

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	6
Knowledge is accurate with a good understanding of the diodes and transistors. There is a need for the conclusion to be more detailed, making reference to relative theory.		
2. Knowledge and Understanding of Subject Extent of knowledge and understanding of concepts and underlying principles associated with the discipline.	10	6
Knowledge is accurate with a good understanding of the diodes and transistors. There is a need for the conclusion to be more detailed, making reference to relative theory.		
3. Analysis Analysis, evaluation and synthesis, logic, argument and judgement, analytical reflection, organisation of ideas and evidence.	30	13
Have made valid comments throughout and included relative calculations relating to the obtained data. There is a need to expand upon some of the comments and to include reasons.		
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	30
Excellent practical work, very little guidance was needed. All relative calculations were obtained 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	6
Work is coherent and fluent and is well structured and organised.		

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?	✓
61%		



School of Applied Computing ASSIGNMENT SPECIFICATION

Student name:	Thomas Wolsey	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.

Tom Wolsey 126039

PDSE4004 - ELECTRONICS 1

Diode and Transistor Characteristics

Jason Pointer

Contents

1. Diodes.....	3
Introduction and Theory	3
Forward and reverse bias of Silicon and Germanium	4
Part B.....	6
2. Static Characteristics of BJTs	9
Conclusion	12
References.....	13

1. Diodes

Introduction and Theory

Diode

A diode is what could be described as a one-way valve, a diode will only allow voltage and current flow through it in one direction. There are two main types of diodes, Silicon and Germanium. The main difference between the two is that that Silicon diode will allow current flow from 0.7V across the diode whereas the Germanium start allowing current flow at 0.3V. All diodes will allow a very small amount of current and voltage to flow in the reverse direction know as reverse leakage current. Diodes also have what's known as a break down voltage, this is when the voltage that is applied in the reverse is greater than the diodes limits and the diode will normally close circuit when this happens. The brake down voltage is normally rather high for example the diode 1N4001 has a break down voltage of 50V.

Transistor

Transistors are basically an amplifier or a switch, they are made up of basically two diodes connected with either positive to positive, or negative to negative. This can be seen in figure 1 below. Transistors have three connections on a Base, Collector and an Emitter. The centre of both device is made up of two similar materials. In Figure 2 the symbol can be seen for both PNP and NPN transistors.

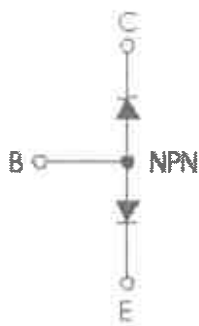
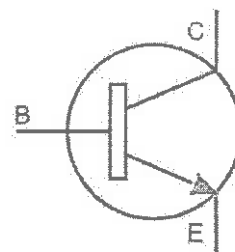
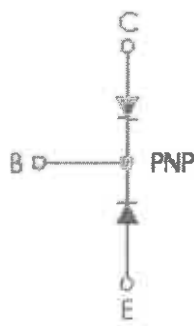
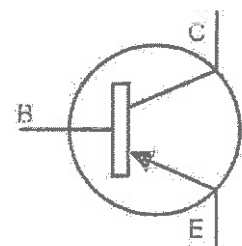


Figure 1



n-p-n transistor

Figure 2



p-n-p transistor

Forward and reverse bias of Silicon and Germanium

Silicon Forward

Dynamic

$$\Delta R = \frac{\Delta V}{\Delta I} = \frac{0.7 - 0.66}{19 \times 10^{-3}} = 12.105 \Omega$$

Static Resistance

$$RS = \frac{VS}{IS} = \frac{0.7}{6.46 \times 10^{-3}} = 108.36 \Omega$$

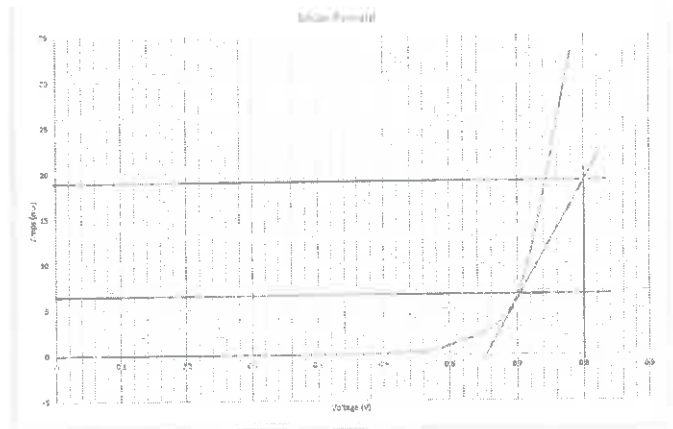


Figure 3

Silicon Reverse

Dynamic

$$\Delta R = \frac{\Delta V}{\Delta I} = \frac{9}{1.4 \times 10^{-9}} = 6.429 \text{ G}\Omega$$

Static Resistance

$$RS = \frac{VS}{IS} = \frac{9}{10.23 \times 10^{-9}} = 879.77 \times 10^6 = 0.87$$

unit

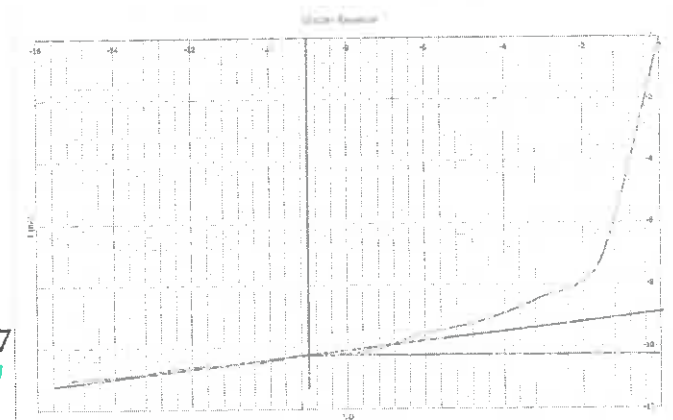


Figure 4

Germanium Forward

Dynamic

$$\Delta R = \frac{\Delta V}{\Delta I} = \frac{0.7 - 0.34}{7.1 \times 10^{-3}} = \frac{0.36}{6 \times 10^{-3}} = 50.7 \Omega$$

