DESIGN AND DEVELOPMENT OF AN AUTOMATIC TESTING EQUIPMENT FOR A SWITCH MODE POWER SUPPLY (SMPS) AND ITS ANALYSIS AND DATA ACQUISITION USING LABVIEW.

[1]Omkar Vilas Bhoite, [2]Pramod Bhausaheb Divekar, [3]Kshitij Vijay Bhalerao, [4]Mr.Hemant Chaudhari
[1]UG Student, [2] UG Student, [3] UG Student, [4]Professor
[1,2,3,4]Department of Instrumentation and Control Engineering,
[1,2,3,4]All India Shri Shivaji Memorial Society's Institute of Information Technology, Pune, India

Abstract: An automated testing equipment plays a key role in increasing the speed, accuracy and efficiency for testing any electronic equipment. This paper presents detailed review of the designing of an automatic testing equipment for SMPS. Here we measure, evaluate and analyze different performance characteristics of SMPS using the testing equipment, LabVIEW Software is used for data acquisition and analysis of the test data acquired from the testing equipment.

Acronyms

Acronym - **SMPS**: Switch Mode Power Supply; **LabVIEW**: Laboratory Virtual Instrument Engineering Workbench; **MOSFET**: Metal Oxide Semiconductor Field Effect Transistor; **UUT**: Unit Under Test; **Op-amp**: Operational amplifier.

I. INTRODUCTION

Testing is a very crucial process for detecting the faults in any equipment. One needs to be very cautious while performing the testing and also while analyzing and validating the test data, which forms the basis to detect the faulty unit. In this paper we are going to discuss about the testing equipment for SMPS. A SMPS (Switch Mode Power Supply) is a device that provides a constant and uninterrupted voltage & current supply and is used as a power source in many electronic devices. Manual testing of SMPS is a very time consuming and may not also be error free. In order to save time and get results with desired accuracy we have designed an automatic testing equipment to test the SMPS. The automatic testing equipment is based on the concept of load regulation and line regulation. Load Regulation is a static characteristic, that ascertains the ability of the power supply to remain within specified output range for a preordained load change.[1]. Line Regulation is the ability of the power supply to maintain the constant output voltage for uncertain changes in the input voltage. The analysis and validation of the test data of the UUT is carried out by LabVIEW software. The data acquired by the software from the hardware, is processed based upon the algorithm developed, and then it is displayed in numerical and graphical formats. LabVIEW is system engineering software that is used to test, measure and control with rapid access to hardware and data insights.

II. TESTING OF SMPS

The automatic testing equipment is designed to test the various performance characteristics of SMPS as follows:

- Soft start: It is a gradual tuning of the power supply to avoid the stressing of the electronic components by sudden current and voltage surge associated with the initial charging of the capacitors and transformers.
- Over shoot: It is the occurrence of high peak voltage as result of addition of incoming voltage wave and reflected voltage wave, due to the mismatch of impedance in a power supply.
- Dynamic load response: Measurement of the variations in the output voltage of the power supply due to changes in the load.
- Output voltage ripple: Measurement of the residual periodic variation of the DC voltage in power supply derived from an AC (Alternating Current) source.
- Settling time: Time required by the system to restrain its output value to specified band.

III. DC PROGRAMMABLE LOAD

In order to carry out the load regulation testing of SMPS we use DC programmable load. A DC programmable load is a testing equipment which emulates the DC /AC resistance loads which is used for testing of batteries, power supply, solar cell etc. Figure (1) shows the circuit diagram of DC programmable load. The operational amplifier (A1) is a buffer/voltage follower circuit whose main function is to provide a voltage isolation between input stage and op-amp (A2) of the DC programmable load and also to reduce loading effect on op-amp (A2), so that the input signal reaches the op-amp (A2) without any distortion and noise. The operational amplifier (A2) is used in non-inverting amplifier with negative feedback configuration, which forms the basis for the working of DC programmable load, in here the amplifier tries to maintain the same voltage across the two input terminals which leads to change in the output of the op-amp.

