The University Of Sheffield.

Electronic & Electrical Engineering.

FIRST YEAR LABORATORY 2013 MPW

Work-Station Familiarisation Exercise - Part 2 (EEE-WS2)

Aims

These laboratory exercises will give you:-

1. Practical 'hands-on' experience by using a set of fundamental electronic instruments to measure and observe voltages and waveforms.
2. An appreciation of some of the fundamental considerations you need to apply when using measurement instrumentation equipment.
3. Practical experience of interpreting a simple circuit diagram and building an electronic circuit.
4. An opportunity to test the electronic circuit using the instruments and knowledge gained.

- **The laboratory exercises 1-4 should take up to 1½ hours to complete, with the remaining 1½ hours for the soldering and circuit construction (exercise 5).**
- **Work in pairs,** but also share experience and knowledge with colleagues.
- **A number of experienced demonstrators are available** to check your progress and answer queries. They will guide you through the exercises helping you to work in a logical and sequential manner to construct your conclusions.
- **Read through the lab sheets before starting the exercises.**
- **Write all results and answers in your laboratory notebook.**
- **Get a demonstrator to sign your laboratory notebook after completing exercise 4 and again after exercise 5, while also ensuring your name is recorded on the attendance register with your final mark.**

Purpose

In WS1, you became familiar with the basic properties of the work-station instrumentation. WS2 looks at how we can observe and measure waveforms and signals. This is particularly important given that the use of electronic measurement equipment is now wide spread across all disciplines, in particular medical and biological sciences, physical sciences, chemistry and engineering but also in social sciences, arts and media. With the omnipresent nature of digital electronics, especially in the area of computers, the analysis, verification and trouble-shooting of interface circuits for example is becoming more and more complex.

After this session you should be a little more familiar with the shapes of digital and pulse waveforms. Digital signals are obviously fundamental to electronic communication technology, while it should be remembered that pulse signals play a major role in biological and biomedical communication systems. The following exercises will help you to manipulate the oscilloscope controls to observe a variety of waveform shapes and to make readings relating to frequency, period, width, height, rise-time, and fall-time.

The final part of the session is a circuit construction exercise which will allow you to practice your soldering technique and to use the work-station equipment to test your finished circuit.

Procedure

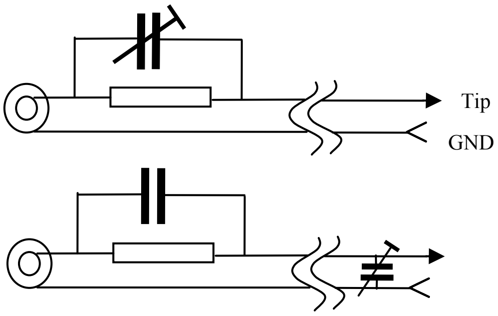
Switch 'On' the oscilloscope and work through the exercises in sequence, **noting down your measurement results and answering all the questions in your laboratory notebook**.

Exercise 1 – Oscilloscope Probes

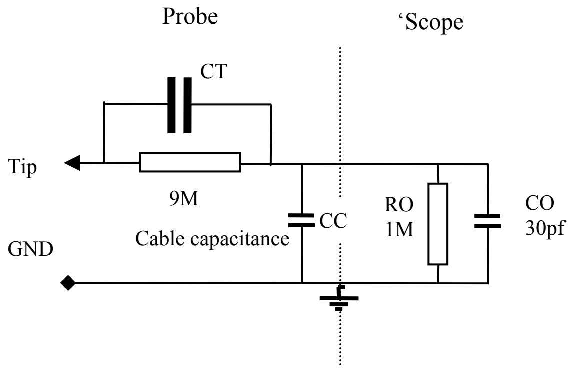
The oscilloscope probe is the interface between the oscilloscope and the circuit to be tested. It therefore needs to present **very high input impedance**, so that it will have the least loading effect on the circuit under test. In other words, it should be as close to an electrical open-circuit as possible. Electrically, it actually appears as a resistance and capacitance in parallel to earth, and so the resistance needs to be very high, whilst the capacitance very small. The oscilloscope Y amplifier input values are 1 MΩ and 180 pF and the resulting impedance from these values may be too low for many applications. Therefore, the x10 probe increases this impedance by a factor of 10 (10 MΩ/ 20 pF), but at the expense of **attenuating the signal by a factor of 10**.

