

Electronics

ASSIGNMENT 1

AARON GRIFFITHS

Diodes

A diode is a polarised component capable of restricting/allowing the flow of electrons. In forward bias, current will flow through the diode once a desired voltage is achieved. In reverse bias the flow of electrons is restricted. (J Bird, 2007)

A diode is constructed of two semiconductor materials, one positively charged, and one negatively charged, this is called a P-N junction. A semi-conductor is a material which can conduct electricity under certain conditions, we use a method called doping to enable conductivity within the material. Doping is where we take a stable element such as silicon, which on its own has a covalent bond and add impurity atoms to it. The electrons become unstable and able to move around, thus

increasing conductivity of the material.

P-type doping is where the silicon would be doped with an atom which has trivalent bond characteristics within its outermost shell of its atomic structure, produces gaps in the previously stable silicon atoms and allows electrons to move around when a voltage is applied. N-type doping uses an impurity atom with pentavalent bond characteristics, this adds electrons to the previously stable atom, which look for holes to move in to. The P-N junction consists of the two doped materials together,

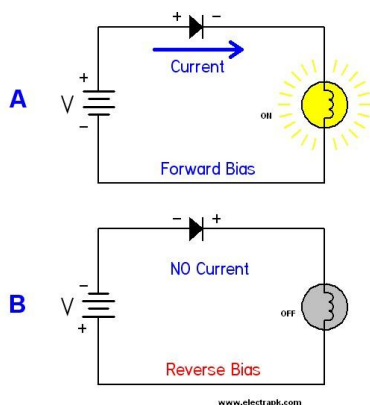


Figure 1 Forward and Reverse Bias Characteristics

and as a battery is placed across the junction, the electrons will flow around the circuit if the polarity is correct.

The Depletion region is situated at the core of a P-N junction and the positively and negatively charged electrons gather here. The depletion region will break down when in forward bias as long as the voltage is superior to the internal resistance of the semiconductor material, for silicon this value is around 0.7V and for germanium it is around 0.3V. In reverse bias, the electrons are not drawn to the battery terminal (P to +) and (N to -), in this instance the depletion region grows within the PN junction and no current will flow within the circuit. (D Buchla, 1999)

Commented [RB1]: Full stop goes after quoting reference and in text citation use only Sir name and year, no initials are required.

Commented [RB2]: Do you mean disappear?

Commented [RB3]: Good explanation at atomic level.

Light emitting diode (LED): Forward biased diode which must have a current limiting resistor in series with it in order to prevent the LED from deconstructing. Commonly used as indicators on displays. (*Britannica, LED*)

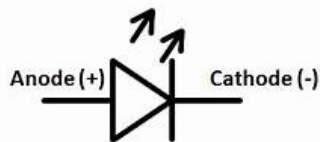


Figure 3 LED symbol



Figure 2 Physical LED

Zener Diode: The semiconductor materials in this P-N junction are heavily doped, which enable the Zener diode to continue working in its breakdown region to regulate voltage. Zener diodes are manufactured to a range of different voltage regulation values, which even as a supply voltage increases the diode will maintain a relatively stable voltage for a load. They are used in Power supplies. When used in forward bias it acts the same as a rectifier diode. (*Circuit Digest, Zener Diode*)



Figure 4 Zener Diode

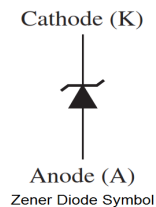


Figure 5 Zener Diode Symbol

Rectifier Diode: Used in reverse bias in order to restrict the flow of current signals within certain parts of a circuit, used to rectify an alternating signal within power supplies but also to stop the flow of unwanted data to a part of circuit within other applications.

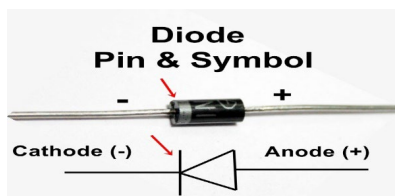


Figure 6 Diode Symbol and Physical structure

Task 1 (ii) – full wave rectifier with C1 smoothing and BZX55C5V6 voltage regulation

What is a Bridge Rectifier (B-R)?

A B-R is a device used to rectify the negative half cycle of an AC source to a fully positive AC source using the forward bias characteristics of the rectifier diodes. It consists of 4 diodes connected in the formation shown in Figure 1. The output waveform can be seen in Figure 2.

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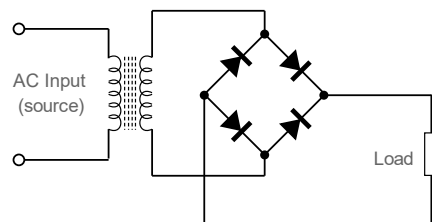


Figure 7 Bridge rectifier structure

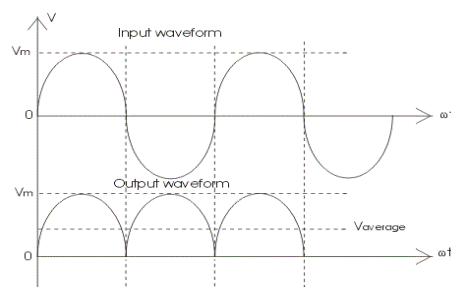


Figure 8 Output rectified waveform

Calculations

Part	Value	Comment
Zener diode	BZX55C5V6	Chosen for task, used for datasheet reference
Zener voltage	5.6V	Referred to BZX55C5V6 datasheet to see the breakdown voltage, at which It regulates a supply. 5.6V±0.4
Supply voltage (V _s)	9V _{AC}	Sufficient supply chosen in order to switch on Zener diode for regulation, if Zener does not operate in reverse bias, there will be no stable DC output.
Zener diode power dissipation	500mW	Referred to Data sheet, required to workout maximum current rating before the diode becomes saturated.
Max Zener Current (I _{ZMAX})	89.29mA	$I_{Zmax} = \frac{500mW}{5.6V} = 89.29mA$
Min Zener Current (I _{ZMIN})	1mA	Found in Datasheet – this value is the minimum current value for Zener leave the cut off region and begin operating
Series resistor Min (R _{SMIN})	38Ω	$R_{smin} = \frac{V_s - V_z}{I_{Zmax}} = \frac{9 - 5.6}{89.29mA} = 38\Omega$
Series resistor Max (R _{SMAX})	3400Ω	$R_{smax} = \frac{V_s - V_z}{I_{Zmin}} = \frac{9 - 5.6}{1mA} = 3400\Omega$
Current series resistor (I _{RS})	28.3mA	$I_{rs} = \frac{V_s - V_z}{R_s} = \frac{9 - 5.6}{120} = 28.3mA$
Load resistor Min (R _{LMIN})	205Ω	$R_{Lmin} = \frac{V_z}{I_{rs} - I_{Zmin}} = \frac{5.6}{28.3 - 1} \times 1000 = 205\Omega$
Load resistor Max (R _{LMAX})	Infinite(Ω)	$R_{Lmax} = \frac{V_z}{I_{rs} - I_{Zmax}} = \frac{5.6}{28.3 - 89.29} \times 1000$ $= -91.82\Omega = infinite$
Smoothing Capacitor	100uF	Used to Stabilise the fully rectified AC input to maintain an above 5.6V threshold to assist the Zener diode in regulating the voltage to a smooth DC output.

Commented [RB5]: very impressive, you have explained each and every bit in a good detail.

1. Series current limiting resistor maximum ($R_{S\text{MAX}}$)

The point at which R_s is too large and prevents the Zener diode meeting the $I_{Z\text{MIN}}$ of 1mA.

2. Series current limiting resistor minimum ($R_{S\text{MIN}}$)

The minimum resistance required to prevent the current flowing through the Zener diode to surpass 89.29mA.

3. Current flowing through R_s (I_{RS})

Using a resistor value of 120Ω for R_s , in the lower side of my $R_{S\text{MIN}}$ and $R_{S\text{MAX}}$ parameters, so that a proportionate amount of current will flow through the Zener diode for it to maintain good working efficiency.

