

Equipment set for measuring the speed of light U8476460

Instruction sheet

02/08 TL



1. Safety instructions

The equipment set conforms to safety regulations for electrical measuring, control, monitoring and laboratory equipment, as specified under DIN EN 61010, section 1, and is designed to be classified as protection class I equipment. It is intended for operation in a dry environment suitable for the operation of electrical equipment and systems.

Safe operation of the equipment is guaranteed, provided it is used correctly. However, there is no guarantee of safety if the equipment is used in an improper or careless manner. If it is deemed that the equipment can no longer be operated without risk (e.g. visible damage has occurred), the equip-

ment should be switched off immediately and secured against any unintended use.

- Before putting the equipment into operation, confirm it is compatible with the local mains voltage.
- Before setting starting any experiments, check the basic unit for any damage.
- In the event of any malfunction/defect or visible damage, switch off the equipment immediately and secure it against any unintentional use.
- The instrument may only be connected to the mains via a socket that has an earth connection.
- The equipment may only be opened/repaired by qualified and trained personnel.

2. Description

Equipment set U8476460 is used for determining the speed of light by electronically measuring the time it takes to travel a certain path.

Extremely short light pulses are transmitted from an LED light source via a beam splitter before finally reaching two photo-voltaic converters connected to two amplifiers that send voltage pulses to outputs “A” and “B” for evaluation on an oscilloscope. Output “B” provides the reference signal while output “A” outputs a signal that is delayed by the time it takes for light to travel from the source to the mirror and back to the detector. The oscilloscope can be triggered via a pulse from output “C”.

The equipment set U8476460-115 is for operation with a mains voltage of 115 V ($\pm 10\%$), and the unit U8476460-230 is for operation with a mains voltage of 230 V ($\pm 10\%$).

3. Scope of delivery

- 1 Basic unit including light emitter, receiver and integrated power supply
- 1 Fresnel lens on stem
- 1 Triple prism reflector on stem
- 3 BNC cables

3. Technical data

Basic unit

Light emitter:	LED
Pulse rate:	30 kHz approx.
Power input:	3 W approx.
Voltage:	115/230 V, 50/60 Hz
Dimensions:	103 x 56 x 175 mm ³
Stem:	150 mm x 10 mm diam.
Weight:	1 kg approx.

Lens

Fresnel lens:	$f = 375$ mm
Lens surface:	245 mm x 245 mm
Dimensions:	285 mm x 285 mm
Stem:	54 mm x 10 mm diam.
Weight:	200 g approx.

Mirror

Design:	Micro-prism mirror
Mirror diameter:	100 mm approx.
Dimensions:	170 x 170 x 40 mm ³
Stem:	54 mm x 10 mm diam.

4. Operation

4.1 Experiment set-up

The basic unit and the Fresnel lens are mounted on riders along an optical bench and should be aligned together with the microprism along the optical axis.

The minimum distance between the basic unit and the lens (distance a) should be approximately f , the focal length of the lens. If $a = f$, then distance b would be infinity.

$$b = \frac{a \cdot f}{a - f}$$

The minimum distance between the light emitter and the mirror should be approximately 150 cm if the lens is positioned in the middle. If the distance to the reflector is increased, then the ideal distance for a comes down towards approximately 37 cm. Distance b then tends towards infinity.

To achieve optimum results, take special care to maintain sufficient accuracy in the horizontal and vertical alignment of the basic unit and the lens.

The red spot projected onto the reflector is clearly visible in the position illustrated and it continues to appear in full on the reflector segment even at a distance of up to approximately 8 m.

Outputs “A” and “B” of the basic unit are connected to the Y inputs of the oscilloscope via high-frequency leads of equal length and equal impedance (see Fig. 2).

The synchronising trigger for the oscilloscope should be set to “ext”. A synchronising trigger pulse is provided by output “C”.

