

MARKING CRITERIA AND STUDENT FEEDBACK

This section details the assessment criteria. The *extent* to which these are demonstrated by you determines your mark. The marks available for each criterion 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.

Common Assessment Criteria Applied	Marks available	Marks awarded
1. Research-informed Literature Extent of research and/or own reading; selection of credible sources; application of appropriate referencing conventions	10	4
References to a limited range of mostly relevant sources. Some omissions and minor errors.		
2. Knowledge and Understanding of Subject Extent of knowledge and understanding of concepts and underlying principles associated with the discipline.	10	5
Evidence of basic knowledge and understanding of the relevant diodes and transistors. Need to include all calculation work i.e. voltage regulator design.		
3. Analysis Analysis, evaluation and synthesis; logic, argument and judgement; analytical reflection; organisation of ideas and evidence	30	10
Some evidence of analysis for some of the assignment elements, but for the most part descriptive. There was an attempt at an overall conclusion but was lacking in detail, need to make links to relative theory.		
4. Practical Application and Deployment Deployment of methods, materials, tools and techniques; application of concepts; formulation of innovative and creative solutions to solve problems.	40	28
Very good practical work, required some guidance. All relative calculations were obtain and showed a clear understanding of the procedures.		
5. Skills for Professional Practice Attributes in professional practice: individual and collaborative working; deployment of appropriate media; presentation and organisation.	10	5
Mostly coherent work and is in a suitable structure.		

Assignment 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)

Up to four weeks late

First Attempt?

✓

52%



School of Applied Computing ASSIGNMENT SPECIFICATION

Student name:	Carys Williams	Student P number:	
Programme:	HND Electrical/Electronic Engineering		
Lecturer:	Jason Pointer	Internal Verifier:	Steve Roberts
Assignment Title:	Diode and Transistor Characteristics		
Hand Out Date:	10/11/17	Submission deadline:	15/12/17

Referencing:	In the main body of your submission you must give credit to authors on whose research your work is based. Append to your submission a reference list that indicates the books, articles, etc. that you have read or quoted in order to complete this assignment (e.g. for books: surname of author and initials, year of publication, <u>title of book</u> , edition, publisher: place of publication).		
Disclosure:	I declare that this assignment is all my own work and that I have acknowledged all materials used from the published or unpublished works of other people. All references have been duly cited.		
Student's Signature:	<i>Hardcopy assignments will not be accepted without a signature here</i> 	Date:	

Late submission will result in a late penalty mark, as follows:

Up to four weeks late, maximum mark of 40% for first attempts and 0% for resubmissions.

(Academic Quality Handbook 2015/16 7.5 (5))

Learning Outcomes tested (from module syllabus)

1. Demonstrate an understanding of semi-conductor components and characteristics and their application in analogue and digital electronic circuits.

2. To design, simulate, build, test and evaluate analogue and digital electronic circuits using information gained from datasheets.

Assignment name: Diode and Transistors Characteristics

Module code: PSDE 4004

Assignment number 1 of 3

Tutor: Jason Pointer

Student Name: Carys Williams

Student Number: 110538

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Introduction

This assignment will show the characteristics of a diode and also the static characteristics of a bipolar transistors. It will show results from test that have been carried out and graphs to represent the tables with the values recorded. In both sections it will give a detailed explanation of both diode and transistors.

The assignment will also show circuits being built on multisim to show how changing one value it changes the output of the entire circuit. Also this assignment will consist of a lot of maths showing the calculated values compare to the results obtained by measuring with a multimeter.

Task 1: Diodes

In this task it will be about diodes, silicon and germanium, and how they react with different values. A diode is the most common type of junction diode. This consists of a crystal of silicon or germanium. There is a difference between germanium and silicon.

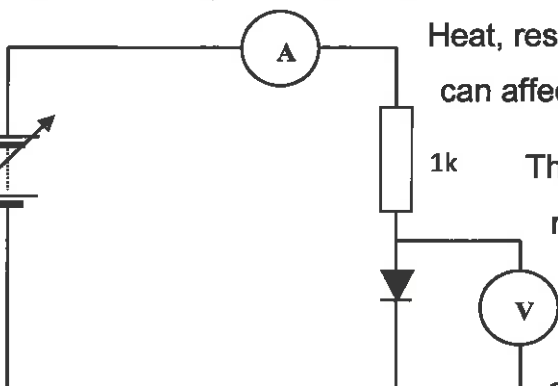
Germanium has a lower forward voltage drop than silicone ("turn on voltage"). The voltage is usually around 0.3V for germanium as for Silicone one is 0.6V. Silicon has a lower reverse leakage than germanium. More power is usually dissipated from a silicon diode then a germanium diode. Silicone diode can handle a higher reverse voltage than the germanium before the breakdown occurs.

(Information above for the introduction of diodes was all accessed from 'Semi-conductor diode' see reference for more information)

Part A

Characteristics of a diode

The experiment that was carried out used a 1K (1,000 Ω) resistor, However when tested for the value it was at 983 Ω . With the resistor having a gold band this shows that the 1K can be up to 5% out from the value it says it is. This is the most accurate type of resistor when the gold band is on it.



Heat, resistance, connections and human errors are all factures which can affect the values provided in all calculations and results.

The following circuit was constructed and was measured to get results. The supply voltage got adjusted so that the diode would go up in increments of 0.1V from 0V to 1V. The equipment and components used would not be very accurate due many factures stated above.

