The Maharaja Sayajirao University of Baroda, Vadodara.
Polytechnic

PROJECT REPORT
ON

TO DESIGN PCB FOR 4-BIT DIGITAL TO ANALOG CONVERTER USING OPAMP

Submitted by

MAVADIYA DARSHIL (2019033800122932)
PADMANI JENISH (2019033800122874)

In fulfillment for the Course of
DIPLOMA
in
Electronics and Communication (HPP)
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Guided by

MR. HIREN JETHAVA
MRS. POONAM PANDEY

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CERTIFICATE

This is to certify that, **MR. DARSHIL MAVADIYA** and **MR. JENISH PADMANI,** students of Electronics and Communication have satisfactory completed their Project Work as a part of course curriculum in Diploma in Electronics and Communication (HPP), Final Year heaving a Project Entitled As: **TO DESIGN PCB FOR 4-BIT DIGITAL TO ANALOG CONVERTER USING OPAMP**

Project Guide:

Mr. Hiren Jethava
Lecture
Electronics and Communication (HPP)
Polytechnic
The Maharaja Sayajirao University of Baroda.

Mrs. Poonam Pandey
Lecture
Electronics and Communication (HPP)
Polytechnic
The Maharaja Sayajirao University of Baroda.

Mrs. Dharmistha Vishwakarma
Astt. Director –EC (HPP)
Electronics and Communication (HPP)
Polytechnic
The Maharaja Sayajirao University of Baroda.

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Last, but not the least, no words are enough to acknowledge the constant support and sacrifies of our parents, because of whom we are able to complete this diploma program successfully.

ABSTRACT

In the last years the technology improvement of Digital-to-Analog Converters (DACs) has extended the use of digital techniques in a multitude of applications. Consequently, there is an increasing attention to DAC topics, from researchers and manufacturers. The paper is aimed at providing a metrological overview and the leading trends of the research in the field of DACs. The use of a 4-bit digital-to-analog converter using R-2R Ladder is designed and presented in this paper. The main components that were used in constructing both circuits were different resistor values, LEDs, operational amplifier (LM741) and single pole double throw switches and for power supply were used different capacitor values and center tapped transformer. Both circuits were designed using PROTEUS software to be able to test the circuit for its ideal application and EASYEDA software for the layout designing and fabrication to the printed circuit board.

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CHAPTER 1: INTRODUCTION

A digital-to-analog converter (DAC or D-to-A) is a device for converting a digital(usually binary) code to an analog signal (current, voltage or charges). Digital-to-Analog Converters are the interface between the abstract digital world and the analog real life. Simple switches, a network of resistors, current sources or capacitors may implement this conversion

A DAC inputs a binary number and outputs an analog voltage or current signal. In block diagram form, it looks like this:

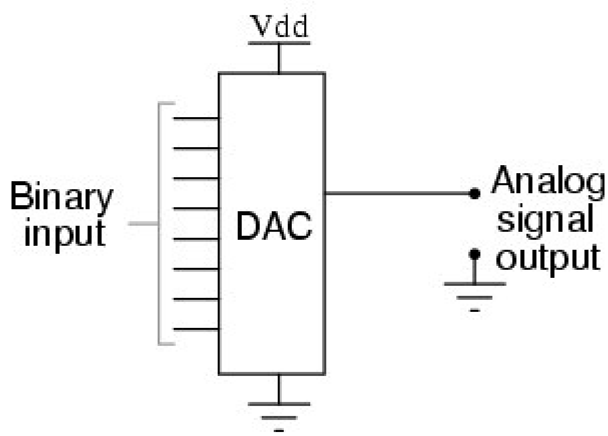


Fig. 1 DAC block diagram [1]

1.1 DAC types

The most common types of electronic DAC's are:

- The Pulse Width Modulator the simplest DAC type. A stable current(electricity) or voltage is switched into a low pass analog filter with a duration determined by the digital input code. This technique is often used for electric motor speed control, and is now becoming common in high-fidelity audio.

- Over sampling DACs such as the Delta-Sigma DAC, a pulse density conversion technique. The oversampling technique allows for the use of a lowerre solution DAC internally. The DAC is driven with a pulse density modulated signal,created through negative feedback. The negative feedback will act as a highpass filter for the quantization (signal processing) noise, thus pushing this noise out of the pass-band.Most very high resolution DACs (greater than 16 bits) are of this type due to its high linearity and low cost.

- The Binary Weighted DAC, which contains one resistor or current source for each bit of the DAC connected to a summing point. These precise voltages or currents sum to the correct output value. This is one of the fastest conversion methods but suffers from poor accuracy because of the high precision required for each individual voltage or current. Such high-precision resistors and current sources are expensive, so this type of converter is usually limited to 8-bitresolution or less.
- The R2R Ladder DAC, which is a binary weighted DAC that creates each value with a repeating structure of 2 resistor values, R and R times two. This improves DAC precision due to the ease of producing many equal matched values of resistors or current sources, but lowers conversion speed due to parasitic capacitance.
- The Segmented DAC, which contains an equal resistor or current source segment for each possible value of DAC output. An 8-bit binary-segmented DAC would have 255 segments, and a 16-bit binary-segmented DAC would have 65,535 segments. This is perhaps the fastest and highest precision DAC architecture but at the expense of high cost
- Hybrid DACs, which use a combination of the above techniques in a single converter. Most DAC integrated circuits are of this type due to the difficulty of getting low cost, high speed and high precision in one device.

