TROCARDIOGRAM (ECG) SIGNAL
TION & PROCESSING SYSTEM USING
LabVIEW

Submitted in Partial fulfillment of the Requirements for the Degree of

BACHELOR OF TECHNOLOGY

In

INSTRUMENTATION ENGINEERING

By:

Dipankar Dey (Gau-C-11/63)

Anamika Kumari (Gau-C-11/84)

Niron Daimary (Gau-C-11/L-204)

Under the Supervision of

MR. GANESH ROY

(Assistant Professor of IE Dept.)

Central Institute Of Technology
Kokrajhar : : Bodoland
ESTD. : 2006
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तमसो मा ज्योतिर्गमय

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की संस्थान कोकराझार

TECHNOLOGY KOKRAJHAR

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DEPARTMENT OF INSTRUMENTATION ENGINEERING

केन्द्रीय प्रौद्योगिकी संस्थान कोकराझार

CENTRAL INSTITUTE OF TECHNOLOGY KOKRAJHAR

(A Centrally Funded Institute under Ministry of HRD, Govt. of India)
KOKRAJHAR::BTAD::ASSAM::INDIA::783370

Website: www.cit.ac.in

November 2014

DECLARATION

We hereby declare that the project work entitled "ELECTROCARDIOGRAM (ECG) SIGNAL ACQUISITION & PROCESSING SYSTEM USING LABVIEW" is an authenticated work carried out by us under the guidance of Mr. Ganesh Roy for the partial fulfilment of the award of the B.Tech degree in Instrumentation Engineering and this work has not been submitted for similar purpose anywhere else except to Department of Instrumentation Engineering, Central Institute of Technology, Kokrajhar.

DATE: 28/10/2014

PLACE: Kokrajhar

Dipankar Dey
(DIPANKAR DEY)

University Roll: Gau-C-11/63

University Registration No: 014690

Anamika Kumari
(ANAMIKA KUMARI)

University Roll: Gau-C-11/84

University Registration No: 014591

Niron Daimary
(NIRON DAIMARY)

University Roll: Gau-C-11/L-204

University Registration No: 081746

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KOKRAJHAR::BTAD::ASSAM::INDIA::783370

CERTIFICATE BY THE BOARD OF EXAMINERS

This is to certify that the project work entitled **"ELECTROCARDIOGRAM (ECG) SIGNAL ACQUISITION & PROCESSING SYSTEM USING LabVIEW"** submitted by Dipankar Dey, Anamika Kumari and Niron Daimary the Department of Instrumentation Engineering of Central Institute of Technology, Kokrajhar has been examined and evaluated.

The project work has been prepared as per the regulations of Central Institute of Technology and qualifies to be accepted in partial fulfillment of the requirement for the degree of B. Tech.

Project Coordinator

Board of Examiners

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....

DEPARTMENT OF INSTRUMENTATION ENGINEERING

केन्द्रीय प्रौद्योगिकी संस्थान कोकराझार

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KOKRAJHAR::BTAD::ASSAM::INDIA::783370

CERTIFICATE OF APPROVAL

This is to certify that the work embodied in the project entitled, "ELECTROCARDIOGRAM (ECG) SIGNAL ACQUISITION & PROCESSING SYSTEM USING LABVIEW" submitted by DIPANKAR DEY (Gau-C-11/63), ANAMIKA KUMARI (Gau-C-11/84) and NIRON DAIMARY (Gau-C-11-L/204) to the Department of Instrumentation Engineering, is carried out under our direct supervisions and guidance.

The project work has been prepared as per the regulation of Central Institute of Technology, Kokrajhar and we strongly recommended that this project work be accepted in partial fulfillment of the requirement for the degree of B.Tech.

Countersign by

(MR. DIPANKAR SUTRADHAR)
HOD (I/C)
Department of IE

Supervisor

(MR. GANESH ROY)
Asst. Professor, Dept. of IE

DEPARTMENT OF INSTRUMENTATION ENGINEERING

केन्द्रीय प्रौद्योगिकी संस्थान कोकराझार

CENTRAL INSTITUTE OF TECHNOLOGY KOKRAJHAR

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KOKRAJHAR::BTAD::ASSAM::INDIA::783370

CERTIFICATE OF SUBMISSION OF PROJECT REPORT

This is to certify that the following students of 7th semester B.Tech course (Instrumentation Engineering) have submitted their project report on **"Electrocardiogram (ECG) Signal Acquisition & Processing System Using LabVIEW"** to the department in partial fulfilment of the requirements for the B.Tech in Instrumentation Engineering.

DIPANKAR DEY (GAU-C-11/63)

ANAMIKA KUMARI (GAU-C-11/84)

NIRON DAIMARY (GAU-C-11/L-204)

MR. DIPANKAR SUTRADHAR
HOD (I/C) IE DEPARTMENT

ACKNOWLEDGEMENT

It is high privilege for us to express our deep sense of gratitude to all those faculty members who helped me in the completion of the project, especially our guide **Mr. Ganesh Roy** who was always there at hour of need.

Our special thanks to Mr. Anjoy Basumatary of Instrumentation Engineering Department for helping us in the completion of project work.

Finally, to our parents and friends goes my gratitude for their love, support and dedication.

DATE: 28/11/2014
PLACE: Kokrajhar

Dipankar Dey.
(DIPANKAR DEY)

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University Registration No: 014690

Anamika Kumari
(ANAMIKA KUMARI)

University Roll: Gau-C-11/84

University Registration No: 014591

Niran Daimary
(NIRON DAIMARY)

University Roll: Gau-C-11/L-204

University Registration No: 081746

ABSTRACT

The main objective of this work is to develop a portable and cost effective data acquisition (DAQ) system for clinical applications. This DAQ consists of several modules such as power supply, analog to digital converter (ADC), amplifiers, isolators, filters and interfacing circuits. This system mainly aims to collect the ECG signals of frequency between 0.05 Hz and 113 Hz with a gain of 3113. This frequency information from the ECG signal is highly useful clinical applications such as SCA prediction, cardiovascular disease (CVD) detection, etc. ECG signals will be collected from the subjects using 3 leads system and given to DAQ for recording the ECG signal. The acquired signal through this DAQ will then be transferred to the Notebook through NI6008 data acquisition card. This DAQ interface is used to convert the input analog signal to digital signal output and to save the ECG data in the notebook using Labview software. This acquired signal from Labview software is used for further clinical investigation. We also developed a Graphical User Interface (GUI) in LabVIEW software to continuously monitor the ECG signal traces and to record the ECG data with higher precision. The morphology of the acquired ECG signal in the system is highly precise and useful for clinical diagnosis. Furthermore, this proposed system is used for developing sudden cardiac arrest (SCA) prediction in our university.

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LIST OF FIGURES

ABBREVIATIONS

ADC	Analog to Digital Converter
CMRR	Common mode Rejection Ratio Mode
CVD	Cardiovascular Disease
DAQ	Data Acquisition
ECG	Electrocardiogram
GUI	Graphical User Interface
LA	Left Arm
LabVIEW	Laboratory Virtual Instrumentation Engineering Workbench
NI	National Instruments
PC	Personal Computer
RA	Right Arm
RL	Right Leg
SCA	Sudden Cardiac Arrest

CHAPTER 1

1.1 INTRODUCTION:-

Electrocardiogram (ECG) signals plays a vital role in clinical diagnosis especially for diagnosing heart related diseases and disorders such as, cardiovascular disease (CVD), pulmonary disease, sudden cardiac arrest (SCA), etc. ECG signal is generated by a nerve impulse stimulus to a heart. The current is diffused around the surface of the body and build on the voltage drop, which is a normally 0.0001 Volt to 0.003 Volt and the signals are within the frequency range of 0.05 Hz to 100 Hz. ECG signals are usually recorded at the surface of the body and processed to give important information about the electrical activity of heart. A typical ECG tracing of a normal heartbeat consists of a P wave, a QRS complex and a T wave.

Figure 1.1 shows the usual signal which is acquired from the human body is of very low potential and difficult to analyze the signal variance. Hence, necessary amplification is required before processing the ECG signal to derive any give useful information about the cardiac abnormalities.

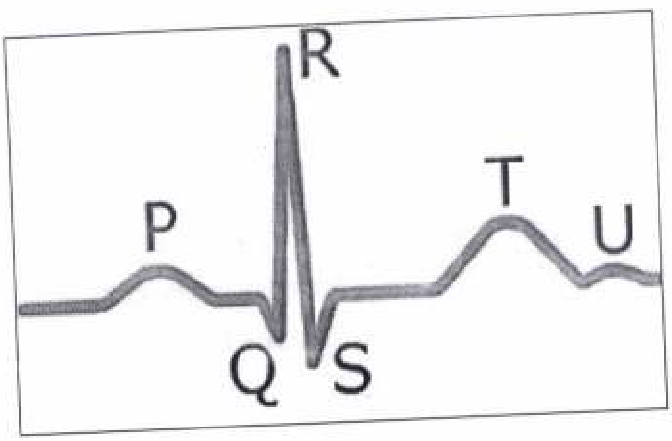


Figure 1.1: The Elements of ECG Complex

The active filter is used to obtain ECG signal with a frequency range of 0.05 Hz to 150 Hz and used NI USB 6008 DAQ card to integrate with LabVIEW. In general, multi-stage amplifiers are required to amplify the ECG signals with a larger gain. Meanwhile, the amplifiers should have a high common-mode rejection ratio (CMRR) to amplify the ECG signal. This amplified usually amplify the most useful information of heart activities along with inherent noises developed in a system during data acquisition. These noises are filtered using both high and low pass filters to extract the ECG signal between 0.05 Hz and 113 Hz. This filtered signal is digitized by using NI USB 6008 card and to be read and interpreted using LabVIEW software.

1.2 INTRODUCTION TO LabVIEW:-

LabVIEW is a fully featured programming language produced by National Instruments. It is a graphical language quite unique in the method by which code is constructed and saved. There is no text based code as such, but a diagrammatic view of how the data flows through the program. Thus LabVIEW is a much loved tool of the scientist and engineer who can often visualise data flow rather than how a text based conventional programming language must be built to achieve a task.

LabVIEW programs are called virtual instruments, or VIs, because their appearance and operation imitate physical instruments, such as oscilloscopes and multimeters. LabVIEW contains a comprehensive set of tools for acquiring analyzing, displaying, and storing data, as well as tools to help you troubleshoot your code. LabVIEW VIs contain three components- the front panel, the block diagram, and the icon and connector pane. In LabVIEW, you build a user interface, or front panel, with controls and indicators. Controls are knobs, push buttons, dials, and other input devices. Indicators are graphs, LEDs, and other displays. After you build the user interface, you add code using VIs and structures to control the front panel objects. The block diagram contains this code. In some ways, the block diagram resembles a flowchart. We can use LabVIEW to communicate with hardware such as data acquisition, vision, and motion control devices, and GPIB, PXI, VXI, RS-232, and RS-484 devices. LabVIEW also has built-in features for connecting your application to the Web using the LabVIEW Web Server and software standards such as TCP/IP networking using LabVIEW. We can create test and measurement, data acquisitions, instrument control, datalogging, measurement analysis, and report generation applications. You also can create stand-alone executables and shared libraries, like DLLs, because LabVIEW is true 32-bit compiler software.

