Operating Instructions

for the MICRO ELECTRODE AMPLIFIER MEA Type 695
and its preamplifier
HEADSTAGE FOR MEA HS-XX Type 695-XX

Prel. version 1.1 prod. 8/99 St

Introduction, manufacturer's details

These Operating Instructions describes the function and use of the PLUGSYS module MICRO ELECTRODE AMPLIFIER MEA Type 695 and its preamplifier HEADSTAGE FOR MEA Type 695-XX. They form part of the equipment and have to be kept close to it. All the information in these Instructions has been drawn up after careful examination but does not represent a warranty of product properties. Alterations in line with technical progress are reserved.

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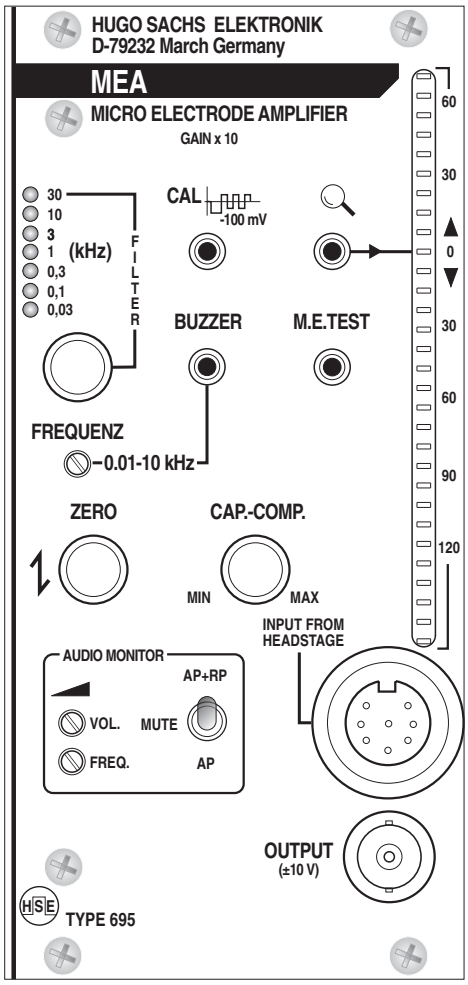
Trademark
PLUGSYS is a registered trademark of Hugo Sachs Elektronik, March-Hugstetten.

Safety notes
Warning: the equipment is not suitable for operation in hazardous areas and/or in a flammable atmosphere.

The equipment is not approved for use on humans.



Front panel

General description, application
The MEA Module Type 695 is a module for the PLUGSYS measuring system. It represents a microelectrode amplifier for use in physiological and pharmacological research. Using suitable recording electrodes (microelectrodes) and an appropriate experimental setup it is employed for measuring intracellular or extracellular voltage potentials.

Warning:
the amplifier input has to be protected against overvoltages!

The input of the headstage preamplifier may be damaged or destroyed through application of voltages

greater than ± 15 Volt. You should therefore take appropriate precautions when handling the preamplifier. In particular avoid electrostatic charges or discharges by earthing yourself through a high resistance (1 MOhm protection resistance) using an ESD safety wrist band and an ESD discharge cable. Arrange your working area such that there is if possible no build-up of electric charges: antistatic floor and/or bench covering, antistatic stool, antistatic working clothing, in particular antistatic shoes.

Constituents

The complete amplifier consists of:

- PLUGSYS housing with built-in power supply, e.g. standard 19-inch rack housing Type 603 or MiniCase Type 609
- MEA module Type 695
- Headstage (preamplifier) Type 695/1, for plugging in to MEA

Controls

Description of the front panel controls for the item numbers in the adjacent diagram

1 Signal output (BNC socket) **OUTPUT (±10 V)**. The amplification factor (GAIN) of the MEA is fixed at G = 10. The output signal is then 10 times as large as the input signal.

