LOGBOOK

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General notes:

- **Include a cover page with your name and SID, while submitting your logbook**
- **Each activities should have objectives, introduction, experimental procedure, results and discussion (with critical analysis) and conclusion. Include other relevant section if necessary.**
- **Provide pictures, screenshots, graphs, tables (whichever is relevant) as an evidence of the work carried out**
- **Do not hesitate to ask your tutor if you have a question.**

Important: Working in a red font input your notes, observations and any calculations into this word document as you undertake your activities work and save it on your H drive.

Module 102SE Activity Led Learning (ALL) 2017/18

Introduction

Following on from the induction week you will join with a group of fellow students to undertake ALL activities. These activities are designed to promote key aspects of related to the early stage of your chosen degree. Hopefully you will find them interesting and exciting. Also the social contacts made will enable you to accustom yourself quickly to campus life.

ALL provides an opportunity to:

- Work in small groups towards a common goal.
- Use computer-aided techniques to assist the development of products and systems.
- Develop knowledge essential to the physical principles governing the behaviour of amplifiers and signal measurements
- Develop skills in design, modelling and analysis in the context of a given range of practical problems.
- Develop and conduct test procedures
- Develop skills in relation to the collection and analysis of data.
- Develop and practise communication and presentation skills.

ALL Implementation:

The Activity Led Learning will form the main method of learning throughout the module. The learning outcomes of the module will be achieved by way of support activities which will, in part, be taught material and laboratory study and part group activity. Two projects will be undertaken. Each project will be assessed (see module guide for the schedule of submission dates). Recoding note taking it is important to keep records of all of your 102SE activities as the module progresses you may do this by a number of methods, logbook, word document, note pad etc.

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Session T1: Introduction to basic circuits and measurements

The aims of this activity are:

- To build an electronic circuit system
- To test an electronic system.

The purpose of the electronic system is to determine ambient light level in Lux.

(For further information on Lux see http://en.wikipedia.org/wiki/Lux)

The key component of such a system would be a light sensitive device such as Light Dependant Resistor or LDR. For the experimentation that will follow we will be using the NORP 12 device, a data sheet for this can be found in 102SE Moodle.

Circuit symbol

Figure 1 LDR Circuit Symbol and Actual Device

Activity 1 Measurement of LUX

You have been supplied with an LDR a proto board and a Digital Multi-Meter. Using the proto board connect up the circuit shown and then using an appropriate range on the DMM measure the resistance of the LDR.

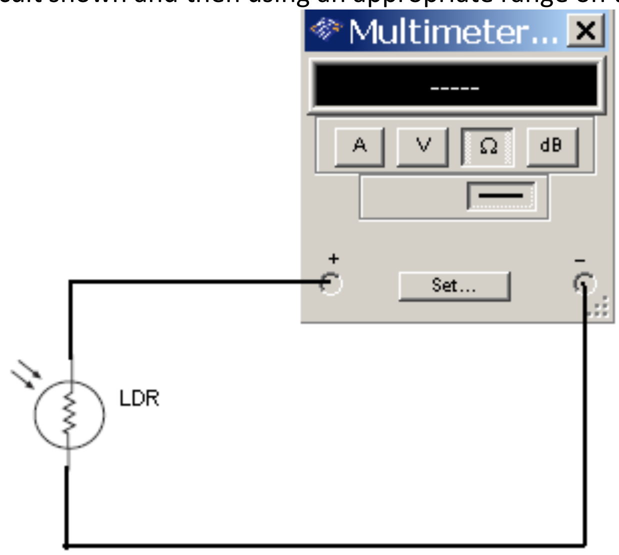

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Figure 2 Measuring LDR Resistance

From your measurement of LDR resistance determine LUX level; make a few more measurements to confirm your result including 250 Lux level (note the Lux level will vary dependant on local light conditions; expect range to be 180 to 500 LUX in the laboratory see figure 4 on page 3 of the data sheet for information i.e. 'Resistance as a function of illumination'). Visualise the data sheet graph and your measurements on the same plot.

Objective:

The purpose of the electronic system is to determine ambient light level in Lux.

Introduction:

This experiment is going to focus on measuring the light intensity (Lux Level). Lux is a term that is used to refer to light intensity, it is defined mathematically as one lumen per square meter. The symbol for Lux is Lx. We would be conducting an experiment to determine how the resistance of a light dependent resistor would vary in relation to light intensity.

LDR's are basically variable resistors which are controlled by light. At night time, the Light Dependent Resistors, would have a very large resistance due to the fact that the electrons that are present do not have enough kinetic energy to move about and break out of their crystalline shape. Also, as the light intensity increases the electrons gain kinetic energy and begin to move about which accounts for why they would be a reduction in the resistance level. This is accounted in the kinetic theory of matter statement.

This is the same concept that is also applied in burglar alarms and in providing illumination in offices. It may interest you to know that Lux sensors are also used in photography and video filming. We would also work with digital multi-meters which would help us to measure the resistance across the Light Dependent Resistor. A typical example of multi meter is shown in the snapshot below.

Methodology:

The various implementation methods used in building the circuit were:

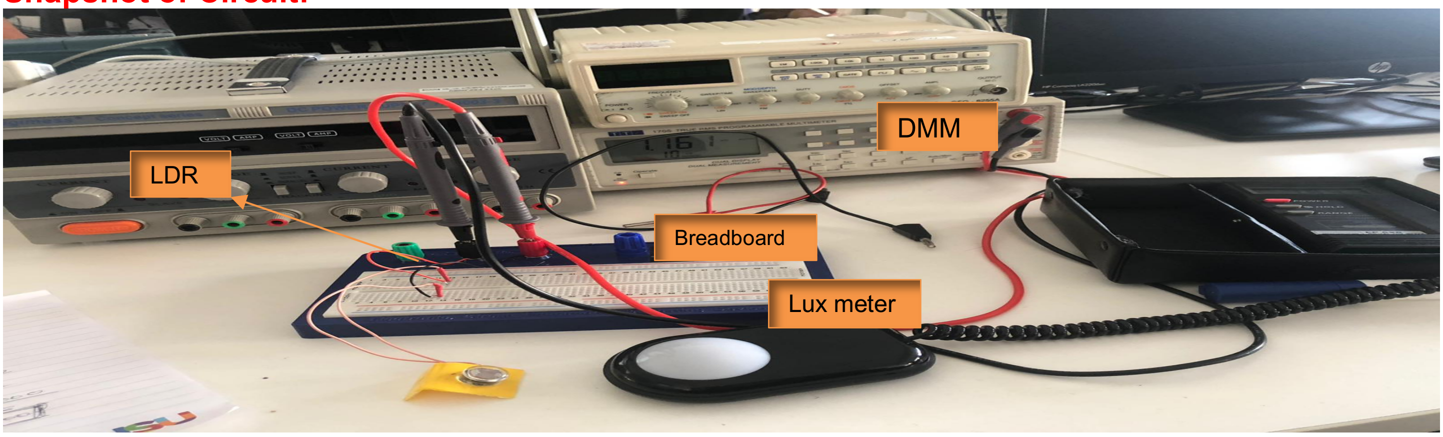
1) The ohmmeter was connected across the terminals of the light dependent resistor
2) The light meter is then used to measure the light intensity in Lux
3) The digital multi meter is used to measure the resistance in Ohms
4) The light conditions were varied and the LDR readings were taken

Apparatus:

The following instruments and components were used in building the circuit:

1) Digital Multi Meter (DMM) (Set to measure resistance in Ohms)
2) Breadboard
3) Torch
4) Light Dependent Resistor (LDR)
5) Light Meter
6) DC Power Supply Unit

Snapshot of Circuit:



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Results:

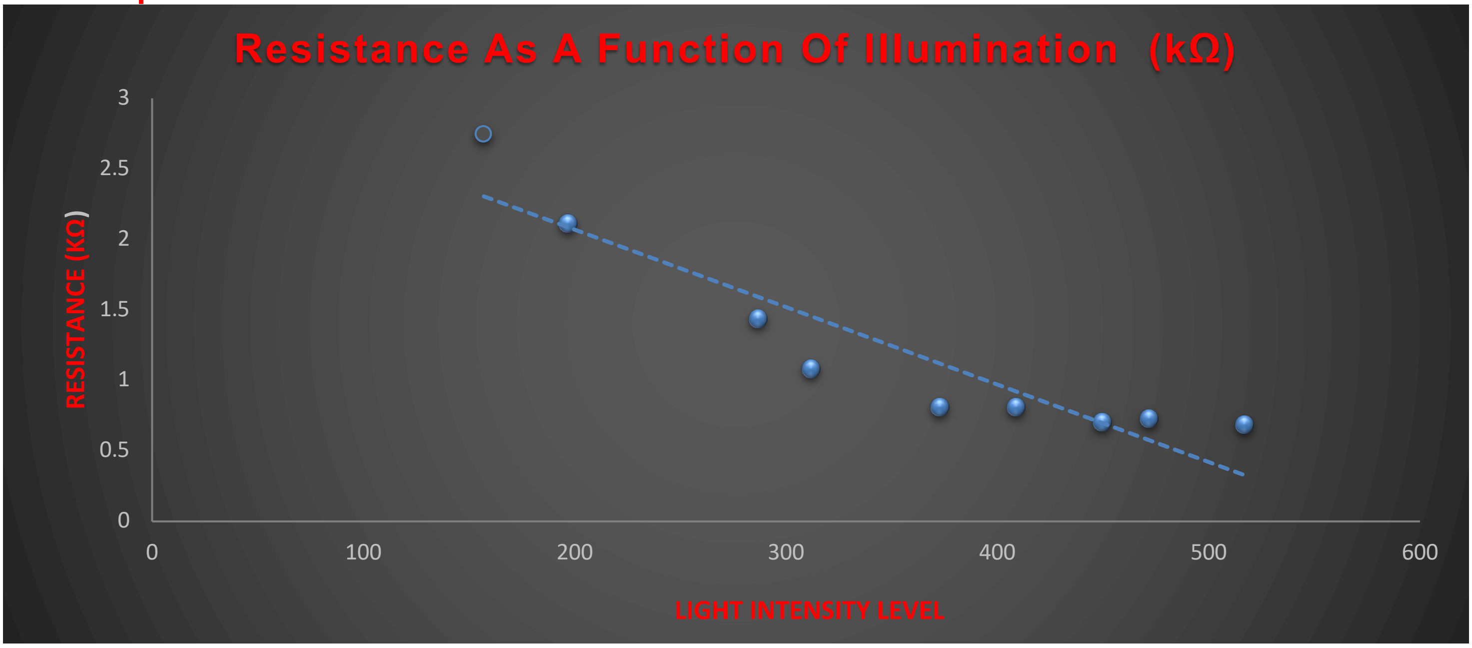
Table illustrating resistance as a function of Illumination.

S/N	Lux Level	Resistance (kΩ)
1	157.00	2.743
2	197.00	2.110
3	287.00	1.430
4	312.00	1.075
5	373.00	0.805
6	409.00	0.804
7	472.00	0.723
8	450.00	0.700
9	517.00	0.684

Discussion:

The circuit was connected as shown in the snapshot above. The Digital multi-meter was set to show results in Ohms. Different light intensity Levels (Lux) were taken from 157Lx to 517Lx and what is easily observed is that as the light intensity increases the resistance across the light dependent resistor decreased. This is due to the fact the LDR's are very light sensitive. For instance, the resistance decreased from 2.743KΩ all the way to 0.684KΩ

Data Graph:



Conclusion:

We have been able to measure the ambient light level in lux. As seen in the chart above the resistance of the Light Dependent resistor decreased as the light Intensity (lux) increased. This is due to the fact that the LDR's are '**light Sensitive'** which accounts for why there is a change in resistance when exposed to light.

Sources of errors that may have occurred while undergoing the experiment include:

1. **Human Errors**: While taking measurements the values shown weren't constant so taking the exact reading was a little difficult, so an average had to be taken to reduce the errors.
2. **Environmental Errors**: While undergoing the experiment, the external conditions have to be taken to consideration which means that the light level wasn't constant due to the wind and this disrupted the readings and an average had to be taken in order to reduce the error.

In Conclusion, the experiment helped portray the effect of resistance as a function of illumination. This concept is why they are used widely especially when building burglar alarms as previously stated.

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Activity 2 Voltage Measurement of LUX Practical

In an electronic measurement system the physical quantity being measured is often converted into a current or a voltage. In the case of a LDR it is fairly straightforward to convert change in resistance into a change in voltage. All that is needed is to incorporate the LDR as part of a potential divider chain.

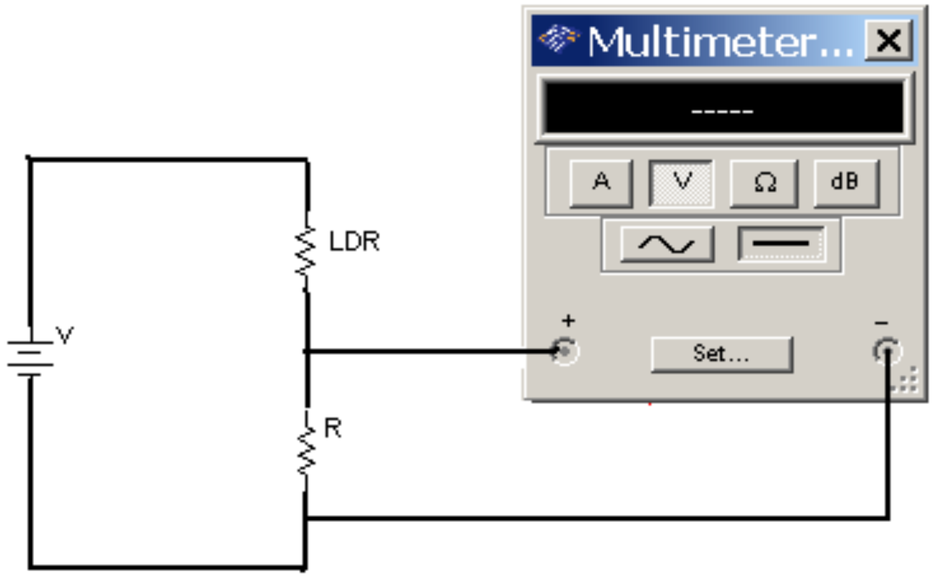


Figure 3 Potential Divider

Setting up the Potential Divider, there are several tasks associated with the setting up of the potential divider such as specifying the value of R in the divider chain. The factors that affect the choice of R link to LUX level and the power dissipation limit of the LDR.

Measurement: assuming the source voltage V is to be 10 volts and that we wish to set the potential difference across R to be 4 volts when the LDR is subjected to 250 Lux, calculate the required R value using the voltage divider rule. You need to use the LDR resistance at 250 Lux from previous measurements. Confirm your measured value of R with your tutor. Choose a practical resistance value close to your calculated one. (**Optional:** You can also use some circuit analysis techniques to build the calculated resistance exactly). Once this confirmation has been made with your tutor, proceed to build the circuit on the proto board. Then, measure the output voltage across R terminals (Vout), and compare it with the expected value (4 v). Report a table of measurements of (Vout) for different lux values. Include a snapshot of your implementation in your report.

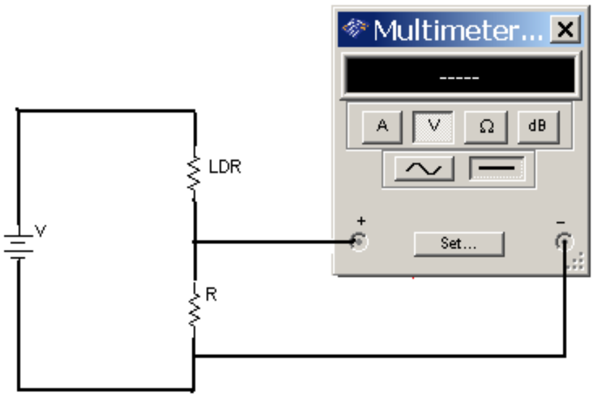
Objective:
Measuring the voltage across a Light Dependent Resistor at different light intensity values (Lux).

Introduction: Light dependent resistors also referred to as variable resistors. They have the ability to vary their resistance. It would be connected as part of a potential divider circuit. In choosing the value Of R, the factors that affect the choice include the Light intensity level and the power dissipated by the Light Dependent Resistor as well. This would enable us measure different output voltages (Vout) for different lux values. One application of light Dependent Resistor would be in lightening systems i.e. Security lights which turn on at a certain light level.

Methodology:
In connecting the Circuit as shown below the various apparatus would be used:

1. Light Dependent Resistor
2. Dc Power Supply Unit
3. Resistor (1KΩ)
4. Digital Multi Meter (Set to measure voltage in Volts)
5. Torch
6. Lux Meter

Circuit Diagram:



Experimental Procedure:

1. Set up the potential divider as shown in the simulation.
2. Set the Dc Supply to 10 volts
3. Measure the output voltage across (Vout)
4. Compare the reading to the expected value of 4V

Calculating the Value R:

Source Voltage = 10V

R = 4Ω

LDR = 1500 $VR = \frac{V \times R}{R + R_{LDR}}$

$\frac{4 = 10 \times R}{R+1500}$

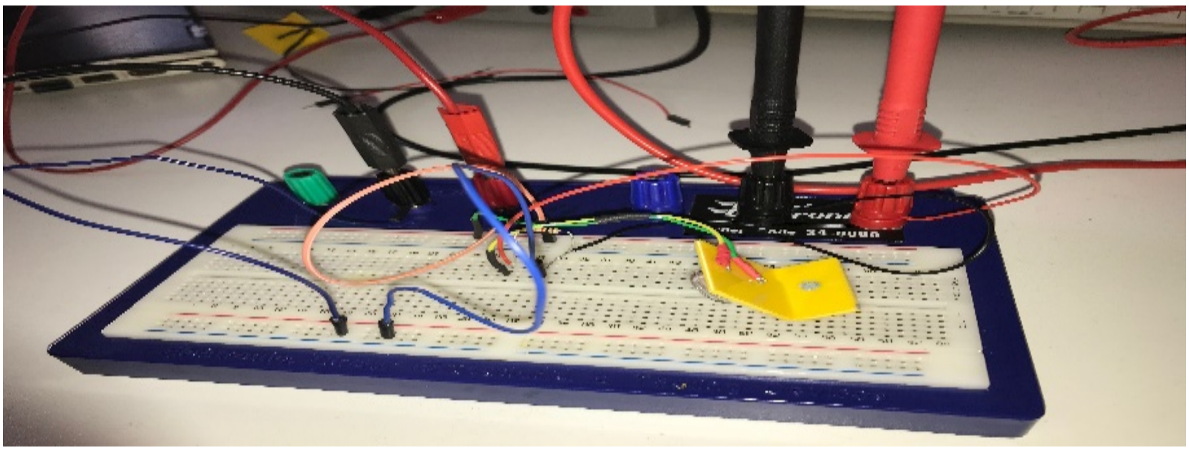
4(R + 1500) = 10R

4R + 6000 = 10R

6000R = 6R

R= 1000Ω

Snapshots of Circuit:



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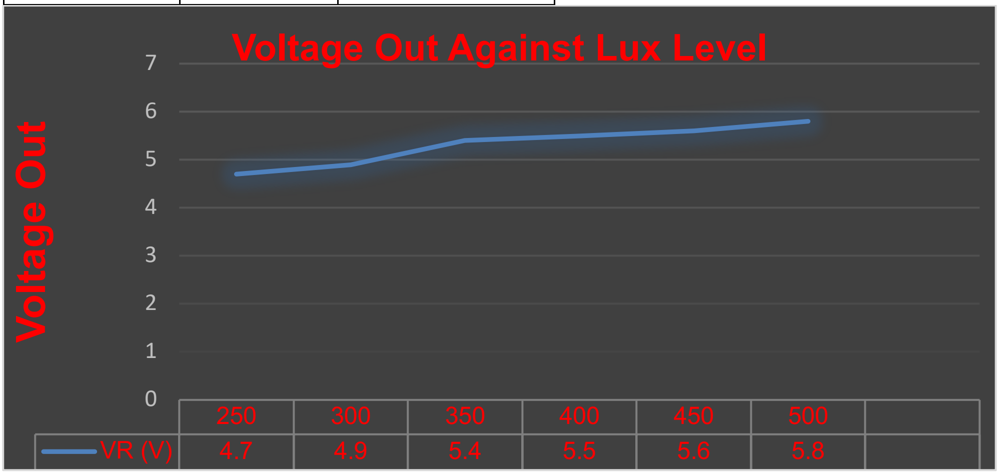
Results:

Table of Readings:

Lux Level	Voltage Source (V)	VR (V)
250	10	4.7
300	10	4.9
350	10	5.4
400	10	5.5
450	10	5.6
500	10	5.8



Conclusion:

The light dependent resistor was connected as part of a potential divider circuit with a resistor of 1kWhile undergoing the experiment it was easy to note that as we increased the light intensity across the light dependent resistor, the output voltage also increased as well. The source voltage was kept constant at 10Volts.The reason for this is that as light intensity increases, the resistance of the light dependent resistor decreases which enables more current to pass through leading to an increase in output voltage.

Possible errors that may have occurred include

1. **Human Errors:** while taking the readings, the measured values weren't constant in nature and had to be repeated in order to reduce the error.

Random Errors: While undertaking the experiment, noise levels wold have to be in taken into consideration. And an average had to be taken to reduce this type of error.

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Activity 3 Voltage Measurement of LUX Theory

Comparison with data sheet (You don't need any lab components for this activity and therefore you can do it later, if you are limited by time in the lab): use the data sheet provided to determine the resistance of the LDR at 250 Lux and compare it with your previous measurements and calculations.

Aim: Voltage Measurement of Light intensity theory

Introduction:
We have previously experimented with using a light dependent resistor in a voltage divider arrangement. We concluded that as light intensity across the light dependent resisitor increased, the total voltage also increases as well.
For this activity, we would be comparing the measurements and calculations with those provided in the data sheet. As this is purely theoretical, no lab equipment's would be needed.

Methodology:

1. Use the data sheet and determine the resistance at 250 lux level and relate it to previously calculated and measured values.
2. Comment on the results

Results:
When using the data sheet to determine the resistance at 250Lux, I got a value of 1.2KΩ.
The calculated value from previous activities 1kΩ. This is approximately the same. This helps to reconfirm that our calculations were correct.