Static Resistance

$$RS = \frac{VS}{IS} = \frac{0.7}{6 \times 10^{-3}} = 116.6 \Omega$$

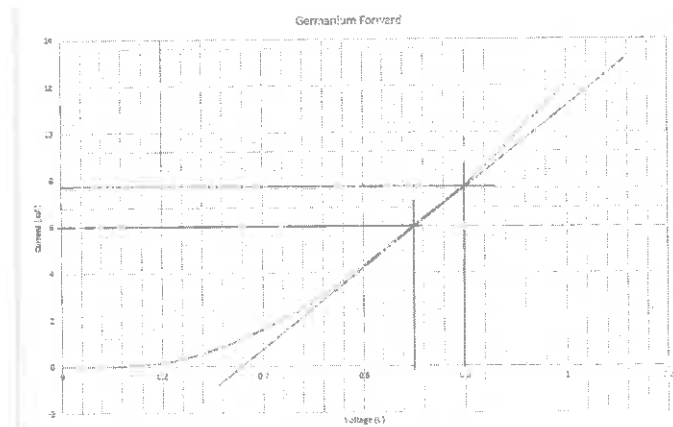


Figure 5

Germanium Reverse

Dynamic

$$\Delta R = \frac{\Delta V}{\Delta I} = \frac{4}{10.1 \times 10^{-6}} = 396.03 k\Omega$$

Static Resistance

$$RS = \frac{VS}{IS} = \frac{9}{10.1 \times 10^{-6}} = 891.09 k\Omega$$

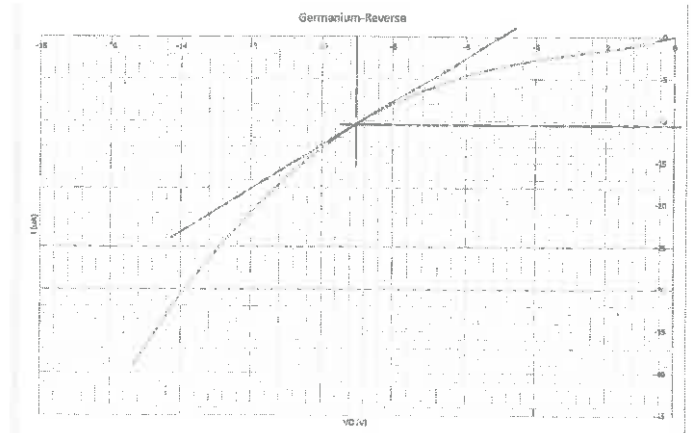


Figure 6

As can be seen from the calculations and graphs above there is not much of a similarity between the Silicon and Germanium diodes. The Silicon diode has a much higher barrier voltage at 0.6V compared to the Germanium diode which is 0.2V. The Silicon diode allows more current though when it does start reach the barrier voltage compared to the Germanium which doesn't allow much current through until the input voltage reaches 1V. These diodes both have benefits and disadvantages depending on the situation that they are required in.

The Reverse biased is where the current flows backwards through the diode, all diodes have what's called a leakage current which is normally so small it's not worried about. All diodes also have a breakdown voltage, this is where the reverse current get so high the diode cannot longer stop it. In Figure 4 the Silicon diode is not allowing much current and voltage to flow in the reverse direction. When compared to Figure 6 the Silicon diode appears to allow a lot less current though.

You could have related your comments to the resistance values for each diode

Part B

A)

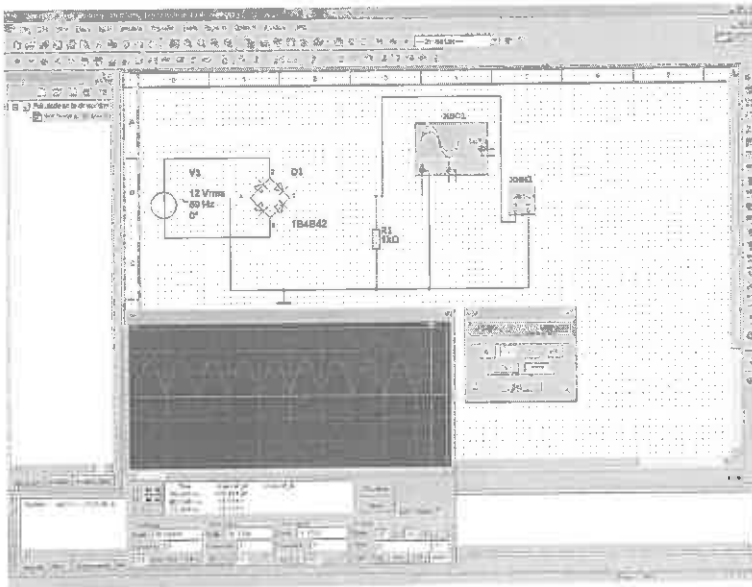


Figure 7

In Figure 7 above, can be seen a bridge rectifier made using a 12V AC 50Hz power supply, a 1B4B42 rectifier and a 1K load resistor. The circuit above has a peak voltage of 15.714V, and an output voltage is 9.729V. The output voltage is rather low compared to the input voltage as the output is an average of a full cycle.

The full wave rectifier consists of four power diodes configured in as seen in Figure 8. When the AC power is in the positive cycle, power will flow through D1 and back through D2 and when the AC supply is in the negative cycle the power will then flow through D3 then making a positive output and then flows back through D4.

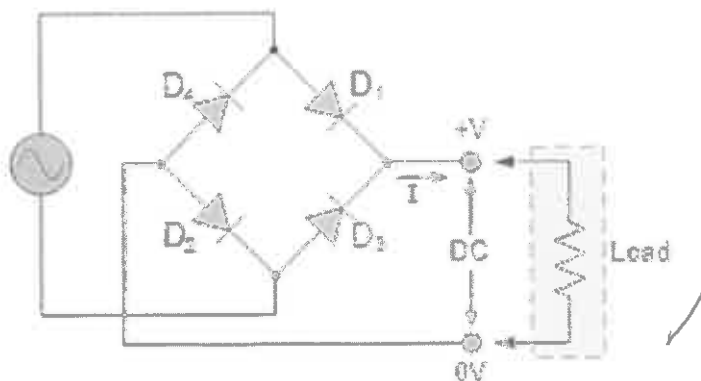


Figure 8

http://www.electronics-tutorials.ws/diode/diode_6.html

B)

