Experiment 2
Characterization of Passive Circuit Elements (R, L, C)

Part A: ADDITIONAL OPERATIONS ON DSO

Note: Please refer to the Expt.1 handout on DSO and FG. In this experiment you would familiarize yourself with some additional features of the DSO. These features would be helpful in making accurate measurements.

Use of CURSOR, and MEASURE functions are explained below. There are several other functions such as, ACQUIRE, DISPLAY, MATH, etc which are not required for normal use. Familiarize yourself with the CURSOR and MEASURE functions as they would be required in most of the experiments.

a) **Function keys**

There are five function keys (F1, F2, F3, F4, and F5) appearing on the side of the display, with the F1 function on the top one and F5 at the bottom. These are used along with other function/menu buttons to choose various operations of the DSO.

b) **Use of Cursors for measurements**

Press the CURSOR button on the front panel (located on the top, 2nd row). Two cursors would appear (vertical cursors for horizontal measurements or horizontal cursors for vertical measurements). The following features are available with the cursors:

Cursors for X measurements: Source(CH-1 or CH-2), X1(X value (time) of the *left* cursor in s, ms, μs or ns), X2 (X value (time) of the *right* cursor), X1X2 (ΔX value, i.e. X1 – X2).

Cursors for Y measurements: Source(CH-1 or CH-2), Y1(Y value of the *top* cursor in volts), Y2 (Y value of the *bottom* cursor in volts), Y1Y2 (ΔY value, i.e. Y1 – Y2).

Note that all the above values, i.e. X1, X2, ΔX, and Y1, Y2, ΔY, can be changed by choosing the appropriate function button (one of the four function keys, F1, F2, F3, F4) and the turning the VARIABLE knob (located on the top left side of the front panel).

When the bottommost function key (F5) is pressed, the function toggles between X and Y cursors. Cursors may be switched off by pressing the CURSOR button again.

c) Measurement functions

Up to Nineteen measurements (12 voltage and 7 time measurements) are possible with this DSO. Results of five measurements for CH-1 and CH-2 can be displayed on the left side of the display by choosing them from the list of 19. The measurement functions possible are: Vpp, Vmax, Vmin, Vamp, Vhi, Vlo, Vavg, Vrms, ROVShoot, FOVShoot, RPREShoot, FPREShoot, Frequency, Period, RiseTime, FallTime, +Width, -Width, DutyCycle. Each function key can be assigned any one of the above measurements. This is done as explained below:

Press the MEASURE button, located next to the CURSOR button. DSO would show the current list of five measurements assigned to F1 to F5 function keys. To assign a measurement function to F1, press F1. In the next menu the present assignment would appear on F3, with a graphical illustration at the F4 location. Press the F3 key to show the full list of 19 functions. Using the VARIABLE knob on the top, move the pointer on the function menu to the desired one. When done, press the F5 key to take you back to the main display. In a similar fashion other functions keys may be assigned functions from the list.

The most useful functions are **Vpp** (Peak-to-peak voltage), **Vrms** (RMS value of the signals), **Vavg** (average value of the signals), **Frequency** (frequency of the signals) and **Period** (period of the signals), etc. For pulse measurements, functions such as **+Width**(width of the +ve pulse), **Duty Cycle** (the ratio of the positive pulse width to the signal period, expressed as a percentage), **RiseTime** (time taken from 10% to 90% of the signal), **FallTime** (time taken from 90% to 10% of the signal), etc may be used. Other functions may also be used, if required.

d) Help function

On-line help, regarding all the keys and operations, is provided by the DSO. This is useful in case help is required regarding any key or function. Press the HELP button (rightmost last but one key on the top row) followed by any key to show the on-line help on the LCD display. Press the HELP button again to exit the HELP mode.

