ASEA DRIVES

TYRECT C

Three phase thyristor convertor (40-120 A) types YGMM and YHMM

Manual YT 220-314 E
Reg. no 4890 064-52

TYRECT C

THREE PHASE THYRISTOR CONVERTOR (40-120 A)
TYPES YGMM AND YHMM

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Manual

TYRECT C

THREE PHASE THYRISTOR CONVERTOR TYPES YGMM AND YHMM

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1
GENERAL

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

The convertor 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.

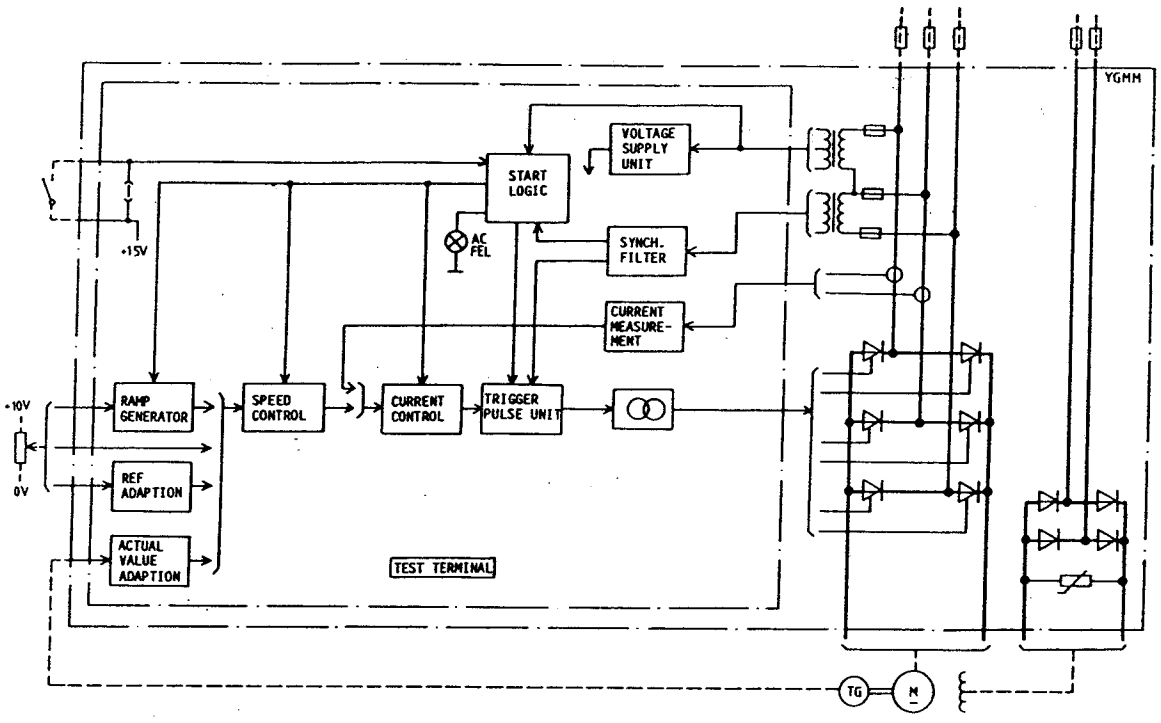


Fig. 1 Block diagram - YGMM

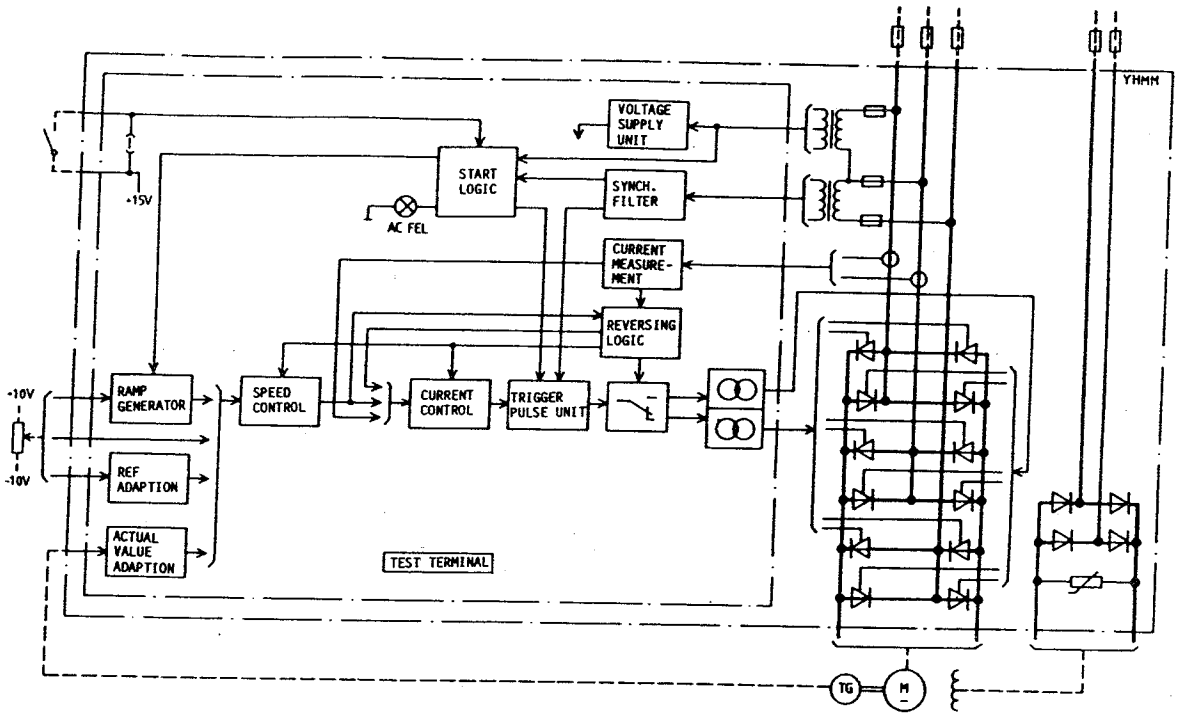


Fig. 2 Block diagram - YHMM

2
FUNCTION DESCRIPTION

2.1
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 invertor or buffer amplifier. The remaining input is provided with a trimpotentiometer for signal interfacing.

