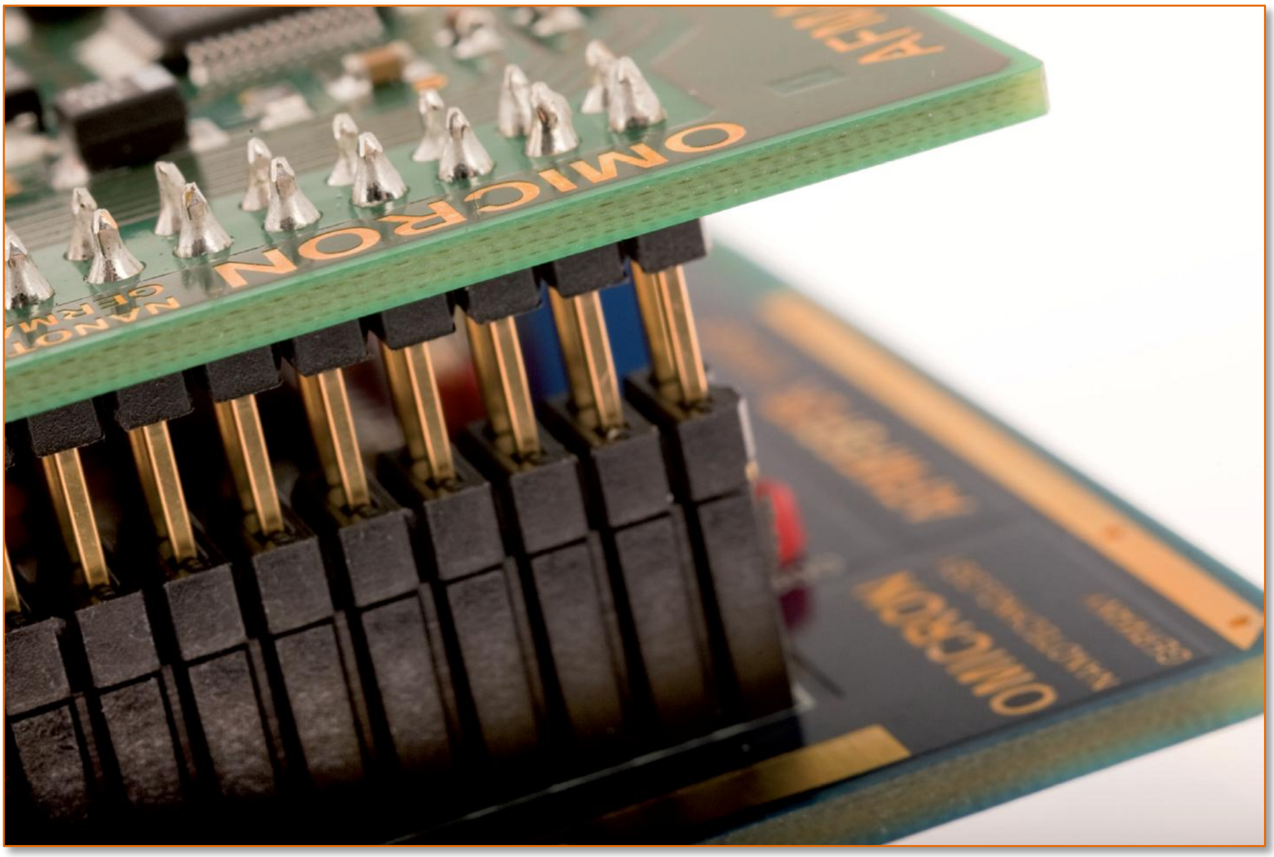
MATRIX Technical Reference Manual

Version 3.1 • 11 May 2016



Help Line:
German Headquarters and Service Centre:
Scienta Omicron GmbH
Limburger Str. 75
65232 Taunusstein, Germany
Tel.: +49(0) 61 28 / 987-230
Fax: +49(0) 61 28 / 987-33-230
E-Mail: services@scientaomicron.com

PN05649

scientaomicron

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 Scienta Omicron GmbH.

Notice

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

Notice

This documentation is available in English only.

Notice

Please read the safety information on pages 8 to 10 before using the instrument.

Copyright

Warranty

Scienta 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) Scienta Omicron ensures that all products supplied by Scienta Omicron which are de-commissioned and which are labelled with a WEEE Registration Number will be taken back by Scienta Omicron free of charge.

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

- Declare the returned material is free from contamination or hazardous materials from usage (include Decontamination Declaration sheet),

- Request a valid Return Material Authorisation (RMA) available from the Scienta Omicron service department,
- Ship all returned goods to the advised destination "Scienta Omicron Returned-WEEE-Centre, DDP (INCOTERMS)".

Otherwise Scienta Omicron will not accept any shipment.

Normal Use

The Scienta 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 Scienta Omicron MATRIX system consists of the following subunits

1. Matrix Control Unit (Matrix CU V3)
2. MATRIX Rack
3. Windows 7 computer
4. Matrix SPM control software
5. HC 1100 for direct sample heating (optional)

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

- **complete** and in combination with SPM heads which are explicitly specified for this purpose by Scienta Omicron
- with original Scienta 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.

Caution

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.

Caution

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

Conditions of CE Compliance

Scienta 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 Scienta 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 Scienta Omicron spare parts and replacements.

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

Exceptions

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

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

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

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

even if performed by an Scienta Omicron service representative.

Spare Parts

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

Notice

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.

Contents

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Safety Information

Caution

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 and grounding/earth 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.

Caution

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.

Attention

Inrush Current

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

Warning

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/computer (if applicable).

Caution

Never

- Never exceed a total 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.

Caution

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
- Condensation of humidity, particularly on water-cooled equipment, must be avoided.

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 its 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 functionalities such as multichannel feedback, input/output trigger control, pre-emptive feedback, and non-orthogonal and non-linear scan generation.

The Matrix system supports different types of boards dedicated to different purposes:

- *Native boards* have been developed specifically for the MATRIX system.
- *Analogue boards* (such as the PDC6N piezo driver) have been designed to support the MATRIX system.

Furthermore, the Matrix card frame supports two different types of native boards, see figure 1 below:

- *Front boards* have access to the compact peripheral component interconnect (CPCI) and provide complex digital logic and optionally analogue hardware dedicated to specific purposes. Examples of such boards are the MRTC and SRTC.
- *Rear boards* require a dedicated front board as controller interface and usually provide special analogue or interface hardware. Supported rear boards are the SCAR, SASS and AFM-SPU2.

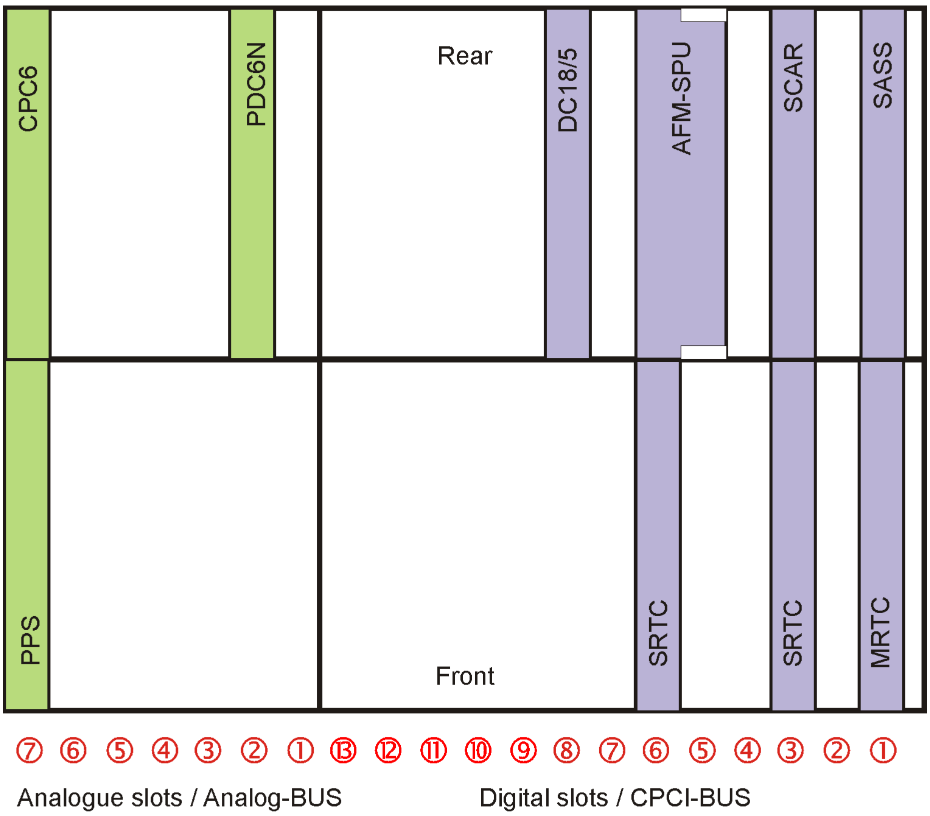


Figure 1. MATRIX basic hardware concept, top view schematic with AFM and QPlus.

At the moment the MATRIX CU can be divided into 4 quarters, as shown in figure 1 on page 11. On the CPCI side rear boards are responsible for analogue processes (e.g. scanning, regulation and data acquisition) whereas the corresponding front boards serve for control and configuration of their related rear boards as well as data transfer to the computer.

Every front board falls into one of two categories:

- *Master* — Required for controlling the operation of a Matrix rack; this board type is also providing the command and control interface for the Matrix PC software. Only one master board per Matrix card frame is supported; this board must be located in CPCI slot #1 of a card frame. Currently, the board type MRTC can be utilised as master board of a Matrix CU V3.

- *Satellite* — Autonomous boards dedicated to a specific purpose. Satellite (SRTC) boards can reside in any of the remaining CPCI slots of a Matrix card frame.

Example: The SRTC (*Satellite Real-Time Controller*) is a front board used for controlling the hardware resources of a SASS, SCAR or AFM-SPU rear board. Similar to the MRTC, an SRTC acts as a generalised digital interface and does not contain specific analogue electronics.

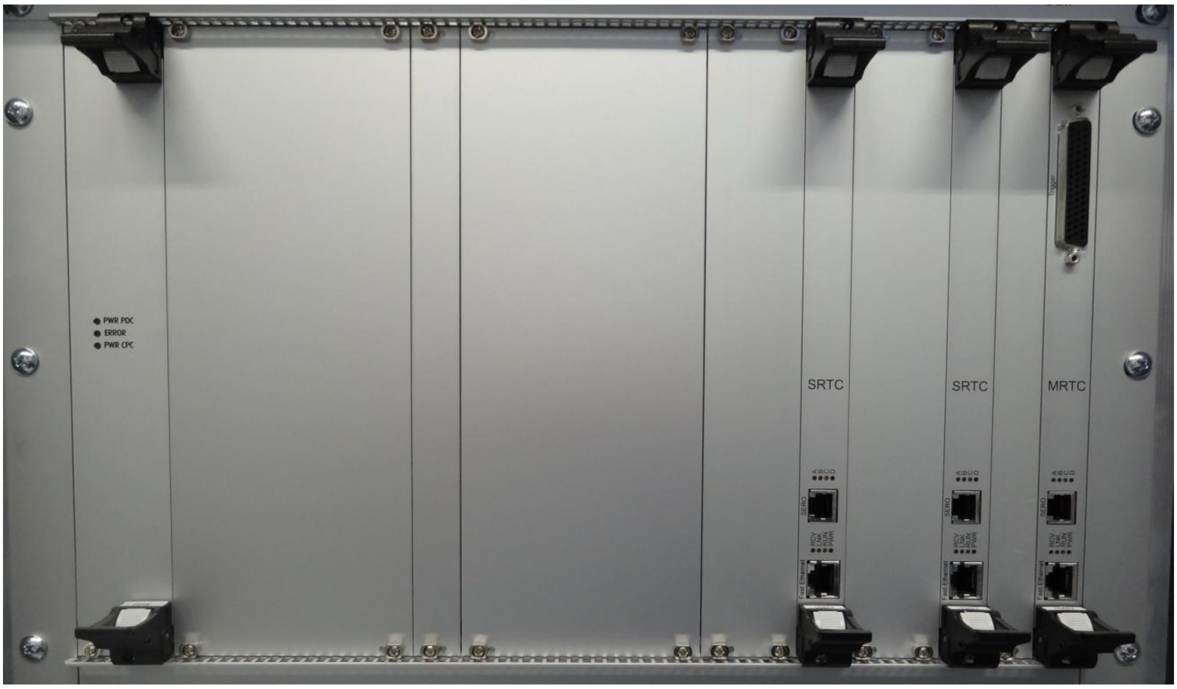
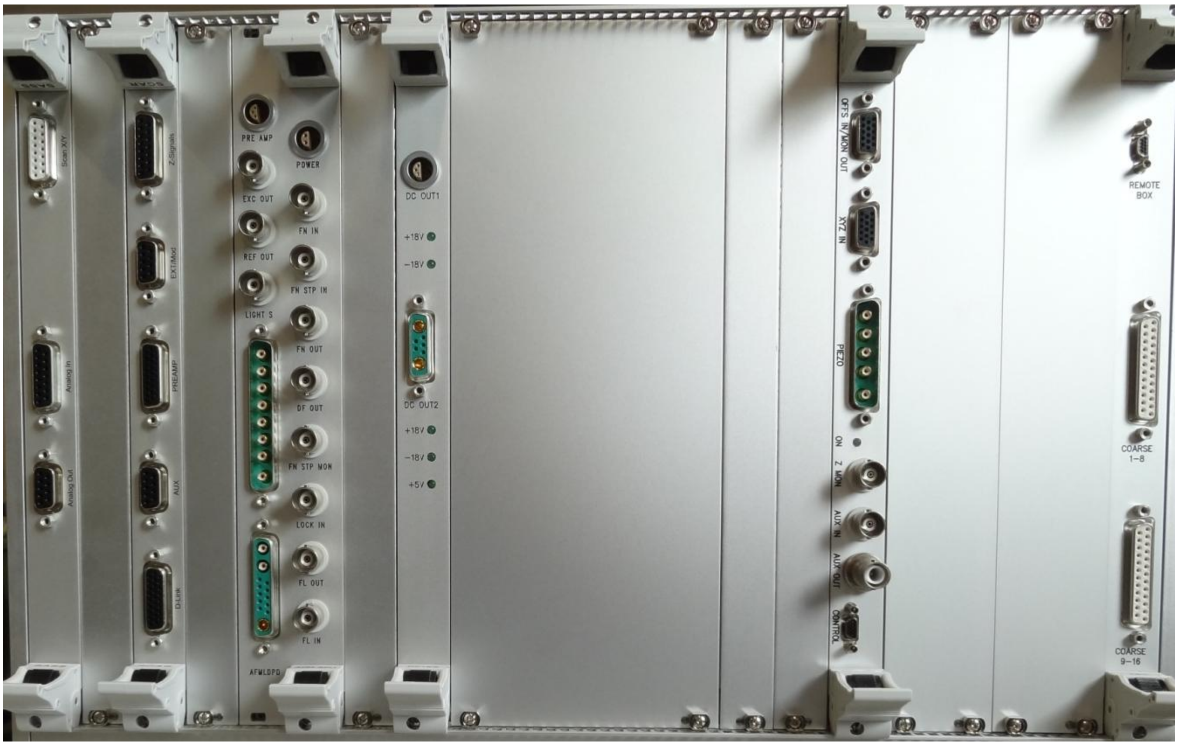


Figure 2. MATRIX control unit for STM, front view.

Figure 3. BNC connector terminal.



SASS SCAR AFM-SPU DC18/5 PDC6N CPC

Figure 4. MATRIX control unit for STM with QPlus, rear view.

Figure 5. MATRIX control unit power supply. Note: clean or change the air filters at regular intervals.

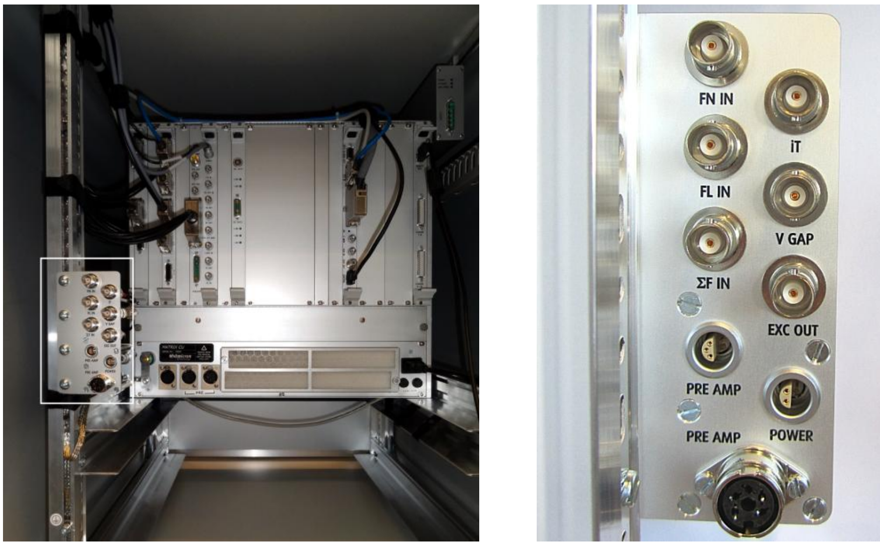


Figure 6. Preamp panel mounted to the side of the rack.

2. MATRIX CU Native Boards

On the front side of the MATRIX CU we have two types of native boards: a master board and satellite boards. At the moment the standard configuration has one or two satellite boards (SRTC) and one master board (MRTC). On the rear side we have two measurement boards: SASS and SCAR, each connected to a satellite time controller SRTC.

The differences between front boards and rear boards are listed in table 1 below.

