Design and Modeling of a Collision Prevention System for Four Wheelers Project Report 2002-2003

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BONAFIDE CERTIFICATE

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This report is submitted in partial fulfillment of the requirements for the award of the **DEGREE OF BACHELOR OF ENGINEERING IN MECHATRONICS ENGINEERING** of the Bharathiar University.

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ACKNOWLEDGEMENT

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SYNOPSIS

SYNOPSIS

Most of the accidents on today's roads are due to over-speeding and driver negligence, due to which head on collisions take place. Such an alarming rate of loss of human life and property is a cause of concern for all humanity. In lieu of such a situation, we have come up with a novel idea of preventing such accidents using sensor technology.

The principle behind obstacle sensing is that of the sonar, where ultrasonic waves transmitted, rebound after hitting solid objects and the time taken to receive this echo is directly proportional to the distance of the object. Thus the ultrasonic transmitter and receiver are placed in the front of the vehicle for the purpose of sensing. By considering the maximum braking force that can be applied, we can arrive at a distance corresponding to each relative velocity between the source and target, after which the two entities are sure to collide. Thus provisions can be made in the software to automatically apply brakes to the source before such an event can occur.

The basic aim of our project is to design and model such a collision prevention system, and simulate its performance under specified conditions. We have used a toy model car, to which sensors were fitted and its obstacle testing capability was tested. The tests were carried out for varying distances of the obstacle from the car and it was found that the performance of the system was very good.

INTRODUCTION TO OBSTACLE SENSING

1. INTRODUCTION TO OBSTACLE SENSING

Obstacle sensing is basically done using proximity or range sensors, whose choice depends on two main factors viz. nature of the measurement and performance characteristics. The nature of operation means the actual field parameters in which the sensor is to be operated i.e. temperature, humidity, measurement distance etc, which critically affect the sensors performance. Performance characteristics are the accuracy, resolution, repeatability, sensitivity, switching frequency etc., there are currently many principles being used for proximity and range measurement. The various proximity sensors currently available are: inductive sensors, capacitive sensors, Hall-effect sensors and contact sensors. Proximity sensors have a small measurement range and can be used only for switching or other decision based operations. Thus they need to have good accuracy, repeatability, and a small response time. But it is not necessary to have a long range and good resolution. These sensors do not suit our application because of their poor range and resolution.

Range sensors on the other hand are used to measure longer distances and so satisfy all the necessary requirements demanded by our problem of obstacle sensing. The popular ranging methods use ultrasonic sensors, infra-red sensors, laser measurement, image processing and thermal imaging. We have chosen ultrasonic sensors as the most feasible type for the required application because of the following reasons:

1. It can measure distances ranging from few millimeters to kilometers.
2. It is not very severely affected by temperature and humidity variations.
3. It can bounce off from any solid object irrespective of its nature.

4. It is a cheaper means of ranging compared to other sensors.

1.1 Principle Behind Ultrasonic Ranging

The principle behind ultrasonic ranging is that of the sonar, which is used for range sensing in submarines. Sound waves at frequencies greater than 20000 Hz (i.e. ultrasonic frequency) are transmitted through an ultrasonic transmitter, and when these sound waves traveling through a medium, hit against an object, they are reflected back as echo to the source itself, and this echo can be detected using an ultrasonic receiver. This principle is shown in figure 1.1. The distance between the source and the target can be calculated using the following formula:

$$S = v * t / 2 \qquad \text{------}(1)$$

Where,

'S' is the distance between the source and target.

'v' is the speed of sound in the given medium.

't' is the time interval between transmission of the waves and reception of the echo.

It is to be noted that speed of sound varies with medium as well as temperature. The relationship between temperature and speed of sound is given by the formula:

$$v = 331.5 + 0.6 * T \qquad \text{------}(2)$$

Where,

'v' is the speed of sound in the given medium in M/sec.

'T' is the ambient temperature in °C.

The various values of speed of sound for various temperatures are given in table 1.1:

TABLE1.1 Variation of speed of sound wrt temperature

Temperature (°C)	Speed of sound (M/sec)
-10	325.5
0	331.5
10	337.5
20	343.5
30	349.5
40	355.5
50	361.5

Because our project involves the design and modeling of the system whose operation is to take place under controlled conditions, we are not concerned with the effect of temperature on the speed of sound.

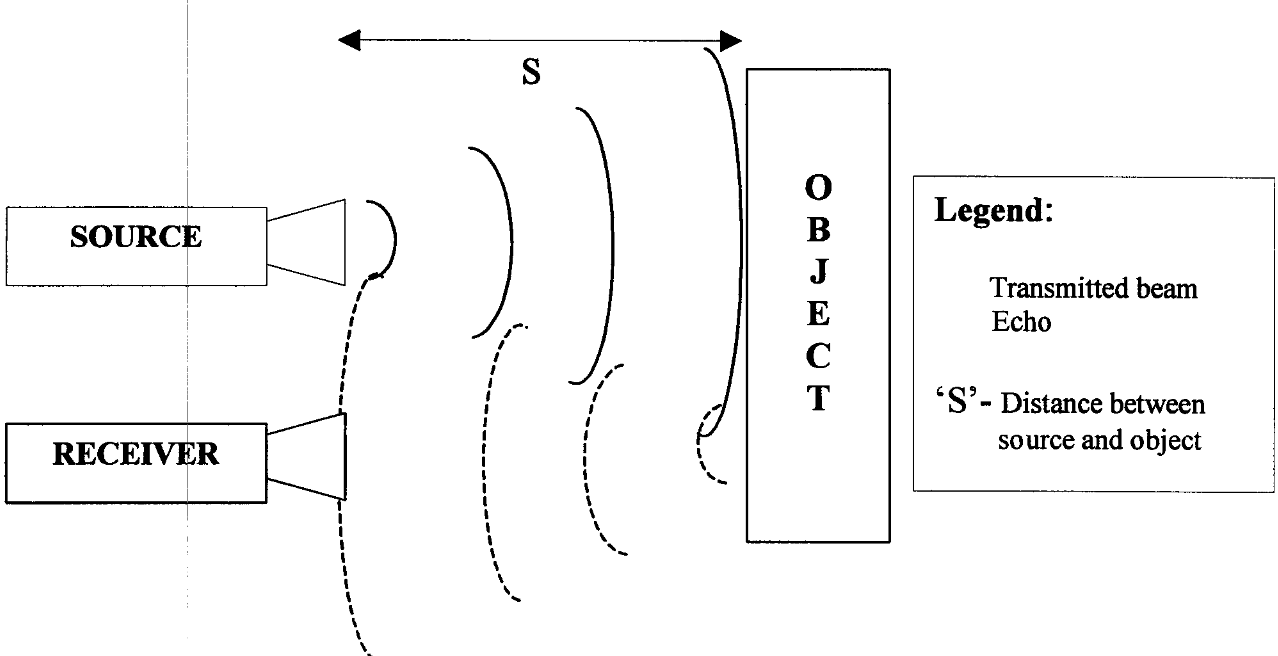


Fig 1.1 Transmission and reception of signals

1.2 The Ultrasonic Transmitter and Receiver

We used the TCT40-2F transmitter and the TCT40-2S receiver manufactured by Sunny Electronics Co. ltd, China. The construction of the transmitter is as shown in the figure 1.2

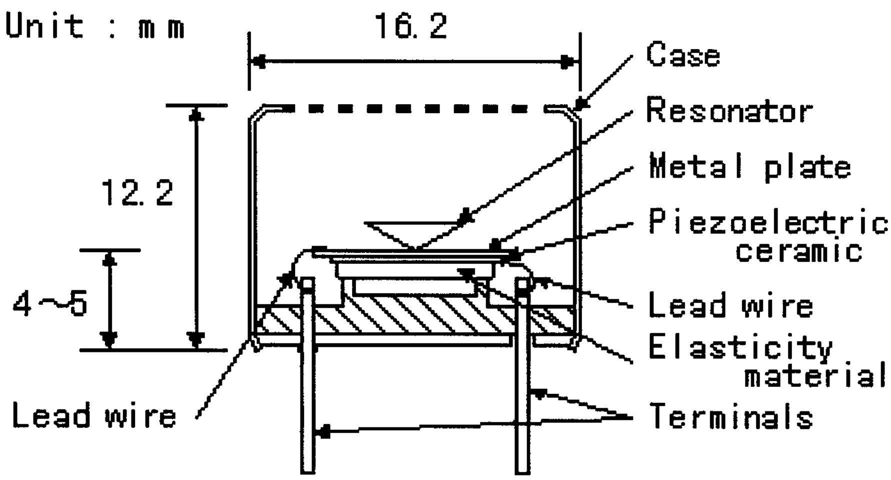


Fig 1.2 Construction of the Sensor

The specification of the ultrasonic sensor is shown in table 1.2.

Table1.2 Specification of the ultrasonic sensor

PARAMETER		VALUE
Resonant frequency (KHz)		40
Sound pressure level (dB)		115 <
Sensitivity (dB)		-64 <
Size (mm)	Diameter	16.2
	Height	12.2
	Terminal interval	10.0

1.3 Choosing Ultrasonic Sensors

This section addresses the radiation patterns and echo variation from targets other than flat surfaces, and the way these parameters can be used to help optimize the selection and operation of ultrasonic sensors for different applications.

1.3.1 Radiation Pattern

Transducer Beam Patterns, The acoustic radiation pattern, or beam pattern, is the relative sensitivity of a transducer as a function of spatial angle. This pattern is determined by factors such as the frequency of operation and the size, shape, and acoustic phase characteristics of the vibrating surface. The beam patterns of transducers are reciprocal, which means that the beam will be the same whether the transducer is used as a transmitter or as a receiver. It is important to note that the system beam pattern of an ultrasonic sensor is not the same as the beam pattern of its transducer, as will be explained later.

Transducers can be designed to radiate sound in many different types of pattern, from omni-directional to very narrow beams. For a transducer with a circular radiating surface vibrating in phase, as is most commonly used in ultrasonic sensor applications, the narrowness of the beam pattern is a function of the ratio of the diameter of the radiating surface to the wavelength of sound at the operating frequency, D/λ. The larger the diameter of the transducer as compared to a wavelength of sound, the narrower the sound beam. For example, if the diameter is twice the wavelength, the total beam angle will be 30°, but if the diameter or frequency is increased so that the ratio becomes 10, the total beam angle will be reduced to 6°. For most ultrasonic sensor applications, it is desirable to have a relatively narrow beam pattern to avoid unwanted reflections. The diameter of the transducers is therefore usually large compared to a wavelength. Figure 1.3 is a 3D representation of the beam pattern produced by a transducer with a diameter that is large compared to a wavelength. As can be seen, the beam is narrow and conical and has a number of secondary lobes separated by nulls. Each of these secondary lobes is sequentially lower in amplitude than the previous one. (Even though the beam is called conical, it does not have straight sides and a flat top as the word might imply.) The beam angle is usually defined as the measurement of the total angle where the sound pressure level of the main beam has been reduced by 3 dB on both sides of the on-axis peak. However, the transducer still has sensitivity at greater angles, both in the main beam and in the secondary lobes. Figure 1.4 shows a family of curves reproduced from Acoustic Design Charts for transducers with circular radiating pistons mounted in an infinite baffle. The curves show the degrees off axis for the beam angle to be reduced from the on-axis amplitude by 3dB, 6dB, 10dB and 20dB, as a function of d/λ .When describing transducer beam patterns, 2D plots are most commonly used. These show the relative sensitivity of the transducer vs. angle θ in a single plane cut through the 3D beam pattern. For a symmetrical conical pattern such as that shown in Figure 1.3, a simple 2D

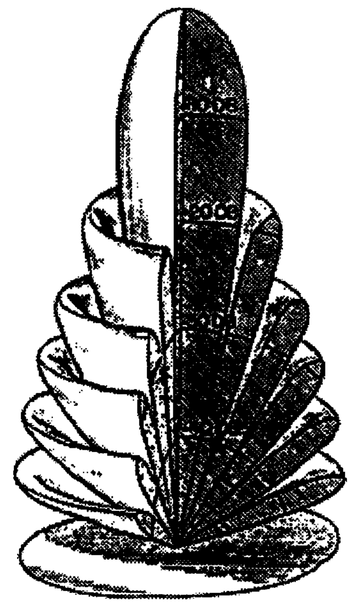


Fig 1.3 Radiation pattern of sensors

plot will describe the entire 3D pattern. Figure 1.5 shows a 2D polar plot from 90° to +90° of the beam of a circular radiating piston mounted in an infinite baffle with a diameter equal to two wavelengths of sound. As can be seen, the dB pattern is smooth as a function of angle, and the 3 dB points are at +15° and 15° off axis, producing a total beam angle of 30°. However, the total angle of the major radiating lobe between the first two nulls is ~70°, and the side lobes peak at approximately +55° and 55°. When using an ultrasonic sensor, it is important to be aware that nearby unwanted targets that are beyond the beam angle can inadvertently be detected because the transducers are still sensitive at angles greater than the beam angle. Some transducers used in sensing applications are specially designed to minimize or eliminate the secondary lobes to avoid detecting unwanted targets. In an echo ranging system, the transmitting transducer sends out sound at reduced amplitudes at different angles, as described by the beam pattern of the transmitting transducer. The receiving transducer has less sensitivity to echoes received at angles off axis, as described by the beam pattern of the receiving transducer. The

