Offline UPS for Regenerative Loads

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Abstract
This paper presents describes about a unique DC Discharge System for Offline UPS. Whenever an offline mode UPS is connected to a motor load, as the motor decelerates either through the change of torque or due to the Dynamic braking there will be a regenerative energy produced. If this regenerative energy flows back into the UPS, then over-voltage condition takes place and causes damage to the UPS. This regenerative energy can bypass through the battery in online mode. But online mode operation of UPS needs high cost as large heat sinks are required. So, offline mode of operation is preferred in most of the cases. The proposed system dissipates the regenerative energy through the connected resistors and the remaining energy is used for the gating of semiconductor switches inside the UPS. The detailed principle of the proposed method is discussed in this project. The entire Discharge System and Gate pulse generating System are simulated in Proteus Software and the results are provided.

Keywords: Offline UPS, DC Discharge System, IGBT triggering

1. Introduction

Today, the world runs on critical infrastructure and technology in Hospitals, Factories, Data centers, Vehicles and the Electrical grid. These are things people depend on every day. An uninterruptible power supply (UPS) is used to protect critical loads from utility- supplied power problems, including spikes, brownouts, fluctuations and power outages, all using a dedicated battery. For the above mentioned reasons, it is important to implement an UPS that has a potential to work under all the conditions.

UPS Provides backup power when utility power fails, either long enough for critical Equipment to shut down gracefully so that no data is lost or long enough to keep required loads operational until a generator installed online.Conditions incoming power so that all-too-common sags and surges don't damage sensitive electronic gear. An uninterruptible power supply (UPS) can range from a 9 volt battery all the way to an extremely large and costly battery system. The UPS sits between a power supply such as a wall outlet and a device like a system of computer to prevent undesired features that can occur within the power source such as outages, sags, surges, and bad harmonics from the supply to avoid a negative impact on the device[1].

The overview of backup power supplies, by considering power quality concerns, types of power supplies available and the limitations are also studied. Specifically the details of Uninterruptible Power Supply

(UPS) system and its types and focuses on detailed patent landscape analysis, which provides patent filing trend, technology spread and geographical patent distribution[2]. IEC 62040-3:2011 applies to a movable, stationary and fixed electronic uninterruptible power systems (UPS) that delivers single or three phase fixed frequency a.c. output voltage not exceeding 1000V a.c. and that incorporate an energy storage system, generally connected through a d.c. link. This standard is intended to specify performance and test requirements of a complete UPS and not of individual UPS functional units. The individual UPS functional units are dealt with in IEC publications referred to in the bibliography that apply so far that they are not in contradiction with this standard[3].

The EN-62040-3 applies to electronic direct a.c. converter systems with electrical energy storage means in the d.c. link.It ensures the continuity of an alternating power source. It also includes the method of specifying all power switches that form integral parts of a UPS and are associated with its output.Included are interrupters, bypass switches, isolating switches, load transfer switches and tie switches. does not refer to conventional mains distribution boards, rectifier input switches or d.c. switches or UPS based on rotating machines.Energy can be stored in different ways.. However, kinetic energy can also be stored in heavy, rotating flywheels or energy can be stored as fuel. In normal mode, the rectifier derives power from the commercial AC source and converts it into DC power for the inverter and battery charger[4].

The battery charges keep the battery in a fully charged and optimum operational condition. The UPS consists of a battery charger, an inverter, output transformer, a set of batteries, control circuits and transient/ EMI filters [5]. The on-line UPS provides a conditioned output voltage when the power is on and charges the battery through the battery charger. The control circuits of UPS automatically switch over to the inverter and supply power from the batteries during power interruption/ failure. The change-over from mains to the battery and back to the mains supply is done automatically by the control circuits. The modern UPS employs IGBT based inverter and pulse width modulators techniques and static switches. The Design for double-conversion uninterruptible power supply (UPS) systems that results in higher power density, higher efficiency, and more flexible parallelism for higher reliability are studied. This design comprises a three-level circuit topology, a custom power semiconductor module, and a cross current sensor less parallel control. The innovative circuit topology results in a UPS with higher efficiency and dramatic size/weight reduction and confirms the advantages of three-level circuits in low-voltage applications [6].