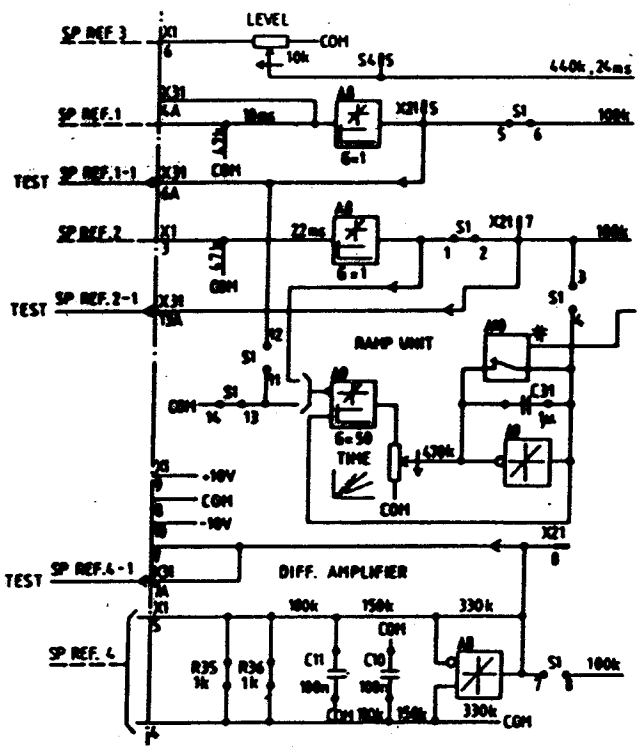


Fig. 3

- "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.

  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 output 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:

a) Differential amplifier with voltage input after the shunt resistors have been removed.

b) Sign-reversing amplifier. X1:4 is connected to X1:8 (0 V).

c) 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 convertor speed controller and can thus be used optionally via terminal X1:7. The resistance of the load is to be $\geq$ 2 kohm.

- "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 "TIME". By replacing capacitor (C31), mounted on solder posts, the ramp time can be changed as follows:

Value of C31	0,1 /uF	1,0 /uF	4,7 /uF
Ramp time	40 ms-0,8 s	0,4 - 8 s	1,9 - 40 s

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

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

2.2
Feedback input

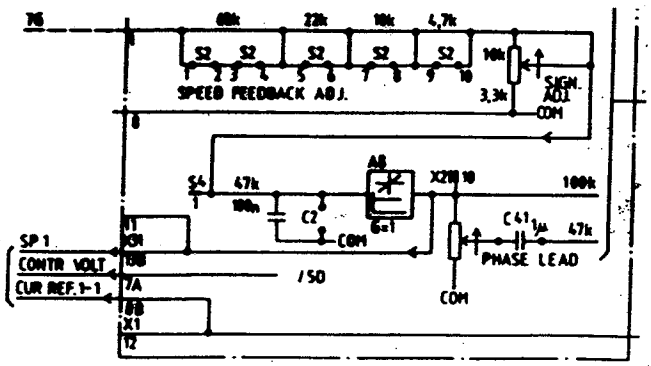


Fig. 4

- "TG": The tachometer generator is connected to the terminals X1:1 and X1:8 (0 V). In the case of single convertors X1:1 then has negative polarity. A suitable adaption to the tachometer voltage is performed with a voltage divider. This is adjusted approximately, in steps, with the straps S2:1-10 and is finally trimmed with the potentiometer "SIGN ADJ".

  The voltage divider output is directly connected to a buffer amplifier coupled as a voltage follower.

In the normal case, the voltage divider is adjusted so that its output voltage (measurement terminal X21:10) becomes 10 V at maximum speed. In the normal version the tachometer voltage is filtered through a low pass filter with time constant 4,7 ms. This time constant can be varied by introducing an external capacitor on solder posts.

For measuring the current speed, a needle instrument (0-10 V, R_i > 2 kohm) can be connected to the output of the buffer amplifier via terminal X1:7 and X1:8 (0 V).

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

Straps removed	Tachometer voltage
-	10 V
S2:9-10	14 - 24 V
S2:9-10, 7-8	22 - 52 V
S2:9-10, 7-8, 5-6	40 - 120 V
S2:9-10, 7-8, 5-6, 3-4, 1-2	90 - 320 V

2.3
Speed controller

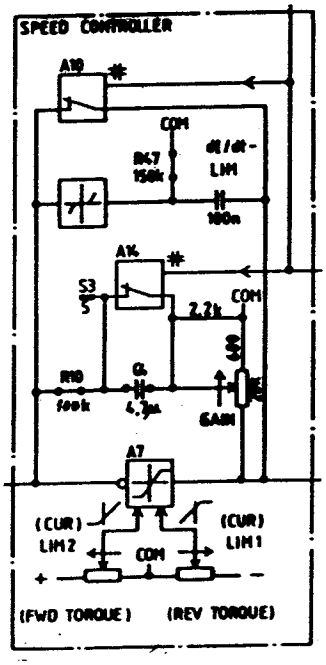


Fig. 5

3.1
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 feed-back circuit are installed on solder posts and can be replaced with components with other values if necessary. They are normally 100 kohm and 4,7 /uF which means that the integration time constant is 0,47 secs.

2.3.2
"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 derivating circuit, which normally consists on a resistor of 47 kohm and a capacitor of 1 /uF, is mounted on solder posts and can therefore be replaced as required.

2.3.3
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 convertors, 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.

2.3.4
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 homogeneous stator ring. Because of this, the speed controller 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 approximately 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.