Front boards MRTC and SRTC	Rear boards SASS, SCAR, AFM-SPU
MRTC: • source of the scan-axis clock system (clock coordinate system, CCS) • global clock generation • master of the system configuration • without SASS rear board: no measurement data connection, only system control • control of the system boot process SRTC: • satellite scan-axis clock system (clock coordinate system, CCS) • clock distribution • boots only in combination with the master Both: • realisation of the external digital interface (SPM digital bus) • no analogue electronics	• no clock generation • boots only in combination with the master • highly specialised analogue electronics for the individual board functionality

Table 1. Front and rear board differences.

Communication Details

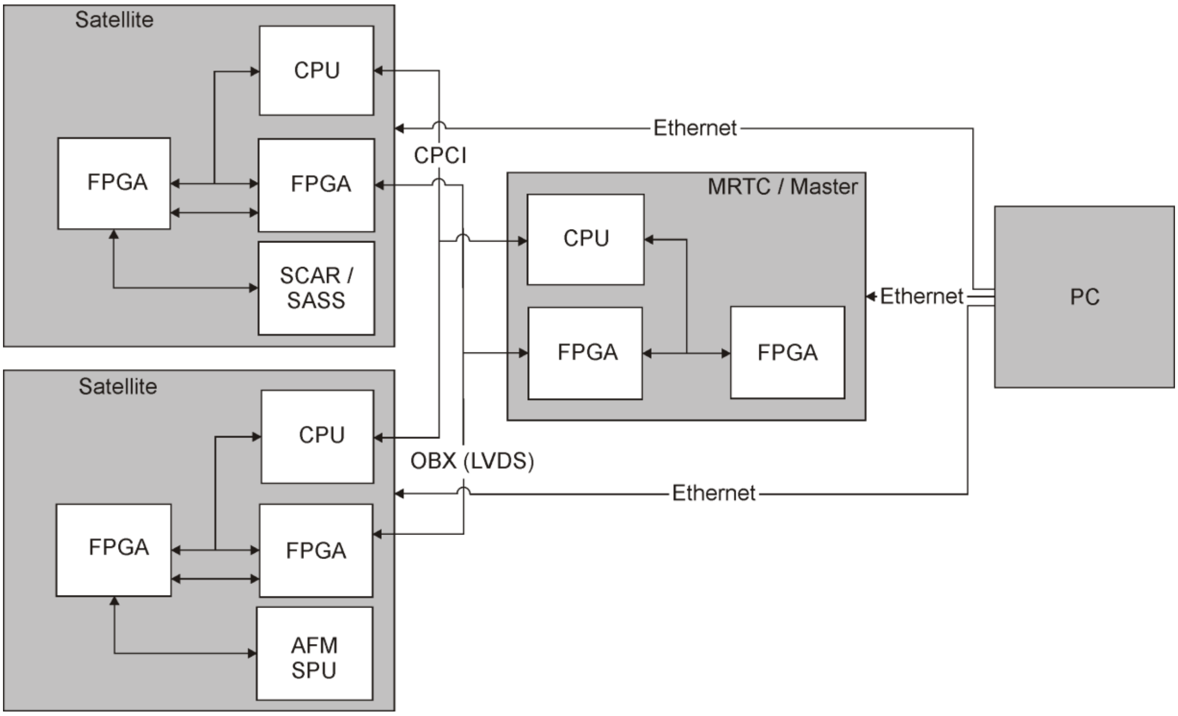


Figure 7. MATRIX communication diagram.

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 MHz) across the back plane using OBX/LVDS (Omicron Bus eXtension / Low Voltage Differential Signalling).

For external communication there are the following provisions taken:

- Fast Ethernet, approx. 80 MB/s (nominal 100 MB/s)
- Transport: TCP/IP (Transmission Control Protocol/Internet Protocol)
- Protocols: OCC (Omicron Comm Control), RDTP (Reliable Data Transfer Protocol, Scienta Omicron) and OSAM (Omicron Standard Address Map)

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

MRTC –Master Real-Time Controller

Location:	MATRIX CU	**Application:**	standard

The functions of the MRTC board are the:

- Realisation of the external digital interface (to CPC and PDC via the analogue bus)
- Global clock generation and clock distribution
- Control of system boot process
- Master of system configuration; responsible for the configuration of the satellite boards
- Realisation of the communication with the PC
- Management of the compact PCI-bus
- DATA transfer

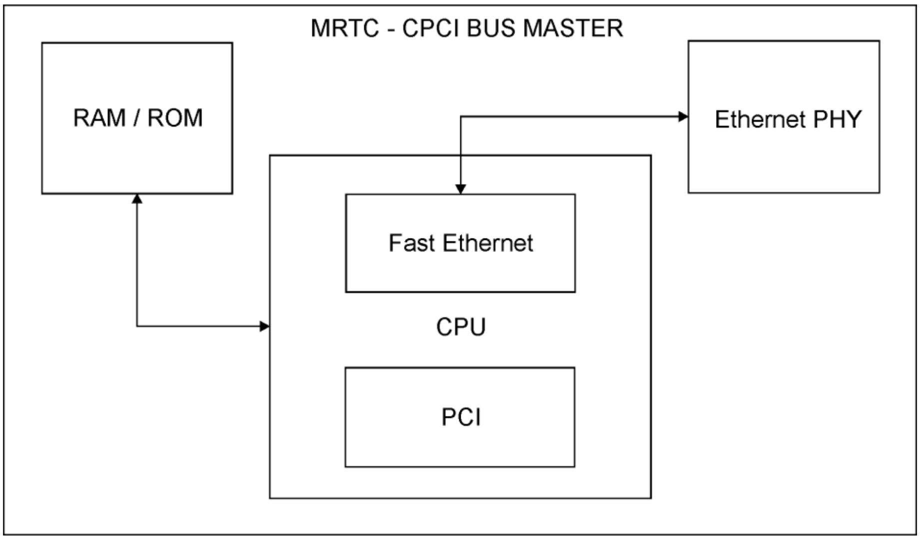


Figure 8. MRTC block diagram.

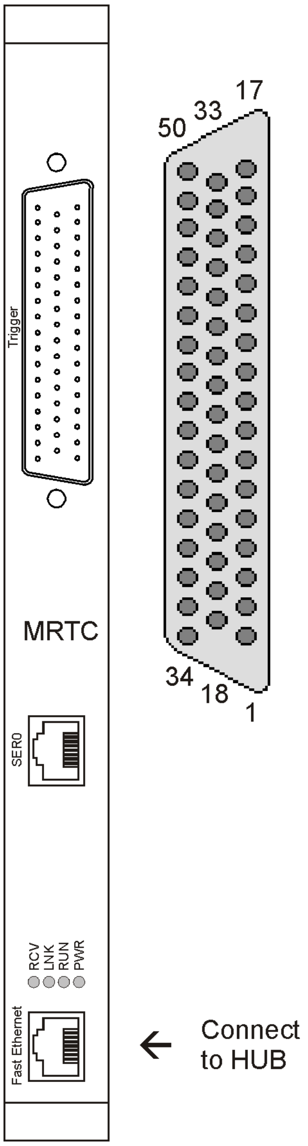


Figure 9. MRTC – central real time controller, panel schematic diagram.

Trigger

Pin number	Signal	Pin number	Signal
1	Analogue ground	26	TTL out 4 / Spectroscopy T4
2	Analogue ground	27	TTL out 6
3	Analogue ground	28	TTL out 8
4	TTL in 1	29	TTL out 10 / LINECLK
5	TTL in 3 / PFUV2 In	30	TTL out 12 / PIXELCLK (SCAN)
6	TTL in 5	31	TTL out 14 / PFUV2 Gain Attenuation 1
7	TTL in 7	32	5 V
8	TTL out 1 / Spectroscopy T2	33	5 V
9	TTL out 3 / Spectroscopy T3	34	Analogue ground
10	TTL out 5	35	Analogue ground
11	TTL out7	36	Analogue ground
12	TTL out 9	37	Analogue ground
13	TTL out 11 / PIXELCLK (ACQ)	38	Analogue ground
14	TTL out 13 / PFUV2 Gain Attenuation 2	39	Analogue ground
15	TTL out 15 / PFUV2 Filter on/off	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 0	45	Analogue ground
21	TTL in 2	46	Analogue ground
22	TTL in 4	47	Analogue ground
23	TTL in 6	48	Analogue ground
24	TTL out 0 / Spectroscopy T1	49	5 V
25	TTL out 2 / Spectroscopy Ramp	50	5 V

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

SRTC3 - Satellite

Location: MATRIX CU	**Application:** standard

The functions of the SRTC / SRTC3 board are the:

- Realisation of the external digital interface (to the SPM-digital bus)
- Local clock generation
- Control and configuration of associated rear board
- Data transfer to the PC

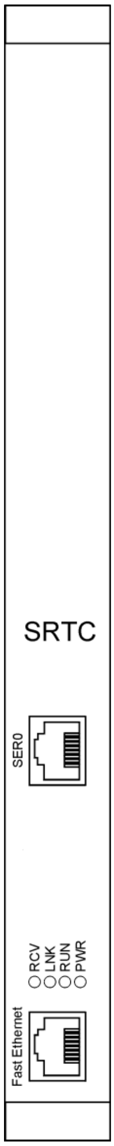


Figure 10. SRTC / SRTC3 – satellite real time controller, panel schematic diagram.

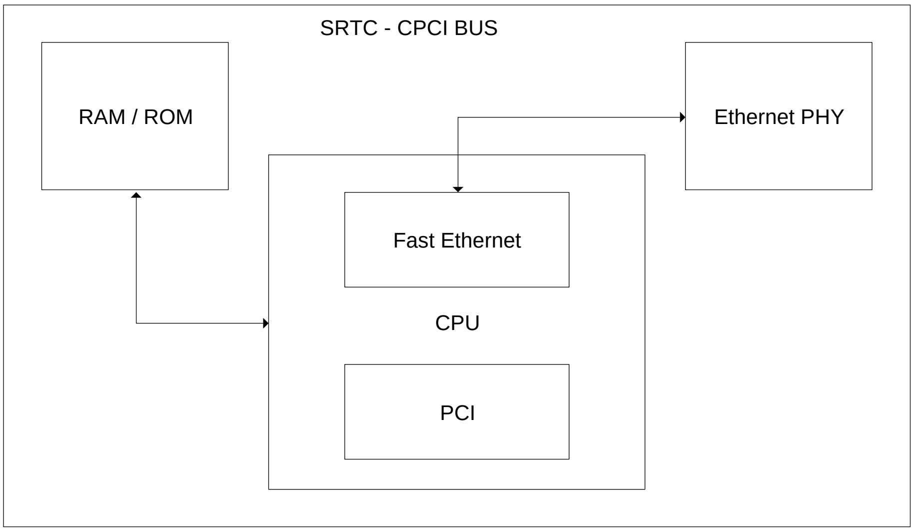


Figure 11. SRTC / SRTC3 block diagram.

SCAR - Signal Conversion And Regulation

Location:	MATRIX CU	**Application:**	standard

Notice

With an SRTC3 front board instead of the SRTC the SCAR board name changes to SCAR3.

A SCAR board is the interface to the preamplifier. It measures and digitises the tunnelling current signal and provides the gap voltage for STM operation. 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.

Additionally it provides a digital feedback system for SPM experiments and 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).

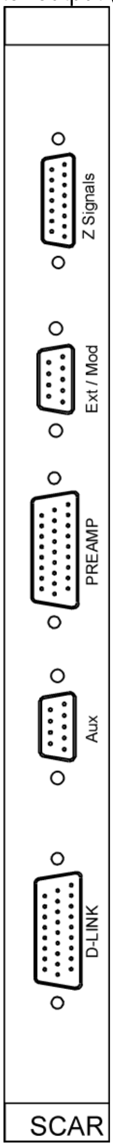


Figure 12. SCAR - Signal Conversion And Regulation board, panel schematic diagram.

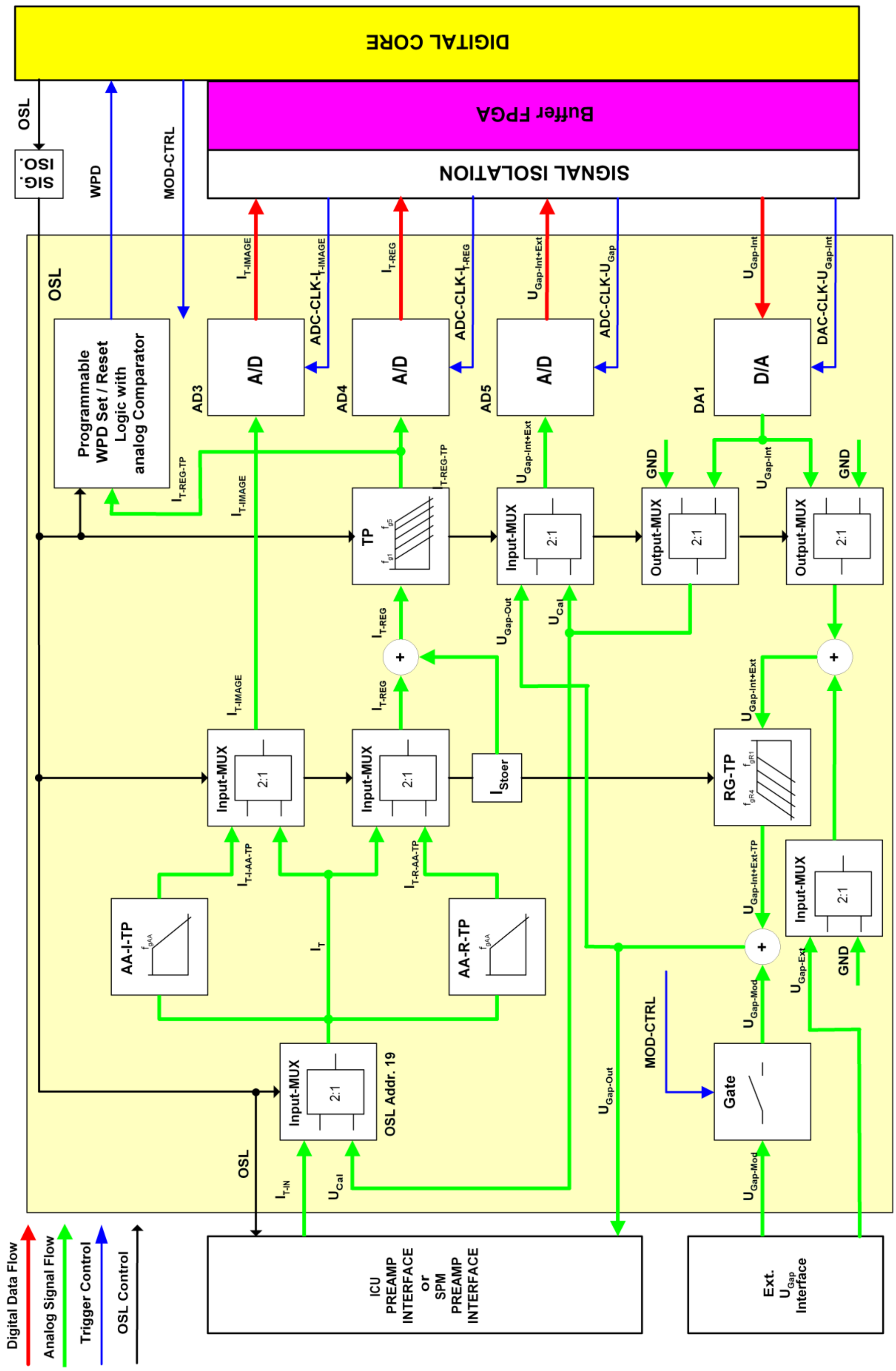


Figure 13. SCAR block diagram, STM signal conversion part.

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.

Notice

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.

Analogue Digital Converter

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

Measurement Branch

- Anti-Aliasing Low Pass: 100 kHz

> **Notice**
>
> 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
>
> $$f_{Nyquist} = \frac{1}{2}\nu$$
>
> High-quality sampling systems ensure that no aliasing occurs by low pass filtering the signal before sampling.

Feedback Branch

- Analogue Low Pass, configurable: 300 Hz, 1 kHz, 3 kHz, 10 kHz, 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, 20 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

> **Notice**
>
> Note that the external input signals are added to the gap voltage before the 1:10 range switch.
>
> Note that the signal at Vmod is inverted: an input of +1 V at Vmod yields -1 V at Vgap, whereas an input of +1 V at Vgap extern yields +1 V at Vgap.

IT Mon

- Buffered output of I_T (gain 1, bandwidth 100 kHz).

