TYRAK XL
Thyristor convertor with microcomputer for large d. c. drive systems

User's manual

Edition 3

Reg. nr. 3ASD 4890 04C 1032.

ABB Industrial Systems

ASEA BROWN BOVERI

TYRAK XL
User's Manual

Contents

Description

Contents:

General

Tyrak XL convertors are designed in accordance with international standard IEC146, and meet the highest demands regarding performance, reliability and immunity to interference.

The control system is fully digital, from reference to trigger pulses. Both control procedures and sequential control functions are implemented digitally. Considerable emphasis has been placed on personnel safety. A powerful operators panel simplifies commissioning, handling and fault tracing of the convertor.

Configuration

The convertor equipment consists of a control cubicle, one or two thyristor cubicles depending on the main circuit configuration, and a field exciter cubicle.

The following type designations are used for the different convertor types:

- 6-pulse single convertor	YGMV
- 6-pulse double convertor	YHMV
- 12-pulse parallel convertor, single	YGMW P
- 12-pulse parallel convertor, double	YHMW P
- 12-pulse series convertor, single	YGMW S
- 12-pulse series convertor, double	YHMW S
- 2* 6-pulse tandem convertor, single	YGMW T
- 2* 6-pulse tandem convertor, double	YHMW T

Form of protection IEC 144-IP22
SEN 2121-S21
DIN 400S0-P21.

BS 2817-Screen protected Drip-proof.

A.C. Power Distribution

Main circuit breakers are not included in the Tyrak XL delivery, however, one or two a.c. or d.c. breakers can be controlled from the drive control equipment.

Control cubicle

The control cubicle contains circuits for auxiliary power supply, motor starters for cooling fans and drive and convertor control units.

Power supply

The control cubicle is supplied by cable from below, connected to terminals at the bottom of the cubicle. The supply voltage can be 380 V, 415 V, 440 - 460 V or 500 V.
The circuit is protected by an incoming current limiting molded case ciruit breaker (MCCB, pos H1.1) of type ABB Sace Limitor.

Control units

The control cubicle is equipped with two or three control units, depending on the main circuit configuration. One control unit contains the drive control. For main circuits with 6 pulse and 12 pulse series connection with synchronous or bridge sequence control, there is one convertor control unit. The slave convertor trigger pulses are generated on a separate trigger pulse board, YPQ203, connected directly to the convertor control board YPQ 201.

With 6 pulse tandem and 12 pulse parallel connection two convertor control units are included.

Each control unit contains three circuit boards, the processor board, YPQ201, the memory module, YPR201, and the I/O-board,YPQ202. The processor board and the I/O-board are mounted on opposite sides of a hinged panel, with the processor board facing front. The memory module is plugged in on top of the processor board.

Each control unit is equipped with a modem unit for communication with a service terminal or PC. The units are equipped with optocouplers which galvanically isolate computer side and terminal side from another.

Internal communication

The control units communicate with each other through an internal serial bus for transmitting data at high speed. An opto link is used to eliminate electrical interference. A communication board, YPK 114, is connected to the ISBX connector on each of the processor boards. From the drive control unit, data is distributed via a distribution board, YPC 111.

Drive control unit, pos B2

The drive control unit (pos. B2) contains the drive's application control program. Space is provided for up to four expansion I/O-units, which are installed as required by the software control program. Space is also provided for a serial communication unit for ABB Master (option). Further, the drive control unit is equipped with two contactors intended for operating external a. c. or d. c. breakers.

Convertor control unit, pos B20

The convertor control unit contains convertor control software. Opto couplers are used for galvanic isolation of the trigger pulses. The unit also contains a current measurement board and a connection unit for current and voltage measurement. Two analog output channels for test purposes are included.
A contactor intended for tripping of an external a. c. breaker is also included.
The convertor control unit contains a transformer, which generates a reference voltage for the thyristor trigger pulses. The transformer is supplied (3*110 V) from an adjustment transformer in the thyristor cubicle.

Convertor control unit, pos B32

With 12 pulse parallel, or tandem drive coupling there is an additional convertor control unit, designated B32. The contents of this unit is identical to that of pos B20.

Processor board YPQ201.

A powerful microcontroller of type Motorola MC68332, running at 16 MHz, is used. The operating system is monitored by diagnostic functions. The monitoring functions include a watch-dog, bus supervision, memory checking and power supply monitoring. In case of a fault, a flashing fault code appears on a two digit LED display. The fault codes are explained in the fault tracing section. During normal conditions the CPU load is monitored and displayed.
Error signals and log values are stored in a RWM (Read Write Memory) with voltage back-up. It retains its contents for 12 hours following a power loss.

Memory module, YPR201

The function of the drive equipment is determined by the control program installed. An application control program is installed in the drive control unit, the main thyristor convertors are controlled by convertor control programs, and the field exciter by a field control program. The control programs are stored in EPROM/ EEPROM memory capsules on memory modules.
A selection of standard memory modules for different applications are available, each delivered with a user manual with a functional description, signal and parameter list. For detailed description of the control program,refer to the user manual.

Electronics power supply

Each control unit is equipped with its own electronics power supply transformer, pos B51.

The three-phase transformer generates two 24 V voltages, designated Q1 and Q2. The microcontroller is supplied by Q1, while external circuits are supplied with Q2.
A high degree of immunity to interference is obtained with separate supply voltages. Each convertor's computers are directly grounded even in plants with a common reference system.
The supply transformers are provided with screens between primary and secondary windings and between the two secondary windings.
The circuits are fused with miniature fuses, Q1 with 6.3 A and Q2 with 4 A fuses.
Approximately 0.5 A (Q2), depending of optional functions added, is available for external circuits.

Grounding

Q1 (computer supply) is grounded directly in the chassis via the screws fixing the circuit boards. The neutral of the other supply voltage is connected and grounded via terminal block B2.52.X1:9. If several convertors have a common reference system, the grounding of all of the convertors but one must be disconnected.

Auxiliary distribution unit, pos B1

The distribution of auxiliary voltages in the control cubicle is shown on pages 60-65 in the CD. The different auxiliary power breakers are placed in pos. B1 in the right part of the cubicle. The number of breakers is dependent upon the needs of the actual application, for example whether one or two thyristor cubicles are included, or whether external motor fans are to be controlled, and so on. The unit also includes a transformer (pos 20) generating the operating voltages M1L and M2L. M1L is a 110 V a.c. voltage with a frequency of 50/60 Hz, and is used as operating voltage for contactors, optional power breakers, digital input ports, and so on. M2L is 220 V alternating current, and can be used as operating voltage for digital input ports, on condition that the discharge resistors on the port is adequate.

The unit is also equipped with contactors intended for the functions "Electrical disconnect" and "Emergency stop".

Terminal units (B50, B51, B52)

The drive control unit may be equipped with expansion I/O-units The customer connection terminals for these units are placed on terminal rail B50 at the bottom of the left compartment of the cubicle..
B51 is the coupling terminal for external connections such as operation functions and cooling fan supply. Terminal B51 is located at the bottom of the right compartment of the control cubicle.
Terminal B52, in the right compartment, consists of a number of plug in connectors for signal interchange between the control and thyristor cubicles. The control pulses for example, are transmitted to the thyristor cubicle via this terminal.

Drive supervision and diagnostics

Tyrak XL convertors have an extensive system for status check, operational supervision and fault diagnosis. These functions combined give a high degree of availability, protect the drive equipment and the object driven and facilitate fault tracing, upkeep and operation.

The control equipment monitors the operation and reports abnormal conditions.

- Protective functions such as earth fault, overload, supervision of speed feedback etc.
- Switch-on and switch-off sequences are supervised and evaluated.

If a command is not acknowledged within a certain time, an error message is presented on the operator's panel display.

The error messages are presented in plain language with first-fault indication and consequential faults with time of occurrence in relation to the first fault.

The error text can be presented in Swedish, German, English or French.

Error statistics

Each fault is allocated a consecutive number 1 - 99. Fault signals are stored in a RWM with voltage back-up and it is therefore possible, at any time, to return to investigate the circumstances of a particular fault. The complete fault list can also be printed via a separate printer.

Logger

This function permits the recording of values from up to six optional signals at individually optional intervals. The log function stores 186 values per signal and the value stored is the mean value during the measurement interval. The signals can be shown graphically on the operator's panel. The function can be used to show trends in certain signals or provide a basis for the analysis of faults which have resulted in tripping of the drive. Signals logged can be used in commissioning, for example when trimming a speed controller.

Thyristor cubicle

General description

The main circuit contains the thyristor bridge, cooling fan, fast acting fuses and other protective functions for the main circuit.

The power components are designed to allow connection to supply voltages from 510 to 1190 V.

Power supply

The main circuit connections at supply and machine side, as well as interconnections between thyristor cubicles, are done by cables from below.

Thyristor bridge

The thyristor bridge (G1) is built up as a three phase, fully controlled 6-pulse coupling. It is available as a single convertor or as a double convertor. In the double convertor version, the thyristors are directly anti-parallel coupled with common fusing and RC-circuits.

Trigger pulse transmission

The trigger pulses are conducted via shielded cables from the opto coupler units in the convertor control units in the control cubicle. From the opto coupler unit, the trigger pulses are conducted via a shielded cable to the pulse amplification unit (B15) in the thyristor cubicle. After galvanic isolation in pulse transformers, the gate pulses are conducted to the different thyristors. The trigger pulses can be measured via test terminals on the pulse amplifier board YXU 201A.

In single convertors, the trigger pulse amplifier is equipped with two circuit boards (YXU 201A + YXU 202A). In double convertors, there are two sets of circuit boards, one set for forward and one set for reverse direction.

Current measurement

The d.c. current is measured on the a.c. voltage side of the thyristor unit with the help of two current transformers, pos. G1.35, 36 (37). The output signal is rectified in a diode bridge (pos.B13) and is adapted with load resistors on the current measuring board YXA 118 pos. Y2.B20. (B32). 8, so that the output voltage is 3,30 V at rated current (3,0 V with parallel bridges). If two thyristor bridges are connected in parallel, the current is measured in all three phases for each bridge. This is to enable the use of the asymmetry protection unit on the current measuring board YXA 118.

Semiconductor fuses

The thyristors are protected by fast acting semiconductor fuses in the branches.

Transient protection (A13)

The transient protection consists of six capacitors which are coupled to form three groups of two serial coupled capacitors. Each such group is coupled between one phase and earth. Each group is protected by a 1500 V 6 A fuse. The fuses, 1 - 3, protect the synchronizing voltage transformer (B8.1) and the earth fault protection unit (B30). The unit A13 also contains fuses for the DC voltage measuring unit (B26.2).

Asymmetry protection

Current asymmetry protection is included in the basic equipment for all convertors in which two thyristor bridges are connected in parallel. The function of the protection is to indicate poor division of current between the parallel connected bridges, and thus hinder overloading of the thyristors. An error indication (and blocking) is obtained when one thyristor arm is loaded with a current which approaches its maximum permitted value and the parallel thyristor arm is loaded with significantly lower current.The current feedback from each thyristor bridge is compared in a current sensor unit placed on the current measuring board YXA 118 in the control cubicle.

An error indication can, for example, be obtained by reason of poor contact in one of the bus connections in the convertor, a trigger pulse error to a thyristor bridge or to a particular thyristor, a trip fast fuse for one or more thyristors or a malfunctioning thyristor.

Any fault that may occur is indicated on the operating panel at the same time as the convertor control orders phase retard and blocking.

Current unbalance detection

In convertors with double bridges, both the a. c. and d. c. current is measured. The d. c. current is measured by means of a shunt in the the d. c. output. The d. c. current feedback is compared with the a. c. current feedback in the convertor control software. If there is a difference, the protection is activated. The aim of the unbalance detection is to give a quick detection if there is a difference between the input a. c. current and the output d. c. current, for instance if a circulating current between the forward and reverse thyristors has come up.

Convertor fan

The thyristor bridge is cooled with a three-phase fan. The fan is D-coupled for 380 V 50 Hz or 440 V 60 Hz supply, and Y-coupled for higher voltages.

Cooling air is taken via the floor, or through louvres on the doors. Air outlet is through the roof.

If the convertor is connected to an anti-clockwise phase sequence, the connections to the fan must be changed to obtain the correct direction of rotation.

Terminal units (B51, B52)

Terminal units B51 and B52 are located at the bottom of the apparatus compartment of the thyristor cubicle. Terminal B51 is used for power supply for the cooling fan. Terminal B52 consists of plug-in connectors for communication between the control and thyristor cubicles.

Field exciter

The motor field circuit is supplied from a three phase digitally controlled field exciter, housed in a separate cubicle. At delivery, the field exciter is bolted on to the control cubicle as shown on dimension prints.

The field exciter consists of a main circuit breaker, thyristor bridge with current measurement, control unit, and a field discharge unit.
The field exciter communicates with the convertor control system via an optical serial link.

Power supply

The field exciter is supplied by cables from below, connected to terminals at the bottom of the cubicle. The thyristor bridge is protected by a moulded case circuit breaker. The standard supply voltages are 380, 415, 440/460 and 500 V.

Main circuit

The main circuit contains phase inductors, thyristor bridge, cooling fan, fast acting fuses, field discharge unit, and auxiliary power supply for the control equipment.

The thyristor bridge is built up as a three phase, fully controlled 6-pulse coupling. It is available as a single or double bridge. Thyristor blocks with two thyristors in each are used.
Phase fuses, RC-circuits and phase inductors are used as protection for the blocks.

Trigger pulse circuits

The pulse transformers are assembled on a circuit board together with current measurement circuits and RC-circuits. The trigger pulses are generated in the control equipment and are transmitted to the thyristor bridge via a ribbon cable.

Current measurement

The d. c. current is measured on the a. c. side of the thyristor unit with help of two current transformers. The output signal is rectified in a diode bridge and is adapted with load resistors so that the output voltage is 1,00 V at rated current.

Convertor fan

Field exciters rated up to 115 A are provided with an axial fan powered with the operating voltage 110 V a. c. (M1).
Field exciters rated 195-515 A are cooled with a radial fan, supplied with 220 V a. c. (M1 - M2).

Communication

Communication with the drive control equipment is possible via the operator's panel, via I/O-units for discrete signals or with serial communication from other computer equipment.

I / O- system

Basic I/O-board YPQ202

External signals are connected to the basic I/O-board YPQ202 via individually disconnectable terminal blocks, accepting up to 2.5 sqmm (AWG14) wires. Following functions are included:

- Three digital output and four digital input channels with fixed functions, for external fans, oil pumps and main breaker operation. These circuits are connected to the 110 V a.c. control voltage.
- Five digital input channels, user defined function.
- One digital output channel, user defined function.
- Four analogue input channels, user defined function. The input signal can be ± 1 V, ± 10 V or 4 - 20 mA.
- Two analogue output channels, user defined functions, connected to test outputs in the door.
- One or two analogue outputs for current actual value, via buffer amplifier on current feedback signal (only on convertor control units).
- One analogue output for speed actual value (buffer amplifier on analogue tacho feedback signal).
- Pulse generator input.
  The unit has three inputs, two measurement channels to detect forward/reverse rotation and one 0-pulse input. One of the standard digital input channels can be programmed to give a synchronization pulse in positioning applications. The maximum pulse frequency is 50 kHz.

The setting of user defined input/output channels is performed from the operator's panel or from a service terminal or PC.

Expansion I/O units (CD 26-29)

The drive control equipment is prepared for four expansion I/O-units which are installed as required by the application control program chosen.

Each expansion unit consists of two circuit boards and an interconnecting ribbon cable. One board is plugged on to the computer board on the drive control module. The other board accommodates the customer connection terminals, and is placed outside the control module (pos B50) for convenient connection of wires.

Following expansion units are available:

- Digital input unit (YPI103 + YPI104).
  Eight channels, adapted for 110 V a.c./d.c. supply.
- Digital output unit (YPO105 + YPO106).
  Eight channels, galvanically free relay contacts.
- Analogue input unit (YPG110 + YPG106).
  Four channels and a voltage divider for analog tachometer signal, a current generator for Pt100 supply and a reference voltage source ±10 V.
- Analogue output unit. (YPM102 + YPM105).
  Four channels (two of which are connected to test outputs).

Analog output channels
Basic I/O (AO37XX) (CD 22)
Expansion I/O (AO34XX) (CD 29)

The analog output channels on the basic I/O-board give ±10 V output. On the expansion unit the signal level can be set for either 0 - +10 V or -10 V - +10 V. using parameter AO34MODE.

Two of the output signals can be multiplied up to 256 times, using parameters AO37.XMU/AO34.XMU . The signals can also be offset by ±100 % using parameters AO37.XOF/AO34.XOF .

Analog input channels
Basic I/O (AI37XX) (CD 22)
Expansion I/O (AI33XX) (CD 28)

Analog input channels are normally used for external references, armature voltage feedback, temperature measurement and tachometer generator input.

Both current and voltage signals can be connected to the analog inputs. The reference type and level for each of the four channels is selected with parameter AI37MODE/AI33MODE as shown in the circuit diagram. The strapping arrays S1-S4 must be changed accordingly.

With a voltage reference with signal level ±1 V or ±10 V, either a differential or a bipolar input can be chosen.

Differential input: Neither strap 1 - 2 nor 3 - 4.
Bipolar input: Insert strap 3 - 4.

With a current reference signal 4 - 20 mA, insert strap 1 - 2. This will permit the passage of current through the 500 ohm resistor.
The input value can be multiplied from -16 to +16 times, using parameter AI37.XMU/AI33.XMU . The parameters are on delivery set to 1.000.

On the basic I/O-board, the filter time constant can be individually chosen for each channel from 3 to 40 ms set by strapping arrays S5 - S8.

On the expansion I/O-unit the filter time constant can be chosen 10 ms or 25 ms, strapping arrays S5 - S6.

The analog input channel must be adapted to the signal type and level connected.

An analog tachometer generator is connected to the voltage divider, voltage level chosen by jumpers A - D as shown in the circuit diagram. By inserting strap S9:1 - 2/S5:1 - 2, the signal is connected to one of the analog input channels.

On delivery, the 4 channels on the expansion analog input board are zero-balanced. If however it should be necessary during commissioning, channel 1 is zero-balanced with R58, 2 with R57, 3 with R60 and channel 4 with R59.

Digital input channels
Basic I/O (DI37XX) (CD 21)
Expansion I/O (DI31XX) (CD 26)

The input resistors are on delivery designed for 110V a.c. or d.c. signals, but other voltages may be used if the input resistors are changed accordingly.

Basic

Voltage	24 V	48 V	110 V	220 V
Resistor 5W	2.2 kΩ	4.7 kΩ	10 kΩ	22 kΩ

Expansion

Voltage	24 V	48 V	110 V	220 V
Resistor 5W	470 Ω	4.7 kΩ	12 kΩ	27 kΩ

All input signals are operated individually. The signal to which the channel is connected is found in function module CONNECT1 and can be displayed on the operator's panel. The input signals can be individually inversed, using parameters DI37INV/DI31INV. Active signal is indicated by a yellow LED.

Digital output channels
Basic I/O (DO37XX) (CD 21)
Expansion I/O (DO32XX) (CD 27)

All output signals are operated individually. Each channel is provided with a galvanically free relay contact. The output signals can be individually inversed, using parameters DO37INV/DO32INV as shown in the program diagram. The parameters are on delivery set to 0.

Signals connected to the output channels can be displayed on the operator's panel, and are found in the function modules from which they derive.

I/O channel data

Digital input

Basic I/O unit:	12 channels
Expansion I/O unit:	8 channels

Isolation by opto-coupler.
Input load resistor on soldering posts.

Resistor value:	10 kΩ, 5 W
Nominal input voltage:	110 V a.c./d.c.
Min. voltage for "1":	90 V
Max. voltage for "0":	11 V
Max. input voltage:	140 V
Filter time constant:	2.4 ms/10 ms

Digital output

Basic I/O unit:	8 channels
Expansion I/O unit:	8 channels

Isolation by relay.

Max. voltage:	250 V a.c./d.c.
Continuous current:	3 A
Relay contact data:	
Min. voltage and current:	5 V, 1 mA
Lim. making capacity:	30 A, 200 ms
Lim. breaking capacity a.c.:	8 A, 250 V, cosFi > = 0.4
Lim. breaking capacity d.c.:	1.2 A, 48 V
	0.3 A, 125 V
	0.2 A, 220 V

Analog input

Basic I/O unit:	4 channels
Expansion I/O unit:	4 channels

Input type:	Differential ampl.
Max. common mode volt.:	±100 V
Input voltage:	±10 V, 5 mA
Current loop:	5 mA
Resolution:	12 bits
Linearity error:	±0.5 LSB

Analog output

Basic I/O unit:	2 channels
Expansion I/O unit:	4 channels

Output:	±10 V, 5 mA
Resolution, basic I/O:	12 bits
Resolution, exp. I/O:	8 bits
Linearity error, basic I/O:	±0.5 LSB

Digital speed measuring

Max. input frequency:	50 kHz
Input signal:	12 V, 24 V, 13 mA
Pulse gen. power supply:	24 V

Serial communication for service unit

RS 422 interface

Max. cable length:	100 m

High speed serial bus

The communication unit, YPK107 (unit 41) has two channels. One channel is used for communication with an ABB Master, the other channel can be utilized for Master/Follower communication between drives.

One modem board, YPC104, per channel is mounted on top of the communication board, unit 41.1 for Master communicaiton, unit 41.2 for master/follower communication.

The ABB Master communication link can address up to sixteen convertors in a multidrop configuration. The convertors are connected together with coaxial cable. The cycle time is 1 ms per drive connected, and the transmission speed is 2 Mbit/s.

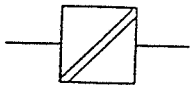
The master/follower communication link can handle up to eight followers connected to one master drive. The cycle time is 1 ms per follower connected.

The unit is provided with a communication circuit of DUSCC (Dual Universal Serial Communication Control) type, a double port memory, a 16 bits processor which reads and writes in this memory and a DMA (Direct Memory Access) circuit. The communication is half duplex in accordance with the specification for the Master Field Bus (modified SDCC protocol). The transmission code used is NRZI.

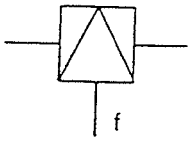
Diagram Symbols

(from 2000 808 - 21 sheet 1)

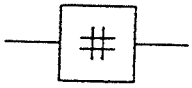
General symbols



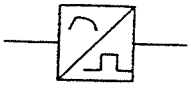
Galvanic isolation.



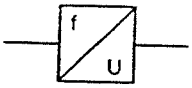
Modulator.



General symbol in digital signal systems.



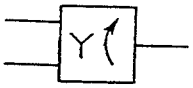
Convertor from an analog signal to pulses.



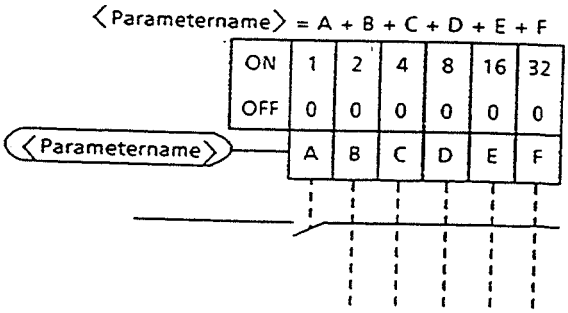
Convertor from freqvency to voltage.

Convertor from a sine wave signal to a square pulse.

Low-pass filter.

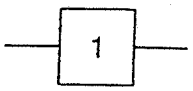


Clockwise phase sequence makes output = "1".

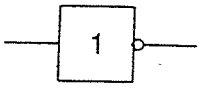


To unpack a compressed integer value to two or more boolean parameters. Above is shown a symbol with six sections (= six boolean parameters), there for example section A is controlling a signal switch.

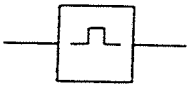
Logical elements



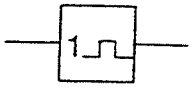
Buffer.



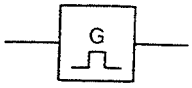
Logic inversion.



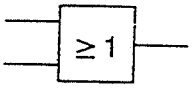
Monostable element.
Possible to re-trigger.



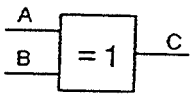
Monostable element.
Not possible to re-trigger.



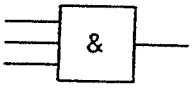
Pulse generator.



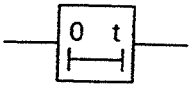
OR-gate.



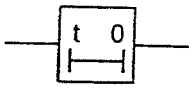
Exclusive-OR. C="1" when only one of the inputs is "1".



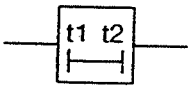
AND-gate.



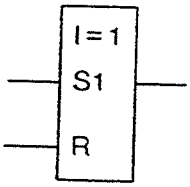
Time delay element.
Time delay when changing to "0"-position.



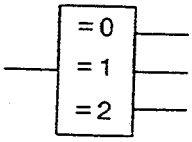
Time delay element.
Time delay when changing to "1"-position.



Time delay element.
Time delay t1 when changing to "1"-position and t2 when changing to "0"-position.



SR flip-flop with SET-signal dominating. At supply connection (Init) the output goes to "1".

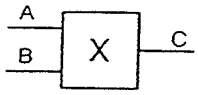


When input has any of values 0, 1 or 2, corresponding output is "1".

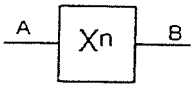
Diagram Symbols

(from 2000 808 - 21 sheet 1)

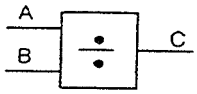
Arithmetical elements



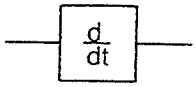
Multiplier
$A \times B = C$



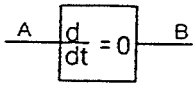
$B = A^n$ with $n = 2, 3, \ldots$



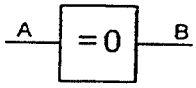
Division
$\frac{A}{B} = C$



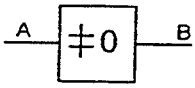
Derivating function.



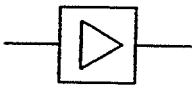
B = "1" when $\frac{dA}{dt} = 0$.



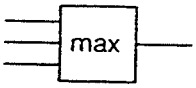
B = "1" when A = 0.



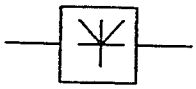
B = "1" when A is not zero.



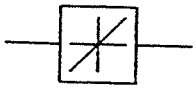
Amplifier.



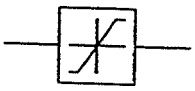
Max. value generator.



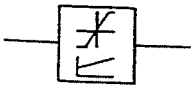
Absolute value generator.



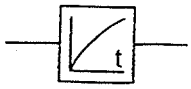
Linear amplifier.



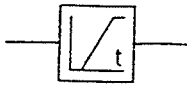
Linear amplifier with positive and negative limitation.



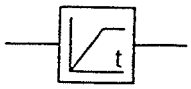
PI-controller.
Linear type with limitation.



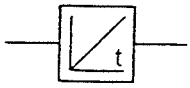
Element with time constant.



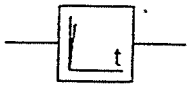
Function generator with limitation.



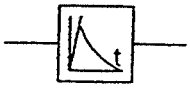
Ramp function.



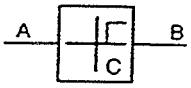
Integrating element.



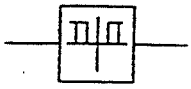
Derevating element.



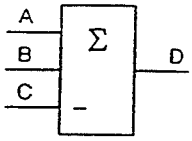
Derevating element with time constant.



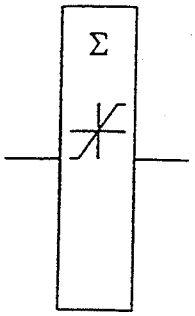
Level detector which makes B = "1" when A > C.



Symmetrical level detector with hysteresis.



Summation element.
$D = A + B - C$



Summation element with limitations.

Diagram Symbols

(from 2000 808 - 21 sheet 2)

Signal symbols

NREF6 — Output signal NREF6 with data size F2 (2 byte "fraction"). Available for operator's panel.

12.F2 NFEEDBPT — Output signal NFEEDBPT with data size 12.F2 (2 byte "integer" and 2 byte "fraction"). Not available for operator's panel.

(POSSPMAX) — Output signal with data size F2 (2 byte "fraction"). Not available for operator's panel.

D033.1 — TRIPPED — Signal switch-box

In this example the digital output board in pos. 33 channel 1 is connected to the software signal TRIPPED.

AOTEST — Parameter. Setting value can be changed from operator's panel.

~~NREF15~~ — Parameter. Setting value can only be changed from a data terminal.

NREF1S — Parameter. Setting value can only be changed from a data terminal.

Remaining symbols

Closing contact.

Breaking contact.

Closing function.

Breaking function.

Change over function.

Control switch with automatic return.

Control switch without automatic return.

Relay with closing contact which is time delayed at opening.

Jumper contact.

Terminal.

Soldering pin.

Disconnectable terminal with test points on both sides of the isolator.

Diagram Symbols

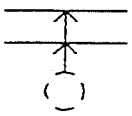
(from 2000 808 - 21 sheet 2)

Remaining symbols (cont.)

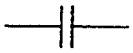

Test point, made as a cage device. Also used as a general symbol.

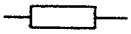

Test point, made as a pin device.

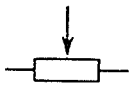

Earth (Ground).

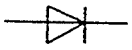

Conductor with screen.

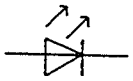

Twisted conductor.


Capacitor.


Resistor.

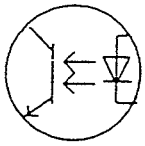

Potentiometer.

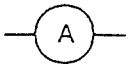

Semi-conductor diode.


Light emetting diode (LED).


Voltage regulator diode.


Signal lamp.
General symbol.


Opto-switch.



Indicating instrument, shown as A-meter.

Tachometer generator.

Installation

Contents

General

These instructions apply to Tyrak XL single and double convertors of type YGMV, YGMW, YHMV, and YHMW.

Note that the attached dimension drawings may be subject to changes. Dimension drawings for the actual equipment delivered should therefore be requested.

Transport and storage

The convertors are delivered in packaging suited to the mode of transport. Check the shipment towards the transportation documents on delivery. Any shortage or damage must be reported to ABB Drives immediately, to avoid delay in installation and commissioning.

If the equipment is not to be installed immediately on delivery, it must be stored suitably protected in its transport packaging, in dry premises protected from dust. The storage temperature must not fall below -25 °C and must not exceed +60 °C (max daily mean temperature +45 °C).

Enclosed convertors, which come attached to loading pallets, must be transported upright by fork-lift truck, trolley or similar equipment.

If there is an overhead travelling crane at the installation location, the lifting beams of the cubicles may be used, see Figure 1.

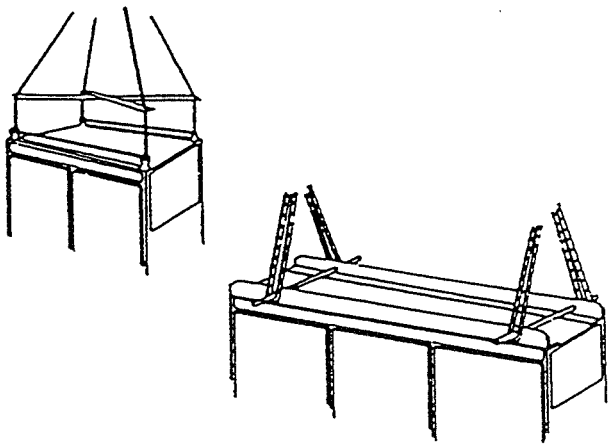


Figure : 1 Lifting instructions

Positioning

The convertors are intended for installation indoors in a normal industrial environment, with an ambient temperature of -5 °C - +40 °C (+50 °C with reduced loading). The air must be free from dust and corrosive gases.

Convertors with air filters may be located in a dusty environment. The filter, which is washable, must be inspected at regular intervals and cleaned if necessary, see section "Maintenance".

The recommended arrangement is for the cubicles to be located close together and preferably in line, directly adjacent to each other as shown in section "Dimensions". If the thyristor cubicle and the control cubicle must be placed apart, the control cables must follow the shortest route and be separated from cables carrying heavy currents.

No precise figure can be stated for the maximum distance between cubicles, since this depends greatly on the level of interference in the environment where the convertor is to be located (proximity of circuit-breakers, other large items of switchgear and magnetic field from inductors etc). As a guide, we recommend that the distance between control cubicles and thyristor cubicles should not exceed 12 metres (40 feet).

The minimum distance from the top of the convertor cubicles to the ceiling is shown on the dimension print. The minimum space between the side of a cubicle and the wall is 40 mm.

The construction of the cubicle requires a flat, well-levelled floor surface (Hus-AMA, tolerance 3B or Class 2), on which several cubicles can be bolted together without special measures being called for.

If several cubicles are to be joined together and the tolerance requirements for the floor surface are not met, each cubicle must be adjusted with respect to the floor, before the cubicles are joined together. This is done by placing sheet metal shims or similar between the bottom beam and the floor.

Cubicles must be assembled first by bolting them together, before they are tightened to the floor. Where cubicles are joined, the maximum tightening torque is 9 Nm.

The thyristor cubicles have doors only on front and may therefore be installed against a wall. Cooling air inlet is through louvres in the doors. The cooling fan is located below the thyristor bridge and the air outlet is through the roof of the cubicle. To ensure proper cooling there must be no external pressure drop. It is essential to keep the cooling air openings clear.

The noise level of a thyristor cubicle does not exceed 75 dBA with good natural damping in the room.

Connections

Main circuit

The main circuit of the convertor is to be connected to the supply and to the motor via cables from below. Cables are connected to bus bars in the thyristor cubicle.

Auxiliary power supply

The auxiliary power power supply voltage can be 380V, 415V, 440 - 460V or 500 V, connected by cable to bus bars marked L1, L2, L3 at the bottom of the control cubicle.

Field supply

The field exciter must be supplied separately by cable, connected to terminals marked L1, L2, L3 at the bottom of the cubicle. Supply voltage can be 380V, 415V, 440 - 460V or 500V. The supply cable to the motor field winding is connected to terminals L+ and L- in the field exciter cubicle.

Serial communication for ABB Master

External coaxial cables are connected to the serial communication connection boards, B53.1 and 2, located at the bottom of the cubicle (see dimension prints). The last convertor in the communication link must be provided with a termination plug, 5217 423-14 (included in the delivery).

Other circuits

Motor starters for convertor and d.c. motor cooling fans are located in the control cubicle with connection terminals (B51) as shown in the dimension prints. Motors starters for heavy start above 22 kW, are located in a separate 400 mm cubicle bolted to the control cubicle.

Interconnections

The control- and field exciter cubicles are on delivery bolted together with all interconnections ready-made. Connections between the contol- and thyristor cubicles are made by cables with plug-in connectors, which are included in the delivery. The cables are connected to terminal units designated B52 in the control and thyristor cubicle.

Cable routing

Convertors contain both electronics and equipment with high power ratings. Circuits in convertors therefore fall into two categories: those that cause interference and those sensitive to interference. The former are the main circuits, the latter the electronic control circuits.

To minimise the risks of interference, conductors sensitive to interference should be run separated, at least 100 - 300 mm, from cables generating interference. Signal cables (up to 110 V dc) connected to optocouplers on the control equipment should not have a length exceeding 300 m.

Electronic signals connected to the neutral of the electronic system (reference values, actual values and certain digital signals) are to be conducted in screened cables. The screen (SC inthe circuit diagram) must not form a closed circuit, since this might give rise to inductive currents.

Screens are connected to special terminal blocks on terminal row B50.

Cables must be dimensioned and installed in accordance with relevant rules and regulations (standards).

Earthing

All units in the convertor are connected to the frame via their fixings.

Since relatively high currents (5 - 10 kA or more) occur in these installations, it is important to earth the various parts of the installation with great care. From an interference point of view, it is important that potential differences, both transient and static, are eliminated to the greatest possible extent. This means that the installation must have a well-dimensioned and carefully-installed earthing network. The control and thyristor cubicles must be connected together with a reliable ground conductor. The cross-sectional area of the earth lines must be generous (to current standards) and must take the shortest possible route between parts of the installation.
For units that carry digital and analog signals it is especially important the earthing points are reliably connected to the common earthing network by earthing lines that are as short as possible. All cubicle frames have an earthing clamp to which the earth line may be connected.

Commissioning

Contents

Page

Introduction

This instruction describes the commissioning of a motor drive supplied from a Tyrak XL convertor. The convertor configuration can be 6-pulse, 6-pulse tandem, 12-pulse parallel or 12-puls serial. (With or without bridge sequence control).

This instruction describes the commissioning procedure in sequencial order. As this instruction is rather comprehensive it is provided with a check list with a summary of the commissioning activities.

The aim of this instruction is that an experienced commissioning engineer, used to smaller convertors such as Tyrak Midi II, should be able to perform the commissioning without earlier experiences of Tyrak XL. The emphasis in the instruction has not been to give precise instructions for commissioning but rather to explain how functions in the control system can be set and tuned for the actual requirements.

The control system of the convertor includes functions to simplify the commissioning process, eg the TESTMODE-function. These functions are described in the section "Built-in aids to commissioning".

Important system parameters, eg various rated data, are grouped in special "start-up" modules (one for each control unit); see the section "Setting rated data".

The control system of Tyrak XL is decentralized. There are three types of control units in the control system; a drive control unit, a convertor control unit and a field exciter control unit.

Commissioning a Tyrak XL often involves commissioning of a complete motor drive system. That means that some time must be spent on preparations for powering-up the convertor, such as checking the groundings, measuring the insulation resistance as well as checking switchgear, transformers and other apparatus external to the convertor.

A large motor drive may, under special circumstances such as current limit, load the supply network close to its prospective short-circuit power. This may cause problems if the converter has to operate in inverting mode. The control system of Tyrak XL is equipped with functions to handle situations like this, see section "Protection against commutation breakdown".
The short accelleration time constant of a low speed motor drive may, together with torsion in the mechanical transmission and big inertial masses, cause problems by exciting natural frequencies. The speed controller used in Tyrak XL is designed to reduce or eliminate resonances, see section "Speed control".
It is important to set aside time for a certain amount of supervision during the initial period of actual service, particularly at maximum load. Some minor adjustments may have to be made and some parameter settings may have to be changed, on protections for instance.

Normally there is no need to change factory settings, unless the commissioning instructions or other documentation says so, but there may be circumstances where this becomes necessary.

The text refers to software signals and parameters. To localise these, a module name is given. The first six letters are the module name; the next two Xs represent the version and revision number.The module names are unique within the Tyrak XL software. If the text does not refer to which control unit a function module is to be found, it can be found by using the module register found in the program diagram (PD) for each control unit).
Finally, a golden rule:
Never tune the control system "harder" than what is required by the process; othervise it will put excessive strain on the mechanical equipment.

Commissioning procedure

The section headed Checklist below sets out a suitable procedure for commissioning. It shows, for example, that the field exciter may be commissioned before power has been applied to the main circuit. As far as the sequence of the various activities is concerned, it will mostly be obvious to an experienced commissioning engineer. However, it is debatable whether it is better to rotate the motor before tuning the current control, or whether the current control should be tuned first. Large motor drives are not so prone to overspeeding as small ones, and experience has shown that it is better to start with the tuning of current control.

Commissioning a large motor drive often includes commissioning high-voltage equipment and certain items of switchgear in the main circuit, such as high-voltage and dc circuit-breakers. It is important to check these first, since the control system of Tyrak XL and the switchgear are not normally tested together before delivery.

It is important to stress that the work with the commissioning should start before travelling to site. This instruction and other relevant documentation should be studied. A preliminary parameter setting list should be made in advance of the commissioning, eg setting of overcurrent detection level.

Checklist

Before starting the commissioning process

- Read the chapter Introduction.
- Study the description of built-in help to commissioning:
  - The "TESTMODE" function
  - The "TESTREF" function
  - The "STEP" function.
- Check equipment, instruments etc required.
- Read General instructions concerning:
  - Safety measures of
    - Personal safety
    - Equipment.
- Appoint authorised person to operate high-voltage circuit-breakers.
- Comments on commissioning methods.

Before powering-up the main circuits of the thyristor cubicle

- Before powering-up the control cubicle, check
  - Grounding.
  - Auxiliary supply circuits.
  - Speed measurement as regards:
    - Jumpers on measurement boards
    - Power supply of pulse transmitters.
  - Other external apparatus.
  - Connection between Control cubicle and external Field exciter.
- Short-circuiting of the memory board back-up supply.
- Powering-up the system.
- Checking the high-voltage supply:
  - Operation
    - Undervoltage signal from high-voltage CB to convertor.
  - Setting the protections.
- Checking / inspection of entire drive system before powering-up:
  - Grounding system
- Insulation resistance measurment
- Motor (visual inspection).
- Settings
  - Setting the start-up modules:
    - Drive system
    - Convertor
    - Exciter.
  - Presetting of protections.
    - Connection of signals via the "CONNECT" function.
- Checking operation of the convertor, "TESTMODE" = 0
  - Connecting a provisional synchronizing voltage.
  - Checking the field circuit.
  - Checking the direct of rotation of fans.
  - Trigger pulse check.
- Commissioning exciter(s)
  - Via operator panel:
    - Setting the current limiting (done in workshop tests)
    - Setting controller gain
    - Setting the integration section
    - Setting blocking devices.
  - Checking the field polarity
  - Checking/setting measurement circuits.
    - Measuring rotor current (done in workshop tests).
- Checks and settings before connecting the high-voltage circuit-breaker:
- Trip signal to high-voltage circuit breaker
- Auxiliary supply for trigger pulse amplifier(s).
- Powering-up the main circuits of the thyristor cubicle.

After powering-up the thyristor cubicle

Before starting the convertor:
- Locking the bridge direction of the convertor
- Checking the level of the supply voltage

Checking the AC-supply voltage measuring
- Setting the undervoltage protection.

Controllability check, "TESTMODE" = 0
- Checking the position of the firing pulses.

Controllability check, "TESTMODE" = 1
- Checking the current and DC voltage measurement
- Calibration of the convertor delay angle.

Self-setting of current regulation, "TESTMODE" = 2.

Current regulation, "TESTMODE" = 3.
- Setting the current regulator for:
  - 6-pulse convertor(s)
  - 12-pulse parallel convertor(s)
  - 12-pulse series convertor(s).
- Compensation of RI-drop in EMF measurement.
- Compensation of voltage drop in supply systems.
- Checking the current indication level.
- Checking of the DC breaker overcurrent tripping.
- Setting and checking the current rate-of-change limiting.

Provisional tuning of speed control, "TESTMODE" = 6.
- The first time the motor is run:

Check the polarity of the speed feed-back
  - Direction of rotation of the motor
  - Checking the speed measurement against actual speed.
- Setting the overspeed protection.
- Setting the overvoltage protection.
- Checking the DC voltage measurement.
- Setting the field weakening curve.
- Setting the minimum field current.
- Setting the speed-dependent current limit.

EMF control, "TESTMODE" = 7.
- Tuning the EMF controller.
- Setting protections and limits.
- Checking and setting of the blocking systems.
- Setting of delay angle limitations.
- Bridge changing, motor with stationary rotor, "TESTMODE" = 3.
- Bridge changing, motor with rotating rotor, "TESTMODE" = 6.

Setting the EMF reference.
- Speed regulation, final tuning, "TESTMODE" = 6.

Position regulation, "TESTMODE" = 8.
- Speed regulation, performance check, "TESTMODE" = 9.

The "zero to base speed step test".

Interaction with higher-level control system, "REMOTE"

MasterField Bus
Master Follower communication
Twin-drive

Concluding procedures

Built-in aids to commissioning

"TESTREF" function

TESTREF is a signal which, with the aid of the "TESTMODE" function becomes the reference for the various setpoints in the control system.

Depending on the value of the TESTMODE signal, TESTREF becomes the reference for the delay angle, rotor current, speed etc of the convertor. For TESTREF to become the rotor current reference, the IDTEST parameter in the convertor control system must be reset to zero.

The TESTREF signal is controlled via an analog input signal TESTREF1 connected to a ramp circuit, or via increase/decrease buttons on the operator panel. The rate of increase of the signal is determined by the parameter RAMPTIME in the function module of TESTDSXX.

A potentiometer may be used to control TESTREF via the analog input. The potentiometer (10 kohm) is connected to +10 V and -10 V and the centre tap is connected to B51.66. Signal TESTREFI has to be connected to AO37.1 via switch box.

"STEP" function

The "STEP" function works together with the STEPTEST menu of the operator panel; see PD. In the STEPTEST menu a STEP signal is generated. Using the "TESTMODE" function, this becomes a step disturbance for the various setpoints in the control system; see below. In addition, for STEP to become a step in the rotor current reference, a parameter IDTEST must be set to zero in the convertor control system. When STEP =1 %, a one percent change in the actual setpoint is obtained.

"TESTMODE" function

The system includes a test function known as the "TESTMODE" function. See also the TESTDSXX function module in the program diagram (PD).

The TEST parameter in the TESTDSXX module is used to activate the "TESTMODE" function, provided that local operation at the operator panel has been selected.

The test function desired is selected by the TESTMODE parameter. Depending on the setting of that parameter, a signal TESTREF is connected as a reference for the various control quantities in the control system (eg delay angle, rotor current, field current, rpm and angular position).

The output signal STEP automatically becomes (with help of the "TESTMODE" function), a step disturbance to the various control loops.

If the "TESTMODE" function is to be used, the convertor must be started via the ON button on the operator panel. A start-up order is then given, with the START button on the operator panel.

To change the "TESTMODE" function, eg the DRIVMODE signal, the convertor has to be switched off.

This means that, if, for example, trigger pulses are to be checked without power on the main circuits, a provisional synchronizing voltage must be connected.
Acknowledgement signals from circuit-breakers must be jumpered; see **Fault tracing instructions**, the section headed **Trigger pulse check**.
When the convertor control system recieves a ON–order , the main circuit of the convertor will normal be energized or the main circuit are energized.

Testmode

Value	Function
0	Open control of delay angle ALPHA with trigger pulses blocked in the trigger pulse amplifiers of the thyristor cubicles. The reference signal TESTREF is automatically connected as a reference for the delay angle. Current control is NOT active. Current measurement is active, and therefore overcurrent protection as well.
1	Open control of delay angle ALPHA with trigger pulses deblocked in the trigger pulse amplifiers of the thyristor cubicles. Current control is Not active. Current measurement is active, and therefore overcurrent protection as well.The motor field is automatically disconnected.The reference signal TESTREF is automatically connected as a reference for the delay angle.
2	Automatic setting of the current control in the armature circuit. Setting is to be done with field exciter connected to motor.Field can be disconnected with parameter FLDEXCS.
3	Checking rotor current control. This function automatically disconnects the motor field. The field can be connected using FLDEXCS in the ORDERH0X module. The reference signal TESTREF is automatically connected as a current reference if the IDTEST signal in the convertor control system is set to "1". STEP automatically becomes a step in the rotor current reference value if the IDTEST signal in the convertor control system, module IREFHAXX, is set to =1. Bear in mind that the limit on the current rate-of-change may affect the "step". With the parameter HIGHSTEP = "1" the current step disturbance via the signal STEP will be increased four times.
4	Automatic setting of the current control in the field circuit. This function is for normal running.
5	Test of field current control. TESTREF is automatically connected as a reference for the field current. STEP automatically becomes a step in the field current reference.
6	Test of speed control. TESTREF is automatically connected to the speed reference. STEP automatically becomes a step in the speed reference.
7	Test of EMF control. The EMF reference is not affected by TESTREF. TESTREF is automatically connected to the speed reference. STEP automatically becomes a step in the EMF reference.
8	Test of position control. The test signal TESTREF is automatically connected as the position reference. STEP automatically becomes a step in the position reference.
9	Performance check of speed control with respect to load disturbance. TESTREF is automatically connected to the speed reference. STEP automatically becomes a step in the torque reference.
10	This function is for normal running.
11	Test of twin-drive controller. Test ref. is automatically connected to the speed reference. Step automatically becomes a step into twin-drive controller.

Example:If the delay angle is to be controlled without deblocking the trigger pulses to the thyristors, the TESTMODE parameter is set to 0. The convertor is then started and a release order to the control system is given via a start order. The delay angle can now be controlled with the TESTREF signal, and the positions of the trigger pulses can be checked with an oscilloscope.

Equipment required

Multimeter 0-1000 V AC and DC, and 10 A DC and AC.

Printer ABLE 24 including cable. Cat. no. YT 290 000-A
Accessories:
Ink ribbon, cat. no. 5697 799-3
Paper roll, cat. no. 5697 799-4.

Liner potentiometer, 10 kohm, 0.5 W, for setting the reference value and simulating signals.
ABB article number 5248 2051-10, for example.

Oscilloscope, triggerable from the mains frequency.
A digital oscilloscope is preferable.

Insulating transformer for oscilloscope.

Insulation tester (≥1000 V), eg Megger.

A VT-100 compatible terminal, eg Microscribe.

Chart Recorder with at least two channels. eg Brusch.

Personnel Computer equipped with software for loading and dumping parameters. Connect to the modem YPK111 included in the convertor equipment.

The following documents are also required:

Circuit diagram (CD)
Program diagram (PD)
Test record for the motor.
Description of switch gears and breakers for the main circuit

Safety measures

Personnel protection

To prevent accidents, observe the following rules:

Never work alone on commissioning.

Make sure that you and anyone else involved know how to switch off the power to the installation.

Appoint an authorised person to operate the high-voltage circuit-breaker. Only that person should operate the circuit-breaker.

Inform people working close to the motor that it may start without warning. If possible, screen off the motor.

As far as possible, work on the convertor should be done with the power off. The auxiliary power supply should also be off.

If the rotor or the coupling between the motor and the driven machine is fitted with a provisional mechanical arrangement, such as a locking device, make sure that this device cannot constitute a hazard to the surroundings.

Equipment

To prevent damage to motor, convertor equipment or driven machine, observe the following rules when current is conducted through a dc motor's armature at stand still:

When manual tuning of the armature current controller is performed, or when compensations for voltage drop caused by the armature current are tuned, current is conducted through a motor without field excitation. The field excitation will during this circumstances automatically be switched off. To keep the motor standing still it is normaly enough with the friction. But the motor must be kept under supervision in case its start to race.

A high current must not be allowed to flow through the motor for a long time. At a current corresponding to the current limit this period should not exceed 5 seconds at a time.

It is important to allow the motor to cool down between periods of loading. Keep the cooling system running all the time.

If the motor cooling system has not been installed when the field exciter is started, there is a risk of the field winding overheating. In such cases the nominal field current must only be applied for two minutes at a time.

Checking the auxiliary supply circuits before power-up the control system

Action when changing the program and on first start at the customer's premises

To avoid problems during commissioning, the 1 farad capacitor on processor board YPQ201 must be shorted. This is done at pins X26:1 and X26:2 near the capacitor. This action is essential when the PROM on the memory board has been changed. Because of the high internal resistance of the capacitor, the short-circuit must be left in place for at least one minute.Do not forget to remove the short-circuit.

Checking the Grounding (auxiliary supply circuits)

Where several convertors share a common analog reference system, and where signal zero is used in the transmission of signals between the converter and the reference system, the zero line (0VE) of the auxiliary supply must only be grounded at a single point. Jumper W4 on terminal board YPQ104 must then be removed in affected convertors.

Checking the installation of a coaxial cable for serial communication

Coaxial cables for serial communication to ABB Master and to another convertor must be checked to make sure that they have been correctly installed. The installation instructions describe how coaxial cables should be connected. Check that the termination sleeve is fitted at the FSK modem where the coaxial cable ends.

