Palestine Polytechnic University

Applied Electronics Program
College of Applied Sciences

Graduated Project

Car Distance Protection System

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Abstract

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This system would be designed to get simple motor control, needs less power, gh efficiency, automatically work, low cost, good safety.

This design contains several types of mechanical and electrical devices, then range eter consists of transmitter to produce laser rays that is needed to travel from the car ntains device to the other car, and receiver to receive the reflected rays reflected om the other car, so then this receiver convert light to voltage value, this converted ltage passes to analog digital converter to be as digital code.

The digital code will be an input to comparator, and will be compared with other gital one that I choose referred to converted voltage introduced when laser reflected m a dangerous distance. When comparator output connected to speed controller stem then system works as: If the digital code comes from ADC larger than ference value, the motor can work in forward mode, and car can be driven forward. the digital code is less than the reference value then motor will rotates reversely er stopped. But when the digital code equals the reference value motor will stop tomatically then car will stop.

Car Distance Protection System helps drivers, passengers to get security that mes from the safety on roads.

Practical implementation of this design should be realized, and some corrections st be introduced in order to achieve successful results and operation.

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Ch.1

Introduction

1. Background

1.1 Increasing Use of Motors

Recent advances in the high energy batteries, combined with the development of smaller and more powerful motors, have opened new markets for a wide range of products, including electric vehicles. Designers concerns, however, for improved performance and more efficient operation are not limited to drives applications. The next generation of motors in many stationary applications will take further advantage of changes that are occurring in both the motors and the drive electronics that control and protect them. Motor drive electronics is experiencing improvements in the packaging, control, and power, as well as in the interconnectivity and communication that will allow motors to run more efficiently, adapt to new applications more quickly, and operate with fewer down time hours.

The size of motor can be as small as a fraction of watt to several kilowatts, depending on the application. Control techniques are changing from none or analog to digital based. Improved semiconductors technology and control schemes can be implemented by advanced integrated circuits and increasingly efficient power devices. The motors are also changing because of new magnetic materials, laminations, and winding insulations, and new designs and approaches to old designs, such as the reluctance made practical by electrical technology.

Some from electronic motor controls was employed in 15 to 20 percent of motor units manufactured in 1994. However, electronic variable speed drives can produce energy savings from an estimated 14 to 47 percent and in some applications, makes motors and their control electronics an important area for investigation. (1)

1.1.2 Need for Increasing Control

The timing couldn't be more ideal for new technology. Increased energy costs, public concern for unnecessary energy consumption and the resulting environmental impact, and legislation that require manufactures to design for improved efficiency are among the key forces that are driving the development and the implementation of new motor controls. It should be no surprise that motors have been targeted for more efficient control.

1.1.3 Implications of more Extensive Motor Control

The benefits provided by motor controls don't occur without some controversial implications, including the need for electromagnetic compatibility (EMC) and to minimumize electromagnetic interference (EMI), deteriorating power quality based on the increasing use of digital control, concern for electrostatic discharge as a source of potential reliability problems for semiconductor components, and a new aspect to safety. No matter what terminology is used to describe the switched, digital control of motor –VSD, variable frequency drives (VFD), or ASD, the switching for the voltage can produce electromagnetic interference. The electronic control of motors and inductive loads, when used without regard to the effect on power lines, has caused damaging voltage transients, lowered the power factor. Safety is also affecting motor controls. (1)

1.2 Problem Domain

A car distance protection system is an optoelectronic device that operates by sending laser light pulses and counting the voltage that introduced by light that reflected back by an object (target). Then the voltage value introduced in the laser receiver will control the work of the speed control circuit of motor that connected to a comparator circuit. Comparator get three types of output pulses, these pulses are the input of speed control circuit that connected to motor. Also the motor speed will be changed reversely to the distance between two cars and that control the car speed too. So this device will be designed to introduce the safety on roads by getting no accidents.

1.3 Studies

Since invitation first car scientists work to design methods to control the car speed to get safety for human using this car. In Palestine Polytechnic University, graduated students work on this aim too, three different projects had the same purpose, these projects are:

1. Mo'nis Batta group designed a device called Cruise Speed Control (CSC), that project idea concerned with the limitation of the vehicle speed by reduce the amount of the injected fuel.

   Cruise Speed Control System compromises three main units; radio wave transmitter, receiver, and electromechanical mechanism. While vehicle cruises at a high speed and passes a head the transmitter of the system, the electromechanical mechanism will be operated to determine the throttle angle which guarantees the limitation of vehicle speed in order not to exceed the maximum permissible speed on the particular roads. This system used to control its function which is the control of the position of butterfly is electronic control unit.

   This project idea depends on an important factor for such accidents is high speed vehicle. So CSC is contending traffic accidents to help and to take part in minimizing human faults, as is well known some hasty drivers don't abide with permissive speed.

2. Ahmad Hasasneh Group used the remote controller and remote monitoring. This design called Automobile Controller. That work used in its design cellular phones, that provided cheep, dependable and feasible technology to control remote objects and monitor far away environmental parameters.

   The purpose of this project was to use the cellular phones as a new technical controlling technique to remotely navigate a toy car, and to request the needs of cellular phones.

   That system needed regular cellular phone attached to microcontroller board of a car to accept commands and data restored in microcontroller. It designed to purpose is (1) Including INITIALIZEING, GO, and REVERSE, LEFT, AND RIGHT. (2) Waits the commands from the user to send data, And including temperature and darkness. Microcontroller in that project is itself automatically, and the data command is border which is sent if any border is in front of the car wile moving. (3).

3. Rami Abu Arqoub Group work on fuel and accelerator pedal, so in this project group would like to control the speed of car by connecting the motor valve to stepper motor that controlled by microcontroller connected to brake. That project titled with Computerized Car Acceleration Pedal.

   In this work throttle angle is the main factor used to control the car speed, then when this angle measured using angle measurement meter, its value inters the microcontroller, this microcontroller then control the fuel that control the car speed. This idea is an intelligent work to control the speed of drivers.

   This work designed to maximize the safety for who used the device, comfort, and efficiency of pedal to do its function as the ideal controller of car speed. That system served as the first step toward an intelligent cruise control system.

1.4 Description of the Problem

1.4.1 Definition

It's an electromechanical device used to control the car speed by controlling its motor speed, the speed control depends on the distance between the car contains the device and other car moves in front of it.

1.4.2 Block Diagram

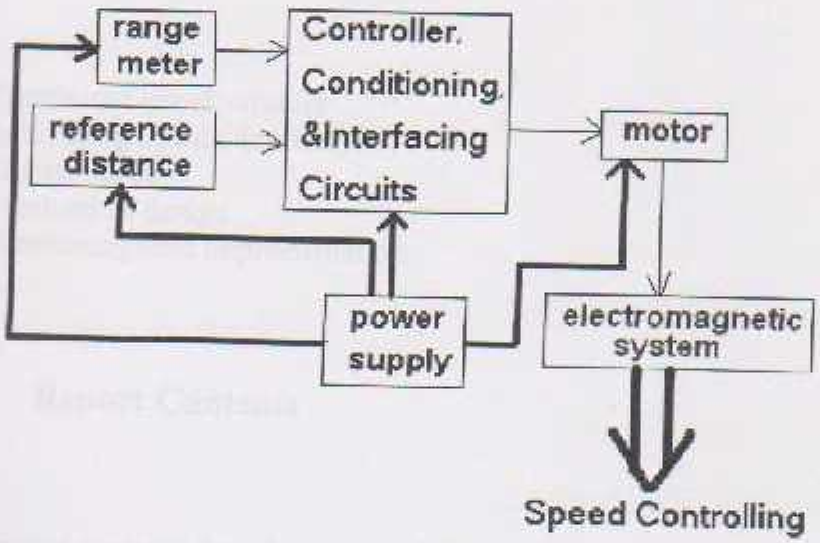


Fig.1.1: block diagram of Car Distance Protection System

1.4.3 *Project Features*

The current goal of this project is to design a device that emits a certain signal that only reflects when it receives its required signal. The receiver can introduce a voltage depends on the distance between two cars. Then I use an operating amplifiers circuit to enlarge voltage introduced from optical sensor, and then this high value of voltage will be compared with a reference value, encoder with comparators can change the analog voltage value to digital that can be an input pulse-work as a switch- to speed control circuit that contains three main functions: (1). Forward, (2). Stop, and (3). Reverse word.

1.5 Subgoals

1. Design the optical source also capable of receiving reflected signals
2. Design a controller circuit to calculate distance between the car and the obstacle.
3. Design a photo receptor that can detect the emitted received signal.
4. Use the comparator to choose the correct choice that used in speed controller.
5. Use the magnetic circuit to get accurate motor speed inversely with the distance between two cars.
6. Applying new techniques in determination the distance.
7. Introducing new system that prevents cars accidents.
8. Practical implementations of theoretical studied courses.

1.6 Helpful Skills

- Photonics/Optoelectronics
- Interfacing circuits (optcoupler)
- Digital design
- Mechanical design
- Electromagnetic implementation

1.7 Report Contents

This project contains five chapters, as follows:

- ✓ Chapter one is an introduction to the project, so it describes the project idea, definition, block diagram, aim of the project, taking its accounts and show some previous works that realized in Palestine Polytechnic University.
- ✓ Chapter two is optical state, so I show in it the use of lenses and their calculations, laser I used in project hardware with wavelength calculations, and the relationship between laser ray density and the sensor voltage introduced, then presented the reflection and refraction nature of light and the problem that cut my project line.
- ✓ Chapter three is a mechanical state, in this chapter I show the work of cars motor, how to control its speed and that change of speed how affects on torque, so how to control the speed of car.
- ✓ Chapter four is a discussion of the electrical circuits and their function with the mechanism of every circuit work, and then shows the final circuit.
- ✓ Chapter five is the last chapter which is the testing of elements and circuits work, and then we show in it the problems we found while we work in this project.
- ✓ Chapter six shows the results of the project and future works

Ch.2

Optics

2.1 Introduction

One of the most fascinating accounts of physics history is the physical nature of light forms. Since ancient time the light has been pictured as particles or waves, but now it become clear wave and particles side by side. One of the most successful theoretical structures in is quantum electrodynamics that was the solution of the wave particle duality problem. The final result of experiments in light is the subatomic particles like electrons that are considered to be manifestation of matter or energy.

Quanta and quanta mechanics born, according to Planck the energy E of quantum of electromagnetic radiation is proportional to the frequency of radiation as in eq.:

$$E = h.v \qquad \text{............} 2.1$$

Where:

$h = 6.63\times10^{-34}$ J.s: Planck's constant.

v: Frequency of radiation.

The light indicated that it is possessing energy and moment so wave length can be associated using moment ρ as a function:

$$\lambda = \frac{h}{\rho} \qquad \text{..............} 2.2$$

2.1.1 *Wave Properties*

Quantum mechanics or wave mechanics combined with moment, energy, velocity as:

$$\rho = \frac{\sqrt{E^2 - m^2c}}{c} \qquad \text{............} 2.3$$

$$\lambda = \frac{h}{v} = \frac{hc}{\sqrt{E^2 - m^2c^4}} \qquad \text{....................} 2.4$$

$$v = \frac{\rho c^2}{E} = c\sqrt{1 - \frac{m^2c^4}{E^2}} \qquad \text{....................} 2.5$$

Where:

m: reset mass.

E: Total energy.

$mv^2/2$: Kinetic energy.

mc^2: reset mass energy.

So there is a very important distinction between electrons and photons, which is the Fermi statistics that's being as in eq.:

$$n = E_e / h.v \qquad \text{..............} 2.6$$

Where:

n: Photon number.

E_e: Irradiance (power/ area).

circuit will increase.

2.2 Light

From ancient life human looks to know light prosperities and its nature, so that comes from the ingredients of the life of the Earth. Plants need light energy, human need it to live, in this project I need light to measure the distance then everywhere and every time life can't be without light.

Greeks told that the light is a tiny of particles, using this theory Newton define the reflection and refraction of light. From Newton definition sciences success that the light has a wave nature, one of theories that comes later is the interference of light and brilliant theory which developed and talk about the magnetic waves.

2.2.1 Measurements of Speed of Light

By experiment light speed equals $3 \times 10^{8}\ m/s$, that was measured when Galileo used two observers on two towers and measure the time period of light movement from two towers. There are two methods to calculate the light speed:

- Roemer's Method: he used one of Jupiter moons and its traveling around Jupiter, he see that the distance of light particle moving was like the radius of the Earth, and then he calculated the speed of light which was $2.3\times10^{8}\,m/s$.
- Fizeau's Method: he used the rotating tooth head wheel to measure the total time light take to travel from source to mirror, then determined the speed as in the equation:

$$c = 2d/t \quad \text{.................2.10}$$

d : Distance between source and mirror

t : Time of travel

Here he found the value of speed of light that equals $c = 3.1\times10^{8}\,m/s$ (2)

2.2.2 *Reflection and Refraction of Light*

2.2.2.1 Reflection of Light

The first property of light we consider is reflection from a surface, such as that of a mirror. This is illustrated in Fig. 2.1.

In the ray traced image above several polished chrome spheres reflect light from varied positions within a checkerboard tiled room. At first we will look at a simpler reflection, one that happens on a flat surface. Below is a picture of such a situation. Here a single ray of light strikes a surface and is reflected from it.

When light is reflected off any surface, the angle of incidence θ_1 is always equal to the angle θ_2 of reflection. The angles are always measured with respect to the normal to the surface. The law of reflection is also consistent with the particle picture of light.

2.2.2.2 Refraction of light

Refraction occurs when light rays change medium as ray is changing its speed, so the direction of ray change too.

In the Fig.2.1 above light rays change direction as they go from air into the glass spheres, and they change direction again when they exit the glass spheres and enter air. This causes the checkerboard patterns to be distorted. Anyone who has ever looked through any type of curved piece of glass has seen similar phenomena.

2.2.2.3 Changing the Speed of Light

Snell's Low:

The bending of light as it enters medium coming from another one differs in its characteristics while traveling. Interface between the media is the meeting place of two different media. All refraction of light (and reflection) occurs at the interface.

When light is incident at a transparent surface, the transmitted component of the light changes direction at the interface. Another component of the light is reflected at the surface, as shown in Fig.2.4, the refracted beam changes direction at the interface and deviates from a straight continuation of the incident light ray.

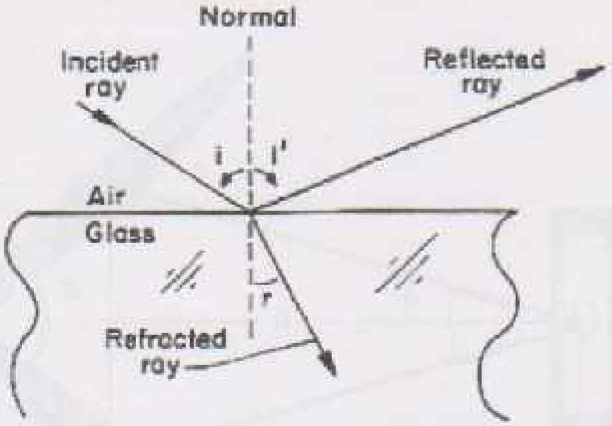


Fig. 2.1: Light in air incident on glass surface where it is partly reflected at the interface and partly transmitted into the glass. The direction of the transmitted ray is changed at the air/glass surface. The angle of refraction r is less than the angle of incidence i.

Snell's low came to find the change of light speed when it refracts as in equation:

$$\frac{n_1}{n_2} = \frac{\sin r}{\sin i} = \frac{v_2}{v_1} = \frac{\lambda_2}{\lambda_1} \quad \dots\dots\dots 2.11$$

n_1 : Medium index

λ_1 : Light wavelength in of incident ray

λ_2 : Light wavelength of refracted ray

i : Incidence angle

r : Refracted angle

v_1 : Incident ray speed

v_2 : refracted ray speed

The change of direction of light as it passes from one medium to another is associated with a change in velocity and wavelength. The energy of the light is unchanged as it passes from one media to another.

2.2.2.4 Critical Angle

Using the refraction simulator, notice how the light bends toward the normal when the light enters a medium of greater refractive index, and away from the normal when entering a medium of lesser refractive index. Then notice what happens when you move the flashlight to an angle close to 90 or -90 degrees in the medium with a higher refractive index. As you approach the critical angle the refracted light approaches 90 or -90 degrees and, at the critical angle, the angle of refractions becomes 90 or -90 and the light is no longer transmitted across the medium/medium interface. For angles greater in absolute value than the critical angle, all the light is reflected. This is called total reflection. (3)

Calculation:

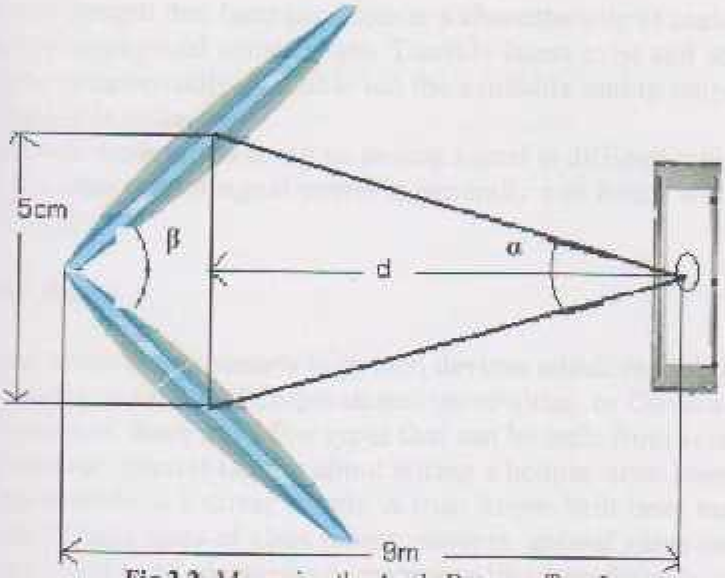


Fig.2.2: Measuring the Angle Between Two Lenses

$\alpha = 2\sin^{-1}(2.5cm/10m) = 0.3°$

$\alpha' = 90 - 0.15 = 89.85°$

$\beta' = 90 - 89.85 = 0.15°$

$\beta = 2 \times 89.85 = 179.7°$

ℜ

2.3 Laser

The laser is an acronym for "light amplitude by the stimulated emission of radiation". Laser produces far and away the best kind of light for optical communication.

The laser is the most important optical device for last fifty years, laser is an optical amplifier. The laser word stands for light amplification by stimulated emission of radiation. Together with optical fibers and semiconductor optoelectronics devices laser has revolutionized optics and optics industry.

2.3.1 *Advantages of lasers*

1. Lasers have been quite expensive by comparison with leds. One of the things that cause lasers to have a high cost is that for lasers used in long distance applications temperature control and output power control is need. Temperature control maintains a stable lasting threshold and power control

ensures that the detector can see a stable signal. Both of these require added cost.

2. The wavelength that laser produces is a characteristic of material used to build it and of its physical construction. Tunable lasers exist and are beginning to become commercially available but the available tuning range is quite narrow and tuning is quite slow.
3. Amplitude modulation using an analog signal is difficult with most lasers because laser output signal power is generally non linear without input signal power. (4)

2.3.2 Laser Basics

While most lasers are extremely high tech devices which require the engineering and manufacturing expertise of corporations, universities, or Government agencies to design and construct, there are a few types that can be built from scratch by the *very* determined amateur. I'm not talking about wiring a helium-neon laser tube to a power supply or a laser diode to a driver circuit. A truly home-built laser may start out as 4 foot lengths of various sizes of glass tubing, mirrors, special gases and chemicals, scrap metal and hardware; electronic components like transformers, rectifiers, capacitors, and resistors - and laser and high voltage warning signs! Converting this collection of materials into a working laser will require many hours of effort as well as blood, sweat, and possibly tears.

Although the laser is a device or instrument based on fundamental quantum mechanics which is very simple in principle - an excited medium between mirrors - building one successfully may require mastering several disciplines not normally found in even the high tech home. These include: glass working, vacuum systems, gas handling, high voltage electronics, and precision mechanical fabrication. Dealing with these can in itself be an excellent educational experience. Access to a university or industrial lab will make things a lot easier but isn't essential - it is possible to build a laser without outside assistance. Academic studies in laser physics or related subjects are also not necessary unless you want to attempt to do serious research as all the lasers that can be reasonably constructed at home are based on well established principles where rules-of-thumb and simple calculations will suffice.

The reason for building a laser from scratch is to learn how lasers work through physical hands on construction. Also, one major feature that you have with home-built lasers, is the unlimited freedom of experimentation, you can control many variables like: power (voltage and currents), gas, optics, materials etc, which otherwise is very difficult or impossible with commercial lasers.

Another rule that I have set when it comes to building lasers: Build the lasers that are more expensive, exotic, and least obtainable like:

- ✓ Carbon Dioxide Laser.
- ✓ Nitrogen Laser.
- ✓ Copper Vapor and or other metal vapor lasers.
- ✓ Solid state lasers - Ruby, Nd:YAG, frequency doubled YAGs.
- ✓ Dye Laser (flash lamp and/or N2 laser pumped). (5)

2.3.3 *Wavelength Measurements*

If light of wave length λ from two luminous points whose phase difference is constant falls in point P, then two beams of light interference. If two vector amplitudes for propagation in x direction are represented by

$$s_i = a_i e^{i(t/\lambda - \delta_i)} \text{ ……………… } 2.12$$

where δ_i represents phases

The individual intensities are given as:

$$I_i = S_i - S_i \text{ ……………………} 2.13$$

the superposition gives

$$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\delta \text{ ………………… } 2.14$$

Where

$$\delta = \delta_1 - \delta_2 \text{ ………………… } 2.15$$

In case of fresnel mirror wave from light source Q falls on to two mirrors inclined angle α, interference patterns observed on screen S, mirror with light source can be replaced two coherent light sources Q_1 & Q_2 separated by distance d. If r is a distance between Q & A which the mirrors are touching.

$$AQ_1 = AQ_2 = r \;\&\; d = 2r\sin\alpha \text{ ………………… } 2.16$$

If distance between screen and mirrors is large compared with distance between two adjacent interference maxima

$$r_2 = r_1 = a \text{ ……………… } 2.17$$

$$r_2 - r_1 = pd / a \text{ ………… } 2.18$$

Since

$$(r_2 - r_1)(r_2 + r_1) = 2pd \text{ ………… } 2.19$$

So

$$\delta = 2\pi(r_2 - r_1)/\lambda = 2\pi pd/\lambda a \text{ ………………… } 2.20$$

maxima occurs on screen for P equals to :

$$P = n\lambda a / d \text{ …………………… } 2.21$$

and minima for

$$P = (n + .5)\lambda a / d \text{ ………… } 2.22$$

The distance d between two virtual light sources is determined by projecting a sharp image of them on screen using lens of focal length f and measuring size of image

$$\frac{1}{g}+\frac{1}{b}=\frac{1}{f}$$

then

$$g/b=d/B \ldots\ldots\ldots\ldots 2.23$$

where g & b represent object to lens and image to lens distances as

$$d=B.f/(b-f) \ldots\ldots\ldots\ldots 2.24$$

a is a distance between two neighboring maxima and case of biprism distance d determined as in mirrors. (6)

Calculations:

► For mirror experiment:

$d=B.f/(b-f)=0.7\times 30/(520-30)=0.0429cm$

$\lambda=dp/na$

$\lambda_1=0.0429\times 1/1\times 536.2=799.3nm$

$\lambda_2=0.0429\times 1.4/2\times 536.2=559.5nm$

$\lambda_3=0.0429\times 1.8/3\times 536.2=479.6nm$

$\lambda_m=(\lambda_1+\lambda_2+\lambda_3)/n=7.993\times 10^{-5}+5.595\times 10^{-5}+4.796\times 10^{-5}=6.128\times 10^{-5}$ cm

Error% = $((6.128\times 10^{-5}$ cm $-$ 536.2nm$)/536.8)\times 100\%=3.16\%$

$\delta=2\pi pd/\lambda a=2\pi\times 3\times 0.0429/6.128\times 10^{-5}\times 536.2=1.664\times 10^{-7}m$

► For biprism experiment:

$d=B.f/(b-f)=3.4\times 30/(414.5-30)=0.265cm$

$\lambda=dp/na=0.265\times 0.1/422=628.6nm$

Error% = $(632.8-628.6/632.8)\times 100\%=2.02\%$

$\delta=2\pi pd/\lambda a=2\pi\times 1\times 0.265/628.6\times 10^{-5}\times 536.2=4.94\times 10^{-7}m$

ℜ The wavelength I use in this project $\lambda=4.4\times 10^{-7}m$

2.3.4 *Laser Principles*

The key principle in laser operation is the principle of stimulated emission as:

1. An electron within an atom starts in a low energy stable state often called the "ground" state.
2. Energy is supplied from outside and is absorbed by the automatic structure where upon the electron enters an excited state.
3. a photon arrives with an energy close to the same amount of energy as the electron needs to give up to reach stable state.
4. The arriving photon triggers a resonance with the exited atom. As a result the excited electron leaves its excited state and transition to a more stable state giving up the energy difference in the form of a photon.

The critical characteristic here is that when a new photon is emitted it has identical wavelength, phase and direction characteristics as the exciting photon. (7)

2.4 Lenses

Lens is a circular piece of glass or transparent plastic, this has two surfaces are grounded to produce convergence and divergence of light, so we have two types of lenses which are concave lenses and convex lenses. Then to find the focal length of the lens we use the equation:

$$\frac{1}{F}=\frac{1}{O}+\frac{1}{I} \qquad \text{.........................2.25}$$

F : Focal length.

O : Observer

I : Image produced.

Then enlarge of the image calculated as:

$$M=-I/O \qquad \text{.....................2.26}$$

2.4.1 *Convex Lenses*

Convex lenses considered as positive lenses, so that coming from causing light rays to converge and concentrate the real image that can project onto screen. Convex lens that shown in Fig.2.3 has a focal length FL and focal point at F, this lens is symmetric so has equal curvature angles on its two sides.

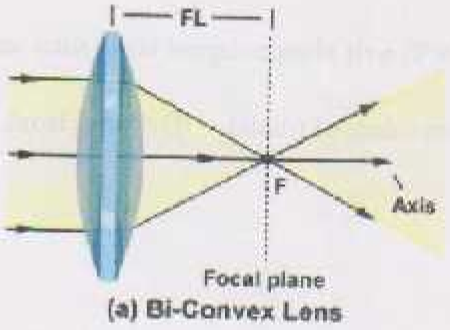


Fig.2.3: Convex Lens

Convex Lenses Calculations

⇒ When the laser transmitter placed on a point back to a lens at 5cm and image will be at point with distance in front of this lens 9m.

