PHYWE
excellence in science

Speed of light meter

11226-99

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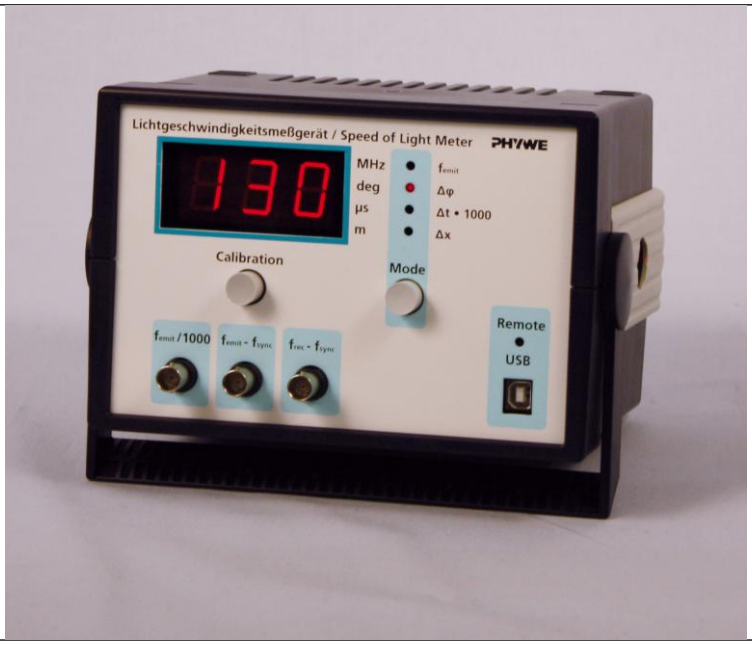

Fig. 1: 11226-99, Speed of light meter.

Operating instructions

CE The unit complies with the applicable EC-Guidelines

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1 SAFETY PRECAUTIONS

Laser radiation
Do not look into the beam
Laser Class 2
according to DIN EN 60825-1

- Read these operating instructions carefully and completely before putting the instrument into operation. This protects and avoids damage to the instrument.
- Only use the instrument for the purpose for which it is intended.
- The instrument is intended for use in dry rooms in which there is no risk of explosion.
- Prior to application of the mains voltage, ensure that the protective earth lead of the power supply is properly connected to the earth lead of the mains. The mains plug is only to be plugged into a mains socket that has an earth lead. Do not cancel the protective effect by use of an extension cable that does not have an earth lead.
- Ensure that the mains voltage given on the type plate of the power supply matches that of your mains supply.
- Set up the experimental arrangement so that the power supply or mains plug of the instrument are freely accessible. Do not cover up the ventilation slots of the experimental arrangement.
- Only use the experimental set-up for the intended purpose.
- Do not open the experimental set-up.
- Do not connect to the instrument any other devices than those intended for use with it.

- Caution: Separate the instrument from the mains before disconnecting, exchanging or removing any cable connections!

2 PURPOSE AND CHARACTERISTICS

The Speed of light meter serves to determine the propagation speed of visible (red) light in air or in transparent liquid or solid media. The light source is a laser diode, the light intensity of which is modulated by a high frequency alternating voltage of approx. 50 MHz; so that the light beam exhibits time markers. After the light beam has travelled a certain distance, a retro-reflector directs it onto a photodiode. Here it generates an alternating voltage of the same frequency but one that is displaced in phase against the original signal in dependence on the length of the light path.

All of the quantities required for the calculation of the speed of light are shown in the display. When various transparent media – water, oil, synthetic resin, acrylic glass – are brought into the light path, then the change in the speed of light caused by the particular material can be measured. Once the speed of light is known, the same instrument can be used to carry out distance measurements.

The experimental procedure does not require an oscilloscope, but there are nevertheless appropriate output sockets for the signals. These enable a simple 2-channel oscilloscope to be connected, so that the measurement method can be didactically presented in more depth.

3 HANDLING

Switch the laser on at least 10 minutes before starting an experiment. This allows thermally-caused fluctuations of the intensity which could affect the result of a measurement to be avoided as much as possible.

