PHYWE

Franck-Hertz Control Unit, USB

09106-99

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Fig. 1: Franck-Hertz Control Unit, USB 09106-99

Operating instructions

CE Das Gerät entspricht den zutreffenden EU-Rahmenrichtlinien

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1 SAEFTY PRECAUTIONS

Caution!

- Carefully read these operating instructions completely before operating this instrument. This is necessary to avoid damage to it, as well as for user-safety.
- Check that your mains supply voltage corresponds to that given on the type plate fixed to the instrument.
- Install the instrument so that the on/off switch and the mains connecting plug are easily accessible.
- Do not cover the ventilation slots.
- Take care that no liquids or objects enter in through the ventilation slots.
- Only use the instrument in dry rooms in which there is no risk of explosion.
- Do not start up this instrument in case of visible signs of damage to it or to the line cord.
- Only use the instrument for the purpose for which it was designed.
- Only use the mains power cable that is supplied with the unit or an equivalent cable.

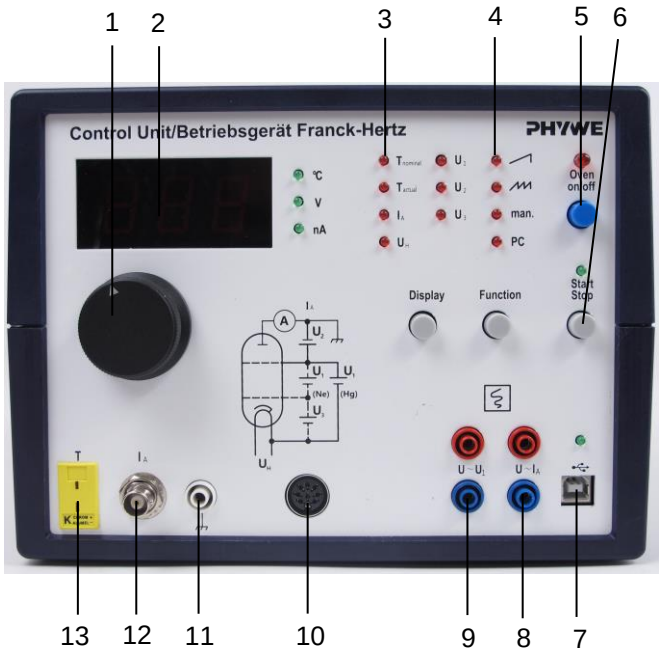
2 PURPOSE AND CHARACTERISTICS

The Franck-Hertz Control Unit is an instrument that has been developed specifically for use in demonstrations and practical work in the teaching of Physics in schools and colleges. It serves to supply voltage to, and control, a connected Hg-tube or Ne-tube, as well as to measure temperature and anode current. The dependence of the anode current on the applied acceleration voltage proofs the existence of discrete energy states of Hg or Ne atoms when free electrons collide with those atoms. The excitation energies of these atoms can be determined from the spectra recorded. The shell model of the atom postulated by Bohr was experimentally confirmed in 1913/14 by means of Franz- Hertz experiments (named after James Franck and Gustav Hertz).
The Franck-Hertz Control Unit must be supplied with a steady operating voltage of 115 V or 230 V (+/- tolerance). Connection via an adjusting transformer is not permissible. The instrument produces the accelerating voltage U1, the counter voltage U2, the control voltage U3 (only for the Ne-tube) and the heating voltage U_H from this supply voltage. None of these voltages are dangerous to touch.

They are applied to the tube via the 5-pin connecting cable. The cables are coded so that the Control Unit recognizes which type of tube is connected and undertakes the basic settings. All adjustable and measurable observables can be displayed by a 3-digit LED display. The presentation and evaluation of the measured values can be carried out in alternate ways, either manually, or with the help of an oscilloscope or via an USB cable using Franck-Hertz measure software.

3 FUNCTIONAL AND OPERATING ELEMENTS

3.1 Functional and operating elements (Fig. 2)



1 Rotary switch
for adjustment of temperature (T_{nom}) and voltages (U_H, U1, U2 and U3).

2 Three digit digital display
with optional display of either temperature T, anode current I_A or voltage U_H, U1, U2 or U3.

3 "Display" pushbutton
for selection of the quantity to be displayed

4 "Function" pushbutton
for selection of a function from "ramp", "saw tooth", "manual control" or "PC control".

5 "Oven on/off" pushbutton
for activation of the Hg oven heating.
"Start/Stop" pushbutton
for initiating or stopping measurement.

