Elekta Neuromag

Elekta Neuromag® System Hardware

Technical manual

Revision F

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ELEKTA

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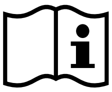
Contents

List of symbols

The following symbols are used in the system and in the manuals. Familiarize yourself with each symbol and its meaning before operating this system.

Caution, consult accompanying documents. Parts of the system are marked with this symbol when it is necessary for the user to refer to important operating and maintenance instructions given in the manuals accompanying the system. In the manuals, it also calls attention to specific instructions. These instructions may contain procedures, practices, conditions or the like which must be correctly performed or adhered to in order to ensure safe operation and to avoid damage to the patient, operator, or the system.



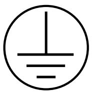
Consult instructions for use. Parts of the system are marked with this symbol when it is necessary for the user to refer to important operating and maintenance instructions given in the manuals accompanying the system. In the manuals, it also calls attention to specific instructions. These instructions may contain procedures, practices, conditions or the like which must be correctly performed or adhered to in order to ensure correct operation and/or increased safety and to avoid damage to the system.

Type BF (body floating) equipment symbol. The applied parts (parts in direct contact with the person being investigated with the system) and the type plate are marked with this symbol to indicate that they fulfill the leakage current requirements of the safety standard IEC 60601-1).

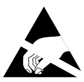
~ Alternating current (power line) symbol.

| On (power line) symbol.

○ Off (power line) symbol.



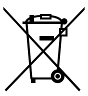
Protective ground (earth) terminal symbol. Used to identify terminals which are intended for connection to an external protective conductor for protection against electrical shock in case of a fault, or to the terminal of a protective ground (earth) electrode.



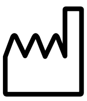
Static electricity symbol. The parts of the system marked with this symbol indicate the presence of components susceptible to static electricity and require the use of antistatic techniques. See *Elekta Neuromag System Hardware: User's Manual*.

Magnetic objects and devices symbol. The use of these symbols in the vicinity of the probe unit indicate that magnetic objects or devices may cause disturbances in the operation of the system; they should therefore be avoided. See *Elekta Neuromag System Hardware: User's Manual*

Non-ionizing radiation, RF transmitter. Marking on equipment or equipment parts that include RF transmitters or that intentionally apply RF electromagnetic energy.



Separate collection of waste electrical and electronics equipment (WEEE) necessary (European Union directive 2002/96/EC on WEEE)



Date of manufacture: year (four digits) followed by month

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CHAPTER 1 Technical data

1.1. The probe unit

1.1.1. General

- Number of MEG channels: 306 channels
- Sensor coverage: whole cortex, 1220 cm^2
- Measurement positions: supine, upright
- Minimum room height required: 2.3 m
- Dimensions and weights: see chapter 2

1.1.2. Sensors

- Type of sensors: 102 identical plug-in triple-sensor-units with two orthogonal planar gradiometer flux transformers, one magnetometer flux transformer, and three dc-SQUIDs (Superconducting Quantum Interference Devices).
- Field components: B_z, $\partial B_z/\partial x$ and $\partial B_z/\partial y$
- Sensor distance from the outside helmet surface of the dewar: average 18 mm
- Material and construction of dc SQUIDs: all-refractory thin-film structures on silicon
- Average triple-sensor-unit spacing: 34 mm
- Size of gradiometers and magnetometers: 28 mm $\times$ 28 mm
- Type of SQUIDs: dc SQUIDs
- Material and construction of gradiometers and magnetometers: all-refractory thin-film structures on silicon
- Base length of gradiometers: 17.0 mm
- Effective total surface area of each oppositely wound gradiometer coil: 2.7 cm^2 and for the magnetometer coils 7.6 cm^2.
- RF interference suppression: integrated *RC*-shunts.
- Low frequency interference suppression: with hardware and computational compensation.
- Integrated heater elements for de-trapping.
- Balance: better than 10^{-3} for gradiometers.

Noise performances for all operational channels are the following:

- Gradiometer noise (white noise, 60Hz < f < 70Hz): max. 5 fT/(cm $\sqrt{Hz}$) for 96% of channels, max. 10 fT/(cm $\sqrt{Hz}$) for all gradiometer channels
- Magnetometer noise (white noise, 60Hz < f < 70Hz): max. 5 fT/$\sqrt{Hz}$ for 96% of channels, max. 10 fT/$\sqrt{Hz}$ for all magnetometer channels
- Gradiometer noise (low frequency, 1Hz < f < 2Hz); max. 12 fT/(cm $\sqrt{Hz}$) for 96% of channels, max. 20 fT/(cm $\sqrt{Hz}$) for all gradiometer channels
- Magnetometer noise (low frequency, 1Hz < f < 2Hz); max. 12 fT/$\sqrt{Hz}$ for 96% of channels, max. 20 fT/$\sqrt{Hz}$ for all channels

1.1.3. Probe unit construction

- Wiring unit: printed circuit board plates, a flexible support tube and a support shell onto which the triple sensor elements are mounted with connectors. Twisted pairs between the dc-SQUIDs and the printed circuit boards on the top of the wiring unit where the components for the dc-SQUID gain control reside.
- Connection wiring: flexible cable assembly from the printed circuit boards to the top flange
- Top flange: preamplifiers and connectors for the cables to the electronics unit
- liquid He-level probe: integrated, superconducting
- Helium siphon: fixed, connects to a flexible part used in transfers
- Thermometers: two Pt-thermometers for monitoring the cool-down and warm-up of the system

1.1.4. Dewar

- Lower end: helmet-shaped
- Shape of the helmet is based on the EN960:1994 standard
- Circumference of helmet outside surface: 629 mm
- Maximum length of the helmet opening: 222 mm
- Maximum width of the helmet opening: 181 mm
- Maximum inside height of the helmet: 210 mm
- Distance from the surface at liquid helium to the outer room temperature surface against the subject’s head: typically 18 mm
- Thermal radiation shielding: superinsulation and a thermally anchored shield
- Material of construction: fiberglass composite
- Total volume of Helium 78 liters

- Boiloff rate of liquid Helium: max. 8 liters per 24 hours
- Exhaust of Helium gas due to liquid Helium boiloff (+20 °C, normal operation at atmospheric pressure): typ. 4 liters per minute
- Helium transfer equipment: see 1.9 below
- Monitoring of the liquid Helium level: integrated sensor and readout electronics
- Separate local liquid Helium level display integrated inside the gantry for follow-up during the transfer
- Automatic helium level data gathering to the computer system
- Relief valve opening pressure: 10 kPa (0.1 bar)
- Safety exhaust rupture pressure: 60 kPa (0.6 bar)
- Safety exhaust duct diameter: 60 mm

1.2. Gantry, bed, and chair

1.2.1. Gantry

- Principal material of construction: fiberglass composite
- Measurement positions: upright (helmet tilted 30° from vertical), supine (helmet tilted 180° from vertical)
- Dewar movements: Two fixed positions. User controlled up- and down-buttons and manual latch bar.
- Movement mechanism: Motor-driven rope, controlled by push-buttons at gantry. Positions secured by safety latches at upright position and mechanical stoppers at supine position. Motor located outside the shielded room. Position indicator display inside the magnetically shielded room.
- Input power: 230 V~ 47–63 Hz. Separate portable step-up transformer if necessary
- Separate docking plate for bed
- Dimensions and weights: see chapter 2
- Side covers under which connectors of auxiliary electronics, EEG, and the local liquid Helium level display
- Cover of the refill opening including a plug for the fixed siphon

1.2.2. Bed

- Principal material of construction: fiberglass composite
- Method of operation: manual, mechanical
- Movement of lower bed: front/back, turning wheels
- Movement of upper bed: front/back

- Movement mechanism: Bed on wheels. Push/pull by hand. Wheels provided with locks. Upper part can be locked in place.
- Removable head rest
- Movement range of the upper bed: 300 mm
- Dimensions and weights: see chapter 2.

1.2.3. Chair

- Principal material of construction: fiberglass composite
- Method of operation: manual, mechanical, hydraulic
- Movement of chair: front/back; movement of seat: up/down
- Vertical movement mechanism: chair on wheels, push/pull by hand using a handle
- Up/down movement range: 320 mm
- Horizontal movement mechanism: Elevation pedal to raise the seat, release pedal to lower the seat.
- Dimensions and weights: see chapter 2.
- Leg rests that can be elevated
- Removable table

1.3. MEG and EEG Electronics

1.3.1. General

The MEG electronics can be divided in the following blocks:

- Preamplifiers inside of the probe unit
- Feedthrough RF filters inside the filter unit
- Control/power feedthrough filter inside the filter unit
- Main electronics racks and real-time data acquisition computers in the VME rack inside the main elecronics cabinet

The EEG system comprises 64 channels, optionally expandable to 128 channels. The electronics is divided into following blocks:

- Preamplifier unit inside the probe unit, including built-in electrode interface
- Optoisolation/feedthrough filter inside the filter unit
- Isolated power supply inside the filter unit
- Control/nonisolated power feedthrough filter inside the filter unit
- EEG main electronics rack in the main electronics cabinet (data acquisition computers common with MEG electronics

For block diagrams and schematic diagrams see Chapter 3.

1.3.2. MEG preamplifiers

- Preamplifiers for MEG channels inside the shielded room on top of the dewar
- SQUID tuning: by an automatic program or manually
- 12 channels on each preamplifier board, connected to a preamplifier motherboard on top of the Dewar top flange
- Flux locked loop operation, controller on main electronics board
- MEG preamplifier based on amplifier noise cancellation
- Integrated heater (detrapping) control in preamplifiers
- Control bus for setting the operating points of the front-end electronics
- User-controlled parameters: bias, offset, amplifier noise cancellation
- No digital traffic during measurement
- Powering: from a single power supply inside the main electronics cabinet via control/power feedthrough unit

1.3.3. EEG preamplifiers

- 8 channels/board, all channels having internal differential input
- 4 preamplifier boards connected to one preamplifier frontplane, 32 channels/frontplane. First 32 channels are always connected as unipolar (also referred as single-ended), using common buffered reference from reference electrode connected to minus input of the preamplifier. Each following group of 32 channels has 28 channels connected as unipolar (single-ended) and 4 channels that can either be connected as bipolar (also referred as differential) or unipolar (requires corresponding cabling in electrode interface)
- 8 boards connected to a preamplifier backplane
- For 64 channels one and for 128 channels two backplanes are utilized, both accommodated by a single subrack
- Noise < 0.4 µVrms (0.1 – 100 Hz), measured with a 10 kΩ impedance across the input
- Input impedance > 100 MΩ
- Software-controlled gain 30/100/1000 of the preamplifier itself, selectable individually for each channel. The optoisolation/feedthrough filter (see 1.3.5) has an additional fixed gain of 5, making the total gain 150/500/5000.
- Common-mode rejection ratio 100 dB (with active ground)
- Amplifier stable for electrode impedances up to 50 kΩ. However, to minimize low-frequency noise, electrode impedances below 20 kΩ (below 10 kΩ for optimum performance) are recommended.

- Test oscillator for testing the channels and for measuring the electrode impedances
- Test oscillator frequency selectable at 20 Hz or 200 Hz
- Test oscillator output amplitude selectable 100 mV_{pp} or 1 mV_{pp} (without load; with 1-MΩ signal terminators the signal coupled to the input of the channels is approximately 49 mV_{pp} or 490 μV_{pp})
- Test oscillator can be connected individually to each channel with the help of software-controlled analogue switches
- Analog high-pass filter cut-offs dc / 0.03 Hz / 0.1 Hz / 10 Hz (–3 dB corner frequency), selectable individually for each channel by software
- Fixed analog low-pass 10 kHz
- Preamplifier dc input offset range ±350 mV
- In dc mode, largest input offset that can be compensated for is ±160 mV
- Leakage currents comply with class BF (body floating) devices according to IEC60601-1
- Buffered reference input
- Active grounding (at frequencies greater than 5 Hz) for increased common-mode rejection
- Channels can be deactivated by software
- No digital traffic during measurement
- Powered from an isolated power supply

1.3.4. Electrode interface

Electrode interface panel

- On the side panel of the gantry
- D37 connectors for electrode caps
- Electrode sockets for bipolar EEG channels, reference electrode (REF), and ground driver (GND)

Elecrode cap:

- Made of flexible fabric
- Fabric withstands repeated washing and chloriding, fast-drying
- Fitted with 60 Ag/AgCl sintered electrodes (standard)
- Electrode wires equipped with female D37 connectors
- Other electrode configurations available upon request or delivered in kit form for end-user made configuration
- Available in three sizes
- Electrode support height 3 mm, diameter of opening 6 mm

- Fully MEG-compatible
- Bridging with EEG paste, skin preparation with liquid gel

Electrode headbox:

- 32 unipolar channels for single electrodes
- Passive
- Electrode sockets for reference electrode (REF) and ground driver (GND)
- D37-connector for cable to electrode interface panel in gantry

1.3.5. Filter unit

MEG feedthrough RF filter

- 12 channels / board
- bidirectional (preamplifier output / flux-locked loop feedback)
- dc coupled
- Cut-off frequency (– 3 dB point) approximately 100 kHz

EEG Optoisolation/feedthrough RF (radio frequency) filter

- 16 channels / board
- Applied part optically isolated, dielectric strength > 4 kV (according to IEC60601-1, Class B), powered from an isolated power supply
- Circuits outside optoisolation powered from control/nonisolated power feedthrough filter, grounded
- Fixed gain of 5.0
- Cut-off frequency (– 3 dB point) 13 kHz
- Input range of linear operation ±500 mV (= preamplifier output)
- Dc coupled
- RF filters as in MEG channels

Control/power feedthrough filter for MEG electronics

- Remote control from real time computers via a fiber-optic link
- Power feedthrough for the MEG preamplifiers (±15 V analog, + 6 V digital from MEG preamplifier power supply)

