MATRIX Technical Reference Manual

Version 1.1

April 04, 2006

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PN02121

Preface

This document has been compiled with great care and is believed to be correct at the date of print. The information in this document is subject to change without notice and does not represent a commitment on the part of Omicron NanoTechnology GmbH.

Please note. Some components described in this manual may be optional. The delivery volume depends on the ordered configuration.

Please note. This documentation is available in English only.

Attention. Please read the safety information on pages 10 to 11 before using the instrument.

Copyright

Warranty

Omicron acknowledges a warranty period of 12 months from the date of delivery (if not otherwise stated) on parts and labour, excluding consumables such as filaments, sensors, etc.

No liability or warranty claims shall be accepted for any damages resulting from non-observance of operational and safety instructions, natural wear of the components or unauthorised repair attempts.

Waste Electric and Electronic Equipment

In compliance with the WEEE directive (2002/96/EC) OMICRON ensures that all products supplied by OMICRON which are de-commissioned and which are labelled with an WEEE Registration Number will be taken back by OMICRON free of charge.

All costs of packing, transport, duty, etc. to the destination of the nearest OMICRON Returned-WEEE-Centre shall be borne by the customer. The customer is required:

- to declare the returned material is free of contamination or hazardous materials from usage (include Decontamination Declaration sheet),
- to request a valid Return Material Authorisation (RMA) available from the OMICRON service department,
- to ship all returned goods to the advised destination "OMICRON Returned-WEEE-Centre, DDP (INCOTERMS)"

Otherwise OMICRON will not accept any shipment

Normal Use

The Omicron MATRIX system comprises software, computer hardware, digital and analogue I/O electronics. MATRIX is determined for instrument control, data acquisition, and visualisation in Scanning Probe Microscopy (SPM).

The Omicron MATRIX system consists of the following subunits

1. Matrix Control Unit (Matrix CU)
2. MATRIX Power Supply
3. MATRIX Rack
4. Windows XP computer
5. Matrix SPM control software

optional:

6. AFM CU II
7. Mobile computer desk/rack combination
8. HC 1100 for direct sample heating

The **Omicron MATRIX system** shall always be used

- **complete** and in combination with SPM heads which are explicitly specified for this purpose by Omicron
- with original Omicron cable sets which are explicitly specified for this purpose
- with all cabling connected and secured, if applicable, and all electronics equipment switched on
- in combination with the up-to-date software release
- in an indoor research laboratory environment
- by personnel qualified for operation of delicate scientific equipment
- in accordance with all related manuals.

Warning: Lethal Voltages!!

The control unit supplies lethal voltages. Adjustments and fault finding measurements as well as **installation procedures and repair work** may only be carried out by authorised personnel qualified to handle lethal voltages.

Experiments in environments other than UHV may only be carried out by authorised personnel qualified to handle lethal voltages.

Attention: Please read the safety information in the relevant manual(s) before using the instrument.

Conditions of CE Compliance

OMICRON instruments are designed for use in an indoor laboratory environment. For further specification of environmental requirements and proper use please refer to your quotation and the product related documentation (i.e. **all** manuals, see individual packing list).

The OMICRON **MATRIX System** complies with CE directives as stated in your individual delivery documentation if used unaltered and according to the guidelines in the relevant manuals.

Limits of CE Compliance

This compliance stays valid if repair work is performed according to the guidelines in the relevant manual and using original OMICRON spare parts and replacements.

This compliance also stays valid if original OMICRON upgrades or extensions are installed to original OMICRON systems following the attached installation guidelines.

Exceptions

OMICRON **cannot** guarantee compliance with CE directives for **components** in case of

- changes to the instrument **not authorised by OMICRON**, e.g. modifications, add-on's, or the addition of circuit boards or interfaces to computers supplied by OMICRON.

The customer is responsible for CE compliance of entire **experimental setups** according to the relevant CE directives in case of

- installation of OMICRON components to an on-site system or device (e.g. vacuum vessel),
- installation of OMICRON supplied circuit boards to an on-site computer,
- alterations and additions to the experimental setup not explicitly approved by OMICRON

even if performed by an OMICRON service representative.

Spare Parts

OMICRON spare parts, accessories and replacements are not individually CE labelled since they can only be used in conjunction with other pieces of equipment.

> **Please note.** CE compliance for a combination of certified products can only be guaranteed with respect to the lowest level of certification. Example: when combining a CE-compliant instrument with a CE 96-compliant set of electronics, the combination can only be guaranteed CE 96 compliance.

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Safety Information

Important:

- Please read this manual and the safety information in all related manuals before installing or using the instrument or electronics equipment.
- The safety notes and regulations given in this and related documentation have to be observed at all times.
- Check for correct mains voltage before connecting any equipment.
- Do not cover any ventilation slits/holes so as to avoid overheating.
- The MATRIX Electronics complete set may only be handled by authorised personnel.
-

Warning: Lethal Voltages!!

- Adjustments and fault finding measurements may only be carried out by authorised personnel qualified to handle lethal voltages.
- Lethal voltages may present at parts of the instrument during operation.
- Lethal voltages are present inside the control unit and computer.

Always

- All connectors which were originally supplied with fixing screws must always be used with their fixing screws attached and tightly secured.
- All connectors which were originally supplied with a short circuit plug must either be connected to the electronics or fitted with their short circuit plug.
- Always disconnect the mains supplies of all electrically connected units before
  - ⇨ venting, pumping down or opening the vacuum chamber
  - ⇨ opening a control unit case,
  - ⇨ touching any cable cores or open connectors,
  - ⇨ touching any part of the in-vacuum components (except for tip and sample exchange as described in this manual).
- Leave for a few minutes after switching off for any stored energy to discharge.

Inrush Current

- After switching any of the control units off wait for at least 90 s before switching back on in order to ensure that the inrush current limitation works properly.

Never

- Never exceed a pressure of 1.2 bar inside the vacuum chamber.
- Never have in-vacuum components connected to their electronics in the corona pressure region, i.e. between 10 mbar and 10-3 mbar, so as to avoid damage due to corona discharge.

This product is only to be used:

- indoors, in laboratories meeting the following requirements:
  - ⇨ altitude up to 2000 m,
  - ⇨ temperatures between 5°C / 41°F and 40°C / 104°F (specifications guaranteed between 20°C / 68°F and 25°C / 77°F)
  - ⇨ relative humidity less than 80% for temperatures up to 31°C / 88°F (decreasing linearly to 50% relative humidity at 40°C / 104°F)
  - ⇨ pollution degree 1 or better (according to IEC 664),
  - ⇨ overvoltage category II or better (according to IEC 664)
  - ⇨ mains supply voltage fluctuations not to exceed ±10% of the nominal voltage

1. Introduction

The MATRIX SPM Control System couples advances in digital electronics with the requirements of the latest SPM applications to offer an unprecedented level of experimental flexibility and data processing control. Fundamental to MATRIX'S modular philosophy are a series of advanced digital boards each equipped with the latest microprocessor technology. Accessed through the MATRIX software, the revolutionary architecture provides for simple tailoring of experiments. Functionality is no longer "hard-wired" at board level. Programmable elements are "soft-wired" opening up to new functionality such as multichannel feedback, input/output trigger control, pre-emptive feedback, and non-orthogonal and non-linear scan generation.

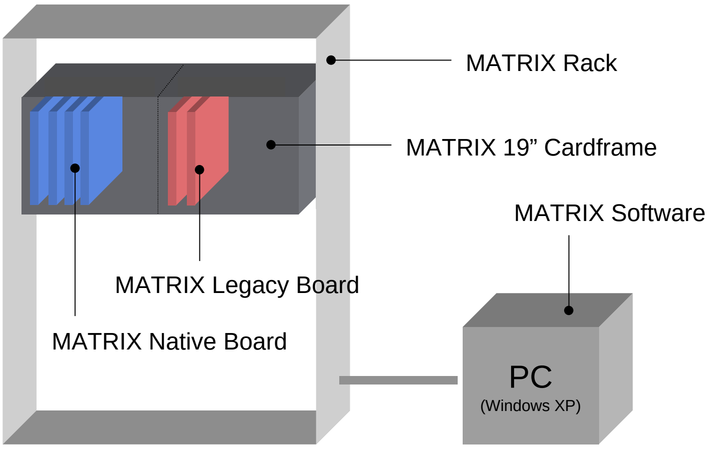
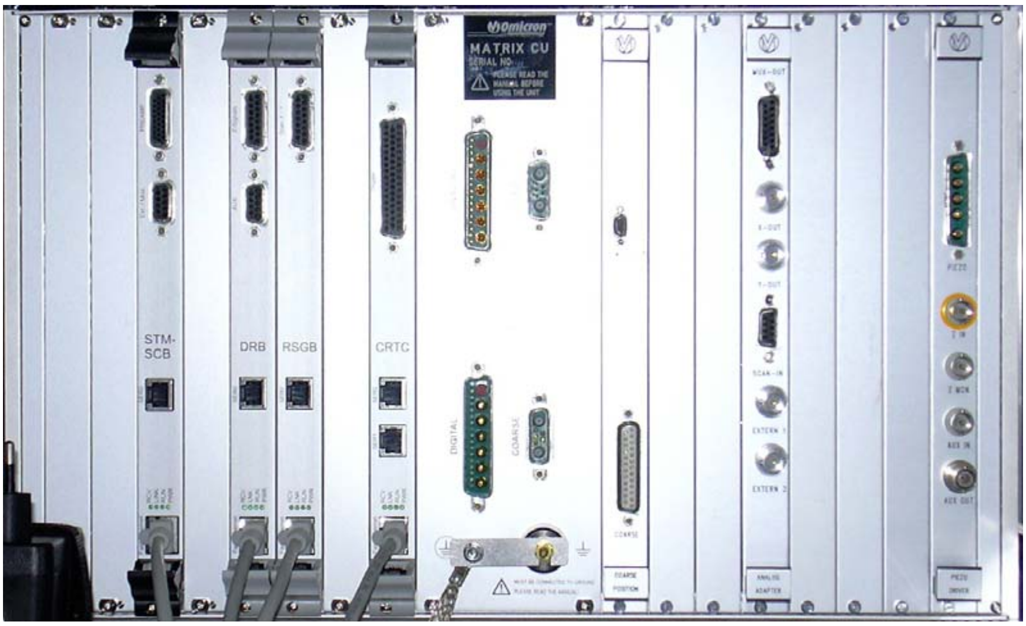


Figure 1. MATRIX basic hardware concept, schematic diagram.

At the moment the MATRIX CU includes five native boards which have been designed particularly for the MATRIX new efficient control system. These boards are called STM-SCB, RSGB, DRB, CRTC and the optional U-SCB.

Some state-of-the-art boards such as the coarse positioning board and the piezo driver, that served so successfully in SCALA, have been adapted with only a few revisions. These are called "legacy boards". A new board in the legacy regime is the Analogue Adapter Board.



Native Boards Power Input Legacy Boards

Figure 2. MATRIX control unit for STM (no U-SCB), back view.

2. MATRIX CU Native Boards

We have two types of native boards: master boards and slave boards. At the moment there are four slave boards (STM-SCB, DRB, RSGB, and U-SCB) and one master board (CRTC). The differences are listed in table 1 below.

Master Board	Salve Board
• source of the scan-axis clock system (clock coordinate system, CCS) • no measurement data connection, only system control • realisation of the external digital interface (SPM digital bus) • global clock generation and clock distribution • no local clock • no analogue electronics • control of the system boot process • master of the system configuration	• no clock generation • boots only in combination with the master • highly specialised analogue electronics for the individual board functionality

Table 1. Master and slave board differences.

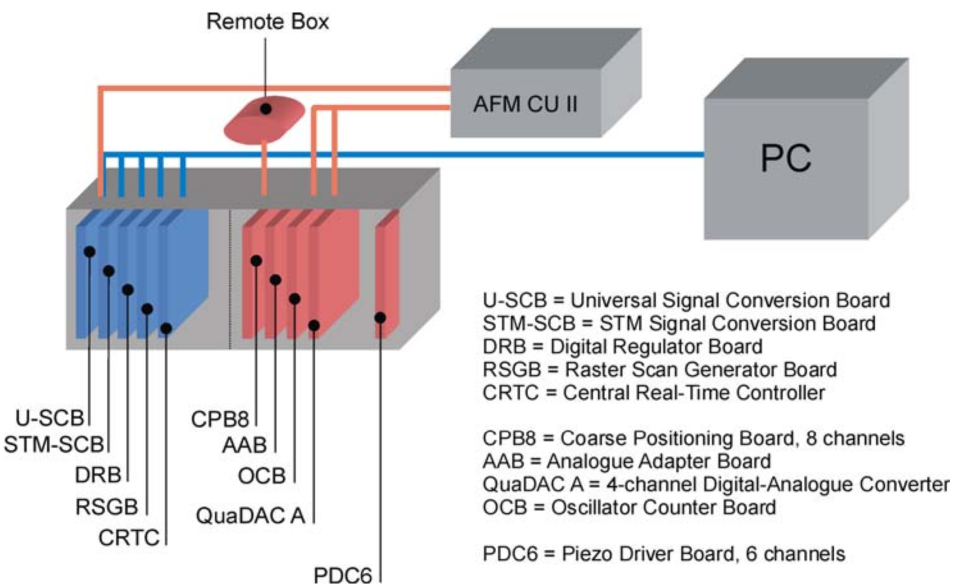


Figure 3. MATRIX basic configuration plus AFM functionality, schematic diagram.

Communication Details

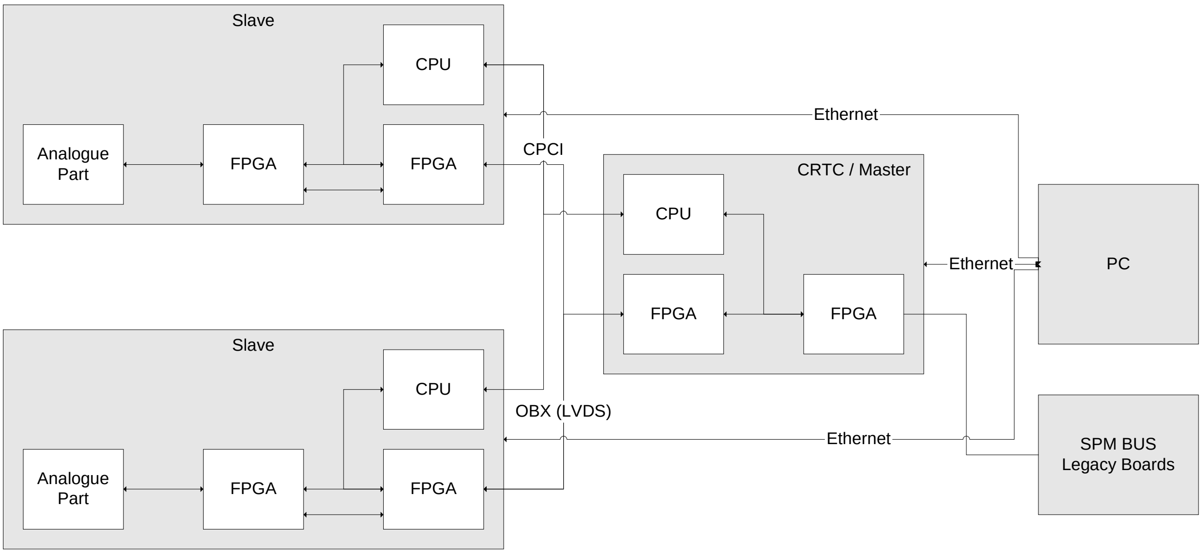


Figure 4. MATRIX communication diagram.

The communication for digital measurement, configuration and control data is realised across the back plane with industrial standard CPCI. Native boards communicate via fast digital board-to-board connections (50 Hz) across the back plane using OBX/LVDS. Hybrid solutions utilise the SPM bus system.

For external communication there are the following provisions taken:

- Fast Ethernet, approx. 8 MB/s (nominal 10 MB/s)
- Peer-to-peer wired or LAN-oriented
- Transport: TCP/IP
- Protocols: OTP (from OPIC standard), and RDTP (Omicron)

For External hardware an additional trigger interface is provided for temperature sensors, actuators etc. Remote access for service purposes is also possible.

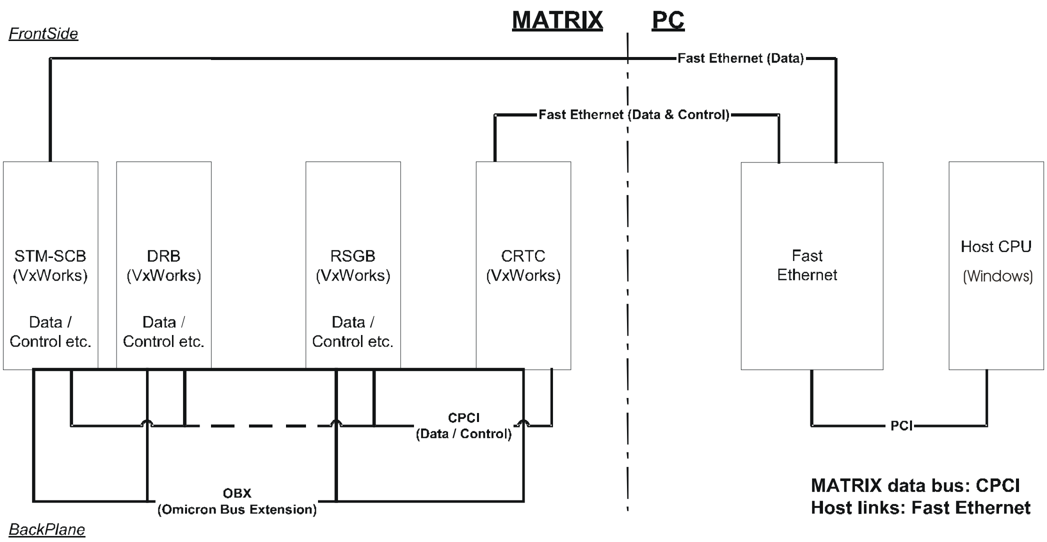


Figure 5. MATRIX bus concept.

CRTC – Central Real-Time Controller (Master)

Location: MATRIX CU	Application:	standard

The functions of the CRTC board are the:

- Source of the scan axis clock system
- Realisation of the external digital interface (to the SPM-digital bus)
- Global clock generation and clock distribution
- Control of system boot process
- Master of system configuration; responsible for the configuration of the slave boards
- Realisation of the communication with the PC
- Management of the compact PCI-bus

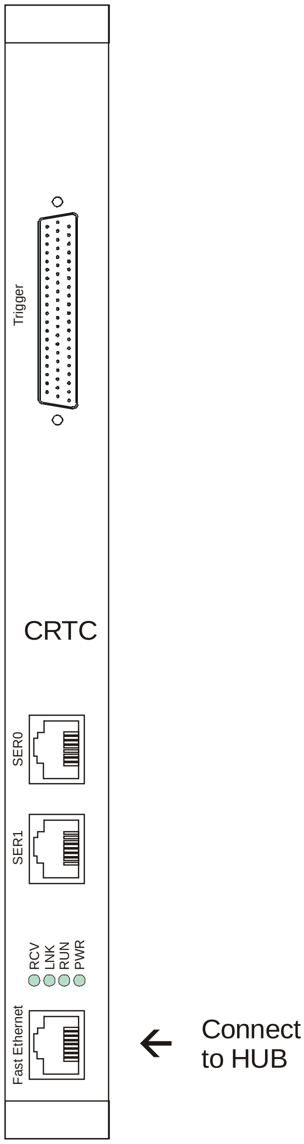


Figure 6. CRTC – central real time controller, panel schematic diagram.

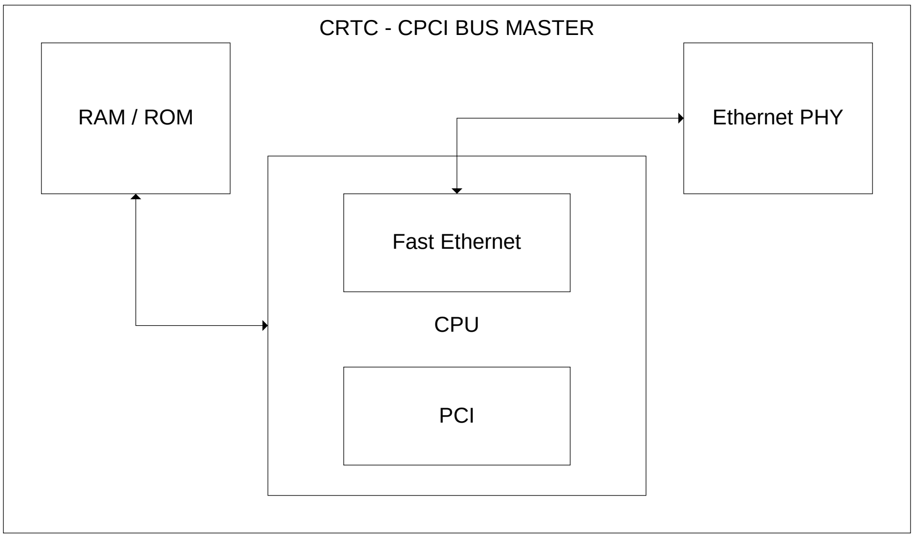


Figure 7. CRTC block diagram.

Trigger

Pin number	Signal	Pin number	Signal
1	Analogue ground	26	TTL out 11
2	Analogue ground	27	TTL out 9
3	Analogue ground	28	TTL out 7
4	TTL in 6	29	TTL out 5
5	TTL in 4	30	TTL out 3
6	TTL in 2	31	TTL out 1
7	TTL in 0	32	5 V
8	TTL out 14	33	5 V
9	TTL out 12	34	Analogue ground
10	TTL out 10	35	Analogue ground
11	TTL out 8	36	Analogue ground
12	TTL out 6	37	Analogue ground
13	TTL out 4	38	Analogue ground
14	TTL out 2	39	Analogue ground
15	TTL out 0	40	Analogue ground
16	5 V	41	Analogue ground
17	5 V	42	Analogue ground
18	Analogue ground	43	Analogue ground
19	Analogue ground	44	Analogue ground
20	TTL in 7	45	Analogue ground
21	TTL in 5	46	Analogue ground
22	TTL in 3	47	Analogue ground
23	TTL in 1	48	Analogue ground
24	TTL out 15	49	5 V
25	TTL out 13	50	5 V

Table 2. Trigger 50-pin D-sub connector pinout.

STM-SCB Signal Conversion Board (Slave)

Location:	MATRIX CU	Application:	standard

The STM-SCB is the interface to the preamplifier. It measures and digitises the tunnelling current signal and provides the gap voltage for STM operation. Designed as a two-branch system it measures the tunnelling current and at the same time provides the feedback signal and allows reading back signals for calibration or offset correction. External inputs allow gap voltage offset or modulation.

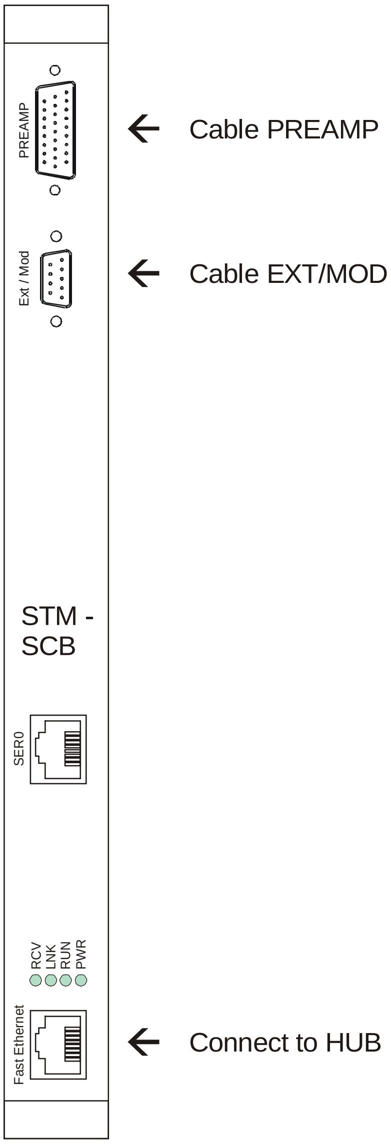


Figure 8. STM-SCB signal conversion board, panel schematic diagram.

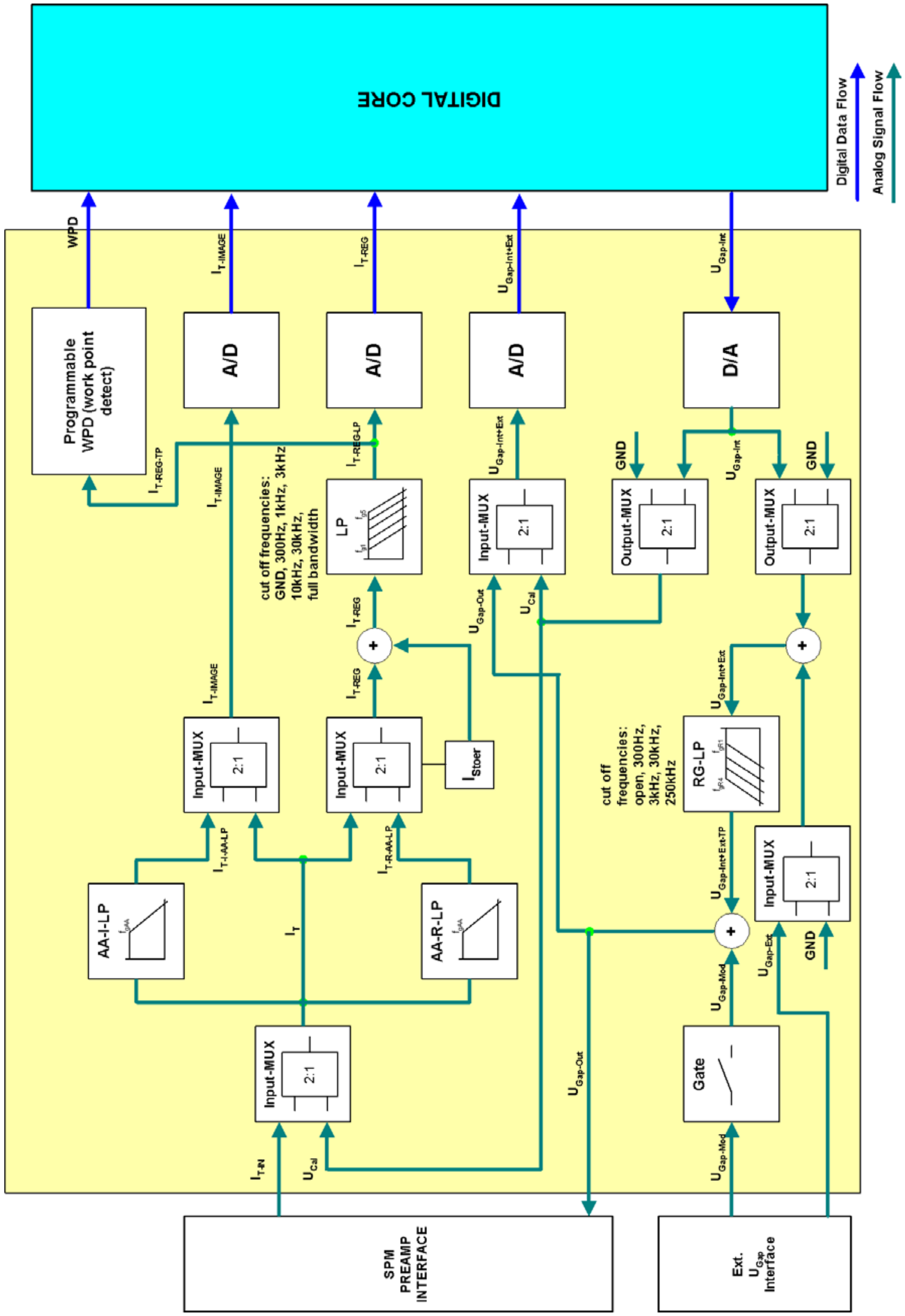


Figure 9. STM SCB block diagram.

Preamp

Pin number	Signal	Pin number	Signal
1	V GAP-	14	+5V
2	A ground	15	
3	I_T-	16	
4	A ground	17	
5	+5V	18	
6		19	V/10 (V GAP switch signal)
7		20	I/10 (I_T switch signal)
8		21	PREAMP Analogue supply +18V
9		22	PREAMP Analogue supply –18V
10	V GAP+	23	Digital Ground DG
11	Analogue ground	24	Digital Ground DG
12	I_T+	25	Digital Ground DG
13	Analogue ground	26	Digital Ground DG

Table 3. Preamp D-sub connector pinout.

Please note. Pins 6 to 9 and 15 to 18 are reserved for future extension. These future connections are differential interfaces and are designed for LVDS signals propagation: Low-Voltage Differential Signalling uses high-speed analogue circuit techniques to provide multi gigabit data transfers on copper interconnects and is a generic interface standard for high-speed data transmission.

Ext / Mod

Pin number	Signal
1	Vgap ext +
2	A ground
3	Vgap mod +
4	A ground
5	IT Mon
6	Vgap ext -
7	A ground
8	Vgap Mod -
9	A ground

Table 4. Ext / Mod D-sub connector pinout.

STM-SCB Characteristics

Analogue Digital Converter

- Resolution: (±10 V/16 bit)
- Maximum sampling rate: 470 ksps

Measurement Branch

- Anti-Aliasing Low Pass: 100 kHz

Note. In order to recover all Fourier components of a periodic waveform, it is necessary to sample at least twice as fast as the highest waveform frequency . So if ν is the sampling rate, the Nyquist frequency, also called the Nyquist limit, is the highest frequency that can be coded at a given sampling rate in order to be able to fully reconstruct the signal

$$f_{Nyquist} = \tfrac{1}{2}\,\nu$$

High-quality sampling systems ensure that no aliasing occurs by low pass filtering the signal before sampling.

Feedback Branch

- Analogue Low Pass, configurable: 0.3-1-3-10-30 kHz
- Anti-aliasing Low Pass: 100 kHz

Vgap

- Vgap internal: (±10 V/16 bit), maximum sampling rate: 500 ksps
- Offset compensation (customer's low current measurements)
- Analogue low pass filter for signal reconstruction : 300 Hz, 3 kHz, 25 kHz, 75 kHz (for Vgap internal and Vgap external excluding Vmod)

External Inputs for Vgap

- Input 1 (Vgap extern) : DC....10 kHz/10 V
- Input 2 (Vmod) : Bandwidth approximately 60 kHz

DRB – Digital Regulator Board (Slave)

Location:	MATRIX CU	Application:	standard

The DRB provides a digital feedback system for SPM experiments. In addition the DRB provides two analogue input channels AUX1 and AUX2 for measuring optional signals. In AFM mode AUX1 is used for regulation and AUX2 can be used for external input signals. Furthermore there are an output for the actuator (Z OUT), a monitor output (Z MON) and an external offset input for the actuator output (Z EXT).

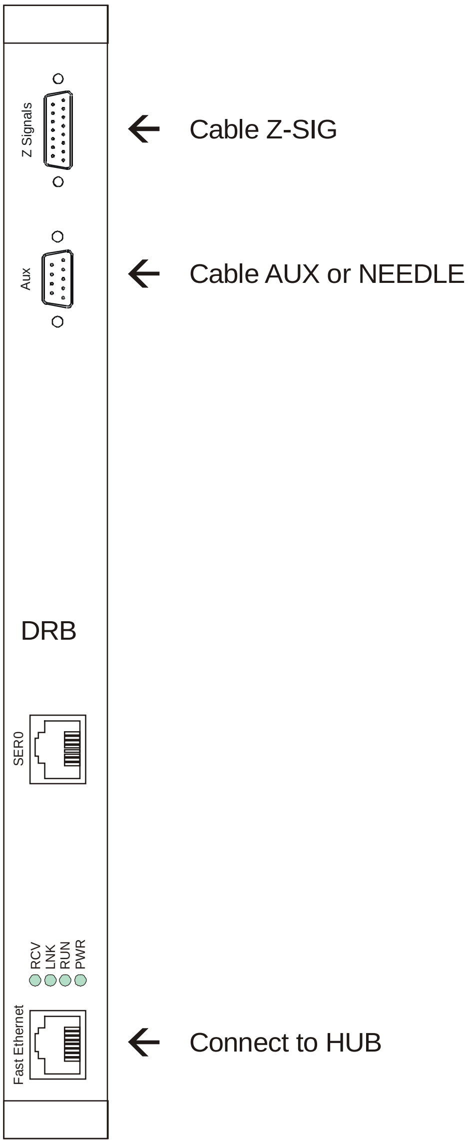


Figure 10. DRB – digital regulator board, panel schematic diagram.

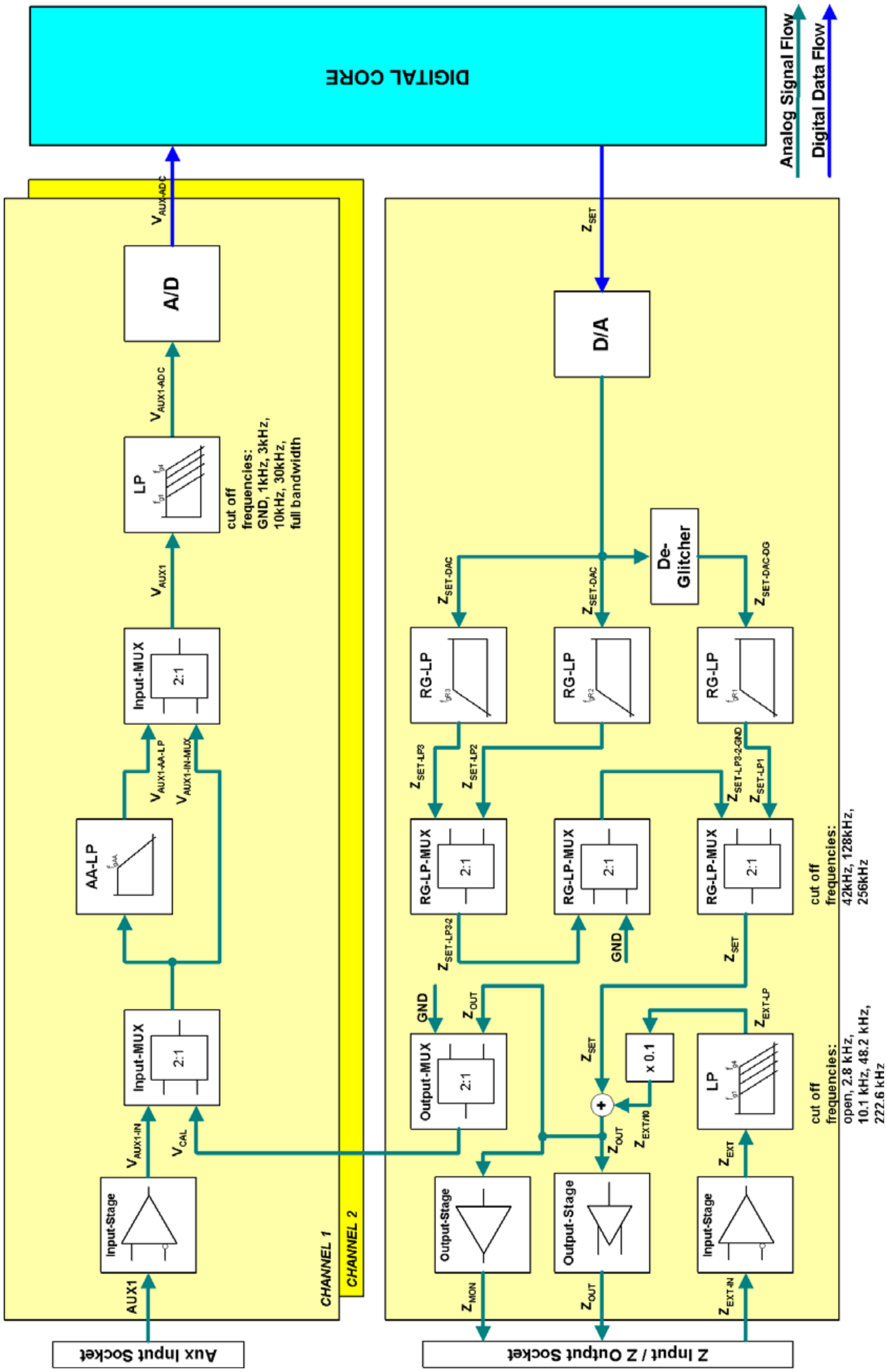


Figure 11. DRB block diagram.

Z Signal

Pin number	Signal
1	Zout +
2	A ground
3	ZEXT IN+
4	A ground
5	ZMON
6	A ground
7	A ground
8	A ground
9	Zout-
10	A ground
11	ZEXT IN-
12	A ground
13	A ground
14	A ground
15	A ground

Table 5. Z Signal 15-pin D-sub connector pinout.

AUX

This is a 9 PIN connector with a two-analogue-differential-input (= an input circuit that actively responds to the difference between two terminals, rather than the difference between one terminal and ground). Hence, the circuit is immune to signals that are identical (which often are due to induced noise) on the two input terminals. Since these two signals are subtracted from each other, the term is differential.

Pin number	Signal
1	Aux 1 +
2	A ground
3	Aux 2 +
4	A ground
5	Not connected
6	Aux 1-
7	A ground
8	Aux 2-
9	A ground

Table 6. AUX 9-pin D-sub connector pinout.

DRB Characteristics

ADC

- ADC resolution 16-bit
- Sampling Rate max. 470 ksps including oversampling for noisy input signals for AUX channels (16 bit ±10V)
- Strictly monotonic within 1 LSB

DAC

- 20-bit resolution correspondingly to 120 dB
- Monotony 18-bit or better
- Data rate approximately 62,5 ksps at 20 bit

Analogue Signal Path (AUX)

- Anti-aliasing low pass with band with 100 kHz
- Second order low pass with selectable band width of 1-3-10-30 kHz

Modulation Input (ZEXT)

- First order low pass with selectable band width of 2.8 kHz, 10.1 kHz, 48.2 kHz, 222.6 kHz
- Fixed gain x0.1

DRB Characteristics-Processor Output

- Digital output provided for further data processing via FPGA/CPU/CPCI-bus or OBX-FPGA or internal cache
- DA-conversion with a 16-bit oversampling system, consisting of DAC/Deglitcher/Filter
- Resolution and monotony 20-bit at 62.5 kHz sampling frequency; 16-bit at 500 kHz sampling frequency
- Deglitcher on/off
- Signal regeneration low pass: 4th or 6th order with 42-128-256 kHz band width
- Trigger lines for WPD, Loop Off and Declaration.