6 USB-socket
for connecting the operating device to the computer.

7 Pair of 4 mm sockets "U~IA"
Analog output (Y): Voltage proportional to the anode current.

8 Pair of 4 mm sockets "U~U1"
Analog output (X): Voltage proportional to the accelerating voltage U1.

9 DIN socket
for supplying voltage (U_H, U1, U2 and U3) to the tube connected.

10 GND connector

11 BNC socket "I_A"
Input for anode current measurement.

12 Temperature input T
Thermocouple socket, to which a NiCr-Ni thermocouple with DIN plug (type K) can be connected.

13 At the back of the instrument:
Grounded socket for the plug that supplies voltage to the temperature-regulating Franck-Hertz oven for the Hg-tube

3.2 Starting up the instrument

Use the connecting cord supplied with the instrument to connect it to the AC mains supply (115 or 230 V), then operate the mains switch at the back of the instrument to switch it on. Connect the Hg-tube or Ne-tube to the control unit with the 5-pin connecting cable and the BNC cable [connections (9) and (11)]. When doing this, make sure that the 4 mm plug labelling matches the socket labelling on the plate. A temperature sensor (12) must be additionally connected when the Hg-tube is to be used. Do this by leading the tip of the probe through the opening in the Franck-Hertz oven and positioning it at the height of the cathode of the tube. Checking that the connecting voltage of the oven matches the local line voltage, then plug the oven connecting cable with the grounded plug into the grounded socket at the back of the Control Unit. **Turn the rotary switch on the oven to its maximum.** This ensures that the bimetallic switch in the oven is first activated to switch off the oven at a very high temperature, and so will not disturb the regulating process. When measured values are to be acquired and presented, connect outputs (7) and (8) to a XYt recorder or to an oscilloscope. For measurement with the aid of a computer, the drive unit must be connected to the interface via a USB cable.

3.2.1 Manual experimental procedure

If the collection current is too high then the measurement will be interrupted automatically by control unit after 7 sec. to protect the tube from being damaged. To avoid the discharges adjust the parameters U2, U3 and U_H as follows: decrease the heating voltage U_H and decrease the voltage U3.

Experiment with the Hg-tube

A) Connect the components as described in section 3.2. Turn on the Control Unit at the on/off switch. This causes the instrument to activate predefined values according the type of tube connected. As examples of this, the heating voltage U_H is preset at 6.3 V and the range of the accelerating voltage U1 limited to 60 V.

B) Use the push button (2) and rotary knob (13) to set the parameters according to the test report supplied with the tubes.
- U3 is not necessary for the Hg-tube.

C) Use pushbutton (4) to switch the oven on. The red LED above pushbutton (4) does not stop flashing until the actual temperature "$T_{act.}$" has reached the target temperature (with a tolerance of approx. +/- 2°C).

D) Set to "manual" with pushbutton (3). Start measurement with pushbutton (5).

Experiment with the Ne-tube

Heating is not required in this case.

A) Connect the components as described in section 3.2. Turn on the Control Unit at the on/off switch.

B) Use the push button (2) and rotary knob (13) to set the parameters according to the test report supplied with the tubes

C) Set to "manual" with pushbutton (3). Start measurement with pushbutton (5).
The luminous layers shown in Fig. 3 are typical for the Ne-tube.
These visible luminous layers (wavelength approx. 640 nm, corresponding to about 2 eV) are generated when Ne atoms that have been excited by collisions with electrons pass over from the 3p level (approx. 19 eV) via the 3s level (approx. 17 eV) back to the ground state.

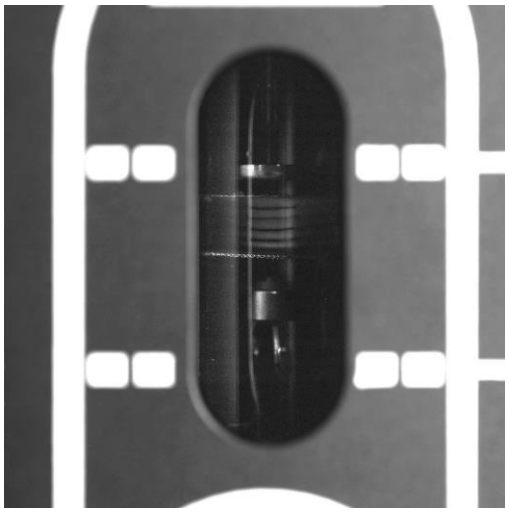


Fig. 3: Franck-Hertz experiment with the Ne-tube: Five typical luminous layers.

3.2.2 Experimental procedure using an oscilloscope

Experiment with the Hg-tube

A) Connect the components as described in section 3.2. Turn on the Control Unit at the on/off switch.

B) Use the push button (2) and rotary knob (13) to set the parameters according to the test report supplied with the tubes.
- U3 is not necessary for the Hg-tube.

C) Switch on the oven with pushbutton (4). The red LED above pushbutton (4) continues to flash until the target temperature is reached.

