College of Engineering & Technology
Electrical and computer Engineering department

Graduation Project

Camps FM Radio Station

Project Team: Deema Nidal Yaghi
Heba Fahed Abu-Quieder
Boshra Foad Al-Janazreh

Project Supervisor : Dr. Ghandi Manasra

Hebron – Palestine
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جامعة بوليتكنك فلسطين

الخليل-فلسطين

كلية الهندسة والتكنولوجيا

دائرة الهندسة الكهربائية **والحاسوب**

اسم المشروع

Campus FM Radio Station

أسماء الطلبة

ديما ياغي　　　　هبه أبو قويدر　　　　بشرى الجنازرة

بناء على نظام كلية الهندسة والتكنولوجيا و**إشراف ومتابعة المشرف المباشر على المشروع** وموافقة أعضاء اللجنة الممتحنة ، تم تقديم هذا المشروع إلى دائرة الهندسة الكهربائية والحاسوب وذلك للوفاء بمتطلبات درجة البكالوريوس في الهندسة تخصص الاتصالات والالكترونيات

توقيع المشرف

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توقيع اللجنة الممتحنة

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توقيع رئيس الدائرة

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Abstract

The special and limited environment of a collage community creates some sort of privacy and requires special connection between individuals of this small community ,the ability of reaching this community is an important aspect of public interest there are many ways including a special paper or websites or printed plates or may be a dedicated radio station used to broadcast a voice that can be heard so an FM radio station can be regarded as good sophisticated way for reaching the group of interest as students or even anyone in the listening area (campus) of the FM transmitter it would broadcast academic, cultural, sports and social awareness programs meant for students. The academic programs, according to university officials, would be prepared by senior faculty members of different faculties, but would be broadcast by students.

many steps should be taken into consideration to get the station on air, making sure that these groups are able to receive the broadcasted signal is regarded as a first step of achieving the purpose of the whole project then taking care of the whole requirements like frequency to use , power level, the overall budget and many other things.

This project is all about building an FM transmitter using a few basic components including a stereo FM transmitter and a PIC microcontroller to control both the frequency according to the users order and also the LCD two line display , with the ability of picking any available frequency in the FM band that is not occupied by any other station with a higher power which make it applicable in any given area the user may pick and to provide the LCD display to be able to define the frequency being used .

FM Radio station is of the students, for the students and by the students.

ملخص

البيئة الجامعية الصغيرة تتطلب نوعا من الخصوصية و التفرد و هذا يترافق مع الحاجة الشديدة للعديد من وسائل التواصل التي تربط أفراد هذا المجتمع الصغير و أمكانية الوصول إلى المجتمع الطلابي تعتبر ذات أهمية وهي واحدة من عدة طرق كالأوراق العلمية **و المواقع الالكترو**نية او محطة إذاعية خاصة . مشروعنا يتمثل ببناء محطة بث راديو تعمل على أكثر من تردد بناءا على البيئة المحيطة في نطاق محدود لا يتجاوز الحرم الجامعي و تستخدم كوسيلة لبث صوت مسموع بحيث تكون الرسالة أكثر وضوحا و تأثيرا لذلك يعتبر الراديو وسيلة ممتازة و راقية للوصول إلى الفئة المستهدفة كطلاب او أي شخص أخر داخل النطاق الذي يغطيه هذا البث و الذي ممكن ان يكون أكاديمي أو ثقافي او رياضي او برامج اجتماعية للطلاب بحيث يتم إعدادها من الطلاب أنفسهم من مختلف التخصصات و المستويات .

Dedication

To the candles of our life … Mom & Dad

Brothers, Sisters, & Friends

To our dear teacher

Dr. Ghandi Manasra

Acknowledgment

First of all, a great thanks for Allah for giving us the strength and knowledge to accomplish our project.

We would like to convey our very special cordial thanks to our supervisor Dr. Ghandi Manasrah for his support and for guiding the work.

Great credit is attributed to the stuff of Computer and Electronic Engineering Department in Palestine Polytechnic University.

Finally, very special thanks to all our classmates in the department.

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1

INTRODUCTION

Chapter One

Introduction

1.1 Overview:

In this chapter we will talk about the general description of project , motivation ,project objectives ,estimated cost ,project scheduling for our system ,and report content.

1.2 General description of project

We are planning to build a campus FM radio station that operates on low power and covers the area of interest which does not exceed the campus of our collage including the building of the university that are close enough to be inside the range of our limited coverage , a relatively small range that is private and exclusive , which is planned to be operated and managed by the students themselves for the purpose of serving their needs and connect them in a satisfying sophisticated way.

FM stations are much more popular since high sound fidelity and stereo broadcasting that overcome the interference problem of the AM and the requirements of the special receivers , as communication and electronic engineers we are concerned with the high quality of the audio signal broadcasting and overcoming problems and shortcomings of that technology.

1.3 Motivation

It is an easy way that everybody can use for listening to music and know about the advisement and other activity in the university , to provide individuals, educational institutions and commercial entities with the highest quality available resources to allow them to legally broadcast on the FM radio.

The reasons for universities ,including students, to support campus radio are many, the value of a station goes far deeper than what is heard on the air. Programming contents to be sure is valuable, also stations create promotional and visibility opportunities for the university and student groups, skills training and networking for students, and grassroots connections to the wider community. Beyond this campus radio stations provide support for emerging artists and new ideas, local news and information, and a vital role in community development

Since educational radio relies mainly on the spoken word, it can speak to people directly and in their own language– even to those without the benefit of literacy. Educational radio programs are relatively cheap to produce and to transmit. The costs are dramatically less than those for television or video, and usually lower than print or formal teaching and learning method , community owned and operated

, not for profit , listener supported radio is surviving in the face of many challenges , but is vulnerable in many places.

1.4 Project Objective

1-To provide the university community and others in its listening area with news reporting, advertisements, entertainment and other appropriate broadcast materials.

2-To play a supportive role to instructional programs.

3-To provide who participates in the operation of the radio station with the opportunities of meaningful activities.

1.5 History of broadcasting

In 1864, German scientist Heinrich Hertz proved English scientist James C. Maxwell's theory that electromagnetic waves exist in the atmosphere and have cretin frequencies . In 1906 , Reginald Fessenden invented wireless telephony , a means for radio waves to carry signal at a significant distance . By 1912, Edwin Howard Armstrong devised a new regenerative circuit. Building on the audio, he took part of the current at the plate and fed it back to the grid to strengthen incoming signals. Testing this concept in his turret room in Yonkers, he began getting distant stations that is loud enough that they could be heard without earphones (which until then were needed). He later found that when feedback was pushed to a high level the tube produced rapid oscillations acting as a transmitter and putting out electromagnetic waves. Thus this single circuit yielded not only the first radio amplifier but also the key to the continuous-wave transmitter that is still at the heart of all radio operations. Also the radio Act assigns three and four letter codes to radio stations and limits broadcasting to the 360m wavelength. By 1920, a Pittsburgh Westinghouse station , transmitted the first commercial radio broadcast. Reacting to problems posed by the Radio Act of 1912, the commerce Department in 1922 allowed powerful stations to use the 400m wavelength as long as they only broadcast live music .[1]

By the year of 1933 , Armstrong developed a wide-band frequency modulation (FM) system that gives much clearer reception than AM. So in 1935 the FM radio is born but only in monophonic systems . In 1941 , the Columbia university radio club opened the first regularly scheduled FM station. By 1945 FM is moved from its original home of 42 -50 MHz to 88-108 MHz to make room for TV. In 1948 A new wavelength plan was set up for Europe . Because of the recent war, Germany (which was not even invited) was only given a few medium-wave frequencies, which are not very good for broadcasting. For this reason Germany began broadcasting on ultra short waves, USW (nowadays called Very High Frequency (VHF)) After some amplitude modulation experience with VHF, it was realized that FM radio was a much better alternative for VHF radio than AM. The number of radio receivers in the world exceeded the number of newspapers printed daily in 1954.The monophonic system has advanced to the stereophonic in the 1960's and RDS has been integrated in the early 1990's. [2]

In 1969, National Public Radio launched by the Corporation for Public Broadcasting . Also, first broadcast from the moon. In 1986 , in Europe, FM radio stations began to use the subcarrier signal of FM radio to transmit digital data. This RDS (radio data system) is used to transmit messages on display screens to radios. By the year of 1992 an experimental digital FM transmitter began operation. [3]

1.6 Related work

Hebron university radio station is an FM radio which is operated inside the university but it does not have the purpose of a campus radio station, its not dedicated to the use of the community of the collage it has the same features as any public radio and it's not monitored by students themselves ,it broadcasts programs and commercials and news for the whole community not the collage students, which are also produced and presented by it broadcasts with high power and a relatively large range not limited by the campus of the university or its buildings.

There are student radio stations that are actually limited to the range of the campus but it's not operated all week long its operation is limited to cretin occasions like holidays and special events and so it broadcasts cretin programs with cretin topics and have limited agenda which is not flexible or can't be modified according to the events or circumstances like the Roskilde festival in the Denmark

Some campus (student) community base radio broadcasting system, has cetin functions like an engineering laboratory to train students in broadcast engineering skills, which are currently being sought to turn into a radio commercial for the students also can improve their skills in terms of broadcast management and broadcast business.

In the united kingdom some student stations operate on the FM waveband for short periods of time it means that its actually bounded by the small period of time under the restricted license while others choose to broadcast full time on the AM waveband.

1.7 Time plane / project schedule

The time plane shows what is done in the first & second semesters .

Table 1.1 Time Planning (first & second semesters)

Task/week	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*
Project Determination	■															
Data Collection		■	■	■	■	■	■	■	■	■	■					
History			■	■	■	■										
Design and Analysis							■	■	■	■	■	■	■	■	■	
Documentation			■	■	■	■	■	■	■	■	■	■	■	■	■	■
Implementation and Testing			■	■	■	■	■	■	■	■	■	■	■	■	■	■
Conclusion and future suggestion															■	■

1.8 Cost Estimation and Budget Breakdown

This section lists the overall cost of the project.

Table 1.2 Cost Estimation

Component	Quantity	Price
BH1417F	1	75 $
Power Amplifier	1	10 $
Resister , capacitor , inductor	17, 32, 2	7 $
Switch	3	2 $
Regulator 78L05	1	2 $
Varactor	1	3 $
Darlington transistor MPSA13 , Led , Crystal	1 ,2, 2	5 $
Electric Mice	1	1$
PIC18F4550	1	20 $
LCD	1	20 $
	Additional cost	100$
	Total cost	245$

1.9 Report contents

The documentation for this project in the first & second semester is categorized into four chapters, the report structure views the outline for discussed subjects in each chapter. The outline of all chapters is summarized briefly as follows :

- **Chapter One : Introduction**

Demonstrates an overview about the system, project importance, history and time planning , finally this chapter shows the structure of the project report.

- **Chapter Two : Theoretical Background**

Focuses on theories and materials that are related to the project.

- **Chapter Three : Project conceptual design**

Describes the detailed system objectives , design options and the general block diagrams of the system and explains how system works.

- **Chapter four : Detailed technical project design**

Describes the detailed subsystems design , overall system design (Schematic diagrams) .

- **Chapter Five : Implementation and Testing**

Describes the construction and testing for the system.

- **Chapter Six : Conclusion and Future suggestion**

CHAPTER

2

Theoretical Background

Chapter Two

Theoretical Background

2.1 Introduction

The propose of a communication system is to transmit an information signal from a sender to a receiver through a communication channel ,and the radio signals are transmitted and received by means of aerials ,but since no kind of aerial can operate at such low frequency it is necessary to shift each signal to some higher frequency .[4] A shift to the range of frequencies in signal is accomplished by using modulation ,which is defined as the process by which some characteristic of a carrier is varied in accordance of modulated wave (signal) .[5]

The variation could be in the amplitude (amplitude modulation) or in the angle of the carrier (angle modulation) in accordance with the baseband signal . For example; if we have a single tone message the AM and FM modulation for it is going to be as shown in the figure bellow .

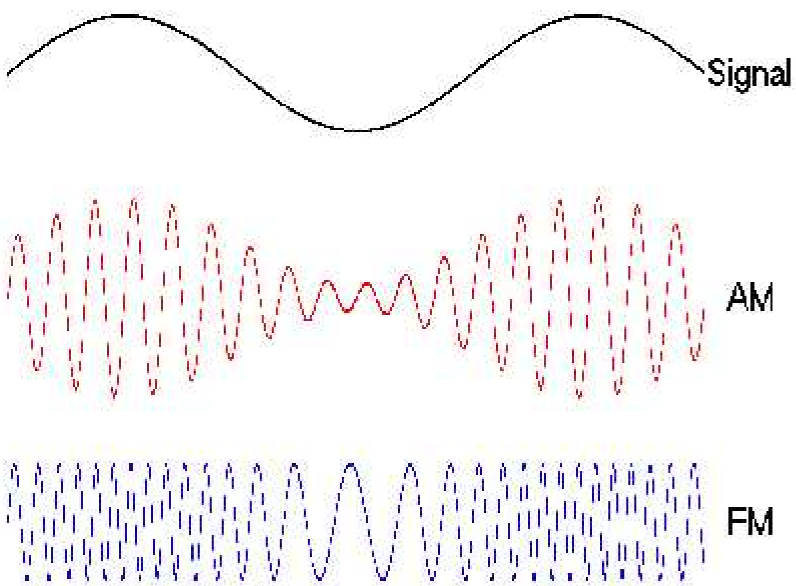

Figure 2.1 : message signal , AM signal and FM signal

2.2 Frequency modulation

Modulation changes the characteristic of signal in order to send it ,and carrier signal is needed for carry it in the channel , assume the massage signal denoted by $m(t)$,and let $\emptyset_i(t)$ denote the angel of modulated sinusoidal carrier ,assume to be a function of massage signal ,the resulting angel-modulated wave is $s\ t\ = A_c \cos\ (\emptyset_i\ t\ )$

Where : A_c is the carrier amplitude , and the instantaneous frequency of angel-modulated signal $s\ t$ as follows: $$f_i\ t\ = \frac{1}{2\pi}\frac{d\emptyset_i(t)}{dt}$$

Frequency modulation is that from angle modulation in which the instantaneous frequency $f_i\ t$ is varied linearly with the massage signal m(t) ,as shown by :

$$f_i\ t\ = f_c + K_f\, m(t)$$

Where f_c represent the frequency of unmodulated carrier , and the K_f represent the frequency sensitivity of modulator .

The angel of modulated carrier will be :

$$\emptyset_i(t)\ = 2\pi f_c t + 2\pi K_f \int_0^t m(\tau)\, d\tau$$

Then the frequency modulated Signal is :

$$s\ t\ = A_c\ \cos[2\pi f_c t + 2\pi K_f \int_0^t m(\tau)\, d\tau]$$

For example : if we consider the modulating signal defined by

$$m\ t\ = A_m\ \cos(2\pi f_m(\ t))$$

Then the instantaneous frequency of ***FM*** signal equals

$$f_i\ t\ = f_c + K_f A_m \cos(2\pi f_m(\ t))$$

$$= f_c + \Delta f \cos(2\pi f_m(t\ ))$$

Where : $\Delta f = K_f A_m$ is the frequency deviation ,representing the maximum departure of instantaneous frequency of the **FM** signal from the carrier frequency . Although it may seem that this limits the frequencies in use to $f_c + \Delta f$,it still neglects the distinction between instantaneous frequency and spectral frequency. The frequency spectrum of an actual FM signal has components extending infinitely, although they become negligible beyond a certain point.

The angel $\emptyset_i(t)$ is obtained as $\emptyset_i(t) = 2\pi \int_0^t f_i\ \tau\ d\tau$

$$\emptyset_i(t) = 2\pi f_c t + 2\pi K_f \int_0^t A_m \cos(2\pi f_m(\tau))\, d\tau$$

$$\emptyset_i(t) = 2\pi f_c t + \frac{\Delta f}{f_m} \sin(2\pi f_m\ t)$$

The ratio of frequency deviation Δf to the modulation frequency f_m is called modulation index of the ***FM*** signal $\beta = \frac{\Delta f}{f_m}$

Then the modulated signal is : $s(t) = A_c \cos[2\pi f_c t + \beta \sin(2\pi f_m t)]$

2.2.1 Modulation index

As in other modulation indices, this quantity indicates by how much the modulated variable varies around its unmodulated level. It relates to variations in the carrier frequency:

$$\beta = \frac{\Delta f}{f_m}$$

Where f_m is the highest frequency component present in the modulating signal $m(t)$, and Δf is the peak frequency-deviation. The maximum deviation of the instantaneous frequency from the carrier frequency is when $\beta \ll 1$, the modulation is called narrowband FM, and its bandwidth is approximately $2f_m$.

But when $\beta \gg 1$, the modulation is called wideband FM and its bandwidth is approximately $2\Delta f$. Although wideband FM uses more bandwidth, it can improve the signal-to-noise ratio significantly; for example, doubling the value of Δf , while keeping f_m constant, results in an eight-fold improvement in the signal-to-noise ratio.[6] (Compare this with Chirp spread spectrum, which uses extremely wide frequency deviations to achieve processing gains comparable to the traditional ones, better-known as spread-spectrum modes).

With a tone-modulated FM wave, if the modulation frequency is held constant and the modulation index is increased, the (non-negligible) bandwidth of the FM signal increases but the spacing between spectra remains the same;. If the frequency deviation is held constant and the modulation frequency increased, the spacing between spectra increases. Similarly some spectral components decrease in strength as others increase.

Frequency modulation can be classified as narrowband if the change in the carrier frequency is about the same as the signal frequency, or as wideband if the change in the carrier frequency is much higher than the signal frequency(modulation index >1). [7] **For example** in the narrowband FM used for two way radio systems such as Family Radio Service, the carrier is allowed to deviate only 2.5 kHz above and below the center frequency with speech signals of no more than 3.5 kHz bandwidth. On the other Wideband FM is used for FM broadcasting, in which music and speech are transmitted with up to 75 kHz deviation from the center frequency and carry audio with up to a 20-kHz bandwidth.

2.2.2 Carson's rule

A rule of thumb, Carson's rule states that nearly all (~98 percent) of the power of a frequency-modulated signal lies within a bandwidth B_T of:

$$B_T = 2\Delta f(1 + \frac{f_m}{\Delta f})$$

$$= 2f_m(1 + \frac{\Delta f}{f_m}) = 2f_m(1 + \beta)$$

Where Δf, as defined above, is the peak deviation of the instantaneous frequency $f(t)$ from the center carrier frequency f_c.

2.2.3 Bessel functions

The harmonic distribution of a sine wave carrier modulated by a sinusoidal single tone signal can be represented with Bessel functions; this provides the basis for a mathematical understanding of frequency modulation in the frequency domain.

The carrier and sideband amplitudes are illustrated for different modulation indices of FM signals (based on Bessel functions).

To show the spectrum for a single tone message:

Bessel function is:

$$J_n(\beta) = \frac{1}{2\pi}\int_{-\pi}^{\pi} \exp[j(\beta \sin x - nx)]dx$$

The Bessel function is used to determine the spectrum of single tone FM signal for arbitrary value of the modulated index (B) .

$$x(f) = \frac{A_c}{2}\sum_{n=-\infty}^{\infty} J_n(\beta)[\delta(f - f_c - nf_m) + \delta(f + f_c + nf_m)]$$

the figure bellow shows the Bessel function versus the modulation index for different positive integer n.

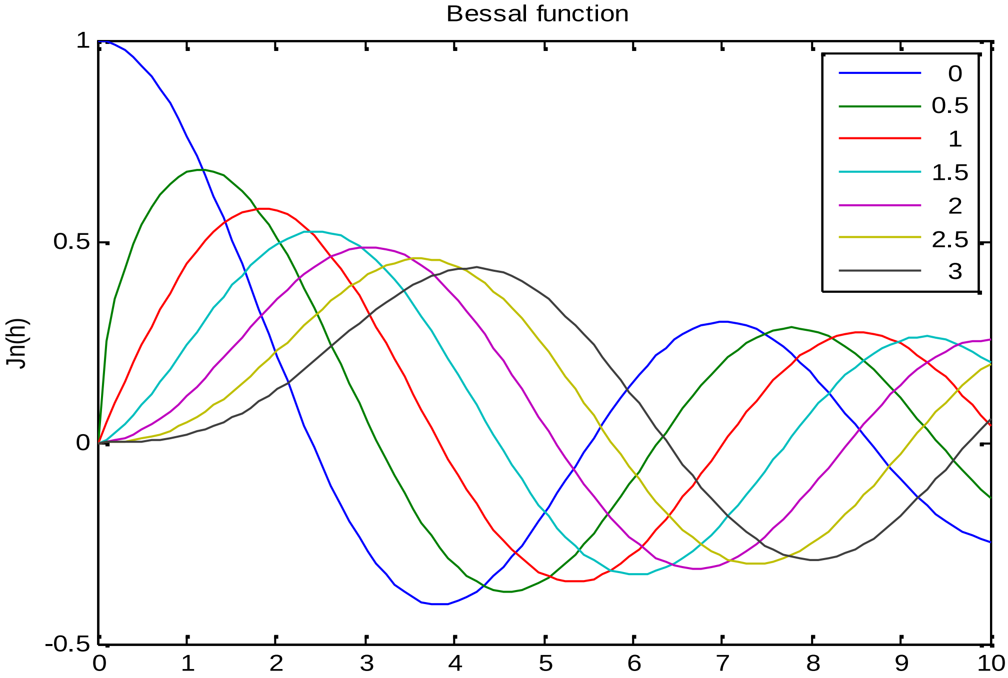

Figure 2.2 : Bessel function of the first kind of varying order

2. 3 Microcontroller

It's a single chip computer ,used to control objects, processes and events ,so any device that measures, stores, controls, calculates is a candidate of putting a microcontroller inside .Microcontrollers make it easy to add features such as the ability to store measurements, to create and store user routines, and to display messages and waveforms, a microcontroller is similar to the microprocessor inside a personal computer, both microprocessors and microcontrollers contain a central processing unit to make a complete computer, a microprocessor requires memory for storing data and programs, and input/output (I/O) interfaces for connecting external devices like keyboards and display.

2.3.1 PIC18F4550

It is an 8-bit microcontroller of PIC 18 family, which based on 16-bit instruction set architecture. And consists of 32Kbit flash memory, 2Kbit Static Random Access Memory (SRAM) and 255 Bytes Electrically Erasable Programmable Read –Only Memory (EEPROM).Also it has a 40 pins consisting of 5 input/output (I/O) ports (PORTA, PORTB, PORTC , PORTD and PORTE). PORTB and PORTD have 8 pins to receive/transmit 8-bit I/O data . The remaining ports have different numbers of pins for I/O data communications.

The PIC can work on different internal and external clock sources. Also can work on a varied range of frequency from 31KHz to 48KHz .

2.4 Phase Locked Loop

Phase-locked loop (PLL) is a feedback loop which locks two waveforms with same frequency but shifted in phase. The fundamental use of this loop is in comparing frequencies of two waveforms and then adjusting the frequency of the waveform in the loop to equal the input waveform frequency. The heart of the PLL is a phase comparator which along with a voltage controlled oscillator (VCO), a filter and an amplifier forms the loop. If the two frequencies are different the output of the phase comparator varies and changes the input to the VCO to make its output frequency equal to the input waveform frequency.[8]

So the components of a PLL that contribute to the loop gain include:

1. The phase detector (PD) and charge pump (CP).
2. The loop filter, with a transfer function of Z(s)
3. The voltage-controlled oscillator (VCO), with a sensitivity of K_V / s
4. The feedback divider, 1 / N

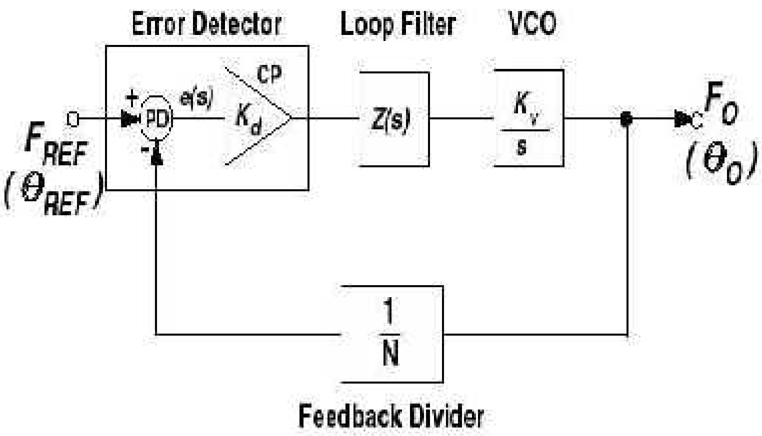

Figure 2.3 : Block diagram for PLL

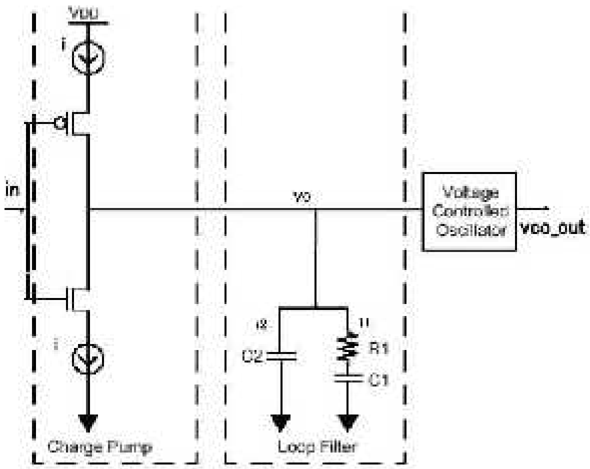

Figure 2.4 : transfer function for PLL

$$Vo = \frac{1}{sC_2} . i_2 = \quad \frac{1}{sC_1} + R_1 \quad . i_1$$

$$i = i_1 + i_2$$

$$\frac{V_o}{i} = \frac{1 + sR_1C_1}{s^2C_1C_2R_1 + s \quad C_1 + C_2}$$

Phase Locked Loop are widely employed in radio, telecommunications, computers and other electronic applications. They can be used to recover a signal from a noisy communication channel, generate stable frequencies at a multiple of an input frequency (frequency synthesis), or distribute clock timing pulses in digital logic designs such as microprocessors.

1) Phase Detector:

Phase detectors for phase-locked loop circuits may be classified in two types. A Type I detector is designed to be driven by analog signals or square-wave digital signals and produces an output pulse at the difference frequency. Type I detector which always produces an output waveform, which must be filtered to control the phase-locked loop voltage-controlled oscillator (VCO). And type II detector which is sensitive only to the relative timing of the edges of the input and reference pulses, and produces a constant output proportional to phase difference when both signals are at the same frequency. This output will tend not to produce ripple in the control voltage of the VCO .

2) Filter:

A low pass filter that passes low frequency signals and attenuates signals with frequencies higher than the cutoff frequency. The actual amount of attenuation for each frequency varies from filter to filter. It is sometimes called a high-cut filter, or treble cut filter when used in audio applications. A low-pass filter is the opposite of a high-pass filter. A band-pass filter is a combination of a low-pass and a high-pass. Low-pass filters exist in many different forms. The moving average operation used in fields such as finance is a particular kind of low-pass filter, and can be analyzed with the same signal processing techniques as are used for other low-pass filters. Low-pass filters provide a smoother form of a signal, removing the short-term fluctuations, and leaving the longer-term trend.

The PLL filter is needed to remove any unwanted high frequency components which might pass out of the phase detector and appear in the VCO tune line. They would then appear on the output of the Voltage Controlled Oscillator, VCO, as spurious signals.

3) Voltage Controlled Oscillator

A voltage controlled oscillator is an electronic oscillator designed to be controlled in oscillation frequency by a voltage input. The frequency of oscillation is varied by the applied DC voltage, while modulating signals may also be fed into the VCO to cause frequency modulation (FM) or phase modulation (PM); a VCO with digital pulse output may similarly have its repetition rate (FSK, PSK) or pulse width modulated (PWM).[9]

VCOs can be generally categorized into two groups based on the type of waveform produced:

1) harmonic oscillators 2) relaxation oscillators.

Harmonic oscillators generate a sinusoidal waveform. They consist of an amplifier that provides adequate gain and a resonant circuit that feeds back signal to the input. Oscillation occurs at the resonant frequency where a positive gain arises around the loop. Some examples of harmonic oscillators are crystal oscillators and LC-tank oscillators. When part of the resonant circuit's capacitance is provided by a varactor diode, the voltage applied to that diode varies the frequency.

Relaxation oscillators can generate a triangular waveform. They are commonly used in monolithic integrated circuits (ICs).

Harmonic oscillator VCOs have these advantages over relaxation oscillators:

- Frequency stability with respect to temperature, noise, and power supply is much better for harmonic oscillator VCOs.
- They have good accuracy for frequency control since the frequency is controlled by a crystal or tank circuit.

A disadvantage of harmonic oscillator VCOs is that they cannot be easily implemented in monolithic ICs. Relaxation oscillator VCOs are better suited for this technology. Relaxation VCOs are also tunable over a wider range of frequencies.

4) The feedback divider

In digital electronics, frequency multipliers are often used along with frequency dividers and phase-locked loops to generate any desired frequency from an external reference frequency. The frequency multiplication is carried out in the phase-locked loop's feedback loop, by using a frequency divider on the output of the voltage controlled oscillator (VCO). This divided-down output is fed-back to the input comparator and compared to the reference frequency. Since the divided down frequency is smaller than the reference frequency, the comparator generates a voltage signal to the VCO, telling it to increase the output frequency. It continues to do this via the feedback loop, raising the VCO output frequency, until the divided-down frequency from the VCO output is equal to the reference frequency. At this point the comparator stabilizes and generates no more signals to the VCO, or only minor changes to maintain stability. The output frequency from the VCO will be stable at the input reference frequency multiplied by the value of the feedback divider.[10]

A PLL with a frequency divider in its feedback loop acts as a frequency multiplier and is a type of frequency synthesizers.

A frequency divider, also called a clock divider is a circuit that takes an input signal of a frequency, f_{in}, and generates an output signal of a frequency:

$$f_{out} = \frac{f_{in}}{n}$$

Where **: n** is an integer. Phase-locked loop frequency synthesizers make use of frequency dividers to generate a frequency that is a multiple of a reference Frequency . Frequency dividers can be implemented for both analog and digital applications .

2.5 Oscillator

Oscillator is an electronic device that generates an output signal without the necessity of an input signal. they are used as a signal sources in all sorts of applications. Different types of oscillators produce Various types of outputs including sine waves ,square waves, triangular waves , saw tooth waves .[11]

A crystal oscillator is an electronic oscillator circuit that uses the mechanical resonance of a vibrating crystal of a piezoelectric material to create an electrical signal with a very precise frequency. This frequency is commonly used to keep track of time (as in quartz wristwatches), to provide a stable clock signal for digital integrated circuits, and to stabilize frequencies for radio transmitters and receivers.

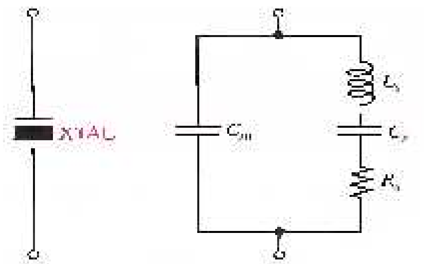

Figure 2.5 : Oscillator Figure

An oscillator crystal has two electrically conductive plates, with a slice or tuning fork of quartz crystal sandwiched between them. During startup, the circuit around the crystal applies a random noise AC signal to it, and purely by chance, a tiny fraction of the noise will be at the resonant frequency of the crystal. The crystal will therefore start oscillating in synchrony with that signal. As the oscillator amplifies the signals coming out of the crystal, the signals in the crystal's frequency band will become stronger, eventually dominating the output of the oscillator. The narrow resonance band of the quartz crystal filters out all the unwanted frequencies.

The output frequency of a quartz oscillator can be either the fundamental resonance or a multiple of the resonance, called an overtone frequency. High frequency crystals are often designed to operate at third, fifth, or seventh overtones.

2.6 Varactor

Varactor diodes are also known as variable-capacitance diodes because the junction capacitance varies with amount of reverse –bias voltage . Varactor diodes are specifically designed to take advantage of this variable-capacitance characteristic.[12] These device are commonly used in electronic tuning circuits used in communication system.

Varactors are operated reverse-biased , so no current flows, but since the thickness of the depletion zone varies with the applied bias voltage, the capacitance of the diode can be made to vary. Generally, the depletion region thickness is proportional to the square root of the applied voltage; and capacitance is inversely proportional to the depletion region thickness. Thus, the capacitance is inversely proportional to the square root of applied voltage.

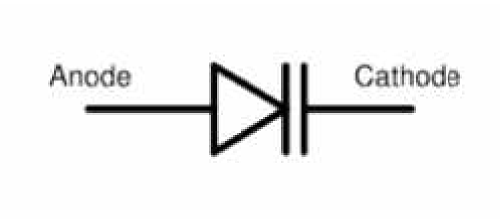

Figure 2.6 : Varactor

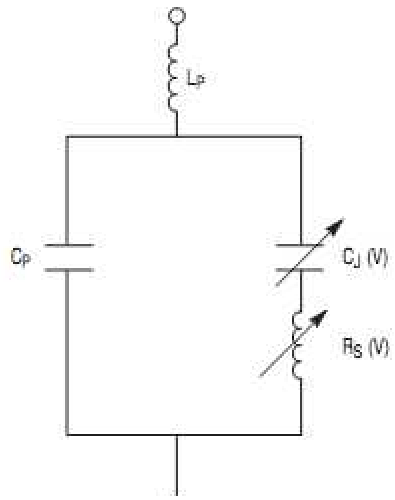

Figure 2.7 : A sample model of a packaged varactor diode

In the above figure, CJ (V) is the variable junction capacitance of the diode die and RS (V) is the variable series resistance of the diode die. CP is the fixed parasitic capacitance arising from the installation of the die in a package. Contributors to the Para- Sitic capacitance are the package material, geometry and the bonding wires or ribbons. These factors also contribute to the parasitic inductance LP. The contribution to the series resistance from the packaging is very small and may be ignored. Similarly, the inductance associated with the die itself is very small and may be ignored.

