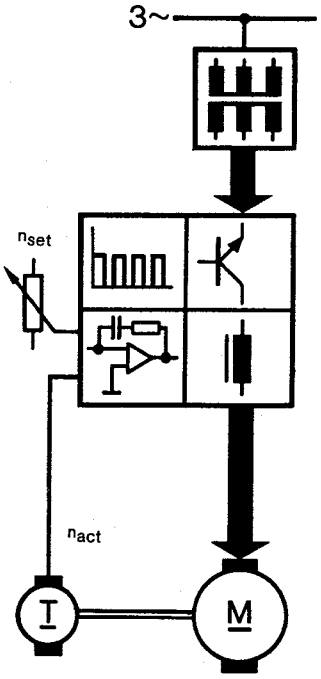
Operating Instructions

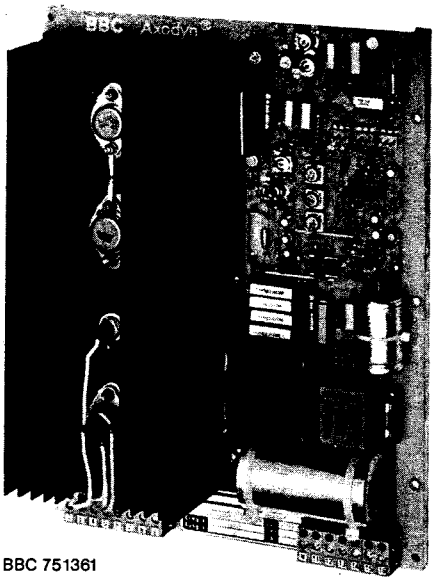
Publikation No.
D NG 71149 E

BBC BROWN BOVERI

Axodyn® Speed regulators

Types 05 LE 07/08/10/11/20/30...
Three phase, single quadrant operation





BBC 751361

Axodyn® speed regulator type 05 LE 10...

Contents

1. General

Axodyn® three phase speed regulators, series 05 LE . . ., are motor drive units suitable for motors in a power range 0.3 to 3 kW. They are for single quadrant operation only – i. e. driving in one direction only.

1.1 Special Features

- Three phase transformer input
- Integrated smoothing choke
- Power regulation using Pulse Duration Modulation (PDM)
- Digital current limitation
- Short circuit proof output
- Fast reaction to drive requirement by dynamic current
- Release input
- Torque Reduction
- Tacho control or Armature Voltage Regulation with IR Compensation
- Supplementary Speed Regulator Input

1.2 Technical Information

Concise technical data can be found in the General Information on Series 05 LE Speed Regulators, Publication No. D NG 60 933 E.

Table 1 **Summary of devices**

Axodyn® speed regulator Type	a. c. supply① voltage		max. total power dissipation at normal rating	Output data				
	regulating and control section	power section		rated② d. c. voltage	rated③ d. c. current	dynamic④ peak current	power rating	dynamic peak power
	V~	V~	W	V–	A–	A	kW	kW
05 LE 07 . . .	220/1~	1000/3~	50	105	6,0	12	0,6	1,2
05 LE 08 . . .	220/1~	1000/3~	60	105	7,5	–	0,7	–
05 LE 10 . . .	220/1~	80/3~	120	90	14,5	20	1,3	1,8
05 LE 11 . . .	220/1~	80/3~	140	90	17,5	–	1,6	–
05 LE 20 . . .	220/1~	140/3~	110	170	13,6	20	2,3	3,4
05 LE 30 . . .	220/1~	120/3~	180	140	25,0	40	3,5	5,6

① permissible tolerances +10 %; −15 %; 48 Hz...63 Hz
② control range of output voltage: 0...100 %
③ ambient temperature: 0...+45°C
operable: −10..+60°C, but power reduction at ambient temp. > +45°C by 2 %/K,
form factor at rated current ≦ 1.05
④ for a duration of up to t_{dyn} = 0.5 s at a maximum duty cycle of 5 %

Table 2 **Axodyn® speed regulating system for single quadrant operation**

Axem® motor		Axodyn® speed regulator		Three-phase mains transformer③			
Type	Rated torque Ncm	Type	Order No. GJR5...	Type	Order No. GJV1...	Size kVA	Voltages prim/sec.④ V~/V~
MA17N	120	05 LE 07 . . .	1080 00 R1	DTK 04a	803 101 R2	0,63	380/80
MA17H	160	05 LE 07 . . .	1080 00 R1	DTK 05a	803 004 R2	0,75	380/ 100
MA17H①	184①	05 LE 08 . . .	1078 00 R1	DTK 05a	803 004 R2	0,75	380/ 100
M19	320	05 LE 10 . . .	1064 00 R1	DTK 10a	803 005 R2	1,90	380/80
M19②	380②	05 LE 11 . . .	1064 00 R2	DTK 10a	803 005 R2	1,90	380/80
M23	637	05 LE 20 . . .	1081 00 R1	DTK 20a	803 009 R2	3,50	380/140
M26	960	05 LE 30 . . .	1100 00 R1	DTK 30a	803 010 R2	5,25	380/120

① applies only for restricted operating cycle; the mean time value must not exceed the rated torque of 160 Ncm.
② applies only for restricted operating cycle; the mean time value must not exceed the rated torque of 320 Ncm.
③ with potential separation to mains (voltage test 2,25 kV~).
④ available also with other primary voltages 220 V, 440 V, 500 V.

2. Installation

The speed regulators are designed for wall-mounting. Ensure that the connection terminals (1 to 16) are positioned only at the top or bottom.
The device is secured by means of four holes provided in the base plate. The minimum length of the fixing screws (M4) should be 15 mm. A clearance of at least 50 mm should be allowed above and below the device in order to provide adequate air circulation (see Fig. 1). If the permissible ambient temperature of 45°C is not exceeded, forced ventilation by an additional fan is not necessary.

2.1 Dimensional drawings and dimensions of the system components

The basic format and the fixing holes are the same for models 05 LE 07/08/10/11... Higher powered devices 05 LE 20/30... are a little longer, but the basic format and fixing holes are the same for both.
All dimensions are shown in Figs. 2 & 3 and tables 3 & 4.

Table 3 **Speed regulators 05 LE...**

Type \ Dimensions	A mm	B mm	C mm
05 LE 07 . . .	52	295	281
05 LE 08 . . .	52	295	281
05 LE 10 . . .	77	295	281
05 LE 11 . . .	77	295	281
05 LE 20 . . .	77	345	331
05 LE 30 . . .	100	345	331