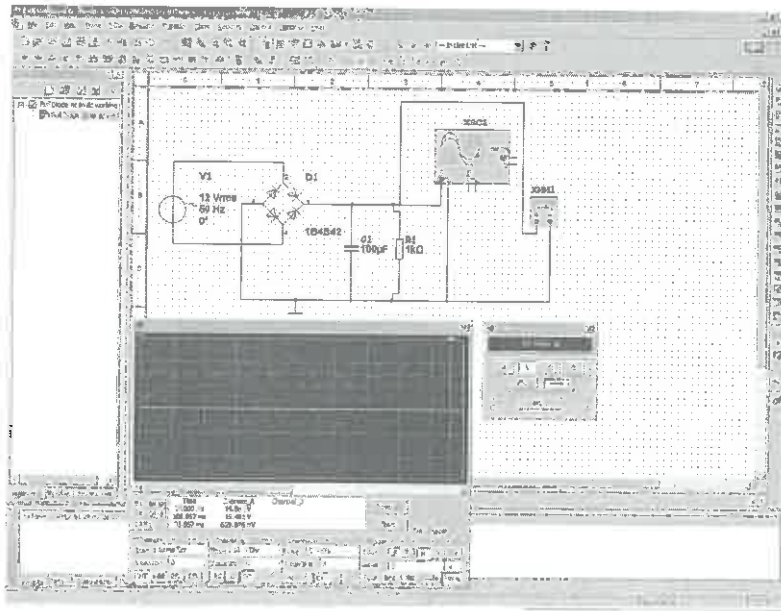


Figure 9

In Figure 9 above there is now a 100uF capacitor been put in parallel with the load, this capacitor then stores power when available and release it when there is less or no power. This then make that wave smother as can be seen on the scope. This will in turn bring that output voltage up to 14.944V and a peak voltage of 15.491V. The bigger the capacitor the smother the power will be, but there becomes a point when capacitor doesn't have time to full charge therefore making it less effective than having a smaller capacitor.

c)

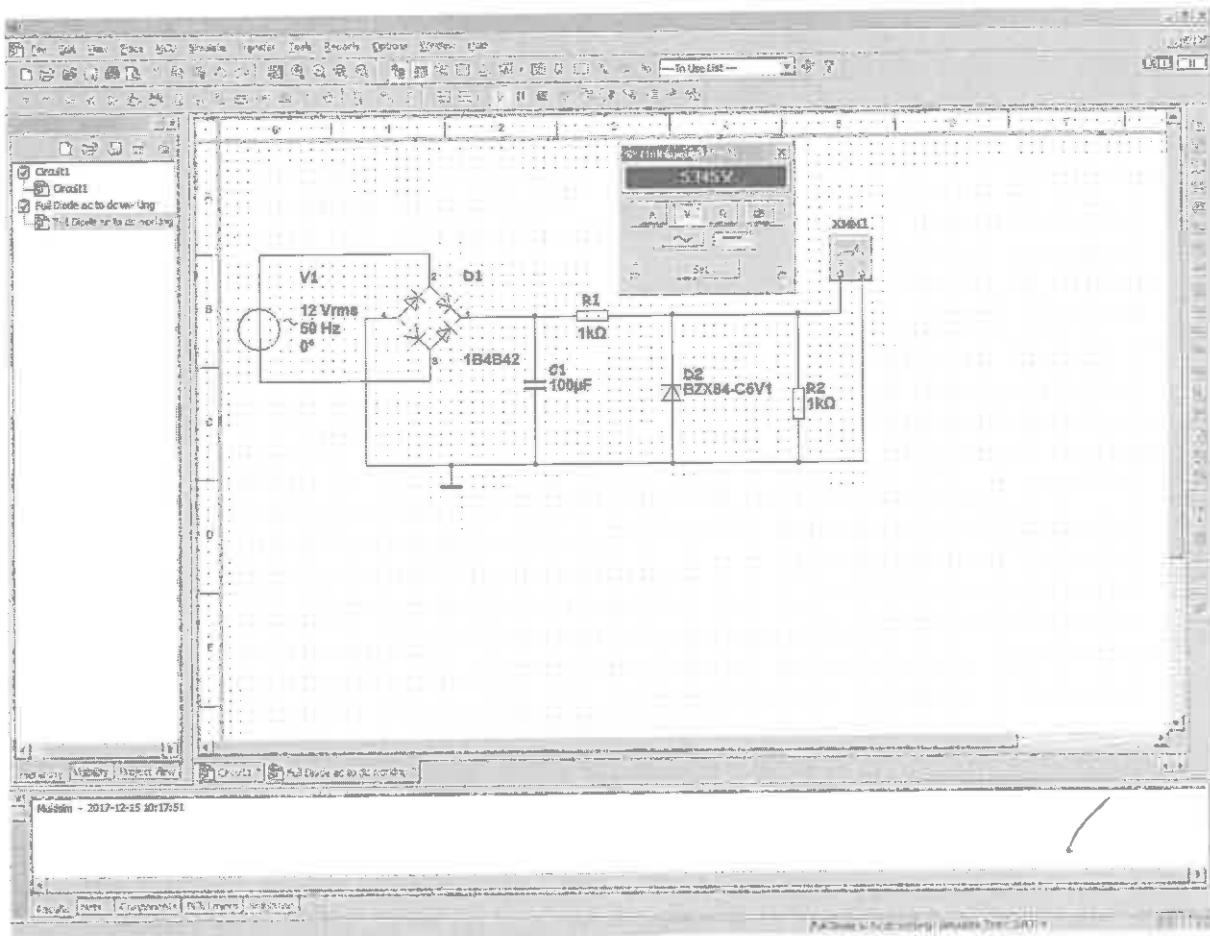


Figure 10

A series voltage regulator was designed using a BZX84c5V1 diode,

$$R_{s \text{ Max}} = R_L \times \left(\frac{V_{in}}{V_Z} - 1 \right)$$

$$R_{s \text{ Max}} = 1000 \times \left(\frac{14.044}{5.1} - 1 \right)$$

$$R_{s \text{ Max}} = 1753\Omega$$

$$R_{s \text{ Min}} = \left(\frac{V_{in} - V_Z}{\frac{P_Z}{V_Z}} \right)$$

$$R_{s \text{ Min}} = \left(\frac{14.044 - 5.1}{\frac{0.550}{5.1}} \right)$$

$$R_{s \text{ Min}} = 82\Omega$$

Based on the above calculations a resistor was selected between the $R_{s \text{ Min}}$ and $R_{s \text{ Max}}$, there was a range of resistors that could have been used, including 680,

820, 1k, 1.2k and 1.5k ohms. The 1K was selected as it best meets the requirements.

