DEVELOPMENT OF AN ALARM SYSTEM FOR ALERTING VEHICLE DRIVERS TO PREVENT ACCIDENT

by

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Dissertation submitted in partial fulfilment of
the requirements for the
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(Electrical & Electronics Engineering)

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Electrical & Electronics Engineering Programme
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____

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MAY 2011

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

(Shahamatul Aizzak Binti Zakaria)

ABSTRACT

Road accident statistics and reports show that the accident has always been critical. In Malaysia, the accidents related to motorcycle have highest statistics. A fatal outcome was more likely to be associated with a larger engine capacity motorcycle, collision with a heavy vehicle, head on collision, and collision at non junction road. This happens because the vehicle drivers do not realize or alert while motorcyclist is overtaking or undertaking with high speed. The aim of this project is to develop an alarm system for alerting vehicle drivers in order to prevent accident from motorcycles. This system will remind vehicle drivers in several levels to help them notice and realize about the motorcyclist appearance from backside of their vehicles. The sensor will sense object or specifically motorcycle at certain distance and then send information to be interpreted as the output. This project can become the potential product for everyday-life applications in Malaysia. It is regarded as an important tool for the vehicles drivers to take precaution to prevent collision.

ACKNOWLEDGEMENT

Praise to Allah. This project has comes to the accomplishment. There were many people involved during the period to finish this final year project. At first, I would first like to express my special gratitude to my supervisor Dr. Likun Xia for his support, insight, assistance, idea, inspiration and supervision throughout the course of my graduate studies. I am indebted to his effort, patience guidance, ideas and countless hours of learning.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

In this project, an alarm system for alerting vehicle drivers to prevent accident is developed. Most vehicle users do not realize if some motorcycles are closing to them from backside and blind spot places. Because motorcycles are smaller and faster, it is difficult for the vehicle driver to notice them in time. Moreover, some of motorcyclists drive ruthless, particularly in Malaysia compared to other vehicles. 90 % of all such collisions are partly due to distracted drivers. The basis of this project is to use ultrasonic components including transmitter, receiver and transducer. These components are responsible to send, receive and process data from distraction object, and then send an input to microcontroller. Meanwhile, for the output devices to alert the drivers, they may consist of LED, speaker or buzzer.

1.2 Problem Statements

Road accident statistics continue to rise. It involves various vehicle users on the road. According to the Transport Minister Datuk Seri Kong Cho Ha, [1] "Motorcyclists topped the list with of deaths, followed by car drivers or occupants with 54 deaths and pedestrians." Chief Traffic Team Bukit Aman, Senior Assistant Commissioner II Abdul Aziz Yusof stated that the Ops Sikap 17th was considered to achieve the mission of reducing fatalities compare to previous years. According to the Aziz, the motorbike rider still recorded the highest mortality during Ops Sikap 17th of 121 people followed the car (48 people) and pedestrians (17 people). He said, "The Federal roads recorded the highest number of deaths of 83 people followed the way of the state (49) and highways (32 people)." He added that the analysis also indicated that 51 per cent of fatal accidents were caused by careless attitude and tiredness. Table 1 below is road accident statistics & death entire Malaysia Ops Sikap XV, 19th December 2007 until January 2008.

Table 1: Road Accident Statistic & Death entire Malaysia Ops Sikap XV, 19th December 2007 until 2nd January 2008 [1]

TYPE OF ROAD	TOTAL ACCIDENTS	TOTAL DEATH ACCIDENT	TOTAL DEATH
EXPRESSWAY	1,350	21	25
FEDERAL ROAD	3,522	81	90
STATE ROAD	2,353	39	41
MUNICIPAL ROAD	5,605	39	42
OTHER ROAD	595	10	12
TOTAL	**13,425**	**190**	**210**

Table 1 shown above is the statistic of road accident and death entire Malaysia. There are the command places that state high accident statistics. Total death accident is a sum of death that happens in the place of accident right after the accident happen. Total death statistic is the total death involving deaths that happen after the accident moment.

1.3 Objective and Scope of Study

The objective of this project is to develop an alarm system to alert vehicle drivers about motorcycle users' appearance close to the car. The system will alert the driver in order to prevent any unexpected accidents by sensing the distance and then producing output to the driver with sound. Instead of direct sound, the ascending sound will be supplied according to the distance. When they are in a critical distance, between vehicles and motorcycles, the system will trigger another indicator such as blinking LEDs and screen that display the distance and direction of the motorcycle.

The scope of study covers from the ultrasonic components, microcontroller and output circuit, how it works and how they are connected. The data from circuits need to be interpreted by microcontroller and then convert as the output. This involves data recognition of the microcontroller and understanding the whole operation of it.

CHAPTER 2

LITERATURE REVIEW

2.1 Existing System

There are several methods that are available currently to assist drivers to avoid rear end collisions. One of the methods is to use Conventional Video Cameras. Such device that is currently available in market is Donnelly Video Mirror with Reverse Aid. This device usually consists of a video camera mounted inside the cabin for the driver to view. Standard cameras have field of view from 30 to 45 degree. This makes it difficult to monitor all danger zones behind the vehicles especially smaller vehicles like motorcycle [2].

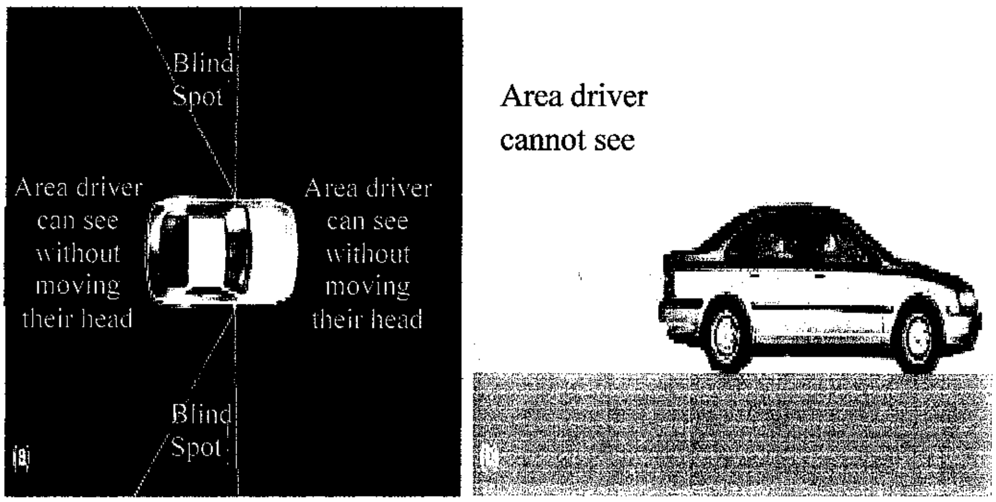

Figure 1: Sensors put at blind spot place [2]

Another method available is called Radar (Radio Detection and Ranging). It is a false alarm device, which sounds the alarm only when there was relative movement between the vehicles and the object. The main drawback of this system is the large vertical angular range, making it impossible to distinguish between objects of varying size and position [2]. A new automotive safety systems built by European researchers will alert drivers to potential hazards by using information from the car, other road users and the roadside infrastructure to predict and prevent traffic accidents [3]. The drawback of this system is the information accuracy conveyed to the user. It may mistakenly predict any information as a potential hazard subject that may cause accident although it may not be like that.

Other features like cameras have been added that track a vehicle's position in the lane (and may later be used for warnings about lane-keeping and road departure). Volvo Accident Warning is a system developed in collaboration with Mobileye from Netherland, introduced in 2007. This system called C2-270 uses radar / camera to warn drivers to brake. It includes a 640 x 480 CMOS camera that is placed on the mirror and then connected to the display unit placed on the dashboard. The cameras will monitor the road in front of the vehicle when the car moves, and will detect any potential collision using EyeQ2, a system used by the Volvo, GM, BMW and Nissan [4]. If there is potential accident detected, the system produces warning sound and a red light on to alert drivers the potential accidents. It is able to respond quickly if there are pedestrians, cyclists or motorcyclists who suddenly cross in front of the car. However, this system only gives a warning to driver and not applies automatic brake system.

A GPS (Global Positioning System) can also be embedded; that supplies data map that continuously updates the car's location and reports the shape of the road [5], Unfortunately, GPS is not applicable at certain places such as the rural area. Safety experts stated that similar technology being developed by other makers will help save more than 125,000 painful and costly whiplash injuries alone each year. Rear-end collisions make up 29 per cent of all reported car accidents.

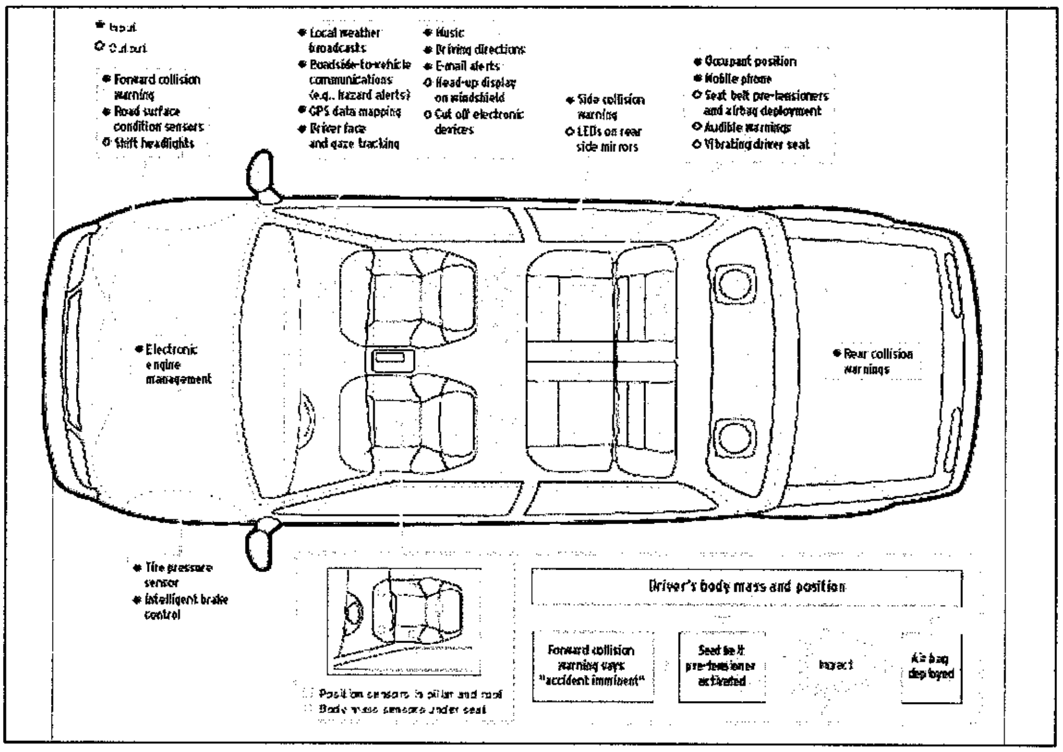

Figure 2: Sensors that can make car safer[3]

Figure 2 above is one of smart car invention with a lot of safety systems. For safety system in term of collision and hazard detection, it consists of forward collision warning placed in front of the car, side collision warning at both sides of the car and rear collision warning at the backsides of the car.

2.2 Ultrasonic Sensor

Ultrasonic sensors (also known as transceivers when they both send and receive) work on a principle similar to radar or sonar which evaluate attributes of a target by interpreting the echoes from radio or sound waves, respectively. Ultrasonic sensors generate high frequency sound waves and evaluate the echo which is received back by the sensor. Sensors calculate the time interval between sending the signal and receiving the echo to determine the distance to an object. This technology can be used for measuring: wind speed and direction (anemometer), fullness of a tank and speed through air or water. For measuring speed or direction a device uses multiple detectors and calculates the speed from the relative distances to particulates in the air or water [6].

Moreover, they have provided a reliable source of obstacle detections. Since they are not vision-based, they are useful under conditions of poor lighting and transparent objects. However, ultrasonic sensors have limitations due to their wide beam-width, sensitivity to specular surfaces [7]. Because of the typical nature of the ultrasonic wave's reflection, only reflecting objects that are almost normal to the sensor acoustic axis may be accurately detected [8]. In addition, they offer poor angular resolution. In an unknown environment, it is important to know about the nature of surface properties in order to interpret infrared sensor output as a distance measurement.

CHAPTER 3

METHODOLOGY

The flow chart below is the overall process of how the system works.

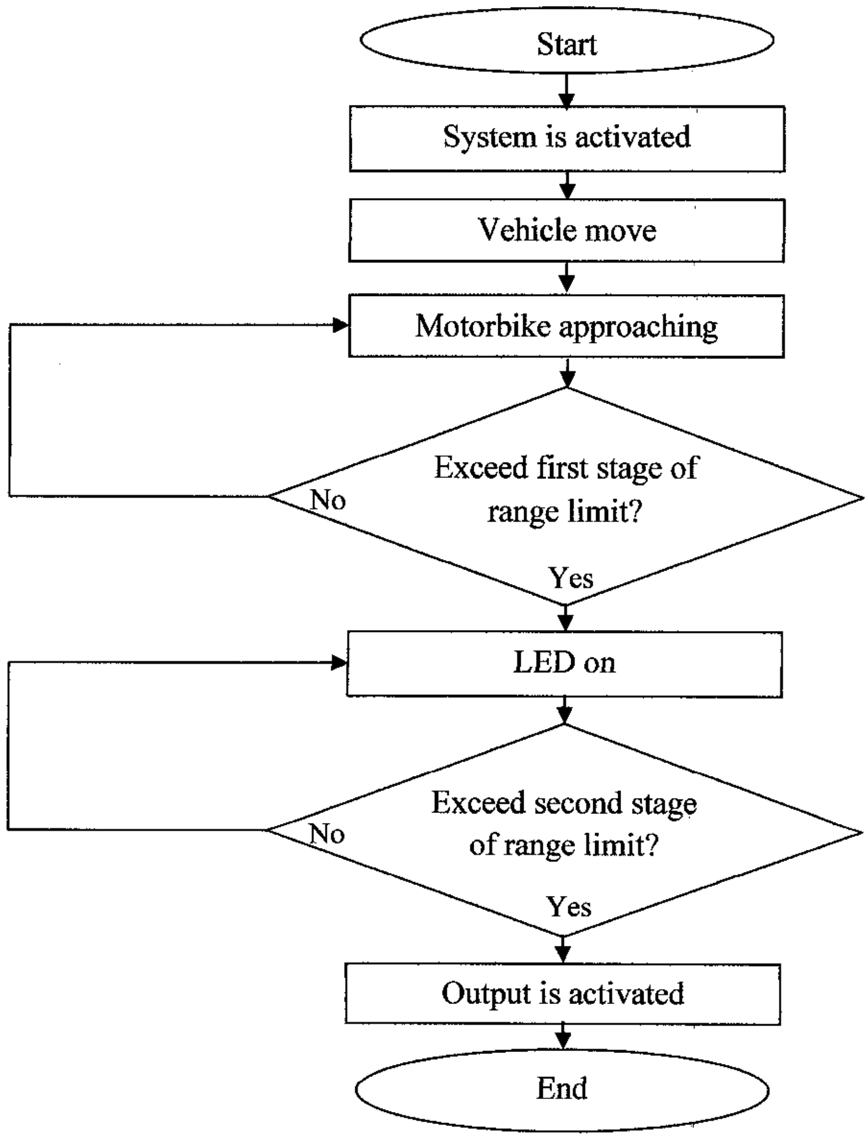

Figure 3: Overall system process

In figure 3 is the flow chart of the overall system process. The system starts with activation of the system and assuming that the car moves under normal condition. When there is an object (motorbike) coming close to the car from backside. The sensor embedded in the system will sense the object appearance based on its specific range. If the object is defined in the range area of the sensor, it is detected as an input of the system. If the object is still outside the range of the sensor, it will not detect any input coming. The range is divided into two parts. At first range, the alert system will be activated in just low level of precaution, when it comes to the second stage, the output signal will be stronger to alert the driver that the object is getting closer to the car. If an input is detected at the first stage of range area, the first output will be activated. The procedure is then repeated for the second stage of range area. If all condition is satisfied, the final output will be activated.

3.1 Ultrasonic Sensor Working Principle:

One of the main components used in this system is ultrasonic sensor. An ultrasonic sensor is a device that converts energy into ultrasound, or sound waves above the normal range of human hearing. Piezoelectric crystals have the property of changing size when a voltage is applied, thus applying an alternating current (AC) across them causes them to oscillate at very high frequencies, thus producing very high frequency sound waves [9]. The ultrasonic sensor consists of three main components: transmitter, receiver and transducer.

The transmitter of the sensor will emit sonic wave to surrounding. When the wave touches any object around it, the wave will bounce and return back to the sensor. The receiver in the sensor is responsible to receive the bounce wave from the object. After that, it will pass the information to transducer. The transducer changed ultrasonic wave to electrical energy and also from electrical energy to ultrasonic wave. After converting the energy, the information can be translated as an output such sound, vibration etc. The ultrasonic method has unique advantages over conventional sensors:

- Measures and detects distances to moving objects.
- Impervious to target materials, surface and color.
- Solid-state units have virtually unlimited, maintenance-free lifespan.
- Detects small objects over long operating distances.
- Resistant to external disturbances such as vibration, infrared radiation, ambient noise and EMI radiation.
- Ultrasonic sensors are not affected by dust, dirt or high-moisture environments.

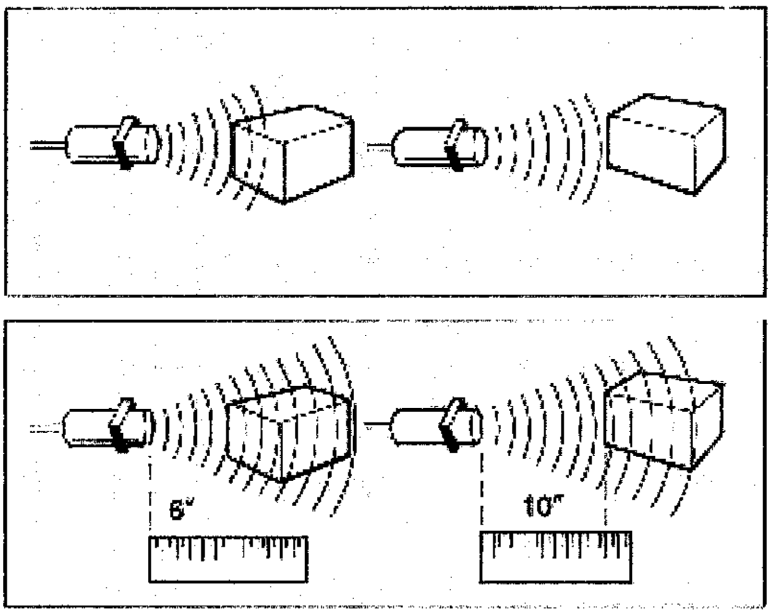

Figure 4: Proximity detection ultrasonic and ranging measurement ultrasonic.

Proximity detection:

An object passing anywhere within the preset range will be detected and generate and output signal. The detect point is independent of target size, material or degree of reflectivity.

Ranging Measurement:

Precise distance(s) of an object moving to and from the sensor are measured via time intervals between transmitted and reflected bursts of ultrasonic sound. The example shows a target detected at six inches from the sensor and moving to ten inches. The distance of change is continuously calculated and outputted [10].

3.2 Circuit Operation

3.2.1 Sensor Circuit Diagram

A diagram of the transmitter circuit is shown in figure 5:

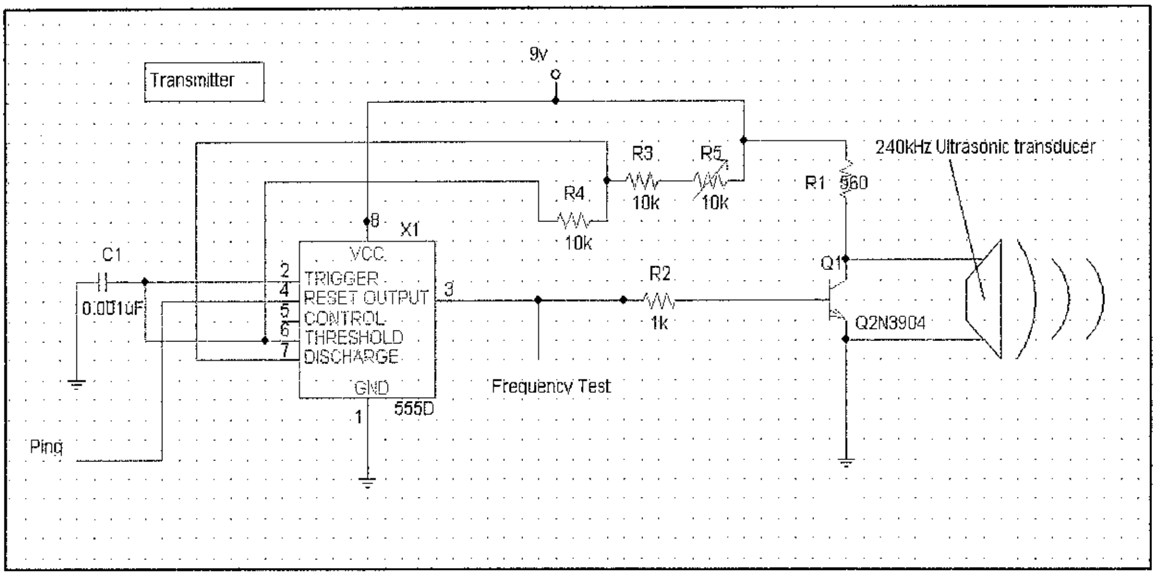

Figure 5: Transmitter circuit diagram

In picture shown in figure 5 is a circuit diagram for the transmitter circuit. The circuit consists of a 555 timer, a 0.001 uF capacitor, two 10k Ω resistors, an 1k Ω resistor, a 360 Ω resistor, a 10k Ω potentiometer resistor, a 2N3904 transistor and an ultrasonic transmitter. The transmitter emits an ultrasonic signal. The 555 timer chip provides the driving 240 kHz signal for the sensor. When the reset pin (pin 4) of the 555 timer goes high, 240 kHz signal will be driven on pin 3. Potentiometer R5 is varied to get the frequency of 240 kHz square pulse. As the signal produced is a bit small, it is amplified by the transistor (2N3904). After transmitter circuit produces a signal, the signal bounces to an object and then receiver will listen to the return echo from the bounced object.

A diagram of the receiver circuit is shown in figure 6:

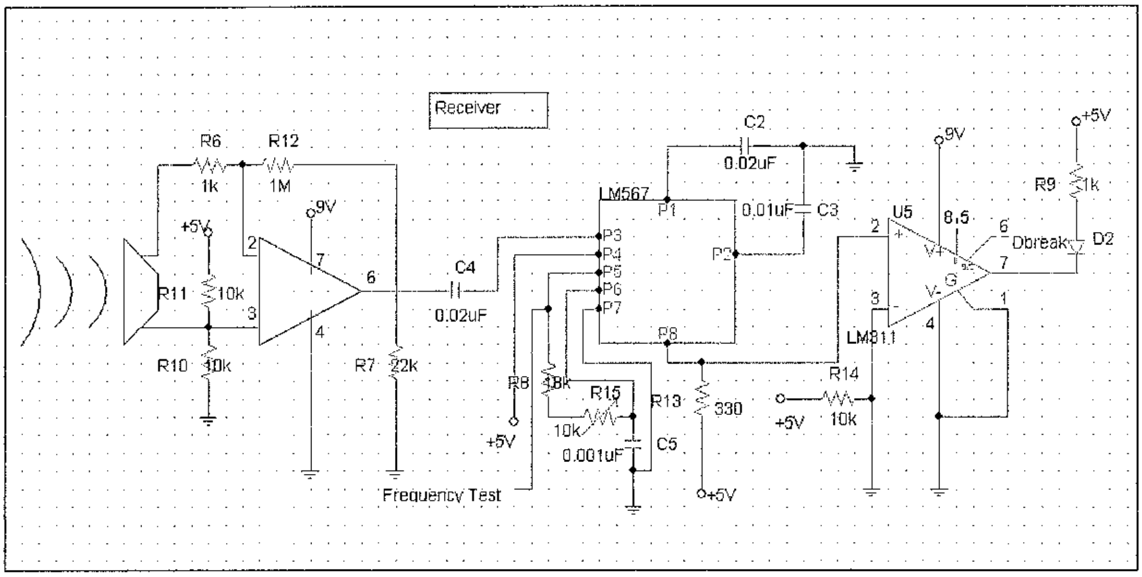

Figure 6: Receiver circuit diagram

A picture shown in figure 6 is a circuit diagram for receiver circuit. The circuit consists of LM 741 op-amp (operational amplifier), LM 567 tone decoder, LM 311 voltage comparator, two 1k Ω resistors, three 10k Ω resistors, a 22k Ω resistor, a 18k Ω resistor, a 330 Ω resistor, an 1M Ω resistor, a 10k Ω potentiometer resistor, two 0.02 uF capacitors, a 0.001 uF capacitor, a 0.01 uF capacitor, an ultrasonic receiver and an LED (Light Emitting Diode) as an output component.

