Palestine Polytechnic University

Collage of Engineering & Technology
Electrical &Computer Engineering Department

Graduation Project

Design of a Navigation Tool for Blind People

Project Team

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Palestine Polytechnic University

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College of Engineering & Technology
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Ayat Al-Awer **Suha Dababseh**

By the guidance of our supervisor, and by the acceptance of all members in the testing committee, this project delivered to department of electrical and computer engineering in the college of engineering and technology, to be as a partial fulfillment of the requirement of the department for the degree of B.Sc.

Supervisor Signature

Testing Committee Signature

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Chief of the Department signature

جامعة بولتكنك فلسطين

الخليل – فلسطين

كلية الهندسة والتكنولوجيا

دائرة الكهرباء والحاسوب

Design of a navigation tool for blind people

أسماء الطلبة

آيات الأعور　　　　　　　　　　　　سهى دبابسة

بناء على نظام كلية الهندسة والتكنولوجيا وإشراف ومتابعة المشرف المباشر على المشروع وموافقة أعضاء اللجنة الممتحنة ، تم تقديم هذا المشروع إلى دائرة الكهرباء والحاسوب ، وذلك للوفاء بمتطلبات درجة البكالوريوس في هندسة الأجهزة الطبية .

توقيع المشرف

توقيع اللجنة الممتحنة

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توقيع رئيس الدائرة

الإهـــــــــــــــداء

يا من أحمل اسمك بكل فخر
أبي
إلى حكمتي..... وعلمي
إلى أدبي........ وحلمي
إلى طريقي .... المستقيم
إلى طريق........ الهداية
إلى ينبوع الصبر والتفاؤل والأمل
إلى كل من في الوجود بعد ا ورسوله أمي الغالية
إلى سندي وقوتي وملاذي بعد ا
إلى من آثروني على نفسهم
إلى من علموني علم الحياة
إلى من أظهروا لي ما هو أجمل من الحياة إخوتي
إلى من كانوا ملاذي وملجئي
إلى من تذوقت معهم أجمل اللحظات
إلى من سأفتقدهم ...... وأتمنى أن يفتقدوني
إلى من جعلهم الله أخوتي با ...... و من أحببتهم بالله طلاب الهندسة الطبية
إلى من يجمع بين سعادتي وحزني
إلى من لم أعرفهم .... ولن يعرفوني
إلى من أتمنى أن أذكرهم ....إذا ذكروني
إلى من أتمنى أن تبقى صورهم ....في عيوني

فريق المشروع

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My sincere thank to my family members, I would like to extend my sincere appreciation to my colleagues, I would like to express my sincere appreciation to all whom help us.

Special thank go to Eng. Ali Amro,and eng Sami Al-salamin, who gives us all the helpful information we needed to complete this project.

Finally I warmly thank everyone who spent time to give knowledge for life

Thank you all..!

Abstract

The overall objective of this project is to design a navigation aid in order to assist blind and visually impaired people to navigate easily ,safely and to detect any obstacles. this project focuses in the electronic blind mobility aid ,that can help blind people traveling by themselves using a pair of ultrasonic sensor, the two sensor put on the waist. it should be able to give information to the blind about urban walking routes and to provide real-time information on the distance of over-hanging obstacles within three meters along the travel path ahead of the user.

The suggested system is based on a microcontroller with synthetic speech output .in addition, it consist of two audio alarm ,two ultrasonic sensor mounted on the users waist one to detect obstacles and the other to detect slopes.

ملخص المشروع

الهدف العام من هذا المشروع هو تصميم أداة تجوال لمساعدة المكفوفين وضعاف البصر على التنقل بسهولة وأمان والكشف عن أية عوائق ومنحدرات تواجههم.حيث ان هذا المشروع هو تقنية الكترونية تستخدم زوج من أجهزة الاستشعار بالموجات فوق الصوتية ،و تكون هذه المجسات على حزام يوضع على خصر الكفيف . بحيث تكون قادرة على اعطاء المعلومات له قبل وصوله الى المنحدر او العائق على بعد ثلاثة امتار بذلك يحقق له سبل الحماية والامان.

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Introduction

Chapter One
Introduction

[1.1] Overview:

Blind since old age have been using walking stick for their mobility purposes. In addition some of them are also using guide-dog for their mobility. Due to the development of modern technologies, many different types of devices are available to assist the blind. They are commonly known as electronic travel aid.

The importance of sensorial and communicational functions results from the fact that the human body is an open biosystem, in a permanent exchange of energy, substances and information with the environment. The human being receives information from the environment: 1% by taste, 1.5% by tactile sense, 3.5% by smell, 11% by hear and 83% by sight. For an efficient reintegration of the disabled people in the family and society. it is strongly needful to assist their diminished functions or to replace the totally lost functions.

Thus, a new branch of technology and engineering is developing: Assistive Technology, meaning any product, instrument, equipment or technical system used by a disabled person, especially produced or generally available, preventing, compensating, relieving or neutralizing the impairment, disability or handicap. So, the need for such devices in our life has encouraged us to design the choose topic of this project (design of a navigation tool for blind people).This project will propose an efficient model of blind cane that is automatically controlled and driven to perform various task.

[1.2] Project Importance:

The importance of the project comes from its wide benefit for blind people. It will enable them to go to their destination safely.

This project was chosen based on the study of the number of blind man in Palestine.

[1.3] Project safety:

In general ,our system is supply with 5 volt and this amount of power doesn't danger on patient .except people whom have pacemaker device in their bodies.
And also we use belt on the waist of the patient made from insulation material. this make our project safety for the people whom use it.

[1.4] Literature Review:

The study of this project depends on some ideas of other projects.

The first project (Autonomous Robot) was done by Ahmad Sahoury, Hammam Omar, and Khalil Al- Fageh. This project was done in Palestine Polytechnic University (ppu) to be the graduation project of this team. this project presents a new module for an automatic controlled robot. The robot is designed to be driven automatically.

This system detects barriers around it using waves from ultrasonic sensors, this sensors are fixed on the front, right, and left sides of the robot, so the system will identify the reflected wave from the front side. If forward the robot it will identify the reflected waves from the right, if barriers a head it will identify the reflected wave from the left, if a barrier a head it will run backward until it find no barrier.

The second project was done by Ahmad Ode; this project was done in Open Jerusalem University to be the gradation project of this student. Name this project (Electronic cane for blind people) , the main idea of the project is to make contact with the blind people by sound tune, to measure the distance between the cane and the obstacles body before 120 cm , and this distance divided to three stages ,each one includes 40cm,the obstacles were detected by (EZ1 SENSOR) in each stage the person can detect that he over 40 cm distances by different tune by set of program software.

[1.5] Estimated Cost:

The overall cost of the components required for implementing the system is shown in table.

Table 1.1: Hardware Cost

Component	Cost
PIC	**12.5 $**
Ultrasonic Device	**112.5 $**
Other Components	**55.5 $**
Battery	**5.5 $**
Total	**183.5 $**

[1.6] Scheduling Table:

The timing management will divide the system hierarchy according to the actions:

T1: *Preparing to the project*: this stage of the project primarily aims to identify the contents of it, discuss the initial information, and evaluate the project tasks and levels.

T2: *The project analysis*: the analysis process includes extensive study for all possible design options of the project.

T3: *Conceptual Design*: project objectives, design block diagram will be done and we will show how our system will work.

T4: *Studying project component and schematic analysis*: it is necessary to study the specifications of project components to meet the requirements of project.

T5: *Programming microcontroller:* writing subprograms from project, and testing them on subsystem circuits in order to the build whole system program.

T6: *Writing the documentation*: writing the documentation of project which will continue during all projects time.

T7: *Hardware Implementation:* include building electronic circuits, and finally combining them together.

T8: *Testing the system*: testing the system, calibration, discovering the problems, and solve them.

T9: *Writing the documentation*: writing the documentation of project.

T10: *Print out the project and discuss it.*

Table 1.2:Timing Plane

Task\Week	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
T1															
T2															
T3															
T4															
T5															
Task\Week															
T6															
T7															
T8															
T9															
T10															

[1.7] Report Contents

This report is divided into six chapters; are described as follow:

Chapter One: (Introduction)

This chapter presents overview, literature review, project objective, and importance of the project, project scheduling, and economical study.

Chapter Two: (Physiology of Human Eye)

This chapter describes the human eye, its function and gives the definition of blindness including the reasons that cause it; and statistics about the_number of blind people in the world.

Chapter Three :(Theoretical Background)

This chapter includes theoretical background of the main components which will be implemented in the project such as ultrasonic, microcontroller…etc .

Chapter Four: (Design Concept)

In this chapter, a general block diagram that describes the system operations is designed .including the description of each stage.

Chapter Five :(Software Design)

This chapter includes an overview about the principle of operation of the microcontroller.

Chapter Six: (System Implementation)

This chapter includes testing of our design which does in this semester; it includes the testing of the project circuit.

Chapter Seven: (Results and Conclusions)

This chapter includes the project conclusions and recommendations.

Chapter Eight : (Future works)

This chapter includes developments that will occur on project later.

2

Physiology of Human Eye

2.1 Human Eye

2.2 General properties

2.3 Eye Components

2.4 Visual Impairment and blindness

2.5 Global Trends

2.6 Causes of Blindness

2.7 Prevention

Chapter Two
Physiology Of The Eye

[2.1]Human Eye

The human eye is an organ which reacts to light for several purposes. As a conscious sense organ, the eye allows vision. Rod and cone cells in the retina allow conscious light perception and vision including color differentiation and the perception of depth. The human eye can distinguish about 16 million colors.

In common with the eyes of other mammals, the human eye's non-image-forming photosensitive ganglion cells in the retina receive the light signals which affect adjustment of the size of the pupil, regulation and suppression of the hormone melatonin and entrainment of the body clock.

[2.2]General Properties

The eye is not properly a sphere; rather it is a fused two-piece unit. The smaller frontal unit, more curved, called the cornea is linked to the larger unit called the sclera. The corneal segment is a sixth of the unit] it is typically about 8 mm (0.3 in) in radius. The sclera constitutes the remaining five-sixths; its radius is typically about 12 mm. The cornea and sclera are connected by a ring called the limbos. The iris – the color of the eye – and its black center, the pupil, are seen instead of the cornea due to the cornea's transparency.

To see inside the eye, an ophthalmoscope is needed, since light is not reflected out. The funds (area opposite the pupil) shows the characteristic pale optic disk (papilla), where vessels entering the eye pass across and optic nerve fibers depart the globe.

[2.3]Eye Components

The eye is made up of three coats, enclosing three transparent structures. The outermost layer is composed of the cornea and sclera. The middle layer consists of the choroid, ciliary body, and iris. The innermost is the retina, which gets its circulation from the vessels of the choroid as well as the retinal vessels, which can be seen in an ophthalmoscope.

Within these coats are the aqueous humor, the vitreous body, and the flexible lens. The aqueous humor is a clear fluid that is contained in two areas: the anterior chamber between the cornea and the iris and exposed area of the lens; and the posterior chamber, behind the iris and the rest. The lens is suspended to the ciliary body by the suspensor ligament (Zonule of Zinn), made up of fine transparent fibers. The vitreous body is a clear jelly that is much larger than the aqueous humor, and is bordered by the sclera, zonule, and lens. They are connected via the pupil.

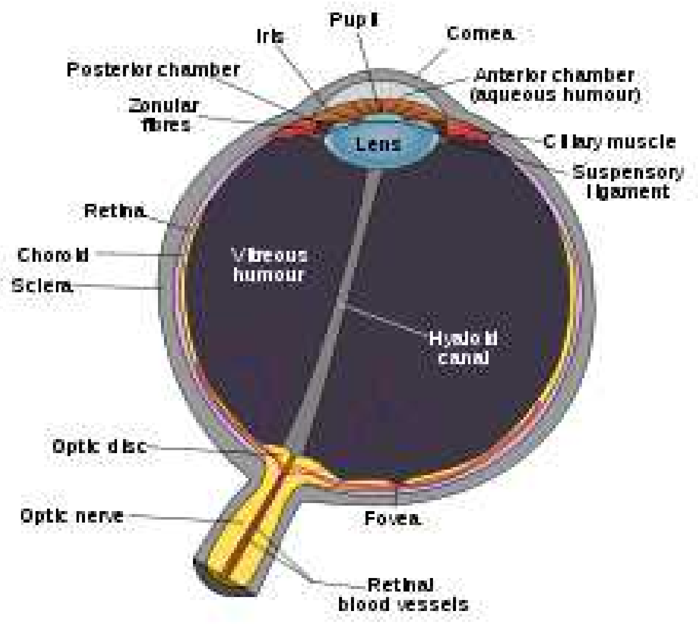

Figure 2.1 components human eye [1]

[2.4] Visual Impairment and blindness

About 314 million people are visually impaired worldwide; 45 million of them are blind. Most people with visual impairment are older, and females are more at risk at every age, in every part of the world. About 87% of the worlds visually impaired live in developing countries.

The number of people blinded by infectious diseases has been greatly reduced, but age-related impairment is increasing. Cataract remains the leading cause of blindness globally, except in the most developed countries.

Correction of refractive errors could give normal vision to more than 12 million children (ages five to 15). About 85% of all visual impairment is avoidable globally.

-There are four levels of visual function:

Normal vision

Moderate visual impairment.

Serve visual impairment

Blindness.

- Distribution of Persons With Disability 2004 \Palestine

Table 2.1 Percentage Distribution of Persons With Disability /Palestine

Palestinian Territory	18.7
West Bank	20.9
Gaza Strip	14.4
Sex	
Males	16.9
Females	21.3
Age	
0-4	6.4
5-14	16.5
15-29	18.4
30-39	13
40-49	16.4
50-59	27.8
60+	27.7

[2.5]Global Trends

Global trends since the early 90s show reduced rates of visual impairment worldwide and a shift in the causes. Visual impairment and blindness caused by infectious diseases have been greatly reduced (an indication of the success of international public health action), but there is a visible increase in the number of people who are blind or visually impaired from conditions related to longer life Globally about 314 million people are visually impaired; 45 million of them are blind

Presbyopia, the inability to read or perform near work that occurs with ageing, causes visual impairment if it is not corrected. The scope of the problem is not known, but preliminary studies indicate that the problem could be vast, especially in developing countries.

[2.6] Causes of Blindness

Globally, the leading causes of blindness, in order of frequency, are: cataract (a clouding of the lens of the eye that impedes the passage of light), uncorrected refractive errors (near-sightedness, far-sightedness or astigmatism), and glaucoma(a group of diseases that result in damage of the optic nerve), Age-related macular degeneration (which involves the loss of a person's central field of vision).

Other major causes include corneal opacities (eye diseases that scar the cornea), diabetic retinopathy (associated with diabetes), blinding trachoma, and eye conditions in children such as cataract, retinopathy of prematurity (an eye disorder of premature infants), and vitamin A deficiency.

[2.7] Prevention

Globally, about 85% of all visual impairment and 75% of blindness could be prevented or cured worldwide. Since the 90s, areas of significant prevention progress on a global scale include: further development of eye health care services, which has led to increased availability and affordability; increased commitment to prevention and cure from national leaders, medical professionals and private and corporate partners; higher awareness and use of eye health care services by patients and the general population; and Implementation of effective eye health strategies to eliminate infectious causes of vision loss.

Global partnerships of Member States, nongovernmental organizations and community groups (such as Vision 2020 the Right to Sight and Global Elimination of Blinding Trachoma by 2020) have played key roles in eliminating avoidable visual impairment.

3

Theoretical Background

3.1 Introduction

3.2 Hardware Ultrasonic Sensor

3.2.1Ultrasonic Transmitter

3.2.2 Ultrasonic Receiver

3.2.3 Transmitter and Receiver Pair

3.2.4 Ultrasonic Range Detectors

3.3 Measuring using an Ultrasonic Sensor.

3.3.1 Introduction

3.3.2 Theory of Operation

3.3.3 Calculating the Distance of an Object (D).

Chapter Three

Theoretical Background

[3.1] Introduction

Transmitter and receiver circuits will discussed through out this section; this discussion includes their operations, parts, and main parameters.

The transmitter consists of ultrasonic pulse oscillator which is responsible of control the sending-out time of the ultrasonic pulse. The receiver consists of the receiver sensor, signal amplification which amplifies weak received signal, the microcontroller gives a trigger for the ultrasonic sensor to detect the obstacles and continuously give a trigger when there is no any obstacles.

Ultrasonic or ultrasound, derived from the Latin words "ultra," meaning beyond, and "sonic," meaning sound, is a term used to describe sound waves that vibrate more rapidly than the human ear can detect.

Most people can only detect frequencies of sound that fall between 16 and 16,000 Hz. Some insects can produce ultrasound with frequencies as high as 40 kHz. Small animals such as cats and dogs hear frequencies of up to 30 kHz.

[3.2] Hardware Ultrasonic Sensor:

The principle of operation of an ultrasonic sensor can be describes as follows, The sensor transmits ultrasonic waves and waits for reflected sound waves. After receiving reflected sound wave ,echo, In our project we use SRF05 ultrasonic sensors.

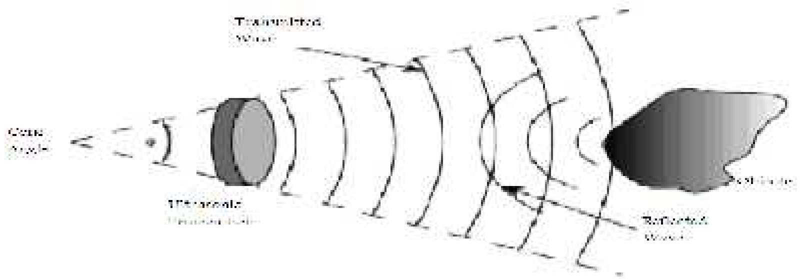

Figure 3.1 Ultrasonic sensor [3]

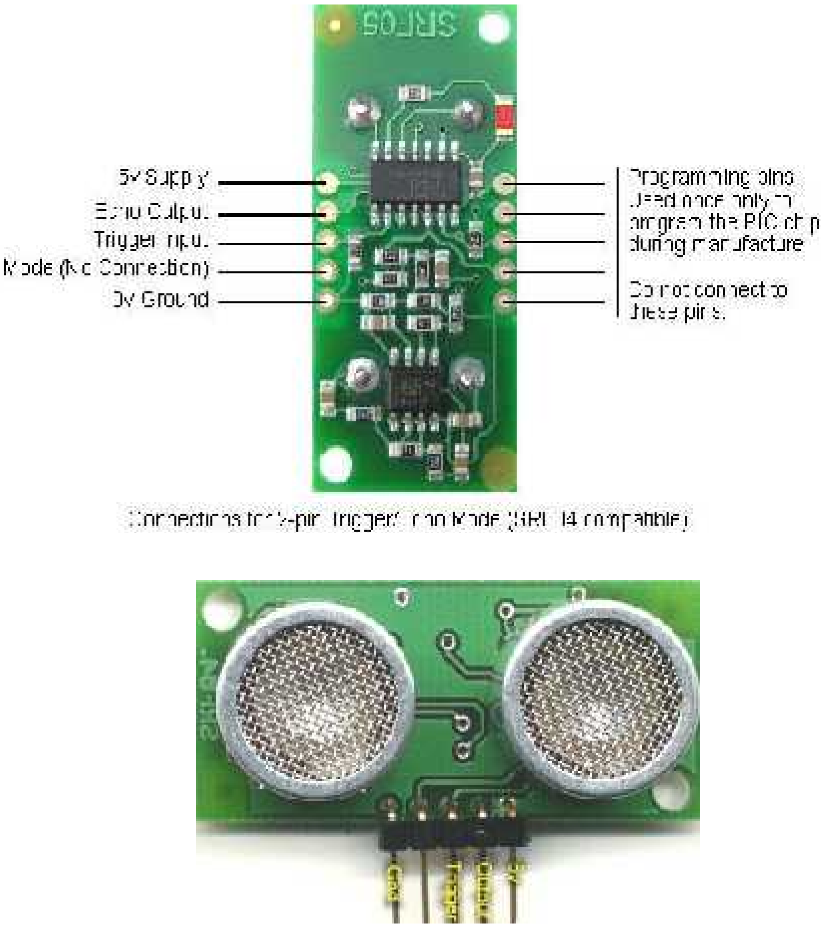

Figure 3.2 SRF05 Ultrasonic range sensor [4]

The ultrasonic device is very small, and its dimension is in mm.

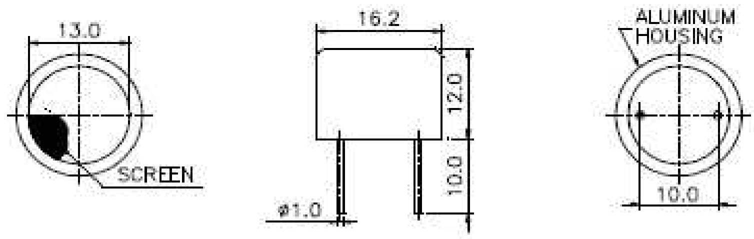

Figure 3.3 SRF05 Ultrasonic device dimension [5]

One of the main features of SRF05 is that it contains only four pins. One for Vdd (+5V), one for Vss (GND), one for Trigger and one for Echo. Also one additional pin is given to adjust the range of the sensor. The other specifications of SRF05 ultrasonic sensors are:

Voltage -5Vonly required

Current -30mA type 50mA Max

Frequency - 40 KHz

Max Range - 3 m

Min Range - 3 cm

Sensitivity - Detect 3cm diameter broom handle at > 2 m

Input Trigger - 10uS Min

Small Size - 43mm x 20mm x 17mm height.