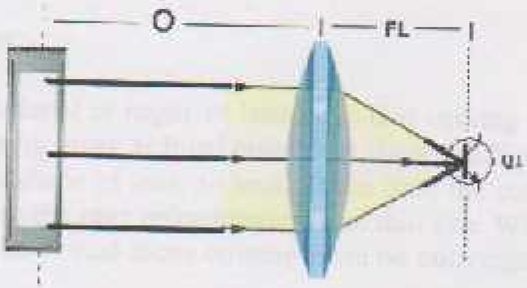


Fig. 2.4: Convex Lens Calculation

$$\frac{1}{F}=\frac{1}{O}+\frac{1}{I}$$

► $F=\frac{I\cdot O}{I+O}=\frac{9\times5\times10^{-2}}{9+5\times10^{-2}}=4.997cm$

♣ We can choose a lens with focal length equals five (F = 5cm)

⇒ When the reflected laser return to the receiver from a point placed on 9m and its image will concentrate on a phototransistor placed on 2cm back of the lens then the lens have a focal length:

$$\frac{1}{F}=\frac{1}{O}+\frac{1}{I}$$

► $F=\frac{I\cdot O}{I+O}=\frac{9\times5\times10^{-2}}{9+5\times10^{-2}}=4.997cm$

- We can choose a lens with focal length equals five (F = 5cm)

it I choose a lens with focal length (F = 10cm) to make more enlarge and take better ficiency.

ien,

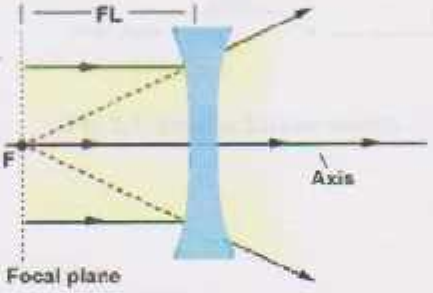
$$= \frac{1}{O} + \frac{1}{I}$$

$$I = \frac{O \cdot F}{O - F} = \frac{9 \times 10 \times 10^{-2}}{9 - 10 \times 10^{-2}} = 10cm$$

Phototransistor will be placed back to lens at distance 10cm

.2 *Concave Lenses*

Concave lenses considered as negative lenses, so that coming of divergence of ssing waves or scattering away at focal point F as shown in Fig 2.9, divergence oduced because of the shape of lens, so lens is then onto the center and thick onto e periphery that making the rays refract away from thin site. Waves concave on the gative focal point F, the virtual focus coming from no convergence on F so image lled virtual image.



(b) Bi-Concave Lens

Fig.2.5: Concave Lens (3)

oncave Lenses Calculations

hen the laser transmitter placed on a point back to a lens at 5cm and image will be point with distance in front of this lens 9m.

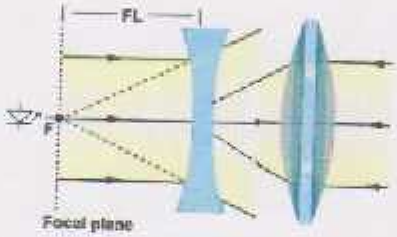


Fig 2.6: Distance between Two Lenses

$$\frac{1}{F}=\frac{1}{O}+\frac{1}{I}$$

► $F=\frac{I\cdot O}{I+O}=\frac{3\times10^{-2}\times2\times10^{-2}}{2\times10^{-2}+3\times10^{-2}}=1.2cm$

- We can choose a lens with focal length equals five (F = 5cm)

Concave Lens Enlarge Factor:

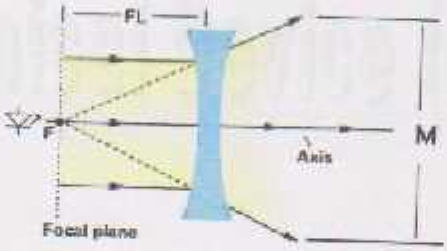


Fig.2.7: Enlarge Measurements

$M=-I/O$

► $I=\frac{3}{0.5}=6cm$

Or:

► $H'=\frac{M}{H}=\frac{10}{0.3}=33.3cm$

Phototransistor will be placed back to lens at distance 10cm

Ch.3

Mechanical Device (Motor)

3.1 Introduction

Direct current motors are seldom used in ordinary industrial applications because all electric utility systems furnish alternating current. However, for special applications such as a steel mills, mines, and electric trains, it's sometimes advantages to transform the alternating current into direct current in order to use dc motors. The reason is that the torque speed characteristics of dc motors can be varied over a wide range while retaining high efficiency.

Today, this general statement can be challenged because the availability of sophisticated electronic drives has made it possible to use alternating current motors for variable speed applications. Nevertheless, there are millions of dc motors still in service and (8)

3.2 The Motor Classification

Motors are often ranged by function, such as motor for sewing machines, blenders, washing machines. While this supplies information about their use, it says nothing about the type of the motor. This is better done by designations such as those in table 3.1.

The basic concept behind the function of a motor is very simple and depends on the forces of attraction and repulsion between magnets. These consist of two types: permanent magnets and electromagnets. A permanent magnets made of metals or alloys that can be magnetized; an electromagnet is a coil of wire carrying an electric current, either dc or ac.

Table 3.1 Motor Types

	Alternating Current		
Direct Current	**Single Phase**	**Polyphase**	**Electronic**
Shunt	Split-phase	Squirrel-cage rotor	Brushless, slotless, coreless
Series	Repulsion-induction	Wound rotor	Hall effect
Compound	Universal	Slip ring	Logic circuit
Split field	Capacitor	Brush shifting	Electronic control types
Differential Interpole Universal Tapped field universal	series	Shaded pole	Disc stepping Power stepper

The armature is mounted on a shaft, supported at its ends by bearings. The rotation of the armature results in useful work can be done this machine. The field coil, fixed in position, can receive its operating voltage directly. The armature does present a problem and that problem is how to supply current to a rotating coil. This is done by commutator segments made of copper and mounted in the form of a cylinder on a shaft. The copper segments are connected to the coils of armature. A carbon brush, positioned against the commutator segments, supplies a good electrical contact without interfering with the rotation of the armature. The brushes are connected to dc or ac voltage source. In this way an electrical current flows from the source voltage into the brushes and then from the brushes into the armature coils. It's this current that results in a magnetic field around the coils.

The current flowing through the field coils also produces a magnetic field. It is the reaction between this magnetic field and that surrounding the armature that results in the rotation of the armature. And, when the armature turns, so does shaft on which it's positioned.

This is the basic way in which a motor works, and while it's simple, there are a large number of motor types as in Fig.3.1, each designed to produce certain results. Some have a large amount of turning power, known as torque; others have a constant speed; still others can have their speed controlled easily; some are more efficient than others; some are low power types, while some demand a high amount of power input. (9)

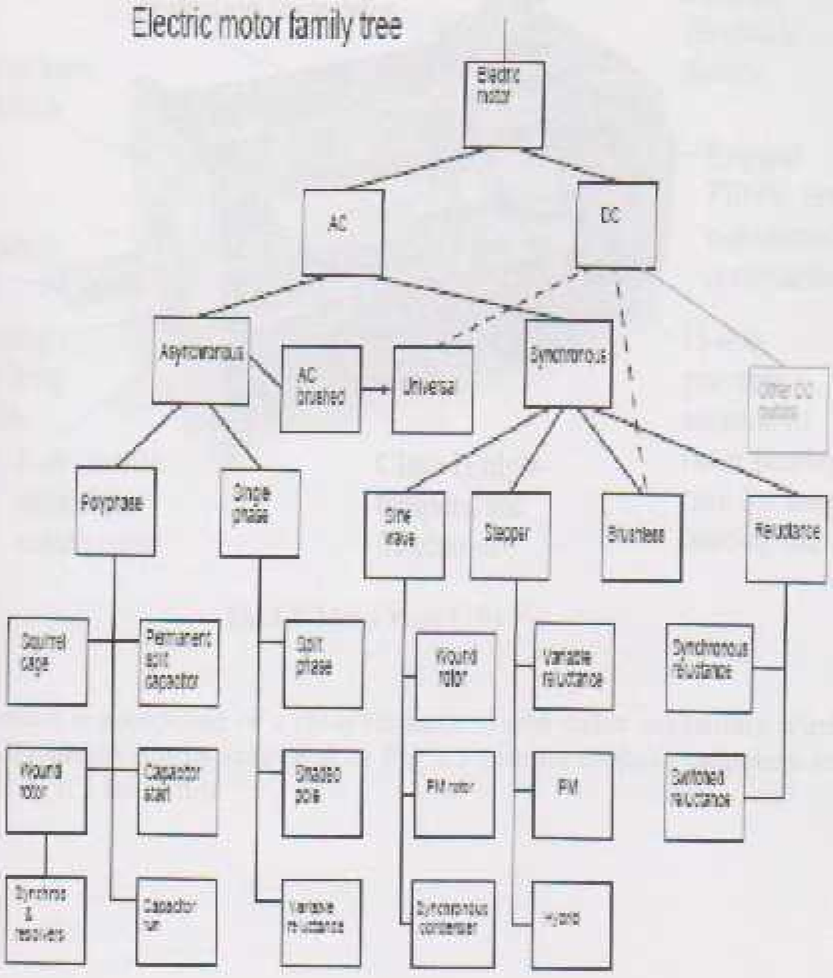


Fig.3.1: Electric Motor Family Tree

3.3 Electric Motor Basics

3.3.1 Motor Construction

A motor consists of two types: primary winding and secondary winding. These consist of oils of wire wound around an iron core, both fixed in position. One of windings known as armature or rotor is allowed to rotate. The other, fixed position winding, is referred to as the field or stator.

Windings have no physical connection; the stator is wound so that it forms a housing surrounding the rotor, the rotor is amounted n a shaft and is fastened to it. is shaft, a rod made of steel, protrudes from the rotor and turns with it, it's this rotating shaft that supplies the torque or turning power or gears, levers, cams or other mechanical arrangements as in Fig.3.2

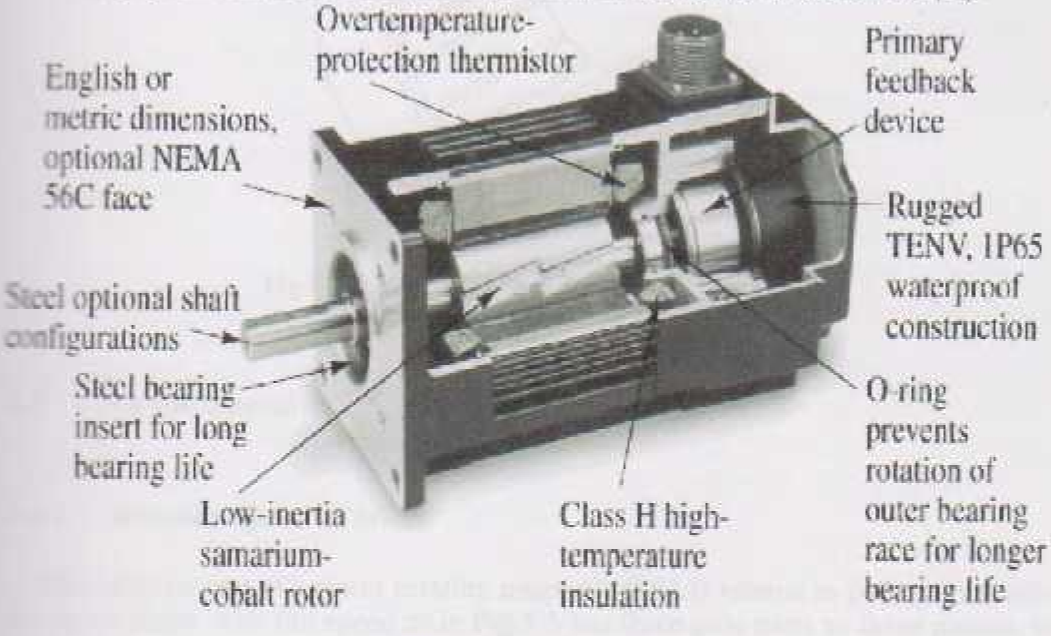


Fig.3.2: Motor Parts (10)

Induction motors is composed of a rotor (armature) and stator containing windings connected to poly-phase energy source as in Fig.3.3 Simple 2-phase induction motor below is similar to 0.5 hp motor.

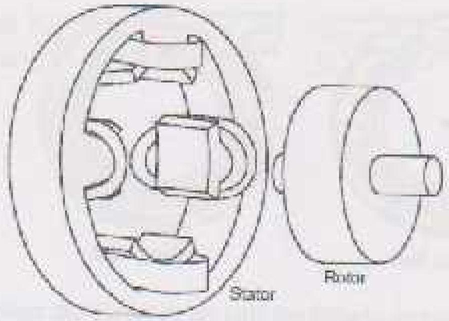


Fig.3.3: Phase Induction Motor

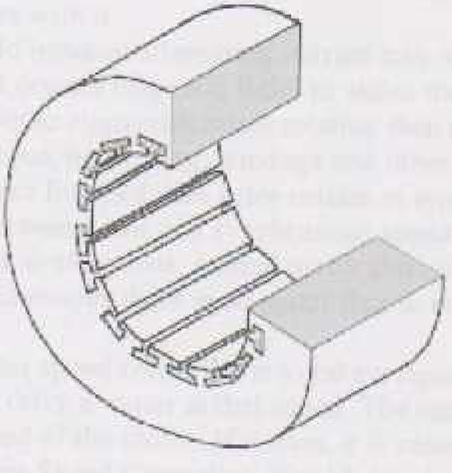


Fig.3.4: Stator Frame Showing Slots for Windings (9)

3.4 Motor Speed

3.4.1 Rotating Speed of Motor

The relation rate of a stator rotating magnetic field is related to pole pairs number per stator phase. The full speed as in Fig.3.5 has three pole pairs so three phases, but motor need only one pair and one phase to get 1 pole pair/ phase. The magnetic field rotates once per sine wave cycle. At 60 Hz power, field rotates 60 times per second. In 50 Hz power it rotates 50 times which are the synchronous speeds of motor. For rotator motor can't achieve this speed so it needs the upper limit. To solve this problem designers used double motor poles, then synchronous speed is cut in half rotation because the magnetic field rotates 180 degree for 360 degree of electrical sine wave.

Synchronous speed calculated as:

$$N_s = 120.f/P \quad \ldots\ldots\ldots\ldots 3.1$$

N_s: Synchronous speed in rpm.

f: Frequency of applied power in Hz.

P: Total number of poles per phase, multiple of 2.

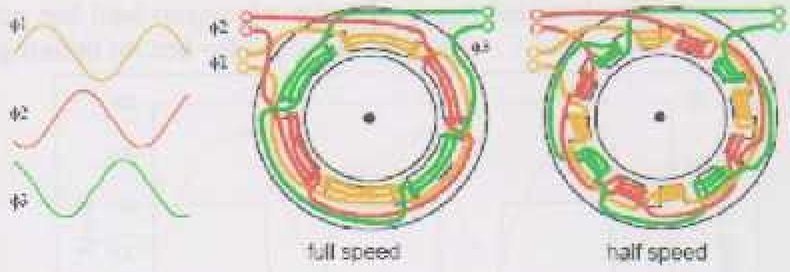


fig.3.5: Doubling the Stator Poles half the Synchronous Speed

Main idea said that inductance motor is that the rotating magnetic produced by the stator makes rotor rotates with it.

Stator's magnetic field induced alternating current into rotor squirrel cage conductors. This current creates magnetic field, so stator magnetic field interacts with rotor field which attempts to align with stator rotating then rotor squirrel cage rotates. That be if there is no torque, no bearing, windage and other losses, but if these mechanical parameters are founded then rotor rotates at synchronous speed. Torque developed by the slip between rotor and synchronous speed stator. Magnetic flux cut rotating rotor conductors as slips does, loaded motor then slips in proportion to mechanical load. In synchronous there is no stator flux to cut rotor and no current induces it so no torque.

The purpose of a motor speed controller is to take a signal representing the demanded speed, and to drive a motor at that speed. The controller may or may not actually measure the speed of the motor. If it does, it is called a Feedback Speed Controller or Closed Loop Speed Controller, if not it is called an Open Loop Speed Controller. Feedback speed control is better, but more complicated, and may not be required for a simple robot design.

Motors come in a variety of forms, and the speed controller's motor drive output will be different dependent on these forms. The speed controller presented here is designed to drive a simple cheap starter motor from a car, which can be purchased from any scrap yard. These motors are generally series wound, which means to reverse them, they must be altered slightly. (11)

3.4.2 Theory of DC Motor Speed Control

The speed of a DC motor is directly proportional to the supply voltage, so if we reduce the supply voltage from 12 Volts to 6 Volts, the motor will run at half the speed. How can this be achieved when the battery is fixed at 12 Volts?

The speed controller works by varying the average voltage sent to the motor. It could do this by simply adjusting the voltage sent to the motor, but this is quite inefficient to do. A better way is to switch the motor's supply on and off very quickly. If the switching is fast enough, the motor doesn't notice it, it only notices the average effect.

When you watch a film in the cinema, or the television, what you are actually seeing is a series of fixed pictures, which change rapidly enough that your eyes just see the average effect - movement. Your brain fills in the gaps to give an average effect.

The time that it takes a motor to speed up and slow down under switching conditions is dependant on the inertia of the rotor (basically how heavy it is), and how much friction and load torque there is. The graph below shows the speed of a motor that is being turned on and off fairly slowly: (10)

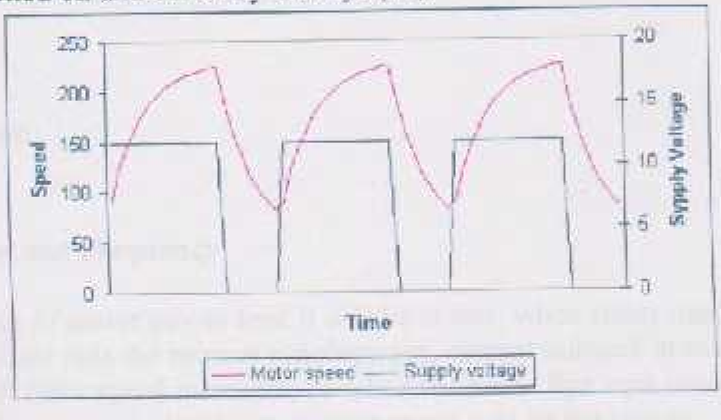


Fig.3.6: Relationship between Time and Speed and Voltage Supply.

3.4.3 *Speed Control Circuits*

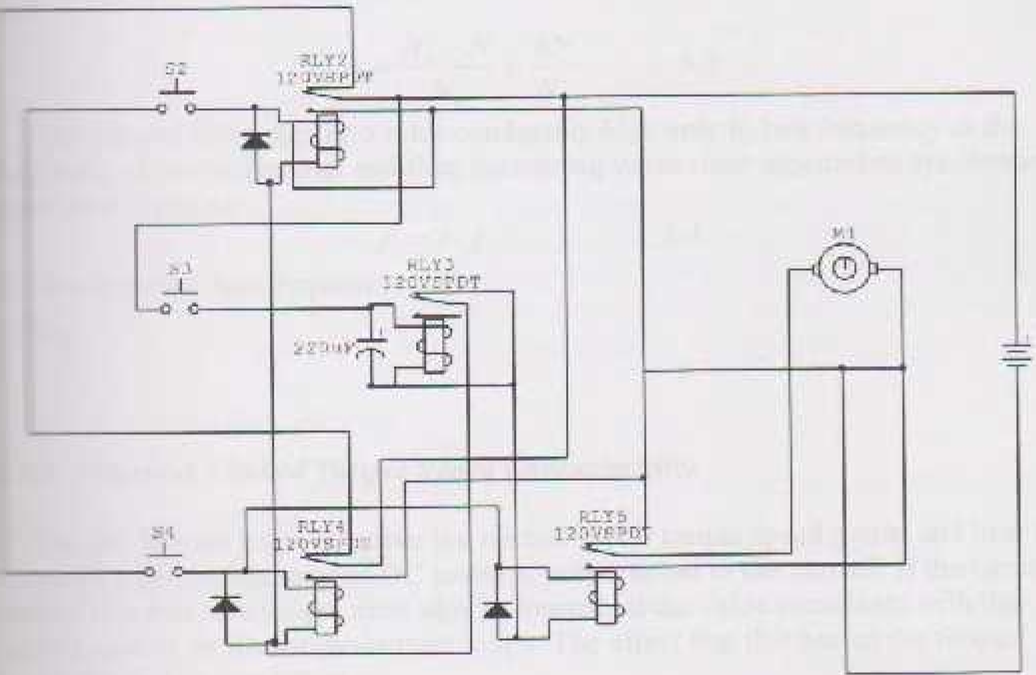


Fig.3.7: Electromagnetic Field Circuit and with Speed Controller (12)

When car switch ON all components of controller system will work, one of these components is the speed controller circuit. When car work, then speed controller work at the voltage of cars battery. If in this circuit press FORWARD switch, car work on pedal controlling and driver controls the car speed, so FORWARD switch when pressed relay A will be ON then A1 be ON too, that makes A2 work then motor work as in forward mechanism. If switch STOP pressed A1 will be OFF then A2 becomes OFF and relay B and so relay D be ON, so D1 becomes momently ON and then be

OFF, B2 can now be on AND motor will stop its motion speed. When REVERSE switch pressed, B1 becomes OFF and so B2 is now on then motor will work reversely.

3.5 Torque

3.5.1 Torque and Frequency

At beginning of motor power feed it will be at rest, when stator magnetic field rotates, stator field cuts the rotor at synchronous, current induced in rotor turns be maximum, then rotor speed increases, so when the stator flux cuts rotor the difference between synchronous speed and actual rotor speed will be the rate as:

$$\Delta N = N_s - N \text{ ....3.2}$$

ΔN : Speed rate.

N_s : Synchronous speed.

N : Rotor speed.

The ratio of actual flux that cuts rotor to synchronous speed is determined from the slip:

$$s = \frac{N_s - N}{N_s} = \frac{\Delta N}{N_s} \text{ ....3.3}$$

The induced frequency into rotor conductors high only in line frequency at the beginning of power feeding, and then decreasing when rotor approaches synchronous speed so it given as:

$$f_r = s \cdot f \text{ ....3.4}$$

f : Stator power line frequency.

s : Slip.

3.5.2 Current Limited Torque Speed Characteristics

The DC Motors page describes the normal motor torque speed graph, and how the torque of a permanent magnet DC motor is proportional to the current. If the current is limited however, the torque must also be limited, at the value coincident with the limited current on the torque-current graph. The effect that this has on the torque speed graph is shown below:

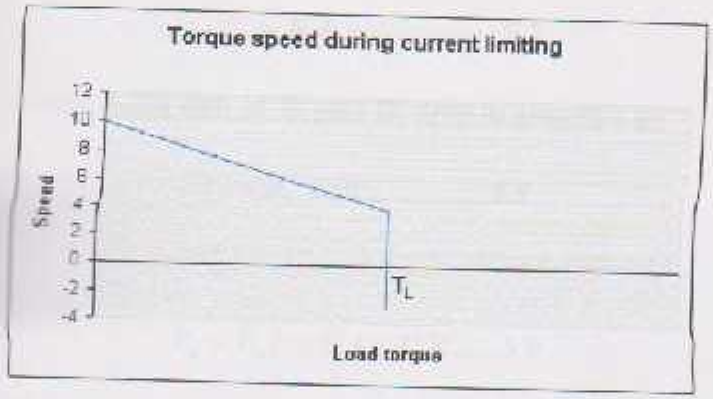


Fig3.8: Speed Torque Characteristics

As the load torque increases, the speed drops - we are following the line in the torque speed characteristic from the left hand side towards the right, drooping down. This is the same as the uncontrolled motor. The motor torque always equals the load torque when the motor is running at constant speed (this follows from Newton's first law - "An object in motion tends to stay in motion with the same speed and in the same direction unless acted upon by an unbalanced force." The motor torque and load torque must be balanced out if the speed is not changing).