The operation starts after the receiver detects the small echo signal from transmitter, it is amplified 1000 times using an operational amplifier (LM741 op-amp). The output of the op-amp is then fed into a tone decoder (LM567) set to lock onto a 240 kHz signal. LM 567 is a general purpose tone decoders designed to provide a saturated transistor switch to ground when an input signal is present within the passband. The last part of the receiver circuit is a voltage comparator part (LM 311). LM 311 is designed to operate over a wider range of supply voltages: from standard ±15V op amp supplies down to the single 5V supply used for IC logic. The output from the tone decoder is fed into a voltage comparator set to trigger at the appropriate level. To minimize the effects of noise, plenty of bypass capacitors added. This can lead better performance for the output. The LED at the output of the comparator acts as a visual indicator when an echo is detected.

3.2.2 Theory of Operation

In the transmitter circuit, there are two main components used; 555 timer and ultrasonic transmitter. The system start at 555 timer, it is a timing circuit that produces a 240 kHz square wave signal. It triggers the ultrasonic transmitter to emit the ultrasonic signal.

After transmitting the signal, the receiver detects the 240 kHz signal after it bounces off an object. If the signal does not bounce any object, it will not return to the receiver and the transmitter keeps on transmitting a signal. After the receiver receives the signal, the op-amp (LM741) amplifies the signal and sends it to the tone decoder (LM567). The LM567 consists of a twice frequency voltage-controlled oscillator (VCO) and quadrature dividers which establish the reference signals for phase and amplitude detectors. [11]

To help minimize false triggering, the output signal from the tone decoder is fed into a voltage comparator (LM311) that is set to trigger at the appropriate level. At this stage, the overall process for ultrasonic sensor is completed. To make the system more flexible in term of output performance, the output from the voltage comparator is connected to microcontroller circuit. By using the microcontroller circuit, the output for the system can be varied into more specific. Such dividing the output level based on the range detected by the ultrasonic detector.

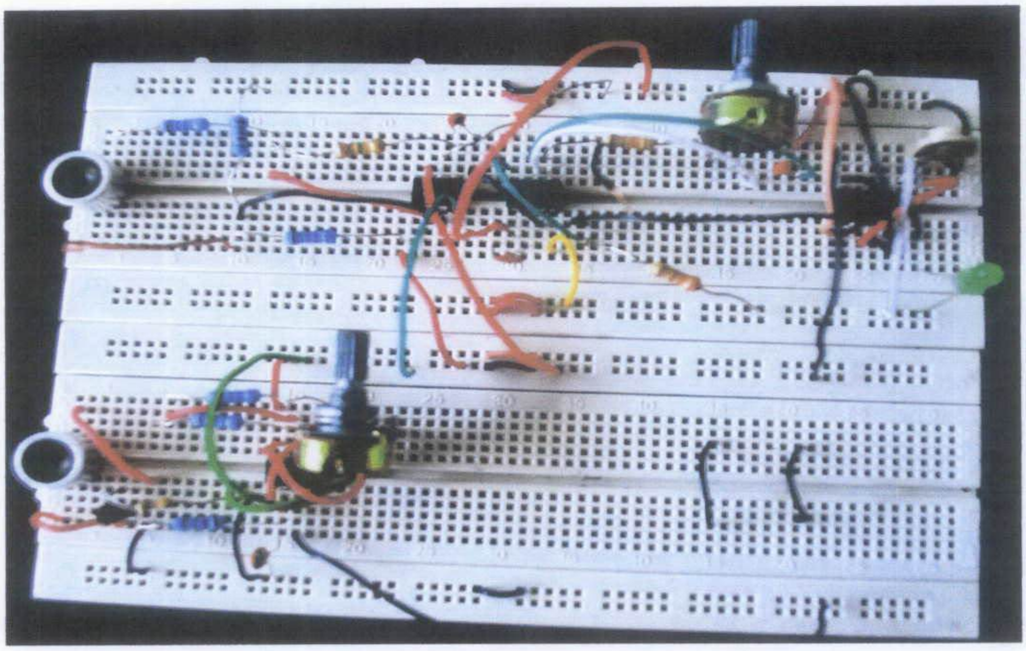

Figure 7: Transmitter and receiver circuit for ultrasonic sensor

Figure 7 above is a picture of the actual circuit created, consists both for transmitter and receiver circuit of the sensor. The ultrasonic transmitter and receiver sensor are placed nearly apart to give better receiving capability to the transmitter.

3.2.3 Microcontroller Introduction:

A microcontroller is a small computer on a single integrated circuit (IC) containing a processor core, memory, and programmable input/output peripherals. Program memory in the form of NOR flash or OTP[1] ROM[2] is also often included on chip, as well as a typically small amount of RAM[3] [12].

NOR flash is a non-volatile memory that can hold the stored data even when the power is out. It allows random data access, and provides fast reading and processing of data, which first made it ideal for code storage [13]. OTP is a type of EPROM[4] sold in plastic packaging. OTP Memory cannot be erased once it has been programmed. OTPs are typically programmed by the customer. ROM devices are programmed at the fabrication step using a special mask containing the customer code. Therefore, the code can not be modified after that step. Costs are highly depending on the flexibility given to the device (ability to be easily erased or programmed) [14].

Microcontrollers are designed for embedded applications [12]. An embedded product is controlled by its own internal microcontroller as opposed to an external controller. Typically, in an embedded system, the microcontroller's ROM is burned with a purpose for specific functions needed for the system. Each one of these peripherals has a microcontroller inside it that performs only one task [15].

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[1] One Time Programmable

[2] Read Only Memory

[3] Random Access Memory

[4] Erasable Programmable Read Only Memory

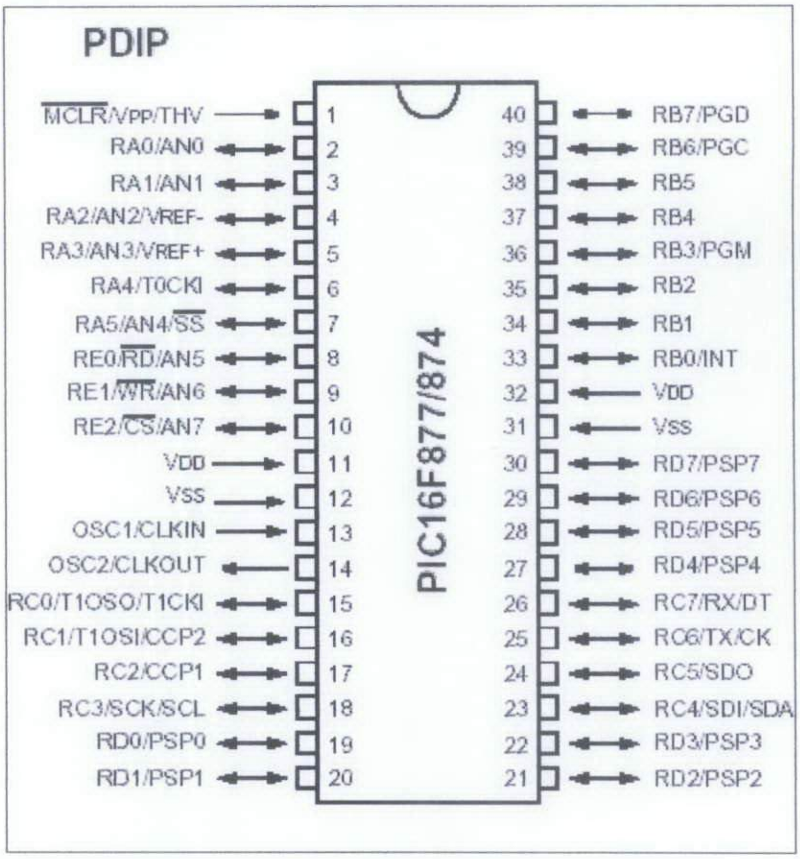


Figure 8: Microcontroller PIC16F877/874

In figure 8 above, is a picture of PIC16F877 microcontroller pin label. It is a chip consists of 40 pins that has a RISC architecture that comes with standard features such as on-chip program (code) ROM, data RAM, data EPROM, clock configuration, timers ADC (Analog to Digital Converter), and I/O (Input/Output) ports [15].

PIC Downloader Process:

Figure 9 below is the programmer device used to program a microcontroller. After compiling the source code using MikroC PRO and test it using PIC Simulator IDE, the code then is programmed into real PIC microcontroller. Device used to program PIC microcontroller is Cytron Downloader and software interface is PICkit 2 Programmer V2.55.

Figure 9: Cytron Downloader to program PIC microcontroller

The software interface used to program PIC microcontroller is PICkit 2 Programmer. The source code compiled by MikroC PRO generate .hex file along with .c file. This .hex file is used by PICkit 2 Programmer to program the PIC microcontroller. After the .hex file is imported, then all data is written into PIC microcontroller. At this stage, the source code compiled before is already downloaded into PIC microcontroller device.

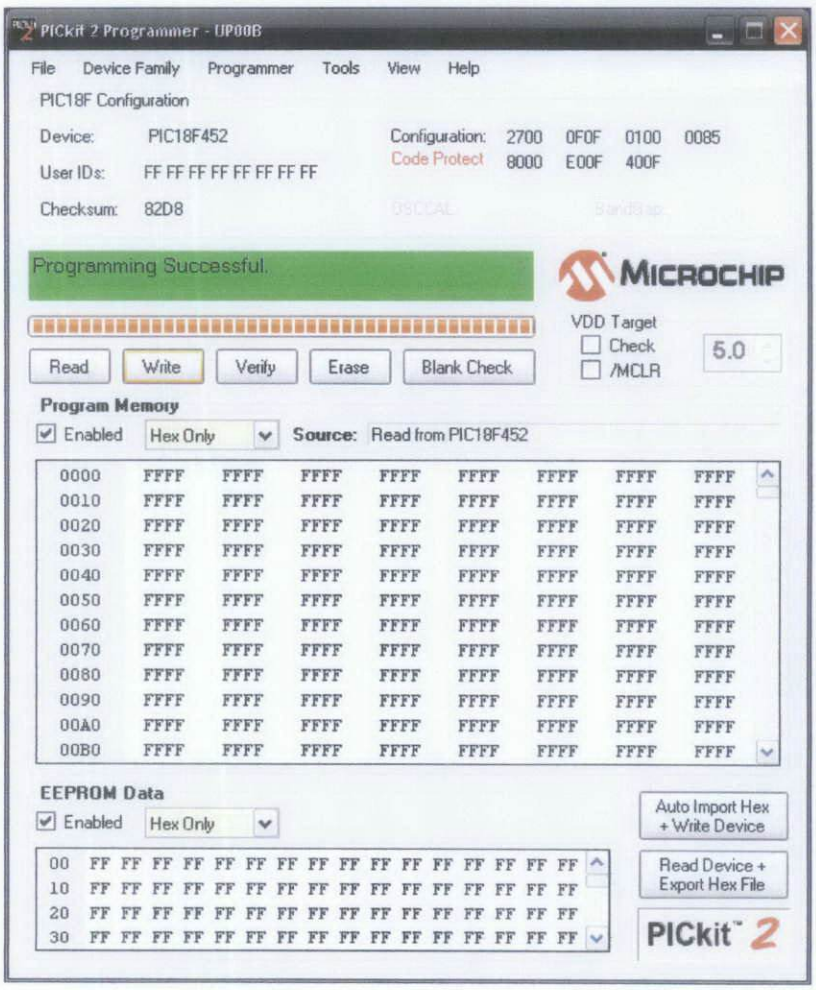


Figure 10: PICkit 2 Programmer

CHAPTER 4

RESULT AND DISCUSSION

Theoretically, ultrasonic transmitter emits a burst signal of about 100 kHz to 250 kHz. This burst from the transmitter travels through the air, hits an object and then bounces back to receiver. At the receiver part, the output signal can be improved higher compare to the transmitter. This is because it is amplified by the op-amp which gives greater output frequency. An experiment is conducted to check minimum and maximum frequency for both transmitter and receiver. This experiment conducted to synchronize and maintain same frequency value so they can transmit and receive signal at same frequency.

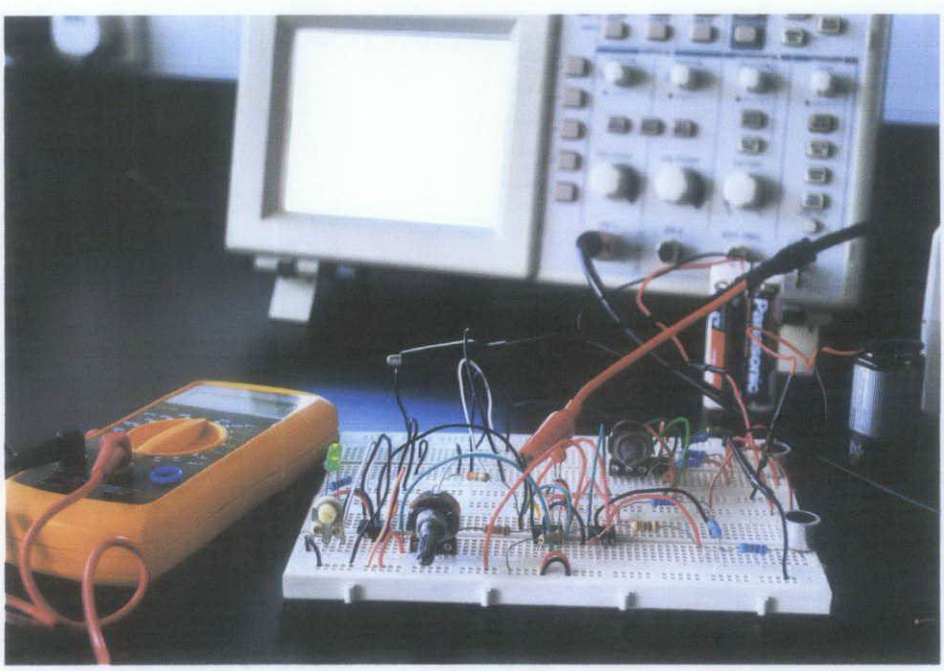


Figure 11: Experiment conducted to check signal frequency

4.1 Frequency Testing

Figure 11 shows experiment conducted to check signal frequency for both transmitter and receiver parts of the ultrasonic sensor. Digital oscilloscope is used to check the frequency at both parts. For transmitter, the frequency can be varied by adjusting 10k Ω potentiometer R5 (refer Figure 5) from minimum to maximum for better performance. To adjust frequency of the receiver part, it can be varied by adjusting 10 k Ω potentiometer R15 (refer Figure 6) in the receiver circuit. Figure 10 is the picture of the frequency results by varying the 10k Ω potentiometer value (R5):

4.1.1 Part 1 (Transmitter)

The experiment for part 1 involving frequencies at transmitter circuit at R5 = 0.16k ohm, 5.83k ohm, and 10.67k ohm.

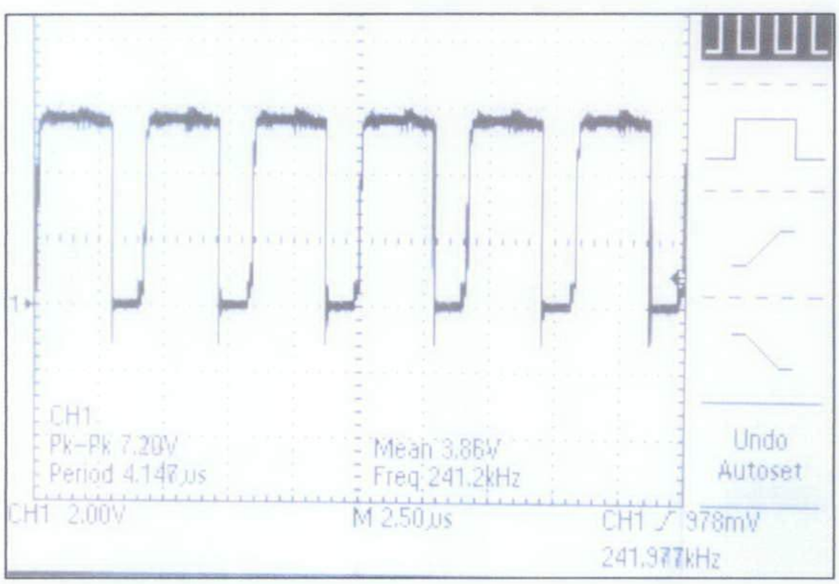


Figure 12: Frequency signal = 241.2 kHz at R5 = 0.16k ohm

In figure 12, frequency signal resulted is 241.2 kHz when 10k Ω potentiometer is adjusted about 0.16k Ω. Peak-to-peak amplitude is about 7.20V.

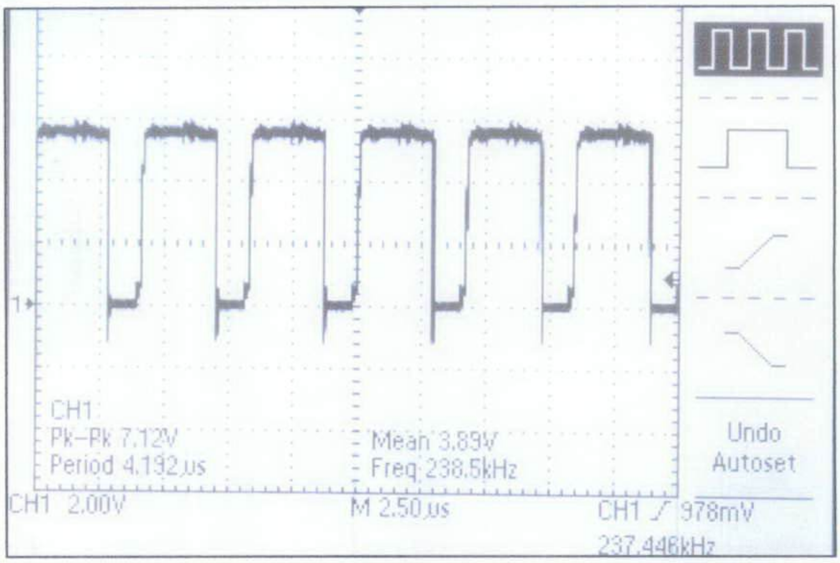


Figure 13: Frequency signal = 238.5 kHz at R5 = 5.83k ohm

In figure 13, the 10k Ω potentiometer value is increased to 5.83k Ω. The frequency signal is decreased to 238.5 kHz higher than the result got in figure 10. The peak-to-peak amplitude is not that differ with the previous result which 7.12V.

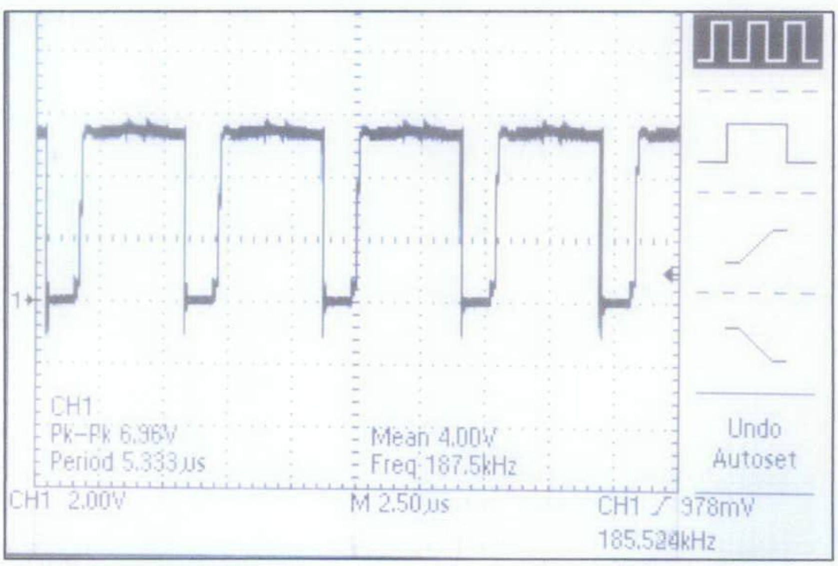


Figure 14: Frequency signal = 187.5 kHz at R5 = 10.67k ohm

In figure 14, 10k Ω potentiometer is adjusted in highest value which is 10.67k Ω and give result of minimum frequency value of 187.5 kHz with peak-to-peak 6.96V amplitude.

The purpose of this experiment is to check the frequency of transmitter circuit emitted by the transmitter sensor. Theoretically, ultrasonic can burst about 100 kHz to 250 kHz frequency. This experiment is done to check the minimum and maximum frequency that the transmitter sensor can emits. Experiment is conducted in room temperature, indoor, in a protected environment. Figure 10, 11 and 12 are the results got from the experiment. The shape of waveform displayed in oscilloscope is a pulse waveform. There are spikes and noise in the waveform displayed. The spikes and noise happen due to disturbance from the environment, such as air wetness, wind, temperature etc. Here is the summary from the data collected in the experiment part 1:

Table 2: Data summary of frequencies at transmitter circuit

	R5 Value (k ohm)	**Frequency Value (kHz)**
1.	0.16	241.2
2.	5.83	238.5
3.	10.67	187.5

From the data collected in table 2, the minimum frequency that the ultrasonic transmitter sensor can drive is about 187.5 kHz. Meanwhile, to get the highest frequency for the sensor, R5 is adjusted in minimum value, thus it gives value of about 241.2 kHz. These frequencies then are received by the receiver to produce final output.

4.1.2 Part 2 (Receiver)

For part 2 experiment, it involves frequencies checking at receiver part. The objective of this experiment is to check minimum and maximum frequency that the receiver can drive. Theoretically, receiver circuit can drive higher maximum frequency compare to transmitter circuit. This is because, the signal received at the receiver is amplified by operational amplifier and make it higher than the original signal.

The minimum frequency at the receiver is obtained by setting R15 at maximum value. Whereas, the maximum frequency at the receiver obtained by setting R15 at minimum value. Fixed frequency value can be set for both transmitter and receiver circuit after getting the minimum and maximum frequency value for the receiver circuit.