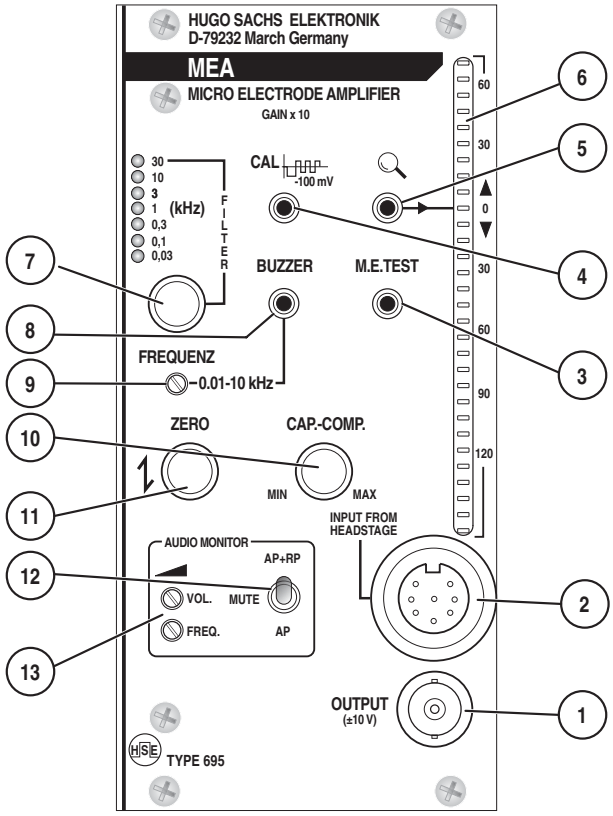
2 Input socket (8-pin) for connecting up the preamplifier, **INPUT FROM HEADSTAGE**

3 M.E.TEST key (MICROELECTRODE TEST). On operating this key a defined current is fed into the microelectrode. Depending on the electrode resistance there is then a potential step which permits an approximate estimate of the instantaneous electrode resistance. The current depends on the type of preamplifier (headstage) used.

HS-type	Test current	Potential step
695-1G	1 nA	1 mV/MOhm
695-100M	10 nA	10 mV/MOhm
695-10M	100 nA	100 mV/MOhm
695-1M	1 pA	1 V/MOhm

The current flow is automatically limited to 2 seconds in order to avoid damage to the electrode through electrolysis.

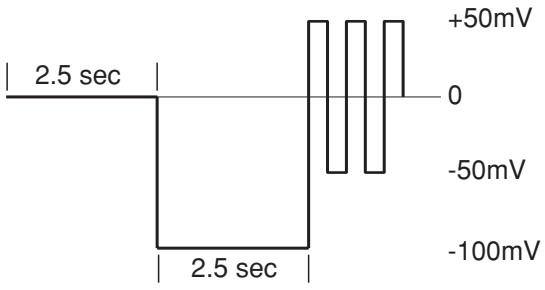
4 CAL key. On operating this key the existing microelectrode input signal is disconnected and instead a calibration signal with the profile shown below is injected. The voltage data are referred to the microelectrode input.



Controls. For legends to the item numbers see text.

5 „Magnifier“ key. On operating this key the sensitivity of the bargraph indication is increased by a factor of 5. The key function is useful for accurate zeroing.

6 LED bargraph indication with 30 LEDs as signal monitor for visually checking the course of the input signal. The sensitivity is 7.5 mV per LED referred to the input. The bargraph can therefore indicate input voltages in the range from -150 mV to +67.5 mV. Pressing the magnifier key (5) produces a sensitivity of 1.5 mV per LED; the indication range is then correspondingly reduced (-30 mV to +13.5 mV).



Calibration signal

7 Control **FILTER** for setting the upper frequency limit (-3dB) of the MEA: 0.03 to 30 kHz. At these specified frequencies the amplitude has decreased by 3 dB (30%). The setting selected is indicated by the corresponding LED lighting up.

8 BUZZER key. During insertion of the microelectrode this function assists the electrode tip in piercing the cell membrane. When the key is operated an AC voltage is applied to the electrode. The frequency of the AC voltage can be set with a screwdriver on the selector switch (9).