Control/power feedthrough filter for EEG electronics

- remote control from real time computers via a fiber-optic link,
- preamplifier control powered from separate isolated power supply
- Nonisolated power feedthrough for non-isolated EEG circuits (other than applied parts) and MEG feedthrough filters (±15 V analog, + 6 V digital from MEG preamplifier power supply)

Other feedthrough RF filters

- RF feedthrough filter for auxiliary electronics
- Safety-isolating power supply for EEG front-end (see 1.4.2)
- Lifting mechanism control unit and position indicator/ RF filter feedthrough unit

1.3.6. MEG main electronics

- Principle: digital flux-locked feedback control loop realized with a digital signal processor (DSP)
- SQUID Controller Unit (SQC) for 12 channels
- One digital signal processor (DSP) per SQC
- Resolution: 24 bits/sample, effective bits due to oversampling typ. 27. Word length 16 bits or 32 bits
- DC coupled
- Drift elimination: integrating feedback control via DSP
- High-pass cutoff: adjustable (predefined values DC – 10Hz)
- Low-pass filter type: 6th order Butterworth IIR filter via DSP
- Cutoff of low-pass filter: adjustable (predefined values 150 Hz – 3,3 kHz)
- Connected over dedicated Ethernet to parallel real-time data acquisition computers. Accessible also through workstations.
- SQC boards also connected with each other over proprietary synchronous backplane bus
- Number of subracks: 2
- Number of SQC boards: 27 (MEG) + 1 (HPI signals)
- System Controller Board (SCC) for timing, backplane bus control and stimulus trigger input/output
- Trigger event identification: 2 x 16 channels in/out (digital)
- Triggers generated internally by the digital I/O interface included in the data acquisition unit or generated by an external stimulator and acquired via the digital I/O interface.
- Number of System Control Card (SCC) units: 1
- Located outside of the magnetically shielded room inside a rf-shielded cabinet (main electronics cabinet).
- Powering: Separate power supply for each set of four slots inside the rf-shielded cabinet
- Fan units: mains operated

1.3.7. EEG main electronics

- Signal acquisition module (SAM) for 12 channels
- one digital signal processor (DSP) per SAM
- Resolution of A/D conversion: 16 bits
- Type of coupling: dc
- Input stage realized with instrumentation amplifiers with software controlled gain of 1 or 10, corresponding to SAM input ranges of ±10 V or ±1 V, respectively
- All conversions started simultaneously, synchronized with MEG channels
- Sampling rate equivalent to that of MEG channels
- Low-pass filters identical to those in MEG channels (DSP-based)
- 2 SAM / remote processor unit (RPU)
- Connected over dedicated Ethernet to parallel real-time data acquisition computers. Accessible also through workstations.
- SAM boards reside in the EEG rack inside themain electronics cabinet
- Number of subracks: 1
- Number of SAM boards: 6 (64 ch.) / 12 (128 ch.)
- Powering: Separate power supply for each set of four slots inside the main electronics cabinet
- Fan unit: mains operated.

1.4. MEG and EEG Power Supplies

1.4.1. Front-end MEG power supply

- Power rating: 400 W
- Mains: 230 V~, 47…63 Hz, from a dedicated isolation transformer
- Control: manual power switch
- Number of units: 1
- Output: ±15,5 V= 9 A (analog), 24V~ 4 A (for isolated EEG), +6,3 V= 8 A (digital)
- Output cabling to the filter unit
- Primary fuses: 3.15 A slow blow
- Feeds also the non-isolated part of the EEG system
- Overload protection: current-limiting circuit
- Location: inside main electronics cabinet

1.4.2. Front-end EEG power supply (isolated)

- Input 24 V~ unregulated, supplied by the MEG preamplifier power supply
- Output ±12.6 V, 60 W total
- Applied part isolated with sector-wound transformer (24 V~/2 x 16 V~), dielectric strength > 4 kV (according to IEC60601-1, Class B)
- Output cabling to the filter unit
- Number of units: 1
- RF feedthrough filters in non-isolated circuit
- Location: inside the filter unit

1.4.3. MEG and EEG electronics power supply unit

- Power rating: 145 W
- Mains: 230 V~, 47…63 Hz, from a dedicated isolation transformer
- Control: manual power switch
- Number of units: 7 (MEG) + 2 (64 ch EEG) or 4 (128 ch EEG)
- Output: ± 15,5 V= 0.8 A (analog), +6,3 V= 1.2A, –6.3 V= 1.6 A (analog), 5 V= 4 A (digital)
- Output cabling: internal, directly to backplane
- Primary fuses: 230 V 0.63 A slow blow
- Overload and over-temperature protection, undervoltage detection
- Status indicators
- Fan unit: external, permanently mounted in cabinet
- Location: inside main electronics cabinet, integrated to the MEG or EEG subracks

1.4.4. Real-time data acquisition computer power supply

- Power rating: 400 W
- Mains: 230 V~, 47…63 Hz, from dedicated isolation transformer
- Control: manual power switch
- Number of units: 1
- Output: +5 V= 60A, +3.3 V= 35A, ± 12 V= 10 A with current share on outputs that are > 10 A
- Output cabling: internal in the local subrack
- Primary fuse: 10 A (internal)
- Overload protection: current-limiting circuit
- Fan unit: built-in

- Location: inside main electronics cabinet, integrated to the VME subrack

1.4.5. Main iIsolation transformers

- Number of units: 3 (MEG, Stimulus, 3D digitizer)
- Primary: 100 / 115 / 120 / 200 / 230 / 240 V~ 50/60 Hz
- Secondary: 230 V~. For stimulus cabinet same as primary.
- Power rating: 2 kVA (MEG), 3.5 kVA (stimulus), 650 VA (3D digitizer)
- Safety isolating, approved for medical electrical equipment
- Permanent installation
- Primary fuses: in main electricity distribution panel of the building (customer's responsibility). Recommendation 16 A slow (200/230/ 240 V), 30 A slow (100/115/120 V)

1.5. Filter Unit Cabinet and Electronics Cabinet

1.5.1. Filter unit cabinet

- RF filter cutoff for all signals: 130 kHz, –20 dB/octave
- Maximum signal levels to any feedthrough input/output: ±15 V
- Dimensions and weights: see chapter 2

1.5.2. MEG Electronics cabinet

- Cabinet type: Schroff HF1
- Cabinet RF attenuation: –90 dB @ 30 MHz, –70 dB @ 300 MHz, –50 dB @ 1 GHz
- RF mains filter: 12 A 250 V~ dual filter (L,N)
- Mains distribution unit with manual circuit breakers for subsystems
- Power failure release switch with thermal overcurrent protection (10 A)
- Filtered power outlets inside cabinet, max. current: 10 A in total
- Mains power: via a dedicated isolation transformer (see 1.4.5) and harmonic filter, permanent installation
- Cooling: forced convection, air flow from base plate (dust filtered) to top cover (equipped with temperature-controlled fans)
- Dimensions and weights: see chapter 2

1.6. Auxiliary electronics

1.6.1. Head Position Indicator (HPI)

- Method: marker coils are attached to the head of the subject
- Excitation: DSP-controlled current drive for each HPI-coil
- Detection of signals: by sensor array
- Number of coils: 3, 4, or 5 permanently attached to a connector.
- Current: typ. 70 µA
- Coil size: Ø 7 mm, thickness 2 mm
- Coils insulated (BF type, dielectric strength 1500 V)
- Determination of position of the marker coils with respect to a subject frame of reference: 3D digitizer included in the system, see 1.6.2.

1.6.2. 3D digitizer

- Polhemus Fastrak unit including transmitter and receiver
- Specifications: see Polhemus Fastrak User's Manual
- Non-magnetic goggles with an additional receiver for movement correction
- Separate portable medical isolation transformer 650 VA
- Power requirement 85-264 V~, 47-63 Hz
- Connected to data acquisition workstation over optically isolated serial line
- Location: in operator area

1.6.3. Phantom

- Method: line current elements (current dipoles) in spherical geometry
- Length of line current elements: 5 mm
- Radius of curvature: 89 mm
- Number of dipoles: 32
- Number of integrated head position indicator coils: 4
- Connected over phantom current driver / multiplexer to the side panel of the gantry
- Dimensions and weights: see chapter 2

1.6.4. Phantom current driver / multiplexer

- Number of outputs: 32, one active at a time
- Transconductance 1.8 mS
- Output ±18 mA

- Input ±10 V
- Maximum load impedance: 100 Ω

1.6.5. Liquid Helium level gauge and display

- Readout: remotely by real-time data acquisition computer or manually over local display
- Probe active length (nominal): 55 cm
- Probe resistance (nominal, at 300 K): 300 Ω
- Probe resistance (nominal, at 10 K): 250 Ω
- Local display on side panel of the gantry: on/off button, display 0–100 %

1.6.6. Stimulus cabinet

- Cabinet type: Schroff HF1
- Cabinet RF attenuation: –90 dB @ 30 MHz, –70 dB @ 300 MHz, –50 dB @ 1 GHz
- mains line RF filter: 10 A 250 V max. dual filter (L,N)
- Installation of the mains line RF filter: permanent
- Filtered power outlets inside cabinet: 6, manual circuit breaker with indicator light
- Max. current of the outlet sockets: 10 A in total
- Mains power: via an isolation transformer (see 1.4.5), permanently installed
- Auxiliary feedthrough filters: BNC 1–2, XLR NC connectors 1–2: 20 dB/decade above 20 kHz, feedthrough resistance 7 Ω; BNC 3–5, XLR NC connector 3: –20 dB @ 10 MHz, –65 dB @ 100 MHz, feedthrough resistance < 1Ω.
- Signal feedthrough filters (option): 1 x 32 differential channels, 60 dB/decade above 60 kHz. Feedthrough resistance 70 Ω.
- Maximum signal input/output level to any feedthrough: ±15 V. Note! the actual value depends on instrument connected by the user to the feedthrough inside the cabinet.
- Cooling: free convection, air flow from base plate (dust filtered) to top cover
- Dimensions and weights: see chapter 2

1.6.7. Audio electronics interface

- Earphone output for patient and assistant
- Tubal insert earphones
- Feedthrough RF filter for audio stimulus signals

- Microphone input for voice intercom

1.6.8. Thermometer sensors (for maintenance only)

- Number: 2
- Locations: lower end of helmet, upper end of wiring unit
- Type: Pt-resistor
- Nominal resistance at 273 K: 100 Ω

1.6.9. Voice intercom (option)

- Desk Unit on operator’s table
- Main unit connected to a microphone inside probe unit and to a loudspeaker outside of the magnetically shielded room
- Connect / disconnect
- Automatic control of speech direction
- Manual control of speech direction selectable
- Muting of operator microphone

1.6.10. Video monitor (option)

- Rf-shielded color camera mounted on shielded room wall
- Color monitor

1.7. Data Acquisition System Hardware

1.7.1. Real-time data acquisition computer system

- Real-time computer: Motorola PowerPC -based system
- Number of real-time computers: 2 (depends on configuration)
- Unit architecture: VME bus
- Mode of data acquisition: continuous
- Maximum number of sampled analog channels: 370 (306+64), 434 as an option (306+128)
- Maximum sampling rate 5.0 kHz with 306 MEG and 64 EEG channels. Optionally 10 kHz (for 306 MEG channels)
- Data acquisition hardware electronics location: outside of the magnetically shielded room inside the main electronics cabinet
- Dedicated control optic link for EEG preamplifiers
- Dimensions and weights: see chapter 2

1.7.2. Stimulus I/O interface unit

- Two stimulus I/O interface units, each unit 16 channels

- The units can be operated either in a mirroring mode duplicating the input/output at two physically separate places (16 lines total, default mode) or independently (32 lines total, optional)
- Each channel individually selectable as input or output
- Internal trigger line generation to 16 lines
- The trigger lines are optically isolated and synchronized to the MEG/EEG sampling

Stimulus input:

- Input pulse level: TTL (+ 5 V high, 0 V low), trigger on rising or falling edge (each channel individually user-configurable).
- Each input has a user-selectable pull-up for connection of passive switches
- Minimum input pulse width: 10 µs
- Absolute maximum ratings for input voltage: –0.5 V…+5.5 V
- Input impedance: 1 MΩ (without pull-up)
- Pull-up loop current 500 µA
- Input mode: single-ended. Optically isolated from main electronics.
- Delay from interface unit to trigger acquisition less than 50 µs
- Minimum detectable pulse length 50 µs

Stimulus output:

- Pulse level: TTL (+ 5 V high, 0 V low), rising or falling edge (each channel individually user-configurable)
- Pulse width: typ. 10 ms
- Pulse rate: adjustable from data acquisition program
- Maximum output current: 25 mA
- Output mode: single-ended. Optically isolated from main electronics
- Delay from trigger generation to interface unit less than 50 µs
- Pulse length determined in acquisition program (minimum 1 ms)

Input power:

- +8…12 V⁼, 100 mA. Double-insulated separate supply.