Calculation and jumpering of the analog input board with tacho feedback

Tachometer voltage at maximum speed is calculated as follows:

$Umax = k \times n_{max}$, where

k =	0.1	for type BD 2510
	0.2	for type TDP 1306
	0.06	for type REO 444
	0.025	for type TGRB 1-5 A

Analogue input board YPQ202 is jumpered as shown in the table in the Circuit Diagram (CD). Select the voltage range above the range calculated.

The time-constant can also be selected with a jumper. Unless the speed control is subject to severe demands, it should be jumpered for 11 ms; see the table in the circuit diagram (CD).

Adaptation of board YPQ202 for digital speed feedback

The supply for the pulse transmitter can be taken from YPQ202 when it requires 24 V. The supply is brought out to terminals 87 and 88 on terminal block B51.

If the pulse transmitter requires another power supply, it must be taken from a separate power supply unit.

Terminal board YPQ202 must also be jumpered to suit the feedback from the pulse transmitter. Jumper positions are shown in a table in the circuit diagram.

24 V S10: 3-4. 7-8, 11-12
13 mA S10: 1-2, 5-6, 9-10.

Maximum pulse frequency from the pulse transmitter must be jumpered on I/O board YPQ202; it is calculated as follows:

$$\text{Maximum pulse frequency} = \frac{\text{Nmax}}{60} \times P$$

where

Nmax = the maximum speed at which the DC motor will be run and
P = the number of pulses per revolution from the pulse transmitter.

The number of pulses for the transmitter is stated on its rating plate.The maximum pulse frequency is jumpered as shown on the circuit diagram (CD).

Checking the main circuits

Checking the grounding system

Correct grounding is essetial for trouble-free operation. The installation instructions describe how the various parts of the convertor should be grounded.

In an installation with an ABB Master communicating with the convertor via MasterFieldbus, the ground connections of the MasterPiece must be checked relative to the convertor. The overriding control system must be grounded upstream relative to the convertor, i.e. the convertor must be grounded closer to the grounding point. This is because transients in the supply network may cause high capacitive ground currents, creating "common-mode" interference which may disrupt communication.

Checking the insulation resistance

Before the convertor and motor are powered up, the insulation resistance to ground must be checked. Both the a.c. and the d.c. side of the convertor must be checked, including d.c. or a.c circuit-breakers. A 1000 V insulation tester should be used.
The fuses to the transient protection and the ground fault protection A13:1-3, 12-14 must be removed, to avoid incorrect ground fault readings.

Checking the DC motor(s)

General

Since this will be the first time the motor(s) has been started, the maintenance and commissioning instructions for the motor(s) must be observed.

Before the first start

If the driven object cannot rotate (or only slowly) in the opposite direction without the risk of damage, the coupling between the d.c. motor and the driven object must be opened, with the separate coupling halves fixed to their respective shafts.

- Check that rotor circuits, field circuits and pulse transmitter / tachometer are connected.
- Check that the field windings are correctly connected for the voltage and that the brushes are in contact with the commutator.

If the motor is equipped with a lubrication system, its operation must be supervised. Pressure and flow detectors can be connected to spare digital inputs and tied to the fault signal processing system in the drive control unit, where module FSIGHAXX, signal MOALUBFT or MOBLUBFT are intended for this purpose.

Checking series fields

If the d.c. motor has a series winding, check that it is active. Measure the voltages across S1 – S2 and F1 – F2. The polarity of S1 and F1 must be the same.

Under load

It is important to check the commutation of the motor under heavy load. Poor commutation may be caused by the current rate-of-change limit, parameter IADERMAX in function module IREFHAXX, being set too high.

Setting the "rated data"

Start-up modules of the drive system

DCBRS — This parameter is set to 1 when there is a DC circuit-breaker in the main circuit.

EMFNOM — This parameter is set to the value that corresponds to nominal EMF. The nominal EMF can be found in the motor no load characteristic which normally is attacked to the motor testrecord. If this value is not known, the parameter can be preset to 90 % of UANOM. Under the heading Automatic field weakening there is a section that describes how to check the nominal voltage of the motor.

FOLLOW1S — This parameter must be set to 1 in the convertor that is normally to operate as follower in the leader/follower operation.

IANOM — The parameter is set to the value which appears on the motor rating plate as the nominal value of the rotor current.

IFNOM — The parameter is set to the value which appears on the motor rating plate as the nominal value of the field current.

NBASE — The parameter is set to the value which appears on the motor rating plate as the base speed of the motor.

NBREDGES — When both channel A and channel B from the pulse transmitter are connected to terminal board YPQ202, this parameter is set to 4. (Channel A X6:1, channel B X6:3)

NBRPPR — This parameter is set to the number of pulses that the pulse transmitter gives per revolution.

NMAX — This parameter is set to the maximum speed of the drive.

ONEFLEX — This parameter is set to 1 if there is only one field exciter.

SEL12PP — This parameter is set to 1 if the convertor configuration is 12-pulse parallel.

SECTYPE — This parameter is used to define which of the convertors in a leader/follower drive is the leader and which is the follower.The values can be set as shown in the table below:

Value	Meaning
0	Master/follower communication switched off. The parameter must be set to 0 when communication is not used.
1	If the motor drive is normally to serve as a leader drive.
2	If the motor drive is normally to serve as a follower drive.

TWINDRIV — The parameter is set to 1 if the application is using twin drive controller.

UANOM — The parameter is set to the value which appears on the motor rating plate as the nominal terminal voltage.

The start-up module of the convertor

CONVMODE	Convertor configuration mode select. CONVMODE = 1: not used CONVMODE = 2: 6-pulse CONVMODE = 3: 12-pulse series CONVMODE = 4: Bridge sequence control
DC-SHUNT	This parameter is set to 1 if there is a d.c. shunt current measurement.
DOUBCONV	This parameter is set to 1 if the convertor is a double convertor.
FREQDEV	This parameter is set to a value expressed in Hz which is the highest permitted level of changes in the period-time measurement. A severely deformed voltage causes disturbances to the period measurement.
FREQNOM	This parameter is set to a value expressed in Hz which corresponds to the nominal frequency.
IDMNF	Set to the value that appears on the rating plate of the motor. It stands for nominal current in the forward direction.
IDMNR	Set to the value that appears on the rating plate of the motor. It stands for nominal current in the reverse direction.
LINEVOLT	This parameter is set to the line no load voltage, phase to phase.
LMAINS	Line short-circuit inductance per phase in uH.
PHSHIFT	Slave convertor phase displacement rel. to master.
TRAINACT	Interaction between secondary transformer windings; 0 = low interaction ; 1 = high interaction.
UVLEVEL	This parameter is set to a value relative to the nominal supply voltage level, 100 %.
UVNOM	This parameter is set to the value that appears on the rating plate of the convertor. It stands for nominal convertor no load voltage, phase-to-phase.

The start-up module of the field exciter

IDMN	This parameter is set to the value that appears on the rating plate of the field exciter. It stands for nominal current.
FREQDEV	This parameter is set to a value expressed in Hz which is the highest permitted level of changes in the period-time measurement. A severely deformed voltage causes disturbances to the period measurement.
FREQNOM	This parameter is set to a value expressed in Hz which corresponds to the nominal frequency.
UVLEVEL	This parameter is set to a value relative to the nominal supply voltage level, 100%.

Control of operating circuits

General

The ON and OFF switches referred to in this document are marked with I and O on the operating panel. References to start and stop switches relate to the switches marked START and STOP.

When the convertor is tripped, a red lamp lights up on the operator panel. Resetting of error conditions is accomplished by pressing the RESET button on the operator panel. Certain self-correcting problems, for example a motor overload, do not require resetting before restarting the convertor.

A red blinking light on the operating panel indicates a warning of a problem which does not immediately lead to the convertor cutting out. In spite of the warning signal the convertor remains operative, that is the signal RDYREF remains ="1". However, after a certain period the warning results in a trip.

Preparation

If the operating circuits are intended to be checked before powering up the thyristor cubicle, a temporary reference voltage (for the trigger pulse generation) must be switched in. For this purpose a power supply of 3 x 7 V is lead to terminal +Y.2.B20.X12 (CD sh 49).

Under no circumstances should power be applied to the main circuits when the temporary reference voltage is connected. This means that the high tension circuit breaker must be open, and that precautions must be taken to ensure that no-one closes the circuit breaker by mistake.

When the temporary voltage has been applied, the provisional connections can be made as follows:

B20.X12:1-4 moved to
B20.X12:5-8

For 12-pulse convertor operation or tandem connection, convertor control system B must also have a temporary reference voltage connected.

An acknowledgement signal must be received at terminals B51.95 and B51.96 (sh 30) in order for the trigger pulses to be deblocked. If the installation does not have a low voltage circuit breaker, and the acknowledgement signal is received from the high tension breaker, provisional transitions should be made as follows:

B51.97 => B51.95
B51.97 => B51.96

Do not forget to remove all provisional connections when the operating tests are completed.

Checking of auxiliary supply voltage

Use a voltmeter to check that the incoming auxiliary supply voltage is in accordance with the rating, with a tolerance of ±10 %. If the supply voltage is common with the exciter, the phase sequence should be positive, that is L1, L2 and L3. If the phase sequence is incorrect, this will be indicated by the error signal PHSEQFLT, which will be set equal ="1".

Checking of emergency trip relay and emergency stop relay

In accordance with standards, the convertor is equipped with a mechanical emergency trip relay (B1.21). This relay is controlled by push button and cuts out the equipment upon deactivation. Check that the relay is activated and also check which external switches deactivate the relay (CD sh 64).

Connection of signals with help of signal exchange function CONNECT

Handling of this function is described in section "Operators panel management".

When the equipment is delivered, digital I/O ports are connected in accordance with the standard circuit diagram, unless the order for the convertor states otherwise.

Large motor drive systems may require control of external apparatus from the convertor's control system. Examples of this are the high and low tension circuit breakers and dc-breakers. It may also be that there is a requirement to collect data (for example drive status) from apparatus external to the convertor control system, such as mechanical safety relays.

The control system for Tyrak XL is prepared for communication with external apparatus to a greater extent that is usual for a less standard convertor. The error handling system is prepared with error messages and spare (reserved) entry points to function modules. For example, the sequence control function makes it possible to operate connecting devices in various different ways.

The software contains a source for every signal in the system, that is a function module, where the signal is defined. Normally, this source is another module, but to certain unused entry points there is no source module. Since all signals must be defined, these missing signals must be defined in another way.

When a program is created, the function modules are connected when input and output signals with identical names are linked. Input signals for function modules which are not linked to an output signal of another function module are automatically connected to a CONNECT module. The CONNECT module is a special function module for unconnected signals, and is called:

CONNXXXX in the drive system computer
CONNCSXX in the convertor computers
CONNFEXX in the exciter computers.

When there is a limit to the number of signals which the operator panel can handle, certain signals, which will normally not be used, are defined in CONNECT modules but they can not be accessed via operator's panel. These signals can be connected to I/O by using terminal, and they are marked by parenthesis in PD.

Choice of start sequence

The convertor start sequence may be split or not split. When the start sequence is split, the preparatory service connection is made with the ON signal, whilst the convertor is prepared for reference with a START1 signal.

The convertor start sequence is described in the following table. More information is given in the **Description.**

Start Sequence	SEQMODE	Fan breakers	Field exciter	ac and dc breaker	Prepared for reference
Not split	0	START1	START1	START1	START1
Split	1	ON	START1	START1	START1
Split	2	ON	ON	START1	START1
Split	3	ON	ON	ON	START1

Checking the convertor fans

The fans in the thyristor cubicle are operated by contacts in the control cubicle. When the convertor is erected at the installation site, a special cable must be laid out between the control cubicle and the thyristor cubicle. See **Instructions for installation**.

In the function module TESTDSXX the parameter TESTMODE is set ="0" via the operating panel. If the motor's field winding cannot be connected to power, the SEQMODE parameter (see the reference above) should be set ="1". Local control is selected by pressing the LOC button on the operating panel, whereupon the associated LED will light up. Press the operating panel ON switch. Check that the convertor fan(s) start and that they rotate in the correct direction. The flow of air should be upwards. Adjustment of thermal protections for the motors and of pressure switches need not be done while it has been done at the factory test.

Checking external fans

Switch on the supply current to the fans and push the ON button (operating panel). Check that external fans rotate in the correct direction. If the motor is fitted with airflow protection, such as pressure switches, this must also be checked. The error handling system includes reserved entry points for airflow protection, which can be connected with the help of the CONNECT function to digital entry points.

Thermal motor protections for external fans should be set for the rated current of different motors. Additionally, a choice should be made between automatic or manual reset of these protections.

Commissioning of the field exciter

General

Commissioning of the field exciter can take place from the operators panel or from the drive system.

If the operation of the exciter from the drive system computer is to be checked without operation of the main circuit breakers, the parameter SEQMODE should be changed to ="2". See the section **Choice of start sequence**.

Initial settings

If the field exciter is a double convertor, the current direction should be locked in one direction until the blocking system of the field exciter is properly adjusted. Set LOCKBRCH = "1".

Checking and adjustment of current measurement

The scaling of the current response, IDACT, is normalized so that the exciter's continuous rated DC current is equivalent to 100 % (internal representation 2^{13}). When the field current shows 100 % the voltage level of the current response should be -5.0 V between YPQ201 X25:1-2 (CD sh 75).

Checking the supply voltage

With the help of a voltmeter please check that the incoming supply voltage agrees with the rated supply, and that it is within a ±10% tolerance. The phase sequence should be positive, that is L1, L2 and L3.

Operation from the operators panel

When the exciter is to be operated from its own panel, the DS communication (communication between the drive system and exciter computers) should be turned off, and local control activated. The communication to the drive system has to be turned off by setting the parameter SCFEASEL/SCFEBSEL = "0" in drive systems function module DSCTRAXX and FLDEXNR = 0 in field exciter system, function module FSCTRAXX. After setting these parameters, the control system for drive and exciter must be restarted.

Local control is activated by setting the parameter IFTEST ="1" in function module IFREHAXX. The exciter can now be operated from its own operating panel, via the ON and OFF switches and can control the field current reference, IDREF, with help of parameter IFREFCOM. Before the exciter is started, the parameters in its start-up module should be adjusted (see section **Adjustment of Start-up Modules**). Additionally, since the DS communication is disconnected, the parameter IFNOMSTA in function module FSCRECXX must be set to a value which corresponds to the nominal field current of the motors.

Adjusting the system amplification and proportional amplification

The field current regulator's amplification is the product of the value of the system amplifier, OMEGA_L and N_OMEGAL, and the value of the parameter IFGAIN. The system model can be adjusted with help of the parameters OMEGA_L and N_OMEGAL. An indication that the parameters are correctly set is that the signal I_CONT is set ="1" when the current is continuous.

The most natural way to determine whether the field current is continuous or not is to connect an oscilloscope to the field current response, YPQ201 X25:1-2. In certain cases it can nonetheless be difficult to determine, even with an oscilloscope connected, whether the field current is continuous or not (CD sh 75).

Another method is to observe the exciter's output voltage with an oscilloscope. In this case, connect a measuring probe for high voltage (1 kV) to the exciters DC voltage. In this case the oscilloscope must be supplied via a insulating transformer.

When the field current is continuous, the DC voltage is saw-toothed, where every tooth is a part of the exciter's connection voltage. When the current is discontinuous, the appearance of the DC wave changes in such a way that the saw tooths changes somewhat from the form it had when the current was continuous. See figure 1 below.

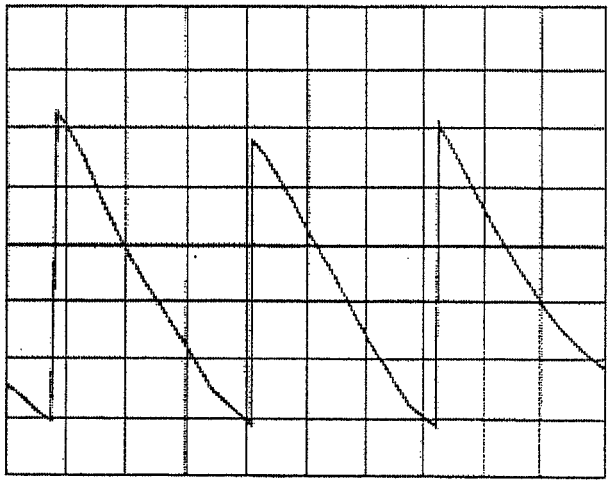


Figure 1. The shape of DC-voltage when current is discontinuous.

In both cases, when the changing-over current for continuous / discontinuous operation, Id0, is measurable, method 1 below should be used. If it proves impossible to determine by measurement whether the current is continuous or not, method 2 should be used.

Adjustment is as follows:

Method 1

Connect signal I_CONT by means of the CONNECT function to an indicator on the operating panel, for example DOOP.1.

Setting of system amplification

The system amplification should be set to a preliminary value. N_OMEGAL is set to the value =1 and OMEGA_L to the value 6900. Set IFGAIN =0.4. Start the exciter and adjust the field current reference using the parameter IFREFCOM until the current just becomes continuous. Increase the value of the parameter N_OMEGAL in steps of one unit until the signal I_CONT just changes and becomes ="1" (continuous current). Thereafter the value of parameter OMEGA_L should be reduced until the signal I_CONT just changes to ="0". At this point the system amplification is correctly adjusted.

Tuning of proportional amplification, IFGAIN

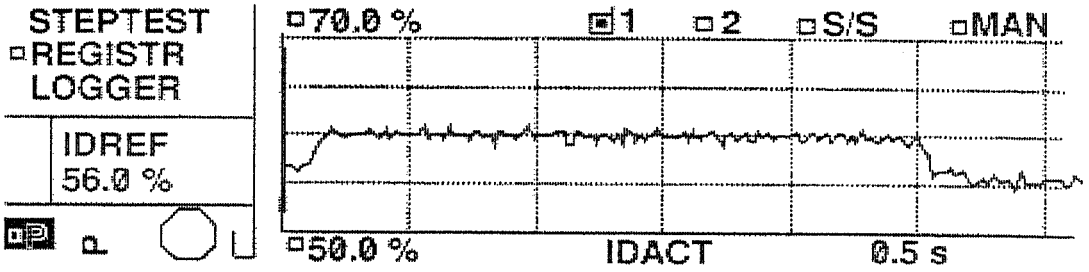
Tuning of current control should be performed with the largest possible field, that is with a field current where the inductance is at its lowest. Generate a step disturbance in the current reference with help of the signal IDSTEP in the STEPTEST function. The step disturbance is not allowed to be so large that it causes the delay angle to reach a limiting value, ALPHAMIN or ALPHAMAX. This is controlled by comparing the smallest / largest value of the signal ALPHA in the operating panel REGISTR image with the limiting values. IFGAIN is increased until a pulse time of less than 20 ms is obtained or until a ringing starts on the voltage response.See picture, figure 2, below.

Method 2

In this case another adjustment method is used, where the parameters for system amplification are set by fine tuning of the regulatory power ratio. This method lacks the precision in setting the system amplification, but in most instances the lack of precision is not significant.

Adjustment

Set the parameter IFGAIN =0.5. Generate a step disturbance in the current reference with help of the signal IDSTEP in the STEPTEST function. The step disturbance does not need to be so large that it causes the delay angle to reach a limiting value, ALPHAMIN or ALPHAMAX. This is controlled by comparing the smallest / largest value of the signal ALPHA in the operating panel REGISTR image with the limiting values. IFGAIN is increased until a pulse time of less than 20 ms is obtained or until a ringing starts on the voltage response. N_OMEGAL should be seen as the coarse adjustment parameter, and OMEGA_L should not be set higher than 6900. See picture, figure 2, below.



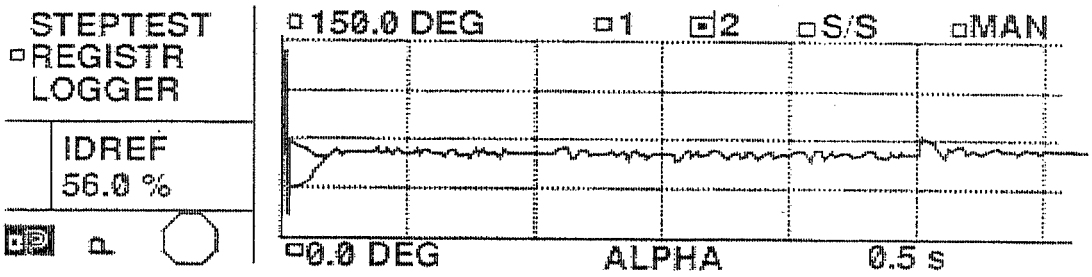


Figure 2. Field current control.

Tuning of integration time, IFCON_TI

Tuning of the integration time should be done with the lowest possible field current, that is when the inductance is as high as possible.

Set IFCON_TI to 200 ms. Start the exciter and generate a step disturbance. Check in the same manner as for fine tuning of proportional amplification that the delay angle does not reach a limiting value. Nonetheless, the step disturbance should be as great as possible.

Reduce IFCON_TI until a overshoot in the step response becomes noticeable or until a overshoot which was present increases. Then increase IFCON_TI until the change in the overshoot disappears.

Check the step response for overshoot with large step disturbances and adjust IFCON_TI if necessary.

Adjustment of the blocking system

Single convertor

For a single convertor the function need only be blocked by setting the parameter LOCKBRCH ="1". The LOCKDIR parameter determines whether the forward or reverse bridge should be deblocked. If the exciter is a single convertor, the parameter should be set ="1". No further adjustments are required.

Double convertor

The LOCKBRCH parameter should be set ="0" for double convertor applications. The blocking function is then released, and the bridge direction IADIR is determined by the current reference IDREF.

The parameter ILEVBRCH activates the inertia function in the bridge switching control. Normally there is no requirement for delay in starting the bridge switching control and the parameter should be set ="0".

The REVTIMFR/REVTIMRF parameter determines the interval without current before a new bridge direction is activated. The normal value is 3 ms.

The exciter can be equipped with a barrier / blocking current measuring device for indication of no power. The device is used when optimal and fast bridge switching is required.

Before the exciter is started with the parameter LOCKBRCH set ="0", certain other parameters must have been adjusted. See below.

<u>With offstate / blocking voltage measuring device</u>

Set the parameter OFFSTMEA ="1". The parameter REVTIMFR/REVTIMRF can be set =3ms.

<u>Without offstate/blocking voltage measuring device</u>

In this case, a software based zero current detector must be adjusted. Its threshold value is set by the parameter IFDISC. A suitable level is a level just above the lowest controlable current. By the parameter BLOCKDEL the event of "zero current" detection is time delayed. The time delay setting is in ms.

If the smallest controllable current is continuous, BLOCKDEL must be set to a value which corresponds to the time required to force the current from the value of IFDISC to zero.

If there are requirements for a particularly fast field reversal, and the lowest adjustable field current is clearly less than the limiting current for continuous power (<50 %), the value of the parameter BLOCKDEL can be set to a lower value (3 - 10 ms).
If there are no special requirements for a fast field reversal the parameter BLOCKDEL is set to a high value (> 20 ms).

The REVTIMFR/REVTIMRF parameter should not be adjusted shorter than 3 ms nor longer than 20 ms.

Operation of main circuit connecting devices

General

AC circuit breaker

The control system of the Tyrak XL is designed to operate the a.c. circuit breaker either on the low tension side or the high tension side.

If the a.c. circuit breaker is on the high tension side, there are different ways to operate it.

The usual method, which is the recommended one, is that closing of the high tension circuit breaker is not controlled by the Tyrak XL, but by separate operation. Tripping of the circuit breaker should, in this case, be ordered from the Tyrak XL control system. For this purpose, special digital outputs are reserved, AC BREAKER OFF_N (MSOFF_N), in the convertor control unit and a.c. breaker A/B TRIP-N (ACBRATRP/ACBRBTRP) in the drive control unit. The drive system control unit is prepared with two digital outputs. One for breaker A (B51:60, 61) and one for breaker B (B51:62-63). The reason is that the drive can contain two h.t. breakers. The convertor control unit has one digital output, B51:114-115 from the control unit for convertor A, and B51:124-125 from the control unit for convertor B (CD sh 49 and 59).

The digital output for breaker A from the drive system control unit should be coupled in series with the digital output from the control unit in convertor A and on to the trip-coil for breaker A. For tandem and 12 pulse convertor operation fed via two breakers, the trip-coil for breaker B should be connected in a corresponding fashion.

The other method of operation of high tension circuit breakers, which is not recommended (too high coupling frequency) is to operate it as a low tension breaker, as described below.

If the AC circuit breaker is a low tension breaker, it is dimensioned for a high coupling frequency. In this case, both the opening and closing of the breaker is controlled from the Tyrak XL. For this purpose two special digital outputs are reserved on the drive system control unit. These are MCONTA ON (the signal MCONTAON), and MCONTB ON (the signal MCONTBON), in the function modul ORDERHXX controlled by the signal MCONTON. The two signals MCONTAON and MCONTBON are controlling two auxiliary contactors +Y.2.B2:6 and 7 (CD sh 30).

For every low tension breaker A and B which shall be operated, a potential free contact from each contactor shall be connected in series to the respective digital output AC BREAKER OFF (the signal MSOFF_N) from the convertor control unit.

The MCONTON signals are also available as pulse signals, one for closing (MCONTONP) and one for opening (MCONTOFP). These can, if necessary, be switched out, with help of the CONNECT function, to spare digital outputs.

There are two digital inputs reserved in the drive system control unit for acknowledgement signals from the AC circuit breakers. These are ACK MCONTA B51:95 for breaker A and ACK MCONTB B51:96 for breaker B (sh 30).

Another way to operate the high tension breaker is to order closing via the MCONTAON/MCONTBON-signals, and to order trip via the ACBREAKER OFF_N (signal MSOFF_N), AC BREAKER A/B TRIP_N (signals ACBRATRP/ACBRBTRP).

DC circuit breaker

The Tyrak XL control system is constructed to operate two d.c. circuit breakers. In the start-up module, in the drive systems control unit, there is a parameter (DCBRS) which should be set ="1" when there is a DC circuit breaker. Closing of a d.c. circuit breaker is ordered by the signals MCONTAON and MCONTBON. There are two digital outputs reserved for operation of DC breakers. For this purpose there are free contacts on the auxiliary contactors B2:6 and B2:7, se page 30 in the circuit diagram (CD).

The acknowledgement signals from the d.c. breaker can be switched to reserved digital inputs in the drive system control unit, ACK DCBREAKER A for breaker A and ACK DCBREAKER B for breaker B.

In the convertor control unit is a special function to generate a trip order to the d.c. breaker via the breaker's quick release. The trip order (DCBRFOUT) is given if undervoltage is indicated in connection with regenerating mode of the convertor or if differential current or overcurrent is indicated. The trip signal is logical (DCBRFOUT) and can be connected to a reserved digital output with help of the CONNECT function.

Checking the low tension circuit breaker operations

If the convertor transformer has not been powered up special preparations will be necessary. See the section **Preparations** under **Checking the operating circuits**.

When the parameter TESTMODE ="0", the control pulses are blocked in the control pulse amplifier, and the exciter does not start. It is therefore desireable to use this feature only when the breakers operation is to be checked. The parameter SEQMODE should be given the value =3. Check that local operation is selected, ie the corresponding LED is lit.

Press the ON switch on the operating panel. Check that the low tension circuit breaker operates correctly, and that the acknowledgement signal is received. In certain cases if may be necessary to take a check measurement of the resistance at the breaking point in order to verify the function.

If the low tension circuit breaker includes a function for trip in conditions of undervoltage, this must be removed. Undervoltage trip will be determined by the Tyrak XL control system.

If the low tension breaker includes a function for overcurrent trip, the trip level must be adjusted for selectivity. See the section **Adjustment of protection for high tension supply**. Concerning the selectivity of the convertor and DC circuit breakers, the same rules apply for low and high tension breakers.

Checking the DC circuit breaker functions

The low tension breakers receive an ON order at the same time as the DC breakers. Check that the breakers operate correctly and that the acknowledgement signal is received. The level for overcurrent trip must be set so selectivity is maintained relative to the convertor's overcurrent trip.

It is desireable that the level is set 10 – 20 % higher than the convertor's value, so the convertor has the possibility to control down the current.

In connection with the tuning of the main circuit current control, the DC breakers overcurrent trip should also be checked. This can be achieved by supplying a higher current reference than the trip level for a short time. Use the STEP-function with TESTMODE =3. A step disturbance can be increased four times when the parameter HIGHSTEP ="1". Alternatively the trip can be checked at a lower power than the currently adjusted trip level.

Checking the trip order to high tension circuit breakers

If low tension circuit breakers are not included in the installation, the high tension breakers will, in accordance with the section **General**, above, trip with help of the signal MSOFF_N. This signal is generated in the control units of both the drive system and the convertor. A check must be made before powering up, that this signal really activates the tripping of the breaker.
Tripping should be activated if any of the control units deenergize their outputs.

High tension supply

Adjustment of protection

When the high tension circuit breakers are taken into operation, the commissioning instructions for them must be carefully observed.

When the trip level for overcurrent is adjusted, it must be set so selectivity is maintained between the convertor and the DC breakers. The trip level should be set 10 – 20 % over the level at which the DC breakers or, if they are absent, the level at which the convertor will trip.

Checking of trip signal from high tension circuit breakers

So that the Tyrak XL control system can control down the main circuit current before the high tension circuit breaker opens, information from the breaker relay must be switched to a special digital input on the control unit of the convertor.

The information that the breaker is about to open should ideally be received by the convertor control unit(s) 70-100 ms before it actually does open. For this purpose there are two reserved digital inputs,
AC BREAKER TRIP B51:111 (CD sh 41) in the control unit for convertor A, and AC BREAKER TRIP B51:121 (CD sh 51) in the control unit for convertor B.

The interval between the signal from the breaker being set ="1" and the breaker opening should be verified by measurement. This is most easily done by the use of a recorder. The signal from the breaker is connected to one channel. The other channel is connected to I/O port YPG109 X1:5, where the rectified reference voltage is accessible if a clamp is mounted on pin S3:1-2.

After power up of main circuits

Checking of phase sequence

Tyrak XL operates only with a positive phase sequence. The phase sequence is checked with help of signal PHSEQCW1 in function module FACSSXX from the operating panel. If this signal is ="1", the phase sequence is positive (L1, L2, L3).

Setting the convertor mode

Parameter CONVMODEI in the start-up module determines the mode of operation of the convertor, see the "Start-up module of the convertor".

Check - for 12-pulse and bridge sequence controlled serial convertors only

General

A12-pulse convertor consists of two 6-pulse convertors connected in series. There is only one convertor control unit controlling both the 6-pulse convertors. The 6-pulse convertor recieving its pulses from board YPQ203 is called the slave convertor.

Checking of the slave convertor's phase sequence.

Manual checking of phase sequence must be done. A three phase voltage, 3X110 V, with the same phase order as the main voltage of the convertor is available at the secondary terminals of transformer Y.4.B8.1 (CD sh. 90). Use a line-trigged oscilloscope to measure the phase sequence.

NOTE! Slave convertor must have the same phase sequence as the master convertc

Checking of the slave convertor's phase displacement relative to the master.

Parameter PHSHIFT in the convertor's startup-module determines the phase shift of the thyristor firing pulses to the master and the slave convertor and must have correct settings. It is important that this phase check is done carefully. An incorrect value of PHSHIFT may, in the worst case, cause an overcurrent which will trip breakers and possibly blow the thyristor fuses.

The real phase shift between the two supply lines to the master and the slave 6-pulse convertors must be checked at commissioning, because there is no monitoring of the mains supply voltage in the slave convertor control system. If, f.ex. PHSHIFT = 150 DEG, while the real phase displacement is -30°, concequences might be fatal!

To achieve correct firing instants, the parameter PHSHIFT in the convertor's startup module must be set in accordance with the relative phase angle between the main voltages of the master and the slave convertor. Generally there are 6 possible phase shifts, dependant on different transformer connections. Thus, the program accepts one of the following 6 angles that may enable 12-pulse operation. For bridge sequence operation, CONVMODE =4, 0° and 180° phase shift between master and slave networks is possible in addition to values listed below. All other values will cause the convertor to trip. Possible phase shifts with CONVMODE =3 are:

The phase shift of the slave relative the master.

-150°	30°
-90°	90°
-30°	150°

Negative values means lagging of the firing pulses to the slave convertor of the master convertor.

Practical procedure:

Set parameter TESTMODE =0. That means that all firing pulses are blocked. Use a line-trigged oscilloscope when measuring the incoming 110 V as follows:

Master: L1,L2 and L3 at +Y.3.B8.1. Slave: L1,L2 and L3 at +Y.4.B8.1 (CD sh 80, 90).

Measure f.ex. the phase angle between the RS-voltage in the master and in the slave.

NOTE! If the slave lags the master, PHSHIFT must be negative! Select PHSHIFT and make a new init, (operating voltage off and on). If the phase angle does not equal one of the values given, the transformer(s) must be incorrect and 12-puls operation can not be achieved.

Checking the voltage level

After powering up the convertor's main circuits, the connection voltage level must be checked. This is easiest done by measuring on the primary side of the transformer +Y.3.B8.1 in the thyristor cubicle. See pages 80 and 90 in the circuit diagram (CD).

NOTE! It is important that the voltmeter is connected to the main circuits by fuses. Before the voltmeter is connected, a check must be made that the voltmeter is correctly rated for the voltage class to which it is intended to be used.

If the phase-to-phase voltage is too high for the voltmeter, a phase-to-zero voltage can be used for measuring. In the ground fault protection device +B30, (CD 80), there is a zero point available via terminal X1:5.

The connection voltage without load should be in agreement with rating (Uv0 on the convertor's rating plate), with a max. tolerance of ±10 %. Consideration should be given to possible fluctuations in the high tension supply, by consulting someone with experience of the local situation, before the actual voltage level is considered satisfactory. If necessary the transformer tapping must be changed at the incoming transformer. Lower nominal level of the connection voltage is handled by the LINEVOLT parameter, see below.

Checking of supply voltage measurement (part of work shop test)

In Tyrak XL the convertor's connection voltage is measured via a rectified reference voltage, UDI0. In connection with powering up, this measurement should be checked. If the connection voltage is measured per above, the voltmeter's reading should be in agreement with the value of signal UVVOLTshown on the operators panel, in function module IUMEAS0X. Signal UDI0 is normalized so that the convertor's ideal d.c. no-load voltage, Udi0, corresponds to 100 % (internal representation 2^{13}).

If parameter LINEVOLT in the convertor's start-up module, STRTCSXX, agrees with the voltmeter, and if parameter UVNOM agrees with the rating plate, but signal UVVOLT does not agree with the value shown on the voltmeter, the scale value must be changed.
The scaling is changed by adjusting parameter UDI0SCAL in function module IUMEAS0X.

NOTE! Parameter LINEVOLT <= UVNOM

For a new scale value to be activated, the control system must be restarted (switch supply voltage off - on).
Parameter VCSMARG (voltage control safety margin) shall be set to 95% in applications with regenerative braking, in other cases the setting should be 100%.

Adjustment and checking of undervoltage protection

The level of undervoltage protection is set with the parameter UVLEVEL in function module STRTCSXX. In the Tyrak XL there are two under-voltage protections, a fast hardware-based protection (MSUV) and a somewhat slower, software-based protection (LOWMAIN). The level for the latter protection can be differentiated from the former with the parameter LOWMAINL in function module IREGSXX.

At no load

Adjustment of the hardware-based protection should be checked and calibrated with the help of a test. This test is performed by increasing the value of UVLEVEL successively from a low level until indication of undervoltage is received. If the actual value of UVVOLT is measured, and set, in relation to parameter UVNOM, the actual trip level is obtained from the following:

$$\text{Real setting} = \text{UVLEVEL} \times \frac{\text{UVVOLT}}{\text{LINEVOLT}}$$

UVLEVEL should be set so that actual trip occurs at 80 %. This adjustment must be checked under load (see below).

The parameter LOWMAINL should be set so that indication of undervoltage occurs at 85 % of nominal connection voltage.

With load

When power is applied to the convertor, a check should be made that undervoltage trip is not achieved. Therefore generate a large current step, less than 5 seconds in duration, from zero to a current corresponding to the maximum current limit. Give the motor time to cool down between current steps. Check that the convertor does not trip and then reduce the value of parameter UVLEVEL successively, until indication of undervoltage is received. Set the parameter to 85 % of the level at which undervoltage was indicated, if that level is lower than the level which was set at no load.

If necessary parameter LOWMAINL must be adjusterd so that indication of undervoltage is achieved at 85% of nominal connection voltage.

Check of controllability

This test is only for series convertors, CONVMODE > 2. If the convertor is a bridge sequence controlled convertor, set parameter SEQTEST ="1" in the IREGS function module.
Even if the phase shift between the two supply lines is checked and the PHSHIFT parameter is set accordingly, a verification must be done that the firing pulses give correct voltage. Select TESTMODE = 1, so the delay angle can be varied from TESTREF. Prior to the test, adjust TESTREF to 0 and set the overcurrent-protections OCURFL and OCURRL to very low levels.
Push the ON-button. If the behaviour is normal, release the control by a START-order. Increase the reference very slowly while reading the signal ALPHA in the IREG-module. With an inccorrect PHSHIFT, in addition to a distorted shape of the 12-pulse convertor's output voltage, the current will be continous at delay angles as follows:

PHSHIFT is correct:	Continous current at a = 90°
PHSHIFT is 60° too low	Continous current at a = 60°
PHSHIFT is 120° too low	Continous current at a = 30°
PHSHIFT is 60° too high	Continous current at a = 120°
PHSHIFT is 120° too high:	Continous current at a = 150°.
PHSHIFT is 180° too high:	WORST CASE. WILL CAUSE HIGH OVERCURRENT EVEN AT START. (According to a delay angle of 60°).

If phase position is incorrect, change PHSHIFT and repeat the test!

Checking and calibration of delay angle

In the FACSSXX module of Tyrak XL's software based control pulse device, parameter TLAG is used to calibrate the internal delay angle against the actual delay angle. The internal delay angle, signal ALPHA_M/ALPHA_S, can be measured on the operators panel in function module IREGSXX. In case of a series convertor, CONVMODE = 3 (12-pulse) and CONVMODE = 4 (bridge sequence control), the ALPHA.S signal is used to delay the firing pulses of the slave convertor. If CONVMODE = 4 the parameter SEQTEST in the IREGS module must be set during this test.

Calibration of control pulses and tuning of parameter TLAG is conducted as part of the factory testing, and the results are documented in the test report. If, however, there is reason to suspect that the calibration is faulty, it must be checked. A quick method of checking this is to set TESTMODE =1 and set delay angle ALPHA_M to 90.0°, with the help of TESTREF. At that setting of the delay angle the direct current through the convertor should just be continuous. If this is not the case, the delay angle must be recalibrated.

Calibration of delay angle

Connect an oscilloscope to the current response and start the convertor. Increase power and increase TESTREF until the delay angle is 90.0° or until the current is continuous, whichever occurs first. If the current becomes continuous before the delay angle reaches 90.0° TLAG must be adjusted until the current becomes definitely discontinuous. The delay angle can then be increased until it reaches 90.0°.

By keeping the delay angle ALPHA_M constant and simultaneously carefully increasing or decreasing parameter TLAG, the current can be changed so that it just becomes continuous. The change to TLAG should not exceed ±200 units.

Armature current control

General

A precondition for tuning of the current control is that the current measurement has been calibrated and tuned. This is normally done at the factory test. If the current response requires recalibrating, see the section **Other convertor functions**.

Current control includes functions for automatic tuning of the system amplification in the armature circuits. The system amplification is an important information for the control system, and is used by several control functions.

In order that automatic tuning of the system amplification will work, the average value of the current ripples (current bubbles) must be greater than a certain value. This average value falls where the level for the limit current, discontinuous / continuous operation, is greater than 7 – 8 % of the convertor's rated current.

The current control includes in addition a convertor model of which the value of the system amplification is a part. The model is adjusted with the system amplification, that is with the parameters OMEGA_L and N_OMEGAL. An indication that the parameters are correctly set is that the signal I_CONT becomes ="1" when the current is continuous.

The current control's performance is adjusted with the parameters IAGAIN and IACON_TI under continuous current,
and IADIS_TI under discontinuous current.

The preset values of IAGAIN =0.30, IACON_TI =25 ms and IADIS_TI =20 ms for the regulator's tuning parameters will provide a suitably fast current control for most applications, when the system amplification has been tuned. The step response should nonetheless be documented in the usual way. If a different level of performance is required, the control should be tuned as described below.

Step generator for tuning of current control

In the function module IREFHAXX in the convertor's control system is a step generator which can be activated by setting the parameter IDTEST = "1". With the parameter STEPTIME the period of the generator's output signal can be set (period = STEPTIME x 3.3 ms (50 Hz) or STEPTIME x 2.7 ms (60 Hz)). The base reference is normally set via the reference TESTREF, but can also be set with a parameter represented by IDREFCOM.

Special conditions with 12-pulse parallel

For a 12-pulse parallel drive the tuning of system amplification must be done in 12-pulse operation, ie both convertors must be selected in function module CONSELXX.

Tuning of the current control cannot be done with help of the step generator mentioned above. It is very important that the step disturbances and the base references to the both current controllers are equal in size and time. Otherwise problem may arise with saturation of the DC-side iron-core inductor.

For 12-pulse parallel operation the drive system's step generator (the STEP function) is used and the base reference is set with TESTREF. This means that the above mentioned step generator cannot be used. The parameter IDTEST should therefore be set to zero. For further information see the section **Built-in aids to commissioning**

Automatic tuning of system amplification, TESTMODE = 2

The automatic tuning can only be applied to 6-pulse drives and where the limit current for discontinous /continous operation is higher than 10% of the convertor's nominal current, I_{dmNf}
Automatic tuning is started when the convertor receives an ON order with the TESTMODE parameter set =2 and when the convertor has been released via a START order.

When automatic tuning is complete, a message is passed to function module IREGSXX through the AT_DONE (Automatic Tuning Done) signal which is set ="1". Simultaneously the calculated system amplification is displayed in the signals OMEGALT and NOMEGALT. The values of these signals should be noted, and OMEGA_L adjusted to the value shown by OMEGALT. Similarly the value of N_OMEGAL should be set to the value shown by NOMEGALT. This completes the tuning of the system amplification.

If the signal AT_DONE is not set ="1", then the automatic tuning function cannot complete its task because of too little current ripple. In this case the automatic tuning must be interrupted manually with an OFF order to the convertor. The system amplification must then be manually set, as below.

Manual setting of the system amplification, TESTMODE = 3

Connect signal I_CONT with the help of the CONNECT function to an LED-indicator on the convertor's operating panel, for example to DOOP.1.

In case of a bridge sequence controlled convertorm, CONVMODE = 4, parameter SEQTEST in function module IREGS must be set.

Connect an oscilloscope to the current response.

Give the system amplification a preliminary value. N_OMEGAL should be set to the value "1" and OMEGA_L to 6900.

Start the convertor and adjust the current reference with help of parameter TESTREF until the current is just continuous on,
see figure 3 below.

Increase the value of parameter N_OMEGAL in steps of one unit until the signal I_CONT just changes to "1" (continuous current).
Then reduce the value of parameter OMEGA_L until signal I_CONT just becomes ="0". Observe that the setting of OMEGA_L must be lower than the value of parameter LOWMAINL x 8192.

The system amplification is then tuned.

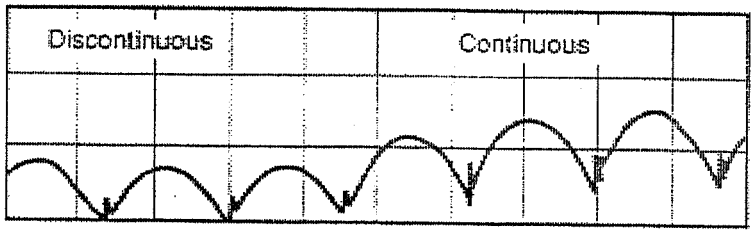


Figure 3. Discontinuous and continuous current.

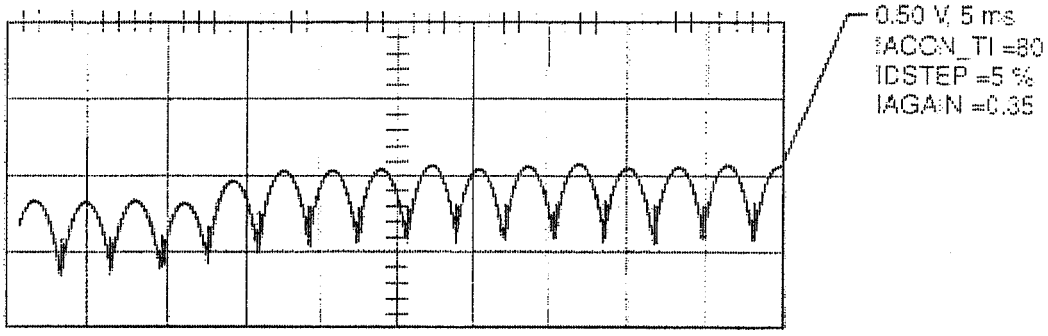


Figure 4. Step response, continous current.

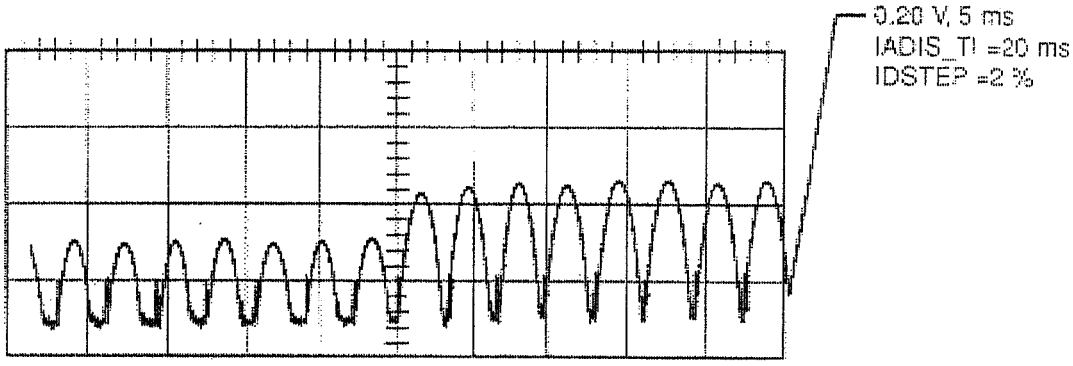


Figure 5. Step response, discontinuous current.

If the convertor is bridge sequence controlled, the setting of OMEGA_L and N_OMEGAL must be checked with the parameter SEQTEST set to "0". For this purpose, start the convertor and increase the current reference until the current feedback becomes continous by checking with an oscilloscope. Signal I_CONT should now be "1". If not, parameters OMEGA_L and N_OMEGAL must be retuned.

Tuning of control at continuous current, TESTMODE = 3

Preliminary adjustments

Set IACON_TI to a value of 100 ms.

Fine tuning of P-part, IAGAIN

Start the convertor and release the current regulator with a START order. Increase the current reference until the current is continuous. Generate step disturbances either with IDSTEP or with the STEP function in the drive system. Adjust the current's step response with IAGAIN in order to obtain the required rapidity. The current regulation should be trimmed for rapidity so that the first current bubble reaches approximately 70 % of the final value. See figure 4 above.

Fine tuning of I-part, IACON_TI

Reduce IACON_TI until a overshoot in the step response becomes noticeable, or until the overshoot which was present increases. IACON_TI should then be increased until the change in the overshoot disappears. Check the step response with large step disturbances, 25 - 50 % of motor current, to see if overshoots appears. If so, increase the value of IACON_TI.

Tuning of control at discontinuous current

Tuning of regulator parameter IADIS_TI is not necessary to ensure a rapid control. The main determinant of the rapidity of current regulation is the feed forward technique used in the regulator under discontinuous current operation. Step response should be documented and should have a shape as in figure 5 above.

Other convertor functions

Checking and tuning of current response

The current is measured in two different ways in Tyrak XL. First AC-side measurement, which is the main source and allways included. Second DC-side measurement which is available only when the convertor is double bridge.

Line-side current measurement

Tuning of the current measurement, ID1SCAL, is performed as part of the factory testing, and is documented in the test report.

The calibration of the current response is normalized so that the convertor's continuous rated DC current in the forward direction Idmn(f) is equivalent to 100 % (internally represented by 8192).

Calibration of the current response is controlled most easily by simulating a current response with the help of an adjustable stabilized DC voltage source.

NOTE! The mains supply must not be connected to the thyristor cubicle during this test.

Disconnect two a.c.-voltage cables to Y.3B13 and an adjustable d.c. voltage source is connected via an ampere meter to Y.3:B13. See the circuit diagrams (CD), page 80. This simulates current in convertor A.

If a current simulation is also required in convertor B, under 12-pulse parallel and tandem driving, the adjustable DC voltage source is connected in the same way.

The voltage from the adjustable DC voltage source is increased until the ampere-meter shows $\frac{Idmnf}{4000}$A . Then, provided that parameter IDMNF in function module STRTCSXX is properly set, the signal IDAMP in function module IUMEASXX should show a value which agrees with the current on the primary side of the current transformer. The value of the primary current is obtained by multiplying the transformer's output by $\frac{Idmnf}{4000}$A. Current transformer has ratio 4000:1.

A measurement error can be corrected by changing the parameter ID1SCAL. In order that a new calibration should affect the current response, the control system must be restarted so that the initialization routines are performed.

DC-side current measurement

Tuning of the current measurement, ID2SCAL is performed as part of the factory testing, and is documented in the test report. The calibration of the current response is normalized so that the convertor's continous rated d.c. current in the forward direction Idmn(f) is equivalent to 100%. Calibration of the current response is controlled most easily by simulating very low d.c. voltage in mV. with the help of an adjustable stabilized DC-voltage source.

NOTE! The main supply must not be connected to the thyristor cubicle during this test.

Disconnect B26:1:17,20 (CD 82, 92). Connect the d.c. voltage (mV) to B26:1:17, 20 increase the d.c. voltage up to $[\frac{Idmnf}{4000} x\ 60]$ mV

Check the signal IDACT2 by terminal (PD324) the value should be about 8192 (100%).

Before doing this test, the parameter DC_SHUNT in start-up-module STRTCSXX has to be set to "1" and control system must be restarted.

A measurement error can be corrected by changing the parameter ID2SCAL. In order that a new calibration should affect the current responsem the control system must be restarted so that the initialization routines are performed.

The d.c. shunt used has ratio of 4000 A to 60 mV.

Auto correction of IDACT

Line side current measurement is always included and used for current control and for the monitoring functions. For double convertors d.c.-side current measurement is also inluded. This measurement is used for detection of differential current between the d.c. and a.c. side, and to auto-calibrate the current feed-back from the line side current measurement, in order to get the same high precision as the d.c. shunt measuring. The terminal parameter IDGAIN is nromally not to be touched but the auto-correction ca be switched off by IDGAIN = 0.

Differential current detection

The current measurement on line side should always be the same as current response from d.c. side with respect to differencies in the precision. If a significant difference occurs, the trip signal DIFCUR is set to "1". The trip level can be set by parameter DIFCURL in function module IUMEASXX if the preset value is causing nuisance trips.

Direct voltage measurement

Tuning of voltage measurement (UDSCAL) is performed during normal factory testing and the results are documented in the test report.

In connection with the provisional commissioning of the speed control, the direct voltage measurement should be checked. For a double convertor the check should be made before the bridge changing functions are released. If the parameter LOCKBRCH in the function module BRCHCSXX is set ="1", the bridge changing is locked. If the parameter LOCKDIR in the same function module is set ="1", the convertor is locked in the forward direction.

A voltmeter should be connected between A13:4-5 in the convertor's thyristor cubicle. The voltmeter is connected to the convertor's DC side via fuses (CD sh 81,91).