NOTE: in the interest of achieving stable intracellular recording over longer periods the electrode should be inserted into the cell as quickly as possible, within half-an-hour after the animal has been killed. Using careful electrical stimulation (e.g. 0.3 Hz) the inserted electrode should then be allowed to „heal“ in the cell membrane. It is known that with delayed insertion of the electrode the healing process does not proceed so well and unstable recordings have to be expected.

9 Selector switch „**FREQUENZ 0,01 - 10 kHz**“ for selecting the „BUZZER“ frequency in order to adjust it to the requirements of the particular experiment. Using a screwdriver the following frequencies can be selected: 10, 20, 40, 60, 80, 100, 200, 400, 600, 800, 1k, 2k, 4k, 6k, 8k and 10 kHz. The buzzer function can be monitored by sound if you select a frequency in the readily audible range (400 Hz - 4 kHz).

10 Control **„CAP.COMP“** (capacity compensation). This control can be used to neutralise the interfering parasitic electrical capacity of the microelectrode against its surroundings. The compensation range depends on the headstage preamplifier used. For example, the compensation range of Type 695-1G extends to about 8 pF.

Note: capacity compensation has to be used with care!

Over-compensation causes the input circuit to oscillate at a relatively high frequency (a few hundred Hertz to above 30 kHz, depending on the actual electrode resistance and the parasitic capacities at the input), resulting in damage to the cell and the microelectrode. You should therefore always monitor the output signal with an oscilloscope when you alter the setting of the capacity compensation.

Note page 5 in this connection.

11 Control **ZERO** for zeroing the amplifier. The adjustment range covers ±0.4 V referred to the input.

12 AUDIO MONITOR switch. This switch can be used to select the function of the built-in acoustic frequency-modulated signal generator.

AP+RP: rest potential (RP) with superimposed action potential (AP) as indicated. In this switch position a signal tone is produced continuously. The pitch of the tone changes with the input voltage of the MEA. Variations in pitch are noticed very sensitively so that very small fluctuations in the rest potential can be clearly recognised without requiring visual observation of the signal course, e.g. on the built-in bargraph or on the screen of an oscilloscope or data acquisition system. The response sensitivity level for the RP is -100 mV. At a lower RP the signal generator is switched inaudible (muted).

MUTE: signal generator is switched off.

AP: only the action potential is signalled. There is no signal tone in the pauses between the action potentials. The response sensitivity is at an AP amplitude of about 20 mV.

13 Trimmers for setting the loudness **VOL.** and the base frequency **FREQ.** of the audio monitor (12).

Headstage

Description of the components and connections of the headstage. The item numbers refer to the illustration alongside.

H1 Metal screen housing of the preamplifier HEADSTAGE for MEA Type 695-1G with fixing rod (H3) and integral microelectrode holder (H2).

H2 Input socket for connecting the microelectrode. Suitable pin plug 2 mm diameter, not spring-loaded (the built-in socket has spring-loading). In order to protect the highly sensitive input amplifier against electrostatic discharges while handling the headstage the input socket is mounted in a plastic recess (approx. 7 mm).

Warning! the connection for the microelectrode has to be protected against excessive input voltages! At voltages above ±15 Volt the amplifier may be damaged or destroyed.

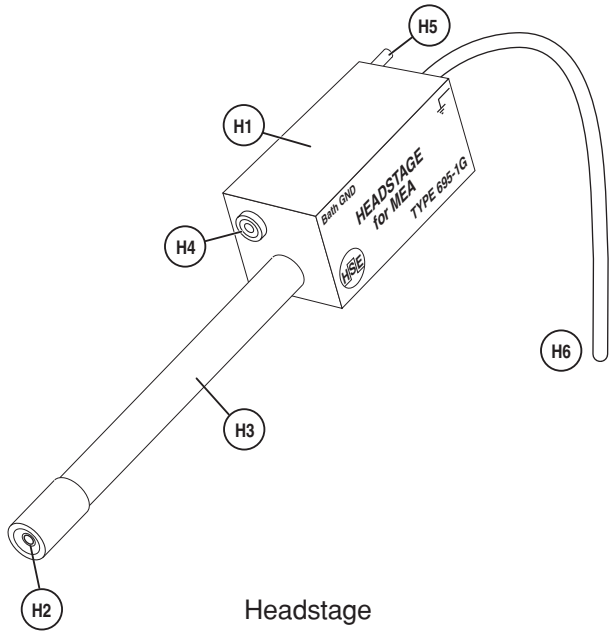
H3 Headstage mounting rod for fixing the headstage on the micromanipulator. Dimensions: diameter 8 mm (metal tube) or 9 mm (plastic end), length 75 mm (metal tube) and 12 mm (plastic end).