A new topology of uninterruptible power supply (UPS) by using a Z-source inverter, where a symmetrical LC network is employed to couple the main power circuit of an inverter to a battery bank. With this new topology, the proposed UPS can maintain the desired ac output voltage at the significant voltage drop of the battery bank with high efficiency, low harmonics, fast response, and good steady-state performance in comparison with traditional UPSs. These were studied under the suitable conditions [7]. The central controller in the parallel operation mode guarantees synchronization with an external real/fictitious utility, and critical bus voltage amplitude restoration [8].

2. Proposed model

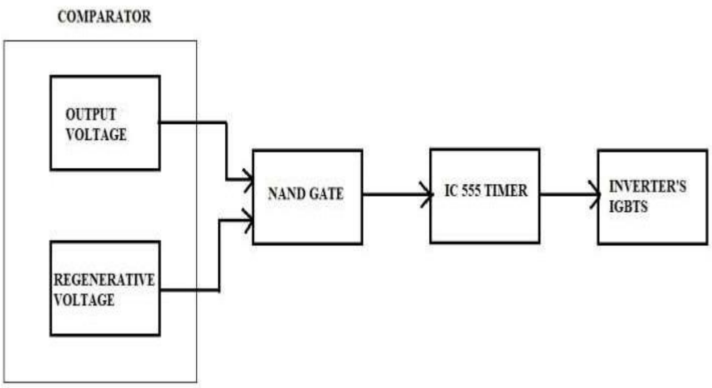

Figure 1: Block diagram of DC Discharging Kit

Block diagram of DC discharging kit consists of comparator which compares the output voltage fromthe inverter and the regenerative voltage that has been comes from the connected regenerative loads like motor, The NAND gate or “NOT AND” gate is the combination of two basic logic gates, the AND gate and the NOT gate connected in series The NAND gate and NOR gate can be called the universal gates since the combination of these gates can be used to accomplish any of the basic operations. The function of timer includes As you can see the 555 IC is wired in Monostable mode of operation. Please read the article Monostable Multivibrator using 555 Timer for more details. In this mode the output is LOW (0V) when there is notriggering, when it is triggered via 2nd pin the outputgoes HIGH (Vcc) for some time.

This time period isdetermined by the expression T=1. 11 RC (R=R2; C=C2 in the diagram). Trigger is applied via a differentiator circuit to make sharp pulses. The resistor of differentiator is connected to Vcc to generate negative trigger pulses and the diode avoidspositive spikes. And now this output is modulated using the input voltage applied at the control pinof the IC. So, whenever the Trigger pin pulses become low the output of the IC switchesto high and as a result the discharge transistor (internal to the 555 IC attached to the7th pin) is disabled. So C2 charges through R2. This capacitor keeps on charging until the voltage is above the input controlvoltage, at which the IC changes its state. Now theoutput is low which makes the discharge transistoractivated thereby discharging the capacitor C2.

Hence the output pulse width is determined by the control voltage. This process continues, and we get a continuous stream of pulses which can be used for motor control, driving LED’s, transmitting servosignals for remote control applications etc. An insulated gate bipolar transistor (IGBT) is a device in which a IGBT is combined with a bipolar transistor. The utility model has the advantages thatthe power IGBT is easy to drive, the control issimple, the switching frequency is high, and the power transistor has low on-voltage, large on-state current and small loss. According to Toshiba, the on- resistance of the 1200V/100A IGBT is 1/10 of the power IGBT of the same withstand voltage specification, and the switching time is 1/10 of the GTR of the same specification. Due to these advantages, IGBTs are widely used in the design ofuninterruptible power systems (UPS). This online UPS using IGBT has the significant advantages of high efficiency, high impact resistance and highreliability.