Please note. In AFM experiments the feedback for the regulation is realised by linking the Aux 1 D-SUB connector to the ΔFN out BNC socket of the compare board of the AFM CU.

In NEEDLE experiments the feedback for the regulation is realised by linking the Aux 1 D-SUB connector to the DPHIXOUT BNC socket of the OCB2 board.

RSGB – Raster Scan Generator Board (Slave)

Location: MATRIX CU	Application:	standard

This board generates the scan movement, i.e. the reference voltages for the Piezo Driver Board PDC 6 (X/Y movement, the Z displacement signal comes from the DRB). The RSGB uses vectors to describe the scan. It comprises a memory chip for storing up to 4000 scan vectors. Its digital concept also allows the generation of non-linear scan paths.

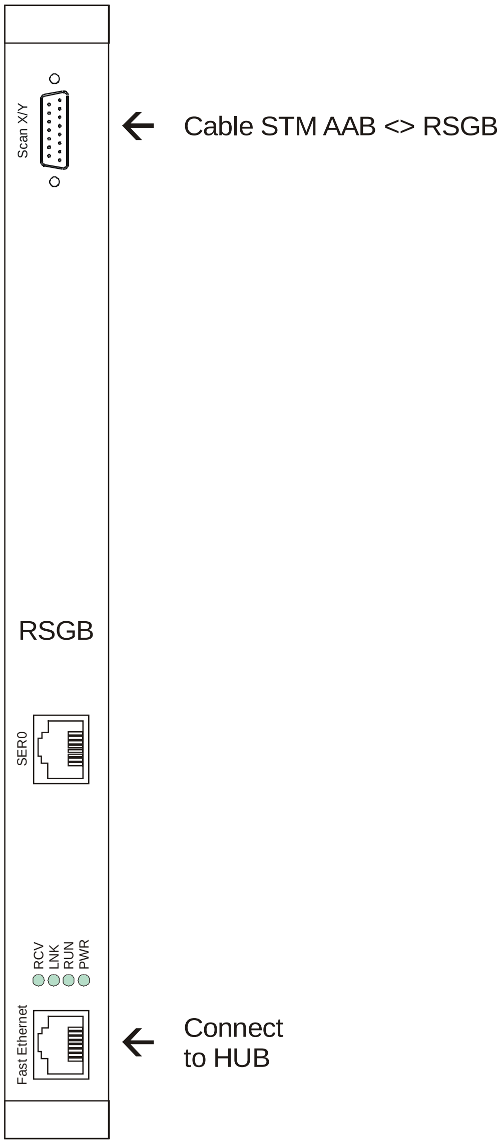


Figure 12. RSGB – raster scan generator board, panel schematic diagram.

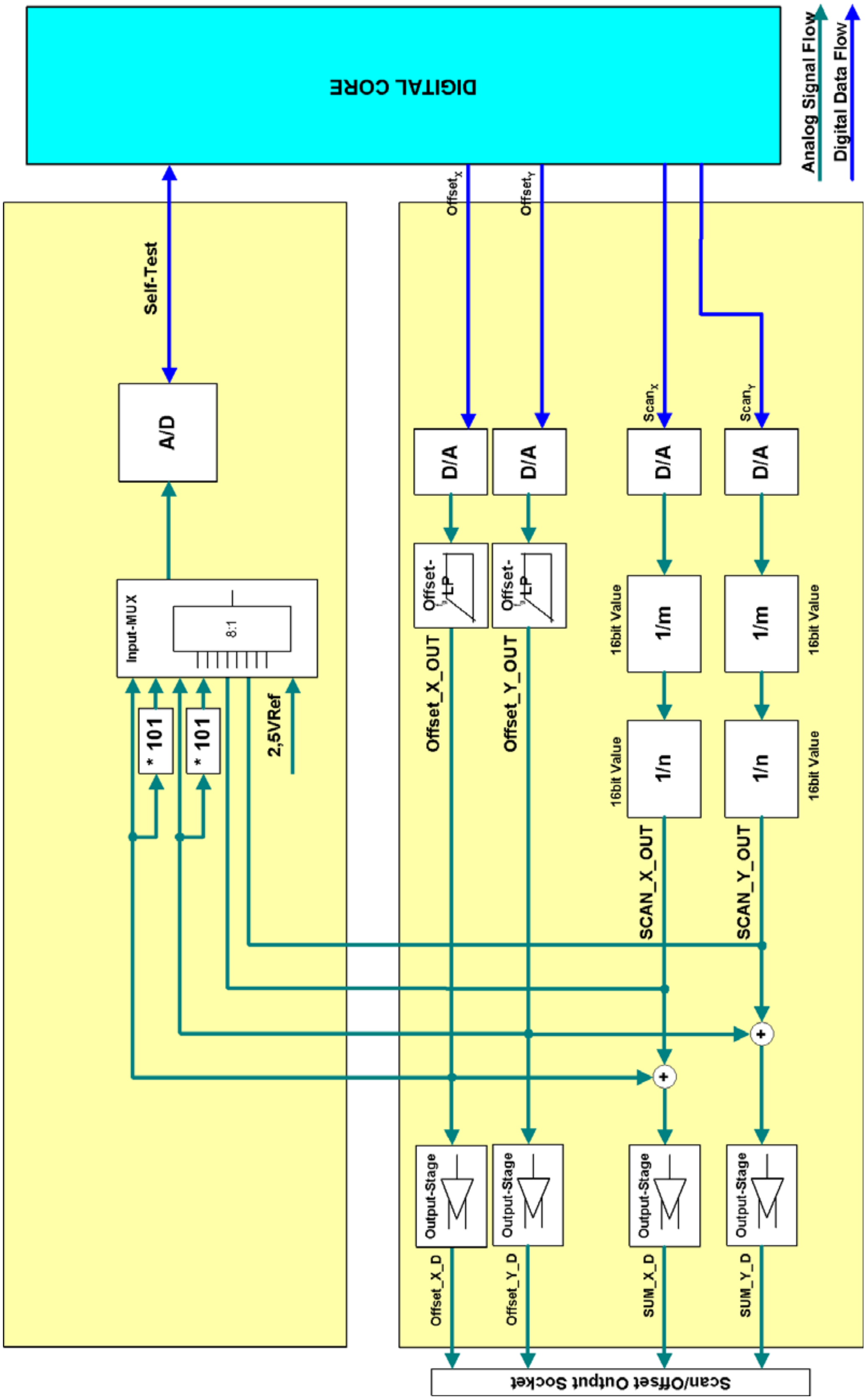


Figure 13. RSGB block diagram.

SCAN XY

Pin number	Signal
1	SUMX D+
2	A ground
3	SUM Y D-
4	A ground
5	OFFSET X D+
6	A ground
7	OFFSET Y D+
8	A ground
9	SUM X D-
10	A ground
11	SUM Y D-
12	A ground
13	OFFSET X D-
14	A ground
15	OFFSET Y D-

Table 7. Scan XY 15-pin D-sub connector pinout.

The following figure shows the signal path from the electronics board to the scanner:

Figure 14. RSGB signal path.

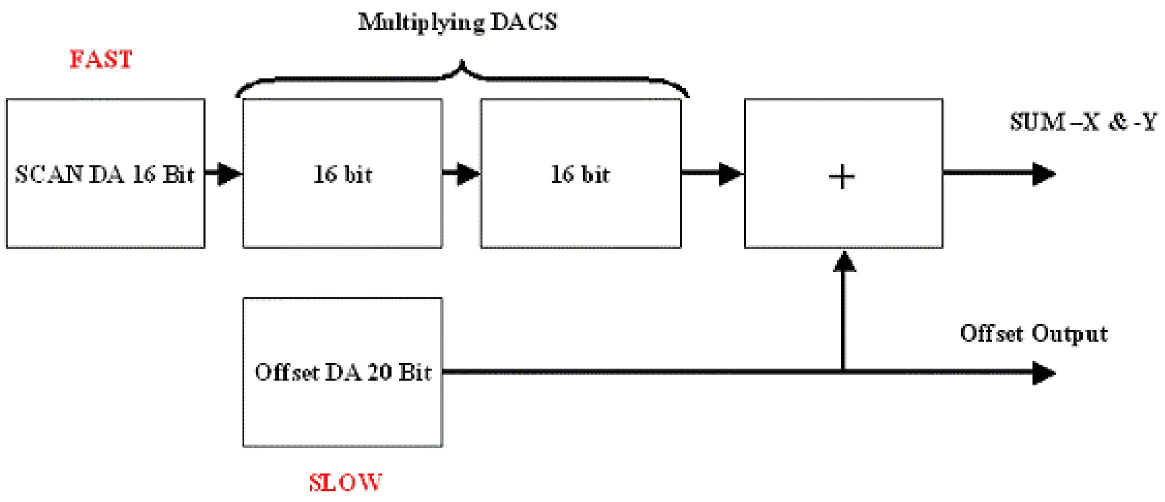


Figure 15. RSGB – digital/analogue converters.

Please note. The data transmission speed is limited by the multiplying DACs.

Samples per second (SPS): transmission rate for signals. In practice, transmission rates are usually stated in ksps (thousands of samples per second) or Msps (millions of samples per second).

Assignment Function

Provides the x-,y-Scan voltages and the x-and y-offset voltages

U-SCB – Universal Signal Conversion Board (Slave)

Location:	MATRIX CU	Application:	AFM

The U-SCB board is normally used for acquiring AFM signals (e.g. damping, frequency difference, etc.) On this board you have four analogue input channels and two analogue output channels. Note that the output channels are not used in any standard application.

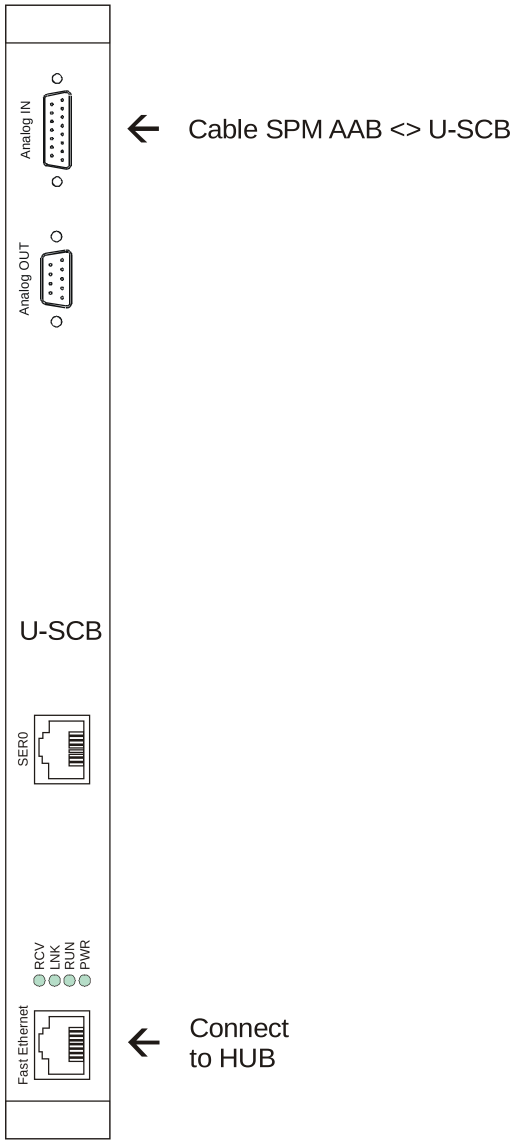


Figure 16. U-SCB – universal signal conversion board, panel schematic diagram.

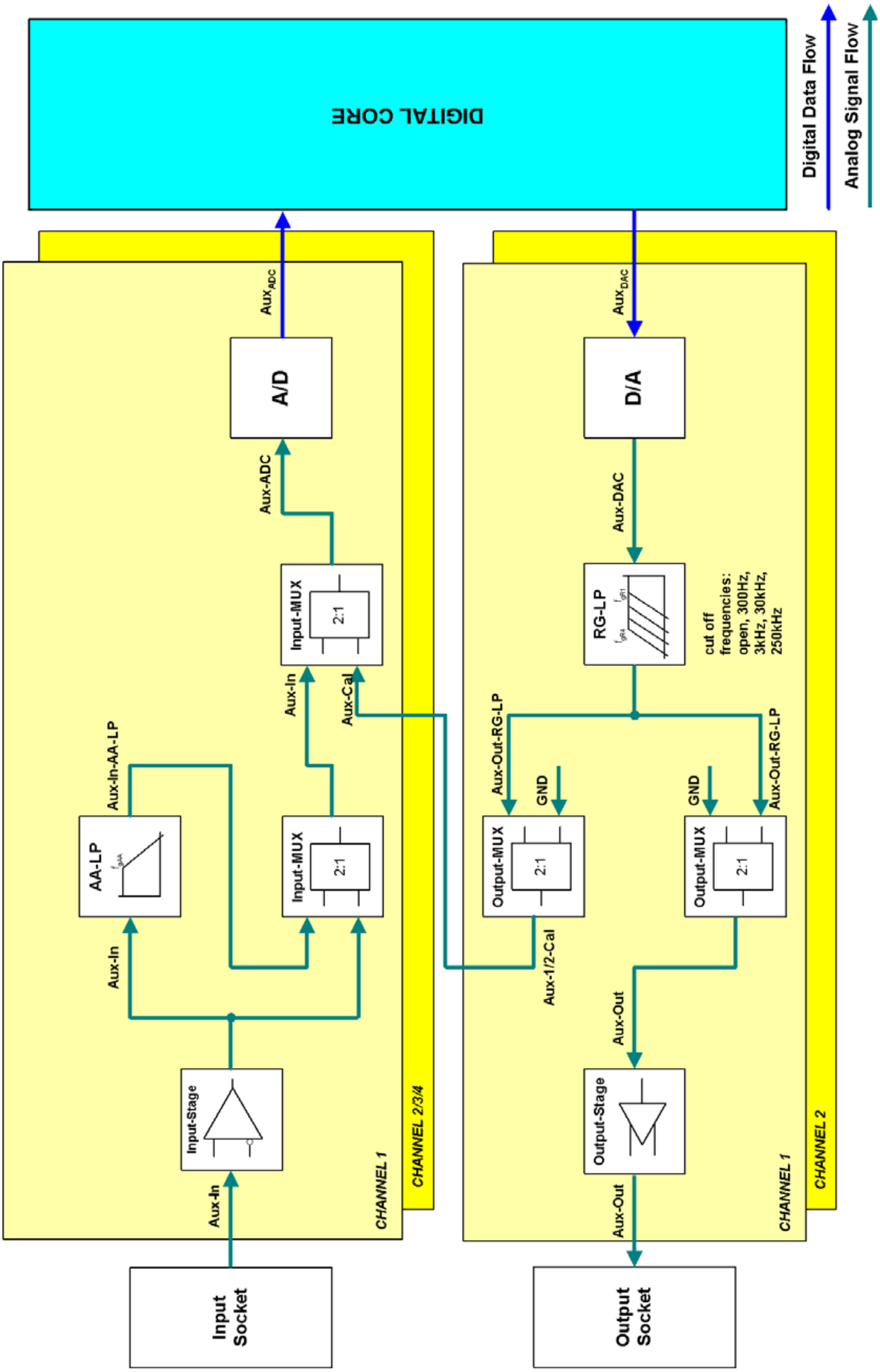


Figure 17. U-SCB block diagram.

Analog IN

Pin number	Signal	Limits
1	N+ ADC0	0-10 V
2	A ground	
3	N+ ADC1	0-10 V
4	A ground	
5	N+ ADC2	0-10 V
6	A ground	
7	N+ ADC3	0-10 V
8	A ground	
9	N- ADC0	0-10 V
10	A ground	
11	N- ADC1	0-10 V
12	A ground	
13	N- ADC2	0-10 V
14	A ground	
15	N- ADC3	0-10 V

Table 8. Analog IN 15-pin D-sub connector pinout.

Analog OUT

Pin number	Signal	Limits
1	Vout 0+	0-10 V
2	A ground	
3	Vout 1 +	0-10 V
4	A ground	
5	Not connected	
6	Vout 0-	0-10 V
7	A ground	
8	Vout 1-	0-10 V
9	A ground	

Table 9. Analog OUT 9-pin D-sub connector pinout.

3. MATRIX CU Power Input

The MATRIX CU receives its power input from the MATRIX CU power supply via four D-SUB mixed cables.

Figure 18. MATRIX CU power input block.

Attention. Connect the black grounding connection of the PIC cable (system ground) and all green-and-yellow grounding cables to the right hand side grounding port.

If the system grounding cable (part of the PIC cable) is disconnected from the electronics or from the system close the grounding bridge to ensure proper grounding. Otherwise disconnect the two ground connections from each other (open the bridge) to avoid ground loops.

4. MATRIX CU Legacy Boards

Analog Adapter Board

Location: MATRIX CU	Application:	standard

The Analog Adapter Board provides the connecting link between the newly developed, intelligent digital boards and the analogue legacy boards.

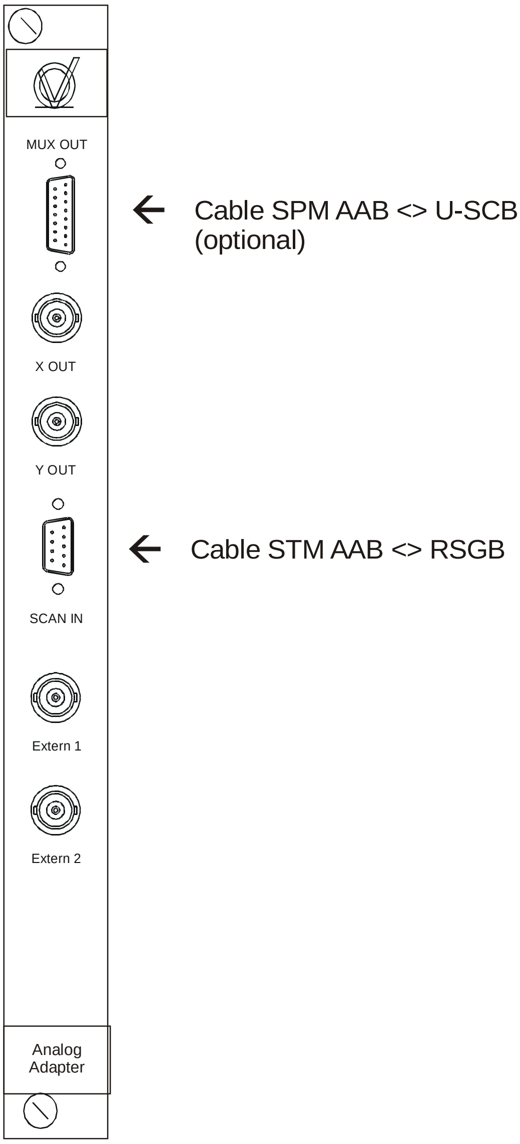
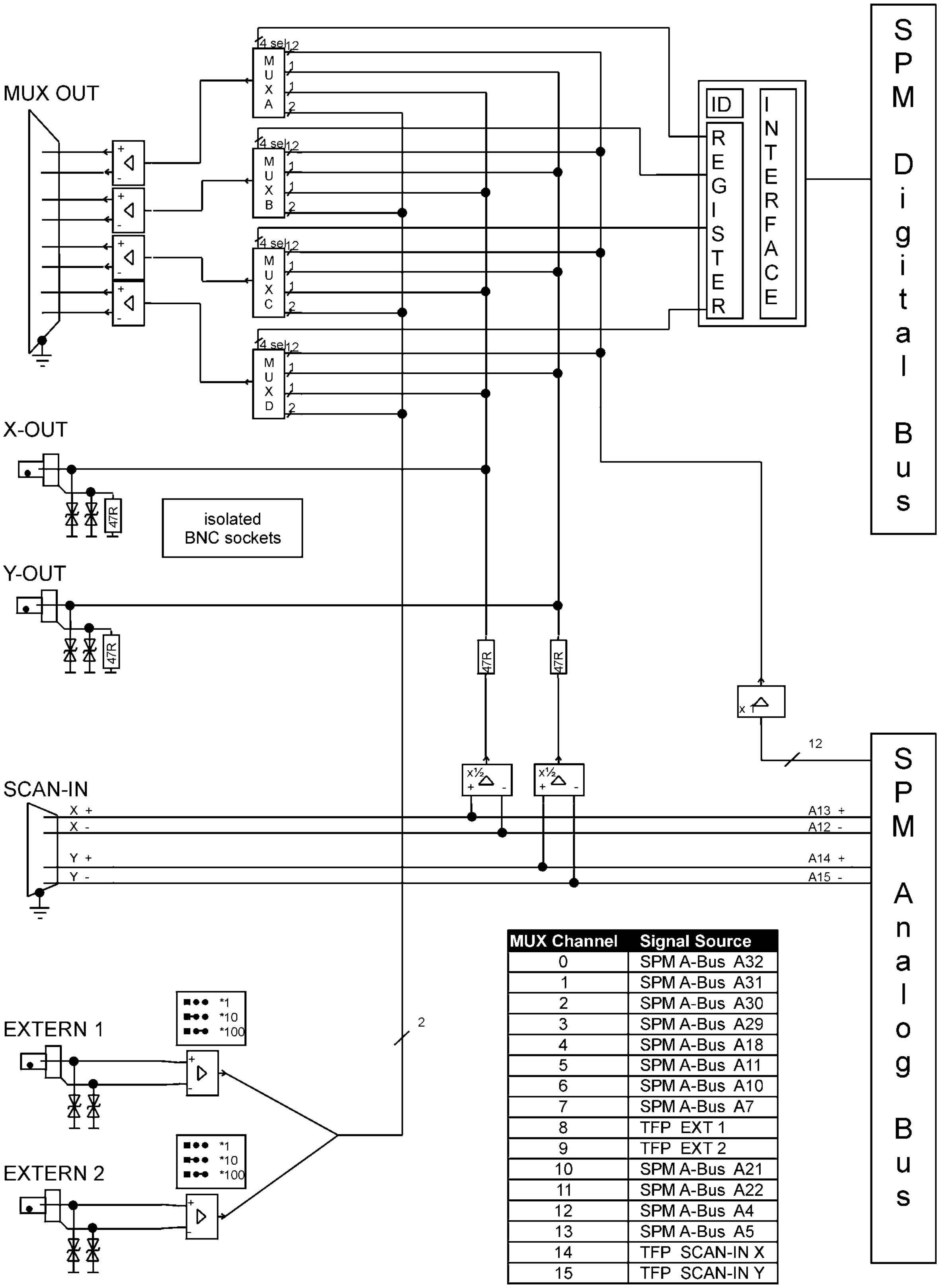


Figure 19. AAB – analog adapter board



MUX Channel	Signal Source
0	SPM A-Bus A32
1	SPM A-Bus A31
2	SPM A-Bus A30
3	SPM A-Bus A29
4	SPM A-Bus A18
5	SPM A-Bus A11
6	SPM A-Bus A10
7	SPM A-Bus A7
8	TFP EXT 1
9	TFP EXT 2
10	SPM A-Bus A21
11	SPM A-Bus A22
12	SPM A-Bus A4
13	SPM A-Bus A5
14	TFP SCAN-IN X
15	TFP SCAN-IN Y

Figure 20. Analog Adapter board block diagram.

MUX OUT

Pin number	Signal
1	A_MUX +
2	A ground
3	B_MUX +
4	A ground
5	C_MUX +
6	A ground
7	D_MUX-
8	A ground
9	A_MUX-
10	A ground
11	B_MUX-
12	A ground
13	C_MUX-
14	A ground
15	D_MUX-

Table 10. MUX OUT 15-pin D-sub connector pinout.

SCAN IN

Pin number	Signal
1	X scan +
2	A ground
3	Y scan +
4	A ground
5	Not connected
6	X scan -
7	A ground
8	Y scan-
9	A ground

Table 11. SCAN IN 9-pin D-sub connector pinout.

Coarse Positioning Board - CPB8

Location:	MATRIX CU	Application:	standard

The coarse positioning board can drive eight independent piezo inertia drives for sample or tip coarse positioning and connects to the remote box.

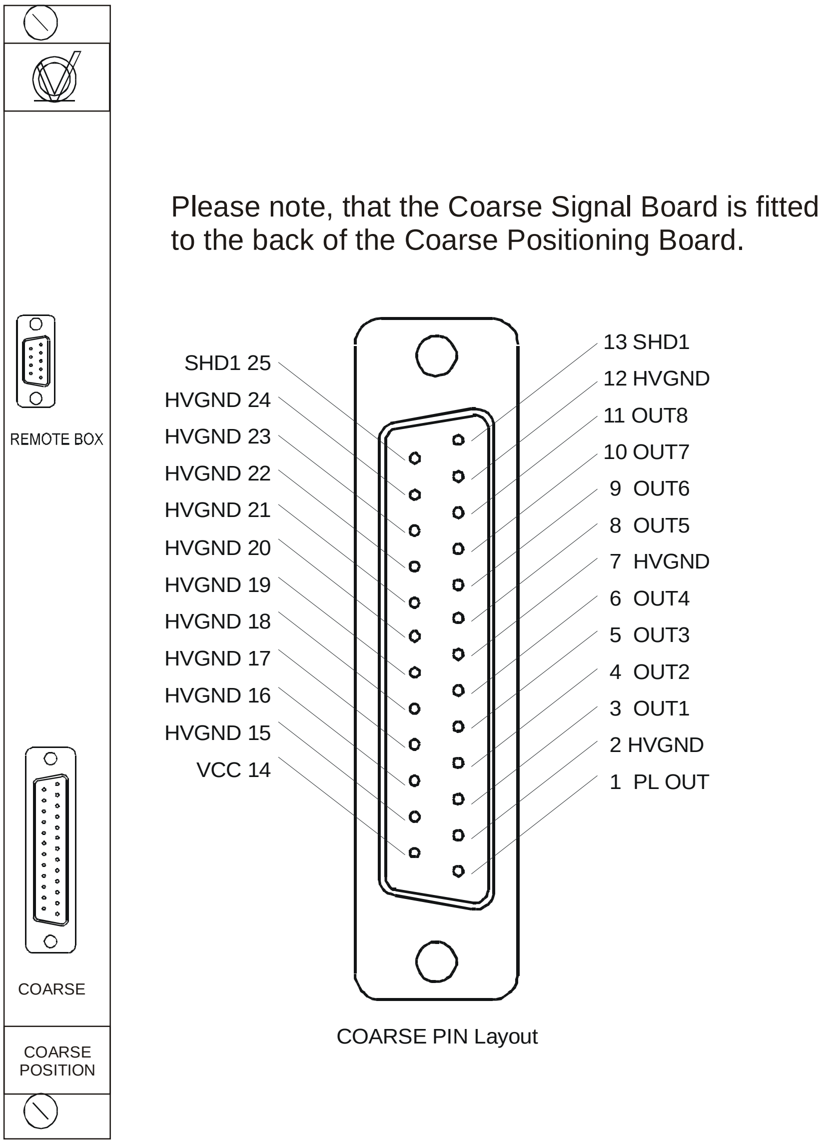


Figure 21. Coarse positioning board, panel schematic diagram.

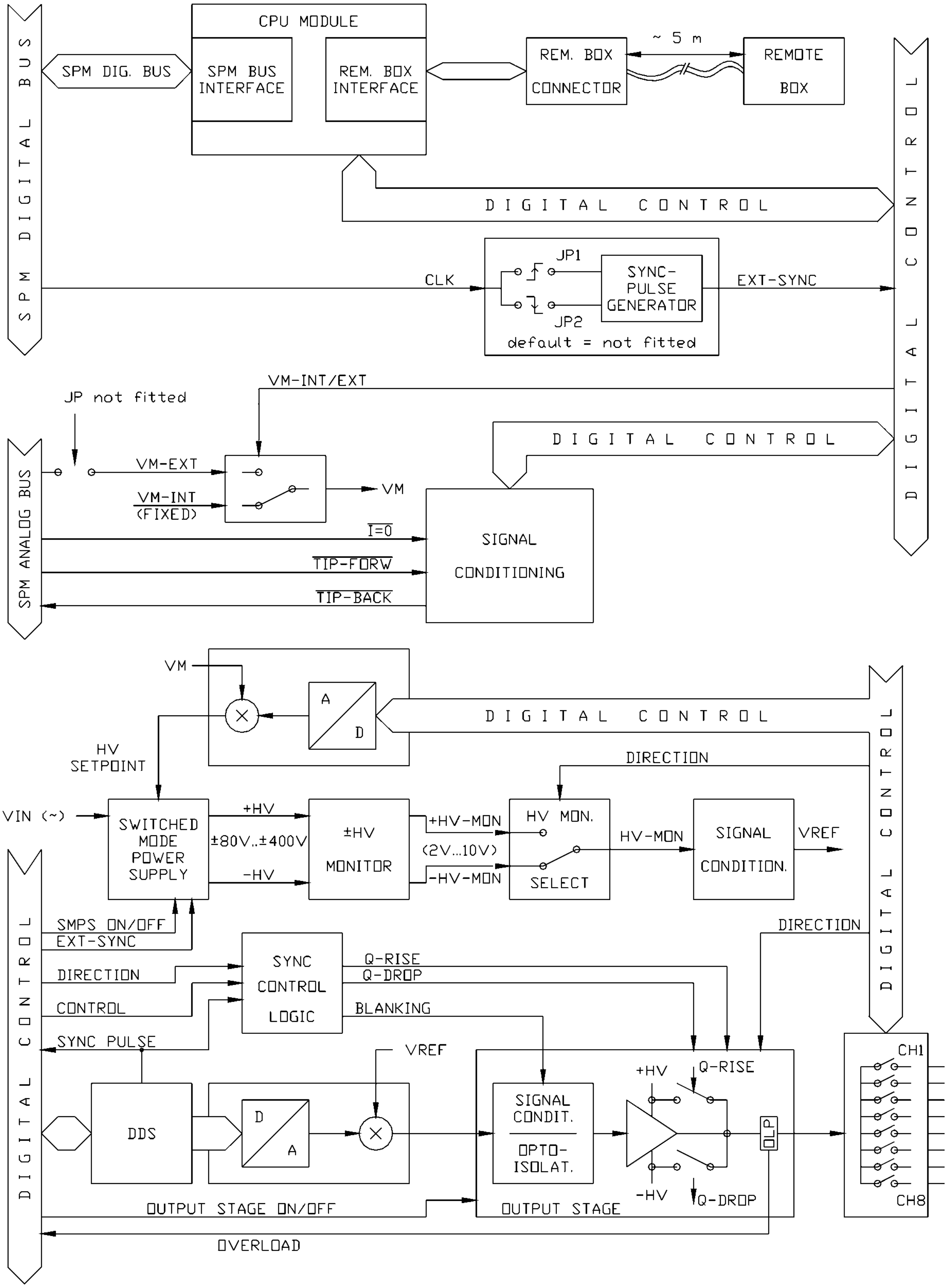


Figure 22: Coarse Positioning board layout, schematically.

Piezo Driver - PDC 6

Location:	MATRIX CU	Application:	standard

Hexa piezo driver for tripod or single tube scanners

The 6-channel piezo driver provides six amplifiers to give an output voltage of up to ±135 V for motion control during measurements. The four amplifiers for the X- and Y-signals are identical. They receive their input signal via the analogue bus connection (AB).

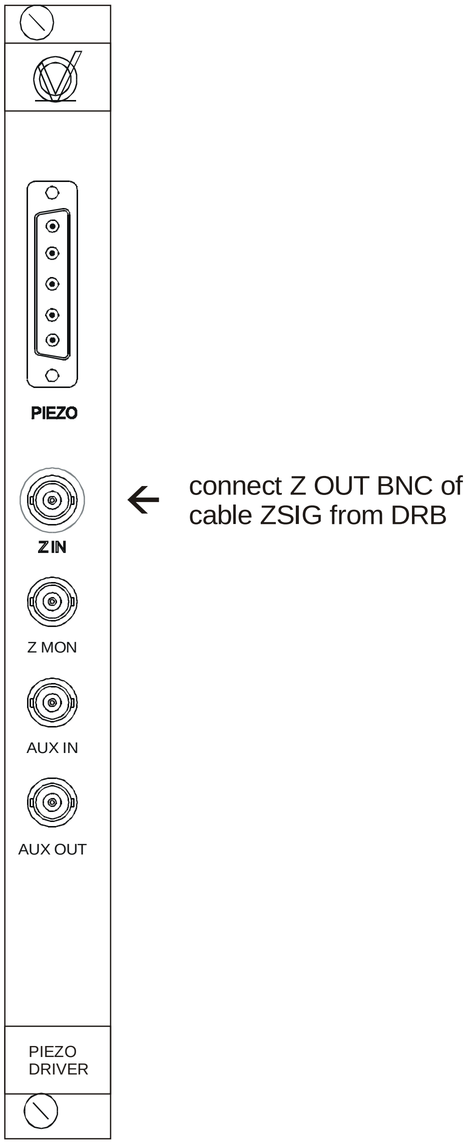


Figure 23. Piezo driver board PDC6, panel schematic diagram.

> **Attention.** The Piezo Driver board used with the Multiscan stage differs considerably from the Piezo Driver board described here. These boards must never be mixed up otherwise the scanner may be severely damaged.

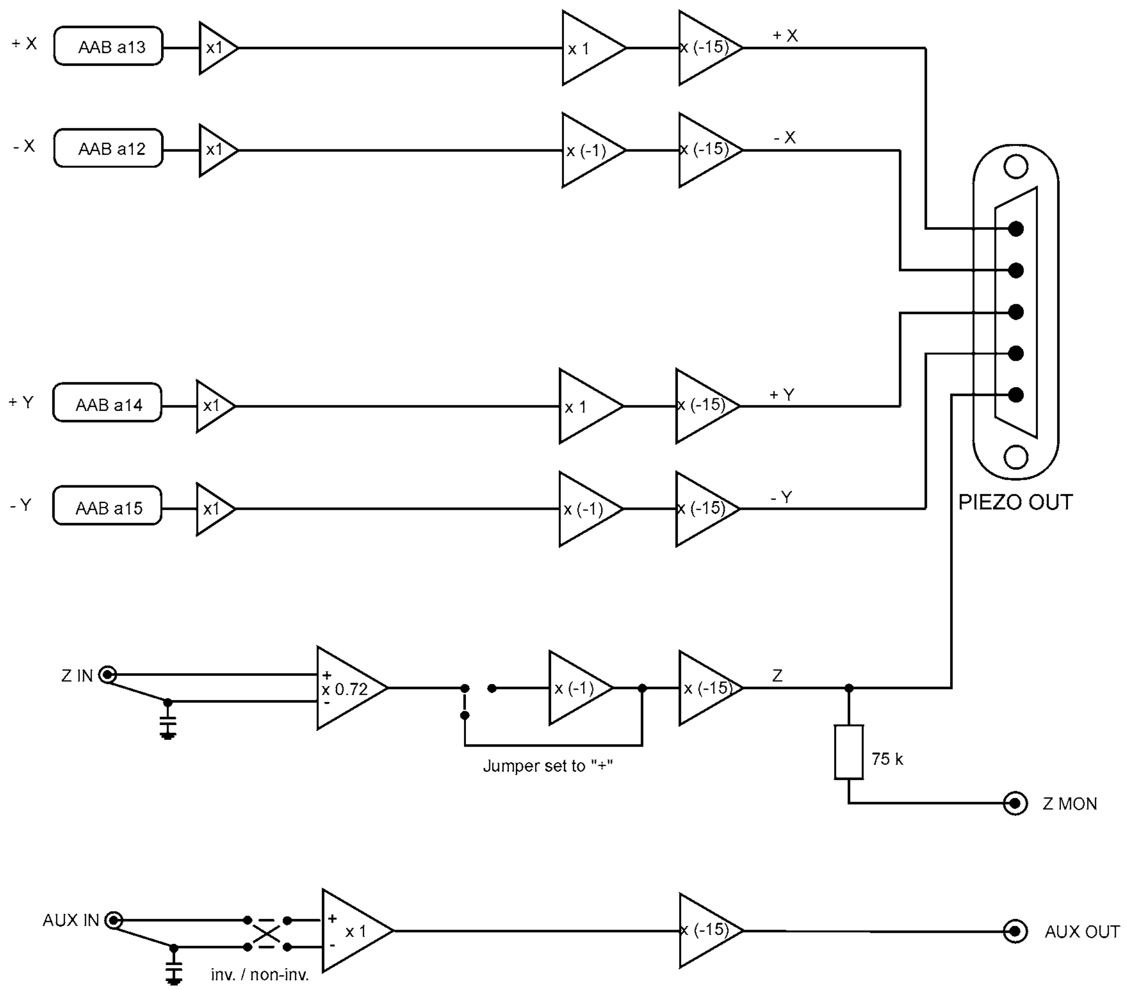


Figure 24: Piezo Driver board layout, schematically.

channel	source	input	gain	polarity jumper	default	output	connector
+X	AB	±9 V	+15	no		±135 V	sub-D mixed PIEZO OUT
-X	AB	±9 V	-15	no		±135 V	sub-D mixed PIEZO OUT
+Y	AB	±9 V	+15	no		±135 V	sub-D mixed PIEZO OUT
-Y	AB	±9 V	-15	no		±135 V	sub-D mixed PIEZO OUT
Z IN	BNC	±12 V	±10.8	yes	+)*	±130 V	sub-D mixed PIEZO OUT and BNC Z MON
AUX IN	BNC	±9 V	±15	yes	+)*	±135 V	SHV AUX OUT

Table 12. Piezo driver signals. AB = analogue bus.)* Gain is negative when jumper reads "+" (default) and vice-versa.