NOTE! It is important that the voltmeter is connected to the main circuits by fuses. Before the voltage meter is connected, a check must be made that it is correctly rated for the voltage class to which it will be connected. Remember that the direct voltage contains a superpositioned ripple voltage.

Thereafter the convertor can be started with parameter TESTMODE set ="6", and the motor drive increased to its base speed, for which see the preset value in the start-up module, STRTXXXX. The DC power measurement in module IUMEASXX via signal UDVOLT should then agree with the value displayed on the voltmeter.

The scale of the voltage measurement is normalized so that the convertor's ideal no load DC voltage, Udi0 represents 100 % (internal representation 8192).

Measuring errors can be corrected by altering the parameter UDSCAL. In order for a new scale value to affect the calibration of the voltage response, the control system must be restarted, so that the initialization routines are performed.

Blocking system

General

In a single convertor application the bridge changing function should be blocked. This is achieved by setting the parameter DOUBCONV ="0". During commissioning and testing the bridge switching can be locked by setting parameter LOCKBRCH ="1". The parameter LOCKDIR determines whether the forward or rear bridge should be unblocked. For a single convertor the parameter should be set ="1".

Tuning of double convertor

This tuning need only be done on a double convertor.

In double convertor applications the parameter LOCKBRCH should be set ="1" until the current response has been checked. See the section **Direct current measurement**.

When the LOCKBRCH is set ="0" the bridge change functions are released and the bridge direction IADIR is determined by current reference IDREF.

The parameter ILEVBRCH activates an inertia function in the bridge switching control. Normally there is no requirement for delay in the initiation of bridge changing and the parameter can therefore be set to zero.

The parameters REVTIMFR and REVTIMRF determine the interval with no current before a new bridge direction is activated. The parameter REVTIMFR refers to the change from forward to back, whilst the parameter REVTIMRF refers to the change from back to forward. These parameters are normally set to 6.6 ms.

NOTE! The parameters REVTIMFR and REVTIMRF should not be set to longer times than 20 ms.

The convertor can be fitted with a off state / blocking voltage measuring device for the indication of zero current, which is then used when optimally fast bridge changing is desired.

The blocking system includes certain parameters which do not normally require changing from the factory installed value. These are:

IODIST = shortest time of the zero current interval to be regarded as zero current with respect to blocking of trigger pulses

IOLEV = the highest level for the discontinuous current which is to be regarded as zero current with respect to blocking of trigger pulses.

Compensation for mains drop in UDI0

In the function module IUMEASXX is a parameter MDROPCOM, which should be set so the signal UDI0 is not affected by the voltage drop which the current in the convertor causes to the voltage at the convertor connection point.

The Tuning is performed by the generation of large step disturbances of short duration in the rotor current, via the STEP function, and studying the effects of the disturbance on the UDI0 signal. Since the current is causing heating of the motor commutator. This process should not last more than about four seconds at the time. By connecting the signal UDI0 to a recorder via the signal switch, the change can be studied and tuned away with the help of parameter MDROPCOM.

Setting of EMF response, compensation of RI drop

An EMF actual value is calculated in function module EMFCAL by subtracting from a signal proportional to the convertor's output voltage (UDMV) a resistive and inductive voltage drop. The resistive voltage drop is proportional to the armature current, and can be tuned away with the ARMRES parameter. The inductive voltage drop is proportional to the armature current's derivative and is eliminated with the ARMIND parameter.

Fine tuning is performed by the generation of large step disturbances of short duration in the rotor current, via the STEP function, and studying the effects of the disturbance on the EMFACT signal. Since the current is causing heating of the motor commutator, this process should not last more than about four seconds at a time. By connecting the signal EMFACT to a printer via the CONNECT-function, the change can be tuned away with the help of the ARMRES and ARMIND parameters.

In normal applications it is not necessary to eliminate the inductive potential drop, that is, ARMIND can be set to zero.

Voltage adaptation

Voltage adaption is used to control the convertor output voltage (via its delay angle) to a value close to the motor's counter voltage (EMF).The voltage adaption is activated when the current control is released and makes the time between release order and control contact (for the current controller) as short as possible.

The voltage adaption is made in two stages:

1. Via feed-forward of the measured motor voltage via the EMFFILT signal to the delay angle ALPHA.
2. With the OPTVEC-function which select which thyristor pair are the most optimal to fire on.

In order that the voltage adaption is controlled by the actual motor voltage, the parameter EMFACTS in function module EMFCALXX should be set ="1". In most applications the OPTVEC function does not need to be activated. It is accessible through the terminal, and, when the OPTVEC parameter is set to zero, the function is deactivated.

With the parameter CURRARL in function module IREFHAXX the reference value is set for the first current pulse after a release order to the current control and with this parameter the voltage adaption can be set safetly. When CURRARL is set to a value <100 % the current reference IDREF1 is equal to ID0*CURRARL. When CURRARL is set to value =100 % the current reference IDREF1 is not affected by the parameter CURRARL.

Independent of which value, the current reference for the first current pulse, has got from the CURRARL parameter, no higher value than the max current reference rate-of-change is possible, see below. Normally the factory-set value, CURRARL = 70 %, does not need to be altered.

Current rate-of-change limiter

Current derivative limitation is a protection for the motor commutator. The ability to withstand high current derivative is for some motors speed dependant. For this reason the value that determines the derivative limitation is received from a function generator. The preset value of these parameters (IADERMAX, IADERM and IADERMIN) are on delivery set to 3.33 % / ms, which gives a rate of change of 33 times the rated current of the convertor per second and if higher rates of change are required, the value of the parameter can be increased. Normally the value should not be increased to more than 20 % / ms, but the highest possible value to set is 40 % / ms.

NOTE! In the event that older, not fully laminated motors are used, avalue for the parameter of 10% / ms is likely to be too high, and can result in sparking, which may be damage the motor's commutator. The commutation in the motor must be checked after commissioning and during the worst load conditions which can be in production.

Protection against commutation breakdown and emf reference generation

General

The protection against inverter collapse and the e.m.f. reference generation is a part of a common control strategy in order to optimise the power conversion process (el. to mech.) of the motor. This process is most efficient when the motor operates on the highest possible e.m.f.-level, with respect to the motor speed. In order to operate the motor on the highest e.m.f.-level it calls for a special control strategy.

This control strategy consists of three parts:
1) Optimal firing control in regenerative mode.
2) Load dependent e.m.f. reference generation.
3) Automatic locking of bridge reversal due to excessive e.m.f..

The control strategy is based on a value of the the power supply short-circuit inductance at the convertor connection point. In case of a double convertor or a sequence controlled convertor the above mentioned short circuit inductance must be confirmed through measurments.

Measurement of short circuit inductance

If there is any uncertainty about the value of the commutating inductance (short circuit inductance) at the convertors connection point, the following experimental method can be used for determining this value. The measuring procedure consists of number of activities described below.

1) **Connect a oscilloscope to one phase-to-phase voltage.**
Connect one channel of a digital oscilloscope phase L11 to L0V and the other channel to phase L21 to L0V on the secondary side of transformer +Y.2.B1.5 (line side synchronizing voltage, CD 31). Set the oscilloscope to measure the difference between the channels (two phase to ground voltages into one phase to phase voltage).

2) **In case of automatic triggering of the oscilloscope.**
Connect the external trig on the oscilloscope to an analogue output with the current feedback. Set the trigger level to be equivalent to 100% of rated convertor current, Idmn. Set the oscilloscope for single sweep. Set the time scale to give a resoultion where individual commutation noches can be ovserved clearly.
Alternativly can the oscilloscope be triggered manually.

3) **Control system set up.**
Set the control system in TESTMODE = 3. Current limits should not be set below 100% motor current.

4) **Calibrate oscilloscope at noload voltage.**
The osilloscope-readings of the undistorted voltage must be calibrated at noload.
In convertor control system is a op-ignal,UVVOLT in the IUMEASXX-module. Read this signal at the same time as the oscilloscope is triggered manually. Read from the oscilloscope picture have many divisions is corresponding the peak-to-peak voltage(2 * sqrt(2) * UVVOLT). From this reading is possible to calibrate the voltage measurment interms of VOLTS/DIV.

5) **Trigger the osilloscope at a high steady state current.**
Generate a current step of 100% Idmn during short duration (5-10s). Check if the oscilloscope has been triggered or do a manual trigg of the oscilloscope when the current has reached steady state. Adjust trigger or step value until a clear recording of the individual commutation noches is obtained.

6) **Evaluate the oscilloscope reading.**
Find the commutation noch close to voltage zero crossing where the voltage goes to zero during commutation.

Measure the voltage amplitude just before, uv1 and just after the noch, uv2, see figure 6 below.
Use the calibration, in VOLTS/DIV, that is done above, 4).

As an alternative uv1 and uv2 can be calculated using the peak value of the Uv0 voltage. This is sometimes easier due to the distorsion of the voltage uv2. Calculation of uv1 and uv2 will now be:

uv1 = sqrt(2) x Uv0 x cos (R1)
uv2 = sqrt(2) x Uv0 x cos (R2)
where Rx is the angle between uvx and Uv0 peak.

Measure the commutation time, tk (noch width)

The commutation inductance per phase can now be calculated as:

Lk = tk x (uv1 + uv2) / 4 / Idmn

Observe that if a different current level than Idmn has been used during measurement of the commutation noch, then this actual current shall be used instead in the formula above.

A good advice is to repeat, at least one time, the measurment and the evaluation in order to avoid errors.

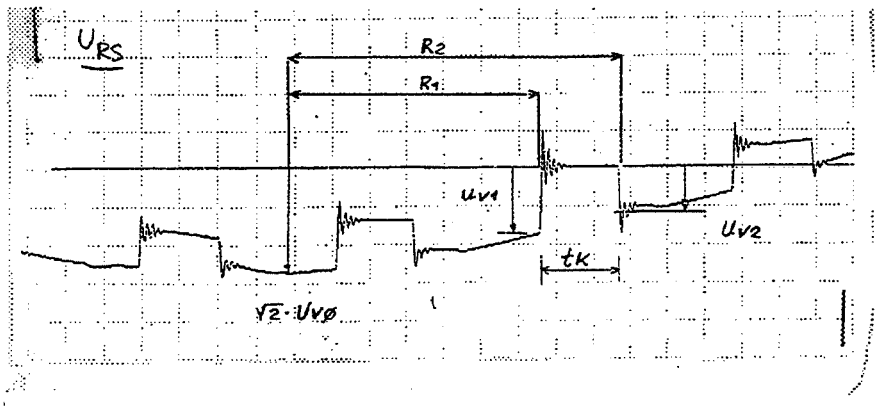


Fig 6 Voltage amplitude u_{V1} and u_{V2}

About calculation of short circuit inductance

The value of Lk that derives from the measurment above must be compared with the value that derives from a calculation. The calculation method is described in YT280-003 chapter 3.3 "Supply data calculation".

In case the customer has different incoming supply possibilities, which differ in short circuit power, the calculation shall naturally be based on the weakest supply alternative.

Power utilisation control

The power utilisation control can only be applied to drives operating in a field weakening speed region. In constant torque application the load dependent e.m.f. reference generation is not applicable but the other two functions can still be used.

Optimal firing control in regenerative mode

This control function, activated by parameter OPTBETAS, in the FIALCSXX-module, is very important for the control strategy of the power utilisation.

The control function consists of two sub-functions; BETACALC and IDMAX. The two functions share most of the inputs.

The input signal LMAINS, which is a parameter in the start-up module STRTCSXX, has to be set to the highest short circuit inductance value, measured or calculated.

Parameter TQ represents the maximal value of the thyristor recovery time and has to be set in accordance with the table below. Which thyristor type that is used can be found from the settings in the thyristor temperature monitor, TYTEMP. The thyristor type is YSTXX-RATESEL.
RATESEL is a parameter in the TYTEMP-module and YSTXX is the tyristor size that is selected.

YSTXX-RATESEL	TQ
WE540-01(a1)	500
YST14-202	400
YST35-01	300
YST35-21	600
YST35-22	400
YST45-21	700
YST45-26	400
YST45-27	600
YST60-21	800
YST60-25	400

CMARGC represents the desired commutation margin in regenerative mode to compensate for uncertainties, like overshoot of current , errors in voltage measurings, etc. The setting, for normal applications, shall be 35 %. If present power supply line is to supply arc-furnace or other asymmetric loads the value shall be increased to 50 %.

TRAINACT is a parameter in the start-up module STRTCSXX that should be set to "1" if the converter is supplied from a three winding transformer and if the transformer has a high degree of inductive coupling between the secondary windings (this is the normal case for three winding transformers).

BETAMINI is a min value for the inverting mode firing angle BETAN. For normal application the setting should be 20 degrees. BELIMVAR and VARIDBRS must be set to "1" .

Variable maximum delay angle limit

is a function that also extends the current control range of the convertor in regenerative mode, in such a way as to make it possible to control a lower discontinous current than if a constant delay angle limit has been selected.

Load dependent e.m.f. reference generation

This function is generated by the function module EXCDCMXX and is controlling the motor e.m.f. in the field weakening speed region via the signal EMFCORR.
The function is activated by setting the parameter OPTMAG = "1".

The current levels, ILRV1 - ILRV3, has a default setting of 25, 50, and 100 % which should be sufficient for normal applications. In some applications where the armature current is shifting extreemly fast from high motoring to regenerating mode can a setting of 33, 66 and 100 % be considered or a setting with even greater displacment of ILRV1 and ILRV2 from zero.

The setting of EMFMAX depends on what is the lowest no-load voltage level of the supply where the drive performace is maintained. This level Uv0(XX) is normally 90 or 95 % of the nominal voltage level.

In YT280-003 chapter 3.4 "Calculation of d.c. voltage in rectifier mode" is the calculation of Udmax(rect) described. It's important that the calculation of Udmax is based on Uv0(XX), as it's defined above. This voltage Udmax(XX) is then used to calculate EMFMAX as below.

$$Emfmax \leq \left(U_{dmax}(XX) - L\frac{dIa}{dt} - R \times I_{amax} \right) 1/Vcsm\arg$$

$$= (U_{dmax}(XX) - duL - duR)\ 1/Vcsmarg$$

In calculation of **duL** the highest value of the current rate-of change limitation (IADERMAX, IADERM or IADERMIN in module IREFHAXX) be used. L represents the total inductance of the main circuit.

In calculation of **duR** the highest value of the current limitation (IALIMP1or IALIMN1 in module IAREFHXX DSRB) be used. R is representing the total resistance of the main circuit

VCSMARG is a parameter in the IUMEASXX-module and is lowering the main-voltage level used in the field exciter control to compensate for supply voltage variations. In drives with regenerative braking should the default setting of 95 % be used. For one-quadrant drive the settin shall be 100%.

$EMFMAX > U_{dmax}(XX) - L\ dIa/dt - R\ I_{amax}$

There is also one field forcing function acting on PHIREF and a function to compensate for armature reaction of the motor. The adjustment of these functions will be described in section **Automatic field weakening.**

Automatic locking of bridge change

This function is to prevent commutation failure that can occur if regenerative convertor bridge firing is deblocked at a moment of excessive motor e.m.f..
The safe operating voltage is below the voltage level represented by the signal EMFLEV2R in module EXCDCMXX.

No settings is required when power utilisation control is activated but with parameter EMFBCBL (default 100%) in module BRCHCSXX is it possible to lower that level even further.

Constant regenerative mode firing angle limit

If a constant firing angle in regenerative mode is selected (BELIMVAR in function module FIALCSXX set to "0") the optimal power utilisation control is deactivated.
The minimal value of the regenerative mode firing angle β_{min} must then be calculated using equation (1) given below. The recieved min. value is then entered into the control system by parameter BETALIM. The parameter BETAMINI must be set to the same value as BETALIM.

Maximal EMF

The e.m.f. reference to field weakened motor drives is adjusted with help of parameter EMFNOM in the drive system start-up module, STRTDSXX, and parameter EMFSETP (default 100 %) in function module EMFRG1XX. However is there a possibility to set a load dependent e.m.f.-profile in the module EXCDCMXX.
When the EMF reference is to be set, attention should be paid, amongst other things, to the ability of the mains supply to commutate the current in the convertor in regenerating mode. This ability results from the short circuit power at the convertor's terminal. The maximum EMF to be set in connection with regenerative mode is dependent upon the required braking torque, that is proportional to a regenerative current.The maximal regenerative current limits the lowest permissible setting of the regenerative mode firing angle, β_{min}, via the parameter BETALIM.

The level of the motor-e.m.f. [Emf_{max}] shall be selected so the value of maximal delay angle limitation (b_{min}), according to equation (1) below, will be enough to control down the current to the discontinuous area when inverting mode, with a good margin. For a convertor, of the 6- or 12-pulse type, which is single connected to a transformer, the following relation is relevant:

Equation (1):

$$\beta_{min} = \arccos\left(\frac{Emf_{max}}{1{,}378 * U_{v0} * 0{,}9}\right) - 7{,}5_{deg}$$

where U_{v0} = the voltage level in the connection point of the convertor under no load condition
0,9 = is equivalent to a 10 percent decreasing of mains

Limiting of regenerative current

If the maximum delay angle, b_{min}, as above is set in equation (2) below, a value is obtained for the maximal permitted regenerative current I_{dbr}. For a convertor of the 6-pulse or 12-pulse type, which is connected alone to a transformer, the following applies:

Equation (2):

$$I_{dbr} = \frac{0{,}9 * U_{v0} * 1{,}414}{4\pi * f * L_k * 1{,}25}(1 - \cos\beta_{min})$$

where:
L_K = commutation inductance per phase
I_{dbr} = maximal regenerative current
U_{V0} = nominal voltage at the convertor's connection point
0.9 = the equivalent of a 10 % drop in supply voltage
1.25 = safety factor.

In order to avoid commutator breakdown, there is a parameter IDBRMAX, which limits the current reference value in regenerative mode. The parameter should be set to the value obtained from equation (2) above.

Automatic locking of bridge change

In order to reduce the risk of invertor collapse due to bridge switching to regenerative bridge(s), which results from too high an EMF across the motor, the motor's voltage is monitored. If it goes over a certain level, the bridge switching locks automatically. This voltage level can be adjusted with the help of parameter EMFBCBL (deafult 100 %) in function module BRCHCSXX. The parameter BETALL in module EXCDCMXX shall be set to value between 5 to 10 degrees.

An automatic adjustment to the actual mains supply voltage results from the locking of bridge switching being proportional to the actual mains voltage level. Similarly the relationship between EMF reference and actual mains voltage is a constant.

Built-in test possibilly

Three of the control functions, 1-3, can be tested by simulation of current and voltages as well as line frequecy.
The test possibility is activated by the parameter FIAL_TST in module FIALCSXX.

The generated inverting mode firing angle, BETACALC, can be checked by changing the parameters TSTIDAMP, TSTUVOLT and TSTFNHZ.

By changing the parameter TSTEVOLT the influence of varying motor e.m.f. on the inverting mode current limit can be studied.

The motor e.m.f. reference generation can be checked by changing the parameter IA_TST in module EXCDCMXX.

Provisional commissioning of the speed control

General

At this stage only a provisional commissioning of the speed control is possible, since a final adjustment can only be made when the motor is coupled to its load. The final adjustment also requires that the EMF control has been commissioned.

The motor drive must be able to be speed controlled in order to ease the checking of the convertor's output voltage, and for the speed related current limits to be adjusted. In addition the motor speed must be controlled before the bridge reversal function can be checked with regard to voltage adaption.

Preparations

Before the motor is rotated for the first time

Mechanical coupling between the motor and its loading object should be opened. Check that the loosened coupling half on the motor axle is properly attached. This prevents the possibility of loose parts coming free when the armature turns.

Check that parameter ADIGSP in function module SPMEASXX is set ="1".

Parameter NACTTC (the filter time constant) should normally be set to 10 ms. If extremely fast speed control is required, the parameter can be set to 5 ms. It should not be set higher than 63 ms.

Check that the parameters in the drive system's start-up module, STRTDSXX are properly adjusted.

NOTE! If the adjutsment of parameter NMAX NBRPPR (in function module STRTDSXX) or MOTOSPL (in function module SPMONXX) goes overthe maximum pulse frequency at 50 kHz, the convertor will cut because of "OVERRUNNING".

When the motor is rotated for the first time

Rotating the motor's armature for the first time is a critical moment in the commissioning process. At that time, incorrect handling can damage the motor and other equipment. One cause of this being a critical time is that, when the motor drive is being driven under speed control, for the first time,there is a significant chance (50 %) that the motor will race because the speed feedback has the wrong sign.

If the speed feedback has the wrong sign, there will be positive feedback, which means that the speed control is unable to control the speed. The result is that the motor drive races.

Since the motor drive is very likely to race, it is important for the commissioning engineer to limit the effects of racing. This is achieved by limiting the output voltage from the convertor via ALPHALIM and excitation of the motor with maximum field current preventing the activation of the field weakening function.

By the above measures, the motor speed is limited when the convertor output voltage reaches its limit.

Before starting the convertor, its delay angle should be limited to 80°. This is done in function module FIALCSXX using parameter ALPHALIM (if the system has two convertor control systems, this must be done for both of them).

The current reference should be limited to approximately 5 -10 %, which is most easily achieved with the help of parameter IALIMMAX (function module IAREFHXX) in the control unit for the drive system.

The convertor's bridge changing should also be locked with the para-meter LOCKBRCH (function module BRCHCSXX) in the convertor's control unit. If the convertor is a 12-pulse parallel or a 2 x 6-pulse (tandem motor drive there two mechanically coupled motors are controlled as one motor), this must be done in both control units.

If the drive in question is a tandem motor drive, the motors can be rotated one at a time with the help of parameters CONVA and CONVB in function module CONSELXX. In order that these parameters will operate on the selected convertor / motor, the parameter CONLM must be set to zero.

The Speed control's amplification - NGAIN - is temporarily set to a low value, about 1.0, and the regulator's integral action is uncoupled with the help of parameter NPROP.

Set the speed controller integral time constants to temporary values.Set NTC1 = 1000 – 2000 ms, set NTC2 and NTC3 =100 ms respectively.

The motor should be excitated with a nominal magnetizing current when it is rotated for the first time. This must be checked when the convertor is started.

The field weakening function should be deactivated by setting the parameter NBASE in function module STRTDSXX to a value similar to the value of parameter NMAX, and by setting the value of EMFSETP to 100 %.

The trip-out level of the overspeed protection, the parameter MOTOSPL in function module SPMONXX, should be given a low value, such as 20 %.

It is recommended that the speed reference is controlled with the help of a potentiometer, as this will give a better control over the reference handling than push-buttons for increase / decrease.
See the section "the **TESTREF function**".

When the motor's armature rotates for the first time, it should be kept under observation by someone, who can warn the commissioning engineer if there is a tendency to race.

Sometimes it occurs that the motor is just allowed to rotate slow in one of the two directions. The commissioning engineer must, in such a case, be warned if the motor starts to rotate in the wrong direction.

The motor's current, speed and voltage should be recorded with the help of a chart recorder or equivalent instrument. The actual values for current and voltage are obtainable as analogue signals, for which see the circuit diagrams (CD). For digital speed measurement there is no analogue measurement signal available. On the other hand, the digital measurement signal NACT is available at terminal B51:64, via an analogue output board. It is also possible to have a voltmeter connected to the convertor's output voltage, which is available though meter fuses.

Set parameter TESTMODE = "6".
Start after that the convertor with an ON-order from the drive system operator panel. Check that the motor(s) are excited with nominal field current.Therafter is a release order given to the entire control system for the drive, via the push-button marked with START on the drive system operating panel.

Carefully increase the speed reference with the help of the potentio-meter, check that an armature current is obtained, with the help of a chart recorder. The speed reference should be increased until the motor's armature begins to rotate or the armature current reaches its limit.

If 5 – 10 % power is insufficient to rotate the armature, the value of the parameter IALIMMAX must be increased. The necessary breakaway torque may be considerable if the armature has not been rotated for a long time.

If the armature does not rotate in spite of relatively high current, the motor must be examined.

NOTE! When current passes through a stationary motor's armature circuits, there is a partial heating effect on the commutator, which can be harmful. The motor must therefore be given time to cool down after current has been applied.

Checking the direction of rotation

If a DC motor's armature begins to race, the tachometer (pulse transducer) or the field winding connections are reversed.

If the motor races with the correct direction of rotation, the speed feedback has the wrong polarity, and channels A and B from the pulse transducer should be changed. If the revolution count is measured by a tachometer, the tachometer connections should be reversed.

If the motor races with the wrong direction of rotation, the field current has the wrong polarity. Change the connections to the DC motor's field winding.

If the DC motor's speed is adjustable, ie if its speed corresponds to the reference value, but it rotates in the wrong direction, channels A and B in the pulse transducer should be changed. For analogue speed measurement, the signal leads from the tachometer should be changed, and the field winding connections should be reversed.

NOTE! Do not forget to reset provisionally altered parameters. Do not forget to reset provisional alterations to the measuring circuits.

Temporary tuning of speed control

In order to avoid unnecessary problems with instability of speed control it is suitable to make a temporary tuning of the controller.

Start the motordrive with TESTMODE =6 and increase the speed setpoint to 50 % of base speed (NBASE).
Begin with tuning of proportional gain, NGAIN with NPROP ="1". Set up a suitable speed step (STEP), eg SIZE =1 % and TIME =500 ms. Increase the setting of the parameter IALIMMAX so the current reference value is not limited.

Connect the signal NSTEPEV, in the function module NCTR2XX to channel 1, and actual current IAACT, in the function module ASIGHAXX, to channel 2 of the operater panel logger.

Adjust the amplification of the displayed picture, see Instruction YT 280 – 304. Increase NGAIN in steps, until a step response like in figure 6 below is recieved.

Set NPROP ="0" and a tuning of the controller's time-constants is not needed at this stage of the commissioning.NTC1 ≈1000 – 2000ms.

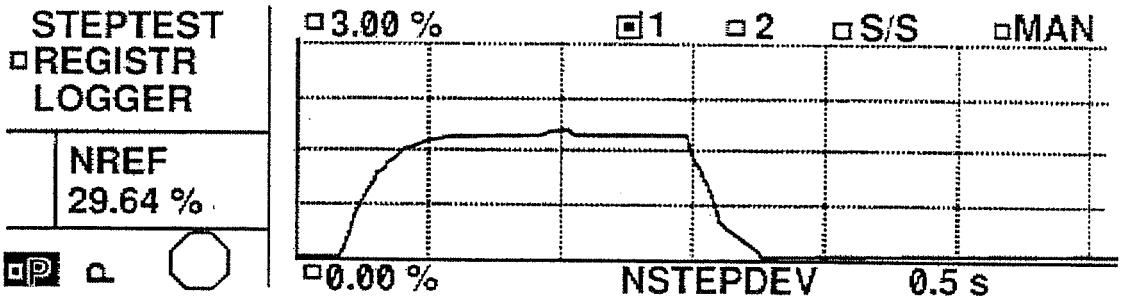


Figure 6. Step response of a temporary tuned speed control.

Checking the motor speed measurement

Static conditions

The speed measurement which is connected to the speed controller's feed-back input should be checked by independent measurement. The pulse transducer/ tachometer may be faulty. It may be, for example, the transducer does not give the correct number of pulses per revolution.

It is most satisfactory if the motor's revolution count can be checked directly on the motor shaft, with the help of a hand tachometer.

If no hand tachometer is available, or if, for some other reason it is not possible to measure the motor speed directly on the motor shaft. Then an alternative indirect method can be used. In such cases, magnetize the motor with a nominal field current, that is a current inaccordance with the value of the motor's rating plate.The motor speed is then increased until the motor's terminal voltageagrees with its nominal EMF.

The nominal EMF can be evluated from the motor's no load characteristic, which normally is attached to the motor's test record.

Read the actual motor speed, signal NACTRPM in function module SPMEASXX (function module SPMEAMXX in mine hoist software). Compare this reading with the speed corresponding to the motor's nominal EMF. These values of motor speed should approximately agree to each other.

If the motor's maximum EMF is not known, it can be approximated by 90 % of the motor's nominal terminal voltage.

NOTE! In order that the new scale values (NMAX, NBRPPR and NBREDGES) will affect the speed measurement, the motor drive must be stopped.

Speed ripple

The speed feed-back normally contains a superinposed ripple on the measured signal. The amplitude of this ripple is varying from values hardly noticeable to values wich cause problems.The ripple is caused by nonsymmetrical slots in the pulse transmitter and perhaps of bad alignment of the pulse transmitter due to bad mounting (erection).

A check of the ripple must be carried out before the motor is coupled to the loading object. The loading object can introduce additional disturbances on the speed measurement.

The ripple should not exceed 1 %. A normal value is 0.5 % of maximum speed. If the ripple is to large the pulse transmitter installation should be checked. For filtering of the actual speed measuring, function module SPMEASXX contains a first order low-pass filter. The filtering time constant can be altered by changing the value of parameter NACTTC

NOTE! The filtering time constant must be kept to a value as low as possible.

Checking the overspeed protection

Start the motor drive and increase the speed reference to 50 % or to a value which is proportional to the base speed.

Check that the protection is tripping the motor drive, by reducing the trip level MOTOSPL in function module SPMONXX. The convertor will trip as a result of overspeed. Check the fault indication.

Adjustment of nominal speed with analog speed measuring

Start the convertor via the operating panel and increase NREF (which is shown numerically on the operating panel) to 50 % or to a value which is proportional to the base speed.

Read off the motor speed with a voltmeter which is connected to the tachometer generator.

Now adjust parameter NACTADJ in the function module SPMEASXX until the signal NACT shows a value proportional to the motor's revolution. A reduction of the parameter value increases the revolution count. Do not reduce the value of the parameter more than 5 % at a time, and never to a lower value than 1.050.

Adjustment of current limits in motoring mode

General

Current limit in generating mode (of operation) is set in the convertor control unit in the function module IREFHAXX. See section **"Protection against commutation breakdown and e.m.f. reference generation"**.

A superior control system has the possibility to control the current limits. See the section **"description of function module"**. It is also possible to set the current limits locally in the convertor, in the control unit for the drive system in function module IAREFHXX. Locally set current limits can be made speed dependent.

Constant current limits

By setting the value of the parameter NDPIA, which is a terminal accessible parameter, to ="0", and the value of IALIMPC/IALIMNC to ="1", the current limits are determined by the parameters IALIMPS and IALIMNS. This is subject to the condition that the absolute value of these parameters is less than the value of parameter IALIMMAX.

Speed dependent current limits

For certain motors, the maximum current which can be applied is dependent upon the speed. The reduction of current with the speed is normally supplied in a diagram, which is usually obtained from the motor supplier.

By setting the value of the parameter NDPIA (NDPIA is a terminal accessible parameter) to ="1", the function is activated.

The speed dependent current limits are generated in a function generator whose break point is set with the help of parameters NBP1-IBP1, NBP2 - IBP2 and NBP3 - IBP3. The break points are selected from the motor supplier's diagrams so that the straight-lined approximation from the function generator does not give a higher current than that marked in the diagram. The constant current limits IALIMPS, IALIMNS and IALIMMAX are set to a somewhat higher value than the highest permissible current in the motor.

For adjustment

Begin the adjustment by setting IBP1 to the maximum permitted current from zero speed to the first break point, NBP1. Subsequently are the break points IBP2 / NBP2 and IBP3 / NBP3 adjusted. Verify the adjustment by driving the motor through the speed range and measure the signal IALIMP1 or IALIMN1.

Automatic field weakening and flux control

General

The E.M.F. control in Tyrak XL consists of three parts. One part is a open loop control of the field current reference ,via a feed-forward of a flux reference, generated from the actual motor speed. The second part is a feed-back control of the E.M.F. by a PI-controller.The conversion from flux to field current is done in a function generator. The third part is a feed forward compensation of the armature reaction voltage drop.

Setting of motor field current

When the parameters in the start-up modules have been correctly adjusted with regard to IFNOM in function module STRTDSXX and IDMN in function module STRTFEXX, the correct field current is automatically obtained. The parameter IFSET in function module ECTRL1XX can then be used to change the field current reference from its nominal value.

The parameter IFADAP in function module ECTRL1XX is set equal to the ratio between the nominal field current at no load and the nominal field at nominal load, both at base speed. Values of these currents must be supplied by motor manufacturer. The parameter IFMIN in the ECTRL1XX module should be set to just below the lowest field current that is obtained at max. speed, no load and lowest supply voltage. For d.c. drives IFADAP should be set to 100%.

Checking the motor's nominal E.M.F.

If the motor's nominal e.m.f. is not known, it must be determined. This is done by exciting the motor with a nominal field current, and bringing the motor up to base speed. The motor's base speed is shown on its rating plate, and should also be set by the parameter NBASE in the drive system's start-up function module, STRTDSXX. If the motor is not loaded, the voltage drop can be ignored, and the motor's e.m.f. is then the same as its terminal voltage.

Setting of e.m.f. reference

The e.m.f. reference is set with parameter EMFNOM in function module STRTDSXX. The e.m.f. reference is however not a constant value. Inthe earlier chapter, "Protection against ...", a load dependant e.m.f. reference was adjusted. When tuning the e.m.f. control this function shall temporarily be switched off (OPTMAG = "0"). Parameter EMFSETP in function module EMFRG1XX is used to reduce the motor's e.m.f., if needed.

Parameter EMFSETP has a double function, which means that it also changes the speed level at which the field weakening starts. This means that below that speed level, the motor is excited with nominal flux. When the mains voltage is varying this produces the same effect as if the value of parameter EMFSETP is changed. When the mains voltage is lowered the setpoints are also lowered in order to keep a constant relation between e.m.f. and supply voltage.

In order to avoid too rigid coupling to the mains, the increase (which occurs when the mains voltage increases from a low level) takes place via a ramp function. The ramp time can be changed if necessary, with the help of parameter RTUP.

Parameter EMFSCAL should be set to 100%. A terminal parameter PHIREF1 which is for testing purposes is set to 0 and is not supposed to be changed.

Armature reaction compensation

Via the signal REAC_FAC to the emf-controller, module ECTRL1XX, is there a possibility to compensate for the armature reaction of the motor.

For the majority of high power dc-motors there is no need for this kind of compensation but for some motors this compensation can be useful in order to improve the characteristic of the motor in the field weakening speed region.

The armature reaction is proportional to armature current and the degree of compensation is adjustable with the parameter ARMREAC in the EXCDCMXX-module of the convertor control program. The setting must be find in field weakening close to max. speed. Make a big speed step (5-10 %) at noload and with a reduced current limitation (IALIMMAX = 25 - 50 %). The effects of the armature reaction noticeable in the emf feedback. When the armature current is steady the measured emf -signal (EMFACT) must be proportional to the actual speed.

For motors where the current , independent of sign, has a demagnetising effect on the motor flux must the parameter ABR-FACS be set to "1".

Field forcing below base speed

The EXCDCM-module in the convertor control program contains a function for field forcing below base speed. The function is activated by setting OPTMAG = "1" and to set PHIMAX > 100 %.

Field forcing is a way to increase the maximal torque of a given motor by increasing the air gap flux of the motor over its nominal value. This can cause problems with bad commutation of current in the motor at high motor speeds but not at low speeds (at standstill no commutation occurs).

Due to the saturation of the motor is it required approximately 200 % field current in order to produce 110 % flux. This is simple to verify with a test. Let the drive run at noload and at 50 % of base speed. Increase the field current and measure the emf, nominal field and 50 % of base speed gives a emf of 50 %.

Keep in mind that field forcing can cause overheating of the field windings. However is the thermal time-constant rather long.

A field forcing up to 10 % is realistic to achieve, higher values requires a huge oversizing of the field exciter convertor (the thermal time-constant is about 60 seconds).

The field current that was needed in order to produce the required flux must be noted and used as a setting of the parameter IFMAX, see section **Automatic setting of flux feed forward** below.

The field forcing level is set by the parameter PHIMAX. NLEV1 is a motorspeed level where the forcing flux starts to decrease and NLEV2 is the speed level where the forcing flux is down on the nominal level. NLEV2 and NLEV1 are both levels below base speed and the settings must be confirmed by the motor manufacturer or by practical tests of the motor.

IMAX is a parameter which setting is greater than 100 % but also less or equal to current limit.

Setting of flux feed forward (function generator)

Check that the bridge changing function is locked, i.e. that LOCKBRCH is set ="1".

Reduce the e.m.f. reference by setting parameter EMFSETP to 80 %. Then set the following parameters:

EMFPROP = "0"
EMFTC = 2000 ms
EMFGAIN = 0.50 ms.
FILIMP = 50 %
FILIMN =-50 %

On delivery the parameters IFCONST1, 2 and 3, in function module ECTRL1XX, are set to the following:

IFCONST1 =29.0 %
IFCONST2 =53.5 %
IFCONST3 =79.5 %.

Start the motor drive and increase the speed until the signal, FLUXREF, in function module EMFRG1XX reaches 90 %. Adjust parameter IFCONST3 until the output signal from the PI regulator, EREGOUT becomes ="0".

Increase the speed again until FLUXREF becomes 70 %. Adjust the parameter IFCONST2 until the output signal from the PI regulator, EREGOUT becomes =0.

Increase the speed a third time until FLUXREF becomes 40 %. Adjust the parameter IFCONST1 until the output signal from the PI regulator, EREGOUT, becomes =0.

Automatic setting of flux feed forward

Preparations

To achieve correct result of the automatic settin, be sure that the e.m.f. and field current measurements are correct. The maximal excitation current, If(max) A, at base speed and maximal armature current, must be known.
Set the parameter IFMAX = [If(max) / If(100%)] x 100%.
If(100%) is the field current at base speed and nominal armature current.

Set temporary FIMAX to the same value as IFMAX.
The setting of IFADAP must be correct, see previous section
Set temporary IFMIN to a low value, such as 10%.

In order to generate a FLUXREF-signal, the input to the flux-to-current function generator, which is bigger than FIMAX, set PHIREF1S to "1" and PHIREF1 to 8192 (50%). The actual field current reference is then determinded to the setting of IFMAX.

Check that the torque direction switching function is locked, ie that LOCKBRCH in the convertor control system is set = "1".

Make the following temporary settings of the e.m.f. feedback controller.

EMFPROP ="0"
EMFTC =500 ms
EMFGAIN =0.1
FILIMP =0%
FILIMN =0%

Set temporary IFMIN to a low value, such as 10%.

Procedure

Start the motor drive and let it run at base speed.
Activate the automatic function by FITEST = "1". Then it takes some time until it's noticeable that the function is in operation, e.g. field current starts to decrease.

When the field current reference is decreased to a value, which corresponds to IFMIN, the automatic function is ready.

Read, on the operators panel, the values of; FIIFMAX, IFFI90, IFFI70 and IFFI40. Make a note of the values.

Stop the motor drive and set FITEST = "0".

Use the operating panel and set:

FIMAX =FIIFMAX
IFCONST3 =IFFI90
IFCONST2 =IFFI70
IFCONST1 =IFFI40

Tuning of e.m.f. control

Stop the motordrive by pushing the OFF push-buttom. Set the parameter TESTMODE =7 and EMFSETP =90 %.

Make sure that EMFACTS is "1" and that IDMINL is "0". The e.m.f. control is activated when the actual e.m.f. is higher than the setting of RELCTRLL. The e.m.f. setpoint, EMFREF1, is speed dependant and the reference value is correct even below base speed. A suitable level to activate the e.m.f. control is 50%.

The e.m.f. -controller output is adapted by the actual speed (NACT) in order to maintain constant amplification in the whole speed range.
The parameter NADAPTL1 is limiting the gain compensation, that is achieved by the division with NACT. The setting of NADAPTL1 should be approximately the motor speed where the e.m.f. control is activated.
INPSEL is a parameter that should be set to "1". ("0" is valid for LCI drives).
Start the motordrive and increase the speed reference using the TESTREF-function until approximally 5 % above the level at which the field weakening takes place.

Connect with the CONNECT- function the signal EMFACT, in function module ECTRL1XX, to one channel on a chart recorder and the field exciter actual current to the other channel.

Tune the controller's proportional gain by increasing the value of EMFGAIN. Check the result between every new setting, by generating a step disturbance. EMFACT should go between the two levels without overshoot and as fast as possible, se figure 7a below. EMFGAIN should not be changed more than 0.2 at a time.

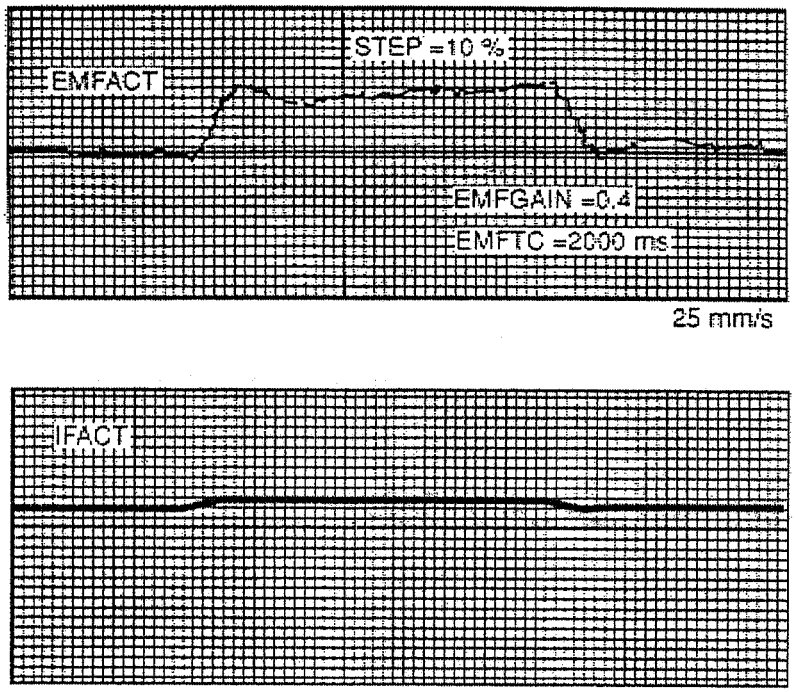


Figure 7a. Step response, tuning of EMFGAIN.

Tune the controller's integral part by lower value of the EMFTC. EMFTC should not be changed more than 200 ms at a time.
Every new setting has to be checked by a step disturbance. EMFTC is reduced until a small overshoot appears on the step response, see figure EMFTC.

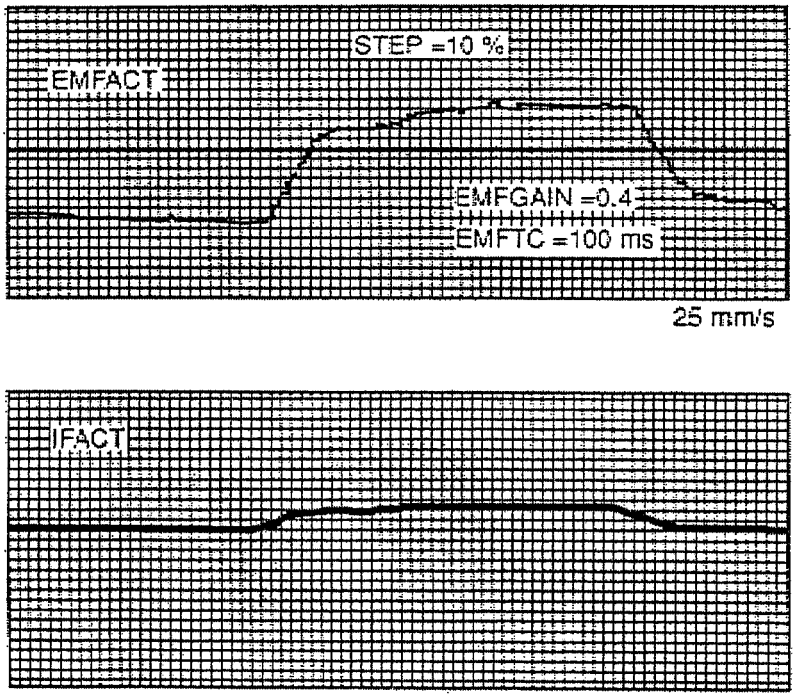


Figure 7b. Step response, tuning of EMFTC.

This tuning is normally sufficient for the e.m.f. controller. The requirement for a quick response from the e.m.f. controller, which normally is associated with the use of short ramp times for the speed reference, is reduced in this e.m.f. control system. The rapid action of the e.m.f.-control system, needed for the field weakening, is mainly achieved by the feed forward technique, which is used.
Normally the stability of the e.m.f. control is also checked with a speed step. This check is performed after the optimisation of the speed controller.

The tuning of the e.m.f. controller as it is shown in figures 7a and 7b is somewhat exaggerated in order to have nice pictures. Keep in mind the golden rule and do not tune the controller "harder" than needed. EMFGAIN = 0,2 and EMFTC = 200 ms should have been sufficient.

Checking the field weakening

The result of the settings and tunings which has been done so far, see above, should be checked by increasing the speed reference value with the fastest ramp time which the drive system will be exposed to.The ramptime for this test can be set in function module TESTDSXX with the help of parameter RAMPTIME.

Check that this ramp time is the shortest in the reference path. For example, in the program DSRBXX there is a function module NRAMP3XX, which includes a ramp function. This ramp time must be temporarily set to a shorter time than RAMPTIME or to an equal time, when this check of field weakening is done.

The easiest method to check the field weakening is by using a multi channel chart recorder and record (during acceleration) the actual speed (NACT), e.m.f. actual value and the actual field current. The e.m.f. actual value is accessible in both the control unit for the convertor (signal EMFACT in function module EMFCALCXX) and in the control unit for the drive system (signal EMFACTMM in function module ASIGHAXX).

The e.m.f. actual value can thereafter be connected to empty analogue output ports with the help of the CONNECT function. The field current actual value is, on the other hand, accessible as a hardware signal on the circuit board YPQ201.

When an acceleration has been recorded then a result similar to figur 8 below should be achieved. If the overshoot of the e.m.f. actual value is too high when the motor speed is accelerated into the field weakening region, then a slower ramp time must be used. A somewhat better result can evetually be obtained if the tuning of the e.m.f.-controller is obtimized.

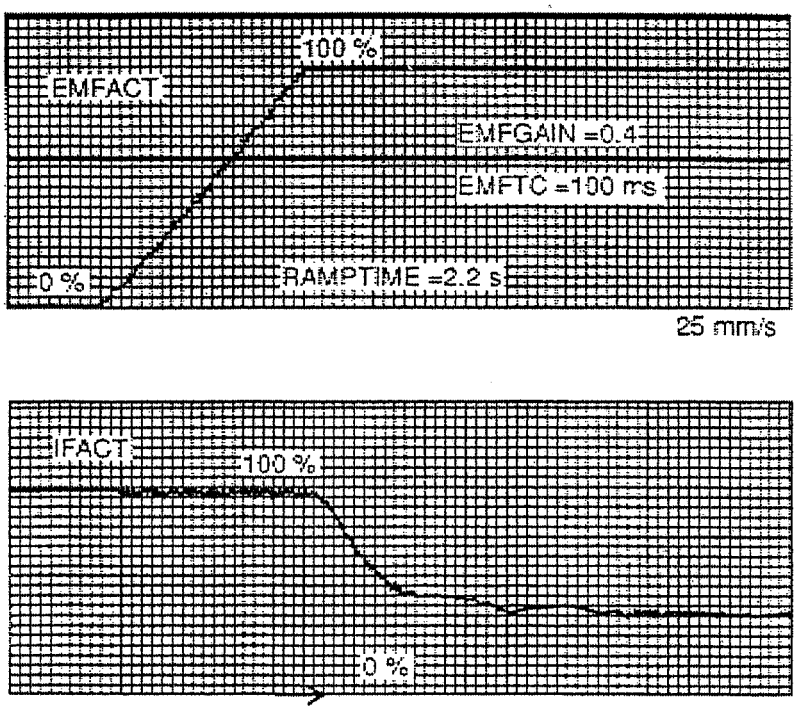


Figure 8. Emf actual value when acceleration with a fast ramp.

Another way to record the performance of the field weakening function is to use the built-in log, in the operating panel. In order to trigger the log, use function module TEST3X. Connect signal EMFACT to AO72.1 in the CONNECT menu. Set parameter AATRIGL to 20 %, this corresponds to EMFACT=80 %. Parameter ATRIG is calibrated for signals with 100 % as their maximum value. EMFACT has 400 % as the maximum value.

Increase the speed by pressing the REF+ button on the operating panel. When the value for signal EMFACT =80 % the log is triggered and the text ANALOG TRIGGER is shown. Check the REGISTR screen for signal EMFACT.

NOTE! If the recording must be repeated, press the RESET button on the operators panel.

If the overshoot is greater than 5 %, a slower ramp time must be used. The overshoot can possibly be reduced if the e.m.f. regulator's parameters are adjusted.

If the e.m.f. regulator's parameters have been changed a new test of the speed regulator's dynamics must be made.

Speed control

General

Final tuning of the speed control should be done when the motor has been mechanically coupled to the drive object. Another precondition is that the control system for the motor's excitation (for example control of field weakening) has been adjusted and fine tuned. Additionally the tuning should be done in no load condition, ie with an unloaded drive object.

The speed control of the motor is a part of the convertor control system, which, in many applications, has a major influence on the entire performance of the process, ie the kind of industrial process where the mtor-drive is a part. A good rule is therefore to determine the dynamic requirements on the speed control from the actual application and then not tune the control harder than required.

Advanced speed controller (NCTR2)

The speed controller can be given different characteristics by parameter NMODE.

NMODE setting	Function
0	PI
1	PIPI or PDPI
2	PI-LP
3	RFE

Preparations

Set the parameter TESTMODE ="6".
Release the possibility for regenerative braking (only dual convertors) by setting parameter LOCKBRCH ="0".
Check the setting of the current limit.

Pre-set the speed control as follows:
NPROP ="1"
NGAIN = 1.0 or that value which the provisional setting gave
NTC1 = 1000 ms
NDERKD = 0.0.

Connect actual values for speed and current to a multichannel recorder.

Since the speed step disturbance is small compared to the speed set-point, the setpoint value has to be subtracted from the speed feedback signal connected to the chart recorder. This is done to get a good resolution of the step responce. For this purpose one output signal NSTEPDEV is generated in the speed controller.
The actual values of the current are accessible as hardware signals.

The speed actual value, NACT, is coupled on delivery to an analogue output port, see the circuit diagrams, CD. The current actual value is accessible as a hardware signal.

A suitably step disturbance is about 2 % and of one second's duration for each step. The step's size should not be so large that the regulator's output signal is limited by the installed current limits.
In order to find the regulator settings quickly, the operating panel's REGISTR function can be used with advantage.

Adjustment of the speed control

NMODE = 0, PI controller

In drives without resonances of back-lash (fixed coupling - short shaft), the PI controller is often a good solution.

Set parameter NMODE = 0.

PI controller with derivating feedback gain

The controller's proportional part is set via the parameter NGAIN. The time integrating constant is set with parameter NTC1. The size of the derivating feedback gain is set via parameter NDERKD.

Increase the speed of the motor drive to a speed just below the base speed so that STEP and the actual NREF are less than the base speed. Generate a step disturbance by activating STEP. Check the step response and increase NGAIN in successively smaller steps till the shortest step response without overshoot is obtained. See figure 11 below.

Check the step response after each adjustment.

Check also that the current reference value is not limited by the current limit settings.

