# H76518 – Ultrasonic Kit

The Unilab Ultrasonic Kit is similar in appearance to the older Microwave Kit, so it is instructive to emphasise the differences and reasons for them.

| | Ultrasonic Waves | Microwaves |
|---|---|---|
| Wavelength | 8mm | 2.8cm |
| Frequency | 40 kHz | 10.7 GHz |
| Velocity in air | 320 m $s^{-1}$ | $3 \times 10^8$ m $s^{-1}$ |
| Nature | Longitudinal (not subject to polarisation effects) | Transverse (show polarisation phenomena) |
| Source | Piezoelectric transducer driven by oscillator with internal battery | Gunn diode or klystron in waveguide with external low voltage supply |
| Horn | Exponential, circular | Linear flare, rectangular |
| Detector | Piezoelectric transducer feeding amplifier | Diode in waveguide |

## Use of the Horns

The horns are a push fit on the transmitting and receiving transducers. They have the effect of concentrating the ultrasonic beam into a narrow angle, thus permitting much greater range in limited directions. In the instructions which follow, use without horns is assumed, in which case the signal should be adequate for table-top experiments.

## Facilities

The transmitter H29231 is completely self-contained **(Tx)**. To change the internal battery type PP9, remove the four Philips screws. A transducer H29243 may be driven from the transmitter, as in figure 5. The transmitted ultrasonic beam may be pulse modulated, i.e., turned on and off in a regular manner, as in figure 7.

The transmitter may also be speech modulated, by connecting the output of an audio amplifier to the modulation terminals. The receiver should then be connected to another audio amplifier. Speech can be transmitted over more than 100m by this method, if the exponential horns are fitted; and this method of transmission is legal and requires no licence. Adjust transmitter tuning, and receiver and amplifier gains, for best results.

The self contained receiver H29255 **(Rx)** is also powered by a PP9 battery, which may be changed by removing the four Philips screws. The output should be connected to a meter having a full-scale deflection of 1mA. The gain control may be set such that the meter does not go 'off scale'. If the transmitter is being speech modulated (see above), connect the receiver to an audio amplifier instead of a meter.

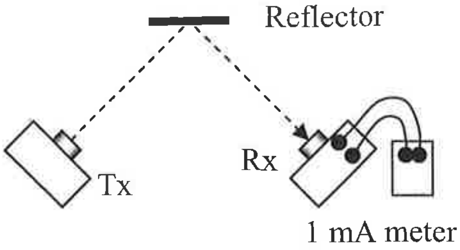
The slave transducer H29243 can only be driven from the **Tx**. Connect the two transducer terminals to those market "monitor output" on the transmitter. Ordinary 4mm-plug leads of up to 1m may be used.

NOTE: The received signal must be expected to vary in amplitude because of the short wavelength, the high percentage of ultrasonic energy reflected from most common materials and the strong influence of air currents.

**NFU 645**

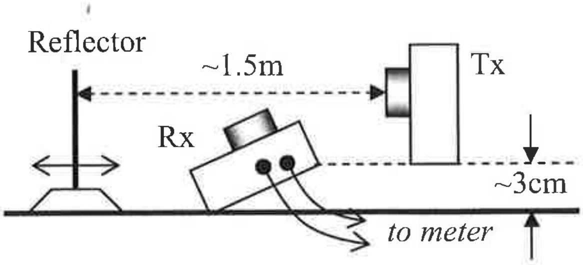
## Ultrasonic Kit

### Setting Up



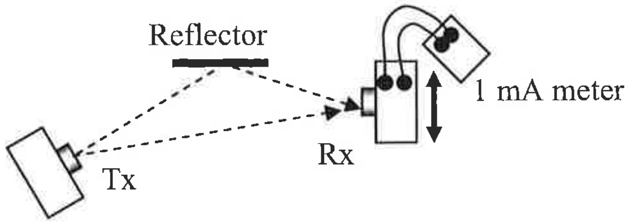

The path length should be ~1.5m. Switch Tx and Rx on (without horns). Turn Rx gain clockwise, then turn Tx tune until the meter reading goes high (usually off scale). In turn, decrease Rx gain and readjust Tx tune until a full-scale reading where Tx tune is at the maximum position.

