Electronic Instruments for the Life Sciences

made to measure

OPERATING INSTRUCTIONS AND SYSTEM DESCRIPTION FOR THE

EXT-10C

EXTRACELLULAR AMPLIFIER MODULE FOR EPMS SYSTEMS

VERSION 2.2
npi 2020

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Table of Contents

1. Safety Regulations

<u>VERY IMPORTANT</u>: Instruments and components supplied by npi electronic are NOT intended for clinical use or medical purposes (e.g. for diagnosis or treatment of humans), or for any other life-supporting system. npi electronic disclaims any warranties for such purpose. Equipment supplied by npi electronic must be operated only by selected, trained and adequately instructed personnel. For details please consult the GENERAL TERMS OF DELIVERY AND CONDITIONS OF BUSINESS of npi electronic, D-71732 Tamm, Germany.

1) GENERAL: This system is designed for use in scientific laboratories and must be operated only by trained staff. General safety regulations for operating electrical devices should be followed.

2) AC MAINS CONNECTION: While working with the npi systems, always adhere to the appropriate safety measures for handling electronic devices. Before using any device please read manuals and instructions carefully.
   The device is to be operated only at 115/230 Volt 60/50 Hz AC. Please check for appropriate line voltage before connecting any system to mains.
   Always use a three-wire line cord and a mains power-plug with a protection contact connected to ground (protective earth).
   Before opening the cabinet, unplug the instrument.
   Unplug the instrument when replacing the fuse or changing line voltage. Replace fuse only with an appropriate specified type.

3) STATIC ELECTRICITY: Electronic equipment is sensitive to static discharges. Some devices such as sensor inputs are equipped with very sensitive FET amplifiers, which can be damaged by electrostatic charge and must therefore be handled with care. Electrostatic discharge can be avoided by touching a grounded metal surface when changing or adjusting sensors. **Always turn power off when adding or removing modules, connecting or disconnecting sensors, headstages or other components from the instrument or 19” cabinet.**

4) TEMPERATURE DRIFT / WARM-UP TIME: All analog electronic systems are sensitive to temperature changes. Therefore, all electronic instruments containing analog circuits should be used only in a warmed-up condition (i.e. after internal temperature has reached steady-state values). In most cases a warm-up period of 20-30 minutes is sufficient.

5) HANDLING: Please protect the device from moisture, heat, radiation and corrosive chemicals.

2. EPMS-07 Modular Plug-In System

2.1. *General System Description / Operation*

The npi EPMS-07 is a modular system for processing of bioelectrical signals in electrophysiology. The system is housed in a 19" rackmount cabinet (3U) has room for up to 7 plug-in units. The plug-in units are connected to power by a bus at the rear panel.
The plug-in units must be kept in position by four screws (M 2,5 x 10). The screws are important not only for mechanical stability but also for proper electrical connection to the system housing. Free area must be protected with covers.

2.2. *EPMS-07 Housing*

The following items are shipped with the EPMS-07 housing:

- ✓ EPMS-07 cabinet with built-in power supply
- ✓ Mains cord
- ✓ Fuse 2 A / 1 A, slow (inserted)
- ✓ Front covers