Conclusion:
The calculated value and the value derived from the data sheet were approximately the same. This value helps to show the relationship between the light falling on a cell and its corresponding resistance.

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Session T2: Amplifiers as building blocks

You have worked with LDR and a potential divider circuit last session. The circuit can be considered as a transducer. Further processing of a transducer signal (i.e. the output of your potential divider) is normally required before the signal can be processed or transmitted. The process can be for example, compensation for low amplitude and increasing the amplitude of the transducer signal prior to transmission.

As explained in the lecture session, one of the common signal conditioning processes is to **limit the effects of “loading”** and **isolate** the output impedance of the voltage divider circuit from the input impedance of next connected circuit. This is important to avoid the effect of any other connected circuit to the output of the transducer. The **‘fix’** is often to incorporate a **buffer amplifier** (i.e. unity gain, high input impedance and low output impedance type) between the transducer signal and the next stage system.

Activity 1 The Operational Amplifier as a Buffer Amplifier

A common building block in electronics is the Operational Amplifier or OP-Amp (see lecture slides, you will also study more about it in module 101CDE).

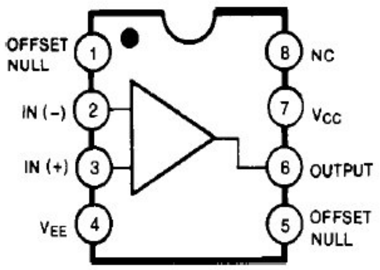


Figure 5. 741 IC

It is possible to configure this device to perform a multitude of signal processing functions. In the context of the problem of “loading” it can be configured as a Buffer i.e. a unity gain, high input impedance and low output impedance device. Figure 6 shows details of a circuit that contains your existing LDR in the potential divider and shows a buffer amplifier connected to the potential divided output.

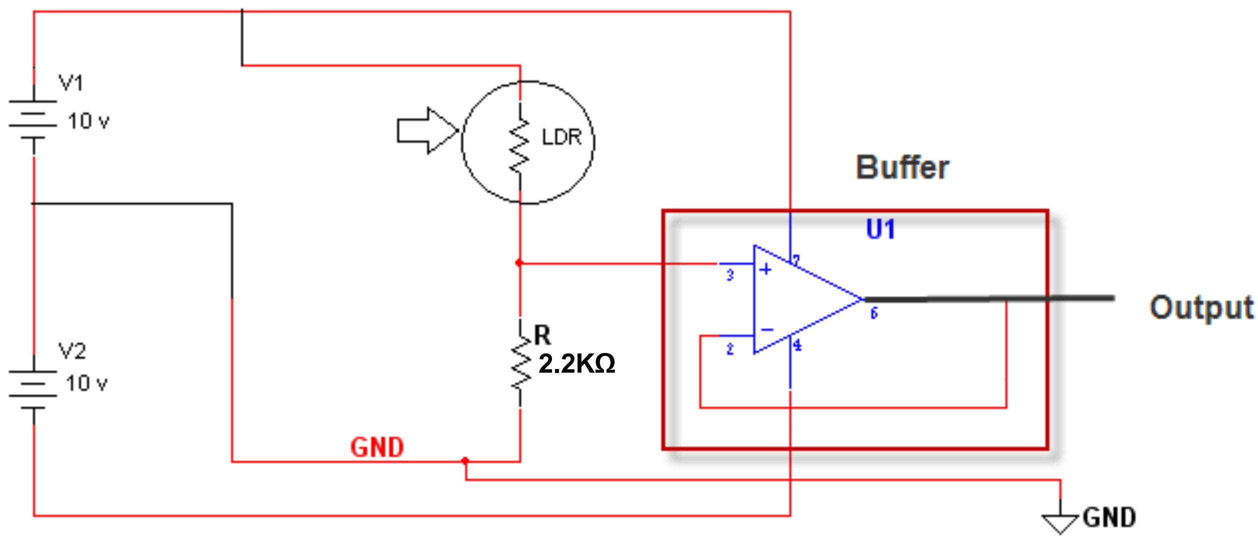


Figure 6

Important: Working in a red font input your notes, observations and any calculations into this word document as you undertake your activities work and save it on your H drive.

Construction: first build the potential divider circuit (left part of figure 6) and then connect it to the buffer amplifier (right part of figure 6). Power the amplifier, and change the light to achieve at least 3 different Lux values (low, mid, high). Then use the multi-meter to make notes of the voltages at amplifier pins 3-GND and 6-GND to confirm the amplifier is working correctly. Report the results in a table and include a snapshot of your implementation in your report.

Please see other relevant material and extra tasks in the Moodle web

Aim: Connecting the Operational Amplifier as a Buffer Amplifier (Unit Gain)

Introduction: I would like to firstly define what an amplifier is firstly. An amplifier is a device that when you put a signal into it, it boosts the output signal.

Example: Let A be the amplifier, Is-Input signal and Os-output signal. Therefore, amplification would be: Is- $\boxed{A}$ -Is*A (Os). This shows that amplification would be the product of the input signal and the

Amplification value which would give the output signal. Moving on to operational amplifiers, they have two inputs which are: + (Non-inverting Input) and – (Inverting Input). They have a very high gain which make them very suitable for feedback circuits. Buffer Amplifiers on the other hand are types of amplifiers which the output literally mirrors the input signal. It does this by providing high input and also low output impedance type between the transducer signal and the system.

Methodology:

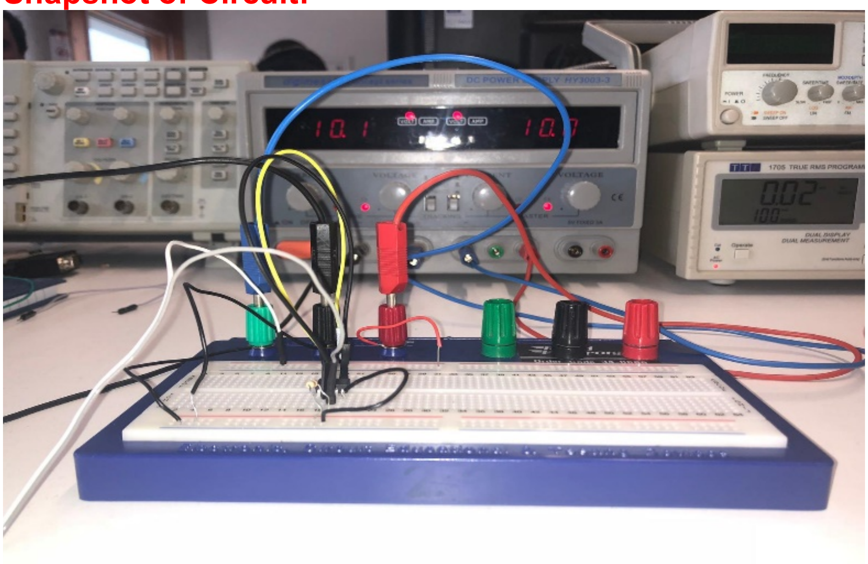
The various apparatus used in preparing the circuit were:

1. Bipolar Power supply Unit.
2. Breadboard.
3. 741 IC Operational Amplifier.
4. Light Dependent Resistor.
5. Digital Multi-meter.

Experimental Procedure:

1. Set the bi-polar power supply to +10V and -10V
2. Then connect the circuit as shown below
3. Power the amplifier and vary the light intensity to three different lux values (Low, Mid and High)
4. Use the multi-meter to confirm that pins 3 and pin 6 are the same. (This is due to the fact that the amplifier is a unit amplifier meaning it would give the exact input as the non-inverting input).

Snapshot of Circuit:



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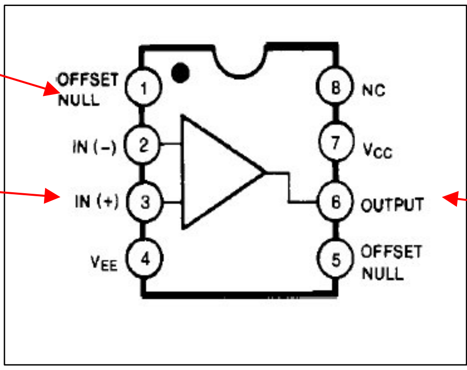
Schematic Diagram of the Operational Amplifier:

While placing the Op-Amp, ensure that this side faces you

Non-inverting Pin



Output

Results:

Measurement of the voltage in different light Conditions (3-GND & 6-GND)

G-ND	**Lux**	**Voltage (V)**
3	510 (High)	6.8V
6	510 (High)	6.8V
3	250 (Mid)	1.40V
6	250 (Mid)	1.40V
3	10 (Low)	600mV
6	10 (Low)	600mV

Conclusions:

At the end of the experiment the following conclusions were arrived at:

1. At the same light intensity (Lux) the Voltage values for the pin at 3-Gnd and at 6-Gnd were approximately the same.
2. The Voltage value rises as we increase the intensity of the light (Lux).

It is also important to note that the weather conditions weren't constant during this experiment, so an average of results had to be taken.

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Activity 2 The Operational Amplifier as a Non Inverting-Amplifier

To demonstrate another amplifier configuration i.e. the **'Non Inverting Amplifier'** the Buffer Amplifier Circuit shown at Figure 7 is going to be modified to become that shown at figure 7.

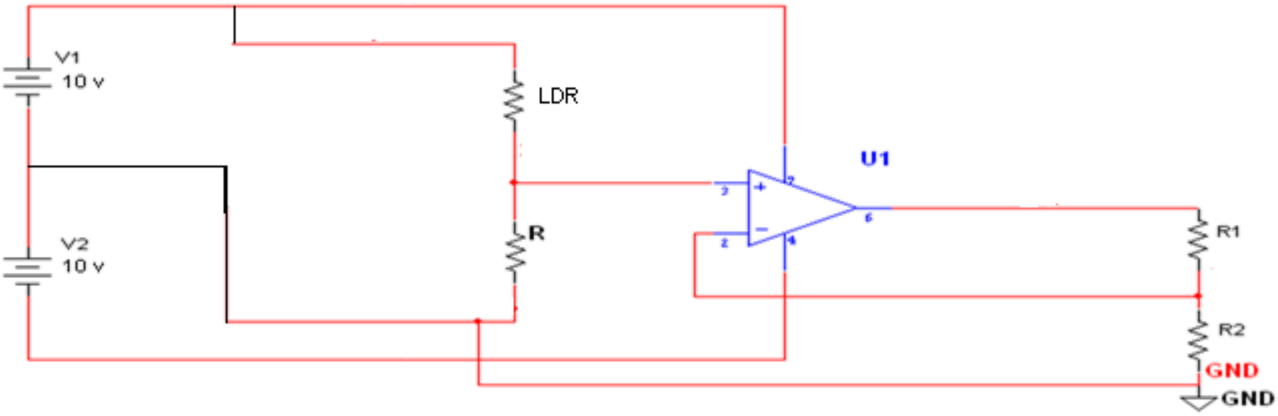


Figure 7

Assuming the gain in ratio form of the non-inverting amplifier can be found from:

$$Av = \frac{R1}{R2} + 1$$

Equation 1

If the gain of the amplifier is to be equal to a value of 1.5 and R1 is 2.7 kΩ:

- Determine a value of R2
- Choose a practical value of value R2
- Modify your existing circuit in figure 6 to create the amplifier
- Make notes of the voltages at amplifier pins 3-GND and 6-GND to confirm the amplifier is working correctly in **one lux** values. Include a snapshot of your implementation in your report.
- Measure the gain of the amplifier.
- Replace the LDR and R with a 10 kΩ linear potentiometer connecting the centre tap to the amplifier input (pin 3). Using the digital voltmeter adjust the potentiometer output to approximately 0 volts. Then incrementally increase the voltage applied to the amplifier noting the voltage at pins 3 and 6 until the maximum voltage at pin 3 is achieved (approximately +10 volts). Plot the input and output measurements to have the transfer characteristic of the amplifier. Make causal observations about the shape of the plotted characteristic. Include a snapshot of your implementation in your report.

Please see other relevant material and extra tasks in the Moodle web

Aim: Connecting the operational Amplifier as a non-inverting amplifier.

Introduction: this activity would deal with connecting and implementing non-inverting amplifiers in a circuit. The non-inverting input is pin 3-Gnd. The gain of a closed loop for a non-inverting amplifier is $Av = \frac{R1}{R2} + 1$ .As the name implies the input signal is not inverted and is directly in phase with the output signal. The experiment would enable us make notes of voltage, at different Lux Values.

Methodology: The following apparatus were used while implementing the circuit:

1. Bipolar Power supply Unit.
2. Breadboard.
3. 741 IC Operational Amplifier.
4. Light Dependent Resistor.
5. Digital Multi-meter.
6. Resistor Values (2.7KΩ and 5.4KΩ)

Experimental Procedure:

1. Connect the circuit as shown above
2. Determine the value of R2 using the formula-

$$Av = \frac{R1}{R2} + 1$$

3. Confirm the amplifier is working correctly by making note of the voltage at 3-GND and at 6-GND at 1 lux level.

4. Measure the gain.

Calculation:

1.5 = (2700/R2) + 1

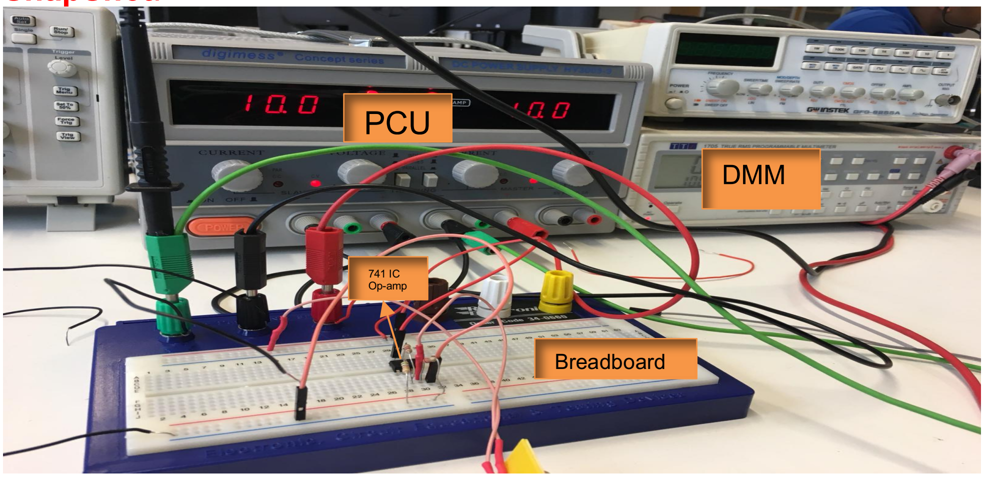
1.5 = $\frac{2700+R2}{R2}$

1.5R2 = 2700 + R2

0.5R2 = 2700

R2 = 5400Ω.

SnapShot:



Results:

G-ND	Lux	Voltage (V)
3	100(Low)	3.50
6	100(Low)	5.50
3	300(Mid)	4.90
6	300(Mid)	7.10
3	600(High)	5.60
6	600(High)	8.30

Activity 2:

Aim: Observing the shape of the plotted characteristic graph when replacing the LDR and R with a Potentiometer.

Experimental Procedure:

1. Replacing the LDR and R with a 10kΩ Potentiometer.
2. Adjust the output of the potentiometer to 0 volts as shown in pin 3-GND
3. Then adjust the voltage applied to the pin 3 and 6 until the maximum value is reached (10V)
4. Plot the transfer and output measurements
5. Make observations about the shape of the plotted graphical figure
6. Include a snapshot

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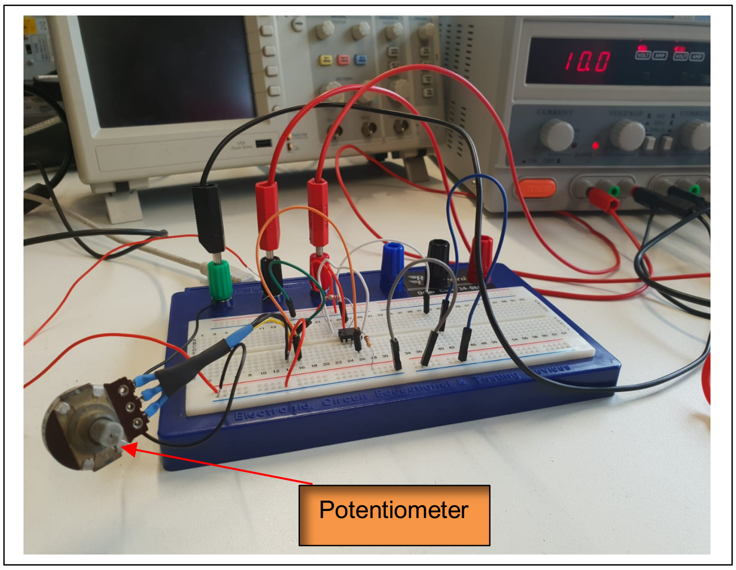
Snapshot of the circuit:



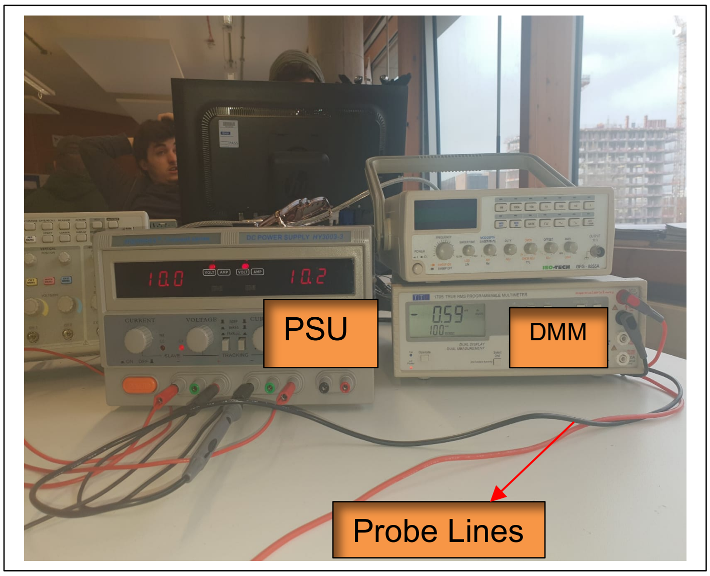
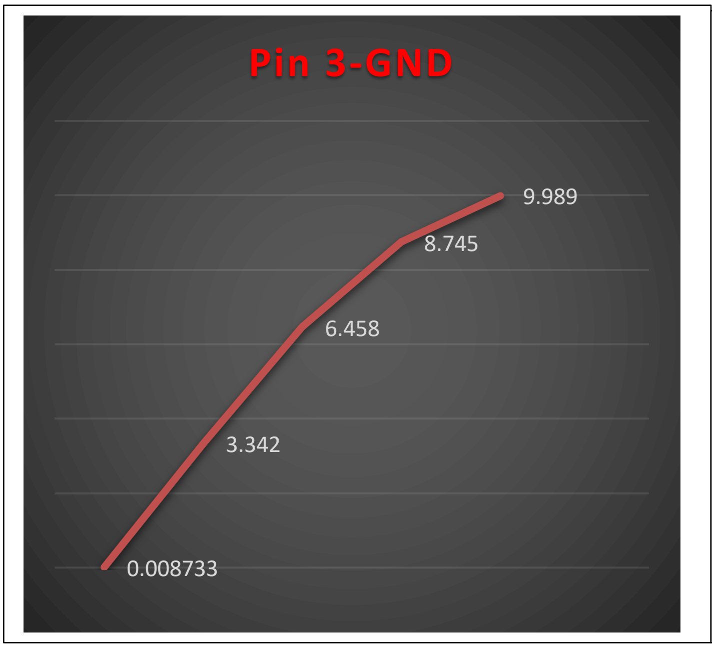
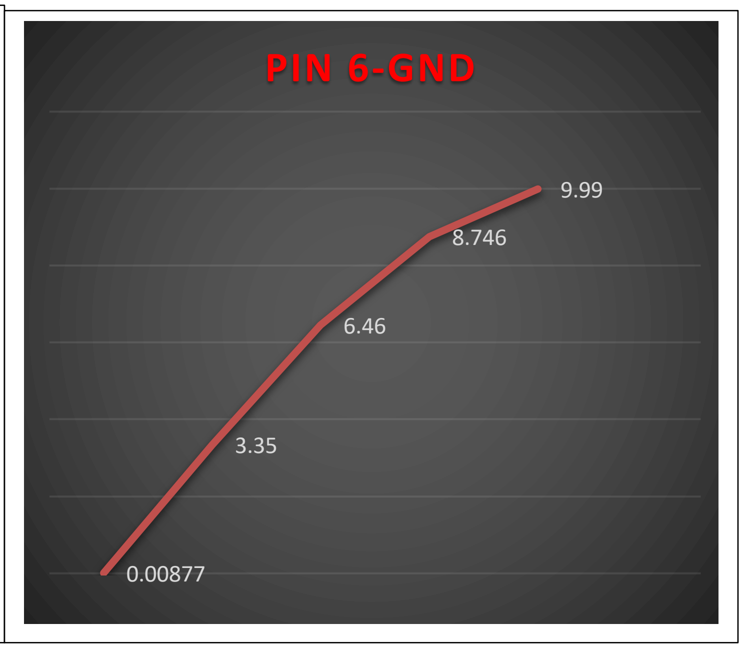


Table of Values showing the transfer characteristic of the Operational Amplifier

s/N	3-GND(VOLTS)	6-GND(VOLTS)
1	0.008733V	0.00877V
2	3.342V	3.350V
3	6.458V	6.460V
4	8.745V	8.746V
5	9.989V	9.990V





Discussion:
as seen in the plotted graphs, the output from pin 3 and 6 are very identical. This is due to the fact that the input signal is directly in phase with the output signal as shown above. When it gets to the maximum voltage of 10Volts, the curve starts to curve downwards. This shows the transfer characteristic of the amplifier.

Conclusion: the first activity had to do with light dependent resistors and what was observed from that experiment was that the output voltage increases as the light intensity moves from low values to high values. The second activity showed the relationship between the 3-GND pin and the 6-GNDpin, the values at both pins were approximately the same. Also, it wasn't possible to get a value of 0 volts on the multimeter which was why we had a value of 873.3mV.

Session T3: Digital storage oscilloscope, operation and practical activity

The activity this week involves using a digital storage oscilloscope; you need to read the guide provided document, **'week2-lab1'**, for Using the TDS 2002 Digital Storage Oscilloscope (DSO) in Moodle. (**We recommend you to read this document before coming to the second week lab**).
Once this document has been reviewed, you are able to undertake the following practical activity.