CHAPTER 2

2.1 BLOCK DIAGRAM OF THE PROJECT:-

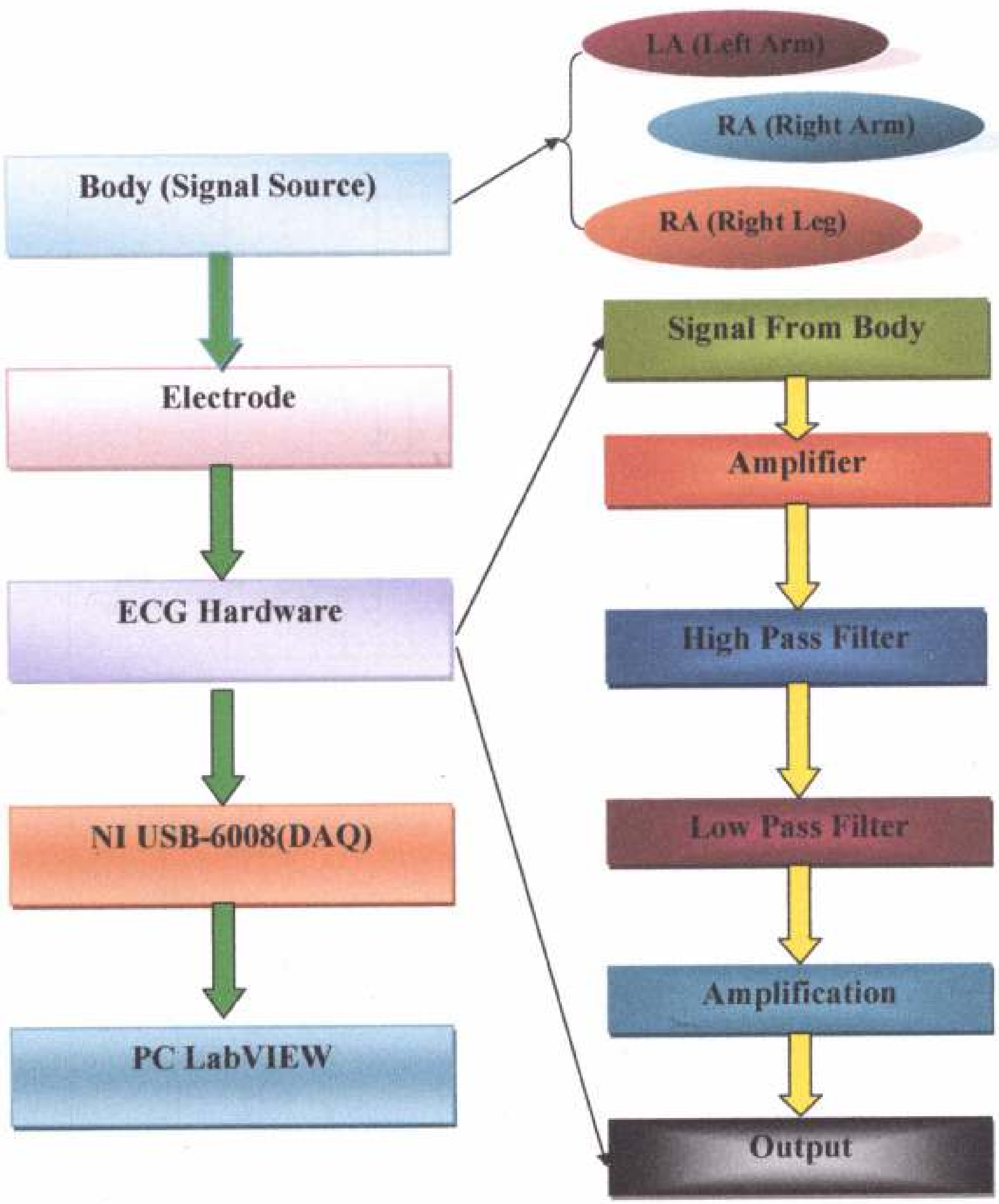


Figure 2.1: Block Diagram of ECG Signal Acquisition.

2.2 CIRCUIT DIAGRAM AND DESCRIPTION:-

The ECG signal acquisition and processing system consists of a detecting circuit, a filtering circuit (0.05Hz ~ 159Hz band pass), an amplifying. The ECG signal is detected by the electrodes and amplified by the general instrument amplifier and filtered by the filter, and then the ECG analog signal is obtained.

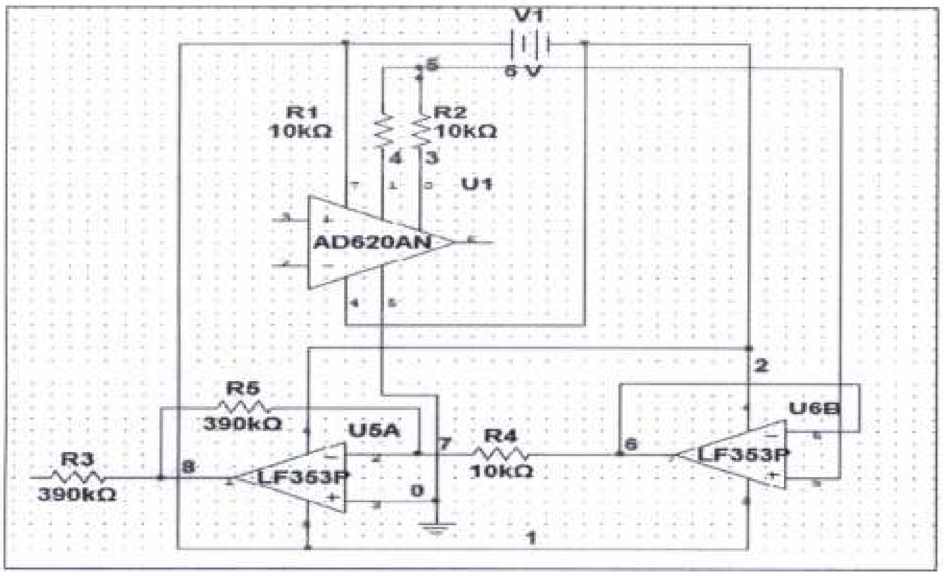
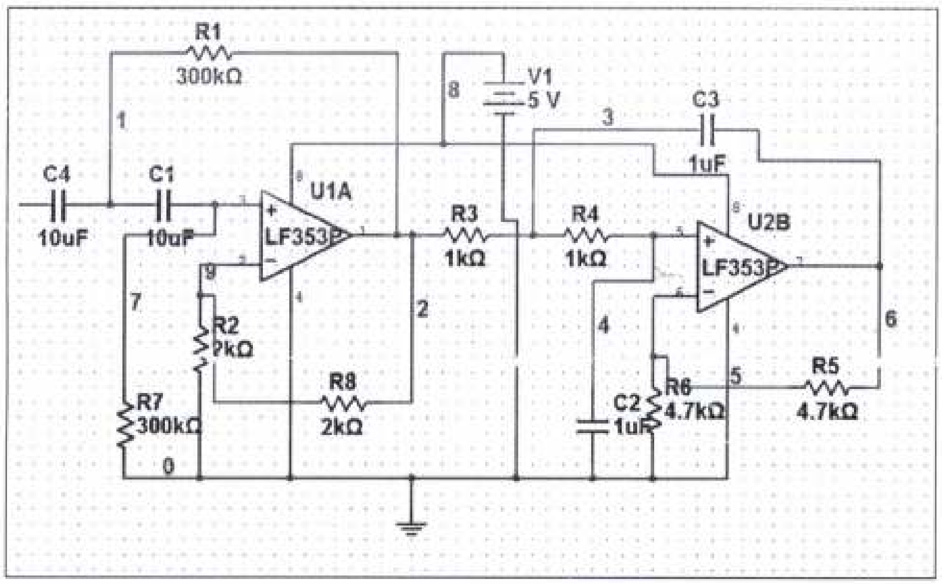
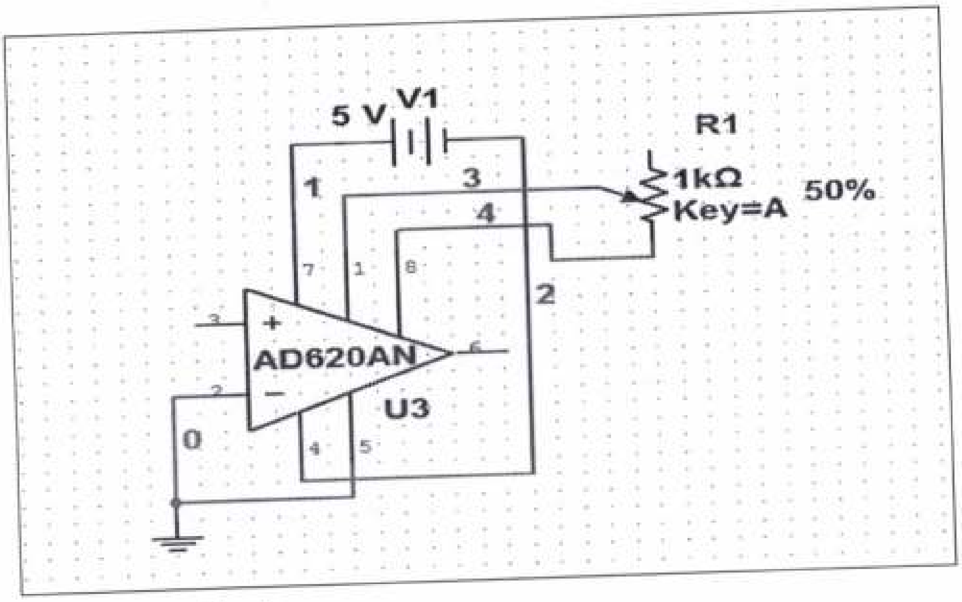


Figure 2.2: A) Detecting and Amplification.



B) Filter Circuit.



C) Amplifier Circuit.

Signal detecting, filtering and amplifying circuit design as shown in Figure 2.2A, 2.2B and 2.2C respectively. The ECG signal detecting and amplifier circuit consist of AD620 is precision instrumentation amplifier, the magnification of which is designed for + 3.5 times. LF353P operational amplifier and some resistors. LF353P is high input impedance, low bias current operational amplifier. With the surrounding resistance, it made up the right foot drive circuit, and the output end RL is connected with the patient's right foot to reduce the input common-mode voltage to increase amplifying accuracy. LA and RA are lead electrodes which are connected with the non-inverting and inverting terminal of AD620. Filtering circuits consist of LF353P surrounded with some capacitors and resistors. The magnification of which is designed for + 2 times make up a 159Hz low-pass filter (anti-aliasing filter), and the magnification of which is designed for + 2 times. U3 is the instrument amplifier AD620. Controlled by R1 potentiometer, it provides a magnification of + 71.43. So the total magnification is:

$3.5\times 2\times 2\times 71.43 = 1000$

In the ECG data acquisition circuit, IC's require ±5 volt. Hence, we have developed a dual power supply output for this circuit. The power supplies has been developed using voltage regulator series IC's. LM7805 and LM7905 are used for obtaining ±5 volt. A transformer of 230/15 V step down transformer with 1A current is used to transferring the AC electrical power from the input power supply.