Appendix 1-4 shows the reverse and forward bias of each silicon and germanium. Graphs in the appendix show the forward and reverse biases which were calculated to find out R_s and ΔR below. With the forward bias the supply voltage was increased from 0V and

Voltage (V)	Current (mA)
0	0
0.1	0.00004
0.2	0.00023
0.3	0.00157
0.4	0.01235
0.5	1.01
0.6	1.631
0.7	5.59
0.8	32.5

increased in increments of 0.1V to the maximum voltage of 1V.

Both tables on the left and right show the results after testing the diodes in the forward direction. The table on the left is the results of the silicon diode. The silicon diode only goes up to 0.8V because the supply voltage couldn't give enough current to allow it to go up to 0.9V and 1V.

Voltage (V)	Current (mA)
0	0
0.1	0.014
0.2	0.186
0.3	0.757
0.4	1.82
0.5	3.05
0.6	4.54
0.7	6.27
0.8	8.14
0.9	10.22
1	12.25

In the results it shows that a silicon diode doesn't leave current through unless it's at or above 0.5V. After 0.6V the value of current (in mA) increases dramatically which means the current can flow through the diode. Referring back the 'semi-conductor diode' in the introduction it dose specify that silicone diode normally leave current through at 0.6V.

V1	V2 (mV)	V_D	I (nA)
0	0	0	0
-1.5	60	-1.56	-6
-3	67	-3.067	-6.7
-4.5	72	-4.572	-7.2
-6	77	-6.077	-7.7
-7.5	79	-7.579	-7.9
-9	79	-9.079	-7.9
-10.5	83	-10.583	-8.3
-12	84	-12.084	-8.4
-13.5	84	-13.584	-8.4
-15	84	-15.084	-8.4

v1	v2	vd	I (uA)
0	0	0	0
-1.5	7	-1.507	-0.7
-3	13	-3.013	-1.3
-4.5	24	-4.524	-2.4
-6	42	-6.042	-4.2
-7.5	68	-7.568	-6.8
-9	102	-9.102	-10.2
-10.5	144	-10.644	-14.4
-12	196	-12.196	-19.6
-13.5	256	-13.756	-25.6
-15	323	-15.323	-32.3

The table above to the left is to show the reverse bias values of the silicone diode that had been recorded. On the right above is the result from the geranium reveres bias values. In the tables on Excel, where the V_D results got calculated and the formula to the right shows how we calculated V_D and I (A) which helped to form the graphs. (graphs are appendix 1-4 with calculations below them).

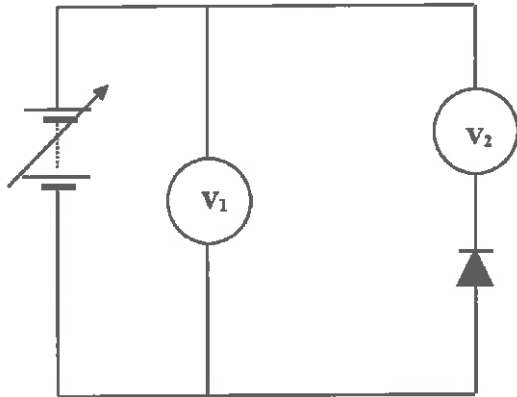
In the reverse direction the leakage current is very small which can be determined using the resistance of the multimeter (10M Ω).

where:

$$I = \frac{V_2}{10 \times 10^6}$$

and $V_D = V_1 - V_2$

Note to get a measurable voltage for the germanium diode place a 10k Ω in parallel with V_2 .



