THE OSCILLOSCOPE

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LEAVING CERTIFICATE PHYSICS

THE OSCILLOSCOPE

CONTENTS

CATHODE RAY OSCILLOSCOPE

DATA LOGGING OSCILLOSCOPE

THE OSCILLOSCOPE

The oscilloscope is described in detail on pages 168 to171 in the Physics Teacher Reference Handbook. Each school has a copy of this book and the accompanying CD. This should be read to familiarise oneself with the various controls on the oscilloscope, their functions and how to use them.

To View the Trace on the Oscilloscope

1. Switch on the oscilloscope.
2. Set VERT MODE at CHA (on some oscilloscopes this may be marked as MODE).
3. Set TIME/DIV on the oscilloscope to 0.2 ms.
4. Adjust the Channel A Vertical Position control ↕ and the Horizontal Position control ↔ until the trace is centred on the screen.
5. Adjust INTENSITY to a minimum for comfortable viewing.
6. Adjust FOCUS for a clear, sharp trace.
7. On a dual trace oscilloscope, a second trace can be displayed by setting VERT MODE at CHB.
8. To display both traces simultaneously, set VERT MODE at DUAL.

TO EXAMINE D.C. VOLTAGE

1. Switch on the oscilloscope and centre the trace.
2. Set TIME/DIV on the oscilloscope to 0.2 ms.
3. Set Channel A on oscilloscope to DC.
4. Set COUPLING at AUTO.
5. Set SOURCE at CHA.
6. Turn the VAR button for the time base fully to the right.
7. Set the VOLT/DIV for CHA to 2 V. Make sure the VAR on the VOLT/DIV control is turned fully to the right.
8. Set VERT MODE on the oscilloscope to CHA.
9. Connect the BNC cable to the Channel A input.
10. Connect the two leads of the cable to a 6 V battery. See that the beam is moved up or down depending on the connections to the battery.
11. Reverse the connections to the battery; the beam is deflected in the opposite direction

Each vertical square is 2 V. The beam has been deflected by three squares. This means that the voltage of the battery is $3 \times 2 = 6$ V.

Note

The d.c. output from many power packs is not fully smoothed. When examined on an oscilloscope it can look like an a.c. voltage. Because of this it is recommended to use a dry cell or battery.

TO EXAMINE A.C.VOLTAGE

1. Set Channel A on oscilloscope to A.C.
2. Set COUPLING at AUTO.
3. Set SOURCE at CHA.
4. Turn the VAR button fully to the right.
5. Set the VOLT/DIV for CHA to 2 V (don't touch the VAR control).
6. Set TIME/DIV on the oscilloscope to 5 ms.
7. Set VERT MODE on the oscilloscope to CHA.
8. Connect the BNC cable to the Channel A input.
9. Connect the two leads of the cable to a power pack set at 4 V a.c.
10. Observe the pattern on the screen.
11. To see a stationary display, adjust the TRIG LEVEL and HOLD OFF buttons gently.

