BOSCH

Industrieausrüstung

Bosch Servodyn
Inverter System
Servo Module SM . . -T

Handbook No. 12

P.-Nr. 3841/E1 – 03/86

Antriebstechnik

Contents

1.	Design of the Inverter System	1
1.1	Construction and function SM . .-T	1
1.2	Regulation and monitoring functions SM . .-T	1
2.	Technical Data	4
2.1	Type designation	4
2.2	Power unit	4
2.3	Regulating and control unit	5
2.3.1	Control inputs	5
2.3.2	Motor feedback	5
2.3.3	Control outputs	5
2.3.4	Test points	6
2.4	Diagnostics module	6
3.	Application Instructions	7
3.1	Recommended module/motor combinations	7
3.2	Option diagnostics module	9
3.3	Option tandem drive	9
3.4	Option backlash compensation	9
3.5	Option ramp generator	10
3.6	Option short circuit braking	10
4.	Dimensioned Drawings	12
4.1	Dimensioned drawing – servo module SM . .-T	12
4.2	Dimensioned drawing – ramp generator	13
4.3	Dimensioned drawing – short circuit braking module	13
5.	Mounting Instructions	14
5.1	Configuration and mounting position	14
5.2	Cabinet	15
5.3	Connection cables	15
5.4	Mounting instructions SM . .-T	16
6.	Electrical Connection	17
6.1	Basic circuit drawing SM . .-T + VM 60-T	17
6.2	Basic circuit drawing SM . .-T + VM 100/R-T	18
6.3	Front plate designations SM . .-T	19

© 1986
ROBERT BOSCH GMBH

Errors and technical
modifications excepted

6.4	Connection - servo module	20
6.4.1	Earth	20
6.4.2	Motor connection	20
6.4.3	DC link connection	21
6.4.4	Circuitry for resistors for fast discharge of DC link	21
6.4.5	Connector X5: control signals from motor	22
6.4.6	Terminal strip X1	23
6.4.7	Terminal strip X6	23
6.4.8	Connector X8	25
6.4.9	Connector X9	25
6.4.10	Terminal strip X7	25
6.4.11	Terminal strip X31	27
6.4.12	Test points	27
6.4.13	Terminal strip X14	27
6.4.14	Connection of ramp generator	29
7.	Integration Instructions	30
7.1	Safety	30
7.2	Preparing the integration	30
7.2.1	Drive components	30
7.2.2	Module mounting and electrical connection	30
7.2.3	Preoptimisation of Speed Regulator	31
7.2.4	Reduction of the unit limit current via DIP switch	32
7.3	Integration	33
7.3.1	Power supply	33
7.3.2	Ready	33
7.3.3	Command adjustment	33
7.3.4	Direction of motor rotation	34
7.3.5	Speed adjustment	34
7.3.6	Speed drift	34
7.3.7	Speed monitoring	35
7.3.8	Speed regulator optimisation	35
7.3.9	Adaption to the positional servo loop	37
7.4	Component layout optimisation card	38
7.5	Circuit drawing optimisation card	39

1. Design of the Servodyn Inverter System

Bosch inverter systems are of modular construction. At least one supply and one servo module are required to make up an operative installation.

The supply module generates a DC link voltage and various supply voltages (for logic and driver circuits) from the mains (3 x 380 – 3 x 415 V).

The individual modules are connected to one another by plug-in cables which are supplied with them.

On an installation with several modules up to 10 SM modules can be connected to one supply module, depending on the size of the modules.

Since the mechanical construction and the electrical connection to the supply module are the same as for the ASM system (inverter system for standard asynchronous motors) as well as the SPM system (inverter system for controlled spindle drives) combinations of these systems are possible (for instance 3 SM modules and 1 SPM module for the main spindle).

1.1 Construction and Function of Servo Module SM..-T

Bosch AC inverters of the SM..-T range allow optimum utilization of the brushless Bosch servo motors.

In conjunction with a rotor position recognition function and a brushless tacho the servo module regulates the motor torque and motor speed.

In a inverter stage with power semiconductors voltages and currents are generated in such a way that the machine can produce the required torque at any speed.

1.2 Regulating and Monitoring Functions Servo Module SM..-T

Speed Regulation Function

The speed regulator is contained on an optimisation card. Two speed command signals and one actual speed signal are available as input quantities (SW1, SW2 and tacho). The output (UN) is the command for the current regulator. The regulating process can be influenced in several ways.

The speed commands SW1 and SW2 and the tacho signal are transmitted via differential amplifiers. The differential amplifier for SW1 is linked to a slope limiting device in order to smooth out the stepped output of most NC controls (see 7.3.3). Its input voltage of 7 V to 11 V can be adapted. SW2 has a fixed amplification of 1 : 1.

The tacho signal can be adapted within the wide range of 500 to 4000 rpm with micro-switches and an additional potentiometer for fine adjustment. It is also possible to connect an active filter between the tacho input amplifier and the speed regulator (see 7.3.8).

The speed regulator has a PI circuit as standard. For special cases derivative action can also be realized (see 7.3.8).

The I-portion of the regulator can be switched off via an external interface signal. For purposes of integration and testing the regulator can be limited to 1 : 1 amplification in the P-portion via a switch.

When the enable signal for the regulator has not been given the P-portion is also limited to 1 : 1 and command 1 (SW1) is short-circuited.
There are two possible responses when the enable signal is switched off.
First possibility: SW1 is short circuited; P-portion = 1 : 1 amplification; the drive idles down to zero speed. Second possibility: braking to zero speed with the maximum servo module current (see 7.2.3 R68, R69).

The speed regulator output (UN) can be limited as command for the current regulator by an external interface signal (Mred), which determines the maximum acceleration current (see connections 6.4.13).

If the motor is jammed this also results in a limitation of UN, in that the maximum current will be reduced to 50% after 2 seconds.

Current Regulator Functioning

The current regulator compares the speed regulator output as a current command with the actual current value and sends a suitable control signal for the adaptive control of the pulse inverter for electronically motors.

In conjunction with the commutation encoder of the motor the pulse inverter control operates the power semi conductors of a bridge circuit.

This makes it possible to regulate the current in the motor windings, in which an instant torque can be generated depending on the rotor position.

Monitoring Functions

All the monitoring functions described below can be displayed and stored on an optional diagnostics card.

PSU Fault (NF)
The internal supply voltages of servo module are monitored for overvoltage or undervoltage (14 V and 16 V). If one of these faults occurs Ready 2 (BTB 2) is switched off and the internal enable (FG I) is taken away.

With the aid of the optional diagnostics module the PSU fault (NF) can be displayed with an LED and signalled to a higher level control via an interface signal.

Module Fault (MF)
This fault signal is produced if the load circuit (motor connection) is interrupted or short-circuited.

Ready 2 (BTB 2) is switched off and FG 1 is taken away. Further processing of the signal possible with the diagnostics module (see PSU fault).

Tacho Fault (TF)
This signal is produced if the tacho line is interrupted or short-circuited.
Ready 2 (BTB 2) is switched off; FG I is taken away. Further processing possible with the diagnostics module (see PSU fault).

Commutation Monitoring (KF)
This monitoring function produces a fault signal if inadmissible combinations of commutation signals come from the rotor position encoder, if the tacho connector is not plugged in, or if there is a fault in the tacho electronics or the tacho line.

Ready 2 (BTB 2) is switched off; enable signal FG I is taken away. Further processing possible with the diagnostics module (see PSU fault).

Excess Heat Sink Temperature (δK)

When the temperature of the heat sink of the power unit exceeds δ max, Ready 1 (BTB 1) is switched off and signal δK is set, if there is a diagnostics module.

But the axis remains active for one more minute (in order to initiate "Feed Hold", for instance). Only then is the internal enable signal (FG I) taken away. This condition remains stored even if the fault signal disappears after a drop in temperature, in order to prevent an automatic restarting of the axis.

The fault signal can be reset via the diagnostics module on the condition that the enable has been switched off externally first.

If the diagnostics module is not used the drive must be switched off; the signal is then reset with mains ON.

Excess Motor Temperature (δM)

This fault signal is produced when the motor winding temperature exceeds 140°C.

Further processing of the fault signal corresponds to that for the excess heat sink temperature (δK).

Motor Blocked (I x t)

This signal appear on the diagnostics module if the motor receives the maximum current for more than 2 seconds without moving. After this time the maximum current is reduced to 50%.

The drive will remain in this condition until the cause of the motor blocking is eliminated.

The signal (I x t) has no further effect. Further processing of the signal is possible with the diagnostics module (see PSU fault).

Speed Monitoring (n<nx)

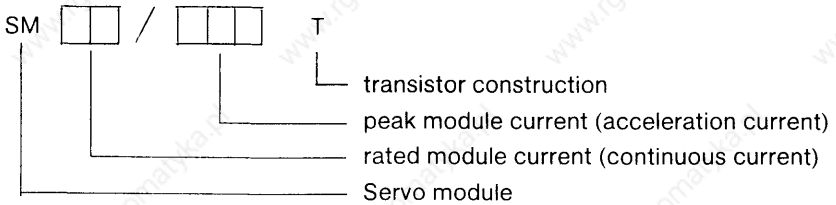
This signal is produced if the speed at any one time is below a predetermined minimum speed.

The signal can be displayed via the diagnostics module. By changing components on the optimisation card this signal can be made to appear only at standstill. This signal has no further effect.

The monitoring speed (nx) is predetermined by the value of a component on the optimisation card (see integration instructions 7.3.7).

