

DESIGN & FABRICATION OF MICRO- CONTROLLER BASED 120Hz EARTH TESTER

*Thesis submitted in partial fulfillment of the requirements for the award of
degree of*

**Master of Engineering
in
Power Systems & Electric Drives**



Thapar University, Patiala

By:

**Samir Kumar
(80641019)**

Under the supervision of:

**Mr. Parag Nijhawan
Sr. Lecturer, EIED**

JUNE 2008

**ELECTRICAL & INSTRUMENTATION ENGINEERING DEPARTMENT
THAPAR UNIVERSITY
PATIALA – 147004**

CERTIFICATE

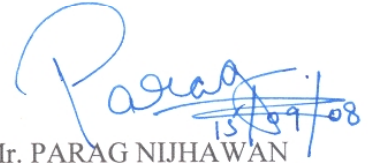
I hereby certify that the work which is being presented in the thesis entitled, “**Designing & Fabrication of Micro-Controller Based 120Hz Earth Tester**”, in partial fulfillment of the requirements for the award of degree of Master of Engineering in *Power Systems & Electric Drives* submitted in Electrical & Instrumentation Engineering Department of Thapar University, Patiala, is an authentic record of my own work carried out under the supervision of *Mr. Parag Nijhawan, Sr. Lecturer, EIED*.

The matter presented in this thesis has not been submitted for the award of any other degree of this or any other university.



SAMIR KUMAR

This is to certify that the above statement made by the candidate is correct and true to the best of my knowledge.



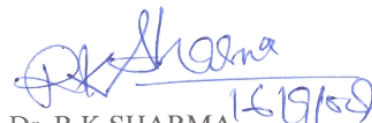
Mr. PARAG NIJHAWAN
Sr. Lecturer

Electrical & Instrumentation Engg. Department
Thapar University
Patiala

Countersigned by



Dr. S. GHOSH
Professor & Head
Electrical & Instrumentation Engg. Department
Thapar University
Patiala



Dr. R.K. SHARMA
Dean (Academic Affairs)
Thapar University
Patiala

ACKNOWLEDGEMENT

First of all, I would like to thank the Almighty for granting perseverance and achievements. I would like to express my gratitude to **Mr. Parag Nijhawan, Sr. Lecturer, EIED, Thapar University, Patiala**, for his patient guidance and support throughout this thesis work. I was truly very fortunate to have the opportunity to work under him as a student. It was both an honour and a privilege to work with him. He also provides help in technical writing and presentation style and I found this guidance to be extremely valuable.

I take this opportunity to express my gratitude and sincere thanks to **Dr. Smarajit Ghosh, Prof. & Head, EIED, Thapar University, Patiala** for his valuable support and help without which it would not have been possible for me to complete this work. I am also thankful to all my friends who devoted their valuable time and helped me in all possible ways towards successful completion of this work, I do not find enough words with which I can express my feeling of thanks to the entire faculty and staff of EIED, Thapar University, Patiala, for their help, inspiration and moral support which went a long way in successful completion of my work. I thank all those who have contributed directly or indirectly to this work.

Lastly, and more importantly, I would like to thank my parents for their years of unyielding love and encouragement. They have always wanted the best for me and I admire my parent's determination and sacrifice to put me through college.

Samir Kumar

ABSTRACT

The basic idea behind the operation of earth tester is to measure the voltages drop and leakage current through ground. Correspondingly the value of earth resistance is obtained using micro-controller based circuit. The aim of the work was to design & fabricate micro-controller based 120Hz Earth Tester. The micro-controller used in the fabrication of this earth tester is AT89S8252. The fabricated instrument is calibrated and then tested in the laboratory. The ground resistance values obtained using the fabricated instrument are compared with those obtained using current injection 3-point method. The various circuits sections that are used to fabricate 120Hz Earth tester are as follow:-

1. SMPS(Switched Mode Supply) is used to provide 100V by using Fly Back Topology with Boost up voltage from 12V Battery To 100Volts.This voltage is feeding to high voltage electrode where as the second electrode is connected directly with the reference ground and by changing the position of third electrode we are getting the no. of outputs.
2. Microcontroller section having 2 no's of Analogous to Digital converter, one of them which is used to provide voltage reading and the other one is providing current readings.
3. Frequency generating section using 556 timer circuits is used to provide 120Hz frequency.
4. Operational Amplifier section is used to invert the signal.
5. Additional Power supply is used to run operational amplifier section.
6. Switching section-MOSFET (Metal oxide field effect transistor) is used as a switch.

TABLE OF CONTENTS

Certificate.....	i	
Acknowledgement.....	ii	
Abstract.....	iii	
Table of contents.....	iv	
List of Figures.....	vi	
List of Tables.....	vii	
Chapter-1	INTRODUCTION.....	1
	1.1 Overview.....	1
	1.2 Literature Review	2
	1.3 Scope (or Objective)	7
	1.4 Organization of Thesis.....	7
Chapter-2	EARTH TESTER.....	9
	2.1 Introduction	9
	2.2 Important parameters of grounding system.....	9
	2.2.1 Soil resistivity.....	9
	2.2.2 Ground Resistance.....	9
	2.2.3 Measurement of soil resistivity.....	10
	2.2.4 Measurement of ground resistance.....	12
	2.3 Precautions while making measurements.....	14
	2.4 Design requirements.....	14
Chapter-3	DESIGN & FABRICATION.....	15
	3.1 PCB Designing.....	15
	3.1.1 Types of PCB.....	15
	3.1.2 Functions of PCB.....	16
	3.1.3 Technique used for PCB design.....	16
	3.1.4 Basic design steps in CAD- system.....	17
	3.1.5 PCB design software.....	17
	3.2 Power supply design.....	18
	3.3 Switch Mode Power Supply.....	20
	3.3.1 Switching Fundamentals.....	20

	3.3.2	Pulse Width Modulation (PWM)	21
	3.3.3	Switching Converter Topologies.....	22
	3.3.4	Generating Multiple Output.....	29
	3.4	Operational Amplifiers.....	30
	3.4.1	Feature.....	30
	3.4.2	Applications.....	30
	3.5	120Hz Frequency Generator & Switching Section.....	33
	3.5.1	120Hz Frequency Generator Introduction.....	33
	3.5.2	Applications.....	33
	3.5.3	Pin description of 556 timer.....	34
	3.5.4	Switching Section.....	34
	3.6	Embedded system.....	37
	3.6.1	AT89S8252 Micro-Controller.....	38
	3.6.2	A/DC-0804 Interfacing With AT89S52.....	45
	3.7	Hardware Interfacing of LCD(JHD162A)	47
	3.8	Microcontroller Programming	49
Chapter-4		RESULTS AND CONCLUSION.....	50
	4.1	Experimental Testing	50
	4.2	Comparison of fabricated earth tester with 3-electrode experiment method.....	51
		4.2.1 Case-1.....	52
		4.2.2 Case-2.....	53
		4.2.3 Case-3.....	54
		4.2.4 Case-4.....	55
	4.3	Conclusion.....	57
	4.4	Scope for future work.....	57
		References.....	58
APPENDIX-A		Datasheet of AT89S8252.....	61
APPENDIX-B		Datasheet of ADC 0804.....	64
APPENDIX-C		High voltage fast-switching npn power transistor.....	66
APPENDIX-D		Components Used.....	68

LIST OF FIGURES

Figures	Pg.No
Chapter-2	
Figure 2.1	Four Electrode Method.....11
Figure 2.2	Configurations of Electrodes for Measurement of Ground Resistance....13
Figure 2.3	Electrode Spacing Effects-Uniform Soil.....13
Chapter-3	
Figure 3.1	Transformer Theory.....21
Figure 3.2	Duty cycle.....22
Figure 3.3	Buck regulator.....23
Figure 3.4	Buck Regulator Inductor Current.....24
Figure 3.5	Boost regulator.....25
Figure 3.6	Buck- boost regulator.....26
Figure 3.7	Fly back regulator.....27
Figure 3.8	SMPS with Fly back Topology28
Figure 3.9	Typical multiple output fly back.....29
Figure 3.10	Operational amplifier circuit for V-measuring A/DC and I-Measuring A/DC31
Figure 3.11	Power supply for Op-Amp Sections.....32
Figure 3.12	Pin Description Of 556 Timer34
Figure 3.13	Symbol of MOSFET.....35
Figure 3.14	TO-220 Packages.....35
Figure 3.15	120Hz Frequency generating circuit with Switching Circuit.....36
Figure 3.16	Pin Diagram of AT89S8252.....40
Figure 3.17	Block diagram of AT89S8252.....41
Figure 3.18	Pin diagram of ADC-0804.....45
Figure 3.19	Circuit Diagram of Measuring Section.....46
Figure 3.20	LCD47
Chapter-4	
Figure 4.1	Experimental Testing.....51

LIST OF TABLES

Table		Pg.No
Table 3.1	Constant Positive Voltage Regulators.....	19
Table 3.2	Constant Negative Voltage Regulators.....	19
Table 3.3	Pin Description.....	42
Table 3.4	Alternate Functions of Port Pins.....	43
Table 3.5	Pin No. Name and Their Functions.....	48
Table 4.1(a)	True Value (From 3-Electrode Method).....	52
Table 4.1(b)	Actual Value (From Fabricated Instrument)	52
Table 4.1(c)	Comparison between True sand Actual Values of Earth resistance.....	52
Table 4.2(a)	True Value (From 3-Electrode Method).....	53
Table 4.2(b)	Actual Value (From Fabricated Instrument).....	53
Table 4.2(c)	Comparison between True and Actual Values of Earth resistance.....	53
Table 4.3(a)	True Value (From 3-Electrode Method).....	54
Table 4.3(b)	Actual Value (From Fabricated Instrument).....	54
Table 4.3(c)	Comparison between True and Actual Values of Earth resistance.....	54
Table 4.4(a)	True Value (From 3-Electrode Method).....	55
Table 4.4(b)	Actual Value (From Fabricated Instrument).....	55
Table 4.4(c)	Comparison between True and Actual Values of Earth resistance.....	56

CHAPTER-1

INTRODUCTION

1.1 OVERVIEW

The Earth surface potentials result when a ground fault occurs and short circuit current flows between the grounding system and the surrounding soil, can give rise to large touch and step voltages. The potential to which the grounding system of a station is raised during a ground fault is equal to the product of the ground resistance and the magnitude of the current that flows through the grounding system and surrounding earth. The grounding system design limits these voltages to permissible values to ensure personnel safety, equipment protection and safe operation of power system. Sometimes these voltages may be of the order of several kilovolts. So, to verify the adequacy of a grounding system and to ascertain which, if any, additional measures are needed to protect the personnel, control and the communication equipment, it is necessary to measure the ground resistance and earth surface potentials. At old stations where grid design is unknown, adequacy of the grounding system needs to be tested. Also if periodical measurements are not carried out, it is impossible to monitor the degree of safety and to detect any changes in their protective qualities.

In addition to the measurement of the performance of a grounding system, the measurement of the soil resistivity at the site of a generating station or sub-station is important. The soil resistivity is one of the most important parameters on which the performance of grounding system depends.

When performing the earth ground resistance measurement, consideration must be given to certain items that will influence the test procedures and, ultimately, the results. These include:

- ✓ The type of test being performed.
- ✓ The type of test equipment being used.
- ✓ Spacing of any auxiliary electrode.
- ✓ The possible influence of buried metal objects such as conduits, pipelines, etc.

1.2 LITERATURE REVIEW

Several references in technical literature can be found for Designing and Fabrication of 120Hz Earth Tester.

A.K. Jha presents a single stage single switch AC/DC converter which is an integration of input current shaper and one active switch. The converter is applicable for digital input power supply with tight output voltage regulation. The focus of the topology is to reduce the DC voltage at light load without compromising with voltage regulation. The concept behind this topology is direct power transfer scheme [1].

The author presents the methodologies for the resistance measurements of grounding systems in transmission lines, it summarizes the implemented procedures, description of the earth tester used and a statistical analysis of results in the measurements of more than three thousand towers of high voltage line[2].

The authors proposed that a single apparent resistivity value calculated from the steady state resistance equation and the measured steady state resistance can be used as a simplification for lightning current transient performance modeling of a driven rod earth electrode in multi-layer soil. The proposal is verified against results obtained using transient analysis of an equivalent circuit that includes the effect of soil ionization and full-scale experimental results of current impulse tests on a single vertical earth rod in three-layer soil [3].

The authors describes new software techniques to perform analysis, diagnosis, and isolation of failures in analog and mixed-signal circuits including switched mode power supplies. Unique methods and algorithms for schematic entry, setting of failure characteristics, definition of test strategies, recording of simulation based measurements, creation of fault trees and sequencing tests are all discussed [4].

The author observed that the soil conduction under high magnitude impulse currents is affected by the magnitude of applied current, the type of soil and its moisture content. Also, a threshold electric field intensity (E_c) has been identified above which soil

ionization occurs. The aim of this investigation is to quantifying the effects of impulse polarity; grain size and threshold electric field (E_c) on soil electrical properties [5].

Clayton L. Hallmark in year 1997 describes a horizontal earthing electrode consisting of graphite cement encasing a counterpoise wire. The ground bed electrode offers improved grounding and electrical protection to Telecommunication facilities. Its substantial horizontal length and large cross section allow the ground bed to quickly and efficiently disperse lightning currents over a wide area around the site [6].

D. Mukhedka *et.al* in year 1984 describes ground electrode impedance field measurements and their analysis at Hydro-Quebec's Yamaska substation, using both high and low current injection methods. In the low current injection method, numerous measurements were performed in different directions, describing how the mutual coupling effects between the auxiliary current and potential probes can be removed with adequate analytical tools. A comparison is also made between ground impedance values at 60 and 70 Hz. It also includes characteristics of some of the equipment used during these measurements [7].

Donald W. Zipse observed that the uncontrolled flow of continuous electric current over the earth, building steel, metallic piping, etc. has become a serious problem that lacks recognition by the greater part of the electrical industry. The corrective actions are presented to eliminate the continuous flow of stray, uncontrolled current over the earth [8].

E.I dvorak in year 1996 presents four basic grounding methods used for maintenance of transmission lines. These are three-phase bracket grounding, Combination grounding, Single-phase worksite grounding, and Three-phase worksite grounding. The results are summarized and evaluated to assess the effectiveness of the grounding methods and to determine the counter measures needed to mitigate the electrical shock hazards that may exist during ground faults at the work site [9].

The authors described a systematic approach of testing and modelling grounding system performance of large multi-grounded power stations. Simple and detailed test

methods using 65-70 Hz current injection are explained. A simple model including distribution neutrals and shielding factors has been developed to validate measurements and is based on hand calculations [10].

Golam Toaha Rasul *et.al* presents a switch mode AC Buck- Boost regulator which is proposed to maintain constant voltage across a medium size domestic or commercial appliance [11].

The authors described a new concept of power supply. Using the main transformer to transfer the secondary regulation signal on a primary winding, a new developed IC controls the primary and secondary voltages to provide more protection in case of disturbance [12].

Hiroshi Yamane *et.al* proposes a technique for measuring earthing resistance without using auxiliary electrodes. A new measurement technique and a measurement tool (earth tester) are introduced and discussed. A lead wire is connected to the earth electrode under test, and the return wire is connected only to a signal generator V_s . The other side of the return wire is free. The lead and the return wires with insulator covers are on the earth soil. This new technique is examined by comparing with the existing method (three poles method). The earthing resistance deviation between the new technique and the existing method are less than 10-20%. It is found that the new technique is useful to evaluate or check earthing resistance when earth soil surface is covered by pavement or stones [13].

The purpose of this IEEE guide is to describe and discuss the technique of measuring ground resistance and impedance, earth resistivity, potential gradients from currents in the earth, and the prediction of the magnitudes of ground resistance and potential gradients from scale model tests. Factors influencing the choice of instruments and the techniques for various types of measurements are covered [14].

The purpose of this IEEE guide is to present practical instrumentation methods that may be used for the measurement of impedance to remote earth, step and touch potentials, and current distributions of large extended or interconnected grounding systems ranging in complexity from small grids to large grids [15].

The purpose of this guide is to cover outdoor ac substation, distribution, transmission, and generating plant substation with proper caution, the methods described herein are also applicable to indoor portions of such substation, or to sub stations that are wholly indoors[16].

