SIEMENS

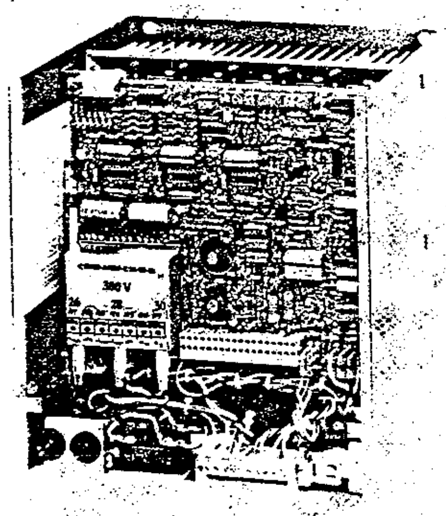
SIMOREG Compact Convertors
6RA21

Suitable for Cubicle Mounting
11 kW to 225 kW;
Three-Phase Bridge-Connected
Fully Controlled

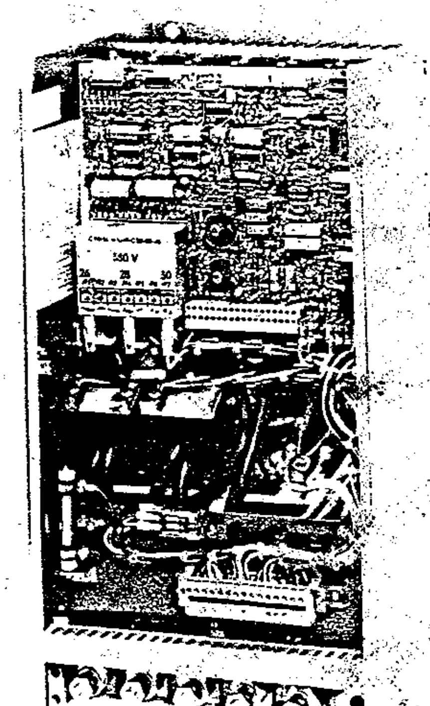
Operating Instructions

Order No. C98130-A1009-A1-03-7619

Type reference	Order No.
D460/ 24 Mre-GcE 6S20	6RA2116-6DS20
D460/ 35 Mre-GcE 6S20	6RA2120-6DS20
D460/ 57 Mre-GcE 6S20	6RA2124-6DS20
D460/ 85 Mre-GcE 6S20	6RA2127-6DS20
D460/130 Mre-GcE 6S20	6RA2132-6DS20
D460/170 Mre-GcEF6S20	6RA2174-6DS20
D460/240 Mre-GcEF6S20	6RA2176-6DS20
D460/300 Mre-GcEF6S20	6RA2178-6DS20
D460/375 Mre-GcEF6S20	6RA2181-6DS20
D600/ 35 Mre-GcE 6S20	6RA2120-6GS20
D600/ 57 Mre-GcE 6S20	6RA2124-6GS20
D600/ 85 Mre-GcE 6S20	6RA2127-6GS20
D600/130 Mre-GcE 6S20	6RA2132-6GS20
D600/170 Mre-GcEF6S20	6RA2174-6GS20
D600/240 Mre-GcEF6S20	6RA2176-6GS20
D600/300 Mre-GcEF6S20	6RA2178-6GS20
D600/375 Mre-GcEF6S20	6RA2181-6GS20



Naturally-cooled unit without fan



Forced-cooled unit with cooling fan

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1. DESCRIPTION

SIMOREG compact convertors are used as sources of regulated and rectified d.c. thyristors being used as rectifying elements. Power and control sections are combined into one compact assembly.

1.1 APPLICATION

The equipment is used as controlled power source for dc loads.

1.1.1 DC Loads

Main use:

Armature supply to separately excited dc motors for single-quadrant drives.

Other uses:

Armature supply to separately excited dc motors to provide motoring torque in one direction and braking torque in the opposite direction.

Controlled field supply to dc and synchronous machines.

Further uses when fitted with supplementary function boards:

Armature supply as for main use but with regenerative braking to stand-still by external field reversal.

Armature supply to separately excited dc motors with EMF control.

Regulated supply with controlled field weakening dependant on armature voltage (dc motor control with field weakening).

1.1.2 Mode of Operation

The convertor thyristors are connected into a fully controlled three-phase bridge circuit (B6C) which can supply a direct voltage of either polarity but can conduct current only in one direction. When used for the armature supply of a dc motor, this can operate in the following mode:

Unidirectional torque, bidirectional rotation.

Reversal of rotation is achieved by reversing armature or field connections either at the terminals or by switching.

1.1.3 Mains supply

The convertors must be connected to a three-phase supply system. A commutation choke or a transformer and special semi-conductor fuses for the protection of the thyristors (see 1.4.1. and 1.4.2) must be connected between the supply and the input terminals of the convertor.

PAGE

All technical data apply provided the supply is derived from a three-phase system complying with the usual statutory requirements. Convertors are available suitable for connection to 380 V or 500 V three-phase systems. As supplied ex works they are suitable for 50 Hz systems. If required, they can be reconnected by the user for 60 Hz supplies (see 2.3.3). Supply frequency variations of up to ±2% are acceptable. With voltage reductions of up to −5% the convertor is still able to supply its rated output voltage due to the reserve built into the firing angle control range. Short-time mains voltage reductions to approximately 70% of rated supply voltage do not affect the operation of the equipment. Greater voltage reductions, however, even if they occur only in one phase, lead to automatic controller blocking and an alarm (see safety circuit, page 5). Only the power section may be connected to supply voltages which are lower than the rated voltage. The maximum output voltage available under these conditions will be reduced in proportion with the reduced input voltage.

1.1.4 Environment

Ambient or cooling air temperatures.

The permissible limits for the ambient or cooling air are:

for operation	0°C to +65°C
for storage and transport	−30°C to +85°C

The rated dc currents quoted in the selection tables refer to an ambient temperature of +45°C for self-cooled SIMOREG Compact convertors and to a cooling air inlet temperature of +35°C for forced-cooled convertors.

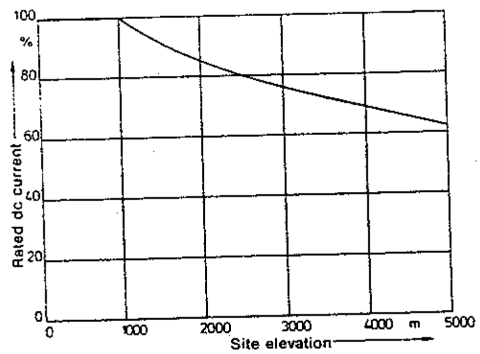
When SIMOREG compact convertors are housed inside cubicles or boxes which also contain the usual associated control components, a temperature rise of 10 K of the internal air over the external ambient temperature must be taken into account.

With different ambient or cooling air temperatures the rated dc current is changed as follows:

Ambient or cooling air temperature	Associated increase or decrease of the rated dc current	
	Self-cooled	Forced-cooled
°C	%	%
+30	+13	+ 4
+35	+ 8	0
+40	+ 4	− 6
+45	0	−12
+50	− 6	−17
+55	−11	
+60	−18	
+65	−25	

Site elevation

The rate dc currents quoted in the selection table refer to site elevations up to 1000 m above sea level. At higher altitudes the rated currents are reduced as per the graph below:



Degree of protection:
IP 00 in accordance with IEC 144

Tropicalization
SIMOREG compact convertors have been designed for operation under normal climatic conditions. They comply with the requirements for humidity class F according to DIN 40040.

1.1.5 Power section

The thyristors are connected into a fully controlled three-phase bridge circuit (B6C). With six-pulse operation the harmonic content of the output voltage is low and generally no smoothing chokes will be required. Each thyristor is protected against internal overvoltages by its own hole storage protection circuit. This circuit is laid out for a 4% commutation reactance. In conjunction with the latter it is also able to provide protection against low-energy mains-borne transients. If the supply system is likely to contain high-energy transients generated for example, by transformer switching, surge arrestors will have to be included in the input circuit to the convertor. The operational heat loss is conducted to a potential-free aluminiun heat sink, fully insulated from the power circuit. Convertors up to 130 A rated dc current are self-cooled, those with higher current ratings are forced-cooled by an integral cooling fan.

1.1.6 Field Supply Rectifier

All convertors are equipped with a single-phase bridge-connected (B2) diode rectifier.

Its rating is adequate to provide the field supply of a dc motor with a rated armature current commensurate with the rating of the convertor.
(See technical data for maximum dc ratings, para. 1.3.2).

In all convertors with rated currents up to and including 240 A this circuit is protected by two integral fuses. Field current monitoring by external equipment is recommended to prevent the motor armature from being energized without the motor being excited.

1.1.7 Control Section

The control section has been designed bearing in mind the main use of the convertor. If used for other duties, modifications may be necessary (see also Optimising; Section 3.4).
External circuits are connected to the converter in accordance with the terminal list (para. 2.3.2).
Solder links are provided to allow the user to modify the circuit within prearranged limits, if required (see para. 2.3.3).

Power supply

The integral power supply for the control and logic circuits of the convertor can also supply power to external circuits; the available currents and voltages are quoted in the terminal list (para. 2.3.2). The stated maximum currents must not be exceeded. The integral power supply will also supply supplementary circuit board 6RA8211, when fitted. In this case the current consumption of this circuit board must be deducted from the current reserve available for external circuits.

The power supply equipment provides the following supplies, all of which are completely isolated from the mains supply:

- synchronizing voltage for the firing pulse generator circuit;
- unsmoothed dc for supply to the voltage monitoring circuit;
- smoothed dc ±24V for firing pulses and relays;
- two series regulators are connected to this system to provide a regulated supply of ±15V for the control system;
- zener diodes are used to further stabilise this supply at ±10V; this voltage can be used as reference voltage or for similar duties; it is used to supply the speed setting potentiometer.

Firing Pulse Generator

This generates the firing pulse for the thyristors. The pulses can be blocked by external application of M potential to terminal 17. The firing pulses are also automatically inhibited should certain undesirable operating conditions arise (see Safety Circuit; page 5).
Pulse blocking is always accompanied by controller blocking.

Current Controller

The current controller has PI characteristics; its response shaping feedback circuit is tuned to the armature circuit parameters of conventional dc motors. If used for other applications some readjustments may be necessary (see Optimising, Section 3.4). The current feed-back signal is derived from two V-connected current transformers in the three-phase supply circuit to the convertor. Their outputs are rectified (circuit arrangement B6) and fed to burden resistance R51. At rated current the voltage drop across this resistance is −10V.

The current reference is obtained from the speed controller in the major loop. It is also possible to use an external current reference; in this case the link ch-ci has to be removed. The current reference can then be fed in via pin 8 of plug X103 or through terminal 16 and link ea-eb which has to be fitted. The current controller output is limited by amplifiers V72.1 and V72.2 in accordance with the setting of potentiometers R6 and R7, respectively.

The maximum value of control angle $\alpha_{inv.}$ is set at the works to 150° el. and cannot be increased further; however, it can be reduced during commissioning if the drive requires this.

The current controller can be enabled by an external +24 V signal applied to terminal 15; it is normally enabled automatically by the internal monitoring circuit. In both cases the enabling signal is applied through FET V2.

Speed Controller

This controller is part of the major control loop; it also has PI characteristics, the components of the feed-back circuit having been selected to suit its main function.

It can also operate as armature voltage controller or function as a sign-reversing amplifier (feed-back capacitor short-circuited).

The speed controller has three external inputs, one for the reference signal (e.g. for base speed), one for the feed-back signal, and one for a supplementary reference signal (e.g. for dancer roller control). The input resistances of the supplementary reference input are attached to solder pins to allow them to be altered to suit the particular drive conditions. An internal input has also been provided for a supplementary correcting reference signal should this be required. The controller output is limited; this limit is adjustable in the positive direction (current limit); in the negative direction it is set to M potential at the works. By changing a link it is also possible to provide a minimum current limit (e.g. for field current control). The limiting circuits are active circuits. It is also possible to limit the maximum positive voltage to lower values by an externally applied positive voltage (0 to +10 V).

Speed and current controllers are both blocked by FET V1. For details concerning reference and feed-back signals see paras. 1.4.4 and 1.4.5.

Safety and Alarm Circuits

With visual indication (light-emitting diode).
The phase sequence monitoring circuit blocks the control system and the firing pulse generating circuits if the phase rotation of the supply system is anticlockwise; it also transmits an alarm signal. Phase failure and undervoltage are alarmed instantaneously. With undervoltage, only the controllers are blocked; with phase failure (blown fuse) controllers and firing pulses are inhibited. Should undervoltage or phase failure last longer than 150 to 200 msec, Relay K1 in the converter drops off. Its contacts should be connected into the external control relay coil maintaining circuit in such a manner that the drive is shut down.

The safety circuit makes it possible for a single switch to be used for energising the power circuits, the control system, and the relay circuits.

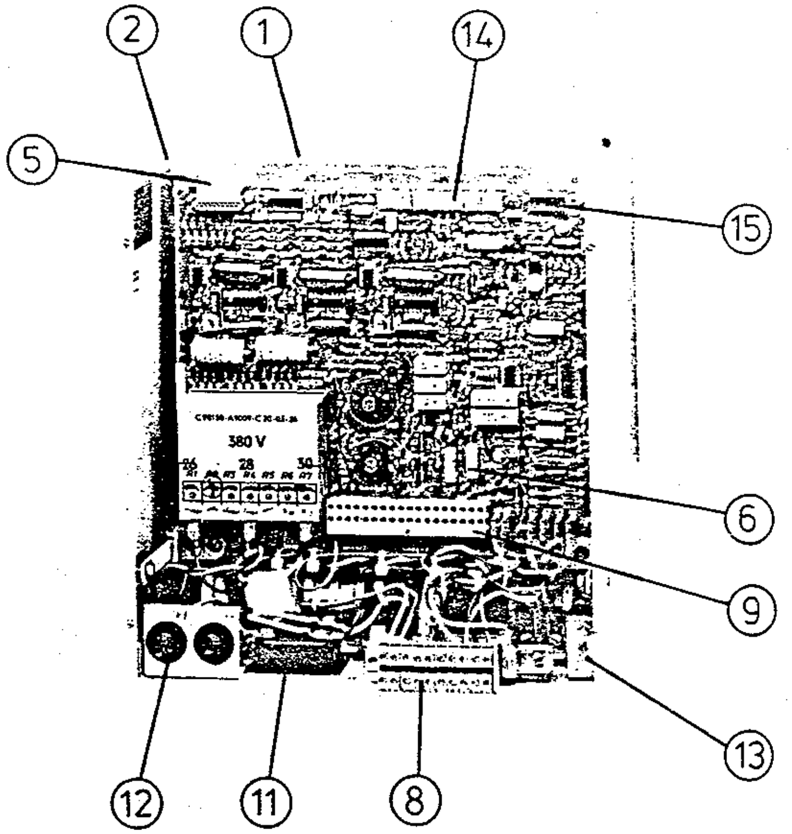
Connection to a system with incorrect phase rotation does not damage the convertor.