Variation of the junction capacitance and the junction series resistance as a function of applied reverse voltage is reported in the individual varactor data sheets of this catalog.

A common package configuration is to assemble two junctions in one package in a common cathode or common anode configuration. An empirical model for this dual configuration assumes the same value of parasitic capacitance in parallel with each junction die as for a single junction assembly. On the other hand, the parasitic inductance LP may be assumed to be common for the assembly. **For example**, suppose two junctions each with a junction capacitance of 0.5 pF (CJ = 0.5 pF) are assembled together in one package which has a parasitic capacitance of 0.15 pF (CP = 0.15 pF) and a parasitic inductance of 0.5 nH (Lp = 0.5 nH). The model for this case may be represented by two diodes with total capacitance of 0.65 pF , each (CJ + CP = 0.5 +0.15) in parallel or in series depending on the configuration. The inductance of 0.5 nH would appear in series with the entire assembly.

Key Electrical Parameters

The Key electrical parameters guiding the selection and usage of a varactor diode are :

- Reverse breakdown voltage and reverse leakage current .
- Capacitance value and the capacitance voltage change behavior.
- Quality Factor

2.7 Darlington transistor

It's a compound structure consisting of two bipolar transistors connected in such a way that the current amplified by the first transistor is amplified further by the second one. This configuration gives a much higher current gain than each transistor taken separately and, in the case of integrated devices, can take less space than two individual transistors because they can use a shared collector. Integrated Darlington pairs come packaged singly in transistor or as an array of devices in an integrated circuit. A Darlington pair behaves like a single transistor with a high current gain . In fact, integrated devices have three leads B , C and E , broadly equivalent to those of a standard transistor.

So in our project we will use the MPSA13 – NPN Darlington transistor ,this

Figure 2.8 : MPSA13

device is designed for use in switching application and for applications requiring extremely high current gains at up to 1.2 Amps. It is well suited for relay drivers from extremely low input currents. Use this transistor to interface from Logic ICs to drive the outside world such as relays, lamps, solenoids, and more.

2.8 Power amplifier

The term amplifier is very generic, the purpose of an amplifier is to take an input signal and make it stronger (or in more technically correct terms, increase its amplitude). Amplifiers find application in all kinds of electronic devices designed to perform any number of functions. There are many different types of amplifiers, each with a specific purpose in mind. For example, a radio transmitter uses an RF Amplifier (RF stands for Radio Frequency); such an amplifier is designed to amplify a signal so that it may drive an antenna.[13] The output signal of all amplifiers contains additional components that are not present in the input signal; these additional characteristics may be lumped together and are generally known as distortion. There are many types of distortion; however the two most common types are known as harmonic distortion and inter modulation distortion.

All power amplifiers have a power rating; the units of power are called watts. The power rating of an amplifier may be stated for various load impedances; the units for load impedance are ohms.

The quality of an amplifier can be characterized by a number of specifications:

1- Gain
2- Bandwidth
3- Efficiency
4- Linearity
5- Noise
6- Output dynamic range
7- Slew rate
8- Rise time
9- Settling time and ringing
10- Overshoot.

1) gain

The gain of an amplifier is the ratio of output to input power or amplitude, and is usually measured in decibels.

$$G\ dB = 10log_{10}(\frac{P_{out}}{P_{in}})$$

The gain controls are used to match the amplifiers gain to the gain of the other amplifiers in the system in case of a multiple amplifiers .

2) Bandwidth

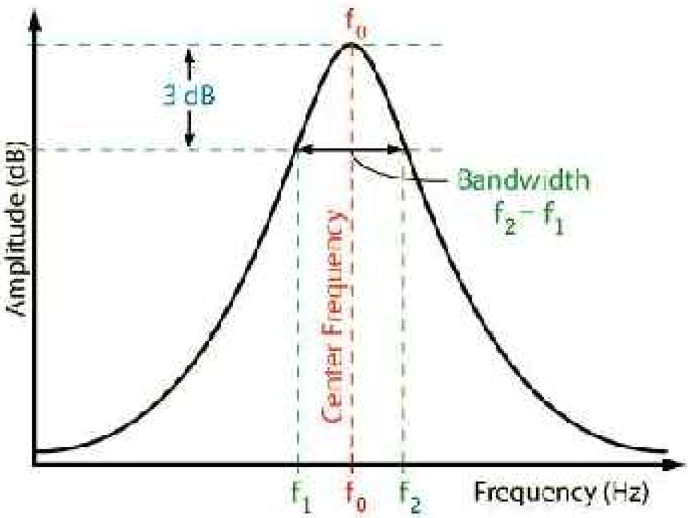

Figure 2.9 : Bandwidth

The bandwidth represents the amount or "width" of frequencies, or the "band of frequencies," that the amplifier is most effective in amplifying. However, the bandwidth is not the same as the band of frequencies that is amplified. The bandwidth (BW) of an amplifier is the difference between the frequency limits of the amplifier

$$BW = f_2 - f_1$$

3) Efficiency

Efficiency is a measure of how much of the power source is usefully applied to the amplifier's output

$$\text{efficiency} = \frac{\text{output power}}{\text{input power}}.$$

4) Noise

One of the factors which govern the performance of any amplifier system is the noise in the system. Noise might be defined as signals in the system which are unwanted and which degrade the desired signal content in the system.

As far as the amplifier system is concerned, noise can be divided into noise it receives at its input and noise it generates itself. A good system is one in which the noise generated by the amplifier itself is small compared to noise from the incoming source.

2.9 Signal –to –noise ratio in FM system

During the transmission, a frequency modulated signal will be subjected to noise and interference voltage . The effect of these unwonted voltage is to vary both the amplitude and phase of the FM signal. The amplitude variations thus produced have no effect on the performance of the system since they will have been removed by a limiter circuit in the radio receiver. The phase deviation of the signal ,however means that the carrier is effectively frequency modulated by the noise, and a noise voltage will appear at the output of the radio receiver .

The magnitude of the output noise voltage is directly proportional to frequency and gives rise to the triangular noise spectrum .The output noise voltage rise linearly from frequency until, theoretically ,at a frequency equal to the rated system deviation ,its equal to the noise output voltage from an AM system subject to the same noise /interfering voltage [4], for many systems not all of the noise is able to pass through the audio stage of the receiver since the frequency deviation is larger than the audio pass band .

2.10 PRE- EMPHASIS

Most waveforms transmitted by communication system contains a large number of components at different frequencies .Usually the higher – frequency components are of smaller amplitude than the components at lower frequency . For example ; the frequencies contained in a speech waveform mainly occupy the band 100-10000 Hz but most of the power is contained at frequencies in the range of 500 Hz for men and 800 Hz for women. Since the noise appearing at the output of a frequency-modulated system increases linearly with increase in frequency ,the signal to noise ratio falls at high frequencies .

For a multichannel system this means that the signal to noise ratio will be worse in the highest frequency channel . To improve the signal to noise ratio at the higher frequencies , pre-emphasis of the modulating signal is applied at the transmitter.[4]

The modulating signal is passed through a pre-emphasis network which accentuates the amplitudes of the high frequency components of the signal relative to the low frequency components , before it is applied to the ratio transmitter . During its transmission from transmitter to receiver , noise and interference will be superimposed upon the signal so that the output of the radio receiver will exhibit the triangular noise spectrum .

In telecommunication, Emphasis is a system process designed to decrease, (within a band of frequencies), the magnitude of some (usually higher) frequencies with respect to the magnitude of other (usually lower) frequencies in order to improve the overall signal-to-noise ratio by minimizing the adverse effects of such phenomena as attenuation differences or saturation of recording media in subsequent parts of the system.

For example :

FM broadcasting in the US, the standard pre-emphasis / de-emphasis is "75 microseconds." This means that the RC network has a time constant of 75 microseconds. To convert this to a 3 dB corner frequency, take the reciprocal:

$\omega=1/75\times10^{-6}$ = 13.33 radians/sec, or 2.1 KHz.

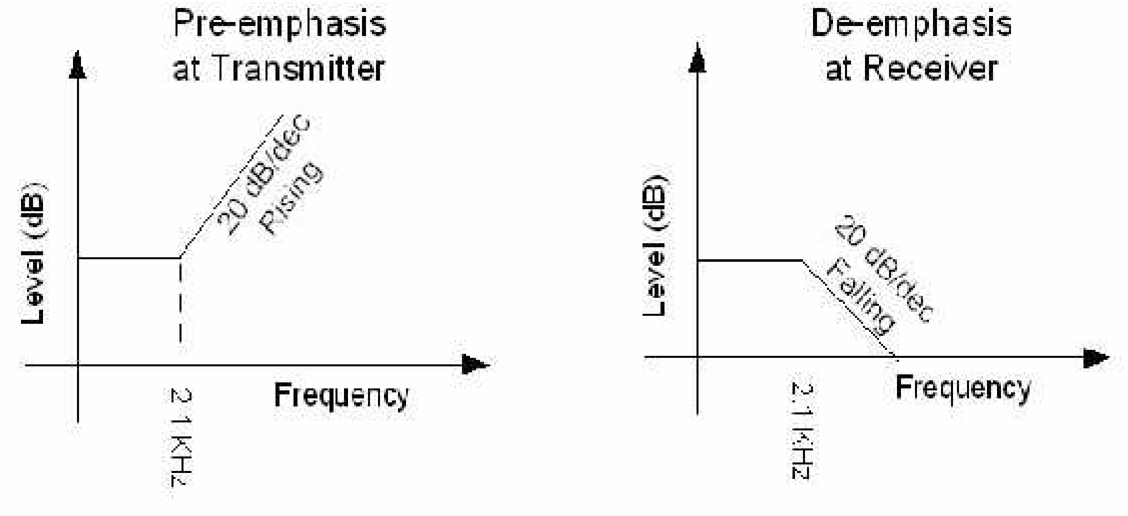

Figure 2.10 : pre-emphasis and de-emphasis

The image above shows the concept below the 2.1 KHz. Both the transmitter and receiver are flat. Above that, the pre-emphasis at the transmitter is exactly offset by the de-emphasis at the receiver , so the net is a flat frequency response , measured from transmitter input to receiver output . [14]

2.11 coil (inductor)

Inductance (L) results from the magnetic field forming around a current-carrying conductor which tends to resist changes in the current. Electric current through the conductor creates a magnetic flux proportional to the current. A change in this current creates a corresponding change in magnetic flux which, in turn, by Faraday's Law generates an electromotive force (EMF) that opposes this change in current. Inductance is a measure of the amount of EMF generated per unit change in current. For example, an inductor with an inductance of 1 Henry produces an EMF of 1 volt when the current through the inductor changes at the rate of 1 ampere per second. The number of loops, the size of each loop, and the material it is wrapped around all affect the inductance. For example, the magnetic flux linking these turns can be increased by coiling the conductor around a material with a high permeability such as iron. This can increase the inductance by 2000 times.[15]

The formula for an inductor:

$$L = n^2 \frac{4r^2}{36r + 1.6\,l} \qquad OR \qquad n = \frac{\overline{L(36r + 1.61)}}{4r^2}$$

Where: L is the inductance in μH.
r is the radius of coil in inches.
l is the length of coil in millimeters (mm).
n is the number of turns on coil.

Using the above values, the inductance of L can be calculated. A diameter of 5.5mm = 0.22 inches, the radius is half this value or 0.11 inch, the length is 4.5mm and number of turns, n = 6.

So $$L = 6^2 \frac{4(0.11)^2}{36\ 0.11\ + 1.6\ 4.5} = 0.156\ \mu H$$

CHAPTER

3

Project conceptual design

Chapter three

Project Conceptual Design

3.1 Introduction

Data transfer process requires two main parts, the transmitter and the receiver, the transmitters main function is to transmit the data as a signal and the receiver receives it.

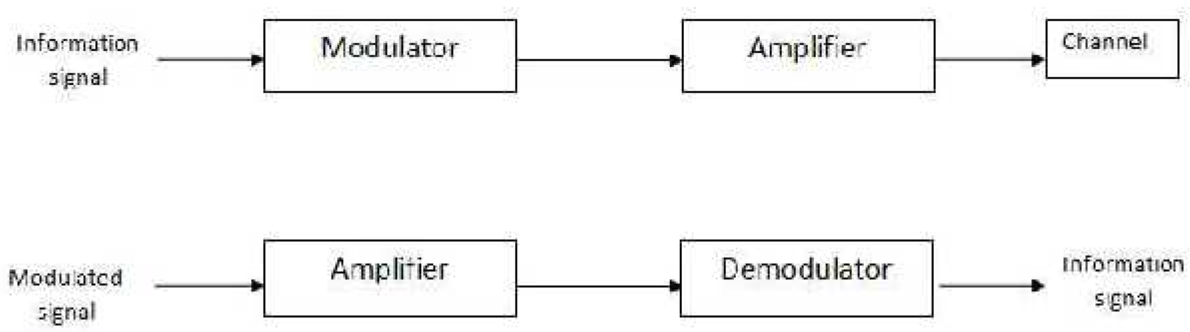

Figure 3.1 : transmitter and receiver system

Signals coming from different information sources cannot be transmitted through any given transmission medium so the source modifies the signal in a way make it possible to transmit that signal through the channel (transmission medium) used in the system. This particular part is called the modulator which varies one or more of the properties of high frequency waveform called the carrier signal with a modulating signal which typically contains information to be transmitted among a lot of advantages, modulation process helps to avoid interference between different signals .

The amplifier is a very important part of the transmitter ,which is an electronic device that increases the voltage, current, power of a signal which protects the signal from being completely attenuated and make it strong enough to reach the receiver . And after the amplifier there is the transmission medium.

In the same manner we have an amplifier at the receivers side which is used to amplify the signal after getting so weak as a result of interference with other signals and noise that adds to the signal as it travels through the channel after that the signal goes to the demodulator which operates in an opposite manner to the modulation where the signal is extracted from the high frequency carrier and get the original information bearing signal from the modulated carrier wave .

This project is specialized in the transmission part and uses frequency modulation Which conveys information by varying its instantaneous frequency.

3.2 How to built Frequency Modulated Transmitter

In frequency modulation (FM) the modulating signal combines with the carrier to cause the frequency of the resultant wave to vary with the instantaneous amplitude of the modulating signal .
Figure 3-2 shows you the block diagram of a frequency-modulated transmitter.

The modulating signal applied to a variable capacitor causes the reactance to vary. The variable capacitor is connected across the tank circuit of the oscillator, with no modulation, the oscillator generates a steady center frequency. With modulation applied, the variable capacitor causes the frequency of the oscillator to vary around the center frequency in accordance with the modulating signal.[16]

The oscillator output is then fed to a frequency multiplier to increase the frequency and then to a power amplifier to increase the amplitude to the desired level for transmission.

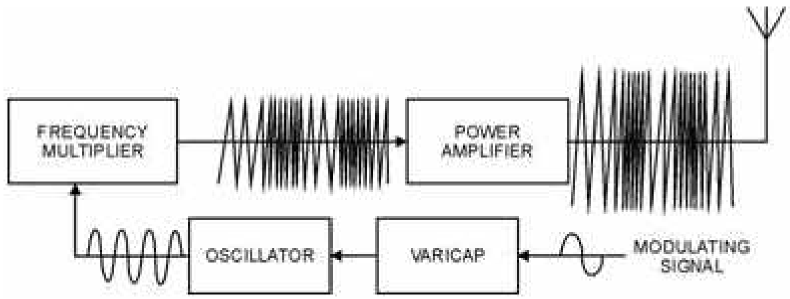

Figure 3.2 : FM transmitter block diagram.

3.3 How the system work

The design of the general transmitter can be broken up into four major components: microcontroller, LCD module, audio modulating/transmitting circuitry, and power supply. Additional smaller components include: antenna, pushbuttons.

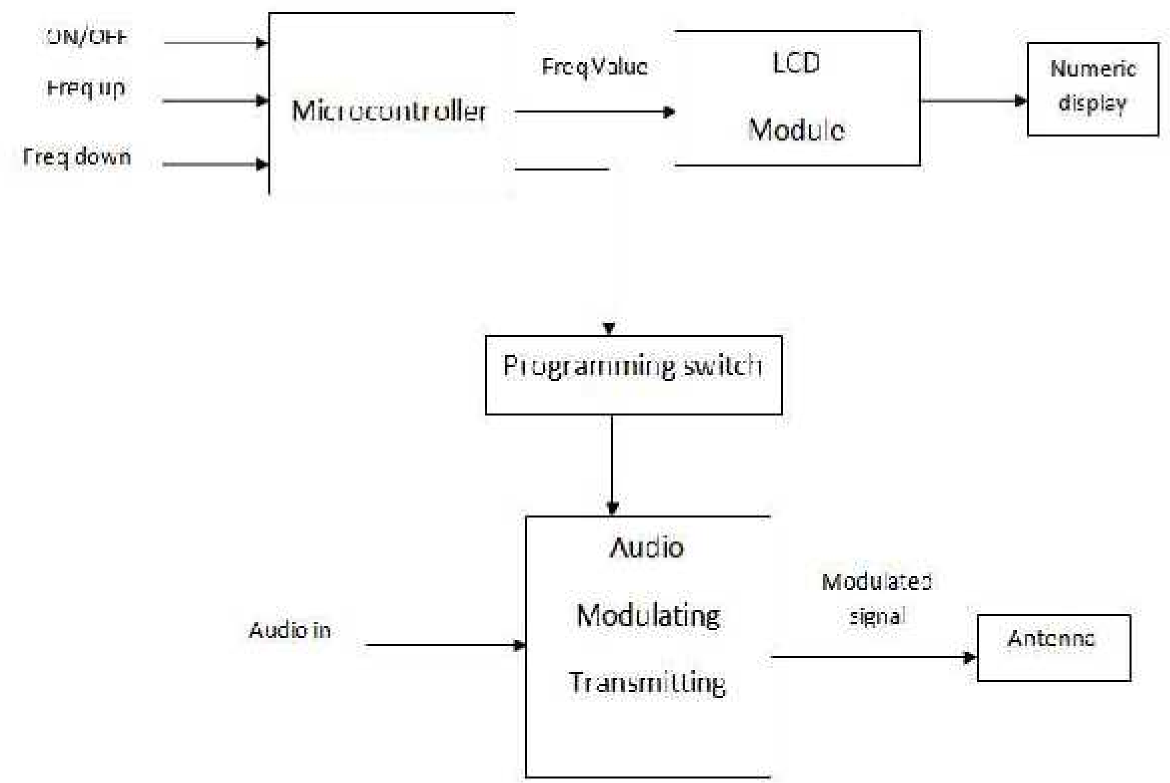

Figure 3.3 : Transmitter system

This part will explain the transmission process and what is the function of each part.

At first voice signal will be inhered in the modulator and the modulator will modulate this signal using the carrier frequency supplied by the microcontroller , the microcontroller uses three user inputs consisting of frequency up, frequency down , and ON/OFF for power, to control the processes of the transmitter. It outputs the transmission frequency to the LCD module and the audio modulating/transmitting , the carrier frequency is obtained depending on the programmable controller .Since the range of FM is (87-108) MHz and to send at different frequency we need to increase/decrease the frequency of transmitter . The pushbutton(frequency up)is used to increase the transmitted frequency by 0.2MHz, and also by pushing (frequency dawn)the carrier frequency will decrease by 0.2MHz. If (frequency dawn) is pushed twice the carrier frequency will decrease by 0.4 MHz and so on . After the frequency have been chosen the microcontroller is connected to the LCD module , The LCD module interface to write characters to the screen.

The audio modulating/transmitting interfaces with the microcontroller using programming switches to control the modulation frequency. The circuitry inside the integrated circuit multiplexes the audio input signals with a pilot signal, frequency modulates the composite signal, and outputs a signal ready for transmission through an antenna.

3.3.1 MICROCONTROLER WORK

Microcontroller is the heart of the project, since it gives order to other part to work. It controls the LCD module and the audio modulating unit depending on user input. If the switch up is on the microcontroller will send order to audio modulator in order to increase the frequency by 0.2MHz and send to LCD to display the transmitted frequency ,and if the switch down is pressed microcontroller send to audio modulator in order to increase the frequency by 0.2MHz and send to LCD to display the new frequency .

This flow chart describes the job of microcontroller in this project.

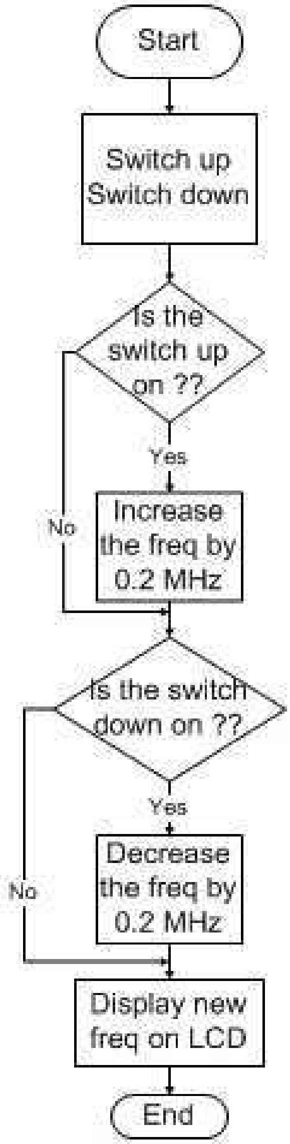

Figure 3.4 : Microcontroller work

3.3.2 Audio Modulating / Transmitting circuit

In the sound broadcast system , the baseband signal for an FM stereophonic is composed of two audio streams (left and right channels), from any source an MP3 decoder, electrets microphone, these two streams are band limited to bandwidth form 30 Hz to 15 KHz then they are pre emphasized to increase the signal –to –noise ratio ,then it will be encoded.

Stereo multiplexing is a form of frequency-division multiplexing designed to transmit two Separate signals via the same carrier. It is widely used in FM radio broadcasting to send two different elements of a program ,so as to give a spatial dimension to its perception by a listener at the receiving end.[5]

The specification of standards for FM stereo transmission is influenced by two factors:

1. The transmission has to operate within the allocated FM broadcast channel
2. It has to be compatible with monophonic radio receivers.

Figure 3.5 shows the block diagram of the multiplexing system used in an FM stereo transmitter .

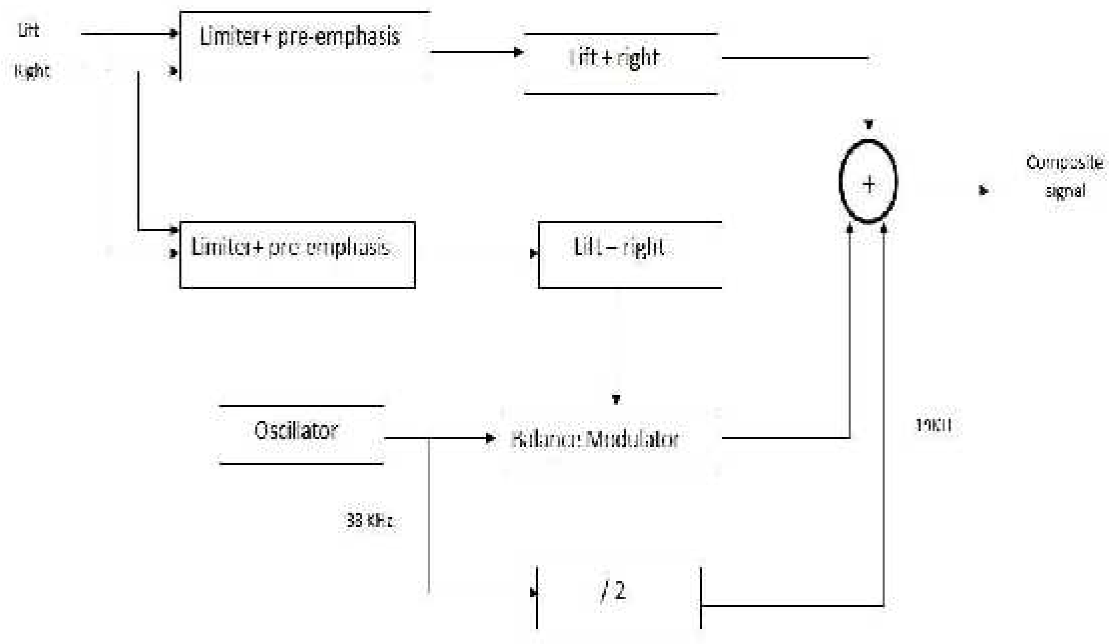

Figure 3.5 stereo encoder

The left channel (L) and right channel (R) are fed into a summing and differential amplifier to get an L+R and L-R signal respectively. The reason L+R and L-R signals are encoded rather than L and R is that a mono receiver can just demodulate the L+R signal and ignore the rest of the signal. The channel difference signal is then combined with a 38 kHz carrier in a balanced modulator to form a double sideband signal centered at 38 kHz. Back in the receiver, once the Stereo Decoder has extracted the L+R and L–R signals the original left and right signals are easily obtained by (L+R) + (L–R) = 2L and (L+R) – (L–R) = 2R. The third signal, a pilot carrier at 19 kHz, exactly half the frequency of the carrier used to regenerate the missing 38 kHz carrier in the receiver and this 38 kHz carrier is used to demodulate the double sideband signal.

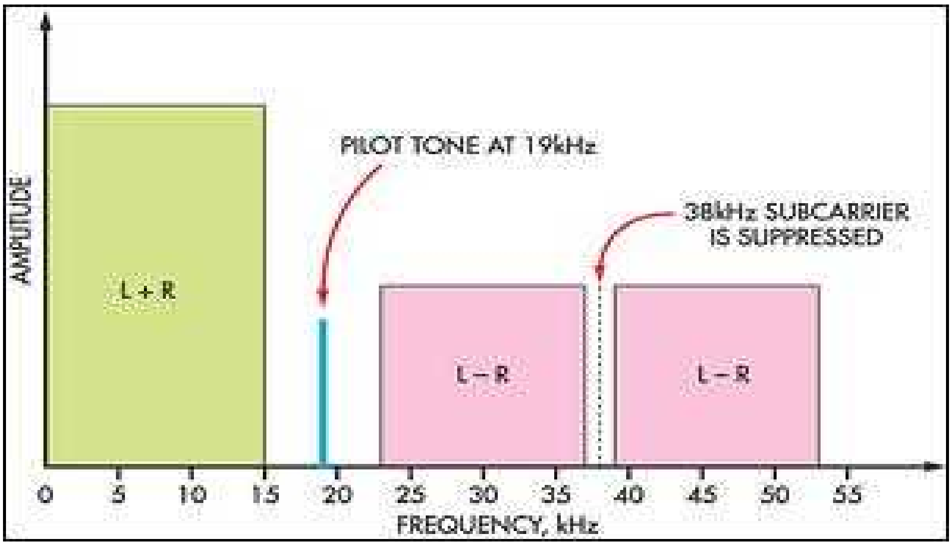

Figure 3. 6 : Spectrum allocation for stereophonic sound

The three signal will add to produce composite signal ,which is the information to be modulated. The three separate signals are not intended to affect each other. Careful filtering can minimize undesirable interactions, most of which would be some kind of beat between the 19 kHz pilot signal and the Left and Right channels and their products .

The frequency is generated using an oscillator then it passes through a divider to produce a reference frequency for the phase comparator which campers it with the modulated signal .

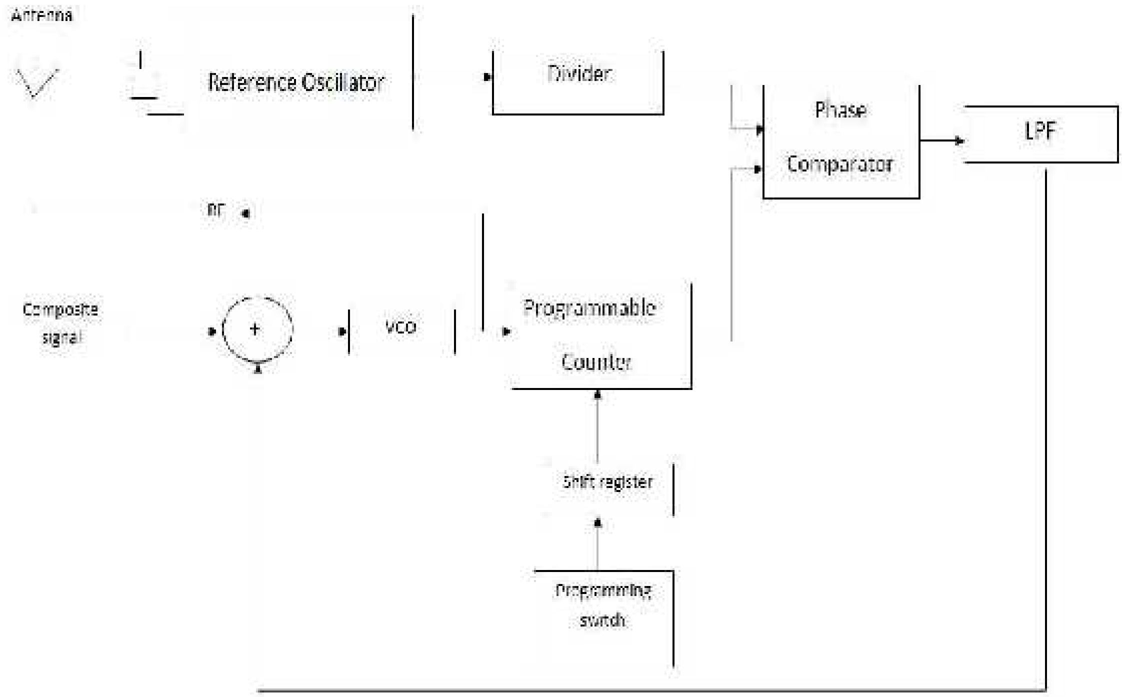

Figure 3.7: Phase locked loop controlled oscillator

The composite signal pass through VCO which produces a frequency depending on its input voltage ,then it will pass to program counter ,which is actually a programmable divider which outputs a divided down value of the RF signal. The signal is then applied to the phase detector which campers the program counter output with the reference value , if there is an error it feedback to change the value of VCO and to correct the frequency .Then the modulated signal will be amplified and sent via an antenna .

3.4 RF Amplifiers

The amplifier is used to increase the power output transmitter, Here we are talking about Radio Frequency (RF) amplifiers`, not audio amplifiers. RF amplifiers have certain important characteristics:

- Bandwidth (Commercial FM Frequency range of 88-108 MHz).
- Gain and Maximum Output Power .
- Input and Output Impedance (input impedance should be matched to driving section of transmitter to amplifier, output impedance typically matched to antenna input impedance 50 ohm).

CHAPTER

4

Detailed technical project design

4.1 Overview

4.2 subsystem detailed design

4.3 Overall System Design

4.4 LCD interfacing with PIC microcontroller

Chapter four

Detailed Technical Project Design

4.1 Overview

This chapter describes the detailed subsystems , like wireless audio IC (BH1417) , power supply , amplifier .

4.2 subsystem detailed design

This section contains detailed description of the subsystems.

4.2.1 Wireless Audio Link IC (BH1417)

The BH1417 is an FM stereo transmitter that includes a lot of features in one small package. It comes with pre-emphasis, limiter so that the music can be transmitted at the multi-audio level, stereo encoder for stereo transmission, low pass filter that blocks any audio signals above 15KHz to prevent any RF interference, PLL circuit that provides rock solid frequency transmission (no more frequency drift), FM oscillator and RF output buffer.

