UN 5000 User's manual

Chapter 4

Part 2
Device Settings

Contents:

4 Configuration and Settings

4.2 Device Settings

The following picture shows the principle arrangement of the hardware devices of the UNITROL® 5000 double channel system.

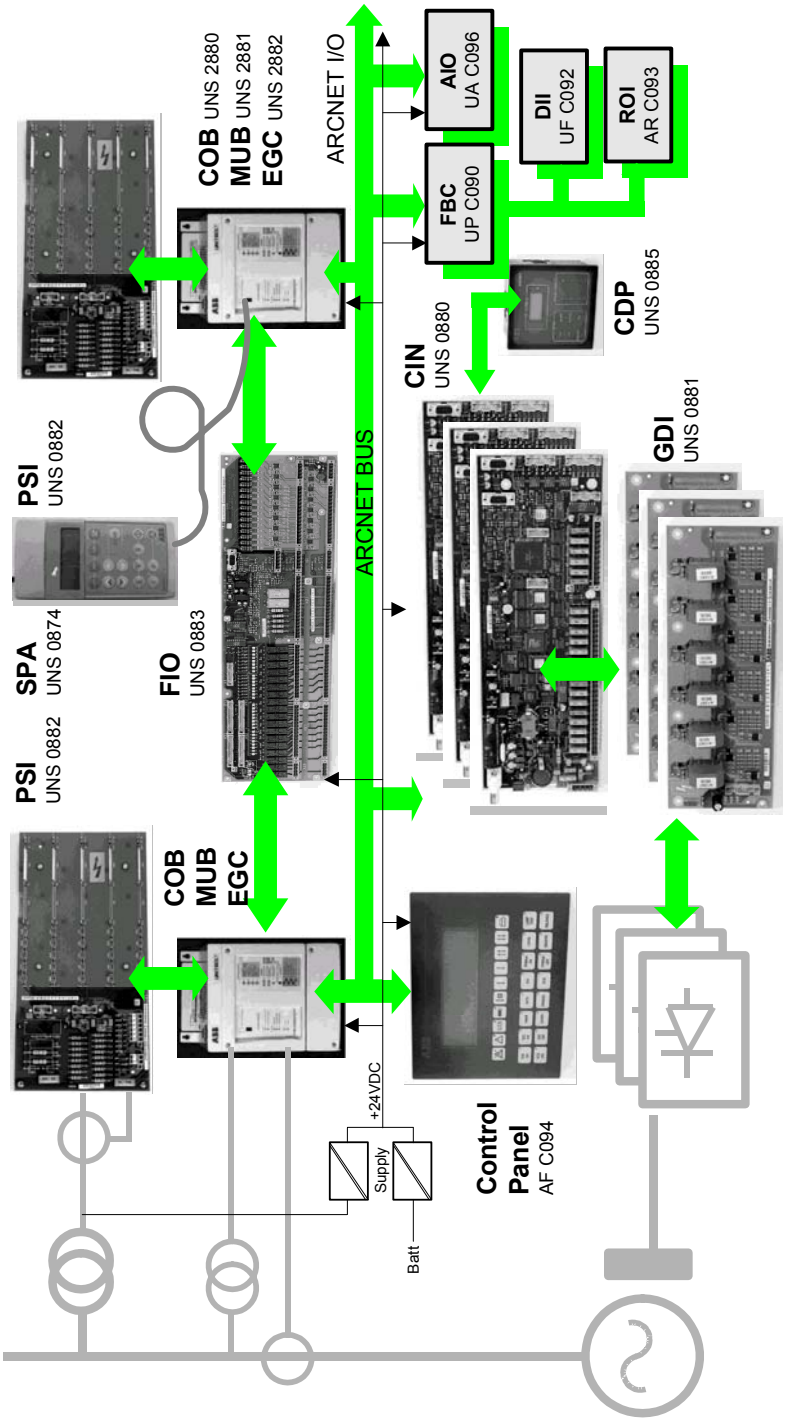


Fig. 4.2-1 Device Arrangement of UNITROL® 5000

4.2.1 Available devices in the UN 5000 system

Type designation for UN 5000 devices

Abbreviation	Type	English name	German name
Control Boards, Gate Controllers			
COB	UNS 2880a-P, V1/V2	Control Board	Rechengerät
MUB	UNS 2881a-P, V1	Measuring Unit Board	Messwerterfassung
EGC	UNS 2882a-P, V1/V2	Extended Gate Controller	Erweiterter Steuersatz
HIR	UNS 2861b-P, V1	Gate Controller 400 Hz	Steuersatz 400 Hz
Interface Boards, input/output devices			
CIN	UNS 0880a-P, V1	Converter Interface	Stromrichterelektronik
GDI	UNS 0881a-P, V1/V2	Gate Driver Interface	Impulsendstufe
PSI	UNS 0882a-P, V1	Power Signal Interface	Messwerterfassung Leistungskreis
FIO	UNS 0883a-P, V1	Fast I/O	Schnelle Ein/Ausgabe
CUS	UNS 0884a-P, V1/V2	Current Sensor	Stromerfassung
SIO	UNS 0886a-P, V1	Small I/O	Ein/Ausgabe 4-fach
AIO	UA C096 AE, V1	Analog In/Out FB-Interface	Analoge Ein/Ausgabe am Feldbus
ROI	AR C093 AE, V1	Relay Output Interface	Relais Ausgabe
DII	UF C092 AE, V1	Digital Input Interface	Digitale Eingabe
LBI	UNC 4674b-P	Local Bus Interface	Uebergabe-Modul
FIU38	UNS 0017a-P,V1	Firing Unit to Crowbar	Zündeiheit zu Crowbar 3800V
FIU14	UNS 0007a-P,V1	Firing Unit to Crowbar	Zündeiheit zu Crowbar 1400V
Panels, display devices			
CDP	UNS 0885a-P, V1	Converter Display	Converter Anzeige
SPA	UNS 0874a-P	Service Panel	Service Panel
LCP	AF C094, V2	Local Control Panel	Lokales Bedien Panel
Fieldbus couplers			
FBC	UP C090 AE	Fieldbus Coupler	Feldbus Koppler
OBI	UP C325 AE	Optical Bus Interface	Optisches Bus Interface
Communication modules			
AC 70	AC70BAS	Advant Controller 70	Advant Controller 70
FCI	CI810V1	Field Commun. Interface	Field Commun. Interface
MBA	NMBA-01	Modbus Adapter	Modbus Adapter
MBP	NMBP-01	Modbus Plus Adapter	Modbus Plus Adapter
PBA	NPBA-02	Profibus Adapter	Profibus Adapter
CMT	CMT/DCS500-Tool	Commissioning and maintenance tool	Commissioning and maintenance tool
GAD	GAD-Tool	Graphical Application Designer	Graphical Application Designer

Normally, the English device names are used.

The English device names always start with a capital letter, from which the capitalised abbreviations are derived.

4.2.2 Device Designation (Screen print with detailed information)

The used devices are marked with a special screen print.

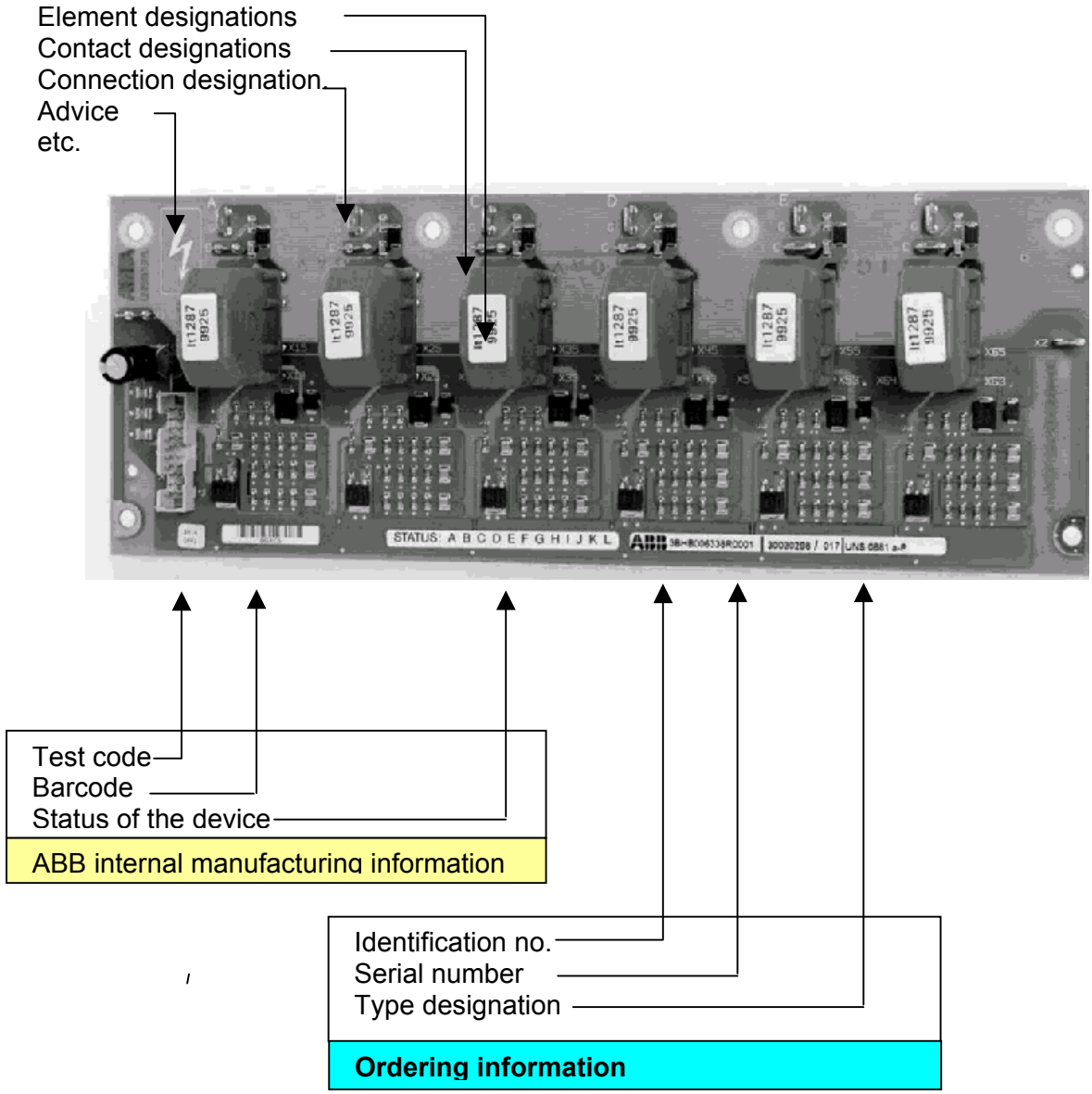


Fig. 4.2-2 Device Designation

4.2.2.1 Ordering information

When ordering devices, the following must be stated:

- Identification number
- Type designation

For repairs, the following must be stated:

- Identification number
- Serial number
- Type designation

4.2.3 ARCnet node addresses

In the UN 5000 system each device on the internal ARCnet fieldbus has a specific node addresse. These addresses are the most important settings because wrongly adjusted adresses are the major cause for communication problems on the ARCnet.

Additional settings are explained in the following chapters.

Node-Addresses of ARCnet-Devices			Minimal Config.	OPTIONAL
Device	Node No. [Hex] HB LB	Node No. [Dez]		
COB CH1	0 1	1	X	
COB CH2	0 2	2		X
AF C094 LOCAL	0 A	10		X
AF C094 REMOTE	0 B	11		X
CIN Conv.1	3 1	49	X	
CIN Conv.2	3 2	50		X
CIN Conv.3	3 3	51		X
CIN Conv.4	3 4	52		X
CIN Conv.5	3 5	53		X
CIN Conv.6	3 6	54		X
CIN Conv.7	3 7	55		X
CIN Conv.8	3 8	56		X
CIN Conv.neg (*)	3 A	58		X
UP C090 Digital I/O 1	2 1	33		X
UP C090 Digital I/O 2	2 2	34		X
UP C090 Digital I/O 3	2 3	35		X
UP C090 Digital I/O 4	2 4	36		X
UA C096 Analog I/O 1	1 1	17		X
UA C096 Analog I/O 2	1 2	18		X

(*) Optional antiparallel converter
for 4-quadrant applications

Fig. 4.2-3 Node addresses

The node addresses are set using

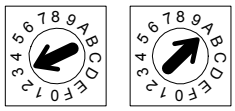
- Hex rotary switches or
- DIL slider switches

Adjustment with Hex switches

The node no. is set in hexadecimal representation

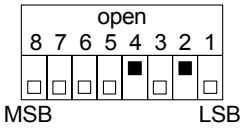
HB High Byte 0.....F [Hex]

LB Low Byte 0.....F [Hex]



Adjustment with DIL switches

The node no. is set in binary representation



binary weight of each switch (open = log. 1)

switch	1	2	3	4	5	6	7	8
weight	1	2	4	8	16	32	64	128
	LSB							MSB

LSB: Least Significant Bit

MSB: Most Significant Bit

Note	It is essential that the node addresses are set correctly. Other node addresses lead to a breakdown in communications.

4.2.4 Control Board UNS 2880a-P (COB)

4.2.4.1 Features

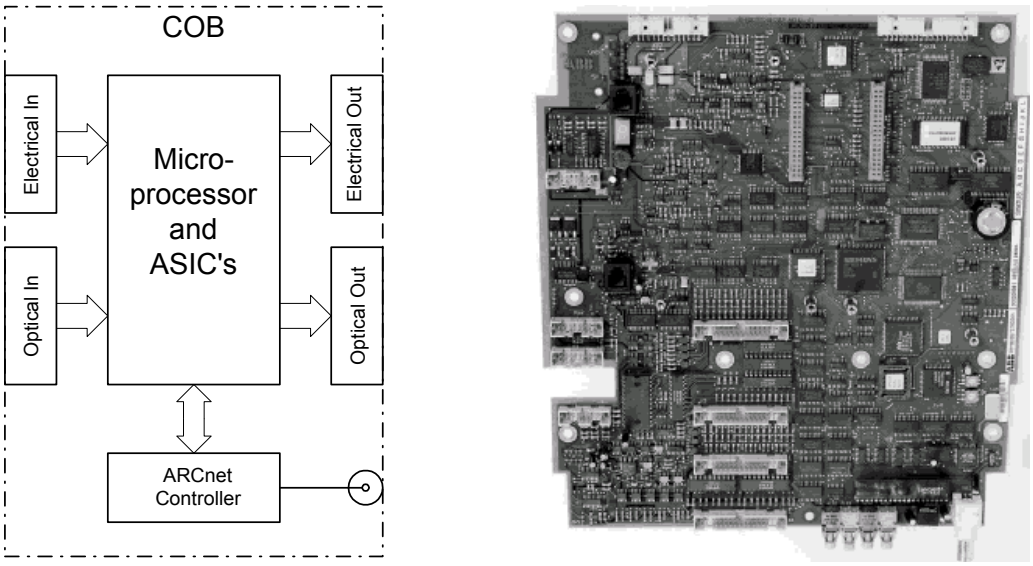


Fig. 4.2-4 Block diagram and view of control board COB

The COB (Control Board) is the central processing unit of the system. It contains the software for sequence control, all the control loops (regulators) as well as the protection and monitoring functions. Further, the so called gate control unit is included in the COB which serves to generate the firing pulses to the power converters.

The entire software is represented in the software diagram (see chapter 10 of this manual). It is configured and adapted to the specific needs of your application by means of parameters. The complete parameterlist is appended in chapter 11.

There are several ways to communicate with the COB for parameter adjustment. They are described in chapter 3.

During normal operation, all parameter values are stored in volatile memory (RAM). For permanent storage, Flash-PROM are provided. The procedure for back-up storage is also described in chapter 3. The volatile memory (RAM) also contains the fault-logger information. This information is retained for 2 days after a complete failure of the power supply.

More properties:

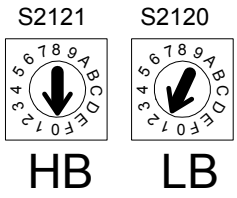
- ARCnet fieldbus controller
- Communication with service panel UNS 0874
- Optical communication interface to CMT tool
- Optical communication interface to various fieldbus couplers (Modbus, Profibus, Advant, etc.)
- Flat cable connections to the devices MUB, FIO, PSI, CIN and EGC
- Optical status display of the board condition and display of last error number by means of seven-segment display (Axxx)
- Optical status display of the ARCnet condition by means of seven-segment display

4.2.4.2 Device settings

The COB is mainly configured using software parameters which can be set with either the CMT or SPT tools (see chapter 3). However, some adjustments like the ARCnet node address and the frequency setting for the gate control unit must be done manually with the aid of jumpers and switches directly on the board.