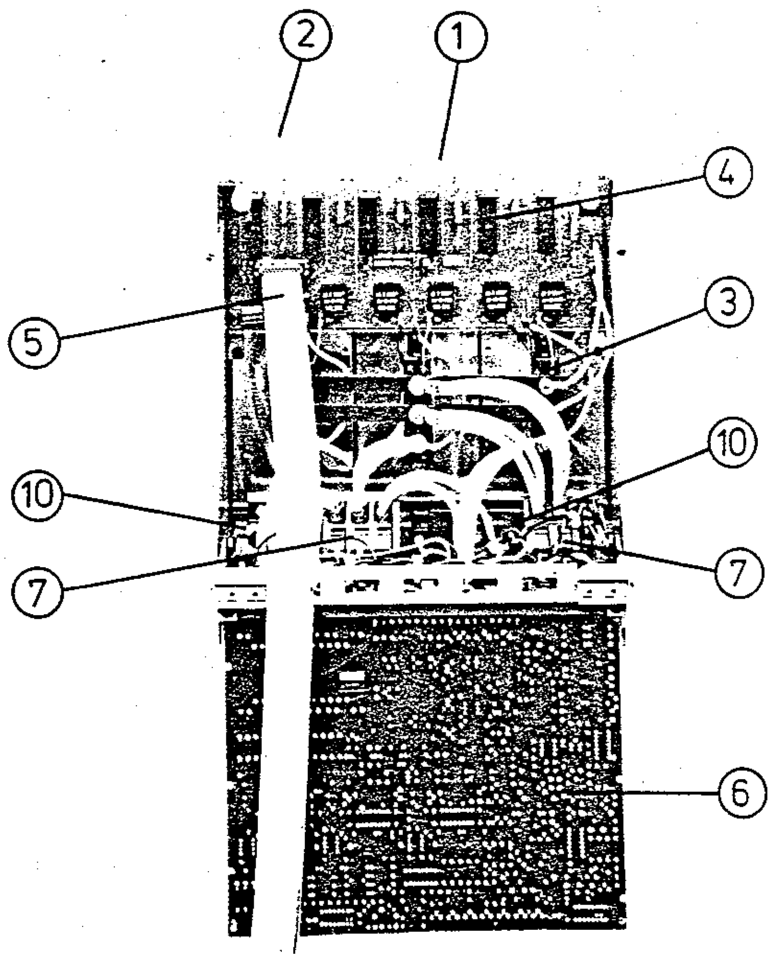
Operation with a missing phase is prevented to avoid damage to the motor by excessive harmonic currents.

Restoration of the supply voltage, after short voltage dips, causes no current surges in the armature circuit.

1.2 CONSTRUCTION

1 Heat sink
2 Enclosure
3 Thyristor module
4 Firing pulse transmitting circuit board
5 Firing pulse connecting cable
6 Control and logic system circuit board
7 Power circuit terminals
8 Relay circuit terminals
9 Control system terminals
10 Feed-back current transformers
11 Field supply rectifier
12 Fuses for rectifier
13 Undervoltage relay
14 Setting potentiometer
15 Connecting facility for supplementary circuit boards or SIMOREG tester





Controller circuit board hinged forward

1.3 TECHNICAL DATA

1.3.1 Power Section

SIMOREG Compact Convertor Type	Order No.	Thyristor type *)	Rated supply voltage	Rated dc voltage	Rated dc current A	Rated output kW	Wt. kg
D460/ 24 Mre-GcE 6S20	6RA2116-6DS20	SKKT 15/12H1	3 ~ 380 V 50/60 Hz	460 V	24	11	12
D460/ 35 Mre-GcE 6S20	6RA2120-6DS20	MTT18M12N			35	16,1	15
D460/ 57 Mre-GcE 6S20	6RA2124-6DS20	MTT25M12N			57	26,2	15
D460/ 85 Mre-GcE 6S20	6RA2127-6DS20	MTT50M12N			85	39,1	15
D460/130 Mre-GcE 6S20	6RA2132-6DS20	MTT95A12N			130	59,8	15
D460/170 Mre-GcEF 6S20	6RA2174-6DS20	MTT50M12N			170	78,2	27
D460/240 Mre-GcEF 6S20	6RA2176-6DS20	MTT95A12N			240	110,0	27
D460/300 Mre-GcEF 6S20	6RA2178-6DS20	L 75A80-V			300	138,0	27
D460/375 Mre-GcEF 6S20	6RA2181-6DS20	M75A80-V			375	172,0	27
D600/ 35 Mre-GcE 6S20	6RA2120-6GS20	MTT25M16N	3 ~ 500 V 50/50 Hz	600 V	35	21,0	15
D600/ 57 Mre-GcE 6S20	6RA2124-6GS20	MTT25M16N			57	34,2	15
D600/ 85 Mre-GcE 6S20	6RA2127-6GS20	MTT50M16N			85	51,0	15
D600/130 Mre-GcE 6S20	6RA2132-6GS20	MTT95A16N			130	78,0	15
D600/170 Mre-GcEF 6S20	6RA2174-6GS20	MTT50M16N			170	102,0	27
D600/240 Mre-GcEF 6S20	6RA2176-6GS20	MTT95A16N			240	144,0	27
D600/300 Mre-GcEF 6S20	6RA2178-6GS20	L 75A110-V			300	180,0	27
D600/375 Mre-GcEF 6S20	6RA2181-6GS20	M75A110-V			375	225,0	27

*) In place of SIEMENS thyristor modules, equivalent modules of type SKKT may also be used.

1.3.2 Field Supply Rectifier

SIMOREG Compact Convertor Type	Order No.	Rectifier type	Max. supply voltage	Max. dc voltage	Max. dc current A
D460/ 24 Mre-GcE 6S20	6RA2116-6DS20	SKB B500/445-4	1 ~ 380 V 50/60 Hz	310 V	4
D460/ 35 Mre-GcE 6S20	6RA2120-6DS20	SKB 15/12 A2			12
D460/ 57 Mre-GcE 6S20	6RA2124-6DS20				
D460/ 85 Mre-GcE 6S20	6RA2127-6DS20				
D460/130 Mre-GcE 6S20	6RA2132-6DS20				
D460/170 Mre-GcEF 6S20	6RA2174-6DS20				15
D460/240 Mre-GcEF 6S20	6RA2176-6DS20				
D460/300 Mre-GcEF 6S20	6RA2178-6DS20	SKB 30/12 A1			22
D460/375 Mre-GcEF 6S20	6RA2181-6DS20				
D600/ 35 Mre-GcE 6S20	6RA2120-6GS20	SKB 15/12 A2	1 ~ 380 V 50/60 Hz	310 V	12
D600/ 57 Mre-GcE 6S20	6RA2124-6GS20				
D600/ 85 Mre-GcE 6S20	6RA2127-6GS20				
D600/130 Mre-GcE 6S20	6RA2132-6GS20				
D600/170 Mre-GcEF 6S20	6RA2174-6GS20				15
D600/240 Mre-GcEF 6S20	6RA2176-6GS20				
D600/300 Mre-GcEF 6S20	6RA2178-6GS20	SKB 30/12 A1			22
D600/375 Mre-GcEF 6S20	6RA2181-6GS20				

1.3.3 Cooling Fan Module

SIMOREG Compact Convertor Type	Order No.	Supply Voltage V	Current comsumption A	Fan Delivery L/sek
D460/ 24 Mre-GcE 6S20 D460/ 35 Mre-GcE 6S20 D460/ 57 Mre-GcE 6S20 D460/ 85 Mre-GcE 6S20 D460/130 Mre-GcE 6S20	6RA2116-6DS20 6RA2120-6DS20 6RA2124-6DS20 6RA2127-6DS20 6RA2132-6DS20	Without cooling fan		
D460/170 Mre-GcEF 6S20 D460/240 Mre-GcEF 6S20 D460/300 Mre-GcEF 6S20 D460/375 Mre-GcEF 6S20	6RA2174-6DS20 6RA2176-6DS20 6RA2178-6DS20 6RA2181-6DS20	1 ~ 380 50/60 Hz	0,45	appr.130
D600/ 35 Mre-GcE 6S20 D600/ 57 Mre-GcE 6S20 D600/ 85 Mre-GcE 6S20 D600/130 Mre-GcE 6S20	6RA2120-6GS20 6RA2124-6GS20 6RA2127-6GS20 6RA2132-6GS20	Without cooling fan		
D600/170 Mre-GcEF 6S20 D600/240 Mre-GcEF 6S20 D600/300 Mre-GcEF 6S20 D600/375 Mre-GcEF 6S20	6RA2174-6GS20 6RA2176-6GS20 6RA2178-6GS20 6RA2181-6GS20	1 ~ 220 50/60 Hz	0,75	appr.130

1.3.4 Control and Relay Section

Steady-state speed holding tolerance:

when supplying dc motor, using temperature-controlled dc tacho-generator, after a warm-up period of 7 min,

with supply voltage varying within ±5% of rated voltage

with ambient temperature varying within ±10°K

with 100% load change (referred to max. value) . . . ±0,8%

Current limit adjustable from 5% to 100% (referring to max. dc current)

Tolerance of firing pulse angle ±2° el.

For external connection details see Terminal List pg 14

1.4 EXTERNAL COMPONENTS

1.4.1 Commutation Choke

The commutation choke limits the current rise in the thyristors and reduces the voltage nicks in the supply voltage wave due to commutation.

The chokes used in the selection table limit the nick in the supply voltage wave with 100% or 80% of rated dc current in accordance with regulation VDE 0160. A transformer with a 4% reactance drop at rated convertor current can be used in place of the commutation choke.

Note: Auto-wound transformers usually have insufficient reactance! In such cases an additional choke is required so that the sum of the reactances of the commutation choke and the transformer is approximately 4%.

SIMOREG Compact Convertor		Commutation Choke present Type Ref.		New Type Ref.	
Type	Order No.	0,8 I_N	1,0 I_N	0,8 I_N	1,0 I_N
D460/ 24 Mre-GcE 6S20	6RA2116-6DS20	—	4EM5000-3CA	—	4EM5000-3CA[1])
D460/ 35 Mre-GcE 6S20	6RA2120-6DS20	—	4EP1404-2CA	—	4EP3801-4CB
D460/ 57 Mre-GcE 6S20	6RA2124-6DS20	—	4EP1507-1CA	4EP3900-6CB	4EP4000-8CB
D460/ 85 Mre-GcE 6S20	6RA2127-6DS20	4EP1506-7CA	4EP1605-7CA	4EP4000-7CB	4EP4101-0CB
D460/130 Mre-GcE 6S20	6RA2132-6DS20	4EP1607-5CB	4EP1706-1CB	4EP4100-7CB	4EP4101-1CB
D460/170 Mre-GcEF 6S20	6RA2174-6DS20	4EP1605-6CA	4EP1800-8CA	4EP4100-8CB	4EP4301-6CB
D460/240 Mre-GcEF 6S20	6RA2176-6DS20	4EP1800-6CA	4EP2008-5CA	4EP4201-4CB	4EP4301-7CB
D460/300 Mre-GcEF 6S20	6RA2178-6DS20	4EP2008-2CA	4EP2108-2CA	4EP4301-4CB	4EP4400-7CB
D460/375 Mre-GcEF 6S20	6RA2181-6DS20	4EP2014-4CB	4EP2114-8CB	4EP4301-8CB	4EP4401-0CB
D600/ 35 Mre-GcE 6S20	6RA2120-6GS20	—	4EP1404-2CA	—	4EP3901-0CB
D600/ 57 Mre-GcE 6S20	6RA2124-6GS20	—	4EP1507-0CA	4EP4000-2CB	4EP4100-3CB
D600/ 85 Mre-GcE 6S20	6RA2127-6GS20	4EP1605-8CA	4EP1704-6CA	4EP4100-2CB	4EP4101-4CB
D600/130 Mre-GcE 6S20	6RA2132-6GS20	4EP1607-6CB	4EP1801-5CB	4EP4200-3CB	4EP4201-7CB
D600/170 Mre-GcEF 6S20	6RA2174-6GS20	4EP1704-8CA	4EP2008-7CA	4EP4201-6CB	4EP4301-0CB
D600/240 Mre-GcEF 6S20	6RA2176-6GS20	4EP2010-5CA	4EP2107-7CA	4EP4300-5CB	4EP4400-2CB
D600/300 Mre-GcEF 6S20	6RA2178-6GS20	4EP2110-4CA	4EP2304-7CA	4EP4300-6CB	4EP4400-8CB
D600/375 Mre-GcEF 6S20	6RA2181-6GS20	4EP2115-0CB	4EP2308-4CB	4EP4400-1CB	4EP4500-4CB

[1]) Single-phase choke; 3 off are required.

1.4.2 Fuses

The fuses quoted in the table below must be connected into the ac supply circuit to the convertor to protect the thyristors. If the SIMOREG convertor is also used for regenerative braking, the dc circuit fuse quoted below must be connected into the armature circuit.

Note! It is possible that the fuse recommended for the dc circuit limits the maximum permitted armature current to less than the rated convertor current.

Fuses are not supplied with the convertor and must be ordered separately.

