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Design and Development of Wireless Transceiver Based on CDMA Technology

A Project Report

Submitted by

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In partial fulfillment for the award of the degree
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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

KUMARAGURU COLLEGE OF TECHNOLOGY
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P- 1872

BONAFIDE CERTIFICATE

Certified that this project report entitled **"Design and Development of Wireless transceiver based on CDMA technology"** is the bonafide work of

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Who carried out the project work under my supervision

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DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

KUMARAGURU COLLEGE OF TECHNOLOGY

COIMBATORE 641 006

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CERTIFICATE OF PARTICIPATION

This is to certify that **P.SOMU** *has participated in* **NCACIS 2007** *and presented a paper entitled Design and Development of a Wireless Transceiver based on CDMA Technology*

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ABSTRACT

In this project the hardware for a wireless transmitter has been designed and developed. Both theoretical and practical aspects of direct sequence spread spectrum are applied in the design. The simulation is done using the MATLAB software to predict the system performance such as signal to noise ratio and bit error rate. The hardware is also tested for performance as per the design specifications.

ஆய்வு சுருக்கம்

இந்த ஆய்வின் மூலம் சி.டி.எம்.ஏ (CDMA) கம்பியில்லா தொலை தொடா்பு கருவிக்கான (Transmitter) வன்பொருள் ஒன்று வடிவமைக்க பட்டிருக்கிறது. இதனை வடிவமைத்து மற்றும் செயல்படுத்தும் பொழுது டைரக்டு சீக்வன்ஸ் ஸ்பிரட் ஸ்பெக்ட்ரம் (DSSS) பற்றிய செய்திகள் உபயோகப்படுத்தப்பட்டன. மேட்லேப் (MATLAB) என்ற மென் பொருள் மூலம் சிமூலேசன் செய்து சிக்னல் மற்றும் பிட் பிழைகளின் உறவு பற்றி அறிய முடிந்தது.

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SYMBOLS	ABBREVIATIONS
CDMA	Code Division Multiple Access
LAN	Local Area Network
FCC	Federal Communication Commission
Pi	3.142 (Constant)
PN	Pseudo Noise
BPSK	Binary Phase Shift Keying
DBPSK	Differentially Binary Phase Shift Keying
D (T)	Data Signal
C (T)	Spreading Code
BER	Bit Error Rate
A/D	Analog to Digital Converter
PCB	Printed Circuit Board
TTL	Transistor Transistor Logic
LO	Local Oscillator
RF	Radio Frequency

CHAPTER 1
INTRODUCTION

1.1 NEED FOR THE PROJECT

We are presently witnessing an explosive growth in the field of wireless communications, so it becomes necessary that efficient and error free communication is necessary. The objective of this project is to design a wireless transceiver which will work in the 2.4 - 2.5 GHz frequency band based on the CDMA technology. The transceiver be an generic hardware system that can be used for many different applications including wireless LAN (Local Area Network) telemetry , wireless links, hand held data transceivers, point-point microwave communication systems,etc. In the ultra high band frequencies it possesses a problem which can be solved by employing suitable filters. One of the significant consequences of this has been the dramatic growth in the number of mobile phone in recent years. The first mobile phone networks used the analogue FDMA (Frequency division multiple access) technique, where a fixed number of users in a cell were allotted certain number of frequency slots, neighbouring cells are not allowed to use these frequencies could be repeated only after a few cells, to avoid interference.

The main disadvantage of this system was its low capacity in terms of number of users in a cell. Then came TDMA (time division multiple access) system, which increased the capacity of the cellular system by large amount. In TDMA system each cell is divided into a number of frequency channels and each channel in a particular cell is time multiplexed to accommodate a specific number of users, thus increasing the capacity of the system. Similar to the FDMA systems, the frequency channels in a particular cell can be only repeated after a number of cells, to avoid any interference. The CDMA (code division multiple access) system was developed by Qualcomm Inc., USA. In a CDMA system all mobile users share the same channel, in a cell and their unique codes enable them to communicate with each other with minimum interference. An advantage of the CDMA system is there are no fixed numbers of users in a CDMA. The capacity of the system is much higher other systems. CDMA system uses Spread spectrum technique.

1.2 OBJECTIVES OF THE PROJECT

* To design and develop a wireless transceiver based on the CDMA technology.

* To implement it on printed circuit board.

1.3 ORGANISATION OF THE REPORT.

The report is divided into seven chapters.
The first chapter gives a brief introduction to the topic, objectives and organization of the report
The second chapter describes in sufficient detail the necessary theory of spread spectrum communications and CDMA technology.
The third chapter discusses the specifications for the system and explains the design of the system.
The fourth chapter details deals with design of the Printed circuit board for the system
The fifth chapter deals with the Hardware implementation
The sixth chapter deals with software simulation of the transceiver
The seventh chapter gives conclusion about the results obtained.