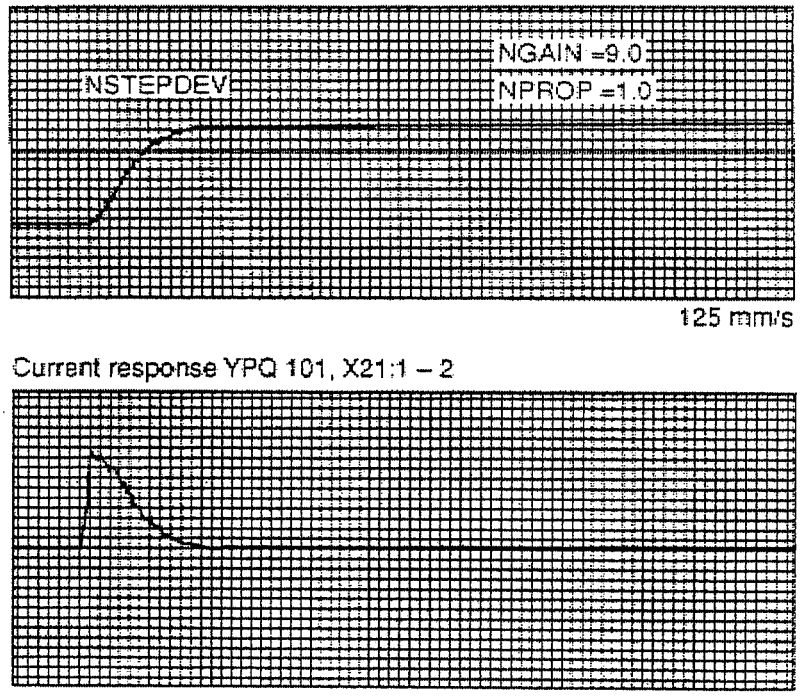


Figure 11. Step response when tuning NGAIN.

Subsequently set the parameter NPROP ="0". Then reduce the regulator's time constant via parameter NTC1 until a certain overshoot is noticed. See figure 12 below. Check the result after each adjustment.

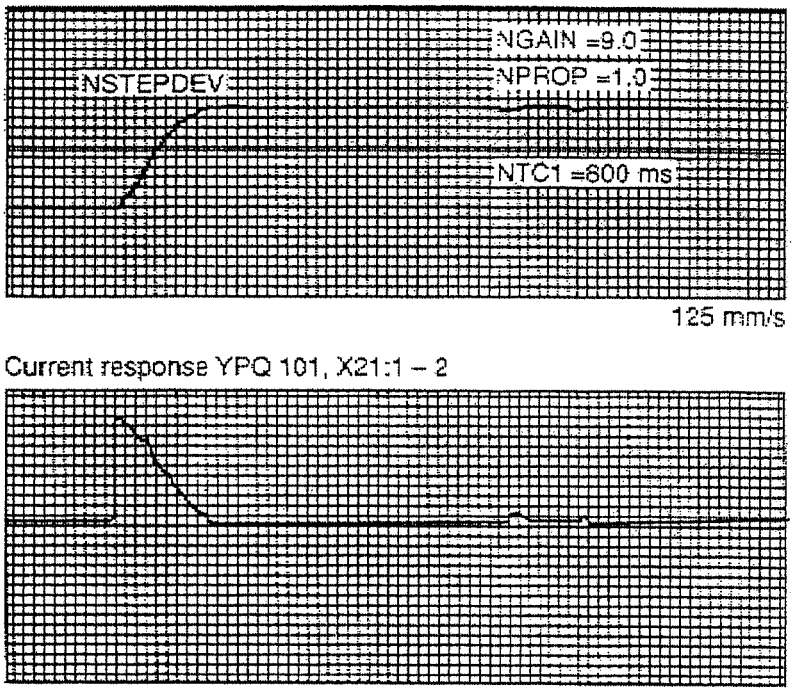


Figure 12.

Low dynamic requirements

If no high dynamic requirements are placed on the speed control, the tuning is completed by increasing the time constant NTC1 until overshoot just disappears.

Guide for minimizing impact speed drop

Following describes a quick method to find the optimal tuning of the speed controller to minimize the influence of load changes, which is normally the most important requirement on a drive system.

Normally the filter time constant NACTTC = 10 ms. The parameter is found in function module SPMEASXX. Choose a value of parameter NTC1 from table 1 below and increase NGAIN until the overshoot and rise time are in accordance with the table below. The estimated rise time is shown in column 3.

NTC1	Overshoot	Estimated rise time
600 ms	10 %	100 ms
300 ms	20 %	60 ms
180 ms	30 %	40 ms

Table 1. NACTTC = 10 ms

In case the performance achieved with this method is insufficient, the filter time constant NACTTC can be set to 0 ms.

Tune the controller in accordance with table 2 below.

NTC1	Overshoot	Estimated rise time
190 ms	20 %	35 ms
110 ms	30 %	25 ms

Table 2. NACTTC = 0 ms

When the performance is sufficient, the derivating function (NDERKD) is used to minimize the overshoot.

In case the performance is still not sufficient, it can be further improved by using the derivating function together with a retuning of the speed controller in accordance wiht table 3 (Kp0 and Ti0 are the values of NGAIN and NTC1 achieved form the tuning above).

NDERKD	NGAIN	NTC1
1.0	1.3 x Kp0	0.7 x Ti0
2.0	1.4 x Kp0	0.4 x Ti0
3.0	1.2 x Kp0	0.25 x Ti0

Table 3. Tuning with derivating function.

Note that with NDERKD = 1 the impact drop is reduced by 50% with NDERKD = 3 the reduction is 4.8 times.

If neccessary the tuning can be further improved by making torque steps with the TQSTEP function (TESTMODE = 9). Minimise the impact drop by adjusting NGAIN and NTC1.

NMODE = 1, PIPI/PDPI-controller

The PIPI/PDPI controller provides the possibility of increasing the gain within certain frequency ranges more than what is possible with an ordinary PI-controller. The adjustment is simplified if the system resonance frequency is known. The controller can then be adjusted with a lower gain in the range around the resonance frequency and higher gain in the range around the resonance frequency and higher gain in other ranges. The controller can be adjusted either as a PIPI controller fig. 4 or as a PDPI-controller fig. 5.

The selection of either PIPI or PDPI depends on the total system. The PIPI controller is normally more stable than PDPI while the latter is faster.

The PIPI/PDPI controller is adjusted as follows:

1. Set the speed controller parameter NPROP to "1" to P-couple the controller.

2. Start the convertor. Increase the speed to approcimately 30% of nominal with the REF+ button. Make steps in the speed reference, using the STEPTEST function. A suitable step is approximately 2% and the duration can be approximately 2s. IAACT and NACT are to be logged. A suitable time setting on the logger for the two signals is 0.5-2 seconds.

Note! IAACT and NACT are normally preset on two of the logger channels when the equipment is delivered.

PIPI-controller

A PIPI-controller is obtained when NTC1 > NTC3 > NTC2. The setting is done as follows:

Set NMODE = 0. Make reference steps and increase NGAIN in suitable steps until signal NACT starts to oscillate.

Measure the time t of n peaks.

Calculate the resonance frequency (Hz) as follows:

$$f_{osc} = \frac{n}{t}$$

t = time in seconds

n= number of peaks

Reduce NGAIN until an overshoot of approximately 10 % is obtained.

Set parameter NPROP to "0".

Adjust NTC1 as for an ordinary PI-controller.

Calculate NTC2 (ms) as follows:

$$NTC2 = \frac{1}{2 \times \pi \times f_{osc}} \times 1000 \quad \text{(ms)}$$

Set NMODE = 1. Set NTC2 to the calculated value , but not lower than 5 ms.

Set NTC3 to a value 2 to 3 times the value of NTC2.

Adjust the controller with parameters NGAIN and NTC3. If NTC3 is increased it is normally also possible to increase NGAIN and vice versa.

The regulator is adjusted until the performance required for the application is reached. The oscillations in current initiated by the resonance must also be kept at an acceptable level.

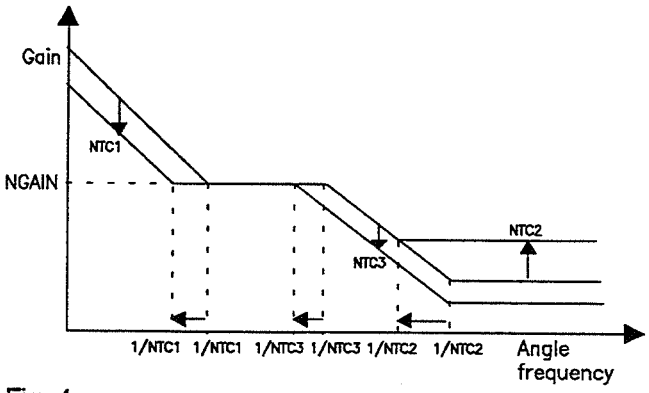


Fig. 4.

PDPI-controller

A PDPI-controller is obtained when NTC1 > NTC2 > NTC3.

The setting is done as follows:

Set NMODE = 0. Adjust NGAIN and NTC1 as for an ordinary PI-con-troller. Measure the rise time of the speed feedback. Set NMODE = 1. Set NTC2 to 0.5 times the rise time as start value. Set NTC3 to 0.5 times NTC2 as start value.

This setting will make it possible to increase NGAIN and decrease NTC2 and NTC3.

As a result of the adjustment the rise time is to be shorter than with a PI-controller.

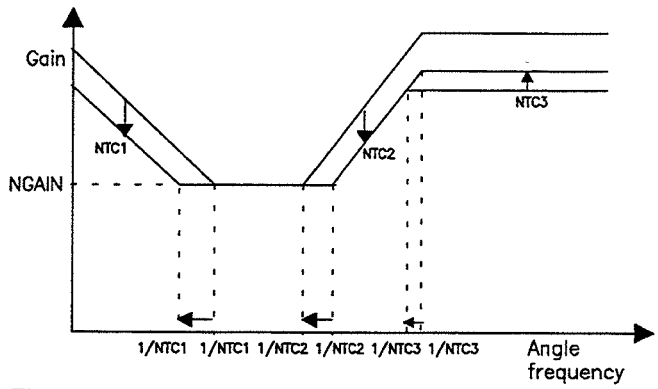


Fig. 5.

NMODE = 2, PI - LP-controller

The PI-LP controller is a PI controller with a second order Butterworth filter. The LP-filter is used in systems with speed measurement noise. It will effectively eliminate high frequency noise. Normally this is not used on resonant systems.

Tuning

Set NMODE = 2 and NTC2 = 0. NTC3 will become the time constant for the LP-filter. NTC3 should be set to approximately the rise time divided by 4 - 5. Setting NTC3 too close to the rise time will generate a too big overshoot.

Tune the PI-controller as described for standard speed controller.

NMODE = 3, RFE-controller

The RFE speed controller is used in systems with resonances and backlash to increase performance by means of active elimination of resonances.

Parameters for tuning the RFE-controller:

NGAIN proportional part
NTC1 integration time constant
NTC2 lead time constant
NLAG lag constant (lead time/lag time)
NKSI0 damping (default 0)

The tuning parameters NGAIN and NTC1 are equivalent to the PI controller. The RFE function is mainly tuned with NTC2 and NLAG. NKSI0 is then used for reducing overshoot in speed step responce.

Set the speed measurement filter time constant to 0 (Function module SPMEASXX, parameter NACTTC). Parameter NDERKD is normally not used and should remain 0.

Find resonance

If the resonance is not known it can be measured by the following sequence:

Record NSTEPDEV from a TQSTEP (TESTMODE = 9). NGAIN should in this case be tuned as low as possible. Use the PI - LP function (NMODE = 2, NTC2 = 0) to avoid controller action for high frequencies.

Recommended settings:

Function module TQLST1:
TQSTRATE = 0
Function module NCTRL2:
NMODE = 2, NTC2 = 0 (PI - LP controller)
NGAIN = 1 (or as low as possible)
NTC1 = 8.19 s (max value)
NTC3 = 200 ms

Step test:
TESTMODE = 9, STEP = 10 % (or more if needed)
TIME = 0.1 s

Measure the time t of n peaks.

Calculate the resonance frequency (Hz) as follows:

$$f_{osc} = \frac{n}{t}$$

t = time in seconds
n= number of peaks

$$\tau_{osc} = \frac{1}{2 \times \pi \times f_{osc}} \times 1000 \quad \text{(ms)}$$

Tuning

Set NMODE = 3.

Initial settings are: NTC2 = 2 x τ_{osc}
NLAG = 2

Adjust NGAIN and NTC1 until acceptable performance is achieved. (This is done with NSTEP of 1 - 2 %). Start as usual with low gain and increase the gain until acceptable performance is achieved. If necessary adjust NLAG. To reduce low frequency oscillations, decrease NLAG, to avoid resonance oscillations, increase NLAG. Typical setting of NLAG is 1.0 - 3.0.

In special cases it may be necessary to reduce NTC2. Typical setting of NTC2 is 1.1 x τ_{osc} - 2.0 x τ_{osc}.

Optimizing the RFE function

The damping is optimized by finding the best combination of NTC2 and NLAG. This is best done by performing a TQSTEP (TQSTRATE = 0). Normally the optimum is found by first adjusting NLAG and then NTC2.

The high frequency gain is NGAIN/$(NLAG)^2$. This means that a high value of NLAG is preferred.

The value of NTC2 must be greater than τ_{osc}

If NTC2 is less than τ_{osc} the system will normally become unstable. Remember that the effect of backlash can give variations in the resonance frequency.

Final tuning

Check the step response. If the overshoot is too high, it can sometimes be reduced by increasing parameter NKSI0.

If higher performance is needed, try to increase NGAIN and/or decrease NTC1. You can change NTC1 without making a new tuning of the RFE, but after changing NGAIN you have to tune the RFE over again (go back to "Optimizing the RFE function").

Remark

The RFE function can in special cases be tuned with NMODE = 2. Then the time lag constant NTC3 should be set to NLAG x NTC2, and NTC2 should be tuned as with NMODE = 3.

In this case the optimization is more difficult.

Robustness test

For all types of controllers it is essential to make a robustness test before leaving the system to production. This is done by checking the stability at a higher NGAIN.

Checking of speed control above base speed

This check is only needed for drives that operate in the field weakening region.

Testing of the speed control is done in the same way as described earlier, with the difference that a step is generated when the motor speed is 90 % of the maximum speed.

The step response for the signal NACT should be the same as after earlier adjustments of the speed control because of signal FLUXREF. This signal increases the speed control's amplification, as compensation for lower field current. If the speed control becomes unstable the following two alternatives provide

1. Reduce parameter ADAPTLIM to half of the difference between maximum and base speed.

2. Reduce NGAIN in the speed control.

Check the above by generating step disturbances and studying the step response. Begin with alternative 1. If the speed control is still unstable, the value of the parameters must be reduced further until the control is stable.

Test of the control regarding to load change

This test is needed only in applications with high dynamic requirements on the speed control.In certain applications is the ability of the speed control to fast eliminiate the speed error, due to a sudden load change, the most important requirement. In order to simplify this test the TESTMODE =9 excists. The signal STEP from the STEP-function is added to the torque reference value after it has passed a ramp function. The time characteristic of the "step" can be adjusted by the parameter TQSTRATE. This is a way of simulating the impact speed drop caused by a bar entering a roll-gap, for example. Thus:

Set DRIVEMODE =9.
Adjust a suitable value on the "torque disturbance", STEP
Start the motor drive and increase the speed setpoint to
a suitable value.

Generate a step disturbance with help of the STEP-function. If the signal NSTEPDEV is registered via a chart recorder, a speed response identic to the picture in figure 14 below will be obtained.

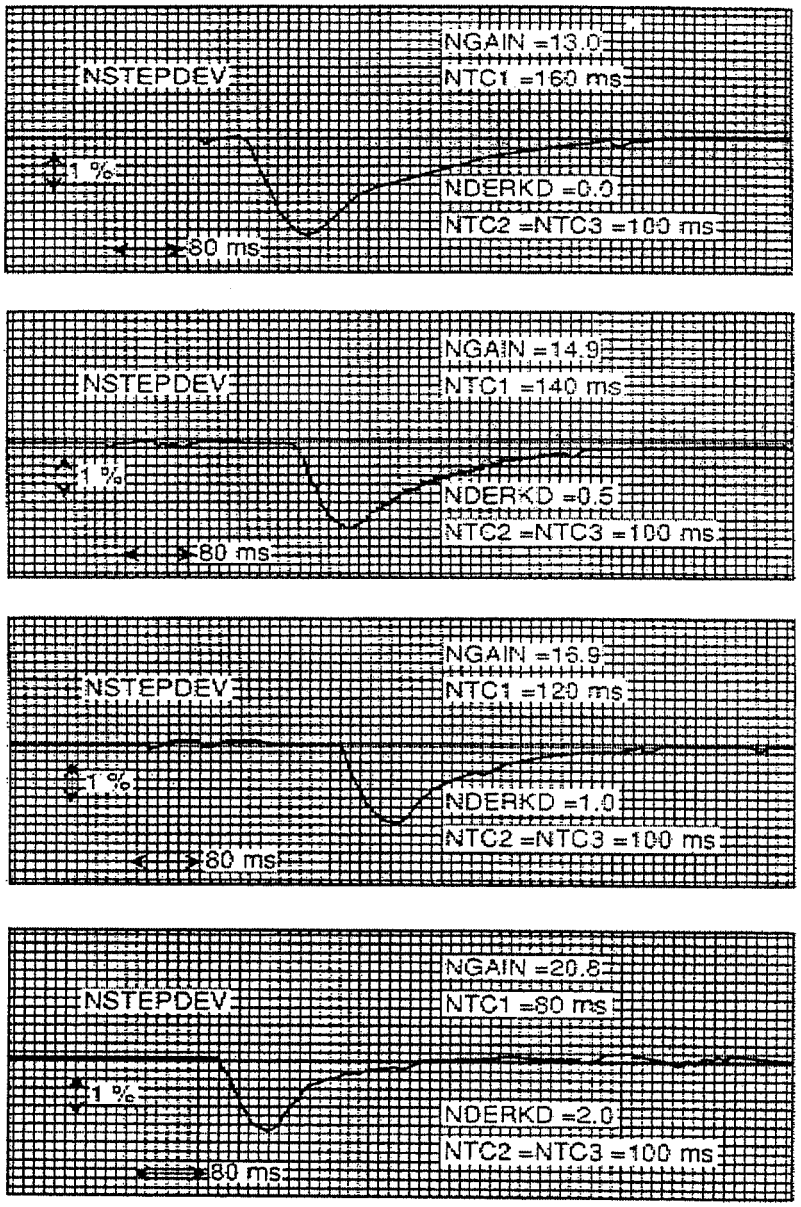


Figure 14. Control-out influence from load change.

Figure 14. Control-out influence from load change.

The total time to recover after a torque step should be 4 – 6 times the time for the initial speed drop. The initial speed drop counts from the point where speed starts to fall, the time when the step was generated, until the point where it just starts o rise again.

Checking the e.m.f. control above base speed

It is important that the e.m.f control settings are checked by a step in speed when the speed controller has been tuned to the required performance. The step-test shall be done at two speed levels. One speed just above the level where the e.m.f. controller isactivated (ECTRLACT ="1"), the other speed close to max. speed. The behaviour of the e.m.f. feedback must be studied. Oscillation is an indication of instability and the e.m.f. control must be retuned.

The positioning system

Position control

Position control is implemented by generating the speed reference as a function of position deviation. Positioning is optimized such that the speed reference ramps down linearly and the drive stops at the desired position. Position measurement is done by counting pulses from the pulse tacho used for speed measurement. Position control can be activated either in the local mode or in the remote mode. It is recommended to use the local mode for commissioning the position controller prior to activating the remote mode.

Range, resolution, scaling and units

All position values are either in pulses or in units. Measurement of position is in pulses; this implies the physical number of tacho pulses x 4 (refer SPMEASXX). One unit is the minimum position displacement in engineering units, (e.g. 0.1, 0.01 mm etc.). All parameters and values to and from the module POSCT are represented in integer number of units.

Conversion from units to pulses and vice-versa is
done using a scaling parameter PPU (pulses per unit); It is represented by an integer part PPUI and a fraction part PPUF. PPU should always be > 1, suitable value is ≥ 3.

The normal range of operation is ± 32767 units
(except signals POSACT, POSMVL, PRECOUNT, RPOSREFL & RSYNCVL which can be ± 2147483647 (2^{31} - 1 pulses)).

Example: A drum, driven by a DC motor via a gear box (z = 4.9) is to be positioned within a range ± 720° with a resolution of 0.25°. A pulse tacho (600 ppr) is mounted on the motor shaft.

Define 1 unit = 0.25°.

PPU = (pulses per rev. of drum/360) x 0.25 =
(600 x 4.9 x 4/360) x 0.25 = 8.166 (which is > 1).

PPUI = 8, PPUF = 0.166. Range = ± 32767 units =
± 8192.75° (which is > 720°). Here, we have a margin to improve our resolution if desired, by using a smaller unit (hence lower PPU).

Synchronization

Position measurement (and hence positioning) will
not function until the position counter is synchronized (preset with a predefined value at a predetermined position). Refer Program Diagram, function module SPMEASXX, for different modes of synchronization. Remote synchronization can be ordered using signal PGMSYNC1. The value to be preset in the counter is determined by signal RSYNCV or parameter LSYNCV (in units). Synchronization can be reset using signal RESYNCRY (in module SPMEASXX).

Position references

Position references can be specified by remote reference RPOSREF or by three parameters PREF1_3 to which AIPREF can be added in the remote mode. PREF3 is also used as the reference in the local mode. All values are in units.

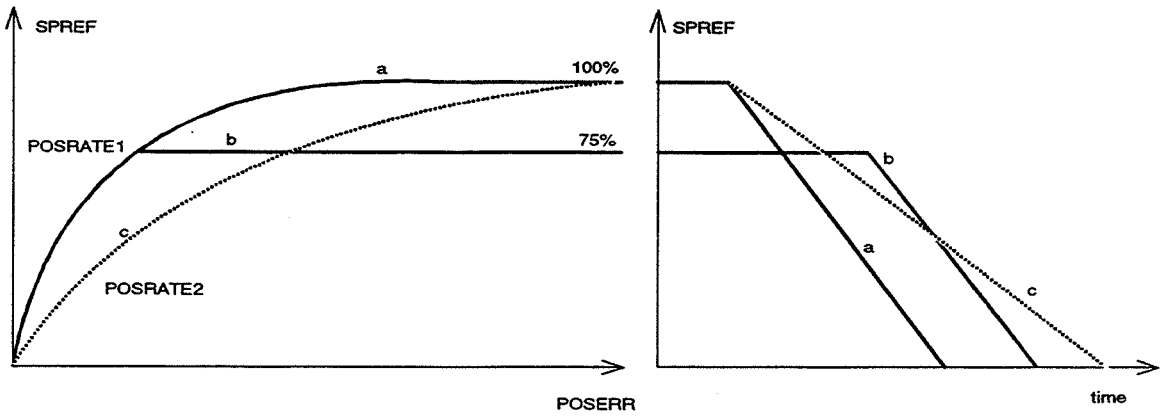


Fig. 2 Speed reference generation for positioning.

Speed references

During positioning, the position controller generates the required speed reference as a parabolic function of the position error. This speed reference is limited to a value specified by signals LSPREF (in module NREFH) RSPPOS, AISPREF or parameter LPOSSP. Speed references are in %.

The maximum rate of change of speed reference during positioning is specified (in NRAMP) by signal RPOSRATE or by parameter LPOSRATE. The "shape" of the parabolic function generator is determined by this value. Ramp rate is in seconds (time required to ramp 100 %). Refer figure 2 which explains this.

Cyclic Positioning

This is best illustrated with an example. Consider a shear (driven by a DC drive) whose rotary blade makes a cyclo of 360°. 0° is defined as the home position. Assume a position reference = 360°, POSACT = 359,7° and DELINPOS = 1; position error = + 0.3°. Now, homing is ordered by changing the reference to 0°. In the normal case, the drive will reverse towards home, which is not desirable here because of the time loss.

A resynchronization is ordered to prevent this:
If parameter PRESTV = 360°, module sets PDIFSYNC the instant the reference is changed to 0°, whereby, the position counter is synchronized to a value of - 0,3°, the position error remains unchanged. This function can be disabled by setting PRSETV = 0.

Master - Follower "Electrical Shaft"
(Not in DSRB)

Master-follower position control is designed primarily for the "Electronic Shaft" system. This function is not available in program DSRB. The master drive controls the average position of the two drives and the follower drive controls the difference in their positions (skew). The parameter MFLAG should be set in the master drive and reset in the follower drive.
If this function is not required, the communication link should be disconnected and parameter MFLAG = 0.

Levels

Signal DELINPOS is set when the position error is within INPOSL (units) for a duration > INPOSTD (ms). This signal is provided for the ABB Master to take appropriate action (e.g. set RSTPOS = 0).

When the position exceeds parameters PLVL1 & PLVL2, signals PGTLVL1 & PGTLVL2 are set. If level checks are to be done at large position values with lower resolution, parameter PMVSCALE can be used to rescale the level check circuit.

Other features

If the drive is kept phase advanced even when positioned, the parameter LPGAIN can be set to an appropriate value (e.g. 0.2) to reduce the gain.

By setting parameter ESYNCSP = 0, the drive will stop if synchronization is lost during positioning.

Positioning control tuning

Before commissioning the position controller, the drive should be tuned for optimal speed response. A measure of the speed rise time should be made.

Put the drive in local mode and set LPOSON = 1. Set RTIMESPC to the measured speed rise time in ms, PGAIN = 0.5 and MFLAG = 0. Record NREF1 & POSMV during the following.
Set TESTMODE = 8.
Synchronizing the position counter. "Manual" synchronization can be done by jogging (set LPOSON = 0) the drive to the synchronization position. If automatic synchronization is desired, set LSPREF to a suitable low value (of appropriate polarity). When STARTed, the drive will run at this speed; when is passes the synchronization position, the position counter will be synchronized and the drive will automatically move to the set position reference.

Set STEP to a large value so that the drive can reach the set LSPREF at start of positioning. Make a position step and adjust LPOSRATE (NRAMP3XX) such that the desired torque limit is reached (e.g. rated current) during acceleration to LSPREF. Now adjust POSSTEP such that the drive just reaches LSPREF and then starts decelerating towards the desired position (fig. 9 a). Increase PGAIN (normal value = 1.0) so that the drive decelerates linearly to zero speed without over/under shoots, as it reaches the desired position (fig 9 b).

Reduce STEP such that the drive start decelerating well short of LSPREF. If the position controller is correctly tuned, the shape of the deceleration characteristic will be the same as for the larger step (fig 9 c). Adjust PGAIN if desired.

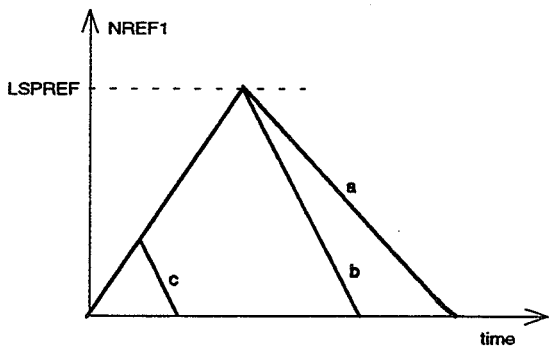


Fig. 9 Position Control Trimming

If PGAIN is well beyond the normal value (0.9 to 1.1), the value of parameter RTIMESPC is incorrect.

Switch to remote mode and test remote positioning.

A P-controller for speed control gives better positioning performance than a poorly tuned PI-controller.

Thyristor temperature, supervision via thermal model

Description

Temperature supervision

The function module TYTEMPXX contains an advanced temperature model for the supervision of the thyristor crystal temperature, which should normally not exceed 125°C. The input signals to the module are, amongst others, the ambient temperature inside the thyristor cubicle and the average value of the currents in the forward and reverse bridges. The thyristors' power dissipation consists of on-state power loss and switch losses, which are continuously calculated. The calculation of the switch losses is based upon the actual delay angle and the level of the main circuit voltage.

The heat is conducted away by heat sinks and forced air flow. The temperatures are calculated in the model. The model is a series of low-pass functions with different time constants and heat transfer data. Information about actual physical data and time constants are to be found in a library for all possible combinations of thyristors and heat sinks. If the fan stops or the air pressure falls too low, the input signal COOLON is set to zero, and the temperature model is given new heat transfer data. The model is in this way adapted automatically to the new condition, and a warning is activated.

Testing and commissioning function

In order to study the thyristor temperature under various loading conditions, with the convertor in off-condition, there is a special test module, TYTESTXX. The module generates special actual values of current for the testing of TYTEMPXX. For commissioning and test, a special load cycle simulator can be used, in which the parameters are set in accordance with a desired load profile. Alternatively a constant current can be generated in the forward or reverse direction. The module can be used as a field tool for testing whether the convertor can handle a particular load or load profile.

Adjustment of TYTEMPXX

Choice of components

In order to have the right data in the temperature model, a component choice must be made.

1) Thyristors, main type

Parameters WE540S, YST14S, YST35S, YST45S and YST60S are all of a logical nature. The parameter corresponding to the actual thyristor type should be activated.

2) Thyristors, voltage class

The thyristors have an extension in their type number, which refers to the voltage class. This must be supplied using parameter RATESEL.
When the thyristor type is WE540-a1 then set parameter RATESEL = 1.

3) Heat Sink

There are two types of heat sinks:
YAP 8-03 (older type heat sink) and YAP X-XX (new heat sink).
Parameter YAP803S or YAPXXXS should be activated.

The temperature model's data is calculated at the start of the control system (INIT level). If any component choice is incorrect, for example double-defined components, or a voltage class which does not exist, an error message is activated on the operating panel:
"THERMAL DATA INCORRECT".

Example:
A bridge with YST 45-27 and YAP 8-03.

The parameters should be supplied as follows:

WE540S="0",	YST14S="0",	YST35S="0",	YST45S="1",
YST60S="0",	RATESEL=27,	YAP803S="1"	and YAPXXXS="0".

If an error message is presented, the parameters should be corrected. Switch the operating voltage off and on, so that a new INIT will be effected.

Other parameters to be set

If the thyristor ambient temperature is measured with the Pt100-element inside the thyristor cubicle the parameter PT100S is set ="1". If the ambient temperature is not measured it is adjusted to a value equivalent to the highest likely ambient temperature with the parameter AMBTEMPS. In another case it can also be set with the parameter AMBTEMPS. AMBTEMPS is set to a constant value, equivalent to the highest likely ambient temperature.

The parameters CURSHF and CURSHR are current sharing factors for forward and reverse bridges. The net inductance per phase, the short circuit inductance at the convertor's connection point, should be input in µHenry with the parameter LMAINS found in the start-up module STRTCS.

The number of parallel thyristors in the forward and reverse bridges is set with the parameters NOPFTHY and NOPRTHY.

Adjustment of indication levels

Normally the same levels will be set for forward and reverse bridges. A high temperature is indicated by signal THYHT and an error message about which bridge is indicating high temperature is written into the fault logger. The levels are set with the parameters THYHTLF and THYHTLR, normally 115°C.

The level for overtemperature should be 125°C and is set with parameters THYOTLF and THYOTLR. At overtemperature, the convertor will trip.

Adjustment of ambient temperature (calibration of input signal from Pt100 element).

The metering resistance for a Pt100 element, according to DIN 43760, is: T=0°C: R=100 , T=100°C: R=138.5 ; the resistance increases linear with the temperature. The Pt100 element is connected to a 5 mA current generator on board YPQ202.

Adjustment can be performed in two ways:

A) Ambient temperature is known

If there is a thermometer available, for example a mercury thermometer, the adjustment is made as follows:

Set parameter PT100S="1". Read off the signal AMBTEMP on the operator panel. The signal is adjusted with parameter AI37.1MU/AI37.2MU, until it shows the same value as the thermometer.

B) Ambient temperature is unknown

A potentiometer of maximum 500 W is set to 100 W, and coupled to AI37.1/AI37.2. The parameter PT100S="1". Read off AMBTEMP on the operator panel and adjust with AI37.1MU/AI37.2MU until the signal displays 0°C. Replace the potentiometer thereafter with the Pt100-element.

Testing of protection with help of TYTEST0X

Load cycle simulator

Load cycle simulation is activated by setting the parameter TESTTYPE=1. In order to use this function, the program diagram (PD) should be available.

The use of the simulator is explained best with an example.

Assume that, for a certain type of production, a mill generates a certain load profile for the convertor, such as, for example:

Acceleration	3 s	130 %	of the convertor's rated current
Working	20 s	80 %	of the convertor's rated current
Braking	5 s	100 %	of the convertor's rated current
Idling	10 s	3 %	of the convertor's rated current

The load consists of 8 rolling passes, ie a total load cycle which consists of 8 shorter cycles.

Set the parameters thus:

IDACCEL	=130 %,	TBASE	=20 s,
IDWORK	=80 %,	TRETARD	= 5 s,
IDRETARD	=100 %,	TIDLE	=10 s,
IDIDLE	=3 %,	NCYCLES	= 8.
TACCEL	= 3 s,		

If the direction of rotation should change after every pass, the parameter ALTROTD should be ="1". For a fixed positive direction, the parameter ALTROTD should be set to "0". With the parameter EXPFACT it is possible to expand the time for load, in accordance with the following formula:

$$TWORK_1 = TBASE \qquad TWORK_{(k+1)} = EXPFACT \times TWORK_k$$

Example:
There is a requirement that the working interval should expand 150 % for each new pass. Set EXPFACT to 150 %. This means that the times will become:

$$TWORK_1 = 20s, \quad TWORK_2 = 30s, \quad TWORK_3 = 45s.$$

If the work interval should be constant, EXPFACT is set to 100 %.

Test with constant current

Set parameter TESTTYPE=2. In this state it is possible to enter a constant load in percentage of the convertor's rated current, with the parameter IDTETEST. The direction is determined by the parameter IDTEFWD, which is set to "1" for forward direction. The load can be changed, by changing the parameter IDTETEST at any time during the test.

Activation of the test

When all parameters are correctly entered, the test can begin. It is activated by setting parameter TESTON="1". The test can be stopped at any time by resetting TESTON="0". If TESTON is activated again, the test restarts from the beginning. The temperatures, TYTEMPF and TYTEMPR can be read on the operating panel under the caption for function module TYTEMPXX. When the convertor has received an ON order, the test can not be conducted. If the parameter COOLONT is set to "0" during the test, the temperature development can be studied in the thyristors when the fan stops or the cool air flow falls too low.

NOTE! Remember to reset TESTTYPE = 0 and TESTON = "0" when the test is completed.

Adjustment of various protective and supervisory functions

General

The protective functions mentioned below is not a complete list. Only those protective functions are mentioned, which cannot be finally set during factory testing, and which do need to be tested together with the actual motordrive.

Choice of trip or warning

It is possible to choose warnings instead of cut-outs for a number of the convertor's protective and supervisory functions. During commissioning, the choice of warning or trip is made in consultation with the customer.

When a signal is sent from a protective or supervisory function, and the signal is coupled for a warning, the red lamp on the drive system operator panel begins to blink. An error message is sent to the error log, where it is stored as the last message.

When a warning (the signal TRIPWARN) has been activated, a timing element is started. When the time period, TPWARDEL, has expired, the signal TRIPWTO (trip warning time out) is set to "1". This generates a trip via the signal TRIP3, if parameter REMSTOR is "0". If this parameter, on the other hand, is set to "1", it is possible to block a trip via the superior control system, provided signal ACKTRIPW="1" when the information about the warning is received by the superior control system.

Speed supervision

Over speed

Check

Start the convertor and increase speed to 100%.

Set parameter MOTOSPL in function module SPMONXX to 99 %. The convertor should trip because of over-speeding.

Adjustment

Normal adjustment of parameter MOTOSPL is 110 %, which allows the speed to be 10 % higher than nominal.

NOTE! With pulse transducer feedback the following applies. If parameter MOTOSPL is set much too high, so that it results in a pulse frequency higher than the maximum pulse frequency of 50 kHz, the convertor trip because of "OVER-SPEEDING".

Loss of speed feedback

Adjustment

Normal adjustment of the protective feature is as follows: parameter ALPHANSP is equal to 60, parameter MOTNSPL is equal to 5 %. The time delay, parameter NSPTIME, is set equal to 200 ms.

It must be checked that the protection is not tripping the convertor when the motor accelerates fully from stationary state with rated load.

If the convertor cuts out because of lost speed feedback, the value of parameter ALPHANSP must be reduced (5° at a time, but not below 30°). Alternatively the time delay must be increased.

Overvoltage protection

General

It is possible to supervise the motor voltage in several ways: in the convertor control unit (function module IUMONXX) and in the drive system control unit (in function modules EMFMONXX and FSIGHAXX).

When the overvoltage trip level is to be set, the following considerations regarding the choise of trip level has to be made:

- The trip level has to be set as low as possible in order to protect the motor.
- The trip level should be set to a level which is high enough in order to avoid unnecessary trips.

It must also be considered that:

- Motors are always tested with a applied voltage of 125 % of the rated terminal voltage.
- The convertor, in applications where a large motor drive is operating on a weak line supply, can be controlled to maximal output voltage ($=0^{o}$) in order to force-up the current.

The trip level is to be set relative to the nominal no load DC voltage under full modulation, ie relative to a voltage equivalent to 1.35 x UVNOM. Uvnom is a parameter in the start-up module of the convertor.

Motors are to be tested with a voltage, 25 % over the nominal terminal voltage.

The trip level must not, under any circumstances, exceed 125 % of the motor terminal voltage. The trip level should, in normal applications, not exeed 100 % of the convertor maximal output voltage at no load, U_{di0}

Convertor control system

In the convertor control unit, in function module IUMONXX, the average value of the convertor's output voltage, UMDV, is supervised.
The trip level is set relative to the nominal no load DC voltage under full modulation of the convertor.

Normal adjustment: ARMOVL is equal to 100 % and ARMOVDEL is 40 ms.

Drive system control

There are two possibilities to supervise the motor voltage.
With the CONNECT function it is possible to connect an analogue signal proportional to the motor's voltage to the input signal EMFACT1 in function module EMFMONXX. With parameter MOTOVL the trip level is set.
Alternatively, a digital signal can be connected to the signal MOT10V/MOT20V, via the CONNECT function. These digital input signals are prepared to come from a electromechanical overvoltage relay, which can be ordered as an option.

Overload protection of the motor

The output signals from this function module are connected to function module FSIGHAXX, in which signal ARMOL is created from ARMOL1, and ARMHL from signal ARMHL1.

The output signal ARMOL is normally set to trip, but, with the help of parameter ARMOLS in function module TRPDSXX the trip can be disconnected, and a warning selected instead, with the parameter AOLTRP3S, which is accessed via the terminal.

Adjustment of parameters MOTCURM and MOTORTC, in function module MOTOL1XX, is dependent upon the type of motor being used. Examples of satisfactory settings for a large motor is MOTORTC =600 s and MOTCURM =200 %.

NOTE! After adjustment of the parameters in function module MOTOL1XX the control system must be restarted, in order that the change will be activated.

Overload protection of the field

The output signal FLDOL from the function module FLDOLMXX is normally set to trip, but with the help of parameter FLDOLS in function module TRPFEXX the trip can be disconnected, and a warning will be activated. Adjustment of parameters FLDCURM and FLDTC, in function module FLDOLMXX, is dependent upon the type of field being used. Default setting is normally OK. FLDTC = 300 sec and FLDCURM = 200 %.

NOTE! After adjustment of the parameters in function module FLDOLMXX the control system must be restarted, in order that the change will be activated.

Overcurrent protection

Overcurrent protection is set to 115% of the highest value on the installed current limit in function module IAREFHXX, positive current limit (signal IALIMP1) or negative current limit (signal IALIMN1). The trip level is set in amperes, with the aid of parameter OCURFL (forward direction) and OCURRL (reverse level) in function module IUMONXX.

Drives which are not equipped d.c. breakers, an overcurrent indication should trip also the field circuit. In this case parameter AOCTRP2S in the drive control unit must be set to "1".

Current ripple protection

The protection supervises the current response and indicates disturbances which are not caused by speed regulation. The indicated level is set relative to the normal ripple current caused by the convertor, ID0 (limit value for continuous current).

The parameter ARMRPLL can be used to set a level relative to ID0. A constant value can be added to this with the aid of parameter ARMRPLL2. The reason for this is that in certain motors the armature circuit has a high impedance and the limiting current ID0 becomes very low. Normally ARMRPLL is set to zero. The motor supplier should be consulted when installing the indication level ARMRPLL.

In order to determine the equivalent of ID0 in amperes, the value of ID0 should be multiplied by the value of the parameter IDMNF in function module STRTCSXX. Using the parameter ARMRPLTS in function module TRPCSXX it is possible to choose whether an indication will result in trip or warning. By default, an indication results in a warning.

Indication of interruption in the armature current circuit

The protection is used to detect fuse interruptions or to indicate a thyristor which does not trig. If the indication via signal ARMNC is to result in a trip, parameter ARMNCTS must be set to "1".

The signal ARMNCNBR indicates which thyristor is not conducting current.

Supervision of motor temperature with Pt100 transmitter

Function module MOTEMPXX is normally used to supervise the DC motors winding temperature, but can also be used to supervise the bearing temperature and, in certain cases, air temperature.

On delivery of the motor which has been equipped with the Pt100 transmitter, the enclosed documentation (XO manual) gives the temperature level at which a temperature warning should be given, and the temperature level at which the protection will trip the convertor.

See also maintenance and commissioning instructions for the actual motor.

On the terminal card to the analogue input card is a 5 mA current generator for supplying the Pt100 transmitter with 5 mA. Jumpers 1-2 and 3-4 should be removed on the actual input. The actual input on the analogue input card should have jumpers set for 1 V.

The trip level for overheating of the windings is set with parameter MWOTL. Warning of high temperature in the windings is set by the parameter MWHTL, accessible via the terminal, in such a way that its value is subtracted from the value of the parameter MWOTL.

Supervision of bearing lubrication

Digital input signals from, for example, pressure switches, can be connected to the input signals MOALUBFT and LOBLUBFT in function module FSIGHAXX, using the CONNECT function.

Supervision of thyristor temperature with the Pt100 transmitter

Function module TYTEMPXX supervises the thyristor crystal temperature with the aid of the Pt100 transmitter mounted on the thyristor cooler.

On the terminal card to the analogue input card is a 5 mA current generator for supply of the Pt100 transmitter. Jumpers 1-2 and 3-4 should be removed for the actual input. The actual input on the analogue input card should have jumpers set for 1 V.

High thyristor temperature is indicated by the signal THYHT and the level is set with parameter THYHTL. If the level of parameter THYOTL is exceeded, signal THYOT is set to "1" and the convertor will trip.

The parameters are adjusted in connection with factory testing, and do not normally need to be altered on commissioning.

Installing of protection against external problems

In the module it is possible to choose between delay for trip or warning. It is also possible to choose whether an external problem should result in trip or warning.

NOTE!	The standard installation of the parameter gives a warning

Earth fault main circuit

The function of the earth fault protection device is tested in the work shop. This may lead to a too sensitive setting. For this reason the device must be kept under observation (LED on front) when the drive is accellerating and decellerating at low current (discontinous). If the setting is too sensitive, contact ABB for instructions.

Adjustment of drive stalled protection

The drive stalled protection is primarily intended to be a protection for the motor and especially its commutator.

On DC motor drives a current through a stationary motor can damage the commutator by partial temperature increases. In applications where large vibrational torque can be needed it may be necessary to adjust the pre-installed parameter values.

Normally the armature current level is set to 100%, via parameter STALLIAL. The speed level is set with parameter STALLSPL to 2 %. The delay is set with parameter STALLTD to 3 seconds.

Changing torque direction by means of field reversing

Using a single bridge armature convertor, the torque direction can be changed with a double bridge field exciter. The system allows some different control strategies:

- Optitorq function (torque set point controlled excitation).
- Full field reversing
- Combined optitorq / full field reversing where the control strategy will be chosen with the signal OPTTORQ (PD278).
- The functions above can be combined with field weakening over base speed and voltage control.

Test procedure:

The system should be brought to the final commissioning state for a single bridge armature convertor with a single bridge field exciter before the field reversing will be activated. As the armature convertor can run in inverter mode, (control quadrant 4) the instructions regarding protection against commutation break down have to be taken in consideration before further activities.

First field reversing

Set the bridge change control module and the parameters IFDISC and BLOCKDEL (PD 454) according to the commissioning instructions for "double convertor" field exciter.

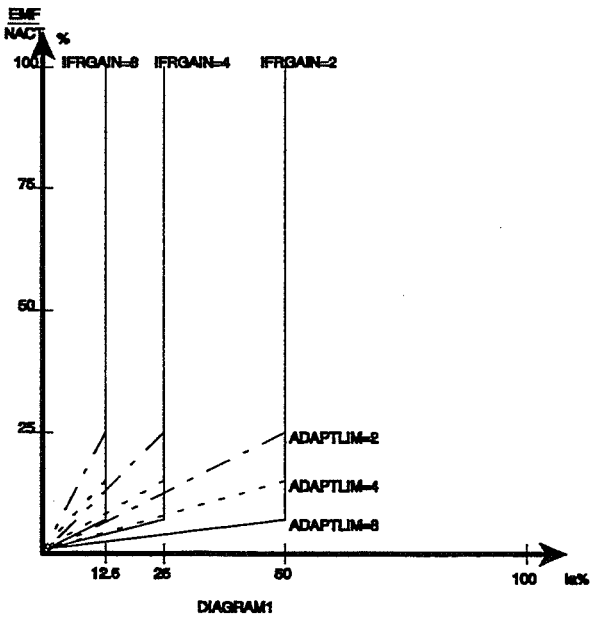
OPTITORQ combined with normal field weakening above base speed

Set OPTITORQ "1" and FFWD "0" (PD 278).

Choose control strategy for the signal IFREF4 (PD 425). Normally the parameter OPTORQS will be set "1", forming a minimum flux reference to the excitation system.

Choose a minimum excitation level which gives a well defined torque direction in the motor (10%). Insert this value on IFHYST (PD278) and IFMIN (PD 426).

Set IFRGAIN and ADAPTLIM according to diagram1 (PD 278 - 279)



The diagram is valid for CONVBSEL="0" and SEPGAIN=2 (PD 279). We recommend you to start with the default value 3 for ADAPTLIM. If stability problems occurs at low armature current, try to increase ADAPTLIM.

Full field reversing combined with field weakening above base speed

Set OPTITORQ = "0" (PD 278).

OPTITORQ / full field reversing with field weakening above base speed

The OPTITORQ function can be switched on / off by an external order via signal OPTTORQ when the drive is running. The switching will be performed smoothly according to the setting of FLDCHIN1 (PD 278).

Field reversing without field weakening above base speed

Set FILIMN, FILIMP and FILREL_N to 0 (PD 426).
Set NBASE = NMAX (PD 207).

Combined running of the superior system, with another drive system

MasterFieldbus

Check that the node number, that is the value of parameter UNIT_NO, agrees with the value used in the ABB master system.

The communication is activated by first setting parameter BUSSEL to "1", and then restarting the control system, ie a re-initialising of the program.

It is easy to check that communication as been correctly established, that is that ABB master has contact with the convertor and vice versa, by observing whether the LEDs RX and TX on the modem card YPC104, position 1, are lit.

If the system consists of a tandem coupled motor drive, and if the possibility is desired to choose from the superior control system whether convertor A or convertor B or both are active, Parameter CONLM in function module CONSELXX must be set to "1".

Master-follower communication

Check that parameters SECTTYPE and FOLLOW1S in function module STRTDSXX and parameter FNOD_NO in function module CVTRAXX are properly set.

DRIVE TYPE	Single	Leader	Follower
SECTTYPE	0	1	2
FOLLOW1S	"0"	"1"	"0"
FNOD_NO		0	1

It is easy to check that communication as been correctly established, that is that ABB master has contact with the convertor and vice versa, by observing whether the LEDs RX and TX on the modem card YPC104, position 1, are lit.

Concluding measures

The connections of I/O-signals which are required for the drive (signals to meters for example) should be done if they not yet has been done. Connection of signals can naturally be done successively during the commissioning and documented by entering signal name and page references in the circuit diagram (CD).

Remove the error log by occasionally setting the parameter FCLEAR in function module FLTLXXXX to "1".

Preset the signal logger to six signals which may be of interest at fault tracing, and start the log.

Set breaker S10, at the top of the computer card YPQ201, in position PS. A cross should now be visible in the circle on the monitor (prevents resetting of the parameter).

Maintenance

Contents

General

Tyrak XL convertors contain no components subject to wear in the usual sense of the word.

The maintenance of these convertors is therefore mainly of a preventive nature. This type of maintenance is common to all electrical equipment and can therefore be included in the general service routine of the installation.

Check points

The convertor should be inspected at regular intervals, determined by the nature of its operation and its working environment (vibration, dust, humidity etc.).

The following points should then be checked:

- Fouling
- Connections
- Fixings

Personnel safety! The power supply to the convertor must be disconnected during maintenance work.

Fouling

Cubicles must be cleaned from all accumulated fouling. Dust and scraps of material are easiest removed with a vacuum cleaner. Compressed air can be used in extreme cases but the air supply must be free from condense.

Stubborn fouling can be removed with isopropyl alcohol solvent followed by blowing with clean compressed air. If badly soiled, the display can be cleaned with a cloth dampened with a mild solution of detergent.

If the convertor cubicle contains an air filter or screened ventilation opening, this should be checked at regular intervals and cleaned as necessary or replaced. he filter should be removed from its holder and cleaned at such a distance from the convertor that the dust etc. does not reenter the cubicle.

A lightly soiled filter can be cleaned carefully with compressed air but any considerable fouling may require washing in a mild detergent solution.

The convertor should be inspected for signs of physical damage, overheated components etc. after cleaning.

Connections

Main circuits

Test with a torque wrench all cable termination's and bus bars joints. Check particularly connections to aluminium parts and connections to the thyristor modules and the fast acting fuses.
Following torque values should be set on the wrench:

Mechanical fixings

M4	1.4 Nm
M5	2.9 Nm
M6	9 Nm
M8	20 Nm
M10	40 Nm
M12	72 Nm

For thread-forming screws in sheet metal (T = 2 mm), use 6 Nm.

Other circuits

Check, with a screwdriver, wire connections to electrical components and to terminal blocks.

Fixing

Ensure that all parts are fixed securely and that there are no loose screws or nuts.

Check the fixing and connections of the circuit boards on the control equipment.

Cables are to be routed and supported to avoid chafing against sharp edges.

Replacement of parts

Fast acting fuses

When replacing fuses, ensure that the new fuses are of the correct type and rating. Check towards the apparatus list of the convertor concerned.

Fan, field exciter 40 - 120 A

- Un-plug the fan connector and remove the earth connection. Remove one screw holding the fan. Slide the fan sideways (right) and out.
- Move the fan connector to the new fan, (check connections) and install the new fan in the opposite manner.

Fan, field exciter 195 - 530 A

- Un-plug the fan connector and remove the earth connection. Remove the two screws holding the fan. Lift the fan up and out.
- Move the fan connector to the new fan, (check connections) and install the new fan in the opposite manner.

Fan, armature bridge

- Disconnect the cable at the fan motor terminals.
- Disconnect the earth cable between the fan housing and the cubicle.
- The fan housing can now be unscrewed and lifted out.

Thyristor

Installation of thyristors

The following procedures must be followed when installing thyristors and thyristor modules on heat sinks.

- If the contact surfaces of the heat sink and/or the thyristor are uneven, oxidised or soiled:

  Polish the contact surface very lightly (2 strokes) with abrasive cloth (gauge 600). Clean the contact surfaces with denatured alcohol and a lint-free cloth. Apply a very thin layer of silicon grease to the contact surface using a lint-free cloth.

- Field exciter thyristor modules:

  Place the module in position and tighten the screws with the following torque:

	Mechanical fixings	Electrical connections
M5	4 Nm	4 Nm
M6	5.5 Nm	5.5 Nm
M8		15 Nm

- "Puck" thyristors:

  Locate the guide pin in the corresponding hole in the heat sink/thyristor. Adjust the heat sink/thyristor with the guide pin. Check that the thyristor is oriented correctly (a conduction symbol is located on the component).

