Equipment Set for Propagation of Sound in Rods

230 V, 50/60 Hz: 1018469/U8557180-230
115 V, 50/60 Hz: 1018468/U8557180-115

Instruction manual

04/15 TL/UD

1. Safety instructions

Safe operation of the equipment set is assured as long as it is used as specified. Safety cannot be guaranteed if it is used incorrectly or carelessly.

- If the plug-in power supply exhibits a break in the lead, visible damage or any other faults, it should no longer be plugged into the mains.
- If the power supply comes into contact with water, label it as faulty and stop using it.
- Use of the power supply unit is permissible with degrees of pollution to levels 1 and 2.

2. Equipment

1 Stainless steel rod, 400 mm
2 Mats (3x)
3 Stainless steel rod, 100 mm
4 Aluminium rod, 100 mm
5 Hardwood rod, 200 mm
6 PVC rod, 200 mm
7 Stainless steel rod, 200 mm
8 Brass rod, 100 mm
9 Glass rod, 200 mm
10 Acrylic rod, 200 mm
11 Aluminium rod, 200 mm
12 Copper rod, 100 mm
13 Microphone box
14 Beater in protective tube (2x)
15 Plug-in power supply
16 Microphone probes (2x)

3. Materials and lengths

Stainless steel:	100, 200, 400 mm
Aluminium:	100, 200 mm
Copper:	100 mm
Brass:	100 mm
Hard wood:	200 mm
PVC:	200 mm
Acrylic:	200 mm
Glass:	200 mm
Diameter:	10 mm

4. Technical data

Complete equipment set:

Dimensions:	430x310x80 mm approx.
Weight:	2.2 kg approx.
Microphone box:	
Band width:	10 Hz – 42 kHz
Gain:	20 – 70
Output impedance:	1 kΩ
Output signal:	Switchable between signal, level and pulse modes
Signal:	0 – 14 V_{pp}
Level:	0 – 7 V DC
Pulse:	Low: 0 V High: 8 V DC Length: 150 ms
Inputs:	2 x 3.5 mm jack sockets
Outputs:	2 x BNC sockets
Power supply:	Plug-in power supply 12 V AC, 700 mA, pollution degree 2, protection class 2
Dimensions:	100x75x35 mm approx.
Weight including power supply:	450 g approx.

5. Description

The equipment set consists of test rods of various lengths, made of different materials, two microphone probes, a microphone box for recording and

amplifying signals and outputting them to an oscilloscope along with three mats.

Sound waves are created inside the rods by hitting them with a beater. These waves propagate along the rods and are reflected at the ends. The sound is picked up using microphone probes. With the long rods, oscilloscope traces show clearly delineated oscillating pulses. The short rods exhibit sinusoidal oscillation due to the formation of standing waves. From the length of the rods and the interval between two pulses or the period of the sinusoidal oscillation, it is possible to calculate the speed of sound specific to the material in question.

Equipment set 1018468 is designed for a mains voltage of 115 V (+/-10%), while set 1018469 is for 230 V (+/-10%)

6. Sample experiments

Required equipment:

1 Equipment set for propagation of sound in rods	1018551
1 USB oscilloscope 2x50 MHz	1017264
2 HF cables	1002746

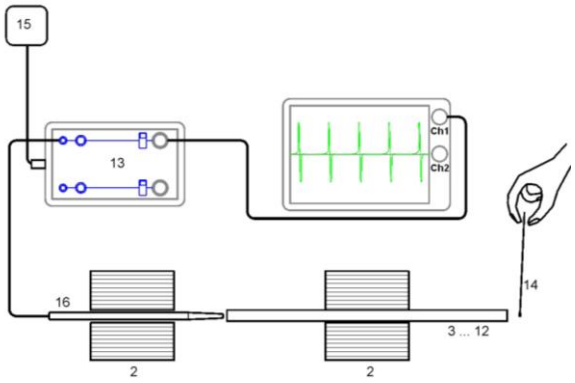

Fig. 1 Experiment set-up

- Lay a test rod on one mat and a microphone probe on another (Fig. 1).
- Connect the microphone probe to input A of the microphone box and position it at a distance of about 1 mm from one of the ends of the test rod.
- Take note of the instruction manual for the microphone box. Set the microphone box to maximum gain and its mode to Signal (selector switch in the top position). Use an HF cable to connect the output of the microphone box to channel CH1 of the oscilloscope. Example oscilloscope settings could be time base: 40 µs/div, vertical deflection: 2 V/div DC; trigger: source CH1, type edge, mode normal, threshold 1 – 2 V.

Note:
Correct choice of trigger threshold and the strength with the rod is struck are key to the successful execution of these experiments. In normal mode, the oscilloscope trace will be frozen when the signal amplitude drops below the trigger threshold. If the trigger level is too low, the start of the oscillation will be overwritten and only the decay will be displayed. If the trigger is too high, then there will nothing displayed at all if the rod is beaten gently..

- Use the beater to strike the rod on the opposite end to the microphone probe (Fig. 1).

Such a pulse-like excitation creates a sound wave which propagates along the rod.

6.1 Sound propagation in long rods

In long rods, the oscilloscope trace exhibits instances of oscillation which are clearly distinct from one another (Fig. 2).

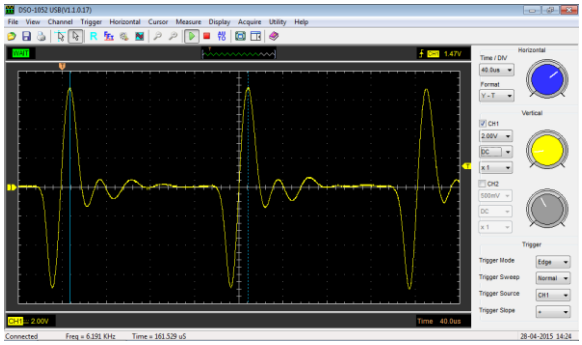

Fig. 2 Oscillation pulses in a 400-mm stainless steel rod struck with a pulse-like beat.

