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FOREWORD

I warmly welcome all and sundry to the volume 3 issue 1 of Federal Polytechnic – Journal of Pure and Applied Sciences (FEPI-JOPAS) which is a peer reviewed multi-disciplinary accredited Journal of international repute. FEPI-JOPAS publishes full length research work, short communications, critical reviews and other review articles. In this issue, readers will find a diverse group of manuscripts of top-rated relevance in pure and applied science, engineering and built environment. Many of the features that you will see in the Journal are result of highly valuable articles from the authors as well as the collective excellent work of our managing editor, publishing editors, our valuable reviewers and editorial board members.

In this particular issue, you will find that Joseph and Adebanji provided innovative technology on light traffic control system. Ogunkoya and Sholotan engaged standard method for microbiological assessment of shawarma from Igbesa metropolis for possible microbial contamination. Ilelaboye and Kumoye unveiled the effect of inclusion of different nitrogen source on growth performance of mushroom. Ogunyinka et al utilized Fletcher Reeves conjugate gradient method as a robust prediction model for candidates' admission to higher institutions. Omotola and Fatunmbi examined the impact of thermal radiation with convective heating on magnetohydrodynamic (MHD), incompressible and viscous motion of non-Newtonian Casson fluid. Aako and Are meticulously investigated factors affecting mode of delivery using binary dummy dependent models. Abiaziem and Ojelade successfully synthesized biologically active silver nanoparticles using *Terminalia catappa* bark as the eco-friendly source.

In addition, Olowosebioba et al. assessed the rectifying effects of various diodes in power supply units using multisim circuit design software programme. Olujimi et al. successfully accomplished the use of fingerprint based biometric attendance system for eliminating examination malpractices with enhanced notification. Alaba reported the nutritional status assessment of school age children (6-12 years) in private primary school in Ilaro. Muhammed-lawal et. al. assessed the execution and effect of corporate social responsibilities and return to marketing. Awolola and Sanni's research was about achieving quality of engineering education and training in Nigeria using Federal Polytechnic, Ilaro as the case study. Oladejo and Ebisin expatiated on virtual laboratory as an alternative laboratory for science teaching and learning.

Finally, Aneke and Folalu investigated the prospect and problems of the hotels in Ilaro, Ogun State.

I would like to thank and extend my gratitude to my co-editors, editorial board members, reviewers, members of FEPI-JOPAS, especially the Managing Editor, as well as the contributing authors for creating this volume 3 issue 1. The authors are solely responsible for the information, date and authenticity of data provided in their articles submitted for publication in the Federal Polytechnic Ilaro – Journal of Pure and Applied Sciences (FEPI-JOPAS). I am looking forward to receiving your manuscripts for the subsequent publications.

You can visit our website (https://www.fepi-jopas.federalpolyilaro.edu.ng) for more information, or contact us via e-mail us at fepi.jopas@federalpolyilaro.edu.ng.

Thank you and best regards.

E-Signed
Prof. Olayinka O. AJANI

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https://fepi-jopas.federalpolyilaro.edu.ng ***Experimental***

Assessment of Rectifying Effects of Various Diodes in Power Supply Units Using Multisim Circuit Design Software Programme

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Abstract

A power supply unit which consists of transformer (whose voltage regulated to Low Voltage Direct Current of 5v) with the arrangement of diodes as full-wave bridge rectifiers was set up on Multisim circuit design software. The voltage readings of eight (8) different diodes were taken before and after rectification to measure their AC and DC response output respectively. Measurements of each diode were taken on the Multisim Circuit Design software multimeter and oscilloscope. The result shows that the maxima and minima points on DC curve were 5.478v for transient voltage suppressor and -32.029v for silicon controlled rectifiers respectively. The points of inflexion ranging between 4v to 5v showed the arrangement of the best response of other rectifiers in the descending order.

Keywords*:* diode, full-wave bridge rectifiers, multisim, power supply unit, voltage drop

INTRODUCTION

In electronics, a diode is a two-terminal component that conducts primarily in one direction (asymmetric conductance). It has low (ideally zero) resistance to the current in one direction, and high (ideally infinite) resistance in the other (Wikipedia, 2021). Most of the diodes are made from semiconductors like Si (silicon), but sometimes, Ge (germanium). Semiconductor diodes play relevant and crucial roles in various electronics and electrical circuits. Diodes are active non-linear circuit elements with non-linear voltage-current characteristics (Ben, 2009).

Fleming valves were the first type of diodes that worked inside a glass tube (much like a light bulb) (Jed, 2004). There was a small metal wire and a large metal plate inside the glass bulb. The small metal wire would heat up and emit electricity, which was captured by the plate. However, the large metal plate would not heat up enough to emit electricity because it was too big. This allows electricity to flow through one direction but not in the other direction.

Semiconducting diodes are usually made of two types of semiconducting metals connected to each other. One type of metal has atoms connected together with a few electrons to spare. The other metal has atoms connected together and needs a few electrons to be completed. Because one metal has too many electrons and the other metal has too few, the uninterrupted flow of electrons will occur from the metal with many electrons into the metal with few. However, electrons will not be freely travelled in the opposite direction - from metal with few electrons to metal with many.

Silicon with arsenic dissolved in it makes a good metal with electrons to spare, while silicon with aluminum dissolved in it makes a good metal with too few electrons to be completed (Wikipedia, 2021). There are actually many types of combinations of metals that will make p-type and n-type semiconductors. Forward voltage for silicon diodes are approximately 0.7v while it is 0.3v for germanium diodes (Electronics Hub, 2015). A diode is formed by joining two equivalently doped materials known as P-type and N-type semiconductor together. The P-type semiconductor is a semiconducting material with positive charge that contains excess holes while the N-type semiconductor is a semiconducting material with negative charge that contains excess electrons. At the point of contact of the P-type and N-type regions, the holes in the P-type attract electrons in the N-type material. Hence the electron diffuses and occupies the holes in the P-type material causing a small region of the N-type near the junction to lose electrons and behaves like intrinsic semiconductor material, in the P-type a small region gets filled up by holes and behaves like an intrinsic semiconductor (Mediawiki, 2015), as shown Fig. 1.1(a). A very narrow region (about 0.5 μm thick) that is depleted of mobile charges now exists around the PN junction (Allen, 1986). This thin intrinsic region is called depletion layer or space charge region, since the charges within the region are emptied and unloaded (Figure 1.1(b)) and hence offers high resistance to the flow of electron through the region because it prevents further diffusion of majority carriers. The PN junction is actually a diode that permits easy conduction when forward-biased and practically no conduction when reverse-biased (Allen, 1986). In physical terms the size of the depletion layer is very thin.