1.8. Computer system hardware

- Continuous acquisition time: over 1 hour with 306 MEG and 64 EEG channels sampled at 3 kHz.
- Computers: H-P's PA-RISC UNIX workstations with two monitors
- Removable magneto-optical disk (option)

- Backup device: compressing DAT tape drive (option)
- CD-ROM Drive: 650 MB
- Expandability: additional workstations
- Magnetic resonance image (MRI) importing: DICOM 3.0 supported (Conformance Statement available upon request)
- Peripherals (optional): full range available
- Hardcopy devices (optional): black-and-white laser printers, color solid-ink printers
- Data transfer to other systems
- Ethernet connection to data acquisition system via a media converter (optical LAN link)

1.9. Helium transfer equipment

- From standard storage Dewar with flexible siphon, connecting to integral fixed siphon part in the probe unit
- Flexible siphon
- 2 filter cartridges
- Flexible siphon extension tube
- Cryogenics kit
- Transfer exhaust hose (silicon) with hose clamp
- Pressurizing unit

1.10. Environmental and power requirements, grounding

- Temperature during operation (performance guaranteed): +20°C…+24°C
- Temperature during operation (performance not guaranteed, IEC 60601-1 requirements fulfilled): +10°C…+40°C
- Temperature during storage and transport: +0°C…+40°C
- Relative humidity during operation (performance guaranteed): 40%…70% RH, non-condensing
- Relative humidity during operation (performance not guaranteed, IEC 60601-1 requirements fulfilled): 30%…75% RH, non-condensing
- Relative humidity during storage and transport: 10%…95% RH, non-condensing. Special packaging instructions must be obeyed (available from Elekta Neuromag Oy).
- Mains power voltage: 100/115/200/230/240 V~ ± 10 %
- Mains frequency: 47…63 Hz

Table 1. Power consumption of system units. The total consumption depends on system configuration.			
Unit	**Power [W]**	**Appar. [VA]**	**Notes**
Main electronics cabinet	1700/1900	1800/2000	64 ch EEG / 128 ch EEG
Lifting unit	10/750	20/1200	Idle/working (20 s / run)
3-D digitizer	40	60	
Acq. workstation, 2 TFT monitors (typ.)	400		
Anal. workstation, 2 TFT monitors (typ.)	400		
Trigger I/O unit (2 pcs, total)	20		
Voice intercom (typ.)	10		
CCTV video monitoring (typ.)	50		
Finger response pad	10		
DAT drive (typ.)	100		
MOD drive (typ.)	100		
Color printer (typ.)	250 /1650		Norm./max.
Monochrome printer (typ.)	30/600		Idle/printing
Video projector (typ.)	800		
Electrical stimulator (typ.)	10		
Audiovisual stimulus system (typ.)	200		
Feed-forward active compensation	200		
Note 1 Stimulus cabinet not included as a unit since the consumption depends on the equipment used Note 2 Ratings marked with "typ." are representative values only, actual values depend on the exact model used			

- Power consumption of whole system: depends on system configuration, see Table 1
- Connection of the main electronics cabinet and stimulator cabinetto mains via separate isolation transformers, see Fig. 3.11 and 1.4.5.
- Grounding: magnetically shielded room, main electronics cabinet, and stimulator cabinet permanently grounded at a single point,see Fig. 3.11.

1.11. Classification (IEC 60601-1-1)

Classification according to IEC 60601-1-1:

- Class I equipment
- BF-type equipment

1.12. Miscellaneous

- Disinfection of applied parts: pure alcohol
- Mode of operation: continuous

1.13. Options

As an option, e.g., the following units may be included:

- Two-way voice intercommunication system
- CCTV video monitoring system
- Audiovisual stimulus system
- Back projection screen
- Stimulus video projector
- Chair insert for pediatric measurements
- Finger response pad
- Additional workstation (analysis)
- EEG extension to 128 channels
- DACQ sampling rate upgrade
- Electrical stimulator
- DAT drive for backup
- Magneto-optical disk drive
- Additional hard disk drive
- EEG caps, 60 channels, three sizes
- EEG cap, 124 channels
- Colour printer
- Monochrome printer
- Additional subject chair
- Additional subject bed
- Side walls for bed
- Feedforward active compensation
- Helium level meter for storage dewars (“Dip Stick”)
- On-site spare part kit

1.14. Electromagnetic compatibility (EMC)

1.14.1. General

Parts of the Elekta Neuromag® system (the measurement unit) must be permanently installed inside a magnetically shielded room. Prior to installation, a magnetic site survey and determination of necessary magnetic shielding must be performed for each installation site as a normal part of the site planning. The magnetic shield also comprises an RF shield. The electronics cabinets with the dedicated feedthroughs to the magnetically shielded room must be properly installed by authorized personnel. Such combination of the magnetically shielded room and the Elekta Neuromag® system must be always be considered together as an entity.

The magnetically shielded room should have a minimum RF shielding effectiveness and, for each cable that exits the shielded location, a minimum RF filter attenuation of 40 dB from 1 MHz to 1000 MHz.

NOTE! The exemption specified in IEC 60601-1-2, clause 36.202.3 b 9, regarding large permanently installed systems has been used. The system has not been tested for radiated RF immunity over the entire frequency range 80 MHz to 2.5 GHz. The system has been tested of RF immunity only at selected frequencies using conducted RF current-injected from an RF generator whose output is 80 % amplitude modulated at 2 Hz in the frequency range 150 kHz – 220 MHz.

1.14.2. List of cables, transducers and other accessories

External cables connected to the magnetically shielded room and to the electronics cabinets may affect electromagnetc compatibility. They comprise

- Mains power cables of main electronics cabinet and stimulus cabinet (three-wire mains cable, length 20 m)
- Lifting unit motor control cable (twisted pair, length 8 m)
- Audio stimulus cables (shielded twisted pairs, length 10 m)
- Polhemus Fastrak system with transmitter (3A0369-07, length 3 m), stylus receiver(4A0318-01, 3 m), and goggle receiver (4A0314-01, 3 m), and serial cable (twisted pair, length 15 m)
- Microphone cable (shielded twisted pair, length 5 m), loudspeaker cable (shielded twisted pair, 5 m), and connection cable (twisted pair, 10 m) for voice intercom option

NOTE! The use of accessories, transducers, and cables other than those specified, with the exception of accessories, transducers and cables sold by the manufacturer of the system as replacement parts for internal components, may result in increased emissions or decreased immunity of the system.

1.14.3. Guidance and manufacturer’s declaration

NOTE! The Elekta Neuromag MEG system should not be used adjacent to other systems, and if adjacent operation is necessary, the system should be observed to verify normal operation in the configuration in which it will be used.

NOTE! The Elekta Neuromag® system should only be used permanently installed together with magnetically shielded room, see 1.14.1. It is essential that the actual RF shielding effectiveness and filter attenuation of the shielded location be verified to ensure that they meet or exceed the specified minimum values.

NOTE! Inside the magnetically shielded room, the use of devices radiating RF energy such as portable and mobile RF communications equipment such as mobile phones is prohibited. Use of other equipment except accessories and options supplied with the system should be avoided; only equipment verified not to affect system performance may be used. A notice concerning this should be posted at the entrance of the magnetically shielded room.

Guidance and manufacturer's declaration – electromagnetic emissions		
The Elekta Neuromag® system is intended for use in electromagnetic environment specified below. the customer or the user of the Elekta Neuromag® system should assure that it is used in such an environment.		
Emissions test	**Compliance**	**Electromagnetic environment – guidance**
RF emissions CISPR 11	Group 1	The Elekta Neuromag® system uses RF energy only for its internal function. Therefore, its RF emissions are very low and are not likely to cause any interference in nearby electronic equipment.
RF emissions CISPR 11	Class A	The Elekta Neuromag® system, when installed properly as described in 1.14.1 is suitable for use in all establishments other than domestic and those directly connected to the public low-voltage network that supplies buildings used for domestic purposes.
Harmonic emissions IEC61000-3-2	Class A	
Voltage fluctuations / flicker emissions IEC61000-3-3	Not applicable	

Guidance and manufacturer's declaration – electromagnetic immunity

The Elekta Neuromag® system is intended for use in electromagnetic environmen specified below. The customer or the user of the Elekta Neuromag® system should assure that it is used in such an environment.

Immunity test	**IEC 60601 test level**	**Compliance level**	**Electromagnetic environment – guidance**
Electrostatic discharge (ESD) IEC 61000-4-2	±6 kV contact ±8 kV air	±6 kV contact ±8 kV air	Floors should be wood, concrete or ceramic tile. If floors are covered with synthetic material, the relative humidity should be at least 30 %. An ESD preventing floor covering is recommended.
Electrical fast transients / burst IEC 61000-4-5	±2 kV for power supply lines ±1 kV for input/output lines	±2 kV for power supply lines ±1 kV for input/output lines	Mains power quality should be that of a typical commercial or hospital environment.
Surge IEC 61000-4-5	±1 kV differential mode ±2 kV common mode	±1 kV differential mode ±2 kV common mode	Mains power quality should be that of a typical commercial or hospital environment.
Voltage dips, short interruptions and voltage variations on power supply input lines IEC 61000-4-11	Not applicable	Not applicable	Mains power quality should be that of a typical commercial or hospital environment. The system is equipped with no-voltage mains release switch; after mains interruption a normal power-up sequence by the operator is necessary. If the user of the Elekta Neuromag® system requires continued operation during power mains interruptions, it is recommended that the Elekta Neuromag® system be powered from an uninterruptible power supply.
Power frequency (50/60 Hz) magnetic field IEC 61000-4-8	Not applicable	Not applicable	The system is intended to measure magnetic fields at a very low level in a frequency range that includes 50/60 Hz. A magnetic site survey and adjacent determination of necessary magnetic shielding must be performed for each installation site prior to installation as a normal part of the site planning.

Guidance and manufacturer's declaration – electromagnetic immunity

The Elekta Neuromag® system is intended for use in electromagnetic environment specified below. The customer or the user of the Elekta Neuromag® system should assure that it is used in such an environment.

Immunity test	IEC 60601 test level	Compliance level	Electromagnetic environment – guidance
			Portable and mobile RF communications equipment should be used no closer to any part of the Elekta Neuromag® system combined with the magnetically shielded room (see 1.14.1), including cables, than the recommended separation distance calculated from the equation applicable to the frequency of the transmitter. **Recommended separation distance**
Conducted RF IEC 61000-4-6	3 Vrms 150 kHz to 80 MHz	3 V	$d = 1.2\sqrt{P}$
Radiated RF IEC 61000-4-6	3 V/m 80 MHz to 2.5 GHz	3 V/m	$d = 1.2\sqrt{P}$ 80 MHz to 800 MHz $d = 2.3\sqrt{P}$ 800 MHz to 2.5 GHz
			where P is the maximum output power rating of the transmitter in Watts (W) according to the transmitter manufacturer and d is the recommended separation distance in metres (m). Field strengths from fixed RF transmitters, as determined by an electromagnetic site survey,[a] should be less than the compliance level in each frequency range. [b] Interference may occur in the vicinity of equipment marked with the following symbol: 

NOTE 1 At 80 MHz and 800 MHz, the higher frequency range applies.

NOTE 2 These guidelines may not apply in all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects and people.

[a] Field strengths from fixed transmitters, such as base stations for radio (cellular/cordless) telephones and land mobile radios, amateur radio, AM and FM radio broadcast and TV broadcast cannot be predicted theoretically with accuracy. To assess the electromagnetic environment due to fixed RF transmitters, an electromagnetic site survey should be considered. If the measured field strength in the location in which the [Elekta Neuromag® system is used exceeds the applicable RF compliance level above, the Elekta Neuromag® system should be observed to verify normal operation. If abnormal performance is observed, additional measures may be necessary, such as reorienting or relocating the Elekta Neuromag® system

[b] Over the frequency range 150 kHz to 80 MHz, field strengths should be less than 3 V/m.

Recommended separation distances between portable and mobile RF communications equipment and the Elekta Neuromag® system

The Elekta Neuromag® system is intended for use in an electromagnetic environment in which radiated RF disturbances are controlled. The customer or the user of the Elekta Neuromag® system can help prevent electromagnetic interference by maintaining a minimum distance between portable and mobile RF communications equipment (transmitters) and the Elekta Neuromag® system as recommended below, according to the maximum output power of the communications equipment.

Rated maximum output power of transmitter W	**Separation distance according to frequency of transmitter** m		
	150 kHz to 80 MHz $1.2\sqrt{P}$	**80 MHz to 800 MHz** $1.2\sqrt{P}$	**800 MHz to 2,5 GHz** $2.3\sqrt{P}$
0.01	0.12	0.12	0.23
0.1	0.38	0.38	0.73
1	1.2	1.2	2.3
10	3.8	3.8	7.3
100	12	12	23

For transmitters rated at a maximum output power not listed above, the recommended separation distance d in metres (m) can be estimated using the equation applicable to the frequency of the transmitter, where P is the maximum output power rating of the transmitter in watts (W) according to the transmitter manufacturer.

NOTE 1 At 80 MHz and 800 MHz, the separation distance for the higher frequency range applies.

NOTE 2 These guidelines may not apply in all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects and people.

1.15. Final disposal

'Final disposal' is disposal of the equipment or any part of it, in such a way that it can no longer be used for its intended purpose(s).

Never dispose of Elekta® products into the domestic waste stream.

Disposal must always be executed in an environmentally sensitive manner that complies with all local and international regulations and laws. Materials hazardous to health and the environment must be separately removed and disposed of through competent, licensed facilities. The remaining material should be recycled where facilities and local regulations permit. Prior to disposal, always contact Elekta for advice.

Where applicable, information will be available for treatment facilities and recyclers in accordance with Article 11 of directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment (WEEE).