Activity 1 A Practical Application in using the TDS 2002B Oscilloscope
In the experimentation that follows we will be investigating the circuit response of the following RC network (figure 8) to a variety of input signals in different frequencies:

Vp-p=6v,
f=1 KHZ

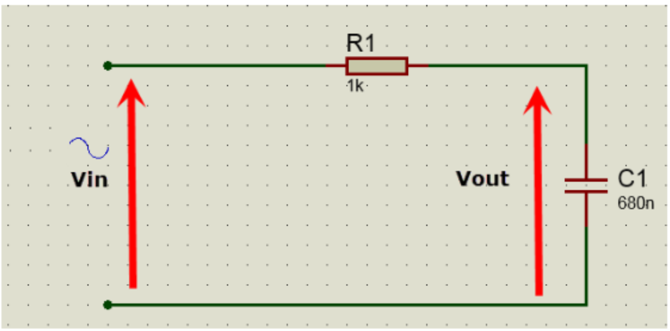


Figure 8. An RC circuit

You need to build this circuit first. The following list of apparatus are required:

Breadboard
Signal/Function generator Instek GFG-8255A or LFM4
Tektronix TDS 2002B Oscilloscope with two scope probes
1k Resistor
680nF capacitor
Breadboard connecting links
BNC connector lead and a set of 4mm leads,

Circuit Building:
Connect the circuit and resistance on the bread board and make a closed circuit loop by connecting the input terminal **Vin** of your circuit to the terminals of the Signal Generator. This input is connected to a Signal Generator. Please find the guide about using signal generators in the document provided; **'Signal Generators and Terminals_Guide'**, in this week folder in Moodle.

The signal source should be set to give a sine wave output with an amplitude of 6 Volts Peak-to-Peak (the amplitude of the sin wave is 3 v), at a frequency of 1 KHz.

You can adjust the signal type and frequency using the ∿ key and **FREQUENCY** knob on the signal generators. For adjusting the amplitude, first you need to visualise the signal using Oscilloscope and then use the '**AMPL**' knob on the signal generator.

Adding Measuring Device to The Circuit:

The Tektronix TDS2002 Digital Storage Oscilloscope will be used to monitor both input and output sides of our circuit.

Channel 1 of the oscilloscope should be connected to the input of our circuit in other words across the Signal Generator terminals. Please use the right scope probes for this connection as some Signals Generators require 4mm terminal connections while others need a BNC connection (see **'Signal Generators and Terminals_Guide'**). Observe correct probe/terminal connections.
Channel 2 of the oscilloscope should be connected to the output of our circuit shown as **Vout** in Figure 8 above.
Figure 9 (a) and (b) below show the corresponding Multisim schematic diagram and the implemented circuit respectively.

Important: Working in a red font input your notes, observations and any calculations into this word document as you undertake your activities work and save it on your H drive.

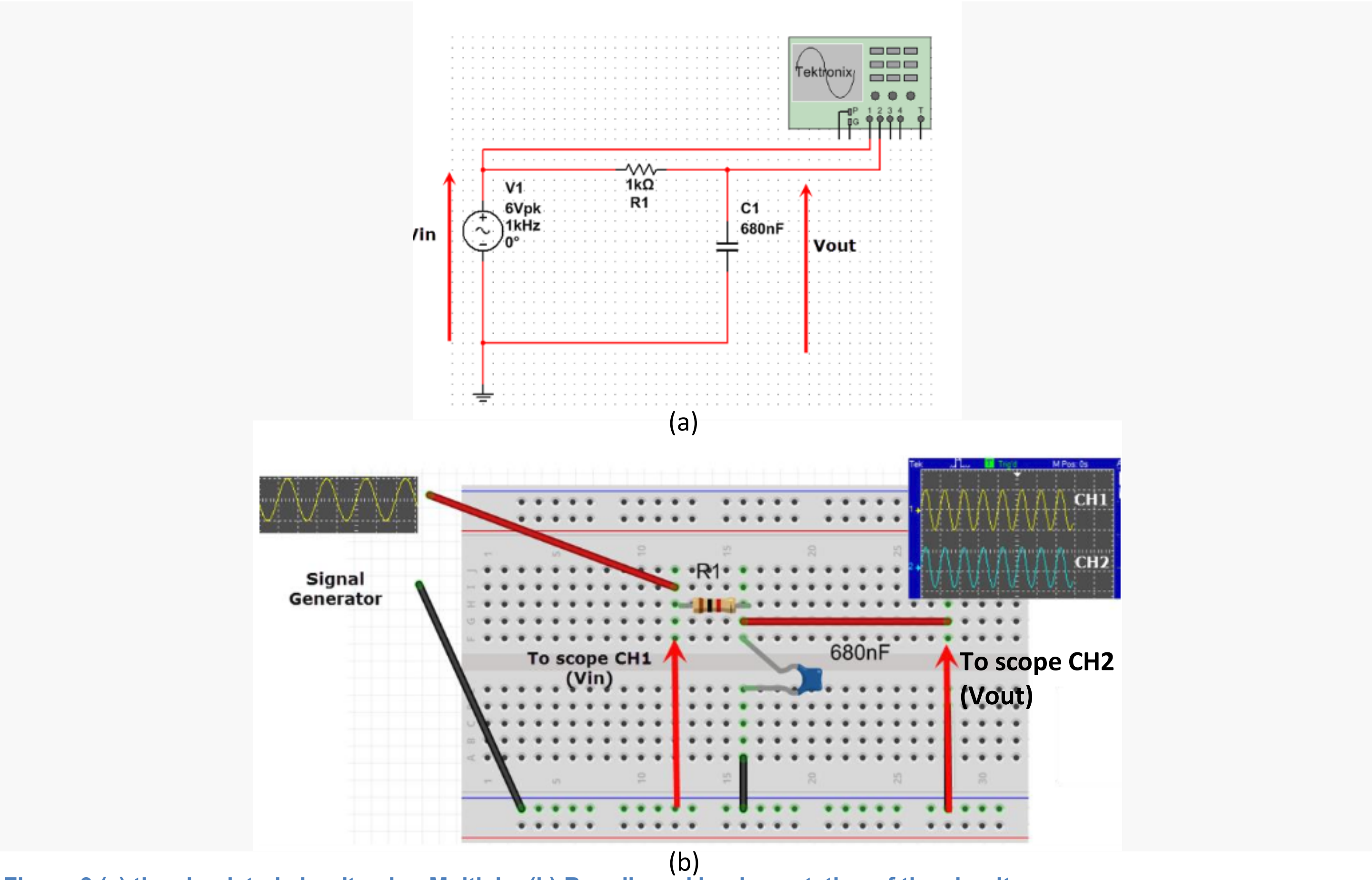


Figure 9 (a) the simulated circuit using Multisim (b) Breadboard implementation of the circuit

Having made the correct circuit connections and referring to the TDS introductory material, address the following questions and reflect including snapshot of your implemented circuit:

1. Using the Cursor Measurement option on your scope to measure **Vin** and **Vout** at **20 Hz**, **1kHz** and **10 kHz**. (you need to use vertical and horizontal knobs including VOLTS/DIV and SEC/DIV selection knobs as well as POSITION knobs to achieve appropriate display of signals.)
   - Produce a table of your readings.
   - Capture a small evenly distributed selection of your waveforms using the Tektronix **OpenChoice** waveform capturing software on your PC. (search for **OpenChoiceDesktop** on your PC and use the guide provided on page 19 of **Week2_Lab1** document in Moodle) and include the images in your logbook report with appropriate captions.Discuss your observations of the waveforms captured.(explain the filtering behaviour of your circuit. What is the circuit function?)
   - Using the Time Cursor Measurement option of your scope position cursor1 on the V **peak** of your input waveform and cursor 2 on the V**peak** of your output waveform and measure the Δt at **20 Hz** and **10 kHz**. (see page 14 of **Week2_Lab1** for curser measurement guide). Discuss about the changes (connect it to the filtering behaviour)
   - Show Δt on your captured waveforms.

2. Change the Signal Generator settings so that your input is now a **square** waveform. In order to do this you will need to make the appropriate selection of the Function Switch Settings on your Signal Generator.

   - Set the Generator frequency to 5 KHz and the Generator output to 5 volt Peak-to-Peak. Capture a screenshot showing the Vin and Vout waveforms (annotate and include your snapshot in your report). Observe and discuss

Important: Working in a red font input your notes, observations and any calculations into this word document as you undertake your activities work and save it on your H drive.

your findings. What is the circuit function? (connect the observation into capacitor charge and discharge process)

3. Exchange the positions of the resistor with that of the capacitor and vice-versa and select a sine wave input form the function selection switches of your Signal Generator. Repeat the same steps you did above only for **sine** wave signal, but this time take readings/measurements at (50 Hz, 1kHz and 10 kHz). Visualise your annotated snapshots and discuss your findings.

4. Select the Triangular waveform function setting. Observe the output response of your circuit in the same frequencies. Visualise your annotated snapshots and discuss your findings.

Please see other relevant material and extra tasks in the Moodle web

Aim: Practical Application in using the TDS 2002B Oscilloscope.

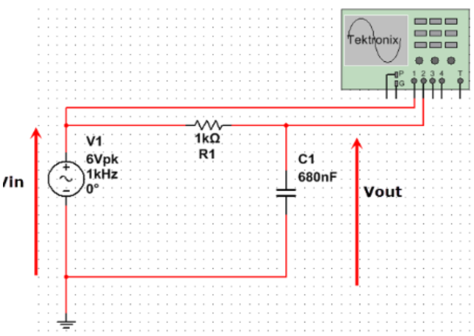
Introduction: An oscilloscope is an electronic device that helps us to see the change in signals or voltages in a wave form. It has two input channels which enables us to receive signals. The type of oscilloscope we are dealing with is The Tektronix TDS2002 Digital Storage Oscilloscope. The special feature that this one has is that the digital signals can be stored and manipulated in various ways. Another advantage is the presence of peripheral ports which allows the oscilloscope to be connected to other devices like Computer Systems or even flash drives. Also it helps us to measure rise times, which is basically the time it takes for a signal to go from a low value to a high value. It also enables us to measure fall times which it is the time it takes for a signal to drop to 10% of its peak value.

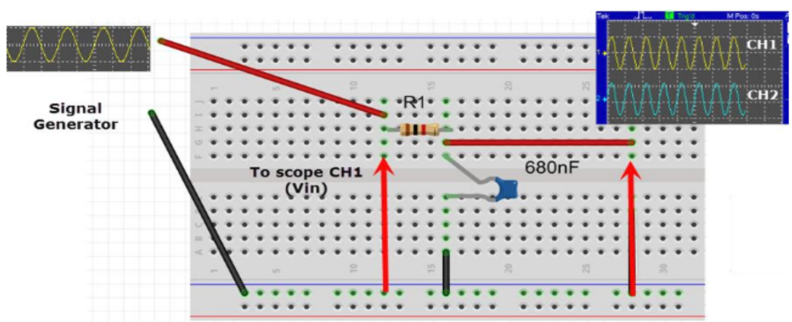
Apparatus:

1. Breadboard
2. Signal/Function generator Instek GFG-8255A or LFM4
3. Tektronix TDS 2002B Oscilloscope with two scope probes
4. 1k Resistor
5. 680nF capacitor
6. Breadboard connecting links
7. BNC connector lead and a set of 4mm leads

Experimental Procedure to build the Circuit:

1. Connect the circuit as shown in the breadboard and multism simulation below:





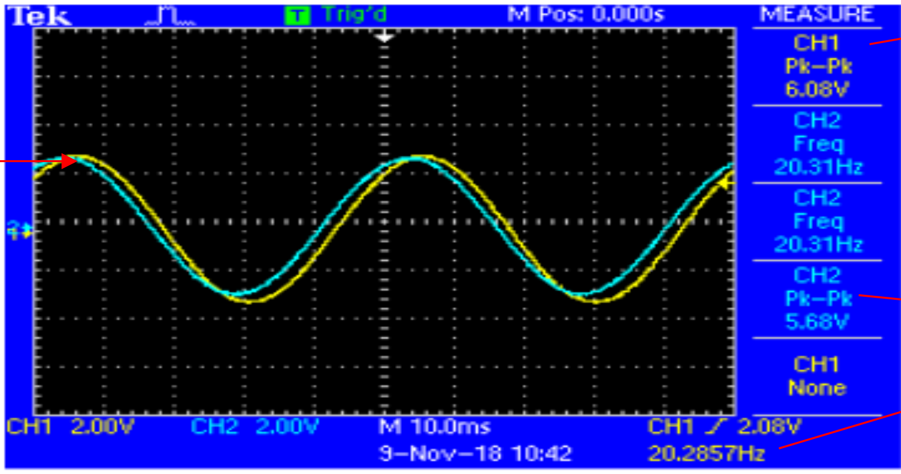
2. Set the signal source to produce a sine waveform and a 6 volts peak-peak amplitude.
3. The channel 1 of the oscilloscope should be connected across terminals of the signal generator.
4. The channel 2 of the oscilloscope should be connected to the output of the circuit.
5. Use the cursor measurement option on the oscilloscope to measure the Vin and Vout at the following frequencies: 20 Hz, 1Khz and 10Khz
6. Tabulate the measured readings
7. Use the openchoice Desktop application to take screenshots of waveforms acquired and show

Results:

20Hz

Important: Working in a red font input your notes, observations and any calculations into this word document as you undertake your activities work and save it on your H drive.

The Yellow waveform shown represents the input from the Signal generator, the blue waveform represents the output. At a frequency of 20 Hz, the signals are similar.



TDS 2002B - 11:35:12 09/11/2018

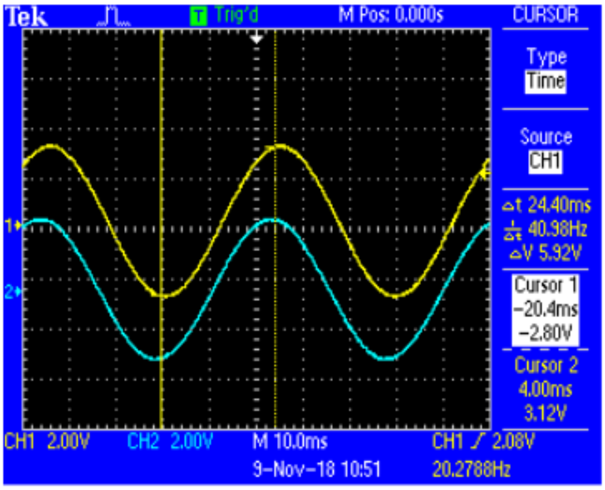
Peak to peak for channel 1

Peak to Peak for channel 2

Frequency of 20Hz from Signal Generator

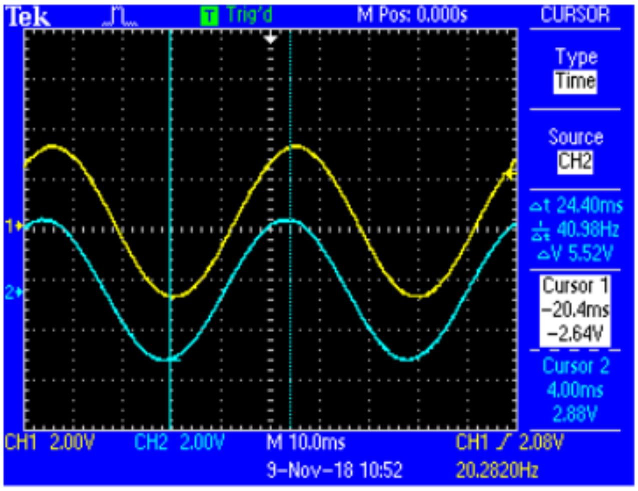
Waveforms showing Δt For 20Hz:

Channel 1:



TDS 2002B - 11:44:21 09/11/2018

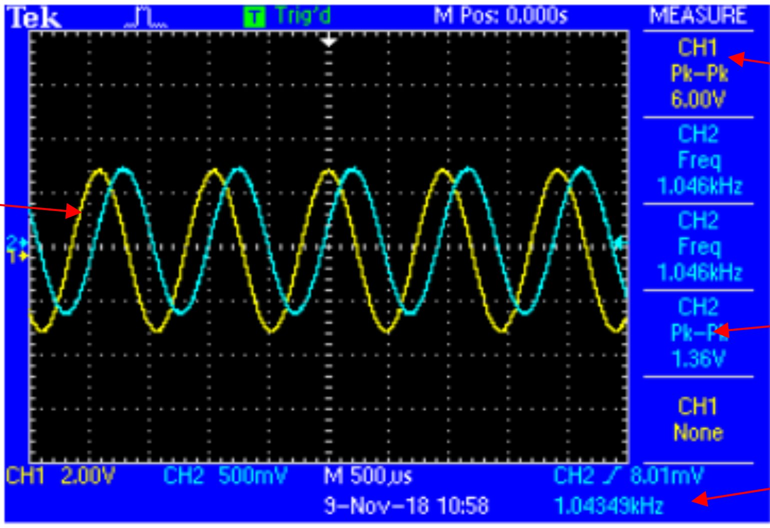
Channel 2:



TDS 2002B - 11:45:01 09/11/2018

1 KHz:

The Yellow waveform shown represents the input from the Signal generator, the blue waveform represents the output. At a frequency of 1 KHz, the signals are dissimilar. The peak to peak also vary.



TDS 2002B - 11:50:55 09/11/2018

6 Volts peak to peak for channel 1

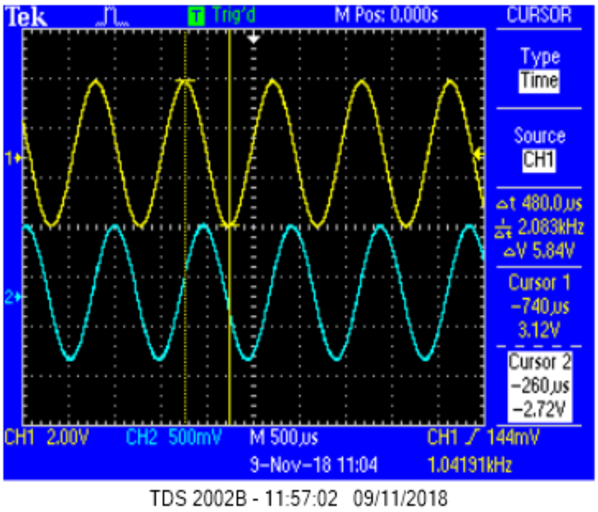
1.36 volts peak to peak channel 2

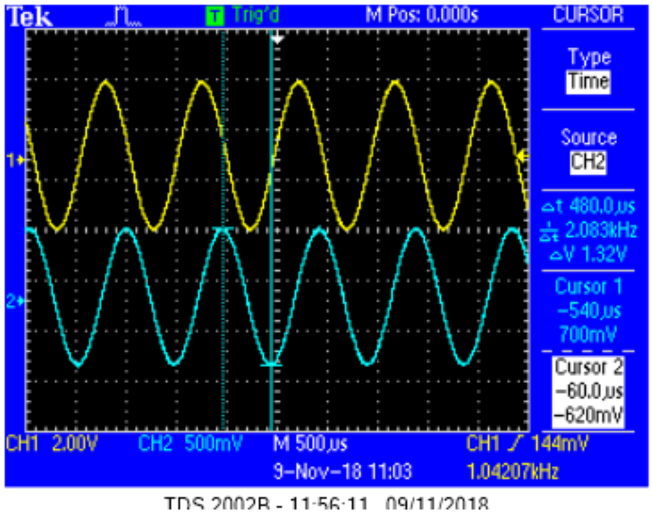
Frequency of 1 KHz from Signal generator

Important: Working in a red font input your notes, observations and any calculations into this word document as you undertake your activities work and save it on your H drive.

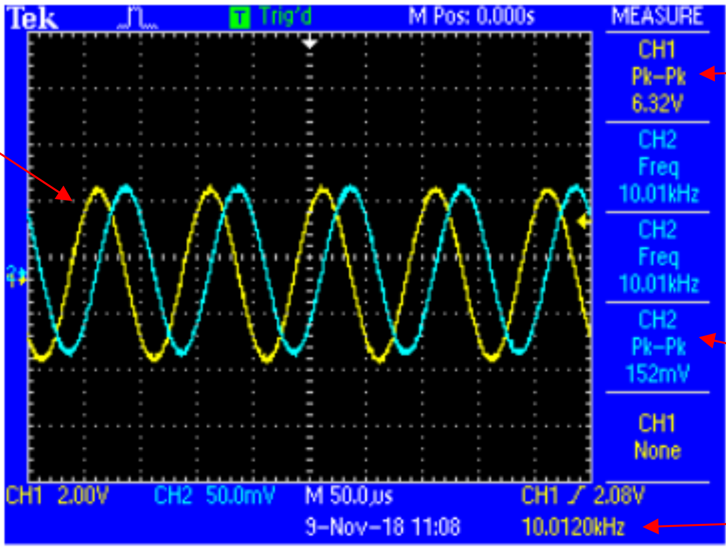
Waveforms showing Δt For 1KHz:

Channel 1 **Channel 2**





The Yellow waveform shown represents the input from the Signal generator, the blue waveform represents the output. At a frequency of 10 KHz, the signals are very dissimilar The peak to peak also varies. The input pk is 6.32V while the output Pk is 152mV



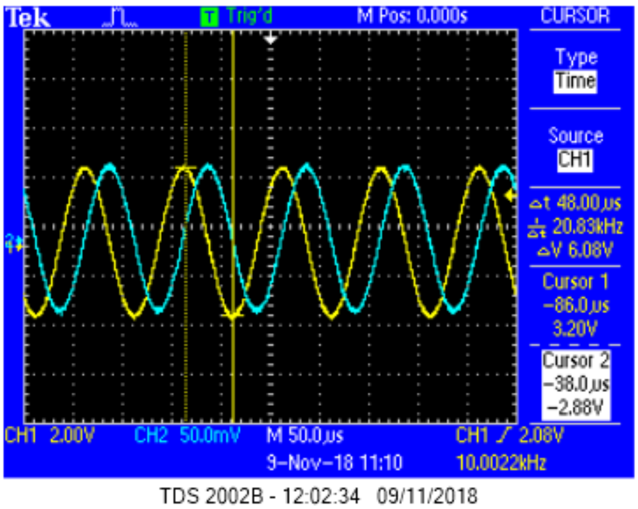
6.32Volts Pk-pk for channel 1

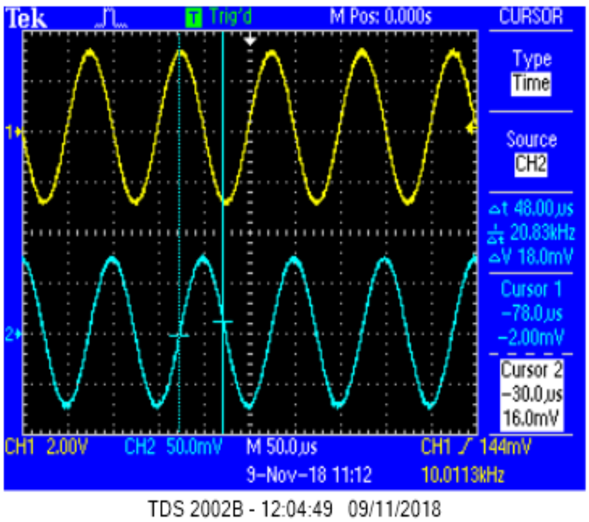
152mV Pk-pk for channel 2

10 KHz frequency from signal generator

Waveforms showing Δt For 10KHz:

Channel 1 **Channel 2**





Important: Working in a red font input your notes, observations and any calculations into this word document as you undertake your activities work and save it on your H drive.

