National University of Sciences and Technology (NUST)
School of Electrical Engineering and Computer Science

Department of Electrical Engineering

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Semester: 4th **Section:** D

EE-215: Electronic Devices and Circuits

Lab 01: Operation of electronic instruments (oscilloscope, function generator, multimeters, power supplies etc.)

		PLO4/CLO4		PLO5/CLO5	PLO8/CLO6	PLO9/CLO7
Name	**Reg. No**	**Viva /Quiz / Lab Performance** **5 marks**	**Analysis of data in Lab Report** **5 marks**	**Modern Tool Usage** **5 marks**	**Ethics and Safety** **5 marks**	**Individual and Teamwork** **5 marks**
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Lab 01: Operation of electronic instruments (oscilloscope, function generator, multimeters, power supplies etc.)

Objective:

1. The primary purpose of this lab is to understand various functions and usage of Oscilloscopes, Signal Generators and Handheld Multi-meters. These devices are used most commonly for testing circuits and devices. Therefore, developing an understanding of these devices is essential for observing and measuring different quantities for practical purposes.

Note:

Now is an appropriate time for a comment on circuit debugging. At various points, during the labs for this course, you are likely to have trouble getting your circuit to work. That is to be expected—nobody is perfect. However, don't simply assume that a non-working circuit must imply a malfunctioning part or bench instrument. That is almost never true; 99% of all circuit problems are simple wiring or biasing errors. Even experienced engineers can make such mistakes, and consequently, learning how to "debug" circuit problems is a very important part of your learning process. It is NOT the Instructor's, Lab Engineer's or any of the Lab staff's responsibility to diagnose errors in your circuit, and if you find yourself relying on others in this way then you are missing a key point of the lab and you will be unlikely to succeed in later coursework. The best thing to do when things aren't working is to just turn off the power supply and look for simple explanations before blaming parts or equipment. The DMM (Multimeter) is a valuable detective tool in this regard.

Components Required:

2. The following component and test equipment is required.
   - Oscilloscope (Rigol DS1102)
   - Function Generator (Twintex tfg3220e)
   - Resistors
   - Capacitors
   - Power Supply

Introduction:

1) Oscilloscopes:

The oscilloscope is basically a graph-displaying device – it draws a graph of an electrical signal. In most applications the graph shows how signals change over time: the vertical (Y) axis represents voltage and the horizontal (X) axis represents time. The intensity or brightness of the display is sometimes called the Z axis. This simple graph can tell you many things about a signal. Here are a few:

- You can determine the time and voltage values of a signal
- You can calculate the frequency of an oscillating signal
- You can tell how often a particular portion of the signal is occurring relative to other portions
- You can tell if a malfunctioning component is distorting the signal
- You can find out how much of a signal (DC) or (AC) is
- You can tell how much of the signal is noise and whether the noise is changing with time

An oscilloscope's front panel includes a display screen and the knobs, buttons, switches, and indicators used to control signal acquisition and display. Front-panel controls normally are divided into Vertical, Horizontal, and Trigger sections, and in addition, there are display controls and input connectors. See if you can locate these front-panel sections in Figures 1 as well as on your oscilloscope.