When a diode is zero biased, it shows that it has no bias, it just stays. However, if anode and cathode are connected to galvanometer, insignificant small voltage or current might be observed (Figure 1.1(c)) since the electromagnetic spectrum present by default in our environment knocks off the electrons that constitutes current in the semiconductor lattice. For practical reasons, this current can be considered zero. In reverse bias the P-type region is connected to negative voltage and N-type is connected to positive terminal (Fig. 1.1(d)). In this condition the electrons in the battery/cell filled up the holes in P-type of the diode and the positive terminal of the battery extracts the electrons in the N-type material of the diode. Due to this, the diodes' depletion layer gets widens up (Fig. 1.1(d)) and it occupies the entire diode. The resistance offered by the diode is very huge. The current that flows in reverse bias is only due to minority charge which is in nano amperes in silicon and micro amperes in high power silicon and germanium diodes (Mediawiki, 2015). The positive terminal of the battery is connected to the P-region of the diode and the negative terminal connected to N-region (Fig. 1.1(e)). During the forward bias the following processes occur:

i. the positive of the battery pumps more holes into the P-region of the diode.

ii. the negative terminal pumps electrons into the N-region.

The excess of charges in P- and N-region applies pressure on the depletion region to make it collapse. As the voltage increases the depletion layer becomes thinner and shut down. Then, diode offers lesser and lesser resistance. Since the resistance decreases the current increases, though not proportional to the voltage. On getting to the threshold (V_f) voltage, otherwise known as firing or cut-off voltage, the space region vanishes. Then charges surged over the region (Figure 1.1(e)) and start to conduct very easily. Hence, the diode current increases exponentially to the voltage applied.

Diodes are used in a wide variety of applications in communication systems (limiters, gates, clippers, mixers); computers (clamps, clippers, logic gates); radar circuits (phase detectors, gain-control circuits, power detectors, parameter amplifiers); radios (mixers, automatic gain control circuits, message detectors); and television (clamps, limiters, phase detectors, etc.). The ability of diodes to allow the flow of current in only one direction is commonly exploited in all these applications (Ben, 2009). Diodes can also be applied as rectifiers for power supplies. Basically, a diode is used for rectifying waveforms, within radio detectors or within power supplies (Tarun, 2015). Because of the alternating nature of the input AC sine wave, the process of rectification alone produces a DC current, though unidirectional, that consists of pulses of current (Mahobia & Kumrey, 2016). By allowing the passage of the rectifier's output through a filter to form the ripple-free output (that is, removal of AC components), the direct current is generated. Although, various types of filters can be used, the simplest type of filter is a capacitor.

The type of diode which is the best fit for power supply unit will be noted for the production of any save electronics gadgets. The goal of this research is to assess and specify the diode type used for rectification that is the best among the most common and easily accessible ones in the local markets using multisim circuit design software programme.

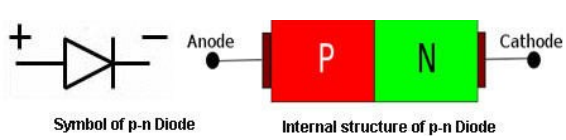

Fig. 1.1(a): A Junction Diode behaves like intrinsic semiconductor (adapted from Nikhil, 2012)

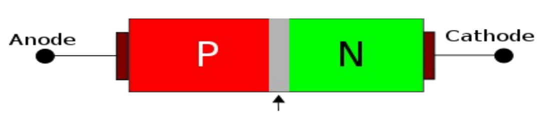

Fig. 1.1(b): Diode creates an intrinsic semiconductor material at depletion region (adapted from Nikhil, 2012)

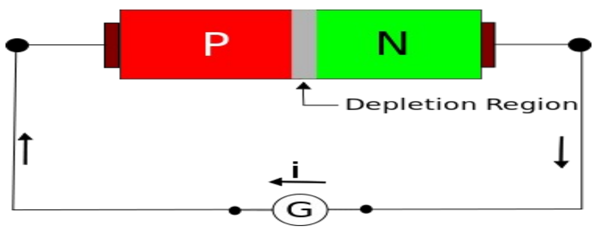

Fig. 1.1(c): Zero Bias shows neither current nor voltage flows through depletion region (adapted from Nikhil, 2012)

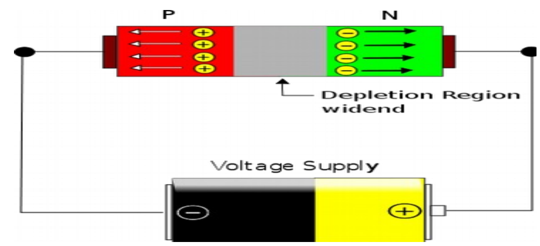

Figure 1.1(d): Reverse Bias widens the depletion region (adapted from Nikhil, 2012)

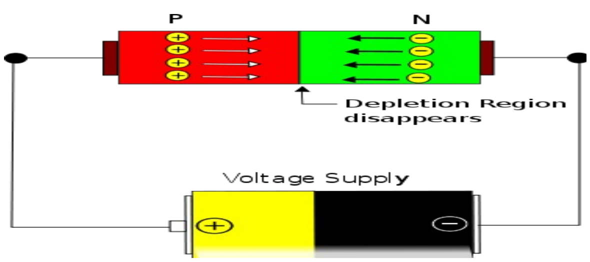

Figure 1.1(e): Forward Biased disappear depletion region (adapted from Nikhil, 2012)

MATERIALS AND METHODS

In this study, the power supply units of electronics system which consists of 5vDC transformer with full-wave bridge rectification were set up. The rectifiers are then varied in order to observe their output response before and after rectification. Readings of the AC power source were taken using multimeter and oscilloscope on multisim circuit design programme. The same was done at the DC source. The outputs were noted and the readings from AC source were compared with the DC source.

Rectifying Effect of Diodes using Multisim Circuit Design Programme Set Up

The Figures 2.1(a) to 2.1(h) show the set-up of different diodes on NI MULTISIM circuit design Programme where diodes were arranged as full-wave bridge rectifiers. Measurements of each diode were taken with the Multisim's multimeter and oscilloscope.

