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Electrometer Amplifier

13621.00

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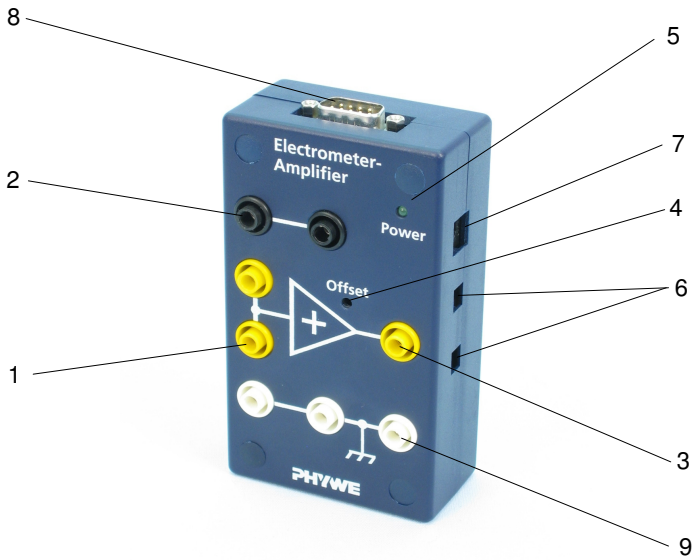

Fig. 1: Front view of the Electrometer Amplifier 13621.00.

Operating instructions

CE The unit complies with the corresponding EC guidelines.

CONTENTS

1 SAFETY PRECAUTIONS

- Carefully read these operating instructions completely before operating this instrument. This is necessary to avoid damage to it, as well as for user-safety.
- Only use the instrument in dry rooms in which there is no risk of explosion.
- Only use the instrument for the purpose for which it was designed.

2 PURPOSE AND DESCRIPTION

Charges that have resulted from static electricity can be determined by transferring the charge to a capacitor of known capacitance and measuring the electrical potential of this. It is difficult to measure this potential with customary measuring instruments, as a current flows through the measuring instrument and this leads to decay of the applied charge. The smaller the internal resistance of the measuring instrument, the quicker the potential is reduced. Customary measuring instruments have an internal resistance of about 10 M Ohms.

This electrometer amplifier has it its disposal a voltage input with a very high internal resistance (> 10^{13} Ohms), and can so be used to measure such charges.
In general, the electrometer amplifier can be implemented to measure so-called "soft" voltages, i.e. of voltages that break down with small flows.

For example:
- Potential across a charged capacitor
- Voltage of a weakly lit solar cell
- Voltages that decay at a high ohmic resistance

The electrometer amplifier described here can so be used to demonstrate many physical effects in electrostatics. Individual measuring procedures are described in section 7.

3 FUNCTIONAL AND OPERATING ELEMENTS

1 *Amplifier input (high ohmic)*
(19 mm socket distance).

2 *Auxiliary input*
(19 mm socket distance). For attachment of potential dividers, resistors, capacitors etc..

3 *Amplifier output (low ohmic)*
For connection of measuring instruments, recorders etc..

4 *Trimmer for offset voltage*
(See operating notes for adjustment).

5 *LED for display of operating voltage*
Lights up when an alternating voltage supply (12 V~) is applied and when Cobra3 Basic-Unit is connected.

6 *4 mm Connecting socket*
For alternating voltage supply (12 V~) with external power supplies for example 13505.9X*.

7 *Connecting socket for plug-in power supply unit with hollow plug*
Inputs (*6*) and (*7*) are connected in parallel.

8 *SUB-D socket*
For connection to Cobra3 Basic-Unit. No additional supply voltage is then required.

9 *Reference potential (earth)*

Caution!
A direct voltage that is not dangerous to touch (< 60 V or a maximum voltage of 1 kV that is limited to 2 mA) can be applied at auxiliary socket (*2*) after appropriate wiring with potential divider elements. The dimensioning of these potential divider elements must be so that the ±10 V permissible voltage at the amplifier input is not exceeded.

Higher voltages can result in the instrument being destroyed.

Further to this, attention must always be paid to sufficient dielectric strength of the voltage divider elements used.