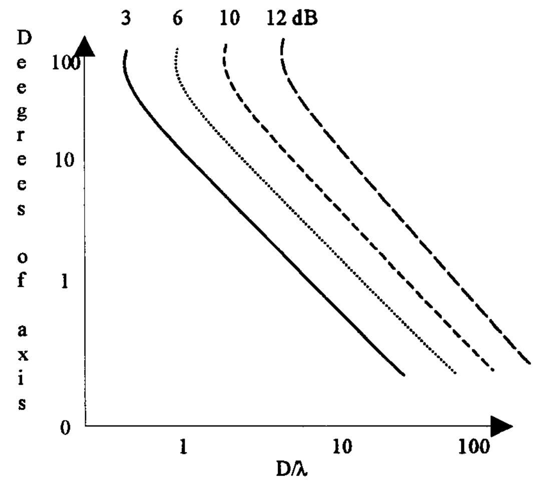


Fig 1.4 Degrees of axis of beam angle Vs d/λ

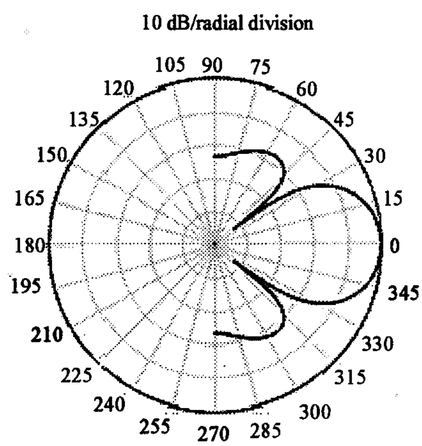


Fig 1.5 Polar plot of beam

system beam pattern is the sum in decibels of the transmitter's and the receiver's beam patterns.

The solid curve of Figure 1.6 is a plot of the beam pattern of Figure 1.5 on rectilinear coordinates for angles from 0° to 30° off axis. This beam pattern is the same for the transducer whether it is transmitting or receiving. The dashed curve shows the system beam pattern for a sensor using this same transducer to both transmit and receive. As can be seen, the system beam pattern for the ultrasonic sensor is narrower than the pattern of the transducer alone.

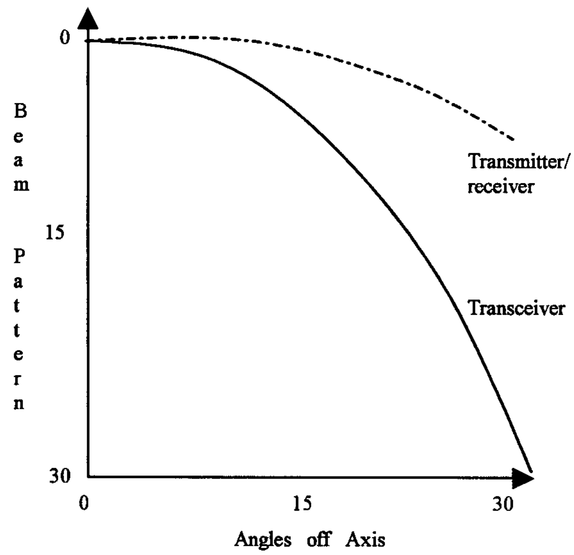


Fig 1.6 Plot of beam pattern for angles from 0 to 30^{0}

A target located on the acoustic axis (θ= 0°) will produce an echo that is not reduced in amplitude due to the transmitting beam pattern, and the voltage the echo will cause the receiving transducer to produce will not be diminished due to its beam pattern. If a target is 15° off axis, however, the sound pulse from the transmitter will be reduced by 3 dB due to the beam pattern, which will cause the magnitude of the resulting echo to be reduced by 3 dB. When the echo reaches the receiver, the resulting voltage produced will be reduced by another 3 dB from the voltage that the same magnitude of echo would have produced if it had been received on the acoustic axis of the transducer . Therefore, the 3 dB reduction in echo level plus the 3 dB reduction in receive sensitivity result in a total reduction of 6 dB in the voltage produced by a target 15° off axis as compared to the same target located directly on the acoustic axis. The magnitude of the voltage in the system produced by a target echo as a function of angle will therefore be reduced by twice the number of decibels as indicated by the beam pattern of the transducer alone, if the same transducer is used to both transmit and receive. Since this difference can obviously have a significant effect on ultrasonic sensor operation, system beam patterns, not transducer beam patterns, should be used when evaluating a sensor application.

1.3.2 Targets' Effect On Echoes

The relative echo levels from large flat surfaces where the reflector is larger than the entire incident sound beam is typical for an ultrasonic sensor used in applications such as liquid level control. For other types or sizes of targets, though, the echo levels are affected differently. Figure 1.7 illustrates the behavior of a small sphere as a target. As can be seen, the sphere intercepts only a portion of the sound beam and then reradiates the sound pulse. During this process, the pressure is reduced by spreading loss, 20 log (R/R_0), as it travels from the sensor to the target. When the sound reradiates from the target, the sound pressure is again reduced by spreading loss as it travels back toward the sensor.

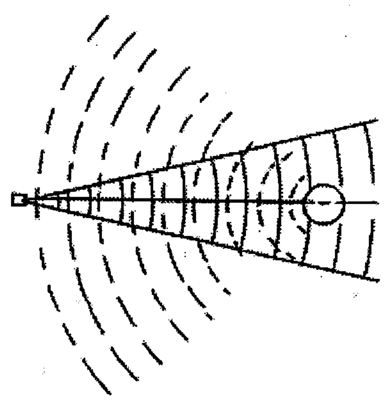


Fig 1.7 Behaviour of a small sphere as a target

In the case of a reradiating target, the total spreading loss will therefore be 40 log (R/R_0), which is the sum of the spreading loss for the sound traveling to the target plus the spreading loss of the reradiated sound returning to the sensor.

The measure of the reflectivity of a target is called Target Strength (TS). It is defined as 10 × the logarithm to the base 10 of the intensity of the sound returned by a target at a reference distance from its "acoustic center," divided by the incident intensity of the transmitted sound pulse. The TSs of simple geometric shapes can be theoretically computed; Table 1.3 contains the expressions of TS for a few types of target forms. When using this table, all dimensional units must be the same, including the reference range, R_0, the range distance to the target, R, and all dimensions of the targets.

Table 1.3 Theoretical Target Strengths for Simple forms

R_0= reference range; $k=2\pi/\lambda$; R= range to target

(All dimensions. Including R an R_0, must be in same units)

Form	t (TS=10logt)	Definitions	Direction of incidence	Conditions
Sphere	$a^2/4$	a=radius of sphere	Any	ka>1 R>a
Cylinder, Infinitely long	aR/2	a=radius of cylinder	Normal to cylinder axis	ka>1 R>a
Cylinder, Finite Length	$aL^2/2\lambda$	L=length a=radius	Normal to cylinder axis	ka>1 $R>L^2/\lambda$
Smooth Convex Object	$S/16\pi$	S=total surface area of object	Average over all directions	All dimensions >1
Ellipsoid	(bc/2a)2	a, b, c = semi-major axes of ellipsoid	Normal to major axis	ka,kb,kc>1 R>a,b,c

Such idealized computations of TS should be used only as approximations of real targets, since actual targets are usually not simple reflectors but rather are complex with multiple surfaces of reflection. The sound reflecting from each of these multiple surfaces will produce echoes of different amplitudes that will sum together when they return to the sensor. Since the sound pulse is reflected at different times by the various reflecting surfaces as it propagates across the target, the individual echoes will be different in both amplitude and phase. The total received echo will therefore be a complex summation of these multiple pressure waves of different amplitudes and phases. Any movement of the target, or any variation in the relative velocity of sound due to air turbulence along the various acoustic path lengths from the different reflecting surfaces of the target, will cause a dramatic change in the TS. The result can be large variations in the echo level produced by a target from one pulse to another during ultrasonic sensor operation. The extent of the variations in TS for a specific target in a given environment can be experimentally determined by measuring the changes in the magnitudes of echoes from the target for a series of pulses at all expected variations of target position and over all expected environmental conditions.

For reradiating targets, the echo level as a function of target range is:

$$\mathbf{EL_f (R) = SPL(R_0) * 40 \log (R/R_0) * 2\alpha_f R + TS} \qquad \text{------(3)}$$

Where,

$EL_f (R)$ = echo level at frequency f

R = range distance to target

$SPL(R_0)$ = sound pressure level of transmitter at reference distance R_0

α_f = attenuation coefficient of sound at frequency f

TS =target strength

Equation (3) can be used to compute the relative effect that varying the sound frequency will have on echoes produced from reradiating targets at different distances from the sensor. For example, it is assumed that the same sound pressure level is produced by the sensor at all frequencies, and that the same target is placed in line with the acoustic axis of the transducer. For illustration, the target is assumed to be a sphere with a

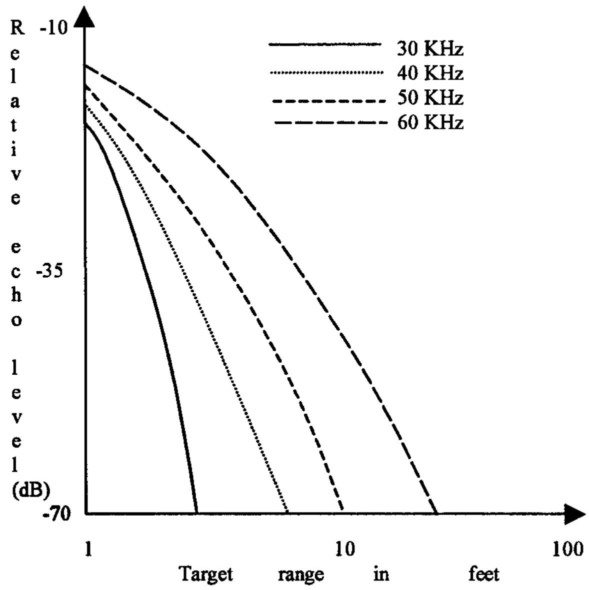


Fig 1.8 Echo from a flat plate Vs a Sphere

radius equal to 6 in. (1/2 ft). From Table 1.3, this will result in a TS equal to 12 dB. Figure 12 shows plots of the relative EL_f (R) from a reflecting sphere with a 6 in. radius at different distances from sensors operating at different frequencies. Figure 1.8 shows that there is a considerable reduction in level when an echo from a large flat reflector is compared to an echo from a 6-in.-radius sphere at the same range and frequency. This shows that the maximum range of a sensor can be greatly reduced by different targets.

1.3.3 Selecting And Using Ultrasonic Sensors

When selecting an ultrasonic sensor for a particular application, it is important to consider how the echo will be affected by the acoustical fundamentals. There is a wide variety of sensors available that operate at different frequencies and have different beam angles. In addition, systems can have different electronics options such as temperature sensing and signal averaging. The proper choice of sensor parameters will help optimize the system performance.

1.3.4 Frequency Variation In Sensors.

In general, the lower the frequency of the sensor, the longer the range of detection, while a higher frequency sensor will have greater measurement resolution and less susceptibility to background noise. The background noise produced under most conditions is lower in amplitude at higher frequencies, and will attenuate more at higher frequencies as it travels toward the sensor. Because most sensors produce relatively narrow beam angles, the physical size of the transducer in the sensors will typically become larger as the frequency decreases.