Before using the probes to take measurements you need to make sure that each probe is impedance matched to the oscilloscope Y-amplifier input characteristics; otherwise you will get erroneous readings of both magnitude and shape. This **MUST** be done **EVERY TIME** a new oscilloscope/ probe combination is used. To facilitate this, oscilloscopes have a square wave calibration signal available on the front panel.

Different types of probe circuits

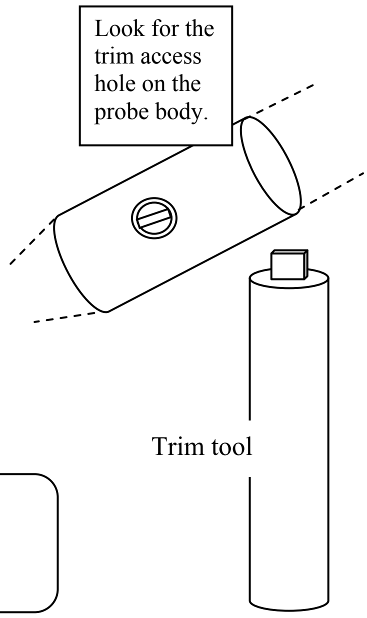


The equivalent circuit seen by the circuit under test when using a probe

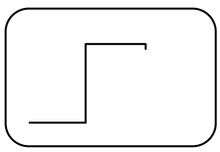


Set up the oscilloscope as follows:-

- Press the 'Default Setup' key on the oscilloscope front panel.
- **CH1** should be 'On'.
- Connect the two probes into the appropriate **CH1** (yellow) and **CH2** (green) input BNC sockets on the front panel.
- Locate the calibration voltage terminal, **Probe Comp** (the left-hand vertical tag at the bottom of the front panel); this gives out a standard square wave output of **2.5 V pp.**
- Clip **both** probe tips to it and connect each probe's black croc-clip to the adjacent, (horizontal) EARTH terminal (⏚).



- Set the **Trigger Mode/ Coupling** to AC using the softkeys.
- Adjust the **Horizontal** scaling control to display 2 cycles and adjust the **Vertical** scaling and offset controls to give an amplitude display of 5 screen grid divisions.
- With the small black plastic trim tool *(diagram)*, adjust the yellow capacitive trimmer in the probe tip body *(diagram)*, to give the best, sharpest corner on the square wave, as shown here:- > > > > > > > > > >

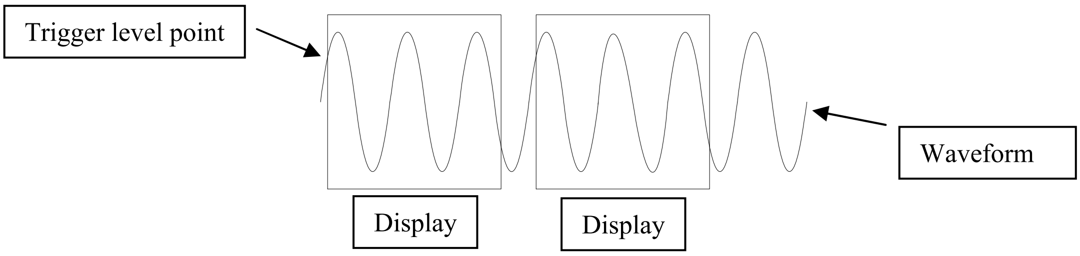


- Select **CH2** and repeat the procedure for the second probe.
- **The probes are now matched to the oscilloscope input amplifier circuit, and as long as they are not interchanged, should remain so. Do not readjust the probes.**
- Now use the grid and the volts per division scaling to measure the waveform amplitude on the screen and note this down in your laboratory notebook.