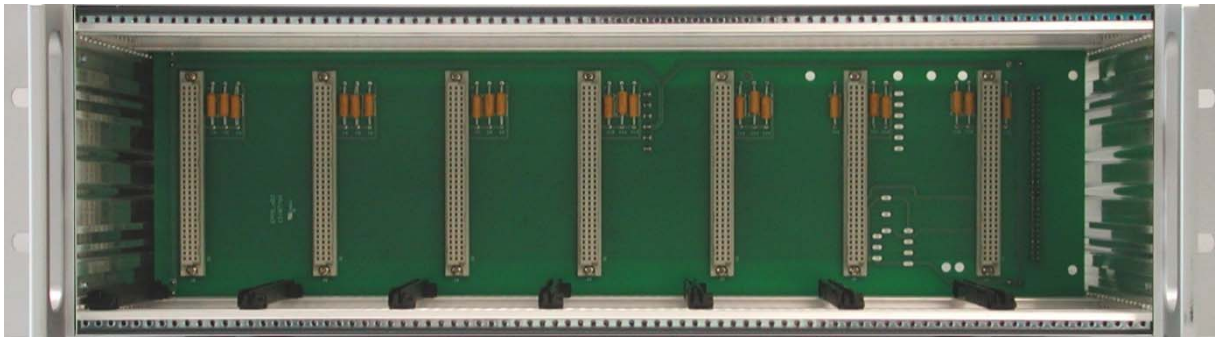


Figure 1: Left: front view of empty EPMS-07 housing.

In order to avoid induction of electromagnetic noise the power supply unit, the power switch and the fuse are located at the rear of the housing (see Figure 2, right).

2.3. *EPMS-H-07 Housing*

In addition to the standard power supply of the EPMS-07, the EPMS-H-07 has a built-in high voltage power supply. This is necessary for all MVCS / MVCC modules, the HVA-100, HV-TR150 and HVC-03M modules. The output voltage depends on the modules in use.

2.4. *EPMS-E-07 Housing*

The following items are shipped with the EPMS-E-07 housing:

- ✓ EPMS-E-07 cabinet
- ✓ External Power supply PWR-03D
- ✓ Power cord (PWR-03D to EPMS-E-07)
- ✓ Mains chord
- ✓ Fuse 1.6 A / 0.8 A, slow (inserted)
- ✓ Front covers

The EPMS-E-07 housing is designed for low-noise operation, especially for extracellular and multi channel amplifiers with plugged in filters. It operates with an external power supply to minimize distortions of the signals caused by the power supply.

2.5. *EPMS-03*

The following items are shipped with the EPMS-07 housing:

- ✓ EPMS-07 cabinet with built-in power supply
- ✓ Mains cord
- ✓ Fuse 0,4 A / 0,2 A, slow (inserted)
- ✓ Front covers

Figure 2: Left: front view of EPMS-03 housing. Right: rear panel detail of EPMS-03 and EPMS-07 housing.

In order to avoid induction of electromagnetic noise the power supply unit, the power switch and the fuse are located at the rear of the housing (see Figure 2, right).

2.6. *PWR-03D*

The external power supply PWR-03D is capable of driving up to 3 EPMS-E housings. Each housing is connected by a 6-pole cable from one of three connectors on the front panel of the PWR-03D to the rear panel of the respective EPMS-E housing (see Figure 3, Figure 4). A POWER LED indicates that the PWR-03D is powered on (see Figure 3, left). Power switch, voltage selector and fuse are located at the rear panel (see Figure 3, right).

Note: The chassis of the PWR-03D is connected to protective earth, and it provides protective earth to the EPMS-E housing if connected.

Figure 3: Left: PWR-03D front panel view Right: PWR-03D rear panel view.

Note: This power supply is intended to be used with npi EPMS-E systems only.

2.7. *System Grounding*

EPMS-07/EPMS-03

The 19" cabinet is grounded by the power cable through the ground pin of the mains connector (= protective earth). In order to avoid ground loops the internal ground is isolated from the protective earth. The internal ground is used on the BNC connectors or GROUND plugs of the modules that are inserted into the EPMS-07 housing. The internal ground and mains ground (= protective earth) can be connected by a wire using the ground plugs on the rear panel of the instrument. It is not possible to predict whether measurements will be less or more noisy with the internal ground and mains ground connected. We recommend that you try both arrangements to determine the best configuration.

EPMS-E-07

The 19" cabinet is connected to the CHASSIS connector at the rear panel. It can be connected to the SYSTEM GROUND (SIGNAL GROUND) on the rear panel of the instrument (see Figure 4).
The chassis can be linked to PROTECTIVE EARTH by connecting it to the PWR-03D with the supplied 6-pole cable **and** by interconnecting the GROUND and PROTECTIVE EARTH connectors on the rear panel of the PWR-03D (see Figure 3). Best performance is generally achieved without connection of the chassis to protective earth.