2.3 POWER SUPPLY:-

As show figure2.2 below shows the dual 5 Volt DC power supply used in whole circuit. There is one step down transformer, four diodes 1N4007 – D1 to D4 acting full-wave rectifier. The output signal of full wave rectifier is make filter waveform to smooth with a capacitor C1, C2 (1uF), Then entered to input of IC LM7805 and LM7905 of positive and negative voltage regulated IC respectively. The output of voltage regulator may present some of AC component, so it is again filtered by the capacitor using C4, C5 (1mF) in both positive and negative output.

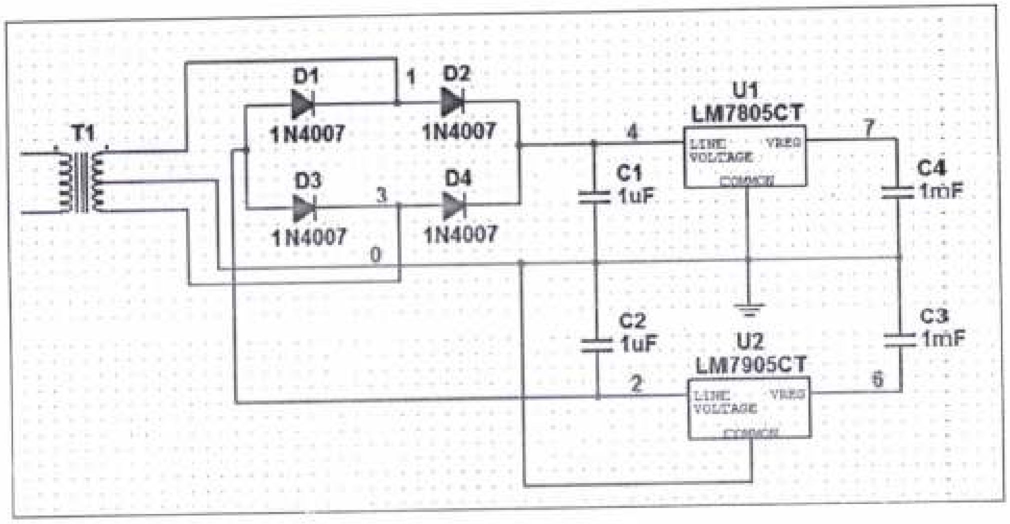


Figure 2.3: Dual 5 Volt DC Power Supply.

CHAPTER 3

3.1 HUMAN BIOPOTENTIALS:-

Bio-potential is a voltage produced by a tissue of the body particularly muscle tissue during a contraction. Electrocardiography depends on measurement of changing potentials in contracting heart muscle. Electromyography and electroencephalography function similarly in the diagnosis of neuromuscular and brain disorders, respectively.

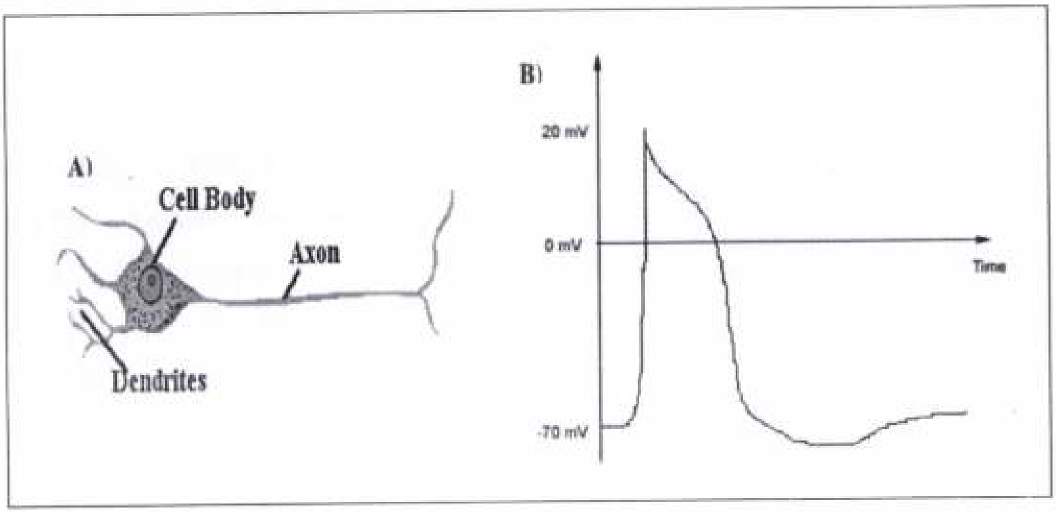


Figure 3.1: A) A Typical Nerve Cell. B) A Typical Muscle Action Potential.

A typical nerve cell is made up of a cell body, an axon, and dendrites (Fig 3.1A). The cell body contains the nucleus or command centre of the cell, the axon, which is responsible for transmitting the action potential along the cell, and the dendrites, which are responsible for receiving inputs to the cell in the form of neurotransmitters. Nerve and muscle cells in the body communicate with each other via action potentials. Action potentials are voltage impulses that propagate along a nerve or muscle and may cause neurotransmitter release when the action potential reaches a specific area of the nerve cell. A typical action potential recorded from a muscle is shown in Fig 5B. These voltage impulses arise from tiny currents in the nerve or muscle cells. These currents are a result of charged ions flowing in and out of voltage-gated channels in the membrane of the cells. Kirchoff's Law from basic circuits tells us that V=IR, where V is a measured voltage, I is a current, and R is a resistance. The cell membrane has a specific resistance. Therefore, the ionic currents flowing across the membrane of the cell create a voltage, i.e., a bio potential.

Figure 3.1: A) A typical nerve cell. B) A typical muscle action potential, with resting potential at -70 mV. The membrane of a cell is a layer of lipids. The lipid membrane separates the inner structures of the cell from the rest of the body. There are specific concentrations of ions inside and outside of the cell including sodium (Na^+), potassium (K^+), and chloride (Cl^-). These ions are either positively or negatively charged. Therefore, a separation of charge exists across a cell membrane. The standard convention used in neurology is that the potential of the cell is the relative potential inside the cell with respect to the outside of the cell. All along the cell membrane there are openings or channels made of proteins. These channels allow ions to flow in and out of the cell. Each channel is specific to a specific ion. For example, there are sodium ion channels, potassium ion channels, etc. There are two types of channels that transverse the cell membrane, resting channels and gated channels. Resting channels are open all of the time and, along with active ion pumps, are responsible for maintaining the resting membrane potential of a cell. The gated channels will be discussed later in this laboratory.

3.2 EINTHOVEN'S TRIANGLE:-

Einthoven's triangle is an imaginary formation of three limb leads in a triangle used in electrocardiography, formed by the two shoulders and the pubis. The shape forms an inverted equilateral triangle with the heart at the centre that produces zero potential when the voltages are summed. It is named after Willem Einthoven, who theorized its existence.

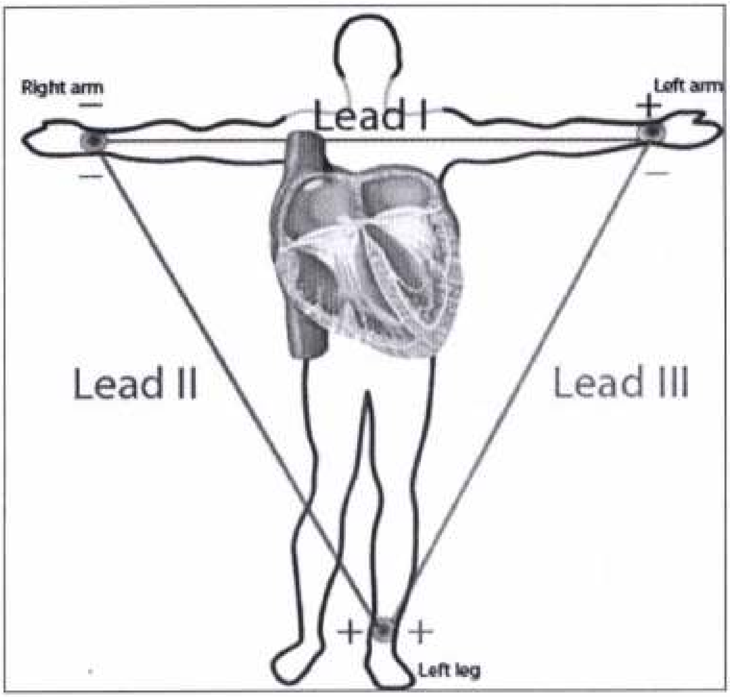


Figure 3.2: Lead Arrangement of Einthoven's Triangle

LEAD PLACEMENTS:

Lead I – This axis goes from shoulder to shoulder, with the negative electrode placed on the right shoulder and the positive electrode placed on the left shoulder.

$$I = LA - RA$$

Lead II – This axis goes from the right arm to the left leg, with the negative electrode on the shoulder and the positive one on the leg.

$$II = LL - RA$$

Lead III- This axis goes from the left shoulder (negative electrode) to the left leg (positive electrode).

$$III = LL - LA$$

CHAPTER 4

4.1 INSTRUMENTATION AMPLIFIER:-

An instrumentation amplifier is a type of differential amplifier that has been outfitted with input buffer amplifiers, which eliminate the need for input impedance matching and thus make the amplifier particularly suitable for use in measurement and test equipment. Additional characteristics include very low DC offset, low drift, low noise, very high open-loop gain, very high common-mode rejection ratio, and very high input impedances. Instrumentation amplifiers are used where great accuracy and stability of the circuit both short and long-term are required.

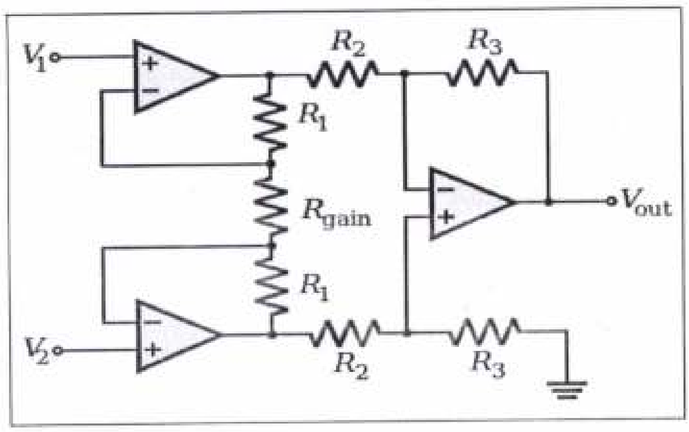


Figure 4.1: Typical Instrumentation Amplifier.

The ideal common-mode gain of an instrumentation amplifier is zero. In the circuit shown, common-mode gain is caused by mismatches in the values of the equally numbered resistors and by the mis-match in common mode gains of the two input op-amps. Obtaining very closely matched resistors is a significant difficulty in fabricating these circuits, as is optimizing the common mode performance of the input op-amps. An instrumentation amp can also be built with two op-amps to save on cost and increase CMRR, but the gain must be higher than two (+6 dB).

Instrumentation amplifiers can be built with individual op-amps and precision resistors, but are also available in integrated circuit form from several manufacturers (including Texas Instruments, National Semiconductor, Analog Devices, Linear Technology and Maxim Integrated Products). An IC instrumentation amplifier typically contains closely matched laser-trimmed resistors, and therefore offers excellent common-mode rejection. Examples includeAD8221 , MAX4194 , LT1167 and INA128 .