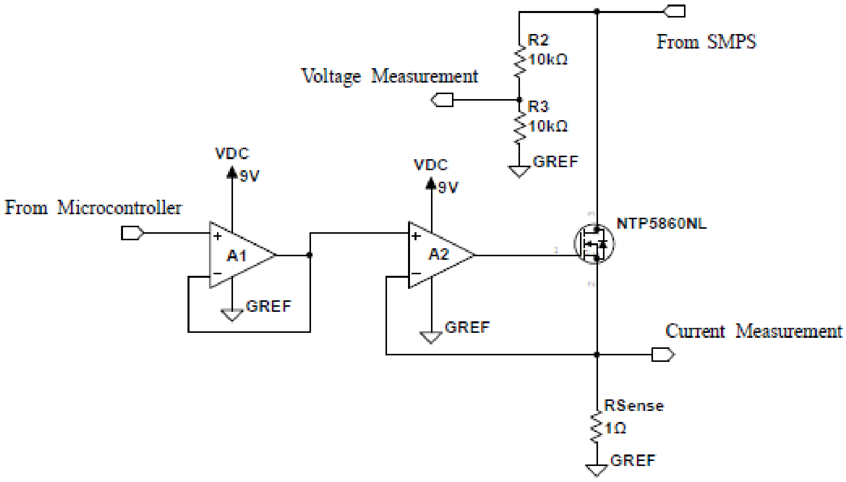

Figure (1)

MOSFET plays a very important role in the working of the DC programmable load circuit by generating variable load resistance when used in the ohmic (active) region. MOSFET is voltage-controlled device and has an advantage over a simple transistor as it has the capability to handle large amount of current, very high switching speed, low switching losses, requires very small current to operate and also MOSFET can operate in three different regions; cut off, ohmic and saturation. It can be seen that as the current flowing between drain and source I_D, not only depends on the voltage applied to the gate V_{GS} but also on the voltage between drain and source V_{DS}. When the voltage at the gate terminal is lower than the device threshold voltage V_{TH}, the MOSFET is operating in its cut-off region. No channel is created between drain and source and the MOSFET will not carry drain current. In its ohmic region, the MOSFET can be treated as a voltage-controlled resistor. The gate voltage will control the resistance between drain and source. When operating in its saturation region the drain current is independent of the voltage between drain and source [2].

In order for DC programmable load to work, we use the MOSFET in ohmic region where $V_{GS} > V_{th}$ and $V_{DS} < V_{GS} - V_{th}$. As shown in figure (1) the basic control loop of the op-amp (A2) tries to maintain the same voltage across the input terminals, Thus the error signal generated which is the difference between the input reference signal V_{input} and feedback signal $V_{feedback}$ is amplified to control the MOSFET. The gate voltage controls the current flowing through the MOSFET and the current sensing resistor R_{sense} and therefore the feedback voltage [2] and the equation (1) models the flow of current from drain to source in an ohmic region, where V_{GS} is gate to source bias, V_{th} is device threshold voltage, V_{DS} is drain to source bias, μ_n is charge carrier effective mobility, W is gate width, L Gate length, C_{ox} is the gate oxide capacitance per unit area . Thus, by giving a controlled structured input to the DC programmable load from the microcontroller (Arduino Uno) we control the output voltage of op-amp (A2), which drives the gate terminal of the MOSFET and in turn we control the resistance between the drain and source terminals, and as a result the MOSFET acts a voltage-controlled resistor.

$$I_D = \mu_n C_{ox} \frac{W}{L}\left((V_{GS} - V_{th})V_{DS} - \frac{V_{DS}^2}{2}\right) \qquad (1)$$

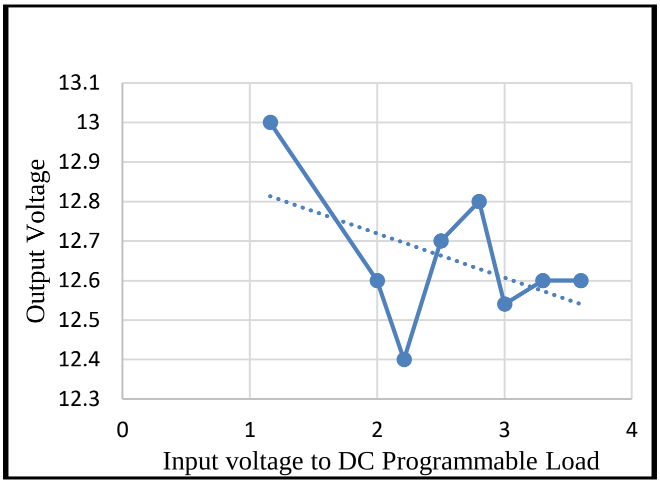

Figure (2). The above graph shows that how the output voltage of the SMPS operated on 230*V* AC input, varies as the function of load change.