1.3.5 Absolute accuracy, relative accuracy, and resolution.

The concepts of absolute accuracy, relative accuracy, and resolution are different in ultrasonic sensors. Absolute accuracy is the uncertainty error in the exact distance measurement from the face of the ultrasonic sensor to the target. Relative accuracy is the uncertainty error in the change in distance measurement when the target moves relative to the sensor. Resolution is the minimum change in distance that can be measured by the sensor when the target moves relative to it. These measurements are affected by factors such as the wavelength of the sound, the Q of the transducer, the reflecting characteristics of the target, the operation of the target detection electronics in the sensor, and the uncertainty in the assumed value of the speed of sound. Uncertainty in accurately knowing the exact speed of sound over the entire transmission path is usually the major contribution to inaccuracy in the absolute measurement of the range to the target.. During operation, the ultrasonic sensor measures the time interval from when the sound pulse is transmitted to when the echo is received, Δt, and computes the target range. In the vicinity of room temperature, a 1°C change in temperature will produce an uncertainty in sound speed of 23 ips. This causes an uncertainty error in the accuracy of the absolute distance measurement for a 1°C temperature change of:

$$\mathbf{err_{Rin}(R) = 0.0017 * R} \qquad \text{------(4)}$$

$$\mathbf{err_{Rft}(R) = 0.0204 * R} \qquad \text{------(5)}$$

Where,

$err_{Rin}(R)$ = uncertainty error in target range in inches for a 1°C uncertainty in temperature when target range R is in inches

$err_{Rft}(R)$ = uncertainty error in target range in inches for 1°C uncertainty in temperature when target range R is in feet.

Figure 1.9 plots the uncertainty error in the absolute target range measurement in inches as a function of target range for a 1°C uncertainty in temperature, as computed by Equations (4) and (5). The solid curve shows the measurement error if the target range R is in feet; the dashed curve is for target range in inches.

Uncertainties in the average value of the speed of sound along the acoustic path can occur for a variety of reasons. A sensor with an internal temperature probe will obviously have less uncertainty in sound speed approximation than a sensor that does not measure the temperature. In some applications, however, the temperature in the transmission medium between sensor and target can be different from the temperature at the sensor, which therefore will cause an error even if a temperature probe is used. If there is air turbulence along the path from the sensor to the target, then the average speed of sound will randomly change, causing the target range computed by the sensor to randomly vary from pulse to pulse. Similar variations in the arrival time of a target echo will appear if the target surface is moving, such as when a liquid surface contains waves. For these applications, measurement accuracy will increase if the sensor is capable of averaging a number of measurements before providing a target range output. The uncertainty in sound speed over the acoustic path has much less effect on the sensor's relative accuracy when a change in target range is being measured. For this situation, equation (4) becomes:

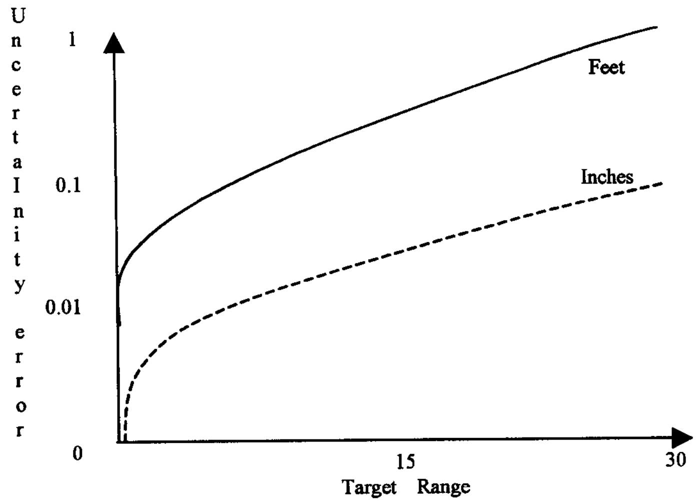


Fig 1.9 Uncertainty Range for target in Feet and Inches

$$\mathbf{err_{Rin}(\Delta R) = 0.0017 * \Delta R} \qquad \text{-------(8)}$$

Where,

$err_{Rin}(\Delta R)$ = uncertainty error in relative change in target range in inches for a 1°C uncertainty in temperature when target range changes by ΔR inches.

If the temperature is unknown by 5°C, and a target at a range of 100 in. moves 0.500 in. toward the sensor, the error in the absolute target range measurement of 100 in. will be 0.85%, or 0.85 in. However, the error in the relative distance measurement of 0.500 in. will be only 0.004 in.

The resolution of a range measurement made with an ultrasonic sensor is influenced by many factors. Since the sensor is measuring the arrival time of an acoustic pulse, the higher the ultrasonic frequency the greater the resolution because both the wavelength and period of the echo signal are smaller at higher frequencies. The accuracy of the time-measuring circuits in the sensor also affects the resolution, as will the averaging capabilities of a sensor if there is turbulence along the sound path. The best way to measure the true resolution of an ultrasonic sensor for a particular application is to place a target at a fixed distance and obtain a stable range measurement. Then slowly move the target forward or backward until the sensor indicates a measurable change in target range. Accurately measure the distance the target moved. This change in distance is the resolution of the sensor. Compare the actual distance the target moved to the change in range measured by the sensor. This is the error in the resolution of the device.

1.3.6 Target Range Measurement.

For each application, it is important to select a sensor that will detect the desired targets when they are located within a specified area in front of the sensor, but ignore all targets outside this area. As previously noted, a lower frequency sensor should be selected for longer ranges of detection and a higher frequency sensor should be used for shorter range, higher resolution measurements.

Table 1.4 Ranges for the relkative echo levels from flat and spherical targets to reach-60dB//1μPa for different frequencies

	Target Range for EL=60dB//1μPa		
Frequency (KHz)	**Target large flat reflector(ft.)**	**Target 6in. Radius Sphere(ft.)**	**Decrease in Target Range for Spherical target(ft.)**
200	5.2	3.5	1.7 (33%)
160	6.5	4.0	2.5 (38%)
100	10.5	5.6	4.9 (47%)
63	18.2	7.8	10.4 (57%)
40	30.2	10.0	20.0 (67%)

Sensor beam angles should be selected to cover the desired detection geometry, and to reject unwanted targets. The maximum range at which an ultrasonic sensor can detect a target is affected by attenuation of the sound and the target strength. These effects can be illustrated by using the data in and Figure 1.8, and setting a minimum echo detection threshold. Table 1.4 was prepared by arbitrarily choosing for illustration-60 dB//1μPa as the minimum echo level the sensor can detect. It shows that the range at which the echo level reaches 60 dB//1μPa will vary for sensors operating at different frequencies between 40 kHz and 200 kHz for both a large flat target and a 6-in.-radius sphere. These range values are therefore the maximum detection ranges for the sensors and targets used in this illustration. As can be seen from Table 1.4, the lower the frequency of sound, the longer is the detection range. The maximum detection range of a sensor is greatly reduced, however, when the target is spherical rather than a large flat reflector, and the percentage of range reduction is greater for lower frequencies. At 200 kHz, the maximum range between the targets is decreased by 33%, while at 40 kHz the range reduction is 67%. Humidity can also have a significant effect on the target range. The curve of Figure 1.8 use values of attenuation that are greater than the maximum attenuation that would be caused by humidity variations at each frequency.

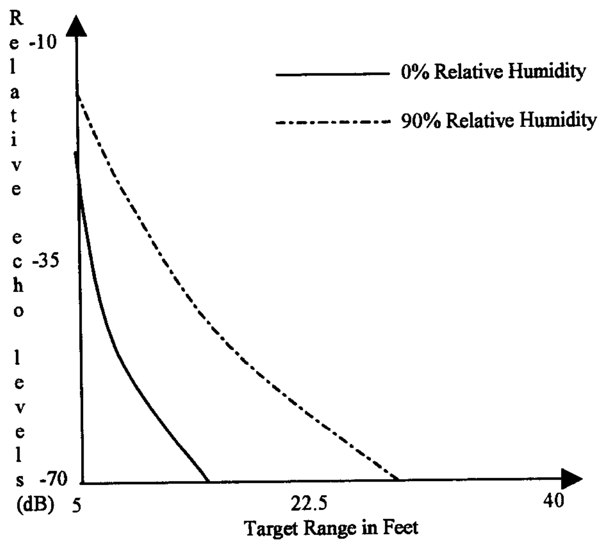


Fig 1.10 Relative echo levels from a flat target for sensor operating at 100KHz

There is a large variation in attenuation at any particular frequency as the humidity varies. For example, at 100 kHz the attenuation varies from 0.5 dB/ft at 0% RH to 1.3 dB/ft at 90% RH. This means that if a target is at a range of 10 ft from the sensor, the echo level will change a total of 16 dB if the humidity changes from 0% to 90%. Figure 1.10 shows plots of the relative echo levels from a large flat target that can be obtained with a sensor operating at 100 kHz for humidity values of 0% RH and 90% RH. As can be seen, the magnitude of the echoes at each range changes dramatically between the two humidity values, so the maximum detectable range of the sensor for a given target will also be greatly affected by humidity. It is therefore possible to successfully install a sensor for a particular application, and at a later date find that it is no longer detecting targets if the humidity changed enough to cause the target echoes to attenuate below the detection threshold of the sensor.

1.3.7 Effective Beam Angle

It is important to consider an ultrasonic sensor's effective beam angle, which is the angle around the acoustic axis where a target will be detected. If the target moves closer to the sensor, or if a target with greater TS is used, then the effective beam angle will increase. At only one range for a particular target will the effective beam angle be equal to the classical beam angle that is obtained from the polar radiation pattern. Therefore, the classical beam angle can be used only as a first order guide in determining whether targets will be detected or ignored by the sensor. At the maximum detection range, the amplitude of the target echo is just barely large enough to be detected by the sensor electronics when the target is directly in line with the transducer's acoustic axis. Reducing the echo level by rotating the target slightly off the beam's acoustic axis will lower the amplitude of the echo below the sensor's detection threshold. Under these operating conditions, the effective beam angle of the sensor will therefore be essentially 0°. As a target moves closer to the sensor, the echo level increases dramatically. For a sensor operating at 100 kHz and using a large flat plate as a target, the echo level can increase more than 60 dB as the target moves from a range of 10 ft to a range of 1/2 ft. This means that at a range of 1/2 ft, for any angle off the acoustic axis where the sensor beam pattern has not reduced more than 60 dB, the flat target will produce an echo larger than that from the target on axis at a range of 10 ft. For a sensor with a transducer radiation pattern as shown in Figures 1.5 and 1.6, a large flat target at a 1/2 ft range would be detected almost continuously as the sensor is rotated ±90°. Some sensors have variable gain amplifiers that lower the detection levels for close targets, and therefore reduce the tendency to widen the effective beam angle of the sensor.

INTRODUCTION TO ELECTRIC BRAKING & VOLTAGE CONTROL

2. ELECTRICAL VOLTAGE CONTROL AND BRAKING OF D.C MOTORS

2.1 Permanent Magnet Dc Motor

A Permanent Magnet DC motor is a motor whose poles are made of permanent magnets. It is essentially a shunt type DC motor with the field circuit replaced by permanent magnets. These motors are some times used instead of shunt dc motor for smaller loads since they are less complicated.

By definition, the flux of a Permanent Magnet DC motor is fixed, so it is varying the field current or flux cannot control speed. The only method of speed control available for Permanent Magnet DC motors are armature voltage variation and armature resistance control.

2.2 Braking

There are three types of electrical braking, all of which are applicable to the usual type of electric motor

1. Regenerative Braking
2. Rheostatic or Dynamic Braking
3. Plugging or Reverse Current Braking

2.2.1 Regenerative Braking

Regenerative braking implies operating the motor as a generator, while it is still connected to the supply. Mechanical energy is converted into electrical energy, part of which is returned to the supply, as shown in fig 2.1. Rest of the energy is lost as heat in the winding and bearing of the electrical machine. Regeneration does not, in most cases, involve any switching operation, unless it is required to change the speed at which it becomes effectively. Most electrical machines pass smoothly from motoring to generating regime, when over driven by the load.