In the Figures 2.1(a) to 2.1(h), the AC power source represented by V1 was rated at $220V_{rms}$ and 50Hertz. This serves as the input for the transformer T1 rated to contains the ratio of Number of turns between primary and secondary coils at 44:1. Boxes labeled XSC1 and XMM1 represent both the oscilloscope and multimeter at the AC side of PSU after being stepped down to 5v. These are useful for taking the input readings before rectification. Also, the boxes labeled XSC2 and XMM2 represent both the oscilloscope and multimeter at the DC side of PSU. These are useful for taking the output readings after rectification. The multimeter measurements on multisim were represented by the boxes labeled V(PR1) in each figure. The set of each diode type used for rectification were labeled D1, D2, D3, D4 and others respectively.

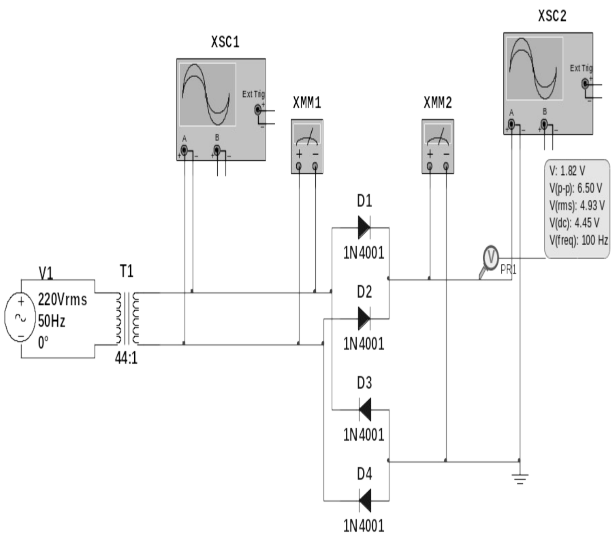

Figure 2.1(a): Power Diode (1N 4001) Rectifier circuitry on multisim

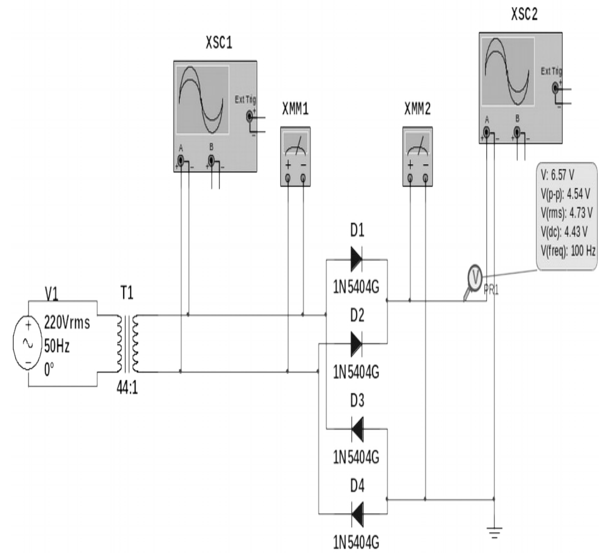

Figure 2.1(b): General Purpose Rectifier / Standard Recovery Rectifier (1N 5404G) circuitry on multisim