4. Load Resistor Minimum ($R_{L\text{MIN}}$)

If the value R_L is too low, a higher proportion of I_{RS} will flow through it, preventing I_z from achieving 1mA and stopping voltage regulation.

5. Load Resistor Maximum ($R_{L\text{MAX}}$)

This value is the boundary for which too much current will flow through the Zener diode and break it. As I_{RS} does not surpass $I_{Z\text{MAX}}$ anyway, a load resistor is not essential to this circuit. Calculating $R_{L\text{MAX}}$ gave a negative value, which indicates the value is infinite as there is less than 0 resistance required at the load for the diode to operate safely. I included it anyway for added protection.

To help this make sense I assumed that I_{RS} was in fact 120mA and in this case there would be a $R_{L\text{MAX}}$ value, As follows:

EXAMPLE

$$R_{L\text{min}} = \frac{5.6}{120 - 1} = 47.1\Omega$$

$$R_{L\text{max}} = \frac{5.6}{120 - 89.29} \times 1000 = 182.35\Omega$$

This would mean that $I = V/R = 5.6/182.35 = 30.7\text{mA}$ (current through R_L)

Using Kirchhoff's current laws, this means that the current through I_z would be $120 - 30.7 = 89.3\text{mA}$ or $I_{Z\text{MAX}}$.

Commented [RB6]: Well done Arron, you have explained it comprehensively.

6. IL assuming Zener regulation of 5.6V with a load of 1000Ω

$$I_L = \frac{V_Z}{R_L} = \frac{5.6}{1000} = 5.6mA$$

7. Smoothing capacitor (C1) = 100uF

The smoothing capacitor is a storage device, which prevents the positive supply voltage from completely fluctuating between 0-9V (closer to 7.6V when accounting for 1.2-1.4V drop across the bridge rectifier). The capacitor will charge up for the first half of a cycle and as the voltage begins to decrease, the capacitor begins to discharge, until the next cycle arrives, and it charges again. This happens many times per second, so the capacitor has a especially small amount of time to fully discharge, it maintains the voltage at a positive level. If the Capacitor value increased, there would be a slower discharge rate at the same frequency and therefore reducing the ripple in the output voltage.

Commented [RB7]: Spot on.

Schematic:

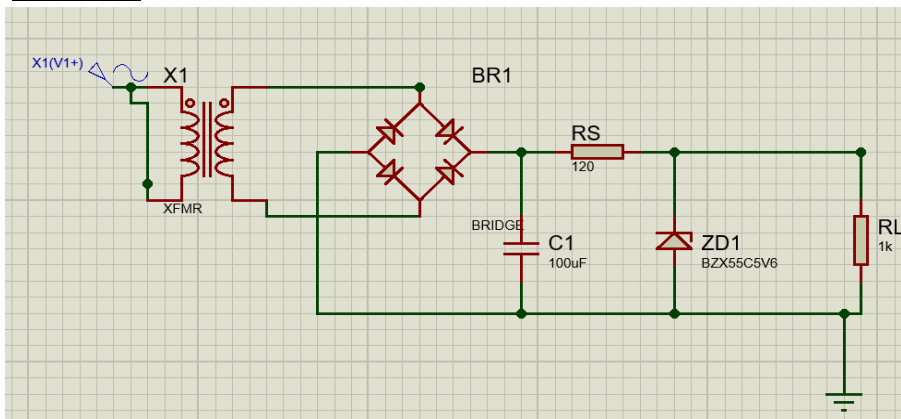


Figure 9 Regulated Power supply 5.6V

(iii) Simulation circuit build and test

I assembled the circuit using simulation software verify that my calculated values where similar to a simulation. Assuming my calculations are correct, the simulation is no more or less accurate than my calculations as it relays on the specific values and tolerances pre-stated within the programme.

I worked out the turns ratio needed for the Stepdown transformer by:

$$\text{Turns Ratio} = \frac{V_{in}}{V_{required}} = \frac{220}{9} = 24.44444444 = 24.44:1$$

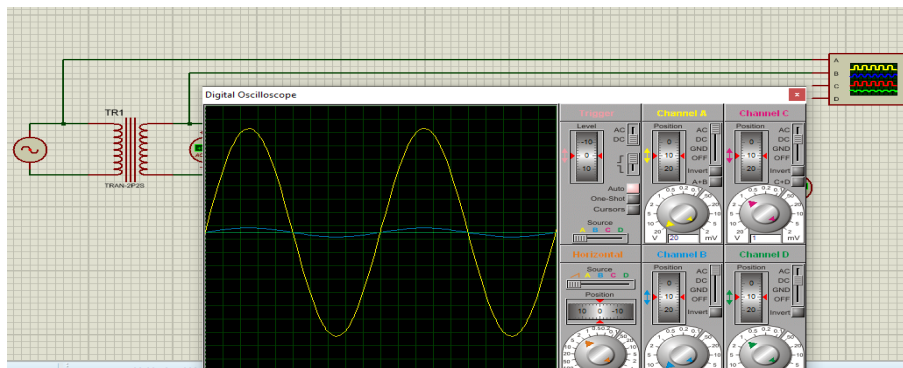


Figure 10 Step Down Transformer waveforms

Note : The slight drop in amplitude of the Output signal represents the volt drop across the two rectifier diodes.

Commented [RB8]: Good point.

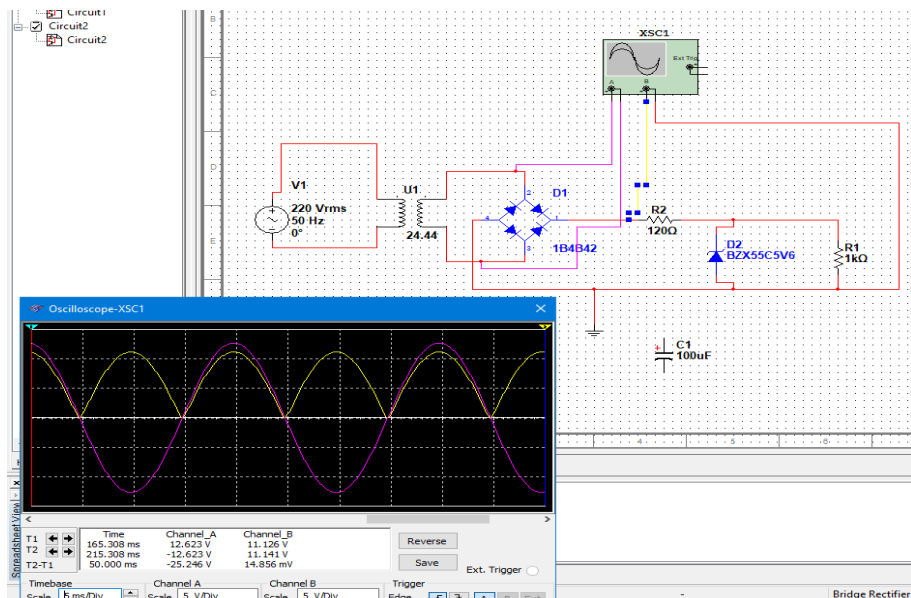


Figure 11 Full Wave rectification of 9V input with smoothing capacitor removed

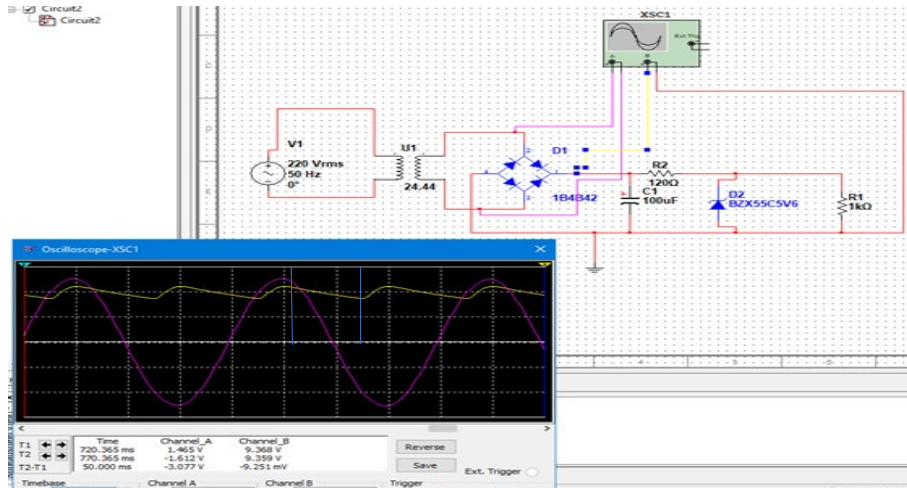


Figure 12 Smoothened output waveform due to capacitor introduction

Voltages

Supply: 220V_{AC}

Stepdown transformer: 8.92V_{AC} (slightly below 9, due to rounding to 2 decimal places when working out turns ratio).