CHAPTER 2: LITERATURE SURVEY

In the construction of DAC using opamp IC LM741 Operational Amplifier is used. Other components that are used are transformer, switches, resistors and capacitors.

2.1 Introduction to IC LM741 Operational Amplifier

The acronym of the term Op-Amp is an operational amplifier and it is a one type solid state integrated circuit. The op-amp is the basic building blocks of analog electronic circuits that perform a various types of analog signal processing tasks. Operational amplifiers use external feedback to control its functions and these are the multipurpose devices in all electronic devices. Op-Amp has two inputs and one output termed as inverting and noninverting. IC 741 op amp is the most common op-amp used in various electronic circuits.

2.1.1 Pin Description

As shown in figure 1 IC741 consists of 8 pins.

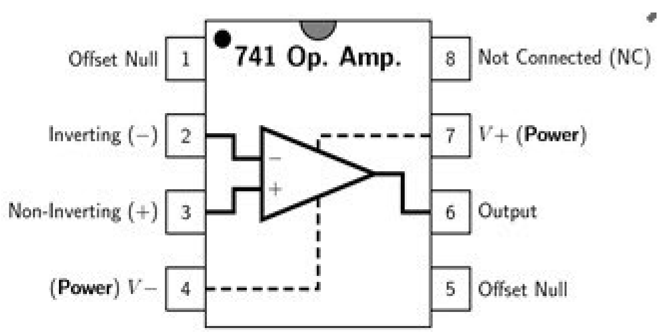


Fig. 2 IC 741 Pin Diagram [2]

1. Pin 1 and 5: Offset Null

The operational amplifier has an increased level of voltage gain. Because of this, even minimal variations in the voltages at both non-inverting and inverting inputs those are happened because of the abnormalities in the constructional procedure or other anomaly's will show an impact on the output. In order to overcome this, an offset value of the voltage to be applied at pin 1 and pin 5, and this generally accomplished by a potentiometer.

2. Pin 2 and 3: Input

These are input pins for the IC. Pin2 is the inverting input and Pin3 is the non-inverting input. If the voltage at Pin2 is greater than the voltage at Pin3, i.e., the voltage at inverting input is higher, the output signal stays low. Similarly, if the voltage at Pin3 is greater than the voltage at Pin2, i.e., the voltage at non-inverting input is high, the output goes high.

3. Pin 4 and 7: Power Supply

Pin7 is the positive voltage supply terminal and Pin4 is the negative voltage supply terminal. The 741 IC draws in power for its operation from these pins. The voltage level between these pins can be in the range of 5 – 18V.

4. Pin 6: Output

The output which is delivered from the IC 741 op amp is received from this pin. The output voltage that is received at this pin is based on the feedback approach that is used and the voltage level at the input pins. When the voltage value at pin 6 is high, this corresponds that output voltage is similar to the positive supply voltage. In the same way, when the voltage value at pin 6 is low, this corresponds that output voltage is similar to the neagative supply voltage.

2.1.2 Ic 741 Specification

- Power Supply: Requires a Minimum voltage of 5V and can withstand up to 18V
- Input Impedance: About 2 MΩ
- Output impedance: About 75 Ω
- Voltage Gain: 200,000 for low frequencies (200 V / mV)
- Maximum Output Current: 20 mA
- Recommended Output Load: Greater than 2 KΩ
- Input Offset: Ranges between 2 mV and 6 mV
- Slew Rate: 0.5V/µS (It is the rate at which an Op-Amp can detect voltage changes)

2.2 Resistor:

Resistor is that component which are called "passive device". It can contain no source of power or amplification only attenuate or reduce the voltage or current signal. Resistors are use as load in circuit for controlling the one of current and voltage. The results is expressed as electrical energy being loss in the form of the heat as the resistor the flow of electron through it. Then a potential difference is require between the two terminals resistor for current to flow. This potential difference balance out the energy lost. When use in DC circuit the potential difference, also known as resistor voltage drop, is measure across the terminal and circuit current flows through the resistor. Most types of resistor are linear devices that produce voltage drop across themselves. Symbol resistor and how resistor looks like as shown below.