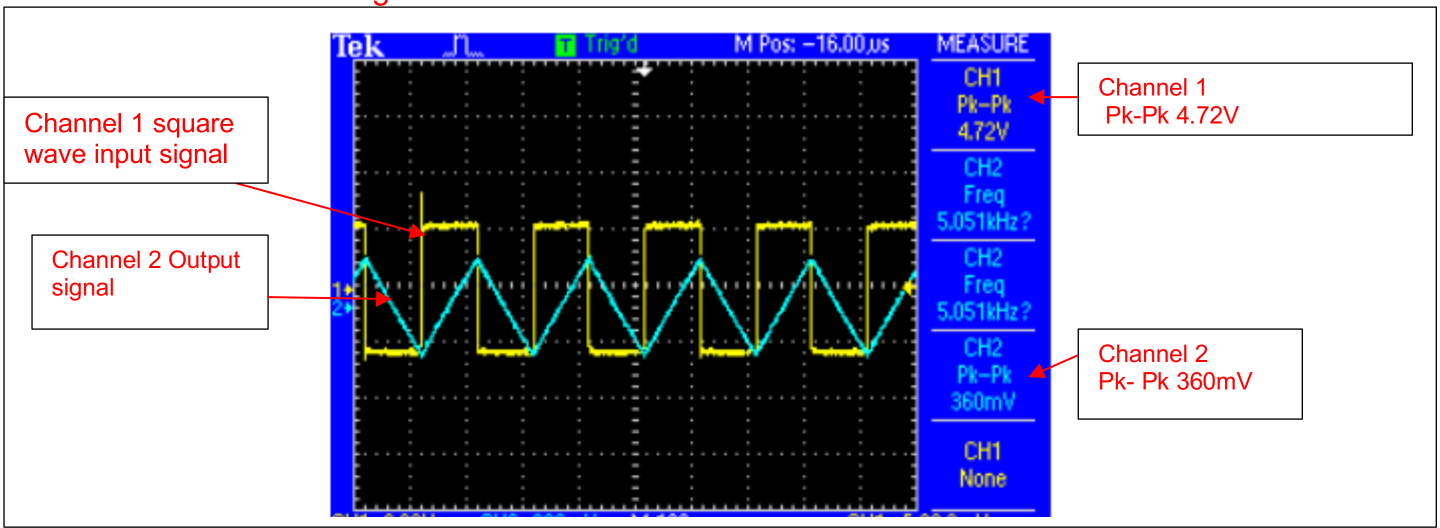
Frequency (Hz)	Voltage Out (Volts)	Voltage In (Volts)
20 Hz	5.68 Volts	6.08 Volts
1 KHz	1.36 volts	6 Volts
10 KHz	152 mv	6 Volts

Discussion:
The function of the circuit is to act as a filter.
The three waveforms above all have a different filtering behaviour. Filtering behaviour refers to the nature at which circuits pass signals in certain frequency range and avoids the rest which almost leads to a zero output. In the first filter circuit at 20Hz, it is observed that the circuit acts a low pass filter because it completely passes out all the signals at that frequency. The position of the sine wave also confirms that. As the frequency increases to 1 KHz and 10 KHz, it is observed that the output voltage is reduced. This reconfirms that the circuit is a 'Low pass Filter' because it passes out low frequencies and avoids the rest in higher frequencies. The peak to peak values also emphasize that point. The peak to peak values for the output signal varies largely as the frequency is increased in relation to the input signal.

(2)

Experimental Procedure:

1. Change the input generator settings to a square waveform.
2. Set the generator frequency to 5 KHz and set the peak-peak voltage to be 5V.
3. Using the OpenChoiceDesktop take a screenshot and annotate the diagram and further discuss on the readings.



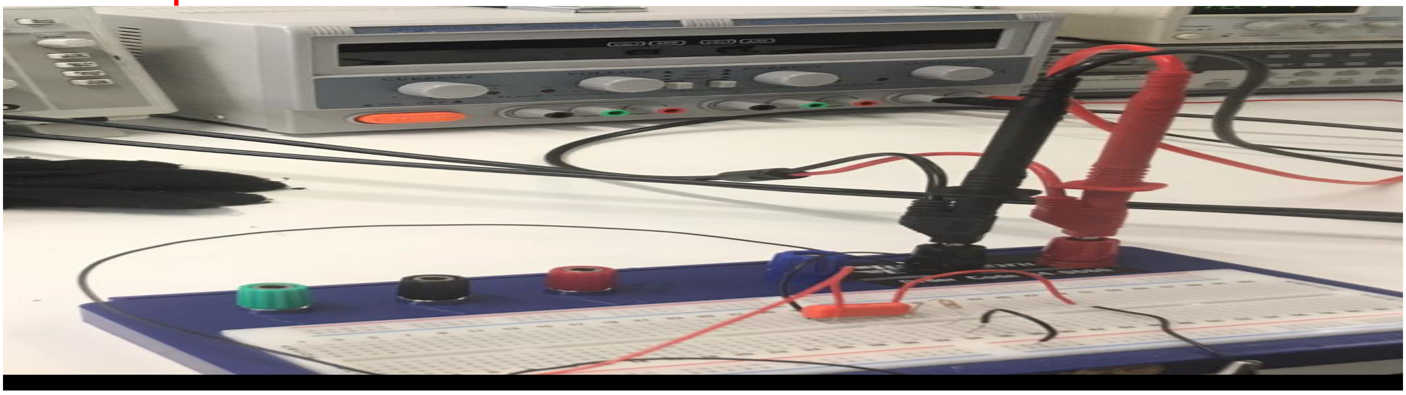
Discussion:
The above circuit is basically an RC circuit (Resistor-Capacitor) which is driven by 5 voltage power supply. The input Frequency is at 5.051 KHz. The function of the circuit is to act as low pass filter which filters certain frequencies and allows the rest to pass through. The triangular waveform above is observed to consist of alternate but equal positive and negative ramps. It also shows that as the capacitor is fully charged the output voltage would be 0. The charge and discharge of the capacitor also accounts for the rise and fall time of the triangular wave form.

Im
word document as you undertake your activities work and save it on your H drive.

Experimental Procedure:

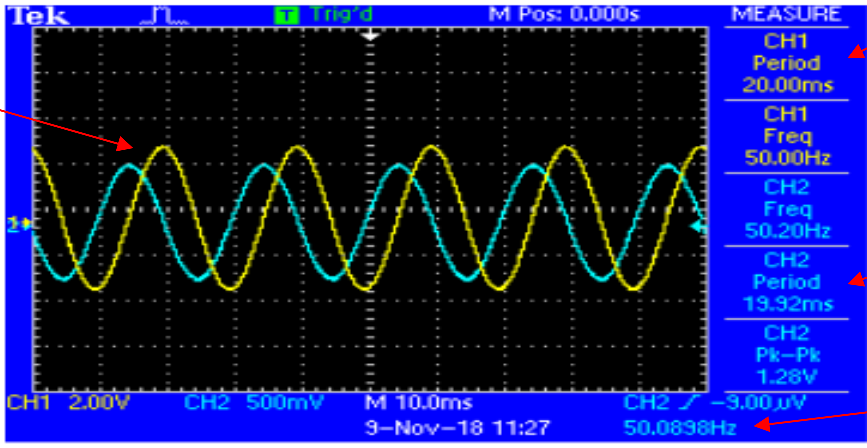
1. (Connect the circuit as shown in the circuit snapshot below.)
2. Select a sine- wave function from the signal generator.
3. Take Time readings and measurements at 50Hz, 1 KHz and 10 KHz.
4. Take appropriate snapshots and annotate them accordingly.

Circuit Snapshot:



Waveform at 50Hz

The yellow waveform represents the input signal while the blue waveform represents the output signal. The peak to peak voltages also varies.



TDS 2002B - 12:20:02 09/11/2018

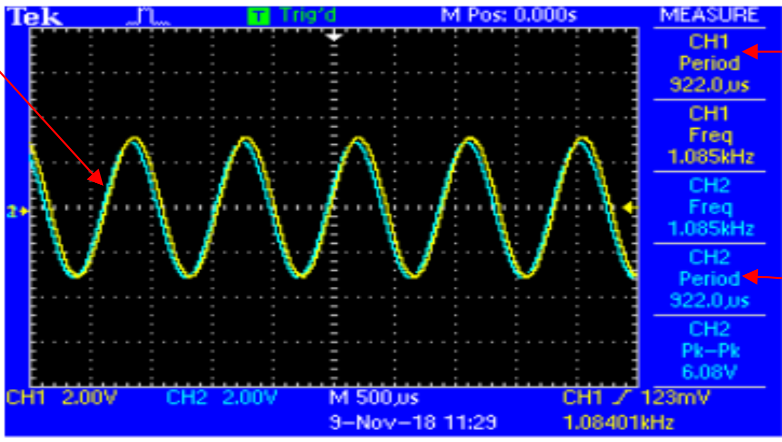
Channel 1 period

Channel 2 Period

Input frequency from generator

Waveform at 1 KHz

The yellow wave from represents the input signal while the output signal is the waveform in blue.is the output voltage. The two waveforms are very similar. The filter here acts a high pass filter.



TDS 2002B - 12:22:07 09/11/2018

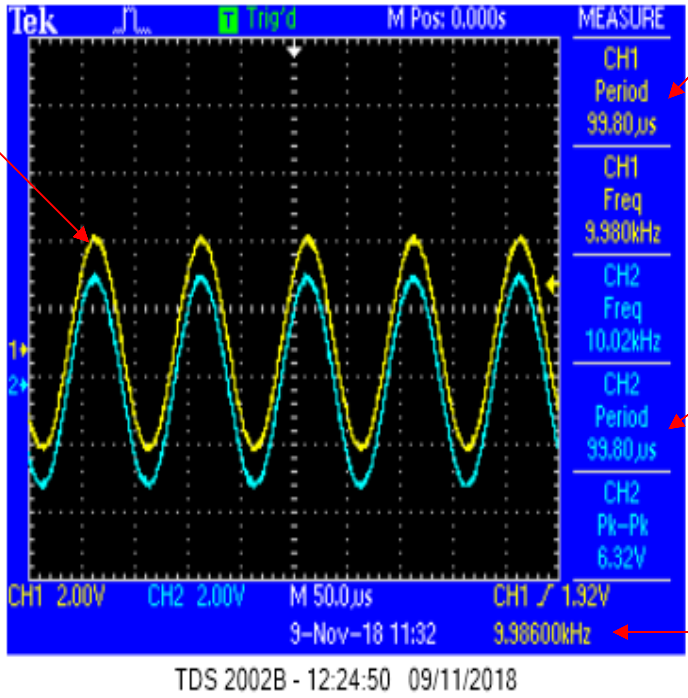
Period of 922.0μs for channel 1

Period of 922.0μs for channel 2

Important: **Working in a red font input your notes, observations and any calculations into this word document as you undertake your activities work and save it on your H drive.**

Waveform at 10 KHz

The yellow waveform represents the channel 1 input signal while the blue waveform represents the output signal. The peak to peak for both waveforms are very similar as observed on the graph on the right.



Period of 99.80µs for channel 1

Period of 99.80µs for channel 2

frequency of 10KHZ from the signal generator

Discussion:

While undergoing the experiment, the resistor and the capacitor were exchanged as observed in the circuit diagram above and what was observed was that the filtering behaviour of the circuit allowed it to pass high frequencies implying that the circuit acted as a '**High Pass Filter'**. This is because frequencies with high values i.e. 1 KHz and 10KHz were passed through and those with smaller frequencies i.e. 50Hz were filtered out.

Frequency (Hz)	**Pk-Pk Channel 1 (Volts)**	**Pk-Pk Channel 2 (Volts)**	**Period Channel 1 (s)**	**Period Channel 2 (s)**
50 Hz	6.08V	1.28V	20.00ms	19.92ms
1 KHz	6.10V	6.32V	922.0µs	922.0µs
10 KHz	6.74V	6.32V	99.80µs	99.80µs

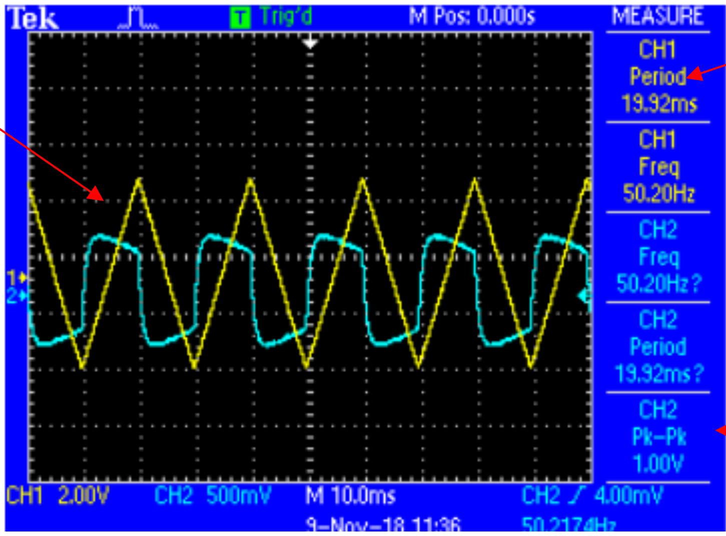
Important: Working in a red font input your notes, observations and any calculations into this word document as you undertake your activities work and save it on your H drive.

Experimental Procedure:

1. Select the triangular waveform function from the signal generator.
2. Observe the output of the circuit for the following frequencies : 50Hz, 1Khz and 10KHz

Triangular Waveform at 50Hz

The yellow triangular waveform is the input signal while the irregular blue waveform is the output signal. The peak to peak for both signals also differs.

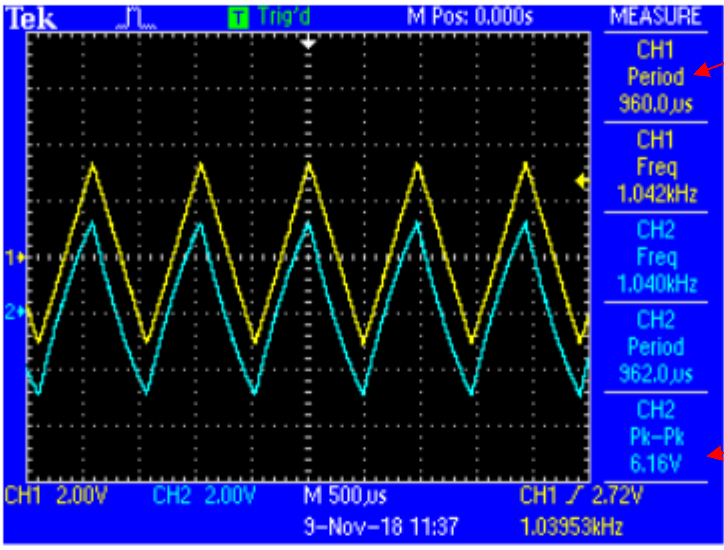


Period of 19.92ms for channel 1

Pk to Pk for channel 2

Triangular waveform at 1KHz

The yellow triangular waveform is the input signal. While the blue waveform is the output signal. It is also noticeable that the output voltage has a lag at its peak.



TDS 2002B - 12:29:34 09/11/2018

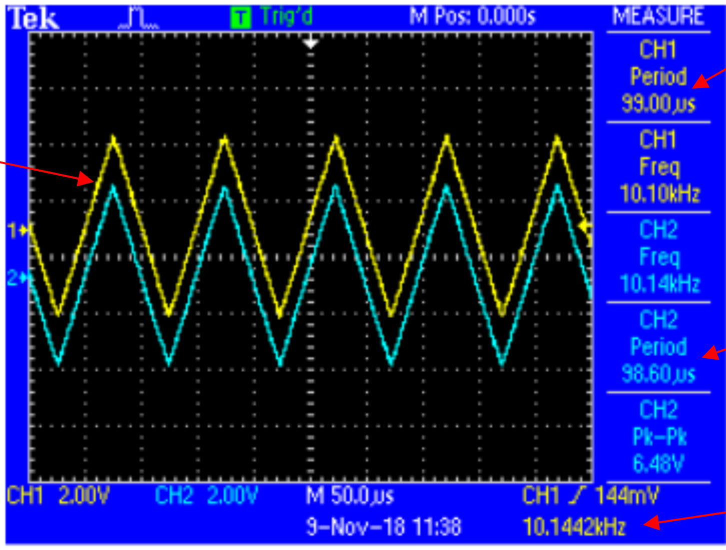
Period of 960.00 µs for channel 1

Pk to Pk of 6.16V for channel 2

Important: **Working in a red font input your notes, observations and any calculations into this word document as you undertake your activities work and save it on your H drive.**

Triangular waveforms at 10KHz

The yellow waveform is the channel 1 input signal while the blue one is the output signal is the blue triangular waveform. Both waveforms are very similar and peak to peak values are similar as well



TDS 2002B - 12:31:10 09/11/2018

Channel 1 period of 99.00μs

Channel 2 period of 98.60μs

Frequency of 10Hz from signal generator

Conclusion: the circuit above was seen to be a filter which allows high frequencies to pass through and filters frequencies with low values. An error that may have occurred during the experiment was that the input pin was not fully pressed into the breadboard and when this was discovered the experiment had to be repeated.

Important: Working in a red font input your notes, observations and any calculations into this word document as you undertake your activities work and save it on your H drive.

Session T4: Testing an optical signalling system (LDR System)

The theme of this week's activity is that of testing the LDR light measurement system under dynamic conditions.

Before you make this test you are required to make a calculation for a resistance value (see Activity 1) and then adapt your current circuit to that as shown in figure 10.

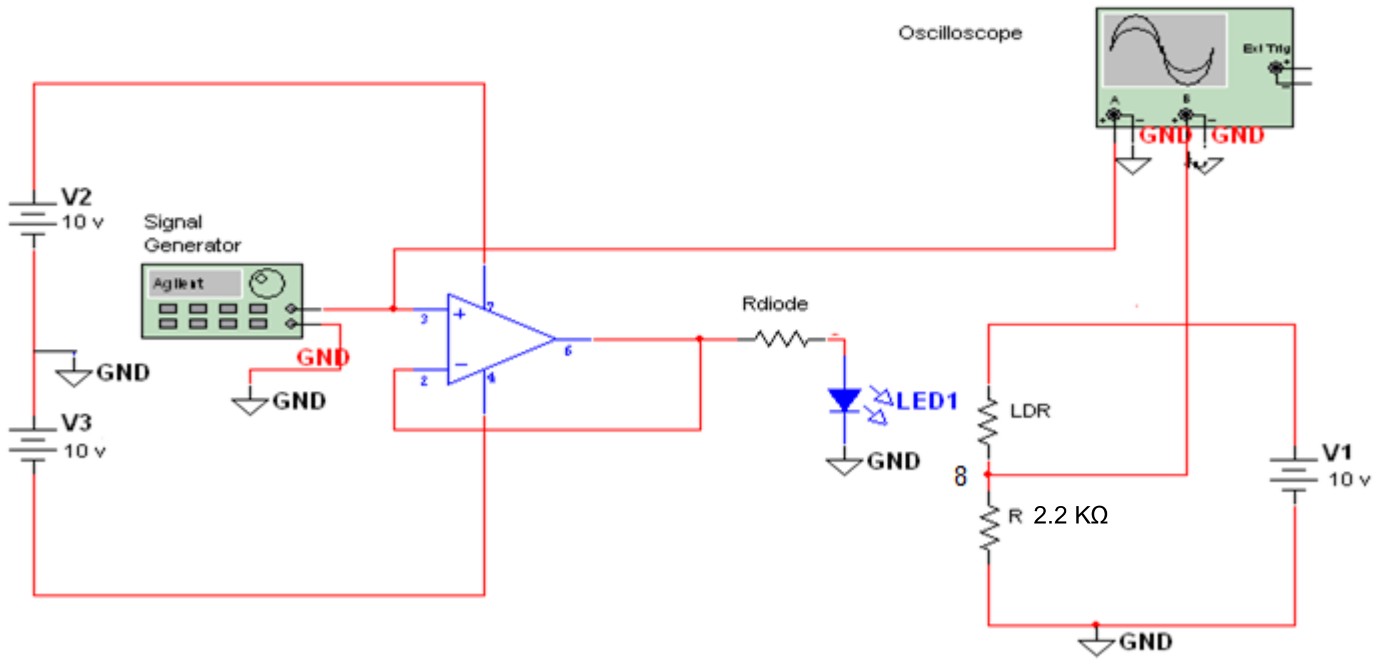


Figure 10

The circuit above shows detail of the system that will be used to investigate the dynamic response of the LDR optical receiver.

<u>Activity 1</u> Determine the Value of R_{diode}

Assuming that the LED will be driven by a TTL pulse train, 5 volts (logic 1) and 0 volt (logic 0), it is important to limit (via the use of a resistor R_{diode}) the current flowing through the Led when it is forward biased.