4 NOTES ON OPERATION

This high-quality instrument fulfils all of the technical requirements that are compiled in current EC guidelines. The characteristics of this product qualify it for the CE mark.

This instrument is only to be put into operation under specialist supervision in a controlled electromagnetic environment in research, educational and training facilities (schools, universities, institutes and laboratories).
This means that in such an environment, no mobile phones etc. are to be used in the immediate vicinity. The individual connecting leads are each not to be longer than 2 m.

The instrument can be so influenced by electrostatic charges and other electromagnetic phenomena that it no longer functions within the given technical specifications. The following measures reduce or do away with disturbances:
Avoid fitted carpets; ensure potential equalization; carry out experiments on a conductive, earthed surface, use screened cables, do not operate high-frequency emitters (radios, mobile phones) in the immediate vicinity.

When the instrument has been in operation for some time, it may be necessary to carry out offset matching. To do this, connect the amplifier input (socket *1*) to earth socket (*9*) and use offset trimmer (*4*) and a connected voltmeter to adjust the output voltage of the amplifier to 0 volts.

5 TECHNICAL SPECIFICATIONS

(Typical for 25 °C)	
Operating temperature range	5... 40 °C
Relative humidity	< 80%
Amplification	1.0
Input resistance	$\geq 10^{13}\ \Omega$
Input current	≤ 0.5 pA
Input voltage	
Amplifier (socket 1)	±10 V
Auxiliary input (socket 2)	1 kV-
External power supply	12 V~/25 mA alternatively: Choice of connection via
Only one power supply voltage is to be connected!	2x4 mm sockets or hollow plug, *id* = 2.1 mm, *od* = 5.5 mm or ±15 V via SUB-D socket to Cobra3.
Output voltage	±10 V (with 12 V~ supply voltage)
Output	1 mA, short circuit proof
Output resistance	≤ 500 Ω
Dimensions (mm)	approx. 65 x 113 x 35 (W, H, D)
Weight	approx. 150 g

6 MODES OF OPERATION

6.1 Operation as independent instrument

Accessories required:

Suitable voltage supply, such as:	
Power supply 12 V~/500 mA	11074.9X*
Power supply 0 – 12 V-/6 V, 12 V~	13505.9X*
Power supply , universal	13500.9X*
Cable with 4 mm bunch plug	
Output voltage display, for example:	
Digital multimeter	07128.00
Analogue demonstration multimeter, ADM 1	13810.00
Analogue demonstration multimeter, ADM 2	13820.00
Cable with 4 mm bunch plug	

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* Voltage and frequency (see type plate) depending on local power grid

xxxxx.93 = 230 V/50 – 60 Hz
xxxxx.90 = 115 V/50 – 60 Hz
xxxxx.99 = 110 – 240 V/50 – 60 Hz
Special voltages and fixed frequencies on request.

See section 7 for further accessories as required for particular measurements.

6.2 Operation with the "Cobra3" computer interface

In this case, the supply voltage required is supplied via the "Cobra3" computer interface and connecting cable 12150.07. The output signal is brought to display by the "Universal recorder" software module 14504.61.

Acessories required for this mode of operation:

Cobra3 Basic-Unit	12150.00
Cobra3 power supply	12151.99
Data cable 2xSUB-D, 9 pin	14602.00
Cobra3 cable for sensors (9/9)	12150.07
Software Cobra3 Universal recorder	14504.61

The requirements of further accessories are dependent on the measurement to be carried out, and are described in section 7.

6.3 Operation with the "Cobra4" computer interface

Acessories required for this mode of operation:

Power supply 12 V AC/500 mA	11074.93
Cobra4 Wireless Manager	12600.00
Cobra4 Wireless-Link	12601-00
Cobra4 Sensor-Unit Electricity, current ±6 A / voltage ±30 V	12644.00
Connecting cord, 32 A, 250 mm, blue	07360.04
Connecting cord, 32 A, 250 mm, red	07360.01

The requirements of further accessories are dependent on the measurement to be carried out, and are described in section 7.