4.1.1 AD620:-

The AD620 is a low cost, high accuracy instrumentation amplifier that requires only one external resistor to set gains of 1 to 10,000. Furthermore, the AD620 features 8-lead SOIC and DIP packaging that is smaller than discrete designs and offers lower power (only 1.3 mA max supply current), making it a good fit for battery-powered, portable (or remote) applications. The AD620, with its high accuracy of 40 ppm maximum nonlinearity, low offset voltage of 50 μV max, and offset drift of 0.6 μV/°C max, is ideal for use in precision data acquisition systems, such as weigh scales and transducer interfaces. Figure8 shows the pin diagram of the AD620 Instrumentation Amplifier.

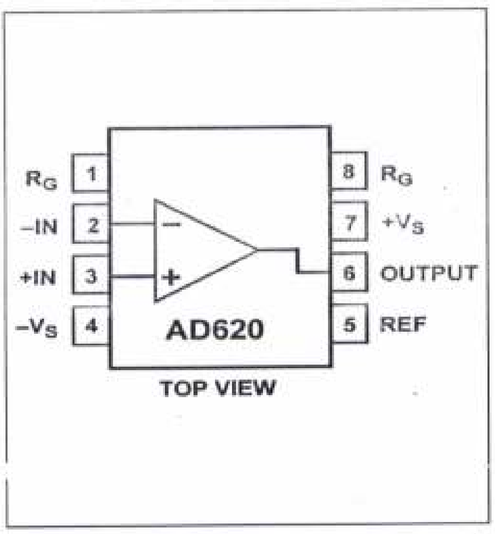


Figure 4.2: Pin Diagram of AD620 Instrumentation Amplifier

Furthermore, the low noise, low input bias current and low power of the AD620 make it well suited for medical applications, such as ECG and non-invasive blood pressure monitors. The low input bias current of 1.0 nA max is made possible with the use of Superбeta processing in the input stage. The AD620 works well as a preamplifier due to its low input voltage noise of 9 nV/√Hz at 1 kHz, 0.28 μV p-p in the 0.1 Hz to 10 Hz band, and 0.1 pA/√Hz input current noises. Also, the AD620 is well suited for multiplexed applications with its settling time of 15 μs to 0.01%, and its cost is low enough to enable designs with one in-amp per channel.

4.2 LF353P Wide Bandwidth Dual JFET Input Operational Amplifier:-

This device is a low-cost, high-speed, JFET-input operational amplifier with very low input offset voltage. It requires low supply current yet maintains a large gain-bandwidth product and a fast slew rate. In addition, the matched high-voltage JFET input provides very low input bias and offset currents.

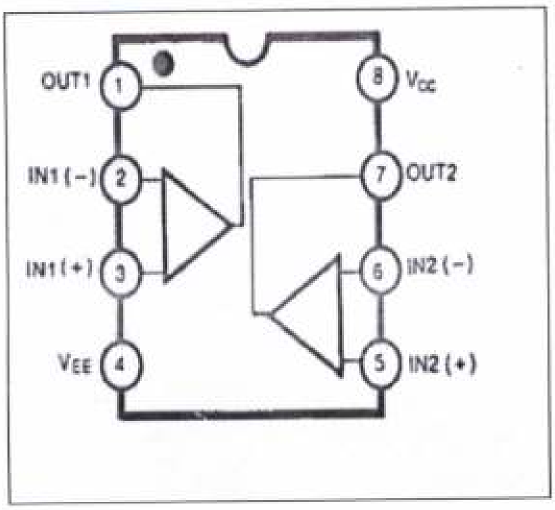


Figure 4.3: Pin Diagram of LF353P Operational Amplifier.

The LF353 can be used in applications such as high-speed integrators, digital-to-analog converters, sample-and-hold circuits, and many other circuits. The LF353 is characterized for operation from 0°C to 70°C. The LF353 is 8 pin compatible with the standard LM1558 allowing designers to immediately upgrade the overall performance of existing LM1558 and LM358 designs. These amplifiers may be used in applications such as high speed integrators, fast D/A converters, sample and hold circuit sand many other circuits requiring low input offset voltage, low input bias current, high input impedance, high slew rate and wide bandwidth. The devices also exhibit low noise and offset voltage drift.

4.3 TRANSFORMER:-

A transformer is an electrical device that transfers energy between two or more circuits through electromagnetic induction. A varying current in the transformer's primary winding creates a varying magnetic flux in the core and a varying magnetic field impinging on the secondary winding. This varying magnetic field at the secondary induces a varying electromotive force (emf) or voltage in the secondary winding. Making use of Faraday's Law in conjunction with high magnetic permeability core properties, transformers can thus be designed to efficiently change AC voltages from one voltage level to another within power networks. Transformers range in size from RF transformers less than a cubic centimeter in volume to units interconnecting the power grid weighing hundreds of tons. A wide range of transformer designs is encountered in electronic and electric power applications.

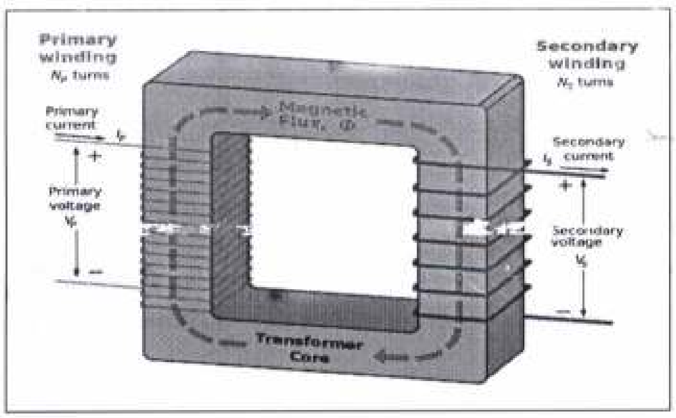


Figure 4.4: Typical Diagran of Transformer.

4.4 VOLTAGE REGULATOR:-

A voltage regulator is designed to automatically maintain a constant voltage level. A voltage regulator may be a simple "feed-forward" design or may include negative feedback control loops. Figure 8: shows a typical LM7805 IC voltage regulator It may use an electromechanical mechanism, or electronic components. Depending on the design, it may be used to regulate one or more AC or DC voltages.

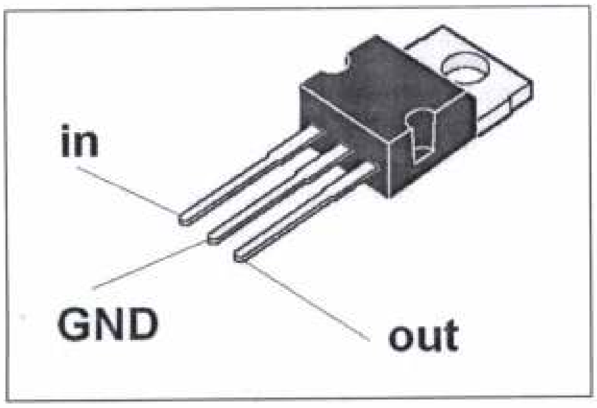


Figure 4.5: A LM7805 Voltage Regulator.

Electronic voltage regulators are found in devices such as computer power supplies where they stabilize the DC voltages used by the processor and other elements. In automobile alternators and central power station generator plants, voltage regulators control the output of the plant. In an electric power distribution system, voltage regulators may be installed at a substation or along distribution lines so that all customers receive steady voltage independent of how much power is drawn from the line.

The voltage controller may be of positive or negative voltage controller and they also comes in various series. In our project we used LM7805 for +5V supply and LM7905 for -5V supply.

4.5 DIODE:-

In electronics, a diode is a two-terminal electronic component with asymmetric conductance; it has low (ideally zero) resistance to current in one direction, and high (ideally infinite) resistance in the other. It acts like a gate or a valve, allowing electricity to go in one direction, but not the other. A semiconductor diode, the most common type today, is a crystalline piece of semiconductor material with a p–n junction connected to two electrical terminals.[5] A vacuum tube diode has two electrodes, a plate (anode) and a heated cathode. Semiconductor diodes were the first semiconductor electronic devices. The discovery of crystals' rectifying abilities was made by German physicist Ferdinand Braun in 1874. The first semiconductor diodes, called cat's whisker diodes, developed around 1906, were made of mineral crystals such as galena. Today, most diodes are made of silicon, but other semiconductors such as selenium or germanium are sometimes used.

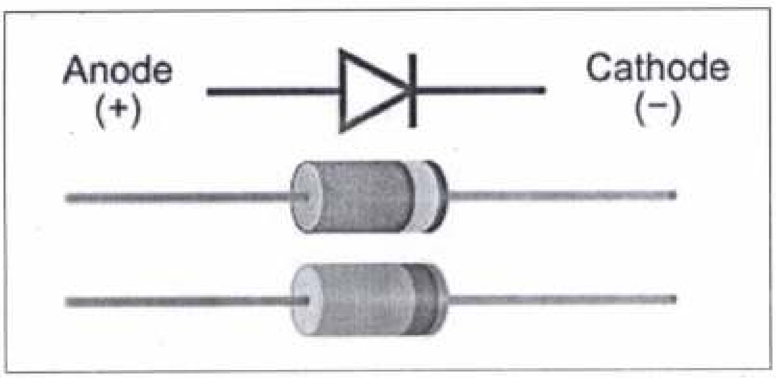


Figure 4.6: Typical Diagram of Diode.

Diodes can be used to convert alternating current to direct current (Diode bridge). They are often used in power supplies and sometimes to decode amplitude modulation radio signals (like in a crystal radio). Light-emitting diodes (LEDs) are a type of diode that produce light and are used in many places. Today, the most common diodes are made from semiconductor materials such as silicon or sometimes Germanium.

4.6 POTENTIOMETER:-

A potentiometer informally a pot, is a three-terminal resistor with a sliding or rotating contact that forms an adjustable voltage divider. If only two terminals are used, one end and the wiper, it acts as a variable resistor or rheostat. A potentiometer measuring instrument is essentially a voltage divider used for measuring electric potential (voltage); the component is an implementation of the same principle, hence its name.

Potentiometers are commonly used to control electrical devices such as volume controls on audio equipment. Potentiometers operated by a mechanism can be used as position transducers, for example, in a joystick. Potentiometers are rarely used to directly control significant power (more than a watt), since the power dissipated in the potentiometer would be comparable to the power in the controlled load.

Figure 4.7: Potentiometer.

4.7 RESISTOR:-

A resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element. Resistors act to reduce current flow, and, at the same time, act to lower voltage levels within circuits. In electronic circuits resistors are used to limit current flow, to adjust signal levels, bias active elements, terminate transmission lines among other uses. High-power resistors that can dissipate many watts of electrical power as heat may be used as part of motor controls, in power distribution systems, or as test loads for generators. The current through a resistor is directly proportional to the voltage across the resistor's terminals. The ratio of the voltage applied across a resistor's terminals by the intensity of current through the circuit is called resistance. The relation is represented by ohm's law

$$V = I \cdot R.$$

Where I is the current through the conductor units of amperes, V is the potential difference measured by across the conductors in units volts, and R is the resistance of conductor in units of ohms. In specifically, Ohm's law states that the Ris the relation of constant, independent of the current.