- Search in internet for the provided ***white LED C535A-WJN-CU0V0231*** and look in its data sheet table for forward current, I_f and voltage V_f, then Calculate the value of R_{diode}.

Please see other relevant material and extra tasks in the Moodle web

Aim: Determine the value of R_{diode}

Experimental Procedure:

1. Search the web for '*white LED C535A-WJN-CU0V0231*'
2. Look in its data sheet for the voltage and forward current
3. Calculate the value of R_{diode}

Results:

5 =Rx.If.V

5= Rx (20*0.001) + 3.2

Which means, Rx = 90ohms

Discussion: The light emitting diode has typical & electrical characteristics some of which include: A current condition of 20mA and a typical voltage of 3.2Volts. This is then used to calculate the value of the R_{diode}. Sharifzadeh, S. (2018) Testing An Optical Signalling System [Online Lecture] module 102SE, 15th November. Coventry: Coventry University. Available from https://cumoodle.coventry.ac.uk/pluginfile.php/2432370/mod_resource/content/1/Week3_Lab1.pdf [15th September 2018]

Activity 2 The Bit Stream Bandwidth Test

After confirmation that R_{diode} value is correct, build the circuit on the proto board.

- Connect the signal generator to node 3 and ground
- Connect the oscilloscope Ch1 and Ch2 as shown.
- Adjust the output frequency of the generator to TTL at 1 Hz (we are using TTL to simulate a digital bit stream).

Note: there will be a need to adjust the alignment and distance between the LED and LDR also it may be advisable to create a paper cover to mask out ambient light etc.

- Include a snap shot of your circuit implementation to your report.
- Observe the waveforms at Ch1 and Ch2 and include your annotated snapshots to your report. (you might need to use the RNU/STOP bottom on the Oscilloscope to fix the signal condition for your measurements. You can use the **OpenchoiceDesktop** software for saving the displayed signals).
- Incrementally increase the generator frequency observing the effect of each increase on the waveform observed at nodes 3 (Ch1) and 8 (Ch2). Use the **automatic measurement** of the Oscilloscope to find the rise time and fall time of the output signal at 10Hz,50 Hz and 1KHz (see page 12 of **week2-Lab1** document about **measurement** menu). Visualize the results.

Please see other relevant material and extra tasks in the Moodle web

Aim: Investigating the dynamic response of the LDR optical receiver.

Introduction:

We would be investigating the dynamic response of the light dependent resistor in relation to the receiver. The illumination would vary in relation to the TTL signal generator. We would be using a C535A-WJN-CU0V0231 white LED. The longer end of the terminals would be the anode and the shorter end would be the cathode. As calculated in the previous activity, the forward voltage for the LED is 3.2V and a corresponding forward current of 20mA. So for this experiment as stated we would be investigating the response of LDR receiver, a good way of measuring this change would by measuring the Rise and fall time.

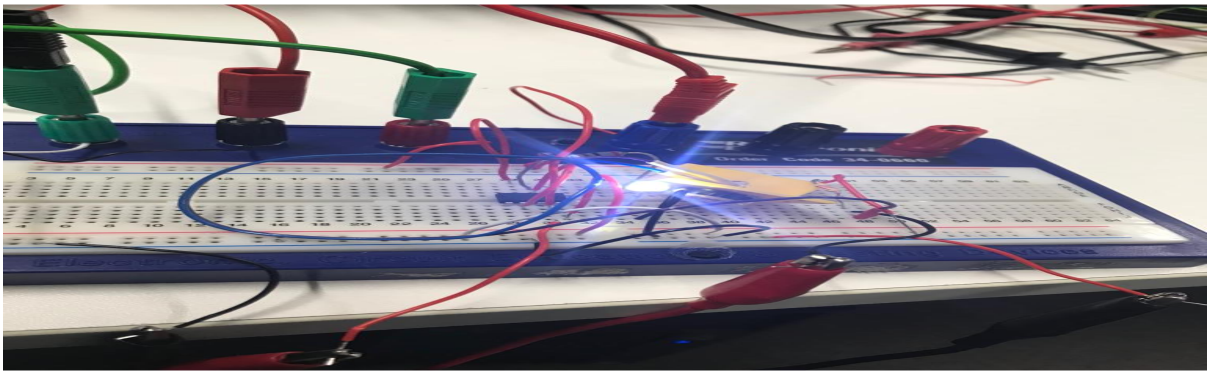
Rise time is basically the total time taken for a signal to change from a low value to a high value. This is mainly taken from **10%** and **90%** of the total pulse.

While for the fall time, it is the total time taken for a signal to change from a high value to a low value. This is most times **10%** of the maximum value.

Methodology: The various steps used in implementing the circuit include:

1. Build the circuit as shown in the snapshot below
2. Observe the waveforms at Channel 1 and Channel 2.
3. Annotate the snapshots appropriately
4. Measure the frequency at 10Hz, 50Hz and 1 KHz and use the measure feature on the Oscilloscope to measure the rise and fall time.

Snapshot:



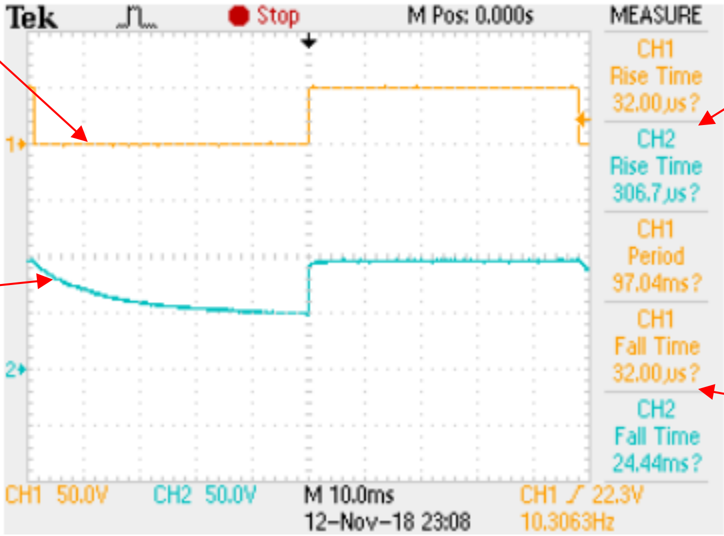
Important: Working in a red font input your notes, observations and any calculations into this word document as you undertake your activities work and save it on your H drive.

Results:

Waveform at 10Hz

Output from Node 3 (Channel 1)

Output from Node 8 (Channel 2)

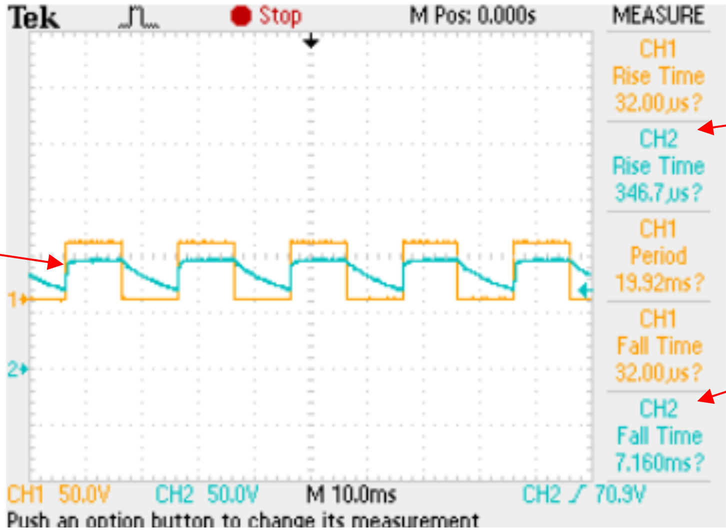


The time taken for both channels signal to change from a low value to high value

The total time taken for both channel signals to drop to 10% of its maximum/peak value

Waveform at 50Hz

They yellow waveform represents the output at node 3(Channel 1) and the blue waveform represents the output at node 8 (Channel 2)

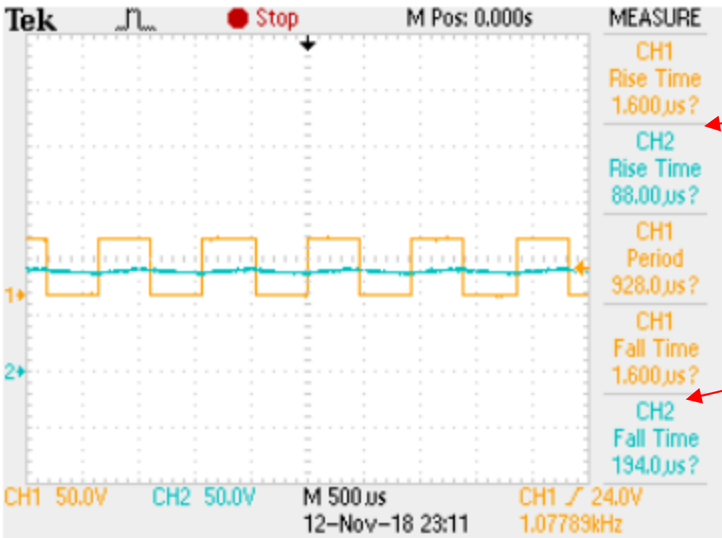


The time taken for both channels signal to change from a low value to high value

The total time taken for both channel signals to drop to 10% of its maximum/peak value

Waveforms at 1 KHz

They yellow waveform represents the output at node 3(Channel 1) and the blue waveform represents the output at node 8 (Channel 2)



The time taken for both channel signal to change from a low value to high value

The total time taken for both channel signals to drop to 10% of its maximum/peak value

Important: Working in a red font input your notes, observations and any calculations into this word document as you undertake your activities work and save it on your H drive.

Table showing Rise and Fall Times at different frequencies

Frequency (Hz)	Rise Time (Channel 1) (s)	Fall Time (Channel 1) (s)	Rise Time Channel 2 (s)	Fall Time Channel 2 (s)
10.00	32.00µs	32.00µs	346.7µs	24.44ms
50.00	32.00µs	32.00µs	306.70µs	7.160ms
1000.00	1.600µs	1.600µs	88.00µs	1.600µs

Discussion: The experiment was undertaken as enlisted in the methodology. The output from node 3 was connected to the first channel of the oscilloscope while the output from the node 8 was connected to the second channel of the oscilloscope. At 10Hz, the output is not ideal, but good. The rise time for channel 2 at 10Hz was 306.7µs while the fall time was 23.44ms. And also at 50Hz, the rise time for channel 2 at 50Hz was 346.70µs while the fall time was 32.00µs. Lastly, the rise time for channel 2 at 1 KHz was 88.00µs while the fall time was 194.0µs. What is easily observed on the waveforms above is that the output signal tends to decrease as the frequency increases. For instance, at 1 KHz the waveform is almost a straight line.

Conclusion: While undergoing the experiment possible errors that may have occurred include the fact that the light level wasn't even and a paper cover had to be used to mask out ambient light. After doing these two other experiments were taken and an average was taken to reduce error level. From the above measurements the LDR-LED are a good in terms of its communication performance but is not an ideal communication form.

Important: Working in a red font input your notes, observations and any calculations into this word document as you undertake your activities work and save it on your H drive.

Session T5: Improving optical signalling system

From our previous measurements (Session T4), we can clearly see the limitations of the communication performance of the system using the LED-LDR arrangement. Communication speed can be greatly improved by choosing components that will be fitting for this. In this task, the Infrared Emitting Diode (**RAPID 58-0320**) and the matching IR Photodiode **(Rapid 58-0115)** are used here, replacing the normal LED and the corresponding LDR receiver component. These two components give a faster response to the signal changes and at the same time provide immunity to interference from ambient light conditions.
(See Moodle page for the data-sheets)

<u>Activity 1:</u> The Bit Stream Bandwidth Test
The Fig. 10 shows the schematic of Infrared-photodiode communication circuit. Using the schematic, develop a circuit in breadboard to test the performance of the communication system. Follow all the steps in the T4 to obtain the following results:

- Re-calculated the value for R1 by consulting your data (check T4 for the details).
- Repeat the measurements as previously taken and calculate rise and fall times. Ensure that you capture required waveforms using the OpenChoice desktop software.
- Identify the highest frequency that your system will respond to?
- Discuss your findings and make comparison with LED-LDR results.

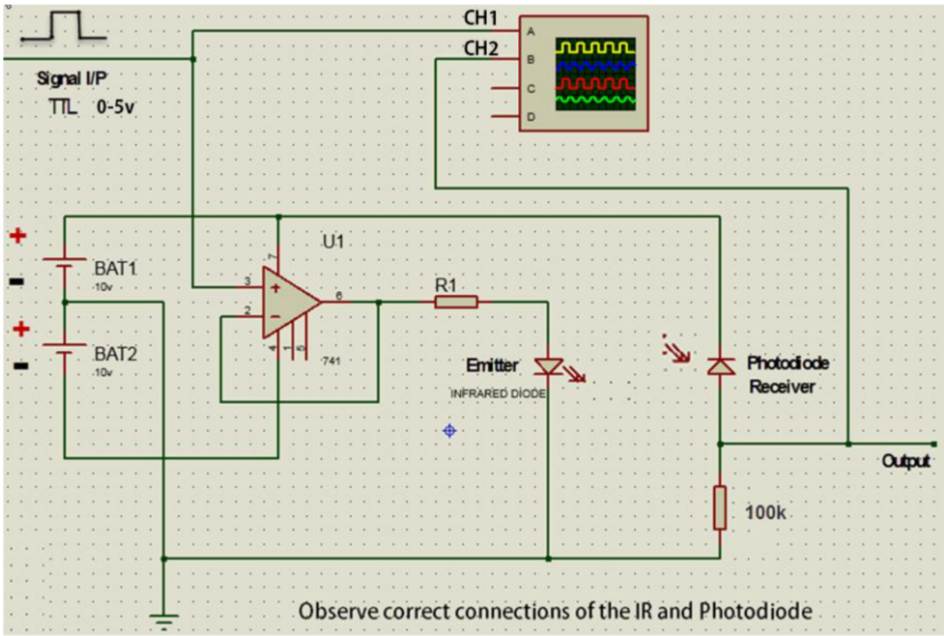


Figure 10: Infrared (IR) communication schematic diagram

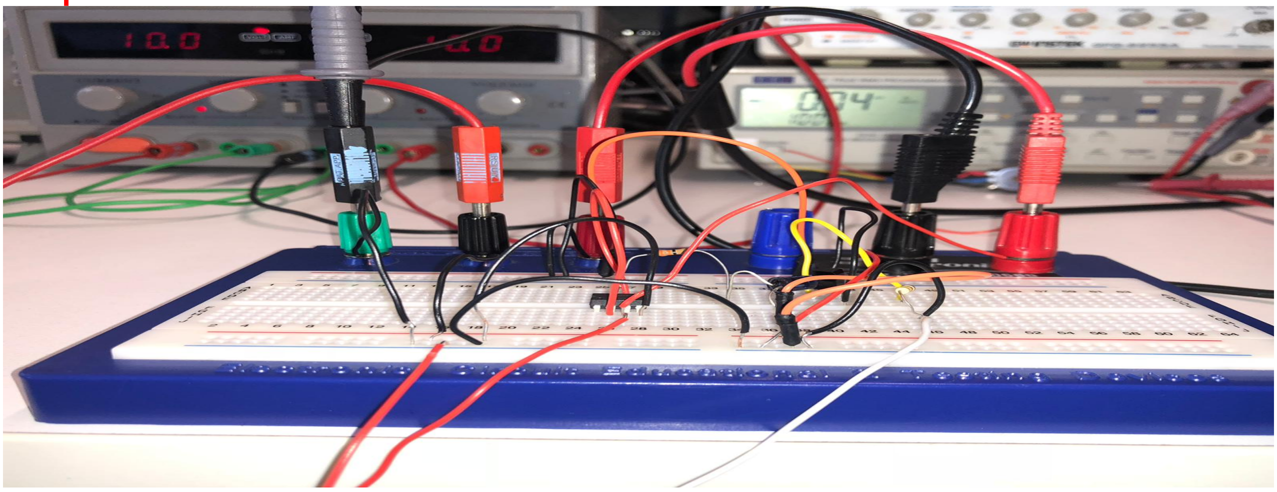
Please see other relevant material and extra tasks in the Moodle web
Aim: Improving the Optical Signalling System
Introduction:
In the previous session, we worked with an LDR and LED in order to help improve the optical signalling system. In this, session we would work with an infrared diode emitter and also with a photodiode receiver. A few features of the infrared diode include that it has blue transparent lens and also that it follows and complies with rules set by the Restriction of Hazardous Substances Directive (RoHS). Rapid (2007) *Rapid Data Sheet* [Online]. Available from https://www.rapidonline.com/pdf/58-0320.pdf [16th September 2018]. In relation to the Photodiode receiver a few feature of it is that it has an active face which is very 'light sensitive'. Rapid (2007) *Rapid Data Sheet* [Online] Available from https://www.rapidonline.com/pdf/58-0115.pdf [16th September 2018].

Methodology:

The various steps implemented include:

1. Recalculate the value of R1
2. Take appropriate waveforms and annotate them appropriately
3. Identify the highest frequency that that the system will respond to
4. Compare readings to those obtained while using an LED-LDR system

Snapshot of Circuit:



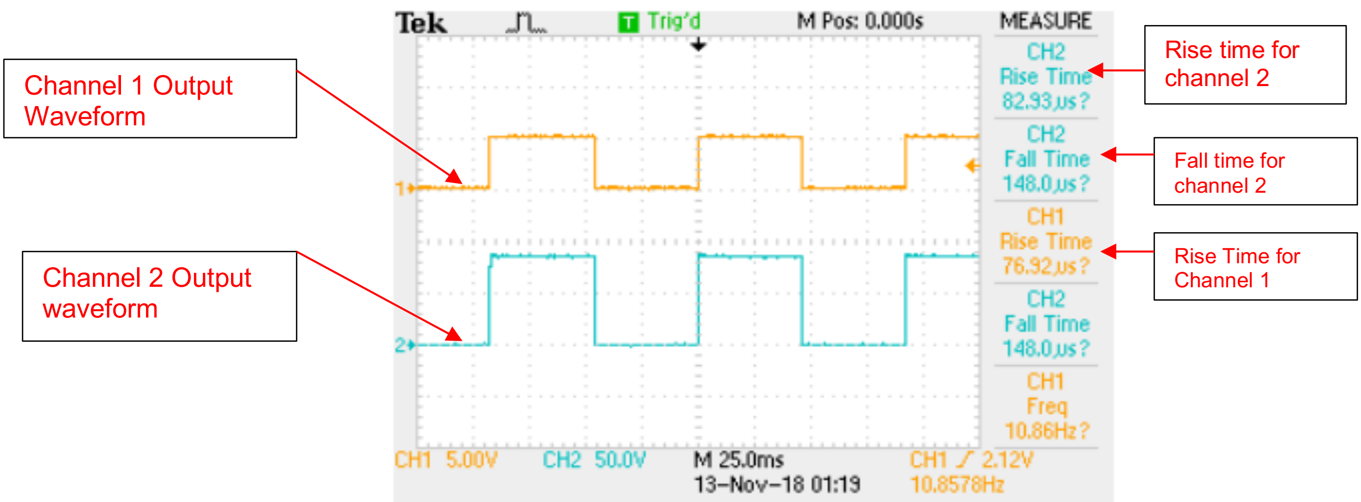
Apparatus:

1. Bipolar Power Supply Unit
2. 741 IC Operational Amplifier
3. Breadboard
4. Signal/Function generator Instek GFG-8255A or LFM4
5. Tektronix TDS 2002B Oscilloscope with two scope probes
6. infrared diode
7. Photodiode receiver

Results:

Ask how they got the calculation for r1

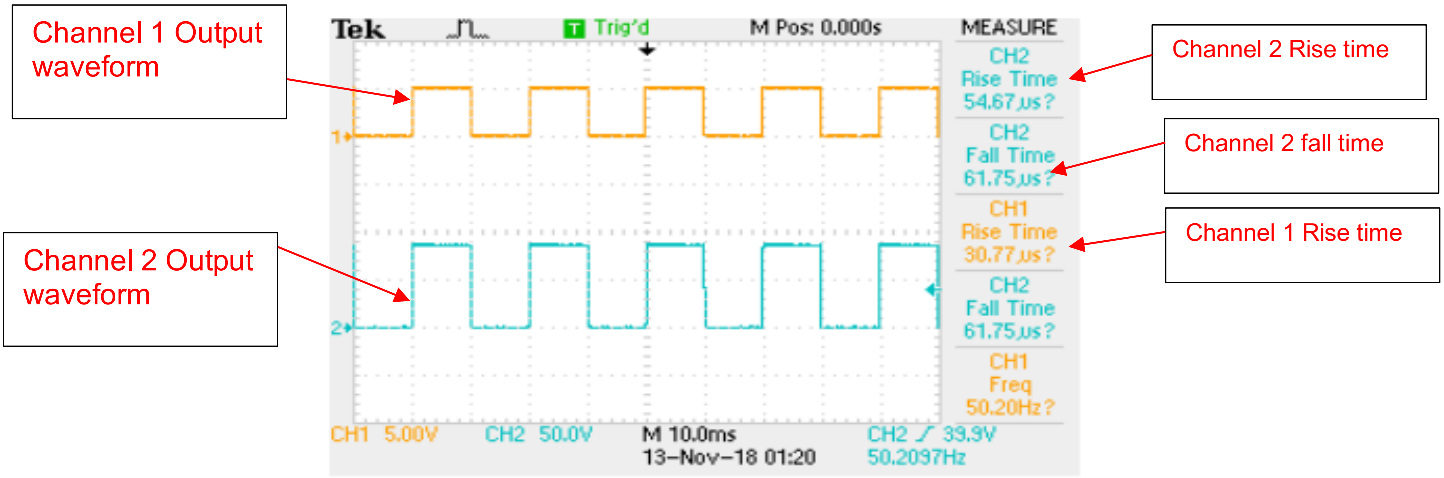
Waveform at 10Hz



TDS 2002C - 17:53:32 12/11/2018

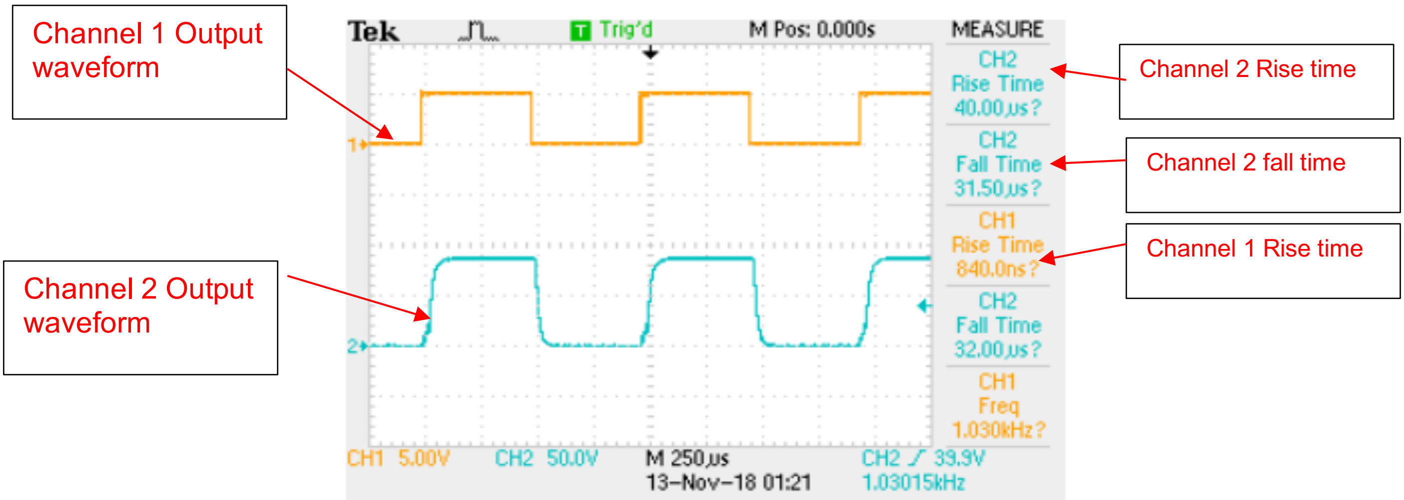
Important: Working in a red font input your notes, observations and any calculations into this word document as you undertake your activities work and save it on your H drive.