Hum on Output: No mains frequency should be visible in the noise signal.

Please note.

For a small signal modulation (2 V_{pp} output) **no cross talk should be visible.**

Voltage supply: (±145 ± 2.5) V; output level: ±135 V (Z: ±130 V.)

Electrical Specifications

Channel:	XY	Z	Aux
Bandwidth (-3 dB)	>100 kHz	>100 kHz	>100 kHz
...with up to 10 nF load	(small signal)		
Slew rate	≈2 V/ µs		
Noise at 20 MHz Bandwidth	1.5 mV_{pp}	1.5 mV_{pp}	1.5 mV_{pp}
Noise at 200 kHz Bandwidth	1 mV_{pp}	1 mV_{pp}	0.7 mV_{pp}
Noise at 20 kHz Bandwidth	0.7 mV_{pp}	0.7 mV_{pp}	(0.5 mV_{pp})
Noise at 2 kHz Bandwidth	0.4 mV_{pp}	0.4 mV_{pp}	0.3 mV_{pp}

Table 13. Piezo Driver electrical specifications.

QuaDAC A

Location:	MATRIX CU	Application:	AFM

The (optional) QuaDAC A board is a standard double Eurocard module to be fitted in slot 7 of the MATRIX CU. It provides an additional digital interface for driving an AFM, see figure 26.

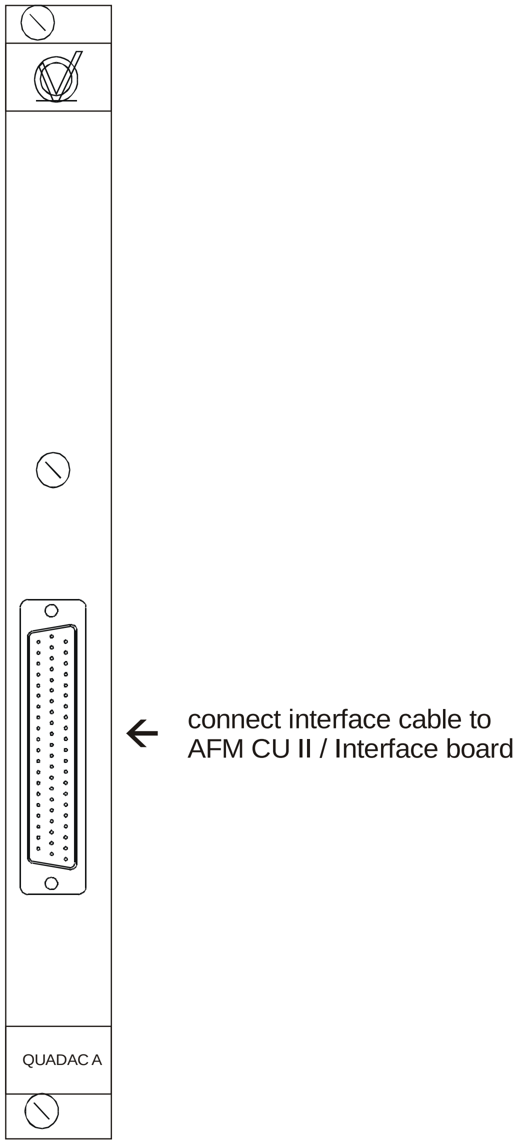


Figure 25. QuaDAC A board, panel schematic diagram.

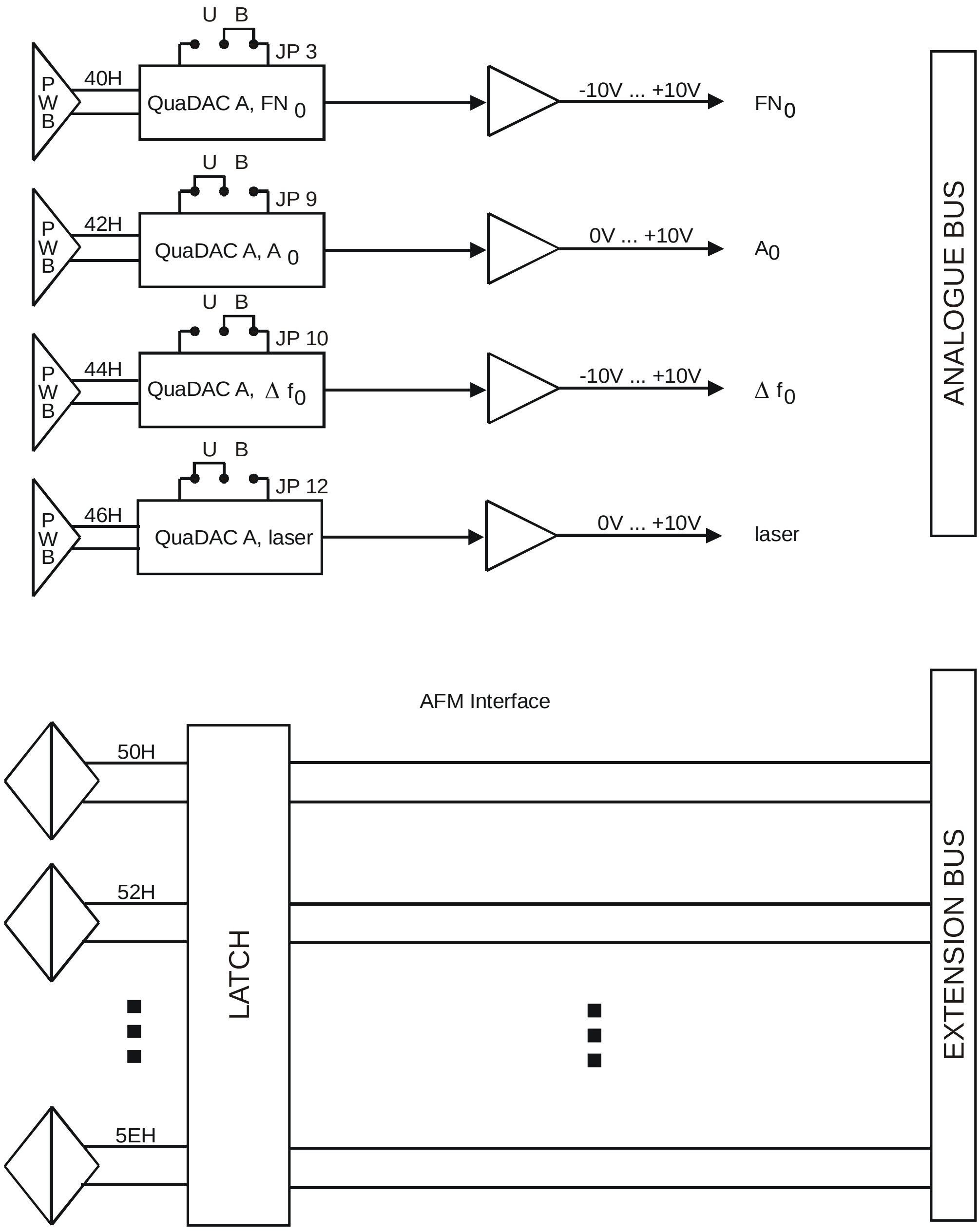


Figure 26: QuaDAC A board, schematically. A jumper J P allows selecting the output voltage to be bipolar (-10 V to +10 V, jumper position B) or unipolar (0 to +10 V, jumper position U). The lower part of the board provides the AFM digital interface.

QuaDAC U

Location:	MATRIX CU	Application:	Cryogenic SFM

The (optional) QuaDAC U board is a standard double Eurocard module to be fitted in slot 5 or slot 6 of the MATRIX CU. It is only present for Cryogenic SFM.

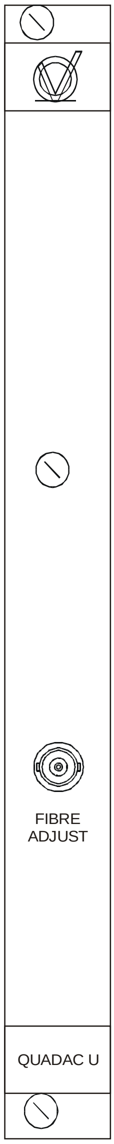


Figure 27. QuaDAC U board, panel schematic diagram.

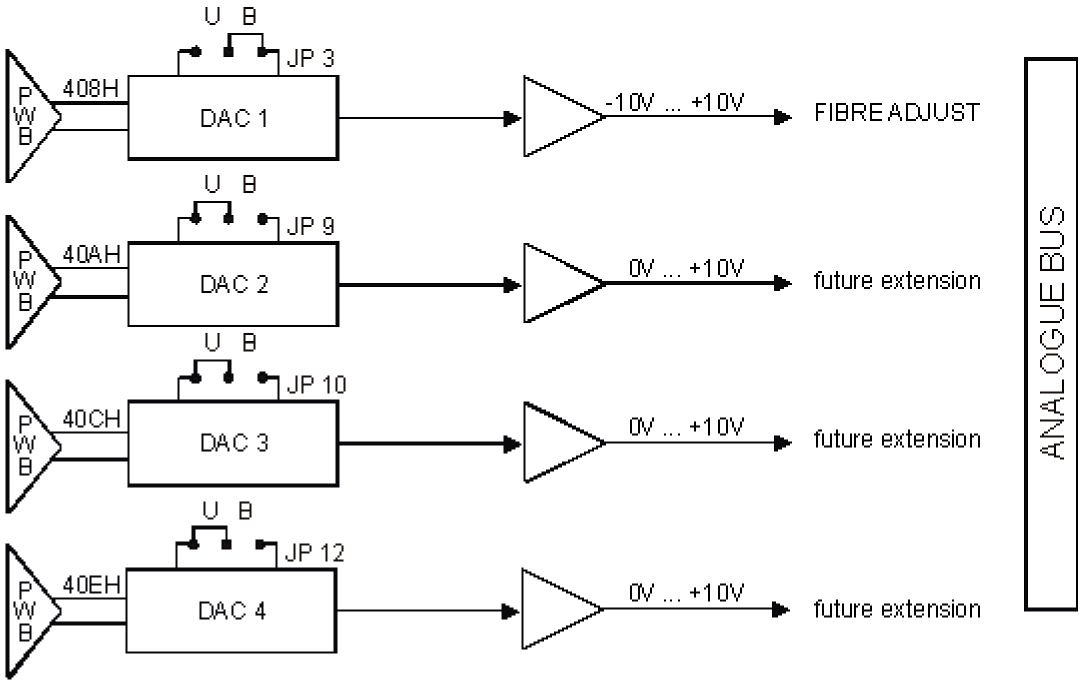


Figure 28. QuaDAC U board, schematically. A jumper J P allows selecting the output voltage to be bipolar (-10 V to +10 V, jumper position B) or unipolar (0 to +10 V, jumper position U).

Oscillator/Counter Board (OCB 2)

Location:	MATRIX CU	Application:	AFM non-contact

The Oscillator/Counter Board (OCB 2) is an optional addition to the OMICRON MATRIX system for AFM non-contact mode. It measures the sensor frequency and generates the reference frequency for the FM-Demodulator board (AFM CU).

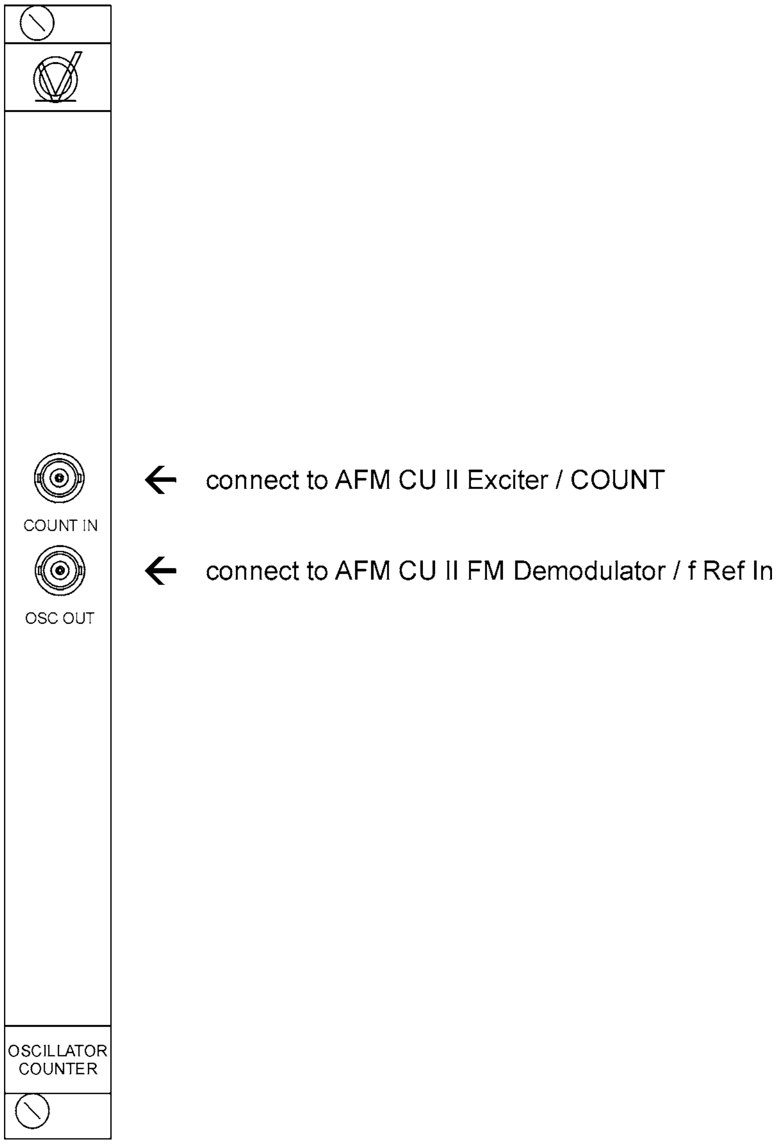


Figure 29. OSCILLATOR/COUNTER BOARD 2, panel schematic diagram.

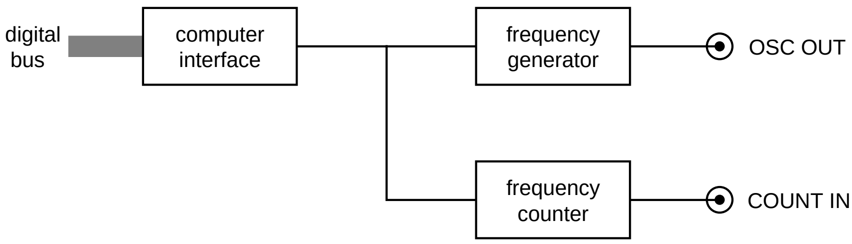


Figure 30. The Oscillator/Counter Board schematic circuit diagram.

Oscillator Phase Detector Board

Location:	MATRIX CU	Application:	NEEDLE Sensor

The OPD board excites a forced longitudinal oscillation with fixed amplitude and frequency in the needle sensor (quartz resonator). The resulting small electrical AC current is phase-coupled to the mechanical oscillation of the needle sensor (typically 1 nm to 10 nm). This current signal is amplified by the NEED PRE and compared to a reference frequency for phase difference evaluation.

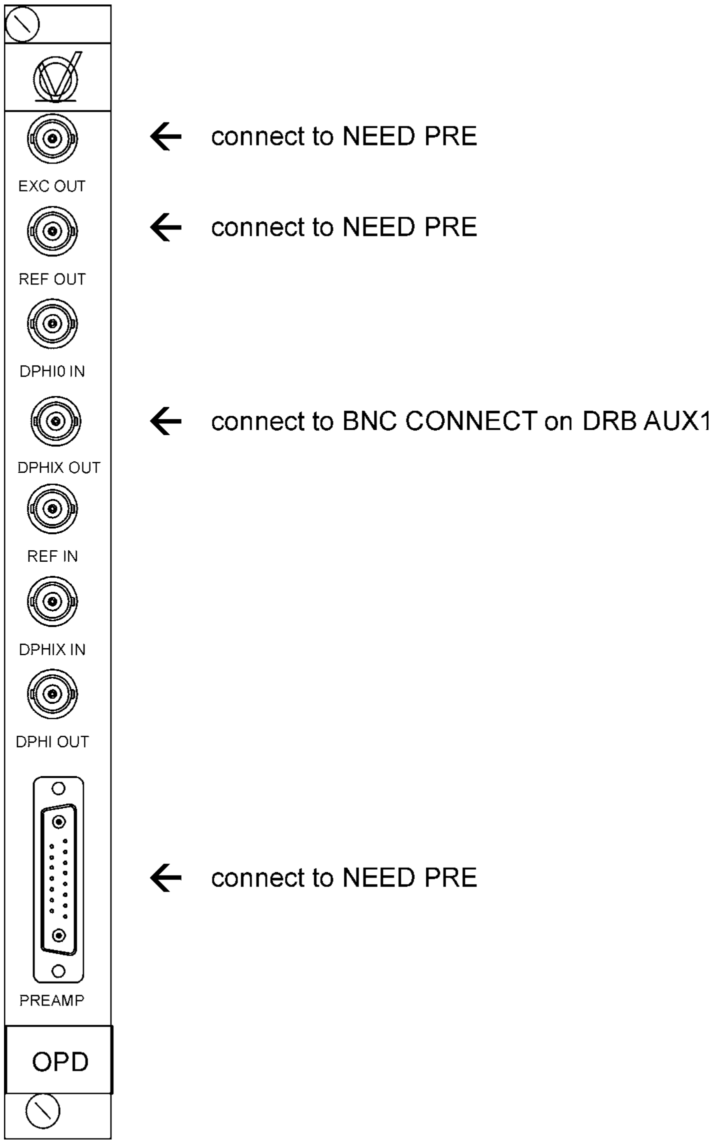


Figure 31. OPD board, panel schematic diagram.

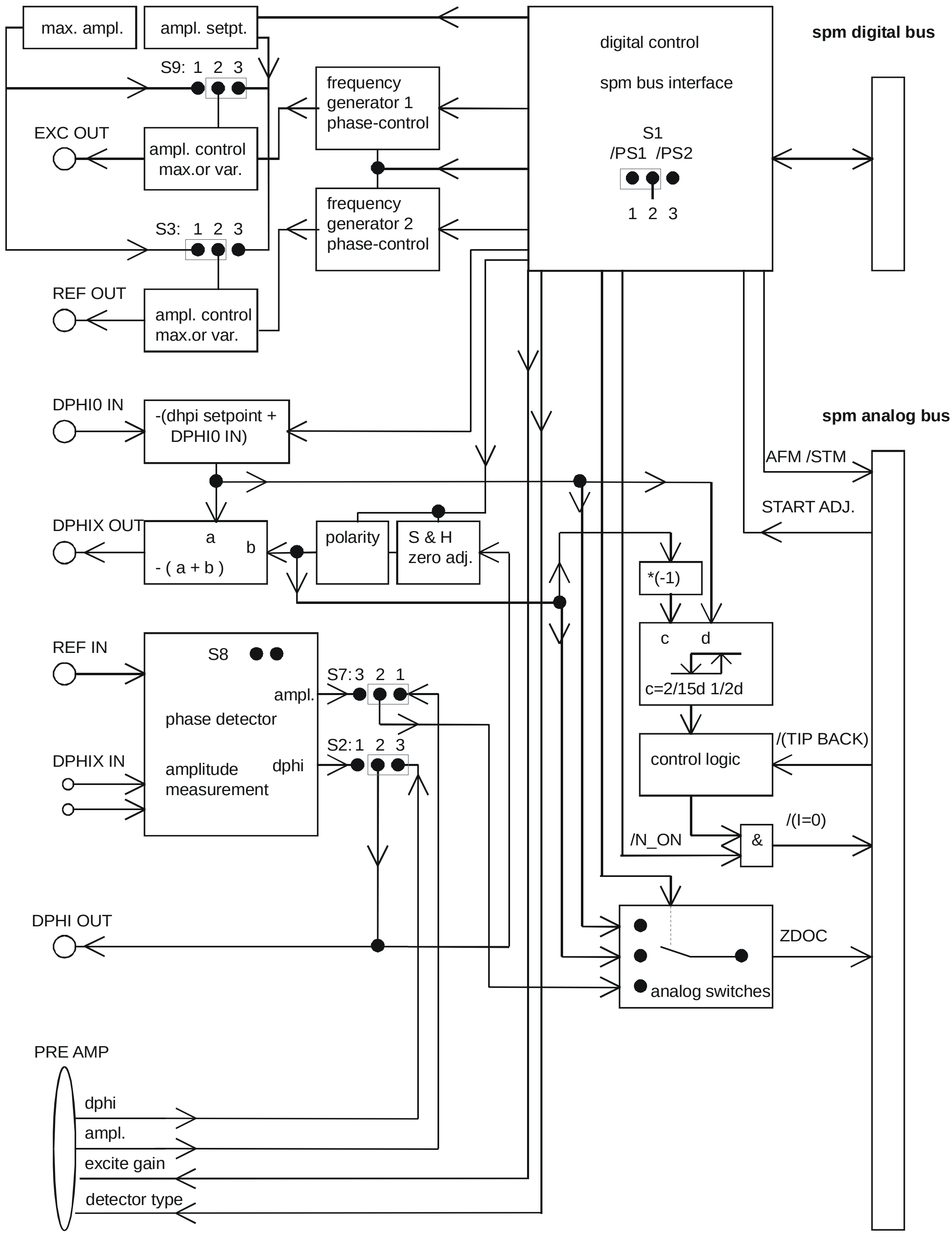


Figure 32. OPD board block diagram, needle sensor configuration.

MATRIX with Needle Sensor Function

The NEED AFM option for the OMICRON VT STM or LS STM is a special scanner variant which allows AFM and combined AFM/STM operation using a needle sensor.

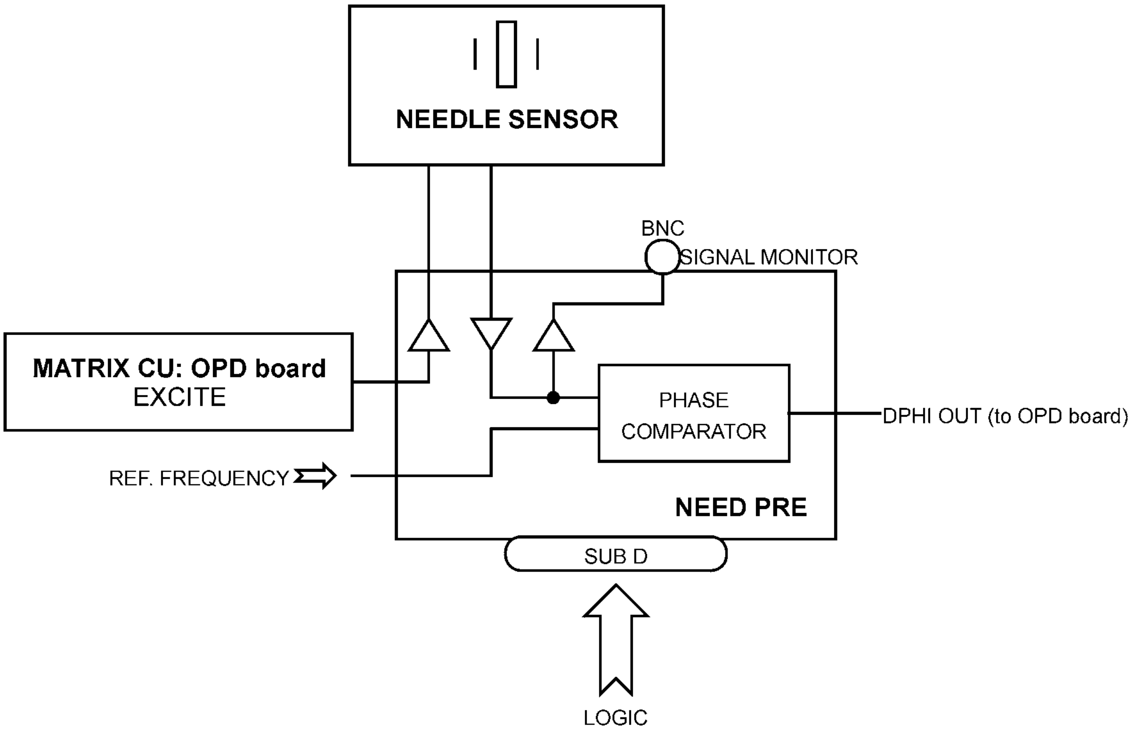


Figure 33. Function principle of the NEED AFM.

Attention. Never connect the AFM CU II and the OPD board (e.g. for Needle Sensor operation) simultaneously as this may cause a serious signal mismatch, possibly leading to hardware destruction.

If you want to control a Needle head and an AFM or STM head with the same Matrix CU some boards have to be disconnected. Please contact the Omicron service department for detailed instructions.

CIC Board Important Information

Location:	MATRIX CU	Application:	NEEDLE Sensor

This board can be used as an alternative for the coarse positioning card (CPC). Instead of high voltages for driving the piezo motors this board yields TTL signals for triggering a customer-designed piezo driver. The function of the remote box is not affected.

Figure 34. CIC board panel view. Note that the Auto socket has been deactivated.

Output Details

On the Omicron Coarse Remote Box press X, Y or Z to set the respective signals to "low", see figure below.

On outputs D+/D- pulses are available for every channel, depending on the selected direction. The pulse output is the same as for the HV signals: pressing down the button once generates a single pulse, holding the button down generates a series of pulses as shown below, with the pulse frequency selectable on the remote box (set DIAL to frequency, see below).

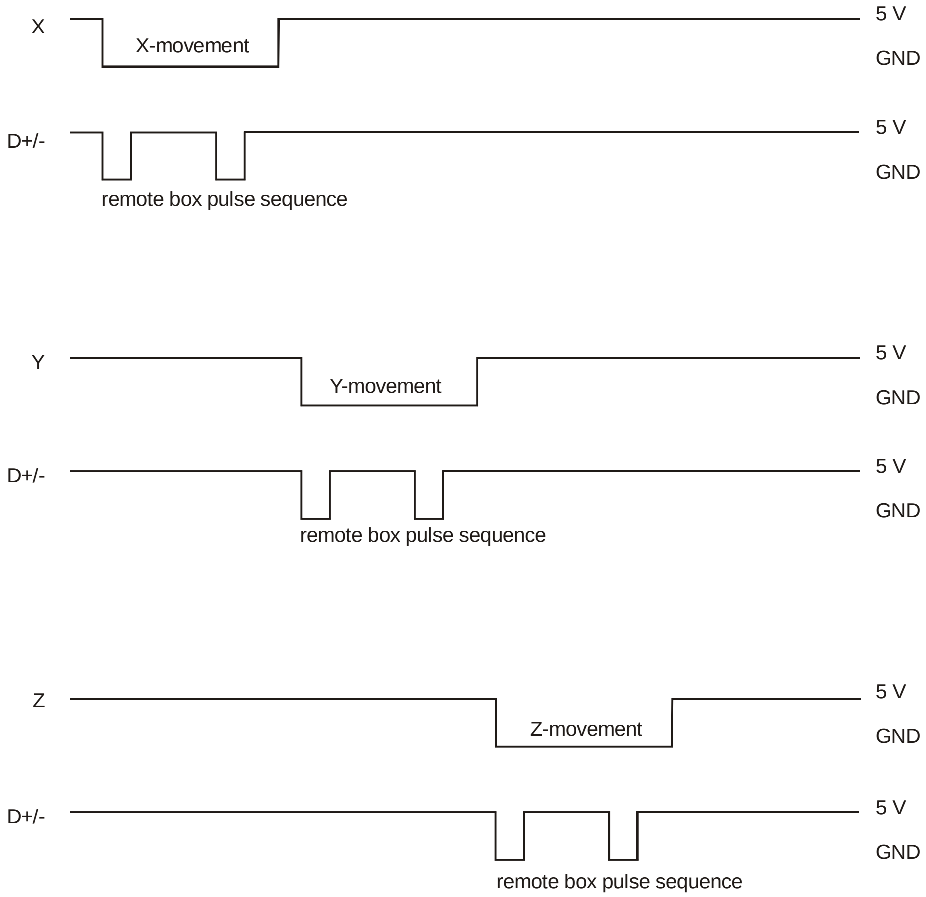


Figure 35. CIC board output pulse progression. All outputs are active low.

TIP BACK output is also active low, i.e.

Signal	Tip	Coarse Positioning	Regulator
5 V	forward	inactive	active
0 V	backward	active	inactive

Pressing AUTO on the remote box generates the AUTOAPPROACH-related pulse sequence at TIP BACK. Note that the number of coarse steps per approach cycle can also be set in the remote box menu.

Changing the SPEED Dial Setting

The SPEED dial on the remote box normally controls the step width (voltage) of the stepper motor. This is useful for manual coarse approach where the step width needs to be reduced when you come closer to the surface. Sometimes, however, direct control over the step frequency is desirable in order to achieve the correct position quickly. For this purpose the SPEED dial can be set to control step frequency instead of voltage (default) using the SETTINGS menu.

Piezo Driver - PDC 5MQ

Location:	MATRIX CU	**Application:**	QPlus

Piezo driver for QPlus scanners

The 5-channel piezo driver provides five amplifiers with gain 10.8 to give an output voltage of up to ±135 V for motion control during measurements. The four amplifiers for the X- and Y-signals are identical. They receive their input signal via the analogue bus connection.

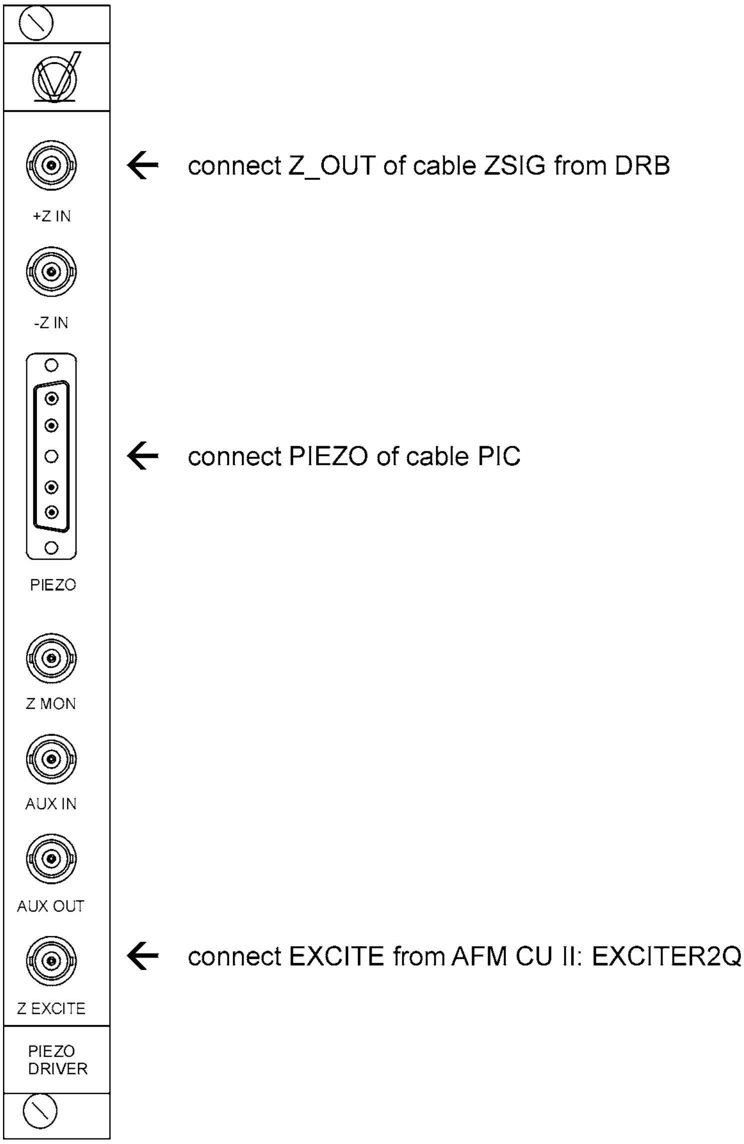


Figure 36. PDC5MQ board panel view, schematic diagram.

Attention. This Piezo Driver board differs considerably from the PDC 6 Piezo Driver board described on page 38. These boards must never be mixed up otherwise the scanner may be severely damaged.

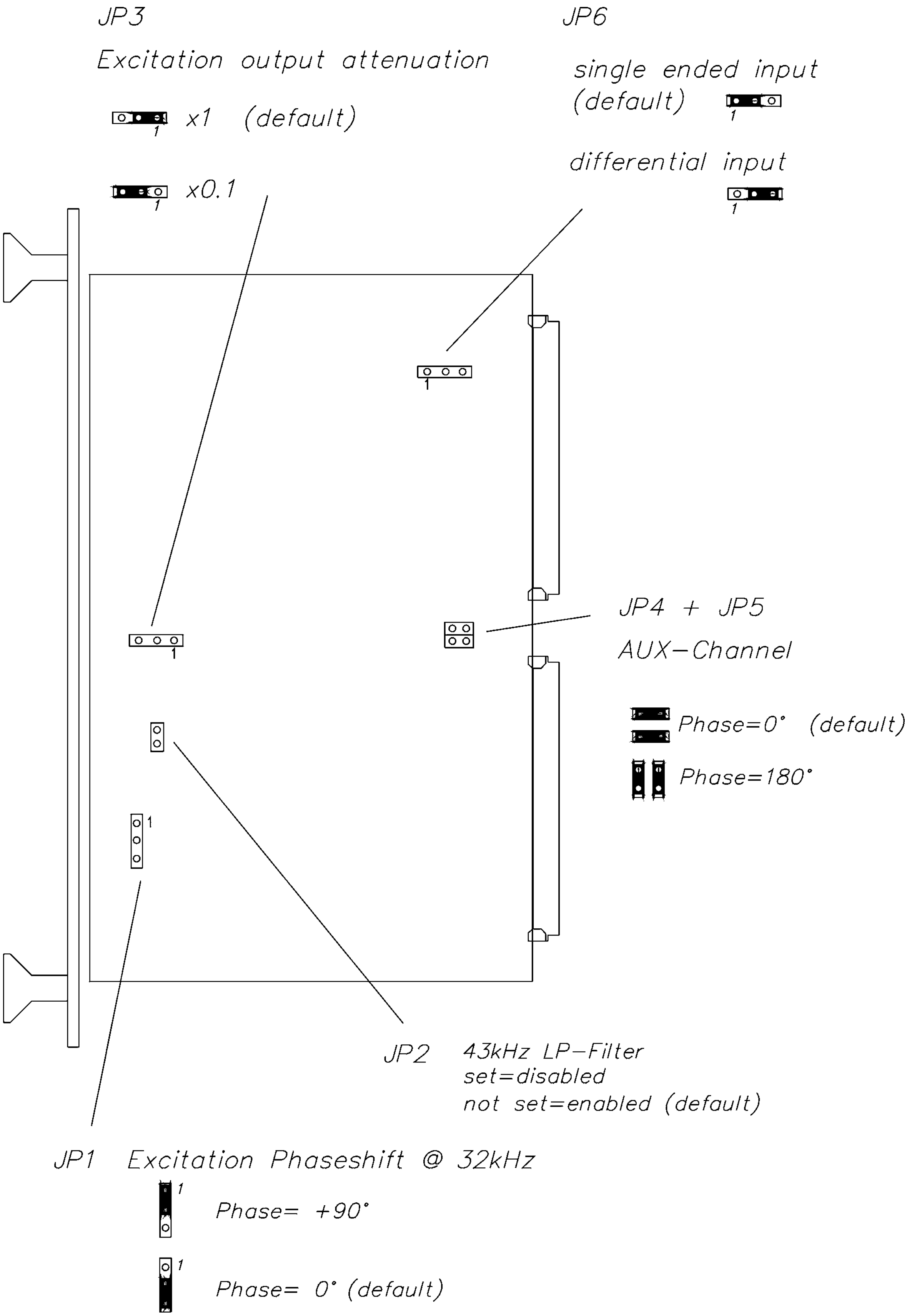


Figure 37. PDC5MQ board jumper layout, schematic diagram.

5. MATRIX Power Supply

In MATRIX the Power Supply unit is not integrated in the control unit but carried out as a separate 3 HE rack module. It allows boards to be fitted from the front and from the back, see figure 38 below.

Figure 38. MATRIX power supply, front and back panels showing the relevant units.

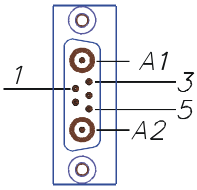
The MATRIX power supply provides operating voltages for the MATRIX control unit, AFM control unit, the fan block and the Ethernet HUB. The low voltage and high current supplies are generated in the Kniel® modules of the power supply unit. Low supply voltages like FAN and those generated by the DCOUT53 and TEC Power Supply are provided via DIN and D-SUB connectors on the back panel.

Figure 39. MATRIX power supply cable feedthroughs.

Front Panel Boards

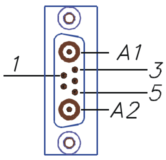
Piezo Power Supply

The Piezo Power Supply is a high voltage board generating the voltages necessary for driving the scan piezos. The related Piezo cable on the back panel has to be connected to the Piezo socket on the MATRIX control unit power input block, see figure 18 on page 32.

 Piezo	A1 +220 V A2 -220 V	1 220 V GND 2 220 V enable 3 N.C. 4 220 V fail 5 Signal GND

Coarse Power Supply

The Coarse Power Supply is a high voltage board generating the voltages necessary for driving the coarse positioning piezos. The related Coarse cable on the back panel has to be connected to the Coarse socket on the MATRIX control unit power input block, see figure 18 on page 32.