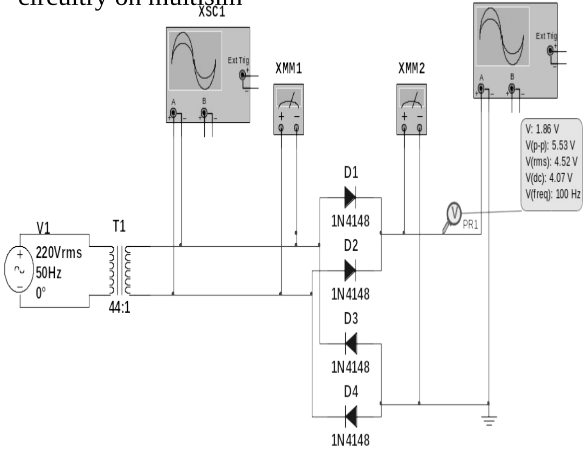

Figure 2.1(c): Signal Diode Rectifier (1N 4148) circuitry on multisim

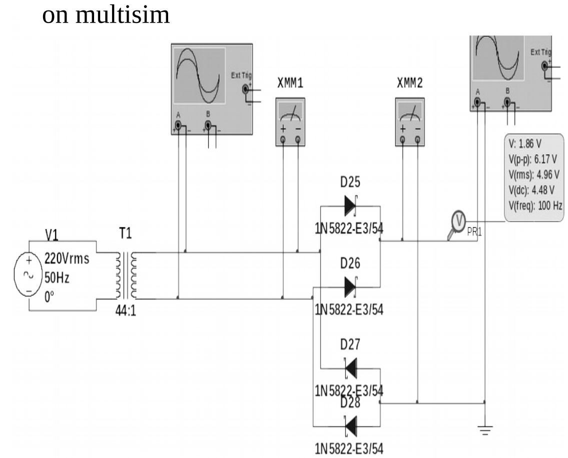

Figure 2.1(d): Schottky Barrier Rectifier (1N 5822-E3/54) circuitry on multisim

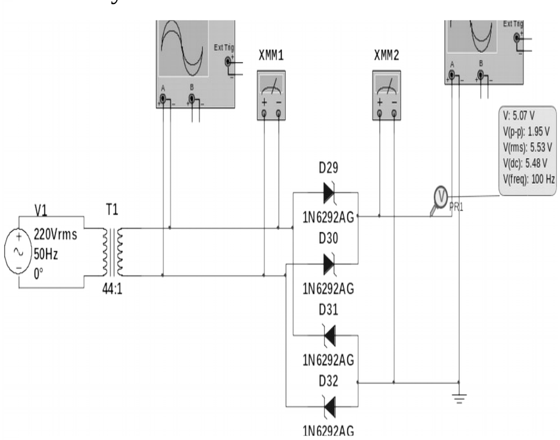

Figure 2.1(e): Transient Voltage Suppressor (1N 6292 AG) circuitry on multisim

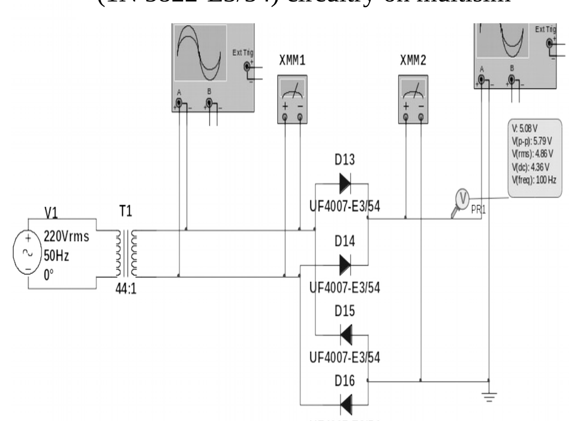

Figure 2.1(f): Ultra-Fast Plastic Rectifier (UF4007-E3/54) circuitry on multisim

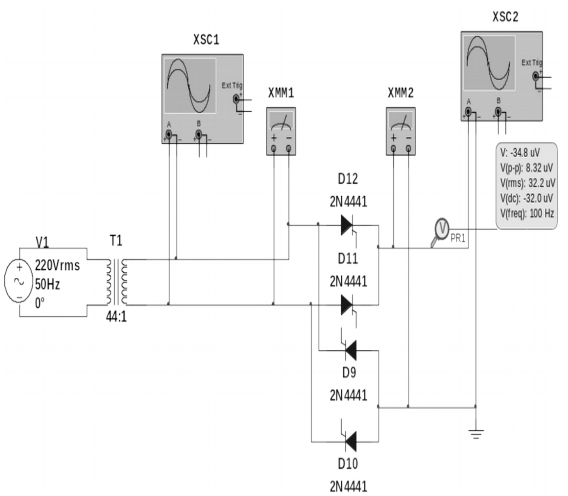

Figure 2.1(g): Silicon Controlled Rectifier (2N 4441) circuitry on multisim

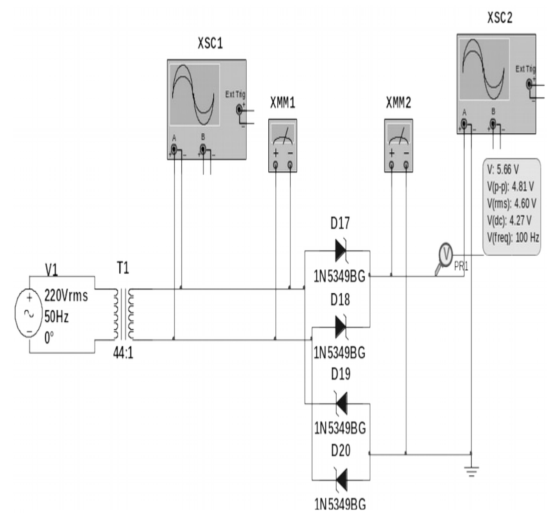

Figure 2.1(h): Zener Diode-12v (1N 5349 BG) circuitry on multisim

RESULTS AND DISCUSSION

Results

Results of Rectifying Effect of Diodes using Multisim Circuit Design Programme Set Up

The oscilloscope waveforms before rectification (that is, when AC has been stepped down to approximately 5v using transformer) are shown in the Fig. 3.1(a) to Fig. 3.8(a) while the oscilloscope waveforms after rectification (that is, when the stepped down voltage has been converted to DC) are as well shown in Fig. 3.1(b) to 3.8(b) respectively.

Table 3.1 was the result of the diode response on the Multisim circuit design programme's multimeter showing the output before and after rectification.

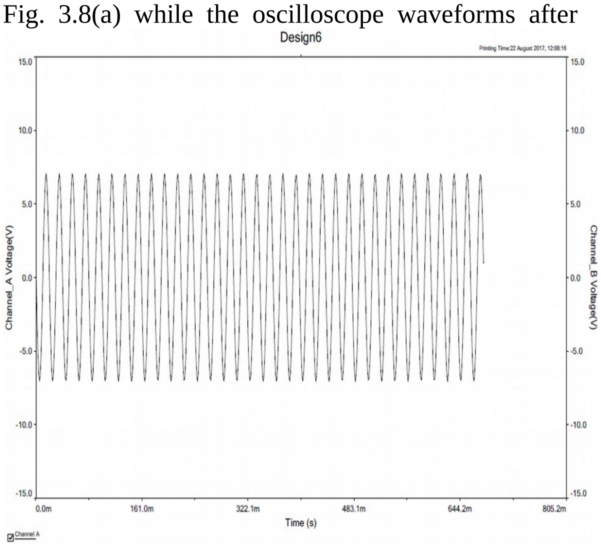

Figure 3.1(a): Power Diode (1N 4001) Rectifier waveform before rectification on multisim

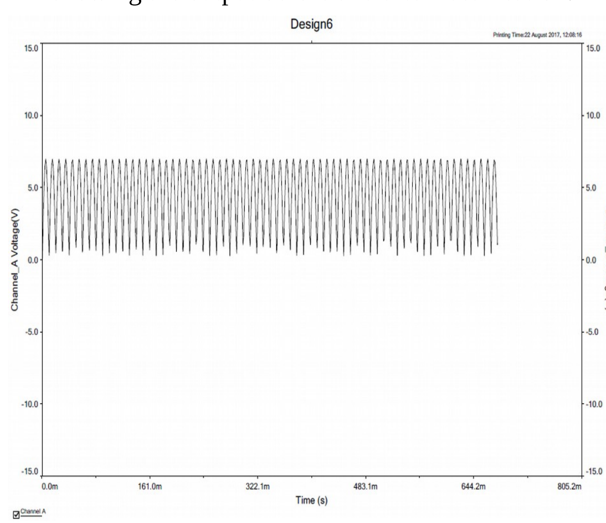

Figure 3.1(b): Power Diode (1N 4001) Rectifier waveform after rectification on multisim

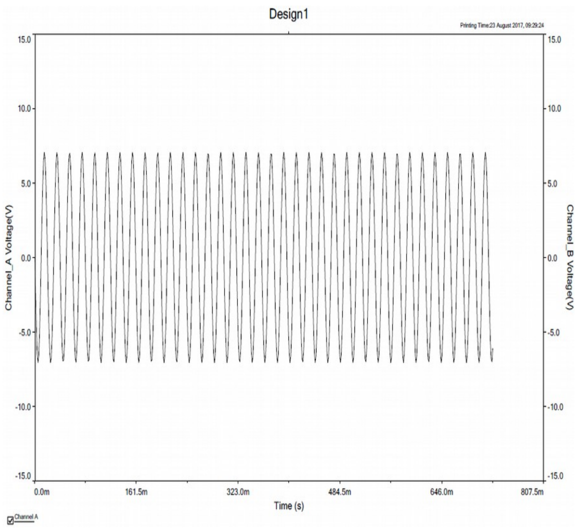

Figure 3.2(a): General Purpose Rectifier / Standard Recovery Rectifier (1N 5404G) waveform before rectification on multisim