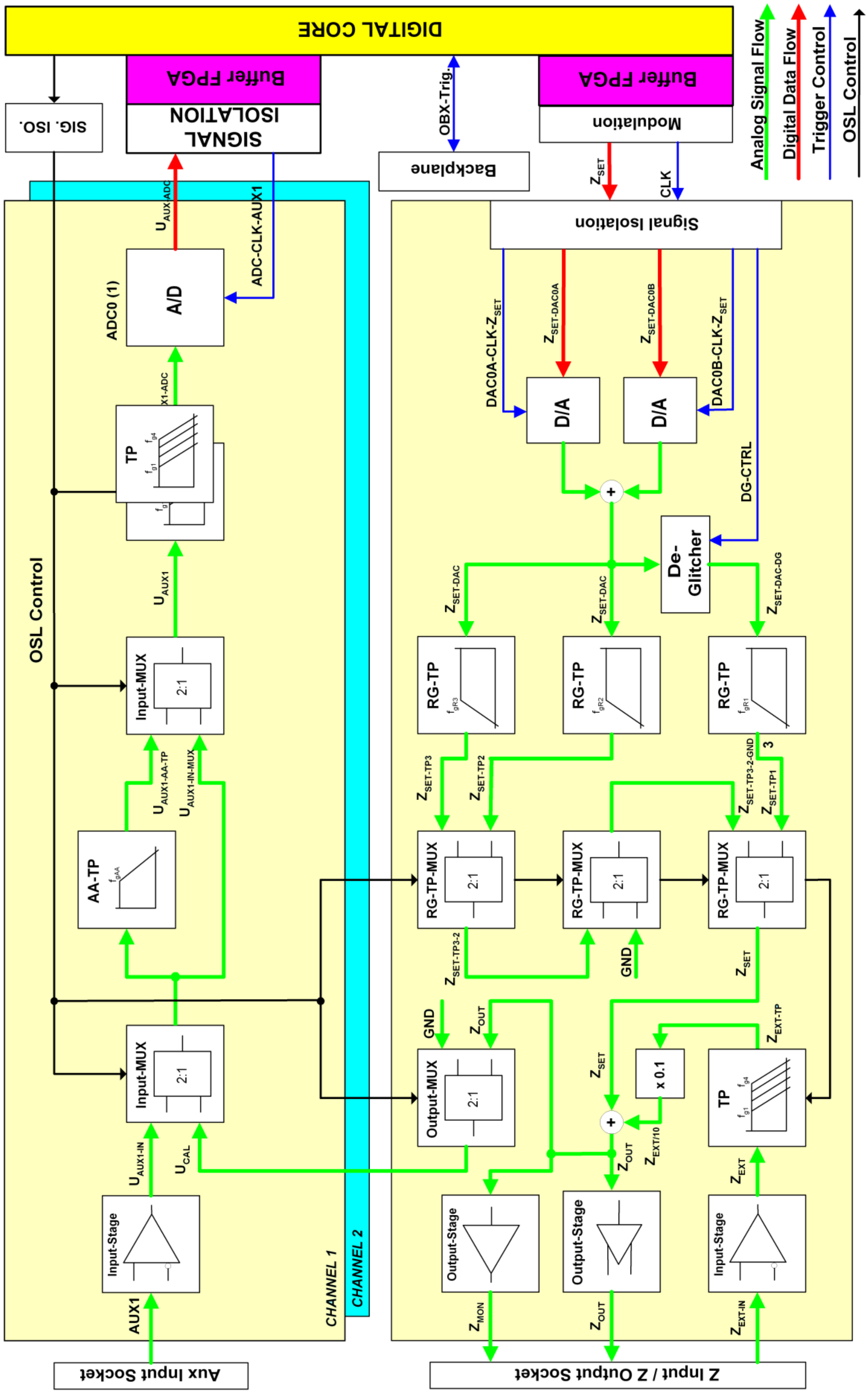


Figure 14. SCAR block diagram, regulation part.

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.

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 bandwidth 100 kHz
- Second order low pass with selectable bandwidth of 1 kHz, 3 kHz, 10 kHz, 30 kHz

Modulation Input (ZEXT)

- First order low pass with selectable bandwidth of 3 kHz, 10 kHz, 48 kHz and 80 kHz
- Fixed gain x0.1

SCAR 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 bandwidth
- Trigger lines for WPD, Loop Off and Declaration.

SASS (Scanning And Signal Sampling)

Location:	MATRIX CU	**Application:**	standard

Notice

With an SRTC3 front board instead of the SRTC the SASS board name changes to SASS3.

A SASS 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 SCAR). The SASS 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.

In addition this board provides four analogue input channels and two analogue output channels for acquiring special AFM signals (e.g. damping, frequency difference, etc.) Note that the output channels are not used in any standard application.

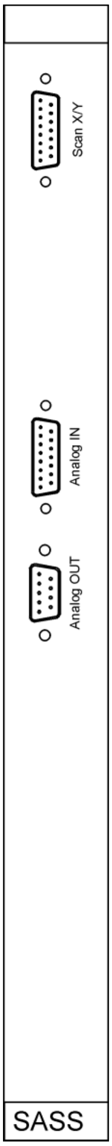


Figure 15. SASS - Scanning And Signal Sampling board, panel schematic diagram.

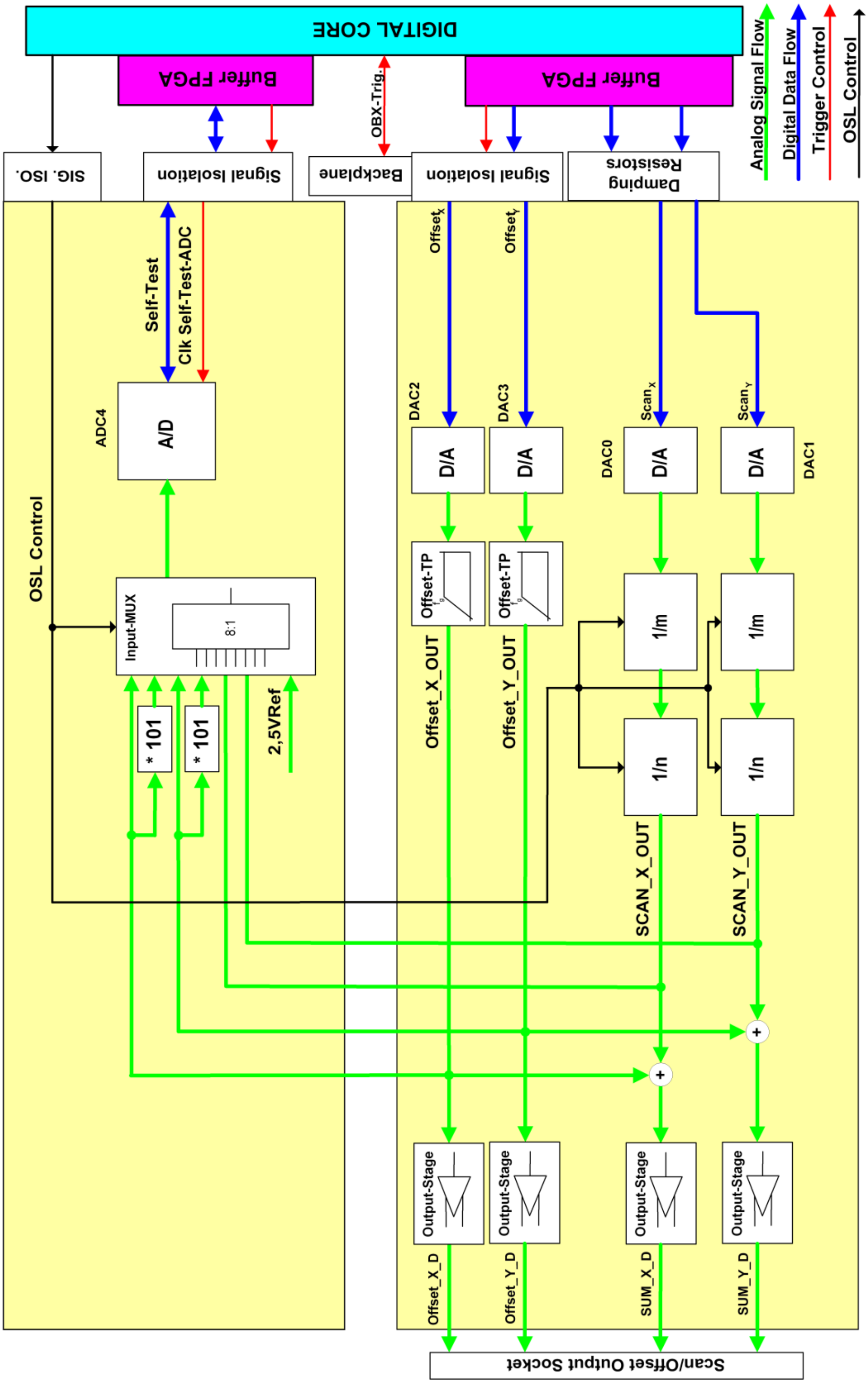


Figure 16. SASS block diagram, scanning part.

SCAN XY

Pin number	Signal
1	SUM X 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:

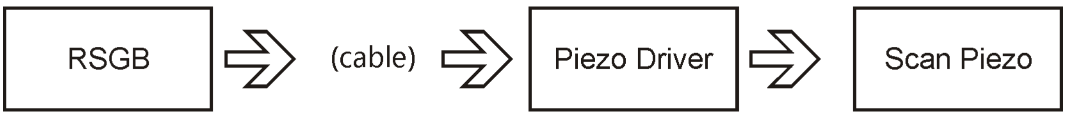


Figure 17. SASS signal path. Note that the PDC6N and PDC4N have a front connector XYZ IN.

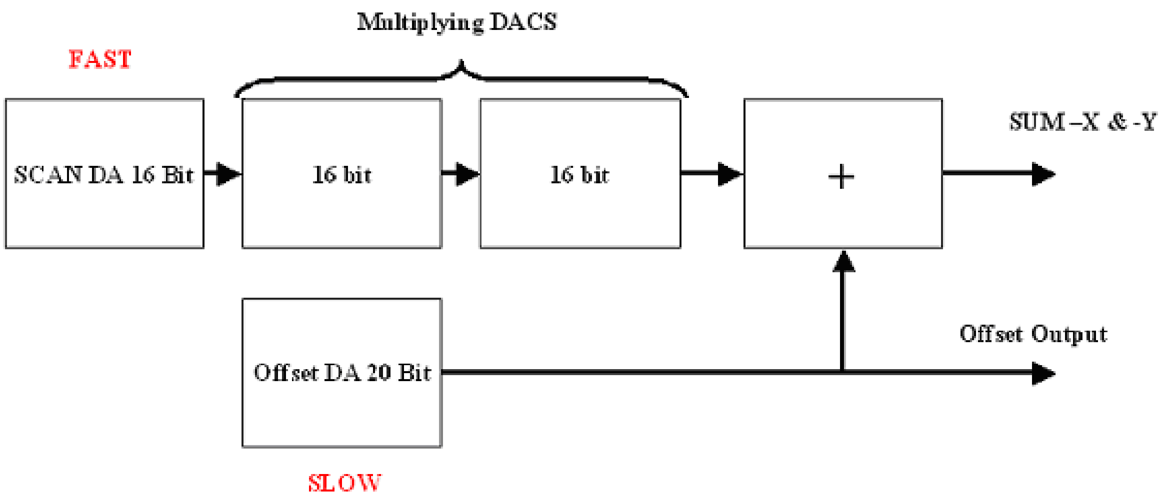


Figure 18. SASS – digital/analogue converters.

Notice

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

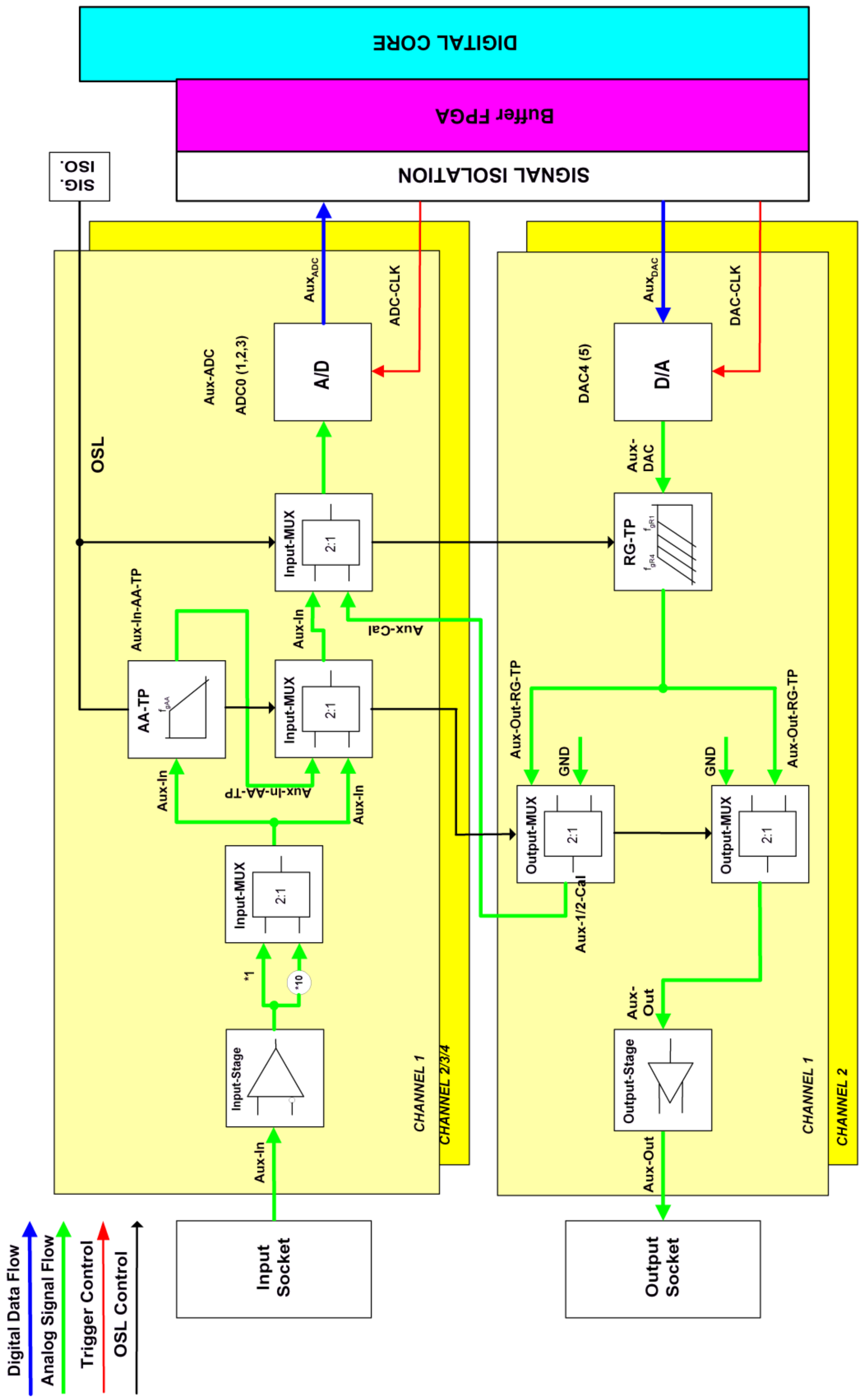


Figure 19. SASS block diagram, signal sampling part.

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.

AFM-SPU - Atomic Force Microscopy Signal Processing Board

Location: MATRIX CU	**Application:** AFM

Notice

With an SRTC3 front board instead of the SRTC the AFM-SPU board name changes to AFM-SPU3.

The AFM-SPU provides the controls and functions for AFM measurements and all necessary supply voltages for the various Scienta Omicron AFM instruments.

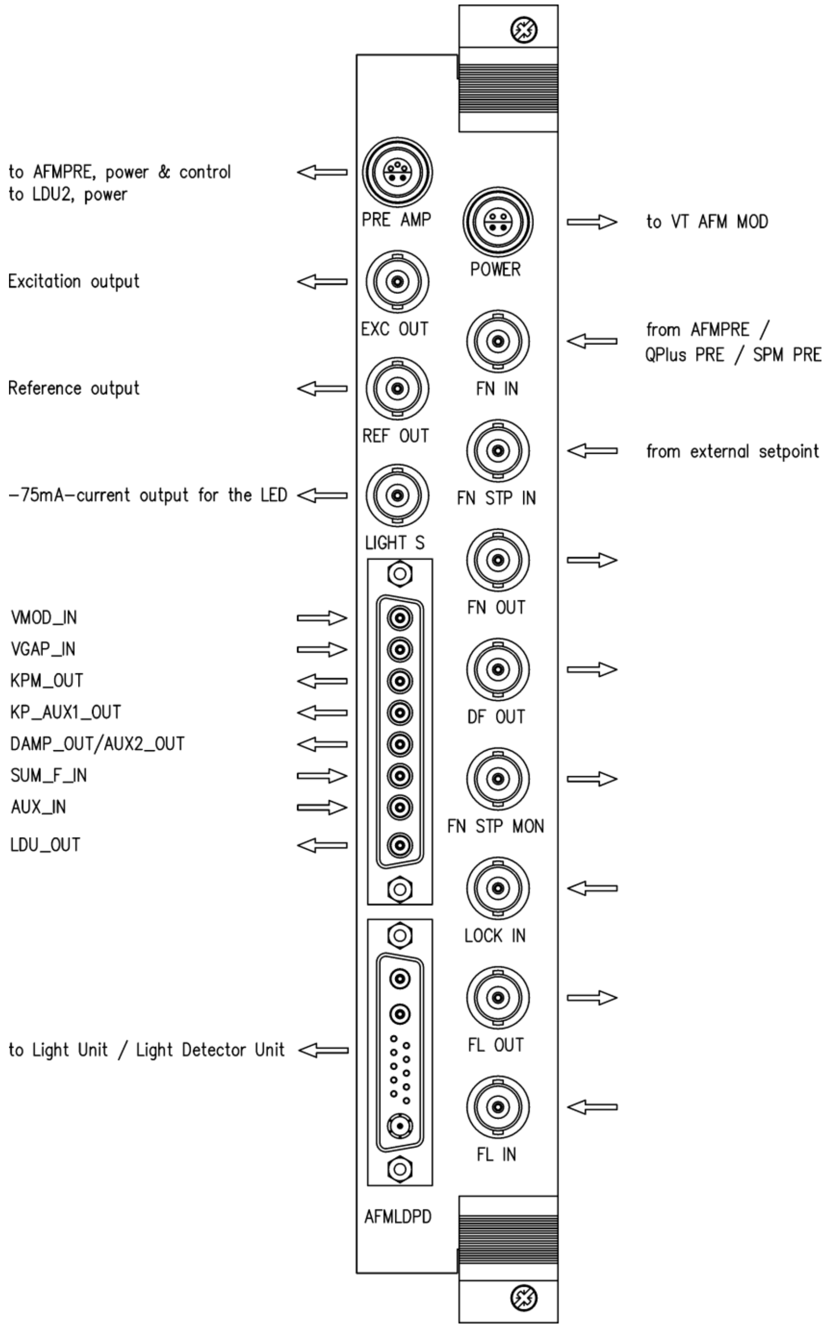


Figure 20. AFM-SPU double board panel, schematic diagram. For details please turn over.

The measurement signals from the AFM preamplifier are fed to the AFM-SPU where they are filtered and digitised according to the predefined settings. The feedback signal derived from the measurement data is then forwarded to the MATRIX CU for feedback regulation.

In Contact-Mode this means that the setpoint is subtracted from the measured value (normal FN or lateral FL).

