DATE	COURSE/YEAR/GROUP	NAME

UNIVERSITY OF PLYMOUTH

Department of Communication & Electronic Engineering

COMPUTER SIMULATION USING "ELECTRONICS WORKBENCH"

USE OF THE OSCILLOSCOPE TO OBSERVE AC VOLTAGES

Learning Objectives

Introduction to the controls on the simulated Oscilloscope

Vertical Amplifier gain
Timebase setting
X POS and Y POS

Measurement of RMS, peak, and peak-to-peak voltages.

Measurement of Period and Frequency.

Use of the Function Generator.

Properties of Sine, Square, and Triangle Waves.

The voltage divider & the potentiometer using ac

NB You will need some prior knowledge of RMS voltages.

Introduction

The cathode ray oscilloscope (CRO), or 'scope for short, is a sophisticated instrument.

Learning to drive one competently takes about as long as learning to drive a car. The effort is worth it. For observing and measuring AC waveforms, the 'scope' is an indispensable tool for the electronic/communication engineer.

AC Waveforms are commonly sinusoidal, square or triangular. For the purpose of testing circuits or sub-circuits, they are normally obtained from a function generator (also known as a signal generator).

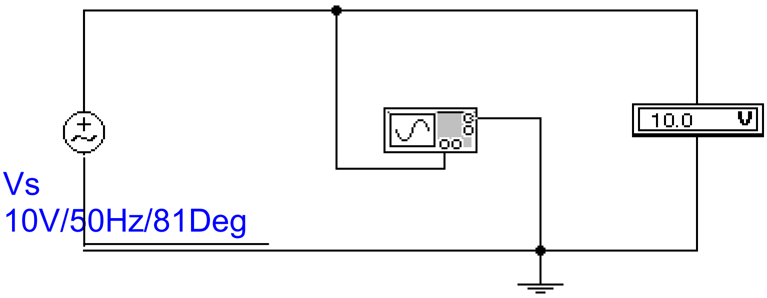
Sine Waves

We shall start off using an AC Voltage Source, and progress later to the Function Generator.

Connect the AC Voltage Source to an Oscilloscope and Voltmeter as shown in Fig.1. Both instruments will measure the voltage of the source.

Are the instruments connected in series or parallel? ....

Fig. 1



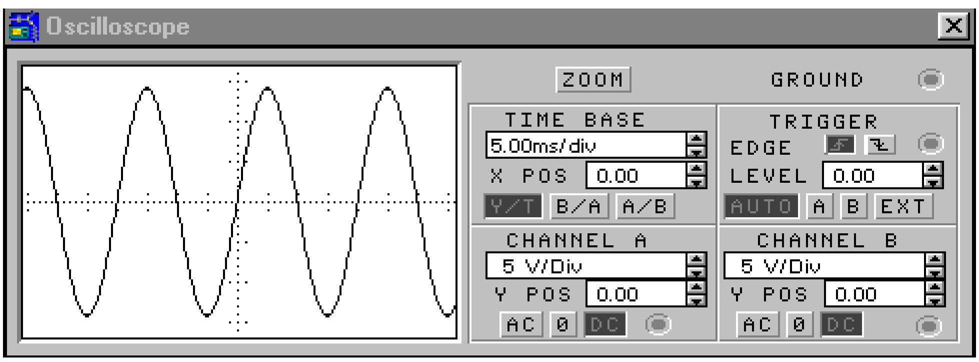
Double click on the voltmeter to bring up its control panel. Change its mode from DC to AC.

Double click on the voltage source to get its control panel. Set it to the values shown.

(The reason for this peculiar phase angle of 81 degrees is to get the wave shape to align properly with the grid on the screen. For some reason best known to itself, the trace starts one tenth of a square to the left of a grid line. Unfortunately X POS can only be adjusted in steps of two tenths of a square. On real oscilloscopes, X POS is normally an analogue rotary control, allowing exact positioning across the screen.)

Zoom the oscilloscope by double clicking on it, and set its controls as shown below in Fig.2. In its normally setting, Y/T, the voltage is plotted on the Y axis against time on the X axis. Hence the oscilloscope can be used to measure these two quantities. In fact, the time scale gives us both the period T and frequency f.

Fig. 2



Measuring Peak Voltage

Expand the oscilloscope further to full screen by clicking the “ZOOM” button

Record the voltmeter reading ....

The calibration of channel A in volts/div ....

The peak voltage, measured up from the horizontal axis ....

The peak to peak voltage ....