Let's call the current limit value i_L and the equivalent torque value on the torque-current graph at this current is T_L. When the load torque exceeds T_L, the motor can no longer create an equal and opposite torque, and so the load will push the motor backwards in the opposite direction - we are now following the line as it drops downwards into negative speed. Let's take an example: an opponent's robot is more powerful than ours (or his current limit is set higher), and we are in a pushing match. As each pushes harder, our speed controller reaches its current limit first. Our robot is now pushing at a constant force (since the motor torque is now constant at its highest value). As the opponent pushes harder, our wheels start to rotate backwards, and the pair of robots accelerates backwards at a rate given by Newton's second law:

$$F = ma \quad \text{or} \quad a = F/m \qquad \ldots\ldots\ldots\ldots 3.5$$

Where F is the difference between the forces of the two robots pushing and m is the total mass of the two robots. (9)

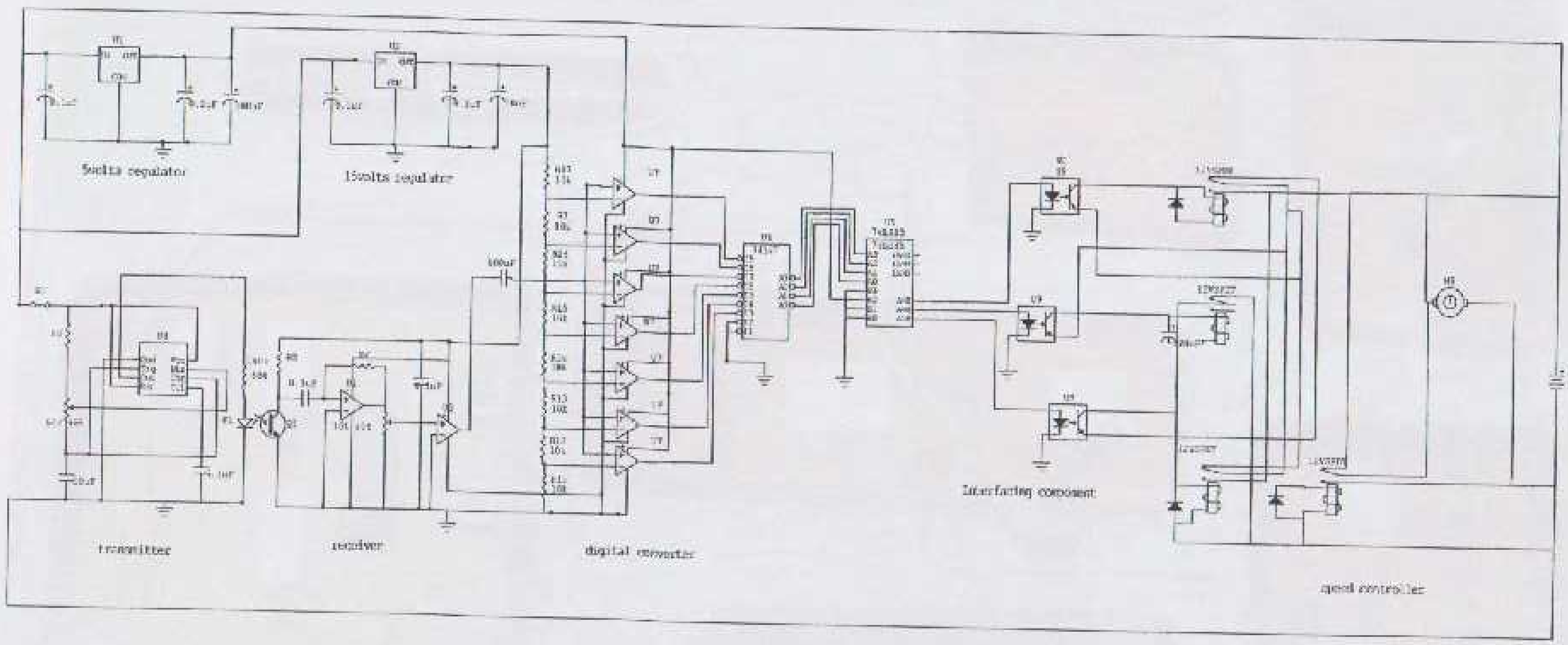
Mechanical Power and Torque

The power and torque of the dc motor are two of its important properties. We now derive two simple equations that enable us to calculate them:

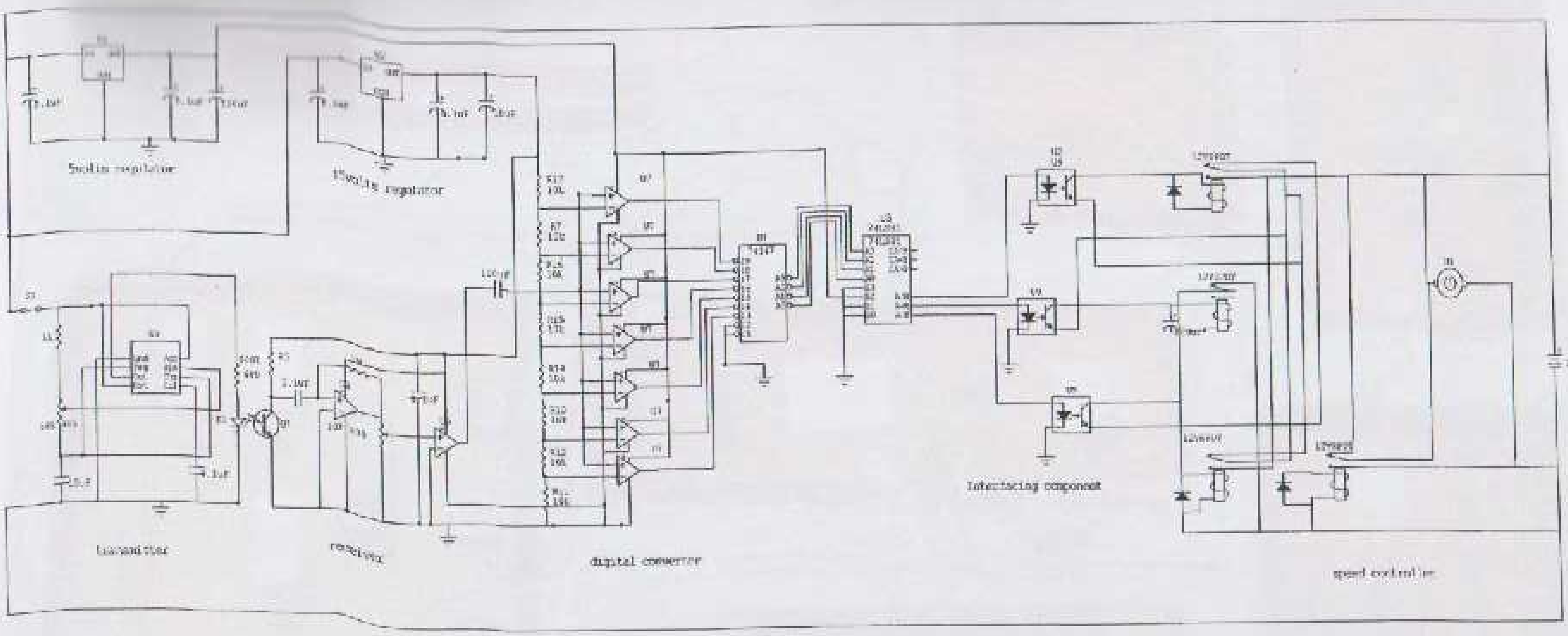
1. The cemf induced in a lapwound armature is given by:

$$E_o = Zn\phi / 60 \qquad \ldots\ldots\ldots\ldots 3.6$$

Electrical power P_a supplied to the armature is equal to supply voltage E_s multiplied by the armature current:



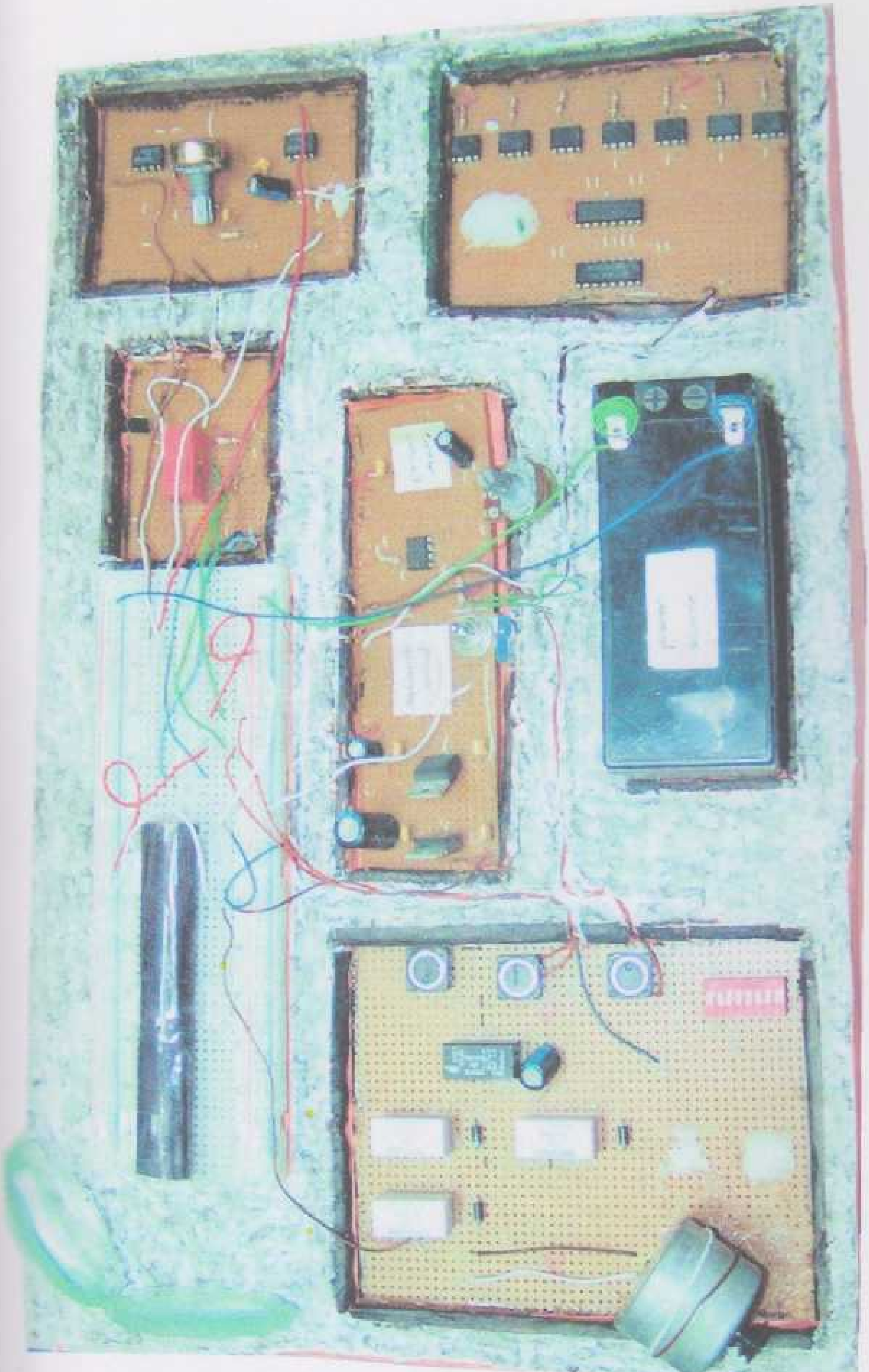
Designer:Nida' Y.M. Abu Noufal
Car Distance Protection System
Palestine Polytechnic University Applied Sciences Department Applied Electronics Program



Designer:Nida' Y.M. Abu Noufal

Car Distance Protection System

Palestine Polytechnic University
Applied Sciences Department
Applied Electronics Program



Ch.5

Implementation & Testing

Design Testing

1 *Voltages Transient Testing and Protection*

Electronic circuits are inherently susceptible to sudden failure from transient over ages. There are two basic ways of dealing with voltage spikes.

- The first is to clamp or absorb the voltage spike.
- The second is to isolate the electric circuit from the voltage spike with some type of electronic switch that opens when an over voltage condition is detected.

Individual Test

ach module of the system was tested individually, to be sure that it works ctly and gives, the desired result.

- We tested if the system can be operated individually on a component basis before combining it.
- We tested the suitability of my system on test motor.
- Electrical test for electrical circuits was completed to be sure that it works properly.
- IC's was tested prior to their assembly.
- We checked applicability of choice sensors for their intended applications.
- Control unit also was tested.

Integration Test

ecked the individual board works correctly. All parts of the same board are ted together to test their response under the real conditions.

Interfacing Circuit Test

In this situation I tested the interfacing components which are opto-couplers to connect digital circuits with speed controller so I check these components n be used or not and they good choice to be interfacing components as ches for speed controller.

Motor Speed Test

is test depends on the work of speed controller system, so here I check if the natic circuit or not when I connected it to three switches, 1st for forward anism, 2nd switch for stop function, and the 3rd switch for reverse anism.

5.4 *Receiver and Transmitter Test*

Here I will check the circuit design as electrical circuit using simple meters like multimeter device and oscillator.

Transmitter Test:

Transmitter is in this project a led with power so led has a continuous light, but I work in this checking to convert it to flasher led, so I use a timer 555 to convert it, then I test the duty that I want to choose.

Receiver Test:

On circuit maker I check the receiver, so the device work as following table 5.1:

Table: 5.1

Type		Input Voltage	Voltage
®	No light on the output of receiver and no distance	5v 15v	3.86v 12.61v
®	With light on the output of receiver and no distance	5v 15v	3.6v 12v
®	Voltage on phototransistor with light and no distance	5v 15v	145mv 198mv

5.5 *Laser Test*

Laser will have a safety design, so have very low power and travels to large distance.We will take one type of lasers pulsed laser or continuous laser and chose the best type to connect it in the system design.

In this test we test the wavelength for led light we used, then I check the power that we can use if can introduced to more time than the ideal batteries do.

We check then the lenses we can choose and the quality of these lenses and the distance that we can work on it to get accurate efficiency in my work.

5.6 *Comparator and Converter Circuits Test*

We connect every comparator alone in its circuit, check the output if it was digital or not then connects all of circuit components together and checking the output on circuit maker and on bread.

5.7 *Final Test*

After connecting all the parts of the system together we connect the hall system to car motor, then checking if motor work as aim we work on it when we choose the project.

Ch.6

Conclusion

6.1 Visible Study

6.1.1 Cost Table:

Needs	Cost
1. Collection of information	JD 20
2. Electrical components	JD 150
3. Printing and paper sheets	JD 20
4. Overhead	JD 100
Average	**JD300**

At maximum I need JD300

6.1.2 Components Table:

Component	Value	Chips number	Comp. number
Resistors	R = 1MΩ	-	1
	R = 100KΩ	-	1
	R = 10KΩ (pot)	-	1
	R = 68KΩ (pot)	-	1
	R = 10KΩ	-	8
	R = 1KΩ		1
	R = 680Ω		1
Capacitors	C = 0.1µF Ceramic	-	7
	C = 220µF	-	1
	C = 10µF	-	3
	C = µF		
Phototransistor	NPN	-	1
Comparators	-	UA741CN	7
	-	SN74LS85N	1
	-	LM741CN	1
Op-Amp	-	LM386N	1
Encoder	-	CD74HC147E	1
ADC	-	ADC0808CN	1
Relays	12v	C93418	4
Diodes	0.7v	-	3
Timer	-	NE555N	2
Lenses	F = 5cm	-	2
	F =10 cm	-	2
Wires	-	-	-
Breads	-	-	-
Regulators	5volt reg.	LM7805C	1
	15volt reg.	78L15	1

6.1.3 Time Table:

Work	Time Need
Collecting informations	4 weeks
Collecting elements	6 weeks
Copying & printing	6 weeks
Produce circuits and make real device's design	10 weeks
Testing and calibrations	2 weeks

Maximum time I need is about two semesters.

6.1.4 Time Plane:

6.2 Conclusion

Car Distance Protection System (CDPS) is a new idea for ensuring a safety life for people, both drivers and passengers. This system can used in all systems contains DC motors like cars, trains, plans, and ships too. I use it here in cars because I have roads in my life. High curve of accidents will be less with CDPS so it work on laser nature prosperities, that's because rays can be reflected from any body cut its road.

It was hard work to accomplish this work, that combined three branches of science, mechanics, electronics, and optics that is the main controller for all system work.

I found while working in this project many problems, and these problems are:

⇒ While connecting all parts of system I have many problems, one of these is the work of the device, it wasn't as I would like to get.

⇒ Nature of light was a difficult problem because it affects on the laser receiver introduced voltage.

⇒ The nature effects like rain that affects on reflection and also incidence rays, was affected on the device work.

⇒ Some components like laser tube couldn't be founded, so I choose components have less efficiency that affected on the final system efficiency.

6.3 Future Ideas

1. To continue on this project I will convert the laser transmitter and receiver with ultrasonic transmitter and receiver, because its more affective and safety than laser in humanity nature.
2. In this project I use single transmitter- receiver device, any student can use multi-transmitter-receiver device in all sides of the car. And protect it from all sides.
3. Other future project is when transmitter placed in car and the receiver in other car not both in only one car, so this introduced more efficiency and less time.

6.4 Figure Related To Tested Elements

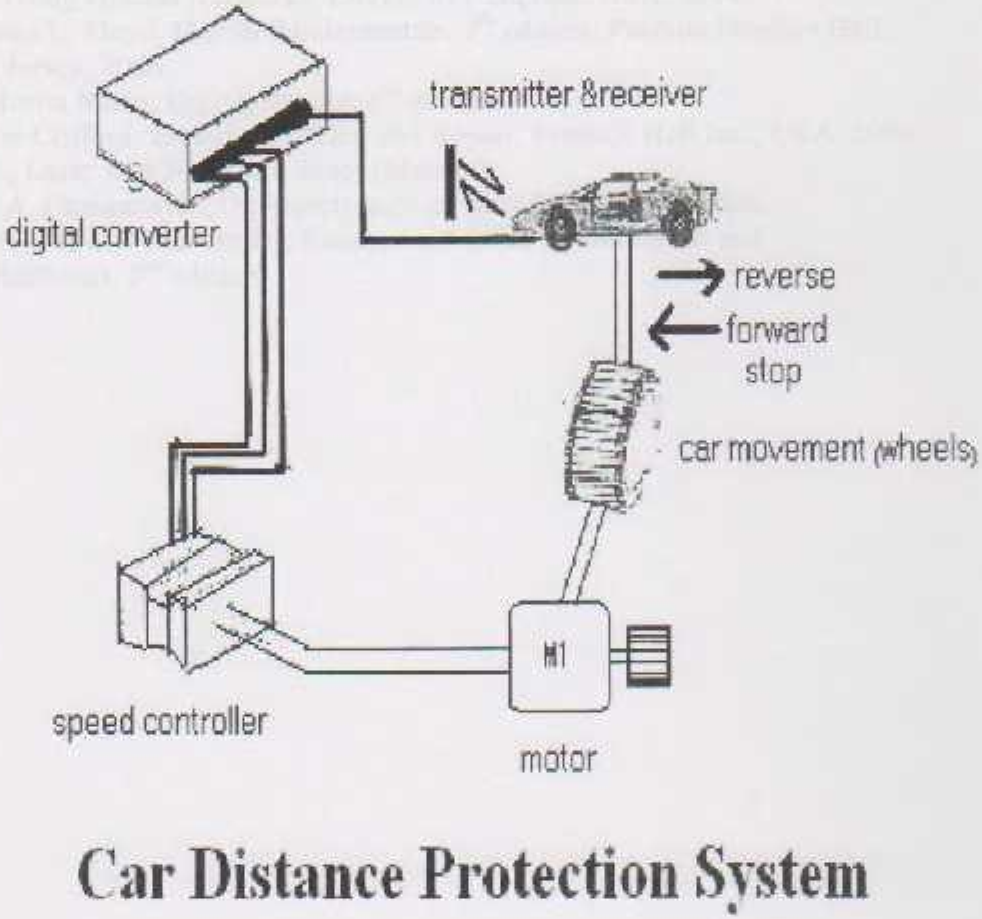


Fig.6.2: Tested Diagram

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Appendix A
Datasheet

5v regulator datasheet

National Semiconductor

January 1995

LM109/LM309 5-Volt Regulator

General Description

The LM109 series are complete 5V regulators fabricated on a single silicon chip. They are designed for local regulation on digital logic cards, eliminating the distribution problems association with single-point regulation. The devices are available in two standard transistor packages. In the solid-kovar TO-5 header, it can deliver output currents in excess of 200 mA, if adequate heat sinking is provided. With the TO-3 power package, the available output current is greater than 1A.

The regulators are essentially blowout proof. Current limiting is included to limit the peak output current to a safe value. In addition, thermal shutdown is provided to keep the IC from overheating. If internal dissipation becomes too great, the regulator will shut down to prevent excessive heating.

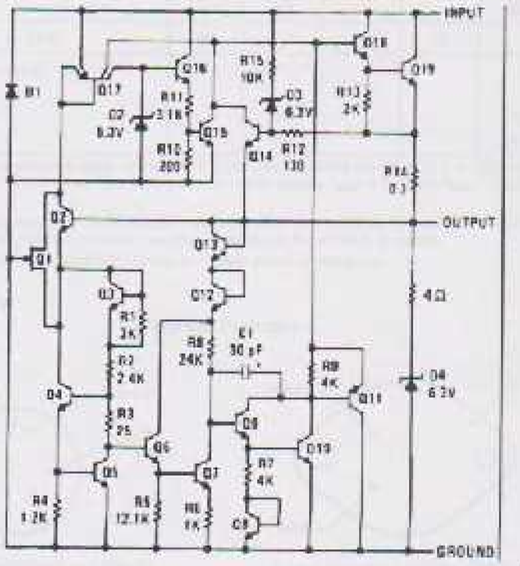
Considerable effort was expended to make these devices easy to use and to minimize the number of external components. It is not necessary to bypass the output, although this does improve transient response somewhat. Input bypassing is needed, however, if the regulator is located very far from the filter capacitor of the power supply. Stability is also achieved by methods that provide very good rejection of load or line transients as are usually seen with TTL logic.

Although designed primarily as a fixed-voltage regulator, the output of the LM109 series can be set to voltages above 5V, as shown. It is also possible to use the circuits as the control element in precision regulators, taking advantage of the good current-handling capability and the thermal overload protection.

Features

- Specified to be compatible, worst case, with TTL and DTL
- Output current in excess of 1A
- Internal thermal overload protection
- No external components required

Schematic Diagram



TL/H/7138-1

LM109/LM309 5-Volt Regulator

Absolute Maximum Ratings

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

(Note 3)

Input Voltage	35V
Power Dissipation	Internally Limited
Operating Junction Temperature Range	
LM109	−55°C to +150°C
LM309	0°C to +125°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec.)	300°C

Electrical Characteristics (Note 1)

Parameter	Conditions	LM109			LM309			Units
		Min	Typ	Max	Min	Typ	Max	
Output Voltage	$T_j = 25°C$	4.7	5.05	5.3	4.8	5.05	5.2	V
Line Regulation	$T_j = 25°C$ $7.10V \le V_{IN} \le 25V$		4.0	50		4.0	50	mV
Load Regulation TO-39 Package TO-3 Package	$T_j = 25°C$ $5 mA \le I_{OUT} \le 0.5A$ $5 mA \le I_{OUT} \le 1.5A$		 15 15	 50 100		 15 15	 50 100	 mV mV
Output Voltage	$7.40V \le V_{IN} \le 25V$, $5 mA \le I_{OUT} \le I_{MAX}$, $P < P_{MAX}$	4.6		5.4	4.75		5.25	V
Quiescent Current	$7.40V \le V_{IN} \le 25V$		5.2	10		5.2	10	mA
Quiescent Current Change	$7.40V \le V_{IN} \le 25V$ $5 mA \le I_{OUT} \le I_{MAX}$			0.5 0.8			0.5 0.8	mA mA
Output Noise Voltage	$T_A = 25°C$ $10 Hz \le f \le 100 kHz$		40			40		µV
Long Term Stability			10			20		mV
Ripple Rejection	$T_j = 25°C$	50			50			dB
Thermal Resistance, Junction to Case TO-39 Package TO-3 Package	(Note 2)		 15 2.5			 15 2.5		 °C/W °C/W

Note 1: Unless otherwise specified, these specifications apply $-55°C \le T_j \le +150°C$ for the LM109 and $0°C \le T_j \le +125°C$ for the LM309; $V_{IN} = 10V$, and $I_{OUT} = 0.1A$ for the TO-39 package or $I_{OUT} = 0.5A$ for the TO-3 package. For the TO-39 package, $I_{MAX} = 0.2A$ and $P_{MAX} = 2.0W$. For the TO-3 package, $I_{MAX} = 1.0A$ and $P_{MAX} = 20W$.

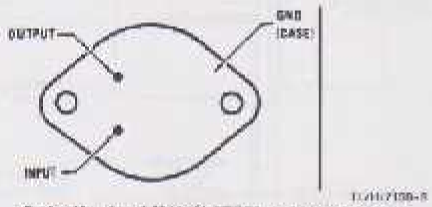
Note 2: Without a heat sink, the thermal resistance of the TO-39 package is about 150°C/W, while that of the TO-3 package is approximately 35°C/W. With a heat sink, the effective thermal resistance can only approach the values specified, depending on the efficiency of the sink.

Note 3: Refer to RETS109H drawing for LM109H or RETS109K drawing for LM109K military specifications.

Connection Diagrams

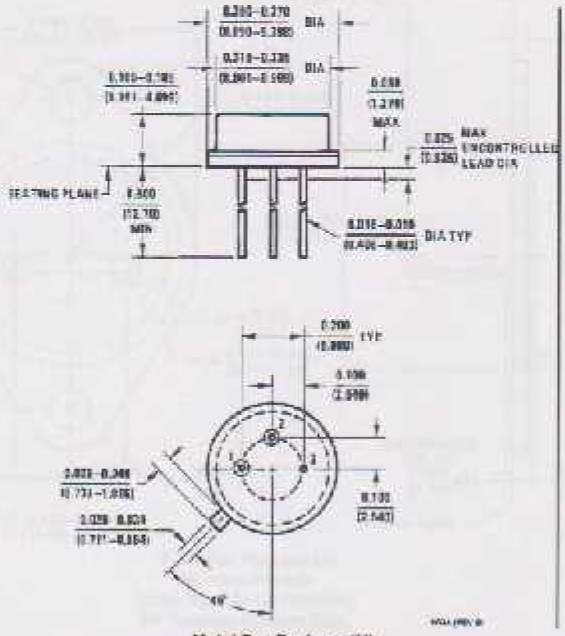
Metal Can Packages

Order Number LM109H, LM109H/883 or LM309H
See NS Package Number H03A

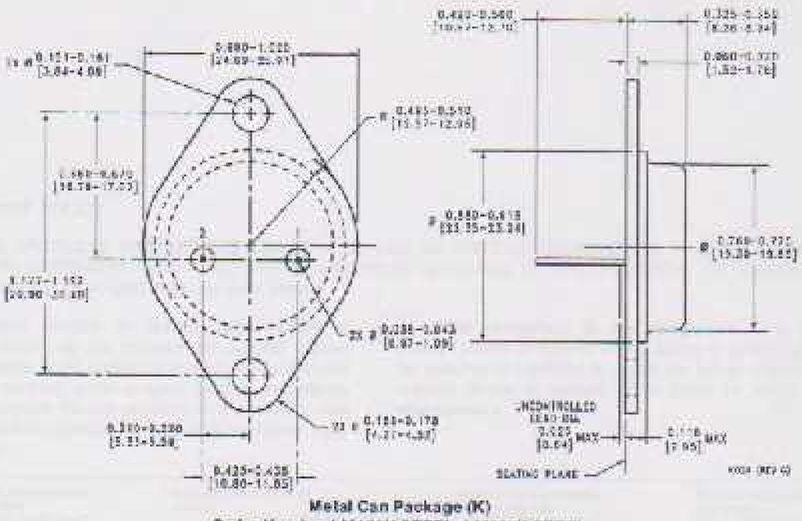


Order Number LM109K STEEL or LM309K STEEL
See NS Package Number K02A
Order Number LM109K/883
See NS Package Number K02C

Physical Dimensions inches (millimeters)

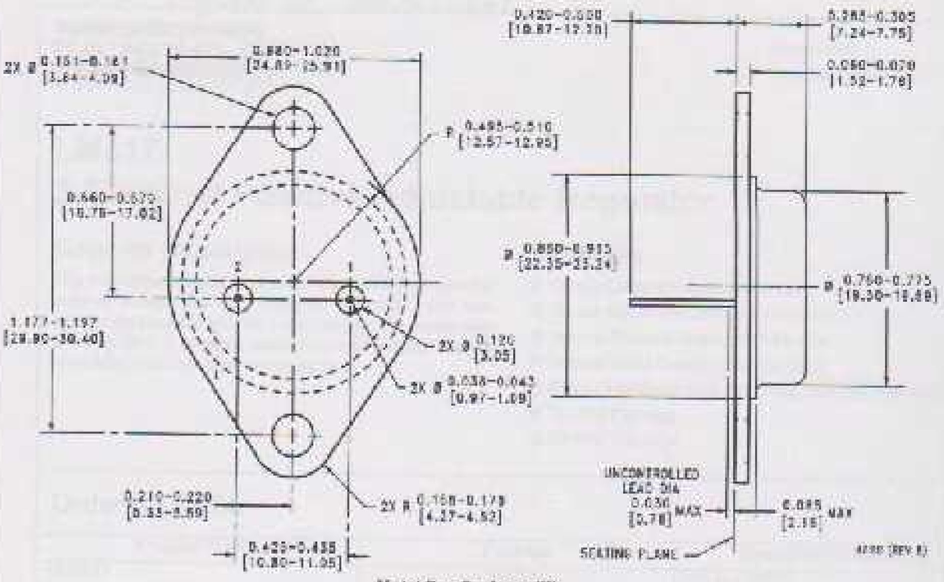


Metal Can Package (H)
Order Number LM109H, LM109H/883 or LM309H
NS Package Number H03A



Metal Can Package (K)
Order Number LM109K STEEL, LM309K STEEL
NS Package Number K02A

Physical Dimensions inches (millimeters) (Continued)



Metal Can Package (K)
Mil-Aero Product
Order Number LM109K/883
NS Package Number K02C

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15v regulator datasheet

FAIRCHILD SEMICONDUCTOR®

March 2000
Revised June 2005

LM317
3-Terminal Positive Adjustable Regulator

General Description

This monolithic integrated circuit is an adjustable 3-terminal positive voltage regulator designed to supply more than 1.5A of load current with an output voltage adjustable over a 1.2 to 37V. It employs internal current limiting, thermal shut-down and safe area compensation.