SIMOREG Compact Convertor Type	Order No.	Power Section Line Fuse Order No	A	With regenerative Braking Line fuse Order No.	A	DC Circuit Fuse Order No.	A
D460/ 24 Mre-GcE 6S20	6RA2116-6DS20	3NE8003	35	3NE8003	35	3NE8003	35
D460/ 35 Mre-GcE 6S20	6RA2120-6DS20	3NE8017	50	3NE8017	50	3NE8017	50
D460/ 57 Mre-GcE 6S20	6RA2124-6DS20	3NE8017	50	3NE8017	50	3NE8018	63
D460/ 85 Mre-GcE 6S20	6RA2127-6DS20	3NE8020	80	3NE8020	80	3NE8021	100
D460/130 Mre-GcE 6S20	6RA2132-6DS20	3NE8022	125	3NE8022	125	3NE8022	125
D460/170 Mre-GcEF 6S20	6RA2174-6DS20	3NC8423	150	3NE4121	100	3NE4122	125
D460/240 Mre-GcEF 6S20	6RA2176-6DS20	3NC8425	200	3NC8423	150	3NC8425	200
D460/300 Mre-GcEF 6S20	6RA2178-6DS20	3NC8431	350	3NC8431	350	3NC8431	350
D460/375 Mre-GcEF 6S20	6RA2181-6DS20	3NC8434	500	3NC8431	350	3NC8434	500
D600/ 35 Mre-GcE 6S20	6RA2120-6GS20	3NE8017	50	3NE4117	50	3NE4117	50
D600/ 57 Mre-GcE 6S20	6RA2124-6GS20	3NE8017	50	3NE4117	50	3NE4117	50
D600/ 85 Mre-GcE 6S20	6RA2127-6GS20	3NE8020	80	3NE4120	80	3NE4120	80
D600/130 Mre-GcE 6S20	6RA2132-6GS20	3NE8022	125	3NE3421	100	3NE3322	125
D600/170 Mre-GcEF 6S20	6RA2174-6GS20	3NC8423	150	3NE4120	80	3NE4121	100
D600/240 Mre-GcEF 6S20	6RA2176-6GS20	3NC8425	200	3NE4121	100	3NE4122	125
D600/300 Mre-GcEF 6S20	6RA2178-6GS20	3NC8431	350	3NC8427	250	3NC8431	350
D600/375 Mre-GcEF 6S20	6RA2181-6GS20	3NC8434	500	3NC8431	350	3NC8434	500

SIMOREG Compact Convertors up to and including 240A rated dc current contain 2 fuses type FF16/500G for the field supply rectifier.

1.4.3 Smoothing Choke

With three-phase bridge-connected convertors the ripple content of the dc output voltage is generally so low that the armature circuit inductance of the dc motor provides sufficient smoothing. The dc motor list states when additional smoothing is required.

1.4.4 Speed/Armature Voltage Feed-back

Speed Control

A speed transducer is required to feed back to the control system a dc signal equivalent to the actual motor speed. At maximum speed this signal must be at least 10V but must not exceed 200V. Transducers with an output of e.g. 0 to 20mA can be used, provided the current signal is passed through a burden resistance for conversion into a voltage signal. It will depend on the mode of operation which of the speed transducers quoted in the table on page 11 is the most suitable. The speed holding accuracy of a drive depends in the first instance on the quality of the speed transducer.

Armature Voltage Control

The speed controller of the convertor can also be used for armature voltage control with IR compensation. For safety reasons it is advisable to employ a voltage transducer to provide a potential-free feed-back signal; supplementary circuit board 6RA8211-2A is most suitable for this purpose.

1.4.5 Reference Voltage

The choice of which of the speed reference voltages quoted in the table overleaf must be fed to the speed controller will depend on the mode of operation of the convertor. An external speed setting potentiometer (4,7 to 10 kΩ, approx. 20 W) can be connected to the ±10 V stabilised supply of the convertor. The speed reference signal can also be obtained from an external superimposed control system or from a ramp function generator.

If required, a supplementary reference signal can be added, e. g., a voltage proportional to the position of a dancer roll. The effectiveness of this supplementary speed reference is controlled by the ratio of the input currents at terminals 10 and $n_{ist}1$ ($n_{feed\text{-}back}1$).

Mode of operation	Feed-back Speed Transducer		Speed Reference Voltage
	Polarity of tacho voltage does not change with direction of rotation[1])	Polarity of tacho voltage changes with direction of rotation	
Unidirectional driving torque only	Yes Feed-back (+)	Yes Feed-back (+)	0 to −10 V
Unidirectional driving torque only, braking to stand-still by external field reversal and use of supplementary circuit board 6RA8211-1A	Conditional[2])	Yes Feed-back (+)	0 to −10 V
Driving torque in one direction, braking torque in opposite direction	No	Yes Feed-back (+) to (−)	−10 V to +10 V

Table
Speed feed-back source and speed reference voltage

[1]) E.g. ac tacho-generator with rectifier as Minitacho 1GU1051.

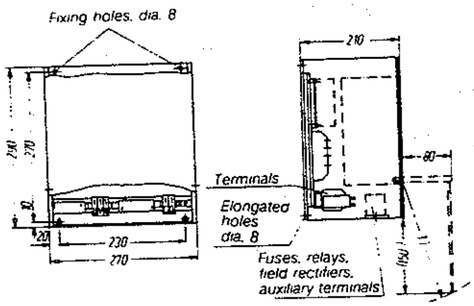
[2]) Only if, after the motor has come to rest, a reversal of rotation due to external effects (e. g. web pull) is not possible or if the zero speed detection range is adequate (adjustable on the supplementary circuit board) to ensure immediate and undelayed switch-off.

2. MOUNTING

2.1 OUTLINE DRAWINGS

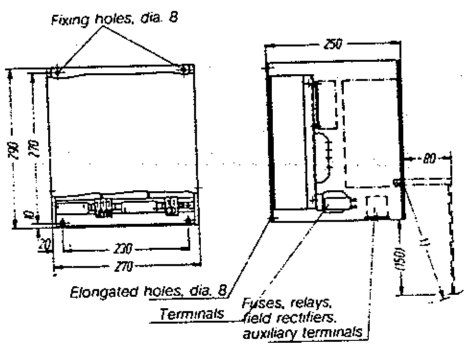
(Dimensions in mm)

SIMOREG Compact Convertor

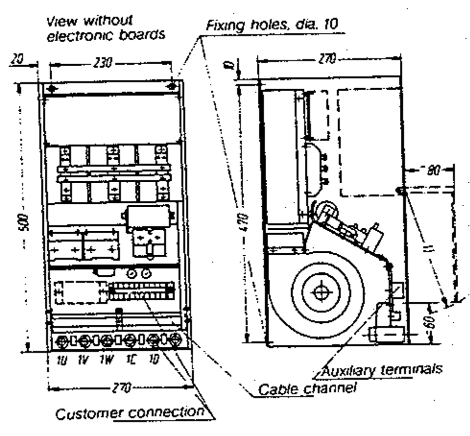


SIMOREG Compact Convertor

Type	Order No.
D460/ 24 Mre—GcE 6S20	6RA2116—6DS20
D460/ 35 Mre—GcE 6S20	6RA2120—6DS20
D600/ 35 Mre—GcE 6S20	6RA2120—6GS20



Type	Order No.
D460/ 57 Mre—GcE 6S20	6RA2124—6DS20
D460/ 85 Mre—GcE 6S20	6RA2127—6DS20
D460/130 Mre—GcE 6S20	6RA2132—6DS20
D600/ 57 Mre—GcE 6S20	6RA2124—6GS20
D600/ 85 Mre—GcE 6S20	6RA2127—6GS20
D600/130 Mre—GcE 6S20	6RA2132—6GS20



Type	Order No.
D460/170 Mre—GcEF 6S20	6RA2174—6DS20
D460/240 Mre—GcEF 6S20	6RA2176—6DS20
D460/300 Mre—GcEF 6S20	6RA2178—6DS20
D460/375 Mre—GcEF 6S20	6RA2181—6DS20
D600/170 Mre—GcEF 6S20	6RA2174—6GS20
D600/240 Mre—GcEF 6S20	6RA2176—6GS20
D600/300 Mre—GcEF 6S20	6RA2178—6GS20
D600/375 Mre—GcEF 6S20	6RA2181—6GS20

1) Space requirement with the electronic unit swung out 220 mm from the front edge

User to make allowance for the tilting of the board when determining the lenght of his connections.

2.2 MOUNTING INSTRUCTIONS

The convertors must be mounted vertically.

The terminal arrangement is such that connecting cables must be led in from below. Self-cooled units must not be mounted horizontally since this will seriously affect the flow of cooling air over the heat sinks. A minimum distance of 100 mm to the nearest adjacent components above and below the convertor must be maintained.

Forced-cooled convertors must not be connected to a duct system without the use of an additional fan since the built-in fan is not sufficiently powerful for this duty.

When convertors are mounted inside enclosures the internal air temperature must not be allowed to rise above the maximum permitted operating temperature.

The convertor losses can be approximately calculated as follows:

$$V = 3 \cdot I_d + 2 \cdot I_E$$

I_d = the armature current of the dc motor in A

I_E = the current supplied by the field rectifier

2.3 EXTERNAL CONNECTIONS

The convertor must be connected in accordance with the circuit diagrams supplied with it and, if necessary, also in compliance with any specific plant diagrams.

A list of the circuit boards with which the convertor is equipped and the associated circuit diagrams will be found in a side pocket.

The external circuit diagram shown on page 16 is merely one example of a convertor used for a single-quadrant drive.

2.3.1 Conductor Sections

SIMOREG Compact Convertor Type	Order No.	Power Connections 2) ac	dc		Relay Circuits	Control System Circuits
D460/ 24 Mre-GcE 6S20	6RA2116-6DS20	4 mm²	2x4 mm²			
D460/ 35 Mre-GcE 6S20	6RA2120-6DS20	16 mm²	16 mm²			
D460/ 57 Mre-GcE 6S20	6RA2124-6DS20	16 mm²	25 mm²			
D460/ 85 Mre-GcE 6S20	6RA2127-6DS20	25 mm²	35 mm²			
D460/130 Mre-GcE 6S20	6RA2132-6DS20	35 mm²	35 mm²	3)	4 mm²	2,5 mm²
D460/170 Mre-GcEF 6S20	6RA2174-6DS20	M10				1)
D460/240 Mre-GcEF 6S20	6RA2176-6DS20	M10				
D460/300 Mre-GcEF 6S20	6RA2178-6DS20	M10				
D460/375 Mre-GcEF 6S20	6RA2181-6DS20	M10				
D600/ 35 Mre-GcE 6S20	6RA2120-6GS20	16 mm²	16 mm²			
D600/ 57 Mre-GcE 6S20	6RA2124-6GS20	16 mm²	25 mm²			
D600/ 85 Mre-GcE 6S20	6RA2127-6GS20	25 mm²	35 mm²			
D600/130 Mre-GcE 6S20	6RA2132-6GS20	35 mm²	35 mm²	3)	4 mm²	2,5 mm²
D600/170 Mre-GcEF 6S20	6RA2174-6GS20	M10				1)
D600/240 Mre-GcEF 6S20	6RA2176-6GS20	M10				
D600/300 Mre-GcEF 6S20	6RA2178-6GS20	M10				
D600/375 Mre-GcEF 6S20	6RA2181-6GS20	M10				

1) stranded conductor with ferrule ≦ 2,5 mm²

2) DIN 57113 (VDE 0113, Tabelle 2 – allg. Maschinen, in Leitungskanal)

3) to determine 2) terminals ~ 50 mm² – 70 mm² are needed between unit and cable

2.3.2 Terminal List

Terminal	Function	Kind[1]	Supply data	Observations
1	Screen	–		
2 3	N24 N15	O O	−24V max. −15V 50mA	
9	N10	O	−10V stab. max. 5mA	Speed ref.
4, 5, 6	M24, M15, 0V	I/O	Reference potential	
7 8	P15 P24	O O	+15V reg. max. +24V 50mA	
18	P10[2])	O	+10V max. 5mA	Link dz-ah fitted
16	P10, N10, M15 or 2nd ref.	O I	±10V max. 1mA +10V	As required
10	Suppl. ref. Speed control	I	−10V to +10V see also	
11 12 13	Speed ref. Speed feed-back Speed feed-back	I I I	0 to −10V paras +10V to +30V 1.4.4 +30V to +85V and 1.4.5	Link ax-ay fitted
			+85V to +200V	Link ay-ay not fitted
14	Ext. current limit	I	0 to +10V	0V = low current
15	Controller enabling	I	+12V to +30V	Connect to term'l 8 or H-signal = Contr. enabled; −1,5 to −30V or term'l 15 unconnected = Contr. blocked Fir'g pulse at α_{inv}
17	Ext. pulse inhibit	I	M, 0V	0 to 1,5V = Pulses inhibited; 3,5 to 30V or term'l 17 uncon-nected = Pulses free
2U (26) 2V (28) 2W (30)	Power Supply L1 Power Supply L2 Power Supply L3	I I I	3-ph. 380V, 0,1A 500V, 0,08A	380V units 500V units
35/36	Temperature monitoring	O	1 NC 250V, 3A 30V dc, 3A non-ind.	Over 70°C circ't 35–36 open
37/38	Supply to cooling fan motor	I	1-ph 380V, 0,45A 1-ph 220V, 0,75A	380V units 500V units
3U, 3V	Supply to field rectifier	I	max. 1-ph., 380V	*)
3C, 3D	Feed to motor field	O	max. 310V, dc	Current see para. 1.3.2
51/52/53	Undervoltage monitoring	O	1 changeover 250V, 7,5A 250V, dc, 0,2A non-ind.	Alarm 51/52 closed 51/53 open

[1]) I = Incoming
O = Outgoing
[2]) Only for circuit board C98043-A1035-L5, L6

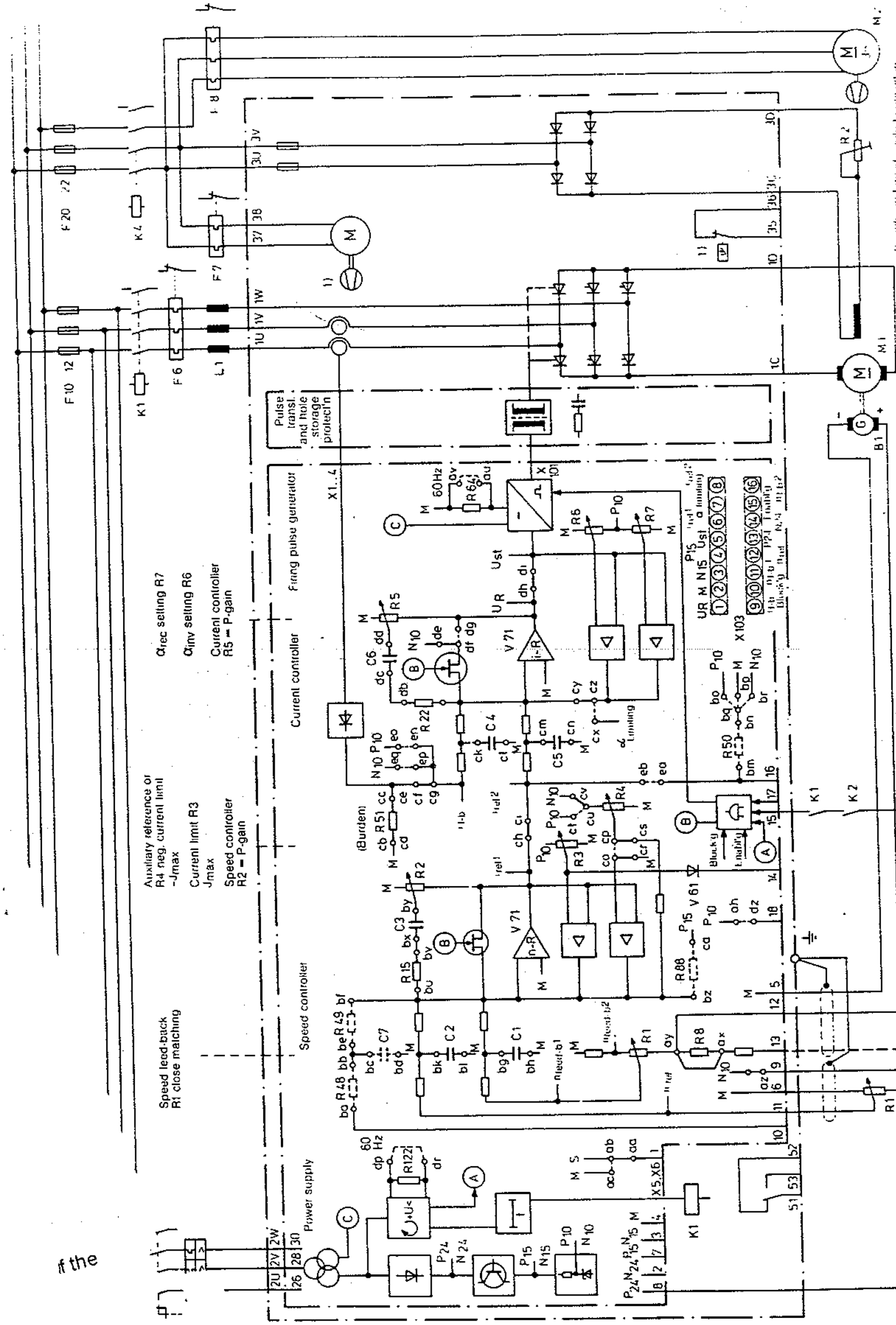
*) Fault level must be limited by feeding from dead side of thyristor fuses or similar switchgear. However, with force-cooled 500V units supply must not be taken from dead side of thyristor fuses (see External Connections).