Waveform at 50Hz



TDS 2002C - 17:54:49 12/11/2018

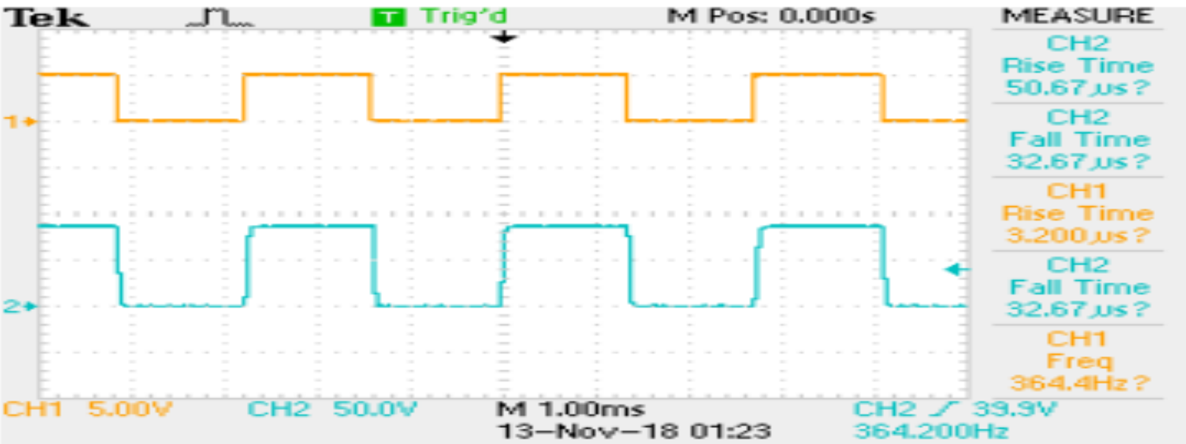
Waveforms at 1 KHz



TDS 2002C - 17:55:25 12/11/2018

Frequency (Hz)	**Channel 1 (Rise Time) (s)**	**Channel 2 (Rise Time) (s)**	**Channel 2 (Fall Time) (s)**
10.00	76.92µs	82.93µs	148.00µs
50.00	30.77µs	54.67µs	61.75µs
1000.00	840.0ns	40.00µs	31.50µs

The highest frequency that the system will respond to in relation to our experiments is **364Hz**



TDS 2002C - 17:57:44 12/11/2018

Important: Working in a red font input your notes, observations and any calculations into this word document as you undertake your activities work and save it on your H drive.

Discussion:

As the experiment went on, we can clearly see the improvement in the communication pathway, the time taken for the system to respond has improved in relation to when we used the LDR-LED. The reason being is that both the photodiode receiver and infrared diode emitter are both optical devices.

They also help to reduce the effect of ambient light by masking it out. In comparism with the LDR-LED, we can tell just by observing the rise time that the system has improved. The rise time is the total time taken for a system to move from 10% to 90% of its peak value. It is the time taken for the signal to move from a low value to a high value.

The best results we got were at 364Hz.

Conclusion:

The system had drastically improved in relation with the LED-LDR setup. This is because that both systems are both optically matched and gives a better response time. It also masks out the effects of ambient light on the system.

Activity 2: Improvements of the optical signalling system

The theme of this activity is shaping the pulse received at the LDR back into a square pulse. Use the circuit you develop in the activity 1 and add additional signal conditioning system to improve the performance (see relevant document in Moodle for detail).

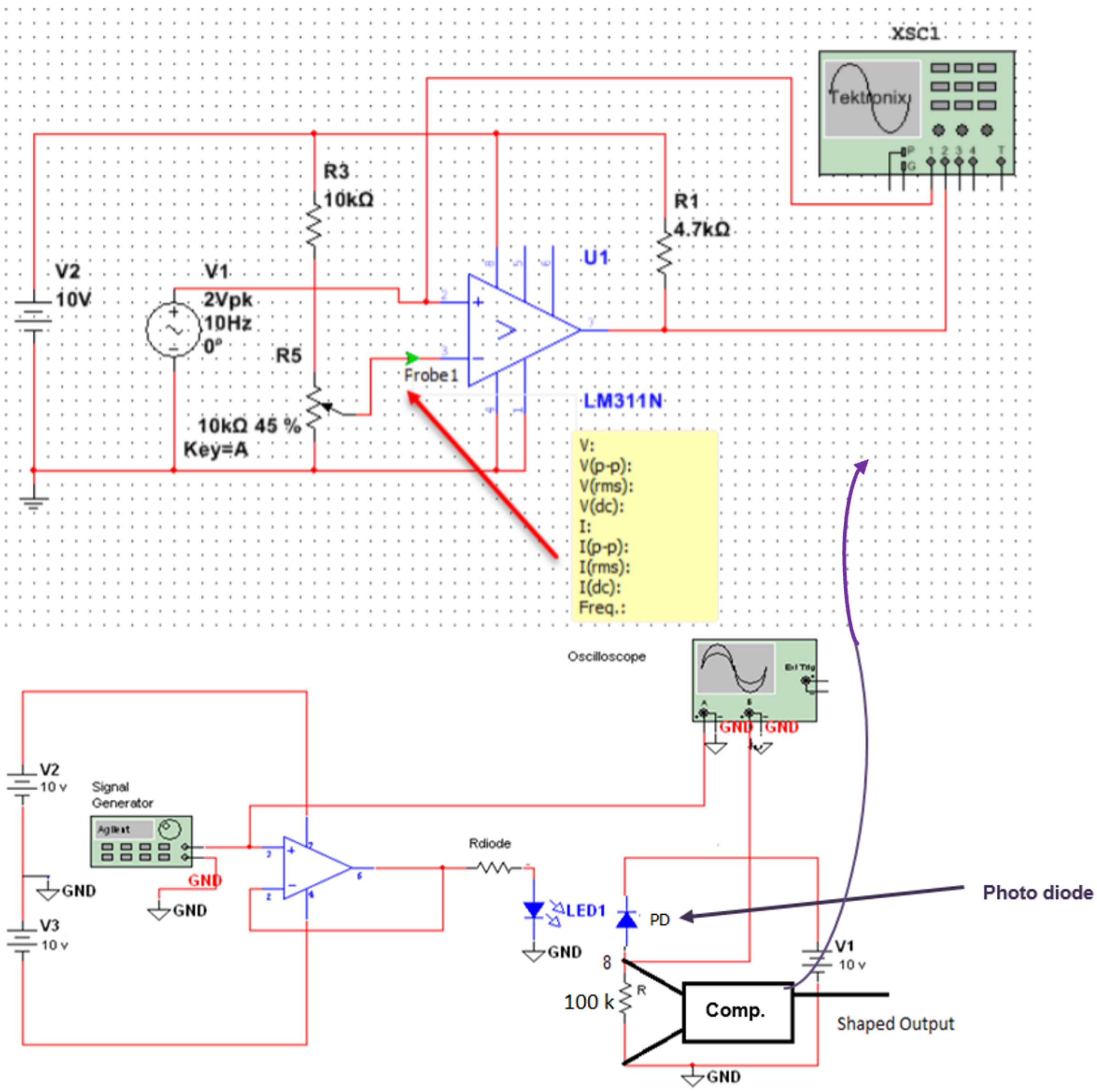


Figure 11: Schematic of Optical communication with signal conditioning system

1. Investigate LM311 circuit that could be connected to the nodes 8 and ground that would square the signal which is being derived from that node.
2. Assemble the circuit on the proto board
3. Adjust the output frequency of the generator for TTL. We are using TTL to simulate a digital bit stream. (select frequency based on measurements in the activity 1)
4. Make tests to confirm comparator circuit is working and then record your results.
5. Compare the transmitted waveform (i.e. waveform from signal generator) and received waveform (output of the comparator system) and comment on your observation.

Please see other relevant material and extra tasks in the Moodle web
Aim: Improving the Optical Signalling System While using a comparator.
Introduction: We have worked with LED-LDR systems and the response wasn't ideal. We have replaced the LDR and LED with a Photodiode and Infrared optical device. This is due to the fact that the response we got while using the LED-LDR system was not ideal and the output signal was poor. For this experiment we would be using a comparator to shape the output signal IR-Photodiode system. We would use this to try and shape the output signal to a square wave. For comparators they have two input voltages. The first one is the (+ve) (The non-inverting input) and

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word d

the second one is the inverting input(-ve).

While dealing with the comparators, if the non-inverting input (+ve) is greater than the inverting input (-ve); the output would be positively saturated (Vcc). V_{out} = +Vcc. Also, if the if the non-inverting input (+ve) is less than the inverting input (-ve); the output would be negatively saturated (Vcc). V_{out} = -Vcc. In relation to the comparator used for this experiment we would be using a dedicated LM311 comparator. One of the advantages of using this comparator is that it can operate from either a dual or single voltage source.). Fair Child (2001) *Fair Child Semi-Conductor Data Sheet* [Online]. Available from https://www.fairchildsemi.com/datasheets/LM/LM311.pdf [16th September 2018].

Apparatus:

The following apparatus were used in implementing the circuit

1. LM311
2. R=10 KΩ, 4.7KΩ, 10K potentiometer
3. TTL signal Generator
4. Bipolar +- 10 Volt PSU
5. TDS2002 DSO Oscilloscope
6. 4mm and crocodile Connectors
7. Breadboard

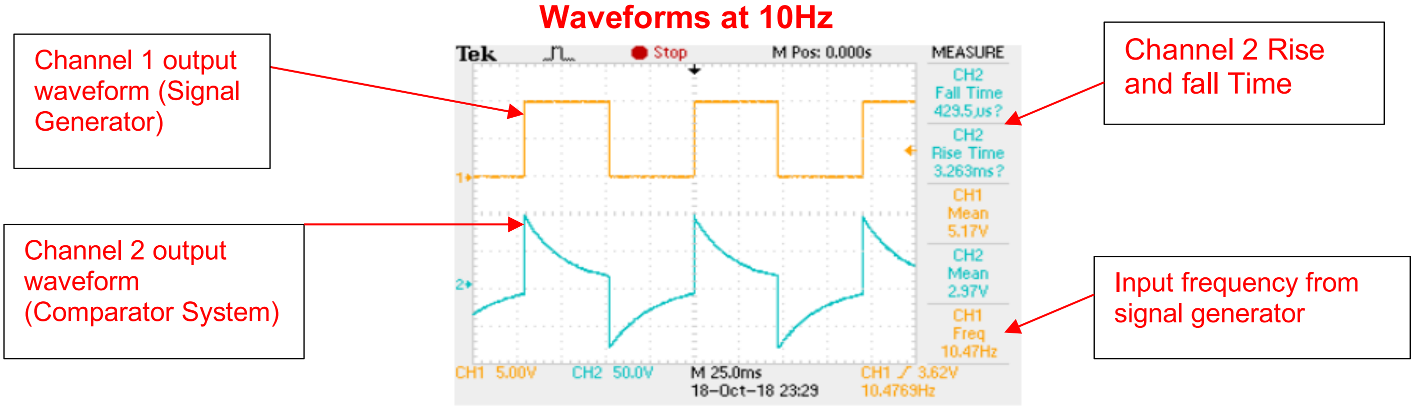
Methodology:

1. Assemble the circuit as shown in the snapshot below
2. Adjust the output frequency of the TTL
3. Make tests to confirm comparator is working
4. Compare the waveforms and discuss appropriately.

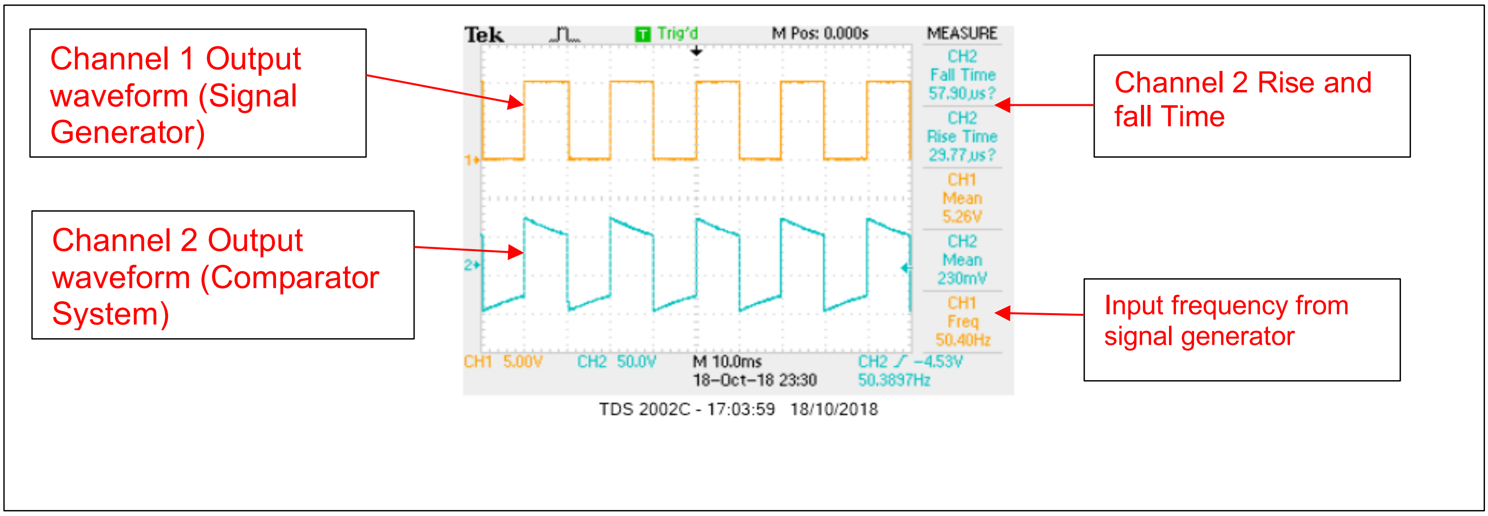
Snapshot of circuit:

Results:

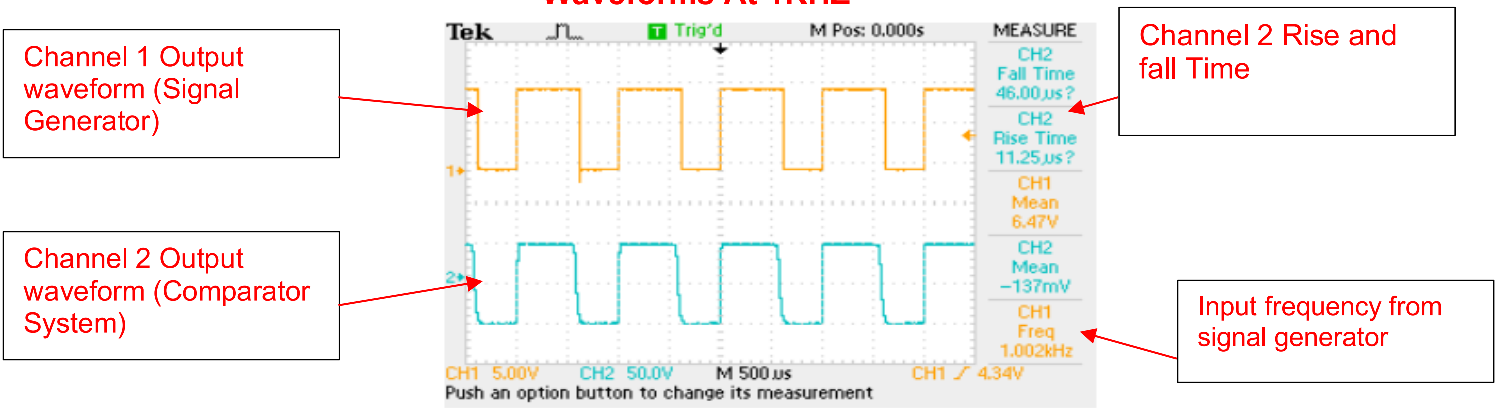
Waveforms at 10Hz



Waveforms at 50Hz



Waveforms At 1KHZ



TDS 2002C - 17:05:00 18/10/2018

Frequency (Hz)	**Channel 2 (Rise Time) (s)**	**Channel 2 (Fall Time) (s)**
10.00	3.263ms	429.5µs
50.00	29.77µs	57.90µs
1000.00	11.25µs	46.00µs

Discussion:

While using the LM311, at a frequency of 10Hz, we have a rise time of 3.263ms and a fall time of 429.5µs. What is also observed, is that as the frequency increases up to 1KHz. The rise time also increases from 3.263ms (10 Hz) to 11.25µs (1Khz). The fall time for channel 2 also increases from 429.5µs(10Hz) all the way to 46.00µs(1Khz).

Conclusion:

We worked with using an IR diode emitter and a Photodiode receiver to improve the optical signalling system. The comparator was useful when it came to shaping the output signal and also providing a better response, because one of the oscilloscopes were not functioning well, we did the experiment as two groups (Group 5 & Group 6).

Session T6: Keyboard

This lab session is about PS2 keyboard and its communication with PC. As explained in the provided support document, PC keyboard utilises a microcontroller that controls, decodes and denounces the keys pressed and sends appropriate Scan Code to the host PC through a serial interface protocol. There also a keyboard controller in PC motherboard that receives all the signals that are sent by keyboard and pass them to the software that is being used by the user (e.g Microsoft word). Based on the information provided in the support document about the keyboard signals (data and clock), and the communication protocol between keyboard and host such as the make scan code and break scan code, complete the following tasks.

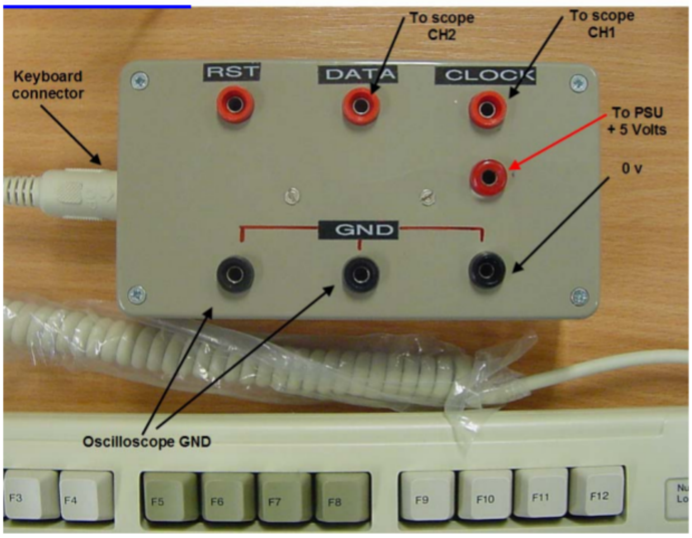


Figure 12.

Apparatus

AT keyboard, 5v PSU, Keyboard break out box, Oscilloscope, with 2 sets of 4mm probes, 2 sets of 4mm probes for PSU.

Activity 1: Investigation on PS2 keyboard communication with PC

- Make all the connections between the AT keyboard and the break out box as shown in Figure 12.
- Capture 10 make/break scan key codes and identify and annotate on the timing diagram the position of Star, Stop, LSB, and Parity bits.
- Identify the HEX value of the key involved.
- Using the Tektronix oscilloscope measure the frequency of the clock. (used the curser menu)
- Measure the time for one bit by choosing an appropriate key.
- Measure the time of a complete character frame.
- Provide detailed screenshots of your captured scan code waveforms in your report with full details and discussions.

Objectives: Investigating the PS2 keyboard and its communication with the PC.
Introduction: The keyboard is an input device. it has a micro controller in it that decodes the keys that are pressed. These keys are referred to as make or break codes. Make codes are the scan codes that are sent when a key is pressed while break codes are the scan codes that are sent when the keys are released. As said above the keyboard has a micro controller that decodes and sends the appropriate scan code to the PC. The keyboard uses a serial path of communication by sending through a specific

Important: Working in a red font input your notes, observations and any calculations into this word document as you undertake your activities work and save it on your H drive.

serial interface protocol. This means that data is being sent one bit at a time. We would make use of the Tektronix oscilloscope to measure the frequency of the clock.