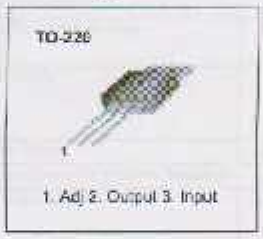
Features

- Output Current In Excess of 1.5A
- Output Adjustable Between 1.2V and 37V
- Internal Thermal Overload Protection
- Internal Short Circuit Current Limiting
- Output Transistor Safe Operating Area Compensation
- TO-220 Package
- D2 PAK Package

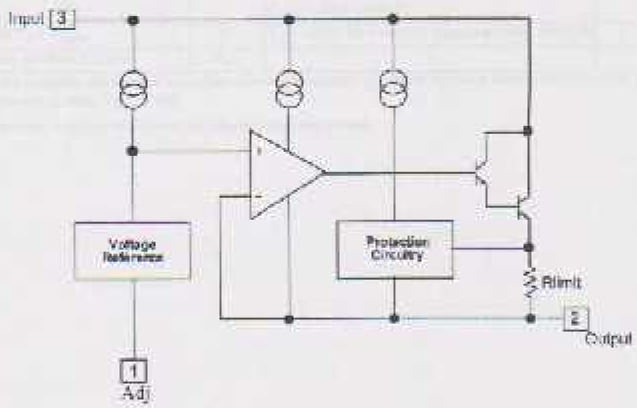
Ordering Code:

Product Number	Package	Operating Temperature
LM317T	TO-220	0°C to +125°C
LM317D2TXM	D2 PAK	0°C to +125°C

Connection Diagrams



Internal Block Diagram



Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
Input-Output Voltage Differential	$V_I - V_O$	40	V
Lead Temperature	T_{LEAD}	230	°C
Power Dissipation	P_D	Internally limited	W
Operating Junction Temperature Range	T_J	0 ~ +125	°C
Storage Temperature Range	T_{STG}	-65 ~ +125	°C
Temperature Coefficient of Output Voltage	$\Delta V_O/\Delta T$	±0.02	% / °C

Note 1: Absolute Maximum Ratings are those values beyond which the safety of the device cannot be guaranteed. The device should not be operated at these limits. The parametric values defined in the Electrical Characteristics tables are not guaranteed at the absolute maximum ratings. The "Recommended Operating Conditions" table will define the conditions for actual device operation.

Electrical Characteristic

($V_I - V_O = 5V$, $I_O = 0.5A$, $0°C \le T_J \le +125°C$, $I_{MAX} = 1.5A$, $P_{DMAX} = 20W$, unless otherwise specified)

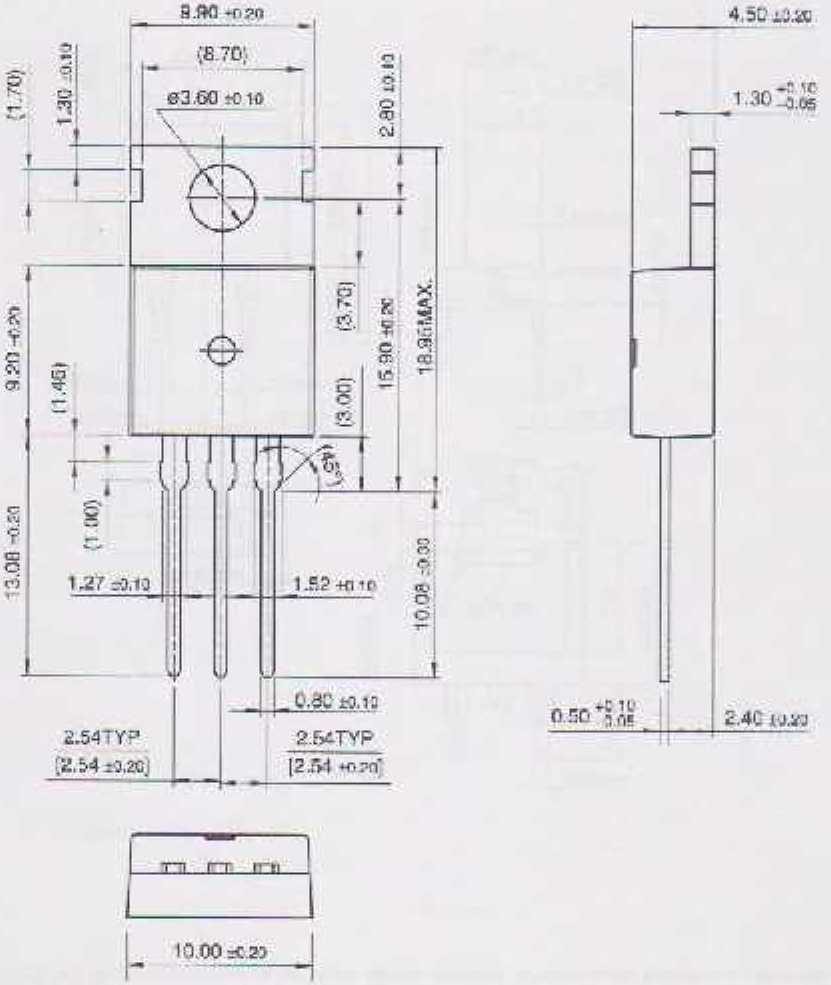
Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Line Regulation (Note 2)	Rline	$T_A = +25°C$ $3V \le V_I - V_O \le 40V$	-	0.01	0.04	% / V
		$3V \le V_I - V_O \le 40V$	-	0.02	0.07	% / V
Load Regulation (Note 2)	Rload	$T_A = +25°C$, $10mA \le I_O \le I_{MAX}$ $V_O < 5V$ $V_O \ge 5V$	-	18.0 0.4	25.0 0.5	mV% / V_O
		$10mA \le I_O \le I_{MAX}$ $V_O < 5V$ $V_O \ge 5V$	-	40.0 0.8	70.0 1.5	mV% / V_O
Adjustable Pin Current	I_{ADJ}	-	-	46.0	100	μA
Adjustable Pin Current Change	ΔI_{ADJ}	$3V \le V_I - V_O \le 40V$ $10mA \le I_O \le I_{MAX}$ $P_D \le P_{MAX}$	-	2.0	5.0	μA
Reference Voltage	V_{REF}	$3V \le V_{IN} - V_O \le 40V$ $10mA \le I_O \le I_{MAX}$ $P_D \le P_{MAX}$	1.20	1.25	1.30	V
Temperature Stability	ST_T	-	-	0.7	-	% / V_O
Minimum Load Current to Maintain Regulation	$I_{L(MIN)}$	$V_I - V_O = 40V$	-	3.5	12.0	mA
Maximum Output Current	$I_{O(MAX)}$	$V_I - V_O \le 15V$, $P_D \le P_{MAX}$ $V_I - V_O \le 40V$, $P_D \le P_{MAX}$ $T_A = 25°C$	1.0	2.2 0.3	-	A
RMS Noise, % of V_{OUT}	eN	$T_A = +25°C$, $10Hz \le f \le 10KHz$	-	0.003	0.01	% / V_O
Ripple Rejection	RR	$V_O = 10V$, $f = 120Hz$ without C_{ADJ} $C_{ADJ} = 10\mu F$ (Note 3)	66.0	60.0 75.0	-	dB
Long-Term Stability, $T_J = T_{HIGH}$	ST	$T_A = +25°C$ for end point measurements, 1000HR	-	0.3	1.0	%
Thermal Resistance Junction to Case	$R_{θJC}$	-	-	5.0	-	°C / W

Note 2: Load and line regulation are specified at constant junction temperature. Change in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used. ($P_{MAX} = 20W$)

Note 3: CADJ, when used, is connected between the adjustment pin and ground.

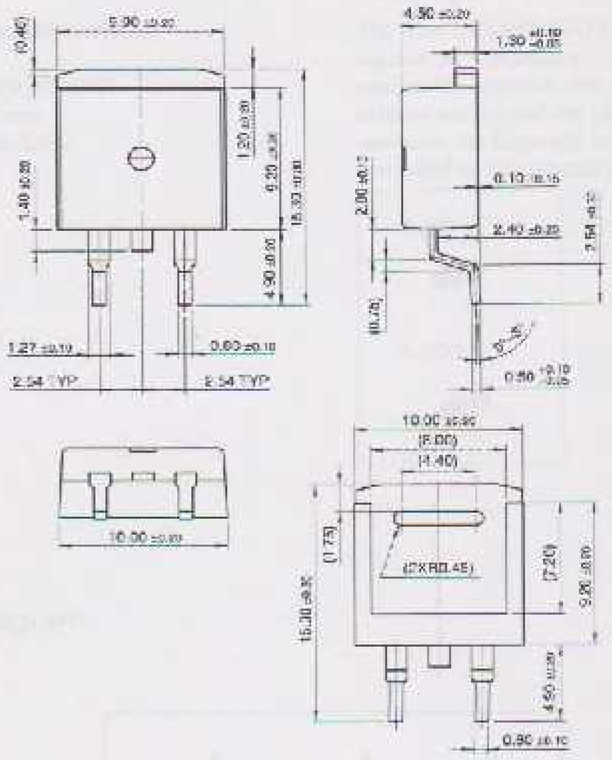
Physical Dimensions inches (millimeters) unless otherwise noted

TO-220



Physical Dimensions inches (millimeters) unless otherwise noted (Continued)

D^2-PAK



Dimensions in Millimeters

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2. A critical component in any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

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Timer datasheet

FAIRCHILD
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LM555/NE555/SA555

Single Timer

Features

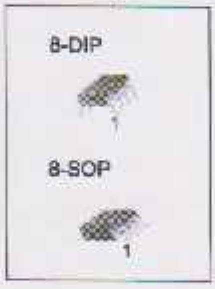
- High Current Drive Capability (200mA)
- Adjustable Duty Cycle
- Temperature Stability of 0.005%/°C
- Timing From µSec to Hours
- Turn off Time Less Than 2µSec

Applications

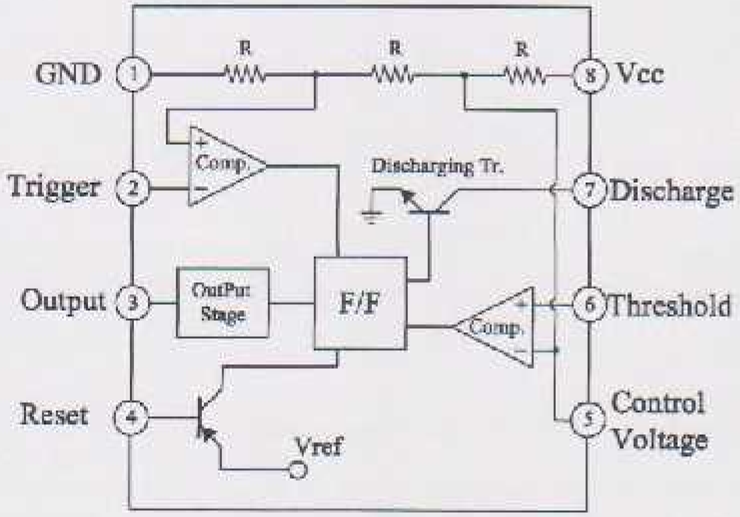
- Precision Timing
- Pulse Generation
- Time Delay Generation
- Sequential Timing

Description

The LM555/NE555/SA555 is a highly stable controller capable of producing accurate timing pulses. With a monostable operation, the time delay is controlled by one external resistor and one capacitor. With an astable operation, the frequency and duty cycle are accurately controlled by two external resistors and one capacitor.



Internal Block Diagram



Rev. 1.0.3

Absolute Maximum Ratings (T_A = 25°C)

Parameter	Symbol	Value	Unit
Supply Voltage	V_{CC}	16	V
Lead Temperature (Soldering 10sec)	T_{LEAD}	300	°C
Power Dissipation	P_D	600	mW
Operating Temperature Range LM555/NE555 SA555	T_{OPR}	 0 ~ +70 -40 ~ +85	°C
Storage Temperature Range	T_{STG}	-65 ~ +150	°C

Electrical Characteristics

(T_A = 25°C, V_{CC} = 5 ~ 15V, unless otherwise specified)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Supply Voltage	V_{CC}	-	4.5	-	16	V
Supply Current (Low Stable) (Note1)	I_{CC}	V_{CC} = 5V, R_L = ∞	-	3	6	mA
		V_{CC} = 15V, R_L = ∞	-	7.5	15	mA
Timing Error (Monostable) Initial Accuracy (Note2) Drift with Temperature (Note4) Drift with Supply Voltage (Note4)	ACCUR Δt/ΔT Δt/ΔVCC	R_A = 1kΩ to100kΩ C = 0.1μF	-	1.0 50 0.1	3.0 0.5	% ppm/°C %/V
Timing Error (Astable) Intial Accuracy (Note2) Drift with Temperature (Note4) Drift with Supply Voltage (Note4)	ACCUR Δt/ΔT Δt/ΔVCC	R_A = 1kΩ to 100kΩ C = 0.1μF	-	2.25 150 0.3	-	% ppm/°C %/V
Control Voltage	V_C	V_{CC} = 15V	9.0	10.0	11.0	V
		V_{CC} = 5V	2.6	3.33	4.0	V
Threshold Voltage	V_{TH}	V_{CC} = 15V	-	10.0	-	V
		V_{CC} = 5V	-	3.33	-	V
Threshold Current (Note3)	I_{TH}	-	-	0.1	0.25	μA
Trigger Voltage	V_{TR}	V_{CC} = 5V	1.1	1.67	2.2	V
		V_{CC} = 15V	4.5	5	5.6	V
Trigger Current	I_{TR}	V_{TR} = 0V		0.01	2.0	μA
Reset Voltage	V_{RST}	-	0.4	0.7	1.0	V
Reset Current	I_{RST}	-		0.1	0.4	mA
Low Output Voltage	V_{OL}	V_{CC} = 15V I_{SINK} = 10mA I_{SINK} = 50mA	-	0.06 0.3	0.25 0.75	V V
		V_{CC} = 5V I_{SINK} = 5mA	-	0.05	0.35	V
High Output Voltage	V_{OH}	V_{CC} = 15V I_{SOURCE} = 200mA I_{SOURCE} = 100mA	12.75	12.5 13.3	-	V V
		V_{CC} = 5V I_{SOURCE} = 100mA	2.75	3.3	-	V
Rise Time of Output (Note4)	t_R	-	-	100	-	ns
Fall Time of Output (Note4)	t_F	-	-	100	-	ns
Discharge Leakage Current	I_{LKG}	-	-	20	100	nA

Notes:

1. When the output is high, the supply current is typically 1mA less than at V_{CC} = 5V.
2. Tested at V_{CC} = 5.0V and V_{CC} = 15V.
3. This will determine the maximum value of $R_A + R_B$ for 15V operation, the max. total R = 20MΩ, and for 5V operation, the max. total R = 6.7MΩ.
4. These parameters, although guaranteed, are not 100% tested in production.

Application Information

Table 1 below is the basic operating table of 555 timer:

Table 1. Basic Operating Table

Threshold Voltage (V_{th})(PIN 6)	Trigger Voltage (V_{tr})(PIN 2)	Reset(PIN 4)	Output(PIN 3)	Discharging Tr. (PIN 7)
Don't care	Don't care	Low	Low	ON
V_{th} > 2Vcc / 3	V_{th} > 2Vcc / 3	High	Low	ON
Vcc / 3 < V_{th} < 2 Vcc / 3	Vcc / 3 < V_{th} < 2 Vcc / 3	High	-	-
V_{th} < Vcc / 3	V_{th} < Vcc / 3	High	High	OFF

When the low signal input is applied to the reset terminal, the timer output remains low regardless of the threshold voltage or the trigger voltage. Only when the high signal is applied to the reset terminal, the timer's output changes according to threshold voltage and trigger voltage.

When the threshold voltage exceeds 2/3 of the supply voltage while the timer output is high, the timer's internal discharge Tr. turns on, lowering the threshold voltage to below 1/3 of the supply voltage. During this time, the timer output is maintained low. Later, if a low signal is applied to the trigger voltage so that it becomes 1/3 of the supply voltage, the timer's internal discharge Tr. turns off, increasing the threshold voltage and driving the timer output again at high.

1. Monostable Operation

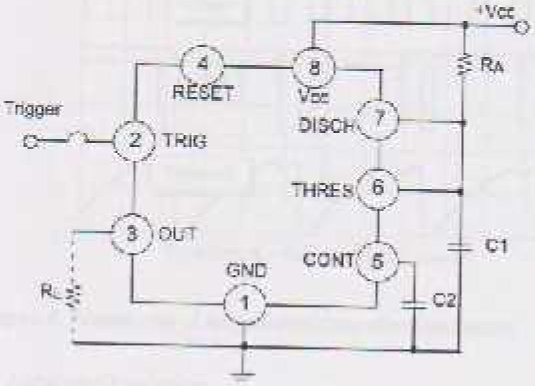


Figure 1. Monostable Circuit

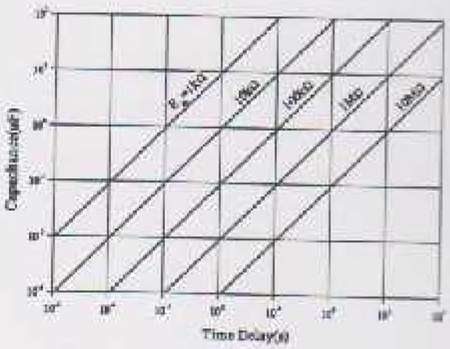


Figure 2. Resistance and Capacitance vs. Time delay(td)

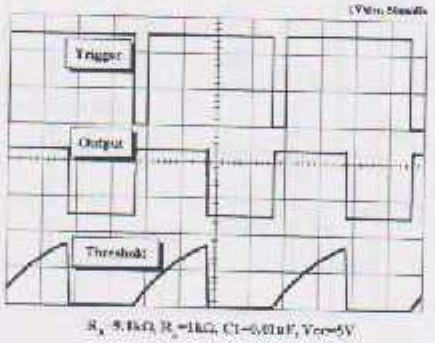


Figure 3. Waveforms of Monostable Operation

Figure 1 illustrates a monostable circuit. In this mode, the timer generates a fixed pulse whenever the trigger voltage falls below Vcc/3. When the trigger pulse voltage applied to the #2 pin falls below Vcc/3 while the timer output is low, the timer's internal flip-flop turns the discharging Tr. off and causes the timer output to become high by charging the external capacitor C1 and setting the flip-flop output at the same time.
The voltage across the external capacitor C1, V_{C1} increases exponentially with the time constant $t=R_A*C$ and reaches 2Vcc/3 at $td=1.1R_A*C$. Hence, capacitor C1 is charged through resistor R_A. The greater the time constant R_AC, the longer it takes for the V_{C1} to reach 2Vcc/3. In other words, the time constant R_AC controls the output pulse width.
When the applied voltage to the capacitor C1 reaches 2Vcc/3, the comparator on the trigger terminal resets the flip-flop, turning the discharging Tr. on. At this time, C1 begins to discharge and the timer output converts to low.
In this way, the timer operating in the monostable repeats the above process. Figure 2 shows the time constant relationship based on R_A and C. Figure 3 shows the general waveforms during the monostable operation.
It must be noted that, for a normal operation, the trigger pulse voltage needs to maintain a minimum of Vcc/3 before the timer output turns low. That is, although the output remains unaffected even if a different trigger pulse is applied while the output is high, it may be affected and the waveform does not operate properly if the trigger pulse voltage at the end of the output pulse remains at below Vcc/3. Figure 4 shows such a timer output abnormality.

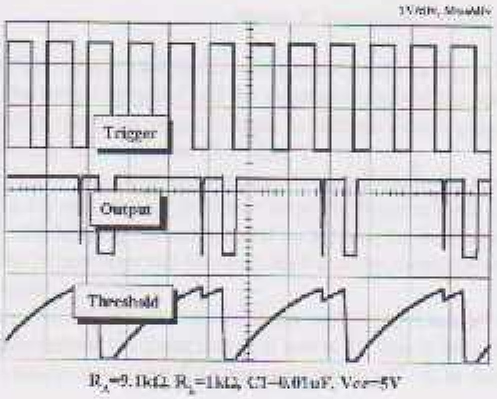


Figure 4. Waveforms of Monostable Operation (abnormal)

2. Astable Operation

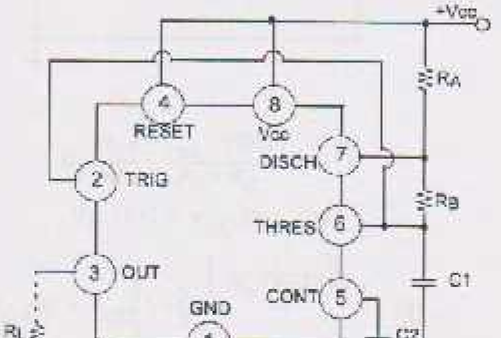


Figure 5. Astable Circuit

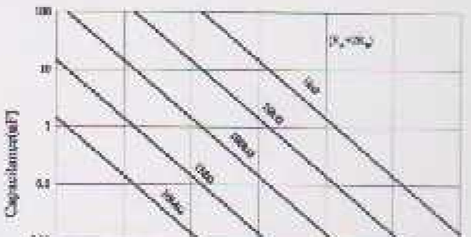
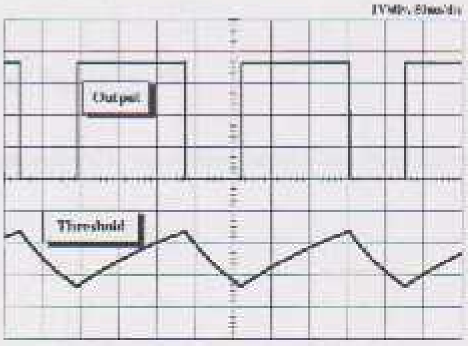


Figure 6. Capacitance and Resistance vs. Frequency



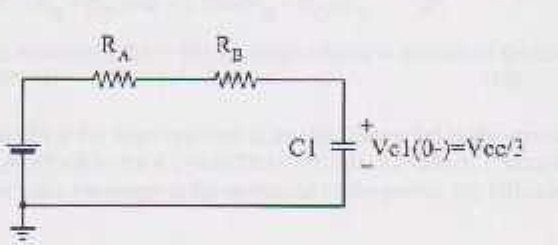
R_A=1kΩ, R_B=1kΩ, R_L=1kW, C1=1nF, Vcc=5V

Figure 7. Waveforms of Astable Operation

An astable timer operation is achieved by adding resistor R_B to Figure 1 and configuring as shown on Figure 5. In the astable operation, the trigger terminal and the threshold terminal are connected so that a self-trigger is formed, operating as a multi vibrator. When the timer output is high, its internal discharging Tr. turns off and the V_{C1} increases by exponential function with the time constant (R_A+R_B)*C.

When the V_{C1}, or the threshold voltage, reaches 2Vcc/3, the comparator output on the trigger terminal becomes high, resetting the F/F and causing the timer output to become low. This in turn turns on the discharging Tr. and the C1 discharges through the discharging channel formed by R_B and the discharging Tr. When the V_{C1} falls below Vcc/3, the comparator output on the trigger terminal becomes high and the timer output becomes high again. The discharging Tr. turns off and the V_{C1} rises again.

In the above process, the section where the timer output is high is the time it takes for the V_{C1} to rise from Vcc/3 to 2Vcc/3, and the section where the timer output is low is the time it takes for the V_{C1} to drop from 2Vcc/3 to Vcc/3. When timer output is high, the equivalent circuit for charging capacitor C1 is as follows:



$$C_1\frac{dv_{C1}}{dt} = \frac{V_{CC} - V(0-)}{R_A + R_B} \qquad (1)$$

$$V_{C1}(0+) = V_{CC}/3 \qquad (2)$$

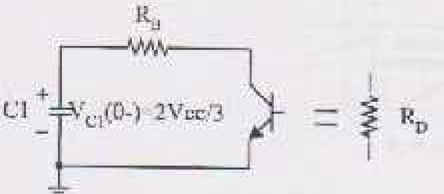
$$V_{C1}(t) = V_{CC}\left(1 - \frac{2}{3}e^{-\left(\frac{1}{(R_A+R_B)C1}\right)}\right) \qquad (3)$$

Since the duration of the timer output high state(t_H) is the amount of time it takes for the $V_{C1}(t)$ to reach 2Vcc/3,

$$v_{C1}(t) - \frac{2}{3}V_{CC} = V_{CC}\left(1 - \frac{2}{3}e^{\left(-\frac{t_H}{(R_A+R_B)C1}\right)}\right) \qquad (4)$$

$$t_H = C_1(R_A+R_B)\ln 2 = 0.693(R_A+R_B)C_1 \qquad (5)$$

The equivalent circuit for discharging capacitor C1, when timer output is low is, as follows:



$$C_1\frac{dv_{C1}}{dt} + \frac{1}{R_A+R_B}v_{C1} = 0 \qquad (6)$$

$$v_{C1}(t) - \frac{2}{3}V_{CC}e^{-\frac{t}{(R_A+R_D)C1}} \qquad (7)$$

Since the duration of the timer output low state(t_L) is the amount of time it takes for the $V_{C1}(t)$ to reach Vcc/3,

$$\frac{1}{3}V_{CC} - \frac{2}{3}V_{CC}e^{-\frac{t_L}{(R_A+R_D)C1}} \qquad (8)$$

$$t_L = C_1(R_B+R_D)\ln 2 = 0.693(R_B+R_D)C_1 \qquad (9)$$

Since R_D is normally $R_B >> R_D$ although related to the size of discharging Tr.,

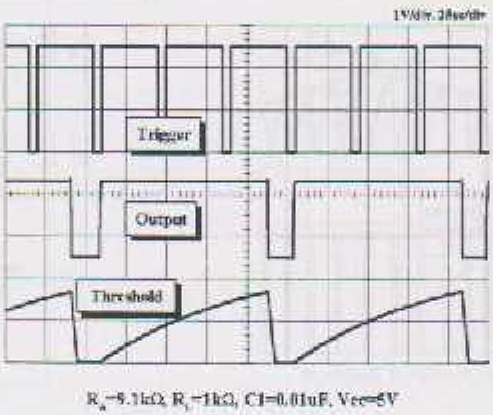
$t_L = 0.693R_BC_1$ (10)

Consequently, if the timer operates in astable, the period is the same with '$T = t_H + t_L = 0.693(R_A+R_B)C_1 + 0.693R_BC_1 = 0.693(R_A+2R_B)C_1$' because the period is the sum of the charge time and discharge time. And since frequency is the reciprocal of the period, the following applies.

$$\text{frequency,} \quad f = \frac{1}{T} = \frac{1.44}{(R_A+2R_B)C_1} \qquad (11)$$

3. Frequency divider

By adjusting the length of the timing cycle, the basic circuit of Figure 1 can be made to operate as a frequency divider. Figure 8. illustrates a divide-by-three circuit that makes use of the fact that retriggering cannot occur during the timing cycle.