The BH1417 have 22 pins each with a special connection :

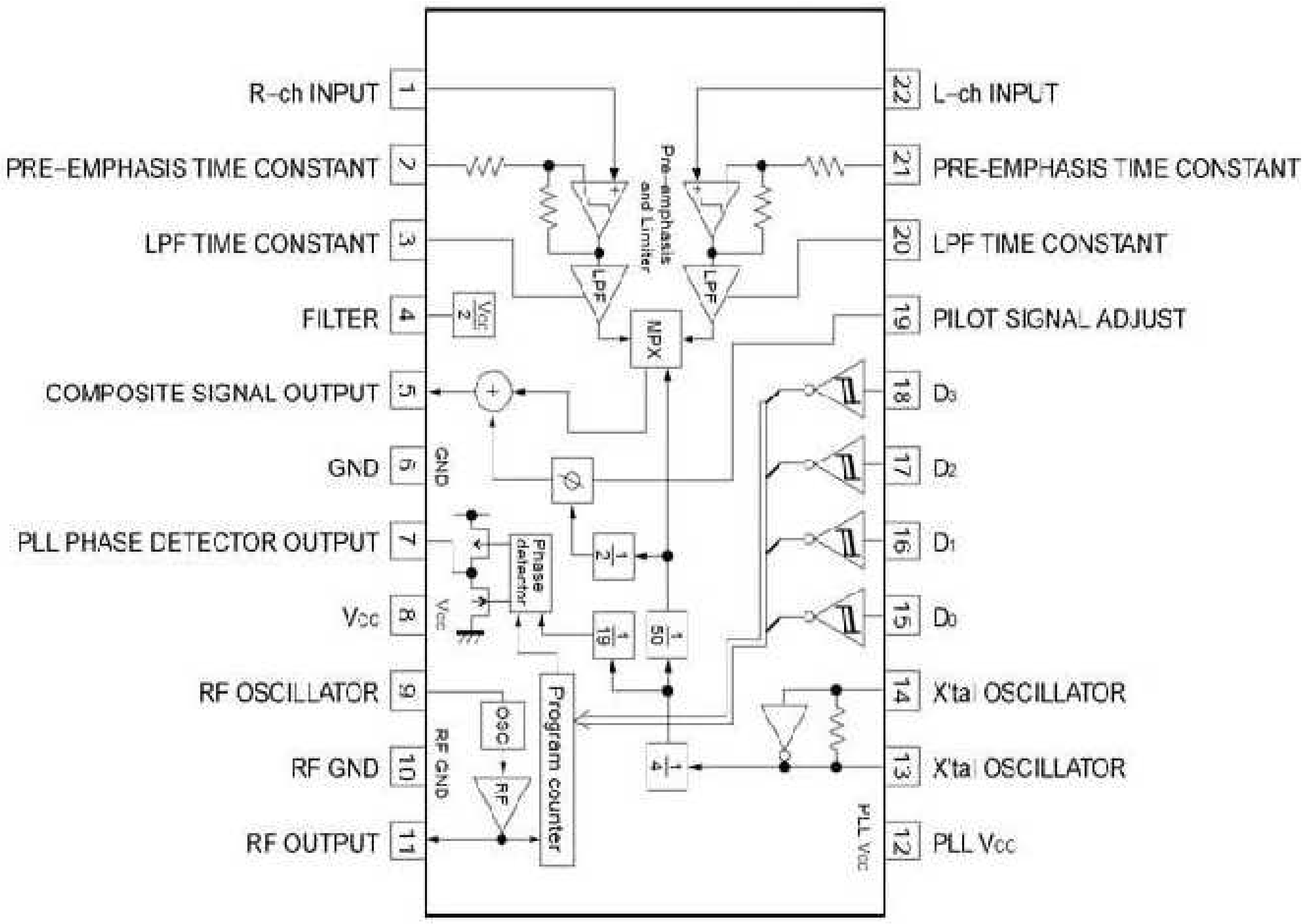

Figure 4.1 BH1417

As shown in Figure 4.1, the BH1417 includes two separate audio processing units, for the left and right channels . The left channel audio signal is applied to pin 22 of the chip , while the right channel signal is applied to pin 1 . The left and right audio input signals are fed via c3, c5(1µF) capacitors which are included to prevent DC current flow due to any DC offsets at the signal source output and then applied to attenuator circuits consisting of R3,R4 (10kΩ) fixed resistors and 10kΩ trimpots (R1 & R2), the signals are coupled into pins 1 and 22 via 1µF bipolar capacitors (c1,c4).

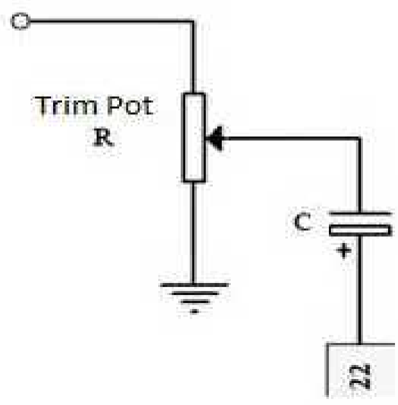

Figure 4.2 : Circuit Limiter

For coupling $C_{1,4} = \frac{1}{2\pi f Zin}$

$$C_{1,4} = \frac{1}{2\pi * 3000 * 50\Omega} = 1\ \mu F$$

These two channels are then applied to a pre-emphasis circuit which are designed to increase the magnitude of some frequencies with respect to the others within a frequency band .This stage helps to overcome the noisy medium of the FM radio and the loud noise of the high frequencies by improving the signal to noise ratio of the received signal, it works by using an expletive de-emphasis in the receiver to attenuate the boosted high frequencies after demodulation; so that ,the frequency response is set by the value of the capacitors connected to pins 2 and 21 . The value of the time constant is specified by the relation :

Time constant = 22.7$K\Omega$ X capacitance value .

$$50\mu s = 22.7K\Omega\ \ X\ C_{11,2}$$

$$\rightarrow C_{11,2} = 2.2\ nF$$

Within the pre-emphasis section there is the limiting circuit which attenuates signals above a certain threshold to avoid overloading the following stages. That's in turn prevents over-modulation and reduces distortion.

After pre-emphasis stage the signals from both the left and right channels are processed through two low pass filters (LPF), these filters are required to roll off the response above 15 KHz and this is important to make sure that the bandwidth of the FM signal is restricted to the commercial broadcast FM transmitters . The time constant of the low pass filters are supplied on pins 3 and 20.

$$f_c = \frac{1}{2\pi\tau}$$

For $f_c = 15\ KHz\ \rightarrow\ \tau = 1.0610 * 10^{-5} s$

$$\tau = RC$$

For R= 70.7 $K\Omega$, $\tau = 1.0610 * 10^{-5}s \rightarrow C_{7,12} = 150\,pF$

The outputs from the right and left LPFs are in turn applied to a multiplex box (MPX), this stage is use to produce the sum and difference signals of the left and right signals which are then modulated onto a 38 KHz carrier, then the carrier is removed to produce the double- sideband suppressed carrier signal. It is then mixed in a summing (+) block with a 19kHz pilot tone which is supplied on pin 19 with phase and level set by a capacitor on that pin to give a composite signal output (with full stereo encoding) at pin 5.

The 38kHz multiplex signal and 19kHz pilot tone are derived by dividing down the 7.6MHz crystal oscillator located at pins 13 & 14. The frequency is first divided by four to obtain 1.9MHz and then divided by 50 to obtain 38 kHz. This is then divided by two to derive the 19kHz pilot tone.

$$7.6MHz * \frac{1}{4} * \frac{1}{50} = 38KHz$$

$$7.6MHz * \frac{1}{4} * \frac{1}{50} * \frac{1}{2} = 19KHz$$

In addition, the 1.9 MHz is divided down by 19 to produce a 100 KHz signal, which is then applied to the phase detector which also monitors the program counter output. This program counter is actually a programmable divider which outputs a divided down value of the RF signal. The dividing ratio of this divider is specified by a certain code that reaches from the Microcontroller by that’s the controller specifies the carrier frequency used in the modulation. The division ratio of this counter is set by the voltage levels at pins 15, 16 , 17 , 18 (D0-D3) . Table 1 shows how the voltage level is set to select one of 14 different transmission frequencies.

For example, when D0-D3 are all low, the programmable counter divides by 877. Thus, if the RF oscillator is running at 87.7MHz, the divided output from the counter will be 100kHz and this matches the frequency divided down from the 7.6MHz crystal oscillator .

Table 4.1 : Frequency selection

Control Data				Frequency in MHz
Pin 15	Pin 16	Pin 17	Pin 18	
0	0	0	0	87.7
1	0	0	0	87.9
0	1	0	0	88.1
1	1	0	0	88.3
0	0	1	0	88.5
1	0	1	0	88.7
0	1	1	0	88.9
1	1	1	0	Uncontrolled
0	0	0	1	106.7
1	0	0	1	106.9
0	1	0	1	107.1
1	1	0	1	107.3
0	0	1	1	107.5
1	0	1	1	107.7
0	1	1	1	107.9
1	1	1	1	Uncontrolled

4.2.2 RF OCILLATOR

The RF oscillator output is at pin 9. This is a Coliptts oscillator and is tuned using inductor L2.

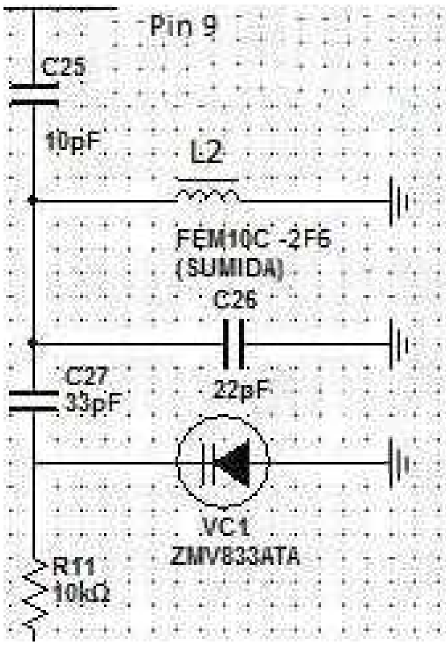

Figure 4.3 : Voltage controlled oscillator

There is the 33pF (C27) fixed capacitor which performs two functions. First, it blocks the DC voltage applied to Variable capacitor diode (VC1), to prevent current from flowing into L2. And second, because it is in series with VC1, it reduces the effect of changes in the variable capacitor by pin 9. The 10pF (C25) capacitor prevents DC current flow into L2 from pin 9.

4.2.3 Frequency modulation

Of course, in order to transmit audio information, we need to frequency modulate the RF oscillator. We do that by modulating the voltage applied to the varicap diode using the composite signal output at pin 5.

The composite output signal is fed via a 10µF(C16) capacitor to trimpot R7.This trimpot sets the modulation depth. From there, the attenuated signal is fed via another 10µF (C17) capacitor and two 10kΩ (R8, R11) resistors to variable capacitor diode(VC1).

The phase lock loop control (PLL) output at pin 7 is used to control the carrier frequency. This output drives high-gain Darlington transistor Q1 and this, in turn, applies a control voltage to VC1 via two 3.3kΩ (R6, R9) series resistors and the 10kΩ (R11) isolating resistor. The 2.2nF (C19) capacitor at the junction of the two 3.3kΩ(R6,R9) resistors provides high-frequency filtering.

4.2.4 Power Supply

The system has components that need 12 V power supply such as amplifier and other components that need 5 V power supply such as the microcontroller and BH1417 , so the circuit that show in the figure below was designed to feed the system with the desired power by using 12 Volt and LM78L05 voltage regulator.

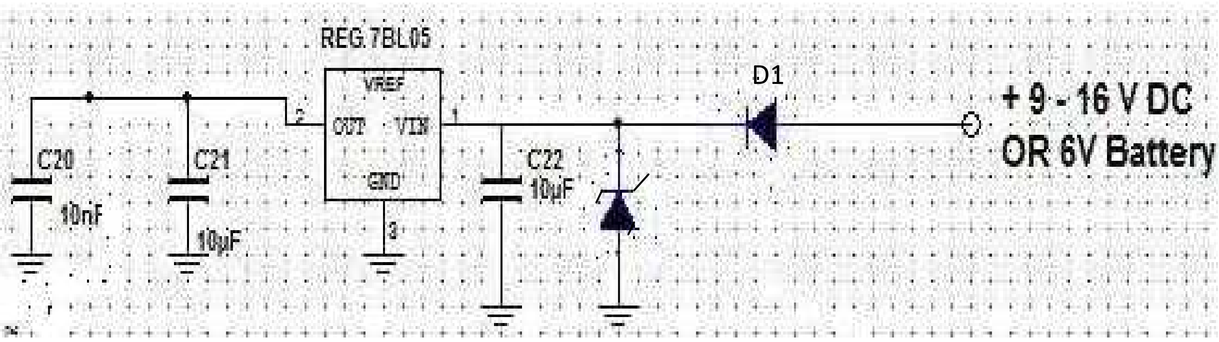

Figure 4.4 : Power Supply

The diode D1 allows current to go in one direction when the polarity of the voltage corresponds to the direction of the forward bias of the diode, and doesn't allow (cuts off) the current in the opposite direction when the polarity of voltage corresponds to the direction of the reverse bias of the diode. So it is provides reverse polarity protection.

A Smoothing Capacitor is used to generate ripple free DC,and ZD1 protects the circuit against high-voltage transients, while regulator REG78l05 provides a steady +5V rail to power the circuit.

4.2.5 Power Amplifier

The modulated RF output appears at pin 11 of the BH1417 and is fed to an RF power amplifier that converts the low-power radio-frequency signal at the output of the circuit into a larger signal of significant power this power amplifier is called MAR-1+ Darlington amplifier which is a wideband amplifier offering high dynamic range and has a repeatable performance and high gain of, 17.8 dB type at 0.1 GHz, its internally matched to 50 Ohms and low noise figure.

The figure 4.7 illustrates the design of Darlington amplifier, the resistor R5 set the bias current, where : Vd ~(VCC-R5*ICC)

The value of C10,C14 determines the low frequency cut off of the amplifier circuit. The Capacitors value is chosen to suit the frequency that the amplifier
circuit is going to be used for, and L1 is used to isolate the resistor R5 so that it does not appear in parallel with the output load of the amplifier, degrading the output match of the amplifier. Capacitor C15 should be used in conjunction with the L1 to present a low impedance path to ground for any signal that manages to get past the L1.

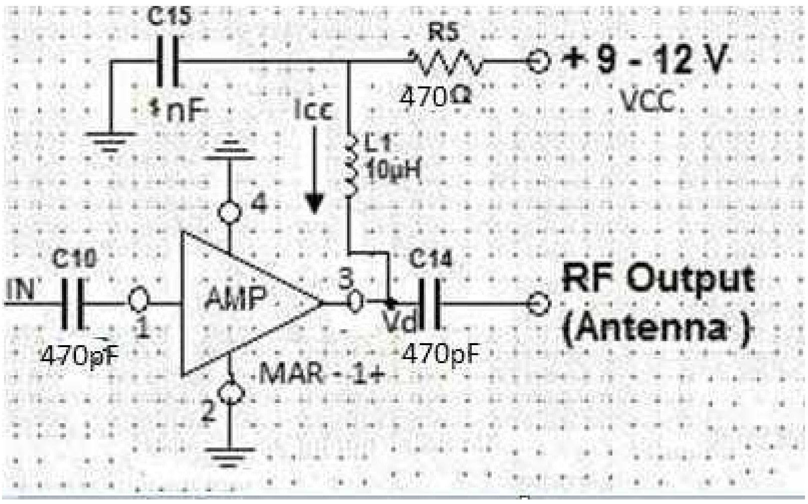

Figure 4.5 : Power Amplifier

4.3 Overall System Design

The system design is shown in the following figure :

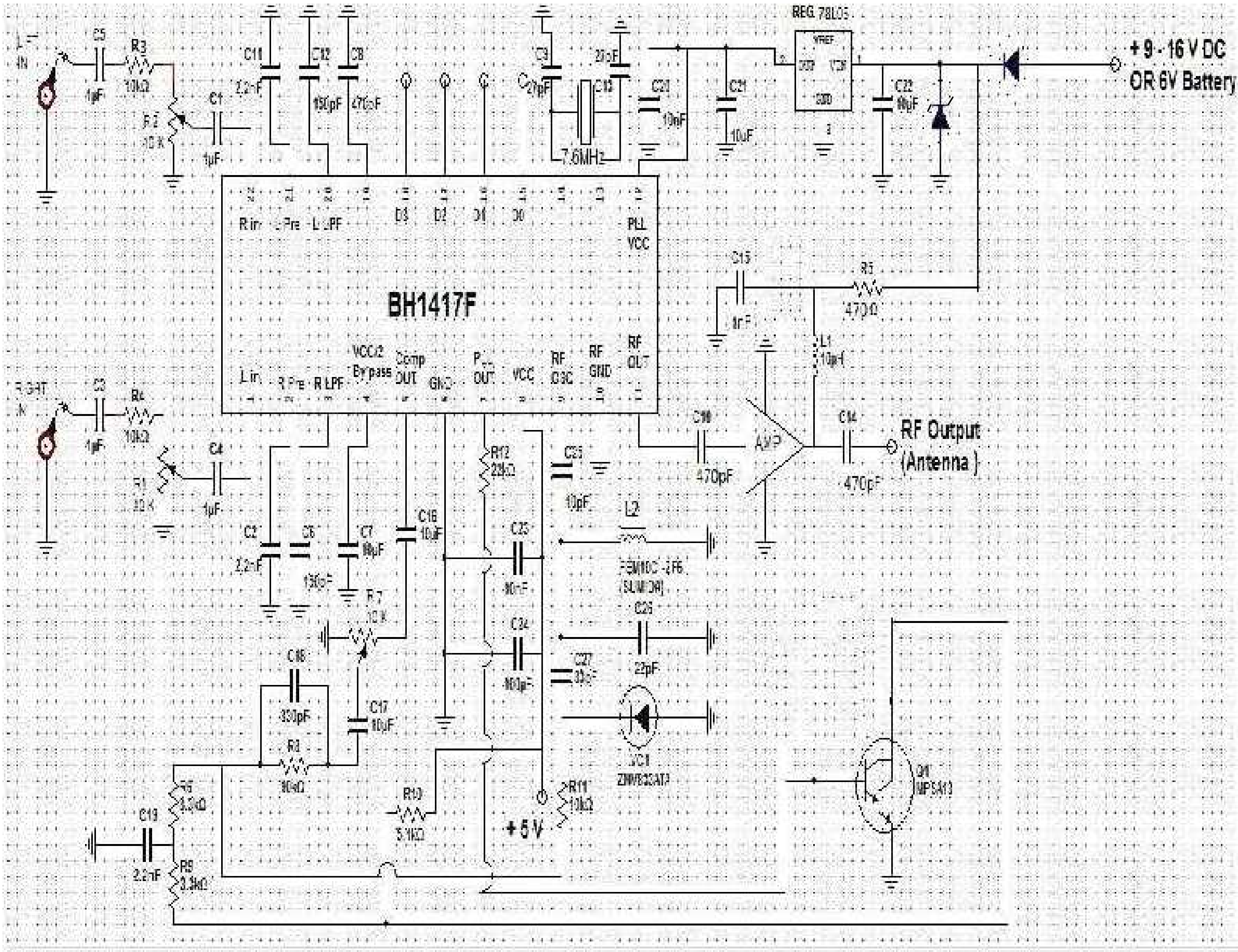

Figure 4.6 : Overall System Design

4.4 LCD interfacing with PIC microcontroller

The LCD display was chosen to meet our visual requirement of displaying the active frequency .It has two lines with sixteen characters for each .The size of viewing area 62x16mm.

The LCD operate an 5 volt power supply and the input line to LCD are directly connected to the PIC and controlled as this manner.

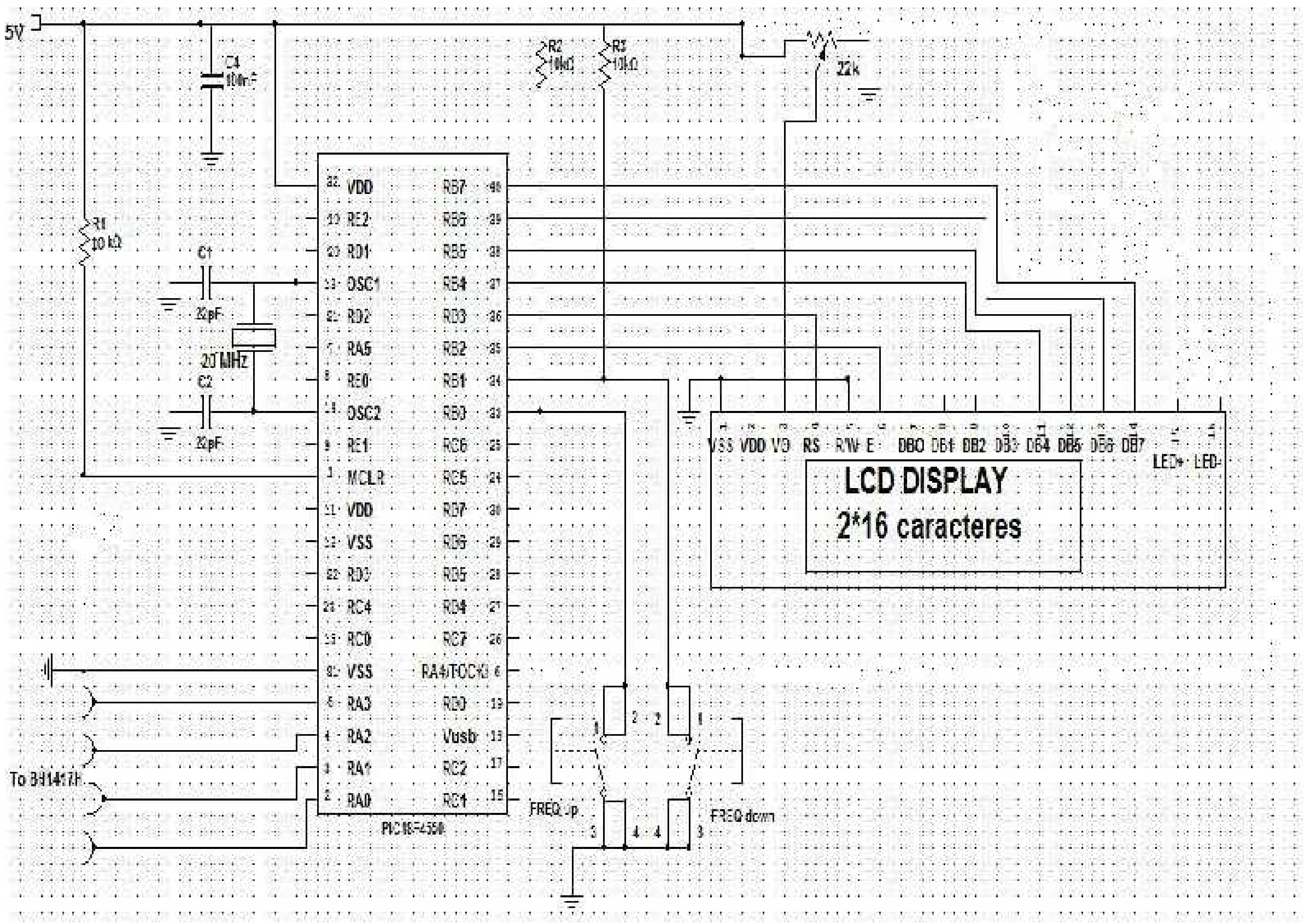

Figure 4.7: LCD interfacing with Microcontroller

CHAPTER

5

Implementation and Testing

Chapter Five

Implementation and Testing

5.1 Overview

In this chapter the construction and testing for the system would be shown ,the construction and testing processes are very important to insure that the system work successfully .After collecting all the necessary information related to the project and analyze them , the group starts to build the system using all the ICs that depicted the design chapter and after each part of the system the group tested them to get the wanted result , and when the whole system has been finished a complete testing process had been done over the whole system .

5.2 Construction :

At the beginning all the required components to build the project are provided ,then the whole project is divided into two main parts , hardware and software, in the hardware part, we built the circuit and we soldered the electronic components onto the board , with taking polarity of capacitors an diodes and zener diodes into consideration ,while the software part is all about programming the

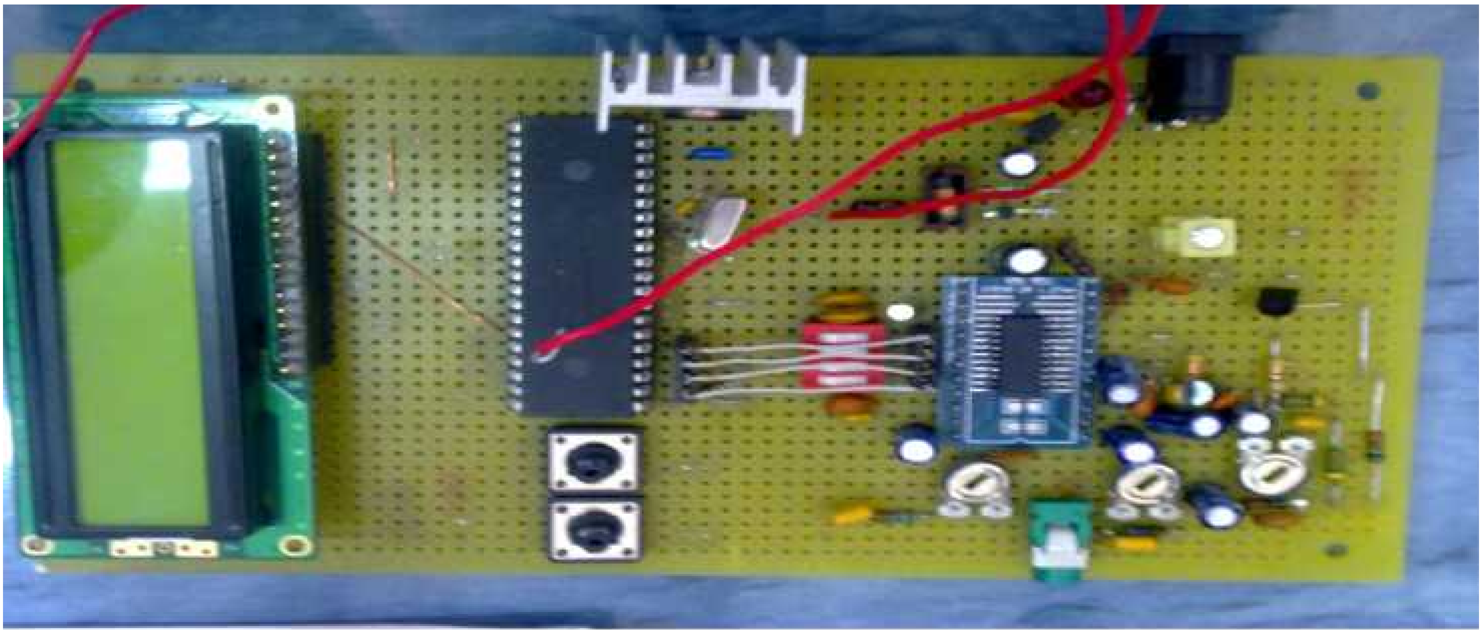

Figure 5.1 Overall project

microcontroller with the right code that guarantees the required performance of the microcontroller.

5.3 Testing

First of all ,we need the tuner (L2)so that the RF oscillator operates over the correct range. It done by these steps :

1. We select the transmission frequency so that its not occupied by a higher power station in the campus with taking into consideration that this frequency is within the FM commercial band in order to avoid interference with that stronger signal.

2. We adjust the value of the coil (L2) in order to tune the oscillator to the selected frequency ,no further adjustments to L2 should be required if you subsequently switch to another frequency within the selected band. However, if change to a frequency that's in another other band, L2 will have to be readjusted .

Figure 5.2 : Coil (Variable inductor)

To adjust the trimpots (R1,R2) to achieve better sound quality from the tuner , we have temporarily disconnect the signal source to make each adjustment. There should be sufficient signal to eliminate any background noise but without any noticeable distortion. The R1 and R2 must each be set to the same position, to maintain the left and right channel balance.

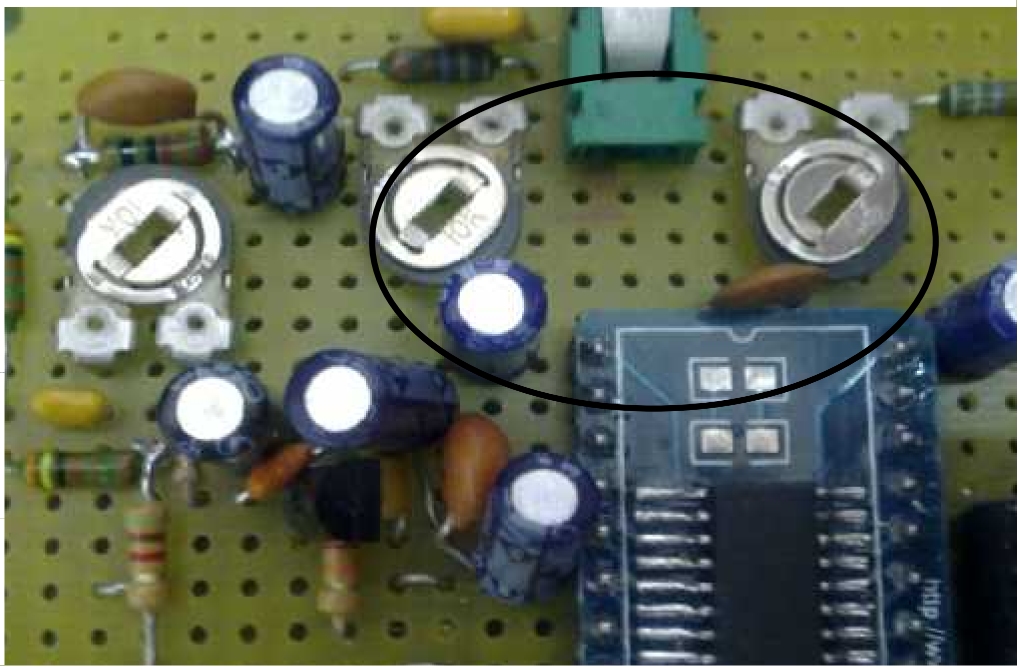

Figure 5.3 Trimpots

- **Output frequency from the spectrum analyzer :**

- frequency: 88.5 MHz
- power:- 13.8dBm

Figure 5.4 Spectrum of the Transmitted frequency

- frequency: 87.9 MHz
- Power: -22.2dB

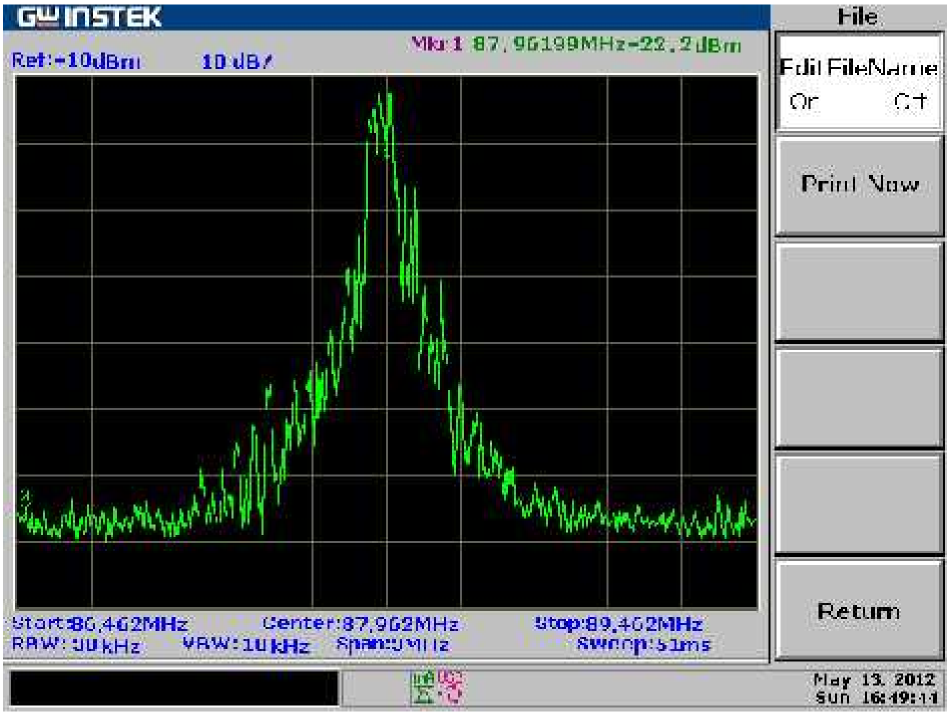

Figure 5.5 Spectrum of the Transmitted frequency

By looking at the two frequency analyzer pictures we noticed that second picture , the one with the higher frequency suffers higher interference as a result of having a higher power station broadcasting at the same frequency in this particular area. For that reason the first try broadcasting at 88.5 frequency is regarded better than the second one.

As a last step of the testing process we performed an outdoor testing, the transmitter is fixed seven floors off the ground in the B+ building , and we started broadcasting the signal on different frequencies and made sure that the signal can be received all the way to building A with a distance of almost 350 meters.

CHAPTER

6

Conclusion and Future suggestion

Chapter Six

Conclusion and Future suggestion

6.1 Overview :

After building the circuits of the system, as was shown in chapter Five. We came to cretin conclusions.

6.2 Conclusions:

Many experiences were added to the team cognitive knowledge through this project.It became more obvious how real work and application in the real life can be complicated and way harder than simulation in addition, it can suffer a lot of effects and have a lot of problems and how its away from ideal situations that we are used to picture, also we became more familiar with the way to provide the required components which was not easy at all , besides as we are using already occupied broadcasting frequencies from another high power stations we suffered from high interference which also differs from one area to another depending at the coverage area of those stations not to mention high noise which affects the broadcasted signal so badly .

6.3 Future considerations and suggestions:

As the transmitter is working properly and exactly as it was planned for , its time to get it into operation, after specifying the audience of interest and making them familiar with it ,also make it an acceptable tool and consider it as away to contact them.

In addition to expand the range of our coverage so to include other collages of the university ,looking forward to include the collage of administrative science and fawze kaawash center of excellence in Abu Romman which means broadcasting on a higher power to a chive higher range of coverage , besides it would be more elegant to be able to broadcast a cretin message (a name for the station for example) which indicates that it’s the signal of university's station.

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[17]: BH1417 datasheet.