Note

The screen shows the peak voltage, not the root mean square (r.m.s.) value**.**

To find the relationship between the peak voltage and the r.m.s. voltage

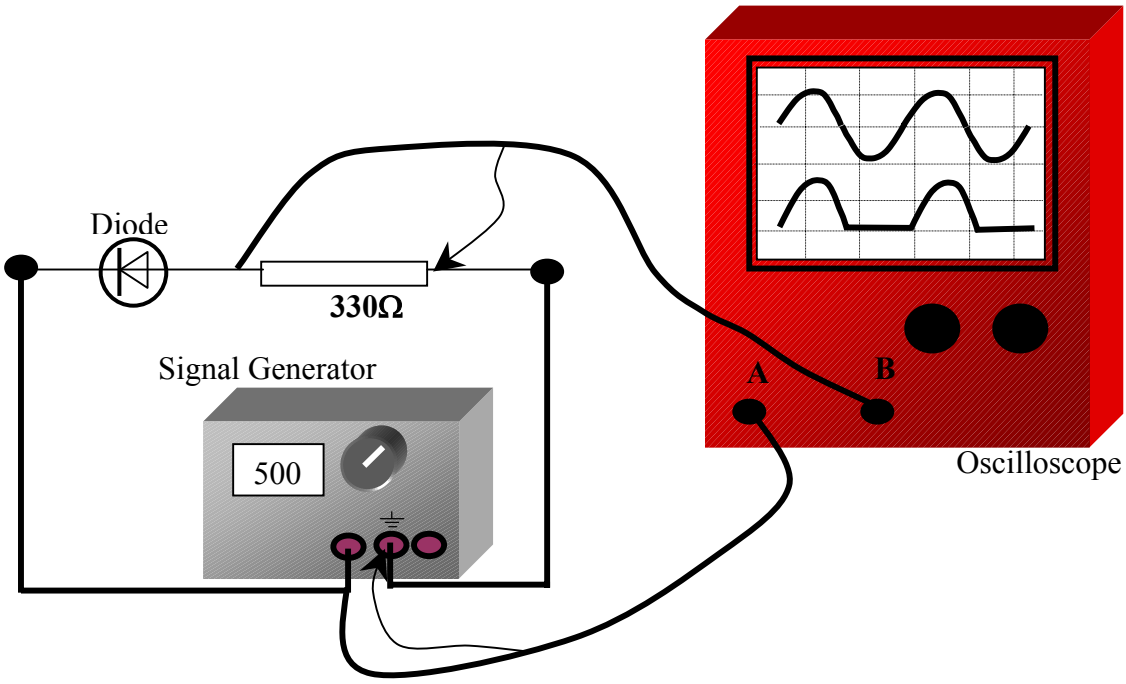
1. Find the voltage from top of a crest to bottom of a trough. Each vertical square is 2 V. This reading is twice the peak voltage, V_{Peak}.
2. Connect a multimeter across the output of the power pack to get the r.m.s. voltage, V_{rms}.

It is found $V_{Peak} = \sqrt{2}\, V_{rms}$ (within experimental error).

TO DEMONSTRATE HALF WAVE RECTIFICATION

Apparatus

Signal generator, 330 Ω resistor, diode, oscilloscope and two BNC leads.



Arrangement

1. Connect the 330 Ω resistor and diode to the signal generator as shown before putting any connections to the oscilloscope..
2. Connect the BNC lead from the Channel A input to the low impedance output of the signal generator.
3. Connect the other BNC lead from the Channel B input across the resistor, making sure there is a common earth. .

Procedure

1. Set Channel A and Channel B on oscilloscope to AC.
2. Set COUPLING at AUTO.
3. Set SOURCE at CHA.
4. Turn the VAR button fully to the right.
5. Set both VOLT/DIV controls on the oscilloscope controls to 2 V (don't touch the VAR controls).
6. Set TIME/DIV on the oscilloscope to 0.5 ms.
7. Set VERT MODE on the oscilloscope to DUAL.
8. Switch on the oscilloscope; two horizontal lines appear.
9. Use the POSITION buttons to set these lines ¼ and ¾ ways down the screen.

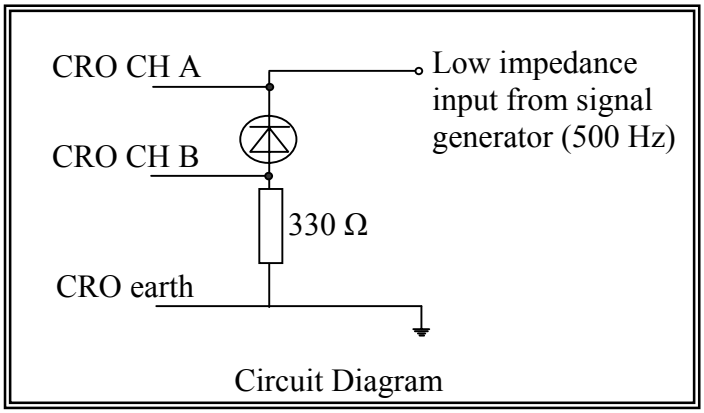
10. Switch on the signal generator and set it at 500 Hz at maximum amplitude. Two traces appear on the screen.
11. The top one is the input voltage in Channel A while the bottom one is the rectified output voltage across the resistor in Channel B.
12. To see a stationary display, adjust the TRIG LEVEL and HOLD OFF buttons gently.

Notes

For this experiment the diode must be connected to the live output of the signal generator, as shown in the diagram. This ensures that Channel A and Channel B have a common earth.

The rectified output will be less than the corresponding input as there is a p.d. across the diode.

This demonstration can also be done using a single beam oscilloscope. The full wave can be observed first by connecting the BNC lead from the oscilloscope to the signal generator. The lead can then be connected across the resistor and the half wave can be observed.