Questions:

1. **What is the actual Probe Comp waveform amplitude?**
2. **Why is it always advisable to use a x10 (or higher) probe?**

Exercise 2 - Time-base Triggering



For you to accurately observe and measure waveforms the trace needs to remain stationary on the screen. Therefore we need to set where the oscilloscope looks at the waveform (or trigger a sweep) and for this to be at the same point on the waveform cycle each time. The oscilloscope trigger controls allow you to select the required triggering point. Two parameters are needed to uniquely define the trigger point on a waveform, and these are the **LEVEL** (or amplitude) and the **SLOPE**, i.e. whether the waveform is positive or negative going at that point. The level control can be thought of as selecting the point on the vertical grid at which the waveform will trigger. The control that selects the triggering waveform is labelled **'Trigger'**.

The **Trigger mode/ coupling** has the option of **AUTO** or **NORMAL**. Normal is the basic process i.e. no trigger, no sweep (no trace). Auto is modified for convenience, so if there is no trigger after a predetermined time, the sweep will free run and a (normally unstable and blurred) trace will appear.

The Trigger Level

- To show this more clearly disconnect the probes from the calibration terminal. Leave **CH1 'On'** and switch **CH2 'Off'.**
- Connect the long BNC plug/ croc-clip lead to the **Gen Out** BNC socket (right of the Oscilloscope 'On/ Off' switch).
- Connect the CH1 probe tip to the red croc-clip and the probe's black croc-clip to the lead's black croc-clip.
- Switch on the function generator (**Wave Gen**) and using the softkeys set an output of 5 V pp, 1 kHz sine wave.
- Press the 'Trigger' key and set the **Trigger Source** to **CH1** (if not already set).
- Set the **Trigger mode/ Coupling** to **DC.**
- Adjust the **Horizontal** and **Vertical** scaling controls to give a display of 2 cycles and an amplitude of 5 grid divisions.
- Use the **Horizontal** left to right control ◄ ► and keep moving the trace to the right, until you see the **very start** of the display trace sweep.
- Push the **Trigger level** control knob to set the level at 50%.
- Slowly adjust the **Trigger level** control (turn clockwise) until the display trace becomes unstable. While performing this action, observe the changing Trigger point **(T)** of the display trace sweep.
- Now slowly re-adjust (turn anticlockwise) to the point where the display trace becomes stable again and observe the Trigger point **(T)** of the display trace sweep.

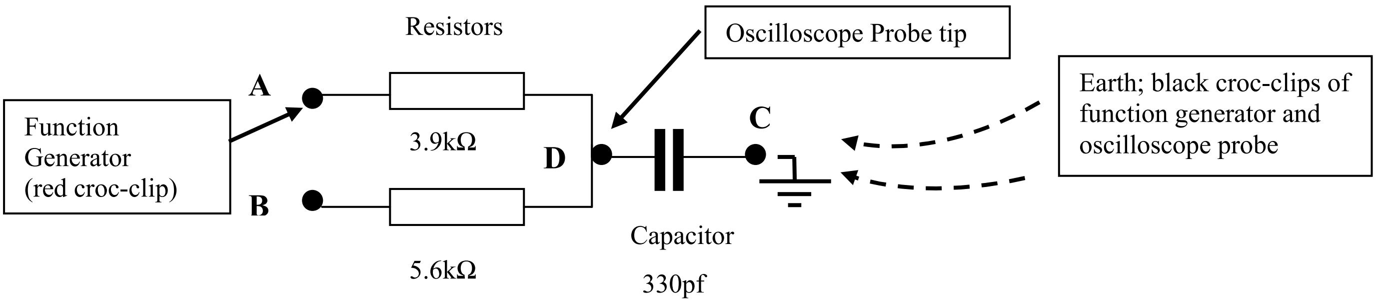
Question:

3. **Why does the trace become unstable?**

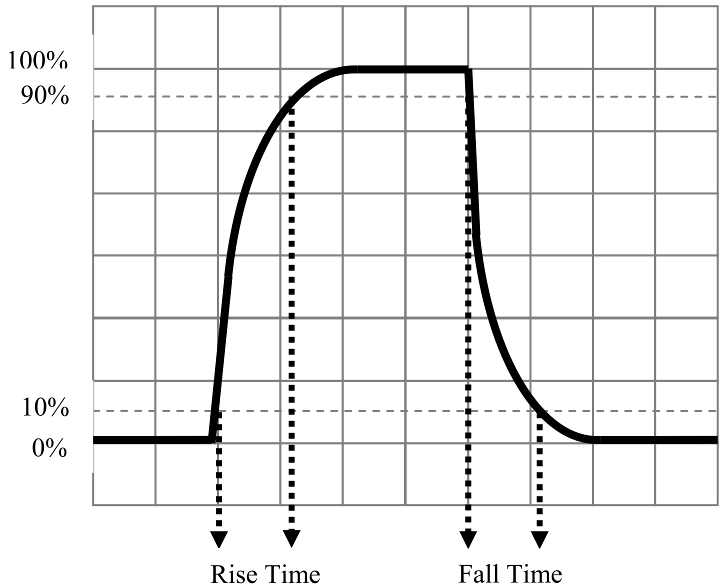
Exercise 3 - Rise and Fall Times

Rise and fall times (along with pulse width – Exercise 4) are very important parameters of pulses and waveforms, for example they can be the characteristics that determine the high speed switching of digital circuits, and in activating and observing nerve stimulation.

For timing purposes the convention used is defined as the rise and fall times **between the 10% and 90%** of the waveform peak values.
Using the RC (Resistor, Capacitor) network (the small printed circuit board), connect up as described below.



- Set the function generator (**Wave Gen**) output to 20 kHz square wave and at 5 V pp across points A and C (earth).
- Connect the oscilloscope probe between point D and point C (with the earth clip on point C).
- Push the **Trigger level** control knob to set the level at 50%.
- Adjust the **Horizontal** and **Vertical** scale to display a single cycle on the screen.
- Press the **Measure (Meas)** key and from the Measurement Menu select **Type: Rise Time** *(push the 'Select' knob to confirm selection).*
- Note the rise time value.
- From the Menu select **Type: Fall Time** *(push the 'Select' knob to confirm selection)* and note its value.



Record the rise and fall time values for inputting the signal at point **A** and point **B** in your laboratory notebook.

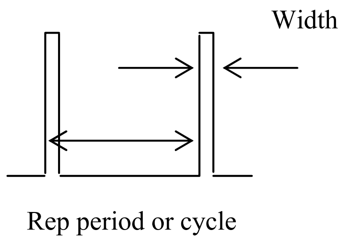
20 kHz Square Wave injected at point	*Rise Time*	*Fall Time*
A		
B		

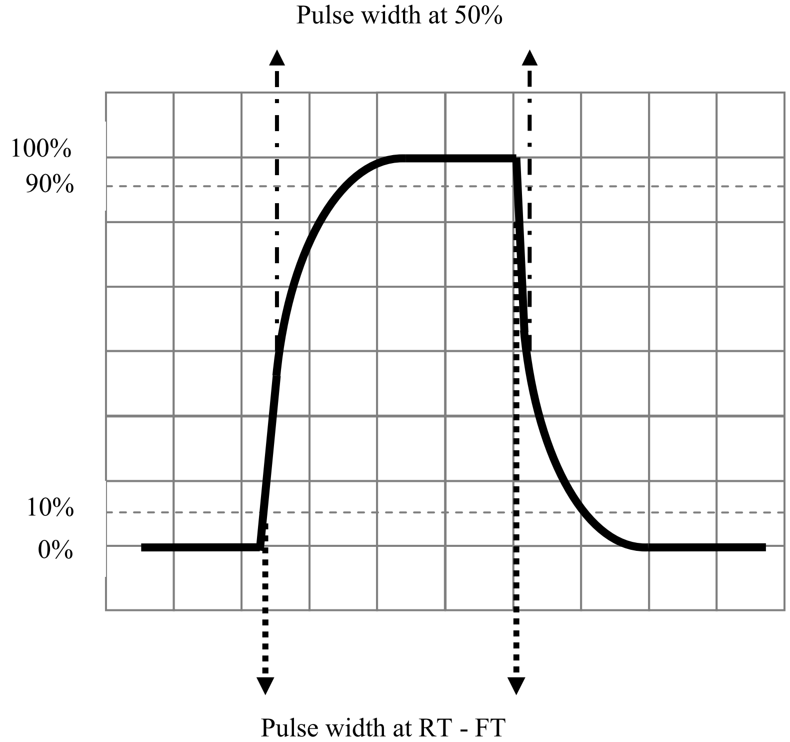
Question:

4. What determines the rise/ fall time in this circuit?

Exercise 4 - Pulse Width

The **PULSE WIDTH** can be defined as either the time between the start of the Rise Time (RT) and the start of the Fall Time (FT), or the time between the 50% levels. The latter is usually the one used.





- Leave the settings as for Exercise 3, but reconnect the **Gen Out** lead to point **A** on the RC Network board and check the probe tip is still connected to point **D**.
- Press the **Wave Gen** key to select the function generator menu and then select the **Pulse** waveform. Set the **Width to 10.00 µs** and display 2 cycles of the waveform.
- Press the **Meas** key to access the Measurement Menu and in turn select **Type: +width** and **–width** *(push the 'Select' knob to confirm selection).*

- **Measure the +Pulse width and the –Pulse width.**
- **Sketch one complete cycle of the pulse waveform to show the + and – width.**
- **Measure the time period (1 cycle) of the pulse waveform.**
- **Use the time period value to manually calculate the frequency using** $f = {}^{1}\!/_{T}$

Record the values in your laboratory notebook.

Measured +Pulse Width	
Measured –Pulse Width	
Measured Time Period	
Calculated Frequency	

Before moving on to the soldering exercises, have your work checked and signed in your laboratory notebook by a demonstrator.

Exercise 5 - Soldering and Circuit Construction

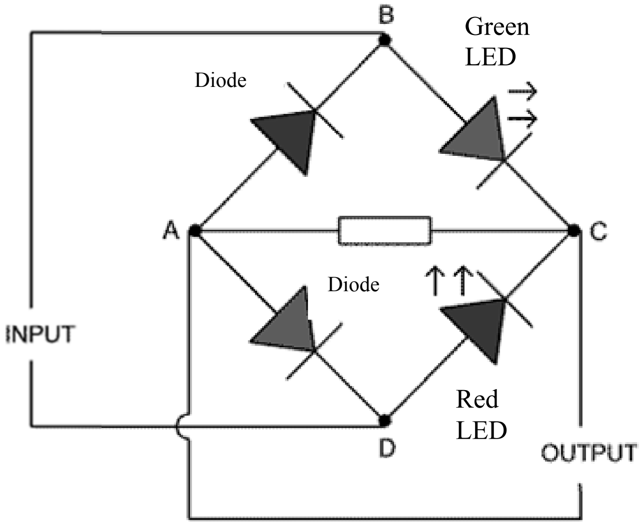
To assist you, refer to WS1 and the separate sheet 'Hand Soldering – terminology and processes'.

USE EYE PROTECTION WHEN SOLDERING AND TESTING THE CIRCUIT!

There are two circuits for you to construct and test. Do them in sequence.