Important: clamp it only in the region of the metal tube.

H4 Socket for connecting the bath earth. Suitable pin plug 2 mm diameter, not spring-loaded (the socket incorporates spring elements).

H5 Plug pin (D = 2 mm) for connecting the headstage to the central earth and screen. Suitable cable coupling socket 2 mm diameter, spring-loaded. Note that couplings without spring loading do not ensure reliable contact.

H6 Connecting cable with connector plug (8-pin) to the MEA. Cable length 1.5 m approx.

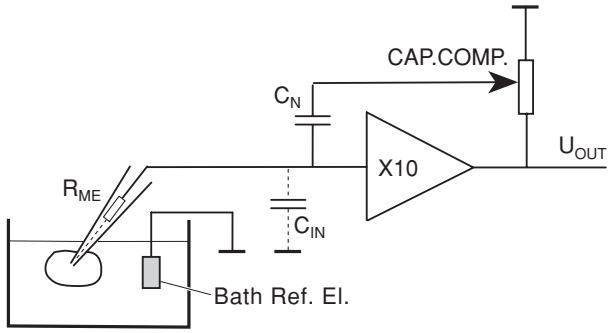


Headstage

Organ bath and electrode connection

The illustration alongside shows schematically the connection of a microelectrode to the preamplifier input of the MEA. The organ bath vessel contains a muscle preparation immersed in perfusion solution. The microelectrode is inserted into a cell of the preparation. The microelectrode is linked to the amplifier input through a connection which should be kept as short as possible.

A counter electrode **Bath Ref. El.** is required for recording the action potential of the muscle cell; it is also located in the organ bath solution. The material used for the reference electrode is usually silver/silver chloride (Ag/AgCl) in order to avoid polarisation voltages.



Organ bath and MEA connection

Capacity compensation

As described previously, the parasitic electrical capacity C_{IN} in the region between microelectrode tip and amplifier input represents somewhat of a problem. The parasitic capacity C_{IN} together with the electrical resistance R_{ME} of the microelectrode acts as a low-pass filter and thereby reduces the maximum signal frequency which can be recorded (= steep components of the signal amplitudes!).

In order to reduce this problem the MEA incorporates a device for neutralising the parasitic capacity, the capacity compensation **CAP. COMP.** For this purpose an adjustable amplified proportion of the input voltage is fed back in-phase to the input through the capacity C_N. For various reasons the compensation can not be complete and is accompanied by disadvantages (increased noise level, optimum adjustment is critical). In order to improve the recorded bandwidth it is therefore advisable not to rely on capacity compensation alone but to keep the parasitic capacity essentially as low as possible. This can be achieved in different ways.

The best method is to consider the individual partial capacities which make up the total parasitic capacity, and to reduce them to a minimum.

The „transmural“ capacity of the part of the microelectrode which is immersed in the bath liquid, may be rather large. A typical value is about 1 pF or more per millimetre insertion depth.

An effective measure to reduce the capacity consists of increasing the wall thickness of the microelectrode. For example, the electrode can be coated in the appropriate region with Silicone (Sylgard) or equivalent material in order to increase the effective wall thickness.

