TYRECT C

ASEA DRIVES

Three phase thyristor convertor (230-400 A)
types YGMM and YHMM
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types YGMM and YHMM

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DESCRIPTION

GENERAL

The TYRECT C converter for three-phase connection, type YG(H)MM is an advanced thyristor converter in modular form, for d.c. drive systems up to 248 kW.

The converter is intended for the supply of separately excited d.c. motors in drive systems in which a high degree of reliability and current and speed control accuracy is required.

Fig. 1  Block diagram - YGMM

Fig. 2  Block diagram - YHMM
FUNCTION DESCRIPTION

Reference inputs

Four inputs are available for connection of external references.

Two high-ohm summation inputs are coupled via an operational amplifier. One of the other inputs is coupled to a differential amplifier. This can be used alternatively as a reference input for 0 (or 4) - 20 mA, sign inverter or buffer amplifier. The remaining input is provided with a trim potentiometer for signal interfacing.

This reference signal can be directly connected to the speed controller input via strap S1:1-2 but is also permanently connected to an input on the ramp generator. The reference input has a connection point in common with the output of the ramp generator and can therefore not be used as a direct input to the speed controller while the input “SP REF 1” is utilized via the ramp generator. Note that the straps S1:1-2 and S1:3-4 are not to be connected at the same time.

“SP REF 3”:
Reference 3 is connected to X1.6. The input consists of a potentiometer with resistance 10 kohm to 0 V. This output is connected to a 440 kohm direct input to the speed controller. The sensitivity of the input is therefore 0 - 20 % of the sensitivity of the other inputs. The time constant in the low-pass filter is approximately 24 ms.

“SP REF 4”:
Reference 4 is connected to X1.4-5. The input is a differential input to an amplifier and is primarily intended for connection of reference signals from current generating transducers. Two parallel-connected shunt resistors each of 1000 ohm are located directly between X1.4 and X1.5 which means 10 V over the differential input with a 20 mA current signal.

The differential amplifier has gain 1 and its output signal which via strap S1:7-8 is connected to the speed controller input thus becomes 10,0 V with a 20 mA input signal.

Certain types of current generating transducer give a 4 - 20 mA output signal. The potentiometer input X1.6 can then be utilized for zero balancing.

The shunt resistor is installed on solder posts and can be exchanged if necessary.

The amplifier output is connected to terminal output X1:7.

In addition to the application described, the amplifier can be used as:

1) Differential amplifier with voltage input after the shunt resistors have been removed.
2) Sign-reversing amplifier. X1:4 is connected to X1:8 (0 V).
3) Non sign-reversing amplifier. X1:5 is connected to X1:8 (0 V).

With the strap S1:7-8 open, the amplifier output is disconnected from the converter speed controller and can thus be used optionally via terminal X1:7. The resistance of the load is to be > 2 kohm.

Fig. 3

“SP REF 1”:
Reference 1 is connected to X1.2 (or X31:4A).
The input is loaded with 47 kohm to 0 V.
The signal is applied directly to an amplifier coupled as a voltage follower (GAIN = 1). The signal is filtered in a low-pass filter with time constant 10 ms.
The reference signal can either be connected directly to the speed controller input via strap S1:5-6 or via the ramp generator by moving the strap S1:13-14 to S1:11-12.

“SP REF 2”:
Reference 2 is connected to X1.3. The input has the same design as “SP REF 1” but the filter time-constant in the low-pass filter is here 22 ms.
"Rampdon": As previously named, the reference 2 (X1:3) is connected either individually or together with reference 1 (X1:2) to the ramp generator.

The basic version of the ramp generator has an adjustable ramp time between 0.4 and 8 seconds. The ramp time is set with potentiometer "TIMD". By replacing capacitor (C31), mounted on solder posts, the ramp time can be changed as follows:

<table>
<thead>
<tr>
<th>Value of C31</th>
<th>0.1 μF</th>
<th>1.0 μF</th>
<th>4.7 μF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ramp time</td>
<td>40 ms - 0.8 s</td>
<td>0.4 - 0.8 s</td>
<td>1.9 - 40 s</td>
</tr>
</tbody>
</table>

The times given apply for a 10 V change of the output voltage from the ramp generator.

When the converter output is reduced, the ramp generator output voltage is forced to zero.

Feedback input

---

For measuring the current speed, a needle instrument (0 - 10 V, R1 = 2 kohm) can be connected to the output of the buffer amplifier via terminal X1:11 and X1:8 (0 V).

The following table shows the setting range of the voltage divider:

<table>
<thead>
<tr>
<th>Straps removed</th>
<th>Tachometer voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10 V</td>
</tr>
<tr>
<td>S2:9-10</td>
<td>14 - 24 V</td>
</tr>
<tr>
<td>S2:9-10, 7-8</td>
<td>22 - 52 V</td>
</tr>
<tr>
<td>S2:9-10, 7-8, 5-6</td>
<td>40 - 120 V</td>
</tr>
<tr>
<td>S2:9-10, 7-8, 5-6, 3-4, 1-2</td>
<td>90 - 320 V</td>
</tr>
</tbody>
</table>

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Speed controller

---

Function principle

The speed controller is built up as a conventional controller with a PID characteristic. The gain in the controller is adjusted with the potentiometer "GAIN" and can be adjusted from 1 to 40. Both resistor (P-section) and capacitor (integration section) in the controller feedback circuit are installed on solder posts and can be replaced with components of other values if necessary. They are normally 100 kohm and 4.7 μF which means that the integration time constant is 0.47 s.
"PHASE LEAD"

The derivation circuit is parallel with the input circuit for the tachometer signal of the speed controller. Its gain (0.3) is adjusted with the potentiometer "PHASE LEAD". The capacitor in the deri-
vation circuit, which normally consists of a resistor of 47 kohm and a capacitor of 1 μF, is mounted on solder posts and can therefore be replaced as required.

Current limit

The output voltage of the speed controller which constitutes the current reference can be limited with potentiometers "LIM 1" (positive output signal) and "LIM 2" (negative output signal). For single conver-
tors, the potentiometer "LIM 1" is set in position 0 whereas potentiometer "LIM 2" is set in a position which corresponds to the required current limit.

Current derivative limit

A d.c. motor has a limited capacity to withstand rapid changes of current. A modern motor with laminated stator is in this respect better than one with a homo-
genous stator ring. Because of this, the speed con-
troller is provided with a circuit which limits the speed of change of the current reference and thereby the current derivative of the motor.

In its normal version, this circuit is dimensioned to limit the current reference derivative to approxima-
tely 100 V/s. This corresponds to 20 times the rated current of the motor per second provided that the current response signal is adjusted so that 5.0 V corresponds to the rated current of the motor.

If another value is required, resistance R47, mounted on solder posts (150 kohm on delivery), can be changed.

\[
R47 = \frac{1}{u^1} \times \frac{1.5}{10^{-7}}
\]

R47 = resistance value in ohms

U^1 = current reference derivative in V/s.