Important: Always adhere to the appropriate safety measures.

Figure 4: Rear panel connectors of the EPMS-E-07

2.8. *Technical Data*

EPMS-07, EPMS-E-07 and EPMS-H-07

19” rackmount cabinet, for up to 7 plug-in units
Dimensions: 3U high (1U=1 3/4” = 44.45 mm), 254 mm deep

EPMS-07 and EPMS-H-07

Power supply: 115/230 V AC, 60/50 Hz, fuse 2 A / 1 A slow, 45-60 W

EPMS-E-07

External power supply (PWR-03D) 115/230 V AC, 60/50 Hz, fuse 1.6/0.8 A, slow
Dimensions of external power supply: (W x D x H) 247 mm x 180 mm x 90 mm

EPMS-03

Power supply: 115/230 V AC, 60/50 Hz, fuse 0.4 A / 0.2 A slow
Maximum current supply: 500 mA
Dimensions: 3U high (1U=1 3/4” = 44.45 mm), 245 mm deep, 265 mm wide

3. EXT-10C

3.1. *EXT-10C Components*

The following items are shipped with the EXT-10C system:

- ✓ Amplifier module for the EPMS-07 system
- ✓ GND- (2.4 mm banana plug) and REF. (SMB) connectors for headstage
- ✓ Headstage
- ✓ User manual

3.2. *System Description*

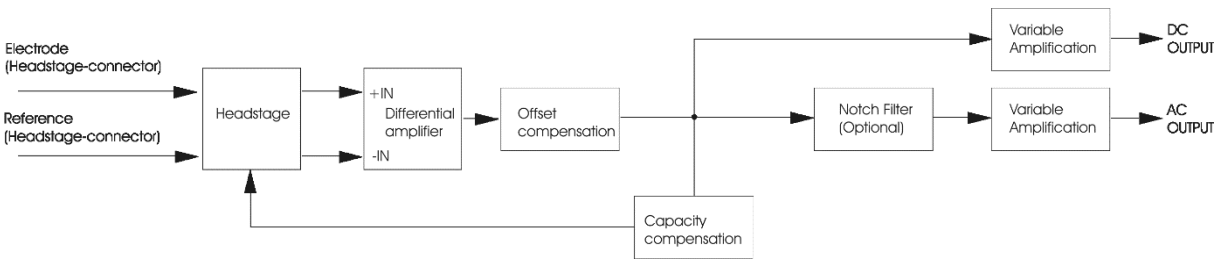
The EXT-10C was designed for performing low noise recordings of small extracellular signals in slices or in *in vivo* preparations using fine tipped glass or metal microelectrodes. The system consists of a module for the npi EPMS-07 modular system and a small headstage with a holding bar.

The EXT-10C has a differential input with high input resistance for minimizing noise. The incoming signal can be compensated for offset and capacity of the microelectrode by the two potentiometers OFFSET and C-COMP. An analog balance monitor makes the control of offsets easy. The recorded signal can be obtained either AC with GAIN of 100, 1k or 10k or DC with GAIN of 10, 100 or 1k. An optional NOTCH filter eliminates 50/60 Hz noise in AC measurements.

The EXT-10C is designed to be used with the DPA-2F preamplifier/filter module from npi which combines additional gain stages with high- and lowpass filters.

3.3. *Signal Flow Diagram*

The signal is passed through the EXT-10C as shown below.