The author's presents a Class-D power amplifier for band-pass pulse width modulated (BP-PWM) and band-pass delta sigma modulated (BP-DSM) signals at 20 MHz. A 1-bit 6th order topology is used in the modulator. The push-pull amplifier part of the Class-D amplifier was fabricated CMOS process and the band-pass filter was composed of a LC ladder network realized with discrete components [17].

Kenneth M.Michaels in year 1995 found that the test procedure must be given to ensure that an accurate measurement will be achieved. The author also provides recommendations on measurement techniques to minimize errors and ensure valid test results. Previously accepted test methods for resistance measurements of a grounding electrode system may incorrectly indicate that high or low resistance connections have been established. Testing of several grounding electrode systems was conducted by the author. The results of these tests to illustrate deficiencies in grounding electrode resistance test methods that have been previously accepted [18].

Laverne E. Stetson and Riley George in year 1998 conducted grounding tests on steel poles with and without ground rods. These tests revealed that the steel poles were effectively grounded whether with or without a parallel ground rod. Rock fill around the poles in place of soil did not greatly reduce the grounding resistance to earth [19].

Lisha Li compares the existing compensation methods for operational amplifiers. It explores a method to stabilize the Op-Amps without sacrificing bandwidth. The author also provides sufficient accuracy to predict the circuit performance realistically. The new feed forward compensation method overcomes the serious drawback of the widely used pole splitting method, which greatly narrows the bandwidth. It can improve the phase margin as well as optimize the bandwidth of the Op-Amplifier [20].

The authors observed that the land around most telecommunication buildings has been paved with asphalt or concrete. The measurement itself has become difficult using the traditional earth tester, which uses assistant electrodes; the author developed a new method of measuring the Earth resistance of each of the mutually bonded electrodes under these circumstances [21].

P. Simonds investigated that much of the equipments operates on 5 V or less and is often subjected to higher steady-state transients. A properly designed low-resistance system can ensure the operation of critical equipment that often creates its own hazards, such as harmonics and transients. An additional benefit also comes in enhanced personnel safety [22].

The author presents the converter which is used to alter the DC voltage supplied by the power source. Several DC-DC converters of different types and topologies are described and analyzed. Switched converter of buck topology is discussed. Three control schemes are analyzed PWM (Pulse-Width Modulation), PFM (Phase-Frequency Modulation), and Sliding control. PWM is found to be most appropriate for implementation with this type of converter. Further, basic operation of the buck converter which includes two modes of operation CCM (Continuous-Conduction Mode) and DCM (Discontinuous-Conduction Mode) is described. Finally several techniques for power conversion improvement are presented [23].

Ricky Yuen proposed a fully differential version of the switched Op-Amp along with a fast common mode feedback circuit that reduce the “turn on” time of the Op-Amp such that the sampling frequency can be greatly increased. This improved switched Op-Amp circuit is capable of running at 1.0V [24].

R. J. Gustafson *et.al* in year 1990 presents the results of a 16-month study in the State of Minnesota focused on seasonal variations in distribution system grounding resistance and their effect on Neutral to earth voltage. Neutral to earth (NE) voltage is a potential problem for live stock producers, particularly dairy operations. NE voltages result from the neutral currents on primary and secondary circuits of grounded neutral distribution system. One of the important electrical parameters affecting NE voltage is the grounding

resistance of the distribution system. There is limited data on values of distribution system grounding resistance, particularly variations due to soil types, precipitation, and frozens oil [25].

The author describes a methodology for memory analysis and optimization of embedded system design with the goal of reducing memory usage. It acts as a guide to optimize the memory module of the embedded systems in an efficiently way, by which the design-time optimization can be achieved [26].

Shawn Kuo presents two general types of power amplifiers (PA), linear PAs and switch mode PAs. Switch mode PAs offer better efficiency than linear PAs. In practical designs, efficiency enhancing techniques are used on linear PAs to meet the requisite efficiency while maintaining its linearity. Similarly, switch mode PAs vary their power supply to meet the necessary linearity requirement while keeping its efficiency high. The goal of this design is high efficiency, a switch mode PA will be used [27].

1.3 OBJECTIVE

The objective of this thesis is to measure the earth resistance by using digital micro-controller based resistance measuring circuit. In this we are using three electrodes. The one electrode to which we are giving DC voltage i.e.100Volts generated by Switched Mode Power Supply, another electrode is connected directly with the reference ground and by changing the position of third electrode we are getting the no. of readings. The basic operation of earth tester is to measure the voltages drop and leakage current through ground and correspondingly the value of earth resistance is obtained using micro-controller based circuit. The earth resistance values obtained using the fabricated instrument are compared with those obtained using current injection 3-point method, to check the accuracy of the instrument.

1.4 ORGANIZATION OF THESIS

Chapter 1 includes the basic introduction of earth ground resistance measurement and literature review covering various researches conducted on earth tester and ground resistance measurements techniques.

Chapter 2 covers the brief introduction of earth tester, some important parameters of grounding systems and available methods for measurement of soil resistance.

Chapter 3 includes the designing of PCB (Printed Circuit Board), switched mode power supply, operational amplifiers, 120Hz Frequency generator and it also covers microcontroller section i.e. a measuring section having programming in C language.

Chapter 4 includes results, conclusion and scope for future work.

CHAPTER-2

EARTH TESTER

2.1 INTRODUCTION

The resistance to the earth of any earth electrode is influenced by the resistivity of the surrounding soil. This will depend to a large extent on the nature of the soil and its moisture content. Resistivity may change with depth, temperature, moisture content and can vary from place to place depending on the strata of the soil and rock formation [2,3].

2.2 IMPORTANT PARAMETERS OF GROUNDING SYSTEM

2.2.1 SOIL RESISTIVITY

The performance of a grounding system is highly dependent on the soil resistivity of the area in which grounding system is installed. As such, soil resistivity measurement at the site of the station is required as a first step towards design of grounding system.

The main constituents of earth, silicon oxides and aluminum oxide are excellent insulators. Conductivity of soil is therefore due to presence of salts and moisture and is electrolytic in nature. Conduction in soil being electrolytic in nature, soil resistivity depends on chemical contents, composition and moisture content. Increase in temperature reduces resistivity but effect is more pronounced near freezing temperature.

Soil resistivity in an area is rarely uniform, yet a uniform resistivity soil model has been extensively used in earth electrode performance calculations. This assumption is generally made to simplify calculation but may lead to serious errors [5,13].

2.2.2 GROUND RESISTANCE

The components of total ground resistance are as under.

- Resistance of metallic earth circuit, whether this be conduit sheathing or earth continuity conductor, plus the lead to the earth electrode and electrode itself.
- The contact resistance between surface of electrode and main body of earth.
- The resistance of the body of earth surrounding the electrode.

The resistance of conductor is negligible because it consists of metallic items often of considerable size or cross-sectional area. The second component, the contact resistance is also a negligible part of the total resistance, provided the electrode is not coated with paint or grease etc. and that the soil is packed firmly around it, when installed. Air pockets adjacent to the electrode reduces the area of contact giving higher overall contact resistance, hence rocky soils can present a problem. The third component of total ground resistance is the one, which forms by far the largest proportion that is resistance of the body of soil surrounding the electrode [18,25].

2.2.3 MEASUREMENT OF SOIL RESISTIVITY

The work of designing the grounding electrode begins with measurement of soil resistivity at the site where the electrode is to be placed. It is essential to carry out the soil resistivity measurements at the site of all generating stations and sub stations. Measurement of the soil resistivity yields valuable information which can be useful for strategic planning and design of earthing system [6,7].

A number of methods are available for measurement of soil resistivity at a site. Wenner four electrode method is the most commonly used method and is described below:-

➤ Wenner Four Electrode Method

Soil resistivity can be measured by four-electrode method suggested by Dr.F.Wenner Figure 2.1 shows the test set up of this method. Four metal rods (electrodes) whose diameter is small as compared to its length are driven in to earth at equal distances in a straight line. They are driven such that the depth of insertion is less than 1/10th of the distance between the electrodes. A known current I is passed between electrodes 1 and 4, and potential drop V measured between electrodes 2 and 3.

The current I produces an electric field proportional to current density and soil resistivity. The voltage is proportional to this field. Therefore the soil resistivity is proportional to the ratio V/I and is given by

$$\rho = \frac{4\pi DR}{1 + 2D/\sqrt{(D^2 + 4h^2)} - D/\sqrt{D^2 + h^2}} \quad \dots\dots 1.1$$

Where ρ = Soil resistivity in Ωm

D = Horizontal distance between two successive electrodes in m

h = Depth of Burial in m

$R=V/I$ = Resistance in Ω

If $h \ll D$ equation 1.1 is simplified to

$$\rho = 2\pi DR$$

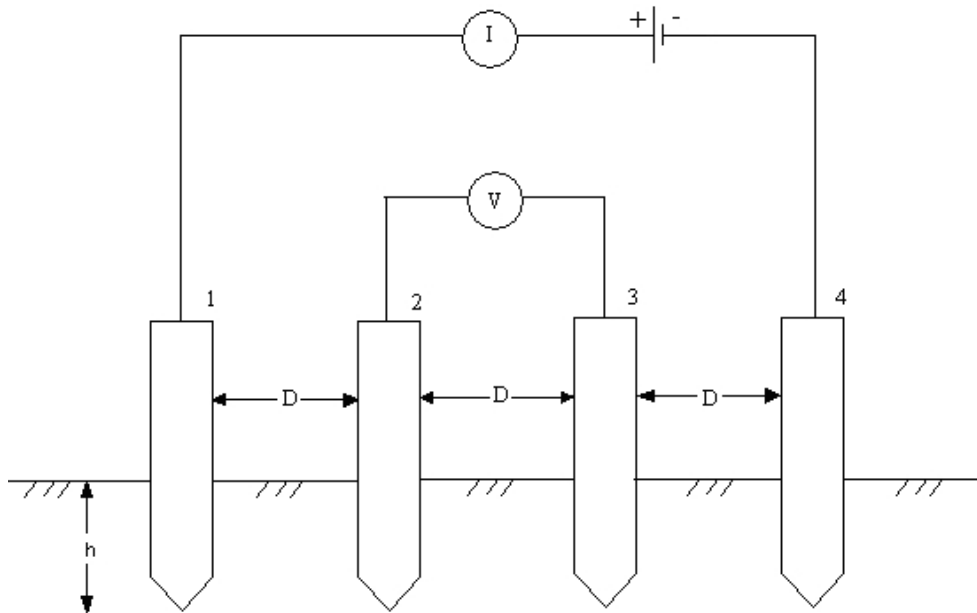


Figure 2.1 Four Electrode Method

For the measurement in the field, earth testers based upon the above principles are available. They are calibrated to indicate the ratio V/I directly. The measurement of the resistivity is to be made along a number of radial lines at different locations such that the whole area of the station is covered. The spacing between the probes should be varied from the smallest values of 0.5 or 1 meter to large values depending upon size of the station and the conditions on the ground. The largest spacing will depend on the space available. The soil along the radial should be free from buried conductive pipes and it should not be recently filled and therefore not yet compacted. For convenience, one probe may be fixed near the location of earth tester and the other three moved as required [8,10].

2.2.4 MEASUREMENT OF GROUND RESISTANCE

Ground resistance is the resistance of soil to the passage of electric current. Compared to a copper conductor, the earth could be regarded as a relatively poor conductor of electricity. However, because of enormous mass and hence large cross sectional area for current path its resistance is quite low and earth in reality, therefore, acts as a good conductor. Fall of potential method is most commonly used for measurement of earth resistance and is described in next section [9,10].

➤ Fall of Potential Method

This method essentially consists of measuring the resistance of a single ground rod, driven to different depths. It is also known as three-pin method. The test set up of this method is shown in Figure 2.2. A known current is circulated between the ground rod (test electrode) and the auxiliary electrode, which is far away from the sub-station site. The potential difference between the ground rod and the potential electrode P is measured. The Fall of Potential curve can be obtained by placing the potential electrode P at various points between the ground rod i.e. electrode under test and auxiliary electrode with the three electrodes being in straight line [14,21].

If the test and the auxiliary electrodes are sufficiently apart the zones of influence of the two electrodes are such that the potential electrode shall pass from the zone of one to that of other as the distance from the test electrode increases. The fall of potential curve then has a portion that appears to be nearly flat as shown in figure 2.3. If the distance between the electrodes is not very large, the flat portion does not exist.

When the soil structure is not uniform, the fall of potential curve may not exhibit any flat portion, for even large separation between the two electrodes. In case of flat portion of the curve is not obtained, computer analysis of the test arrangement shall have to be made to obtain the ground resistance of the test electrode by comparing the experimental fall of potential curve with the compared curve [14,15,16].

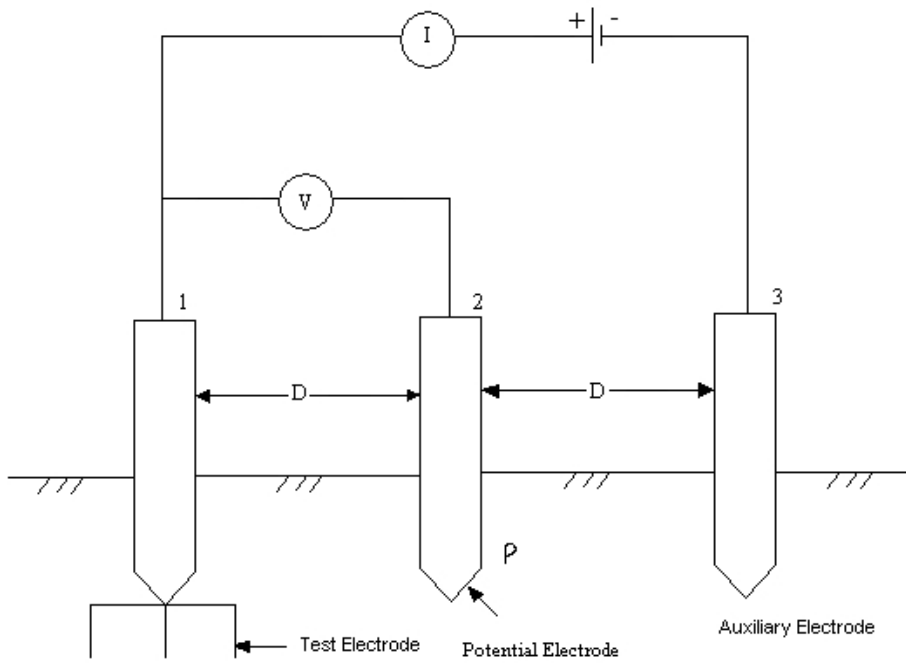


Figure 2.2 Configuration of Electrodes for Measurement of Ground Resistance

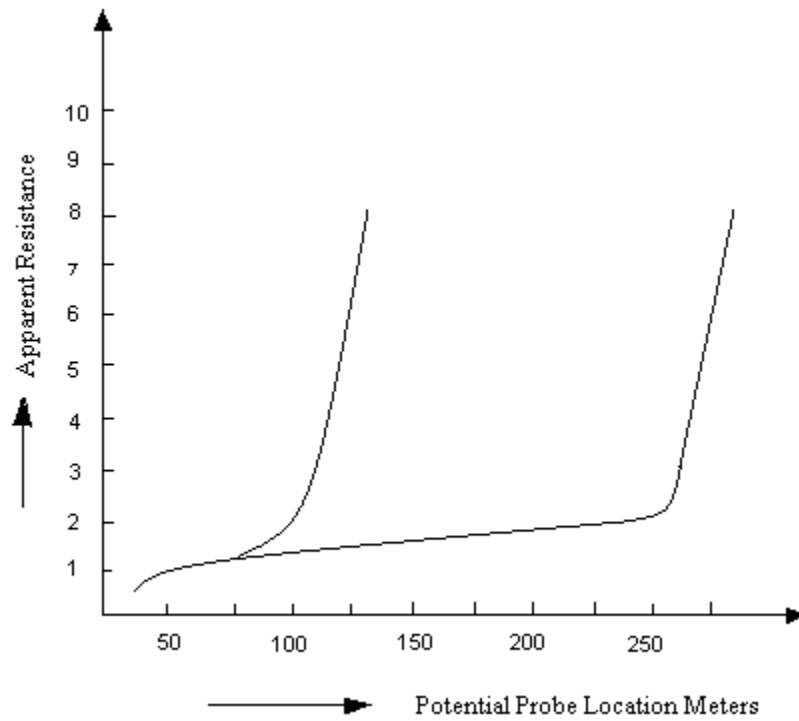


Figure 2.3 Electrode Spacing Effects-Uniform Soil

2.3 PRECAUTIONS WHILE MAKING MEASUREMENTS

i) Current and Voltage Leads

There can be mutual effect between the current and potential leads. Since the voltage being measured is small, it is advisable that the current and the potential leads are kept a distance from each other to minimize the induction effect. It is preferable that the two are mutually perpendicular.

ii) Potential Probe

The potential electrode should make good contact with soil at the point of measurement. A little water may be poured at the point to facilitate good contact.

iii) Leads

Flexible test leads must be used since these have to be wound up several times during the measurements. Adequate length of such leads must be available and test lead impedance must be low. Steel or copper rods may be used as ground probes and these should have pointed ends. The top portion of these rods should be insulated with insulated tape for safe handling [14,19].