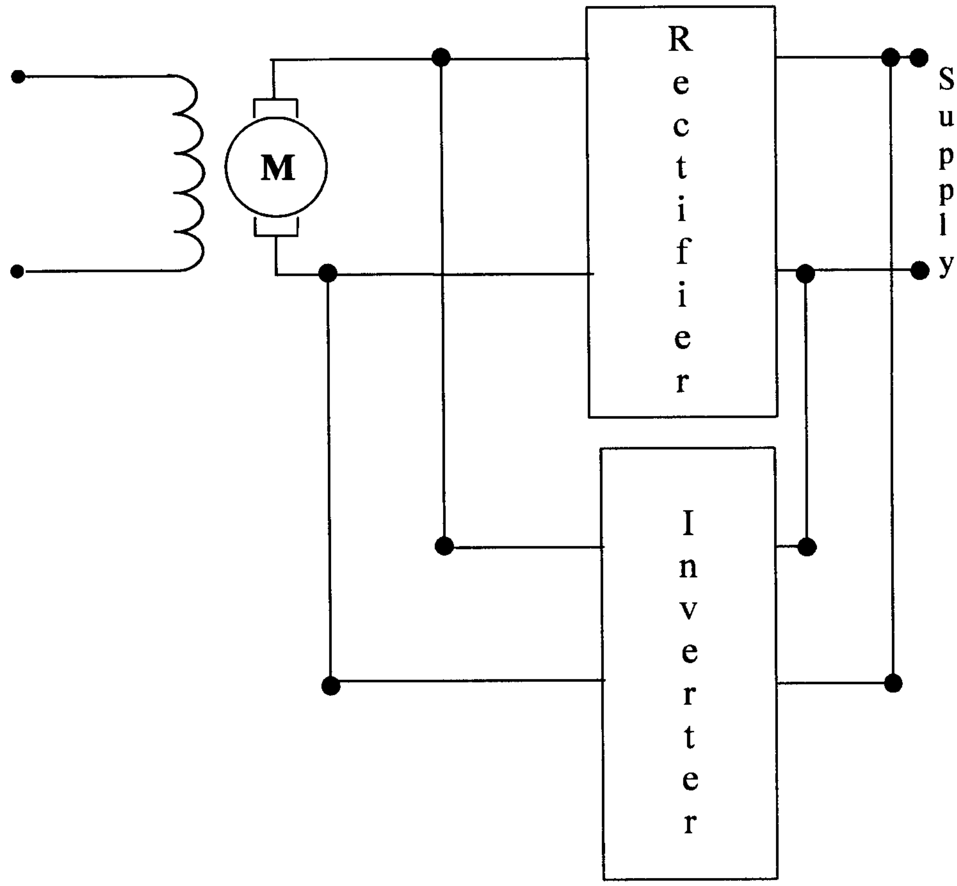


Fig 2.1 **Scheme for regeneration**

2.2.2 Rheostatic Braking

Rheostatic braking implies operating the motor as a generator so that the mechanical energy is converted into electrical energy, which is dissipated as heat in the resistance of the machine winding or in resistors connected to them as an electrical load, as shown in fig 2.2. The only problem is to dissipate the heat generated effectively and at a very fast rate.

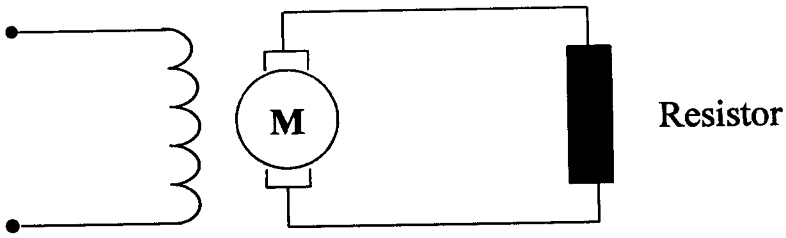


Fig 2.2 Scheme for dynamic braking

2.2.3 Plugging

Plugging involves reconnecting the power supply to the motor so that it tends to drive in the opposite direction. It is obvious that, left to itself, the system will come to rest and then accelerates in the reverse direction. In case it is required to bring the drive system to rest, it is necessary to include a relay to disconnect the supply exactly at the instant when the motor stops. This is the most inefficient technique of electric braking since, in addition to dissipating the electrical energy converted from mechanical energy, in the resistance of the circuit, the electrical energy drawn from the supply is wasted. But it is the fastest method of braking the motor.

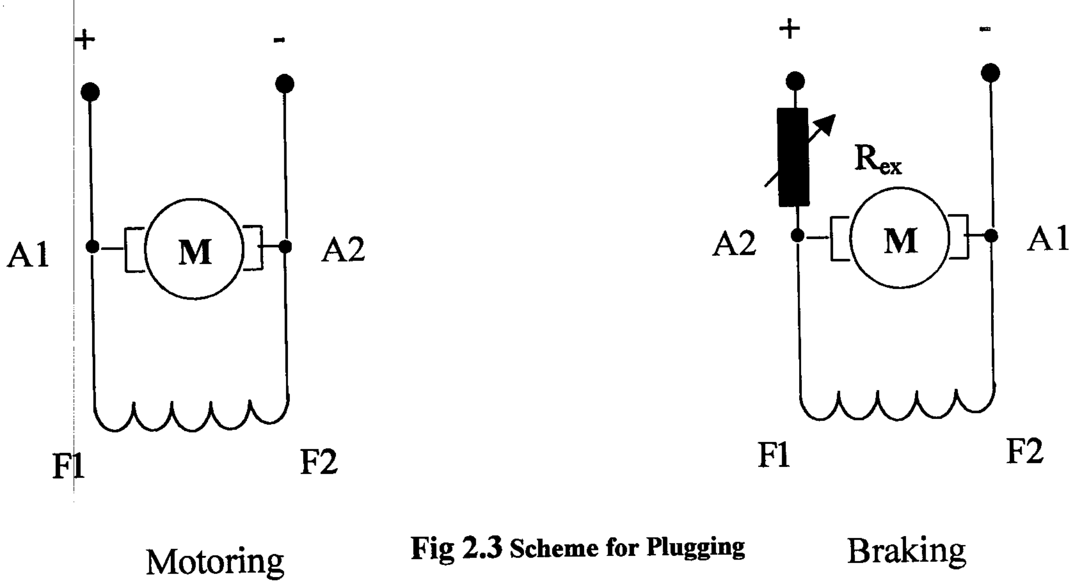


Fig 2.3 Scheme for Plugging

2.3 Speed Control Of D.C Motors Using Armature Voltage Control

The speed control of D.C motors can be done in many methods of which Armature voltage control is the most popular. A simple chopper circuit can be used to vary the input voltage to the motor. The chopper is essentially a switch which connects or disconnects the motor to the supply. This is illustrated in figure 2.4. The output average voltage depends on the duration for which the switch is closed and opened. This is shown in figure 2.5.

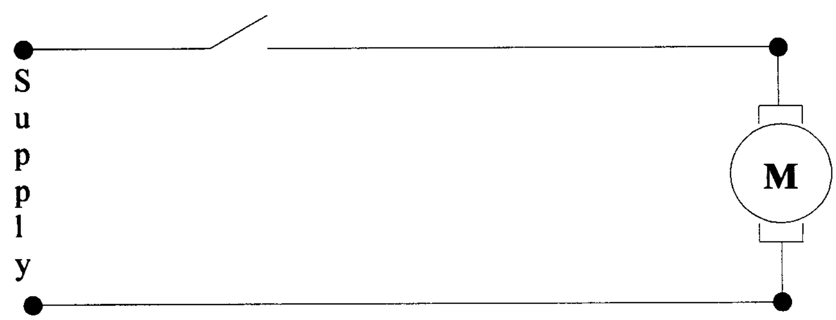


Fig 2.4 Scheme for voltage control using chopper

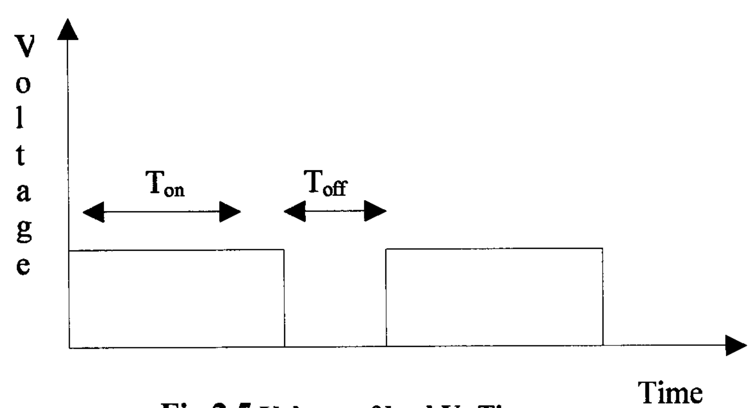


Fig 2.5 Voltage of load Vs Time

$$\delta = T_{on} / (T_{on} + T_{off}) \quad \text{———(9)}$$

$$V_{out} = V_{in} * \delta \quad \text{———(10)}$$

Where,

δ = duty cycle of operation of the switch.

V_{out} = voltage supplied to the motor.

V_{in} = Supply Voltage

So by varying T_{on} or T_{off}, we can decrease the effective voltage supplied to the D.C motor. The elements commonly used as choppers are Transistors, MOSFETs, and SCRs etc.

INTRODUCTION TO LABVIEW

3. INTRODUCTION TO LabVIEW

3.1 What is LabVIEW?

LabVIEW is a graphical programming language that uses icons instead of lines of text to create applications. In contrast to text-based programming languages, where instructions determine program execution, LabVIEW uses dataflow programming, where data determine execution.

In LabVIEW, a user friendly interface is built by using a set of tools and objects. The user interface is known as the front panel. Code is then added using graphical representations of functions to control the front panel objects. The block diagram contains this code. If organized probably, the block diagram represents a flowchart. Several add-on software toolsets can be purchased for developing specialized applications. All the toolsets are integrated seamlessly in LabVIEW.

LabVIEW is fully integrated for communication with hardware such as GPIB, VXI, PXI, RS-232, RS-485, and plug-in data acquisition devices. It also has built in features to connecting applications to the internet, using the LabVIEW web server and software standards such as TCP/IP networking and ActiveX.

Using LabVIEW, 32-bit compiled applications with fast execution speeds needed for custom data acquisition, test, measurement, and control solutions can be created. Stand-alone executables and shared libraries, like DLLs can also be created. LabVIEW contains comprehensive libraries for data collection, analysis, presentation and storage. LabVIEW also includes traditional program development tools. We can set breakpoints, animate program execution, and single step through the program to make debugging and development easier. LabVIEW also provides numerous mechanisms for connecting to external code or software through DLLs, shared libraries. ActiveX, and more. In addition, numerous add-on tools are available for a variety of application needs.

3.2 How LabVIEW works

LabVIEW programs are called virtual instruments, or VIs, because their appearance and operation imitate physical measurements, such as oscilloscopes and multi-meters. Every VI uses functions that manipulate input from the user interface or other sources and display that information or move it to other files or other computers.

A VI contains the following three components:

1. **Front panel** - It serves as a user interface.
2. **Block diagram-** Contains the graphical source code of the VI that defines its functionality.
3. **Icons and connector pane-** Identifies the VI so that it can be used in another VI. A VI within another VI is called a sub VI. A sub VI corresponds to a subroutine in text based programming languages.

3.2.1 Front Panel

The front panel is the user interface for the VI. It can be built up with controls and indicators. Controls are knobs, push buttons, dials and other input devices. Indicators are graphs, LEDs, and other displays. Controls simulate instrument input devices and supply data to the block diagram of the VI. Indicators simulate instrument output devices and display data the block diagram acquires or generates.

3.2.2 Block Diagram

Code is added using graphical representations of functions to control the front panel objects. The block diagram contains this graphical source code. Front panel objects appear as terminals on the block diagram. Every control or indicator on the front panel has a corresponding terminal on the block diagram. Additionally, it contains functions and structures from built in LabVIEW VI libraries. Wires connect each of the nodes on the block diagram, including control and indicator terminals, functions and structures.

3.2.3 Palettes

LabVIEW palettes give the options needed to create and edit the front panel and the block diagram. The different palettes available are:

1. **Tools palette-** It is used to operate and modify front panel and block diagram objects.
2. **Controls palette-** It is available only in the front panel and is used to create the user interface.
3. **Functions palette-** It is available only in the block diagram. It contains the objects used to program the VI, such as arithmetic, instrument I/O, file I/O, and data acquisition operations.

VEHICLE ELECTRONICS

4. VEHICLE ELECTRONICS

The different electronic systems used in our model are elucidated in the following sections. These include the ultrasonic transmitter and the receiver, the power supply and level conversion circuits and finally the braking circuit. The complete circuit diagram is given in figures 4.1, 4.2, 4.3 and 4.4.

4.1 Ultrasonic Transmitter

We have used two 555 timer ICs for the transmitter circuit of the ultrasonic. The operation and function of the two timers are as follows:

4.1.1 The Pulse Oscillator

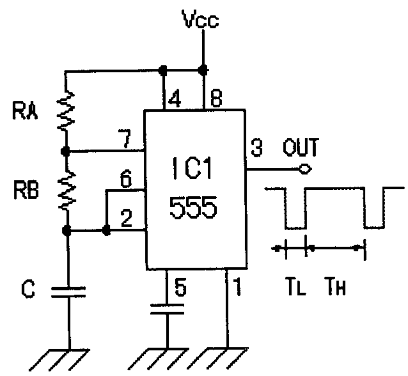


Fig 4.1 Pulse Oscillator

IC1 is the oscillation circuit to control the time of transmitting the ultrasonic pulse. The time of the oscillation pulse can be calculated by the following formula. Actually, with the error of the parts, it is different from the calculation a little. The values chosen for the various components are: RA = 9.1MΩ, RB = 150KΩ, C = 0.01μF.