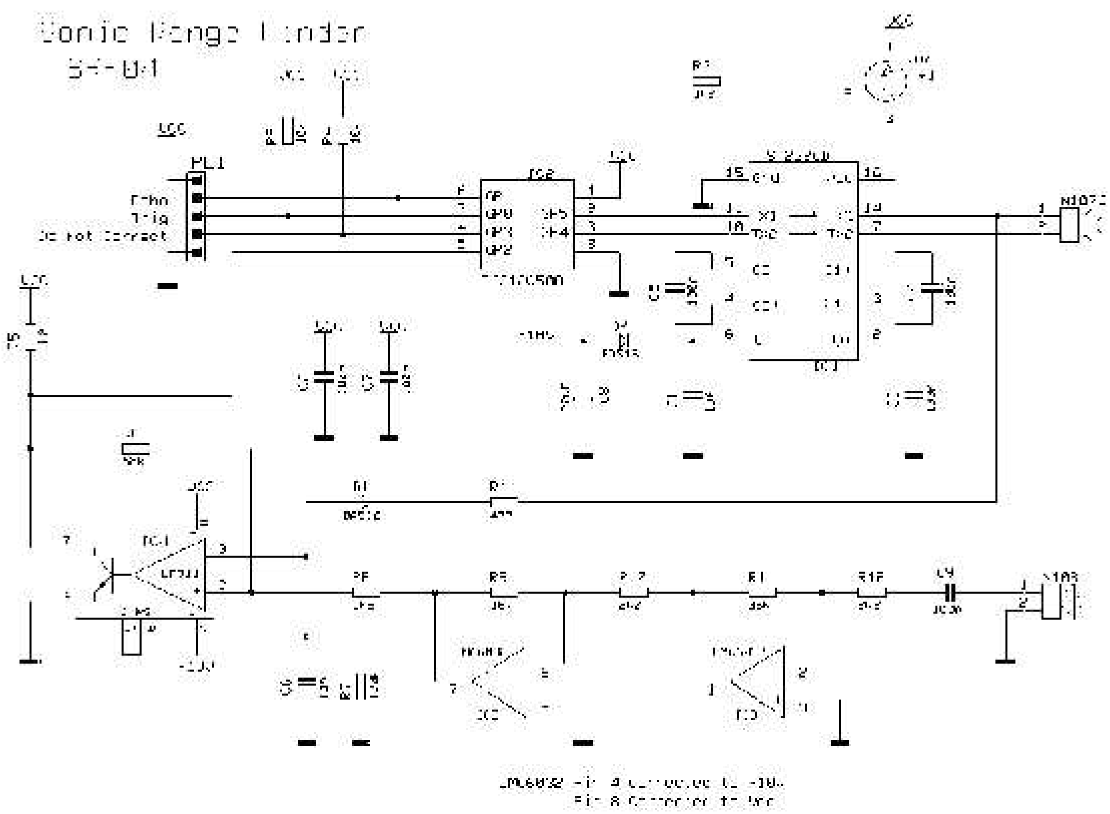

Figure 3.4 Schematic Diagram for SRF05 Ultrasonic sensor[6]

The circuit is designed to be low cost. It uses a PIC12C508 to perform the control functions and standard 40 kHz piezo transducers.

The receiver is a classic two stage op-amp circuit. The input capacitor C9 blocks some residual DC which always seems to be present. Each gain stage is set to 24 for a total gain of 576. This is close the 25 maximum gain available using the LM1458. The output of the amplifier is fed into an LP311 comparator. A small amount of positive feedback provides some hysterics to give a clean stable output.

In operation, the processor waits for an active low trigger pulse to come in. It then generates just eight cycles of 40khz. The echo line is then raised to signal the host processor to start timing. the returning echo will be detected and the PIC will lower the echo line. The width of this pulse represents the flight time of the sonic burst. If no echo is detected then it will automatically time out after about 30mS. Because the st232 is shut down during echo detection, you must wait at least 10mS between measurement cycles for the +/- 10v to recharge.

Performance of this design is, quite good. It will reliably measure down to 3cm and will continue detecting down to 1cm or less but after 2-3cm the pulse width doesn't get any smaller.

Maximum range is a little over 3m. As and example of the sensitivity of this design, it will detect a 2.5m. Average current consumption is reasonable at less than 50mA and typically about 30mA.

[3.2.1]Ultrasonic Transmitter:

The transmitter consists of an electronics circuitry and an electromechanical transducer. The electronic circuitry generates the required frequency electrical signal and the electromechanical transducer converts that electrical signal into the physical form and activates the open medium surface. This oscillating physical surface creates the ultrasonic Waves. The oscillating surface creates a pressure variation and ultimately a pressure wave with a frequency equal to that of the surface oscillation.

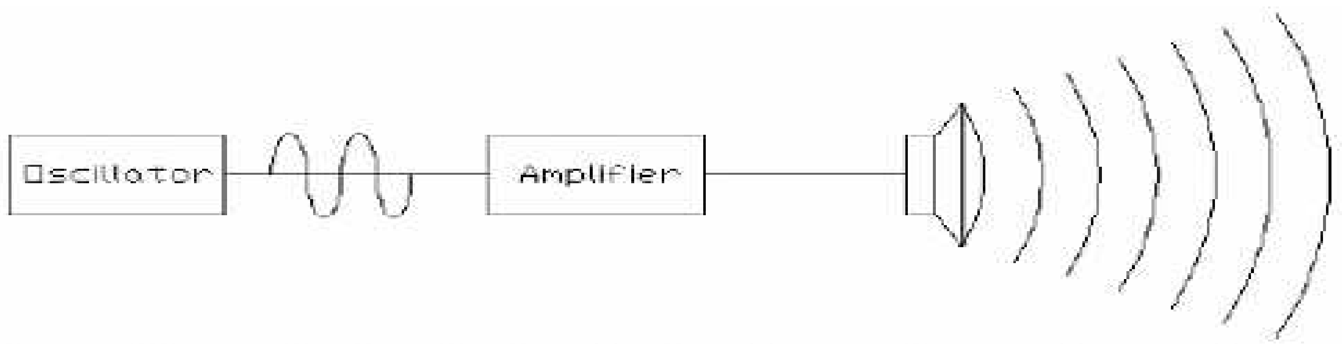

Figure 3.5 Ultrasonic Transmitters [7]

[3.2.2] Ultrasonic Receiver:

The receiver that converts the sound waves into an electrical signal after sending from the transmitter . The sound waves travel into the medium and are reflected by an object in the path of the waves. This reflected waves is then sensed by the receiver.

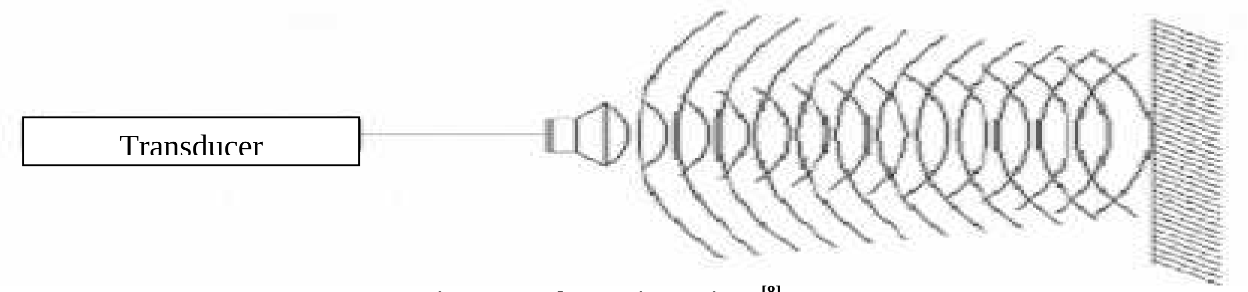

Figure 3.6 ultrasonic receiver [8]

[3.2.3] Transmitter and Receiver Pair:

It consists of a transmitter and receiver pair on the device. There are two different transducers for transmitter and receiver. The transmitter transmits and the receiver waits for the reflected signals. [9]

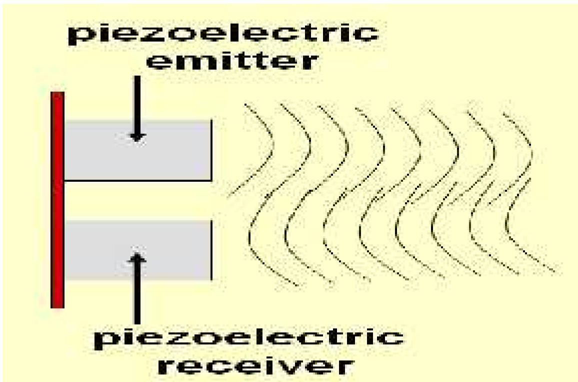

Figure 3.7 transmitter and receiver [10]

[3.2.4] Ultrasonic Range Detectors:

Figure 3.8 show that the approximate frame for the ultrasonic(radar) ,in this project the circumference of Radar is constant from the SRF05 device by approximately 2.5–3 m.

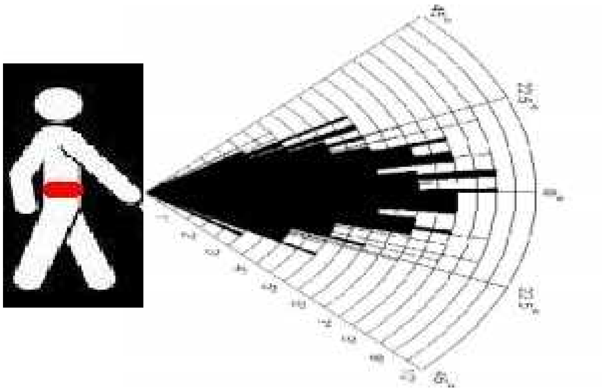

Figure 3.8 : Beam Pattern of the sensor

[3.3] Measuring using an Ultrasonic Sensor:

[3.3.1] Introduction

Ultrasonic distance sensor provides precise, non-contact distance measurements from about 2 cm to 3 meters. It is very easy to connect to microcontrollers, requiring only one I/O pin. Sensor works by transmitting an ultrasonic burst and providing an output pulse that corresponds to the time required for the burst echo to return to the sensor. By measuring the echo pulse width the distance to target can easily be calculated.

[3.3.2] Theory of Operation

The sensor detects objects by emitting a short ultrasonic burst and then "listening" for the echo.

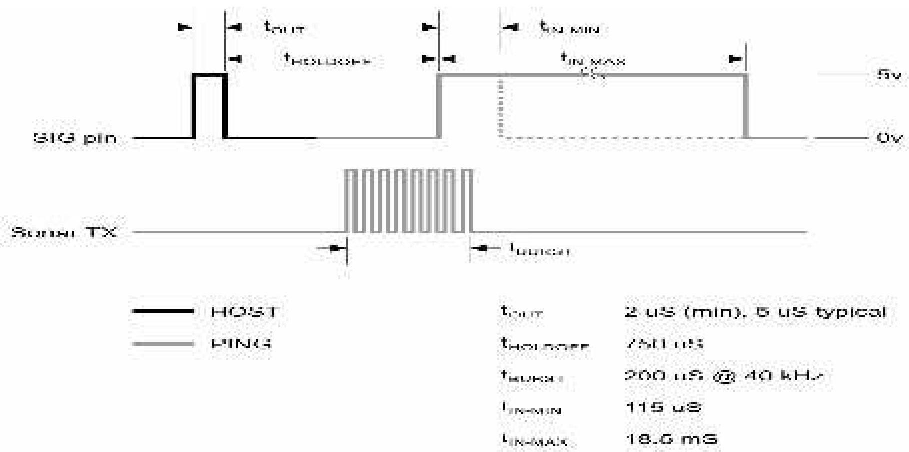

Figure 3.9 sensor operation [11]

Under control of a host microcontroller (trigger pulse), the sensor emits a short 40 kHz (ultrasonic) burst. This burst travels through the air at about 1130 feet per second, hits an object and then bounces back to the sensor. The sensor provides an output pulse to the host that will terminate when the echo is detected; hence the width of this pulse corresponds to the distance to the target.

[3.3.3] Calculating the Distance of an Object(D).

The distance that the sensor can reach depends on:

-Sound speed

-Time

According to:

$D = 0.5 * C * (T_1 - T_0)$,

Where:-

D= Distance of object

S=Speed of Sound
T0 = Time at which sonic wave is transmitted
T1 = Time at which sonic wave is received [12]

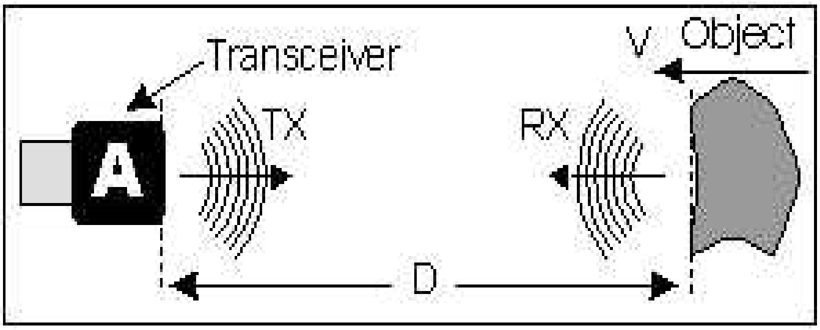

Figure 3.10 distance between u\s sensor and object

4

Design Concept

Chapter Four

Design Concept

[4.1] Introduction:

The system consists of two sensors implemented to a waist belt to detect obstacles or slopes,the first sensor(SRF05A) senses obstacles and barriers in front of the blind man and gives an audio alarm. The second sensor (SRF0B) detects the slopes in front of the blind person, and gives another different audio alarm.

[4.2] Waist Belt (Obstacels)

The sensor that appear on the man belt in figure 4.1, used to detect the obstacles that 2.5m away from the person.

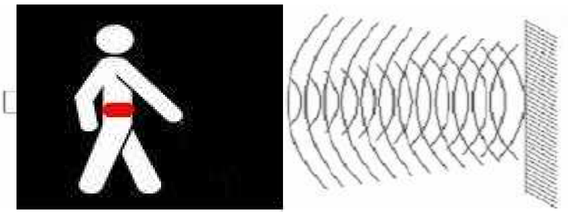

Figure 4.1 : position of the sensor that detect obstacles

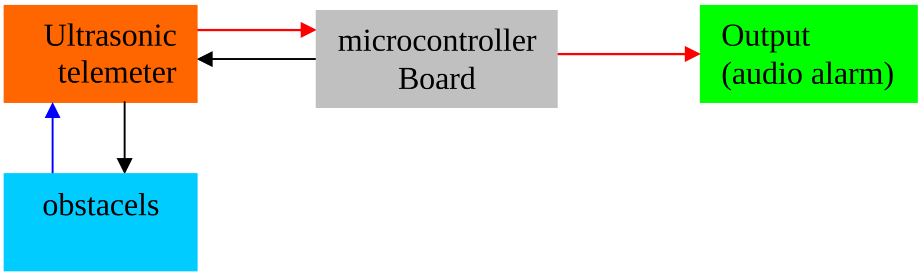

Figure 4.2:general block diagram of the waist belt (obstacles)

[4.3] Waist Belt (Slopes)

The sensor that appear on the man belt in figure 4.3, used to detect the slopes that 2.5m away from the person.

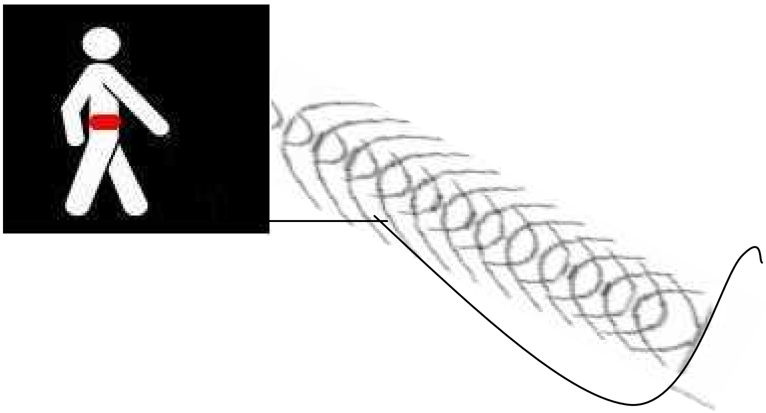

Figure 4.3 : position of the sensor that detect slopes

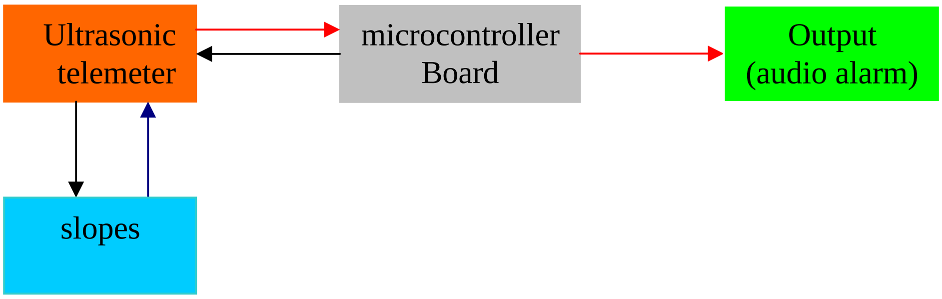

Figure 4.4:General Block Diagram of the waist belt (slopes)

[4.4] The system principle of operation.

microcontroller plays an important rule in the project it will trigger an ultrasonic sensor and then wait for echo pulse; according to SRF05 timing diagram shown in figure 4.5 the microcontrollers supply a short 10uS pulse to the trigger input to start the ranging. The SRF05 will send out an 8 cycle burst of ultrasound at 40 kHz and raise its echo line high. It then listens for an echo, and as soon as it detects one it lowers the echo line again. The echo line is therefore a pulse whose width is proportional to the distance to the object. By timing the pulse it is possible to calculate the range in inches/centimeters or anything else. If nothing is detected then the SRF05 will lower its echo line anyway after about 30mS.

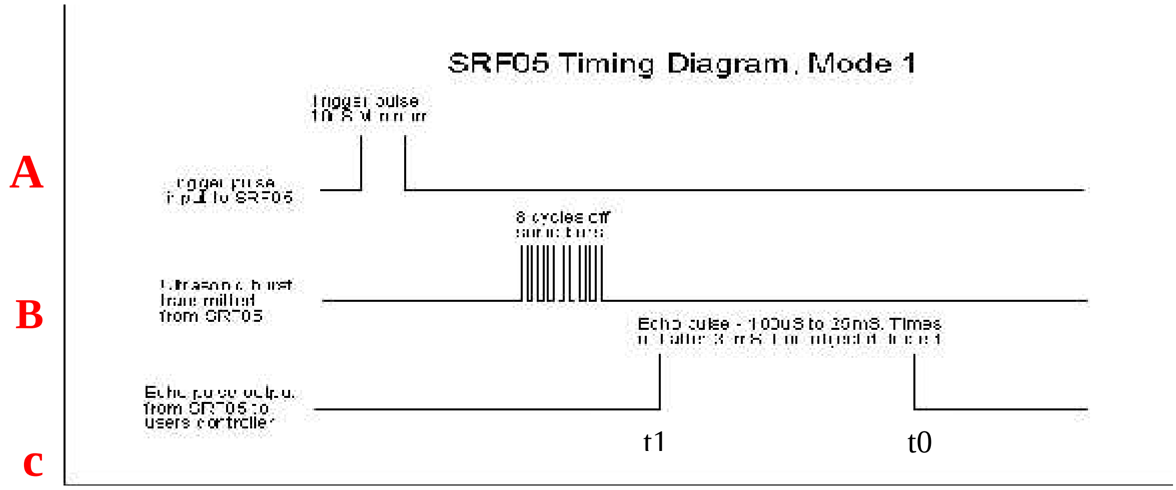

Figure 4.5:Timing Diagram [13]

According to figure 4.5c when $(t_1\text{-}t_0)<30$ ms the sensor will detect the obstacles ; so the output system should give an audio alarm that say:(***be careful there is an obstacles***), and when $(t_1\text{-}t_0)<30$ ms the sensor will detect aslope so the output system should give another different audio alarm that say :(***be careful there is a slope***)

[4.5] Battery:

As mentioned before the idea of the project is to design battery driven system that will supply a specific voltage for the system .

specification :

Table 4.1: battery specification

Minimum voltage (v)	6 V
Current (ma)	250 mA

IN = 6V

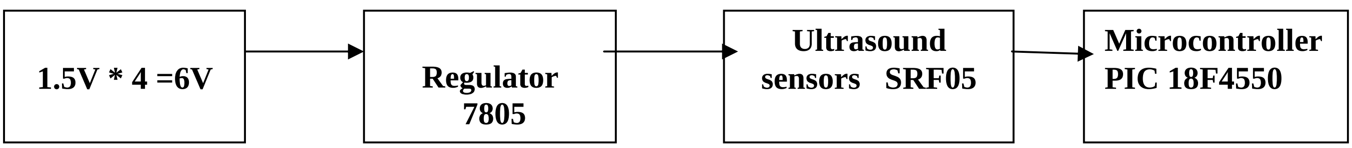

Figure 4.6 :General Block of the u/s sensor power

[4.6] Regulator 7805:

The 7805 power regulator IC as in the *figure 4.7* takes in a DC voltage at the "INPUT" "I" leg (the same voltage as the AC power pack outputs on a Sega system around 9V-12V) . It's "OUTPUTS" "O" leg is DC + 5V which powers the Sega system. "COMMON" is connected to ground. In this project to supply microcontroller and other chips.