ARCnet node addresses

AVR-channel	HB	LB
Channel 1: = COB 1	**0**	**1**
Channel 2: = COB 2	**0**	**2**



Note	It is essential that the node addresses are set correctly. Other node addresses lead to a breakdown in communications.

Temperature measurement with PSI

S3: 1-2	Temperature measurement with UNS 2861b (Type C7) Analogue input at connector X12. 2	open
S3: 3-4	Analogue input for shunt measurement on PSI	jumper

16 2/3 Hz excitation systems

S2: 7-8	16 2/3 Hz excitation systems External synchronisation pulse from EGC to X5:7	open
S2: 9-10	Normal 50/60 Hz application	jumper

R 6246 + R 6249	Field voltage 3-phase, 50/60 Hz	Resistor in place
	Field voltage 1-phase, 16 2/3 Hz	Resistor out

Only for internal use

S2: 1-2	Only used for factory tests	open
S2: 3-4	Normal mode	jumper
S2: 5-6	Only used for factory tests	open
S1: 1-10	Only used for factory tests	open

4.2.4.3 Position of setting elements

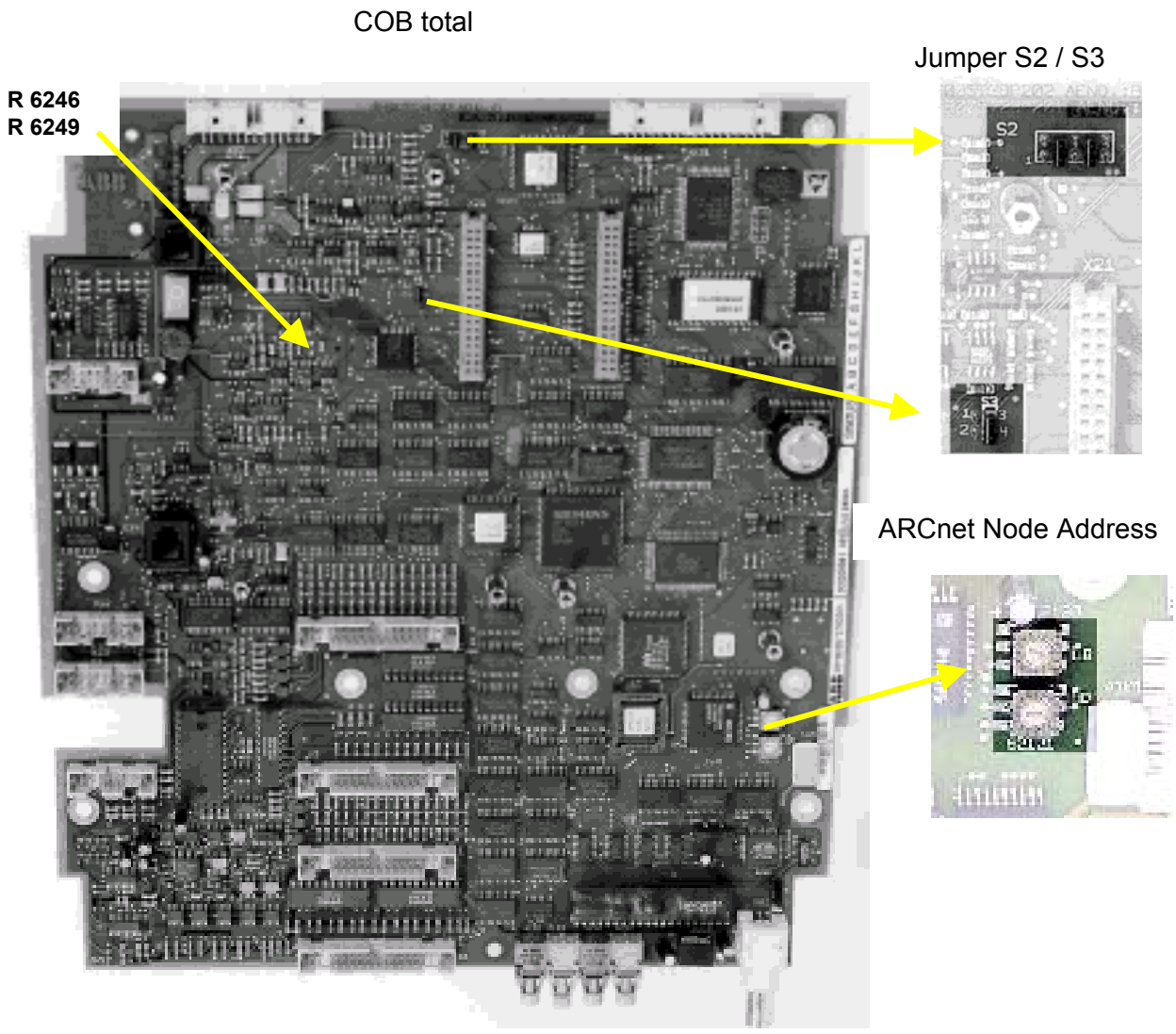


Fig. 4.2-5 Position of setting elements on control board COB

4.2.5 Signal measuring unit UNS 2881a-P (MUB)

4.2.5.1 Features

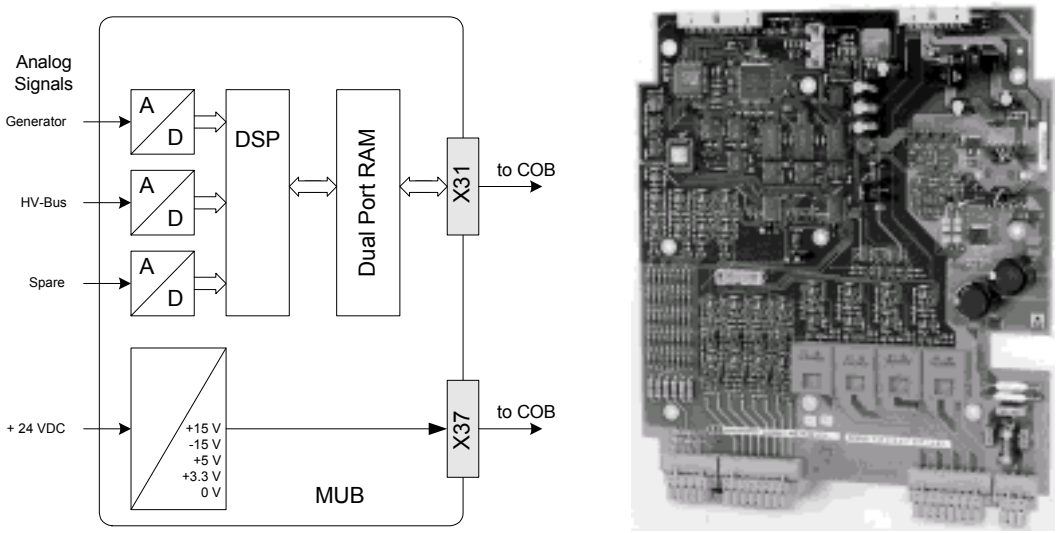


Fig. 4.2-6 Block diagram and view of signal measuring unit MUB

The MUB board (Measuring Unit Board) is used to measure and condition the machine stator values. 3 Phase machine voltage and current are measured directly. Other values like active power, reactive power, frequency and RMS values for current and voltage are calculated from these signals. Single phase measurement is also possible. Two additional inputs can be used to sense voltage and current of the tie line.

The MUB also contains some additional functions which require fast signal processing, i.e. the so called power system stabilizer (PSS) and a monitoring function for rotating diodes in an indirect excitation system. Further, there is a P.T. monitoring function included.

The MUB also serves as a power supply unit for the COB and FIO boards. It creates all internally used voltages from a centralized 24V supply.

Most adjustments on the MUB are software parameters and are set via the COB board just like COB parameters. They are written down in the software drawing and the parameter list (see chapters 10 and 11).

More properties:

- Measurement of machine voltage and machine current from external voltage and current transformers. Voltage inputs have high input resistance (5MΩ) and do not provide internal voltage transformers
- Frequency range 16 2/3 Hz ... 60 Hz
- Digital signal processing using 24 bit DSP (digital signal processor)
- PT-fail and other monitoring functions.

4.2.5.2 Device settings

Most inputs of the MUB can be scaled by software. Only the spare inputs 1 to 4 must be configured by jumpers:

Analogue inputs Res1.....Res4

Voltage measurement : ± 10V

internal signal representation ±100%

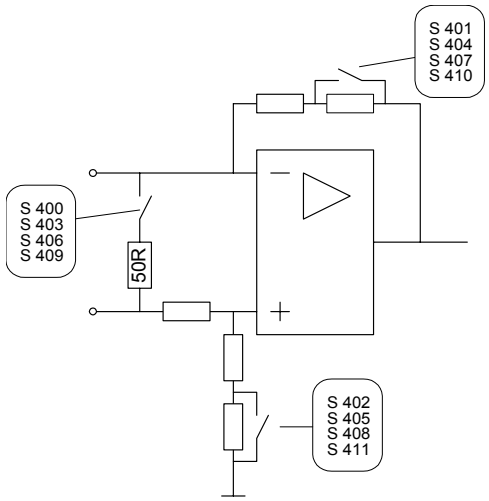
gain = 0.5

Current measurement : ± 20 mA

internal signal representation ±100%

resistor: 50 Ohm

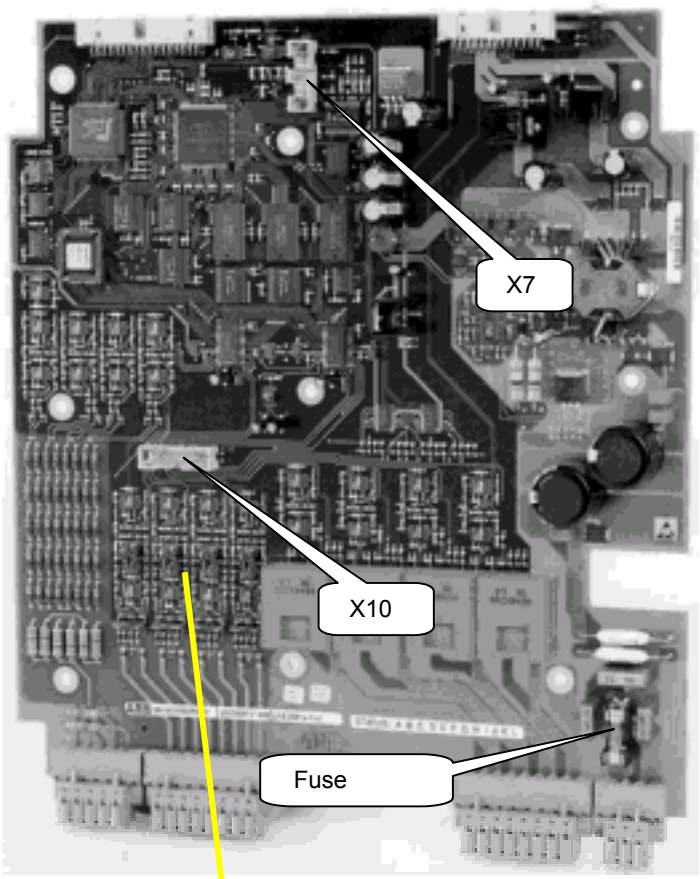
gain = 5

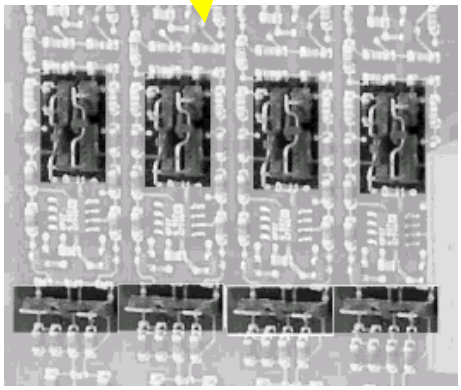


setting of switches S400…S411

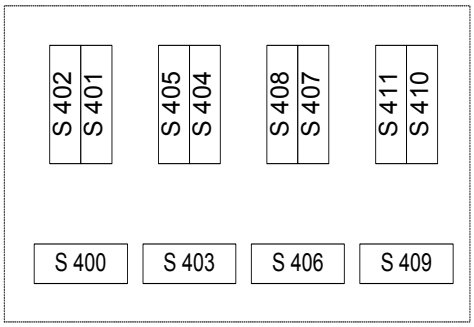
Input	Voltage measurement		Current measurement	
	Switch open	Switch closed	Switch open	Switch closed
Res. 1	S400	S401, S402	S401, S402	S400
Res. 2	S403	S404, S405	S404, S405	S403
Res. 3	S406	S407, S408	S407, S408	S406
Res. 4	S409	S410, S411	S410, S411	S409

4.2.5.3 Position of the setting elements





Position switches S400…S411



Additional elements

Fuse	Fuse 5x20	2 A slow, for power supply to MUB + COB
Connector X7	Only for internal use (autom. factory test)	
Connector X10	Only for internal use (stimulation connections for dig. generator model)	

Fig. 4.2-7 Position of the setting elements on signal measuring unit MUB

4.2.6 Converter Interface UNS 0880a-P (CIN)

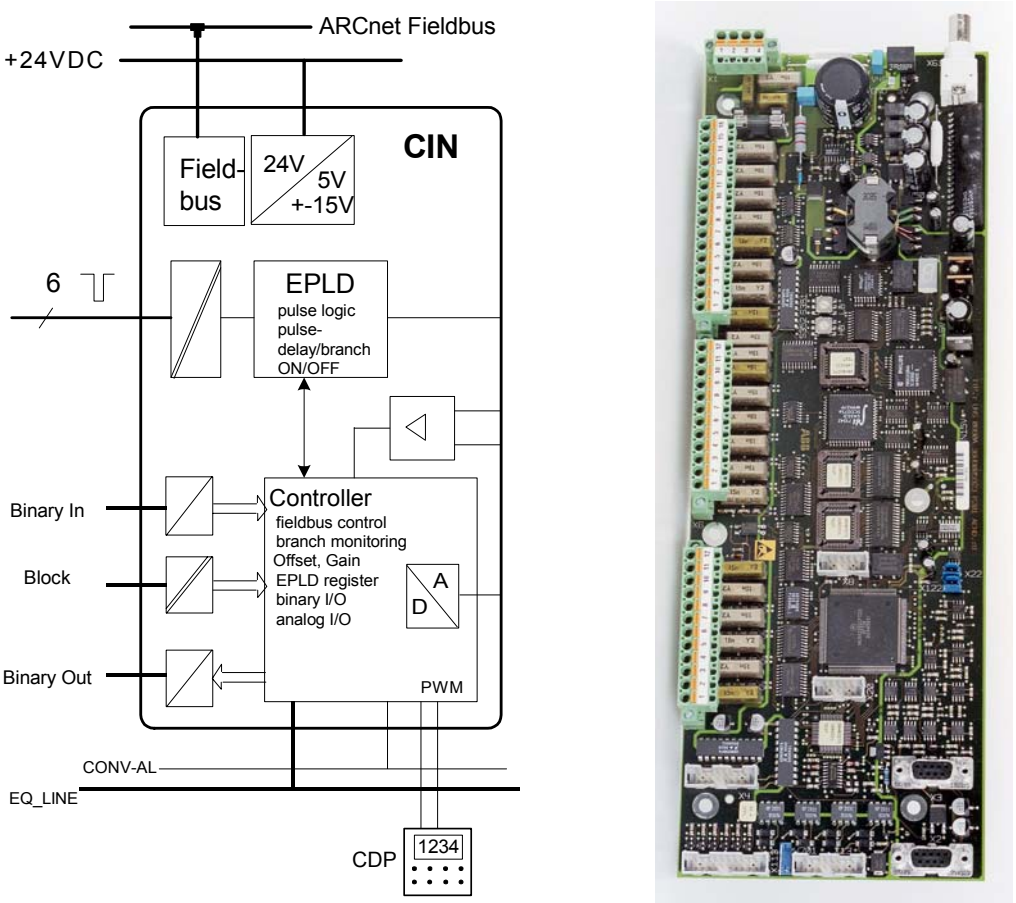


Fig. 4.2-8 Block diagram and view of converter interface CIN

4.2.6.1 Features

In addition to the central processing board COB, the CIN boards (Converter Interface) provide decentralized control logic which is related to the power converters. Each CIN contains the control and monitoring functions for one converter bridge, e.g. fan control and air flow monitoring, temperature monitoring etc. In case of a fault the respective bridge will be disabled automatically.