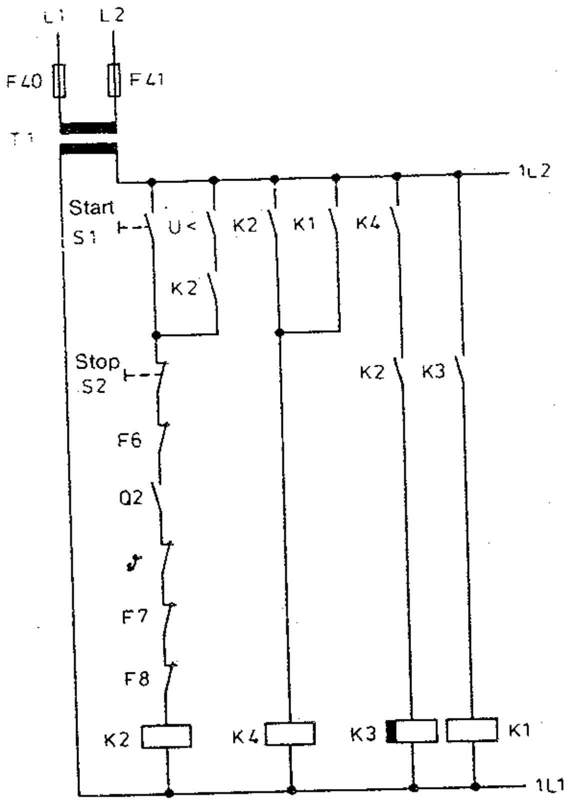
2.3.3 Solder Links

Circuit	3	3	13	22	21/22	22	22	22	25	24/25	25	25	25	25	25	25	26	26	27	27	27	31	23	17	18	17	18
Link	aa-ab	ab-ac	au-av	ax-ay	bm-bn	bo-bq	bp-bq	bq-br	cf-cg	ch-ci	co-cp	co-cr	cp-cs	cr-cs	ct-cu	cu-cv	cx-cz	cy-cz	de-df	df-dg	dh-di	dp-dr	ea-eb	ec-ed	ed-ee	ef-eg	eg-eh
As supplied	+	0	0	+	0	0	0	0	+	+	0	+	+	0	0	+	0	+	+	0	+	0	0	0	+	0	+
Conversion to 60 Hz			+																			+					
Feed-back voltage > 85 V				0																							
Screen to earth	+	0																									
Screen to M	0	+																									
Negative current reference limiting																											
to 0 V											0	+															
to 0 V to − 10 V											+	0	0	0	+												
to 0 V to + 10 V											+	0	0	+	0												
Supplementary speed ref. 0 V														+													
int'ly adjustable 0 to − 10 V											0	+	+	0	0	+											
int'ly adjustable 0 to + 10 V											0	+	+	0	+	0											
Terminal 16 to M					+		+																0				
− 10 V					+			+															0				
+ 10 V					+	+																	0				
Terminal 16 as current reference input for field supply convertors					0					0													+				
For measurement and fault finding																											
Disconnect speed controller from current controller										0																	
Disconnect current controller from firing pulse generator																						0					
Disconnect current feed-back from current controller (only when power section is not connected or external current reference is used!)									0																		
With supplementary Circuit Board																											
6RA8211–1A Brake current contr. active										0																	
6RA8211–2A																											
6RA8211–2B																											
6RA8211–3 Control by current controller										0												+					
Control direct to pulse gen.																						0					
Test with SIMOREG Tester:																											
Inject current ref.										0																	
Inject control voltage																						0					

+ . . . Link 0 . . . Link open

2.3.4 Typical external circuit diagram





Relay circuit section of typical external circuit diagram

Q1	Isolator
Q2	Circuit breaker for control supply
K1	Power supply contactor
K2	Master relay
K3	Relay with delayed drop-off, approx. 200 msec
K4	Field supply contactor
F10–F12	Power supply fuses
F20–F22	Fuses for auxiliary circuits
F40–F41	Control circuit fuses
F6	Thermal overload relay, drive motor
F7	Thermal overload relay, convertor fan motor
F8	Thermal overload relay, cooling fan motor
L1 (–3)	Commutation choke (3 single-phase units for 24 A unit)
M1	Drive motor, dc, separately excited
M2	Cooling fan motor, ac, 3-phase, cage induction
B1	DC tacho-generator
R1	Speed reference setting potentiometer 10 kΩ
R2	Field circuit adjusting resistance
S1	Start button
S2	Stop button
T1	Control supply transformer
δ	Convertor cooling air temperature mon
U<	Undervoltage detector and phase seq monitor

2.3.5 Internal Circuit Diagrams

The diagrams of the, as supplied, internal circuits will be found in the plastic pocket at the side c unit. This pocket also contains a list of all the relevant diagrams.

3. COMMISSIONING INSTRUCTIONS

All SIMOREG Compact convertors are works-tested before delivery. Solder links are fitted as stated in the table "Solder Links" (para. 2.3.3); control angle limits ($\alpha_{inv} = 150°$ el, $\alpha_{rect} = 5°$ el) and current limits are set as stated in "Technical Data" (para. 1.3.4). Amplifier gain settings and speed feed-back matching do not form part of the works test programme since these are parameters which have to be set on site to suit the drive requirements.

Attention! In case of gross mal-optimization (maximum position of various potentiometers) the power unit could be damaged.

The initial commissioning instructions (Section 3.1) are based on the following assumptions:

- The SIMOREG Compact convertor is being used for the speed control of a dc motor and has been connected as shown in the "Typical External Circuit Diagram", para. 2.3.4.
- No special drive conditions exist which call for readjustment of control angles α_{inv} and α_{rect} or the resetting of the current limit or optimising of speed and current controllers. Should any of these be required, consult Sections 3.2 to 3.5.

The following instruments are required for initial commissioning:

1 Multirange dc voltmeter
0 to 1000V, internal resistance 100 kΩ/V, suitable for measurements in electronic circuits, e.g., Siemens μA-Multizet;

1 AC current and voltage measuring instrument
0 to 1000V, 0 to 10A, internal resistance 1 kΩ/V, e.g. Siemens AV Multizet;

1 Hand tachometer

3.1 INITIAL COMMISSIONING

3.1.1 Check solder links in circuit board A1 and, if necessary, change to position as demanded by the mode of operation.

No changes are required if the convertor is in the 'as supplied' condition and the supply is from a 50 Hz system. For further guidance see "Description" (section 1) and the table "Solder Links" (para. 2.3.3).

3.1.2 Check external connections

See "Typical External Circuit Diagram" (para. 2.3.4). If a visual check of the correct phase relationship of the three-phase supply connections to the power and control sections is not possible, or if a transformer is used for the control section supply, proceed as follows:

Disconnect armature circuit (opening one pole suffices); switch-on three-phase supply and check voltages between input terminals of power and control sections. If connected correctly, the following voltages should be found:

without transformer . . . Between 1U and 2U, 1V and 2V, and 1W and 2W always 0V

with auto-transformer . . . Between 1U and 2U, 1V and 2V, and 1W and 2W the difference between the primary and secondary voltages divided by $\sqrt{3}$, e.g. transformer 440/380V, measured voltage $60/\sqrt{3} = 34{,}5$ V

with Y-Y transformer . . . A temporary connection must be made between terminals 1U and 2U. The difference voltage between primary and secondary voltages must then appear across terminals 1V and 2V, 1W and 2W, e.g. transformer 440/380V, measured voltage = 60V.

3.1.3 Preliminary setting of potentiometers on circuit board A1.

R1 . . l.h.*) end stop . . speed feed-back set to minimum speed
R2 . . l.h. end stop . . minimum speed controller gain
R5 . . l.h.*) end stop . . minimum current controller gain

*) Note: Direction of rotation of potentiometer is reversed on circuit boards C98043-A1035-L1 and L2.

3.1.4 Checking polarity of tacho voltage

Turn the motor by hand and check polarity of voltage between terminals 12 or 13 and 5; 12 or 13 must be positive. If the test cannot be carried out for mechanical reasons (e.g. motor cannot be uncoupled from the drive and turning by hand is too difficult), connect a voltmeter between terminals 12 or 13 and 5, and observe polarity by starting the motor as described in para. 3.1.7.

3.1.5 Adjust motor field current

Switch on supply to the field rectifier (terminals 3U/3V) and adjust field voltage by means of external resistance.

Provided that the field current of the motor, as stated on the rating plate, is not higher than the rated dc current of the field rectifier (see "Technical Data", para. 1.3.2), set the voltage to approximately 90% of the rated field voltage of the motor. If the field current is higher than that which the rectifier can supply, a separate external field supply rectifier has to be used.

On force-ventilated convertors, switching-on the field also causes the fan motor to start (terminals 37/38).

3.1.6 Set speed reference to lowest setting, preferably 0V.

Setting of minimum speed:

Conflicting requirements exist as regards minimum speed setting; these depend on the user's operating conditions.

a) With zero speed reference applied the drive must remain at rest and drifting of the speed controller must be prevented.

b) With zero speed reference applied the drive must run at a very low speed so that the operator can see that it has been started.

Requirement a) can be met by applying a low positive reference voltage via resistance R88 (e.g. 2,2 MΩ) and by connecting the slider of potentiometer R4 to M or by opening link cp–cs.

Requirement b) can be met by not fitting R88 and by adjusting the slider of pot. R4 so that when this is in the zero position the required low speed is obtained.

3.1.7 Switch on drive

If motor fails to start and light-emitting diode V102 lights up, switch off. Probably the phase rotation of the supply to the power and control sections is counter-clockwise. Reverse phase connections at the convertor terminals, maintaining however the phase relationships 2U/1U, 2V/1V, and 2W/1W. If the drive does not start and diode V102 fails to light up, slowly increase speed reference until motor starts; observe polarity of tacho voltage and direction of rotation of the motor.

Note: With incorrect tacho voltage polarity, motor can run up to top speed and be out of control!

3.1.8 Raise speed reference slowly to maximum value (−10V).

Note: When operating with motors with armature voltages considerably lower than the rated output voltage of the SIMOREG converter, observe recommendations of para. 3.1.10.

3.1.9 Wait until motor has gained steady speed and run-up is completed.

3.1.10 Adjusting convertor output voltage for base speed

Measure motor speed by hand tachometer or tacho voltage by voltmeter connected between terminals 12 or 13 (+) and 5. Provided the tacho-generator is correctly connected the motor speed will be too low. It has to be raised by turning potentiometer R1 clockwise (circuit boards C98043-A1035-L5 and L6) until the required maximum speed or tacho voltage has been obtained. If the desired speed cannot be attained this is due to the convertor running up against control angle α_{rect}. This can be checked by measuring the current controller output voltage; connect voltmeter between solder link dh–di and terminal 5, α_{rect} corresponds to approximately 1,8V. Weaken the motor field in small steps until the required speed can be set on R1. Now check motor armature voltage; should this be too high, continue weakening the motor field until the rated motor voltage has been attained.

Note: It is recommended, particularly for motors with low rated armature voltages (e.g. 200V), to check the armature voltage and, if necessary, start field weakening with only half reference (−5V) applied to avoid overvoltage at the motor terminals.

If the control is stable, i.e., no hunting is evident and the drive does not require any further adjustments of current limit, speed and current controller operation or control angle limits, commissioning is completed. Otherwise proceed in accordance with the instructions of Sections 3 to 5.

3.2 CURRENT LIMIT

The current limit of every SIMOREG Compact convertor is set at the works to the maximum dc current of the convertor. Potentiometer R3 on circuit board A1 will have been set to its r. h. end stop. Other setting may become necessary for a number of reasons, e. g.

- The convertor limit current is too high for the motor or the driven machine (coupling, gearing) or
- The acceleration due to maximum current is too severe for the drive.

The setting can be altered as follows:

- by inspecting the potentiometer setting

  the r. h. end stop of potentiometer R3 corresponds to maximum current, the l. h. one to zero current. The characteristic of the potentiometer is linear, it can therefore be set to any intermediate current value.

  Example: Desired current limit is 75% of maximum convertor current.
  Move potentiometer counterclockwise from r. h. end stop by approximately 1.7 scale divisions

- by measuring the limited current reference.

  This method is more direct than that referred to above.

  Proceed as follows:

  Open motor armature circuit by disconnecting one lead.

  Switch on three-phase supply to convertor.

  Measure speed controller output voltage (between solder link ch-ci and terminal 5).

  With potentiometer R3 at its r. h. end stop this voltage (+ 10 V) corresponds to the current reference for maximum convertor current. By turning potentiometer R3 counter-clockwise, this voltage can be set to any desired lower value.