CHAPTER 2
SPREAD SPECTRUM COMMUNICATION

2.1 INTRODUCTION

Spread spectrum (SS) communication systems have many applications mainly in the mainly communication because of its anti-jamming and anti-interception properties. Developed during World War II to counteract radar jamming. SS technique is most widely used in the U.S. global positioning systems (GPS), which consists of constellation of 24 satellites. The advantage of SS technique is that it allows all satellites to operate on the same frequency band without mutual interference. Although SS was thought to be too expensive for non-military applications, the recent progress in communication devices has reduced the cost of spread spectrum technique. A spread spectrum navigational system (Differential GPS with "carrier phase reconstruction") allows ground based receivers to calculate three dimensional positions to the sub-centimeter level. One of the most significant application of SS technique is in mobile cellular CDMA systems .The allocation of the three frequency bands for spread spectrum communication came about in 1985 by the Federal Communications Commission (FCC). As this transmission technique has greater immunity to interference and noise compared to conventional radio transmission techniques and because an increasing number of users can use the same frequency band, rules are thus designed to drive usage towards local data communications. Under these regulations users of FCC certified spread spectrum products do not require license from FCC, instead the only requirement is that the manufactures of spread spectrum products must meet the FCC spread spectrum regulations.

2.2 SPREAD SPECTRUM THEORY

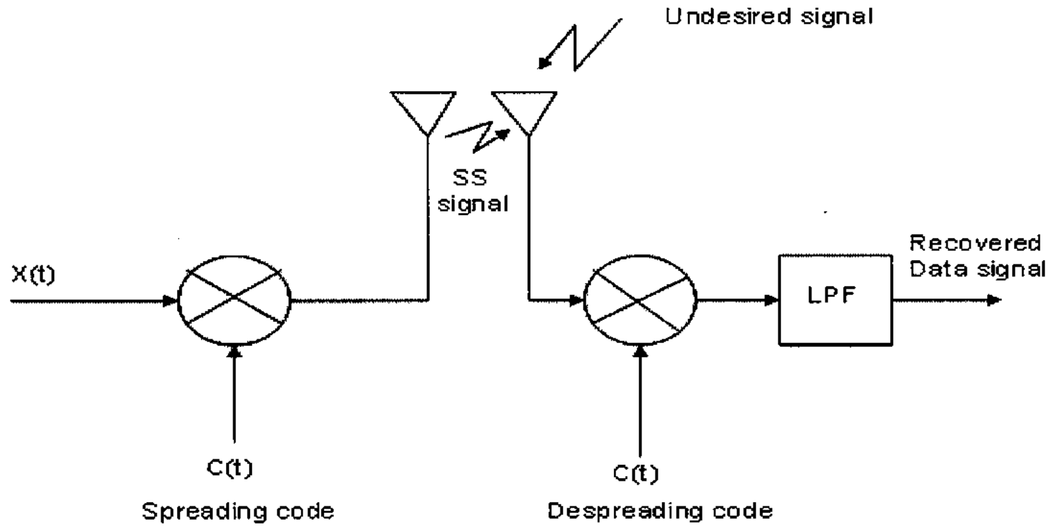


Fig 2.1 Simple model of SS communication system

Spread spectrum can be defined as radio frequency modulation technique where the radio energy is spread over a wide frequency bandwidth, in excess of the minimum bandwidth required to transmit the information being sent. This can be visualized by taking a base band signal with bandwidth of a few KHz and distributing it over a MHz wide band, usually accomplished by modulating the data with a wideband encoding signal. Figure below shows a simple model of a SS communication system. The base band signal is spread by spreading code sent over the communication channel. The transmitted signal is affected by noise and interference signals, but at the receiver end, the received signal is dispread to remove the noise and recover the signal.

Bit duration of data signal = T_b.

Bandwidth of data signal =W=1/ T_b.

Bandwidth of spreading code =$W_c = T_c$

Bandwidth of spreading signal =$W_{ss} = 1/ T_b$

At the transmitter, the transmitted signal is s (t) = x (t) c (t)

Since the data signal x (t) is narrowband compared to the spreading signal c (t), the resulting s (t) has approximately the bandwidth of the spreading signal. At the receiver, the desired signal is dispread by a local replica of the spreading signal c (t). The data signal can be recovered by passing the dispread signal through a filter with bandwidth W. The undesired signal is spread by the local replica of the spreading signal c (t).After passing through the filter; most of the undesired power will be rejected.