2.4 DESIGN REQUIREMENTS

The equipment to be designed in this work is to satisfy the following requirements:

- i) It should be small in size.
- ii) It should be portable and easily transportable.
- iii) It should operate on battery.

3.1 PCB DESIGNING

PCB stands for “PRINTED CIRCUIT BOARD”. Printed circuit board (PCB) provides both the physical structure for mounting and holding the components as well as the electrical interconnection between the components. That means a PCB = PWB (printed wiring board) is the platform upon which electronic components such as integrated circuit chips and other components are mounted. A PCB consists of a non-conducting substrate (typically fiber glass with epoxy as resin) upon which the conductive pattern or circuitry is formed. Copper is the most prevalent conductor although nickel, silver and tin are also used in some cases.

3.1.1 TYPES OF PCB

PCB may be of different types:-

- 1) Single-sided
 - 2) Double-sided
 - 3) Multilayer
- **Single sided PCBs:** - As the name suggest in these designs the conductive pattern is only at in one side. And also the size is large in these case but these are cheap.
 - **Double sided PCBs:** - These are the PCBs on which the conductive pattern is in on both sides. The size of board is small in this case but it is costlier than that of above.
 - **Multilayer PCBs:** - In this case the board consists of alternating layers of conducting pattern and insulating material. The conductive material is connected across the layers through plated through holes. The size of this PCB is smaller than that of double sided PCB but it is very costly.

PCBs may also be either rigid, flexible, or the combination of two (rigid-flex). When the electronic components have been mounted on the PCB, the combination of PCB and components is an electronic assembly, also called PRINTED CIRCUIT

ASSEMBLY. This assembly is the basic building block for all the electronic appliances such as television, computer and other goods.

3.1.2 FUNCTIONS OF PCB

Printed circuited boards are dielectric substrates with metallic circuitry formed on that. They are sometimes referred to as the base line in electronic packaging. Electronic packaging is fundamentally an inter connection technology and the PCB is the baseline building block of this technology.

3.1.3 TECHNIQUE USED FOR PCB DESIGN

There are mainly two techniques which are use for the PCB designs.

1. Hand Taping
2. Computer Aided Design

1) PCB

(i) USING HAND TAPING

- PCB design using hand taping is the process of technical drawing.
- In hand taping method layout should be prepared on grid paper.
- In hand taping, components pads can be prepared by using black pads.
- Routing of the board can be done by tapes with different widths.
- Each layer (top, bottom) has to prepare separately.

Disadvantages of Hand-Taping For PCB Designing

- Each layer has to be designed separately.
- We cannot generate NCD files for CNC drilling.
- Difficult to modify the design in the designing process or after designing.
- Difficult to get good design overview.

(ii) PCB DESIGNING USING CAD

All the above difficulties can be removed by using CAD system. CAD system for PCB designing requires following:

- A computer system.
- PCB design software like OrCad, CADSTAR, Protel, TANGO, Mentor etc.

- A photo plotter for art work generation.

There are many enhanced features in electronics design automation tools which not possible in the hand taping. The main advantages are given below:

- Auto placement
- Auto routing
- After routing, optimization of tracks can be done
- Provides physical design reuse modules
- Electrical rule check (ERC)
- All the layers are generated from the same design by giving different options
- Bill of material can be generated which contains number of different components used
- We can draw conductors as an arc, semi-circular at different angles.
- Design Rule Check
- Advanced CAD systems have high speed analysis
- CAD system provides all NCD files and Gerber data files for photo plotting

3.1.4 BASIC DESIGN STEPS IN CAD- SYSTEM

The following design steps are very common while designing a PCB in CAD:

- Entry the schematic diagram
- Net list file creation
- Placement of components manually or automatically
- Routing of the board using manual routing tools or auto router
- Design rule check physical and electrical
- Artwork generation

3.1.5 PCB DESIGN SOFTWARE

There many software which are used for PCB designs. Some of them are given below:-

- OrCad
- CADSTAR
- Protel

- TANGO
- Mentor

The most commonly software which are used for PCB design in India are Protel and OrCad.

3.2 POWER SUPPLY DESIGN

First part of electronics ckts. is power supply. The main power supply is in AC but mostly electronic ckts. work with DC. So a system is required to convert AC to DC and these sources should able to produce stable supplies [1,22].

Power supplies may be used in different types such as regulated, unregulated, SMPS etc.

- **UNREGULATED POWER SUPPLIES**

These are the power supplies in which the output is not constant. That it is varies with input voltage, load, and also effected by the environment conditions such as temperature, etc. so these are the variable supplies. Commonly these supplies are not employed as there efficiency is very less. The unregulated power can be obtained using rectifying circuit after AC supply [4].

- **REGULATED POWER SUPPLIES**

These are the power supplies in which the output voltage is constant, i.e. the output voltage is independent of the input voltage, load and other external conditions, so to obtain the regulated voltage using different regulators. The regulator voltage is mainly the DC voltage; it may AC to DC or DC to DC voltage. A better approach to power supply design is to use enough capacitance to reduce ripple to low level, then use an active feedback circuit to eliminate the remaining ripple and dependence of output voltage on input, load and environment conditions. These active devices are known as Regulators. These regulators can be used to produce negative and positive voltage of required value [11].

The voltage regulators are of three types:-

- 1) Constant positive voltage regulators
- 2) Constant negative voltage regulators
- 3) Variable voltage regulators

1) Constant Positive Voltage Regulators:-These are the regulators which are able to produce positive and constant voltage. These regulators are used according to the required voltage need. Some of them are given below:-

Table 3.1: Constant Positive Voltage Regulators

S. no.	Name of regulator	Output voltage
1	LM 7805	5V
2	LM 7810	10V
3	LM 7812	12V
4	LM 7815	15V

The LM78XX series of three terminal positive regulators are available in the TO-220 package and with several fixed output voltages, making them useful in a wide range of applications. Each type employs internal current limiting, thermal shut down and safe operating area protection, making it essentially indestructible. If adequate heat sinking is provided, they can deliver over 1A output current. Although designed primarily as fixed voltage regulators, these devices can be used with external components to obtain adjustable voltages and currents.

2) Constant Negative Voltage Regulators:-These are also the constant output voltage regulator but there output is negative in polarity. These regulators are also employed according to voltage requirements. Some of them are given below with there outputs:-

Table 3.2: Constant Negative Voltage Regulators

S. no	Name of regulator	Output voltage
1	LM7905	-5V
2	LM7910	-10V

3	LM7912	-12V
4	LM7915	-15V

3) Variable Voltage Regulators:-These are the regulator whose output voltage can be varied according to the desired need. These regulators again of two types i.e.:-

- Positive
- Negative

The output of these regulators can be varied by varying the resistance of the variable resistance which is connected to the adjustable pin the regulators. So these are the most commonly used regulators in the electronic industry as wide range of stable voltage can be obtained from single chip by varying the resistance connected to the adjustable pin of the regulators. The most commonly used variable regulators are:-

- LM317 (it is positive regulator)
- LM 337(it is negative regulator)

3.3 SWITCH MODE POWER SUPPLY

The switch mode regulated power supply is increasing in popularity because it offers the advantages of higher power conversion efficiency and increased design flexibility (multiple output voltages of different polarities can be generated from a single input voltage).The operating principles of the four most commonly used switching converter are:-

Buck: used to reduce a DC voltage to a lower DC voltage.

Boost: provides an output voltage that is higher than the input.

Buck-Boost (invert): an output voltage is generated opposite in polarity to the input.

Fly back: an output voltage that is less than or greater than the input can be generated, as well as multiple outputs [12].

3.3.1 SWITCHING FUNDAMENTALS

Before beginning explanations of converter theory, some basic elements of power conversion will be presented:

Transformer Operation

A transformer is a device that has two or more magnetically-coupled windings. The action of a transformer is such that a time-varying (AC) voltage or current is transformed to a higher or lower value, as set by the transformer turns ratio. The basic operation is shown in Figure:-

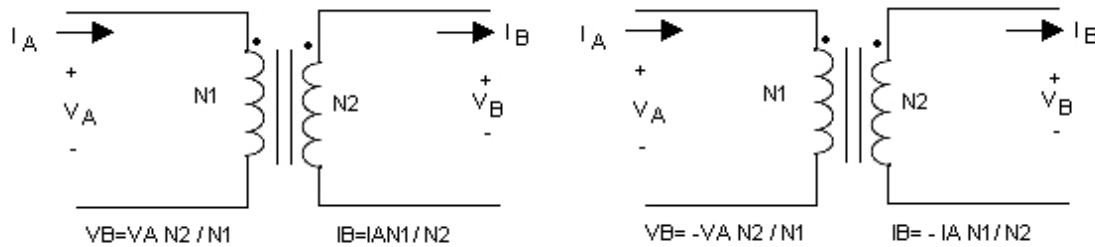


Fig.3.1 Transformer Theory

The transformer does not add power, so it follows that the power ($V \times I$) on either side must be constant. That is the reason that the winding with more turns has higher voltage but lower current, while the winding with less turns has lower voltage but higher current. The dot on a transformer winding identifies its polarity with respect to another winding, and reversing the dot results in inverting the polarity [23].

3.3.2 PULSE WIDTH MODULATION (PWM)

Pulse-width modulation (PWM), which controls the power switch output power by varying its ON and OFF times. The ratio of ON time to the switching period time is the duty cycle. The higher the value of duty cycle, the higher the power semiconductor switch output power. An efficient technique employs pulse width modulation (PWM) to produce the constant current through the coil. The duty cycle can be anywhere from 0, the signal is always off, to 1, where the signal is constantly on. A 50% D results in a perfect square wave. A few terms are associated with PWM [17]:-

Period - how long each complete pulse cycle takes.

Frequency - how often the pulses are generated. This value is typically specified in Hz (cycles per second).

Duty Cycle - refers to the amount of time in the period that the pulse is active or high. Duty Cycle is typically specified as a percentage of the full period.

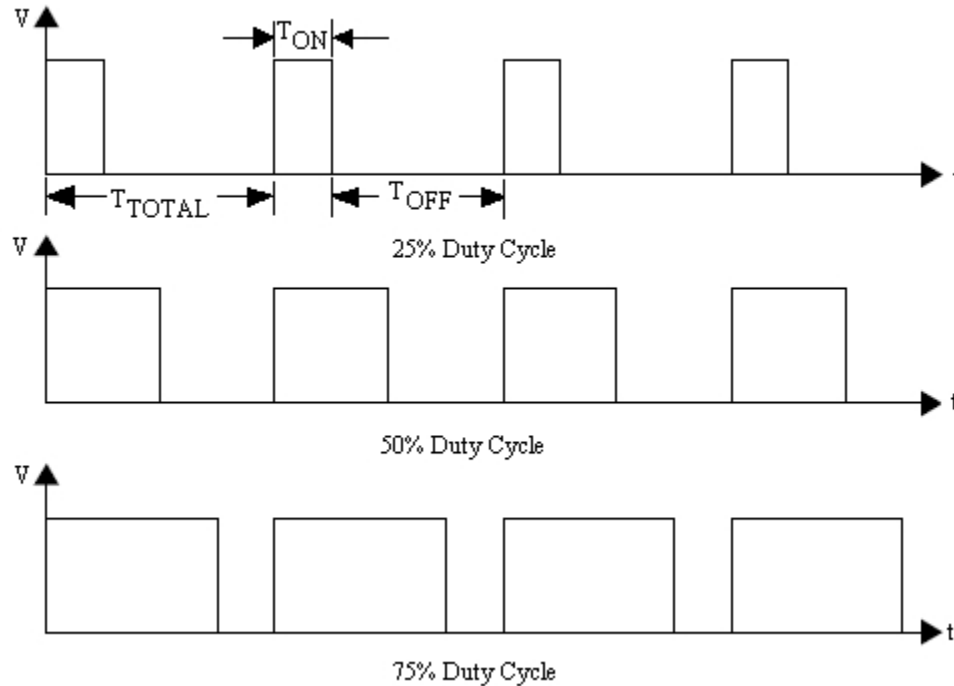


Fig.3.2 Duty Cycles

All of the switching converters use a form of output voltage regulation known as Pulse Width Modulation (PWM). The series of square wave pulses is filtered and provides a DC output voltage that is equal to the peak pulse amplitude multiplied times the duty cycle (duty cycle is defined as the switch ON time divided by the total period). This relationship explains how the output voltage can be directly controlled by changing the ON time of the switch [27].

3.3.3 SWITCHING CONVERTER TOPOLOGIES

The most commonly used DC-DC converter circuits will now be presented along with the basic principles of operation.

➤ **Buck Regulator**

The most commonly used switching converter is the Buck, which is used to down-convert a DC voltage to a lower DC voltage of the same polarity. This is essential

in systems that use distributed power rails (like 24V to 48V), which must be locally converted to 15V, 12V or 5V with very little power loss. The Buck converter uses a transistor as a switch that alternately connects and disconnects the input voltage to an inductor.

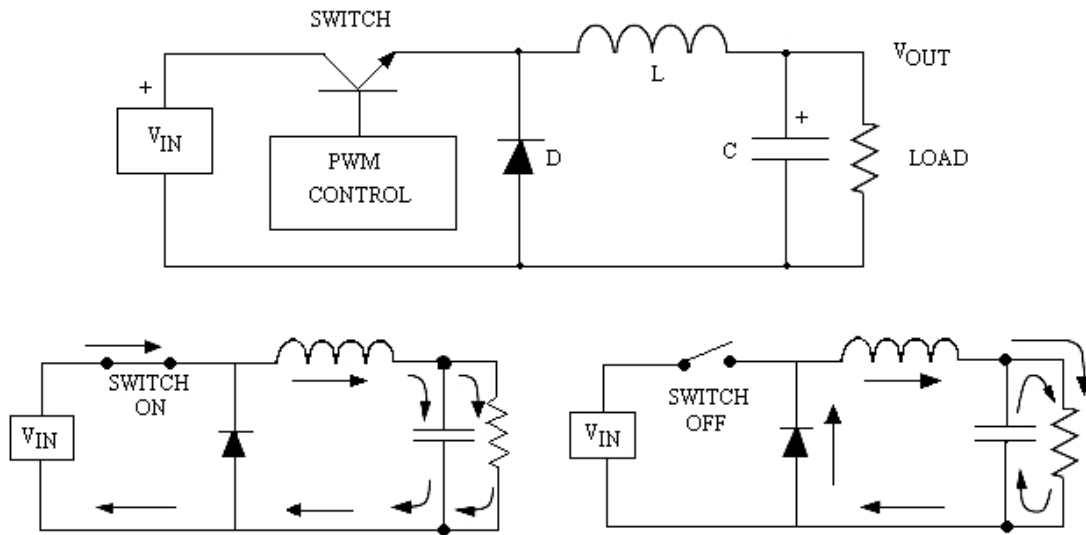


Fig.3.3 Buck regulator

Fig.3.3 shows the current flow paths when the switch is on and off. When the switch turns on, the input voltage is connected to the inductor. The difference between the input and output voltages is then forced across the inductor, causing current through the inductor to increase. During the on time, the inductor current flows into both the load and the output capacitor (the capacitor charges during this time). When the switch is turned off, the input voltage applied to the inductor is removed. However, since the current in an inductor can not change instantly, the voltage across the inductor will adjust to hold the current constant. The input end of the inductor is forced negative in voltage by the decreasing current, eventually reaching the point where the diode is turned on. The inductor current then flows through the load and back through the diode. The capacitor discharges into the load during the off time, contributing to the total current being supplied to the load (the total load current during the switch off time is the sum of the inductor and capacitor current). The shape of the current flowing in the inductor is shown in Fig.3.4.