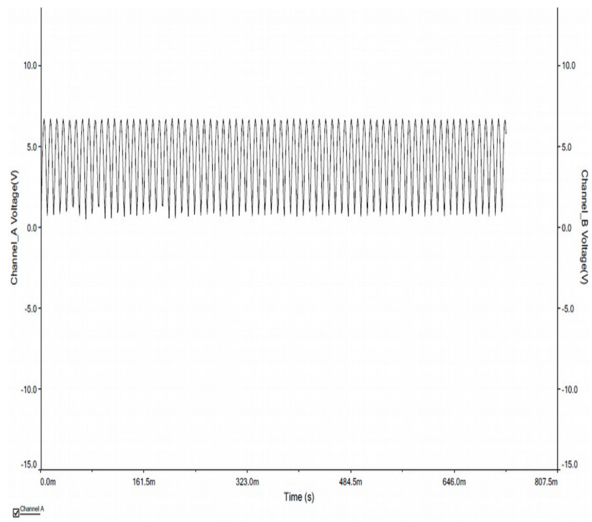

Figure 3.2(b): General Purpose Rectifier / Standard Recovery Rectifier (1N 5404G) waveform after rectification

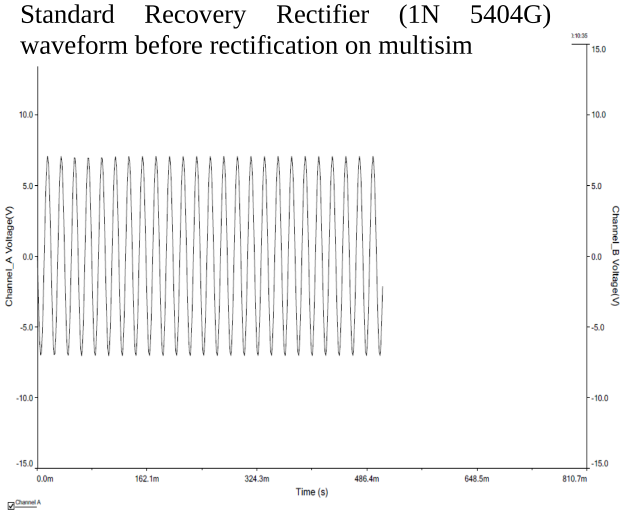

Figure 3.3(a): Signal Diode Rectifier (1N 4148) waveform before rectification on multisim

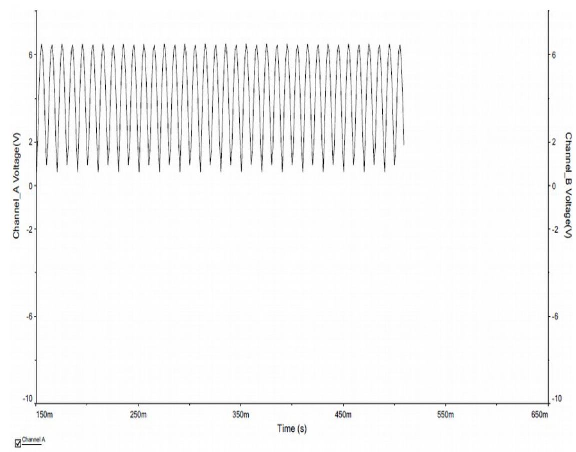

Figure 3.3(b): Signal Diode Rectifier (1N 4148) waveform after rectification on multisim

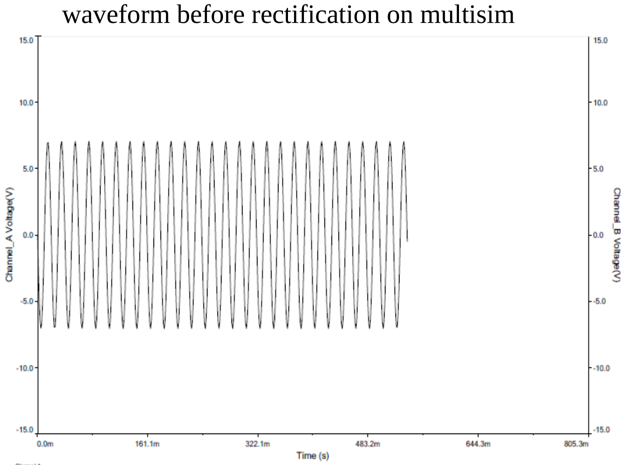

Figure 3.4(a): Schottky Barrier Rectifier (1N 5822-E3/54) waveform before rectification on multisim

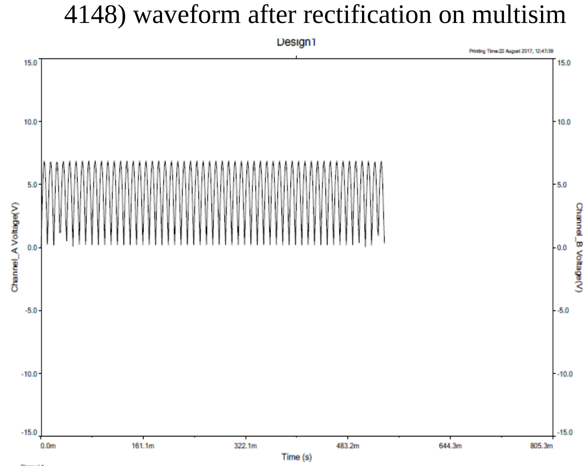

Figure 3.4(b): Schottky Barrier Rectifier (1N 5822-E3/54) waveform after rectification on multisim

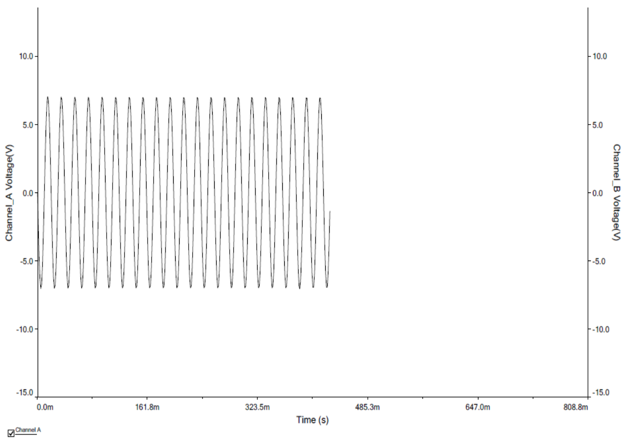

Figure 3.5(a): Transient Voltage Suppressor (1N 6292 AG) waveform before rectification on multisim