Note that $R47 = \frac{1}{U^1} \times \frac{1,5}{10^{-7}}$

R47 = resistance value in ohms

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

With current feedback 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

The speed controller output voltage is connected, via strap S1:9-10, to the current controller input to measurement terminal X21:6, the ribbon cable contacts X32:1A and X32:8B and terminal block output X1:12.

2.3.5
Convertor inhibition

When the convertor output is reduced, the current reference is forced to 0 V.

2.4
Current controller

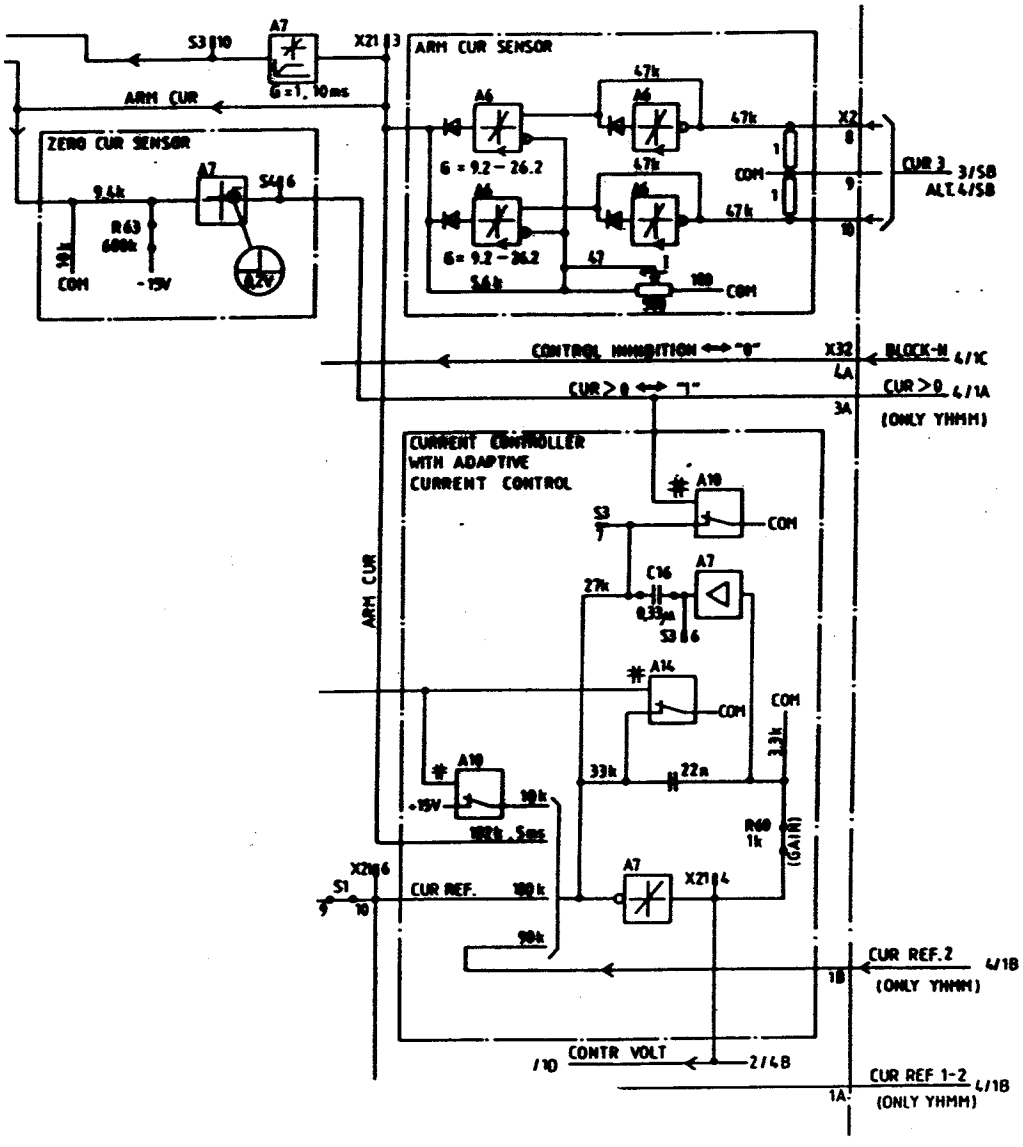


Fig. 6

2.4.1
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 approx. +10 V and -10 V.

2.4.2
Adaptive control

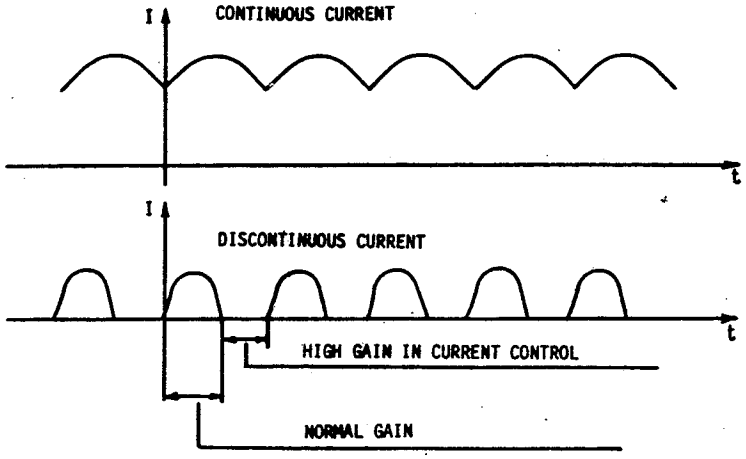


Fig. 7

To obtain a certain change of the d.c. voltage (resulting in a corresponding current change) a larger change of the control voltage is required with discontinuous than with continuous current.

The purpose of the adaptive control is to compensate for this amplification variation in the relationship between d.c. voltage U_d and the control voltage "CONTR VOLT" by increasing the gain in the current controller with discontinuous direct current. The dynamic properties of the current control is thereby maintained largely unchanged, irrespective of the magnitude of the current.