In Non-Contact-Mode the digitised AFM-Signal (FN) is demodulated using a phase locked loop (PLL) or alternatively a demodulator with a fix reference frequency. The frequency shift setpoint is then subtracted from the centre frequency of the PLL (or the resonance frequency of the demodulator) and the result of the demodulation is then forwarded to the MATRIX CU z-regulator.

The AFM-SPU generates the signal for excitation of the sensor in Non-Contact-Mode with respect to the digital signal generator of the PLL (DDS) or with respect to the AFM measurement signal (self excitation). The excitation amplitude can be controlled via a regulator which adjusts the measured AFM signal amplitude to match the predefined setpoint.

For Kelvin Probe measurements the AFM-SPU provides an additional regulator.

Fast Signal Processing Part

Power	Output, power supply for VT AFM MOD via PIC cable Pin number Signal 1 +15 V 2 -15 V 3 AGND
FN IN	Input for FN signal (actual value) from AFM PRE, SPM PRE or Ω Out from QPlusPRE. The input signal can be filtered via high pass filters, AC coupled or passed on directly. Voltage range: 1 V RMS (2.8Vpp); frequency range: 4 kHz to 3 MHz
FN STP IN	Input for external setpoint (if FN_SETP2_ON = active) Voltage range: ±10 V; frequency range: DC to 50 kHz
FN OUT	Output for FN IN or FN-FN0; can be used to monitor FN IN, optional filtering and output limitation to ±1.4 V for FN OUT = FN IN: V_{OUT} = ±1.4 V, f = DC...3 MHz for FN OUT = FN – FN0: V_{OUT} = ±10 V, f = DC...3 MHz
DF OUT	Output Delta f OUT or Delta PHI OUT, can be used for monitoring (in Non-Contact mode only) or as input for an external LOCK-IN amplifier (Kelvin Probe mode) V_{OUT} = ±10 V, f = DC...50 kHz
FN STP MON	Output, monitoring of setpoint = external setpoint – internal setpoint V_{OUT} = ±10 V, f = DC...50 kHz
LOCK IN	Input for connecting external LOCK-IN amplifier; AD conversion with a resolution of ±2.5 V / 16-Bit V_{IN} = ±10 V, f = DC...50 kHz
FL OUT	Output for monitoring FL or FL-FL0; FL: f_{OUT} = DC...3 MHz, optional filtering (high pass, low pass, band pass) FL-FL0: f = DC...70 kHz V_{OUT} = ±10 V
FL IN	Input from AFM PREAMP V_{IN} = 1 V RMS (2.8 Vpp), f = 4kHz...3 MHz

block diagram of the AFM-fast signal processing part

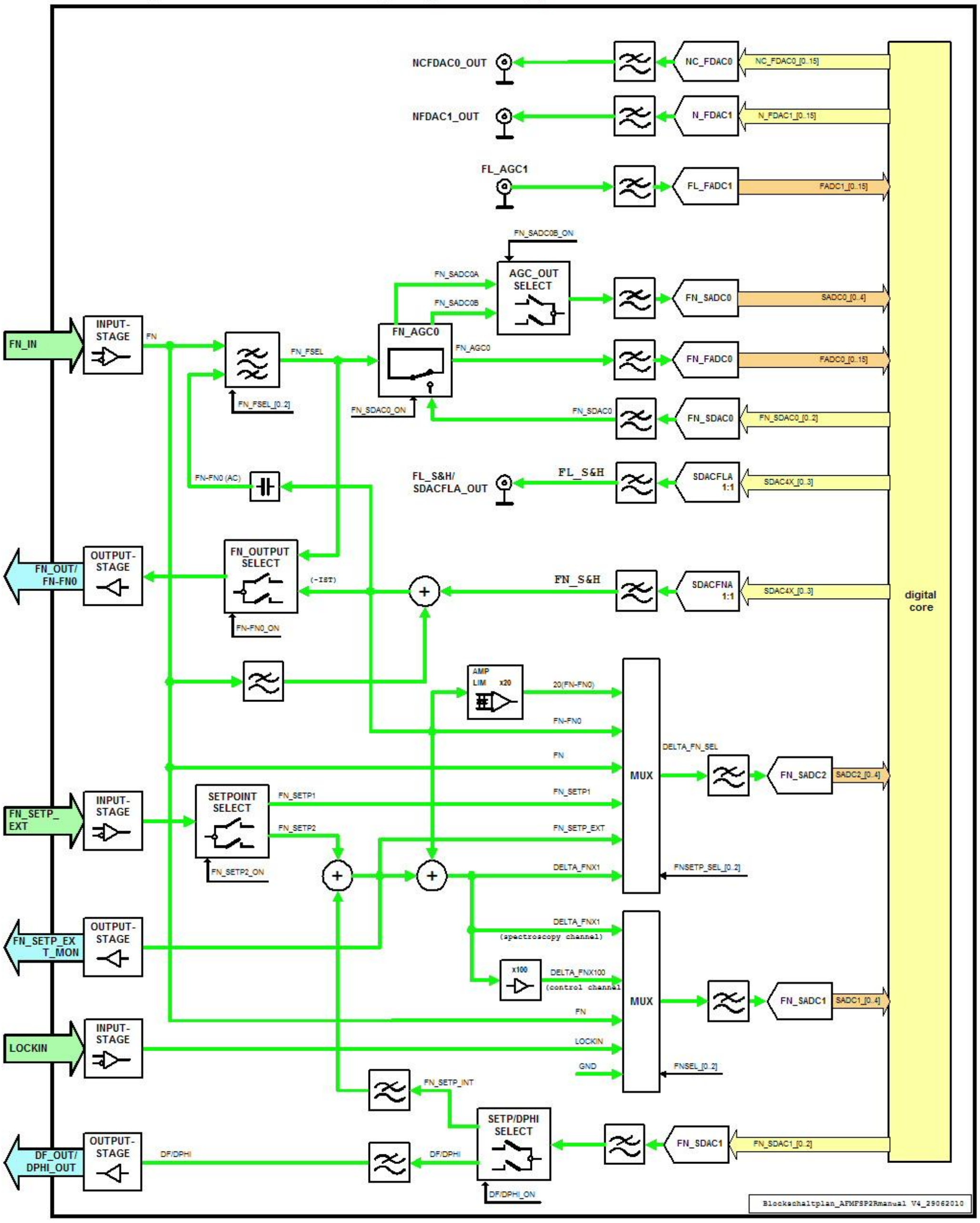


Figure 21. AFM-SPU fast signal processing part.

Attention

Maximum voltage for all inputs is ±10 V; heed limits stated on page 34.

Advanced Signal Processing Part

PRE AMP	Output, power supply for AFM PREAMP; control signal for background subtraction Pin number — Signal 1 — +18.5 V 2 — AGND 3 — -18.5 V 4 — FL_ADJ_0; S1 5 — FL_ADJ_1; /S2
EXC OUT	Output; first internal DDS generator; in case of self exciting mode: excitation signal derived from FN IN to VT AFM MOD via PIC cable V_{OUT} = 0...+2,5 Vpp sin, f = 15 kHz... 3 MHz
REF OUT	Output; second internal DDS generator can be used as reference signal, e. g. for external LOCK-IN amplifier in case of self exciting mode: excitation signal derived from FN IN V_{OUT} = 0...+2,5 Vpp sin, f = 15 kHz... 3 MHz
LIGHT S	Power supply for the in-vacuum LED $I_{OUT\ @\ LS\ ON=active}$ = -75 mA DC or -190 mA DC, depending on LED type
MultiKoax-DSUB	Interface for various signals **Pin** — **Signal** — **Pin** — **Signal** A1 — LDU OUT — A5 — KP AUX1 OUT A2 — AUX IN — A6 — KPM OUT A3 — SUM F IN — A7 — VGAP IN A4 — DAMP OUT / AUX2 OUT — A8 — VMOD IN
SUM F IN	Input, sum signal of the four quadrant detector V_{IN} = ±10 V, f = DC...50 kHz
DAMP OUT	Output, damping signal of the amplitude regulator V_{OUT} = ±10 V, f = DC... 30 kHz
KP AUX1 OUT	Output, regulator output signal of the Kelvin Probe regulator V_{OUT} = ±10 V, f = DC... 30 kHz
KPM OUT	Output, VGAP IN + VMOD IN + KP AUX1 OUT V_{OUT} = ±10 V, f = DC... 500 kHz
AFMLDPD	Interface for Light Unit / Light Detector Unit (Cryogenic SFM) **Pin** — **Signal** — **Pin** — **Signal** A1 — DETECT IN — 5 — +5VL A2 — SETPOINT LIGHT — 6 — FL_ADJ_0; S1 A3 — P MON — 7 — -15 V 1 — FL_ADJ_1; /S2 — 8 — +15 V 2 — AGND — 9 — AGND 3 — +5VLD — 10 — +5VL 4 — AGND

block diagram of the AFM-advanced signal processing part

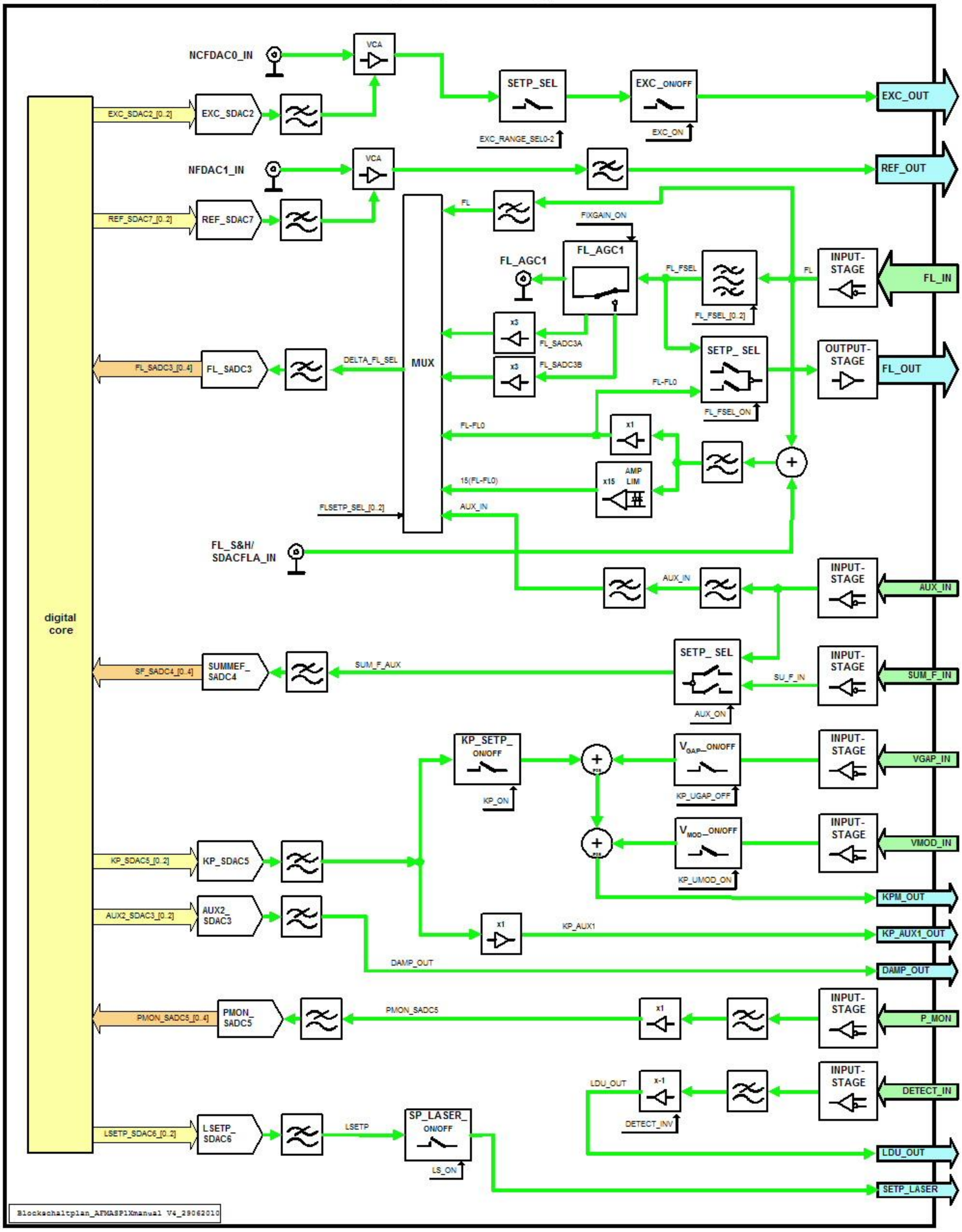


Figure 22. AFM-SPU advanced signal processing part.

> **Attention**
>
> Maximum voltage for all inputs is ±10 V

AFM/STM	FN IN, FL IN, SUM F IN: signal inputs from AFM/STM-Preamp LIGHT S: power supply for in-vacuum LED
VT AFM, LS AFM, NC and C-mode	FN IN, FL IN, SUM F IN: signal inputs from AFMPRE7 PRE AMP: power supply and control signals for AFMPRE7 AFMLDPD: interface for Light Unit, LU6 or LU7 POWER: power supply for VTAFMMOD (only for non-contact-mode)
VT AFM/STM with QPlus, LS AFM/STM with QPlus	FN IN: signal input for *ω-OUT* of the SPMPRE4 U/E-Q QPlus-part DCOUT2 (DC18/5): power supply for the SPMPRE4 U/E-Q QPlus-part POWER: power supply for VT AFM MOD (only for non-contact-mode)
LT STM with QPlus	FN IN: signal input for QPlusPRE *ω-OUT* DCOUT2 (DC18/5):power supply for QPlusPRE *ω-OUT* POWER: power supply for VTAFMMOD (only for non-contact-mode)
CRYOGENIC SFM	AFMLDPD: interface for Light Detector Unit, LDU2 PRE AMP: power supply for LDU2 via cable adapter PN03943 (alternatively from DC18/5 – DCOUT1) LDU OUT: signal output via cable adapter PN03944 to SUM F IN, FN IN and connector terminal (from here to SASS-analog in CH1) POWER: power supply for VTAFMMOD (only for non-contact-mode)
KELVIN PROBE with BEAM DEFLECTION, non-contact-mode (NC)	AM-mode FN IN: FN OUT from AFMPRE7 FL IN: FN OUT from AFMPRE7 (via T-piece) FL OUT: connect to signal input of external LOCK-IN amplifier LOCK IN: input of KelvinProbeRegulator, connect to output of external LOCK-IN amplifier VGAP IN: VGAP-voltage from SCAR board VMOD IN: connect reference output of external LOCK-IN amplifier KPM OUT: to VGAP (blue) of SPMPRE4 KP AUX1 OUT: monitor for KP signal (regulator control signal, setpoint is always 0) FM-mode FN IN: FN OUT from AFMPRE7 FL IN: FL OUT from AFMPRE7 DF OUT: connect to signal input of external LOCK-IN amplifier LOCK IN: input of KelvinProbeRegulator, connect to output of external LOCK-IN amplifier VGAP IN: VGAP-voltage from SCAR board VMOD IN: connect reference output of external LOCK-IN amplifier KPM OUT: to VGAP (blue) of SPMPRE4 KP AUX1 OUT: monitor for KP signal (regulator control signal, setpoint is always 0)
All variants	EXC OUT: excitation voltage for all non-contact applications

DC18/5 - Power Supply

Location:	MATRIX CU	**Application:**	AFM

The DC18/5 is a power supply for the AFM Preamp and QPlus Preamp.

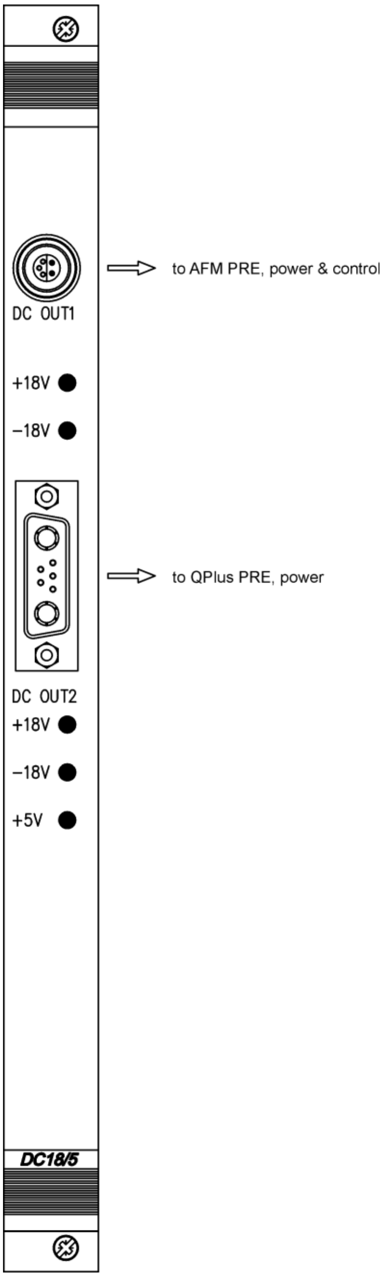


Figure 23. DC18/5 preamp power supply.

DC1 OUT	Power supply for AFM PREAMP; control signal for background subtraction Pin number Signal 1 +18.5 V 2 AGND 3 -18.5 V 4 FL_ADJ_0; S1 5 FL_ADJ_1; /S2
DC2 OUT	Power supply for QPlus PREAMP Pin number Signal A1 AGND A2 +5 V 1 AGND 2 AGND 3 -18.5 V 4 n.c. 5 +18.5 V

CPC - Coarse Positioning Card

Location:	MATRIX CU	Application:	standard

The coarse positioning card can drive 16 independent piezo inertia drives for sample or tip coarse positioning and connects to the remote box.