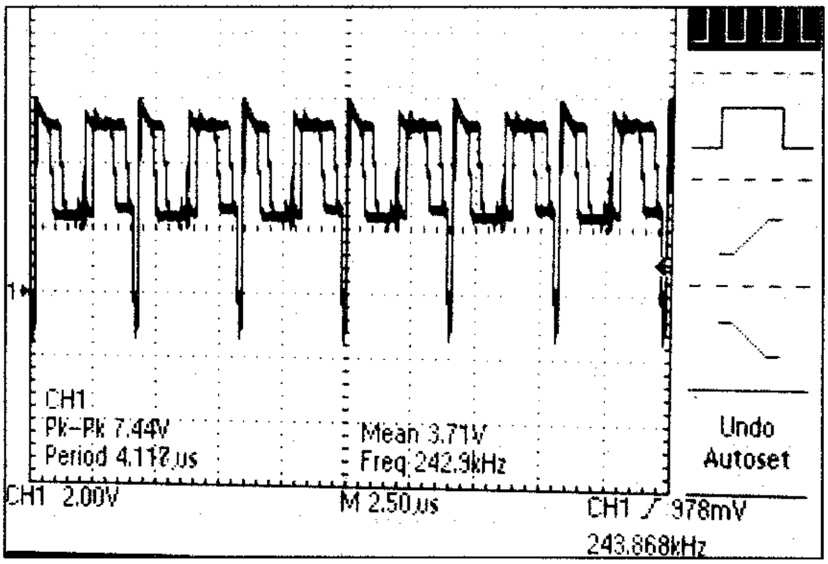


Figure 15: Frequency signal = 242.9 kHz (min) at R15 = maximum

Figure 15 is the result of minimum frequency drive at receiver circuit when 10k Ω potentiometer is adjusted in highest value. The peak-to-peak amplitude value is 7.44V.

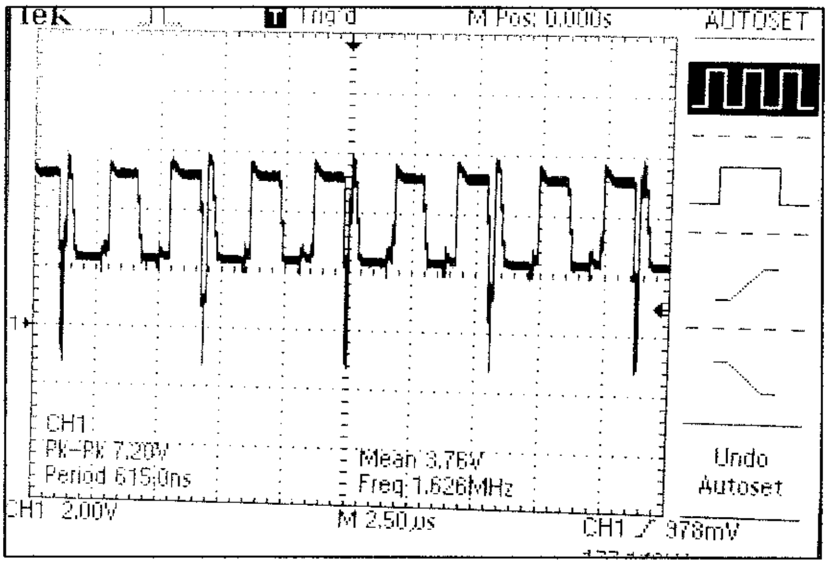


Figure 16: Frequency signal = 1.626 MHz at R15 = minimum

Figure 16 is the result of adjusting the 10k Ω potentiometer in lowest value. The maximum frequency resulted is 1.626 MHz. The peak-to-peak voltage value is 7.20V.

In experiment part 2, the frequency checking is tested at the receiver part of the circuit. Table 3 is the summary result by setting up minimum and maximum frequency at receiver circuit:

Table 3: Data summary of frequencies at receiver circuit

	R15 Value (k ohm)	**Frequency Value (kHz)**
1.	10 (max)	241.9
2.	0 (min)	1600.0

The maximum and minimum range of frequency at receiver is a bit higher than the transmitter circuit. This is because; the signal received at the receiver is amplified by op-amp and drive through transistors. As conclusion, the minimum frequency the receiver sensor can drive is about 241.9 kHz and the maximum frequency is about 1.6 MHz. To make the frequency acted synchronize with the transmitter, it can be maintain at about 240 kHz. The output performances depend on several factors such as wind, temperature, and light. These natural disturbances can thoroughly affect the final result for the experiment.

4.1.3 Synchronizing Frequency Value

After getting expected frequency value in both transmitter and receiver circuit such as minimum and maximum value that the circuit can drive, the fixed frequency value must be set up in both circuits. This is to make sure that both transmitter and receiver can operate synchronically. To maintain the frequency for both circuits, they are fixed to about 240 kHz.

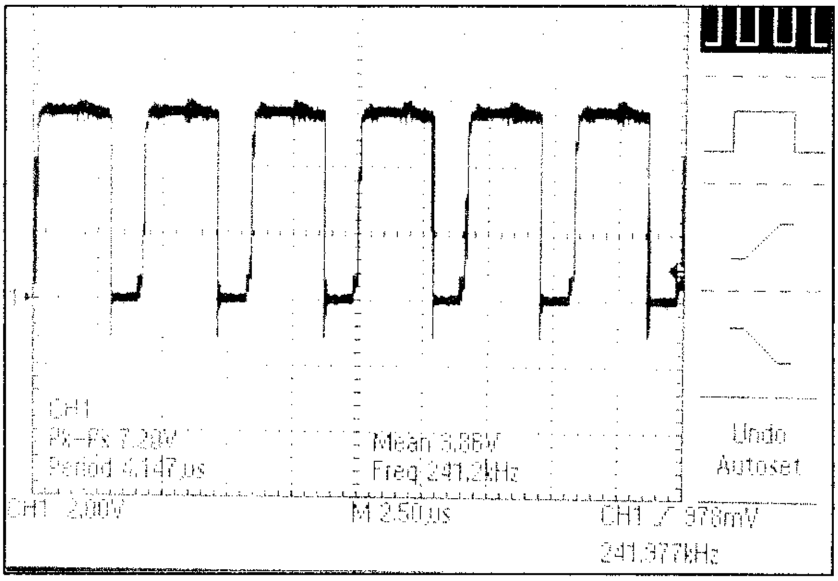


Figure 17: 241.2 kHz frequency at transmitter

Figure 17 is the result of specified frequency value that the transmitter can drive. This value then is synchronizing with frequency at receiver circuit.

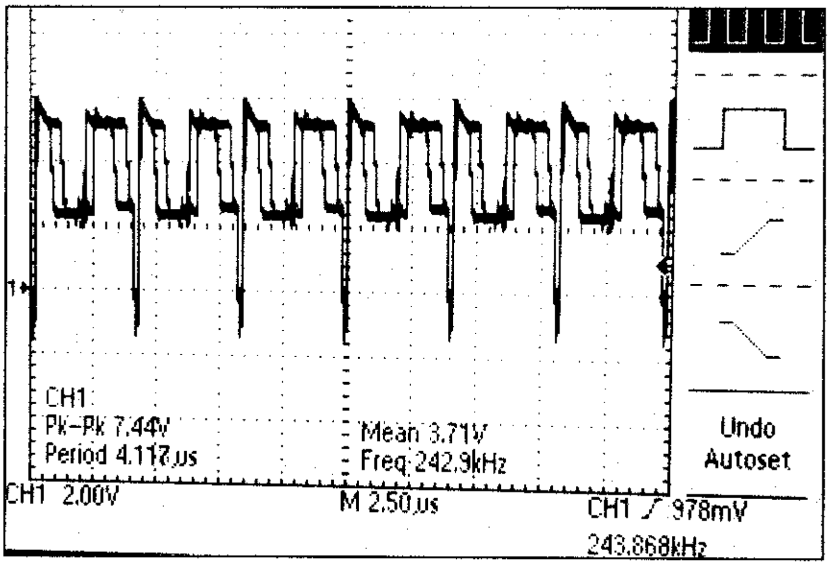


Figure 18: 242.9 kHz frequency at receiver

Figure 18 is the frequency value that is fixed to make it synchronize with the transmitter. The 10k Ω potentiometer is adjusted to get the nearest value of 240 kHz. Thus, both circuit operated in same frequency to maintain the receiving part. The exact 240 kHz value is not that easy to get, as hardware always getting changed due to environment disturbance such as resistance, wind, temperature etc.

4.2 Output Voltage Level

The outputs from sensor circuit are varied base on the input sensed. The voltage difference produced from output is sent to microcontroller circuit for further process. This experiment was conducted to check voltage difference produced at the output. The voltage difference is used to divide the stage level for the final output types. The voltage range declared in microcontroller source code determines what kind of output it should produce.

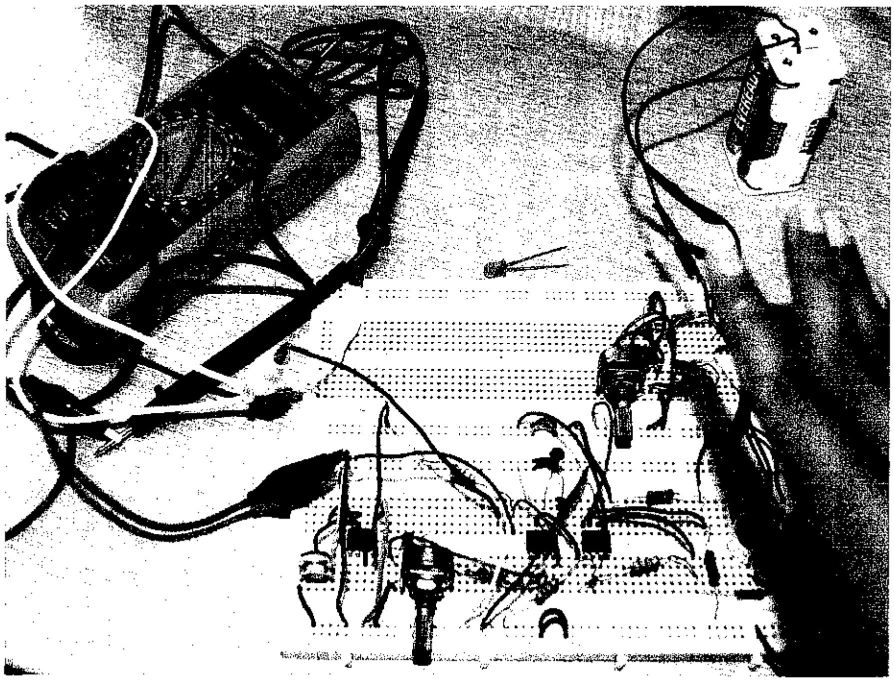


Figure 19: Experiment conducted to test voltage difference

Figure 19 is a picture during the experiment conducted; the output voltage values are not constant. It changed when distraction (hand move on the sensor) is applied on the sensor. The values range is about 1.74V to 1.92V. These values then declared as a constant in microcontroller source code to divide the types of output level.

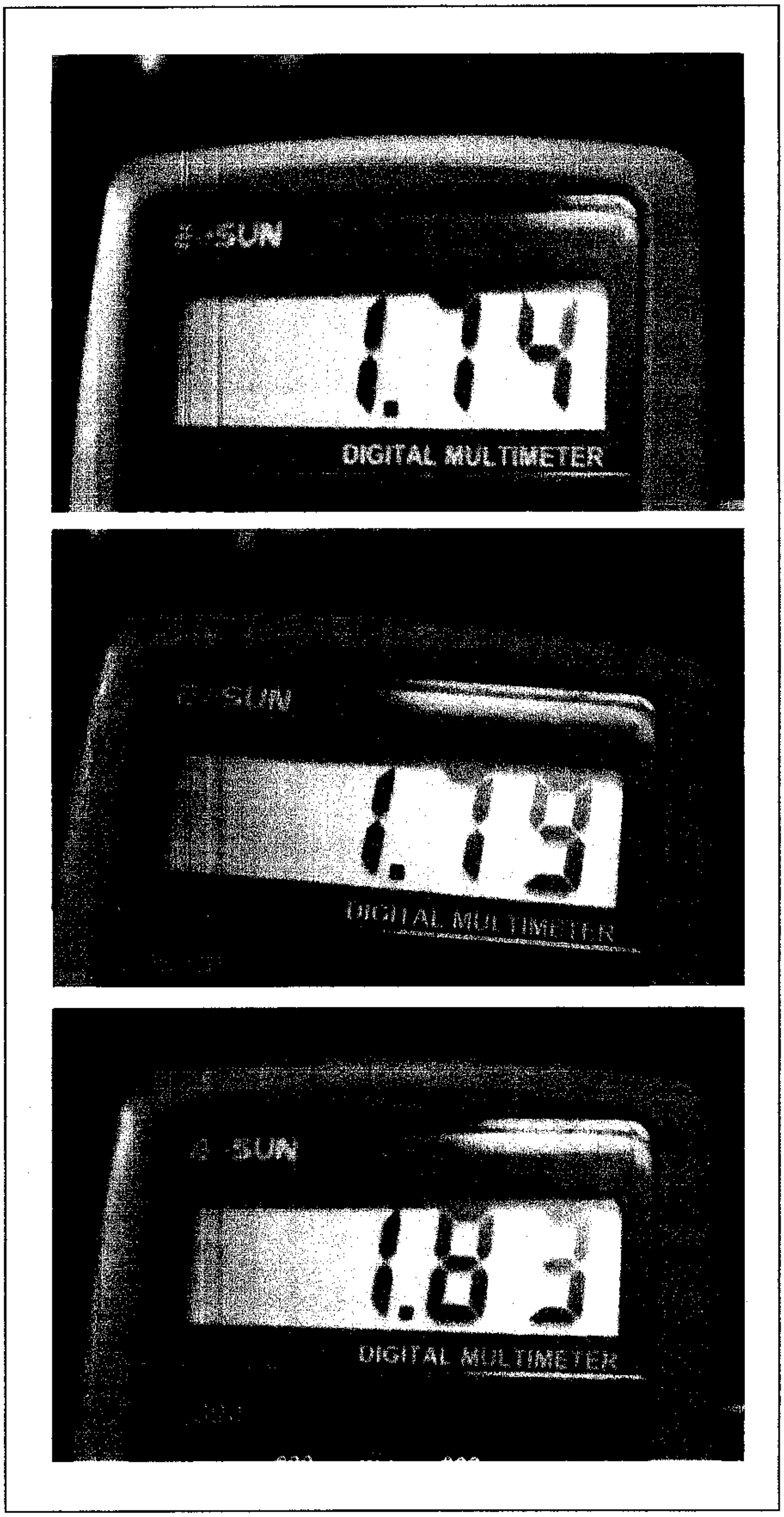


Figure 20: Output voltage difference

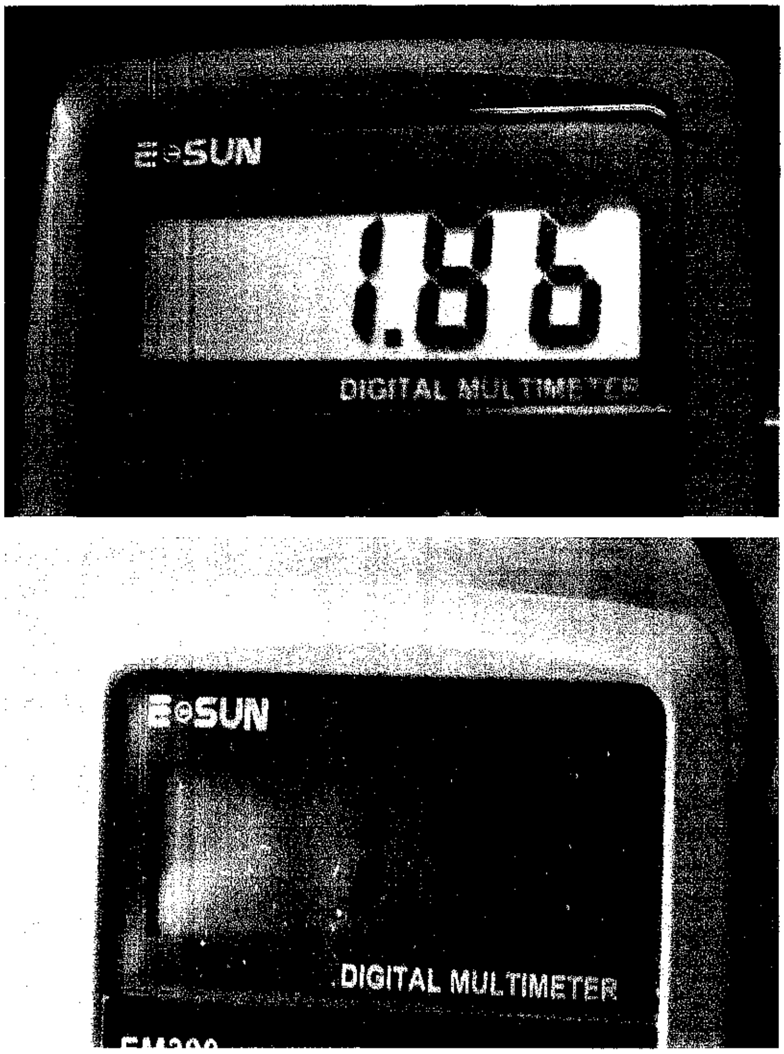


Figure 21: Output voltage difference

From the experiment, the output produced varies when input is applied. The input is distance of distraction between sensor and object. The voltage increases when the object is approaching the sensor. The voltage difference is used to define specific range for the microcontroller input. To be more specific, microcontroller defines two stages for its input. Meanwhile, both inputs have their own output and it is different from each other.

4.3 PIC Programming:

This project involves hardware and software combination. For the software part, the program is written to program PIC microcontroller to read data from sensor circuit. Language used for this project is C language, and compiler used is *MikroC Pro for PIC* version 4.60 (figure 22). Before programming the PIC in hardware using the code, it can be tested first using PIC Simulator IDE software.

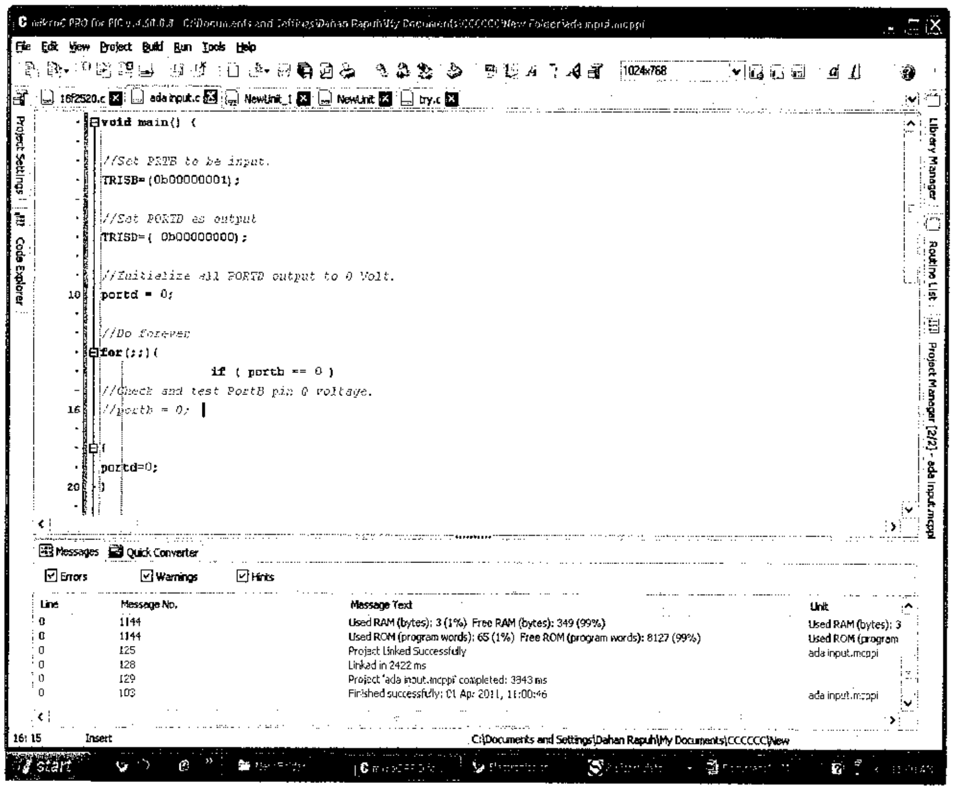


Figure 22: MikroC PRO for PIC C compiler

The basic process for the source code is to read data from sensor circuit, then analyzing the input to decide either it has to send output or not. The PIC Simulator is running automatically after being simulated, the input must be manually declared in the source code to make it read the data. The coding was edited from the original code which is programmed into the PIC, in other words, it has two conditions when input is high and input is low.

```
void main() {

//Set PORTB, to be input.
TRISB=(0b00000001);

//Set PORTD, as output
TRISD=( 0b00000000);

//Initialize all PORTD output to 0 Volt.
portd = 0;

//Do forever
for(;;){
               if ( portb == 0 )

//Check and test PortB pin 0 voltage.

{
portd=0;
}

else

{
portd=0b11111111;
delay_ms(500);
portd=0;
delay_ms(500);

//Turn ON LED (blinking with 0.5 sec delay) when input (PORTB) is high.

      // output_high(PORTD);  //LED Turn ON (blinking)
   }
   }


//Turn OFF LED when input (PORTB) is low.

/*else
      {
        output_low(PORTD);  //LED Turn OFF

        }


   }*/ // close for loop


} // close main
```

Figure 23: Basic source code for microcontroller

In figure 23 above is the basic source code for the microcontroller. It is consists of input-output declaration, assigning input port, input value, output port and output value.

```
//Set PORTB, to be input.
TRISB=(0b00000001);

//Set PORTD, as output
TRISD=( 0b00000000);
```

Figure 24: Input and output declaration

Figure 24 above is the coding fragment for input and output declaration for microcontroller. To declare any specified port as an input port, it has to be written as 'TRISx = (0b00000001)' where 'x' is the port desired to be declared as an input port. Here, PORTB is declared as an input port (TRISB = (0b00000001)). While, to declare a specified port as an output, it has to be written as 'TRISx = (0b00000000)' where x is declared as PORTD to make it an output port (TRISD = (0b00000000)).

```
//Do forever
for(;;){
if ( portb == 0 )

//Check and test PortB pin 0 voltage.

{
portd=0;
}

else

{
portd=0b11111111;
delay_ms(500);
portd=0;
delay_ms(500);
```

Figure 25: Input and output instructions

In figure 25, is the coding fragment to instruct the input and output condition. 'For (;;)' is for looping of the program. At first, input (PORTB) value is divided into two conditions, whether it is logic low (0) or logic high (1). If the input is in logic low, the output in PORTD will equal to '0' or in other words, no output. If the input is in logic high (1), so the value in output (PORTD) will be '1', means there is output produce. The output in logic high (1) is declared as blinking output with delay 0.5 second.

4.3.1 Input Low

```
void main() {

//Set PORTB, to be input.
TRISB=(0b00000001);

//Set PORTD, as output
TRISD=( 0b00000000);

//Initialize all PORTD output to 0 Volt.
portd = 0;

//Do forever
while (1)
{

//Check and test PortB pin LOW voltage.
portb = 0;

portd=0;                            //portd in logic low

}
}
```

Figure 26: Source code when input is low (no input)

Before programming the hardware with the source code, it has to be tested first in software called PIC Simulator IDE. The program running automatically after it is simulated, so it need fix input value for it to display the output. The whole source code is divided into two, input low and input high. Figure 25 above is the coding fragment for input low which resulting no output produce in output port.