Appendix

A

```
// LCD module connections
// LCD module connections
sbit LCD_RS at RB3_bit;
sbit LCD_EN at RB2_bit;
sbit LCD_D4 at RB4_bit;
sbit LCD_D5 at RB5_bit;
sbit LCD_D6 at RB6_bit;
sbit LCD_D7 at RB7_bit;
sbit LCD_RS_Direction at TRISB3_bit;
sbit LCD_EN_Direction at TRISB2_bit;
sbit LCD_D4_Direction at TRISB4_bit;
sbit LCD_D5_Direction at TRISB5_bit;
sbit LCD_D6_Direction at TRISB6_bit;
sbit LCD_D7_Direction at TRISB7_bit;
// End LCD module connections
unsigned int   dw ;
unsigned int   up ;
unsigned int   frq ;
unsigned int   q ;

void scan ()
{
q=100;
while(q>1)
q-- ;
delay_ms(2);
up   =portb.f0;
dw        =portb.f1;
{
if(up==0){frq ++};
if(dw==0){frq --};
{
void main(){                              //  main function
TRISD = 0Xf0;                            // port D is output
PORTD = 0x00;                           // port D = 0
TRISA = 0x00 ;
TRISB0_bit=1 ;
TRISB1_bit=1;                          // port A is input
ADCON1= 0x0f;                        //ADC config all porta
aer digital
Lcd_Init();                          // Initialize LCD
Lcd_Cmd(_LCD_CURSOR_OFF);             // Cursor off
Lcd_Cmd(_LCD_RETURN_HOME );           // LCD return home
Lcd_Out_cp("FM station”;
delay_ms(500);

while(1){
Scan();
if(frq==0){lcd_out(2,1,"0000    87.7 Mhz");porta=0b0000};
if(frq==1){lcd_out(2,1,"1000    87.9 Mhz");porta=0b1000};
if(frq==2){lcd_out(2,1,"0100    88.1 Mhz");porta=0b0010};
if(frq==3){lcd_out(2,1,"1100    88.3 Mhz");porta=0b1100};
if(frq==4){lcd_out(2,1,"0010    88.5 Mhz");porta=0b0010};
if(frq==5){lcd_out(2,1,"1010    88.7 Mhz");porta=0b1010};
if(frq==6){lcd_out(2,1,"0110    88.9 Mhz");porta=0b0110};
if(frq==7){lcd_out(2,1,"0001   106.7 Mhz");porta=0b0001};
```

```
if(frq==8){lcd_out(2,1,"1001   106.9 Mhz");porta=0b1001};
if(frq==9){lcd_out(2,1,"0101   107.1 Mhz");porta=0b0101};
if(frq==10){lcd_out(2,1,"1101   107.3 Mhz");porta=0b1101};
if(frq==11){lcd_out(2,1,"0011   107.5 Mhz");porta=0b0011};
if(frq==12){lcd_out(2,1,"1011   107.7 Mhz");porta=0b1011};
if(frq==13){lcd_out(2,1,"0111   107.9 Mhz");porta=0b0111};
if(frq>14){frq=0};
}
}


//                    ****End ****
```

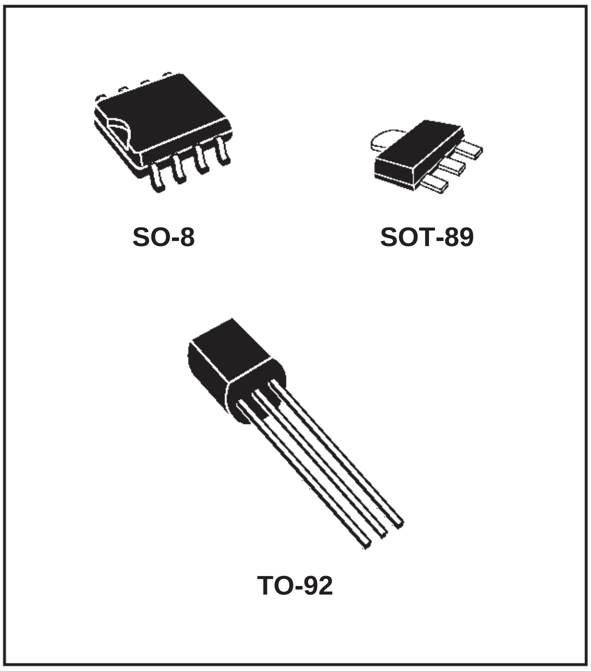
Appendix

B

L78L00 SERIES

POSITIVE VOLTAGE REGULATORS

- OUTPUT CURRENT UP TO 100 mA
- OUTPUT VOLTAGES OF 3.3; 5; 6; 8; 9; 12; 15; 18; 24V
- THERMAL OVERLOAD PROTECTION
- SHORT CIRCUIT PROTECTION
- NO EXTERNAL COMPONENTS ARE REQUIRED
- AVAILABLE IN EITHER ± 5% (AC) OR ± 10% (C) SELECTION

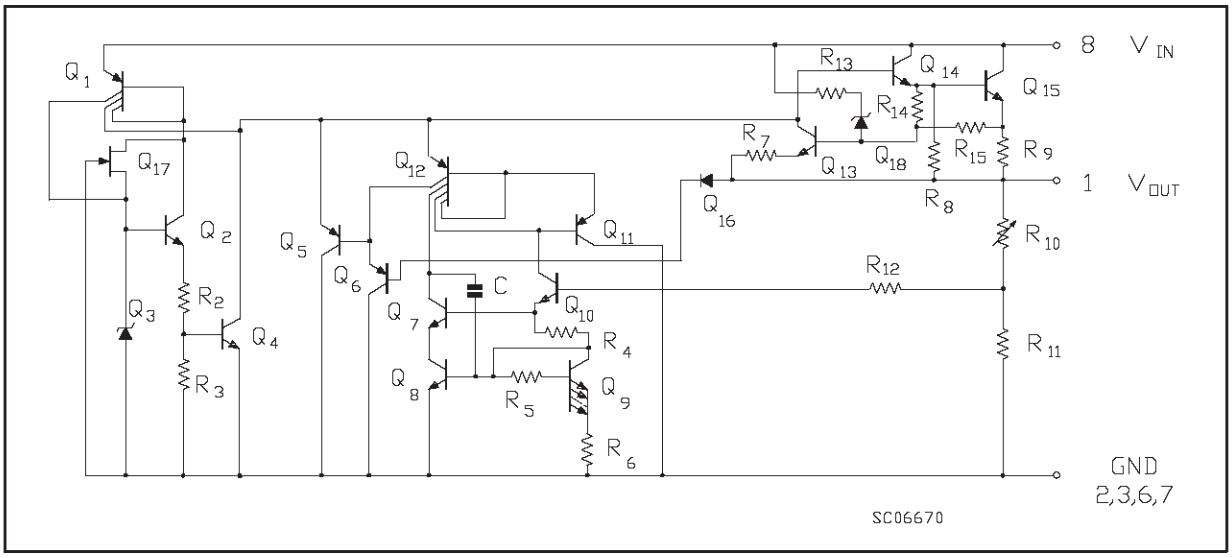


DESCRIPTION

The L78L00 series of three-terminal positive regulators employ internal current limiting and thermal shutdown, making them essentially indestructible. If adequate heatsink is provided, they can deliver up to 100 mA output current. They are intended as fixed voltage regulators in a wide range of applications including local or on-card regulation for elimination of noise and distribution problems associated with single-point regulation. In addition, they can be used with power pass elements to make high-current voltage regulators.

The L78L00 series used as Zener diode/resistor combination replacement, offers an effective output impedance improvement of typically two orders of magnetude, along with lower quiescent current and lower noise.

BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATING

Symbol	Parameter		Value	Unit
V_i	DC Input Voltage	V_o = 3.3 V to 9 V	30	V
		V_o = 12 V to 15 V	35	V
		V_o = 18 V to 24 V	40	V
I_o	Output Current		100	mA
P_{tot}	Power Dissipation		Internally limited (*)	
T_{stg}	Storage Temperature Range		- 40 to 150	°C
T_{op}	Operating Junction Temperature RangeFor L78L00C, L78L00AC For L78L00AB		0 to 125 - 40 to 125	°C °C

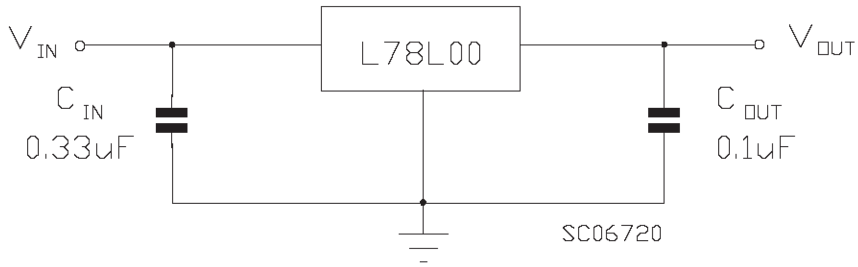
(*) Our SO-8 package used for Voltage Regulators is modified internally to have pins 2, 3, 6 and 7 electrically commoned to the die attach flag. This particular frame decreases the total thermal resistance of the package and increases its ability to dissipate power when an appropriate area of copper on the printed circuit board is available for heatsinking. The external dimensions are the same as for the standard SO-8

THERMAL DATA

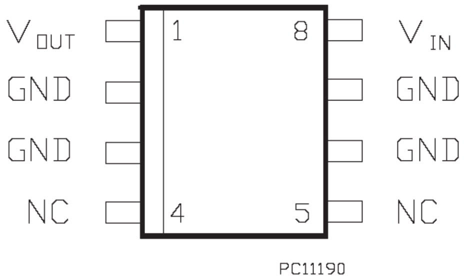
Symbol	Parameter		SO-8	TO-92	SOT-89	Unit
$R_{thj\text{-}case}$	Thermal Resistance Junction-case	Max	20		15	°C/W
$R_{thj\text{-}amb}$	Thermal Resistance Junction-ambient	Max	55 (*)	200		°C/W

(*) Considering 6cm^2 of copper Board heat-sink

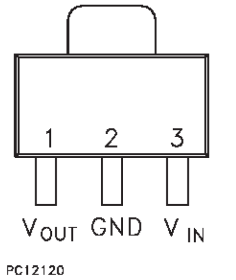
TEST CIRCUITS



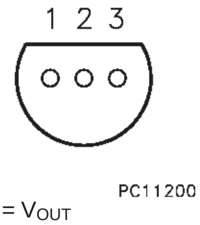
CONNECTION DIAGRAM AND ORDERING NUMBERS (top view)



SO-8



SOT-89



pin 1 = V_{OUT}
pin 2 = GND
pin 3 = V_{IN}

TO-92
BOTTOM VIEW

ORDERING NUMBERS

Type	SO-8	TO-92	SOT-89	Output Voltage
L78L33AC	L78L33ACD	L78L33ACZ	L78L33ACU	3.3 V
L78L33AB	L78L33ABD	L78L33ABZ	L78L33ABU	3.3 V
L78L05C	L78L05CD	L78L05CZ		5 V
L78L05AC	L78L05ACD	L78L05ACZ	L78L05ACU	5 V
L78L05AB	L78L05ABD	L78L05ABZ	L78L05ABU	5 V
L78L06C	L78L06CD	L78L06CZ		6 V
L78L06AC	L78L06ACD	L78L06ACZ	L78L06ACU	6 V
L78L06AB	L78L06ABD	L78L06ABZ	L78L06ABU	6 V
L78L08C	L78L08CD	L78L08CZ		8 V
L78L08AC	L78L08ACD	L78L08ACZ	L78L08ACU	8 V
L78L08AB	L78L08ABD	L78L08ABZ	L78L08ABU	8 V
L78L09C	L78L09CD	L78L09CZ		9 V
L78L09AC	L78L09ACD	L78L09ACZ	L78L09ACU	9 V
L78L09AB	L78L09ABD	L78L09ABZ	L78L09ABU	9 V
L78L12C	L78L12CD	L78L12CZ		12 V
L78L12AC	L78L12ACD	L78L12ACZ	L78L12ACU	12 V
L78L12AB	L78L12ABD	L78L12ABZ	L78L12ABU	12 V
L78L15C	L78L15CD	L78L15CZ		15 V
L78L15AC	L78L15ACD	L78L15ACZ	L78L15ACU	15 V
L78L15AB	L78L15ABD	L78L15ABZ	L78L15ABU	15 V
L78L18C	L78L18CD	L78L18CZ		18 V
L78L18AC	L78L18ACD	L78L18ACZ	L78L18ACU	18 V
L78L18AB	L78L18ABD	L78L18ABZ	L78L18ABU	18 V
L78L24C	L78L24CD	L78L24CZ		24 V
L78L24AC	L78L24ACD	L78L24ACZ	L78L24ACU	24 V
L78L24AB	L78L24ABD	L78L24ABZ	L78L24ABU	24 V

ELECTRICAL CHARACTERISTICS FOR L78L05 (refer to the test circuits, T_j = 0 to 125 ^oC, V_i = 10V, I_o = 40 mA, C_i = 0.33 μF, C_o = 0.1 μF unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_o	Output Voltage	T_j = 25 ^oC	4.6	5	5.4	V
V_o	Output Voltage	I_o = 1 to 40 mA V_i = 7 to 20 V I_o = 1 to 70 mA V_i = 10 V	4.5 4.5		5.5 5.5	V V
ΔV_o	Line Regulation	V_i = 7 to 20 V T_j = 25 ^oC V_i = 8 to 20 V T_j = 25 ^oC			200 150	mV mV
ΔV_o	Load Regulation	I_o = 1 to 100 mA T_j = 25 ^oC I_o = 1 to 40 mA T_j = 25 ^oC			60 30	mV mV
I_d	Quiescent Current	T_j = 25 ^oC T_j = 125 ^oC			6 5.5	mA mA
ΔI_d	Quiescent Current Change	I_o = 1 to 40 mA			0.2	mA
ΔI_d	Quiescent Current Change	V_i = 8 to 20 V			1.5	mA
eN	Output Noise Voltage	B = 10Hz to 100KHz T_j = 25 ^oC		40		μV
SVR	Supply Voltage Rejection	I_o = 40 mA f = 120 Hz T_j = 25 ^oC V_i = 8 to 18 V	40	49		dB
V_d	Dropout Voltage			1.7		V

ELECTRICAL CHARACTERISTICS FOR L78L06 (refer to the test circuits, T_j = 0 to 125 ^oC, V_i = 12V, I_o = 40 mA, C_i = 0.33 μF, C_o = 0.1 μF unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_o	Output Voltage	T_j = 25 ^oC	5.52	6	6.48	V
V_o	Output Voltage	I_o = 1 to 40 mA V_i = 8.5 to 20 V I_o = 1 to 70 mA V_i = 12 V	5.4 5.4		6.6 6.6	V V
ΔV_o	Line Regulation	V_i = 8.5 to 20 V T_j = 25 ^oC V_i = 9 to 20 V T_j = 25 ^oC			200 150	mV mV
ΔV_o	Load Regulation	I_o = 1 to 100 mA T_j = 25 ^oC I_o = 1 to 40 mA T_j = 25 ^oC			60 30	mV mV
I_d	Quiescent Current	T_j = 25 ^oC T_j = 125 ^oC			6 5.5	mA mA
ΔI_d	Quiescent Current Change	I_o = 1 to 40 mA			0.2	mA
ΔI_d	Quiescent Current Change	V_i = 8 to 20 V			1.5	mA
eN	Output Noise Voltage	B = 10Hz to 100KHz T_j = 25 ^oC		50		μV
SVR	Supply Voltage Rejection	I_o = 40 mA f = 120 Hz T_j = 25 ^oC V_i = 9 to 20 V	38	46		dB
V_d	Dropout Voltage			1.7		V

ELECTRICAL CHARACTERISTICS FOR L78L08 (refer to the test circuits, T_j = 0 to 125 °C, V_i = 14V, I_o = 40 mA, C_i = 0.33 µF, C_o = 0.1 µF unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_o	Output Voltage	T_j = 25 °C	7.36	8	8.64	V
V_o	Output Voltage	I_o = 1 to 40 mA V_i = 10.5 to 23 V I_o = 1 to 70 mA V_i = 14 V	7.2 7.2		8.8 8.8	V V
ΔV_o	Line Regulation	V_i = 10.5 to 23 V T_j = 25 °C V_i = 11 to 23 V T_j = 25 °C			200 150	mV mV
ΔV_o	Load Regulation	I_o = 1 to 100 mA T_j = 25 °C I_o = 1 to 40 mA T_j = 25 °C			80 40	mV mV
I_d	Quiescent Current	T_j = 25 °C T_j = 125 °C			6 5.5	mA mA
ΔI_d	Quiescent Current Change	I_o = 1 to 40 mA			0.2	mA
ΔI_d	Quiescent Current Change	V_i = 11 to 23 V			1.5	mA
eN	Output Noise Voltage	B = 10Hz to 100KHz T_j = 25 °C		60		µV
SVR	Supply Voltage Rejection	I_o = 40 mA f = 120 Hz T_j = 25 °C V_i = 12 to 23 V	36	45		dB
V_d	Dropout Voltage			1.7		V

ELECTRICAL CHARACTERISTICS FOR L78L09 (refer to the test circuits, T_j = 0 to 125 °C, V_i = 15V, I_o = 40 mA, C_i = 0.33 µF, C_o = 0.1 µF unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_o	Output Voltage	T_j = 25 °C	8.28	9	9.72	V
V_o	Output Voltage	I_o = 1 to 40 mA V_i = 11.5 to 23 V I_o = 1 to 70 mA V_i = 15 V	8.1 8.1		9.9 9.9	V V
ΔV_o	Line Regulation	V_i = 11.5 to 23 V T_j = 25 °C V_i = 12 to 23 V T_j = 25 °C			250 200	mV mV
ΔV_o	Load Regulation	I_o = 1 to 100 mA T_j = 25 °C I_o = 1 to 40 mA T_j = 25 °C			80 40	mV mV
I_d	Quiescent Current	T_j = 25 °C T_j = 125 °C			6 5.5	mA mA
ΔI_d	Quiescent Current Change	I_o = 1 to 40 mA			0.2	mA
ΔI_d	Quiescent Current Change	V_i = 12 to 23 V			1.5	mA
eN	Output Noise Voltage	B = 10Hz to 100KHz T_j = 25 °C		70		µV
SVR	Supply Voltage Rejection	I_o = 40 mA f = 120 Hz T_j = 25 °C V_i = 12 to 23 V	36	44		dB
V_d	Dropout Voltage			1.7		V

ELECTRICAL CHARACTERISTICS FOR L78L12 (refer to the test circuits, T_j = 0 to 125 ^oC, V_i = 19V, I_o = 40 mA, C_i = 0.33 μF, C_o = 0.1 μF unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_o	Output Voltage	T_j = 25 ^oC	11.1	12	12.9	V
V_o	Output Voltage	I_o = 1 to 40 mA V_i = 14.5 to 27 V I_o = 1 to 70 mA V_i = 19 V	10.8 10.8		13.2 13.2	V V
ΔV_o	Line Regulation	V_i = 14.5 to 27 V T_j = 25 ^oC V_i = 16 to 27 V T_j = 25 ^oC			250 200	mV mV
ΔV_o	Load Regulation	I_o = 1 to 100 mA T_j = 25 ^oC I_o = 1 to 40 mA T_j = 25 ^oC			100 50	mV mV
I_d	Quiescent Current	T_j = 25 ^oC T_j = 125 ^oC			6.5 6	mA mA
ΔI_d	Quiescent Current Change	I_o = 1 to 40 mA			0.2	mA
ΔI_d	Quiescent Current Change	V_i = 16 to 27 V			1.5	mA
eN	Output Noise Voltage	B = 10Hz to 100KHz T_j = 25 ^oC		80		μV
SVR	Supply Voltage Rejection	I_o = 40 mA f = 120 Hz T_j = 25 ^oC V_i = 15 to 25 V	36	42		dB
V_d	Dropout Voltage			1.7		V

ELECTRICAL CHARACTERISTICS FOR L78L15 (refer to the test circuits, T_j = 0 to 125 ^oC, V_i = 23V, I_o = 40 mA, C_i = 0.33 μF, C_o = 0.1 μF unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_o	Output Voltage	T_j = 25 ^oC	13.8	15	16.2	V
V_o	Output Voltage	I_o = 1 to 40 mA V_i = 17.5 to 30 V I_o = 1 to 70 mA V_i = 23 V	13.5 13.5		16.5 16.5	V V
ΔV_o	Line Regulation	V_i = 17.5 to 30 V T_j = 25 ^oC V_i = 20 to 30 V T_j = 25 ^oC			300 250	mV mV
ΔV_o	Load Regulation	I_o = 1 to 100 mA T_j = 25 ^oC I_o = 1 to 40 mA T_j = 25 ^oC			150 75	mV mV
I_d	Quiescent Current	T_j = 25 ^oC T_j = 125 ^oC			6.5 6	mA mA
ΔI_d	Quiescent Current Change	I_o = 1 to 40 mA			0.2	mA
ΔI_d	Quiescent Current Change	V_i = 20 to 30 V			1.5	mA
eN	Output Noise Voltage	B = 10Hz to 100KHz T_j = 25 ^oC		90		μV
SVR	Supply Voltage Rejection	I_o = 40 mA f = 120 Hz T_j = 25 ^oC V_i = 18.5 to 28.5 V	33	39		dB
V_d	Dropout Voltage			1.7		V

ELECTRICAL CHARACTERISTICS FOR L78L18 (refer to the test circuits, T_j = 0 to 125 °C, V_i = 27V, I_o = 40 mA, C_i = 0.33 µF, C_o = 0.1 µF unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_o	Output Voltage	T_j = 25 °C	16.6	18	19.4	V
V_o	Output Voltage	I_o = 1 to 40 mA V_i = 22 to 33 V I_o = 1 to 70 mA V_i = 27 V	16.2 16.2		19.8 19.8	V V
ΔV_o	Line Regulation	V_i = 22 to 33 V T_j = 25 °C V_i = 22 to 33 V T_j = 25 °C			320 270	mV mV
ΔV_o	Load Regulation	I_o = 1 to 100 mA T_j = 25 °C I_o = 1 to 40 mA T_j = 25 °C			170 85	mV mV
I_d	Quiescent Current	T_j = 25 °C T_j = 125 °C			6.5 6	mA mA
ΔI_d	Quiescent Current Change	I_o = 1 to 40 mA			0.2	mA
ΔI_d	Quiescent Current Change	V_i = 23 to 33 V			1.5	mA
eN	Output Noise Voltage	B = 10Hz to 100KHz T_j = 25 °C		120		µV
SVR	Supply Voltage Rejection	I_o = 40 mA f = 120 Hz T_j = 25 °C V_i = 23 to 33 V	32	38		dB
V_d	Dropout Voltage			1.7		V

ELECTRICAL CHARACTERISTICS FOR L78L24 (refer to the test circuits, T_j = 0 to 125 °C, V_i = 33V, I_o = 40 mA, C_i = 0.33 µF, C_o = 0.1 µF unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_o	Output Voltage	T_j = 25 °C	22.1	24	25.9	V
V_o	Output Voltage	I_o = 1 to 40 mA V_i = 27 to 38 V I_o = 1 to 70 mA V_i = 33 V	21.6 21.6		26.4 26.4	V V
ΔV_o	Line Regulation	V_i = 27 to 38 V T_j = 25 °C V_i = 28 to 38 V T_j = 25 °C			350 300	mV mV
ΔV_o	Load Regulation	I_o = 1 to 100 mA T_j = 25 °C I_o = 1 to 40 mA T_j = 25 °C			200 100	mV mV
I_d	Quiescent Current	T_j = 25 °C T_j = 125 °C			6.5 6	mA mA
ΔI_d	Quiescent Current Change	I_o = 1 to 40 mA			0.2	mA
ΔI_d	Quiescent Current Change	V_i = 28 to 38 V			1.5	mA
eN	Output Noise Voltage	B = 10Hz to 100KHz T_j = 25 °C		200		µV
SVR	Supply Voltage Rejection	I_o = 40 mA f = 120 Hz T_j = 25 °C V_i = 29 to 35 V	30	37		dB
V_d	Dropout Voltage			1.7		V

ELECTRICAL CHARACTERISTICS FOR L78L33AB AND L78L33AC

(refer to the test circuits, V_i = 8.3V, I_o = 40 mA, C_i = 0.33 μF, C_o = 0.1 μF,
T_j = 0 to 125 °C for L78L33AC, T_j = -40 to 125 °C for L78L33AB, unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_o	Output Voltage	T_j = 25 °C	3.168	3.3	3.432	V
V_o	Output Voltage	I_o = 1 to 40 mA V_i = 5.3 to 20 V I_o = 1 to 70 mA V_i = 8.3 V	3.135 3.135		3.465 3.465	V V
ΔV_o	Line Regulation	V_i = 5.3 to 20 V T_j = 25 °C V_i = 6.3 to 20 V T_j = 25 °C			150 100	mV mV
ΔV_o	Load Regulation	I_o = 1 to 100 mA T_j = 25 °C I_o = 1 to 40 mA T_j = 25 °C			60 30	mV mV
I_d	Quiescent Current	T_j = 25 °C T_j = 125 °C			6 5.5	mA mA
ΔI_d	Quiescent Current Change	I_o = 1 to 40 mA			0.1	mA
ΔI_d	Quiescent Current Change	V_i = 6.3 to 20 V			1.5	mA
eN	Output Noise Voltage	B = 10Hz to 100KHz T_j = 25 °C		40		μV
SVR	Supply Voltage Rejection	I_o = 40 mA f = 120 Hz T_j = 25 °C V_i = 6.3 to 16.3 V	41	49		dB
V_d	Dropout Voltage			1.7		V

ELECTRICAL CHARACTERISTICS FOR L78L05AB AND L78L05AC

(refer to the test circuits, V_i = 10V, I_o = 40 mA, C_i = 0.33 μF, C_o = 0.1 μF,
T_j = 0 to 125 °C for L78L05AC, T_j = -40 to 125 °C for L78L05AB, unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_o	Output Voltage	T_j = 25 °C	4.8	5	5.2	V
V_o	Output Voltage	I_o = 1 to 40 mA V_i = 7 to 20 V I_o = 1 to 70 mA V_i = 10 V	4.75 4.75		5.25 5.25	V V
ΔV_o	Line Regulation	V_i = 7 to 20 V T_j = 25 °C V_i = 8 to 20 V T_j = 25 °C			150 100	mV mV
ΔV_o	Load Regulation	I_o = 1 to 100 mA T_j = 25 °C I_o = 1 to 40 mA T_j = 25 °C			60 30	mV mV
I_d	Quiescent Current	T_j = 25 °C T_j = 125 °C			6 5.5	mA mA
ΔI_d	Quiescent Current Change	I_o = 1 to 40 mA			0.1	mA
ΔI_d	Quiescent Current Change	V_i = 8 to 20 V			1.5	mA
eN	Output Noise Voltage	B = 10Hz to 100KHz T_j = 25 °C		40		μV
SVR	Supply Voltage Rejection	I_o = 40 mA f = 120 Hz T_j = 25 °C V_i = 8 to 18 V	41	49		dB
V_d	Dropout Voltage			1.7		V

ELECTRICAL CHARACTERISTICS FOR L78L06AB AND L78L06AC

(refer to the test circuits, V_i = 12V, I_o = 40 mA, C_i = 0.33 µF, C_o = 0.1 µF,
T_j = 0 to 125 °C for L78L06AC, T_j = -40 to 125 °C for L78L06AB, unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_o	Output Voltage	T_j = 25 °C	5.76	6	6.24	V
V_o	Output Voltage	I_o = 1 to 40 mA V_i = 8.5 to 20 V I_o = 1 to 70 mA V_i = 12 V	5.7 5.7		6.3 6.3	V V
ΔV_o	Line Regulation	V_i = 8.5 to 20 V T_j = 25 °C V_i = 9 to 20 V T_j = 25 °C			150 100	mV mV
ΔV_o	Load Regulation	I_o = 1 to 100 mA T_j = 25 °C I_o = 1 to 40 mA T_j = 25 °C			60 30	mV mV
I_d	Quiescent Current	T_j = 25 °C T_j = 125 °C			6 5.5	mA mA
ΔI_d	Quiescent Current Change	I_o = 1 to 40 mA			0.1	mA
ΔI_d	Quiescent Current Change	V_i = 9 to 20 V			1.5	mA
eN	Output Noise Voltage	B = 10Hz to 100KHz T_j = 25 °C		50		µV
SVR	Supply Voltage Rejection	I_o = 40 mA f = 120 Hz T_j = 25 °C V_i = 9 to 20 V	39	46		dB
V_d	Dropout Voltage			1.7		V

ELECTRICAL CHARACTERISTICS FOR L78L08AB AND L78L08AC

(refer to the test circuits, V_i = 14V, I_o = 40 mA, C_i = 0.33 µF, C_o = 0.1 µF,
T_j = 0 to 125 °C for L78L08AC, T_j = -40 to 125 °C for L78L08AB, unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_o	Output Voltage	T_j = 25 °C	7.68	8	8.32	V
V_o	Output Voltage	I_o = 1 to 40 mA V_i = 10.5 to 23 V I_o = 1 to 70 mA V_i = 14 V	7.6 7.6		8.4 8.4	V V
ΔV_o	Line Regulation	V_i = 10.5 to 23 V T_j = 25 °C V_i = 11 to 23 V T_j = 25 °C			175 125	mV mV
ΔV_o	Load Regulation	I_o = 1 to 100 mA T_j = 25 °C I_o = 1 to 40 mA T_j = 25 °C			80 40	mV mV
I_d	Quiescent Current	T_j = 25 °C T_j = 125 °C			6 5.5	mA mA
ΔI_d	Quiescent Current Change	I_o = 1 to 40 mA			0.1	mA
ΔI_d	Quiescent Current Change	V_i = 11 to 23 V			1.5	mA
eN	Output Noise Voltage	B = 10Hz to 100KHz T_j = 25 °C		60		µV
SVR	Supply Voltage Rejection	I_o = 40 mA f = 120 Hz T_j = 25 °C V_i = 12 to 23 V	37	45		dB
V_d	Dropout Voltage			1.7		V

ELECTRICAL CHARACTERISTICS FOR L78L09AB AND L78L09AC

(refer to the test circuits, V_i = 15V, I_o = 40 mA, C_i = 0.33 µF, C_o = 0.1 µF,
T_j = 0 to 125 °C for L78L09AC, T_j = -40 to 125 °C for L78L09AB, unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_o	Output Voltage	T_j = 25 °C	8.64	9	9.36	V
V_o	Output Voltage	I_o = 1 to 40 mA V_i = 11.5 to 23 V I_o = 1 to 70 mA V_i = 15 V	8.55 8.55		9.45 9.45	V V
ΔV_o	Line Regulation	V_i = 11.5 to 23 V T_j = 25 °C V_i = 12 to 23 V T_j = 25 °C			225 150	mV mV
ΔV_o	Load Regulation	I_o = 1 to 100 mA T_j = 25 °C I_o = 1 to 40 mA T_j = 25 °C			80 40	mV mV
I_d	Quiescent Current	T_j = 25 °C T_j = 125 °C			6 5.5	mA mA
ΔI_d	Quiescent Current Change	I_o = 1 to 40 mA			0.1	mA
ΔI_d	Quiescent Current Change	V_i = 12 to 23 V			1.5	mA
eN	Output Noise Voltage	B = 10Hz to 100KHz T_j = 25 °C		70		µV
SVR	Supply Voltage Rejection	I_o = 40 mA f = 120 Hz T_j = 25 °C V_i = 12 to 23 V	37	44		dB
V_d	Dropout Voltage			1.7		V

ELECTRICAL CHARACTERISTICS FOR L78L12AB AND L78L12AC

(refer to the test circuits, V_i = 19V, I_o = 40 mA, C_i = 0.33 µF, C_o = 0.1 µF,
T_j = 0 to 125 °C for L78L12AC, T_j = -40 to 125 °C for L78L12AB, unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_o	Output Voltage	T_j = 25 °C	11.5	12	12.5	V
V_o	Output Voltage	I_o = 1 to 40 mA V_i = 14.5 to 27 V I_o = 1 to 70 mA V_i = 19 V	11.4 11.4		12.6 12.6	V V
ΔV_o	Line Regulation	V_i = 14.5 to 27 V T_j = 25 °C V_i = 16 to 27 V T_j = 25 °C			250 200	mV mV
ΔV_o	Load Regulation	I_o = 1 to 100 mA T_j = 25 °C I_o = 1 to 40 mA T_j = 25 °C			100 50	mV mV
I_d	Quiescent Current	T_j = 25 °C T_j = 125 °C			6.5 6	mA mA
ΔI_d	Quiescent Current Change	I_o = 1 to 40 mA			0.1	mA
ΔI_d	Quiescent Current Change	V_i = 16 to 27 V			1.5	mA
eN	Output Noise Voltage	B = 10Hz to 100KHz T_j = 25 °C		80		µV
SVR	Supply Voltage Rejection	I_o = 40 mA f = 120 Hz T_j = 25 °C V_i = 15 to 25 V	37	42		dB
V_d	Dropout Voltage			1.7		V

ELECTRICAL CHARACTERISTICS FOR L78L15AB AND L78L15AC

(refer to the test circuits, V_i = 23V, I_o = 40 mA, C_i = 0.33 µF, C_o = 0.1 µF,
T_j = 0 to 125 °C for L78L15AC, T_j = -40 to 125 °C for L78L15AB, unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_o	Output Voltage	T_j = 25 °C	14.4	15	15.6	V
V_o	Output Voltage	I_o = 1 to 40 mA V_i = 17.5 to 30 V I_o = 1 to 70 mA V_i = 23 V	14.25 14.25		15.75 15.75	V V
ΔV_o	Line Regulation	V_i = 17.5 to 30 V T_j = 25 °C V_i = 20 to 30 V T_j = 25 °C			300 250	mV mV
ΔV_o	Load Regulation	I_o = 1 to 100 mA T_j = 25 °C I_o = 1 to 40 mA T_j = 25 °C			150 75	mV mV
I_d	Quiescent Current	T_j = 25 °C T_j = 125 °C			6.5 6	mA mA
ΔI_d	Quiescent Current Change	I_o = 1 to 40 mA			0.1	mA
ΔI_d	Quiescent Current Change	V_i = 20 to 30 V			1.5	mA
eN	Output Noise Voltage	B = 10Hz to 100KHz T_j = 25 °C		90		µV
SVR	Supply Voltage Rejection	I_o = 40 mA f = 120 Hz T_j = 25 °C V_i = 18.5 to 28.5 V	34	39		dB
V_d	Dropout Voltage			1.7		V

ELECTRICAL CHARACTERISTICS FOR L78L18AB AND L78L18AC

(refer to the test circuits, V_i = 27V, I_o = 40 mA, C_i = 0.33 µF, C_o = 0.1 µF,
T_j = 0 to 125 °C for L78L18AC, T_j = -40 to 125 °C for L78L18AB, unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_o	Output Voltage	T_j = 25 °C	17.3	18	18.7	V
V_o	Output Voltage	I_o = 1 to 40 mA V_i = 22 to 33 V I_o = 1 to 70 mA V_i = 27 V	17.1 17.1		18.9 18.9	V V
ΔV_o	Line Regulation	V_i = 22 to 33 V T_j = 25 °C V_i = 22 to 33 V T_j = 25 °C			320 270	mV mV
ΔV_o	Load Regulation	I_o = 1 to 100 mA T_j = 25 °C I_o = 1 to 40 mA T_j = 25 °C			170 85	mV mV
I_d	Quiescent Current	T_j = 25 °C T_j = 125 °C			6.5 6	mA mA
ΔI_d	Quiescent Current Change	I_o = 1 to 40 mA			0.1	mA
ΔI_d	Quiescent Current Change	V_i = 23 to 33 V			1.5	mA
eN	Output Noise Voltage	B = 10Hz to 100KHz T_j = 25 °C		120		µV
SVR	Supply Voltage Rejection	I_o = 40 mA f = 120 Hz T_j = 25 °C V_i = 23 to 33 V	33	38		dB
V_d	Dropout Voltage			1.7		V

ELECTRICAL CHARACTERISTICS FOR L78L24AB AND L78L24AC

(refer to the test circuits, V_i = 33V, I_o = 40 mA, C_i = 0.33 µF, C_o = 0.1 µF,
T_j = 0 to 125 °C for L78L24AC, T_j = -40 to 125 °C for L78L24AB, unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_o	Output Voltage	T_j = 25 °C	23	24	25	V
V_o	Output Voltage	I_o = 1 to 40 mA V_i = 27 to 38 V I_o = 1 to 70 mA V_i = 33 V	22.8 22.8		25.2 25.2	V V
ΔV_o	Line Regulation	V_i = 27 to 38 V T_j = 25 °C V_i = 28 to 38 V T_j = 25 °C			350 300	mV mV
ΔV_o	Load Regulation	I_o = 1 to 100 mA T_j = 25 °C I_o = 1 to 40 mA T_j = 25 °C			200 100	mV mV
I_d	Quiescent Current	T_j = 25 °C T_j = 125 °C			6.5 6	mA mA
ΔI_d	Quiescent Current Change	I_o = 1 to 40 mA			0.1	mA
ΔI_d	Quiescent Current Change	V_i = 28 to 38 V			1.5	mA
eN	Output Noise Voltage	B = 10Hz to 100KHz T_j = 25 °C		200		µV
SVR	Supply Voltage Rejection	I_o = 40 mA f = 120 Hz T_j = 25 °C V_i = 29 to 35 V	31	37		dB
V_d	Dropout Voltage			1.7		V

Figure 1: L78L05/12 Output Voltage vs Ambient Temperature

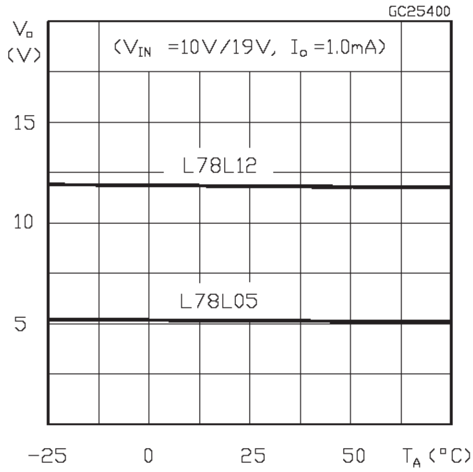


Figure 2 : L78L05/12/24 Load Characteristics.