Circuit Diagram

TO EXAMINE SOUND WAVES USING THE OSCILLOSCOPE

1. Set Channel A on oscilloscope to AC.
2. Set COUPLING at AUTO.
3. Set SOURCE at CHA.
4. Turn the VAR button fully to the right.
5. Set the VOLT/DIV for CHA to 1V (don't touch the VAR controls).
6. Set TIME/DIV on the oscilloscope to 0.5 ms.
7. Set VERT MODE on the oscilloscope to CHA.
8. Connect the low impedance output of the signal generator to the Channel A input using the BNC cable.
9. Set the frequency of the signal generator at 500 Hz.
10. Connect a speaker across the output of the signal generator.
11. A wave trace appears on the screen and the corresponding sound can be heard.
12. Change the frequency and the amplitude settings on the signal generator and observe the effects on the wave trace.

TO MEASURE FREQUENCY USING THE OSCILLOSCOPE

1. Set Channel A on oscilloscope to AC.
2. Set COUPLING at AUTO.
3. Set SOURCE at CHA.
4. Turn the VAR button fully to the right.
5. Set the VOLT/DIV for CHA to 1V (don't touch the VAR controls).
6. Set TIME/DIV on the oscilloscope to 0.5ms.
7. Set VERT MODE on the oscilloscope to CHA.
8. Connect the signal generator to the Channel A input and set the frequency at 500 Hz.
9. Observe the pattern on the screen.

This means that the Period T of the wave $= 4 \times 0.5 \times 10^{-3} = 2 \times 10^{-3}$ s. Each horizontal square represents 0.5 ms i.e. 0.5×10^{-3} s. Crest to crest on the wave on the screen is 4 squares.

$$\text{Frequency } f = \frac{1}{T} = \frac{1}{2 \times 10^{-3}} = 500 \text{ Hz.}$$

Repeat this with the frequency display on the signal generator covered. Calculate the frequency from the display on the screen and compare it with the value on the signal generator.

NOTES

Before an oscilloscope is used, the calibration may need to be checked:

- Set Channel A and Channel B on oscilloscope to AC
- Set COUPLING at AUTO
- Set SOURCE at CHA
- Set (VERT) MODE at CHA
- Connect the BNC cable to the Channel A input
- Locate the CAL connection and connect the red lead of the BNC cable to it using a crocodile clip
- Connect the black lead of the BNC cable to the GND (Earth) socket on the oscilloscope
- Set TIME/DIV on the oscilloscope to 1 ms
- Set the VOLT/DIV for CHA to 0.5 V – a square wave should appear. Using the TRIG LEVEL control, this wave can be made appear stationary. Check that the peak to peak (pp) value of this wave on the screen is the same as the pp value written under the CAL connection on the oscilloscope (in this case it is 2V)
- If adjustment is needed use the VAR button on the VOLT/DIV control. Push it in and turn it until the peak to peak value of the square corresponds with the CAL value. Normally the VAR button will be turned fully to the right

Before repeating this procedure for Channel B, the following adjustments must be made:

- Change SOURCE to CHB
- Change VERT MODE to CHB

If the trace is not horizontal, the TRACE ROTATION control can be used to realign it. This is adjusted using a small screwdriver.

Some oscilloscopes use CH1 and CH2 or CHX and CHY instead of CHA and CHB.