3. Simulation output

Circuit 1: +VDC

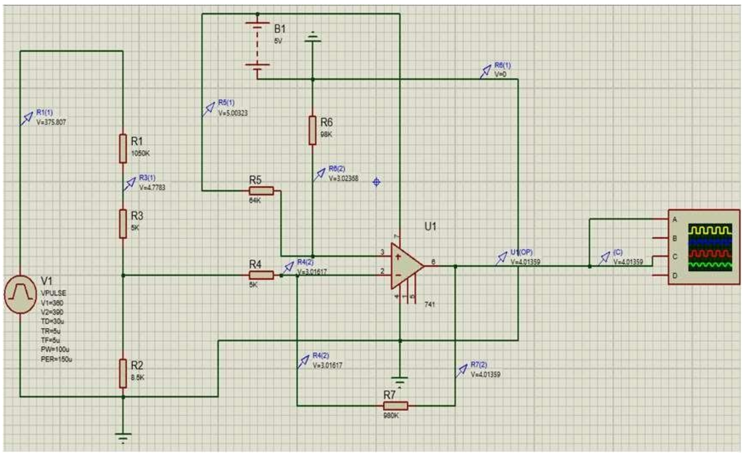

Figure 2: Simulation Diagram of +VDC

+VDC Comparator circuit is designed by using Operational amplifier to compare. The voltages in both control circuit and main circuit. It compares thevoltage range of 320V to 400v. When the voltage range exceeds 365V in control circuit then we have to consider +VDC circuit. Comparator triggers the output to the NAND gate. Similarly when the voltage range exceeds 380V. When regenerativeload condition then the main circuit triggers theoutput to the other NAND gate. This generally compares the output voltage which will be in the positive half cycle. This can be used in both the control circuit and the main circuit. The main objective of designing this circuit is to compare the two voltage ranges from the output and the regenerative load.

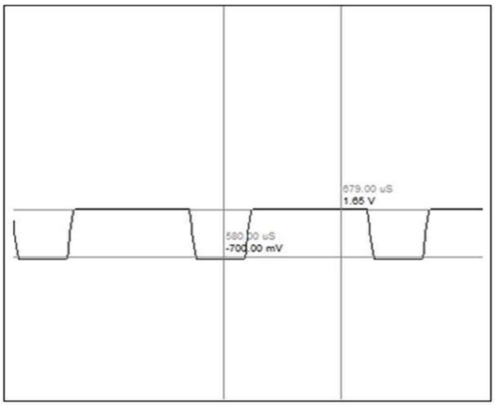

Figure 3: Simulation output of +VDC

Peak to Peak voltage: 4 V
Time period: 480 microseconds
Inference: From this we have inferred that theoutput voltage of +VDC with amplifier is around 3.5 to 4V. This could be the high input to the NAND gate. The above figure displays the output ofthe +vdc simulated diagram which feds the input of + 35.805V and results in the output of about 4.01359V due to the resistance and inverting amplifier connected through it.

Circuit 2: -VDC

- VDC Comparator circuit is designed by usingsimilar components of +VDC circuit and the voltageranges remains the same as +VDC circuit for both control and main circuit. The control circuit and main circuit triggers the output to NAND gate at thevoltage range of -365 and the voltage ranges remains the same as +VDC circuit for both control and maincircuit.

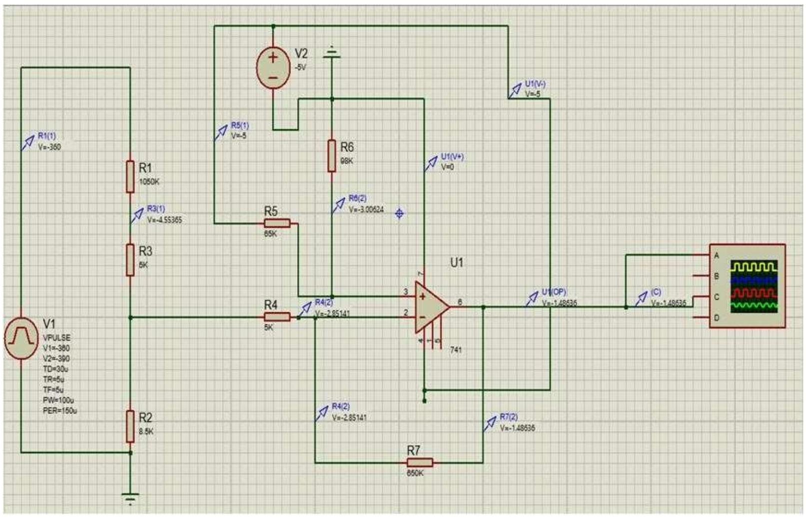

Figure 4: Simulation Diagram of -VDC

But in terms of negative voltage range to -380V. In-VDC circuit the input voltage is given from 320V to 400V in the inverting terminal of operationalamplifier and the reference voltage (Vref) is given atthe non-inverting terminal by using the voltage divider network.