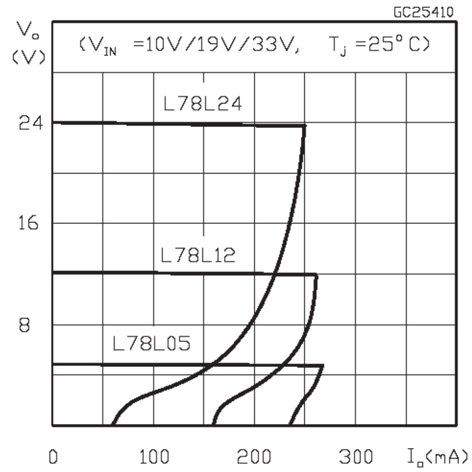


Figure 3 : L78L05/12/24 Thermal Shutdown.

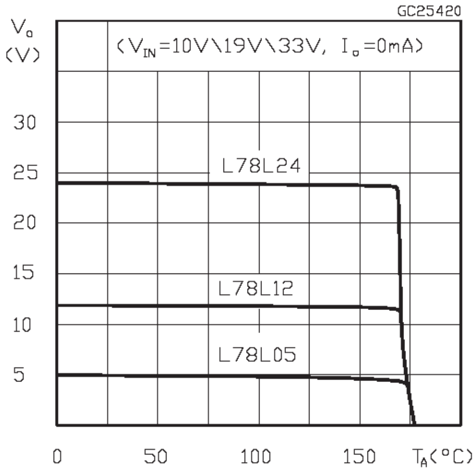


Figure 4 : L78L05/12 Quiescent Current vs Output Current

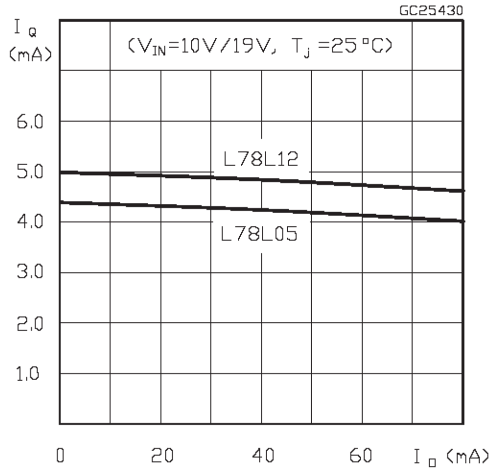


Figure 5 : L78L05 Quiescent Current vs Input Voltage.

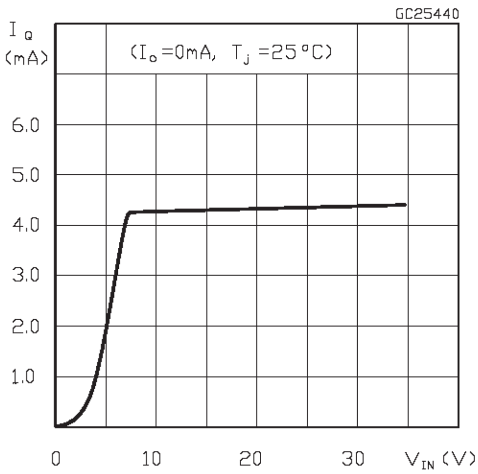


Figure 6 : L78L05/12/24 Output Characteristics.

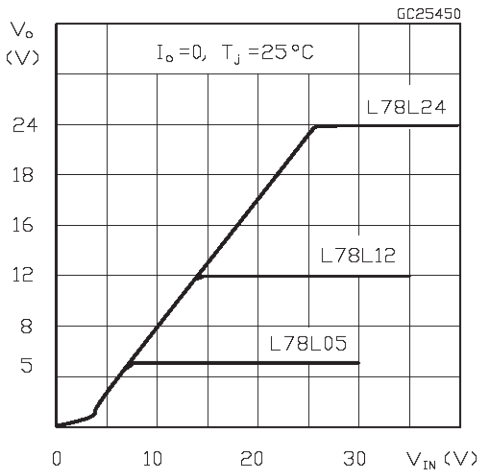


Figure 7 : L78L05/12/24 Ripple Rejection.

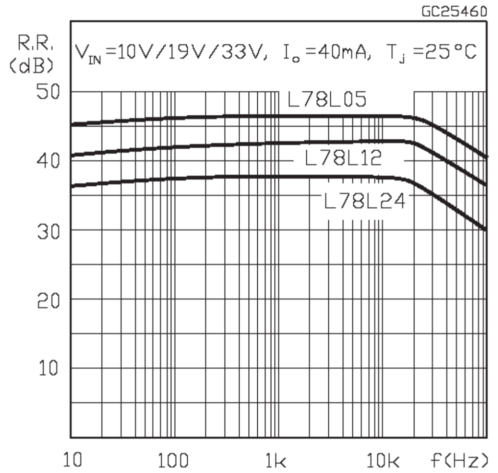


Figure 8 : L78L05 Dropout Characteristics.

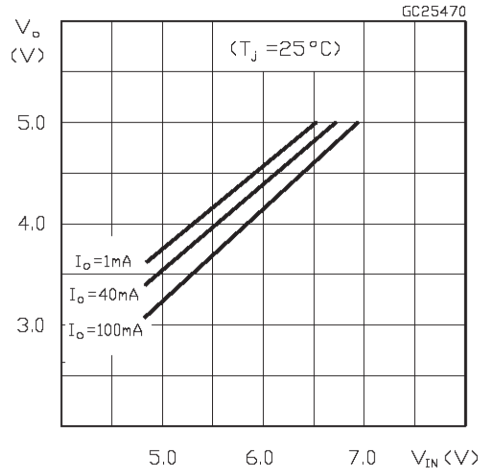
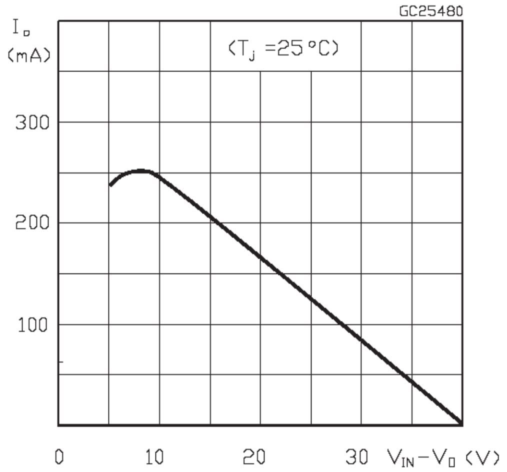


Figure 9 : L78L00 Series Short Circuit Output Current.



TYPICAL APPLICATIONS:

Figure 10: High Output Current Short Circuit Protected

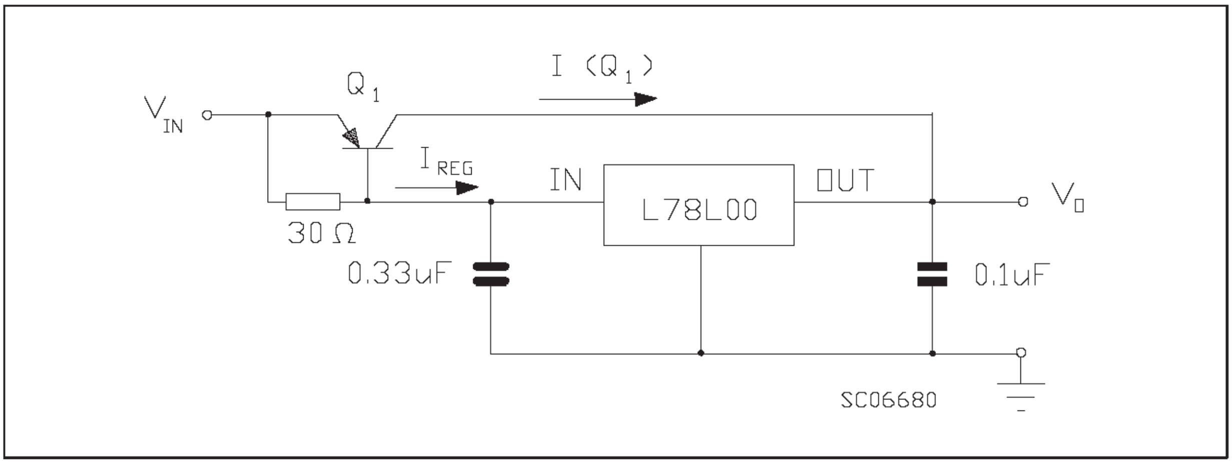


Figure 11 : Output Boost Circuit.

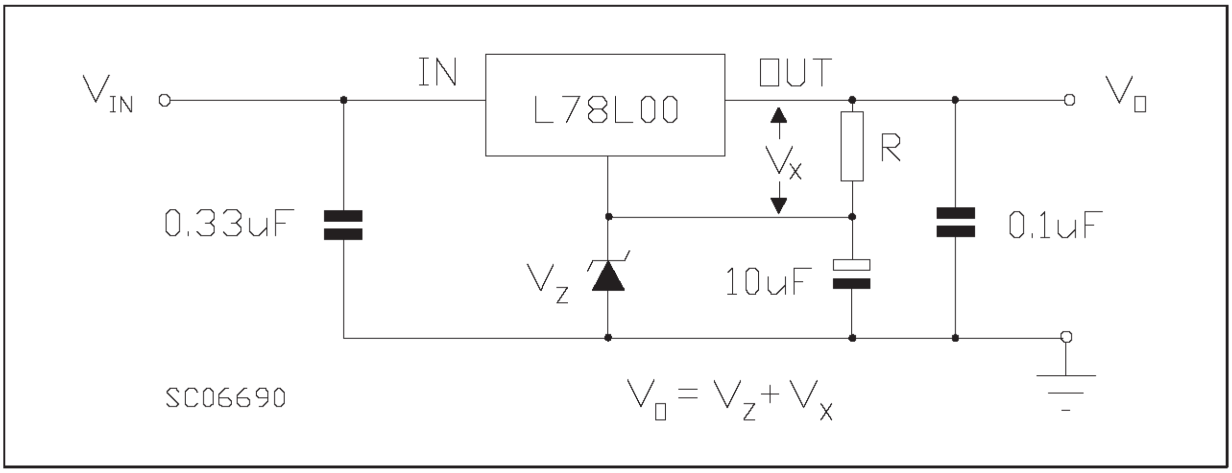


Figure 12 : Current Regulator.

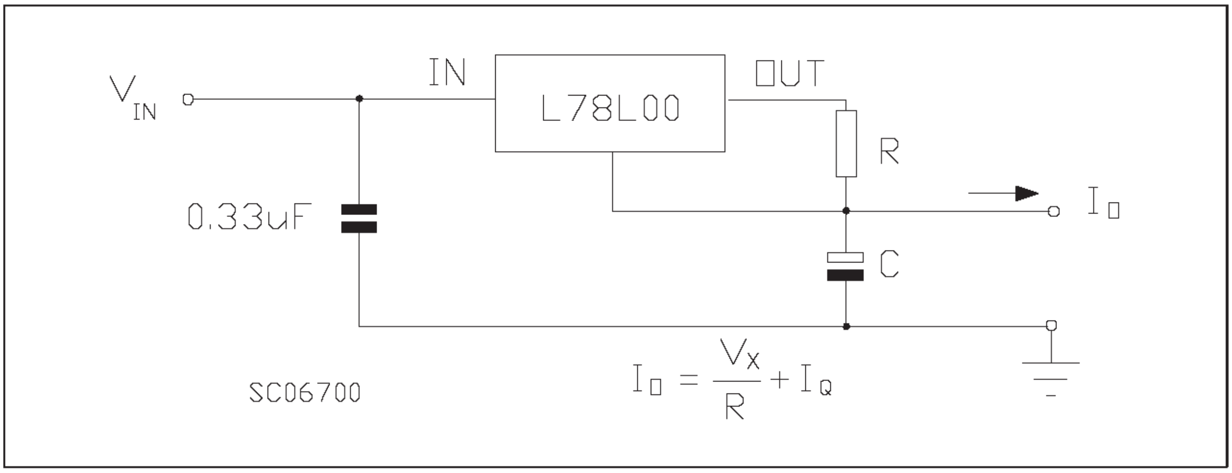
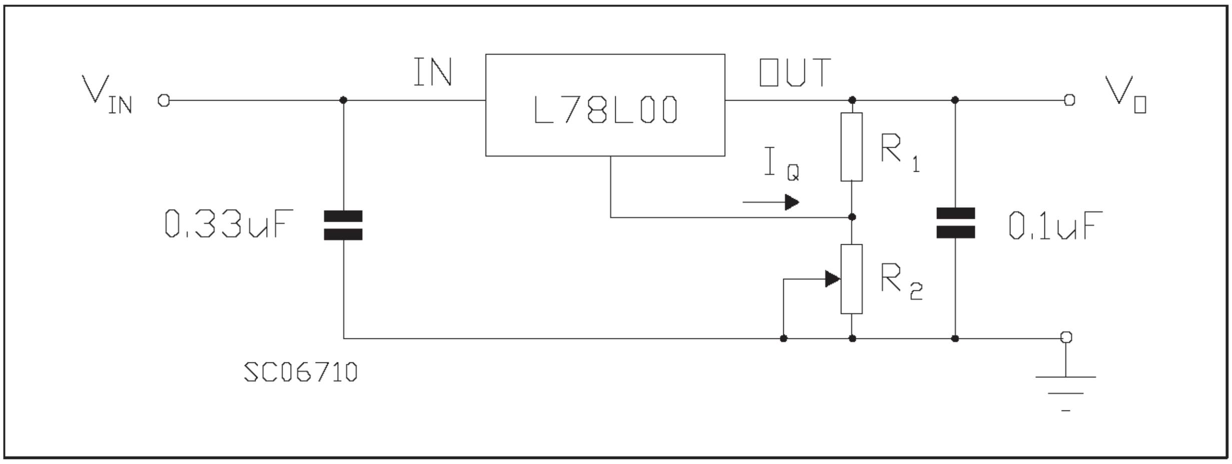
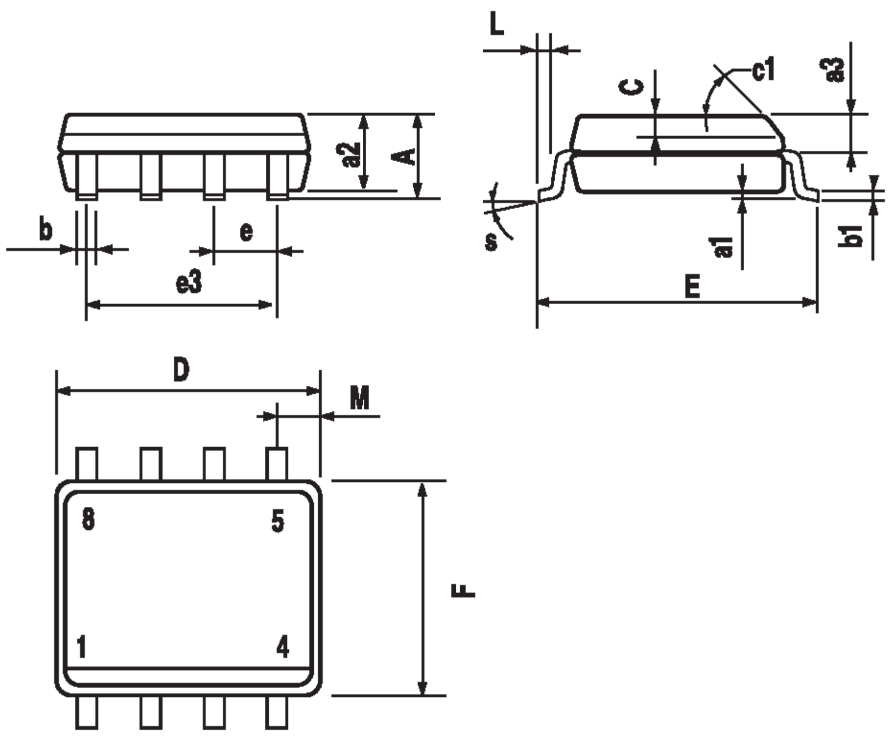


Figure 13: Adjustable Output Regulator



SO-8 MECHANICAL DATA

DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			1.75			0.068
a1	0.1		0.25	0.003		0.009
a2			1.65			0.064
a3	0.65		0.85	0.025		0.033
b	0.35		0.48	0.013		0.018
b1	0.19		0.25	0.007		0.010
C	0.25		0.5	0.010		0.019
c1	45 (typ.)					
D	4.8		5.0	0.188		0.196
E	5.8		6.2	0.228		0.244
e		1.27			0.050	
e3		3.81			0.150	
F	3.8		4.0	0.14		0.157
L	0.4		1.27	0.015		0.050
M			0.6			0.023
S	8 (max.)					



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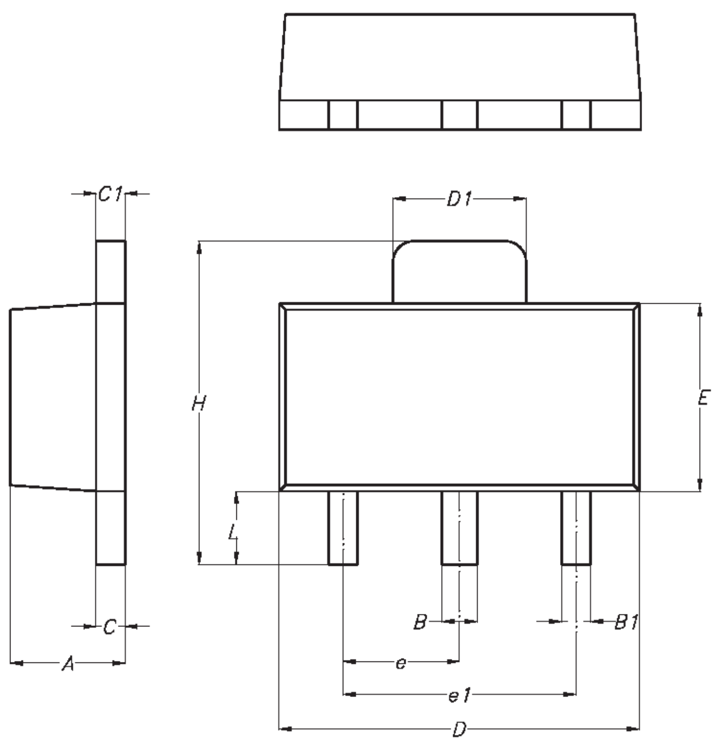
SOT-89 MECHANICAL DATA

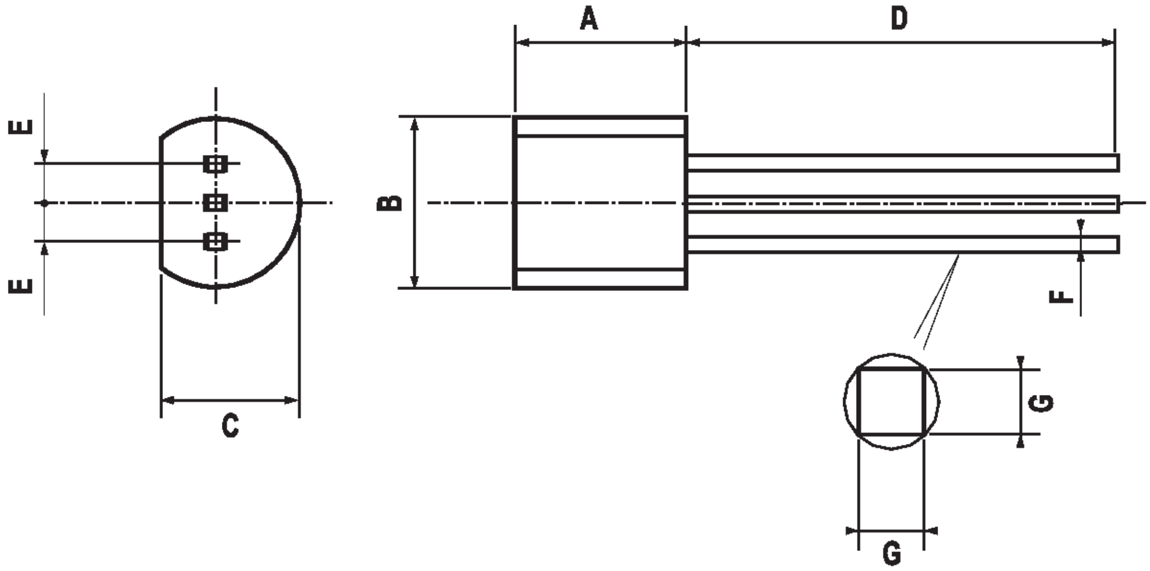
DIM.	mm			mils		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A	1.4		1.6	55.1		63.0
B	0.44		0.56	17.3		22.0
B1	0.36		0.48	14.2		18.9
C	0.35		0.44	13.8		17.3
C1	0.35		0.44	13.8		17.3
D	4.4		4.6	173.2		181.1
D1	1.62		1.83	63.8		72.0
E	2.29		2.6	90.2		102.4
e	1.42		1.57	55.9		61.8
e1	2.92		3.07	115.0		120.9
H	3.94		4.25	155.1		167.3
L	0.89		1.2	35.0		47.2



P025H

TO-92 MECHANICAL DATA

DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A	4.58		5.33	0.180		0.210
B	4.45		5.2	0.175		0.204
C	3.2		4.2	0.126		0.165
D	12.7			0.500		
E		1.27			0.050	
F	0.4		0.51	0.016		0.020
G	0.35			0.14		



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LM78L05,LM78L09,LM78L12,LM78L15,LM78L62, LM78L82

LM78LXX Series 3-Terminal Positive Regulators

TEXAS INSTRUMENTS

Literature Number: SNVS754G

April 14, 2011

LM78LXX Series

3-Terminal Positive Regulators

General Description

The LM78LXX series of three terminal positive regulators is available with several fixed output voltages making them useful in a wide range of applications. When used as a zener diode/resistor combination replacement, the LM78LXX usually results in an effective output impedance improvement of two orders of magnitude, and lower quiescent current. These regulators can provide local on card regulation, eliminating the distribution problems associated with single point regulation. The voltages available allow the LM78LXX to be used in logic systems, instrumentation, HiFi, and other solid state electronic equipment.

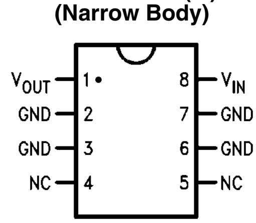
The LM78LXX is available in the plastic TO-92 (Z) package, the plastic SO-8 (M) package and a chip sized package (8-Bump micro SMD) using National's micro SMD package technology. With adequate heat sinking the regulator can deliver 100mA output current. Current limiting is included to limit the peak output current to a safe value. Safe area protection for the output transistors is provided to limit internal power dissipation. If internal power dissipation becomes too high for the heat sinking provided, the thermal shutdown circuit takes over preventing the IC from overheating.

Features

- LM78L05 in micro SMD package
- Output voltage tolerances of ±5% over the temperature range
- Output current of 100mA
- Internal thermal overload protection
- Output transistor safe area protection
- Internal short circuit current limit
- Available in plastic TO-92 and plastic SO-8 low profile packages
- No external components
- Output voltages of 5.0V, 6.2V, 8.2V, 9.0V, 12V, 15V
- See AN-1112 for micro SMD considerations

Connection Diagrams

SO-8 Plastic (M)
(Narrow Body)



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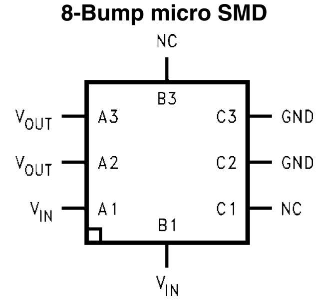
Top View

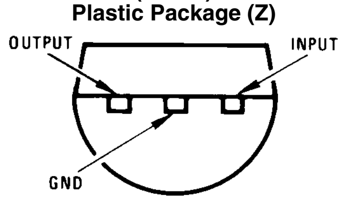
8-Bump micro SMD



774424

Top View
(Bump Side Down)

(TO-92)
Plastic Package (Z)



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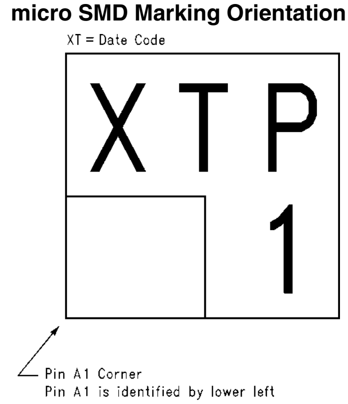
Bottom View

micro SMD Marking Orientation



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Top View

Ordering Information

Package	NSC Drawing	Output Voltage	Order Number	Supplied As
micro SMD	BPA08AAB	5V	LM78L05IBPX	Reel of 3000
Thin micro SMD	TPA08AAA	5V	LM78L05ITP	Reel of 250
			LM78L05ITPX	Reel of 3000
		9V	LM78L09ITPX	Reel of 3000
SOIC Narrow	M08A	5V	LM78L05ACM	Rail of 95
			LM78L05ACMX	Reel of 2500
			LM78L05AIM	Rail of 95
			LM78L05AIMX	Reel of 2500
		12V	LM78L12ACMX	Reel of 2500
		15V	LM78L15ACMX	Reel of 2500
TO-92	Z03A	5V	LM78L05ACZ	Box of 1800
		6.2V	LM78L62ACZ	Box of 1800
		9V	LM78L09ACZ	Box of 1800
		12V	LM78L12ACZ	Box of 1800
		15V	LM78L15ACZ	Box of 1800

Absolute Maximum Ratings (Note 1)

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

Power Dissipation (Note 5)	Internally Limited
Input Voltage	35V
Storage Temperature	−65°C to +150°C
ESD Susceptibility (Note 2)	1kV
Operating Junction Temperature	
SO-8, TO-92	0°C to 125°C
SO-8 (5V Only)	-40°C to 125°C
micro SMD	−40°C to 85°C
Soldering Information	
Infrared or Convection (20 sec.)	235°C
Wave Soldering (10 sec.)	260°C (lead time)

LM78LXX Electrical Characteristics

Limits in standard typeface are for $T_J = 25°C$, **Bold typeface applies over the entire operating temperature range of the indicated package.** Limits are guaranteed by production testing or correlation techniques using standard Statistical Quality Control (SQC) methods. Unless otherwise specified: $I_O = 40mA$, $C_I = 0.33\mu F$, $C_O = 0.1\mu F$.