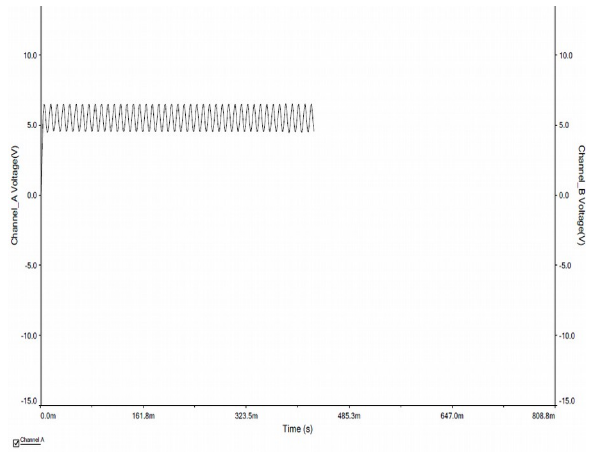

Figure 3.5(b): Transient Voltage Suppressor (1N 6292 AG) waveform after rectification on multisim

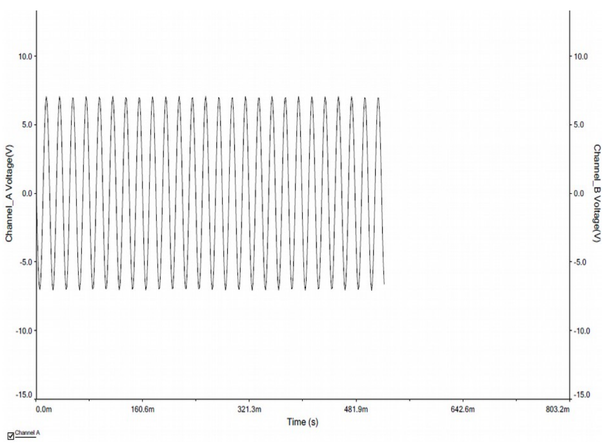

Figure 3.6(a): Ultra Fast Plastic Rectifier (UF4007-E3/54) waveform before rectification on multisim

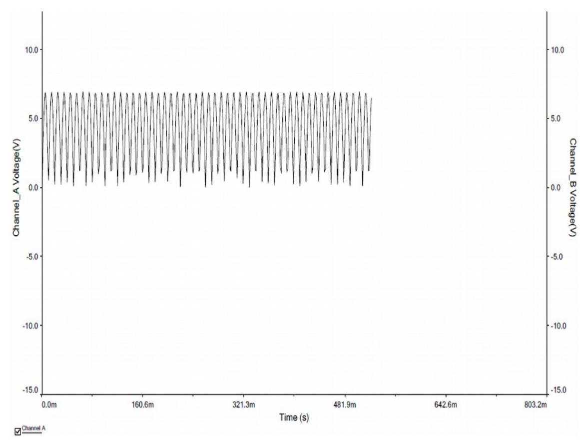

Figure 3.6(b): Ultra Fast Plastic Rectifier (UF4007-E3/54) waveform after rectification on multisim

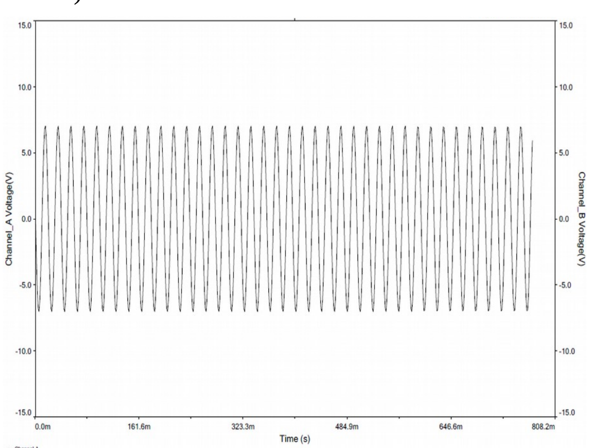

Figure 3.7(a): Silicon Controlled Rectifier (2N 4441) waveform before rectification on multisim

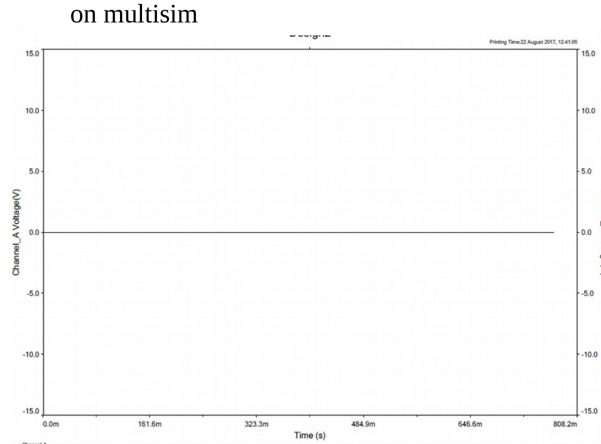

Figure 3.7(b): Silicon Controlled Rectifier (2N 4441) waveform after rectification on multisim

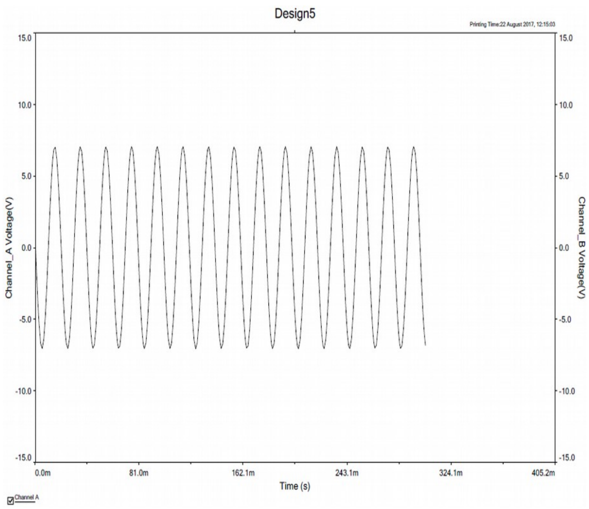

Figure 3.8(a): Zener Diode-12v (1N5349BG) waveform before rectification on multisim