Time Period Calculation:

$$\mathbf{T_{LOW} = 0.69 \times RB \times C}$$

$$= 0.69 \times 150 \times 10^{3} \times 0.01 \times 10^{-6}$$

$$= 1 \times 10^{-3}$$

$= \mathbf{1\ msec}$

$T_{HIGH} = \mathbf{0.69 \times (RA + RB) \times C}$

$= 0.69 \times 9250 \times 10^{3} \times 0.01 \times 10^{-6}$

$= 64 \times 10^{-3}$

$= \mathbf{64\ msec}$

Therefore, the ultrasonic pulse is sent out once in 65 msec. for the remaining duration, the oscillator is in the off state.

4.1.2 The Ultrasonic Oscillator

IC2 is the circuit used to generate the ultrasonic frequency of 40KHz. The Oscillator's operation is same as that of IC1. The value of RB is chosen such that it is greater than RA to bring the duty cycle of the oscillation wave close to 50%. The frequency of the ultrasonic must be adjusted to the resonant frequency of the ultrasonic sensor. This can be done by making the RB a variable resistor (VR1).The output of IC1 is connected with the reset terminal of IC2 through the inverter. When the reset terminal is in the High level, IC2 oscillates. The ultrasonic of 40 KHz is sent out for the 1 millisecond and pauses for the 64 milliseconds.

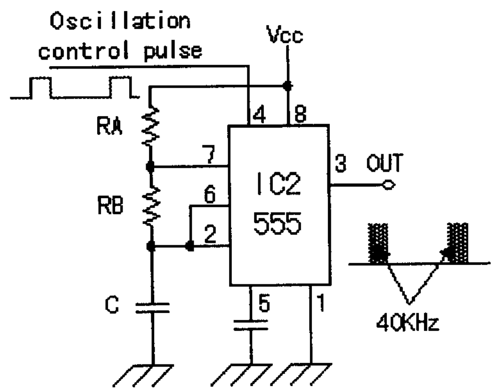


Fig 4.2 Ultrasonic Oscillator

Time Period Calculation:

To obtain an output frequency of 40 KHz, The values of the timing elements are: RA = 1.5KΩ, RB = 15KΩ. C = 1000pF.

T_{LOW} $= \mathbf{0.69 \times RB \times C}$

$= 0.69 \times 15 \times 10^3 \times 1000 \times 10^{-12}$

$= 10.35 \times 10^{-6}$

$= \mathbf{10\ \mu sec}$

T_{HIGH} $= \mathbf{0.69 \times (RA + RB) \times C}$

$= 0.69 \times 16.5 \times 10^3 \times 1000 \times 10^{-12}$

$= 11.39 \times 10^{-6}$

$= \mathbf{11\ \mu sec}$

Frequency $= \mathbf{1 / (T_L + T_H)}$

$= 1 / ((10.36 + 11.39) \times 10^{-6})$

$= 46.0 \times 10^3$

$= \mathbf{46.0\ KHz}$

4.1.3 Ultrasonic sensor drive circuit

The inverter is used to drive the ultrasonic sensor. The two inverters are connected in parallel because the transmission of electric power is increased. The phase at which voltage is

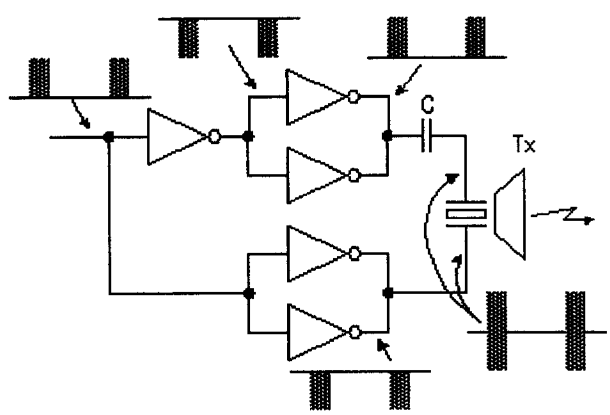


Fig 4.3 Sensor driver circuit

applied to the positive terminal and the negative terminal of the sensor has been shifted by 180 degrees. Because direct current of the capacitor is cut, about twice the voltage of the inverter output is applied to the sensor. The complete circuit of the transmitter is given in figure 4.10.

4.2 Receiver Circuit

4.2.1 Signal Amplification Circuit

The ultrasonic signal which was received by the receiver, is amplified by 1000 times (60dB) with an operational amplifier with two stages. It is 100 times at the first stage (40dB) and 10 times (20dB) at the next stage. Generally, the positive and the negative power supply are used for the operational amplifier. The circuit this time works with the single power supply of +9 V. Therefore, for the positive input of the operational amplifiers, the half of the power supply voltage is applied as the bias voltage and it is made 4.5 V in the central voltage of the amplified alternating current signal. When using the operational amplifier with the negative feedback, the voltage of the positive input terminal and the voltage of the negative input terminal become equal approximately. So, by this bias voltage, the side of the positive and the side of the negative of the alternating current signal can be equally amplified. When not using

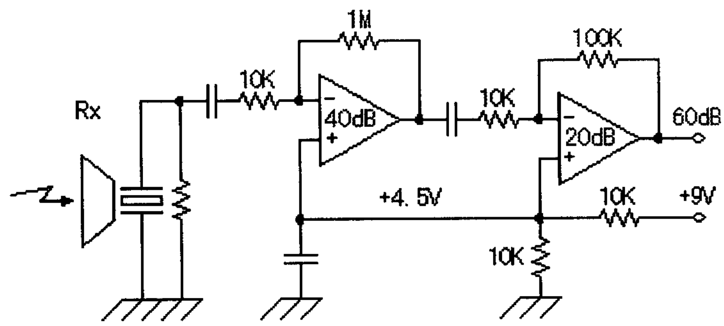


Fig 4.4 Signal Amplification Circuit

this bias voltage, the distortion causes an alternating current signal.

4.2.2 Detection Circuit

The detection is used to detect the received ultrasonic signal. It is a half-wave rectification circuit which uses Schottky barrier diodes. The DC voltage according to the level of the detection signal is got by the capacitor behind the diode. Schottky barrier diodes are used because of their high frequency characteristic is good.

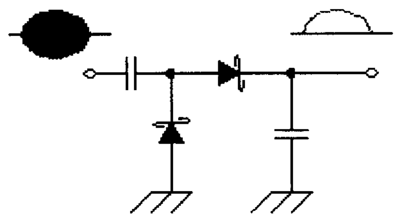


Fig 4.5 Signal Detection Circuit

4.2.3 Signal Detector

This circuit detects the echo which returns from the measurement object. The output of the detection circuit is detected using a comparison. An operational amplifier of single power supply is used instead of a comparator. The operational amplifier amplifies and outputs the difference between the positive and the negative input. Generally, the operational amplifier has tens of thousands of μ factors. So, when the positive input becomes a little higher than the negative input, the difference is tens of thousands of times amplified and the output becomes the same as the power supply almost.(It is the saturation state) Oppositely, when the positive input becomes a little

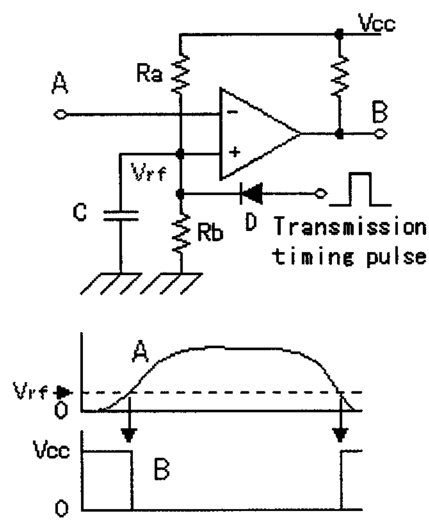


Fig 4.6 Signal detector circuit

lower than the negative input, the difference is tens of thousands of times amplified and the output becomes 0 V almost.(It is in the OFF condition) This operation is the same as the operation of a comparator. However, because the circuits of a comparator and the operational amplifier are different, the comparator can not be used as the operational amplifier. In the circuit, the output of the detection circuit is connected to the negative input of the signal detector and the voltage of the positive input is made constant. The value of this reference voltage (Vrf) is calculated below

$$\mathbf{Vrf} = (Rb \times Vcc)/(Ra + Rb)$$
$$= (47K\Omega \times 9V)/(1M\Omega + 47K\Omega)$$
$$= \mathbf{0.4V}$$

So, when the rectified ultrasonic signal becomes more than 0.4 V, the output of the signal detector goes to the low level (Approximately 0 V). There is another device in this circuit. It is the diode (D) which connects to the non inverting input. The pulse oscillator signal of the transmitter is applied to this diode. So, it does not detect the transmission signal which is crowded when sent out and directly goes to the receiver, by making the voltage of the positive input of the signal detector rise in the pulse oscillator timing signal. The transmission signal has the remaining signal even if it stops the transmission timing pulse. So, it makes the falling of the transmission timing pulse gentle

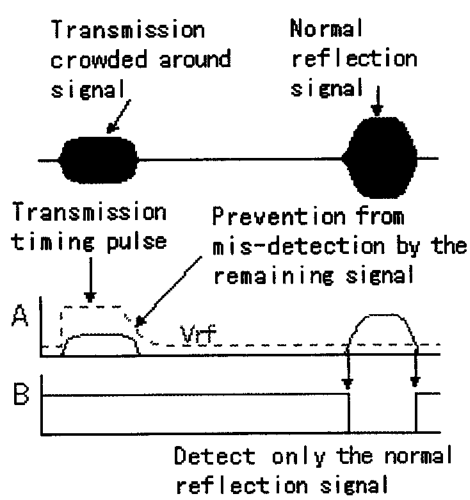


Fig 4.7 Mis-detection prevention

with the capacitor (C) and prevents misdetection by the remaining signal. The value of this capacitor is the one point which decides the efficiency of the equipment. The detection start time becomes late when the value of this capacitor is big and can not do the measurement of the short distance. The equipment this time makes the transmission pulse long (About 1 millisecond) to make the measurement possible to the about 10-m distance and makes the capacitor of the detector big a little. Therefore, the shortest measurable distance becomes about 40 cm. To measure short distance, we have to make T_{Low} of IC1 short. The value of the capacitor of the signal detector must be made small.

4.2.4 Time Measurement Gate Circuit

This circuit is used to measure the time taken by the ultrasonic wave, to travel the distance between the transmitter to the measurement object and then comeback to the receiver as echo. It uses an RS (the set and the reset) flip-flop. The set condition occurs when the transmitter sends out the ultrasonic signal. It uses the transmission timing pulse, to detect this point. The reset condition occurs when a signal is received. That is, the time that the output of SR-FF (D) is in the ON condition, is the time taken for the echo to be received after transmission. The complete circuit of the receiver is given in fig 4.11.

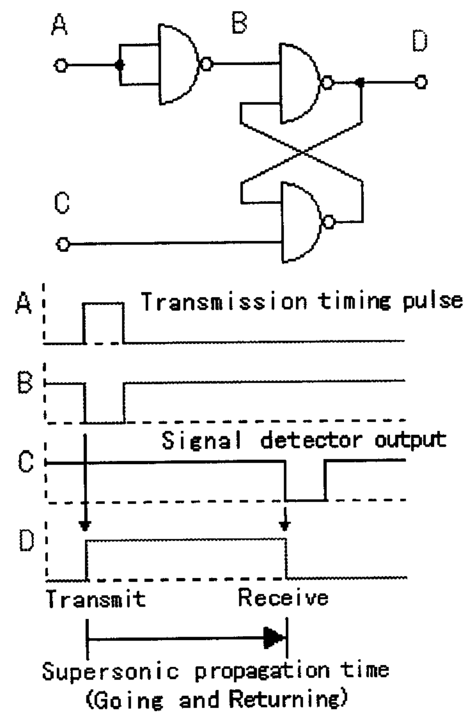


Fig 4.8 Time measurement gate circuit

4.3 Power Supply Circuit

We have used the three pin regulators as shown in the figure for providing a ripple free D.C voltage for the operation of the electronic circuitry. The two levels of regulators used are for providing 5V and 9V. This is constructed using the 7805 and 7809 ICs respectively. The capacitors are used to suppress A.C signals. The 9V regulated supply is used to drive the transmitter and the receiver circuitry, while the 5V regulated supply is used to convert the output from Flip flop to TTL levels, because LabVIEW accepts only TTL levels. The circuit is illustrated in fig 4.12

4.4 Level Conversion Circuit

As the output from the receiver is processed by LabVIEW, the signal cannot be directly fed into the data acquisition card, because it is in CMOS levels whereas LabVIEW accepts only TTL signals. So it was essential to perform level conversion without any loss in the signal. This circuit was thus constructed around the 4049, which is a hex inverter buffer, and can be used for any level conversion. The circuit diagram to realize this function is given in figure 4.13

4.5 Motor Voltage Control And Braking

The basic idea in replacing an IC engine with an Electric motor is because of their inherent analogous nature and the cost and design factors involved. For example, the speed of the engine shaft can be reduced by decreasing the fuel supply. Similarly, by reducing the voltage supplied to the motor, we can reduce its speed. Also, Braking in vehicles is done by wasting energy in the brake pads and bushes. This is analogous to wasting energy in dynamic braking of motors as discussed above. So we are using a permanent magnet DC motor as a substitute to the IC engine vehicle. The voltage control and braking circuit used is illustrated below.