Dimensions in mm

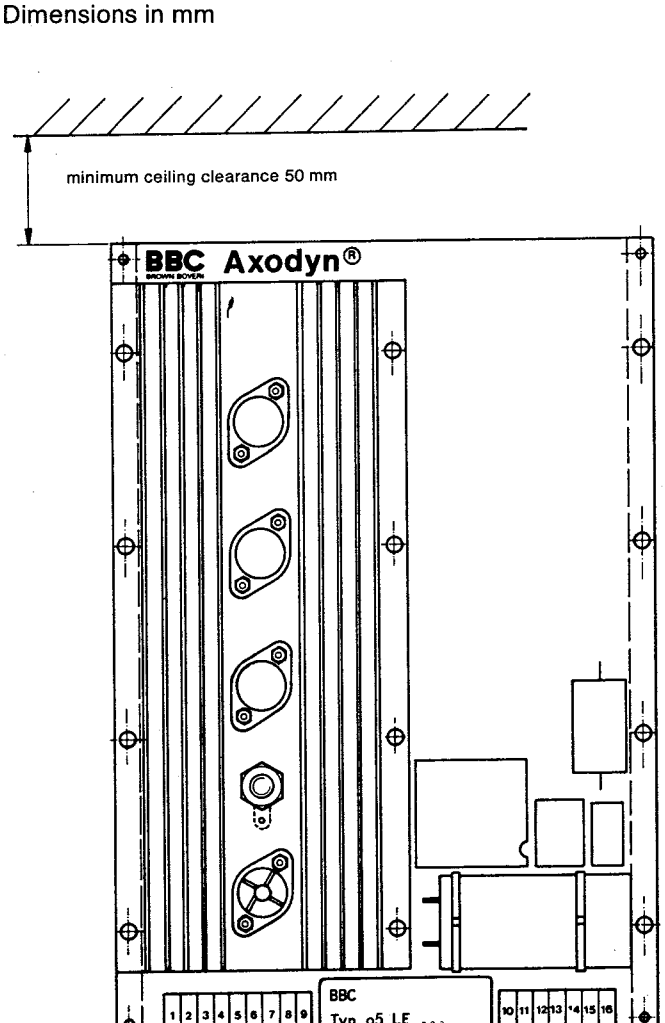


Fig. 1
Mounting clearances

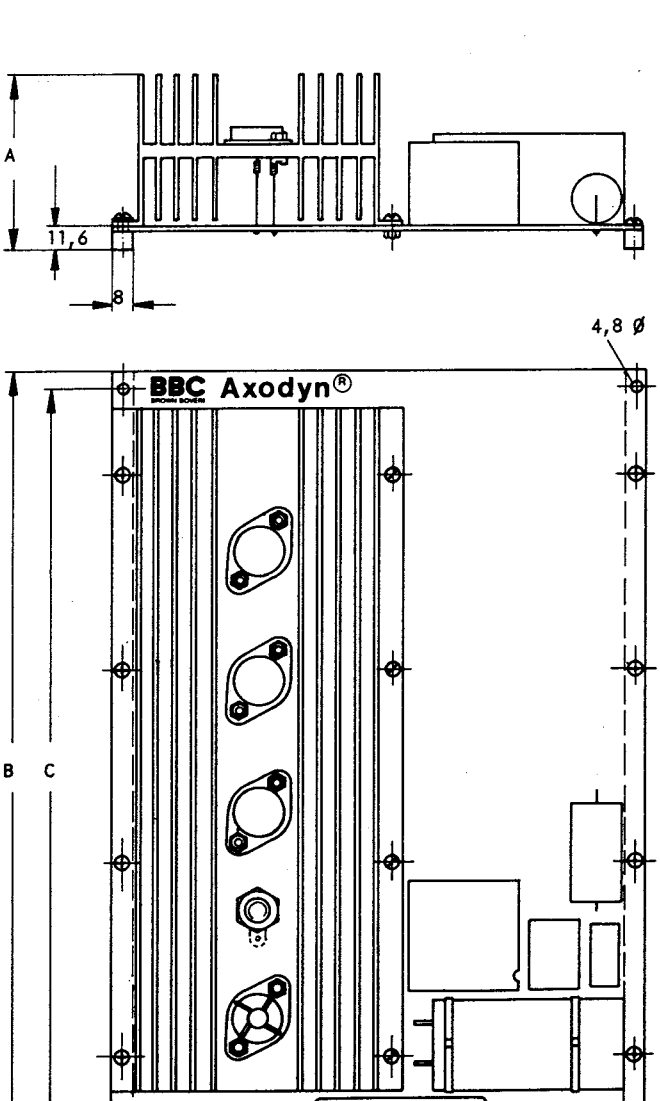


Fig. 2
Dimensional drawing 05 LE 07/08/10/11/20/30...

Table 4 **Three phase mains transformers**

Type	Order No.	Size kVA	Dimensions in mm								Total weight approx. kg
			a	b	c	d	e	f	g	h	
DTK 04a	GJV 1 803 101 R.	0,63	180	160	190	98	80	69	49	9	11
DTK 05 a	GJV 1 803 004 R.	0,75	240	211	250	104	78	77	52	10	16
DTK 10 a	GJV 1 803 005 R.	1,90	285	259	285	133	107	92	67	11	33
DTK 20 a	GJV 1 803 009 R.	3,50	285	259	285	163	137	107	82	11	48
DTK 30 a	GJV 1 803 010 R.	5,25	360	290	380	142	112	100	75	11	56

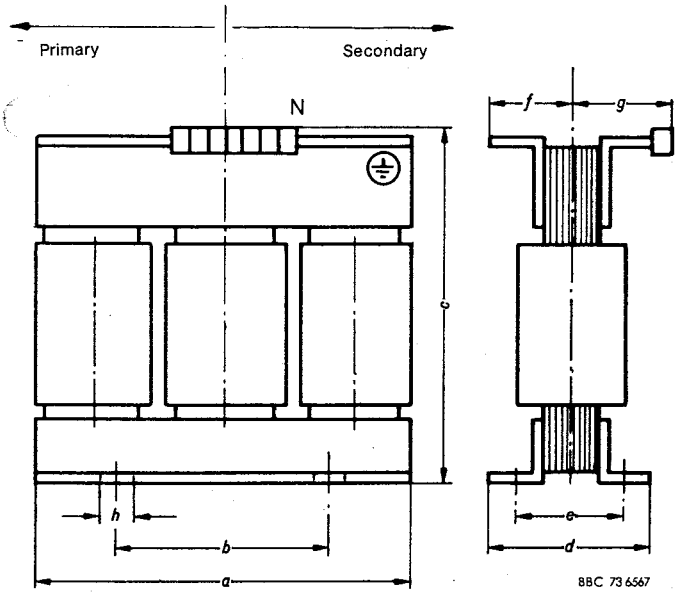


Fig. 3
Dimensional drawing of three phase mains transformers

3. Connection

All the connecting terminals are located in a row at the front of the unit. The connections are made by screw terminals.

3.1 Terminal allocations

All the devices have the same terminal allocations. The allocations can be seen in Fig. 4.

3.2 Mains Conditions

Axodyn speed regulators remain fully operable with mains voltage fluctuations of +10 % and −15 %. This applies both to the voltage supply to the regulating and control section and to the power section. The mains frequency is of secondary importance since the voltages in the power section and regulating and control section are rectified internally. In order to counteract brief peak voltages and voltage reductions such as occur in industrial supplies, interference elimination elements are integrated which are adequately effective in normal cases.

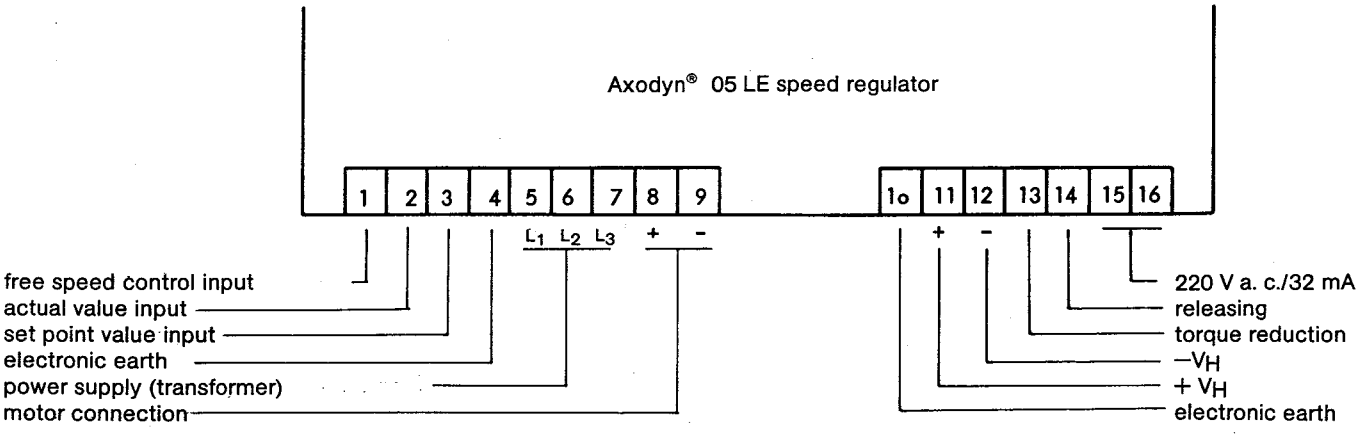


Fig. 4
Terminal connections for Axodyn® 05 LE 07/08/10/11/20/30...
single quadrant speed regulators

3.3 Mains connection

Axodyn® speed regulator should be connected to the mains supply as shown in Fig. 5.
The regulating and control section must be connected to a 220 V a. c. supply, i. e. to one phase and neutral (terminals 15 and 16).
Power matching from the mains to the Axodyn® speed regulators is via a threephase mains transformer.
The mains transformers listed in table 2 are recommended for this purpose. These transformers will provide optimum matching of the regulators to the mains supply.
Mains transformers are also available for other primary voltages. Figs. 6 & 7 show examples for connection to three-phase supplies of 220 V, 440 V and 500 V.

3.4 Connecting Wiring

The dimensions for the power wiring should correspond to the particular current requirement of the devices (see VDE 0100 and tables 1 and 2).
The connecting terminals on the Axodyn® speed regulators are designed for single wires of cross-section up to 4 sq mm and multi-cored wires of 2.5 sq mm (except 05 LE 30...: terminals 8 and 9, motor connection, 10 sq mm resp. 6 sq mm). Details for wiring the control leads can be found in table 5 and sections 4.3 and 4.6.

3.5 Connection Examples

Fig. 8 shows an example of connection for speed control by tachogenerator. Speed control other than tacho control is described in section 5.

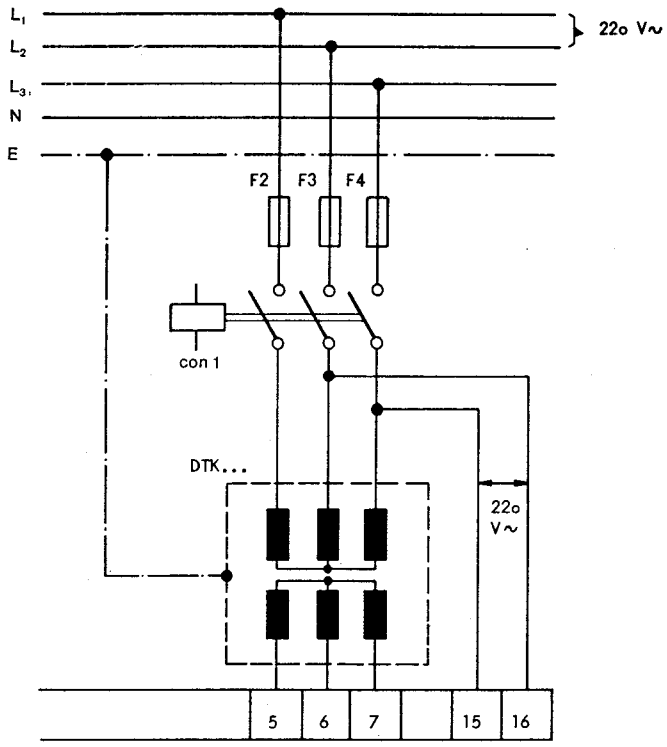


Fig. 6
Example of connection to three phase a. c. mains supply 220 V

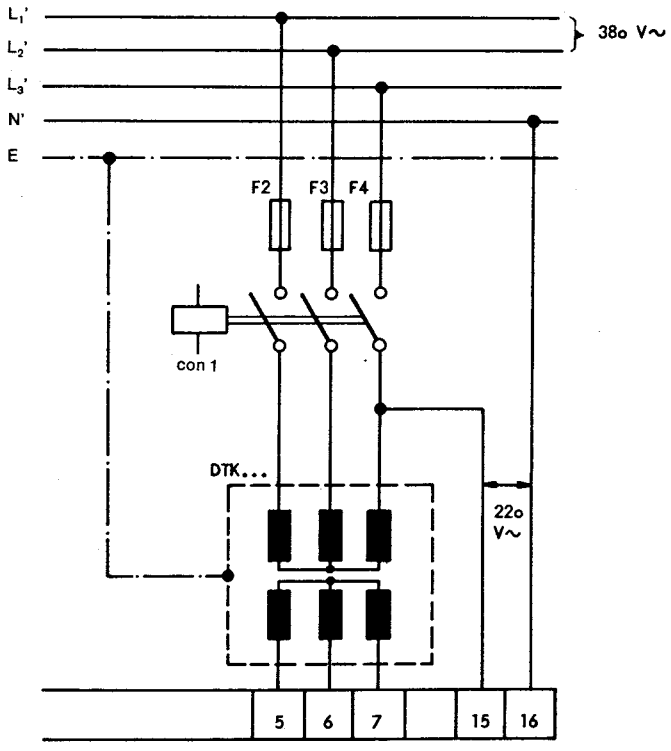


Fig. 6
Example of connection to three phase a. c. mains supply 380 V

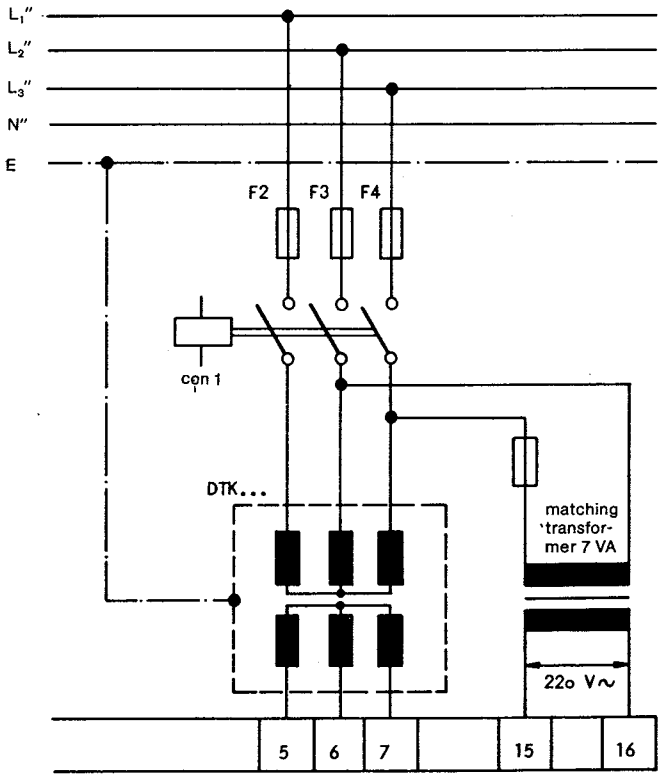


Fig. 7
Example of connection to three phase a. c. mains supply 440 or 500 V

Table 5 **Control leads**

Inputs/Outputs	Terminals	Wiring
Set-point speed potentiometer	3-10-11	Shielded cable with twisted internal conductors (screen on one side of electronic earth) Lay leads separately from the mains connections
Actual speed tachogenerator	2-4	
Free speed control input	1-4	

Releasing	12-14	Twisted wires up to 500 mm With lengths over 500 mm screened cable with twisted internal conductors Use switchgear with low contact resistance (reed relay, gold point contact)
Torque reduction	10-13	
Electronic earth	4 10	Do not earth!

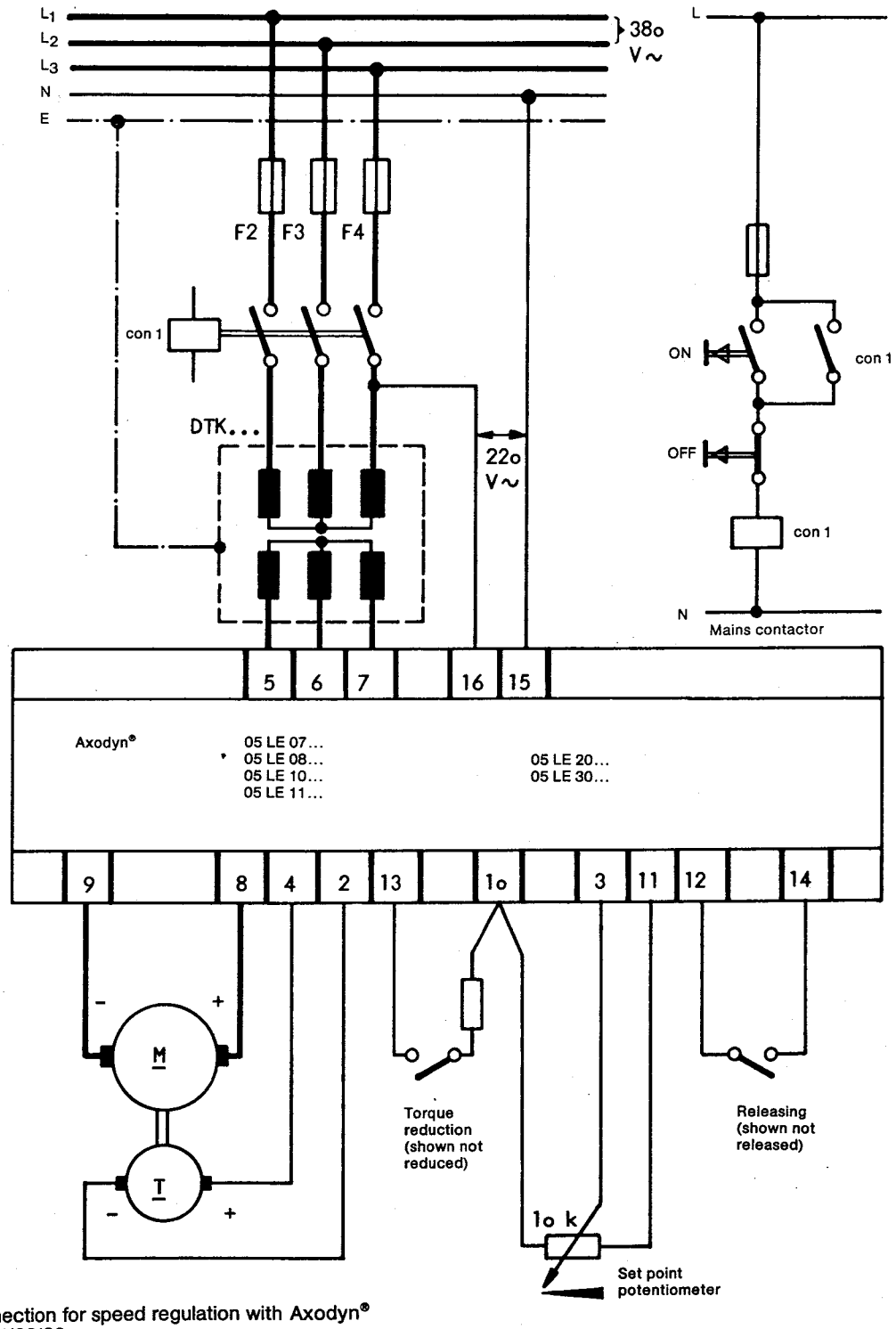


Fig. 8
Example of connection for speed regulation with Axodyn®
05 LE 07/08/10/11/20/30...

3.6 Fuse Protection

The regulating and control section is internally fused with a 5 Ø x 20 mm, 32 mA slow-blow fuse. The power section of the speed regulator is protected by digital current limitation contained in the device.
The input end of the mains transformer can be fused according to table 6.

3.7 Directives

In addition to the basic regulations concerning the installation of switchgear, distributors and control gear (VDE 0100/5.73 and VDE 0110), VDE 0160 Part 1 and Part 2 combined with VDE 0660 Part 5 also apply for combinations of switching devices with electronic components. For control equipment for machining and processing machinery, VDE 0113 must also be observed. The user must ensure that the device and its associated components are installed in accordance with these regulations; e. g. installation in a control cabinet.

4. Setting to Work

The functions of the components which are referred to in the following chapters can be seen in the simplified circuit diagram, Fig. 9, while Fig. 10 shows the position of the components on the pcb.

Table 6 **Input fusing for three-phase mains transformers**

Three-phase Mains transformer	Slow-blow Fuse (F 2, F 3, F 4) For connection to			
	220 V~	380 V~	440 V~	500 V~
DTK 03 a	4 A	2 A	2 A	2 A
DTK 05 a	4 A	2 A	2 A	2 A
DTK 10 a	6 A	4 A	4 A	4 A
DTK 11 a	10 A	6 A	6 A	6 A
DTK 20 a	16 A	10 A	10 A	10 A
DTK 30 a	20 A	16 A	16 A	16 A

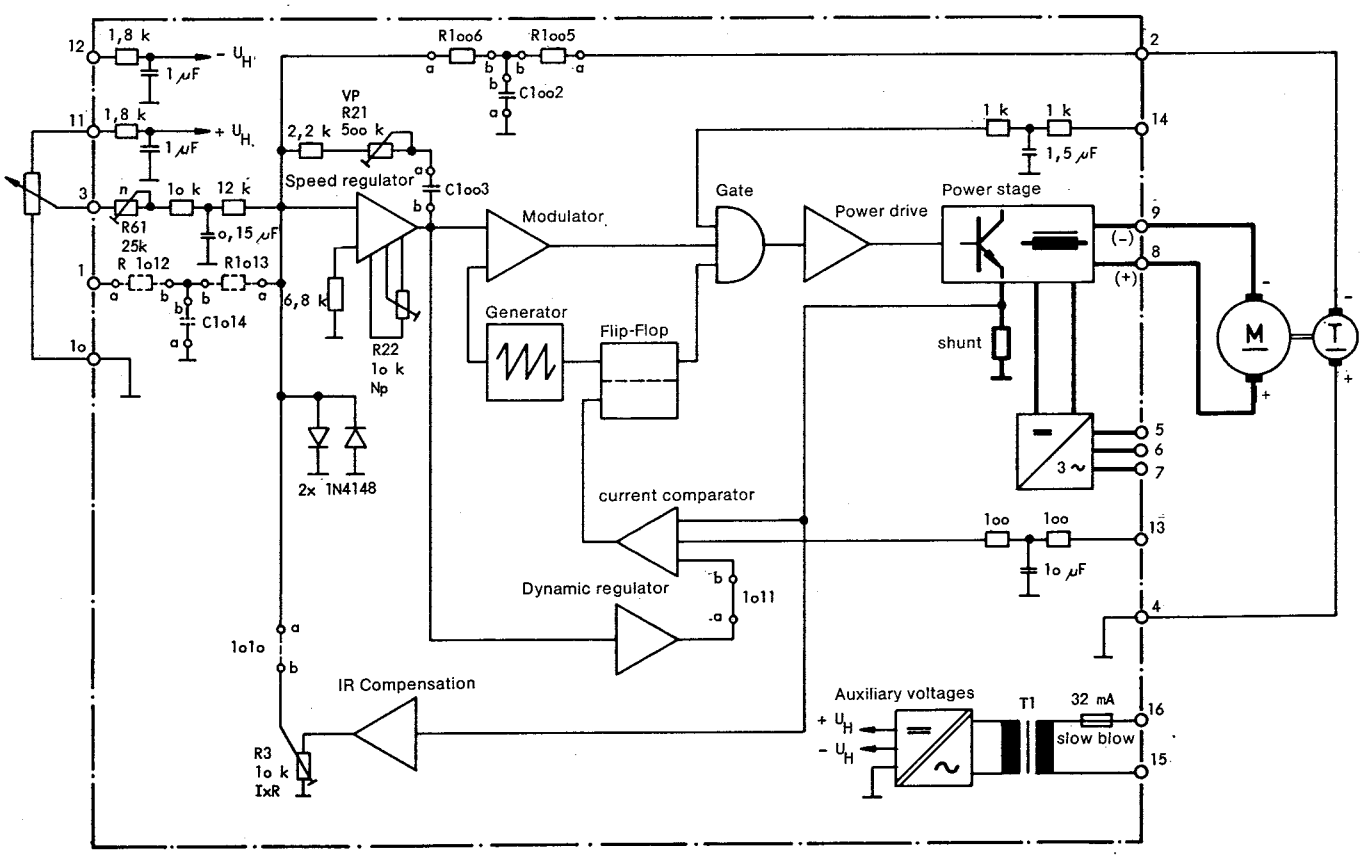
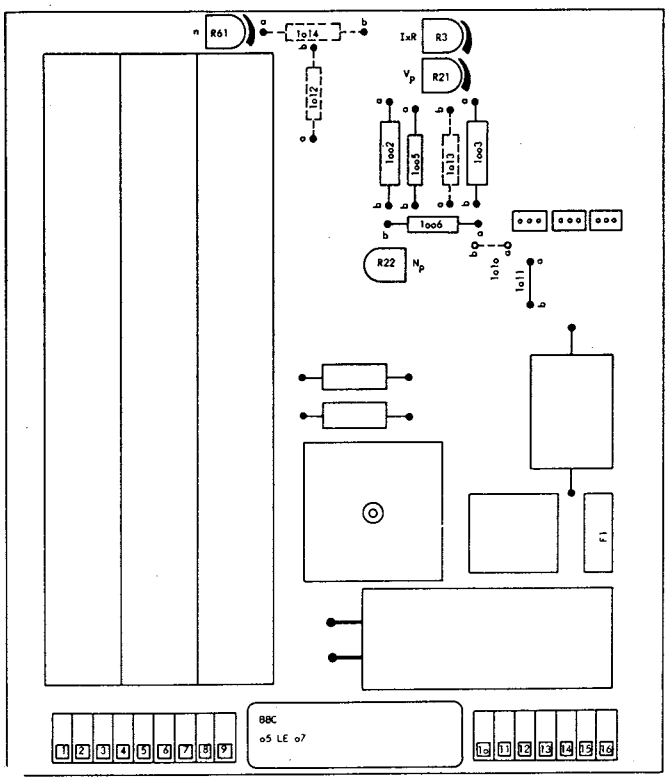
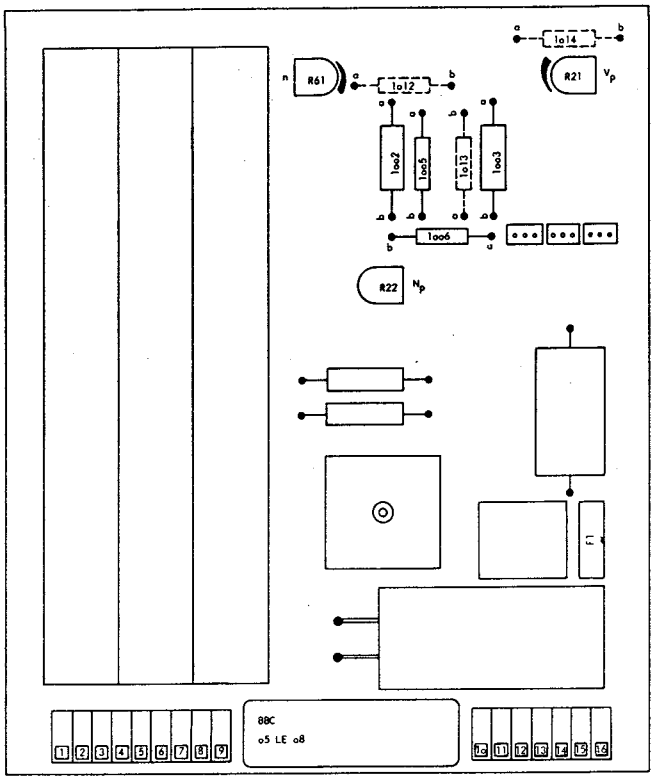


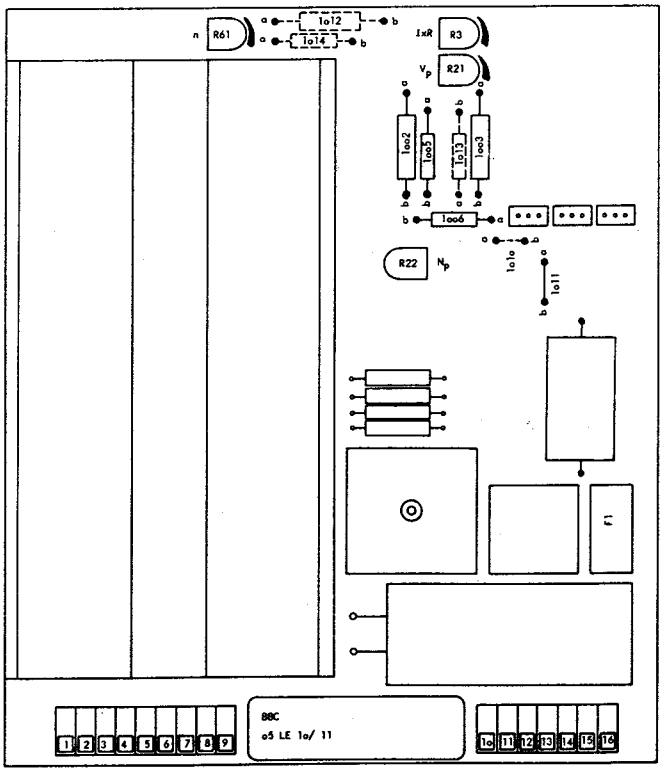
Fig. 9
Simplified circuit diagram: Axodyn® 05 LE 07/08/10/11/20/30... single quadrant speed regulators.
(05 LE 08/11...: no dynamic regulator; 05 LE 08...: no IR compensation)



a) component layout 05 LE 07...

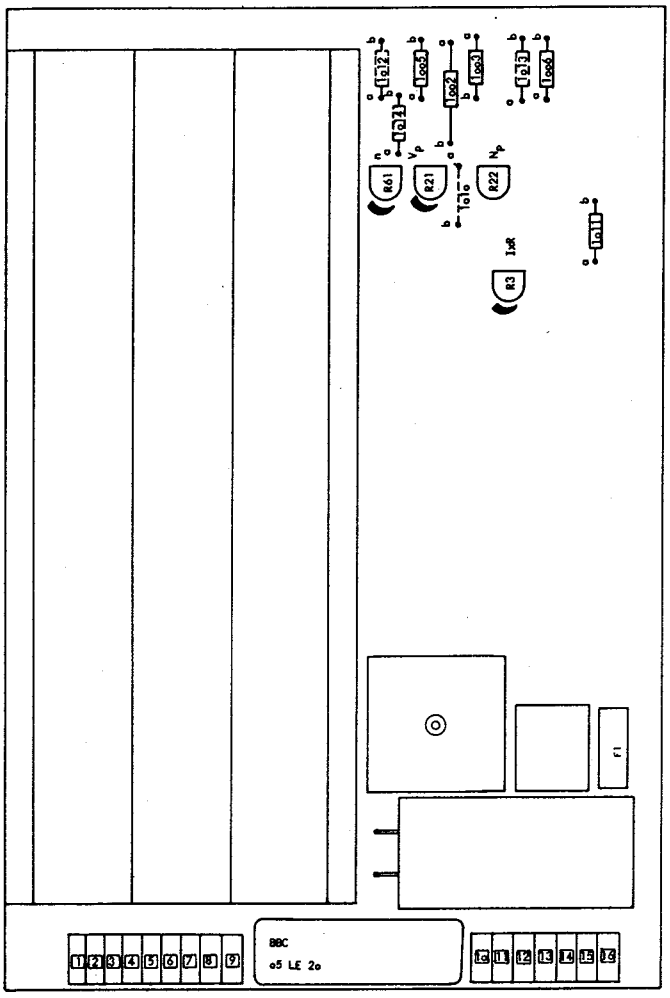


b) component layout 05 LE 08...

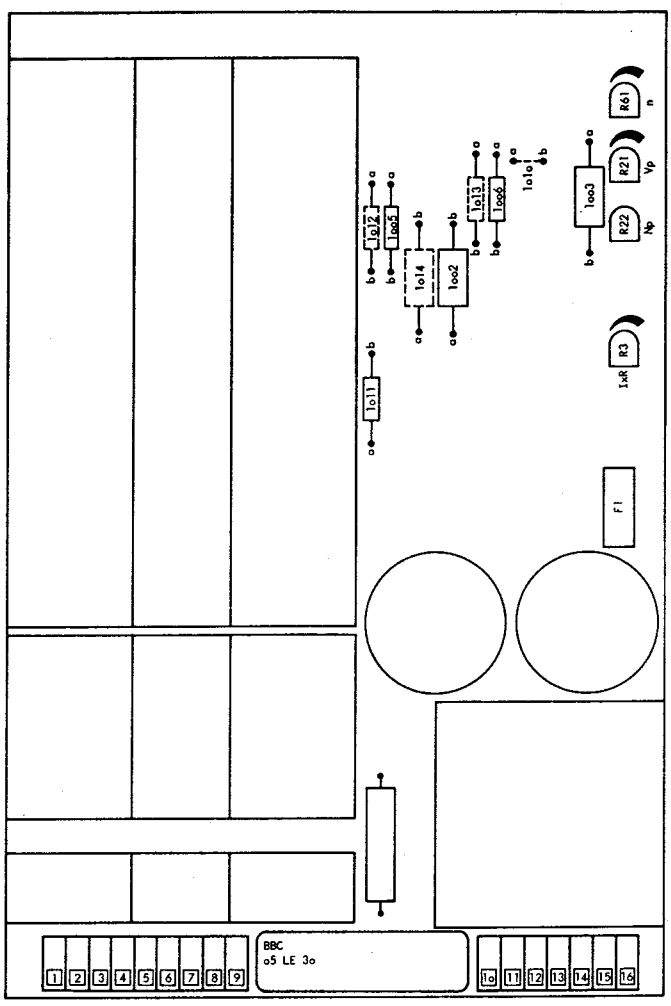


c) component layout 05 LE 10/11...

Fig. 10
Component layout information



d) component layout 05 LE 20...



e) component layout 05 LE 30...

4.1 Preparatory work

The following must be checked in a no-volt condition:

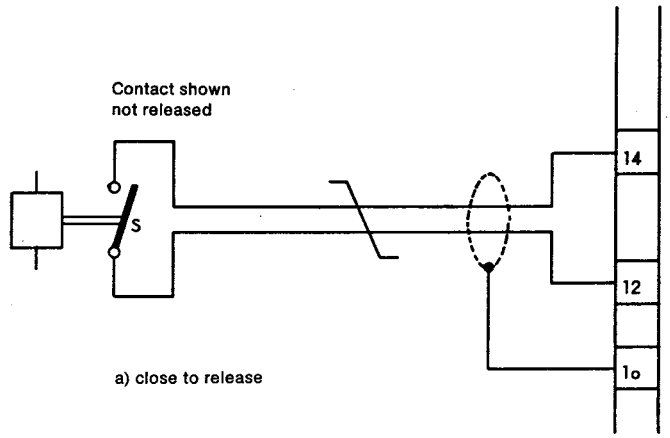
- Is the three-phase transformer output connected correctly to terminals 5, 6, 7 (see section 3.3)?
- Does the output voltage from the three-phase transformer correspond to the connected voltage of the power section of the regulator (see table 1)?
- Is the regulating and control section correctly connected to terminals 15 and 16 (see section 3.3)?
- Are the polarities of the motor and tachogenerator correct (see Fig. 8 and section 4.7)?

4.2 Switching ON and OFF

The power supplies to the regulating and section and the power section must be switched on and off together. Switching examples are illustrated in Figs. 5, 6, 7 and 8. For the mains contactor a BBC B 1021 (Order No. GH B102 1106V0) may be used.

Releasing

Releasing means that the motor remains without current and voltage and can therefore develop no torque.
The device is released by connecting terminals 14 and 12 together. This is illustrated in Fig. 11a. Fig. 11b shows a variation which has the advantage that in the event of a bad contact or wire breakage the device goes into the safe, i. e. released condition.
The conditions specified in table 5 apply for the wiring of the release input. If the lead between the switching element and the regulator is longer than 0.5 m, a screened cable with twisted core conductors should be used as shown in Fig. 11.



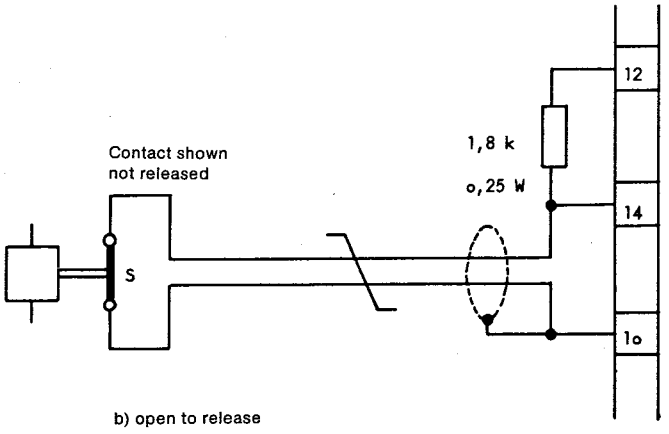


Fig. 11
Alternative connection of release input

4.4 Current limitation

current limit is set at the works to the value of the rated current of the device (see identification plate).
If it is required to lower the current an external resistor can be connected (see section 4.6).

4.5 Dynamic peak current

The dynamic peak current, which is considerably higher than the rated current, provides the disc armature motor with a greater acceleration torque and thereby shortens the starting time.
The settings for both peak current time (max. 0.5 s) and maximum duty cycle (= 5 %) of the peak current are permanently fixed.
If no dynamic peak current is required, it can be de-activated by removing wire link 1011.
Regulators 05 LE 08... and 05 LE 11... do not have dynamic peak current.

4.6 Torque Reduction

The current limit of the regulator can be reduced externally by using terminal 13. This is equivalent to reducing the maximum possible torque of the motor, since with the Axem disc-armature motor the torque of the motor is proportional to the current supplied to the motor.
The current limit can be set at will in the range 1 : 1 to approx. 0.1 : 1.
If a 100 kΩ resistor is connected between terminals 13 and 10 the range is 1 : 1, and if shorted together the range is 0.1 : 1.
It should be ensured that the correlation between the reduced current and the resistance is non-linear.
Fig. 12 shows a typical correlation between the resistance and the ratio.
The reduction in torque can be achieved both by means of a fixed resistor or a potentiometer (see Figs. 13 & 14).

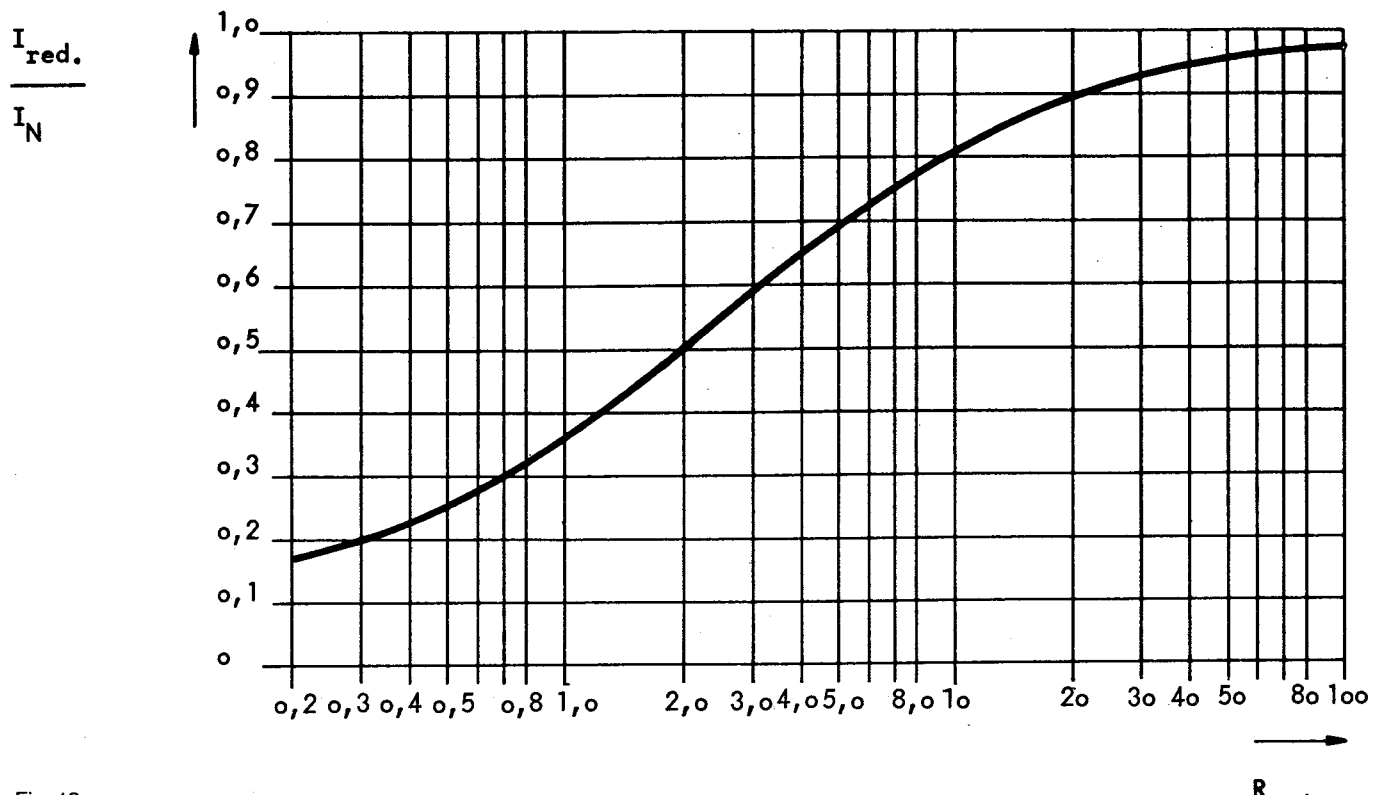


Fig. 12
Relationship between reduction ratio and resistance

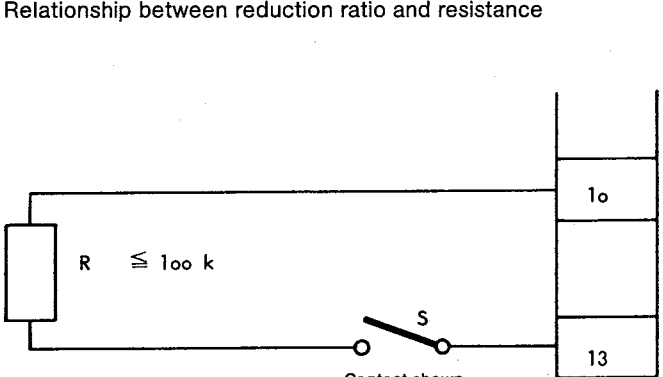


Fig. 13
Torque reduction with a fixed resistor

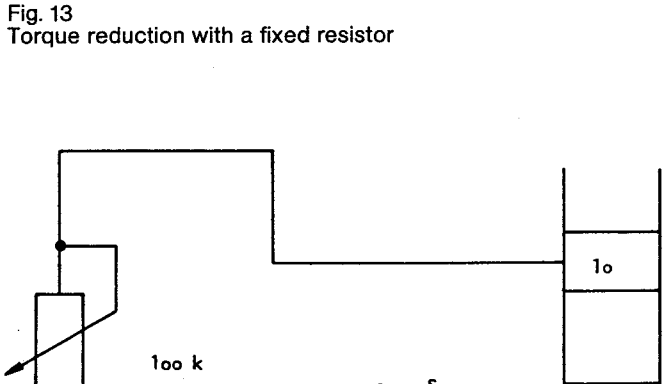


Fig. 14
Torque reduction with a variable resistance

4.7 Tachogenerator Connections

If the polarities of the motor and tachogenerator are known, they are connected according to the connection example Fig. 8.
If the polarities are not known, there are two methods of determining them. The first method is only possible if the motor has not yet been securely built in and the motor shaft is still accessible. A d. c. voltage measuring instrument is connected to the tachogenerator and the motor shaft is rotated a few revolutions by hand until the measuring instrument registers a deflection. The polarity of the tachogenerator is determined according to the polarity of the instrument. The polarity of the motor must be ascertained by the same principle.
The second method can be employed with the motor built in. The motor is connected to the regulator, capacitor C1003 short-circuited and the proportional gain turned to a minimum (see layout plan. Fig. 10, potentiometer R21). The rated voltage must now be reduced to zero and the connections from the tachogenerator disconnected from the regulator and linked to a d. c. voltage measuring instrument.
If the unit is now switched on and the set point voltage gradually increased, the motor will start to rotate in one direction. If this is the wrong direction it can be changed by reversing the connections to the motor. The rotary motion of the motor induces a voltage in the tacho-generator which causes a deflection on the measuring instrument. The polarity of the tachogenerator is determined according to the polarity of the measuring instrument. The positive connection should now be made to terminal 4 (or 10), the negative connection to terminal 2.
After this has been carried out the original regulating parameters should be reset.

4.8 Speed Matching

The regulators supplied with the components listed in table 2 (three-phase mains transformer, motor with tachogenerator F12T) are ready for operation without modification. If a tachogenerator is used which has different voltages from the F12T, the actual speed input of the regulator must be matched with this voltage.
For this purpose resistors R1005 and R1006 must be changed and the new values are calculated as follows:

- Determine the voltage of the tachogenerator (V) at maximum speed (≦ rated speed of motor).
- The total matching resistance (R) can be calculated by the following equation:
  $R \approx (V \times 2.4)\ k\Omega$
- Divide the calculated resistance between the two resistors R1005 and R1006:
  $R1005 \approx R1006 \approx \frac{1}{2} R$

The resistors which correspond most closely to the rated values should be soldered onto the insertion points 1005 and 1006 (see layout plan Fig. 10).
Table 7 shows the values of the resistors R1005 and R1006 for various tachogenerator voltages.

Table 7 **Actual speed matching**

U_{tacho} V–	R1005 kΩ	R1006 kΩ
18	**22①**	**22①**
30	33	39
60	68	82
90	100	120
120	150	150
150	180	180
180	220	220

all resistors: 0.25 W
① as fitted

4.9 Speed Regulator Optimisation

On delivery of the regulator, the regulating action is set so that with loads on the motor of 1 to 5-fold inertia moment and the system components listed in table 2, it is possible to achieve optimum performance without the need for adjustments. Only with modes of operation going beyond this might it become necessary to change the circuitry of the speed regulator and the following procedures should be adopted:
Changing the proportional gain of the speed regulator:

- Short circuit C1003.
- Turn potentiometer R21 (Vp) gradually towards maximum until the system oscillates.
- Turn potentiometer R21 (Vp) back to half the former setting.
- Remove short circuit from C1003.

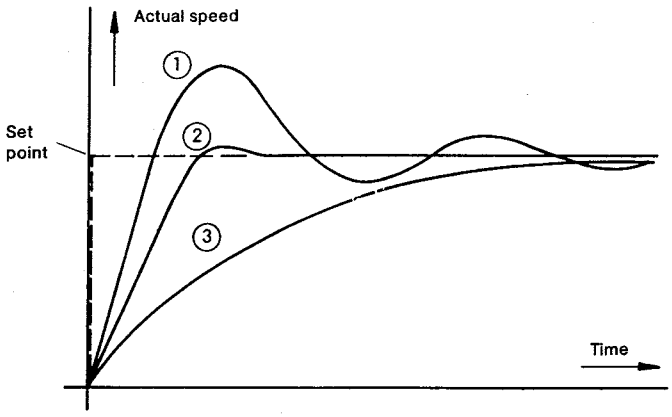
If an adequate degree of optimization is not achieved, the value of C1003 must be changed. An oscilloscope is required for evaluating the new value.

Note: make sure the oscilloscope is at zero potential (isolating transformer in the mains supply or battery operated).

The oscilloscope is connected to terminals 2 and 4 (terminal 4 is the electronic earth).

Fig. 15 shows different characteristic curves for the actual speed with a stepped set point course. In order to obtain the corresponding characteristic curves, a defined set point step must be applied at the input of the regulator (terminal 3) and the value of C1003 found by the following procedure.

- Set the proportional gain as described above.
- Connect a capacitor decade in place of C1003 and begin with a high capacitance e. g. 10 µF.
- Reduce the capacitance until at a set point step the run of the actual speed curve on the oscilloscope corresponds to curve 2 in Fig. 15. Overshooting from 10 to 15 % is permitted.
- Solder the new value capacitor in the C1003 position.



① R21 (Vp) too great or C1003 too small
② R21 (Vp) and C1003 at optimum
③ R21 (Vp) too small or C1003 too great

Fig. 15
Actual speed curves

4.10 Speed limitation

When supplying the set point potentiometer with the positive auxiliary voltage, it is possible to set higher set point voltages than required for the maximum speed. In devices 05 LE . . . c-E, a potentiometer (R61) is fitted in order that the upper speed limit can be set. This is carried out as follows:

- Turn the potentiometer R61 to minimum.
- Turn the set point potentiometer to maximum.
- Turn potentiometer R61 towards maximum until the rated speed of 3000 rpm or any desired lower speed is reached.

With devices 05 LE . . . a-E and 05 LE . . . b-E, an external potentiometer must be used for speed limitation according to the suggested circuit in Fig. 16. The setting is as described above.

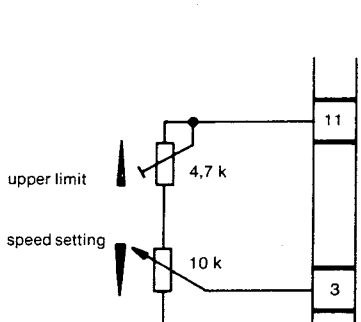


Fig. 16
Speed limiting

4.11 Supplementary Speed Regulator

An additional input to the speed regulator (terminal 1) with input filter R1012, R1013 and C1014 is available for special uses. (This input is not available on regulators 05 LE . . . a-E). This input can be used for example, for introducing a simple facility for switching to a permanently set speed (rapid or creeping), which is independent of the setting of the set point potentiometer. Fig. 17 illustrates such a speed-change arrangement.