With current response signal 5.0 V corresponding to the rated current of the motor, the current derivative limit becomes

\[\frac{U^1}{5.0}\] times the rated motor current per second
Function principle

The current controller is built up as a PI controller with double feedback circuits, one functioning in a circuit for automatic gain adaption (adaptive controller). The output signal from the current controller constitutes the control voltage "CONTR VOLT" to the trigger pulse unit. The control voltage can have signal levels between approximately +10 V and -10 V.
Adaptive control

The function principle of the double converter YHMM is that the direction of the direct current is determined by the polarity of the "CUR REF". Negative polarity is defined as the forward direction.

As the current feedback can only have positive values (as a result of the design of the current measurement circuit), the sum of the current references must always be negative. When the current reference "CUR REF" becomes positive, the sign-reversed signal "CUR REF 2" is connected to the current controller via an input resistor of 90 kohm which constitutes half of the input resistance for "CUR REF". The sum of "CUR REF" and "CUR REF 2" is therefore always in agreement with the negative absolute value of "CUR REF".

Connecting of "CUR REF 2" is performed by the pole reversal logic on the pulse transformer board YXU (157, 163).

Inhibition

When the output of the converter is reduced, the current controller output is forced to its maximum negative value by applying a powerful positive (+ 15 V) signal at its input.

In double converters YHMM, inhibition of the current controller is activated during each pole reversal by means of the signal "BLOCK-N" from the blocking unit on the pulse transformer board YXU (157, 163).

Trigger pulse generation

Function principle

The purpose of the trigger pulse unit is to convert the analog control voltage "CONTR VOLT" to trigger pulses with such a phase position that the d.c. voltage $U_d$ becomes proportional to the control voltage (with continuous current).
Delay angle

Trigger pulses, 120° long, are obtained after logical signal processing of the pulses, as described above, in an ASEA manufactured LSI circuit, each trigger pulse consisting of a high frequency (100 kHz) pulse train. The pulses are amplified then in a transistor driver before supply to the pulse transformer board YXU (156, 157, 162, 163).

Synch voltages

Fig. 10

The generation of the a.c. voltage for mains synchronization of the trigger pulses begins by measuring the main voltages L3 - L2 via the single phase synch. transformer. A phase-correct 6-phase system consisting of the synch. voltages L1, -L1, L2, -L2, L3 and -L3 is then obtained by means of a combination of a 30 degree and a 60 degree RC-filter and a number of analog amplifiers. The synch. voltages have a peak value of 5 V.

Phase sequence and under-voltage monitors

Fig. 11

For the trigger pulse unit to function, it is necessary for the convertor to be connected to a three phase mains supply with a correct phase sequence. The TYRECT C therefore has an integral phase sequence monitor which with faulty phase sequence prevents the starting of the convertor by blocking the +24 V supply to the trigger pulse transformers.
In the phase sequence monitor, a voltage in phase with -L2 is first generated by starting with the voltage L3 - L2 from the auxiliary power transformer and phase displacing this 30°. The voltage obtained thus is zero balanced with the correct phase sequence of the synch. voltage L2. With reversed phase sequence an imbalance develops which is detected by the amplifier A13.

In the under-voltage monitor the synch. voltages L1, L2 and L3 are rectified to a three pulse voltage, the level of which is monitored by the level detector A2. The protection operates instantaneously and the tripping level is approximately 75% of the nominal voltage.

The combination, under-voltage and phase sequence monitors, permits detection of incorrect phase sequence, under-voltage and phase failure.

When a fault is detected, a red LED illuminates, the controllers are inhibited and the trigger pulses are blocked via the automatic start-up logic.

Start logic

The start logic manages automatic inhibition on release of the controllers and the ramp unit and blocking of the trigger pulses at switch-on/switch-off the mains voltage when the strap S3:34 is in place.

Function

When voltage is switched on normally, a "clear" signal must be first obtained from the under-voltage and phase sequence monitors after which the relay K1 picks up after a delay of 50 ms. One of the auxiliary contacts of the relay connects +24 V supply to the trigger pulse transformers and the other activates "RDY F REF" of the control equipment.

External inhibition

If external inhibition/release is required, strap S3:34 is removed and an external relay contact is connected between contact X1:13 and X1:14. With respect to the operating sequences, see INSTALLATION.

As indicated previously, an inhibition via the start logic means that the output voltages of the ramp generator and the speed controller are forced to zero volt and that the current regulator output voltage is forced to the negative end position, i.e. the trigger pulses are displaced to the limit position for inversion (β-11m).

Current measurement circuits, current feedback

Measurement principle

The alternating current is measured with current transformers in the phases L2 and L3. The secondary currents can each generate voltages over its lead resistance of 1 ohm. Both of these voltages are rectified in an "ideal" active rectifier with adjustable gain. A current feedback is obtained at the output which is a correct representation of the curve form of the direct current. The current feedback is, however, always positive, irrespective of the direction of the direct current. The variable gain permits adaption of the signal level to the rated motor current. A setting at 5 V at the rated motor current is recommended.

<table>
<thead>
<tr>
<th>Converter current rating</th>
<th>Current transformer ratio</th>
<th>Number of primary turns</th>
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<tbody>
<tr>
<td>40 A</td>
<td>300:1</td>
<td>3</td>
</tr>
<tr>
<td>80 A</td>
<td>500:1</td>
<td>1</td>
</tr>
<tr>
<td>120 A</td>
<td>1000:1</td>
<td>1</td>
</tr>
<tr>
<td>230 A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>400 A</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1) E.g. With 3 primary turns, the resulting ratio is 100:1.

Ammeter

A separate output X1:15, connected to the current feedback via the buffer amplifier A7 is provided for connection of an external ammeter. The signal is filtered.

Zero current sensor

A zero current sensor A7 is provided in connection with the current measurement circuit. When the current feedback is less than approximately 0,2 V, the output signal "CUR > 0" becomes a logical zero. This signal controls the adaptive control regulation and the reversal logic on the pulse transformer board YXU (157, 163).
Voltage supply unit

The voltage supply is obtained from a single phase transformer, the secondary winding of which is provided with a middle tap. The following voltages are obtained from the unit supplying voltage to the electronic units.

- 24 V Unregulated voltage is used for supply of the trigger pulse transformers.
- 24 V
- 15 V Unregulated voltage for external voltage.
- 15 V Regulated voltage from an integrated voltage regulator.
- 15 V
- 6.8 V and -6.2 V Is a zener-stabilized voltage if the control board YXT 121 is one of the generation variants GV1 and GV2. From then after generation variant GV3, an integrated voltage regulator is included.
- 6.8 V and -6.2 V

Only a lesser part of the supply power can be used for external purposes. The current available for external loads is as follows:

The higher values apply from and including the generation variant GV3 (as from mid 1984).