NB The voltages can be obtained more accurately by dragging the red or blue cursor sideways to the desired spot, and reading off VA1 or VA2

If you wish to shrink the scope to its “middle size”, click the “REDUCE” button.

Three Measures of AC Voltage

It is obvious that, in dealing with AC voltages, we have to make it clear exactly what we are talking about – RMS, peak, or peak-to-peak.

Explain why the peak voltage is not 10V. (Hint - remember RMS values)

....
....
....

Measuring the Period

Record the timebase setting in ms/div ....

The number of horizontal divisions for one cycle ....

Calculate the period T in ms ....

The frequency f = 1/T ....

Compare the frequency setting of the voltage source ....

In practice, if you are using an oscilloscope to measure frequency, you will first adjust the timebase to give a convenient number of cycles on the screen.

Change the timebase to 0.01 s/div, and repeat the above measurements

Record the number of horizontal divisions for one cycle ....

Calculate the period T in ms ....

Did you get the same answer as before? I hope so.

X POS – X Position – ie moving the Trace Horizontally

Return to a time base of 5 ms/div. Immediately under the timebase control is the XPOS control. Click on the little up or down arrows.

Describe and explain the effect on the trace. How far does it shift for each 0.2 step?

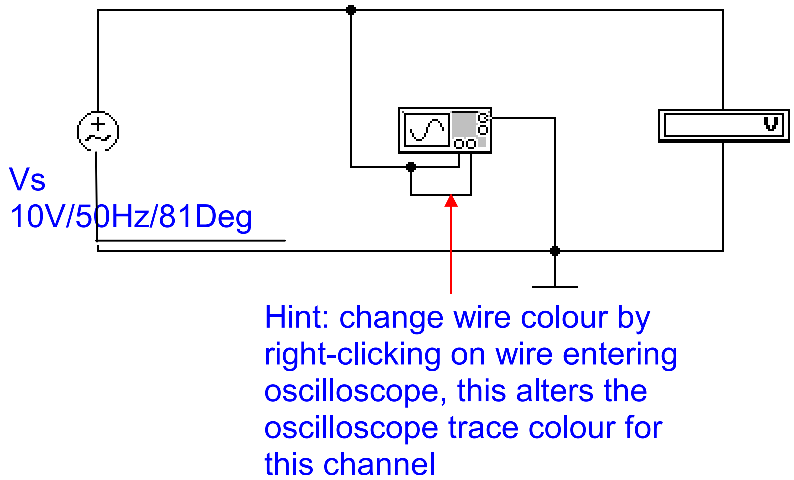
....
....
....

Note This is not a very useful facility in simulation.

Y POS - Moving the Trace Vertically

Modify the circuit as in Fig 3. You have now connected the signal voltage to both channels (channels A and B). Set them both on 10V/div vertically.

Fig.3



What adjustments do you have to make to Y POS to get the following trace? (Fig. 4) Decide which trace is which, and label them ‘A’ and ‘B’.

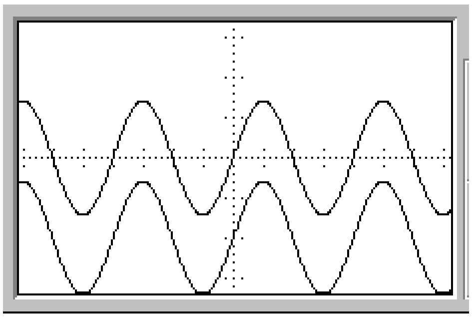


Fig. 4 Y POS = ……on channel

This facility is very useful for positioning two different voltage traces on the screen of a real ‘scope

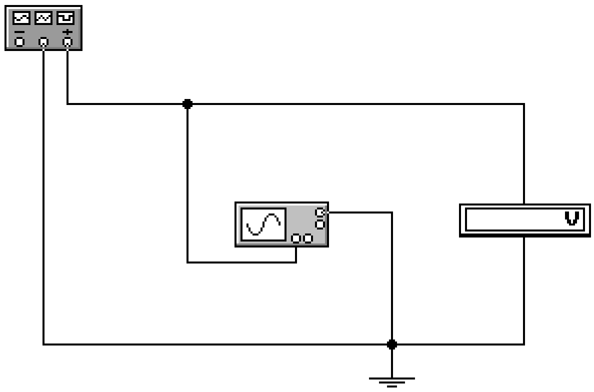
On a real oscilloscope, how big are the main grid squares?

....

Square and Triangle Waves

Replace the Voltage Source by a Function Generator, as shown in Fig. 5.

