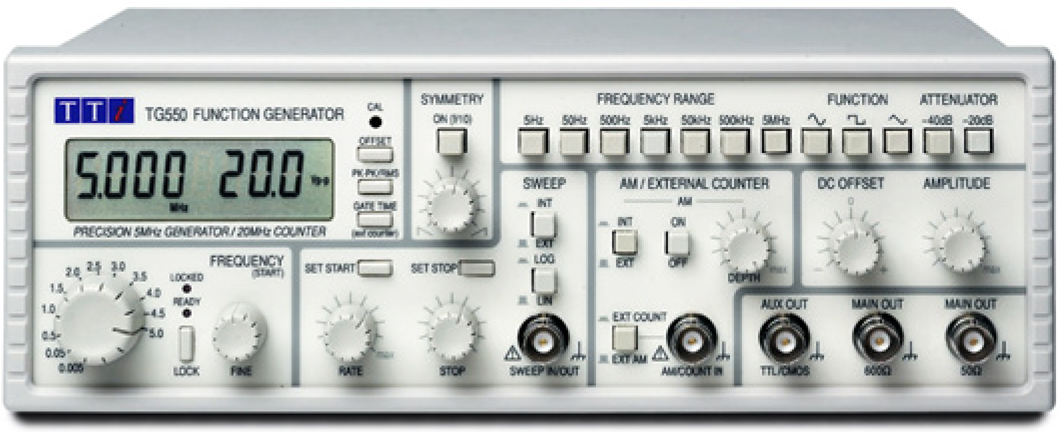
# X0

## Introduction to Lab Equipment

This exercise is an introduction to some of the equipment that you will use throughout your engineering career. It is designed as a ‘how-to’ guide for you to refer back to in the future. It is essential that you gain a good working knowledge of this lab, else you will struggle in later labs.



**Schedule**

| | | |
|---|---|---|
| Preparation time | : | 3 hours – evidence of this is expected in your log book |
| Lab time | : | 3 hours |

**Items provided**

| | | |
|---|---|---|
| Tools | : | Laboratory toolkit |
| Components | : | Various passive components from the component drawers |
| Equipment | : | Oscilloscope, bench PSU, Multimeter, Function Generator |
| Software | : | OpenChoice Desktop |

**Items to bring**

Essentials. A full list is available on the Laboratory website at https://secure.ecs.soton.ac.uk/notes/ellabs/databook/essentials/

***Before*** you come to the lab, it is essential that you read through this document and complete ***all*** of the preparation work in section 2. Only preparation which is recorded in your laboratory logbook will contribute towards your mark for this exercise. There is no objection to several students working together on preparation, as long as all understand the results of that work. Before starting your preparation, read through all sections of these notes so that you are fully aware of what you will have to do in the lab.

**Academic Integrity** – *If you undertake the preparation jointly with other students, it is important that you acknowledge this fact in your logbook. Similarly, you may want to use sources from the internet or books to help answer some of the questions. Again, record any sources in your logbook.*

**Revision History**

| | | |
|---|---|---|
| August, 28, 2013 | David Oakley | Revised for 2013/14 |
| September 19, 2012 | David Oakley (do) | Revised for 2012/13 |
| July 7, 2012 | Tim Forcer (tmf) | |

## 1 Aims, Learning Outcomes and Outline

This laboratory exercise aims to:

- Provide an introduction to the electronics equipment
- Experience of locating and using passive components to assemble a simple circuit

Having successfully completed the lab, you will be able to:

- use the bench power supplies to set up multiple voltage "rails"
- build a simple circuit using a protoboard
- use a digital multimeter to obtain measurement of resistance and voltage
- use a function generator to produce a sinusoidal output
- use an oscilloscope, a selection of test leads and a ×10 oscilloscope probe

This exercise introduces you to the equipment on the laboratory benches, and to using passive components to build a simple circuit. The object is that you should not waste time in future labs learning how to get the equipment to operate effectively. Staff will be on hand to help you – **please do not struggle, ask for assistance if you need it**. You should work individually for this exercise.

You should follow standard practice and record your work in your laboratory logbook as you go through it. Even for an introductory exercise such as this, the logbook will provide a valuable source of information for your future reference.