CHAPTER 2 Dimensions and weights

2.1. Dewar dimensions

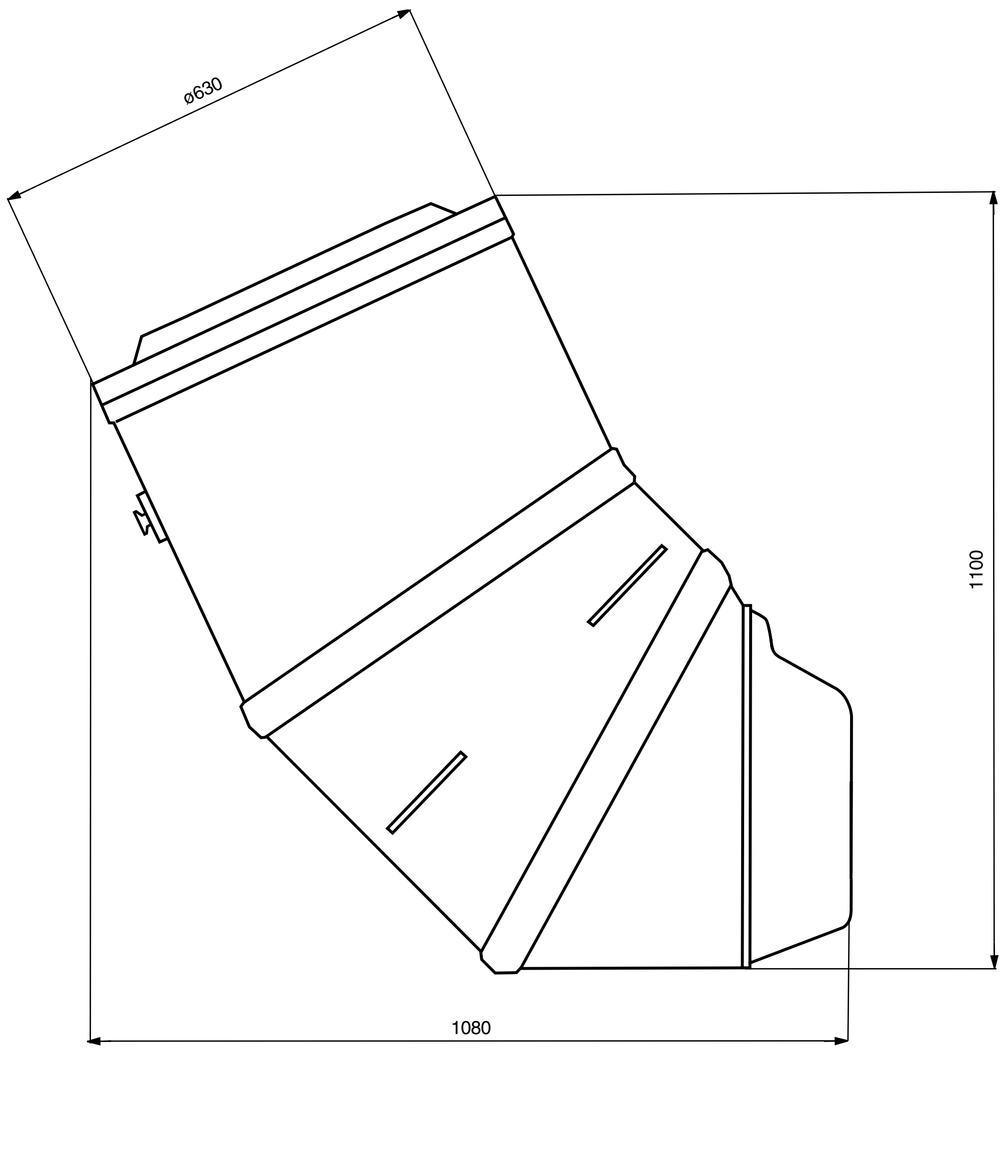


Figure 2.1. Dewar side view. Dimensions in millimeters.

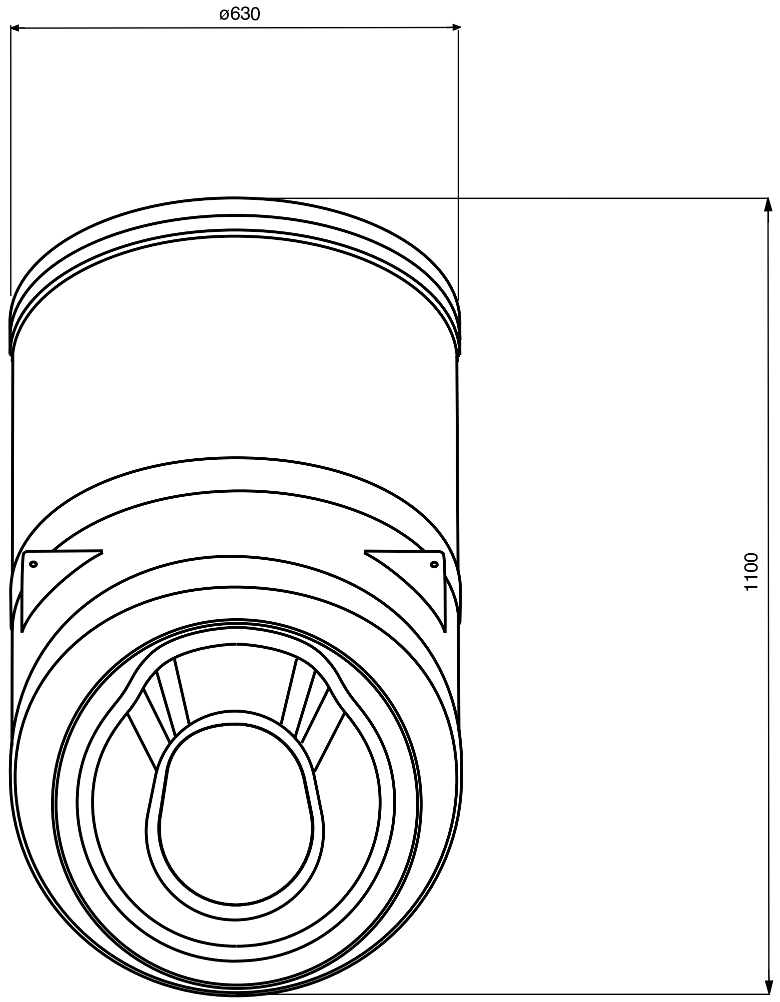


Figure 2.2. Dewar front view. Dimensions in millimeters.

2.2. Gantry and chair dimensions

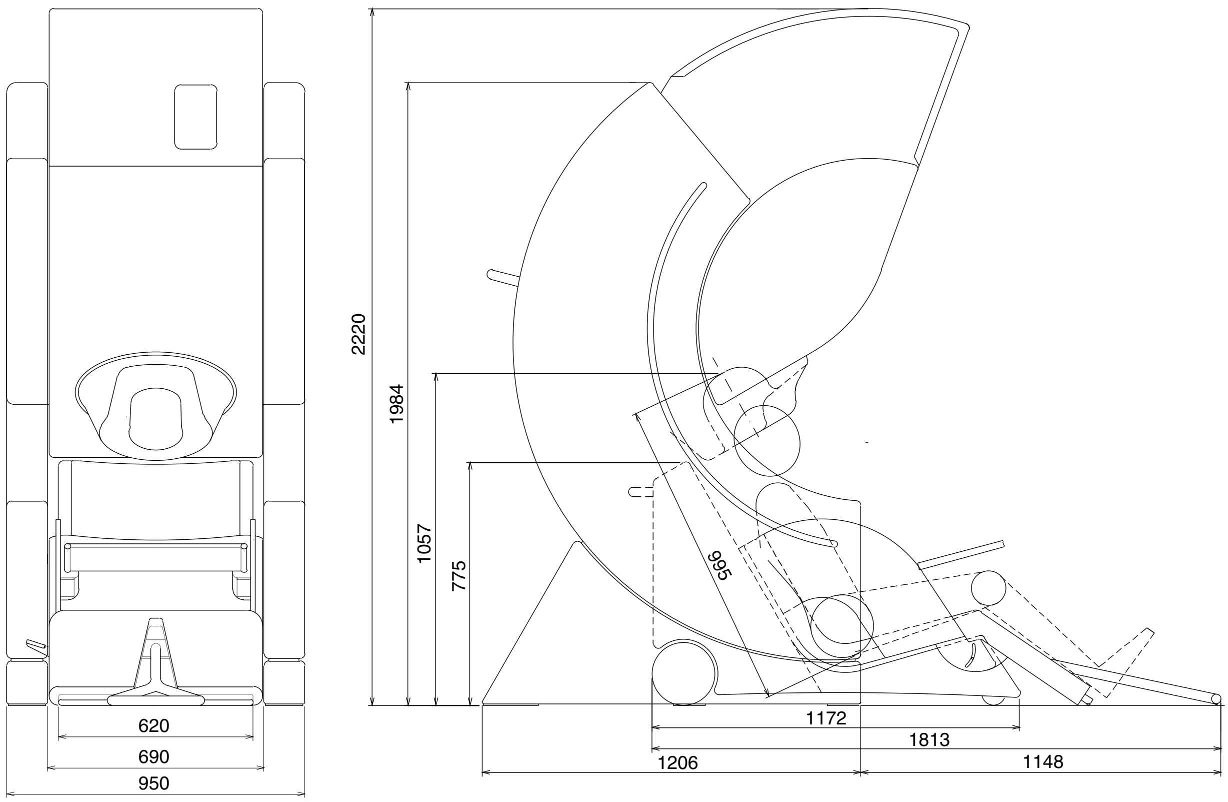


Figure 2.3. Gantry in upright measurement position.Dimensions in millimeters.

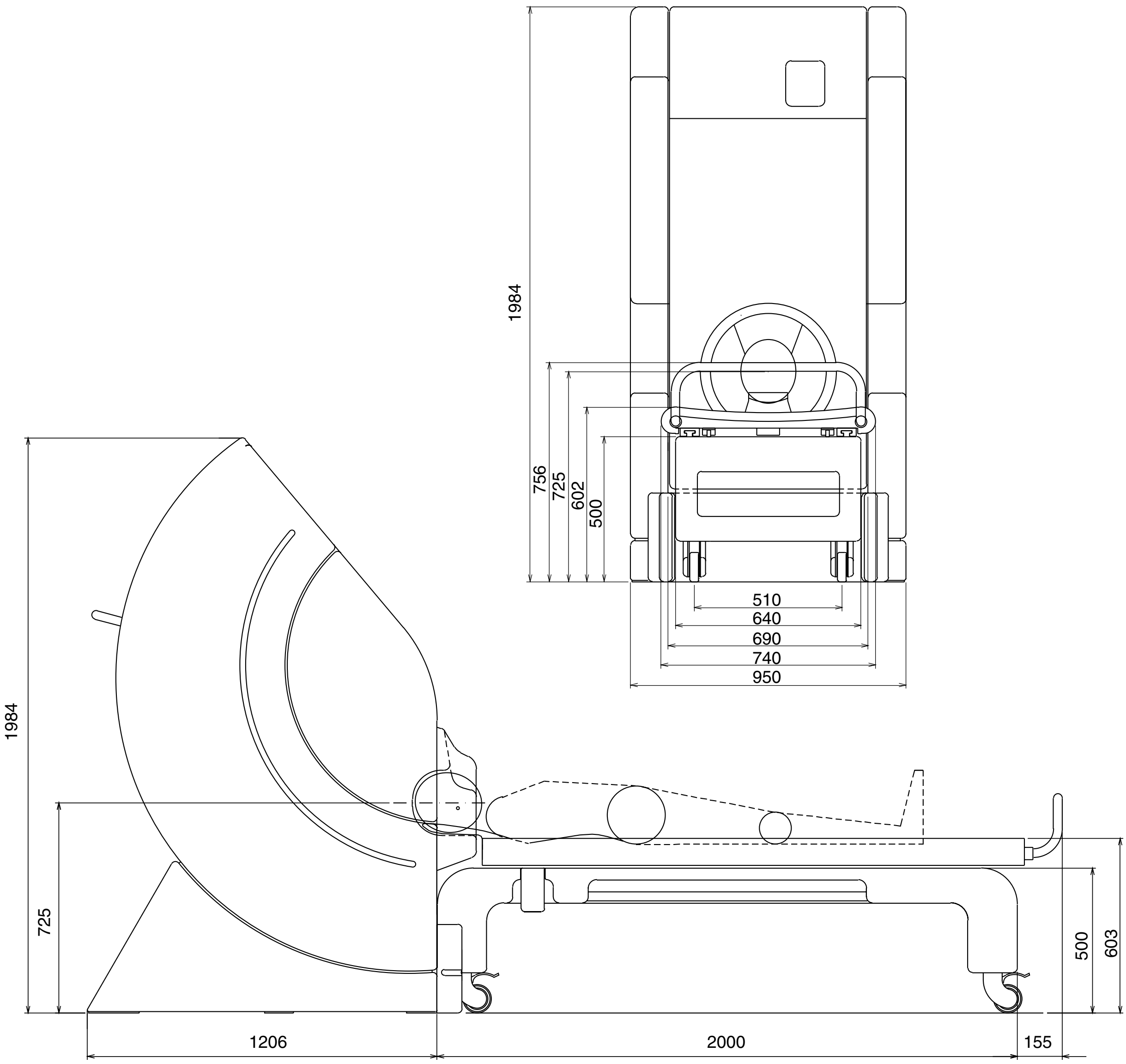


Figure 2.4. Gantry in supine position..Dimensions in millimeters.

2.3. Dimensions of cabinets

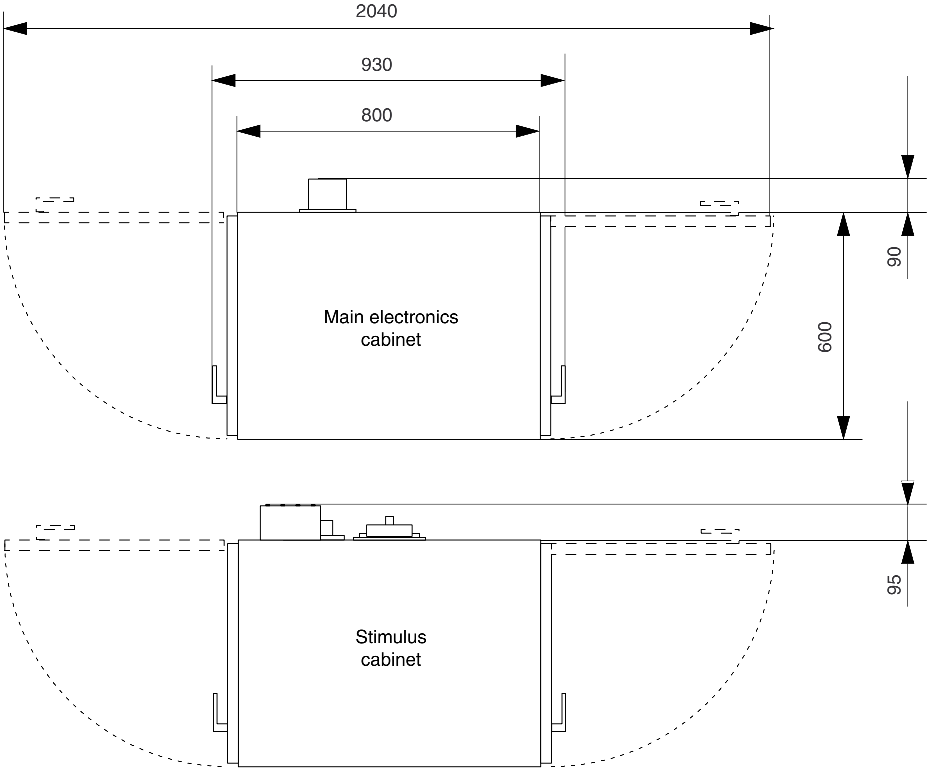


Figure 2.5. Electronics and stimulus cabinet dimensions (in millimeters). For heights, see section 2.4.