D) Set to "saw tooth" with pushbutton (3). Connect outputs (7) and (8) to the oscilloscope, then select the XY operating mode for the oscilloscope. Start measurement with pushbutton (5). In this "saw tooth" mode, the voltages set for U1 and U2 are applied to the Hg-tube with a frequency of 28 Hz. The typical Franck-Hertz curve that results is shown in Fig. 4.

Experiment with the Ne-tube

A) Connect the components as described in section 3.2. Turn on the Control Unit at the on/off switch.

B) Use the push button (2) and rotary knob (13) to set the parameters according to the test report supplied with the tubes.
- A target temperature is not required here,

C) Set to "saw tooth" with pushbutton (3). Connect outputs (7) and (8) to the oscilloscope, then select the XY operating mode for the oscilloscope. Start measurement with pushbutton (5). If the current is too high then the measurement will be interrupted automatically by control unit after 7 sec. to protect the tube from being damaged. Adjust the settings in B) and use pushbutton (5) to repeat the measurement any time required.

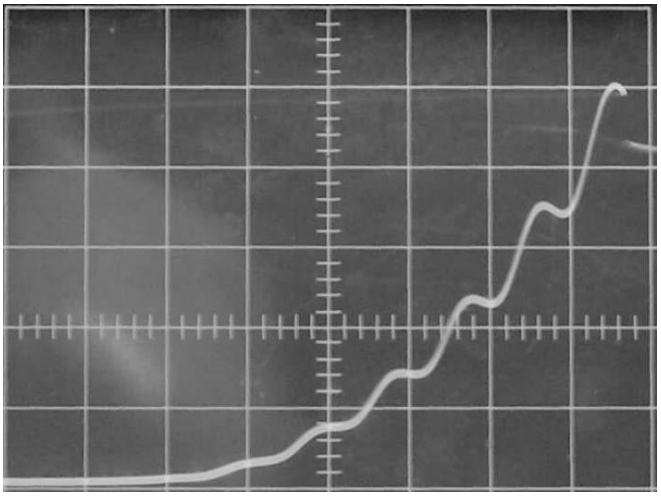


Fig. 4: Franck-Hertz-Experiments with the Hg-tube: Saw tooth measurement displayed by an Oscilloscope.

3.2.3 Experimental procedure using a computer

Connect the Control Unit to the computer with an USB cable. The measure software carries out the steering of the Control Unit and the acquisition, presentation and evaluation of all measured values. No other external measuring equipment is required

A) Connect the components as described in section 3.2 (see Fig. 7). Turn on the Control Unit at the on/off switch. Set to “PC” with pushbutton (3).

B) Start the measure software. This automatically recognizes if the Hg tube or the Ne-tube is connected. The parameters required are predefined (see Fig. 8). The values given in Fig. 8 are typical values with which it should be possible to successfully record a measurement curve.
If the collection current is too high then the measurement will be interrupted automatically by control unit after 7 sec. to protect the tube from being damaged. To avoid the discharges, adjust the parameters U2, U3 and U_H as follows: decrease the heating voltage U_H and decrease the voltage U3.

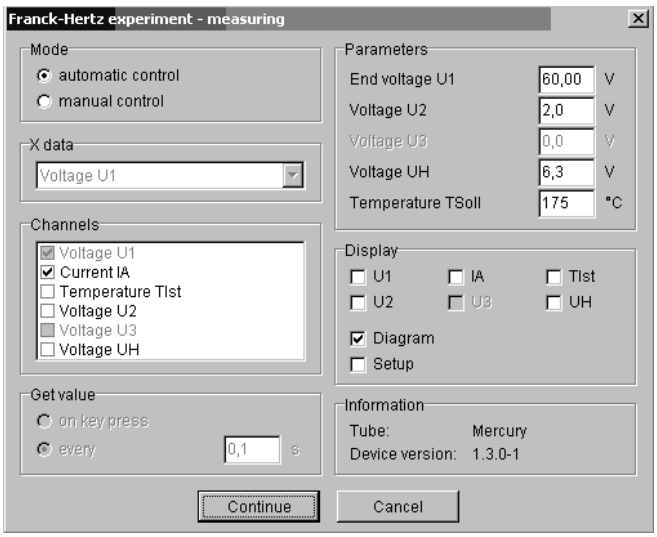


Fig. 5: Measurement parameters of the measure software

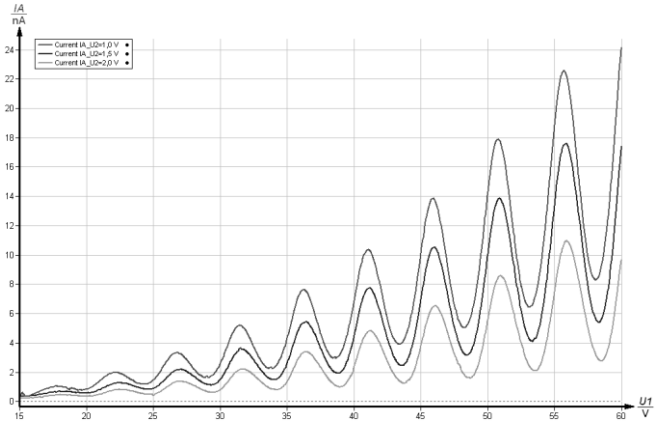


Fig. 6: Franck-Hertz-curve for Hg-tube and different counter voltages U2.