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## 2 Preparation

Read through the course handbook statement on safety and safe working practices, and your copy of the Standard Operating Procedures. Make sure that you understand how to work safely. Read through this document so you are aware of what you will be expected to do in the lab.

Preparation work can be done on your own, with someone else, or in a small group. Do not leave preparation until the last minute. Your preparation should be recorded in your logbook. If you have problems, seek help from fellow students, your tutor or the laboratory organiser.

### 2.1 Prepare your logbook and your logbook technique

If you have not yet done so, complete the work and answer the questions in the "Introductory Logbook work and Questionnaire" sub-section of the first part of the Laboratory Handbook.

During your preparation and the lab you are expected to make effective notes in your logbook to record your work and progress. In your logbooks you need to:

- Label all sections,
- Use a ruler when appropriate,
- Label axes and title figures,
- **Always** write in pen,
- Never erase any work – any errors must be crossed through with a single line.

### 2.2 Find out what you will be doing in this exercise

Read through all the notes for this exercise. Highlight any aspects which you find confusing and try to find out the information which will remove this confusion – you can ask a colleague or your tutor if you wish.

*Which types of components and lab equipment will you be using during this lab session? Make a list in your logbook.*

### 2.3 Finding out where to find things out

Explore the ECS website, particularly those areas relating to the laboratories at https://secure.ecs.soton.ac.uk/notes/ellabs/1 (where these notes can be seen),and https://secure.ecs.soton.ac.uk/notes/ellabs/databook (where you will find the document referred to in section 3.5 - write down the URL for this in your logbook).

Read through Section 1 of your Lab Handbook, particularly the information about the components and equipment you will be using in this exercise – to do this, you will need the list that you produced in section 2.2.

### 2.4 Terminology, units and abbreviations

*Write down in your logbook the meaning of the following:*

*dB,*
*DC,*
*DMM,*
*E12*series,
*URL,*
$V_{pk\text{-}pk}$,
$V_{rms}$.

*If you don't know, find out, and write alongside each definition the source for this definition (i.e. where you found it).*

### 2.5 Digital Multi Meter (DMM)

A digital multi meter it a hand held device that can measure alternating/direct current andvoltage as well as measuring resistance and continuity.

To make a measurement the probe leads must be connected into the right sockets. The black lead always goes into the COM socket, while the red one should go into one of three different sockets. For measuring current there are two sockets: one for small currents under 200µA and the other for currents up to 10A. The last socket is to be used when measuring other parameters.

| | | |
|---|---|---|
| $\tilde{A}$ | Alternating Current | Range 10A – 200uA |
| $\overline{\overline{A}}$ | Direct Current | Range 10A – 200uA |
| $\tilde{V}$ | Alternating Voltage | Range 600V – 200mV |
| $\overline{\overline{V}}$ | Direct Voltage | Range 600V – 200mV |
| $\Omega$ | Resistance | Range 20MΩ - 200Ω |
| ▶\| | Continuity test | Determining whether two points are connected, beeping if they are. |

If OL is displayed on the screen it suggests that the value is out of range and that the scale setting needs increasing. The OL indication is normal for some functions; for example, resistance and continuity.

In the lab there are also analogue meters. In essence these operate in the same way as the digital multi meters, however they have an analogue display. The advantage of using these over a DMM is when you are reading a DC current that may be fluctuating. These meters will show the fluctuations as the needle moves around. However because a DMM averages the input to produce the display they often lose any fluctuations in the signal.

**THEDMM HAS NO POWER SAVING FUNCTION:**
**ALWAYS TURNIT OFF TO PRESERVE THE BATTERY.**

## 2.6 Floating power supplies

A Power Supply Unit (PSU) has three connectors and can be considered as a mains powered battery and an earth connection, as shown in FIGURE 1.

With the output enabled, the voltage supplied between the output terminals is "floating" – ie unreferenced. **The red '+' terminal is made an amount positive of the black '–' terminal**. Each unit has a third terminal provided, which is connected to mains earth (⏚). Within the laboratory, mains earth is the 0V reference, treated as such by all signal sources and measurement systems. Care must be taken when using multiple devices to reference from one earth as slight variances can occur between devices. If a +ve and 0V reference voltage are needed then you should connect the –ve terminal to the earth. If a –ve and a 0V reference is needed then the +ve should instead be connected to the earth.