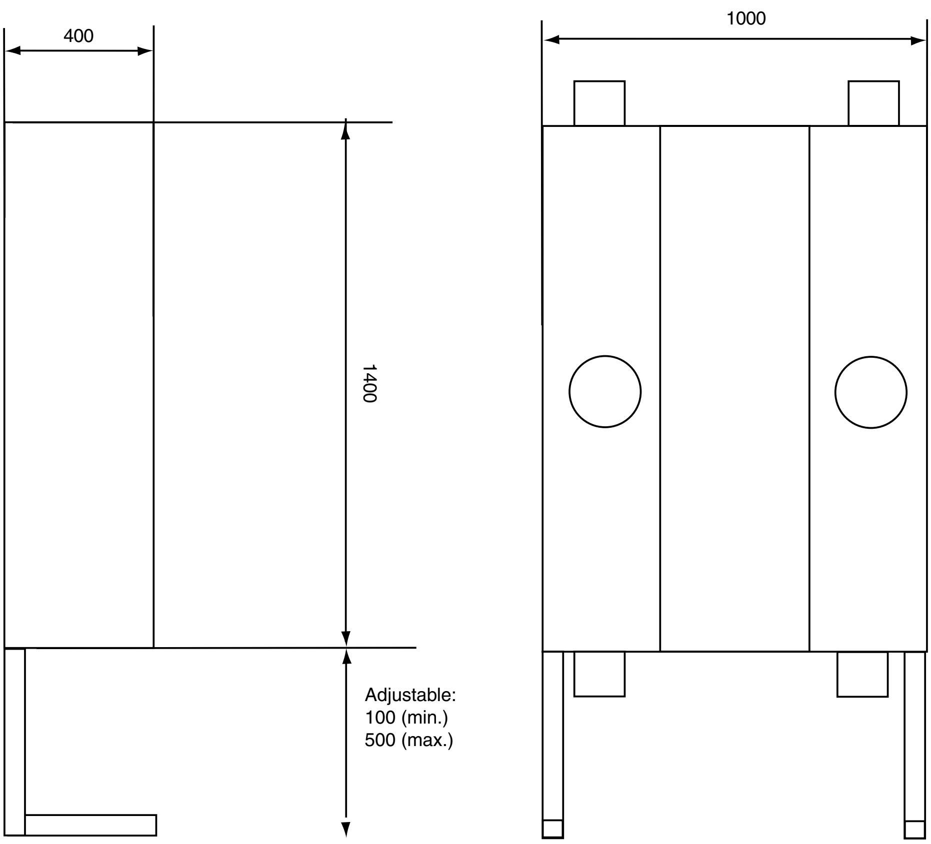


Figure 2.6. Filter cabinet dimensions.

2.4. Table of dimensions and weights

Unit	W [cm]	L/D [cm]	H [cm]	Mass [kg]
Measurement unit supine/upright	96	128/160	198/223	350
Patient’s bed (bed surface/maximum)	75	230	60/76	75
Patient’s chair	70	135	78	80
Filter unit cabinet (adjustable)	100	40	150-190	150
Electronics cabinet	60	80	212	250
Stimulus cabinet	60	80	202	100
Acq. workstation, typ.	70	75	68	25
Analysis workstation, typ.	70	75	68	25
Workstation TFT Monitor, typ. (each)	41	20	46	9
HPI chair	54	56	98	10
Phantom	18	18	60	1
Gantry movement unit	37	64	37	30
Control unit of 3-D digitizer	29	28	9	2
Back-projection screen (screen/pedestal)	118	6/33	186	35

3

CHAPTER 3 Diagrams

3.1. Electronics diagrams

3.1.1. System diagrams

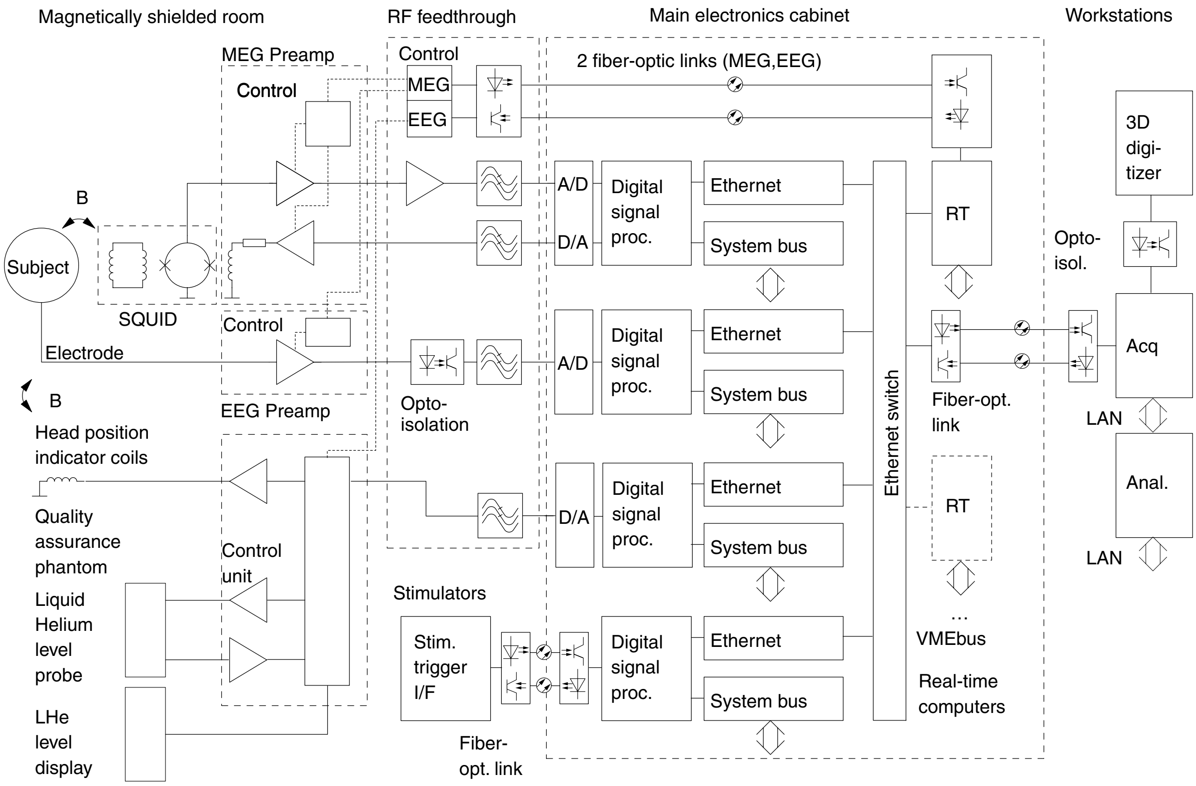


Figure 3.1. Schematic diagram of the electronics.

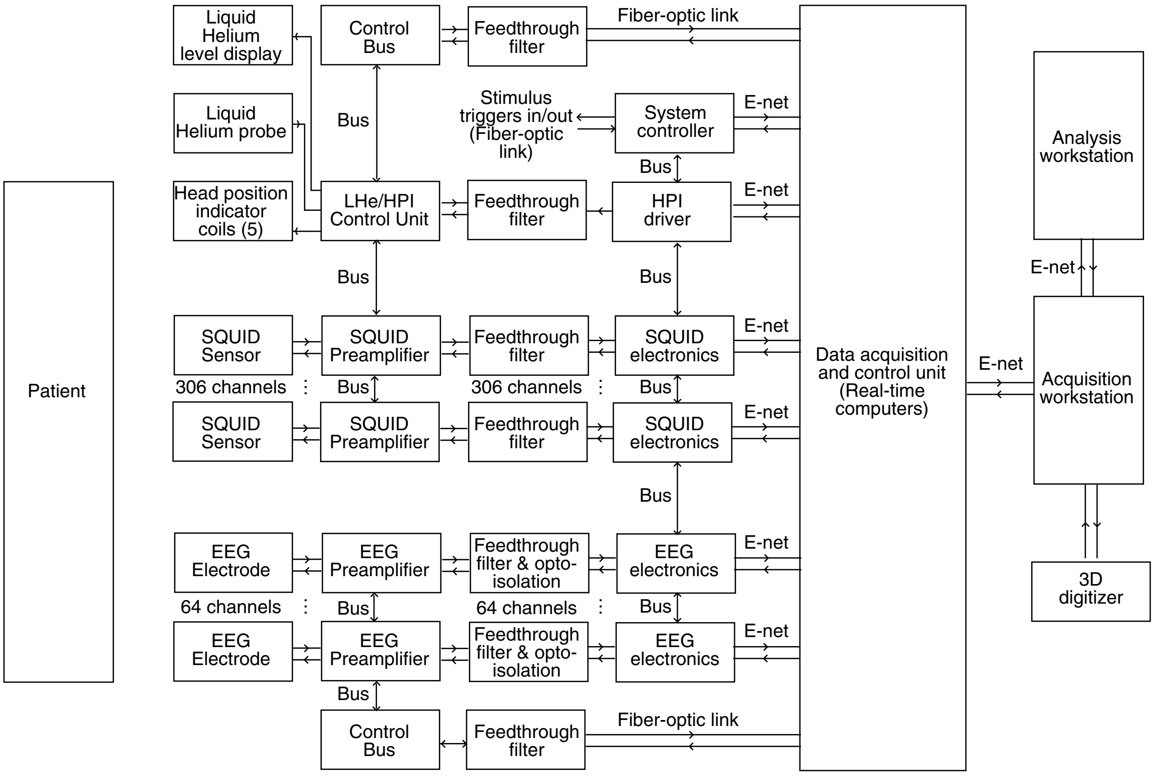


Figure 3.2. Block diagram of the electronics.