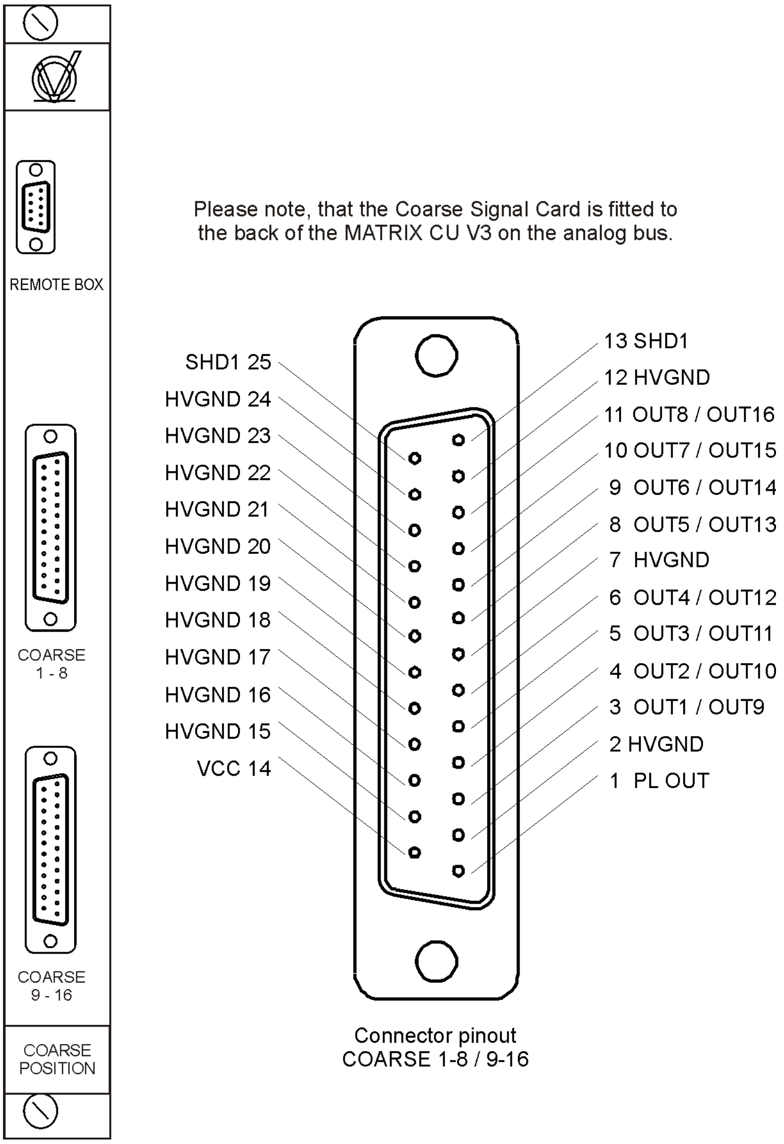


Figure 24. Coarse positioning card, panel schematic diagram.

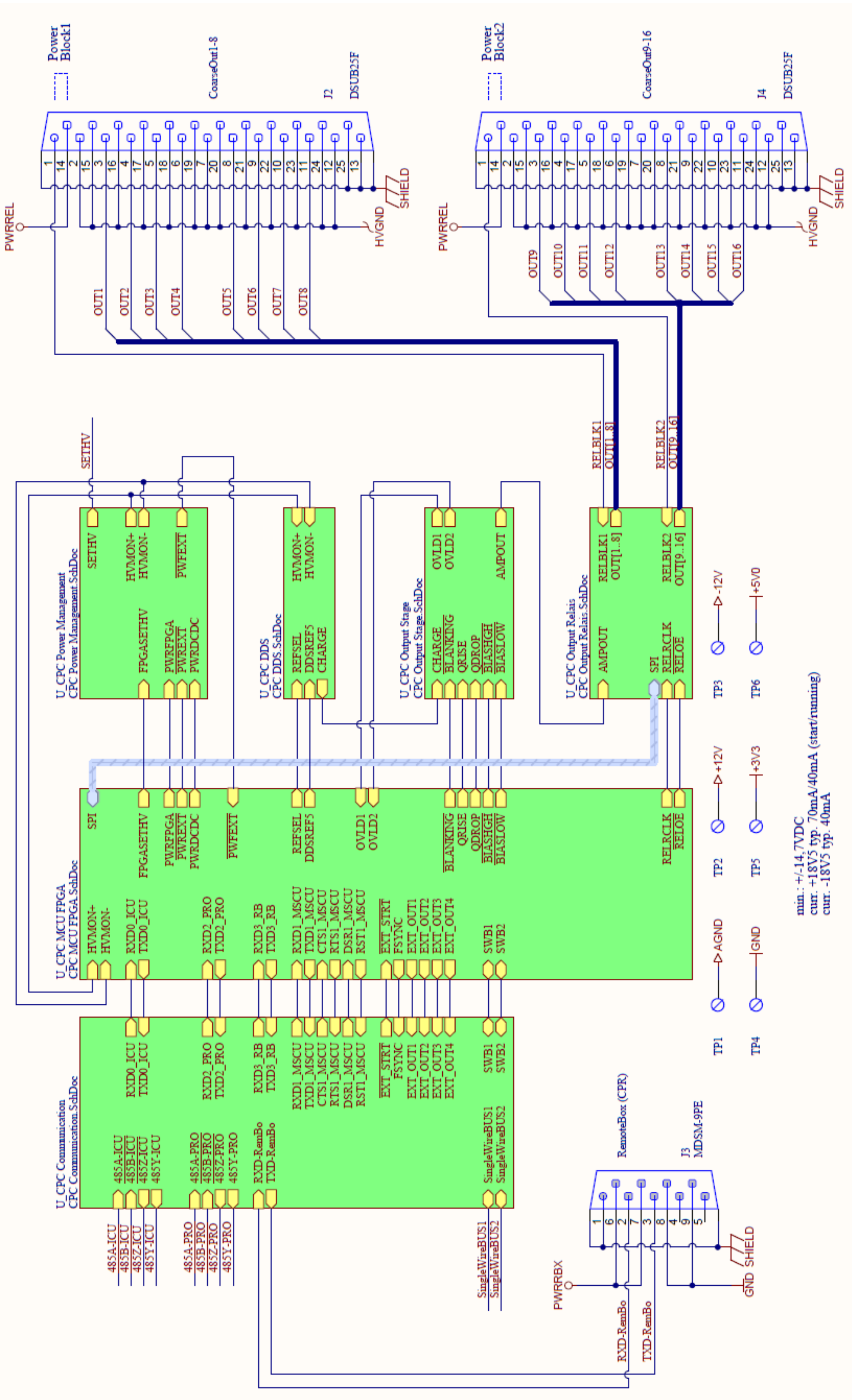


Figure 25: Coarse positioning card layout, schematically.

PDC6N - Piezo Driver Card

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 front connector XYZ IN.

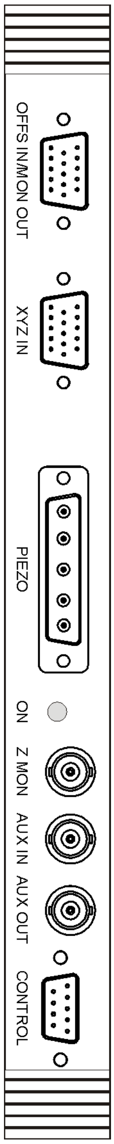


Figure 26. Piezo driver board PDC6D, panel schematic diagram.

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.

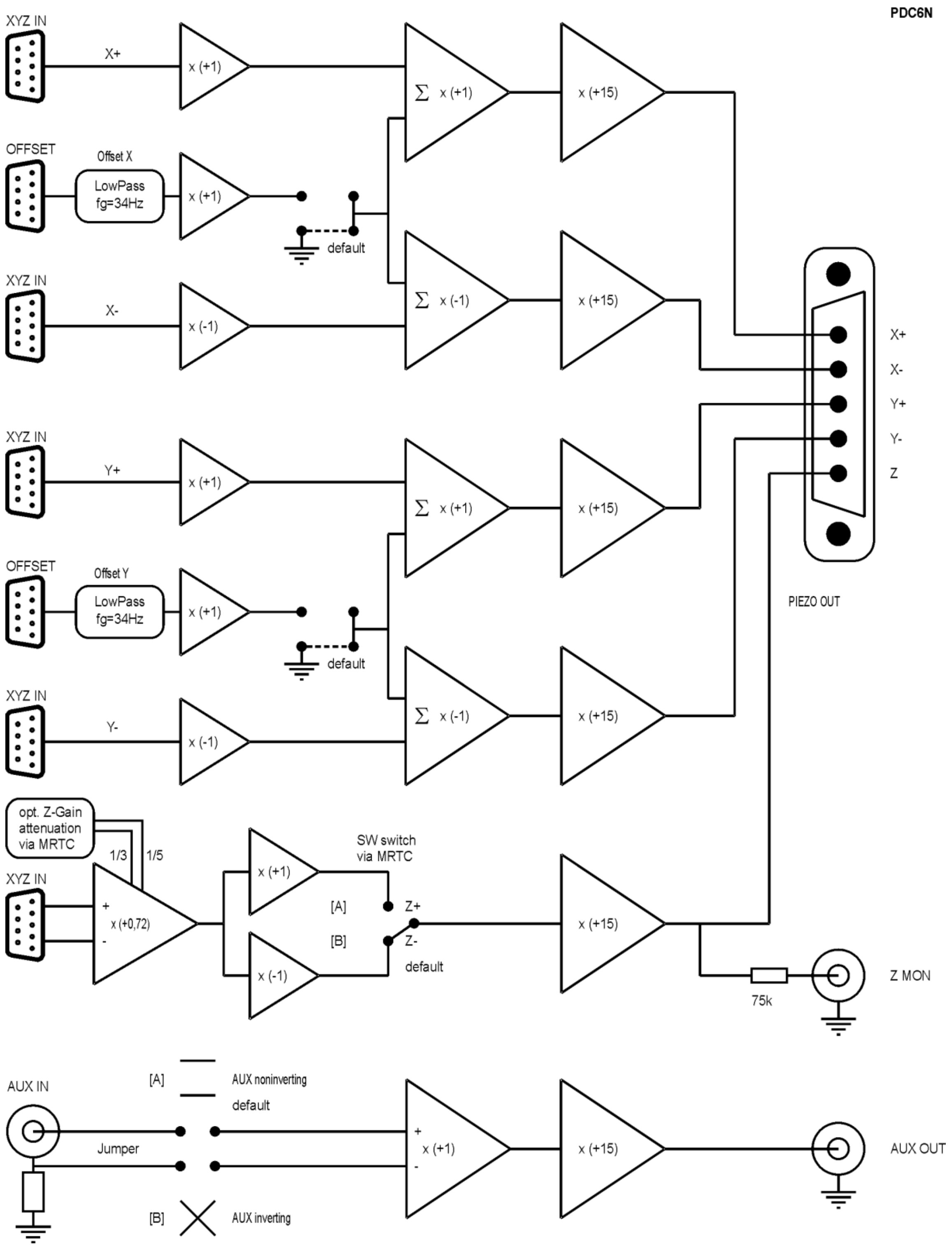


Figure 27: Piezo Driver board layout, schematically.

channel	source	input	gain	polarity control	default	output	connector
Offset X	sub-D1	±9 V	+15	no	deactivated	n/a	
Offset Y	sub-D1	±9 V	+15	no	deactivated	n/a	
+X	sub-D2	±9 V	+15	no		±135 V	sub-D mixed PIEZO OUT
-X	sub-D2	±9 V	+15	no		±135 V	sub-D mixed PIEZO OUT
+Y	sub-D2	±9 V	+15	no		±135 V	sub-D mixed PIEZO OUT
-Y	sub-D2	±9 V	+15	no		±135 V	sub-D mixed PIEZO OUT
Z IN	sub-D2	±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 10. Piezo driver signals.

Notice

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

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

Table 11. Piezo Driver electrical specifications.

PFU - Piezo Filter Unit

The PDC6N may be used together with an PFU box. This filter box is mounted inside the MATRIX rack and is wired in between the PDC6N and its PIC cable. The PFU V1 is a passive filter unit. It has to be disconnected if filtering is not wanted. The PFU V3 can be switched on and off via software.

Figure 28. Piezo filter unit PFU V1.

Electrical Specifications

Channel:	XY	Z	Aux
Bandwidth (-3 dB)	1.3 kHz	2.0 kHz	>100 kHz

Table 12. PDC6N with PFU electrical specifications.

3. MATRIX Input and Mains Switch

In MATRIX the power supply unit is integrated in the control unit. A separate rack module provides a mains socket and switch as well as a grounding/earth stud.

Figure 29. MATRIX mains input.

Notice
Remove dust from the air filters at regular intervals (≈ 6 months) using a vacuum cleaner.

Mains IN Block

An auto ranging mains input supplies the MATRIX CU with power.

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

Figure 30. MATRIX CU mains input.

4. 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 operating menus. A "SPEED" dial allows manual regulation of the coarse motor speed: this dial can be assigned with the step size (*Voltage*) (default for most heads) or with repetition *Frequency* in MATRIX (Coarse Control window, *Dial Selection*). For information on the default settings for the various SPM heads please refer to pages 61ff.

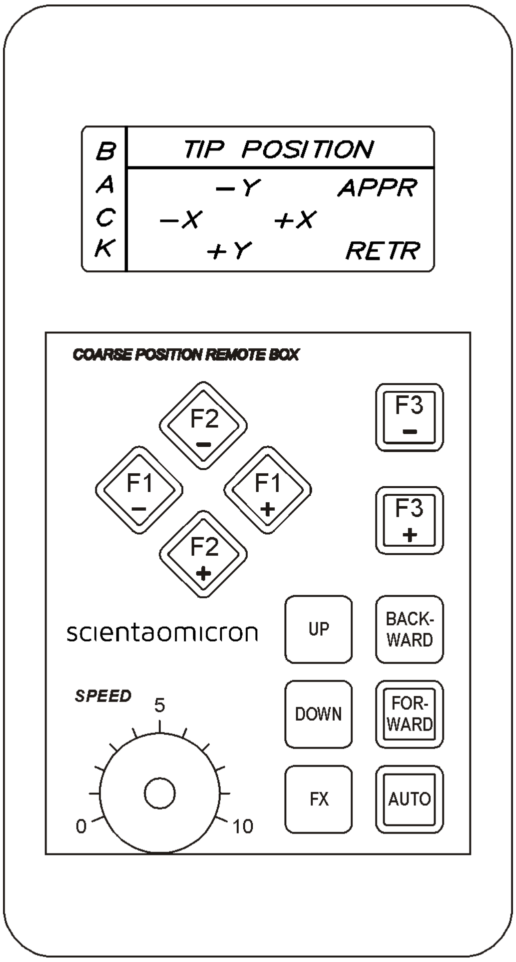


Figure 31. Remote box layout, schematic diagram.

Before you start we recommend that you study the flowchart concerning your specific SPM head, see pages 61 ff. This gives you a short pictorial overview of the functions and scope of the Coarse Position Remote Box.

To use the remote box the MATRIX hardware and software must have been started. The SPM head has normally been configured in factory. The setting can be changed via the *Tools -> Calibrate* menu in MATRIX. The remote box initially comes up with the BACKWARD menu, see below.

> **Notice**
>
> When you receive your Remote Box together with your SPM head there is no need to enter the *Calibrate* menu, since all relevant parameters have already been configured at Scienta Omicron.

Attention

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

All operating menus have a similar display structure, see figure 32.

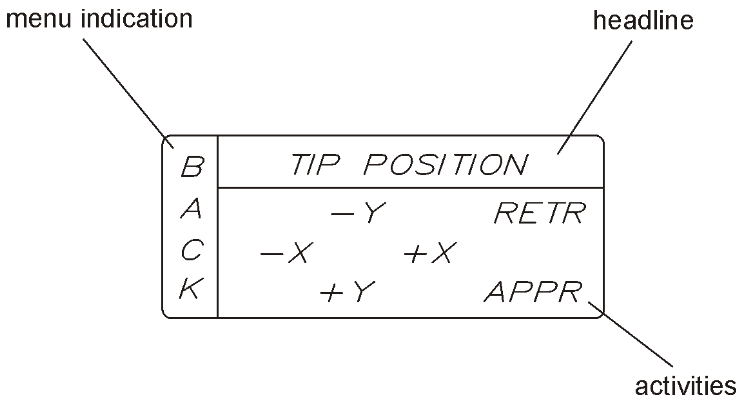


Figure 32. Operating menu display structure. VT STM/SPM version shown as example.

- 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 32 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.

Notice

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.

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

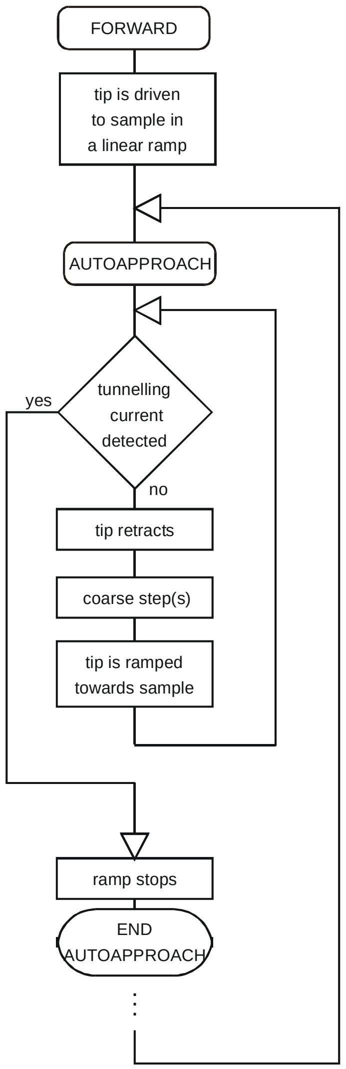


Figure 33: Flowchart diagram of STM auto approach logic.