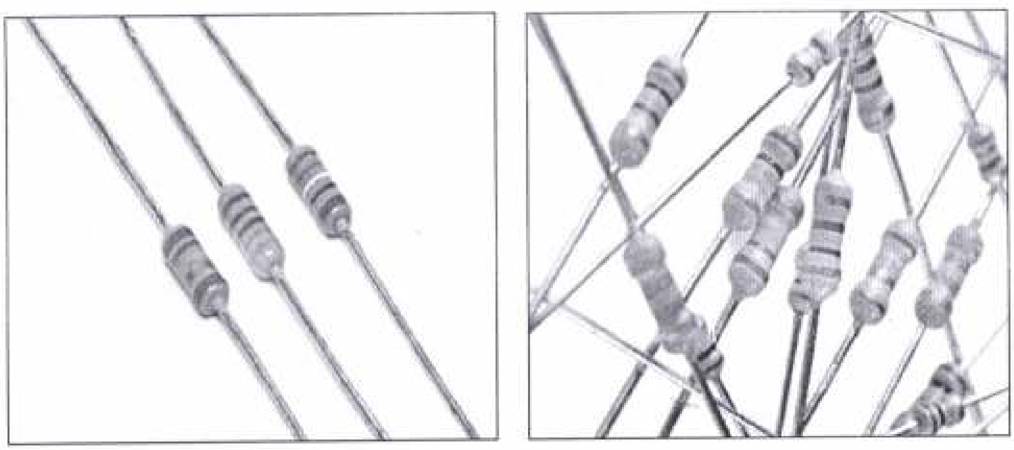


Figure 4.8: Axis Lead Resistors

4.8 CAPACITOR:-

A capacitor (originally known as a condenser) is a passive two-terminal electrical component used to store energy electro statically in an electric field. The forms of practical capacitors vary widely, but all contain at least two electrical conductors (plates) separated by a dielectric (i.e. insulator). The conductors can be thin films, foils or sintered beads of metal or conductive electrolyte, etc. The "non conducting" dielectric acts to increase the capacitor's charge capacity. A dielectric can be glass, ceramic, plastic film, air, vacuums, paper, mica, oxide layer etc. Capacitors are widely used as parts of electrical circuits in many common electrical devices. Unlike a resistor, an ideal capacitor does not dissipate energy. Instead, a capacitor stores energy in the form of an electrostatic field between its plates.

A capacitor consists of two conductors separated by a non-conductive region. The non-conductive region is called the dielectric. In simpler terms, the dielectric is just an electrical insulator. Examples of dielectric media are glass, air, paper, vacuum, and even a semiconductor depletion region chemically identical to the conductors. A capacitor is assumed to be self-contained and isolated, with no net electric charge and no influence from any external electric field. The conductors thus hold equal and opposite charges on their facing surfaces,[11] and the dielectric develops an electric field. In SI units, a capacitance of one farad means that one coulomb of charge on each conductor causes a voltage of one volt across the device.

An ideal capacitor is wholly characterized by a constant capacitance C, defined as the ratio of charge ±Q on each conductor to the voltage V between them:

$$C = \frac{Q}{V}$$

Because the conductors (or plates) are close together, the opposite charges on the conductors attract one another due to their electric fields, allowing the capacitor to store more charge for a given voltage than if the conductors were separated, giving the capacitor a large capacitance. Sometimes charge build-up affects the capacitor mechanically, causing its capacitance to vary. In this case, capacitance is defined in terms of incremental changes:

$$C = \frac{\mathrm{d}Q}{\mathrm{d}V}$$

When there is a potential difference across the conductors (e.g., when a capacitor is attached across a battery), an electric field develops across the dielectric, causing positive charge $+Q$ to collect on one plate and negative charge $-Q$ to collect on the other plate. If a battery has been attached to a capacitor for a sufficient amount of time, no current can flow through the capacitor. However, if a time-varying voltage is applied across the leads of the capacitor, a displacement current can flow.

An ideal capacitor is characterized by a single constant value for its capacitance. Capacitance is expressed as the ratio of the electric charge Q on each conductor to the potential difference V between them. The SI unit of capacitance is the farad (F), which is equal to one coulomb per volt (1 C/V). Typical capacitance values range from about 1 pF (10^{-12} F) to about 1 mF (10^{-3} F).

Capacitors are widely used in electronic circuits for blocking direct current while allowing alternating current to pass. In analog filter networks, they smooth the output of power supplies. In resonant circuits they tune radios to particular frequencies. In electric power transmission systems, they stabilize voltage and power flow.

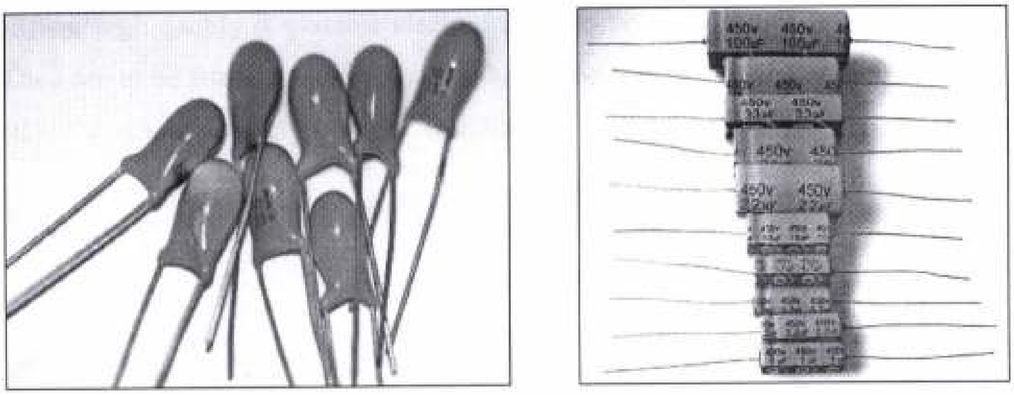


Figure 4.9: Capacitor

4.9 DISPOSABLE SURFACE ECG/EKG ELECTRODE:-

This ECG/EKG electrode is ideal for a variety of purposes and is frequently used for Neurofeedback and Biofeedback. It has a unique, patented pre-gelled adhesive side with non-irritating gel, especially developed to prevent allergic reactions. This foam electrode is latex free and therefore suitable for every skin type.The snap-on connector can easily be pushed on or removed from the electrode lead. Therefore you have optimal user friendliness as you dispose this electrode after every session! No more greasy electrodes as the H135SG will cover the surface of the electrode. This extends the life of your electrodes.

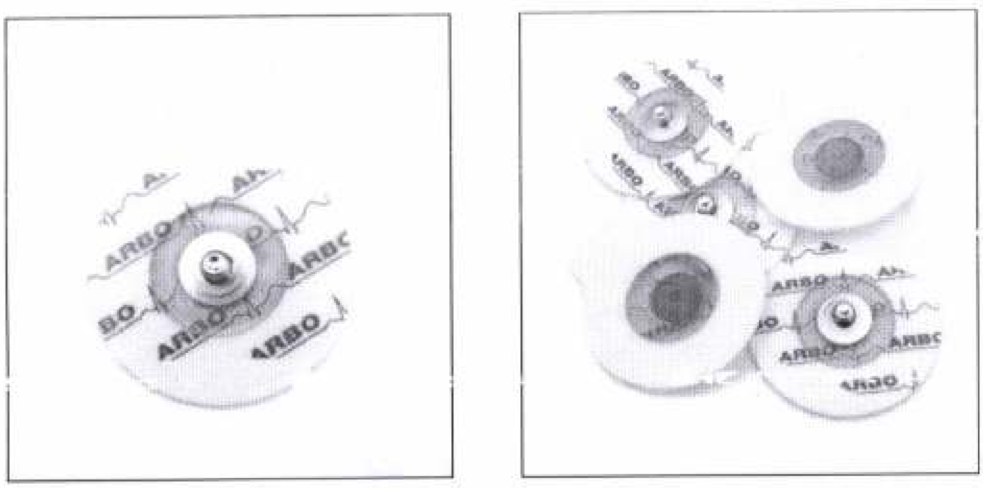


Figure 4.10: A Typical Disposable ECG Electrode.

These high quality disposable electrodes are to be used to measure EEG, ECG and EMG. They are to be used once and are very handy because of integrated gel. They adhere very well to the skin and are clean to use. One bag contains 60 electrodes.

CHAPTER 5

5.1 COST ANALYSIS:-

SL. No.	Components Name	Specification	Quantity	Price per unit(₹	Net price(₹
1.	Transformer	A.C 230V,1A-15V	1	150	150
2.	Voltage Regulator	LM7805,LM7905	2	25	50
3.	Instrumentation Amplifier	AD620	2	390	780
4.	Op-Amp	LF353P	2	35	70
5.	Diode	4007	4	10	40
6.	Capacitor	1000μF,10μF,1μF	8	5	40
7.	Resistor	1K,2K,10K,300K,4.7K	15	5	75
8.	ECG Electrodes	Ag/AgCl gelled type	3	5	15
9.	Potentiometer	1kΩ	1	5	5
10.	Vero board	Small	1	30	30
		TOTAL COST			1255

CHAPTER 6

6.1 RESULT AND DISCUSSION:-

The Figure6.1 shows the output response of the signal acquisition from human body. Here the output signal becomes triggered above 6 Volt. The general waveform of ECG signal of human body have P-wave, QRS-complex and T wave. In the project the obtained waveform have some variation of signals due to some noises occurred because of the loose connections. The advance study of the signal may determine the exact matches by using proper acquisition.

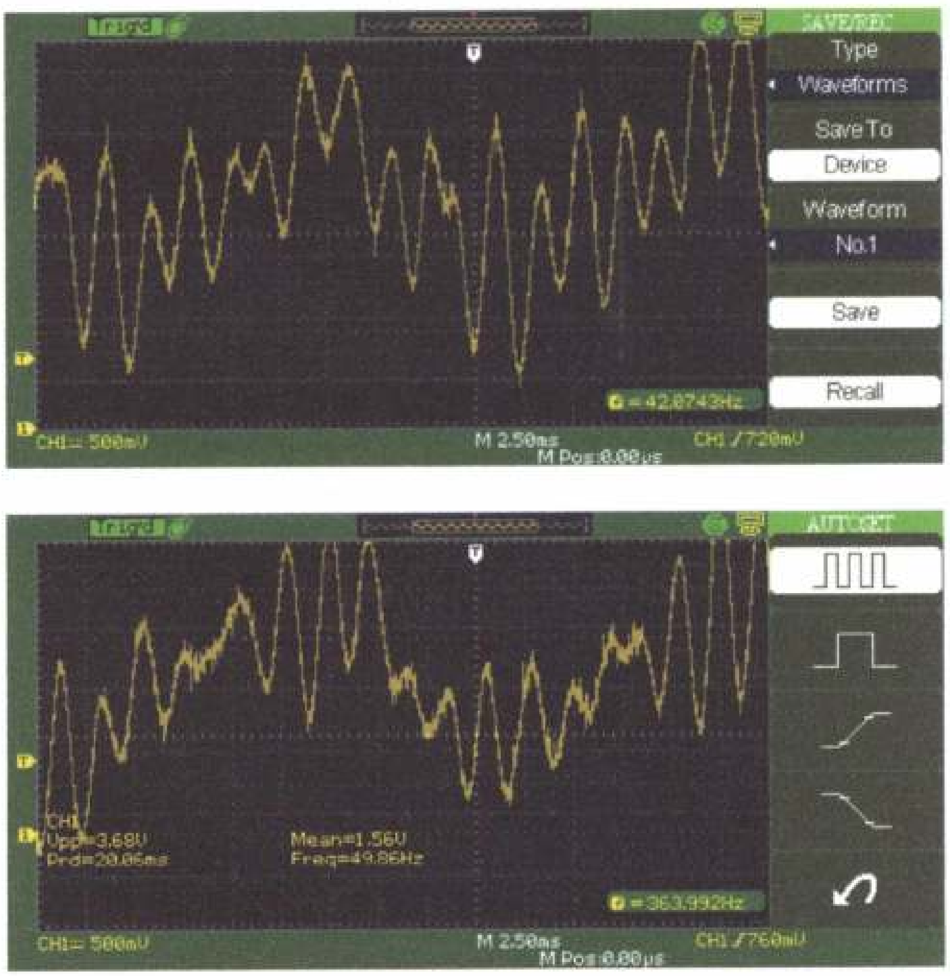


Figure 6.1 Output Waveform of ECG Sigmal

CHAPTER 7

7.1 FUTURE CONCERN:-

The waveform obtained from human body is not exact one but aim is to generate P-wave, QRS-complex and T wave accurate. In next semester the concern is to convert the analog signal to the digital signal or make signal acquisation using DAQ NI USB-6008 and analyze the signal with the halp of LabVIEW software on PC.