LM78L05

Unless otherwise specified, $V_{IN} = 10V$

Symbol	Parameter	Conditions	Min	Typ	Max	Units
V_O	Output Voltage		4.8	5	5.2	V
		$7V \le V_{IN} \le 20V$ $1mA \le I_O \le 40mA$ (Note 3)	**4.75**		**5.25**	
		$1mA \le I_O \le 70mA$ (Note 3)	**4.75**		**5.25**	
ΔV_O	Line Regulation	$7V \le V_{IN} \le 20V$		18	75	mV
		$8V \le V_{IN} \le 20V$		10	54	
ΔV_O	Load Regulation	$1mA \le I_O \le 100mA$		20	60	
		$1mA \le I_O \le 40mA$		5	30	
I_Q	Quiescent Current			3	5	mA
ΔI_Q	Quiescent Current Change	$8V \le V_{IN} \le 20V$			**1.0**	
		$1mA \le I_O \le 40mA$			**0.1**	
V_n	Output Noise Voltage	f = 10 Hz to 100 kHz (Note 4)		40		µV
$\frac{\Delta V_{IN}}{\Delta V_{OUT}}$	Ripple Rejection	f = 120 Hz $8V \le V_{IN} \le 16V$	47	62		dB
I_{PK}	Peak Output Current			140		mA
$\frac{\Delta V_O}{\Delta T}$	Average Output Voltage Tempco	$I_O = 5mA$		−0.65		mV/°C
V_{IN} (Min)	Minimum Value of Input Voltage Required to Maintain Line Regulation			6.7	7	V
θ_{JA}	Thermal Resistance (8-Bump micro SMD)			230.9		°C/W

LM78L62AC

Unless otherwise specified, V_{IN} = 12V

Symbol	Parameter	Conditions	Min	Typ	Max	Units
V_O	Output Voltage		5.95	6.2	6.45	V
		8.5V ≤ V_{IN} ≤ 20V 1mA ≤ I_O ≤ 40mA (Note 3)	**5.9**		**6.5**	
		1mA ≤ I_O ≤ 70mA (Note 3)	**5.9**		**6.5**	
ΔV_O	Line Regulation	8.5V ≤ V_{IN} ≤ 20V		65	175	mV
		9V ≤ V_{IN} ≤ 20V		55	125	
ΔV_O	Load Regulation	1mA ≤ I_O ≤ 100mA		13	80	
		1mA ≤ I_O ≤ 40mA		6	40	
I_Q	Quiescent Current			2	5.5	mA
ΔI_Q	Quiescent Current Change	8V ≤ V_{IN} ≤ 20V			**1.5**	
		1mA ≤ I_O ≤ 40mA			**0.1**	
V_n	Output Noise Voltage	f = 10 Hz to 100 kHz (Note 4)		50		µV
$\frac{\Delta V_{IN}}{\Delta V_{OUT}}$	Ripple Rejection	f = 120 Hz 10V ≤ V_{IN} ≤ 20V	40	46		dB
I_{PK}	Peak Output Current			140		mA
$\frac{\Delta V_O}{\Delta T}$	Average Output Voltage Tempco	I_O = 5mA		−0.75		mV/°C
V_{IN} (Min)	Minimum Value of Input Voltage Required to Maintain Line Regulation			7.9		V

LM78L82AC

Unless otherwise specified, V_{IN} = 14V

Symbol	Parameter	Conditions	Min	Typ	Max	Units
V_O	Output Voltage		7.87	8.2	8.53	V
		11V ≤ V_{IN} ≤ 23V 1mA ≤ I_O ≤ 40mA (Note 3)	**7.8**		**8.6**	
		1mA ≤ I_O ≤ 70mA (Note 3)	**7.8**		**8.6**	
ΔV_O	Line Regulation	11V ≤ V_{IN} ≤ 23V		80	175	mV
		12V ≤ V_{IN} ≤ 23V		70	125	
ΔV_O	Load Regulation	1mA ≤ I_O ≤ 100mA		15	80	
		1mA ≤ I_O ≤ 40mA		8	40	
I_Q	Quiescent Current			2	5.5	mA
ΔI_Q	Quiescent Current Change	12V ≤ V_{IN} ≤ 23V			**1.5**	
		1mA ≤ I_O ≤ 40mA			**0.1**	
V_n	Output Noise Voltage	f = 10 Hz to 100 kHz (Note 4)		60		µV
$\frac{\Delta V_{IN}}{\Delta V_{OUT}}$	Ripple Rejection	f = 120 Hz 12V ≤ V_{IN} ≤ 22V	39	45		dB
I_{PK}	Peak Output Current			140		mA

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$\frac{\Delta V_O}{\Delta T}$	Average Output Voltage Tempco	I_O = 5mA		−0.8		mV/°C
V_{IN} (Min)	Minimum Value of Input Voltage Required to Maintain Line Regulation			9.9		V

LM78L09AC

Unless otherwise specified, V_{IN} = 15V

Symbol	Parameter	Conditions	Min	Typ	Max	Units
V_O	Output Voltage		8.64	9.0	9.36	V
		11.5V ≤ V_{IN} ≤ 24V 1mA ≤ I_O ≤ 40mA (*Note 3*)	**8.55**		**9.45**	
		1mA ≤ I_O ≤ 70mA (*Note 3*)	**8.55**		**9.45**	
ΔV_O	Line Regulation	11.5V ≤ V_{IN} ≤ 24V		100	200	mV
		13V ≤ V_{IN} ≤ 24V		90	150	
ΔV_O	Load Regulation	1mA ≤ I_O ≤ 100mA		20	90	
		1mA ≤ I_O ≤ 40mA		10	45	
I_Q	Quiescent Current			2	5.5	mA
ΔI_Q	Quiescent Current Change	11.5V ≤ V_{IN} ≤ 24V			**1.5**	
		1mA ≤ I_O ≤ 40mA			**0.1**	
V_n	Output Noise Voltage			70		μV
$\frac{\Delta V_{IN}}{\Delta V_{OUT}}$	Ripple Rejection	f = 120 Hz 15V ≤ V_{IN} ≤ 25V	38	44		dB
I_{PK}	Peak Output Current			140		mA
$\frac{\Delta V_O}{\Delta T}$	Average Output Voltage Tempco	I_O = 5mA		−0.9		mV/°C
V_{IN} (Min)	Minimum Value of Input Voltage Required to Maintain Line Regulation			10.7		V

LM78L12AC

Unless otherwise specified, V_{IN} = 19V

Symbol	Parameter	Conditions	Min	Typ	Max	Units
V_O	Output Voltage		11.5	12	12.5	V
		14.5V ≤ V_{IN} ≤ 27V 1mA ≤ I_O ≤ 40mA (*Note 3*)	**11.4**		**12.6**	
		1mA ≤ I_O ≤ 70mA (*Note 3*)	**11.4**		**12.6**	
ΔV_O	Line Regulation	14.5V ≤ V_{IN} ≤ 27V		30	180	mV
		16V ≤ V_{IN} ≤ 27V		20	110	
ΔV_O	Load Regulation	1mA ≤ I_O ≤ 100mA		30	100	
		1mA ≤ I_O ≤ 40mA		10	50	
I_Q	Quiescent Current			3	5	mA
ΔI_Q	Quiescent Current Change	16V ≤ V_{IN} ≤ 27V			**1**	
		1mA ≤ I_O ≤ 40mA			**0.1**	
V_n	Output Noise Voltage			80		μV

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$\frac{\Delta V_{IN}}{\Delta V_{OUT}}$	Ripple Rejection	f = 120 Hz 15V ≤ V_{IN} ≤ 25	40	54		dB
I_{PK}	Peak Output Current			140		mA
$\frac{\Delta V_O}{\Delta T}$	Average Output Voltage Tempco	I_O = 5mA		−1.0		mV/°C
V_{IN} (Min)	Minimum Value of Input Voltage Required to Maintain Line Regulation			13.7	14.5	V

LM78L15AC

Unless otherwise specified, V_{IN} = 23V

Symbol	Parameter	Conditions	Min	Typ	Max	Units
V_O	Output Voltage		14.4	15.0	15.6	V
		17.5V ≤ V_{IN} ≤ 30V 1mA ≤ I_O ≤ 40mA (Note 3)	**14.25**		**15.75**	
		1mA ≤ I_O ≤ 70mA (Note 3)	**14.25**		**15.75**	
ΔV_O	Line Regulation	17.5V ≤ V_{IN} ≤ 30V		37	250	mV
		20V ≤ V_{IN} ≤ 30V		25	140	
ΔV_O	Load Regulation	1mA ≤ I_O ≤ 100mA		35	150	
		1mA ≤ I_O ≤ 40mA		12	75	
I_Q	Quiescent Current			3	5	mA
ΔI_Q	Quiescent Current Change	20V ≤ V_{IN} ≤ 30V			**1**	
		1mA ≤ I_O ≤ 40mA			**0.1**	
V_n	Output Noise Voltage			90		μV
$\frac{\Delta V_{IN}}{\Delta V_{OUT}}$	Ripple Rejection	f = 120 Hz 18.5V ≤ V_{IN} ≤ 28.5V	37	51		dB
I_{PK}	Peak Output Current			140		mA
$\frac{\Delta V_O}{\Delta T}$	Average Output Voltage Tempco	I_O = 5mA		−1.3		mV/°C
V_{IN} (Min)	Minimum Value of Input Voltage Required to Maintain Line Regulation			16.7	17.5	V

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Electrical specifications do not apply when operating the device outside of its stated operating conditions.

Note 2: Human body model, 1.5 kΩ in series with 100pF.

Note 3: Power dissipation ≤ 0.75W.

Note 4: Recommended minimum load capacitance of 0.01μF to limit high frequency noise.

Note 5: Typical thermal resistance values for the packages are:

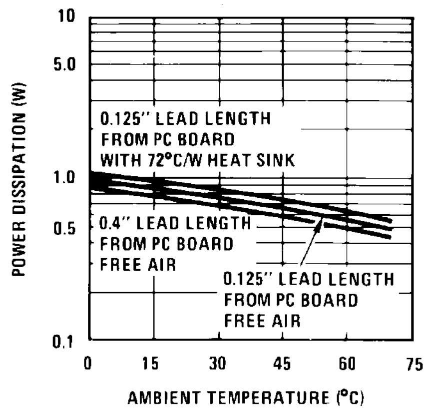
Z Package: θ_{JC} = 60 °C/W, = θ_{JA} = 230 °C/W

M Package: θ_{JA} = 180 °C/W

micro SMD Package: θ_{JA} = 230.9°C/W

Typical Performance Characteristics

Maximum Average Power Dissipation (Z Package)



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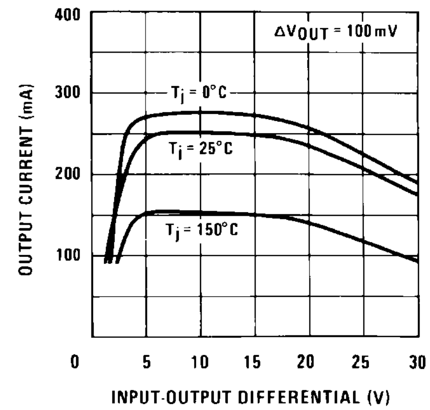
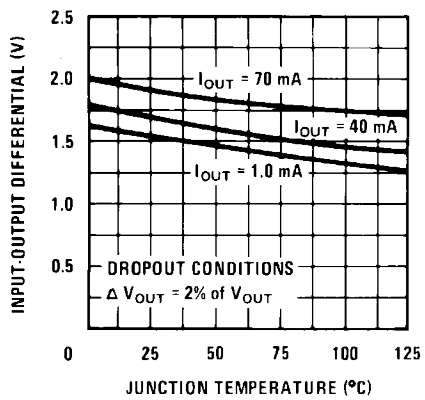
Peak Output Current



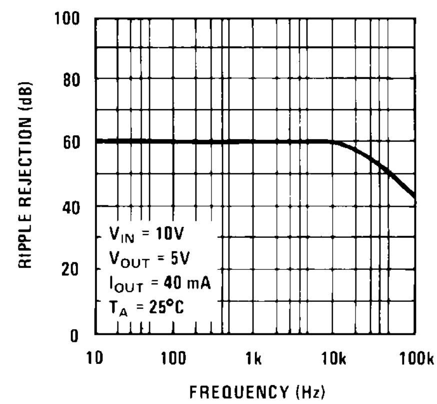
774416

Dropout Voltage



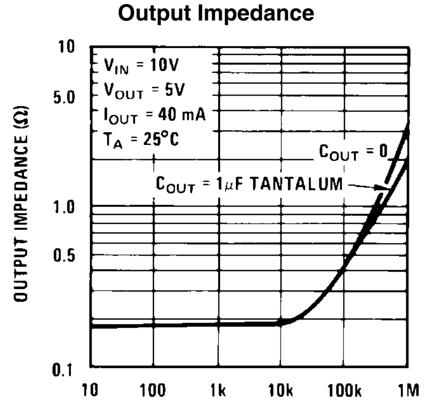
774417

Ripple Rejection



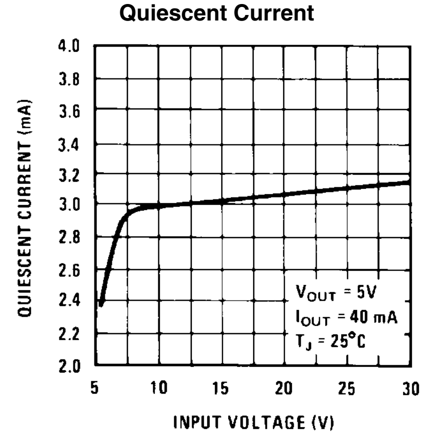
774418

Output Impedance



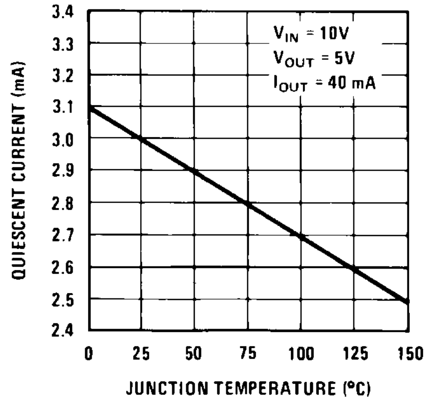
774419

Quiescent Current



774420

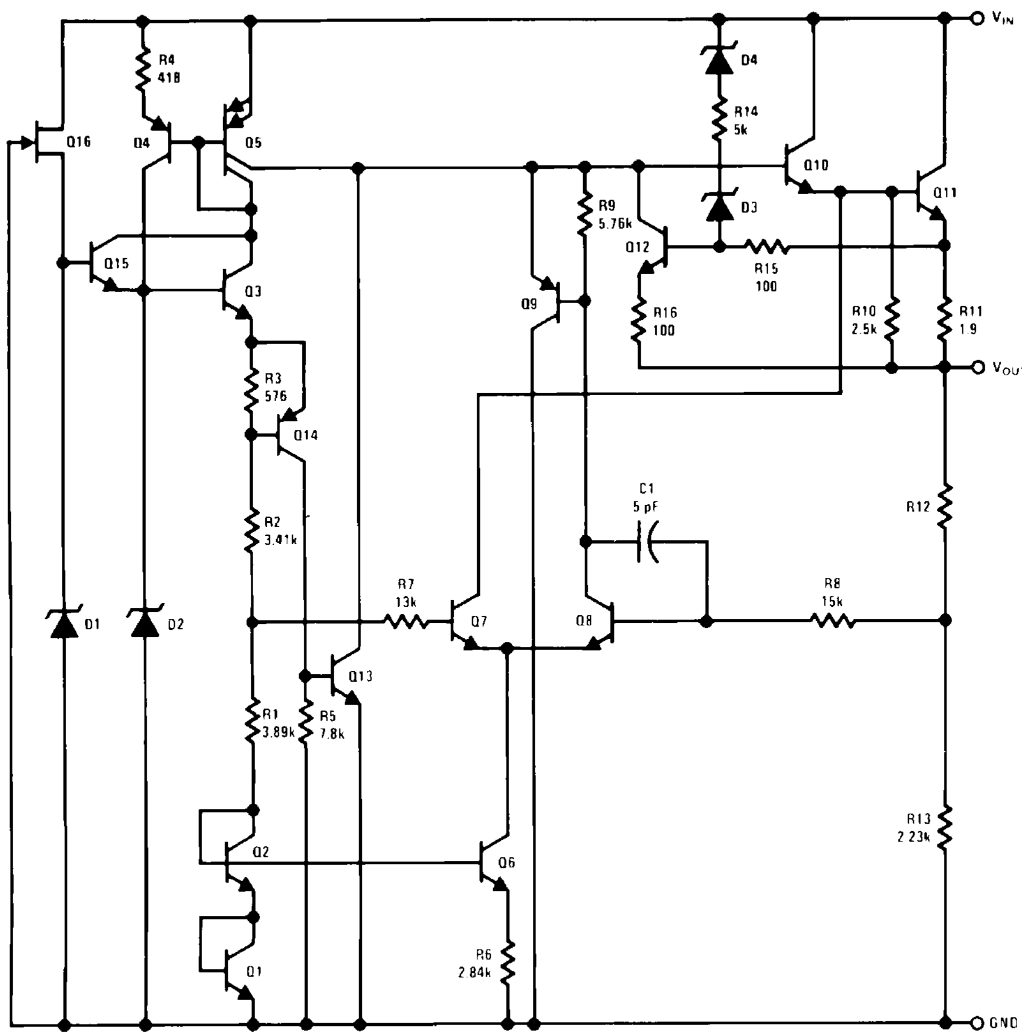
Quiescent Current



774421

Equivalent Circuit

LM78LXX



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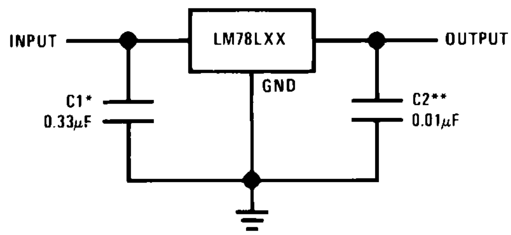
Typical Applications

Fixed Output Regulator



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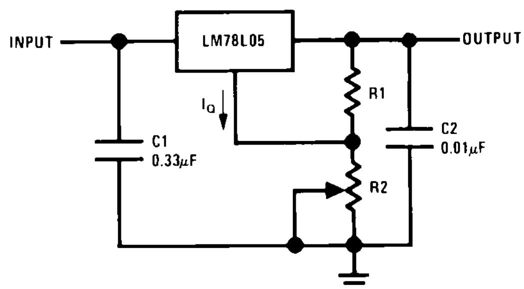
*Required if the regulator is located more than 3″ from the power supply filter.

**See (*Note 4*) in the electrical characteristics table.

Adjustable Output Regulator



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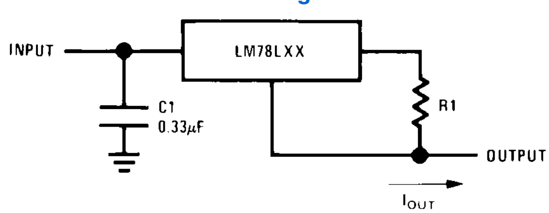
$V_{OUT} = 5V + (5V/R1 + I_Q)\ R2$

$5V/R1 > 3\ I_Q$, load regulation $(L_r) \approx [(R1 + R2)/R1]\ (L_r$ of LM78L05)

Current Regulator



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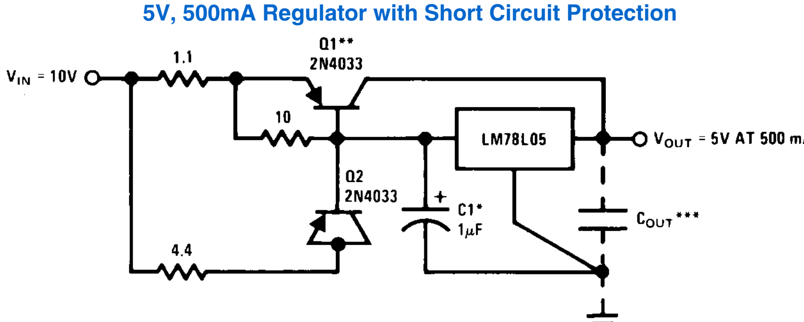
$I_{OUT} = (V_{OUT}/R1) + I_Q$

$>I_Q = 1.5mA$ over line and load changes

5V, 500mA Regulator with Short Circuit Protection



774411

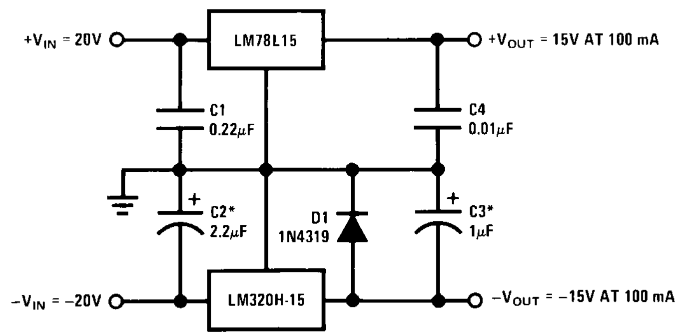
*Solid tantalum.

**Heat sink Q1.

***Optional: Improves ripple rejection and transient response.

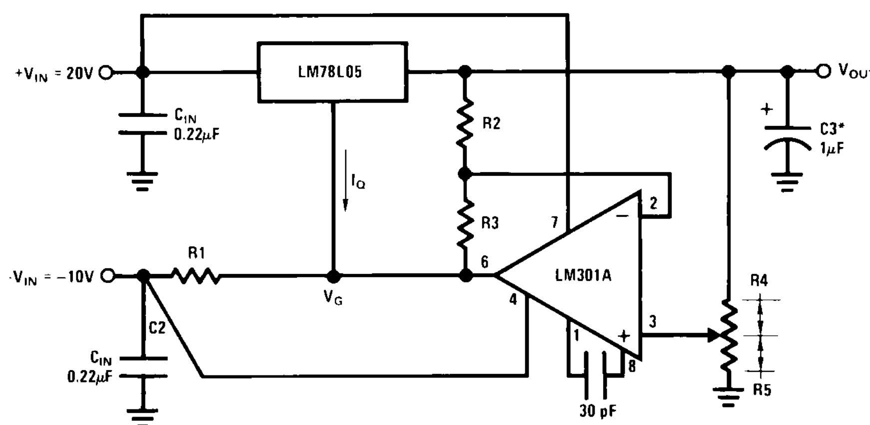
Load Regulation: 0.6% $0 \leq I_L \leq 250mA$ pulsed with $t_{ON} = 50ms$.

±15V, 100mA Dual Power Supply



*Solid tantalum.

Variable Output Regulator 0.5V-18V



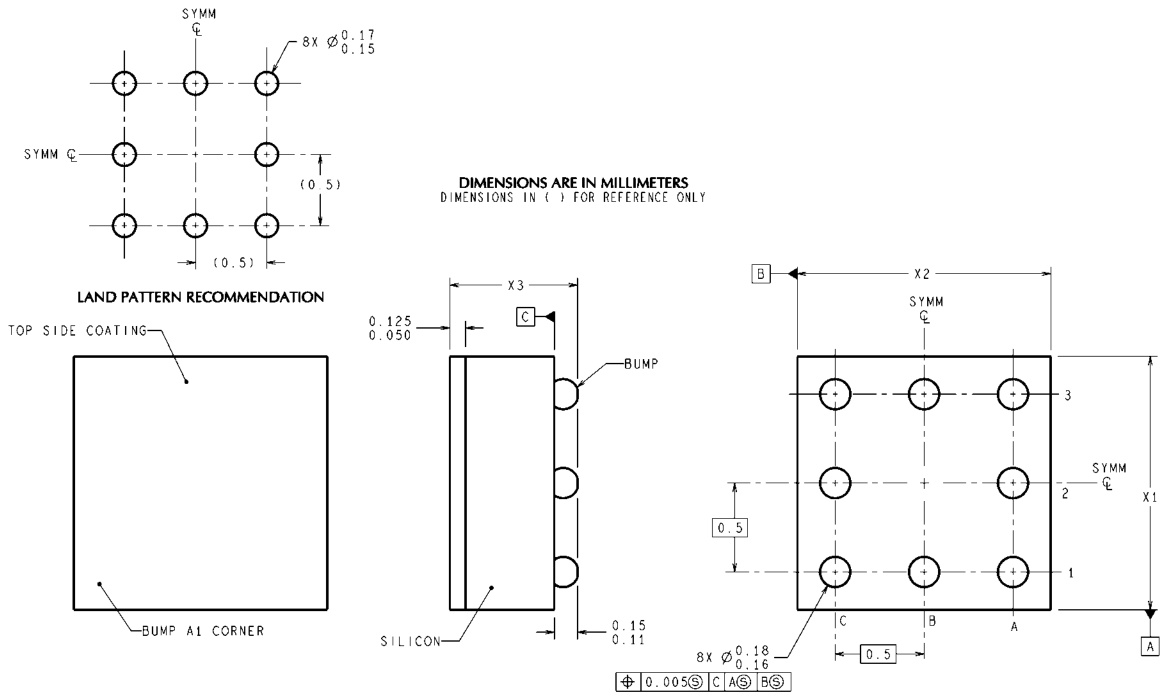
*Solid tantalum.

$V_{OUT} = V_G + 5V$, $R1 = (-V_{IN}/I_{Q\ LM78L05})$

$V_{OUT} = 5V\ (R2/R4)$ for $(R2 + R3) = (R4 + R5)$

A 0.5V output will correspond to $(R2/R4) = 0.1$ $(R3/R4) = 0.9$

Physical Dimensions inches (millimeters) unless otherwise noted

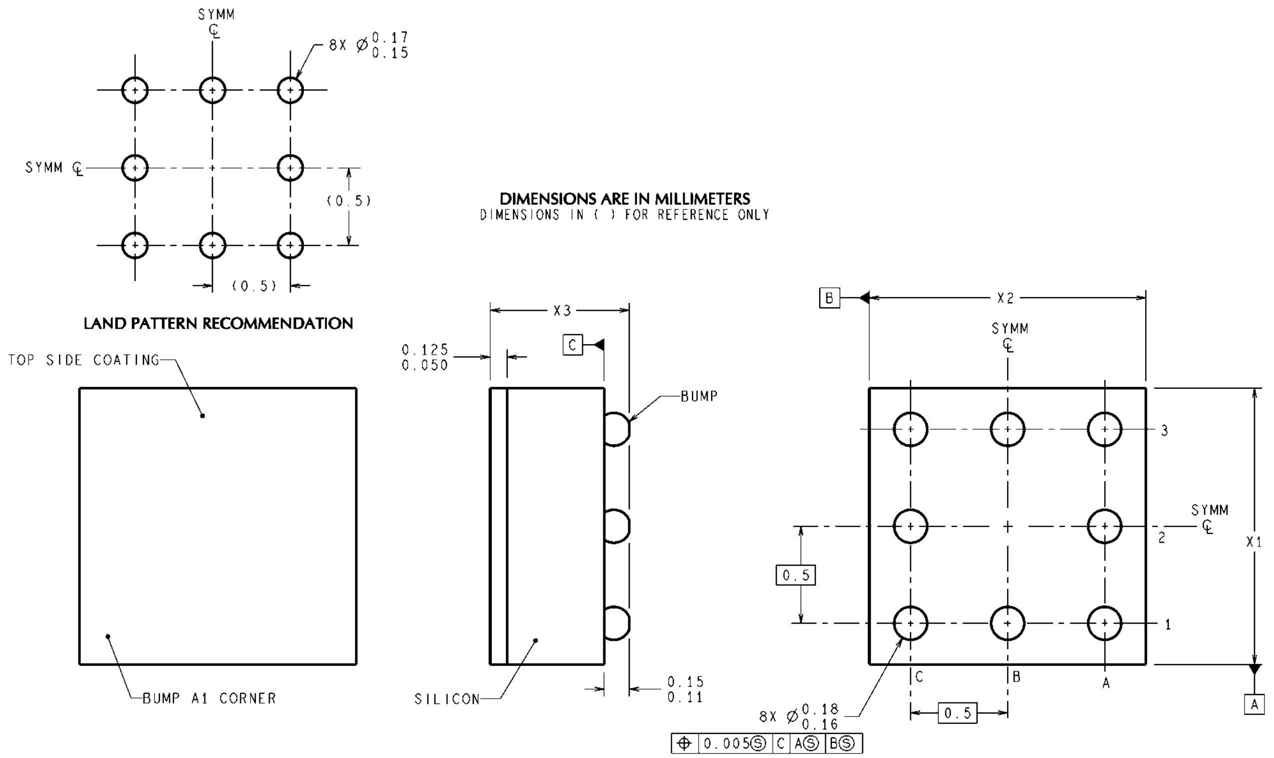


BPA08XXX (Rev D)

NOTES: UNLESS OTHERWISE SPECIFIED

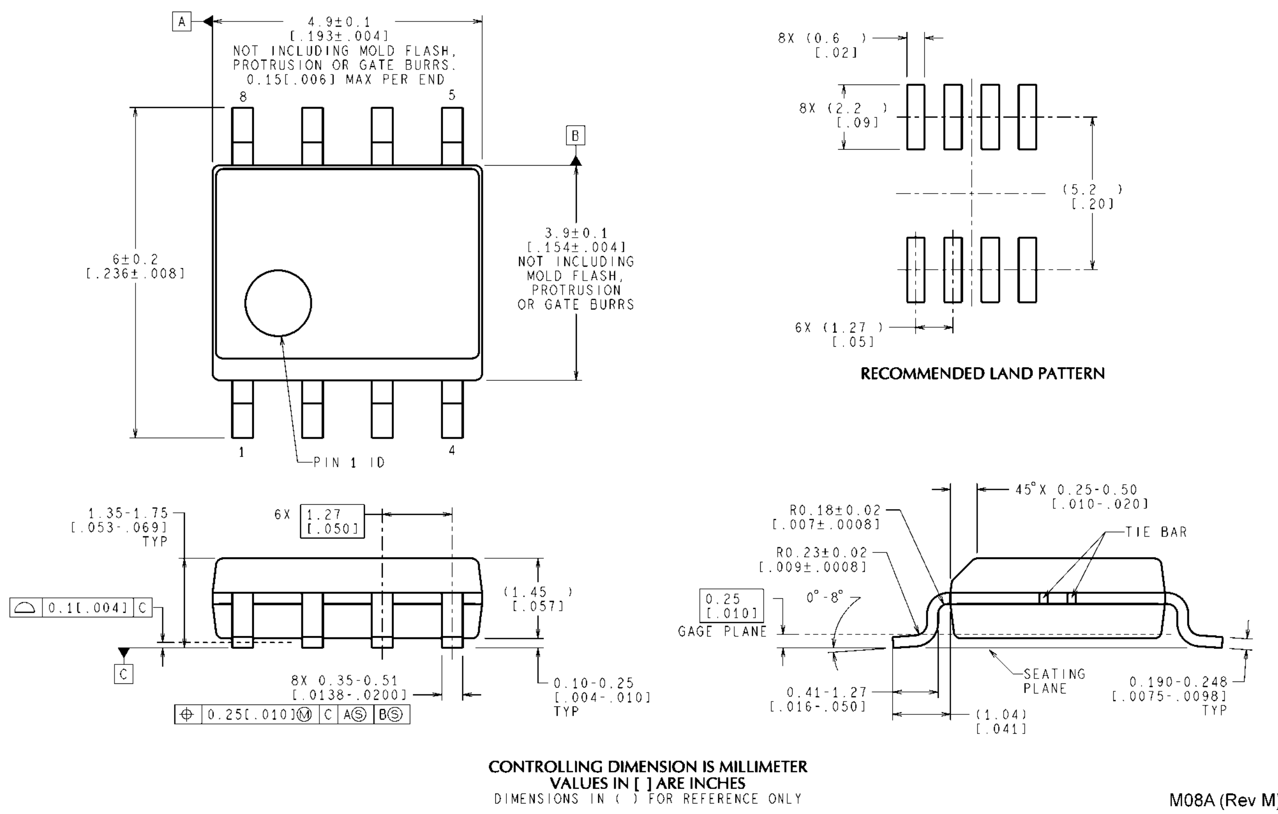
1. EPOXY COATING
2. 63Sn/37Pb EUTECTIC BUMP
3. RECOMMEND NON-SOLDER MASK DEFINED LANDING PAD.
4. PIN A1 IS ESTABLISHED BY LOWER LEFT CORNER WITH RESPECT TO TEXT ORIENTATION. REMAINING PINS ARE NUMBERED COUNTERCLOCKWISE.
5. XXX IN DRAWING NUMBER REPRESENTS PACKAGE SIZE VARIATION WHERE X_1 IS PACKAGE WIDTH, X_2 IS PACKAGE LENGTH AND X_3 IS PACKAGE HEIGHT.
6. REFERENCE JEDEC REGISTRATION MO-211, VARIATION BC.

8-Bump micro SMD
NS Package Number BPA08AAB
X1 = 1.285mm X2 = 1.285mm X3 = 0.850mm



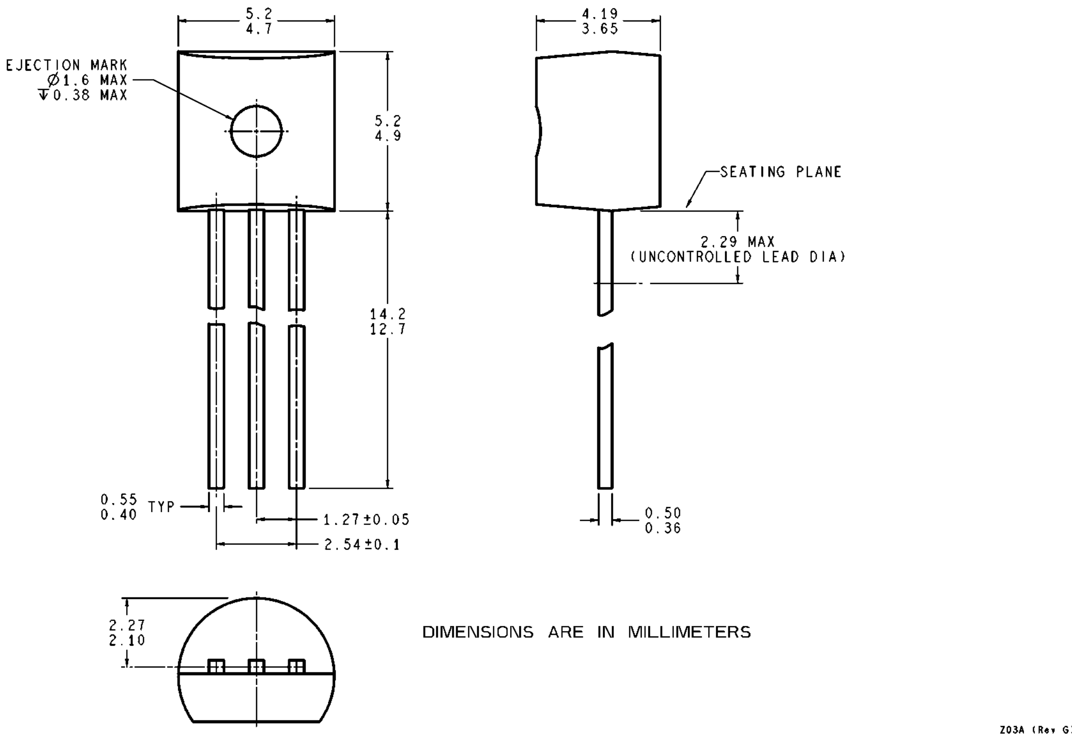
TPA08XXX (Rev B)

8-Bump Thin micro SMD
NS Package Number TPA08AAA
X1 = 1.285mm X2 = 1.285mm X3 = 0.500mm



M08A (Rev M)

S.O. Package (M)
NS Package Number M08A



Molded Offset TO-92 (Z)
NS Package Number Z03A

Notes

For more National Semiconductor product information and proven design tools, visit the following Web sites at: www.national.com

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Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265

Drop-In

Monolithic Amplifier DC-1 GHz

Product Features

- Wideband, DC to 1 GHz
- High gain, 17.8 dB typ. at 0.1 GHz
- Low noise figure, 3.5 dB typ.
- Exact foot print substitute for MSA-0185
- Low current, 17mA
- Cascadable, unconditionally stable
- Aqueous washable
- Protected by US Patent 6,943,629

Typical Applications

- Cellular
- PCN instrumentation

MAR-1+

CASE STYLE: VV105
PRICE: $0.99 ea. QTY. (30)

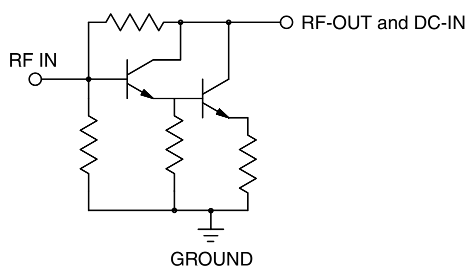
+ RoHS compliant in accordance with EU Directive (2002/95/EC)

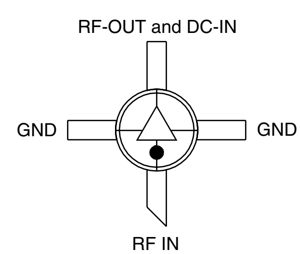
The +Suffix has been added in order to identify RoHS Compliance. See our web site for RoHS Compliance methodologies and qualifications.

General Description

MAR-1+ (RoHS compliant) is a wideband amplifier offering high dynamic range. It has repeatable performance from lot to lot. It is enclosed in a Micro-X package. MAR-1+ uses Darlington configuration and is fabricated using InGaP HBT technology. Expected MTBF is 15,000 years at 85°C case temperature.

simplified schematic and pin description





Function	Pin Number	Description
RF IN	1	RF input pin. This pin requires the use of an external DC blocking capacitor chosen for the frequency of operation.
RF-OUT and DC-IN	3	RF output and bias pin. DC voltage is present on this pin; therefore a DC blocking capacitor is necessary for proper operation. An RF choke is needed to feed DC bias without loss of RF signal due to the bias connection, as shown in “Recommended Application Circuit”.
GND	2,4	Connections to ground. Use via holes as shown in “Suggested Layout for PCB Design” to reduce ground path inductance for best performance.