Fig.5

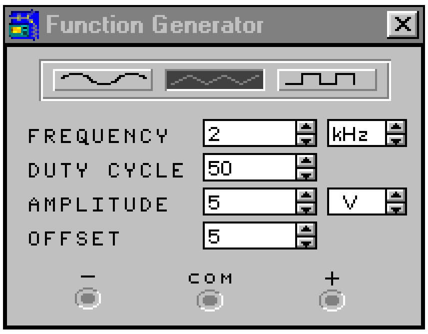


Set X POS back to zero.

Note that the ground wire is connected to the central output socket on the function generator.

"Zoom up" the function generator, (Fig. 6)
and set it to

Fig.6



Wave shape	Sinusoidal
Frequency	2 kHz
Duty Cycle	50%
Amplitude	5V
Offset	0

Close down the function generator again.

Calculate suitable values for the timebase and vertical amplifier gain to give a nice trace on the screen, showing three cycles filling the screen. (ZOOM the scope to full screen)

Timebase .... ms/div

Vertically .... V/div

See if these values work.

Look at the amplitudes:

Voltmeter ....

Oscilloscope .... peak value

Do these agree with the figure you set on the function generator? Explain any differences.

....
....

Change the wave shape to square, then triangular, and record:

	Amplitude	Period	RMS Voltage
Sine			
Square			
Triangle			

Try to explain the differences in the RMS voltages, particularly the 5V of the square wave.

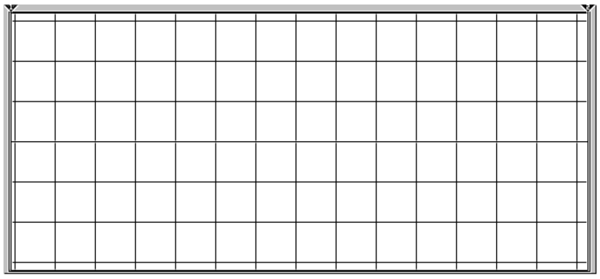
....
....
....

Offset Voltage

Zoom up the function Generator again, and change the offset from zero to 3V.

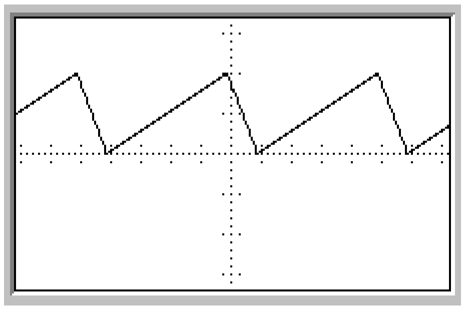
Select the sine wave shape

Sketch the resultant waveform.



Such a waveform has an AC component and a DC component, and is quite common in practice.

Fig.7



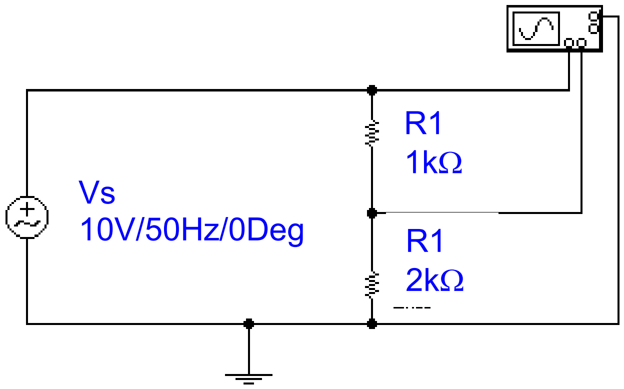
See if you can make a sawtooth voltage

which is always positive, as in Fig. 7.

Hint: You will need to fiddle with the Duty Cycle.

The Voltage Divider in an AC Circuit

Wire up the series circuit below. This time, use a source of Alternating Current (AC). Note that I have labelled (Circuit & Label) the 10V AC voltage supply Vs (source voltage V_s). To observe the voltage waveforms, pick an oscilloscope off the instrument shelf.



A and B are the inputs to channel A (V_s) and channel B (V_2) on the oscilloscope. Select the wire to input A and change its colour to red. Make the wire to input B blue. The advantage of this is that the traces on the CRO screen then have the same colours, making it easy to see which is which.