APPENDIX: A

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- https://www.ee.iitb.ac.in/uma/~wel/wel12/Components%20Records/analog%20ic_datasheet/lf353.pdf
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APPENDIX: B

1. Datasheet of Instrumentation Amplifier AD620
2. Datasheet of Operational Amplifier LF353P

ANALOG DEVICES

Low Cost, Low Power Instrumentation Amplifier

AD620

FEATURES
EASY TO USE
Gain Set with One External Resistor (Gain Range 1 to 1000)
Wide Power Supply Range (±2.3 V to ±18 V)
Higher Performance than Three Op Amp IA Designs
Available in 8-Lead DIP and SOIC Packaging
Low Power, 1.3 mA max Supply Current

EXCELLENT DC PERFORMANCE ("B GRADE")
50 μV max, Input Offset Voltage
0.6 μV/°C max, Input Offset Drift
1.0 nA max, Input Bias Current
100 dB min Common-Mode Rejection Ratio (G = 10)

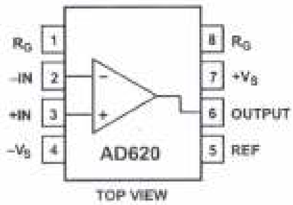
LOW NOISE
9 nV/√Hz, @ 1 kHz, Input Voltage Noise
0.28 μV p-p Noise (0.1 Hz to 10 Hz)

EXCELLENT AC SPECIFICATIONS
120 kHz Bandwidth (G = 100)
15 μs Settling Time to 0.01%

APPLICATIONS
Weigh Scales
ECG and Medical Instrumentation
Transducer Interface
Data Acquisition Systems
Industrial Process Controls
Battery Powered and Portable Equipment

CONNECTION DIAGRAM

8-Lead Plastic Mini-DIP (N), Cerdip (Q) and SOIC (R) Packages



PRODUCT DESCRIPTION

The AD620 is a low cost, high accuracy instrumentation amplifier that requires only one external resistor to set gains of 1 to 1000. Furthermore, the AD620 features 8-lead SOIC and DIP packaging that is smaller than discrete designs, and offers lower power (only 1.3 mA max supply current), making it a good fit for battery powered, portable (or remote) applications.

The AD620, with its high accuracy of 40 ppm maximum nonlinearity, low offset voltage of 50 μV max and offset drift of 0.6 μV/°C max, is ideal for use in precision data acquisition systems, such as weigh scales and transducer interfaces. Furthermore, the low noise, low input bias current, and low power of the AD620 make it well suited for medical applications such as ECG and noninvasive blood pressure monitors.

The low input bias current of 1.0 nA max is made possible with the use of Superβeta processing in the input stage. The AD620 works well as a preamplifier due to its low input voltage noise of 9 nV/√Hz at 1 kHz, 0.28 μV p-p in the 0.1 Hz to 10 Hz band, 0.1 pA/√Hz input current noise. Also, the AD620 is well suited for multiplexed applications with its settling time of 15 μs to 0.01% and its cost is low enough to enable designs with one in-amp per channel.

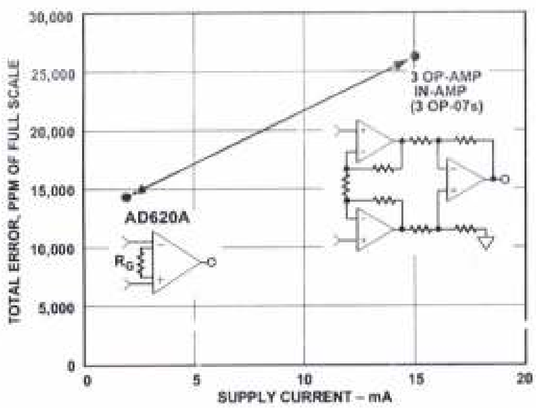


Figure 1. Three Op Amp IA Designs vs. AD620

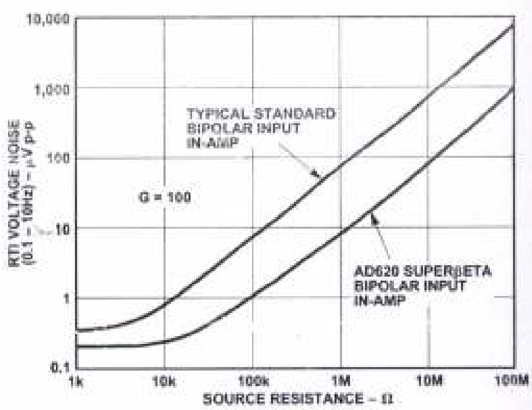


Figure 2. Total Voltage Noise vs. Source Resistance

REV. E

One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106, U.S.A.
Tel: 781/329-4700 World Wide Web Site: http://www.analog.com
Fax: 781/326-8703

AD620–SPECIFICATIONS (Typical @ +25°C, V_S = ±15 V, and R_L = 2 kΩ, unless otherwise noted)

Model	Conditions	AD620A Min	AD620A Typ	AD620A Max	AD620B Min	AD620B Typ	AD620B Max	AD620S[1] Min	AD620S[1] Typ	AD620S[1] Max	Units
GAIN	G = 1 + (49.4 k/R_G)										
Gain Range		1		10,000	1		10,000	1		10,000	
Gain Error[2]	V_{OUT} = ±10 V										
G = 1			0.03	0.10		0.01	0.02		0.03	0.10	%
G = 10			0.15	0.30		0.10	0.15		0.15	0.30	%
G = 100			0.15	0.30		0.10	0.15		0.15	0.30	%
G = 1000			0.40	0.70		0.35	0.50		0.40	0.70	%
Nonlinearity,	V_{OUT} = −10 V to +10 V,										
G = 1–1000	R_L = 10 kΩ		10	40		10	40		10	40	ppm
G = 1–100	R_L = 2 kΩ		10	95		10	95		10	95	ppm
Gain vs. Temperature											
	G =1			10			10			10	ppm/°C
	Gain >1[2]			−50			−50			−50	ppm/°C
VOLTAGE OFFSET	(Total RTI Error = V_{OSI} + V_{OSO}/G)										
Input Offset, V_{OSI}	V_S = ±5 V to ±15 V		30	125		15	50		30	125	µV
Over Temperature	V_S = ±5 V to ±15 V			185			85			225	µV
Average TC	V_S = ±5 V to ±15 V		0.3	1.0		0.1	0.6		0.3	1.0	µV/°C
Output Offset, V_{OSO}	V_S = ±15 V		400	1000		200	500		400	1000	µV
	V_S = ±5 V			1500			750			1500	µV
Over Temperature	V_S = ±5 V to ±15 V			2000			1000			2000	µV
Average TC	V_S = ±5 V to ±15 V		5.0	15		2.5	7.0		5.0	15	µV/°C
Offset Referred to the Input vs. Supply (PSR)	V_S = ±2.3 V to ±18 V										
G = 1		80	100		80	100		80	100		dB
G = 10		95	120		100	120		95	120		dB
G = 100		110	140		120	140		110	140		dB
G = 1000		110	140		120	140		110	140		dB
INPUT CURRENT											
Input Bias Current			0.5	2.0		0.5	1.0		0.5	2	nA
Over Temperature				2.5			1.5			4	nA
Average TC			3.0			3.0			8.0		pA/°C
Input Offset Current			0.3	1.0		0.3	0.5		0.3	1.0	nA
Over Temperature				1.5			0.75			2.0	nA
Average TC			1.5			1.5			8.0		pA/°C
INPUT											
Input Impedance											
Differential			10‖2			10‖2			10‖2		GΩ‖pF
Common-Mode			10‖2			10‖2			10‖2		GΩ‖pF
Input Voltage Range[3]	V_S = ±2.3 V to ±5 V	$-V_S$ + 1.9		$+V_S$ − 1.2	$-V_S$ + 1.9		$+V_S$ − 1.2	$-V_S$ + 1.9		$+V_S$ − 1.2	V
Over Temperature		$-V_S$ + 2.1		$+V_S$ − 1.3	$-V_S$ + 2.1		$+V_S$ − 1.3	$-V_S$ + 2.1		$+V_S$ − 1.3	V
	V_S = ±5 V to ±18 V	$-V_S$ + 1.9		$+V_S$ − 1.4	$-V_S$ + 1.9		$+V_S$ − 1.4	$-V_S$ + 1.9		$+V_S$ − 1.4	V
Over Temperature		$-V_S$ + 2.1		$+V_S$ − 1.4	$-V_S$ + 2.1		$+V_S$ − 1.4	$-V_S$ + 2.3		$+V_S$ − 1.4	V
Common-Mode Rejection Ratio DC to 60 Hz with 1 kΩ Source Imbalance	V_{CM} = 0 V to ±10 V										
G = 1		73	90		80	90		73	90		dB
G = 10		93	110		100	110		93	110		dB
G = 100		110	130		120	130		110	130		dB
G = 1000		110	130		120	130		110	130		dB
OUTPUT											
Output Swing	R_L = 10 kΩ, V_S = ±2.3 V to ±5 V	$-V_S$ + 1.1		$+V_S$ − 1.2	$-V_S$ + 1.1		$+V_S$ − 1.2	$-V_S$ + 1.1		$+V_S$ − 1.2	V
Over Temperature		$-V_S$ + 1.4		$+V_S$ − 1.3	$-V_S$ + 1.4		$+V_S$ − 1.3	$-V_S$ + 1.6		$+V_S$ − 1.3	V
	V_S = ±5 V to ±18 V	$-V_S$ + 1.2		$+V_S$ − 1.4	$-V_S$ + 1.2		$+V_S$ − 1.4	$-V_S$ + 1.2		$+V_S$ − 1.4	V
Over Temperature		$-V_S$ + 1.6		$+V_S$ − 1.5	$-V_S$ + 1.6		$+V_S$ − 1.5	$-V_S$ + 2.3		$+V_S$ − 1.5	V
Short Current Circuit			±18			±18			±18		mA