### Measuring wavelength by standing wave




Elevate Tx approximately 3cm above the bench. Lie Rx on its back, and elevate the end nearest to Tx by 3cm. Place the reflector approximately 1.5m away from Tx. Slowly move the reflector back and forth between two minima (nodes) on the meter. The distance between nodes (i.e. the distance you moved the reflector) is half the wavelength. The typical result is 4mm corresponding to a wavelength of 8mm.

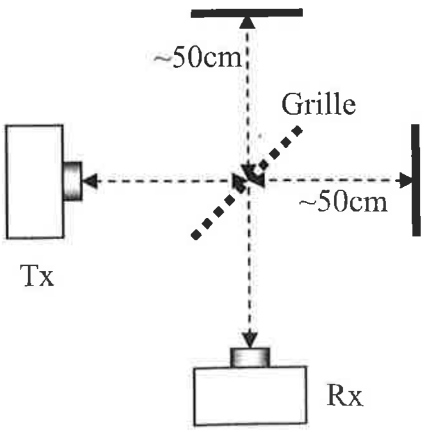
### A Model of Lloyd's Mirror




By using a mirror, two incident sound sources can be set up. This creates an interference pattern which can be observed by moving the receiver along the line perpendicular to the reflector.

### A Model of the Michelson Interferometer

The perforated plate splits the sound into two beams, which are reflected and recombined at the receiver. By moving either of the reflectors along the direction of the incident beam, the path of one of the beams is altered, thus setting up an interference pattern which can be observed from the output of the receiver.

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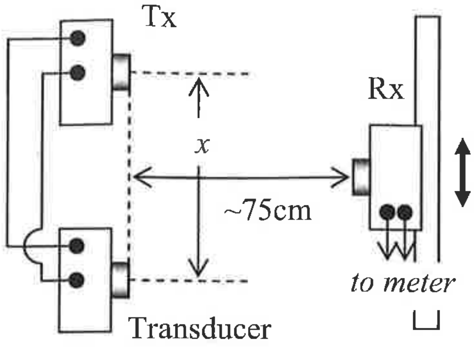
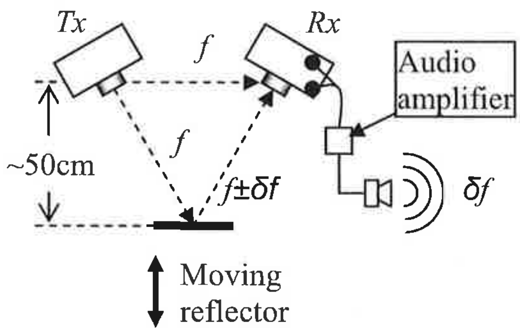
## A Model of Young's Slits (two coherent sources)




Connect the transducer to the monitor and earth terminals on the transmitter. The transducer will now emit a signal with the same amplitude and phase as the transmitter. (Twin or separate leads are satisfactory up to a separation of 1m). If a meter rule is secured on the bench, and Rx moved up and down it, minima and maxima are observed, the separation of which depends on $x$ which represents to the distance between slits in a Young's optical experiment.

## Doppler Effect and "Beats"

In the arrangement shown, some of the signal reaches the receiver directly, and some after reflection from a moving object (typically the hand). The reflected signal is shifted in frequency, and the two different frequencies produce "beats" which can be heard through the amplifier. The beat frequency is proportional to velocity of the reflector. This is the principle of the radar speed trap.