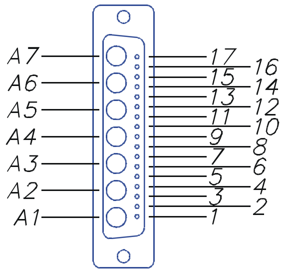
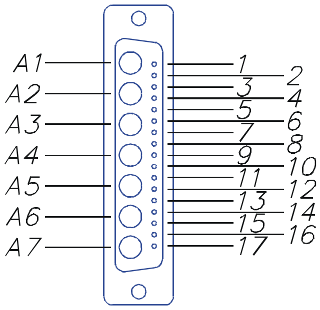
 Coarse	A1 +450 V A2 -450 V	1 450 V GND 2 450 V enable 3 N.C. 4 450 V fail 5 Signal GND

Kniel Low Voltage Modules

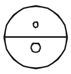
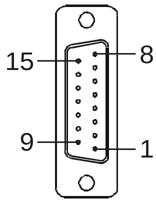
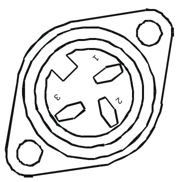
The Kniel® modules generate different voltages that can be monitored and adjusted using front panel access points. A green LED is lit when the module is on.

Figure 40. Kniel® modules on the MATRIX Power Supply front panel.

The Kniel® modules feed the following connectors:

 Analog	A1 +8 V A2 -8 V A3 +18 V A4 -18 V A5 18 V GND A6 8 V GND A7 N.C.	1 N.C. ... 17 N.C.
 Digital	A1 N.C. A2 +5 V A3 +3.3 V A4 5 V GND A5 +3.3 V GND A6 N.C. A7 N.C.	1 N.C. ... 6 +3.3 V sense 8 +3.3 V GWD sense ... 17 N.C.

These outputs supply low voltages but high currents to the analogue and digital parts of the MATRIX native boards. The Analog and Digital cables on the back panel have to be connected to the related Analog and Digital sockets on the MATRIX control unit power input block, see figure 18 on page 32.

VT DC 	2-pin Lemo connector for supplying +18 V to the VT drift control (PIC cable). male +18.5 V female 18.5 V GND
AFM CU 	15-PIN D-SUB connector for power supply to the AFM control unit. Note that the present AFM CU II has its own DC power supply and hence this connection is not used at the moment. 1 +18.5 V — 9 GND 2 +18.5V — 10 GND 3 +5 V — 11 5 V-GND 4 +5 V — 12 5 V-GND 5 +5 V — 13 5 V-GND 6 N.C. — 14 GND 7 -18.5V — 15 GND 8 -18.5 V
FAN 	3 pin DIN connector for supplying power to fan block 1 FAN + (typically 10 V DC) 2 FAN GND 3 N.C.

Back Panel Units

Mains IN/OUT Block

A selector allows setting the unit for the local mains voltage. Two settings are possible:

Mains voltage	F1 (Piezo and Coarse)	F2 (Kniel® modules)
230 V	2 A	3.15 A
100 V	4 A	6.3 A
115 V	4 A	6.3 A

To change the fuses unscrew the fuse holders labelled F1 and/or F2. Replace with slow fuses only.

Figure 41. MATRIX power supply mains input.

DCOUT53

The DCOUT53 board supplies two 3-pin and one 4-pin XLR connectors for SPM PRE 4 and CSW for SPM PRE 4.

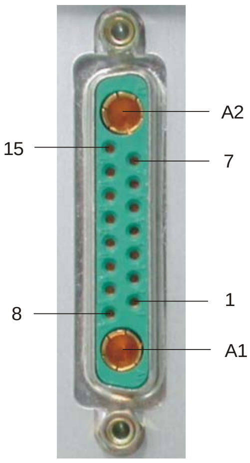
Figure 42. DCOUT53 power supply board.

	3-pin XLR 5 V for SPM PRE 4: power supply for preamplifier SPM PRE 4. The DCOUT53 can supply a double preamp using both 3-pin XLR sockets 1 +5 V 2 5 V GND 3 N.C.
	4-pin XLR 8.5 V for CSW: power supply for switchbox "CSW for SPM PRE 4" 1 +8.5 V 2 +8.5 V GND 3 -8.5 V GND 4 -8.5 V

TEC Power Supply

The TEC power supply provides the signals necessary to keep the FM Demodulator board on the AFM CU at a constant temperature in order to prevent electronic drift.

Figure 43. TEC power supply board.

<table>
<tr><td>Thermoelectric Cooler

</td><td>Thermoelectric Cooler connects to the FM Demodulator board, see figure 62 on page 73.
<table>
<tr><td>1</td><td>IN-</td><td>9</td><td>AGND</td></tr>
<tr><td>2</td><td>IN+</td><td>10</td><td>-15 V</td></tr>
<tr><td>3</td><td>N.C.</td><td>11</td><td>+15 V</td></tr>
<tr><td>4</td><td>N.C.</td><td>12</td><td>AUX</td></tr>
<tr><td>5</td><td>PWRGND</td><td>13</td><td>SETP.MON</td></tr>
<tr><td>6</td><td>RELAY</td><td>14</td><td>SETP.EXT</td></tr>
<tr><td>7</td><td>TEMP.MON</td><td>15</td><td>SIGNAL GND</td></tr>
<tr><td>8</td><td>N.C.</td><td></td><td></td></tr>
<tr><td>A1</td><td>Output</td><td>A2</td><td>PWRGND</td></tr>
</table></td></tr>
<tr><td>

LEDs</td><td>4 green LEDs indicate proper functioning of the TEC power supply (±15 V for noise reduction and ±12 V for TEC).
A red LED (ERR) indicates one of the following
• Cable not connected.
• Cable connected the wrong way round.
• Overheating of the TEC Power supply. In this case switch off the AFM CU II including the TEC power supply and wait about 60 minutes for all elements to cool down. Check if the convection slots are blocked or the lab temperature is too high. Attention. After a T>max switch-off an increased drift may occur in frequency measurements for about 48 hours, see also on page 74.</td></tr>
</table>

Monitor 	Omicron service only! Please do not use the Monitor socket, it is reserved for fault finding procedures only.	1 +15 V 2 -15 V 3 AGND 4 N.C. 5 N.C. 6 AUX 7 SETP.MON 8 TEMP.MON. 9 SETP.EXT

6. Coarse Position Remote Box

The digital remote box has a 4-line liquid crystal display (LCD) and a 12-button membrane keypad which gives access to several configuration- and operating menus. A "SPEED" dial allows manual regulation of the coarse motor speed: this dial can be assigned with the step size (default for most heads) or with repetition frequency in the settings menu. For information on the default settings for the various SPM heads please refer to pages 98ff.

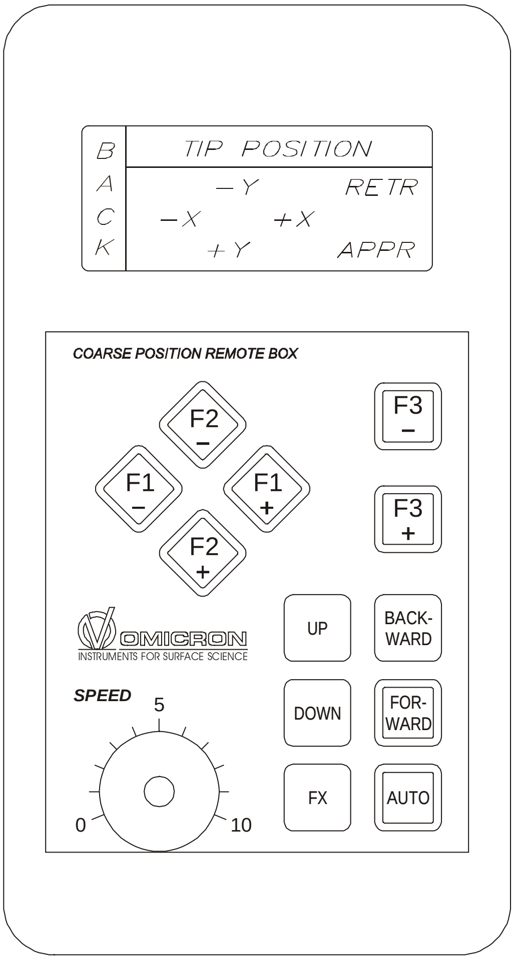


Figure 44. Remote box layout, schematic diagram.

Before you start we recommend that you study the flowchart concerning your specific SPM head, see pages 98 ff. This gives you a short pictorial overview of the functions and scope of the Coarse Position Remote Box.

Upon switching on the MATRIX CU the remote box display shows an initialisation array for 30 seconds (can be skipped by pressing the DOWN button). This consists of the OMICRON Logo together with the name of the SPM head that has been configured. The remote box then switches to the BACKWARD menu, see below.

All operating menus have a similar display structure, see figure 45.

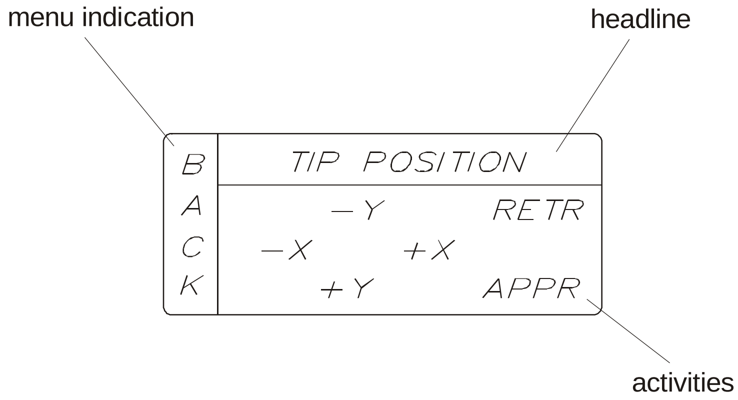


Figure 45. Operating menu display structure. VT STM/SPM version shown as example.

- The left column indicates the menu type, e.g. BACK, FORW or AUTO.
- The headline indicates the activities that can be taken, e.g. tip positioning, sample positioning or mirror positioning (AFM).
- The main field shows the functions of the numbered F-buttons ±F1, ±F2 and ±F3. In the example shown in figure 45 pressing the +F3 button retracts the tip away from the surface.

There are three operating menus/modes available for each head, these can be activated by pressing the relevant button (BACKWARD, FORWARD and AUTO).

- In the BACKWARD mode the fine positioning piezo is fully retracted and you can perform coarse positioning activities like X-Y positioning or manual tip-surface approach (-Z) or retraction (+Z).
- In the FORWARD mode the fine positioning piezo is more or less extended, depending on the feedback signal. If no feedback signal can be detected the fine positioning piezo will be fully extended. Attention. this may lead to a tip crash, e.g. if the feedback signal selection in the software is incorrect!
- In the AUTO mode the SPM control software performs an automatic approach procedure, see below.

The BACKWARD Menu

The BACKWARD menu may look different depending on the SPM head connected/loaded. Depending on the loaded SPM head, and hence of the connected scanner, there are different actions possible for tip/sample positioning, e.g. +X, -X, approach, retract, etc. Due to limited display space a number of abbreviations have become necessary. These are listed below.

APPR	approach
RETR	retract
←ROT	rotation left
ROT→	rotation right

The BACKWARD menu serves three main purposes:

- Selecting the surface area to be scanned.
- Manual tip-surface approach. Since the step width for the auto approach function is normally rather small in order to avoid crashing the tip in the last sequence, this procedure may take quite a while when started with the coarse motion drive fully retracted. We therefore recommend to bring the tip as close as possible manually (using the functions of the BACKWARD menu) before starting the auto approach.
- Manual tip-surface retraction. For changing the tip or the sample the coarse motion drive needs to be fully retracted to safeguard the fine positioning piezos. Depending on your SPM head there may also be other situations where you want to retract the scanner, e.g. when heating or cooling the sample plate.

> **Please note.** in the BACKWARD mode the fine positioning Z-piezo is fully retracted.

The coarse positioning buttons in the BACKWARD menu have two possibilities:

- Pressed for a short duration (< DELAYTIME) a single step will be performed.
- Pressed for a longer duration (> DELAYTIME) a continuous mode is activated after the first step. This continuous operation mode is active for as long as the respective button is pressed. Entering and leaving the continuous mode is indicated with a beep.

> **Attention.** For very long approach procedures there also is the possibility to **lock the continuous mode** by pressing the FX button (after the first beep) with the respective motion button held down. The display will then start flashing to indicate that the locked continuous mode is on. In this mode continuous operation can be aborted by pressing any button of the remote box. However, this is still a **dangerous function** which may easily destroy your tip when left unattended: **THERE IS NO AUTOMATIC STOP in this mode.**

From the BACKWARD menu you may switch to AUTO for auto approach, to FORWARD to extend the Z-piezo or press UP and DOWN simultaneously to enter the SETTINGS menu.

The FORWARD Menu

In most cases the FORWARD menu does not offer any options other than switching back to BACKWARD or starting auto approach. In the FORWARD position the Z-piezo is more or less extended and its position is controlled by the feedback loop. This is the normal position during SPM experiments and the tip control is transferred from the remote box to the computer where it can be directed using the SPM software.

> **Attention.** Do not leave the remote box tip positioning switch in FORWARD position if tunnelling cannot be achieved. Note that this condition in combination with extreme scan range/frame positioning parameters and long duration or scanner temperatures above 50°C **may lead to scanner depolarisation**.

The AUTO APPROACH Menu

In AUTO mode the Control Unit performs an automatic approach procedure:

- The tip is ramped towards the sample with a delay of a few milliseconds by superimposing a linear ramp to the regulator output.
- If no feedback signal (e.g. tunnelling current) is detected, the tip (or sample) is retracted in one step (fine control Z-piezo).
- The coarse approach step motor drive moves a specified number of steps forward (1-10, selectable in the settings menu). The tip moves towards the sample (or vice versa) by this number of steps (step size adjustable, default = DIAL for most heads).
- The tip is then again ramped towards the sample.
- If no feedback signal is detected, this sequence will be repeated automatically.
- If a feedback signal is detected the auto approach stops, the ramp stops and the feedback loop becomes active.

To bring the fine control Z-piezo to the middle of its positioning range a number of manual coarse steps may still be necessary (select BACKWARD to do so). The required number of coarse steps depends on the step width setting and the Z-positioning range of the scanner.

Press the AUTO button to start the auto approach procedure. The number of steps performed will be counted. If the tip surface distance is close enough for the current regulation to become active or if the FORWARD button is pressed the auto approach stops and the FORWARD menu becomes active. A beep gives an acoustic signal for the end of auto approach and the number of coarse steps is displayed for another 3 seconds. Note: this display can be stopped by pressing any button, e.g. press BACKWARD to directly jump to the BACKWARD menu.

If any button (except FORWARD) is pressed, the auto approach procedure will be aborted and the BACKWARD menu becomes active. Pressing FORWARD takes you to the FORWARD-menu.

The Settings Menu

The SETTINGS menu allows general configuration settings concerning the SPM head and also some settings which were previously accessible by changing jumpers on circuit boards.

> **Please note.** When you receive your Remote Box together with your SPM head there is no need to enter the settings menu, since all relevant parameters have already been configured at OMICRON.

To change the configuration of the Remote Box press the UP and DOWN buttons simultaneously (within a time delay of about 100 ms) to enter the SETTINGS menu.

In the display the SETTINGS entry menu will be shown. Use EDIT to access further settings pages or EXIT to return to the BACKWARD menu.

- DOWN always takes you to the subsequent sub-menu, see flowchart.
- UP always takes you back to the previous (sub)-menu, see flowchart.
- PREV and NEXT take you to the available parameters for the indicated setting.
- To accept a parameter you can either press UP or DOWN (i.e. continue editing) or EXIT (i.e. leave the SETTINGS menu).

Use the SET HEAD menu to initialise the settings for a specific SPM head. For all heads in the menu specialised settings are available and can be edited, in this case an asterisk will be displayed after the head name. Use the UP and DOWN buttons to access further SET menus.

The edited settings can be saved to be accessible in future sessions. You may also save user-specific settings for various SPM heads. To reset a single parameter choose RESET in the SET (PARAMETER) menu. To delete all user-specific settings select RESET in the SET HEAD menu.

> **Please note.** RESET always returns a parameter setting or head setting to the factory installed default value(s). To return to the configuration established before starting the EDIT session select **UNDO** in the SETTINGS CHANGED !!! menu. (Remark: if you do not enter this menu upon pressing EXIT, no changes have been done to the configuration during this editing session.)

In case of an incomplete set of parameters (e.g. two simultaneous DIAL assignments), the remote box will display an error message. In order to leave the settings menu the ambiguities have to be resolved first.

The following settings can be adjusted via the SETTINGS menu.

SET FREQUENCY

The SET FREQUENCY menu defines the frequency of the coarse approach driving voltage. The option DIAL is blocked if VOLTAGE has already been set to DIAL.

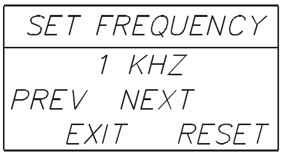


Figure 46. The frequency setting menu.

SET VOLTAGE

The SET VOLTAGE menu defines the amplitude of the coarse approach driving voltage. The option DIAL is blocked if FREQUENCY has already been set to DIAL.

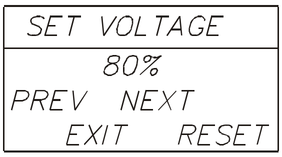


Figure 47. The voltage setting menu.

SET STEPS

The SET STEPS menu defines the number of steps for a cycle in the auto approach.

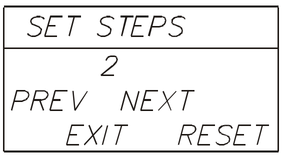


Figure 48. The steps setting menu.

SET Z-DIRECTION

The SET Z-DIRECTION menu defines the direction of coarse Z movement during tip positioning (can be positive or negative).

```
  SET Z-DIRECTION
        -
PREV   NEXT
    EXIT    RESET
```

Figure 49. The Z-direction setting menu.

SET DELAYTIME

The SET DELAYTIME menu defines the time lag within which a button switches from "step" operation to "continuous" operation.

```
 SET DELAYTIME
      0.6 SEC
PREV   NEXT
    EXIT    RESET
```

Figure 50. The delay time setting menu.

Leaving the SETTINGS Menu

Having changed one or several parameters in the SETTINGS menu you have the following options

- EXIT + UNDO to leave the editing mode with all settings unchanged.
- EXIT + SAVE stores the changed values in the unprotected EPROM partition and leaves the SETTINGS menu.

Please note. When you receive your remote box together with your SPM head, you do not need to change any settings.

Attention. Wrong values may lead to uncontrolled or faulty coarse movements and can destroy your hardware.

For detailed information on manual and automatic coarse approach, please refer to your SPM head manual.

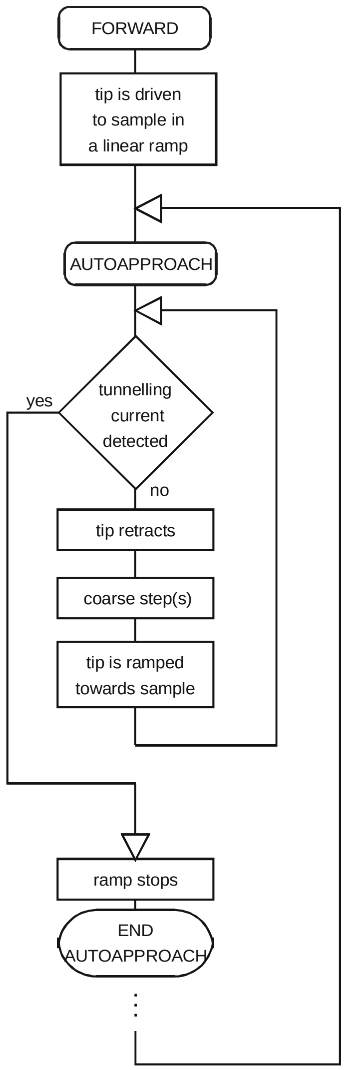


Figure 51: Flowchart diagram of STM auto approach logic.

7. AFM CU II

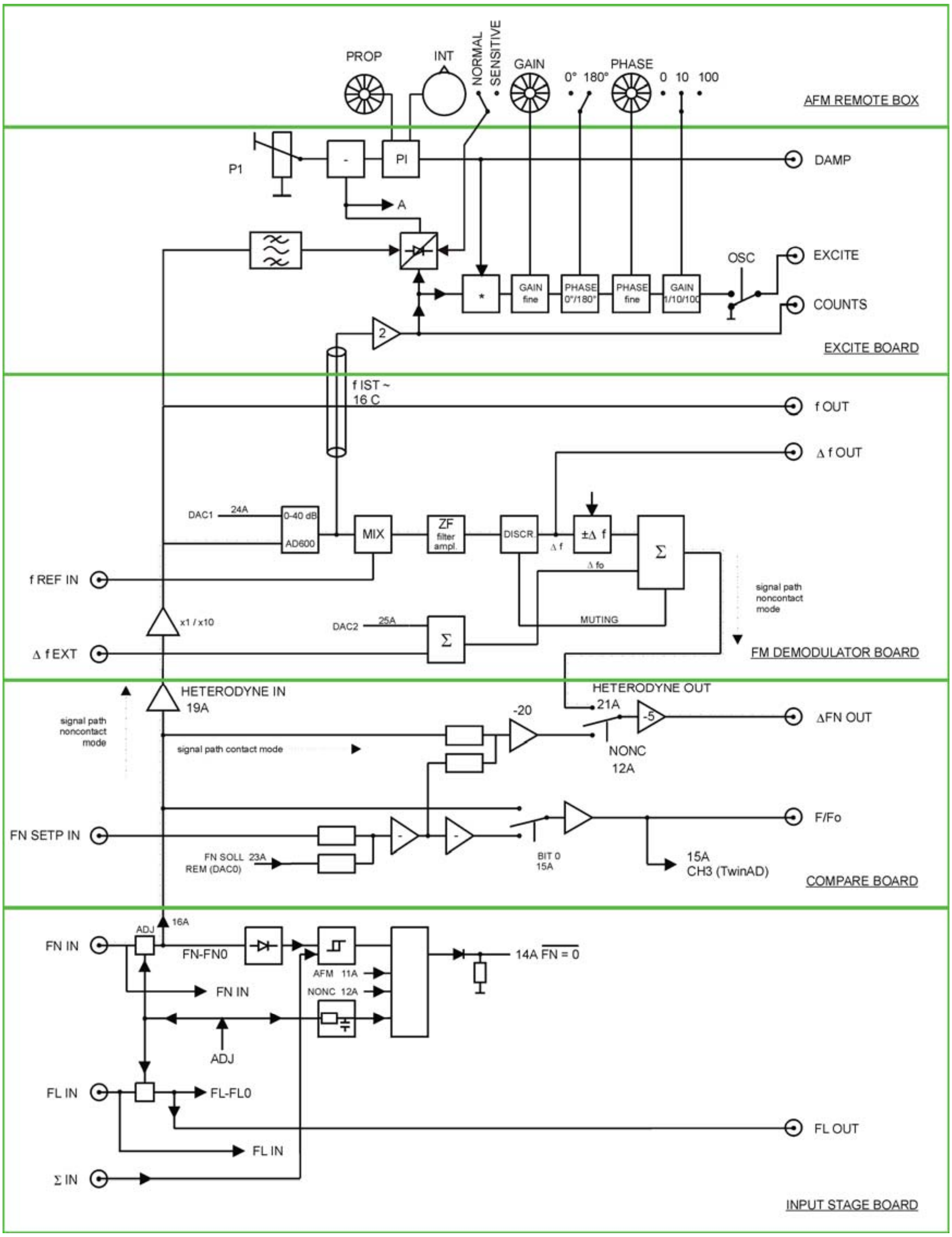


Figure 52. Block diagram of the AFM CU, including AFM REMOTE BOX and slotcards INPUT, COMPARE, FM DEMODULATOR and EXCITER. Signal paths for contact mode and non-contact mode are also shown.

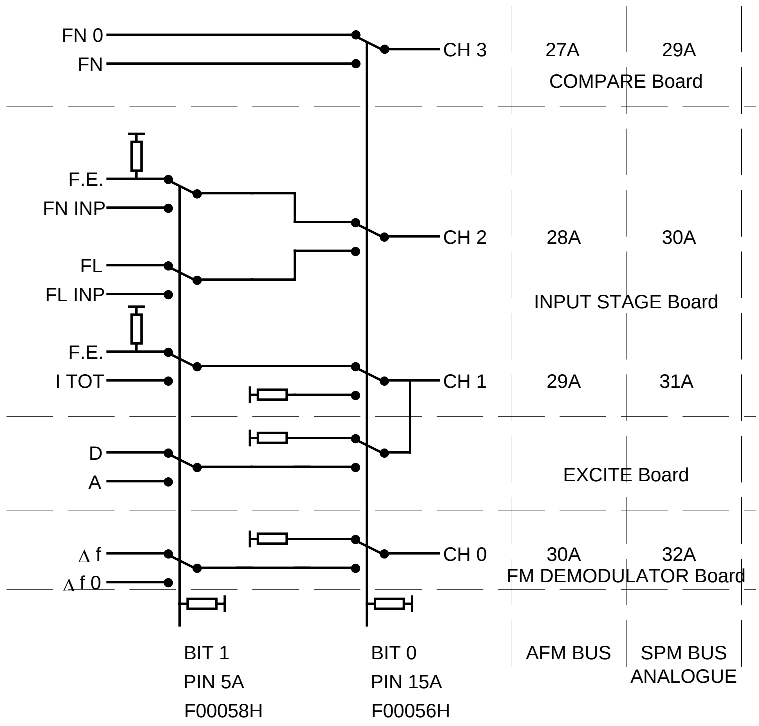


Figure 53. ADC input switch, schematic diagram.

> **Attention.** Never connect the AFM CU II and the OPD board (e.g. for Needle Sensor operation) simultaneously as this may cause a serious signal mismatch, possibly leading to hardware destruction.
>
> If you want to control a Needle head and an AFM or STM head with the same Matrix CU some boards have to be disconnected. Please contact the Omicron service department for detailed instructions.

Auto Approach Control (S/Q)

Location:	AFM CU II	Application:	AFM

The Auto Approach Control exists in three variants, "Auto Approach Control" for use with the UHV AFM/STM, "Auto Approach Control S" for use with the Cryogenic SFM, the VT AFM and LS Beam Deflection AFM and "Auto Approach Control Q" for use with the QPlus sensor. While the circuit diagrams and board layouts for the three variants are different the appearance and principal functions are the same.

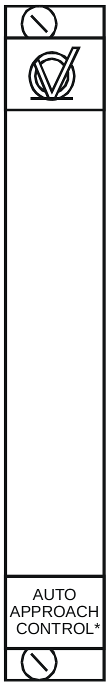


Figure 54. Auto approach control board, panel schematic diagram.*) Three versions available: normal, "S" and "Q", see above.

This board controls the AUTOAPPROACH function for both AFM modes, the contact mode and the non-contact mode. The board disables the AUTOAPPROACH if the probe has reached sample "contact" or if a problem was encountered during AUTOAPPROACH. The control function can be reset by switching to BACKWARD on the remote box.

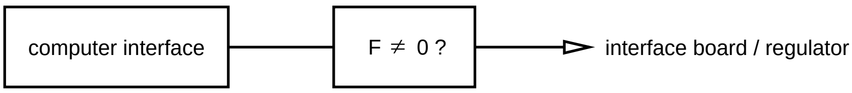


Figure 55. Auto Approach Control, schematic circuit diagram.

Compare Board

Location:	AFM CU II	Application:	AFM

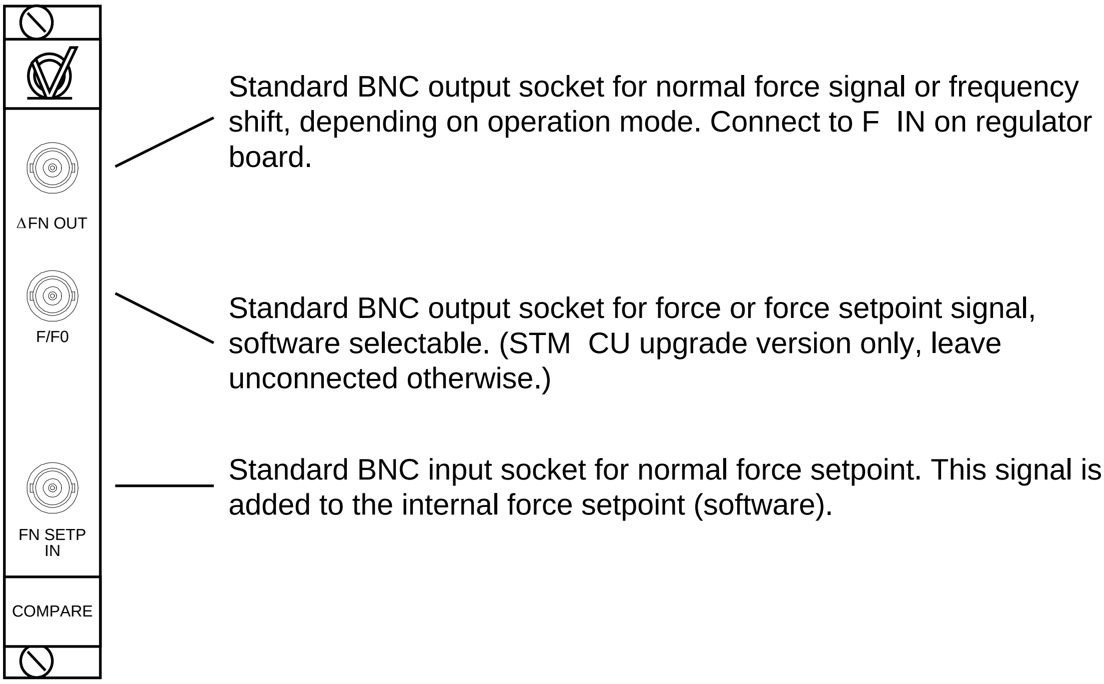


Figure 56. Compare board, panel schematic diagram.

The Compare board switches between setpoint values and gives the signal

(actual value - setpoint) x 100

to the SPM Regulator board. The force setpoint can be adjusted in the software and is transferred to the compare board via QuaDAC A. Furthermore an external voltage can be added on "F_N SETP. IN" to change/modulate the force setpoint.

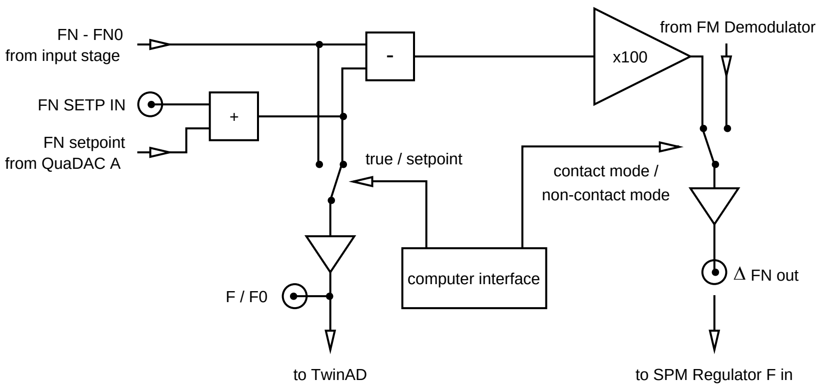


Figure 57: Compare board schematic circuit diagram.

Digital Board

Location:	AFM CU II	Application:	AFM

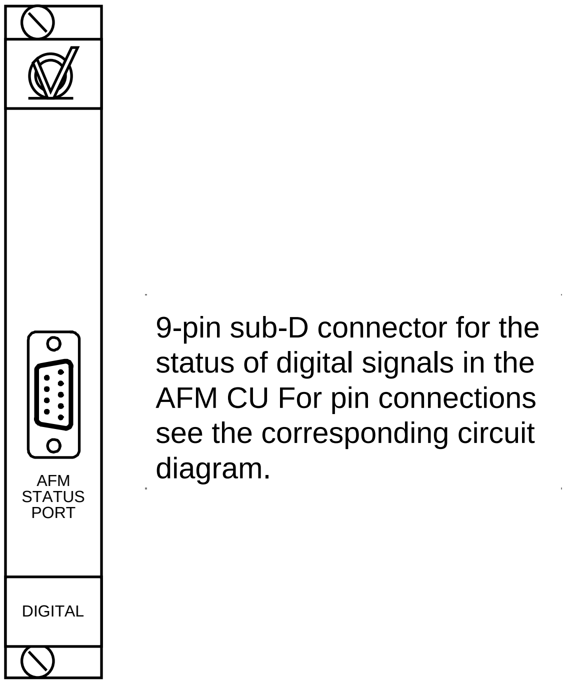


Figure 58. Digital board, panel schematic diagram.

The digital board is the digital interface between the AFM CU and the MATRIX CU as well as between the boards inside the AFM CU. It connects to the other boards via the bus board and is responsible for all control functions initiated by the RTMC.

The status port provides additional digital outputs of the AFM CU (not yet supported by the OMICRON SPM software).

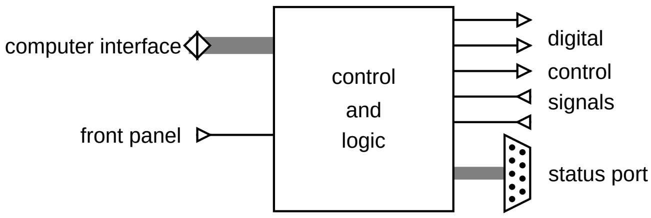


Figure 59. Digital board, schematic circuit diagram.

Exciter 2/2Q

Location:	AFM CU II	Application:	AFM non-contact

The Exciter Board exists in two variants, version 2Q has been adapted especially for use with the QPlus sensor.

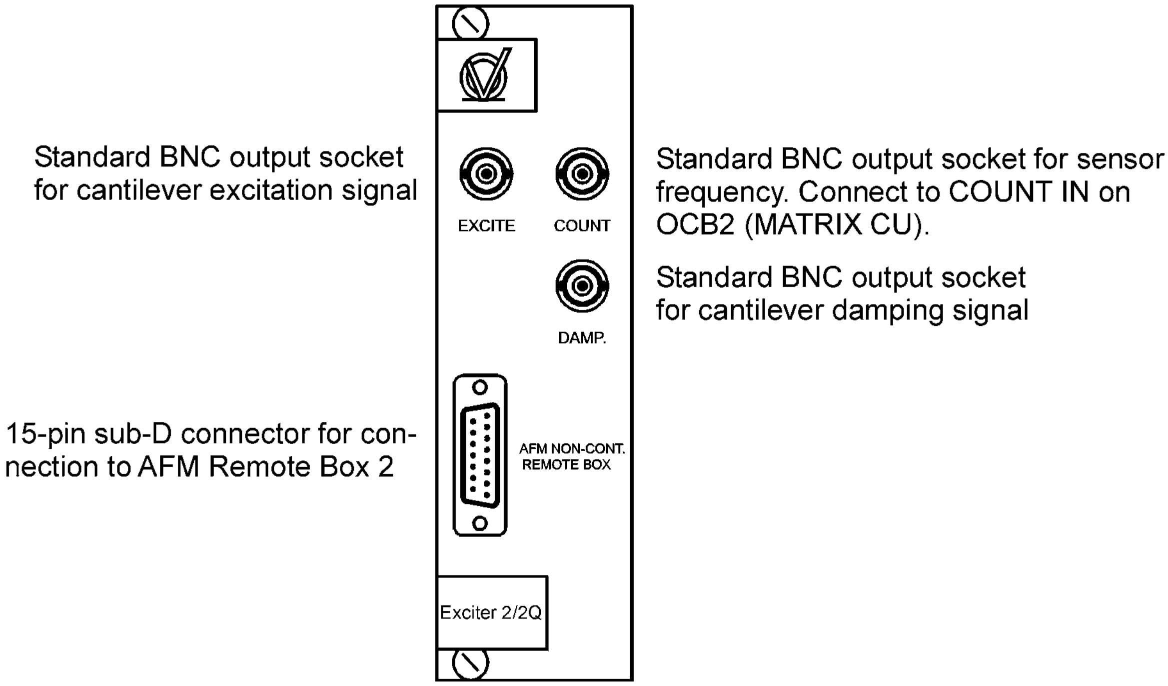


Figure 60. Excite board, panel schematic diagram..

The excite board takes the AC component of the F_N signal and measures its amplitude. This signal is in turn amplified in order to keep the vibration amplitude input constant. A phase regulation unit and an output amplifier are also included on this board.

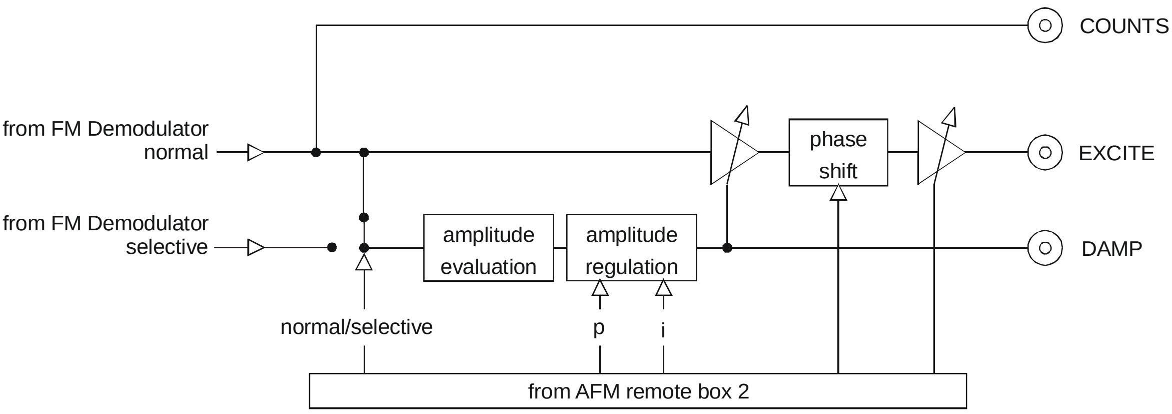


Figure 61. Excite board, schematic circuit diagram.

FM Demodulator 2/2Q

Location:	AFM CU II	Application:	AFM non-contact

The FM Demodulator Board exists in two variants, version 2Q has been adapted especially for use with the QPlus sensor.