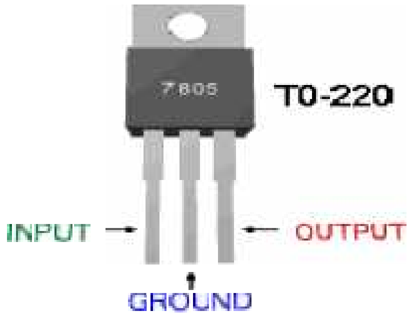

Figure 4.7 : 7805 regulator[14]

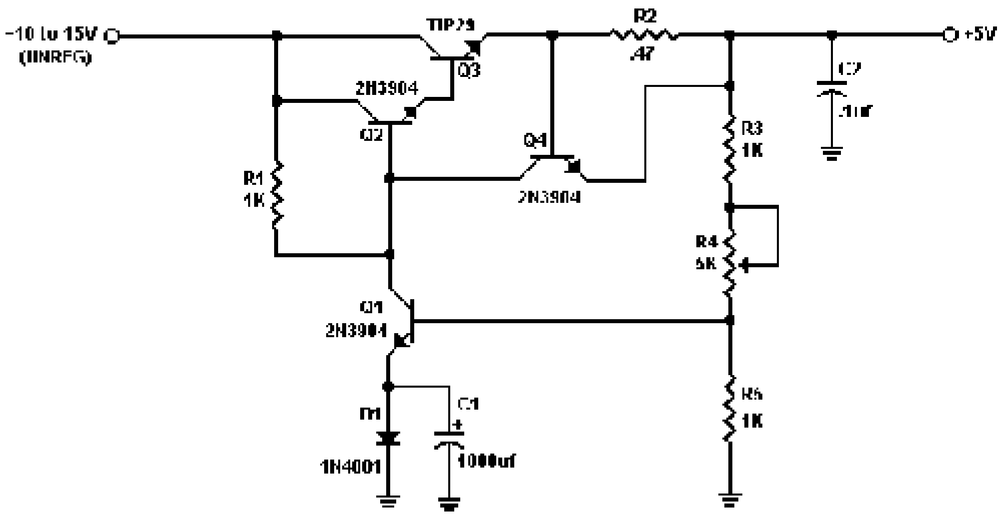

Figure 1

Figure 4.8: Schematic Diagram of LM7805

5

Software Design

Chapter Five
Software Design

[5.1] Introduction

This chapter gives brief descriptions of microcontroller then flowchart and necessary software program required to the project are designed.

[5.2] Microcontroller

A microcontroller (also micro computer, MCU or µC) is a small computer on a single integrated circuit consisting internally of a relatively simple CPU, clock, timers, I/O ports, and memory. Microcontrollers are designed for small or dedicated applications. Thus, in contrast to the microprocessors used in personal computers and other high-performance or general purpose applications, simplicity is emphasized. Some microcontrollers may use four-bit words and operate at clock rate frequencies as low as 4 kHz, as this is adequate for many typical applications, enabling low power consumption (mill watts or microwatts). They will generally have the ability to retain functionality while waiting for an event such as a button press or other interrupt; power consumption while sleeping (CPU clock and most peripherals off) may be just nanowatts, making many of them well suited for long lasting battery applications. Other microcontrollers may serve performance-critical roles, where they may need to act more like a digital signal processor (DSP), with higher clock speeds and power consumption.

[5.2.1] Types of Microcontroller:

1. Flash devices.

Can be reprogrammed by the programmer.

2. One Time Programmable Devices (OTP).

Once programmed cannot be reprogrammed. All OTP devices however do have a windowed variety, which enables them to be erased under ultra violet light in about 15 minutes, so that they can be reprogrammed

[5.2.2] Microcontroller Architecture Contents:

1. Microprocessor.
2. Memory.
3. I/O.

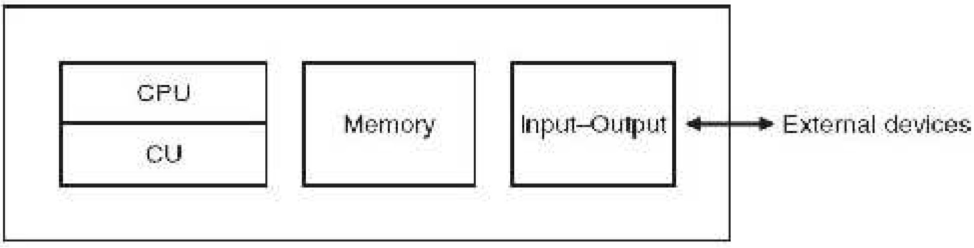

Figure5.1:The simplest microcontroller architecture [15]

[5.2.3] Hardware features of microcontrollers:

1. Supply voltage

Most microcontrollers operate with the standard logic voltage of 5V. Some microcontrollers can operate at as low as 2.7 V and some will tolerate 6 V without any problems.

2. Clock

The clock is usually provided by connecting external timing devices to the microcontroller. Some microcontrollers have built-in timing circuits and they do not require any external timing components.

3. Timers

A timer is basically a counter which is driven either from an external clock pulse or from the internal oscillator of the microcontroller. Most timers can be configured to generate an interrupt when they reach a certain count (usually when they overflow).

4. Watchdog

The watchdog is basically a timer which is refreshed by the user program and a reset occurs if the program fails to refresh the watchdog the watchdog timer is used to detect a system problem, A watchdog is a safety feature that prevents runaway software and stops the microcontroller from executing meaningless and unwanted code.

5. Reset input

A reset input is used to reset a microcontroller, Resetting puts the microcontroller into a known State, An external reset action is usually achieved by connecting a push-button switch to the reset input.

6. Interrupts

An interrupt causes the microcontroller to respond to external and internal events very quickly; when an interrupt occurs the microcontroller leaves its normal flow of program execution and jumps to a special part of the program.

7. Brown-out detector

They reset a microcontroller if the supply voltage falls below a nominal value, they can be employed to prevent unpredictable operation at low voltages, especially to protect the contents of EEPROM-type memories.

8. Analogue-to-digital converter

(A/D) is used to convert an analogue signal such as voltage to a digital form so that it can be read by a microcontroller, A/D converters usually generate interrupts when a conversion is complete so that the user program can read the converted data quickly. A/D converters are very useful in control and monitoring applications since most sensors (e.g. temperature sensor, pressure sensor, force sensor, etc.) produce analogue output voltages.

9. Serial I/O

Serial communication enables a microcontroller to be connected to another microcontroller or to a PC using a serial cable.

10. EEPROM data memory

The advantage of an EEPROM memory is that the programmer can store nonvolatile data in such a memory, and can also change this data whenever required.

11. LCD drivers

LCD drivers enable a microcontroller to be connected to an external LCD display directly; these drivers are not common since most of the functions provided by them can be implemented in software.

12. Analog comparator

Analogue comparators are used where it is required to compare two analogue voltages.

13. Real-time clock

Real-time clock enables a microcontroller to have absolute date and time information continuously.

14. Sleep mode

The main reason of using the sleep mode is to conserve the battery power when the microcontroller is not doing anything useful. The microcontroller usually wakes up from the sleep mode by external reset or by a watchdog time-out.

15. Power-on reset

Keep the microcontroller in reset state until all the internal circuitry has been initialized.

16. Low power operation

It is important in portable applications where the microcontroller based equipment is operated from batteries. [16]

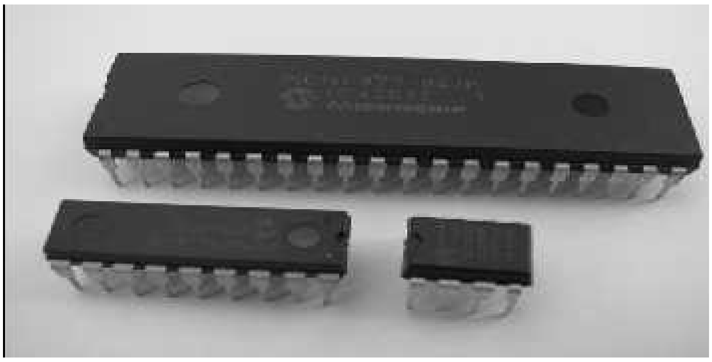

Figure5. 2: some PIC microcontroller IC [17]

[5.2.4]Microcontroller PIC18F4550:

The Microchip PIC18F4550 microcontroller , including a large 32kbytes of program memory, optimized for C programs and including a hardware multiply. This microcontroller also features a total of 13 input A/D channels, making the system ideal for use in real-world monitoring applications.

Our new PIC18F4550 Development Board, will get you started with an inexpensive, ready-to-run solution, which is ideal for the student or hobbyist.

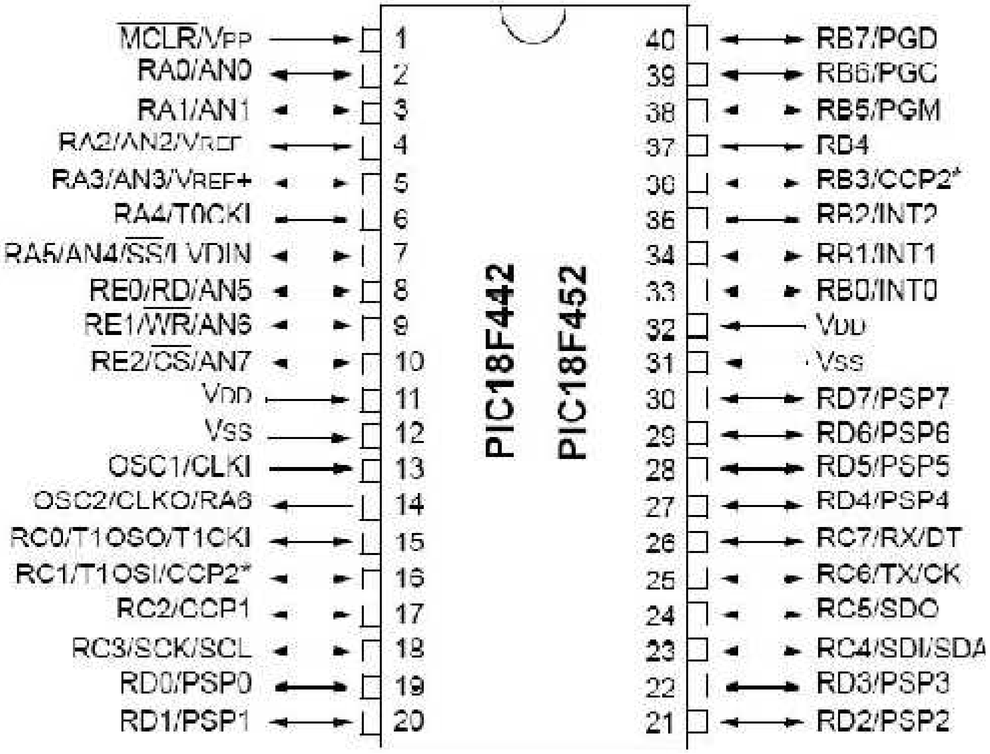

Figure 5.3 : pic18f4550 pins[18]

Features of 18F452PIC Microcontroller:

-32kBytes Program Flash Memory

-256 Bytes EEPROM Memory.

-2048 Bytes RAM Memory

-13-bit analog to digital converter

-40 pin chip

-40MHz max operating frequency.

[5.3] Flowcharts :

Flowcharts Explanation:

[5.3.1] Waist Belt (Obstacles-SRF05A)

in figure (5.4) depicts the principle of operation of obstacles detectors. microcontroller supply the system with 10 µs trigger and take the reading from the sensor and then examine whether (t_1-t_0) is more than 30ms , then continue and keep checking by supply the system with another 10µs trigger. At the moment that(t_1-t_0) become less than 30 ms then the system will give an output audio alarm.

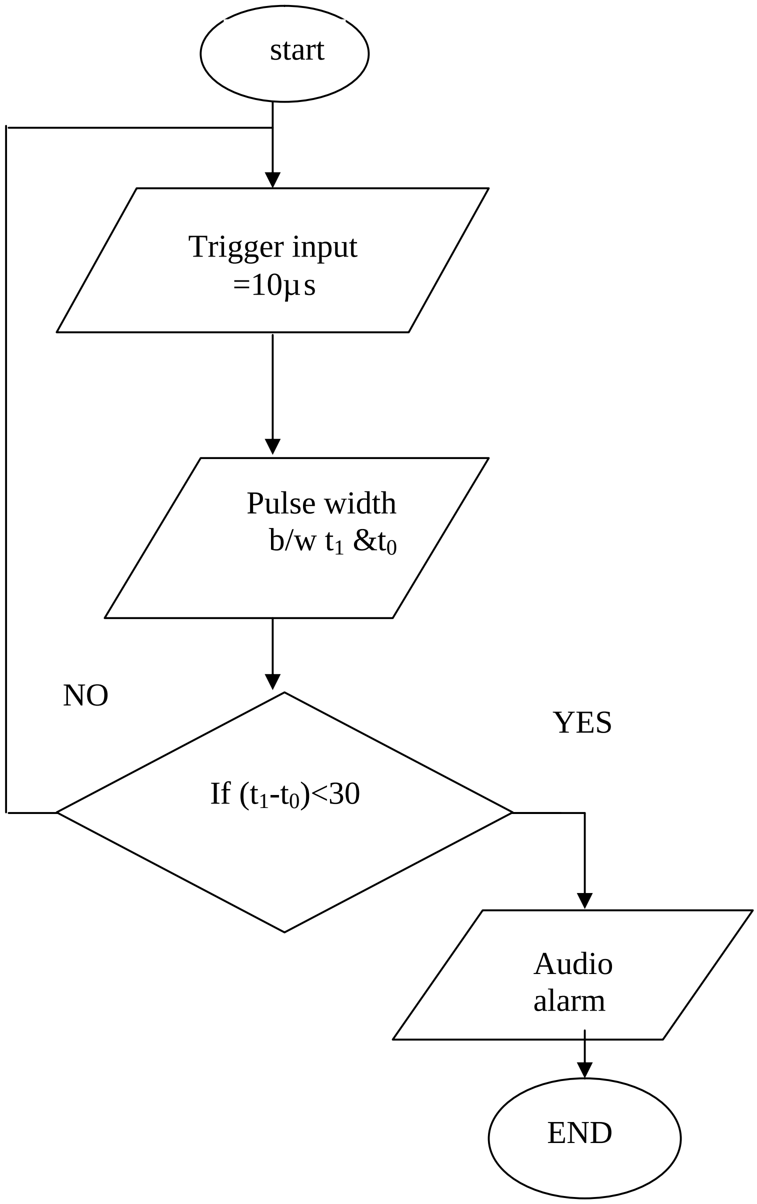

Figure 5.4: flow chart for waist belt (obstacles-SRF05A)

[5.3.2] Waist Belt (Slopes-SRF05B)

figure(5.5) depicts the principle of operation of obstacles detectors. we start the program and take the reading from the second sensor and then examine whether (t_1-t_0) is less than 30 ms ,then continue and keep checking by supply the system with another 10μs trigger. Then if (t_1-t_0) more than 30 ms , another audio alarm will be activated.

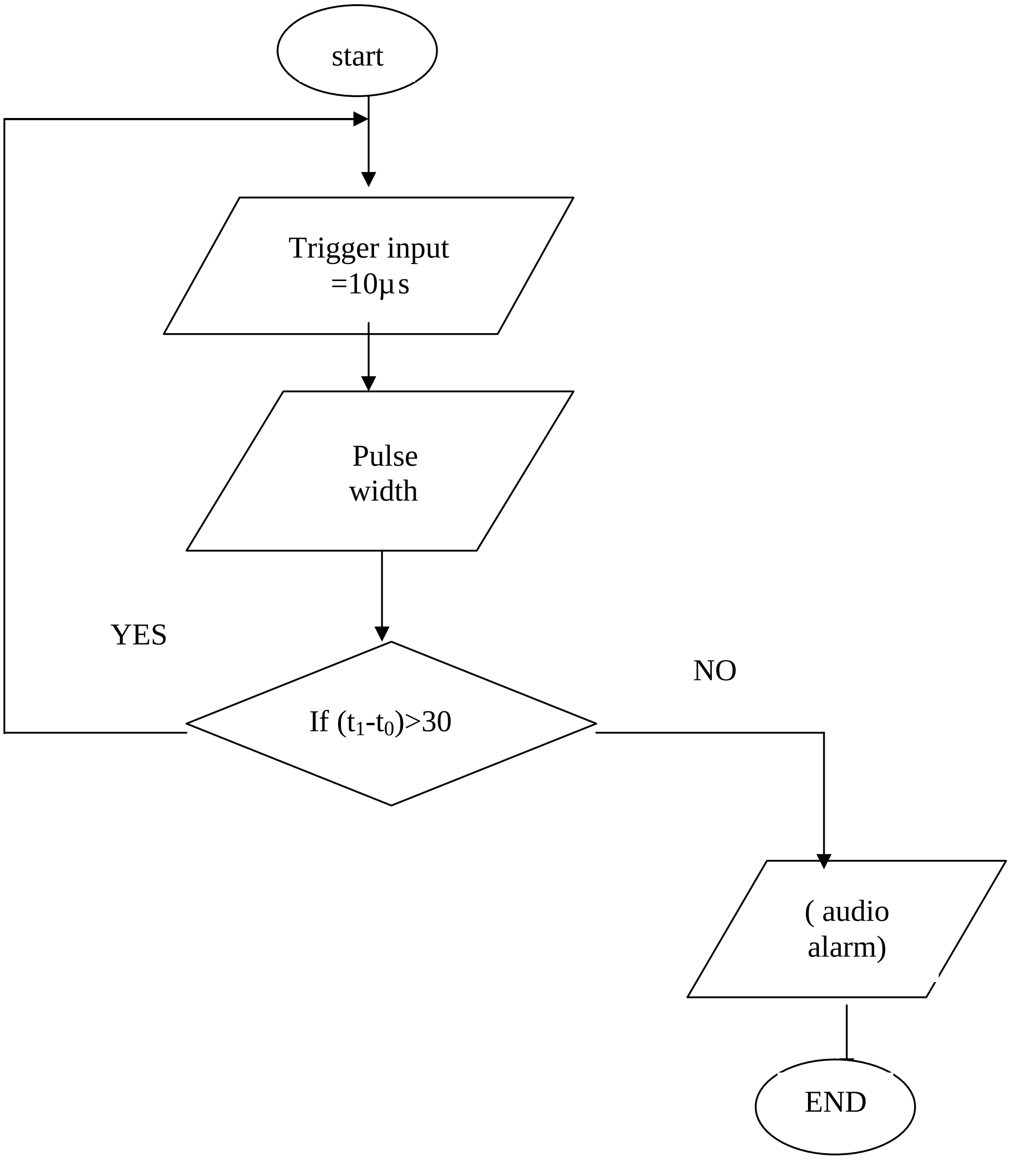

Figure 5.5 : flow chart for waist belt (slopes-SRF05B)

[5.4] Software Needed for the Project:

PIC microcontroller can be programmed using C-language or assembly. PIC18f4550 programmed using C-language because it is easier.

Case 1:

```
#include<delays'>
#include<p18f4550.h>
#include<adc.h>
#include"gamelcd_v3.h"
#include"gamelinit.h"
#include<timers.h>
#include<portb.h>
#pragma config WDT=OFF
#pragma config LVP=OFF
#pragma config FOSC=INTOSC_HS
//program for SRF04/05 measure in inch
void main(void)
{
int i;
ADCON1=15;
TRISB=0b00001000; //RB1 output and RB3 input        //determine the direction
OpenTimer0( TIMER_INT_OFF & T0_16BIT & T0_SOURCE_INT &
T0_PS_1_1);//Active the timer to count 8 pulse//
while(1)
{
PORTBbits.RB1=1; //turn the buzzer on//
Delay10TCYx(3);
PORTBbits.RB1=0; // turn  the buzzer off //
while(!PORTBbits.RB3); Rb3 is the output of the echo
WriteTimer1(0);
Delay10TCYx(1);  //delay b\w on \ off the pulse//
```

```
while(PORTBbits.RB3);
i=ReadTimer0();
i=(int)i*0.02994;   //convert to inch//
Delay10TCYx(450);
} }
```

Case2:

```
void main(void)
{
int result;
OSCCON=OSCCON | 0b01110000; //oscillation of the crystal //
ADCON1=15;
PORTA=0;
TRISA=255; //determine the direction(input)//
PORTD=0;
TRISD=0; //determine the direction (output)//

OpenADC (ADC_FOSC_64  & ADC_RIGHT_JUST & ADC_2_TAD,ADC_CH1 &
ADC_INT_OFF & ADC_REF_VDD_VSS , ADC_2ANA);
//active the ADC to convert the analog signal to digital//
while(1)
{
ConvertADC();
while(BusyADC()); //when ADC finish the covert to digital read it and stop the
operation//
result=(unsigned int)ReadADC();

if ((result/2)>90)  //each 1 inch --→10 mv//
PORTD=255;
else
PORTD=0;

Delay1KTCYx(100);}}
```

6

System Implementation

6.1 Circuit Diagram Components

6.2 Electrical and Electronic system of the project

6.3 Final Form

Chapter Six

System Implementation

[6.1] Circuit Diagram Components:

The circuit in figure 6.1 contains the whole system components. each one has its specific function as follows.