7 MEASUREMENT PROCEDURES

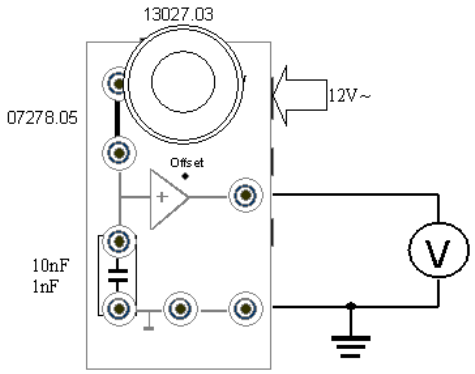
7.1 Measurement of charge

Fig. 2: Experimental set-up for the measurement of a charge that is filled into a Faraday pail by means of a hollow ball coated with graphite.

The charge to be measured is to be given to a capacitor of known capacitance, e.g. via a Faraday vessel. The potential that the capacitor has acquired is measured. The amount of charge present is to be calculated using the relationship:

$Q = C \cdot U$; with Q: Charge [Cb]; C: Capacity $\left[\frac{Cb}{V}\right]$ and U: Voltage [V]

Schematical experimental set-up



Caution!

Appropriate earthing of the person carrying out the experiment is necessary here to reduce additional electrostatic effects. Further to this, the electrometer amplifier is to be earthed via the available earth connector.

Note:

The capacitance values given on capacitors are nominal values and may deviate from the actual values. To obtain exact measurement results, the actual capacitance must be experimentally determined.

Examples of experiments:

Determination of the capacitance of a spherical capacitor

Apply a voltage of 500 V to charge the hollow ball with conductive surface. Transfer the charge to a Faraday vessel. A potential is generated at the 1 nF capacitor. It can be shown that the charge is transferred in "portions". The formula for the capacitance "C" of a spherical capacitor can so be experimentally checked:

$C = 4\pi\varepsilon_0 \cdot r$, with $\varepsilon_0 = 8{,}85 \cdot 10^{-12} \frac{Cb}{V \cdot m}$; r : spherical radius [m].

Measurement of charge generated by friction

Rub two rods of different materials against each other and successively dip them into the Faraday vessel. It can be recognized that the charges generated are opposite. When only the front parts of the rods are used, it can be shown that the opposite charges are of the same size.

Recommended accessories:

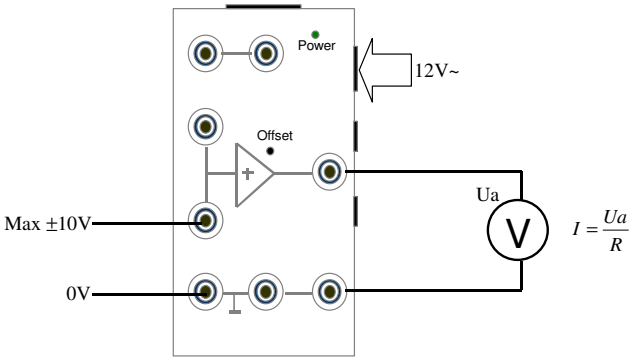
Faraday pail, d = 40 mm, h = 75 mm (small vessel)	13027.03
Crocodile clips, bare, 10 pcs	07274.03
Connecting plugs, set of 2	07278.05
alternatively:	
Faraday cup (large vessel)	06231.00
Plug with 3 sockets, red, pack of 2	07206.01
Connecting plug, 4 mm/19 mm (for short-circuiting)	39170.00

Support rod with 4 mm hole (for earthing the experimenter)	02036.01
Capacitor 10 nF, 250 V, in casing G1	39105.14
Capacitor 1 nF, 100 V in casing G1	39105.10
Hollow plastic ball (with conductive surface)	06245.00
Fishing line, *d* = 0.7 mm, *l* = 20 m	02089.00
Rod, polypropylene, *d* = 8 mm, *l* = 175 mm	13027.07
Acryl resin rod, *d* = 8 mm, *l* = 175 mm	13027.08
Cable with 4 mm bunch plug	

7.2 Measurement of direct voltages:

7.2.1 Measurement of direct voltages of up to 10 V

Schematical experimental set-up:



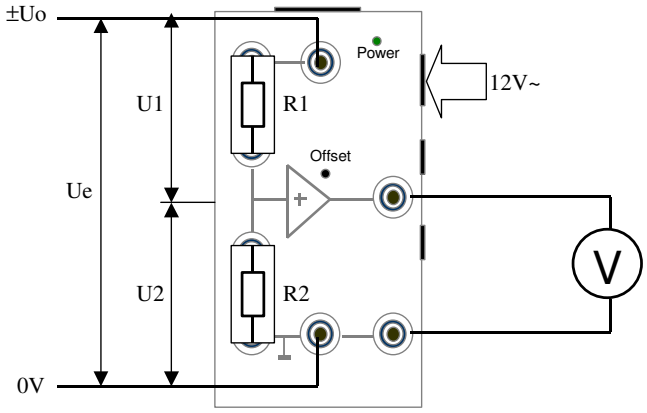
Recommended accessories:

Cable with 4 mm bunch plug

7.2.2 Measurement of direct voltages of more than 10 V

7.2.2.1 High ohmic measurements

Schematical experimental set-up:



Such measurements are based on the following principle:

The applied voltage is divided across an ohmic potential divider:

$$U_e = U_1 + U_2 \text{; with } \frac{U_1}{R_1} = \frac{U_2}{R_2}$$

$$\Rightarrow U_e = (1 + \frac{R_1}{R_2}) \cdot U_2 ,$$

On choosing R1 >> R2, then the following approximation is valid:

$$\Rightarrow U_e \approx \frac{R_1}{R_2} \cdot U_2 .$$

To avoid damage to the instrument, R1 and R2 must be so chosen that the voltage on amplifier input (*1*) does not exceed 10 V, and that the maximum potential between auxiliary input (*2*) and the electrometer amplifier earth does not exceed 1 kV.

Caution!

Ensure that only correspondingly voltage resistant resistors are used!

Note:

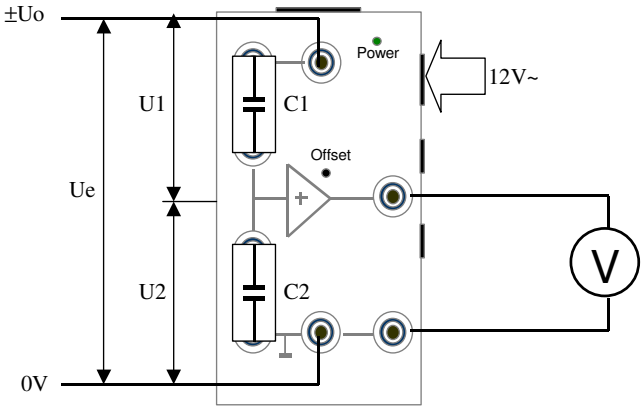
The resistivity values given on resistors are nominal values and may deviate by up to 5% from the actual values. To obtain exact measurement results, the actual resistances must be experimentally determined.

Recommended accessories:

Film resistor 10 GΩ, 5%, in G1 casing	39104.77
Film resistor 1 GΩ, 5%, n G1 casing	39104.76
Film resistor 100 MΩ, 5%, n G1 casing	39104.75
Film resistor 10 MΩ, 5%, n G1 casing	39104.58
Cable with 4 mm bunch plug	

7.2.2.2 Quasi-static measurement

Schematical experimental set-up:



This measurement is based on the following principle:
The applied voltage is divided across a capacitive potential divider

$$U_e = U_1 + U_2 \text{; with } C_1 \cdot U_1 = C_2 \cdot U_2$$

$$\Rightarrow U_e = (1 + \frac{C_2}{C_1}) \cdot U_2 ,$$

On choosing C2 >> C1, then the following approximation is valid:

$$\Rightarrow U_e = (1 + \frac{C_2}{C_1}) \cdot U_2 ,$$

To avoid damage to the instrument, C1 and C2 must be so chosen that the voltage on amplifier input (*1*) does not exceed 10 V, and that the maximum potential between auxiliary input (*2*) and the electrometer amplifier earth does not exceed 1 kV.

Caution!
Ensure that only correspondingly voltage resistant capacitors are used!