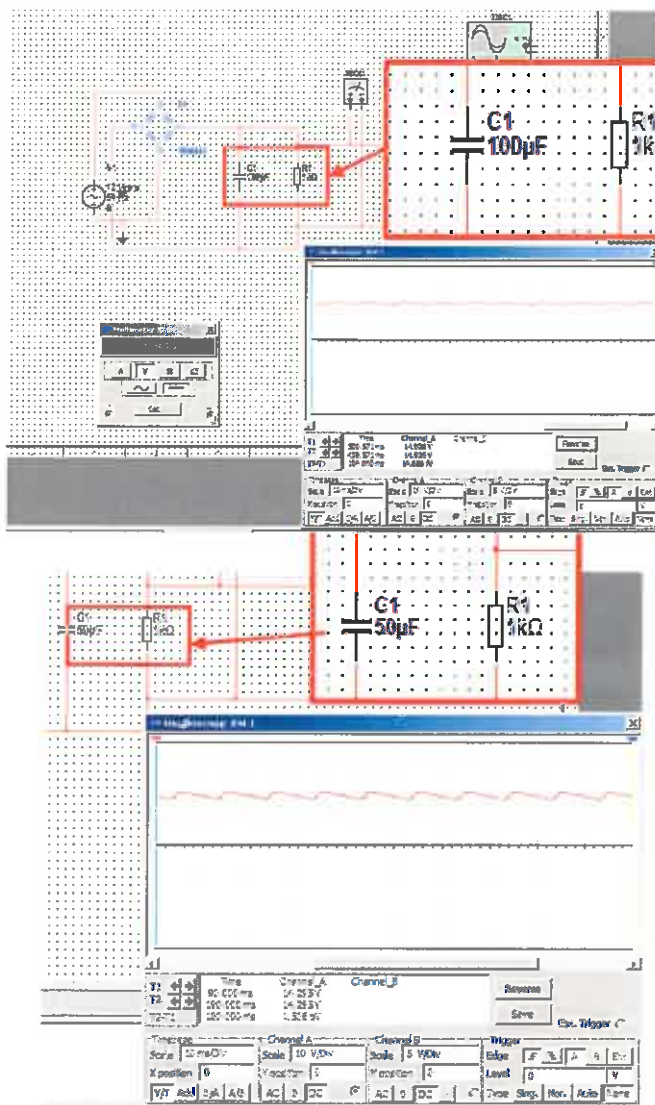
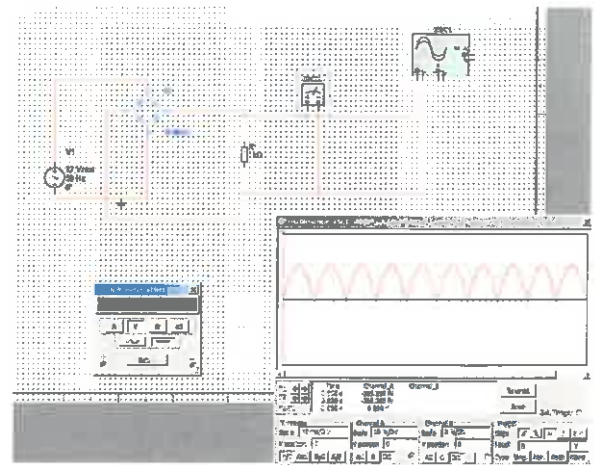
The circuit to the left is the circuit that was constructed to be used to make the reverse bias calculations. Although for the germanium diode there was a $10\text{K}\Omega$ resistor added in parallel to the V_2 . The reason the resistor has been added to the germanium and not silicon is because the germanium resistance is low and the multimeter resistance would cancel out the diode resistance. So the $10\text{K}\Omega$ resistor is to solve the resistance between both the diode and the multimeter.

Part B

In multisim the circuit below shows that the rectifier in the circuit to be positive as shown on the oscilloscope in multisim. A traditional AC wave length goes down to the negative as part of it cycle, however in the figure it shows the AC only being in the positive segment.

This happens due to the fact that the positive and negative flow travels through the load in the same direction make no negative cycle on the wave form.

Figure 5 (appendix) is a diagram showing how the direction of flow for negative and positive pass through the rectifier. This is how the wave form manages to change.

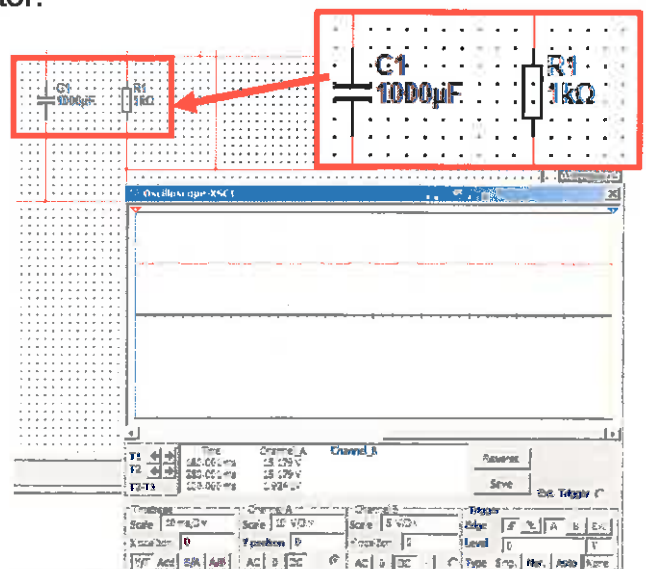


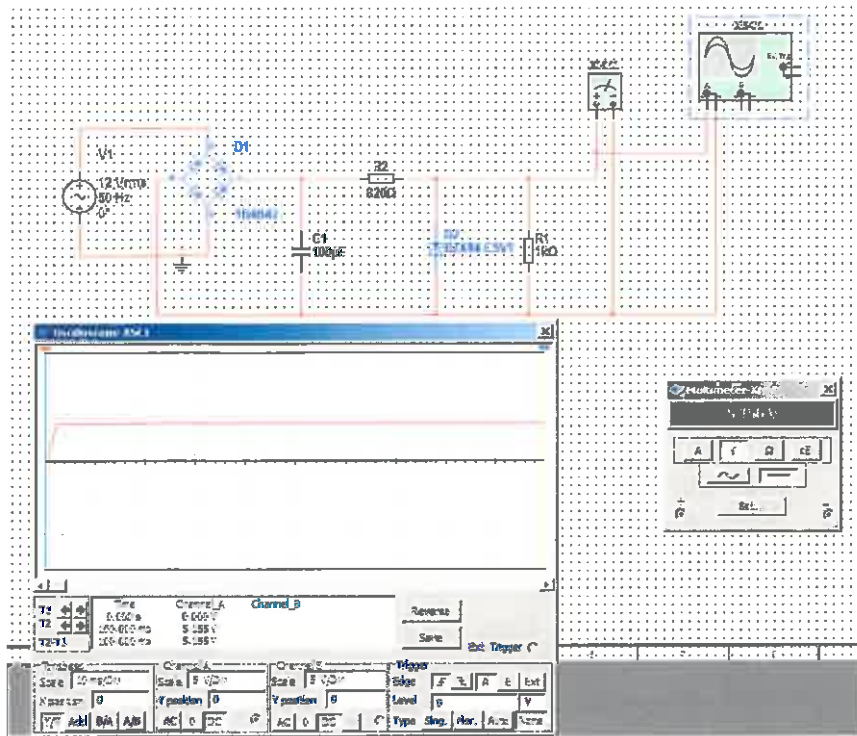
Here is an image of the same circuit on multisim however there is a capacitor added into the circuit. The capacitor does affect the output by converting it to a DC voltage supply; however, it isn't a perfect conversion due to the fact that the line isn't horizontal to the x axis. By using different capacitors the oscilloscope will change and will cause the DC voltage to fluctuate.

