LABORATORY REPORT - CHAPTER 1

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Date	10.10.22
Total Grade	/100

Remarks: Record all your measurements and write all your answers in the boxes provided. Do not write anything in the cells labelled as GRADE. Never forget to explain your results and to specify the units of your measurements.

Preliminary Work

1. Multimeter

A multimeter is a combination measuring instrument that can act like as voltmeter, ammeter, ohmmeter and in some cases as capacitance meter.

1. Read the manual of your multimeter. Find the smallest and largest resistance, DC voltage, AC voltage, DC current and AC current your multimeter can measure. Note that some multimeters cannot read AC current.

R_{low}= 1Ω R_{high}= 40MΩ

DC: V_{low}= 0.5V V_{high}= 600V

AC: V_{low}= 0.4V V_{high}= 600V

DC: I_{low}= 1mA I_{high}= 9.999A

AC: I_{low}= 2mA I_{high}= 9.999A

1.1. GRADE:

2. Most good multimeters have a RANGE button. If you know the approximate value of the resistance you want to measure, you can set the specific range of measurement by repeatedly pressing the RANGE button. Otherwise, the multimeter is in the slower AUTO mode. Find out if your multimeter has a "RANGE" function. If it does, learn how it functions.

RANGE function present? No

Explain how it works: My multimeter is smart so there is no range button or settings, it detects the range to be measured by itself

1.2. GRADE:

3. Some multimeters have a "HOLD" function. If you press the HOLD button during a measurement, the reading will be held. Find out if your multimeter has a HOLD function. If it does, learn how it functions.

HOLD function present? Yes

Explain how it works: When I press the HOLD button during the measurement, the value read on the screen remains constant.

1.3. GRADE:

4. As we do not have four eyes, in difficult circumstances we cannot look at the measurement probes and the multimeter scale at the same time. Some good multimeters have a "AUTO HOLD" function. If you make a measurement after activating the AUTO HOLD, the reading will be held for us to look at it later. Find out if your multimeter has a AUTO HOLD function. If it does, learn how it functions.

AUTO HOLD function present? No :(

Explain how it works:

1.4. GRADE:

5. Some multimeters have capacitance measurement capability. Find out if your multimeter has this capability. If it does, find out the minimum and maximum capacitance values it can measure.

Capacitance measurement function present? Yes

Minimum capacitance= 4nF Maximum capacitance= 4000μF

1.5. GRADE:

Experimental Work

1. Multimeter

1. Use your multimeter to measure the value of a resistance. Measure the resistance between your two hands using Ω scale of your multimeter (it becomes an *ohmmeter*). Wet your fingers and repeat the measurement. Record the readings.

R(normal)= 1.479MΩ R(wet fingers)= 1.026MΩ

1.1. GRADE:

2. Get one more resistance of the same value. If your multimeter has a RANGE button, press the RANGE button to set the appropriate range. Measure the resistances. Since the resistance of your hands is not infinite, make sure that you do not touch your fingers while you make resistance measurements. Record your readings. Are the readings consistent with the color code of the resistors (see the color code Table in p. 37)? Compare the variation in the resistance values with the tolerance of the resistor shown by the color code.

Colors of resistor= Brown /Green/Blue/Purple	
Color coded nominal value $R=$ 1.5 × 10⁶	Color coded tolerance= ∓%0.1
Measured: $R=$ 1.549M Ω	$R=$ 1.531M Ω
Measured maximum tolerance = 0,018 ~ %0,02	

1.2. GRADE:

3. Use your multimeter to measure the voltage of the power supply: Adjust the power supply to +5.00V. Set your multimeter to DC voltage scale (your multimeter becomes a *DC voltmeter*) and measure the voltage, V_{DC}, across the terminals. Record and compare the readings.

Adjusted: $V_{DC}=$ 5.00V	Measured: $V_{DC}=$ 5.01V

1.3. GRADE:

4. An *ideal* voltmeter has infinite resistance not to disturb the voltage it is measuring. But real voltmeters have a finite resistance. Measure the resistance, R_V, of your voltmeter at DC and AC scales using another multimeter and record it. Compare it with the data given in the manual of the multimeter.