See also the installation instructions supplied with the thyristor.

Thyristor, field exciter 40 - 115 A

Each thyristor module contains 2 thyristors.

- Disconnect all cables from the module which is to be replaced. Note the markings of all conductors to avoid confusion when these are replaced.
- Unscrew the thyristor module itself.
- Check towards the apparatus list that the new module is of the correct type before installing it.

Thyristor, field exciter 195 - 515 A

Each thyristor module contains two thyristors.

- Disconnect the flat tabs to the trigger pulse cables on the thyristor module concerned. Note the cable numbers, to avoid confusion when replacing these. ate and cathode have flat tabs of different sizes so that these cannot be replaced incorrectly.
- Slacken, approximately 5 turns, all screws to the copper bars L+ and L- which connect the modules.
- Remove all screws to the module which is to be replaced.
- The module can now be removed towards the left.
- Check towards the apparatus list that the new module is of the correct type before it is screwed in place.

Thyristor, armature bridge

- Remove the trigger pulse connections (red and white leads).
- Loosen the mounting clamp at the top of the thyristor stack. After initial loosening, make sure to snap out the indication spring to avoid damage during the continued loosening.
  When the force of the mounting clamp is released, the tip of the indication spring should be flush with the upper surface of the mounting clamps.
- Attach the disassembly tool at the faulty thyristor and pry the upper and lower heat sinks apart, see fig. 1. The copper bars need not to be loosened.
- Pull out the thyristor.
- Check towards the apparatus list that the new thyristor is of the correct type before it is put in place. Ensure that the thyristor is correctly oriented.

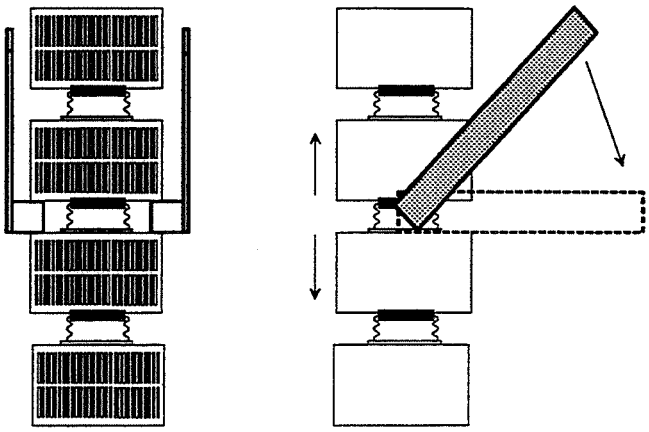


Fig. 1 Thyristor stack armature bridge
Front view *Side view*

Circuit boards

The main voltage must be disconnected when replacing circuit boards.

Important!
Circuit boards are easily damaged by discharge of static electricity.

The person handling a circuit board should always first discharge himself to the cubicle frame, preferably using an earthed wrist band. Circuit boards are always to be stored in envelopes of conductive plastic.

Remove all ribbon cables and/or screw terminal blocks from the board.

Remove all screws holding the board.

Check jumpers and components on solder posts to ensure agreement between the new and the old board.

Some boards require special handling.

Pulse transformer unit, field exciter 40 - 530 A

- Disconnect ribbon cable X31 and the screw connector X1.
- Lift the upper part of the PC board off its plastic holders.
- Pull the board straight out. Remove the trigger pulse connectors.

Circuit board for operator's panel

- Remove the ribbon cables X32 (key pad) and X33.
- Remove the 4 nuts holding the board.

PROM-capsules

Unnecessary handling of loose PROM's should be avoided. When exchanging control programs, it is recommended that the complete memory board is replaced.

If, however, replacement of any individual PROM-capsule is necessary, the following rules are to be observed:

- The convertor must be switched off.
- The operator should use a conductive wristband.
- Handle the PROM's carefully, protected from static electricity. It is recommended that PROM's are stored in the packing in which they were received from ABB Industrial Systems.
- Make sure that the correct PROM was removed, that the replacement is correct and properly inserted in the socket.
- Before the convertor is returned to service after replacement of a PROM, the 1 F capacitor for memory back-up power on processor board YPQ201 must be short-circuited at pins X26.1 and 2 adjacent to the capacitor. Because of the high internal resistance in the capacitor, the short-circuiting must continue for at least 1 minute.

Key pad for operator's panel

- Disconnect ribbon cable X32 to the key pad.
- Remove the text strip for the push buttons.
- Lever up one corner of the key pad, for example with a knife, and remove the complete key pad.
- Clean the panel carefully with denatured alcohol and allow to dry before pasting on the new button set.
- Remove the protective backing paper on the new button set and slide in the ribbon cable in the opening. Note! The adhesive sticks immediately.
- Use the display as a guide and press from the middle toward the edges.
- Return the text strip and connect the ribbon cable.

  Note! A button set installed incorrectly cannot be removed without being damaged and must therefore be scrapped.

Fault tracing

Contents

Introduction

General advice for fault tracing is given in section **General.**

Important advice on Safety is given in section **Safety**.

Certain faults do not result in an indication on the operator's panel. See section **General malfunctions**.

Faults detected by the built-in protection and monitoring system are presented in plain language on the operator's panels. The fault texts, together with possible causes and corrective action, are covered in appendices entitled **fault texts**, **drive system**, **converter** and **field exciter**.

Many of the printed circuit boards have LED's for indications. These are explained in the section headed **LED indications on boards**.

In a control system with feedback it is often hard to determine what is cause and, what is effect. The control system for TYRAK XL is therefore equipped with a special test function that makes it possible to test each control loop individually. This is described in the section headed **Built-in test function**.

Faults in the software application are sometimes of an intermittent nature. In such cases the operator's panel is used for fault tracing, as described in the section headed **Fault tracing using the operator's panel**.

General

When the convertor will not start, or when a malfunction occurs in service, a hardware fault should always be suspected. Generally this is due to a badly connected cable, or a fault in a switching device, transducer or electronics board.

Converter malfunctions may also arise in conjunction with changes in duty, such as higher load, speed, etc. These malfunctions are generally due to protection limits that are too narrowly set. Another cause of malfunctions that take the form of software errors is variation of measurement signals due to temperature drift, causing the signals to go beyond limits set in the software.

Recommended procedure on fault tracing is to read indications on operator's panels, determine the operating conditions associated with the tripping and note the location of any faulty components or circuit boards.

The aim of fault tracing on this level is to eliminate the cause of a malfunction that disturbs operation. The actual cause of the malfunction may not be traced, but the system is restored to operation.

The precise cause of the malfunction need not be determined as far as the system hardware is concerned, simply traced to a replaceable unit.

For certain types of fault, for instance tripping for over-current or differential current, repeated switching-on of the convertor should be avoided as this puts unnecessary strain on the convertor, motor and switch gear.

The power supply to the main circuit and control system MUST be switched off when convertor components (such as circuit boards) are being replaced.

After each fault tracing operation, check that any jumpers on newly-fitted circuit boards are correctly set, and that any parameters that have been temporarily changed for fault tracing purposes have been restored to their original settings.

Safety

The greatest possible care must be taken when tracing faults in the main circuits of TYRAK XL. In most cases the voltage and prospective short-circuit current at the connection point of the convertor are so high that a mistake could have disastrous consequences for personnel and equipment.

The converter control equipment is located in a special cubicle, separate from the main circuits in the thyristor cubicle. All measurement signals in the control cubicle are galvanically isolated from the main circuits.

Normally there is no need to use a voltmeter or ammeter on the main circuit, since the parameters that are of most interest, such as voltage and current, are measured by the control system and can be read on the operator's panel in volts and amperes.

If is essential to carry out measurements on the main circuit, fuse-protected test points are available.

It is never necessary to undertake fault tracing in the thyristor cubicle with the main supply switched on. In exceptional cases, faults may be located more rapidly by doing so, but ***Extreme Caution Must Be Taken.***

There are no hazardous voltages on the circuit boards in the control units.

Fault tracing equipment

The circuit diagram (CD) and the program diagram (PD) must be available. The parameter setting list should also be available.

An oscilloscope is essential for certain operations, such as fault tracing on trigger pulse circuits or in current measurement circuits. The oscilloscope must have at least two measurement channels. It must obtain its auxiliary power supply from an isolating transformer.

Fault tracing is easier with a current measuring probe such as the Tektronix P6021.

A multimeter to measure voltage, current and resistance will be required.

In certain cases, fault tracing is easier if a chart recorder is available. It must be of the y-t type and have at least two inputs.

A VT-100 compatible terminal is necessary for some fault tracing operations, e.g. on the system hardware. A printer for the operator's panel, ABLE 24, cable included. Catalogue number YT 290 000 - A.

Accessories:

Printer ribbon. Catalogue number 5697 799-3.
Printer paper. Catalogue number 5697 799-4.

Built-in test function

For fault tracing and other purposes the system includes a function known as the TESTMODE function.

The TEST parameter in the TESTDS module activates the function, provided that local operation has been selected at the operator's panel.

The TESTMODE parameter is used to select the test function to be used; see the list below.

Depending on the value of this parameter, a signal TESTREF is applied as the reference value for delay angle, armature current, field current, speed and position.

The TESTREF signal is either controlled via an analog input signal TESTREF1, which is connected to a ramp unit, or via raise/lower push buttons on the operator's panel. The rate of increase of the signal is determined by the parameter RAMPTIME in the TESTDS module.
A potentiometer may be used to control TESTREF via an analog input. A 10 kohm potentiometer is connected to +10 V and -10 V. The slider terminal is connected to terminal B51.66.

If the TESTMODE function is to be used, the convertor must be started with the ON button on the operator's panel. A start order is then given with the START button on the operator's panel.

Test-mode	Function
0	Open control of the delay angle ALPHA with the trigger pulses blocked in trigger pulse amplifiers Current regulation NOT active. Current measurement active.
1	Open control of the delay angle ALPHA with the trigger pulses deblocked in trigger pulse amplifiers Current regulation NOT active. Current measurement active.
2	Automatic setting of current control in the armature circuit. Setting is done with the field connected to the motor; the field can be switched off with the FLDEXCS parameter.
3	Test of armature current control. The function automatically switches off the motor field. The field can be switched on with FLDEXCS in the ORDERH module. The reference signal TESTREF is automatically switched in as a current reference.
4	Automatic setting of current control in the field circuit. The function is not yet implemented.
5	Test of field current control. The reference signal TESTREF is automatically switched in as a field current reference.
6	Test of speed control. The reference signal TESTREF is automatically switched in as an speed control reference.
7	Testing of EMF-controller. Step is used as E.M.F.-step.
8	Position control test. The reference signal TESTREF is automatically switched in as a position control reference.
9	Speed controller performance test. Step is used as torque step.
10	Normal running mode.
11	Test of twin-drive controller. Test ref. is automatically connected to the speed reference. Step automatically becomes a step into the twin-drive controller.

Example: If the delay angle has to be controlled without de-blocking control pulses to the thyristors, the TESTMODE parameter is set to 0. The converter is then started and a phase-advance order is given via a start order. The delay angle can now be controlled with the TESTREF signal, and the position of the trigger pulses can be checked with an oscilloscope.

Fault tracing using the operator's panel

For more detailed study, Operators panel management.

Persistent faults in control functions

The operator's panel is used for fault tracing in the software. The display on the operator's panel is used for measurements.

Signals for measurement are to be found under the heading for the module from which they originate.

Unconnected input signals are grouped in the module CONNXXXX.

For visual checking, connection boards for logical output and input signals have LED's that indicate active input and output channels.

A signal can be connected via the signal switch, for testing hardware inputs. For test purposes any signal can be connected temporarily to any output.

NOTE:	Remember to re-connect the signal after the test is completed.

An external chart recorder can be connected via ANALOG OUT. Using the signal switch, any signal in the software can be connected. For the four channels, facilities for adjustment of the offset and for multiplication are provided.

Intermittent faults

The operator's panel display for logger and registration must be used. The logger can register up to six different signals, logical or arithmetical. Suitable signals are set. The time scale is chosen for good resolution.

The event line is set so that the signals can be studied with sufficient length before and after tripping. The loggers is started. The program now reads these signals with 186 measured values per set time scale. On tripping, the measured values are frozen and the values for every set channel can be studied under the registration display. The logger can also be stopped manually by pressing ENTER with the cursor at the s/s position on the registration display.

If required, the printer can be connected and hard copies of the displays can be made.

With module TESTXX it is possible to connect any signal, logical or arithmetic. When the signal exceeds the triggering level the logger stops and stored logger values are frozen. There is also a facility for stopping the logger by rate-of-change-dependent triggering.

Registration over a long period

The operator's panel displays for logger and registration are used. The logger is set to a logical or arithmetical signal. The time scale is set to ±500 ms.

On the registration display, the text for "AUTO" is scrolled up in the top right-hand corner.

The signal will now be updated with 186 measured values over the set time scale. This updating is continuous and can be seen on the registration display. The s/s position is used to stop updating. If required, the printer can be connected and hard copies of the displays can be made.

General malfunctions

In the event of faults that are not indicated on the operator'ss panel check:

- The two-digit LED display on the YPQ201 board. If system error is indicated see section **System Hardware**.

- No fuses are blown and no compact breaker (MCCB) has tripped. A blow fuse or a tripped compact breaker must always be treated as a secondary fault. The circuits or equipment supplying must therefore be checked. Check the circuits protected by the fuse concerned. Fast acting fuses are to be checked by observing the red indicator on the fuse. It is possible, in some cases, that the fuse ruptures without indication. If a fast acting fuse has ruptured, check the thyristors in the main circuit. Use an ohmmeter to check that the thyristor is not short-circuited. Always remove other connections that will shunt the measurement.

- That the electronic supplies are correct. The two-digit LED display on the YPQ201 board indicates code 15 or 24 upon voltage failure.

- That 110/220 V control voltage is OK. Measure across terminals on supply transformer B1.20:

  7 - 8 is to be 110 V a.c.
  8 - 9 is to be 110 V a.c.
  7 - 9 is to be 220 V a.c.

In certain cases other parts of the auxiliary power supply system must be checked with a voltmeter, from the incoming power feed.

Refer to the circuit diagram (CD) especially the pages covering "POWER SUPPLY" and "POWER DISTRIBUTION".
The values of the supply voltages are given in the circuit diagram (CD).

The cabling on the control system should be checked in certain cases, for example if malfunction occur in service or if there are problems with operating the motor drive.

In such cases check:

- that cabling between the control system cubicle and the superior control system and between the control system cubicle and the thyristor cubicle is securely terminated and correctly installed. Screw terminals should be tightened after the convertor has been in service for about six months.
  See servicing and maintenance instructions.

- that the screen and earth connections have been properly made. See servicing and maintenance instructions.

- that earth connections to control, field exciter and thyristor cubicles are securely terminated and correctly installed. See servicing and maintenance instructions.

- Finally, check that none of the cable cores is open circuit.

Control system hardware

Brief description

The control system of Tyrak XL consists of a number of units that communicate with each other via a Drive System bus (the DS-bus). The DS-bus is an opto serial link communication system which is a way of sending / receiving data.

A control unit comprises a computer unit, an operator's panel, a unit for serial bus communication and I/O units. In a control cubicle for Tyrak XL there are three different types of control unit. These are:

- drive system control
- convertor control
- field exciter control.

There is a standard software control program for each type of control unit. It is stored in removable EPROM memory chips mounted on removable memory boards (YPR201).

The various types of standard control unit are equipped with different numbers of I/O units.

General instructions for fault tracing in the control system

The strategy that should be applied during fault tracing is to attempt to trace the fault to one of the control units. After this, the fault is traced to one or more electronics boards, which can then be replaced.

When tracing faults in the system hardware it is important to note the information provided by the system itself. For example, if the computer unit has stopped, the LED's display a fault code to indicate the cause. See the section headed **LED indications on boards**.

If it proves impossible to trace the fault to a control unit, boards must be replaced in turn until the fault disappears. The fault can be traced to a particular board at a later time when operation of the system will not be affected.

Faults in the control system

The two-digit LED display indicates system faults by a fault code.(see the section headed **LED Indication on boards**)

Check that the LED 24VOK is lit on all computer units of the control system. If the LED is not lit, check the power supply; see the section headed **General malfunctions**.

Check the two-digit LED display, to check the power supply, hardware and system faults.(see the section headed **LED Indication on boards**)

If there is indications for ±15V and +5V fault, change the computer unit.

If the two-digit LED display indicates for system faults, try to restart the system..

To start with, perform a "warm start" of the entire control system (i.e. restart the programs of all control units without clearing the voltage back-up parts of RAM memories). This is done by switching off the supply voltage, for example by operating switch unit B1.1, leaving the power off for a minute or so and then switching it on again.

If the LED still indicate for system fault after a "warm start", perform a "cold start". To do this, switch of the power supply (switch B1.1) and short-circuit the capacitor that backs up the RAM memory. This capacitor is located on the CPU board. Short-circuit pins X26:1 and 2 and keep them shorted for at least one minute. Then remove the short circuit and switch on the power supply.

If the LED after a "cold start" still indicate for system faults, a terminal should be connected for fault tracing.

A system fault may be due to the DS-bus communication. See the section headed **Other faults in the control unit**.

Carry out a number of start attempts and note the error messages that are printed out on the terminal screen.
The whole print-out on the terminal screen has to be noted and sent to ABB. An example of the print-out is shown below:

```
>
Time-out trap at address :
Stack overflow, check .....
AA = xxx  IR = xxx SC = xxx
PC = xxx  SR = xxx US = xxx SS = xxx.
```

If an error has occurred in a control unit where a terminal was not connected, the message of error is still saved in the computer unit memory. If the control system should be restarted or if the computer voltage supply disappears, the message of error will also disappear. If an read-off of the message of error is wanted then a terminal is to be connected to the computer unit without disconnecting the voltage supply. With help of the command ER a printed copy of the message of error is obtained, see example below.

Example:

```
Press <ENTER> until...
>
Write ER...
> ER
and press <ENTER> .
```

Then the following message of error is obtained.

```
Last error = Time-out trap at address:
AA = xxx  IR = xxx SC = xxx
          PC = xxx  SR = xxx US = xxx
          SS= xxx
```

Other faults in the control unit

DCB bus communication

To get the communication to start the green leds V9 of all communication boards YPK114 must be lit, indicating that the initiation of the program on YPK114 has executed correctly. If not there could be a faulty board YPK114 or that the software for serial bus communication is not present in the application program.

When communication is working properly the yellow led V16 on YPK114 is lit for broadcast communication and the yellow led V11 for normal communication

If the green leds are lit on all YPK114 boards and the communication fail to start, check the following parameters.
In the Drive system: SCCASEL, SCCBSEL, SCFEASEL, SCFEBSEL are set to =1

In the converter: CONVNR set to respective number

In the field exciter: FLDEXNR set to respective number
Check that the green led on the optical star board is lit. Check the connections between the drive system and the optical star board and the connections between the optical star board and the convertors and field exciter.

For broadcast communication check that:
If application is 6-pulse, 12-pulse or 12-pulse sequence.
Drive system channel A, D22 on the board YPK114, is connected to converter, D21 on the board YPK114 with optical fibre cable.
If application is 12-pulse paralell or 2*6-pulse tandem:
Drive system channel A, D22,D21 on the board YPK114, are connected to V2,V1 on the board YPC111 and then from (V11,V12),(V21,V22) on this board to D21,D22 on the board YPK114 on each convertor with optical fibre cable.
For normal communication check that:
Drive system channel B, D6 and D8 on the YPK114, are connected to V2,V1 on board YPC111, and then from (V11,V12),(V21,V22),(V31,V32) on this board to D8,D6 on each convertor(A,B)/field exciter.
On the YPK114 check that the strapping S3:1-2 and S3:5-6 are connected with jumpers and that the 2 sockets for flash prom are containing programmed flash proms.

Convertor control

In certain cases, the zero-current indication must be checked, for example if there has been differential current trip. The simplest way to do this check is to use the TESTMODE function; see the section headed **"Built-in test function"**.

Connect an oscilloscope to the current feedback signal.

Using TESTMODE=3, raise and lower the current around the limit level for continuous current.

Check that the signal CURZERO in the module FACSSXX is set ="1" on discontinuous current and that it changes status when the current is continuous; see diagram below, figure 1.

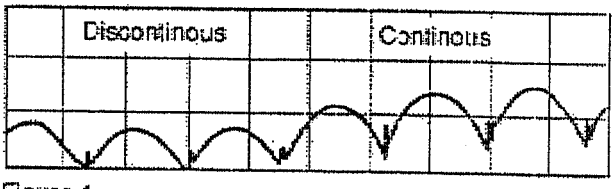


Figure 1.

MP communication

In the event of a fault on MP communication and leader/follower communication, check which LED's on board YPK107 and YPC104 are lit; see the section headed **"Board indications"**.

A common reason for communication not starting is that jumpers on YPK107 are missing or incorrectly set. Check the jumpers against the circuit diagram (CD), page 18

When communication with the ABB Master system is established, the two yellow LED's on YPC104 and the yellow LED CHA on YPK107 must be lit.

If the only LED lit is RX, this is probably because the wrong node number has been given.

Check the parameter UNIT_NO in the module MFBREXXX against what is used in ABB Master.

Another possible cause of faults is failure of communication to start because the communication program has not been activated by BUSSEL, in the function module SEQH1XX

Check that the MP communication is connected to YPK107 via a modem board YPC104, in the upper position B2.41.

In leader/follower communication this must be done via the modem board at position B2.41.2. When communication with the control system of the follower has been set up, the two yellow LED's on YPC 104, position 2, and the yellow LED CHB on YPK107, must be lit.

Measuring board YPG108

A self-test of the board is carried out whenever the control system is started. See the section headed **"Faults in the control system"**.

If a fault is found it is indicated as a fault code; see the table below. The fault code can be read via the operator's panel as a value of the signal AIERR33 in the function module IUMEASXX.

Fault code	Cause of fault	Action
0		None
1	Jumpers set wrong.	Check against circuit diagram.
2	Counter not working.	Check external supply,±15 VE.
4	No measurable signal.	Check external supply,±15 VE.

A simple function test of the measuring board can be carried out using the parameter AITESTV. The test must be done with the convertor switched off. With AITESTV, process signals are disconnected and constant signals are automatically connected to the board, as shown in the table below. The value of the AITESTV parameter determines the measuring function.

AITESTV	Board measures:
0	Process signals
1	0 V
2	10,0 V

Measuring circuits

General

The measuring circuits include units in both the control cubicle and thyristor cubicle.

There are many different kinds of faults and errors, such as scaling errors, open measurement circuit or defective hardware (transducers, I/O units etc.). If there is a scaling error, the internal representation of reality inside the control system does not agree with reality (current/voltage in the thyristor cubicle, motor speed etc.)

Hardware faults

Measuring board YPG108 can be checked by activating its test function; see the section headed Measuring board YPG108. Check that the parameters in the STRTCSXX module in all control units are correct. See the **Commissioning instructions**.

Current measurement

Line current measuring

Scaling of the current feedback signal is standardised so that the continuous rated direct current in the forward direction Idmn(f) corresponds to 100% (internal representation 2^{13}). The easiest way to check the scaling of the current feedback signal is to simulate a current feedback signal with a stabilised DC power supply .

NOTE:	The mains voltage must not be connected to the thyristor unit during this check.

Unplug two of the a.c. connections on the diode bridge B13.1 and B13.2.(see page 80, or page 90 if B convertor is to be simulated, in the circuit diagram). and connect the d.c.-power supply via an ammeter. This simulates current in convertor.

Increase the voltage from the DC power supply until the ammeter reads 1.000 A. The signal IDAMP in function module IUMEASXX shall then show a value which corresponds to primary current in the current transformers. The value of the primary current is obtained by multiplying 1.000 A by the ratio (4000:1). Scaling errors can be corrected by changing the parameter ID1SCAL. A new scaling factor only affects the scaling of the current feedback signal after the system has been restarted.

If there is an open-circuit in the current measuring circuit, the above method may be used to study the measurement function. In addition, use an ohm-meter to check that the circuit through the current transformers is complete.

A simplier method is to connect an oscilloscope to the input and use the TESTMODE function with TESTMODE =1. See the section headed **Built-in test function**.

Carefully increase the value of TESTREF until the output voltage of the convertor just becomes a sawtooth voltage without a zero-voltage interval, see figure 2 below. The current in the armature circuit should now be between 5 and 40 % of the nominal current of the motor, i.e. the current must be measurable. After this, it is a simple matter to check the current in the measuring circuit by checking the voltage across the current feedback signal resistors, on the YXA118 board (see page 47 or 57 in the circuit diagram).

NOTE:	Do not forget to restore the original parameters after any temporary changes. Do not forget to restore the original circuits after temporary changes in the measuring circuits.

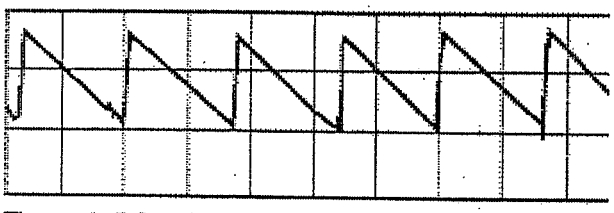


Figure 2. DC voltage (t) from thyristor bridge.

DC current measured by shunt

DC-current measurement is available only with a double convertor.
Scaling of the current feedback signal is standardized so that the continous rated direct current in the forward direction (IDMNF) corresponds to 100%. The easiest way to check the scaling of this current feedback signal is to simulate a current feedback via B26:9 input 17,20. Simulate DC-voltage in mV, and measure the input voltage on B20:X1.3,4 when it is about 5V then the signal IDACT2 in function module IUMEASXX is equal to 8192 (2^{13}). This signal can only be read by terminal. Scaling error can be corrected by changing the parameter ID2SCAL.
A new scaling factor only affects the scaling of the voltage measurement after the system has been restarted.

DC voltage measurement

If a bridge voltage measurement fault is suspected and the convertor is a double convertor, bridge changing must be locked. This is done with the parameter LOCKBRCH in the module BRCHCSXX.

Connect a voltmeter between A13.4 and 5 in the convertor thyristor cubicle. Doing this connects the voltmeter to the DC side of the convertor via fuses.

NOTE: It is important to connect the voltmeter to the main circuit via fuses. The voltage class of the voltmeter must be checked before it is connected. Remember that a ripple is superimposed on the DC voltage.

The convertor can then be started with the parameter TESTMODE=6 and the motor drive is run up to base speed; see the set value in the start-up module. The voltage measured in the module IUMEASXX via the UDVOLT signal must then be the same as that shown by the voltmeter.

The scaling of the voltage measurement is standardised so that the ideal no-load DC voltage Udi0 corresponds to 100% (internal representation 2^{13}).

A scaling error can normally be corrected by changing the parameter UDSCAL in the module IUMEAS. A new scaling factor only affects the scaling of the voltage measurement after the system has been restarted.

If an open-circuit in the measurement circuit is suspected, this can be checked by measuring the voltage at the input of connection unit YPG109; see CD pages 45.01 and 55.01. Measure the voltage between X1:1 and X1:2 on connection board YPG109. When the speed is varied between zero and base speed, the output voltage of the convertor must change in proportion to the change in the speed.

NOTE: Do not forget to restore the original settings after temporary changes in the measuring circuits.

Mains voltage measurement

If it is suspected that the mains voltage is being incorrectly measured, this can be checked by measuring the voltage on the primary side of transformer B8 in the thyristor cubicle. See the circuit diagram (CD), pages 80 and 90.

NOTE: It is important to connect the voltmeter to the main circuit via fuses. The voltage class of the voltmeter must be checked before it is connected. Remember that a ripple is superimposed on the AC voltage.

The voltmeter reading must correspond to the reading of the UVVOLT signal in the IUMEASXX module, on the operator's panel.

The scaling of the voltage measurement is standardised so that the ideal no-load DC voltage Udi0 corresponds to 100% (internal representation 2^{13}). A scaling error can normally be corrected by changing the parameter UDI0SCAL in the module IUMEASXX. A new scaling factor only affects the scaling of the voltage measurement after the system has been restarted.

If an open-circuit in the measurement circuit is suspected, this can be checked by measuring the voltage at the input of connection unit YPG109; see CD pages 45.01 and 55.01. Measure the voltage between the terminals X1:6, X1:7, X1:8 and X1:4 on connection board YPG109. The voltage be proportional to the convertor supply voltage.

NOTE:	Do not forget to restore the original settings after temporary changes in the measuring circuits.

Speed measurement

The probable causes of a scaling error are that the parameter NMAX in the module STRTDSXX is incorrectly set, or that, for some reason, the pulse transmitter is not delivering the correct number of pulses per revolution.

A new scaling factor only affects the scaling of the voltage measurement after the system has been restarted.

One result of an open-circuit in the connection between the pulse transmitter and the speed measurement board for one or both pulse transmitter channels is that the measured speed is zero. To find out where the fault lies - pulse transmitter, pulse transmitter cable or measurement board - the motor must be rotated, otherwise the pulse transmitter will not deliver any pulses. Since the motor is often to large to be rotated manually, the convertor must be used to rotate the motor. The simplest way to do this is to use TESTMODE=6. See the section headed **Built-in test function**.

Before the convertor is started, its delay angle must be limited to 75 °. This is done in the FIALCSXX module via the ALPHALIM parameter. (If there are two convertor systems, this must be done on both). In addition, the current reference must be limited to 5-10%. The simplest way to do this is to use the IALIMMAX parameter (in the IAREFHXX module) in the control unit of the drive system.

In addition, convertor bridge changing should be locked using the LOCKDIR parameter in the BRCHCSXX module in the control unit of the convertor. If there are two convertor systems, this must be done on both.

The gain of the speed control system - NGAIN is set temporarily to a low value, about 1.0. The integral action of the controller is disabled with the NPROP parameter. Since 5-10% current is not enough to rotate the armature, the value of the IALIMMAX signal must be increased.

NOTE	Do not forget to restore the original parameters after any temporary changes. Do not forget to restore the original circuits after temporary changes in the measuring circuits.

Fault tracing in main circuits

Earth faults

If an earth fault has been indicated, the insulation resistance between the main circuit and earth must be checked. Before doing this it is extremely important to ensure that the main circuit cannot become live. The fuses to the mains filters in the thyristor cubicle must be removed.

NOTE:	Put back the fuses when the measurement is complete.

Rapid fuses

If fuses blow, this must always be treated as a secondary fault, and the primary fault must be located by following the fault tracing procedures described in other sections. If a fuse blows, the related thyristor must always be checked.

When a fuse blows, a red plug projects from its usual flush position as an indication. Occasionally the plug fails to project even though the fuse has blown.

After a fuse has blown, check to make sure that all thyristors conduct, i.e. that there are six current "pulses" per mains cycle (period). The simplest way to do this is to use the built-in test function.

Connect an oscilloscope to the current feedback signal. Set the parameter TESTMODE=3 and follow the instructions in the section headed **Built-in test function**.

If a large number of fuses have blown, circulating current must be suspected; i.e. thyristors in the forwards and reverse bridges have been conducting current at the same time. The zero-current indication must be checked before double-convertor operation can be permitted; see the section headed **Control system hardware** (convertor control). Bridge changing can be locked with the LOCKBRCH parameter.

Thyristor faults

Generally there are two types of fault, anode-cathode short circuit and firing failure.

Short circuit

Anode-cathode short circuit is indicated by a blown fuse and over current tripping. The suspect thyristor is located in the same thyristor branch as the blown fuse.

If an ohmmeter connected across the thyristor with the blown fuse reads less than 100 ohm, the thyristor or the capacitor in the RC circuit may be faulty.

For converters with thyristor bridges connected in parallel, a faulty thyristor cannot be located until all fuses have been removed. In a double convertor, only one of two thyristors connected in anti-parallel may be shorted, so the connections between the two anti-parallel thyristors must be removed.

Thyristor replacement is described in the servicing and maintenance instructions.

After a thyristor has been replaced it is advisable to check that the current feedback signal is correct, i.e. that the current feedback signal contains six current "bubbles" per mains cycle. The simplest way to do this is to use the test function TESTMODE=3. See also the section headed **Built-in test function**. It is important to check both current directions, i.e. to give both a positive and a negative current reference via TESTREF.

If faults recur, the trigger pulses must be checked; see the subsection headed Trigger pulse check in this section.

Failure to fire

Failure of a thyristor to fire as a result of a fault in the thyristor itself is extremely unusual. A more likely cause of failed firing is a fault in the trigger pulse circuits. Fault tracing is described in the section headed Trigger pulse circuits.

If no fault can be found in the trigger pulse circuits, replace the thyristor. The symptoms of failure to fire may be the same as those of a blown fuse, i.e. missing current "pulses" in the current feedback signal.

Trigger pulse circuits

Transmission/generation

Failure of one or more thyristors to fire is the most likely result of faults in the trigger pulse circuits.

Trigger pulses are generated by the software-based trigger pulse unit in the convertor control system. On their way to the thyristors in the thyristor cubicle they pass through the following circuit boards: convertor board YPQ201, optocoupler board YXM187D, trigger pulse amplifier YXU201 and the speed up unit YXU202. Between the trigger pulse amplifier and the thyristor there is a trigger pulse transformer to isolate the control electronics from the main circuits.

There is a trigger pulse amplifier for all parallel-connected valve bridges placed in a thyristor cubicle that are associated with the same bridge direction. For a double convertor there are always two trigger pulse amplifiers. When checking the trigger pulses it is essential to check the circuit diagram (CD) to find out which trigger pulse amplifier is associated with which bridge direction.

In view of the danger, fault tracing should only be done when there is no voltage on the main circuit. For this to be possible, a temporary reference voltage must be applied to the trigger pulse unit. See the section headed **Checking the trigger pulses** below.

NOTE:	Do not forget to remove the temporary reference voltage after checking the trigger pulses.

The method to be used when tracing faults without voltage on the main circuit is described below in the section headed **Checking the trigger pulses**.

If fault tracing has to be done on the trigger pulse circuits with voltage on the main circuit, avoid measuring directly across the thyristor gate, i.e. between gate and cathode. This is inadvisable, since these points are not accessible via fuses. Use a current measuring probe when measuring the thyristor gate current.

Low amplitude and steepness of gate current

Another fault that may be due to faulty trigger pulses is that the amplitude and steepness of the gate current are too low at the thyristor gates. This is a serious fault which may lead to thyristor failure.

Figure 3 shows what a correct gate pulse should look like. To check the amplitude and steepness of the trigger pulses, carry out the check described below in the section headed Checking the trigger pulses, except that here it is the first part of the trigger pulse that is of interest.

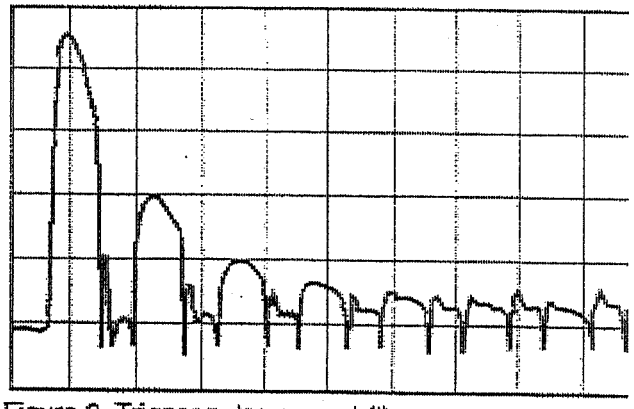


Figure 3. Trigger pulse current (t).

Interference

Faulty trigger pulses may also be due to interference. This may be caused by the trigger pulse cables. The routing of the trigger pulse cables may be unsuitable, and this may result in them picking up interference.

The control and thyristor cubicles may not be properly earthed; see Installation instructions. The earthing method is particularly important when the control cubicle is installed separately from the thyristor cubicle.

Check that the earth connections of control cubicle, thyristor cubicle and field exciter cubicle (field current >120 A) comply with the recommendations given in **Installation instructions.**

Trigger pulse check

Check with no voltage on main circuit

- Take steps to ensure that no voltage can be applied to the main circuit.
- Temporarily remove the jumper between terminals B20.X12:1-4 and replace it by terminal X12:5-8.
- For 12-pulse or tandem connection, a synchronizing voltage must also be supplied to convertor system B. Make the same changes on B32.X12 as were made on B20.X12.
- Set the TESTMODE parameter to 1 and follow the instructions given in section **Built-in test functions**.
- Set the following parameters in module BRCHCSXX of the convertor system:

  LOCKBRCH= 1 to lock bridge changing,
  LOCKDIR= 1 to deblock the forward bridge or
  0 to deblock the reverse bridge.

- Connect one channel of an oscilloscope to the gate terminal of the thyristor via the current measuring probe. Connect the other channel to the trigger pulse amplifier output that generates the trigger pulse for the thyristor in which the current is to be measured. The test terminals for measurement are listed in the test terminal tables .
- Start the convertor, deblocking the trigger pulses.
- Check gate pulse/gate current to each individual thyristor. The gate pulses must be 120° el. apart. Compare the trigger pulses with Figure 4 below.
- Change the bridge direction by changing the value of the LOCKDIR parameter. Check the trigger pulses again.
- When the trigger pulse check is completed, remove the temporary bridges to B20.X12 and (if used) B32.X12. Reset all changed parameters.

Checking with voltage on the main circuit

In this case there is no need for temporary bridges to the trigger pulse unit.
This method isn't reccomendable since the measuring of the thyristor gate pulses means condition of measuring devices close to the power parts.

Test terminal table

Table for trigger pulse checking FORWARD bridge direction, trigger pulse amplifier YXU201.

Gate pulse	YXM187D	YXU201	Thyristor
no.	Terminal	test point	position
P1	X1:1	X2:1-2	1 (L1+)
P2	X1:2	X3:5-6	2 (L3-)
P3	X1:3	X2:3-4	3 (L2+)
P4	X1:4	X3:1-2	4 (L1-)
P5	X1:5	X2:5-6	5 (L3+)
P6	X1:6	X3:3-4	6 (L2-)

REVERSE bridge direction, trigger pulse amplifier YXU201.

Gate pulse	YXM187D	YXU201	Thyristor
no.	Terminal	test point	position
P1	X1:1	X2:1-2	7 (L1+)
P2	X1:2	X3:5-6	8 (L3-)
P3	X1:3	X2:3-4	9 (L2+)
P4	X1:4	X3:1-2	10 (L1-)
P5	X1:5	X2:5-6	11 (L3+)
P6	X1:6	X3:3-4	12 (L2-)

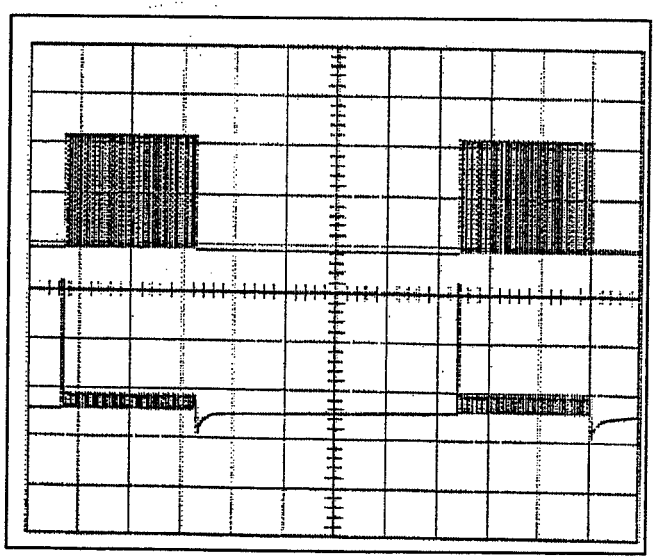


Figure 4. Upper signal; input signal for YXU201. Lower signal; the current for the Thyristor Gate.

Controllability check

It may sometimes be necessary to check the controllability of the convertor, for example if it is suspected that the thyristors are NOT firing at times corresponding to the delay angle ALPHA. For this check the TESTMODE function should be used, with TESTMODE=1 . See the example in the section headed **Built-in test functions**.

To check the controllability, one channel of an oscilloscope must be connected to a trigger pulse, for example to P1, test point X2:1-2 on trigger pulse amplifier YXU201, i.e. trigger pulses to thyristor 1. See the circuit diagram (CD) page 81 (and page 91). The second channel is connected to the phase voltage L11. See the circuit diagram (CD) page 45 (and 55).

When the convertor has been started and has received a release order, the delay angle a, the signal ALPHA in module IREGSXX, can be controlled with TESTREF. When the delay angle is equal to 150°, the display on the oscilloscope looks like Figure 5 below.

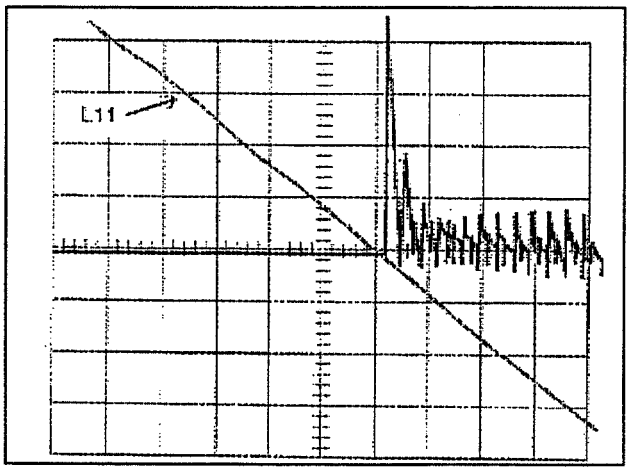


Figure 5. The position of control pulse relative L11.

Field exciter

General fault tracing

Normally the exciter receives ON and OFF orders from the drive system control unit, but in some cases there may be advantages in controlling the field exciter from its own control panel. For this, the parameter IFTEST in the IFREHAXX module must be set to 1 and the parameter FLDEXNR in the FSCTRAXX module and the parameter SCFE(A,B)SEL in the DSCTRAXX module (in the drive system) must be set to "0". The parameter IFNOMSTA has to be set to the nominal excitation current of the motor. The system must then be restarted.

Current measurement

Scaling of the current feedback signal - IDACT is standardised so that the continuous rated DC current of the field exciter corresponds to 100% (internal representation 2^{13}). The internal measuring circuit in the control unit can be checked by simulating dc-voltage on board YPQ201 X25:1,2, at -5V the signal IDAMP in the IFMEASXX module should be the same as IDMN in ampere.During this test the ribbon cable X72 on YPQ201 must be disconnected.

IMPORTANT: Never do this with the field exciter switched on.

Faults in the control unit

See the section headed Control system hardware.

Blown fuses

Fuses may blow as a result of thermal fatigue without there being anything wrong with the field exciter itself. Normally, because of the long time-constant, over current should not cause fuses to blow, but a short in the field circuit may blow a fuse. Another possible cause is incorrect current measurement.

In double convertors, fuses may blow because the zero current indication level (parameter IFDISC) is wrong set (FIAFEXX module) or that the parameter BLOCKDEL has been incorrectly set.

Instructions for checking the setting are given in **Commissioning instructions**.

LED indications on boards

Explanations of the LED's used

CPU board YPQ201

24V OK (green) = lit when incoming 24V supply is correct.

The two-digit LED display indicates system faults by a fault code. The fault code appears flashing with appr. 1 Hz frequency. Other fault codes than the ones listed below must be analyzed by ABB Industrial Systems AB system specialists.

Code	00	No application program installed
	15	15 V power supply failure
	24	24 V power supply failure
	30	Hardware fault. Check ribbon cable and coaxial cable connections.
	9X	System fault. Try to restart the system.

Basic I/O-board YPQ202

Yellow LED's indicate active digital input- and output signals.

Digital input YPI103

Fault	(red)	=	Hardware fault. Board parameter ADI3X is set to zero.

Digital output YPO103

Fault	(red)	=	Hardware fault. Board parameter ADO3X is set to zero.

Analog input YPG110

Fault	(red)	=	Hardware fault. Board parameter AAI3X is set to zero.

Analog output YPM102

Fault	(red)	=	Hardware fault. Board parameter AAO3X is set to zero.

Analog output YPM106

Fault	(red)	=	Hardware fault. Board parameter AAO3X is set to zero.

MP communication YPK107

CHA	(yellow)	=	Channel A communicati
CHB	(yellow)	=	Channel B communicati
OK	(green)	=	Program initialising complete.
FLT	(red)	=	Hardware fault.
BERR	(red)	=	Computer bus error.

Star board YPC111

	(green)	=	The green led are lit whe the 24 V DC is OK.
	(yellow)	=	The yellow leds for each used channel are glowin

FSK modem YPC104

RX = V1	(yellow)	=	Receiving.
TX = V2	(yellow)	=	Sending.
PW = V3	(green)	=	Lit when 5 V supply is O

Communication board YPK114

V9	(green)	=	Lit when YPK114 progra have made initiation.
V11	(yellow)	=	Lit when normal communication is workir
V15	(yellow)	=	Lit when terminal contac established to YPK114.
V16	(yellow)	=	Lit when broadcast communication is workir Other leds on YPK114 a not used in this applicati

Analog input YPG108

FAULT	(red)	=	Lit for hardware fault or jumpers on the board ha been incorrectly set.

Fault texts

Drive system

The faults in the tables are listed in alphabetical order.

Fault text	Signal name	Cause/corrective measure
AC BREAKER FAULT	ACBRFLT	Main breaker cooling fan inoperative.
AC EARTH FAULT	ETHFTAC	Tripped for earth fault on AC side. See **Main circuits** under **Earth faults.**
BEARING HIGH TEMPERATURE	MOBEARHT	Incorrect transducer signal. Parameters incorrectly set. Bearing lubrication failed. Contact person responsible for lubrication.
BEARING OVER TEMPERATURE	MOBEAROT	Incorrect transducer signal. Check for incorrectly set parameters. Bearing lubrication failed. Contact person responsible for lubrication.
CONV.CONTR NOT RUNNING	CPUSTLCS	Convertor control unit not working. See System hardware for further information.
CONVERTER A FAULT	DRIVEA	Fault in convertor A. See fault text on operator's panel.
CONVERTER B FAULT	DRIVEB	Fault in convertor B. See fault text on operator's panel.
COOLING AIR HIGH TEMP.	CAHT	Incorrect transducer signal. Check for incorrectly set parameters. Cooling air temperature is high.
COOLING AIR OVER TEMP.	CAOT	Incorrect transducer signal. Check for incorrectly set parameters. Cooling air temperature is high.
DC BREAKER EQUIPM.FAULT	DCBRFLT	DC breaker tripped. No acknowledgement signal.
DC BREAKER TRIPPED	DCBRTRP	DC breaker is tripped.
DC EARTH FAULT	ETHFLTDC	Tripped for earth fault on DC side. See **Main circuits** under **Earth faults.**
DRIVE STALLED	STALL	DC machine overloaded. Field current too low. No speed feedback signal. Incorrectly set parameters in the STALLM module.
EARTH FAULT	ETHFLT	Earth fault in one of the power or auxiliary supplies. Check whether the parameters in the ECURM module are set incorrectly .
FIELD EXCITER EARTH FAULT	FLDEFLT	Check for incorrectly set parameters. Check insulation resistance of field winding.
EXCITER A FAULT	EXCITA	Fault in field exciter A. See the fault text on the field exciter operator's panel.
EXCITER B FAULT	EXCITB	Fault in field exciter B. See the fault text on the field exciter operator's panel.
EXTERNAL FAULT A1	EXFLTA1F	External arithmetic signal has exceeded the set tripping level.
EXTERNAL FAULT D(1,2)	EXFLTD(1,2)F	External logic signal has indicated a fault state.
EXTERNAL FAULT WARNING	EXFLTW	External signal indicated warning.
FAULT DC BREAKER	DCBRF	DC circuit-breaker faulty. No acknowledgement. Possible open circuit in a wire. Check sensing voltage.
FAULT MAIN CONTACTOR	MCONTF	Main contactor/circuit-breaker faulty. No acknowledgement, wire open-circuit. I/O unit YPQ 202 faulty. Supply voltage M1L absent.
FIELD EXC. CONT. NO RUN	CPUSTLFE	Field exciter control unit not working. See System hardware for further information.
LOW FIELD CURRENT	FLDLC	Check whether the field exciter has tripped. Check for blown fuses. Check for open field circuit. Check whether contactor is faulty. The level of the field current is lower than the level for high field current. See **Field exciter.**

MECH. BRAKE FAULT	BRAKEFLT	Brake fault. Check for open circuits in wiring or poor contact. Check for incorrectly set parameters in the BRMEC module.
MOTOR OVERLOAD	MOTOL	The signal is an external monitoring of the motor for overloading. Check the setting of protections.
MOTOR COOLING FAULT (1-5)	COOLFLT(1-5)	Motor cooling faulty. Check setting of protection.
MOTOR FAN OVERLOAD	FANOL	Fan motor thermal protection has tripped. Check setting of protection. Measure motor current.
MOTOR GENERAL FAULT	MOGENFLT	General motor fault.
MOTOR LUB.FAULT	MOLUBFLT	Motor bearing lubrication inoperative.
MOTOR OVER SPEED	MOTOSP	Speed control not properly adjusted. Check whether the MOTOSPL parameter is incorrectly set.
MOTOR OVERVOLTAGE	MOTOV	Extern indication of over voltage. Acceleration too great at speeds above base speed. Maximum e.m.f. is too high. Field weakening not working. Check for any incorrectly set parameters in the EMFMON module. Check for any incorrectly set parameters in the EMFRG1 or ECTRL1 modules in the field exciter system..
NO ACK. DC BREAKER	DCBRNA	No acknowledgement signal. DC circuit-breaker faulty.
NO ACK. MAINCONTACTOR	MCONTNA	Contactor/main circuit-breaker faulty. I/O unit YPQ 202 faulty. Supply voltage M1L absent.
NO ACKN. MOTOR FAN	FANNA	No acknowledgement signal. Thermal protection of fan motor has tripped.
NO ACK. FIELD CURRENT (A,B)	FLD(A,B)NA	Field exciter does not start. Check for blown fuses. Check for open field circuit. Check whether contactor is faulty. The level of the field current is lower than the level for min. field current. See **Field exciter.**
NO CONVERTOR SELECTED	NCONVSEL	Parameters incorrectly set.
NO DATA FR. OP PANEL	LNK35	Communication with the operator's panel has stopped. Press any button on the operator's panel. Check sending and receiving on the SOUT and SIN LED's on YPQ201. Change YPP109 (YPN107) first, and secondly YPQ201.
NO DATA FR.CONVERTOR	LNK32F	Master/follower communication interrupted (time-out). Check LED's on YPK107 and YPC104 as described under LED indications on boards, in all convertors that communicate via the master/follower connection. The level of interference on the master/follower communication line is too high. Check earth connections of YPK107 and YPC104. Check routing and connection of coaxial cable.
NO EMF-FEEDBACK	ARMNEMF	Open circuit or poor contact in the measuring circuit. See the section **Measuring circuits DC-voltage measurement.**
NO SPEED FEEDBACK	NSPFBACK	For information see Measuring circuits.
OIL PUMP NOT ACK	OPUMPNA	No acknowledgement signal.
OIL PUMP OVERLOAD	OPUMPOL	Thermal protection of oil pump motor has tripped.
OVERCURRENT FIELD	FLDOC	Check the external field exciter.
OVERLOAD ARMATURE	ARMOL	Excessive load on DC machine. Check for any incorrectly set parameters in the MOTOL1 module.
PRESSURE FAULT THY AIR	APREFLT	Motor cooling air pressure low. Check air filter.
SERIAL COM BOARD FAULT	HWFDSC	**HWFDSC** set when YPK114 fails to change a toggle bit in the dual port memory, indicating that YPK114 has stalled or stop functioning.
SUP CONTR NOT RUN	CSTALLMP	Check for incorrectly set parameters. Check whether communication between MP and convertors is faulty. See Control system hardware.