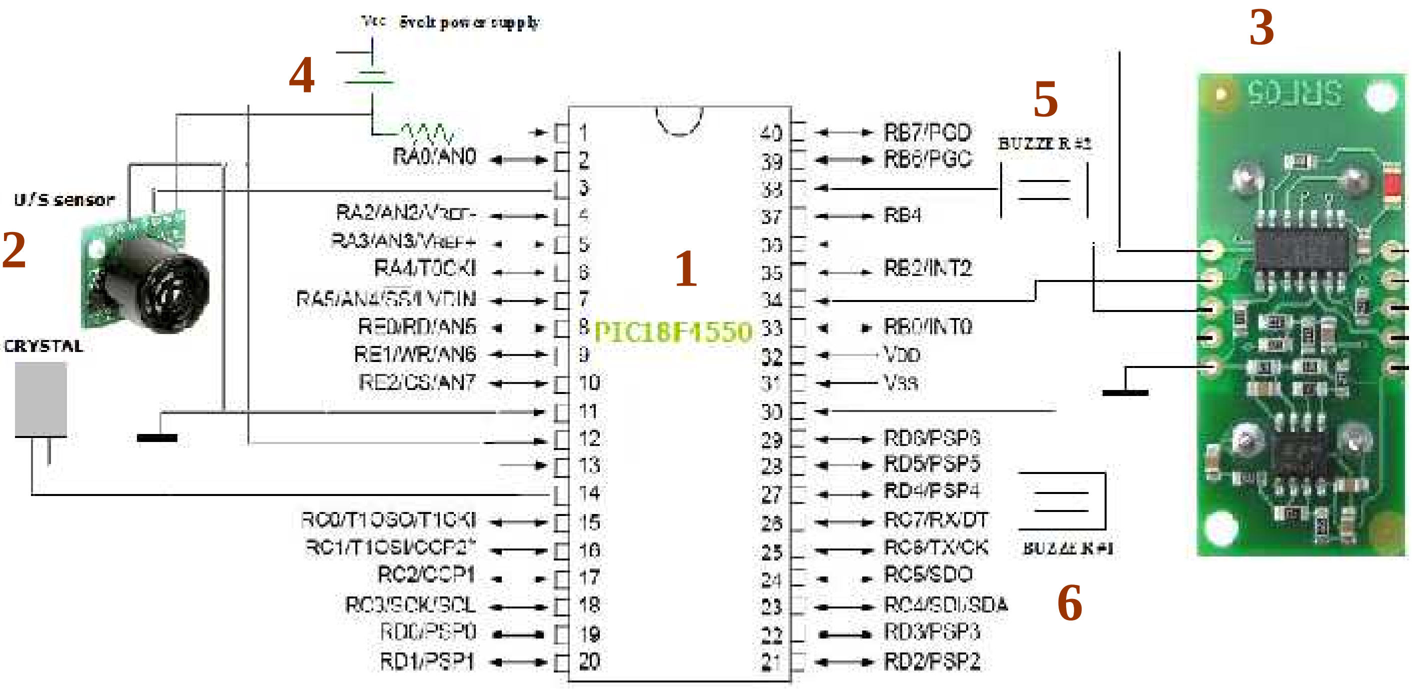

Figure 6.1: Circuit Diagram Components

-Simple description about the components of the circuit diagram:

1-PIC18F4550 microcontroller : it's the main component in the circuit that control all the other components .

2-Ultrasound Sensor (EZ1): it consists of number of pins .each one is connected with suitable port in microcontroller .it consists of transmitter and receiver .

3- Another ultrasound sensor (SRF05): the same as EZ1.

4- power supply: 5 volt power supply used to supply the circuit with appropriate voltage .

5-Buzzer #1 : it's a sound tool .gives an alarm when there is obstacles in front of the patient.

6-Buzzer #2 : Another sound tool .gives an alarm when there is slopes in front of the patient.

[6.2] Electrical and Electronic system of the project :

PIC Microcontroller is the main circuit and contain as shown in figure 6.2

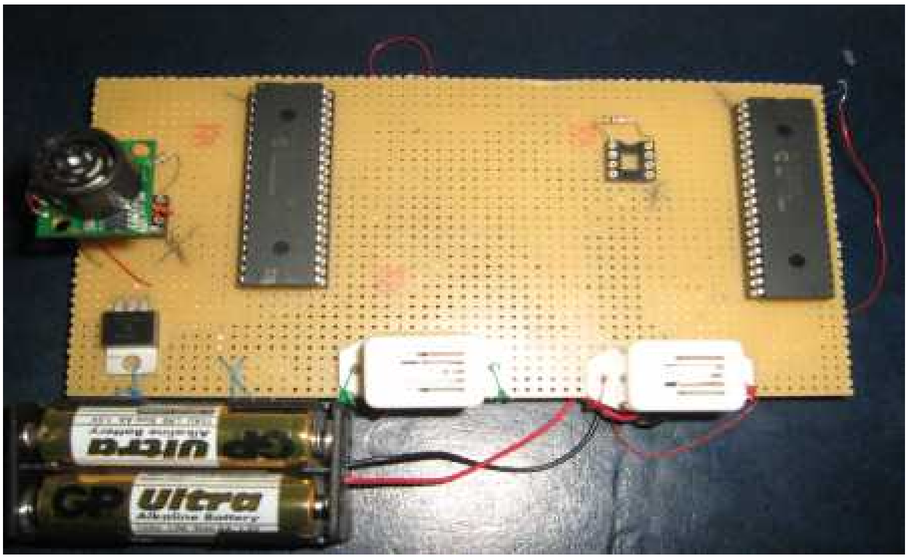

Figure 6.2: Electrical and Electronic system of project

[6.3] Final Form:

As the two figure show, the picture explains the final combination for the project.

Figure 6.3: General picture for project

Figure 6.4: Waist Belt of Blind People

7

Results and Conclusions

7.1 Results

7.2 Conclusions

Chapter Seven

Result and Conclusion

[7.1] Results:

- We designed the project with two identical sensor, only one sensor is available.

- Because of expensive rechargeable batteries we use four parallel batteries rather than 6 volt rechargeable batteries.

- Check Ultrasonic Telemeter for the obstacles case by using led's

As we mentioned in the introduction of ultrasonic , two ultrasonic sensors are connected with pic18f4550 as shown in the circuit diagram.

The figure 7.1 show that the led is on when there is obstacles while figure7.2show that there is no output on the led's when there is no obstacles.

Note : we put our hand as obstacles.

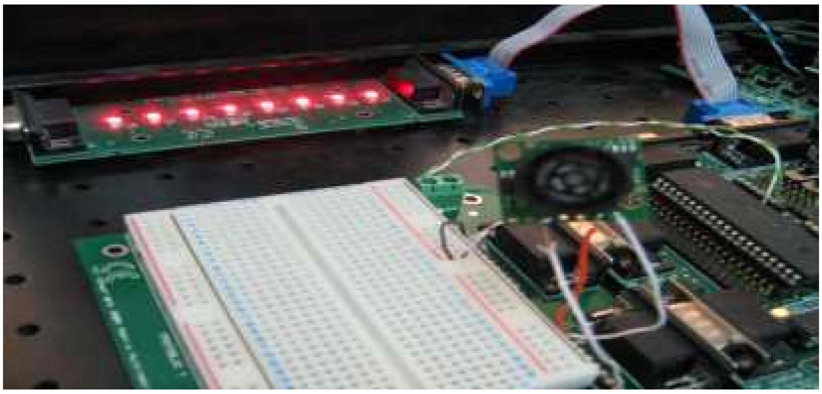

Figure 7.1: The Output of the sensor when detect Obstacles

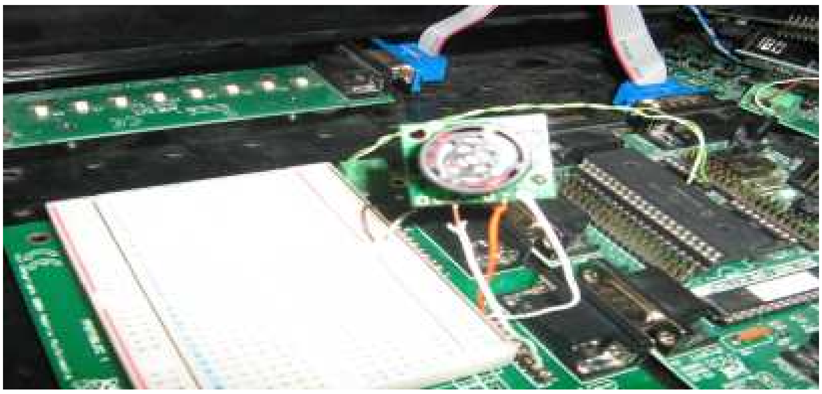

Figure 7.2: The Output of the Sensor when there is no Obstacles

[7.2] Conclusions

- After implementing the hardware system, we introduce the theoretical data and analysis for constructing a navigation tool, also we discussed all parts of this project such as hardware ,PIC microcontroller ,ultrasonic sensor.

-PIC 18F4550 is very useful programmable, easy used device. So we recommend using it in graduated projects.

-Our project shows two cases to detect obstacles and slopes each case has a different alarm from the other.

-The ultrasound sensor transmits the waves as a conical shape to detect all the obstacles that fall within the 45^0 degree.

- The waves that transmit from the sensor detect the obstacles at a distance of 2.5m.

-The tool are provided with ultrasonic sensors, in which can be used to detect any object(obstacles) in front of the patient ,but some time the sensor doesn't detect the accurate object since small obstacles.

8

Future work

8.1 Future work

Chapter Eight
Future Work

1-Generalize the system by using this technique in cars to detect the obstacles behind it to avoid collision.

2- Generalize the system ,to detect the kind of obstacles(material),such as water, wall ,wood depends on the attenuation of the materials .

3-Can develop the system to detect obstacles by using vibration\audio alarm.

4-Can use this technique in kids games like remote control .

References:

Books

[9] Ian R.Sinclair, “sensors and Transducers”, Third Edition, Newness’

[10] Joseph D.Bronzino, "Biomedical Engineering hand book", Ultrasound, vol.1.

[16] John Morton, " The PIC Microcontroller: your personal introductory course, Third Edition, Newness’.

Websites	Visit date
[1],[2] http://www.web-books.com/eLibrary/Medicine/Physiology/Eye/Eye.htm	**06/03/2010**
[3] http://www.ultratechnology.se	**06/03/2010**
[4]http://www.pages.drexel.edu/~kws23/tutorials/ultrasonic/ultrasonic.html	**16/03/2010**
[5] http://www.acroname.com/robotics/parts/R93-SRF05.html	**16/03/2010**
[6] http://www.lsa.isep.ipp.pt/~osvaldo/pt/robotica_aprender.html	**20/04/2010**
[7],[8] http://www.answers.com/topic/ultrasound	**22/04/2010**
[11],[13] http://www.superdroidrobots.com/product_info/SRF05.htm	**02/05/2010**
[12] http://www.trossenrobotics.com/devantech-srf05-ultrasonic-range-sensor.aspx	**06/10/2010**
[14]http://www.me.berkeley.edu/ME102/Past_Proj/s05/18	**16/10/2010**
[15] http://www.cs.binghamton.edu/~reckert/480/424LECT1_f03.html	**26/10/2010**
[17] http://www.evilmadscientist.com/article.php/mcus	**14/11/2010**
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Appendix

A

Circuit Diagram

Appendix

B

Key Terms

KEY TERMS

Cycle

—One wave expansion and compression.

Hertz

—A unit of measurement for frequency abbreviated Hz. One hertz is one cycle per second.

Kilohertz (kHz)

—One thousand hertz.

Megahertz (MHz)

—One thousand kilohertz.

Piezoelectric

—A material that becomes electrically charged when compressed, generating an electric current.

Transducer

—An electronic device used to generate ultrasound.

Ultrasound

—Another term for ultrasonic waves; sometimes reserved for medical applications.

Wavelength

—The distance between two consecutive crests or troughs in a wave.

Appendix

C

Datasheets

MC7800, MC7800A, MC7800AE, NCV7800

1.0 A Positive Voltage Regulators

These voltage regulators are monolithic integrated circuits designed as fixed-voltage regulators for a wide variety of applications including local, on-card regulation. These regulators employ internal current limiting, thermal shutdown, and safe-area compensation. With adequate heatsinking they can deliver output currents in excess of 1.0 A. Although designed primarily as a fixed voltage regulator, these devices can be used with external components to obtain adjustable voltages and currents.

- Output Current in Excess of 1.0 A
- No External Components Required
- Internal Thermal Overload Protection
- Internal Short Circuit Current Limiting
- Output Transistor Safe-Area Compensation
- Output Voltage Offered in 1.5%, 2% and 4% Tolerance
- Available in Surface Mount D^{2}PAK-3, DPAK-3 and Standard 3-Lead Transistor Packages
- NCV Prefix for Automotive and Other Applications Requiring Site and Control Changes
- Pb-Free Packages are Available

MAXIMUM RATINGS (T_A = 25°C, unless otherwise noted)

Rating	Symbol	Value			Unit
		369C	221A	936	
Input Voltage (5.0 – 18 V) (24 V)	V_I	35 40			Vdc
Power Dissipation	P_D	Internally Limited			W
Thermal Resistance, Junction-to-Ambient	$R_{\theta JA}$	92	65	Figure 15	°C/W
Thermal Resistance, Junction-to-Case	$R_{\theta JC}$	5.0	5.0	5.0	°C/W
Storage Junction Temperature Range	T_{stg}	−65 to +150			°C
Operating Junction Temperature	T_J	+150			°C

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.
*This device series contains ESD protection and exceeds the following tests:
Human Body Model 2000 V per MIL_STD_883, Method 3015.
Machine Model Method 200 V.

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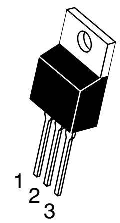
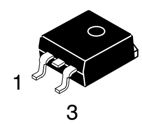


TO-220-3
T SUFFIX
CASE 221AB

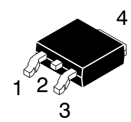
Heatsink surface connected to Pin 2.



Pin 1. Input
2. Ground
3. Output

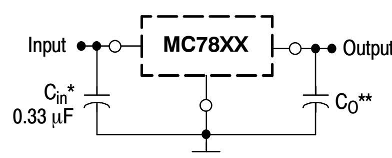
D^{2}PAK-3
D2T SUFFIX
CASE 936

Heatsink surface (shown as terminal 4 in case outline drawing) is connected to Pin 2.



DPAK-3
DT SUFFIX
CASE 369C

STANDARD APPLICATION



A common ground is required between the input and the output voltages. The input voltage must remain typically 2.0 V above the output voltage even during the low point on the input ripple voltage.

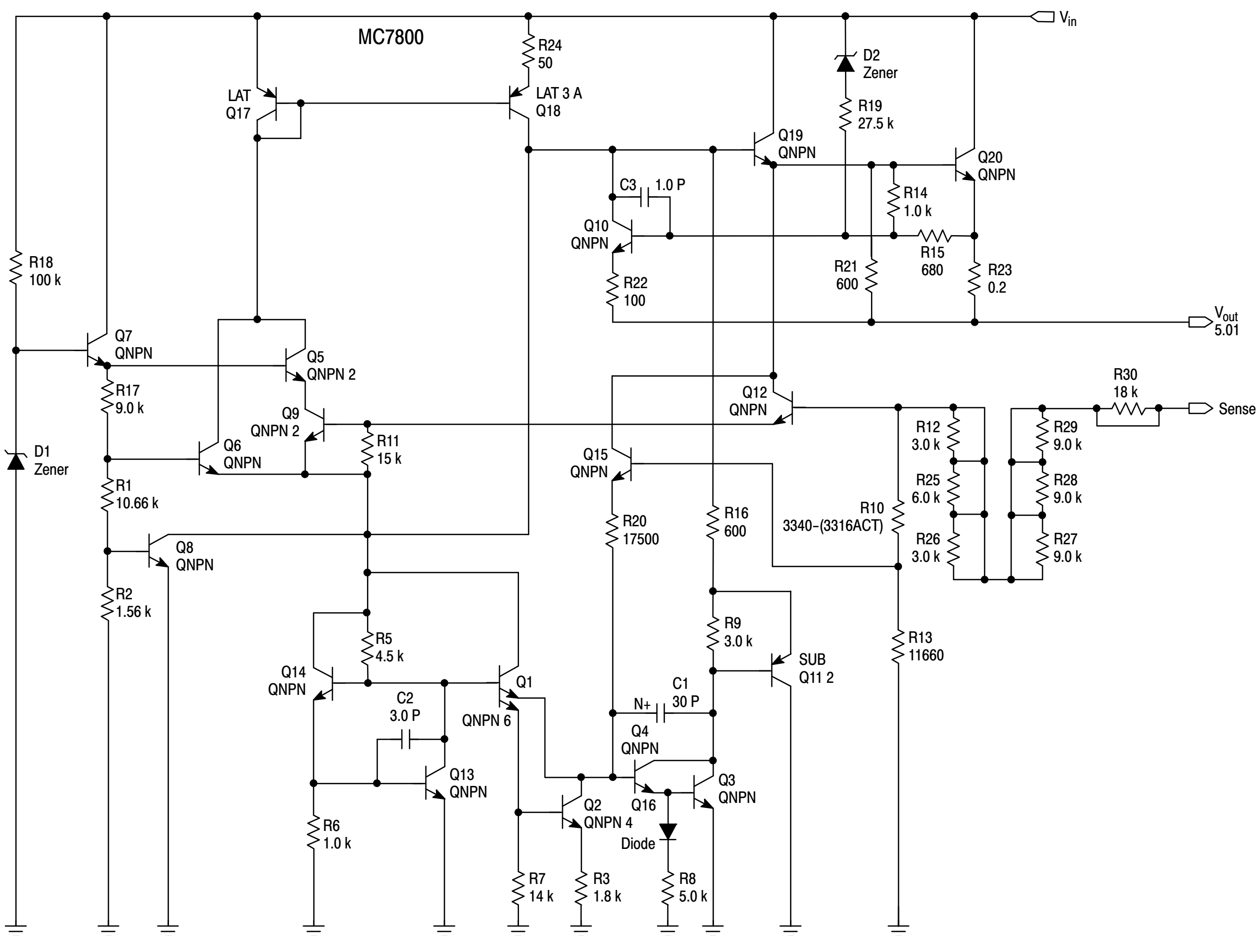
XX, These two digits of the type number indicate nominal voltage.
* C_{in} is required if regulator is located an appreciable distance from power supply filter.
** C_O is not needed for stability; however, it does improve transient response. Values of less than 0.1 μF could cause instability.

ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 23 of this data sheet.

DEVICE MARKING INFORMATION

See general marking information in the device marking section on page 30 of this data sheet.



This device contains 22 active transistors.