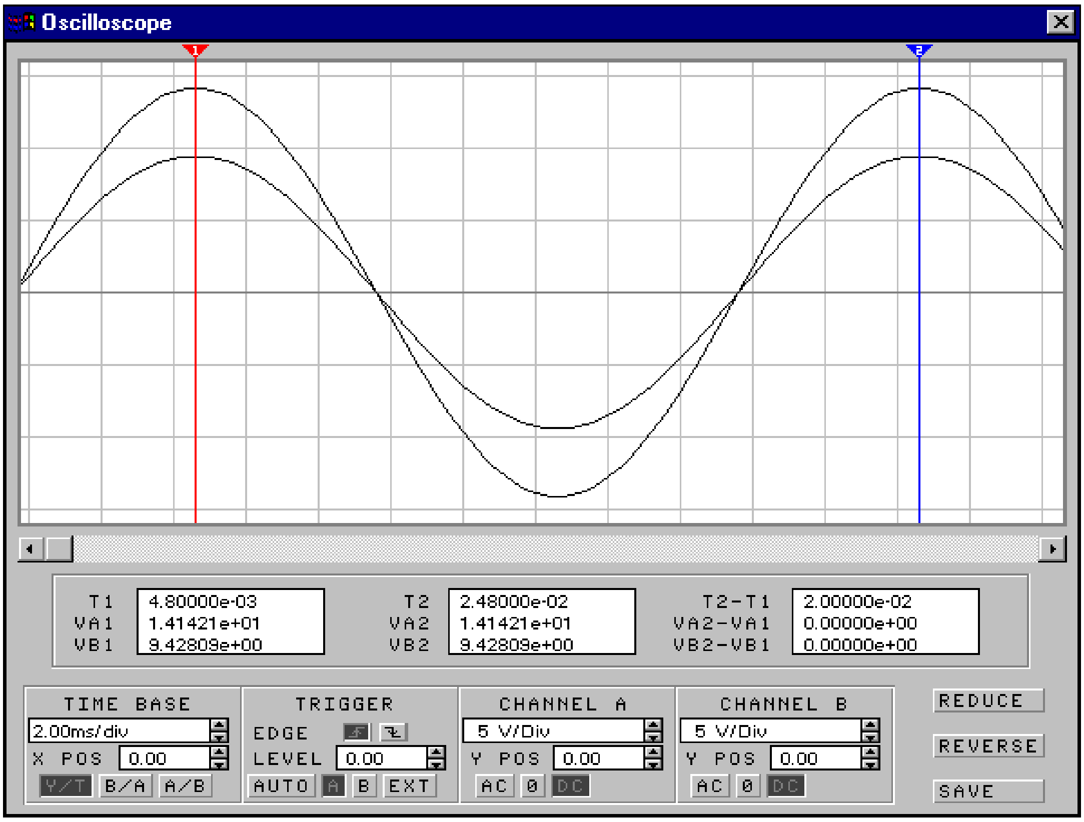
Highlight the voltage source, and change its values to those above. 50 Hz is the frequency of the mains supply in the UK (It is 60 Hz in the USA)

Double click on the CRO to expand it. Press the "GO" toggle switch, top right on the screen.

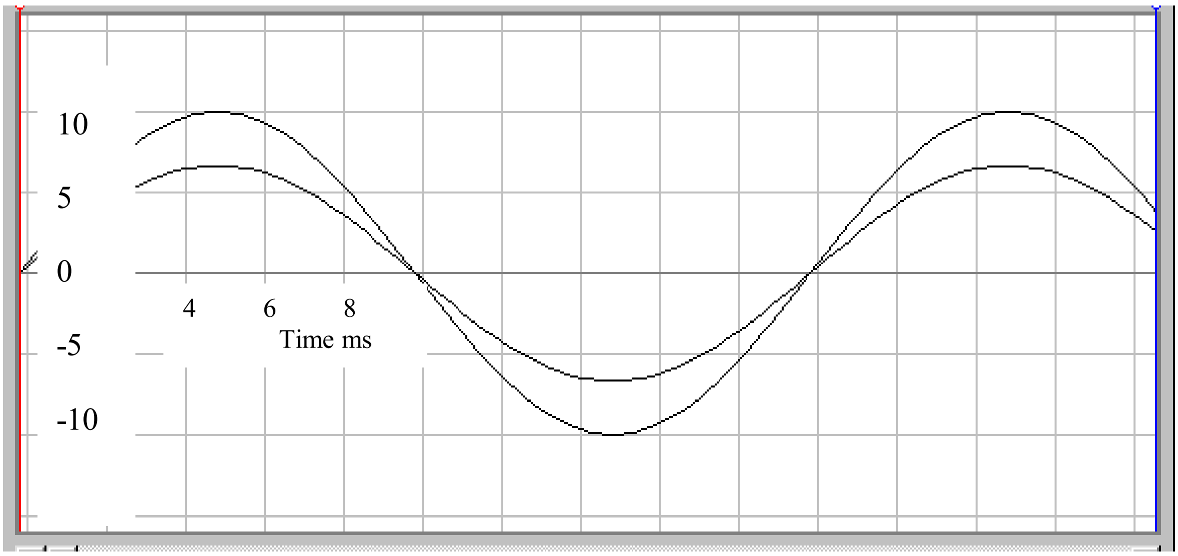
To get a satisfactory picture, adjust the CRO scales as follows. See the images on page 7.