TESTREF TOO HIGH	TESTRFTH	Reduce the value of the reference.
TORQUE FAULT	TQFLT1	Excessive load on DC machine. Motor stalled. No speed feedback signal. Check for faults in the external monotoring.
TRANSM FAULT SERIAL BUS	DSCLNK	DSCLNK is the overall fault signal for serial bus communication in the Drive system. Receive: converter/field exciter A-C not responding or semaphore time out in the dual port memory of YPK114 have occurred. Transmit: broadcast or normal communication stops transmitting or semaphore time out in the dual port memory of YPK114.
TRANSM. FAULT CONVERTOR	LNK37F	Leader/follower communication suffering interference. Check earthing of YPK107 and YPC104. Check routing and connection of coaxial cable. Parameter LNK37D is set with too little margin.
TRANSM. FAULT OP PANEL	LNK40F	Communication with operator's panel suffering interference. Check earthing of YPP109 (YPP106) and YPQ201 and the ribbon cable between them.
TRIP FROM OVERRIDING	TRIPMP	Tripping ordered from superior control system (MasterPiece)
TRIP WARNING	TRIPWT	Warning of tripping
TRIP WARNING TIME OUT	TRIPWTO	Delayed tripping.
TRIP1 EXTERNAL FAULT	TRIP1EX	External tripping signal category 1.
TRIP2 EXTERNAL FAULT	TRIP2EX	External tripping signal category 2.
TRIP3 EXTERNAL FAULT	TRIP3EX	External tripping signal category 3.
UNDERVOLTAGE AUX.SUPPLY	ASUV	Voltage Q1 or Q2 missing (+24 V DC). Check for open circuits in wires or faulty connectors. Check for blown fuses. Check whether there is a transformer fault.
WINDING HIGH TEMPERATURE	MOWINHT	Warning. The air filters may be clogged. Transducer signal may be incorrect. Parameters incorrectly set. Extreme motor load? Consult the person in charge of production.
WINDING OVER TEMPERATURE	MOWINOT	Check whether the air filters are clogged. Check whether the transducer signal is faulty. Check whether any parameters are incorrectly set. Check whether the motor load is excessive. Consult the person in charge of production.

Convertor

The faults in the table are listed in alphabetical order.

Fault text	Signal name	Cause/corrective measure
AC BREAKER IS TRIPPED	MSEF	External fault indication for main supply.
ARMATURE OVERVOLTAGE	ARMOV	Acceleration too great at speeds above base speed. Maximum e.m.f. is too high. Field weakening not working. Check for any incorrectly set parameters in the IUMON module. Check for any incorrectly set parameters for e.m.f. control. See **Commissioning instructions**, the section headed **EMF control.**
CONVETOR DIFF. CURRENT	DIFCUR	Differential current is in convertor bridge. Check the current measuring circuit. Check for short circuit in the cabling or thyristor bridge.
CURRENT ASYMMETRY	CURRASYM	Poor current sharing between valve units connected in parallel. Check the fuses. Check whether any trigger pulses are missing. Check for loose connections.
DRIVE CONTROL IS STOPPED	CPUSTLDS	The control unit of the drive system is not working. See **Control system hardware** for further information.
EARTH FAULT AC VOLTAGE	ETHFLTAC	Tripped for earth fault on AC side. See **Main circuits** under **Earth faults.**
EARTH FAULT DC VOLTAGE	ETHFLTDC	Tripped for earth fault on DC side. See **Main circuits** under **Earth faults.**
ERROR IN PHASE SEQUENCE	PHSEQFLT	Main supply connected with wrong phase sequence. Reconnect the phases correctly.
FAULT IN AI UNIT POS 33	HWF10.33	Board YPG108 is faulty. Change the board. Check that any jumpers on the new board are correctly set.
FAULT IN MAIN SUPPLY	MSFLT	Group indication for main supply fault.
FAULT IN UNIT YPQ203	HWF_203	Board YPQ203 is faulty. Replace the board. Check that jumpers on the new board are correctly set.
FREQ MEASURE NOT STABLE	FREQUSTA	Parameters for frequency filters incorrectly set. Contact ABB Industrial Systems if a fault is indicated.
FREQUENCY FAULT MAINS	FREQFLT	High-voltage circuit-breaker tripped; AC machines that are running maintain the voltage level for a time, but at low frequency. The supply frequency is not stable. Incorrectly set parameters, FREQNOM and FREQDEV.
HIGH ARMATURE CURR RIPPL	ARMRPL	Oscillations are occurring in the load. The current controller is not properly adjusted. The speed controller is not properly adjusted. Ripple protection incorrectly set.
HIGH TEMP THYRISTOR FWD	THYHTF	Warning. High temperature in thyristor bridge, forward direction.
HIGH TEMP THYRISTOR REV	THYHTR	Warning. High temperature in thyristor bridge, reverse direction.
INCORRECT THERMAL DATA	SELNOTOK	Not permitted combination, thyristors and heat-sink. Please check the parameters set in function module TYTEMP.

LOW VOLTAGE MAINS SUPPLY	LOWMAIN	Low main supply voltage. Check whether the parameters LOWMAINL and MDROPCOM are incorrectly set. See **Commissioning instructions**. Check whether the fault is in the measuring circuit. See **Fault tracing instructions**, the section headed **Measuring circuits**.
MAIN SUPPLY OVER VOLTAGE	MSOV	Main power too high, check tramformer output
MAIN SUPPLY HIGH VOLTAGE	MSHV	Check the output voltage of transformer.
NO ACKN. THY FAN (1-2)A	CFAN(1-2)ANA	Fan contactor for fan convertor 1 or 2 is faulty. Open circuit in wires or poor contact at connectors. Supply voltage M1L missing. Thermal overload protection has tripped (fuse blown).
NO ACKN. THY FAN (1-2)B	CFAN(1-2)BNA	Fan contactor for fan convertor 1 or 2 is faulty. Open circuit in wires or poor contact at connectors. Supply voltage M1L missing. Thermal overload protection has tripped (fuse blown).
NO ARMATURE CURR FEEDB	ARMNC	See **Fault tracing instructions**, the section headed **Trigger pulses**, for further information. Check that the protection is correctly set. Check the setting of the ARMNCL parameter.
NO EMF FEEDBACK	ARMNEMF	Interruption or poor contact in the measurement circuit.
OPERATOR'S PANEL NO DATA	LNK35	Communication with the operator's panel has stopped. Press any button on the operator's panel. Check sending and receiving on the SOUT and SIN LED's on YPQ201. Replace YPP109 (YPN107) first, and secondly YPQ201.
OVERCURR ARMATURE EXTERN	ARMOCE1	External fault indication for over current in armature circuit. For action, see causes of fault, in list below.
OVERCURR ARMATURE FWD	ARMOCF	Using the signal ARMOCNBR, check in which thyristor branch the fault occurs before pressing the Reset button. Armature current control may be incorrectly set. Check for short circuits in the cabling or armature winding. Check for commutator flashover. Check for possible thyristor faults or trigger pulse faults. Loss of power supply in inverted mode. Check whether over current protection is incorrectly set.
OVERCURR ARMATURE REV	ARMOCR	Using the signal ARMOCNBR, check in which thyristor branch the fault occurs before pressing the Reset button. Armature current control may be incorrectly set. Check for short circuits in the cabling or armature winding. Check for commutator flashover. Check for possible thyristor faults or trigger pulse faults. Loss of power supply in inverted mode. Check whether over current protection is incorrectly set.
OVERLOAD THY FAN (1-2)A	CFAN(1-2)AOL	Thermal overload protection tripped for fan convertor 1 or 2. Check for blown power supply fuse. Fan convertor 1 or faulty. Check for open circuit in wires or poor contact. Check whether connection unit YPQ202 is faulty. Supply voltage M1L missing.

OVERLOAD THY. FAN (1-2)B	CFAN(1-2)BOL	Thermal overload protection tripped for fan convertor 1 or 2. Check for blown power supply fuse. Fan convertor 1 or faulty. Check for open circuit in wires or poor contact. Supply voltage M1L missing.
OVERTEMP THYRISTOR FWD	THYOTF	Excessive load on thyristor bridge, forward direction. Cooling air flow non-existent or insufficient. Check that air filter is not clogged. Check whether Pt100 sensor is faulty. Check for incorrectly set parameters in the TYTEMP module.
OVERTEMP THYRISTOR REV	THYOTR	Excessive load on thyristor bridge, reverse direction. Cooling air flow non-existent or insufficient. Check that air filter is not clogged. Check whether Pt100 sensor is faulty. Check for incorrectly set parameters in the TYTEMP module.
PRESSURE FAULT (1-2) THY AIR	APREFLT(1-2)	Low pressure in the cooling air flow of the thyristor cubicle. Check air filter. Pressure transducers may be faulty.
REDUNDANT FAN STARTED	RDFANONF	Redundant fan has started.
REDUNDANT FAN TRIPPED	RDFANTRP	Redundant fan has tripped.
SERIAL COM BOARD FAULT	HWFCSC	**HWFCSC** set when YPK114 fails to change a toggle bit in the dual port memory, indicating that YPK114 has stalled or stop functioning.
TRANSM FAULT SERIAL BUS	CSCLNK	**CSCLNK** is the overall fault signal for serial bus communication in the converter. Poll from drive system, both in broadcast and normal communication mode, is not coming during time out time or semaphore time out have occurred in the dual port memory of YPK114.
TRIGGER PULSE FAULT	TRIPUFLT	There are no control pulses to the thyristors of the convertor .
UNDERVOLT TRIG PULSE AMP	TAMPUV	Power supply to trigger pulse amplifier missing. Miniature circuit-breaker tripped. See circuit diagram.
UNDERVOLTAGE AUX SUPPLY	EXASUV1	External indication of under voltage auxiliary supply.
UNDERVOLTAGE COMPUTER	ASUV	Voltage Q1 or Q2 missing (+24 V DC).Check whether there is an open circuit in a wire or connector. Check for blown fuses. Check for transformer faults.
UNDERVOLTAGE MAIN SUPPL	MSUV	Low supply voltage. Check for blown fuses. Check whether there is an open circuit in a wire or connector. Check whether the MINVOLT parameter is incorrectly set. Check for transformer faults.

Field exciter

The faults in the table are listed in alphabetical order.

Fault text	Signal name	Cause/corrective measure
DRIVE CONTROL NOT RUN	CPUSTLDS	The control unit of the drive system is not working. See **Control system hardware** for further information.
EARTH FAULT	EARTHFLT	Earth fault in one of the power or auxiliary supplies. Check whether the parameters in the ETHMFE module are incorrectly set.
ERROR IN PHASE SEQUENCE	PHSEQFLT	Main supply connected with wrong phase sequence. If possible, Reconnect the phases correctly.for positive phase sequence.
FAULT IN AI UNIT POS33	HWF10.33	Board YPG108 is faulty. Replace the board. Check that jumpers on the new board are correctly set.
FAULT MAIN CONTACTOR	MCONTF	Main contactor faulty. Acknowledgement may have been lost in service. Check whether connection unit YPQ202 is faulty.
FIELD OVERCURRENT	FLDOC	Check whether the field current regulation is incorrectly set. Check whether there is a short circuit in the cabling or the field winding. Check whether the over current protection is incorrectly set. Check whether there is a fault in the current measurement system.
FIELD OVERVOLTAGE	FLDOV	Field discharge circuit indicates high voltage. There may be a fault in the field exciter control system. Check whether the fault is a secondary fault due to high transient current in the armature circuit.
FREQ MEAS NOT STABLE	FREQUSTA	Check whether parameters for frequency filters are incorrectly set. Contact ABB Industrial Systems if a fault is indicated.
MAIN SUPPL.UNDERVOLTAGE	MSUV	Low supply voltage may be the cause. Check for blown fuses. Check whether there is an open circuit in a wire or connector. Check whether the UVLEVEL parameter is incorrectly set. Check for transformer faults.
MAINS FREQUENCY FAULT	FREQFLT	High-voltage circuit-breaker tripped; AC machines that are running maintain the voltage level for a time, but at low frequency. The supply frequency is not stable. Incorrectly set parameters, FREQNOM and FREQDEV.
NO ACK FIELD EXCITER FAN	CFANNA	Fan contactor is faulty. Check for open circuit in wires or poor contact at connectors. Check whether connection unit YPQ202 is faulty. Supply voltage M1L missing. Thermal overload protection may have tripped (fuse blown).
NO ACK MAIN CONTACTOR	MCONTNA	Contactor faulty. There is no acknowledgement, possibly because of an open circuit in a wire or poor contact. Check whether connection unit YPQ202 is faulty.
OVERLOAD EXCITER MACHINE	FLDOL	The signal is an external monitoring of the field exciter machine motor for overloading. Check the setting of protections.

OVERLOAD FAN	CFANOL	Thermal overload protection may have tripped. Check for blown power supply fuse. Check whether the fan motor is faulty. Check for open circuit in wires or connectors. Connection unit YPQ202 may be faulty. Supply voltage M1L missing.
OVERTEMP+THYRISTOR	THYOT	Excessive load on thyristor bridge. Cooling air flow non-existent or insufficient. Check that air filter is not clogged. Check for incorrectly set parameters in the THYTEMXX module.
POWER LOW COMPUTER	ASUV	Voltage Q1 or Q2 missing (+24 V DC).Check for open circuits in wires or faulty connectors. Check for blown fuses. Check whether there is a transformer fault.
SERIAL COM BOARD FAULT	HWFFSC	**HWFFSC** set when YPK114 fails to change a toggle bit in the dual port memory, indicating that YPK114 has stalled or stop functioning.
TRANSM FAULT SERIAL BUS	FSCLNK	**FSCLNK** is the overall fault signal for serial bus communication in the field exciter. Poll from drive system, both in broadcast and normal communication mode, is not coming during time out time or semaphore time out have occurred in the dual port memory of YPK114.

Operator's panel management

Contents

Operator's panel management

Introduction

There is a continuous demand for improved communication between man and machines. ABB has developed an operator's panel to satisfy this requirement with respect to motor drive systems.

The operator's panel permits simple and accurate measurement of variable signals, setting of parameters, the performance of step tests in drive systems etc.

The different displays which can be presented on the operator's panel have been designed to enable the operator to learn quickly the functions used most frequently. To obtain basic knowledge it is sufficient to read Section **"General characteristics of the operator's panel"**. The next step is to continue with practical training with the equipment.

This document can then be used as a reference to provide more detailed information when required.

General characteristics of the operator's panel

Display design

The total display is divided into four fields.
The format of Field 1 remains constant. The three display designations at the top of Field 1 can be varied as described below.

The contents of fields 2 - 4 vary and depend upon which display designation is in the middle position of the three currently presented in Field 1.

To change the display , the display designations are moved upwards or downwards as described under "Display Exchange" below.

Cursor movement

The operator's panel can be used to change the value of a system parameter, command a printout, change a scale value etc. The factor common to these operations is that a cursor is moved to specific positions on the display. The positions to which the cursor can be moved are marked with squares. For examples, see fig. 2.

The buttons ↘ or ↖ are pressed to move the cursor to the position required.

Figs 3 and 4 show examples of the path of the cursor when ↘ or ↖ are pressed under different conditions.

When the ↘ or ↖ button is depressed continuously, the cursor moves automatically between the different cursor positions.

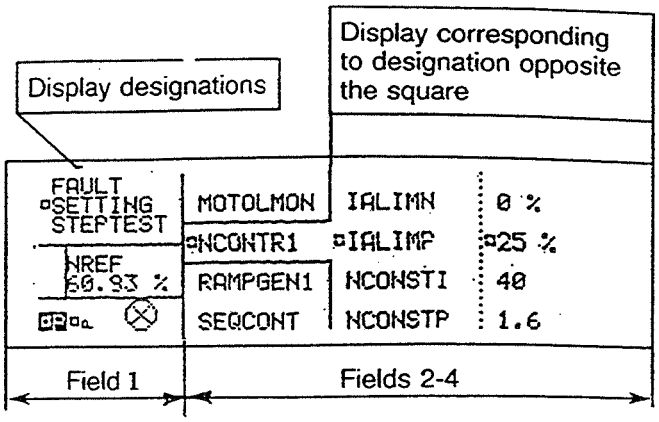


Figure 1. Arrangement of operator's panel display.

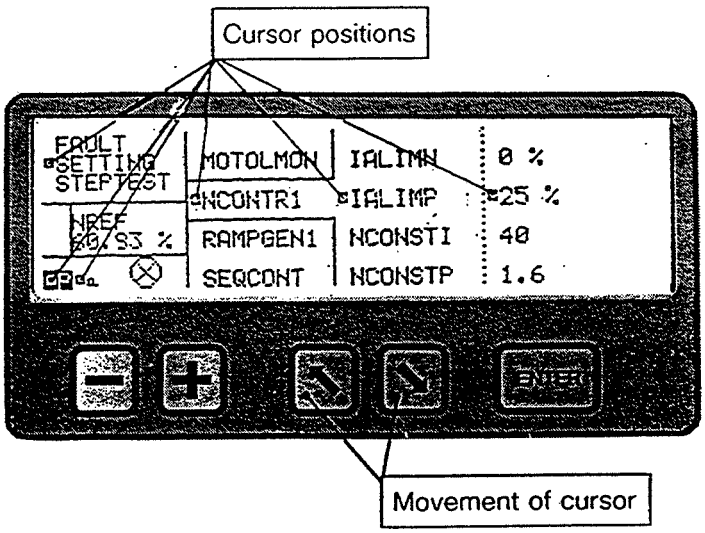


Figure 2.

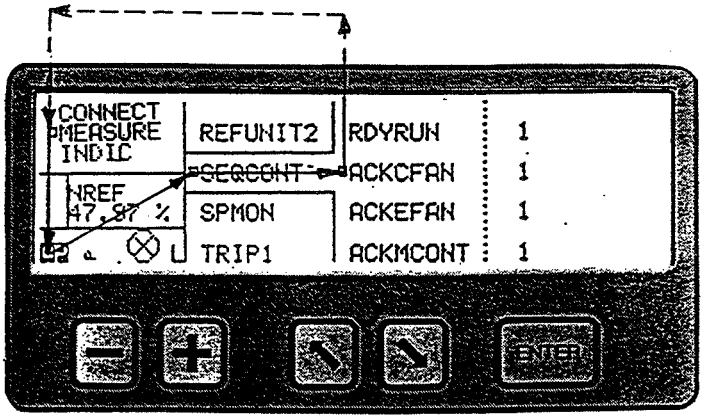


Figure 3. Display MEASURE.
Example of cursor movement on pressing ↘ . The cursor moves in the opposite direction when ↖ is pressed.

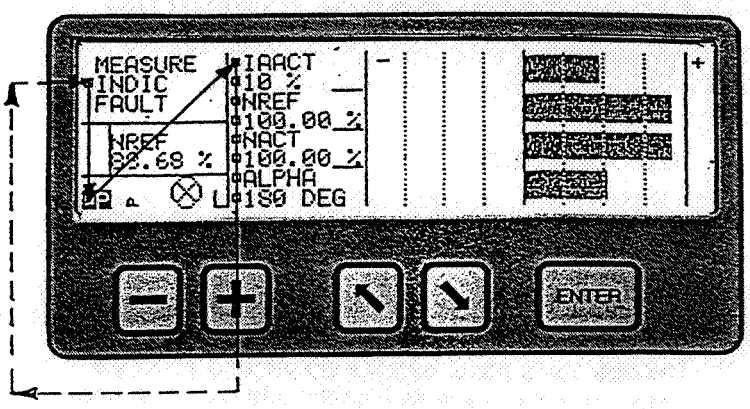


Figure 4. Display INDIC (ATION). Example of cursor movement on pressing ↘ . When ↖ is pressed, the cursor moves in the opposite direction.

Display exchange

Different displays can be obtained on the operator's panel by placing the cursor as shown in fig. 5 and then pressing + or – .

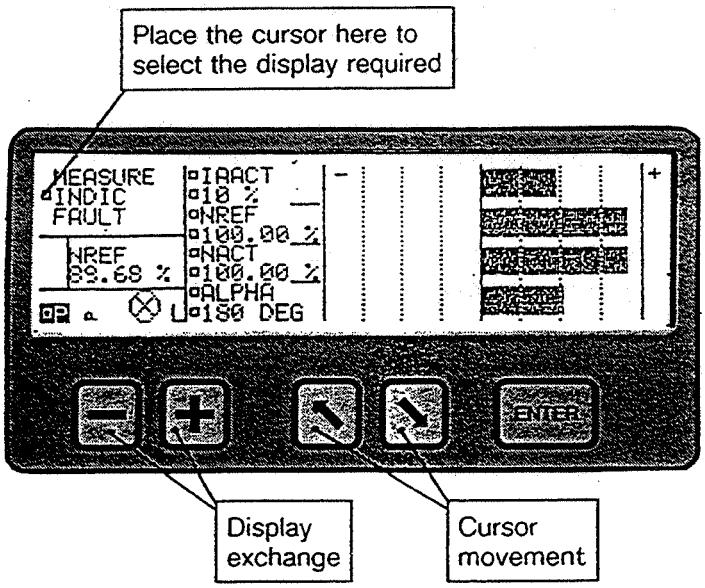
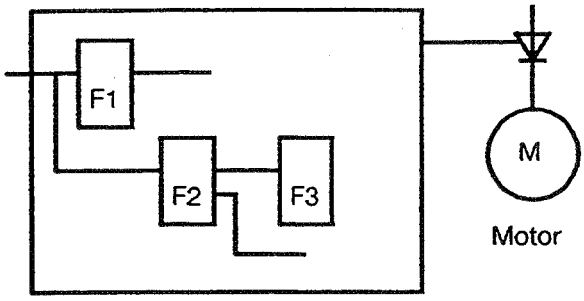


Figure 5. Display selection.

Functions, signals and parameters

The control and regulation system of a motor drive system is an assembly of a large number of function modules. See fig. 6.

These function modules contain parameters and signals and a typical function module is illustrated in fig. 7. The signals and parameters with identities given on the circuit diagram can be measured and set respectively via the operator's panel.



F1 - F3: Function modules.

Figure 6. Control and regulation system for motor drives.

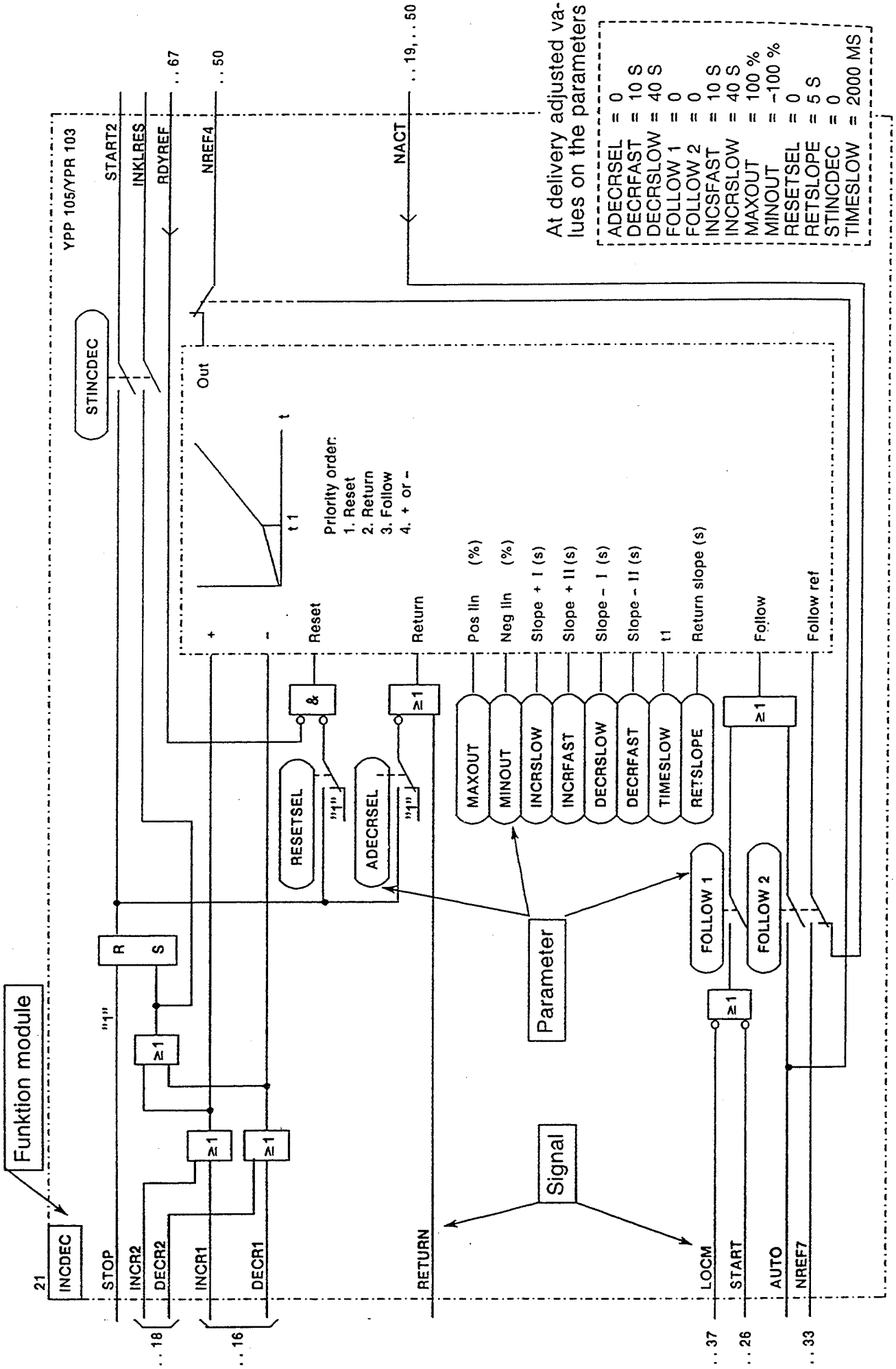


Figure 7. Example of a function module.

The figures 8 and 9 show the displays for measurement (MEASURE) and parameter setting (SETTING) respectively.

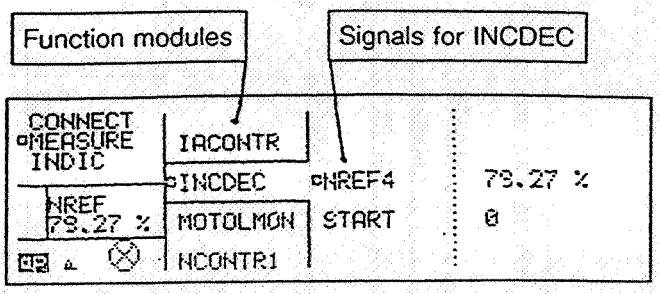


Figure 8. Measurement.

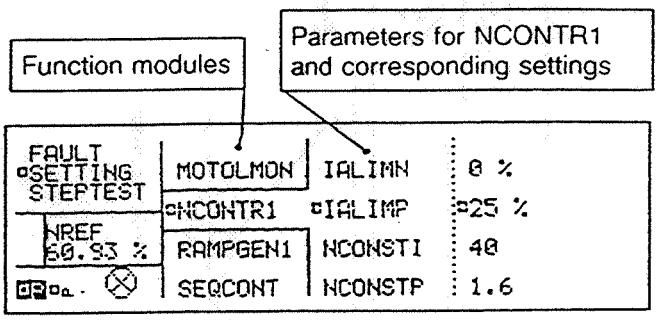


Figure 9. Parameter setting.

Table arrangement

The + or – buttons are pressed to change between different displays on the operator's panel or to switch between function modules during parameter setting for example. See **"Display exchange"** above. The texts can be considered to be on a rotating drum which rotates forwards one step when + is pressed and backwards one step when – is pressed. See fig. 10. This model applies for all of the displays available.

The tables for function modules, signals and parameters are arranged in alphabetical order.

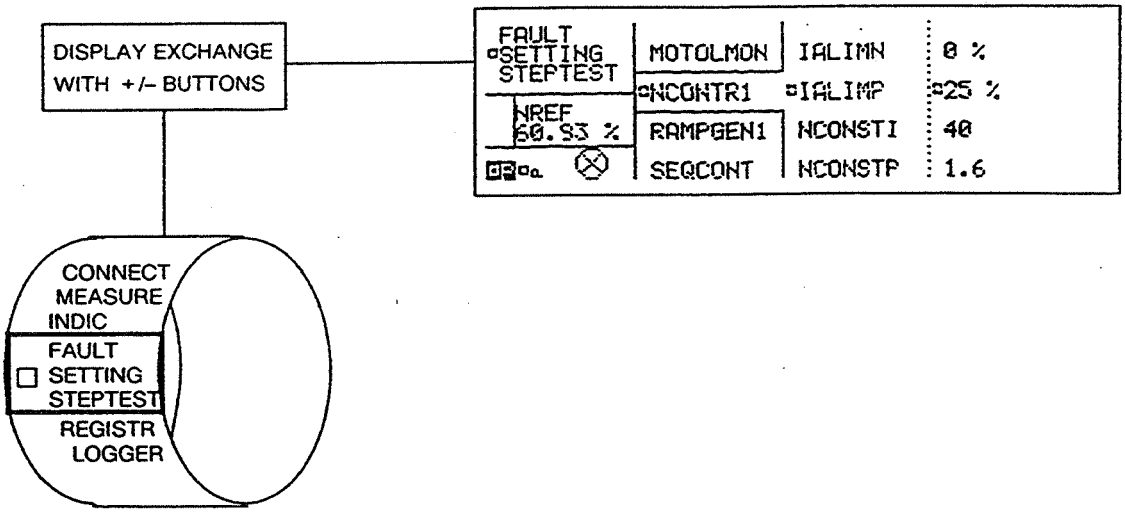


Figure 10. Model to illustrate text presentation (in this case, display designations at top of Field 1).

Printout

Printouts of the operator's panel display are available in three different sizes with different degrees of resolution. When a printout is required, place the cursor in the position shown in fig. 11. Then press **ENTER**, + or – . The printout size is dependent on whether + or – is pressed, as shown in figs 12 - 14. The printer is connected at contact X31 on the operator panel circuit board on the inside of the door.

The printer can be connected or disconnected during operations.

It is not possible to print the GENERAL screen.

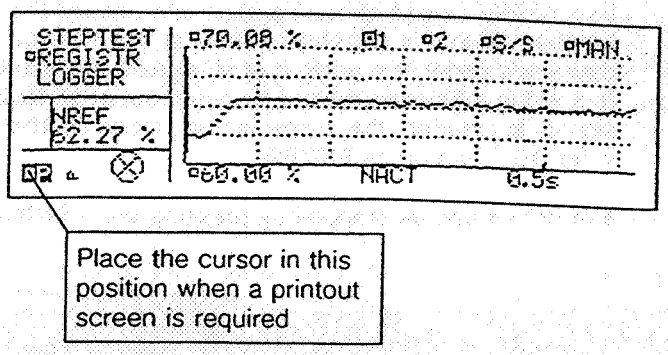


Figure 11. Printout.

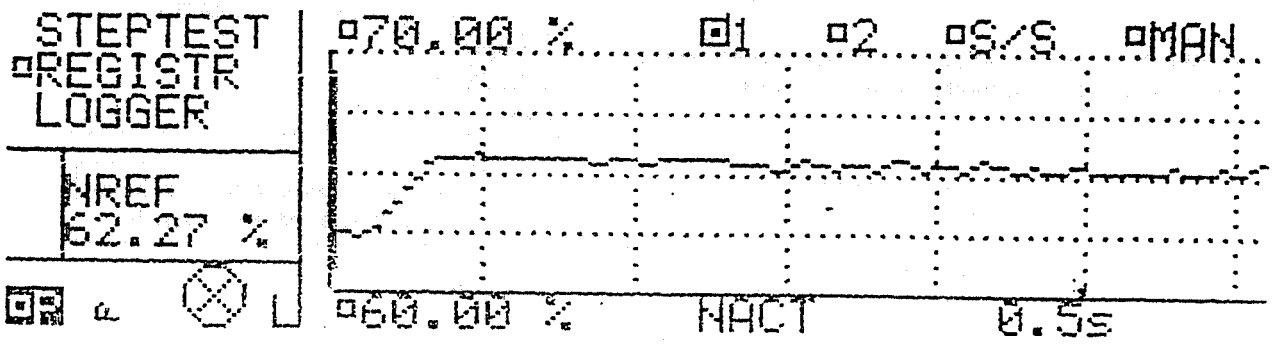


*Figure 12. Appearance of printout when **ENTER** is pressed.*

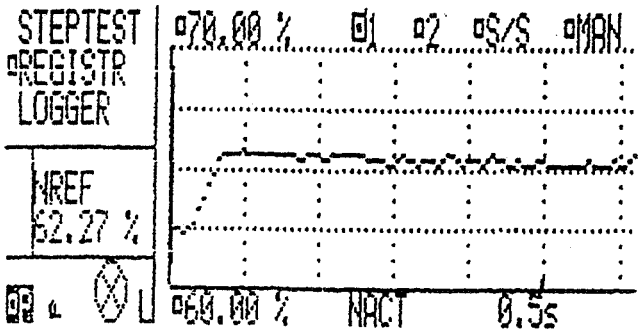


Figure 13. Appearance of printout when + is pressed.

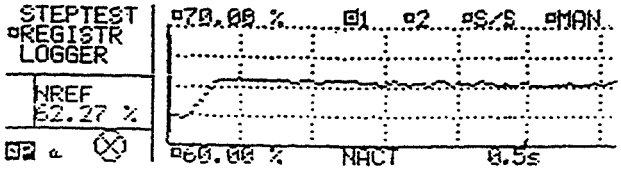


Figure 14. Appearance of printout when – is pressed.

The number of signals and parameters within a function module as well as fault signals can exceed the number which it is possible to show at one time on the operator's panel. If a printout of all signals or parameters within a function module or a printout of all fault signals is required, the cursor is first placed as shown in fig. 15. Then press **ENTER**.

The printer can be stopped by pressing the **–** **button**.

```
NCONTR1
=======
IADERMAX = 100
IALIMN   = 0 %
IALIMP   = 25 %
NCONSTI  = 40
NCONSTP  = 1.6
NDERCONS = 6.9
NFILTTC  = 121 MS
```

If instead **+** is pressed in the SETTING screen all parameters in all function modules will be printed.

```
FAULTS   TYRAK
===============

OVERLOAD ARMATURE
GROUP : 03    TIME : 00

HIGH ARMATURE CURR DIFF
GROUP : 02    TIME : 00

OVERCURR ARMATURE
GROUP : 02    TIME : 00

UNDERVOLTAGE MAINS SUPPL
GROUP : 01    TIME : 00

NO EARLIER FAULTS STORED
```

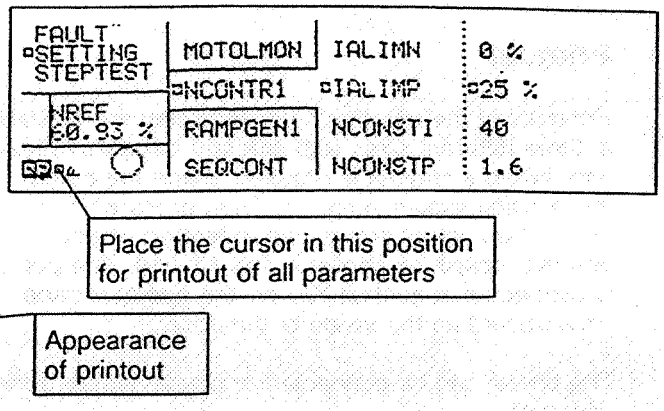


Figure 15. Printout of all parameters within a function module.

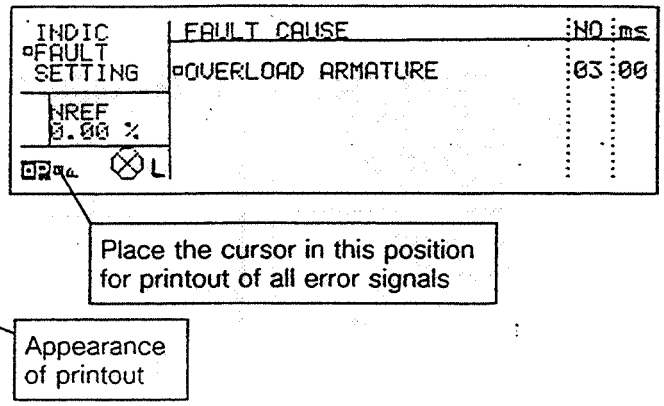


Figure 16. Printout of all error signals within a function module.

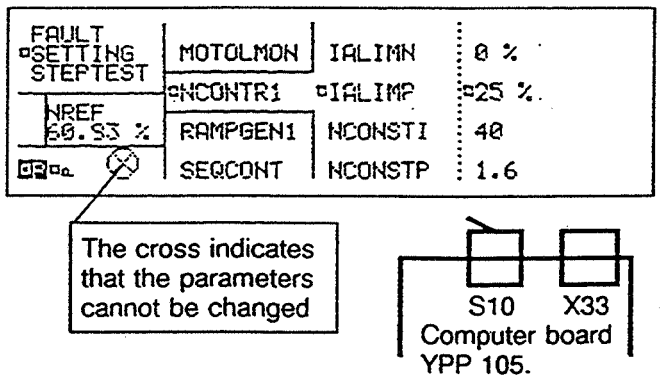


Figure 17. Latch function active. Parameters cannot be changed.

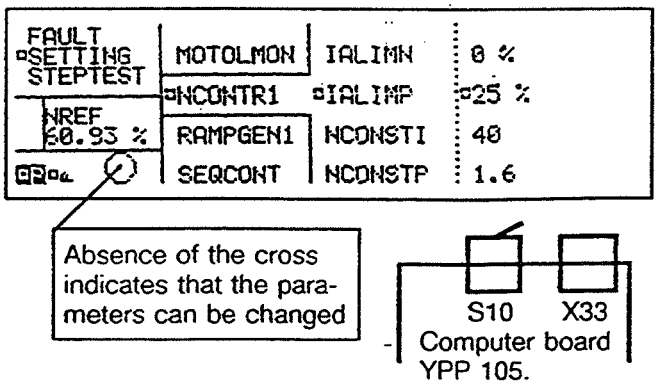


Figure 18. Latch function inactive. Parameters can be changed.

Latch function

A latch function has been introduced to prevent unintentional change of parameters. If the parameters are blocked, a cross appears in the ring as shown in fig. 17. This cross disappears when parameter values can be changed. See fig. 18. The latch is located on the computer board YPP 105 and its status, active or inactive, can be changed by operating switch S10 at the top of the computer board.

Pushbuttons for convertor operation.

To activate the convertor press button **I**. To deactivate the convertor, press button **O**. When the convertor is active, a green field illuminates. This extinguishes when the convertor is deactivated. See Fig. 19.

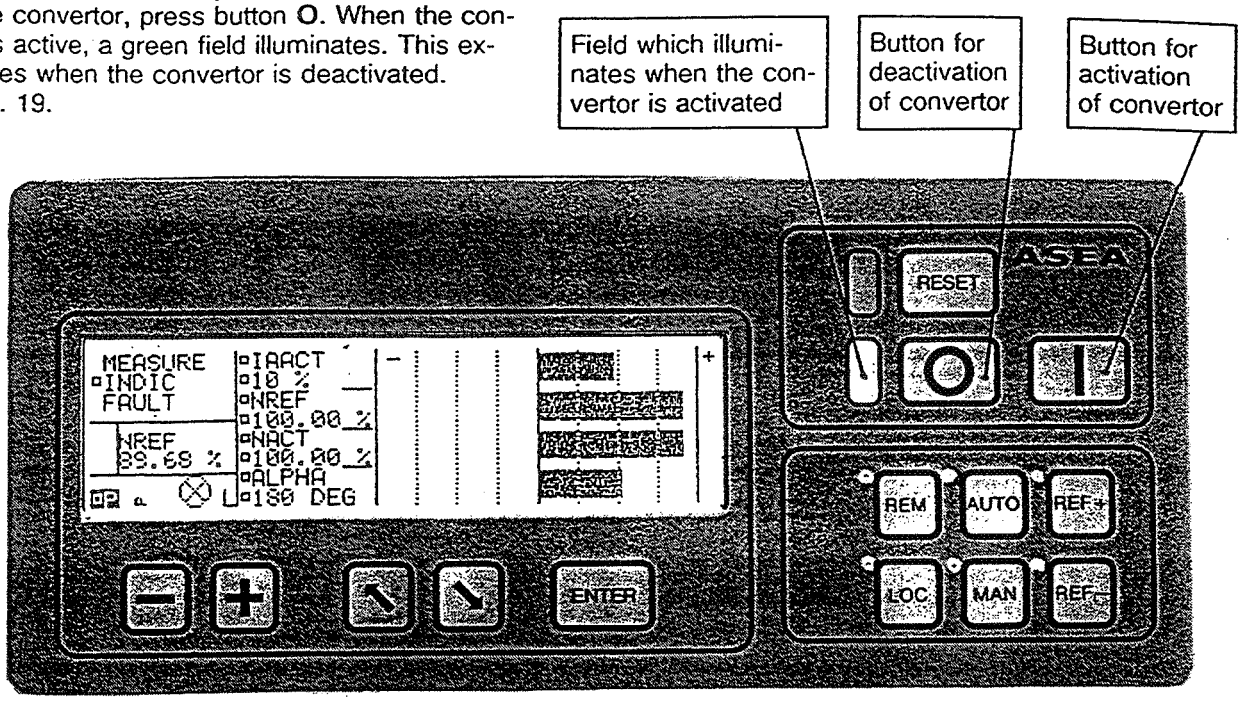


Figure 19. Activation and deactivation of convertor.

If a protection trips because of some malfunction, a red field illuminates and the drive system is deactivated. The malfunction must be corrected and the **RESET** button pressed, extinguishing the red field, before the system can be restarted. See Fig. 20.

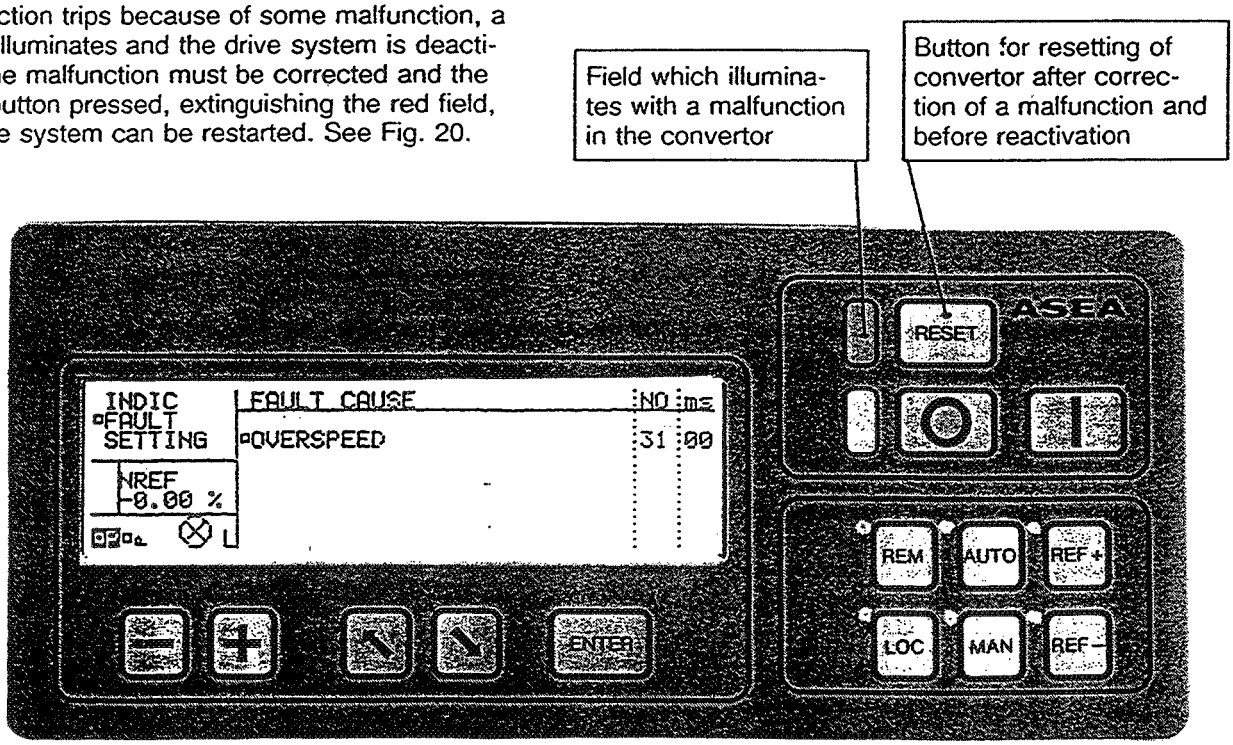
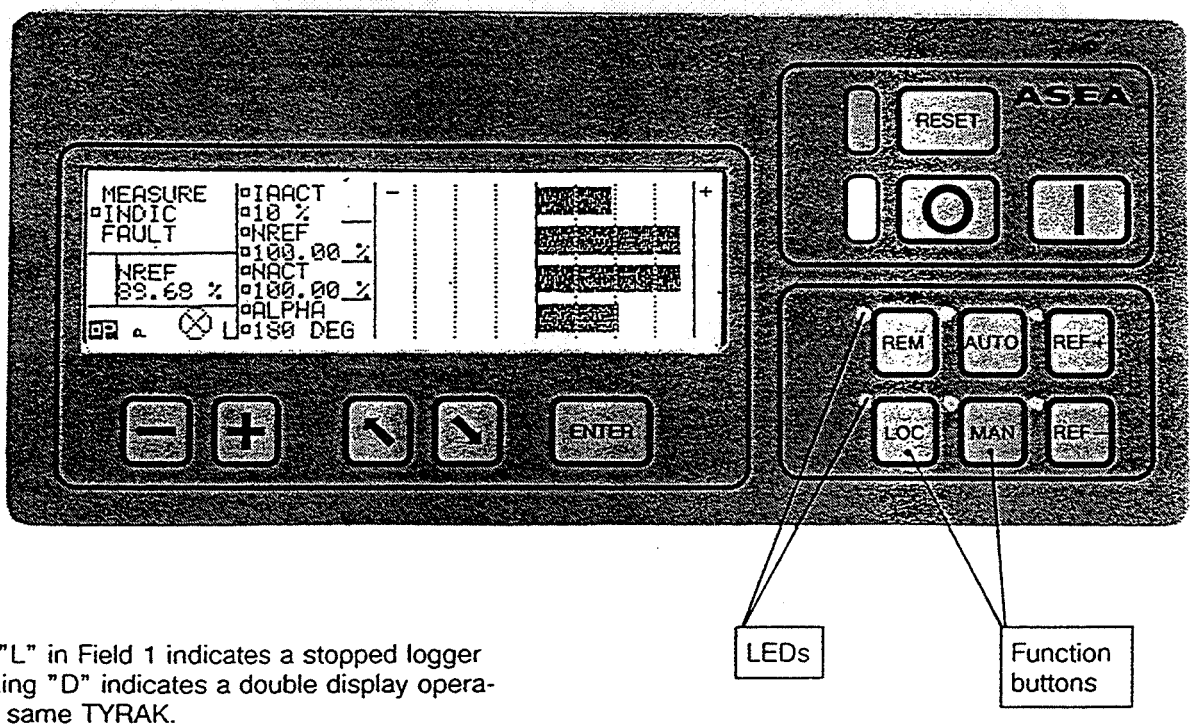


Figure 20. Resetting of convertor before reactivation .

Six buttons for commanding functions are located at the lower right hand corner of the panel. See Fig. 21. The function of each push button is inscribed on each button. The functions of the buttons can vary in different installations and the text can be changed accordingly. Each button contains a light emitting diode which may be used as a feedback from the application process.



A flashing "L" in Field 1 indicates a stopped logger and a flashing "D" indicates a double display operation on the same TYRAK.

Figure 21. Function buttons.

General display, designation GENERAL

The operator's panel text is available in 4 different languages, Swedish, English, German and French. To change the language, the cursor is placed as shown in fig. 22 and the + button is pressed until the required language is opposite the cursor. If **ENTER** is pressed also all fault texts will be changed into the selected language.

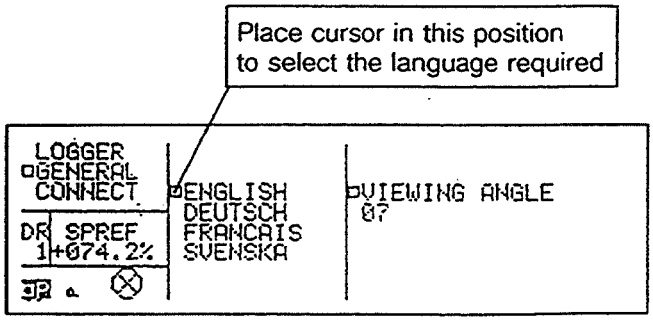


Figure 22. Display General. Selection of language.

Function module names, parameter names and signal names do not change when the panel language is changed.
See figs. 23 and 24.

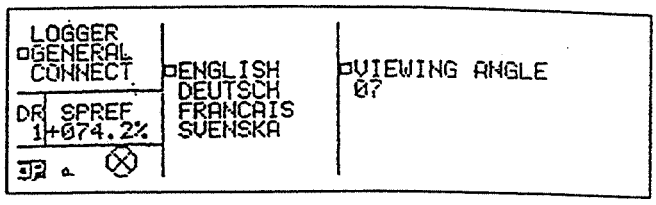


Figure 23. General.

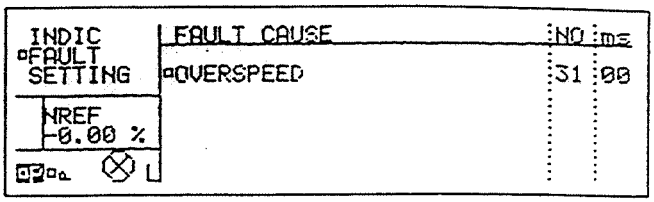


Figure 24. Fault Indication.

The operator's panel was only clearly legible when viewed from within a limited angle. This angle is adjustable to permit the best viewing conditions for both tall and short operators. To adjust the viewing angle, the cursor is first placed as shown in fig. 25 and then the + or – button is pressed. The angle can be varied through a scale range 0 - 15. Press **ENTER** for permanent storage of the viewing angle selected.

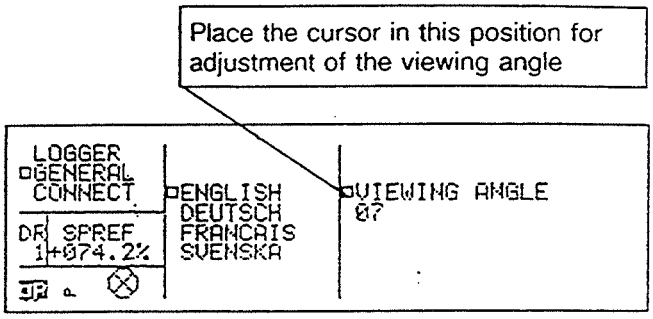


Figure 25. General.
Adjustment of viewing angle.

Indication display, designation INDIC

Four **arithmetical** signals can be measured and presented simultaneously when the INDIC display is selected. The magnitudes of the signal values are indicated by horizontal staples.

If a signal is to be exchanged, the cursor is to be placed before the signal to be replaced. Press + or – until the required signal is presented and then press **ENTER**. The result of pressing + or – is explained above under **"Table arrangement"**.

When setting a scale factor, place the cursor in front of the number which is to be changed. Then press + or – to increase or decrease the scale factor.
See fig. 27.