Communication between COB and CIN is done via the serial ARCnet link using a single coaxial cable. Firing pulses from the gate control part of the COB are transmitted via a ribbon cable.

The CIN also features an automatic current sharing function. For this purpose, an equalization line is connected to all CIN. With this signal, the CIN can calculate the deviation of each individual branch current from the average value.

Most settings on the CIN are software parameters and are adjusted via the COB board just like COB parameters.

More properties:

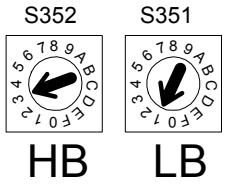
- Power supply from +24VDC supply bus.
- Galvanically isolated sensing of the firing pulses from the COB.
- Generation of the firing pulse chains for the Gate Driver GDI.
- Converter blocking input (galv. isolated).
- 10 binary inputs.
- 8 binary outputs 24VDC.
- 2 measuring inputs for KTY10 temperature measurement.
- Conduction monitoring (evaluation of the Hall probes at the two outputs).
- Active current balancing regulation between parallel converter bridges through individual firing pulse delay for each branch.
- Display of branch failure and bridge status on sep. Converter Display (CDP).
- LCD display of the entire bridge current on the Converter Display CDP.

4.2.6.2 Device settings

Most settings on the CIN are done with the CMT or SPT tools. However, some converter monitoring functions are completely independent from the COB. Therefore, the bridge configuration must be adjusted using a jumper.

CIN: ARCnet node addresses

CIN of converter (n)	**HB**	**LB**
CIN of converter No. 1	3	1
CIN of converter No. 2	3	2
CIN of converter No. 3	3	3
CIN of converter No. 4	3	4
CIN of converter No. 5	3	5
CIN of converter No. 6	3	6
CIN of converter No. 7	3	7
CIN of converter No. 8	3	8
CIN of the antiparallel converter	3	A



Note	It is essential that the node addresses are set correctly. Other node addresses lead to a breakdown in communications.

Converter configurations

Configuration : **E** Economic – 1 converter

Configuration : **S** Standard – (n-1) redundancy

Configuration : **T** Twin – (1+1) redundancy (100% converter redundancy)

Configuration : **N** Negative converter bridge

Setting for each converter with W 701

Config	Conv. no. 1	Conv. no. 2	Conv. no.(n)	Antiparallel Neg. Conv.
E	1-2	--	--	--
S	1-2	1-2	1-2	--
T	1-2	1-3	--	--
N	1-2	1-2	1-2	1-3

Fuse

F 5 Fuse 5x20 2A slow

4.2.6.3 Position of the setting elements

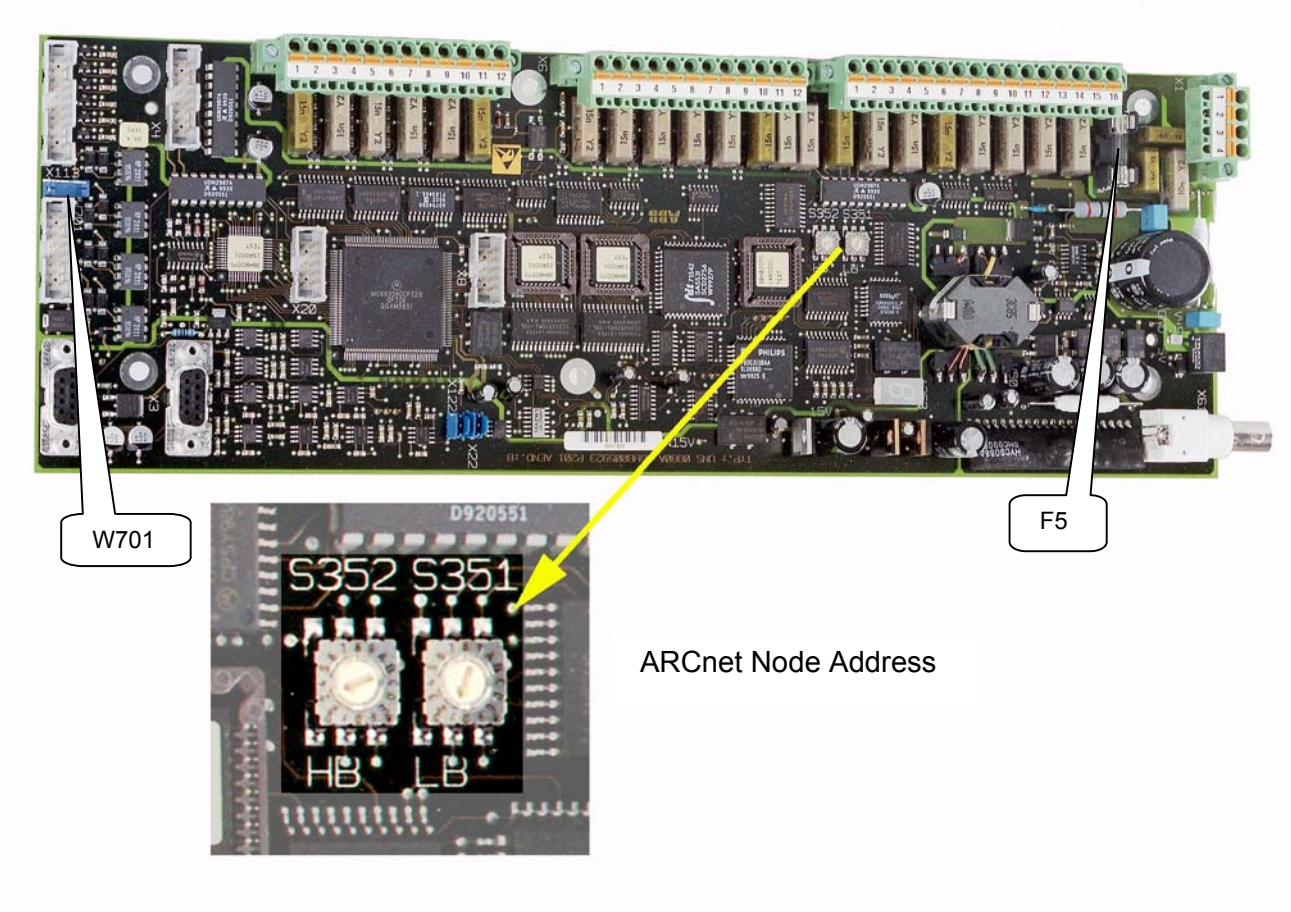


Fig. 4.2-9 Position of the setting elements on converter interface CIN

4.2.7 Gate Driver Interface UNS 0881a-P, V1/V2 (GDI)

4.2.7.1 Features

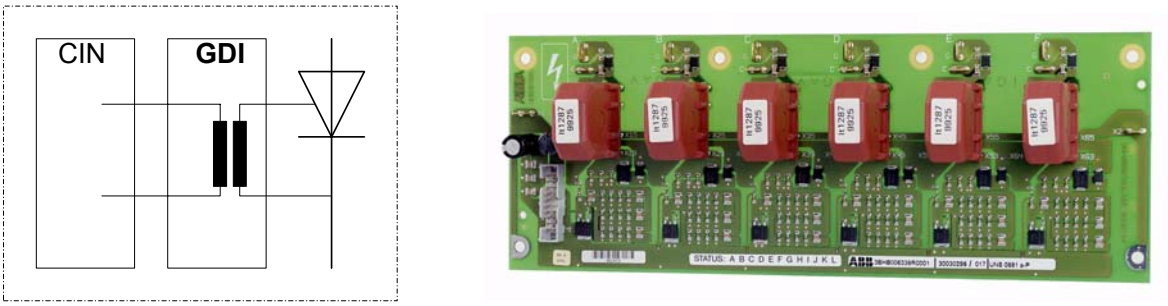


Fig. 4.2-10 Block diagram and view of Gate Driver Interface GDI

The GDI (Gate Driver Interface) contains the power amplifiers and impulse transformers for a complete 6 pulse thyristor bridge. Alternatively, a 2 pulse bridge can also be controlled. The GDI serves to separate the control and power parts of the sytem galvanically.

- Interface for disk type thyristors of 1.5 up to 4 inches in size
- Transmission of 62 kHz pulse train
- Variant 1 with 5 kV pulse transmitter
- Variant 2 for external 8 kV pulse transmitter
- Flat cable connection to CIN (Converter Interface)
- Twisted pair connection to each thyristor

4.2.7.2 Device settings

No settings need to be carried out on the Gate Driver Interface (GDI) UNS 0881.

Assignment of the bridge branches

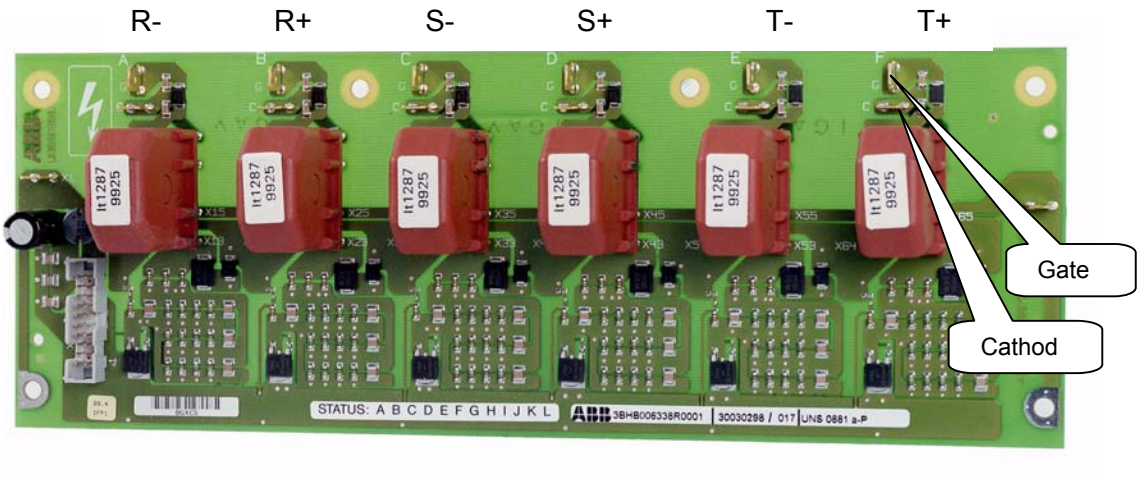


Fig. 4.2-11 Bridge branches on Gate Driver Interface GDI

4.2.8 Power Signal Interface UNS 0882a-P (PSI)

4.2.8.1 Features

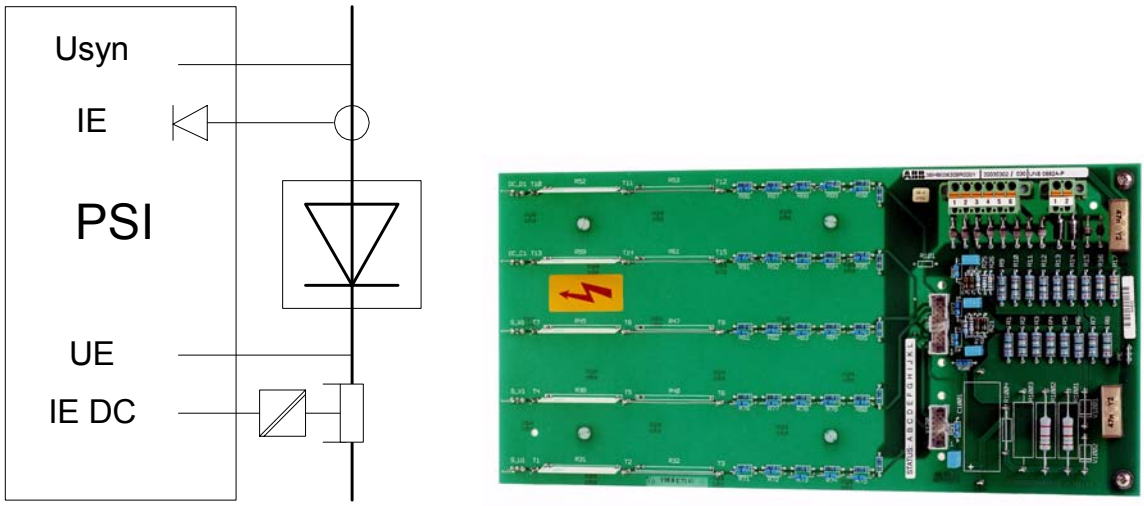


Fig. 4.2-12 Block diagram and view of Power Signal Interface PSI

The PSI (Power Signal Interface) board is used to measure the signals related to the power part of the excitation system, i.e. the input and output voltages of the power converters, the total input current and if required also the output current.

The input current is measured using current transformers. For the output current an extra shunt resistor and measurement transducer are required.

All voltage inputs have a high input resistance (5MΩ) and do not use internal voltage transformers.

More features:

- Connection to the COB using ribbon cable

4.2.8.2 Schematic circuit diagram

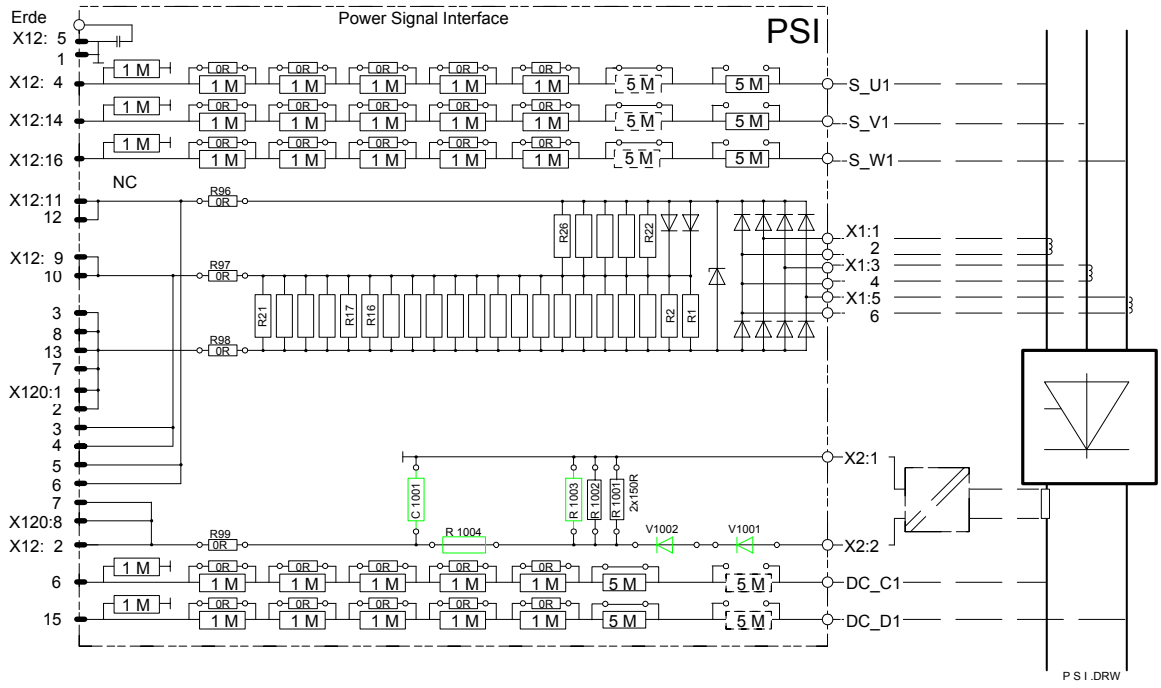


Fig. 4.2-13 Schematic circuit diagram of Power Signal Interface PSI

4.2.8.3 Device settings

Voltage measurement (installed resistors)

Usyn **U EXC SENSE V** **(Par. 508)** **UE**	R71 R76 R81 R86,R91	R72 R77 R82 R87,R92	R73 R78 R83 R88,R93	R74 R79 R84 R89,R94	R75 R80 R85 R90,R95	R32 R40 R47 R53,R61
(*) 500 VAC	Bridge	Bridge	Bridge	Bridge	Bridge	Bridge
600 VAC	Resistor	Bridge	Bridge	Bridge	Bridge	Bridge
700 VAC	Resistor	Resistor	Bridge	Bridge	Zero-Ohm	Bridge
800 VAC	Resistor	Resistor	Resistor	Bridge	Zero-Ohm	Bridge
900 VAC	Resistor	Resistor	Resistor	Resistor	Zero-Ohm	Bridge
1000 VAC	Resistor	Resistor	Resistor	Resistor	Resistor	Bridge
1100 VAC	Resistor	Zero-Ohm	Zero-Ohm	Zero-Ohm	Zero-Ohm	Resistor
1200 VAC	Resistor	Resistor	Zero-Ohm	Zero-Ohm	Zero-Ohm	Resistor
1300 VAC	Resistor	Resistor	Resistor	Zero-Ohm	Zero-Ohm	Resistor
1400 VAC	Resistor	Resistor	Resistor	Resistor	Zero-Ohm	Resistor
1500 VAC	Resistor	Resistor	Resistor	Resistor	Resistor	Resistor

Bridge present

Zero-Ohm Resistor present

Resistor aktive i.e. Zero-Ohm Res. cut out

Note	The exciter voltage measurement UE must always be equipped with the same voltage divider as the Usyn measurement.