Figure 1. Representative Schematic Diagram

ELECTRICAL CHARACTERISTICS (V_{in} = 10 V, I_O = 500 mA, T_J = T_{low} to 125°C (Note 1), unless otherwise noted)

Characteristic	Symbol	MC7805B, NCV7805			MC7805C			Unit
		Min	Typ	Max	Min	Typ	Max	
Output Voltage (T_J = 25°C)	V_O	4.8	5.0	5.2	4.8	5.0	5.2	Vdc
Output Voltage (5.0 mA ≤ I_O ≤ 1.0 A, P_D ≤ 15 W) 7.0 Vdc ≤ V_{in} ≤ 20 Vdc 8.0 Vdc ≤ V_{in} ≤ 20 Vdc	V_O	– 4.75	– 5.0	– 5.25	4.75 –	5.0 –	5.25 –	Vdc
Line Regulation (Note 4) 7.5 Vdc ≤ V_{in} ≤ 20 Vdc, 1.0 A 8.0 Vdc ≤ V_{in} ≤ 12 Vdc	Reg_{line}	– –	5.0 1.3	100 50	– –	0.5 0.8	20 10	mV
Load Regulation (Note 4) 5.0 mA ≤ I_O ≤ 1.0 A 5.0 mA ≤ I_O ≤ 1.5 A (T_A = 25°C)	Reg_{load}	– –	1.3 0.15	100 50	– –	1.3 1.3	25 25	mV
Quiescent Current	I_B	–	3.2	8.0	–	3.2	6.5	mA
Quiescent Current Change 7.0 Vdc ≤ V_{in} ≤ 25 Vdc 5.0 mA ≤ I_O ≤ 1.0 A (T_A = 25°C)	ΔI_B	– –	– –	– 0.5	– –	0.3 0.08	1.0 0.8	mA
Ripple Rejection 8.0 Vdc ≤ V_{in} ≤ 18 Vdc, f = 120 Hz	RR	–	68	–	62	83	–	dB
Dropout Voltage (I_O = 1.0 A, T_J = 25°C)	$V_I - V_O$	–	2.0	–	–	2.0	–	Vdc
Output Noise Voltage (T_A = 25°C) 10 Hz ≤ f ≤ 100 kHz	V_n	–	10	–	–	10	–	μV/V_O
Output Resistance f = 1.0 kHz	r_O	–	0.9	–	–	0.9	–	mΩ
Short Circuit Current Limit (T_A = 25°C) V_{in} = 35 Vdc	I_{SC}	–	0.2	–	–	0.6	–	A
Peak Output Current (T_J = 25°C)	I_{max}	–	2.2	–	–	2.2	–	A
Average Temperature Coefficient of Output Voltage	TCV_O	–	−0.3	–	–	−0.3	–	mV/°C

1. T_{low} = 0°C for MC78XXC, MC78XXAC,
   = −40°C for NCV78XX, MC78XXB, MC78XXAB, and MC78XXAEB
2. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

ELECTRICAL CHARACTERISTICS (V_{in} = 10 V, I_O = 1.0 A, T_J = T_{low} to 125°C (Note 3), unless otherwise noted)

Characteristic	Symbol	MC7805AB/MC7805AC/NCV7805AB			Unit
		Min	Typ	Max	
Output Voltage (T_J = 25°C)	V_O	4.9	5.0	5.1	Vdc
Output Voltage (5.0 mA ≤ I_O ≤ 1.0 A, P_D ≤ 15 W) 7.5 Vdc ≤ V_{in} ≤ 20 Vdc	V_O	4.8	5.0	5.2	Vdc
Line Regulation (Note 4)	Reg_{line}				mV
7.5 Vdc ≤ V_{in} ≤ 25 Vdc, I_O = 500 mA		–	0.5	10	
8.0 Vdc ≤ V_{in} ≤ 12 Vdc, I_O = 1.0 A		–	0.8	12	
8.0 Vdc ≤ V_{in} ≤ 12 Vdc, I_O = 1.0 A, T_J = 25°C		–	1.3	4.0	
7.3 Vdc ≤ V_{in} ≤ 20 Vdc, I_O = 1.0 A, T_J = 25°C		–	4.5	10	
Load Regulation (Note 4)	Reg_{load}				mV
5.0 mA ≤ I_O ≤ 1.5 A, T_J = 25°C		–	1.3	25	
5.0 mA ≤ I_O ≤ 1.0 A		–	0.8	25	
250 mA ≤ I_O ≤ 750 mA		–	0.53	15	
Quiescent Current	I_B	–	3.2	6.0	mA
Quiescent Current Change	ΔI_B				mA
8.0 Vdc ≤ V_{in} ≤ 25 Vdc, I_O = 500 mA		–	0.3	0.8	
7.5 Vdc ≤ V_{in} ≤ 20 Vdc, T_J = 25°C		–	–	0.8	
5.0 mA ≤ I_O ≤ 1.0 A		–	0.08	0.5	
Ripple Rejection 8.0 Vdc ≤ V_{in} ≤ 18 Vdc, f = 120 Hz, I_O = 500 mA	RR	68	83	–	dB
Dropout Voltage (I_O = 1.0 A, T_J = 25°C)	$V_I - V_O$	–	2.0	–	Vdc
Output Noise Voltage (T_A = 25°C) 10 Hz ≤ f ≤ 100 kHz	V_n	–	10	–	μV/V_O
Output Resistance (f = 1.0 kHz)	r_O	–	0.9	–	mΩ
Short Circuit Current Limit (T_A = 25°C) V_{in} = 35 Vdc	I_{SC}	–	0.2	–	A
Peak Output Current (T_J = 25°C)	I_{max}	–	2.2	–	A
Average Temperature Coefficient of Output Voltage	TCV_O	–	–0.3	–	mV/°C

3. T_{low} = 0°C for MC78XXC, MC78XXAC,
   = −40°C for NCV78XX, MC78XXB, MC78XXAB, and MC78XXAEB
4. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

ELECTRICAL CHARACTERISTICS (V_{in} = 11 V, I_O = 500 mA, T_J = T_{low} to 125°C (Note 5), unless otherwise noted)

Characteristic	Symbol	MC7806B/NCV7806B			MC7806C			Unit
		Min	Typ	Max	Min	Typ	Max	
Output Voltage (T_J = 25°C)	V_O	5.75	6.0	6.25	5.75	6.0	6.25	Vdc
Output Voltage (5.0 mA ≤ I_O ≤ 1.0 A, P_D ≤ 15 W)	V_O							Vdc
8.0 Vdc ≤ V_{in} ≤ 21 Vdc		–	–	–	5.7	6.0	6.3	
9.0 Vdc ≤ V_{in} ≤ 21 Vdc		5.7	6.0	6.3	–	–	–	
Line Regulation, T_J = 25°C (Note 6)	Reg_{line}							mV
8.0 Vdc ≤ V_{in} ≤ 25 Vdc		–	5.5	120	–	0.5	24	
9.0 Vdc ≤ V_{in} ≤ 13 Vdc		–	1.4	60	–	0.8	12	
Load Regulation, T_J = 25°C (Note 6) 5.0 mA ≤ I_O ≤ 1.5 A	Reg_{load}	–	1.3	120	–	1.3	30	mV
Quiescent Current (T_J = 25°C)	I_B	–	3.3	8.0	–	3.3	8.0	mA
Quiescent Current Change	ΔI_B							mA
8.0 Vdc ≤ V_{in} ≤ 25 Vdc		–	–	–	–	0.3	1.3	
5.0 mA ≤ I_O ≤ 1.0 A		–	–	0.5	–	0.08	0.5	
Ripple Rejection 9.0 Vdc ≤ V_{in} ≤ 19 Vdc, f = 120 Hz	RR	–	65	–	58	65	–	dB
Dropout Voltage (I_O = 1.0 A, T_J = 25°C)	$V_I - V_O$	–	2.0	–	–	2.0	–	Vdc
Output Noise Voltage (T_A = 25°C) 10 Hz ≤ f ≤ 100 kHz	V_n	–	10	–	–	10	–	μV/V_O
Output Resistance f = 1.0 kHz	r_O	–	0.9	–	–	0.9	–	mΩ
Short Circuit Current Limit (T_A = 25°C) V_{in} = 35 Vdc	I_{SC}	–	0.2	–	–	0.2	–	A
Peak Output Current (T_J = 25°C)	I_{max}	–	2.2	–	–	2.2	–	A
Average Temperature Coefficient of Output Voltage	TCV_O	–	–0.3	–	–	–0.3	–	mV/°C

5. T_{low} = 0°C for MC78XXC, MC78XXAC,
   = −40°C for NCV78XX, MC78XXB, MC78XXAB, and MC78XXAEB
6. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

ELECTRICAL CHARACTERISTICS (V_{in} = 11 V, I_O = 1.0 A, T_J = T_{low} to 125°C (Note 7), unless otherwise noted)

Characteristic	Symbol	MC7806AC			Unit
		Min	Typ	Max	
Output Voltage (T_J = 25°C)	V_O	5.88	6.0	6.12	Vdc
Output Voltage (5.0 mA ≤ I_O ≤ 1.0 A, P_D ≤ 15 W) 8.6 Vdc ≤ V_{in} ≤ 21 Vdc	V_O	5.76	6.0	6.24	Vdc
Line Regulation (Note 8)	Reg_{line}				mV
8.6 Vdc ≤ V_{in} ≤ 25 Vdc, I_O = 500 mA		–	5.0	12	
9.0 Vdc ≤ V_{in} ≤ 13 Vdc, I_O = 1.0 A		–	1.4	15	
Load Regulation (Note 8)	Reg_{load}				mV
5.0 mA ≤ I_O ≤ 1.5 A, T_J = 25°C		–	1.3	25	
5.0 mA ≤ I_O ≤ 1.0 A		–	0.9	25	
250 mA ≤ I_O ≤ 750 mA		–	0.2	15	
Quiescent Current	I_B	–	3.3	6.0	mA
Quiescent Current Change	ΔI_B				mA
9.0 Vdc ≤ V_{in} ≤ 25 Vdc, I_O = 500 mA		–	–	0.8	
9.0 Vdc ≤ V_{in} ≤ 21 Vdc, I_O = 1.0 A, T_J = 25°C		–	–	0.8	
5.0 mA ≤ I_O ≤ 1.0 A		–	–	0.5	
Ripple Rejection 9.0 Vdc ≤ V_{in} ≤ 19 Vdc, f = 120 Hz, I_O = 500 mA	RR	58	65	–	dB
Dropout Voltage (I_O = 1.0 A, T_J = 25°C)	$V_I - V_O$	–	2.0	–	Vdc
Output Noise Voltage (T_A = 25°C) 10 Hz ≤ f ≤ 100 kHz	V_n	–	10	–	µV/V_O
Output Resistance (f = 1.0 kHz)	r_O	–	0.9	–	mΩ
Short Circuit Current Limit (T_A = 25°C) V_{in} = 35 Vdc	I_{SC}	–	0.2	–	A
Peak Output Current (T_J = 25°C)	I_{max}	–	2.2	–	A
Average Temperature Coefficient of Output Voltage	TCV_O	–	−0.3	–	mV/°C

7. T_{low} = 0°C for MC78XXC, MC78XXAC,
   = −40°C for NCV78XX, MC78XXB, MC78XXAB, and MC78XXAEB
8. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

ELECTRICAL CHARACTERISTICS (V_{in} = 14 V, I_O = 500 mA, T_J = T_{low} to 125°C (Note 9), unless otherwise noted)

Characteristic	Symbol	MC7808B/NCV7808B			MC7808C			Unit
		Min	Typ	Max	Min	Typ	Max	
Output Voltage (T_J = 25°C)	V_O	7.7	8.0	8.3	7.7	8.0	8.3	Vdc
Output Voltage (5.0 mA ≤ I_O ≤ 1.0 A, P_D ≤ 15 W)	V_O							Vdc
10.5 Vdc ≤ V_{in} ≤ 23 Vdc		–	–	–	7.6	8.0	8.4	
11.5 Vdc ≤ V_{in} ≤ 23 Vdc		7.6	8.0	8.4	–	–	–	
Line Regulation, T_J = 25°C, (Note 10)	Reg_{line}							mV
10.5 Vdc ≤ V_{in} ≤ 25 Vdc		–	6.0	160	–	6.0	32	
11 Vdc ≤ V_{in} ≤ 17 Vdc		–	1.7	80	–	1.7	16	
Load Regulation, T_J = 25°C (Note 10) 5.0 mA ≤ I_O ≤ 1.5 A	Reg_{load}	–	1.4	160	–	1.4	35	mV
Quiescent Current	I_B	–	3.3	8.0	–	3.3	8.0	mA
Quiescent Current Change	ΔI_B							mA
10.5 Vdc ≤ V_{in} ≤ 25 Vdc		–	–	–	–	–	1.0	
5.0 mA ≤ I_O ≤ 1.0 A		–	–	0.5	–	–	0.5	
Ripple Rejection 11.5 Vdc ≤ V_{in} ≤ 18 Vdc, f = 120 Hz	RR	–	62	–	56	62	–	dB
Dropout Voltage (I_O = 1.0 A, T_J = 25°C)	$V_I - V_O$	–	2.0	–	–	2.0	–	Vdc
Output Noise Voltage (T_A = 25°C) 10 Hz ≤ f ≤ 100 kHz	V_n	–	10	–	–	10	–	$\mu V/V_O$
Output Resistance f = 1.0 kHz	r_O	–	0.9	–	–	0.9	–	mΩ
Short Circuit Current Limit (T_A = 25°C) V_{in} = 35 Vdc	I_{SC}	–	0.2	–	–	0.2	–	A
Peak Output Current (T_J = 25°C)	I_{max}	–	2.2	–	–	2.2	–	A
Average Temperature Coefficient of Output Voltage	TCV_O	–	–0.4	–	–	–0.4	–	mV/°C

9. T_{low} = 0°C for MC78XXC, MC78XXAC,
   = −40°C for NCV78XX, MC78XXB, MC78XXAB, and MC78XXAEB
10. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

ELECTRICAL CHARACTERISTICS (V_{in} = 14 V, I_O = 1.0 A, T_J = T_{low} to 125°C (Note 11), unless otherwise noted)

Characteristic	Symbol	MC7808AB/MC7808AC			MC7808AEB			Unit
		Min	Typ	Max	Min	Typ	Max	
Output Voltage (T_J = 25°C)	V_O	7.84	8.0	8.16	7.88		8.12	Vdc
Output Voltage (5.0 mA ≤ I_O ≤ 1.0 A, P_D ≤ 15 W) 10.6 Vdc ≤ V_{in} ≤ 23 Vdc	V_O	7.7	8.0	8.3	7.88		8.12	Vdc
Line Regulation (Note 12) 10.6 Vdc ≤ V_{in} ≤ 25 Vdc, I_O = 500 mA 11 Vdc ≤ V_{in} ≤ 17 Vdc, I_O = 1.0 A 10.4 Vdc ≤ V_{in} ≤ 23 Vdc, T_J = 25°C	Reg_{line}	 – – –	 6.0 1.7 5.0	 15 18 15	 – – –	 6.0 1.7 5.0	 15 18 15	mV
Load Regulation (Note 12) 5.0 mA ≤ I_O ≤ 1.5 A, T_J = 25°C 5.0 mA ≤ I_O ≤ 1.0 A 250 mA ≤ I_O ≤ 750 mA	Reg_{load}	 – – –	 1.4 1.0 0.22	 25 25 15	 – – –	 1.4 1.0 0.22	 25 25 15	mV
Quiescent Current	I_B	–	3.3	6.0	–	3.3	6.0	mA
Quiescent Current Change 11 Vdc ≤ V_{in} ≤ 25 Vdc, I_O = 500 mA 10.6 Vdc ≤ V_{in} ≤ 23 Vdc, I_O = 1.0 A, T_J = 25°C 5.0 mA ≤ I_O ≤ 1.0 A	ΔI_B	 – – –	 – – –	 0.8 0.8 0.5	 – – –	 – – –	 0.8 0.8 0.5	mA
Ripple Rejection 11.5 Vdc ≤ V_{in} ≤ 21.5 Vdc, f = 120 Hz, I_O = 500 mA	RR	56	62	–	56	62	–	dB
Dropout Voltage (I_O = 1.0 A, T_J = 25°C)	$V_I - V_O$	–	2.0	–	–	2.0	–	Vdc
Output Noise Voltage (T_A = 25°C) 10 Hz ≤ f ≤ 100 kHz	V_n	–	10	–	–	10	–	$\mu V/V_O$
Output Resistance f = 1.0 kHz	r_O	–	0.9	–	–	0.9	–	mΩ
Short Circuit Current Limit (T_A = 25°C) V_{in} = 35 Vdc	I_{SC}	–	0.2	–	–	0.2	–	A
Peak Output Current (T_J = 25°C)	I_{max}	–	2.2	–	–	2.2	–	A
Average Temperature Coefficient of Output Voltage	TCV_O	–	−0.4	–	–	−0.4	–	mV/°C

11. T_{low} = 0°C for MC78XXC, MC78XXAC,
= −40°C for NCV78XX, MC78XXB, MC78XXAB, and MC78XXAEB
12. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

ELECTRICAL CHARACTERISTICS (V_{in} = 15 V, I_O = 500 mA, T_J = T_{low} to 125°C (Note 13), unless otherwise noted)

Characteristic	Symbol	MC7809B Min	MC7809B Typ	MC7809B Max	MC7809C Min	MC7809C Typ	MC7809C Max	Unit
Output Voltage (T_J = 25°C)	V_O	8.65	9.0	9.35	8.65	9.0	9.35	Vdc
Output Voltage (5.0 mA ≤ I_O ≤ 1.0 A, P_D ≤ 15 W) 11.5 Vdc ≤ V_{in} ≤ 24 Vdc	V_O	8.55	9.0	9.45	8.55	9.0	9.45	Vdc
Line Regulation, T_J = 25°C (Note 14) 11 Vdc ≤ V_{in} ≤ 26 Vdc 11.5 Vdc ≤ V_{in} ≤ 17 Vdc	Reg_{line}	– –	6.2 1.8	32 16	– –	6.2 1.8	32 16	mV
Load Regulation, T_J = 25°C (Note 14) 5.0 mA ≤ I_O ≤ 1.5 A	Reg_{load}	–	1.5	35	–	1.5	35	mV
Quiescent Current	I_B	–	3.4	8.0	–	3.4	8.0	mA
Quiescent Current Change 11.5 Vdc ≤ V_{in} ≤ 26 Vdc 5.0 mA ≤ I_O ≤ 1.0 A	ΔI_B	– –	– –	1.0 0.5	– –	– –	1.0 0.5	mA
Ripple Rejection 11.5 Vdc ≤ V_{in} ≤ 21.5 Vdc, f = 120 Hz	RR	56	61	–	56	61	–	dB
Dropout Voltage (I_O = 1.0 A, T_J = 25°C)	$V_I - V_O$	–	2.0	–	–	2.0	–	Vdc
Output Noise Voltage (T_A = 25°C) 10 Hz ≤ f ≤ 100 kHz	V_n	–	10	–	–	10	–	$\mu V/V_O$
Output Resistance f = 1.0 kHz	r_O	–	1.0	–	–	1.0	–	mΩ
Short Circuit Current Limit (T_A = 25°C) V_{in} = 35 Vdc	I_{SC}	–	0.2	–	–	0.2	–	A
Peak Output Current (T_J = 25°C)	I_{max}	–	2.2	–	–	2.2	–	A
Average Temperature Coefficient of Output Voltage	TCV_O	–	−0.5	–	–	−0.5	–	mV/°C

13. T_{low} = 0°C for MC78XXC, MC78XXAC,
= −40°C for NCV78XX, MC78XXB, MC78XXAB, and MC78XXAEB
14. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

ELECTRICAL CHARACTERISTICS (V_{in} = 15 V, I_O = 1.0 A, T_J = 0°C to 125°C, unless otherwise noted)

Characteristic	Symbol	MC7809AC Min	MC7809AC Typ	MC7809AC Max	Unit
Output Voltage (T_J = 25°C)	V_O	8.82	9.0	9.18	Vdc
Output Voltage (5.0 mA ≤ I_O ≤ 1.0 A, P_D ≤ 15 W) 11.5 Vdc ≤ V_{in} ≤ 24 Vdc	V_O	8.65	9.0	9.35	Vdc
Line Regulation (Note 15) 11.5 Vdc ≤ V_{in} ≤ 26 Vdc, I_O = 500 mA 12 Vdc ≤ V_{in} ≤ 17 Vdc, I_O = 1.0 A 11.5 Vdc ≤ V_{in} ≤ 24 Vdc, T_J = 25°C	Reg_{line}	 – – –	 6.2 1.8 5.2	 16 7.0 16	mV
Load Regulation (Note 15) 5.0 mA ≤ I_O ≤ 1.5 A, T_J = 25°C 5.0 mA ≤ I_O ≤ 1.0 A 250 mA ≤ I_O ≤ 750 mA	Reg_{load}	 – – –	 – – –	 25 25 15	mV
Quiescent Current	I_B	–	3.3	6.0	mA
Quiescent Current Change 11.5 Vdc ≤ V_{in} ≤ 26 Vdc, I_O = 500 mA 11.5 Vdc ≤ V_{in} ≤ 24 Vdc, I_O = 1.0 A, T_J = 25°C 5.0 mA ≤ I_O ≤ 1.0 A	ΔI_B	 – – –	 – – –	 0.8 0.8 0.5	mA
Ripple Rejection 11.5 Vdc ≤ V_{in} ≤ 21.5 Vdc, f = 120 Hz, I_O = 500 mA	RR	 56	 61	 –	dB
Dropout Voltage (I_O = 1.0 A, T_J = 25°C)	$V_I - V_O$		2.0		Vdc
Output Noise Voltage (T_A = 25°C) 10 Hz ≤ f ≤ 100 kHz	V_n	 –	 10	 –	µV/V_O
Output Resistance f = 1.0 kHz	r_O	–	1.0	–	mΩ
Short Circuit Current Limit (T_A = 25°C) V_{in} = 35 Vdc	I_{SC}	–	0.2		A
Peak Output Current (T_J = 25°C)	I_{max}	–	2.2	–	A
Average Temperature Coefficient of Output Voltage	TCV_O	–	−0.5	–	mV/°C

15. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

ELECTRICAL CHARACTERISTICS (V_{in} = 19 V, I_O = 500 mA, T_J = T_{low} to 125°C (Note 16), unless otherwise noted)

