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Micro Controller Based DPS

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Abstract: The advent of industry [BPO], hospitals, retail outlets and computers and computer controlled equipment entering the rural domain of India has necessitated the requirement of variable power supply for variety of equipment. For meeting this requirement a multipurpose supply source is envisaged. Until now, the digital supply has carried a variety of meanings: one whose parameters or functions are set digitally by external logic signals; or a power supply for a "digital system," like a cell phone; or a power supply providing a digital readout. The greater functionality and new monitoring features of today’s power supply requires more sophisticated control and communications. As complexity and intelligence grow, so does the difficulty of designing power supplies using traditional analog only techniques. In addition, requirements for lower costs, smaller form factors and compressed development cycles continue to escalate, pressing power supply designers as never before. The digital power supplies are proving to be a better and futuristic option over the analog power. The architecture of the microcontroller is out of the preview of this paper. Thus we designed a project “A Digital Power Supply” aimed at solving the practical problems envisaged in the power supply to the rural areas of India. It is a practical application of software for the controlled power supply from a single platform to a varied variety of equipment expected to be used in hospitals, BPOs etc. The software programming has been incorporated using C language and has been kept out of the purview of this presentation as the program itself is a subject of independent presentation. The design has been made incorporating user friendly features and easy usage for the operators.

Key words: DPS (Digital Power Supply) · DAC (Digital to Analog Convertor) · ADC (Analog to Digital Convertor

INTRODUCTION

We prefer a digital power supply control over an analog one for the following reasons.

- Programming flexibility is the key advantage of digital over analog control [1].
- Programmability enables manufacturers to use single control platform in a wide range of power supply products.
- Enhanced control and monitoring capabilities.
- Systems in development can be tuned quickly using software based calibrations.
- rogrammability enables power supply redesigns with more efficient topologies that take advantage of advanced non linear digital control techniques for optimum performance over the complete operating range of the power supply.

Salient Design Features:

The following design features have been incorporated for academic interest of this paper.

- The digital power supply covers a range of -30 to +30 Volts, a resolution of 0.1 volts with dual output.
- The power supply is capable of sourcing 10 Amps of current.
- The model has an LCD display for voltage generated and current drawn.

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- It has a keypad interface for providing inputs for the voltage which needs to be generated.
- The design of power supply has an overload and short circuit protection.
- It has an audio and visual alarm indicator for short circuit and overload.

Design Details: The main features of the basic design are shown in the diagram given above.

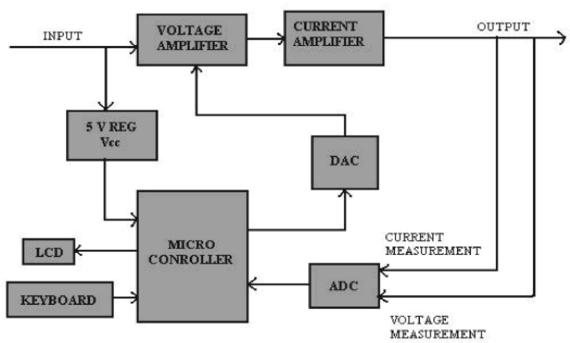

Fig. 1: Basic Design

Basic Functions: The microcontroller is fed with the values of voltage required at the output through the keyboard. The microcontroller gives a digital output to the DA converter which bears a linear relationship to the preset value of voltage. The DA converter produces an analogue voltage for this. Since the output voltage has to be up to 30 volts, the output of DA converter has to be amplified. A pnp & npn transistor combination is used as a voltage amplifier. Since the current O\P of the D\A converter is less and the power supply has to cater for current output of up to 10 Amps, a Darlington pair is used to amplify the current [2-5].

Control Loop: The voltage and current are measured at the output and converted into digital value to be fed to the microcontroller. The microcontroller checks the current for overload. The overload protection is provided here in the software, so it has to be fast to be effective. The output voltage is compared to the preset voltage and the microcontroller adjusts the output of the DA converter accordingly. This constitutes the control loop. The microcontroller has a LCD attached to display the preset as well as the actual voltage and current. The microcontroller also has a buzzer connected to provide the audio alarm in case of overload [6-10].

Major Systems of the Design

D/A Converter: To avoid using a separate DA converted it was easier to use a R2R ladder connected directly to the microcontroller pins as the D\A converter because it is simple, fast and the free of I\O pins of the microcontroller would be effectively utilized. The R2R ladder has only two types of resistors. One with value R and one with twice the value of R. A 3 bit R2R D\A converter is shown in the diagram. The control logic moves the switches between ground and V_{cc}. A digital "1"connects the switch to V_{cc} and a digital "0"connects it to the ground thus creating an analogue step signal. This circuit provides voltage in steps of Vcc\8. The inner resistance of the circuit as seen from the output is R. Instead of using separate switches we can connect the R2R ladder to the microcontroller output lines. Since the voltage output has to be in steps of 0.1 volts, a total of 300 steps are required for 0-30 volts range. 8 bit DA converter would give only 256 steps for control. A 10 bit resolution was decided upon, so as to effectively utilize the resolution of inbuilt AD converter of PIC microcontroller [11-15].