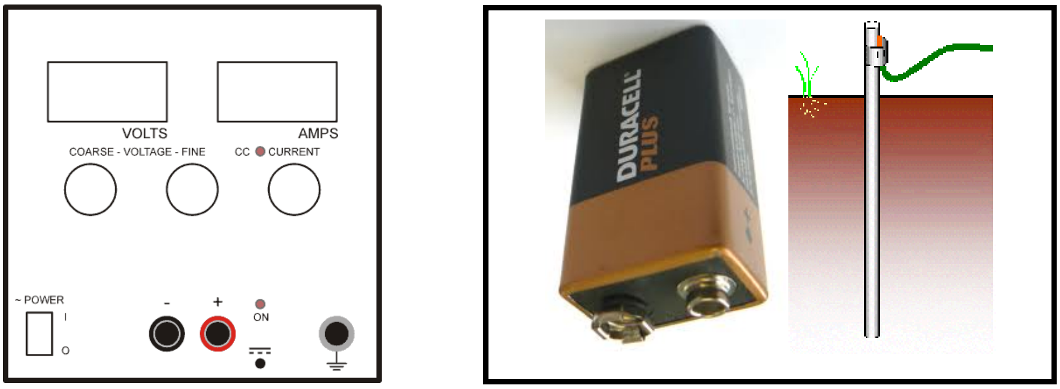


FIGURE 1:Representation of bench mains power supply units

Each unit is independent, and has two on/off switches. The left-hand rocker switch (1) (labelled ~POWER) turns the unit's mains supply on and off. The small black button (2) towards the lower right (labelled ON and ⎓, meaning DC) enables the output so that power is actually supplied to the output terminals (3) (labelled - and +). The third terminal is the earth connector (4).

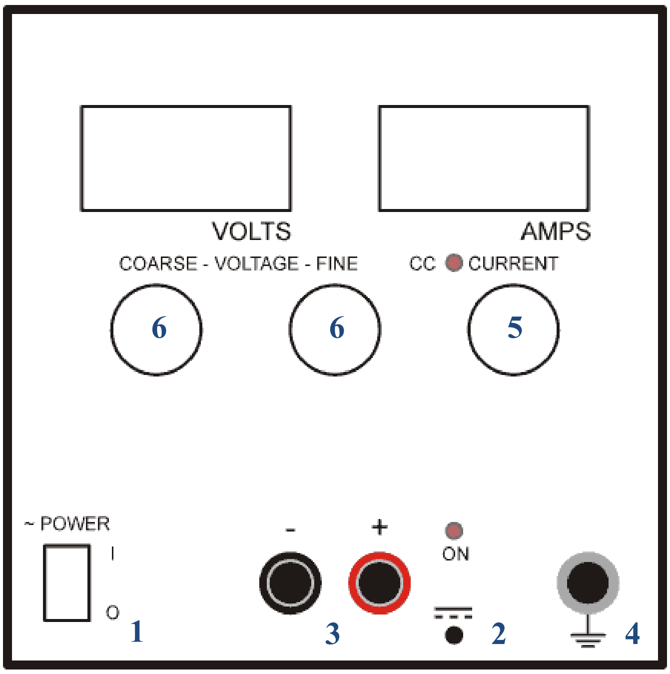


FIGURE 2:Bench mains power supply unit

The right-hand rotary knob (5) sets the maximum current which the unit will supply when the output is enabled, the other two set the maximum voltage (6) supplied when the output is enabled.

With the power on but the output disabled, the result of these settings appears on the 3/4-digit displays “VOLTS” and “AMPS”. When the output is enabled, the displays change to show the voltage between the output terminals, and the current delivered. Only use this reading as a guide; always use a DMM to confirm the values.