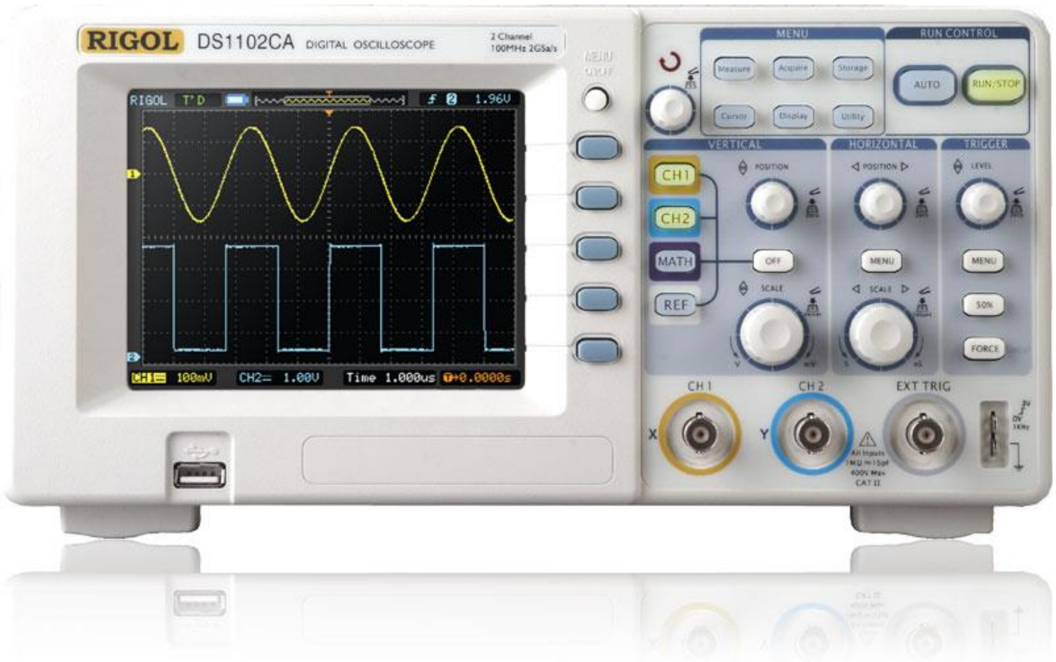
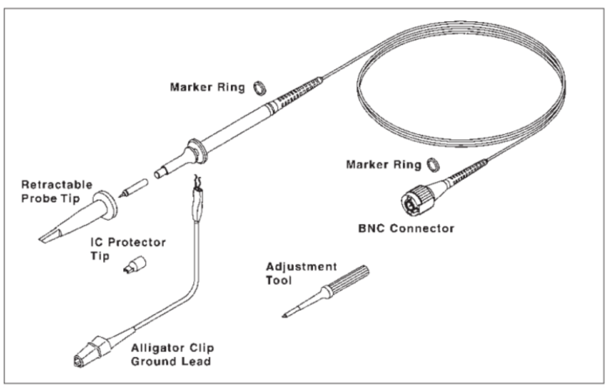


Figure 1. Front Panel



Using Passive Probes

Most passive probes have some attenuation factor, such as 10X, 100X, and so on. By convention, attenuation factors, such as for the 10X attenuator probe, have the X after the factor. In contrast, magnification factors like X10 have the X first. The 10X (read as "ten times") attenuator probe minimizes circuit loading and is an excellent general purpose passive probe. Circuit loading becomes more pronounced at higher frequencies, so be sure to use this type of probe when measuring signals above 5 kHz. The 10X attenuator probe improves the accuracy of your measurements, but it also reduces the amplitude of the signal seen on the screen by a factor of 10.

Where to Clip the Ground Clip

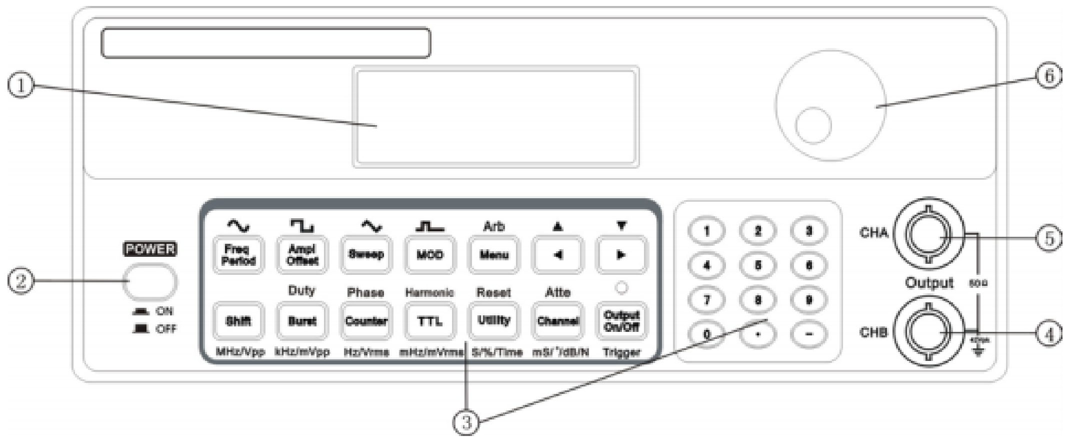
Measuring a signal requires two connections: the probe tip connection and a ground connection. Probes come with an alligator-clip attachment for grounding the probe to the circuit under test. In practice, you clip the grounding clip to a known ground point in the circuit, such as the metal chassis of a stereo you are repairing, and touch the probe tip to a test point in the circuit. If you connect it anywhere else you are practically creating a short circuit which may damage your components.

2) Signal Generator:

The signal generator is exactly what its name implies: a generator of signals used as a stimulus for electronic measurements. Most circuits require some type of input signal whose amplitude varies over time. The signal may be a true bipolar AC signal (with peaks oscillating above and below a ground reference point) or it may vary over a range of DC offset voltages, either positive or negative. It may be a sine wave or other analog function, a digital pulse, a binary pattern or a purely arbitrary wave shape.