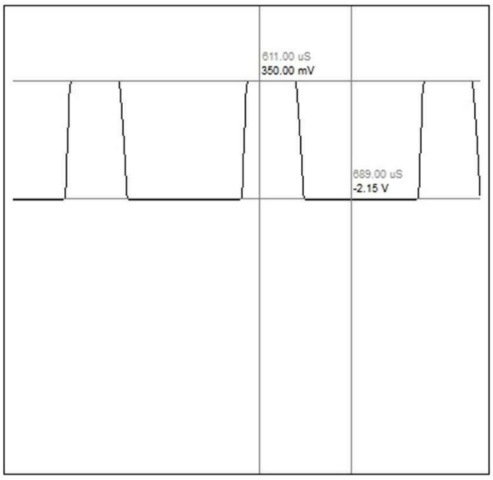

Figure 5: Simulation output of –VDC

Peak to Peak voltage: -3.5V
Time period: 610 microseconds
Inference: From this we have inferred that the output voltage of –VDC with amplifier is around -3to -3.5.So this has to be amplified with an amplifier.The above figure displays the output of the -vdc simulated diagram which feds the input of -360V and results in the output of about -1.486V due to theresistance and inverting amplifier connected through it.

Circuit 3: -VDC with Amplifier

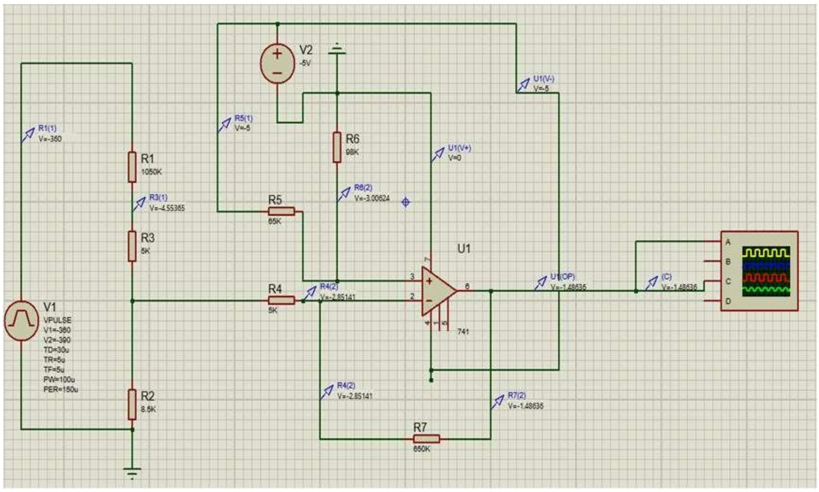

Figure 6: Simulation Diagram of -VDC withamplifier

VDC Amplifier circuit is used in both control and main circuits. This amplifier circuit amplifies the output from the -VDC comparator circuit and sendsthe amplified output voltage to the NAND gate inputterminal. During the amplification process it produces an 180^0 phase shift in the output. Thus, thenegative voltage will be changed to positive voltage inthe output of amplifier circuit.

Then now the positive voltage ranges from -VDC amplifier circuit and +VDC circuit is given to the NAND gate of both control and main circuits and then the NAND gates output is given to the AND gate. The AND gate compares the output from both the NAND gates andwhen both outputs are high then the AND gate triggers the output to the 555 PWM circuit.

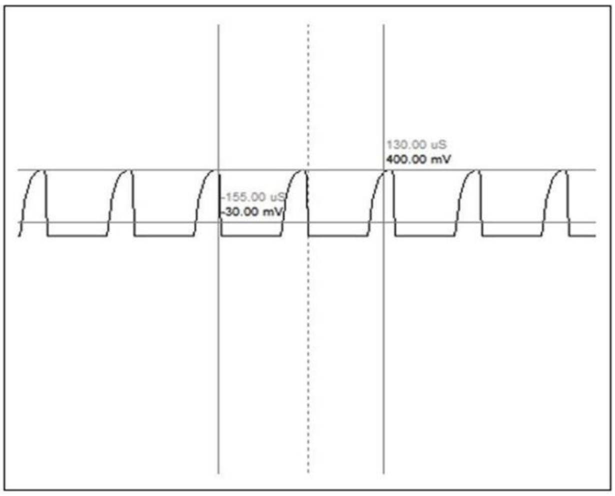

Figure 7: Simulation output of -VDC with Amplifier

Peak to Peak voltage: 4.8 V
Time period**:** 130 microseconds
Inference: From this we have inferred that the output voltage of –VDC with amplifier is around 4 to 4.85V. This could be the high input to the NANDgate. The above figure displays the output of the - vdc with

amplifier simulated diagram which feds theinput of -360V and results in the output of about 4.9836 V due to the resistance and non-inverting amplifier connected through it.