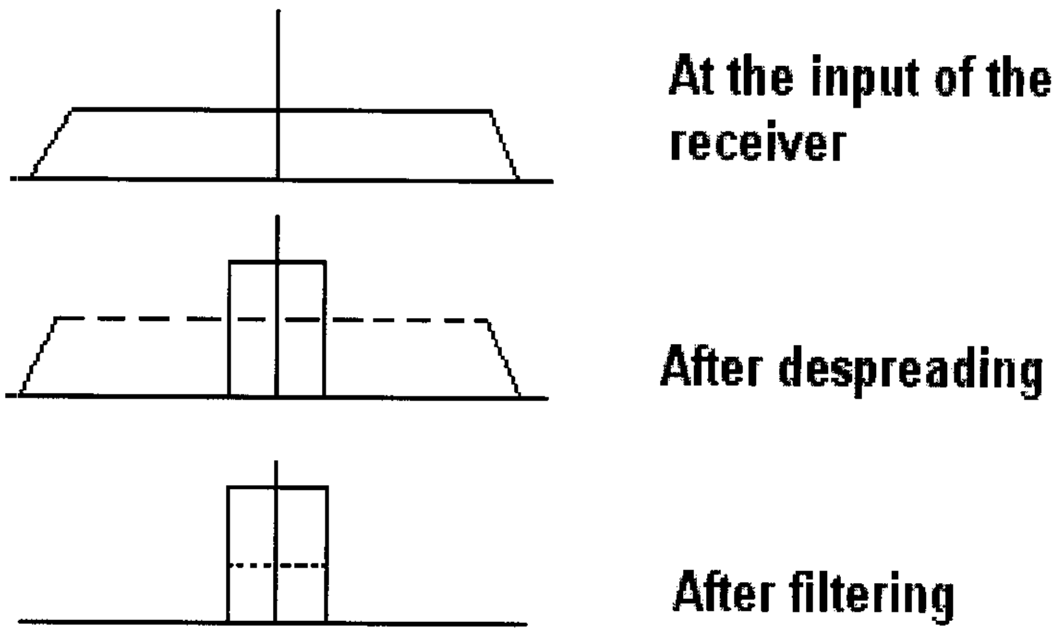


Fig 2.2 Dispreading and Filtering of data signal

The following observations are noted from the figure above:

1) Data signal is protected by the spreading – dispreading process.
2) Multiple by the spreading signal once spreads the signal bandwidth.
3) Multiple by the spreading signal twice, once followed by filtering, recovers the original signal.
4) The desired signal gets multiplied twice, but the interference signal gets multiplied Only once.

2.2.1 Processing Gain

The underlying principle of SS which provides protection against interfering signal is that distributing a low dimensional data signal in a high dimensional environment. In this way, the signal is hidden, since an external observer would be unable to know, which coordinates are being used at a time. If a D-dimensional signal is put in an N-dimensional space the SNR should be improved by a factor N/D, which is called the processing gain of the system. It can be shown that this is approximately equal to the ratio of the SS band width to the minimum bandwidth that would be required to transmit the information signal.
Hence,

$$\text{Processing gain} = N / D = W_{SS} / W_D$$

A more useful formula for processing gain in dB is given by

$$\text{Processing gain in dB} = 10 \text{ LOG [chip rate / bit rate]}$$

Where the chip rate is the rate of PN codes produced in chips per second .This is usually much higher than the data rate. A nominal value of processing gain would be 10Db.

2.2.2. Pseudo Noise (Pn) Sequences

Theoretically, to generate a perfect spreading code, undetectable by a observer (jammer), a totally random sequence must be employed, for example by the flipping of a fair coin. However in practice, PN sequences are used, so that the same sequence can be generated simultaneously at the transmitter and the receiver.

A PN sequence consists of plus and minus ones those posses certain specific autocorrelation properties. There are two general classes of PN sequences – periodic and periodic. A periodic sequence does not repeat itself in a periodic fashion. It is usually assumed that the sequence has a value of zero outside its stated interval. The periodic sequences however are a sequence of plus and minus ones that repeat exactly within specific period.

Properties of PN sequences are:

(1) Easy to generate.

(2) It possesses randomness properties.

(3) It has long periods.

(4) They are difficult to construct from a short segment.

2.2.2.1 Aperiodic Sequences

An aperiodic sequences is described analytically by a sequence of N plus or minus and is denoted by

$$(a_1, a_2 \ldots\ldots a_N) \qquad a_i = \pm 1.$$

To be considered a true PN sequences this sequence must have certain properties. One such properties is autocorrelation, defined

$$\text{As} \qquad C(k) = \Sigma a_n \, a_{n+k} \quad k=0, 1 \ldots N-1.$$

Consider a sequence of four digits, a_1 through a_4, where each of a's is either plus or minus one. The autocorrelation is obtained by multiplying elements of this sequence by multiplying elements of the same sequence shifted by one digit.