This function is obtained by disconnecting one of the two feedback circuits (PI-links) between the current pulses and is executed by the "analog switch" A10, which hereby connects the connection point between the resistor and the capacitor C16 to 0 V.

2.4.3
"GAIN" and signal levels for current reference and current feedback

The gain in the current control need not normally be trimmed. The level for the current feedback signal is adjusted with the potentiometer "I" so that 5 V corresponds to the motor current rating. If trimming is considered to be necessary, this is performed by changing the resistor R60 which is mounted on solder posts.

The standard value is 22 kohm and higher resistance increases the gain. The current regulator inputs for current reference "CUR REF" and current feedback "ARM CUR" have resistance values 180 kohm and 182 kohm respectively. The signal levels for these two signals therefore become virtually the same.

2.4.4
Double convertor

The function principle of the double convertor 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 boards YXU (157, 163).

2.4.5
Inhibition

When the output of the convertor 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 convertors 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).

2.5
T gger pulse generation

2.5.1
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).

2.5.2
Delay angle

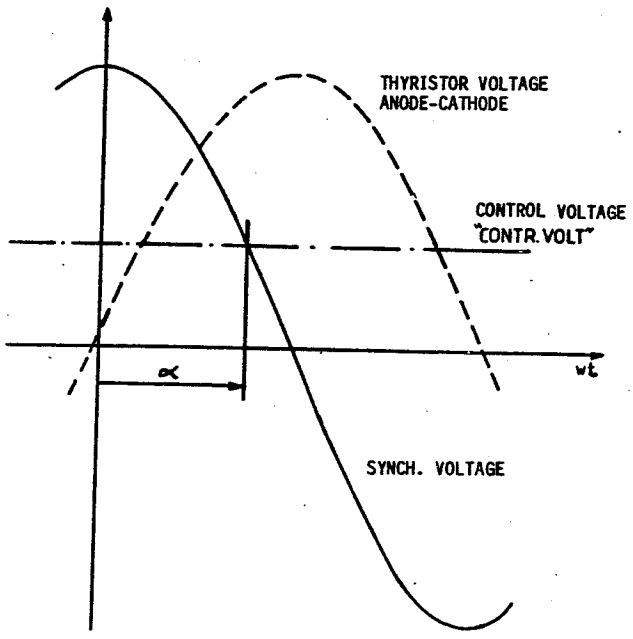


Fig. 8

The delay angle α (= firing delay) is determined by means of so-called vertical control. This means that for each of the six trigger pulses the control voltage is compared in a comparator with a synch voltage phase displaced 90 ^{o} before the main voltage for the thyristor concerned (cosine function). When the signals cross each other, a pulse is obtained with a phase position expressing the delay angle α .

Function relationship: $\cos \alpha = 0{,}1 \times$ "CONTR VOLT"

D.c. voltage $U_d \approx 1{,}35 \times U_v \times \cos \alpha$.

where U_v = mains voltage.

A further two pulses are generated in a similar way, these defining maximum and minimum for the different delay angles.
The following apply for TYRECT C:

$\alpha_{min} = 5^{o}$, $\alpha_{max} = 150^{o}$

α_{max} is also designated $\beta_{lim} = 180 - \alpha_{max} = 30^{o}$

2.5.3
Trigger pulse

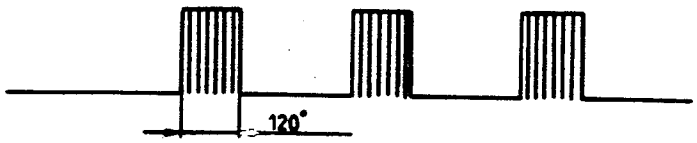


Fig. 9

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).

2.5.4
Synch voltages

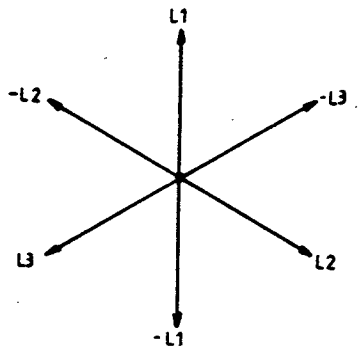


Fig. 10

The generation of the a.c. voltages for mains synchronization of the trigger pulses begins by measuring the main voltages L_3-L_2 via the single phase synch. transformer. A phase-correct 6-phase system consisting of the synch. voltages L_1, $-L_1$, L_2, $-L_2$, L_3 and $-L_3$ 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.

2.5.5
Phase sequence and under-voltage monitors

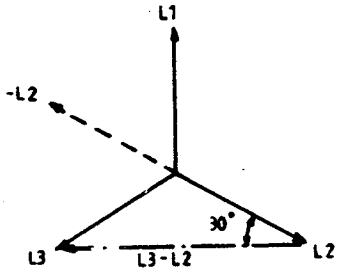


Fig. 11

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 $-L_2$ 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.

2.6
Start logic

The start logic manages automatic inhibition and release of the controllers and the ramp unit and blocking of the trigger pulses at switch-on/switch-off of the mains voltage when the strap S3:3-4 is in place.

2.6.1
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 release "RDY F REF" of the control equipment.

.6.2
External inhibition

If external inhibition/release is required, strap S3:3-4 is removed and an external relay contact is connected between contact X1:13 and X1:14. With respect to the operating sequences, see the Installation instruction YT 220-124E.

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-lim).

2.7
Current measurement circuits, current feed back

..7.1
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 load resistance of 1 ohm. Both of these voltages are rectified in an "ideal" active rectifier with adjustable gain. A current feed back is obtained at the output which is a correct representation of the curve form of the direct current. The current feed back 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.

Convertor current rating	Current transformer ratio	Number of primary turns 1)
40 A	300:1	3
80 A	"	2
120 A	"	1
230 A	500:1	1
400 A	1000:1	1

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

2.7.2
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.

2.7.3
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).

2.8
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 Unregulated voltage for external voltage.

+15 V Regulated voltage from an integrated voltage regulator.