C) The programme allows manual or automatical increase of the accelerating voltage. Fig. 9 shows three curves that were plotted at different counter voltages U2 (= 1 V; 1.5 V; 2 V).

D) The excitation energies of mercury or neon atoms can be determined from the distance between minimum values. Typical results obtained are 4.9 V for Hg atoms and 12 V for Ne atoms.

4 NOTES ON OPERATION

This high-quality instrument fulfills 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. Following a blackout failure, operate the on/off switch for a reset.This instrument corresponds to Class A, Group 1 of the EN 55011 Standard and can only be operated without limitation outside of residential areas.
Should electromagnetic disturbances occur in surrounding residential areas although operation is limited to the technical room of a school or other training facility, then it can be demanded of the operator that he carries out adequate measures (e.g. screening, greater distance, reduction in the operating time) at his own cost.
The Operating Instructions for the Franck-Hertz Oven 091005.93/.90 are to be carefully followed whenever this piece of equipment is put into operation.

Caution!

A change of safety fuse is only to be carried out when the instrument is dead (unplug the mains plug), whereby it must be ensured that fuses (see the type plate for values) are allotted to the appropriate fuse holder FU1 or FU2. They must under no circumstances be inserted in the wrong holder. Remove a blown fuse by undoing the safety cap (with a slight turn anticlockwise) and replace it with a new one.

6 TECHNICAL DATA

Operating temperature range 5...40°C,
Relative humidity < 80 %

Inputs

Temperature T
NiCr-Ni-DIN-socket (Typ K)
Measurement range 0°C...999°C
Resolution 1°C

Current I_A
BNC-socket
Measurement range 0...50 nA
Resolution 0.1 nA

Outputs

Analog output U~U1
Pair of 4 mm sockets
Output voltage 0...10 V (10 V == 100 V)
Output current max. 10 mA

Analog output U~I_A
Pair of 4 mm sockets
Output voltage 0...10 V (10 V == 50

Tube supply
DIN socket
Voltage U1 0...99.9 V
Resolution 0.1 V

Voltage U2 0...12 V
Resolution 0.1 V

Voltage U3 0...6 V
Resolution 0.1 V

Voltage U_H 0...10 V
Resolution 0.1 V
Output current max. 400 mA

Oven supply
Grounded plug Back of instrument
Voltage Corresponds to the mains voltage, see below
Power output max. 600 VA

Data output
USB-socket

Digital display
Type of display 7 segment LED
Character height 20 mm

Mains supply
Protection class I
Connecting voltage 115 V/230 V
(+6% / -10%)
Mains frequency 50/60 Hz
Power consumption with oven approx. 625 VA
Power consumption with
Ne-tube ca. 40 VA
Mains fuse see type plate
(5 mm x 20 mm)
Housing dimensions (mm) 230 x 236 x 168 (W, H, D)
Weight approx. 3.4 kg

7 MATERIAL

A. For Franck-Hertz experiments with Hg-tube, without a PC

Franck-Hertz Control Unit, USB	09106-99
Franck-Hertz Hg-tube	09105-10
Franck-Hertz Oven	09105-93
NiCr-Ni Thermocouple	13615-01 or 13615-02
5-pin connecting cable, for Hg-tube	09105-30
BNC-cable, l = 100 cm	07542-11

B. For Franck-Hertz experiments with Ne-tube, without a PC

Franck-Hertz Control Unti, USB	09106-99
Franck-Hertz Ne-tube	09105-40
5-pin connecting cable, for Ne-tube	09105-50
BNC-cable, 75 cm	07542-11

C. For Franck-Hertz experiments with a PC
As in A. oder B. above and additionally:

Software measure	14522-61

8 WARRANTY

We guarantee the instrument supplied by us for a period of 24 months within the EU, or for 12 months outside of the EC. This guarantee does not cover natural wear nor damage resulting from improper handling. The manufacturer can only be held responsible for the function and technical safety characteristics of the instrument, when maintenance, repairs and changes to the instrument are only carried out by the manufacturer or by personnel who have been explicitly authorized by him to do so.

9 WASTE DISPOSAL

The packaging consists predominately of environmental 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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