Zener regulated voltage: 5.71V_{DC}

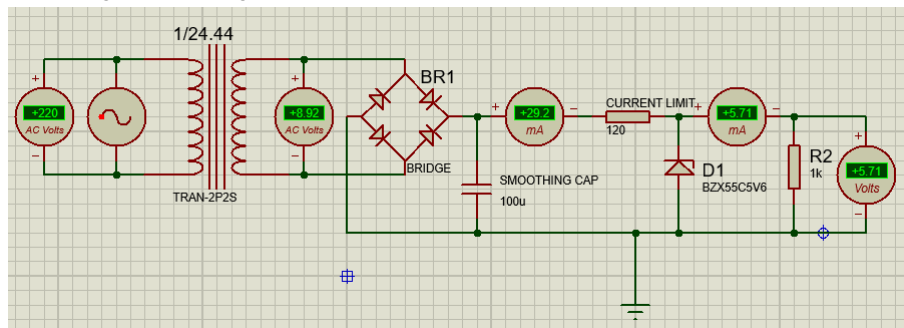


Figure 13 Circuit voltage regulation

The following screenshots show the impact of the smoothing capacitor:

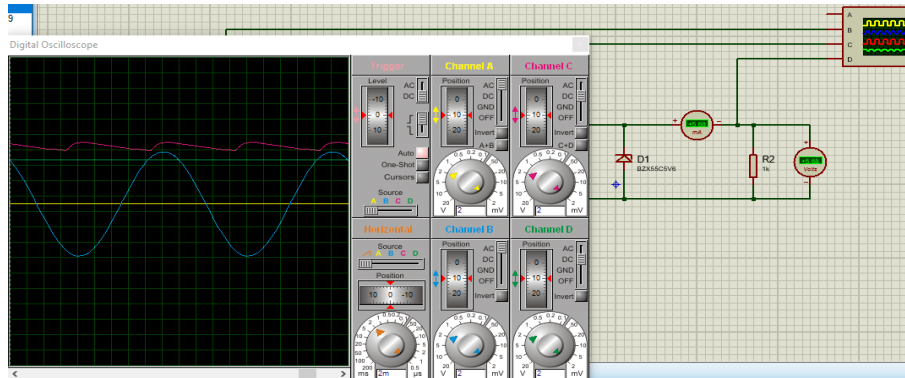


Figure 14 Output waveforms with capacitor smoothing

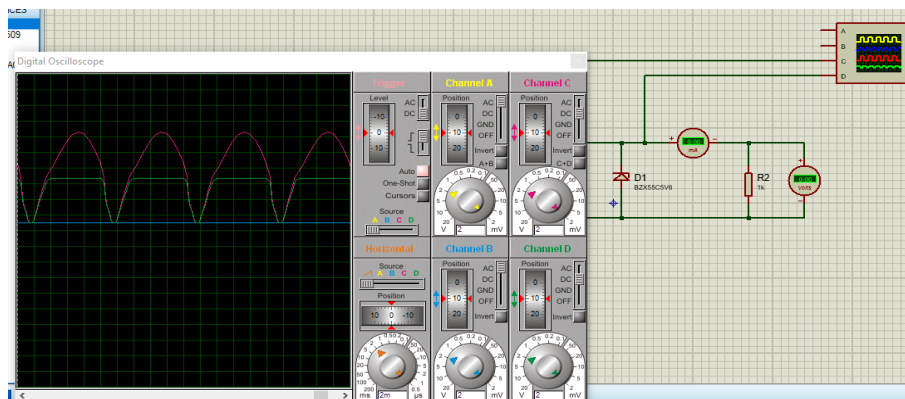


Figure 14 Waveforms without capacitor smoothing

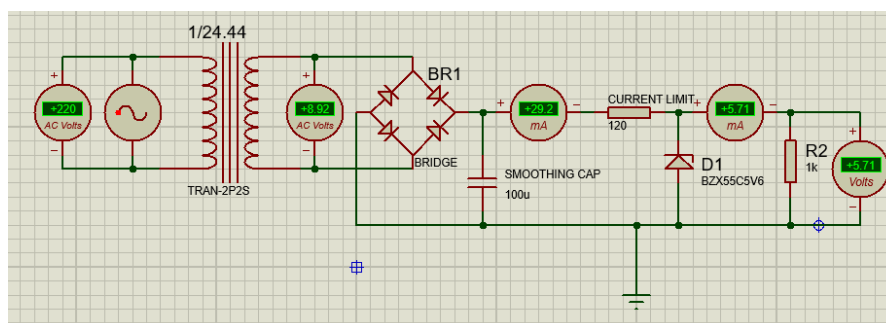


Figure 16 Current values within circuit

(IV)

Circuit build and Test

1. Gathered components and checked values are within tolerance
2. Gathered test equipment consisting of:
 - Digital multimeter
 - Digital Oscilloscope
 - Function Generator
3. Build circuit
4. Set Function Generator to 9V_{AC} P-P at 50Hz and verified using a multimeter prior to connecting to circuit.
5. Set the Oscilloscope to easily readable displays, 2V per division was sufficient.
6. I connected the ground probe of both Oscilloscope channels to the ground circuit node, this is used as reference for the oscilloscope.
7. I proved the functionality of the circuit by probing the following points to view the output waveform.
 - a. Removed C1 and checked B-R output to confirm its functionality
 - b. Re-Inserted C1 and confirmed the smoothened waveform by probing the output of the B-R.
 - c. Probed the Zener diode which showed a constant 5.6V_{DC} output voltage.

I used a multimeter to measure the following:

Zener Diode part #	BZX55C5V6
V _Z	5.6V
V _I	9V _{AC}
I _R	28.1mA
I _L	5.6mA
V _{OUT}	5.6V

Commented [RB9]: All nicely stated.

(V)

I removed the Zener Diode looked at the affect of changing the values of the load resistor has on the voltage ripple in the smoothened capacitor output signal. To measure this I probed between the load resistor and ground then manually adjusted the oscilloscope cursors to view the difference between the two values.

1K Ω = 1.1V

800 Ω = 1.3V

1.8K Ω = 1V

I can see from these results that as the load resistance gets bigger there is less of a ripple in the output of the capacitor, this means the output is smoother.

Commented [RB10]: Could explain the reason?