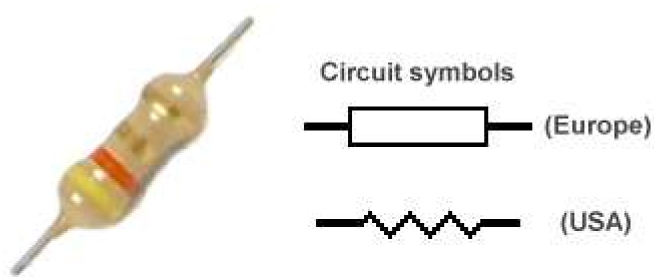
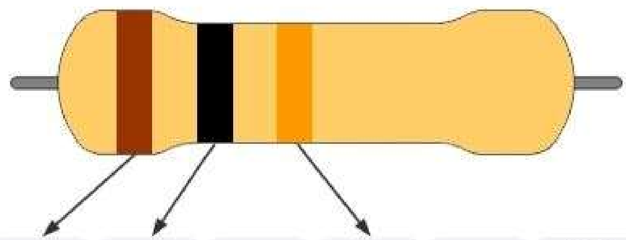


Fig. 3 Symbol of Resistor [3]

Electrical current flow through them because they obey ohms law and different value of residence which the different values of current or voltage. This can be very useful in electronic circuit by controlling or the current flow or voltage produce across them, using voltage to current & current to voltage converter. Resistor is achieved through a color band of resistor. Value of resistor is found by considering rate of color band as per below table.



	1st digit	2nd digit	3rd digit	multiply	tolerance	TCR (ppm/K)
Black	0	0	0	1	1% (F)	100
Brown	1	1	1	10	2% (G)	50
Red	2	2	2	100		15
Orange	3	3	3	1K		25
Yellow	4	4	4	10K		
Green	5	5	5	100K	0.5% (D)	
Blue	6	6	6	1M	0.25% (C)	10
Violet	7	7	7	10M	0.1% (B)	5
Gray	8	8	8	100M	0.05% (A)	
White	9	9	9	1G		
Gold				0.1	5% (J)	
Silver				0.01	10% (K)	
None					20% (M)	

Fig. 4 Format of resistor colour code [4]

2.3 Capacitor:

Capacitor is also known as condenser. The electrically can be stored with the help of this kind of passive device. Capacitor is a device which is having excellent capacity of storage of energy. It will be in the form of electrical charge for producing a potential difference. The capacitor can be consists as a two or more parallel metal plates are not connected to each other. In between the two plates there were having a dielectric modern as in form of air or by some of good insulating material.

The symbol of capacitor is look like below figures:

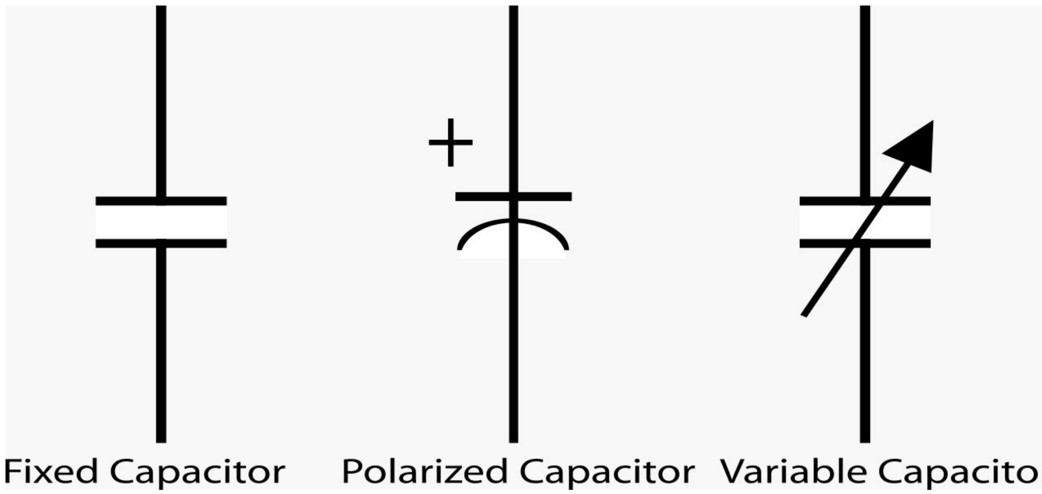


Fig. 5 Symbolic representation of capacitor [5]

For our circuit designing we are using electrolyte capacitor and ceramic capacitor for power supply. We are using these capacitors as a filter capacitor. Where as electrolyte capacitor is shown in below figure:

Fig. 6 Electrolyte capacitor [6]

As ceramic capacitor is having a fixed value in which the ceramic material will act as dielectric medium. It is non polarized device. Where as ceramic capacitor is shown in below figure:

Fig. 7 Ceramic capacitor [7]

The ceramic capacitor is only device which use ceramic material in a construction of ceramic capacitor, as also referred as insulator, ceramic capacitor has very small size and very low voltage rate. As it is a ceramic capacitor which means they are safe component which can connect with AC source. It has good frequency source due to a low parasitic effect as resistance or inductance.

2.4 Transformer:

Basically transformer is an electrical component, which consists of two or more coils of wire use to transfer the electrical energy into an magnetic field.

Figure shows basics structure of transformer:

Fig. 8 Transformer [8]

One of the main reason, that we use alternating AC voltage and current in our home or workplace. That AC supply can easily generated. One of the main reason for choosing transformer is that alternating AC current and voltage transformer are used in routine environment. Ac supply can easily generated at convenient voltage, transformer can convert it into a much higher voltage level.