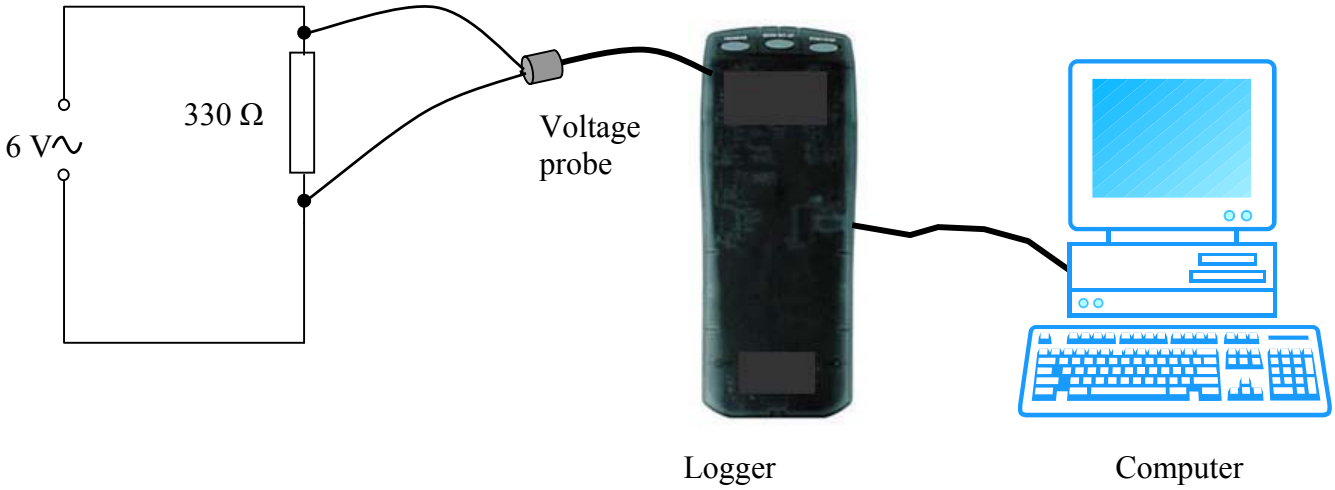
The letters BNC stand for ‘bayonet connector. This is the type of connector found on most standard light bulbs. Some oscilloscopes use ‘screw-in’ or ‘screw-on’ connectors, as do some bulbs. The cable used is a coaxial cable. In the coaxial cable the central wire carrying the signal (usually a red lead) is shielded from stray electric fields by an outer shield of braided wires (usually a black or shorter lead). The outer shield is earthed via the oscilloscope.

On a signal generator the black input socket is connected to earth.

TO EXAMINE A.C. VOLTAGE

Apparatus

Logger, voltage probe, computer, a.c.supply and 330 Ω resistor.

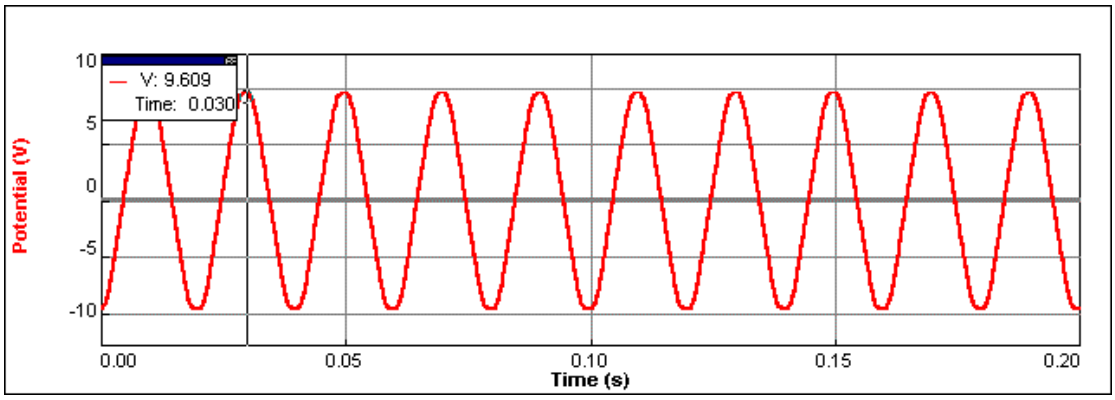


Arrangement

1. Set up the circuit shown in the diagram.
2. Connect the voltage probe to CH1 of the logger.
3. Connect the logger to the computer.
4. Start the computer logger program.
5. Click on Set Up.
6. In the Set Up menu click on Data Collection.
7. In the pop-up window, click on Real Time Collect.
8. Click on Sampling
   Set Experiment Length at 0.2s.
   Set Sampling Speed at 10000 per sec.
9. Click OK.

Procedure

1. Switch on the a.c. supply.
2. Click on Collect.
3. Observe the pattern on the screen.



4. Click on Analyse.
5. Select Examine.
6. Use the mouse to select a peak and read the value of the peak voltage which is 9.609 V in this example.
7. Connect a multimeter to the a.c. supply and read the voltage which is 6.78 V. This is the r.m.s. voltage.
8. Find the relationship between V_{Peak} and $V_{rms.}$

It is found $V_{Peak} = \sqrt{2}\, V_{rms}$ (within experimental error).

Note

The voltage probe could be connected directly to the voltage supply.