Note	**(*)** The 500 VAC setting is the smallest possible value for a test voltage of 2.5 kV. Values within the range 100V…500V can only be scaled to 100 % with the software parameters U SYN V NOMINAL (Par. 504) and U ECX V NOMINAL (Par.501).

Note	The resistors R31, R38, R45, R52, R59 can be bridged for measurements from external voltage transformers or external transducers. This special application is only permitted in co-ordination with our Engineering Department.

4.2.8.4 View of total PSI

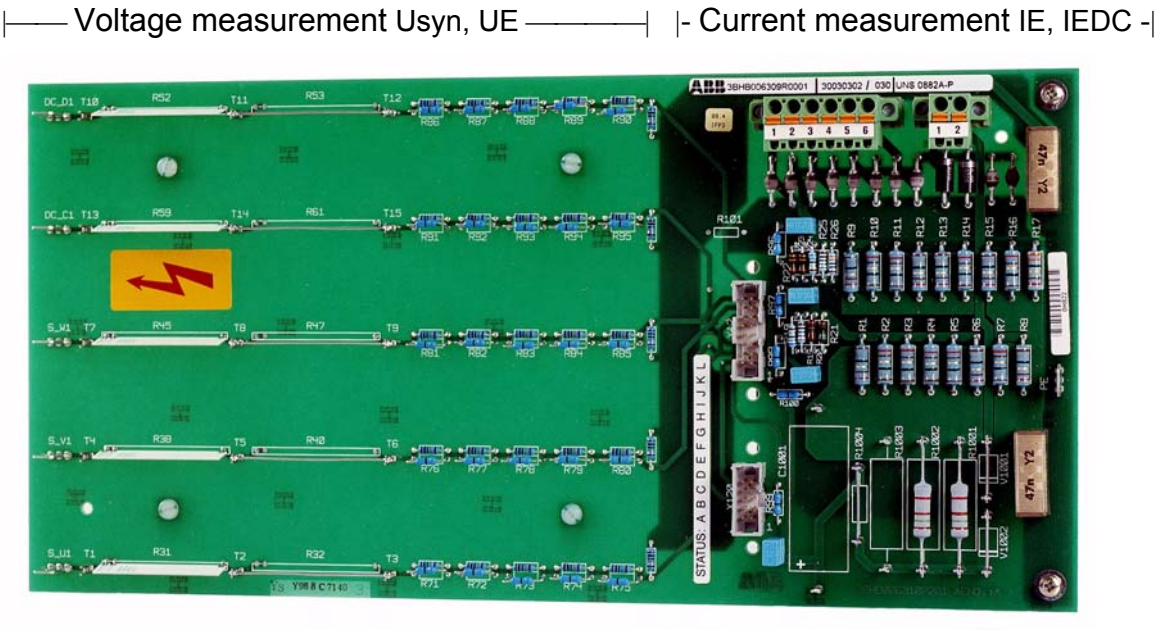


Fig. 4.2-14 View of Power Signal Interface PSI

4.2.8.5 Current measurement : Detail view

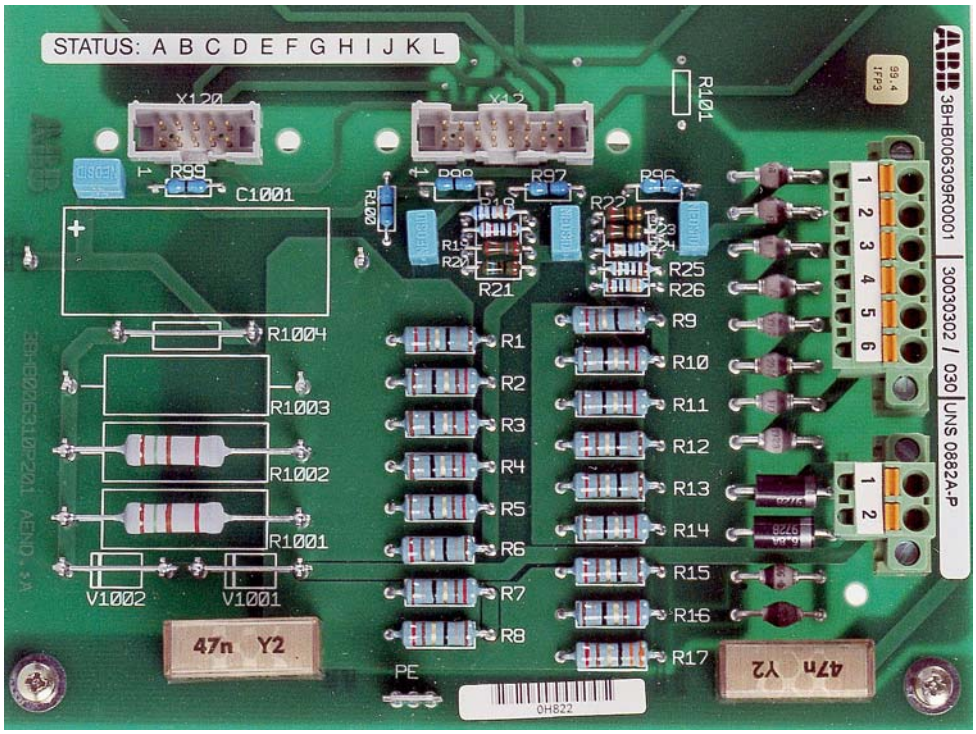


Fig. 4.2-15 Detailed view of Current measurement

4.2.8.6 Exciter current measurement (on AC side of the converter)

The secondary side of the current transformer is always designed for 1A nominal current.

The nominal burden voltage (measured between the connections X12:10 and X12:13) should be 1.3….1.5V for I converter.

The fine adjustment is carried out by means of I EXC SENSE A (parameter 507)

The resulting burden resistor is derived from the paralleling of the installed resistors R1....R21.

The adaptation of the current transformer is always carried out in the system test location by configuration of this resistor chain, i.e. through the setting of the calculated burden resistance.

4.2.8.7 Zero-current detection (on AC side of the converter)

The setting of the required burden resistance for zero-current detection is achieved in the same way by the resistor chain R22....R26.

The zero-current detection is only required with 4-quadrant applications with antiparallel converters.

4.2.8.8 Exciter current measurement (AC side) with one current transformer for two PSI

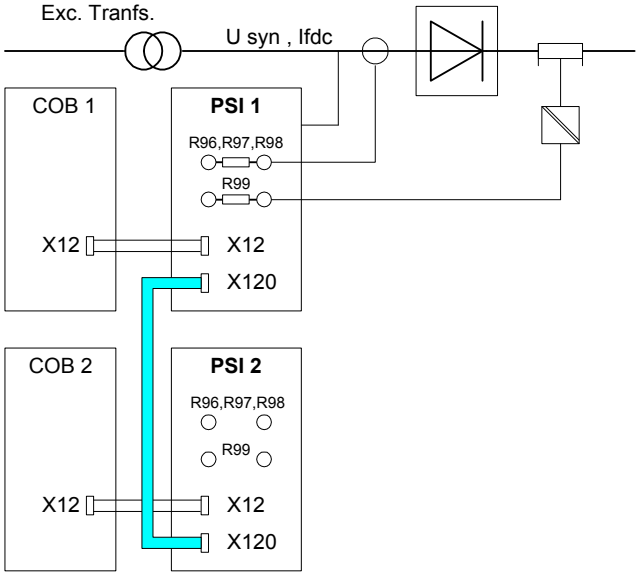


Fig. 4.2-16 Exciter current measurement with single current transformer

If only one current transformer is used for field current measurement on the AC side of the converter, then the resistors R96,R97,R98,R99 on PSI 2 are to be removed.

In addition, the flat cable connection X120 – X120 between the two PSI is necessary.

4.2.8.9 DC field current actual value

The measuring of the DC field current by means of a shunt and a transducer is normally realised using this input. The actual value signal in mA is passed via an adjustable burden (R1001 to R1003). The nominal burden voltage is **1.5 V** at **current transformer nominal current**. ("LEM-transformer "; shunt voltage/transducer current)

Additional filtering (R1004, C1001) in the output path is possible as an option.

If an LEM-transformer with unipolar voltage supply is used as a transducer, then the two diodes V1001 and V1002 must be fitted in the input-side current path. The signal path up to the burden is designed for 1.5 A.

In the basic configuration of the board, jumpers are fitted in the longitudinal path in place of the diodes and 2 x 150 Ohm resistors in the transverse path.

4.2.9 Fast I/O unit UNS 0883a-P (FIO)

4.2.9.1 Features

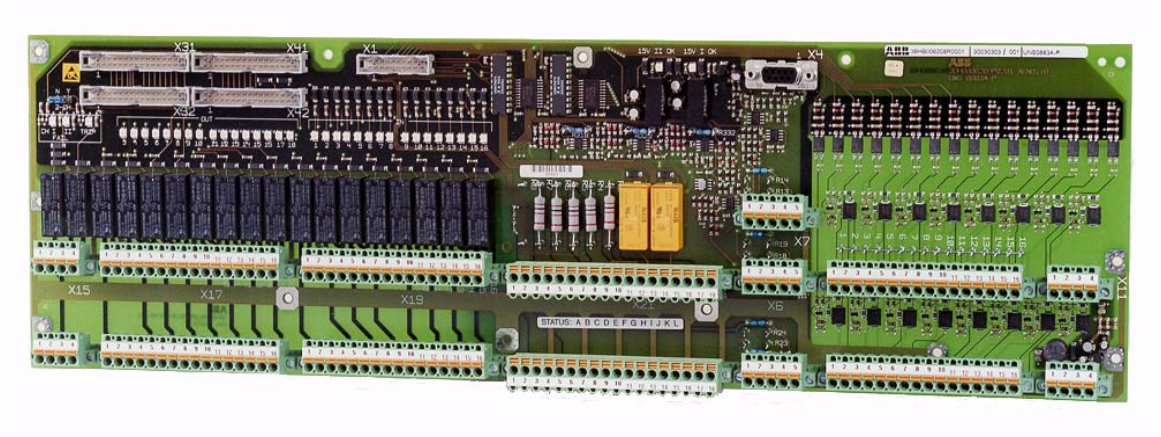


Fig. 4.2-17 View of Fast I/O unit FIO

The FIO (Fast Input / Output) unit is the centralized I/O-device for binary signals. It serves to interface with the low voltage equipment inside the exciation system (e.g. relays, circuit breakers etc.). Signals for remote operation from the control room are also transmitted across the FIO. In addition, the device features a certain number of analog inputs and outputs.

The FIO offers fast data transmission. Unlike the other I/O devices connected to the ARCnet (AII, DII, ROI) it is directly connected to the COB boards and transmits data with less than 5ms delay.

In double channel systems, there is one FIO common to both control channels. Only the active channel can drive the FIO outputs.

To increase the number of fast in- and outputs a maximum of 2 FIO can be used in parallel.

More features:

- 16 potential-isolated digital inputs for 24VDC nominal voltage.
- 18 output relays with switching contacts for 250 VAC/DC.
- 4 analogue outputs, switched to the active channel.
- 3 analogue inputs (voltage or current inputs) ±10V or ±20mA.
- Analogue amplifier input for Crowbar current measurement.
- 3 analogue amplifier inputs for current, voltage or resistance measurements.
- Test points for checking the analogue actual values.
- Short-circuit-proof 24VDC voltage source as control voltage for the external contacts.

4.2.9.2 Single- or double-channel configuration

In single-channel systems S5… / D5…,
the jumper 2-CH should be set
to Pos. N (No)

In double-channel systems A5…,
the jumper 2-CH should be set
to Pos. Y (Yes)

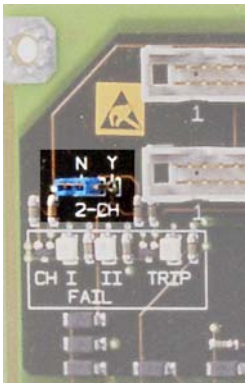


Fig. 4.2-18 Jumper double-channel configuration

4.2.9.3 Reference potential of the digital inputs

A single return line can be used for digital inputs with the same reference potential.

In the basic version, the jumpers Y1- Y16 are connected with one another.

If separate input channels are required, these are to be separated from the others. The reference potential, whether from an internal or external source, is always connected via one of the terminals X9.

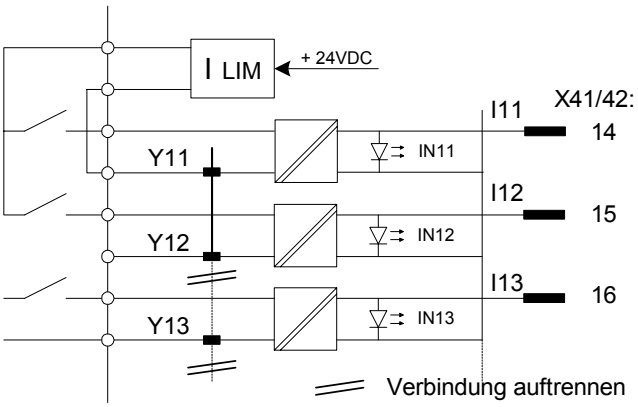


Fig. 4.2-19 Example: Input 13 separated

4.2.9.4 Analogue voltage / current inputs

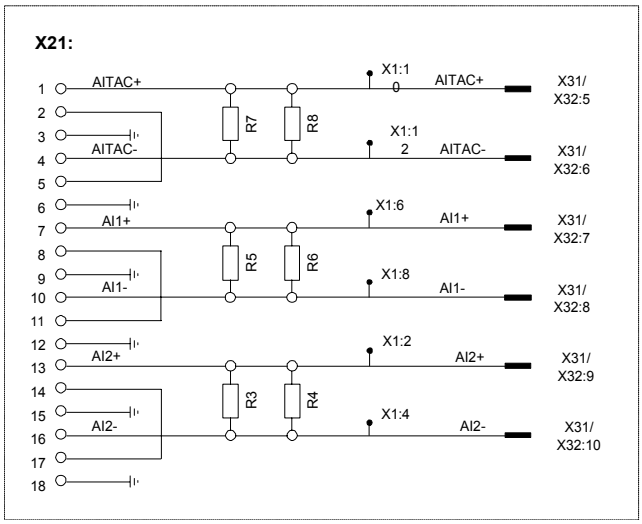
Direct, unbuffered inputs to X21

AITAC,AI1, AI2 are bipolar differential inputs and can be assigned to internal SP inputs by means of software parameters in the COB (SP = Standard Program blocks).

The voltage inputs are designed for ±10V signals.

The current inputs are designed for ±20mA. The burden is 500 Ohm.

For other current input signals, the associated burdens R3-R8 are to be adapted accordingly, whereby the burden voltage may be max. ±10V.



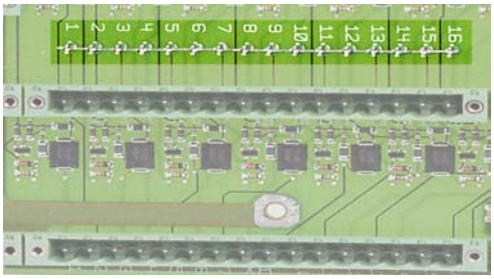


Fig. 4.2-20 Unbuffered, direct inputs to X21 (basic version is designed for ±20mA current inputs)

4.2.9.5 Buffered, HW-parameterizable differential inputs

AIOPT1, AIOPT2 and AI4 provide 3 identical analogue inputs, whereby AIOPT1 and AIOPT2 are prepared for PT elements.

All three can also be used as normal analogue inputs.

In the case of current inputs, the burdens must be adapted accordingly.

The gain can be adjusted by means of resistors.