Electrical Specifications at 25°C and 17mA, unless noted

Parameter		Min.	Typ.[3]	Max.	Units
Frequency Range*		DC		1	GHz
Gain	f=0.1 GHz f=1 GHz	 15[2]	17.8 16.5		dB
Input Return Loss	f=DC to 1 GHz		17.5		dB
Output Return Loss	f=DC to 1 GHz		21		dB
Output Power @ 1 dB compression	f=0.5 GHz		+2.5		dBm
Output IP3	f=0.5 GHz		+14		dBm
Noise Figure	f=0.5 GHz		3.3		dB
Recommended Device Operating Current			17		mA
Device Operating Voltage			5.0		V
Thermal Resistance, junction-to-case[1]			203		°C/W

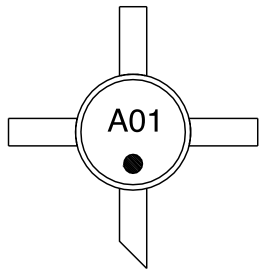
*Guaranteed specification DC-1 GHz. Low frequency cut off determined by external coupling capacitors.

Absolute Maximum Ratings

Parameter	Ratings
Operating Temperature	-40°C to 85°C
Storage Temperature	-55°C to 100°C
Operating Current	40mA
Power Dissipation	200mW
Input Power	13dBm

Note: Permanent damage may occur if any of these limits are exceeded.
These ratings are not intended for continuous normal operation.
[1]Case is defined as ground leads.
[2]Full temperature range.
[3]Based on test data of Model MAR-1SM+ (Case Style WW107).

Product Marking



Additional Detailed Technical Information

Additional information is available on our web site. To access this information enter the model number on our web site home page.

Performance data, graphs, s-parameter data set (.zip file)

Case Style: VV105

Plastic micro-x, .085 body diameter, lead finish: tin/silver/nickel

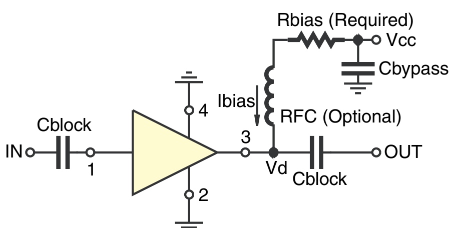
Tape & Reel: F20

Suggested Layout for PCB Design: PL-262

Evaluation Board: TB-432-1+

Environmental Ratings: ENV08T3

Recommended Application Circuit



Test Board includes case, connectors, and components (in bold) soldered to PCB

R BIAS	
Vcc	**“1%” Res. Values (ohms) for Optimum Biasing**
7	118
8	178
9	237
10	294
11	357
12	412
13	464
14	536
15	590

ESD Rating

Human Body Model (HBM): Class 1B (500v to < 1000v) in accordance with ANSI/ESD STM 5.1 - 2001

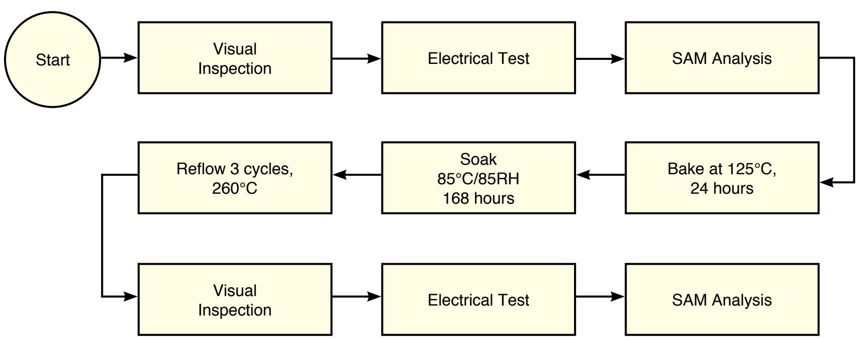
Machine Model (MM): Class M1 (< 100v) in accordance with ANSI/ESD STM 5.2 - 1999

MSL Rating

Moisture Sensitivity: MSL1 in accordance with IPC/JEDEC J-STD-020C

No.	Test Required	Condition	Standard	Quantity
1	Visual Inspection	Low Power Microscope Magnification 40x	MIP-IN-0003 (MCT spec)	45 units
2	Electrical Test	Room Temperature	SCD (MCL spec)	45 units
3	SAM Analysis	Less than 10% growth in term of delamination	J-Std-020C (Jedec Standard)	45 units
4	Moisture Sensitivity Level 1	Bake at 125°C for 24 hours Soak at 85°C/85%RH for 168 hours Reflow 3 cycles at 260°C peak	J-Std-020C (Jedec Standard)	45 units

MSL Test Flow Chart



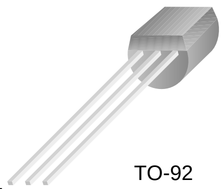
FAIRCHILD
SEMICONDUCTOR®

July 2007

MPSA13

NPN Darlington Transistor

- This device is designed for applications requiring extremely high Current gain at collector Currents to 1.0A.
- Sourced from process 05.



1 TO-92

1. Emitter 2. Base 3. Collector

Absolute Maximum Ratings T_a = 25°C unless otherwise noted

Symbol	Parameter	Value	Units
V_{CES}	Collector-Emitter Voltage	30	V
V_{CBO}	Collector-Base Voltage	30	V
V_{EBO}	Emitter-Base Voltage	10	V
I_C	Collector Current - Continuous	1.2	A
T_J, T_{STG}	Operating and Storage Junction Temperature Range	-55 to +150	°C

Electrical Characteristics T_a=25°C unless otherwise noted

Symbol	Parameter	Test Condition	Min.	Max.	Units
Off Characteristics					
$V_{(BR)CES}$	Collector-Emitter Breakdown Voltage	I_C = 100μA, I_B = 0	30		V
I_{CBO}	Collector-Cutoff Current	V_{CB} = 30V, I_E = 0		100	nA
I_{EBO}	Emitter-Cutoff Current	V_{EB} = 10V, I_C = 0		100	nA
On Characteristics *					
h_{FE}	DC Current Gain	V_{CE} = 5.0V, I_C =10mA V_{CE} = 5.0, I_C = 100mA	5,000 10,000		
$V_{CE\ (sat)}$	Collector-Emitter Saturation Voltage	I_C = 100mA, I_B = 0.1mA		1.5	V
$V_{BE\ (on)}$	Base-Emitter On Voltage	I_C = 100mA,V_{CE} = 5.0V		2.0	V
Small Signal Characteristics					
f_T	Current Gain Bandwidth Product	I_C = 10mA, V_{CE} = 10V, f = 100MHz	125		pF

* Pulse Test: Pulse Width≤300μs, Duty Cycle≤2%

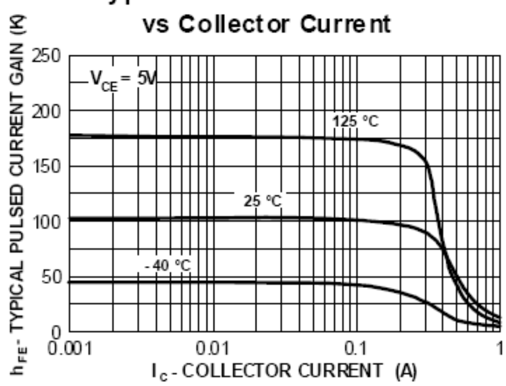
Thermal Characteristics T_a=25°C unless otherwise noted

Symbol	Parameter	Max.	Units
P_D	Total Device Dissipation Derate above 25°C	625 5.0	mW mW/°C
$R_{\theta JC}$	Thermal Resistance, Junction to Case	83.3	°C/W
$R_{\theta JA}$	Thermal Resistance, Junction to Ambient	200	°C/W

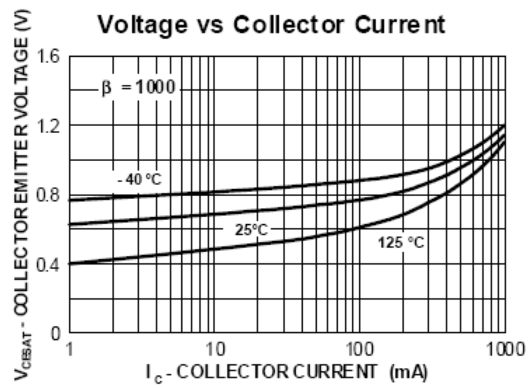
* Device mounted on FR-4PCB 1.6" × 1.6" × 0.06".

Typical Characteristics

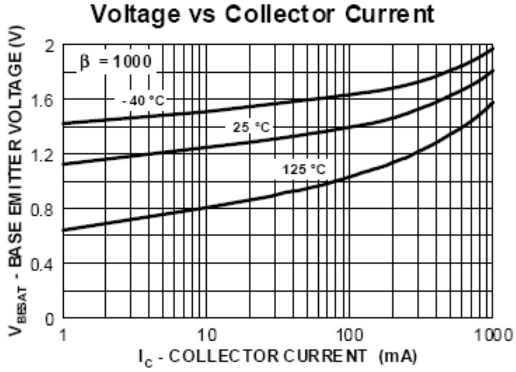
Typical Pulsed Current Gain vs Collector Current



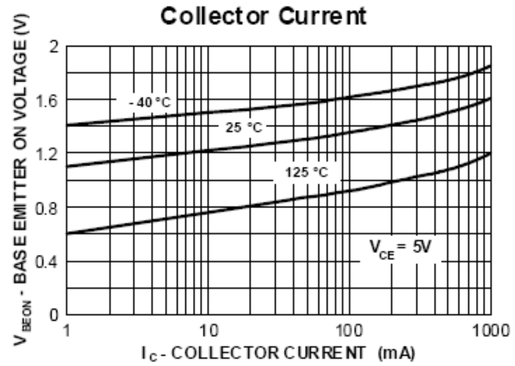
Collector-Emitter Saturation Voltage vs Collector Current



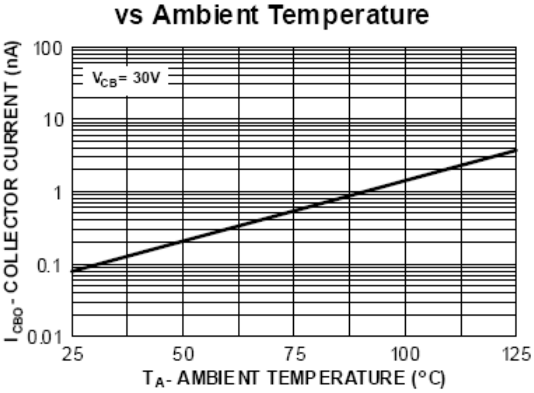
Base-Emitter Saturation Voltage vs Collector Current



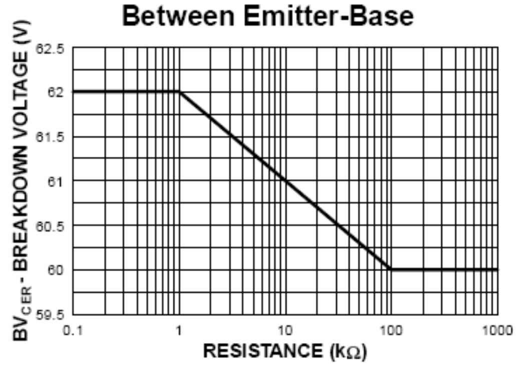
Base Emitter ON Voltage vs Collector Current



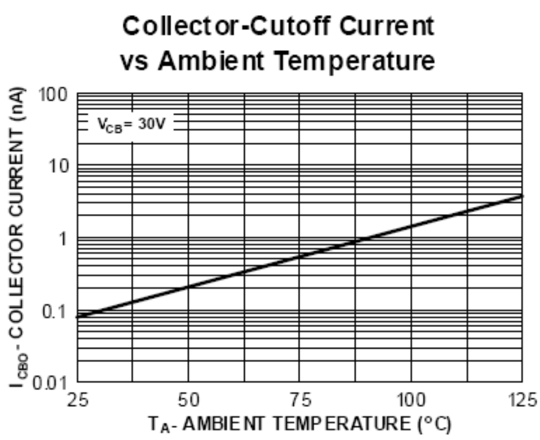
Collector-Cutoff Current vs Ambient Temperature

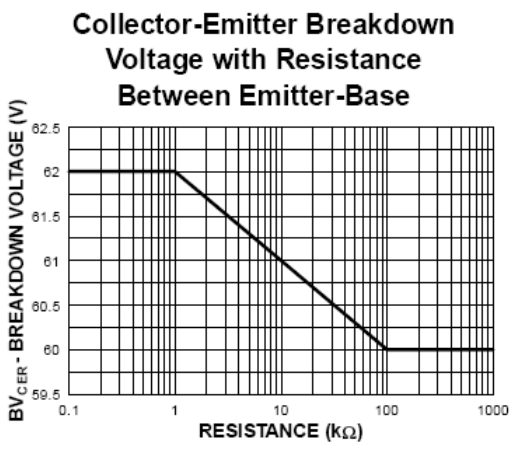


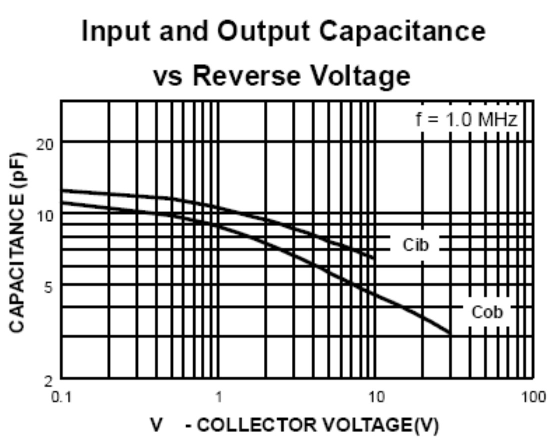
Collector-Emitter Breakdown Voltage with Resistance Between Emitter-Base

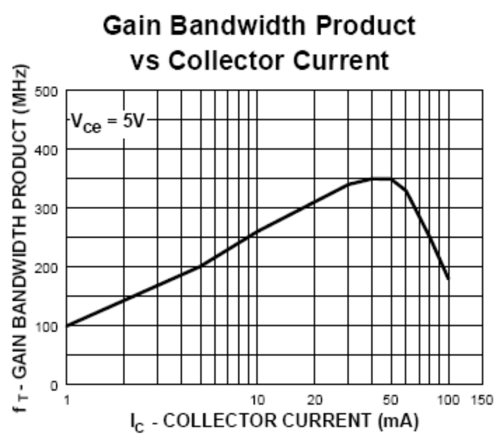


Typical Characteristics (continued)



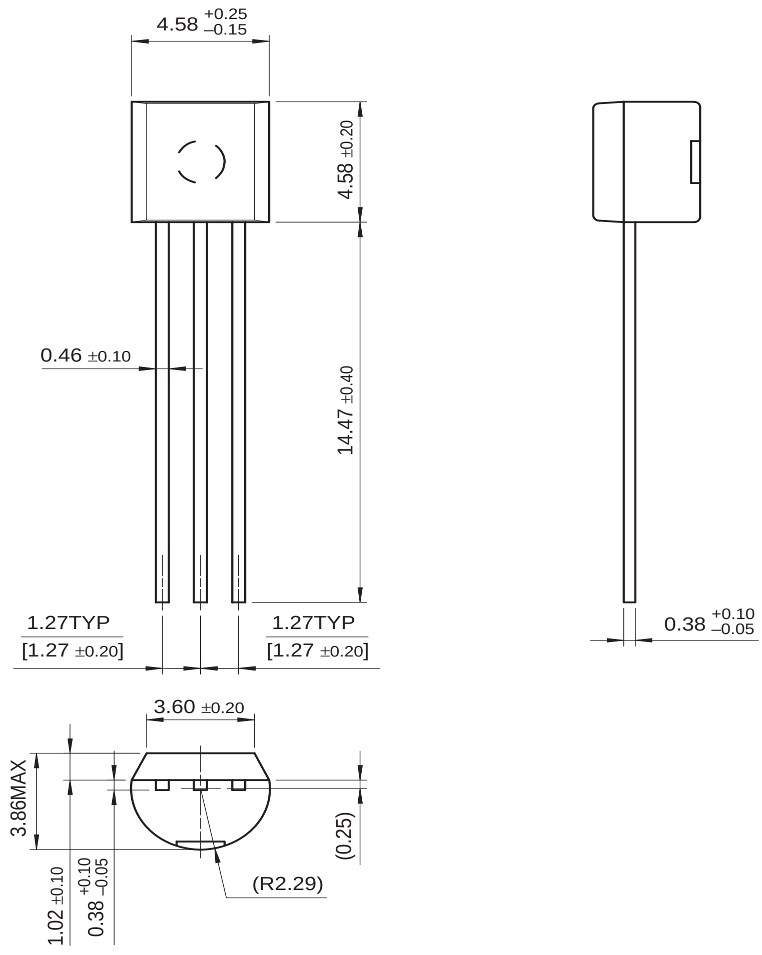






Mechanical Dimensions

TO-92



Dimensions in Millimeters

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No Identification Needed	Full Production	This datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve design.
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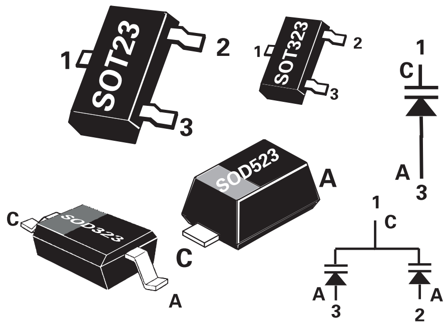
Rev. I25

SILICON 28V HYPERABRUPT VARACTOR DIODES

ZC829, ZDC833, ZMV829, ZMDC830, ZV831 Series



Device Description

A range of silicon varactor diodes for use in frequency control and filtering. Featuring closely controlled CV characteristics and high Q. Low reverse current ensures very low phase noise performance. Available in single or dual common cathode format in a wide rage of miniature surface mount packages.

Features

- Close tolerance C-V characteristics
- High tuning ratio
- Low I_R (typically 200pA)
- Excellent phase noise performance
- High Q
- Range of miniature surface mount packages

Applications

- VCXO and TCXO
- Wireless communications
- Pagers
- Mobile radio

*Where steeper CV slopes are required there is the 12V hyperabrupt range.

ZC930, ZMV930, ZV930, ZV931 Series

830 series

TUNING CHARACTERISTICS at Tamb = 25°C

PART	Capacitance (pF) V_R=2V, f=1MHz			Min Q V_R=3V f=50MHz	Capacitance Ratio C_2 / C_{20} at f=1MHz	
	MIN.	NOM.	MAX.		MIN.	MAX.
829A	7.38	8.2	9.02	250	4.3	5.8
829B	7.79	8.2	8.61	250	4.3	5.8
830A	9.0	10.0	11.0	300	4.5	6.0
830B	9.5	10.0	10.5	300	4.5	6.0
831A	13.5	15.0	16.5	300	4.5	6.0
831B	14.25	15.0	15.75	300	4.5	6.0
832A	19.8	22.0	24.2	200	5.0	6.5
832B	20.9	22.0	23.1	200	5.0	6.5
833A	29.7	33.0	36.3	200	5.0	6.5
833B	31.35	33.0	34.65	200	5.0	6.5
834A	42.3	47.0	51.7	200	5.0	6.5
834B	44.65	47.0	49.35	200	5.0	6.5
835A	61.2	68.0	74.8	100	5.0	6.5
835B	64.6	68.0	71.4	100	5.0	6.5
836A	90.0	100.0	110.0	100	5.0	6.5
836B	95.0	100.0	105.0	100	5.0	6.5

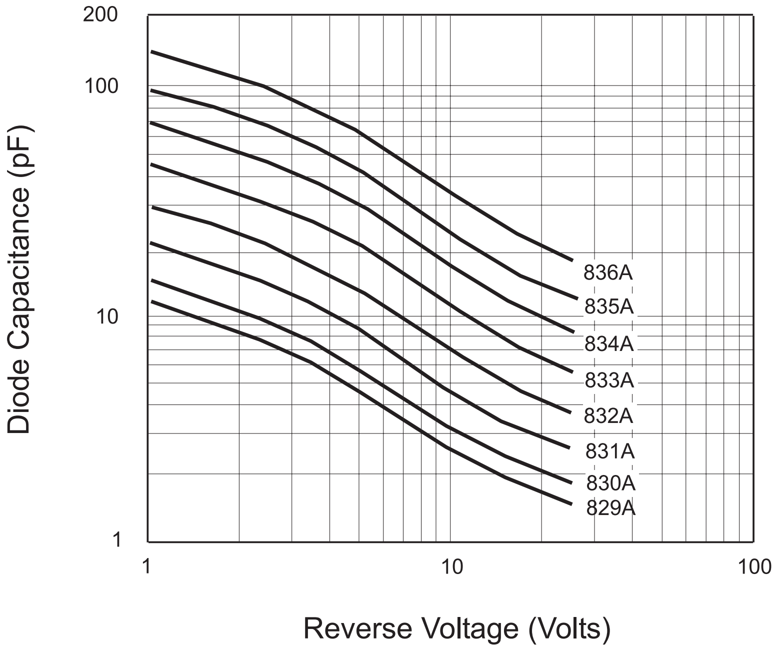
ABSOLUTE MAXIMUM RATINGS

PARAMETER	SYMBOL	MAX	UNIT
Forward current	I_F	200	mA
Power dissipation at T_{amb} = 25°C SOT23	P_{tot}	330	mW
Power dissipation at T_{amb} = 25°C SOD323	P_{tot}	330	mW
Power dissipation at T_{amb} = 25°C SOD523	P_{tot}	250	mW
Operating and storage temperature range		-55 to +150	°C

ELECTRICAL CHARACTERISTICS at Tamb = 25°C

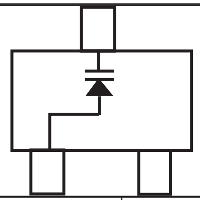
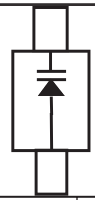
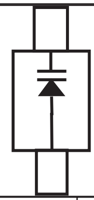
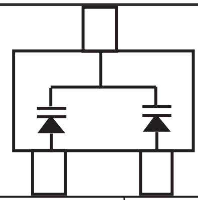
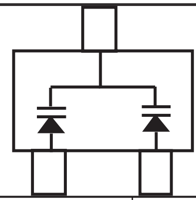
PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
Reverse breakdown voltage	I_R = 10uA	25			V
Reverse voltage leakage	V_R = 20V		0.2	20	nA
Temperature coefficient of capacitance	V_R = 3V, f = 1MHz		300	400	ppCm/°C

TYPICAL CHARACTERISTICS



Diode Capacitance

ORDER CODES AND PART MARKING

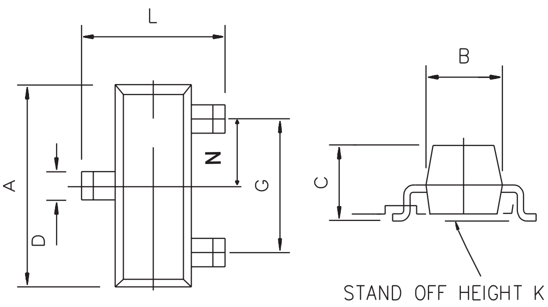
SOT23		SOD323		SOD523		SOT23		SOT323	
									
ORDER CODE	PART MARK	ORDER CODE	PART MARK	ORDER CODE	PART MARK	ORDER CODE	PART MARK	ORDER CODE	PART MARK
ZC829ATA	J9A	ZMV829ATA	AA						
ZC829BTA	J9B	ZMV829BTA	CA						
ZC830ATA	J1A	ZMV830ATA	AB						
ZC830BTA	J1B	ZMV830BTA	CB						
ZC831ATA	J3A	ZMV831ATA	AC						
ZC831BTA	J3B	ZMV831BTA	CC	ZV831BV2TA	81			ZMDC831BTA	CC
ZC832ATA	J4A	ZMV832ATA	AD						
ZC832BTA	J4B	ZMV832BTA	CD	ZV832BV2TA	82			ZMDC832BTA	CD
ZC833ATA	J2A	ZMV833ATA	AE			ZDC833ATA	C2A		
ZC833BTA	J2B	ZMV833BTA	CE						
ZC834ATA	J5A	ZMV834ATA	AF			ZDC834ATA	C5A		
ZC834BTA	J5B	ZMV834BTA	CF						
ZC835ATA	J6A	ZMV835ATA	AG						
ZC835BTA	J6B	ZMV835BTA	CG						
ZC836ATA	J7A								
ZC836BTA	J7B								

TAPE AND REEL INFORMATION

The order codes are shown as TA which is for 7 inch reels. For 13 inch reels substitute TC in place of TA in the order code.

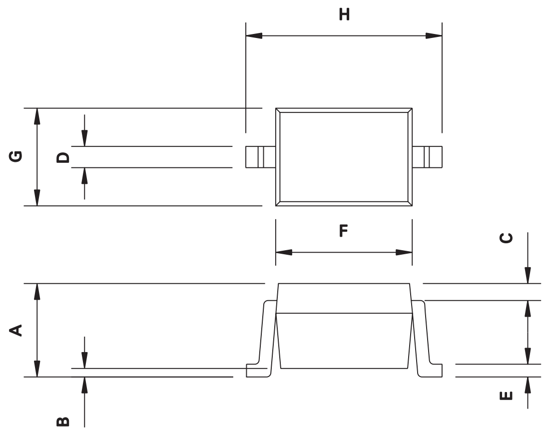
REEL CODE	REEL SIZE	TAPE WIDTH	QUANTITY PER REEL
TA	7 inch (180mm)	8mm	3000
TC	13 inch (330mm)	8mm	10000

SOT23 PACKAGE DIMENSIONS



DIM	Millimetres		Inches	
	Min	Max	Min	Max
A	2.67	3.05	0.105	0.120
B	1.20	1.40	0.047	0.055
C	–	1.10	–	0.043
D	0.37	0.53	0.0145	0.021
F	0.085	0.15	0.0033	0.0059
G	NOM 1.9		NOM 0.075	
K	0.01	0.10	0.0004	0.004
L	2.10	2.50	0.0825	0.0985
N	NOM 0.95		NOM 0.037	

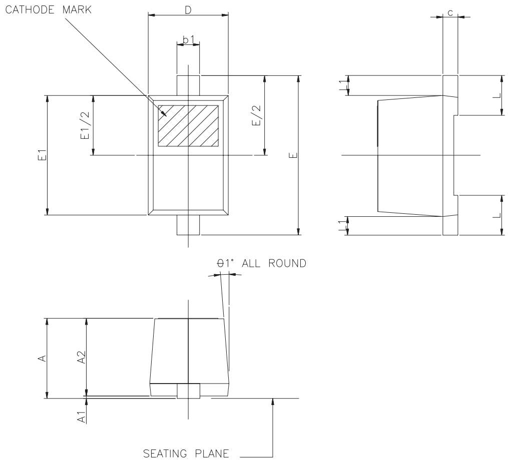
SOD323 PACKAGE DIMENSIONS



DIM	**Millimetres**		**Inches**	
	MIN	**MAX**	**MIN**	**MAX**
A	0.91	1.16	0.036	0.046
B	0.0	0.1	0.0	0.004
D	0.33	0.4	0.013	0.016
E	0.127	0.2	0.005	0.008
F	1.52	1.77	0.060	0.070
G	1.11	1.37	0.044	0.054
H	2.46	2.71	0.097	0.107

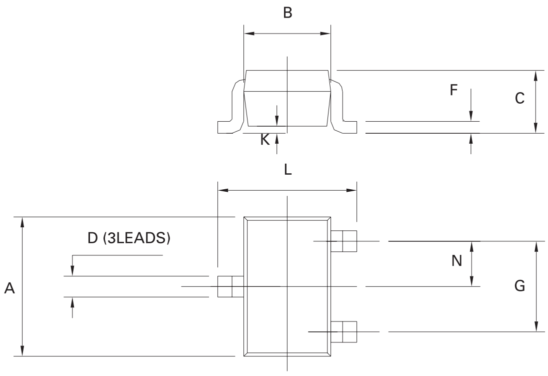
830 series

SOD523 PACKAGE DIMENSIONS



DIM	MILLIMETRES	
	MIN.	MAX
A	—	0.800
A1	0.000	0.100
A2	0.600	0.800
b1	0.160	0.300
c	0.080	0.220
D	0.700	0.900
E	1.500	1.700
E1	1.100	1.300
L	0.200	0.400
L1	0.170	0.230
Θ1°	4°	10°

SOD323 PACKAGE DIMENSIONS



DIM	Millimetres		Inches	
	MIN	MAX	MIN	MAX
A	1.8	2.2	0.071	0.087
B	1.15	1.35	0.045	0.053
C	0.8	1.0	0.031	0.039
D	0.2	0.4	0.008	0.016
F	0.1	0.25	0.004	0.01
G	1.2	1.4	0.047	0.055
K	—	0.1	—	0.004
L	2.0	2.2	0.079	0.087
N	0.60	0.70	0.023	0.028

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Wireless Audio Link IC

BH1417F

The BH1417F is a FM stereo transmitter IC that transmits simple configuration. The IC consists of a stereo modulator for generating stereo composite signals and a FM transmitter for broadcasting a FM signal on the air. The stereo modulator generates a composite signal which consists of the MAIN, SUB, and pilot signal from a 38kHz oscillator.
The FM transmitter radiates FM wave on the air by modulating the carrier signal with a composite signal.
Frequency is set for North America.

●Applications

Wireless speakers, Personal computer(sound board), Game machine, CD changer, Car TV, Car navigation

●Features

1) It is possible to improve the timbre because it has the pre-emphasis circuit, limiter circuit, and the low-pass filter circuit.
2) Built-in pilot-tone system FM stereo modulator circuit.
3) The transmission frequency is stable because it has a PLL system FM transmitter circuit.
4) PLL controls data input in parallel (4bits, 14ch for North America).

●Absolute maximum ratings (Ta = 25°C, In measurement circuit.)

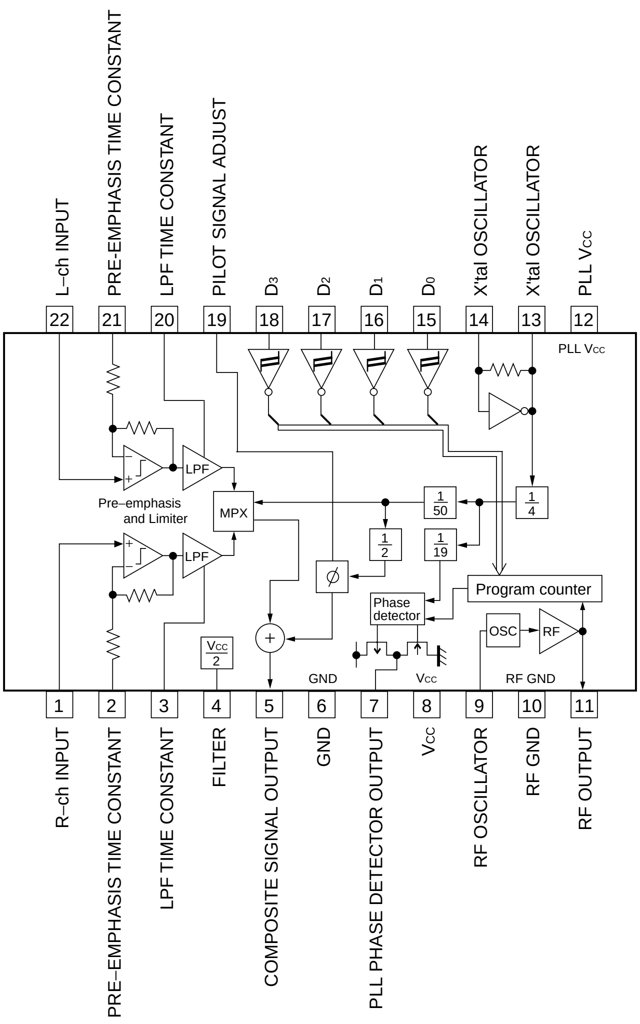
Parameter	Symbol	Limits	Unit	Conditions
Supply voltage	V_{CC}	+7.0	V	Pin8,12
Date input voltage	V_{IN-D}	–0.3~V_{CC}+0.3	V	Pin15,16,17,18
Phase comparator output voltage	V_{OUT-P}	–0.3~V_{CC}+0.3	V	Pin7
Power dissipation	Pd	450*	mW	
Storage temperature	Tstg	–55~+125	°C	

* Derating : 4.5mW/°C for operation above Ta=25°C.