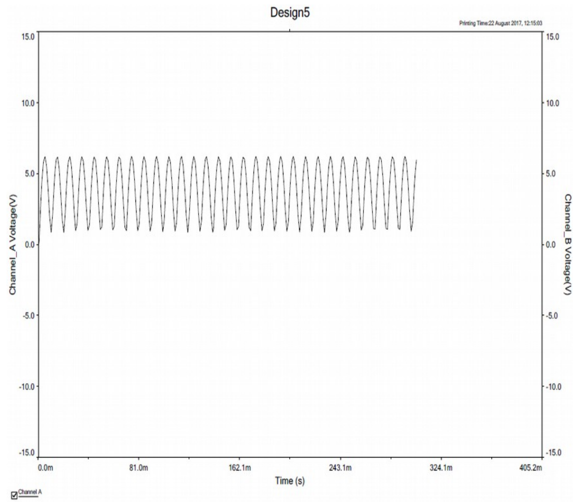

Figure 3.8(b): Zener Diode-12v (1N5349BG) waveform after rectification on multisim

Table 3.1: Multimeter Measurement of different Diode Types / Rectifiers on Multisim Circuit Design Programme

S/N	**Diode Type / Rectifiers**	**Diode Number**	**Multimeter Readings (v)**		**VD**
			AC (before rectification)	**DC (after rectification)**	
1.	Power diode	1N 4001	4.997	4.448	0.549
2.	General Purpose Rectifier	1N 5404G	5.015	4.431	0.584
3.	Signal diode rectifier	1N4148	5.001	4.065	0.936
4.	Schottky Barrier Rectifier	1N5822-E3/54	4.998	4.487	0.511
5.	Transient Voltage Suppressor (TVS)	1N6292 AG	5.000	5.478	-0.478
6.	Ultra-Fast Plastic Rectifier	UF 4007	4.989	4.359	0.630

7.	Silicon Controlled Rectifier (SCR)	2N 4441	5.000	-32.029	37.029
8.	Zener Diode-12v	1N 5349BG	5.015	4.271	0.744

DISCUSSION

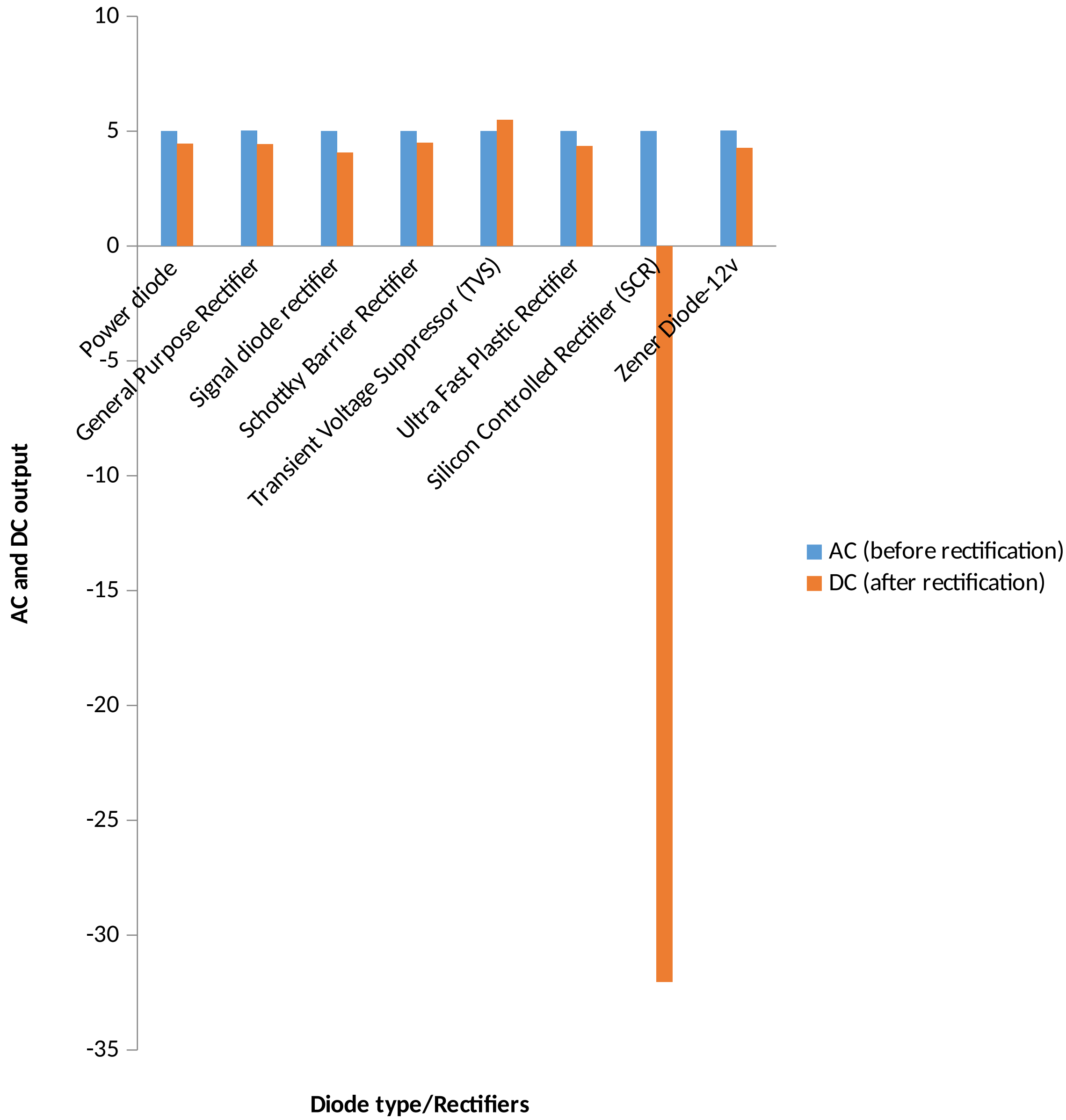

Figure 3.9: Chart of Diode types / Rectifiers against AC and DC output on Multisim