(VI)

Results

	Calculated	Simulated	Measured
BZX55C5V6	Used	Used	Used
V_{IN}	9V _{AC}	8.92V _{AC}	9V _{AC}
I_R	28.3mA	29.2mA	28.1mA
I_L	5.6mA	5.71mA	5.6mA
V_{OUT}	5.6V _{DC}	5.71V _{DC}	5.6V _{DC}

The Simulated results vary in comparison with the rest. I allow for the fact that I had rounded the turns ratio on the transformer, which in turn let the desired V_s of 9V drop to 8.92V, but with this the results show characteristics which indicate a larger V_s. The values found in conjunction to the Zener diode all met specified tolerances within the BZX55C5V6 Datasheet. The fluctuation in I_R values across my results are due to the specific volt drop across the bridge rectifier (between 0.6-0.7V) and then the actual value of R_s with regards to its tolerance. The simulation shows a much higher value of current draw, which is an example of issues seen with pre-programmed simulation software, as you cannot account for the actual programmes accepted values for each component. That said, the values are all far below my calculated I_{ZMAX} value and therefore do not affect the functionality of the circuit.

Commented [RB11]: Good comparison.

Task 2

Transistors

Transistors consist of 2 PN junctions, which are either N-P-N or P-N-P. They have three legs which are the Collector, Base and Emitter.

The transistor base is connected to both the collector and emitter legs, they are used as either amplifiers or switches within electronic circuits. The base acts as a switch for the flow of electrons across the transistor. When a forward bias voltage of $+0.7$ is applied at the base of the transistor, the flow of electrons begins between the collector and emitter. (K L Kishore, 2010)

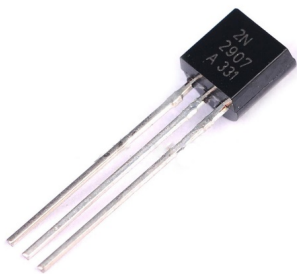


Figure 16 Transistor

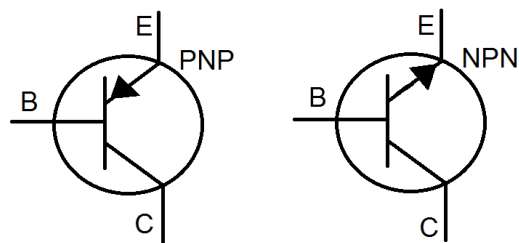


Figure 15 NPN PNP bipolar junction transistor symbol

(a) Common Emitter Amplifier

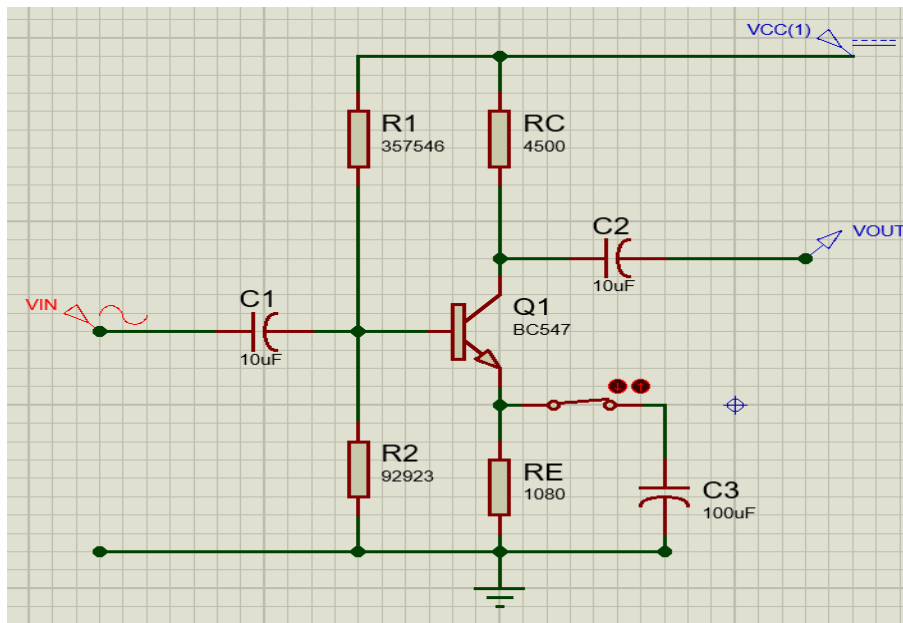


Figure 17 Common Emitter amplifier circuit

Value	Workings/Comment	
Transistor	BC457	Chosen / datasheet acquired
V _{CC}	9V _{DC}	Chosen
HFE	540	Using Multimeter, within datasheet specified tolerance or between 100-600.
I _{QMAX}	10mA	Datasheet
I _Q	1mA	10% of max used for calculations
V _C	4.5V	Needs to be about half of V _{CC} in order to prevent the swing in signal of the output affecting the Saturation (0V and MAX current) or Cut off (MAX V _{CC} and 0 current) region of the transistor.
R _C	4500Ω	$R_C = \frac{V_C}{I_Q} = \frac{4.5}{1 \times 10^{-3}} = 4500$
V _E	1.08V	Between 10 to 15% of V _{CC} , I used 12%. $9 \times 0.12 = 1.08$
I _E	1mA	I _E = I _C
R _E	1080Ω	$R_E = \frac{V_E}{I_E} = \frac{1.08}{1 \times 10^{-3}} = 1080$
I _B	1.851microA	$I_B = \frac{I_C}{HFE} = \frac{1mA}{540} = 1.851$
V _{BE}	0.64V	Datasheet specifies between 0.58 and 0.7V
V _B	1.72V	$V_B = V_E + V_{BE} = 1.08 + 0.64 = 1.72$
I _{R1}	18.51microA	10×I _B
I _{R2}	18.51microA	10×I _B
R ₂	92923Ω	$R_2 = \frac{V_B}{10 \times I_B} = \frac{1.72}{18.51 \times 10^{-6}} = 92923$
R ₁	357546Ω	$R_1 = \frac{V_{CC} - V_B}{11 \times I_B} = \frac{9 - 1.72}{20.36 \times 10^{-6}} = 357546$
C ₁	10uF	This is placed in series with the AC supply and is used to filter out DC voltage
C ₂	10uF	This is placed in series with the AC supply and is used to filter out DC voltage
C ₃	100uF	This placed in parallel with the R _E and is used to filter out AC signals

Commented [RB12]: Good way of explaining each step

Commented [RB13]: Need to check C2, it is placed at output

(b) Circuit Build and Test

I gathered my components and selected reasonably similar resistor values to my calculations, it is unlikely for them to be exact anyway, due to mass manufacturing techniques.

Commented [RB14]: Good point

Component: Calculated/Used

R₁: 357546Ω / 360000Ω (±5%)

R₂: 92923Ω / 91000Ω (±5%)

R_C: 4500Ω / 4700Ω (±5%)

R_E: 1080 Ω/ 1100Ω (±5%)

- DC Conditions

The following measurements were taken with no input signal, this is to show the bias conditions of my selected component values with V_{CC} only.

Value	Measured	Using a Multimeter:
V _C	4.98V	Set to VDC I measured between V _C and Ground
V _{CE}	4.01V	Set to VDC I measured between V _C and V _E
V _E	1.01V	Set to VDC I measured between V _E and Ground
V _{BE}	0.68V	Set to VDC I measured between V _B and V _E
V _B	1.68V	Set to VDC I measured between V _B and Ground
I _C	0.92mA	Set to milliamps, I removed the leg between R _C and the collector and measured between there and the collector leg.

- AC Conditions

Due to the Coronavirus pandemic, I was unable to complete this part of the task in practical.

The Output characteristics of this circuit can be determined by the gain and frequency response.

To measure Frequency response I would have connected a function generator to the input of the circuit and selected a range of frequencies to test. I would then measure V_{OUT} and divide it by V_{IN} to work out the gain. The table would have looked similar to below.

Frequency (KHz)	V _{in}	V _{out}	Gain(V _{out} /V _{in})	Gain DB 20log(gain)
1	9V			
50	9V			
100	9V			
250	9V			
500	9V			
1000	9V			
1500	9V			
2000	9V			
2500	9V			
3000	9V			
3500	9V			

I would have set the Function Generator to 1mV at 1KHz, then used a DGM to measure the change in output voltage. I would have used the formula V_{OUT}/V_{IN} to calculate gain and converted it in to DBs by using the formula $20\log(\text{gain})$.