Another possibility for reducing the transmural capacity of the microelectrode consists of selecting a lower liquid level in the bath, thereby reducing the immersed area of the electrode. This measure is not always successful since, due to the surface tension of the bath liquid, electrically conducting bath liquid creeps upwards along the outside of the electrode glass surface and thus increases the capacity again. This upwards creeping can be avoided by rendering the electrode surface hydrophobic through immersing it before use in mineral oil (or Silicone oil). Note that the electrode has to be filled with electrolyte before it is made hydrophobic!

Finally an effort should be made to ensure that electrically conducting and earthed objects around the microelectrode and around the connection to the headstage input are arranged at a maximum possible distance from the electrode.

Fitting the module in a housing

If the module is supplied separately you should read this section. If however the module is supplied already installed you can omit this section. For example, the module has always been installed by the manufacturer if the MEA is ordered together with the PLUGSYS MiniCase Type 609.

Before you can use the MEA module it has to be installed in a suitable HSE PLUGSYS housing Series 600. If the module is supplied as part of a completely installed PLUGSYS measuring system the work described below has already been carried out and the selected signal paths have been entered in the bus diagram.

Installation procedure

Before installing the module in a housing you have to designate the amplifier output of the module to the required bus line by fitting a jumper, as described below.

IMPORTANT: do not forget to enter the selected connections in the bus diagram (in the white Operating Instructions folder under Section 1).

Warning:
While out of the housing, the MEA module has to be protected against electrostatic discharges. The MEA module contains highly sensitive MOS components which may be damaged or even destroyed by electrostatic discharges. If you remove the module from the housing or if you carry out any operations on it while outside the housing, you have to ensure potential equilibration before you touch part of the printed circuit. (Touch any earthed item such as earthed housing, PLUGSYS housing or similar).

Brief procedure (for full details see the Operating Manual for the housing):

- Pull out the mains plug on the housing.
- Unscrew the blank panels at the housing slot position intended for the MEA module.
- Plug the internal jumper of the output on to the required bus line as described below.
- Insert the MEA module, note the guide rails.
- Push the module firmly into the bus connector.
- Screw on the front panel.
- Reconnect the mains plug to the housing.
- Plug in the headstage.

The microelectrode amplifier is now ready for use.

Making the bus connection

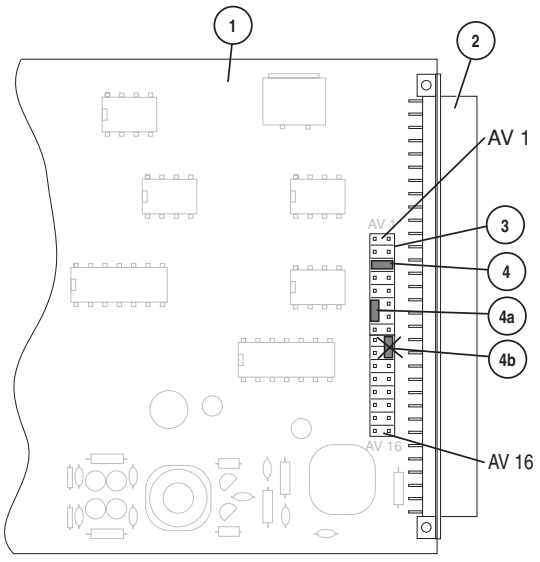
Before you can install the MEA module in the PLUGSYS housing you have to plug in a jumper on the circuit board to ensure that the output signal is connected to the appropriate or required bus line. The equipment can only be used properly if the bus line is connected correctly.

Do not forget to enter the selected assignment of the signals in the bus diagram of the PLUGSYS housing (the bus diagram is included in the Operation Instructions file under Section 1).

When the module is supplied in a completely installed PLUGSYS measuring system, the work described below has already been carried out and the selected signal paths have been entered in the bus diagram.

Note: use only a free bus line!
When selecting the bus line (AV1 - AV16), ensure that you use a free bus line and check this on the bus diagram. If there are no appropriate entries in the diagram you can establish the bus line assignment only by removing all modules and determining the signal paths selected on them, using the Operating Instructions.