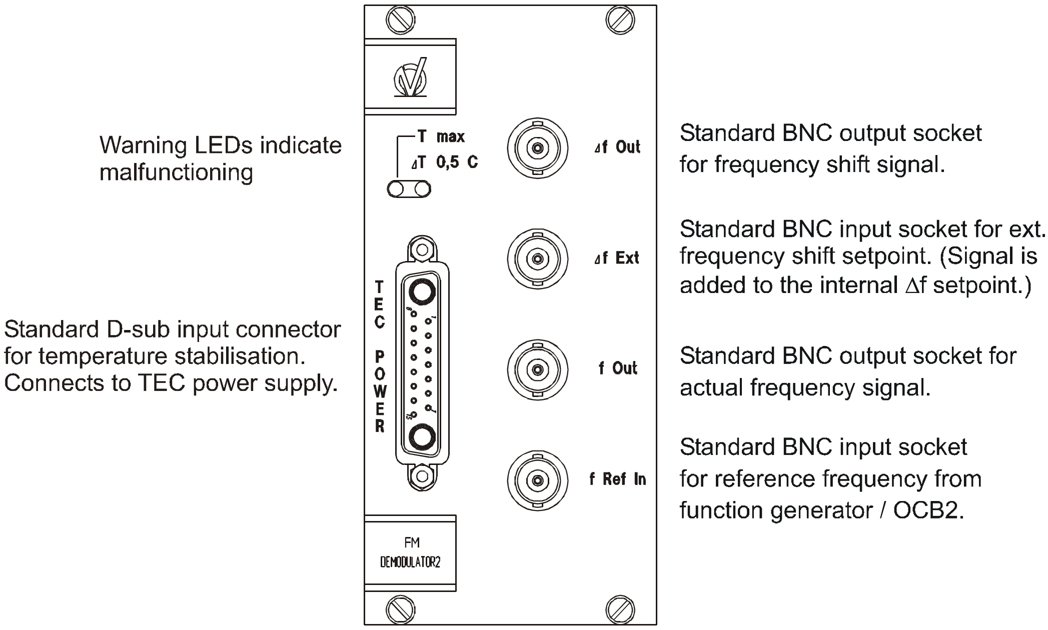


Figure 62. FM Demodulator board, panel schematic diagram.

> **Attention.** Input levels for Δf_{EXT} must stay between ±7.5 V (between ±2.5 V for QPlus sensor) at all times.

The FM demodulator board has a number of different functions.

- An analogue multiplier combines the reference and sensor frequencies:

  $A \sin(f_{SENSOR}) \times B \sin(f_{REF}) = C \sin(f_{REF} + f_{SENSOR}) + D \sin(f_{REF} - f_{SENSOR})$.
- A band pass filter removes the first term of the mixed signal. This requires fREF to be adjusted in order to give $f_{REF} - f_{SENSOR} \approx 455$ kHz.
- The FM demodulator converts the frequency signal into an analogue voltage: $\Delta f_{OUT} = 5\ \text{mV/Hz} \times (455\ \text{kHz} - f_{REF} + f_{SENSOR})$.
- Finally the difference between the actual frequency shift and the frequency shift setpoint, multiplied with the selected polarity, is transferred to the compare board for gap width regulation.

The FM demodulator is temperature stabilised. Drift free operation can be expected after a stabilisation period of about 30 minutes.

The FM demodulator has two temperature indicating LEDs.

- dT<0.5°C indicates that the electronics temperature deviates from the setpoint by more than 0.5°C.

  In this case wait for the electronics to reach near setpoint temperature (LED switches off). This should not take longer than 10 minutes after switching on.
- T>max indicates that the maximum allowed temperature of the stabiliser has been exceeded and the Peltier element has been switched off.

In this case switch off the AFM CU II including the TEC power supply and wait about 60 minutes for all elements to cool down. Check if the convection slots are blocked or the lab temperature is too high.

Attention. After a T>max switch-off an increased drift in the frequency measurements may occur for about 48 hours.

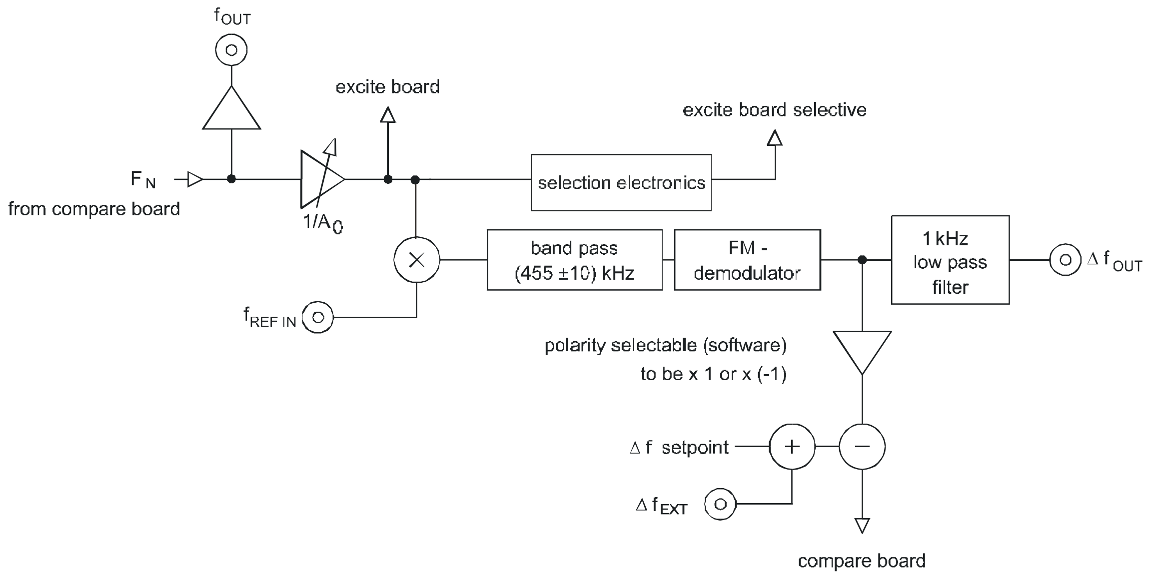


Figure 63. FM demodulator board, schematic circuit diagram.

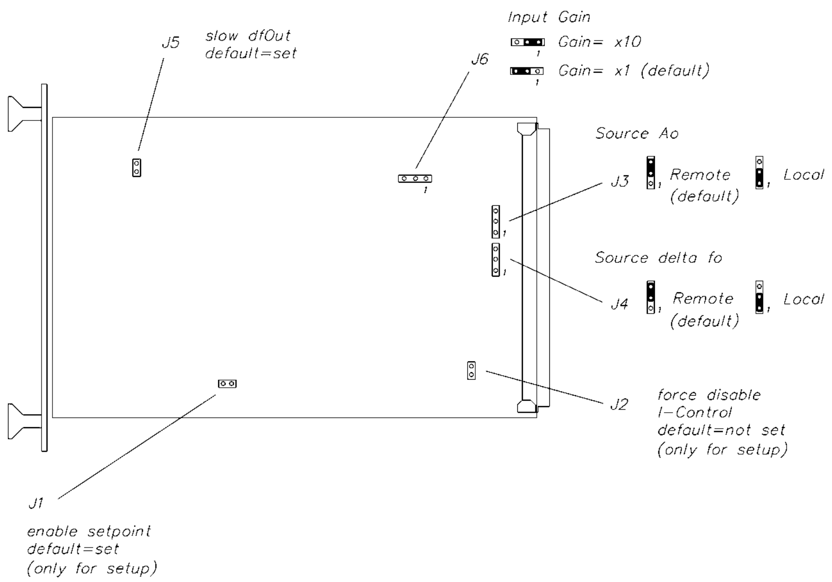


Figure 64. FM Demodulator jumper plan, schematic diagram.

Input Stage (S)

Location:	AFM CU II (S)	Application:	AFM

The Input Stage exists in two variants, "Input Stage" for use with the UHV AFM/STM and "Input Stage S" for use with the Cryogenic SFM and the VT AFM. While the circuit diagrams and board layouts for the two variants are different the appearance and principal functions are the same.

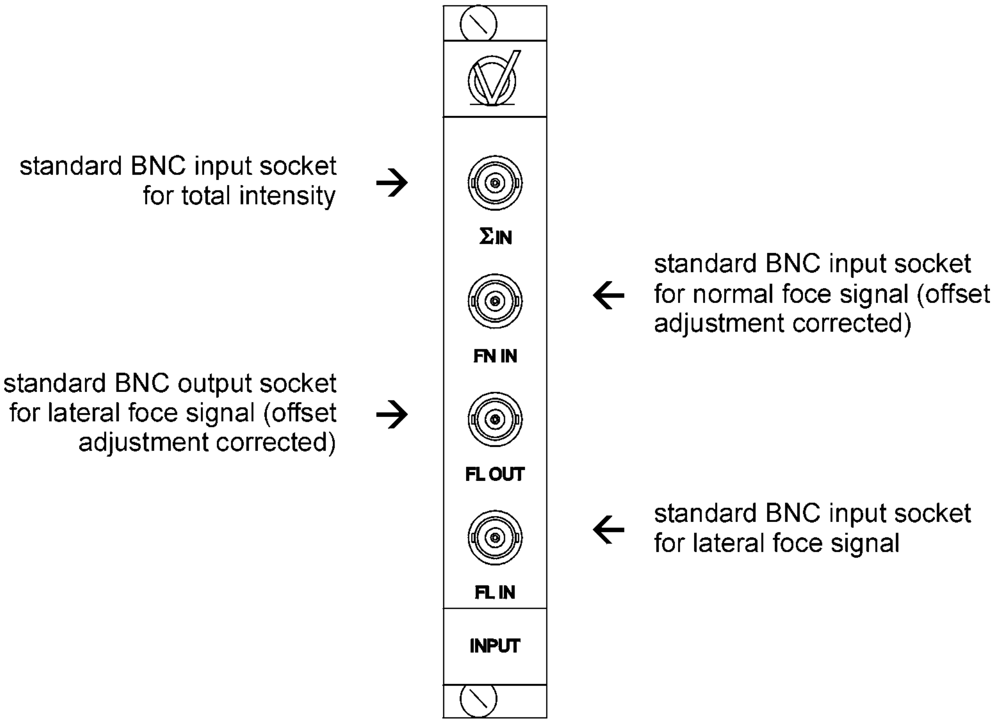


Figure 65. Input board, panel schematic diagram.

- Accepts input from the Preamp box.
- Performs offset adjustment, see below and page 82.

- Samples the force level: if F_N > 19% of total intensity a signal is given to the regulator board (function not valid for Input Stage S).

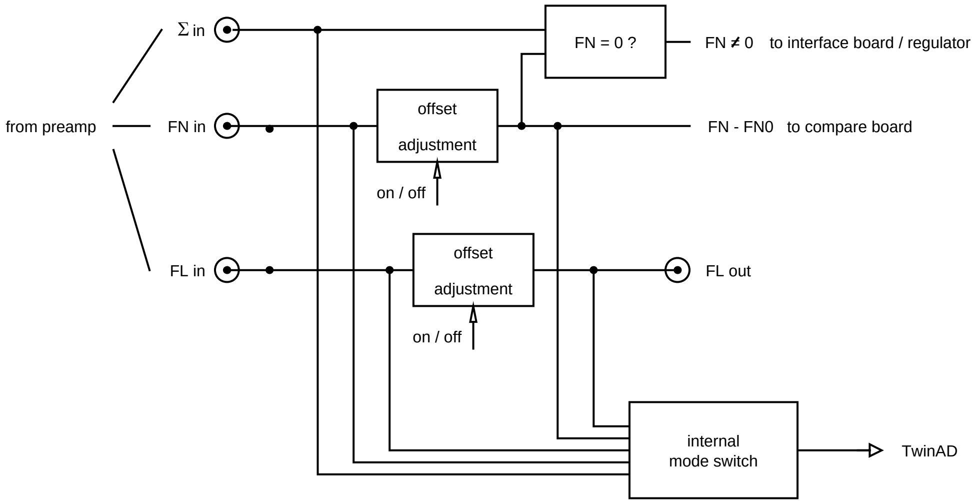


Figure 66: Input stage, schematic circuit diagram.

Interface Board

Location: AFM CU II	Application: AFM

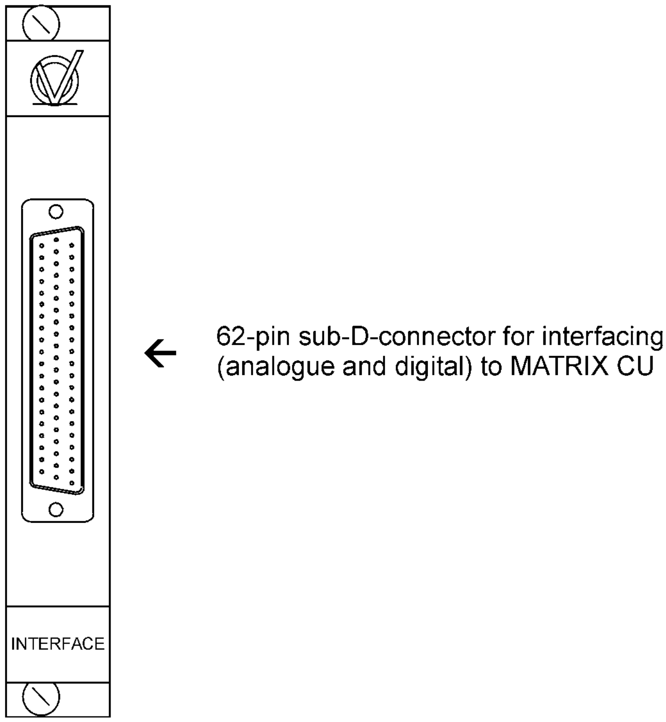


Figure 67. Interface board, panel schematic diagram.

The AFM interface board provides a connection between the AFM CU Bus (ACB) and the External Interface Bus (EIB) which connects to the MATRIX CU.

- All digital signals are directly connected.
- Analogue signals are de-coupled using a differential amplifier.
- Every analogue signal has a corresponding “GND sense” connection.

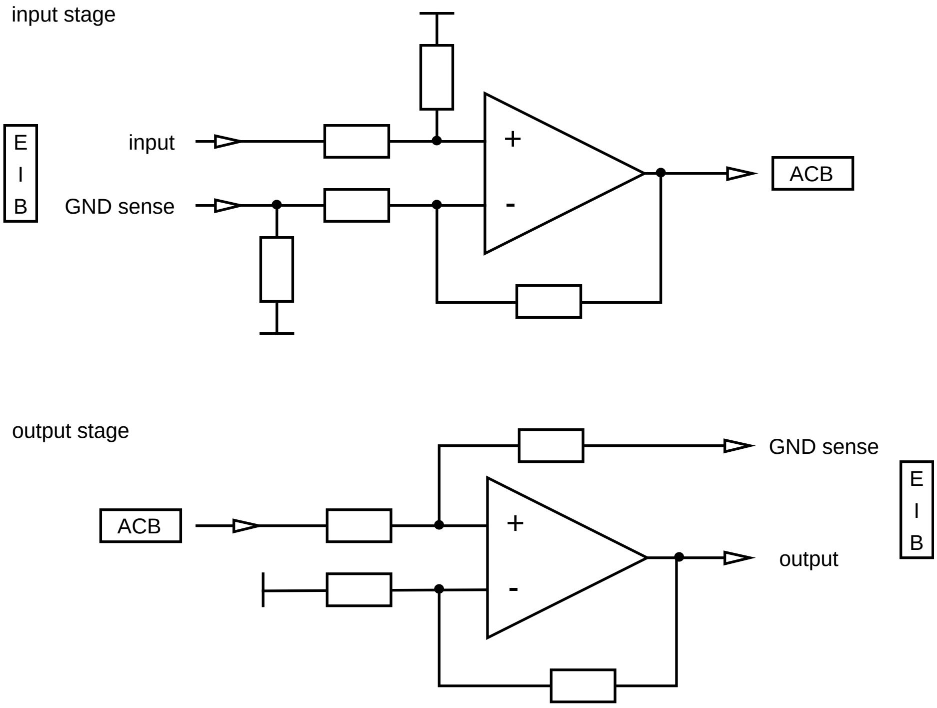


Figure 68: Schematic circuit diagram of AFM interface differential amplifiers.

Light Source Control

Location: AFM CU II	Application: AFM

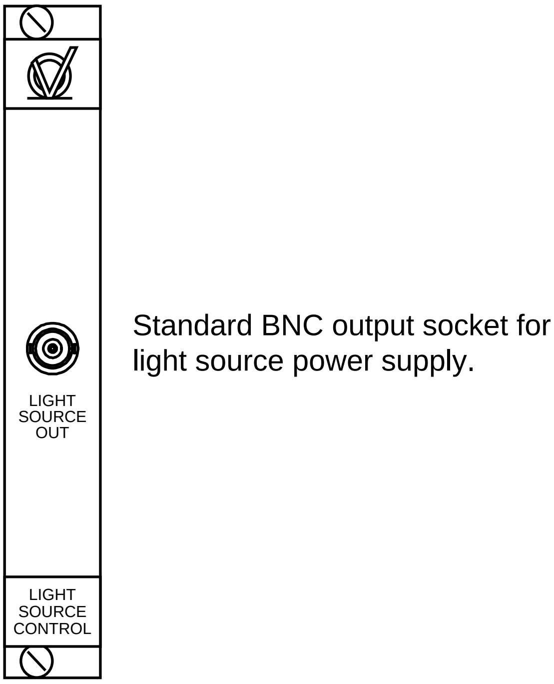


Figure 69. Light source control board, panel schematic diagram.

The Light Source Control board provides the LED with a stabilised DC current of 75 mA and assures slow power increase/decrease upon switching processes to protect the LED.

The LED may be switched on/off using the Sensor Alignment window. In the latter case the Light Source Control stabilises the current at 0 mA. The on-board trim potentiometer is pre-set but may need to be adjusted.

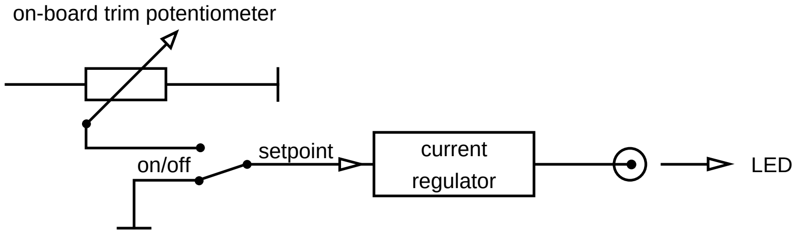


Figure 70: Light Source Control, schematic circuit diagram.

Please note: For Cryogenic SFM or VT AFM the Light Source Control board is replaced by the Laser Interface Board.

Laser Interface Board

Location:	AFM CU II S	Application:	Cryogenic SFM or VT AFM

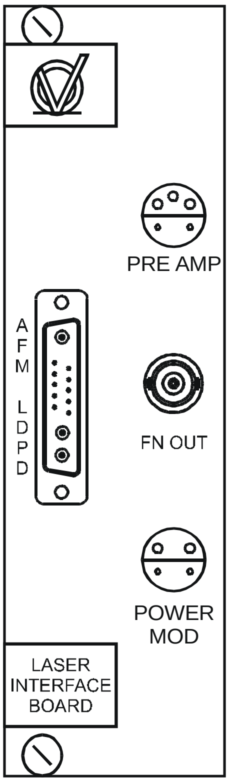


Figure 71. Laser Interface Board, panel schematic diagram.

The Laser Interface Board provides the Laser Unit (VT AFM) or Laser Detector Unit (Cryogenic SFM) with the setpoints for a software controlled DC current of 0 to 90 mA (max. 100 mA) and slow power increase/decrease upon switching processes to protect the laser. The laser may be switched on/off using the Sensor Alignment window. In the latter case the Laser (Detector) Unit stabilises the current at 0 mA.

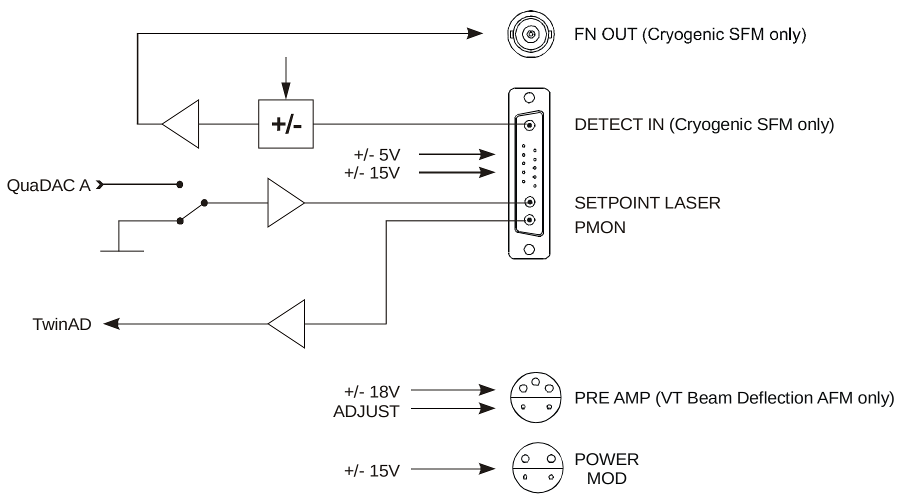


Figure 72: Laser Interface Board, schematic circuit diagram.

DC supply 2 AFM CU

Location:	AFM CU II	Application:	AFM/QPlus

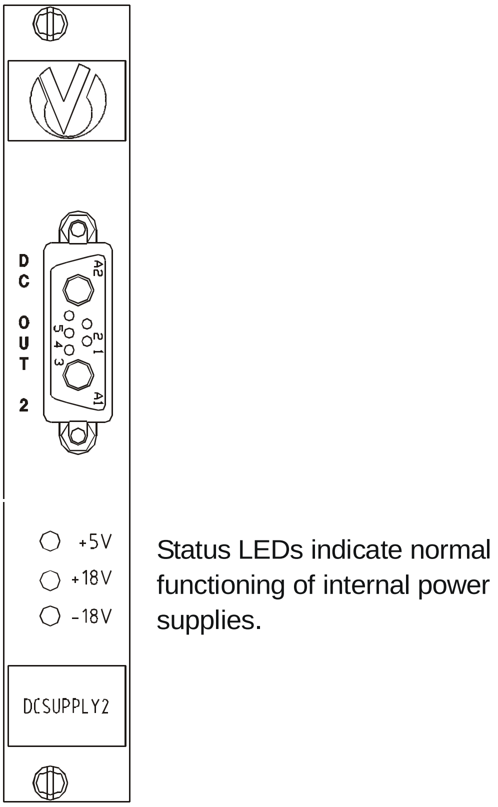


Figure 73. DC supply 2 board AFM CU, panel schematic diagram.

The DC supplies board transforms the incoming AC voltage. The LEDs on the back panel indicate proper functioning of the DC supply when lit.

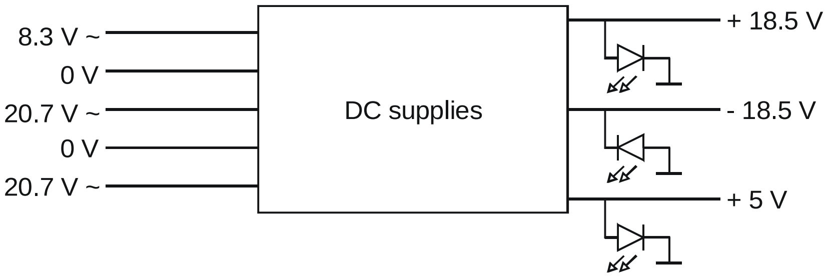


Figure 74. DC supply 2, schematic circuit diagram.

AC Power Supply AFM

Location:	AFM CU II	Application:	AFM

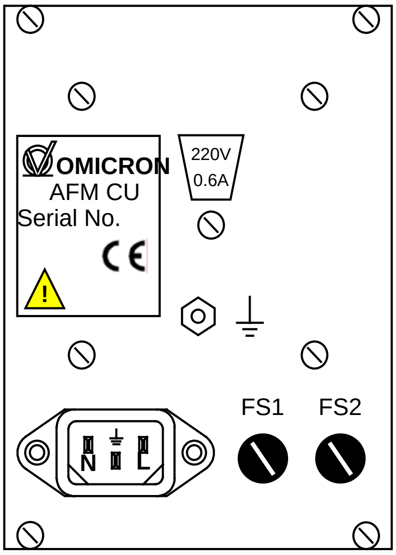


Figure 75. AC power supply board, panel schematic diagram.

The power supply provides the AFM CU with all necessary voltages. It comes complete with a standard European socket and has been configured to take 100/110/120/ 220/240 Volts ±10%, 50 or 60 Hz and 80 VA, according to customer specification. **Please check for correct mains voltage before connecting any equipment!**

AFM Offset Adjustment

If the cantilever is not in contact with the sample there is no detectable force between the cantilever and the sample. However, the detector may still show a force signal due to a misalignment of mirror 2 (VT AFM: PSD mirror). To correct this arbitrary zero of the force detector the offset function may be used.

- The offset adjustment function is an electronic circuit which performs an analogue subtraction of the „zero"-voltage U_0.

The offset adjustment function is activated every time the piezo starts to move forward from the fully retracted position. It may also be activated or de-activated manually.

Offset voltages at the input sockets are stored at the moment when the adjustment function is switched on. These are subsequently subtracted from the input voltages.

adjustment OFF	$U_{OUT} = U_{IN}$
adjustment from OFF to ON	$U_{IN} \equiv U_0$ is stored
adjustment ON	$U_{OUT} = U_{IN} - U_0$

Table 14: Adjustment functions.

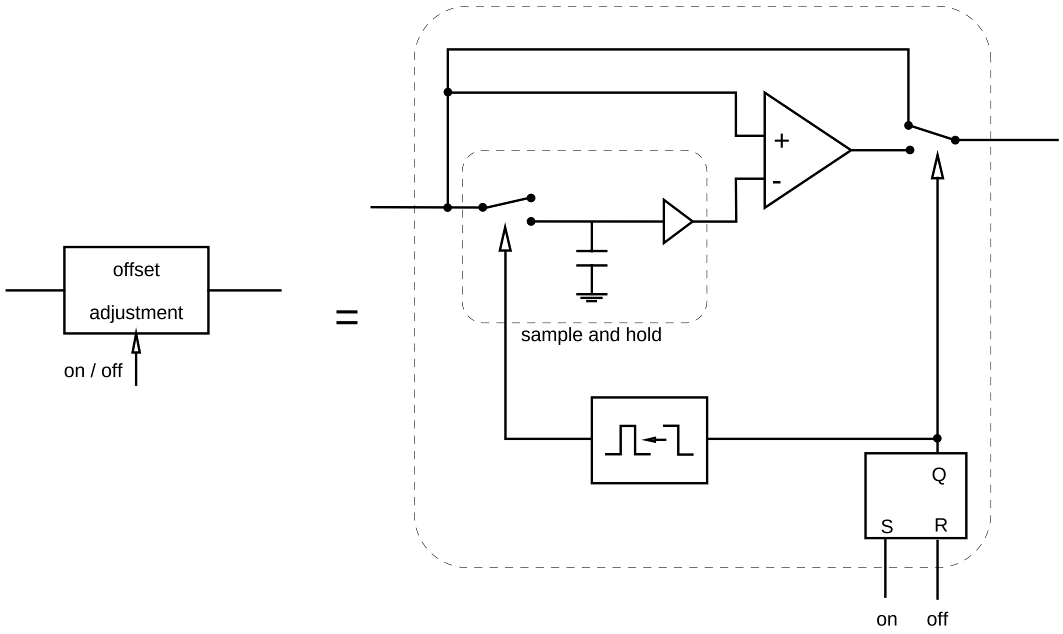


Figure 76: Offset adjustment.

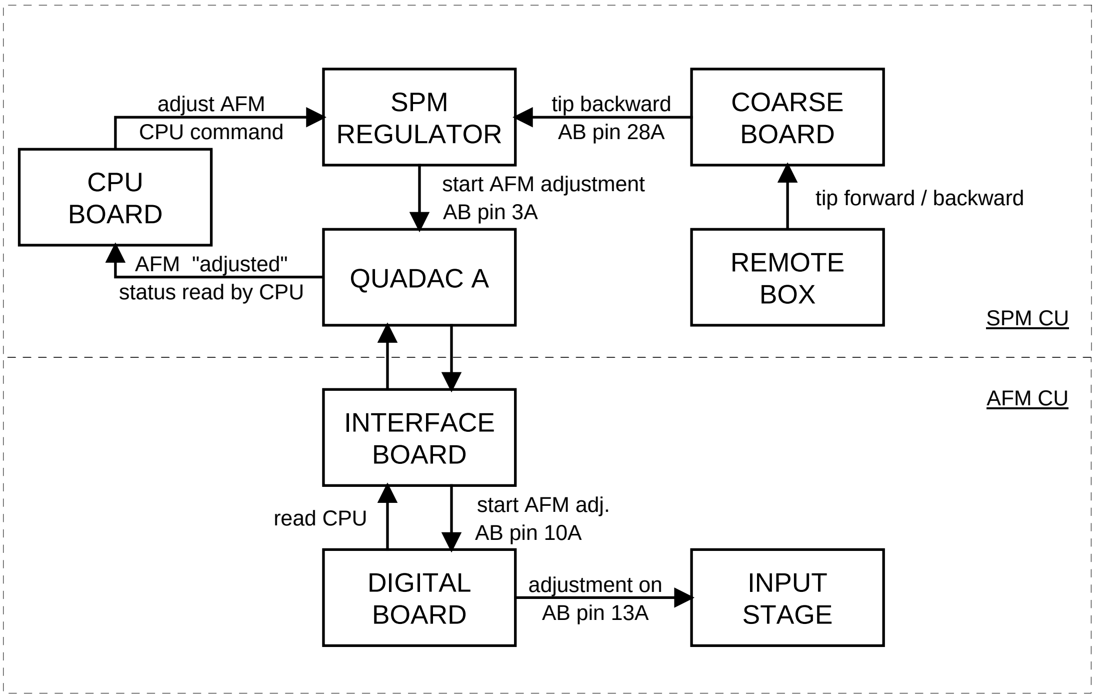


Figure 77. Automatic offset adjustment, schematic diagram.

8. AFM Remote Box 2

The AFM Remote Box 2 is needed for AFM non-contact mode only. It contains a number of controls for adjusting those parameters which influence the sensor vibration stability.

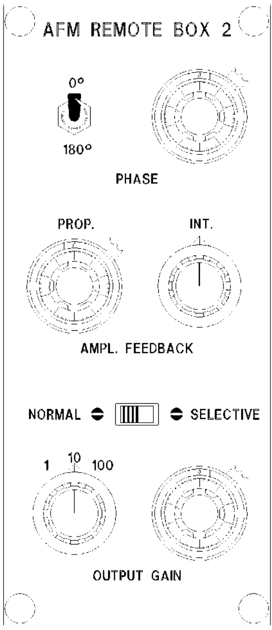
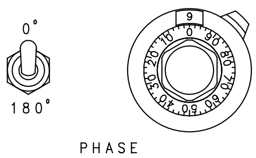
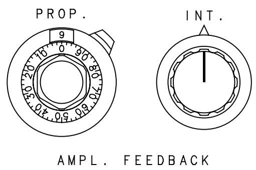
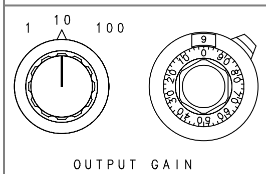


Figure 78. The AFM Remote Box 2, schematic diagram.

The switches and potentiometers drive the corresponding functions on the excite board.

	Adjustable phase shift between vibration signal and excite voltage. The switch allows selecting a coarse phase shift of 0° or 180°. The ten-turn potentiometer allows phase shift fine control
	Adjustable regulation speed of the amplitude feedback loop. PROP. : proportional part of the regulation speed (ten-turn poti). INT. : integral part of the regulation speed (single-turn poti).
	Gain regulation of the excitation circuit output amplifier. Coarse adjustment with rotary switch: 1, 10 or 100. Fine adjustment using a ten-turn potentiometer.
	Mode selection for amplitude regulation. normal: amplitude evaluation of input signal selective: selective amplitude evaluation of input signal including broad band noise suppression (recommended for noisy signals and feedback setpoints between±500 Hz)

9. HC 1100

HC 1100 Front and Back Panels

Application:	VT DH / VT DRH

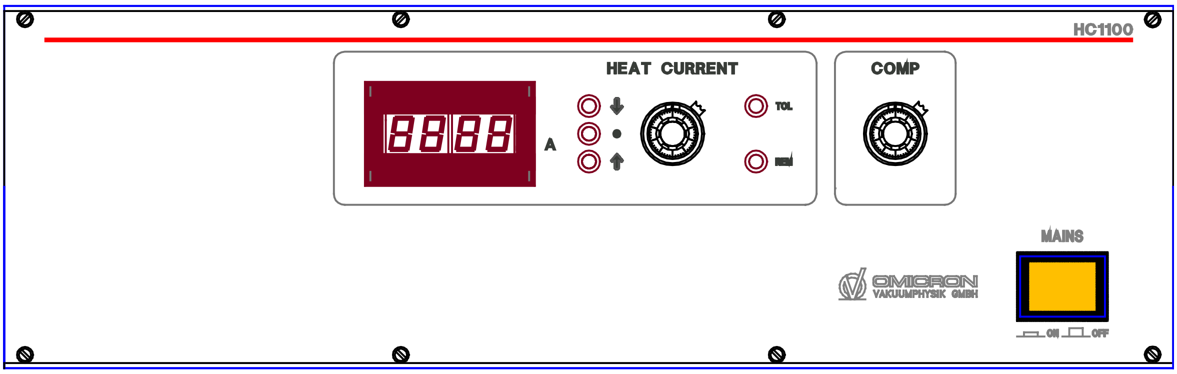
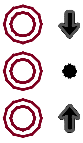
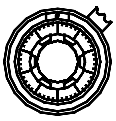
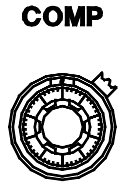
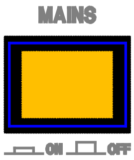


Figure 79. HC 1100 front panel layout, schematic diagram.

	The front panel display shows the actual heating current in Amps. With the potentiometer set to zero the display may still indicate a few digits, typically around 2 mA. The accuracy of the display is ±(2%+2 digits).
	The three LEDs next to the display are employed to avoid problems when switching between remote and local mode. The software, when activated, inquires and adopts the actual potentiometer setting and switches the middle LED green. In remote mode the current setting is exclusively computer controlled. Problems only arise when the potentiometer setting is different from the software setting and you want to switch back to local mode. The two red LEDs when lit indicate that the potentiometer setting differs by more than 5 mA from the currently employed heating current. In this case turn the potentiometer to the value used by the software or change the software setting to match the potentiometer. Switching from remote to local mode should only be carried out when both red LEDs are off and the green LED is lit. Otherwise you may melt the sample by accidentally applying a very high current. Also a major voltage change may lead to a tip crash or the sudden temperature change may result in drift problems.
HEAT CURRENT 	Ten-turn potentiometer for setting the heating current between zero and 2 A. Note that the accuracy of the display is ±(2%+2 digits).
	Thermal overload, red LED. If this LED is lit it indicates a thermal overload in the electronics. Note, however, that the TOL LED always lights up for some 5 s after switching power on.
	Remote control, green LED. If lit this LED indicates that the remote control mode is active.

	Ten-turn potentiometer to set the compensation voltage U_{comp} relative to the heating voltage. When tunnelling on a uniform sample this potentiometer sets the parameter $\lambda_x/\lambda_{sample}$, see page 87.
	Power supply switch. Press to switch the unit on, press again to switch off.

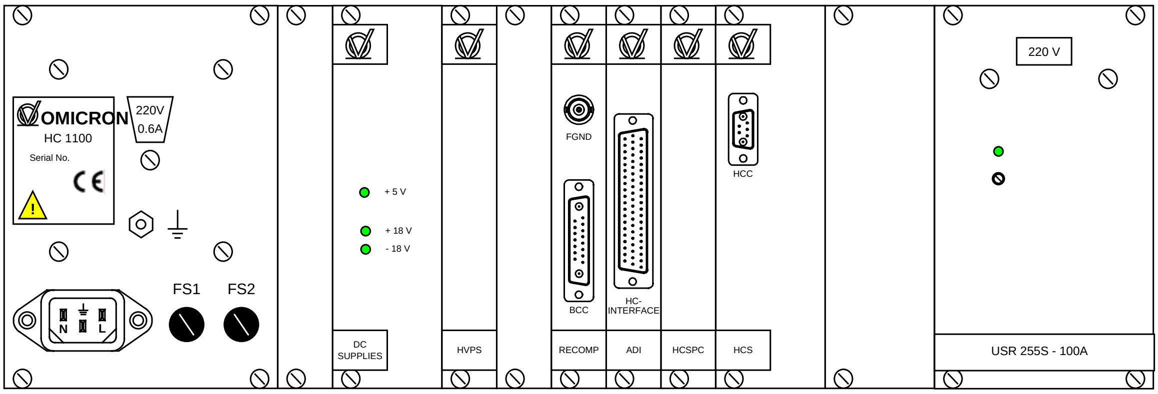
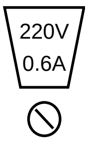
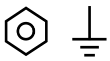
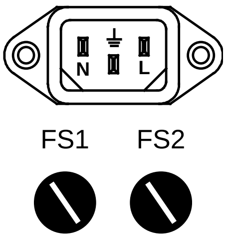
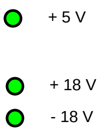
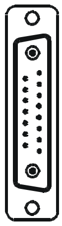
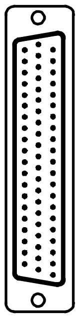
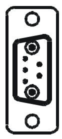


Figure 80. HC 1100 back panel layout, schematic diagram.