3.1.2. EEG electronics

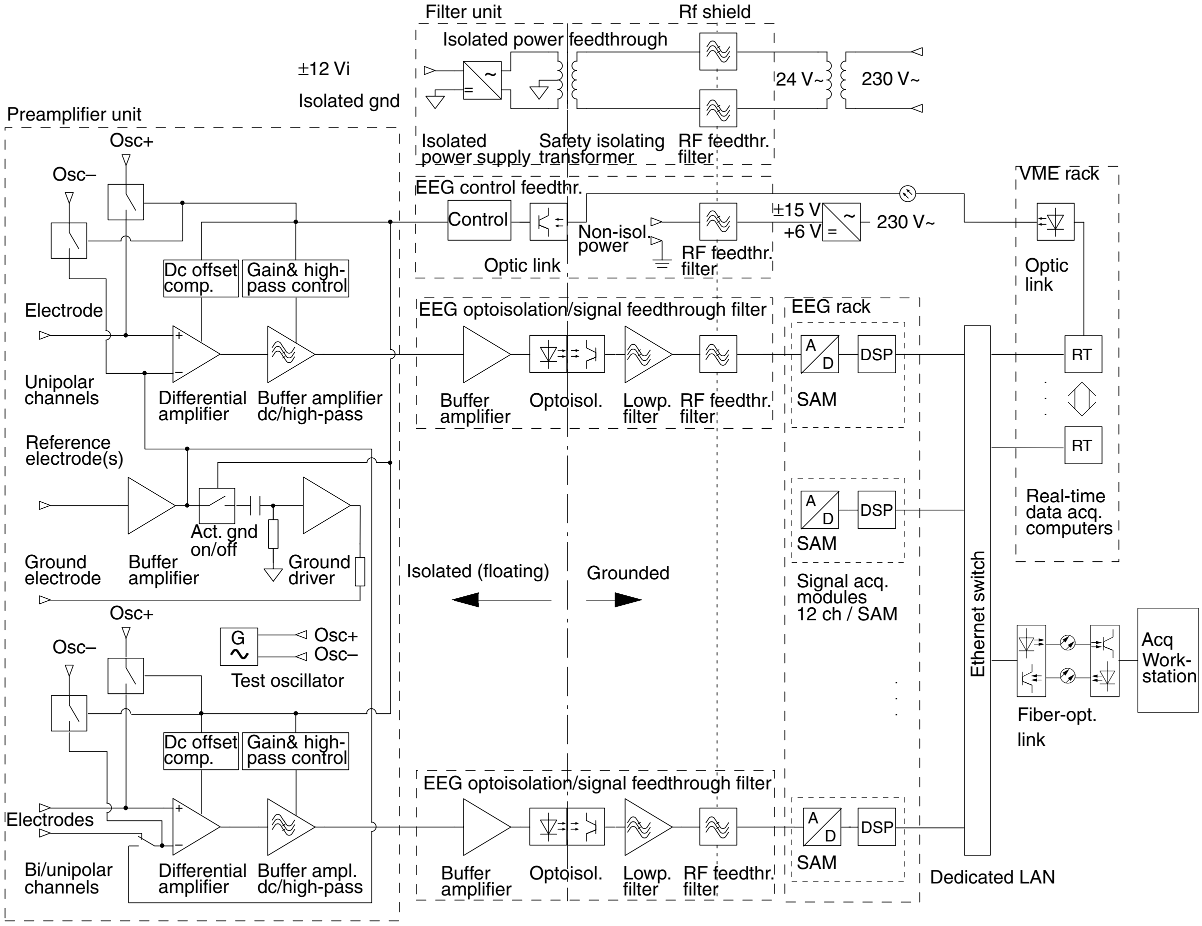


Figure 3.3. Schematic diagram of the EEG electronics

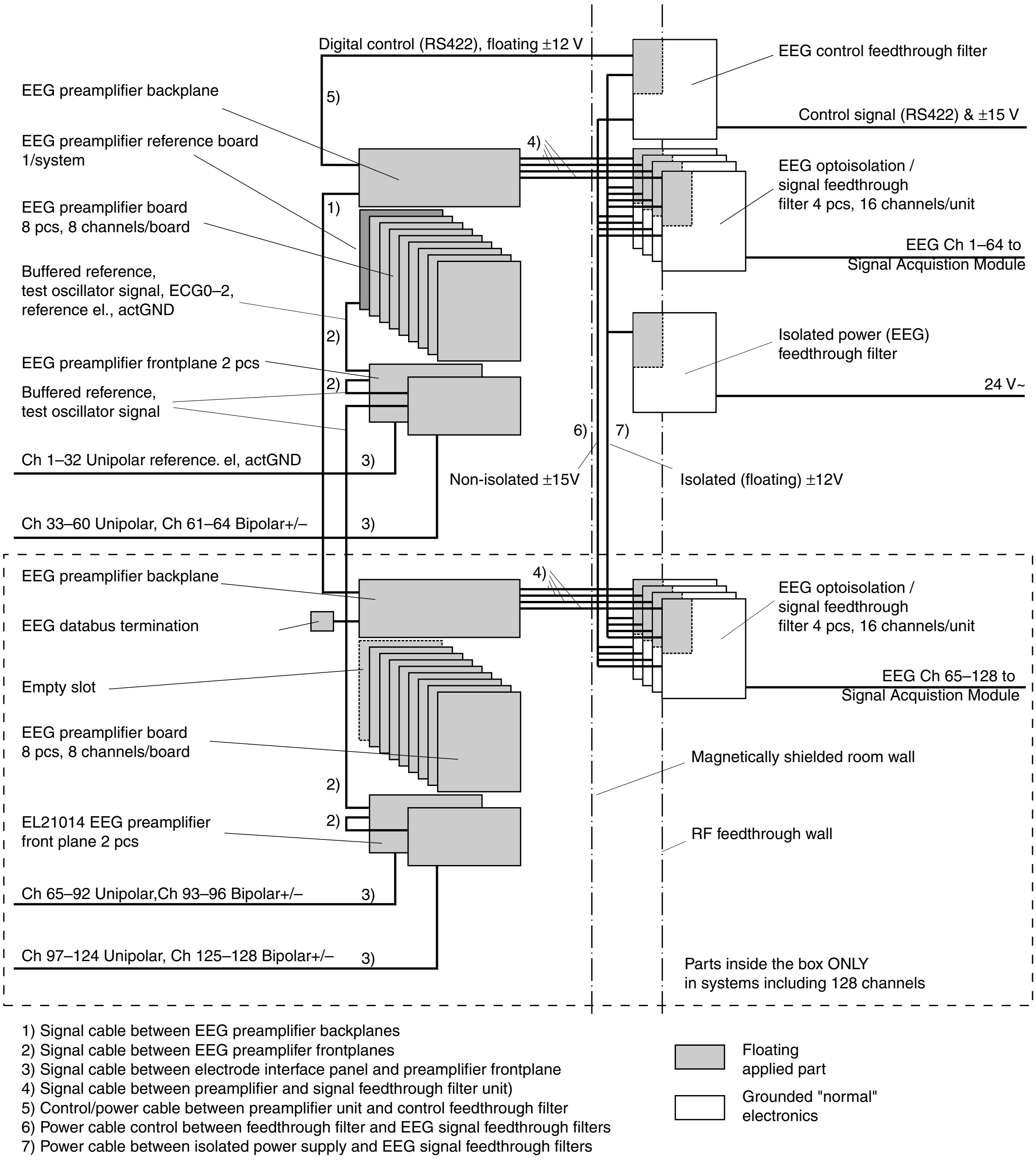


Figure 3.4. Block diagram of the EEG electronics

3.1.3 Auxiliary electronics

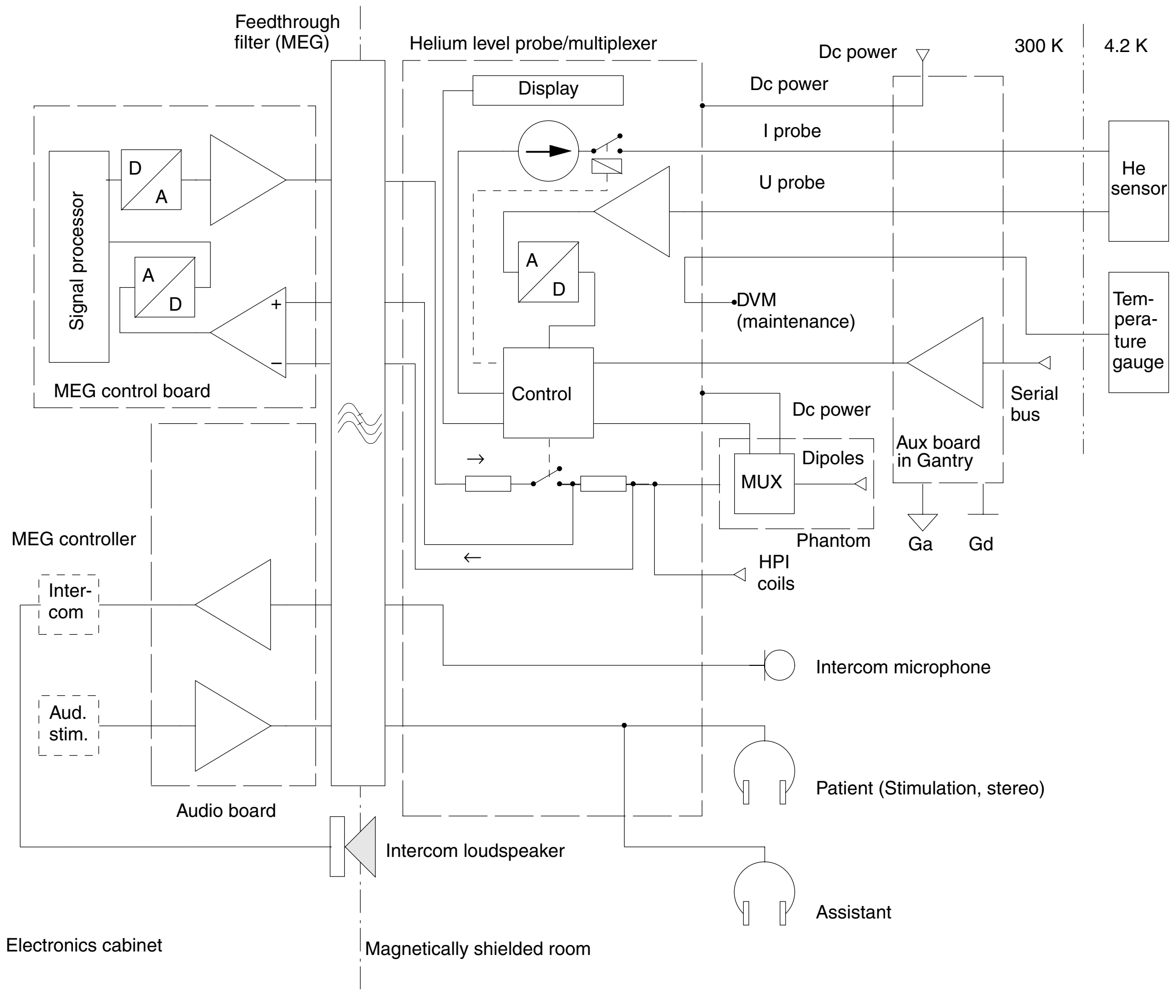


Figure 3.5. Schematic diagram of auxiliary electronics

3.1.4 Lifting mechanism

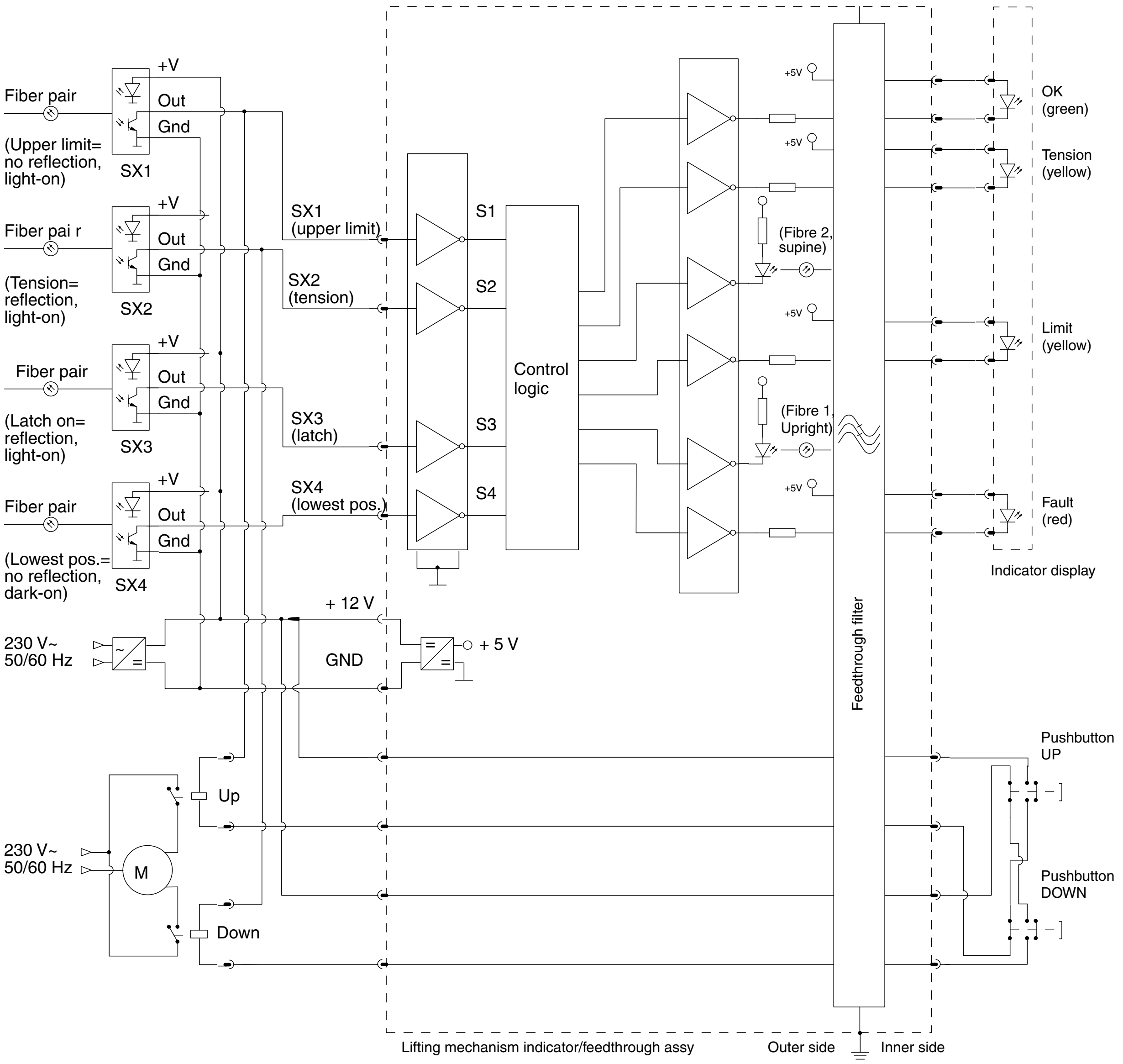


Figure 3.6. Schematic diagram of lifting mechanism electronics

3.2. Electronics cabinets

3.2.1. Main electronics cabinets

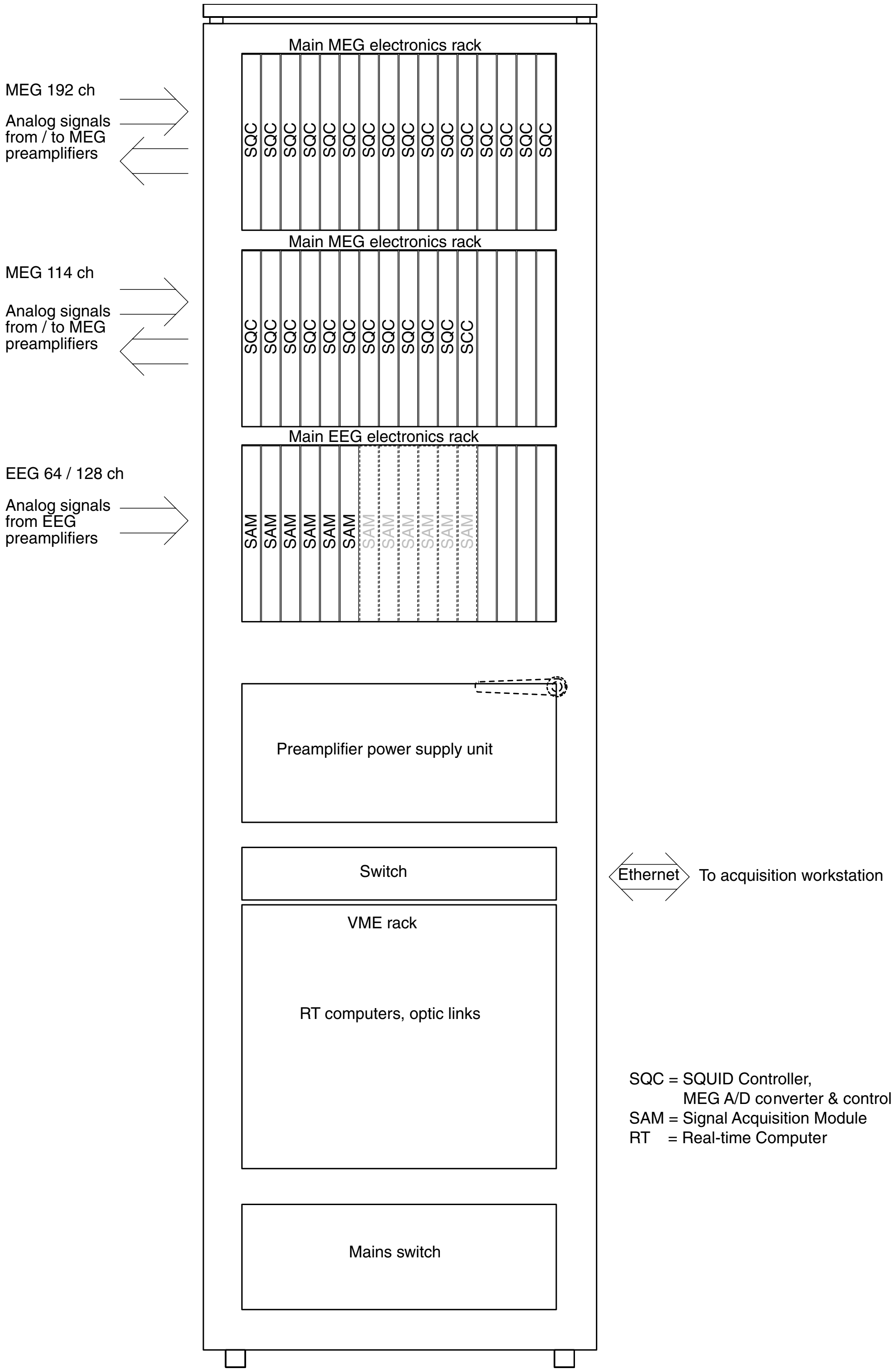


Figure 3.7a. Main electronics cabinet, front view

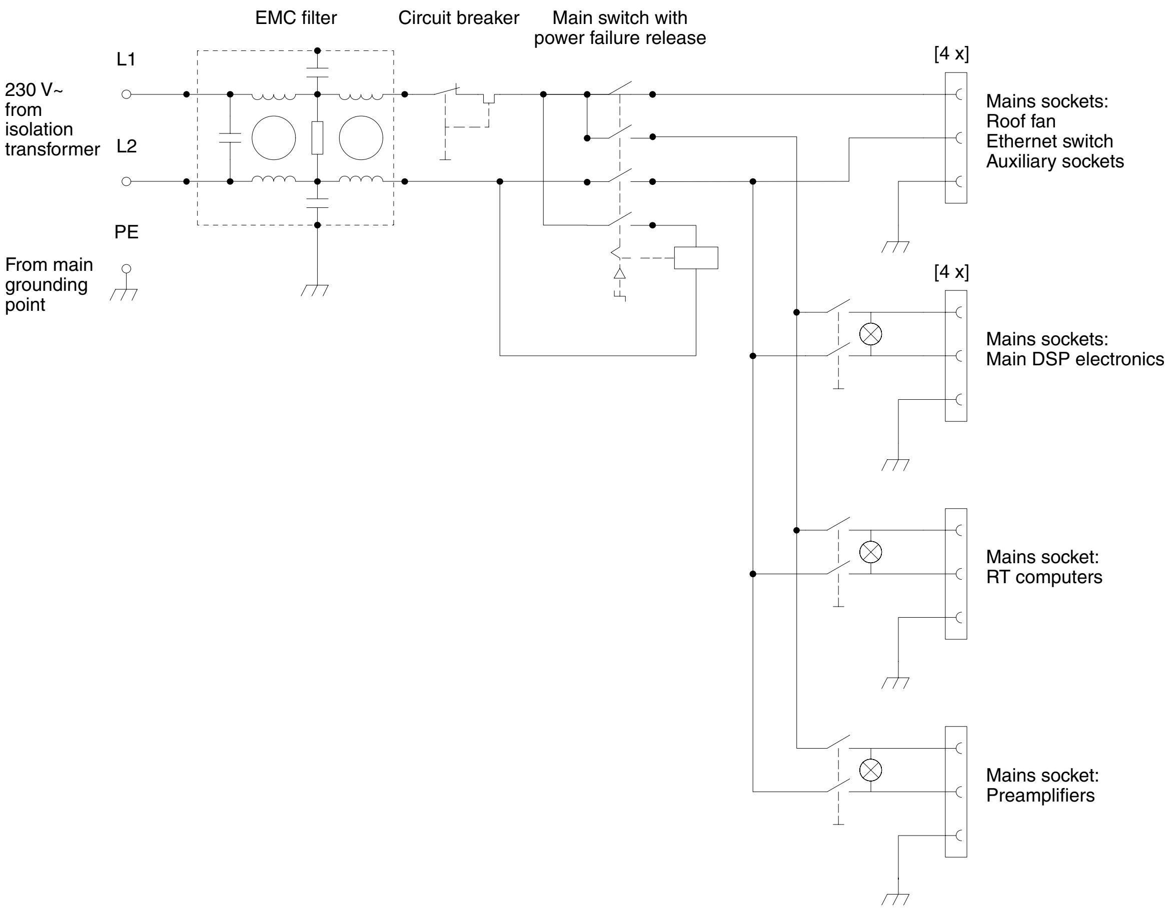