The transformer can be electrical component rather than electronics component. It is usually very simple static electronics magnetic passive electrical device. Eventually, it works on the principle of FARADAY'S LAW.

2.5 SPDT Switch:

A Single Pole Double Throw (SPDT) switch is a switch that only has a single input and can connect to and switch between the 2 outputs. This means it has one input terminal and two output terminals.

A Single Pole Double Throw switch can serve a variety of functions in a circuit. It can serve as an on-off switch, depending on how the circuit is wired. Or it can serve to connect circuits to any 2 various paths that a circuit may need to function in.

Below is a figure of a single pole double throw switch.

Fig. 9 SPDT Switch [9]

2.6 Diodes:

The 1N400x (1N4001 or 1N4007) series is a family of popular 1 Amp (ampere) general-purpose silicon rectifier diodes commonly used in AC adapters for common household appliances. Its blocking voltage varies from 50 volts (1N4001) to 1000 volts (1N4007). This JEDEC device number series is available in the DO-41 axial package, and similar diodes are available in SMA and MELF surface mount packages (in other part number series).

The 1N540x (or 1N5400) series is a similarly popular family of diodes for higher-current 3 Amp applications. These diodes are typically available in the larger DO-201AD axial package to dissipate heat better.

These are fairly low-speed rectifier diodes, being inefficient for square waves of more than 15 kHz. These devices are widely used and recommended.

The series was second source by many manufacturers. The 1N4001 series were in the Motorola Semiconductor Data Manual in 1965, as replacements for 1N2609 through 1N2617. The

1N5400 series were announced in Electrical Design News in 1968, along with the now lesser known 1.5 Amp 1N5391 series.

Fig. 10 Diode [10]