Below are two images of the same circuit on multisim as on page 5. However, the only difference is that the capacitors have changed values to show how much difference it can affect the oscilloscope wave form.

Here is a screenshot of part of a circuit with a capacitor of a 50µf (microfarads). By comparing this oscilloscope reading (50µf) and the reading on the 100µf circuit, the difference is surprising seeing as it is a small amount of difference in the values of the capacitor.

With this figure to the right the circuit has a 1000µF capacitor. Also when looking at the oscilloscope, it is nearly a perfect line which means it's close to a perfect DC Voltage.





In the figure to the left it shows a straight wavelength in the oscilloscope this is due to the fact that there is an extra diode and also a larger value on the capacitor and has formed a perfect DC voltage. With the resistor and capacitor being in the circuit this causes a higher resistance throughout the circuit which helps prevent any AC voltage from fluctuate the output voltage.

The main factor for the line to be perfectly straight is due to the diode being a zener diode. According to the data sheet BZX84c5V1 it states that the base internal resistance of the diode is 15Ω at 20mA or 60Ω at 5mA at about 25°C. With the diode being a voltage regulator it won't allow current

to pass through unless the voltage is around 5V and because of this it keeps the graph as a straight line because there is a constant high voltage.

Task 2: Transistors

In this section it will have information about the different transistors or Bipolar Junction transistor and how it works. There are two basic types of transistors; these are P-N-P and N-P-N. All transistors are semiconductors devices which is way they are used for many functions because if they are connected properly they can do many functions. Most common transistors these days are made with silicon or germanium to form two P-N junctions.

Characteristics of BJTs

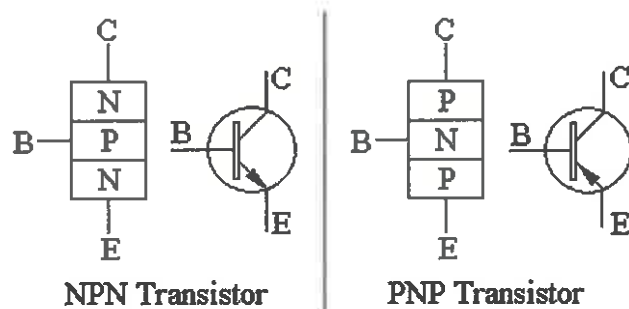
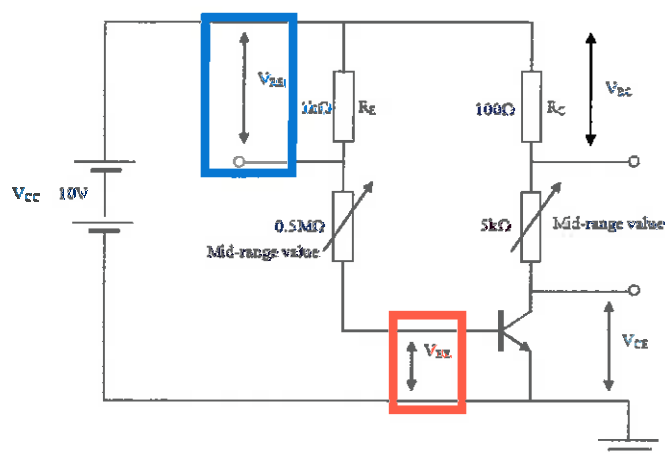


Figure 2 (on the left) shows the type of transistors and their symbol of both N-P-N and P-N-P. As shown they aren't much difference between both transistors. There is however a few difference between them both.

'P-N-P and N-P-N are completely the opposite of each other when it comes to how they operate. N-P-Ns emitter is negative with respect to the base as for with a P-N-P transistor the emitter is positive. And then with the collector P-N-P is negative and the N-P-N is positive'. (Introducing transistors, national extension college trust Ltd).

With the circuit that was required to build and record the values shown on meters, there are many factures that need to be taken into account when looking at the results for example the resisters can by up to 5% out of the value their meant to be. Also human error, heat and many other factors can affect the results that are produced.