-15 V Is a zener-stabilized voltage if the control board YXT 121 is one of the generation variants GV1 and GV2. From and after generation variant GV3, an integrated voltage regulator is included.

+/-11 V Are zener-stabilized voltages intended for reference generation.

+6,8 V Are zener-stabilized voltages intended LSI-
-6,2 V circuits and its input and output units.

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

2.9 Double convertor

2.9.1 Function principle

Each of the six valve branches in the double convertor 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 convertor 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 convertor.

2.9.2
Reversing procedure

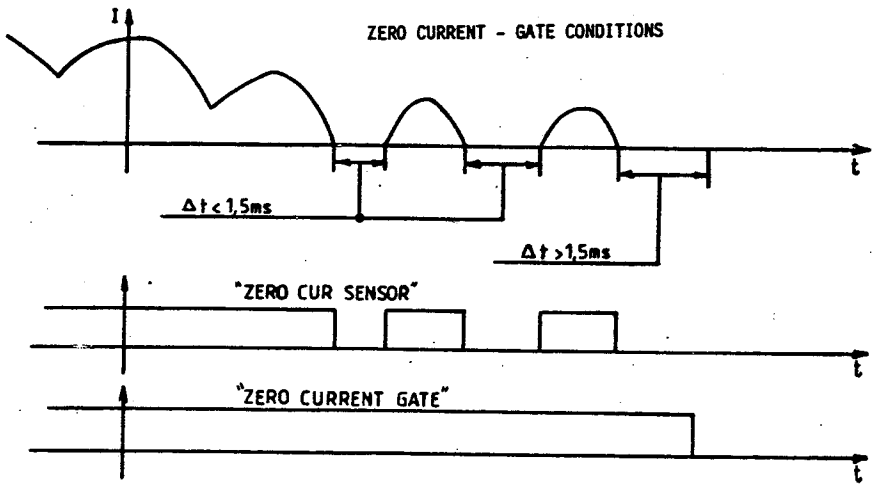


Fig. 12

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 in 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 indicated 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 deblocking of its trigger pulses. A rapid and reliable reversal can thus be obtained with the convertor "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 point 2.4.4, 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.