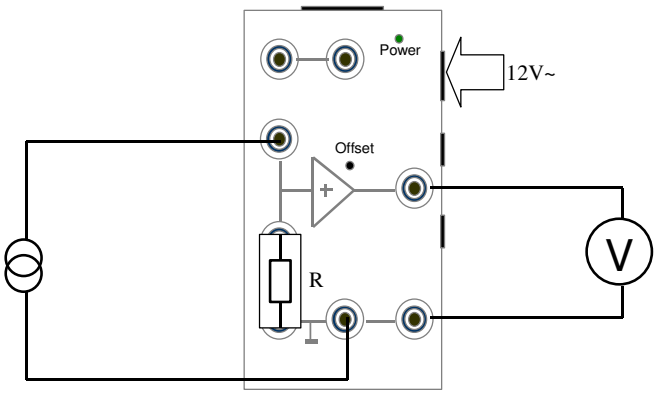
Note:
The capacitance values given on capacitors are nominal values and may deviate from the actual values. To obtain exact measurement results, the actual capacitance must be experimentally determined.

Recommended accessories:

Capacitor 0.1 µF, 250 V, in casing G1	39105.18
Capacitor 10 nF, 250 V, in casing G1	39105.14
Capacitor 1 nF, 100 V, in casing G1	39105.10
Capacitor 100 pF, 100 V, in casing G1	39105.04
Cable with 4 mm bunch plug	

7.3 Measurement of small currents

Schematical experimental set-up:



The measurement is based on Ohm's law:
By measuring the decreasing voltage at a known resistance, the current flowing through the resistor can be calculated.

$$I = U/R = U_e/R = U_a/R$$

This method is always then used, when small currents are to be measured with which falsification would occur with a low ohmic measuring instrument connected in parallel.

Recommended accessory:
Cable with 4 mm bunch plug

8 SETS OF EQUIPMENT FOR EXPERIMENTS WITH THE ELECTROMETER AMPLIFIER:

Electrometer Amplifier, Set 1 **07650.88**

This set of equipment for experiments on measuring charges comprises:

Faraday pail, *d* = 40 mm, *h* = 75 mm (small version)		13027.03
Crocodile clips, bare, 10 pcs		07274.03
Connecting plugs, set of 2		07278.05
Connecting plug (for short-circuiting) 4 mm/19 mm, white		39170.00
Support rod with 4 mm hole (for earthing the experimenter)		02036.01
Capacitor 1 nF, 100 V, in casing G1		39105.10
Rod, polypropylene, *d* = 8 mm, *l* = 175 mm		13027.07
Acryl resin rod, *d* = 8 mm, *l* = 175 mm		13027.08
Electrometer Amplifier		13621.00

Electrometer Amplifier, Set 2 **07651.88**

This supplementary set of equipment for experiments on measuring charges, voltages and small currents comprises:

Film resistor 10 GW, 5%, in G1 casing		39104.77
Film resistor 1 GW, 5%, in G1 casing		39104.76
Film resistor 100 MW, 5%, in G1 casing		39104.75
Film resistor 10 MW, 5%, in G1 casing		39104.58
Capacitor 0.1 µF, 250 V, in G1 casing		39105.18
Capacitor 10 nF, 250 V, in G1 casing		39105.14
Capacitor 100 pF, 100 V, in G1 casing		39105.04
Zinc electrode, 76 mm x 40 mm	(2x)	45214.00

9 NOTES ON THE GUARANTEE

We guarantee the instrument supplied by us for a period of 24 months within the EU, or for 12 months outside of the EU. Excepted from the guarantee are damages that result from

disregarding the Operating Instructions, from improper handling of the instrument or from natural wear.

The manufacturer can only be held responsible for the function and technical safety characteristics of the instrument, when maintenance, repairs and alterations to the instrument are only carried out by the manufacturer or by personnel who have been explicitly authorized by him to do so.

10 WASTE DISPOSAL

The packaging consists predominately of environmentally compatible materials that can be passed on for disposal by the local recycling service.

Should you no longer require this product, do not dispose of it with the household refuse. Please return it to the address below for proper waste disposal.

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