Implementation of 15-Step Digital Power Supply for Utilities

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***Abstract*—Power supply is a device that supplies electric power to an electrical load. A regulated power supply is one that controls the output voltage or current to a specific value the controlled value is held nearly constant despite variations in either load current or the voltage supplied by the power supply's energy source. A power supply may be implemented as a discrete, stand-alone device or as an integral device that is hardwired to its load which include the low voltage DC power supplies that supplies power to parts desktop computers and consumer electronics devices for example, dc inverters(dc15v), chargers(dc13v,15v), keyboard(dc15v), mouse(dc15v), all battery powered applications. The 15-step digital power supply is a circuit to obtain a variable dc voltage in reasonably small steps. This circuit mainly consists of four integrated chips(IC).The operation of the circuit mainly depends upon the operation of four IC's. Those are a Schmitt trigger, a binary up-down counter, a voltage regulator and a decoder. The output voltage in this circuit is divided among the bridge fashionably arranged resistors. The output can be taken across resistors in steps varying from minimum to maximum.**

***Index Terms*—digital power supply, schmitt trigger, binary Up-down counter, voltage regulator, decoder**

I. Introduction

Today in the world the integrated chip size is drastically reduced. As the size is reduced the voltage, current and power specifications are also changing day by day. So we either use a single power supply or different power supplies to meet the voltage requirements of various devices. Power supply is a device which converts available power of one set of characteristics to another set of characteristics to meet specified requirements. Conventional series regulated linear supplies maintain a constant voltage by dissipating excess power in ohmic losses. The linear regulator therefore, tends to be very efficient. So if we use a variable voltage supply we can feed any device.

Nowadays the voltage and current specifications of various devices are changing day by day. In latest trends the size of electrical equipments and also integrated chips sizes also decreasing day by day. So the voltage, current, power specifications are also changing day by day. Especially the voltage requirements are drastically changing. So in order to meet the latest trends we should have variable power supply by which we can obtain variable voltage to feed any device. In this paper a device is designed to obtain the variable voltage in 15-steps, meet the requirements of various devices and provide better flexibility.

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II. Power Supply Module

A power supply [1] is a device that supplies electrical energy to one or more electric loads. The term is most commonly applied to devices that convert one form of electrical energy to another, though it may also refer to devices that convert another form of energy (e.g., mechanical, chemical, solar) to electrical energy. A regulated power supply is one that controls the output voltage or current to a specific value; the controlled value is held nearly constant despite variations in either load current or the voltage supplied by the power supply's energy source.

A. Linear Regulated Power Supply (LRPS)

The voltage produced by an unregulated power supply will vary depending on the load and on variations in the AC supply voltage. For critical electronics applications a linear regulator may be used to set the voltage to a precise value, stabilized against fluctuations in input voltage and load.

B. Switched Mode Power Supply (SMPS)

A switched-mode power supply (SMPS) works on a different principle. AC input, usually at mains voltage, is rectified without the use of a mains transformer, to obtain a DC voltage. This voltage is then switched on and off at a high speed by electronic switching circuitry, which may then pass through a high-frequency, hence small, light, and cheap, transformer or inductor. The duty cycle of the output square wave increases as power output requirements increase. Switched-mode power supplies are always regulated. If the SMPS uses a properly-insulated high-frequency transformer, the output will be electrically isolated from the mains, essential for safety.

C. Programmable Power Supply

Programmable power supplies allow for remote control of the output voltage through an analog input signal or a

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computer interface such as RS232 or GPIB. Variable properties include voltage, current, and frequency (for AC output units). These supplies [2] are composed of a processor, voltage/current programming circuits, current shunt, and voltage/current read-back circuits.

III. 15-Step Digital Power Supply

A. Circuit Description

Here is a simple circuit to obtain variable DC voltage from 1.25V to 15.19V [3] in reasonably small steps as shown in the table. The input voltage may lie anywhere between 20Vand 35V. The first section of the circuit comprises a digital up-down counter built around IC1— a quad 2-input NAND Schmitt trigger (4093) [4], followed by IC2— a binary up-down counter (4029). Two gates of IC 4093 are used to generate up-down logic using push but-tons S1 and S2, respectively, while the other two gates form an oscillator to provide clock pulses to IC2 (4029). The frequency of oscillations can be varied by changing the value of capacitor C1 or preset VR1. IC2 receives clock pulses from the oscillator and produces a sequential binary output.