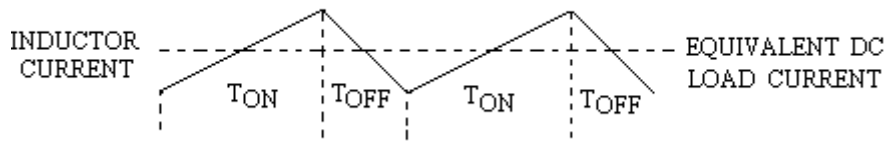


Fig.3.4 Buck Regulator Inductor Current

As explained, the current through the inductor ramps up when the switch is on, and ramps down when the switch is off. The DC load current from the regulated output is the average value of the inductor current. The peak-to-peak difference in the inductor current waveform is referred to as the inductor ripple current, and the inductor is typically selected large enough to keep this ripple current less than 20% to 30% of the rated DC current [1,4].

Continuous Vs. Discontinuous Operation

In most Buck regulator applications, the inductor current never drops to zero during full-load operation (this is defined as continuous mode operation). Overall performance is usually better using continuous mode, and it allows maximum output power to be obtained from a given input voltage and switch current rating. In applications where the maximum load current is fairly low, it can be advantageous to design for discontinuous mode operation. In these cases, operating in discontinuous mode can result in a smaller overall converter size (because a smaller inductor can be used). Discontinuous mode operation at lower load current values is generally harmless, and even converters designed for continuous mode operation at full load will become discontinuous as the load current is decreased.

➤ Boost Regulator

The Boost regulator takes a DC input voltage and produces a DC output voltage that is higher in value than the input (but of the same polarity). The Boost regulator is shown in Fig.3.5 along with details showing the path of current flow during the switch on and off time.

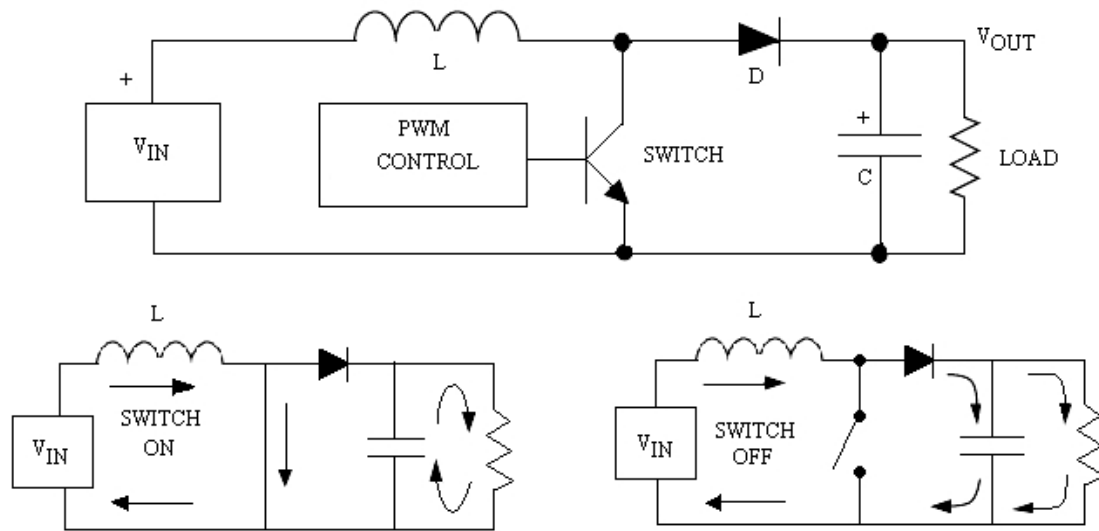


Fig.3.5 Boost regulator

Whenever the switch is on, the input voltage is forced across the inductor which causes the current through it to increase (ramp up).

When the switch is off, the decreasing inductor current forces the "switch" end of the inductor to swing positive. This forward biases the diode, allowing the capacitor to charge up to a voltage that is higher than the input voltage. During steady-state operation, the inductor current flows into both the output capacitor and the load during the switch off time. When the switch is on, the load current is supplied only by the capacitor.

An important design consideration in the Boost regulator is that the output load current and the switch current are not equal, and the maximum available load current is always less than the current rating of the switch transistor. It should be noted that the maximum total power available for conversion in any regulator is equal to the input voltage multiplied times the maximum average input current (which is less than the current rating of the switch transistor). Since the output voltage of the Boost is higher than the input voltage, it follows that the output current must be lower than the input current [1].

➤ **Buck-Boost (Inverting) Regulator**

The Buck-Boost or Inverting regulator takes a DC input voltage and produces a DC output voltage that is opposite in polarity to the input. The negative output voltage can be either larger or smaller in magnitude than the input voltage.

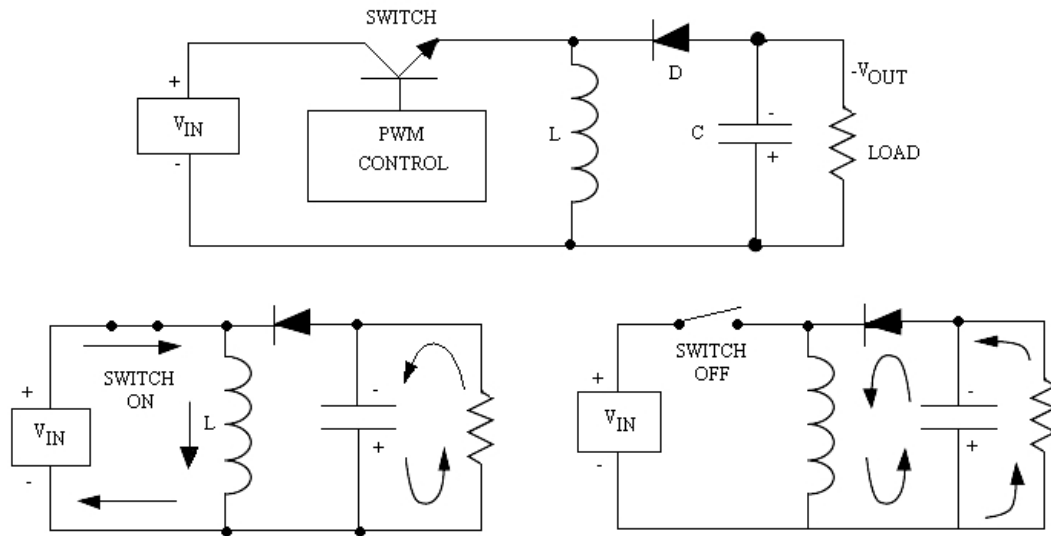


Fig.3.6 Buck- boost regulator

When the switch is on, the input voltage is forced across the inductor, causing an increasing current flow through it. During the on time, the discharge of the output capacitor is the only source of load current.

This requires that the charge lost from the output capacitor during the on time be replenished during the off time. When the switch turns off, the decreasing current flow in the inductor causes the voltage at the diode end to swing negative. This action turns on the diode, allowing the current in the inductor to supply both the output capacitor and the load. As shown in fig.3.6 the load current is supplied by inductor when the switch is off, and by the output capacitor when the switch is on [4,11].

➤ **Fly back Regulator**

The Fly back is the most versatile of all the topologies, allowing the designer to create one or more output voltages, some of which may be opposite in polarity. Fly back converters have gained popularity in battery-powered systems, where a single voltage must be converted into the required system voltages (for example, +5V, +12V and -12V) with very high power conversion efficiency. The basic single-output fly back converter is shown in Fig.3.7.

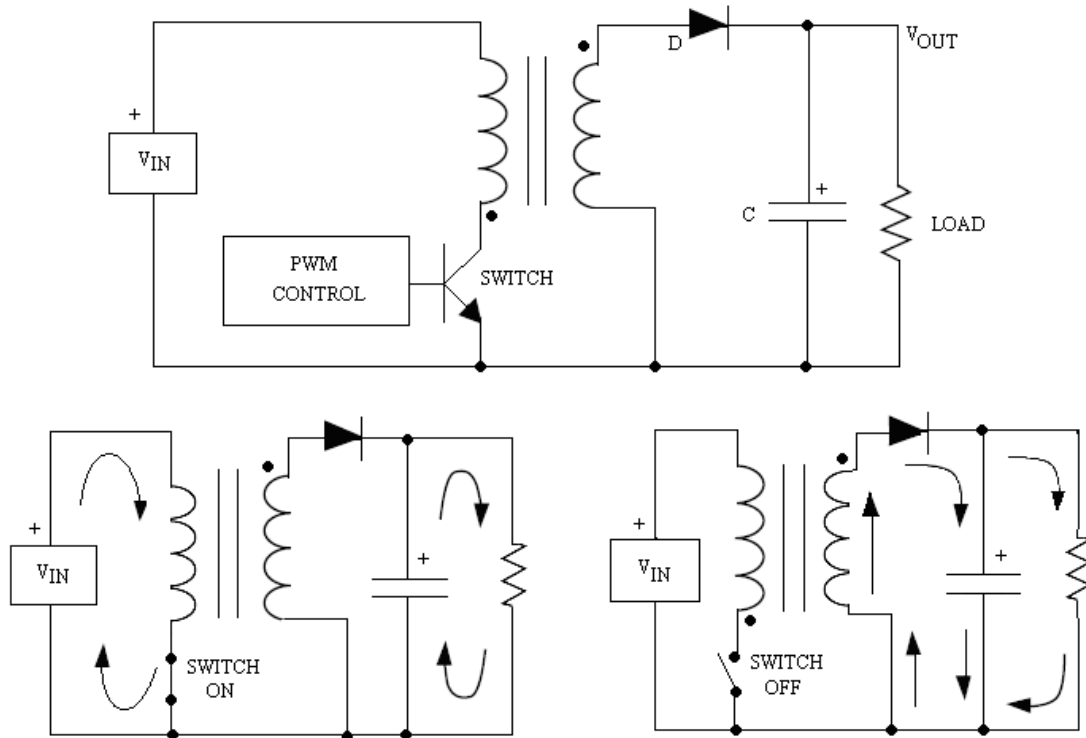


Fig.3.7 Fly back regulator

The most important feature of the Fly back regulator is the transformer phasing, as shown by the dots on the primary and secondary windings. When the switch is on, the input voltage is forced across the transformer primary which causes an increasing flow of current through it. Note that the polarity of the voltage on the primary is dot-negative, causing a voltage with the same polarity to appear at the transformer secondary. The dot-negative voltage appearing across the secondary winding turns off the diode, preventing current flow in the secondary winding during the switch on time. During this time, the load current must be supplied by the output capacitor alone. When the switch turns off, the decreasing current flow in the primary causes the voltage at the dot end to swing positive. At the same time, the primary voltage is reflected to the secondary with the same polarity. The dot-positive voltage occurring across the secondary winding turns on the diode, allowing current to flow into both the load and the output capacitor. The output capacitor charge lost to the load during the switch on time is replenished during the switch off time. Fly back converters operate in either continuous mode (where the secondary current is always >0) or discontinuous mode [4].

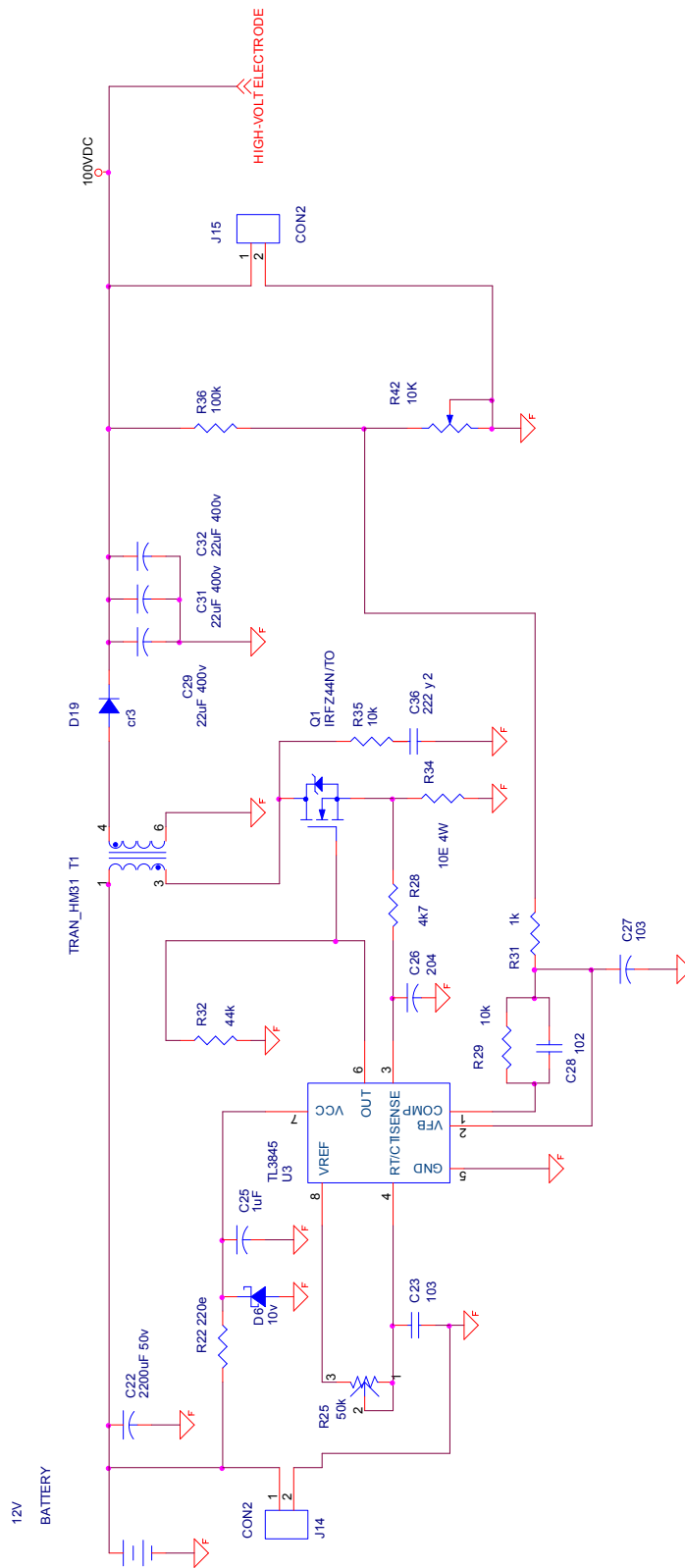


Fig.3.8 SMPS with Fly back Topology

3.3.4 GENERATING MULTIPLE OUTPUTS

Another big advantage of a Fly back is the capability of providing multiple outputs (see Fig.3.9). In such applications, one of the outputs (usually the highest current) is selected to provide PWM feedback to the control loop, which means this output is directly regulated. The other secondary winding(s) are indirectly regulated, as their pulse widths will follow the regulated winding. The load regulation on the unregulated secondary is not great (typically 5 - 10%), but is adequate for many applications. If tighter regulation is needed on the lower current secondary, an LDO post-regulator is an excellent solution. The secondary voltage is set about 1V above the desired output voltage, and the LDO provides excellent output regulation with very little loss of efficiency [23].