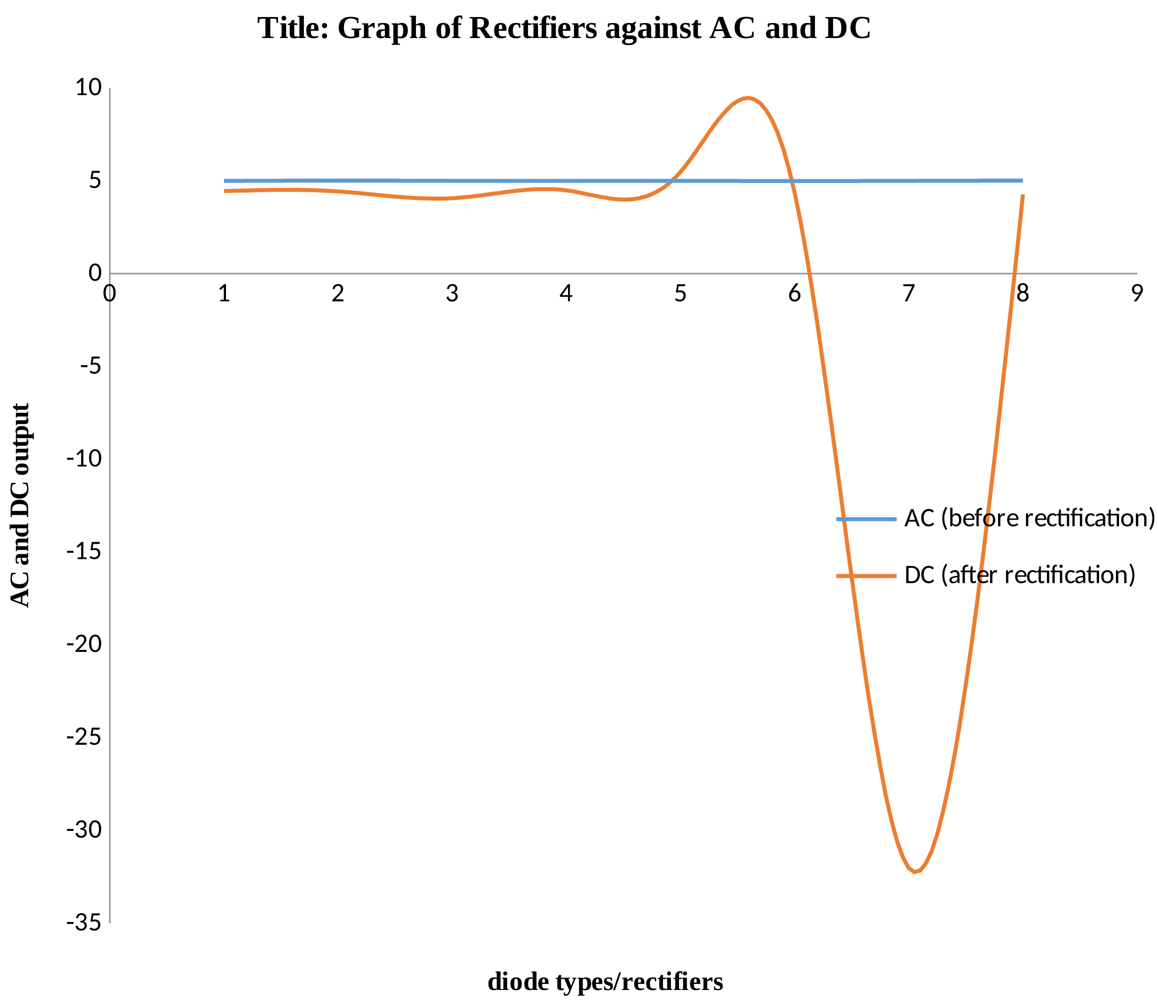

Figure 3.10: Graph of Diode types / Rectifiers against AC and DC output on Multisim

Keys:

Power diode	=	1
General Purpose	=	2
Signal Diode	=	3
Schottky Barrier	=	4
Transient Voltage Suppressor (TVS)	=	5
Ultra-Fast	=	6
Silicon Controlled Rectifier (SCR)	=	7
Zener Diode-12v	=	8

The result was represented in form of the bar chart in Figure 3.9. At AC side, each diode shows a little changes in voltage (Δv) from the actual 5v stepped down voltage when rectifiers were connected. At DC side, additional changes in voltage (Δv) was recorded. This led to an effect known as voltage drop (VD). In some of the rectifiers, there was either voltage gain or voltage loss.

Figure 3.10 shows the graph of Rectifiers against AC and DC output on Multisim. The maxima and minima points on DC curve were 5.478v and -32.029v respectively. Other rectifiers had shown the points of inflexion on the graph ranging between 4v to 5v which were arranged in the descending order of the best response.

a) Schottky Barrier Rectifier - 4.487v
b) Power diode - 4.448v
c) General Purpose diode - 4.431v
d) Ultra-fast Plastics Rectifier - 4.359v
e) Zener diode-12v - 4.271v
f) Signal diode rectifier - 4.065v
g) The maxima point had shown the DC voltage of Transient Voltage Suppressors (TVS)
h) The minima point showed the DC voltage of Silicon Controlled Rectifier (SCR).

The rectifying response of Transient Voltage Suppressors (TVS) and Silicon Controlled Rectifier (SCR) were abnormal since they do not obey the existing theoretical norm on I-V characteristic curve of diode which shows that silicon diode has voltage loss of approximately 0.6v and germanium diode has voltage loss of about 0.3v after rectification. The TVS rectifying response displayed a voltage drop of -0.478v that was far above the expected Low Voltage Rectification (LVR) which is 5v in this case. The rectifying response of SCR was parallel to the time-axis (Figure 3.7b) since it displayed a voltage drop of 37.029v. That is, there was no rectification. This means that practically, a good rectifying output could not be achieved with these types of diode if used as rectifier for a circuit required LVR.

CONCLUSIONS

In conclusion, Schottky Barrier diode is the rectifier with the best response output on multisim circuit design software programme while power diode, general purpose rectifier, ultra-fast rectifier, Zener diode-12v and signal diode rectifier are rectifiers with the better response output. Transient Voltage Suppressor (T.V.S.) displayed negative voltage drop which eventually result in increase in temperature of the component. A good rectifying output could not be achieved with Silicon Controlled Rectifier (S.C.R.) for circuits that required Low Voltage Direct Current (LVDC). It is recommended that those rectifiers should be used to test for the output response of PSU that required High Voltage Direct Current (HVDC).

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