	0	a_1	a_2	a_3	a_4
	a_1	a_2	a_3	a_4	0
C(1) =	0	$a_1 + a_2$	$a_2 + a_3$	$a_3 + a_4$	0

An ideal periodic sequence would have an auto correlation given by

$$C(K) = N \qquad K = 0$$

$$0 \text{ or } +1 \qquad K = 0$$

Such sequences are called Barker sequences, but they are known to exist for only a few values of N. specifically they have been found for N = 1,2,3,4,5,7,11,13. Thus such sequences are normally too short for the use as a spreading function.

2.2.2.2 Periodic Sequences

A periodic sequences consists of an infinite sequence of plus and minus ones divided up into blocks of length, in which the particular sequence in each block is the same.

$$\ldots\ldots\, a_{N-1},\ a_N,\ \ a_1,\ a_2 \ldots\ldots\ a_N\, ,\ a_1, \ldots\ldots$$

Such sequence is said to be pseudorandom if it satisfies the following conditions.

1. In every period, the number of plus ones differs from the number of minus ones by exactly one Hence N is an odd number.

$$N_+ + N_- = N$$
$$N_+ - N_- = 1$$

2. In every period, half of the runs of the same sign have length 1, one fourth have length 2, one eight have length 3, and so forth. Also the number of positive runs equals the number of negative runs.

3. The autocorrelation of a periodic sequence is two halved, that is it can be described by

$$C\,(k) = N, \quad k = 0, N, 2N\ldots$$

$$= -\,1, \quad \text{otherwise}$$

For example of five digits in each period, the auto correlation for a shift of one digit is given by:

$$\ldots\ldots a_3\ a_4\ \ a_1\ \ a_2\ a_3\ a_4\ a_5\ a_1 \ldots\ldots$$

$$\ldots\ldots a_4\ a_1\ \ a_2\ \ a_3\ a_4\ a_5\ a_1\ a_2 \ldots\ldots$$

$$C\,(1) = a_1\, a_2 + a_2a_3 + a_3a_4 + \ a_4a_5 + a_5a_1$$

Next we describe the most commonly used PN sequences

(1) M-sequences and

(2) Gold codes.

2.2.2.2.1 M-Sequences

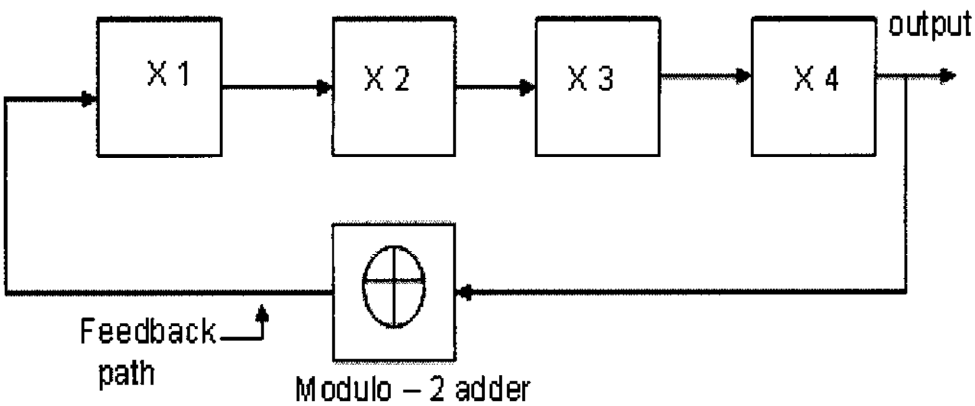


Fig 2.3 Generation of M- sequence with a 4 –stage shift register

M-sequences (maximum – length linear feedback shift register) are the most common types of PN sequences and are generated with M-stage shift registers. The M - sequence has a period of $N = 2^m - 1$, $m = 1, 2, 3\ldots$ Thus some typical lengths are N = 7, 15, 31, 63, 127, 255, 511....The sequences satisfies the recursion relationship

$$C = \sum_{k=1}^{m} a_k c_{n-k} \,(\text{mod } 2);\ a_m = 1$$

The periodic cycle of the states depends on the initial states and the coefficients $\{a_k\}$. For example using a four stage shift register as shown in figure 2.3 (here) a_k=1) .we get PN sequence 1111010110011000, where mapping {1, 0} -> {-1, 1} is used.