R_A=9.1kΩ, R_L=1kΩ, C1=0.01uF, Vcc=5V

Figure 8. Waveforms of Frequency Divider Operation

. Pulse Width Modulation

he timer output waveform may be changed by modulating the control voltage applied to the timer's pin 5 and changing the eference of the timer's internal comparators. Figure 9 illustrates the pulse width modulation circuit.
Vhen the continuous trigger pulse train is applied in the monostable mode, the timer output width is modulated according to e signal applied to the control terminal. Sine wave as well as other waveforms may be applied as a signal to the control erminal. Figure 10 shows the example of pulse width modulation waveform.

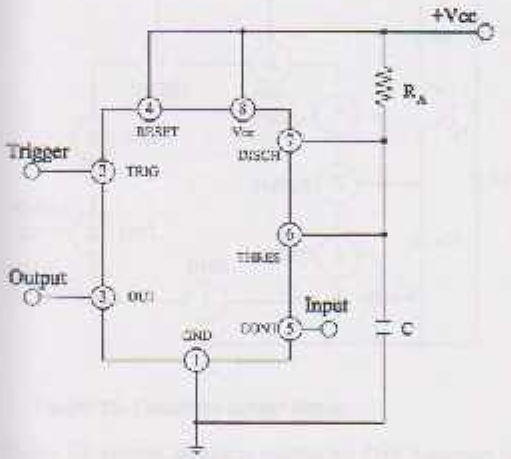
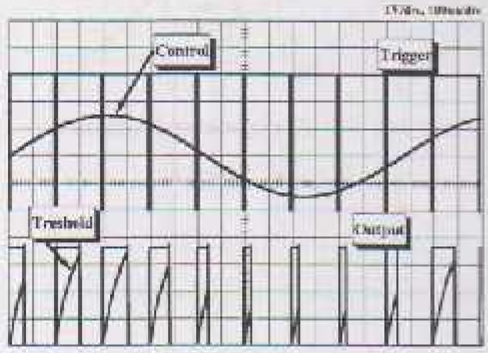


Figure 9. Circuit for Pulse Width Modulation



R_A=9.1kΩ, R_L=1kΩ, C1=0.01uF, Vcc=5V

Figure 10. Waveforms of Pulse Width Modulation

. Pulse Position Modulation

f the modulating signal is applied to the control terminal while the timer is connected for the astable operation as in Figure 11, e timer becomes a pulse position modulator.
n the pulse position modulator, the reference of the timer's internal comparators is modulated which in turn modulates the mer output according to the modulation signal applied to the control terminal.
igure 12 illustrates a sine wave for modulation signal and the resulting output pulse position modulation : however, any wave hape could be used.

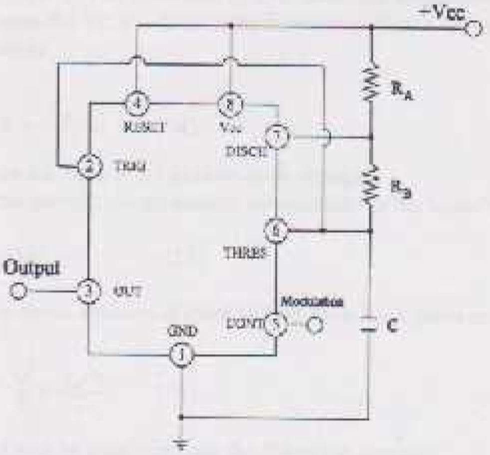


Figure 11. Circuit for Pulse Position Modulation

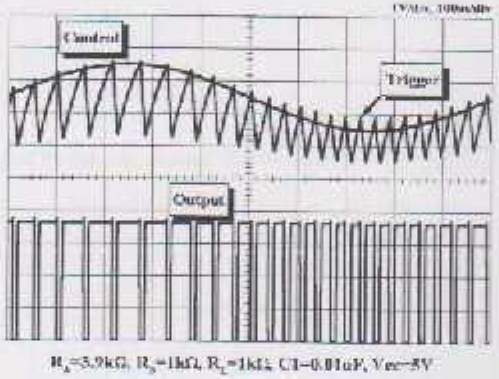
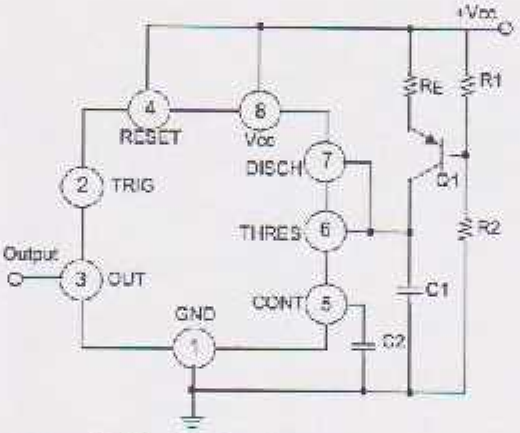


Figure 12. Waveforms of pulse position modulation

6. Linear Ramp

When the pull-up resistor RA in the monostable circuit shown in Figure 1 is replaced with constant current source, the VC1 increases linearly, generating a linear ramp. Figure 13 shows the linear ramp generating circuit and Figure 14 illustrates the generated linear ramp waveforms.



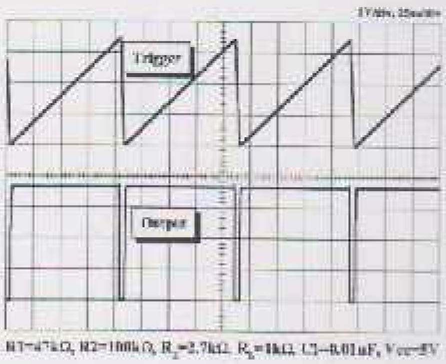


Figure 13. Circuit for Linear Ramp

Figure 14. Waveforms of Linear Ramp

In Figure 13, current source is created by PNP transistor Q1 and resistor R1, R2, and RE.

$$I_C = \frac{V_{CC} - V_E}{R_E} \qquad (12)$$

Here, V_E is

$$V_E = V_{BE} + \frac{R_2}{R_1 + R_2} V_{CC} \qquad (13)$$

For example, if Vcc=15V, RE=20kΩ, R1=5kW, R2=10kΩ, and VBE=0.7V,
VE=0.7V+10V=10.7V
Ic=(15-10.7)/20k=0.215mA

When the trigger starts in a timer configured as shown in Figure 13, the current flowing through capacitor C1 becomes a constant current generated by PNP transistor and resistors.
Hence, the V_C is a linear ramp function as shown in Figure 14. The gradient S of the linear ramp function is defined as follows:

$$S = \frac{V_{p-p}}{T} \qquad (14)$$

Here the Vp-p is the peak-to-peak voltage.
If the electric charge amount accumulated in the capacitor is divided by the capacitance, the V_C comes out as follows:

$$V=Q/C \qquad (15)$$

The above equation divided on both sides by T gives us

$$\frac{V}{T} = \frac{Q/T}{C} \qquad (16)$$

and may be simplified into the following equation.

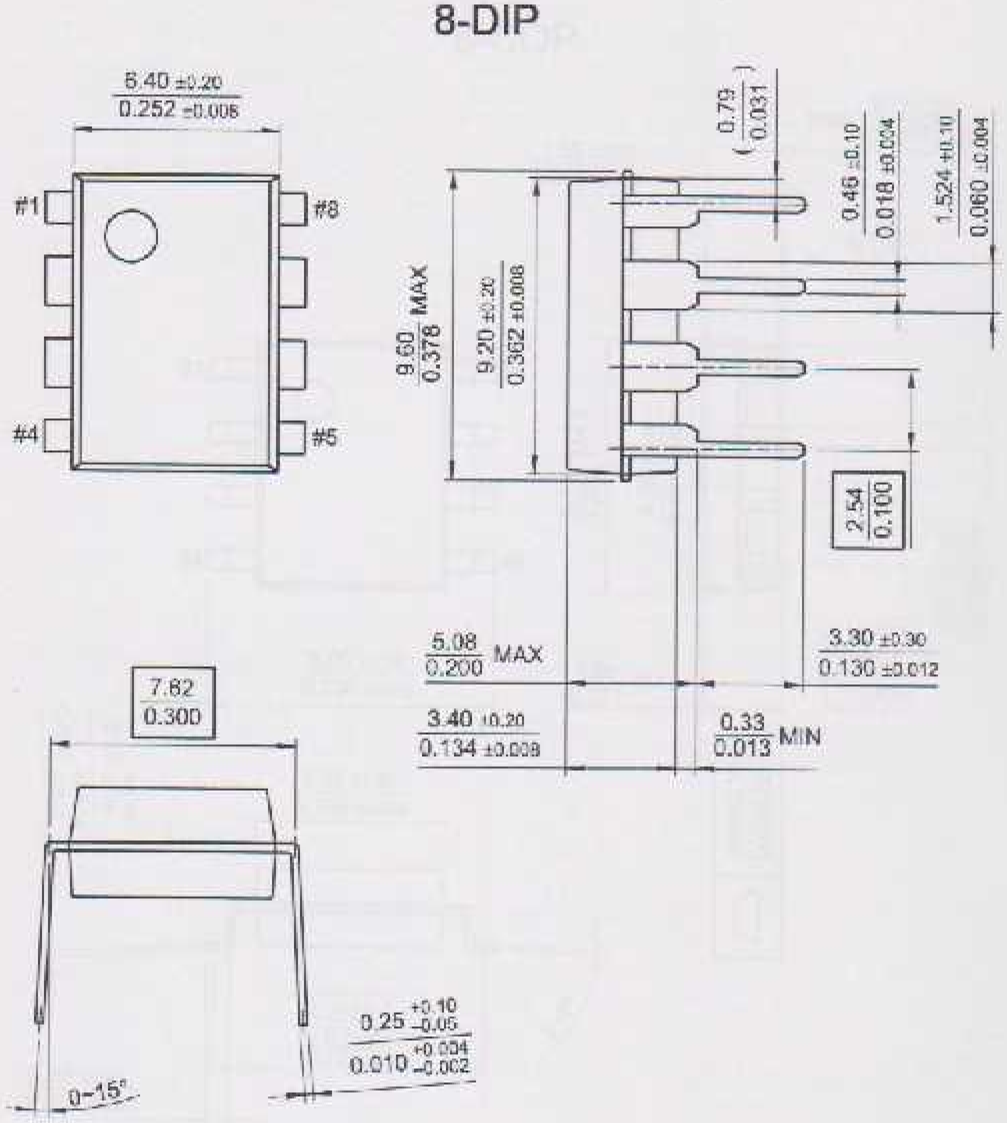
$$S=I/C \qquad (17)$$

In other words, the gradient of the linear ramp function appearing across the capacitor can be obtained by using the constant current flowing through the capacitor.
If the constant current flow through the capacitor is 0.215mA and the capacitance is 0.02µF, the gradient of the ramp function at both ends of the capacitor is S = 0.215m/0.022µ = 9.77V/ms.

Mechanical Dimensions

Package

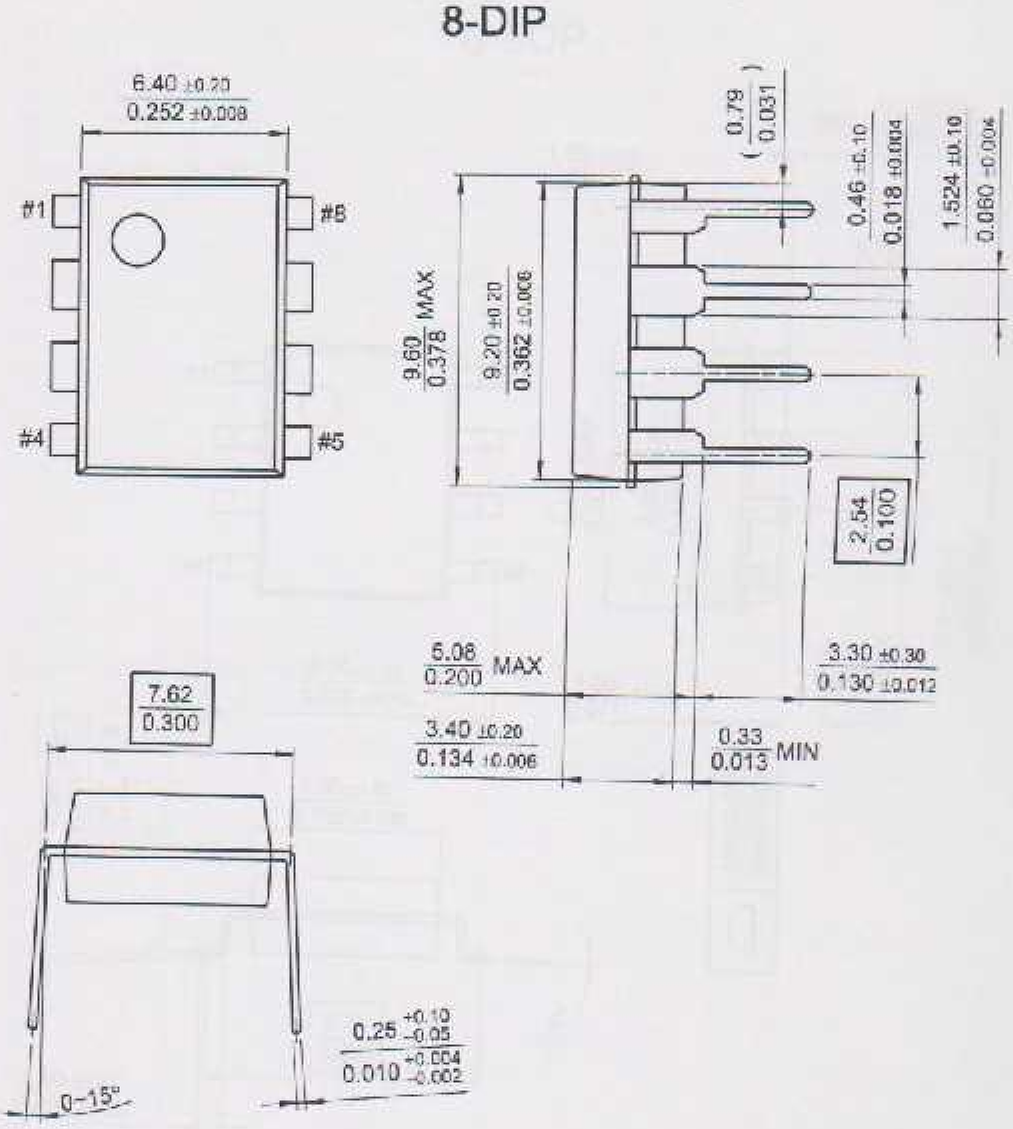
Dimensions in millimeters



Mechanical Dimensions

Package

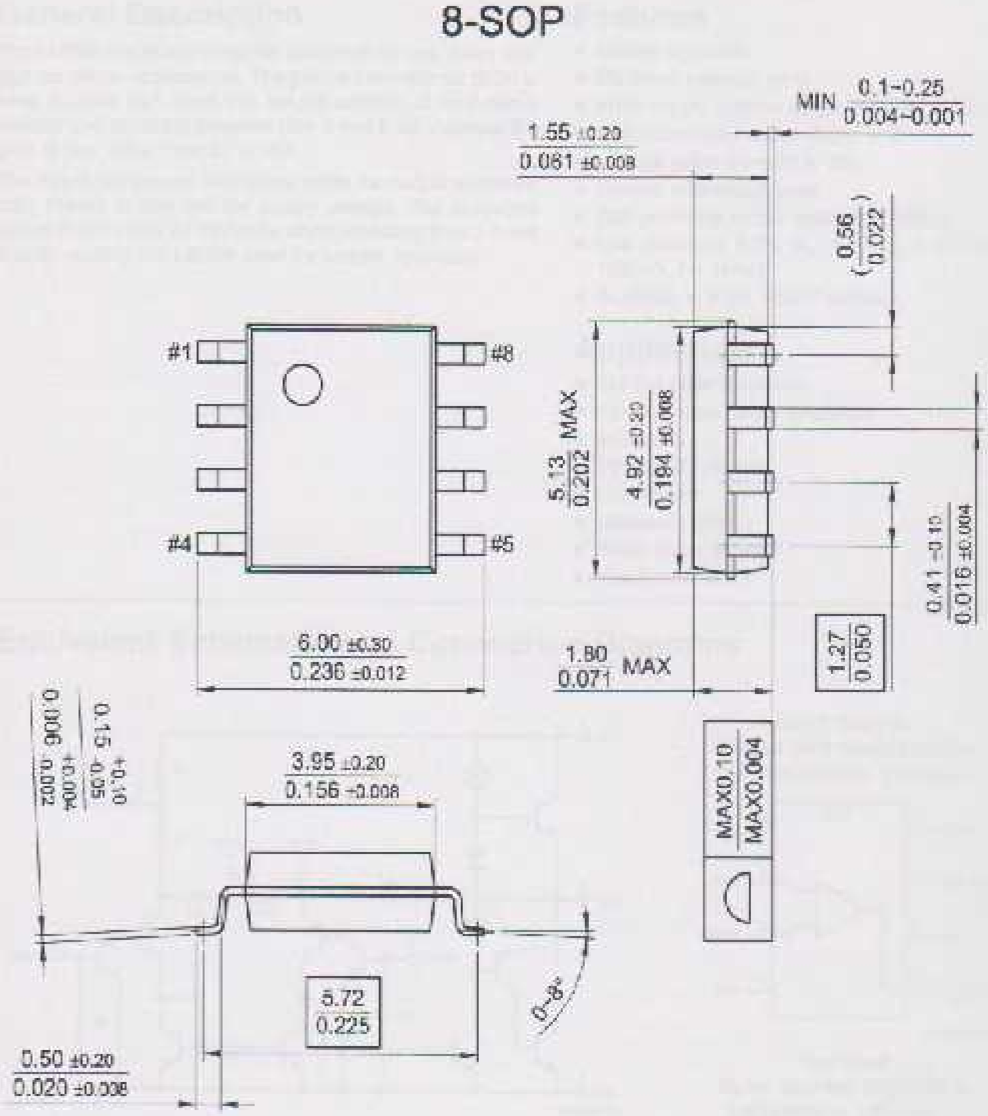
Dimensions in millimeters



Mechanical Dimensions (Continued)

Package

Dimensions in millimeters



audio power amplifier datasheet

National Semiconductor

August 2000

LM386
Low Voltage Audio Power Amplifier

General Description

The LM386 is a power amplifier designed for use in low voltage consumer applications. The gain is internally set to 20 to keep external part count low, but the addition of an external resistor and capacitor between pins 1 and 8 will increase the gain to any value from 20 to 200.

The inputs are ground referenced while the output automatically biases to one-half the supply voltage. The quiescent power drain is only 24 milliwatts when operating from a 6 volt supply, making the LM386 ideal for battery operation.

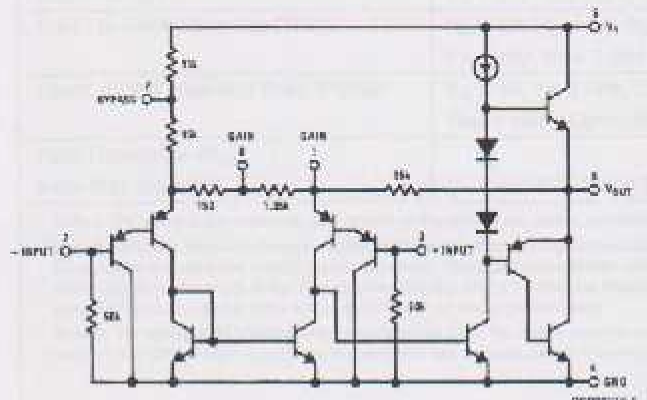
Features

- Battery operation
- Minimum external parts
- Wide supply voltage range: 4V–12V or 5V–18V
- Low quiescent current drain: 4mA
- Voltage gains from 20 to 200
- Ground referenced input
- Self-centering output quiescent voltage
- Low distortion: 0.2% (A_V = 20, V_S = 6V, R_L = 8Ω, P_O = 125mW, f = 1kHz)
- Available in 8 pin MSOP package

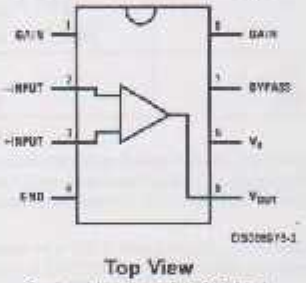
Applications

- AM-FM radio amplifiers
- Portable tape player amplifiers
- Intercoms
- TV sound systems
- Line drivers
- Ultrasonic drivers
- Small servo drivers
- Power converters

Equivalent Schematic and Connection Diagrams



Small Outline, Molded Mini Small Outline, and Dual-In-Line Packages



Top View
Order Number LM386M-1, LM386MM-1, LM386N-1, LM386N-3 or LM386N-4
See NS Package Number M08A, MUA08A or N08E

Absolute Maximum Ratings (Note 2)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

Supply Voltage (LM386N-1, -3, LM386M-1)	15V
Supply Voltage (LM386N-4)	22V
Package Dissipation (Note 3)	
(LM386N)	1.25W
(LM386M)	0.73W
(LM386MM-1)	0.595W
Input Voltage	±0.4V
Storage Temperature	−65°C to +150°C
Operating Temperature	0°C to +70°C
Junction Temperature	+150°C
Soldering Information	
Dual-In-Line Package	
Soldering (10 sec)	+260°C
Small Outline Package (SOIC and MSOP)	
Vapor Phase (60 sec)	+215°C
Infrared (15 sec)	+220°C

See AN-450 "Surface Mounting Methods and Their Effect on Product Reliability" for other methods of soldering surface mount devices.

Thermal Resistance	
θ_{JC} (DIP)	37°C/W
θ_{JA} (DIP)	107°C/W
θ_{JC} (SO Package)	35°C/W
θ_{JA} (SO Package)	172°C/W
θ_{JA} (MSOP)	210°C/W
θ_{JC} (MSOP)	56°C/W

Electrical Characteristics (Notes 1, 2)

T_A = 25°C

Parameter	Conditions	Min	Typ	Max	Units
Operating Supply Voltage (V_S)					
LM386N-1, -3, LM386M-1, LM386MM-1		4		12	V
LM386N-4		5		18	V
Quiescent Current (I_Q)	V_S = 6V, V_{IN} = 0		4	8	mA
Output Power (P_{OUT})					
LM386N-1, LM386M-1, LM386MM-1	V_S = 6V, R_L = 8Ω, THD = 10%	250	325		mW
LM386N-3	V_S = 9V, R_L = 8Ω, THD = 10%	500	700		mW
LM386N-4	V_S = 16V, R_L = 32Ω, THD = 10%	700	1000		mW
Voltage Gain (A_V)	V_S = 6V, f = 1 kHz		26		dB
	10 µF from Pin 1 to 8		46		dB
Bandwidth (BW)	V_S = 6V, Pins 1 and 8 Open		300		kHz
Total Harmonic Distortion (THD)	V_S = 6V, R_L = 8Ω, P_{OUT} = 125 mW f = 1 kHz, Pins 1 and 8 Open		0.2		%
Power Supply Rejection Ratio (PSRR)	V_S = 6V, f = 1 kHz, C_{BYPASS} = 10 µF Pins 1 and 8 Open, Referred to Output		50		dB
Input Resistance (R_{IN})			50		kΩ
Input Bias Current (I_{BIAS})	V_S = 6V, Pins 2 and 3 Open		250		nA

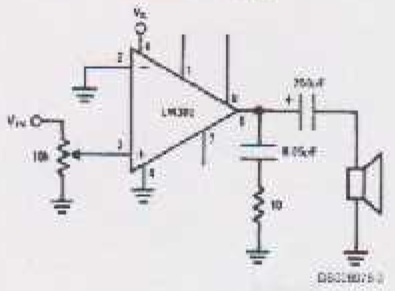
Note 1: All voltages are measured with respect to the ground pin, unless otherwise specified.

Note 2: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional, but do not guarantee specific performance limits. Electrical Characteristics state DC and AC electrical specifications under particular test conditions which guarantee specific performance limits. This assumes that the device is within the Operating Ratings. Specifications are not guaranteed for parameters where no limit is given, however, the typical value is a good indication of device performance.

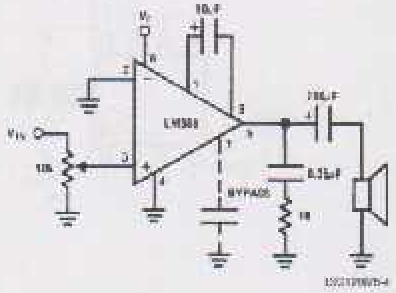
Note 3: For operation in ambient temperatures above 25°C, the device must be derated based on a 150°C maximum junction temperature and 1) a thermal resistance of 107°C/W junction to ambient for the dual-in-line package and 2) a thermal resistance of 170°C/W for the small outline package.