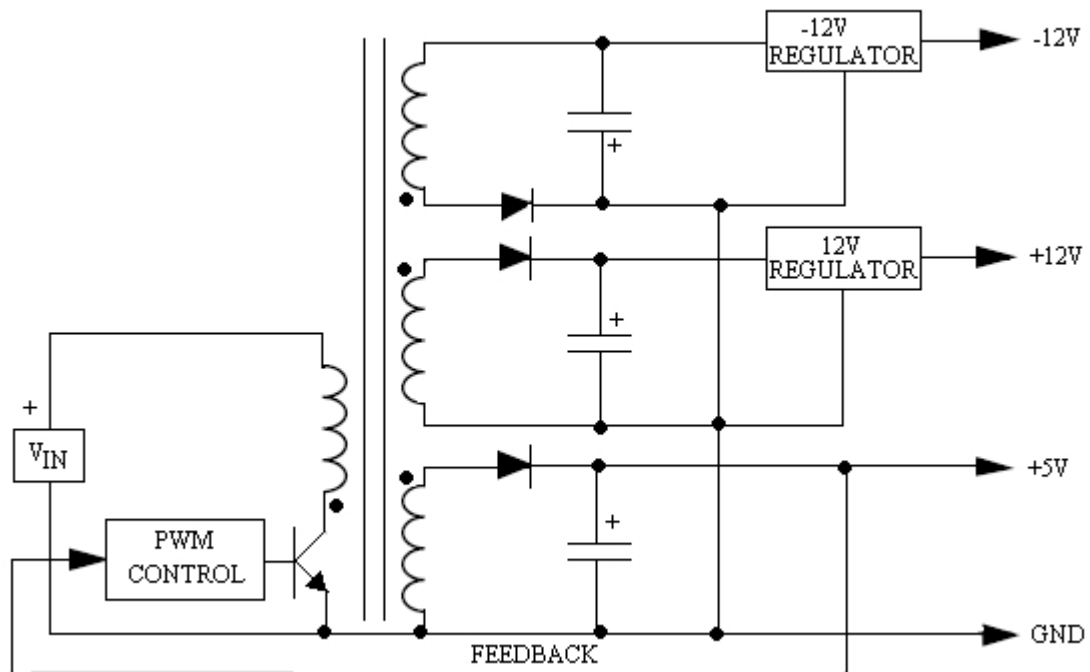


Fig.3.9 Typical multiple output fly back

3.4 OPERATIONAL AMPLIFIERS

Operational Amplifier offers excellent performance in applications requiring low offset voltage; low drift with time and temperature and very low noise. Linear's OP-07 is interchangeable with many of the precision Op-Amp device types. The OP-07 also offers a wide input voltage range, high common mode rejection and low input bias current. These features result in optimum performance for small signal level and low frequency applications. Use of advanced design, processing and testing techniques make Linear's OP-07 a superior choice over similar products [20].

3.4.1 FEATURE

1. Drift: 1.3 V/ C Max
2. Ultra-Stable vs. Time: 1.5 V/Month Max
3. Low Noise: 0.6 Vp-p Max
4. Wide Input Voltage Range: 14 V
5. Wide Supply Voltage Range: 3 V to 18 V
6. Fits 725,108A/308A, 741, AD510 Sockets
7. 125 C Temperature-Tested Dice.

3.4.2 APPLICATIONS

- Thermocouple Amplifiers
- Strain Gauge Amplifiers
- Low Level Signal Processing
- Medical Instrumentation [24].

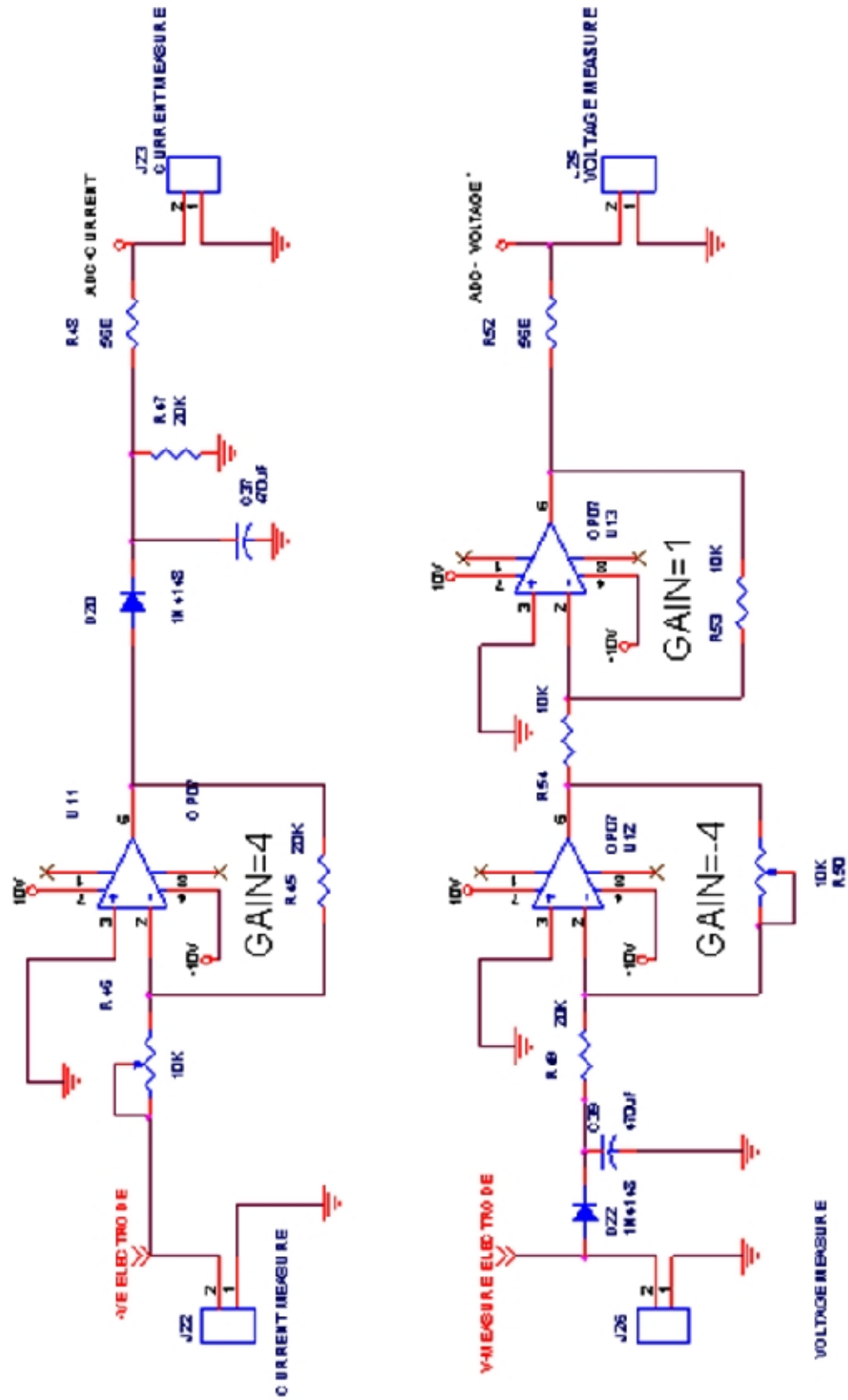


Fig.3.10 Operational amplifier circuit for V-measuring A/DC and I- Measuring A/DC

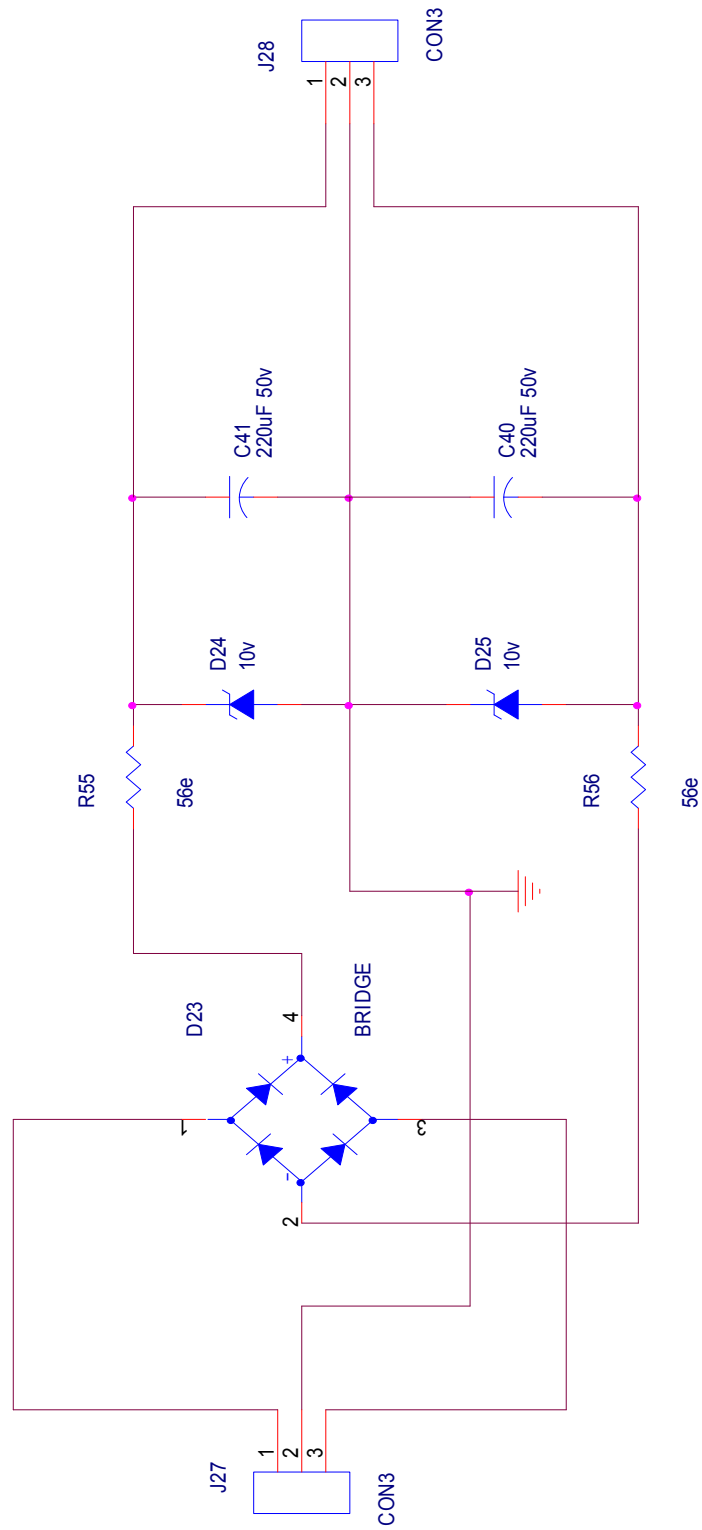


Fig.3.11 Power supply for Op-Amp Sections

3.5 120Hz FREQUENCY GENERATOR & SWITCHING SECTION

3.5.1 120Hz FREQUENCY GENERATOR INTRODUCTION

The 556 timer is one of the most useful electronic devices in the market. The 556 timer was first introduced by Signetics but today it is manufactured by almost every semiconductor firm. For this reason it is very cheap and broadly available. These devices are precision monolithic timing circuits capable of producing accurate time delays or oscillation. In the time-delay or mono stable mode of operation, the timed interval is controlled by a single external resistor and capacitor network. In the stable mode of operation, the frequency and duty cycle may be independently controlled with two external resistors and a single external capacitor.

The 556 has some unique advantages and capabilities, such as: low- price, big range of operating voltage (5-15V), the capacity to drive ``high" currents, the ability of being reset by small currents and the design to be used as a stable or multi-vibrator.

3.5.2 APPLICATIONS

The broad use of the 556 timer is in both astable and mono stable modes. On the other hand the 556 can be an inexpensive alternative to many other different chips; therefore it is possible to solve many problems.

- Low turn off time
- Maximum operating frequency greater than 500 KHz
- Timing from microseconds to hours operates in both astable and monostable modes
- High output current can source or sink 200mA
- Adjustable duty cycle
- TTL compatible temperature stability of 0.005% per °C

3.5.3 PIN DESCRIPTION OF 556 TIMER

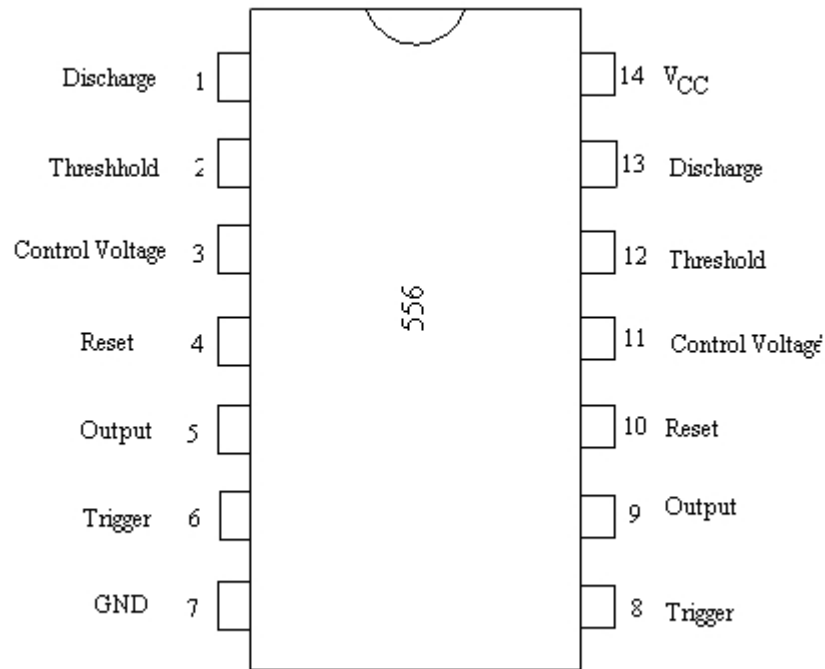


Fig.3.12 556 Timer

3.5.4 SWITCHING SECTION

For switching purpose here we are using MOSFET (Metal oxide Field Effect Transistor). The n-type Metal-Oxide-Semiconductor Field-Effect-Transistor (MOSFET) consists of a source and a drain, two highly conducting n-type semiconductor regions which are isolated from the p-type substrate by reversed-biased p-n diodes. A metal (or poly-crystalline) gate covers the region between source and drain, but is separated from the semiconductor by the gate oxide. In this circuit we are using IRFZ44N/TO [28,29,30].

SYMBOLIZATION

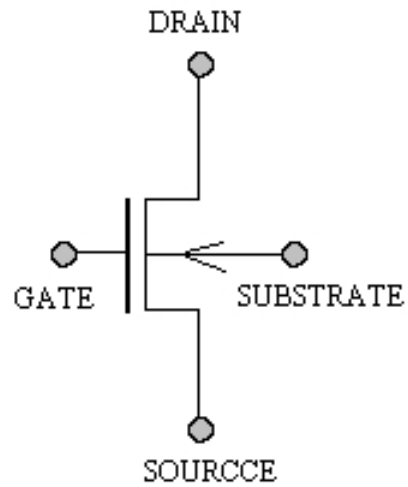


Fig.3.13 Symbol of MOSFET

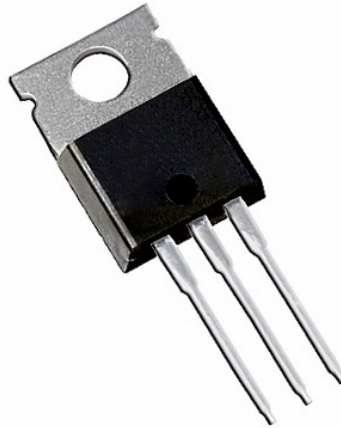


Fig.3.14 TO-220 Package

CONFIGURATION

- IRFZ44 - Power MOSFET
- $V_{dss}=55V$
- $R_{DS(ON)}=17.5m\Omega$
- $I_D=49A$
- $175^{\circ}C$ Operating Temperature
- Fast switching
- Maximum power 150W

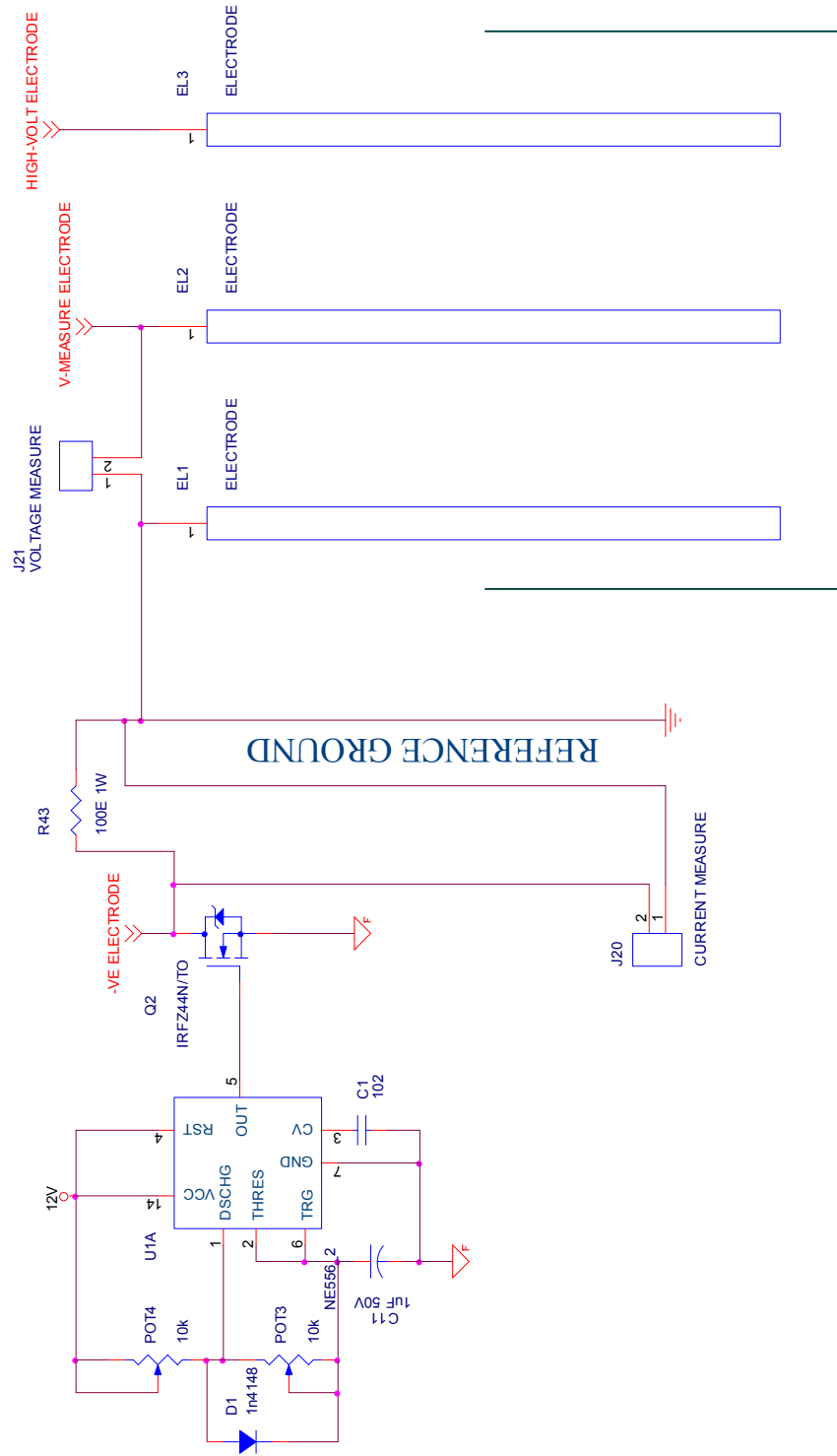


Fig.3.15 120Hz Frequency generating circuit with Switching Circuit

3.6 EMBEDDED SYSTEM

Embedded system employs a combination of software & hardware to perform a specific function. It is a part of a larger system which may not be a “computer” Works in a reactive & time constrained environment.