- 24 V: 20 mA, 100 mA
- 24 V: 20 mA, 100 mA
- 15 V: 10 mA, 100 mA
- 15 V: 10 mA, 100 mA
- 11 V: 10 mA
- 11 V: 10 mA

Double converter

Function principle

Each of the six valve branches in the double converter contains two anti-parallel coupled thyristors designated F and B. The thyristors F1 - F6 belong to the "Forward" bridge and B1 - B6 belong to the "Reverse" bridge. The index numbers 1 - 6 indicate the commuting sequence in the bridge.

The double converter works in accordance with the principle that only one bridge at a time is to conduct current. As mentioned previously, the function is based on the polarity of the current reference "CUR REF" determining the direction of the direct current and thereby also which bridge is to be active.

Negative current reference activates the "Forward" bridge and positive activates the "Reverse bridge".

The bridge which is not to conduct current is inactivated by blocking the trigger pulses. The electronics circuits which execute the reversing between the bridges are therefore designated the blocking unit. This function unit is located on the pulse transformer boards YXU (157, 163) which are therefore different from the pulse transformer boards YXU (156, 162) of the single converter.

The double converter works in accordance with the principle that only one bridge at a time is to conduct current. As mentioned previously, the function is based on the polarity of the current reference."

Reversing procedure

Fig. 12

The reversing of the current direction (pole reversal) is briefly as follows, see Fig. 13.

When the speed reference is reduced or changes polarity, the current reference "CUR REF" first falls to 0 and then begins to increase the opposite direction. The current is thereby reduced to zero.

The polarity of the inverted current reference is measured in the blocking unit by the Forward/Reverse discriminator A1. Its change to the new direction is however interlocked by means of a very high hysteresis level until the zero current gate indicates that the interval between the current pulses exceeds 1.5 ms.

At the same time that the Forward/Reverse discriminator switches over, the trigger pulses to the active bridge are blocked via the pole reversal logic and the current then stops. During a transition interval of approximately 8 ms after the trigger pulses block both bridges, the bridge previously inactive is activated by the de-blocking of its trigger pulses. A rapid and reliable reversal can thus be obtained with the converter "dead".

During the transition interval, inhibition of the speed and current controllers is obtained with the signal "BLOCK-N". This action is taken to obtain a smooth change to the new current direction.
As mentioned in section CURRENT CONTROLLER, a sign-reversed current reference "CUR REF 2" is connected to the current controller when the "Reverse" bridge is active. This function is executed by the analog switch A2 in the blocking unit.
Fig. 13

Measurement terminals

The measurement terminals for the 19 most important signals are assembled in the contact X31 which is intended for connection to the test unit VX1115 or alternatively for connection of process accessories. There is in addition a 19-contact measurement terminal for connection by means of ordinary measurement clamps.

The diagrams in appendices 1 - 4 shows a number of test terminals additional to those mentioned above. These are primarily intended for use when tracing faults and for delivery testing of circuit boards in the workshop. They can be used for detailed fault tracing directly in the converter but care must be taken when making connection because of their small dimensions.
INSTALLATION

The converter is intended for outdoor installation in an ordinary industrial environment with ambient temperatures – 5°C to +40°C. The air is to be free from dust and aggressive gases.

Physical installation

The converter is to be installed vertically with the connections downwards. It can be placed directly on a wall (screen protected) or enclosed in a cubicle. No particular cubicle type or installation procedures are required. The following points should however be observed.

1. The converter module must receive an adequate supply of cooling air.
   The air temperature 10 cm under the thyristor bridge must be less than 45°C for the converter to be loaded in accordance with the ratings.
   Avoid installing the converter over apparatus developing any quantity of heat.

2. Space must be left free 10 cm above and below the converter and 5 cm at the sides.
   The space at the side of fan-cooled 230-400 A converter modules should not be excessive as this can lead to internal circulation of cooling air with unacceptable overheating as a result.

3. The free passage for cooling air before and after the converter (cubicle intake and exhaust) should not be less than 500 cm².

Cable routing

Power lines should not be routed closer than 10 cm from the converter module. Signal cables are to be located as far as possible from cables generating interference (e.g. power cables, control cables for contactors and relays). Minimum distance 10 cm. The signal cables are to be screened but the screens need not be earthed.

Earthing

A special clamp is located on the base plate of the converter module for connection to a protective earth.

CONNECTIONS

A.c. voltage

- Three phase a.c. voltage L1, L2, L3 is to be connected to the main circuit. The maximum permissible short-circuiting current (symmetrical rms value) in the mains supply is 50 kA.

- Single phase a.c. voltage is to be connected to the rectifier for field supply.

- 220/230 V single phase voltage is to be connected to the converter cooling fans.

See figure 1.
When several converters are supplied with voltage from the same mains, double converters of Y/YMM type must be connected via phase reactors. The inductance of the reactors is to be approximately 6 µH/phas for connection voltages 220 - 500 V. A suitable reactor unit, can be ordered separately.

Catalogue number 4903 1000 CCM

Note! For converters with 400 A rated current, the reactor unit must be placed 1 - 2 dm above the fans of the converter module or be provided with a separate fan.

Sufficient inductance is obtained if the length of the supply cable from the closest converter is approximately 25 m (220 - 500 V).

The converter connection points are shown in DIMENSION.
Overload protection

The use of a direct on-line starter in the a.c. voltage supply is recommended as overload protection for the motor. The equation used for calculating current when installing the protection is:

\[ \text{Phase current} = 0.82 \text{ d.c. current} \]

Fuses

The converter is to be connected to the mains via a switch and fuses. The fuse capacity selected depends on the rated current of the converter.

<table>
<thead>
<tr>
<th>Rated current</th>
<th>Max fuse</th>
</tr>
</thead>
<tbody>
<tr>
<td>230 A</td>
<td>315 A</td>
</tr>
<tr>
<td>400 A</td>
<td>500 A</td>
</tr>
</tbody>
</table>

Field excitation

Single phase a.c. voltage \( Uv \) up to a maximum of 440 V is to be used.

\[ \text{The rectified field voltage } U_{\text{field}} = \frac{U_v}{1.1} \]

In certain cases, an auto-connected transformer may be needed to adapt the a.c. voltage so that the correct field voltage for the motor concerned is obtained.

The a.c. voltage supply is fused in the conventional way with dialed or equivalent fuses. (If the field current is less than 1.5 A, the auxiliary supply fuses 13 and 14 in the converter, accessible on the connection terminal block, can be utilized).

Convertor fan

The fans are to be connected to single phase 220/330 V, 50/60 Hz. The a.c. voltage is fused in the conventional way with dialed or equivalent fuses.

The fans are provided with integral thermal protection (X4:5-6, X4:7-8) which is to be connected in the operating circuit.

D.c. voltage

The rotor and field circuits of the motor are to be connected to the convertor module in accordance with figure 1.

Control circuit

The speed reference and speed feedback are to be connected to the control board contact, X1, as shown in figure 1.

