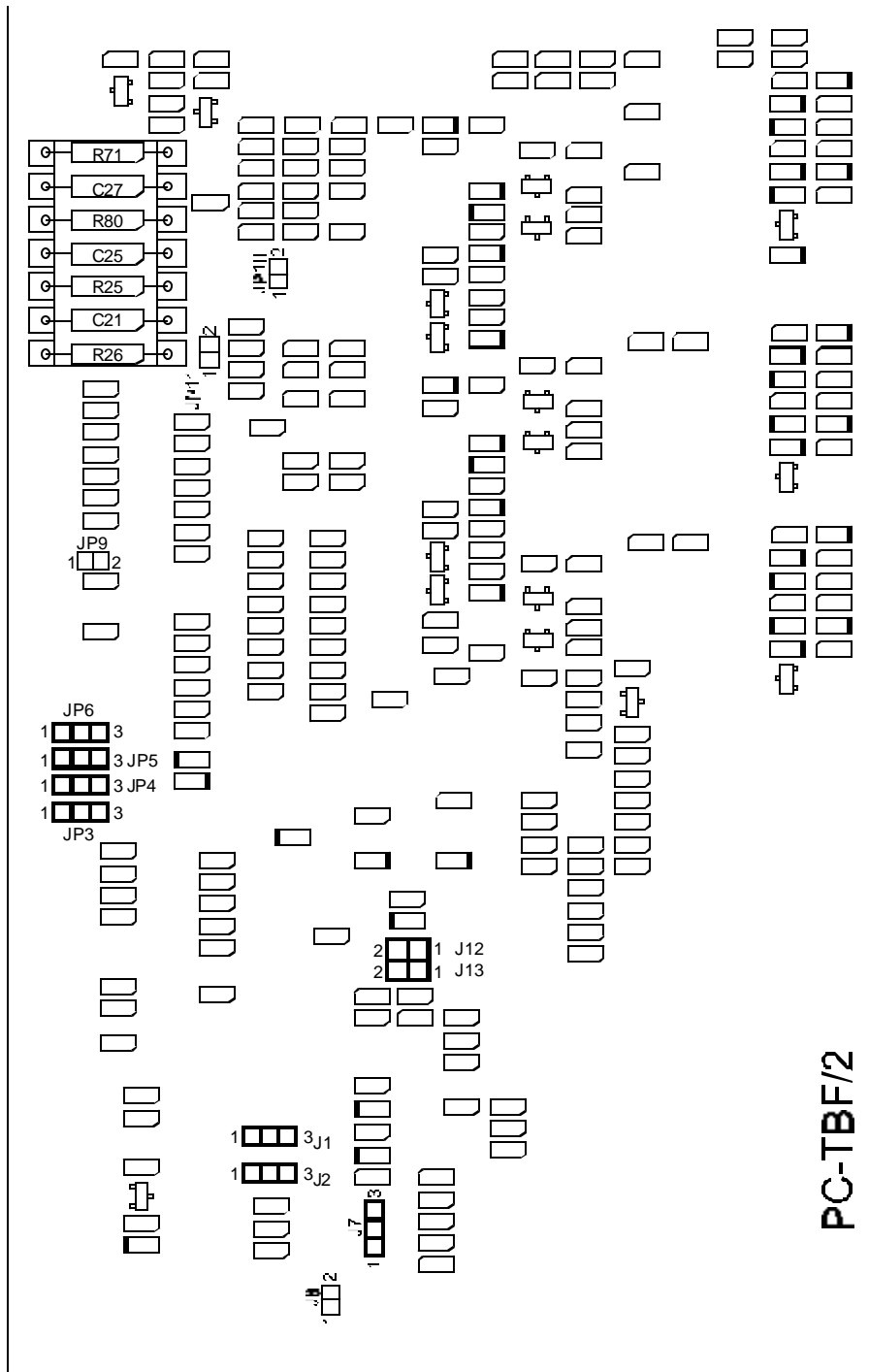


Figure 17: Components Inserted (lower side)