2. Technical Data

2.1 Type Designation



2.2 Power Unit

Type	SM5/10-T	SM10/20-T	SM17/35-T	SM25/70-T	SM35/70-T	SM50/100-T
rated current [A] at amb. temp. = 45 °C at amb. temp. > 45 °C	5 current reduction by 1,2% per degree K	10	17	25	35	50
peak current [A] (2 sec)	10	20	35	50	70	100
DC link voltage	460 $V_{rated} < V_N < 700\ V_{max}$					
speed regulating range	> 1 : 10,000					
requirement for energy – power supply [W]	20	20	22	24	26	30
max. power loss [W]	60	90	150	200	250	350
Cooling	–	–	X	X	X	X
mass [kg]						
max. operating temperature max. storage temperature			0 °C to + 55 °C – 25 °C to + 70 °C			
max. operating height			1000 m amsl			
protection standard			IP 00 to DIN 40050 and IEC 144			
admissible humidity			class F and DIN 40040			
cooling			forced ventilation with 1 axial blower, supply: 24 V DC, 100 mA			

2.3 Regulating and Control Unit

2.3.1 Control inputs	differential command inputs	SW 1: range ±7 V to ±11 V on connector X6, PINS 5 and 6, internal setting of slope limitation for stepped NC output
		SW 2: range ±10 V with fixed input amplification 1 : 1
	enable	FG: X6.3 +24 V and X6.4 0 V, opto-coupler input
	torque reduction (reduction of the peak current of the unit)	M_{red} = 0 V ... 10 V on X14.4 and 3 reduction from 100 down to 10% via component R25
	switching off integral portion of speed regulator	P-REG: X14.1 and 2 +24 V signal on X14.2 and 0 V on X14.1
2.3.2 Motor Feedback	rotor position encoder	X5; digital signals A, B, C/1, 2, 3
	tacho voltage	X5.4 and 5 analogue ±2,7 V/ 1000 min^{-1}
2.3.3 Control Outputs	Ready 1	BTB 1: X1.3 and 4 potential-free relay contact max. contact load: 24 V 1 A DC
	Ready 2	BTB 2: X1.1 and 2 potential-free relay contact max. contact load: 24 V 1 A DC
	tacho voltage; measuring output	Ta: X6.8 short circuit proof measuring output 2.7 V/1000 rpm ±5%
	standardized current; measuring output	I_{norm}: X6.7 short circuit proof measuring output 0 ... ±8 V, ±8 V ≙ peak current of unit
	command output, standardized	SW 1a: X6.2 short circuit proof output

2.3.4 Test Points (with high frequency protection)

command 1	SW 1:	measured against ⏚ level: 0 to ±7.5 V
tacho	T:	measured against ⏚ level: 0 to ±2.7 V per 1000 rpm
standardized current	I_{norm}:	measured against ⏚ level: 0 to ±8 V 8 V ≙ unit peak current
speed regulator output	U_N:	measured against ⏚ level: 0 to ±8 V 8 V ≙ unit peak current

2.4 Diagnostics Module (Option)

voltage supply	external: +24 V ±15% I = 100 mA per output
control outputs	24 V DC; max. load 100 mA 300 mA short-time (relay pull-in current); short circuit proof and protected against surge voltages resulting from the switching of inductive loads
LED displays	LED red: PSU fault NF; module fault MF; commutation fault KF; tacho fault TF yel.: excess heat sink temp. δK; excess motor temp. δM; speed monitoring n<nx; motor blocked I x t
reset input	Res: X7.1 for ext. reset signal +24 V DC, 20 mA
reset pushbutton	S 1

3. Application Instructions

3.1 Recommended Module/ Motor Combinations

type of motor SD-... (1)	type of module SM..-T 5/10	10/20	17/35	25/50	35/70	50/100	capacitor module KM....-T 1-axis	≧2-axes
B3.031.030	X	–	–	–	–	–	–	–
B3.050.030	X	–	–	–	–	–	–	
	–	X	–	–	–	–	–	
B3.068.030	–	X	–	–	–	–	–	
B3.095.030	–	X	–	–	–	–	–	
B4.070.030	–	X	–	–	–	–	–	
B4.092.020	–	X	–	–	–	–	–	
B4.140.020	–	X	–	–	–	–	–	
	–	–	X	–	–	–	–	1100
B4.140.030	–	–	X	–	–	–	–	
	–	–	–	X	–	–	–	1100
B4.180.020	–	X	–	–	–	–	–	
	–	–	X	–	–	–	–	1100
B5.250.015	–	–	X	–	–	–	1100	1100
B5.250.020	–	–	X	–	–	–	–	1100
	–	–	–	X	–	–	1100	2200
B5.380.012	–	–	X	–	–	–	1100	1100
	–	–	–	X	–	–	1100	2200
B5.380.020	–	–	–	X	–	–	1100	2200
	–	–	–	–	X	–	1100	2200
B6.480.020	–	–	–	–	X	–	1100	2200
	–	–	–	–	–	X	1100	2200
B6.720.020	–	–	–	–	–	X	2200	2200
B6.960.010	–	–	–	–	X	–	1100	2200
	–	–	–	–	–	X	1100	2200
B6.960.015	–	–	–	–	–	X	2200	2200

(1) Motors in ferrite construction
Technical data see handbook 01

3.2 Diagnostics Module (option)

The diagnostics module is available as an option. It can be used in all modules of the Servodyn range.

This module facilitates fast fault diagnosis in the area of the drive electronics by the enduser's maintenance personnel. 8 different diagnostic signals are output. 4 of these signals are stored and displayed via red LEDs.

The other 4 signals are warning signals and they are displayed with yellow LEDs.

In addition all faults can be signalled to a higher-level control via 24 V DC interface signals. For this purpose each diagnostics module has a separate 24 V DC supply which will supply the fault stores and the interface even when the drive is switched off (by E.Stop, for instance).

Each type of module has a space for this card on the right side behind the front plate. The 24 V DC diagnostic signals can be taken directly from a 10-pole terminal strip on the front plate. The external 24 V DC is connected via a 2-pole terminal strip.

The fault stores can be reset either via a reset input, "RES" (+24 V DC), or via a reset button located on the diagnostics module.

3.3 Option Tandem Drive

on request

3.4 Option Backlash Compensation

on request

3.5 Option Ramp Generator

This additional module allows a limitation of the leading and trailing edge of the command signal, thereby limiting the time for motor acceleration and braking (t_{min} = 5 ms; t_{max} = 10 s). Leading and trailing edge can be set separately (for range see the section on connections, 6.4.14 and the drawings in 4.2).

The card is designed to be clipped onto a tophat rail and is supplied with a ±15 V auxiliary voltage from the supply module VM.

3.6 Option Short Circuit Braking

In order to prevent the feed axes from slowing down in an uncontrolled way in the event of an E.Stop the feed motors can be shut down by short circuiting the motor windings.

The values of the short circuit braking resistors are chosen to ensure that the short circuit current achieves 3 to 4 times the rated current, and therefore also 3 to 4 times the rated torque, in the initial phase.

The required resistor values are calculated on the basis of the rotational energy ($W_{rot} = \frac{1}{2} J\omega^2$), which needs to be converted, assuming n = max. speed and load inertia = motor inertia.

The resistors can be purchased as individual resistors or incorporated into a complete resistor module.

Selection Table for Short Circuit Braking Module

(condition:
total inertia = 2 x motor inertia)

Servodyn Ferrite

type of motor	resistance R_X [Ohm]	min. energy [Ws] *KB	stock no. Bosch
SD-□3.031.030	8,2	57	105-913544
SD-□3.050.030 SD-□3.068.030 SD-□3.095.030	3,3	293	105-913545
SD-□4.070.030 SD-□4.092.020	5,6	261	105-913546
SD-□4.140.020 SD-□4.180.020 SD-□4.140.030 SD-□5.250.015	3,3	293	105-913545
SD-□5.250.020 SD-□5.380.012 SD-□5.380.020	3,3	785	105-913547
SD-□6.480.020 SD-□6.720.020 SD-□6.960.010 SD-□6.960.015	1,0	4085	105-913862

R_X (±10%)	Each module consists of 3 resistors Individual resistor see above table
max. conn. size	4 mm^2
test voltage	2500 V AC
max. ambient temperature	55 °C
mounting	snap-on fastening on 35 mm tophat rail to DIN
prot. standard	IP 20
dimensioned drawing	see section 4.3

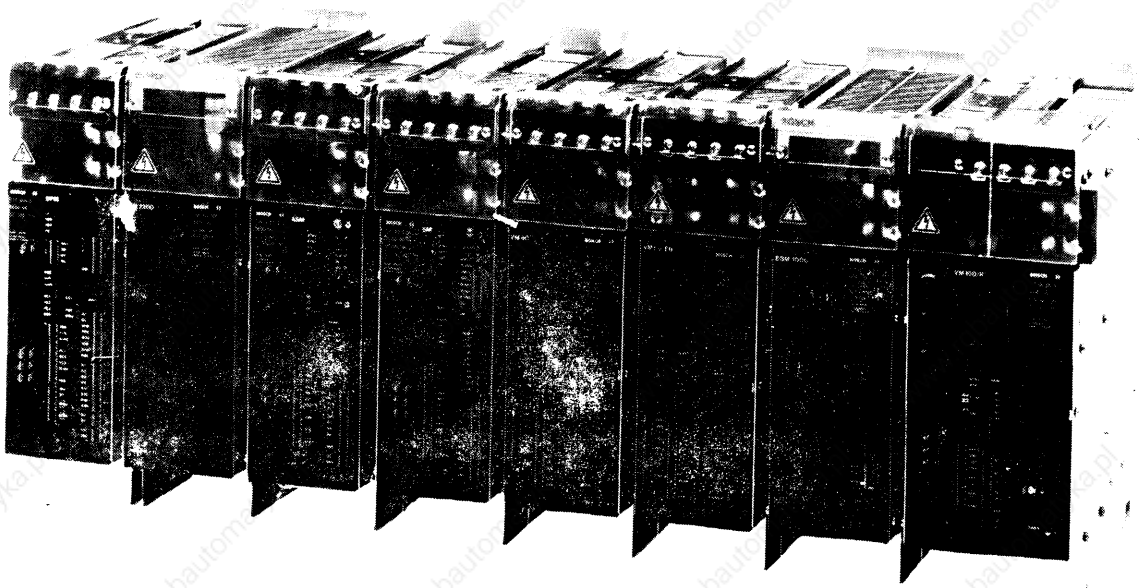
*KB = short-time operation – to be specified when ordering the resistor!

5.2 Cabinet

The modules must be mounted in switch cabinets to protection standard IP 54 or IP 44 (dust filters in front of the air inlet and outlet).

The flow of cooling air through the modules, which is directed upwards, must not be impeded by other components or parts of the switch cabinet. To ensure this a clearance of at least 100 mm must be provided above and below the modules.

No minimum clearance is required at the sides.
The air temperature within the cabinet must not exceed +55 °C. Condensation is not admissible.