1. LED Bridge

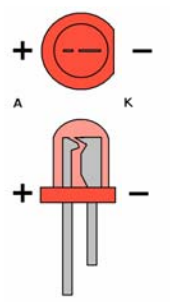
Circuit diagram



The kit comprises:

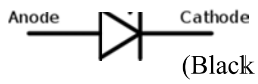
1 Red LED
1 Green LED
2 Diodes
1 220 Ohm Resistor
1 PCB

LED



LED

DIODE



(Black line)

- Switch 'On' the soldering iron and wear the eye protection (safety glasses) provided.
- Construct the LED Bridge using the kit provided.
  The components should be mounted on the top side (plain side) of the PCB, in the positions as shown in the circuit diagram. **Ensure that you have correctly orientated the LED's and diodes.**

*This type of circuit is known as a **full wave bridge rectifying circuit** and is used to convert alternating current/ voltage to direct current/ voltage.*

Testing your circuit:-

Write your comments and answers in your laboratory notebook.

- Set the function generator (Wave Gen) to produce a 1 Hz, 5 V square wave and connect it to the circuit at points B and D (ac input) using the BNC to croc-clip lead.

Questions:

5. **Observe the LED's and briefly explain what is happening in the circuit with regard to current flow?**

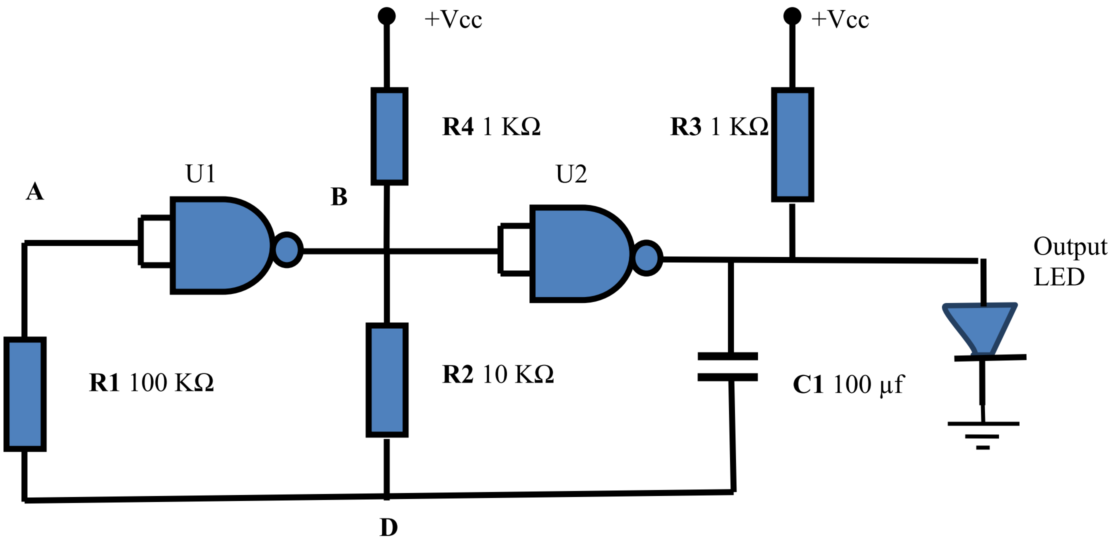
6. **If current in the first half cycle is passing in sequence through points BCAD (as shown in the circuit diagram above), which of the following is the correct sequence of points for current passing in the second half cycle?**

   a) DACB
   b) DABC
   c) DCAB

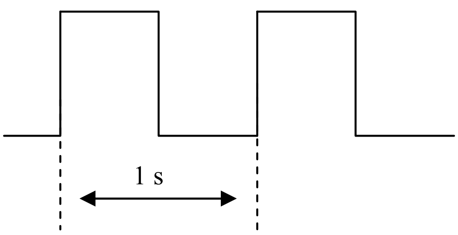
2. Astable Circuits

An astable is an oscillator circuit which produces a square wave output from a DC input. The circuit is designed so as to have no stable output state, resulting in an output that constantly flips between a high and a low state.
The easiest type of astable to build uses logic chips and a capacitor to create an output that is fed back into the input. Every time the feedback changes state, it triggers the logic chips to change the state of the output that is fed back in to the input and so on, in an endless loop.
The circuit you are going to build uses logic chips called NAND gates; you may have come across them in maths. A NAND gate connected as shown below will act as an inverter or NOT gate, changing an input to an output of the opposite state. Logic is usually talked of in terms of zeros and ones, with '0' representing a low state or 'Off' and '1' representing a high state or 'On'; their electronic values are ground and a DC voltage level.