Speed reference

a) In the simplest cases, a potentiometer is used (5 kohm, 2 W).

b) The inputs SP REF 1 and SP REF 2 are also intended for connection to an external set-point generator with signal level \((-10 \text{ V}) - 0 \text{ V} + 10 \text{ V}\).

c) The inputs SP REF 3 is provided with a potentiometer "LEVEL" which can be used, for example, for setting minimum speed, for RIR compensation with speed control with voltage feedback or for compensation in accordance with point d).

d) Input SP REF 4 is intended for reference generators with signal level 0 (or 4) - 20 mA. With signal level 4 - 20 mA, input SP REF 3 is to be coupled to \(-10 \text{ V}\) and potentiometer "LEVEL" is used for compensation of 4 mA.

Speed feedback

a) With speed control using tachometer feedback, the tachometer is connected in accordance with figure 1. The max. permissible voltage is 330 V. Note the polarity.

b) With speed control using voltage feedback, the use of a voltage measurement device is recommended to isolate the main circuit from the control circuit. The feedback from the voltage measurement device is connected in the same way as the feedback from the tachometer.
OPERATION

Switch-on

No special coupling sequence is necessary as the control equipment automatically adopts a ready-for-run status approximately 50 ms after switching on the supply voltage.

Switch-off/tripping

a) When using a single convertor, YGMM, no special operating sequence is necessary for switch-off/tripping.

b) The following general rules apply for double convertor switch-off operations *):

- Activate the external inhibition via inhibiting relay connected to X1:13-14. See also EXTERNAL INHIBITION.
- Open the main contactor (on-line starter) after a delay of approximately 75 ms or more.

*) An exception can be made from this general rule if the motor in a particular drive is always "dead" or at rest at switch-off/tripping.

External inhibition (X1:13-14)

a) For the convertor, activation of external inhibition means that the trigger pulses are displaced to the limit for maximum conversion and the output voltage from the speed regulator (v = current reference) and the output voltage from the ramp generator are forced to zero volt.

b) An open contact X1:13-14 means inhibition of the convertor. The relay contacts are intended for loading currents less than 3 mA.

c) When external inhibition is used, strap S3 3-4 is to be removed from the control board YXT 121.

d) External inhibition can be utilized for both single and double convertors in drive equipment in which, under certain conditions, the motor is to be disconnected or is to be stopped without operating the main contactor (on-line starter).
Maximum cable areas:

<table>
<thead>
<tr>
<th>Contact</th>
<th>Max cable area mm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>X1: 1-15</td>
<td>2.5</td>
</tr>
<tr>
<td>X4: 1-10</td>
<td>2.5</td>
</tr>
</tbody>
</table>

1) Signal level max. ± 10 V  
Max. permissible load current 10 mA.

2) Relay for external release/inhibition.  
See EXTERNAL INHIBITION.

3) Signal level 0 V - +10 V.  
Max. permissible load current 10 mA.

4) Max. permissible load current ± 10 V = 10 mA.
DIMENSIONS

Convertor module

Holes for M6 screws

Template for fixing screws

Reactor unit

Holes for M6 screws

Template for fixing screws
COMMISSIONING

SAFETY PRECAUTIONS

Danger to personnel

The voltage to the converter is to be switched off when work is being performed in which contact can be made with parts carrying voltage.

- Do not work alone when commissioning the equipment.
- Notify persons working near the machine that it can start without warning.

Danger to equipment

Stationary machines without connected field may not be loaded for more than 10 sec at a time. The current is not to exceed the rated value and between each load, the motor must be turned so that the same segments in the commutator are not loaded.

EQUIPMENT REQUIRED

2 Multimeters 0 - 1000 V d.c. and a.c.
R1 ≥ 10 kohm/ V d.c.. One of the instruments can be of the digital voltmeter type.
1 Set of test leads with contacts of “EZ MINI HOOK” type
1 Potentiometer 10 kohm ≥ 0.5 W for setting of references.

N.B. The converter is prepared for connection of test unit YXO 115, which is recommended both for commissioning and fault tracing. YXO 115 has built-in potentiometers for reference generation and a digital voltmeter for measurement of all important signal voltages. This thereby replaces one of the multimeters.

RECOMMENDED SEQUENCE OF OPERATIONS, CHECK LIST

☐ a. Check the mains connection and the connection of the d.c. machine, rotor, field and tachometer.
   - Check and set any external overload protection.
   - Check the strappings and make suitable presettings of the trim potentiometers.
   - Adjust the current reference to the rated current of the motor.
   - Connect the reference unit (speed reference).

☐ b. Check the polarity reversal (double converters only).

☐ c. Trim the current regulation (without field).

☐ d. Connect field and check the field current.

☐ e. Trim the speed regulation.
   - Adjust voltage or tachometer feedback on strap connector S2.
   - Check the direction of the machine rotation with the field connected.
   - Set the final current limits.
   - Trim the static and dynamic speed regulation.

☐ f. Trim the IR compensation (with speed regulation by means of voltage feedback).

☐ g. Set the ramp-unit.
INSTRUCTIONS, BY FUNCTIONS

Check and presetting

Make the following checks:

- Check that the convertor is connected to the correct mains voltage and that this is within +/− 10% of the nominal value.

- Check also that the convertor is fused with semiconductor fuses.

- The convertor is assumed to be connected to the mains via an external contactor which closes or breaks all voltage. The expressions "SWITCH ON" and "SWITCH OFF" respectively are used for these actions in this document.

- Check that the rotor circuit, field circuit and tachometer are connected correctly.

- An external overload circuit must be set. An overload protection is provided for the convertor fan and is also provided for the main convertor current and a possible fan.

- Check the most important strips on the circuit board YXT 121 with the assistance of the circuit diagram.

Make the following preliminary settings:

- "LEV" (R42) Signal level adjustment. Turn to the extreme anticlockwise position.

- "LIM 1" (R13) Positive current limit. With single convertor (YGMM), turn to 0, i.e. the extreme anticlockwise position. With double convertor (YHM), turn and set at 25% reading approx.

- "LIM 2" (R16) Negative current limit. Turn and set at 25% scale reading.

- "PHASE LEAD" (R140) Deriv. input for speed-actual value. Turn to extreme anticlockwise position.

- "SIGN ADJ" (R7) Adjustment of speed-actual value. Turn to extreme clockwise position.

- If the convertor release circuit (RDY F REP) is connected to an external release switch, this can be short-circuited temporarily during the commissioning by inserting the jumper S3:3-4.

Ensure that the current is zero when "SWITCH OFF" is performed with a double convertor.

Perform a final adjustment as follows:

- "T" (R79) Adjustment of I-actual value. Rotate from one end position to the other and note the anticlockwise end position of the screwdriver slot. Turn then this slot to the scale value (4-10) which corresponds to the rated current of the motor (in amperes) in accordance with the diagram, figure 3.
Fig 3

The purpose of this setting is to ensure that the current actual value "ARM CURR" (X21:31) is 5.0 V with the rated current of the motor.