Typical Applications

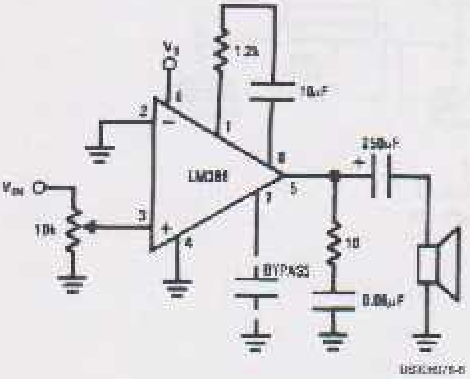
**Amplifier with Gain = 20
Minimum Parts**



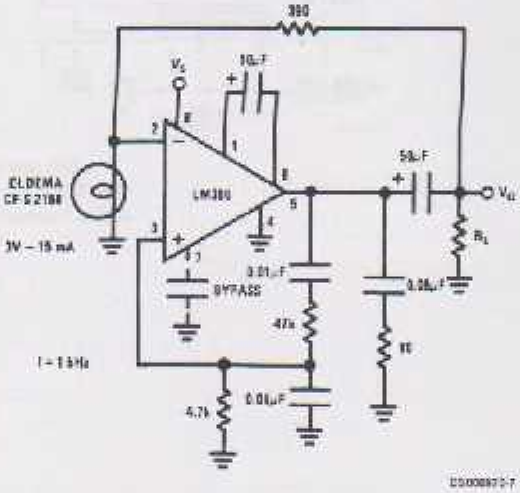
Amplifier with Gain = 200



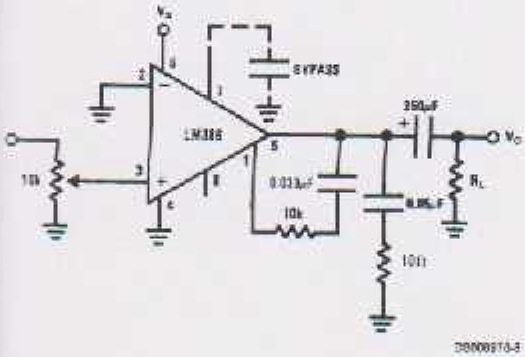
Amplifier with Gain = 50



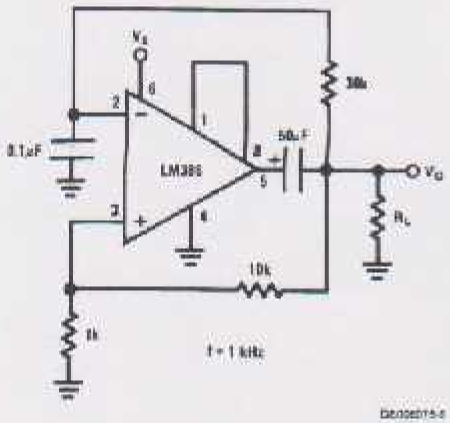
Low Distortion Power Wienbridge Oscillator



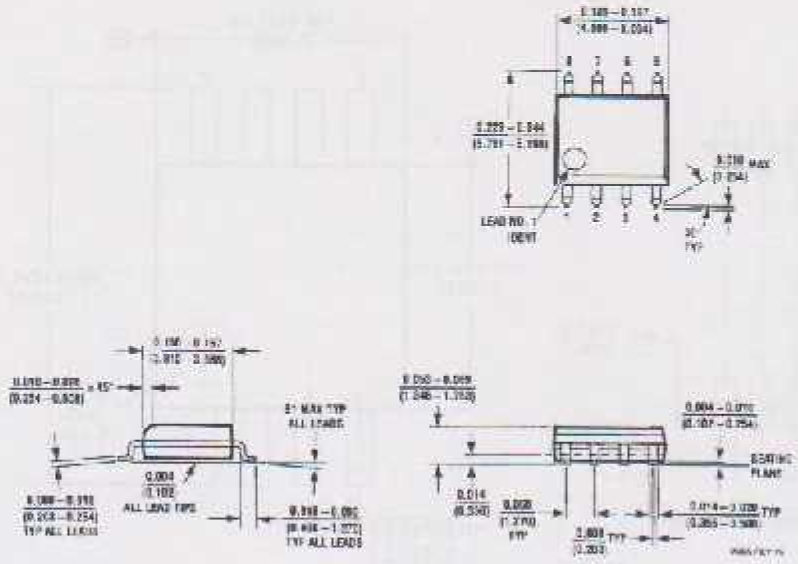
Amplifier with Bass Boost



Square Wave Oscillator

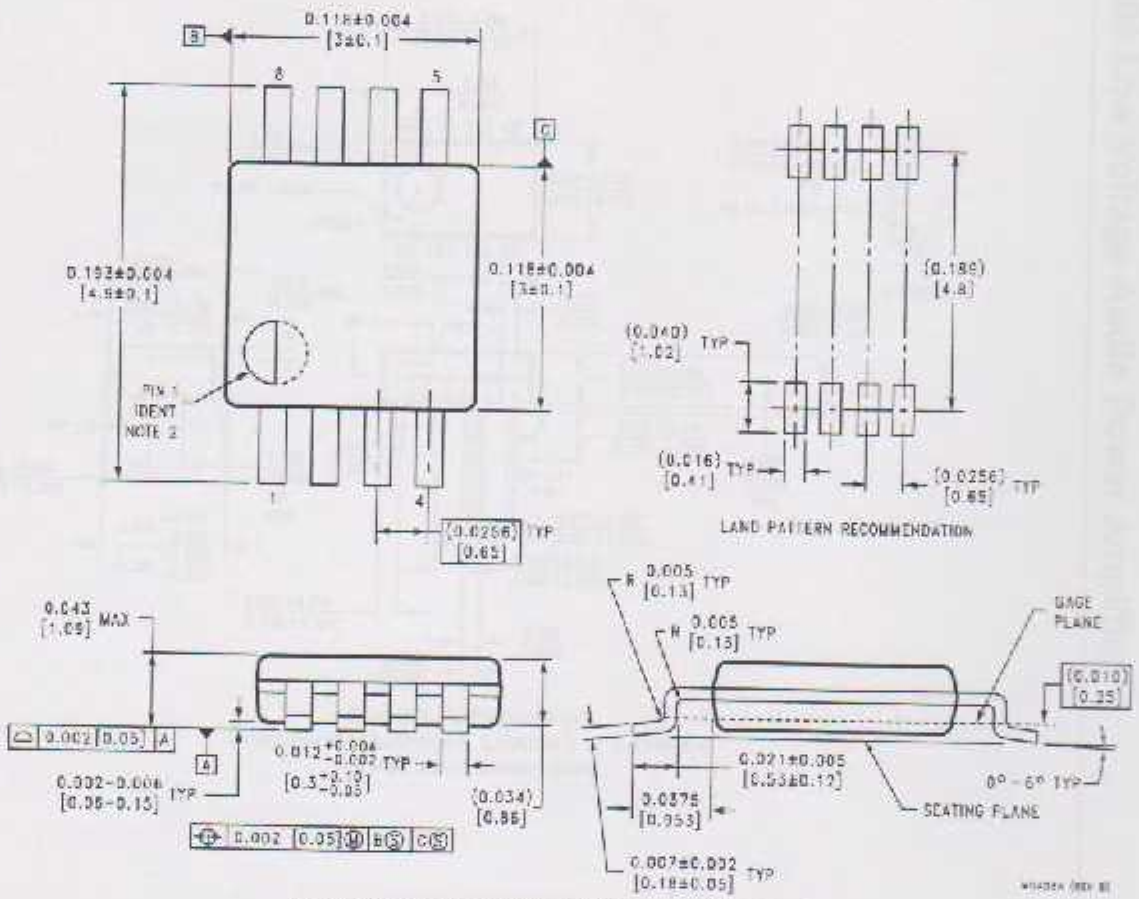


Physical Dimensions inches (millimeters) unless otherwise noted



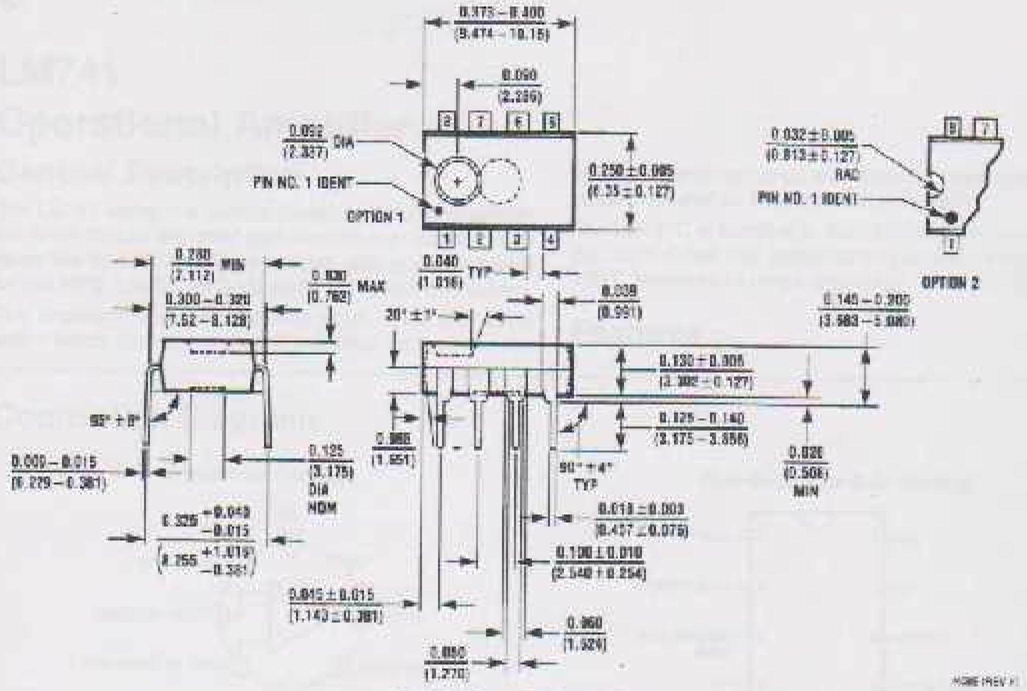
SO Package (M)
Order Number LM386M-1
NS Package Number M08A

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)



8-Lead (0.118" Wide) Molded Mini Small Outline Package
Order Number LM386MM-1
NS Package Number MUA08A

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)



Dual-In-Line Package (N)
Order Number LM386N-1, LM386N-3 or LM386N-4
NS Package Number N08E

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operational amplifier (comparator) datasheet

National Semiconductor

August 2000

LM741 Operational Amplifier

General Description

The LM741 series are general purpose operational amplifiers which feature improved performance over industry standards like the LM709. They are direct, plug-in replacements for the 709C, LM201, MC1439 and 748 in most applications.

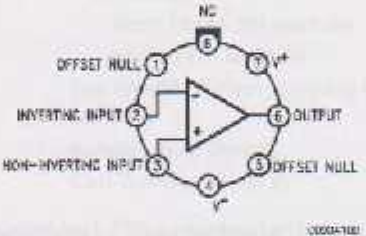
The amplifiers offer many features which make their application nearly foolproof: overload protection on the input and output, no latch-up when the common mode range is exceeded, as well as freedom from oscillations.

The LM741C is identical to the LM741/LM741A except that the LM741C has their performance guaranteed over a 0°C to +70°C temperature range, instead of −55°C to +125°C.

Features

Connection Diagrams

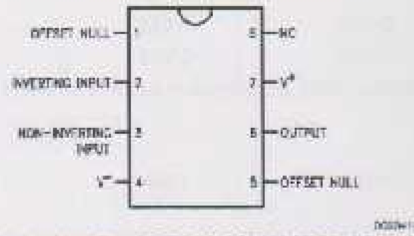
Metal Can Package



Note 1: LM741H is available per JM38510/10101

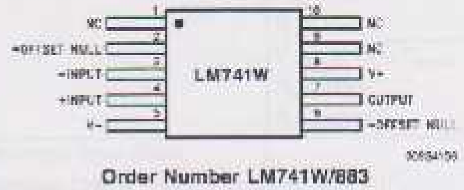
Order Number LM741H, LM741H/883 (Note 1), LM741AH/883 or LM741CH
See NS Package Number H08C

Dual-In-Line or S.O. Package



Order Number LM741J, LM741J/883, LM741CN
See NS Package Number J08A, M08A or N08E

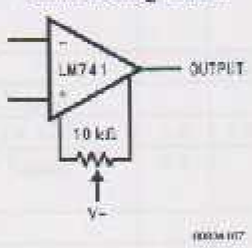
Ceramic Flatpak



Order Number LM741W/883
See NS Package Number W10A

Typical Application

Offset Nulling Circuit



Absolute Maximum Ratings (Note 2)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.
(Note 7)

	LM741A	LM741	LM741C
Supply Voltage	±22V	±22V	±18V
Power Dissipation (Note 3)	500 mW	500 mW	500 mW
Differential Input Voltage	±30V	±30V	±30V
Input Voltage (Note 4)	±15V	±15V	±15V
Output Short Circuit Duration	Continuous	Continuous	Continuous
Operating Temperature Range	−55°C to +125°C	−55°C to +125°C	0°C to +70°C
Storage Temperature Range	−65°C to +150°C	−65°C to +150°C	−65°C to +150°C
Junction Temperature	150°C	150°C	100°C
Soldering Information			
N-Package (10 seconds)	260°C	260°C	260°C
J- or H-Package (10 seconds)	300°C	300°C	300°C
M-Package			
Vapor Phase (60 seconds)	215°C	215°C	215°C
Infrared (15 seconds)	215°C	215°C	215°C

See AN-450 "Surface Mounting Methods and Their Effect on Product Reliability" for other methods of soldering
surface mount devices.

	LM741A	LM741	LM741C
ESD Tolerance (Note 8)	400V	400V	400V

Electrical Characteristics (Note 5)

Parameter	Conditions	LM741A			LM741			LM741C			Units
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	$T_A = 25°C$										
	$R_S \le 10\ k\Omega$					1.0	5.0		2.0	6.0	mV
	$R_S \le 50\Omega$		0.8	3.0							mV
	$T_{AMIN} \le T_A \le T_{AMAX}$										
	$R_S \le 50\Omega$			4.0							mV
	$R_S \le 10\ k\Omega$						6.0			7.5	mV
Average Input Offset Voltage Drift				15							μV/°C
Input Offset Voltage Adjustment Range	$T_A = 25°C, V_S = \pm 20V$	±10				±15			±15		mV
Input Offset Current	$T_A = 25°C$		3.0	30		20	200		20	200	nA
	$T_{AMIN} \le T_A \le T_{AMAX}$			70		85	500			300	nA
Average Input Offset Current Drift				0.5							nA/°C
Input Bias Current	$T_A = 25°C$		30	80		80	500		80	500	nA
	$T_{AMIN} \le T_A \le T_{AMAX}$			0.210			1.5			0.8	μA
Input Resistance	$T_A = 25°C, V_S = \pm 20V$	1.0	6.0		0.3	2.0		0.3	2.0		MΩ
	$T_{AMIN} \le T_A \le T_{AMAX}$, $V_S = \pm 20V$	0.5									MΩ
Input Voltage Range	$T_A = 25°C$							±12	±13		V
	$T_{AMIN} \le T_A \le T_{AMAX}$				±12	±13					V

ectrical Characteristics (Note 5) (Continued)

Parameter	Conditions	LM741A			LM741			LM741C			Units
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Signal Voltage Gain	$T_A = 25°C$, $R_L \geq 2\ k\Omega$										
	$V_S = \pm 20V$, $V_O = \pm 15V$	50									V/mV
	$V_S = \pm 15V$, $V_O = \pm 10V$				50	200		20	200		V/mV
	$T_{AMIN} \leq T_A \leq T_{AMAX}$, $R_L \geq 2\ k\Omega$,										
	$V_S = \pm 20V$, $V_O = \pm 15V$	32									V/mV
	$V_S = \pm 15V$, $V_O = \pm 10V$				25			15			V/mV
	$V_S = \pm 5V$, $V_O = \pm 2V$	10									V/mV
t Voltage Swing	$V_S = \pm 20V$										
	$R_L \geq 10\ k\Omega$	±16									V
	$R_L \geq 2\ k\Omega$	±15									V
	$V_S = \pm 15V$										
	$R_L \geq 10\ k\Omega$				±12	±14		±12	±14		V
	$R_L \geq 2\ k\Omega$				±10	±13		±10	±13		V
t Short Circuit	$T_A = 25°C$	10	25	35		25			25		mA
t	$T_{AMIN} \leq T_A \leq T_{AMAX}$	10		40							mA
on-Mode	$T_{AMIN} \leq T_A \leq T_{AMAX}$										
ion Ratio	$R_S \leq 10\ k\Omega$, $V_{CM} = \pm 12V$				70	90		70	90		dB
	$R_S \leq 50\Omega$, $V_{CM} = \pm 12V$	80	95								dB
Voltage Rejection	$T_{AMIN} \leq T_A \leq T_{AMAX}$,										
	$V_S = \pm 20V$ to $V_S = \pm 5V$										
	$R_S \leq 50\Omega$	86	96								dB
	$R_S \leq 10\ k\Omega$				77	96		77	96		dB
ent Response	$T_A = 25°C$, Unity Gain										
Time			0.25	0.8		0.3			0.3		μs
rshoot			6.0	20		5			5		%
idth (Note 6)	$T_A = 25°C$	0.437	1.5								MHz
Rate	$T_A = 25°C$, Unity Gain	0.3	0.7			0.5			0.5		V/μs
Current	$T_A = 25°C$					1.7	2.8		1.7	2.8	mA
Consumption	$T_A = 25°C$										
	$V_S = \pm 20V$		80	150							mW
	$V_S = \pm 15V$					50	85		50	85	mW
41A	$V_S = \pm 20V$										
	$T_A = T_{AMIN}$			165							mW
	$T_A = T_{AMAX}$			135							mW
41	$V_S = \pm 15V$										
	$T_A = T_{AMIN}$					60	100				mW
	$T_A = T_{AMAX}$					45	75				mW

: "Absolute Maximum Ratings" indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is onal, but do not guarantee specific performance limits.

Electrical Characteristics (Note 5) (Continued)

Parameter	Conditions	LM741A Min	LM741A Typ	LM741A Max	LM741 Min	LM741 Typ	LM741 Max	LM741C Min	LM741C Typ	LM741C Max	Units
Large Signal Voltage Gain	$T_A = 25°C$, $R_L \geq 2\ k\Omega$										
	$V_S = \pm20V$, $V_O = \pm15V$	50									V/mV
	$V_S = \pm15V$, $V_O = \pm10V$				50	200		20	200		V/mV
	$T_{AMIN} \leq T_A \leq T_{AMAX}$,										
	$R_L \geq 2\ k\Omega$,										
	$V_S = \pm20V$, $V_O = \pm15V$	32									V/mV
	$V_S = \pm15V$, $V_O = \pm10V$				25			15			V/mV
	$V_S = \pm5V$, $V_O = \pm2V$	10									V/mV
Output Voltage Swing	$V_S = \pm20V$										
	$R_L \geq 10\ k\Omega$	±16									V
	$R_L \geq 2\ k\Omega$	±15									V
	$V_S = \pm15V$										
	$R_L \geq 10\ k\Omega$				±12	±14		±12	±14		V
	$R_L \geq 2\ k\Omega$				±10	±13		±10	±13		V
Output Short Circuit	$T_A = 25°C$	10	25	35		25			25		mA
Current	$T_{AMIN} \leq T_A \leq T_{AMAX}$	10		40							mA
Common-Mode	$T_{AMIN} \leq T_A \leq T_{AMAX}$										
Rejection Ratio	$R_S \leq 10\ k\Omega$, $V_{CM} = \pm12V$				70	90		70	90		dB
	$R_S \leq 50\Omega$, $V_{CM} = \pm12V$	80	95								dB
Supply Voltage Rejection	$T_{AMIN} \leq T_A \leq T_{AMAX}$,										
Ratio	$V_S = \pm20V$ to $V_S = \pm5V$										
	$R_S \leq 50\Omega$	86	96								dB
	$R_S \leq 10\ k\Omega$				77	96		77	96		dB
Transient Response	$T_A = 25°C$, Unity Gain										
Rise Time			0.25	0.8		0.3			0.3		µs
Overshoot			6.0	20		5			5		%
Bandwidth (Note 6)	$T_A = 25°C$	0.437	1.5								MHz
Slew Rate	$T_A = 25°C$, Unity Gain	0.3	0.7			0.5			0.5		V/µs
Supply Current	$T_A = 25°C$					1.7	2.8		1.7	2.8	mA
Power Consumption	$T_A = 25°C$										
	$V_S = \pm20V$		80	150							mW
	$V_S = \pm15V$					50	85		50	85	mW
LM741A	$V_S = \pm20V$										
	$T_A = T_{AMIN}$			165							mW
	$T_A = T_{AMAX}$			135							mW
LM741	$V_S = \pm15V$										
	$T_A = T_{AMIN}$					60	100				mW
	$T_A = T_{AMAX}$					45	75				mW

Note 2: "Absolute Maximum Ratings" indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional, but do not guarantee specific performance limits.

Electrical Characteristics (Note 5) (Continued)

Note 3: For operation at elevated temperatures, these devices must be derated based on thermal resistance, and T_j max. (listed under "Absolute Maximum Ratings"). $T_j = T_A + (\theta_{jA} P_D)$.

Thermal Resistance	Cerdip (J)	DIP (N)	HO8 (H)	SO-8 (M)
θ_{jA} (Junction to Ambient)	100°C/W	100°C/W	170°C/W	195°C/W
θ_{jC} (Junction to Case)	N/A	N/A	25°C/W	N/A

Note 4: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

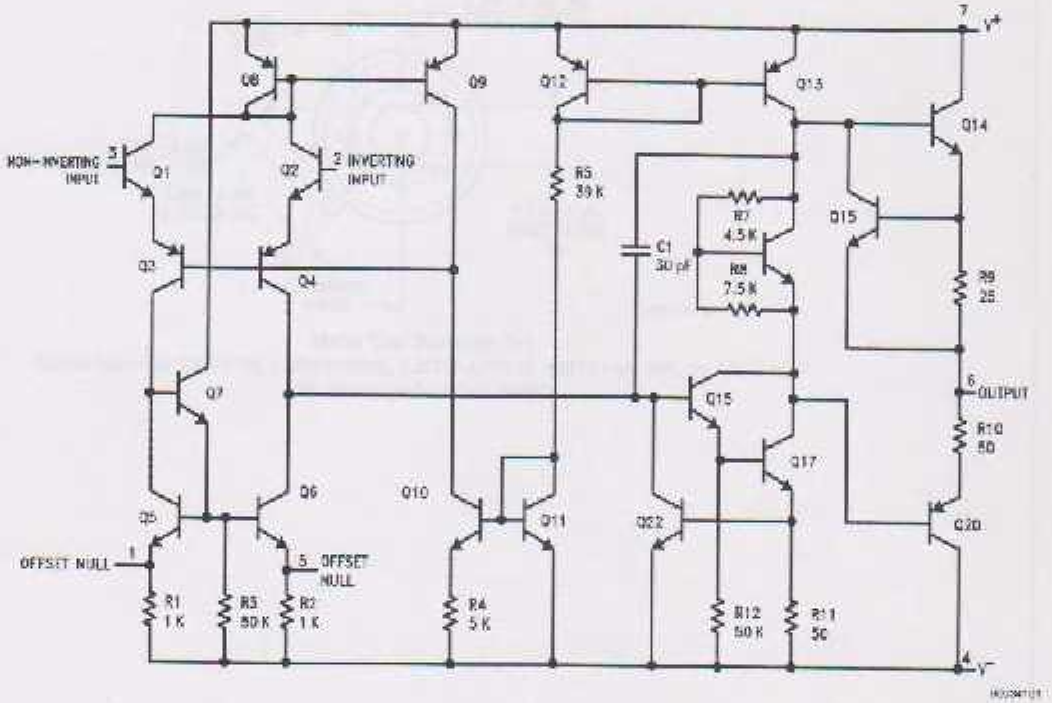
Note 5: Unless otherwise specified, these specifications apply for $V_S = \pm 15V$, $-55°C \le T_A \le +125°C$ (LM741/LM741A). For the LM741C/LM741E, these specifications are limited to $0°C \le T_A \le +70°C$.

Note 6: Calculated value from: BW (MHz) = 0.35/Rise Time(µs).

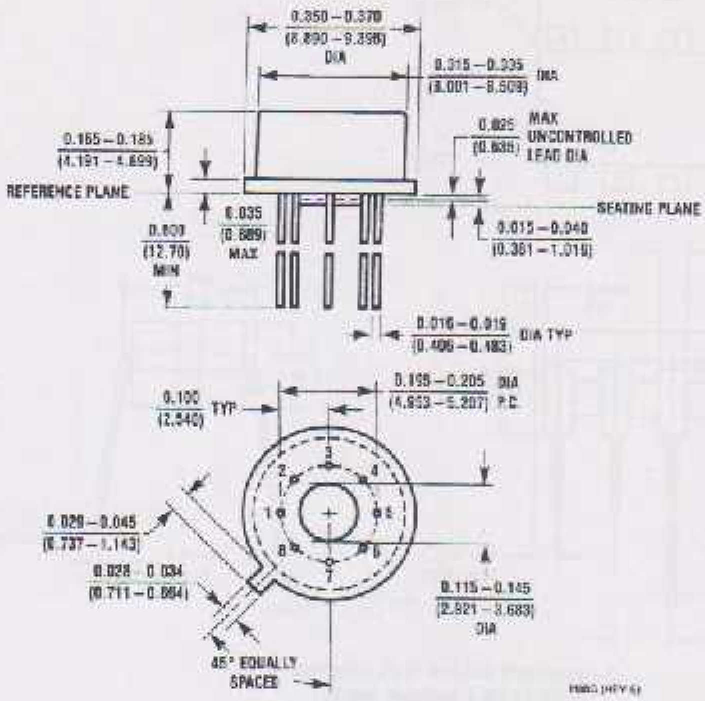
Note 7: For military specifications see RETS741X for LM741 and RETS741AX for LM741A.

Note 8: Human body model, 1.5 kΩ in series with 100 pF.