Model	Conditions	AD620A Min	AD620A Typ	AD620A Max	AD620B Min	AD620B Typ	AD620B Max	AD620S[1] Min	AD620S[1] Typ	AD620S[1] Max	Units
DYNAMIC RESPONSE											
Small Signal -3 dB Bandwidth											
G = 1			1000			1000			1000		kHz
G = 10			800			800			800		kHz
G = 100			120			120			120		kHz
G = 1000			12			12			12		kHz
Slew Rate		0.75	1.2		0.75	1.2		0.75	1.2		V/µs
Settling Time to 0.01%	10 V Step										
G = 1-100			15			15			15		µs
G = 1000			150			150			150		µs
NOISE											
Voltage Noise, 1 kHz	*Total RTI Noise* $= \sqrt{(e^2_{ni}) + (e_{no}/G)^2}$										
Input, Voltage Noise, e_{ni}			9	13		9	13		9	13	$nV/\sqrt{Hz}$
Output, Voltage Noise, e_{no}			72	100		72	100		72	100	$nV/\sqrt{Hz}$
RTI, 0.1 Hz to 10 Hz											
G = 1			3.0			3.0	6.0		3.0	6.0	µV p-p
G = 10			0.55			0.55	0.8		0.55	0.8	µV p-p
G = 100–1000			0.28			0.28	0.4		0.28	0.4	µV p-p
Current Noise	f = 1 kHz		100			100			100		$fA/\sqrt{Hz}$
0.1 Hz to 10 Hz			10			10			10		pA p-p
REFERENCE INPUT											
R_{IN}			20			20			20		kΩ
I_{IN}	V_{IN+}, $V_{REF} = 0$		+50	+60		+50	+60		+50	+60	µA
Voltage Range		$-V_S + 1.6$		$+V_S - 1.6$	$-V_S + 1.6$		$+V_S - 1.6$	$-V_S + 1.6$		$+V_S - 1.6$	V
Gain to Output			1 ± 0.0001			1 ± 0.0001			1 ± 0.0001		
POWER SUPPLY											
Operating Range[4]		±2.3		±18	±2.3		±18	±2.3		±18	V
Quiescent Current	V_S = ±2.3 V to ±18 V		0.9	1.3		0.9	1.3		0.9	1.3	mA
Over Temperature			1.1	1.6		1.1	1.6		1.1	1.6	mA
TEMPERATURE RANGE											
For Specified Performance			–40 to +85			–40 to +85			–55 to +125		°C

NOTES

[1]See Analog Devices military data sheet for 883B tested specifications.

[2]Does not include effects of external resistor R_G.

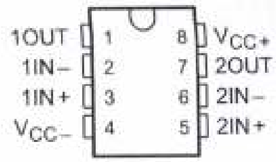
[3]One input grounded. G = 1.

[4]This is defined as the same supply range which is used to specify PSR.

Specifications subject to change without notice.

- Low Input Bias Current . . . 50 pA Typ
- Low Input Noise Current 0.01 pA/√Hz Typ
- Low Input Noise Voltage . . . 18 nV/√Hz Typ
- Low Supply Current . . . 3.6 mA Typ
- High Input Impedance . . . 10^{12} Ω Typ
- Internally Trimmed Offset Voltage
- Gain Bandwidth . . . 3 MHz Typ
- High Slew Rate . . . 13 V/μs Typ

D OR P PACKAGE
(TOP VIEW)



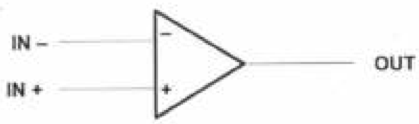
description

This device is a low-cost, high-speed, JFET-input operational amplifier with very low input offset voltage. It requires low supply current yet maintains a large gain-bandwidth product and a fast slew rate. In addition, the matched high-voltage JFET input provides very low input bias and offset currents.

The LF353 can be used in applications such as high-speed integrators, digital-to-analog converters, sample-and-hold circuits, and many other circuits.

The LF353 is characterized for operation from 0°C to 70°C.

symbol (each amplifier



AVAILABLE OPTIONS

T_A	V_{IO}max AT 25°C	PACKAGE	
		SMALL OUTLINE (D)	PLASTIC DIP (P)
0°C to 70°C	10 mV	LF353D	LF353P

The D packages are available taped and reeled. Add the suffix R to the device type (ie., LF353DR).

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

Supply voltage, V_{CC+}	18 V
Supply voltage, V_{CC-}	–18 V
Differential input voltage, V_{ID}	±30 V
Input voltage, V_I (see Note 1)	±15 V
Duration of output short circuit	unlimited
Continuous total power dissipation	500 mW
Operating temperature range	0°C to 70°C
Storage temperature range	–65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	260°C

NOTE 1: Unless otherwise specified, the absolute maximum negative input voltage is equal to the negative power supply voltage.

recommended operating conditions

	MIN	MAX	UNIT
Supply voltage, V_{CC+}	3.5	18	V
Supply voltage, V_{CC-}	−3.5	−18	V

electrical characteristics over operating free-air temperature range, $V_{CC\pm} = \pm 15$ V (unless otherwise specified)

PARAMETER		TEST CONDITIONS		T_A†	MIN	TYP	MAX	UNIT
V_{IO}	Input offset voltage	$V_{IC} = 0$,	$R_S = 10\ k\Omega$	25°C		5	10	mV
				Full range			13	
α_{VIO}	Average temperature coefficient of input offset voltage	$V_{IC} = 0$,	$R_S = 10\ k\Omega$			10		μV/°C
I_{IO}	Input offset current‡	$V_{IC} = 0$		25°C		25	100	pA
				70°C			4	nA
I_{IB}	Input bias current‡	$V_{IC} = 0$		25°C		50	200	pA
				70°C			8	nA
V_{ICR}	Common-mode input voltage range				±11	−12 to 15		V
V_{OM}	Maximum peak output voltage swing	$R_L = 10\ k\Omega$			±12	±13.5		V
A_{VD}	Large-signal differential voltage	$V_O = \pm 10$ V,	$R_L = 2\ k\Omega$	25°C	25	100		V/mV
				Full range	15			
r_i	Input resistance	$T_J = 25°C$				10^{12}		Ω
CMRR	Common-mode rejection ratio	$R_S \le 10\ k\Omega$			70	100		dB
k_{SVR}	Supply-voltage rejection ratio	See Note 2			70	100		dB
I_{CC}	Supply current					3.6	6.5	mA

† Full range is 0°C to 70°C.
‡ Input bias currents of a FET-input operational amplifier are normal junction reverse currents, which are temperature sensitive. Pulse techniques must be used that will maintain the junction temperatures as close to the ambient temperature as possible.
NOTE 2: Supply-voltage rejection ratio is measured for both supply magnitudes increasing or decreasing simultaneously.

operating characteristics, $V_{CC\pm} = \pm 15$ V, $T_A = 25°C$

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{O1}/V_{O2}	Crosstalk attentuation	f = 1 kHz		120		dB
SR	Slew rate		8	13		V/μs
B_1	Unity-gain bandwidth			3		MHz
V_n	Equivalent input noise voltage	f = 1 kHz, $R_S = 20\ \Omega$		18		nV/√Hz
I_n	Equivalent input noise current	f = 1 kHz		0.01		pA/√Hz

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LF353D	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	LF353	Samples
LF353DG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	LF353	Samples
LF353DR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	LF353	Samples
LF353DRE4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	LF353	Samples
LF353DRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	LF353	Samples
LF353P	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	0 to 70	LF353P	Samples
LF353PE4	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	0 to 70	LF353P	Samples

[1] The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

[2] Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

[3] MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

[4] There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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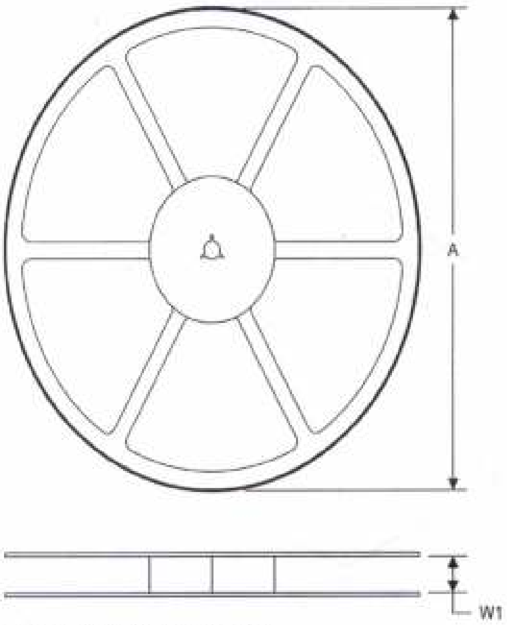
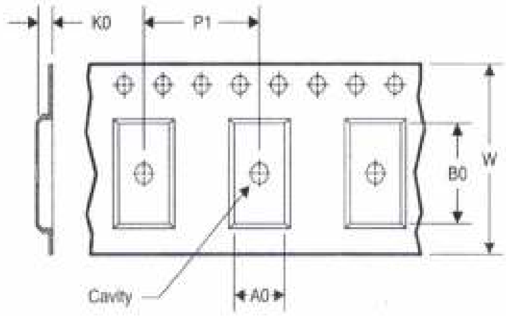
TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



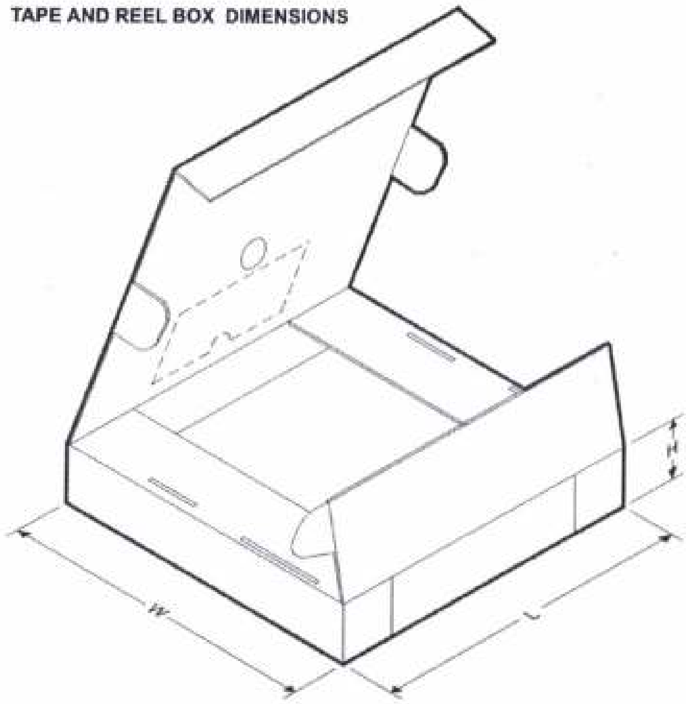
A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

TAPE AND REEL INFORMATION

*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LF353DR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LF353DR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1