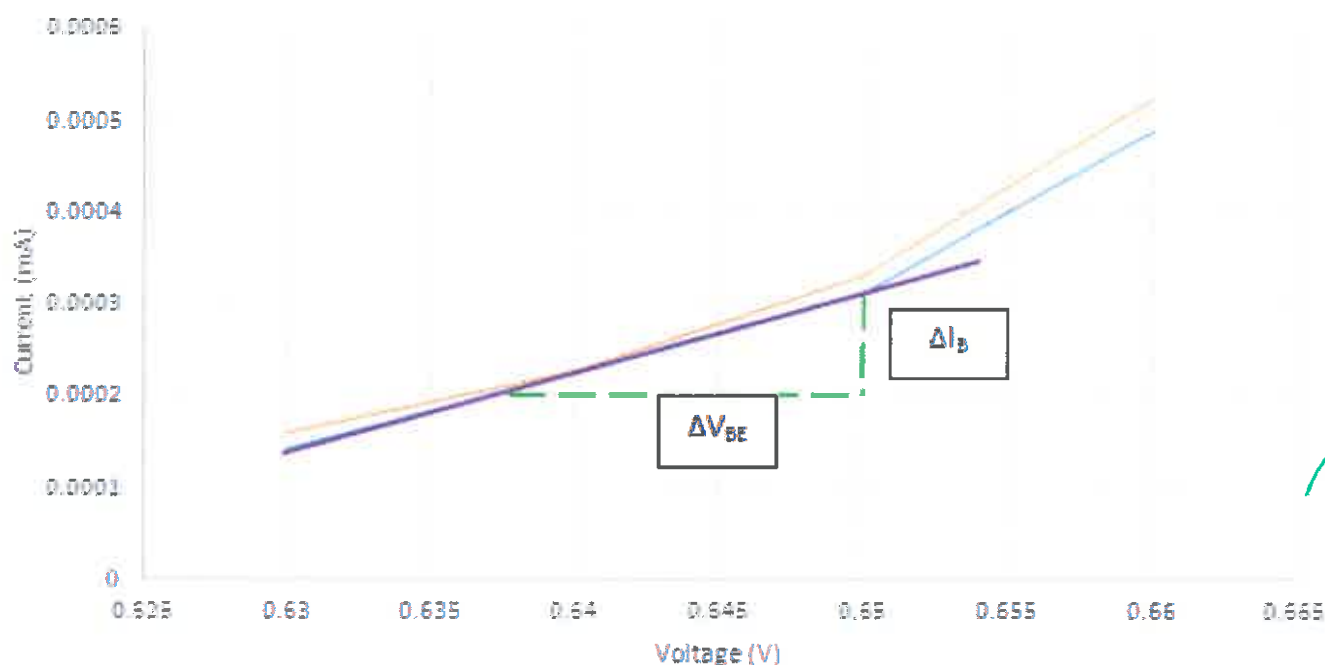
$V_{CE} = 3V$			$V_{CE} = 5V$		
V_{BE}	V_{RB}	$I_B = V_{RB}/R_B$	V_{BE}	V_{RB}	$I_B = V_{RB}/R_B$
0.63V	0.1416	0.0001416	0.63V	0.159	0.000159
0.64V	0.222	0.000222	0.64V	0.226	0.000226
0.65V	0.311	0.000311	0.65V	0.33	0.00033
0.66V	0.487	0.000487	0.66V	0.521	0.000521



Above is the table with the results that were recorded from the experiment which required measurements and calculations. As shown the voltage was either at 3V or 5V and V_{BE} went up in increments of 0.01V and the value on the multimeter was recorded.

To the left is the diagram that was used to set up the circuit to be able to measure V_{BE} and V_{RB} (highlighted in the diagram) which was then divided together to give I_B . Below is a graph that has been constructed from the result table and a tangent line was drawn to calculate h_{ie} . The calculation is below as well.

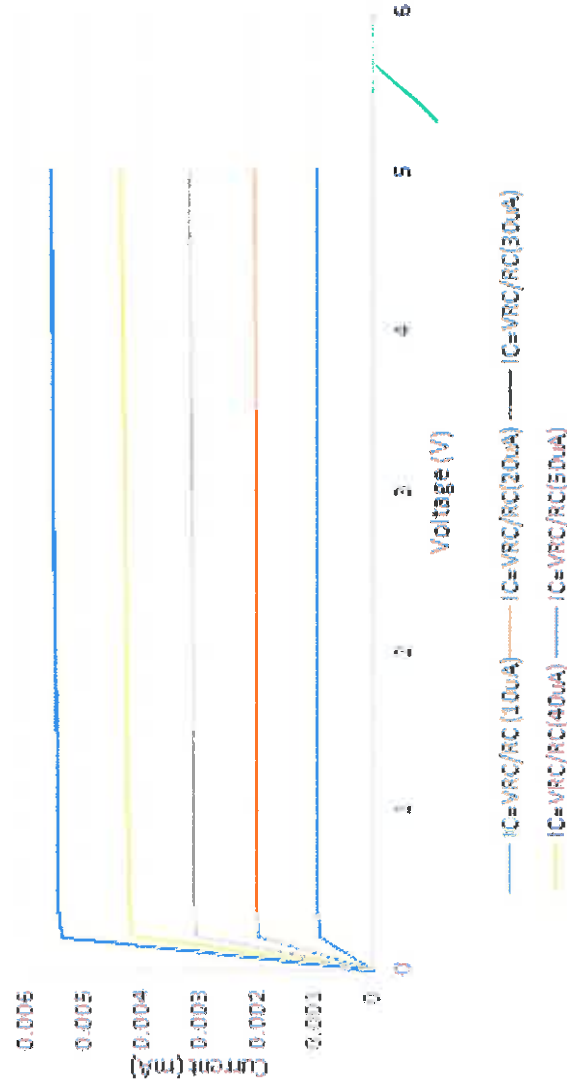
$$I_B = V_{RB}/R_B(V3)$$



$$\begin{aligned}
 h_{ie} &= \frac{\Delta V_{BE}}{\Delta I_B} \\
 &= \frac{0.0125}{0.00012} \\
 &= 104.16\Omega
 \end{aligned}$$