  Example: Voltage measured with R3 at r. h. end stop = 10,2 V.
  Current required to be limited to 75% of rated convertor current.
  Turn potentiometer counterclockwise until voltmeter reads 10,2 x 0,75 = 7,65 V.

3.3 ADJUSTING CONTROL ANGLES

3.3.1 Control angle adjustment (α_{rect} and α_{inv}) is only required if potentiometers R7 and R8 on circuit board A1 had been moved from the positions set at the works.

α_{rect} can also be readjusted if another output voltage is required from the SIMOREG Compact convertor than was set at the works. A decrease of approximately 15% is possible by moving α_{rect} from 5° to 30°. This decrease is necessary provided the convertor has to operate in the regenerative mode (α_{rect} – 30°).

Required instruments:

1 double-beam c.r. oscilloscope.

3.3.2 Prepare drive for measurement

Open armature circuit by disconnecting one lead;
Switch on three-phase supply.

3.3.3 Connect oscilloscope

Input 1 . . . to solder pin al on circuit board A1 (synchronizing voltage)

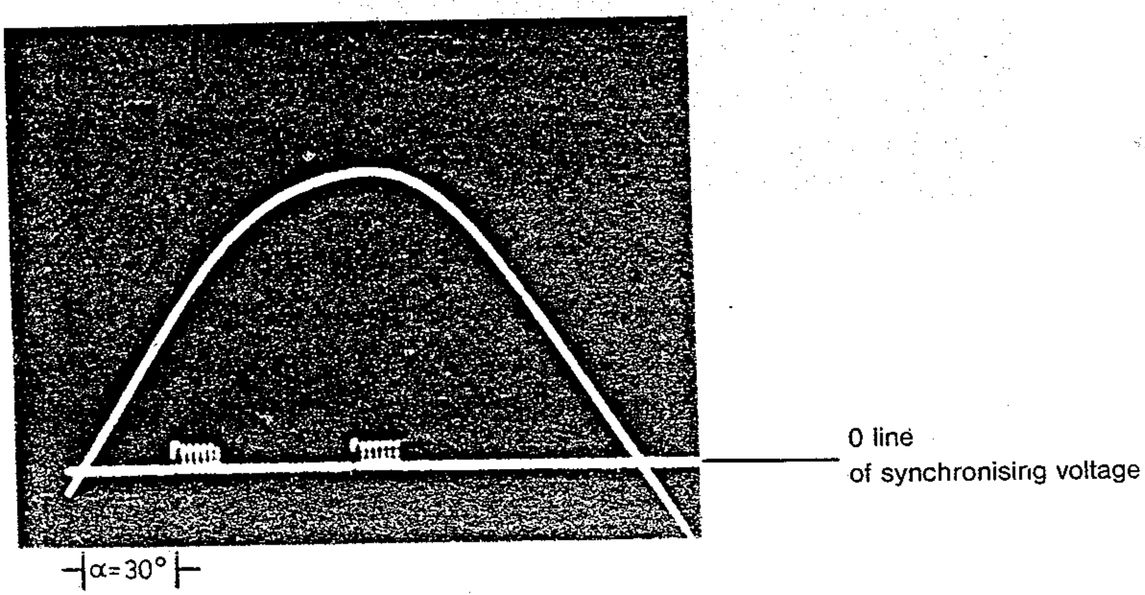
Input 2 . . . to solder pin +R on circuit board A1 (thyristor firing pulses)

Oscilloscope reference potential . . . Terminal 5 (controller −M).

3.3.4 Setting control angle α_{rect}

Enable controller (close circuit from terminal 8 to 15) and set speed to any value.

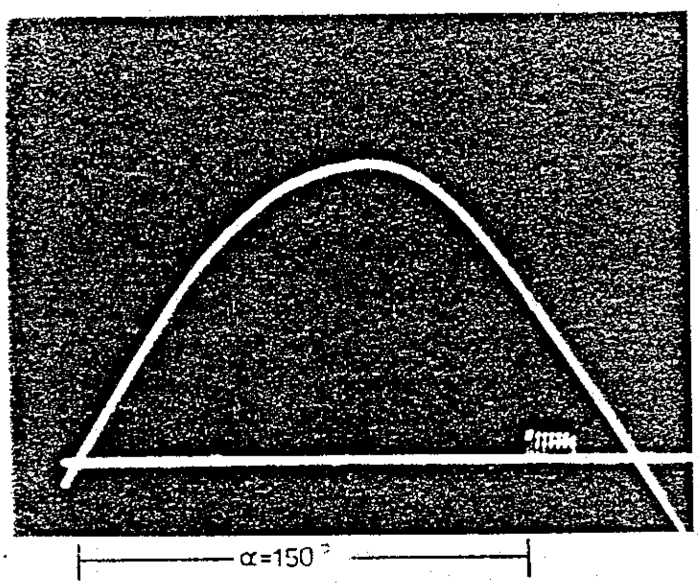
Use potentiometer R7 to set α_{rect} as required.



3.3.5 Setting control angle α_{inv}

Block controller (open circuit from terminal 8 to terminal 15).

Use potentiometer R6 to set α_{inv} as required.



3.4 OPTIMISING

3.4.1 Optimising of current and speed controllers is generally only necessary when special control responses are required or the control system is unstable because the drive conditions differ considerably from the average ones on which the standard settings and circuits are based.

The method described below is an empirical method which can be applied without requiring a detailed knowledge of control theory, yet leads to controller responses which are close to the theoretical optimum. It is assumed that initial commissioning (Section 3.1) has been completed.

If convertor voltage adjustment (para. 3.1.10) could not be completed because of the instability of the system, first of all optimise the system. Then readjust the convertor output voltage and finally recheck and, if necessary, reoptimise the controller.

Required instruments:

1 High-speed recorder

Single-channel, input resistance = 1 MΩ; input voltage 0 to −10 V.

Paper feed 10 to 50 mm/s

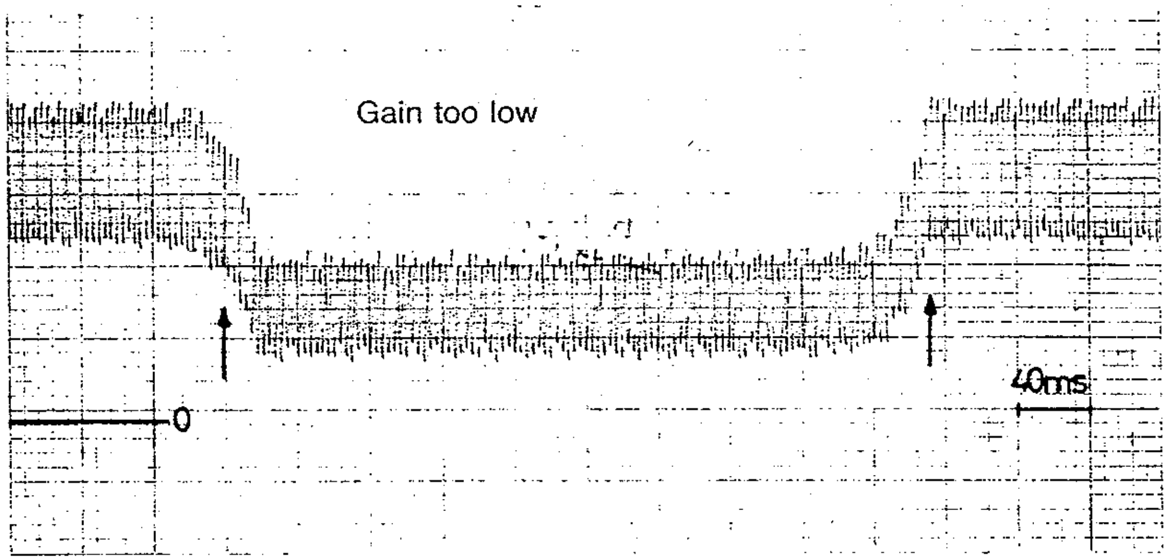
e. s. Siemens OSZILLOREG

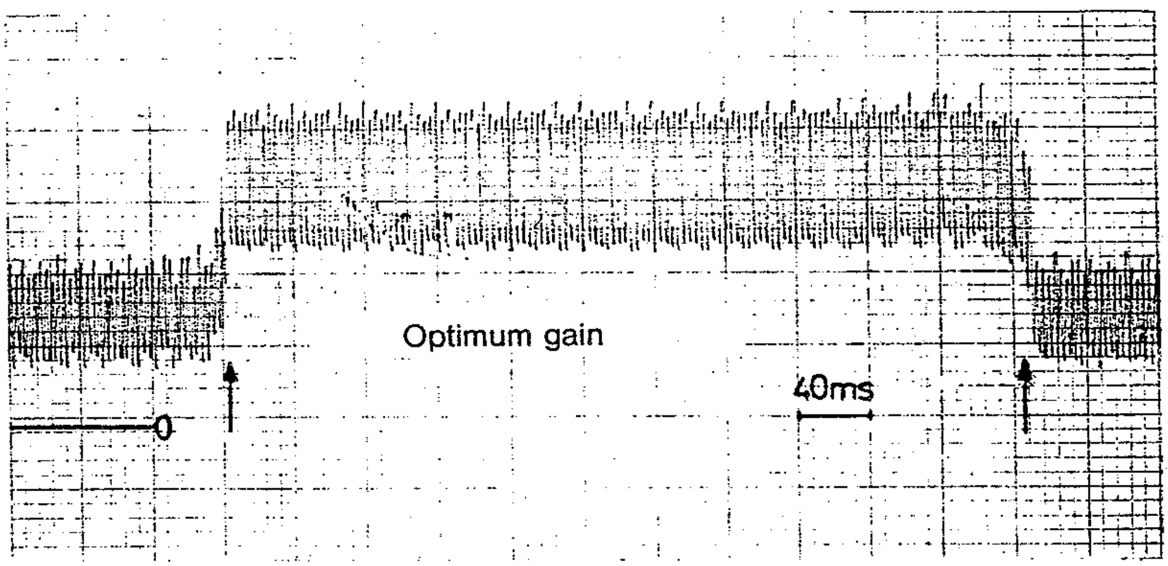
2 Battery boxes

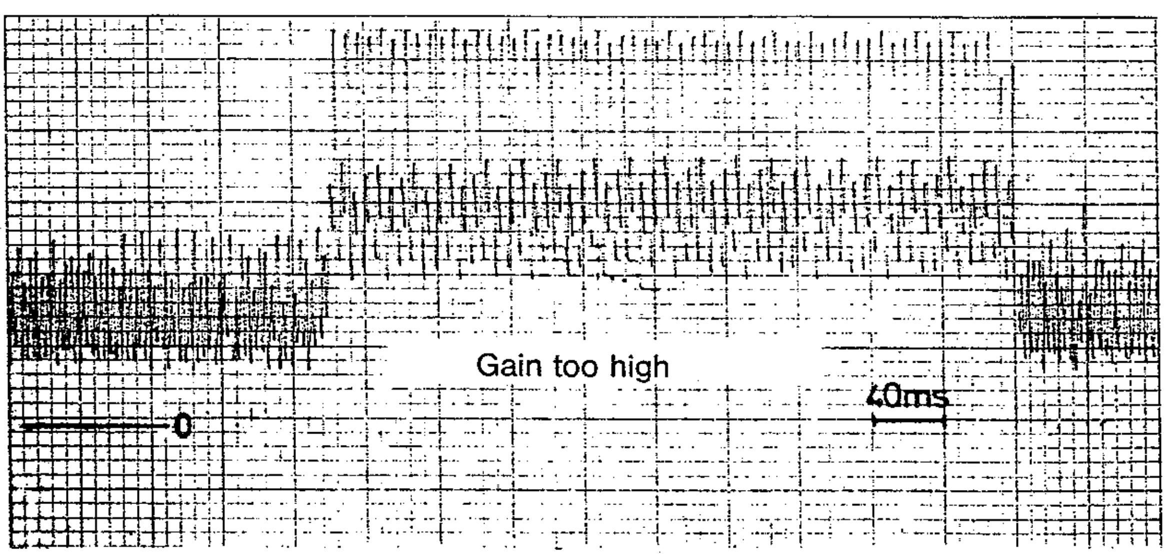
Auxiliary supply 0 to 10 V, adjustable on potentiometer

3.4.2 Preparation

- Disconnect motor field
- Unsolder capacitor C5 on circuit board A1 (current reference smoothing)
- Short capacitor C3
- Unsolder smoothing capacitor (C7) from one of the unused inputs of the speed controller; if mounting space for R48/49 unused, solder in resistances (each 22—200 kΩ)
- Connect battery box 1 between input terminal 10 and M (terminal 5), set voltage to 0 V
- Disconnect speed setting potentiometer and replace by battery box 2, connected between terminals 11 and 6, set voltage to 0 V
- Connect high-speed recorder between solder link cf-cg and terminal 5 (current feed-back).


Gain too low
0
40ms

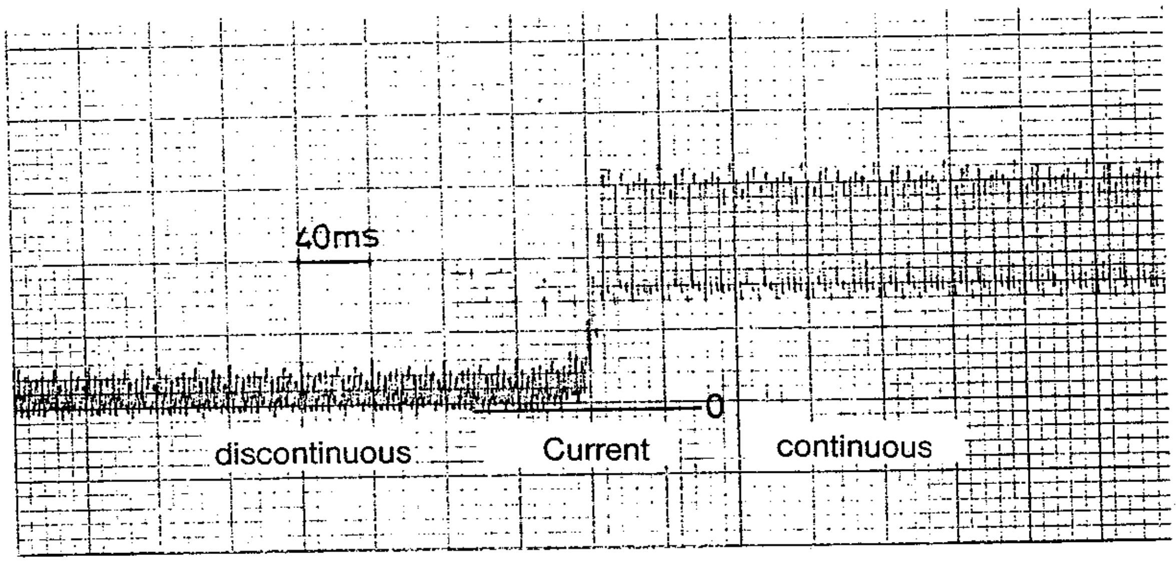

Optimum gain
0
40ms


Gain too high
0
40ms

3.4.3 Switch on drive

3.4.4 Set·convertor output current

– Raise voltage of battery box 2 (negative pole connected to terminal 11) until the armature current is well outside the discontinuous region. The current feed-back signal will then always be greater than zero (observe on high-speed recorder).