8.1.3 Component mounting diagram - sub-board

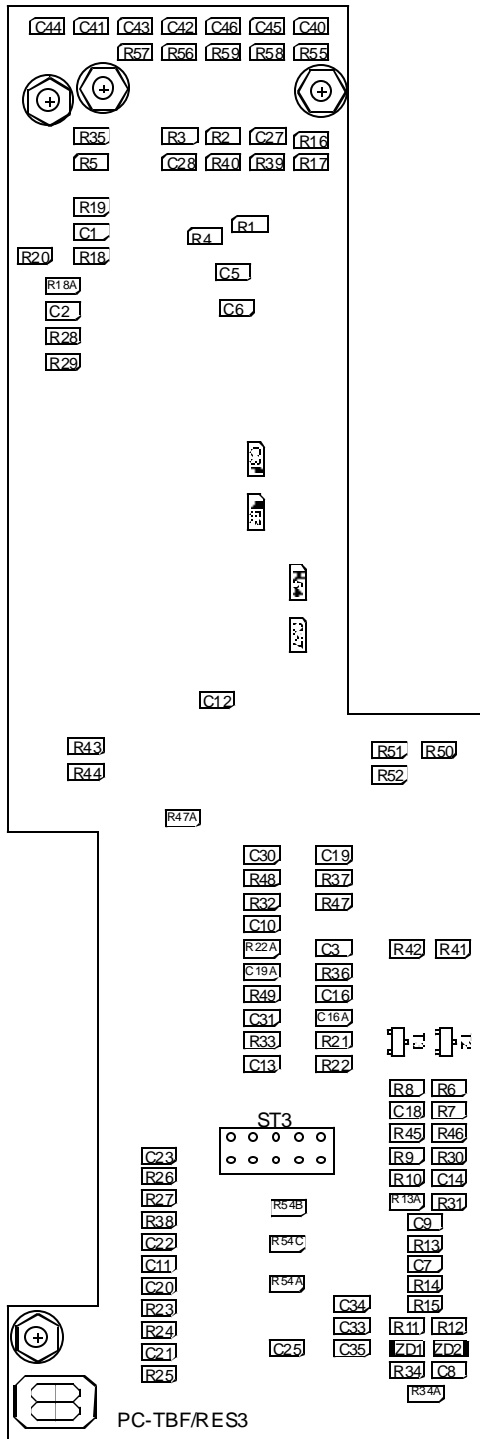


Figure 18: Components on lower side

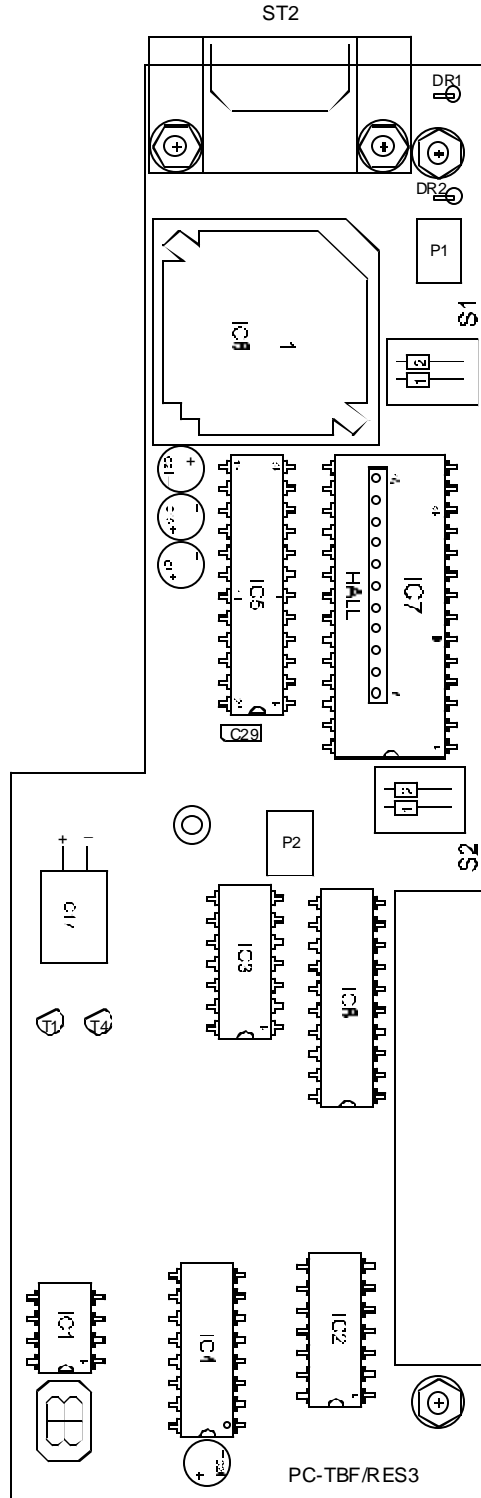


Figure 19: Components on upper side