4.5.1 Voltage Control

As discussed in the previous section, voltage control can be done using a chopper connected in series with the motor and supply. The supply voltage will be applied across the motor only when the chopper is switched on. Thus by varying the duty cycle of the chopper, we can vary the output voltage. We have used a transistor to perform the function of a chopper. It is connected as shown in figure 4.9 to the supply. The PNP 2N2904 is used for this purpose.

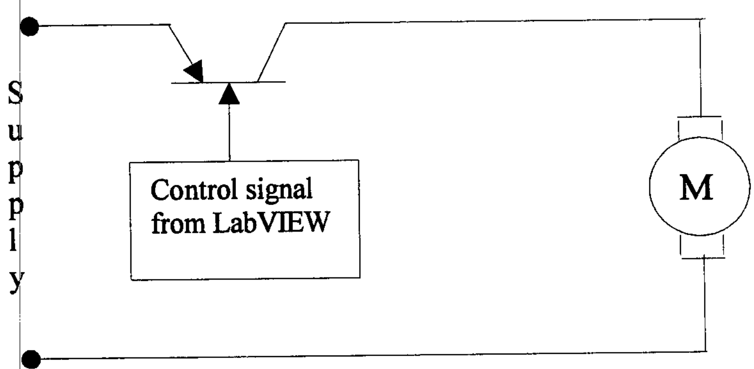


Fig 4.9 Voltage control circuit using chopper

The braking circuit is based on dynamic braking and consists of a transistor in shunt with the motor. When it is deemed that braking is necessary, the voltage control transistor is switched off and the braking transistor is switched on to drain the energy stored as inertia in motor, through a resistor of 1Ω. The complete voltage control and braking circuit is illustrated in figure 4.12. It is to be noted that both the transistors are never on at the same time, as it will cause short circuit and thus the supply will fail.