.2.2.2.2.2. Gold codes

One of the main goals of the spread spectrum system design for a military – access system is to find a set of spreading codes or waveforms such that as many users as possible can use a band of frequencies with as little mutual interference as possible .The specific amount of interference from a user employing a different spreading code is related to the cross-correlation between the two spreading codes. The Gold codes invented in 1967 Magnavox Corporation, have well controlled cross-correlation properties. The full period cross-correlation between two spreading codes is

$$\rho_{a,b} = 1/N \sum_{n=0}^{N-1} a_n \; a_{n+k}$$

Where a = b cross -correlation becomes auto- correlation

Gold codes are constructed using m-sequences. Certain special pairs of m-sequences whose cross-correlation spectrum is three valued, where those three values are

$$-1/N\,(t(n),-1/N \text{ and } 1/N\,[t(n)-2]$$

Where $t(n) = 1+2^{0.5(n+1)}$ for n odd.

$= 1+2^{0.5(n+1)}$ for n even.

Where the code period $N = 2^m-1$ are called preferred pairs of M-sequences. Let a and b represent a preferred pair of m- sequences having a period $N = 2^n -1$.Thenthe family of codes defined by {a, b , a + b , a + b(1) , a + b(2) ,.. a + b (N-1)} is called the set of goldes for this pair of M-sequences. The notation b(j) represents a phase shift of m- sequence b by j units. Gold codes have the property that any pair if codes in the set have a three valued cross-correlation spectrum which take on values given above there are a total of N+2 coded in any family of gold codes, with each having period N.

2.2.3 MODULATION TECHNIQUES.

2.2.3.1 Binary Phase Shift Keying (Bpsk)

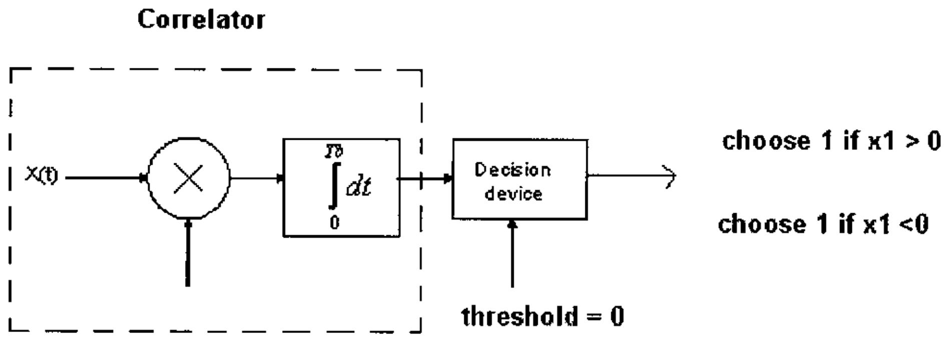


Fig 2.4 BPSK Receiver model

In Binary phase shift keying (BPSK) signaling schemes the signal is

$$S(t) = d_n \sqrt{2S} \cos(w_0 t)$$

Where $\{d_n\}$ is a random binary sequence with levels +1 and -1, S is the signal power, t is defined over the interval $[nT, (n+1) T_b]$ for some integer n and T_b is the bit duration BPSK is appropriate in applications where phase coherence between the transmitted signal and received signal can be maintained over a time interval.

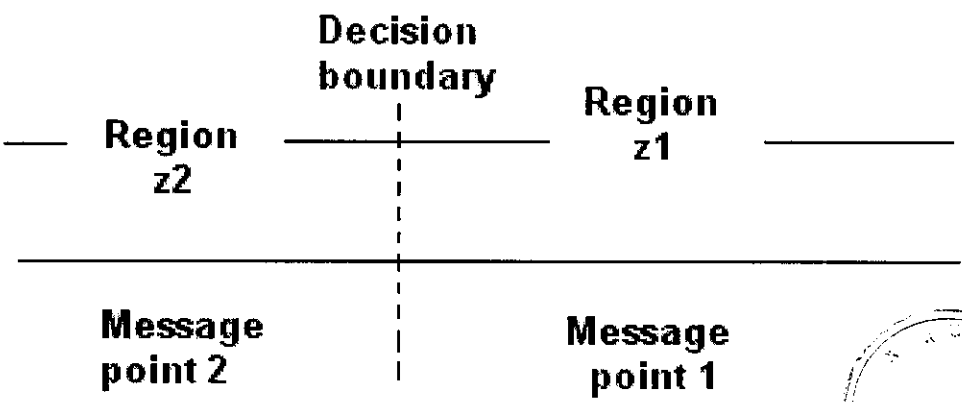


Figure 2.5 Shows the signal space diagram for the BPSK System.

The decision rule is thus

[

1) S_1 was transmitted if the received signal falls in region Z_1.
2) S_2 was transmitted if the received signal falls in region Z_2.