CHAPTER 3: WORKING OF THE MODULE

3.1 Working On Proteus For DAC Designing

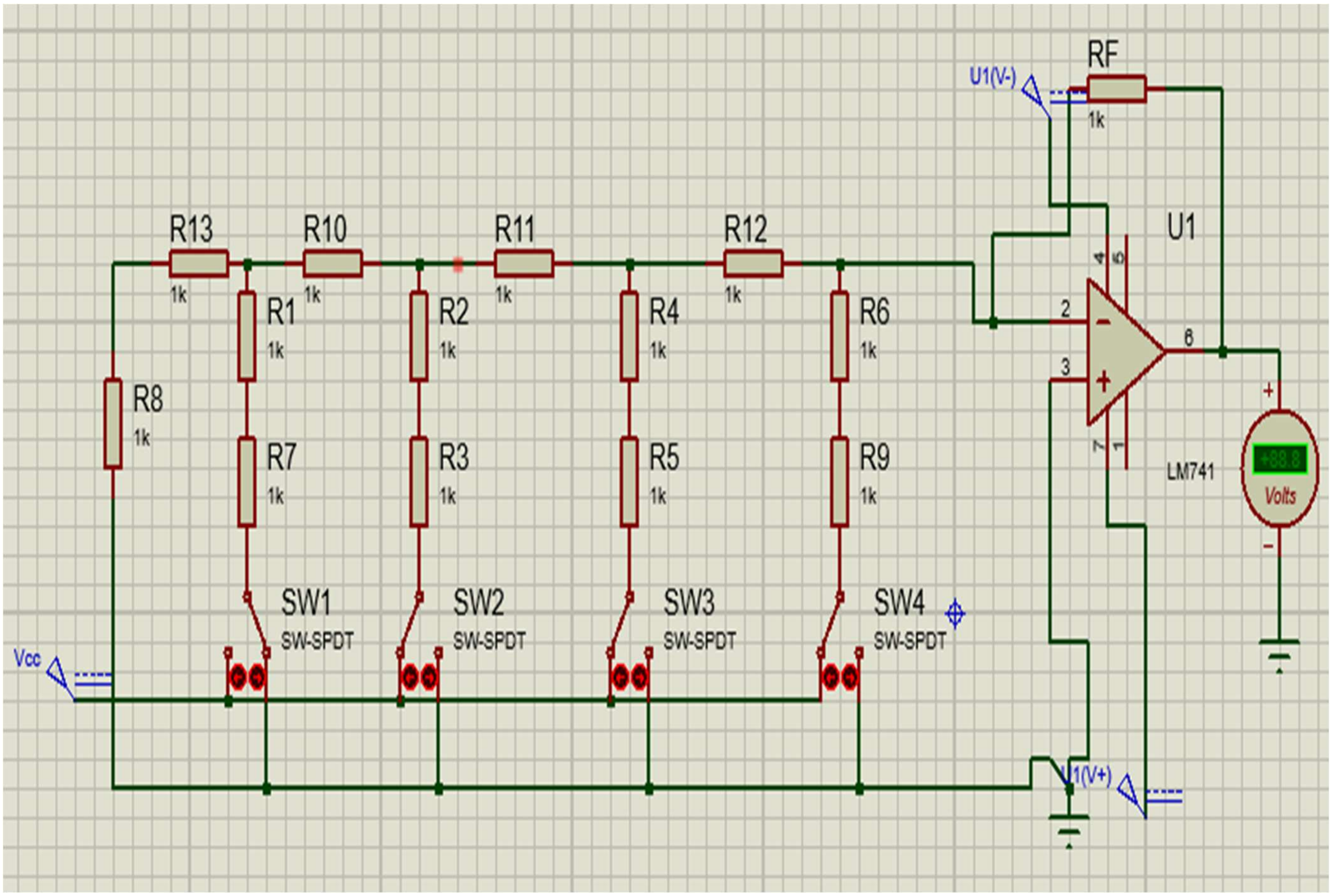


Fig. 11 Simulation of DAC in proteus software

3.1.1 Component Used:

VCC supply, SPDT switch, Resistors, IC LM 741, DC voltage meter

3.1.2 Procedure:

- SPDT switch connected with resistor in series.
- All switches are inputs of ladder network.
- Ladder network is connected with op-amp in inverting configuration.

- One terminal of switch is grounded and one gets VCC connected.
- DC volt meter is connected with output of op-amp.
- Pin number 4 of op-amp is connected with -12 volt.
- Pin number 7 of op-amp is connected with +12 volt.