*To make use of the battery analogy, draw out in your logbook how you would connect two 9V PP3 batteries to provide a supply of +9V, 0V and -9V.*

*Either print or copy FIGURE 2 into your logbook twice to represent the two supplies on your desk. Sketch the connections between the PSU terminals needed to provide voltages of +9V, 0V and -9V.*

*What would be a suitable current limit for a 9Vcircuit supplying a 100 Ohm load? Hint: use Ohm’s Law.*

*You should write all of these values down, with an explanation for your decisions.*

### 2.7 Prototyping board

Find the description of your protoboard in Section 1 of your handbook. This is a reusable tool for quickly building a circuit, that has multiple holes that are connected inside by copper tracks.

*Sketch part of the boards illustration into your logbook and decide how to arrange the components and connections needed for this lab in section FIGURE 4.*

### 2.8 Self-evaluation

If you have not already done so, work through the “Electronics Laboratory Skills Self-assessment” in the first part of this Handbook. You may want to indicate the results by writing an abbreviated date in the appropriate cell of the table, so that you can repeat the tests later and see your progress as a time series dataset.

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## 3 Laboratory Work

### 3.1 Setting up and using bench power supplies

Confirm the operation of a single PSU is as per section 2.5above, using your DMM and a length of hook-up wire.

Using two PSUs on your bench, a grey box with leads and 4mm plugs (see FIGURE 3below) from the tray under your bench’s upstand, and some standard “hook-up” wire, set up voltages of +9V, 0V and -9V (with appropriate current limits) as per your logbook sketch. Enable the supply outputs and use your DMM to confirm that the voltages provided as intended

*Are the voltages correct?*

*Can you confirm that you are getting zero volts, with reference to the rest of your circuit?*

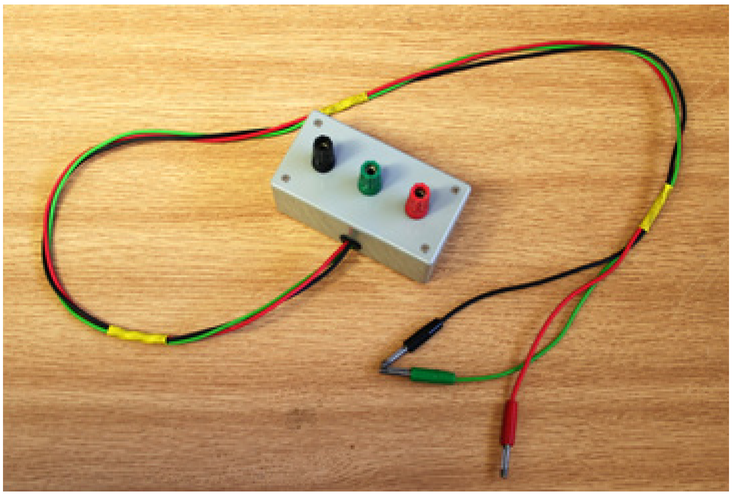
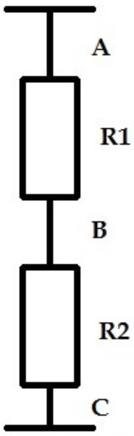


FIGURE 3:Power Supply connector extension unit, "grey box"

Using a short length of hook-up wire, short-circuit the output of each supply in turn. Confirm that, while the short-circuit load is applied, the displayed voltage of that supply drops to zero, while its displayed current rises to the limit value and the "CC" (current limit reached) indicator comes on. Remove the short circuit.

### 3.2 Making DC measurements in a circuit

Fit the components to your protoboard to achieve the circuit shown in FIGURE 4 below, connecting 9V to point A and 0V to point C.




R1 = 100kΩ

R2 = 1kΩ

FIGURE 4:Voltage divider circuit

Enable the power supplies – if the supply shows a "CC" indication, disable the supply and check your circuit to see what has gone wrong. If necessary, seek assistance. You must clear this error before moving on. Measure the voltages at points A,B and C relative to 0V. You'll notice that you may have to change the range to get the best readings.

*Write down your readings.*

Now disable the power supplies and disassemble the circuit.