Any electronic system that uses a CPU chip, but that is not a general-purpose workstation, desktop or laptop computer is known as embedded system. Such systems generally use microprocessors; microcontroller or they may use custom-designed chips or both. They are used in automobiles, planes, trains, space vehicles, machine tools, cameras, consumer and office appliances, cell phones and other handhelds as well as robots and toys. The uses are endless, and billions of microprocessors are shipped every year for a myriad of applications [26].

In embedded systems, the software is permanently set into a read-only memory such as a ROM or flash memory chip, in contrast to a general-purpose computer that loads its programs into RAM each time. Sometimes, single board and rack mounted general-purpose computers are called "embedded computers".

Embedded System Applications:-

- Consumer electronics, e.g., cameras, cell phones etc.
- Consumer products, e.g. washers, microwave ovens etc.
- Automobiles (anti-lock braking, engine control etc.)
- Industrial process controller & defense applications.
- Computer/Communication products, e.g. printers, FAX machines etc.
- Medical Equipments.
- ATMs
- Aircrafts

Mainly the people are confused between microprocessor and microcontroller; to vanish this confusion, the difference between microprocessors and microcontrollers are as follow:-

- A Microprocessor is a general purpose digital computer central processing unit (C.P.U) popularly known as CPU on the chip. The Microprocessors contain no RAM, no ROM, and no I/P O/P ports on the chip itself.

- On the other hand a Microcontroller has a C.P.U (microprocessor) in addition to a fixed amount of RAM, ROM, I/O ports and a timer all on a single chip.
- In order to make a Microprocessor functional we must add RAM, ROM, I/O Ports and timers externally to them i.e any amount of external memory can be added to it.
- But in controllers there is a fixed amount of memory which makes them ideal for many applications.
- The Microprocessors have many operational codes for moving data from external memory to the C.P.U.
- Whereas Microcontrollers may have one or two operational codes.

Disadvantages of microprocessors over microcontrollers are as follow:-

- System designed using Microprocessors are bulky
- They are expensive than Microcontrollers
- We need to add some external devices such as PPI chip, Memory, Timer/counter chip, Interrupt controller chip, etc. to make it functional.

3.6.1 AT89S8252 MICRO-CONTROLLER

AT89S8252 is an ATMEL controller with the core of intel MCS-51. It has same pin configuration as 8051 microcontroller. The AT89S8252 is a low-power, high-performance CMOS 8-bit microcomputer with 8K bytes of Downloadable Flash programmable and erasable read only memory and 2K bytes of EEPROM. The device is manufactured using Atmel's high density nonvolatile memory technology and is compatible with the industry standard 80C51 instruction set and pin out. The on-chip Downloadable Flash allows the program memory to be reprogrammed in-system through an SPI serial interface or by a conventional nonvolatile memory programmer. By combining a versatile 8-bit CPU with Downloadable Flash on a monolithic chip, the Atmel AT89S8252 is a powerful microcomputer which provides a highly flexible and cost effective solution to many embedded control applications. The AT89S8252 provides the following standard features: 8K bytes of Downloadable Flash, 2K bytes of EEPROM,

256 bytes of RAM, 32 I/O lines, programmable watchdog timer, two Data Pointers, three 16-bit timer/counters, a six-vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator, and clock circuitry. In addition, the AT89S8252 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The Idle Mode stops the CPU while allowing the RAM, timer/counters, serial port, and interrupt system to continue functioning. The Power down Mode saves the RAM contents but freezes the oscillator, disabling all other chip functions until the next interrupt or hardware reset.

The Downloadable Flash can be changed a single byte at a time and is accessible through the SPI serial interface. Holding RESET active forces the SPI bus into a serial programming interface and allows the program memory to be written to or read from unless Lock Bit 2 has been activated [28,29,30].

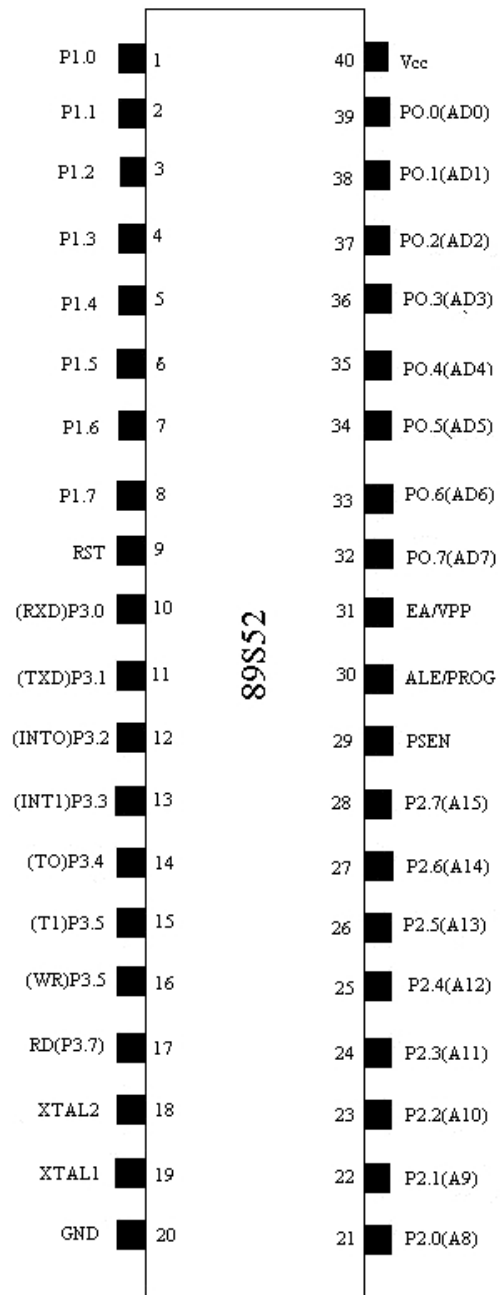


Fig.3.16 Pin diagram of AT89S8252

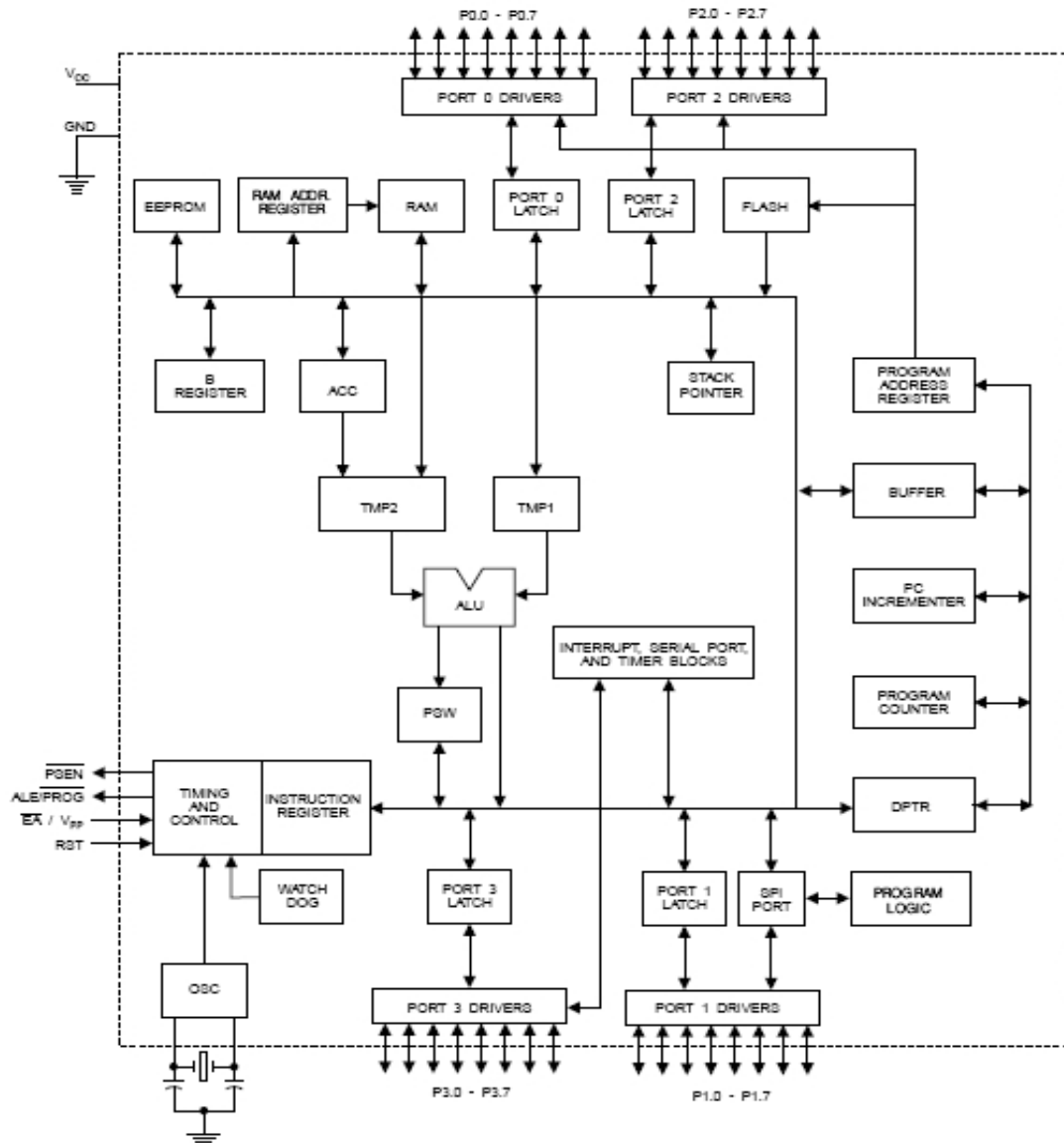


Fig.3.17 Block diagram of AT89S8252

3.6.1.1 Features

- 8K bytes of In-System Reprogrammable Downloadable Flash Memory
- ✓ SPI Serial Interface for Program Downloading
- ✓ Endurance: 1,000 Write/Erase Cycles
- 2K bytes EEPROM
- ✓ Endurance: 100,000 Write/Erase Cycles
- 4.0V to 6V Operating Range
- Fully Static Operation: 0 Hz to 24 MHz

- Three-Level Program Memory Lock
- 256 x 8 bit Internal RAM
- 32 Programmable I/O Lines
- Three 16 bit Timer/Counters
- Nine Interrupt Sources
- Programmable UART Serial Channel
- SPI Serial Interface
- Low Power Idle and Power Down Modes
- Interrupt Recovery From Power Down
- Programmable Watchdog Timer
- Dual Data Pointer
- Power Off Flag

3.6.1.2 Pin description

Furthermore, P1.4, P1.5, P1.6, and P1.7 can be configured as the SPI slave port select, data input/output and shift clock input/output pins as shown in the following table.

Table 3.3: Pin Description

PORT PIN	ALTERNATE FUNCTIONS
P1.0	T2(External Count input to Timer/Counter 2),Clock-out
P1.1	T2EX(Timer/Counter 2 Capture/reload trigger and direction control)
P1.4	SS(Slave port select input)
P1.5	MOSI(Master Data output ,slave Data input pin for SPI channel)
P1.6	MISO(Master Data input, slave Data output for SPI channel)
P1.7	SCK(Master Clock Output, Slave clock input pin for SIP channel)

- **Port 1:-** It also receives the low-order address bytes during Flash programming and verification.
- **Port 2:-** Port 2 is an 8-bit bidirectional I/O port with internal pull ups. The Port 2 output buffers can sink/source four TTL inputs. When 1s are written to Port 2 pins, they are pulled high by the internal pull ups and can be used as inputs. As inputs, Port 2 pins that are externally being pulled low will source current because of the internal pull ups. Port 2 emits the high-order address byte during fetches from external program memory and during accesses to external data memory that uses 16-bit addresses. In this application, Port 2 uses strong internal pull-ups when emitting 1s. During accesses to external data memory that use 8-bit addresses, Port 2 emits the contents of the P2 Special Function Register. Port 2 also receives the high-order address bits and some control signals during Flash programming and verification.
- **Port 3:-** Port 3 is an 8 bit bidirectional I/O port with internal pull ups. The Port 3 output buffers can sink/source four TTL inputs. When 1s are written to Port 3 pins, they are pulled high by the internal pull ups and can be used as inputs. As inputs, Port 3 pins that are externally being pulled low will source current because of the pull ups. Port 3 also serves the functions of various special features of the AT89S8252, as shown in the table 3.7. Port 3 also receives some control signals for Flash programming and verification.

Table 3.4: Port pin and alternate functions

Port Pin	Alternate Functions
P3.0	R×D(serial input port)
P3.1	T×D(serial output port)
P3.2	—— INT0(external interrupt 0)
P3.3	—— INT1(external interrupt 1)
P3.4	T0(timer 0 external input)

P3.5	T1(timer 1 external input)
P3.6	— WR(external data memory write strobe)
P3.7	— RD(external data memory read strobe)

- **RST:-**Reset input. A high on this pin for two machine cycles while the oscillator is running resets the device.
- **ALE/PROG:-**Address Latch Enable is an output pulse for latching the low byte of the address during accesses to external memory. This pin is also the program pulse input (PROG) during Flash programming. In normal operation, ALE is emitted at a constant rate of 1/ 6 the oscillator frequency and may be used for external timing or clocking purposes.
- **PSEN:-**Program Store Enable is the read strobe to external program memory. When the AT89S8252 is executing code from external program memory, PSEN is activated twice each machine cycle, except that two PSEN activations are skipped during each access to external data memory.
- **EA/VPP:-**External Access Enable. EA must be strapped to GND in order to enable the device to fetch code from external program memory locations starting at 0000H up to FFFFH. Note, however, that if lock bit 1 is programmed, EA will be internally latched on reset. EA should be strapped to VCC for internal program executions. This pin also receives the 12-volt programming enable voltage (VPP) during Flash programming when 12-volt programming is selected.
- **XTAL1:-** Input to the inverting oscillator amplifier and input to the internal clock operating circuit.
- **XTAL2:-** Output from the inverting oscillator amplifier [28].