		$I_B = 10\mu A$		$I_B = 20\mu A$		$I_B = 30\mu A$		$I_B = 40\mu A$		$I_B = 50\mu A$
V_{CE}	V_{RC}	$I_C = V_{RC}/R_C$	V_{RC}	$I_C = V_{RC}/R_C$	V_{RC}	$I_C = V_{RC}/R_C$	V_{RC}	$I_C = V_{RC}/R_C$	V_{RC}	$I_C = V_{RC}/R_C$
0.0V	0	0	0	0	0	0	0	0	0	0
0.2V	0.928	0.00928	0.1976	0.001976	0.3033	0.003033	0.4157	0.004157	0.5352	0.005352
0.4V	0.94	0.0094	0.1993	0.001993	0.3072	0.003072	0.4214	0.004214	0.5436	0.005436
0.8V	0.943	0.00943	0.1997	0.001997	0.308	0.00308	0.4224	0.004224	0.5446	0.005446
1V	0.945	0.00945	0.1995	0.001995	0.3084	0.003084	0.4244	0.004244	0.5464	0.005464
3V	0.952	0.00952	0.2012	0.002012	0.3116	0.003116	0.4302	0.004302	0.5517	0.005517
5V	0.958	0.00958	0.2025	0.002025	0.3147	0.003147	0.4347	0.004347	0.5574	0.005574

$I_C = V_{RC}/R_C$



Here is a table and graph to represent the results of I_C from $10\mu A$ up to $50\mu A$, going up in increments of $10\mu A$.

With the graph and drawing a tangent it wasn't necessary due to the fact that the tangent line would completely cover the result line. The calculation is still possible and here is the result (below).

$$H_{FE} = \frac{I_C}{I_B}$$

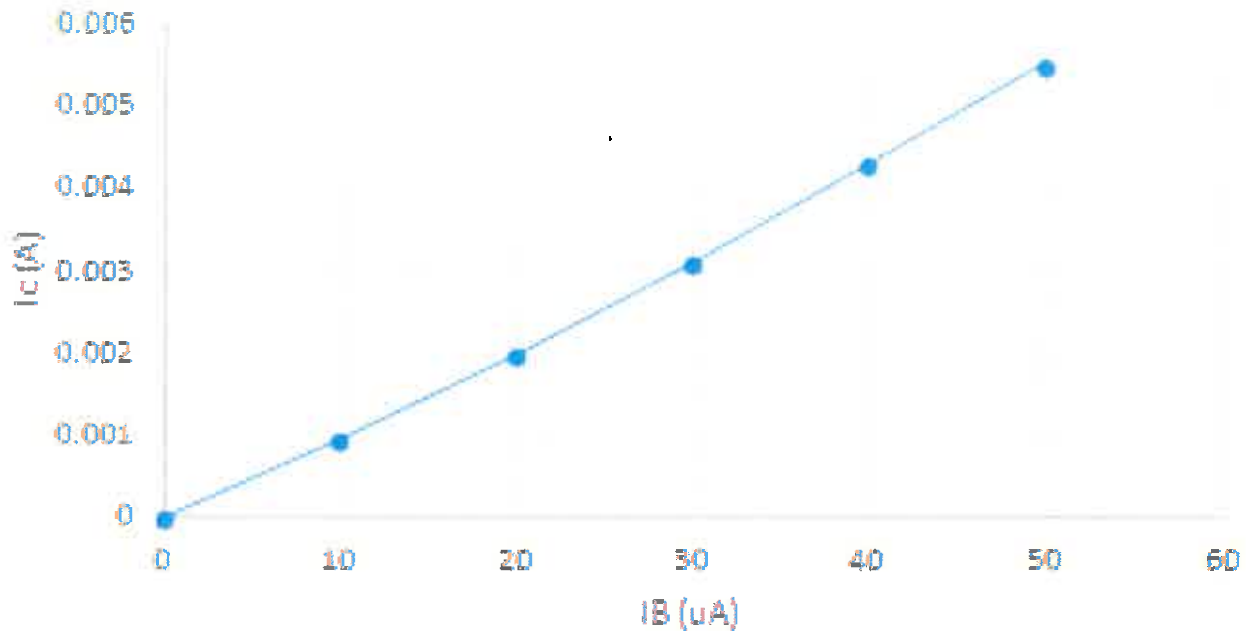
$$\frac{\Delta V_{CE}}{\Delta I_C}$$

$$= \frac{0.005574 - 0.005352}{4.8}$$

$$= 46.25\mu S$$

$$= 46.25\mu S$$

For $V_{ce} = 3V$



$$I_C/I_B = 0.002/20\mu = 100$$

Here is a graph and calculation for V_{CE} for 3V. As the graph shows it goes across with I_B and up with I_C . With the calculation it from the point 0 to 20 on the I_B and up from 0 to 0.002 on the I_C and because of the units it gave the answer 100. There isn't a unit when calculating V_{CE} .

Conclusion

All information obtained above in the report is accurate according to datasheets. All the values may be out slightly due to human errors or other features that could affect the results. However the values are close enough to give an answer similar to the data sheets values. It's also interesting finding out what happens when extra components get added or values increase in value how it effects the oscilloscope result.

Need more detail in the conclusion make links to relative theory.