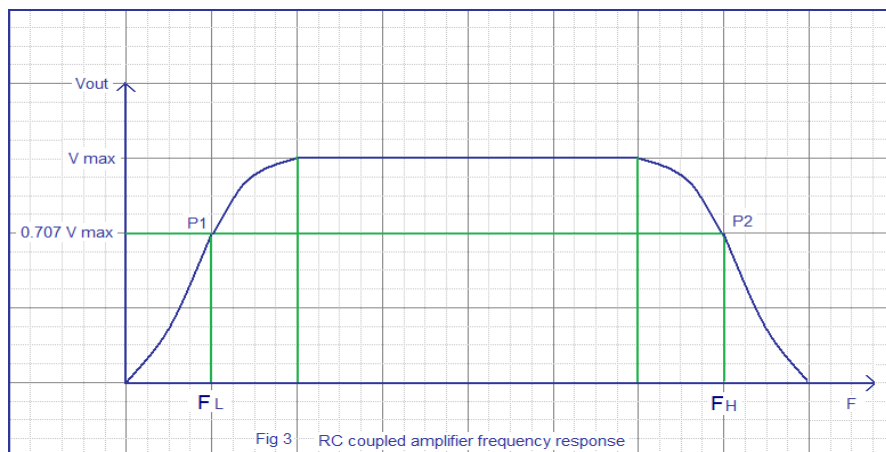


Figure 18 Frequency response example

After all results were gathered, I'd of plotted a graph for Frequency (X axis) against Gain(db) (Y axis) and expect to see that as the frequency went up, Gain increases until a point where it remains constant across a frequency range, until it reaches a frequency where the gain begins to decrease. A line could be drawn across the X-axis at -3db below the optimum gain (this point is essentially the drop in voltage seen across the transistor). Where this line crosses the X-axis points, signifies the upper and lower cut off frequencies of the amplifier. To find the bandwidth, I would have subtracted the lower cut off frequency from the upper cut off frequency.

Commented [RB15]: Well explained.

(c) Circuit Simulation

Due to the Coronavirus pandemic, I had to use simulator software which I downloaded at home in order to try complete this part of the task.

- DC conditions

Results

Value	Measured	Explained
V_C	5.07V	DC Voltmeter (See figure.19)
V_{CE}	4.12V	DC Voltmeter (See figure.19)
V_E	0.95V	DC Voltmeter (See figure.19)
V_{BE}	0.67V	DC Voltmeter (See figure.19)
V_B	1.62V	DC Voltmeter (See figure.19)
I_C	0.87mA	DC Ammeter set to Milliamps (See figure
$I_{R1/2}$	20.7microA	DC Ammeter set to Microamps (See figure
I_B	3.31microA	DC Ammeter set to Microamps (See figure

Kirchhoff's laws state that the sum of the volt drops across a series loop of a supply circuit are equal to the total supply voltage. Using figure .. I can see that the RC circuit loop voltages read $3.93 + 5.07 = 9V$.

(1)

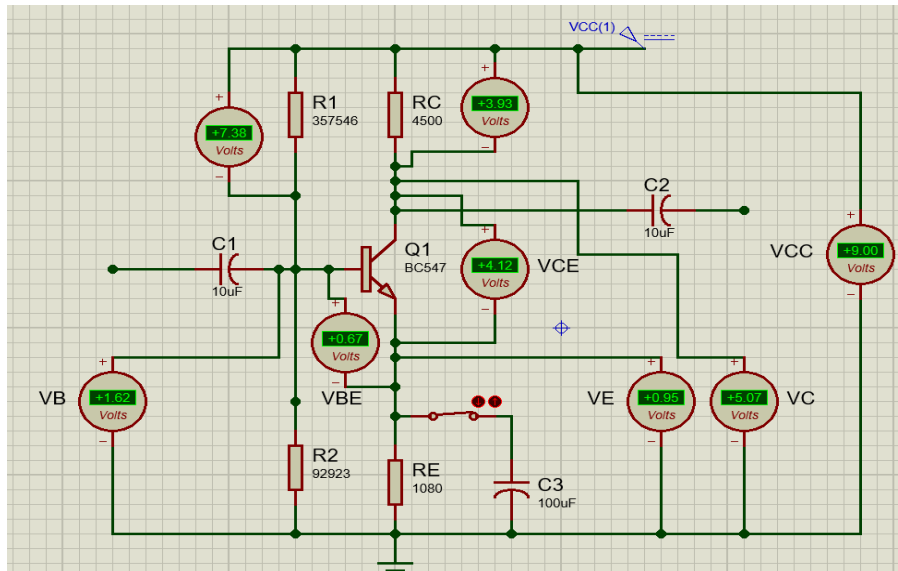


Figure 19 Circuit DC condition voltages

(2)

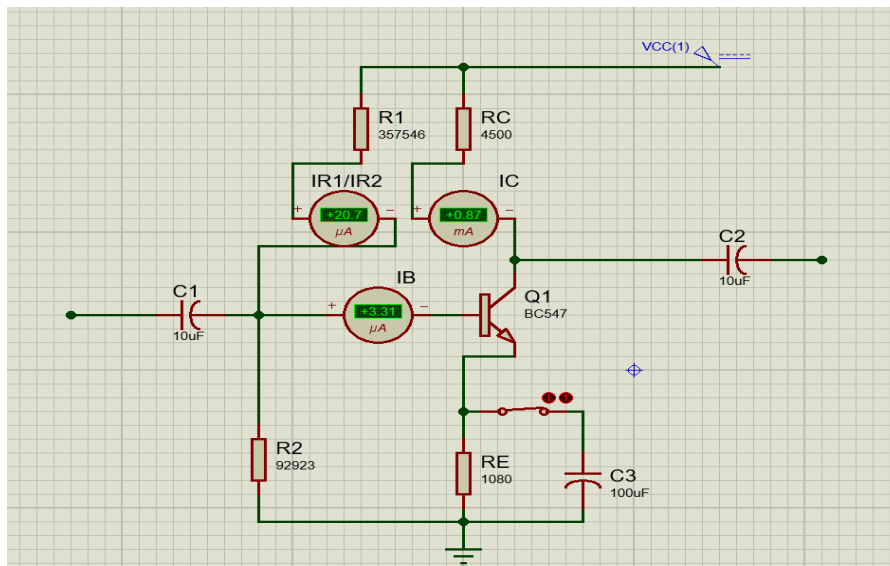


Figure 20 IC, IB and IR1

- AC conditions

I then connected a Signal generator to the input and gathered the following Results:

Value	Measured
Max gain	42.8DB
Lower Cutoff frequency (at -3DB point)	53.2Hz (shown in figure 25)
Upper Cutoff frequency (at -3DB point)	3.26MHz (shown in figure 26)
Bandwidth	$3,260,000 - 53.2 = 3,259,946.8\text{Hz}$

Commented [RB16]: All good.