1.2 Front and Rear Panel

Front panel



1. LCD display	2. Power switch	3. Keypad
4. Channel B output	5. Channel A output	6. Rotary knob

Figure 2. Signal generator

<u>Key Description</u>

There are 26 keys on the front panel. The black word on each key represents the basic function. Simply press the key to use the basic function. The green word at the upper of key represents the second function of the key. Press key [Shift], the sign “↑” will be displayed at the lower right of the LCD. Then press the function key, you can select the second function.

Numeric keys

Key name	Main function	Second function	Key name	Main function	Second function
0	Input digit 0	——	7	Input digit 7	——
1	Input digit 1	——	8	Input digit 8	——
2	Input digit 2	——	9	Input digit 9	——
3	Input digit 3	——	●	Input decimal point	——
4	Input digit 4	——	▬	Input negative sign	——
5	Input digit 5	——	◀	Flash digit left shift	Add digit
6	Input digit 6	——	▶	Flash digit right shift	Subtract digit

Function keys

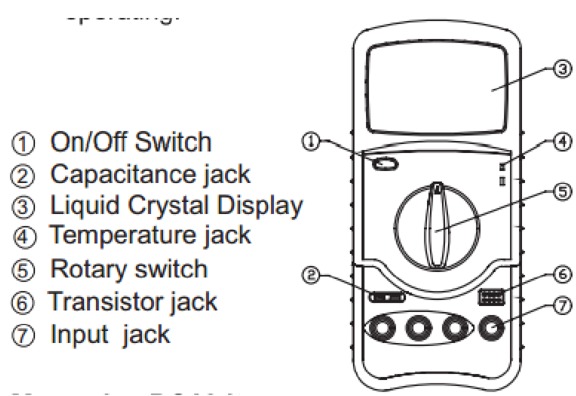
Key name	Main function	Second function	Unit function
Freq/Period	Frequency /period selection	Sine selection	——
Ampl/Offset	Amplitude/offset selection	Square selection	——
Sweep	Sweep selection	Triangle selection	——
MOD	Modulation selection	Ramp selection	——
Menu	Menu selection	Waveform selection	——
Burst	Burst selection	Duty cycle selection	kHz/mVpp
Counter	Frequency counter selection	Phase selection	Hz/Vrms
TTL	TTL selection	Harmonic wave selection	mHz/mVrms
Utility	System setup selection	Reset selection	s/%/Time
Channel	Channel selection	Attenuation selection	ms/° /dB/N

Other keys

Key name	Main function	others
Output On/Off	Signal output on/off	Single trigger for sweep and burst function
Shift	Shift to 2'nd function with other keys and exit remote control	Unit MHz/Vpp

3) Digital Multi-meter:

A **multimeter** or **multitester** also known as a **VOM** (Volt-Ohm meter), is an electronic measuring instrument that combines several measurement functions in one unit. A typical multimeter would include basic features such as the ability to measure voltage, current, and resistance. The rotary switch shows various markings which correspond to various measurements. Note that the numbers written around the rotary switch specify a range from 0(zero) to that specific value. For instance if rotary switch is set to $20 \underset{\cdots}{-} V$, the multimeter can measure all DC Voltages up till 20Vdc. If the voltage exceeds the range multimeter shows a "1".



Measuring DC Voltage

1. Connect the black test lead to "COM" jack and red test lead to "V" jack.
2. Set the rotary switch to "⎓ V".
3. Connect the test leads across with the object to be measured. LCD appears the measuring value and also the polarity of the red test lead.

⚠**Caution**

1) If magnitude of the voltage is unknown, always start with the highest range and reduce until satisfactory reading is obtained.
2) If "1" is shown on the LCD, which means the Meter is overloaded, then set to a higher measurement range.
3) "⚠" means never exceed the maximum input limits 1000V, otherwise internal circuit of the Meter will be damaged.
4) Take extra care of voltage leakage when measuring high voltage.

Measuring AC Voltage

1. Connect the black test lead to "COM" jack and red test lead to "V" jack .
2. Set the rotary switch to" V~".
3. Connect the test leads across with the object to be measured.

⚠**Caution**

1) Refer to "DC Voltage Caution" 1, 2, 4 .
2) "⚠" means never exceed the maximum input limit 750V, otherwise internal circuit of the Meter will be damaged.

Measuring DC Current

1. Connect the black test lead to "COM" jack. When measuring 200mA (2A for UT51) or below, connect the red test lead to mA jack. When measuring 20A (10A) or below, connect the red test lead to "A" jack.
2. Set the rotary switch to "A⎓"
3. Connect the test leads in series with the object to be measured, the LCD display the measuring value and polarity of red test lead.