The position of the jumper is shown in the diagram below. Plug the jumper into the position of a free and desired bus line (AV1 to AV16).



Position of the jumpers on the printed circuit board (PCB).

1: PCB, **2**: 64-pin bus connector, **3**: row of pins for jumper AV1-16, **4**: correctly connected jumper on AV3, **4a**: jumper in parking position, **4b**: incorrectly selected parking position.

CE Declaration of Conformity

This product and accessories conform to the requirements of the Low-voltage Directive 73/23 EEC as well as the EMC Directive 89/336 EEC and are accordingly marked with the CE mark. For conformity to the standards during operation it is essential that the details in the instructions provided are observed.

Technical data

A. Microelectrode amplifier module MEA Type 695

Input: via separate preamplifier (headstage) for direct intracellular and extracellular potential recording.
Gain: 10 times, fixed
Input socket: 8-pin Binder or Amphenol Tuchel for socket with screw lock
Input capacity compensation: continuously adjustable, range 0 to 8 pF
Signal output: filtered output signal ±10 Volt
Internally on the PLUGSYS system bus via a jumper, assigned to one of the signal lines AV-1 to AV-16.
Externally through a BNC socket on the front panel.
Amplifier bandwidth: DC to 30 kHz (-3 dB)
Output filter: low-pass with 7 steps covering 30 Hz to 30 kHz (-3 dB)
Zero adjustment: compensation of input offset voltage in the range ±400 mV
Buzzer: helps microelectrode insertion through AC injection into the microelectrode. Buzz frequency from 10 Hz to 10 kHz in 16 settings to suit individual requirements.
Calibration signal: on pressing the CAL key a complex calibration signal with the values 0 Volt, 100 mV and ±50 mV referred to the input is introduced.
Analogue indication: LED bargraph with 30 LEDs for visual monitoring of the applied signal (7.5 mV per LED referred to input). For accurate zeroing the indication range of the bargraph can be spread by pressing a key (magnifier function) (1.5 mV per LED referred to input).
Audio monitor: audible monitoring system for the measured signal through a monitoring tone frequency-modulated according to the signal amplitude. The loudness and the base pitch are adjustable individually through trimmers on the front panel.
Microelectrode test: testing the microelectrode by injecting a constant measurement current via the headstage for approximate determination of the instantaneous electrode resistance. Current duration limited to 2 seconds.
Power supply: 5 V 1.2 A from the PLUGSYS housing used (MiniCase or rack housing).
Size: 19-inch PLUGSYS module, width 12 E (60.96 mm), height 3 U (128.7 mm)
Weight: 0.4 kg approx.
Accessories: Operating Instructions, headstage e.g. Type 695-1G

Important, please note when ordering:
The MEA Type 695 can not be used without headstage. When not otherwise indicated on the order it is supplied with a standard headstage Type 695-1G.

B. Preamplifier headstage Type 695-1G

Construction: screened metal housing, microelectrode holder integral with mounting rod, 2 mm connection socket for bath reference, 2 mm pin plug screen connection and central earth.
Mounting: rod with D = 8 mm and integral microelectrode holder, suitable for the mounting arrangement of conventional micromanipulators.
Microelectrode resistance: suitable for microelectrodes in the range 1 to 100 MOhm
Input circuit: fully solid-state electrometer amplifier with driven screen, bootstrapped supply voltage and capacity compensation.
Input current: < 1 pA
Coupling resistance: 1 GOhm
Capacity compensation: adjustment range 0 - 8 pF
Frequency range: DC to 75 kHz (- 3 dB)
Supply: via the MEA microelectrode amplifier Type 695
Connecting cable: signal and power supply, approx. 1.5 m long, with 8-pin Binder or Amphenol Tuchel plug to suit MEA microelectrode amplifier.
Dimensions: length 140 mm, width 22 mm, height 22 mm
Weight: 160 g
Accessories: Operating Instructions, connecting cable to bath earth, earth cable to central earth

Important, please note when ordering: The headstage Type 695-1G can only be operated with the HSE microelectrode amplifier MEA Type 695.

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