(1)

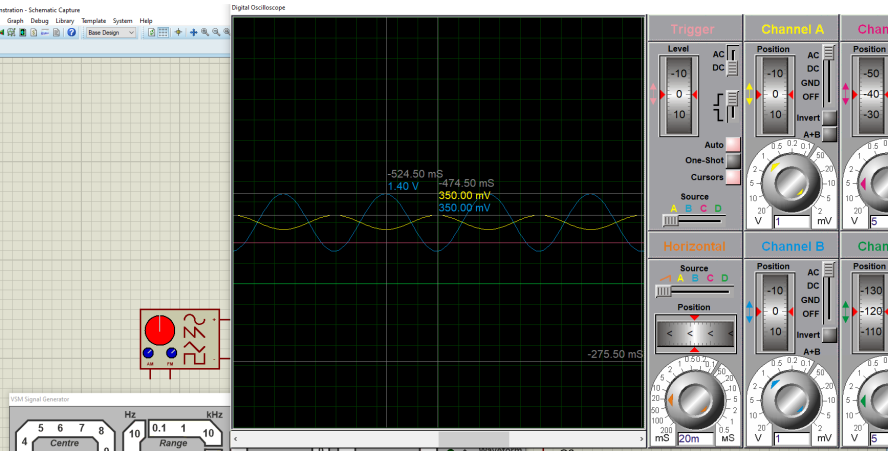


Figure 21 Amplified signal

(2)

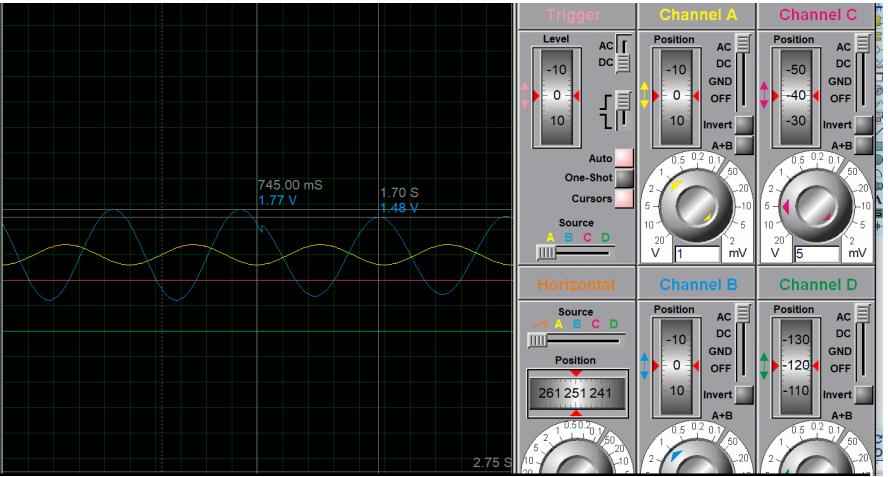


Figure 22 Effect of Decoupling capacitor on gain

(3)

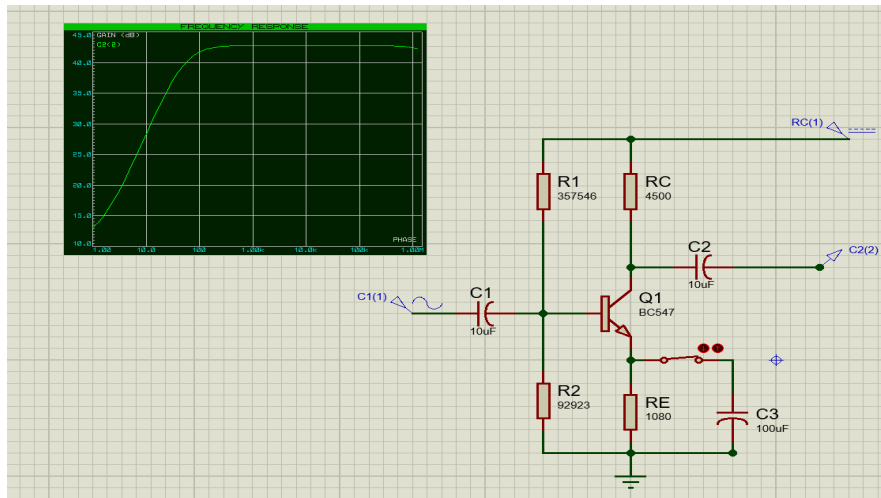


Figure 23 Bode Plotter frequency response in AC conditions

(4)

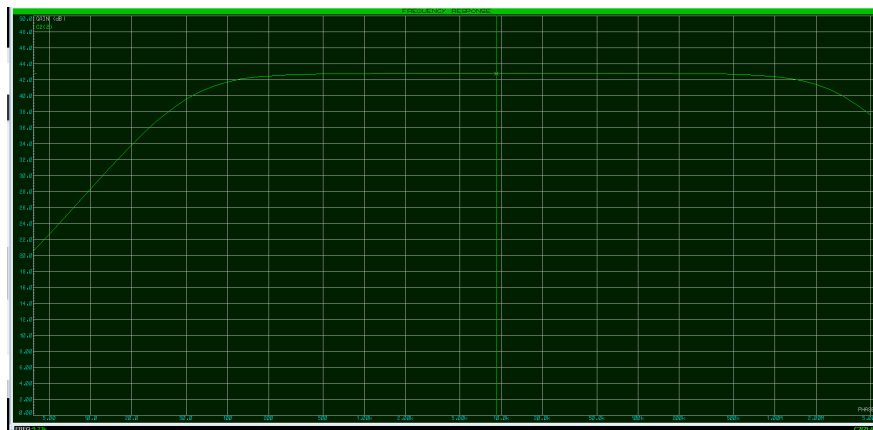


Figure 24 centre frequency with optimum gain

(5)

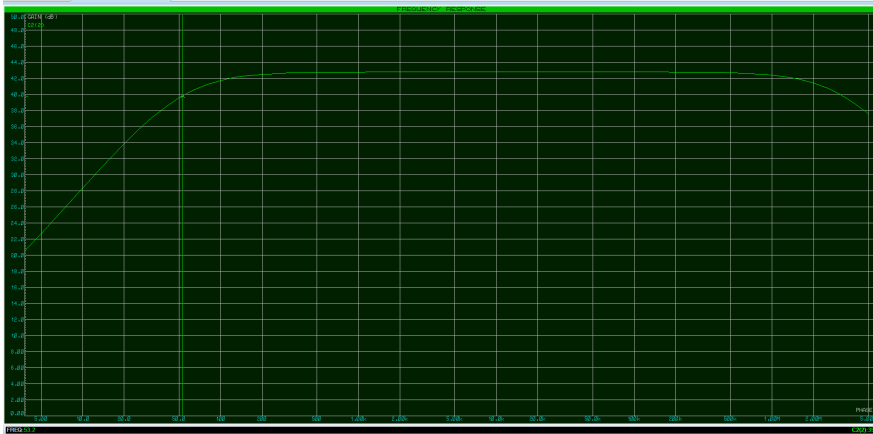


Figure 25 -3db point of the lower cut off frequency

(6)

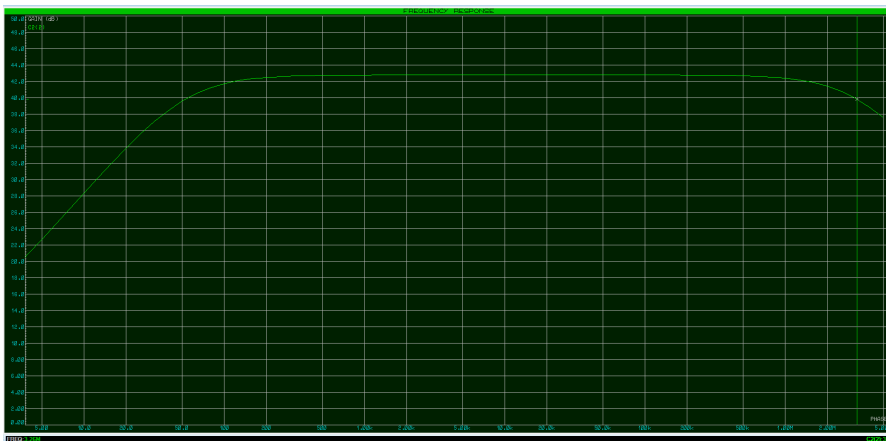


Figure 26 -3db point of the upper cut off frequency

(7)