3.2 Working On Easy EDA For PCB Designing

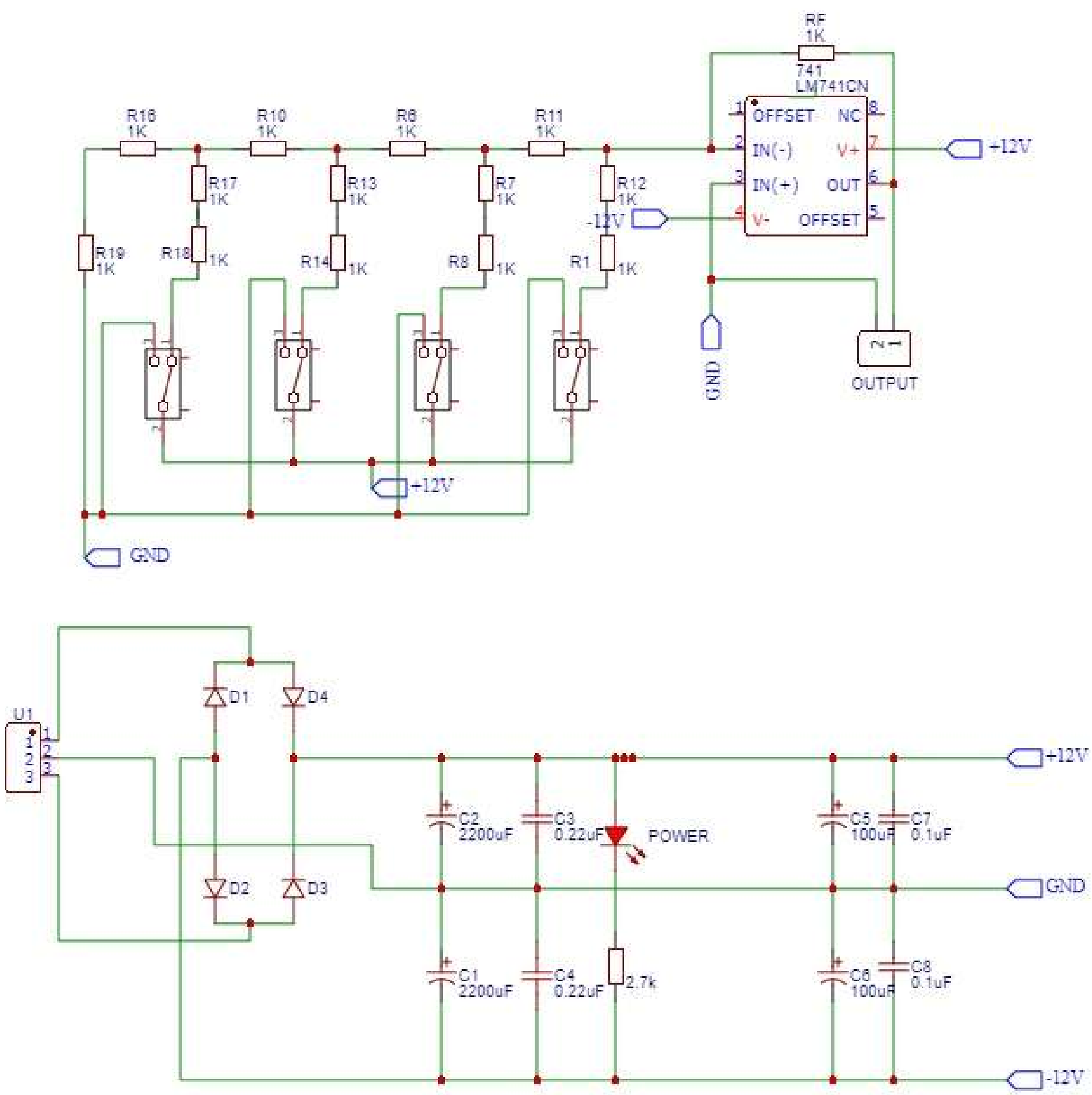


Fig. 12 Schematic of DAC and power supply in EsayEDA

3.2.1 Components Used:

IC LM 741, Resistors, Capacitors, SPDT Switch, LED, Connectors

3.2.2 Procedure:

- Input of bridge rectifier is connected to the step-down transformer via connector.
- Output of bridge rectifier is faded to the filter capacitor for filtering ripple.
- Filter DC is given as supply to the op-amp.
- All switches acts as a inputs of a ladder network.
- One connector is placed at the output side for observing the output.

3.2.3 PCB Layout

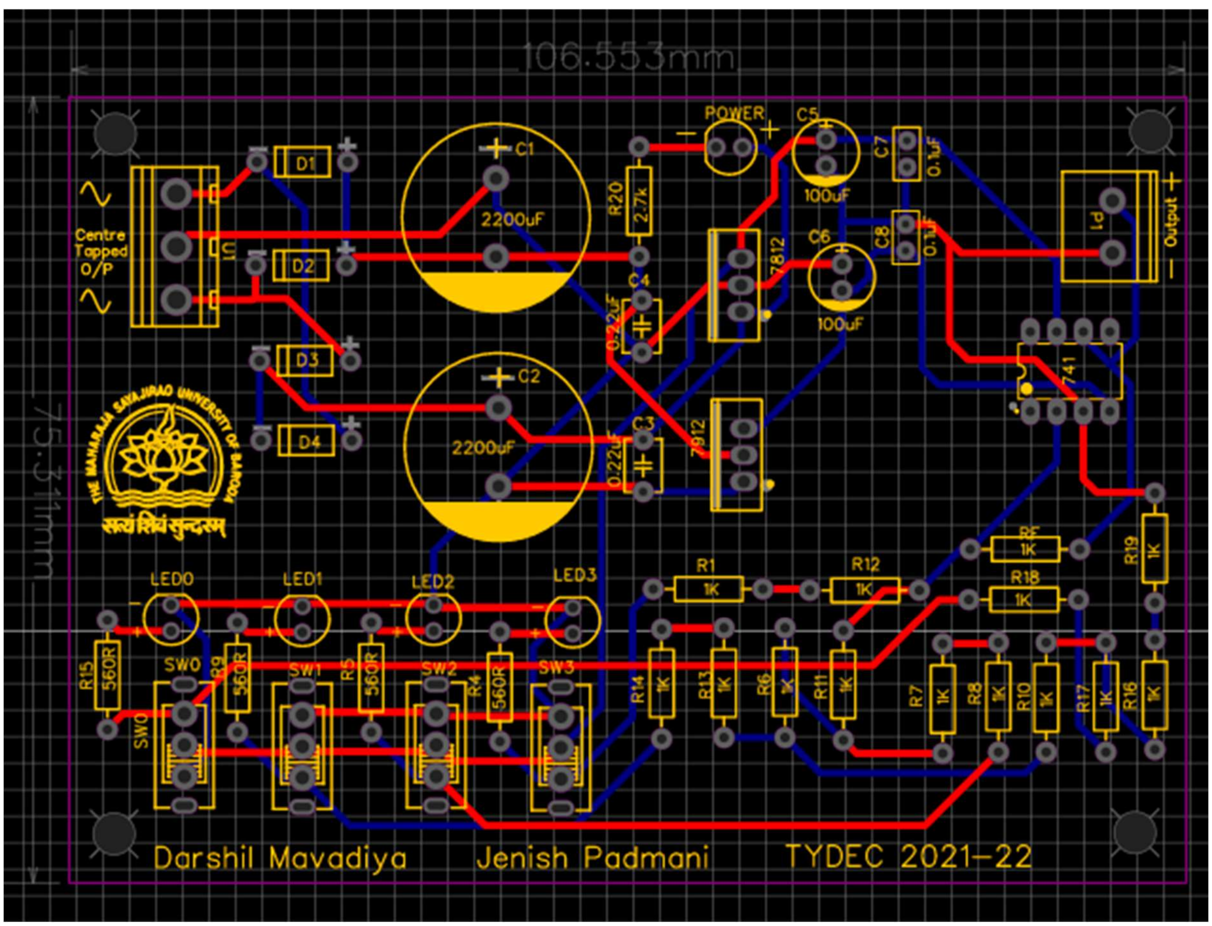


Fig.13 PCB Layout

CHAPTER 4: HARDWARE DESIGN

4.1 Component:

Sr. No.	Component	Quantity
1	Step Down Transformer	1
2	Diode	4
3	Capacitor	8
4	LED	1
5	Resistor	15
6	IC LM741	1
7	SPDT Switch	4
8	2 Pin Connector	1
9	3 Pin Connector	1
10	IC Socket	1