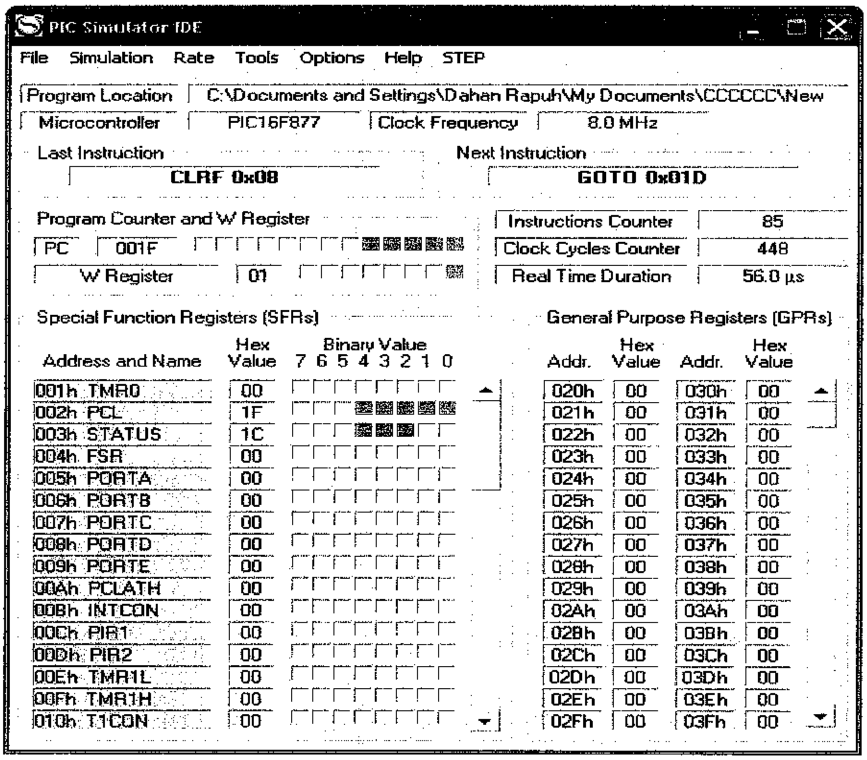


Figure 27: PIC Simulator IDE simulation process

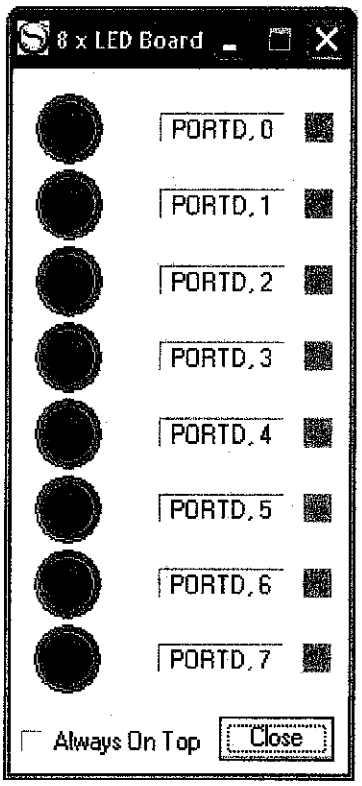


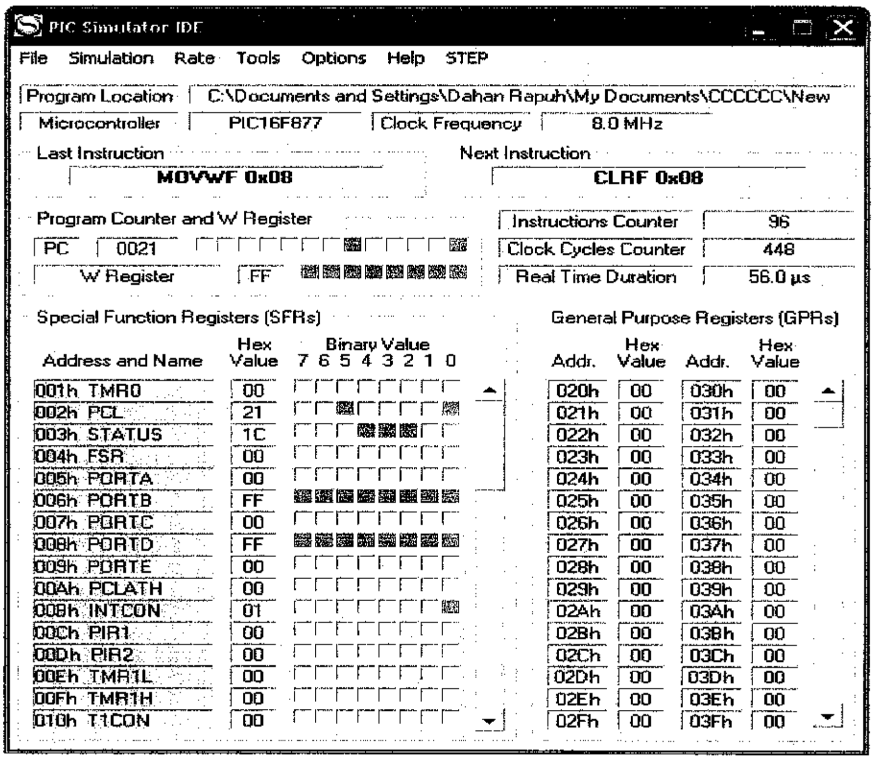
Figure 28: 8 x LED Board for PIC Simulator Output Tool

In figure 26, the input (declared in PORTB in PIC pin) is set as low. Figure 27 shown is the PIC Simulator IDE used to test the coding. When simulating the program, the output (declared in PORTD in PIC pin) doesn't produce any output. The view the output, 8 x LED Board is used and PORTD is assigned as output as shown in figure 28. As a result, no output display both in the LED Board and also SFRs (Special Function Register) shown in figure 27.

4.3.2 Input High

```
void main() {

//Set PORTB, to be input.
TRISB=(0b00000001);

//Set PORTD, as output
TRISD=( 0b00000000);

//Initialize all PORTD output to 0 Volt.
portd = 0;

//Do forever
while (1)
{

//Check and test PortB pin HIGH voltage.
portb = 255;

portd=0b11111111;     //portd in logic high
delay_ms(500);
portd=0;                        //portd in logic low (to
get LED blinking effect)
delay_ms(500);

}
}
```

Figure 29: Source code when input is high (input available)



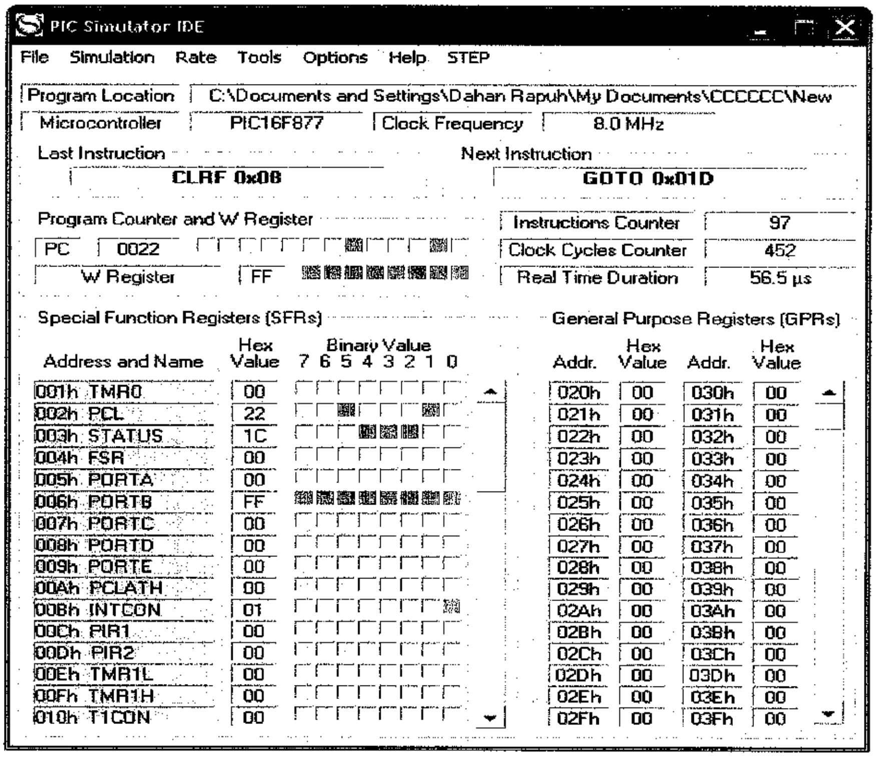


Figure 30: PIC Simulator IDE simulation process

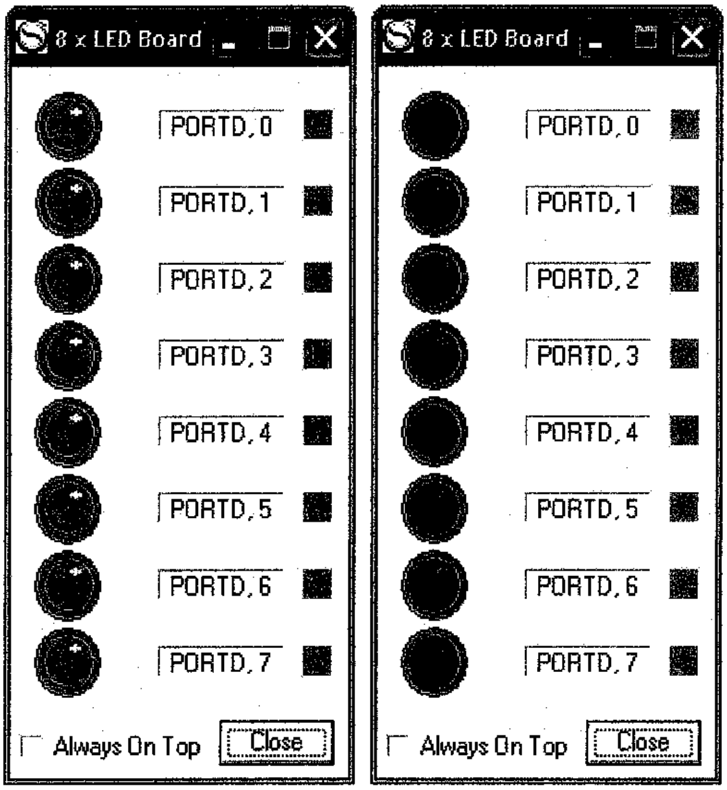


Figure 31: 8 x LED Board for PIC Simulator Output Tool

Figure 29 shown is the coding fragment for input high. The input (declared in PORTB in PIC pin) is set as high. When simulating the program, the output (declared in PORTD in PIC pin) produce output. The view the output, 8 x LED Board is used and PORTD is assigned as output as shown in figure 31. In the coding (figure 29), the output is instructed to blinking with delay of 0.5 second each. As a result, LED in the LED Board blinking for 0.5 second when the program is simulating. Same with SFRs (Special Function Register) in the main window of PIC Simulator IDE (figure 30). The SFR for PORTD highlighted continuously with 0.5 second delay.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

It is known there are many factors that can lead to road accident, and collision is one of them. Therefore, it is necessary to develop sensitive detection tools to help drivers to take precaution during driving. The car sensor development is a very useful product to be implemented. It is an alternative tool to reduce car accident statistics. The whole process involved hardware and software design. This project also requires prototype fabrication to prove the system's function.

The project is done by using ultrasonic transducer as the main sensing device. Input and output recognition is controlled by microcontroller part. It can read data and send input to produce output. The overall process for this project involved hardware and software interfacing. It is a useful project and need to be improved for better performance. In conclusion, this project is a useful system in automobile technology, which is used to warn the driver of the immediate danger of collision and prevent accident.

5.2 Recommendation

Several modifications were made to accommodate the project goal and objective. The sensor itself must be sensitive enough to detect any upcoming object. The detection accuracy must be controlled to avoid any unnecessary noise or disturbance. Microcontroller enhancement will lead to more sophisticated project and improve the system performance.

Although the basic objective of this project to design an alarm system to prevent accident, the sensor can not differentiate what kind obstacle approaching. It will recognize everything as potential hazard that may cause accident. So the further works will focus on special recognition system on how to differentiate object whether it is a potential hazard object that may cause accident or not.

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APPENDIX A

Gantt Chart Fyp 1

Gantt Chart Fyp 2

APPENDIX C

Gantt Chart Fyp 1

No.	Detail/ Week	1	2	3	4	5	6	7		8	9	10	11	12	13	14
1	Title selection	■							MID SEMESTER BREAK							
2	Preliminary research work		■	■												
3	Submission of preliminary report				■											
4	Continue project work					■	■	■								
5	Submission of progress report									■						
5	Project work continue- Model															
6	Seminar										■	■				
7	Project work											■	■	■		
8	Draft report submission														■	
9	Final report submission															■

APPENDIX C

Gantt Chart Fyp 2

	Task	January				February				March				April				May		
1.	Hardware establishment				■	■														
2.	Writing source code for software					■	■													
3.	Interfacing software and hardware						■	■	■	■										
4.	Submission of Progress Report										14/3									
5.	Project work on Recommendation Task from Progress Report										■	■	■	■						
6.	Submission of Draft report														12/4					
7.	Submission Final Report (soft bound)																28/4			
8.	Submission of Technical Paper																28/4			
9.	Oral Presentation																	3/5		
10.	Submission Final Report (hard bound)																			26/5

APPENDIX B

Datasheets

PIC 16F877

MICROCHIP

PIC16F87X
Data Sheet

28/40-Pin 8-Bit CMOS FLASH Microcontrollers

PIC16F87X

28/40-Pin 8-Bit CMOS FLASH Microcontrollers

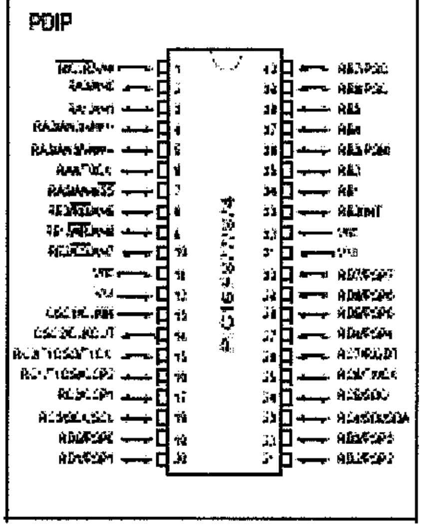
Devices Included in this Data Sheet:

- PIC16F873
- PIC16F874
- PIC16F876
- PIC16F877

Microcontroller Core Features:

- High performance RISC CPU
- Only 35 single word instructions to learn
- All single cycle instructions except for program branches which are two cycle
- Operating speed: DC - 20 MHz clock input
  DC - 200 ns instruction cycle
- Up to 8K x 14 words of FLASH Program Memory,
  Up to 368 x 8 bytes of Data Memory (RAM)
  Up to 256 x 8 bytes of EEPROM Data Memory
- Pinout compatible to the PIC16C73B/74B/76/77
- Interrupt capability (up to 14 sources)
- Eight level deep hardware stack
- Direct, indirect and relative addressing modes
- Power-on Reset (POR)
- Power-up Timer (PWRT) and Oscillator Start-up Timer (OST)
- Watchdog Timer (WDT) with its own on-chip RC oscillator for reliable operation
- Programmable code protection
- Power saving SLEEP mode
- Selectable oscillator options
- Low power, high speed CMOS FLASH/EEPROM technology
- Fully static design
- In-Circuit Serial Programming™ (ICSP) via two pins
- Single 5V In-Circuit Serial Programming capability
- In-Circuit Debugging via two pins
- Processor read/write access to program memory
- Wide operating voltage range: 2.0V to 5.5V
- High Sink/Source Current: 25 mA
- Commercial, Industrial and Extended temperature ranges
- Low-power consumption:
  - < 0.6 mA typical @ 3V, 4 MHz
  - 20 µA typical @ 3V, 32 kHz
  - < 1 µA typical standby current

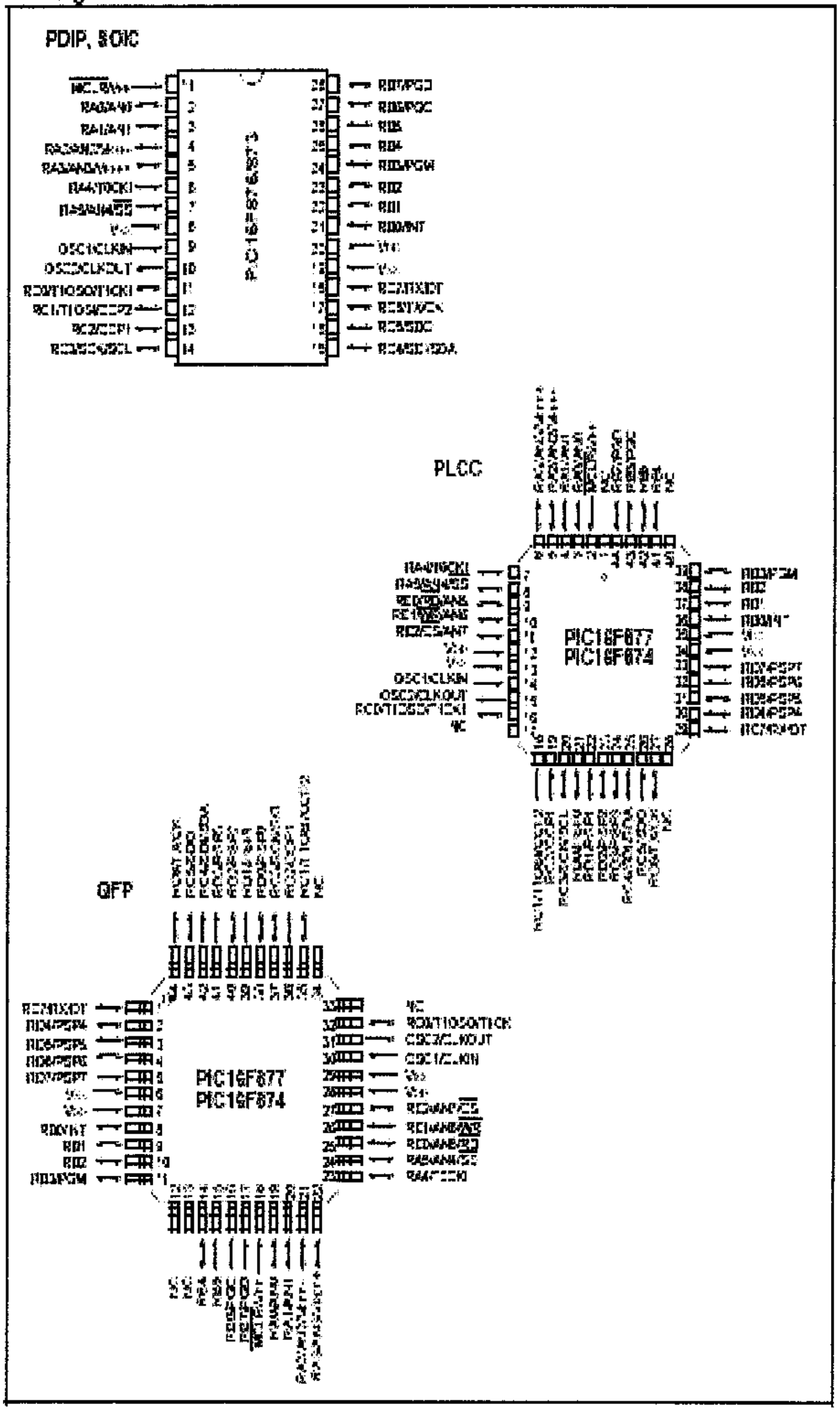
Pin Diagram



Peripheral Features:

- Timer0: 8-bit timer/counter with 8-bit prescaler
- Timer1: 16-bit timer/counter with prescaler, can be incremented during SLEEP via external crystal/clock
- Timer2: 8-bit timer/counter with 8-bit period register, prescaler and postscaler
- Two Capture, Compare, PWM modules
  - Capture is 16-bit, max. resolution is 12.5 ns
  - Compare is 16-bit, max. resolution is 200 ns
  - PWM max. resolution is 10-bit
- 10-bit multi-channel Analog-to-Digital converter
- Synchronous Serial Port (SSP) with SPI™ (Master mode) and I²C™ (Master/Slave)
- Universal Synchronous Asynchronous Receiver Transmitter (USART/SCI) with 9-bit address detection
- Parallel Slave Port (PSP) 8-bits wide, with external RD, WR and CS controls (40/44-pin only)
- Brown-out detection circuitry for Brown-out Reset (BOR)

Pin Diagrams



Key Features PICmicro™ Mid-Range Reference Manual (DS33023)	PIC16F873	PIC16F874	PIC16F876	PIC16F877
Operating Frequency	DC - 20 MHz	DC - 20 MHz	DC - 20 MHz	DC - 20 MHz
RESETS (and Delays)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)
FLASH Program Memory (14-bit words)	4K	4K	8K	8K
Data Memory (bytes)	192	192	368	368
EEPROM Data Memory	128	128	256	256
Interrupts	13	14	13	14
I/O Ports	Ports A,B,C	Ports A,B,C,D,E	Ports A,B,C	Ports A,B,C,D,E
Timers	3	3	3	3
Capture/Compare/PWM Modules	2	2	2	2
Serial Communications	MSSP, USART	MSSP, USART	MSSP, USART	MSSP, USART
Parallel Communications	—	PSP	—	PSP
10-bit Analog-to-Digital Module	5 input channels	8 input channels	5 input channels	8 input channels
Instruction Set	35 Instructions	35 Instructions	35 Instructions	35 Instructions

1.0 DEVICE OVERVIEW

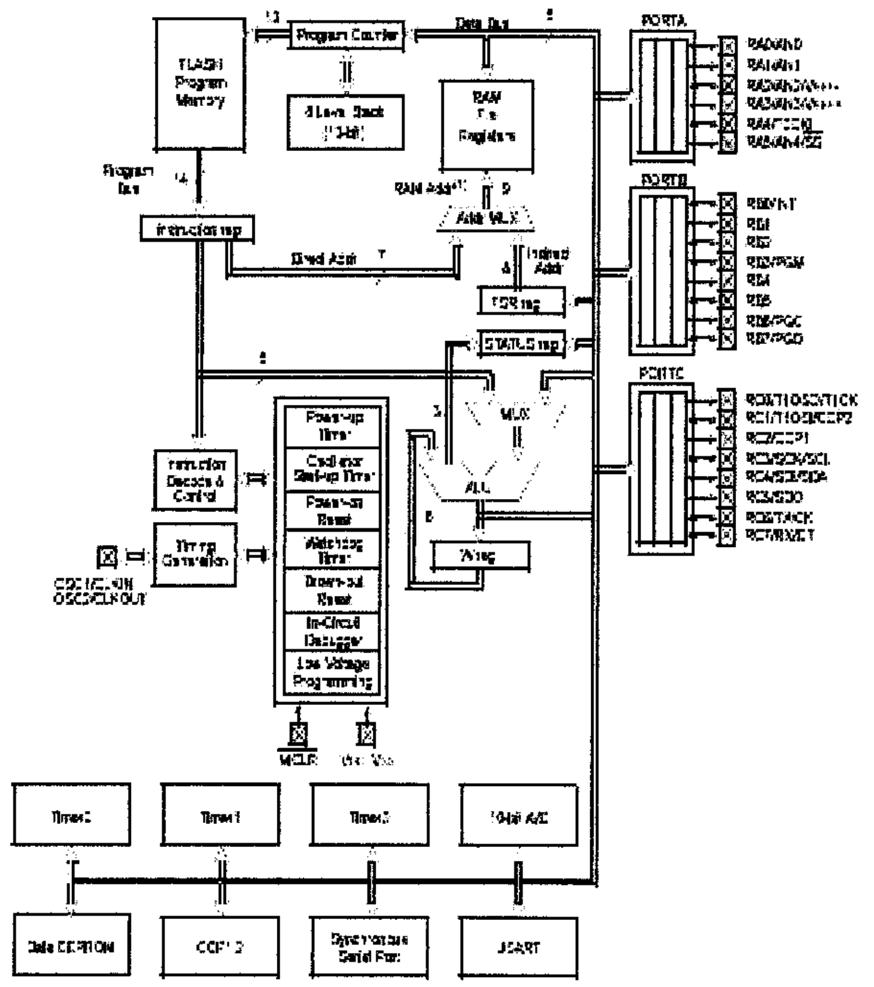
This document contains device specific information. Additional information may be found in the PICmicro™ Mid-Range Reference Manual (DS33023), which may be obtained from your local Microchip Sales Representative or downloaded from the Microchip website. The Reference Manual should be considered a complementary document to this data sheet, and is highly recommended reading for a better understanding of the device architecture and operation of the peripheral modules.