Reference

'Semi-conductor diodes', national extension college trust ltd.

'Introducing Transistors', national extension college trust ltd.

Horowitz.P and Hill.W(1990) '*The Art of Electronics*', 2nd edition. Cambridge: Press Syndicate.

<http://www.radio-electronics.com/info/circuits/diode-rectifier/bridge-rectifiers-circuits.php> figure 1

<http://www.mouser.com/ds/2/149/BZX84C5V1-888708.pdf> information on the BZX84c5V1

<https://www.autodesk.com/products/eagle/blog/transistors-world-modern-electrons/> Figure 2

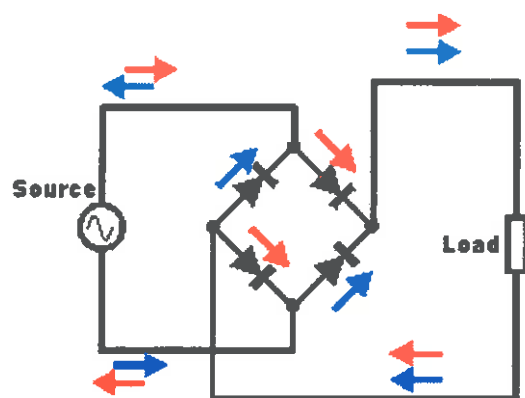
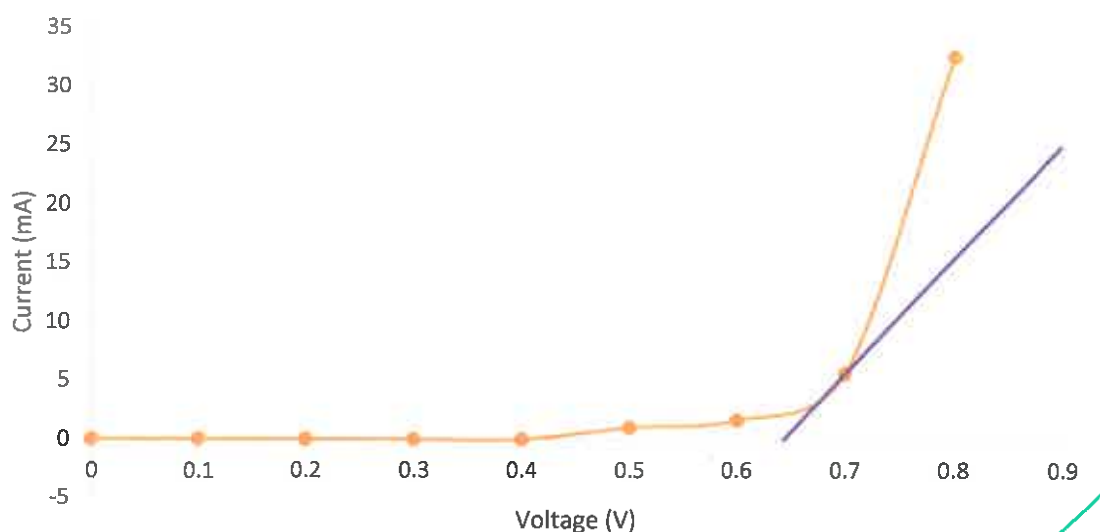


Figure 5

1.

Silicon Forward Bias



$$R_s = \frac{V_s}{I_s}$$

$$= \frac{0.7}{8.59 \times 10^{-3}}$$

$$= 125.2 \, \Omega$$

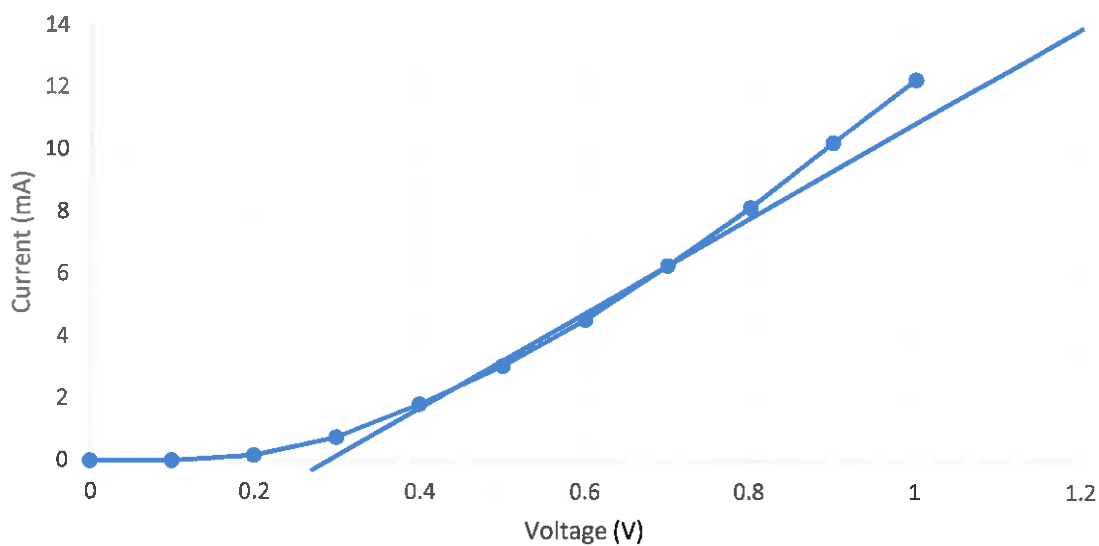
$$\Delta R = \frac{\Delta V}{\Delta I}$$

$$= \frac{0.9 - 0.5}{25 \times 10^{-3}}$$

$$= 10 \, \Omega$$

2.