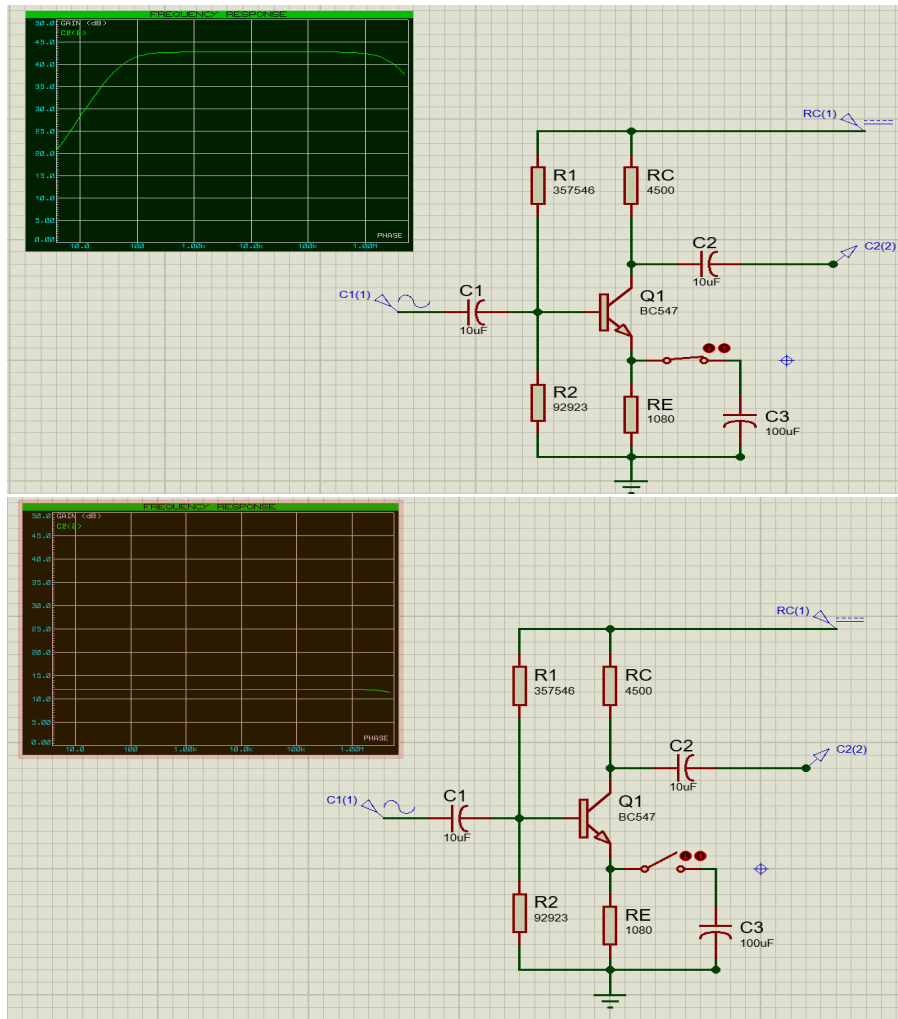


Figure 27 Difference in gain with and without the decoupling (AC filter) capacitor on the output

- Results from Practical and Simulation

DC CONDITIONS

VALUE	MEASURED	SIMULATED
V_C	4.98V	5.07V
V_{CE}	4.01V	4.12V
V_E	1.01V	0.95V
V_{BE}	0.68V	0.67V
V_B	1.68V	1.62V
I_C	0.92mA	0.87mA

My results are consistent with one another and any slight discrepancies seen can be attributed to rounding during calculations, component tolerances and Pre-programmed simulation settings. During the practical I used resistor values nearest to my calculated values by what was available in college. In the simulation, I used the calculated values, rounded to the nearest whole number as I was able to type in the exact value. This shows in my results, for example the value I used for R_C in my practical was 4.7K and for my Simulation it was 4.5K, this shows in the difference on my V_C values as my practical showed a larger volt drop across R_C . The ideal value for V_C would have been half of V_{CC} , if I were to re do this experiment, I'd increase R_C until V_C reduced to nearer 4.5V for more protection of the transistor from fluctuation in the output signal. I can see that I_C is roughly 10% of the $I_{C_{MAX}}$ in both sets of results, which coincides with my calculated values.

Commented [RB17]: Good point.

AC CONDITIONS

As a result of the coronavirus pandemic, I was unable to acquire actual values for the AC conditions in my practical test.

I can say that I would have expected to have been able to draw a graph similar to my simulated results as my conditions for my DC circuitry were consistent with one another.

Commented [RB18]: Understandable.

(d)

The circuit performs well as an amplifier and has a steady gain of over 40db for a wide range of frequencies.

OP-AMP

OP-AMPs are dual input, single output devices which are used to amplify a small signal. OP-AMP chips are configured using resistors, transistors and capacitors. They get the name 'operational' due to their capability to carry out the mathematical operations of Addition, Subtraction, Integration, and differentiation. A standard OP-AMP chip will have 8 pins, the 5 shown here, plus two offset pins and a ground.

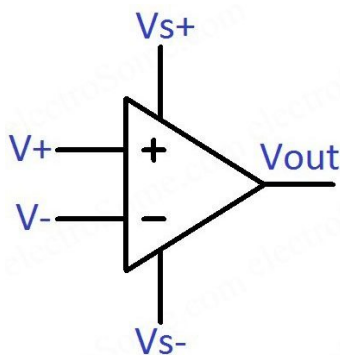


Figure 28 Op-Amp pins

1. V_{s+} is the positive battery supply input
2. V_{s-} is the negative battery supply input
3. V_+ is the Non-Inverting input pin, V_{out} is in phase with the input on this pin.
4. V_- is the Inverting input, V_{out} is 180 degrees out of phase to the input in this configuration
5. V_{out} this is the amplified output of the input signal.

V_+ is always equal to V_- in an OP-AMP.

Parameters

Battery supply: The overall voltage amplification is unable to exceed the external power supply voltage, regardless of internal gain.

Open loop voltage gain (A): The measured difference of the output signal to the input signal. It does not have a feedback loop and is the internal gain of the device.

Input impedance (in AC amplifier): Phase delay of input voltage compared to input current, expressed in ohms.

Output impedance (in AC amplifier): Ratio of open circuit voltage to short circuit output current, expressed in ohms.

Offset voltage: The voltage that needs to be applied to make the output voltage exactly 0V.

Bandwidth: Frequency range at which the optimum output AC voltage swing falls by 0.707V.

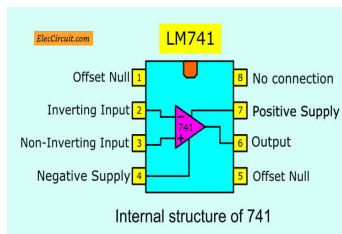


Figure 29 Chip pin configuration of 741 op-amp

Commented [RB19]: Good point

Ideal Characteristics

Infinite open loop gain ($A > 20000$): The gain is infinite and only limit once the output is equal to the level of the input supply.

Infinite input impedance ($> 10\text{Mohm}$): This intends the input current signal to $= 0$.

Zero output impedance: Allows the output current signal to be very high to power large load.

Zero offset voltage: This is so that the Output voltage is 0 when the two inputs are both 0.

Infinite bandwidth: Would mean that the Gain of the amplifier remains at its optimum level for any input frequency.

Inverting amplifier

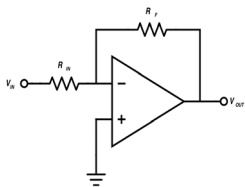


Figure 30 inverting amplifier

An inverting amplifier has the input signal induced to the (-) pin and employs a parallel connected negative feedback loop to determine the gain of the amplifier. The Non-inverting input is connected to ground to drain any leakage input current. The inverting input has a resistor connected in series with the supply to restrict current flow. The

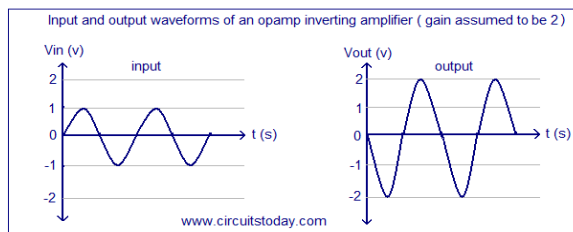


Figure 31 Inverted amplified output

feedback resistor allows the user to choose the gain of the amplifier. The closed loop voltage gain of this amplifier is calculated by using the formula:

$$\text{Closed loop Voltage Gain} = -\frac{R_f}{R_{in}} = \frac{V_{out}}{V_{in}}$$

Note: R_f is negative as the output signal out of phase with the input signal.