DC Voltmeter, Measured: $R_V=$ 9.23MΩ	Data: $R_V=$ 10MΩ
AC Voltmeter, Measured: $R_V=$ 10.74MΩ	Data: $R_V=$ 10MΩ

1.4. GRADE:

5. Use your multimeter to measure the current through a resistor: Choose a resistor between 100 Ω and 220 Ω. Measure its value using your multimeter. Set the power supply voltage to +5.00V. Measure it with your multimeter. Connect one lead of the resistance to the positive terminal of the power supply (set at +5.00V). Set your multimeter to current reading scale (it becomes an *ammeter*) and place the multimeter in *series* with the resistor and the negative terminal to the power supply to measure the current through the resistor. DO NOT place the leads of your multimeter directly across the power supply; you may blow the fuse of your ammeter! Record the current reading. Find out if Ohm's law is satisfied. Does the resistance of the ammeter affect the measurement?

Measured: $R=$ 150,3 Ω   Measured: $V=$ 4,98 V

Measured: $I=$ 33,25 mA   Calculated: $I = V/R=$ 0,03A $= \frac{5}{150}$

Comments: Resistor's inner resistence results with difference between Measued and calculated currents. Also multimeter's inner resistance.

1.5. GRADE:

6. Measure the resistance, R_A, of your ammeter by using another multimeter in its Ω scale. Does it explain the difference between the calculated and measured values in the item 1.5? Comment on your results.

Measured: $R_A=$ 1,6 Ω

Comments: An ideal Ampermeter (Ammeter) should has zero inner resistance but our ~~ameter~~ has 1.6Ω so it explains difference in 1.5

1.6. GRADE:

We note that measuring current is always more difficult than measuring voltage. To measure the current the multimeter must be placed in series with the branch. This usually means the circuit must be modified to be able to measure current. On the other hand, measuring voltage is easier. You can just touch the terminals in parallel with the multimeter leads. There is no need to modify the circuit. That is why *nodal* analysis is preferred instead of *mesh* analysis.

7. Some multimeters have capacitance measurement capability. Find out if your multimeter has this capability. If your multimeter has capacitance measurement capability, get two capacitors, one larger than the minimum and the other less than the maximum. Measure the values. Compare with the values written on the capacitors. Note that most capacitors with values less than 1 μF, have numeric codes indicating their values in *picofarads* (pF) similar to the resistor codes. For example, 103 means 10 plus three zeros: 10,000 pF. 221 means 220 pF.

Capacitance value: 4,7 nF   Measured capacitance value: 4.9 nF

Capacitance value: 470 uF   Measured capacitance value: 493 uF

1.7. GRADE:

2. Soldering

1. You will learn good soldering in this exercise. Soldering is a chemical process to form an alloy of solder and the soldered metal pieces. Soldering iron must be hot and its tip must be shiny in order to make good solder joint. Put some water on the soldering sponge and keep it wet through out the soldering session. Turn the soldering iron on and wait until it is hot. Solder must immediately melt on the tip when it is hot enough. Put some solder on the tip and wipe the tip with wet sponge. The tip will shine. This process is called tinning. Now the iron is ready to make a solder joint.

If the tip is not shiny, the heat transfer from the tip to the component is poor. You may end up with a *cold* solder. Cold solders are very problematic, they may conduct intermittently. It is very difficult to find where the cold solder is. So it is best to make a good solder to begin with.

The joint to be soldered must be mechanically sturdy enough before solder is applied, so that when the solder is hot and in fluid form, the joint must not move. Place the tip in contact with the joint, touching all parts to be soldered. Place the solder in contact with the parts (not the tip) opposite to the tip. Solder must melt within a second. Remove the tip and the solder.

2. Solder wire contains a flux that assists the solder in making a wetted joint. When heated, the flux gives off a potentially irritant vapor. Avoid inhaling this smoke.