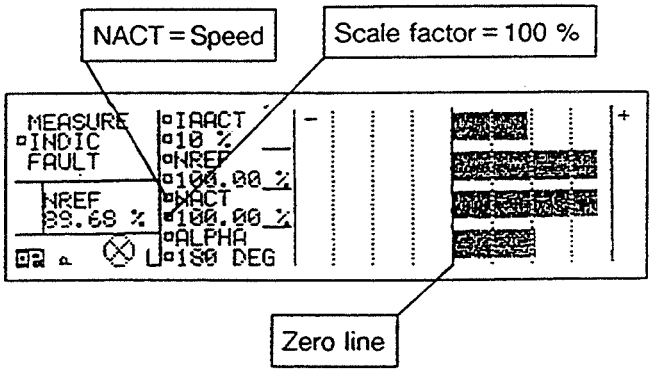


Figure 26. Appearance of Indication display.

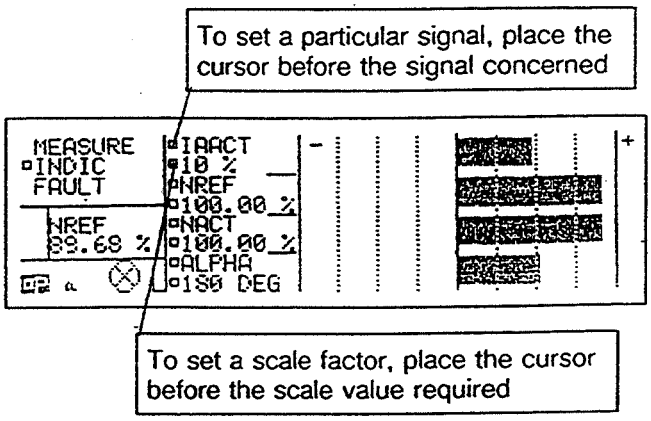


Figure 27. Display INDIC.
Setting of signal and scale factors.

Fault indication display, designation FAULT

The Fault Indication display is of great assistance when tracing faults. The display FAULT is shown automatically when a fault is detected and if a series of faults occurs, these are presented in order of occurrence. The first fault is given the time 0 and the subsequent faults are time tagged in relation to this. See fig. 28. Only the faults in the sequence which occur within 255 ms are indicated. Each fault is given a number. Only the first fault within a group get the group number. The rest just gets " + ".

After the fault has been corrected, the faulty status is concluded by the operator processing the **RESET** button.

To obtain a survey of all of the faults which have occurred after the commissioning of the convertor, the cursor is placed as shown in fig. 29 and the + or – button is pressed. Fault texts are not normally displayed until a fault is detected. This means that the latest error message is "above" the uppermost line on the operator's panel. The most recent fault can then be presented by pressing the – button.

The fault memory accommodates 200 faults. The group numbering is restarted at 99. If it should become fully occupied, the oldest error is written over and the group numbering restarts at 01.

The contents of the fault memory can be erased after commissioning by briefly setting the parameter FCLEAR to 1 in the function module $FLTLOG_{XX}$.

When malfunction has been detected its cause must be corrected first. After this, the **RESET** button must be pressed before the drive system can be reactivated.

Measurement display, designation MEASURE

For measurement of signal values in the control system, the display MEASURE is paged forward. Four signal values can be presented at a time on this display. The appearance of the measurement display is shown in fig. 30.

When a signal within a certain function module is to be measured the cursor is first placed in Field 2 to scroll the function module required. See fig. 31.

When the cursor is placed in Field 2, press the + or – button until the function module required is presented opposite the cursor. The modules are available in alphabetical order. A table of the signals included in the module is now presented in Field 3.

When the function module required is set, the cursor is placed in Field 3 to permit "rotating" forward the signal required. See fig. 32. Press then the + or – button until the signal required appears on the operator's panel.

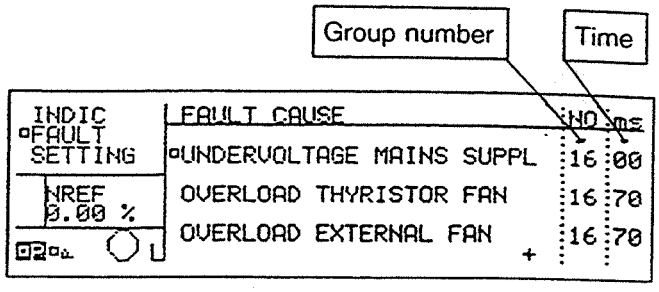


Figure 28. Fault Indication.

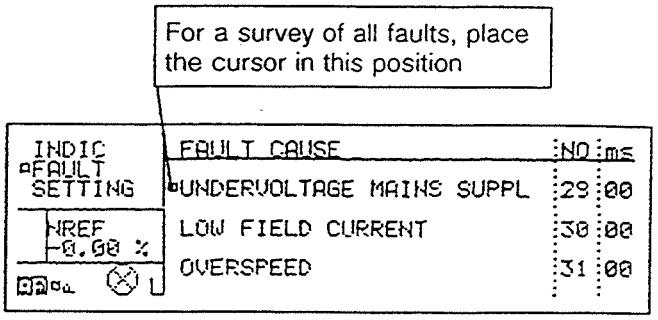


Figure 29. Fault statistics.

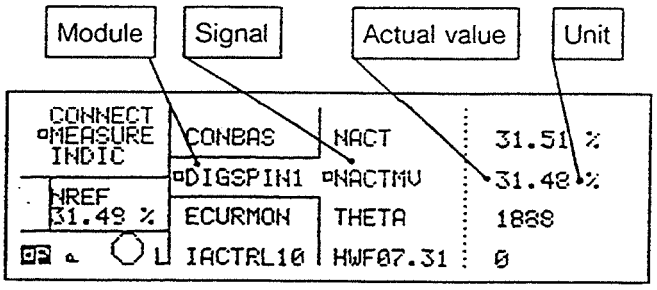


Figure 30. Measurement of signals.

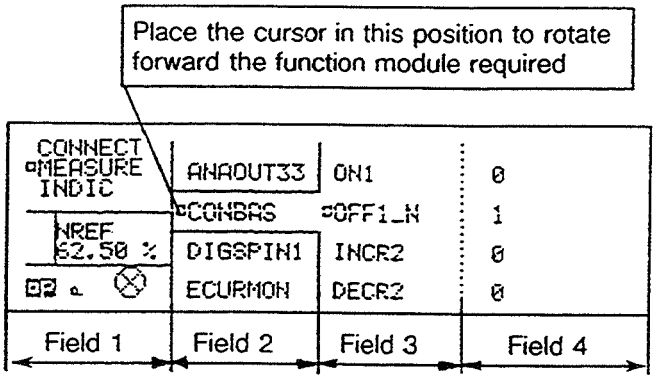


Figure 31. Measurement of signals.
Setting of required function module.

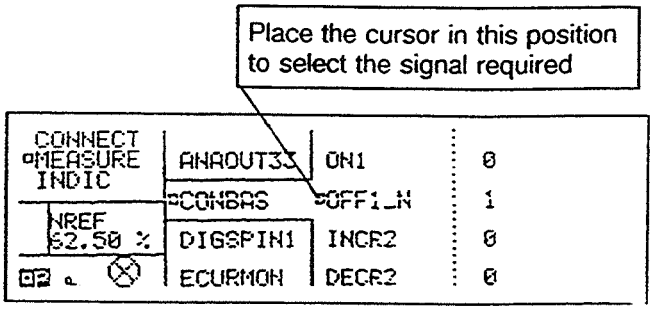


Figure 32. Measurement of signals.
Selection of a signal.

Display for setting of parameters, designation SETTING

The function of a control system is determined by a large number of parameters which can be increased or decreased via the operator's panel.

To determine the current value of a parameter or to give a parameter a new value, the function module containing the parameter is selected first. The cursor is located as shown in fig. 33. Press then the + or – buttons until the name of the required module appears by the cursor. The modules are stored in alphabetical order. A table of the parameters included in the function selected now appears to the right of the function table.

When the required function module has been selected, the cursor is moved to the position shown in fig. 34. Press then the + or – button until the parameter required appears on the screen. The parameters are also stored in alphabetical order.

When a parameter value is to be changed, the parameter concerned is placed opposite the cursor in Field 3, see fig. 35.

The latch must first be inactivated. See section **"Latch function"**. When double display operation is used also the authority parameters in module $OPCH_{XX}$ must have appropriate settings.

When the name of the parameter concerned is placed as shown in fig. 35, the cursor is moved to Field 4. Press the + or – buttons until the parameter value required is shown. When the value set is that required, the button **ENTER** is pressed. The new parameter value is now transmitted to the convertor computer where it is stored in an EEPROM and is used directly in the control system.

N.B: The previous parameter value is stored in the display computer so that it can be recalled quickly if any control probem should develop with the new value. The previous value is obtained if ENTER is depressed a second time.

Registration display, designation REGISTR

The behavior of an arithmetic or logic signal can be registered with the display REGISTR. When a step test is performed on an optional signal the response to the step becomes available for study.

The logger can be stopped in three different ways:

1. The convertor has been tripped by a fault signal.
2. A step test has been commanded.
3. The logger is stopped manually.

A flashing "L" on the display indicates that the logger has stopped. If the convertor has tripped, the logger must be restarted manually by pressing **ENTER** in position S/S.

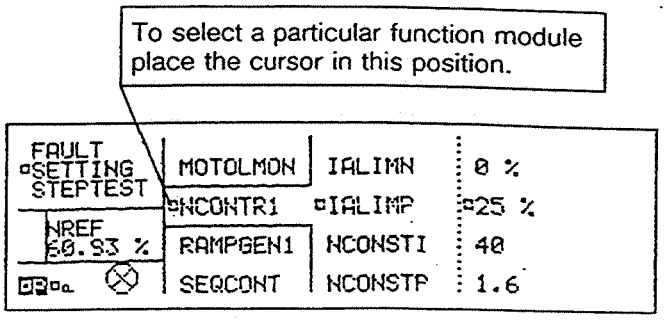


Figure 33. Parameter display. Selection of function module.

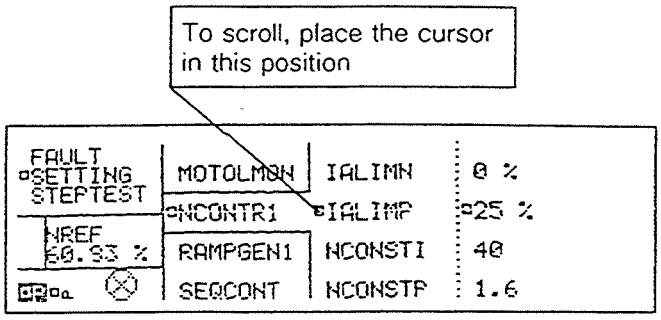


Figure 34. Parameter display. Parameter check.

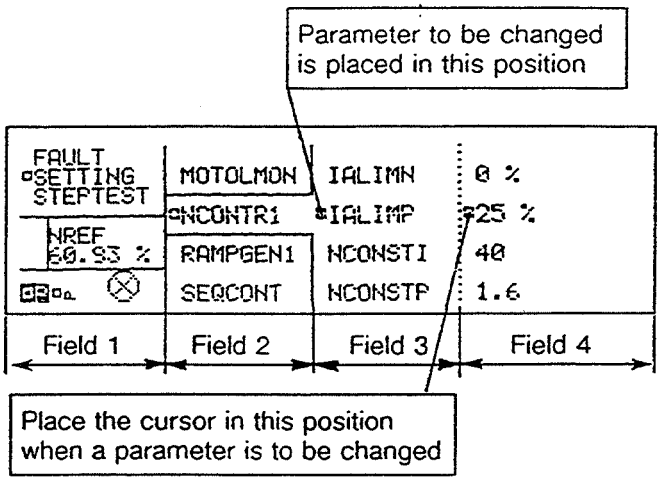


Figure 35. Parameter display. Setting of parameter.

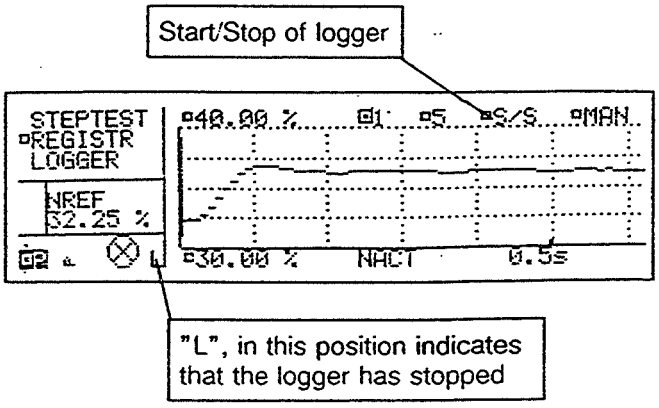


Figure 36. REGISTR. Start of logger.

When the upper limit of the amplitude scale is to be changed, the cursor is first placed in the upper position as shown in fig. 37. Press + or – until the required value is presented and then **ENTER**. The procedure is similar for changing the lower limit.

If the upper limit is selected slightly above the lower, a "part- enlargement" of a control level of particular interest can be obtained.

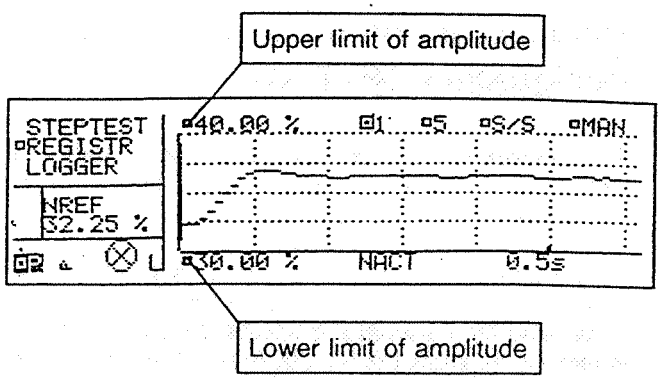


Figure 37. Registration.
Setting of amplitude.

To select a channel on the registration display, the cursor is placed as shown in fig. 38. The signal which is active in the channel is specified in the display LOGGER. When the cursor is placed in the required position, press + or – until the channel required is presented. Then press **ENTER**.

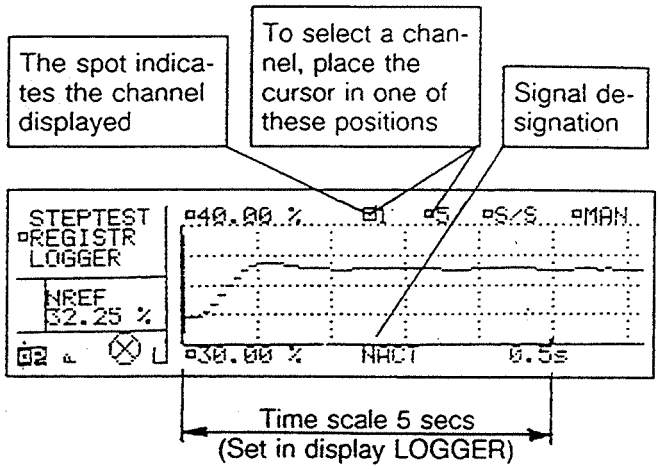


Figure 38. Registration.
Selection of channel.

Two logger channels can be stored simultaneously in the display computer. The number of the channel required is specified in position A or position B as in fig. 39. If **ENTER** is then pressed the signal in the channel selected is presented. The logger must be inactive if the channel is to be changed i.e. a flashing "L" must be visible.

If the signal currently displayed is to be compared with another signal, the cursor is placed in position A or position B. See fig. 39.

Then press ENTER to obtain a presentation of the other signal. The original signal is recovered by pressing **ENTER** again. A rapid exchange is obtained if **ENTER** is held in its depressed position.

Example: Assume that the signal on channel 1 is displayed and that the cursor is at position A as in fig. 40. If **ENTER** is pressed, the signal on channel 5 is presented and the cursor moves to position B as in fig. 41. If **ENTER** is pressed again, the display shown in fig. 40 returns.

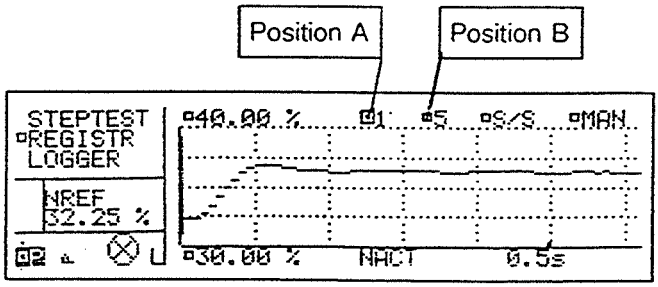


Figure 39. Registration.

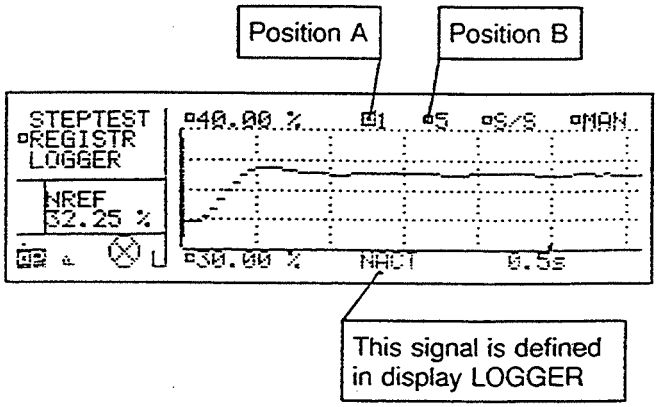


Figure 40.

Step testing is defined in the section **"Display for setting of step testing, designation STEPTEST"**. Step testing can however be commanded in the display REGISTR, either manually in single steps or automatically in a series of steps.

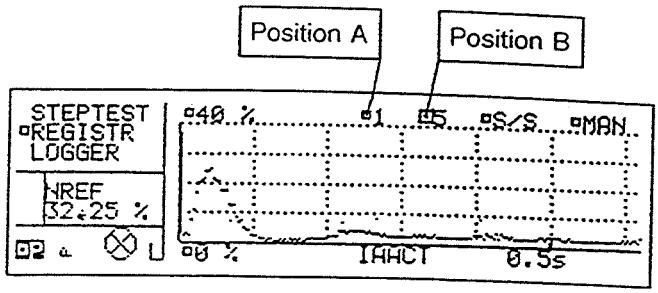


Figure 41.

When a manual step test is to be performed, the cursor is placed in the position shown in fig. 42. Press + or – until MANual is presented. **ENTER** is pressed to activate the stepping in the value. This triggers the logger which means that the logger registers the signal and continues recording until its memory is filled. The signal curve is then presented on the REGISTR display.

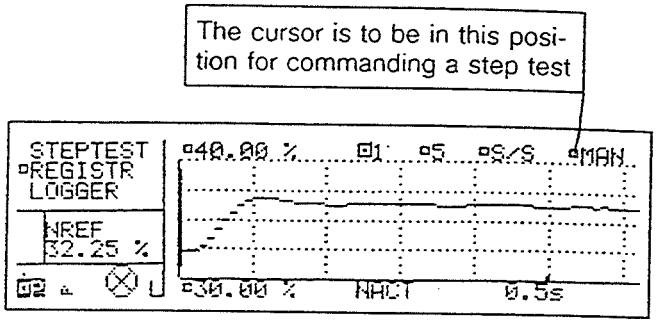


Figure 42. Registration.
Manual step testing.

If a step test is to be repeated automatically, the cursor is first placed in the position shown in fig. 43 and the + or – button is pressed until the text REP is presented. Automatic repetition of the step test is started when **ENTER** is depressed.

The step test is stopped by pressing **ENTER** once again. The cursor will then move out to the text REGISTR in Field 1 as in fig. 43.

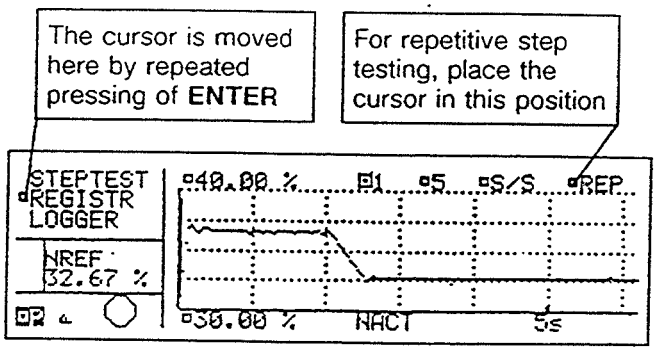
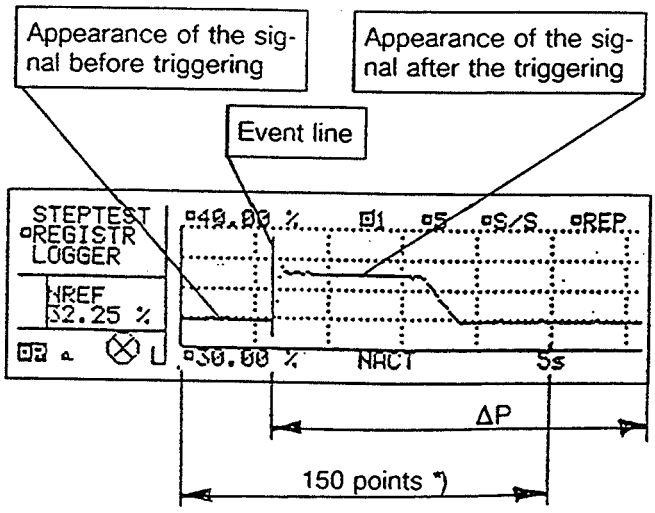


Figure 43. Registration.
Repetition of step testing.

The amplitude of the step, its duration and the signal to which it is applied are set on the STEPTEST display. The time between each test step is dependent on where the event line is placed and the time scale factor in the registration display. It is however always greater than ten seconds. See fig. 44.

The different durations of the square wave steps are described in more detail in fig. 45.



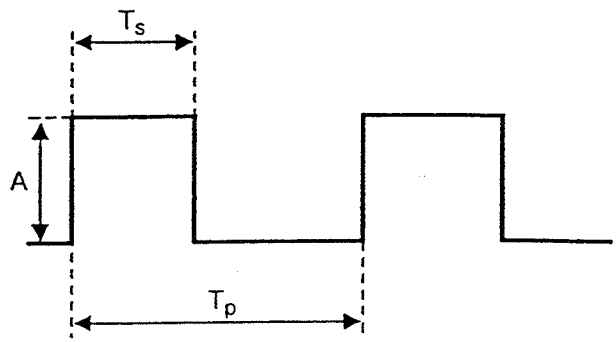
*) For Tyrak: 150 points in a 50 Hz-system
180 points in a 60 Hz-system

ΔP: Number of points after the event line.
Defined in display LOGGER.

Figure 44.

The amplitude + 100 % means a maximum positive step.

This is equal to the maximum of any other signal even if maximum of a tested signal is defined e.g. as 400 %.



A: Amplitude of the test step. Defined in display STEPTEST

T_s: Duration of the test step. Defined in display STEPTEST

T_p: The time between each step

$$(T_p)_{max} = \Delta P \times \frac{\text{Scale factor for time in registration display}}{150} + 1 \text{ (sek)}$$

ΔP: Number of points after the event line. Defined in display LOGGER.

Figure 45. Step test with automatic repetition.

If the variations in a signal are to be studied continuously, the cursor is placed as shown in fig. 46. Press + or – until the text AUTO is presented. Then press **ENTER**, the display then showing how the signal varies in time. Note that the time scale for the channel must then be set to ≥ 500 seconds.

To stop the automatic updating, place the cursor in front of AUTO and press **ENTER**. The cursor is then automatically transferred to the display designation REGISTR.

A documentation of the variation of an interesting signal may be required. The cursor should be placed at S/S (Start/Stop) and the button **ENTER** pressed. Make a printout, return the cursor to S/S and then press **ENTER** again.

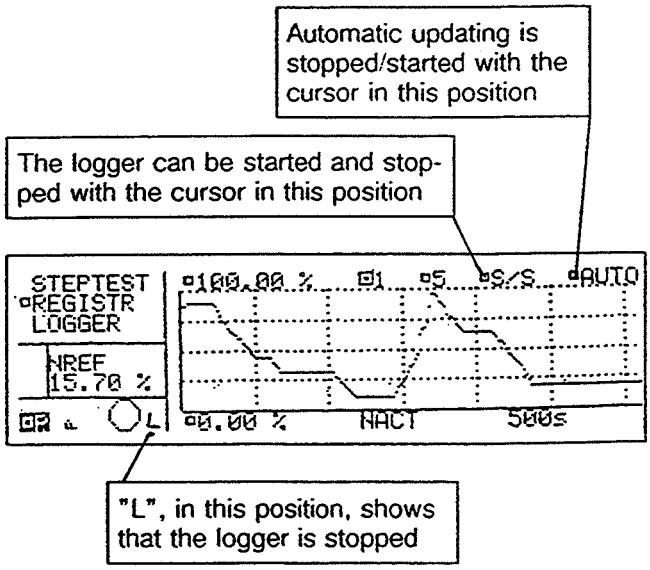
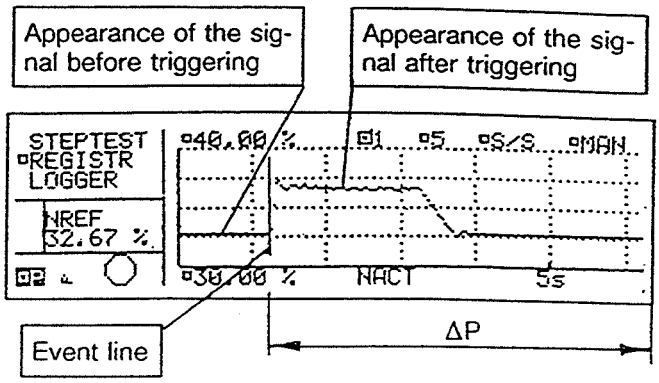


Figure 46. Registration. Automatic updating.

When performing step tests, the signal after the triggering point is that most interesting. The event line is then set at the extreme left (ΔP 157 or 186). In the case of a fault, the events leading up to the failure are of more interest. The event lines are therefore to be set at the extreme right during normal operations (ΔP approx. 30).

If the logger is not started before the steptest is done, the display will show old values before the event line.



ΔP: Number of points set in the LOGGER display.

Figure 47. Registration.
Significance of the event line.

The position of the event line is set in the LOGGER display. The number of points is specified there. See fig. 48. For a more detailed description of the logger, see below.

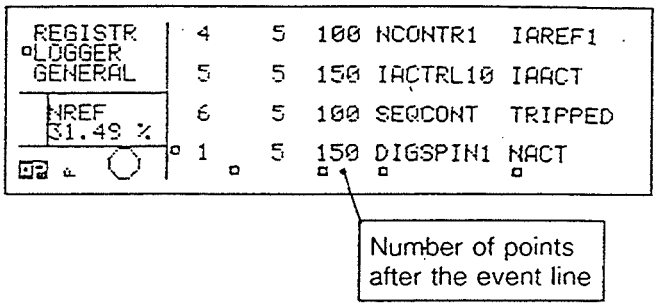


Figure 48. Logger.
Setting of event line.

Logger display, designation LOGGER

The logger is a memory in which 186 values from each of 6 channels can be stored. When a new value is stored in a channel, the oldest value from the channel disappears. The contents of the logger can be read in graphic form on the REGISTR display, each point corresponding to a mean value of measured values.

The signals in the different channels are specified in the LOGGER display. The time scale and the number of measured values after the event line are also given there. See fig. 49.

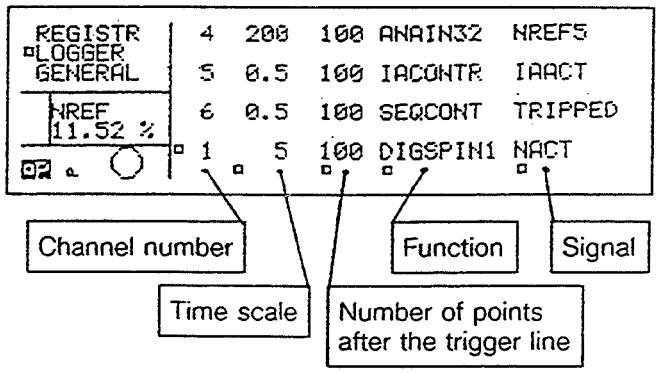


Figure 49. Logger.

A function for table scrolling is used to determine the signals in all of the channels in the logger. The cursor is first placed in the position shown in fig. 50 and then + or – is pressed.

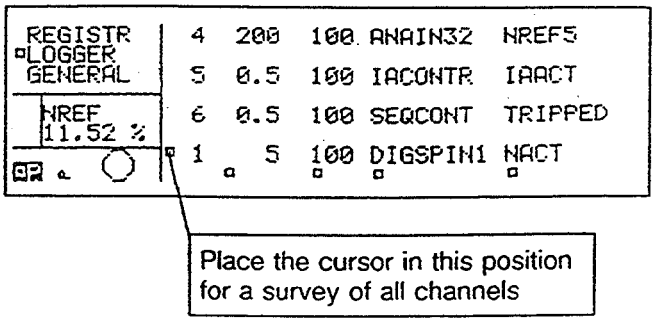


Figure 50. Logger.
Channel survey.

If new data is to be defined in the logger, the channel to be changed is first placed on the bottom line as shown in fig. 51.

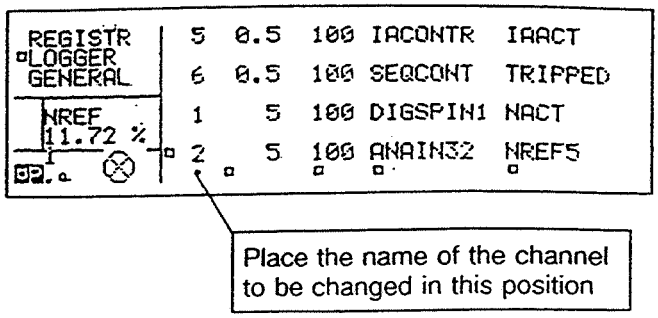


Figure 51. Logger.

To change the time scale, the cursor is placed in the position shown in fig. 52. Press + or – until the time scale required is shown. The time from the start to the time markings on the REGISTR display is given in seconds.

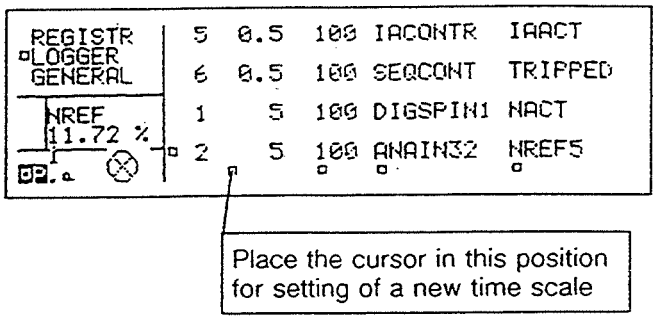


Figure 52. Logger.
Setting of time scale.

To change the number of measured values after the event line, the cursor is placed in the position shown in fig. 53. Press + or – until the number of measured values after the event line is that required.

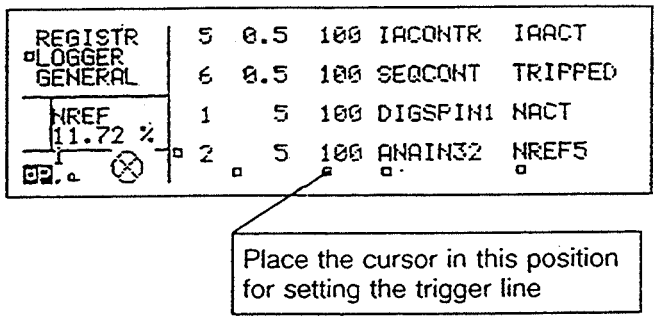


Figure 53. Logger.
Setting of event line.

The function module concerned must be defined before the new signal can be found. This is done by first placing the cursor as shown in fig. 54 and then pressing the + or – button until the identity of the required function module is shown. The first signal within this function module is then shown at the right.

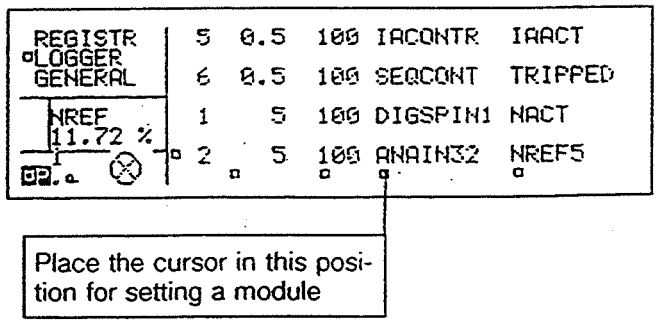


Figure 54. Logger.
Setting of function.

When the function module required is set, the cursor is placed as shown in fig. 55 and + or – pressed until the signal required is presented within the function module.

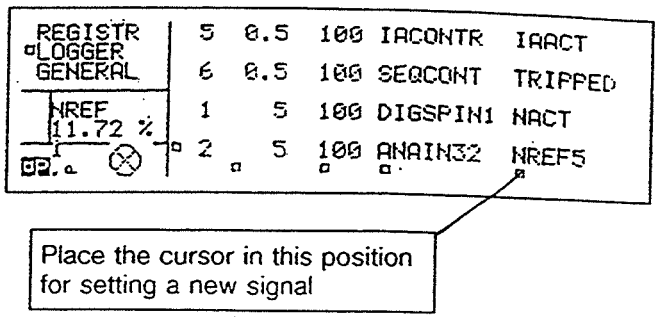


Figure 55. Logger. Setting of a new signal.

When the new setting is that required, the cursor is placed as shown in fig. 57 and the **ENTER** button pressed. The new setting will now be stored.

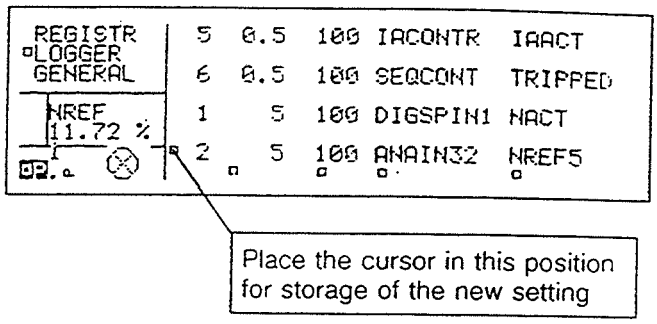


Figure 56. Logger. Storage of a new setting.

If a step test is performed (manually or automatically) or if a fault is detected, the logger is stopped and an "L" on the operator's panel begins flashing, irrespective of the display set. See fig. 57.

If any fault develops in the drive system, the logger is tripped and all signal values are frozen. It is therefore important to restart the logger before the drive system is restarted after malfunction or a step test. This is done by placing the cursor in position S/S (Registration display) and then pressing **ENTER**. See fig. 57.

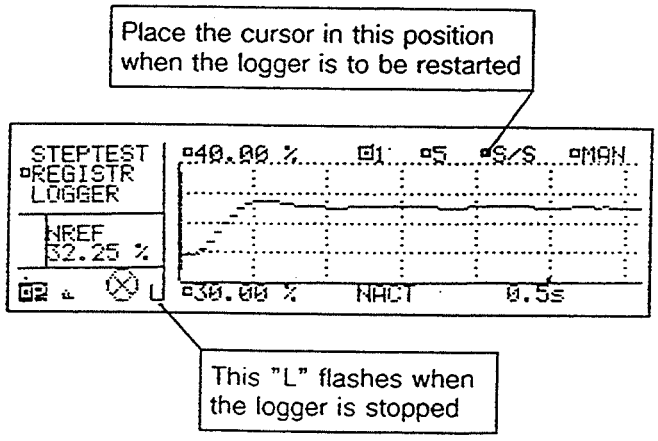


Figure 57. Registration display.

Display for setting step testing, designation STEPTEST

STEPTEST, REGISTR and LOGGER are three interdependent displays. When a step test is performed, the registration display changes forward automatically when the logger memory is fully occupied. The functions of the registration and logger are described under **"Registration display, designation REGISTR"** and **"Logger display, designation LOGGER"**.

When a step test is to be performed on a function, the cursor is to be placed in Field 2. Press + or – until the required function is presented beside the cursor. See fig. 58.

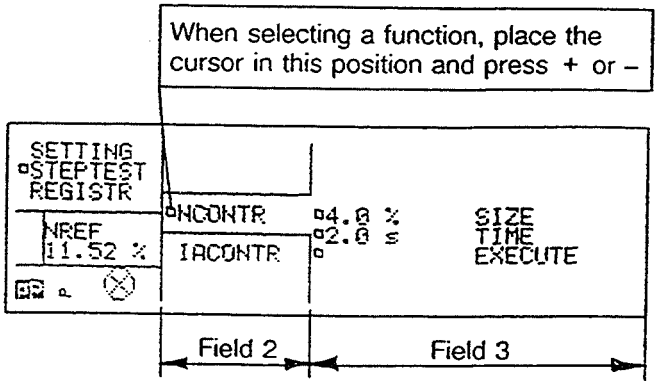


Figure 58. Step testing. Selection of function.

When the required function is set in Field 2, place the cursor in front of the text SIZE in Field 3 and then press + or – until the amplitude required is displayed. When the required amplitude is reached, press **ENTER**.

To set the duration of the step in the value, place the cursor in front of the text TIME. Press + or – until the required time is presented on the operator's panel and then press **ENTER**.

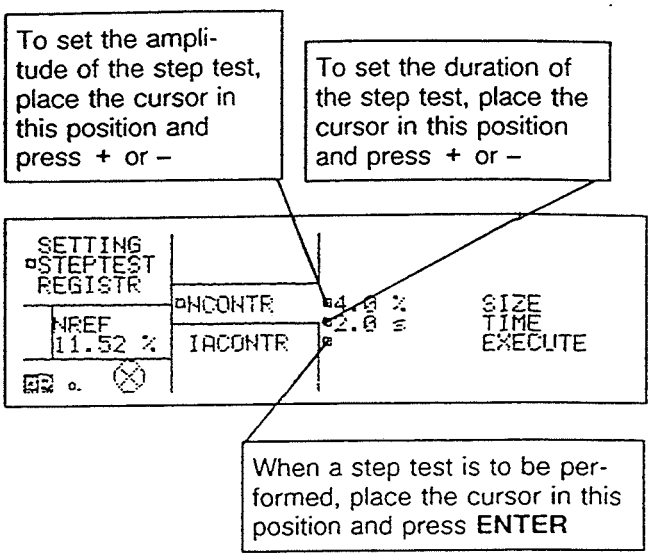


Figure 59. Step testing. Setting of amplitude.

When the required function, amplitude and duration of the test step have been set, place the cursor in front of the text EXECUTE and press **ENTER**.

The REGISTR display will then be presented as soon as the logger memory is full. The measurement time is set in the LOGGER display. See fig. 60.

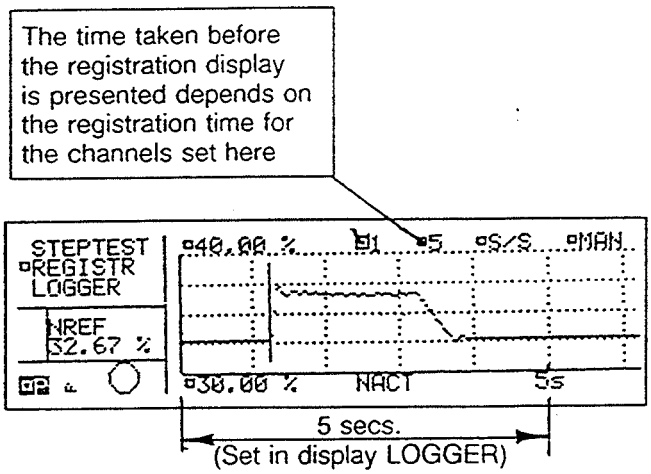


Figure 60. Registration.

Display for connection of external signals, designation CONNECT.

With the display CONNECT, it is possible to reconnect the signals on the different I/O units connected to the computer board. It is also possible to redefine push buttons and LEDs on the operator's panel.

The CONNECT display appears as shown in fig. 61. The significance of, for example, DOOP.3 is given in the section **"Abbreviations"**.

When signals are to be reconnected, the channel concerned is first placed on the bottom line by placing the cursor in position 1 and then pressing + or – until the channel required is presented, see fig. 61. The required function module is given in position 2 and the signal required is given in position 3. When the new setting is performed, the cursor is returned to position 1 and **ENTER** is pressed.

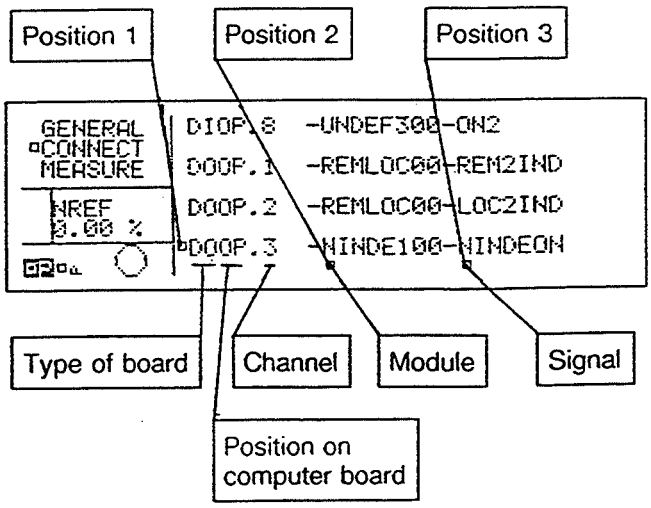


Figure 61. Appearance of the display.

Safety

Certain blocking functions are provided for protection against incorrect handling. In addition, when signals are exchanged in position 3, only arithmetical signals are selected for analogue units and logical signals for digital units. See fig. 62.

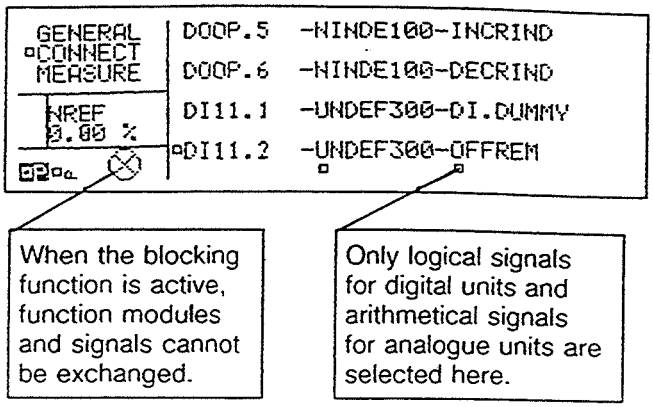


Figure 62. Safety functions.

The situations against which no protection is provided are shortcircuiting and the connection of an output to an inport or vice versa. See fig. 63.

N.B. The operator must be observant here and register the connections made.

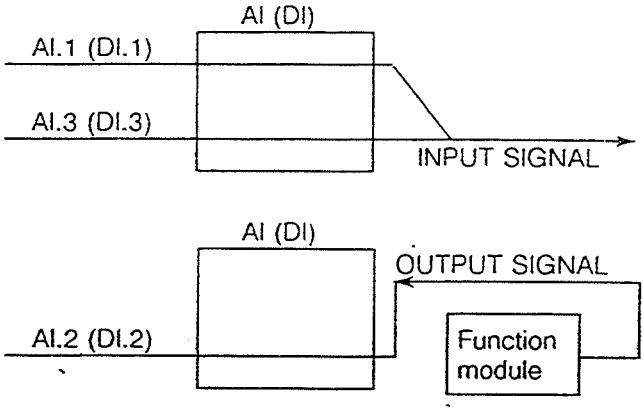


Figure 63. Situations against which no protection is provided.

Abbreviations

AI = Analogue IN-put.
AO = Analogue OUT-put.
DI = Digital IN-put.
DO = Digital OUT-put.

The numbering of the positions on the computer board and the operator's panel are numbered as shown in figs 64 and 65.

AI33.4 corresponds to ANALOGUE IN, placed in position 33 and the signal concerned is connected to channel 4.

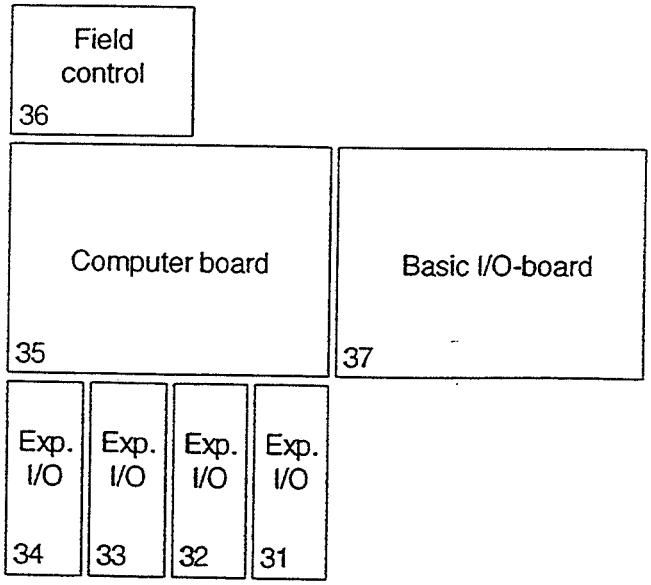


Figure 64. Board item designations, Tyrak Midi II.

DOOP.3 corresponds to LED number 3 (Digital OUT) on the operator's panel.

DIOP.5 corresponds to push button number 5 on the operator's panel.

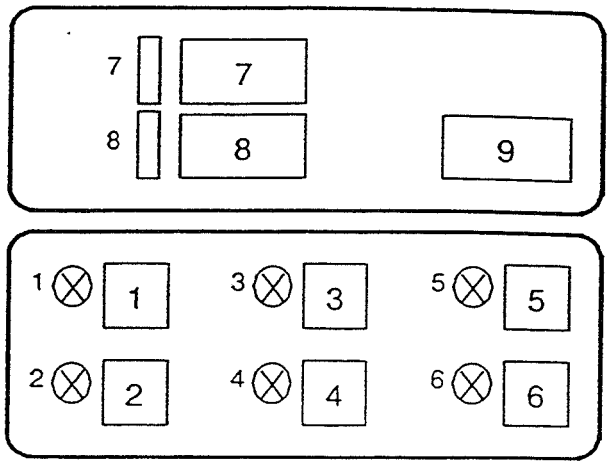
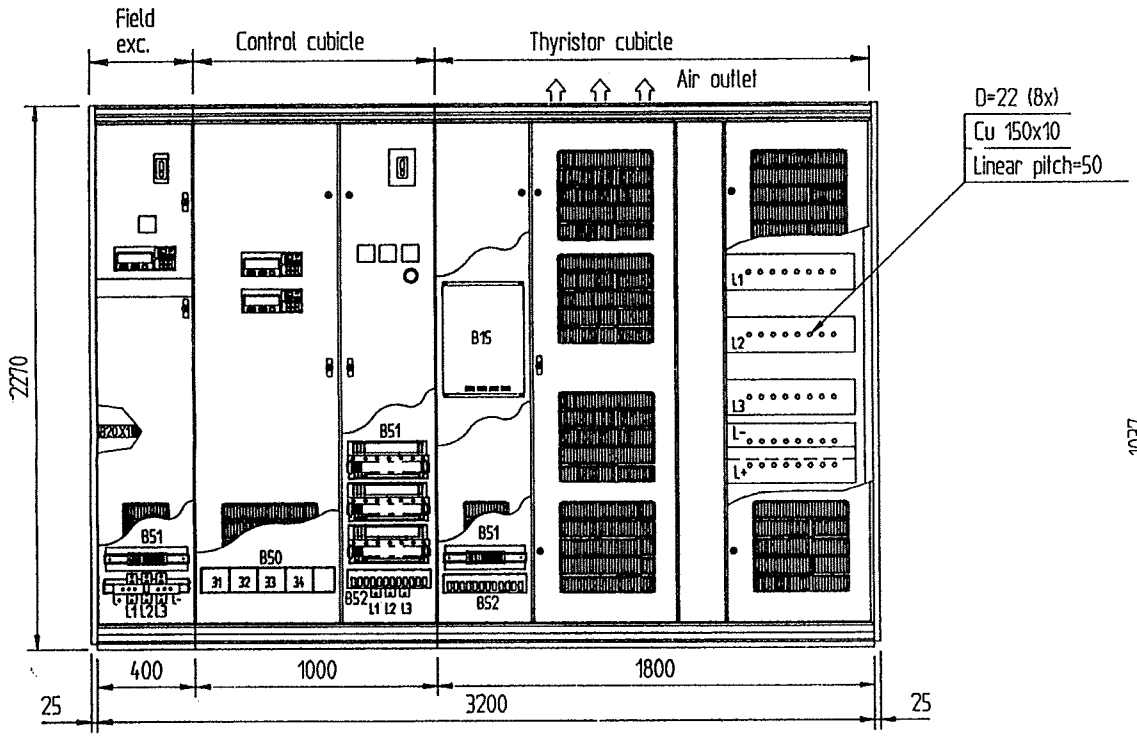
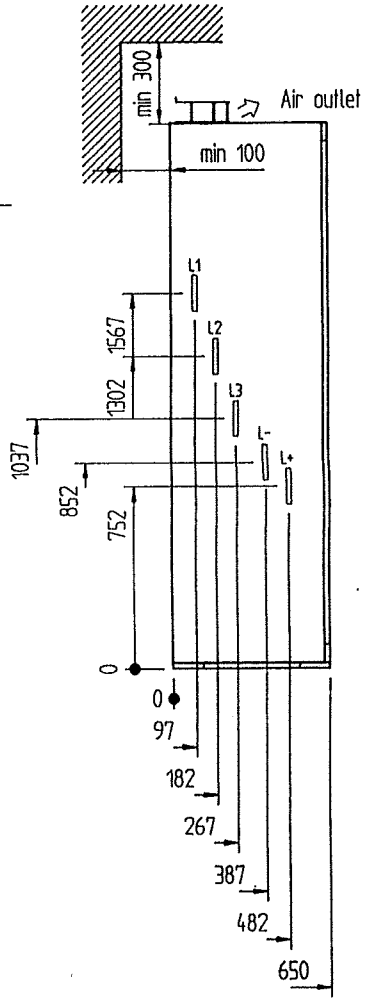


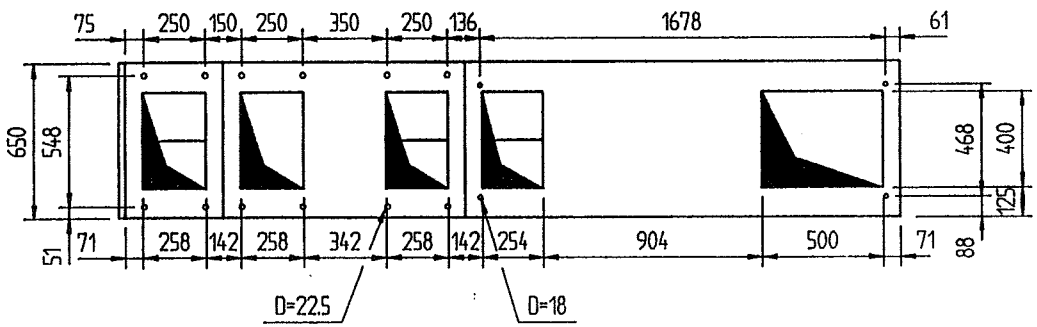
Figure 65. Numbering of push buttons and LEDs on the operator's panel.