Commented [RB20]: Good explanation with supporting pictures

Non-Inverting amplifier

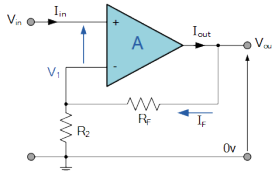


Figure 32 Non inverting Amplifier

The input signal is applied to the (+) pin and results in the amplified output signal being in phase with the input signal. The Inverting input here is connected to ground and the negative feedback loop remains connected in parallel with this input. The Closed Loop Voltage Gain of this amplifier is worked out by:

$$\text{Closed loop Voltage Gain} = \frac{R_f}{R_{in}} + \frac{R_{in}}{R_{in}} = \frac{R_f}{R_{in}} + 1$$

The total circuit resistance can be worked out using:

$$R = \frac{R_{in} \times R_f}{R_{in} + R_f}$$

Closed loop configuration

Part of an output signal is taken back to the input for comparison.

There are two types of feedback for this:

(1) Regenerative/Positive Feedback:

This is where the output signal which is fed-back to the input in phase with it.

(2) Degenerative/Negative Feedback:

This is where the output signal which is fed-back is out of phase with the input.

Negative feedback loops are used when an OP-AMP is an amplifier, the overall gain is reduced but gain stability is greater over a large range of input voltages and frequencies. The gain of the amplifier is determined by the values of the exterior resistors connected to the input and the feedback loop. The output is less distorted compared to an open loop voltage gain circuit. (D C Green, 1998)

DC Amplification

The OPAMP can be used to amplify DC signals, the gain is determined by the input impedance and the resistance of the negative feedback loop. The DC amplification is limited by the coupled dc supply which powers the internal components of the op amp. If a supply is 12V and the input signal is 1.2V, with an internal gain of 10, determined by the feedback resistor, the maximum input signal for optimum gain is 1.2V, if it were any higher, it would be unnecessary use of power as the output is a maximum of 12.

Commented [RB21]: Good point

AC Amplification

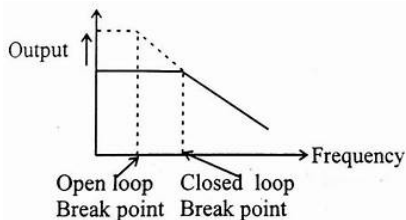


Figure 33 Frequency response of open loop and closed loop gain

The frequency response is shown here, it shows that the closed loop configuration is far more stable across a larger range of frequencies yet has lower gain, whereas the open loop is higher gain but has a smaller bandwidth.

The gain bandwidth product is a parameter which looks at the effect of gain in relation to

frequency. The higher the gain the smaller the operating bandwidth, the lower the gain, the larger the operating bandwidth. It is calculated using:

$$\text{Gain Bandwidth Product} = \text{Gain} \times \text{Bandwidth (expressed in Hz)}$$

The phase angle may differ between the input and output of the OP-AMP due to capacitive or inductive loads on the output, this can cause a closed loop configured OP-AMP to become unstable when the gain is at its unity value.

Slew rate

The slew rate is the time taken for an amplifier to respond to an instant change of input signal, due to the internal components of the OPAMP, the change isn't

instantaneous. When an input signal

amplitude is higher, the output waveform shows a time lag before the desired signal is achieved. The time taken for the OP-AMP to achieve the desired level is called the rise time.

With sinusoidal waveforms, as the frequency increases, the OP-AMPs gain is limited by

how fast it can respond to the change, the wave then changes from a smooth sine wave to a triangular clipped waveform as it is not able to respond to the alternating input at a higher frequency. Notice that the phase angle becomes lagged on the output as the

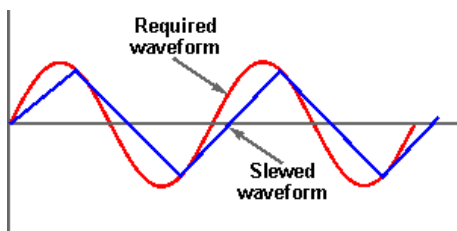


Figure 35 Sine wave slew rate

frequency increases because the OP-AMP is unable to cope with the rate of change.

Commented [RB22]: Good point

Commented [RB23]: Spot on

Commented [RB24]: Here in the conclusion you could say that internal slew rate of op-amp can impair the functionality of op-amp as amplifier at high frequency and high output voltages.

Otherwise, it's a really an impressive piece of work. I do appreciate your efforts, keep it up.

References

Author	Year	Title (in italics)	Edition	Place	Publisher
J Bird	2007	<i>Electrical and Electronic Principles and Technology</i>	3 rd		
M Tooley	2015	<i>Electronic Circuits: Fundamentals and applications</i>	4th		Routledge
D C Green	1998	<i>Digital Electronics</i>			Longman
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STUDENT FEEDBACK FORM

This section details the *extent* to which the assessment criteria are demonstrated by you, which in turn determines your mark. The marks available for each category of skill are shown. Lecturers will use the space provided to comment on the achievement of the task(s), including those areas in which you have performed well and areas that would benefit from development/improvement.

Generic Assessment Criteria	Marks available	Marks awarded
1. Engagement with Literature Skills	15	
You have used a wide range of the literature including books and relevant website to provide supporting evidence for your explanations throughout the assignment. However, you have missed the Harvard referencing style and also need to pay attention to text-citation style to score better in this section.	60% 15	9
2. Knowledge and Understanding Skills	30	
You have demonstrated the excellent and detailed knowledge and understanding of the basic underlying concepts of diodes and transistors and Op-amps. For each task, you have explained the concept in a comprehensive manner with illustrations in place. Especially, your explanation on calculations and parameters of Zener diode is commendable. However, for transistor task, you could consider the biasing, DC load line and different operating regions of the transistor to explain its function as an amplifier in more detail.	85% of 30	25.5
3. Cognitive and Intellectual Skills	15	
You have exhibited excellent cognitive and intellectual skills by verifying simulated and measured results against the calculated values and providing the explanation for any variation in the measured and simulated results. All the calculations are accurate and well presented by stating the formulas and the reason behind each step. The way you have shown and explained the calculations for the designing of the power supply unit and	88% of 15	13.2

common emitter transistor circuits is worth appreciation. Well done, Aaron.		
4. Practical Application Skills	25	
Whilst performing simulation and practical work in classroom, you have demonstrated your exceptional ability to use different approaches to find solutions for the encountered problems. I acknowledge that you could not provide the evidence for all practical activities due to unforeseen closure of the college. However, the efforts you have made to complete the simulation work despite the college closure are commendable. Your simulated results are very well explained with every evidence in place, showing your outstanding understanding of the underlying concepts.	90% 25	22.5
5. Transferable Skills for Life and Professional Practice	15	
You have demonstrated exceptional presentation skills by putting your calculations in tabular format to make it easier to follow on. Your usage of equation editor and pictures when required to explain the concept deeply is worth appreciation. Overall, I would say your work is accurate, exceptionally coherent, very fluent and presented well, demonstrating your exceptional skills for employment requiring the exercise of some personal responsibility with an appetite for further development. Well done Aaron!	90% 15	13.5

Assessment Mark (Assessment marks are subject to ratification at the Exam Board. These comments and marks are to give feedback on module work and are for guidance only until they are confirmed.)	Late Submission Penalties (tick if appropriate)		83.7%
	Up to 1 week late (40% Max)		
	Over 1 week late (0%)		