Position the Speed of light meter on the holder for it on the optical bench. The magnetic film on the bottom of the instrument ensures a stable position but does not interfere with the horizontal alignment. Align the instrument and the retro-reflector so that the beam strikes the reflector as central as possible no matter on what x-position of the optical bench it is positioned.

4 FUNCTIONAL AND OPERATING ELEMENTS

The unit is accommodated in an impact resistant plastic housing. A retractable carrying handle is recessed into the unit and can be folded down so that the instrument slopes down towards the back. Four rubber feet provide resistance to slipping. The unit can be stacked onto other units of the same design, because the rubber feet fit into cup-shaped recesses of the unit beneath, ensuring that the top instrument does not slide off. The sloped position can only be used for the uppermost unit of the stack.

The supplied connecting cord is used to connect the unit to the AC mains. The cord is inserted into the equipment connector at the back of the unit. The mains switch for operating the unit is situated in the immediate vicinity of the equipment connecting plug at the back of the unit.

The centre of the back plane provides a thread for the attachment of the support clamp for small case (02043-10), which is optional available (see Fig. 2). By use of that clamp, the unit can be fixed to various support rods. Thereby, the visibility will be increased in demonstration experiments.

Attention!

To avoid damage to the inner electrical components of the unit and to prevent people from getting harmed by electric shock, use the provided support clamp 02043-10, only.

You must not use screws with lengths over 16 mm!

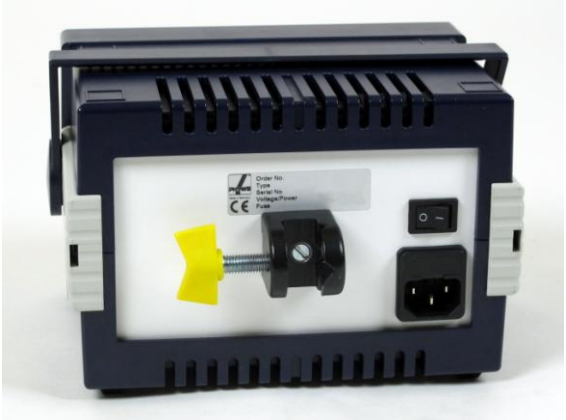

Fig. 2: Back plane of a device in the small case with support clamp attached.

All other functional and operating elements are located on the front panel of the unit (see figure 1):

1 Mode button

The *Mode* button toggles through the five different instrument modes, or rather the display of them. The particular mode that is active is shown by the LED that lights up red:

a) OFF

This is the initial mode. It is active as soon as voltage is applied to the instrument. The laser is switched off, the digital display shows OFF, every LED is off.

b) f_{emit}

The modulation frequency of the emitted laser light is displayed.

c) $\Delta\varphi$

In this mode, the phase displacement between the signal emitted and that received is displayed in degrees. The resolution is 1 degree, the value range from 0 to 359 degrees.

d) $\Delta t \cdot 1000$

The transit time of the signal can be directly calculated from the phase displacement and the modulation frequency and be shown here. As the phase displacement is measured by a heterodyne procedure at 1/1000 of the modulation frequency,1000 times the transit time is to be shown here, so that the impression is not given that measurement is made directly of times in the ns range.

e) Δx

This mode is suitable for differential distance measurements. Here, the literature value of the speed of light is used internally to calculate the changed distance from the retro-reflector Δx from the difference in transit times Δt. In accordance with the modulation frequency of 50 MHz and the measurement procedure, Δx can only be unambiguous in the range from 0 to 2.99 m. The resolution of the display is 1 cm, the maximum tolerance is 5 %.

2 Calibration button

A press on the "Calibration" button sets the $\Delta\varphi$, $\Delta t \cdot 1000$ and Δx starting points for the measurement. They are set to zero when the laser beam is reflected back to the instrument. The position of the mirror at this point in time is then so to speak the spatial zero point of the measurement. The function of this button is in principle comparable to that of the "tare" button of a digital balance.

The setting of the phase difference between the signal emitted and the signal received acts immediately on the signals at the BNC sockets and can so also be well followed via a connected oscilloscope.

This procedure must be carried out once after switching the instrument on for measurements to be able to be carried out. When the instrument receives the reflected laser beam, "CAL" blinks in the digital display, in as much as this had not been previously carried out.