Apparatus:

The following apparatus were used in implementing the experiment

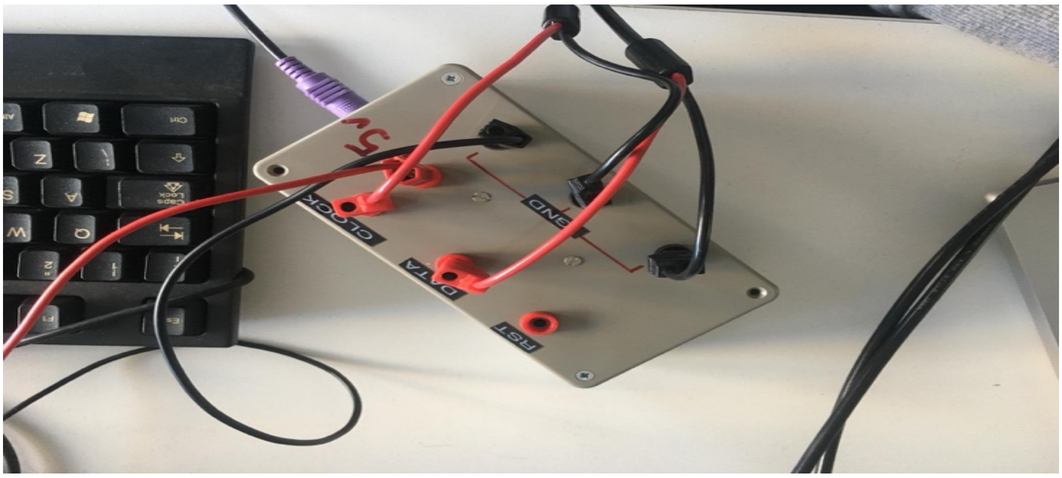
1. 5 Volts Power Supply Unit
2. AT. Keyboard
3. Tektronix TDS 1002 Oscilloscope
4. 2 x 4mm leads for connection to Power Supply Unit

Experimental Procedure:

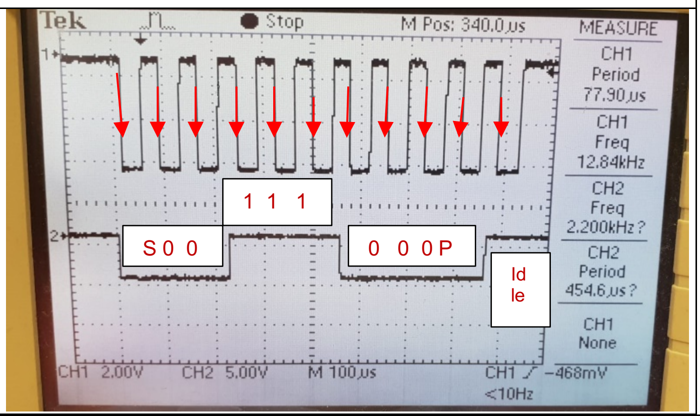
The following methods were used in implementing this activity include

a. Connect the circuit as shown in the snapshots below
b. Capture at least 10 make/ break code identify on the diagram the start, stop , least significant bit and also the parity bits
c. Identify the hex codes of keys pressed
d. Measure the time for one bit
e. Measure the complete time

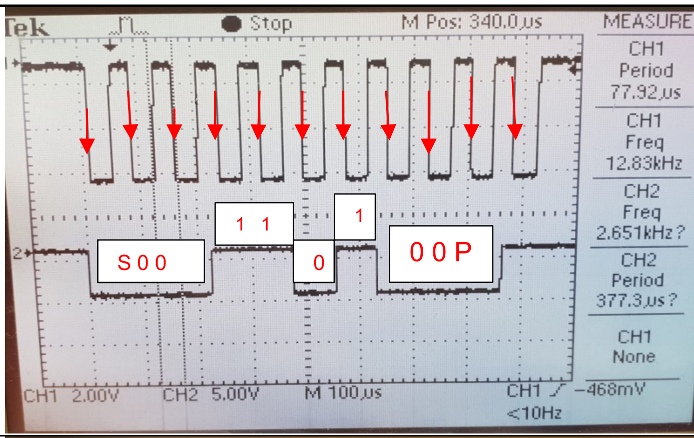
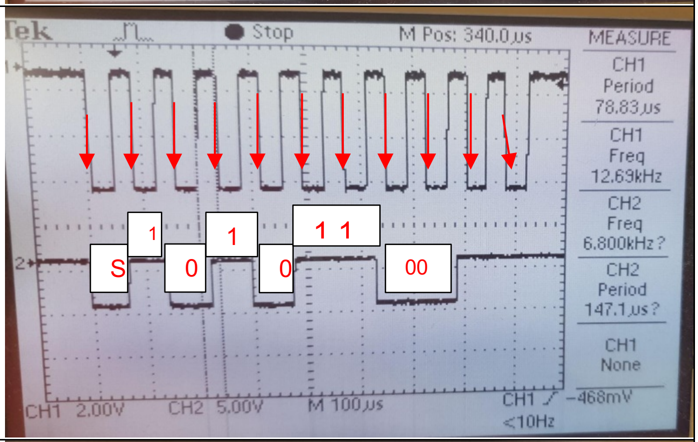
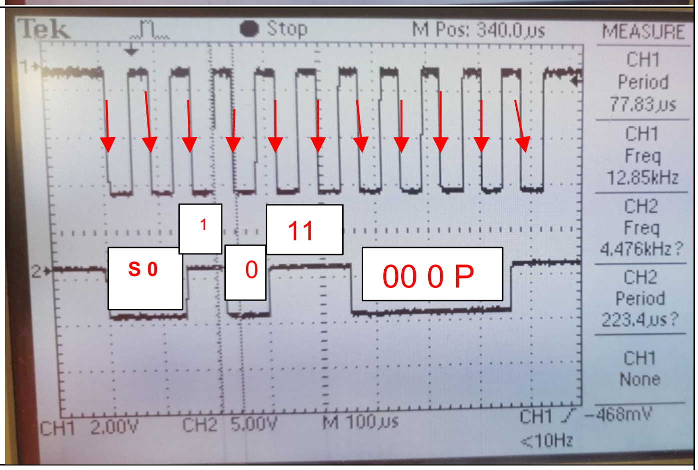
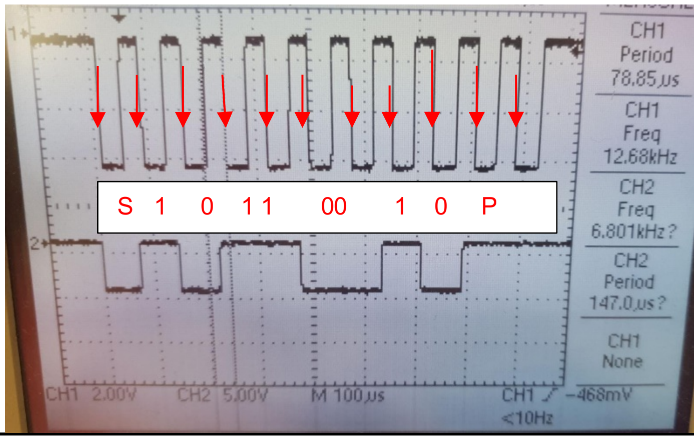
Snapshot of circuit:



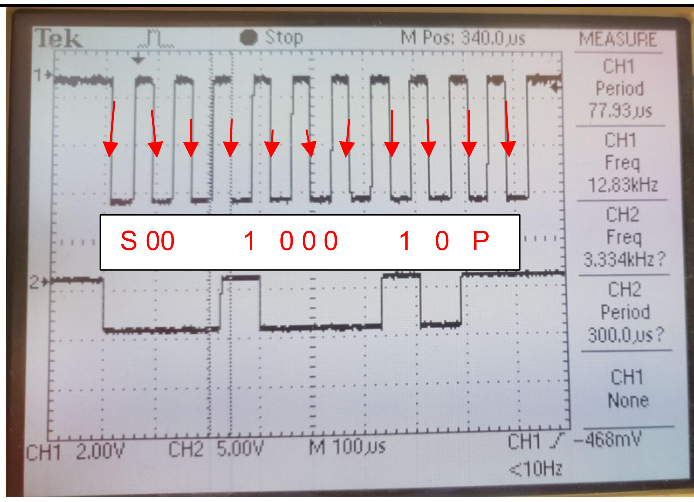
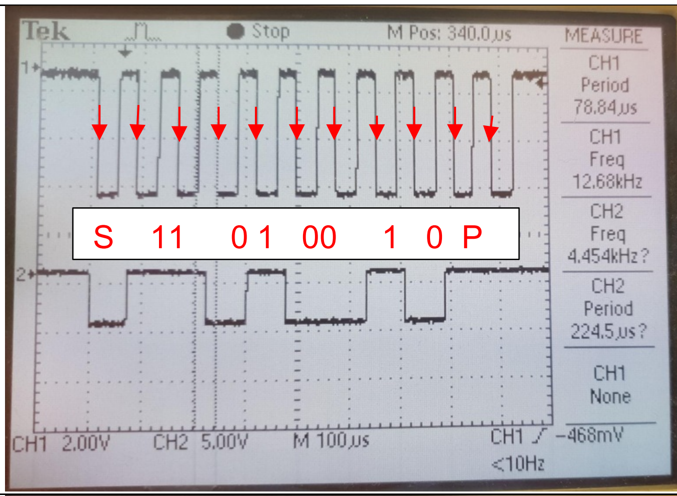
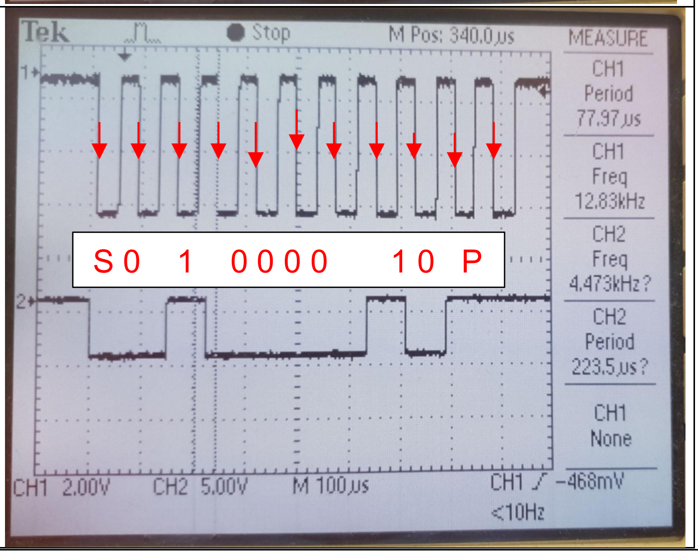
Results:

Make Code	Hex Value	Clock Frequency (Hz)	Bit Time (s)	Character frame time (S)	Waveform
a	1C	12.48KHz	44.00µs	454.6µs	

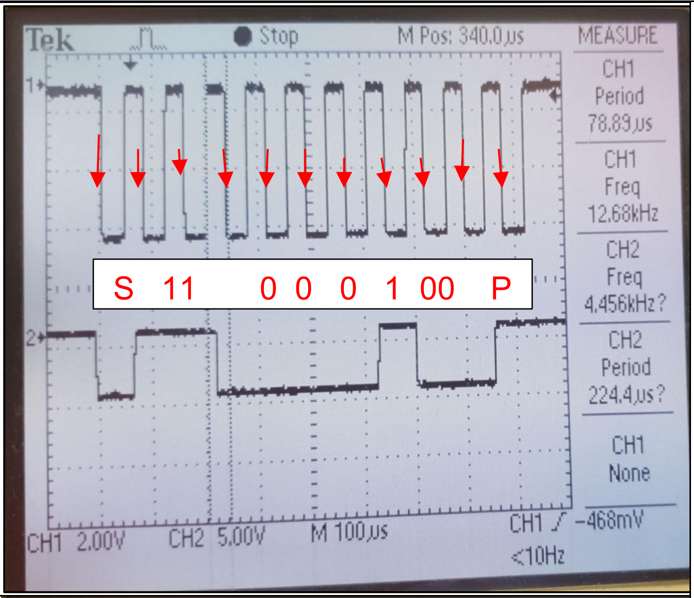
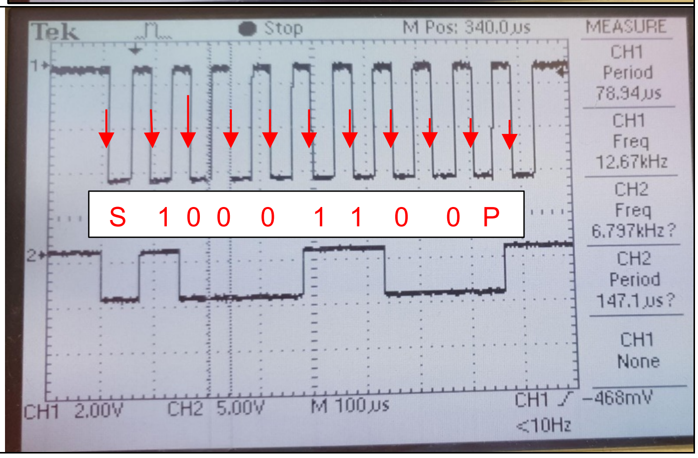
Important: Working in a red font input your notes, observations and any calculations into this word document as you undertake your activities work and save it on your H drive.

t	2C	12.83KHz	44.00µs	377.3µs	
y	35	12.69KHz	36.00µs	147.1µs	
z	1A	12.85KHz	40.00µs	223.4µs	
p	4D	12.68KHz	40.00µs	147.0µs	

Important: **Working in a red font input your notes, observations and any calculations into this word document as you undertake your activities work and save it on your H drive.**

o	44	12.83KHz	40.00μs	300.0μs	
L	4B	12.68KHz	40.00μs	224.5μs	
k	42	12.83KHz	40.00μs	223.5μs	

Important: **Working in a red font input your notes, observations and any calculations into this word document as you undertake your activities work and save it on your H drive.**

i	3B	12.68Khz	40.00µ s	224.4µs	
n	31	12.67KHz	40.00µ s	141.1µs	

Discussions:
While undergoing the experiment what is very obvious is that the clock frequency for the keys are approximately the same. The data is being sent on the falling edge of the waveform as observed on the waveform. There are 10 bits which are properties of asynchronous waveforms as said above. They include the Start bit, the Least significant Bit and Parity Bits.
The Character frame time are also measured and shown in the table above

Problems Encountered:
While doing the experiment during free time on the mezzanine floor, the only available oscilloscope was the Tektronix TDS 1002 Oscilloscope, which is black & white in hue. This explains why the waveforms above are monochromatic.
Also, when it came to taking appropriate snapshots of the waveforms the Open Choice Desktop application was not working on the particular system that was used. So the only option at that point was to take photographs from a phone and crop and scale.

Conclusion:
As said in the introduction, we have come to understand how the PS2 keyboard communicates with the CPU. We have seen that it does this through serial transmission lines. While doing the experiment, we have seen that the bit time for each code is the same.

Session T7: Serial Communications

This week experiment is about serial communication. As explained in the provided support document, for asynchronous serial communication, a pair of wires is used between the transmitter and receiver. In a full duplex transmission method, information can be transmitted in both directions simultaneously. Information about Baud rate and serial interface standards such as RS232 are also provided in the support document. The schematic diagram as well as the RS232 board as well as the system connections are illustrated in figure 13 below.
You need to follow the guide provided in the support document to launch the HyperTerminal program (port settings: 9600 baud rate, 8 bit data, no parity, one stop bit and no flow control) and accomplish the following activities.

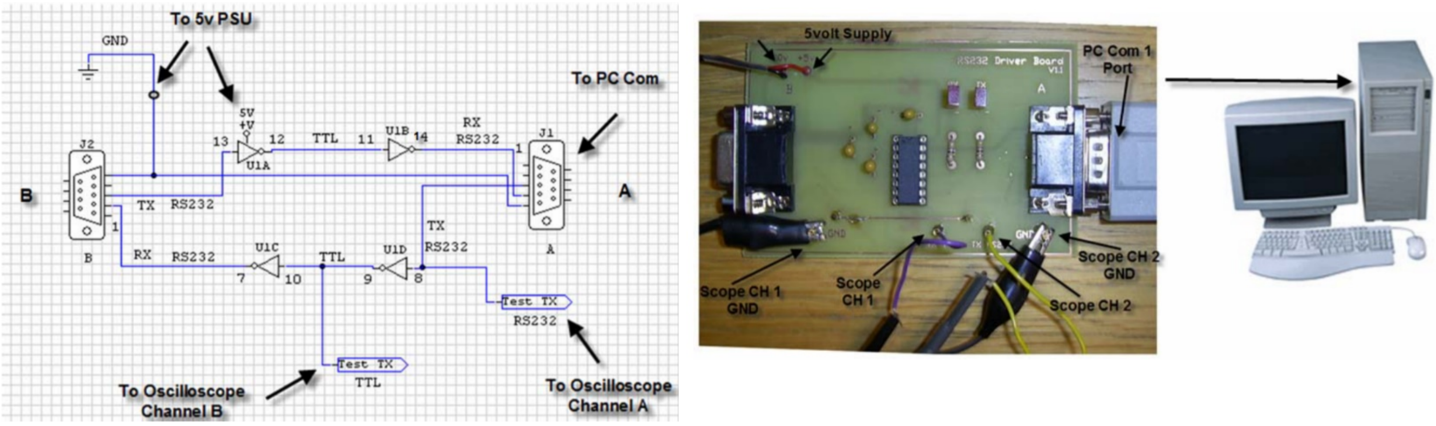


Figure 13

Apparatus:
PC with serial DB9 serial comms port and HyperTerminal program, oscilloscope, two oscilloscope probes (x10), 5v PSU , RS232 driver experimental module, two 9-pin serial comms cables.

Activity1. Test the TX RS232 and TX TTL Signal

First configure HyperTerminal program adjustments as explained in the support document. Then use oscilloscope CH2 to test TX RS232 driver board and CH1 to test TX TTL on the MAX 232 driver board. Follow the guides in the document to adjust the setting for oscilloscope for this activity.
Then from the HyperTerminal console send ASCII character A simply by typing A on the keyboard. Observe the waveforms in both test points (CH1 and CH2) on the oscilloscope. Using the ASCII code conversion table in the appendix, find the Hex code for A. Compare the code with the acquired waveform and include annotated snapshots of both signals in your report. Discuss about the TTL and RS232 signal forms.
Repeat the experiment for ASCII characters 'a,u,U,3,p,*'. Verify your observations with the ASCII table in appendix of the support document. Identify the Start, Data and Stop bits for at least one of the observations.

Activity2. Measure Bit Time

Theoretical calculation of one bit time can be done using the Baud Rate detention as explained in the support document:

$$Baud\ Rate = \frac{1}{Bit\ Time}$$

Using the cursor measurement setting as explained in the support document, measure the bit time (for example input character ASCII character U) and compare it with your baud rate settings. Then change the baud rate setting to 2400b/s as described in the support document and repeat the above steps.

Activity 3. (Optional) Connecting two PCs through an RS232 link

For this activity Two PCs are required. The two adjacent laboratory groups can share the experimentation. A second serial com cable is provided. One side of this is connected to the second PC and the other side is connected to the B connector of the RS232 board. (see figure 14)

Important: Working in a red font input your notes, observations and any calculations into this word document as you undertake your activities work and save it on your H drive.

Use the setting provided in the support document (baud rate 9600, 8 data bit, 1 stop bit, no parity, flow control none) for both PCs and on ASCII setup tab, tick the two items, Echo typed character locally and send line ends with line feeds .

- Type a message in PC1 terminal and check it is received and showed on PC2 terminal. Then send via PC2 and receive on PC1. (Full duplex transmission) .Change the settings for 2400 baud rate and repeat. Observe and discuss your findings. Make changes in the other settings and describe your observations.
- You should be able also to send and receive files. Follow the instruction provided in the support document to end a file from one PC to another. Discuss your observations. Including snapshots.

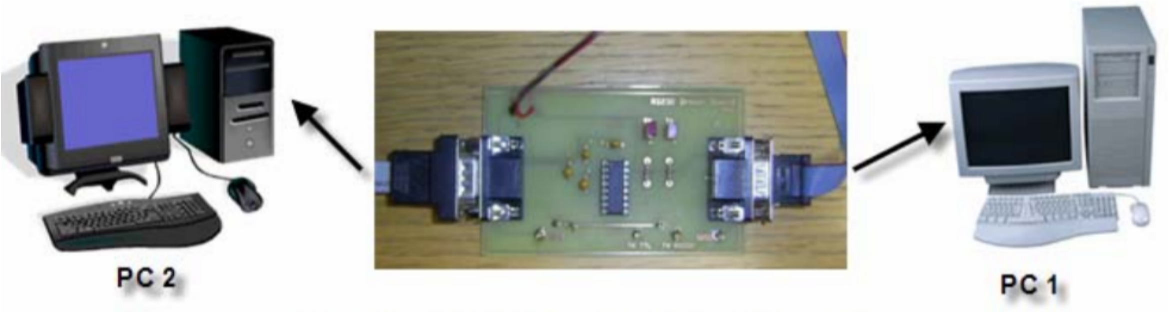


Figure 14

Objectives:
Investigating how serial communications work and data transmission lines

Introduction:
When micro controllers exchange data with other devices they use transmission lines. These transmission lines are basically pathways for data and information to be shared between the sender and the receiver. Also when microcontrollers send data they use either serial or parallel data lines. For this experiment we would be using a serial communication path. This basically means that there is only one serial path for communication. They are two types of serial communication types. They are

1. **Synchronous Data Transmission**: When the data is being sent, they should be a form of synchronization between the sender and the receiver. A clock bus signal is used and also a data signal is also used.
2. **Asynchronous Data Transmission**: when the data is sent, there is only one form of signal. This is the data signal. For this type of data transmission, clock signals are not required. For the fact that there is no clock signal, start bits are used, parity bits are also used and stop bits are used.

In terms of asynchronous data transmissions not all the bits used are data bits. In order to correct confusion a term called baud rate is used. This is basically $\frac{1}{Bit\ Time}$.