⚠**Caution**

1) If magnitude of the current is unknown, always start with the highest range and reduce until satisfactory reading is obtained.
2) If "1" is shown on the LCD, which means the Meter is overloaded, then set to a higher measurement range.
3) "⚠" means never exceed the maximum input limit 200mV (2A for UT51), otherwise will cause the burn of fuse. 20A range does not have fuse protection while UT51 at 10A range has.

Measuring AC Current

1. Connect the black test lead to "COM" jack. When measuring 200mA (2A for UT51) or below, connect the red test lead to mA jack. When measuring 20A (10A), connect the red test lead to "A" jack.
2. Set the rotary switch to"A~" .
3. Connect the test leads in series with the object to be measured.

⚠**Caution**

1) Please refer to DC Current Caution 1, 2, 3.

Measuring Resistance

1. Connect the black test lead to "COM" jack and red test lead "Ω" jack.
2. Set rotary switch to "Ω"
3. Connect the test leads across with the object to be measured.

⚠**Caution**

1) If "1" is shown on the LCD, which means the Meter is overloaded, then set a higher measuring range. If resistance is above 1MΩ, the reading will only be steady after few seconds which is normal for measuring high value of resistance.
2) "1" is displayed when open circuit or no input.
3) Cut off the power to the circuit and discharge all capacitors before measuring resistance.
4) 10 digits display when short-circuiting 200MΩ, which should be subtracted from subsequent measured readings. For example, when measuring 100M Ω, the reading is 101.0, which should substract the 10 digits to obtain a accurate reading.

Diode Test and Continuity Beeper

Range	Comment	Measuring Condition
⊣▶⊢	Display diode forward-voltage near value, Unit "mV"	Forward DC current abt 1 mABackward DC voltage about 2.8V
•)))	Beeper sounds if Continuity Resistance ≤70Ω.Display near value. Unit "Ω"	Voltage at open circuit about 2.8V

Exercises

Patch the circuit, shown in figure 3, on a breadboard. Use jumper wires to avoid clutter and ease of measurements. Note that the capacitor used in the experiment will be electrolytic capacitor rather than a non-electrolytic capacitor used in simulation. Electrolytic capacitors have a positive terminal (anode) and a negative terminal (cathode). Therefore, polarity has to be considered when connecting an electrolytic capacitor.

To differentiate between the anode and cathode look closely at the two pins(terminals) of your capacitor. Both pins are not of equal length. The longer pin is normally the anode whereas the shorter pin is cathode. However, if it is difficult to differentiate the lengths of two pins, the cathode or negative terminal is usually marked with "-"sign on the capacitor.

Leave the voltage source part as we will use a signal generator to generate a sine wave in our exercise.