Schematic Diagram

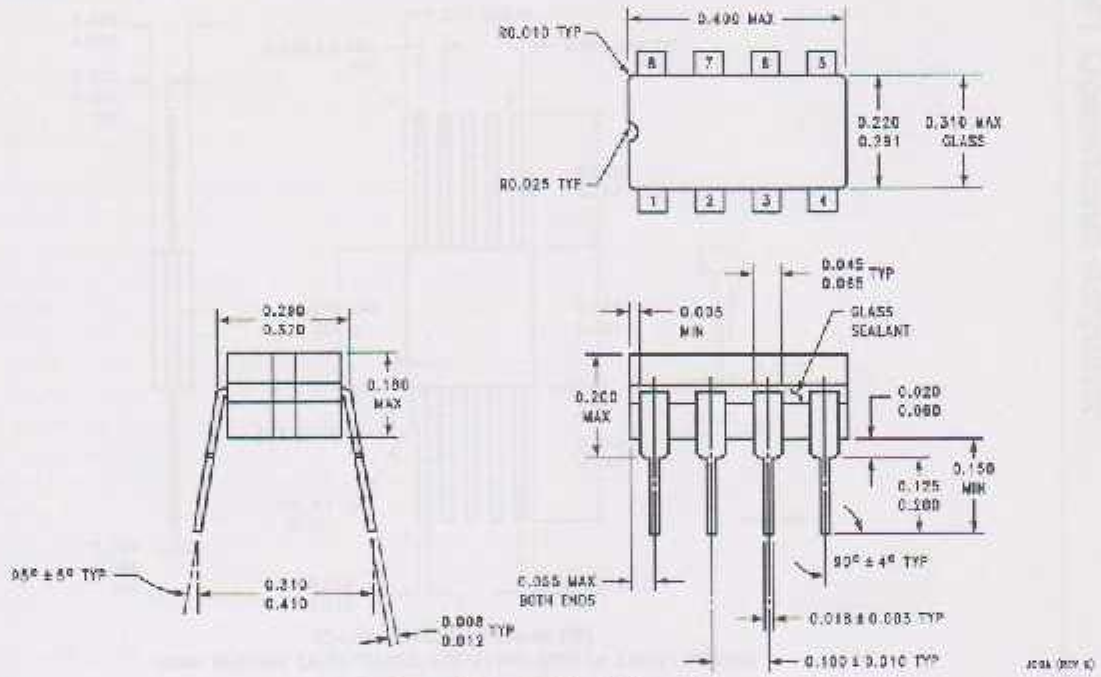


Physical Dimensions inches (millimeters) unless otherwise noted

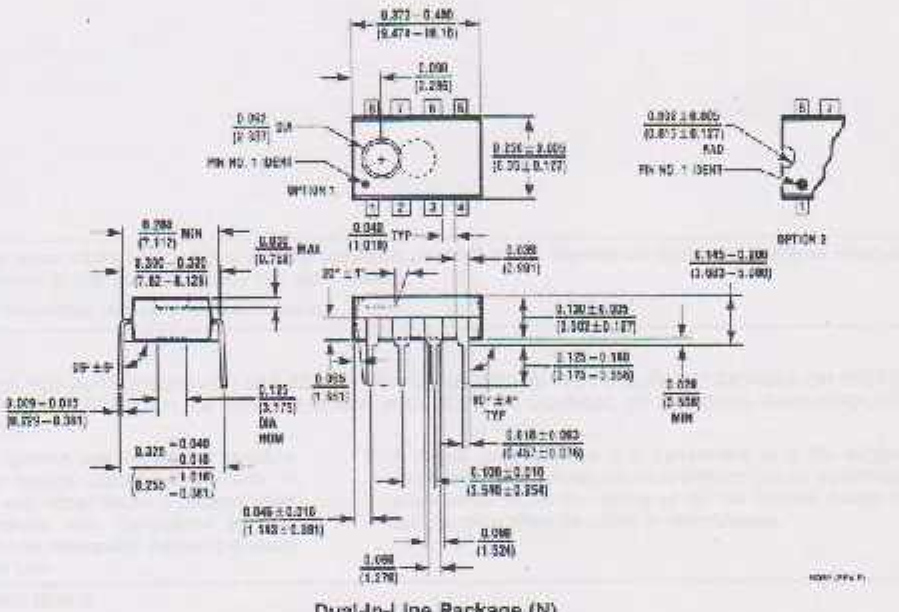


Metal Can Package (H)
Order Number LM741H, LM741H/883, LM741AH/883, LM741AH-MIL or LM741CH
NS Package Number H08C

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)

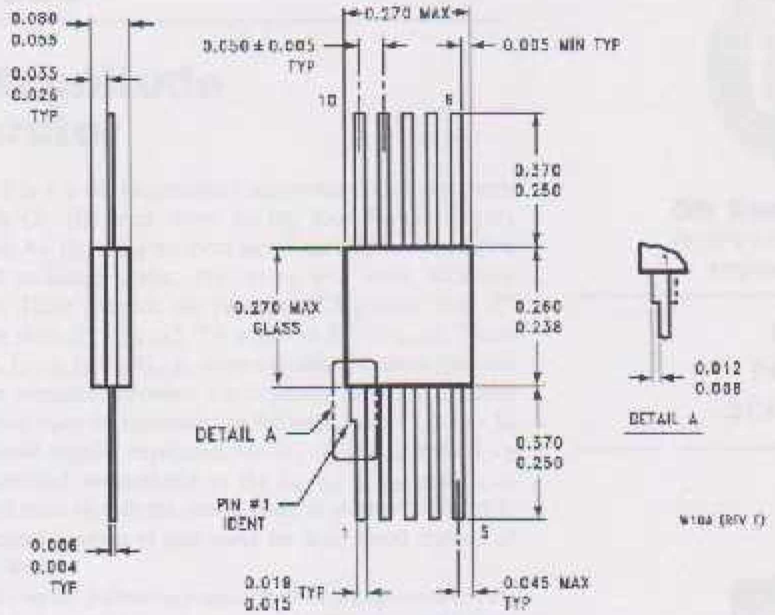


Ceramic Dual-In-Line Package (J)
Order Number LM741J/883
NS Package Number J08A



Dual-In-Line Package (N)
Order Number LM741CN
NS Package Number N08E

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)



10-Lead Ceramic Flatpak (W)
Order Number LM741W/883, LM741WG-MPR or LM741WG/883
NS Package Number W10A

National Semiconductor Americas Customer Support Center
Email: new.feedback@nsc.com
Tel: 1-800-272-9959

National Semiconductor Europe Customer Support Center
Fax: +49 (0) 180-530 85 86
Email: europe.support@nsc.com
Deutsch Tel: +49 (0) 69 9508 6208
English Tel: +44 (0) 870 24 0 2171
Français Tel: +33 (0) 1 41 91 8790

National Semiconductor Asia Pacific Customer Support Center
Email: ap.support@nsc.com

National Semiconductor Japan Customer Support Center
Fax: 81-3-5639-7507
Email: jpn.feedback@nsc.com
Tel: 81-3-5639-7560

www.national.com

magnitude comparator datasheet

SN74LS85

4-Bit Magnitude Comparator

The SN74LS85 is a 4-Bit Magnitude Camparator which compares two 4-bit words (A, B), each word having four Parallel Inputs (A_0-A_3, B_0-B_3); A_3, B_3 being the most significant inputs. Operation is not restricted to binary codes, the device will work with any monotonic code. Three Outputs are provided: "A greater than B" ($O_{A>B}$), "A less than B" ($O_{A<B}$), "A equal to B" ($O_{A=B}$). Three Expander Inputs, $I_{A>B}$, $I_{A<B}$, $I_{A=B}$, allow cascading without external gates. For proper compare operation, the Expander Inputs to the least significant position must be connected as follows: $I_{A<B} = I_{A>B} = L$, $I_{A=B} = H$. For serial (ripple) expansion, the $O_{A>B}$, $O_{A<B}$ and $O_{A=B}$ Outputs are connected respectively to the $I_{A>B}$, $I_{A<B}$, and $I_{A=B}$ Inputs of the next most significant comparator, as shown in Figure 1. Refer to Applications section of data sheet for high speed method of comparing large words.

The Truth Table on the following page describes the operation of the SN74LS85 under all possible logic conditions. The upper 11 lines describe the normal operation under all conditions that will occur in a single device or in a series expansion scheme. The lower five lines describe the operation under abnormal conditions on the cascading inputs. These conditions occur when the parallel expansion technique is used.

- Easily Expandable
- Binary or BCD Comparison
- $O_{A>B}$, $O_{A<B}$, and $O_{A=B}$ Outputs Available

GUARANTEED OPERATING RANGES

Symbol	Parameter	Min	Typ	Max	Unit
V_{CC}	Supply Voltage	4.75	5.0	5.25	V
T_A	Operating Ambient Temperature Range	0	25	70	°C
I_{OH}	Output Current – High			−0.4	mA
I_{OL}	Output Current – Low			8.0	mA

ON Semiconductor

Formerly a Division of Motorola

http://onsemi.com

LOW POWER SCHOTTKY

16

1

PLASTIC
N SUFFIX
CASE 648

16

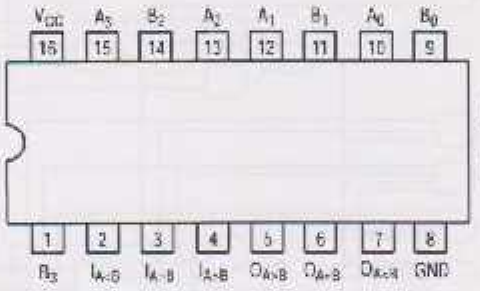
1

SOIC
D SUFFIX
CASE 751B

ORDERING INFORMATION

Device	Package	Shipping
SN74LS85N	16 Pin DIP	2000 Units/Box
SN74LS85D	16 Pin	2500/Tape & Reel

CONNECTION DIAGRAM DIP (TOP VIEW)



NOTE:
The Flatpak version has the same pinouts (Connection Diagram) as the Dual In-Line Package.

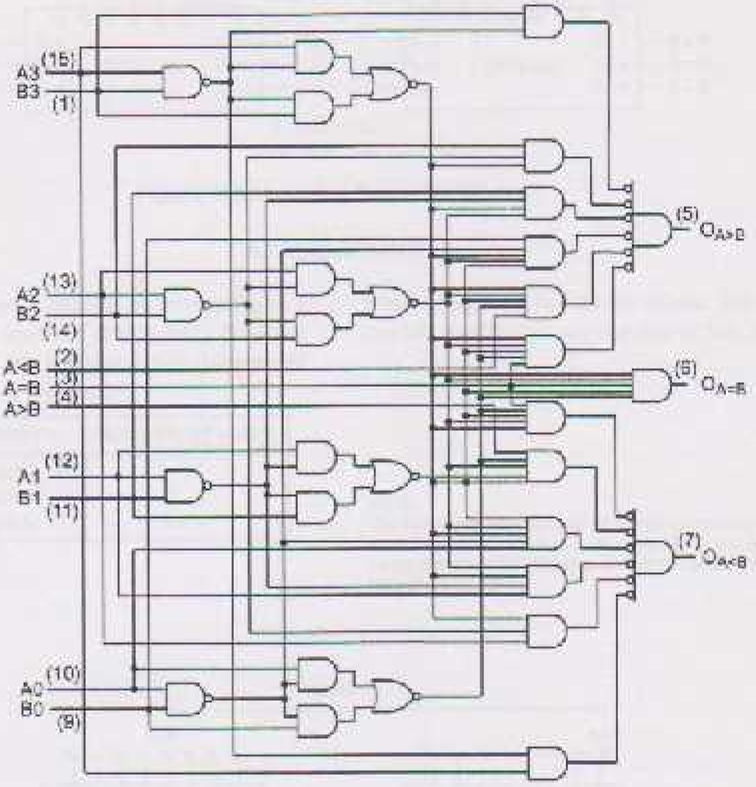
PIN NAMES		LOADING (Note a) HIGH	LOW
$A_0 - A_3$, $B_0 - B_3$	Parallel Inputs	1.5 U.L.	0.75 U.L.
$I_{A=B}$	A = B Expander Inputs	1.5 U.L.	0.75 U.L.
$I_{A<B}$, $I_{A>B}$	A < B, A > B, Expander Inputs	0.5 U.L.	0.25 U.L.
$O_{A>B}$	A Greater than B Output	10 U.L.	5 U.L.
$O_{A<B}$	B Greater than A Output	10 U.L.	5 U.L.
$O_{A=B}$	A Equal to B Output	10 U.L.	5 U.L.

NOTES:
a) 1 TTL Unit Load (U.L.) = 40 μA HIGH/1.6 mA LOW.

LOGIC SYMBOL

V_{CC} = PIN 16
GND = PIN 8

LOGIC DIAGRAM



TRUTH TABLE

COMPARING INPUTS				CASCADING INPUTS			OUTPUTS		
A_3,B_3	A_2,B_2	A_1,B_1	A_0,B_0	$I_{A>B}$	$I_{A<B}$	$I_{A=B}$	$O_{A>B}$	$O_{A<B}$	$O_{A=B}$
$A_3>B_3$	X	X	X	X	X	X	H	L	L
$A_3<B_3$	X	X	X	X	X	X	L	H	L
$A_3=B_3$	$A_2>B_2$	X	X	X	X	X	H	L	L
$A_3=B_3$	$A_2<B_2$	X	X	X	X	X	L	H	L
$A_3=B_3$	$A_2=B_2$	$A_1>B_1$	X	X	X	X	H	L	L
$A_3=B_3$	$A_2=B_2$	$A_1<B_1$	X	X	X	X	L	H	L
$A_3=B_3$	$A_2=B_2$	$A_1=B1$	$A_0>B_0$	X	X	X	H	L	L
$A_3=B_3$	$A_2=B_2$	$A_1=B_1$	$A_0<B_0$	X	X	X	L	H	L
$A_3=B_3$	$A_2=B_2$	$A_1=B_1$	$A_0=B_0$	H	L	L	H	L	L
$A_3=B_3$	$A_2=B_2$	$A_1=B_1$	$A_0=B_0$	L	H	L	L	H	L
$A_3=B_3$	$A_2=B_2$	$A_1=B_1$	$A_0=B_0$	X	X	H	L	L	H
$A_3=B_3$	$A_2=B_2$	$A_1=B_1$	$A_0=B_0$	H	H	L	L	L	L
$A_3=B_3$	$A_2=B_2$	$A_1=B_1$	$A_0=B_0$	L	L	L	H	H	L

H = HIGH Level
L = LOW Level
X = IMMATERIAL

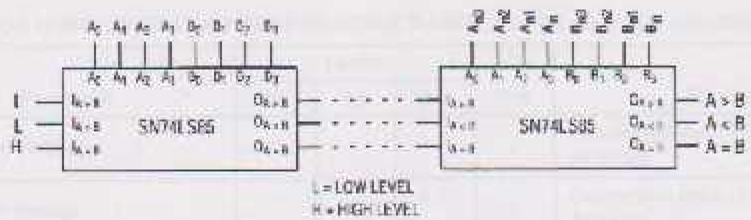


Figure 1. Comparing Two n-Bit Words

APPLICATIONS

Figure 2 shows a high speed method of comparing two 24-bit words with only two levels of device delay. With the technique shown in Figure 1, six levels of device delay result when comparing two 24-bit words. The parallel technique can be expanded to any number of bits, see Table 1.

Table 1

WORD LENGTH	NUMBER OF PKGS.
1 – 4 Bits	1
5 – 24 Bits	2 – 6
25 – 120 Bits	8 – 31

NOTE:
The SN74LS85 can be used as a 5-bit comparator only when the outputs are used to drive the A_0–A_3 and B_0–B_3 inputs of another SN74LS85 as shown in Figure 2 in positions #1, 2, 3, and 4.

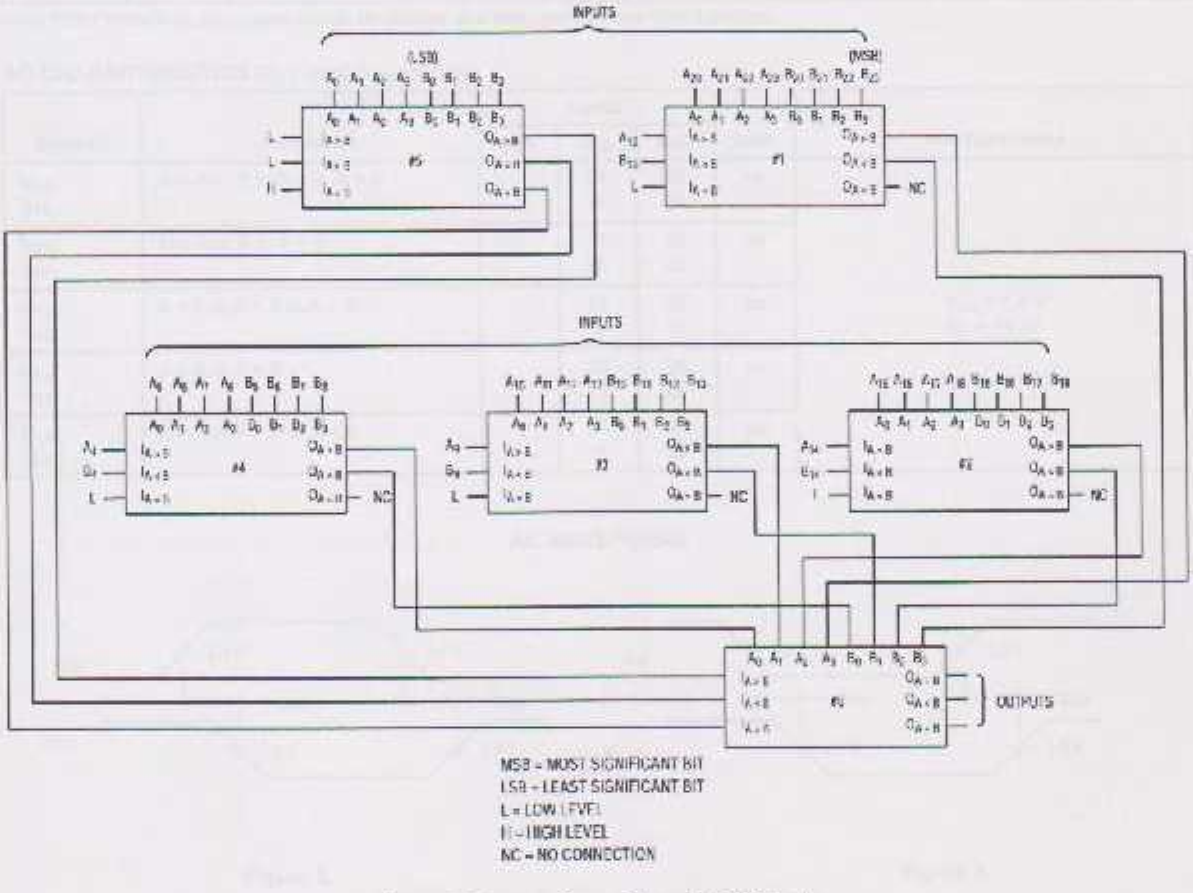


Figure 2. Comparison of Two 24-Bit Words

DC CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE (unless otherwise specified)

Symbol	Parameter	Limits Min	Typ	Max	Unit	Test Conditions
V_{IH}	Input HIGH Voltage	2.0			V	Guaranteed Input HIGH Voltage for All Inputs
V_{IL}	Input LOW Voltage			0.8	V	Guaranteed Input LOW Voltage for All Inputs
V_{IK}	Input Clamp Diode Voltage		−0.65	−1.5	V	V_{CC} = MIN, I_{IN} = −18 mA
V_{OH}	Output HIGH Voltage	2.7	3.5		V	V_{CC} = MIN, I_{OH} = MAX, V_{IN} = V_{IH} or V_{IL} per Truth Table
V_{OL}	Output LOW Voltage		0.25	0.4	V	I_{OL} = 4.0 mA; V_{CC} = V_{CC} MIN, V_{IN} = V_{IL} or V_{IH} per Truth Table
			0.35	0.5	V	I_{OL} = 8.0 mA
I_{IH}	Input HIGH Current A < B, A > B Other Inputs			20 60	µA	V_{CC} = MAX, V_{IN} = 2.7 V
	A < B, A > B Other Inputs			0.1 0.3	mA	V_{CC} = MAX, V_{IN} = 7.0 V
I_{IL}	Input LOW Current A < B, A > B Other Inputs			−0.4 −1.2	mA	V_{CC} = MAX, V_{IN} = 0.4 V
I_{OS}	Output Short Circuit Current (Note 1)	−20		−100	mA	V_{CC} = MAX
I_{CC}	Power Supply Current			20	mA	V_{CC} = MAX

Note 1: Not more than one output should be shorted at a time, nor for more than 1 second.

AC CHARACTERISTICS (T_A = 25°C, V_{CC} = 5.0 V)

Symbol	Parameter	Limits Min	Typ	Max	Unit	Test Conditions
t_{PLH} t_{PHL}	Any A or B to A < B, A > B		24 20	36 30	ns	V_{CC} = 5.0 V C_L = 15 pF
t_{PLH} t_{PHL}	Any A or B to A = B		27 23	45 45	ns	
t_{PLH} t_{PHL}	A < B or A = B to A > B		14 11	22 17	ns	
t_{PLH} t_{PHL}	A = B to A = B		13 13	20 26	ns	
t_{PLH} t_{PHL}	A > B or A = B to A < B		14 11	22 17	ns	

AC WAVEFORMS

Figure 3.

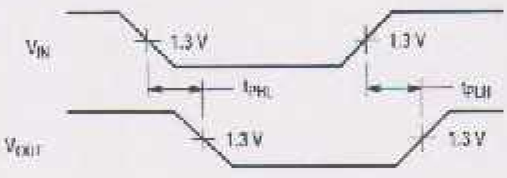


Figure 4.

optocoupler datasheet

FAIRCHILD SEMICONDUCTOR®

April 2007

4N29, 4N30, 4N31, 4N32, 4N33
General Purpose 6-Pin Photodarlington Optocoupler

Features

- High sensitivity to low input drive current
- Meets or exceeds all JEDEC Registered Specifications
- VDE 0884 approval available as a test option
  – add option .300. (e.g., 4N29.300)

Applications

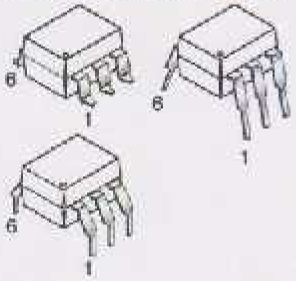
- Low power logic circuits
- Telecommunications equipment
- Portable electronics
- Solid state relays
- Interfacing coupling systems of different potentials and impedances

Description

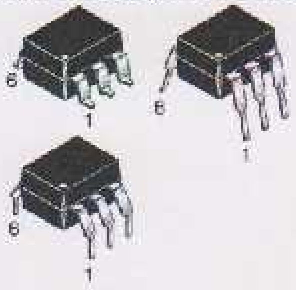
The 4N29, 4N30, 4N31, 4N32, 4N33 have a gallium arsenide infrared emitter optically coupled to a silicon planar photodarlington.

Packages

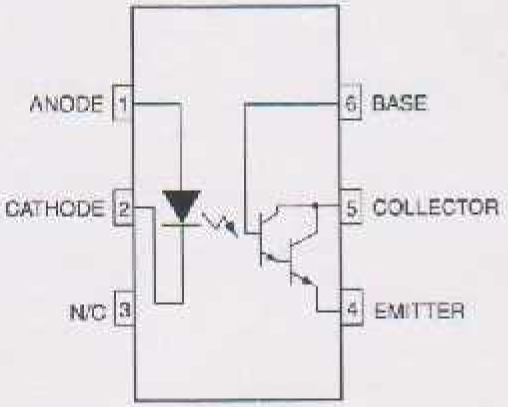
White Package (-M Suffix)



Black Package (No -M Suffix)



Schematic



Absolute Maximum Ratings (T_A = 25°C Unless otherwise specified.)

Symbol	Parameter	Device	Value	Units
TOTAL DEVICE				
T_{STG}	Storage Temperature	Non M	-55 to +150	°C
		M	-40 to +150	
T_{OPR}	Operating Temperature	Non M	-55 to +100	°C
		M	-40 to +100	
T_{SOL}	Lead Solder Temperature	All	260 for 10 sec	°C
P_D	Total Device Power Dissipation @ T_A = 25°C	All	250	mW
	Derate above 25°C		3.3	mW/°C
EMITTER				
I_F	Continuous Forward Current	All	80	mA
V_R	Reverse Voltage	All	3	V
I_F(pk)	Forward Current – Peak (300µs, 2% Duty Cycle)	All	3.0	A
P_D	LED Power Dissipation @ T_A = 25°C	All	150	mW
	Derate above 25°C		2.0	mW/°C
DETECTOR				
BV_{CEO}	Collector-Emitter Breakdown Voltage	All	30	V
BV_{CBO}	Collector-Base Breakdown Voltage	All	30	V
BV_{ECO}	Emitter-Collector Breakdown Voltage	All	5	V
P_D	Detector Power Dissipation @ T_A = 25°C	All	150	mW
	Derate above 25°C		2.0	mW/°C
I_C	Continuous Collector Current	All	150	mA

Electrical Characteristics ($T_A = 25°C$ Unless otherwise specified.)

Individual Component Characteristics

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
EMITTER						
V_F	Input Forward Voltage*	$I_F = 10mA$	–	1.2	1.5	V
I_R	Reverse Leakage Current*	$V_R = 3.0V$	–	0.001	100	µA
C	Capacitance*	$V_F = 0V$, f = 1.0MHz	–	150	–	pF
DETECTOR						
BV_{CEO}	Collector-Emitter Breakdown Voltage*	$I_C = 1.0mA$, $I_B = 0$	30	60	–	V
BV_{CBO}	Collector-Base Breakdown Voltage*	$I_C = 100µA$, $I_E = 0$	30	100	–	V
BV_{ECO}	Emitter-Collector Breakdown Voltage*	$I_E = 100µA$, $I_B = 0$	5.0	8	–	V
I_{CEO}	Collector-Emitter Dark Current*	$V_{CE} = 10V$, Base Open	–	1	100	nA
h_{FE}	DC Current Gain	$V_{CE} = 5.0V$, $I_C = 500µA$	–	5000	–	

Transfer Characteristics

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
DC CHARACTERISTICS						
$I_{C(CTR)}$	Collector Output Current*[1, 2]	$I_F = 10mA$, $V_{CE} = 10V$, $I_B = 0$				mA (%)
	4N32, 4N33		50 (500)	–	–	
	4N29, 4N30		10 (100)	–	–	
	4N31		5 (50)	–	–	
$V_{CE(SAT)}$	Saturation Voltage*[2]	$I_F = 8mA$, $I_C = 2.0mA$				V
	4N29, 4N30, 4N32, 4N33		–	–	1.0	
	4N31		–	–	1.2	
AC CHARACTERISTICS						
t_{on}	Turn-on Time	$I_F = 200mA$, $I_C = 50mA$, $V_{CC} = 10V$	–	–	5.0	µS
t_{off}	Turn-off Time	$I_F = 200mA$, $I_C = 50mA$, $V_{CC} = 10V$				µS
	4N32, 4N33		–	–	100	
	4N29, 4N30, 4N31		–	–	40	
BW	Bandwidth[3, 4]		–	30	–	kHz

Isolation Characteristics

Symbol	Characteristic	Test Conditions	Min.	Typ.	Max.	Units
V_{ISO}	Input-Output Isolation Voltage[5]					
	4N29, 4N30, 4N31, 4N32, 4N33	$I_{I-O} \leq 1µA$, Vrms, t = 1min.	5300	–	–	Vac(rms)
	4N32*	VDC	2500	–	–	V
	4N33*	VDC	1500	–	–	
R_{ISO}	Isolation Resistance[5]	$V_{I-O} = 500VDC$	–	10^{11}	–	Ω
C_{ISO}	Isolation Capacitance[5]	$V_{I-O} = Ø$, f = 1MHz	–	0.8	–	pF

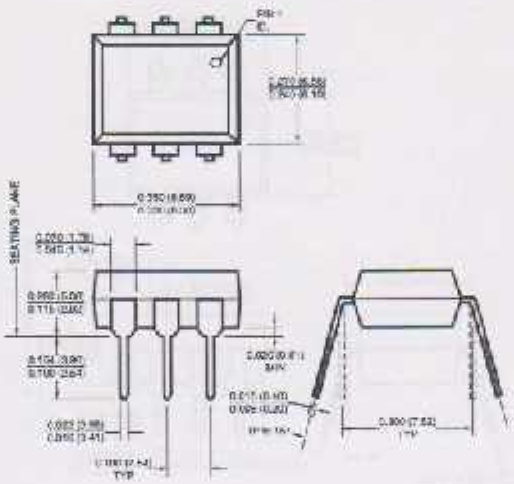
Notes:

* Indicates JEDEC registered data.