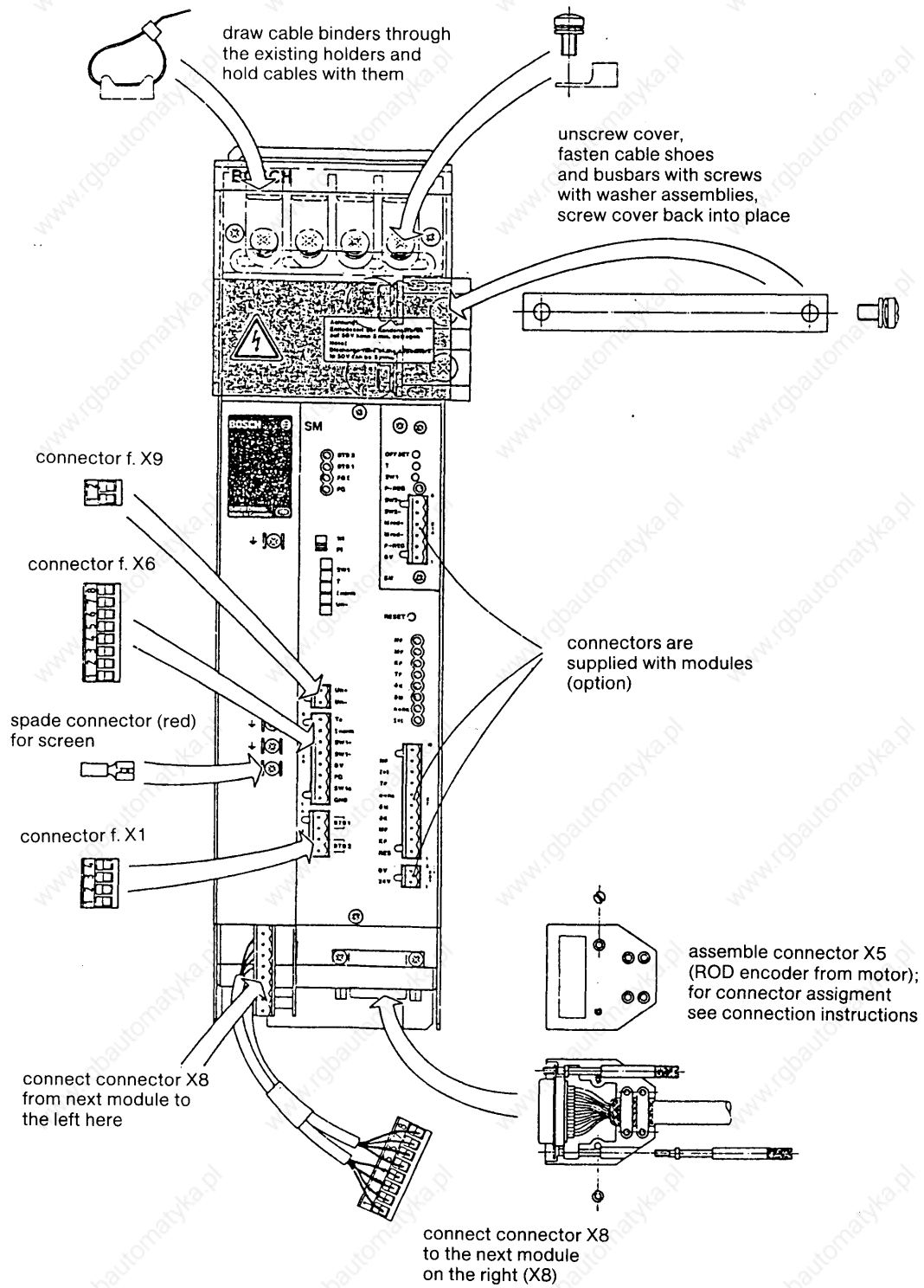


5.3 Connection Cables

Connection cables which go to the terminal board and the PE connection must be combined in a cable tree and attached to existing holders with the aid of 2 cable binders.

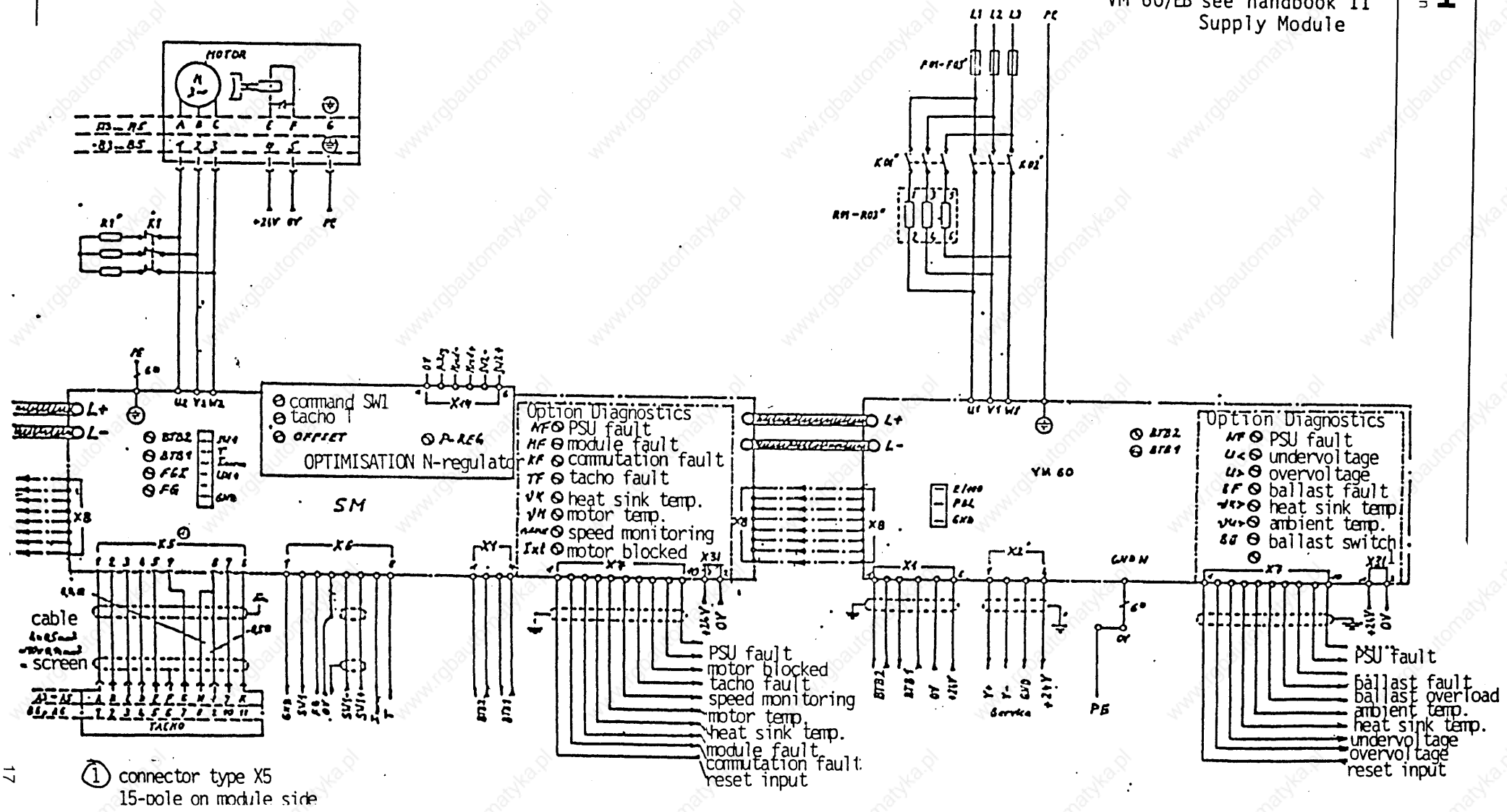
Connection cables going to front plate connectors X1, X6, X9 and to diagnostics X31, X7 and to the optimisation module X14 can be routed directly downwards and into a cable channel which must be mounted below the modules (mounting brackets for the channel are supplied).

5.4 Mounting Instructions Servo Module SM..-T



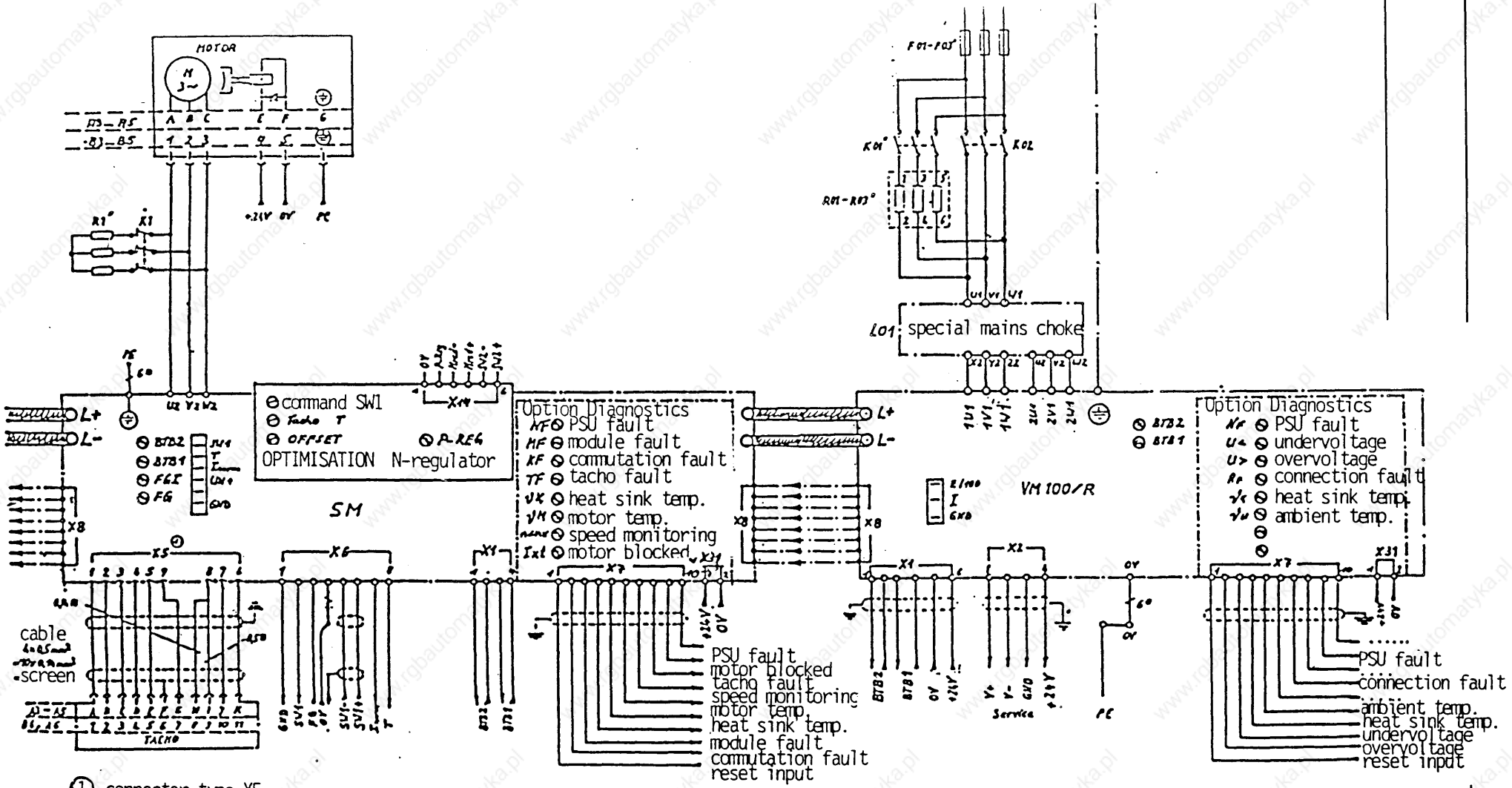
6. Electrical Connection and Front Plate Designations