	Mains voltage setting according to customer specification. Please check for correct value before connecting any equipment. **Note.** The USR 255S-100 A module always needs to be set to the same mains voltage as the AC module.
	Grounding screw.
	Mains input: 100/110/120/220/240 volts ±10%, 50 or 60 Hz and 100 VA, set to customer specification. Mains fuses: 5 mm ∅, 20 mm long use 2 × 0.63 A (T) for 200-240 V AC 2 × 1.25 A (T) for 100-120 V AC
	Status LEDs indicate normal functioning of internal power supplies.
	Standard BNC output socket for monitoring the corrected floating ground potential. For checking always use probes with $R_i \geq 10\ M\Omega$ to minimise the error bar.

 BCC	17-pin mixed D-sub connector for the bias control cable (BCC). The other end goes to the preamp box BCC connector. The cable must be secured using the provided fixing screws.
 HC-INTERFACE	62-pin D-sub bus connector for the ribbon cable between HC 1100 and MATRIX CU (future extension!). This cable will then establish the link between the HC 1100 and the software for remote control.
 HCC	7-pin mixed D-sub connector for the heating control cable (HCC). The other end goes to the HCC socket on the base flange. The cable must be secured using the provided fixing screws.
 (USR 255S-100A)	LED and trimmer to optimise the USR 255S-100A unit between zero and 2.2 A. Maximum output voltage -100 V. This trimmer has been adjusted at factory. Do not change the preset value. If the LED is not lit, check the internal fuse, see page 97. **Note.** Upon delivery this unit is set to the same mains voltage as the AC module. If your mains voltage is different from the value stated on the label, a fuse needs to be changed inside the module. To do so: • Slacken the four screws, remove the unit and turn it upside down. • Fit a fuse according to your mains voltage as stated on the label (3.15 AT for 230 VAC, 6.3 AT for 110 VAC). • Re-fit the unit.

Functions

The HC 1100 is a low noise current regulated power supply for optimum performance, capable of supplying the DH and RH sample plates. It consists of several circuit boards, see the back panel layout on page 85.

The DC supplies board transforms the incoming AC voltage and supplies the other boards of the HC 1100 with stabilised DC voltages. The LEDs on the back panel indicate proper functioning of the DC supply when lit.

The high voltage power supply board (HVPS) provides the voltages for the floating ground signal.

The regulator compensation board (RECOMP) adjusts FGND to equal the corrected floating potential of the tunnelling tip and supplies the signals for the bias control cable (BCC).

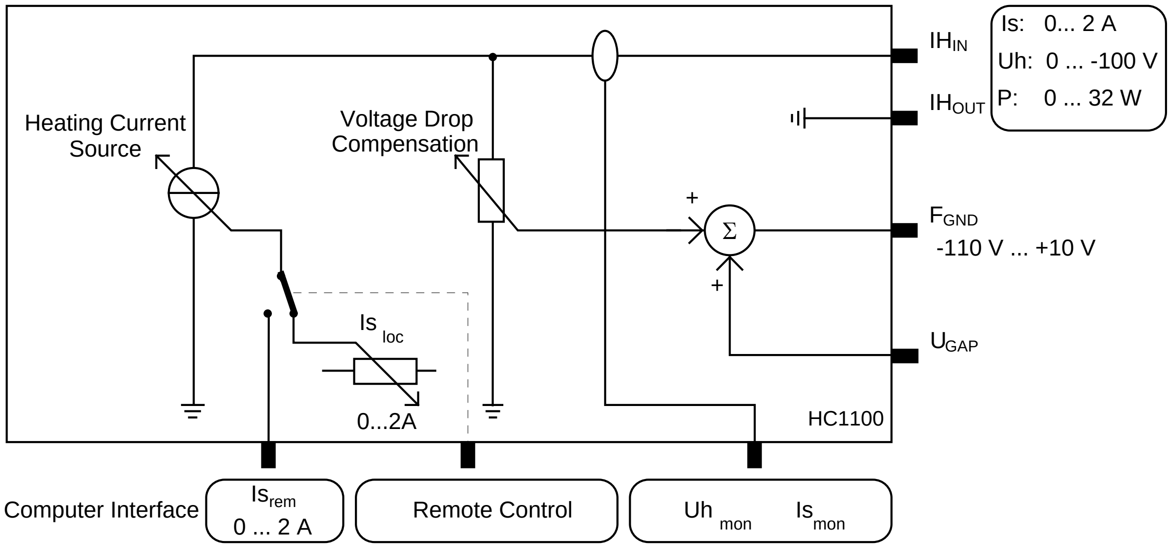


Figure 81. HC 1100 schematic circuit diagram.

The analogue-digital interface board (ADI) provides a bus cable interface for transferring the remote control signals between the HC 1100 and the MATRIX CU.

The heating current source power control board (HCSPC) and the heating current source board (HCS) provide the heating current for the sample heating, which is supplied via the heating control cable (HCC).

The voltage supply board USR 255S-100A has an internal output current limit of 2.2 A. A trimmer on the back panel allows to further reduce the output voltage limit.

Voltage Compensation

The direct heating method passes a current through the sample to exploit ohmic heating. This leads to a voltage drop across the sample. Therefore, the gap voltage depends on the geometrical position of the tip with respect to the sample. The maximum heating voltage is 90 V. However, a compensation voltage V_{comp} is still necessary to adjust the gap voltage to less than a few volts. For constant resistivity across the sample

$$V_{gap}^{eff} = V_{gap} + V_H \cdot \frac{\lambda_x}{\lambda_{sample}} + V_{comp}$$

Therefore, a reference output of the power supply is connected to the floating preamplifier to ensure fully compensated measurements. No further numerical correction has to be made. The gap voltage can be selected arbitrarily between ±10 V to the tip no matter what "heating voltage" V_h drops across the sample. The V_{comp} potentiometer setting is proportional to the geometrical tip position.

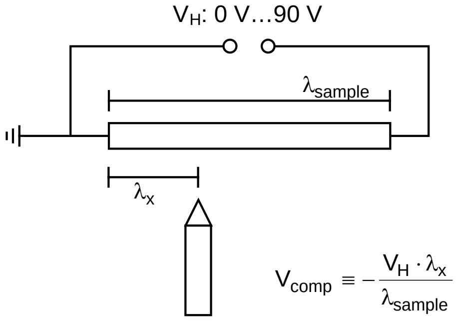


Figure 82. Voltage compensation for the VT DH version.

Very High Resistance Samples

If the sample resistance is rather high a moderate heating current may lead to a massive voltage drop across the sample.

- Example: R_i = 100 Ω and I_H = 80 mA ⇒ V_H = 8 V

A correct setting of the heating current is important as inaccurate values also lead to untrue gap voltage values.

Attention. If not currently heating the sample, set I_H to 0.0 (i.e. potentiometer fully counter clockwise) to achieve $V_H \approx 0$ V.

Specifications

Specifications	
maximum voltage output	90 V
maximum current output	2 A
current display accuracy	±(2%+2 digits)
maximum power output	30 W
monitor signal	FGND (± 1 % / ± 3 mV for $R_i \geq 10$ MΩ)

10. Installing Additional Boards

To install the an additional circuit board to your existing MATRIX CU please follow the instructions given below.

Attention. The circuit board may carry delicate circuits which are very sensitive to **electrostatic discharge (ESD).**

- Always apply appropriate ESD protection.
- Use only tools certified for CMOS handling.
- Do not touch the boards with bare hands.

- Switch off and disconnect the MATRIX CU and all connected electronics units.
- Wait for 10 minutes for any stored energy to discharge.
- At the back of the MATRIX CU remove the relevant blind panel.
- Insert the additional board in the same orientation as the other boards.
- Effectuate the cabling according to the guidelines in the relevant chapter/instruction sheet. You may want to refer to the PC manuals for a back panel layout.
- Plug in the all power cords and switch the control units on.
- Check if any software installation/upgrade is necessary to drive the added circuit board.
- Restart the MATRIX CU and subsequently the MATRIX software.
- Before proceeding make sure to have the correct parameter set loaded.

11. Jumper Control

On some of the circuit boards jumpers offer additional choices not otherwise available.

Attention. All boards carry delicate circuits which are very sensitive to **electrostatic discharge (ESD).**

- Handle only at static safe work places.
- Use only tools certified for CMOS handling.
- Do not touch the board without appropriate ESD protection.

Warning: Lethal Voltages!!

Lethal voltages are present on some of the MATRIX CU boards and back panel connectors. Adjustments **(including jumper settings)** and fault finding measurements may only be carried out by authorised personnel qualified to handle lethal voltages.

To change a jumper please follow the steps below:

- Exit the MATRIX program.
- Switch off all control units (MATRIX rack) and wait for 10 minutes for capacitors to discharge.
- Disconnect all mains connections.
- Pull out the respective board(s).
- Set, remove or change the jumper(s) as desired.
- Re-insert the board(s) and switch control unit on.
- Re-start the MATRIX program.

SPM Jumper Settings

AFM Jumper Settings

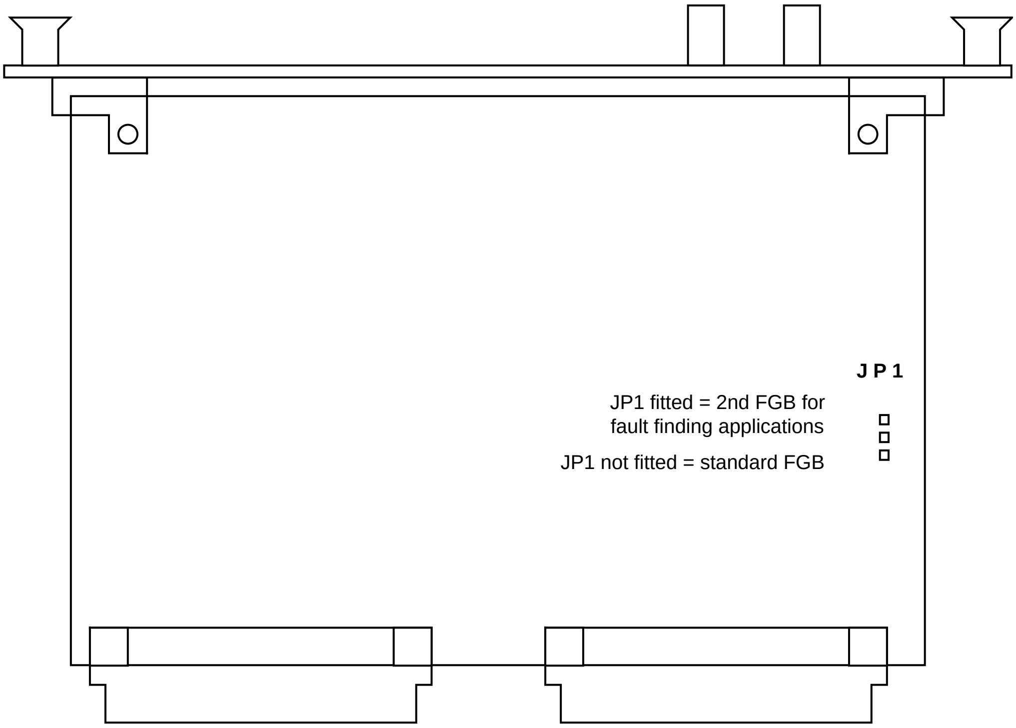


Figure 83. Jumper location: Oscillator/Counter Board (Oscillator/Counter Board).

Demodulator Board (AFM CU)

jumper		jumper set	jumper not set
JP 1	input gain	x 10	x 1
JP 4	output Δf	low pass 1 kHz	low pass 10 kHz
jumper		jumper set 1-2	jumper set 2-3
JP 2	source A_0	STM CU upgrade only	software control
JP 3	source Δf_0	STM CU upgrade only	software control

Table 15. Jumper positions: demodulator board, default settings underlined.

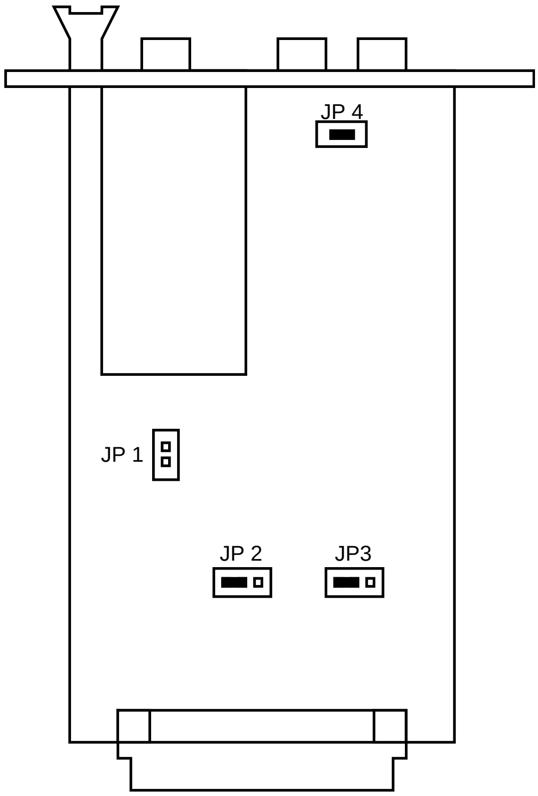


Figure 84. Jumper location: AFM Demodulator Board. Default settings shown.

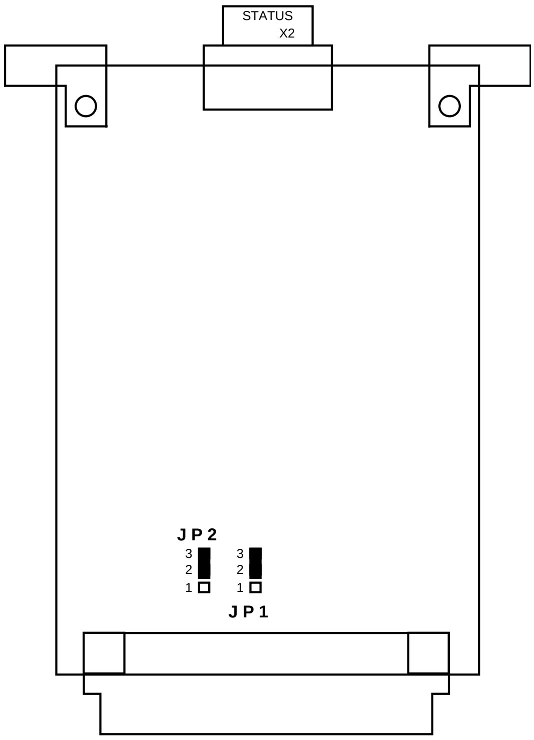


Figure 85. Jumper location: AFM Digital Board. The jumper settings shown are for full software control. For front panel control using the old-style AFM CU, both jumpers must be set to positions 1-2.

OPD Board Jumper Settings (NEEDLE Sensor)

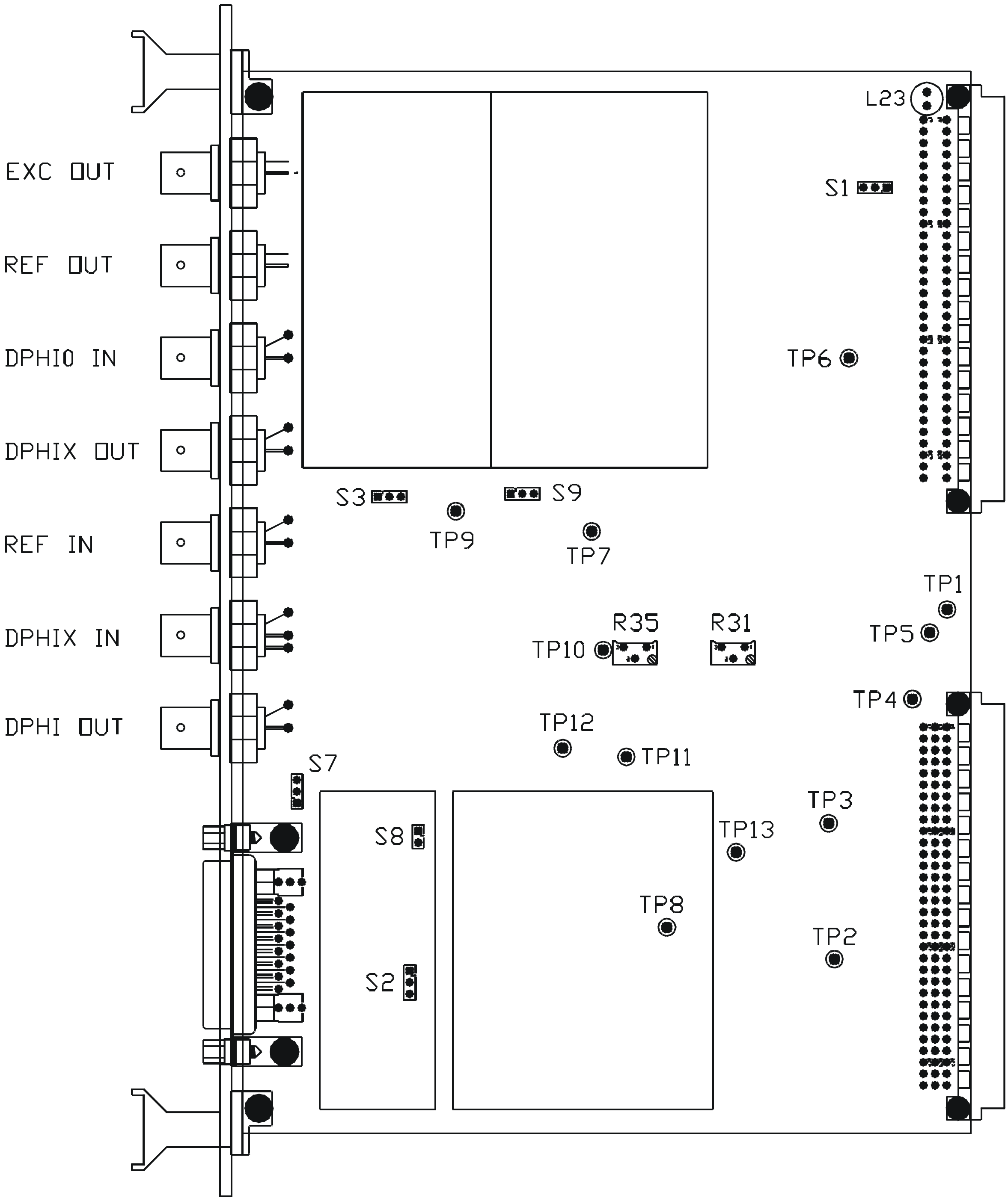


Figure 86. Jumper location: OPD board.

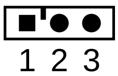
Jumper	Position	Comment
S1	1-2	Digital access, do not change!
S1	2-3	Not used
S2	1-2	For internal phase detector
S2	2-3	For external phase detector (e.g. VT AFM)
S3	1-2	Ref Out amplitude = U_{REF} (max. amplitude)
S3	2-3	Ref Out amplitude = DAC (variable amplitude)
S4	set	AGND - GND connection, fixed
S5	set	AGND - GND connection, fixed
S6	set	AGND - GND connection, fixed
S7	1-2	For external phase detector (e.g. VT AFM)
S7	2-3	For internal phase detector
S8	set	For internal phase detector
S8	not set	For external phase detector (e.g. VT AFM)
S9	1-2	Excite amplitude = U_{REF} (max. amplitude)
S9	2-3	Excite amplitude = DAC (variable amplitude)
		Pin "1" of the jumpers is marked like this.

Table 16. OPD board jumper settings.

Jumper	Position	Comment	
3	set	remote control analogue/pulse counting via software	
4	not set		
23	set	maximum driver voltage for HV-control	0 to 1.0 V
	not set*		0 to 1.2 V*
6	set	Switching a detector on/off via software.	
7	not set		
25	set	Message "detector overload" to software.	
24	not set		
8	not set		
9	not set	Driving voltage for discriminator level.	
10	not set		
11	set		
12	not set		
13	not set	(future extension)	
14	not set		
15	not set		
16	not set		
20	not set	Driving voltage for controlling the detector sensitivity	
5	not set		
18	set		
19	not set		
1	1-2	polarity of output signal	
2	1-2	dead time of pulse former	

Table 17. External DCB jumper settings. *) Note: for photomultiplier module HAMAMATSU H5700 jumper 23 should be "not set".

12. Trouble Shooting

Frequency Measurement Unstable

- Allow 30 minutes warming up time for the FM demodulator and function generator to work properly and about 90 minutes for drift-free operation.
- Keep the FM demodulator running during short breaks to avoid this problem.
- Make sure the room temperature is not too high (should be below 40°C).

Drift Problems

- Keep the laboratory temperature as constant as possible.

Amplitude in Non-contact Mode is not correct

- Check the jumpers on the QuaDAC A board, see MATRIX CU Technical Reference Manual.

Problems with other functions

- Check the LEDs on the DC supplies board. If not all of the LEDs are not lit check the fuses.

HC 1100 Trouble Shooting

No output current

- Check if all plugs are properly connected.
- Check the fuses FS1 and FS2.

Effective gap voltage is wrong

- U_{comp} has not been evaluated correctly.
- The tunnelling area has been shifted macroscopically.
- The sample has a very high resistance, see page 88.

Heating current cannot be set to zero

- The HC 1100 has a zero current of about 250 µA due to its finite internal resistance. This leads to a (false) heating current display about 2 mA.

Front panel LED TOL lights up

- This LED is always lit for about 5 s after switching power on.

Problems with other functions

- Check the LEDs on the DC supplies board. If not all of the LEDs are lit check fuses FS1 and FS2 on the back panel.
- Check the LED on the USR 225S-100A. If it is not lit, check the internal fuse FS3.

13. Fuses Listing

The MATRIX CU contains a large number of fuses on different boards. For your convenience these are listed here together.

Mains Supply Unit Fuses

Mains Input	F1	F2
220/240 V	2 A T	3.15 A T
100/110/120 V	4 A T	6.3 A T

Table 18. Mains supply unit: fuses.

Piezo Driver Board Fuses

Fuse	Si1	Si2
Value	80 mA T	80 mA T

Table 19. Piezo driver board: fuses.

Coarse Positioning Board Fuses

Board	Fuse
Coarse Position Power Board	0.25 A T

Table 20. Coarse positioning board: fuses.

HC 1100 USR 255S-100A

Fuses	for 200-240 V AC	for 100-120 V AC
Rating	3.15 A (T)	6.3 A (T)
Dimensions	5 mm ∅, 20 mm long	5 mm ∅, 20 mm long

Table 21. HC 1100 USR 255S-100A: fuse. This fuse sets the operating voltage for the SNT.

14. Remote Box Instrument Configurations

For every OMICRON instrument that can be controlled with the remote box there is a specific instrument configuration. Every remote box can be used to control every instrument configured at the time of remote box delivery. To change to a different configuration use SET HEAD from the SETTINGS menu, see figure 87 below. Note however, that the correct settings have already been loaded during test at OMICRON if the remote box is shipped together with the instrument.

```
 SET HEAD
     LT STM
PREV  NEXT
   EXIT   RESET
```

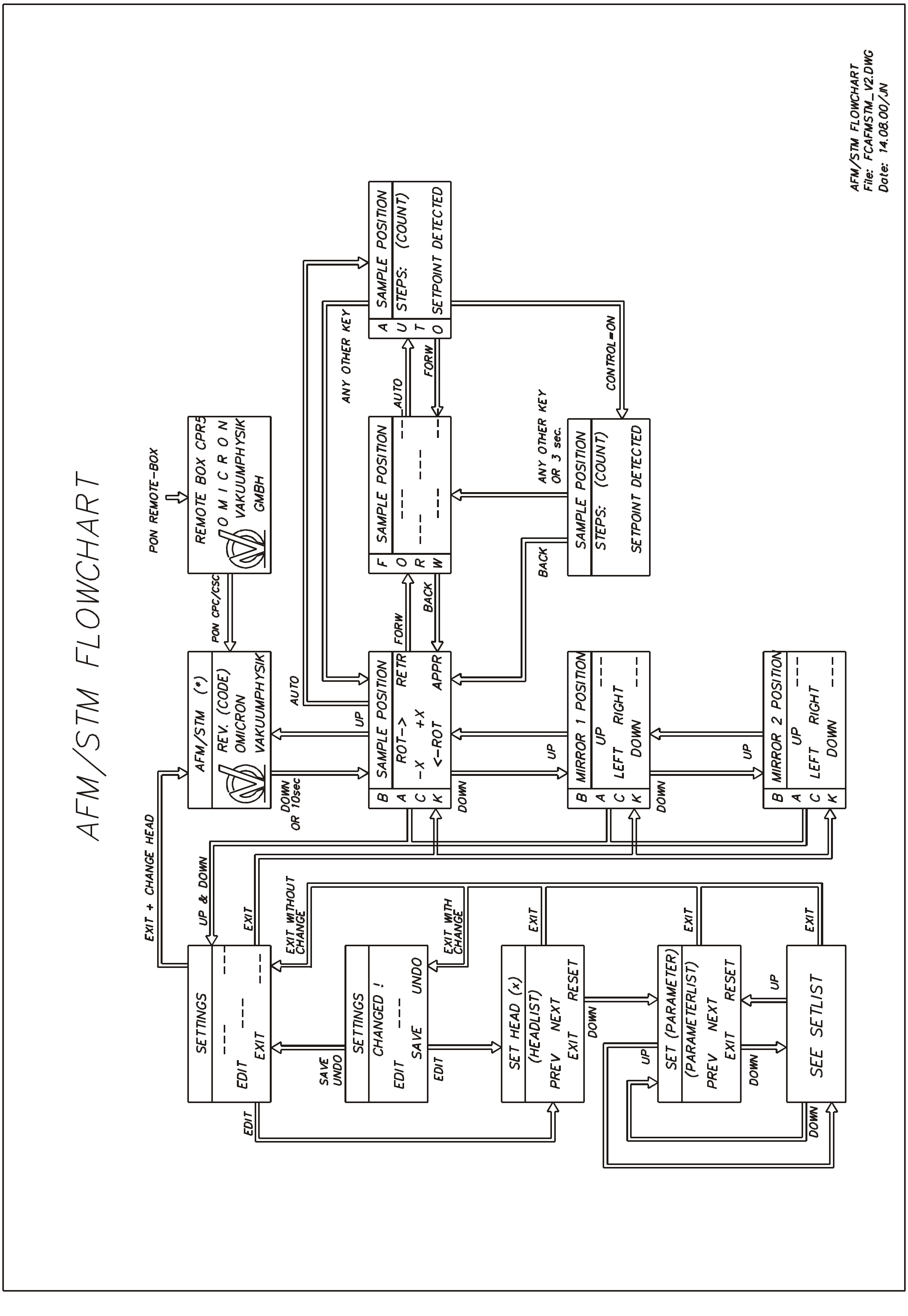
Figure 87. The head setting menu. Example shown.

Every instrument configuration has been documented in form of a flowchart. Here you can see how to navigate through the different menus and where pressing the up/down back and forward buttons lead you. In addition a table lists the available settings and default settings for the given instrument configuration.

Technical Data

Specifications	
Operating Voltage	+5 V
Current consummation	< 100 mA at 5 V

UHV AFM/STM Configuration



AFM Applications

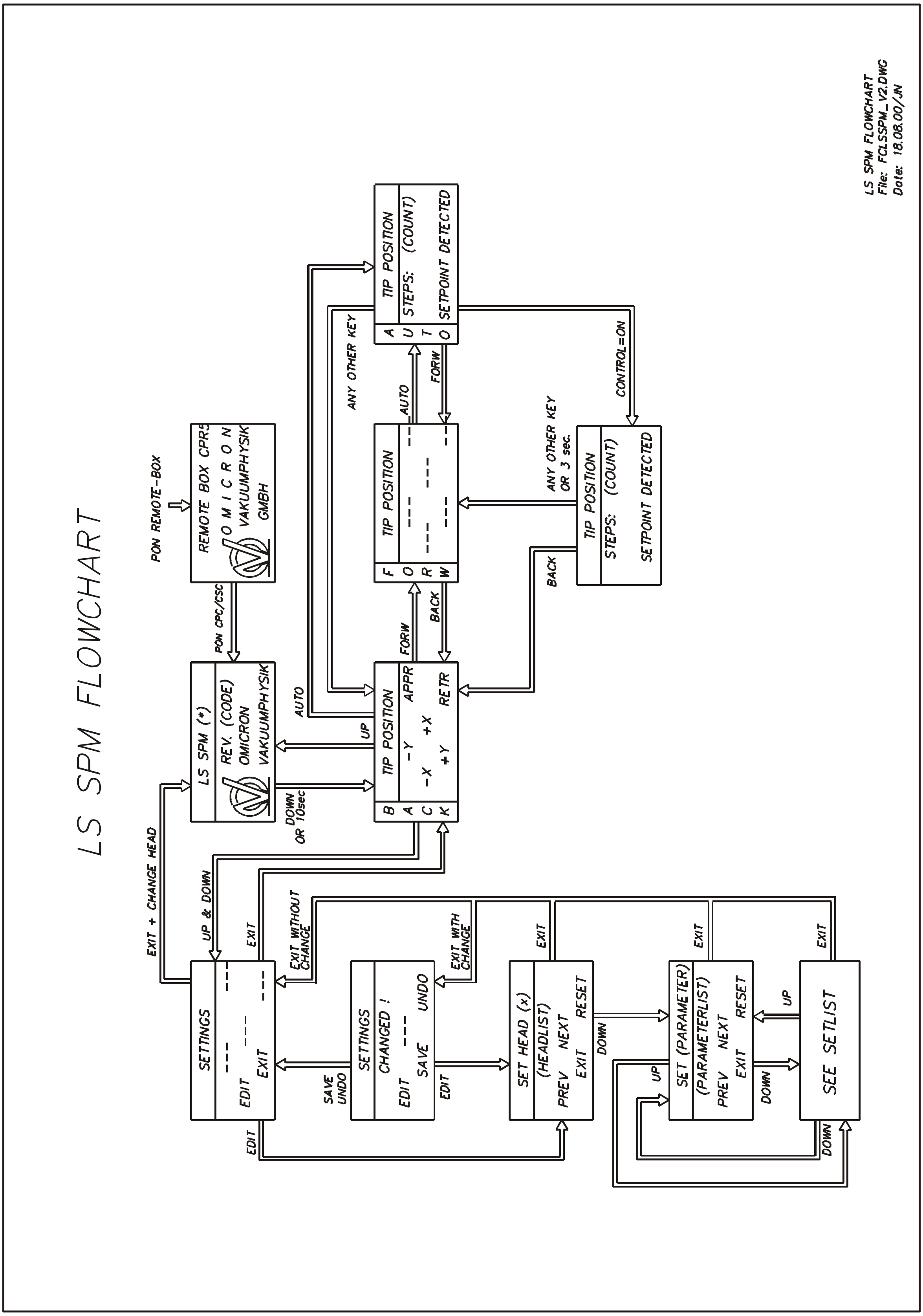
For AFM applications a number of additional menus become active to allow mirror positioning and parameter control for non-contact mode.

Use the UP and DOWN buttons in the BACKWARD menu to switch to the two mirror positioning menus, see flowchart. For detailed mirror positioning instructions please refer to the AFM User's Guide.

Setting	Values	Comment
HEAD	AFM/STM	
FREQUENCY	DIAL, 0.5 kHz, 1 kHz, 2 kHz, 3 kHz, 4 kHz.	"DIAL-Range" 50 Hz - 1 kHz
VOLTAGE	DIAL, 20%, 40%, 60%, 80%, 100%	"DIAL-Range" 20% - 100%
STEPS	1 to 10 in steps of 1; default = 2	
Z-DIRECTION	-, +	
DELAYTIME	0.6 sec to 2 sec in steps of 0.2 sec	
Menu	**Button(s)**	**Active Output(s)**
SAMPLE POS.	-X / +X	OUT1 & OUT2
	<- ROT / ROT ->	OUT1
	APPR / RETR	OUT3
MIRROR 1	LEFT / RIGHT	OUT5
	DOWN / UP	OUT6
	----	---
MIRROR 2	LEFT / RIGHT	OUT7
	DOWN / UP	OUT8
	---	---

Table 22. AFM/STM remote box settings, default values underlined.

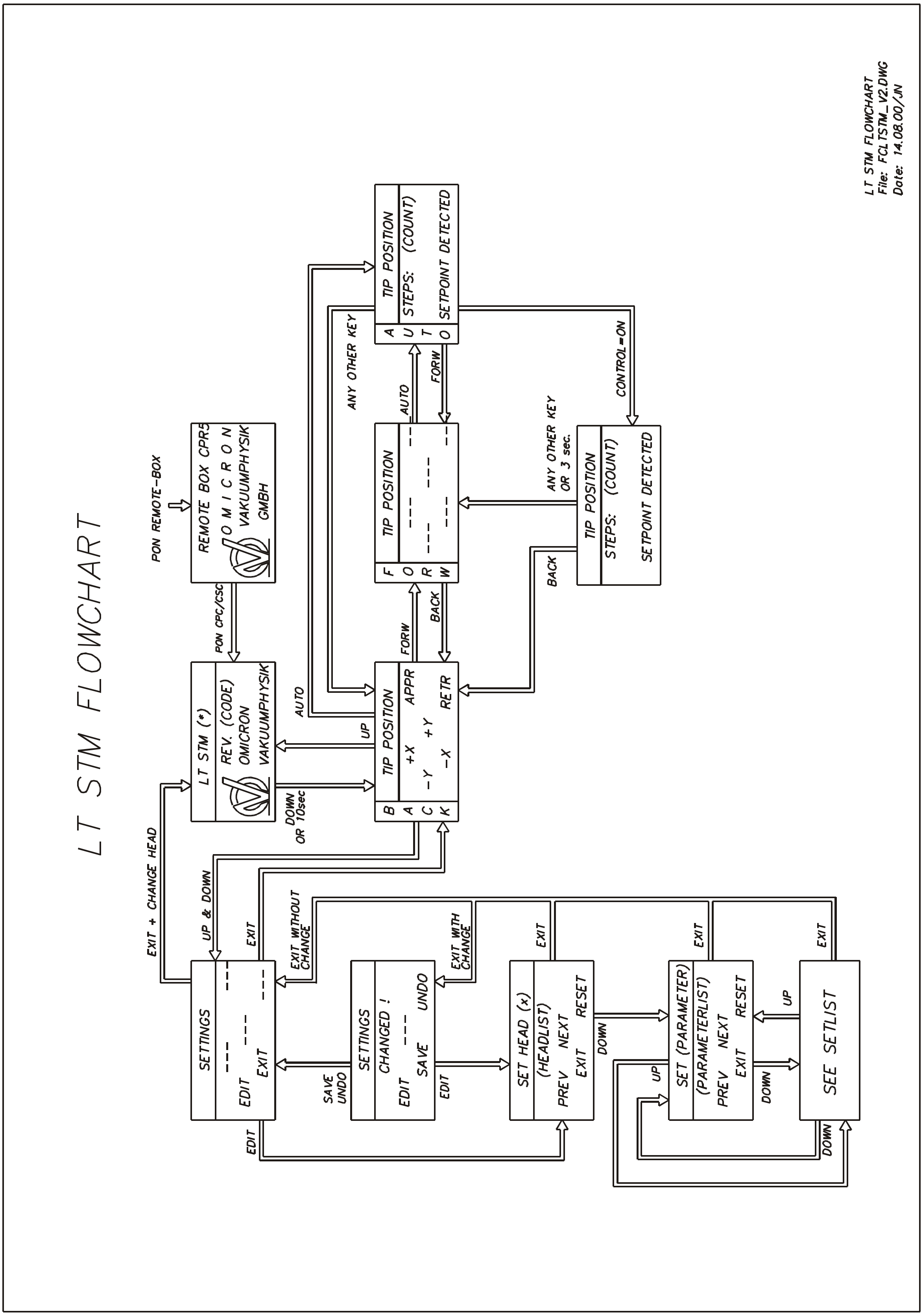
LS SPM


LS SPM FLOWCHART
LS SPM FLOWCHART
File: FCLSSPM_V2.DWG
Date: 18.08.00/JN
PON REMOTE-BOX
REMOTE BOX CPR5
O M I C R O N
VAKUUMPHYSIK
GMBH
PON CPC/CSC
LS SPM (*)
REV. (CODE)
OMICRON
VAKUUMPHYSIK
DOWN OR 10sec
UP
AUTO
TIP POSITION
-Y APPR
-X +X
+Y RETR
B A C K
FORW
BACK
F O R W
TIP POSITION
AUTO
FORW
A U T O
TIP POSITION
STEPS: (COUNT)
SETPOINT DETECTED
ANY OTHER KEY
CONTROL=ON
ANY OTHER KEY OR 3 sec.
BACK
TIP POSITION
STEPS: (COUNT)
SETPOINT DETECTED
EXIT + CHANGE HEAD
UP & DOWN
EXIT
EXIT WITHOUT CHANGE
SETTINGS
EDIT EXIT
SAVE UNDO
SETTINGS
CHANGED !
EDIT SAVE UNDO
EXIT WITH CHANGE
EDIT
SET HEAD (x)
(HEADLIST)
PREV NEXT
EXIT RESET
EXIT
DOWN
SET (PARAMETER)
(PARAMETERLIST)
PREV NEXT
EXIT RESET
UP
DOWN
SEE SETLIST
EXIT
UP
DOWN
EDIT

Setting	Values	Comment
HEAD	LS SPM	
FREQUENCY	DIAL, 0.5 kHz, 1 kHz, 2 kHz, 3 kHz, 4 kHz.	"DIAL-Range" 500 Hz - 4 kHz
VOLTAGE	DIAL, 20%, 40%, 60%, 80%, 100%	"DIAL-Range" 20% - 100%
STEPS	1 to 10 in steps of 1; default = 1	
Z-DIRECTION	-, +	
DELAYTIME	0.6 sec to 2 sec in steps of 0.2 sec	

Table 23. LS SPM settings, default values underlined.