3. Choose four different resistors in the range 10 Ω to 47 Ω. Measure the value of each accurately using your multimeter.

R_1= 27.2 Ω	R_2= 15.0 Ω	R_3= 12.4 Ω	R_4= 18.1 Ω

2.3. GRADE:

4. Solder the four resistors as shown in Fig. 1. Calculate the total resistance of the combination using the measured values of resistors. Measure the total resistance of the combination, R_T, using your multimeter. Comment on any difference.

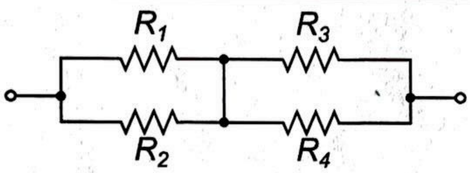


Figure 1: Solder four resistors as shown in the diagram.

Calculated R_T= 16.8 Ω   Measured R_T= 17.4 Ω

Comments: The difference is 0,6 Ω. This error can occur because of inner resistore of resister or maybe soldering.

2.4. GRADE:

3. Oscilloscope

Oscilloscopes are very important and commonly used instruments in Electrical Engineering. Their screens show the voltage as a function of time waveform. They may show more than one waveform simultaneously. Oscilloscopes have many knobs and buttons. To make full use of an oscilloscope, it is mandatory to learn the functions of them. The following steps apply to Tektronix TDS20XX series digital oscilloscopes, shown in Fig. 2. Nevertheless, other brand or model digital oscilloscopes are also very similar.

1. Connect the oscilloscope probe to CH 1. Set the switch on the probe to 10×. Connect the probe tip to PROBE COMP using the probe hook. Press CH 1 MENU button. New options will appear on the screen. Press the Coupling button until it indicates DC (DC coupling means the signal appears on the screen with its DC part.) Now, press AUTOSET button. (Expert engineers do NOT use AUTOSET button! It is there to be used by rookies. Avoid using the AUTOSET button to become an expert :) You should now see a stable square waveform on the screen. Observe that green Trig'd is being displayed indicating that the oscilloscope is *triggered*.

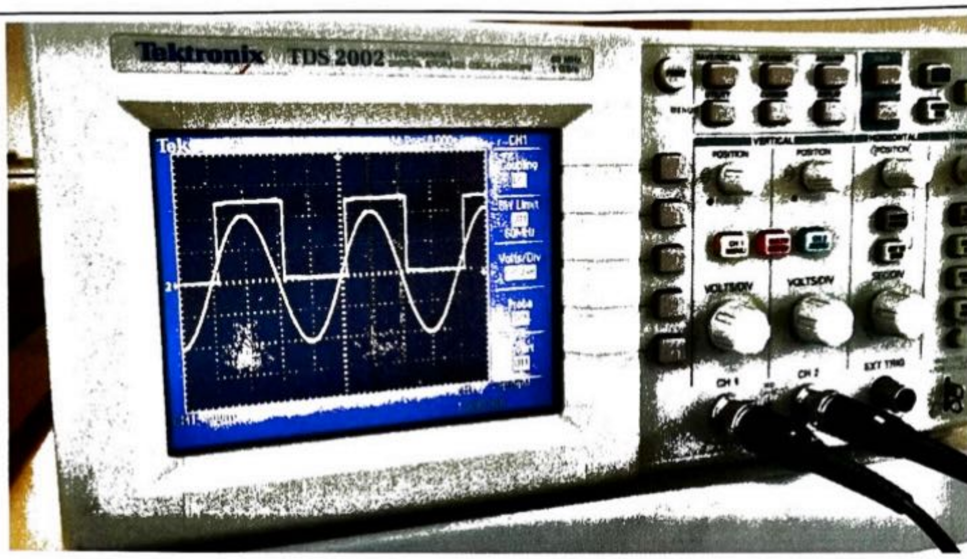


Figure 2: Tektronix TDS2002 two-channel digital oscilloscope.