Circuit 4: Main Circuit

Main circuit diagram is constructed using above thecases used in +VDC, -VDC an –VDC with amplifier in additional to this NAND Gate and IC 555 Timer circuit is added

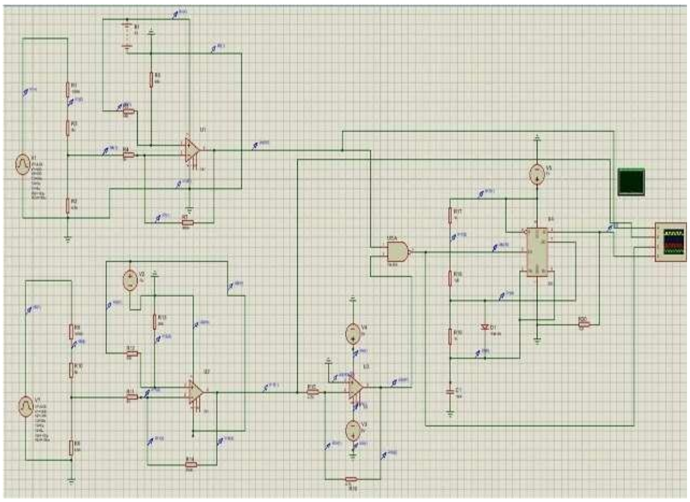

Figure 8: Simulation Diagram of Main circuit

The compared output from the +VDC and -VDC aregiven into a NAND gate which will get an input of 4.5V on each. So the entire output of the NAND gate is 0V. This can be given to the IC 555 Timer and the generated output is displayed.

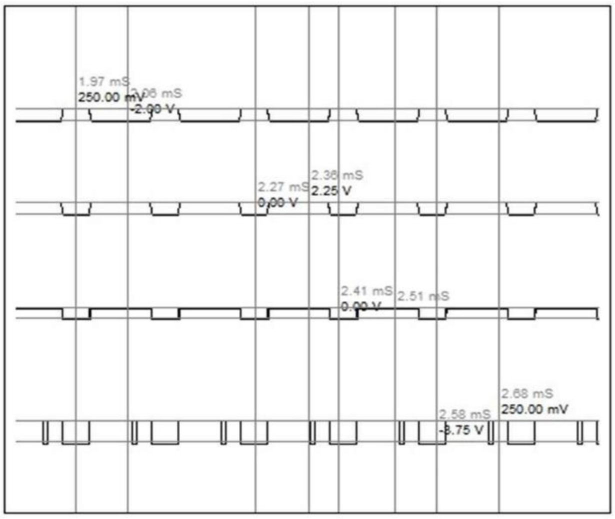

Figure 9: Simulation output of main circuit

Peak to Peak voltage: 0.8 V

Time period: 80 microseconds

Inference: From this we have inferred that the output voltage of the main circuit is 0V.This isgenerally considered as low input for the logic gates. So we have to include another main circuit toget a high output. The above figure displays the output of the main circuit simulated diagram which feds the input of 0 and

-360V and results in the output of about 2.28V due to the resistance and non- inverting amplifier, NAND gate and 555 timer connected through it.

Circuit 5: Final Circuit

The 555 Timer is configured in Astable Multivibrator mode of operation to produce the PWM signal as output which triggers the gate circuitin the output side. 5V supply is given to the VCC pinof 555 Timer IC

