Scientific Journal of Impact Factor (SJIF) : 3.134

ISSN (Print): 2348-6406
ISSN (Online): 2348-4470

International Journal of Advance Engineering and Research Development

An Analysis of a Microcontroller based Variable bench power supply with inbuilt Voltmeter,Ammeter and Timer based autoshutdown

Maitrey Trivedi[1], Elizabeth Jyothi Shajan [2], Dipal patel[3]

1Student, A.D.I.T College, maitreytrivedi@gmail.com
2 Assistant system Engineer, IBM India Limited, jyothi.shajan@gmail.com
3 Trainee Assistant Lecturer, M.B.I.C.T College, dipal042@gmail.com

Abstract: *This paper aims to explain the implications of a variable bench power supply using microcontroller, if implemented in a laboratory. A discussion on the same in a practical scenario has also been discussed, as it was implemented in our college. The aspects discussed are oriented towards ease-of-use, design complexity and market acceptance.*

Keywords- *Microcontroller, Bench power supply, Timer based auto shutdown*

I. INTRODUCTION

Presented here is an economical and cost-effective yet efficient variable bench power Supply that provides one variable and two fixed supply channels. It provides 1.2V to 25VSupply with up to 5-ampere current through one channel, and 5V, 1A and 12V, 1A Supplies through the other two channels. It also displays the voltage on the output terminals, and the current and voltage drawn by the load on an on-board LCD display. The scheme has two sections: the main power module having linear voltage regulator switch rectification and filtering circuitry for supply generation aid regulation, and the other having at microcontroller that is used to sense and display the current and voltage across the variable supply channel.

II. PREFERENCE TO THE VARIABLE BENCH POWER SUPPLY SCHEME

This Microcontroller based variable bench power supply is not the simplest circuit but we assure you that you will not regret the time needed to build it. It is very robust and reliable. You need a lot of parts for this article but those are only cheap standard parts. This power supply is not expensive. But one thing you need to remember as this circuit contains a transformer which is connected to the main power supply (230V or 110Vdependent on your country), Please ensure proper insulation. If you have never worked with power supplies then ask an experienced person to check your circuit with regards to insulation and security before you connect the first time.

The actual schematic using Proteus ISIS is shown below in figure-1. All the symbols used are the standard one which is available in the Proteus ISIS library. The components name and the corresponding rating of the same are specified in both of the circuits. The only thing which must be verified and need to remember is use short only for 2-wire power transformer having the rating below 20V and use open only for 3-wire transformer. The simulation schematic of the system using Proteus ISIS is also shown in figure-2, as the computer cannot handle all models at the same time.

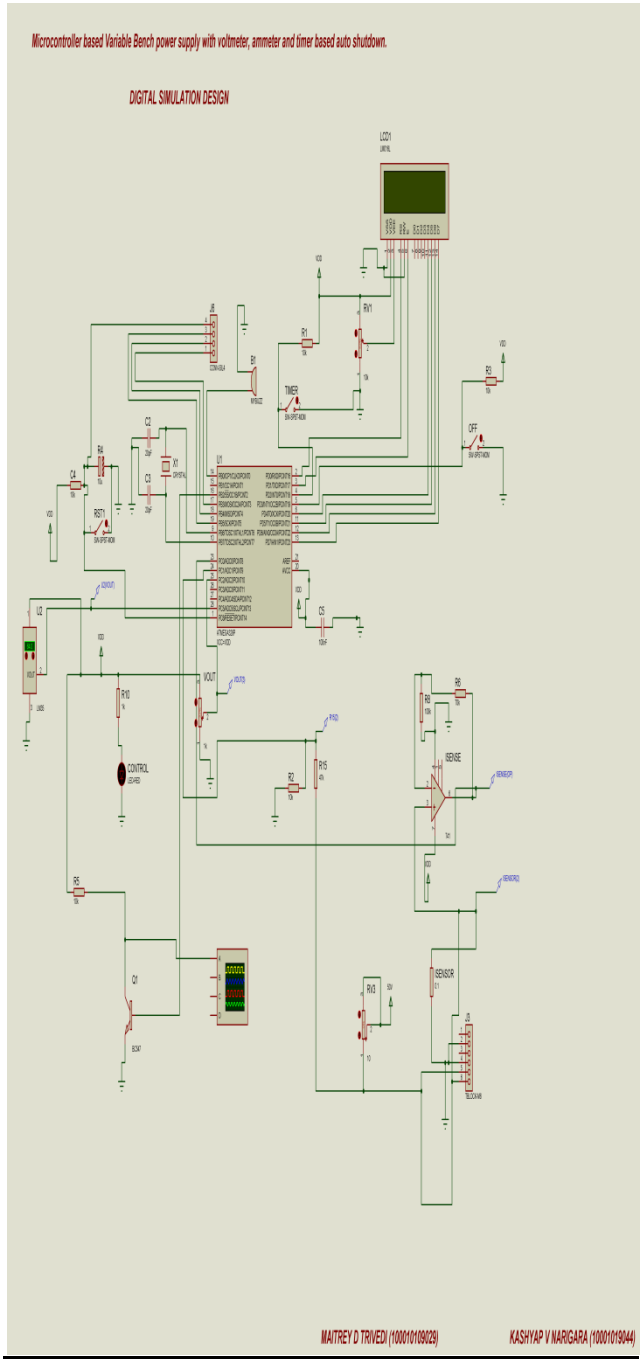

Figure 1-The simulation schematic of the system using Proteus ISIS, as the computer cannot handle all models at the same time.

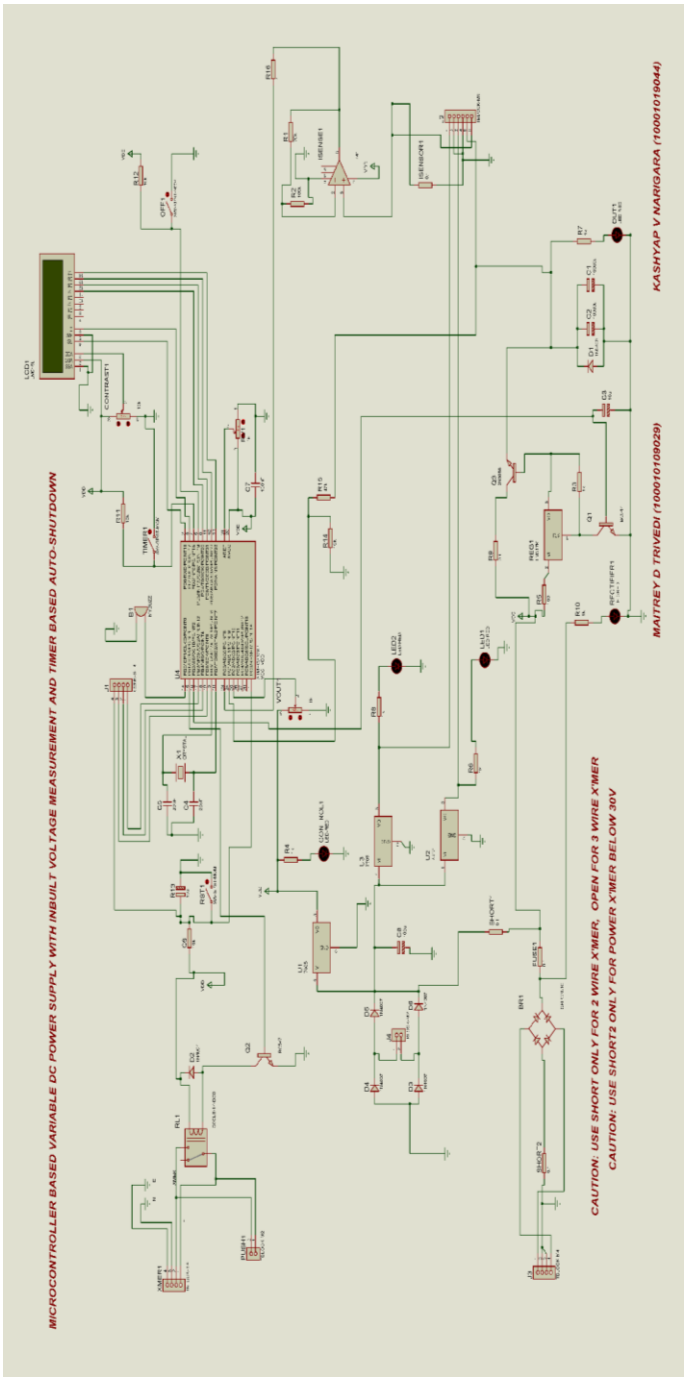

Figure 2- The actual schematic of the whole System made in Proteus ISIS

III. A CASE STUDY

The given system is made up of 4 parts
1. Power section
2. Measurement section
3. Control section
4. Switching section

These blocks define their own purpose as per their name.

1) Power Section

The power section is responsible for the following purposes: 1- To obtain AC power and convert it to DC by rectification. 2- To control the output voltage using a pass element by PWM. The PWM is received from the control section .3- To protect the load in case of control section failure

2) Measurement Section

The measurement section of the system is made up of two voltage divider circuit. The first voltage divider circuit is used to measure the voltage power output section at the load. The second voltage divider is formed by the load and a shunt resistor in series with the load. Thus, the voltage at the shunt resistor being very low and easily detectable by the inbuilt ADC of the Atmega328 microcontroller gives voltage in certain proportion to the current. This can be scaled and displayed on the LCD with the voltage.

3) Control Section

The control section of the system is made up of the Atmega328, the LCD, a potentiometer and special control buttons. The Atmega328 here performs the following functions:1- Generates a PWM signal according to the voltage generated on the potentiometer, which is fed to the ADC.2- It measures the current and voltage using the inputs from the measurement section.3- It keeps record of the time and shuts down system when necessary.4- Gives output on an LCD.5-Controls the relay used to switch the transformer.6.-Give an audio beep for certain events ("e.g." startup of system). The PWM waveform generated at the PWM pin of the microcontroller are given below:

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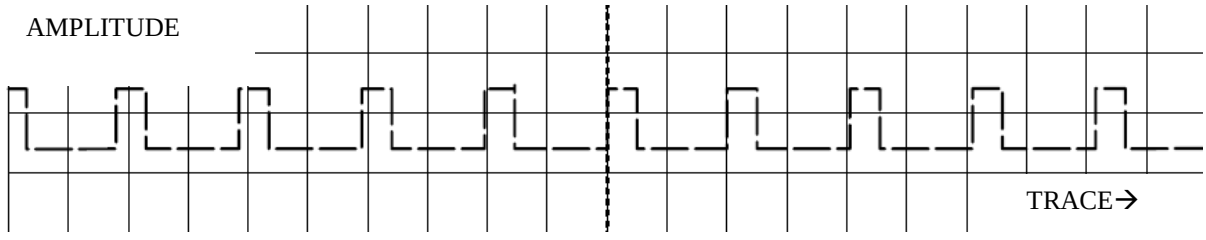

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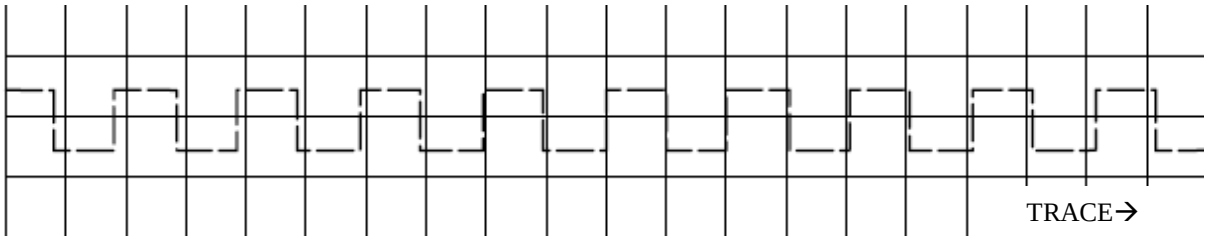

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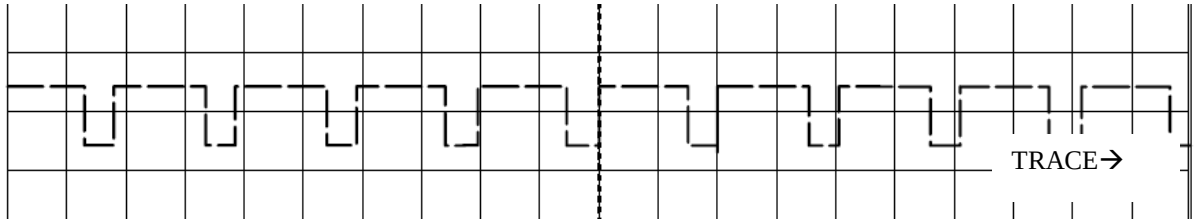

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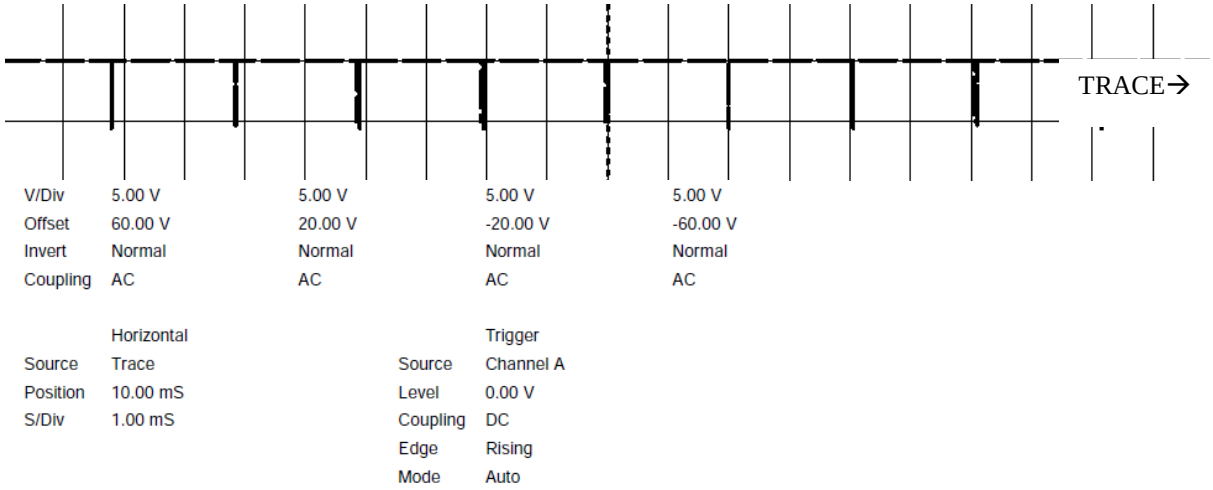


Figure -3 Waveforms for various duty cycles as given along with the figure

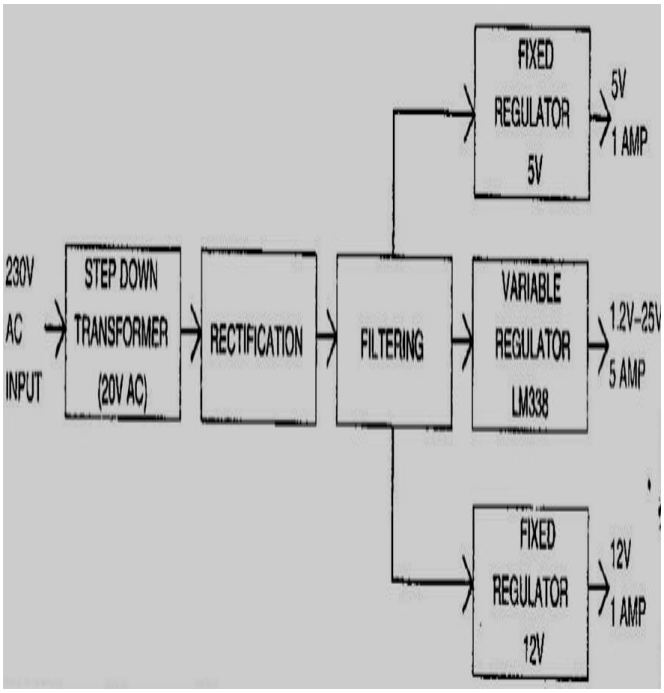
4) Switching section

The switching section consists of a relay, a push button, and a trigger transistor. When the push button is pressed in system 'OFF', the push button provides an alternate Path for the system to activate. Thus, the controller when 'ON', within a matter of milliseconds, keeps the trigger of the transistor high. So, the relay is switched 'ON', and it will now bear the full current required by the transformer. The push button can be released now.

IV. WORKING

This scheme is a replacement for power supplies used in the laboratory. This Power supply has inbuilt digital voltmeter, ammeter and an auto-shutdown feature for power saving. The transformer will convert the voltage to the required level, which will be rectified and applied to regulator IC LM 338. LM 338 is a 5A voltage regulator which can tune the output within the range of 1.25V to 24V. The IC dissipates heat, so will be provided with heat-sink .LM 338 voltage output depends

on the feedback provided to it on the ADJ pin. So, this is controlled by PWM wave generated by 8051 microcontroller, and given to the regulator IC. This will be in turn sensed by the ADC, and the data Will be sent to 8051, so as to give a reading of voltage and current on the LCD. The data obtained from ADC is converted by the controller, and sent to the LCD.



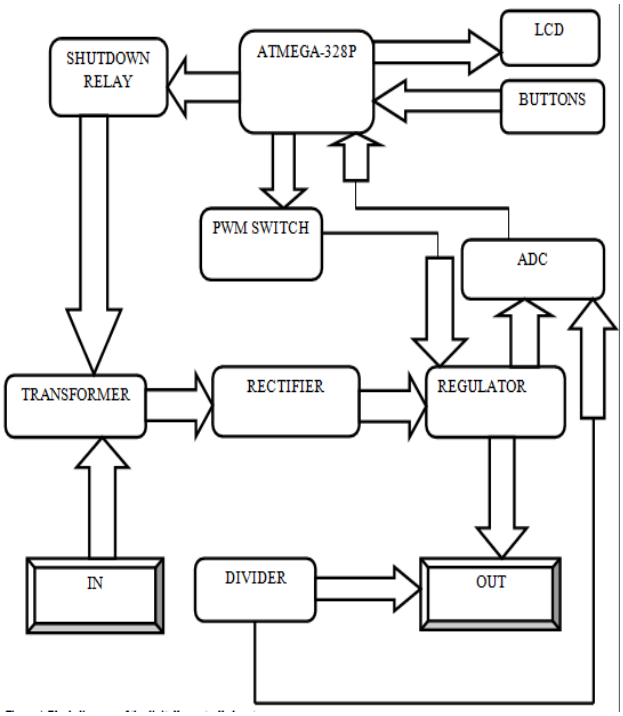


Figure -4 the block diagram in terms of

Multi channel output

Figure 5-Detail block diagram of digitally controlled system

V. ABOUT POWER SUPPLIES IN GENERAL

The basic design model for a power supply consists of a control element in series with a Rectifier and load device. Figure 6 shows a simplified schematic of a series-regulated supply with the phase-controlled pre-regulator depicted as a power switch and the series element detected as a variable resistor. The PWM-controlled pre-regulator minimizes the power dissipated at the series element by maintaining a low and constant voltage drop across the series element. Feedback control Circuits continuously monitor the output and adjust the series resistance to maintain a constant Output voltage. The variable resistance series element of the supply shown in Figure 6 is actually produced by one or more power transistor operating in the linear (class A) mode; Supplies with this type of regulator are often called linear power supplies. Linear power Supplies have many advantages. Because they provide sufficient power with stable regulation and little noise, they usually are the simplest, most effective solution for providing bench power.

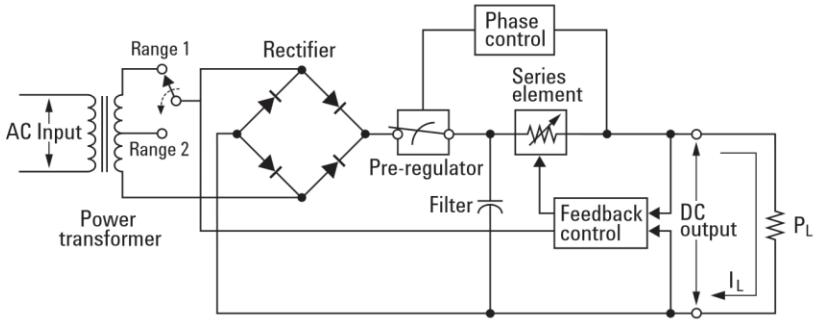


Figure- 6 a generic series element power supply

The power supply shown in Figure 6 has two ranges, allowing more voltage at a lower current or more current at a lower voltage. Single-range supplies can output maximum power only at Full-scale voltages and full-scale current. A linear supply can provide output power that is Close to maximum at full scale for both ranges. The pre-regulator in this power supply uses Solid-state transformer tap switches on the secondary winding of the power transformer. This technique is very effective in reducing the power dissipated in the series element. In terms of performance, a linear regulated supply has very precise regulating properties and responds quickly to variations of the line and load. Hence, its line and load regulation and transient recovery time is superior to supplies using other regulation techniques. A linear Power supply also exhibits low ripple and noise, tolerates ambient temperature changes, and is highly reliable due to its circuit simplicity

VI. MERITS AND DEMERITS

A) MERITS

The power supply described here has the following advantages

1. Fully digital control
2. Inbuilt voltmeter
3. Inbuilt ammeter
4. Timer based auto shutdown for power saving
5. Short circuit protection, no need of fuse replacement
6. Circuit does not need modification for full wave or bridge wave rectification
7. Maximum output rating 24V ,5A
8. Potentiometer for output control
9. LED indication for working of each block for easy diagnosis of a fault

B) DEMRITS

The power supply described here has the following disadvantages:

1. . Cannot work a high DC voltage
2. Cannot work at high frequency due to use of use of power transistor instead of MOSFET
3. Heat dissipation increases with increase in current consumption

VII. APPLICATIONS

1. D.C. variable bench supply (a bench power supply usually refers to a power supply capable of supplying a variety of output voltages useful for bench testing electronic circuits, possibly with continuous variation of the output voltage, or just some preset voltages; a laboratory (lab) power supply normally implies an accurate bench power supply, while a balanced or tracking power supply refers to twin supplies for use when a circuit requires both positive and negative supply rails).
2. Mobile Phone power adaptors
3. Regulated power supplies for embedded systems
4. Various amplifiers and oscillators
5. DC motor speed control
6. Simulation of a lead acid battery (for inverter testing)

VIII. REENGINEERING THE ABOVE SYSTEM

There is a scope for re-engineering the above system in following aspects:

- Use of MOSFET instead of power transistor for high frequency operation, as MOSFET can operate at higher frequency.

- Implementation of communication with PC using RS-232 or USB
- Over temperature shutdown for the supplying transformer.

IX. CONCLUSION

In a nutshell, d.c. Variable bench power supply capable of supplying a variety of output voltages useful for bench testing electronic circuit, possibly with continuous variation of the output voltage, or just some preset voltages, a laboratory (lab) power supply normally implies an accurate bench power supply, while balanced or tracking power supply refers to twin supply for use when a circuit requires both positive and negative supply rails.

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