The Power Spectral Density of the BPSK can be shown to have a shape of $\sin^2(x)/x^2$ with one – sided first null bandwidth equal to $1/T_b$.The BER is given by

$$P_{eb} = Q\left(\sqrt{2}\, E_b / N_0\right)$$

Where $E_b = S\, T_b$ and N_0 is the one sided Power spectral density of Additive white Gaussian noise.

2.2.3.2 Differential Binary Phase Shift Keying (Dbpsk)

The DBPSK is the non-coherent version of BPSK. It eliminates the need for a coherent reference signal at the receiver by combining two basic operations at the transmitter:

(1) Differential encoding of the input binary wave
(2) Phase – shift keying

In effect to send symbol 0, we phase advance the current signal waveform by waveform 180 degrees, and to send symbol 1 we leave the phase of the current signal waveform unchanged. The receiver is equipped with a storage capability, so that it can measure the relative phase difference between the waveforms received during two successive bit intervals. For the generation of this sequence, the following rules are used: If the incoming binary symbol b_k is 1 leave the symbol d_k unchanged with respect to the previous bit. If the incoming binary symbol b_k is 0, change the symbol d_k with respect to the previous bit. The first bit is arbitrary serving as reference. The differentially encoded sequence $\{d_k\}$ thus generated is used to phase – shift a carrier with phase angles 0 and pi radians representing symbols 1 and 0 respectively.

Table 2.1 Generation of DBPSK signal of a sequence of bits.

$\{b_k\}$	1 0 0 1 0 0 1 1
$\{d_k\}$	1 1 0 1 1 0 1 1
Differential encoded Sequence $\{d_k\}$	1 1 0 1 1 0 1 1 1
Transmitted phase (radians)	0 0 pi 0 0 pi 0 0 0

2.2.3.3 Quadrature Phase Shift Keying (Qpsk)

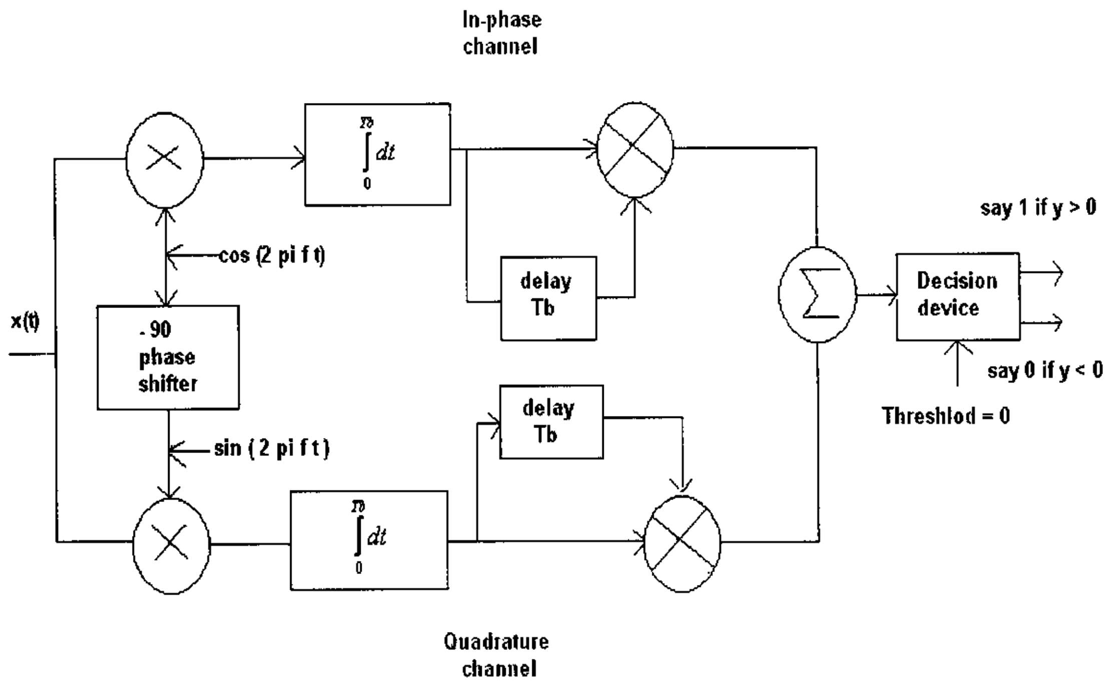


Fig 2.6 Phase shift keying

QPSK signals are explicitly defined by

$$S_i(t) = 2E / T \cos (w_s(t) - i\ pi/2 - pi/4), \quad i = 1,2,3,4$$

The information carried by the transmitted signal is contained in the phase. The carrier signal takes on one of four equally spaced values such as pi/4, 3pi/4, 5pi/4, 7pi/4. The outputs of the integrators are compared with zero and the decision is made based on whether these outputs are greater than the threshold value of zero. The four are separated by 90^0 since each signal occupies a different quadrant of the signal space , decisions can be made by determining which quadrant the observed is in .The probability of bit error is