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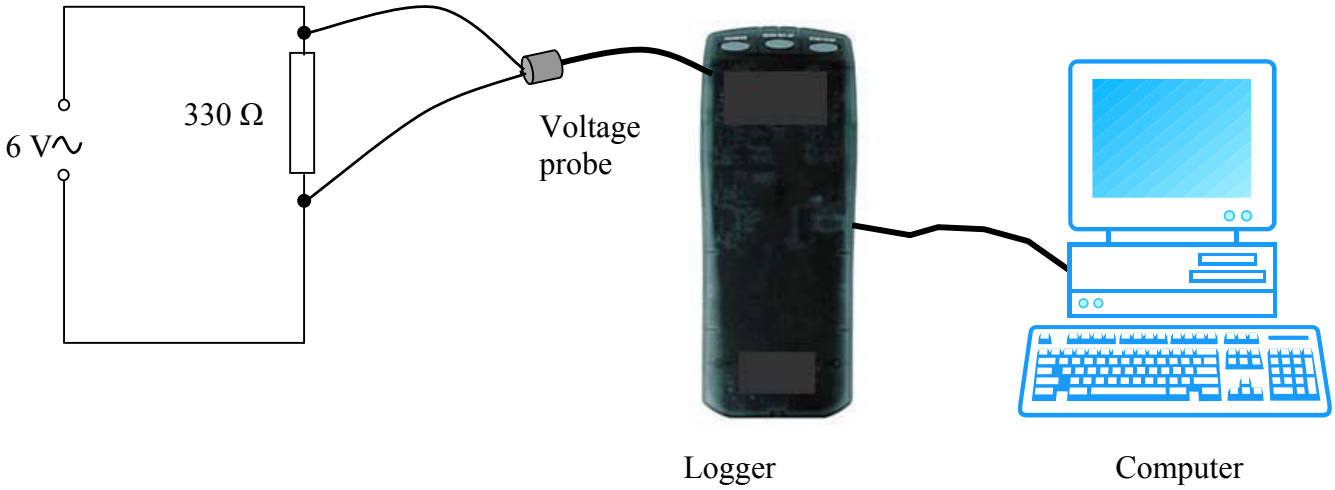
TO MEASURE MAINS FREQUENCY

Apparatus

Logger, voltage probe, computer, a.c. supply and 330 Ω resistor.