Experiment

Asymmetric Pulse Waveform

(a) Generate a square wave of 500 Hz from the FG. Using the Duty cycle control facility (press ***SHIFT*** followed by ***DUTY*** button and then rotate the ***Editing Knob***), adjust the wave to have 0.5 ms high level and 1.5 ms low level. Set the voltage level using the ***Offset*** knob and ***Ampl*** knob of the FG such that the low level of the pulse is at 0 V and the high level is at 5 V. Use the appropriate CURSOR and MEASURE functions to achieve the above. ***Observe and sketch the pulse waveform seen on the CRO.***

(b) Press ***Offset*** button to turn off the offset and observe the waveform.

Part B: FAMILIARIZATION WITH PASSIVE CIRCUIT ELEMENTS

1. Resistors

Resistors are usually classified according to the following three properties:

(a) Composition (e.g., carbon granule, carbon film, metal film, wire wound, etc.)
(b) Power rating (e.g., 1/8 W, $\frac{1}{4}$ W, $\frac{1}{2}$ W, 1 W, etc.)
(c) Tolerance (e.g., 20%, 10%, 5%, 1%, etc.)

The first two specifications (as given in (a) and (b) above) have to be found from the manufacturer's specification sheet. Tolerance is usually indicated on the body of the resistor itself along with the value of the resistance. The value and the tolerance are either printed on the resistor, or are indicated by color bands.

<u>**Resistor Color Code**</u>: The resistance values are color-coded on the resistors using 3 bands. The 1st and the 2nd bands give the first two significant digits of the resistor value, while the 3rd band gives the number of zeros to the right of the two significant digits. The ten colours and the corresponding digits (0-9) are as follows: ***Black*** (***0***), ***Brown*** (***1***), ***Red*** (***2***), ***Orange*** (***3***), ***Yellow*** (***4***), ***Green*** (***5***), ***Blue*** (***6***), ***Violet*** (***7***), ***Grey*** (***8***), and ***White*** (***9***). There is a famous statement which makes the remembering of the order of these color codes easy, it goes as: '***BB ROY*** of ***G***reat ***B***ritain was ***V***ery ***G***ood and ***W***ise', noting that the first ***B*** is ***Black*** with ***0*** value. The 4th band specifies the tolerance, with a ***silver*** band indicating a tolerance of ***10%***, a ***golden*** band indicating ***5%***, and a ***brown*** band ***1%***. ***Absence*** of the 4th band implies a tolerance of ***20%***.

<u>**Experiment**</u>: ***Using the color code, note down the values and the tolerances of the different resistors provided to you.***

2. Capacitors

Capacitors are classified according to the dielectric material used for their fabrication. The ranges of values available vary from type to type. Some of the commonly encountered types are: ***electrolytic*** (above 1 μF), ***polyester*** (0.001-10 μF),

paper (0.001-10 μF), ***mica*** (0.001-0.1 μF), and ***ceramic*** (less than 1 μF). Capacitors that are most commonly used in the laboratory have the values printed on them. Some capacitors use color codes similar to the resistors and the capacitor value is given in pF. Sometimes instead of the color codes, equivalent numerical values are printed. For example, 104 may be printed to indicate a value of 10×10^4 pF. The tolerance is typically 20% unless indicated otherwise.

<u>Experiment</u>: ***Identify the different types of capacitors from their approximate distinguishing features as listed below, and note down their values as well as voltage ratings.*** It must be emphasized that the features given below should be used only as rough guidelines.

(i) ***Electrolytic***: polarity indicated by + and − signs and/or a red mark
(ii) ***Polyester and Paper***: cylindrical or oblong moulded body (no obvious distinction between polyester and paper)
(iii) ***Mica***: flat rectangular body with color dots giving the specifications
(iv) ***Ceramic***: tabular or disc shaped

<u>Caution</u>: *When used in experiments, the voltage rating of the capacitors (as well as their polarity in the case of electrolytic) must be strictly adhered to, failing which the capacitors may explode.*

3. Inductors

An inductor generally consists of a coil of a good conductor (usually copper) wound on an insulating cylindrical base, which may or may not have a ferromagnetic core. The winding may be single-layer, multilayer or honeycomb. ***Note the construction of the different inductors given to you and write down the type of the inductor.***