Voltage Amplifier: Since maximum output of the D\A converter would be 5volts, for 30 V output we must at least amplify it by a factor of 6. For this we combine a PNP and an NPN transistor. A combination of 1Kand 5.6K gives a factor of 6.6 which is good for 30 Volts

Darlington Pair: To amplify the current we use a configuration known as the Darlington transistor. For this two transistors are used, BD137 transistor is kept in front. It has an h_{fe} value of 50-100. This will reduce the current needed to less than 3mA which is manageable with small signal transistors. To have output of 10 Amps we put transistor BD245B in parallel.

A/D Converter: The PIC microcontroller has inbuilt A\D converters. The PIC18f452 microcontroller has a 10 bit, 8 channels A\D converter. One channel will be used for current and one for voltage. Since this microcontroller can measure only up to 5 volts the output voltage has to be dropped across a potential divider and then fed to the A\D converter. For current measurements, since the A\D converter does not measure current, it has to be measured indirectly by measuring the drop across a shunt. The shunt has to have a value of 0.5 ohms, so that at maximum current the drop across the shunt is 5 volts i.e. internal reference voltage of the A\D converter.

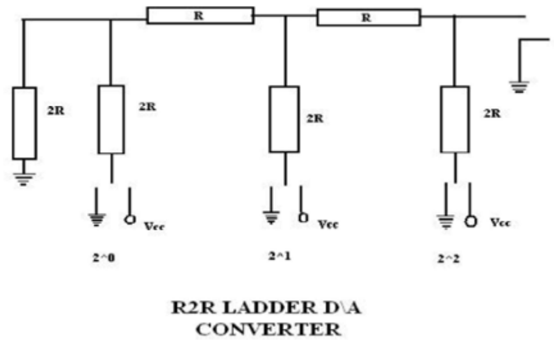

Fig. 2: R-2R Ladder D\A Converter

Keyboard and LCD: 1. 4*3 keyboard; for entering the voltage and current values. 2 16*2 LCD; for displaying voltage and current values.

Transformer, Rectifier and Filter: It uses a 230 V to 280 V step down transformer with current rating of 10 A. Bridge rectifier is used for rectification and 15000 F electrolytic, 45 V capacitor is used as a filter. This circuit provides rectified and filtered 30 Volts DC supply from 230 Volts AC mains. Both the transformer and the rectifier have a current rating of 10 A or more

Microcontroller: The microcontroller is selected according to total I\O pins required for the power supply.

D\A converter	10 pins
A\D converter	02 pins
LCD	08 pins
Keyboard	07 pin
Buzzer	01 pins
Total	28 pins

The best microcontroller for this purpose is a PIC18f452 in 40 pins package because it has total of 30 pins and has a 10 bits, 8 channel A/D converter.

Flowchart: The entire functionality of this power supply lies in the software programming of the microcontroller. The strengths of the design lie in the fact that the hardware functionality has been replaced by the software.

The Explanation for the Flowchart is Given Below:

- On switching on, the power supply would prompt the user to enter the output voltage required. This voltage would be displayed on the LCD and st1ored in the RAM as a variable. This voltage will from now on be referred to as preset voltage. Since this voltage may fall in the range of 0-30 Volts, it is divided by six, since the output of the DA converter can vary only from 0-5 Volts. After this, it is the job of the voltage