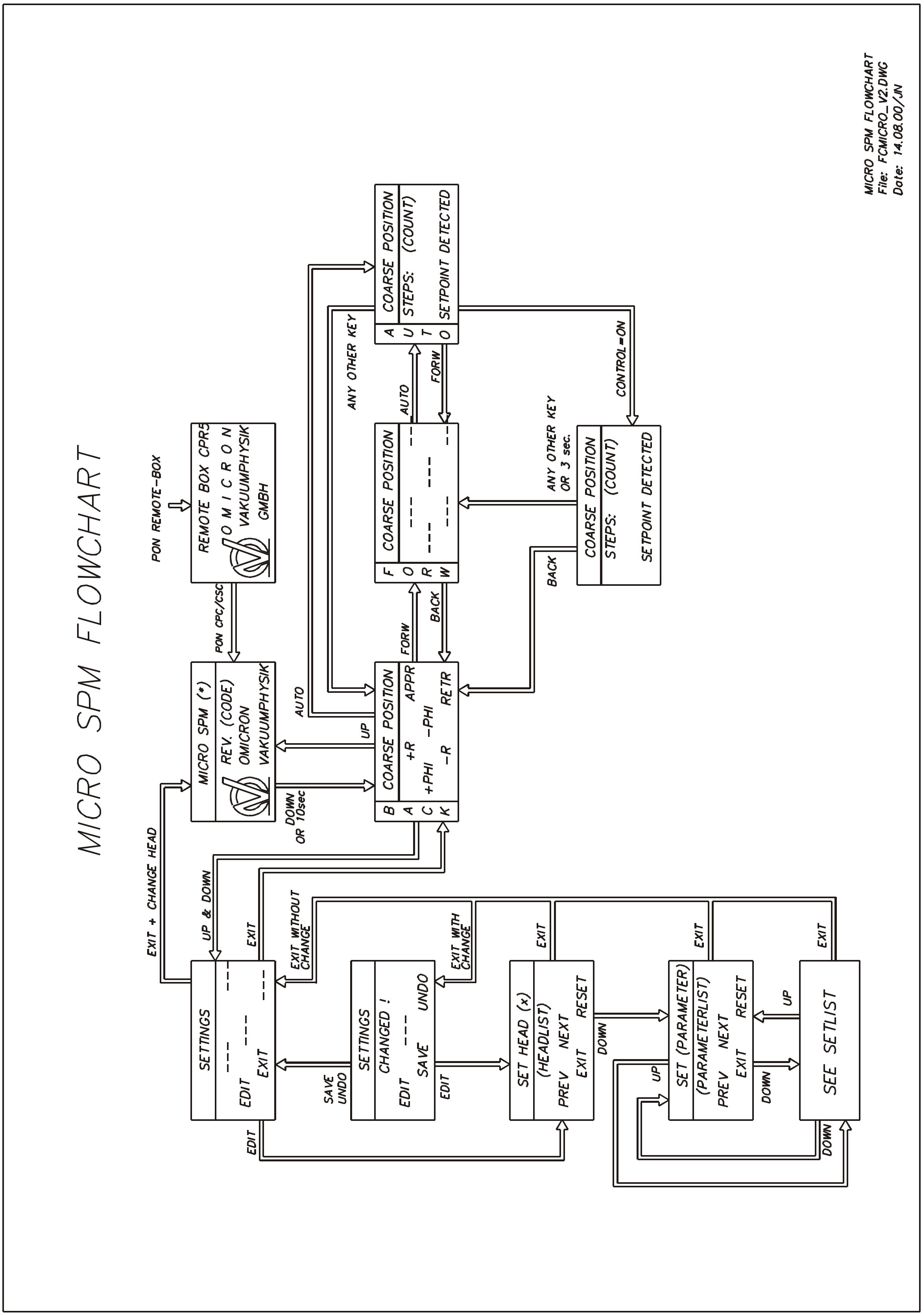
LT STM Configuration



Setting	Values	Comment
HEAD	LT STM	
FREQUENCY	DIAL, 0.5 kHz, 1 kHz, 2 kHz, 3 kHz, 4 kHz.	"DIAL-Range" 500 Hz - 4 kHz
VOLTAGE	DIAL, 20%, 40%, 60%, 80%, 100%	"DIAL-Range" 20% - 100%
STEPS	1 to 10 in steps of 1; default = 1	
Z-DIRECTION	-, +	
DELAYTIME	0.6 sec to 2 sec in steps of 0.2 sec	

Table 24. LT STM remote box settings, default values underlined.

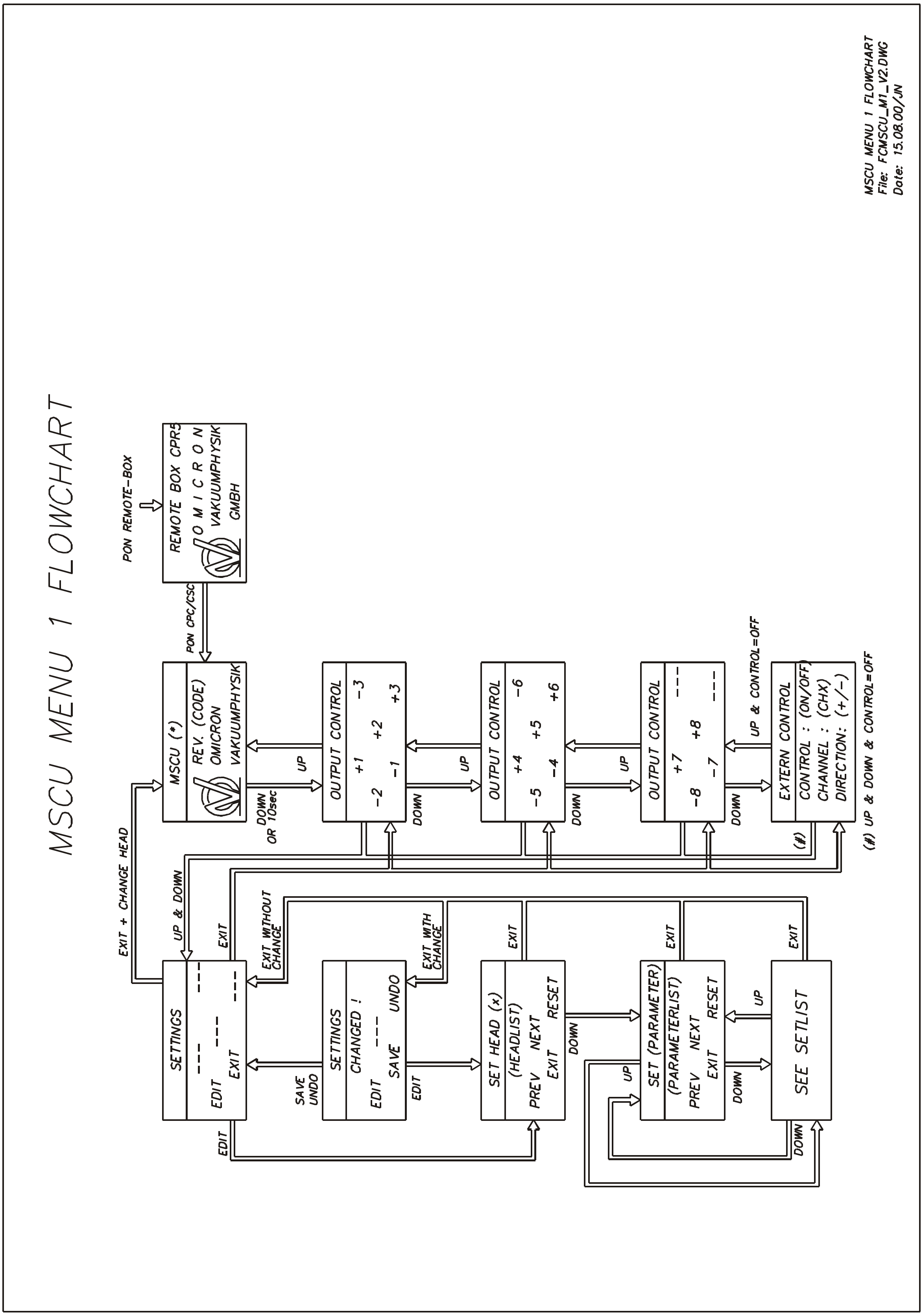
MICRO SPM Configuration



Setting	Values	Comment
HEAD	MICRO SPM	
FREQUENCY	DIAL, 0.5 kHz, 1 kHz, 2 kHz, 3 kHz, 4 kHz.	"DIAL-Range" 500 Hz - 4 kHz
VOLTAGE	DIAL, 20%, 40%, 60%, 80%, 100%	"DIAL-Range" 20% - 100%
STEPS	1 to 10 in steps of 1; default = 1	
Z-DIRECTION	-, +	
DELAYTIME	0.6 sec to 2 sec in steps of 0.2 sec	

Table 25. MICRO STM remote box settings, default values underlined.

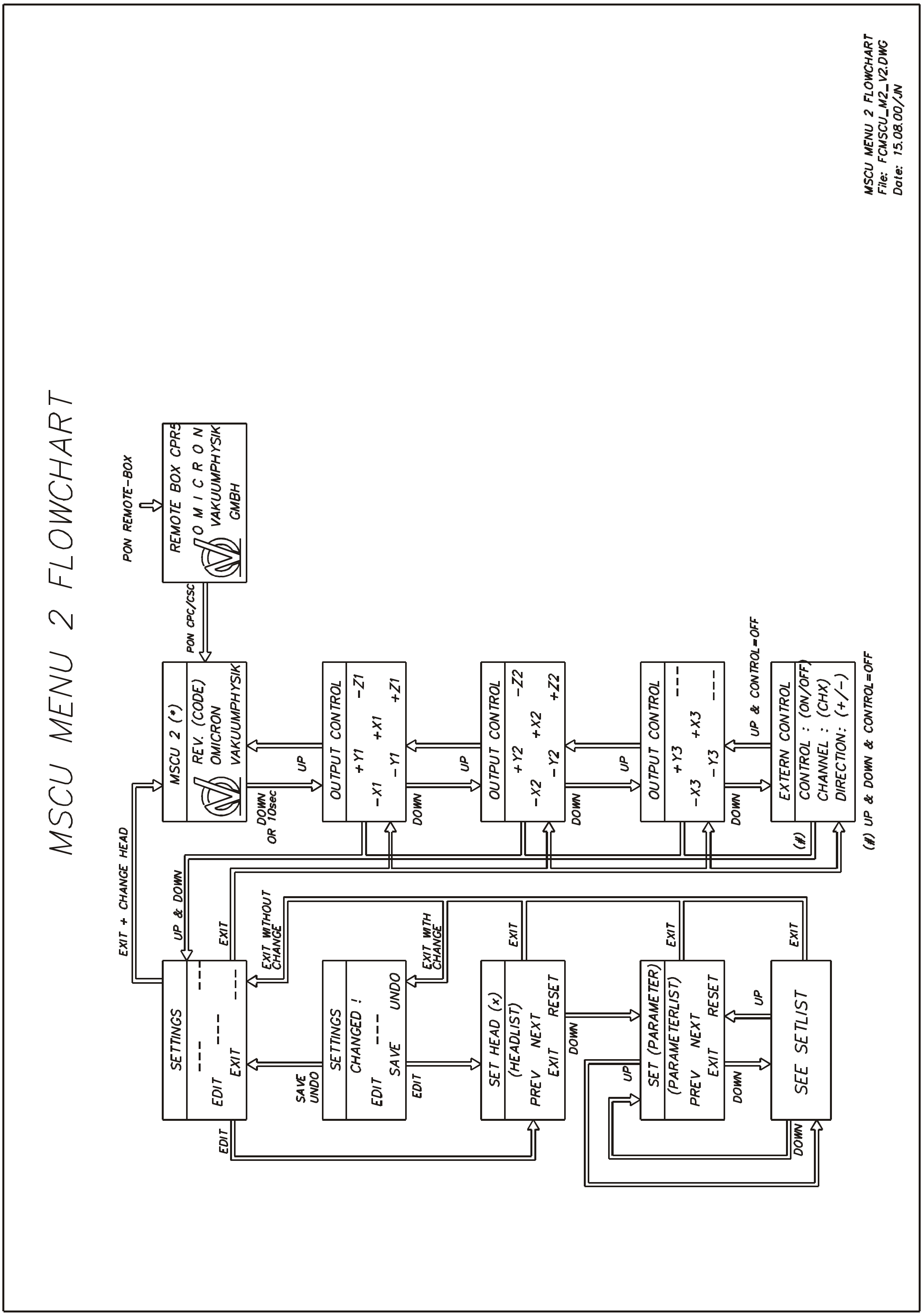
MSCU 1


MSCU MENU 1 FLOWCHART
MSCU MENU 1 FLOWCHART
File: FCMSCU_M1_V2.DWG
Date: 15.08.00/JN
PON REMOTE-BOX
REMOTE BOX CPR5
O M I C R O N
VAKUUMPHYSIK
GMBH
PON CPC/CSC
MSCU (*)
REV. (CODE)
OMICRON
VAKUUMPHYSIK
DOWN
OR 10sec
UP
OUTPUT CONTROL
+1 -3
-2 +2
-1 +3
OUTPUT CONTROL
+4 -6
-5 +5
-4 +6
OUTPUT CONTROL
+7 ---
-8 +8
-7 ---
UP & CONTROL=OFF
EXTERN CONTROL
CONTROL : (ON/OFF)
CHANNEL : (CHX)
DIRECTION : (+/-)
(#)
(#) UP & DOWN & CONTROL=OFF
EXIT + CHANGE HEAD
UP & DOWN
EXIT
EXIT WITHOUT CHANGE
EXIT WITH CHANGE
SETTINGS
--- --- ---
EDIT EXIT ---
SAVE
UNDO
SETTINGS
CHANGED !
EDIT --- UNDO
SAVE
EDIT
SET HEAD (x)
(HEADLIST)
PREV NEXT RESET
EXIT
SET (PARAMETER)
(PARAMETERLIST)
PREV NEXT RESET
EXIT
SEE SETLIST

Setting	Values	Comment
HEAD	MSCU1	
FREQUENCY	DIAL, 0.5 kHz, 1 kHz, 2 kHz, 3 kHz, 4 kHz.	"DIAL-Range" 500 Hz - 4 kHz
VOLTAGE	DIAL, 20%, 40%, 60%, 80%, 100%	"DIAL-Range" 20% - 100%
EXT. CHANNEL	CH1; CH2; ..., CH8	Out1, Out2, ..., Out8
EXT. DIRECTION	-, +	
DELAYTIME	0.6 sec to 2 sec in steps of 0.2 sec	
Menu	**Button(s)**	**Active Output(s)**
OUTPUT CONTROL MSCU1	-CH1 / +CH1	OUT1
	-CH2 / +CH2	OUT2
	-CH3 / +CH3	OUT3
	-CH4 / +CH4	OUT4
	-CH5 / +CH5	OUT5
	-CH6 / +CH6	OUT6
	-CH7 / +CH7	OUT7
	-CH8 / +CH8	OUT8

Table 26. MSCU 1 remote box settings, default values underlined.

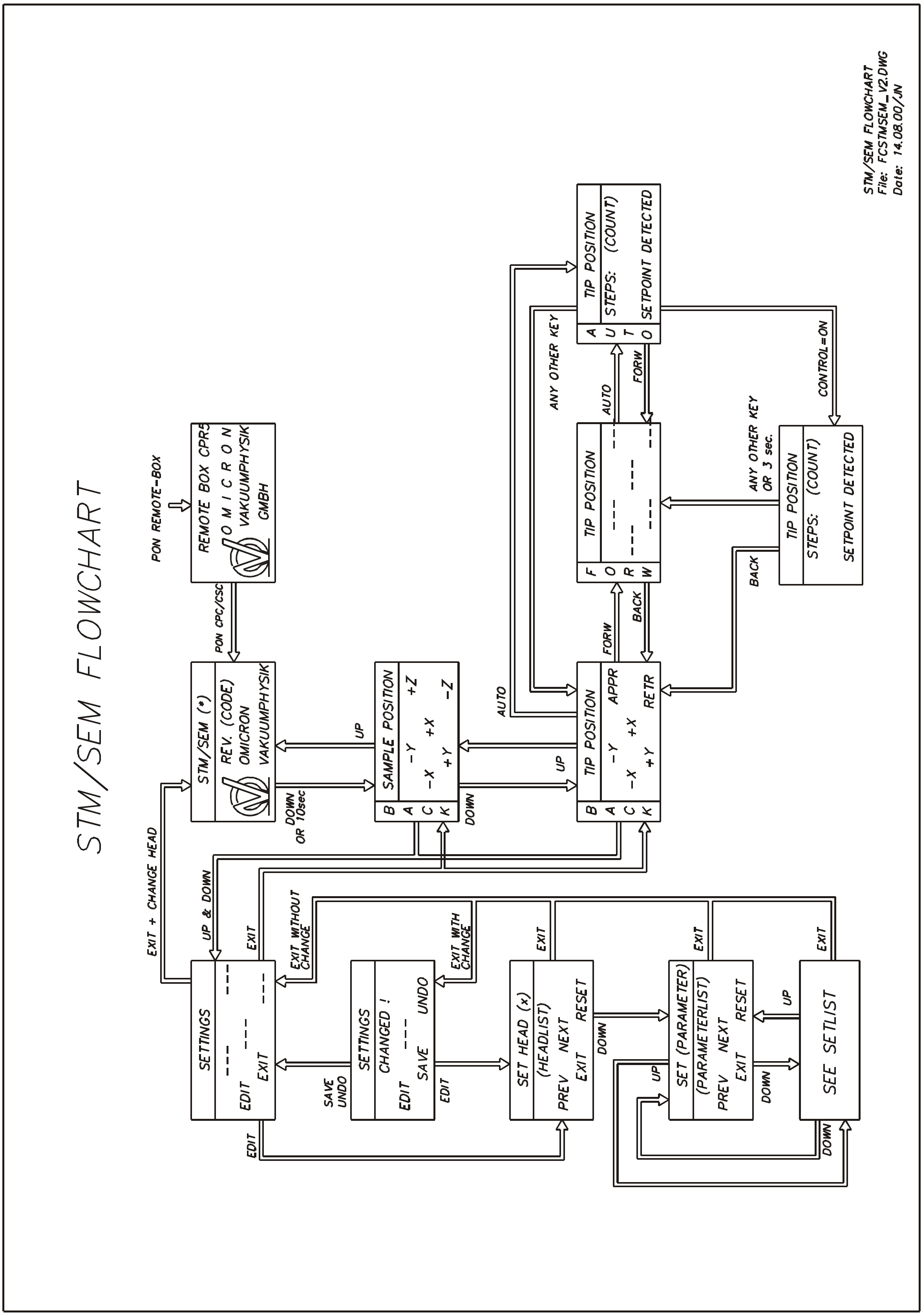
MSCU 2


MSCU MENU 2 FLOWCHART
MSCU MENU 2 FLOWCHART
File: FCMSCU_M2_V2.DWG
Date: 15.08.00/JN
PON REMOTE-BOX
REMOTE BOX CPR5
O M I C R O N
VAKUUMPHYSIK
GMBH
PON CPC/CSC
MSCU 2 (*)
REV. (CODE)
OMICRON
VAKUUMPHYSIK
DOWN OR 10sec
UP
OUTPUT CONTROL
+Y1 -Z1
-X1 +X1
-Y1 +Z1
DOWN
OUTPUT CONTROL
+Y2 -Z2
-X2 +X2
-Y2 +Z2
OUTPUT CONTROL
+Y3 ---
-X3 +X3
-Y3 ---
UP & CONTROL=OFF
EXTERN CONTROL
CONTROL : (ON/OFF)
CHANNEL : (CHX)
DIRECTION: (+/-)
(#)
(#) UP & DOWN & CONTROL=OFF
EXIT + CHANGE HEAD
UP & DOWN
EXIT
EXIT WITHOUT CHANGE
EXIT WITH CHANGE
SETTINGS
--- ---
EDIT --- ---
EXIT
SETTINGS
CHANGED !
EDIT --- UNDO
SAVE
SAVE UNDO
EDIT
SET HEAD (x)
(HEADLIST)
PREV NEXT
EXIT RESET
SET (PARAMETER)
(PARAMETERLIST)
PREV NEXT
EXIT RESET
SEE SETLIST

Setting	Values	Comment
HEAD	MSCU2	
FREQUENCY	DIAL, 0.5 kHz, 1 kHz, 2 kHz, 3 kHz, 4 kHz.	"DIAL-Range" 500 Hz - 4 kHz
VOLTAGE	DIAL, 20%, 40%, 60%, 80%, 100%	"DIAL-Range" 20% - 100%
EXT. CHANNEL	CH1; CH2; ..., CH8	Out1, Out2, ..., Out8
EXT. DIRECTION	-, +	
DELAYTIME	0.6 sec to 2 sec in steps of 0.2 sec	
Menu	**Button(s)**	**Active Output(s)**
OUTPUT CONTROL MSCU2	-X1/+X1	OUT2
	-Y1/+Y1	OUT1
	-Z1/+Z1	OUT3
	-X2/+X2	OUT5
	-Y2/+Y2	OUT4
	-Z2/+Z2	OUT6
	-X3/+X3	OUT8
	-Y3/+Y3	OUT7

Table 27. MSCU 2 remote box settings, default values underlined

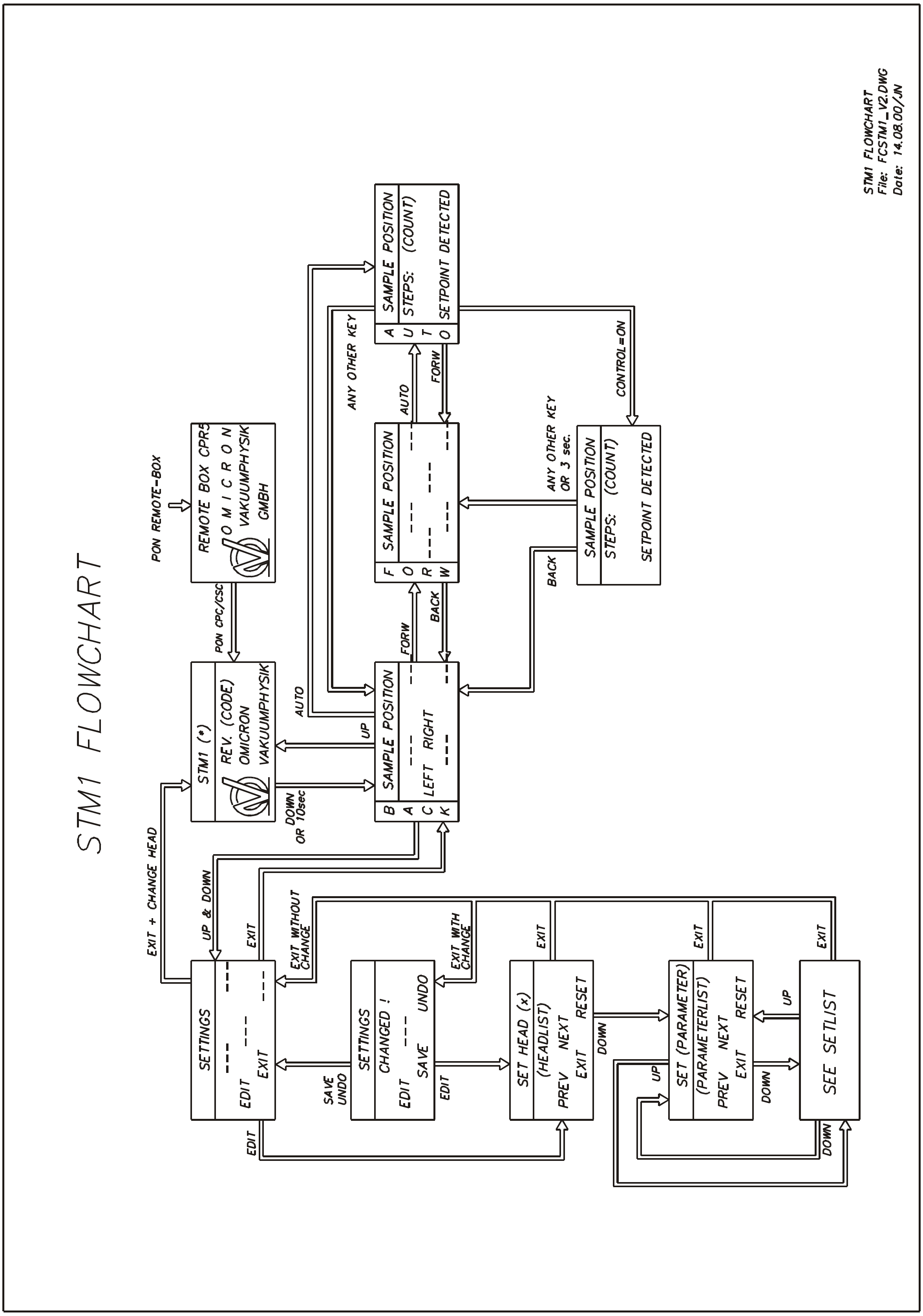
STM/SEM Configuration



Setting	Values	Comment
HEAD	STM/SEM	
FREQUENCY	DIAL, 0.5 kHz, 1 kHz, 2 kHz, 3 kHz, 4 kHz.	"DIAL-Range" 500 Hz - 4 kHz
VOLTAGE	DIAL, 20%, 40%, 60%, 80%, 100%	"DIAL-Range" 20% - 100%
STEPS	1 to 10 in steps of 1; default = 1	
Z-DIRECTION	-, +	
DELAYTIME	0.6 sec to 2 sec in steps of 0.2 sec	

Table 28. STM/SEM remote box settings, default values underlined.

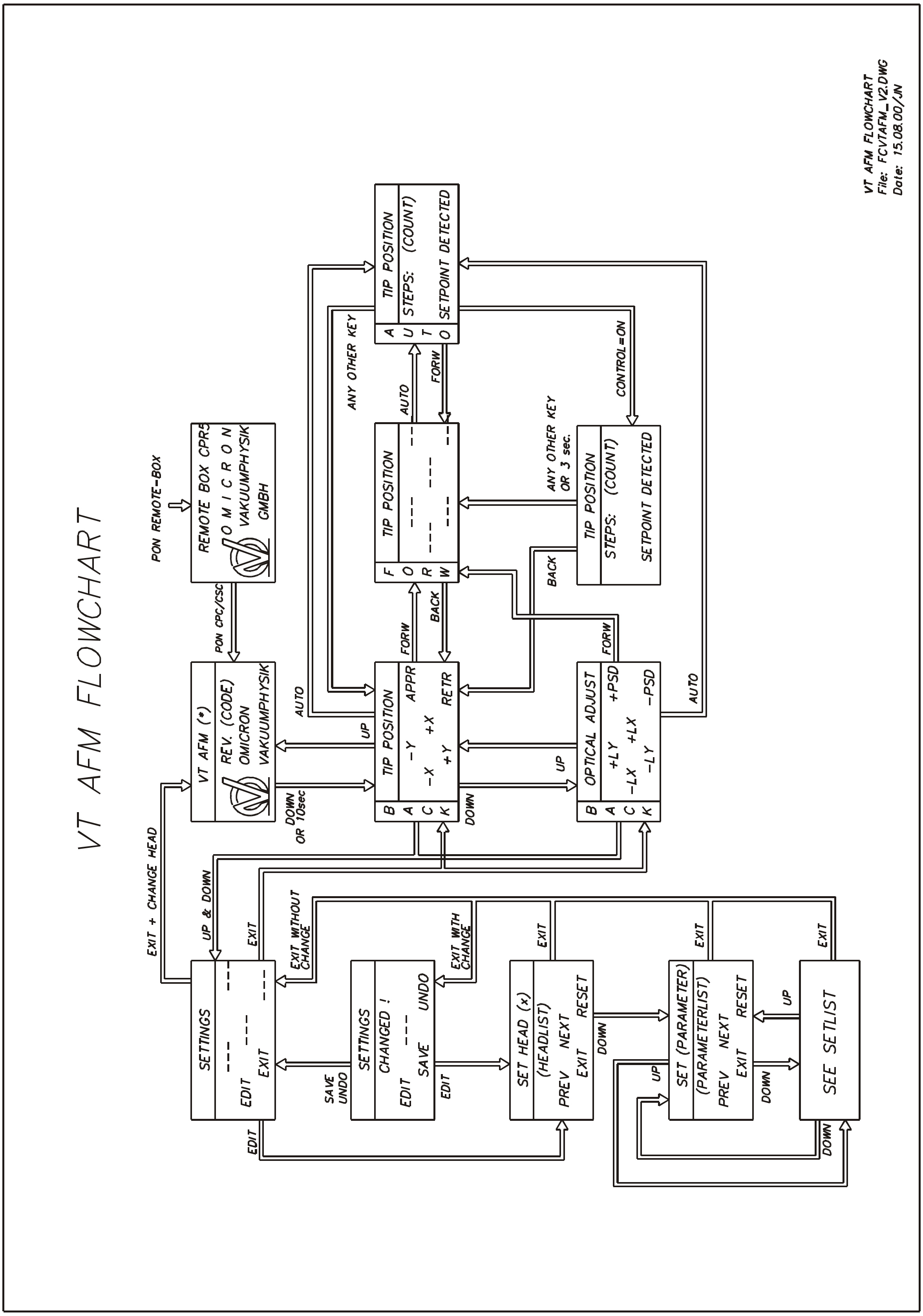
STM 1 Configuration



Setting	Values	Comment
HEAD	STM 1	
FREQUENCY	DIAL, 0.5 kHz, 1 kHz, 2 kHz, 3 kHz, 4 kHz.	"DIAL-Range" 500 Hz - 4 kHz
VOLTAGE	DIAL, 20%, 40%, 60%, 80%, 100%	"DIAL-Range" 20% - 100%
STEPS	1 to 10 in steps of 1; default = 1	
Z-DIRECTION	-, +	
DELAYTIME	0.6 sec to 2 sec in steps of 0.2 sec	

Table 29. STM 1 remote box settings, default values underlined.

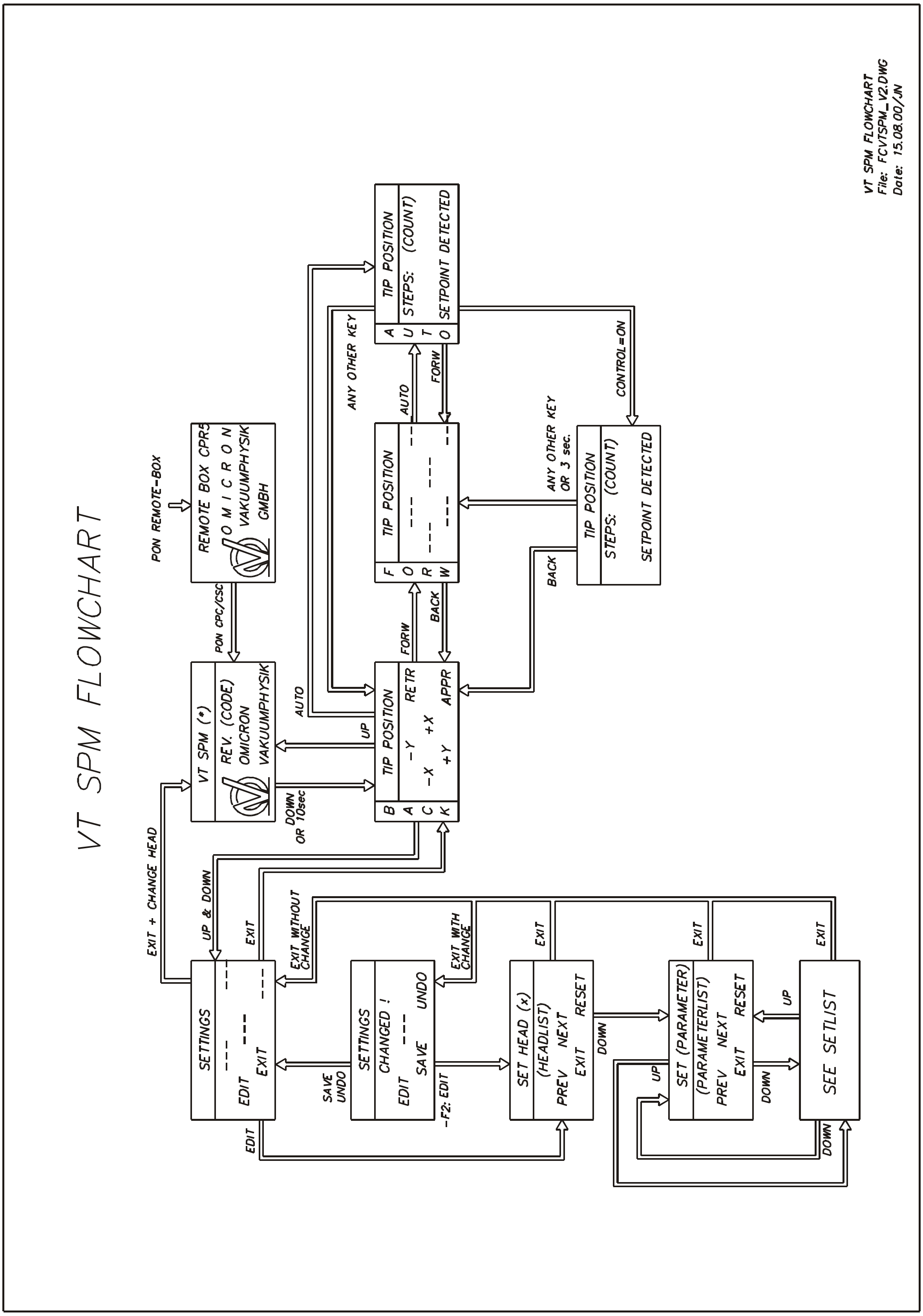
VT AFM


VT AFM FLOWCHART
VT AFM FLOWCHART
File: FCVTAFM_V2.DWG
Date: 15.08.00/JN
PON REMOTE-BOX
REMOTE BOX CPR5
O M I C R O N
VAKUUMPHYSIK
GMBH
PON CPC/CSC
VT AFM (*)
REV. (CODE)
OMICRON
VAKUUMPHYSIK
TIP POSITION
APPR
RETR
-Y +X
-X +Y
AUTO
UP
DOWN OR 10sec
DOWN
FORW
BACK
AUTO
FORW
ANY OTHER KEY
STEPS: (COUNT)
SETPOINT DETECTED
ANY OTHER KEY OR 3 sec.
CONTROL=ON
BACK
OPTICAL ADJUST
+LY +PSD
-LX +LX
-LY -PSD
AUTO
EXIT + CHANGE HEAD
UP & DOWN
EXIT
EXIT WITHOUT CHANGE
EXIT WITH CHANGE
SETTINGS
EDIT
SAVE UNDO
SETTINGS CHANGED !
SAVE
UNDO
SET HEAD (x)
(HEADLIST)
PREV NEXT
EXIT RESET
SET (PARAMETER)
(PARAMETERLIST)
SEE SETLIST

Setting	Values	Comment
HEAD	VT SPM	
FREQUENCY	DIAL, 0.5 kHz, 1 kHz, 2 kHz, 3 kHz, 4 kHz.	"DIAL-Range" 500 Hz - 4 kHz
VOLTAGE	DIAL, 20%, 40%, 60%, 80%, 100%	"DIAL-Range" 20% - 100%
STEPS	1 to 10 in steps of 1; default = 1	
Z-DIRECTION	-, +	
DELAYTIME	0.6 sec to 2 sec in steps of 0.2 sec	
Menu	**Button(s)**	**Active Output(s)**
TIP POS	-X / +X	OUT1
	-Y / +Y	OUT2
	APPR / RETR	OUT3
OPT.ADS	-LX / +LX	OUT5
	+LY / -LY	OUT6
	+PSD / -PSD	OUT7

Table 30. VT AFM remote box settings, default values underlined.

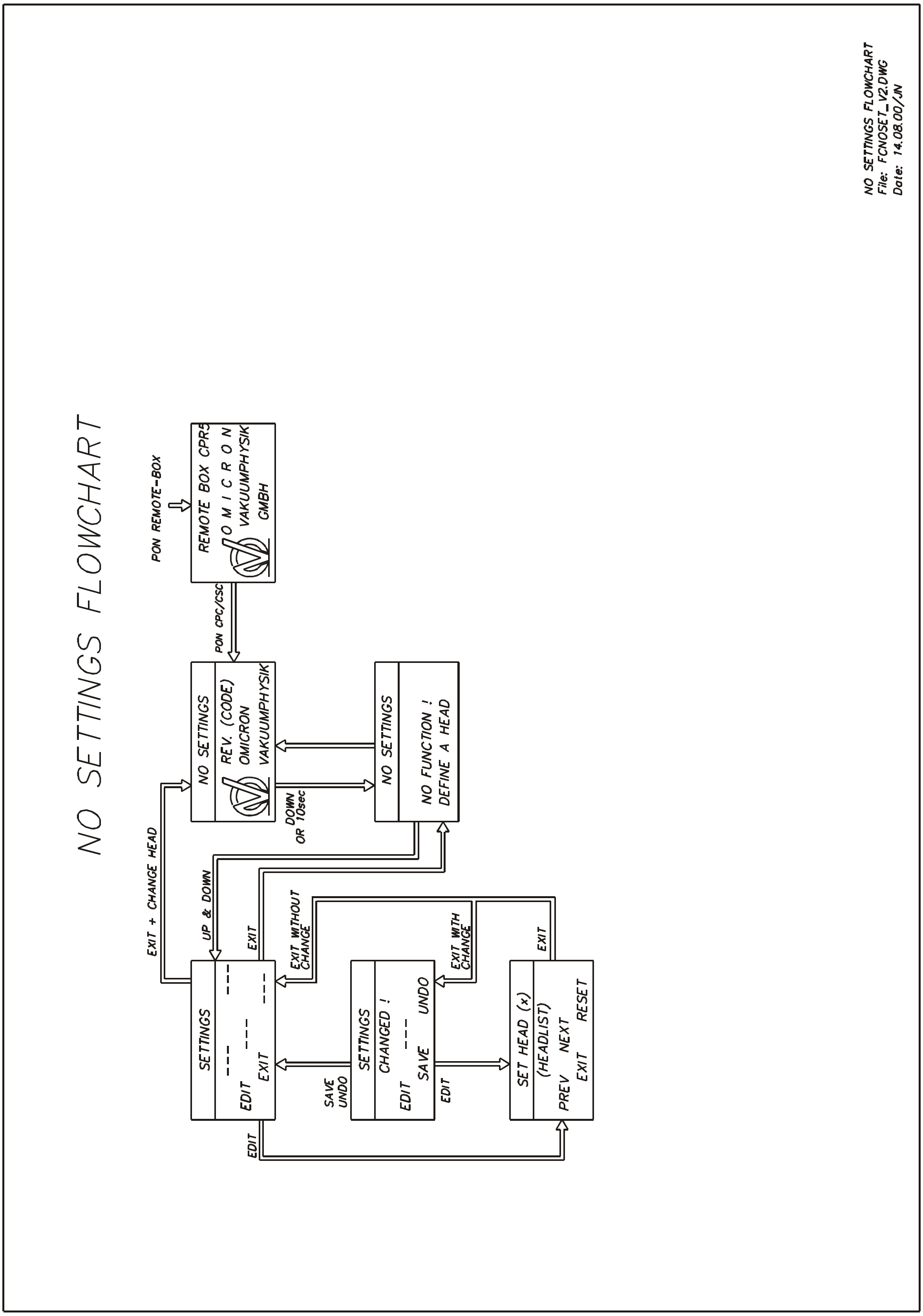
VT STM/SPM Configuration



Setting	Values	Comment
HEAD	VT SPM	
FREQUENCY	DIAL, 0.5 kHz, 1 kHz, 2 kHz, 3 kHz, 4 kHz.	"DIAL-Range" 500 Hz - 4 kHz
VOLTAGE	DIAL, 20%, 40%, 60%, 80%, 100%	"DIAL-Range" 20% - 100%
STEPS	1 to 10 in steps of 1; default = 1	
Z-DIRECTION	-, +	
DELAYTIME	0.6 sec to 2 sec in steps of 0.2 sec	

Table 31. VT STM/SPM remote box settings, default values underlined.