As long as its pin 5 is low, the counter continues to count at the rising edge of each clock pulse, but stops counting as soon as its pin 5 is brought to logic 1. Logic 1 at pin 10 makes the counter to count upwards, while logic 0 makes it count downwards. Therefore the counter counts up by closing switch S1 and counts down by closing switch S2. The output of counter IC2 is used to realize a digitally variable resistor. This section consists of four N/O reed relays that need just about 5mA current for their operation. The switching action is performed using BC548 transistors. External resistors are connected in parallel with the reed relay contacts. If particular relay contacts are opened by the control input at the base of a transistor, the corresponding resistor across the relay contacts gets connected to the circuit.

The table shows the theoretical out-put for various digital input combinations. The measured output is nearly equal to the theoretically calculated output across IC3 (LM317). The output volt-age is governed by the following relation-ship as long as the input-to-output differential is greater than or equal to 2.5V: Vout = 1.25(1+R2'/R1') Where, R1' = R15 = 270 ohms (fixed) and R2' = R11 + R12 + R13 + R14 = 220 + 470 + 820 +1500 ohms = 3,010 ohms (with all relays energized) One can use either the binary weighted LED display as indicated by LED1 through LED4 in the circuit or a 74LS154 IC in conjunction with LED5 through LED20 to indicate one of the 16 selected voltage steps of Table I.

B. Circuit Operation

When the power is switched on, IC2 resets itself, and hence the output at pins 6, 11, 14, and 12 is equivalent to binary zero, i.e. ‘0000’. The corresponding DC output of the circuit is minimum (1.25V). As count-up switch S1 is pressed, the binary count of IC2 increases and the output starts increasing too. At the highest count output of 1111, the output volt-age is 15.19V (assuming the in-circuit resistance of preset VR2 as zero). Preset

VR2 can be used for trimming the output voltage as desired. To decrease the out-put voltage within the range of 1.25V to 15.2V, count-down switch S2 is to be pressed. Note.1. When relay contacts across a particular resistor are opened, the cor-responding LED glows. 2. The output voltages are shown assuming the in-circuit resistance of preset VR2 as zero. Thus when the in-circuit resistance of preset VR2 is not zero, the output voltage will be higher than that indicated here.