6.1 Basic Circuit Drawing SM..-T + VM 60-T



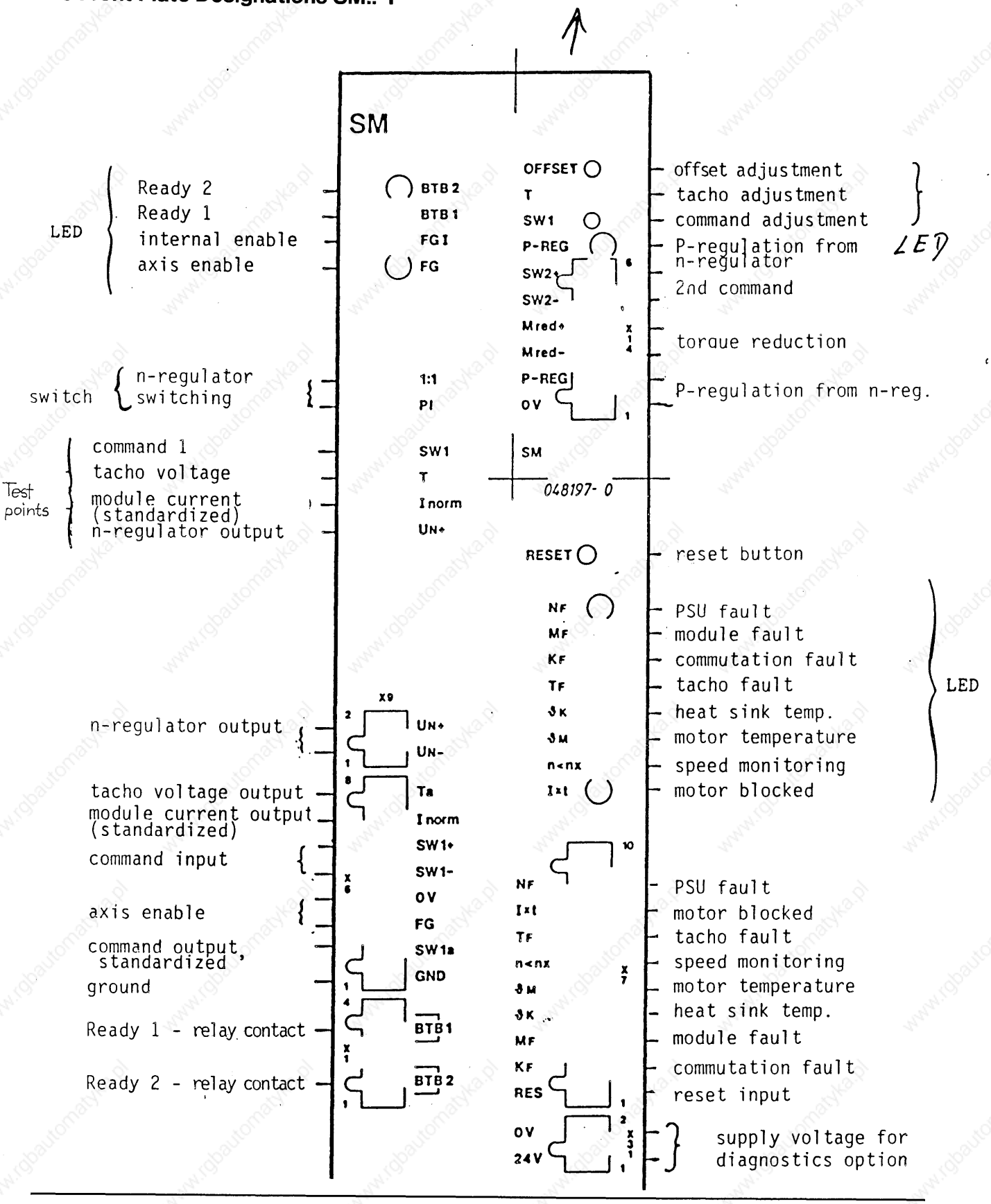
(1) connector type X5
15-pole on module side

6.2 Basic Circuit Drawing SM..-T + VM 100/R-T



① connector type X5
15-pole on module side

6.3 Front Plate Designations SM..-T



6.4 Connection Servo Module

6.4.1 Earth

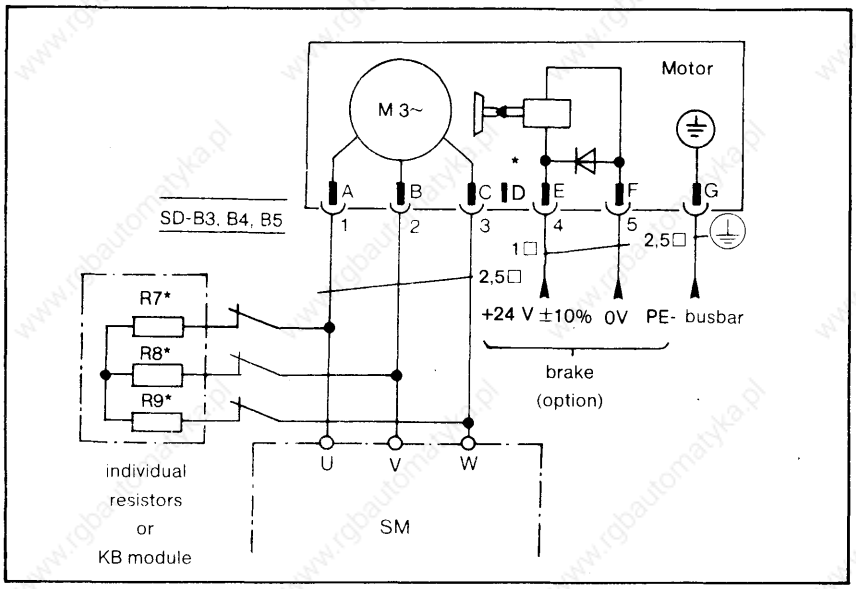
Each servo module (SM) has a connection for the protective earth (power connection, terminal block top right). Protective earth and PE busbar must be connected with a 2.5 mm^2 cable for SM 5/10, 10/20, 17/35 and with a 6 mm^2 cable for SM 25/50, SM 35/70 and 10 mm^2 for SM 50/100.

6.4.2 Motor Connection

The connection to the brushless servo motors is made via terminals U2, V2, W2 of the associated servo modules. On the motors themeselves the connection is made via plug-in connectors.

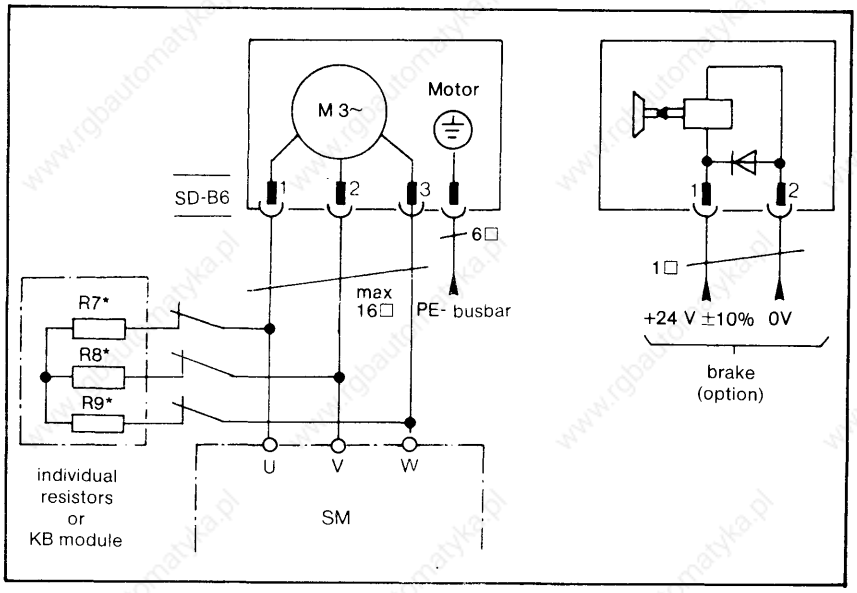
motor sizes
SD-□3
SD-□4
SD-□5

*** Note:**
PIN D (motor star point) must not be connected!



motor size: SD-□6

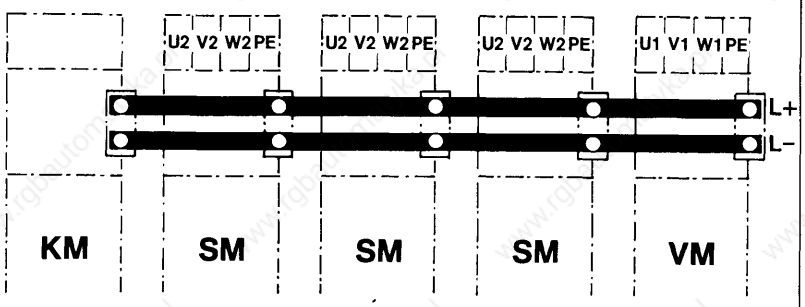
motor type	connection size [mm^2]
SD-□3	1,5
SD-□4	1,5
SD-□5.250.015	1,5
SD-□5.250.020	2,5
SD-□5.380.012	2.5
SD-□5.380.020	4
SD-□6.480.020	6
SD-□6.720.020	16
SD-□6.960.010	10
SD-□6.960.015	16



* short circuit braking for E.Stop condition

6.4.3 DC Link Connection

The DC link voltage for the supply of the servo modules is available on connections L+ and L– of the supply module.

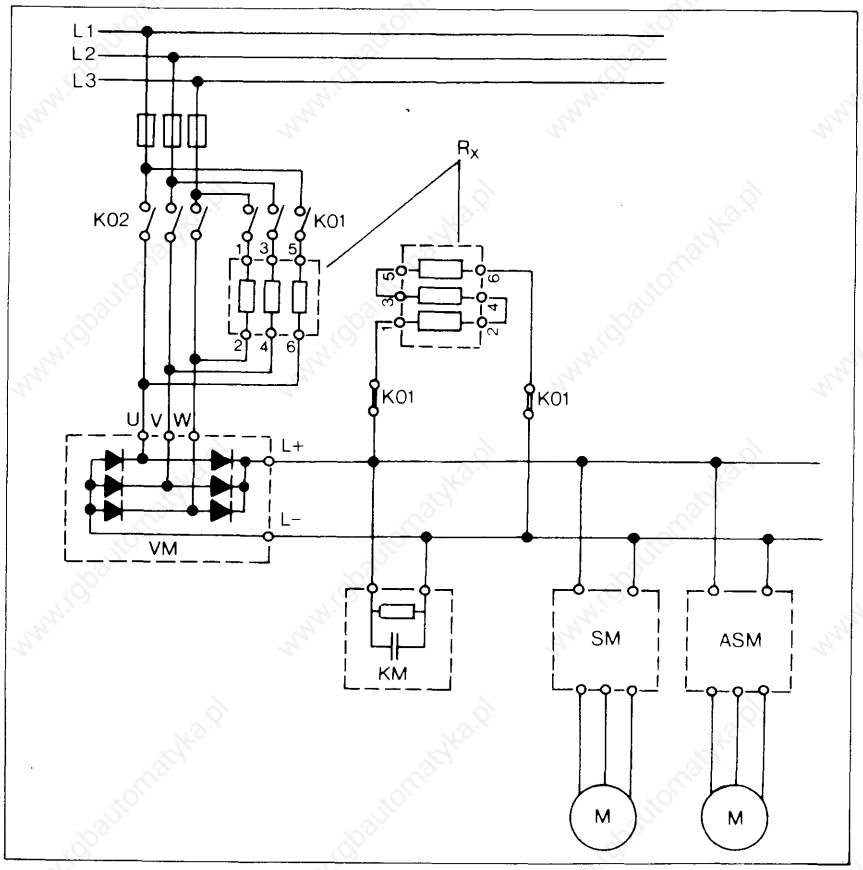


DC link connection for 3 SM modules and 1 KM module

Establish the DC link connection with the busbars and fastening screws supplied in the accessories pack.