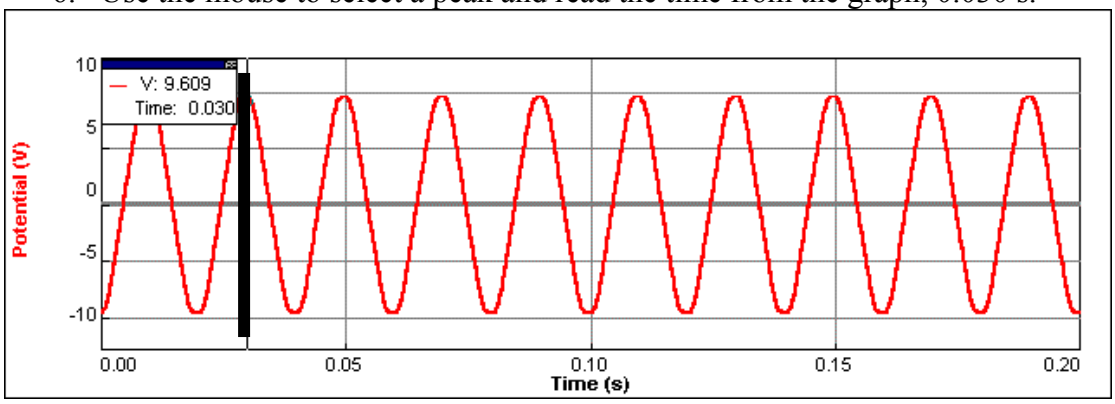


Arrangement

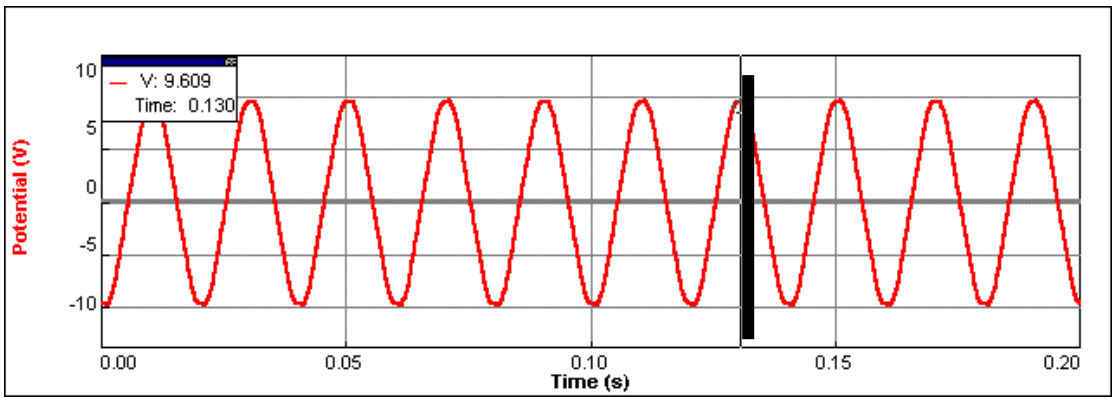
1. Set up the circuit shown in the diagram.
2. Connect the voltage probe across the resistor.
3. Connect the voltage probe to CH1 of the logger.
4. Connect the logger to the computer.
5. Start the computer logger program.
6. Click on Set Up.
7. In the Set Up menu click on Data Collection.
8. In the pop-up window, click on Real Time Collect.
9. Click on Sampling.
   Set Experiment Length at 0.2s
   Set Sampling Speed at 10000 per sec.
10. Click OK.

Procedure

1. Switch on the a.c. supply.
2. Click on Collect.
3. Observe the pattern on the screen.
4. Click on Analyze.
5. Select Examine.
6. Use the mouse to select a peak and read the time from the graph, 0.030 s.



7. Move on five peaks to the right and take the time reading again, 0.130 s.



This gives the period, T, of the wave to be $\frac{0.130 - 0.030}{5} = 0.02$ s.

$$\text{Frequency } f = \frac{1}{T} = \frac{1}{0.02} = 50 \text{ Hz.}$$

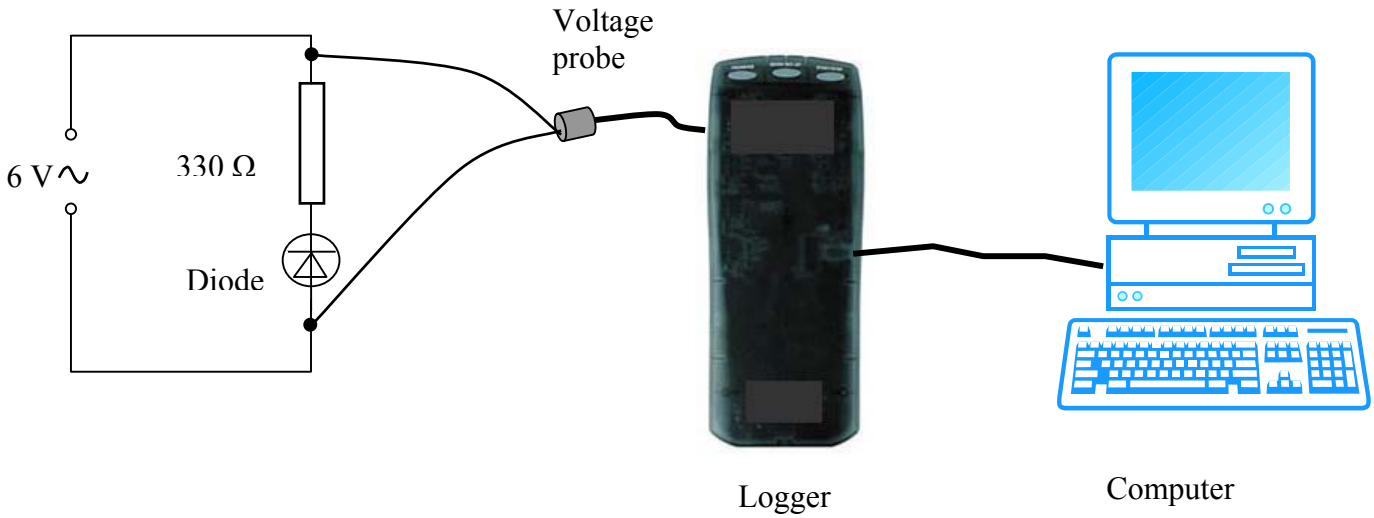
Note

The voltage probe could be connected directly to the voltage supply.