There are four devices (PIC16F873, PIC16F874, PIC16F876 and PIC16F877) covered by this data sheet. The PIC16F876/873 devices come in 28-pin packages and the PIC16F877/874 devices come in 40-pin packages. The Parallel Slave Port is not implemented on the 28-pin devices.

The following device block diagrams are sorted by pin number: 28-pin for Figure 1-1 and 40-pin for Figure 1-2. The 28-pin and 40-pin pinouts are listed in Table 1-1 and Table 1-2, respectively.

FIGURE 1-1: PIC16F873 AND PIC16F876 BLOCK DIAGRAM

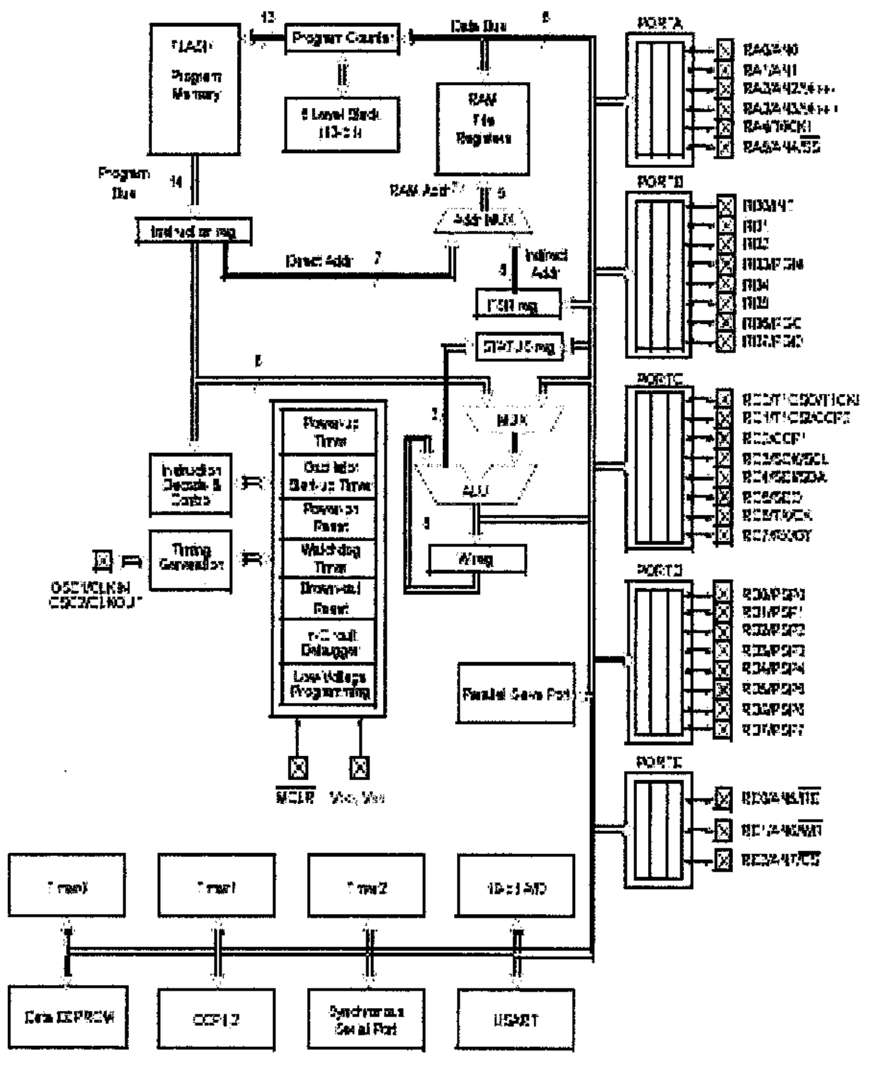
Device	Program FLASH	Data Memory	Data EEPROM
PIC16F873	4K	192 Bytes	128 Bytes
PIC16F876	8K	368 Bytes	256 Bytes



Note 1: Higher order bits are from the STATUS register.

FIGURE 1-2: PIC16F874 AND PIC16F877 BLOCK DIAGRAM

Device	Program FLASH	Data Memory	Data EEPROM
PIC16F874	4K	192 Bytes	128 Bytes
PIC16F877	8K	368 Bytes	256 Bytes



Note 1: Higher order bits are from the STATUS register.

TABLE 1-1: PIC16F873 AND PIC16F876 PINOUT DESCRIPTION

Pin Name	DIP Pin#	SOIC Pin#	I/O/P Type	Buffer Type	Description
OSC1/CLKIN	9	9	I	ST/CMOS(3)	Oscillator crystal input/external clock source input.
OSC2/CLKOUT	10	10	O	—	Oscillator crystal output. Connects to crystal or resonator in crystal oscillator mode. In RC mode, the OSC2 pin outputs CLKOUT which has 1/4 the frequency of OSC1, and denotes the instruction cycle rate.
MCLR/VPP	1	1	I/P	ST	Master Clear (Reset) input or programming voltage input. This pin is an active low RESET to the device.
					PORTA is a bi-directional I/O port.
RA0/AN0	2	2	I/O	TTL	RA0 can also be analog input0.
RA1/AN1	3	3	I/O	TTL	RA1 can also be analog input1.
RA2/AN2/VREF-	4	4	I/O	TTL	RA2 can also be analog input2 or negative analog reference voltage.
RA3/AN3/VREF+	5	5	I/O	TTL	RA3 can also be analog input3 or positive analog reference voltage.
RA4/T0CKI	6	6	I/O	ST	RA4 can also be the clock input to the Timer0 module. Output is open drain type.
RA5/SS/AN4	7	7	I/O	TTL	RA5 can also be analog input4 or the slave select for the synchronous serial port.
					PORTB is a bi-directional I/O port. PORTB can be software programmed for internal weak pull-up on all inputs.
RB0/INT	21	21	I/O	TTL/ST(1)	RB0 can also be the external interrupt pin.
RB1	22	22	I/O	TTL	
RB2	23	23	I/O	TTL	
RB3/PGM	24	24	I/O	TTL	RB3 can also be the low voltage programming input.
RB4	25	25	I/O	TTL	Interrupt-on-change pin.
RB5	26	26	I/O	TTL	Interrupt-on-change pin.
RB6/PGC	27	27	I/O	TTL/ST(2)	Interrupt-on-change pin or In-Circuit Debugger pin. Serial programming clock.
RB7/PGD	28	28	I/O	TTL/ST(2)	Interrupt-on-change pin or In-Circuit Debugger pin. Serial programming data.
					PORTC is a bi-directional I/O port.
RC0/T1OSO/T1CKI	11	11	I/O	ST	RC0 can also be the Timer1 oscillator output or Timer1 clock input.
RC1/T1OSI/CCP2	12	12	I/O	ST	RC1 can also be the Timer1 oscillator input or Capture2 input/Compare2 output/PWM2 output.
RC2/CCP1	13	13	I/O	ST	RC2 can also be the Capture1 input/Compare1 output/PWM1 output.
RC3/SCK/SCL	14	14	I/O	ST	RC3 can also be the synchronous serial clock input/output for both SPI and I²C modes.
RC4/SDI/SDA	15	15	I/O	ST	RC4 can also be the SPI Data In (SPI mode) or data I/O (I²C mode).
RC5/SDO	16	16	I/O	ST	RC5 can also be the SPI Data Out (SPI mode).
RC6/TX/CK	17	17	I/O	ST	RC6 can also be the USART Asynchronous Transmit or Synchronous Clock.
RC7/RX/DT	18	18	I/O	ST	RC7 can also be the USART Asynchronous Receive or Synchronous Data.
VSS	8, 19	8, 19	P	—	Ground reference for logic and I/O pins.
VDD	20	20	P	—	Positive supply for logic and I/O pins.

Legend: I = input O = output I/O = input/output P = power
— = Not used TTL = TTL input ST = Schmitt Trigger input

Note 1: This buffer is a Schmitt Trigger input when configured as the external interrupt.
2: This buffer is a Schmitt Trigger input when used in Serial Programming mode.
3: This buffer is a Schmitt Trigger input when configured in RC oscillator mode and a CMOS input otherwise.

TABLE 1-2: PIC16F874 AND PIC16F877 PINOUT DESCRIPTION

Pin Name	DIP Pin#	PLCC Pin#	QFP Pin#	I/O/P Type	Buffer Type	Description
OSC1/CLKIN	13	14	30	I	ST/CMOS[4]	Oscillator crystal input/external clock source input.
OSC2/CLKOUT	14	15	31	O	—	Oscillator crystal output. Connects to crystal or resonator in crystal oscillator mode. In RC mode, OSC2 pin outputs CLKOUT which has 1/4 the frequency of OSC1, and denotes the instruction cycle rate.
MCLR/VPP	1	2	18	I/P	ST	Master Clear (Reset) input or programming voltage input. This pin is an active low RESET to the device.
						PORTA is a bi-directional I/O port.
RA0/AN0	2	3	19	I/O	TTL	RA0 can also be analog input0.
RA1/AN1	3	4	20	I/O	TTL	RA1 can also be analog input1.
RA2/AN2/VREF-	4	5	21	I/O	TTL	RA2 can also be analog input2 or negative analog reference voltage.
RA3/AN3/VREF+	5	6	22	I/O	TTL	RA3 can also be analog input3 or positive analog reference voltage.
RA4/T0CKI	6	7	23	I/O	ST	RA4 can also be the clock input to the Timer0 timer/counter. Output is open drain type.
RA5/SS/AN4	7	8	24	I/O	TTL	RA5 can also be analog input4 or the slave select for the synchronous serial port.
						PORTB is a bi-directional I/O port. PORTB can be software programmed for internal weak pull-up on all inputs.
RB0/INT	33	36	8	I/O	TTL/ST[1]	RB0 can also be the external interrupt pin.
RB1	34	37	9	I/O	TTL	
RB2	35	38	10	I/O	TTL	
RB3/PGM	36	39	11	I/O	TTL	RB3 can also be the low voltage programming input.
RB4	37	41	14	I/O	TTL	Interrupt-on-change pin.
RB5	38	42	15	I/O	TTL	Interrupt-on-change pin.
RB6/PGC	39	43	16	I/O	TTL/ST[2]	Interrupt-on-change pin or In-Circuit Debugger pin. Serial programming clock.
RB7/PGD	40	44	17	I/O	TTL/ST[2]	Interrupt-on-change pin or In-Circuit Debugger pin. Serial programming data.

Legend: I = input O = output I/O = input/output P = power
— = Not used TTL = TTL input ST = Schmitt Trigger input

Note 1: This buffer is a Schmitt Trigger input when configured as an external interrupt.
2: This buffer is a Schmitt Trigger input when used in Serial Programming mode.
3: This buffer is a Schmitt Trigger input when configured as general purpose I/O and a TTL input when used in the Parallel Slave Port mode (for interfacing to a microprocessor bus).
4: This buffer is a Schmitt Trigger input when configured in RC oscillator mode and a CMOS input otherwise.

TABLE 1-2: PIC16F874 AND PIC16F877 PINOUT DESCRIPTION (CONTINUED)

Pin Name	DIP Pin#	PLCC Pin#	QFP Pin#	I/O/P Type	Buffer Type	Description
						PORTC is a bi-directional I/O port.
RC0/T1OSO/T1CKI	15	16	32	I/O	ST	RC0 can also be the Timer1 oscillator output or a Timer1 clock input.
RC1/T1OSI/CCP2	16	18	35	I/O	ST	RC1 can also be the Timer1 oscillator input or Capture2 input/Compare2 output/PWM2 output.
RC2/CCP1	17	19	36	I/O	ST	RC2 can also be the Capture1 input/Compare1 output/PWM1 output.
RC3/SCK/SCL	18	20	37	I/O	ST	RC3 can also be the synchronous serial clock input/output for both SPI and I²C modes.
RC4/SDI/SDA	23	25	42	I/O	ST	RC4 can also be the SPI Data In (SPI mode) or data I/O (I²C mode).
RC5/SDO	24	26	43	I/O	ST	RC5 can also be the SPI Data Out (SPI mode).
RC6/TX/CK	25	27	44	I/O	ST	RC6 can also be the USART Asynchronous Transmit or Synchronous Clock.
RC7/RX/DT	26	29	1	I/O	ST	RC7 can also be the USART Asynchronous Receive or Synchronous Data.
						PORTD is a bi-directional I/O port or parallel slave port when interfacing to a microprocessor bus.
RD0/PSP0	19	21	38	I/O	ST/TTL(3)	
RD1/PSP1	20	22	39	I/O	ST/TTL(3)	
RD2/PSP2	21	23	40	I/O	ST/TTL(3)	
RD3/PSP3	22	24	41	I/O	ST/TTL(3)	
RD4/PSP4	27	30	2	I/O	ST/TTL(3)	
RD5/PSP5	28	31	3	I/O	ST/TTL(3)	
RD6/PSP6	29	32	4	I/O	ST/TTL(3)	
RD7/PSP7	30	33	5	I/O	ST/TTL(3)	
						PORTE is a bi-directional I/O port.
RE0/$\overline{RD}$/AN5	8	9	25	I/O	ST/TTL(3)	RE0 can also be read control for the parallel slave port, or analog input5.
RE1/$\overline{WR}$/AN6	9	10	26	I/O	ST/TTL(3)	RE1 can also be write control for the parallel slave port, or analog input6.
RE2/$\overline{CS}$/AN7	10	11	27	I/O	ST/TTL(3)	RE2 can also be select control for the parallel slave port, or analog input7.
VSS	12,31	13,34	6,29	P	—	Ground reference for logic and I/O pins.
VDD	11,32	12,35	7,28	P	—	Positive supply for logic and I/O pins.
NC	—	1,17,28,40	12,13,33,34		—	These pins are not internally connected. These pins should be left unconnected.

Legend: I = input O = output I/O = input/output P = power
— = Not used TTL = TTL input ST = Schmitt Trigger input

Note 1: This buffer is a Schmitt Trigger input when configured as an external interrupt.
2: This buffer is a Schmitt Trigger input when used in Serial Programming mode.
3: This buffer is a Schmitt Trigger input when configured as general purpose I/O and a TTL input when used in the Parallel Slave Port mode (for interfacing to a microprocessor bus).
4: This buffer is a Schmitt Trigger input when configured in RC oscillator mode and a CMOS input otherwise.

SGS-THOMSON MICROELECTRONICS

NE555
SA555 - SE555

GENERAL PURPOSE SINGLE BIPOLAR TIMERS

- LOW TURN OFF TIME
- MAXIMUM OPERATING FREQUENCY GREATER THAN 500kHz
- TIMING FROM MICROSECONDS TO HOURS
- OPERATES IN BOTH ASTABLE AND MONOSTABLE MODES
- HIGH OUTPUT CURRENT CAN SOURCE OR SINK 200mA
- ADJUSTABLE DUTY CYCLE
- TTL COMPATIBLE
- TEMPERATURE STABILITY OF 0.005% PER°C

N
DIP8
(Plastic Package)

D
SO8
(Plastic Micropackage)

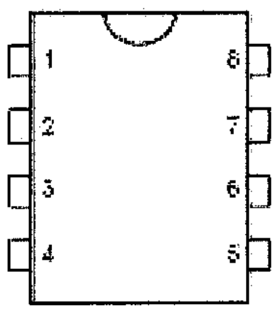
DESCRIPTION

The NE555 monolithic timing circuit is a highly stable controller capable of producing accurate time delays or oscillation. In the time delay mode of operation, the time is precisely controlled by one external resistor and capacitor. For a stable operation as an oscillator, the free running frequency and the duty cycle are both accurately controlled with two external resistors and one capacitor. The circuit may be triggered and reset on falling waveforms, and the output structure can source or sink up to 200mA. The NE555 is available in plastic and ceramic minidip package and in a 8-lead micropackage and in metal can package version.

ORDER CODES

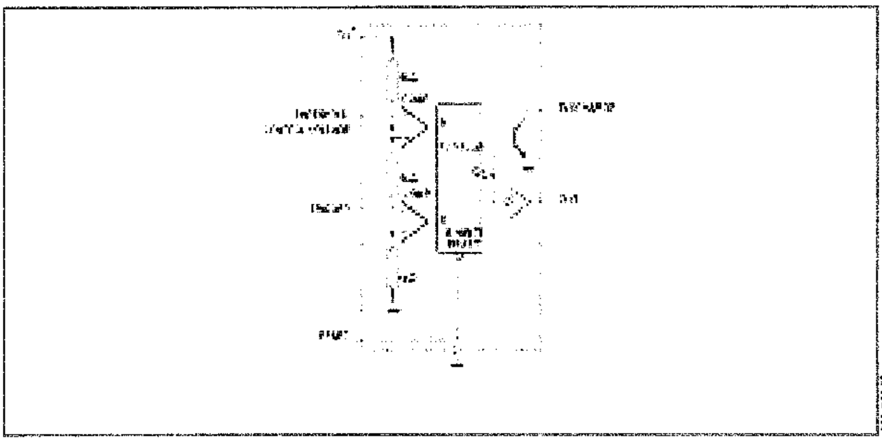
Part Number	Temperature Range	Package	
		N	D
NE555	0°C, 70°C	•	•
SA555	-40°C, 105°C	•	•
SE555	-55°C, 125°C	•	•

PIN CONNECTIONS (top view)

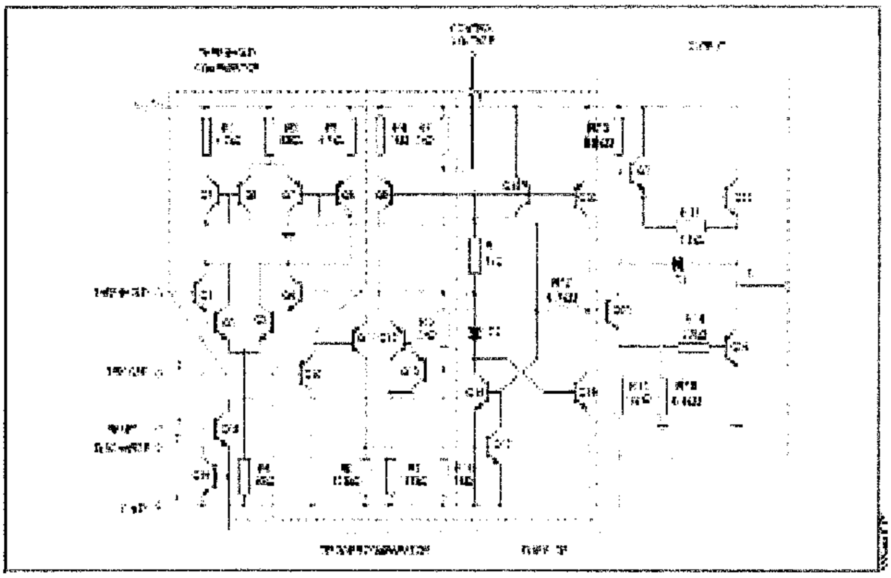


1 - GND
2 - Trigger
3 - Output
4 - Reset
5 - Control voltage
6 - Threshold
7 - Discharge
8 - Vcc

BLOCK DIAGRAM



SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter		Value	Unit
V_{CC}	Supply Voltage		18	V
T_{oper}	Operating Free Air Temperature Range	for NE555 for SA555 for SE555	0 to 70 –40 to 105 –55 to 125	°C
T_j	Junction Temperature		150	°C
T_{stg}	Storage Temperature Range		–65 to 150	°C

OPERATING CONDITIONS

Symbol	Parameter	SE555	NE555 - SA555	Unit
V_{CC}	Supply Voltage	4.5 to 18	4.5 to 18	V
V_{TH}, V_{TRIG}, V_{CL}, V_{RESET}	Maximum Input Voltage	V_{CC}	V_{CC}	V

ELECTRICAL CHARACTERISTICS

T_{amb} = +25°C, V_{CC} = +5V to +15V (unless otherwise specified)

Symbol	Parameter	SE555 Min.	SE555 Typ.	SE555 Max.	NE555 - SA555 Min.	NE555 - SA555 Typ.	NE555 - SA555 Max.	Unit
I_{CC}	Supply Current (R_L = ∞) - note 1)							mA
	Low State V_{CC} = +5V		3	5		3	6	
	V_{CC} = +15V		10	12		10	15	
	High State V_{CC} = 5V		2			2		
	Timing Error (monostable) (R_A = 2k to 100kΩ, C = 0.1μF)							
	Initial Accuracy - (note 2)		0.5	2		1	3	%
	Drift with Temperature		30	100		50		ppm/°C
	Drift with Supply Voltage		0.05	0.2		0.1	0.5	%/V
	Timing Error (astable) (R_A, R_B = 1kΩ to 100kΩ, C = 0.1μF, V_{CC} = +15V)							
	Initial Accuracy - (note 2)		1.5			2.25		%
	Drift with Temperature		90			150		ppm/°C
	Drift with Supply Voltage		0.15			0.3		%/V
V_{CL}	Control Voltage level							V
	V_{CC} = +15V	9.6	10	10.4	9	10	11	
	V_{CC} = +5V	2.9	3.33	3.8	2.6	3.33	4	
V_{TH}	Threshold Voltage							V
	V_{CC} = +15V	9.4	10	10.6	8.8	10	11.2	
	V_{CC} = +5V	2.7	3.33	4	2.4	3.33	4.2	
I_{TH}	Threshold Current - (note 3)		0.1	0.25		0.1	0.25	μA
V_{TRIG}	Trigger Voltage							V
	V_{CC} = +15V	4.8	5	5.2	4.5	5	5.6	
	V_{CC} = +5V	1.45	1.67	1.9	1.1	1.67	2.2	
I_{TRIG}	Trigger Current (V_{TRIG} = 0V)		0.5	0.9		0.5	2.0	μA
V_{RESET}	Reset Voltage - (note 4)	0.4	0.7	1	0.4	0.7	1	V
I_{RESET}	Reset Current							mA
	V_{RESET} = +0.4V		0.1	0.4		0.1	0.4	
	V_{RESET} = 0V		0.4	1		0.4	1.5	
V_{OL}	Low Level Output Voltage							V
	V_{CC} = +15V, $I_{O(SINK)}$ = 10mA		0.1	0.15		0.1	0.25	
	$I_{O(SINK)}$ = 50mA		0.4	0.5		0.4	0.75	
	$I_{O(SINK)}$ = 100mA		2	2.2		2	2.5	
	$I_{O(SINK)}$ = 200mA		2.5			2.5		
	V_{CC} = +5V $I_{O(SINK)}$ = 8mA		0.1	0.25		0.3	0.4	
	$I_{O(SINK)}$ = 5mA		0.05	0.2		0.25	0.35	
V_{OH}	High Level Output Voltage							V
	V_{CC} = +15V, $I_{O(SOURCE)}$ = 200mA		12.5			12.5		
	$I_{O(SOURCE)}$ = 100mA	13	13.3		12.75	13.3		
	V_{CC} = +5V $I_{O(SOURCE)}$ = 100mA	3	3.3		2.75	3.3		

Notes :
1. Supply current when output is high is typically 1mA less.
2. Tested at V_{CC} = +5V and V_{CC} = +15V.
3. This will determine the maximum value of R_A + R_B for +15V operation the max total is R = 20MΩ and for 5V operation the max total R = 3.5MΩ.