The boundary of the discontinuous region depends to a large extent on the parameters of the armature circuit. In general, it lies between 10 and 50% of rated motor current.

– Raise voltage of battery box 1 until armature current has risen by approximately another 20 to 30% of rated motor current.

Note: Current on-time must be kept short to prevent over-heating of commutator.

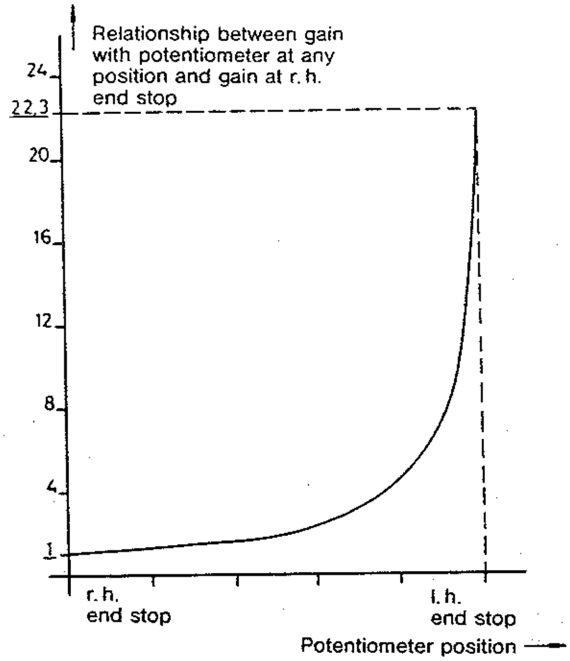
3.4.5 Optimising of current controller

– Switch off voltage from battery box 1 and switch on again; record change of armature current (high-speed recorder).

– Adjust gain of current controller on potentiometer R5 until desired response is obtained.

The motor will normally remain stationary during this test because the field had been disconnected. However, it will not affect the test results should it turn slowly.

When adjusting the potentiometer, note its non-linear characteristic. Caution is required in the high-gain region.



3.4.6 Switch off drive

3.4.7 Prepare for operation with speed control

- Reconnect motor field
- Refit capacitor C5 on circuit board A1
- Set battery box voltages to 0V
- Connect high-speed recorder between solder link ch-ci (speed controller output) and terminal 5

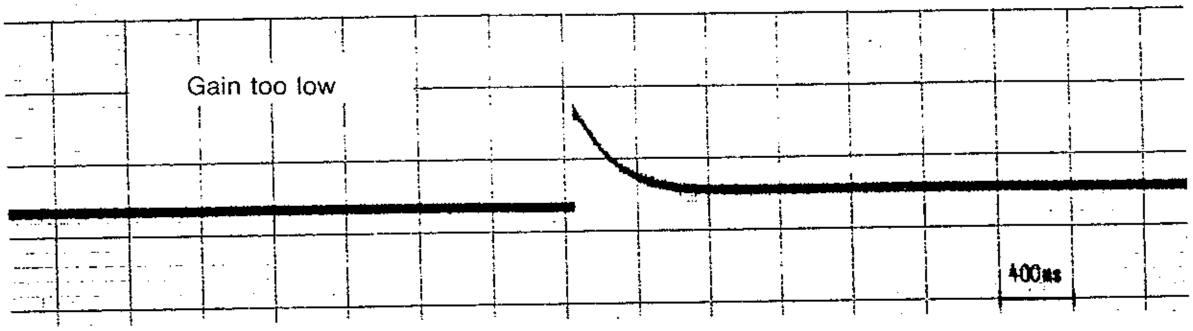
3.4.8 Switch on drive

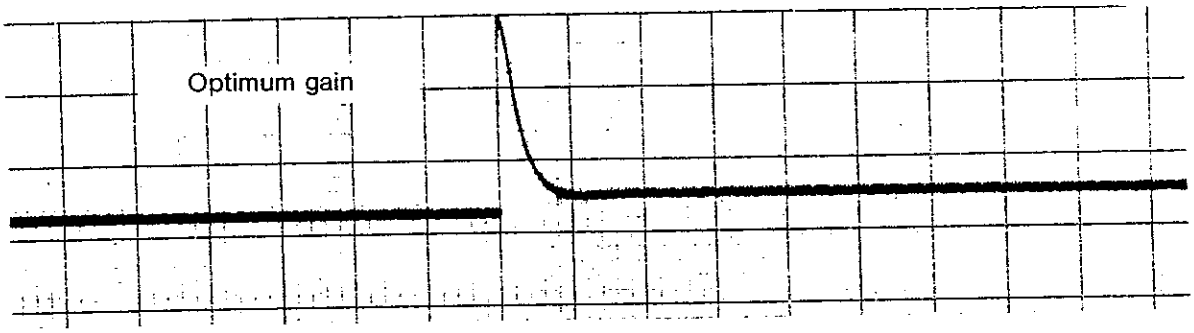
3.4.9 Set speed

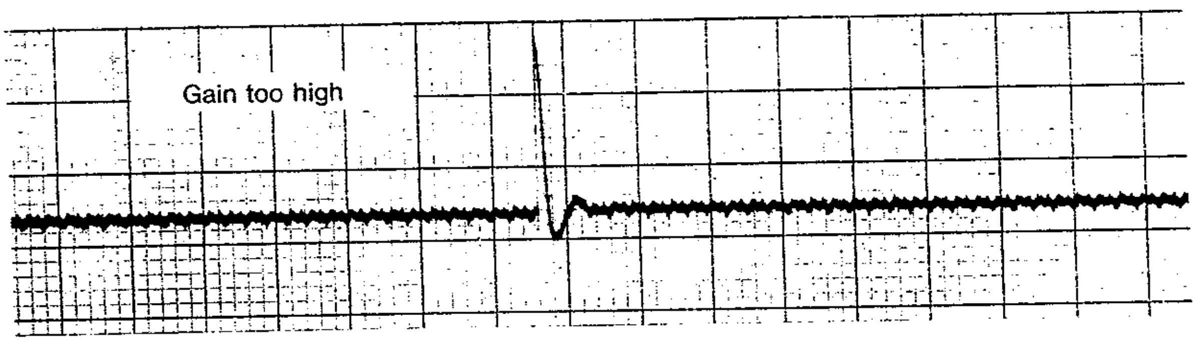
- Raise voltage of battery box 2 until motor runs at approximately 20 to 30% of base speed
- Raise voltage of battery box 1 until speed rises by approximately another 5%

3.4.10 Optimising of speed controller, first step

- Switch off voltage from battery box 1 and switch on again. Record change of speed controller output voltage.
- Adjust gain of speed controller on potentiometer R2 until desired optimum response is obtained. Characteristic of potentiometer R2 is similar to that of potentiometer R5 for current controller gain (see para. 3.4.5).



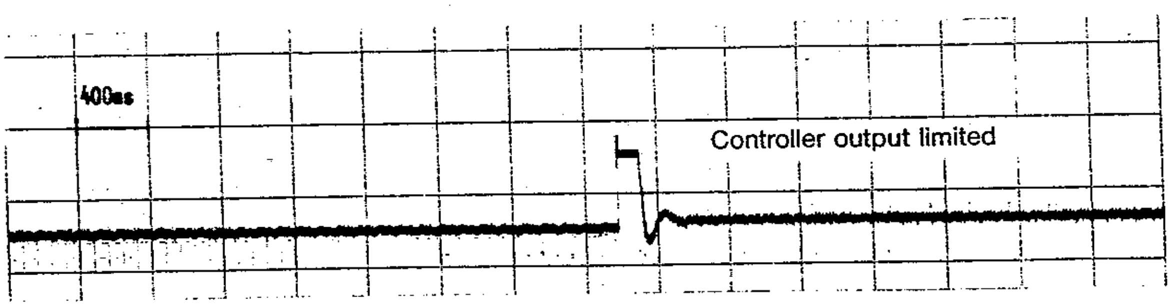




With single-quadrant drives only the excursion in the direction of speed increase is of significance because of the absence of regenerative braking.

- If thr range of potentiometer R2 should be too short, change resistor R15 on circuit board A1.
  Higher resistance . . . increased gain.
  It is recommended to proceed in steps of 1:5 (for example 56 kΩ → 270 kΩ).

  Note: With increasing gain the speed controller output could run up against its limit when the step change is applied. Should this happen, reduce the voltage from battery box 1.



Should the increased speed controller gain cause rapid oscillations, as shown in para, 3.4.15, note the comments there.

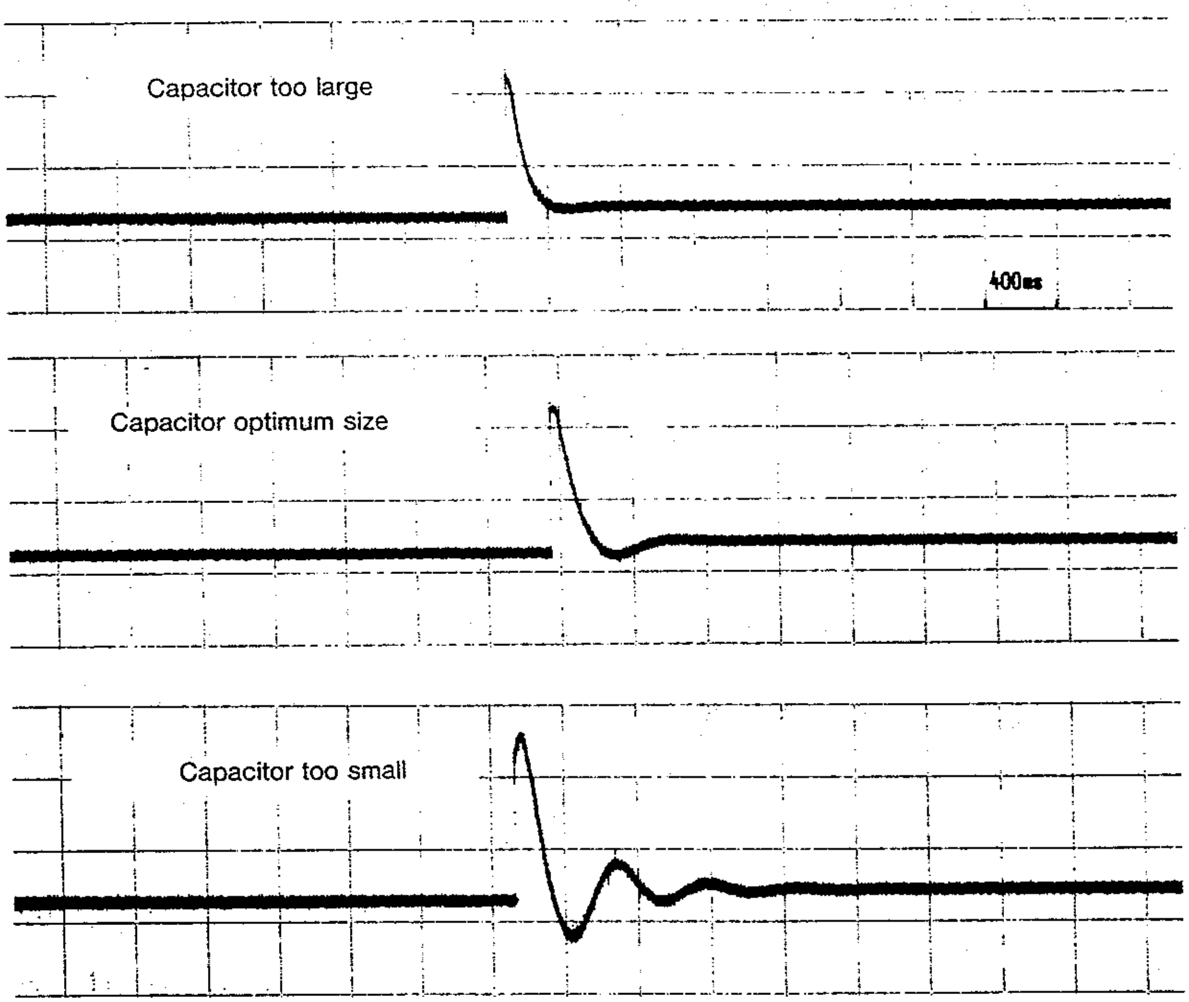
3.4.11 Switch off drive

3.4.12 Remove shorting connections across C3.

3.4.13 Switch on drive, set speed in accordance with 3.4.9.

3.4.14 Optimising of speed controller; second step

- Switch off voltage from battery box 1 and switch on again.
  Record speed response on high-speed recorder.

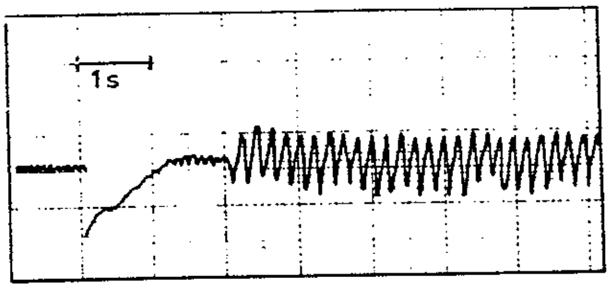


With capacitor C3 no longer shorted out, this voltage no longer represents the actual difference between speed reference and feed-back signals. However, it can be used as a criterion for the response of the controller.

- If necessary, capacitor C3 will have to be changed.
  Increased capacitance . . . more stable response.

3.4.15 Adjusting smoothing of speed feed-back signal

If the drive inertia is heavy and the power transmission between motor and driven machine contains lost motion or flexible members (coupling, gearing), it is possible that the smoothing provided for the speed feed-back signal (Capacitor C1 on circuit board A1) is insufficient. This leads to hunting of the drive, the speed oscillations appearing approximately as shown below.



f ~ 5,5Hz

The frequency generally lies between 3 and 25Hz

It is not so much the load inertia which hunts but mainly the motor, because of the lost motion in the power linkage.

This can lead to mechanical damage.

Hunting can be stopped either by

- a reduction of the speed controller gain to approximately half of that at which hunting commences or
- increasing the smoothing of the feed-back signal by increasing capacitor C1 (on A1). After every increase of C1, the speed controller gain has to be readjusted in accordance with 3.4.10.