As can be seen in Figure 10 the desired output voltage was 5v, and the voltage achieved using the components and values based on the calculations above was 5.145V.

2. Static Characteristics of BJTs

Table 1

V _{CE} = 3V				V _{CE} = 5V			
V _{BE}	V _{RB} (mV)	I _B =V _{RB} /R _B	I _B =V _{RB} /R _B (uA)	V _{BE}	V _{RB} (mV)	I _B =V _{RB} /R _B	I _B =V _{RB} /R _B (uA)
0.63	18.7	0.0000187	18.7	0.63	36.4	0.0000364	36.4
0.64	27.1	0.0000271	27.1	0.64	54.6	0.0000546	54.6
0.65	39.4	0.0000394	39.4	0.65	70.9	0.0000709	70.9
0.66	55.4	0.0000554	55.4	0.66	78.4	0.0000784	78.4

Figure 11

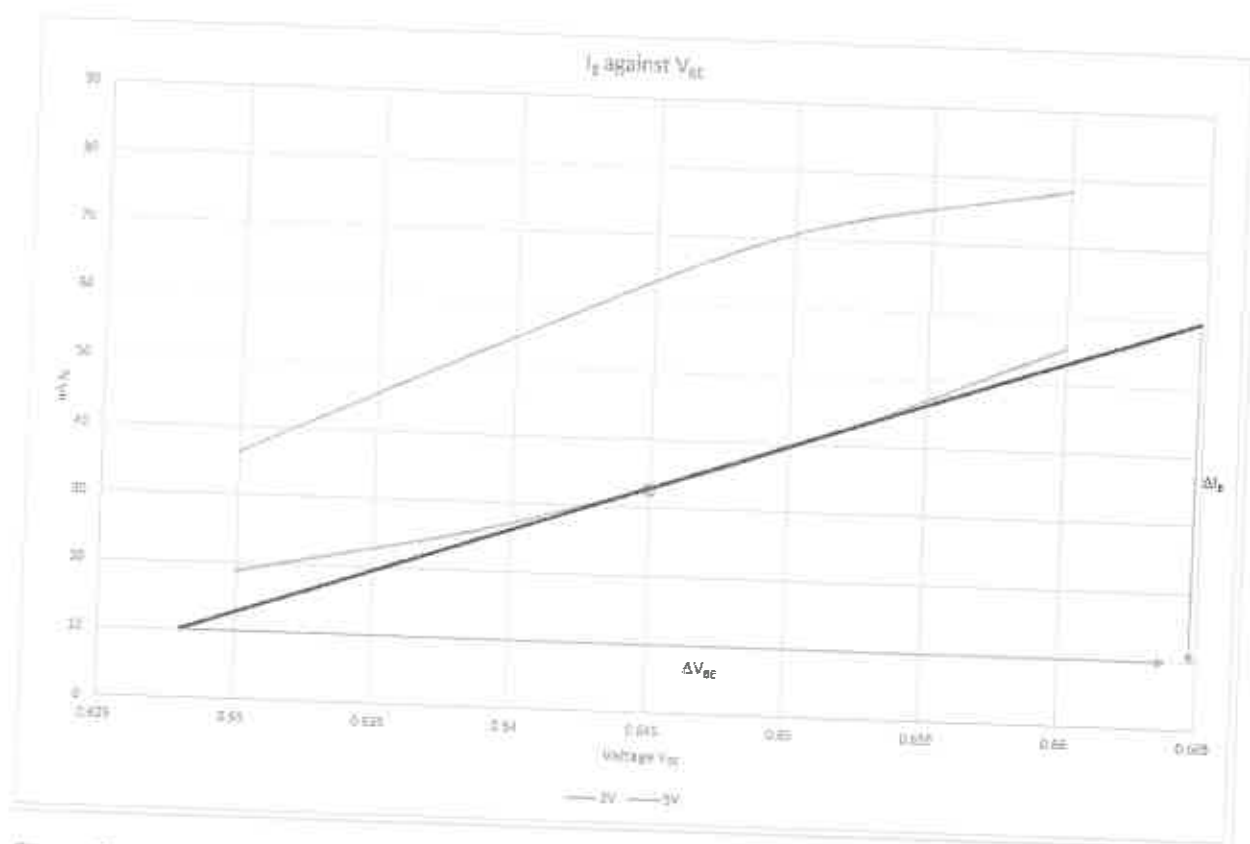


Figure 12

$$H_{ie} = \Delta V_{be} / \Delta I_b$$

$$H_{ie} = 0.038 / 50 \times 10^{-6}$$

$$H_{ie} = 760.00\Omega$$

Table 2

V_{CE}	$I_B = 10\mu A$		$I_B = 20\mu A$		$I_B = 30\mu A$		$I_B = 40\mu A$		$I_B = 50\mu A$	
	$V_{RC} (mV)$	$I_C = V_{RC}/R_C$	$V_{RC} (mV)$	$I_C = V_{RC}/R_C$	$V_{RC} (mV)$	$I_C = V_{RC}/R_C$	$V_{RC} (mV)$	$I_C = V_{RC}/R_C$	$V_{RC} (mV)$	$I_C = V_{RC}/R_C$
0	0	0	0	0	0	0	0	0	0	0
0.2	158	0.00158	339	0.00339	528	0.00528	751	0.00751	960	0.0096
0.4	159	0.00159	342	0.00342	531	0.00531	760	0.0076	977	0.00977
0.8	160	0.0016	344	0.00344	534	0.00534	765	0.00765	990	0.0099
1	161	0.00161	345	0.00345	536	0.00536	767	0.00767	999	0.00999
3	165	0.00165	354	0.00354	549	0.00549	789	0.00789	1026	0.01026
5	168	0.00168	361	0.00361	562	0.00562	808	0.00808	1040	0.0104
H_{OE}	2.08E-05		4.58E-05		7.08E-05		0.00011875		0.000167	
H_{OE}	20.83333 μS		45.83333 μS		70.83333 μS		118.75 μS		166.6667 μS	