Figure 6 : Low Output Voltage versus Output Sink Current

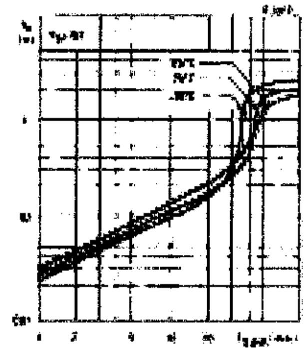


Figure 6 : Low Output Voltage versus Output Sink Current

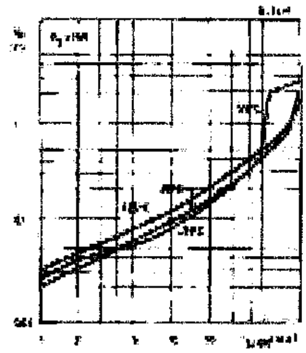


Figure 7 : High Output Voltage Drop versus Output

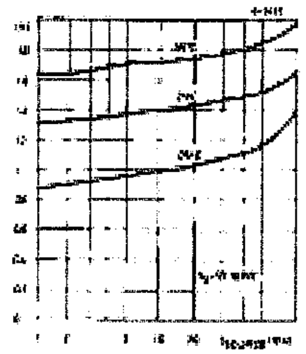


Figure 8 : Delay Time versus Supply Voltage

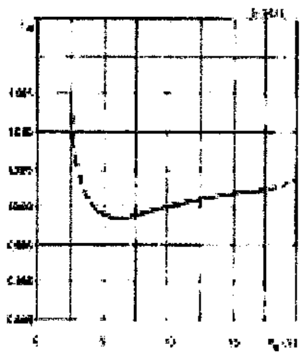
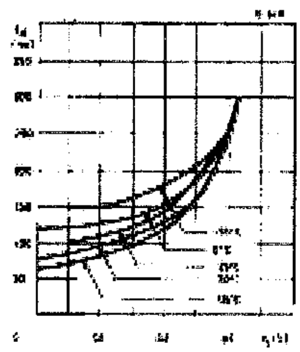


Figure 9 : Propagation Delay versus Voltage Level of Trigger Value



ELECTRICAL CHARACTERISTICS (continued)

Symbol	Parameter	SE555 Min.	SE555 Typ.	SE555 Max.	NE555 - SA555 Min.	NE555 - SA555 Typ.	NE555 - SA555 Max.	Unit
$I_{dis(off)}$	Discharge Pin Leakage Current (output high) (V_{dis} = 10V)		20	100		20	100	nA
$V_{dis(sat)}$	Discharge pin Saturation Voltage (output low) - (note 5)							mV
	V_{CC} = +15V, I_{dis} = 15mA		180	480		180	480	
	V_{CC} = +5V, I_{dis} = 4.5mA		80	200		80	200	
t_r	Output Rise Time		100	200		100	300	ns
t_f	Output Fall Time		100	200		100	300	
t_{off}	Turn off Time - (note 6) (V_{RESET} = V_{CC})		0.5			0.5		µs

Notes : 5. No protection against excessive Pin 7 current is necessary, providing the package dissipation rating will not be exceeded.
6. Time measured from a positive going input pulse from 0 to 0.8x V_{CC} into the threshold to the drop from high to low of the output trigger tied to threshold.

Figure 1 : Minimum Pulse Width Required for Triggering

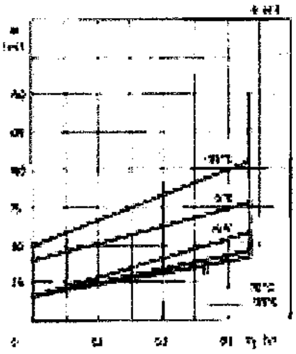


Figure 2 : Supply Current versus Supply Voltage

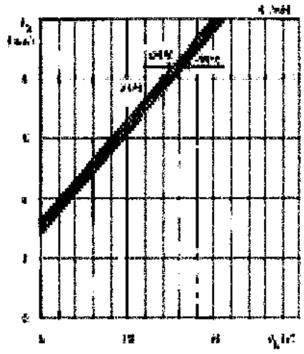


Figure 3 : Delay Time versus Temperature

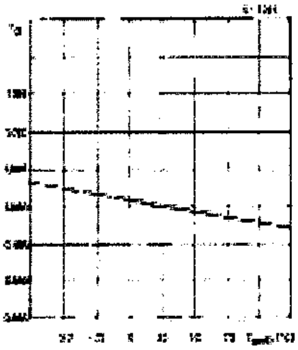
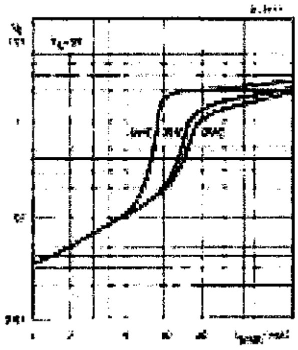


Figure 4 : Low Output Voltage versus Output Sink Current

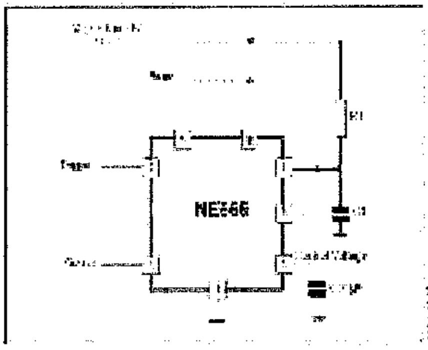


APPLICATION INFORMATION

MONOSTABLE OPERATION

In the monostable mode, the timer functions as a one-shot. Referring to figure 10 the external capacitor is initially held discharged by a transistor inside the timer.

Figure 10



The circuit triggers on a negative-going input signal when the level reaches 1/3 Vcc. Once triggered, the circuit remains in this state until the set time has elapsed, even if it is triggered again during this interval. The duration of the output HIGH state is given by $t = 1.1 R_1C_1$ and is easily determined by figure 12.

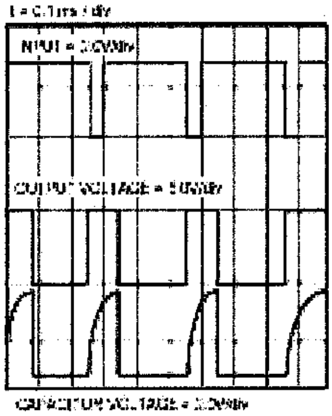
Notice that since the charge rate and the threshold level of the comparator are both directly proportional to supply voltage, the timing interval is independent of supply. Applying a negative pulse simultaneously to the reset terminal (pin 4) and the trigger terminal (pin 2) during the timing cycle discharges the external capacitor and causes the cycle to start over. The timing cycle now starts on the positive edge of the reset pulse. During the time the reset pulse in applied, the output is driven to its LOW state.

When a negative trigger pulse is applied to pin 2, the flip-flop is set, releasing the short circuit across the external capacitor and driving the output HIGH. The voltage across the capacitor increases exponentially with the time constant $\tau = R_1C_1$. When the voltage across the capacitor equals 2/3 V_{cc}, the comparator resets the flip-flop which then discharge the capacitor rapidly and drivers the output to its LOW state.

Figure 11 shows the actual waveforms generated in this mode of operation.

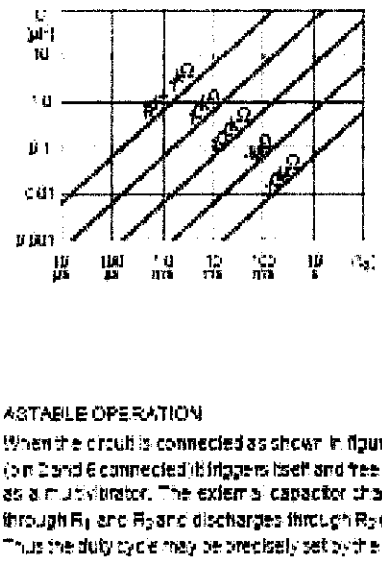
When Reset is not used, it should be tied high to avoid any possibly or false triggering.

Figure 11



$R1 = 9.1k\Omega$, $C1 = 0.01\mu F$, $R_L = 1k\Omega$

Figure 12



ASTABLE OPERATION

When the circuit is connected as shown in figure 13 (pin 2 and 6 connected) it triggers itself and free runs as a multivibrator. The external capacitor charges through R_1 and R_2 and discharges through R_2 only. Thus the duty cycle may be precisely set by the ratio of these two resistors.

In the astable mode of operation, C_1 charges and discharges between 1/3 V_{cc} and 2/3 Vcc. As in the triggered mode, the charge and discharge times and therefore frequency are independent of the supply voltage.

Figure 13

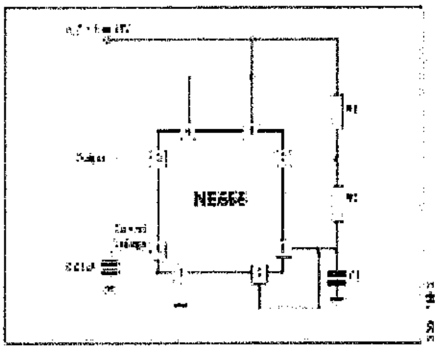


Figure 14 shows actual waveforms generated in this mode of operation.

The charge time (output HIGH) is given by :

$t_1 = 0.693\ (R_1 + R_2)\ C_1$

and the discharge time (output LOW) by :

$t_2 = 0.693\ (R_2)\ C_1$

Thus the total period T is given by :

$T = t_1 + t_2 = 0.693\ (R_1 + 2R_2)\ C_1$

The frequency of oscillation is them :

$$f = \frac{1}{T} = \frac{1.44}{(R_1 + 2R_2)\ C_1}$$

and may be easily found by figure 15.

The duty cycle is given by :

$$D = \frac{R_2}{R_1 + 2R_2}$$

Figure 14

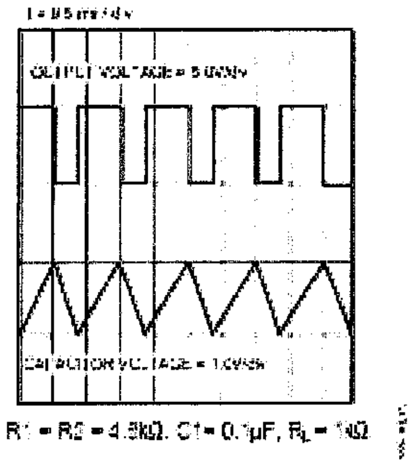
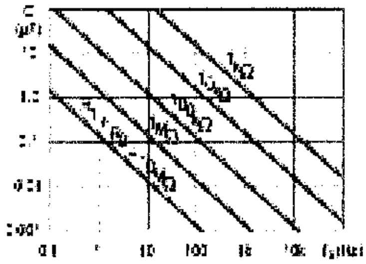


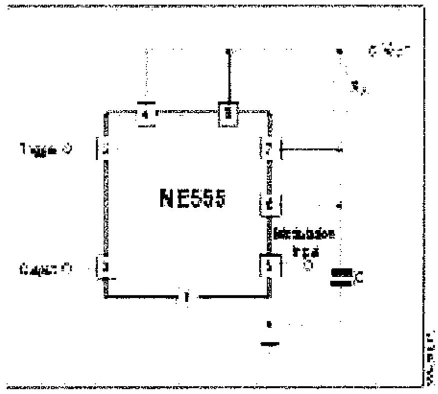
Figure 15 : Free Running Frequency versus R_1, R_2 and C_1



PULSE WIDTH MODULATOR

When the timer is connected in the monostable mode and triggered with a continuous pulse train, the output pulse width can be modulated by a signal applied to pin 5. Figure 16 shows the circuit.

Figure 16 : Pulse Width Modulator.



LINEAR RAMP

When the pull-up resistor, R_A, in the monostable circuit is replaced by a constant current source, a linear ramp is generated. Figure 17 shows a circuit configuration that will perform this function.

Figure 17.

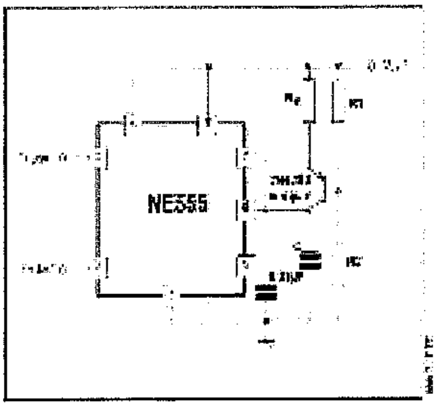
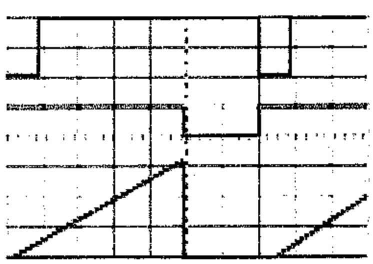


Figure 18 shows waveforms generator by the linear ramp.

The time interval is given by :

$$T = \frac{2/3\ V_{CC}\ R_E\ (R_1 + R_2)\ C}{R_1\ V_{CC} - V_{BE}\ (R_1 + R_2)} \quad V_{BE} = 0.6V$$

Figure 18 : Linear Ramp.



V_{CC} = 5V
Time = 20µs/DIV
R_1 = 47kΩ
R_2 = 100kΩ
R_E = 2.7kΩ
C = 0.01µF

Top trace : input 5V/DIV
Middle trace : output 5V/DIV
Bottom trace : output 5V/DIV
Bottom trace : capacitor voltage 1V/DIV

50% DUTY CYCLE OSCILLATOR

For a 50% duty cycle the resistors R_A and R_B may be connected as in figure 19. The time period for the output high is the same as previous,

$t_1 = 0.693\ R_A\ C$.

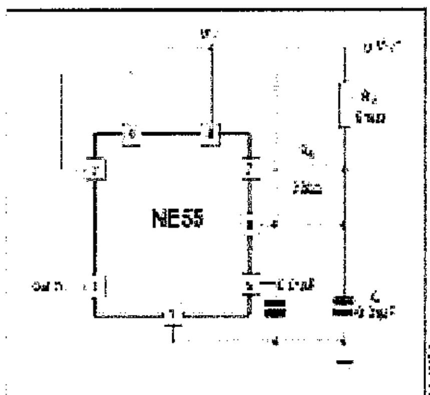
For the output low it is $t_2 =$

$$\left[(R_A R_B)/(R_A + R_B)\right] C\,Ln\left[\frac{R_B - 2R_A}{2R_B - R_A}\right]$$

Thus the frequency of oscillation is $f = \frac{1}{t_1 + t_2}$

Note that this circuit will not oscillate if R_B is greater than 1/2 R_A because the junction of R_A and R_B cannot bring pin 2 down to 1/3 V_{CC} and trigger the lower comparator.

Figure 19 : 50% Duty Cycle Oscillator.

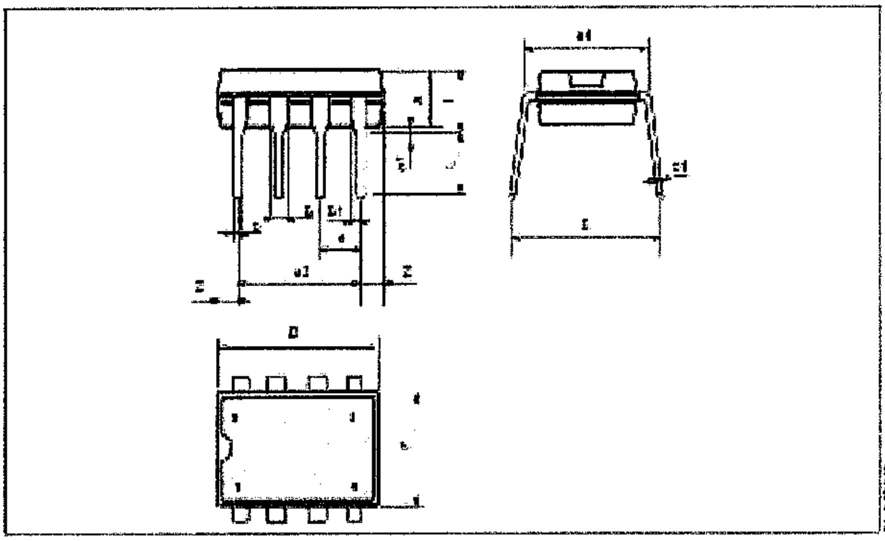


ADDITIONAL INFORMATION

Adequate power supply bypassing is necessary to protect associated circuitry. Minimum recommended is 0.1µF in parallel with 1µF electrolytic.

PACKAGE MECHANICAL DATA

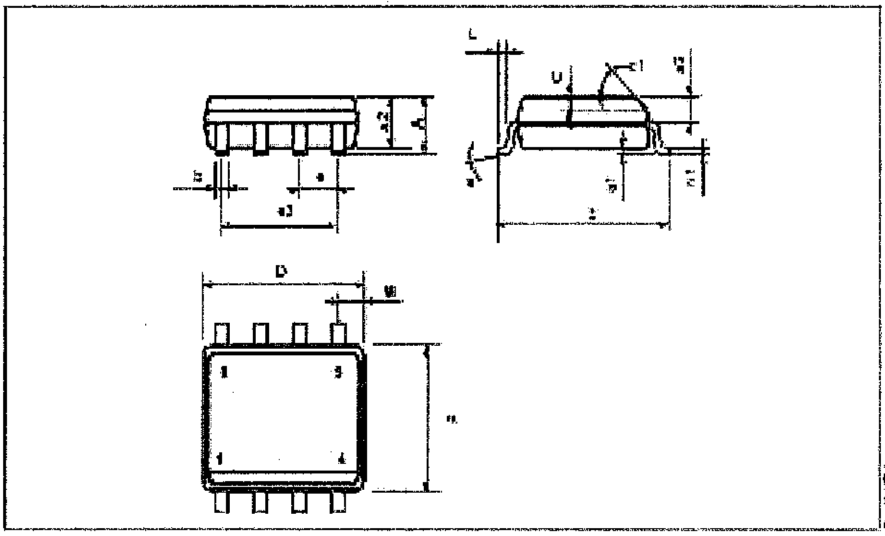
8 PINS - PLASTIC DIP OR CERDIP



Dimensions	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A		3.32			0.131	
a1	0.51			0.020		
B	1.15		1.65	0.045		0.065
b	0.356		0.55	0.014		0.022
b1	0.204		0.304	0.008		0.012
D			10.92			0.430
E	7.95		9.75	0.313		0.384
e		2.54			0.100	
e3		7.62			0.300	
e4		7.62			0.300	
F			6.6			0.260
i			5.08			0.200
L	3.18		3.81	0.125		0.150
Z			1.52			0.060

PACKAGE MECHANICAL DATA

8 PINS - PLASTIC MICROPACKAGE (SO)



Dimensions	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.75			0.069
a1	0.1		0.25	0.004		0.010
a2			1.65			0.065
a3	0.65		0.85	0.026		0.033
b	0.35		0.48	0.014		0.019
b1	0.19		0.25	0.007		0.010
C	0.25		0.5	0.010		0.020
c1	45° (typ.)					
D	4.8		5.0	0.189		0.197
E	5.8		6.2	0.228		0.244
e		1.27			0.050	
e3		3.81			0.150	
F	3.8		4.0	0.150		0.157
L	0.4		1.27	0.016		0.050
M			0.6			0.024
S	8° (max.)					

APPENDIX D

Datasheet

2N3904

2N3904

SMALL SIGNAL NPN TRANSISTOR

PRELIMINARY DATA

Ordering Code	Marking	Package / Shipment
2N3904	2N3904	TO-92 / Bulk
2N3904-AP	2N3904	TO-92 / Ammopack

- SILICON EPITAXIAL PLANAR NPN TRANSISTOR
- TO-92 PACKAGE SUITABLE FOR THROUGH-HOLE PCB ASSEMBLY
- THE PNP COMPLEMENTARY TYPE IS 2N3906

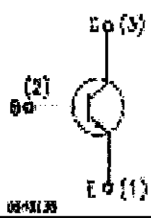
TO-92 Bulk

TO-92 Ammopack

APPLICATIONS

- WELL SUITABLE FOR TV AND HOME APPLIANCE EQUIPMENT
- SMALL LOAD SWITCH TRANSISTOR WITH HIGH GAIN AND LOW SATURATION VOLTAGE

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CBO}	Collector-Base Voltage ($I_E = 0$)	60	V
V_{CEO}	Collector-Emitter Voltage ($I_B = 0$)	40	V
V_{EBO}	Emitter-Base Voltage ($I_C = 0$)	6	V
I_C	Collector Current	200	mA
P_{tot}	Total Dissipation at $T_C = 25$ °C	625	mW
T_{stg}	Storage Temperature	-65 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C

THERMAL DATA

$R_{thj-amb}$ *	Thermal Resistance Junction-Ambient	Max	200	°C/W
$R_{thj-case}$ *	Thermal Resistance Junction-Case	Max	83.3	°C/W

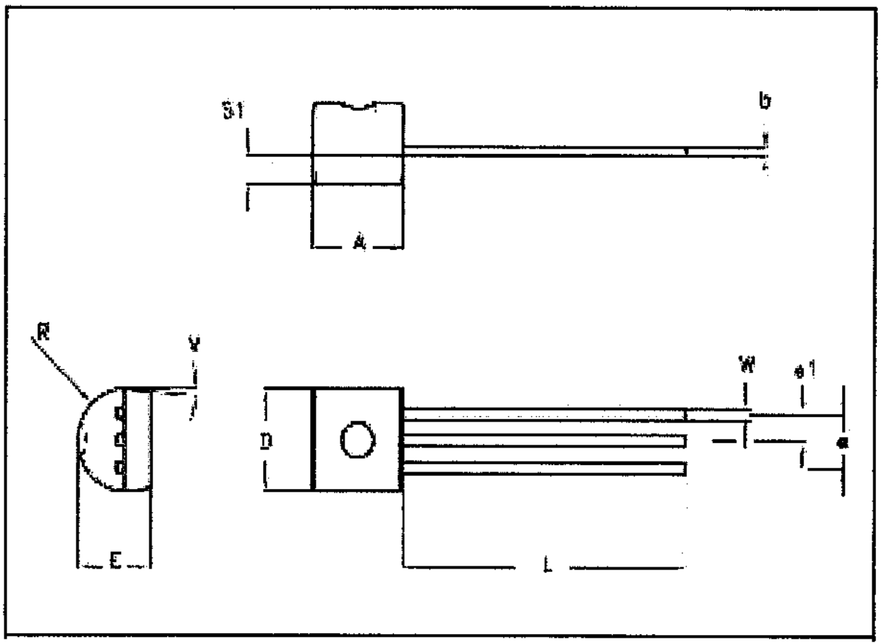
ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CEX}	Collector Cut-off Current (V_{BE} = -3 V)	V_{CE} = 30 V			50	nA
I_{BEX}	Base Cut-off Current (V_{BE} = -3 V)	V_{CE} = 30 V			50	nA
$V_{(BR)CEO}$*	Collector-Emitter Breakdown Voltage (I_B = 0)	I_C = 1 mA	40			V
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage (I_E = 0)	I_C = 10 µA	60			V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage (I_C = 0)	I_E = 10 µA	6			V
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 10 mA I_B = 1 mA I_C = 50 mA I_B = 5 mA			0.2 0.3	V V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 10 mA I_B = 1 mA I_C = 50 mA I_B = 5 mA	 0.65		0.85 0.95	V V
h_{FE}*	DC Current Gain	I_C = 0.1 mA V_{CE} = 1 V I_C = 1 mA V_{CE} = 1 V I_C = 10 mA V_{CE} = 1 V I_C = 50 mA V_{CE} = 1 V I_C = 100 mA V_{CE} = 1 V	60 80 100 60 30		 300 	
f_T	Transition Frequency	I_C = 10 mA V_{CE} = 20 V f = 100 MHz	250	270		MHz
C_{CBO}	Collector-Base Capacitance	I_E = 0 V_{CB} = 10 V f = 1 MHz		4		pF
C_{EBO}	Emitter-Base Capacitance	I_C = 0 V_{EB} = 0.5 V f = 1 MHz		18		pF
NF	Noise Figure	V_{CE} = 5 V I_C = 0.1 mA f = 10 Hz to 15.7 KHz R_G = 1 KΩ		5		dB
t_d t_r	Delay Time Rise Time	I_C = 10 mA I_B = 1 mA V_{CC} = 30 V			35 35	ns ns
t_s t_f	Storage Time Fall Time	I_C = 10 mA I_{B1} = $-I_{B2}$ = 1 mA V_{CC} = 30 V			200 50	ns ns