NO SETTINGS Configuration



15. Appendix

OMICRON Scanners

The following table gives an overview of some of the OMICRON scanners. All scanners except the TS1 (STM 1 standard scanner) have symmetric voltages in X and Y directions. The TS1 has positive or negative voltage with respect to ground.

> **Please note.** The scanners have been calibrated for atomic resolution dimensions. When scanning large areas (i.e. in the µm range) the displayed distance values are **smaller** than the physical lengths. A new calibration may be necessary for measuring accurate long-distance values. The positioning ranges with long distance calibrations are about 1.6 times the values given in table below.

scanner type	X, Y sensitivity	X, Y pos. range	Z sensitivity	Z pos. range
single supply	**maximum voltage between electrodes = 135 V**			
TS 1	5 nm/V	1.35 µm	5 nm/V	1.1 µm
symmetric supply	**maximum voltage between x-y electrodes = 270 V**			
TS 2	5 nm/V	2.7 µm	5 nm/V	1.1 µm
UHV AFM/STM	10 nm/V	5.4 µm	10 nm/V	2.2 µm
VT STM	33 nm/V	17.8 µm	9.0 nm/V	2 µm
VT AFM	15 nm/V	8.1 µm	8.3 nm/V	1.8 µm
LS STM	33 nm/V	17.8 µm	9.0 nm/V	2 µm
LS AFM	15 nm/V	8.1 µm	8.3 nm/V	1.8 µm
LT STM (300 K)	20 nm/V	10.8 µm	6.7 nm/V	1.5 µm
Multiscan STM	43 nm/V	5.2 µm	4 nm/V	1.1 µm
Nanoprobe*	5.1 nm/V	2.8 µm	9.8 nm/V	2.6 µm

Table 32. OMICRON scanners: overview. X, Y positioning range is twice the maximum voltage between the electrodes times the respective X, Y sensitivity. Please note that the above listing may not be complete at the time of delivery. *) Currently not supported by MATRIX.

Maximum Power Consumption

The power input varies for the related unit, see table below.

AFM CU:	80 VA
MATRIX CU:	250 VA
HC 1100	100 VA

Table 33. Power Consumption of the various control units.

Inputs and Outputs

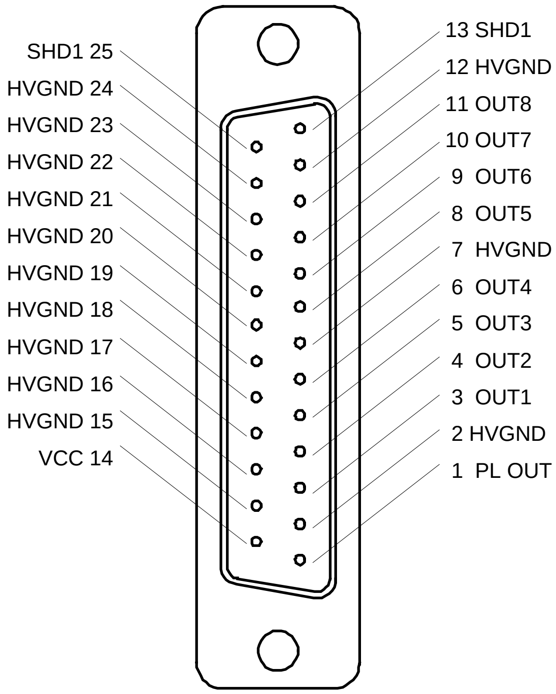
For input and output signals the following limits are generally valid: function guaranteed for voltages between ±10 V, circuit destruction for voltages below -15 V and above +15 V.

board	socket name	signal name	signal type	typ. limits
Input Stage	Σ IN	total intensity	input from preamp	0 to 13 V
Input Stage	FN IN	normal force	input from preamp	±13 V
Input Stage	FL OUT	lateral force (offset adjusted)	output to TwinAD	±13 V
Input Stage	FL IN	lateral force	input from preamp	±13 V
Compare Board	Δ FN OUT	normal force / frequency shift)*	output to regulator	±13 V
Compare Board	FN SETP IN	external force setpoint	user input	±13 V
Compare Board	F/F0	force / force setpoint monitor	output to ADC	±13 V
Light Source Control	LIGHT SOURCE OUT	light source control	output to LED	0 to 190 mA
Digital Board	AFM STATUS PORT	AFM status port	monitor output digital signals	TTL
Excite Board	EXCITE	cantilever excitation	output to AFM	±13 V
Excite Board	COUNT	cantilever frequency	output to OCB or external frequency counter	TTL
Excite Board	DAMP	cantilever damping	monitor output	±13 V
FM Demodulator	Δf OUT	frequency shift	monitor output	±13 V
FM Demodulator	Δf EXT	external frequency shift setpoint	user input	±10 V
FM Demodulator	f OUT	cantilever oscillation	monitor output	±13 V
FM Demodulator	f REF IN	reference frequency	input from OCB	480 kHz to 1.4 MHz; ≈ 3 Vpp

Table 34: BNC connectors available on the AFM CU back panel.)* Non-contact mode only.

Coarse Cable Adaptation

For non-OMICRON SPM heads MATRIX customers need to manufacture their own coarse cable. This section supplies some additional information on the signals provided by the Coarse Positioning Board.



COARSE PIN Layout

Figure 88. Coarse socket pin layout. For signal-channel reference please refer to the remote box settings tables.

Attention. This socket requires a HV proof sub-D plug!

Instrument	Menu	Direction	Signal Form	Direction	Signal Form
AFM/STM	SAMPLE	-X	A	+X	B
		<- ROT	B	ROT ->	A
		APPR	A	RETR	B
AFM	MIRROR 1	M1 LEFT	A	M1 RIGHT	B
		M1 DOWN	B	M1 UP	A
AFM	MIRROR 2	M2 LEFT	B	M2 RIGHT	A
		M2 DOWN	A	M2 UP	B
VT AFM	OPTICAL ADJUST	-LX	B	+LX	A
		-LY	B	+LY	A
		-PSD	B	+PSD	A
MICRO SPM	TIP POSITION	-R	B	+R	A
		-PHI	A	+PHI	B
		APPR	A	RETR	B
OTHERS)*		-X	B	+X	A
		-Y	A	+Y	B
		APPR (-Z)	A	RETR (+Z)	B

Table 35. Signal forms employed for the different OMICRON SPMs. For signal forms "A" and "B" please see figure 89.

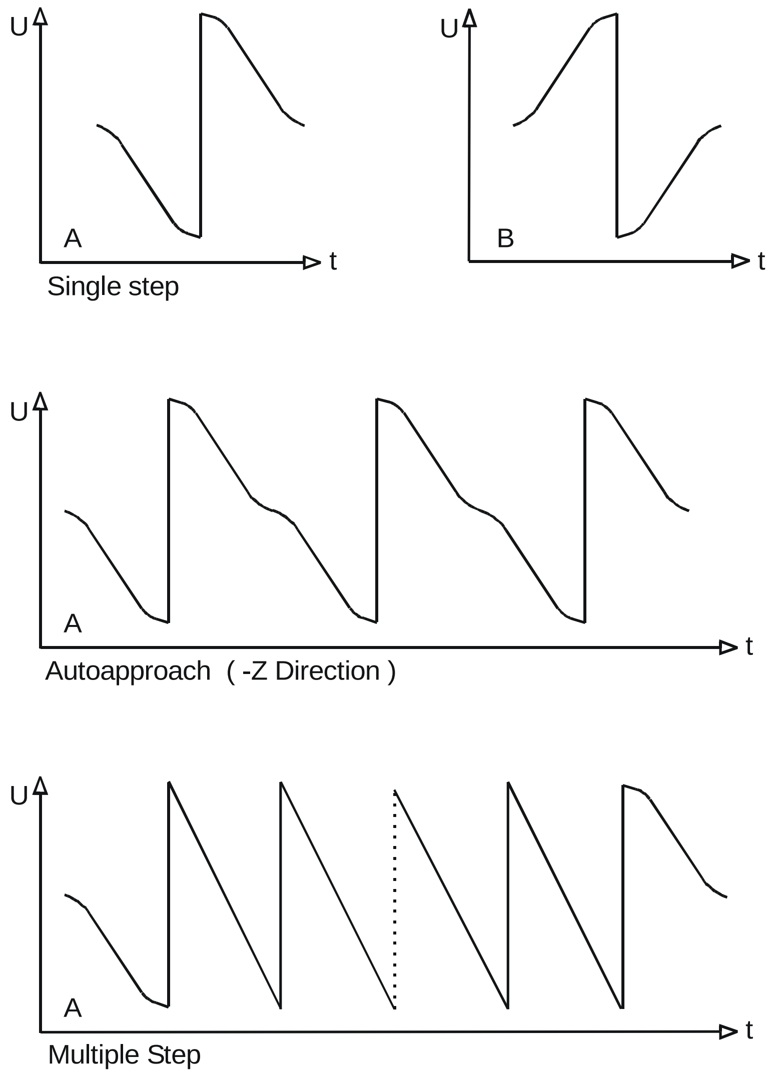
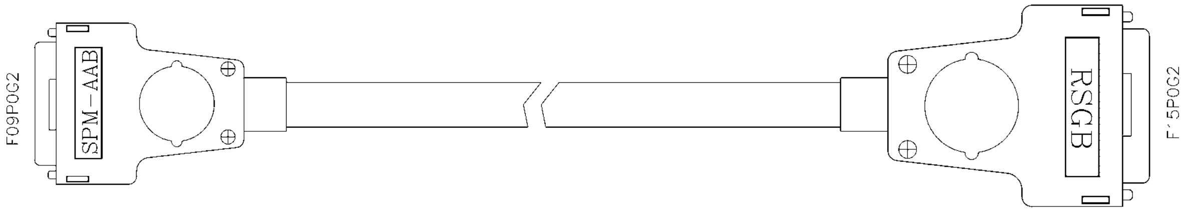


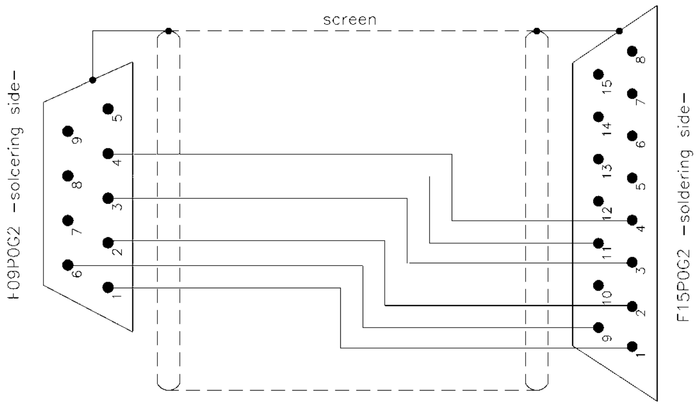
Figure 89. Signal forms of the coarse output channels OUT1 to OUT8.

Please note. Signal forms A and B are used for different directions in the various OMICRON scanning probe microscopes, see table 35. The AUTOAPPROACH procedure is a series of single steps, whereas holding down the button generates a sawtooth voltage.

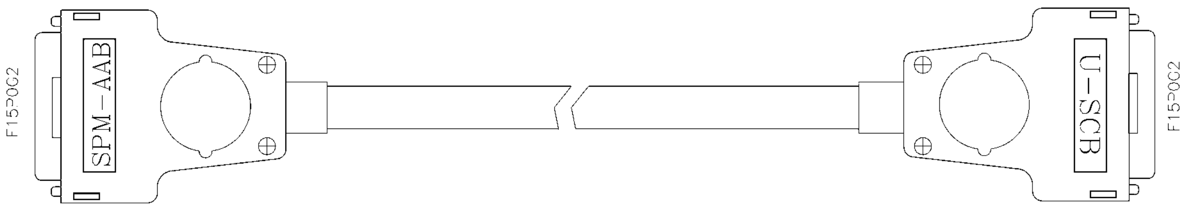
MATRIX Cables

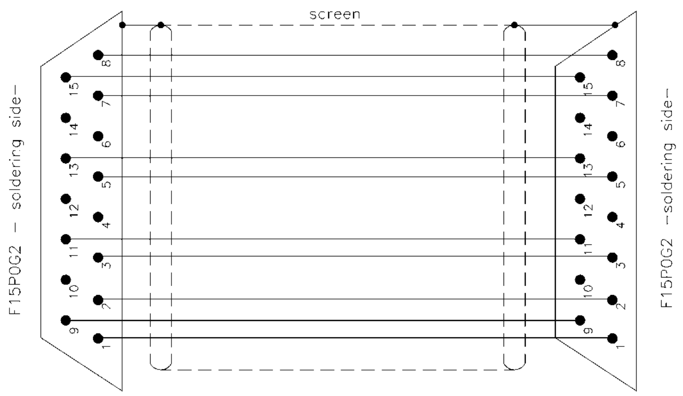
Cable SPM-AAB <-> RSGB



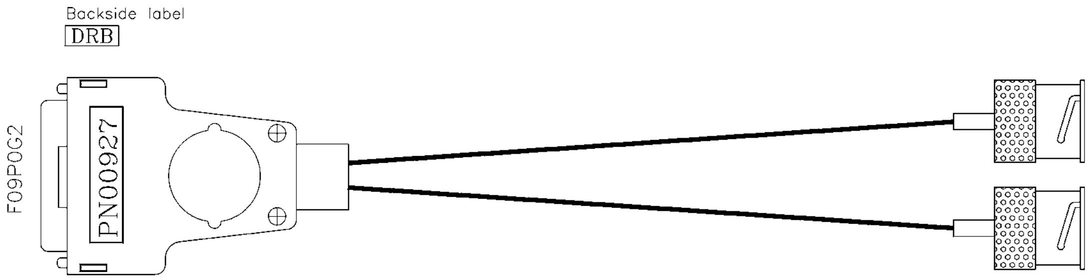


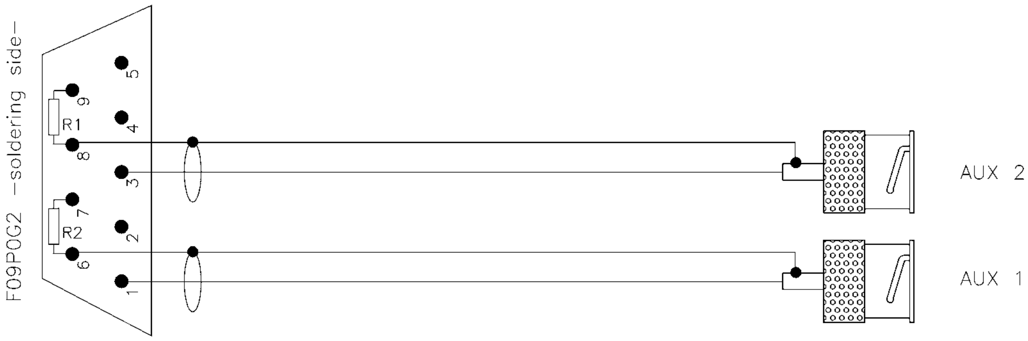
Cable SPM-AAB <-> U-SCB



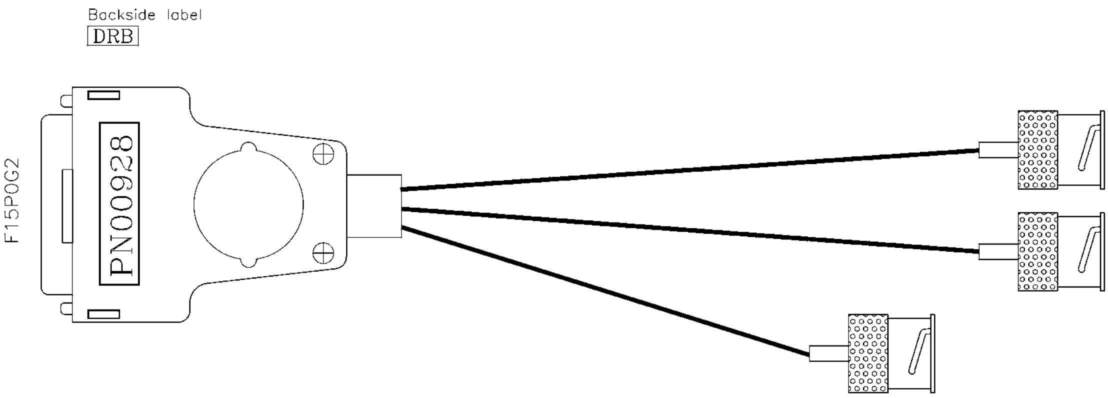


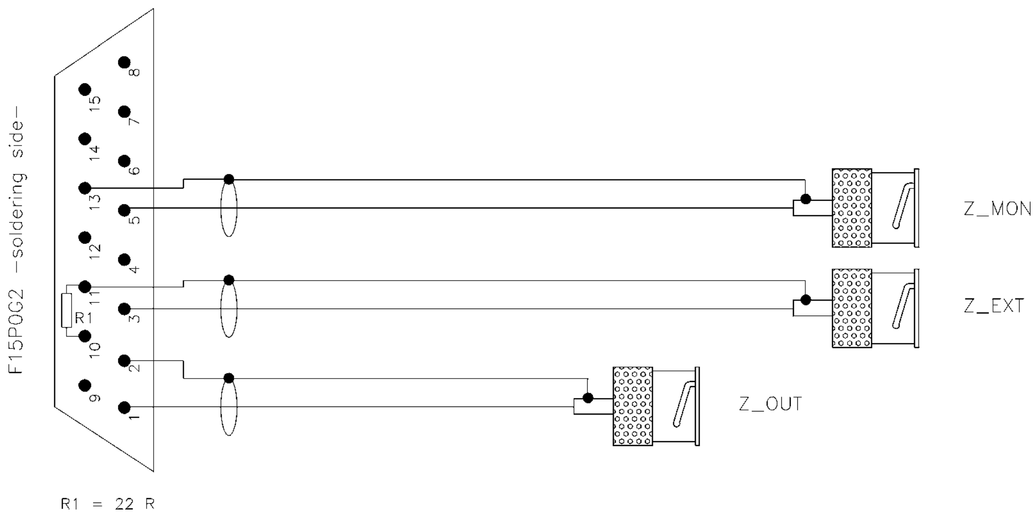
Cable AUX



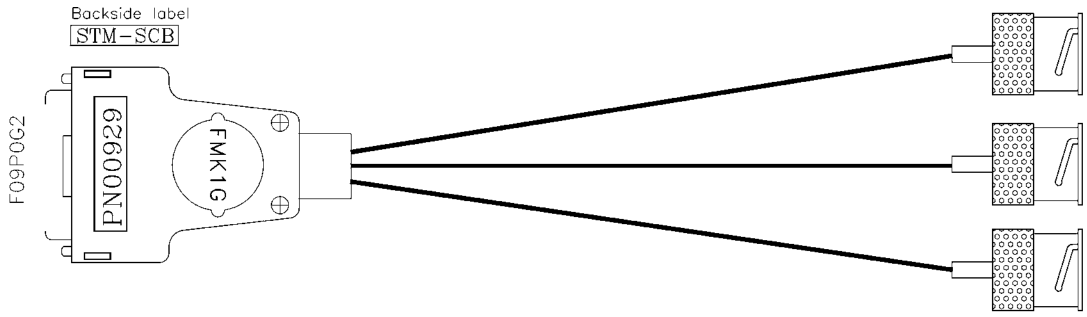


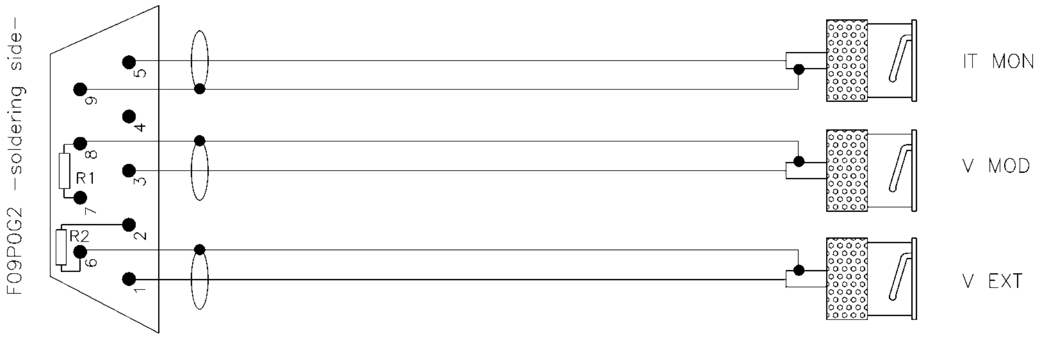
Cable Z-Sig





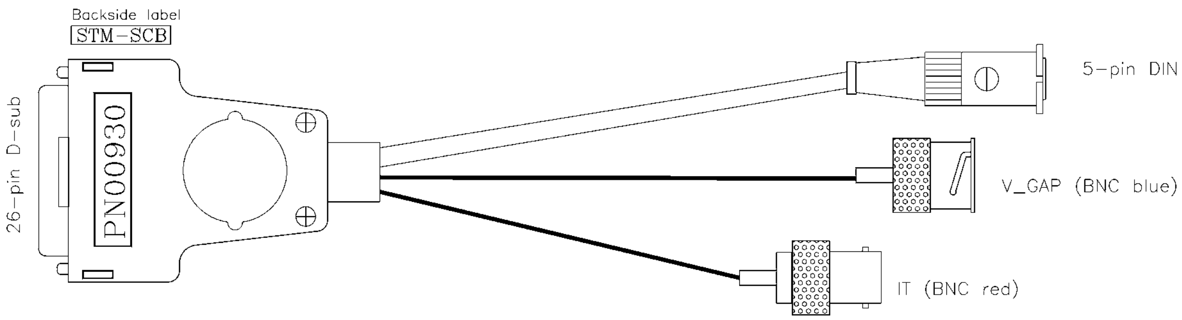
Cable EXT/MOD

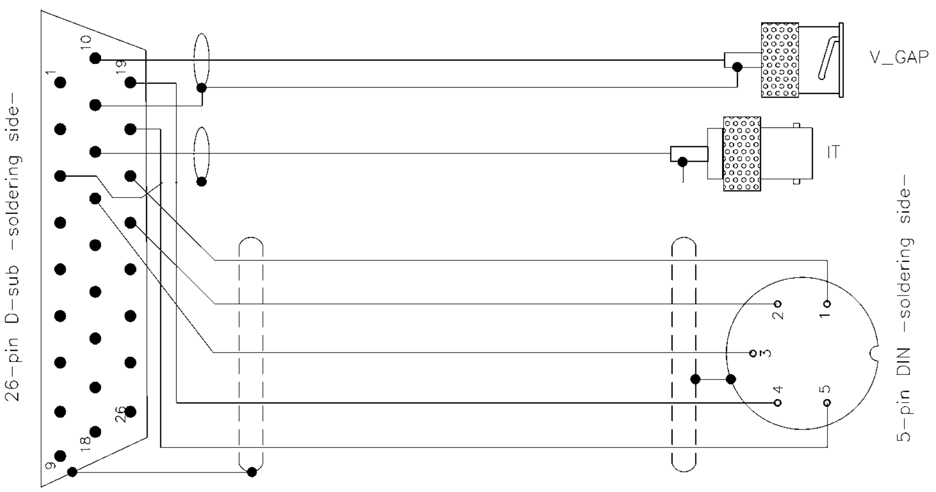




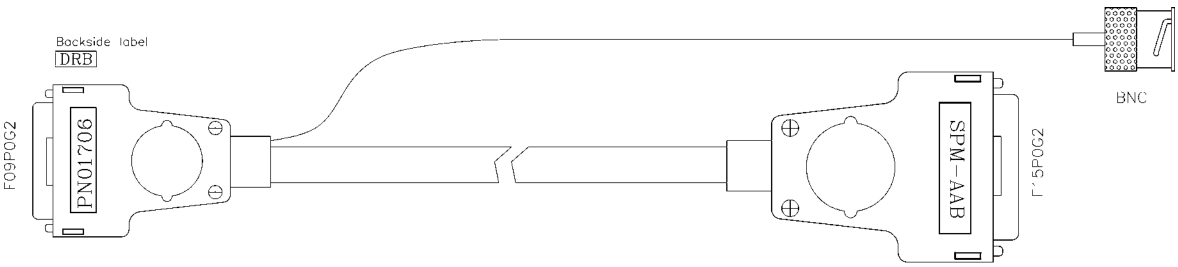
R1, R2 = 22 R

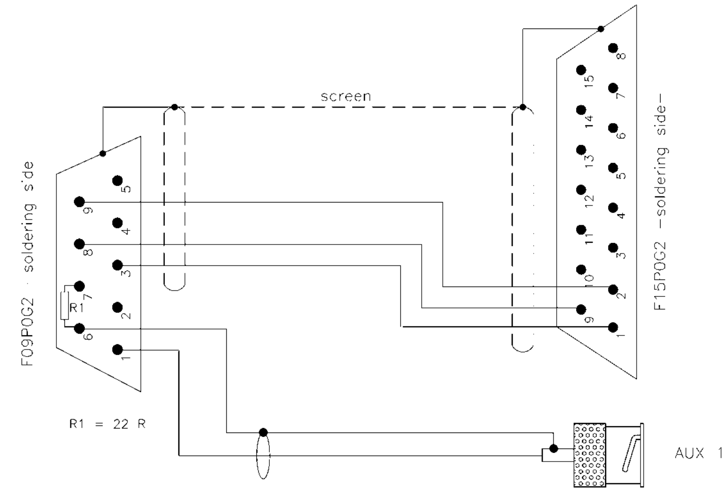
Cable PREAMP



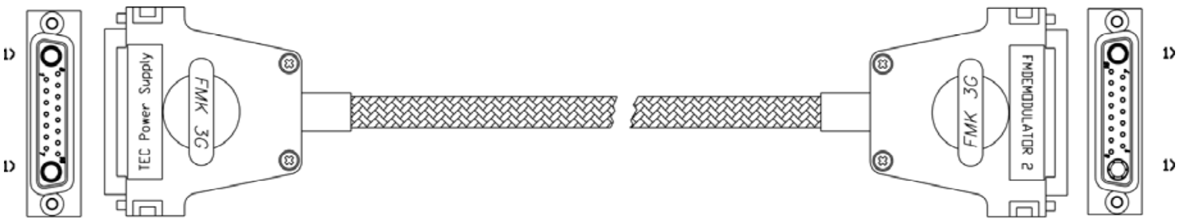


Cable NEEDLE





Cable TEC_FMDEMO2



TEC-Power contact no.	FMDEMO2 contact no.	Signal-name	Colour	Cross sect.
5	3	RPGND	---	0.25 qmm
6	4	RELAIS	---	0.25 qmm
1	7	IN- (RGND)	---	0.25 qmm
9	8	RGND	---	0.25 qmm
11	12	+15V	---	0.25 qmm
10	13	-15V	---	0.25 qmm
2	14	IN+	---	0.25 qmm
A1	A1	TEC-Amp-Out	brown	1.5 qmm
A2	A2	TEC-Amp-GND	black	1.5 qmm

Bus Pin Layouts AFM Box ACB / EIB

Bus Pin Layout: External Interface Bus (EIB)

EIB Pin	Analogue Bus Pin A	Analogue Bus Pin B	Connection (general)	Connection (AFM)
1	32 A		TwinAD channel 0	TwinAD channel 0
2		31 B	GND	GND-sense TwinAD CH0
3	31 A		TwinAD channel 1	TwinAD channel 1
4		30 B	GND	GND-sense TwinAD CH1
5	30 A		TwinAD channel 2	TwinAD channel 2
6		29 B	GND	GND-sense TwinAD CH2
7	29 A		TwinAD channel 3	TwinAD channel 3
8		28 B	GND	GND-sense TwinAD CH3
9	28 A		/tip back	N.C.
10		27 B	GND	GND
11	27 A		/tip forward	N.C.
12		26 B	GND	GND
13	26 A		$I \neq 0$	$FN \neq 0$
14		25 B	GND	GND
15	25 A		N.C.	N.C.
16		24 B	GND	GND
17	24 A		AFM	AFM/STM
18		23 B	GND	GND
19	23 A		GND	N.C.
20		22 B	GND	GND
21	22 A		Y	N.C.
22		21 B	GND	GND
23	21 A		X	N.C.
24		19 B	GND	GND-sense DAC 2
25	(19 A)		DAC channel 2	df_0
26		15 B	GND	GND
27	15 A		Y_0	N.C.
28		12 B	GND	GND
29	12 A		X_0	N.C.
30		11 B	GND	GND
31	11 A		not used	N.C.
32		9 B	GND	GND-sense DAC 0
33	(9 A)		DAC channel 0	FN_0
34		6 B	GND	GND-sense DAC 1
35	(6 A)		DAC channel 1	A_0
36		4 B	GND	GND
37	4 A		F_{OUT}	N.C.
38		3 B	GND	GND
39	3 A		start adjustment	start adjustment
40			N.C.	N.C.
41			N.C.	N.C.
42		2 B	GND	GND-sense DAC 3
43	(2 A)		DAC channel 3	F.E.
44			analogue GND	GND
45			N.C.	
46	1A		- 18.5 V	
47			N.C.	
48	1C		+ 18.5 V	
49			N.C.	
50			+ 5 V	
51			digital GND	

EIB Pin	Analogue Bus Pin A	Analogue Bus Pin B	Connection (general)	Connection (AFM)
52			digital GND	
53			/external busy	
54			external strobe ES	
55			/external read/write	
56			EA 3	
57			EA 2	
58			external address 1	
59			/EW 2	
60			/EW 1	
61			/external write 0	
62			/ER 2	
63			/ER 1	
64			/external read 0	

Table 36. Bus Pin Layout: External Interface Bus (EIB).

Bus Pin Layout: AFM CU Bus (ACB)

Pin	A	B	C
1	+ 5 V	GND	+ 5 V
2	/ER 0	GND	/EW0
3	/ER 1	GND	/EW1
4	/ER 2	GND	/EW2
5	BIT 1	GND	OSC
6	EA 1	GND	/ES
7	EA 2	GND	/E /R /W
8	EA 3	GND	/EBusy
9	-df	GND	LS
10	start adj.	GND	
11	AFM	GND	
12	NONC	GND	
13	adjustment	GND	
14	$FN \neq 0$	GND	
15	BIT 0	GND	
16	$F_N - F_{N0}$	GND	
17	/RES	GND	
18	/RES	GND	
19	heterodyne in	GND	
20	F.E.	GND	
21	heterodyne out * (-1)	GND	
22	F.E.	GND	
23	DAC 0 (FN_0)	GND	
24	DAC 1 (A_0)	GND	
25	DAC 2 (df_0)	GND	
26	DAC 3	GND	
27	TwinAD CH3	GND	
28	TwinAD CH2	GND	
29	TwinAD CH1	GND	
30	TwinAD CH0	GND	
31	+ 18.5 V	GND	+ 18.5 V
32	- 18.5 V	GND	- 18.5 V

Table 37. Bus Pin Layout: AFM CU Bus (ACB). The signals specified above are present at all AFM CU slotcards. Pins 10C to 30C are not interconnected, for pin assignments see figure 90.

AFM CU Bus Layout

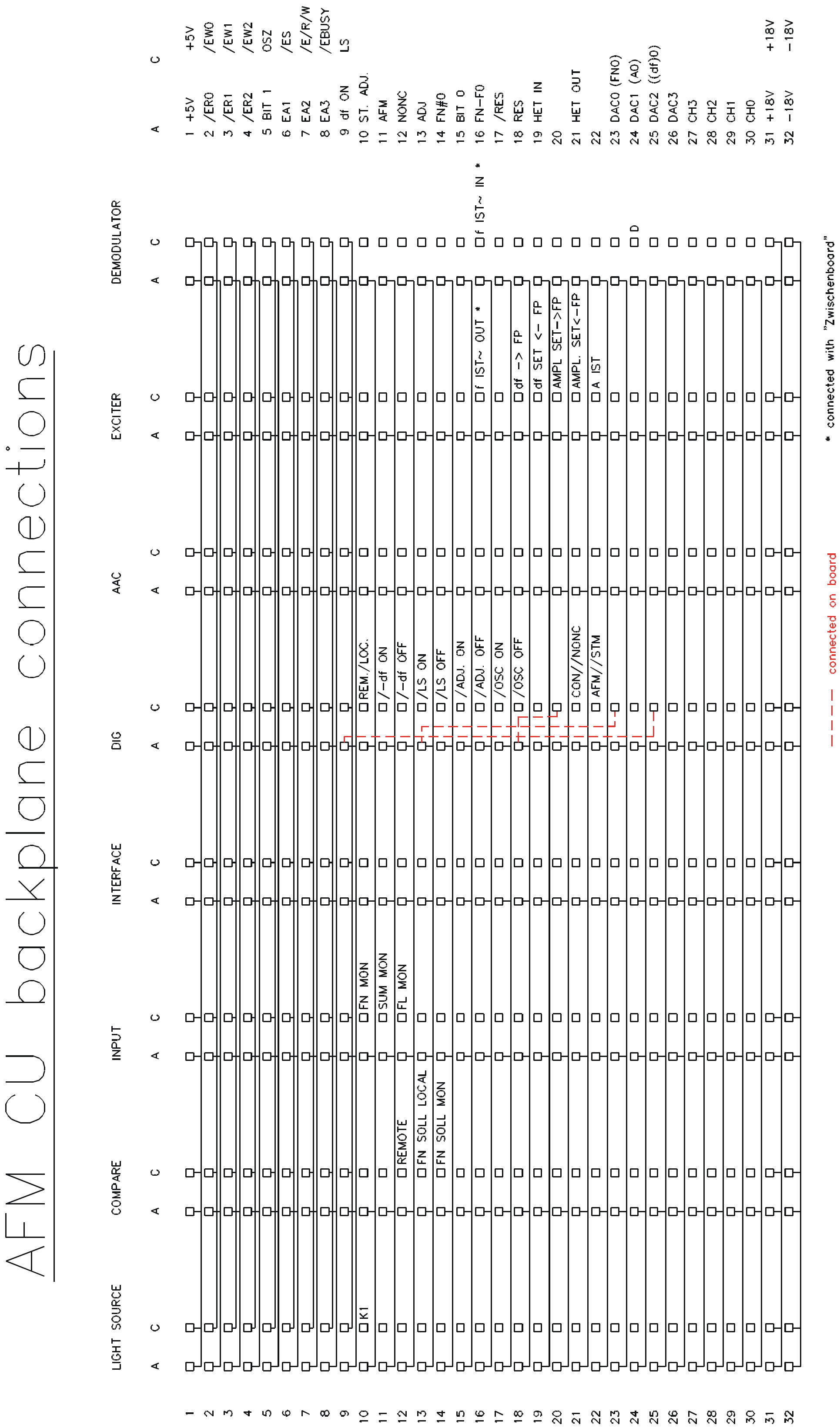


Figure 90. AFM CU bus layout, schematic diagram.

Service at Omicron

Should your equipment **require service**

- Please **contact Omicron** headquarters or your local Omicron representative to discuss the problem. An up-to-date address list is available on our website under

  http://www.omicron.de/contact/representatives.html

  or via e-mail reply service under

  contact.info@omicron.de.

- Make sure all necessary information is supplied. Always **note the serial number(s)** of your instrument and related equipment (e.g. head, electronics, preamp...) or have it at hand when calling.

If you have to **send any equipment back to Omicron**

- Please contact **Omicron headquarters** before shipping any equipment.
- Place the instrument in a polythene bag.
- **Reuse the original packaging and transport locks.**
- Take out a **transport insurance policy.**

For ALL vacuum equipment:

- Include a filled-in and signed copy of the "Declaration of Decontamination" form which can be found at the back of the equipment manual.

> STOP **No repair of vacuum equipment without a legally binding signed decontamination declaration !**

- Wear suitable cotton or polythene gloves when handling the equipment.
- **Re-insert all transport locks (if** applicable).
- Cover the instrument with aluminium foil and/or place it in a polythene bag. Make sure no dust or packaging materials can contaminate the instrument
- Make sure the **plastic transport cylinder (if** applicable) **is clean.**
- Fix the instrument to its plastic cylinder (if applicable).

Index