5. HC 1100

HC 1100 Front and Back Panels

Application:	VT DH / VT DRH

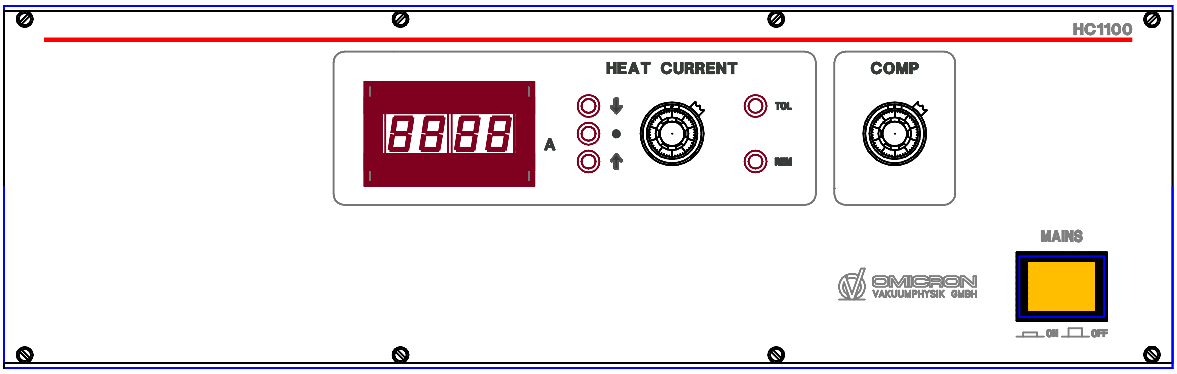
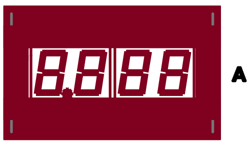
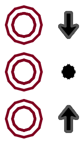
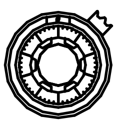
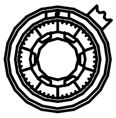
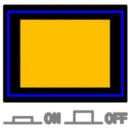


Figure 34. HC 1100 front panel layout, schematic diagram.

	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.

COMP 	Ten-turn potentiometer to set the compensation voltage V_{comp} relative to the heating voltage. When tunnelling on a uniform sample this potentiometer sets the parameter ℓ_x/ℓ_{sample}, see page 56.
MAINS 	Power supply switch. Press to switch the unit on, press again to switch off.

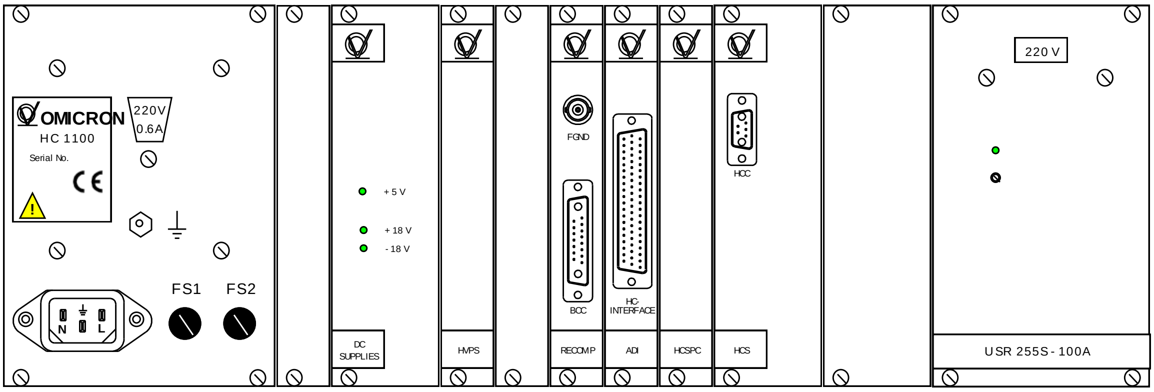
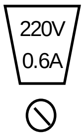
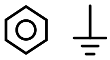
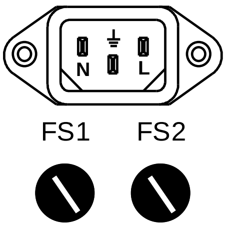
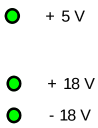
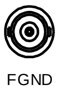
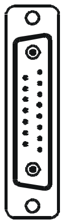
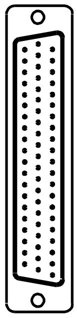
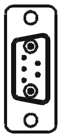


Figure 35. HC 1100 back panel layout, schematic diagram.

	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 60. **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 54.

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).

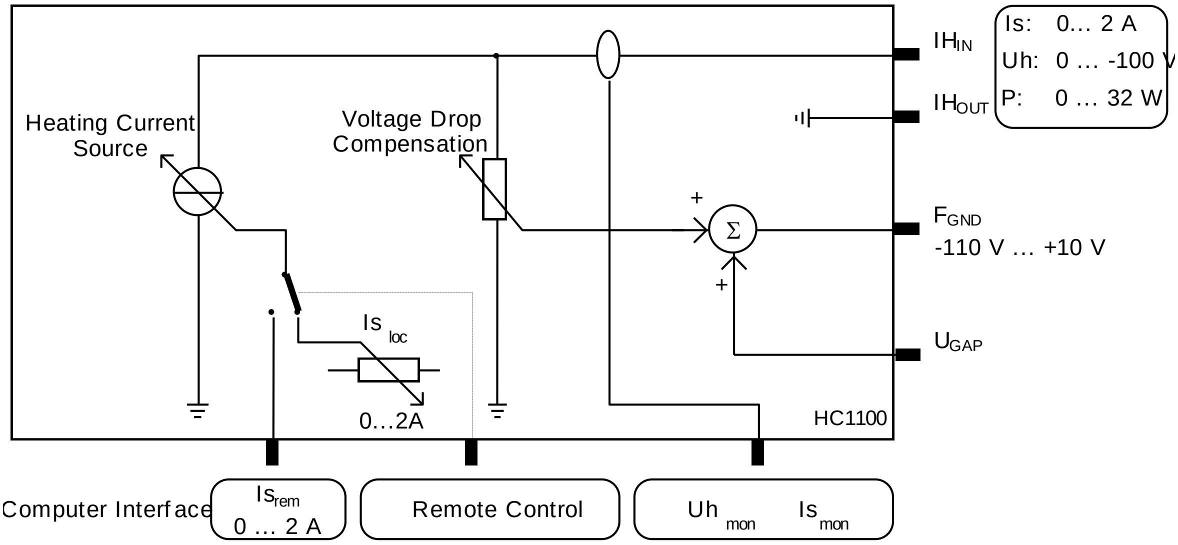


Figure 36. HC 1100 schematic circuit diagram.

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

$$V_{gap}^{eff} = V_{gap} + V_H \cdot \frac{\ell_x}{\ell_{sample}} + V_{comp}$$

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.

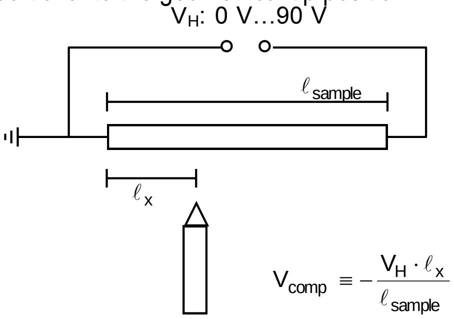


Figure 37. Voltage compensation for the VT DH version.

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)

6. 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.

7. 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.

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

- V_{comp} has not been evaluated correctly.
- The tunnelling area has been shifted macroscopically.
- The sample has a very high resistance, see page 57.

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.

8. Fuses Listing

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

Mains Supply Unit Fuses

Mains Input	F1	F2
auto ranging	2.5 A T	2.5 A T

Table 13. Mains supply unit: 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 14. HC 1100 USR 255S-100A: fuse. This fuse sets the operating voltage for the SNT.

9. Remote Box Instrument Configurations

For every Scienta Omicron instrument that can be controlled with the remote box there is a specific instrument configuration. These can be selected via the *Tools -> Calibrate* menu in MATRIX.

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 15. AFM/STM remote box settings, default values underlined.

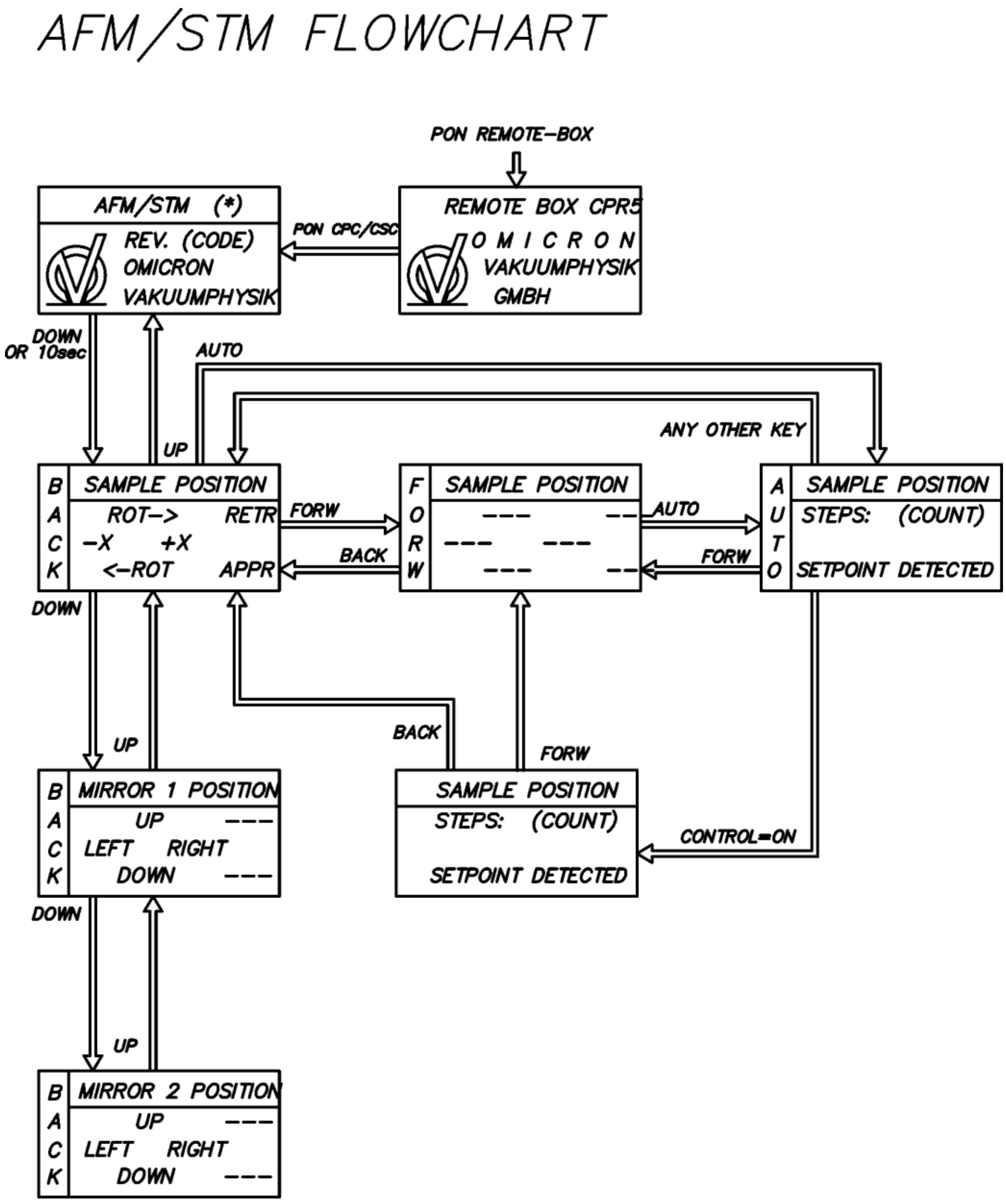


Figure 38. AFM/STM remote box flow chart.

LS SPM

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 16. LS SPM settings, default values underlined.

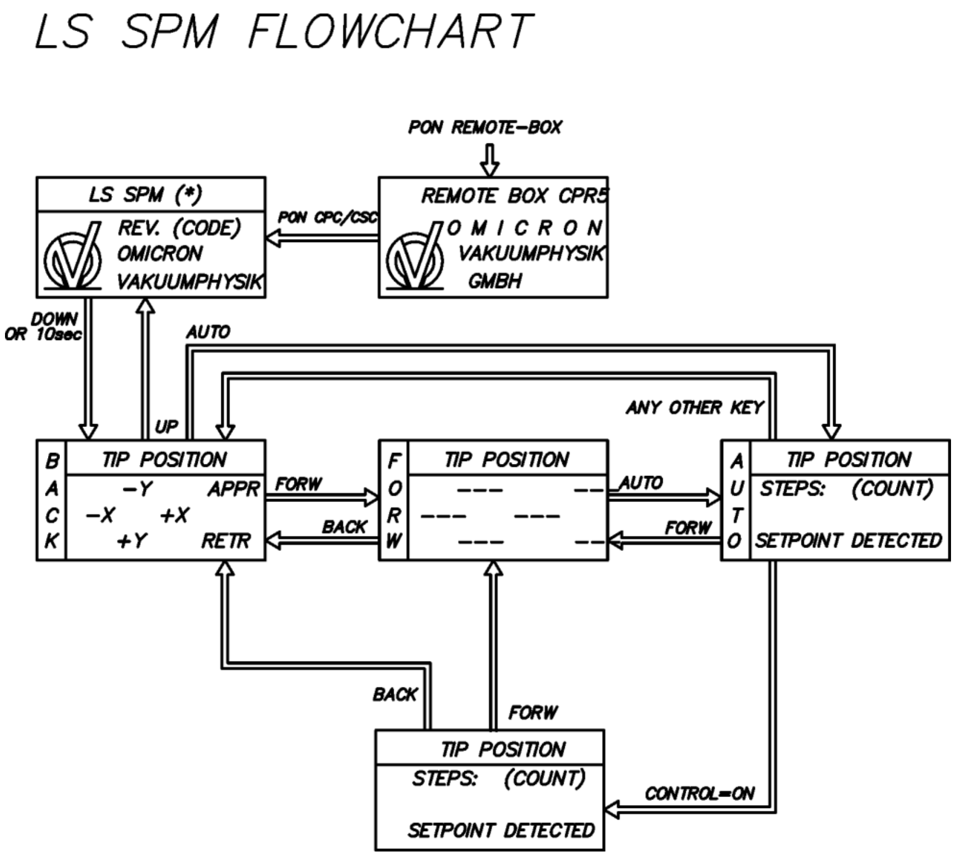


Figure 39. LS SPM flowchart.

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 17. LT STM remote box settings, default values underlined.

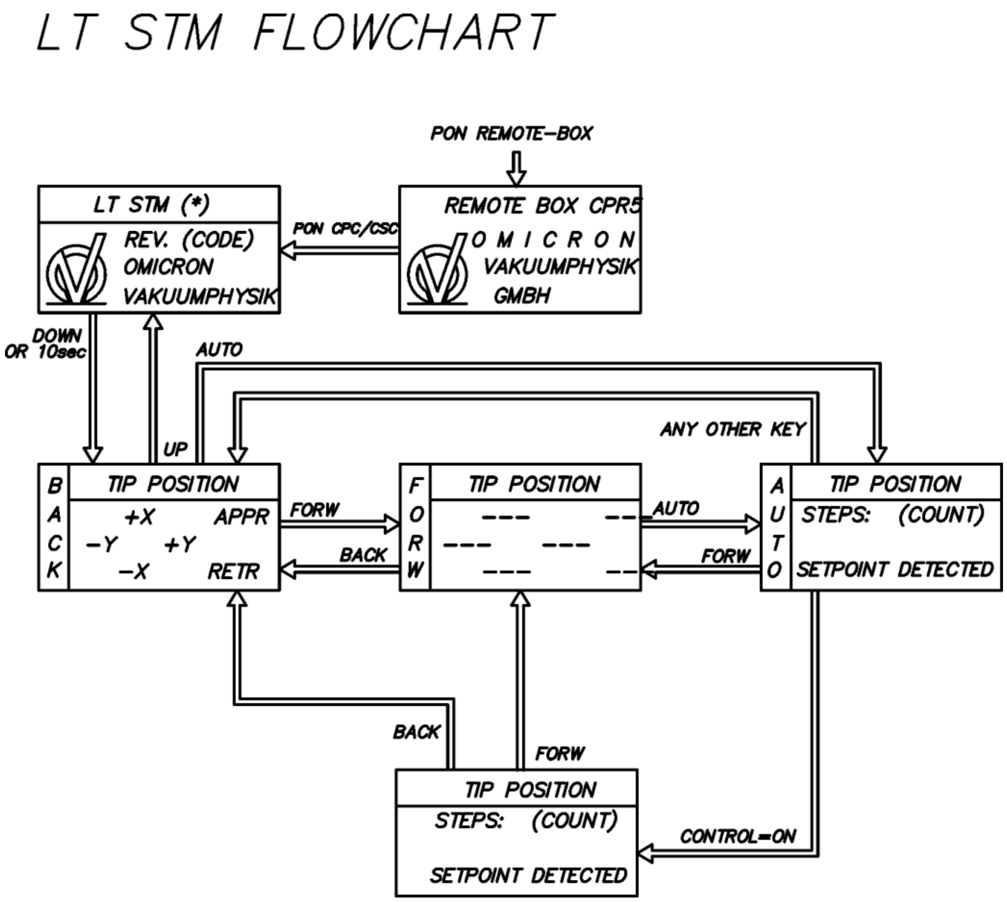


Figure 40. LT STM flowchart.

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 18. MICRO STM remote box settings, default values underlined.