3.5 PRECAUTIONS TO BE TAKEN WHEN HANDLING MOS-CIRCUITS

MOS-circuits are easily affected by pick-up voltages or static potentials; inputs and outputs therefore contain protective features which form part of the integrated circuits.

Never-the-less, it must not be overlooked that plastic flooring materials, non-conducting work surfaces or seats and clothing containing man-made fibres can become charged to an extent which can endanger these citcuits.

Machinery or tools which come into contact with these circuits must all be at the same potential. The work surfaces and the operators who handle these circuits should also be at this potential.

Never insert or remove MOS components into or from holders which are live.

When inserting MOS-circuits into equipment it is essential that the limiting parameters are observed. It is also recommended that the soldering iron is earthed through a high-ohmic resistance.

With p(n)-channel MOS-components no positive (negative) voltages relative to the substrate termination U_{SS} must be applied to any component termination.

If it is likely that during the electrical operation of the MOS-circuits pick-up voltages could reach its terminations, it is essential to ensure that none of the maximum permitted voltages are exceeded. Inparticular, voltages U_{DD}-U_{SS} and U_{GG}-U_{SS} should be bridged as near to the component as possible by capacitors with low impendances at high frequencies.

Pick-up voltages which can assume positive values relative to U_{SS} must be clamped by suitable diode circuits.

4. FAULT FINDING PROCEDURE

4.1 GENERAL OBSERVATIONS

The fault findings procedure outlined below deals with a number of fault symptoms. It is based on the following assumptions:

- The SIMOREG Compact convertor is used to provide the armature supply of a speed-controlled dc motor drive, connected in accordance with the typical external circuit diagram shown in para. 2.3.4;
- The drive had been satisfactorily commissioned and had been operating.

Checking must be carried out step by step in the stated order until abnormal behavior is discovered. Should this point to a fault in the convertor, proceed from then on as stated in the "Testing Modules" section.

The instruments required for fault finding are the same as those required for commissioning, namely:

1 Multirange dc voltmeter
0 – 1000 V, internal resistance 100 kΩ/V, suitable for measurements in electronic circuits, e.g. Siemens μA-Multizet;

1 Instrument for measuring ac voltages and currents
0 – 1000 V, 0 – 10 A, internal resistance 1 kΩ/V, e.g. Siemens AVΩ-Multizet;

1 Double-beam c.r. oscilloscope;

1 Battery box
with potentiometer for adjusting injection voltage (0–10 V);

1 Continuity tester (with battery).

4.2 DRIVE FAILS TO START

4.2.1 Check supply at the inputs to the power and control sections

If supply is absent or voltage is too low, check fuses and state of power supply contactor.

If fuses have blown, replace by new ones and switch on again. Should fuses blow again, proceed as under para. 5 of the "Testing Modules" section.
Only consider a low supply voltage as being the cause of the fault if LED V102 lights up (controllers blocked).

4.2.2 checking controller enabling

Voltage between terminals 18 and 8 against M (terminals 5, 6) must be approximately +24 V.

If voltage at terminal 15 is absent or too low, yet correct at terminal 8, check external control circuit contacts.

If voltage is absent or too low at both terminals 15 and 8, check in accordance with para. 5.3.1 of the "Testing Modules" section.

4.2.3 Checking speed reference

Voltage at terminal 11 must be negative relative to M (terminals 5, 6). If necessary, turn up speed reference potentiometer (0 V corresponds to stand-still, −10 V to maximum speed).

If no voltage at terminal 11, check voltage at terminal 9 relative to M: should be approximately −10 V.

If voltage at terminal 9 is correct, check potentiometer circuit for possible breaks.

If no voltage at terminal 9, carry out check in accordance with para. 5.3.1 of "Testing Modules" section.

4.2.4 Checking speed controller output voltage

With speed controller enabled and maximum speed reference applied, polarity of voltage on solder link ch-ci on circuit board A1 must be positive relative to M.

If polarity is negative or voltage is zero, and cannot be made positive by clockwise turning of potentiometer R3, carry out checks in accordance with para. 5.3.5 of the "Testing Modules" section.

If clockwise movement of R3 is effective, repeat current limit adjustment procedure in accordance with para. 3.2 of the "Commissioning Instructions".

4.2.5 Checking current controller output voltage

If drive fails to start, yet current controller is functioning properly, solder link dh-di must carry positive potential. If not, carry out checks according to para. 5.3.4 of the "Testing Modules" section.

4.2.6 Checking voltage across load terminals of convertor

If voltage at terminal 1C is positive relative to 1D, check power circuit for breaks. Otherwise carry out checks in accordance with para. 5 of the "Testing Modules" section.

5. TESTING MODULES

5.1 GENERAL OBSERVATIONS

The instructions contained in this section should lead to the detection of faulty modules, circuit boards, or even larger components such as thyristors so that they can be replaced. They are not intended to permit the exact location of a fault in a circuit board, so that this can be repaired.

The following instruments are required for these tests:

1 Multirange dc voltmeter
0−1000 V, internal resistance 100 kΩ/V, suitable for measurements in electronic circuits, e.g. Siemens μA-Multizet;

1 Instrument for measuring ac voltages and currents 0−1000 V, 0−10 A, internal resistance 1 kΩ/V, e.g. Siemens AVΩ-Multizet;

1 Double-beam c.r. oscilloscope;

1 Battery box
with potentiometer adjustment of injection voltage (0−10 V);

1 Continuity tester (with battery).

5.2 POWER SECTION

5.2.1 Thyristors V1 – V6

In most cases, faulty thyristors have lost their blocking ability and conduct in both directions.

Test:

- Switch off supply to power and control sections
- Open armature circuit (at terminals 1C or 1D)
- Use continuity tester to check that every thyristor blocks in the direction from anode to cathode (terminals 1U, 1V, 1W relative to terminals 1C and 1D, respectively) as well as in the opposite direction.

With healthy thyristors the tester should record infinitely high resistances.

To replace a faulty thyristor (with all supplies switched off), withdraw all plug connections and break all screw connections. Withdraw the faulty module and replace with a new one. Before inserting a new module, carefully inspect all contact faces, as well as the heat sink for damage and deposits. Also, if possible, coat the contact faces with a smear of a heat-conducting medium (e.g. "Heat Conducting Paste", petroleum jelly, or the like). After about two hours retighten all screws.

Other faults (e.g. failure to conduct) can be detected by means of tests in accordance with paragraphs 5.2.2 and 5.2.3 of this section.

5.2.2 Firing pulse transmitting circuit board

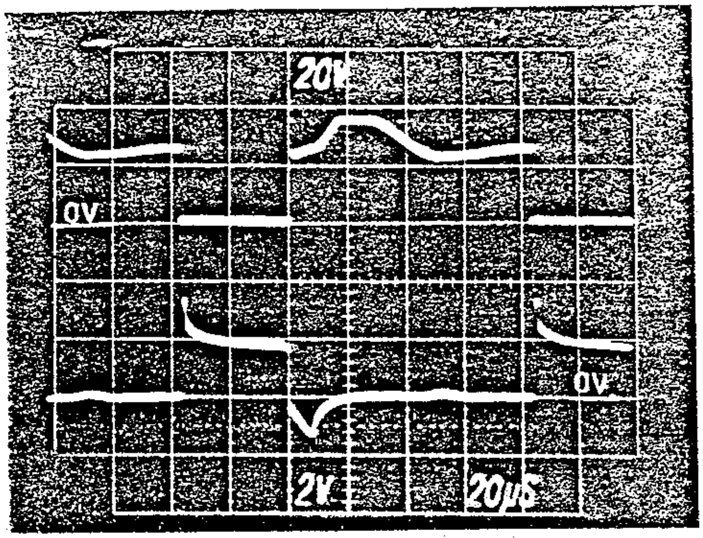
This circuit board can only be checked provided the tests according to paragraphs 5.2.1 and 5.3.3 of this section proved the relevant circuits to be healthy.

Note: When carrying out the tests described below, the oscilloscope may be live! The usual precautions must therefore be taken (connecting via isolating transformer, etc.).

The test procedure is as follows:

- Mains supply connected only to control system and controllers enabled;
- Connect double-beam oscilloscope as follows:
  beam 1 input successively to board A1 pins +R, –T, +S, –R, +T, –S relative to terminals 4, 5 or 6 (controller –M) = input pulse;
  beam 2 input successively to the associated pulse transformer outputs (e.g. for +R: plug G1 and +; for –R: plug G4 and R) = output pulse.

With healthy pulse transmitters the oscilloscope traces should look something like this:

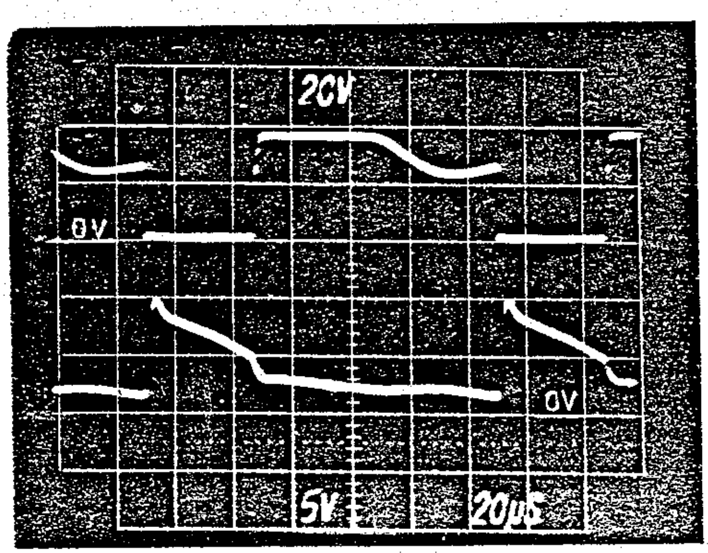


Input pulse

Output pulse (amplitude 1 to 5 V depending on type and specimen)

The illustration below shows the change in the output pulse trace (with input pulse as above) with broken gate connection.

If the fault cannot be located in the external connections, change the respective thyristor module (see para. 5.2.1.



Input pulse

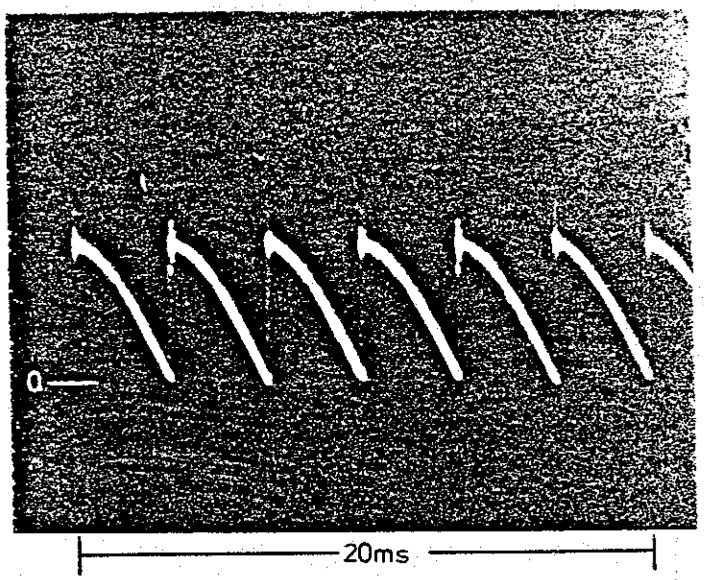
Output pulse

If the output pulse is absent, change circuit board A4.

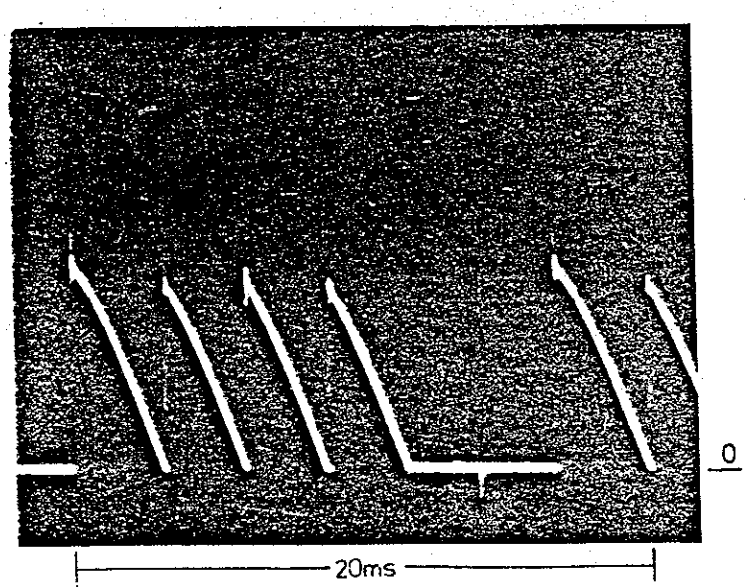
5.2.3 Testing of complete power section

This test can only be carried out provided no faults were found during the tests described in para's. 5.2.1, 5.2.2 and 3.3.

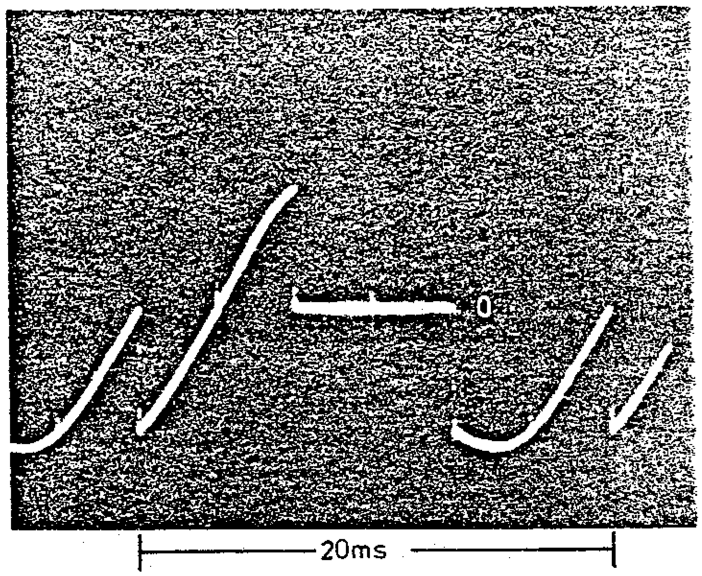
- Disconnect mains supply to power and control sections.
- Open armature circuit (terminal 1C or 1D); temporarily connect a dc ammeter and a suitable resistance across the output terminals (e.g. two heater elements 220V, 10A, in series).
- Open link dh–di on circuit board A1 and connect a battery box between pin di (positive pole) and terminal 4 (–M); set voltage to +10V.
- Switch on mains supply to both sections, reduce voltage from battery box until a dc current of at least 5A flows.
- Connect oscilloscope between terminals 1C and 1D; a trace somewhat similar to the illustration below should appear.