### 3.3 Setting up the function generator and oscilloscope

In this section of the lab you will be using the TG550 function generator, as shown in FIGURE 5. Notice that there is no on/off power switch on the front panel – you will find it on the back of the unit, near the mains connector. This function generator has a wide range of features and facilities, most of which you do not need at this point. Make sure you do not enable them by mistake! In particular, check that the following buttons (marked in red dashed boxes on FIGURE 5) are in the "out" (disabled) state: SYMMETRY "ON (1/10)", SWEEP "EXT", AM/EXTERNAL COUNTER "EXT", "OFF" and "EXT AM". Also check that the "DC OFFSET" control is in its central position (you will fell a distinct "detent" action at this point).

To set up the function generator there are several steps. Set the desired frequency with the course (1) and fine (2) adjustment knobs as well as the frequency range select (3). Then the waveform shape must be set using the function select buttons (4). Finally the amplitude of the desired signal must be chosen. For this you need select Pk-Pk amplitude mode using the Pk-Pk/RMS button (7). Then using the amplitude knob (6) set the value. You can use a wider range using the attenuation buttons (5). Your waveform will be present at both Main Out BNC connectors, for now always use the 50Ohms port (7).

*What is meant by an attenuation of -40dB and -20dB? What happens to the display when you press the button?*

Now adjust the function generator controls to produce a sine wave output of nominal amplitude 1V Pk-Pk and frequency 200Hz.

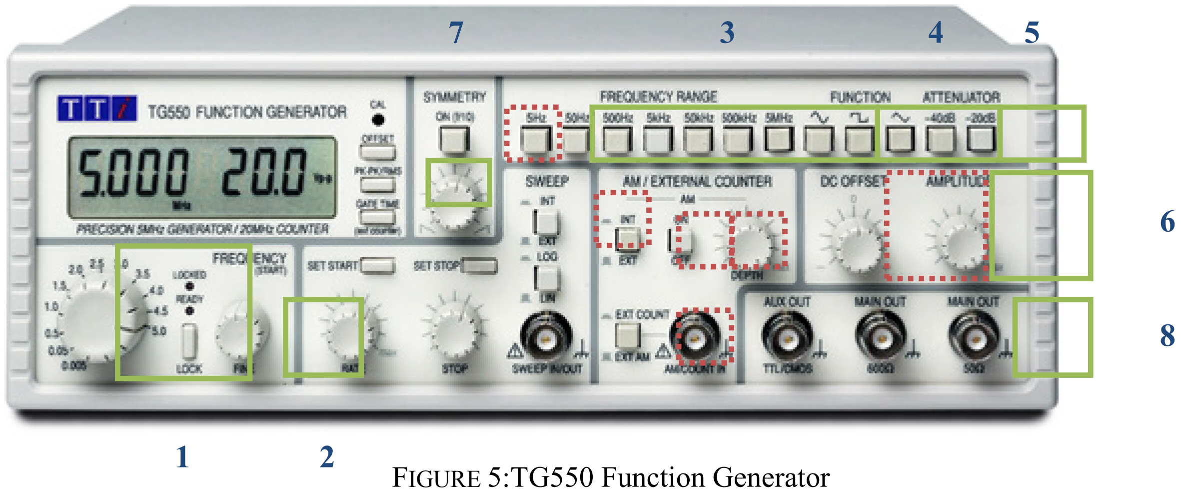
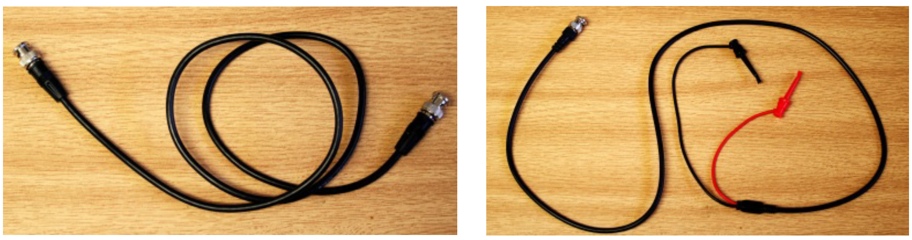



FIGURE 5:TG550 Function Generator

There are two types of leads that are used to connect the function generator to a circuit or piece of equipment. These are a BNC to BNC lead, used to connect two systems and a BNC to test-clip lead, used to connect a generator to a circuit. Both are shown in FIGURE 6. These are the only leads that should ever be used to connect a circuit to a function generator!