Figure 13

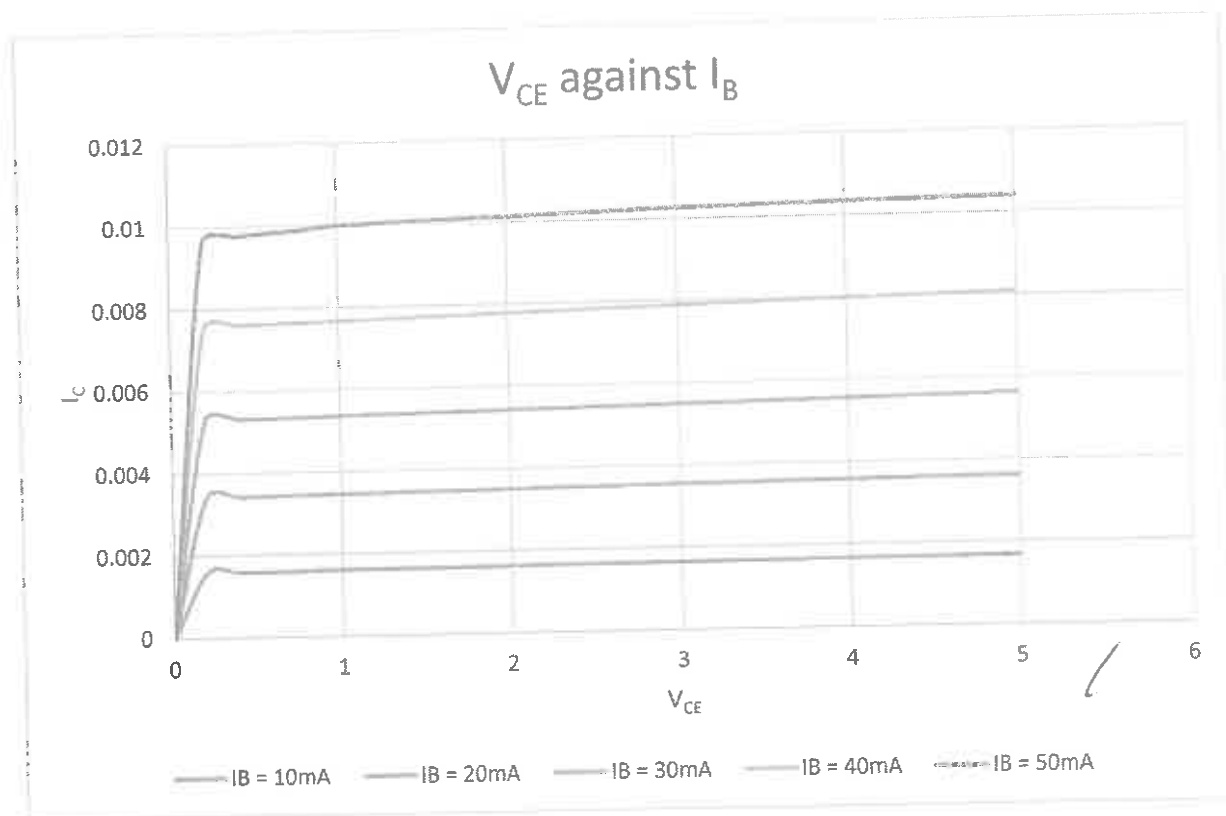


Figure 14

$I_B(\mu A)$	$I_C(A)$
0	0
10	0.00165
20	0.00354
30	0.00549
40	0.00789
50	0.01026

Figure 15

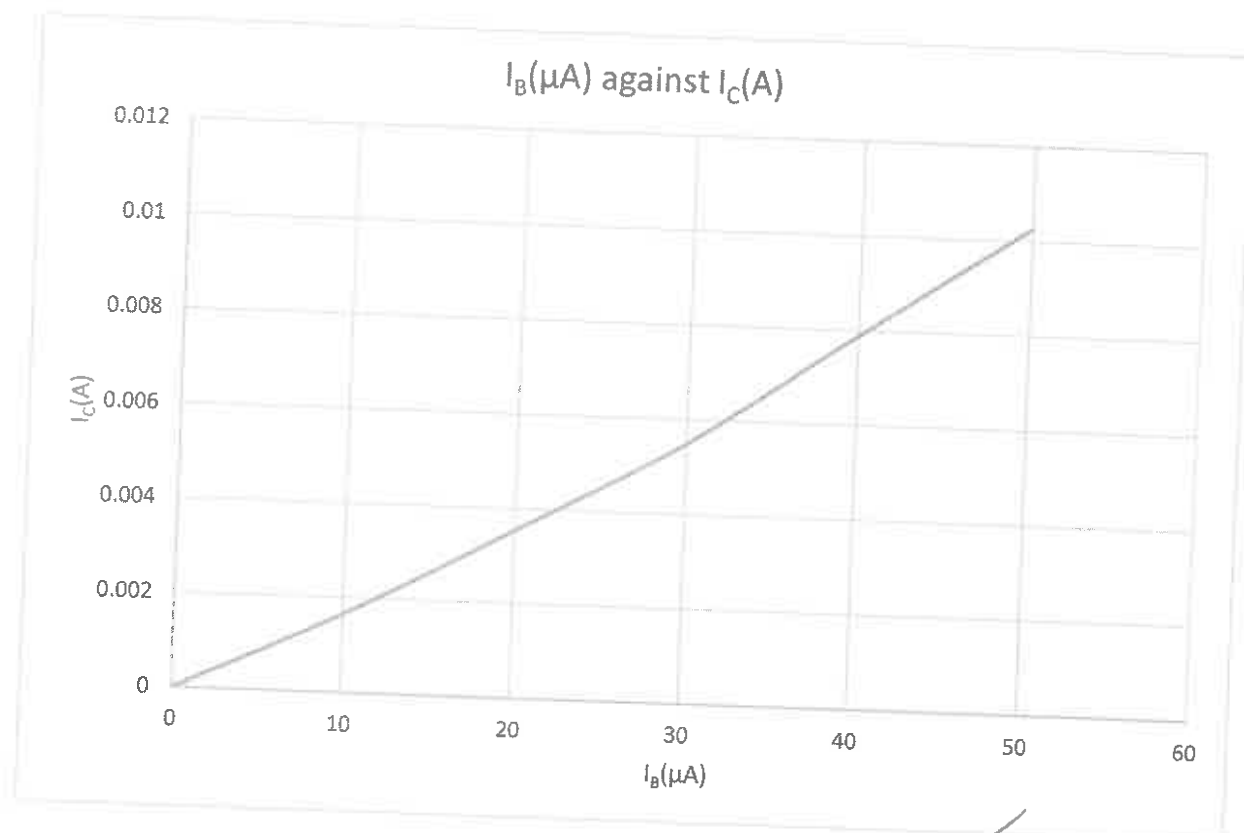


Figure 16

$$I_C/I_B = 0.01 / (50 \times 10^{-6}) = 200$$

$I_B(\mu A)$	$I_C(A)$	H_{fe}
0	0	
10	0.00165	165
20	0.00354	177
30	0.00549	183
40	0.00789	197.25
50	0.01026	205.2