3.4. *Description of the Front Panel*

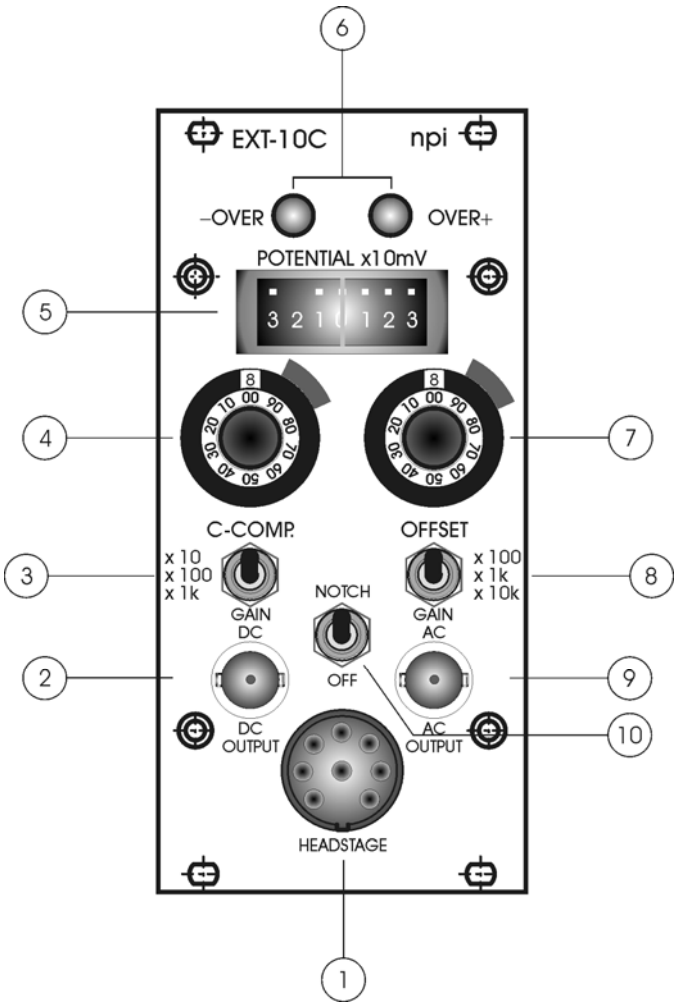


Figure 5: EXT-10C front panel view

In the following description of the front panel elements each element has a number that is related to that in Figure 5. The number is followed by the name (in uppercase letters) written on the front panel and the type of the element (in lowercase letters). Then, a short description of the element is given.

(**1**) HEADSTAGE connector

The HEADSTAGE cable is connected to the unit at an 8-pin connector in the center of the module.

(**2**) DC OUTPUT connector

BNC connector providing the amplified signal DC coupled. The amplification factor is set by the GAIN DC switch (**3**). The DC OUTPUT is always unfiltered.

(**3**) GAIN DC switch

Switch to set the GAIN of the outgoing DC signal. Three GAIN factors are available: x10, x100 or x1k.

(**4**) C-COMP**.** potentiometer

Control for compensation of stray capacities of the microelectrode (10 turn potentiometer, range 0-20 pF).

Note: Capacity compensation is a positive feedback circuit. Overcompensation of the capacity will lead to oscillations which may damage the cell.

(**5**) POTENTIAL x10 meter

The analog POTENTIAL monitor displays the offset in the range of ±30 mV and is used for optimal cancellation of the OFFSET.

(**6**) –OVER +OVER LEDs

LEDs that indicate if the amplifier 10% below it's positive or negative limit (±10 V). The linear range of the amplifier is ±12 V.

(**7**) OFFSET potentiometer

10 turn potentiometer to compensate for the OFFSET of a DC signal.

Note: Position 5 on the OFFSET control corresponds to 0 mV offset.

(**8**) GAIN AC switch

Switch to set the GAIN of the outgoing AC signal. Three GAIN factors are available: x100, x1k or x10k.

(**9**) AC OUTPUT connector

BNC connector providing the amplified signal AC coupled. The amplification factor is set by switch (**8**).

(**10**) NOTCH switch (optional)

Switch to set the NOTCH filter (50 Hz / 60 Hz) or to bypass the NOTCH filter (switch position OFF) for AC measurements.