* Pulsed: Pulse duration = 300 µs, duty cycle ≤ 2 %

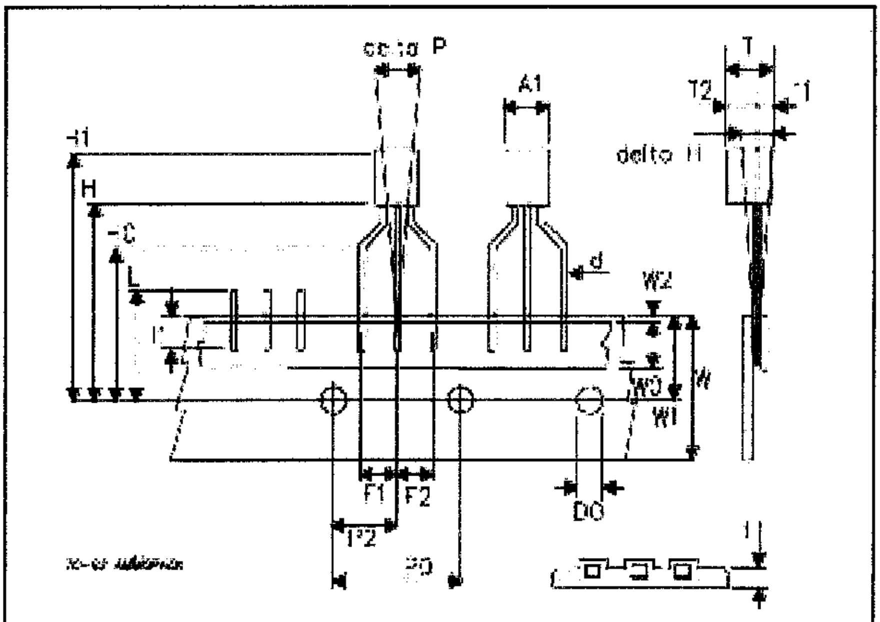
TO-92 MECHANICAL DATA

DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A	4.32		4.95	0.170		0.195
b	0.36		0.51	0.014		0.020
D	4.45		4.95	0.175		0.194
E	3.30		3.94	0.130		0.155
e	2.41		2.67	0.095		0.105
e1	1.14		1.40	0.045		0.055
L	12.70		15.49	0.500		0.609
R	2.16		2.41	0.085		0.094
S1	1.14		1.52	0.045		0.059
W	0.41		0.56	0.016		0.022
V	4 degree		6 degree	4 degree		6 degree



TO-92 AMMOPACK SHIPMENT (Suffix"-AP") MECHANICAL DATA

DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A1			4.80			0.189
T			3.80			0.150
T1			1.60			0.063
T2			2.30			0.091
d			0.48			0.019
P0	12.50	12.70	12.90	0.492	0.500	0.508
P2	5.65	6.35	7.05	0.222	0.250	0.278
F1,F2	2.44	2.54	2.94	0.096	0.100	0.116
delta H	-2.00		2.00	-0.079		0.079
W	17.50	18.00	19.00	0.689	0.709	0.748
W0	5.70	6.00	6.30	0.224	0.236	0.248
W1	8.50	9.00	9.25	0.335	0.354	0.364
W2			0.50			0.020
H	18.50		20.50	0.728		0.807
H0	15.50	16.00	16.50	0.610	0.630	0.650
H1			25.00			0.984
D0	3.80	4.00	4.20	0.150	0.157	0.165
t			0.90			0.035
L			11.00			0.433
l1	3.00			0.118		
delta P	-1.00		1.00	-0.039		0.039



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.

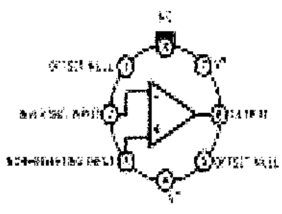
The amplifiers offer many features which make their application nearly foolproof: overload protection on the input and output, no latch-up when the common mode range is exceeded, as well as freedom from oscillations.

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

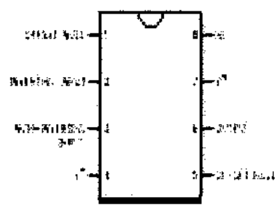
Metal Can Package



Note 1: LM741H is available per JM38510/10101

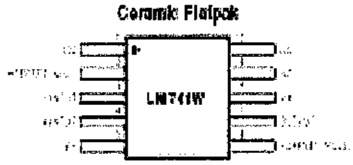
Order Number LM741H, LM741H/883 (Note 1), LM741AH/883 or LM741CH
See NS Package Number H08C

Dual-In-Line or S.O. Package



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

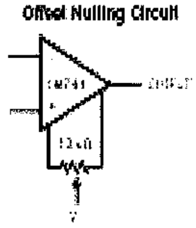
Ceramic Flatpak



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.

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	$T_A = 25°C$										
	$R_S \leq 10\ k\Omega$					1.0	5.0		2.0	6.0	mV
	$R_S \leq 50\Omega$		0.8	3.0							mV
	$T_{AMIN} \leq T_A \leq T_{AMAX}$										
	$R_S \leq 50\Omega$			4.0							mV
	$R_S \leq 10\ k\Omega$						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
	$T_{AMIN} \leq T_A \leq T_{AMAX}$			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
	$T_{AMIN} \leq T_A \leq T_{AMAX}$			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
	$T_{AMIN} \leq T_A \leq T_{AMAX}$, $V_S = \pm 20V$	0.5									MΩ
Input Voltage Range	$T_A = 25°C$							±12	±13		V
	$T_{AMIN} \leq T_A \leq T_{AMAX}$				±12	±13					V

Electrical Characteristics (Note 5) (Continued)

Parameter	Conditions	LM741A			LM741			LM741C			Units
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Large 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
Output 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
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	$R_S \leq 10\ k\Omega$, $V_{CM} = \pm 12V$				70	90		70	90		dB
	$R_S \leq 50\Omega$, $V_{CM} = \pm 12V$	80	95								dB
Supply Voltage Rejection	$T_{AMIN} \leq T_A \leq T_{AMAX}$,										
Ratio	$V_S = \pm 20V$ to $V_S = \pm 5V$										
	$R_S \leq 50\Omega$	86	96								dB
	$R_S \leq 10\ k\Omega$				77	96		77	96		dB
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	$T_A = 25°C$										
	$V_S = \pm 20V$		80	150							mW
	$V_S = \pm 15V$					50	85		50	85	mW
LM741A	$V_S = \pm 20V$										
	$T_A = T_{AMIN}$			165							mW
	$T_A = T_{AMAX}$			135							mW
LM741	$V_S = \pm 15V$										
	$T_A = T_{AMIN}$					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.

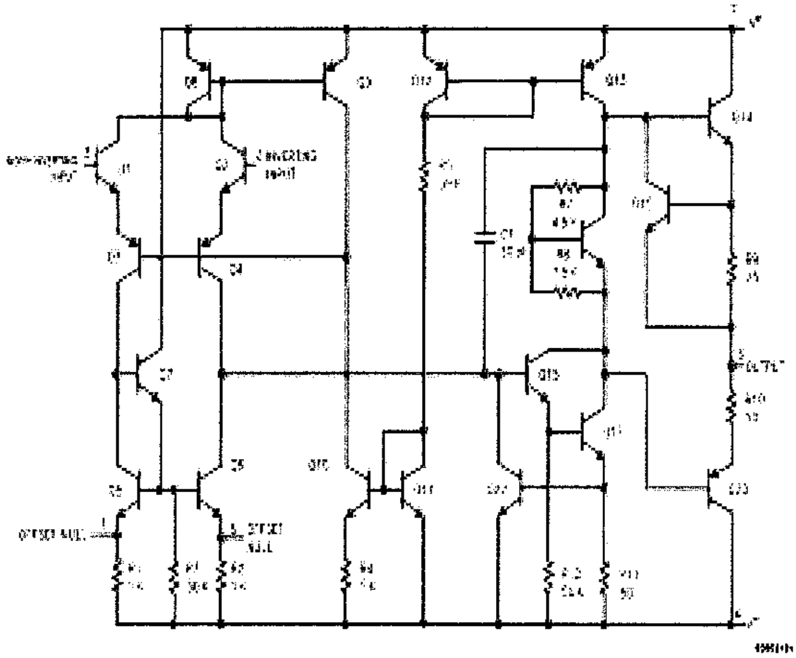
Note 5: Unless otherwise specified, these specifications apply for $V_S = \pm15V$, $-55°C \le T_A \le +125°C$ (LM741/LM741A). For the LM741C/LM741E, these specifications are limited to $0°C \le T_A \le +70°C$.

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

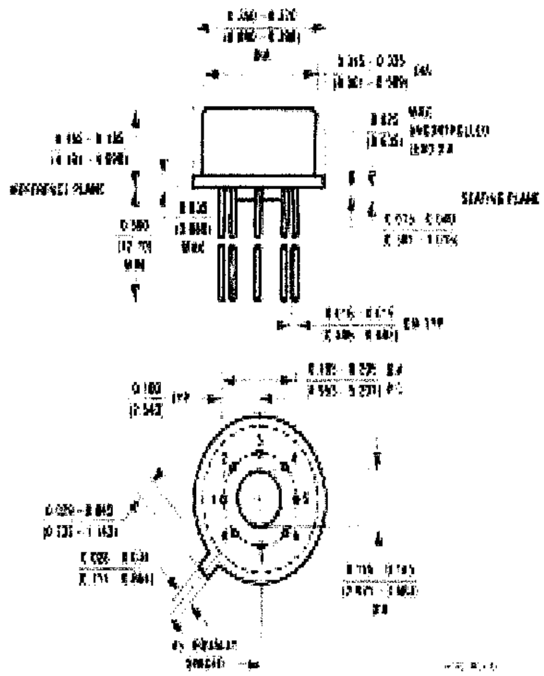
Note 7: For military specifications see RETS741X for LM741 and RETS741AX for LM741A.

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

Schematic Diagram

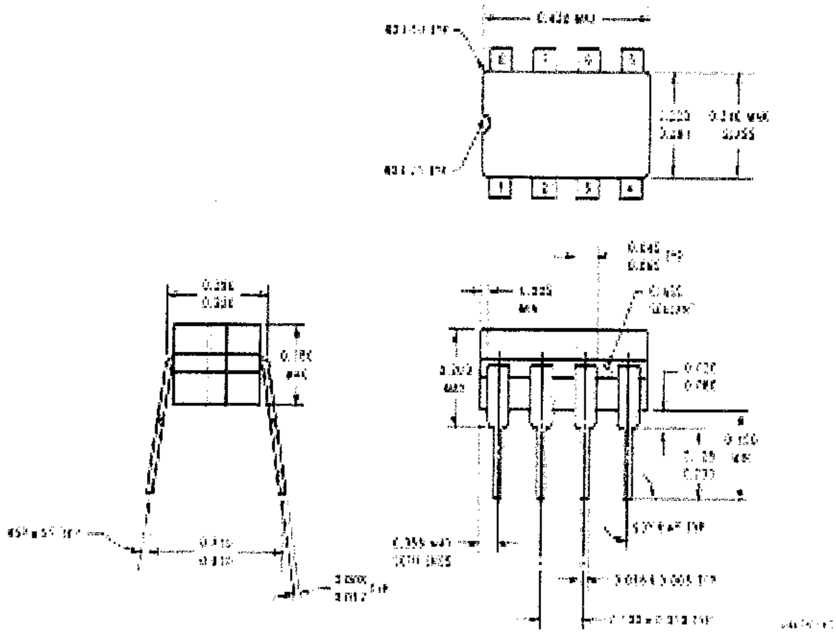


Physical Dimensions inches (millimeters) unless otherwise noted

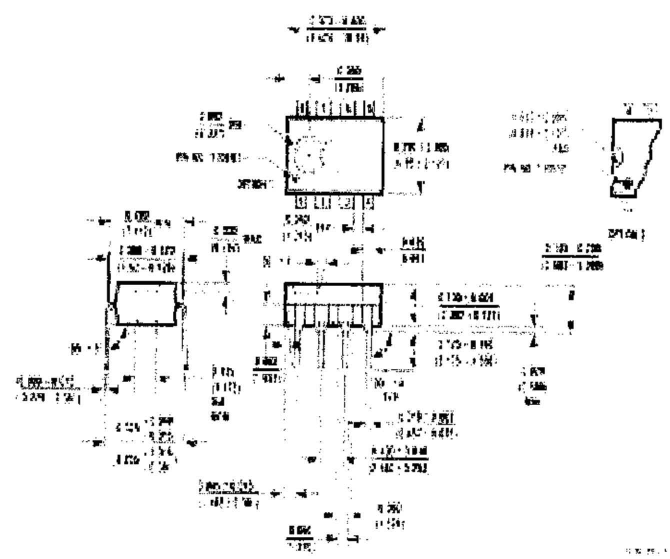


Metal Can Package (H)
Order Number LM741H, LM741H/883, LM741AH/883, LM741AH-MIL or LM741CH
NS Package Number H08C

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

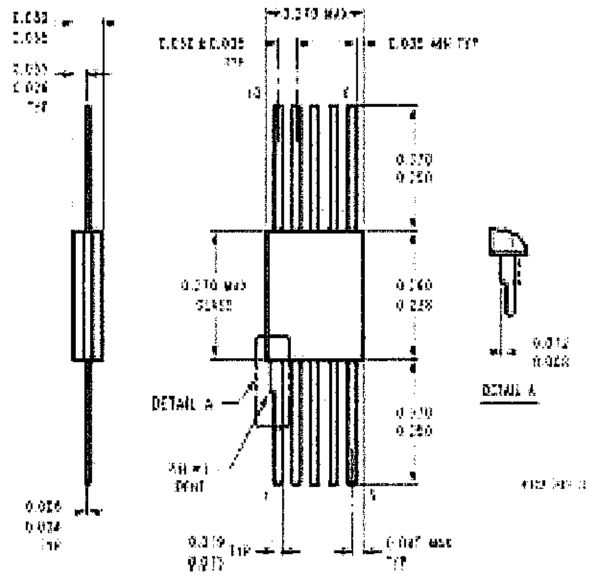


Ceramic Dual-In-Line Package (J)
Order Number LM741J/883
NS Package Number J08A



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

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National Semiconductor

February 2003

LM567/LM567C Tone Decoder

General Description

The LM567 and LM567C are general purpose tone decoders designed to provide a saturated transistor switch to ground when an input signal is present within the passband. The circuit consists of an I and Q detector driven by a voltage controlled oscillator which determines the center frequency of the decoder. External components are used to independently set center frequency, bandwidth and output delay.

Features

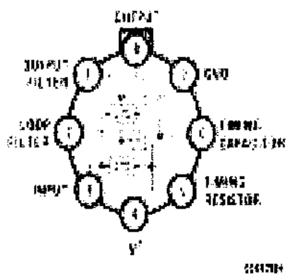
- 20 to 1 frequency range with an external resistor
- Logic compatible output with 100 mA current sinking capability
- Bandwidth adjustable from 0 to 14%
- High rejection of out of band signals and noise
- Immunity to false signals
- Highly stable center frequency
- Center frequency adjustable from 0.01 Hz to 500 kHz

Applications

- Touch tone decoding
- Precision oscillator
- Frequency monitoring and control
- Wide band FSK demodulation
- Ultrasonic controls
- Carrier current remote controls
- Communications paging decoders

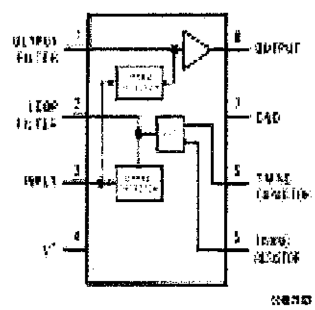
Connection Diagrams

Metal Can Package



Top View
Order Number LM567H or LM567CH
See NS Package Number H08C

Dual-In-Line and Small Outline Packages



Top View
Order Number LM567CM
See NS Package Number M08A
Order Number LM567CN
See NS Package Number N08E

Absolute Maximum Ratings (Note 1)

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

Supply Voltage Pin	9V
Power Dissipation (Note 2)	1100 mW
V_8	15V
V_3	−10V
V_3	V_4 + 0.5V
Storage Temperature Range	−65°C to +150°C
Operating Temperature Range	
LM567H	−55°C to +125°C
LM567CH, LM567CM, LM567CN	0°C to +70°C
Soldering Information	
Dual-In-Line Package	
Soldering (10 sec.)	260°C
Small Outline Package	
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.

Electrical Characteristics

AC Test Circuit, T_A = 25°C, V^+ = 5V

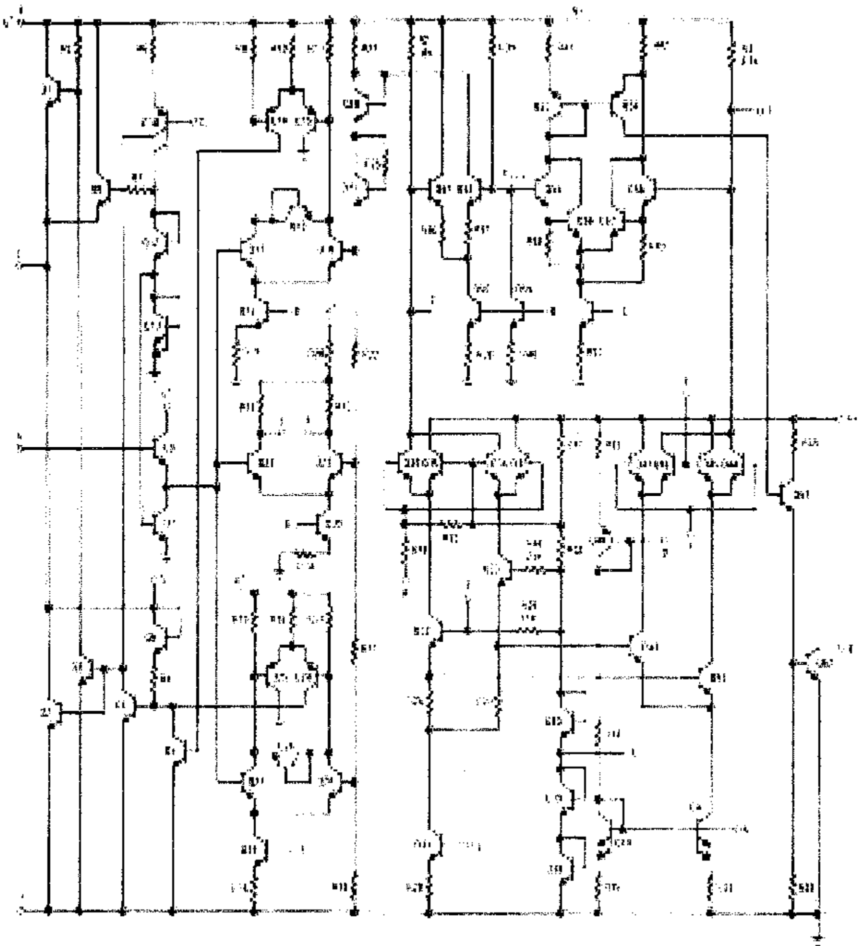
Parameters	Conditions	LM567			LM567C/LM567CM			Units
		Min	Typ	Max	Min	Typ	Max	
Power Supply Voltage Range		4.75	5.0	9.0	4.75	5.0	9.0	V
Power Supply Current Quiescent	R_L = 20k		6	8		7	10	mA
Power Supply Current Activated	R_L = 20k		11	13		12	15	mA
Input Resistance		18	20		15	20		kΩ
Smallest Detectable Input Voltage	I_L = 100 mA, $f_i = f_o$		20	25		20	25	mVrms
Largest No Output Input Voltage	I_C = 100 mA, $f_i = f_o$	10	15		10	15		mVrms
Largest Simultaneous Outband Signal to Inband Signal Ratio			6			6		dB
Minimum Input Signal to Wideband Noise Ratio	B_n = 140 kHz		−6			−6		dB
Largest Detection Bandwidth		12	14	16	10	14	18	% of f_o
Largest Detection Bandwidth Skew			1	2		2	3	% of f_o
Largest Detection Bandwidth Variation with Temperature			±0.1			±0.1		%/°C
Largest Detection Bandwidth Variation with Supply Voltage	4.75–6.75V		±1	±2		±1	±5	%V
Highest Center Frequency		100	500		100	500		kHz
Center Frequency Stability (4.75–5.75V)	$0 < T_A < 70$ $-55 < T_A < +125$		35 ± 60 35 ± 140			35 ± 60 35 ± 140		ppm/°C ppm/°C
Center Frequency Shift with Supply Voltage	4.75V–6.75V 4.75V–9V		0.5	1.0 2.0		0.4	2.0 2.0	%/V %/V
Fastest ON-OFF Cycling Rate			f_o/20			f_o/20		
Output Leakage Current	V_8 = 15V		0.01	25		0.01	25	µA
Output Saturation Voltage	e_i = 25 mV, I_8 = 30 mA e_i = 25 mV, I_8 = 100 mA		0.2 0.6	0.4 1.0		0.2 0.6	0.4 1.0	V
Output Fall Time			30			30		ns
Output Rise Time			150			150		ns

Note 1: 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.

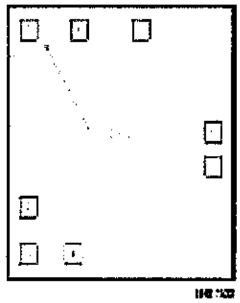
Note 2: The maximum junction temperature of the LM567 and LM567C is 150°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient or 45°C/W, junction to case. For the DIP the device must be derated based on a thermal resistance of 110°C/W, junction to ambient. For the Small Outline package, the device must be derated based on a thermal resistance of 160°C/W, junction to ambient.

Note 3: Refer to RETS567X drawing for specifications of military LM567H version.

Schematic Diagram



LM567C MDC MWC
TONE DECODER



Die Layout (C - Step)

DIE/WAFER CHARACTERISTICS

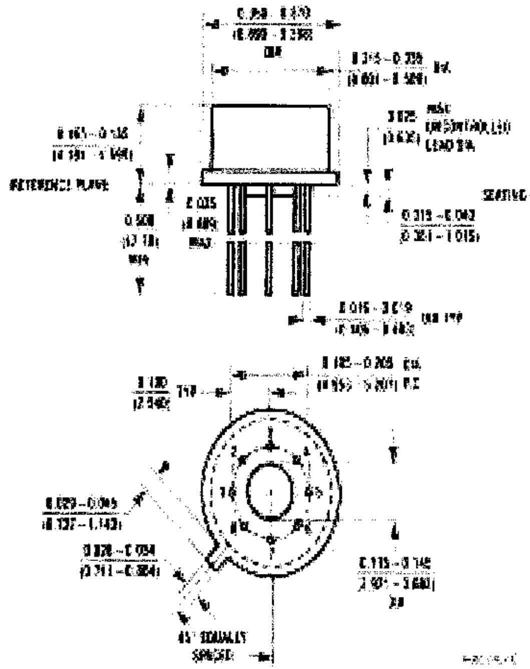
Fabrication Attributes		General Die Information	
Physical Die Identification	LM567C	Bond Pad Opening Size (min)	91µm x 91µm
Die Step	C	Bond Pad Metalization	0.5% COPPER_BAL. ALUMINUM
Physical Attributes		Passivation	VOM NITRIDE
Wafer Diameter	150mm	Back Side Metal	BARE BACK
Dise Size (Drawn)	1600µm x 1626µm 63.0mils x 64.0mils	Back Side Connection	Floating
Thickness	406µm Nominal		
Min Pitch	106µm Nominal		

Special Assembly Requirements:

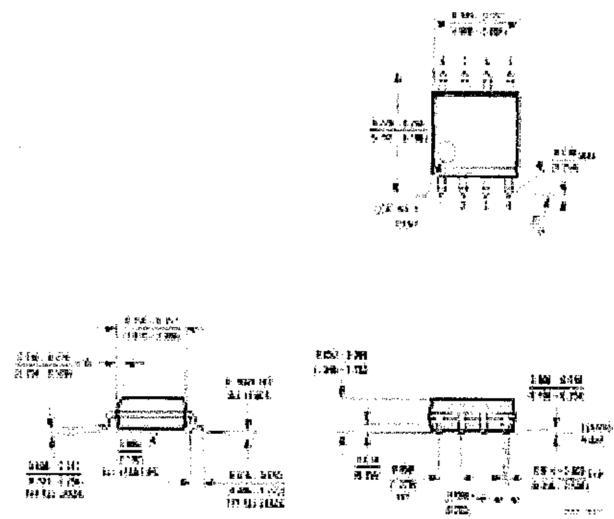
Note: Actual die size is rounded to the nearest micron.