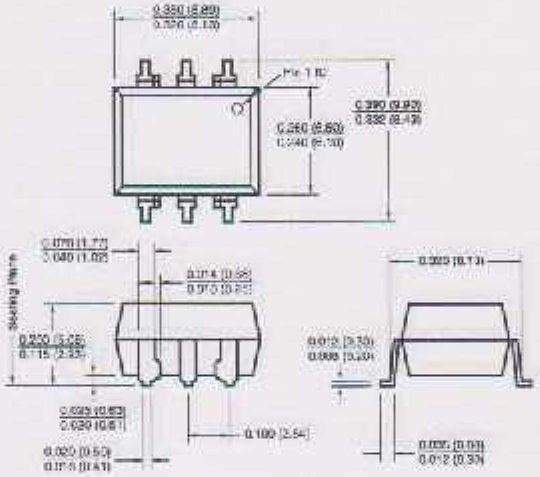
1. The current transfer ratio(I_C/I_F) is the ratio of the detector collector current to the LED input current with V_{CE} @ 10V.
2. Pulse test: pulse width = 300µs, duty cycle ≤ 2.0% .
4. I_F adjusted to $I_C = 2.0mA$ and $I_C = 0.7mA$ rms.
5. The frequency at which I_C is 3dB down from the 1kHz value.
6. For this test, LED pins 1 and 2 are common, and phototransistor pins 4, 5 and 6 are common.

Black Package (No -M Suffix)

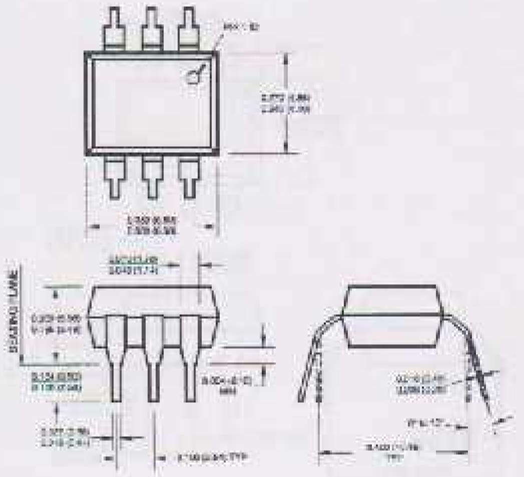
Package Dimensions (Through Hole)



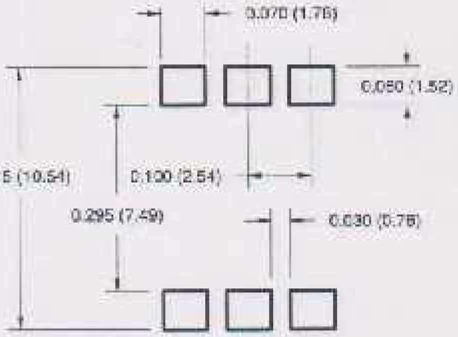
Package Dimensions (Surface Mount)



Package Dimensions (0.4" Lead Spacing)



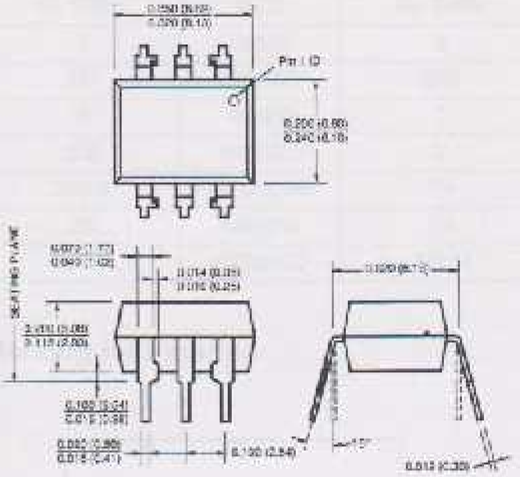
Recommended Pad Layout for Surface Mount Leadform



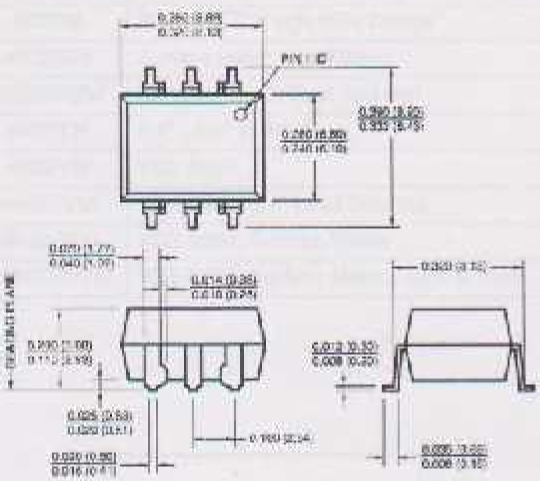
Note:
All dimensions are in inches (millimeters).

White Package (-M Suffix)

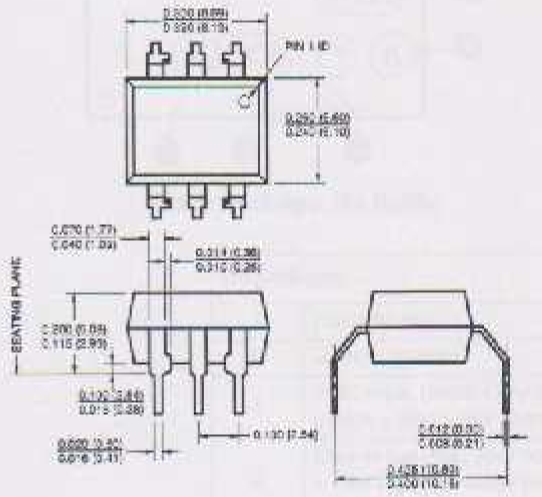
Package Dimensions (Through Hole)



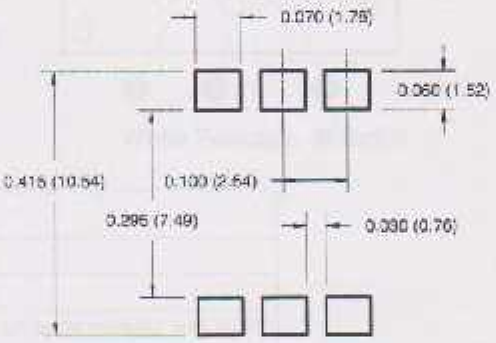
Package Dimensions (Surface Mount)



Package Dimensions (0.4" Lead Spacing)



Recommended Pad Layout for Surface Mount Leadform

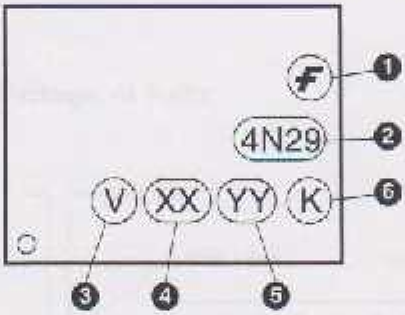


Note:
All dimensions are in inches (millimeters).

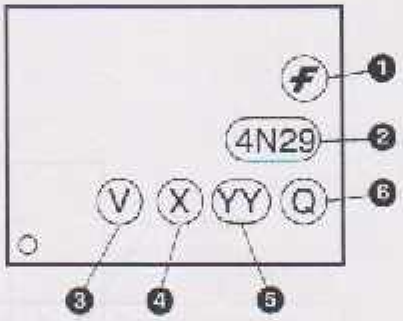
Ordering Information

Black Package (No Suffix)	Example	White Package (-M Suffix)	Example	Option
No Suffix	4N32	No Suffix	4N32M	Standard Through Hole Device
.S	4N32S	S	4N32SM	Surface Mount Lead Bend
.SD	4N32SD	SR2	4N32SR2M	Surface Mount; Tape and reel
.W	4N32W	T	4N32TM	0.4" Lead Spacing
.300	4N32300	V	4N32VM	VDE 0884
.300W	4N32300W	TV	4N32TVM	VDE 0884, 0.4" Lead Spacing
.3S	4N323S	SV	4N32SVM	VDE 0884, Surface Mount
.3SD	4N323SD	SR2V	4N32SR2VM	VDE 0884, Surface Mount, Tape & Reel

Marking Information



Black Package, No Suffix



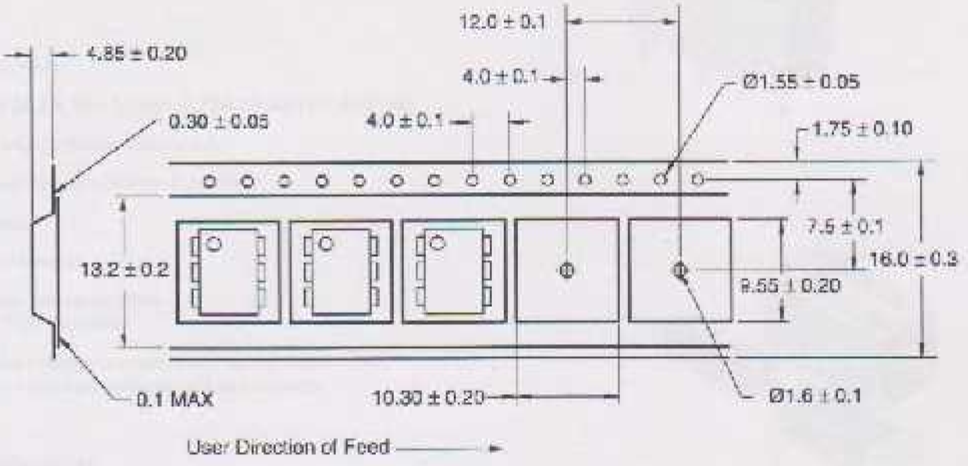
White Package, -M Suffix

Definitions	
1	Fairchild logo
2	Device number
3	VDE mark (Note: Only appears on parts ordered with VDE option – See order entry table)
4	One or two digit year code • Two digits for black package parts, e.g., '07' • One digit for white package parts, e.g., '7'
5	Two digit work week ranging from '01' to '53'
6	Assembly package code

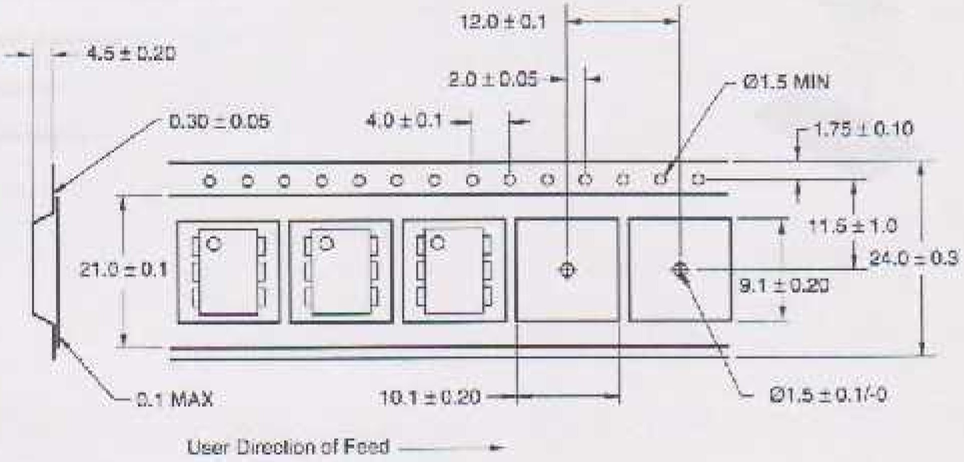
*Note – Parts built in the white package (-M suffix) that do not have the 'V' option (see definition 3 above) that are marked with date code '325' or earlier are marked in the portrait format.

Tape Dimensions

Black Package, No Suffix



White Package, -M Suffix



Note:
All dimensions are in millimeters.

2v Relay datasheet.

2 pole telecom relay, non-polarized,
Through Hole Type (THT)

Relay types: non-latching with 1 coil

Features

- Standard DIL relay
- Dimensions 20.2 x 10 x 11 mm, 0.795 x 0.393 x 0.433 inch
- Switching and continous current 3 A
- 2 changeover contacts (2 form C / DPDT)
- Single contacts
- Immersion cleanable
- Four different coil sensitivities (150, 200, 400, 550 mW)
- Surge voltage resistance meets FCC Part 68 requirement: 1.5 kV (10 / 160 µsec) between coil and contacts

Typical applications

- Communications equipment
- Office equipment
- Measurement and control equipment
- Entertainment electronics
- Medical Equipment
- Consumer electronics

UL 508 File No. E 111441

European Directive conformance:

D2n relay product conformance according to:
- Directive 2000/53/EC: ELV (End of Life of Vehicles)
- Directive 2002/95/EC: ROHS (Restrictions of the use of certain hazardous substances in electrical and electronic equipment)

Compliance is evidenced by written declaration from all raw material suppliers.
Tyco Electronics AXICOM only has responsibility for the proper processing of these materials.
Confirmation is valid for date codes ≥ 0418

Coil Data (values at 23°C) — Ordering Information

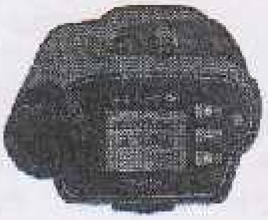
Nominal voltage Unom	Operate/set voltage range		Release/ reset voltage Minimum	Coil power	Coil Resistance	Relay code	Tyco part number
	Minimum voltage U_{min}	Maximum voltage U_{max}					
Vdc	Vdc	Vdc	Vdc	mW	Ω / ± 10 %		
150 mW nominal power consumption							
5	4.0	13.5	0.25	150	188	V23105A5001A201	8-1393792-6
5	4.8	16.2	0.30	150	240	V23105A5002A201	8-1393792-7

Appendix B
Range Meter

2 Introduction

2.1 LaserAce® 300

The personal laser surveying system.



LaserAce 300 with built-in inclinometer

LaserAce 300 with built-in inclinometer and optional compass

LaserAce 300 with built-in inclinometer with the optional horizontal angle encoder and monopod

Now is the time to throw away all your preconceptions of surveying equipment. MDL's revolutionary new LaserAce® 300 is a hand-held laser range finder providing you with a unique personal surveying capability. MDL's innovative personal survey system can be used as a hand-held or pole-mounted system. It enables the professional surveyor, engineer or layman to measure range, height, slope, missing distances and perimeter calculations with 'point and shoot' simplicity.

The LaserAce® 300 incorporates a pulsed laser distance meter and an inclinometer. A Horizontal Encoder and a Digital Fluxgate Compass are each available as options. A visible red dot scope allows the operator to aim and measure range, bearing and vertical angles to passive targets up to 300 meters away with decimetre accuracy. Using retro-reflectors the operator can measure to targets up to 5 kilometres away.

The palm-sized LaserAce® 300 is Class 1 eye safe and weighs only 600g. Measurements and calculations are displayed on a custom back-lit LCD panel. The RS232 data port can be configured to interface the LaserAce® 300 to a range of global positioning systems (GPS), data loggers, palm and pen computers.

In addition to the surveying and measurement functions, the LaserAce® 300 has built-in test and calibration routines, including compass calibration as standard. As well as impressive functionality, the LaserAce® 300 is extremely economical on power and will operate continuously for approximately 5 hours on just 2 AA cells.

2.2 Key Features

The LaserAce® 300 incorporates the following features:

- Eye safe semiconductor 'pulse' laser.
- Polycarbonate construction (600g)
- Range up to 300m reflectorless, up to 5,000m with retroreflectors.
- Accuracy 10cm, resolution 1cm.
- Simple red-dot aiming sight.
- Built-in inclinometer for height measurement of objects and for horizontal path length calculation.
- Optional 'plug in' digital fluxgate compass or horizontal angle encoder.
- Display of the measured data on the backlit LCD panel.
- Built-in buzzer.
- Long operation time from built-in standard "AA" size batteries.
- RS232 data interface.

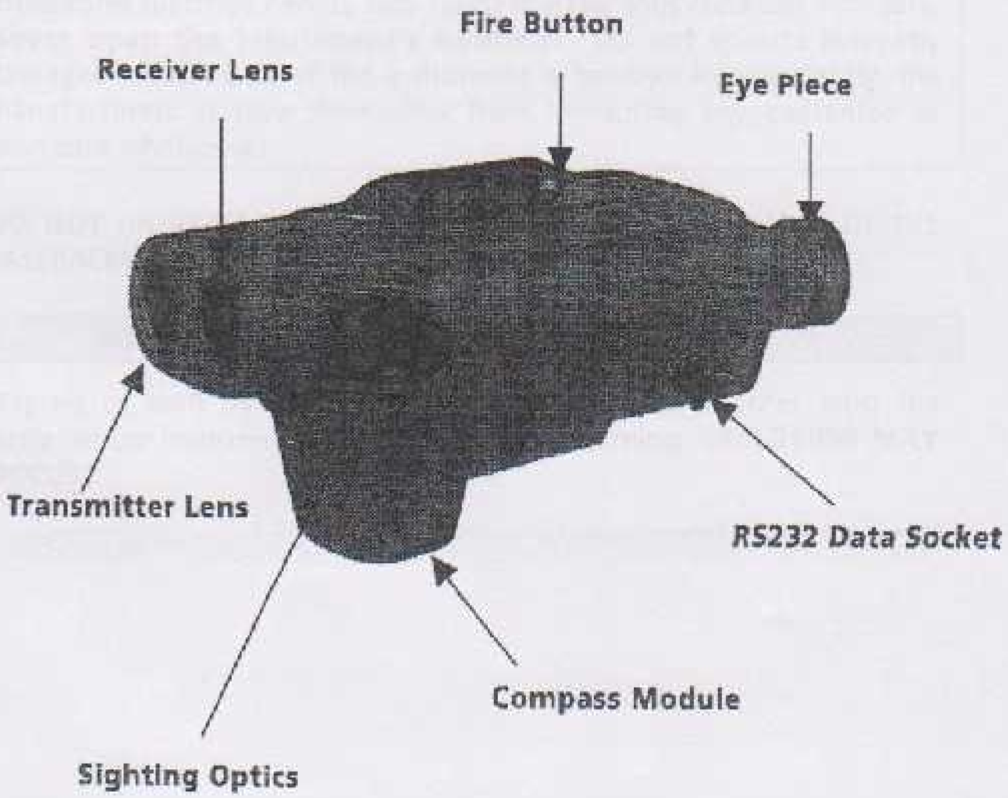


Figure 1 – LaserAce® 300 Features with optional Compass

3 Safety Information

3.1 Laser Safety (EN 60825-1)

The Laser Instrument LaserAce® 300 is classified as a class 1 eye safe laser product in compliance with the European eye safety regulation CENELEC EN60825-1 (1997) and American eye safety regulation FDA Class 1.

CLASS 1
LASER PRODUCT

Nevertheless, we recommend that the instrument is **not directly** pointed at people's eyes, (especially if they are using binoculars). Aligning the LaserAce® 300 with the lenses of CCD-cameras or infrared night vision devices can result in damage to them and is therefore not permitted.

CAUTION! Use of controls or adjustments, or performance of procedures specified herein, may result in hazardous radiation exposure. **Never open the instrument's housing! Do not** operate evidently damaged instruments! If the instrument is handled incompetently, the manufacturers absolve themselves from honouring any guarantee or insurance whatsoever.

DO NOT UNNECESSARILY LOOK INTO THE TRANSMITTER LENS OF THE LASERACE® 300!

3.2 Batteries

Dispose of used batteries sensibly. Under no circumstances must the batteries (or instrument) be disposed of by burning. **EXPLOSION MAY OCCUR!**

3.3 Electromagnetic Compatibility and Emissions

LaserAce® 300 meets or exceeds the requirements of the following European Standards:

EN 50081-1 (*Aug 1993*) **EN 50081-2** (*Aug 1993*) European Community Requirements:

Electromagnetic Compatibility
Generic Emission Standard
Part 1: Residential, Commercial and Light Industry
Part 2: Industrial Environment

The tests are carried out in compliance with:

EN 55011 (*March 1991*) Limits and Methods of Measurement of Radio Disturbance Characteristics of Industrial, Scientific and Medical (*ISM*) Radio frequency Equipment.

EN 55022 (M*arch 1988*) Limits and Methods of Measurement of Radio Interference Characteristics of Information Technology Equipment
LaserAce® is therefore CE approved.

4 Handling and Storage

4.1 Handling

Avoid mechanical shock. Operate within the environmental temperature limits of –10°C to 45°C (storage –25°C to 70°C).

Avoid directing the LaserAce® toward the Sun or other high power, infrared light source.

Do not use paint solvents to clean the instrument. Use mild detergent applied using a cloth.

4.2 Storage

If the instrument remains unused for several weeks, at least one of the batteries should be removed.

If the instrument remains unused for an even longer period of time, it is advisable to remove both the batteries in order to prevent damage to the battery compartment which could occur as a result of leaking batteries.

5 Preparation for use

5.1 Power Supply

The instrument can only be operated from the internal power supply. The batteries that operate the instrument are 2 x AA alkaline battery cells *(do not use cheaper zinc carbon batteries as they do not give enough amperage to fire the laser).*

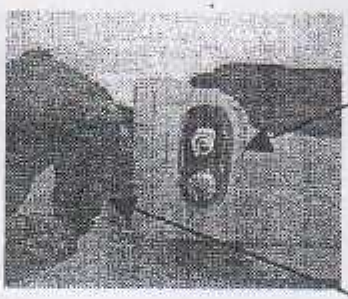


Figure 3 – The Battery Compartment

Insert the batteries as follows:

- Insert a small coin into the groove on the battery cover and give a quarter turn anti-clockwise to release the battery compartment cover. Remove the cover of the battery compartment.

- When inserting the batteries, care should be taken to ensure that the polarity of the batteries is observed. This is clearly marked on the inside of the battery compartment. The battery nearest the **TOP** of the compartment should have the positive terminal (+) visible and the battery nearest the **BOTTOM** of the compartment should have the negative terminal (–) visible.

- The battery compartment has a reverse battery protection device that means incorrect insertion of the batteries cannot result in faulty operation of/or damage to the instrument.

- Replace the battery compartment cover.

5.2 Data Cable

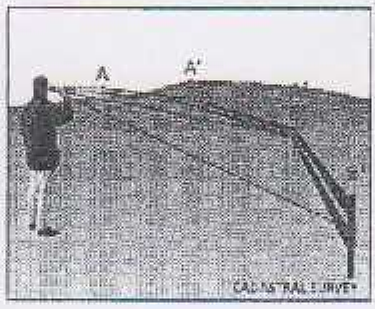
The LaserAce® 300 is normally supplied with 1/2m data cable. The cable pushes into the RS232 Data Socket on the LaserAce® 300 and is placed into an RS232 (serial) socket on your data logger.

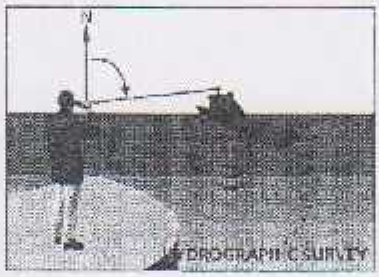
6 Operation

6.1 Overview of Applications

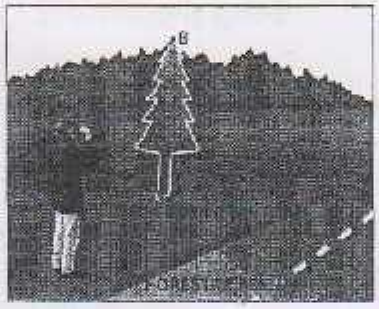
The operator can quickly measure the relative location of any object or point for:

- Agriculture Management
- Asset Mapping
- Building Surveys
- Cable Height Measurement
- Cadastral Surveys
- Forestry Management
- GIS Data Acquisition
- GIS surveys
- GPS offsets
- Gradient Measurements
- Ground Modelling
- Hydrographic Surveys
- In-vehicle Surveying
- Land Reclamation
- Measurement of Pylons
- Quarry Face Surveying
- Remote reconnaissance
- Rock Face Profiling
- Stockpile Surveys
- Stockpile Volume measurements
- Tree height measurement
- Tree width measurements





Some of these measurements will require optional equipment as detailed later in this manual.



List of Symbols

$h = 6.63 \times 10^{-34}$ J.s: Planck's constant.
v : Frequency of radiation.
m : reset mass.
E : Total energy.
$mv^2/2$: Kinetic energy.
mc^2 : reset mass energy.
n : Photon number.
E_e : Irradiance (power/ area).
F :Force
μ :Mass per length
m :Mass
v :Wave speed
R :Radius
B: magnetic flux
d : Distance between source and mirror
t : Time of travel
n_1 : Medium index
λ_1 : Light wavelength in of incident ray
λ_2 : Light wavelength of refracted ray
i : Incidence angle
r : Refracted angle
v_1 : Incident ray speed
v_2 : refracted ray speed
F : Focal length
O : Observer
I : Image
N_e : Synchronous speed in rpm.
f : Frequency of applied power in Hz.
P : Total number of poles per phase, multiple of 2
ΔN : Speed rate.
N_s : Synchronous speed.
N : Rotor speed.
f : Stator power line frequency.
s : Slip.
P : Mechanical power developed by the motor
E_0 : induced voltage in the armature (cemf).
I : Total current supplied to the armature
T : Torque
Z : Number of conductors on the armature
ϕ : Effective flux per pole
I : Armature current