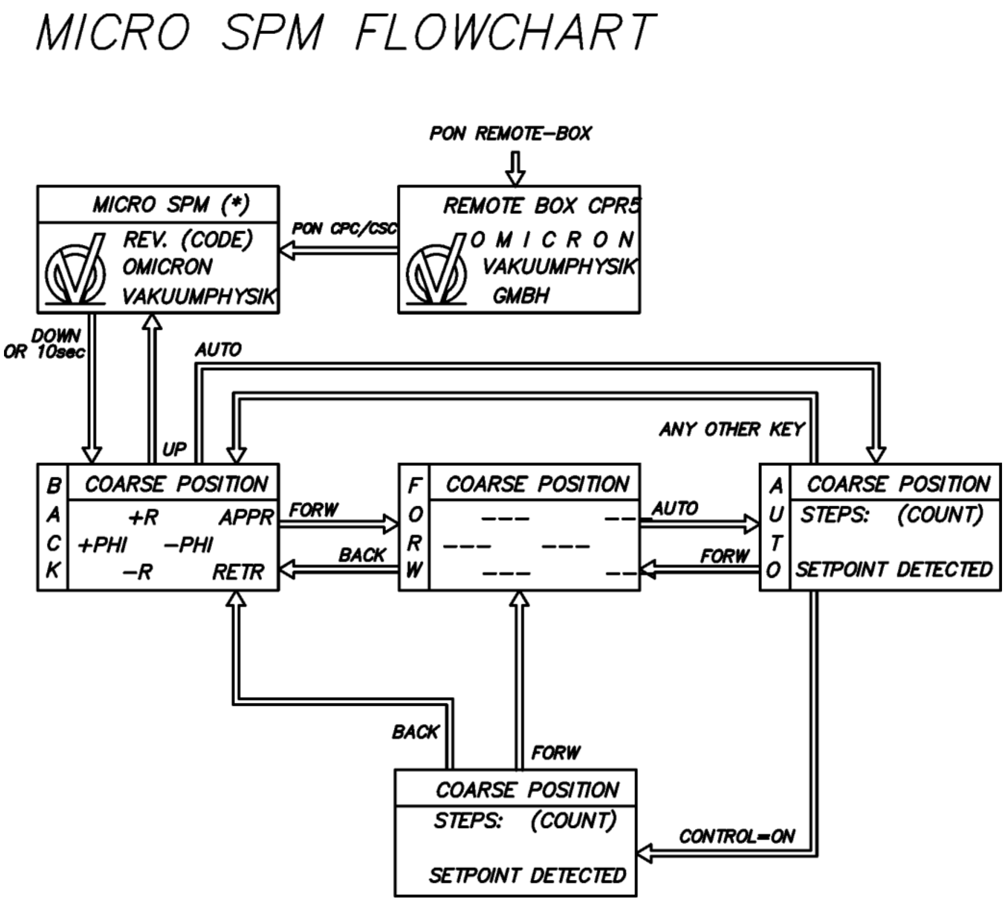


Figure 41. MICRO SPM flowchart.

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 19. STM/SEM remote box settings, default values underlined.

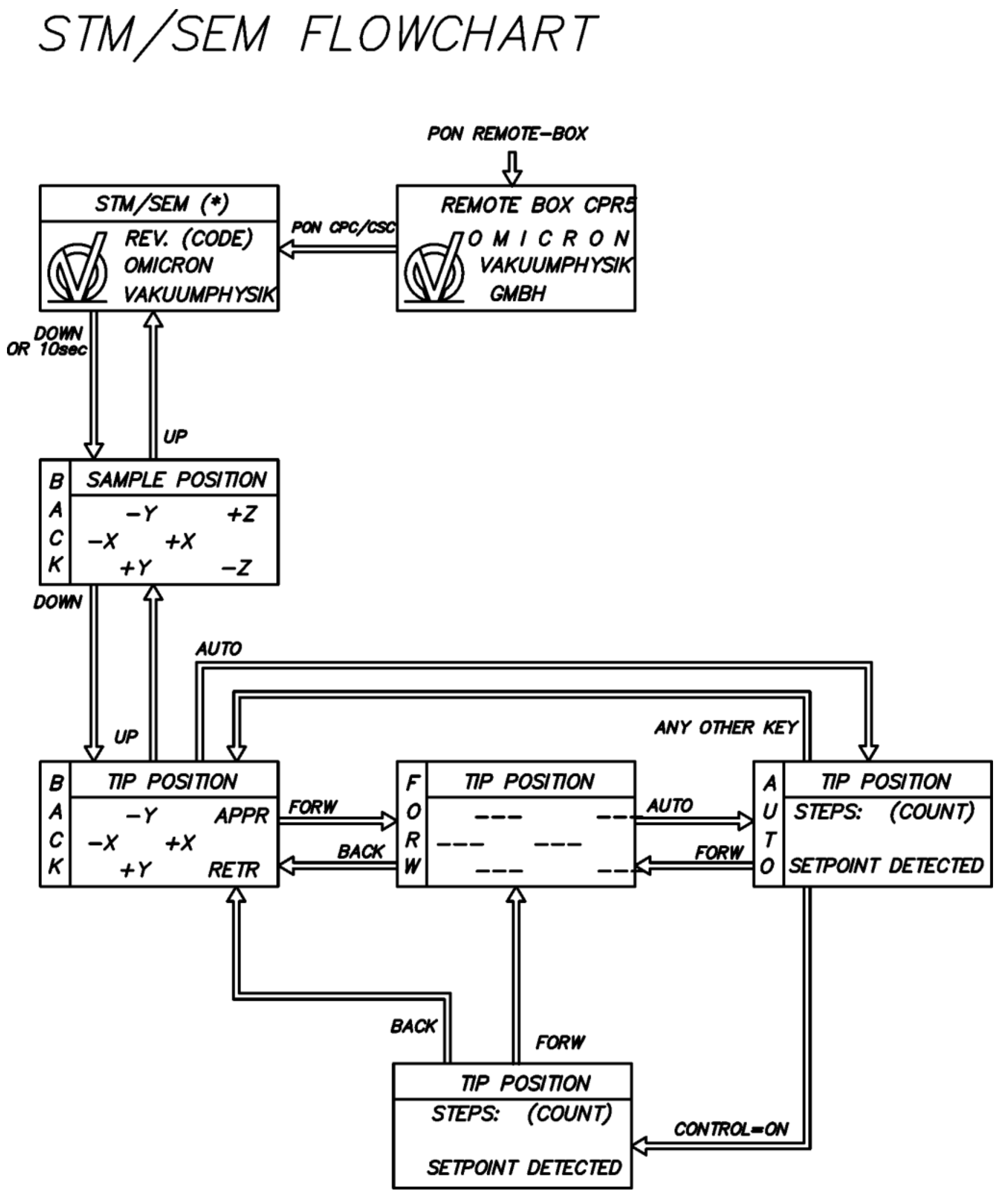


Figure 42. STM/SEM flowchart.

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 20. STM 1 remote box settings, default values underlined.

STM1 FLOWCHART

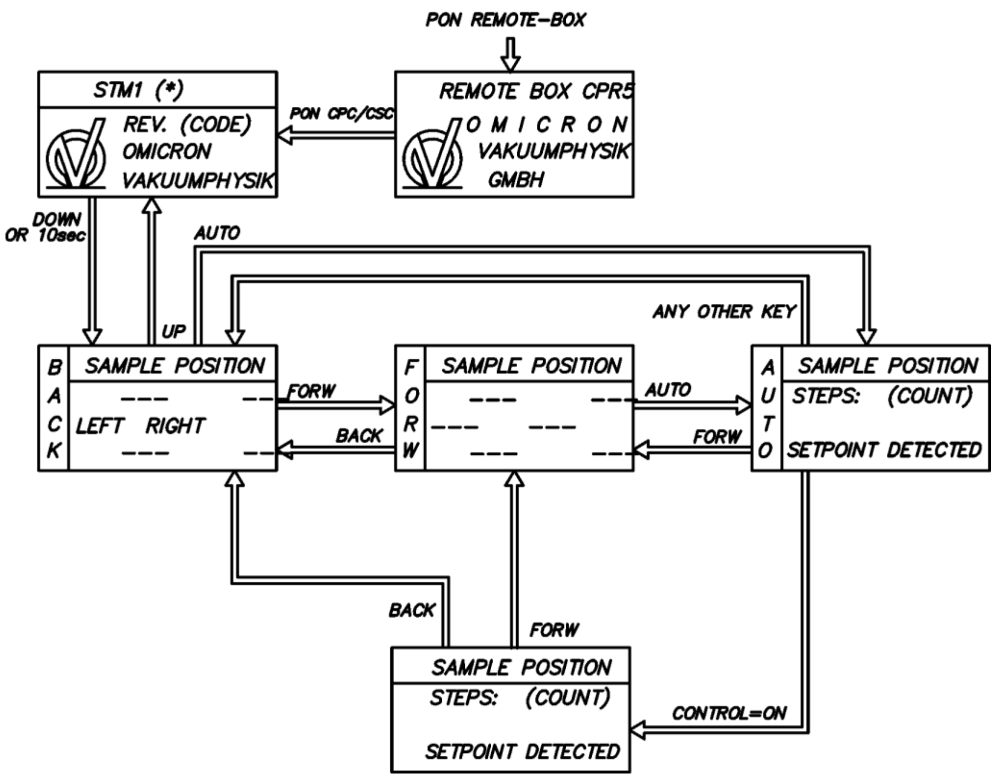


Figure 43. STM 1 flowchart.

VT AFM

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 21. VT AFM remote box settings, default values underlined.

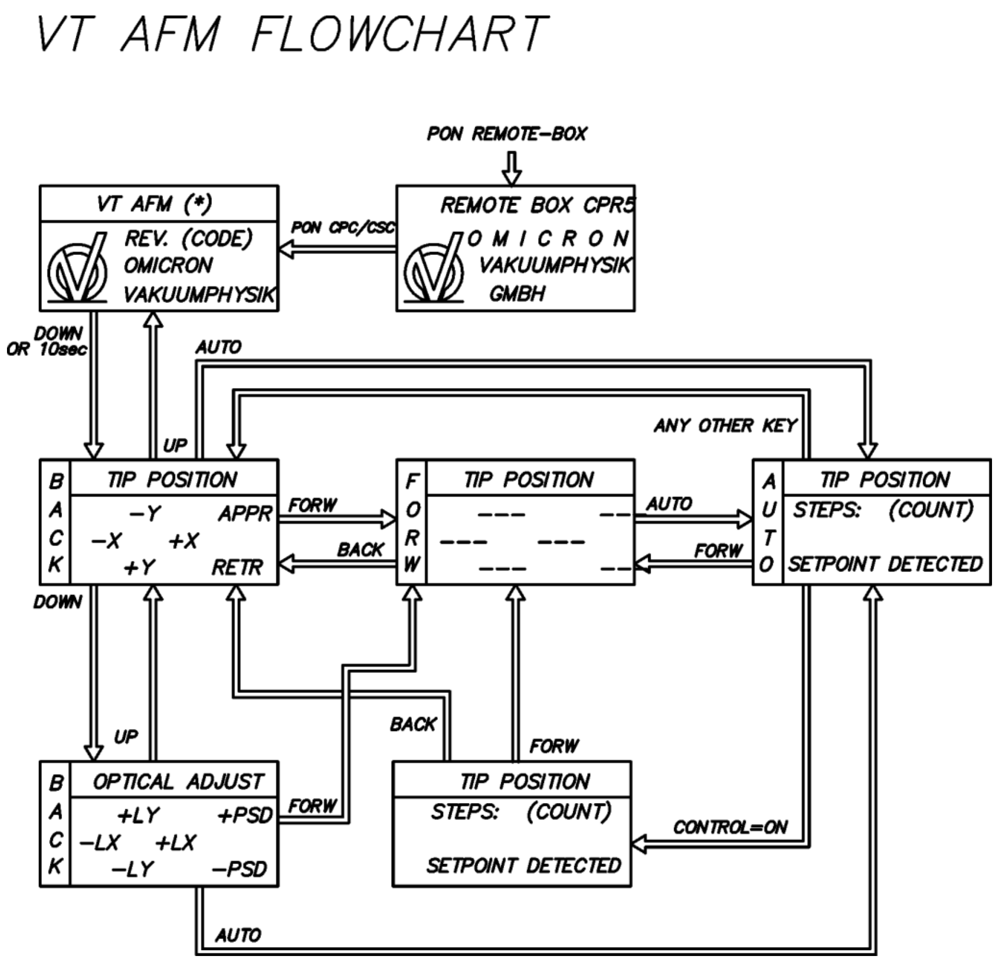


Figure 44. VT AFM flowchart.

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

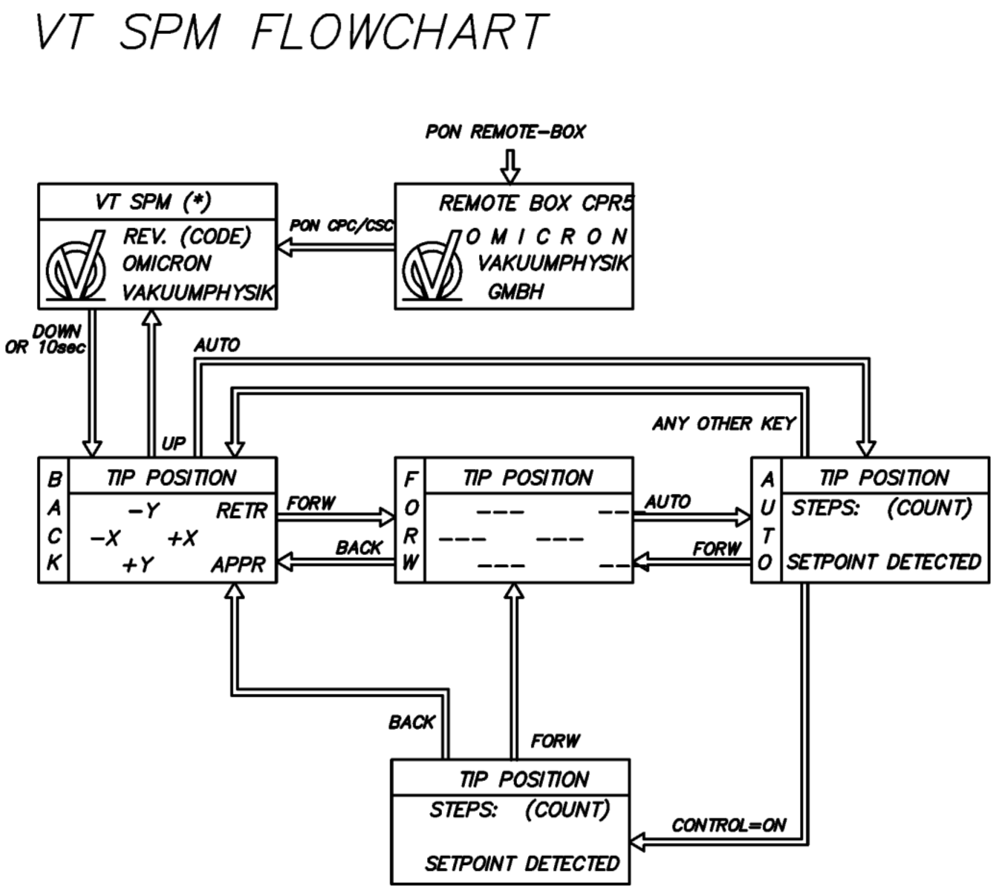


Figure 45. VT STM flowchart.

10. Appendix

Scienta Omicron Scanners

The following table gives an overview of some of the Scienta 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.

Notice

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 23. Scienta 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.

MATRIX CU:	500 VA
HC 1100	100 VA

Table 24. Power Consumption of the various control units.

Coarse Cable Adaptation

For non-Scienta 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 Card.

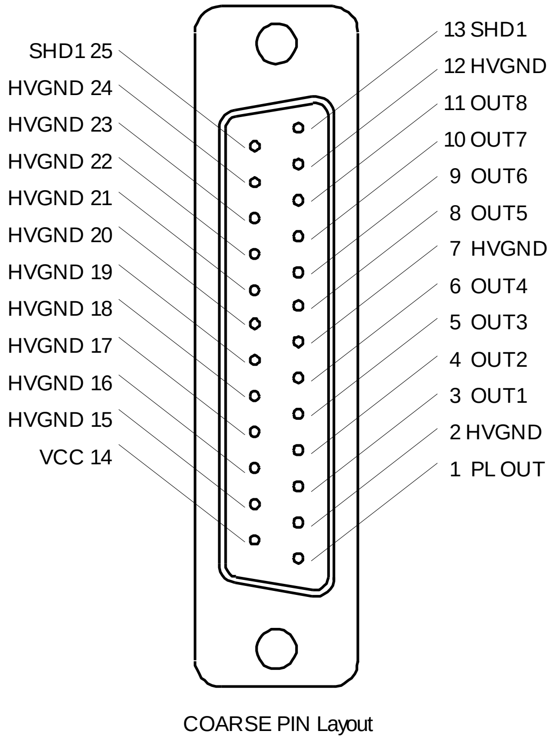


Figure 46. Coarse socket pin layout. For signal-channel reference please refer to the remote box settings tables.

Notice

The normal coarse connection uses the upper connector labelled "COARSE 1-8".

Caution

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 25. Signal forms employed for the different Scienta Omicron SPMs. For signal forms "A" and "B" please see figure 47.