Figure 17

Conclusion

When looking over the measured results compared to the results in the datasheet. When looking at the H_{fe} , the measured result was 183, compared to the data in datasheet which stated 70. Also looking at the stated H_{oe} in the datasheet it says $35\mu S$, the results that were measured where $45.833\mu S$. This could be down to a number of reasons, from tolerances in the resistors to the tolerances of the transistors. The BFY51 is manufactured is bulk meaning the accuracy could vary.

References

BBC - GCSE Bitesize: Diodes. 2017. BBC - GCSE Bitesize: Diodes. [ONLINE] Available at: <http://www.bbc.co.uk/schools/gcsebitesize/design/electronics/componentsrev6.shtml>. [Accessed 22 December 2017].

Diodes - learn.sparkfun.com. 2017. Diodes - learn.sparkfun.com. [ONLINE] Available at: <https://learn.sparkfun.com/tutorials/diodes>. [Accessed 22 December 2017].

Introduction to Diodes And Rectifiers | Diodes and Rectifiers | Electronics Textbook. 2017. Introduction to Diodes And Rectifiers | Diodes and Rectifiers | Electronics Textbook. [ONLINE] Available at: <https://www.allaboutcircuits.com/textbook/semiconductors/chpt-3/introduction-to-diodes-and-rectifiers/>. [Accessed 22 December 2017].

BBC - GCSE Bitesize: Transistors. 2017. BBC - GCSE Bitesize: Transistors. [ONLINE] Available at: <http://www.bbc.co.uk/schools/gcsebitesize/design/electronics/switchesrev3.shtml>. [Accessed 22 December 2017].

Transistors - learn.sparkfun.com. 2017. Transistors - learn.sparkfun.com. [ONLINE] Available at: <https://learn.sparkfun.com/tutorials/transistors>. [Accessed 22 December 2017].

John Hewes. 2017. Electronics Club - Transistors - types, connecting, soldering, testing, choosing, heat sinks. [ONLINE] Available at: <https://electronicsclub.info/transistors.htm>. [Accessed 22 December 2017].

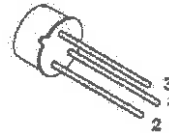
<http://pdf.datasheetcatalog.com/datasheet/SGSThompsonMicroelectronics/mXuuvy.pdf>

BFY50 Data sheet

MEDIUM POWER AMPLIFIER

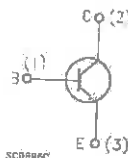
DESCRIPTION

The BFY50 and BFY51 are silicon planar epitaxial NPN transistors in Jædec TO-39 metal case. They are intended for general purpose linear and switching applications.



TO-39

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value		Unit
		BFY50	BFY51	
V_{CE0}	Collector-Base Voltage ($I_E = 0$)	80	60	V
V_{CE0}	Collector-Emitter Voltage ($I_B = 0$)	35	30	V
V_{EB0}	Emitter-Base Voltage ($I_C = 0$)	6		V
I_C	Collector Current	1		A
I_{CM}	Collector Peak Current ($t_p < 5$ ms)	1.5		A
P_{tot}	Total Dissipation at $T_{amb} \leq 25^\circ\text{C}$ at $T_{case} \leq 25^\circ\text{C}$	0.8		W
T_{stg}	Storage Temperature	5		W
T_j	Max. Operating Junction Temperature	-65 to 200		$^\circ\text{C}$
		200		$^\circ\text{C}$

November 1987

1/5

BFY50/BFY51

THERMAL DATA

$R_{th(j-case)}$	Thermal Resistance Junction-Case	Max	35	$^{\circ}\text{C/W}$
$R_{th(j-amb)}$	Thermal Resistance Junction-Ambient	Max	218	$^{\circ}\text{C/W}$

ELECTRICAL CHARACTERISTICS ($T_{case} = 25^{\circ}\text{C}$ unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{ce0}	Collector Cut-off Current ($I_E = 0$)	for BFY50 $V_{CB} = 60\text{ V}$ $V_{CE} = 60\text{ V}$ for BFY51 $V_{CB} = 40\text{ V}$ $V_{CE} = 40\text{ V}$ $T_{case} = 100^{\circ}\text{C}$			50 2.5 50 2.5	nA μA nA μA
I_{E0}	Emitter Cut-off Current ($I_C = 0$)	$V_{EB} = 5\text{ V}$ $V_{ED} = 5\text{ V}$ $T_{case} = 100^{\circ}\text{C}$			50 2.5	nA μA
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage ($I_E = 0$)	$I_C = 100\text{ }\mu\text{A}$ for BFY50 for BFY51	80 60			V V
$V_{(BR)CEO}^*$	Collector-Emitter Breakdown Voltage ($I_B = 0$)	$I_C = 30\text{ mA}$ for BFY50 for BFY51	35 30			V V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage ($I_C = 0$)	$I_C = 100\text{ }\mu\text{A}$	6			V
$V_{CE(sat)}^*$	Collector-Emitter Saturation Voltage	$I_C = 150\text{ mA}$ $I_B = 15\text{ mA}$ for BFY50 for BFY51 $I_C = 1\text{ A}$ $I_B = 0.1\text{ A}$ for BFY50 for BFY51		0.14 0.14 0.7 0.7	0.2 0.35 1 1.6	V V V V
$V_{BE(sat)}^*$	Base-Emitter Saturation Voltage	$I_C = 150\text{ mA}$ $I_B = 15\text{ mA}$ $I_C = 1\text{ A}$ $I_B = 0.1\text{ A}$		0.95 1.5	1.3 2	V V
h_{FE}^*	DC Current Gain	for BFY50 $I_C = 10\text{ mA}$ $V_{CE} = 10\text{ V}$ $I_C = 150\text{ mA}$ $V_{CE} = 10\text{ V}$ $I_C = 1\text{ A}$ $V_{CE} = 10\text{ V}$ for BFY51 $I_C = 10\text{ mA}$ $V_{CE} = 10\text{ V}$ $I_C = 150\text{ mA}$ $V_{CE} = 10\text{ V}$ $I_C = 1\text{ A}$ $V_{CE} = 10\text{ V}$	20 30 15	40 55 30		
h_{fe}^*	Small Signal Current Gain	$V_{CE} = 6\text{ V}$ $f = 1\text{ KHz}$ $I_C = 1\text{ mA}$ for BFY50 for BFY51 $I_C = 10\text{ mA}$ for BFY50 for BFY51		25 30 45 60		
f_T	Transition Frequency	$I_C = 50\text{ mA}$ $V_{CE} = 10\text{ V}$ for BFY50 for BFY51	60 50	100 110		MHz MHz
C_{CB}^*	Collector Base Capacitance	$I_E = 0$ $V_{CB} = 10\text{ V}$ $f = 1\text{ MHz}$		10		pF