Table 1: Hardware Components

4.2 Circuit Diagram:

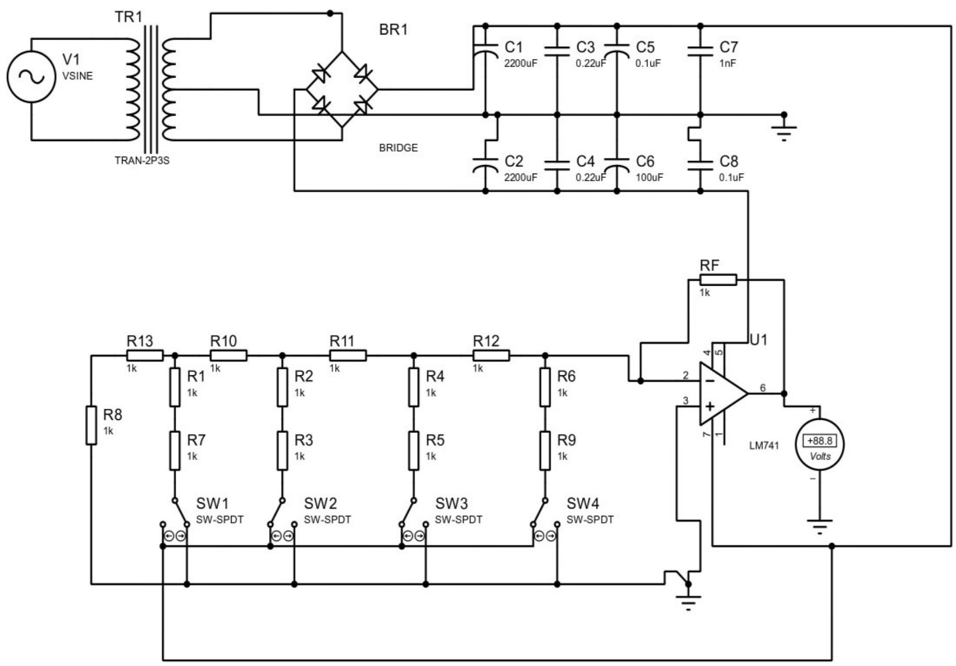


Fig. 14 Circuit Diagram

4.2.1 Procedure:

- 230V AC is given to the center tapped step down transformer. Output of the transformer is given to the input of bridge rectifier.
- Output of bridge rectifier is pulsating DC. Therefore we have to remove to ripple. For removing ripple output of bridge rectifier is given to the filtering capacitors.
- Output of filtering capacitor is pure DC. So output of filtering capacitors is given to the pin no 4 and 7 of the op-amp +12V and -12V respectively as a supply and it also given to the one terminal of the SPDT switches.

- Another terminal of the SPDT switches is connected to the input of the ladder network. Switches are acts as a four inputs of the DAC.
- For changing state of input from 0 to 1 or 1 to 0 we have to toggle the switch.
- Non inverting pin of the op-amp is grounded.
- Ladder network is connected with the op-amp in the inverting configuration. So output of the circuit is inverted.
- Output of the circuit is observed by multimeter.