Figure 3.7b. Mains distribution in the main electronics cabinet

3.2.2. Stimulus cabinet

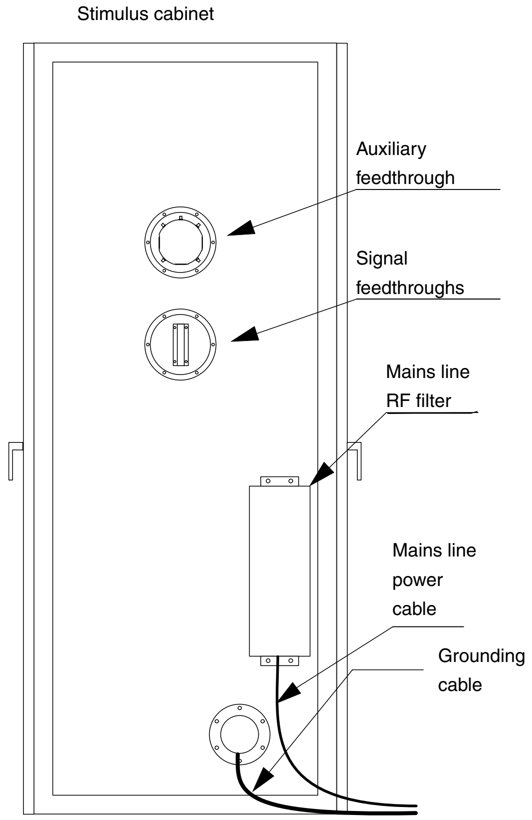


Figure 3.8. Stimulus cabinet, side view (side facing the magnetically shielded room)

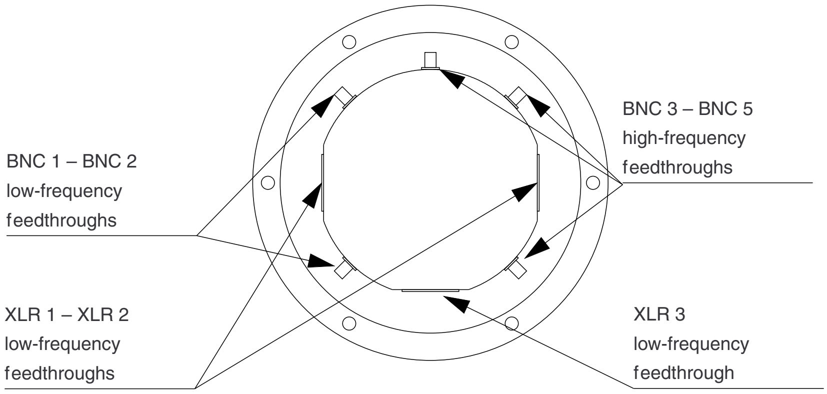


Figure 3.9.a Stimulus cabinet's auxiliary signal feedthrough connectors. For specifications of the feedthrough filters, see 1.6.96.

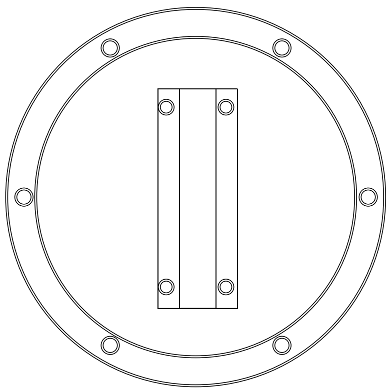


Figure 3.9.b Stimulus cabinet's optional signal feedthrough connectors

3.3. Power supplies

3.3.1. Schematic diagram

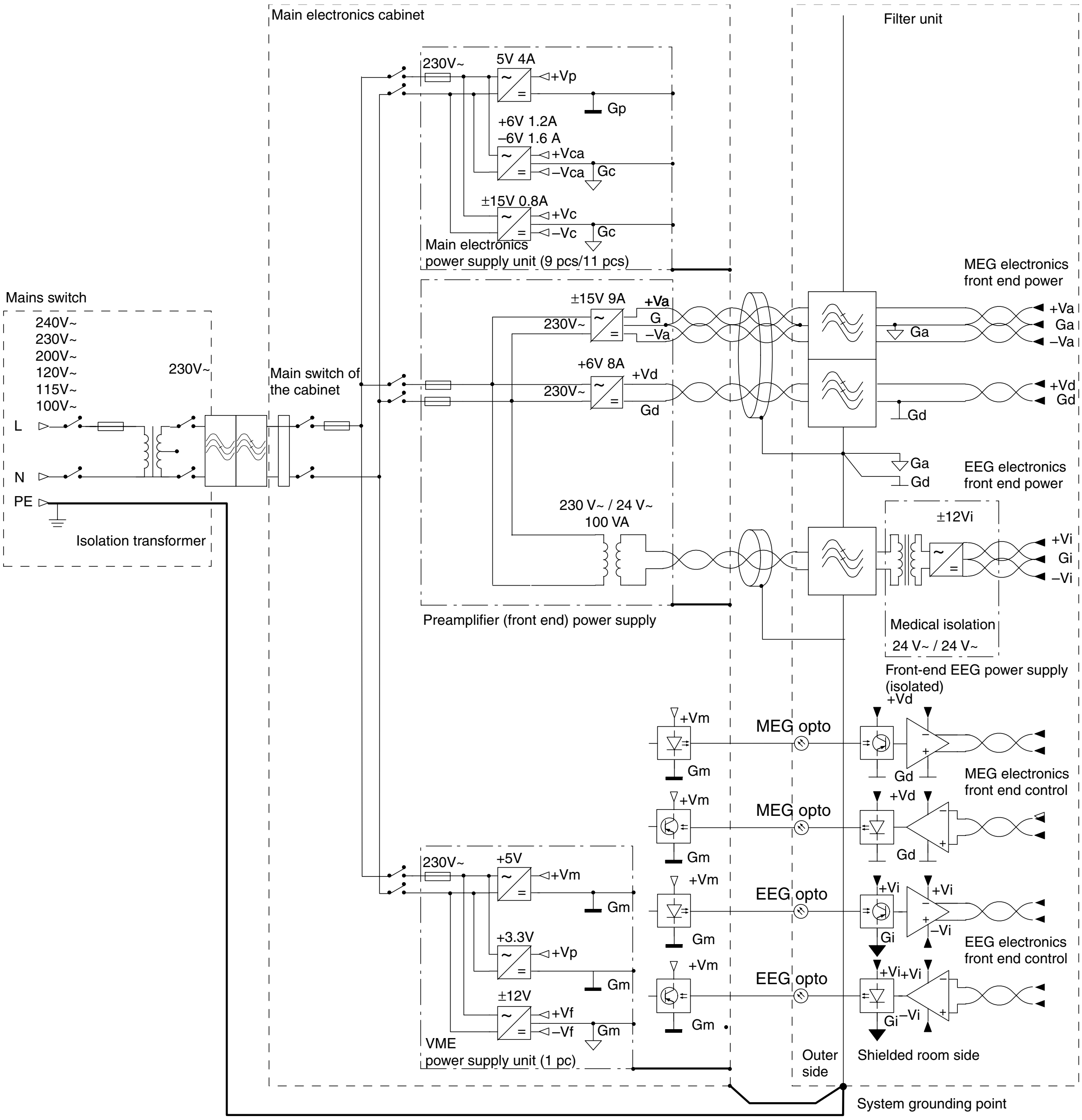
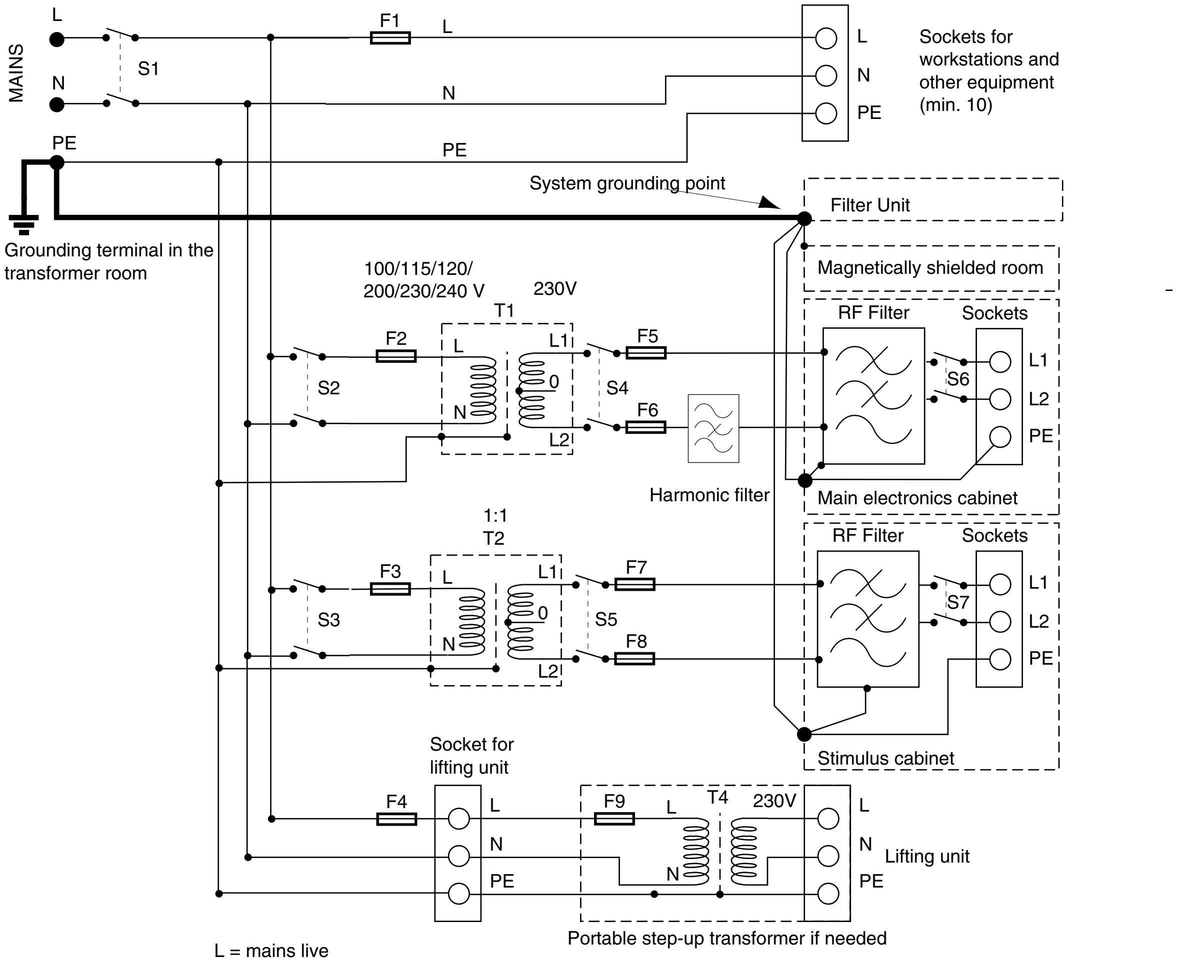