TRANSMITTER CIRCUIT

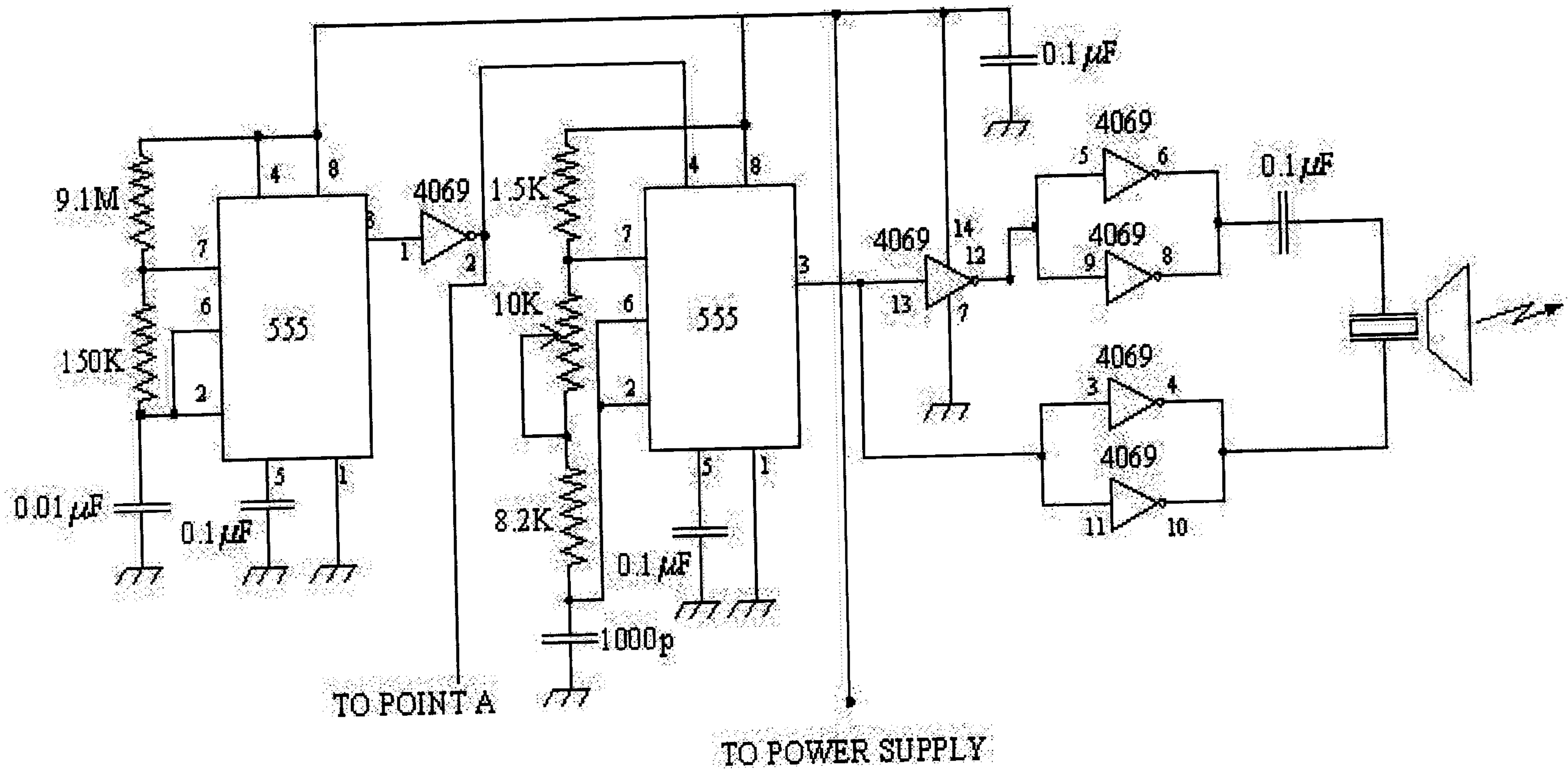


Fig 4.10

RECEIVER CIRCUIT

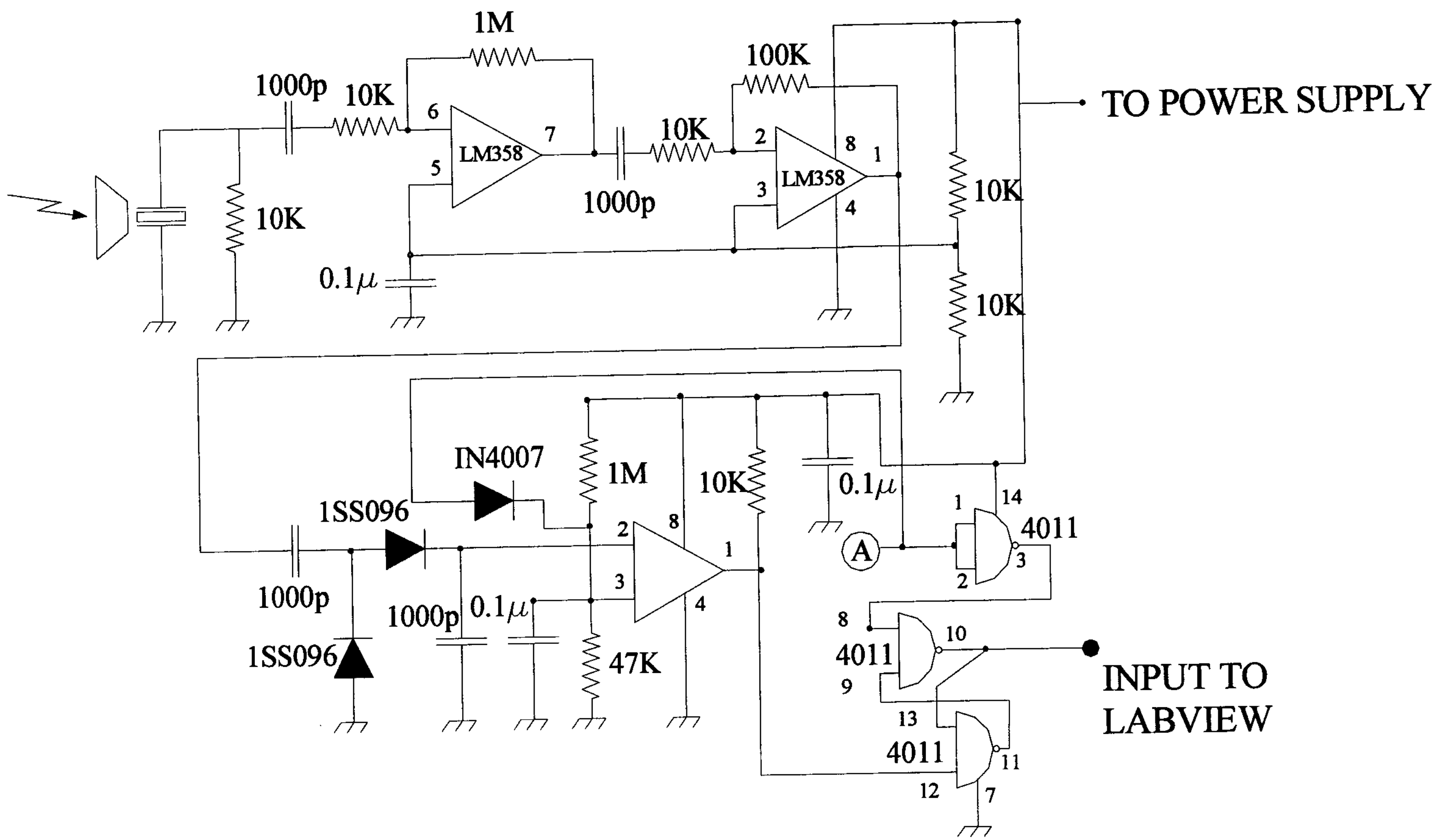


Fig 4.11

POWER SUPPLY CIRCUIT

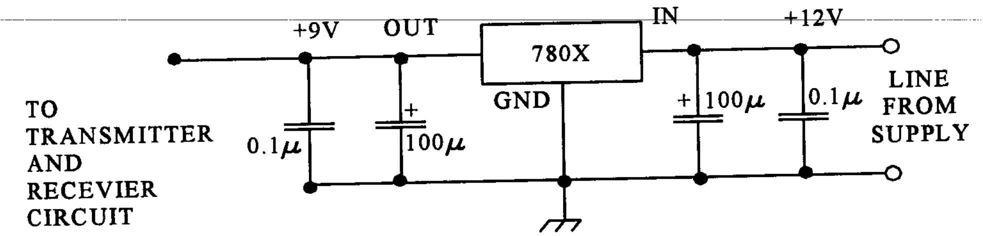


Fig 4.12

CMOS TO TTL CONVERTER

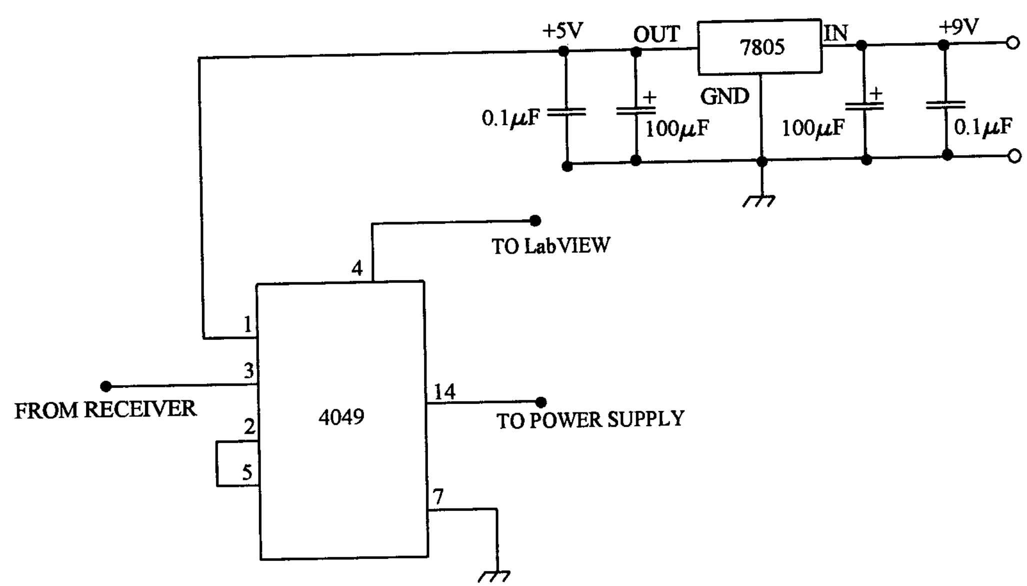


Fig 4.13

MOTOR BRAKING CIRCUIT

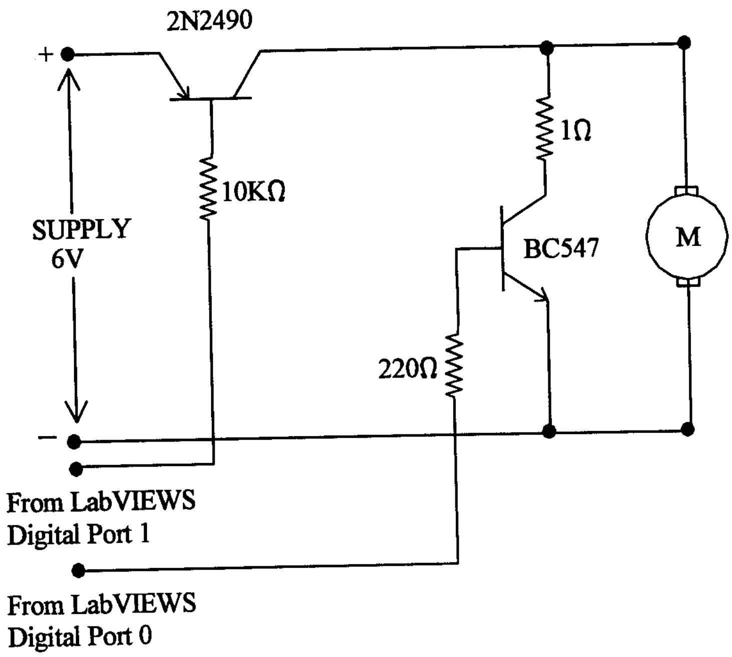


Fig 4.14

SOFTWARE

5. SOFTWARE

The control system for the operation of the circuit is constructed around LabVIEW package by National Instruments, U.S.A. As discussed earlier, LabVIEW can be used to create virtual instruments for the purpose of measurement and automation. There are various add on cards etc available which can be used for data acquisition and to perform control functions. We have used the digital I/O and the counter I/O for programming. The details of the data acquisition system (DAQ) used etc are attached as an appendix. The DAQ basically gets the input from the receiver circuit as a gate input to one of the counters and measures the pulse width, which as discussed earlier is the time interval between the transmission and reception of the ultrasonic signal. This pulse width is used to calculate the distance of the object, which is then used to make decisions and switch on/off the corresponding transistors, as and when required.

The switching of the transistors is done by controlling the base current to them, and this is done via the digital output ports DIO 0 and DIO1. Because we have used only TTL levels for the operation of the motor and braking circuit, no level conversion or isolation was necessary, thus making the software and hardware interfacing simple.
The graphical program and the user interface are shown in figures 5.1 and 5.2 respectively. Although it is very easy to understand the program, a basic idea of the inbuilt functions used is provided.

These functions are basically built themselves and are called Sub-VI's. The Sub-VI's thus severely reduce complications in the programming methodology.

5.1 LabVIEW Sub Vis USED

5.1.1 Measure Pulse-Width Or Period

It measures the pulse-width (length of time a signal is high or low) or period (length of time between adjacent rising or falling edges) of a TTL signal connected to the counter's GATE pin. The method used gates an internal time base clock with the signal being measured. This VI is useful in measuring the period or frequency (1/period) of relatively low frequency signals, when many time base cycles occur during the gate. The VI iterates until a valid measurement, timeout, or counter overflow occurs. A valid measurement exists when count>=4 without a counter overflow. If counter overflow occurs, time base is to be lowered. If pulse-width measurement is started during the phase to be measured, an incorrect low measurement is obtained. Therefore, it is to be made sure that the pulse does not occur until after the counter is started. This restriction does not apply to period measurements.

Connections:

Device is the device number you assigned to the DAQ device during configuration.

Counter identifies the counter(s) the VI configures. The counter(s) specified by counter list must belong to the group identified by task ID. If counter list is empty, the VI programs all the counters in the group.

Type of measurement identifies the type of pulse-width or period measurement to make. The following illustration demonstrates the various values for type of measurement.

0 Measure high pulse-width from rising to falling edge.

1 Measure low pulse-width from falling to rising edge.

2 Measure period between adjacent rising edges. (default)

3 Measure period between adjacent falling edges.

Time base is the internal clock signal to use (default 100 MHz). If the counter overflows because time base is too high, lower it until a valid reading occurs or until the lowest time base is used and a timeout occurs.

Pulse-width/period (s) is the measured pulse-width or period; it equals count/time base and may be valid or invalid.

Valid? It is TRUE if counter has not under flowed (if count <= 4) or overflowed.

Time limit is the period to wait for a valid measurement. If time limit is -1.0 (default), the time limit is set to five seconds or four times the range of the counter at the selected time base (4*65,536/timebase) in seconds for the Am9513 and (4*16,777,216/timebase) for the DAQ-STC), whichever is larger.

Count is the value of the counter at the time it is read. For best accuracy, a time base frequency that maximizes the count without overflowing it is chosen. If there are two Am9513 counters assigned to the task ID, the value of the higher order counter is multiplied by 10000 hex, shifting it to the left 16 bits. The higher order counter is then added to the value of the lower counter. The count will be incorrect if the task ID is for two concatenated DAQ-STC counters.

Counter overflow? is TRUE if counter reaches TC. Overflow does not produce an error.

Timeout is TRUE if a valid reading is not within the prescribed or computed time limit. The timeout parameter does not produce an error.

5.1.2 Write To Digital Line

It sets the output logic state of a digital line to high or low on a digital channel that you specify. If an error occurs, a dialog box appears, giving the option to stop the VI or continue. When this VI is called on a digital I/O port that is part of an 8255 PPI and when the iteration terminal is left at 0, the 8255 PPI goes through a configuration phase, where all the ports within the same PPI chip get reset to logic low, regardless of the data direction. The data direction on other ports, however, is maintained. To avoid this effect, a value other than 0 is connected to the iteration terminal once the desired ports are configured.

Connections:

Device is the device number assigned to the DAQ device during configuration.

Digital channel is the channel name or port number that this VI configures. If using channel names, the name of the configured digital channel is entered. If not using channel names, a port number is entered, i.e. a value of 0 signifies port 0, a value of 1 signifies port 1, and so on; or if using a digital SCXI module, the SCx!Mdy!z syntax, where x is the chassis ID, y is the module device number, and z is the port number is used.

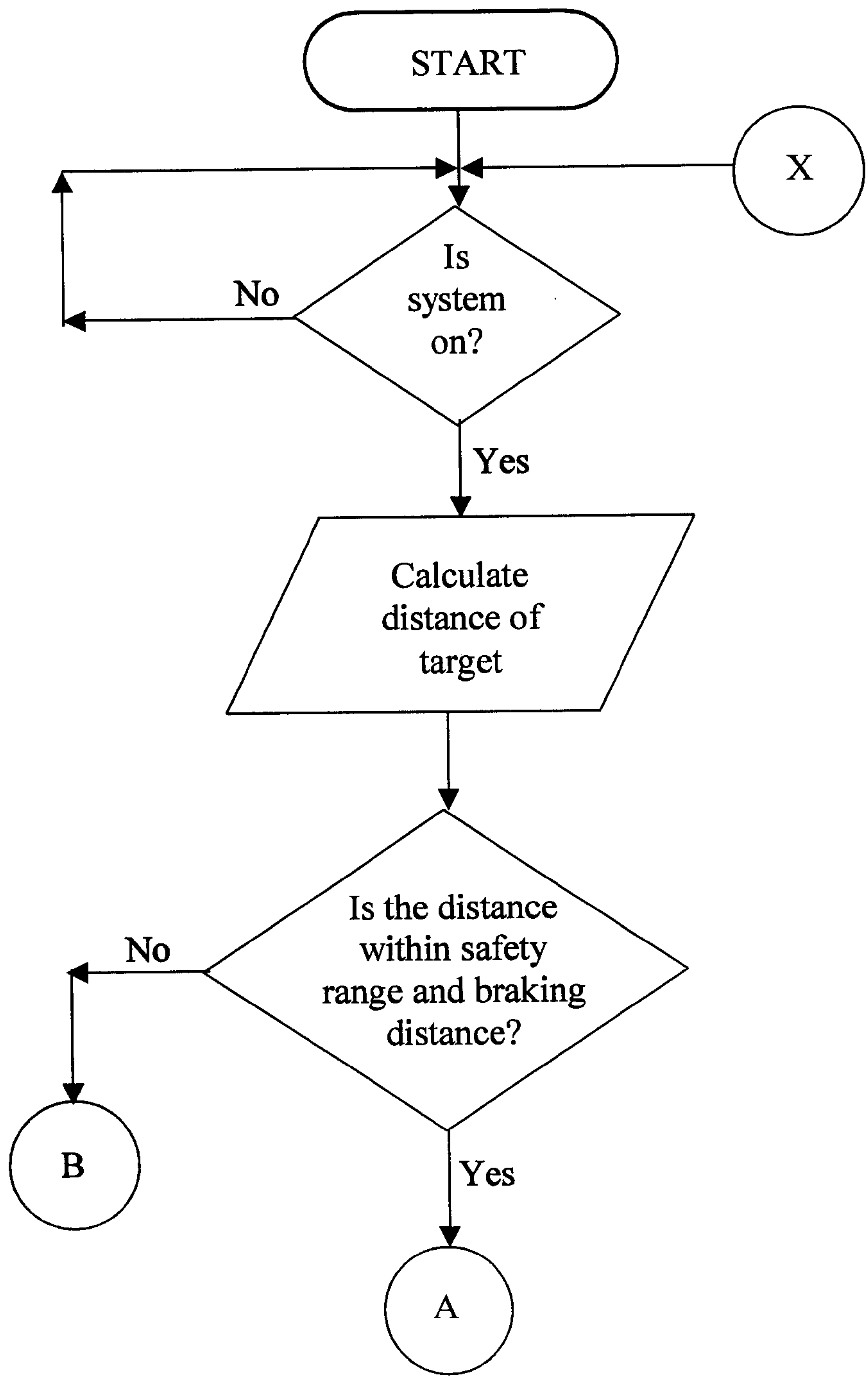
Line is the individual port bit or line to be used for I/O.

Line state is TRUE for high logic, and FALSE for low logic.

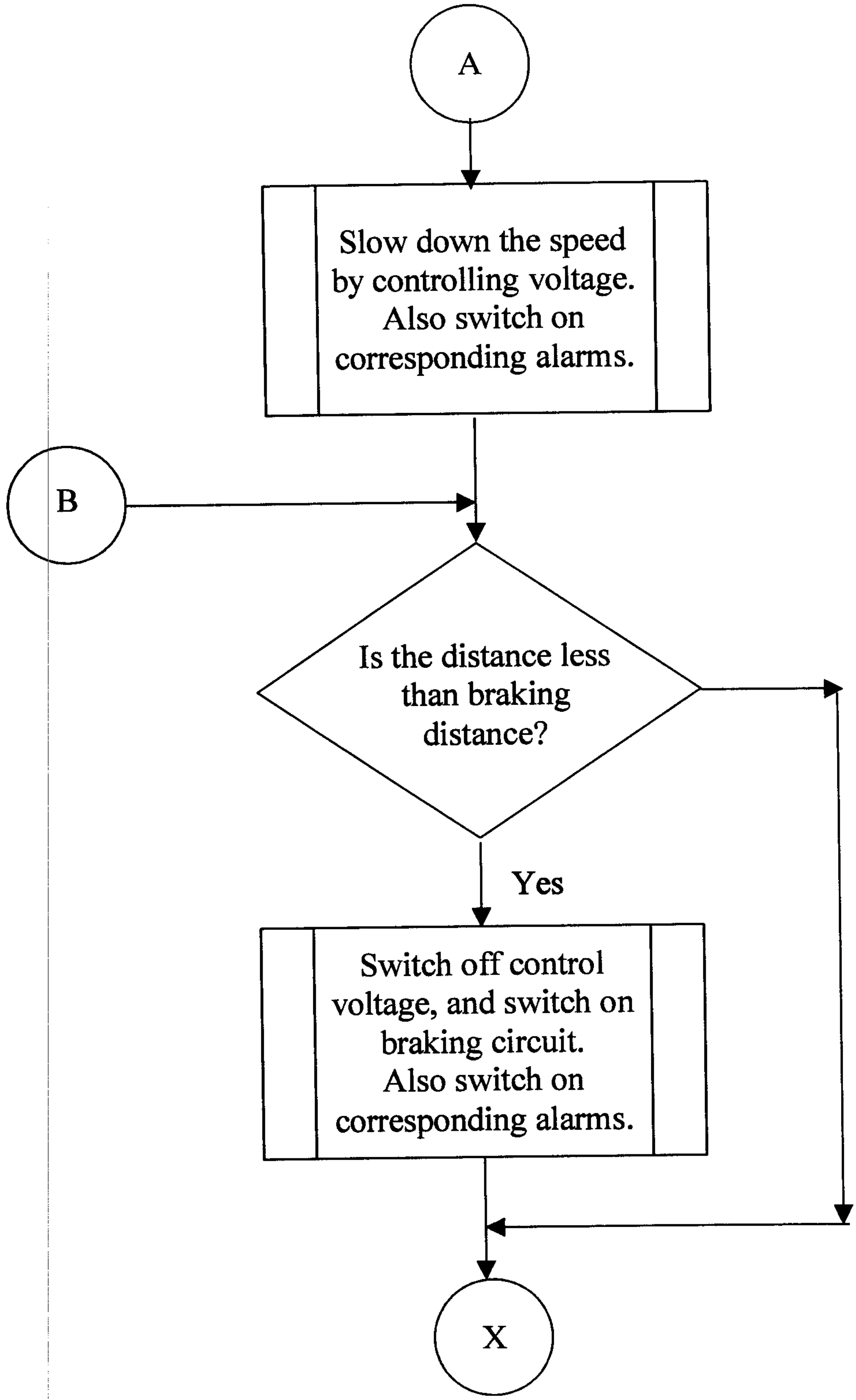
Port width is the total width or the number of lines of the port in bits. For example, combining two 4-bit ports into an 8-bit port on an MIO device can be done by setting port width to 8. If using channel names, port width is not needed and is ignored.