BNC to BNC lead

BNC to test-clip lead
"x1 test lead"

FIGURE 6: Test leads

As a function generator is used for producing a waveform, and oscilloscope is used for viewing a waveform. Inputs for an oscilloscope can be coupled in one of two ways: AC or DC coupled. With AC coupling, the DC component of the signal is removed so that the signal oscillates around the zero axis. This can be advantageous because it can allow you to remove DC offsets and inspect small AC signals. If both the AC and DC parts of the signal are needed then use the DC mode.

The Tektronix TDS2004 oscilloscope is a digital scope with a multitude of functions. However, only a few are needed in order to perform basic analysis. The on/ off button is on the top left corner of the scope. Each scope has four inputs, which all have the same controls and arrangement; The BNC connector (1), vertical scale dial (2), a menu button that toggles the display on/off and also accesses the attenuation and coupling settings, and (3) the vertical position dial (4). The time base (i.e. horizontal scale) is controlled using the horizontal scale dial (5).

In addition, there are five utility function buttons (7) that relate to the on screen options. To acquire a stable and clear waveform on the screen a trigger is usually needed. The menu button (8) accesses the options such as the trigger source, trigger type, trigger mode and the coupling. The desired voltage level for the trigger is set using the trigger level dial (9).

These scopes also have a built in automated measurement facility that will be explained in the next lab.

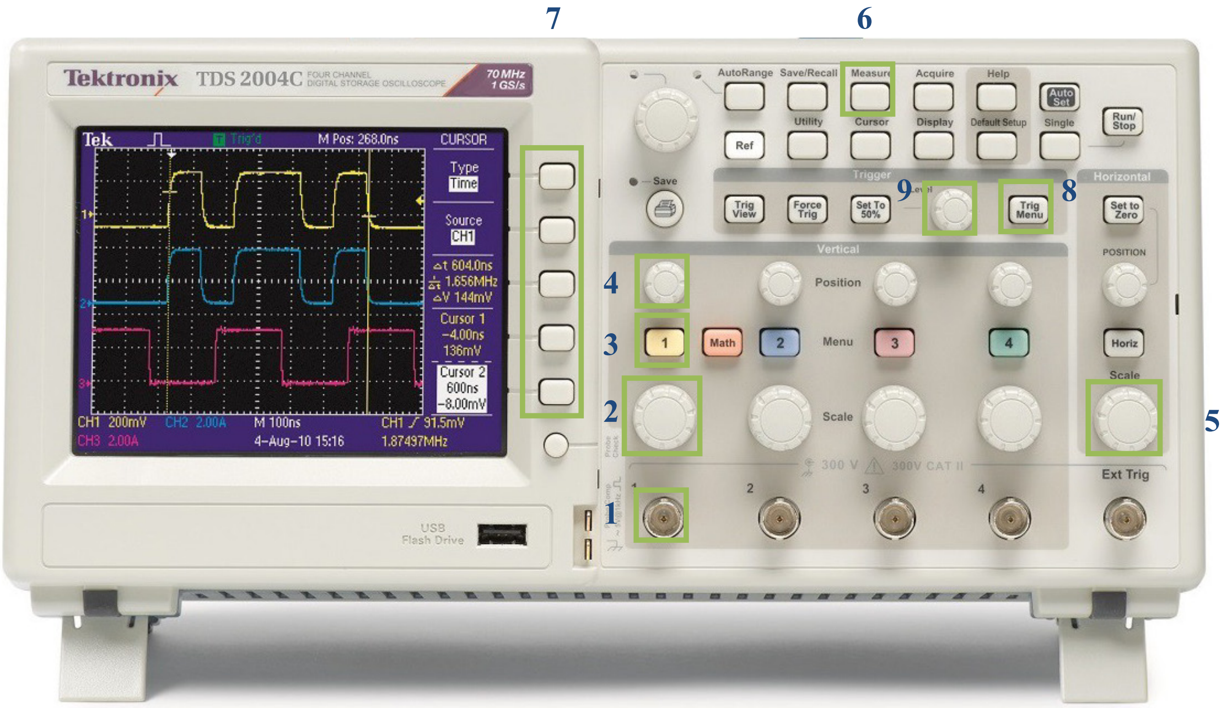



FIGURE 7:TektronixTDS2004Oscilloscope

Turn off all the inputs except Channel One. Then in Channel One's menu (3) use the utility buttons (7) to set it to DC coupled mode and, since you are using a ×1 test lead, set the attenuation to ×1 in Probe Voltage menu.

Now press the trigger menu button (8) and, again using the utility buttons, select **channel one** as the source, **edge** as the trigger type, **normal** triggering mode and **DC** coupling.

*What are these triggering settings doing?*

Use one of the BNC to BNC leads from the tray under your bench's upstand to connect the 50Ω output of the function generator to the oscilloscope's Channel One input (see FIGURE 6above for a picture of this type of lead).

Use the trigger level dial (9) to produce a stable sine wave on the display. Using the channel one scale dial (2) adjust the signal scale and the vertical position dial to find the best position for the waveform on the screen. Finally adjust the horizontal time base using the horizontal scale dial (5) so that around two full cycles of the waveform are visible. Try to achieve the largest possible signal on the screen, while keeping all parts of the waveform visible.

*Sketch the resulting wave form into your logbook. Remember to include axis labels.*

*Is this enough for an accurate record or do you need to print the waveform?*

The Tektronix TDS2004 oscilloscope has a program for acquiring a waveform on the scope to a computer. This application is called OpenChoice Desktop (FIGURE 8)and can be found in the start menu of your computer. To capture a waveform first connect the scope using "Select Instrument" (1), and then acquire the image with "Get Screen" button (2). Now you can save (3) and print the image (remember that print instructions are on the screen.)

Change the waveform generator to output 20kHz and adjust the scope to show the wave forms.

*Print the new waveform and stick into your logbook.*

1
2
3

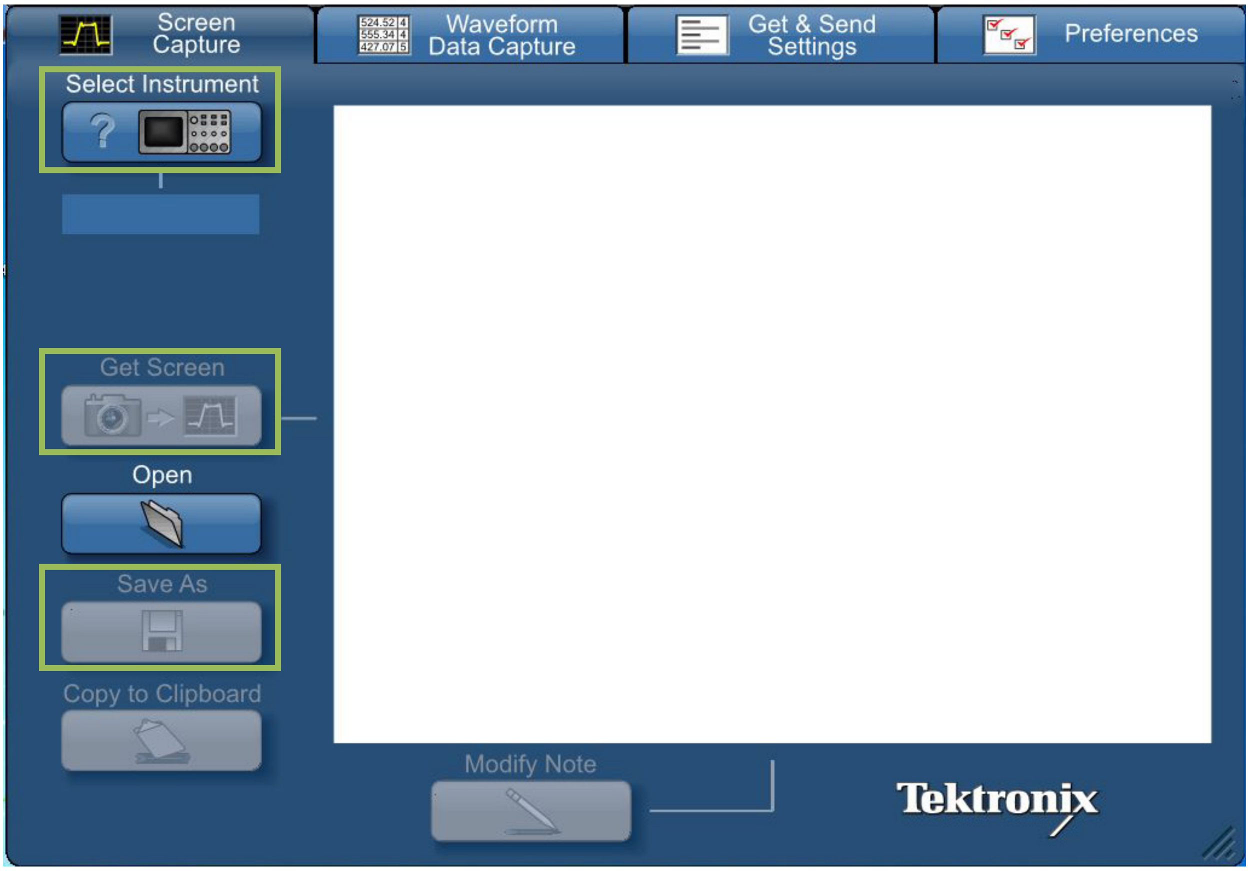



FIGURE 8:Screen shot of OpenChoice Desktop

In turn select the function generators attenuation -20dB and -40dB buttons (5).

*How does this affect the signal?*

*How do you adjust the scope to display the resulting waveform correctly?*

Disconnect the test lead from the 50Ω output of the function generator, and instead connect it to the Aux Out terminal.

*How does this affect the signal?*

*Why does this output differ from the 50Ω output? What is it useful for?*

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# 4 Optional Additional Work

*Marks will only be awarded for this section if you have already completed all of Section 3 to an excellent standard and with excellent understanding.*

## 4.1 Oscilloscope X-Y mode

Most modern oscilloscopes have multiple input channels (i.e. inputs to measure multiple voltages), and thus can be used to plot one varying voltage against another. This X-Y mode is especially useful for graphing I-V (Current against Voltage) curves to track phase differences between multiple input signals. The X-Y mode also allows the oscilloscope to be used as a vector monitor to display images or user interfaces. Many early games, such as Tennis for Two, used an oscilloscope as an output device.

Using the two BCN connectors in the draws connect both the 50Ω and 600Ω function generator outputs to oscilloscope channels One and Two respectively. Then push the display button (near the measure button) and, using the function buttons, change the Format to X-Y mode.

*Can you explain the waveform that you see on the screen?*

*Print the new waveform and stick into your logbook.*

*How could you make the inputs 10 times smaller?*

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# 5 Finishing off

Disable the power supplies and switch off all the equipment. Unplug the grey boxes. Replace them and the BNC leads in the bench tray. If your resistors and capacitors are reusable, replace them in the component drawers, taking care to put them in the right drawer. If you are not sure that you can put them in the right drawer, simply throw them away with your rubbish. Before leaving, make sure you have picked up your essential items.

## 5.1 If you had problems or ran out of time

You are welcome to come back and attempt parts of this exercise that you did not complete in the original session, or to repeat parts which did not seem to make much sense. But you should always check that a bench is available first – use the Web-based PC booking system. Remember that, outside the scheduled session, support staff may not be able to provide assistance as readily as you might wish. Do not come back to a second X0 session – these are for other students.

## References

[1]– TTI - EL301R Power Supply - https://secure.ecs.soton.ac.uk/notes/ellabs/databook/equipment/std-bench/PSU%20EL302P%20Instruction%20Manual%20-%20Iss%205.pdf

[2]– AMPROBE – 30XR-A Digital Multi Meter - https://secure.ecs.soton.ac.uk/notes/ellabs/databook/equipment/std-bench/DMM%20-%20Amprobe%2030XR-A.pdf

[3] –TTI - TG550 Function Generator - https://secure.ecs.soton.ac.uk/notes/ellabs/databook/equipment/std-bench/TTi%20TG550%20Instrction%20Manual.pdf

[4] - TektronixTDS2004Oscilloscope- https://secure.ecs.soton.ac.uk/notes/ellabs/databook/equipment/std-bench/Tektronix_TDS1000C_2000C_User_Manual.pdf