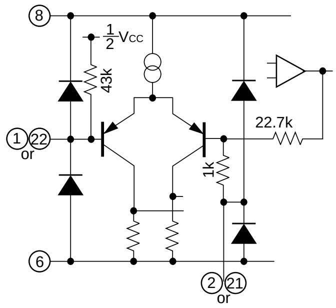
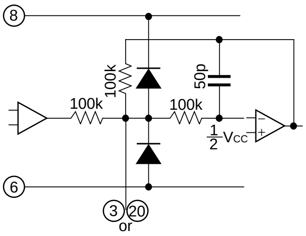
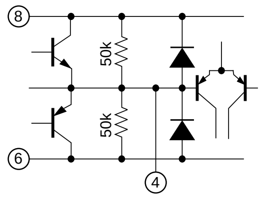
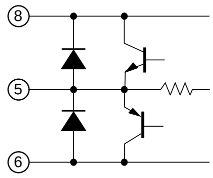
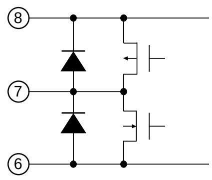
●Recommended operating conditions (Ta = 25°C)

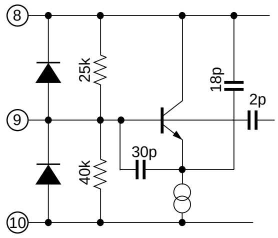
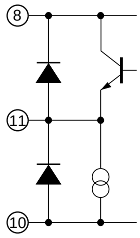
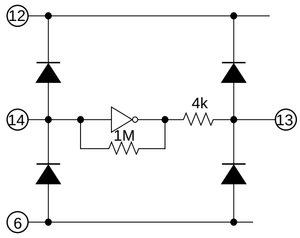
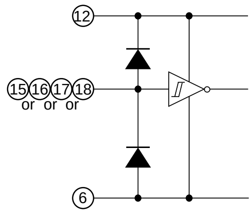
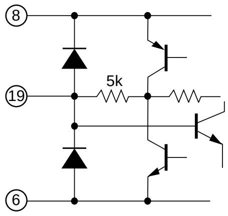
Parameter	Symbol	Min.	Typ.	Max.	Unit	Conditions
Operating supply voltage	V_{CC}	4.0	–	6.0	V	Pin8,12
Operating temperature	Topr	–40	–	+85	°C	
Audio input level	V_{IN-A}	–	–	–10	dBV	Pin1,22
Audio input frequency band	f_{IN-A}	20	–	15k	Hz	Pin1,22
Pre-emphasis time constant set up range	τ_{PRE}	–	–	155	µs	Pin2,21
Transmission frequency(200kHz step)	f_{TX}	87.7 106.7	–	88.9 107.9	MHz	Pin9,11
Control terminal "H" level input voltage	V_{IH}	0.8V_{CC}	–	V_{CC}	V	Pin15,16,17,18
Control terminal "L" level input voltage	V_{IL}	GND	–	0.2V_{CC}	V	Pin15,16,17,18

●**Block diagram**



●**Pin descriptions**

Pin No.	Pin descriptions	Equivalent circuit	DC (V)
1	R–ch audio source input terminal It cuts DC with the capacitor and it inputs R-ch audio signal.		$\frac{1}{2}V_{CC}$
22	L–ch audio source input terminal It cuts DC with the capacitor and it inputs L-ch audio signal.		
2,21	Pre-emphasis time constant terminal It connects a capacitor for the time constant of pre-emphasis. τ=22.7k$\Omega\times$C		$\frac{1}{2}V_{CC}$
3,20	LPF time constant terminal This is 15kHz LPF. It connects a 150pF capacitor.		$\frac{1}{2}V_{CC}$
4	Filter terminal It is a ripple filter for the reference voltage of the audio part.		$\frac{1}{2}V_{CC}$
5	Composite signal output terminal It connects to the FM modulator.		$\frac{1}{2}V_{CC}$
6	GND	———	GND
7	PLL phase detector output terminal It connects to the PLL LPF circuit.		—
8	Power supply terminal	———	V_{CC}

Pin No.	Pin descriptions	Equivalent circuit	DC (V)
9	RF oscillator terminal This is the base terminal of the colpitts oscillator. It connects time constant of the oscillation.		$\frac{4}{7}$Vcc
10	RF GND	——	GND
11	RF transmission output terminal It connects to the antenna through BPF.		Vcc −1.9
12	PLL power supply terminal	——	Vcc
13,14	X'tal oscillator terminal It connects a 7.6MHz crystal oscillator.		—
15	Parallel data set up terminal D_0		—
16	Parallel data set up terminal D_1		
17	Parallel data set up terminal D_2		
18	Parallel data set up terminal D_3		
19	Pilot signal adjust terminal		$\frac{1}{2}$Vcc

● **Electrical characteristics** (Unless otherwise noted, Ta = 25°C, V_{CC} = 5.0V Signal source : f_{IN} = 400Hz)

Parameter	Symbol	Min.	Typ.	Max.	Unit	Conditions	Measurement circuit
Quiescent current	I_Q	14	20	28	mA		Fig.1
Channel separation	Sep	25	40	—	dB	V_{IN}=–20dBV L→R,R→L	Fig.2
Total harmonic distortion	THD	—	0.1	0.3	%	V_{IN}=–20dBV L+R	Fig.3
Channel balance	C.B	–2	0	+2	dB	V_{IN}=–20dBV L+R	Fig.2
Input output gain	Gv	–2	0	+2	dB	V_{IN}=–20dBV L+R	Fig.3
Pilot modulation rate	M_P	12	15	18	%	V_{IN}=–20dBV,L+R Pin5	Fig.3
Sub carrier rejection ratio	SCR	—	–30	–20	dB	V_{IN}=–20dBV L+R	Fig.3
Pre-emphasis time constant	τ_{PRE}	40	50	60	µs	V_{IN}=–20dBV L+R	Fig.3
Limiter input level	$V_{IN(LIM)}$	–16	–13	–10	dBV	Output level at 1dB gain compression	Fig.4
LPF cut off frequency	$f_{C(LPF)}$	12	15	18	kHz	V_O=–3dB Pin2,21 Open	Fig.5
Transmission output level	V_{TX}	96	99	102	dBµV	f_{TX}=107.9MHz	Fig.6
"H" level input current	I_{IH}	—	—	1.0	µA	Pin15,16,17,18 V_{IN}=5V	Fig.7
"L" level input current	I_{IL}	–1.0	—	—	µA	Pin15,16,17,18 V_{IN}=0V	Fig.7
"H" level output voltage	V_{OH}	V_{CC}—1.0	V_{CC}—0.15	—	V	Pin7 I_{OUT}=–1.0mA	Fig.8
"L" level output voltage	V_{OL}	—	0.15	1.0	V	Pin7 I_{OUT}=1.0mA	Fig.8
"off" level leak current1	I_{OFF1}	—	—	100	nA	Pin7 V_{OUT}=5V	Fig.9
"off" level leak current2	I_{OFF2}	–100	—	—	nA	Pin7 V_{OUT}=GND	Fig.9

●Measurement circuits

Quiescent current

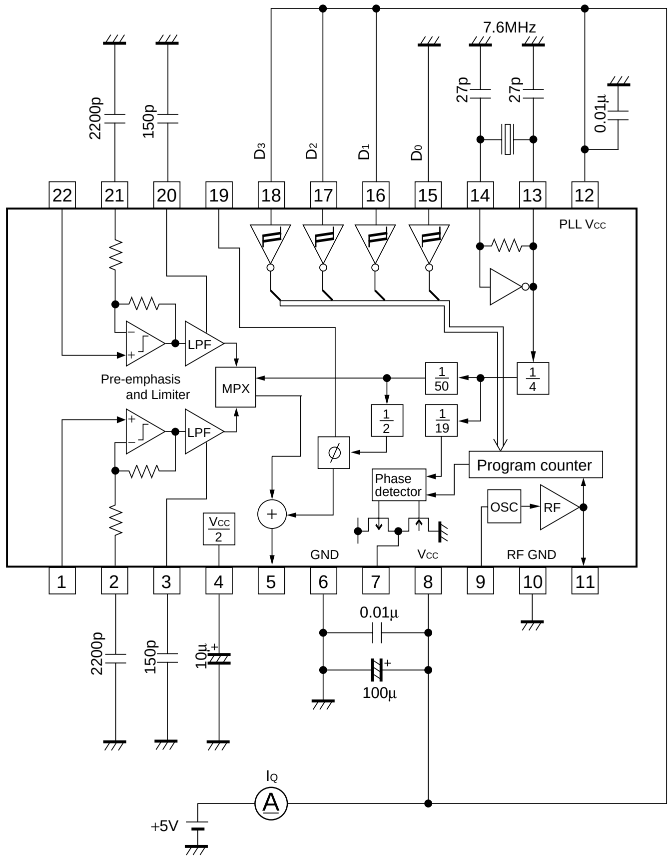


Fig.1

Channel separation
Channel balance

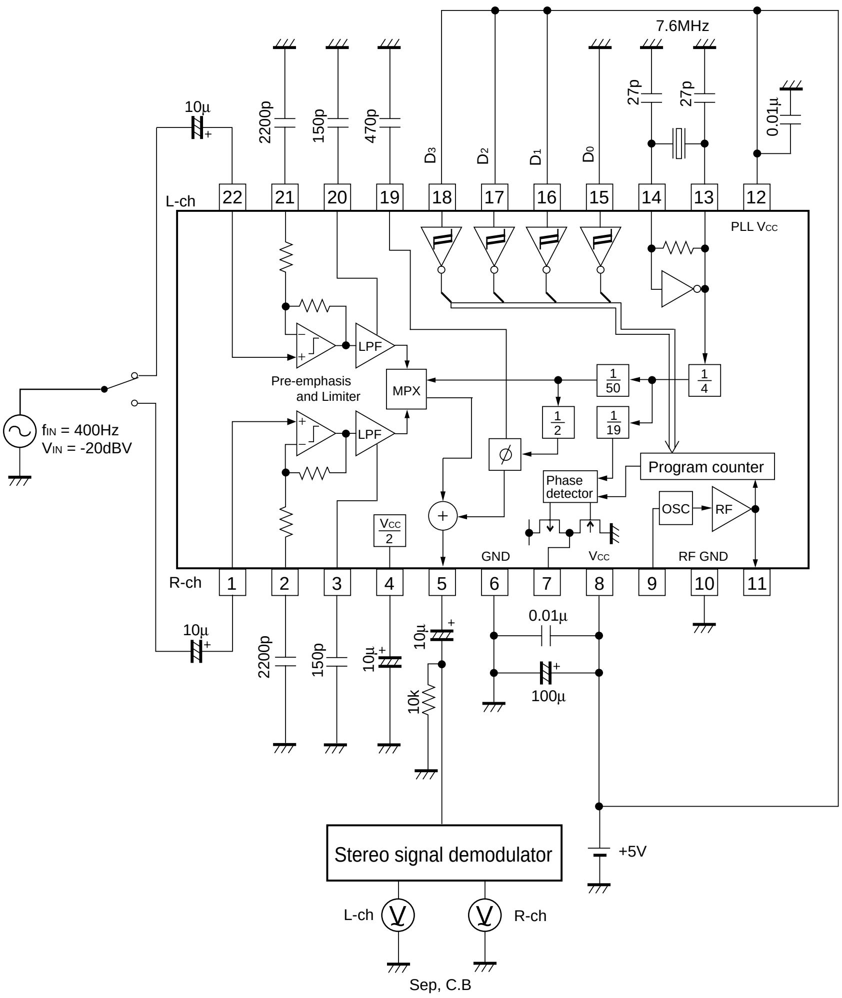
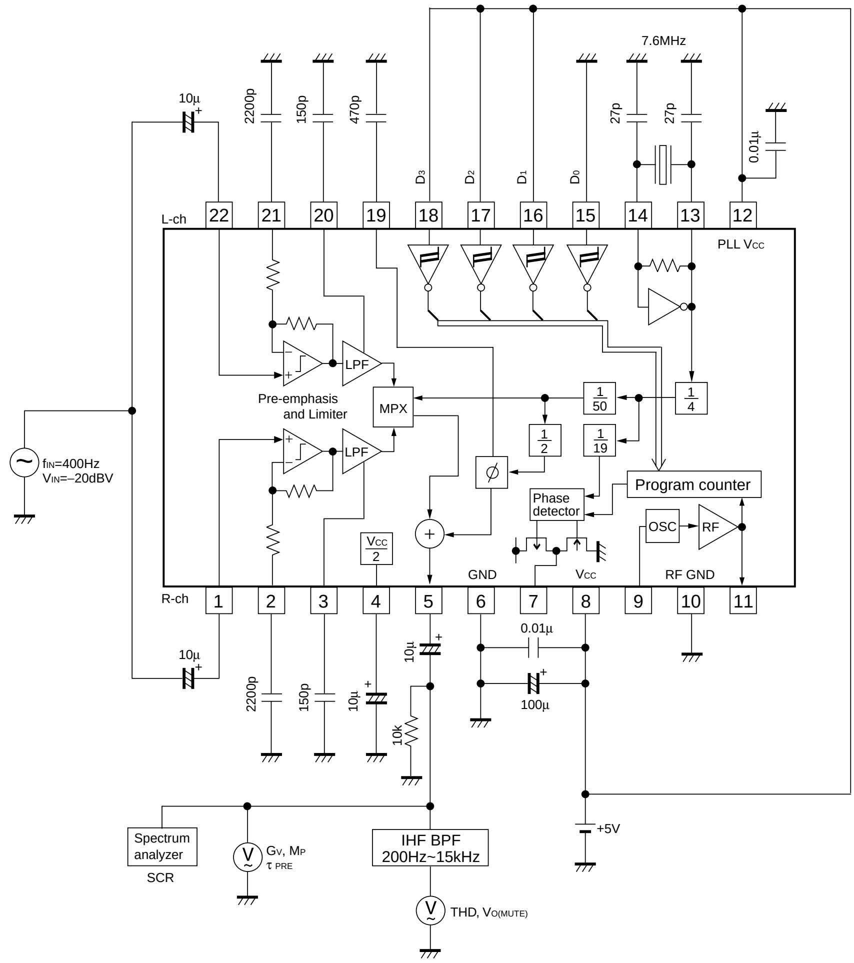


Fig.2

Total harmonic distortion
Input output gain
Pilot index of modulation
Sub carrier rejection ratio
Pre-emphasis time constant



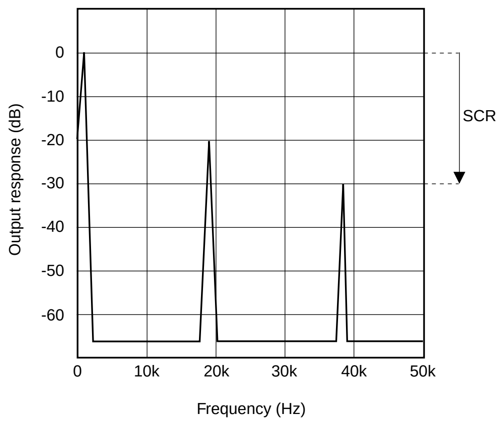
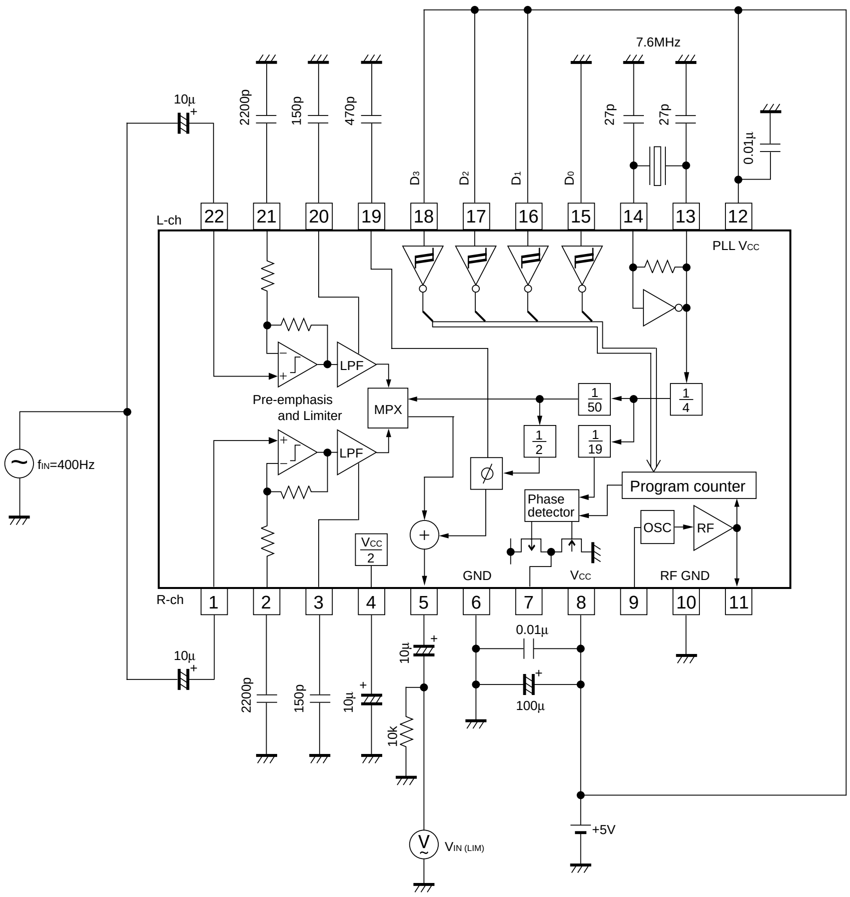


Fig.3

Limiter input level



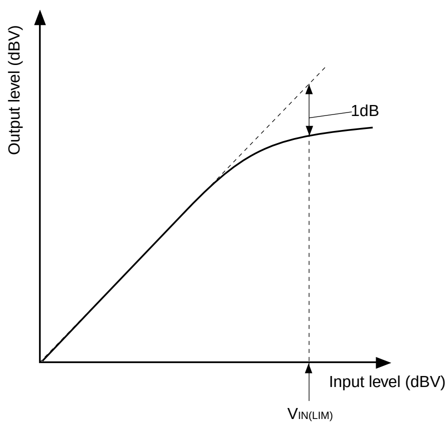
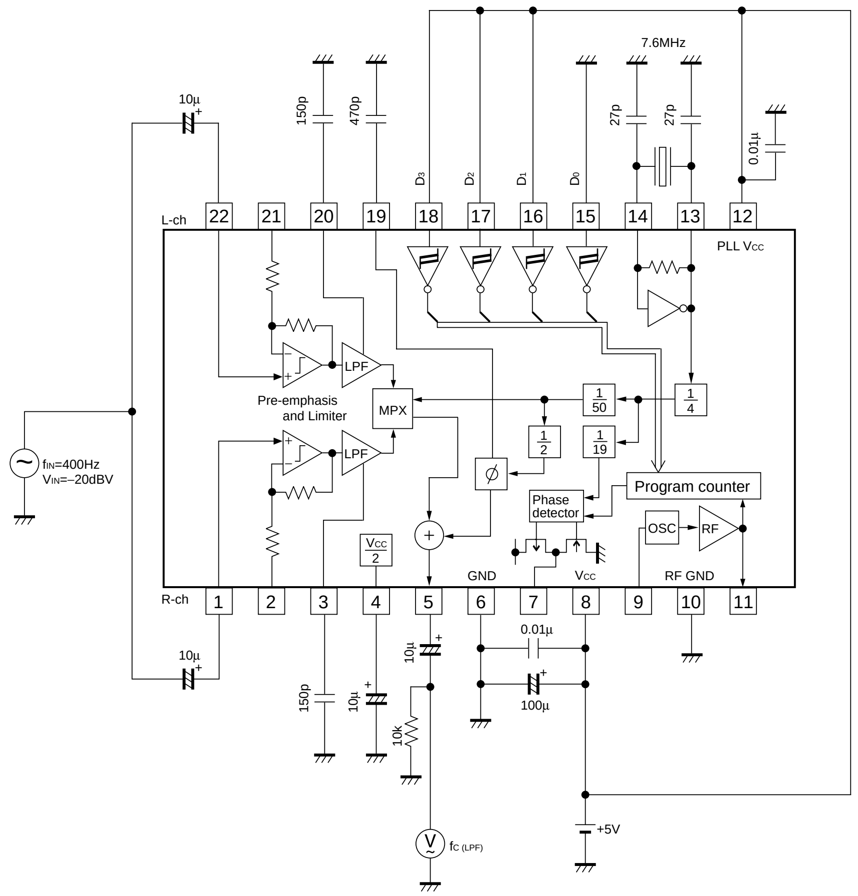


Fig.4

LPF cut off frequency



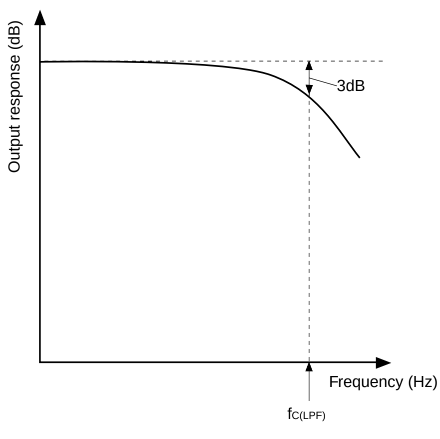


Fig.5

Transmission output level

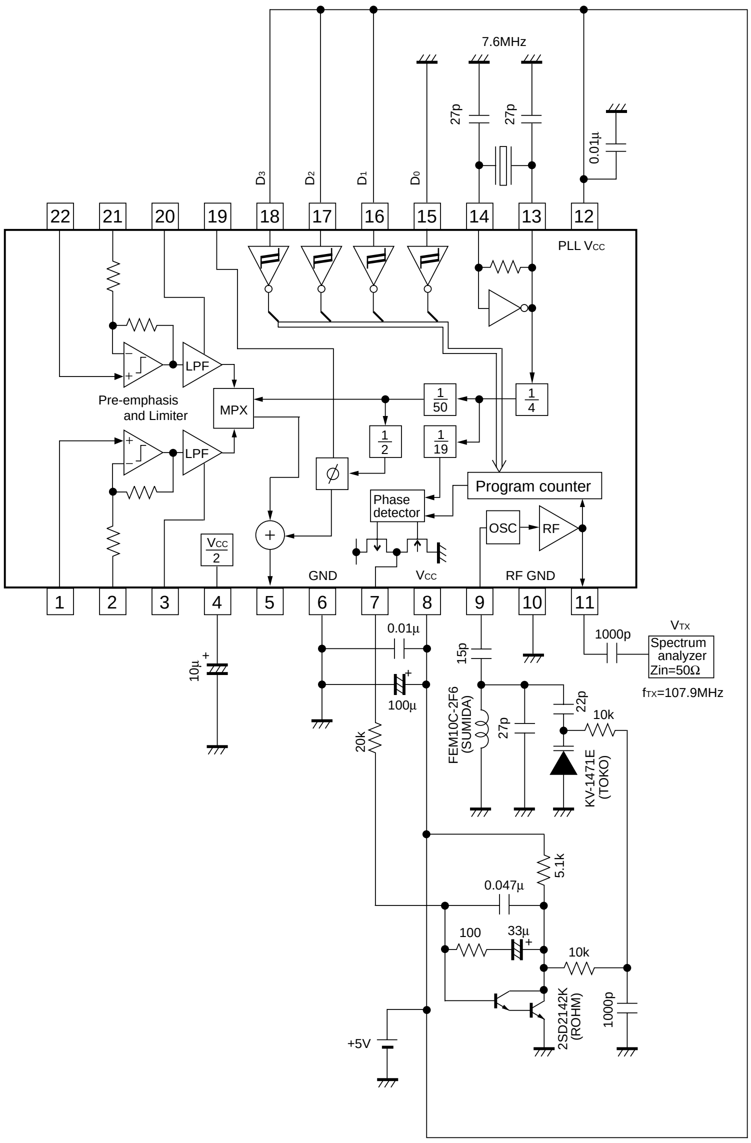


Fig.6

"H" level input current
"L" level input current

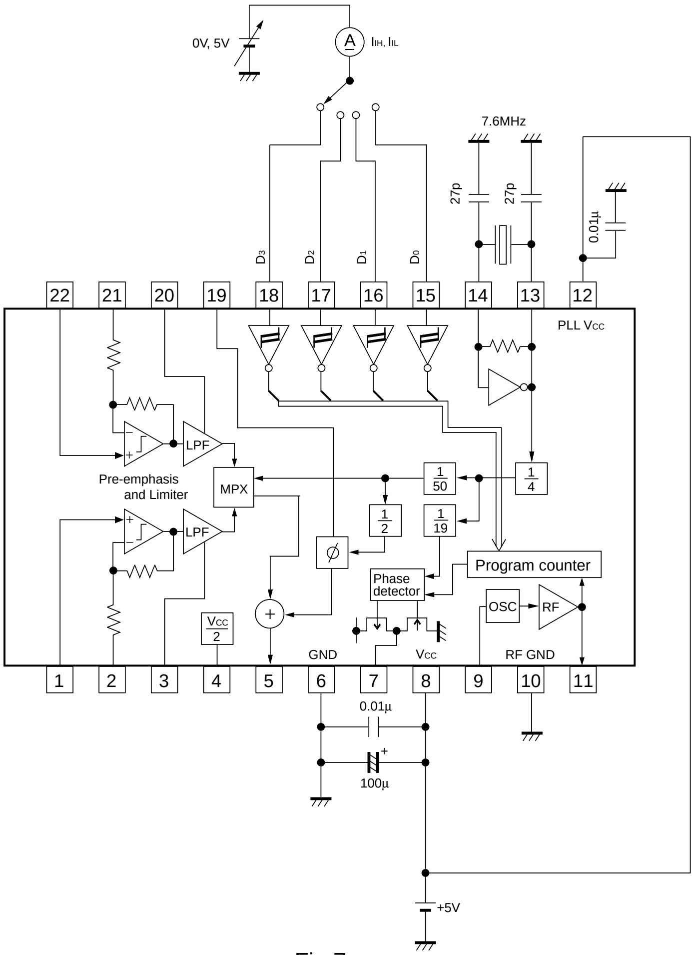


Fig.7

"H" level output voltage
"L" level output voltage

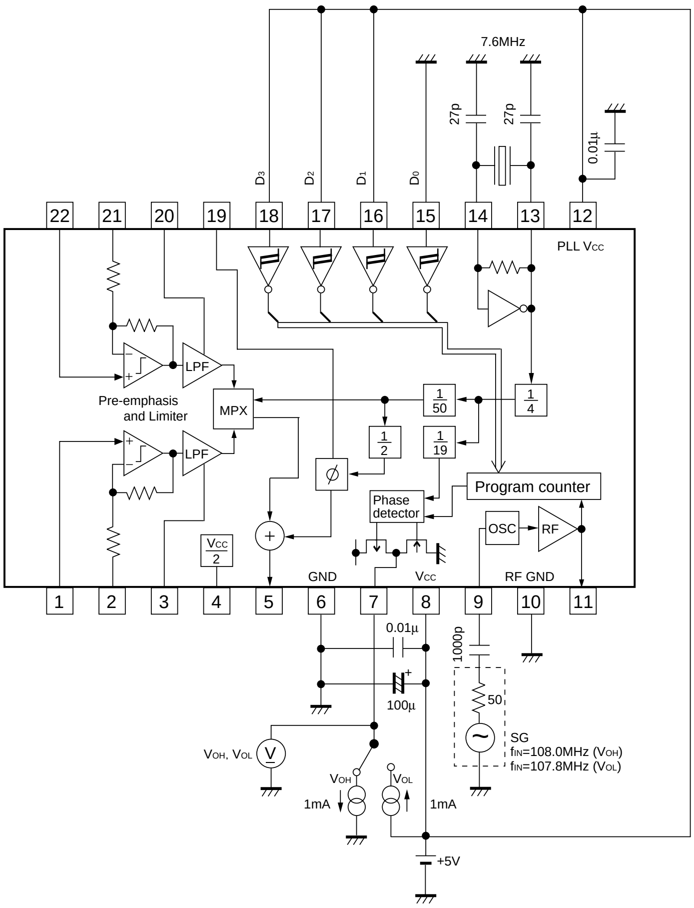


Fig.8

"off " level leak input current

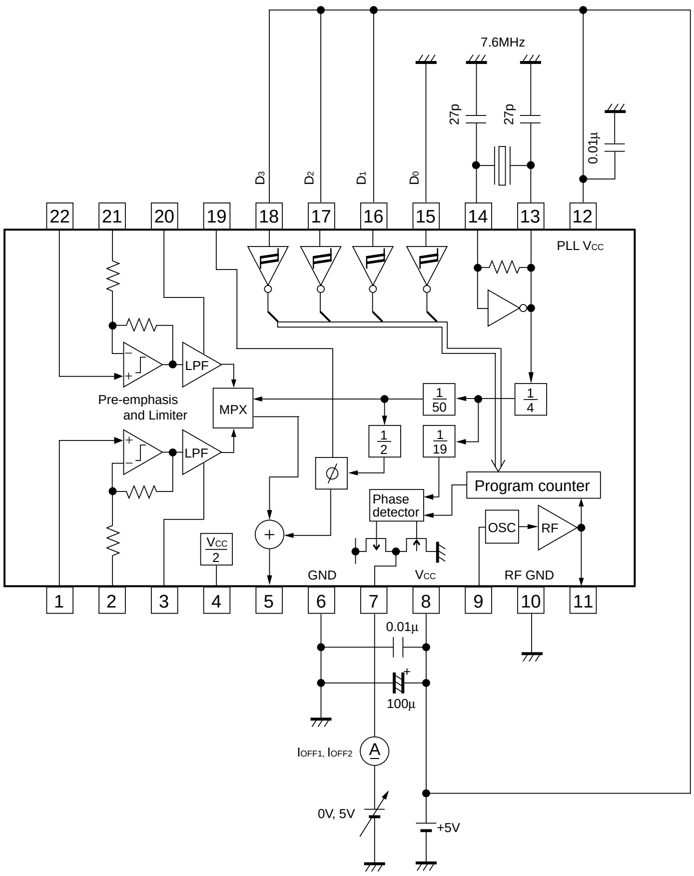


Fig.9

●**Application circuit**

US BAND (88.0MHz~89.2MHz)

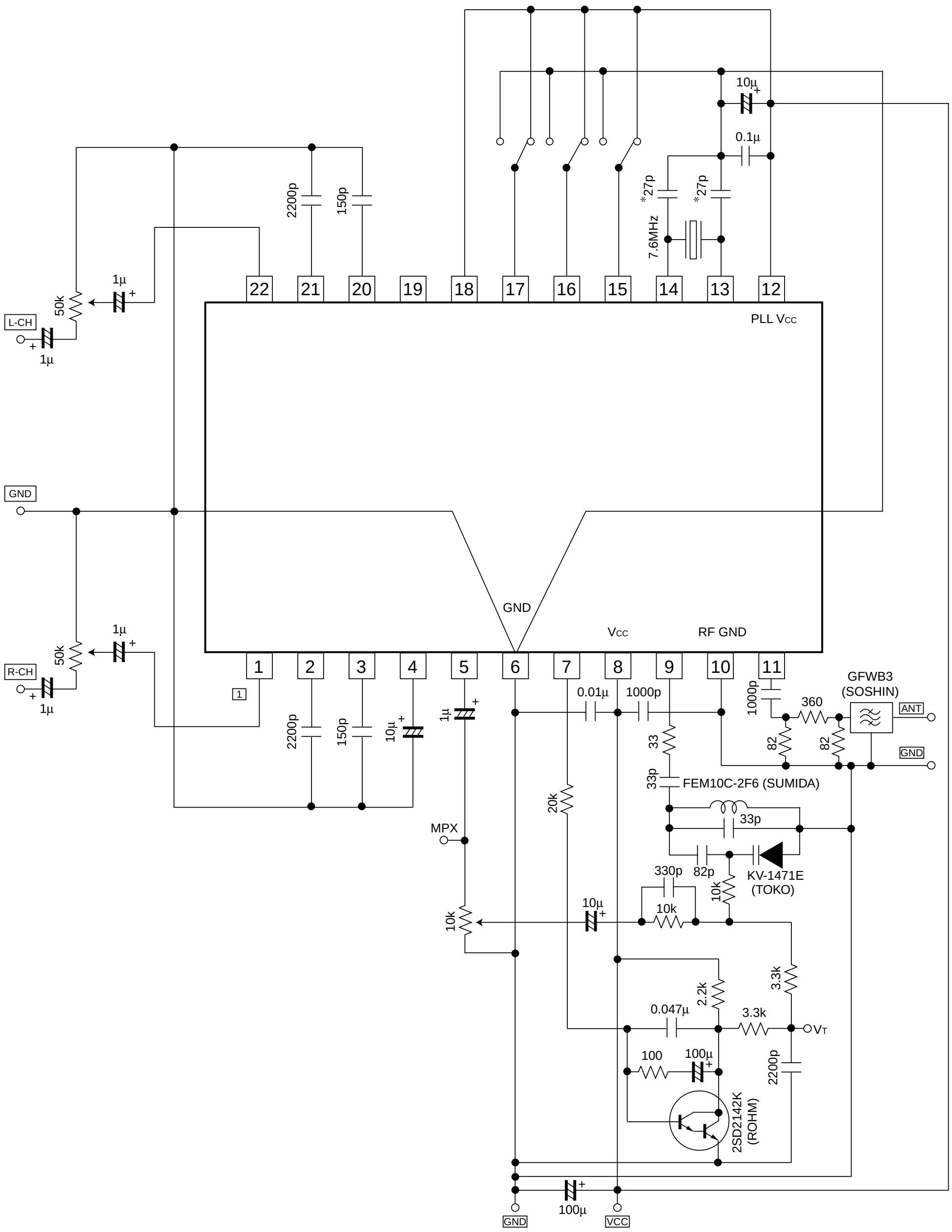


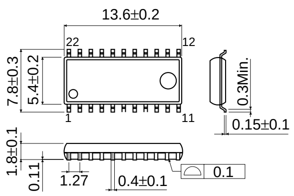
Fig.10

●Circuit operation

Parallel data

Control data				Frequency
D_0 (Pin15)	D_1 (Pin16)	D_2 (Pin17)	D_3 (Pin18)	
L	L	L	L	87.7MHz
H	L	L	L	87.9MHz
L	H	L	L	88.1MHz
H	H	L	L	88.3MHz
L	L	H	L	88.5MHz
H	L	H	L	88.7MHz
L	H	H	L	88.9MHz
H	H	H	L	PLL stops. Phase comparator terminal supports high impedance.
L	L	L	H	106.7MHz
H	L	L	H	106.9MHz
L	H	L	H	107.1MHz
H	H	L	H	107.3MHz
L	L	H	H	107.5MHz
H	L	H	H	107.7MHz
L	H	H	H	107.9MHz
H	H	H	H	PLL stops. Phase comparator terminal supports high impedance.

●External dimensions (Units : mm)



SOP22