TO DEMONSTRATE HALF-WAVE RECTIFICATION

Apparatus

Logger, voltage probe, computer, a.c. supply, diode and 330 Ω resistor.

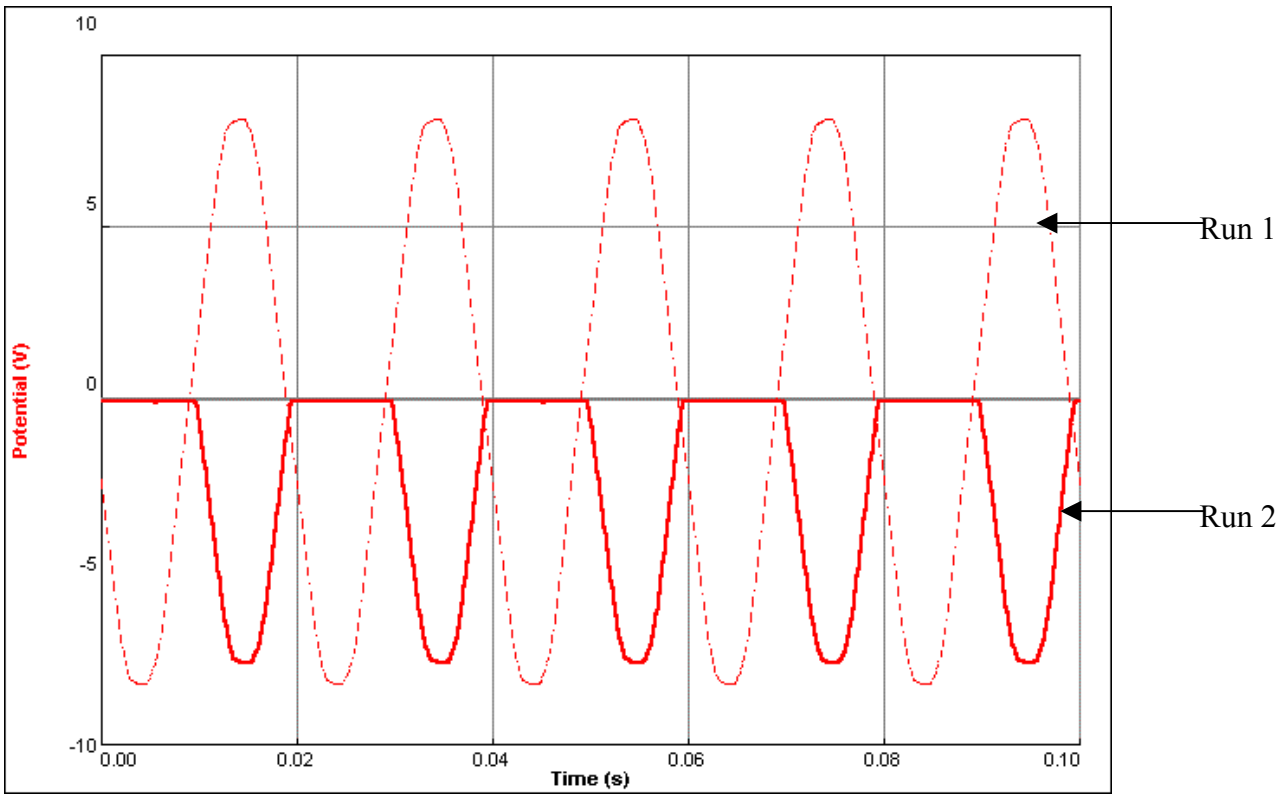


Arrangement

1. Connect the diode and the resistor to the 6V a.c. supply as shown.
2. Connect the voltage probe to CH1 of the logger.
3. Connect the logger to the computer.
4. Start the computer logger program.
5. Click on Set Up.
6. In the Set Up menu click on Data Collection.
7. In the pop-up window, click on Real Time Collect.
8. Click on Sampling
   Set Experiment Length at 0.1s
   Set Sampling Speed at 10000 per sec.
9. Click OK.

Procedure

1. Switch on the a.c.supply.
2. Connect the voltage probe across the output of the a.c. supply
3. Click on Collect.
4. Observe the pattern on the screen (Run 1).
5. Click on Data.
6. Select Store Latest Run – graph is saved (broken lines).
7. Now connect the voltage probe across the resistor.
8. Click on Collect.
9. Observe the pattern on the screen (Run 2) – only half of the wave is present.
10. Reverse the diode and repeat the experiment (Run 3).