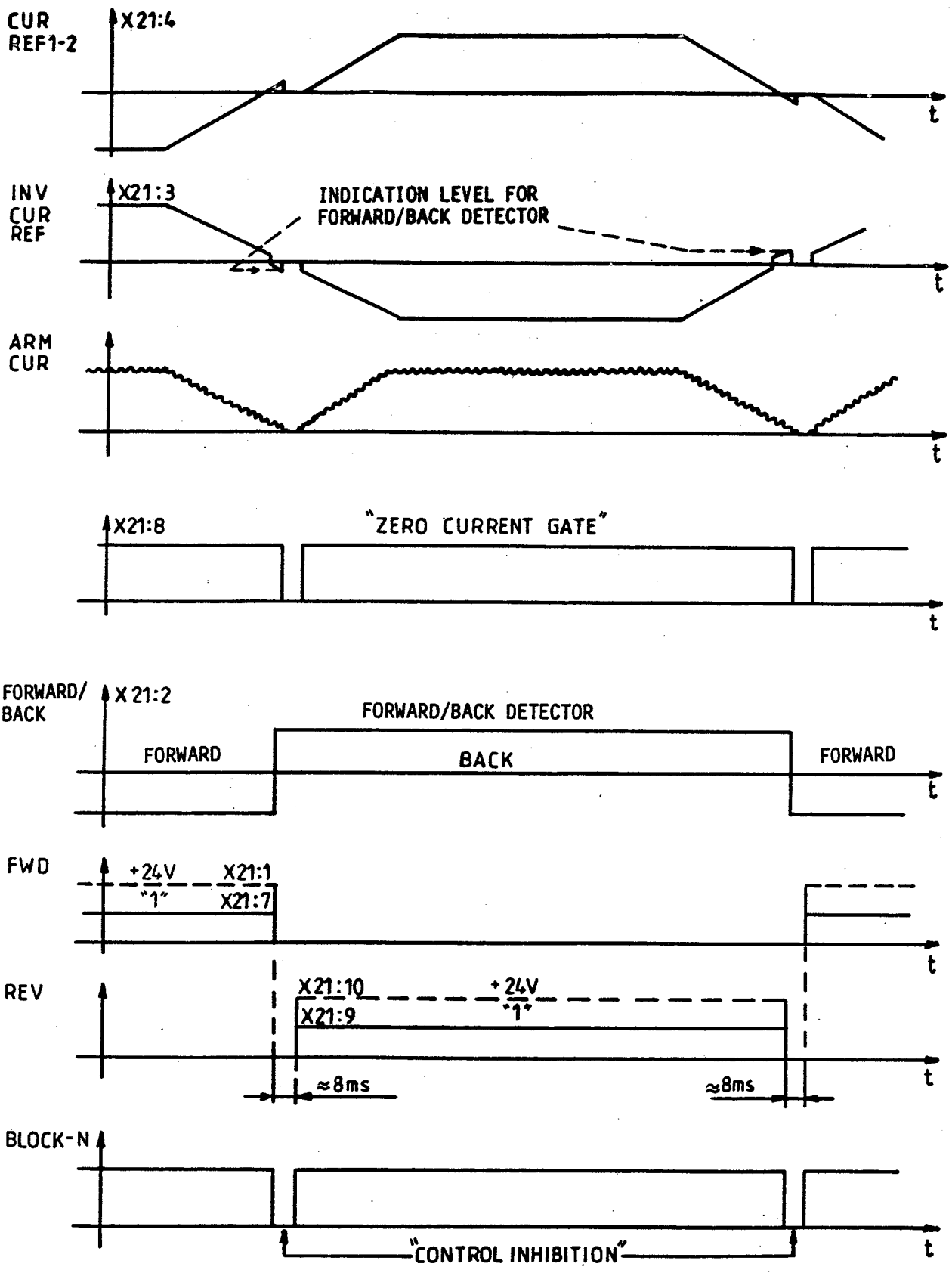
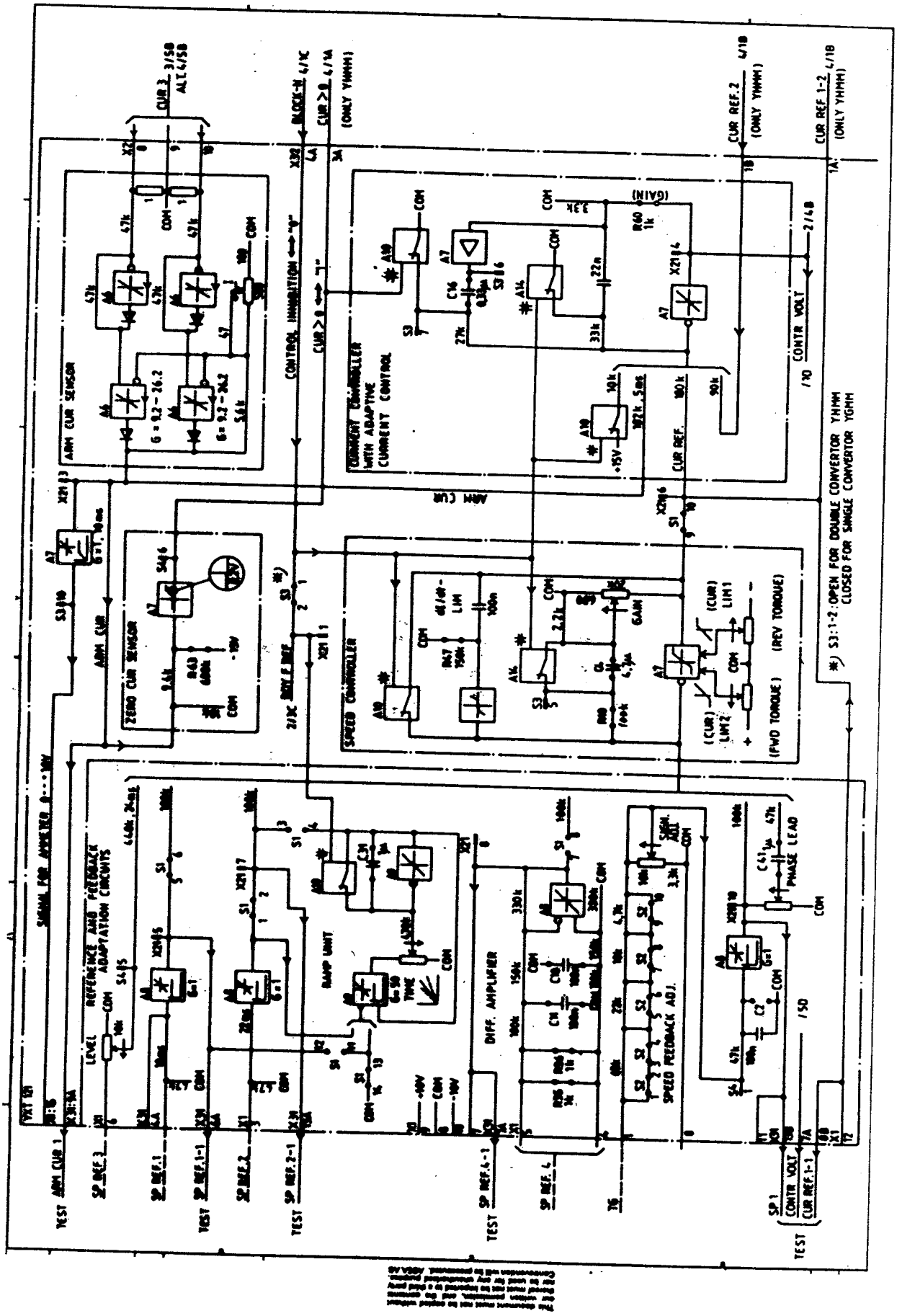

CUR REF1-2
X21:4
t
INV CUR REF
X21:3
INDICATION LEVEL FOR FORWARD/BACK DETECTOR
t
ARM CUR
t
X21:8
"ZERO CURRENT GATE"
t
FORWARD/ BACK
X 21:2
FORWARD/BACK DETECTOR
FORWARD
BACK
FORWARD
t
FWD
+24V "1"
X21:1
X21:7
t
REV
X21:10
+24V "1"
X21:9
≈8ms
≈8ms
t
BLOCK-N
"CONTROL INHIBITION"
t