* Pulsed. Pulse duration = 300 μs , duty cycle $\leq 1\%$

ELECTRICAL CHARACTERISTICS (continued)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
h_{ie}	Input Impedance	$I_C = 10 \text{ mA}$ $V_{CE} = 5 \text{ V}$ $f = 1 \text{ KHz}$ for BFY50 for BFY51		180 220		Ω Ω
h_{re}	Reverse Voltage Ratio	$I_C = 10 \text{ mA}$ $V_{CE} = 5 \text{ V}$ $f = 1 \text{ KHz}$ for BFY50 for BFY51		55 70		10^{-6} 10^{-6}
h_{oe}	Output Admittance	$I_C = 10 \text{ mA}$ $V_{CE} = 5 \text{ V}$ $f = 1 \text{ KHz}$ for BFY50 for BFY51		30 35		μS μS
t_d	Delay Time	$I_C = 150 \text{ mA}$ $V_{CC} = 10 \text{ V}$ $I_{B1} = 15 \text{ mA}$ $V_{BE} = -2 \text{ V}$		15		ns
t_r	Rise Time	$I_C = 150 \text{ mA}$ $V_{CC} = 10 \text{ V}$ $I_{B1} = 15 \text{ mA}$ $V_{BE} = -2 \text{ V}$		40		ns
t_s	Storage Time	$I_C = 150 \text{ mA}$ $V_{CC} = 10 \text{ V}$ $I_{B1} = -I_{B2} = 15 \text{ mA}$		300		ns
t_f	Fall Time	$I_C = 150 \text{ mA}$ $V_{CC} = 10 \text{ V}$ $I_{B1} = -I_{B2} = 15 \text{ mA}$		60		ns

Pulsed Pulse duration $\approx 300 \mu\text{s}$; duty cycle $\leq 1\%$

BZX84C3V3 Data sheet



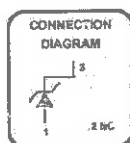
November 2010

BZX84C3V3 - BZX84C33 Zeners

Tolerance: C = 5%



SOT-23



Absolute Maximum Ratings⁽¹⁾⁽²⁾

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only. Values are at $T_A = 25^\circ\text{C}$ unless otherwise noted.

Symbol	Parameter	Value	Unit
I_{FWM}	Repulsive Peak Forward Current	250	mA
I_{ZRM}	Repulsive Peak Working Current	250	mA
P_D	Power Dissipation	Referencing $R_{\theta JA}$, $T_A = 25^\circ\text{C}$	mW
		Referencing ψ_{JL} , $T_L = 25^\circ\text{C}$	
$R_{\theta JA}$	Junction-to-Ambient Thermal Resistance ⁽³⁾	46R	$^\circ\text{C/W}$
ψ_{JL}	Junction-to-Lead Thermal Characteristics (with reference to Cathode)	220	$^\circ\text{C/W}$
T_{STG}	Storage Temperature Range	-55 to +150	$^\circ\text{C}$
T_J	Operating Junction Temperature	-55 to +150	$^\circ\text{C}$

Notes:

- These ratings are based on a maximum junction temperature of 150°C .
- These are steady-state limits. Fairchild Semiconductor should be consulted on applications involving pulsed or low-duty-cycle operations.
- Device mounted on FR-4 PCB, board size = 76.2 mm x 114.3 mm.

Electrical Characteristics

Values are at $T_A = 25^\circ\text{C}$ unless otherwise noted.

Device	Mark	$I_Z = 5.0\text{ mA}$			$I_Z = 1.0\text{ mA}$			$I_Z = 20\text{ mA}$		
		$V_Z\text{ (V)}$		$Z_Z\text{ (}\Omega\text{)}$	$V_Z\text{ (V)}$		$Z_Z\text{ (}\Omega\text{)}$	$V_Z\text{ (V)}$		$Z_Z\text{ (}\Omega\text{)}$
		Min.	Max.		Min.	Max.		Min.	Max.	
BZX84C3V3	Z14	3.1	3.5	95	2.3	2.9	600	3.6	4.2	40
BZX84C3V6	Z15	3.4	3.8	90	2.7	3.3	600	3.9	4.5	40
BZX84C3V9	Z16	3.7	4.1	90	2.9	3.5	600	4.1	4.7	30
BZX84C4V3	Z17	4.0	4.6	90	3.3	4.0	600	4.4	5.1	30
BZX84C4V7	Z1	4.4	5.0	80	3.7	4.7	500	4.5	5.4	15
BZX84C5V1	Z2	4.8	5.4	60	4.2	5.3	480	5.0	5.9	15
BZX84C5V6	Z3	5.2	6.0	40	4.8	6.0	400	5.2	6.3	10
BZX84C6V2	Z4	5.8	6.6	10	5.6	6.6	150	5.8	6.8	6
BZX84C6V6	Z5	6.4	7.2	15	6.3	7.2	30	6.4	7.4	6
BZX84C7V5	Z6	7.0	7.9	15	6.9	7.9	30	7.0	8.0	6
BZX84C8V2	Z7	7.7	8.7	15	7.8	8.7	30	7.7	8.8	6
BZX84C9V1	Z8	8.5	9.6	15	8.4	9.6	100	8.5	9.7	8
BZX84C10	Z9	9.4	10.6	20	9.3	10.6	150	9.4	10.7	10
BZX84C11	Y1	10.4	11.6	20	10.2	11.6	150	10.4	11.8	10
BZX84C12	Y2	11.4	12.7	25	11.2	12.7	150	11.4	12.9	10
BZX84C13	Y3	12.4	14.1	30	12.3	14.0	170	12.5	14.2	15
BZX84C15	Y4	13.8	15.6	30	13.7	15.5	200	13.9	15.7	20
BZX84C16	Y5	15.3	17.1	40	15.2	17.0	200	15.4	17.2	20
BZX84C18	Y6	16.8	19.1	45	16.7	19.0	225	16.9	19.2	20
BZX84C20	Y7	18.8	21.2	55	18.7	21.1	225	18.9	21.4	20
BZX84C22	Y8	20.8	23.3	55	20.7	23.2	250	20.9	23.4	25
BZX84C24	Y9	22.8	25.6	70	22.7	25.5	250	22.9	25.7	25
BZX84C27	Y10	25.1	28.9	80	25.0	28.9	300	25.2	29.3	45
BZX84C30	Y11	28.0	32.0	80	27.8	32.0	300	28.1	32.4	50
BZX84C33	Y12	31.0	35.0	80	30.8	35.0	325	31.1	35.4	55