Die Bond Pad Coordinate Locations (C - Step)						
(Referenced to die center, coordinates in µm) NC = No Connection, N.U. = Not Used						
SIGNAL NAME	PAD# NUMBER	X/Y COORDINATES		PAD SIZE		
		X	Y	X		Y
OUTPUT FILTER	1	-679	686	91	x	91
LOOP FILTER	2	-678	-419	91	x	91
INPUT	3	-673	-686	91	x	91
V+	4	-356	-686	91	x	91
TIMING RES	5	679	-122	91	x	91
TIMING CAP	6	679	76	91	x	91
GND	7	178	686	117	x	91
OUTPUT	8	-518	679	117	x	104

Physical Dimensions inches (millimeters) unless otherwise noted

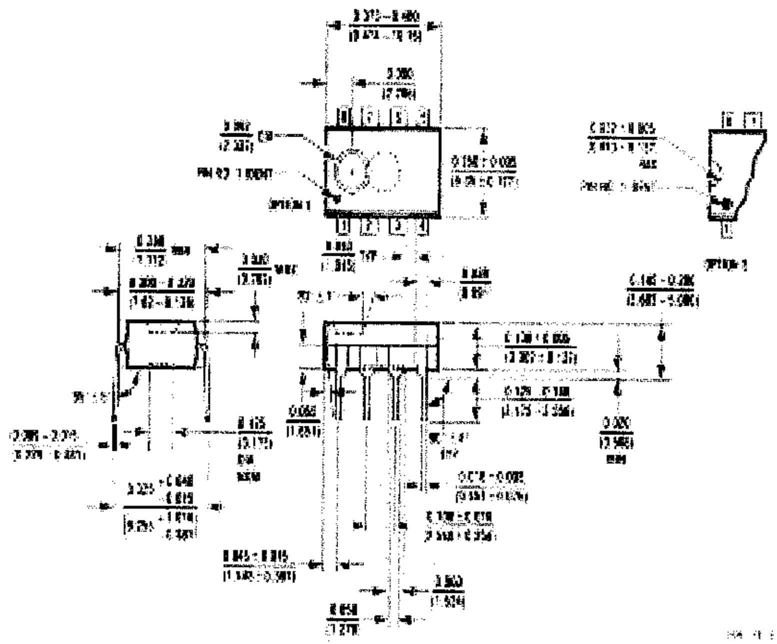


Metal Can Package (H)
Order Number LM567H or LM567CH
NS Package Number H08C



Small Outline Package (M)
Order Number LM567CM
NS Package Number M08A

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



Molded Dual-In-Line Package (N)
Order Number LM567CN
NS Package Number N08E

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
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English Tel: +44 (0) 870 24 0 2171
Français Tel: +33 (0) 1 41 91 8790

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

www.national.com

National Semiconductor

January 2001

LM111/LM211/LM311 Voltage Comparator

1.0 General Description

The LM111, LM211 and LM311 are voltage comparators that have input currents nearly a thousand times lower than devices like the LM106 or LM710. They are also designed to operate over a wider range of supply voltages: from standard ±15V op amp supplies down to the single 5V supply used for IC logic. Their output is compatible with RTL, DTL and TTL as well as MOS circuits. Further, they can drive lamps or relays, switching voltages up to 50V at currents as high as 50 mA.

Both the inputs and the outputs of the LM111, LM211 or the LM311 can be isolated from system ground, and the output can drive loads referred to ground, the positive supply or the negative supply. Offset balancing and strobe capability are provided and outputs can be wire OR'ed. Although slower than the LM106 and LM710 (200 ns response time vs 40 ns) the devices are also much less prone to spurious oscillations. The LM111 has the same pin configuration as the LM106 and LM710.

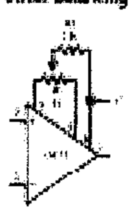
The LM211 is identical to the LM111, except that its performance is specified over a −25°C to +85°C temperature range instead of −55°C to +125°C. The LM311 has a temperature range of 0°C to +70°C.

2.0 Features

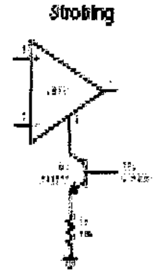
- Operates from single 5V supply
- Input current: 150 nA max. over temperature
- Offset current: 20 nA max. over temperature
- Differential input voltage range: ±30V
- Power consumption: 135 mW at ±15V

3.0 Typical Applications (Note 3)

Offset Balancing

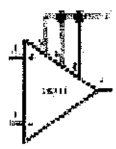


Strobing



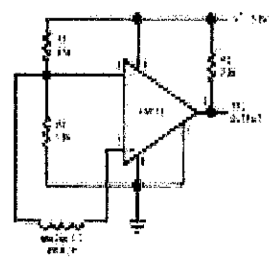
Note: Do Not Ground Strobe Pin. Output is turned off when current is pulled from Strobe Pin.

Increasing Input Stage Current (Note 1)



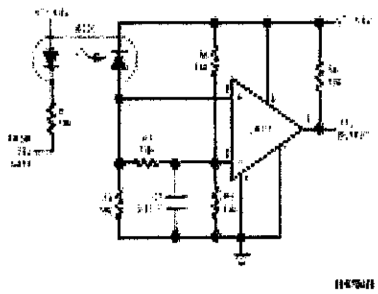
Note 1: Increases typical common mode slew from 7.0V/µs to 18V/µs.

Detector for Magnetic Transducer

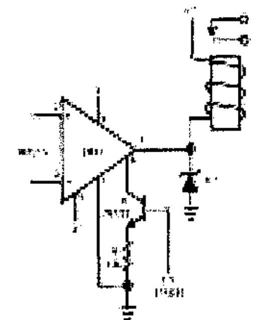


3.0 Typical Applications (Note 3) (Continued)

Digital Transmission Isolator



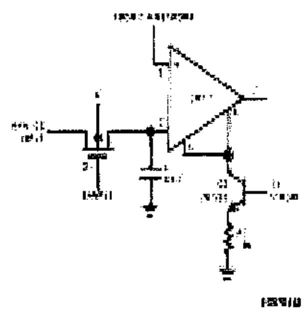
Relay Driver with Strobe



*Absorbs inductive kickback of relay and protects IC from severe voltage transients on V++ line.

Note: Do Not Ground Strobe Pin.

Strobing off Both Input and Output Stages (Note 2)

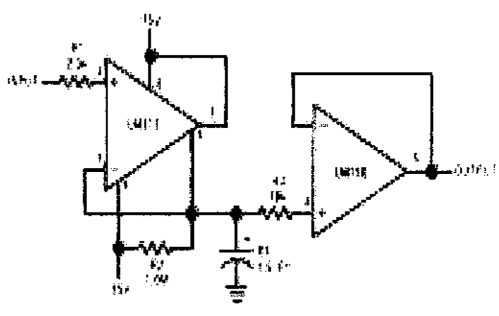


Note: Do Not Ground Strobe Pin.

Note 2: Typical input current is 50 pA with inputs strobed off.

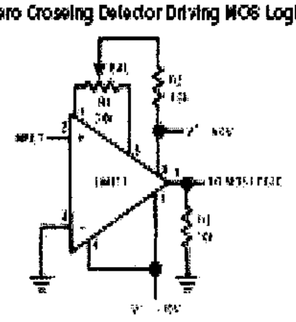
Note 3: Pin connections shown on schematic diagram and typical applications are for H08 metal can package.

Positive Peak Detector



*Solid tantalum

Zero Crossing Detector Driving MOS Logic



4.0 Absolute Maximum Ratings for the LM111/LM211 (Note 10)

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

Total Supply Voltage (V_{84})	36V
Output to Negative Supply Voltage (V_{74})	50V
Ground to Negative Supply Voltage (V_{14})	30V
Differential Input Voltage	±30V
Input Voltage (Note 4)	±15V
Output Short Circuit Duration	10 sec
Operating Temperature Range	
LM111	−55°C to 125°C
LM211	−25°C to 85°C
Lead Temperature (Soldering, 10 sec)	260°C
Voltage at Strobe Pin	V+−5V
Soldering Information	
Dual-In-Line Package	
Soldering (10 seconds)	260°C
Small Outline Package	
Vapor Phase (60 seconds)	215°C
Infrared (15 seconds)	220°C

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

ESD Rating (Note 11)	300V

Electrical Characteristics (Note 6) for the LM111 and LM211

Parameter	Conditions	Min	Typ	Max	Units
Input Offset Voltage (Note 7)	T_A=25°C, R_S≤50k		0.7	3.0	mV
Input Offset Current	T_A=25°C		4.0	10	nA
Input Bias Current	T_A=25°C		60	100	nA
Voltage Gain	T_A=25°C	40	200		V/mV
Response Time (Note 8)	T_A=25°C		200		ns
Saturation Voltage	V_{IN}≤−5 mV, I_{OUT}=50 mA T_A=25°C		0.75	1.5	V
Strobe ON Current (Note 9)	T_A=25°C		2.0	5.0	mA
Output Leakage Current	V_{IN}≥5 mV, V_{OUT}=35V T_A=25°C, I_{STROBE}=3 mA		0.2	10	nA
Input Offset Voltage (Note 7)	R_S≤50 k			4.0	mV
Input Offset Current (Note 7)				20	nA
Input Bias Current				150	nA
Input Voltage Range	V+=15V, V−=−15V, Pin 7 Pull-Up May Go To 5V	−14.5	13.8,-14.7	13.0	V
Saturation Voltage	V+≥4.5V, V−=0 V_{IN}≤−6 mV, I_{OUT}≤8 mA		0.23	0.4	V
Output Leakage Current	V_{IN}≥5 mV, V_{OUT}=35V		0.1	0.5	µA
Positive Supply Current	T_A=25°C		5.1	6.0	mA
Negative Supply Current	T_A=25°C		4.1	5.0	mA

Note 4: This rating applies for ±15 supplies. The positive input voltage limit is 30V above the negative supply. The negative input voltage limit is equal to the negative supply voltage or 30V below the positive supply, whichever is less.

Note 5: The maximum junction temperature of the LM111 is 150°C, while that of the LM211 is 110°C. For operating at elevated temperatures, devices in the H08 package must be derated based on a thermal resistance of 165°C/W, junction to ambient, or 20°C/W, junction to case. The thermal resistance of the dual-in-line package is 110°C/W, junction to ambient.

Note 6: These specifications apply for V_S=±15V and Ground pin at ground, and −55°C≤T_A≤+125°C, unless otherwise stated. With the LM211, however, all temperature specifications are limited to −25°C≤T_A≤+85°C. The offset voltage, offset current and bias current specifications apply for any supply voltage from a single 5V supply up to ±15V supplies.

Note 7: The offset voltages and offset currents given are the maximum values required to drive the output within a volt of either supply with a 1 mA load. Thus, these parameters define an error band and take into account the worst-case effects of voltage gain and R_S.

Note 8: The response time specified (see definitions) is for a 100 mV input step with 5 mV overdrive.

Note 9: This specification gives the range of current which must be drawn from the strobe pin to ensure the output is properly disabled. Do not short the strobe pin to ground; it should be current driven at 3 to 5 mA.

Note 10: Refer to RETS111X for the LM111H, LM111J and LM111J-8 military specifications.

Note 11: Human body model, 1.5 kΩ in series with 100 pF.

5.0 Absolute Maximum Ratings for the LM311 (Note 12)

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

Total Supply Voltage (V_{84})	36V
Output to Negative Supply Voltage (V_{74})	40V
Ground to Negative Supply Voltage (V_{14})	30V
Differential Input Voltage	±30V
Input Voltage (Note 13)	±15V
Power Dissipation (Note 14)	500 mW
ESD Rating (Note 19)	300V
Output Short Circuit Duration	10 sec
Operating Temperature Range	0° to 70°C
Storage Temperature Range	−65°C to 150°C
Lead Temperature (soldering, 10 sec)	260°C
Voltage at Strobe Pin	V^+−5V
Soldering Information	
Dual-In-Line Package	
Soldering (10 seconds)	260°C
Small Outline Package	
Vapor Phase (60 seconds)	215°C
Infrared (15 seconds)	220°C

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

Electrical Characteristics (Note 15) for the LM311

Parameter	Conditions	Min	Typ	Max	Units
Input Offset Voltage (Note 16)	T_A=25°C, R_S≤50k		2.0	7.5	mV
Input Offset Current (Note 16)	T_A=25°C		6.0	50	nA
Input Bias Current	T_A=25°C		100	250	nA
Voltage Gain	T_A=25°C	40	200		V/mV
Response Time (Note 17)	T_A=25°C		200		ns
Saturation Voltage	V_{IN}≤−10 mV, I_{OUT}=50 mA T_A=25°C		0.75	1.5	V
Strobe ON Current (Note 18)	T_A=25°C		2.0	5.0	mA
Output Leakage Current	V_{IN}≥10 mV, V_{OUT}=35V T_A=25°C, I_{STROBE}=3 mA V^- = Pin 1 = −5V		0.2	50	nA
Input Offset Voltage (Note 16)	R_S≤50K			10	mV
Input Offset Current (Note 16)				70	nA
Input Bias Current				300	nA
Input Voltage Range		−14.5	13.8,−14.7	13.0	V
Saturation Voltage	V^+≥4.5V, V^-=0 V_{IN}≤−10 mV, I_{OUT}≤8 mA		0.23	0.4	V
Positive Supply Current	T_A=25°C		5.1	7.5	mA
Negative Supply Current	T_A=25°C		4.1	5.0	mA

Note 12: "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."

Note 13: This rating applies for ±15V supplies. The positive input voltage limit is 30V above the negative supply. The negative input voltage limit is equal to the negative supply voltage or 30V below the positive supply, whichever is less.

Note 14: The maximum junction temperature of the LM311 is 110°C. For operating at elevated temperature, devices in the H08 package must be derated based on a thermal resistance of 165°C/W, junction to ambient, or 20°C/W, junction to case. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

Note 15: These specifications apply for V_S=±15V and Pin 1 at ground, and 0°C < T_A < +70°C, unless otherwise specified. The offset voltage, offset current and bias current specifications apply for any supply voltage from a single 5V supply up to ±15V supplies.

Note 16: The offset voltages and offset currents given are the maximum values required to drive the output within a volt of either supply with 1 mA load. Thus, these parameters define an error band and take into account the worst-case effects of voltage gain and R_S.

Note 17: The response time specified (see definitions) is for a 100 mV input step with 5 mV overdrive.

Note 18: This specification gives the range of current which must be drawn from the strobe pin to ensure the output is properly disabled. Do not short the strobe pin to ground; it should be current driven at 3 to 5 mA.

Note 19: Human body model, 1.5 kΩ in series with 100 pF.

APPENDIX H

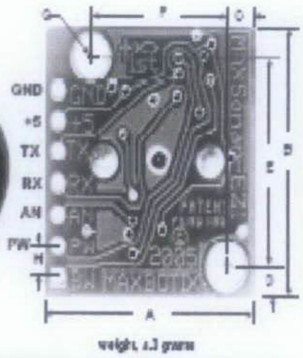
Datasheet

Ultrasonic Sensor

The MaxSonar®-EZ1™ High Performance Sonar Range Finder

The MaxSonar®-EZ1™ offers very short to long-range detection and ranging, in an incredibly small package with ultra low power consumption. The MaxSonar®-EZ1™ detects objects from 0-inches to 254-inches (6.45-meters) and provides sonar range information from 6-inches out to 254-inches with 1-inch resolution. Objects from 0-inches to 6-inches range as 6-inches. The interface output formats included are pulse width output, analog voltage output, and serial digital output.

approximately actual size



weight, 4.3 grams

A	0.785"	19.9 mm	F	0.510"	12.6 mm
B	0.870"	22.1 mm	G	0.124" dia.	3.1 mm dia.
C	0.100"	2.54 mm	H	0.100"	2.54 mm
D	0.100"	2.54 mm	J	0.645"	16.4 mm
E	0.670"	17.0 mm	K	0.610"	15.5 mm

dimensions are nominal

Features

- Continuously variable gain for beam control and side lobe suppression
- Object detection includes zero range objects
- Single 5V supply with 2mA typical current draw
- Readings can occur up to every 50mS, (20-Hz rate)
- Free run operation can continually measure and output range information
- Triggered operation provides the range reading as desired
- All interfaces are active simultaneously
  - Serial, 0 to 5V
    - 9600Baud, 81N
  - Analog (10mV/inch)
  - Pulse width (147uS/inch)
- Learns ringdown pattern when commanded to start ranging
- Designed for protected indoor environments
- Sensor operates at 42KHz
- High output 10V PP square wave sensor drive

Benefits

- Very low cost sonar ranger
- Half the size of other sensors in its class
- Sensor dead zone virtually gone
- No central blind spot
- Quality beam characteristics
- Mounting holes provided on the circuit board
- Lowest power ranger, excellent for multiple sensor or battery based systems
- Can be triggered externally or internally
- Sensor reports the range reading directly, frees up user processor
- Fast measurement cycle
- User can choose any of the three sensor outputs

Beam Characteristics

Sample results for measured beam patterns are shown below on a 12-inch grid. The detection pattern is shown for:

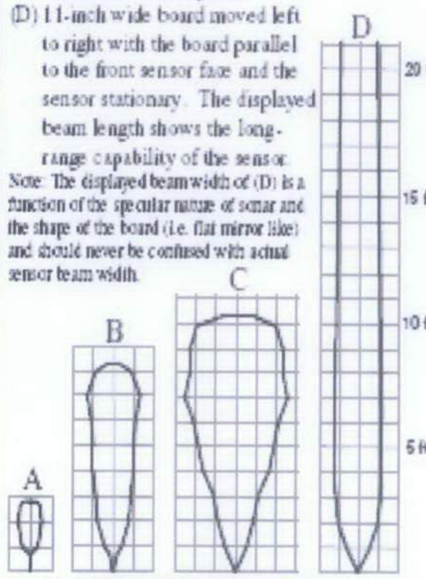
(A) 0.25-inch diameter dowel, note the very narrow beam for close small objects.

(B) 1-inch diameter dowel, dowel, note the long narrow detection pattern.

(C) 3.25-inch diameter rod, note the long controlled detection pattern.

(D) 11-inch wide board moved left to right with the board parallel to the front sensor face and the sensor stationary. The displayed beam length shows the long-range capability of the sensor.

Note: The displayed beam width of (D) is a function of the specular nature of sonar and the shape of the board (i.e. flat mirror like) and should never be confused with actual sensor beam width.



beam characteristics are approximate

MaxBotix® Inc.

8757 East Chimney Spring Drive, Tucson AZ, 85747 USA
1821 Graydon Avenue, Brainerd, MN, 56401 USA
Email: info@maxbotix.com Web: www.maxbotix.com

MaxSonar®-EZ1™ Pin Out

GND – Return for the DC power supply. Must be ripple and noise free for best operation.

+5V – Requires 5VDC +/- 0.5VDC. Current capability of 2mA capacity recommended.

TX – Delivers asynchronous serial with an RS232 format, except voltages are 0-5V. The output is an ASCII capital "R", followed by three ASCII character digits representing the range in inches up to a maximum of 255, followed by a carriage return (ASCII 13). The baud rate is 9600, 8 bits, no parity, with one stop bit. Although the voltage of 0-5V is outside the RS232 standard, most RS232 devices have sufficient margin to read 0-5V serial data. If standard voltage level RS232 is desired, invert, and connect an RS232 converter such as a MAX232.

RX – This pin is internally pulled high. The EZ1™ will continually measure range and output if RX data is left unconnected or held high. If held low the EZ1™ will stop ranging. Bring high for 20uS or more to command a range reading.

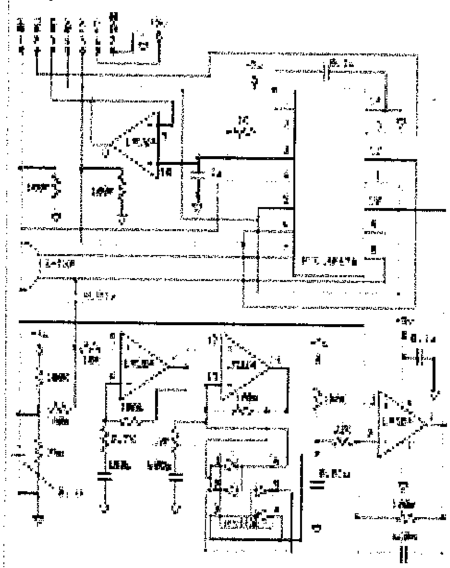
AN – Outputs 0 to 2.55 volts with a scaling factor of 10mV per inch. The output is buffered and corresponds to the most recent range data.

PW – This pin outputs a pulse width representation of range. The distance can be calculated using the scale factor of 147uS per inch.

BW – NC, Reserved.

MaxSonar®-EZ1™ Circuit

The MaxSonar®-EZ1™ sensor functions using active components consisting of an LM324, a diode array, a PIC16F676, together with a variety of passive components.



MaxSonar®-EZ1™ Timing Description

250mS after power-up, the MaxSonar®-EZ1™ is ready to accept the RX command. If the RX pin is left open or held high, the sensor will first run a calibration cycle (49mS), and then it will take a range reading (49mS). Therefore, the first reading will take 100mS. Subsequent readings will take 49mS. The MaxSonar®-EZ1™ checks the RX pin at the end of every cycle. Range data can be acquired once every 49mS.

Each 49mS period starts by the RX being high or open, after which the MaxSonar®-EZ1™ sends seven 42KHz waves, after which the pulse width pin (PW) is set high. When a target is detected the PW pin is pulled low. The PW pin is high for up to 37.5mS if no target is detected. During the next 4.7mS the serial data is sent. The remainder of the 49mS time is spent adjusting the analog voltage to the correct level. When a long distance is measured immediately after a short distance reading, the analog voltage may not reach the exact level within one read cycle. The MaxSonar®-EZ1™ timing is factory calibrated to one percent and in use is better than two percent.

MaxSonar®-EZ1™ General Power-Up Instruction

Each time after the MaxSonar®-EZ1™ is powered up, it will calibrate during its first read cycle. The sensor uses this stored information to range a close object. It is important that objects not be close to the sensor during this calibration reading. The best sensitivity is obtained when it is clear for fourteen inches, but good results are common when clear for at least seven inches. If an object is too close during the calibration cycle, the sensor may then ignore objects at that distance.

The MaxSonar®-EZ1™ does not use the calibration data to temperature compensate for range, but instead to compensate for the sensor ringdown pattern. If the temperature, humidity, or applied voltage changes during operation, the sensor may require recalibration to reacquire the ringdown pattern. If the temperature increases, the sensor is more likely to have false close readings. If the temperature decreases, the sensor is more likely to have reduced up close sensitivity. To recalibrate the MaxSonar®-EZ1™, cycle power, then command a read cycle.

Product specifications subject to change without notice. For more info visit www.maxbotix.com/MaxSonar-EZ1_FAQ

[illegible]