Figure 3.10. Schematic diagram of power supplies. NOTE: Stimulus system is not included.

3.3.2. Recommended power and grounding arrangement

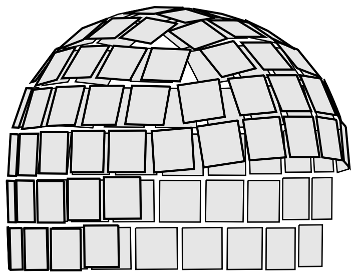


L = mains live
N = mains neutral
PE = protective earth (ground)
L1 and L2 = isolated power terminals (symmetiric with respect to ground)
Switches S6 and S7 are inside cabinets (max. 10A)
Secondary fuses (F5-F8) and switches (S4, S5) are optional

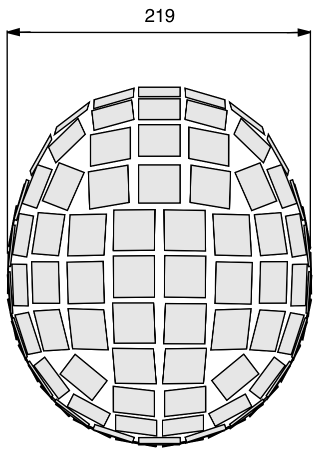
Figure 3.11. Recommended power and grounding arrangements. The specifications of the transformers, switches, and fuses are site-specific.

3.4. Probe unit

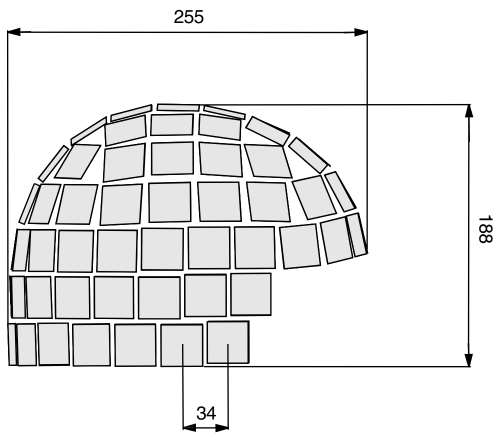
3.4.1. Gradiometer chip and sensor array



Detector array, right frontal view



Detector array, top view



Detector array, side view.
Average distance between sensor elements: 34,6.

Figure 3.12.a Sensor array. Dimensions in millimeters.

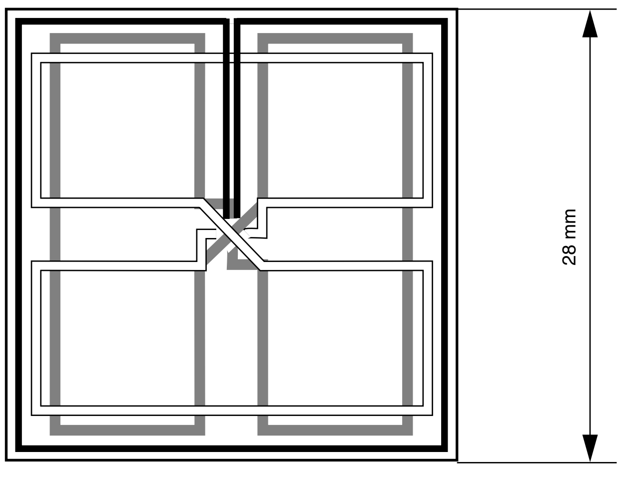


Figure 3.12.b Triple sensor element chip.

3.4.2. Cryogenic insert

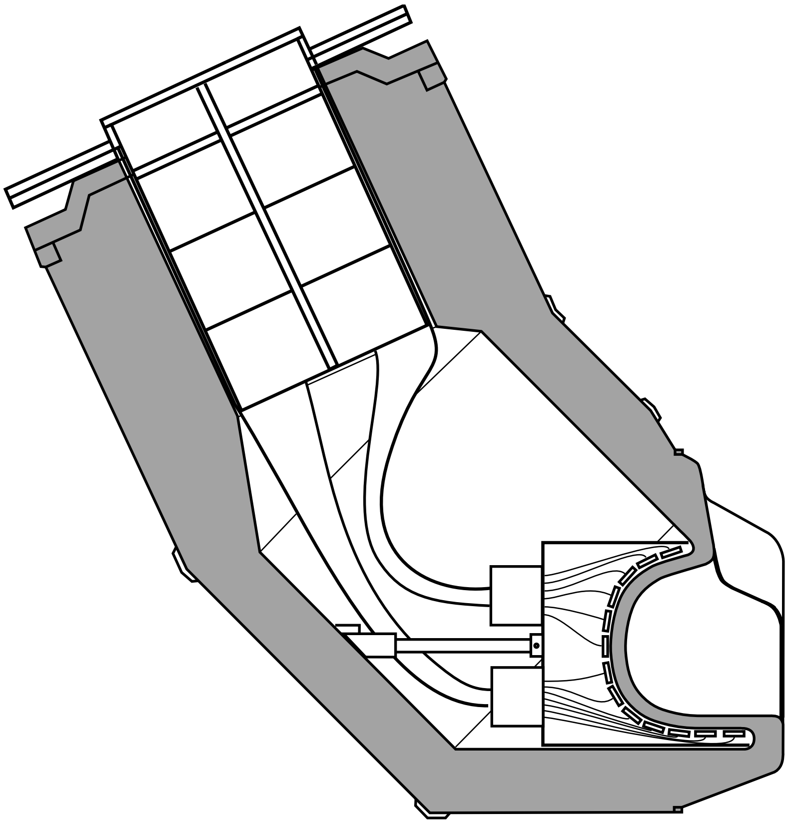


Figure 3.13. Cross-section of the Dewar (see also Fig. 3.14).

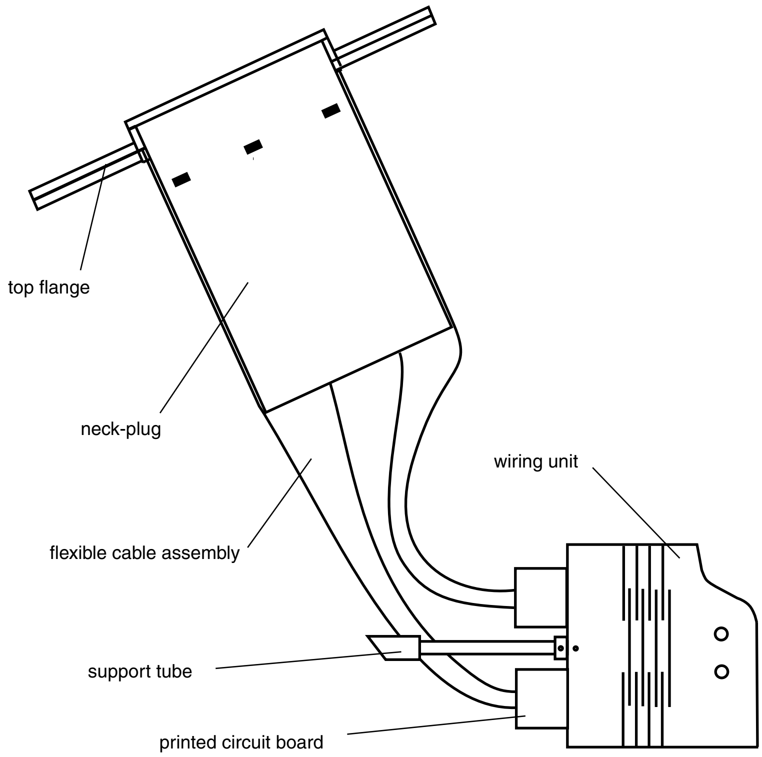


Figure 3.14. Close-up of the insert inside the Dewar (see also Fig. 3.13).

3.6. Data acquisition software block diagram

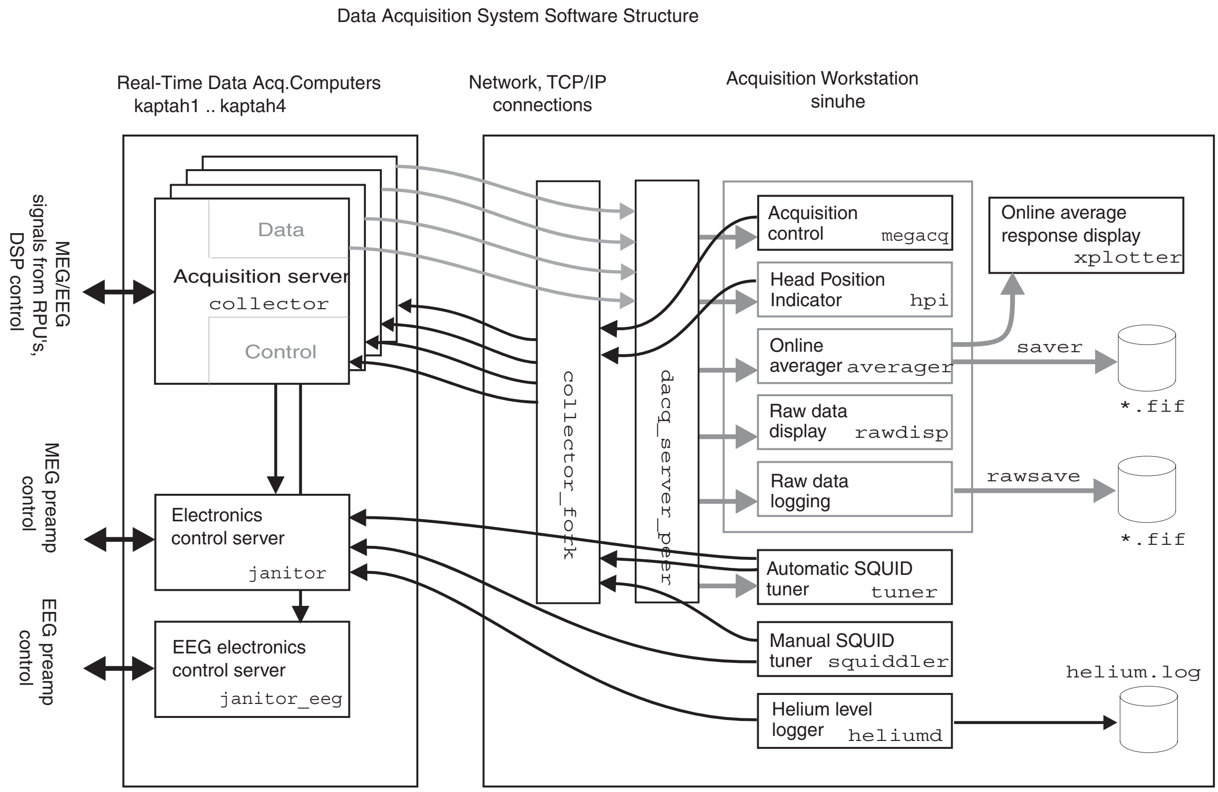


Figure 3.15. Data acquisition software block diagram

Appendix

Additional site-specific data sheets (if applicable)

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