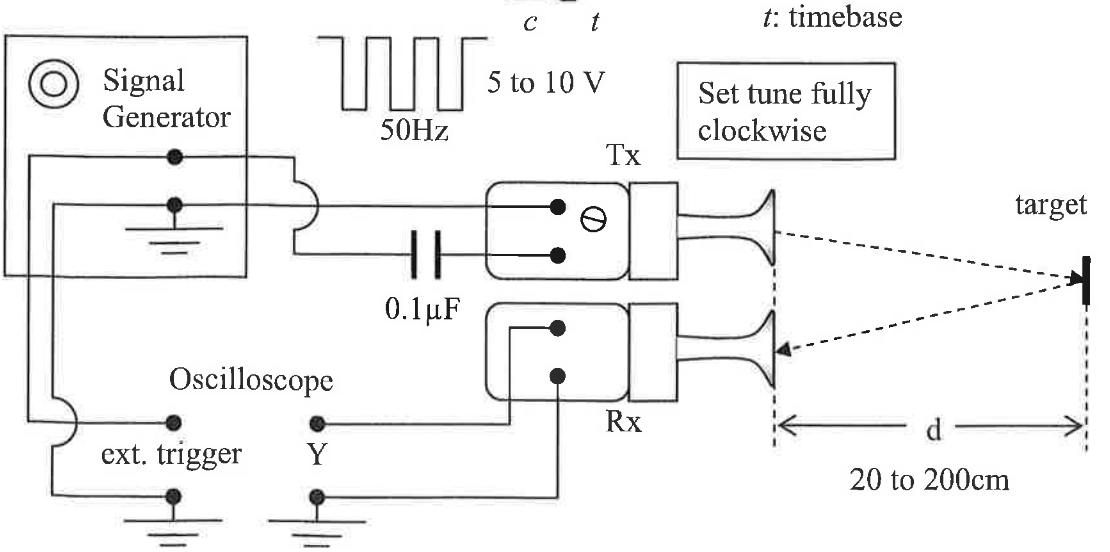



## SONAR ("Sonic Radar")

The arrangement below is a close analogy of RADAR (radio detection and ranging). The transmitter is switched on and off by the square wave from a signal generator, so that it transmits ultrasonic pulses. The reflected pulses are displayed on the oscilloscope screen. The distance $d$ of the reflector can be calculated from the time base setting and the distance $x$ between peaks on the oscilloscope screen:

$$\frac{2d}{c} = \frac{x}{t}$$

$c$: speed of ultrasonic wave
$t$: timebase



| To improve the range: *(for all experiments)* | 1. Tune T for "peak";<br>2. Increase R for "gain";<br>3. Attach the exponential horns. |
|---|---|

## List of products

*The following accessories are included in the Ultrasonic Kit **H76518**, and can be bought separately if need be:*

| | |
|---|---|
| Transmitter **(Tx)** | **H29231** |
| Receiver **(Rx)** | **H29255** |
| Slave Transducer | **H29243** |
| Perforated Plate | **H31511** |
| Reflector | **H31523** |

*The following products, available separately, are used in a number of the experiments described in these notes:*

The Basic Student Meter **H30981** with 1ma/10mA d.c. Shunt **H30932** provides an accurate 74mm scale length to measure and observe the output from the receiver.

The Sound Level Indicator **H30348** has an integral wide angle moving coil microphone, and displays sound levels on an analogue meter calibrated -10 through 0 to +10dBA, centred on the range selected by a six position switch. This gives an overall range of 40 to 110dBA. The overall frequency response is very similar to the internationally accepted A weighting specification. Speed of meter response is switch selectable: "slow" is to display background noise level and "fast" for transients. It is powered by an internal PP3 battery **H68327**.

The Audio Amplifier Including Loudspeaker **H29565** has a 300mW amplifier with variable gain, and 1MΩ input impedance. Also included is a co-axial to two 4mm plug connecting lead which can be plugged directly into the ultrasonic receiver.

Replacement internal 9V PP9 batteries **A54021** are available for the kit.

The Bench Signal Generator **H10568** is capable of signal output over the full audible range and beyond, with minimal distortion. Coarse frequency control is by way of a rotary-switch spanning four decades (10Hz, 100Hz, 1kHz, 10kHz), and a calibrated tuning dial provides for fine frequency setting from ×1 to ×11. It can be switched between square and sine waveform output, and also has an internal speaker operated by an on/off button on the front to listen to the waveform simultaneously if desired.

The Student Oscilloscope **H28226** is a low cost, single channel oscilloscope that lives up to most classroom requirements. It is ideal for the SONAR experiment described in these notes.

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