3.5. *Headstage*

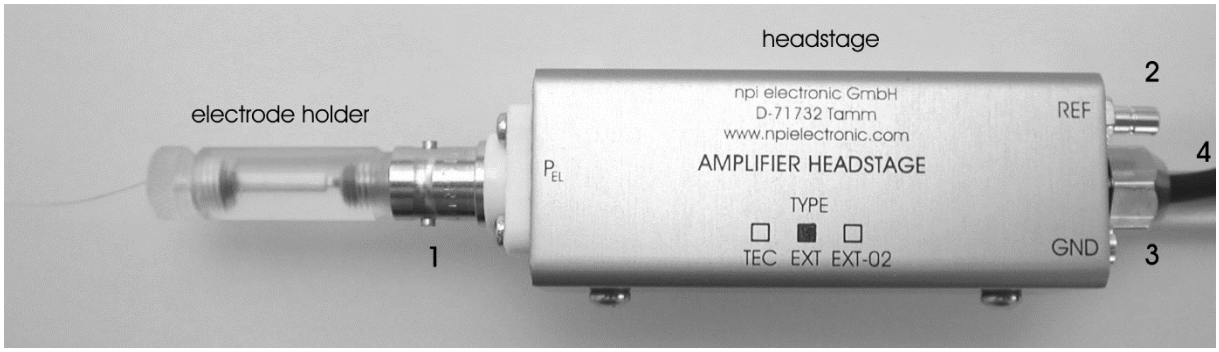


Figure 6: electrode holder (optional) and headstage of the EXT-10C

Headstage Elements

1 P_{EL}: BNC connector for the electrode holder (measuring electrode)
2 REF: SMB connector for the reference electrode
3 GND: Ground connector
4 Holding bar

On request, P_{EL} can be implemented using 1 mm or 2 mm banana jacks or using SMB connectors.

Very Important: EXT-10C headstages are always labeled "EXT" (see Figure 6) and must not be exchanged with headstages from npi electronic's desktop EXT amplifiers, e.g. the EXT-02F which is labeled "EXT-02"!

Also Important: The shield of the BNC connector of the headstage is connected to driven shield, and must not be connected to ground.

3.6. *Operation*

Extracellular measurements are mostly done in slices or *in vivo*, where distortions of the signal caused by other instruments and the animal itself are very common. Additionally, extracellular signals are very small and have to be amplified enormously. The drawback is that noise is amplified as well. Therefore, the headstage of the EXT-10C is equipped with a differential input that minimizes noise pick-up. Differential means, that the signal for the amplifier is the difference between the positive (+) (P_{EL}) and negative (-) (REF) input of the headstage. This results in canceling of all signals which both electrodes record, e.g. noise.

For differential measurements, both inputs of the headstage (REF and P_{EL}) are connected to microelectrodes using cables with grounded enclosure or electrode holders. P_{EL} is connected to the measuring electrode, REF is connected to the reference electrode. The experimental chamber is grounded by an Ag-AgCl pellet (or an AGAR bridge) connected to GND of the headstage (see Figure 7).

If differential measurement is not required (single-ended measurement configuration, see Figure 7), the REF input must be connected to ground (GND). The amplifier is in an undefined state, if the REF is left open, and can go into saturation making reliable measurements impossible.