Characteristic	Symbol	MC7812B/NCV7812B			MC7812C			Unit
		Min	Typ	Max	Min	Typ	Max	
Output Voltage (T_J = 25°C)	V_O	11.5	12	12.5	11.5	12	12.5	Vdc
Output Voltage (5.0 mA ≤ I_O ≤ 1.0 A, P_D ≤ 15 W)	V_O							Vdc
14.5 Vdc ≤ V_{in} ≤ 27 Vdc		–	–	–	11.4	12	12.6	
15.5 Vdc ≤ V_{in} ≤ 27 Vdc		11.4	12	12.6	–	–	–	
Line Regulation, T_J = 25°C (Note 17)	Reg_{line}							mV
14.5 Vdc ≤ V_{in} ≤ 30 Vdc		–	7.5	240	–	3.8	24	
16 Vdc ≤ V_{in} ≤ 22 Vdc		–	2.2	120	–	0.3	24	
14.8 Vdc ≤ V_{in} ≤ 27 Vdc, I_O = 1.0 A		–	–	–	–	–	48	
Load Regulation, T_J = 25°C (Note 17) 5.0 mA ≤ I_O ≤ 1.5 A	Reg_{load}	–	1.6	240	–	8.1	60	mV
Quiescent Current	I_B	–	3.4	8.0	–	3.4	6.5	mA
Quiescent Current Change	ΔI_B							mA
14.5 Vdc ≤ V_{in} ≤ 30 Vdc, I_O = 1.0 A, T_J = 25°C		–	–	–	–	–	0.7	
15 Vdc ≤ V_{in} ≤ 30 Vdc		–	–	1.0	–	–	0.8	
5.0 mA ≤ I_O ≤ 1.0 A		–	–	0.5	–	–	0.5	
Ripple Rejection 15 Vdc ≤ V_{in} ≤ 25 Vdc, f = 120 Hz	RR	–	60	–	55	60	–	dB
Dropout Voltage (I_O = 1.0 A, T_J = 25°C)	V_I – V_O	–	2.0	–	–	2.0	–	Vdc
Output Noise Voltage (T_A = 25°C) 10 Hz ≤ f ≤ 100 kHz	V_n	–	10	–	–	10	–	μV/V_O
Output Resistance f = 1.0 kHz	r_O	–	1.1	–	–	1.1	–	mΩ
Short Circuit Current Limit (T_A = 25°C) V_{in} = 35 Vdc	I_{SC}	–	0.2	–	–	0.2	–	A
Peak Output Current (T_J = 25°C)	I_{max}	–	2.2	–	–	2.2	–	A
Average Temperature Coefficient of Output Voltage	TCV_O	–	−0.8	–	–	−0.8	–	mV/°C

16. T_{low} = 0°C for MC78XXC, MC78XXAC,
= −40°C for NCV78XX, MC78XXB, MC78XXAB, and MC78XXAEB
17. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

ELECTRICAL CHARACTERISTICS (V_{in} = 19 V, I_O = 1.0 A, T_J = T_{low} to 125°C (Note 18), unless otherwise noted)

Characteristic	Symbol	MC7812AB/MC7812AC/NCV7812AB Min	Typ	Max	Unit
Output Voltage (T_J = 25°C)	V_O	11.75	12	12.25	Vdc
Output Voltage (5.0 mA ≤ I_O ≤ 1.0 A, P_D ≤ 15 W) 14.8 Vdc ≤ V_{in} ≤ 27 Vdc	V_O	11.5	12	12.5	Vdc
Line Regulation (Note 19)	Reg_{line}				mV
14.8 Vdc ≤ V_{in} ≤ 30 Vdc, I_O = 500 mA		–	3.8	18	
16 Vdc ≤ V_{in} ≤ 22 Vdc, I_O = 1.0 A		–	2.2	20	
14.5 Vdc ≤ V_{in} ≤ 27 Vdc, T_J = 25°C		–	6.0	120	
Load Regulation (Note 19)	Reg_{load}				mV
5.0 mA ≤ I_O ≤ 1.5 A, T_J = 25°C		–	–	25	
5.0 mA ≤ I_O ≤ 1.0 A		–	–	25	
Quiescent Current	I_B	–	3.4	6.0	mA
Quiescent Current Change	ΔI_B				mA
15 Vdc ≤ V_{in} ≤ 30 Vdc, I_O = 500 mA		–	–	0.8	
14.8 Vdc ≤ V_{in} ≤ 27 Vdc, T_J = 25°C		–	–	0.8	
5.0 mA ≤ I_O ≤ 1.0 A, T_J = 25°C		–	–	0.5	
Ripple Rejection 15 Vdc ≤ V_{in} ≤ 25 Vdc, f = 120 Hz, I_O = 500 mA	RR	55	60	–	dB
Dropout Voltage (I_O = 1.0 A, T_J = 25°C)	$V_I - V_O$	–	2.0	–	Vdc
Output Noise Voltage (T_A = 25°C) 10 Hz ≤ f ≤ 100 kHz	V_n	–	10	–	$\mu V/V_O$
Output Resistance (f = 1.0 kHz)	r_O	–	1.1	–	mΩ
Short Circuit Current Limit (T_A = 25°C) V_{in} = 35 Vdc	I_{SC}	–	0.2	–	A
Peak Output Current (T_J = 25°C)	I_{max}	–	2.2	–	A
Average Temperature Coefficient of Output Voltage	TCV_O	–	−0.8	–	mV/°C

18. T_{low} = 0°C for MC78XXC, MC78XXAC,
= −40°C for NCV78XX, MC78XXB, MC78XXAB, and MC78XXAEB
19. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

ELECTRICAL CHARACTERISTICS (V_{in} = 23 V, I_O = 500 mA, T_J = T_{low} to 125°C (Note 20), unless otherwise noted)

Characteristic	Symbol	MC7815B/NCV7815B			MC7815C			Unit
		Min	Typ	Max	Min	Typ	Max	
Output Voltage (T_J = 25°C)	V_O	14.4	15	15.6	14.4	15	15.6	Vdc
Output Voltage (5.0 mA ≤ I_O ≤ 1.0 A, P_D ≤ 15 W)	V_O							Vdc
17.5 Vdc ≤ V_{in} ≤ 30 Vdc		–	–	–	14.25	15	15.75	
18.5 Vdc ≤ V_{in} ≤ 30 Vdc		14.25	15	15.75	–	–	–	
Line Regulation, T_J = 25°C (Note 21)	Reg_{line}							mV
17.9 Vdc ≤ V_{in} ≤ 30 Vdc		–	8.5	300	–	8.5	30	
20 Vdc ≤ V_{in} ≤ 26 Vdc		–	3.0	150	–	3.0	28	
Load Regulation, T_J = 25°C (Note 21) 5.0 mA ≤ I_O ≤ 1.5 A	Reg_{load}	–	1.8	300	–	1.8	55	mV
Quiescent Current	I_B	–	3.5	8.0	–	3.5	6.5	mA
Quiescent Current Change	ΔI_B							mA
17.5 Vdc ≤ V_{in} ≤ 30 Vdc		–	–	–	–	–	0.8	
17.5 Vdc ≤ V_{in} ≤ 30 Vdc, I_O = 1.0 A, T_J = 25°C		–	–	1.0	–	–	0.7	
5.0 mA ≤ I_O ≤ 1.0 A		–	–	0.5	–	–	0.5	
Ripple Rejection 18.5 Vdc ≤ V_{in} ≤ 28.5 Vdc, f = 120 Hz	RR	–	58	–	54	58	–	dB
Dropout Voltage (I_O = 1.0 A, T_J = 25°C)	$V_I - V_O$	–	2.0	–	–	2.0	–	Vdc
Output Noise Voltage (T_A = 25°C) 10 Hz ≤ f ≤ 100 kHz	V_n	–	10	–	–	10	–	$\mu V/V_O$
Output Resistance f = 1.0 kHz	r_O	–	1.2	–	–	1.2	–	mΩ
Short Circuit Current Limit (T_A = 25°C) V_{in} = 35 Vdc	I_{SC}	–	0.2	–	–	0.2	–	A
Peak Output Current (T_J = 25°C)	I_{max}	–	2.2	–	–	2.2	–	A
Average Temperature Coefficient of Output Voltage	TCV_O	–	−1.0	–	–	−1.0	–	mV/°C

20. T_{low} = 0°C for MC78XXC, MC78XXAC,
= −40°C for NCV78XX, MC78XXB, MC78XXAB, and MC78XXAEB
21. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

ELECTRICAL CHARACTERISTICS (V_{in} = 23 V, I_O = 1.0 A, T_J = T_{low} to 125°C (Note 22), unless otherwise noted)

Characteristic	Symbol	MC7815AB/MC7815AC			Unit
		Min	Typ	Max	
Output Voltage (T_J = 25°C)	V_O	14.7	15	15.3	Vdc
Output Voltage (5.0 mA ≤ I_O ≤ 1.0 A, P_D ≤ 15 W)	V_O	14.4	15	15.6	Vdc
17.9 Vdc ≤ V_{in} ≤ 30 Vdc					
Line Regulation (Note 23)	Reg_{line}				mV
17.9 Vdc ≤ V_{in} ≤ 30 Vdc, I_O = 500 mA		–	8.5	20	
20 Vdc ≤ V_{in} ≤ 26 Vdc		–	3.0	22	
17.5 Vdc ≤ V_{in} ≤ 30 Vdc, I_O = 1.0 A, T_J = 25°C		–	7.0	20	
Load Regulation (Note 23)	Reg_{load}				mV
5.0 mA ≤ I_O ≤ 1.5 A, T_J = 25°C		–	1.8	25	
5.0 mA ≤ I_O ≤ 1.0 A		–	1.5	25	
250 mA ≤ I_O ≤ 750 mA		–	1.2	15	
Quiescent Current	I_B	–	3.5	6.0	mA
Quiescent Current Change	ΔI_B				mA
17.5 Vdc ≤ V_{in} ≤ 30 Vdc, I_O = 500 mA		–	–	0.8	
17.5 Vdc ≤ V_{in} ≤ 30 Vdc, I_O = 1.0 A, T_J = 25°C		–	–	0.8	
5.0 mA ≤ I_O ≤ 1.0 A		–	–	0.5	
Ripple Rejection	RR	60	80	–	dB
18.5 Vdc ≤ V_{in} ≤ 28.5 Vdc, f = 120 Hz, I_O = 500 mA					
Dropout Voltage (I_O = 1.0 A, T_J = 25°C)	$V_I - V_O$	–	2.0	–	Vdc
Output Noise Voltage (T_A = 25°C)	V_n	–	10	–	$\mu V/V_O$
10 Hz ≤ f ≤ 100 kHz					
Output Resistance f = 1.0 kHz	r_O	–	1.2	–	mΩ
Short Circuit Current Limit (T_A = 25°C)	I_{SC}	–	0.2	–	A
V_{in} = 35 Vdc					
Peak Output Current (T_J = 25°C)	I_{max}	–	2.2	–	A
Average Temperature Coefficient of Output Voltage	TCV_O	–	−1.0	–	mV/°C

22. T_{low} = 0°C for MC78XXC, MC78XXAC,
= −40°C for NCV78XX, MC78XXB, MC78XXAB, and MC78XXAEB
23. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

ELECTRICAL CHARACTERISTICS (V_{in} = 27 V, I_O = 500 mA, T_J = T_{low} to 125°C (Note 24), unless otherwise noted)

Characteristic	Symbol	MC7818B			MC7818C			Unit
		Min	Typ	Max	Min	Typ	Max	
Output Voltage (T_J = 25°C)	V_O	17.3	18	18.7	17.3	18	18.7	Vdc
Output Voltage (5.0 mA ≤ I_O ≤ 1.0 A, P_D ≤ 15 W)	V_O							Vdc
21 Vdc ≤ V_{in} ≤ 33 Vdc		–	–	–	17.1	18	18.9	
22 Vdc ≤ V_{in} ≤ 33 Vdc		17.1	18	18.9	–	–	–	
Line Regulation, (Note 25)	Reg_{line}							mV
21 Vdc ≤ V_{in} ≤ 33 Vdc		–	9.5	360	–	9.5	50	
24 Vdc ≤ V_{in} ≤ 30 Vdc		–	3.2	180	–	3.2	25	
Load Regulation, (Note 25) 5.0 mA ≤ I_O ≤ 1.5 A	Reg_{load}	–	2.0	360	–	2.0	55	mV
Quiescent Current	I_B	–	3.5	8.0	–	3.5	6.5	mA
Quiescent Current Change	ΔI_B							mA
21 Vdc ≤ V_{in} ≤ 33 Vdc		–	–	–	–	–	1.0	
5.0 mA ≤ I_O ≤ 1.0 A		–	–	0.5	–	–	0.5	
Ripple Rejection 22 Vdc ≤ V_{in} ≤ 33 Vdc, f = 120 Hz	RR	–	57	–	53	57	–	dB
Dropout Voltage (I_O = 1.0 A, T_J = 25°C)	$V_{il} - V_O$	–	2.0	–	–	2.0	–	Vdc
Output Noise Voltage (T_A = 25°C) 10 Hz ≤ f ≤ 100 kHz	V_n	–	10	–	–	10	–	μV/V_O
Output Resistance f = 1.0 kHz	r_O	–	1.3	–	–	1.3	–	mΩ
Short Circuit Current Limit (T_A = 25°C) V_{in} = 35 Vdc	I_{SC}	–	0.2	–	–	0.2	–	A
Peak Output Current (T_J = 25°C)	I_{max}	–	2.2	–	–	2.2	–	A
Average Temperature Coefficient of Output Voltage	TCV_O	–	–1.5	–	–	–1.5	–	mV/°C

24. T_{low} = 0°C for MC78XXC, MC78XXAC,
= –40°C for NCV78XX, MC78XXB, MC78XXAB, and MC78XXAEB
25. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

ELECTRICAL CHARACTERISTICS (V_{in} = 27 V, I_O = 1.0 A, T_J = T_{low} to 125°C (Note 26), unless otherwise noted)

Characteristic	Symbol	MC7818AC Min	MC7818AC Typ	MC7818AC Max	Unit
Output Voltage (T_J = 25°C)	V_O	17.64	18	18.36	Vdc
Output Voltage (5.0 mA ≤ I_O ≤ 1.0 A, P_D ≤ 15 W) 21 Vdc ≤ V_{in} ≤ 33 Vdc	V_O	17.3	18	18.7	Vdc
Line Regulation (Note 27)	Reg_{line}				mV
21 Vdc ≤ V_{in} ≤ 33 Vdc, I_O = 500 mA		–	9.5	22	
24 Vdc ≤ V_{in} ≤ 30 Vdc, I_O = 1.0 A		–	3.2	25	
24 Vdc ≤ V_{in} ≤ 30 Vdc, I_O = 1.0 A, T_J = 25°C		–	3.2	10.5	
20.6 Vdc ≤ V_{in} ≤ 33 Vdc, I_O = 1.0 A, T_J = 25°C		–	8.0	22	
Load Regulation (Note 27)	Reg_{load}				mV
5.0 mA ≤ I_O ≤ 1.5 A, T_J = 25°C		–	2.0	25	
5.0 mA ≤ I_O ≤ 1.0 A		–	1.8	25	
250 mA ≤ I_O ≤ 750 mA		–	1.5	15	
Quiescent Current	I_B	–	3.5	6.0	mA
Quiescent Current Change	ΔI_B				mA
21 Vdc ≤ V_{in} ≤ 33 Vdc, I_O = 500 mA		–	–	0.8	
21.5 Vdc ≤ V_{in} ≤ 30 Vdc, T_J = 25°C		–	–	0.8	
5.0 mA ≤ I_O ≤ 1.0 A		–	–	0.5	
Ripple Rejection 22 Vdc ≤ V_{in} ≤ 32 Vdc, f = 120 Hz, I_O = 500 mA	RR	53	57	–	dB
Dropout Voltage (I_O = 1.0 A, T_J = 25°C)	$V_I - V_O$	–	2.0	–	Vdc
Output Noise Voltage (T_A = 25°C) 10 Hz ≤ f ≤ 100 kHz	V_n	–	10	–	µV/V_O
Output Resistance f = 1.0 kHz	r_O	–	1.3	–	mΩ
Short Circuit Current Limit (T_A = 25°C) V_{in} = 35 Vdc	I_{SC}	–	0.2	–	A
Peak Output Current (T_J = 25°C)	I_{max}	–	2.2	–	A
Average Temperature Coefficient of Output Voltage	TCV_O	–	−1.5	–	mV/°C

26. T_{low} = 0°C for MC78XXC, MC78XXAC,
= −40°C for NCV78XX, MC78XXB, MC78XXAB, and MC78XXAEB
27. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

ELECTRICAL CHARACTERISTICS (V_{in} = 33 V, I_O = 500 mA, T_J = T_{low} to 125°C (Note 28), unless otherwise noted)

Characteristic	Symbol	MC7824B			MC7824C			Unit
		Min	Typ	Max	Min	Typ	Max	
Output Voltage (T_J = 25°C)	V_O	23	24	25	23	24	25	Vdc
Output Voltage (5.0 mA ≤ I_O ≤ 1.0 A, P_D ≤ 15 W)	V_O							Vdc
27 Vdc ≤ V_{in} ≤ 38 Vdc		–	–	–	22.8	24	25.2	
28 Vdc ≤ V_{in} ≤ 38 Vdc		22.8	24	25.2	–	–	–	
Line Regulation, (Note 29)	Reg_{line}							mV
27 Vdc ≤ V_{in} ≤ 38 Vdc		–	11.5	480	–	2.7	60	
30 Vdc ≤ V_{in} ≤ 36 Vdc		–	3.8	240	–	2.7	48	
Load Regulation, (Note 29) 5.0 mA ≤ I_O ≤ 1.5 A	Reg_{load}	–	2.1	480	–	4.4	65	mV
Quiescent Current	I_B	–	3.6	8.0	–	3.6	6.5	mA
Quiescent Current Change	ΔI_B							mA
27 Vdc ≤ V_{in} ≤ 38 Vdc		–	–	–	–	–	1.0	
5.0 mA ≤ I_O ≤ 1.0 A		–	–	0.5	–	–	0.5	
Ripple Rejection 28 Vdc ≤ V_{in} ≤ 38 Vdc, f = 120 Hz	RR	–	54	–	50	54	–	dB
Dropout Voltage (I_O = 1.0 A, T_J = 25°C)	$V_I - V_O$	–	2.0	–	–	2.0	–	Vdc
Output Noise Voltage (T_A = 25°C) 10 Hz ≤ f ≤ 100 kHz	V_n	–	10	–	–	10	–	μV/V_O
Output Resistance f = 1.0 kHz	r_O	–	1.4	–	–	1.4	–	mΩ
Short Circuit Current Limit (T_A = 25°C) V_{in} = 35 Vdc	I_{SC}	–	0.2	–	–	0.2	–	A
Peak Output Current (T_J = 25°C)	I_{max}	–	2.2	–	–	2.2	–	A
Average Temperature Coefficient of Output Voltage	TCV_O	–	–2.0	–	–	–2.0	–	mV/°C

28. T_{low} = 0°C for MC78XXC, MC78XXAC,
= −40°C for NCV78XX, MC78XXB, MC78XXAB, and MC78XXAEB
29. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

ELECTRICAL CHARACTERISTICS (V_{in} = 33 V, I_O = 1.0 A, T_J = T_{low} to 125°C (Note 30), unless otherwise noted)

Characteristic	Symbol	MC7824AC Min	MC7824AC Typ	MC7824AC Max	Unit
Output Voltage (T_J = 25°C)	V_O	23.5	24	24.5	Vdc
Output Voltage (5.0 mA ≤ I_O ≤ 1.0 A, P_D ≤ 15 W) 27.3 Vdc ≤ V_{in} ≤ 38 Vdc	V_O	23.2	24	25.8	Vdc
Line Regulation (Note 31)	Reg_{line}				mV
27 Vdc ≤ V_{in} ≤ 38 Vdc, I_O = 500 mA		–	11.5	25	
30 Vdc ≤ V_{in} ≤ 36 Vdc, I_O = 1.0 A		–	3.8	28	
30 Vdc ≤ V_{in} ≤ 36 Vdc, T_J = 25°C		–	3.8	12	
26.7 Vdc ≤ V_{in} ≤ 38 Vdc, I_O = 1.0 A, T_J = 25°C		–	10	25	
Load Regulation (Note 31)	Reg_{load}				mV
5.0 mA ≤ I_O ≤ 1.5 A, T_J = 25°C		–	2.1	15	
5.0 mA ≤ I_O ≤ 1.0 A		–	2.0	25	
250 mA ≤ I_O ≤ 750 mA		–	1.8	15	
Quiescent Current	I_B	–	3.6	6.0	mA
Quiescent Current Change	ΔI_B				mA
27.3 Vdc ≤ V_{in} ≤ 38 Vdc, I_O = 500 mA		–	–	0.8	
27 Vdc ≤ V_{in} ≤ 38 Vdc, T_J = 25°C		–	–	0.8	
5.0 mA ≤ I_O ≤ 1.0 A		–	–	0.5	
Ripple Rejection 28 Vdc ≤ V_{in} ≤ 38 Vdc, f = 120 Hz, I_O = 500 mA	RR	45	54	–	dB
Dropout Voltage (I_O = 1.0 A, T_J = 25°C)	$V_I - V_O$	–	2.0	–	Vdc
Output Noise Voltage (T_A = 25°C) 10 Hz ≤ f ≤ 100 kHz	V_n	–	10	–	$\mu V/V_O$
Output Resistance (f = 1.0 kHz)	r_O	–	1.4	–	mΩ
Short Circuit Current Limit (T_A = 25°C) V_{in} = 35 Vdc	I_{SC}	–	0.2	–	A
Peak Output Current (T_J = 25°C)	I_{max}	–	2.2	–	A
Average Temperature Coefficient of Output Voltage	TCV_O	–	−2.0	–	mV/°C

30. T_{low} = 0°C for MC78XXC, MC78XXAC,
= −40°C for NCV78XX, MC78XXB, MC78XXAB, and MC78XXAEB
31. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