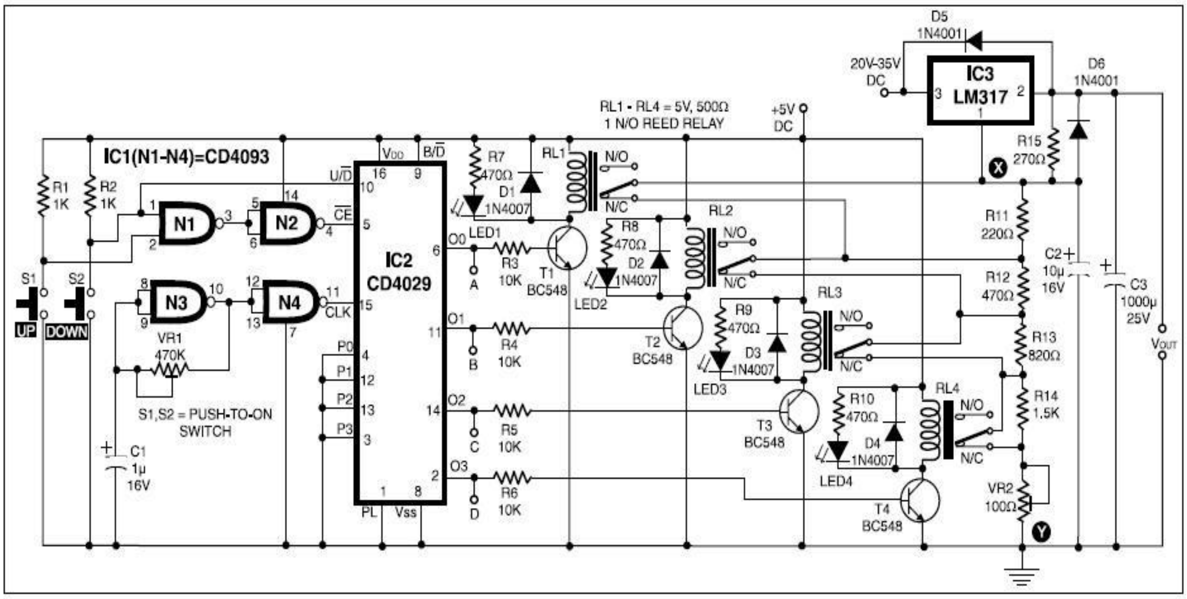

Figure 1. 15 Step digital supply

IV. 15-Step Power Supply Hardware Iplementation (Description of Components)

The 15-Step Variable voltage Digital Power supply[5] [6][7]uses the following main components.

A. Schmitt Trigger (Cd4093)

The CD4093B consists of four Schmitt-trigger circuits. Each circuit functions as a 2-input NAND gate with Schmitt-trigger action on both inputs. The gate switches at different points for positive and negative-going signals. The difference between the positive (VTa) and the negative voltage (VTb) is defined as hysteresis voltage (VH). All outputs have equal source and sink currents and conform to standard B-series output drive

B. Up-Down Counter (Cd4029)

The 4029 is a synchronous counter so its outputs change precisely together on each clock pulse. This is helpful if you need to connect the outputs to logic gates because it avoids the glitches which occur with ripple counters. The count occurs as the clock input becomes high (on the rising-edge). The up/down input determines the direction of counting: high for up, low for down. The state of up/down should be changed when the clock is high.

For normal operation (counting) preset, and carry in should be low. The binary/decade input selects the type of counter: 4-bit binary (0-15) when high; decade (0-9) when low. The counter may be preset by placing the desired binary number on the inputs A-D and briefly making the preset input high. There is no reset input, but preset can be used to reset the count to zero if inputs A-D are all low.

C. Push to on Switch

Push Switch or Push to make switch, allows electricity to flow between its two contacts when held on.

Push button switch is a small, sealed mechanism that completes an electric circuit when you press on it. When it's on, a small metal spring inside makes contact with two wires, allowing electricity to flow. When it's off, the spring retracts, contact is interrupted, and current won't flow. The body of the switch is made of non-conducting plastic. Momentary switches work only as long as you press on them, like the buttons on a phone, calculator or door buzzer. They can be subdivided into normally-on and normally-off types.

Figure 2. Push button

Normally-Off：

With the normally-off switch, there's no connection till you push the button. Most push button switches are used this way. Examples include doorbell buttons, cell phone keys and garage door openers.

Normally-On：

Here the switch conducts normally, but interrupts the circuit when you press on it. This is more specialized, and may be used in conjunction with a wiring trick. For example, connecting a normally-on switch in parallel with a light bulb will light the bulb when the buttons pushed; otherwise, current will flow through the switch, leaving the bulb off.

D. Light Emiting Diode (Led)

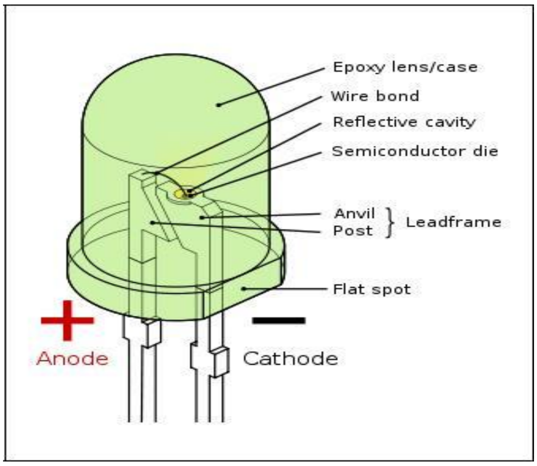

Figure 3. Light emitting diode

E. Regulator

Voltage regulator ICs are available with fixed (typically 5, 12 and 15V) or variable output voltages. They are also rated by the maximum current they can pass. Negative voltage regulators are available, mainly for use in dual supplies. Most regulators include some automatic protection from excessive current and overheating. Different varieties of regulators are available in this work IC7805 is used.