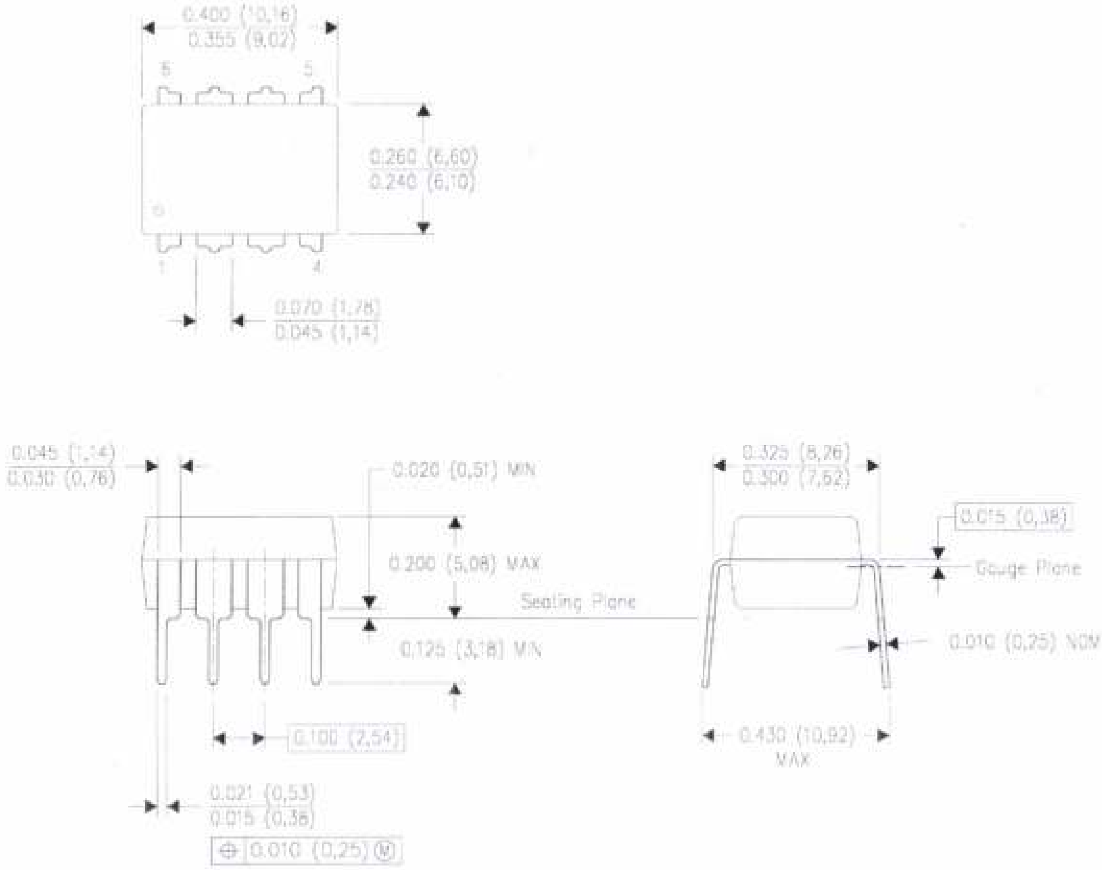
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LF353DR	SOIC	D	8	2500	367.0	367.0	35.0
LF353DR	SOIC	D	8	2500	340.5	338.1	20.6

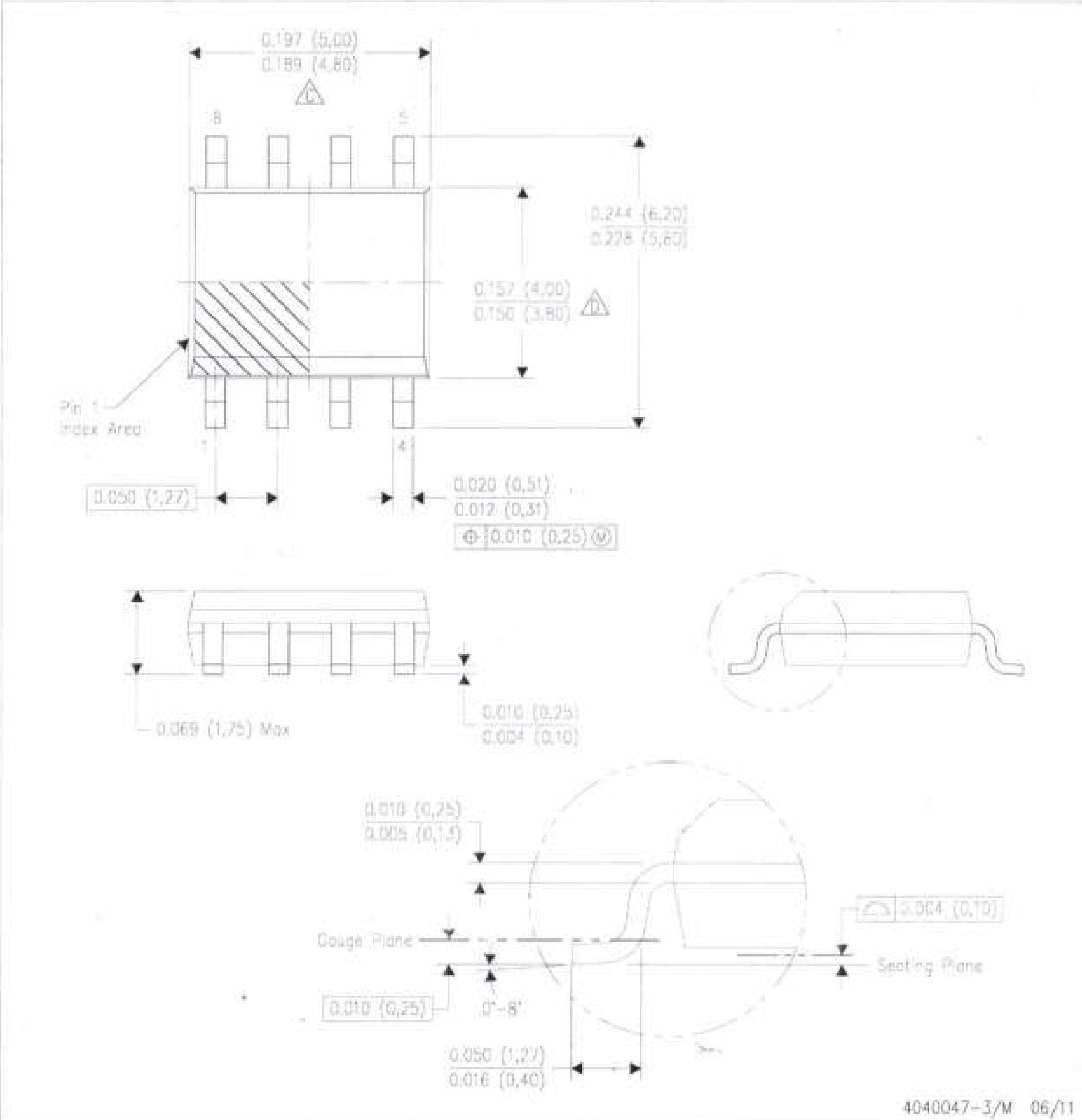
P (R-PDIP-T8) PLASTIC DUAL-IN-LINE PACKAGE



4040082/E 04/2010

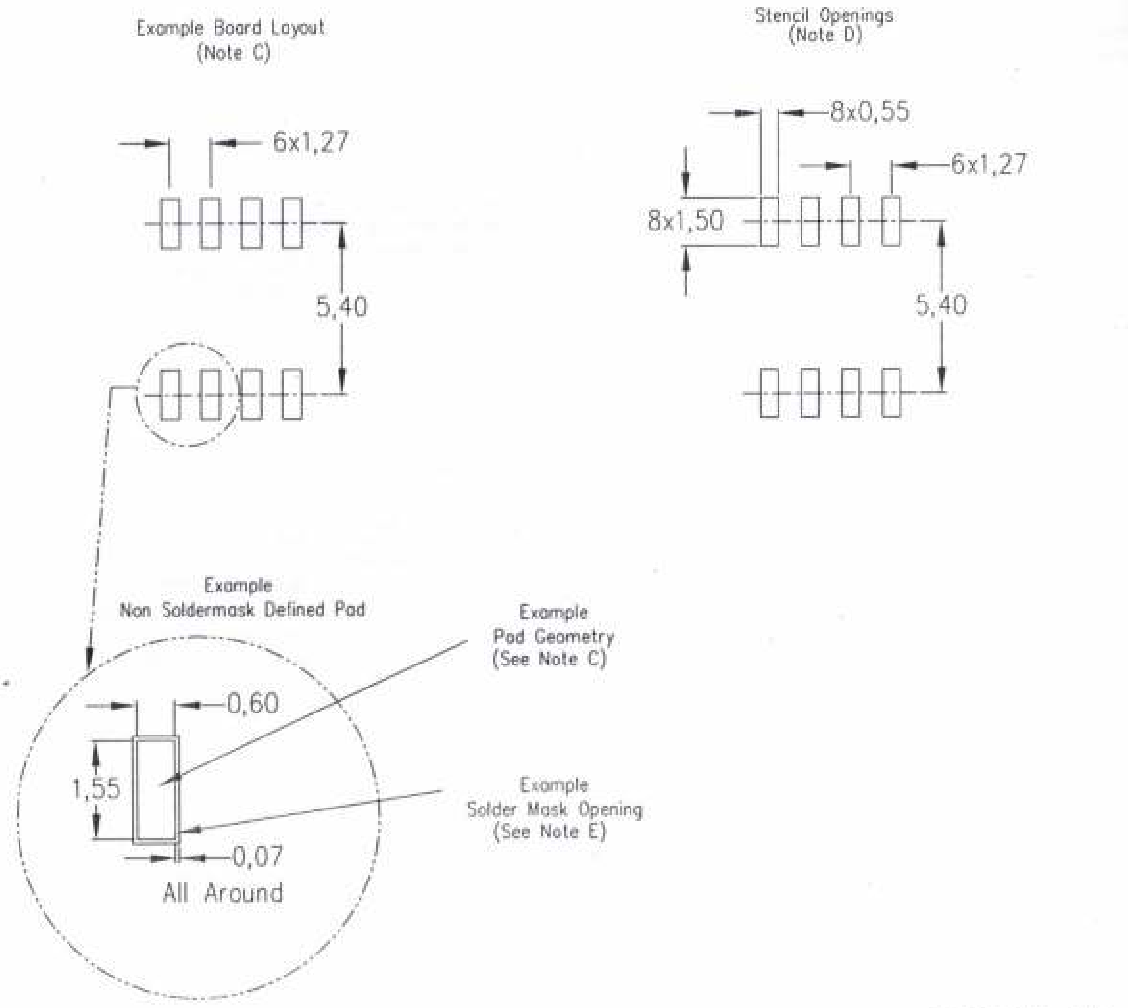
NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Falls within JEDEC MS-001 variation BA.

D (R-PDSO-G8) PLASTIC SMALL OUTLINE



NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
D. Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
E. Reference JEDEC MS-012 variation AA.

D (R-PDSO-G8) PLASTIC SMALL OUTLINE



4211283-2/E 08/12

NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Publication IPC-7351 is recommended for alternate designs.
D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

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