Max. permissible output voltage ; for AI4: ±10V, for AIOPT1/2: 0…+5V

Permissible input potentials

AI4	Analogue **bipolar** differential amplifier input with burden R23/R24 and gain adjustable at R318, V= R318 / 10 kOhm
AIOPT1	Analogue **bipolar** differential amplifier input with burden R18/R19 and gain adjustable at R325, V= R325 / 10 kOhm
AIOPT2	Analogue **bipolar** differential amplifier input with burden R13/R14 and gain adjustable at R332, V= R332 / 10 kOhm,

4.2.9.6 Temperature measurement (basic version equipped for 2-conductor measurement, PT100 or PTC)

- for 4-conductor measurement, the two 0R-resistors (on each side of the burdens) must be cut out.

4.2.9.7 Voltage measurement

- cut out 0R-resistors

4.2.9.8 Current measurement

- use burdens in accordance with current signal, cut out 0R-resistors

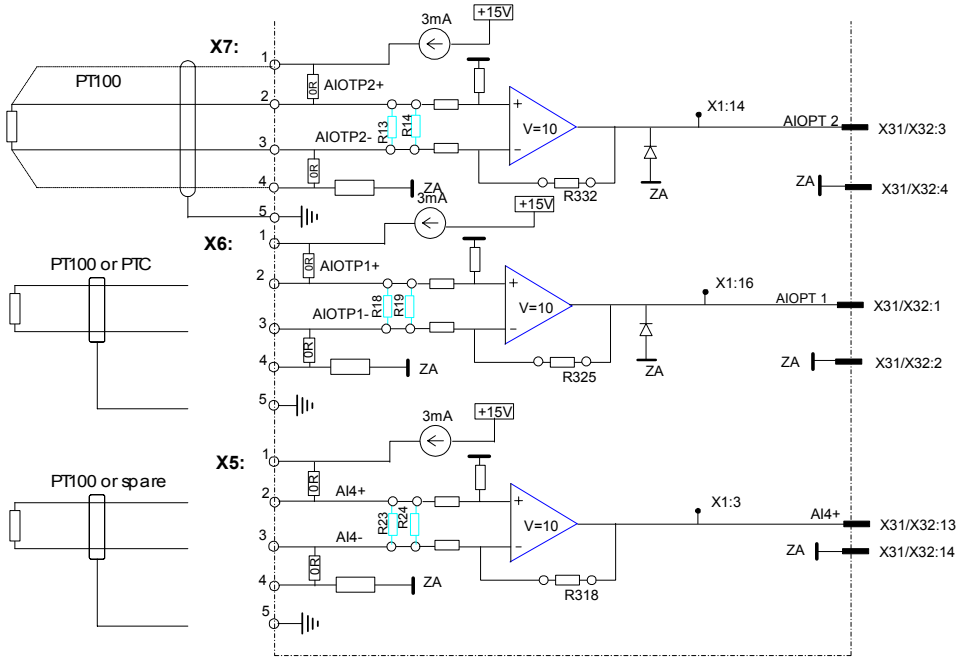


Fig. 4.2-21 Schematic diagram of analogue inputs X5 to X7

4.2.9.9 Configuration of the additional inputs

The input ranges correspond to the maximum possible deviation of the A/D-conversion.

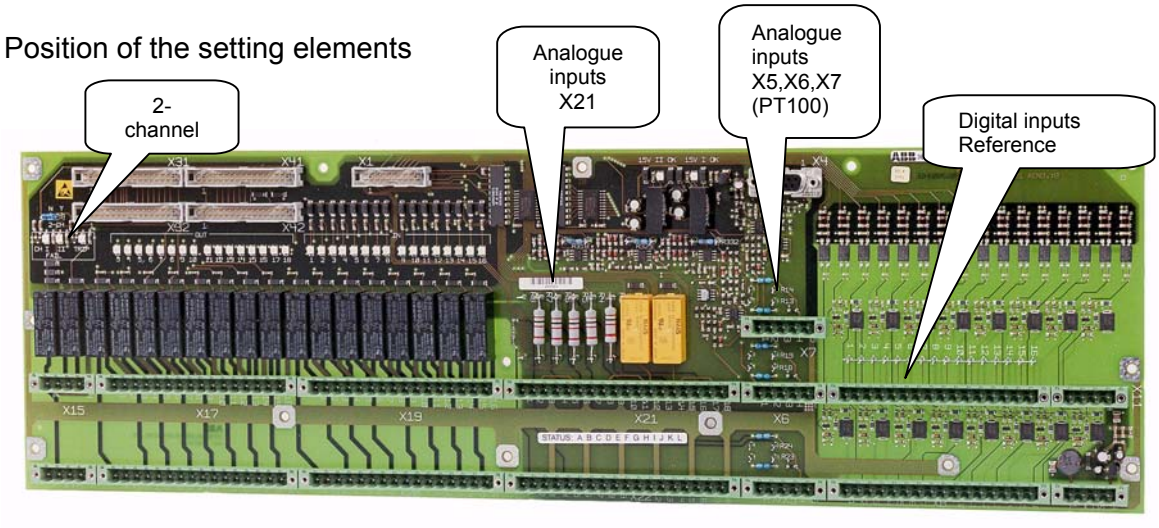
(*) The default settings (PT-100) produce identical decimal values in the COB.

AIOPT1 Signal:	PT… range	Voltage-range	Current-range	Burden	Gain R....	A/D Resolution	Default
PT 100	0...+0.5V	-	-	-	10 R325=100kΩ	12 Bit unipolar	default (*)
PTC	0...+5V	-	-	-	1 R325=10kΩ	12 Bit unipolar	
Voltage	-	0...+5V (without 0R)	-	-	1 R325=10kΩ	12 Bit unipolar	
Voltage	-	0...+10V (without 0R)	-	-	0.5 R325= 5kΩ	12 Bit unipolar	
Current	-	-	0..+10mA (without 0R)	50Ω R18//R19	10 R325= 100kΩ	12 Bit unipolar	
Current	-	-	0..+20mA (without 0R)	50Ω R18//R19	5 R325= 50kΩ	12 Bit unipolar	

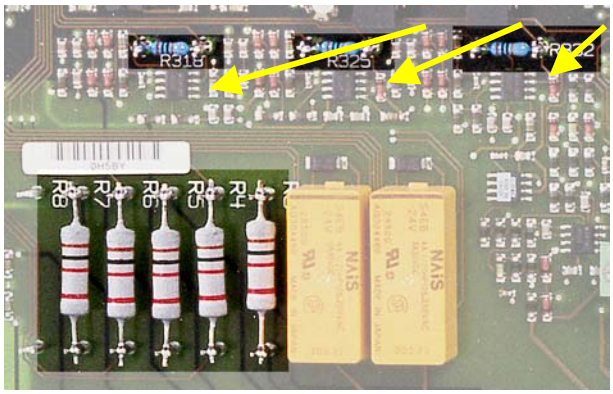
AIOPT2 Signal:	PT… range	Voltage-range	Current-range	Burden	Gain R....	A/D Resolution	Default
PT 100	0...+0.5V	-	-	-	10 R332=100kΩ	12 Bit unipolar	default (*)
PTC	0...+5V	-	-	-	1 R325=10kΩ	12 Bit unipolar	
Voltage	-	0...+5V (without 0R)	-	-	1 R332=10kΩ	12 Bit unipolar	
Voltage	-	0...+10V (without 0R)	-	-	0.5 R332= 5kΩ	12 Bit unipolar	
Current	-	-	0..+10mA (without 0R)	50Ω R13//R14	10 R332= 100kΩ	12 Bit unipolar	
Current	-	-	0..+20mA (without 0R)	50Ω R13//R14	5 R332= 50kΩ	12 Bit unipolar	

AI4 Signal:	PT… range	Voltage-range	Current-range	Burden	Gain R....	A/D Resolution	Default
PT 100	0...+1V	-	-	-	10 R318=100kΩ	11 Bit +Sign bipolar	default (*)
PTC	0...+10V	-	-	-	1 R325=10kΩ	12 Bit unipolar	
Voltage	-	± 10V (without 0R)	-	-	1 R318=10kΩ	11 Bit +Sign bipolar	
Current	-	-	± 20 mA (without 0R)	50Ω R23//R24	10 R318= 10kΩ	11 Bit +Sign bipolar	

4.2.9.10 Position of the setting elements

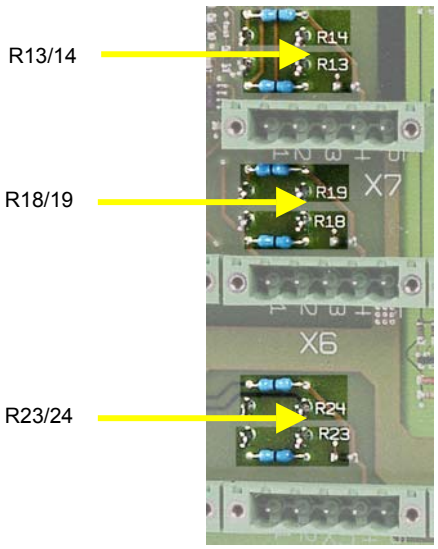


Detail view of analogue inputs to X5, X6, X7 (gain adjusted with R318, R325, R332)



[— R8…R3 ——]

Detail view of analogue input to X21 (burden resistors R3…R8)



Detail view of analogue inputs to X5, X6, X7 (burden resistors R13,14,18,19,23,24)

Fig. 4.2-22 Position of the setting elements on Fast I/O unit FIO

4.2.10 Local Control Panel AF C094 AE, 02 (LCP)

4.2.10.1 Features

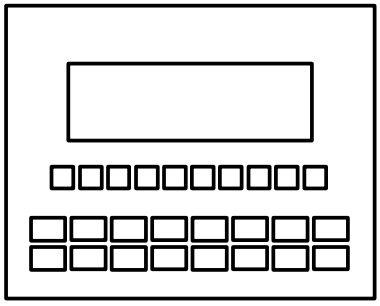


Fig. 4.2-23 View of Control Panel LCP

The LCP (Local Control Panel) is used to locally control the excitation system. It offers a set of push-buttons for the most frequently used operations (e.g. excitation on / off, channel transfer etc.) and a display for either alarm messages or a selection of analog system values.

The LCP can be handled by the operating personal while the CDP is intended for use by the maintenance staff. Operation of the excitation system is described in chapter 7 of this manual.

More features:

- Display with 8 lines, each with 40 characters (240x64 points).
- 10 control keys for operating modes and functions.
- 16 keys with LED's for installation-specific control functions.
- 4 binary inputs with short-circuit-proof +24V supply.
- 3 relay outputs with changeover contact.
- 3 auxiliary voltage outputs, 24V /0V.
- RS-485 serial interface for download.
- RS-232 serial interface for printer.

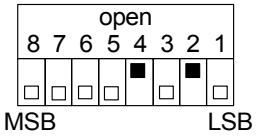
4.2.10.2 ARCnet node addresses

The address switch **S301** determines the node address of the device.

The node addresses for two control panels are defined; other settings lead to a breakdown in communications.

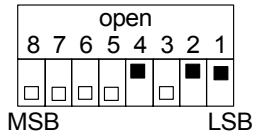
Device		Node no.
AF C094	LOCAL	10 [dec]
AF C094	REMOTE	11 [dec]

Setting the node address of Panel 1 (LOCAL)



Node Adresse 10 [dez]

Setting the node address of Panel 2 (REMOTE)



Node Adresse 11 [dez]

Fig. 4.2-24 Setting ARCnet node address

4.2.11 Extended Gate Controller UNS 2882a-P (EGC)

4.2.11.1 Features

Fig. 4.2-25 View of expanded gate controller EGC

The EGC (Extended Gate Controller) is mainly used as an emergency controller to back-up the COB board. It contains both a field current regulator for MANUAL control and an independent gate control unit. The device is completely independent from the COB and MUB boards and is used both in double channel systems (D5x) and in dual auto-channel configurations with back-up controller (Q5x).

The EGC can maintain the most important system functions even if the COB and / or MUB boards fail. For this purpose, the device not only contains the above mentioned regulator and gate control circuits, but also the most important monitoring and protection functions like overcurrent protection are provided.

The EGC offers an extended frequency range in the gate control unit compared to the corresponding function in the COB. This allows the use of UNITROL 5000 excitation systems also for 16 $^{2}/_{3}$ railway supply systems.

More properties:

- Gate controller for fn = 16 $^{2}/_{3}$, 50 / 60 Hz systems.
- Current regulator for back-up operation (D5…, Q5x-… systems).
- I> back-up overcurrent relay „Inverse Time“ (ANSI 51).
- I>> back-up overcurrent relay, instantaneous (ANSI 50).
- DC short-circuit detection (limitation) in back-up operation.
- Frequency measurement.
- Formation of a high-frequency firing pulse chain.
- Independent power supply from 24VDC source.

4.2.11.2 Board Configuration

Settings carried out using **DIL-switch S450**

Default setting = OFF

S450 Pos.	**Parameter**	**OFF**	**ON**
Pos. 1	Nominal frequency	OFF = 50/60 Hz operation	ON = 16 2/3 Hz operation
Pos. 2	Switch type	OFF = AC switch	ON = DC switch
Pos. 3	Switch control	OFF = FCB does not open	ON = for OFF command
Pos. 4	Twin Converter	OFF = NO	ON = YES
Pos. 5	Switchover D5↔A5	OFF = D5	ON = A5
Pos. 6	Range switchover KCR	OFF = Range 1	ON = Range 2
Pos. 7	Range switchover TCR	OFF = Range1, 10..80ms	ON = Range2, 0.1..0.38s
Pos. 8	Range switchover t(I>)	OFF = Range1, 8...15 s	ON = Range2, 16...90s

4.2.11.3 Startup overcurrent relay

The set value corresponds to the MAX. VALUE of the setpoint generator.

HEX-switch : I>

Pos	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
I> [V]	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8

4.2.11.4 Overcurrent, instantaneous

HEX-switch : I>>

Pos	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
I> [V]	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8

4.2.11.5 Time-delay, inverse time

t(I>) = delay at 2 x startup current I>

$t(s) = 3 * t(I>) / [(I/I>)^2 - 1]$

HEX-switch t (I>)

Range 1 : (S450, Pos. 8, t(I>) SEL = OFF)

Pos	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
t(I>) [s]	OS	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12

OS: Position 0 = no protection

Range 2 : (S450, Pos. 8, t(I>) SEL = ON)

Pos	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
t(I>) [s]	OS	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85

OS: Position 0 = no protection

4.2.11.6 Time-delay, instantaneous

HEX-switch t (I>>)

Pos	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
t(I>>) [ms]	OS	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80

OS: Position 0 = no protection

4.2.11.7 Current regulator, proportional gain KCR

HEX-switch : KCR

Lower value range (S450, Pos. 6, KCR SEL = OFF) logarithmic scale

Pos	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
KCR	0.1	0.13	0.18	0.24	0.32	0.42	0.56	0.75	1.0	1.33	1.78	2.37	3.16	4.2	5.6	7.5

Upper value range (S450, Pos. 6, KCR SEL = ON) logarithmic scale

Pos	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
KCR	0.1	0.14	0.2	0.28	0.4	0.56	0.8	1.12	1.58	2.24	3.16	4.47	6.3	8.9	12.6	17.8

4.2.11.8 Current regulator, time constant TCR

HEX-switch : TCR

Lower value range (S450, Pos. 7, TCR SEL = OFF)

Pos	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
TCR [s]	∞	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80

Pos. 0 = pure P-regulator

Upper value range (S450, Pos. 7, TCR SEL = ON)

Pos	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
TCR [s]	∞	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380

Pos. 0 = pure P-regulator

4.2.11.9 Setpoint preset

HEX-switch : Ref. init

Pos	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
Ref.init [%]	20	23	26	29	32	35	38	41	44	47	50	53	56	59	62	65

Setting : [%] of I>

4.2.11.10 WR-limit

HEX-switch : Alpha MAX

Basic setting α WR = 149 °el

Pos	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
MAX [°el]	125	128	131	134	137	140	143	146	149	152	155	158	161	164	167	170

4.2.11.11 GR-limit

HEX-switch : Alpha MIN

Basic setting α GR = 10 °el

Pos	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
α MIN [°el]	10	13	16	19	22	25	28	31	34	37	40	43	46	49	52	55