Note

This experiment can be done using two voltage probes, allowing both patterns to be viewed simultaneously.
The probes are connected to CH1 and CH2 of the logger. One probe is connected to the output of the a.c. supply and the other is connected across the resistor. Ensure that polarities of the probe leads are connected in common i.e. the red leads are both connected the same side of the resistor.
The sampling speed should be set to 5000 per second.
The two patterns can be viewed by setting the Graph Layout option to 2 Panes when using View in the computer program.

TO EXAMINE SOUND

Apparatus

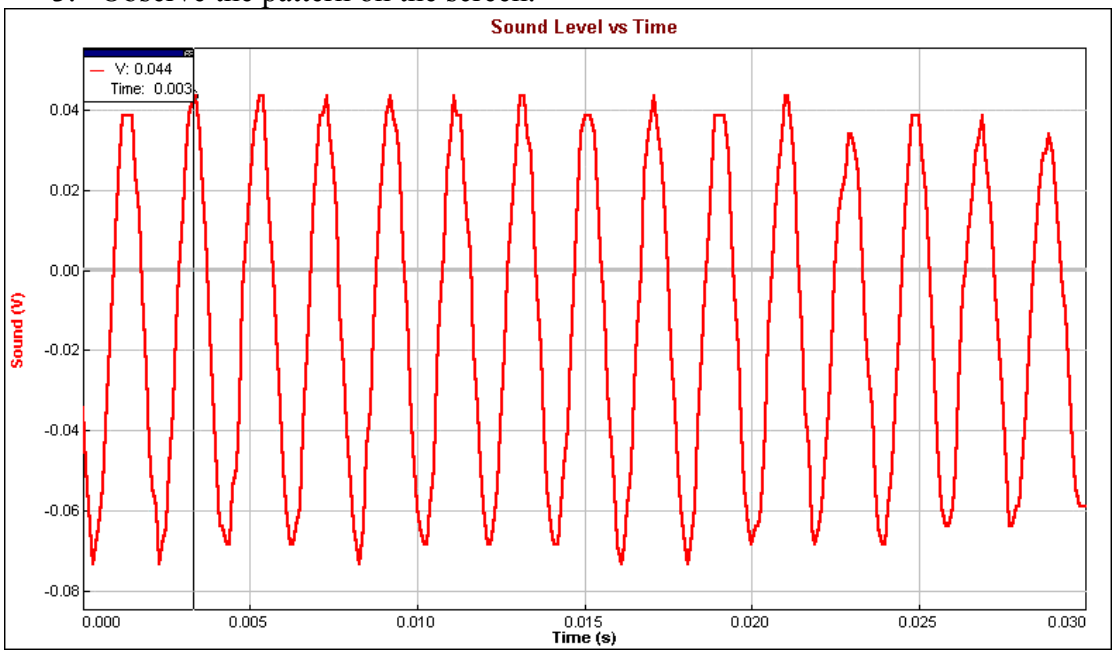
Logger, microphone sensor, computer, and tuning forks.

Arrangement

1. Connect the microphone to CH1 of the logger.
2. Connect the logger to the computer.
3. Start the computer logger program.
4. Click on Set Up.
5. In the Set Up menu click on Data Collection.
6. In the pop-up window, click on Real Time Collect.
7. Click on Sampling.
   Set Experiment Length at 0.03s
   Set Sampling Speed at 10000 per sec.
8. Click OK.

Procedure

1. Hold a vibrating tuning fork in front of the microphone.
2. Click on Collect.
3. Observe the pattern on the screen.



4. Click on Analyse.
5. Select Examine.
6. Use the mouse to select a peak and read the time t_1 from the graph.
7. Count on ten peaks and take the time t_2.

The period T of the wave $= \dfrac{t_2 - t_1}{10}$ and frequency $f = \dfrac{1}{T}$.

Notes

Experiment Length may have to be varied depending on the range of frequencies used.

If there is background noise, it may be necessary to use a trigger setting.

Harmonics, which will distort the pattern produced, may occur for low frequency tuning forks (200-320 Hz). Striking the tuning fork more gently to set it vibrating will reduce this distortion.

Ensure that the Data Collection mode is Real Time Collect as it sometimes changes to Repeat.