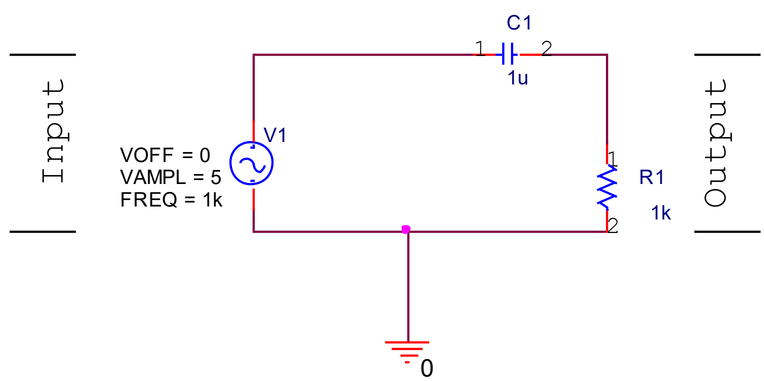


Figure-3

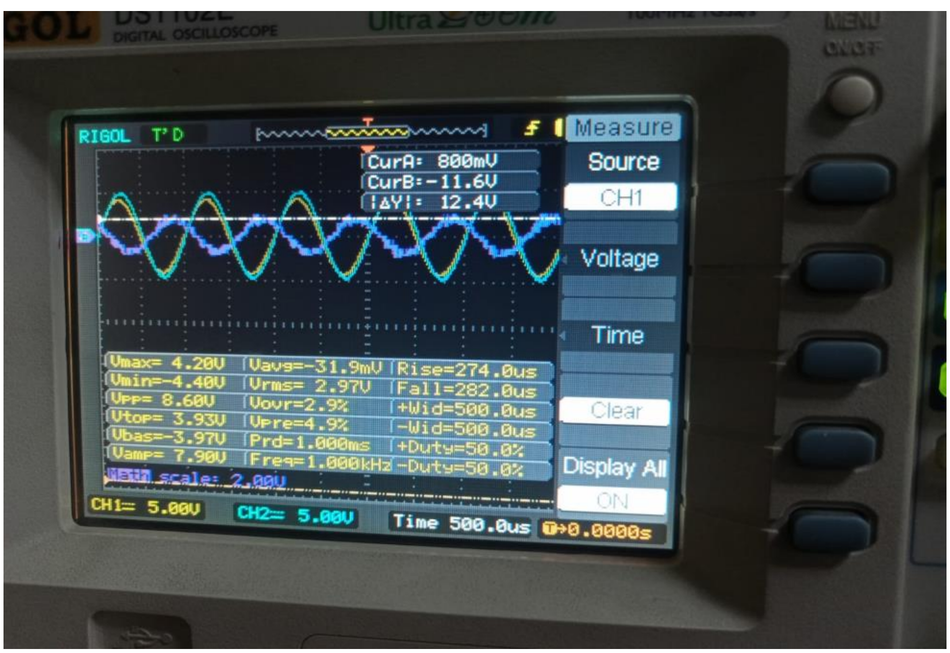
Exercise 1

Generating a sinewave of 1kHz

- Press key [Channel] and select “CHA Frequency” function.
- To set the frequency. Press [Freq] and select “frequency”, then press keys [1] and the soft key corresponding to [kHz] or Adjust the frequency of the channel A: press key [◀] or [▶] to move the cursor left or right, and tune the rotary knob left or right to add or subtract the digit on cursor, or to decrease or increase the digits continuously by steps, so as to make coarse or fine adjustment of the frequency.
- To set the amplitude. Press key [Ampl] and select “Amplitude”, then press keys [5] and the soft key corresponding to [Vpp]. You may also set the amplitude by passing the r.m.s value of the amplitude for that press the [Ampl] key for second time and you may set your V r.m.s.
- To select your desired signal type i.e. Sine, Square, Triangle etc. Press key [Shift] followed by the key for your desired signal type.
- Connect the probe of the channel to the circuit you have patched in figure 3.

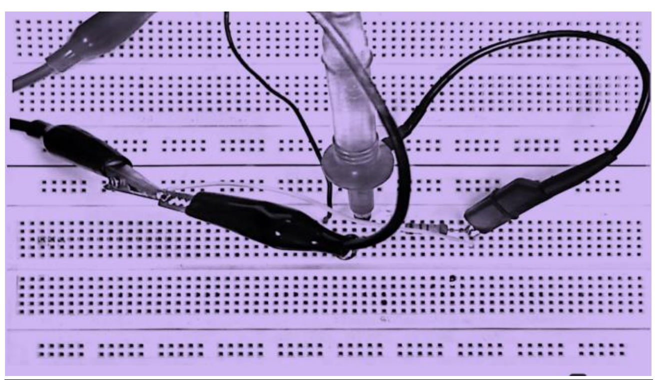
After patching circuit on hardware and connecting the channels of oscilloscope we have:

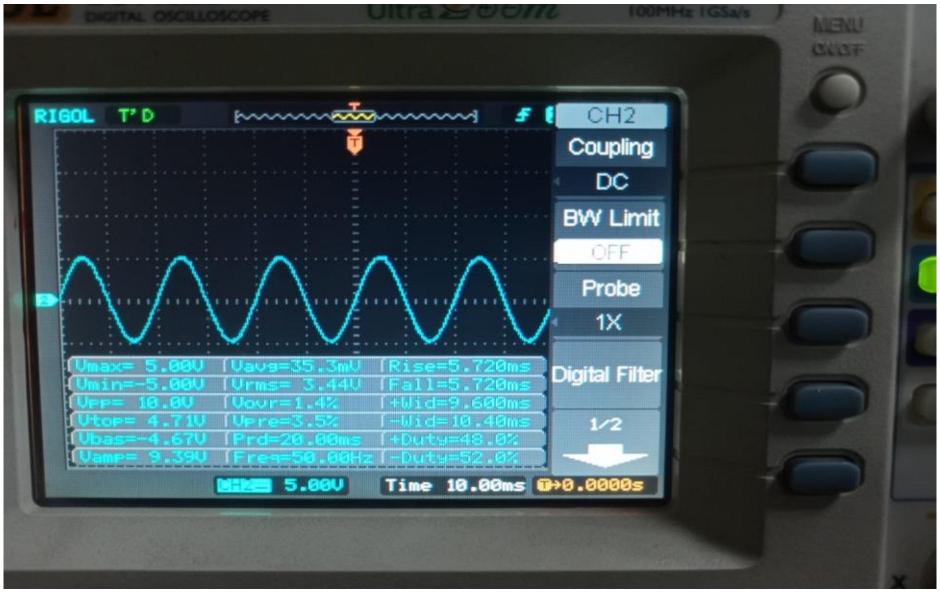
Oscilloscope:



Function Generator:

Hardware Implementation:





Exercise 2

Observing the waveforms using an oscilloscope

- Now that you have completed the circuit in figure 3. It is time to obtain the results.
- Connect the probes of the oscilloscope to measure the input(Channel 1) and output (Channel 2) voltages as labelled on Figure 3. (Take care of where you connect you alligator clip).
- **Press the [auto] key and sketch the resulting waveforms.**
- Play around with the vertical controls and horizontal controls and answer the following questions.

Q1. What is being controlled by turning the scale knobs on both horizontal and vertical sections.

Horizontal:

Rotating the horizontal scale knob clockwise on an oscilloscope expands the timebase horizontally, causing the waveform to spread out horizontally. Conversely, turning it counterclockwise contracts the timebase horizontally, resulting in the waveform becoming more condensed.

Vertical:

Rotating the vertical scale knob clockwise on an oscilloscope increases the size of the waveform displayed, effectively zooming in on the voltage waveform. Conversely, rotating it counterclockwise reduces the size of the waveform, effectively zooming out or decreasing the magnitude of the displayed voltage waveform. This adjustment enables users to better observe and analyze the voltage levels of the measured signal.

Measurements Using Oscilloscope

- Press [Auto] key on your oscilloscope again to return the display to initial settings. Adjust the scales if necessary.
- Press the [measure] key and set the Display setting to on.
- Read and note the following values from the table.
- Vr.m.s:__3.44V___________ , Frequency:_____1k Hz_______,
- Time Period:___1 milli sec______, Vpeak-peak:___10 V________
- Vmax:_______5 V_____________

Exercise 3

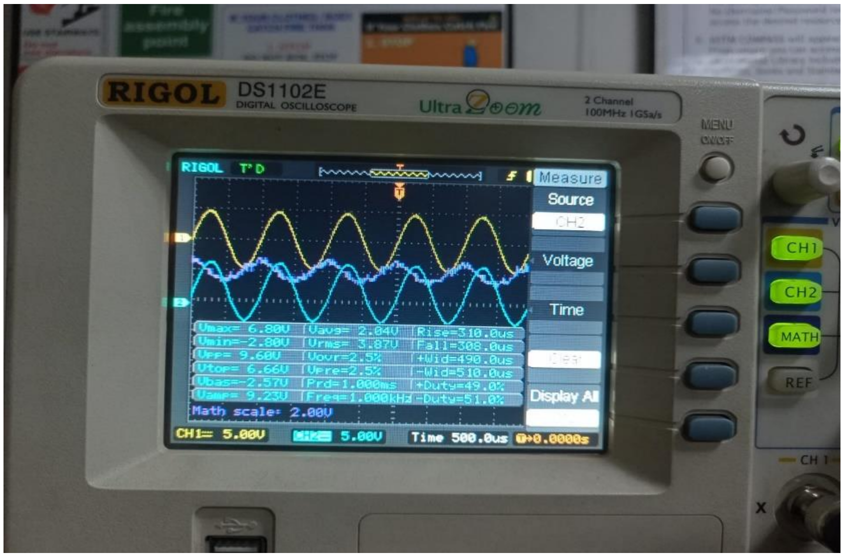
Adding a DC Offset to the source

- Now on your signal generator press the [Ampl] key until you see the offset setting. Set the DC offset to 2.0 Volts
- **Sketch the new waveform for the input Voltage displayed on the oscilloscope.**
- On your oscilloscope press the [CH1] key (or corresponding key for the channel connected to input)
- Check your coupling settings. Is your channel AC coupled , DC coupled or grounded.

  ___________DC____________________

- Change the coupling of your channel to DC if it was AC and vice versa. Observe what happens to the waveform. **Attach the new waveform.**