If one thyristor fails to fire, the following trace will be seen:

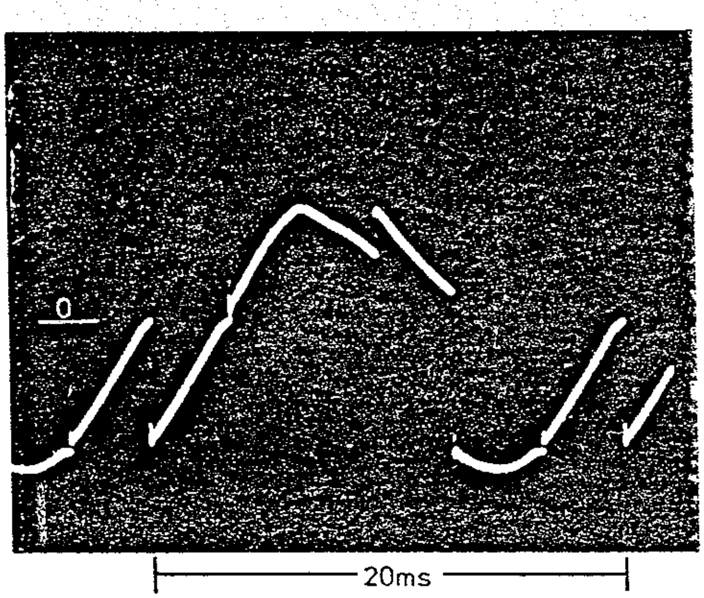


To determine which thyristor is faulty, check the anode-cathode voltage of every thyristor.



Thyristor healthy

(120°-voltage is zero; i.e., the thyristor conducts current).



Thyristor faulty

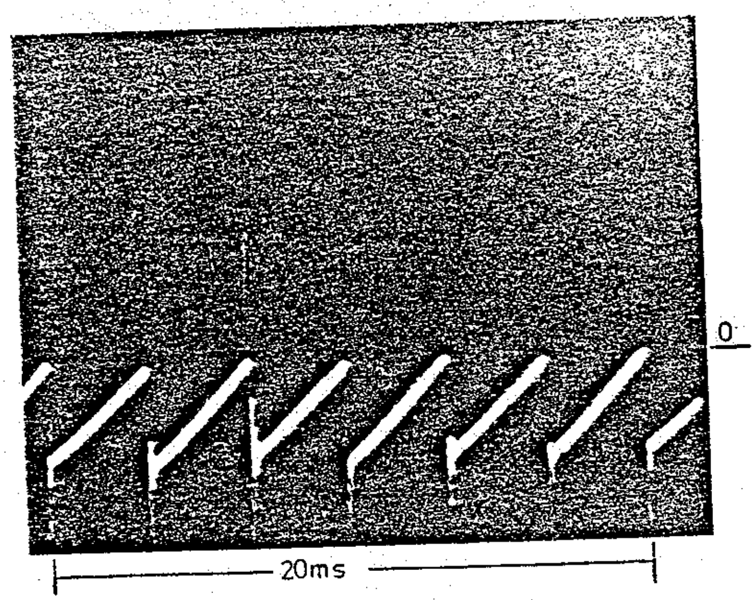
(voltage is never zero; i.e., thyristor never conducts).

The respective thyristor module must be changed (see para. 5.2.1).

All traces were recorded with the same control angle.

To check the current feed-back source:

– Connect oscilloscope between link cf–cg on board A1 and terminal 4 (controller M). With the control angle as above, the voltage trace should look like this:



If the trace is radically different, use a continuity tester and check as follows (mains supply disconnected!).

– Connection between c.t.'s T1 and T2 and board A1;

– Connections to diodes V13 to V18 on board A1;

– Inspect burden resistance R51 on board A1.

5.3 ELECTRONIC CIRCUIT BOARD A1

If this circuit board has to be changed, the new one must be prepared to become identical with the old one. This applies particularly to solder links and resistances and capacitors which may have been changed in the speed and current controller circuits during commissioning. Potentiometers R1 ($n_{feed\text{-}back}$), R2 (G $prop_n$), R3 ($+i_{max}$) and R5 (G $prop_i$) and also, if used, R4 ($-i_{min}$) must be set according to their scale settings on the old board. If speed holding accuracy is of great importance, the convertor output voltage will have to be readjusted (R1) as per para. 3.1.10 of the "Commissioning Instructions". All other potentiometers must be left as set at the works unless they have been inadvertently moved. Should that have happened, the complete commissioning procedure will have to be repeated.

5.3.1 Power supply

To check this, the following dc voltages should be measured
(with rated 380V supply applied):

			Tolerances
Terminal	8	P 24 = +24V	+22 ... +26,5
	2	N 24 = −24V	−22,5 ... −27
	7	P 15 = +15V	+14,3 ... +16,8
	3	N 15 = −15V	−14,3 ... −16,8
	18	P 10 = +10V (link dz-ah fitted)	+ 9,25 ... +10,85
	9	N 10 = −10V	− 9,25 ... −10,85

If any of the above quoted voltages should be found to be outside tolerance, replace circuit board A1.

5.3.2 Controller enabling

This test is only possible provided no fault was found during test 5.3.1 above.

For the tests on "Test Plug" X103 (located next to LED V102) as described below, it is necessary to disconnect any attached interconnecting lead to a supplementary circuit board or alternatively use the parallel plug on the supplementary circuit board.

Checking enabling function

– Connect mains supply only to control section, do not enable controller (if necessary, disconnect lead to terminal 15).

– Measure voltage on pin 15 of plug X103; it should be approximately +13 to +15V.

– Enable controller (apply a voltage of +12 to +30V to terminal 15).

– Check voltage on pin 15 of plug X103; it should now be approximately −13 to −15V.

Checking phase rotation monitoring circuit

– Isolate drive and interchange two phases of the supply to the control section; switch on and enable controller.

– LED V102 should light up, voltage on pin 15 of plug X103 should be about +13 to +15V.

Checking phase-failure alarm

– Disconnect one phase lead in the supply circuit to the control section, switch on supply, enable controller.

– LED V102 should light up, voltage on pin 15 of Plug X103 should be about +13 to +15V.

If the voltages measured differ from those quoted above, change circuit board A1 (see Section 3).

5.3.3 Firing pulse generator

This test can only be carried out provided no faults were found during the tests described in para's. 5.3.1 and 5.3.2.

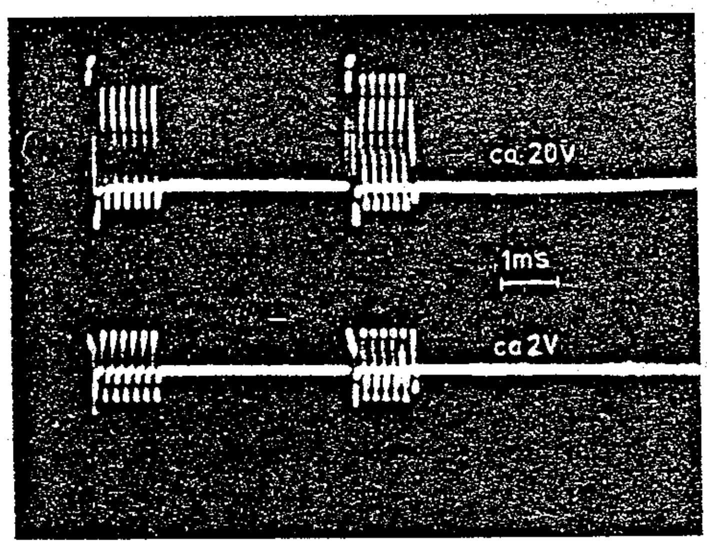
– Open link dh-di on board A1.

– Switch on mains supply to control section only, enable controller.

– Connect battery box to pin di on circuit board A1, set voltage between pin and terminal 4 (controller M) to 0V.

– Connect oscilloscope input 1 as per para. 3.3.3 of the "Commissioning Instructions" section; the trace should appear similar to that in para. 3.3.4 of the above section.

– Connect the second input of the oscilloscope first to +R and then in succession to –T, +S, –R, +T and –S; the pulses must move in equal 60° steps to the right. By stretching the trace it is possible to discern the individual pulses of the pulse train (see illustration below). If the trace differs from the illustration, change board A1.



– Slowly raise voltage of battery box to +10 V relative to terminal 4 (controller M). This will cause the pulses to be shifted to the right by about 150° (=+9,6 V). From then on, the pulses become narrower and eventually disappear at approximately +10,5 V.

– Connect the second input of the oscilloscope again to +R and then in succession to –T, +S, –R, +T and –S; the pulses must move in equal 60° steps to the right.

Should pulses be missing or their shape differ from that shown in the illustration or their space be not 60°, change board A1.

5.3.4 Current controller

This test can only be carried out if no faults were found during the tests described in para's.5.3.1 and 5.3.2.

- Remove links ch-ci, cf-cg, dh-di and cy-cz.
- Short out capacitor C6.
- Switch on supply to control section and enable controller (+12 to +30V to terminal 15).
- Turn potentiometer R5 to the right end stop (applies only to units with diagram references ... −L5 to ... −L6).
- Connect battery box between ci and terminal 5/6 (M) and vary voltage from positive to negative values. Measure controller output voltage between dh and terminal 5/6.

  The output voltage must retain its relationship to the input voltage except that its sign is reversed. This means:

Input		Output
0	...	0
negative	...	positive
positive	...	negative

The ratio output-to-input voltage depends on the resistance of R22. We have:

$$\frac{\text{Output voltage}}{\text{Input voltage}} = \frac{\text{R22 (in k}\Omega)}{6} \ (\pm 5\%)$$

e.g. with R22 = 22k and 1V input voltage

$$\text{Output voltage} = (22/6) \cdot 1\text{V} = 3{,}6\text{V}$$

The maximum obtainable output voltage should be approximately ±10,5V.

- Adjust the battery box voltage so that the output voltage is +10V.
- Turn potentiometer R5 to its left end stop (applies only to units with diagram references ... −L5 to ... −L6). The output voltage must steadily decrease to 0,4–0,5V.
- Leave battery box potentiometer setting as above and transfer connection from ci to cg. The output voltage must again be 0,4 to 0,5V.
- Set battery voltage to −0,1V. Leave R5 at its left end stop (applies only to units with diagram reference ... L5 to ... −L6).

– Remove shorting connection from C6.

The output voltage must rise smoothly to its maximum value of approximately 10,5 V. The rise time depends on capacitor C6; it is (in seconds) approximately C6 (in µF) x 13,6 (±20%).

– Refit links dh-di and cy-cz.

– Set battery voltage to −10 V. Turn potentiometer R6 through its full range (first note scale setting and reset potentiometer to this setting after test).

It must be possible to vary the output voltage from approximately +7 to +10 V.

– Set battery voltage to 10 V. Turn potentiometer R7 through its full range (first note its scale setting and reset it to this setting after test).

It must be possible to vary the output voltage from approximately 0 to 3,5 V.

– Remove controller enabling signal.

The output voltage must now settle to the value at which it had previously been set by potentiometer R6 (provided link de-df is fitted).

If it is not possible to obtain the above voltages, change R22 or C6, respectively, in those cases where these components are of importance.

In all other cases or when changing these components does not result in an improvement, change board A1.

5.3.5 Speed controller

This test can only be carried out if no fault was found during the previous tests described in para's. 5.3.1 and 5.3.2.

– Disconnect leads to terminals 10 to 13.

– Short out capacitor C3.

– Turn potentiometers R2 and R3 to their right-hand end stops.

– If links cp-cs and cu-cv (or cu-ct) are fitted, turn potentiometer R4 to its left-hand end stop.

If links co-cp and cu-cv are fitted, turn potentiometer R4 to its right-hand end stop.

– Switch on supply to control system and enable controller (apply +12 or +30 V to terminal 15).

– Connect battery box between terminals 11 and 5/6 (M) and vary voltage from positive to negative values. Measure controller output voltage between ch and terminal 5/6.

The output voltage must retain its relationship to the input voltage but must be of opposite polarity.

e.g.	
input 0 . . .	output 0
negative . . .	positive
positive . . .	negative

The ratio of output-to-input voltage depends on the resistance of R15. We have:

$$\frac{\text{Output voltage}}{\text{Input voltage}} = \frac{\text{R15 (in k}\Omega)}{2} \quad (\pm 5\%)$$

The maximum obtainable output voltage must be approximately ±10 V.

Note: If link co–cr is fitted, the output voltage cannot go negative; the setting range is then 0 to +10 V.

- Transfer battery box connection from terminal 11 to terminal 10 and repeat the previous test (but only if input to terminal 10 is used operationally). We have:

$$\frac{\text{Output voltage}}{\text{Input voltage}} = 22 \times \frac{\text{R15 (in k}\Omega)}{\text{R48 + R49 (in k}\Omega)} \quad (\pm 5\%)$$

- Transfer battery box connection from terminal 10 to terminal 13 and repeat the previous test with potentiometer R1 first moved to left end stop (only applies to units with diagram references . .-L5 to . . -L6). We have:

$$\frac{\text{Output voltage}}{\text{Input voltage}} = 5 \times \frac{\text{R15 (in k}\Omega)}{\text{32 + R8 (in k}\Omega)} \quad (\pm 5\%)$$

  Turning potentiometer R1 in a clockwise direction (applies to units with diagram references . . . -L5 to . . . -L6), must cause the output voltage to decrease to approximately 1/3 of its previous value.

- Change battery box connection to terminal 11 and set output voltage of speed controller to +10V (potentiometer R2 still remaining at its right-hand end stop).

- Turn R2 to its left-hand end stop.
  The output voltage must decrease gradually to 0.4 – 0.5V.

- Set battery box voltage to –0.1V; leave R2 at its lefthand end stop.

- Remove shorting connection from C3.
  The output voltage must rise smoothly to its maximum value of approximately +10.5V. The rise time depends on capacitor C3. We have:

$$\text{Rise time (in seconds)} \sim \text{C3 (in } \mu\text{F)} \times 4.4 \quad (\pm 20\%)$$

- Set battery box voltage to –10V and slowly turn potentiometer R3 counterclockwise. The controller output voltage must smoothly fall from +10V to 0V.

- Set battery box voltage to +10V. If link co–cr is fitted, the speed controller output voltage must be 0. If links co–cp and cu–cv are fitted, turn potentiometer R4 slowly counterclockwise. The output voltage must smoothly fall from –10V to 0.