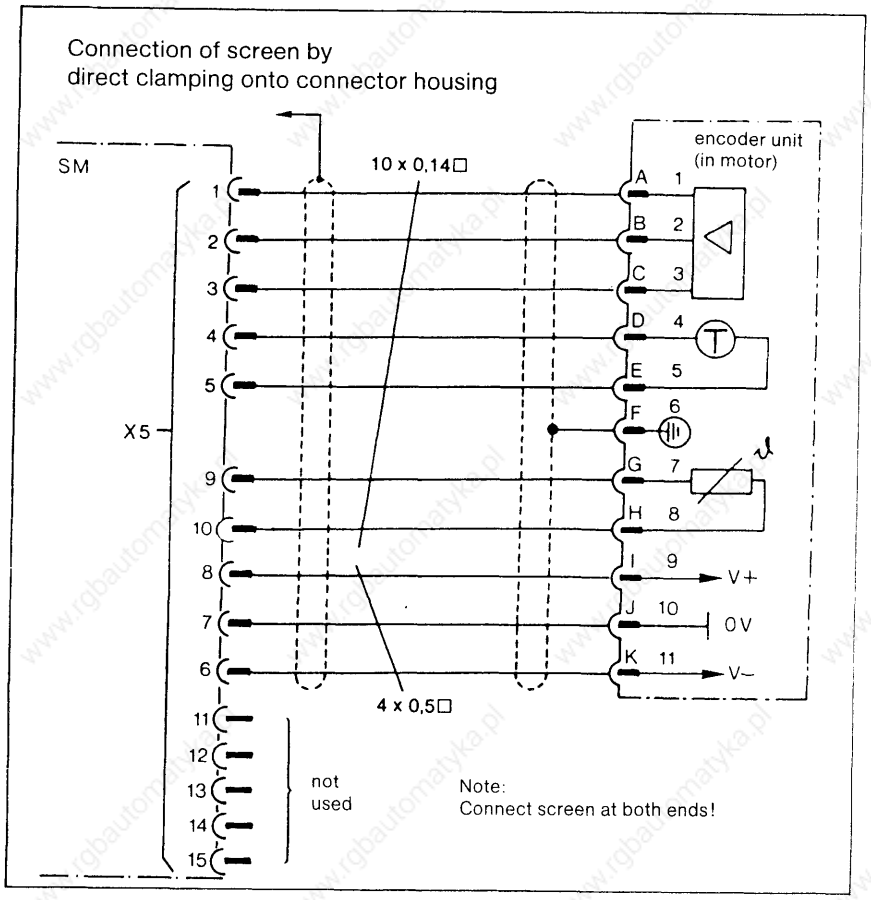
The see-through cover for the terminal block and the busbar connections must be replaced afterwards as protection against accidental contact. The right side of the busbar connection (on the right side of the VM, EBM or KM) must also be protected against accidental contact with an additional black plastic cover (supplied in the accessories pack for VM, KM or EBM).

6.4.4 Circuitry for the Resistors for Fast Discharge of the DC Link



Start-up switching module (Bosch no. 105-913274)
Contactors K01 in series, since DC link voltage up to 1000 V.

6.4.5 Connector X5: Control Signals from Motor (rotor position encoder and tacho)



signal	Souriau motor plug in	colour	encoder unit function
A	1	grey-white	rotor position encoder for commutation control
B	2	violet	
C	3	green	
tacho	4	yellow	brushless DC tacho
N	5	brown-white	V = 2.7 V/1000 rpm ±5%
	6	–	screen connected with PE in motor
ϑ	7	grey	thermistor for motor
ϑ	8	white	temperature monitoring
V+	9	red	±15 V DC voltage supply
GND	10	black	for tacho and encoder
V–	11	blue	

Connection cable X5 encoder: special cable 10 x 0.14 mm^2 + 4 x 0.5 mm^2, screened. Max. cable length 100 m.

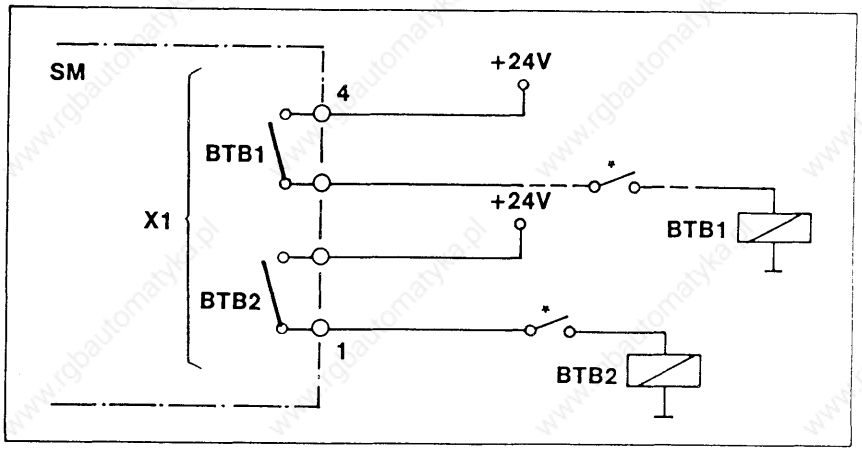
This type of cable is available from Bosch under stock number 070-903 499 (by the meter).

6.4.6 Terminal Strip X1

* For general fault signal:

all ready contacts of the module combination connected in series (VM; SM; ASM; SPM)

Max. contact load: 24 V, 1 A DC



Ready 1 BTB 1

A module specific relay contact is closed when:
- there is no excess heat sink temperature
- there is no excess motor temperature.

If a fault occurs the Ready 1 contact opens and the axis is switched off approx. 1 minute later via the internal enable FG I.

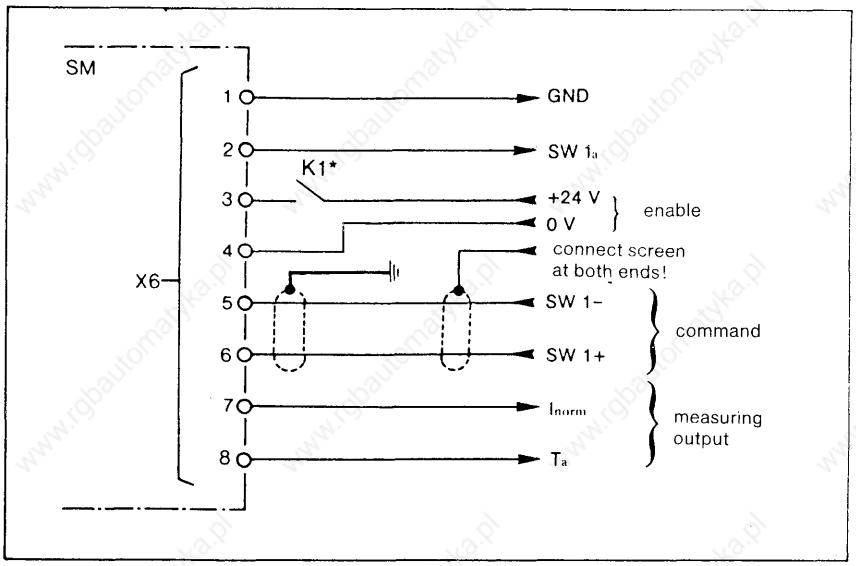
Ready 2 BTB 2

A module specific relay contact is closed when there is:
- no PSU fault
- no current loop fault
- no tacho fault
- no commutation fault.

If a fault occurs the Ready 2 relay contact is opened and the internal enable signal FG I is switched off immediately.

Signal Ready 2 must be incorporated into the latching circuit of the mains contactors (see handbook 11 VM).

6.4.7 Terminal Strip X6



* Interlocking with K1 (mains and braking contactor) must be provided so that the enable signal is switched off during short circuit braking.

Connector Assignment

X 6 **Terminal Strip**

X 6.1 **GND** **ground**
Reference potential for measuring outputs.

X 6.2 **SW1a** **standardized command output**
Single-pole, short circuit proof, +10 V

X 6.3/4 **FG** **axis enable**
Optocoupler input with physical separation. Digital +24 V on X 6.3, 0 V on X 6.4; display via green LED "FG" on the front plate.

- If the signal on X6.3 is high against X6.4 and if Ready 1 and Ready 2 are present the output stage and the regulator are enabled.
- A normally open contact of contactors K01 and K02 (mains contactors) and a normally open contact of each short circuit braking contactor must be connected in series with the enable input. This is necessary to ensure that the enable will be switched off during short circuit braking.
- If the axis can be braked or clamped the enable signal FG must be switched off while the brake or clamping is active.
- There are two possible sequences when the enable is switched off – see section 7.2.3:
  - drive slows down in an uncontrolled manner
  - drive brakes with maximum current.

X6.5 **SW1–/SW1+ command**
Analogue input –10 V to +10 V/10 kOhm

- The command input is designed as a differential input.
- The command connection must always be 2-pole, i.e. terminals 5 and 6 must both be connected.
- The max. command voltage must be in the range ±7 V and ±11 V.
- If the signal is routed via an additional terminal or connector the screen must be laid on ⏚.
- The reference potential of the command source (for instance CNC) must have 0 V level (connection with 0 V busbar see handbook 11 VM).
- The differential input is linked to a slope limiting device in order to smooth out the stepped output of an NC (see optimisation of speed regulator – section 7.3.3).

X6.7 I_{norm} **actual current value**
Measuring output, short circuit proof, 0 ... ±8 V ≙ unit peak current.

X6.8 T_a **tacho voltage**
Measuring output, short circuit proof, ±2.7 V/1000 rpm.

6.4.8 Connector X8 (Connection Cable X8)

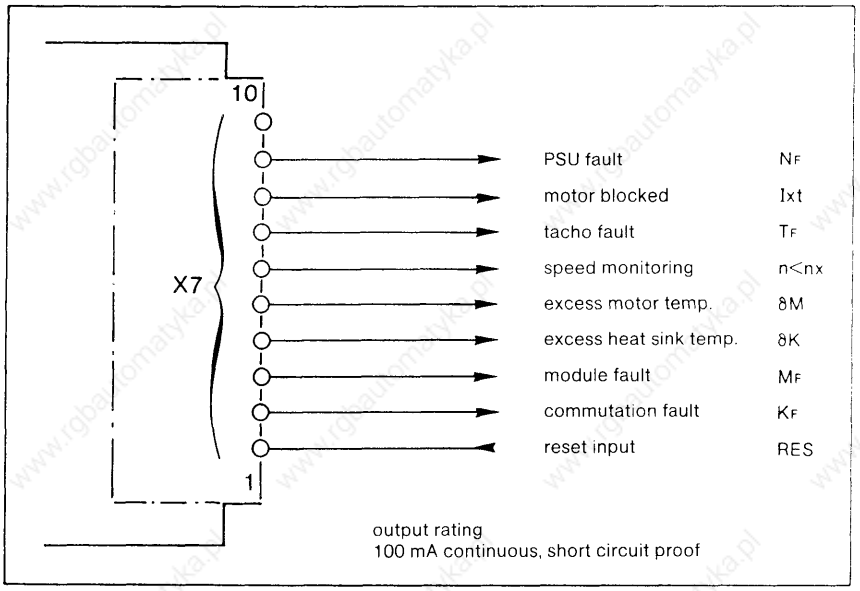
An 8-pole cable, ready connected at the left below the front plate of each module on delivery provides the connection to X8 on the next module to the right.

Terminal strip X8 on the module itself will have cable X8 from the next module to the left connected to it (see connection diagram 6.3).

6.4.9 Connector X9

U_{N+} U_{N-}:
Speed regulator output
Analogue output 0 ... ±8 V

6.4.10 Terminal Strip X7 for Use with Option Diagnostics Card



X 7.1 **Reset Input RES**
Stored fault signals can be reset via a signal on the reset input (+24 V DC pulse) or with reset button.

X 7.2 **Commutation Fault** **LED K_F red, stored**
The signal goes from +24 V to low if:
- the tacho plug is not plugged in
- there is a fault on the tacho PCB (electronics) in the motor
- there is a fault with the tacho cable
- there is an incorrect combination of commutation signals.

Red LED lights. Ready 2 (BTB 2) is switched off.

X 7.3 **Module Fault** **LED M_F red, stored**
The signal goes from +24 V to low if:
- the power unit is defective
- the load circuit (motor connection) is short circuited
- the load circuit is interrupted.

Red LED lights. Ready 2 (BTB 2) is switched off.

X 7.4 **Heat Sink Temperature Monitoring** **LED ϑ_K, yellow**

The signal goes from +24 V to low when:
– the heat sink temperature of the power unit exceeds ϑ_{max}.

Yellow LED lights. Ready 1 (BTB 1) is switched off and after approx. 1 minute the internal enable is taken away.

X 7.5 **Motor Winding Temperature Monitoring** **LED ϑ_M, yellow**

The signal goes from +24 V to low when:
– the motor winding temperature reaches 140 °C.

Yellow LED lights. Ready 1 (BTB 1) is switched off and after approx. 1 minute the internal enable is taken away.

X 7.6 **Speed Monitoring** **LED n<nx, yellow**

The signal goes from +24 V at low level when the current speed is smaller than a predetermined speed. (Through a change on the optimisation card this signal can be made to go high only at standstill).

Yellow LED lights when n<nx. On how to adjust the speed monitoring see section "Integration" 7.3.7.

X 7.7 **Tacho Fault** **LED T_F, red, stored**

The signal goes from +24 V to low when:
– the tacho line is interrupted
– the tacho line is short circuited.

Red LED lights. Ready 2 (BTB 2) is switched off.

X 7.8 **Motor Blocked** **LED I x t, yellow**

The signal goes low when the motor receives maximum module current for more than 2 seconds without turning. After this time the current is automatically reduced to 50% of the maximum current. The drive remains in this condition until the cause of the motor blockage is removed.

Yellow LED lights.

X 7.9 **PSU Fault** **LED N_F, red, stored**

This signal goes from +24 V to low if the two supply voltages +15 V and −15 V for the electronics are outside the admissible tolerances.

Red LED lights. Ready 2 (BTB 2) is switched off.

The table below shows the current limit values achieved by using different values for resistor R25, which is fitted on soldering terminals, when a digital signal* (H = +24 V) is supplied to the optimisation card:

R 25 [kOhm]	reduction to I limit [%]
51.1	90
23.7	67
16.2	50
12.1	33
8.25	10

* X 14.4: +24 V
  X 14.3: 0 V

The table below shows the current limit values achieved if a 5.62 kOhm resistor is fitted for R25 and an analogue signal* is supplied to the optimisation card:

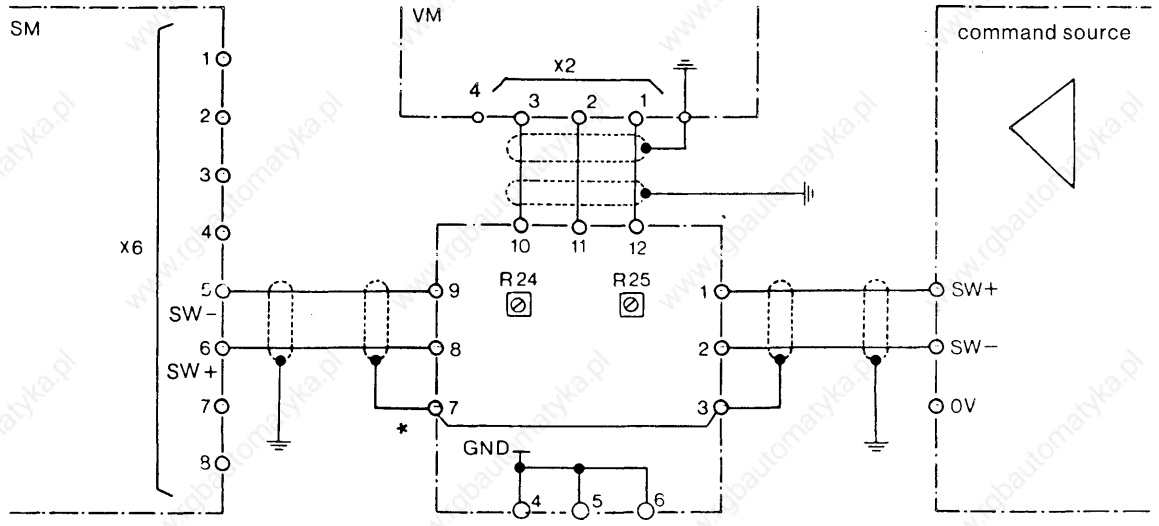
voltage on M_{red} [V]	reduction to I_{limit} [%]
2	92
3	82
4	72
5	62
6	52
8	32
10	12

* X 14.4: e.g. +10 V
  X 14.3: 0 V

X 14.5 + 6 **2nd Command Input** **SW 2+, SW 2–**

Differential input with fixed amplification 1 : 1.
Input signal: 0 to +10 V.

6.4.14 Connection of Option Ramp Generator



6/19 Ramp Generator Connection

Wire the card up according to the above circuit diagram, paying special attention to the command lines!

The required rise and fall times are determined by the value chosen for capacitor C5 on the card.

After evaluation of the operational data according to the example below the capacitance can be derived from the table below:

Example:

$$\frac{5000\ \text{msec}}{10\ \text{V}} = \frac{500\ \text{msec}}{\text{V}}$$

Rise in 5000 msec
Command step to 10 V
Required capacitance acc. to table: 0.470 µF

The rise ramp for acceleration and braking can be adjusted separately with resistors R24 and R25.

C5 [µF]	operational data [msec/V]
0.01	1.1 ... 11
0.047	6 ... 60
0.1	11 ... 110
0.47	60 ... 600
1	110 ... 1100

7.2.3 Preoptimisation of Speed Regulator

All Bosch inverters of the Servodyn range are delivered with the following standard optimisation:

Function	Position	Unit	Value
P-portion speed regulator	R77	kOhm	301
I-portion speed regulator	C9	µF	0.022
SW 1 = 0, DIP switch	S6		OFF
I_{red} current limit, DIP switches	S7, S8		OFF
torque reduction	R25	kOhm	5.62
1 : 1 amplif. speed reg.	PI/1 : 1		switch
slope limitation, command	R62	kOhm	1
switch off enable (standard)	R68	Ohm	0
After switching off enable the drive is slowed down to n = 0 with max. current	R69	Ohm	∞

Before starting the integration the tacho voltage must be adjusted roughly.

Depending on the rapid speed the adjustment can be made in 12 steps acc. to the table below via DIP switches S1-S5.

The fine adjustment of the tacho voltage is carried out later with potentiometer T on the front plate of the SM-optimisation card.

step	n_{min} [rpm]	n [rpm]	n_{max} [rpm]	VT [V]	switch "ON"
1	468	550	633	1.485	none
2	629	740	851	1.998	S 1
3	837	985	1133	2.659	S 2
4	999	1175	1351	3.172	S 1 + S 2
5	1122	1320	1518	3.564	S 3
6	1284	1510	1736	4.077	S 1 + S 3
7	1475	1740	2001	4.696	S 4
8	1640	1930	2219	5.211	S 1 + S 4
9	1849	2175	2501	5.872	S 2 + S 4
10	2133	2510	2886	6.777	S 3 + S 4
11	2663	3133	3603	8.459	S1,S2,S3,S4
12	3527	4150	4773	11.205	S 4 + S 5

7.2.4 Reduction of the Unit Limit Current via DIP Switch

The DIP switch (S1 ... S7) on the optimisation card is used to reduce the limit current of the unit as shown in the table below:

switch no. position OFF	ON	I limit [%]	I stand. [V]
S 7 + S 8	–	100	8
–	S 7	88	8
–	S 8	78	8
–	S 7 + S 8	70	8

7.3 Integration

7.3.1 Power Supply

- Remove fuses for the supply module on the mains side.
- Unplug connector X1 on the supply module.
- Disconnect one coil connection at contactor K01 (see VM connections).
- Switch on power (main switch).
- There must be +24 V present between X1.6 and X1.5 of the supply module.

Note:

If a simple external +24 V supply with B6 rectifiers is used an electrolytic capacitor of at least 4700 µF must be connected to the output terminals (24V).

- Measure the mains voltage at the main fuses with a multimeter. Admissible range: 340 V to 455 V.
- Switch on drive. Contactors K01 and K02 must **not** pull in!
- Switch off main switch.
- Plug connector X1 in on supply module.
- Reconnect coil connection at K01.
- Switch on main switch.
- Switch on drive.
- K01 and K02 must pull in, for as long as the button is depressed, and they must fall off again when the button is released.
- Switch off main switch.
- Reinsert fuses.

7.3.2 Ready

- Switch on main switch, do not give enable signal.
- Switch on drive.
- On the supply modules the green LEDs "Ready 1" (BTB 1) and "Ready 2" (BTB 2) must light.
- K01 and K02 must remain pulled in once the ON button is released.

7.3.3 Command Adjustment

Introduce a command voltage which corresponds to the intended maximum operating voltage on terminals X6.5 and X6.6 of the servo module.

Admissible range: ±7 V to ±11 V.

DIP switch S6 on the optimisation card must be switched off.

Adjustment on the SM-optimisation. Use pot. SW 1 on the front plate of the SM-optimisation card to set the voltage on test point "SW 1" (command) to 7.5 V against "⏚" (turn counter-clockwise to achieve higher voltage on test point "SW 1")

Switch on switch 6 (optimisation card).

Slope limitation for command steps with R62. The parameters are the scanning frequency of the NC and the largest command step per scanning interval.

The value of R62 must be determined by trial and error since the quantity "largest command step per scanning interval" is usually not known. R62 is to be increased (resistance decade) to the highest possible value before the tacho voltage starts to show some overshoot. This adjustment must be made after the speed regulator optimisation.

Standard value for R62 = 1 kΩ.

7.3.4 Direction of Motor Rotation

On motors with disk brake the brake must be released before the enable is switched on!

- Switch PI/1 : 1 (S1) on the regulator card must be set to 1 : 1.
- Set command input to 0 V.
- Switch S6 on the optimisation card must be closed.
- Give enable signal (green LEDs FG and FG I come on).
- Carefully increase command until the axis starts moving.
- Observe the direction of axis rotation!
  A reversal of the direction of rotation can be effected by swapping the command connections on X6.5 and X6.6.
- Switch off enable signal.
- Set switch PI/1 : 1 (S1) to PI.

7.3.5 Speed Adjustment

- Give enable signal.
- Introduce exactly 50% of the intended max. command on X6.5 and X6.6.
- Measure the speed (if possible with a manual revolution counter).
- Use pot. T (optimisation card) to set the speed to exactly 50% of the max. speed (clockwise turning --> higher speed).
- If it is not possible to measure the speed with a separate revolution counter it can be approximated by measuring the tacho voltage.
  At test point "T" there is a voltage of 2.7 mV/rpm ±5% available, i.e. at a speed of 1000 rpm the tacho voltage is approx. 2.7 V (for range SE-B2: ... mV/rpm).

7.3.6 Speed Drift

- Command input to 0 V and short circuiting of terminals X6.5 and X6.6.
- The motor drift can then be reduced to a minimum with pot. OFFSET (optimisation card).

  Note:
  It is usually not possible to eliminate the drift altogether without the positional servo loop being active.
- Undo the short circuiting of terminals X6.5 and X6.6 and switch DIP switch S6 back ON.

7.3.7 Speed Monitoring (with Option Diagnostics)

Speed recognition or monitoring via diagnostics output (n<nx) and LED.

- Determination of the recognition speed by selection of the value for R4 on the speed regulator optimisation card according to the following formula:

$$R4 = \frac{n' \cdot 750\ k}{76.4 - 76 \cdot n'}\ [k\Omega]$$

$$n' = \frac{n\ x}{n_{rapid}}$$

$n\ x =$ recognition speed
$n_{rapid} =$ rapid speed

Standard value for R4 = 10 kOhm = 1500 rpm with n_{rapid} = 3000 rpm.

- Definition of the speed recognition function as standstill display by fitting R72 = 0 Ohm on the optimisation card.

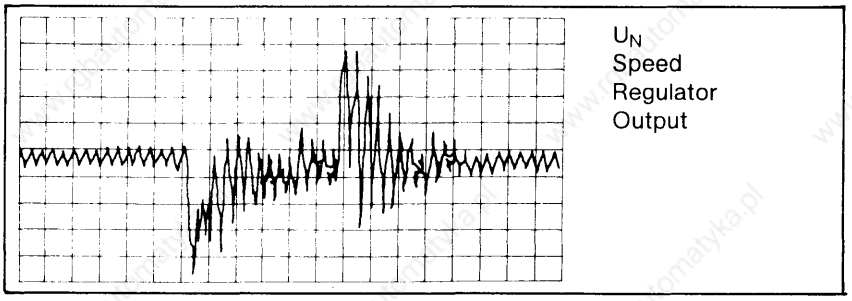
7.3.8 Speed Regulator Optimisation

In 90% of all applications the standard optimisation of the speed regulator (R77 = 301 kOhm, C9 = 22 nF) is suitable for machine tool axes. Should problems arise the optimisation can be checked as follows:

- Switch off main switch.
- Connect an RC decade instead of R77 and C9.
  Starting values: R = 301 kOhm; C9 = 22 nF.
- Connect an oscilloscope to test point "U_{N+}".
- Switch on main switch and drive. Give enable signal.
- Introduce a command step as a function.
  The time constant should lie approx. 10% below the time constant excepted during future operation.

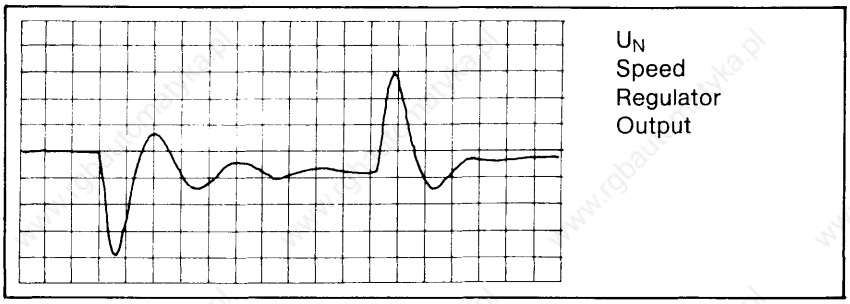
  Example:
  Planned KV factor: KV = 1
  Time constant: T_m = 60 msec
  Set the command for the optimisation to T = 55 msec.
- Select the level of the command signal so that the speed regulator (test point "U_{N+}") operates just below the limit (the limit lies around 8 V).
- The regulator output signal on test point "U_{N+}" can be influenced by changing R77 (P-portion) and C9 (I-portion) as illustrated in the following diagrams:

If the P-portion is too large or the I-portion too small the speed regulator becomes unstable:

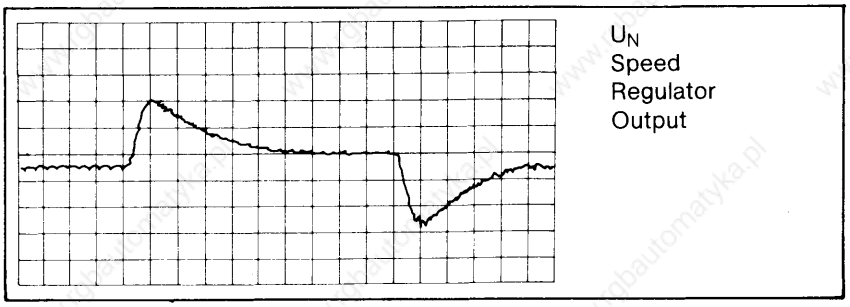


The instability is mainly a result of the excessive tacho ripple.

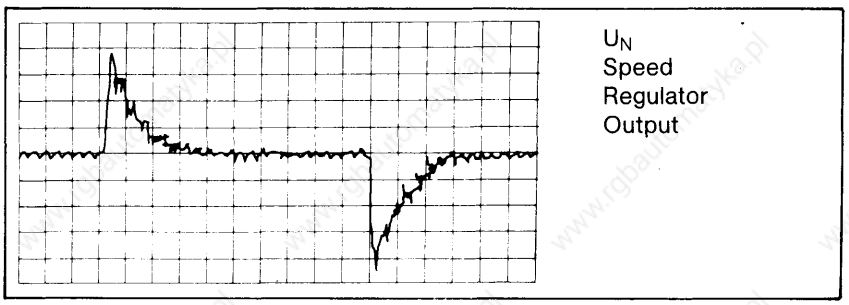
If the p-portion is too small the speed regulator is also unstable, but at a very low frequency.



If the I-portion is too large the speed regulator is stable, but its response is sluggish due to the resulting high time constant in conjunction with a low P-amplification.



When the speed regulator is adjusted correctly the signal will look as foollows:



Once the required values have been determined solder the appropriate components in for R17 and C9.

Derivative Action

For special cases an additional derivative action can be achieved with C13.

Note: Additional active filter at the tacho input.

If R75 is made 0 Ohm an active filter can be connected, which will improve the stability of the servo loop for motors with large inertia in most cases.

7.3.9 Adaption to the Positional Servo Loop

- Connect command source.
- Switch on drive, give enable signal.
- Introduce command "0 V".
- Adjust the lag (following error) to "0" with the appropriate potentiometer on the control (on some types of CNC this is done via parameter input!).
- Drive the axis at a defined feedrate (such as 1 m/min) and measure the resulting lag. The lag depends on the K_V-factor and the axis velocity.

$$LAG = \frac{v}{Kv} = [mm]$$

v = axis velocity [m/min]
K_V = K_V factor [10^3/min]
LAG = lag [mm]

Example:

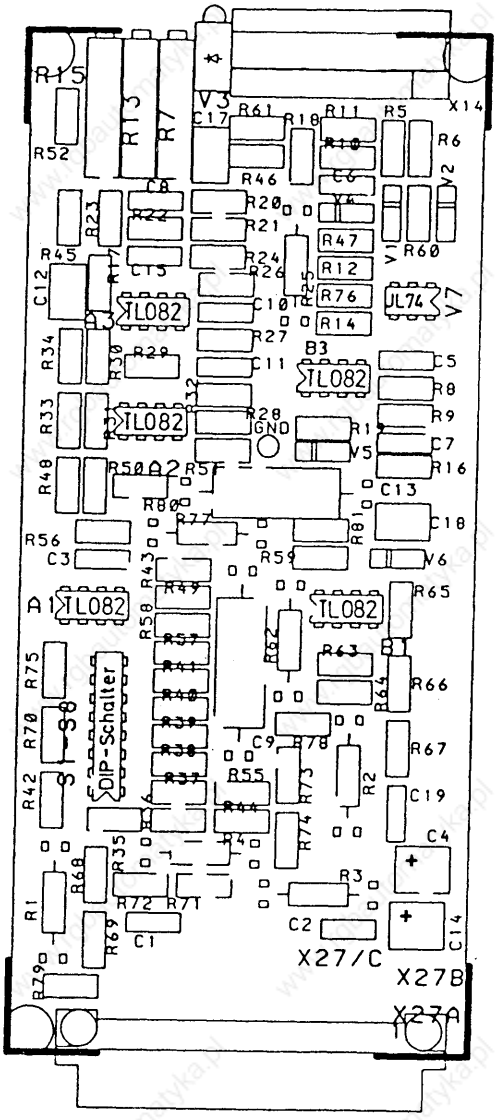
$$V = 1\ \frac{m}{min}$$

$$Kv = 1{,}2\ \frac{10^3}{min}$$

$$LAG = \frac{v}{Kv} = \frac{1}{1{,}2} = \mathbf{0{,}83\ mm}$$

The lag must be set on the CNC with the appropriate potentiometer or by parameter input.