Dimension prints

Contents:







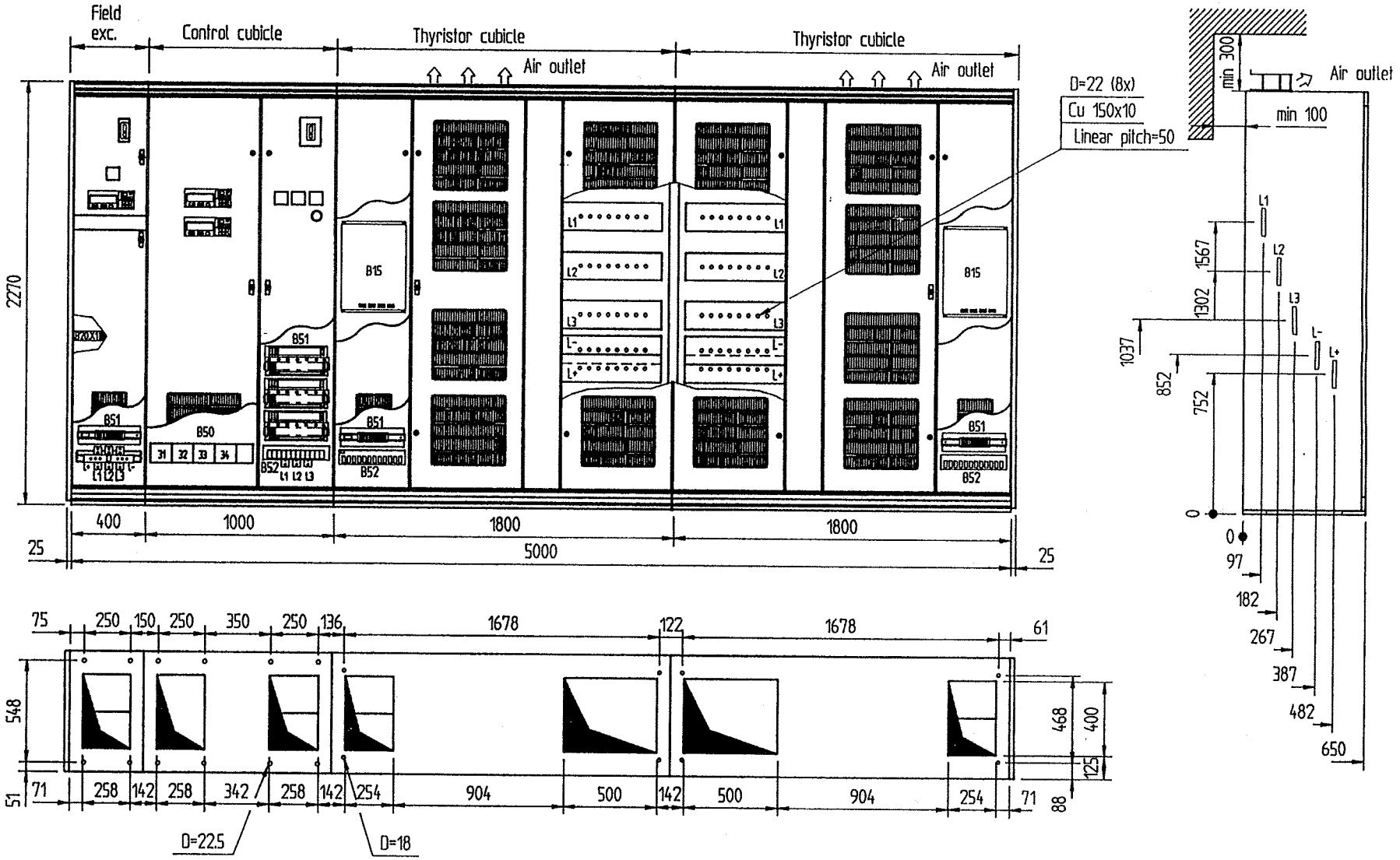
Weight: Thyristor cubicle 750kg
Control cubicle 400kg
Field exciter 200-250kg

Air flow: Thyristor cubicle: 4000m³/h
Field exciter: 100-500 m³/h

When heavy start for external motors is required, a 400 mm cubicle is added between the control- and thyristor cubicle.

Accepted by qual control	Accepted for prod by DPA/H FORSÉN	Description (English) DIMENSION DRAWING 6 PULSE	
Design checked by G PETERSSON	Drawn by M ELFKVIST	Description (own language) MÅTTSKISS 6-PULS	
Drawing checked by G PETERSSON	Issued by Dept DKK Year 93 Week 26	3ASD 489306C149	Lang EN Sheet 1 Rev Ind Cont –
ABB Drives AB			

Rev Ind | Revision | Appd | Year | Week



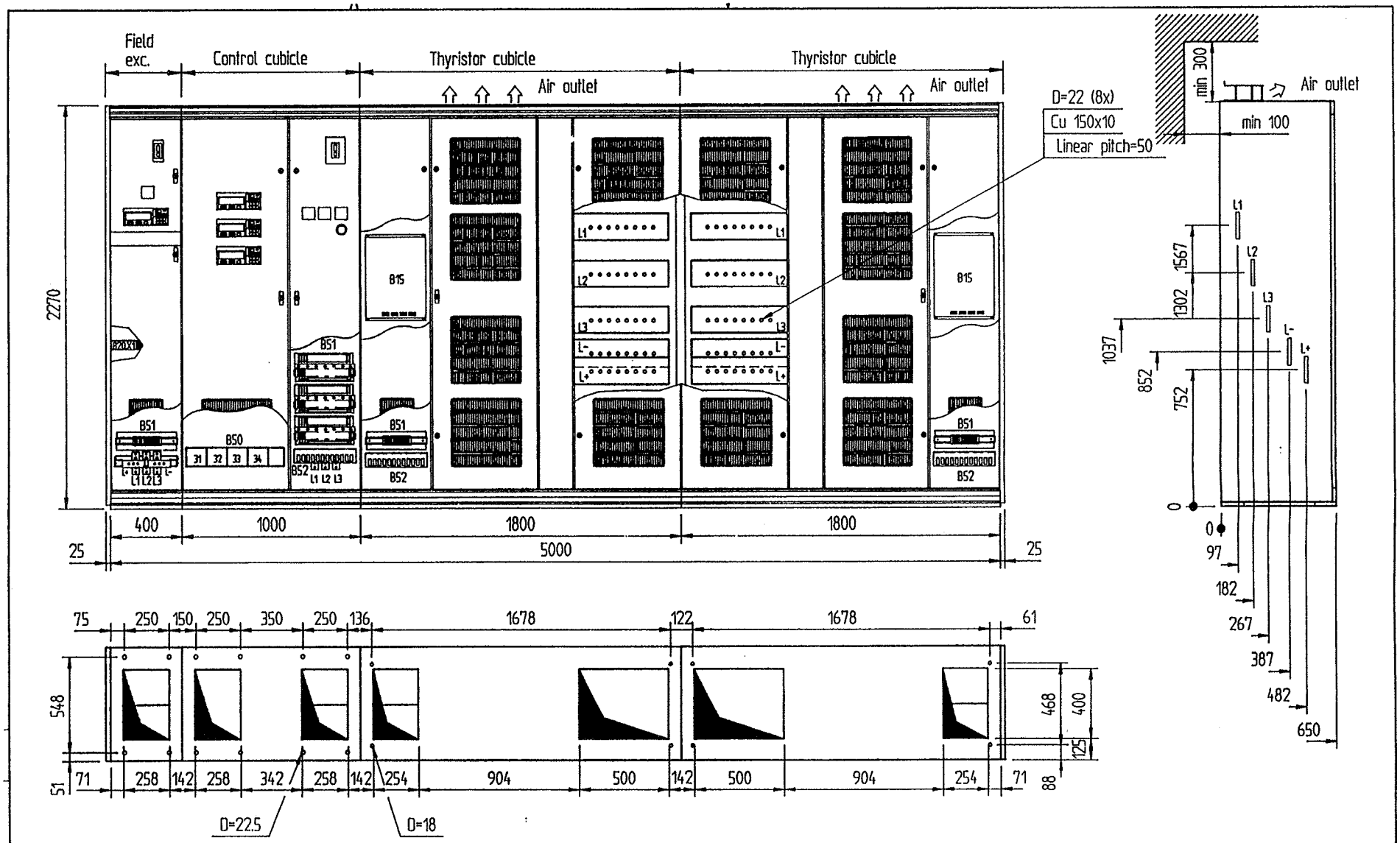
Weight: Thyristor cubicle 750kg each
Control cubicle 400kg
Field exciter 200-250kg

Air flow: Thyristor cubicle: 4000m³/h each
Field exciter: 100-500 m³ /h

When heavy start for external motors is required, a 400 mm cubicle is added between the control- and thyristor cubicle.

Accepted by qual control	Accepted for prod by DPA/H FORSÉN	Description (English) DIMENSION DRAW. 12 PULSE S.6 PULSE //	
Design checked by G PETERSSON	Drawn by M ELFKVIST	Description (own language) MÅTTSKISS 12-PULS SERIE.6-PULS //	
Drawing checked by G PETERSSON	Issued by Dept OKK Year 93 Week 26		Lang EN Sheet 1
ABB Drives AB		3ASD 489306C148	Rev Ind Cont –

Rev Ind | Revision | Appd | Year | Week



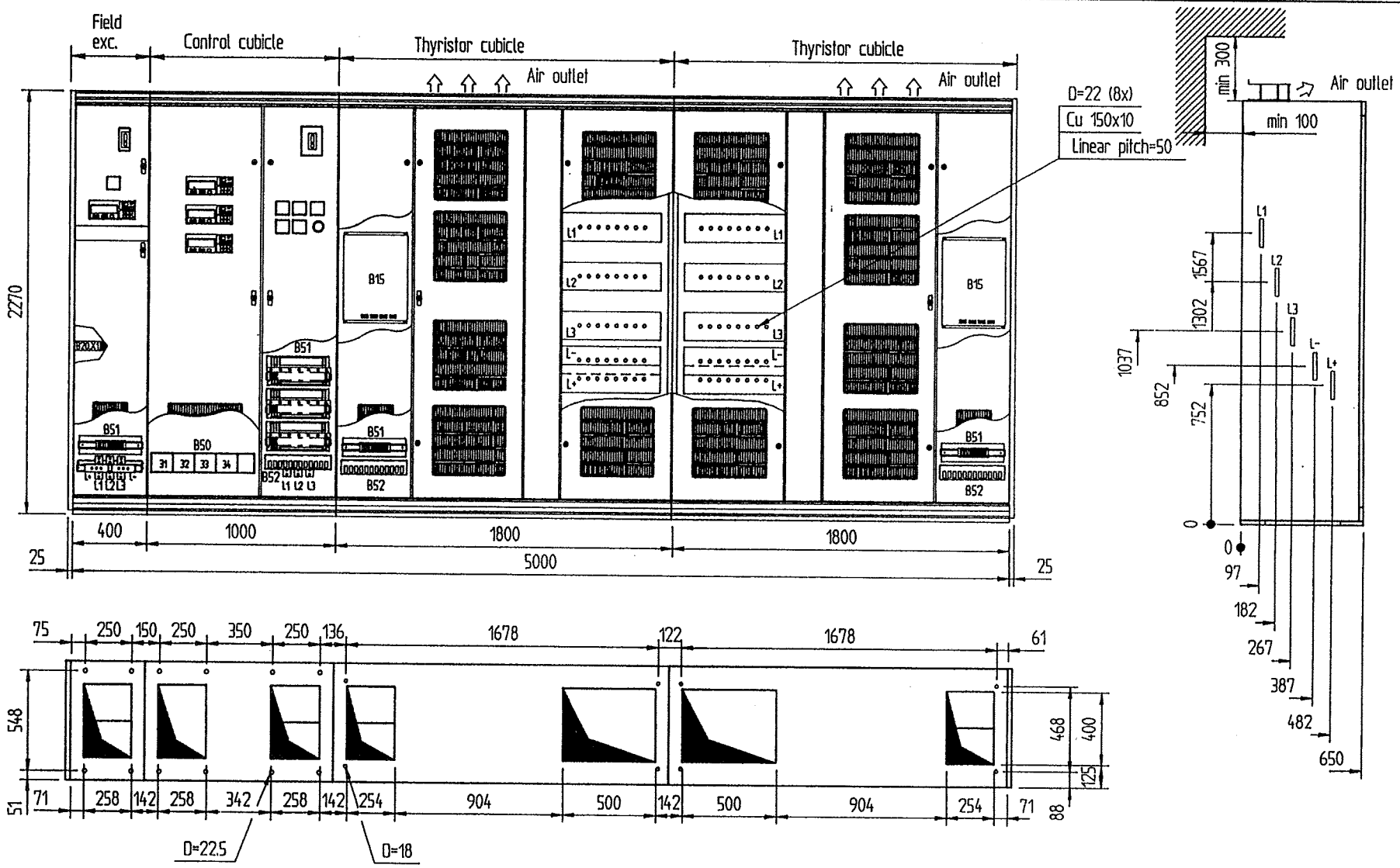
Weight: Thyristor cubicle 750kg each
Control cubicle 400kg
Field exciter 200-250kg

Air flow: Thyristor cubicle: 4000 m^3/h each
Field exciter: 100-500 m^3/h

When heavy start for external motors is required, a 400 mm cubicle is added between the control- and thyristor cubicle.

Accepted by qual. control	Accepted for prod by: OPA/H FORSÉN	Description (English): DIMENSION DRAWING 12 PULSE P	
Design checked by: G PETERSSON	Drawn by: M ELEKVIST	Description (own language): MÅTTSKISS 12-PULS P	
Drawing checked by: G PETERSSON	Issued by Dept: DKK, Year 93, Week 26		Lang: EN; Sheet: 1
ABB Drives AB		3ASD 489306C154	Rev Ind: Conf: -

Rev Ind | Revision | Appd | Year | Week



Weight: Thyristor cubicle 750kg each
Control cubicle 400kg
Field exciter 200-250kg

Air flow: Thyristor cubicle: 4000 m^3/h each
Field exciter: 100-500 m^3/h

When heavy start for external motors is required, a 400 mm cubicle is added between the control- and thyristor cubicle.

Accepted by qual. control	Accepted for prod by: DPA/H FORSÉN	Description (English): DIMENSION DRAWING 2x6 PULSE T
Design checked by: G PETERSSON	Drawn by: M ELFKVIST	Description (own language): MÅTTSKISS 2x6-PULS T
Drawing checked by: G PETERSSON	Issued by Dept: DKK; Year: 93; Week: 26	Lang: EN; Sheet: 1
ABB Drives AB		3ASD 489306C201

Rev Ind | Revision | Appd | Year | Week

List of Apparatus

Contents **Page**

Field exciter 40-115 A Y.1

Where quantities differ between single (YGHR) and double (YHHR) field exciters, two alternatives are given YGHR/YHHR:

Supply unit A32 3ASD 489306B43

Item	Qty	Name		Type / Data	Part number
1	1	Transformer		110/220V	4781 020-ADU

Heater element A40 3ASD 489301A424

Item	Qty	Name		Type / Data	Part number
1	1	Heater element		100W, 240V	5291 2011-30

Main contactor unit B8 3ASD 489306B45

Item	Qty	Name		Type / Data	Part number
1	1	Inductor unit		3x6 uH	3ASD 489301A250
40	1	Contactor	110V	B50-30-11	FPL3511001R0114

Main circuit unit B20

YGHR 40/64 A 3ASD 489306B5
YGHR 115 A 3ASD 489306B6
YHHR 40/64 A 3ASD 489306B7
YHHR 115 A 3ASD 489306B8

Item	Qty	Name	Convertor	Type / Data	Part number
1 to 6	3 alt 6	Thyristor block	40/64A	40 A, 1600 V	4858 232-16
		Thyristor block	115A	90 A, 1600 V	4858 234-16
13,14,15	3	SCR fuse	40/64A	63 A, 660 V	5675 582-411
		SCR fuse	115A	125 A, 660 V	5675 582-414
19	1	Snubber circuit		YXI 115C	3ASD 510001C19
35	1	Computer board		YPQ 201A	YT 204 001-KA
35.1	1	Memory board		FEDC01XX	3ASD 510001C4
35.2	1	DCB board		YPK 114B	3ASD 399002C4
37	1	I/O board		YPQ 202A	YT 204 001-KB
38	1 / 0	Trigger pulse board		YXU 167E	YT 204 001-JA
38	0 / 1	Trigger pulse board		YXU 168E	YT 204 001-JB
42,43	2	Current transformer		600/1	4762 0318-8
50	1	Fan		110 V, 50/60 Hz	6480 177-1
51	1	Transformer		SLTF 0070	3ASD 478101A302
52	1	Rectifier		YXE 152A	YT 204 001-AF
52.F1	1	Min. fuse		6,3 A	5672 2011-22
52.F2	1	Min. fuse		4,0 A	5672 2011-20

Field discharge unit B35

YGHR 3ASD 489306B27
YHHR 3ASD 489306B56

Item	Qty	Name		Type / Data	Part number
1	1	Varistor		400 A	3ASD 524801C1
2	1	Thyristor module		TT210N1800KOC	4858 445-18
3	1	Resistor		10kOhm 50W 5%	5245 2063-510
4	1	Field disch. board		YXZ 225A	3ASD 510001C14
5	0 / 1	Varistor		745VDC/3700pF	5248 135-2
6	0 / 1	Resistor		100Ohm 50W 5%	5245 2063-310

Instrument door D1 3ASD 489306B24

Item	Qty	Name		Type / Data	Part number
1	1	Voltmeter		100%-0-100%	3ASD 569701C34
99.1	1	Display control		YPP 109A	YT 204 001-HS
99.2	1	Indication unit		YPN 107A	YT 204 001-DM
99.3	1	Illuminated display		YPN 104C	YT 204 001-DS
99.4	1	Membrane keyboard			5372 396-10

Test panel D15 3ASD 489306B33

Item	Qty	Name		Type / Data	Part number
1	1	Terminal modem		YPK 111	YT 204 001-HH
3	1	El. outlet			3ASD 538101A320

MCCB unit H1 3ASD 489301A251

Item	Qty	Name	Convertor	Type / Data	Part number
1	1	MCCB breaker	40,64A	80 A	3ASD 534402A1007
	1	MCCB breaker	115A	125A	3ASD 534402A1009
4	1	Current transformer			4762 079-5
4 1	1	Trans. suppr. diode			4856 210-213

Distribution unit H12 3ASD 489306B61

Item	Qty	Name		Type / Data	Part number
1	1	Base device			3ASD 534301A130
1 1	1	Tripping device		6-10 A	3ASD 534303A1001

Field exciter 195-515 A Y.1

Where quantities differ between single (YGHR) and double (YHHR) field exciters, two alternatives are given YGHR/YHHR:

Supply unit A32 3ASD 489306B40

Item	Qty	Name		Type / Data	Part number
1	1	Transformer		110/220V	4781 020-ADU

Heater element A40 3ASD 489301A424

Item	Qty	Name		Type / Data	Part number
1	1	Heater element		100W, 240V	5291 2011-30

Main contactor unit B8 3ASD 489306B45

Item	Qty	Name		Type / Data	Part number
1	1	Inductor unit		3x6 uH	3ASD 489301A250
40	1	Contactor		B50-30-11	FPL3511001R0114

Main circuit unit B20

YGHR 195A	3ASD 489306B12
YHHR 195A	3ASD 489306B13
YGHR 300A	3ASD 489306B14
YHHR 300A	3ASD 489306B15
YGHR 515A	3ASD 489306B16
YHHR 515A	3ASD 489306B17

Item	Qty	Name	Convertor	Type / Data	Part number
1 to 6	3 alt. 6	Thyristor block	195,300A	1800V	4858 445-18
	3 alt 6	Thyristor block	515A	1800V	4858 446-18
13,14,15	3	SCR fuse	195A	200A, 660V	5675 582-416
	3	SCR fuse	300A	315A, 660V	5675 582-418
	3	SCR fuse	515A	550A, 660V	5675 582-422
19	1	Capacitor unit		YXI 116A	YT 204 001-AN
25,26	2	Power resistor set	195,300A	3x15 Ohm	3ASD 524503A215
	2	Power resistor set	515A	3x6,8 Ohm	3ASD 524503A168
35	1	Computer board		YPQ 201A	YT 204 001-KA
35.1	1	Memory board		FEDC01XX	3ASD 510001C4
35.2	1	DCB board		YPK 114B	3ASD 399002C4
37	1	I/O board		YPQ 202A	YT 204 001-KB
38	1 / 0	Trigger pulse board		YXU 167G	YT 204 001-JE
38	0 / 1	Trigger pulse board		YXU 168G	YT 204 001-JF
42,43	2	Current transformer		600/1	4762 0318-8
48	1	Contactor		110V 50/60Hz	GJL1211001R0014
49	1	Capacitor (50Hz)		6 uF 250V	4984 219-7
49	1	Capacitor (60Hz)		5 uF 250V	4984 219-6
50	1	Fan		110 V, 50/60 Hz	3ASD 648001A399
51	1	Transformer		SLTF 0070	3ASD 478101A302
52	1	Rectifier		YXE 152A	YT 204 001-AF
52.F1	1	Min. fuse		6,3 A	5672 2011-22
52.F2	1	Min. fuse		4,0 A	5672 2011-20

Field discharge unit B35 YGHR 3ASD 489306B27
YHHR 3ASD 489306B56

Item	Qty	Name		Type / Data	Part number
1	1	Varistor		400 A	3ASD 524801C1
2	1	Thyristor module		TT210N1800KOC	4858 445-18
3	1	Resistor		10kOhm 50W 5%	5245 2063-510
4	1	Field disch. board		YXZ 225A	3ASD 510001C14
5	0 / 1	Varistor		745VDC/3700pF	5248 135-2
6	0 / 1	Resistor		100Ohm 50W 5%	5245 2063-310

Instrument door D1 3ASD 489306B24

Item	Qty	Name		Type / Data	Part number
1	1	Voltmeter		100%-0-100%	3ASD 569701C34
99.1	1	Display control		YPP 109A	YT 204 001-HS
99.2	1	Indication unit		YPN 107A	YT 204 001-DM
99.3	1	Illuminated display		YPN 104C	YT 204 001-DS
99.4	1	Membrane keyboard			5372 396-10

Test panel D15 3ASD 489306B33

Item	Qty	Name		Type / Data	Part number
1	1	Terminal modem		YPK 111	YT 204 001-HH
3	1	El. outlet			3ASD 538101A320

MCCB unit H1 195-300A 3ASD 489301A283
515A 3ASD 489301A285

Item	Qty	Name	Convertor	Type / Data	Part number
1	1	MCCB breaker	195A	200A	3ASD 534403A1002
	1	MCCB breaker	300A	320A	3ASD 534403A1004
	1	MCCB breaker	515A	500A	3ASD 534404A1004
4	1	Current transformer			4762 079-5
4 1	1	Trans. suppr. diode			4856 210-213

Distribution unit H12 3ASD 489306B61

Item	Qty	Name		Type / Data	Part number
1	1	Base device			3ASD 534301A130
1 1	1	Tripping device		6-10 A	3ASD 534303A1001
41	1	Contactor		110V 50/60Hz	GJL1211001R0014

Control cubicle Y.2

Heater element A40 3ASD 489301A425

Item	Qty	Name		Type / Data	Part number
1,2	2	Heater element		100W, 240V	5291 2011-30

Aux. supply unit B1 3ASD 489306C51

Item	Qty	Name		Type / Data	Part number
1	1	Base dev. control mod.			3ASD 534301A130
1 1	1	Tripp. dev control mod.		6-10A	3ASD 534303A1001
2 to 5	1 to 4	Base dev. trigger pulse			3ASD 534301A130
2.1 to 5.1	1 to 4	Tripp. dev. trigger pulse		1,6-2,4A	3ASD 534302A1004
6 to 9	1 to 4	Base dev. fan			3ASD 534301A130
6.1 to 9.1	1 to 4	Tripp. dev. fan	Fan connection: Y	2,4-4,0A	3ASD 534302A1005
	1 to 4	Tripp. dev. fan	Fan connection: D	6,0-10A	3ASD 534302A1007
6.2 to 9.2	1 to 4	Contactor block fan			3ASD 534301A137
6.3 to 9.3	1 to 4	Aux. contact fan			3ASD 534301A139
10 to 13	0 to 4	Base dev. pump			3ASD 534301A130
10.1 to 13.1	0 to 4	Tripp. dev. pump		0,4-0,6A	3ASD 534302A1001
	0 to 4	Tripp. dev. pump		0,6-1,0A	3ASD 534302A1002
	0 to 4	Tripp. dev. pump		1,0-1,6A	3ASD 534302A1003
	0 to 4	Tripp. dev. pump		1,6-2,4A	3ASD 534302A1004
	0 to 4	Tripp. dev. pump		2,4-4,0A	3ASD 534302A1005
10.2 to 13.2	0 to 4	Contactor block pump			3ASD 534301A137
10.3 to 13.3	0 to 4	Aux. contact pump			3ASD 534301A139
14 to 17	0 to 4	Base dev. external fan	Ext.fan 0,4-40A		3ASD 534301A130
14 to 17	0 to 4	D-O-line starter	Ext.fan 40-45A		3ASD 534401C1
14.1 to 17.1	0 to 4	Tripp. dev. external fan	Ext.fan 0,4-40A	0,4-0,6A	3ASD 534301A1001
	0 to 4	Tripp. dev. external fan	Ext.fan 0,4-40A	0,6-1,0A	3ASD 534301A1002
	0 to 4	Tripp. dev. external fan	Ext.fan 0,4-40A	1,0-1,6A	3ASD 534301A1003
	0 to 4	Tripp. dev. external fan	Ext.fan 0,4-40A	1,6-2,4A	3ASD 534301A1004
	0 to 4	Tripp. dev. external fan	Ext.fan 0,4-40A	2,4-4,0A	3ASD 534301A1005
	0 to 4	Tripp. dev. external fan	Ext.fan 0,4-40A	4,0-6,0A	3ASD 534301A1006
	0 to 4	Tripp. dev. external fan	Ext.fan 0,4-40A	6,0-10,0A	3ASD 534301A1007
	0 to 4	Tripp. dev. external fan	Ext.fan 0,4-40A	10,0-16,0A	3ASD 534301A1008
	0 to 4	Tripp. dev. external fan	Ext.fan 0,4-40A	16,0-25,0A	3ASD 534301A1009
	0 to 4	Tripp. dev. external fan	Ext.fan 0,4-40A	25,0-32,0A	3ASD 534301A1010
	0 to 4	Tripp. dev. external fan	Ext.fan 0,4-40A	32,0-40,0A	3ASD 534301A1011
14.2 to 17.2	0 to 4	Contactor block ext. fan	Ext.fan 0,4-40A		3ASD 534301A137
14.3 to 17.3	0 to 4	Aux. contact ext. fan	Ext.fan 0,4-40A		3ASD 534301A139
20	1	Transformer		SLMF 123	4781 020-ADU
21,22,23	3	Contactor		B9-30-10	FPL1411001R0104
21.1,22.1	2	Pneumatic timer		TP 40 I	FPTN477016R0008
25,26,27	0 to 3	Time relay	Ext.fan >40A		3ASD 563201A324
30,31	2	Capacitor		0,33 uF 10%	4984 220-2

Control module B2 3ASD 489306C1

Item	Qty	Name		Type / Data	Part number
6,7	2	Contactor		110V 40-60Hz	GJL1211001R0014
10	1	Terminal modem		YPK111A	YT 204 001-HH
31	1	Exp. I/O dig. input		YPI 103E	YT 204 001-FB
32	1	Exp. I/O dig. output		YPO 105E	YT 204 001-FR
33	1	Exp. I/O analog input		YPG 110E	YT 204 001-FD
34	1	Exp. I/O analog output		YPM 102E	YT 204 001-FL
35	1	Computer board		YPQ 201T	3ASD 299001B2
35.1	1	Memory board		DSRB01XX	3ASD 510001C2
	1	Memory board		DSTM01XX	3ASD 510001C3
35.2	1	DCB board		YPK 114B	3ASD 399002C4
36	1	Distribution board		YPC 111B	3ASD 510001C18
37	1	I/O board		YPQ 202A	YT 204 001-KB
41	1	MP-communication		YPK 107A	3ASD 489301A410
41.1,41.2	1 or 2	Modem board		YPC 104A	YT 204 001-BT
51	1	Transformer		SLTF 0070	3ASD 478101A302
52	1	Rectifier		YXE 152A	YT 204 001-AF
52.F1	1	Min fuse		6,3 A	5672 2011-22
52.F2	1	Min fuse		4,0 A	5672 2011-20

Control module B20 1) 3ASD 489306C6
6-pulse // 2) 3ASD 489306C126
12-pulse S 3) 3ASD 489306C165

Item	Qty	Name		Type / Data	Part number
1,4	1 1 2	Control circuit		YXM 187D	3ASD 510001C16
2	1	Conn.unit analog output		YPM 105A	YT 204 001-BH
3	1	Conn.unit analog input	2050A 1)	YPG 109AA	3ASD 489306C167
	1	Conn.unit analog input	2050A 1)	YPG 109AB	3ASD 489306C168
	1	Conn.unit analog input	2050A 1)	YPG 109AC	3ASD 489306C169
	1	Conn.unit analog input	2650A 1)	YPG 109AD	3ASD 489306C170
	1	Conn.unit analog input	3200A 1)	YPG 109AE	3ASD 489306C171
	1	Conn.unit analog input	3200A,6400A 1)	YPG 109AF	3ASD 489306C172
	1	Conn.unit analog input	3900,4000,8000A 1)	YPG 109AG	3ASD 489306C173
	1	Conn.unit analog input	5150A,10300A 1)	YPG 109AH	3ASD 489306C174
	1	Conn.unit analog input	4500,4750A 1)	YPG 109AJ	3ASD 489306C175
	1	Conn.unit analog input	4500,4750,4000A 1)	YPG 109AK	3ASD 489306C176
	1	Conn.unit analog input	5700A 1)	YPG 109AL	3ASD 489306C177
	1	Conn.unit analog input	5750A 2)	YPG 109AM	3ASD 489306C178
	1	Conn.unit analog input	5750A 2)	YPG 109AN	3ASD 489306C179
	1	Conn.unit analog input	7000A,7200A 2)	YPG 109AP	3ASD 489306C180
	1	Conn.unit analog input	8000A 2)	YPG 109AQ	3ASD 489306C181
	1	Conn.unit analog input	8100,8550A 2)	YPG 109AR	3ASD 489306C182
	1	Conn.unit analog input	8100,8550A 2)	YPG 109AS	3ASD 489306C183
	1	Conn.unit analog input	9250A 2)	YPG 109AT	3ASD 489306C184
	1	Conn.unit analog input	2050A 3)	YPG 109AU	3ASD 489306C185
	1	Conn.unit analog input	2050A 3)	YPG 109AV	3ASD 489306C186
	1	Conn.unit analog input	2050A 3)	YPG 109AX	3ASD 489306C187
	1	Conn.unit analog input	3200A 3)	YPG 109AY	3ASD 489306C188
	1	Conn.unit analog input	3200A 3)	YPG 109AZ	3ASD 489306C189
	1	Conn.unit analog input	5150A 3)	YPG 109BA	3ASD 489306C190
	1	Conn.unit analog input	4500,4750A 3)	YPG 109BB	3ASD 489306C191

	1	Conn.unit analog input	4500,4750A 3)	YPG 109BC	3ASD 489306C192
	1	Conn.unit analog input	5700A 3)	YPG 109BD	3ASD 489306C193
	1	Conn.unit analog input	2650A 3)	YPG 109BE	3ASD 489306C206
	1	Conn.unit analog input	3900A,4000A 3)	YPG 109BF	3ASD 489306C207
	1	Conn.unit analog input	3200A 1)	YPG 109BG	3ASD 489306C281
	1	Conn.unit analog input	3200A 3)	YPG 109BH	3ASD 489306C282
	1	Conn unit analog outp.	4000A, 8000A	YPG 109 BK	3ASD 489306C415
	1	Conn unit analog outp.	4000A,8000A	YPG 109 BL	3ASD 489306C416
	1	Conn unit analog outp.	7200A	YPG 109 BM	3ASD 489306C417
	1	Conn unit analog outp.	7200A	YPG 109 BN	3ASD 489306C418
	1	Conn unit analog outp.	4000A	YPG 109 BP	3ASD 489306C419
	1	Conn unit analog outp.	4000A	YPG 109 BR	3ASD 489306C420
5	1	Trigg. transformer		SLTF 0020	3ASD 478101C1
6	1	Contactor		110V 40-60Hz	GJL1211001R0014
8,9	1 or 2	Current feedback board	2050A	YXA 118D	3ASD 489306C112
	1 or 2	Current feedback board	2650A	YXA 118E	3ASD 489306C113
	1 or 2	Current feedback board	3200A	YXA 118F	3ASD 489306C114
	1 or 2	Current feedback board	3700A	YXA 118G	3ASD 489306C115
	1 or 2	Current feedback board	4000A	YXA 118H	3ASD 489306C116
	1 or 2	Current feedback board	4450A	YXA 118K	3ASD 489306C117
	1 or 2	Current feedback board	4500A	YXA 118L	3ASD 489306C118
	1 or 2	Current feedback board	4750A	YXA 118M	3ASD 489306C119
	1 or 2	Current feedback board	5700A	YXA 118N	3ASD 489306C120
10	1	Terminal modem		YPK 111A	YT 204 001-HH
31	1	Analog output		YPM 106E	YT 204 001-FN
33	1	Analog input		YPG 108E	YT 204 001-FV
35	1	Computer board		YPQ 201T	3ASD 299001B2
35.1	1	Memory board		CCX601XX	3ASD 510001C5
	1	Memory board	12-pulse synch.	CX1201XX	3ASD 510001C28
	1	Memory board	12-pulse seque.	CCXS01XX	3ASD 510001C6
35.2	1	DCB board		YPK 114B	3ASD 399002C4
36	1	Distribution board		YPC 111B	3ASD 489306C358
37	1	I/O board		YPQ 202A	YT 204 001-KB
38	0/0/1	Trigger pulse board		YPQ 203A	3ASD 510001C17
51	1	Transformer		SLTF 0070	3ASD 478101A302
52	1	Rectifier		YXE 152A	YT 204 001-AF
52.F1	1	Min fuse		6,3 A	5672 2011-22
52.F2	1	Min fuse		4,0 A	5672 2011-20

Convertor module B32 12-pulse P 2x6-pulse T 3ASD 489306C1

Item	Qty	Name		Type / Data	Part number
1	1	Control circuit		YXM 187D	3ASD 510001C16
2	1	Conn.unit analog output		YPM 105A	YT 204 001-BH
3	1	Conn.unit analog input	2050A	YPG 109AA	3ASD 489306C167
	1	Conn.unit analog input	2050A	YPG 109AB	3ASD 489306C168
	1	Conn.unit analog input	2050A	YPG 109AC	3ASD 489306C169
	1	Conn.unit analog input	2650A	YPG 109AD	3ASD 489306C170
	1	Conn.unit analog input	3200A	YPG 109AE	3ASD 489306C171
	1	Conn.unit analog input	3200A,6400A	YPG 109AF	3ASD 489306C172
	1	Conn.unit analog input	3900A,4000A,8000A	YPG 109AG	3ASD 489306C173
	1	Conn.unit analog input	5150A,10300A	YPG 109AH	3ASD 489306C174
	1	Conn.unit analog input	4500,4750A	YPG 109AJ	3ASD 489306C175
	1	Conn.unit analog input	4500,4750,4000A	YPG 109AK	3ASD 489306C176
	1	Conn.unit analog input	5700A	YPG 109AL	3ASD 489306C177
	1	Conn.unit analog input	3200A	YPG 109BG	3ASD 489306C281
5	1	Trigg. transformer		SLTF 0020	3ASD 478101C1
6	1	Contactor		110V 40-60Hz	GJL1211001R0014
8,9	1 or 2	Current feedback board	2050A	YXA 118D	3ASD 489306C112
	1 or 2	Current feedback board	2650A	YXA 118E	3ASD 489306C113
	1 or 2	Current feedback board	3200A	YXA 118F	3ASD 489306C114
	1 or 2	Current feedback board	3700A	YXA 118G	3ASD 489306C115
	1 or 2	Current feedback board	4000A	YXA 118H	3ASD 489306C116
	1 or 2	Current feedback board	4450A	YXA 118K	3ASD 489306C117
	1 or 2	Current feedback board	4500A	YXA 118L	3ASD 489306C118
	1 or 2	Current feedback board	4750A	YXA 118M	3ASD 489306C119
	1 or 2	Current feedback board	5700A	YXA 118N	3ASD 489306C120
10	1	Terminal modem		YPK111	YT 204 001-HH
31	1	Analog output		YPM 106E	YT 204 001-FN
33	1	Analog input		YPG 108E	YT 204 001-FV
35	1	Computer board		YPQ 201T	3ASD 299001B2
35.1	1	Memory board	12-p P, 2x6-p T	CCX601XX	3ASD 510001C5
35.2	1	DCB board		YPK 114B	3ASD 399002C4
37	1	I/O board		YPQ 202A	YT 204 001-KB
51	1	Transformer		SLTF 0070	3ASD 478101A302
52	1	Rectifier		YXE 152A	YT 204 001-AF
52.F1	1	Min. fuse		6,3 A	5672 2011-22
52.F2	1	Min. fuse		4,0 A	5672 2011-20

Terminal unit B50

Item	Qty	Name		Type / Data	Part number
31	1	Conn.unit digital input		YPI 105C	YT 204 001-BK
32	1	Conn.unit digital output		YPO 106A	YT 204 001-EG
33	1	Conn.unit analog input		YPG 106A	YT 204 001-BL
34	1	Conn.unit analog output		YPM 105A	YT 204 001-BH

Connection unit B53

Item	Qty	Name		Type / Data	Part number
1,2	1 or 2	Connection board		YPC 105A	YT 204 001-HE

Instrument door D1

YGMV/YGMW	3 instruments	3ASD 489306C26
YHMV/YHMW	3 instruments	3ASD 489306C28
YGMV/YGMW	5 instruments	3ASD 489306C48
YHMV/YHMW	5 instruments	3ASD 489306C49

Item	Qty	Name		Type / Data	Part number
1,4	1 alt 2	Voltmeter		10-0-10V DC	3ASD 569701C34
2,5	1 alt 2	Voltmeter	YGMV/YGMW	200%= 10V DC	3ASD 569701C15
	1 alt 2	Voltmeter	YHMV/YHMW	10-0-10V DC	3ASD 569701C35
3	1	Voltmeter		10-0-10V DC	3ASD 569701C34
6	1	Actuator		CBK	SK 616 227-A
6	1	Contact block			SK 616 001-B

Display unit E1 3ASD 489306C29

Item	Qty	Name		Type / Data	Part number
1	1	Display control		YPP 109A	YT 204 001-HS
2	1	Indication unit		YPN 107A	YT 204 001-DM
3	1	Illuminated display		YPN 104C	YT 204 001-DS
4	1	Membrane keyboard			5372 396-10

Display unit E2 3ASD 489306C29

Item	Qty	Name		Type / Data	Part number
1	1	Display control		YPP 109A	YT 204 001-HS
2	1	Indication unit		YPN 107A	YT 204 001-DM
3	1	Illuminated display		YPN 104C	YT 204 001-DS
4	1	Membrane keyboard			5372 396-10

Display unit E3 3ASD 489306C29

Item	Qty	Name		Type / Data	Part number
1	1	Display control		YPP 109A	YT 204 001-HS
2	1	Indication unit		YPN 107A	YT 204 001-DM
3	1	Illuminated display		YPN 104C	YT 204 001-DS
4	1	Membrane keyboard			5372 396-10

MCCB unit H1

Ext.fan 0,4-40A	3ASD 489301A251
Ext.fan >40A	3ASD 489301A283

Item	Qty	Name		Type / Data	Part number
1	1	MCCB breaker	Ext.fan 0,4-40A	125A	3ASD 534402A1009
	1	MCCB breaker	Ext.fan >40A	250A	3ASD 534403A1003
4	1	Frame transformer		ILDE 22,3 N=400	4762 079-5
4 1	1	Trans. suppr. diode			4856 210-213

Thyristor cubicle Y.3

Where quantities differ between single (YGMV,YGMW) and double (YHMV,YHMW) convertors, two alternatives are given YGM*/YHM*:

Fuse unit A13 3ASD 489306C134

Item	Qty	Name		Type / Data	Part number
1 to 5	5	Fuse		6A 1500V	5675 563-703
6 to 11	6	MP-capacitor		0,33 uF 10%	4984 220-2
12 to 14	3	Fuse		6A 1500V	5675 563-703

Heater element A40 3ASD 489301A425

Item	Qty	Name		Type / Data	Part number
1,2	2	Heater element		100W, 240V	5291 2011-30

Sync. transformer unit B8 3ASD 489306C150

Item	Qty	Name		Type / Data	Part number
1	1	Transformer		SLTF 0370	3ASD 478101C2

Current measuring unit B13 3ASD 489306C152

Item	Qty	Name		Type / Data	Part number
1,2	2	1-phase bridge		20A 400V	4858 267-4

Trigger pulse unit B15 YGMV/YGMW 3ASD 489306C105
YHMV/YHMW 3ASD 489306C106

Item	Qty	Name		Type / Data	Part number
1 1	1	Base unit		YXU 201A	3ASD 510001C9
1 2	1	Acceleration unit		YXU 202A	3ASD 510001C10
2 1	0/1	Base unit		YXU 201A	3ASD 510001C9
2 2	0/1	Acceleration unit		YXU 202A	3ASD 510001C10
3 51	1	Transformer		SLTF 0070	3ASD 478101A302
3 52	1	Aux. supply rectifier		YXE 152A	YT 204 001-AF
4	1	Relay			3ASD 563201C1
5 to 8	2 alt 4	Power resistor		3x22Ohm50W5%	3ASD 524503A222

Measuring unit B26

Uv0>=1000V	Current + voltage	3ASD 489306C103
Uv0>=1000V	Voltage	3ASD 489306C156
Uv0<1000V	Voltage	3ASD 489306C157
Uv0<1000V	Current + voltage	3ASD 489306C160

Item	Qty	Name		Type / Data	Part number
1	1	Insulation amplifier		60-100 mV	3ASD 569702C1
2	1	Insulation amplifier		1000 V	3ASD 569702C2
3,4	2	Resistor unit	Uv0>=1000V		3ASD 524501C1

Earth fault protection B30

Uv0=510-790V	YXZ 130F	3ASD 489306C121
Uv0=791-1190V	YXZ 130G	3ASD 489306C122

Item	Qty	Name		Type / Data	Part number
1	1	Earth fault protection		RAEUB	RK 667 011-AB
2 to 4	3	Resistor		33kOhm100W5%	5245 2564-533
5 to 7	3	Resistor	Uv0>790V	33kOhm100W5%	5245 2064-533

Resistor element F35

Item	Qty	Name		Type / Data	Part number
1	1	Resistor element		PT100	4276 500-1

Thyristor unit G1

Item	Qty	Name	Convertor	Type / Data	Part number
1 to 12	6 alt 12	Thyristor	2050A, 510V	WE 540,P18	3ASD 485512A1800
	6 alt 12	Thyristor	3200,4450A, 510V	YST 35-01,P18	3ASD 485505A1800
	6 alt 12	Thyristor	5700A, 510V	YST 60-25,P18	3ASD 485510C1800
	6 alt 12	Thyristor	2050A 670/790V	YST 14-202,P28	3ASD 485504A2800
	6 alt 12	Thyristor	3200A 670/790V	YST 35-22,P28	3ASD 485505A2800
	6 alt 12	Thyristor	4500A 670/790V	YST 45-26,P28	3ASD 485507A2800
	6 alt 12	Thyristor	4750A 670/790V	YST 60-25,P28	3ASD 485510A2800
	6 alt 12	Thyristor	2050,2650A 1000V	YST 35-21,P36	3ASD 485505A3600
	6 alt 12	Thyristor	3700A 1000V	YST 45-27,P36	3ASD 485507C3600
	6 alt 12	Thyristor	4000A 1000V	YST 60-21,P36	3ASD 485509B3600
	6 alt 12	Thyristor	2050,2650,3200A	YST 45-27,P42	3ASD 485507A4200
	6 alt 12	Thyristor	4000A 1190V	YST 60-21,P42	3ASD 485509A4200
13-16	6	Semiconductor fuse	2050A 510V	1100A 660V	5675 582-528
	6	Semiconductor fuse	3200,4450A, 510V	2500A 660V	5675 582-537
	6	Semiconductor fuse	5700A, 510V	3000A 660V	5675 582-540
	6	Semiconductor fuse	2050A 670/790V	1100A 1000V	5675 582-628
	6	Semiconductor fuse	3200A 670/790V	1700A 1000V	5675 582-632
	6	Semiconductor fuse	4500A 670/790V	2500A 1000V	5675 582-638
	6	Semiconductor fuse	4750A 670/790V	2500A 1000V	5675 582-638
	6	Semiconductor fuse	2050,2650A 1000V	1500A 1250V	5675 582-732
	6	Semiconductor fuse	3700A 1000V	2000A 1250V	5675 582-735
	6	Semiconductor fuse	4000A 1000V	2100A 1500V	5675 582-935
	6	Semiconductor fuse	2050,2650,3200A	1700A 1500V	5675 582-932
	6	Semiconductor fuse	4000A 1190V	2100A 1500V	5675 582-935
19-24	6	Capacitor	510V	1,5uF10%850VAC	4984 220-6
	6	Capacitor	670-1190V	1,1uF10%2,0kVAC	4984 305-1
25-30	6	Power resistor	510V	20 Ohm 900W5%	5245 0053-2
	12	Power resistor	670-1190V	55 Ohm 900W5%	5245 0053-4
11	1	Shunt		60 mV 4000A	5697 0001-23
35,36,37	2 alt 3	Current transformer			3AST 478115B3
50	1	Fan		380/660V 3,8kW	6480 221-2
61-72	6 alt 12	Transformer		SHPC 42	4783 335-V
75	1	Pressure switch		80-600pA 250VAC	3ASD 566301B1

Thyristor cubicle Y.4

Where quantities differ between single (YGMV,YGMW) and double (YHMV,YHMW) convertors, two alternatives are given YGM*/YHM*:

Fuse unit A13 3ASD 489306C136

Item	Qty	Name		Type / Data	Part number
1 to 5	5	Fuse		6A 1500V	5675 563-703
6 to 11	6	MP-capacitor		0,33 uF 10%	4984 220-2
12 to 14	3	Fuse		6A 1500V	5675 563-703

Heater element A40 3ASD 489301A425

Item	Qty	Name		Type / Data	Part number
1,2	2	Heater element		100W, 240V	5291 2011-30

Sync. transformer unit B8 3ASD 489306C150

Item	Qty	Name		Type / Data	Part number
1	1	Transformer		SLTF 0370	3ASD 478101C2

Current measuring unit B13 3ASD 489306C152

Item	Qty	Name		Type / Data	Part number
1,2	2	1-phase bridge		20A 400V	4858 267-4

Trigger pulse unit B15 YGMV/YGMW 3ASD 489306C105
YHMV/YHMW 3ASD 489306C106

Item	Qty	Name		Type / Data	Part number
1 1	1	Base unit		YXU 201A	3ASD 510001C9
1 2	1	Acceleration unit		YXU 202A	3ASD 510001C10
2 1	0/1	Base unit		YXU 201A	3ASD 510001C9
2 2	0/1	Acceleration unit		YXU 202A	3ASD 510001C10
3 51	1	Transformer		SLTF 0070	3ASD 478101A302
3 52	1	Aux. supply rectifier		YXE 152A	YT 204 001-AF
4	1	Relay			3ASD 563201C1
5 to 8	2 alt 4	Power resistor		3x22 Ohm50W5%	3ASD 524503A222

Measuring unit B26

Uv0>=1000V	Current + voltage	3ASD 489306C103
Uv0>=1000V	Voltage	3ASD 489306C156
Uv0<1000V	Voltage	3ASD 489306C157
Uv0<1000V	Current + voltage	3ASD 489306C160
	Current	3ASD 489306C132

Item	Qty	Name		Type / Data	Part number
1	1	Insulation amplifier		60-100 mV	3ASD 569702C1
2	1	Insulation amplifier		1000 V	3ASD 569702C2
3,4	2	Resistor unit	Uv0>=1000V		3ASD 524501C1

Earth fault protection B30

			Uv0=510-790V	YXZ 130H	3ASD 489306C246
			Uv0=791-1190V	YXZ 130K	3ASD 489306C247
Item	Qty	Name		Type / Data	Part number
1	1	Earth fault protection	YXZ 130F,G	RAEUB	RK 667 011-AB
2 to 4	3	Resistor		33kOhm 100W5%	5245 2564-533
5 to 7	3	Resistor	Uv0>790V	33kOhm 100W5%	5245 2064-533

Resistor element F35

Item	Qty	Name		Type / Data	Part number
1	1	Resistor element		PT100	4276 500-1

Thyristor unit G1

Item	Qty	Name	Convertor	Type / Data	Part number
1 to 12	6 alt 12	Thyristor	2050A, 510V	WE 540,P18	3ASD 485512A1800
	6 alt 12	Thyristor	3200,4450A, 510V	YST 35-01,P18	3ASD 485505A1800
	6 alt 12	Thyristor	5700A, 510V	YST 60-25,P18	3ASD 485510C1800
	6 alt 12	Thyristor	2050A 670/790V	YST 14-202,P28	3ASD 485504A2800
	6 alt 12	Thyristor	3200A 670/790V	YST 35-22,P28	3ASD 485505A2800
	6 alt 12	Thyristor	4500A 670/790V	YST 45-26,P28	3ASD 485507A2800
	6 alt 12	Thyristor	4750A 670/790V	YST 60-25,P28	3ASD 485510A2800
	6 alt 12	Thyristor	2050,2650A 1000V	YST 35-21,P36	3ASD 485505A3600
	6 alt 12	Thyristor	3700A 1000V	YST 45-27,P36	3ASD 485507C3600
	6 alt 12	Thyristor	4000A 1000V	YST 60-21,P36	3ASD 485509B3600
	6 alt 12	Thyristor	2050,2650,3200A	YST 45-27,P42	3ASD 485507A4200
	6 alt 12	Thyristor	4000A 1190V	YST 60-21,P42	3ASD 485509A4200
13-16	6	Semiconductor fuse	2050A 510V	1100A 660V	5675 582-528
	6	Semiconductor fuse	3200,4450A, 510V	2500A 660V	5675 582-537
	6	Semiconductor fuse	5700A, 510V	3000A 660V	5675 582-540
	6	Semiconductor fuse	2050A 670/790V	1100A 1000V	5675 582-628
	6	Semiconductor fuse	3200A 670/790V	1700A 1000V	5675 582-632
	6	Semiconductor fuse	4500A 670/790V	2500A 1000V	5675 582-638
	6	Semiconductor fuse	4750A 670/790V	2500A 1000V	5675 582-638
	6	Semiconductor fuse	2050,2650A 1000V	1500A 1250V	5675 582-732
	6	Semiconductor fuse	3700A 1000V	2000A 1250V	5675 582-735
	6	Semiconductor fuse	4000A 1000V	2100A 1500V	5675 582-935
	6	Semiconductor fuse	2050,2650,3200A	1700A 1500V	5675 582-932
	6	Semiconductor fuse	4000A 1190V	2100A 1500V	5675 582-935
19-24	6	Capacitor	510V	1,5uF10%850VAC	4984 220-6
	6	Capacitor	670-1190V	1,1uF10%2,0kVAC	4984 305-1
25-30	6	Power resistor	510V	20 Ohm 900W 5%	5245 0053-2
	12	Power resistor	670-1190V	55 Ohm 900W 5%	5245 0053-4
34	1	Shunt		60 mV 4000A	5697 0001-23
35,36,37	2 alt 3	Current transformer			3AST 478115B3
50	1	Fan		380/660V 3,8kW	6480 221-2
61-72	6 alt 12	Transformer		SHPC 42	4783 335-V
75	1	Pressure switch		80-600pA 250VAC	3ASD 566301B1

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User's manual,Edition 3
Reg. nr. 3ASD 4890 04C 1032
94 - 10 - 10
To be ordered from
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DPO.