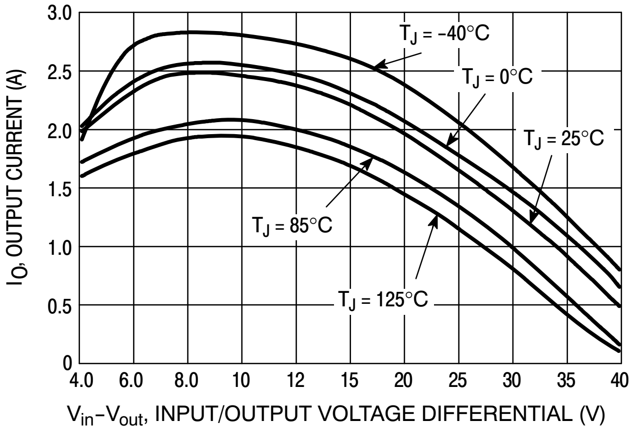


Figure 2. Peak Output Current as a Function of Input/Output Differential Voltage (MC78XXC, AC, B)

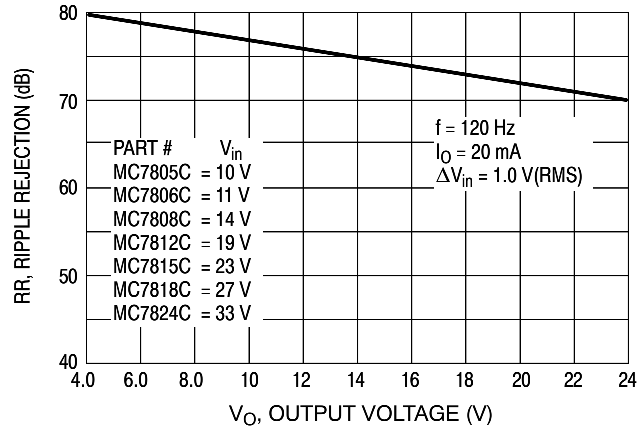


Figure 3. Ripple Rejection as a Function of Output Voltages (MC78XXC, AC, B)

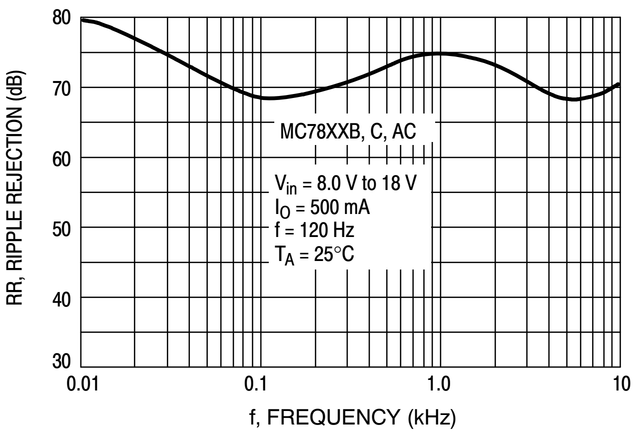


Figure 4. Ripple Rejection as a Function of Frequency (MC78XXC, AC, B)

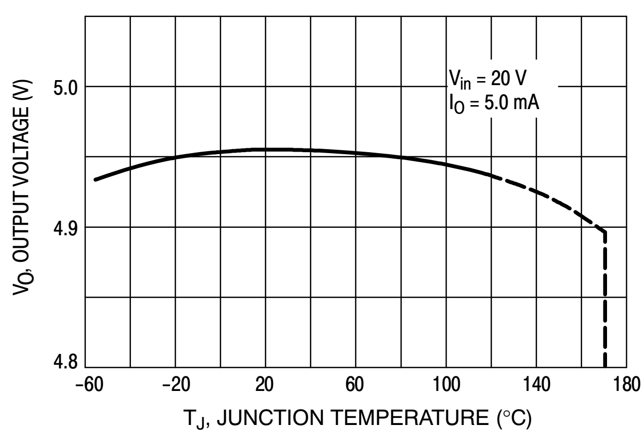


Figure 5. Output Voltage as a Function of Junction Temperature (MC7805C, AC, B)

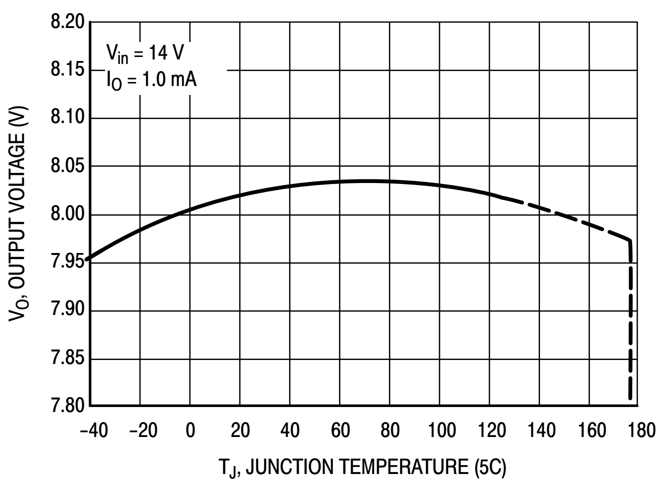


Figure 6. Output Voltage as a Function of Junction Temperature (MC7808AE)

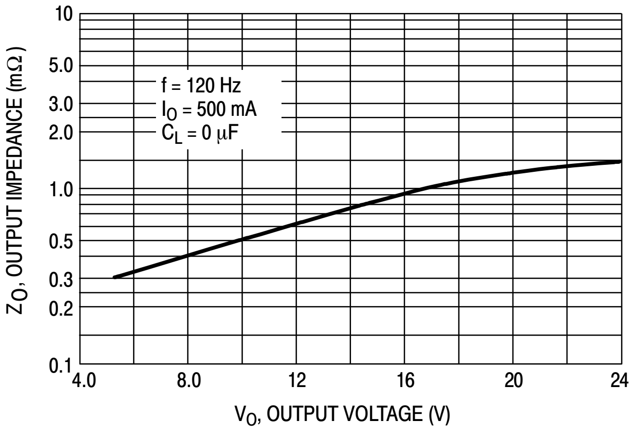


Figure 7. Output Impedance as a Function of Output Voltage (MC78XXC, AC, B)

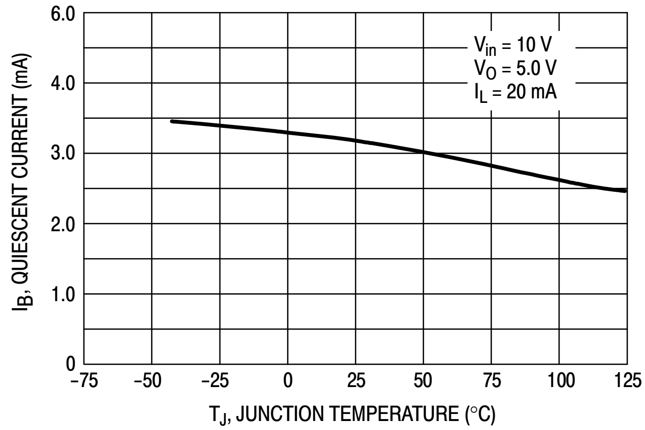


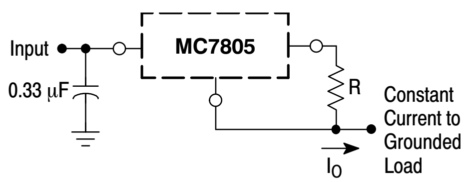
Figure 8. Quiescent Current as a Function of Temperature (MC78XXC, AC, B)

APPLICATIONS INFORMATION

Design Considerations

The MC7800 Series of fixed voltage regulators are designed with Thermal Overload Protection that shuts down the circuit when subjected to an excessive power overload condition, Internal Short Circuit Protection that limits the maximum current the circuit will pass, and Output Transistor Safe-Area Compensation that reduces the output short circuit current as the voltage across the pass transistor is increased.

In many low current applications, compensation capacitors are not required. However, it is recommended that the regulator input be bypassed with a capacitor if the regulator is connected to the power supply filter with long wire lengths, or if the output load capacitance is large. An input bypass capacitor should be selected to provide good high-frequency characteristics to insure stable operation under all load conditions. A 0.33 μF or larger tantalum, mylar, or other capacitor having low internal impedance at high frequencies should be chosen. The bypass capacitor should be mounted with the shortest possible leads directly across the regulators input terminals. Normally good construction techniques should be used to minimize ground loops and lead resistance drops since the regulator has no external sense lead.



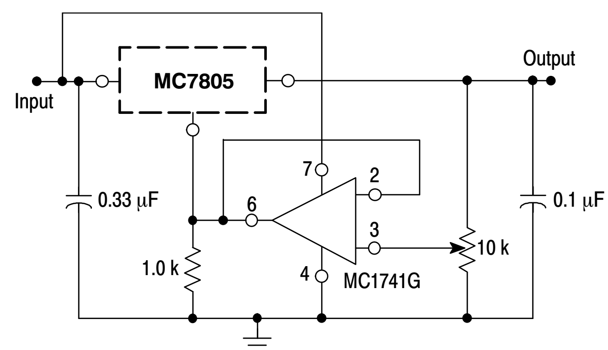
The MC7800 regulators can also be used as a current source when connected as above. In order to minimize dissipation the MC7805C is chosen in this application. Resistor R determines the current as follows:

$$I_O = \frac{5.0\ V}{R} + I_B$$

$I_B \cong$ 3.2 mA over line and load changes.

For example, a 1.0 A current source would require R to be a 5.0 Ω, 10 W resistor and the output voltage compliance would be the input voltage less 7.0 V.

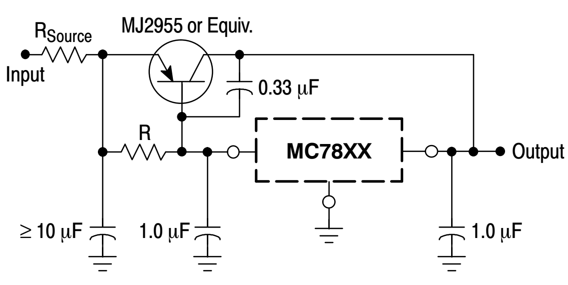
Figure 9. Current Regulator



V_O = 7.0 V to 20 V
$V_{IN} = V_O \geq 2.0$ V

The addition of an operational amplifier allows adjustment to higher or intermediate values while retaining regulation characteristics. The minimum voltage obtainable with this arrangement is 2.0 V greater than the regulator voltage.

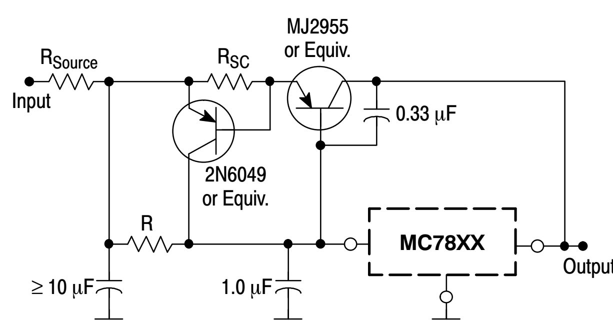
Figure 10. Adjustable Output Regulator



XX = 2 digits of type number indicating voltage.

The MC7800 series can be current boosted with a PNP transistor. The MJ2955 provides current to 5.0 A. Resistor R in conjunction with the V_{BE} of the PNP determines when the pass transistor begins conducting; this circuit is not short circuit proof. Input/output differential voltage minimum is increased by V_{BE} of the pass transistor.

Figure 11. Current Boost Regulator



XX = 2 digits of type number indicating voltage.

The circuit of Figure 11 can be modified to provide supply protection against short circuits by adding a short circuit sense resistor, R_{SC}, and an additional PNP transistor. The current sensing PNP must be able to handle the short circuit current of the three-terminal regulator. Therefore, a four-ampere plastic power transistor is specified.

Figure 12. Short Circuit Protection

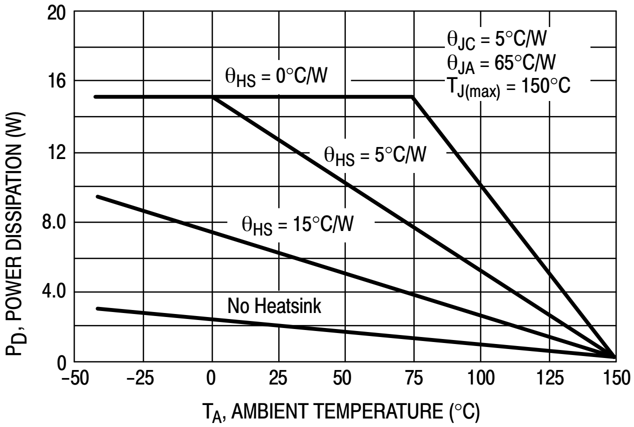


Figure 13. Worst Case Power Dissipation versus Ambient Temperature (Case 221A)

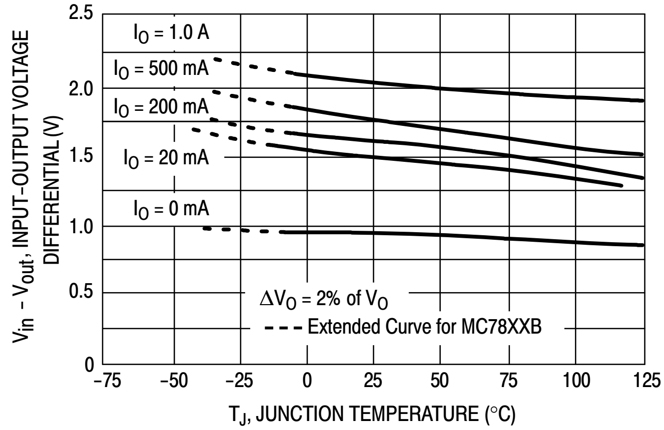


Figure 14. Input Output Differential as a Function of Junction Temperature (MC78XXC, AC, B)

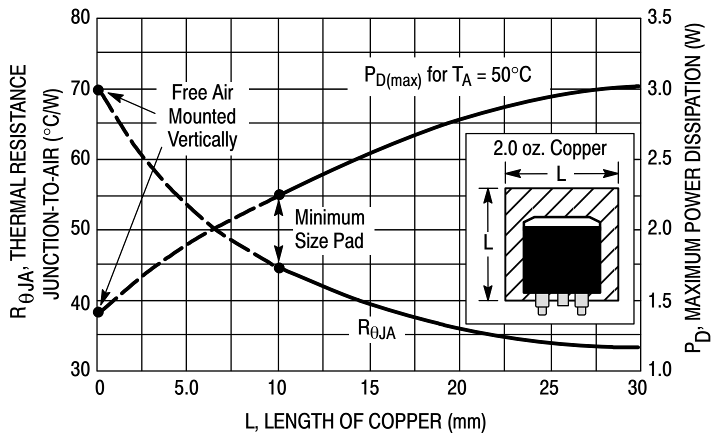


Figure 15. D²PAK Thermal Resistance and Maximum Power Dissipation versus P.C.B. Copper Length

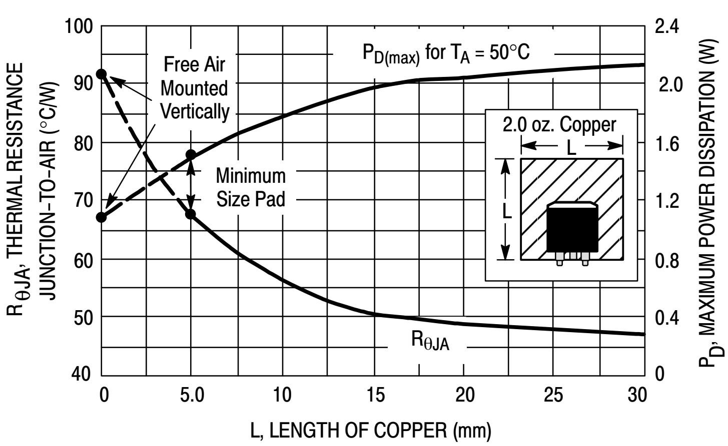


Figure 16. DPAK Thermal Resistance and Maximum Power Dissipation versus P.C.B. Copper Length

DEFINITIONS

Line Regulation – The change in output voltage for a change in the input voltage. The measurement is made under conditions of low dissipation or by using pulse techniques such that the average chip temperature is not significantly affected.

Load Regulation – The change in output voltage for a change in load current at constant chip temperature.

Maximum Power Dissipation – The maximum total device dissipation for which the regulator will operate within specifications.

Quiescent Current – That part of the input current that is not delivered to the load.

Output Noise Voltage – The rms ac voltage at the output, with constant load and no input ripple, measured over a specified frequency range.

Long Term Stability – Output voltage stability under accelerated life test conditions with the maximum rated voltage listed in the devices' electrical characteristics and maximum power dissipation.

ORDERING INFORMATION

Device	Nominal Voltage	Operating Temperature Range	Package	Shipping†
MC7805ABD2T	5.0 V	T_J = −40°C to +125°C	D^2PAK	50 Units /Rail
MC7805ABD2TG			D^2PAK (Pb−free)	50 Units /Rail
MC7805ABD2TR4			D^2PAK	800 / Tape & Reel
MC7805ABD2TR4G			D^2PAK (Pb−free)	800 / Tape & Reel
MC7805ABT			TO−220	50 Units /Rail
MC7805ABTG			TO−220 (Pb−free)	50 Units /Rail
MC7805ACD2T		T_J = 0°C to +125°C	D^2PAK	50 Units /Rail
MC7805ACD2TG			D^2PAK (Pb−free)	50 Units /Rail
MC7805ACD2TR4			D^2PAK	800 / Tape & Reel
MC7805ACD2TR4G			D^2PAK (Pb−free)	800 / Tape & Reel
MC7805ACT			TO−220	50 Units /Rail
MC7805ACTG			TO−220 (Pb−free)	50 Units /Rail
MC7805BD2T		T_J = −40°C to +125°C	D^2PAK	50 Units /Rail
MC7805BD2TG			D^2PAK (Pb−free)	50 Units /Rail
MC7805BD2TR4			D^2PAK	800 / Tape & Reel
MC7805BD2TR4G			D^2PAK (Pb−free)	800 / Tape & Reel
MC7805BDT			DPAK	75 Units / Rail
MC7805BDTG			DPAK (Pb−free)	75 Units / Rail
MC7805BDTRK			DPAK	2500 / Tape & Reel
MC7805BDTRKG			DPAK (Pb−free)	2500 / Tape & Reel

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

*NCV devices: T_{low} = −40°C, T_{high} = +125°C. Guaranteed by design. NCV prefix is for automotive and other applications requiring site and change control.

ORDERING INFORMATION

Device	Nominal Voltage	Operating Temperature Range	Package	Shipping†
MC7805BT	5.0 V	T_J = −40°C to +125°C	TO−220	50 Units /Rail
MC7805BTG			TO−220 (Pb−free)	50 Units /Rail
NCV7805BD2T*			D²PAK	50 Units /Rail
NCV7805BD2TG*			D²PAK (Pb−free)	50 Units /Rail
NCV7805BD2TR4*			D²PAK	800 / Tape & Reel
NCV7805BD2TR4G*			D²PAK (Pb−free)	800 / Tape & Reel
NCV7805BT*			TO−220	50 Units /Rail
NCV7805BTG*			TO−220 (Pb−free)	50 Units /Rail
MC7805CD2T		T_J = 0°C to +125°C	D²PAK	50 Units /Rail
MC7805CD2TG			D²PAK (Pb−free)	50 Units /Rail
MC7805CD2TR4			D²PAK	800 / Tape & Reel
MC7805CD2TR4G			D²PAK (Pb−free)	800 / Tape & Reel
MC7805CDT			DPAK	75 Units / Rail
MC7805CDTG			DPAK (Pb−free)	75 Units / Rail
MC7805CDTRK			DPAK	2500 / Tape & Reel
MC7805CDTRKG			DPAK (Pb−free)	2500 / Tape & Reel
MC7805CT			TO−220	50 Units /Rail
MC7805CTG			TO−220 (Pb−free)	50 Units /Rail
NCV7805ABD2TR4G*	5.0 V	T_J = −40°C to +125°C	D²PAK (Pb−free)	800 / Tape & Reel
MC7806ACT	6.0 V	T_J = 0°C to +125°C	TO−220	50 Units /Rail
MC7806ACTG			TO−220 (Pb−free)	50 Units /Rail
MC7806BD2T		T_J = −40°C to +125°C	D²PAK	50 Units /Rail
MC7806BD2TG			D²PAK (Pb−free)	50 Units /Rail
MC7806BD2TR4			D²PAK	800 / Tape & Reel
MC7806BD2TR4G			D²PAK (Pb−free)	800 / Tape & Reel
MC7806BT			TO−220	50 Units /Rail
MC7806BTG			TO−220 (Pb−free)	50 Units /Rail
MC7806CT		T_J = 0°C to +125°C	TO−220	50 Units /Rail
MC7806CTG			TO−220 (Pb−free)	50 Units /Rail

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.
*NCV devices: T_{low} = −40°C, T_{high} = +125°C. Guaranteed by design. NCV prefix is for automotive and other applications requiring site and change control.