3.6.2 ADC-0804 interfacing with AT89S8252:

The ADC0804 family is CMOS 8-Bit, successive-approximation A/D converters which use a modified potentiometer ladder and are designed to operate with the 8080A control bus via three-state outputs. These converters appear to the processor as memory locations or I/O ports, and hence no interfacing logic is required. The differential analog voltage input has good common mode-rejection and permits offsetting the analog zero-input voltage value. In addition, the voltage reference input can be adjusted to allow encoding any smaller analog voltage span to the full 8 bits of resolution [29].

3.6.2.1 Features

- 80C48 and 80C80/85 Bus Compatible - No Interfacing Logic Required
- Easy Interface to Most Microprocessors
- Differential Analog Voltage Inputs
- TTL Compatible Inputs and Outputs
- On-Chip Clock Generator
- 0V to 5V Analog Voltage Input Range (Single + 5V Supply)
- No Zero-Adjust Required

3.6.2.2 Pin diagram



Fig.3.18 Pin Diagram of ADC-0804

3.7 HARDWARE INTERFACING OF LCD (JHD162A)

On most displays, the pins are numbered on the LCD's printed circuit board, but if not, it is quite easy to locate pin 1. Since the pin is connected to ground, it often has a thicker PCB track connected to it, and it is generally connected to the metal work at some point.

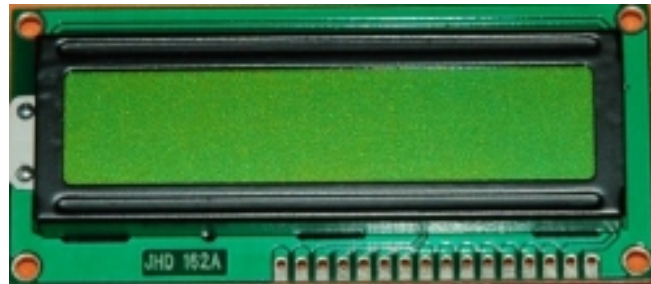


Fig.3.20 LCD

The function of each of the connections is shown in the table below:-

- **Pins 1 & 2** are the power supply lines, V_{ss} & V_{dd} . The V_{dd} pin should be connected to the positive supply & V_{ss} to the 0V supply or ground. Although the LCD module data sheets specify 5V D.C. supply (at only a few milliamps), supplies of 6V & 4.5V both work well, and even 3V is sufficient for some modules. Consequently, these modules can be effectively and economically powered by batteries.
- **Pin 3** is a control pin, V_{ee} , which is used to alter the contrast of the display. Ideally, this pin should be connected to a variable voltage supply. A preset potentiometer connected between the power supply lines, with its wiper connected to the contrast pin is suitable in many cases, but be aware that some modules may require a negative potential; as low as -7V in some cases. For absolute simplicity, connecting this pin to 0V will often suffice.
- **Pin 4 is register select (RS) line:-** Three command control inputs. When this line is low, data bytes transferred to the display are treated as commands, and data bytes read from the display indicate its status. By setting the RS line high, character data can be transferred to and from the module.

- **Pin 5 is (R/W) line:-**This line is pulled low in order to write commands or character data to the module, or pulled high to read character data or status information from its registers.
- **Pin 6 is Enable (E) line:-**This input is used to initiate the actual transfer of commands or character data between the module and the data lines. When writing to the display, data is transferred only on the high to low transition of this signal. However, when reading from the display, data will become available shortly after the low to high transition and remain available until the signal falls low again.
- **Pins 7 to 14** are the eight data bus lines (D0 to D7). Data can be transferred to and from the display, either as a single 8-bit byte or as two 4-bit “nibbles”. In the latter case, only the upper four data lines (D4 to D7) are used. This 8-bit mode is beneficial when using a microcontroller, as fewer I/O lines are required [28,29].

Table 3.5: Pin No. Name and Their Functions

PIN NO.	NAME	FUNCTION
1	Vss	Ground
2	Vdd	+ve supply
3	Vee	Contrast
4	RS	Register select
5	R/W	Read/Write
6	E	Enable
7	D0	Data Bit 0
8	D1	Data Bit 1
9	D2	Data Bit 2
10	D3	Data Bit 3
11	D4	Data Bit 4
12	D5	Data Bit 5
13	D6	Data Bit 6
14	D7	Data Bit 7

3.8 MICROCONTROLLER PROGRAMMING

There are two types of programming language used for microcontroller programming:

- 1) Low Level Language (Assembly Language)
- 2) High Level Language(C Language)

We have used high level language for microcontroller programming due to its given advantages over assembly language:-

Advantages of C over Assembly language programming

- Knowledge of the processor instruction set is not required.
- Details like register allocation and addressing of memory and data is managed by the compiler.
- Programs get a formal structure and can be divided into separate functions.
- Programming and program test time is drastically reduced, this increases efficiency.
- Keywords and operational functions can be used that come closer to how humans think.
- The supplied and supported C libraries contain many standard routines such as numeric conversions.
- Reusable code: Existing program parts can be more easily included into new programs, because of the comfortable modular program construction techniques.
- The C language based on the ANSI standard is very portable. Existing programs can be quickly adapted to other processors as needed.

CHAPTER-4

RESULTS & CONCLUSION

The work presented in this report, the following sections/circuits are used:-

1. SMPS(Switched Mode Power Supply) is used to provide 100V by using Fly Back Topology with Boost up voltage from 12V Battery To 100Volts.This voltage is feeding high voltage electrode where as the second electrode is connected directly with the ground and by changing the position of third electrode we are getting the no. of readings.
2. Microcontroller section-which is having 2 no.s of A/DC(Analogous to digital converter), one of them which is used to provide voltage reading and the other one is providing current readings.
3. Frequency generating section using 556 timer circuit is used to provide 120Hz frequency.
4. Operational Amplifier section is used to invert the signal.
5. Additional Power supply circuit is used to run operational amplifier section.
6. Switching section-MOSFET (Metal oxide field effect transistor) is used as a switch.

4.1 EXPERIMENTAL TESTING

After designing, it is important to check whether the instrument is accurate or not. Generally three tests methods are employed in an industrial facility to test the effectiveness of each method. These tests are:

- 1) The Three-Point method
- 2) The Four-Point method
- 3) Clamp-on Earth Ground Resistance Measurement

Out of these, 3-point method is selected in this work for the purpose of comparison.

4.2 COMPARISON OF FABRICATED EARTH TESTER WITH 3-POINT EXPERIMENT METHOD

To check the accuracy of the instrument compares actual value with the true values of earth resistance. Actual value reflects the earth resistance obtained from designed/actual instrument while the true value reflects the earth resistance measured with current injection 3-point electrode method. The various cases studied for the comparison between the actual value and the true value of earth resistance, to check the accuracy of the instrument are as follows:

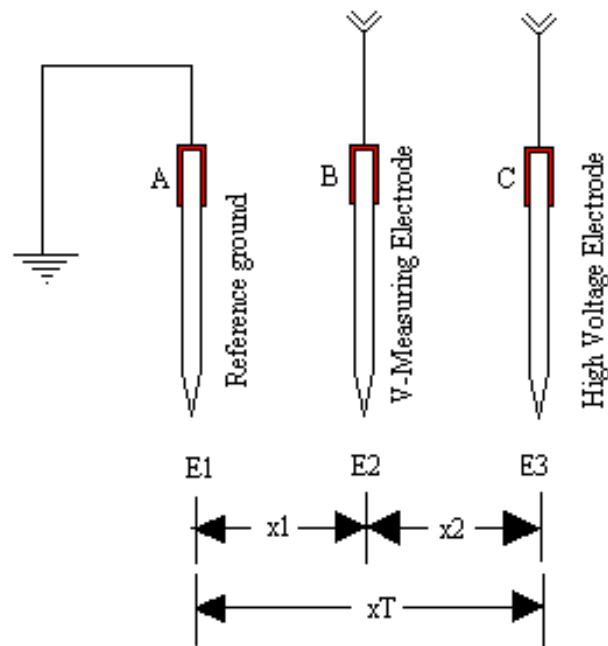


Fig.4.1 Experimental Testing

x_1 – Distance between electrode A and electrode B in meters

x_2 – Distance between electrode B and electrode C in meters

x_T – Total distance between A and C in meters

4.2.1 Case-1

Table 4.1: Total Distance 4 Meters between Outer Electrodes

4.1(a) True Value (From 3-Electrode Method)

S.No.	V(Volts)	I(mA)	R(ohm)	Length(Meters)	
				A-B	B-C
1	29.28	320	91.5	2	2
2	29.27	320	91.46	1.5	2.5
3	30	320	93.75	1	3
4	31.7	320	99.06	0.5	3.5
5	29	320	90.62	2.5	1.5
6	28.1	315	89.20	3	1
7	27	315	85.71	3.5	0.5

4.1(b) Actual Value(From Fabricated Instrument)

1	28.5	320	89.06	2	2
2	27.7	320	86.56	1.5	2.5
3	28.6	320	89.37	1	3
4	33.6	320	105	0.5	3.5
5	28	320	87.5	2.5	1.5
6	27.8	320	86.87	3	1
7	26.8	320	83.75	3.5	0.5

4.1(c) Comparison between True and Actual Values of Earth resistance

S.No.	True value R(ohm)	Actual value R(ohm)	% Error
1	91.5	89.06	2.66
2	91.47	86.56	5.36
3	93.75	89.37	4.66
4	99.06	105	-5.99
5	90.62	87.5	3.44
6	89.21	86.87	2.61
7	85.71	83.75	2.29

Maximum Percentage Error $\pm 6\%$

4.2.2 Case-2

Table 4.2: Total Distance 6 Meters between Outer Electrodes

4.2(a) True value (From 3-Electrode Method)

S.No.	V(Volts)	I(mA)	R(ohm)	Length(Meters)	
				A-B	B-C
1	36.6	290	126.20	3	3
2	37	290	127.58	2.5	3.5
3	36.8	290	126.89	2	4
4	37.3	290	128.62	1.5	4.5
5	37.2	285	130.52	1	5
6	37.7	285	132.28	0.5	5.5
7	38.8	285	136.14	3.5	2.5
8	36.2	285	127.02	4	2
9	35.8	280	127.85	4.5	1.5
10	35.1	280	125.36	5	1
11	34.2	280	122.14	5.5	0.5

4.2(b) Actual value (From Fabricated Instrument)

1	35.7	280	127.5	3	3
2	36.58	280	130.65	2.5	3.5
3	36.48	280	130.31	2	4
4	36.89	280	131.77	1.5	4.5
5	35.66	280	127.37	1	5
6	37.05	280	132.32	0.5	5.5
7	37.26	280	133.08	3.5	2.5
8	36.63	280	130.82	4	2
9	35.72	280	127.57	4.5	1.5
10	33.96	280	121.28	5	1
11	33.02	280	117.92	5.5	0.5

4.2(c) Comparison between True and Actual value of Earth resistance

S.No.	R(ohm)	R(ohm)	% Error
1	126.21	127.5	-1.03
2	127.58	130.66	-2.41
3	126.89	130.31	-2.69
4	128.62	131.77	-2.45
5	130.52	127.37	2.42
6	132.28	132.31	-0.03
7	136.14	133.08	2.24
8	127.02	130.83	-3.00
9	127.86	127.57	0.22
10	125.36	121.28	3.25
11	122.14	117.91	3.46

Total Percentage Error \pm 3%

4.2.3 Case-3

Table 4.3: Total Distance 10 Meters between Outer Electrodes

4.3(a) True value (From 3-Electrode Method)

S.No.	V(Volts)	I(mA)	R(ohm)	Length(Meters)	
				A-B	B-C
1	34.4	310	110.96	5	5
2	32.7	300	109	6	4
3	32.6	300	108.67	7	3
4	32.3	300	107.67	8	2
5	31.3	300	104.33	9	1
6	32.9	300	109.67	4	6
7	33	295	111.86	3	7
8	33.2	295	112.54	2	8
9	33.9	295	114.92	1	9

4.3(b) Actual Value(From Fabricated Instrument)

1	34.76	320	108.62	5	5
2	36.32	320	113.5	6	4
3	33.5	320	104.69	7	3
4	33.2	320	103.75	8	2
5	34.45	320	107.66	9	1
6	35.98	320	112.44	4	6
7	34.12	320	106.63	3	7
8	34.54	320	107.94	2	8
9	34.91	320	109.09	1	9

4.3(c) Comparison between True and Actual value of Earth resistance

S.No	R(ohm)	R(ohm)	% Error
1	110.97	108.62	2.12
2	109	113.5	-4.13
3	108.67	104.69	3.66
4	107.67	103.75	3.64
5	104.33	107.66	-3.18
6	109.67	112.44	-2.53
7	111.86	106.63	4.68
8	112.54	107.94	4.09
9	114.92	109.09	5.07

Total Percentage Error \pm 5%

4.2.4 Case-4

Table 4.4: Total Distance 12 Meters between Outer Electrodes

4.4(a) True value (From 3-Electrode Method)

S.No.	V(Volts)	I(mA)	R(ohm)	Length(Meters)	
				A-B	B-C
1	16.12	320	50.37	6	6
2	15.21	300	50.7	7	5
3	12.1	290	41.72	8	4
4	12.01	285	42.15	9	3
5	12.32	275	44.80	10	2
6	12.11	270	44.86	11	1
7	12.21	270	45.22	5	7
8	12.84	265	48.45	4	8
9	12.89	265	48.64	3	9
10	15.11	265	57.02	2	10
11	15.56	265	58.72	1	11

4.4(b) Actual Value(From Fabricated Instrument)

1	15.45	320	48.28	6	6
2	16.85	320	52.65	7	5
3	13	320	40.62	8	4
4	14	320	43.75	9	3
5	13.58	320	42.44	10	2
6	13.54	320	42.31	11	1
7	14.29	320	44.65	5	7
8	14.97	320	46.78	4	8
9	16.47	320	51.47	3	9
10	17.28	320	54	2	10
11	17.74	320	55.44	1	11

4.4(c) Comparison between True and Actual value of Earth resistance

S.No.	R(ohm)	R(ohm)	%Error
1	50.37	48.28	4.16
2	50.7	52.66	-3.86
3	41.72	40.63	2.63
4	42.15	43.75	-3.80
5	44.80	42.44	5.28
6	44.86	42.31	5.68
7	45.22	44.66	1.25
8	48.45	46.78	3.45
9	48.64	51.47	-5.81

Total Percentage Error $\pm 6\%$

From the above case studies, it is evident that on comparison of the actual values with the true values of resistance the accuracy of the fabricated earth tester is $\pm 8\%$ with the safety margin of 2%.

4.3 CONCLUSION

1. It is observed that SMPS (Switched Mode Power Supply) is providing 100volts effectively.
2. Two Analog to Digital converter are properly interfaced with the microcontroller and providing proper readings on the LCD.
3. 120Hz frequency is properly generated by using 556 Timer circuit.
4. It is observed that by giving 100Volt to soil we are getting corerct results of soil resistivity by using micro-controller effectively.
5. By comparing the actual value with the true values of resistances we found that the percentage error is $\pm 8\%$. This error can be removed by using higher order A/DC's like 12 bit or 16 bit, which need change in microcontroller section which will enhance the cost.

4.4 SCOPE FOR FUTURE WORK

1. The resolution of measurement is restricted by the usage of 8-bit A/D Converter. To enhance the accuracy of the instrument the resolution of measurement can be increased by using higher order A/D Converter like 12 bit or 16 bit.
2. There are two power supply system one is from 12V Battery and other is from 12-0-12Volt Transformer. Work should be done in this field to re-design this instrument with single power supply.
3. By the use of pic controller there is no need of A/D converter sections which provides compactness in the circuit.
4. A new PCB should be designed so that the whole circuit should be completed in a single PCB.