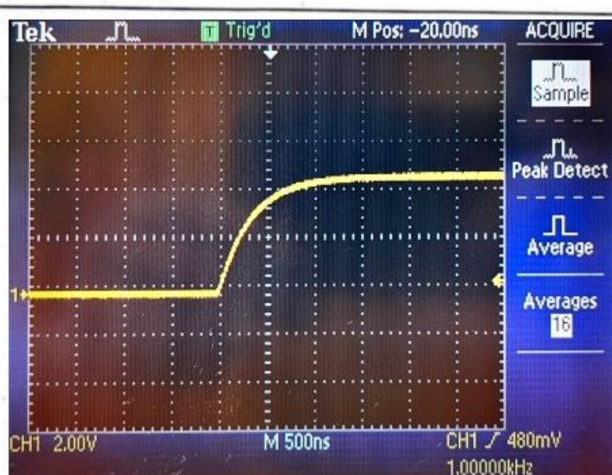
2. Set Coupling: AC using CH1 MENU. Comment on the results. Set Coupling: Ground. Write down the results.

Comments: In AC coupling the line separate waveform to half
In DC coupling the waveform is on top of the line
In ground coupling, AC blocks DC, so waveform turns into a straight line

4.2. GRADE:

3. Rotate SEC/DIV knob to change the time scale to 500nsec. Use the Horizontal Position knob to move the waveform left or right to observe the waveform in detail. Press ACQUIRE and set Average 16 to get a waveform with less noise. Take a photo of the screen for your report.

Screen photo:



4.3. GRADE:

4. Triggering: The trigger determines when the oscilloscope starts to capture data and display a waveform. If the trigger is not set up properly, the display will be unstable or blank. If oscilloscope is triggered, you will see a green colored "Trig'd" display on the top of the screen. It is very important to understand what triggering means.

   Press TRIG VIEW button while turning the TRIGGER LEVEL knob. A dashed line is displayed showing where the trigger level is. Actual triggering occurs at the time point the dashed line intersects the waveform. Rotate the knob until the dashed line is above the square wave so that it does not intersect the waveform. Release the TRIG VIEW button. Trigger is lost. Now you should see an unstable waveform on the screen and green Trig'd readout is gone. Rotate the TRIGGER LEVEL button until the trigger arrow on the right is in the middle of the square wave. Observe that the square wave is triggered again.

   Change the Trigger Slope to Falling. Explain.

Explain: It changes the slope of entire waveform oppositely, gets symmetric about the x-axis

rising ->  falling -> 

4.4. GRADE:

5. Read and record the Trigger Frequency at the lower right corner of the screen.

Trigger frequency: 1.00000 kHz

4.5. GRADE:

6. Press CURSOR button. Set Type: Time and Source: CH1. Adjust Cursor1 and Cursor2 to determine the period (Δt) and frequency ($1/\Delta t$). Find also the peak-to-peak voltage of the square wave from ΔV readout.

$\Delta t =$ 500.0ns $f =$ 2.000MHz $\Delta V =$ 320mV

4.6. GRADE:

7. Rotate DIV/SEC knob until the time scale becomes 500ns per division. Now you should be able to see the falling edge of the square wave in detail. Rotate the TRIGGER LEVEL knob to change the point where the trigger occurs. Write down your observations.

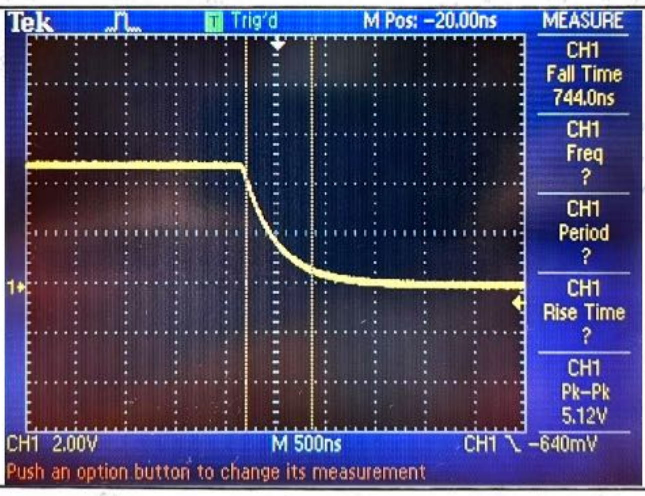
Observations: The waveform gets unstable, when trigger level knob goes out of the range of the waveform