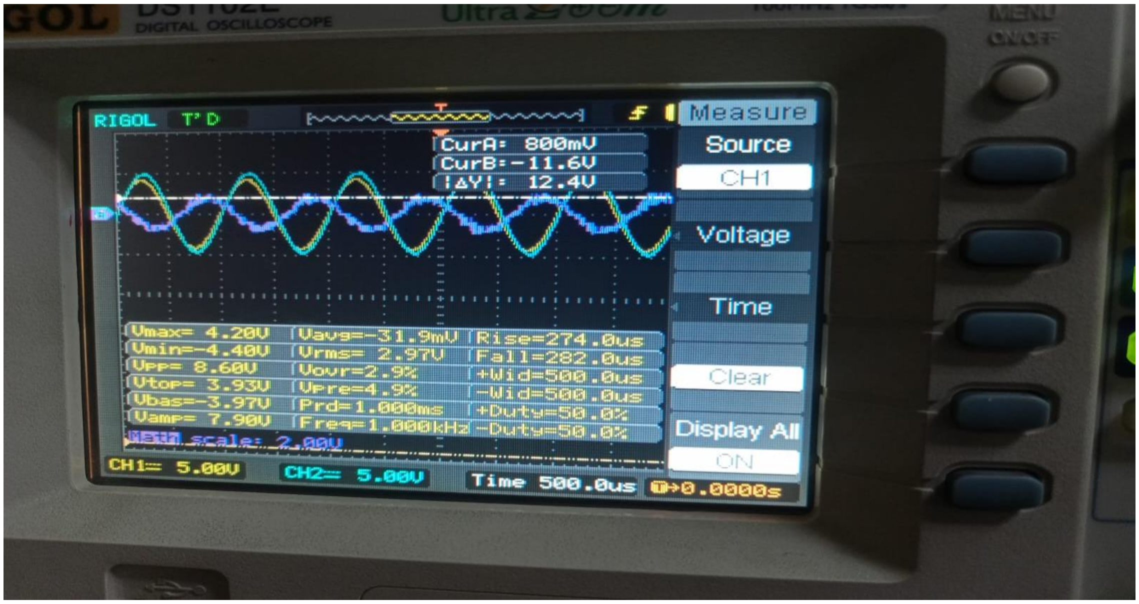
<u>After adding offset, we have:</u>



<u>Exercise 4</u>

- Using your knowledge of passive probes and simulation labs. Try and display the waveform for voltage across the capacitor in figure 3.
- Connect the Channel 1 to the terminal 1 of the capacitor as labeled on figure 3 and connect the Channel 2 to terminal 2 of the capacitor.
- Use math feature of the oscilloscope to obtain the waveform of voltage across capacitor only. **Attach the waveform.**

<u>Waveform:</u>

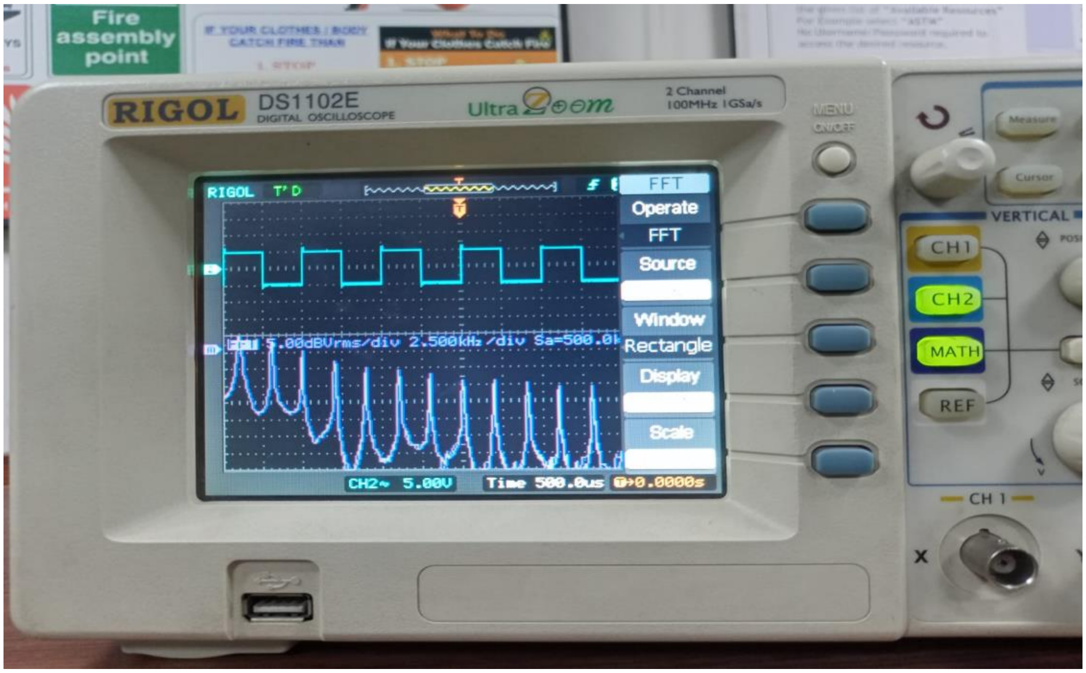


<u>**Exercise 5**</u>

Obtaining Fast Fourier Transform

- Disconnect the signal generator from your circuit.
- Now change the type of signal generated to square-wave.
- Change the DC Offset to zero volts.
- Connect the probes of the signal generator dirctly to the Channel 2 of oscilloscope (Note: fourier analysis is best done on Channel 2)
- Now select the MATH function and change its source to CH2. Adjust the horizontal scale knob to adjust the horizontal frequency scale.
- **Sketch the waveform**

Waveform:



Exercise 6

Using Continuity beeper of the Digitalmultimeter.