Part C: DISPLAY OF I-V CHARACTERISTICS OF R, L, C ELEMENTS

For a two terminal device, the circuit of Fig.2.1 can be used to obtain its I-V characteristics. Note that the resistance R_M is used to measure the current flowing through the device under test (DUT). Also note that while the actual voltage drop across the DUT should be measured to obtain its I-V characteristics, here what is measured (V_0) is the voltage drop across the series combination of the DUT and the current measuring resistance R_M. For this voltage to be a good approximation of the actual voltage dropped across the DUT, the value of R_M should be chosen such that the voltage drop across it (V_M) is negligible as compared to the drop across the DUT, or, in other words, V_0 must be much larger than V_M (by about 100 times or greater).

<u>Resistor</u>:

1. Set up the circuit shown in Fig.2.1. The corresponding values of R_S and R_M to be used are given in Table 2.1. First choose a 10 kΩ resistor as the DUT.
2. Set the FG to produce a signal of 5sin(ωt) (frequency = 100 Hz). ***You will have to use the DSO for measuring the FG output.***
3. Observe the voltage measured by the two channels (CH-1 and CH-2) simultaneously (CH-1 signal displayed in yellow and CH-2 in blue). Verify that the voltage drop across R_M (i.e., V_M) is much smaller than the voltage dropped across the DUT. Note down the two waveforms and their relative positions in time. Observe carefully whether these two waveforms are in phase or not.
4. Put the DSO display into XY mode (through the HORIZONTAL menu). Observe and draw the I-V characteristic of the device. Explain the behavior.
5. Repeat steps 3 and 4 for frequencies of 1 kHz and 10 kHz, using the values of the resistors as given in Table 2.1. ***Use the DSO to measure the frequency of the FG output.***
6. Comment on the results obtained.

<u>Capacitor</u>:

7. Repeat steps 2 to 6 using the given 0.1 μF ceramic capacitor as the DUT. Observe and note the variations in the amplitude of V_M at frequencies of 100 Hz, 1 kHz, and 10 kHz. ***You need to change the value of R_M at 10 kHz, as given in Table 2.1.***

<u>Inductor</u>:

8. For this measurement, set your initial FG output frequency at 100 kHz, and use values of R_S and R_M as given in Table 2.1. Repeat steps 2 to 6 for the given inductor, having a value of 1.0 mH. Repeat for frequencies of 20 kHz and 50 kHz and note carefully the variations in the amplitude of V_M.

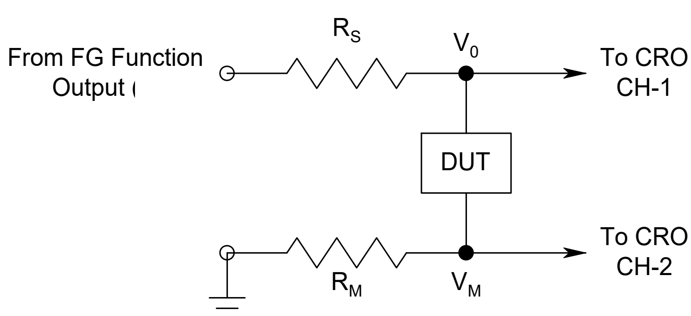

Fig. 2.1 Test Circuit for Part C. Values of R_S and R_M to be used in each part are given in Table 2.1.

Table 2.1

Test frequencies and corresponding resistance values for different DUT.

Device Under Test (DUT)	Resistance	Test Frequencies				
		100 Hz and 1 kHz	10 kHz	20 kHz	50 kHz	100 kHz
Resistor (10 kΩ)	R_S	1 kΩ	1 kΩ	–	–	–
	R_M	100 Ω	100 Ω	–	–	–
Capacitor (0.1 μF)	R_S	1 kΩ	1 kΩ	–	–	–
	R_M	100 Ω	10 Ω	–	–	–
Inductor (1.0 mH)	R_S	–	–	100 Ω	100 Ω	100 Ω
	R_M	–	–	10 Ω	10 Ω	10 Ω

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