Germanium Forward Bias



$$R_s = \frac{V_s}{I_s}$$

$$= \frac{0.7}{6.27 \times 10^{-3}}$$

$$= 111.6 \, \Omega$$

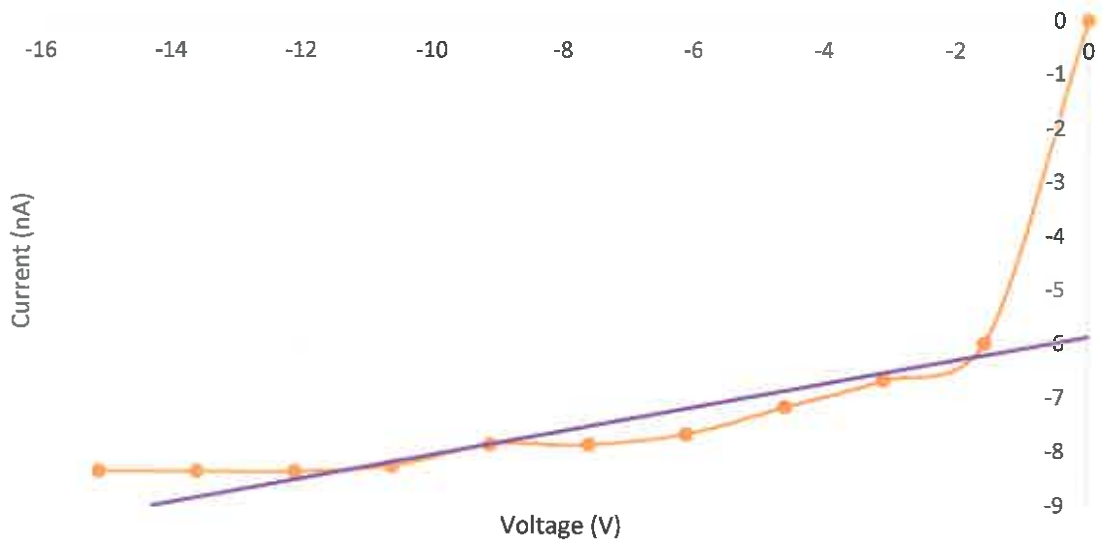
$$\Delta R = \frac{\Delta V}{\Delta I}$$

$$= \frac{1.2 - 0.25}{14 \times 10^{-3}}$$

$$= 67.9 \, \Omega$$

3.

Silicon Reverse Bias



$$R_S = \frac{V_S}{I_S}$$

$$= \frac{-9}{-7.9 \times 10^{-9}}$$

$$= 1.14 \text{ G}\Omega$$

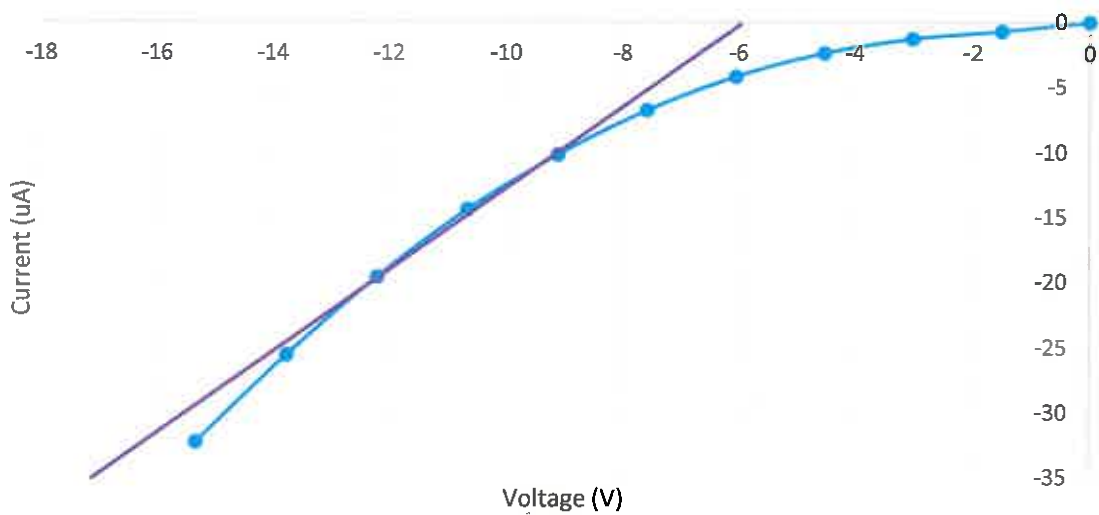
$$\Delta R = \frac{\Delta V}{\Delta I}$$

$$= \frac{-14.2 - -6.2}{-4 \times 10^{-9}}$$

$$= 2 \text{ G}\Omega$$

4.

Germanium Reverse Bias



$$R_S = \frac{V_S}{I_S}$$

$$= \frac{-9}{-10 \times 10^{-6}}$$

$$= 900 \text{ K}\Omega$$

$$\Delta R = \frac{\Delta V}{\Delta I}$$

$$= \frac{-17 - -6}{-35 \times 10^{-6}}$$

$$= 314.3 \text{ K}\Omega$$