ORDERING INFORMATION

Device	Nominal Voltage	Operating Temperature Range	Package	Shipping†
MC7808ABD2T	8.0 V	T_J = −40°C to +125°C	D^2PAK	50 Units / Rail
MC7808ABD2TG			D^2PAK (Pb−free)	50 Units / Rail
MC7808ABD2TR4			D^2PAK	800 / Tape & Reel
MC7808ABD2TR4G			D^2PAK (Pb−free)	800 / Tape & Reel
MC7808ABT			TO−220	50 Units / Rail
MC7808ABTG			TO−220 (Pb−free)	50 Units / Rail
MC7808ACT		T_J = 0°C to +125°C	TO−220	50 Units / Rail
MC7808ACTG			TO−220 (Pb−free)	50 Units / Rail
MC7808AEBTG		T_J = −40°C to +125°C	TO−220 (Pb−free)	50 Units / Rail
MC7808BD2T	8.0 V		D^2PAK	50 Units / Rail
MC7808BD2TG			D^2PAK (Pb−free)	50 Units / Rail
MC7808BD2TR4			D^2PAK	800 / Tape & Reel
MC7808BD2TR4G			D^2PAK (Pb−free)	800 / Tape & Reel
MC7808BDT			DPAK	75 Units / Rail
MC7808BDTG			DPAK (Pb−free)	75 Units / Rail
MC7808BDTRK			DPAK	2500 / Tape & Reel
MC7808BDTRKG			DPAK (Pb−free)	2500 / Tape & Reel
MC7808BT			TO−220	50 Units /Rail
MC7808BTG			TO−220 (Pb−free)	50 Units /Rail
MC7808CD2T	8.0 V	T_J = 0°C to +125°C	D^2PAK	50 Units /Rail
MC7808CD2TG			D^2PAK (Pb−free)	50 Units /Rail
MC7808CD2TR4			D^2PAK	800 / Tape & Reel
MC7808CD2TR4G			D^2PAK (Pb−free)	800 / Tape & Reel
MC7808CDT			DPAK	75 Units / Rail
MC7808CDTG			DPAK (Pb−free)	75 Units / Rail
MC7808CDTRK			DPAK	2500 / Tape & Reel
MC7808CDTRKG			DPAK (Pb−free)	2500 / Tape & Reel
MC7808CT			TO−220	50 Units /Rail
MC7808CTG			TO−220 (Pb−free)	50 Units /Rail

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.
*NCV devices: T_{low} = −40°C, T_{high} = +125°C. Guaranteed by design. NCV prefix is for automotive and other applications requiring site and change control.

ORDERING INFORMATION

Device	Nominal Voltage	Operating Temperature Range	Package	Shipping†
NCV7808BDTG*	8.0 V	T_J = −40°C to +125°C	DPAK (Pb−free)	75 Units / Rail
NCV7808BTG*			TO−220 (Pb−free)	50 Units / Rail
MC7809ACT	9.0 V	T_J = 0°C to +125°C	TO−220	50 Units /Rail
MC7809ACTG			TO−220 (Pb−free)	50 Units /Rail
MC7809BT		T_J = −40°C to +125°C	TO−220	50 Units /Rail
MC7809BTG			TO−220 (Pb−free)	50 Units /Rail
MC7809CD2T		T_J = 0°C to +125°C	D^2PAK	50 Units /Rail
MC7809CD2TG			D^2PAK (Pb−free)	50 Units /Rail
MC7809CD2TR4			D^2PAK	800 / Tape & Reel
MC7809CD2TR4G			D^2PAK (Pb−free)	800 / Tape & Reel
MC7809CT			TO−220	50 Units /Rail
MC7809CTG			TO−220 (Pb−free)	50 Units /Rail
MC7812ABD2T	12 V	T_J = −40°C to +125°C	D^2PAK	50 Units /Rail
MC7812ABD2TG			D^2PAK (Pb−free)	50 Units /Rail
MC7812ABD2TR4			D^2PAK	800 / Tape & Reel
MC7812ABD2TR4G			D^2PAK (Pb−free)	800 / Tape & Reel
MC7812ABT			TO−220	50 Units /Rail
MC7812ABTG			TO−220 (Pb−free)	50 Units /Rail
MC7812ACD2T	12 V	T_J = 0°C to +125°C	D^2PAK	50 Units /Rail
MC7812ACD2TG			D^2PAK (Pb−free)	50 Units /Rail
MC7812ACD2TR4			D^2PAK	800 / Tape & Reel
MC7812ACD2TR4G			D^2PAK (Pb−free)	800 / Tape & Reel
MC7812ACT			TO−220	50 Units /Rail
MC7812ACTG			TO−220 (Pb−free)	50 Units /Rail

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.
*NCV devices: T_{low} = −40°C, T_{high} = +125°C. Guaranteed by design. NCV prefix is for automotive and other applications requiring site and change control.

ORDERING INFORMATION

Device	Nominal Voltage	Operating Temperature Range	Package	Shipping†
MC7812BD2T	12 V	T_J = −40°C to +125°C	D^2PAK	50 Units /Rail
MC7812BD2TG			D^2PAK (Pb−free)	50 Units /Rail
MC7812BD2TR4			D^2PAK	800 / Tape & Reel
MC7812BD2TR4G			D^2PAK (Pb−free)	800 / Tape & Reel
MC7812BDT			DPAK	75 Units / Rail
MC7812BDTG			DPAK (Pb−free)	75 Units / Rail
MC7812BDTRK	12 V	T_J = −40°C to +125°C	DPAK	2500 / Tape & Reel
MC7812BDTRKG			DPAK (Pb−free)	2500 / Tape & Reel
MC7812BT			TO−220	50 Units / Rail
MC7812BTG			TO−220 (Pb−free)	50 Units / Rail
NCV7812BD2T*	12 V	T_J = −40°C to +125°C	D^2PAK	50 Units /Rail
NCV7812BD2TR4*			D^2PAK	800 / Tape & Reel
NCV7812BD2TR4G*			D^2PAK (Pb−free)	800 / Tape & Reel
NCV7812BT*			TO−220	50 Units /Rail
NCV7812BTG*			TO−220 (Pb−free)	50 Units /Rail
MC7812CD2T	12 V	T_J = 0°C to +125°C	D^2PAK	50 Units /Rail
MC7812CD2TG			D^2PAK (Pb−free)	50 Units /Rail
MC7812CD2TR4			D^2PAK	800 / Tape & Reel
MC7812CD2TR4G			D^2PAK (Pb−free)	800 / Tape & Reel
MC7812CDT			DPAK	75 Units / Rail
MC7812CDTG			DPAK (Pb−free)	75 Units / Rail
MC7812CDTRK			DPAK	2500 / Tape & Reel
MC7812CDTRKG			DPAK (Pb−free)	2500 / Tape & Reel
MC7812CT			TO−220	50 Units /Rail
MC7812CTG			TO−220 (Pb−free)	50 Units / Rail
NCV7812ABTG*	12 V	T_J = −40°C to +125°C	TO−220 (Pb−free)	50 Units / Rail

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.
*NCV devices: T_{low} = −40°C, T_{high} = +125°C. Guaranteed by design. NCV prefix is for automotive and other applications requiring site and change control.

ORDERING INFORMATION

Device	Nominal Voltage	Operating Temperature Range	Package	Shipping†
MC7815ABD2T	15 V	T_J = −40°C to +125°C	D^2PAK	50 Units /Rail
MC7815ABD2TG			D^2PAK (Pb−free)	50 Units /Rail
MC7815ABD2TR4			D^2PAK	800 / Tape & Reel
MC7815ABD2TR4G			D^2PAK (Pb−free)	800 / Tape & Reel
MC7815ABT			TO−220	50 Units /Rail
MC7815ABTG			TO−220 (Pb−free)	50 Units /Rail
MC7815ACD2T		T_J = 0°C to +125°C	D^2PAK	50 Units /Rail
MC7815ACD2TG			D^2PAK (Pb−free)	50 Units /Rail
MC7815ACT			TO−220	50 Units /Rail
MC7815ACTG			TO−220 (Pb−free)	50 Units / Rail
MC7815BD2T		T_J = −40°C to +125°C	D^2PAK	50 Units /Rail
MC7815BD2TG			D^2PAK (Pb−free)	50 Units /Rail
NCV7815BTG*	15 V	T_J = −40°C to +125°C	TO−220 (Pb−free)	50 Units / Rail
MC7815BD2TR4			D^2PAK	800 / Tape & Reel
MC7815BD2TR4G			D^2PAK (Pb−free)	800 / Tape & Reel
MC7815BDT			DPAK	75 Units / Rail
MC7815BDTG			DPAK (Pb−free)	75 Units / Rail
MC7815BDTRK			DPAK	2500 / Tape & Reel
MC7815BDTRKG			DPAK (Pb−free)	2500 / Tape & Reel
MC7815BT			TO−220	50 Units / Rail
MC7815BTG			TO−220 (Pb−free)	50 Units / Rail

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.
*NCV devices: T_{low} = −40°C, T_{high} = +125°C. Guaranteed by design. NCV prefix is for automotive and other applications requiring site and change control.

ORDERING INFORMATION

Device	Nominal Voltage	Operating Temperature Range	Package	Shipping†
MC7815CD2T	15 V	T_J = 0°C to +125°C	D^2PAK	50 Units /Rail
MC7815CD2TG			D^2PAK (Pb−free)	50 Units /Rail
MC7815CD2TR4			D^2PAK	800 / Tape & Reel
MC7815CD2TR4G			D^2PAK (Pb−free)	800 / Tape & Reel
MC7815CDT			DPAK	75 Units / Rail
MC7815CDTG			DPAK (Pb−free)	75 Units / Rail
MC7815CDTRK			DPAK	2500 / Tape & Reel
MC7815CDTRKG			DPAK (Pb−free)	2500 / Tape & Reel
MC7815CT			TO−220	50 Units /Rail
MC7815CTG			TO−220 (Pb−free)	50 Units /Rail
MC7818ACT	18 V	T_J = 0°C to +125°C	TO−220	50 Units /Rail
MC7818ACTG			TO−220 (Pb−free)	50 Units /Rail
MC7818BT		T_J = −40°C to +125°C	TO−220	50 Units /Rail
MC7818BTG			TO−220 (Pb−free)	50 Units /Rail
MC7818CD2T		T_J = 0°C to +125°C	D^2PAK	50 Units /Rail
MC7818CD2TR4			D^2PAK	800 / Tape & Reel
MC7818CD2TR4G			D^2PAK (Pb−free)	800 / Tape & Reel
MC7818CT			TO−220	50 Units /Rail
MC7818CTG			TO−220 (Pb−free)	50 Units /Rail

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

*NCV devices: T_{low} = −40°C, T_{high} = +125°C. Guaranteed by design. NCV prefix is for automotive and other applications requiring site and change control.

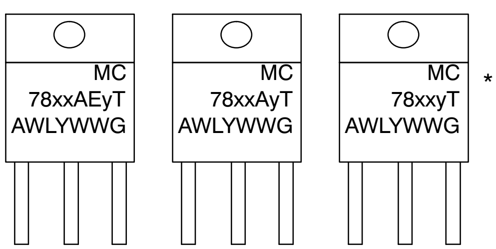
ORDERING INFORMATION

Device	Nominal Voltage	Operating Temperature Range	Package	Shipping†
MC7824ACT	24 V	T_J = 0°C to +125°C	TO−220	50 Units /Rail
MC7824ACTG			TO−220 (Pb−free)	50 Units /Rail
MC7824BD2T		T_J = −40°C to +125°C	D²PAK	50 Units /Rail
MC7824BD2TG			D²PAK (Pb−free)	50 Units /Rail
MC7824BD2TR4			D²PAK	800 / Tape & Reel
MC7824BD2TR4G			D²PAK (Pb−free)	800 / Tape & Reel
MC7824BT			TO−220	50 Units /Rail
MC7824BTG			TO−220 (Pb−free)	50 Units /Rail
MC7824CD2T		T_J = 0°C to +125°C	D²PAK	50 Units /Rail
MC7824CD2TG			D²PAK (Pb−free)	50 Units /Rail
MC7824CD2TR4			D²PAK	800 / Tape & Reel
MC7824CD2TR4G			D²PAK (Pb−free)	800 / Tape & Reel
MC7824CT			TO−220	50 Units /Rail
MC7824CTG			TO−220 (Pb−free)	50 Units /Rail

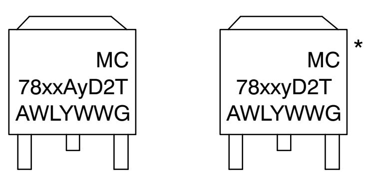
†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

*NCV devices: T_{low} = −40°C, T_{high} = +125°C. Guaranteed by design. NCV prefix is for automotive and other applications requiring site and change control.

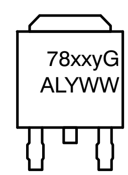
MARKING DIAGRAMS



TO−220−3
T SUFFIX
CASE 221A



D²PAK−3
D2T SUFFIX
CASE 936



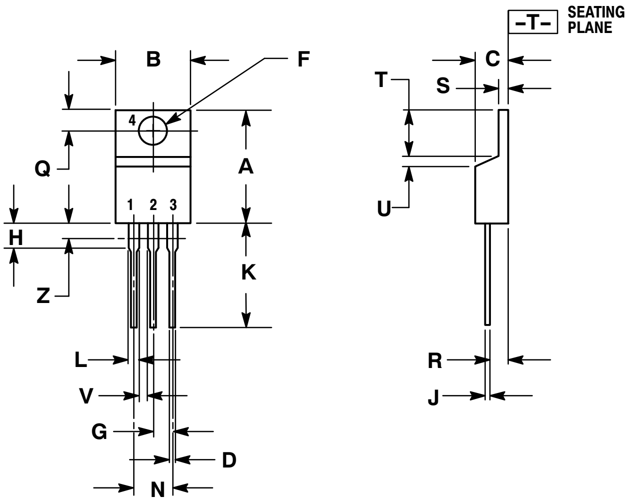
DPAK−3
DT SUFFIX
CASE 369C

*This marking diagram also applies to NCV78xx family.

xx = 05, 06, 08, 09, 12, 15, 18, or 24
y = B or C
A = Assembly Location
WL, L = Wafer Lot
Y = Year
WW = Work Week
G = Pb−Free Device

PACKAGE DIMENSIONS

TO−220, SINGLE GAUGE
T SUFFIX
CASE 221AB−01
ISSUE O

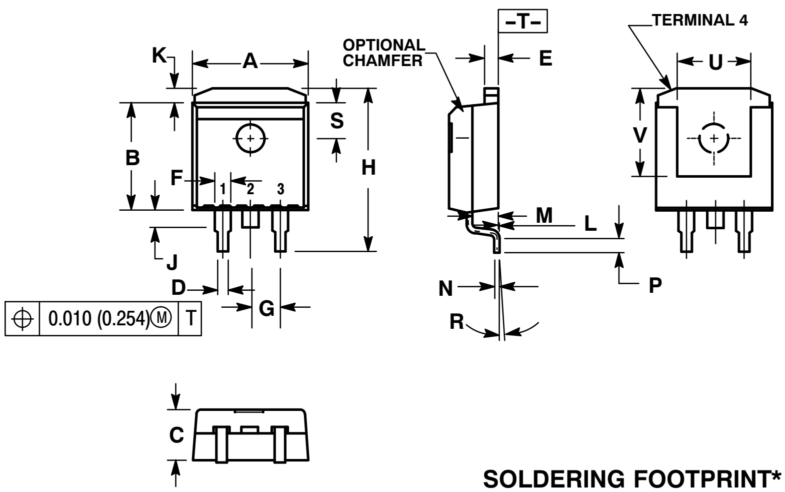


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION Z DEFINES A ZONE WHERE ALL BODY AND LEAD IRREGULARITIES ARE ALLOWED.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.570	0.620	14.48	15.75
B	0.380	0.405	9.66	10.28
C	0.160	0.190	4.07	4.82
D	0.025	0.035	0.64	0.88
F	0.142	0.147	3.61	3.73
G	0.095	0.105	2.42	2.66
H	0.110	0.155	2.80	3.93
J	0.018	0.025	0.46	0.64
K	0.500	0.562	12.70	14.27
L	0.045	0.060	1.15	1.52
N	0.190	0.210	4.83	5.33
Q	0.100	0.120	2.54	3.04
R	0.080	0.110	2.04	2.79
S	0.020	0.055	0.508	1.39
T	0.235	0.255	5.97	6.47
U	0.000	0.050	0.00	1.27
V	0.045	---	1.15	---
Z	---	0.080	---	2.04

PACKAGE DIMENSIONS

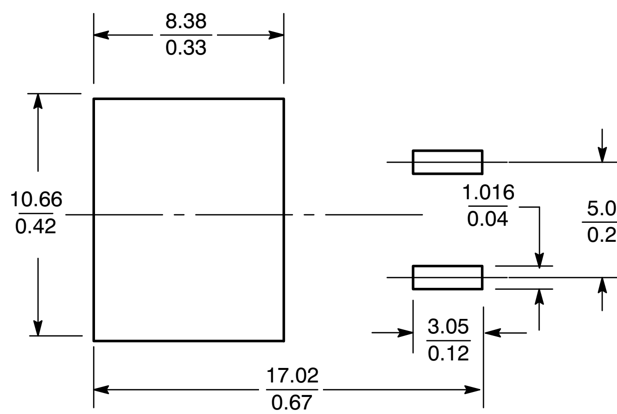
D²PAK-3
D2T SUFFIX
CASE 936-03
ISSUE B



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. TAB CONTOUR OPTIONAL WITHIN DIMENSIONS A AND K.
4. DIMENSIONS U AND V ESTABLISH A MINIMUM MOUNTING SURFACE FOR TERMINAL 4.
5. DIMENSIONS A AND B DO NOT INCLUDE MOLD FLASH OR GATE PROTRUSIONS. MOLD FLASH AND GATE PROTRUSIONS NOT TO EXCEED 0.025 (0.635) MAXIMUM.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.386	0.403	9.804	10.236
B	0.356	0.368	9.042	9.347
C	0.170	0.180	4.318	4.572
D	0.026	0.036	0.660	0.914
E	0.045	0.055	1.143	1.397
F	0.051 REF		1.295 REF	
G	0.100 BSC		2.540 BSC	
H	0.539	0.579	13.691	14.707
J	0.125 MAX		3.175 MAX	
K	0.050 REF		1.270 REF	
L	0.000	0.010	0.000	0.254
M	0.088	0.102	2.235	2.591
N	0.018	0.026	0.457	0.660
P	0.058	0.078	1.473	1.981
R	5° REF		5° REF	
S	0.116 REF		2.946 REF	
U	0.200 MIN		5.080 MIN	
V	0.250 MIN		6.350 MIN	

SOLDERING FOOTPRINT*



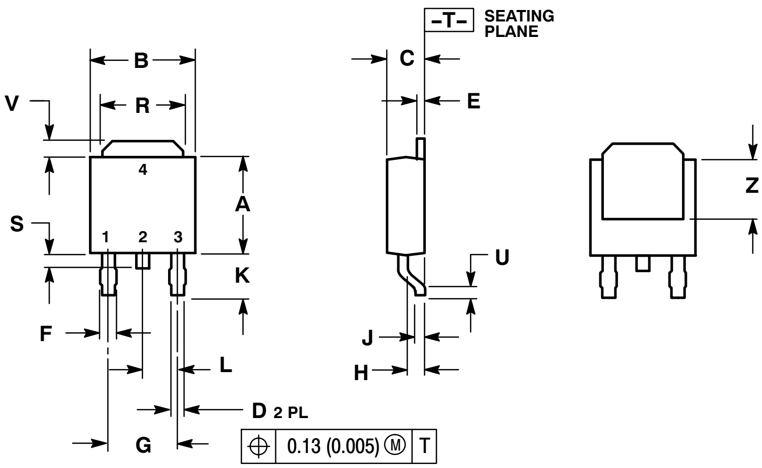
SCALE 3:1 $\left(\frac{mm}{inches}\right)$

D²PAK-3

*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

PACKAGE DIMENSIONS

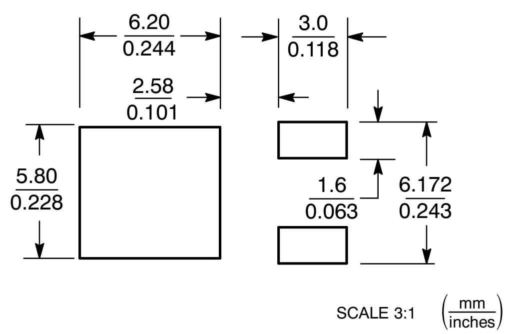
DPAK−3
DT SUFFIX
CASE 369C−01
ISSUE O



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.235	0.245	5.97	6.22
B	0.250	0.265	6.35	6.73
C	0.086	0.094	2.19	2.38
D	0.027	0.035	0.69	0.88
E	0.018	0.023	0.46	0.58
F	0.037	0.045	0.94	1.14
G	0.180 BSC		4.58 BSC	
H	0.034	0.040	0.87	1.01
J	0.018	0.023	0.46	0.58
K	0.102	0.114	2.60	2.89
L	0.090 BSC		2.29 BSC	
R	0.180	0.215	4.57	5.45
S	0.025	0.040	0.63	1.01
U	0.020	---	0.51	---
V	0.035	0.050	0.89	1.27
Z	0.155	---	3.93	---

SOLDERING FOOTPRINT*



*For additional information on our Pb−Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

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