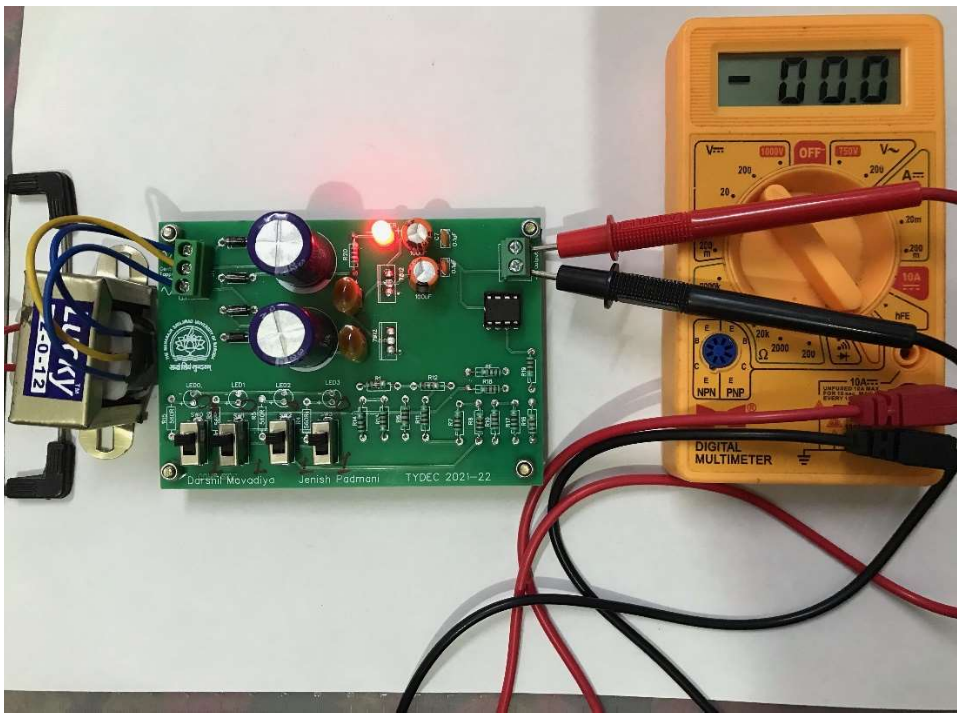


Fig. 15 (a) Hardware PCB

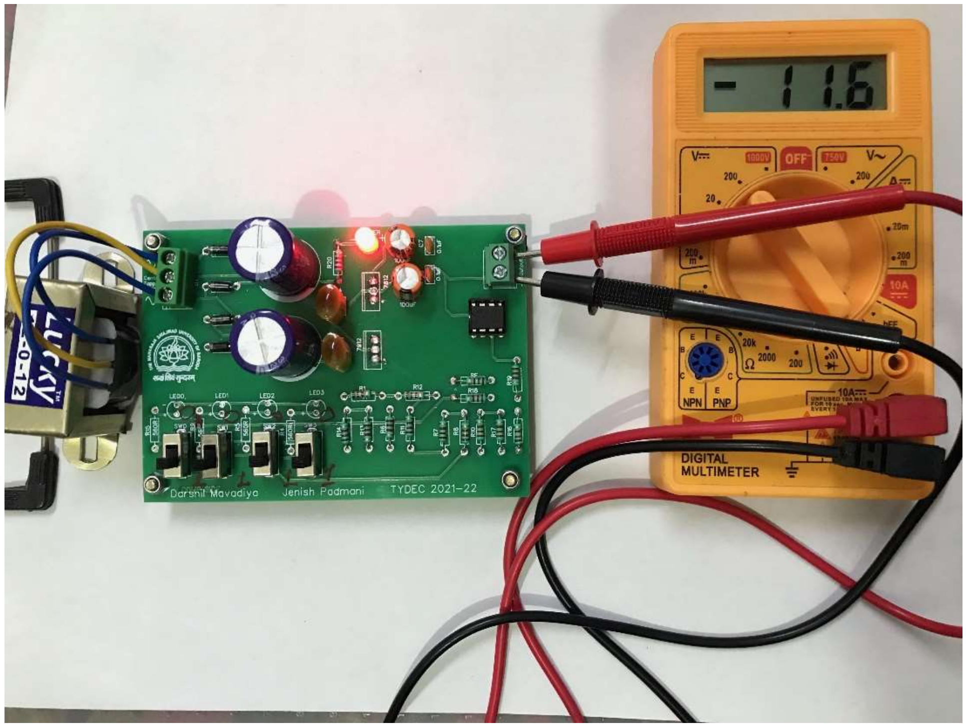


Fig. 15 (b) Hardware PCB

CHAPTER 5: OUTPUT OF THE MODULE

Here is the output of the module.

For Vref = +12V

$$\mathbf{V_{out}} = \mathbf{-\ V_{ref}} \times \frac{\mathbf{Rf}}{\mathbf{R}} \times \left[\frac{\mathbf{SW3}}{\mathbf{2}} + \frac{\mathbf{SW2}}{\mathbf{4}} + \frac{\mathbf{SW1}}{\mathbf{8}} + \frac{\mathbf{SW0}}{\mathbf{16}}\right]$$

Input				**Output (Vout)**	
SW 3	**SW 2**	**SW 1**	**SW 0**	**Theoretical Value (Volts)**	**Practical Value (Volts)**
0	**0**	**0**	**0**	**-0**	**-0**
0	**0**	**0**	**1**	**-0.75**	**-1.7**
0	**0**	**1**	**0**	**-1.5**	**-2.5**
0	**0**	**1**	**1**	**-2.25**	**-3.4**
0	**1**	**0**	**0**	**-3**	**-3.9**
0	**1**	**0**	**1**	**-3.75**	**-4.9**
0	**1**	**1**	**0**	**-4.5**	**-5.3**
0	**1**	**1**	**1**	**-5.25**	**-5.8**
1	**0**	**0**	**0**	**-6**	**-6.8**
1	**0**	**0**	**1**	**-6.75**	**-8.3**
1	**0**	**1**	**0**	**-7.5**	**-9.2**
1	**0**	**1**	**1**	**-8.25**	**-9.9**
1	**1**	**0**	**0**	**-9**	**-10.4**
1	**1**	**0**	**1**	**-9.75**	**-10.4**
1	**1**	**1**	**0**	**-10.5**	**-10.4**
1	**1**	**1**	**1**	**-11.25**	**-10.4**

Table 2 : Output

CHAPTER 6: CONCLUSION

In conclusion, we are able to design a digital to analog converter using R – 2R ladder method. A DAC using R – 2R ladder was designed and implemented having only two different values of resistors, thus having an advantage based on the number of components unlike the binary weighted resistors DAC where in different resistor values were used hence difficulty in attaining the needed output required.

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