- Connect the reference generator. For reference generation, a variable d.c. voltage (-10 V - 0 V + 10 V) is connected via an external potentiometer to a vacant input for speed reference, without using the ramp.
- If necessary disconnect the external speed reference. Set the potentiometer so that 0 V is obtained as a reference at switch-on.
- When using the test unit YXO 115, connect the ribbon cable to the connector X31 on YXT 121 (A, B).

Polarity reversal (Double convertor)

Fig. 4 Pulse transformer unit YXU 163 A
With a double converter (YHMM), check that the current can go in both directions. Follow first the following procedures.

a. Disconnect the field.
b. Lock the machine rotor as required.
c. Proportional connect the speed regulator by short-circuiting the capacitor C4 on YXT 121 (A, B).

"SWITCH ON" the converter and vary carefully the reference connected between positive and negative. Check that the converter reverses polarity.

When using the test unit YXO 115 a visual indication of polarity reversal is obtained by activation and deactivation of the LED "FWD CUR".

**Trimming of current regulation**

For adjustment, the components R60 (P-section) and C16 (I-section) can be removed with a soldering iron as they are mounted on solder posts on YXT 121 (A, B).

The following should be remembered with this trimming:

a. The field is to be disconnected and the field winding of the motor is to be short-circuited.
b. Lock the motor of the machine if appropriate.
c. Reference is given via the speed regulator which is P-connected by short-circuiting the capacitor C4.
d. Make small stepped changes of the reference in the range continuous current. For double converters, one direction is selected. (Check that the converter does not go to the current limit. It may be necessary to increase the current limit.)

**Connection and check of field current**

The converter is to be switched off.

Disconnect the trigger pulses to the thyristors by temporarily disconnecting the ribbon cable connector X33 from the circuit board YXT 121 (A, B).

Connect the field.

Introduce an ammeter in the field current circuit.

"SWITCH ON" the converter and check that the values of field current and field voltage are correct. Note that the resistance in the field winding can increase by 40% when the motor warms up.

If the current needs adjustment, this can be performed with an external serial resistance or by changing the incoming supply voltage.

"SWITCH OFF" the converter and connect the ribbon cable contact X33 on YXT 121 (A, B).

**Speed control with voltage feed-back**

It is assumed that the voltage feedback is received via a voltage measurement unit. With the value 10,0 V for nominal voltage, the following steps are to be closed i.e. S2: 1-2, 3-4, 5-6, 7-8 and 9-10.

Turn the potentiometer "SIGN ADJ" (R7) clockwise to its extreme position.

When trimming, the same procedures can be followed as are given in SPEED CONTROL WITH TACHOMETER FEED-BACK.
Speed control with tachometer feedback

Approximate adjustment of tachometer feedback

Calculate the maximum tachometer voltage using data from the tachometer and the highest speed. Adjust this voltage by strapping in accordance with the table.

<table>
<thead>
<tr>
<th>Tachometer voltage (V)</th>
<th>1-2</th>
<th>3-4</th>
<th>5-6</th>
<th>7-8</th>
<th>9-10</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>-</td>
</tr>
<tr>
<td>14-24</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>-</td>
</tr>
<tr>
<td>22-52</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>40-120</td>
<td>X</td>
<td>X</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>90-320</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

(X = strap connected, = no strap)

If two ranges can be selected, the range for the highest voltage is selected.

The speed regulation is trimmed as follows.

a. Remove any locking of the rotor of the machine.

b. Check that the potentiometer "GAIN" (R44) is at its maximum anticlockwise position.

c. Set the external reference potentiometer to give a speed reference value of approximately 0 V.

d. The speed regulator is assumed to be P-connected in accordance with point TRIMMING OF CURRENT REGULATION.

Preliminary check of controllability

"SWITCH ON" the converter and check that the motor does not begin to race. Be prepared to "SWITCH OFF". Increase the speed reference (to approximately +0.5 V) and check that the motor begins to rotate without racing. If the motor races, i.e. accelerates to top speed, the tachometer feedback or field supply is connected with incorrect polarity.

If the motor races in the correct rotation direction, the tachometer feedback must be reconnected with the correct polarity. If the motor races in the incorrect rotating direction, the field supply polarity must be reversed. If the motor is controllable to all speeds with the reference potentiometer but rotates in the incorrect direction, the polarity of both tachometer and field supply must be altered.

With a double converter, (YHMM) check that the motor is continuously controllable in both directions.

Current limit

It is now appropriate to set the final current limit. "SWITCH OFF" the converter. Disconnect the trigger pulses to the thyristors by temporarily disconnecting the ribbon cable connector X33 from the circuit board YXT 121 (A, B).

Connect a voltmeter to the current reference "CUR REF" (X21:8).

"SWITCH ON" the converter and increase the speed reference to +10.0 V. Then adjust the potentiometer "LIM 2" (R16) so that the current reference is limited to a maximum permissible "current".

\[ U_{\text{X21:8}} = 5 \times \frac{\text{Current limit}}{\text{rated motor current}} \] (V)

In the case of double converters, the speed reference is changed to -10.0 V. Potentiometer "LIM 1" (R13) is then adjusted to the relevant current limit in the same way as for "LIM 2".

When the setting is completed, "SWITCH OFF" the converter and reconnect the ribbon cable connector X33 of YXT 121 (A, B).

Fine trimming of max. speed

Connect a voltmeter to the tachometer feed-back "SP 1" (X1:1). (When regulating the voltage, the motor voltage is measured).

Disconnect the P-connection of the speed regulator by removing the short-circuiting over the capacitor C4.

"SWITCH ON" the converter and increase the speed reference slowly to +10.0 V. Check at the same time that the max. motor speed is not exceeded. Adjust the potentiometer "SIGN ADJ" (R7) so that a maximum speed is obtained.

For a double converter, a check is made that the same speed is obtained in the opposite direction with the speed reference -10.0 V.
Trimming of speed control dynamics

If rapid regulation is necessary the speed control can be trimmed in the conventional way with stepped changes in the reference and observation of the speed actual value (or voltage actual value) on the recorder. Large adjustments for the P-section (R10) and I-section (C4) can be made by soldering new components in place. These components are mounted on solder posts. To damp "overshoot", derivation in the actual value circuit can be introduced by turning the potentiometer "PHASE LEAD" (R140) in a clockwise direction.

On double converters (YHMM) the hysteresis "HYST" (potentiometer R8 on YXU 163 A) is set at 50 % on delivery and normally needs no adjustment. If however the sensitivity, to changes in the current reference of the pole reversal flip-flop is to be changed, this can be done by reducing its hysteresis for the level flip-flop. The pulse transformer unit 163 A is shown in.

POLARITY REVERSAL (DOUBLE CONVERTOR), figure 4.

IR-compensation (with speed control with voltage feed-back)

On single converters, IR-compensation can be introduced by connecting X1:6 and X1:16 on YXT 121 (A and B).