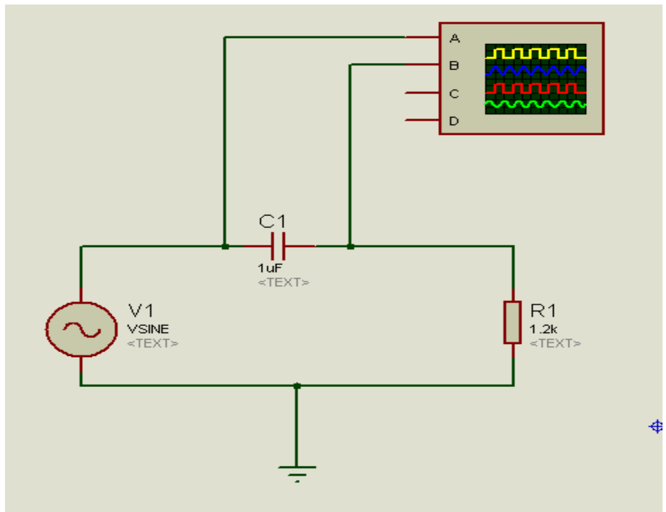
- Set the rotary switch of your multimeter to continuity beeper.
- Connect the red probe with terminal 2 of the capacitor and the black probe with the terminal 1 of the resistor as depicted in figure 3.
- Describe what happens when you do this?

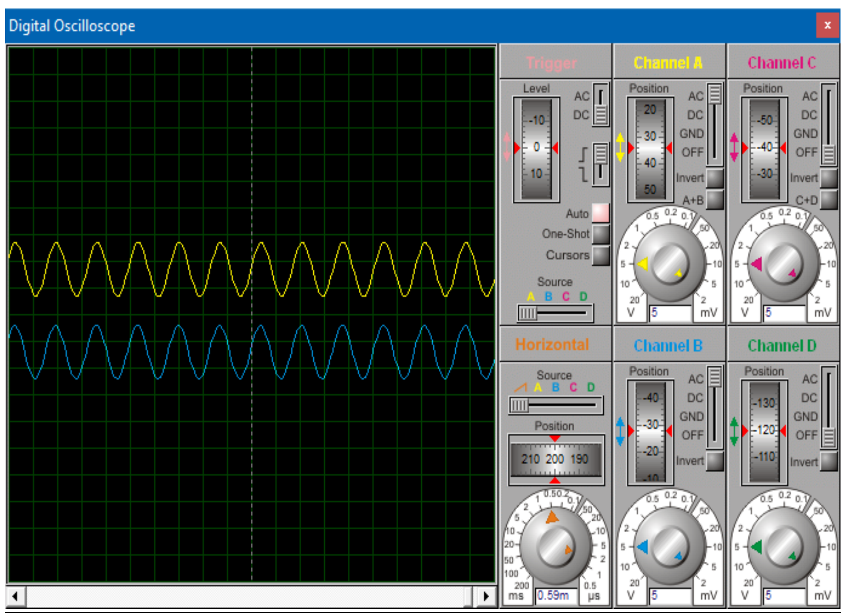
The DMM will beep

- What do you understand about the usage of this seting?

As continuty test is used to check continuty of electrical path so the beep will verify that the leg 2 of capacitor and resistor are interconnected

Schematic:


A
B
C
D
C1
1uF
<TEXT>
V1
VSINE
<TEXT>
R1
1.2k
<TEXT>


Digital Oscilloscope
Trigger
Channel A
Channel C
Horizontal
Channel B
Channel D
Level
Position
Auto
One-Shot
Cursors
Source
Invert
A+B
C+D
AC
DC
GND
OFF

Conclusion:

Through this lab, we have gained a comprehensive understanding of the functions and applications of Oscilloscopes, Signal Generators, and Handheld Multi-meters. These tools are indispensable for testing circuits and devices, enabling us to observe and measure various quantities for practical purposes. Furthermore, we have learned the importance of circuit debugging, recognizing that most issues stem from simple wiring or biasing errors rather than component malfunctions. By mastering the use of these instruments and honing our debugging skills, we are better equipped to succeed in future coursework and practical endeavors in electronics.

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