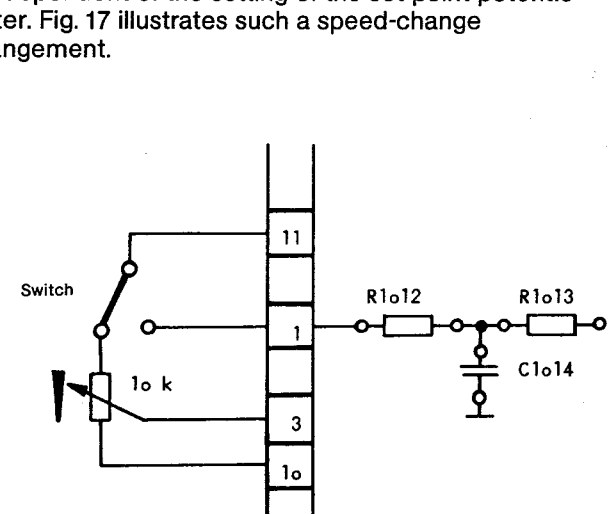


Fig. 17
Example of speed switching

5. Other Modes of Operation

5.1 Armature Voltage control with IR compensation

If no high demands are made on the regulating range and regulating accuracy of the drive motor, a tacho-generator is not necessary and the voltage to the motor (armature voltage) can be used as the value for the actual speed.

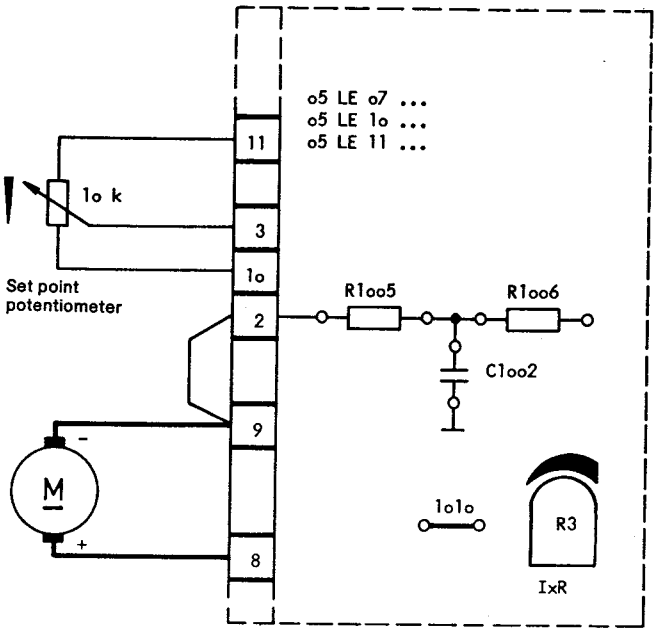
The armature voltage is composed of inner EMF plus a voltage drop across the resistance of the armature winding resulting from the armature current. The armature voltage is used as the value for the actual speed for armature voltage regulation, but only the internal EMF of the motor is proportional to the speed. This results in a false value IR, dependent on the armature current, which is added to the speed regulation, and this can be balanced.

With regulators 05 LE 07/08/10/11 . . ., the output voltage of the regulator (terminal 9) is fed back to the actual speed input (terminal 2), i. e. terminals 9 and 2 are connected (see Fig. 18a). In addition, resistors R1005 and R1006 must be changed in order to match the actual speed input of the speed regulator to the higher voltage. Table 8 lists the resistance values for matching with various motors. For IR compensation it is also necessary to solder in link 1010 (not possible with 05 LE 08 . . .).

With regulators 05 LE 20/30 . . . the inclusion of the link 1010 causes armature voltage to be connected to the speed regulator input (see Fig. 18b). The units are then matched to the corresponding motors (05 LE 20 . . . to M 23; 05 LE 30... to M 26).

The adjustment of the IR compensation uses potentiometer R3 in the following manner:

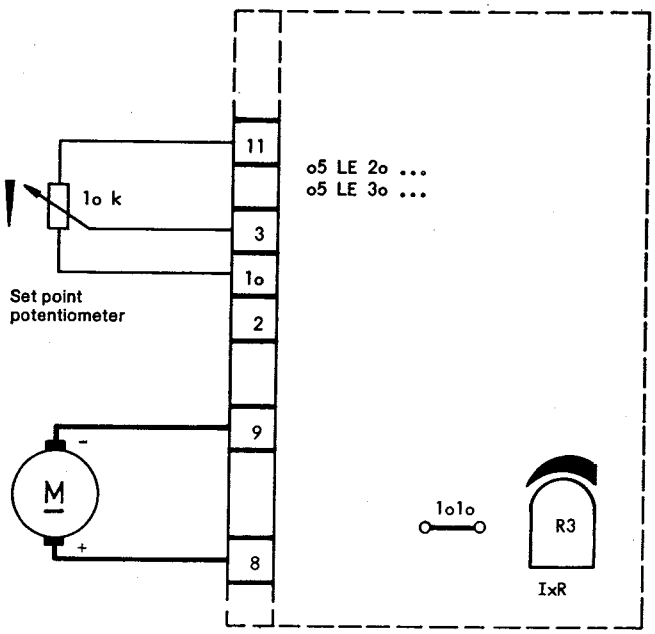
- Set R3 to minimum.
- Set rated speed when the motor is idling.
- When at rated speed, bring the motor under maximum load torque and return it to rated speed by increasing R3. The maximum load torque should be less than the rated torque of the motor.



Actual value adjustment
R1005, R1006 and C1002 must be modified

Connect link 1010

for types 05 LE 07/10/11 . . .
(05 LE 08... has no facility for IR compensation)



Connect link 1010

b) for types 05 LE 20/30...

Fig. 18
Armature voltage control with IR compensation

Table 8 **Armature voltage regulation for 05 LE 07/08/10/11...**

Disc armature Motor, type	R1005 kΩ	R1006 kΩ
MA17N	82	82
MA17H	120	120
M19P	100	120

all resistors: 0.25 W

C 1002 to be reduced to 0.015 µF.

6. Fault Analysis

The following paragraphs are intended as a guide to assist the users to analyse simple faults.

6.1 Control Measurements

When making control measurements the three-phase transformer must be disconnected from the mains. The voltage supply to the regulating and control section (terminals 15 and 16) must be connected to the 220 V a. c. supply. The voltages listed in Table 9 should be checked with a high impedance instrument.
All measurements are related to the electronics earth (terminals 4 and 10) of the regulator.

6.2 Causes of Faults

Table 10 shows a list of some faults and their possible causes.

7. As Fitted Components

See Table 11.

Table 9

Measurement point	Applicable for devices 05 LE... 07/08/10/11... Voltages to be measured	20/30 Voltages to be measured	Functions
Terminal 11	+14.0... +16.0 V	+11.0... +13.0 V	positive auxiliary voltage
Terminal 12	−14.0... −16.0 V	−11.0... −13.0 V	negative auxiliary voltage
Terminal 3	0... 12 V	0... +10 V	speed set point (dependent on slider position of the set point potentiometer)

Point of reference: Terminal 4 and 10

Table 10 **Causes of faults**

Fault	Possible cause
Motor does not turn; no output voltage	No mains voltage No set point Release facility has been activated (see section 4.3)
Motor under load does not start with rated current Note: turn off the device; overloading of motor	Load torque too great Motor shaft blocked
Rated speed cannot be reached	Incorrect actual speed matching (see section 4.8) Load torque too great (current limit reached) Current limitation not matched to the motor (see section 4.4) Torque reduced (see section 4.6)
Motor turns above rated speed; no speed regulation possible	No actual speed value Incorrectly matched actual speed (see section 4.8) Incorrect actual speed polarity (see section 4.7) Set point potentiometer or supply leads defective
Speed fluctuates after change in load	Speed regulator not optimized (see section 4.9)
Motor reaches speed, but drops again after approx. 0,5 secs.	Rated torque exceeded (the required torque is reached short-term as a result of the dynamic peak current)
No dynamic peak current	The drive motor is at the current limit Interval too short Wire link 1011 missing (see section 4.5)
No d. c. voltage at terminals 11 and 12	Fuse on the pcb defective No a. c. voltage (220 V~) to terminals 15 and 16
Fuse on the pcb defective	A. C. voltage too high at terminals 15 and 16

Table 11
Components soldered at the insertion points

Component Insertion point	Value	Function
R1005 kΩ	22	Actual speed matching
R1006 kΩ	22	
R1012 kΩ	not occupied	Matching of additional speed regulator input
R1013 kΩ	not occupied	
C1002 µF	0.047	Smoothing actual speed
C1003 µF	0.1	Integral part speed regulator
C1014 µF	not occupied	Smoothing additional speed regulator input
1010	not occupied	I x R compensation
1011	wire link	dyn. peak current

all resistors: 0.25 W
all capacitors: 160 V