Apparatus:
The apparatus used in this experiment include:

1. RS232 board
2. PC with a DB9 serial comms port with Windows
3. Oscilloscope Tektronix TDS 2002 storage scope)
4. 5 volt PSU
5. RS232 Driver Experimental Module
6. The software used was Hyper Terminal Private Edition

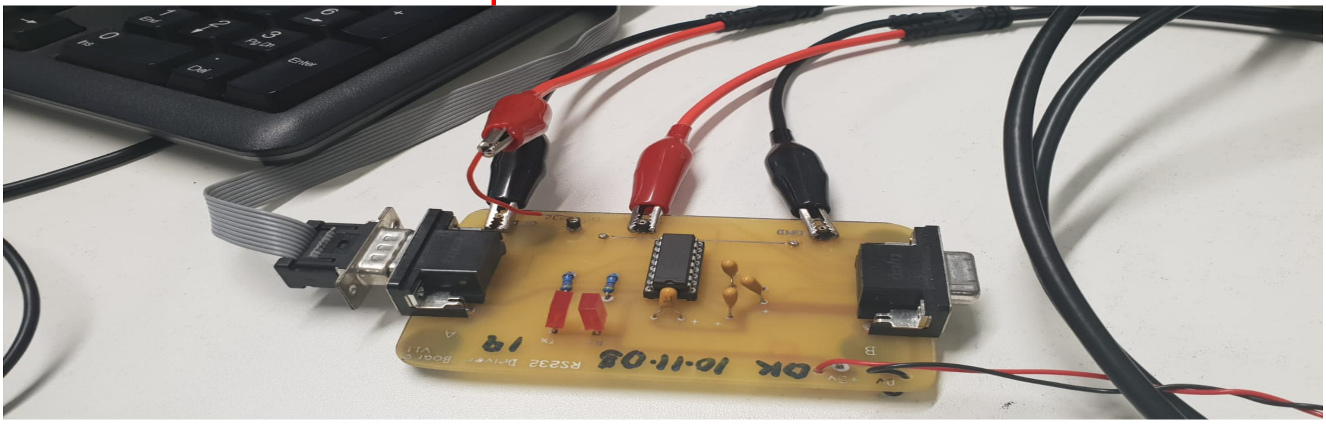
Methodology:

1. Connect the circuit as shown in the snapshot below
2. Then use oscilloscope CH2 to test TX RS232 driver board
3. and CH1 to test TX TTL on the MAX 232 driver board
4. Observe the waveforms generated

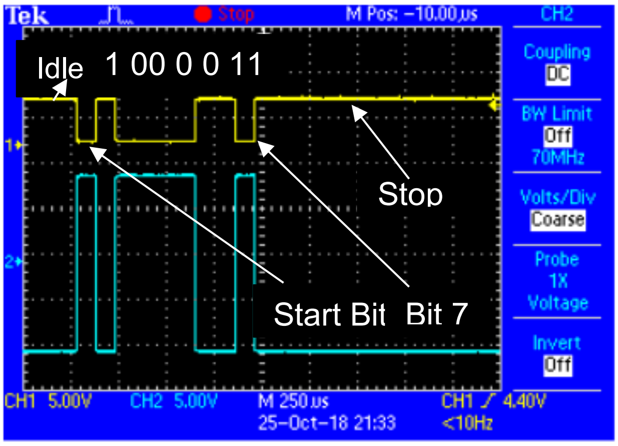
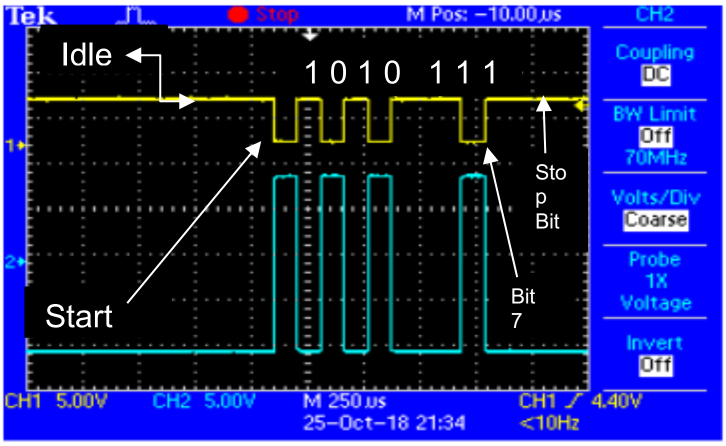
Important: Working in a red font input your notes, observations and any calculations into this word document as you undertake your activities work and save it on your H drive.

5. Using the ASCII code table, convert it to Hex Value
6. Identifty the start, stop bit for at least one of the waveforms

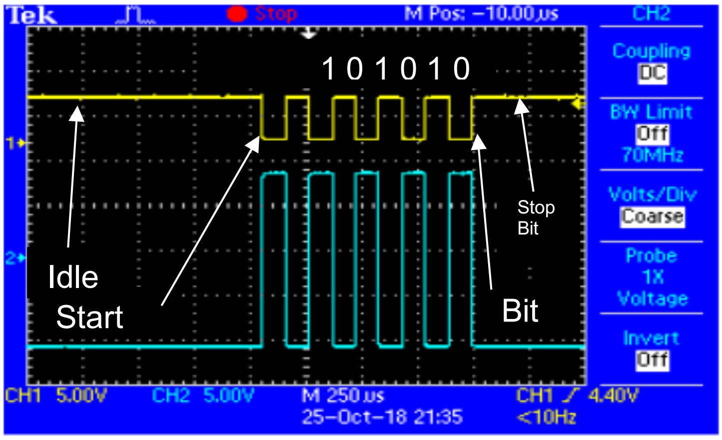
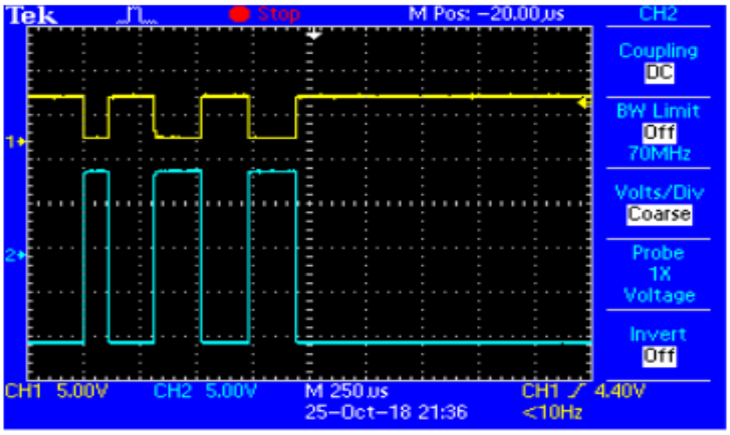
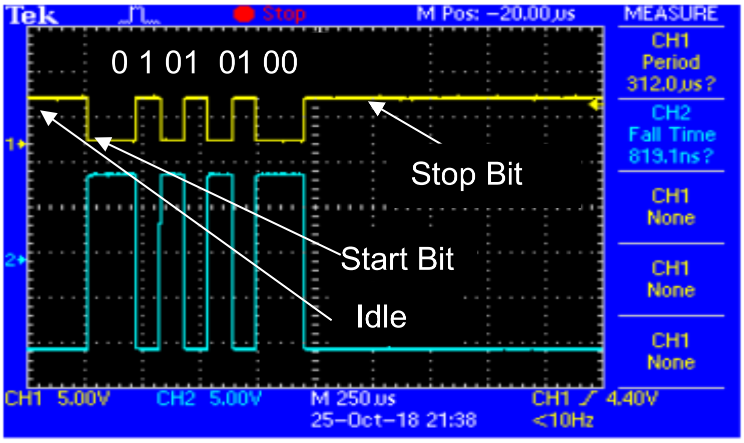
Snapshot Of Circuit:



Results:

ASCII	Hex Code	Bit Time	Baud rate $(\frac{1}{Bit\ Time})$	Snap Shot
a	61	100.0µs	10.00khz	 TDS 2002C - 15:04:34 25/10/2018
u	75	100.0µs	10.00khz	 TDS 2002C - 15:05:21 25/10/2018

Important: **Working in a red font input your notes, observations and any calculations into this word document as you undertake your activities work and save it on your H drive.**

U	55	100.0μs	10.00khz	TDS 2002C - 15:06:45 25/10/2018
3	33	100.0μs	10.00khz	TDS 2002C - 15:07:46 25/10/2018
*	2A	100.0μs	10.00khz	TDS 2002C - 15:09:36 25/10/2018

Discussions: The experiment dealt with ascychronous seraial communications and how data is transmitted. We calculated bit time and also the baud rate time. The baud rate is $\frac{1}{Bit\ Time}$. The bit time and the baud rate for all 5 characters were the same. In the waveforms presented above, I was able to annotate the idle, start and stop bit. I was able to convert from hex to binary using the waveforms. I.e. for "*" the hex form was 2A and the binary was 0010100.

Conclusion:
We were able to see how serial transmission lines work and observe how data is sent between the ender and a receiver using a serial data line which enables it to send one bit at a time.

Important: Working in a red font input your notes, observations and any calculations into this word document as you undertake your activities work and save it on your H drive.

Session T8: Light Controlled Vehicle Activity 1

In this experiment, you will work with a light control vehicle. There are two comparators (LM311) that receive as inputs the voltages from the LDR voltage dividers. A threshold is set by a potentiometer so that, based on the comparison of the sensor inputs with the threshold, the output state is changed and the motor driver (black box in figure 15) controls the wheels. Please read the guide document provided for details of the circuit. Using the following apparatus do the activities. Figures 15 and 16 show the schematic and connections of the circuit.

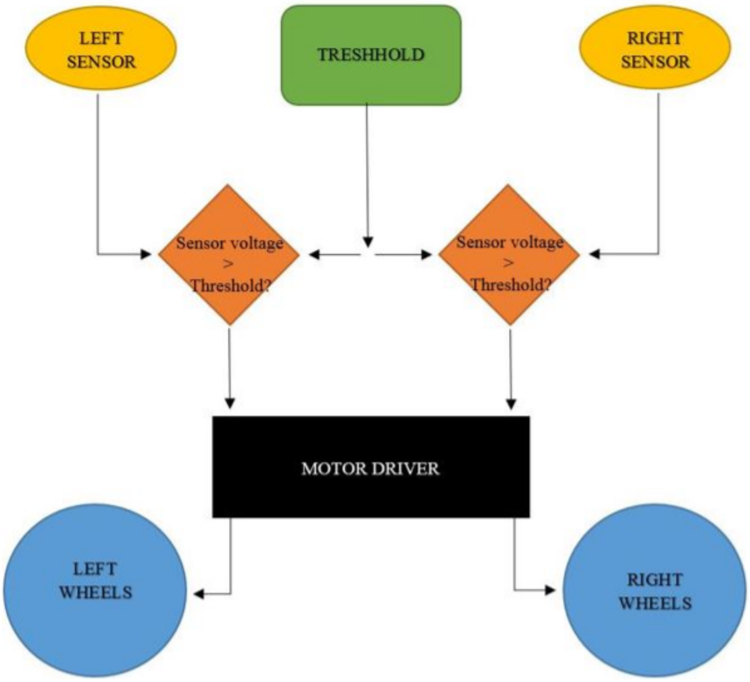


Figure 15

Apparatus

1. 4x Various Resistors (560 Ω, 100 Ω, consult with lab staff) 2. 2x 1k5 Resistors 3. 2x LDRs 2x LEDs 4. 2x LM311 Comparator 5. 1x SN754410 Quad Half H Driver (functional block - black box) 6. 1x 10k Potentiometer	7. 1x Small Breadboard 8. 1x 4 Wheel Vehicle 9. Power supply 10. Logic probe 11. Digital Multi Meter 12. Light Source 13. Light Meter

Important: **Working in a red font input your notes, observations and any calculations into this word document as you undertake your activities work and save it on your H drive.**

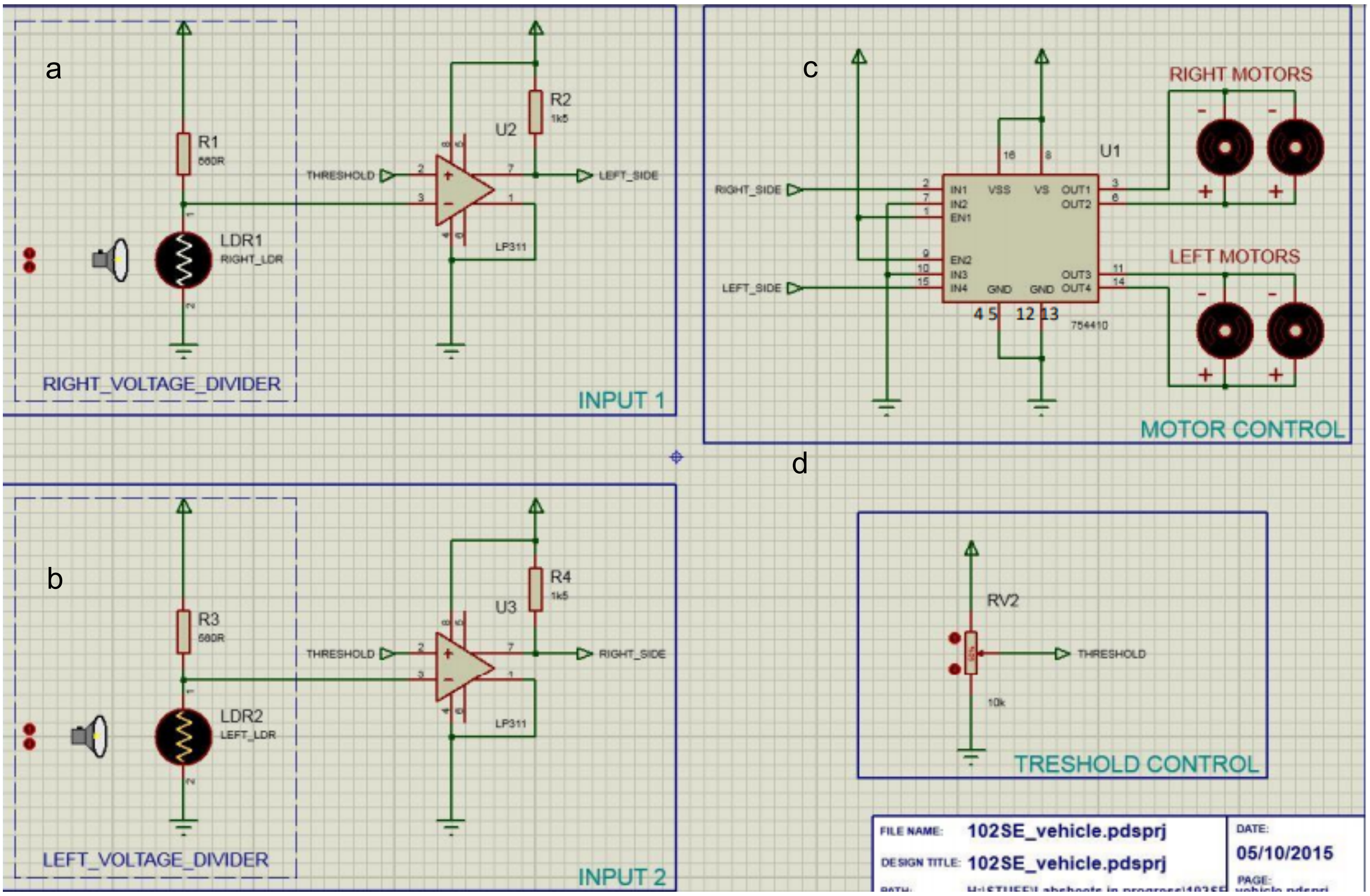


Figure 16.

Activity 1.

For each of the steps, provide snapshots and measurements (if applicable) in your report.

- First, build the two voltage divider circuits for the left and right inputs as shown in Figure 16(a,b).
- Then build the two threshold circuits with potentiometer (figure 16-d). You need to build two of them.
- Connect the two inputs of LM311 to the output of the voltage divider and threshold circuits as shown in figure 16.
- Before connecting the output of comparators (LM11) to the motor driver IC, check if the comparator circuit is working properly by connecting to an LED and resistor as shown in Figure 17. Change the light and adjust the threshold so that, the LED status change based on the light level.
- Connect the out puts of LM311 to the motor driver IC as shown in figure 16-c.
- Test the total circuit by testing the input and the output of the driver IC.
- Attach the breadboard to the top of the vehicle and connect the motors.
- Using a light source, confirm the functionality of the complete system,
- Experiment with LDR orientation to improve performance. Make a note of your observations (e.g. state of the LEDs vs wheel movement, speed, distance at which it responds to light etc.). Please include a link to a video file showing the functionality of the system. Show the names of group members on a paper at the beginning of the video.)

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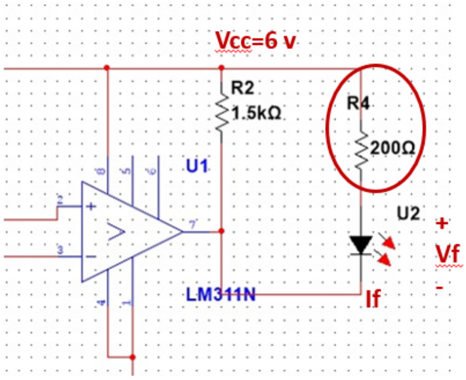

Figure 17

Objectives: Designing A Light Controlled Robotic Vehicle
Introduction: For this activity we would be working to build a light controlled vehicle. The entire apparatus used and methodology followed are listed in below. We would be working with LM311 Comparators, Light dependent resistors, light emitting diodes etc. We would also be observing how these components work together and not just singularly. A schematic diagram is provided below which helps us to see how each component is connected. The vehicle should be able to follow a light source which basically also means that is has to be *'Light sensitive'*. The light intensity would be sensed using a light dependent resistor. One of the features of LDR's is that is very light sensitive which makes it very sensitive for this experiment. For this experiment, we would be using a motor driver which for this experiment would be a SN754410 Quad Half H Driver. Two of its features are that it has a Wide Supply-Voltage Range of 4.5 V to 36 V and also low power dissipation levels Texas Instruments (2005) *SN754410 Quadruple Half-H Driver datasheet* [Online] available from < https://cumoodle.coventry.ac.uk/pluginfile.php/2447355/mod_resource/content/1/SN754410_datasheet.pdf> [18th November, 2018] The structure of the vehicle itself shows that it has four wheels each driven by a motor. In terms of power supply, 5 Alkaline Batteries would be used to drive the motors. **Apparatus**: The various apparatus used in this experiment would be subdivided into two categories: **Components:** 1. 4x Various Resistors (2x560 Ω, 2x200 Ω) 2. 2x 1k5 Resistors 3. 2x LDRs 4. 2x LEDs 5. 2x LM311 Comparator 6. 1x SN754410 Quad Half H Driver 7. 1x 10k Potentiometer 8. 1x Small Breadboard 9. 1x 4 Wheel Vehicle 10. Wire Links **Instrumentation**: 1. Power supply 2. Logic probe 3. Digital Multi Meter 4. Light Source 5. Light Meter (Lux Meter)

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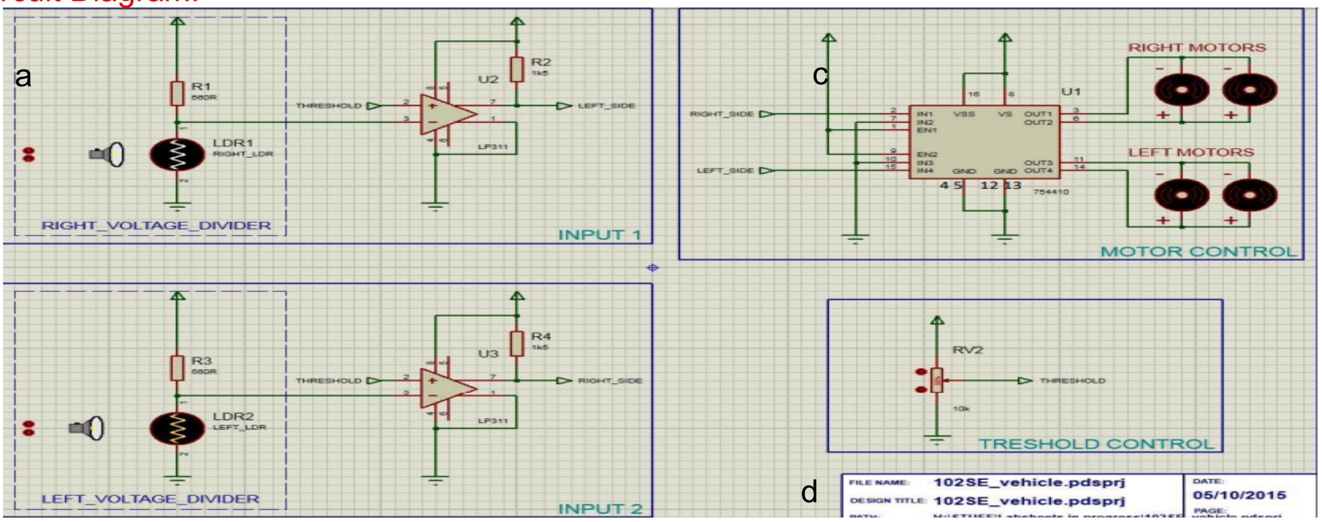
Experimental Procedure:
While building the vehicle, the various steps were taken

1. The two potential dividers were firstly built on the circuit. We also started building the circuit from the left side of the diagram.
2. The two threshold circuits were built as shown in the bottom corner of the schematic diagram
3. Connect the comparator to the threshold output, also ensure that the pins are well pinned to the circuit.
4. Adjust the threshold voltage (Potentiometer) so that we get an output in the Light emitting diode
5. Connect the light emitting diodes to the comparator outputs.
6. Connect the LM311 Comparator to the motor driver IC
7. Attach the completed breadboard circuit to the top of the vehicle
8. Confirm that the entire system is working optimally by using a light source.

Circuit Diagram:



Results:
The link to the video file showing the functionality of the vehicle is below:
https://youtu.be/ecwLAhF2qD0
The vehicle once fully connected was able to follow a moving light source. The light dependent resistors were primarily responsible for that action.

Discussion & Problems Encountered :
Firstly while implementing the circuit, we had a few errors the first being that after connecting the components as shown in the diagram the system still wasn't working. We then tried to troubleshoot and look for what went wrong. We tried changing all the resistors, comparators and also the threshold. Then we finally changed the breadboard, this then made the circuit work. Previously, we had were getting 5 volts in pin 3 and 0 volts in pin 6 while troubleshooting.
After changing the breadboard we got 5 volts in both pin 3-GND and 6-GND.
Lastly, while trying trying to calibrate the threshold to control both LED's. We were getting a response from only one LED. The other LED was not responding.

Conclusions: The activity helped expanding our previous knowledge and understanding of previous work we have done while dealing with LDR's, LED's, and Operational Amplifiers.
In conclusion we were able to build a robotic design designed to autonomously follow a source of moving light.

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