$$P(E) \leq 2\,Q\,[\ \sqrt{E}\ \ / N_0\,] + Q\,[\sqrt{2}\,E / N_0\,]$$

$$P_e = 0.5\ P(E)$$

PSK achieves the same probability of error as a binary system with the same bit rate and the same energy per bit, but uses only one half the bandwidths.

2.2.3.4 Differential Quadrature Phase Shift Keying

Using the concept of differential encoding, as described in section 2.2.4.2 in this case the phase reference for decoding any particular bit in the sequence is the state of the preceding bit. Similar concept can be employed in DQPSK. Each signaling waveform becomes the phase reference for the next waveform. In the case of QPSK, it has been shown that to achieve the same probability of error as QPSK, the signal energy must be increased by 2.3 dB.

2.3 TYPES OF SPREAD SPECTRUM TECHNIQUE

In order to have a better understanding of spread spectrum communication, we shall investigate the different types of techniques available, the advantages and disadvantages and unique features of each method. The classifications of spread spectrum techniques are a follows:

a) Direct Sequence spread spectrum modulation. (DSSS)
b) Frequency Hopping spread spectrum modulation (FHSS)
c) Time Hopping spread spectrum modulation (THSS).

2.3.1 Direct Sequence Spread Spectrum Technique

This is the best known spread spectrum technique so far in which data is mixed or exclusive OR ed with high rate pseudo-random sequence being PSK modulated onto RF carrier. As the chipping data rated is much higher than the actual data rate of transmission, the high rate modulation spreads the spectrum out while dropping the power spectral density, thus causing less interference to those narrow band users. The receiver processing of DS signal is the dispreading of the desired data while further spreading any unwanted signals .This is equivalent to applying a mathematical process called auto-correlation to the received data where the receiver must be able to produce a phase locked exact replica of the pseudo random sequence that is used for spreading. The dispread signal of interest thus falls into its original bandwidth and form, while all other signals that do not correlate with the PN code has its amplitude reduced tremendously. With the dispread signal having its power spectral density increased proportional to the bandwidth reduction, the received signal is now above the noise level and can be demodulated accordingly.

2.3.1.1 DS/BPSK System

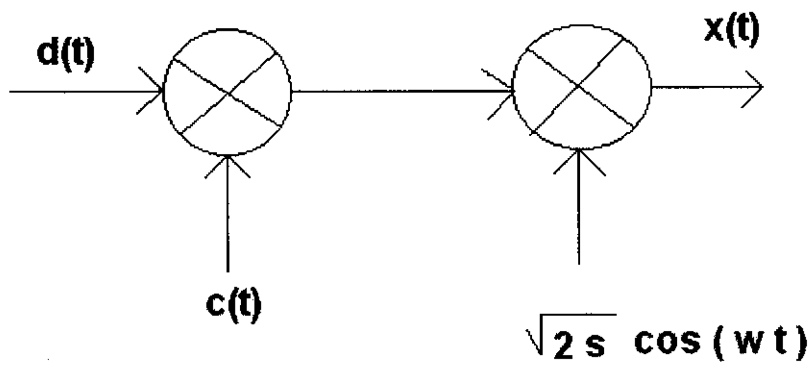


Fig 2.7 DS/BPSK SS Transmitter

DS spreading of the BPSK signal is accomplished by a PN bipolar sequence $\{c_k\}$ whose elements are of +1.The PN Sequence is obtained from a PN sequence generator which generates chips N times faster than the data rate.

That is,

$$T_b = N\ T_c$$

Where T_c is the chip duration. In practice, the PN chip rate might be several megabits per second .The DS/BPSK SS signal can be represented by

$$x(t) = d(t)\ c(t)\ 2\ S\ \cos(w_0\ t)$$

2.3.1.2 DS/BPSK System BER

For the encoded DS/BPSK system, suppose N (t) is the constant noise power at the input of the receiver. Then the received signal is

$$y\ (t) = x\ (t) + N\ (t)$$

is multiplied by a synchronized PN waveform c(t) to obtain

$$r(t) = c(t)\ x(t) + c(t)\ N(t)$$

r(t) is an ordinary BPSK signal imbedded in some additive noise given by c(t) N(t). The BPSK detector output is

$$r\ (t) = d\ \sqrt{Eb}\ + n$$

Where d is the data bit for the observed T_b interval, $E_b = ST_b$ Is the signal energy per bit and n is the noise component.