In order to receive a high proportion of reflected light, the Fresnel lens and, if necessary, the microprism mirror should be realigned so that they are precisely in line. It helps when making the adjustment to look along the line to the mirror from the basic unit. The setting is optimal when the light beam from the source is clearly visible, focussed on the surface of the mirror.

In an experimental set-up involving greater distances ($a + b$) or unfavourable lighting conditions, it may be easier to pick out the beam from the position of the mirror. This means putting your head just in front of the mirror and moving it till you can see the light source through the lens. This should enable you to adjust the lens and the mirror more easily.

4.2 External synchronisation

Socket “C” outputs a synchronising trigger pulse which is coupled to the light beam and precedes the two beam pulses (reference pulse and test pulse) from output “A” and output “B” by 60 ns. This method allows older oscilloscope models to be

used for this experiment as long as their bandwidths are over 20 MHz.

4.3 Oscilloscope settings

Mode: Dual channel operation
 Sensitivity: Y1/Y2 at 100 mV/DIV
 Time base: Minimum value, e.g. 50 ns/DIV
 External triggering: "EXT" (trigger from C)
 (recommended for oscilloscopes with bandwidths of less than 100 MHz)

The test pulse from output "A" should first be optimised to a maximum value by carefully positioning the components required for the experiment.

If the mirror and the lens are optimally positioned, the amplitude of the test signal can be greater than that of the reference signal for a distance of up to 8 m. This being the case, it is then possible to make the amplitudes from outputs "A" and "B" roughly equal by turning the lens very slightly from its "ideal position".

In order to measure or evaluate the delay between "A" and "B" (time taken for light to travel the path), both of the pulse maxima should be adjusted to about the same height. This can be set by adjusting one of the two "Y position" (Y-POS) knobs on the oscilloscope.

4.4 Determining the speed of light

The speed of light c is simply given by the length of the path travelled by the light divided by the time the light takes to cover it.

The length of the beam path is double the distance from the light emitter to the mirror since the light travels this distance twice, there and back.

The time taken for the light to travel this distance is read off from the oscilloscope by measuring the distance between the maxima of the two pulses.

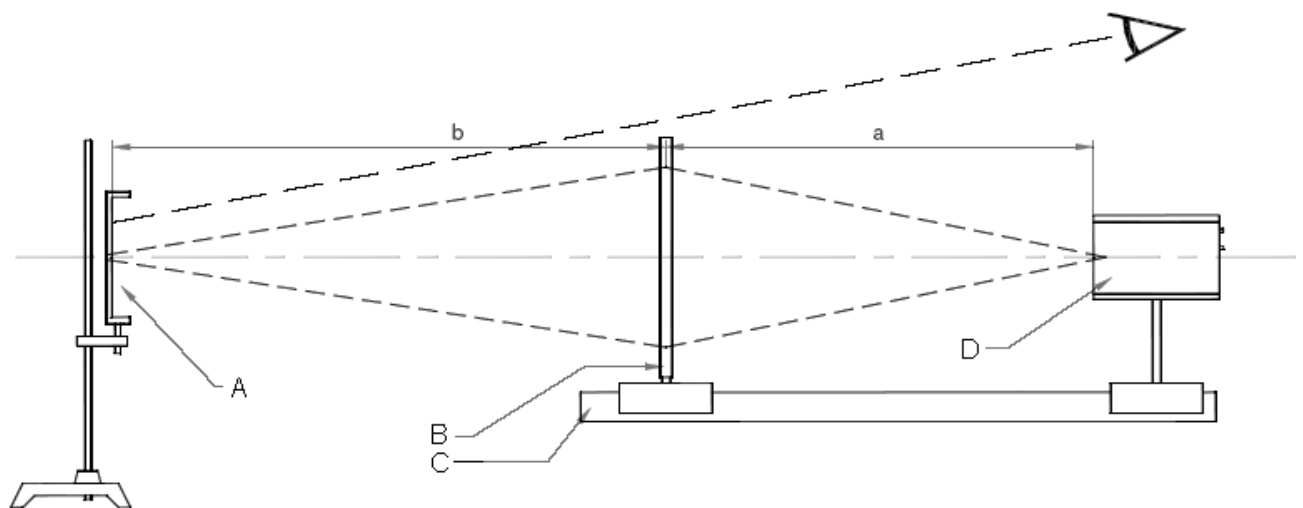


Fig. 1: Experiment set-up: A Microprism mirror, B Fresnel lens, C Optical bench, D Basic unit