4.2.11.12 Fuse

Fuse: F600 5 x 20 2A slow

4.2.11.13 Position of the setting elements

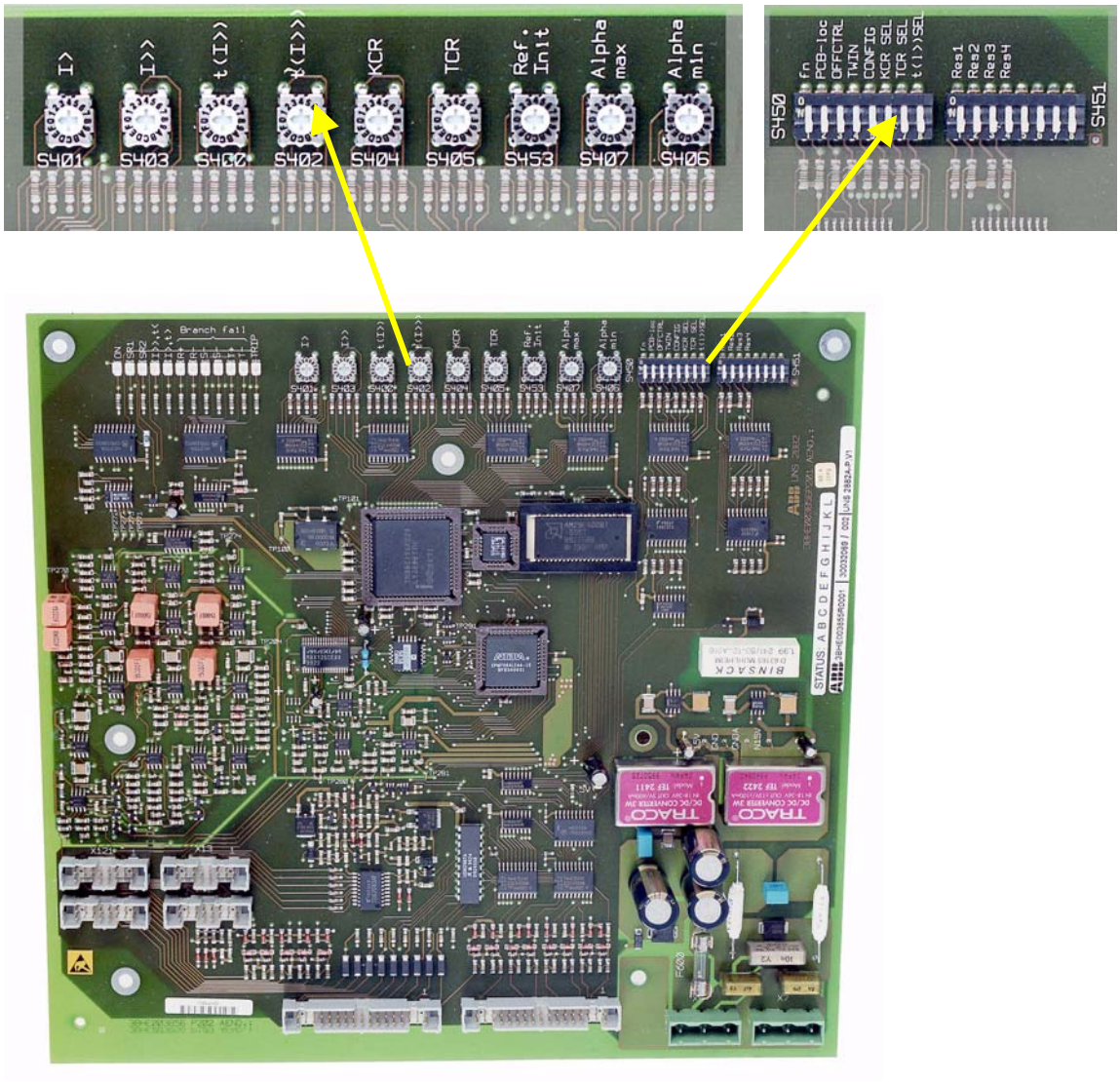


Fig. 4.2-26 Position of the setting elements on expanded gate controller EGC

4.2.12 Fieldbus Coupler UP C090 AE (FBC)

4.2.12.1 Features

Fig. 4.2-27 View of fieldbus coupler FBC

The FBC (Field Bus Coupler) is used as an interface for an extended number of binary signals to the COB. Up to 4 devices can be connected to the ARCnet fieldbus, offering a total of 128 inputs and 128 outputs. The data exchange rate is approx. 50ms.

Additional hardware is required to physically connect the signals to the FBC, i.e. local bus interface LBI, the relay output card ROI and the digital input card DII. The following list shows the connections possible with one FIO:

- two LBI offering — 32 inputs and 32 outputs on 24V level
- one LBI, one ROI and one DII with — 16 inputs and 16 outputs on 24V level,
16 galvanically separated inputs
16 relay outputs
- Two ROI and two DII — 32 galvanically separated inputs
32 relay outputs

Technical data:

- 32 digital inputs
- 32 digital outputs
- power supply from 24 VDC source.

4.2.12.2 Device settings

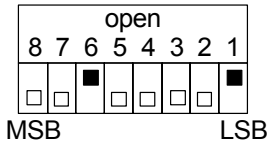
ARCnet Node Address

Set using 8-pin DIP switch **S201** "Node-ID"

The node addresses for 4 UP C090s are defined; other settings lead to a breakdown in communications.

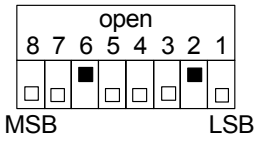
Device	no.	Node no.
UP C090	1	33 [dec]
UP C090	2	34 [dec]
UP C090	3	35 [dec]
UP C090	4	36 [dec]

Setting the node address of UP C090 (no.1)



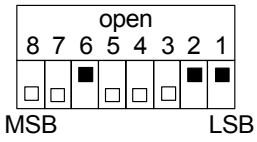
Node Adresse 33 [dez]

Setting the node address of UP C090 (no.2)



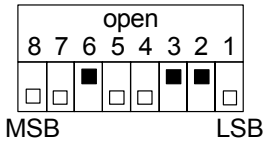
Node Adresse 34 [dez]

Setting the node address of UP C090 (no.3)



Node Adresse 35 [dez]

Setting the node address of UP C090 (no.4)



Node Adresse 36 [dez]

Fuse: 5 x 20 2.5A fast

4.2.12.3 Position of the control elements

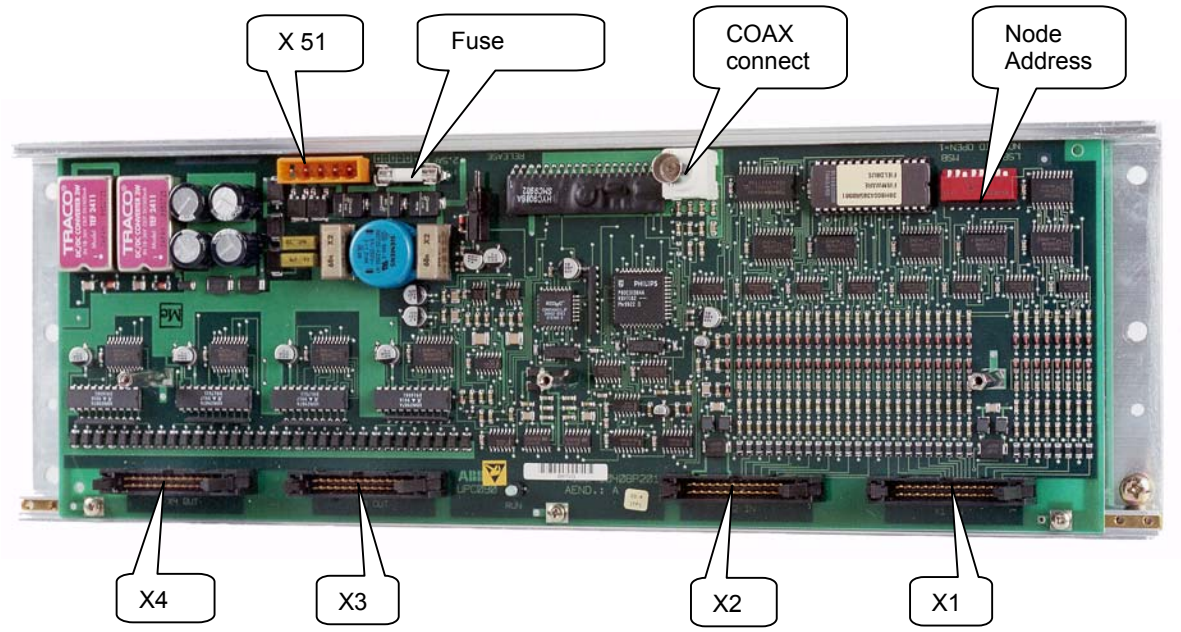


Fig. 4.2-28 Position of the control elements on fieldbus coupler FBC

4.2.13 Local Bus Interface UNC 4674 b-E (LBI)

4.2.13.1 Features

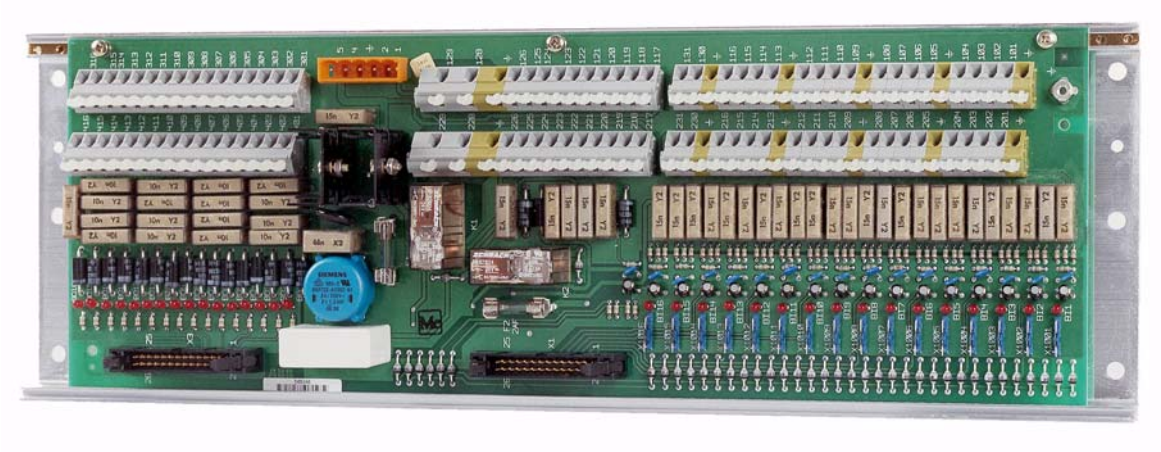


Fig. 4.2-29 View of local bus interface LBI

The LBI (Local Bus Interface) is used to physically connect binary signals to the FBC ARCnet coupler. The signal exchange is effected directly on the 24V level, there is no galvanic separation towards the FBC. These 24V signals must be used exclusively inside the excitation panels. For signal exchange external to the system, the DII and ROI must be used.

More features:

- 16 binary inputs, 24V control voltage
- 16 binary outputs, 24V output voltage
- Additional 24V power supply output, fuse protected

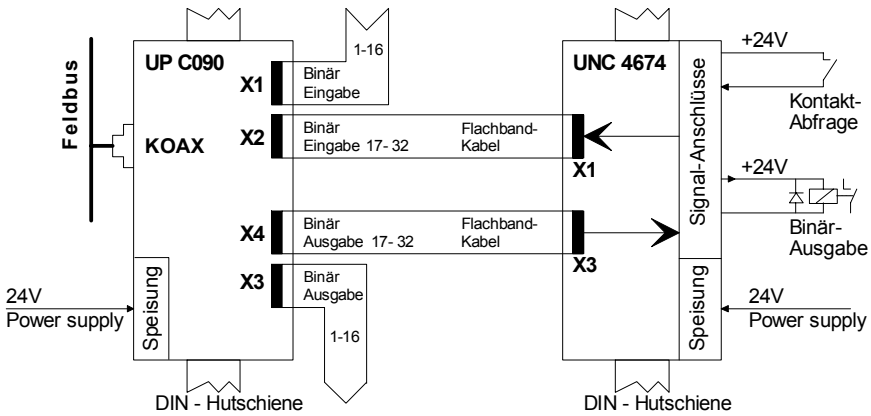


Fig. 4.2-30 Connections to local bus interface module LBI

4.2.13.2 Protection of internal power supply F1

Protection of output current with fuse 5 x 20mm 2A fast

4.2.13.3 Protection of external add-on devices F2

Protection of output current with fuse 5 x 20mm 2A fast

4.2.13.4 Position of setting elements

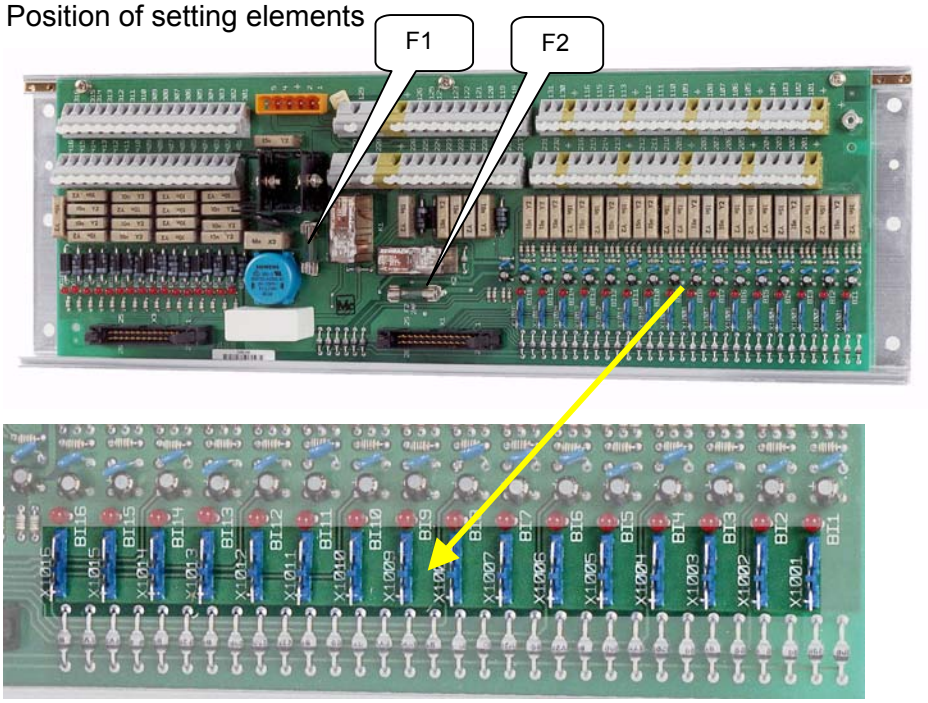


Fig. 4.2-31 Position of setting elements on local bus interface LBI

4.2.14 Analogue I/O interface to fieldbus UA C096 (AIO)

4.2.14.1 Features

Fig. 4.2-32 Block circuit diagram and view of Analogue I/O interface AIO

The AIO (Analog Input / Output Interface) is used as an interface for an extended number of analog signals to the COB. Two devices can be connected to the ARCnet fieldbus, offering a total of 16 analog inputs and 16 analog outputs. The data exchange rate is approx. 50ms

More features:

- up to 8 analogue voltage inputs ±10V
- or up to 8 analogue current inputs ±20mA
- optionally with galvanic isolation of the inputs
- up to 8 analogue voltage outputs ±10V.
- or up to 8 analogue current outputs ±20mA.
- Transmission via ARCnet fieldbus.
- Separate galvanically isolated power supply from 24VDC source.
- inputs and outputs can be individually configured

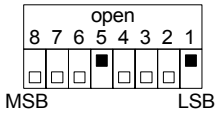
4.2.14.2 ARCnet node address

Setting by means of the 8-pin DIP-switch **S200** "Node-ID"

The node addresses for two UA C096s are defined; other settings lead to a breakdown in communications.

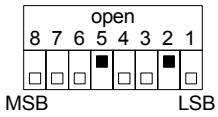
Device	no.	Node no.
UA C096	1	17 [dec]
UA C096	2	18 [dec]

Setting the node address of UP C096 (no.1)



Node Adresse 17 [dez]

Setting the node address of UP C096 (no.2)



Node Adresse 18 [dez]

Setting node address

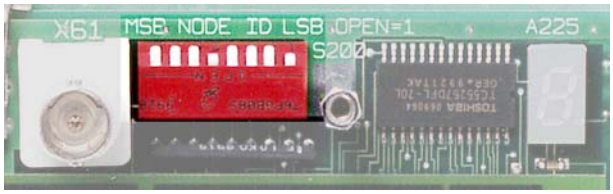


Fig. 4.2-33 Setting node address on Analogue I/O interface AIO

4.2.14.3 Analogue voltage or current measurement

Note	In the basic variant, the device is equipped for the measurement of current signals, i.e. the switches S111...S181 are closed and the switches S112...S182 are set to Pos. I.