3 Digital display

Measured values are presented in digits of 20 mm height by the 3-place LED display according to the mode that is active. The particular unit of the value displayed is shown by the appropriate one of the four red LED lamps that are to the right of the displays.

Should the reflected laser signal be too weak to be evaluated, then a wave that runs to the right is shown in the display.

4 Exit opening for the laser beam

The red laser beam that emerges from the instrument through this opening has a power of less than1 mW. It is therefore assigned to laser class 2 and is so permitted to be used in schools according to current guidelines.

Caution: Do not look into the laser beam!
Observe the rules for handling lasers!

5 Modulation frequency BNC socket

The modulation frequency of the laser light is led to this output reduced by a factor of 1,000 so that it can be measured with a simple oscilloscope. Together with the signals at the other two BNC sockets, this enables measurements to be made that are independent of the values in the digital display.

6 Signal emitted/Signal received BNC sockets

These two sockets can be used to evaluate the signal emitted and the signal received by means of a 2-channel oscilloscope. The phases of the two signals relative to each other are of particular importance here. In order not to have to use the fastest oscilloscope for this task, each of the signals are additively mixed with a synchronisation signal that is modulated to a 50kHz lower frequency than that of the laser light. This leads to signals in the 50 kHz range whose phase positions relative to each other are just the same as those of the original signals, but which can be comfortably evaluated with a normal oscilloscope.

7 USB Connector socket

Via the USB-port all data measured by the Speed of Light meter can be transmitted to a PC for evaluation and graphical presentation of the measurements. For this task you need to have the "Software Speed of Light Meter" (14411-61) installed. This software is part of the software family "measure". This software is characterized by easy and intuitive features and is very user friendly. Especially the optical measurement of distances lends itself to be recorded via software. This way the dynamics of motion (swinging pendulum, moving cart etc.) can be recorded continuously (1000 Hz) without interfering mechanically with the process.

Furthermore this USB-connector can be used for the update of the internal software should that be necessary in the future.

5 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 device can be influenced in ways by electrostatic charges and other electromagnetic phenomena that it no longer functions within the given technical specifications. The following measures reduce or resolve malfunctions:

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.

6 TECHNICAL SPECIFICATIONS

Speed of light meter 11226-00

Modulation frequency	50.0 MHz (quartz stabilised)
Tolerance	max. 5 %
Protective class acc. to DIN EN 60825-1	Laser Class 2
Digital display	3-place LED-Display, Digit height 20 mm
Operating voltage	12 VDC (suitable power supply: 2 VDC/2.25 A, 12151-99. Is standardly supplied with 11226-99)
Power consumption	5 W
Supply connector	Connecting socket for hollow plug d_i = 2.1 mm on back of instrument 12 VDC/400 mA
Housing dimensions	206 mm x 130 mm x 160 mm
Weight	approx. 2 kg

7 PARTS SUPPLIED

11226-00	Speed of light meter
12151-99	Power supply 12VDC/2,25A
11226-01	Retro-reflector with rod
09822-00	Slide mount for optical bench

8 ACCESSORIES

11226-02	Optical bench l = 1800 mm for speed of light measurements
11226-03	Holder for speed of light meter
09822-00	Slide mount for optical bench
11226-04	Acrylic glass cylinder with holder
11226-05	Tubular cell with holder
14411-61	Software Speed of Light Meter
02043-10	Support clamp for small case

Recommended oscilloscope:

11456-99	Digital storage oscilloscope, 25 MHz, 2 channel

9 WARRANTY

We give a warranty of 24 months for units supplied by us inside the EU, and a warranty of 12 months outside the EU. The following is excluded from the warranty: Damage that is due to non-compliance with the operating instructions, improper use, or natural wear.

The manufacturer can only be held liable for the function and safety-relevant properties of the unit, if the maintenance, service, and modifications of the unit are performed by the manufacturer or by an institution that is expressly authorised by the manufacturer.

10 WASTE DISPOSAL

The packaging mainly consists of environmentally-friendly materials that should be returned to the local recycling stations.

Do not dispose of this product with normal household waste. If this unit needs to be disposed of, please return it to the address that is stated below for proper dispoal.

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