IR-compensation is trimmed as follows:
1. Speed up the motor to the rated speed.
2. Measure the no-load speed accurately.
3. Load the motor so that rated current is obtained (not current limit). The speed then drops slightly depending on the armature reaction and the armature voltage drop.
4. Adjust the potentiometer "LEV" (R42) so that the speed increases to the no-load value i.e. the rated speed.

This trimming means compensation at rated speed. If compensation is required at another speed, the trimming is performed with respect to this.

Setting of ramp

If the speed reference is to go via the ramp unit, the speed is stepped (see circuit diagram). The ramp time is set with the potentiometer "TIME" (R29) in the range 0.4 - 8.0 secs for speed reference 0 - 10.0 V. If other ramp times are required, the capacitor C31 mounted on solder posts must be exchanged.

For further information see the function DESCRIPTION.
FINAL PROCEDURES

Disconnect the variable speed reference used during the commissioning. If any external speed reference has been disconnected, this is now to be connected and strapped correctly.

If an external release switch has been short circuited, with strap S3:3-4 on YXT 121 (A, B) during the commissioning, this strap is now to be removed.

If there are units for external reference generation, master regulation etc., these are to be set and trimmed.

Check that the drive equipment can be controlled as intended.

Tighten all screws in all terminals to their correct tightness.

Check that any soldering has been performed correctly.

Check that the circuits boards are firmly screwed in place.

Make notes in the circuit diagram of any change of straps or components.

Make notes of all the levels set.
PREVENTIVE MAINTENANCE

GENERAL

The converter contains no components subject to mechanical wear. The maintenance therefore mainly consists of preventive maintenance. In addition to the following check points, the converter requires general maintenance to avoid interruption to operations.

This type of maintenance is common to all types of electrical equipment and can therefore be considered sufficiently well established as a service routine.

CHECK POINTS

The converter should be inspected at regular intervals. The frequency of these inspections is determined by the nature of the operation and environmental factors (vibration, dust, humidity).

The following points should then be checked:

- Fouling
- Connections
- Installation

Observe the risk of electric shock! Before work is begun in the converter, check that the a.c. supply is disconnected.

Fouling

Cubicles in which foreign material has accumulated must be cleaned. Dust and similar fouling can be removed with a vacuum cleaner. Compressed air can be used to remove stubborn deposits but this should be free from condensation. Fouling, difficult to remove otherwise, can be removed with isopropyl alcohol (or a similar solvent) which may be blown dry with clean air.

A visual inspection should be performed after cleaning to detect any mechanical damage or components damaged by overheating.

Connections

Main circuits
Tighten all screwed cable and bar connections. Check bar joints and connections to thyristors and the high speed fuses on the thyristor unit.

Other circuits
Check the tightness of all screwed connections with a screwdriver (contactors, transformers, circuit boards, terminals, etc.). Check that the circuit board connections are installed correctly.

Installation

Ensure that all units are screwed together firmly and that no screws or nuts are loose.

Check the circuit boards of the control equipment with respect to fixing and connections.

All plastic holders must be intact and the edge contacts must cover the pattern terminals as intended. Wiring is to be fixed to avoid chafing against sharp edges.

REPLACEMENT OF COMPONENTS

Fan unit

Remove the connections to the fans and the earth connection. The unit can then be lifted out directly.

Removal of thyristors

Remove the high-speed fuse. Remove the stirrup which clamps the thyristor against the heat sink. It may also be necessary to remove the flat pin connections to the RC circuit.

Installation of thyristors

The following procedures must be followed when mounting a thyristor on a heat sink.

1. Polish carefully the contact surface on the heat sink with a fine-grained abrasive.
2. Clean the contact surfaces of both heat sink and thyristor with ethanol and a lint-free cloth.
3. Apply a very thin coating of silicon grease to the contact surfaces of heat sink and thyristor with, for example, a lint-free cloth.
4. Adjust the location of the thyristor in relation to the heat sink by means of the guide pin. Check that the thyristor is oriented correctly as shown by the symbol on the component.
5. Thyristor and heat sink are clamped together with a stirrup. Tighten the screws of this yoke by hand, alternately, so that the leaf spring remains parallel with the contact surface between heat sink and thyristor. Continue then to tighten, a half turn at a time with a block spanner. The stirrup has several "snap" positions corresponding to different clamping forces. The screws are to be tightened until the spring indicating the force required snaps over the leaf spring. See also the instructions provided with the thyristor. Thyristor YST 2 is to be clamped with a fixing force of 4 kN.
Circuit board

Remove the screw terminal for external connections by withdrawing this straight out from the board. Loosen then the board from the plastic holder and extract from the inner connector.

N.B. To ensure reliable contact the connector should be pushed on and pulled off no more than 25 times before being replaced. When a new circuit board is installed, new edge contacts supplied with the board, are to be installed.
FAULT TRACING

SERVICE PRINCIPLES

Introduction

The TYRECT C converter has a straightforward functional design with very few component units. The frequency of internal component fault is therefore very low after the converter is operational.

Component fault

The components below are arranged in order of estimated fault frequency. The thyristor modules are the units most subject to component fault as they can be damaged by external effects.

- Thyristor modules
- Control board YXT 121
- Pulse transformer board YXU 162 (163)
- Rectifier bridge including varistors
- Connectors and cables
- Transformers

The above can serve as a primary guide for fault tracing in the converter.

Personnel safety

When tracing faults it may be necessary to work with the supply voltage switched on. The TYRECT C converters provide the highest possible degree of personnel safety by the galvanic isolation of the electronic circuits from the main circuit.

When the front hatch is opened, the heat sink of the main circuit is screened against accidental contact by a transparent plastic cover. Two circuit boards are installed inside the hatch. That at the left, the control board has no dangerous voltages. Most of the test terminals used in service and commissioning are assembled here.

Note that on the board at the right, the pulse transformer board, YXU 162 (163), certain parts carry the main voltage. The dangerous parts are located between the trigger pulse transformers and the trigger pulse connections X5, X6 (X7, X8).

Other parts of the board are galvanically isolated from the main voltage by the trigger pulse transformers and carry no dangerous voltage.

Great care must be observed when testing on this board.

Fault tracing routines

a. Determine if there is any electrical or mechanical fault in the drive equipment.

b. Check if any electrical converter fault is internal or external.

c. In the case of internal fault:
   - Localize the fault to, for example, a thyristor or a circuit board.
   - Replace the faulty component with a spare.

d. Faulty circuit boards are repaired in an ASEA workshop.

Measurement instruments required

Test unit YXO 115

The converter is prepared for connection of the test unit YXO 115. This unit is connected via a ribbon cable to the contact X31 on the control board. 19 important measurement points are connected to this contact.

The test unit YXO 115 (catalogue number YX 290 000-PG) is recommended as a rapid and certain means of checking signal levels and supply voltages in the control equipment without loss of time in identifying all measurement points.