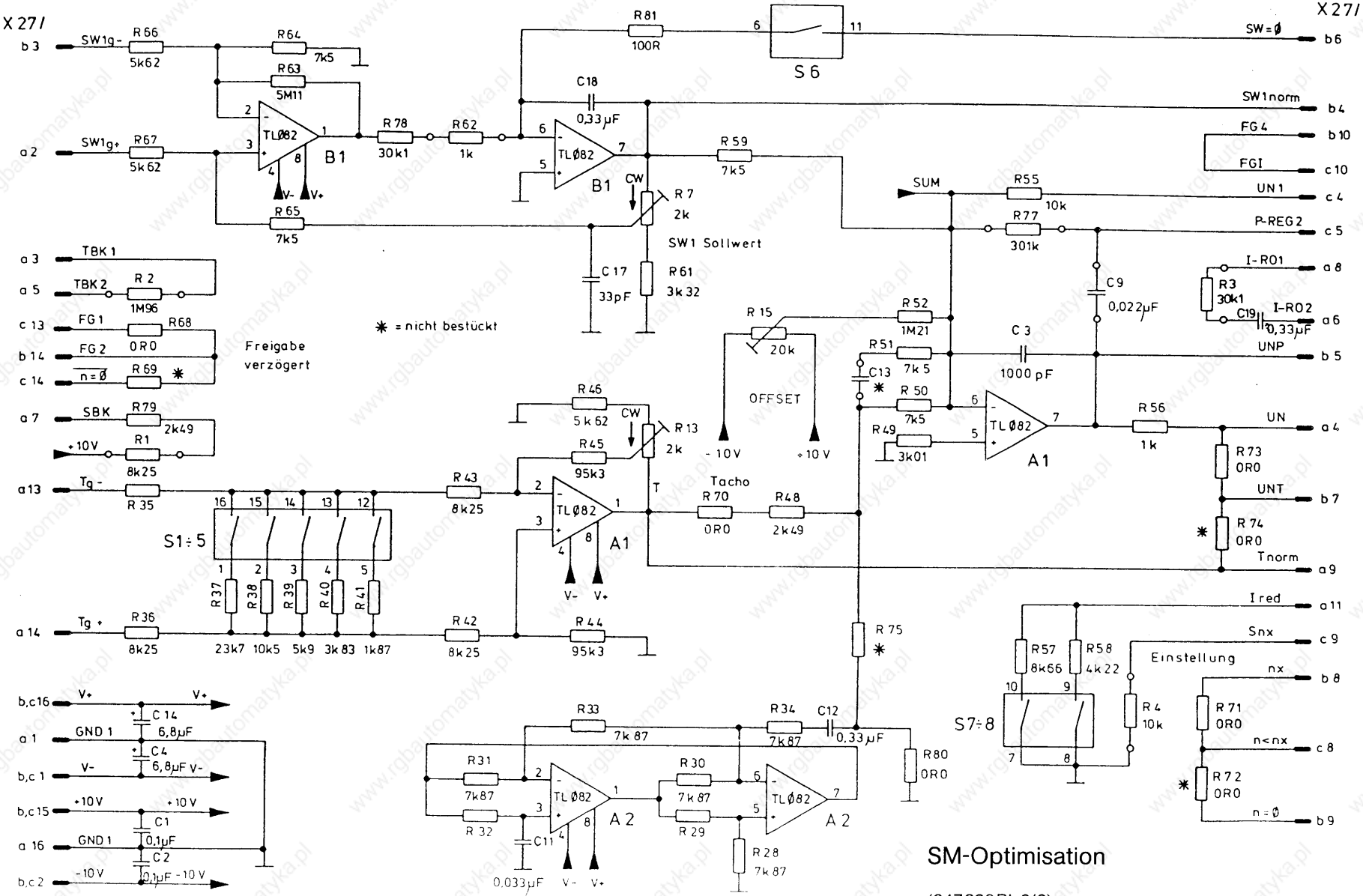
7.4 Component Layout



Optimisation card

(047830-402303)

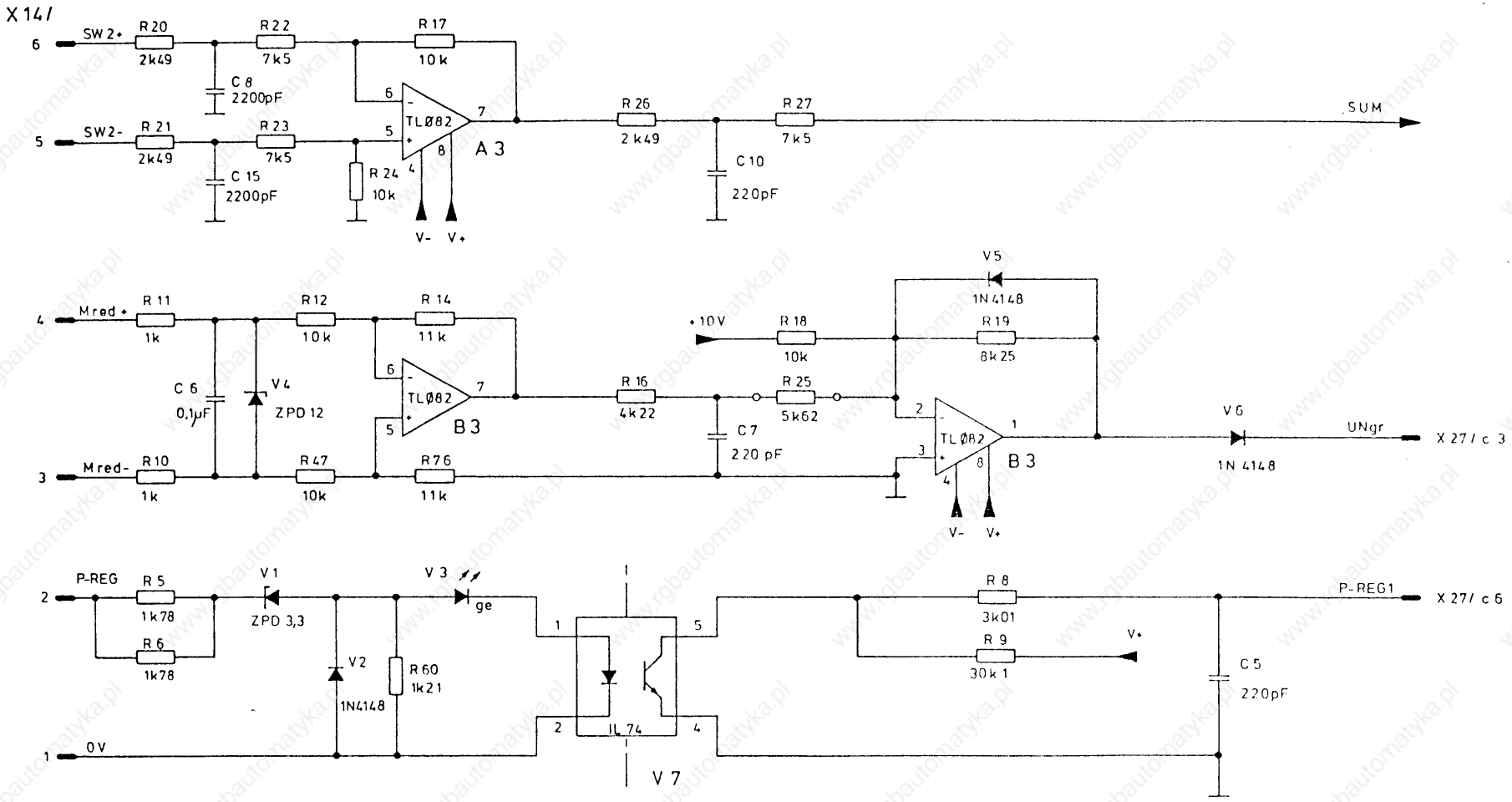
7.5 Circuit drawing



SM-Optimisation

(047830Bl. 2/3)

7.5 Circuit drawing



SM-Optimisation

(047 830 Bl. 3/3)

Kursübersicht

■ = Inhaltsschwerpunkte
□ = Sonstige Inhalte

Produkt-Gruppe	Kurz-Zeichen	Bosch-Produkt	Kursthema	Produktinfo.	Bedienen	Programmieren	Projektieren	Inbetriebnahme	Diagnose	Instandhaltg.	Det. s.S.	Tage Dauer
Numerische Steuerungen	A3-P	CNC Alpha 3	Bedienen, Progr.	□	■	■					–	5
	A2-P	CNC Alpha 2	Bedienen, Progr.	□	■	■					–	5
	A2/3-C	CNC Alpha 2/3	CPC-Progr.		□	■					–	5
	M8/5-B	CNC micro 8/5	Bedienen	□	■	■					6	5
	M8/5-W	CNC micro 8/5	Wartung					□	■	■	6	10
	CC-GL	CC 100	NC-Basiskurs	□	□	□				□	7	5
	CC 100-B	CC 100	Bedienen, Progr.	□	■	■					8	5
	CC 100-I	CC 100	Inbetriebnahme	□				■		□	8	5
	CC 100T-B	CC 100T (Drehen)	Bedienen, Progr.	□	■	■					9	5
	CC 100T-I	CC 100T (Drehen)	Inbetriebnahme	□				■		□	9	5
	CC 200-B	CC 200 (Drehen)	Bedienen, Progr.	□	■	■					10	5
	CC 200-C	CC 200 (Drehen)	Progr. in CPL		□	■					11	5
	CC 200-I	CC 200 (Drehen)	Inbetriebnahme	□				■		□	10	5
	CC 300-B	CC 300	Bedienen, Progr.	□	■	■					11	5
	CC 300-C	CC 300	Progr. in CPL		□	■					11	5
	CC 300-I1	CC 300	Inbetriebn. (Teil 1)	□	■	□		□	□	■	12	10
	CC 300-I2	CC 300	Inbetriebn. (Teil 2)				□	■		□	12	5
Roboter-Steuerungen	R1-B	rho 1	Bedienen	□	■						13	2
	R1-I	rho 1	Bed., Inbetriebn.	□	■	□		■		□	13	5
	R-OP	rho 2, rho 1	Offline-Progr.	□	□	■	□				14	5
	R2-I	rho 2	Inbetriebnahme		■		□	■	□	□	14	5
Schweiß-Steuerungen	PS 2000	Schweißsteuerung	Bedienen	□	■	□						3
		PS 2000	Bedienen, Insthlt.	□	■	□		□		■	15	5
	E81	Schweißsteuerung	Bedienen	□	■	□						2
		E 81 mit KSR	Bedienen, Insthlt.	□	■	□				■	15	5
Speicher-programmier-bare Steuerungen	PC-GL	SPS-Familie	SPS-Basiskurs	□		■	□			□	18	4
	CL 100	CL 100 mit PG3	Programmieren	□		■	□	□		■	18	5
	PC 400-P	PC 400/200 m. PG3	Projektieren	□		■	■				19	5
	PC 400-I	PC 400/600 m. PG3	Instandhaltung	□		□		■		■	19	5
	CL 300-P1	CL 300 mit PG4	Projektieren	□		■	■				20	5
	CL 300-P2	CL 300 mit PG4	Aufbaukurs	□		□	■				20	5
	CL 300-I	CL 300 mit PG4	Instandhaltung	□		□		■		■	21	10
	PC 600-P1	PC 600 mit PG4	Basiskurs (Teil 1)	■		■	□				22	5
	PC 600-P2	PC 600 mit PG4	Aufbaukurs (Teil 2)	□		□	■				22	5
	PC 600-P3	PC 600 mit PG4	Diagnose (Teil 3)	□		■	■		■		23	4
	PC 600-I	PC 600 mit PG3	Instandhaltung	□		□		■	■	■	23	10
	PG 4-W	PG4	Bedienen, Progr.	□	■	□					24	3
	PU 400	PU 400	Instandhaltung		□	□				■	24	3
Servo-antriebe	GA-GL	Servoantriebe	Basiskurs				□	□			25	3
	SD-SY	Servodyn	Systemkurs	□			□	□		□	25	3
	SD-C	Servodyn C	Inbetriebnahme	■			□	□		□	26	2
	SD-T	Servodyn T	Inbetriebnahme	■			□	■		□	26	3
	SD-V	Servodyn, ASM	Inbetriebnahme	■				□		□	–	2

Nähere Informationen:
Robert Bosch GmbH, Schulungszentrum, Postfach 1162, 6120 Erbach/Odenwald, Telefon 0 60 62 / 78-0