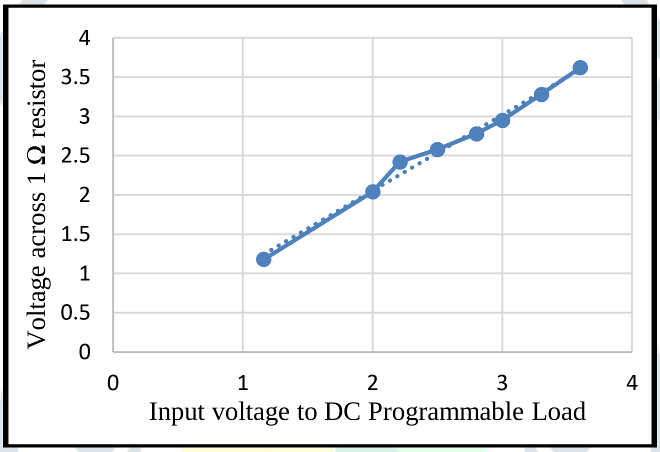

Figure (3). The above graph describes the relationship of variation in voltage across R_{sense} resistor, as a function of changes in input voltage to DC programmable load, for the SMPS operated on 230*V* AC.

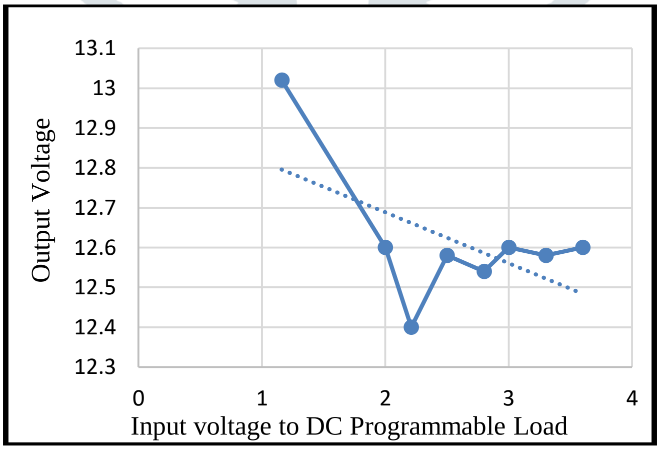

Figure (4). The above graph shows that how the output voltage of the SMPS operated on 110*V* AC input, varies as the function of load change.

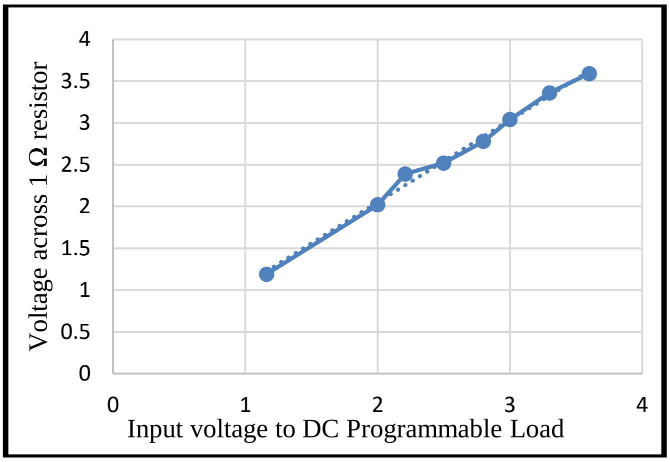

Figure (5). The above graph describes the relationship of variation in voltage across R_{sense} resistor, as a function of changes in input voltage to DC programmable load, for the SMPS operated on 110*V* AC.

IV. RESULTS

The DC programmable load is used for testing of the SMPS, it can be inferred from the figure (2) & (4) that as the SMPS is powered using 230 *V* & 110 *V* AC supply separately, then we observe that there is a sudden overshoot in the output to 13 *V* & 13.02 *V* respectively, further as the input is given to the DC programmable to emulate different loading conditions, the SMPS tries to maintain the output voltage to 12 *V*. The figure (3) & (5) describes that as the load change occurs in the DC Programmable Load, the current supplied by the SMPS powered using 230 *V* & 110 *V* AC supply remains constant within band of 1.90 *A* to 2.08 *A*, as we observe a proportional voltage change across R_{sense} resistor.

V. CONCLUSION

The DC Programmable Load along with the LabVIEW software evaluates and analyses the performance characteristics SMPS based on the variation in the input voltages and the different loading conditions specified for the SMPS.

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