6.2 Sound propagation in short rods

In long rods, the oscilloscope trace exhibits sinusoidal oscillation due to the formation of standing waves (Fig. 3).

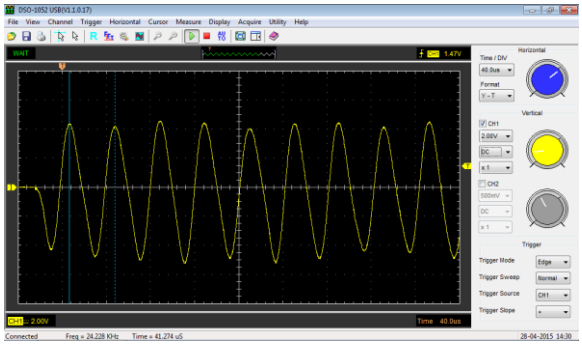

Fig. 3 Sinusoidal oscillation in a 100-mm stainless steel rod struck with a pulse-like beat.

6.3 Determining the speed of propagation of longitudinal sound waves

Long rods:

- Read off the time T_1, e.g. between two maxima of the distinct oscillations, from the oscilloscope trace with the help of the scope's cursors.
- Calculate the speed of sound c from T_1 and the length of the rod L, e.g. for the 400-mm steel rod (see 6.1):

$$c = \frac{2 \cdot L}{T_x} = \frac{0{,}8\,\text{m}}{162\,\mu\text{s}} = 4938\,\frac{\text{m}}{\text{s}}.$$

Not that the sound wave will have traversed twice the length of the during time T_1.

Short rods:

- Read off the time T_2, e.g. between two maxima of the sinusoidal oscillation, from the oscilloscope trace with the help of the scope's cursors.
- Calculate the speed of sound c from T_1 and the length of the rod L, e.g. for the 100-mm steel rod (see 6.2):

$$c = \frac{2 \cdot L}{T_x} = \frac{0{,}2\,\text{m}}{41\,\mu\text{s}} = 4878\,\frac{\text{m}}{\text{s}}.$$

Not that the sound wave will have traversed twice the length of the during time T_2.

6.4 Transverse sound waves

In solid bodies, it is also possible due to shearing forces for transverse sound waves to occur.

- Set up the experiment as shown in Fig. 4. Use the 400-mm stainless steel tube as the sample. Make sure that the distance between the microphone probe and the test rod is about1 mm. Example oscilloscope settings could be time base: 20 µs/div, vertical deflection: 2 V/div DC, CH2 1 V/div DC; trigger: source CH1, type edge, mode normal, threshold 1 – 2 V.

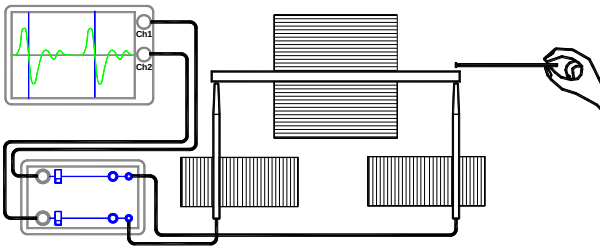

Fig. 4 Experiment set-up for investigating propagation of transverse sound waves in rods

- Use the beater to strike the rod as shown in Fig. 4.

Note:
The strength with which the rod is struck affects the quality of the oscilloscope traces.

In order to attenuate or damp standing transverse waves, the rod can be gently pressed against the mat in the middle with the flat of the hand.

Set up the trigger threshold to suit the height of the pulse as indicated in the note under section 6.

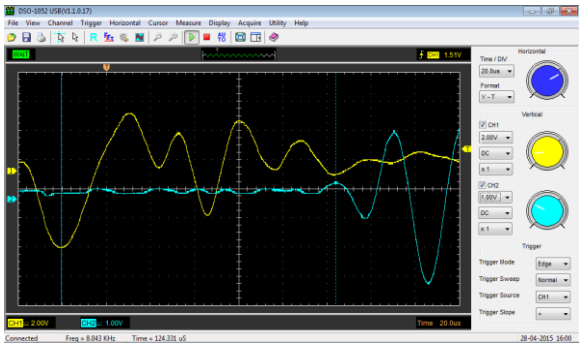

Fig. 5 Oscilloscope trace of a transverse wave in a 400-mm stainless steel rod

Fig. 5 shows an oscilloscope trace for generation of transverse waves in a 400-mm rod. The yellow line represents the signal measured by the microphone probe at the beater end, while the blue line is the signal measured by the probe at the other end.

- Read off the time T between the first minimum of the strike signal and the first maximum of the echo signal from the oscilloscope trace with the help of the scope's cursors.
- Calculate the speed of transverse waves, e.g. for the 400-mm steel rod (see above). Use the die effective length of the rod, which is actually the distance between the two microphone probes (0.39 m in this experiment):

$$c = \frac{L}{T} = \frac{0{,}39\,\text{m}}{124\,\mu\text{s}} = 3145\,\frac{\text{m}}{\text{s}}.$$

Comparing the propagation speeds of longitudinal and transverse sound waves (see 6.3), it can be seen that the speed of the transverse waves is considerably smaller.

7. Storage, cleaning and disposal

- Keep the equipment in a clean, dry and dust-free place.
- Do not clean the unit with volatile solvents or abrasive cleaners.

- Use a soft, damp cloth to clean it.
- The packaging should be disposed of at local recycling points.
- Should you need to dispose of the equipment itself, never throw it away in normal domestic waste. Local regulations for the disposal will apply.