4.7. GRADE:

8. Find the Fall Time, t_f, of the signal (from 90% to 10% voltage points) using cursors. To get a more accurate measurement, you can increase the vertical scale sensitivity to 1V per division using the lower CH1 knob. You can move the signal up and down using the upper CH1 knob. Take a photo of the screen for your report.

$t_f = 744.0\text{ns}$

Screen photo:

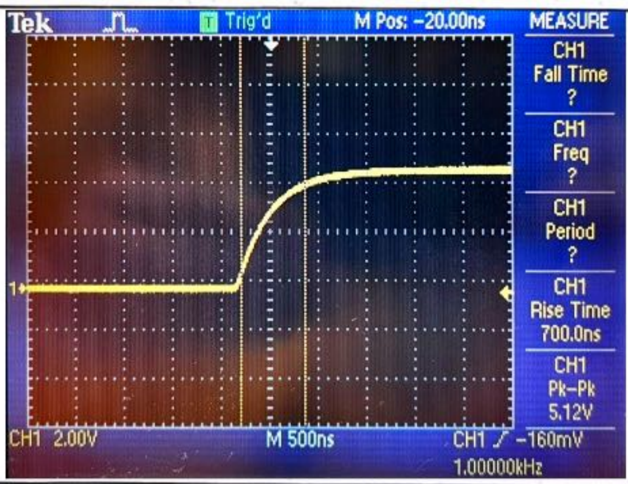


4.8. GRADE:

9. Change the Trigger Slope to Rising. Find the Rise Time, t_r, of the signal (from 10% to 90%). Take a photo of the screen for your report.

$t_r = 700.0\text{ns}$

Screen photo:



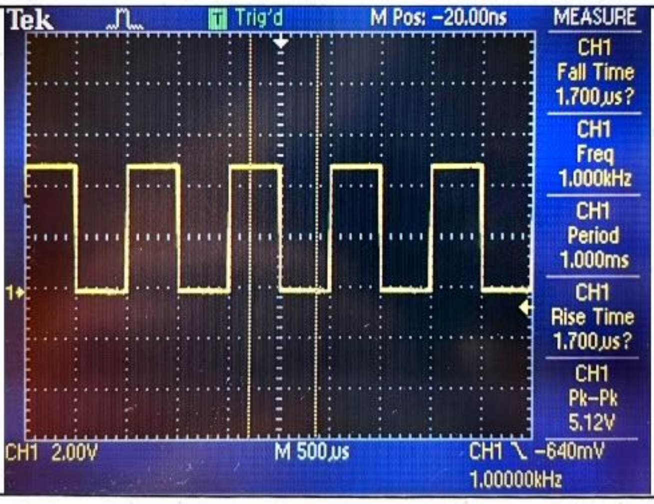
4.9. GRADE:

10. Press MEASURE button and set the appropriate buttons to display Period, Freq, Pk-Pk, Rise Time and Fall Time of the signal automatically. You need to see one full period on the screen to be able to measure period and frequency. Take a photo of the screen for your report. Compare automatic measurement results with those obtained by cursors.

Δt= 1.000 ms $\quad$ f= 1.000 kHz $\quad$ ΔV= 5.12V

t_f= 1.700 μs $\quad$ t_r= 1.700 μs

Screen photo:



4.10. GRADE:

11. Trigger Source: Use the Trigger Source button to choose the signal to be used as a trigger. Press the Source button to change the trigger source to CH 2. Explain the consequences.