Current inputs

- S111 ... S181 closed
- S112 ... S182 to Pos. I

Input current range - 20 mA ... + 20 mA

Input resistance 100 Ohm

Voltage inputs (S111 ... S181 open)

- S111 ... S181 open
- S112 ... S182 to Pos. U

Input voltage range - 10 V ... + 10 VDC

Input resistance 110 k Ohm

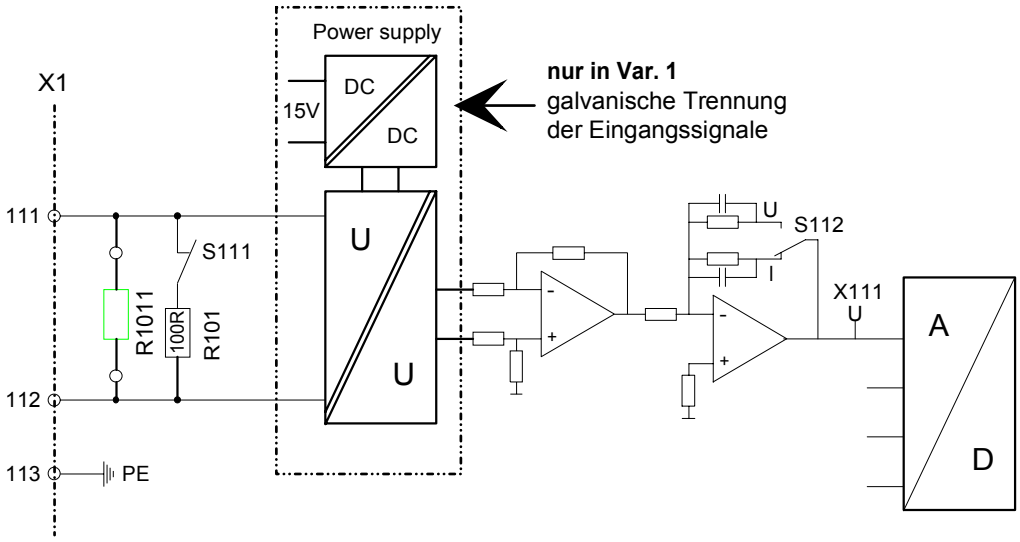


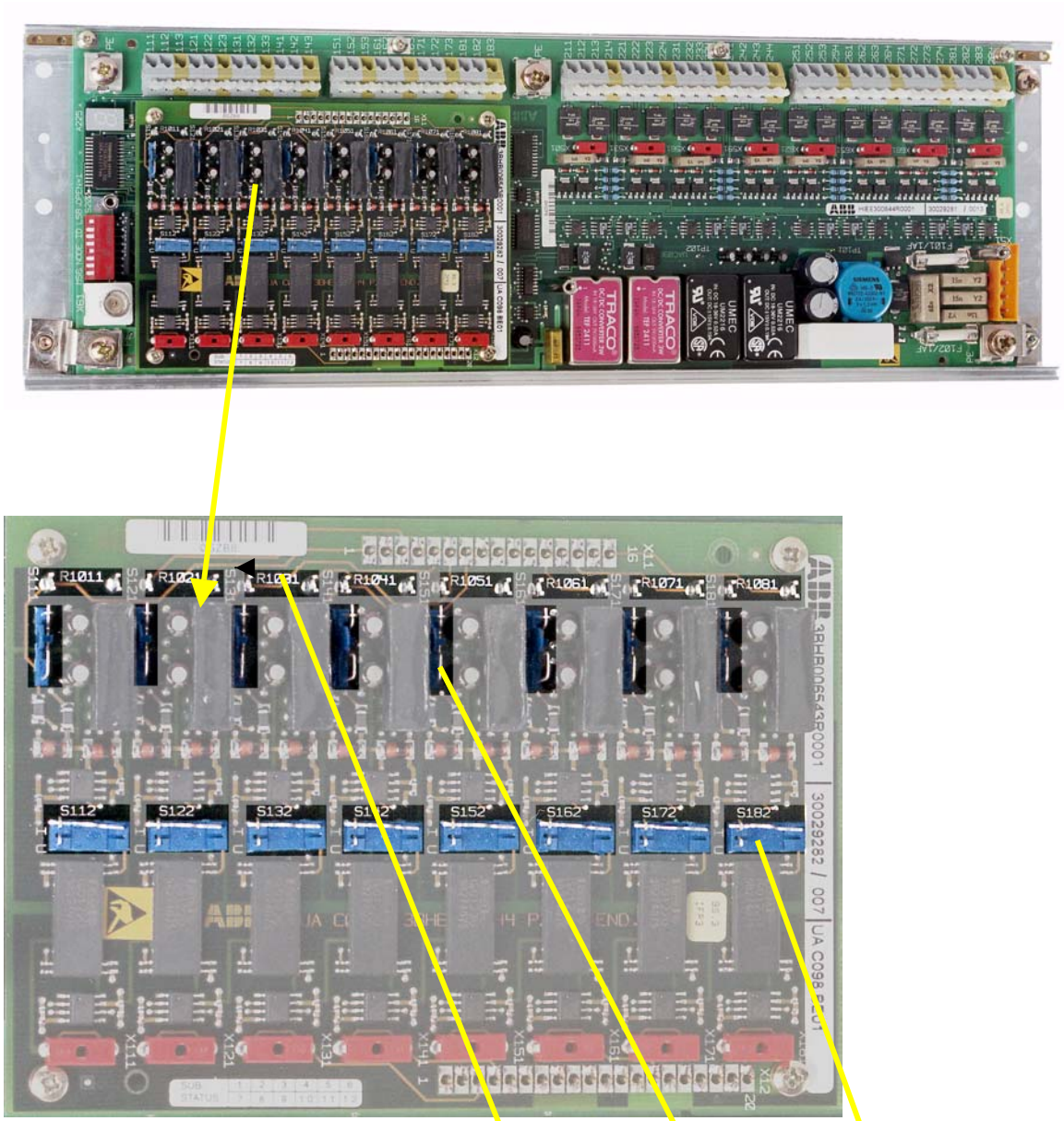
Fig. 4.2-34 Switchover from current- to voltage inputs

The resistors R1011...R1018 are used for individual burden adjustment. They are not included in the basic version.

4.2.14.4 Input fuses F101, F102

Input fuses (5 x 20 mm) 1 A fast

4.2.14.5 Position of the setting elements



Sub-board UA C098

Configuration of the analogue inputs (R1011…R1081, S111…S181, S112…S182)

Fig. 4.2-35 Position of the setting elements on Analogue I/O interface AIO

4.2.15 Firing unit (1400 V) to Crowbar UNS 0007a-P

4.2.15.1 Features

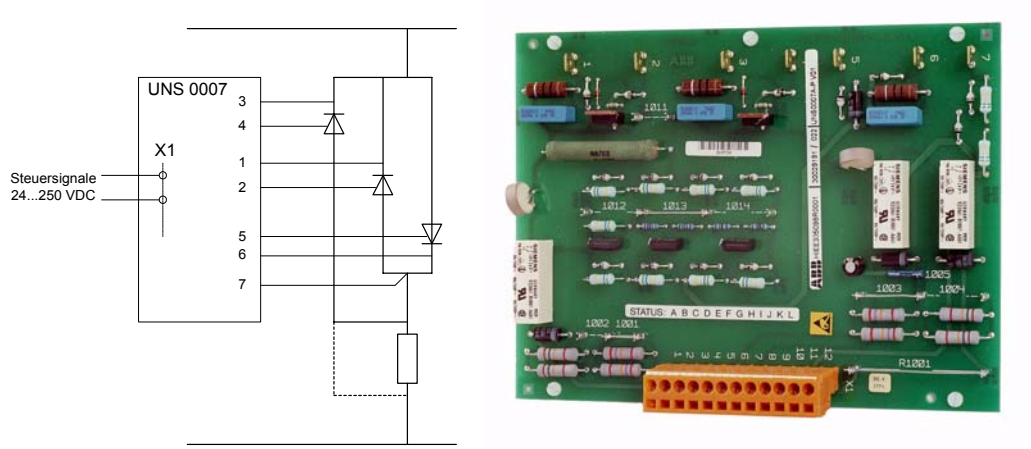


Fig. 4.2-36 Connections and view of firing unit UNS 0007a-P

The firing unit UNS 0007 is part of the static discharge equipment (crowbar) and contains several independent firing circuits for the discharge thyristors.

Two redundant circuits are used for controlled discharge of the machine. They are activated together with the opening coils of the field breaker.

In addition, a voltage sensitive circuit is provided, which automatically fires the thyristors when the field voltage exceeds a preset value. Thus the crowbar is a fully independent overvoltage protection device and protects both the power converters and the field winding against dangerous overvoltage spikes.

More features:

- Overvoltage firing for two antiparallel thyristors (Crowbar).
- Maximum firing voltage 1400V, maximum test voltage 6kV.
- Two controlled firing circuits for discharge.
- Controlled firing via relays.
- Firing energy derived from the anode-cathode voltage of the thyristors.

4.2.15.2 Board Configuration

Crowbar / discharge with **one** discharge thyristor:

- Connections 3 & 4 unused
- Bridge 1011 closed
- Bridge 1005 open.

Crowbar / discharge with **two** discharge thyristors:

- Bridge 1011 open
- Bridge 1005 open.

Basic version from factory:

- The overvoltage firing is set to 1200V
- The control voltage for the relays K1 and K2 is 110V/125V
- The control voltage for the relay K3 is 24V
- The bridges 1011 and 1005 are open.

4.2.15.3 Control voltage relays K1 and K2

Nominal voltage	1001 1003	1002 1004		Range	
24V	ON	ON		20 ... 30V	(-15 / +25%)
110V	ON	OFF		77 ... 160V	(-30 / +45%)
125V	ON	OFF		77 ... 160V	(-40 / +25%)
220V	OFF	OFF		170 ... 310V	(-20 / +40%)
250V	OFF	OFF		170 ... 310V	(-30 / +25%)

4.2.15.4 Control voltage relay K3

Nominal voltage	R1001		Range	
24V	0 Ohm		20 ... 30V	(-15 / +25%)
110V	10 kOhm / 2W		84 ... 160V	(-20 / +45%)
125V	10 kOhm / 2W		84 ... 160V	(-30 / +25%)
220V	22kOhm / 3.2W		170 ... 310V	(-20 / +40%)
250V	22kOhm / 3.2W		170 ... 310V	(-30 / +25%)

4.2.15.5 Overvoltage firing (permitted setting range)

Nominal voltage	1012	1013	1014		Range	Firing current
600V	ON	OFF	ON		+/- 50V	4 ... 6 A
800V	OFF	ON	ON		+/- 50V	6 ... 8 A
1200V	ON	OFF	OFF		+/- 80V	10 ... 12 A
1400V	OFF	OFF	ON		+/- 80V	12 ... 14 A

4.2.15.6 Position of the setting elements

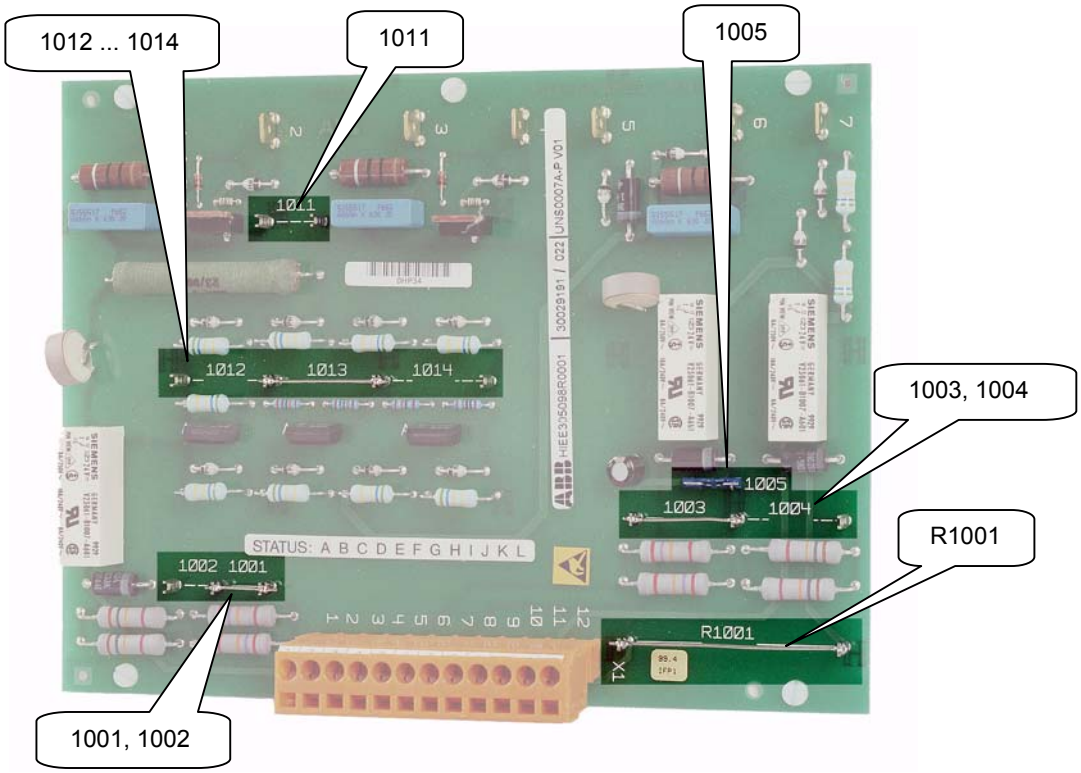


Fig. 4.2-37 Position of the setting elements on firing unit UNS 0007a-P

4.2.16 Firing unit (3800 V) to Crowbar UNS 0017a-P

4.2.16.1 Features

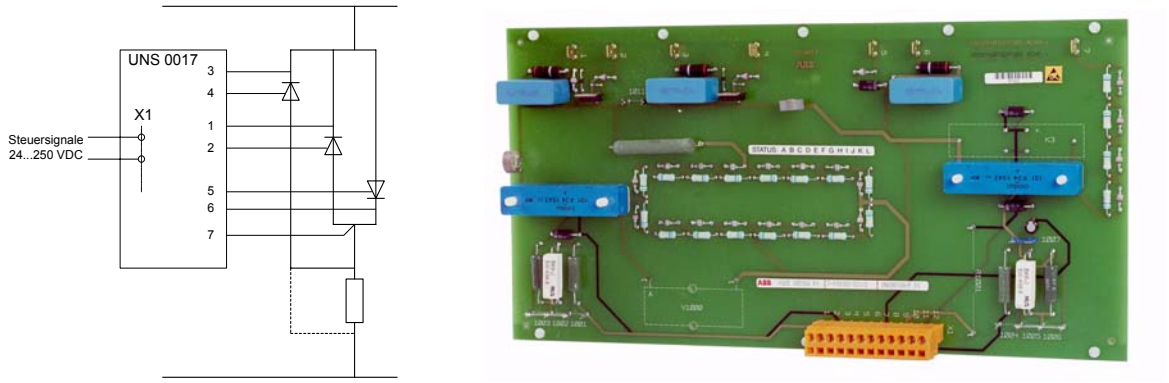


Fig. 4.2-38 Connections and view of firing unit UNS 0017a-P

The firing unit UNS 0017 is part of the static discharge equipment (crowbar) and contains several independent firing circuits for the discharge thyristors.

Two redundant circuits are used for controlled discharge of the machine. They are activated together with the opening coils of the field breaker.

In addition, a voltage sensitive circuit is provided, which automatically fires the thyristors when the field voltage exceeds a preset value. Thus the crowbar is a fully independent overvoltage protection device and protects both the power converters and the field winding against dangerous overvoltage spikes.

- Overvoltage firing for two antiparallel thyristors (Crowbar).
- Maximum firing voltage 3800V, maximum test voltage 8kV.
- Two controlled firing circuits for discharge.
- Controlled firing via relays.
- Firing energy from anode-cathode voltage of the thyristors.

4.2.16.2 Board Configuration

Crowbar / discharge with **one** discharge thyristor:

- Connections 3 & 4 unused
- Bridge 1011 closed
- Bridge 1007 open
- BOD (V1000) installation-specific.

Crowbar / discharge with **two** discharge thyristors:

- Bridge 1011 open,
- Bridge 1007 open
- BOD (V1000) installation-specific.