YXO 115 can also be used for manual setting of references as it has integral potentiometers for both rough and accurate setting of references and selectors for a step function. Further information about YXO 115 is available in Information YX 290-112 E.
"Do it yourself" recommendation

An adapter for quick connection of a multimeter to the measurement contact X31 can be easily made with two 10 point selectors and a ribbon cable with a 26-point female contact.

Printer, oscilloscope

In the case of certain faults and for detailed fault tracing, an oscilloscope and/or a printer is necessary.

Current probe, personnel safety

A current probe is recommended as a supplement to the oscilloscope when measuring trigger pulses to the thyristors. The main advantages of the current probe are the potential-free measurement which is possible without galvanic contact with the main circuit and the unequivocal measurement result obtained.

Multimeter

A multimeter is necessary for general fault tracing in the converter.

In addition to the measurement contact X31 named above, a 10 point measurement terminal, X21, intended for ordinary measurement clamps, is provided.

Fig 1 Three-phase converter module and service aids in the form of testing unit, YXO 115, measurement clamps and a current probe for the oscilloscope.

Fig 2 Connection of different measurement instruments with ribbon cable, measurement clamps and current probe (S40207)
**STANDARD FAULT TRACING ROUTINE**

The following method should permit correction of 9 faults of 10 in drive equipment. The table should be followed point by point in the order given.

<table>
<thead>
<tr>
<th>Prehistory</th>
<th>Discuss, with the operator, his observations when the fault developed.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical load on the motor</td>
<td>Can the motor be turned by hand? Turn the motor by hand if possible.</td>
</tr>
<tr>
<td>Motor damage</td>
<td>Is the commutator intact? Are the surfaces of the commutator smooth? Can the brushes move freely up and down and do they make good contact with the commutator? Are sparks generated at the commutator with current load? Are the tachometer and its connections serviceable?</td>
</tr>
<tr>
<td>Electric power interruption</td>
<td>Check the electric power distribution to the convertor and the cables between the convertor and the motor.</td>
</tr>
<tr>
<td>Excessive generation of heat in the convertor</td>
<td>Inspect the convertor for overheated components and brown discolouration on the electronic boards.</td>
</tr>
<tr>
<td>Faulty thyristor</td>
<td>Is any of the thyristors short-circuited in the forward or reverse direction? Check by means of resistance measurement.</td>
</tr>
<tr>
<td>Speed reference</td>
<td>Is the speed reference missing? Is the external superior control equipment faulty?</td>
</tr>
<tr>
<td>Settings on circuit boards</td>
<td>Check the setting of the potentiometers and the programming jumpers.</td>
</tr>
</tbody>
</table>
TEST UNIT YXO 115

Connection

The test unit is to be connected, via the ribbon cable supplied, to contact X31 on the control board YXT 121.

LED functions

The significance of the illumination of LEDs is as follows:

<table>
<thead>
<tr>
<th>LED</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qt+</td>
<td>+24 V d.c. (unregulated voltage)</td>
</tr>
<tr>
<td>Qt-</td>
<td>-24 V d.c. (unregulated voltage)</td>
</tr>
<tr>
<td>START 1</td>
<td>Converter release is activated</td>
</tr>
<tr>
<td>RDY 1F RUN</td>
<td>The mains voltage has the correct phase sequence and the correct voltage</td>
</tr>
<tr>
<td>RDY 2F RUN</td>
<td>Undervoltage, incorrect phase sequence or phase failure</td>
</tr>
<tr>
<td>RDY 1F REF</td>
<td>Both START 1 and RDY 1F RUN are activated</td>
</tr>
<tr>
<td>FWD CUR</td>
<td>Current in the forward direction with a double converter YHMM (not activated with single converter YGMM)</td>
</tr>
</tbody>
</table>

Rotary selector functions

The following voltages can be checked with the rotary selector and read on the integral digital voltmeter. For signal levels, see section SUMMARY OF MEASURED VALUES.

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>+10 V</td>
<td>Reference voltage</td>
</tr>
<tr>
<td>-10 V</td>
<td>Reference voltage</td>
</tr>
<tr>
<td>+15 V</td>
<td>Regulated supply voltage</td>
</tr>
<tr>
<td>-15 V</td>
<td>Regulated supply voltage</td>
</tr>
<tr>
<td>SP REF 1</td>
<td>Reference via terminal X1:2</td>
</tr>
<tr>
<td>SP REF 2</td>
<td>Either reference via terminal X1:3 or output signal from the ramp generator</td>
</tr>
<tr>
<td>SP REF 4</td>
<td>Reference via terminal X1:4</td>
</tr>
<tr>
<td>SP 1</td>
<td>Speed actual value (tachometer signal)</td>
</tr>
<tr>
<td>CUR REF 1</td>
<td>Current reference (output signal from the speed regulator)</td>
</tr>
<tr>
<td>ARM CUR 1-3</td>
<td>Current actual value</td>
</tr>
<tr>
<td>CONTR VOLT</td>
<td>Control voltage (output signal from the current regulator)</td>
</tr>
</tbody>
</table>
## FAULT SYMPTOMS AND SOURCES OF ERROR

<table>
<thead>
<tr>
<th>Fault symptoms</th>
<th>Indication</th>
<th>Probable source of error</th>
</tr>
</thead>
</table>
| The motor does not rotate                   |            | • Supply voltage absent  
• Supply voltage to the electronics boards absent  
• Release signal absent  
• Field current too low  
• Interrupt between converter and motor  
• Excessive loading torque on the motor  
• Speed reference absent  
• Current lim "LIM 1" and "LIM 2" set incorrectly  
• Current actual value potentiometer "I" is set incorrectly  
• Interrupt in thyristor  
• Control board YXT 121 is faulty  
• Pulse transformer board YXU 162 (163) is faulty |
| Red LED active                              |            | • Incorrect phase sequence  
• Undervoltage  
• Phase loss |
| Motor speed incorrect but controllable      |            | • Faulty tachometer generator  
• Voltage divider for speed actual value is incorrectly adjusted (SIGN ADJ)  
• Faulty speed reference  
• Control board YXT 121 is faulty |
| The motor races                              |            | • Incorrect polarity of the speed actual value  
• Speed actual value absent  
• Incorrect polarity of the field supply  
• Control board YXT 121 is faulty |
| The motor rotates in one direction only (applies to YHMM) |            | • The speed reference has one polarity only  
• The pulse transformer board YXU 163 is incorrect  
• Interrupt in cable connections to the pulse transformer board YXU 163  
• Control board YXT 121 is faulty |
| Abnormal noise from motor, commutation malfunction |            | • Trigger pulse absent  
• Faulty thyristor |
| The semiconductor fuses trip at switch-on    |            | • Short-circuited thyristor  
• Short-circuit/earth faulty in the rotor circuit  
• Fault in current measurement circuits (current transformer or current actual value setting "I")  
• The control board YXT 121 is faulty  
• The pulse transformer board YXU 162 (163) is faulty |
| The semiconductor fuses trip during operations |            | • Defective thyristor  
• Defective motor or earth fault  
• Unstable current control  
• Intermittent fault on the control board YXT 121  
• Intermittent fault on the pulse transformer board YXU 162 (163)  
• Setting of potentiometer GAIN on the control board YXT 121 is too high |
| Inadequate torque. The motor cannot reach the value set. |            | • Field current too low  
• Rotor current too low  
• Motor defect  
• Torque load excessive |
SUMMARY OF MEASURED VALUES