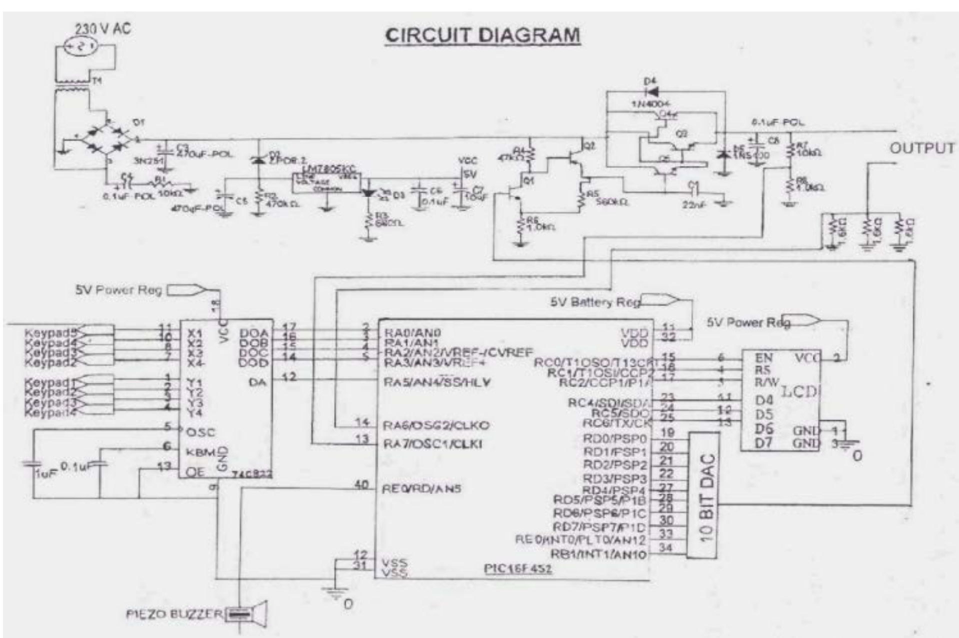

Figure 3:-Final circuit diagram of the Digital Power Supply

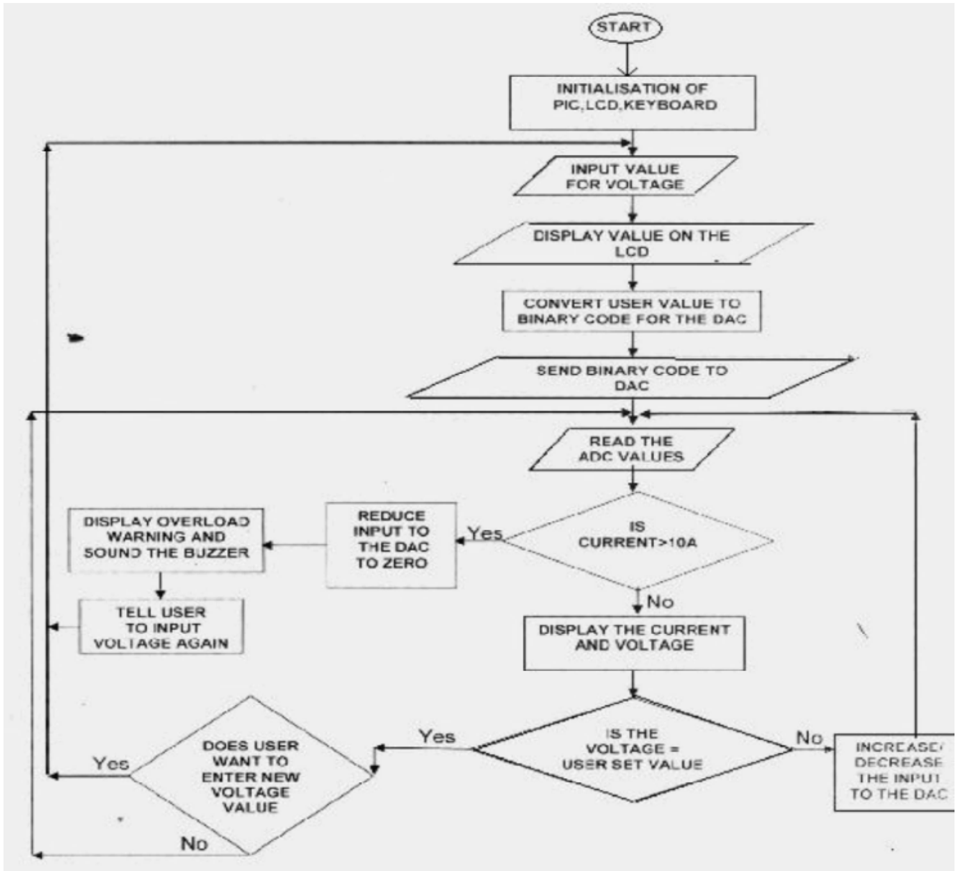

Fig. 4: Flow chart for the Digital power supply working

and current amplifier circuits in the hardware portion of the power supply to amplify it six times and give it to the output.

- Next portion of the software would deal with implementing the control loop. The output current would be read indirectly by reading the voltage drop across the shunt. This voltage would be divided by the shunt resistance, to get the current value.
- If the current value is greater than 10 Amps, then "0"will be fed to the DA converter to immediately reduce the output voltage to a very low value and simultaneously "1"would be output to the pin on which the buzzer is connected. The message " Current overload" would be flashed on the LCD and the program would go back to the instruction where the user enters the voltage after the user responds by entering a new value for voltage, "0" would be output to the pin on which the buzzer is connected.
- If the current is below 10 Amps, then the voltage is read from the second AD converter channel. This voltage is the potential drop across the voltage divider. Total output voltage is calculated from this and then the drop across shunt is subtracted from it to get the actual voltage across the load. This voltage is then compared with the preset voltage and if the voltage is less then the output to the DA converter is decremented. Since this control loop is executed many thousands of times a second the output voltage will become equal to the preset voltage very quickly.

CONCLUSION

The project paper is aimed at solving the practical problems envisaged in the power supply to the rural areas of India. It is a practical application of software for the controlled power supply from a single platform to a varied variety of equipment expected to be used in hospitals, BPOs etc. The software programming has been incorporated using C language and has been kept out of the purview of this presentation as the program itself is a subject of independent presentation. The design has been made incorporating user friendly features and easy usage for the operators.

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