Basic version, from factory:

- V1000, R1001 and K3 are not fitted
- The control voltage for die relays K1 and K2 is 110V/125V
- The bridges 1007 and 1011are open.

4.2.16.3 Control voltage relays K1 and K2

Nominal voltage	1001 1004	1002 1005	1003 1006		Range	
24V	ON	ON	ON		18..28V	(-25 / +15%)
110V	OFF	ON	ON		90..140V	(-20 / +25%)
125V	ON	OFF	ON		100..160V	(-20 / +25%)
220V	OFF	OFF	ON		180..275V	(-20 / +25%)
250V	ON	OFF	OFF		200..310V	(-20 / +25%)

4.2.16.4 Control voltage relay K3

Nominal voltage	R1001	R1001 Idt. no.	Range	
24V	0 Ohm		18..28V	(-25 / +15%)
110V	4,7 kOhm / 3W	3BHC550036R2470	90..140V	(-20 / +25%)
125V	5,6 kOhm / 3W	3BHC550036R2560	100..160V	(-20 / +25%)
220V	10kOhm / 6W	3BHC550039R3100	180..275V	(-20 / +25%)
250V	12kOhm / 7W	3BHC550039R3120	200..310V	(-20 / +25%)

4.2.16.5 Overvoltage firing

Standard values for V1000:

Nominal voltages	Tolerance	Firing current
1200V to 2400V in steps of 200V	+/- 50V	10 ... 20 A
2600V, 2800V	+/- 100V	approx. 25 A

Expanded range for V1000 (not standard modules):

Nominal voltages	Tolerance	Firing current
3000V to 3800V in steps of 200V	+/- 100V	30 ... 40 A

BOD modules

Nominal voltages	Type designation	ABB ident.no.
1200 V	BOD 1- 12R	HEKE 352297 R2012
1400 V	BOD 1- 14R	HEKE 352297 R2014
…….	……	……
3600 V	BOD 1- 36R	HEKE 352297 R2036
3800 V	BOD 1- 38R	HEKE 352297 R2038

4.2.16.6 Position of the setting elements

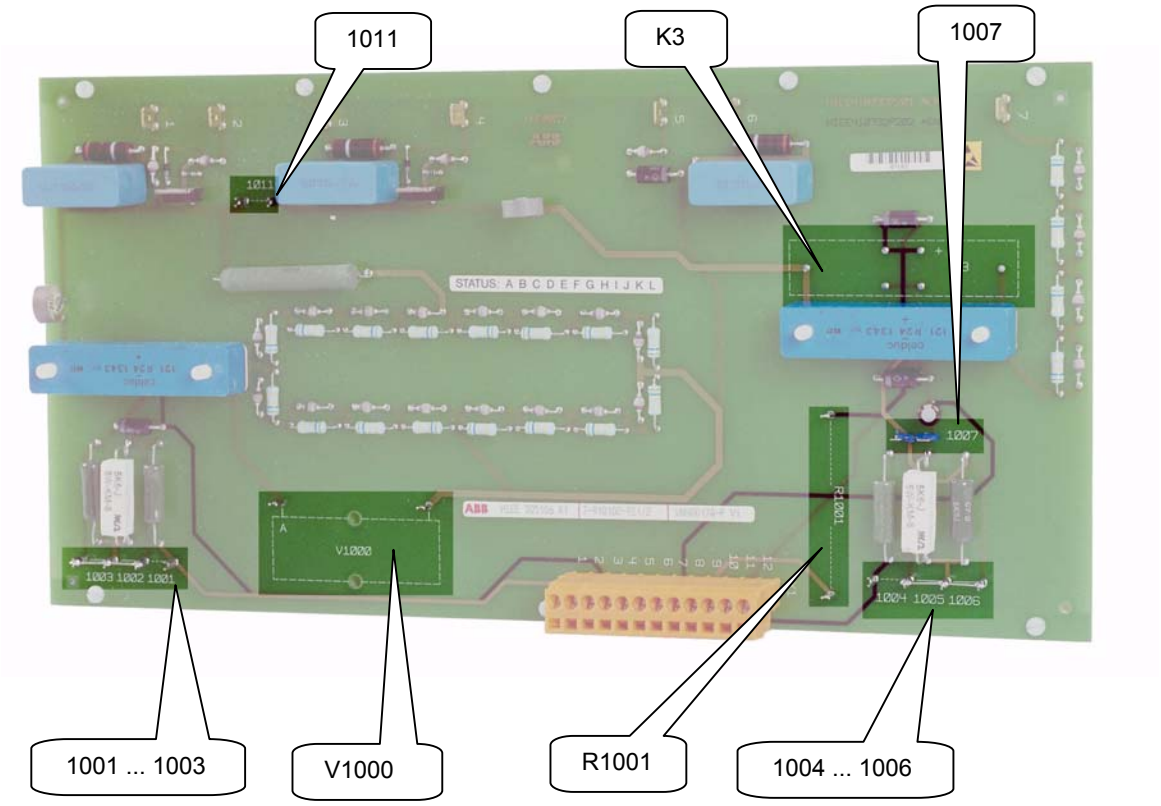


Fig. 4.2-39 Position of the setting elements on firing unit UNS 0017a-P

4.2.17 Optical Bus Interface UP C325 AE (OBI)

4.2.17.1 Features

The OBI (Optical Bus Interface) provides an optical point to point connection for the ARCnet fieldbus. It can be used when an ARCnet device must be located far away from the excitation panel (e.g. LCP in the control room).

- Maximum optical transmission distance: 1500 metres.

4.2.17.2 Selection of operating mode

S 201 Position	Operating mode	In ↔ Out
P	Optocoupler	K
ON	Repeater (electr.)	Port 1 ↔ Port 3

4.2.17.3 Setting the max. transmission distance

S 101 Position	Maximum optical transmission distance
P	500 metres
ON	1500 metres

4.2.18 Converter Display Panel UNS 0885 (CDP)

The current display offset is adjustable with the potentiometer „offset“ accessible from the rear side.

4.2.19 Rotor ground fault detection UNS 3020, V1/V2

4.2.19.1 Features

Fig. 4.2-40 View of Rotor ground fault detection UNS 3020

The UNS 3020 is an independent protection relay. It is used for the ground fault protection of the entire rotor circuit of the machine, including the power converters and the excitation transformer.

More feature:

- Two-step structure.
- Step 1 for alarm, Step 2 for TRIP (example).
- Separate Adjustment of response level and response delay in each step.
- Variant1: for nominal excitation voltages up to 1000V.
- Variant2: for nominal excitation voltages up to 3000V.

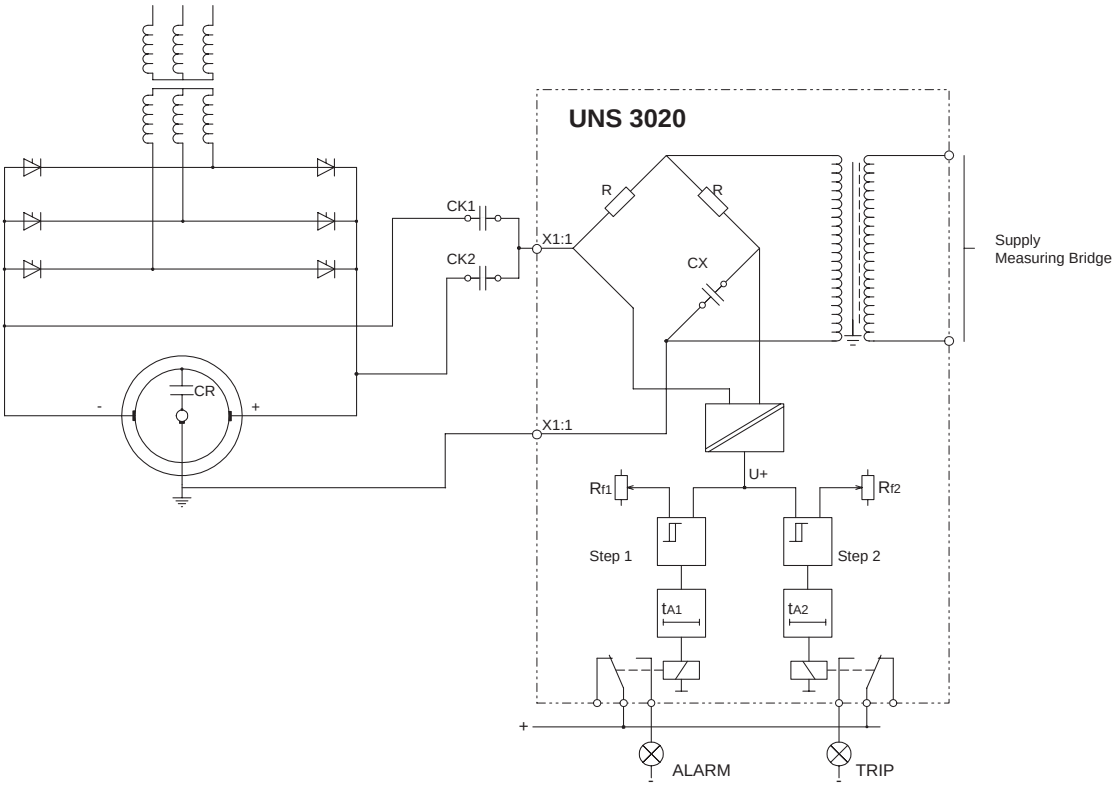


Fig. 4.2-41 Schematic diagram of ground fault detection

4.2.19.2 Device settings

Note	The commissioning of the rotor ground fault detection UNS 3020 is described in details in the "instruction for setting and operation" (document HIER 95 140). The commissioning has to be done according to this instruction!

Subprint

Operating elements	**Function**	**Settings**
Rf1	setting of the response value step1	potentiometer
R1401	setting of the response threshold step1	solder resistor
t A1	setting of the response delay step1	potentiometer
Rf2	setting of the response value step2	potentiometer
R1402	setting of the response threshold step2	solder resistor
t A2	setting of the response delay step2	potentiometer
TST	TEST function	key
RST	RESET function	key

Main Board

Operating elements	Function	Factory settings
S103	frequency setting 50 / 60 Hz	50 Hz
S104	frequency setting 50 / 60 Hz	50 Hz
C1101	adjusting capacity	1µF
C1102	adjusting capacity	1µF
C1103	adjusting capacity	open
C1104	adjusting capacity	open
R1101	burden impedance converter	120 Ω
C1105	bandpass frequency setting	for internal use only
S1	Switching off of the coupling capacitor CK1,CK2	closed
S2	Switching off of the coupling capacitor CK1,CK2	closed
S3	Connection ground potential to internal GND	closed
S1201	only in V1: Remote test: output relay active	open
S1202	only in V1: Remote test: output relay inactive	closed

4.2.19.3 Position of the setting elements

Subprint

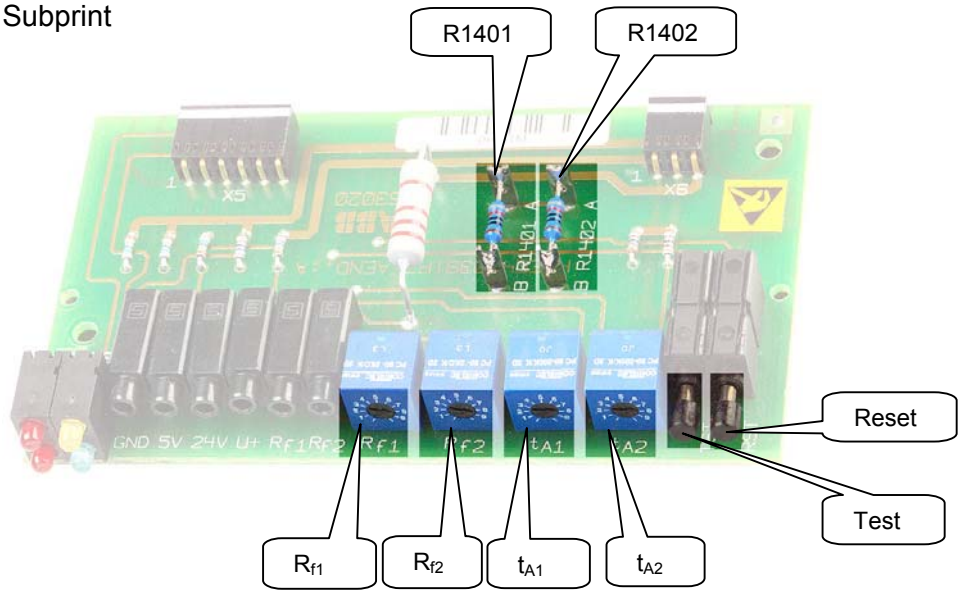


Fig. 4.2-42 Position of the setting elements on Subprint

Main Board

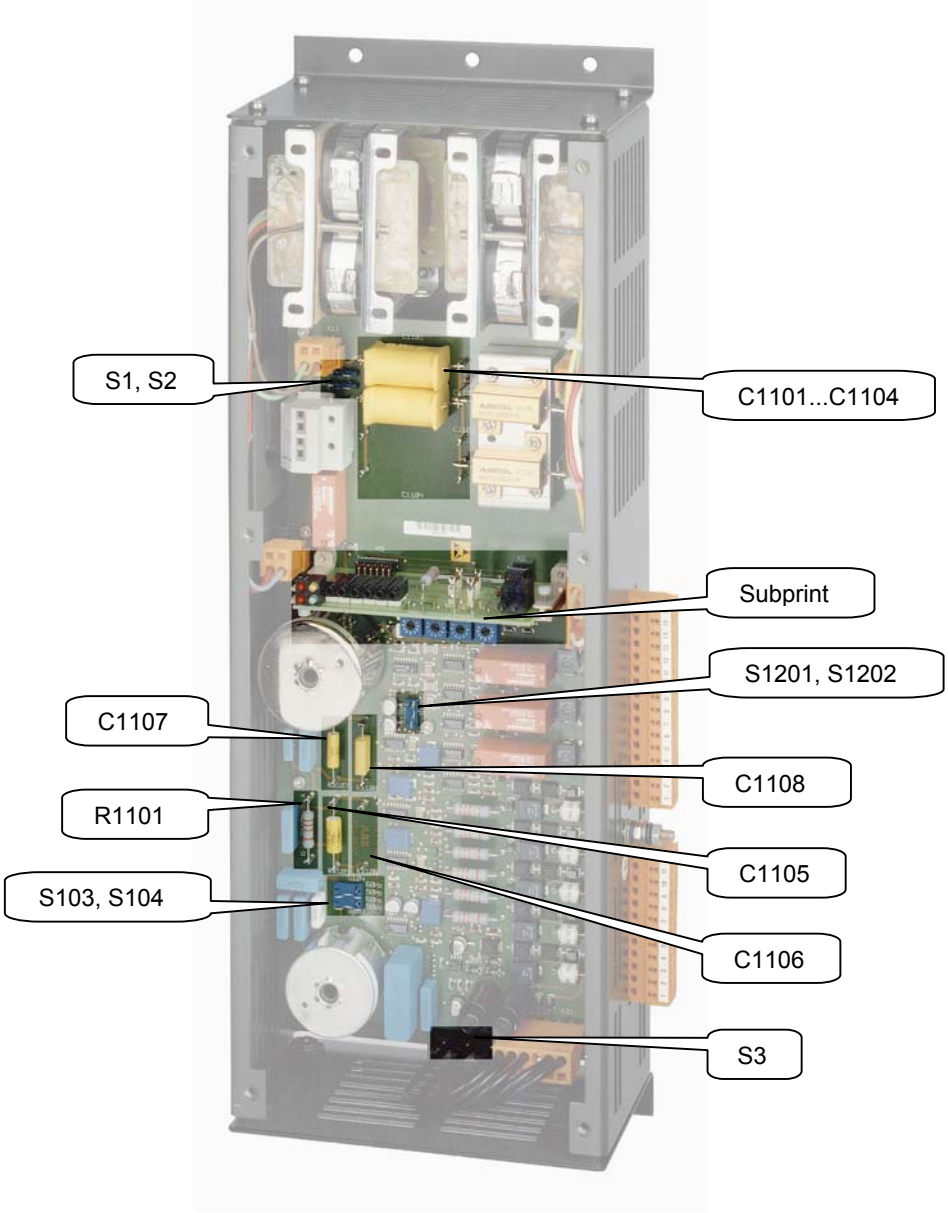


Fig. 4.2-43 Position of the setting elements of Rotor ground fault detection UNS 3020