Consequences: If we change to CH2, it becomes unstable, This wave form is called "noise", this occurs even if there is nothing connected to CH2

4.11. GRADE:

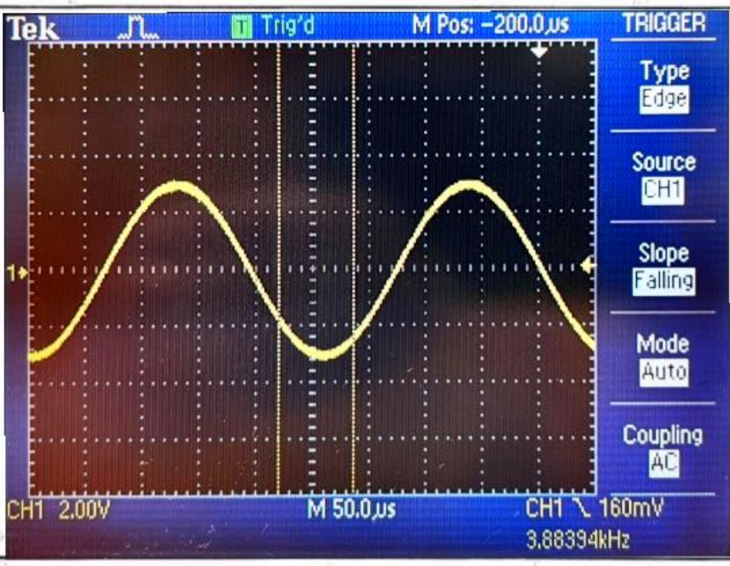
12. Press the Trigger Source button repeatedly until Line is the trigger source. Line means the trigger source is 50 Hz power line of the oscilloscope. If a signal related to 50 Hz line is being investigated, it is very convenient: Use the probe of CH 1 to touch your finger. Your body acts like an antenna to pick the 50 Hz line signal in the environment. Observe the oscilloscope while the trigger source is Line. Explain.

Explain: When we touch to the probe, it displays a sinusodial waveform, because of the signal we give to the oscilloscope

4.12. GRADE:

13. Adjust the signal generator so that it generates a sine wave with a frequency equal to the last four digits of your student ID number. Set the amplitude to 3 V peak-to-peak. Set the oscilloscope to observe one full-cycle of the sinusoidal waveform filling the screen. Do not use AUTOSET! Display the frequency, period and peak-to-peak voltage values. Take a photo of the screen for your report. Comment on the agreement between the signal generator settings and oscilloscope measurements.

Screen photo:



4.13. GRADE:

14. Set the signal generator amplitude to 20 mV peak-to-peak. Notice that the signal is more noisy. Press ACQUIRE button. Change the mode to Average and 16 Averages. The oscilloscope will take the average of 16 (or 64) samples to reduce the noise and to generate a better quality display. Use Average mode when the signal is small and noisy.

15. Set the frequency of the signal generator to 50.1Hz. Set the Trigger source as Line. Change the frequency of the signal generator until the waveform on the screen no longer drifts. Record the frequency value. This value is equal to the frequency of the Line signal at the time of measurement.

f= 50,0274 Hz

4.15. GRADE:

16. By experimenting, find the difference between Trigger mode AUTO and NORM. Explain.

Difference between AUTO and NORM:
Auto: triger is forced it shows unstable waveform
Norm: trigge is never forced it shows last triggered display of wavefom

4.16. GRADE:

17. Connect the signal generator SYNC output to EXT input of the oscilloscope using a BNC cable. Set the Trigger Source to Ext. Since SYNC output generates a square wave signal, the oscilloscope will have no difficulty with the triggering. Change the amplitude of the input signal to very small values. Observe that you do not have to readjust the trigger level and that triggering is always achieved. This configuration is very robust and it should be preferred whenever possible. Explain the benefits of external triggering.

Benefits of External Triggering: Waveform is synchronised by this.
It connects oscilloscope to an external signal. So we can easily capture the waveforms generated by the external signal.

4.17. GRADE:

CHECK POINT: