Design And Construction Of The Pic Microcontroller Based Dc Voltage Selector Switch

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ABSTRACT

A voltage regulator with only three terminals appears to be a simple device, but it is in fact a very complex integrated circuit. It converts a varying input voltage into a constant 'regulated' output voltage. This DC voltage selector switch circuit is available in a variety of outputs like 3V, 5V, 6V, and 9V. This circuit is mainly based on an adjustable voltage regulator IC LM317, and PIC microcontroller IC 16F84A. The output voltage of a regulator circuit can be increased by using a pair of 'voltage-divider' resistors.

Keywords_ PIC 16F84A, microcontroller, a variable voltage regulator LM317, a fixed voltage regulator IC LM7805, four transistor switches, four relay switches and a multiplex seven segment LEDs display

1. INTRODUCTION

The main stream of this paper is to study microcontroller based DC Voltage selector switch using the microcontroller. This circuit uses PIC microcontroller PIC 16F84A, adjustable voltage regulator IC LM 317 and four relays switches and multiplex seven-segment LEDs display. The LM 317 is a complete regulator having internal feedback, regulating and current passing elements and incorporating various types of protection circuits such as current limit (which limits short circuit current to about 2.2 amps.), safe area protection (which limits package power dissipation to 15 W for the TO - 220 package and 20 W for the TO-3 package), and thermal shutdown (to limit junction temperature I_t to about 150 ºC. The LM 317 IC is designed to supply more than 1.5A of load current with an output voltage adjustable over a 1.2 to 37V. The nominal output voltage is selected by means of only a resistive divider, making the device exceptionally easy to use and eliminating the stocking of many fixed voltage regulators. The relay switches are operated via four NPN transistors which are directly driven by the digital input signal. These digital input signal is obtained from PORTB of PIC microcontroller IC 16F84A. For obtaining the accurate voltage in the selected range, a common variable resistor is provided in the circuit.

The only chip used is a Microchip's PIC 16F84A running at 4 MHz crystal. The source code is written in MPASM (Microchip's Processor Assembler). As it is highly optimized for code space, most of the code could not be written a modular format. For the same reason, a lot of subroutines have more than one entry point and some of them are terminated by a GOTO instruction instead of using a RETURN instruction. This circuit is mainly based on PIC 16F84A microcontroller, and adjustable voltage regulator IC LM 317. The block diagram for this construction is shown in Figure 1.

Figure 1.Block diagram of the PIC microcontroller based DC voltage selector switch system.

2. BACKGROUND THEORY

2.1 Power Supply

A power supply is an electrical device that supplies electric power to an electrical load. The primary function of a power supply is to convert electric current from a source to the correct voltage, current, and frequency to power the load. As a result, power supplies are sometimes referred to as electric power converters. Some power supplies are separate standalone pieces of equipment, while others are built into the load appliances that they power. Examples of the latter include power supplies found in desktop computers and consumer electronics devices. Other functions that power supplies may perform include limiting the current drawn by the load to safe levels, shutting off the current in the event of an electrical fault, power conditioning to prevent electronic noise or voltage surges on the input from reaching the load, power-factor correction, and storing energy so it can continue to power the load in the event of a temporary interruption in the source power.

All power supplies have a power input connection, which receives energy in the form of electric current from a source, and one or more power output connections that deliver current to the load. The source power may come from the electric power grid, such as an electrical outlet, energy storage devices such as batteries or fuel cells, generators or alternators, solar power converters, or another power supply. The input and output are usually hardwired circuit connections, though some power supplies employ wireless energy transfer to power their loads without wired connections. Some power supplies have other types of inputs and outputs as well, for functions such as external monitoring and control.

The basic power supply unit has four main stages, illustrated in Fig.2.

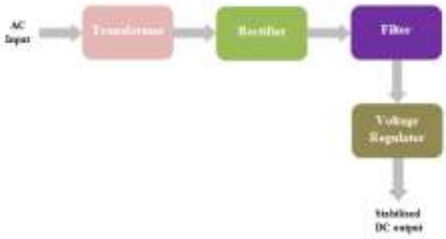

Figure 2 Power Supply Block Diagram.

2.1.1 IC Voltage Regulator

A voltage regulator is one of the most widely used electronic circuitry in any device. A regulated voltage (without fluctuations and noise levels) is very important for the smooth functioning of many digital electronic devices. A common case is with micro controllers, where a smooth regulated input voltage must be supplied for the micro controller to function smoothly.

An IC based voltage regulator can be classified in different ways. A common type of classification is 3 terminal voltage regulator and 5 or multi terminal voltage regulator. Another popular way of classifying IC voltage regulators is by identifying them as linear voltage regulator and switching voltage regulator. There is a third set of classification as

1. Fixed voltage regulators (positive & negative)

2. Adjustable voltage regulators (positive & negative) and

3. Switching regulators. In the third classification, fixed and adjustable regulators are basically versions of linear voltage regulators.

Block diagram of three terminal IC based voltage regulator is shown in Figure 3.

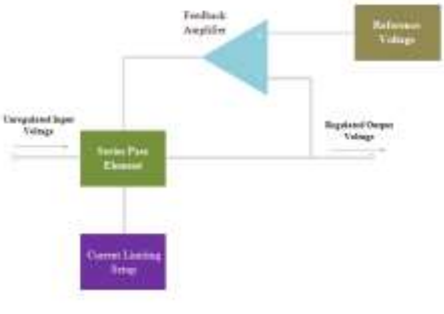

Figure 3 Block Diagram of a Three Terminal IC Voltage Regulator

2.1.2 Adjustable Voltage Regulator

An adjustable voltage regulator is a kind of regulator whose regulated output voltage can be varied over a range. There are two variations of the same; known as positive adjustable voltage regulator and negative adjustable regulator. LM317 is a classic example of positive adjustable voltage regulator, whose output voltage can be varied over a range of 1.2 volts to 37 volts. LM337 is an example of negative adjustable voltage regulator. LM337 is actually a complement of LM317 which are similar in operation and design; with the only difference being polarity of regulated output voltage. Adjustable voltage regulator using LM 317 is shown in Figure 4.

The resistors R1 and R2 determine the output voltage V_{out}. The resistor R2 is adjusted to get the output voltage range between 1.2 volts to 37 volts. The output voltage that is required can be calculated using the equation:

$$V_{out} = V_{ref}\,(1+R_2/R_1) + I_{adj}\,R_2$$

In this circuit, the value of V_{ref} is the reference voltage between the adjustment terminals and the output taken as 1.25 Volt. The value of I_{adj} will be very small and will also have a constant value. Thus the above equation can be rewritten as

$$V_{out} = 1.25\,(1+R_2/R_1)$$

The load regulation is 0.1 percent while the line regulation is 0.01 percent per volt. This means that the output voltage varies only 0.01 percent for each volt of input voltage. The ripple rejection is 80 db, equivalent to 10,000.

The LM 337 series of adjustable voltage regulators is a complement to the LM 317 series devices. The negative adjustable voltage regulators are available in the same voltage and current options as the LM 317 devices.

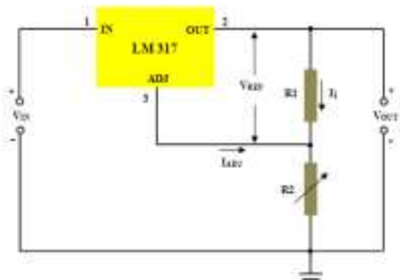

Figure 4 Adjustable voltage regulator using LM317.

2.2 Interfacing an Electromagnetic Relay with PIC Microcontroller

A relay is an electromagnetic switch which is used to switch high voltage/current using low power circuits. Relays isolate as well low power circuits from high power circuits, this is a good feature especially for safety reasons a section of the circuit with high dangerous voltage/current could be isolated from the user. When a low voltage is applied to the relay (coil wounded on a soft ion core), this coil becomes a magnet which in turns energizes the soft ion core which closes or open the high voltage/current contacts of the relay. Electromagnetic relays use an electromagnet to operate a switching mechanism mechanically. A rely can be used to switch higher power devices such as motors, light bulbs and solenoids. A relay should not be connected directly to a microcontroller due to following reasons:

- A microcontroller is not able to supply current required for the working of a relay. The maximum current that a PIC microcontroller can source or sink is 25mA while a relay needs about 50-100mA current.
- A relay is activated by energizing its coil. Microcontroller may stop working by the negative voltages produced in the relay due to its back e m f.

A relay can be easily interfaced with microcontroller using a transistor as shown in figure 5. Transistor is wired as a switch which carries the current required for operation of the relay. When the pin RB7 of the PIC microcontroller goes high, the transistor 2SC1815 turns on and current flows through the relay. The diode D1 is used to protect transistor and the microcontroller from Back EMF generated in the relays coil. Normally 1N4148 is preferred as it is a fast switching diode having a peak forward current of 450mA. This diode is also known as freewheeling diode.

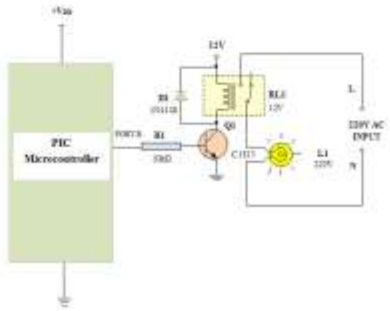

Figure 5 A relay interfaces with PIC microcontroller.

2.3 PIC Microcontroller IC 16F84A

The PIC 16F84A is one of the most popular PIC microcontrollers used in many commercial industrial and hobby applications. This is an 18 pin device which can operate at up 20MHz clock speed. It offers 1024 x 14 flash program memories. 68 bytes of RAM data memory. 64 bytes of EEPROM nonvolatile data memory, 8-bit timer with pre - scalar, watchdog timer, 13 I/O pins, external and internal interrupt sources, and large current sink and source capability.

Figure 6 shows the pin configuration of the PIC 16F84A.

Figure 6.Pin connection diagram of a PIC 16F84A.

3. Design and Construction

3.1 Hardware Design

Figure 7 shows the complete circuit diagram microcontroller based DC Voltage selector switch circuit. The PIC 16F84A microcontroller is configured as PORTB as outputs and PORTA as inputs. The 4MHz crystal oscillator is used to execute the program. Push button switches SW_1 through SW4 are used to select the output voltage of the variable fixed voltage regulator and SW5 is all output voltage disable switch.

AC mains 220 V AC is down converted to 15V AC by the step-down transformer T1, the secondary winding of which can support a current of 1amperes. A bridge rectifier converts the AC to pulsating DC with a peak voltage level of 21V. The output from bridge rectifier is smoothed by 1000 µF capacitor C1.

The LM317T series of adjustable 3-terminal positive voltage regulator is used at the output of rectifier section. It is capable of supplying in excess of 1.5A over a 1.2 V to 37 V output voltage range. However, in this research work it has been used to supply discrete voltage of 3 V, 5 V, 6 V and 9 V with the help of four relay switches RL1 through RL4, which bring in different value resistors between adjust pin of the LM317T regulator and ground, while the resistor R_2 (between Adj. pin and output pin) is a fixed 220 Ω resistor. The output voltage V_0 is given by the relation:

$$V_O = 1.25\,(1+ R_x / R_{15})$$

Where R_x is the resistance connected between adj. pin of regulator and ground.

In 12 V position of the switch (off position), the value of $R_x = R_{16} + R_{17} = 1900\ \Omega$, while the various other positions it is the equivalent of 1900 Ω in shunt with another resistance shown in circuit.

When the voltage selector switch, SW1 is pressed, the high-to- low voltage transition at RA_0 input (pin 17) of PIC 16F84A microcontroller IC produces high level voltage at RB_0 output (pin 6) . This high level voltage is applied to the base of transistor Q_1 via resistor R_8 (10KΩ). Transistor Q_1 is turns on condition and relay RL1 is energized state. Consequently, corresponding output voltage (+3 V) is received from pin 2 output of LM317 voltage regulator IC. In this condition, Transistor Q_2, Q_3, and Q_4 are cutoff and corresponding output voltage is not available. Under these conditions 3 V indicator, LED 1 starts glowing to indicate that 3 V output.

When the voltage selector switch, SW2 is pressed, the high-to- low voltage transition at RA_1 input (pin 18) of PIC 16F84A microcontroller IC produces high level voltage at RB_1 output (pin 7) . This high level voltage is applied to the base of transistor Q_2 via resistor R_{10} (10KΩ). Transistor Q_2 is turns on condition and relay RL2 is energized state. Consequently, corresponding output voltage (+ 5 V) is received from pin 2 output of LM317 voltage regulator IC. In this condition, Transistor Q_1, Q_3, and Q_4 are cutoff and corresponding output voltage is not available. Under these conditions, +5V indicator, LED 2 starts glowing to indicate that + 5V output. Similarly, + 6 V, + 9 V can be selected by using SW 3 and SW 4. Output data measurements of this construction are shown in Table 1.

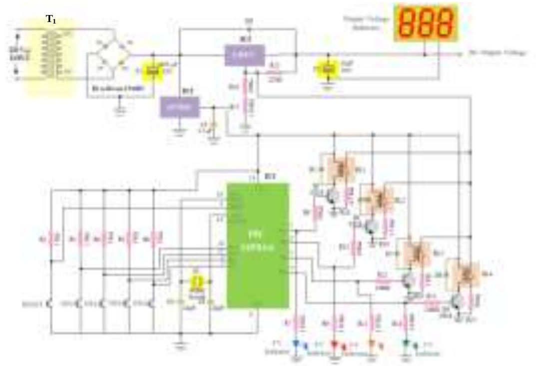

Figure 7 Schematic diagram of the PIC microcontroller based DC voltage selector switch

Table 1 Output data measurements of the PIC microcontroller based DC voltage selector switch

- Output voltage + 3 V condition

Input condition				Output condition				Transistor on/off condition				Relay on/off condition				Output voltage condition			
RA_1	RA_2	RA_3	RA_4	RB_1	RB_2	RB_3	RB_4	Q_1	Q_2	Q_3	Q_4	RL_1	RL_2	RL_3	RL_4	+3V	+5V	+6V	+9V
High to Low	High 4.89 V	High 4.89 V	High 4.89 V	High 4.88 V	Low 0V	Low 0 V	Low 0 V	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF

Voltage Indicator			
LED 1	LED 2	LED 3	LED 4
ON	OFF	OFF	OFF

- Output voltage + 5 V condition

Input condition				Output condition				Transistor on/off condition				Relay on/off condition				Output voltage condition			
RA_1	RA_2	RA_3	RA_4	RB_1	RB_2	RB_3	RB_4	Q_1	Q_2	Q_3	Q_4	RL_1	RL_2	RL_3	RL_4	+3V	+5V	+6V	+9V
High 4.89 V	High to Low	High 4.89 V	High 4.89 V	Low 0 V	High 4.88 V	Low 0 V	Low 0 V	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF

Voltage Indicator			
LED 1	LED 2	LED 3	LED 4
OFF	ON	OFF	OFF

- Output voltage + 6 V condition

Input condition				Output condition				Transistor on/off condition				Relay on/off condition				Output voltage condition			
RA_1	RA_2	RA_3	RA_4	RB_1	RB_2	RB_3	RB_4	Q_1	Q_2	Q_3	Q_4	RL_1	RL_2	RL_3	RL_4	+3V	+5V	+6V	+9V
High 4.89 V	High 4.89 V	High to Low	High 4.89 V	Low 0 V	Low 0 V	High 4.88 V	Low 0 V	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF

Voltage Indicator			
LED 1	LED 2	LED 3	LED 4
OFF	OFF	ON	OFF

- Output voltage + 9 V condition

Input condition				Output condition				Transistor on/off condition				Relay on/off condition				Motor on/off condition			
RA_1	RA_2	RA_3	RA_4	RB_1	RB_2	RB_3	RB_4	Q_1	Q_2	Q_3	Q_4	RL_1	RL_2	RL_3	RL_4	Motor 1	Motor 2	Motor 3	Motor 4
High 4.89 V	High 4.89 V	High 4.89 V	High to Low	Low 0 V	Low 0V	Low 0 V	High 4.88 V	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON

Motor Indicator			
LED 1	LED 2	LED 3	LED 4
OFF	OFF	OFF	ON

3.2 Software Design

The program flow chart of the proposed PIC microcontroller based DC voltage selector switch circuit has been shown in **Figure 8** which explains the whole software design procedures. The program listing (source code) for the PIC microcontroller based DC voltage selector switch circuit is mention in Appendix A. The program is written in Assembly language in the notepad and then saved with the file extension **.asm**. This program is converted into machine code (HEX code) by using MPASM assembler. After converting the HEX code, MPLAB simulation is essentially needed to execute properly for the source code.

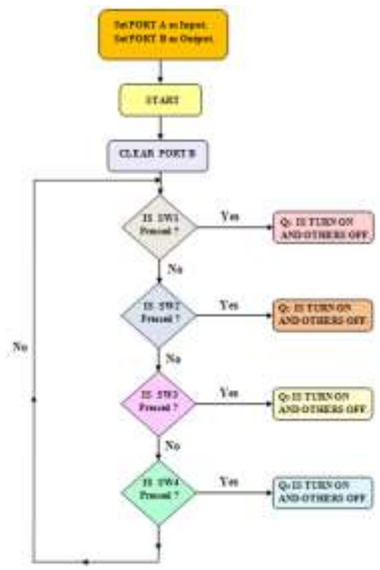

Figure 8 The flow chat for voltage selector switches.

The window of simulation on program execution is shown in Figure 9. If the program has compiled without any errors then MPLAB will return with a message Build Succeeded as indicated in Figure 10 .When the Program is succeed, the HEX code is downloaded into the MCU by the use of Programmer Circuit. DC voltage selector switch is described in APPENDIX A.

Figure 9 Window of simulation on program execution.

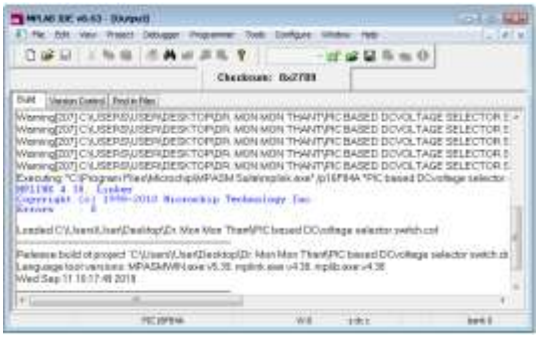

Figure 10 Build Succeeded

4. DISCUSSION AND CONCLUSION

In this research report, the PIC microcontroller based DC voltage selector switch circuit is mainly based on midrange PIC microcontroller IC 16F84A. The program memory word used for the DC voltage selector switch circuit is 1023. The higher version of PIC microcontroller such as 16F628A can also be used by changing the file registers.

Many PIC microcontroller embedded designs will benefit from their low cost and minimize the number of components. Consequently, the system consumes very small amount of power from the source compared to the system using with a few amounts of conventional logic gate ICs.

The constructed PIC microcontroller based DC voltage selector switch circuit can be used to control the power feed to lamps, heater, fan, motors and other electrical appliance. In conclusion, the constructed DC voltage selector switch circuit meets the requirements satisfactorily for use in laboratory and others experimental fields.

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APPENDIX A

Program listing

```
;PIC microcontroller based DC voltage selector
switch.asm
;Dr.Mon Mon Thant,Lecturer,Department Of
Physics,Technological University,Hmawbi
;PORTA as inputs and PORTB as outputs
;Using 4MHz crystal
       List p=16F84A,R=DEC
       __CONFIG H'3FF1'
       ERRORLEVEL -302
       TMR0 EQU 1
       ZEROBIT EQU 2
       PORTA EQU 5
       PORTB EQU 6
       STATUS EQU 3
       TRISA EQU 85H
       TRISB EQU 86H
       SWITCH EQU 7
       ORG 0x00
       GOTO MAIN
       ORG 0x04
MAIN   BSF STATUS,5
       MOVLW B'00001111'
       MOVWF TRISA
       MOVLW B'11110000'
       MOVWF TRISB
       BCF STATUS,5
       CLRF PORTB
LOOP    BTFSS PORTA,0
       GOTO SW1
       BTFSS PORTA,1
       GOTO SW2
       BTFSS PORTA,2
       GOTO SW3
       BTFSS  PORTA,3
       GOTO   SW4
       GOTO   LOOP
SW1    CLRF PORTB
       BSF PORTB,0
       CALL DELAY
SW2    CLRF PORTB
       BSF PORTB,1
       CALL DELAY
SW3    CLRF PORTB
       BSF PORTB,2
       CALL DELAY
SW4    CLRF PORTB
       BSF PORTB,3
       CALL DELAY
DELAY  CLRF TMR0
LOOPA  MOVF TMR0,W
       SUBLW .8
       GOTO LOOPA
       RETLW 0x00
       END
```