IC7805 is a voltage regulator integrated circuit. It is a member of 78xx series of fixed linear voltage regulator ICS. The voltage source in a circuit may have fluctuations and would not give the fixed voltage output. The voltage regulator IC maintains the output voltage at a constant value. The xx in 78xx indicates the fixed output voltage it is designed to provide. 7805 provides +5v regulated power supply. Capacitors [8] of suitable values can be connected at input and upon the respective 78xx integrated circuits. The commonly used in requiring a regulated their ease-of-use and output pins depending voltage levels. The LM78xx is a family of linear voltage regulator 78xx family is electronic circuits [9] [10] power supply due to low cost.

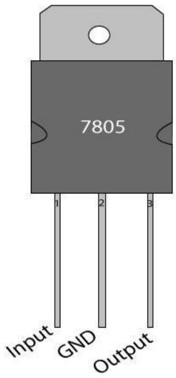

Figure 4. IC7805

V. SCHEMATICS OF HARDWARE KIT

The hardware implementation diagram is as shown in Fig. 5

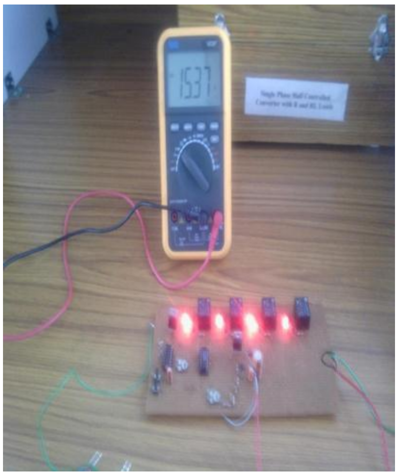

Figure 5. Hardware implementation of 15-step digital power supply

VI. RESULTS

TABLE I. 15-STEPS OF VOLTAGES

S.No	Binary output	Equivalent Decimal no.	LED1	LED2	LED3	LED4	Output Voltage (Volts)
1	0000	0	Shorted	Shorted	Shorted	Shorted	1.54
2	0001	1	Shorted	Shorted	Shorted	ON	2.55
3	0010	2	Shorted	Shorted	ON	Shorted	3.72
4	0011	3	Shorted	Shorted	ON	ON	4.68
5	0100	4	Shorted	ON	Shorted	Shorted	5.34
6	0101	5	Shorted	ON	Shorted	ON	6.35
7	0110	6	Shorted	ON	ON	Shorted	7.52
8	0111	7	Shorted	ON	ON	ON	8.53
9	1000	8	ON	Shorted	Shorted	Shorted	8.37
10	1001	9	ON	Shorted	Shorted	ON	9.37
11	1010	10	ON	Shorted	ON	Shorted	10.53
12	1011	11	ON	Shorted	ON	ON	11.54
13	1100	12	ON	ON	Shorted	Shorted	12.16
14	1101	13	ON	ON	Shorted	ON	13.16
15	1110	14	ON	ON	ON	Shorted	14.32
16	1111	15	ON	ON	ON	ON	15.35

VII. APPLICATIONS OF 15-STEP DIGITAL POWER SUPPLY

TABLE II. APPLICATIONS

S.No	Name of the Device	Required Voltage
1	MOUSE	5 volts
2	KEYBOARD	13 volts
3	USBPORT	5.5 to 6.5 volts
4	ADOPTER	15 volts
5	DC INVERTER	15 volts

VIII. CONCLUSION

Thus we can obtain a dc power supply to meet the latest trends in our Electrical & Electronics field. By using this 15-step digital power supply we can produce different voltages in steps which can be conveniently applied to different applications using single kit.

In this mini project we only obtained voltage in coarse steps. In future we can further design the circuit in such a way that, we can have fine variation of voltage. Thus we can feed any level of voltage that is required by any device.

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