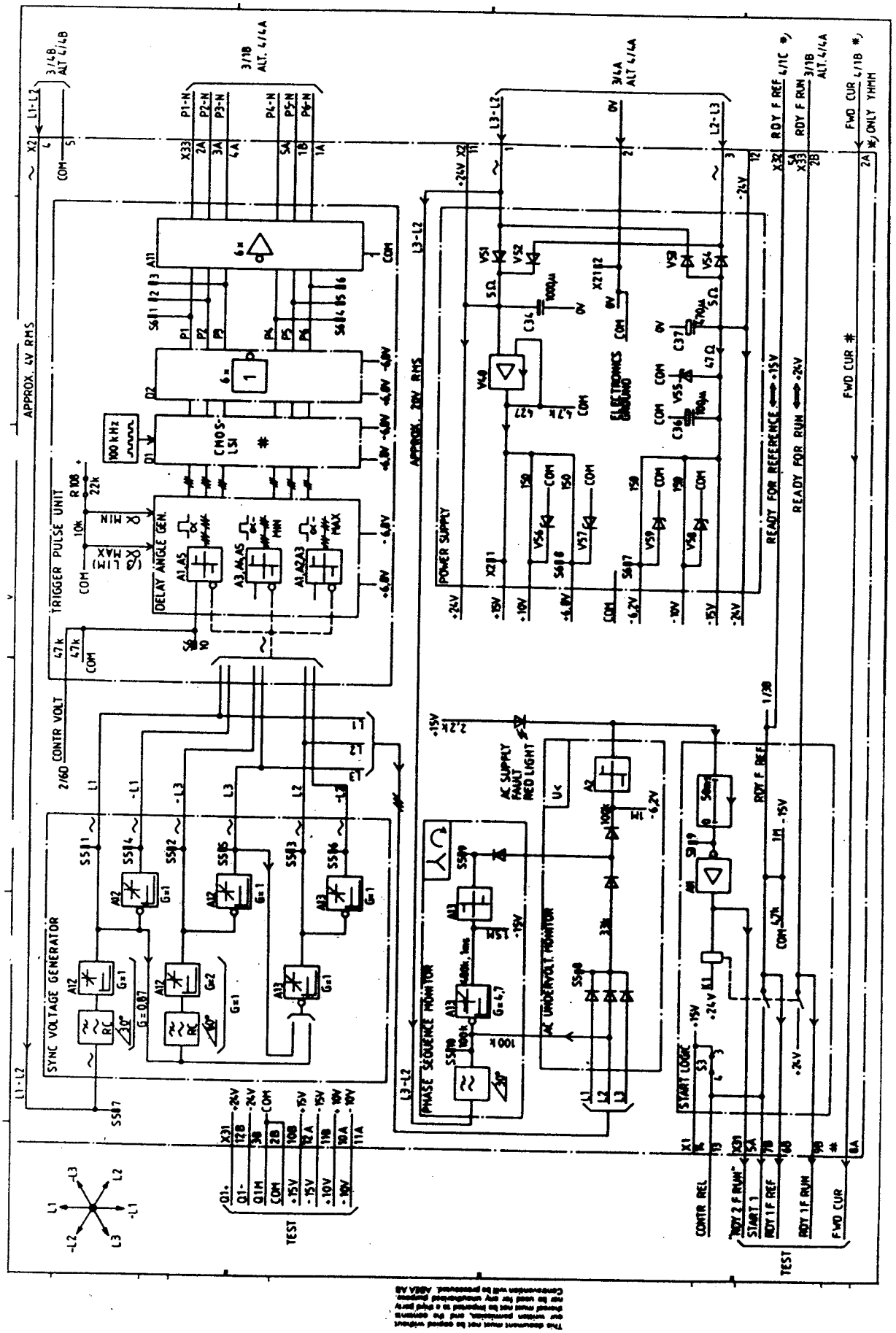
Fig. 13

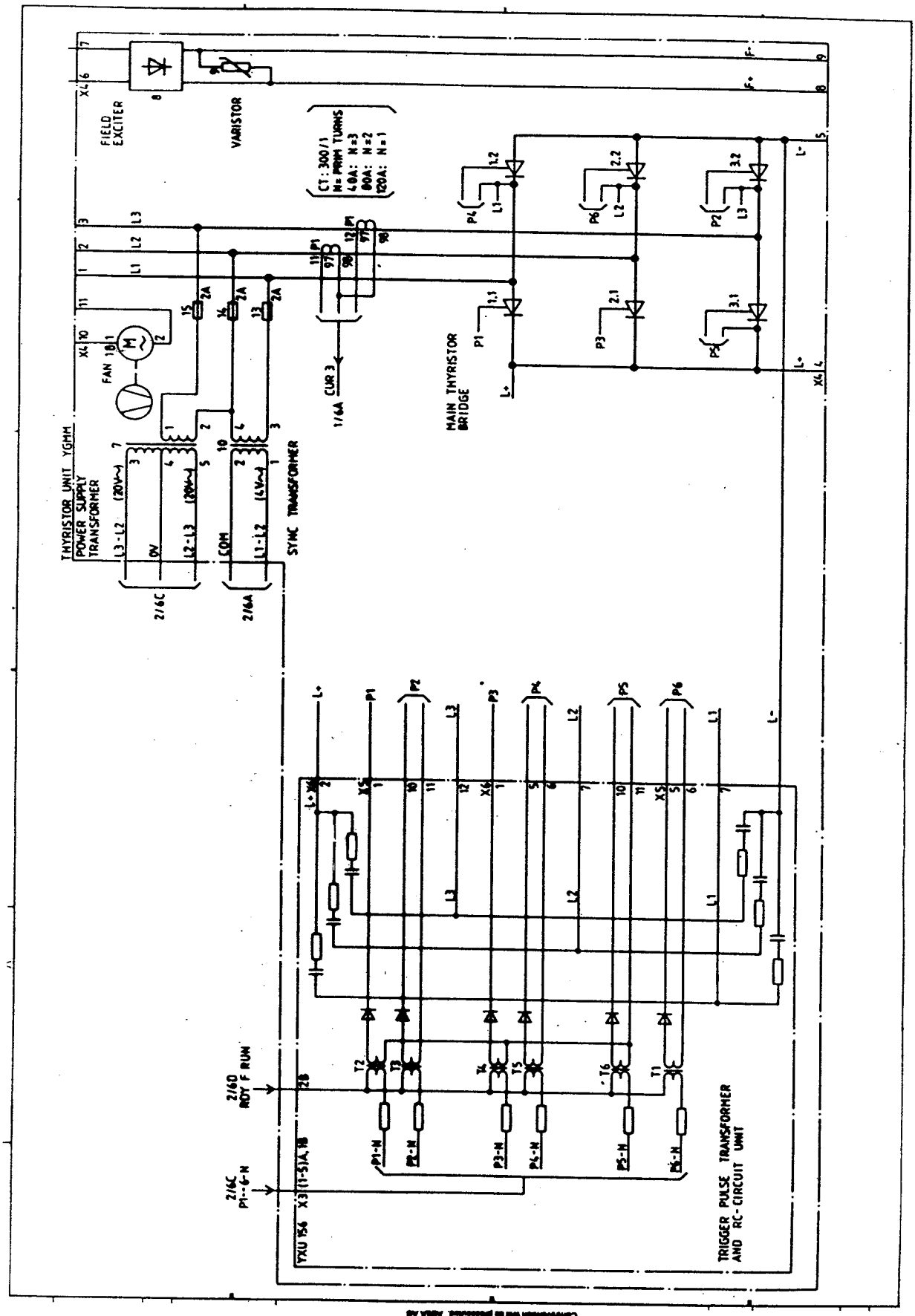
2.10 Measurement terminals

The measurement terminals for the 19 most important signals are assembled in the contact X31 which is intended for connection to the test unit YXO 115 or alternatively for connection of process accessories. There is in addition a 10-contact measurement terminal for connection by means of ordinary measurement clamps.