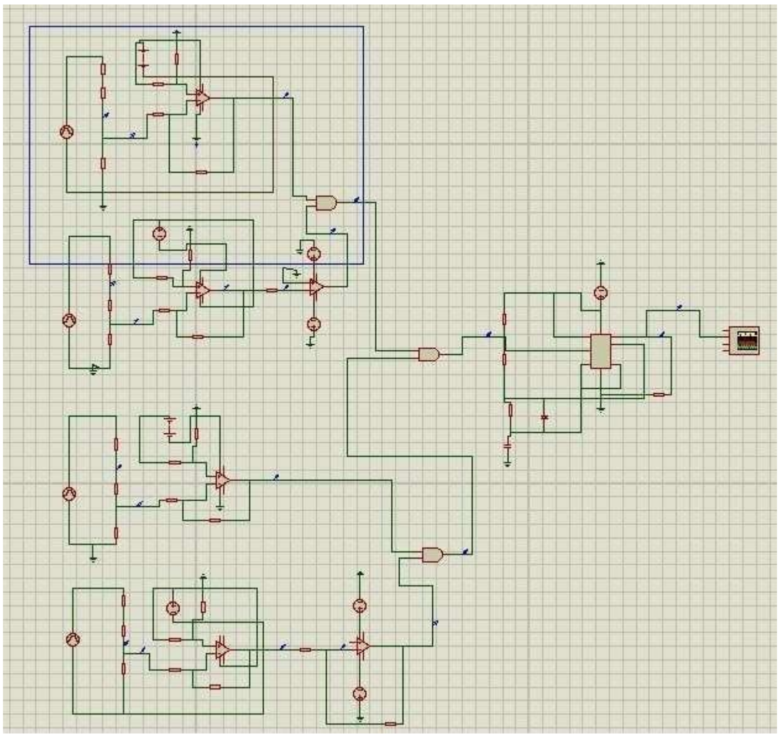

Figure 10: Simulation Diagram of Final circuit

The duty cycle is obtained up to 90% and the ON Time and OFF Time is varied by varying the values of Resistors and Capacitor in thecircuit. The output from singe main circuit is not sufficient to trigger an IGBT. So another control circuit is added and connected through NAND Gatewhich will provide an output of 4.4V. This is the threshold voltage for IGBTs inside the inverter.

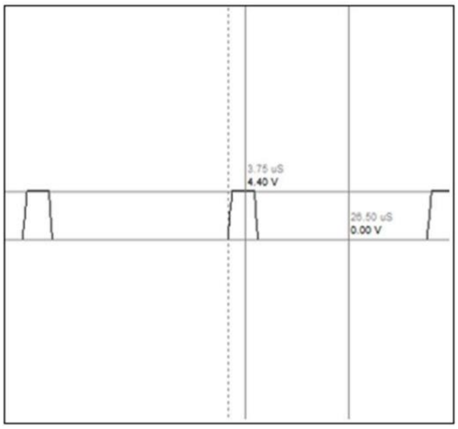

Figure 11: Simulation output of Final circuit

Peak to Peak voltage: 4.4 V
Time period: 3.75 microseconds
Inference: From this we have inferred that the output voltage of the final circuit would be around 4-4.40V.This voltage range is the threshold voltage of any IGBTs gate circuits. So from this the IGBT inthe inverter can be triggered.

4. Result and Discussion

Thus, we have designed the circuit required for DC Discharge kit in order to overcome the damages caused due to the regenerative loads connected to anoffline mode or also referred as battery mode. The discharge kit dissipates the regenerative energy through a series of resistance as heat. The remaining dissipated energy is used to generate gate pulse for the semiconductor switches in the inverter of theUPS. Looking to the future, the study accomplishedup to date ensures reduced voltage in the software basis. We are going to conduct various studies on offline UPS for regenerative loads in future for the betterment of this project.

Sl.No	**Circuit**	**Output Voltage**	**Time period**
1	**+VDC**	4V	480 ms
2	**-VDC**	-3.5V	610 ms
3	**-VDC with amplifier**	4.8V	130 ms
4	**Maincircuit**	0.8V	80 ms
5	**Final Circuit**	4.4 V	3.5 μs

Table 1: Analysis between the output voltage vs time period

The +VDC, -VDC, -VDC with amplifier, main and final circuit has been simulated in the Proteus software and the results are provided. The ultimate output voltage is around 4.4V. This is the required threshold voltage for the IGBT to get triggered in theinverter circuit of the UPS.

Resistance(R)	**Voltage(v)**
1050	4.7783
5	2.0934
98	3.0236
980	4.0136
4.7	1.9031
8.5	2.893

Table 2: comparison between various voltage ranges and their respective resistance

5. Acknowledgement

Eaton is a power management company which manufactures mainly UPS. The problem statement has been given by Eaton power quality pvt ltd is the UPS used for Motor Load produces Regenerative Energy which is either due to the change of torque or Dynamic Braking of motor. If this Regenerative energy left unmanaged, the regenerative load can lead to over voltage that can damage the critical equipment and leads to poor efficiency. Eaton assigned an industrial guide Mr.k.Ashok Singh, Lead engineer, manufacturing unit to help us out with our academic project. Eaton supported us in all the possible way and provided the necessary training to accomplish the project assigned.

6. Authors' Biography

Asmabegam,Gunavathi,Sowmya And Vidhyalakshmi are the students of Sri Manakula Vinayagar Engineering College currently pursuing B.tech in the stream of Electrical and Electronics Engineering. They were guided by Mr.A.Janagiraman,Assistant Professor,Department of Electrical and Electronics Engineering at Sri Manakula Vinaygar Engineering College to do their academic project on the title Offline Ups for Regenerative loads.

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