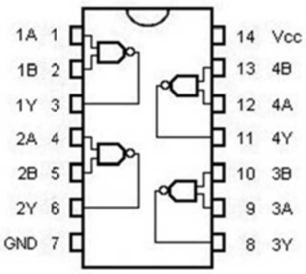
Circuit diagram:



The circuit works by feeding the output at B back to the input at A via D. Since the output is always opposite to the input this makes the gate constantly change state. Suppose that the input is 1, making the output 0. The 0 is sent back round to the input switching the state of the gate and resulting in an output of 1. The 1 is then sent back round to the input and so on in a never ending cycle.
The whole process happens too quickly so we slow it down by adding the capacitor C1 and the resistor R2. Together these two components allow us to control the value at D and hence the input at A. When the capacitor is fully charged it behaves like an open circuit and D will have the same value as B causing the circuit to switch as before. However, when it is fully discharged it behaves like a short circuit and D will have the same value as C which, being the same value as the input at A, stops the circuit from switching. The bigger the capacitor the longer it takes to charge and discharge and the longer the gap between switches, i.e. we control the frequency.
R1 stops the value at A from 'drifting' as the value at D swings between 0 and 1.
The time constant for a NAND gate Astable Multivibrator is given as **T = 2.2 RC** in seconds with the output frequency given as **f = 1/ T** Hz.
For example: if resistor R2 = 10 kΩ and the capacitor C1 = 100 µF, then the oscillation frequency will be given as:
f = 1/ t where **t = 2.2 rc** so **f = 1/ 2.2*10 kΩ*100 µF** giving the frequency as **1.0 Hz**, that equates to a time constant of **1 s** so the output waveform would look like this:



Use the printed circuit board provided to construct the circuit. The connections to the pins (legs) on the I.C.s are shown below, you will notice it has power connections at Vcc and GND which aren't shown on the circuit diagram; it is traditional not to include these in circuit diagrams as they are common connections to all I.C.s and it makes the diagram easier to read if they are assumed to be there without been drawn on the diagram.



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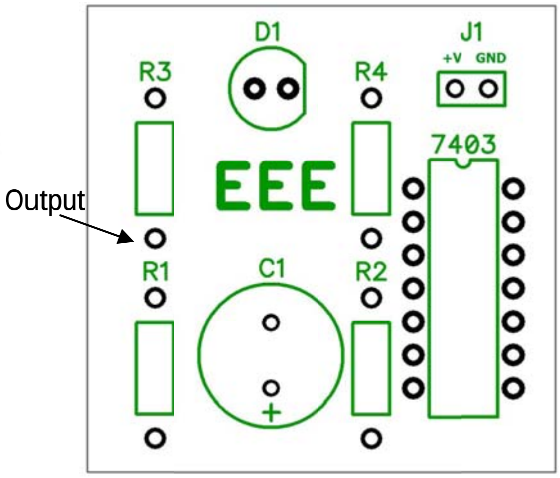

USE EYE PROTECTION WHEN SOLDERING AND TESTING THE CIRCUIT!

- Construct the Astable Circuit using the kit provided.

Testing your circuit:-

Write your comments and answers in your laboratory notebook.

- Connect the fixed **5 V** BBH power supply to the circuit.
- Use the oscilloscope and probe to look at the **Output** (connection at the bottom of R3, as shown on the PCB diagram above). Adjust the **Horizontal** and **Vertical** scaling on the oscilloscope as necessary to view the waveform.
- Sketch the waveform.

Questions:

7. **Measure the time period.**
8. **Which components set the time period?**

Have your soldering work checked and signed in your laboratory notebook by a demonstrator.

Before leaving, make sure that your mark is entered on the attendance register.

<u>Closedown</u> - Please make sure that ALL the equipment is switched 'OFF'.

The circuits you made are yours to keep if you wish!