The diagrams in appendices 1-4 show 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 convertor but care must be taken when making connection because of their small dimensions.


ARM CUR SENSOR
CONTROL INHIBITION
CURRENT CONTROLLER WITH ADAPTIVE CURRENT CONTROL
CUR REF.2
CUR REF 1-2
CONTR VOLT
ZERO CUR SENSOR
SPEED CONTROLLER
SIGNAL FOR ARMATURE
REFERENCE AND FEEDBACK ADAPTATION CIRCUITS
RAMP UNIT
DIFF. AMPLIFIER
SPEED FEEDBACK ADJ.
PHASE LEAD
*) S3:1-2:OPEN FOR DOUBLE CONVERTOR YHHH
CLOSED FOR SINGLE CONVERTOR YGHH


APPROX. 4V RMS
TRIGGER PULSE UNIT
DELAY ANGLE GEN.
CONTR VOLT
SYNC VOLTAGE GENERATOR
CMOS-LSI
100 kHz
POWER SUPPLY
APPROX. 20V RMS
PHASE SEQUENCE MONITOR
AC SUPPLY FAULT RED LIGHT
AC UNDERVOLT. MONITOR
START COUR
CONTR REL
TEST
READY FOR REFERENCE
READY FOR RUN
FWD CUR *
ELECTRONICS GROUND



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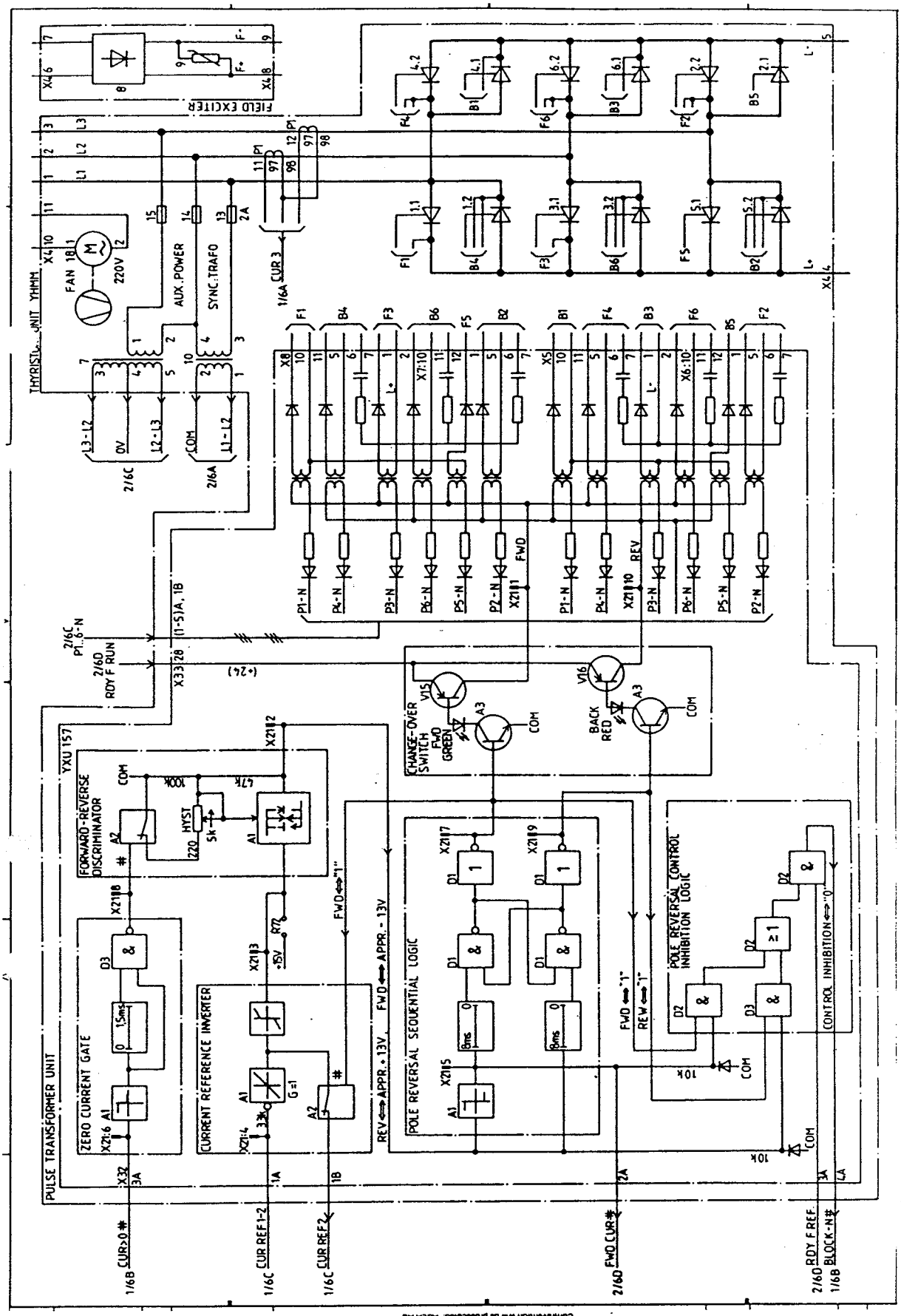

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