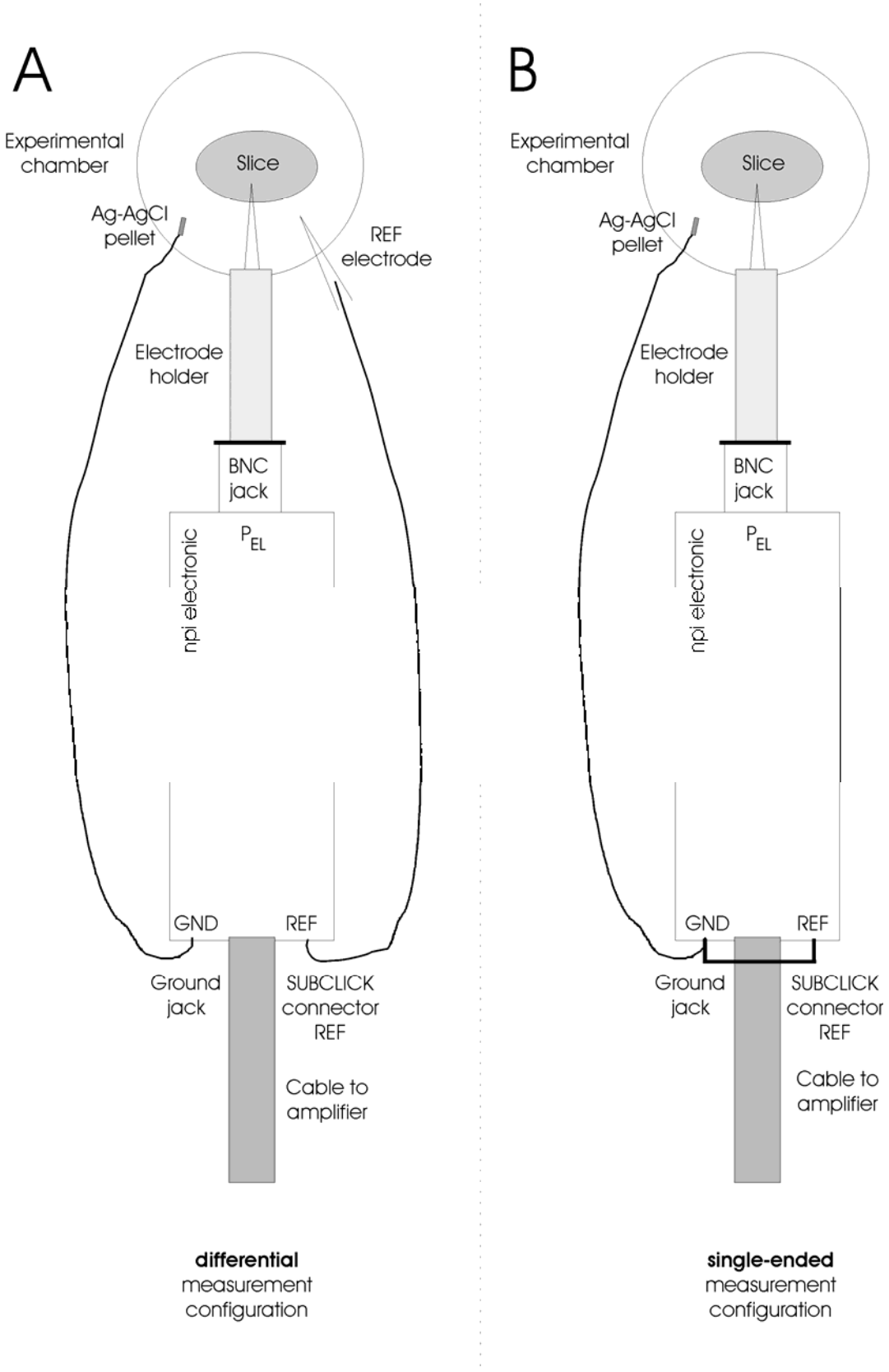


Figure 7: headstage connections, **A**: differential measurement, **B**: single-ended measurement

4. Literature

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5. Technical Data

Differential Input:	CMR >90 dB at 1 kHz (tested with 0 Ω input resistance)
Input resistance:	$>10^{12}$ Ω, range ±1 V
Output DC:	selectable gain (x10, x100, x1k)
	Output range: ±12 V into 1 kΩ / ±1 V into 50 Ω load
Output AC:	selectable gain (x100, x1k, x10k)
	Output range: ±12 V into 1 kΩ / ±1 V into 50 Ω load
	corner frequency 10 Hz
	NOTCH filter 50/60 Hz (optional)
Offset compensation:	10 turn potentiometer, ±100 mV
Potential monitor:	analog display for the electrode offset, range: ±30 mV
Capacity compensation:	0-20 pF, 10 turn potentiometer
Size:	front panel 12 HP (60.6 mm) x 3U (128,5 mm), 7” (175 mm) deep
Headstage Size:	70 x 26 x 26 mm
Holding Bar:	length: 150 mm; diameter: 8 mm.