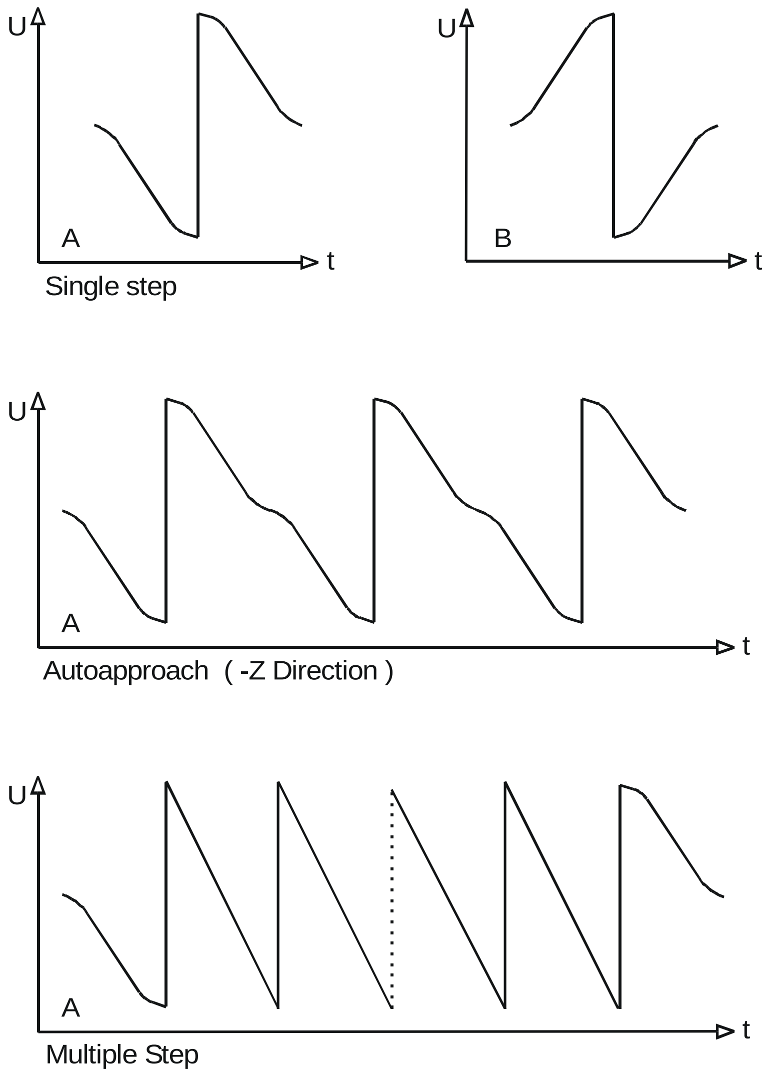


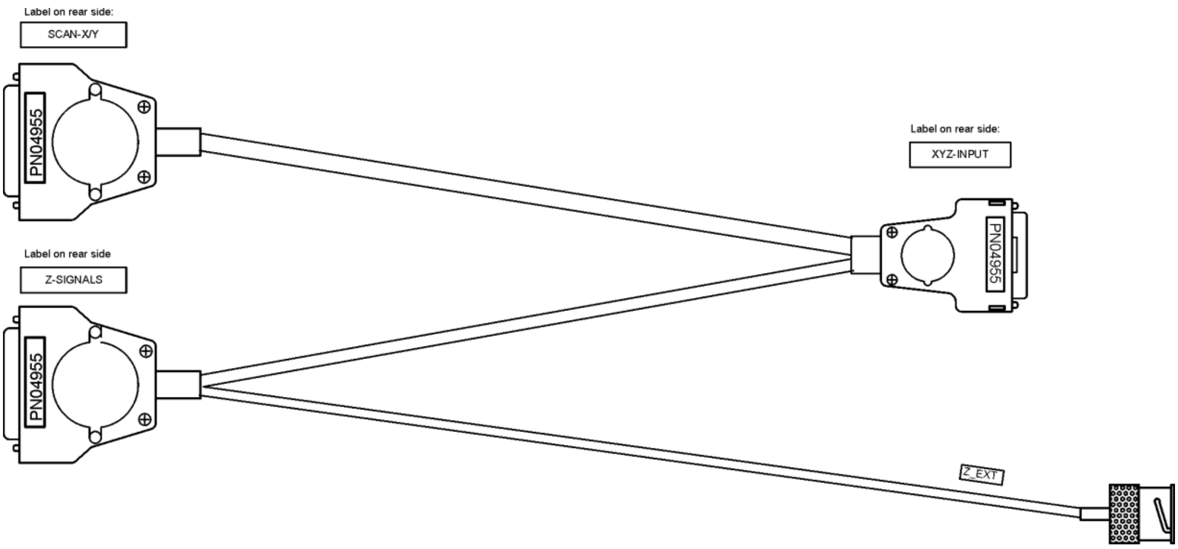
Figure 47. Signal forms of the coarse output channels OUT1 to OUT8.

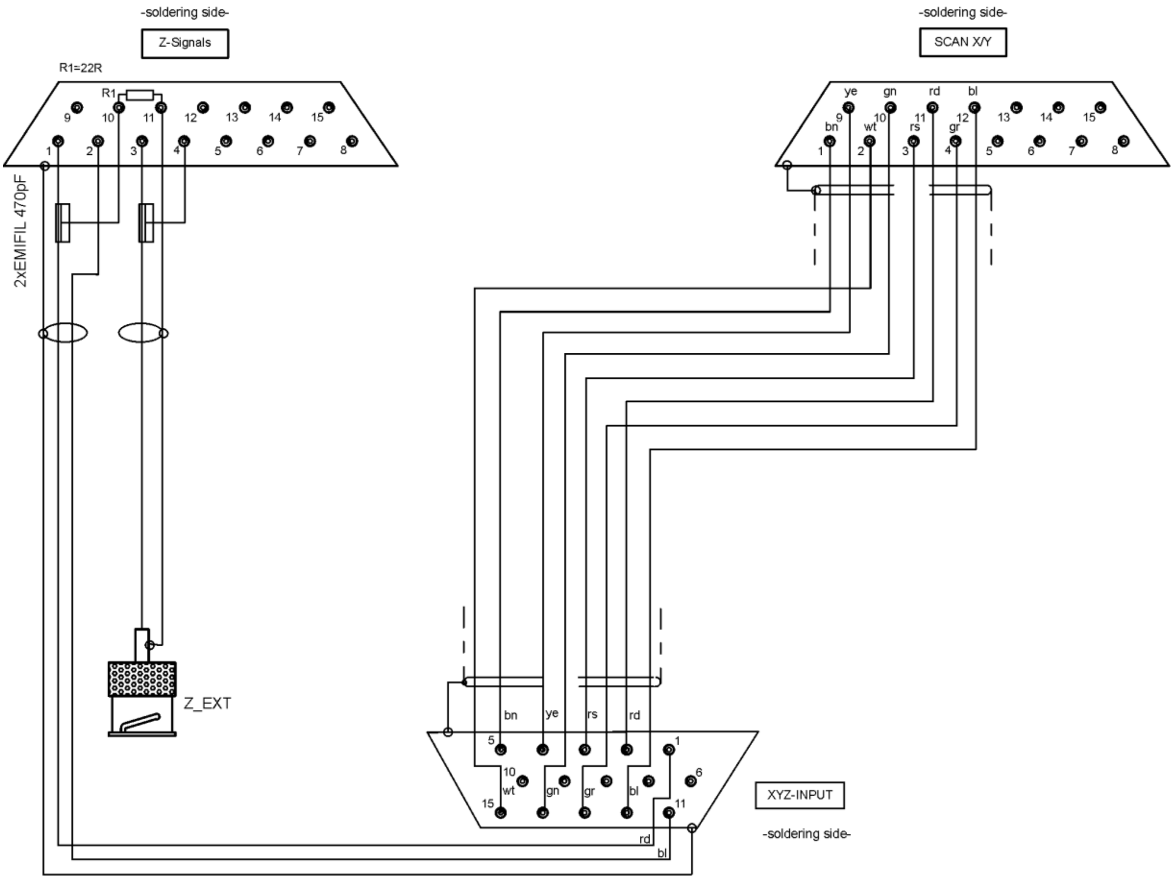
Notice

Signal forms A and B are used for different directions in the various Scienta Omicron scanning probe microscopes, see table 25. The AUTOAPPROACH procedure is a series of single steps, whereas holding down the button generates a sawtooth voltage.

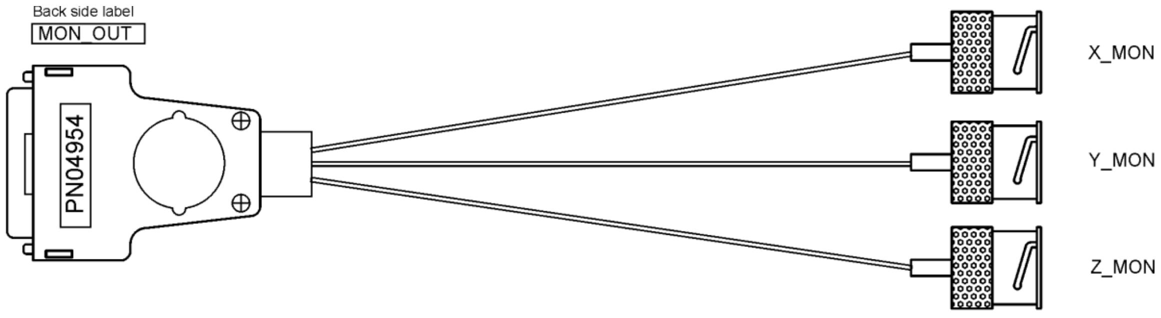
MATRIX Cables

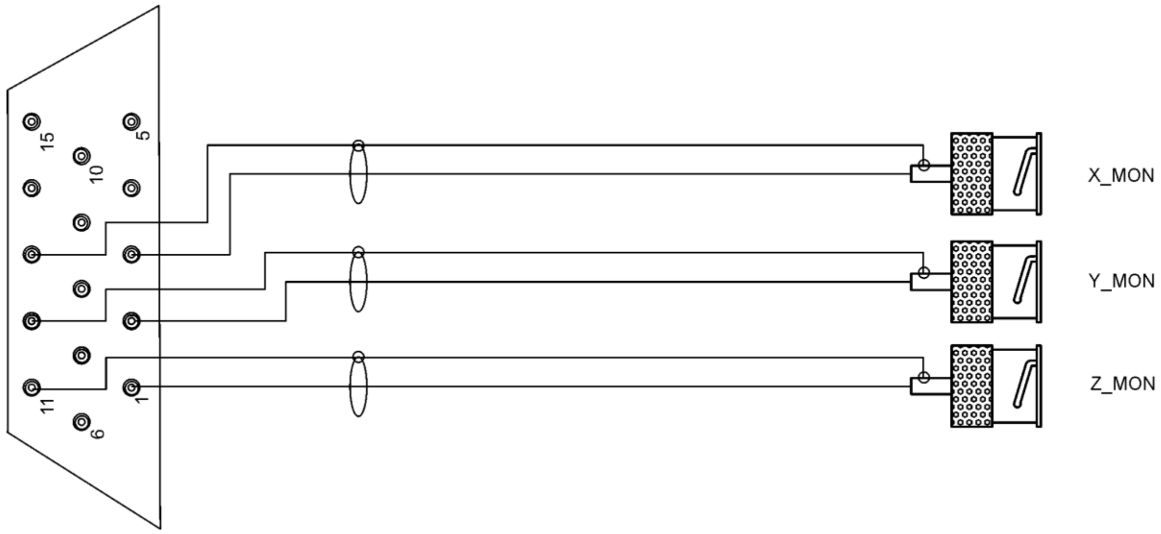
PN04955 Cable SASS & SCAR to PDC6N



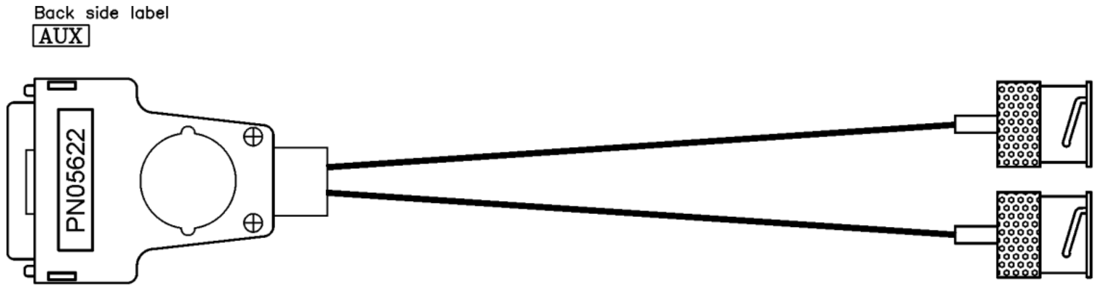


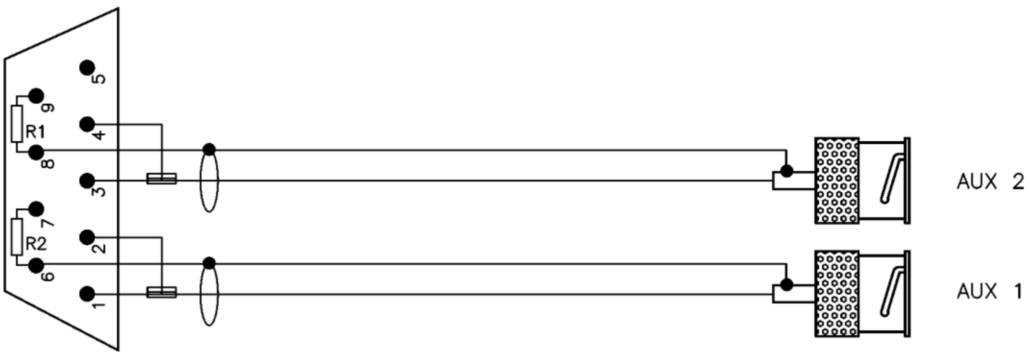
PN04954 Cable XYZ-Monitor-Signals



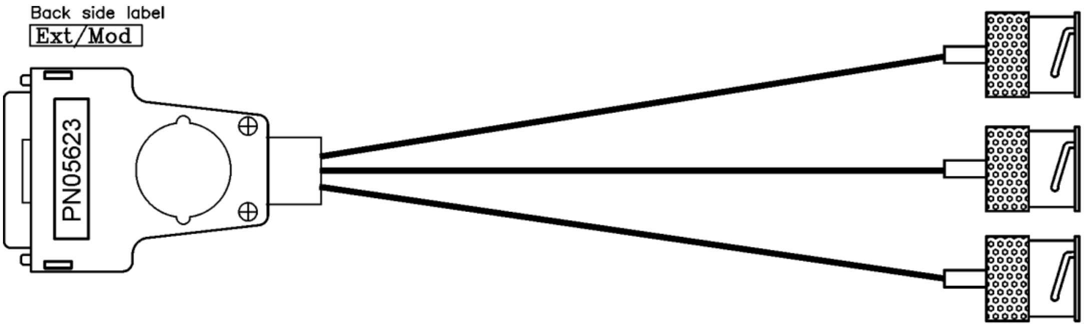


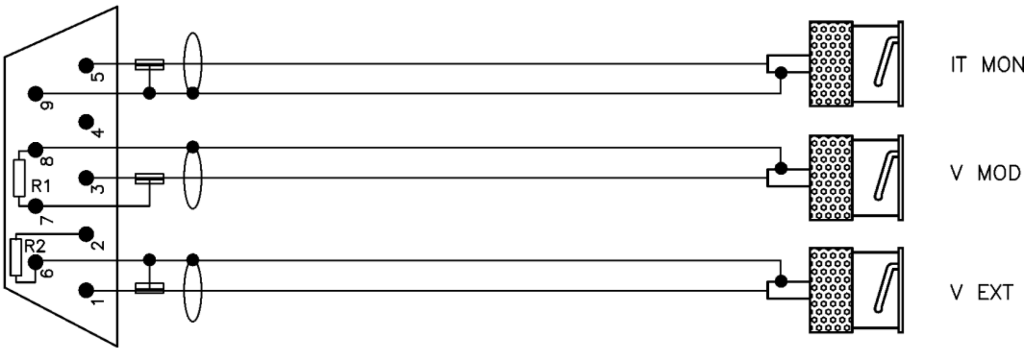
PN05622 Cable AUX SCAR



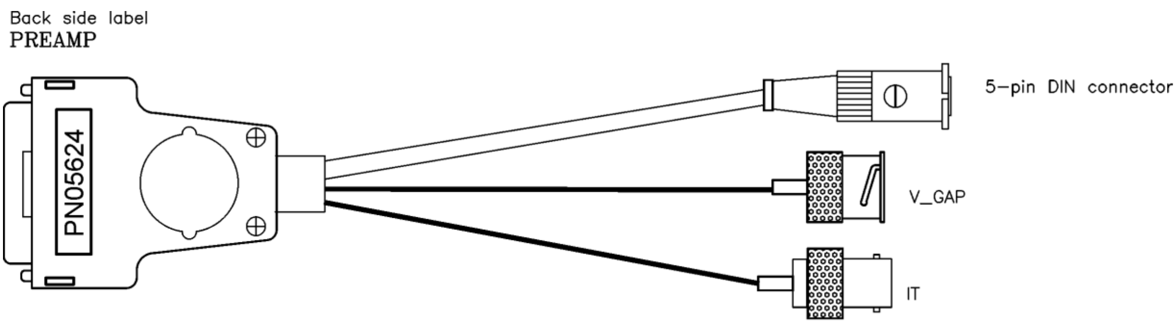


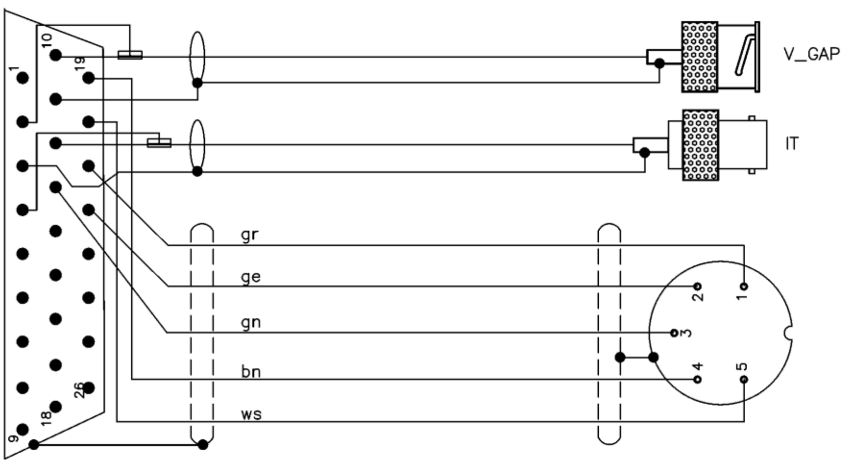
PN05623 Cable EXT/MOD SCAR





PN05624 Cable PREAMP SCAR





Service at Scienta Omicron

Should your equipment **require service**

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

  http://www.scientaomicron.com/

- 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 Scienta Omicron**

- Please contact **Scienta 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.

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