 V_F Forward Voltage = 0.9 V Maximum at $I_F = 10\text{ mA}$ for all BZX84 series

Electrical Characteristics (Continued)

Values are at $T_A = 25^\circ\text{C}$ unless otherwise noted.

Device	V_R (V)	I_R (μA)	Cap ⁽⁴⁾ (pF)	D_{VZ} / D_T at 5.0 mA (mV/k)	
				Min.	Max.
BZX84C3V3	1.0	5.0	450	-3.5	0.0
BZX84C3V6	1.0	5.0	450	-3.5	0.0
BZX84C3V9	1.0	5.0	450	-3.5	0.0
BZX84C4V3	1.0	5.0	450	-3.5	0.0
BZX84C4V7	2.0	3	260	-3.5	0.2
BZX84C5V1	2.0	2	225	-2.7	1.2
BZX84C5V6	2.0	1	200	-2.0	2.5
BZX84C6V2	4.0	3	185	0.4	3.7
BZX84C6V5	4.0	2	155	1.2	4.5
BZX84C7V5	5.0	1	140	2.5	5.3
BZX84C8V2	5.0	0.7	135	3.2	6.2
BZX84C9V1	6.0	0.5	130	3.8	7.0
BZX84C10	7.0	0.2	130	4.5	8.0
BZX84C11	8.0	0.1	130	5.4	9.0
BZX84C12	8.0	0.1	130	6.0	10
BZX84C13	8.0	0.1	120	7.0	11
BZX84C15	10.5	0.05	110	9.2	13
BZX84C16	11.2	0.05	105	10.4	14
BZX84C18	12.6	0.05	100	12.4	16
BZX84C20	14	0.05	85	14.4	18
BZX84C22	15.4	0.05	85	16.4	20
BZX84C24	16.8	0.05	80	18.4	22
BZX84C27	18.9	0.05	70	21.4	25.3
BZX84C30	21	0.05	70	24.4	29.4
BZX84C33	23.1	0.05	70	27.4	33.4

Note:

4. Capacitance at $V_R = 0.0\text{ V}$, $f = 1.0\text{ MHz}$.

Typical Performance Characteristics

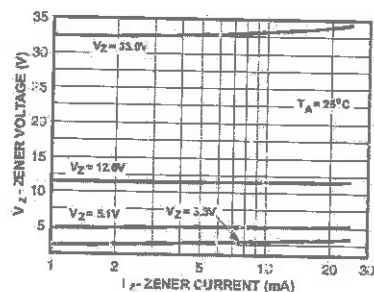


Figure 1. Zener Current vs. Zener Voltage

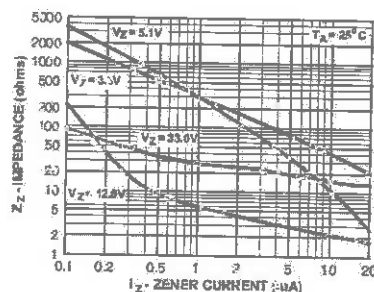


Figure 2. Zener Current vs. Zener Impedance

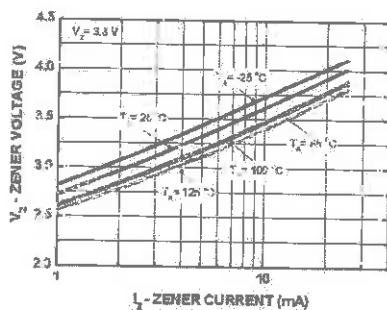


Figure 3. 3.3 V Zener Voltage vs. Temperature

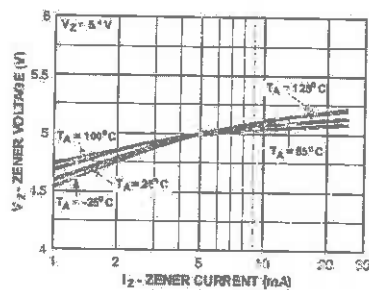


Figure 4. 5.1 V Zener Voltage vs. Temperature

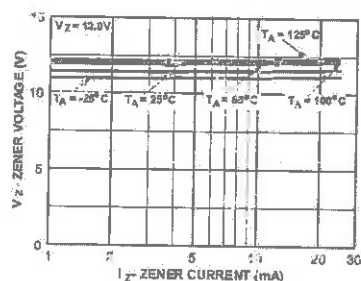


Figure 5. 12 V Zener Voltage vs. Zener Temperature

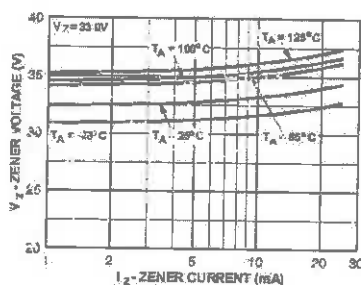


Figure 6. 33 V Zener Voltage vs. Zener Temperature