Vertically	5V per division, both channels
Horizontally	2ms per division

There are ten horizontal divisions on the CRO screen, each of which represents 2ms. So, ten divisions represent 20ms, 0.02s. Hopefully, the traces will spread across the screen, and stop at the end, and the "Simulate" toggle switch will turn off. Click 'Zoom' on the oscilloscope to get a large display (PTO). You can now drag the coloured cursors to take accurate readings.



Tidy up the image below of the CRO screen, and complete the vertical voltage scale, and horizontal time scale.



What is the peak value of V_s ? .... (This is measured up from the centre horizontal axis)

What is the peak value of V_2 ? ....

Does V_2/V_s equal the resistor ratio

Count the number of squares horizontally corresponding to one cycle of the waveform.

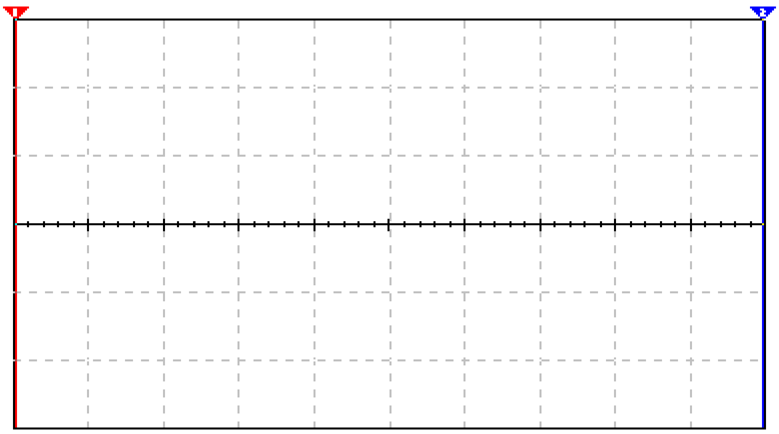
Number of squares = ……………

Each square represents …… ms

So, time for 1 cycle = …… ms

How does this relate to the frequency, 50Hz ?

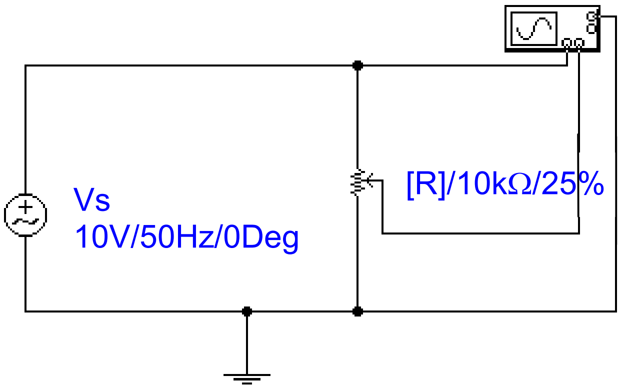
Swap the resistors in the circuit diagram, and sketch the waveforms.



Put the voltage and time scales on the diagram, and check whether the voltage ratio is correct.

$$\frac{V_1}{V_s} = \qquad \frac{R_1}{R_1 + R_2}$$

PART 4. Using a Potentiometer



Replace the two resistors by a potentiometer. Adjust the value to 10 kΩ linear.

The slider of the potentiometer can be adjusted up and down by touching the appropriate key, ‘r’ in the default case. Each adjustment represents a 5% shift in the position of the slider. See the help page for potentiometers.

SHIFT ‘r’ moves it the other way.

Observe the effects on the waveforms.

Make some sketches on the reverse of this page, or get some printouts from EWB.

Explain how this represents the action of a volume control on a radio.

Printouts in EWB

To complete your notes on the simulation, it is well worth taking a few minutes extra to get some printouts of the current circuit.

Choose File & Print

You can select the things you want printed. Try “Schematic” and “XY plot”.