REFERENCES

- [1] A.K. Jha, "A single phase single stage AC/DC converter with tight output voltage regulation", *IEEE Transactions on Electronic Apparatus*, March 2006.
- [2] Alejandro Vargas Avila, Favio Casas Ospina and Gloria Maria Acero, "Measurement of grounding resistance in tower lines", *IEEE Transaction on Power Delivery*, vol.9, no.13, pp.1135-1164, 2003.
- [3] Andrew J. Phillips, Ian R. Jandrell and Kenneth J. Nixon, "A simplified model of the lightning performance of a driven rod earth electrode in multi-layer soil that includes the effect of soil ionization", *IEEE Transaction on Power Delivery*, vol.3, no.4, pp.1375-1379, October 2006.
- [4] B. Halal, C.E. Hymowitz and L.G. Meares, "New techniques for fault diagnosis and isolation of Switched Mode Power Supplies", *IEEE International Mixed Signal Testing Workshop*, pp. 351-359,1994.
- [5] Blattner, "Prediction of soil resistivity and ground rod resistance for deep ground electrodes", *IEEE Transactions on Power Apparatus and Systems*,vol.PAS-99.5,pp.1758-1763,Sept./Oct.,1980.
- [6] Clayton L. Hallmark, "Horizontal strip electrodes for lowering Impedance to ground", *IEEE Transaction on Power Apparatus and Systems*, vol.PAS-70, no.4, October 1997.
- [7] D. Mukhedka, H.G. Sarmiento and J. Fortin, "Ground electrode impedance field measurements with high and low current injection methods", *IEEE Transaction on Power Apparatus and Systems*, vol. PAS-103, no.7, July 1984.
- [8] Donald W. Zipse, "Electrical shock hazard due to stray current", *IEEE Transactions on Industry Applications*, vol. IA-18, no. 4, july/august 1982.
- [9] E.L.Dvorak, "Evaluation of grounding methods used for maintenance of Transmission lines", *IEEE Transactions on Power Delivery*, vol.20, no.2, June1996.
- [10] E. P. Dick and P. R. Pillai, "A review on testing and evaluating substation grounding systems", *IEEE Transactions on Power Delivery*", vol. 7, no.1, January 1992.
- [11] Golam Toaha Rasul, M. A. Choudhury and P. K. Banerjee, "AC Voltage Regulation

- by Switch Mode Buck-Boost Voltage Controller”, *3rd International Conference on Electrical & Computer Engineering, ICECE*, December 2004.
- [12] G. Rilly, J. Rodriguez, P.A. Berland and T. Kieffer, “Switch mode power supply, new concept”, *IEEE Transactions on Power Apparatus and systems*, 1991.
- [13] Hiroshi Yamane, Kazuo murakawa and Mitsuo hattori, “Earthing resistance measurement technique without using auxiliary electrodes”, *IEEE Transaction on Power Apparatus and Systems*, 2003.
- [14] IEEE Std 81-1983, “IEEE guide for measuring earth resistivity and ground impedance”, *The Institute of Electrical and Electronics Engineers*, Inc 345 East 47th Street, New York, NY 10017, USA, 1983.
- [15] IEEE Std 81.2-1991, “IEEE guide for measurement of impedance and safety characteristics”, *The institute of Electrical and Electronics Engineers*, Inc. 345 East 47th Street, New York, NY 10017-2394, USA, 1991.
- [16] IEEE Std 80-2000, “IEEE guide for Safety in AC Substation Grounding”, *The Institute of Electrical and Electronics Engineers*, Inc 3 Park Avenue, New York, NY 10017-5997, USA, 2000.
- [17] Johan Sommarek, Jonne Lindeberg, Jouko Vankka, Kari Halonen and Ville Saari, “A 20 MHz BP-PWM and BP-DSM Class-D”, *Electronics & Communication Engineering Journal*, vol. 5, no. 6, pp.339–348, Dec. 1993.
- [18] Kenneth M. Michaels, “Earth ground resistance testing for low voltage power systems”, *IEEE Transactions on Industry Applications*, vol.31, no.1, January/February 1995.
- [19] Laverne E. Stetson and Riley George, “Application Experience with 69 kV Steel Utility Poles”, *IEEE Transaction on Power Apparatus and Systems*, vol.PAS-93, no.6, 1998.
- [20] Lisha Li, “High gain low power operational amplifier design and compensation techniques”, *IEEE Transactions on Instrumentation and Measurement*, vol. 53, no. 3, pp. 863–876, Jun. 2004.
- [21] Naoto Izumo, Seiichi Muroyama, Shinya Takagi and Yasuo Kishimoto, “A new method of measuring earth resistance applicable to mutually bonded earth electrode systems”, *IEEE Transaction on Power Apparatus and Systems*, vol.25, no.8, 1999.

- [22] P. Simonds, “Designing and Testing of Low-Resistance Grounding Systems”, *IEEE Power Engineering Review*, October 2000.
- [23] Rasid Hadzimusic, “Design of Highly Efficient DC-DC Converters”, *Master thesis in Electronics Systems at Linkoping Institute of Technology*, March 2004.
- [24] Ricky Yuen, “Low-Voltage Switched-Op-Amp Circuits Analog Circuit Design”, *IEEE Transactions on electronic Apparatus*, 1998.
- [25] R. J. Gustafson, R. Pursley and V. D. Albertson, “Seasonal grounding resistance variations on distribution systems”, *IEEE Transactions on Power Delivery*, vol.5, no.2, April 1990.
- [26] Sbenglin Yang, “Methodology for memory analysis and optimization in embedded systems”, *IEEE Transactions on Design Automation of Electronic Systems*, vol.6, no.2, pp-149-206, April 2004.
- [27] Shawn Kuo, “Linearization of a Pulse Width Modulated Power Amplifier” *IEEE Transactions on electronic Apparatus*, June 2004.
- [28] www.alldatasheets.com
- [29] www.datasheetcatalog.com
- [30] www.datasheet4u.com

APPENDIX-A

DATASHEET OF AT89S8252

FEATURES:-

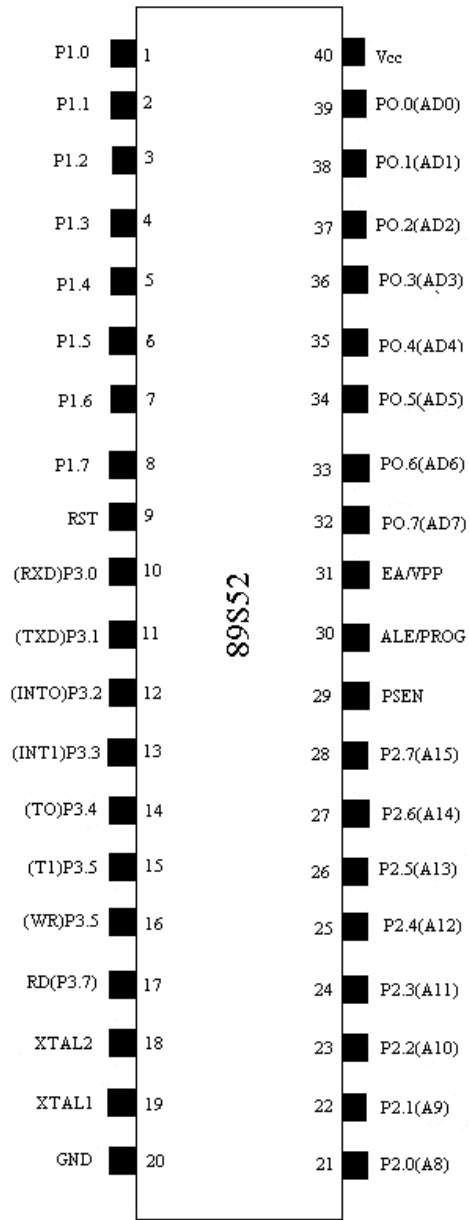
- ✓ 8K Bytes of In-System Programmable (ISP) Flash Memory
 - Endurance: 1000 Write/Erase Cycles
- ✓ 4.0V to 5.5V Operating Range
- ✓ Fully Static Operation: 0 Hz to 33 MHz
- ✓ Three-level Program Memory Lock
- ✓ 256 x 8-bit Internal RAM
- ✓ 32 Programmable I/O Lines
- ✓ Three 16-bit Timer/Counters
- ✓ Eight Interrupt Sources
- ✓ Full Duplex UART Serial Channel
- ✓ Low-power Idle and Power-down Modes
- ✓ Interrupt Recovery from Power-down Model
- ✓ Watchdog Timer
- ✓ Dual Data Pointer
- ✓ Power-off Flag
- ✓ Fast Programming Time
- ✓ Flexible ISP Programming (Byte and Page Mode)
- ✓ Green Packaging Option

ALTERNATE FUNCTIONS OF PORT PINS:-

PORT PIN	ALTERNATE FUNCTIONS
P1.0	T2(External Count input to Timer/Counter 2),Clock-out
P1.1	T2EX(Timer/Counter 2 Capture/reload trigger and direction control)
P1.4	SS(Slave port select input)
P1.5	MOSI(Master Data output ,slave Data input pin for SPI channel)
P1.6	MISO(Master Data input, slave Data output for SPI channel)
P1.7	SCK(Master Clock Output, Slave clock input pin for SIP channel)

PORT PINS:-

PORT 0	PORT 1	PORT 2	PORT 3	PORT BIT
P0.0	P1.0	P2.0	P3.0	D0
P0.1	P1.1	P2.1	P3.1	D1
P0.2	P1.2	P2.2	P3.2	D2
P0.3	P1.3	P2.3	P3.3	D3
P0.4	P1.4	P2.4	P3.4	D4
P0.5	P1.5	P2.5	P3.5	D5
P0.6	P1.6	P2.6	P3.6	D6
P0.7	P1.7	P2.7	P3.7	D7



Pin configuration

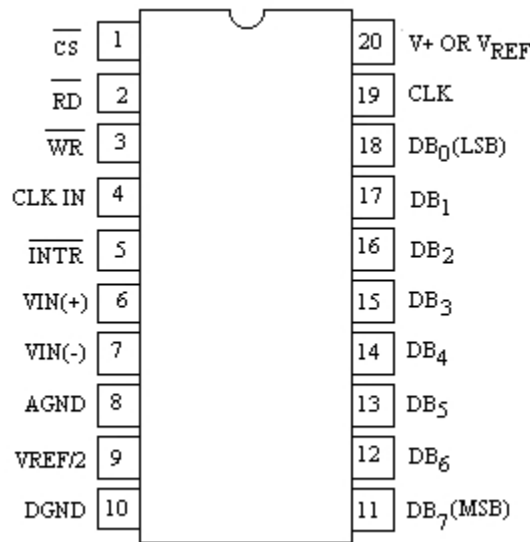
APPENDIX-B

DATASHEET OF ADC0804

FEATURES:-

- ✓ 80C48 and 80C80/85 Bus Compatible
- ✓ Logic Required
- ✓ Conversion Time < 100s
- ✓ Easy Interface to Most Microprocessors
- ✓ Will Operate in a “Stand Alone” Mode
- ✓ Differential Analog Voltage Inputs
- ✓ Works with Band gap Voltage References
- ✓ TTL Compatible Inputs and Outputs
- ✓ On-Chip Clock Generator
- ✓ 0V to 5V Analog Voltage Input Range (Single + 5V Supply)
- ✓ No Zero-Adjust Required

PIN DIAGRAM:-



ABSOLUTE MAXIMUM RATINGS

- ✓ Supply Voltage 6.5V
- ✓ Voltage at Any Input-0.3V to (V⁺ +0.3V)

OPERATING CONDITIONS

Temperature Range

- ✓ ADC0802/03LD. -55°C to 125°C
- ✓ ADC0802/03/04LCD -40°C to 85°C
- ✓ ADC0802/03/04LCN 0°C to 70°C
- ✓ ADC0803/04LCWM -40°C to 85°C

THERMAL INFORMATION

Maximum Junction Temperature

- ✓ Hermetic Package 175°C
- ✓ Plastic Package 150°C
- ✓ Maximum Storage Temperature Range -65°C to 150°C
- ✓ Maximum Lead Temperature (Soldering, 10s) 300°C

APPENDIX-C

DATASHEET OF ST13007

HIGH VOLTAGE FAST-SWITCHING NPN POWER TRANSISTOR

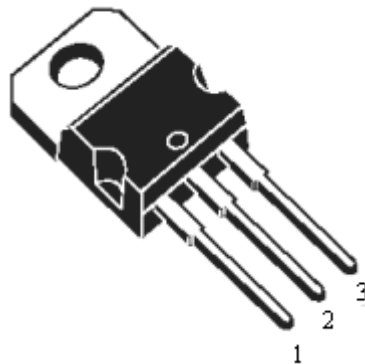
IMPROVED SPECIFICATION:

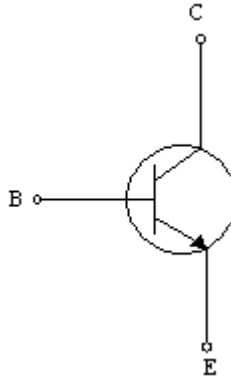
- ✓ Lower leakage current
- ✓ Tighter gain range
- ✓ Direct current gain pre selection
- ✓ Tighter storage time range
- ✓ High voltage capability
- ✓ npn transistor
- ✓ Low spread of dynamic parameters
- ✓ Very high switching speed

APPLICATION:

- ✓ Electronic ballasts for Fluorescent lighting
- ✓ Switch Mode power Supplies

PIN DIAGRAM:



SYMBOL:**PARAMETERS:**

S.No.	Symbol	Parameter	Value	Unit
1	V_{CEV}	Collector-Emitter Voltage ($V_{BE}=-1.5V$)	700	V
2	V_{CEO}	Collector-Emitter Voltage ($I_B=0$)	400	V
3	V_{EBO}	Emitter-Base Voltage ($I_C=0$)	9	V
4	I_C	Collector Current	8	A
5	I_{CM}	Collector Peak Current	16	A
6	I_B	Base Current	4	A
7	I_{BM}	Base peak Current	8	A
8	P_{tot}	Total Dissipation at $T_c \leq 25^\circ C$	80	W
9	T_{stg}	Storage Temperature	-65 to 150	$^\circ C$
10	T_j	Max. Operating Junction Temperature	150	$^\circ C$

APPENDIX-D

COMPONENTS USED

ITEM	QUANTITY	REFERENCE	PART	PRICE
1	2	C1,C28	102	1
2	1	C4	10uF/16V	10
3	3	C5,C6,C19	104	1
4	4	C7,C8,C9,C10	1uf/16v	5
5	1	C11	1uF 50V	1
6	1	C14	2200uF 35v	20
7	2	C16,C17	33PF	0.5
8	2	C20,C30	151	0.5
9	1	C21	1000uf 16v	10
10	1	C22	2200uF 50v	20
11	2	C23,C27	103	0.5
12	1	C25	1uF	0.5
13	1	C26	204	0.5
14	3	C29,C31,C32	22uF 400v	10
15	1	C36	222 y2	1
16	2	C37,C39	470uF	5
17	2	C40,C41	220uF 50v	10
18	3	D1,D20,D22	1N4148	2
19	3	D6,D24,D25	10v	2
20	1	D11	LED	2
21	5	D14,D15,D16,D17,D18	1N4007	2
22	1	D19	cr3	5
23	1	D23	BRIDGE	4
24	3	EL1,EL2,EL3	ELECTRODE	550
25	4	J1,J2,J3,J13	CON8	2
26	1	J5	LCD	120
27	4	J6,J7,J27,J28	CON3	2
28	7	J9,J10,J11,J12,J14,J15,J19	CON2	2
29	1	J18	CON10-dual	2
30	4	J20,J22,J23,J25	CURRENT MEASURE	0.5
31	2	J21,J26	VOLTAGE MEASURE	0.5
32	2	POT1,POT2	5KE	2
33	12	POT3,POT4,R21,R29,R30,R35,R38, R42,R46,R50,R53,R54	10K	2
34	2	Q1,Q2	IRFZ44N/TO	2
35	1	R1	10k SIP 9	5

36	9	R16,R23,R24,R26,R27,R48,R52,R55,R56	56e	0.5
37	3	R22,R40,R41	220E	0.5
38	1	R25	50k	0.5
39	1	R28	4k7	0.5
40	1	R31	1k	0.5
41	1	R32	44k	0.5
42	1	R33	470E	0.5
43	1	R34	10E 4W	0.5
44	1	R36	100k	0.5
45	1	R43	100E 1W	2
46	3	R45,R47,R49	20K	0.5
47	1	T1	TRAN_HM31	200
48	1	U1	NE556_2	20
49	1	U2	AT89S8252	60
50	1	U3	TL3845	30
51	2	U5,U10	TL431	5
52	2	U6,U9	ADC0804	90
53	1	U8	LM7805	10
54	3	U11,U12,U13	OP07	30
55	1	Y1	8 MHz	20
56	1	12V	BATTERY	1500
57	5	PCB	FABRICATED GENERAL PCB	1500
			TOTAL	4225.5