Measurement with multimeter

<table>
<thead>
<tr>
<th>Measurement term on the control board YXI 121</th>
<th>Signal term</th>
<th>Measurement test results</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>X1</td>
<td>x</td>
<td>+15 V</td>
<td>+14,5 - +15,5 V DC</td>
</tr>
<tr>
<td>: 2</td>
<td>x</td>
<td>COM</td>
<td>0 V</td>
</tr>
<tr>
<td>: 3</td>
<td>x</td>
<td>ARM CUR 1</td>
<td>0</td>
</tr>
<tr>
<td>: 4</td>
<td>x</td>
<td>CURR VOLT</td>
<td>+10</td>
</tr>
<tr>
<td>: 5</td>
<td>x</td>
<td>SP REF 1</td>
<td>0</td>
</tr>
<tr>
<td>: 6</td>
<td>x</td>
<td>CURR REF 1</td>
<td>-10</td>
</tr>
<tr>
<td>: 7</td>
<td>x</td>
<td>SP REF 2</td>
<td>0</td>
</tr>
<tr>
<td>: 8</td>
<td>x</td>
<td>SP REF 3</td>
<td>-10</td>
</tr>
<tr>
<td>: 9</td>
<td>x</td>
<td>MOD F REF</td>
<td>+14,5</td>
</tr>
<tr>
<td>: 9</td>
<td>x</td>
<td>MOD F REF</td>
<td>0 V</td>
</tr>
<tr>
<td>: 10</td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>XI</td>
<td>x</td>
<td>+10 V</td>
<td>+10,5</td>
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<tr>
<td>: 10</td>
<td>x</td>
<td>-10 V</td>
<td>-10,5</td>
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<td>X2</td>
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</tr>
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</tr>
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<td>: 2</td>
<td>x</td>
<td>L1 - L2</td>
<td>4 V AC</td>
</tr>
<tr>
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<td>x</td>
<td>L2 - L3</td>
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</tr>
<tr>
<td>: 11</td>
<td>x</td>
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<td>x</td>
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</tr>
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<td>x</td>
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<td>x</td>
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<td>: 56</td>
<td>8</td>
<td>6,8 V</td>
<td>-6,5</td>
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</table>

The table tabulates signals which can be measured with a multimeter during normal fault tracing.

The table also shows which of these signals can be measured directly with the test unit YXI 115. All signals are measured in relation to "COM" (X21:2).

1) The voltage is proportional to the d.c. (+5 V with the rated motor current is the setting prescribed).

2) The voltage is approximately proportional to the d.c. voltage.

3) The voltage is proportional to the speed reference. (Positive voltage with rotation in the forward direction.)

4) Voltage proportional to the current reference. (Positive voltage with connection of the reverse bridge.)

5) Voltage proportional to the speed. (Negative voltage with rotation in the forward direction.)

Measurement with oscilloscope

The circuit diagram Appendices 1 - 5, contains oscillograms which illustrate the curve form at different test points on the circuit board. All signals are measured in relation to "COM" (X21:2).

If measurements are made in the thyristor bridge with the oscilloscope, use the voltage probe. Note that the chassis of the oscilloscope may become "live". All of the thyristor voltages (anode-cathode) can be measured on the connection bars L1, L2, L3, L+ and L-.

Use the current probe (for preference) to check the trigger pulses as previously recommended under section MEASUREMENT INSTRUMENTS REQUIRED.
EXCHANGE OF FAULTY CIRCUIT BOARDS

The circuit boards are easy to exchange because all of the electrical connections can be disconnected by removing the multipole board connectors of clip-on type.

Before a spare board is inserted:

- Check that the programming straps are placed in the correct positions by comparing with the original board and the circuit diagram.
- Set the potentiometers in accordance with the original board or follow the section COMMISSIONING.

THYRISTOR CHECK

a. Resistance measurement

Switch off the converter and remove the main fuses. Measure the resistance between anode and cathode as shown in Fig. 3 with the thyristors in the circuit.

![Fig. 3](image)

If the resistance over some thyristors is less than 1 kohm, one or more thyristors is faulty. Remove then the thyristors fuses and repeat the measurement to determine exactly which thyristor is faulty.

With double converters it is necessary to remove the connection to the thyristor itself to determine which of the two antiparallel connected thyristors is faulty.

b. Simulation of firing pulses

The above method detects most thyristor errors but if a thyristor break-down is suspected, a thyristor firing must be simulated. Note that presspack thyristors are to be under pressure to ensure proper contact and the thyristor is therefore not to be removed from the heat sink. A thyristor firing is simulated most easily by means of a thyristor tester YSP 40 (catalogue number YS 906 102-A). If this is not available a connection as shown in Fig. 4 should be made.

![Fig. 4](image)

If the lamp illuminates without the contact being closed, the thyristor is short-circuited and must be replaced. If the lamp does not illuminate, close the contact. The thyristor should fire and the lamp should illuminate. If this does not occur - the thyristor is unserviceable and must be replaced.

c. Test with high voltage

If despite the above testing, thyristor error is still suspected, the thyristor must be tested with high voltage. The YSP 40 thyristor tester is also suitable for use in this case.

If such a thyristor tester is not available, the thyristor can be connected as shown in Fig. 5.

![Fig. 5](image)

Test the thyristor first with positive voltage at the anode and then with positive voltage at the cathode. Increase the voltage from zero and up to the rated voltage of the thyristor, – 200 V. The current is then not to exceed 5 mA.

The voltage is not to remain applied for any length of time as this can cause damage to the thyristor. If the thyristor is labelled, for example P18, the test should be performed with 18 - 100 – 200 = 1600 V. Instructions for thyristor exchange are given in the section PREVENTIVE MAINTENANCE.
## APPARATUS LIST

### APPARATUS LIST YGMM — 230/400

<table>
<thead>
<tr>
<th>Item</th>
<th>Designation</th>
<th>Data</th>
<th>Catalogue No</th>
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<tbody>
<tr>
<td>1-6</td>
<td>Thyristor without heat sink</td>
<td>YST 2-03 Pi4 k2, Pi4 k2, Pi6 k2, Pi8 k2</td>
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<td>18-23</td>
<td>Semiconductor fuse</td>
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<td>5675 555 -415, 5675 556 -418</td>
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<td>Resistor</td>
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<td>Capacitor</td>
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<td>4781 0542 -Y, 4781 0542 -U</td>
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