Iteration can be used to optimize operation when the VI is executed in a loop. When iteration is 0 (default), LabVIEW calls the DIO Port Config VI to configure the port. If iteration is greater than zero, LabVIEW uses the existing configuration, which improves performance. Usually this terminal is wired to an iteration terminal.

5.2 Flow Chart



The above flowchart illustrates the logic behind obstacle sensing and braking.



The above flowchart illustrates the logic behind obstacle sensing and braking.

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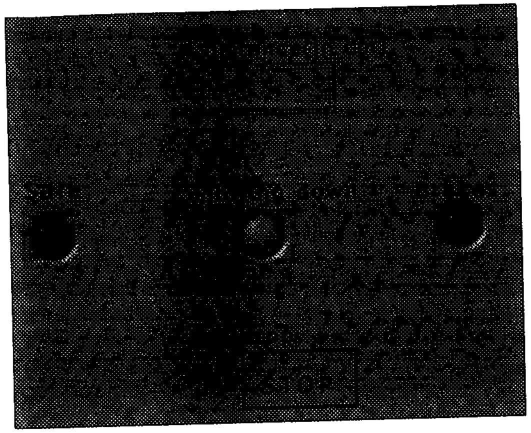
Front Panel



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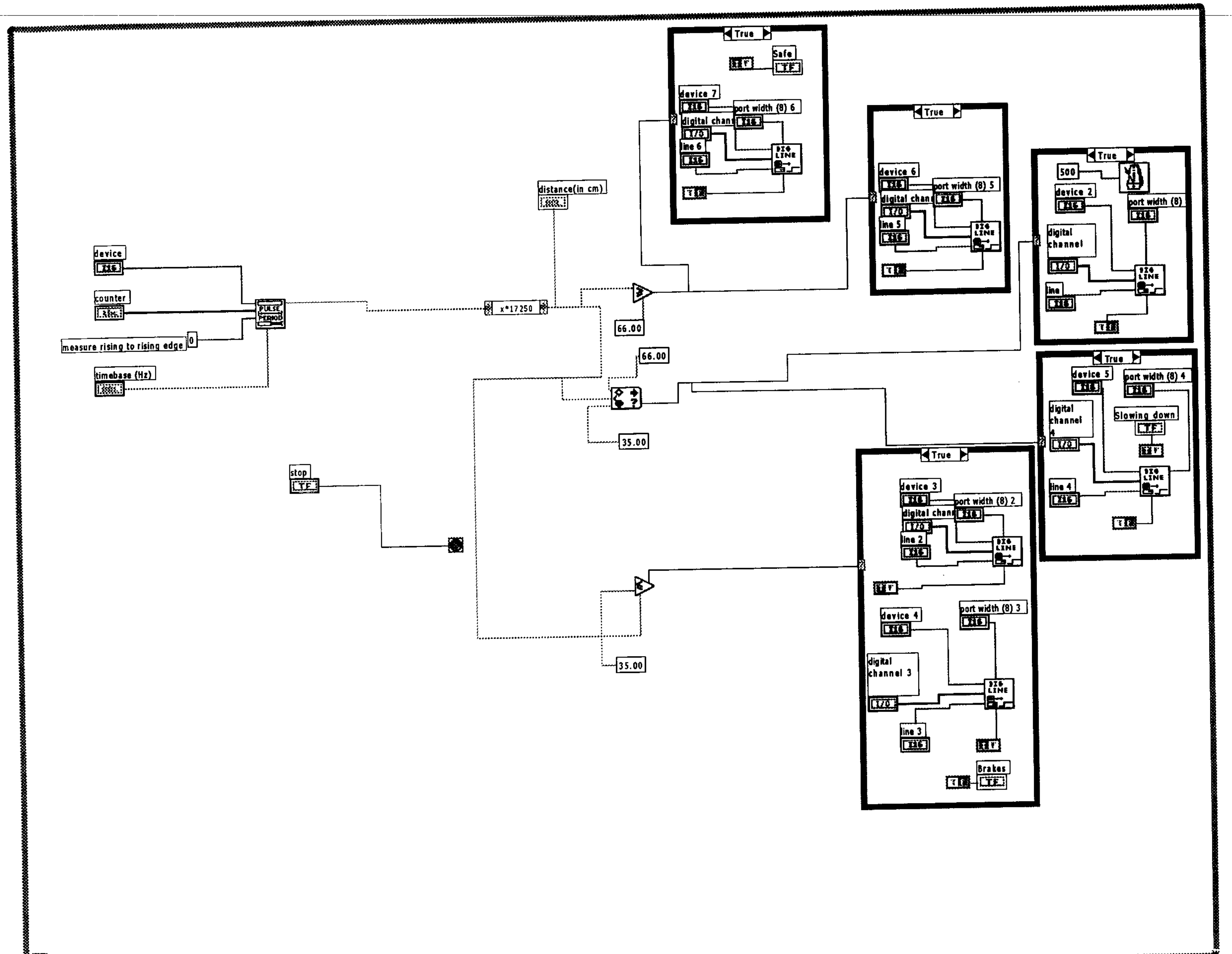
3lock Diagram



IMPLEMENTATION

6. HOW THIS SYSTEM IS TO BE IMPLEMENTED

Our project does not provide the ultimate result where in it can be used in plying automobiles. In this section, we provide a basic idea as to how this system can be implemented for real.

The system should satisfy these following requirements:

1. The sensors should be compensated for temperature and humidity variations.
2. They should be able to emit waves at different frequencies so that the signals of one system do not interfere with others. This can be done by succesive frequency hopping.
3. The control system should be built around 16 bit or 32 bit microcontrollers, because of the accuracy and the speed required.
4. The control system should control the ACS and ABS systems for sprred reduction snd brsking respectively.
5. The system should be rugged enough to defy the elements, and should be highly reliable because of the safety factors involved.
6. The positioning of the sensors on the vehicle should be very accurate.

By following these above guidelines, a foolproof system can be constructed. The only cause for concern is the cost involved because it can cost upto 25% of the vehivles cost. But the cost factor is bound to reduce because of the advacement in sensors and systems technology. The block diagram for implementing such a system is given in the following figure

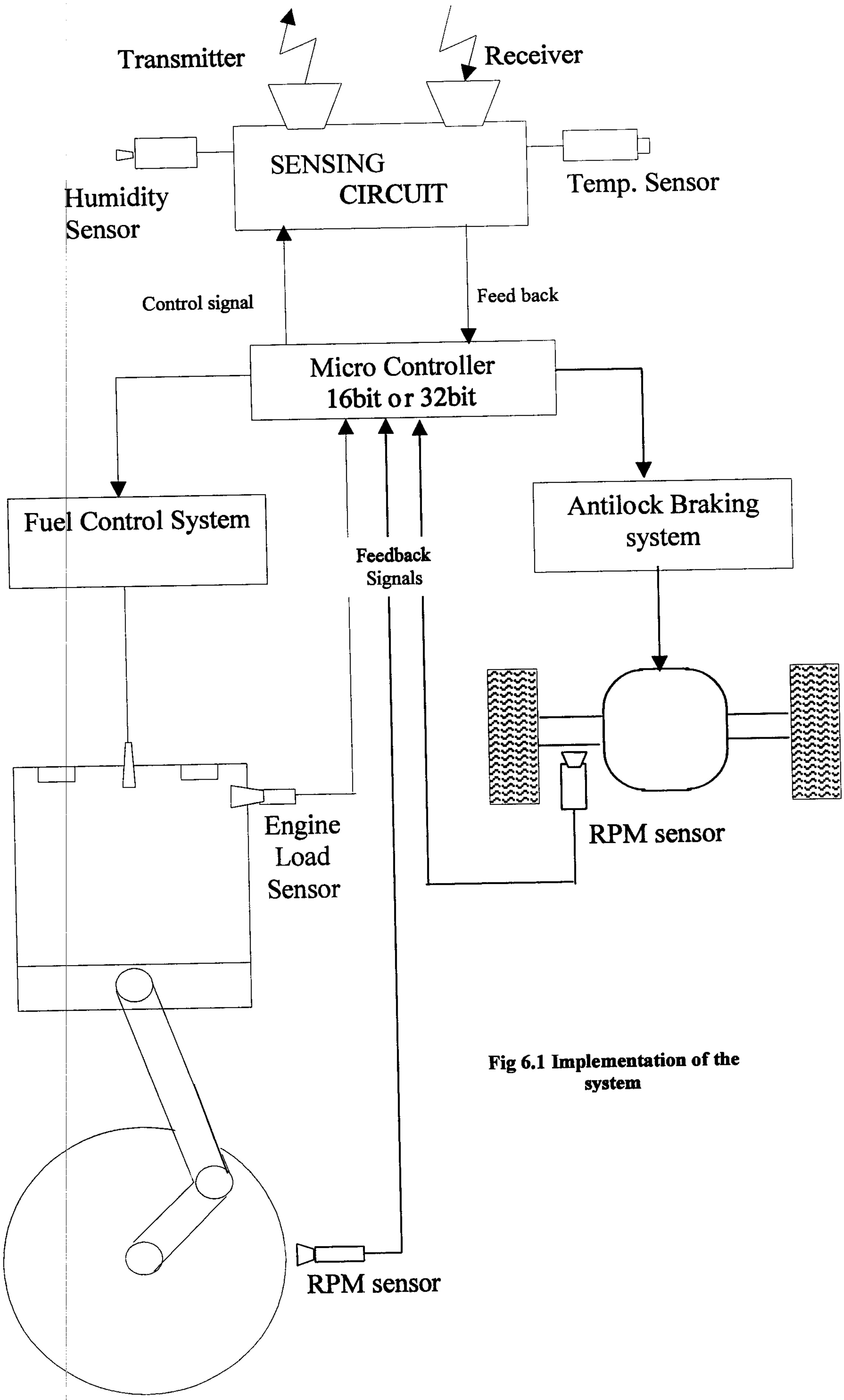


Fig 6.1 Implementation of the system

CONCLUSIONS

7. CONCLUSIONS

Thus the design and modeling of a collision prevention system for four wheelers was performed and its technological feasibilty was asserted to be credible enough, so as to proceed to product development. As the project was done only under laboratory conditions, results of thorough testing are not known, and any attempt to implement the system is to be done only after foolproof testing is performed.

The implementation of such a system, would help in saving lot of lives and property, which was also the main motivation behind such a venture. But the range sensitivity and ruggedness of the ultrasonic sensor used, proved to be a deterrent to achieving a good performance, and thus it is imperative to look for better sensors before further development of the system is carried out.

This experiment has provided an enriching and fulfilling experience to us, and we have gained a lot of theoretical and practical knowledge during the project tenure. To conclude, we once again thank all those who have guided, helped and motivated us for each and every step that we took and guided us through troubled waters.

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8. REFERENCES

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