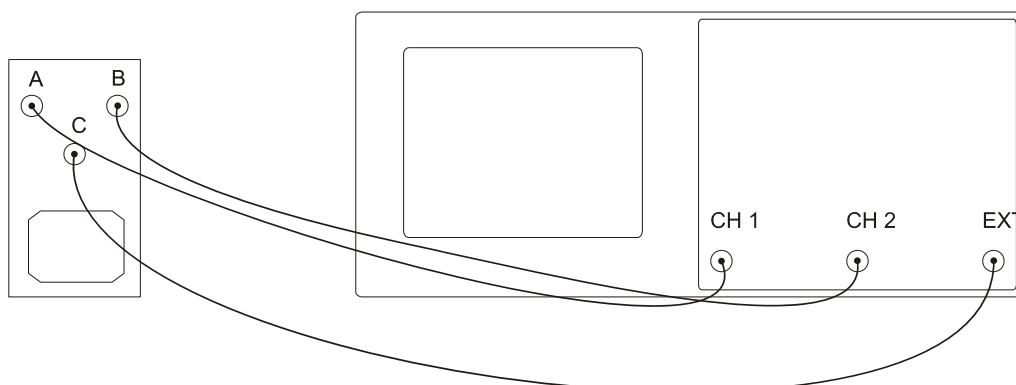


Fig. 2: Connections between the basic unit and the oscilloscope

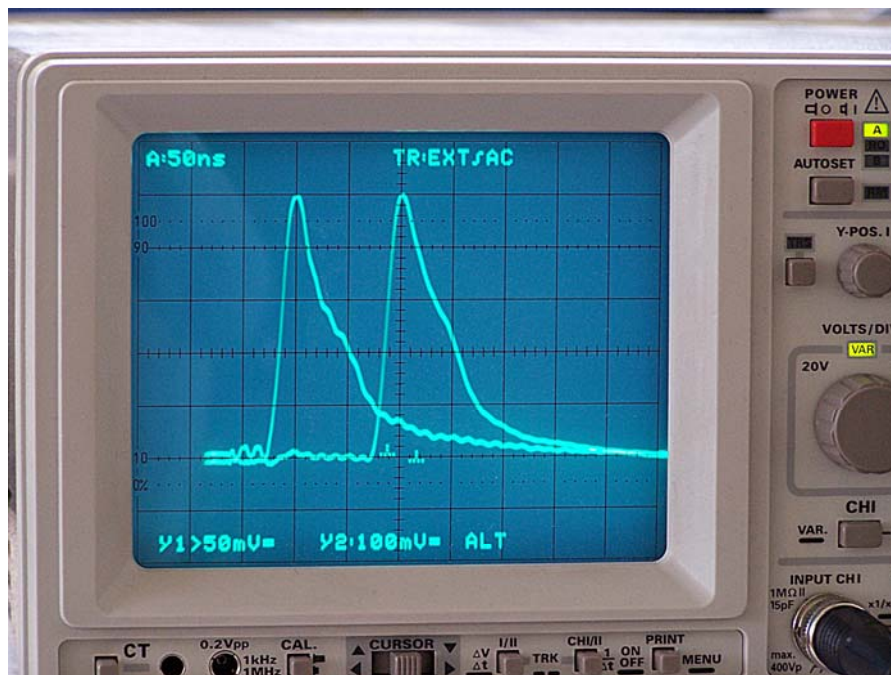


Fig. 3: Measured signal
(Y1 > 50 mV/DIV, Y2 = 100 mV/DIV., t = 50 ns/DIV)