$$n = \sqrt{2}\ / T_b \int_0^{Tb} c(t)\ N(t)\ \cos(\ w_0\ t\ )\ d(t)$$

The typical decision rule is $d = +1,\ r > 0$

$= -1,\ r \leq 0$

It can be proved that the bit error rate is given by

$$P_{eb} = Q\ (2\ E_b\ /\ N_0)$$

Where $N_0 = N\ /\ W_{SS}$

2.3.1.3 Synchronization

Non coherent communications such as DPSK require bit synchronization (the starting and ending of every bit synchronization (the phase of the incoming carrier signal) to permit the modulated signal to be mixed down to base band. In a SS system, in addition to bit synchronization and phase synchronization is required to allow the regeneration of a local copy of the spreading waveform in order to dispread the incoming SS signal. If the two waveforms are out of synchronization by as little as one chip, insufficient signal strength will reach the receiver for reliable data recovery

This process of code synchronization is divided into two steps:

1. Acquisition (coarse synchronization) - This step brings the two spreading waveforms into coarse alignment with one another.
2. Tracking (fine synchronization) – Once the received signal has been acquired , the second step takes over and continuously maintains the fine alignment between the spreading waveforms by means of a feedback loop

CHAPTER 3

WIRELESS TRANSCEIVER BLOCK DIAGRAM DESCRIPITION

3.1 BLOCK DIAGRAM OF WIRELESS TRANSCEIVER

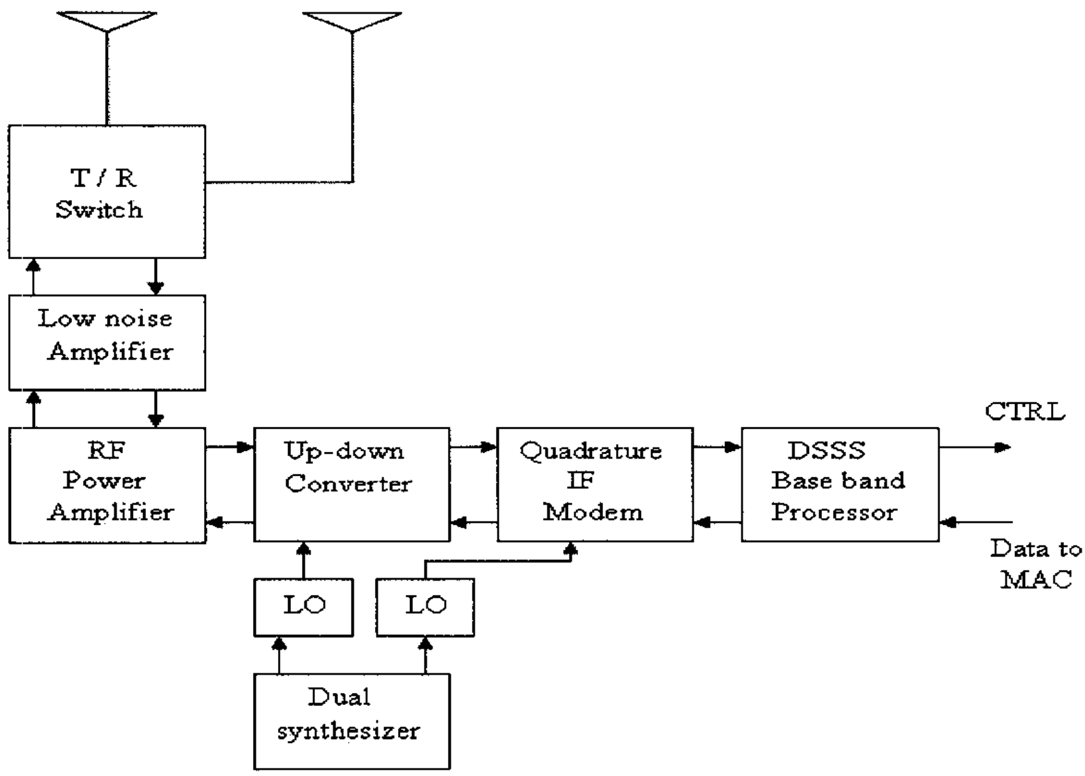


Fig 3.1 Wireless Transceiver Block diagram

The block diagram shows the Base band processor, quadrature IF modem, Dual synthesizer, RF Power amplifier, Up-down converter, Low noise amplifier.

3.1.1. Base band Processor

The base band processor consists of two on board 3-bit analog to digital converters (ADC) which accept analog I (in-phase) and Q (quadrature) inputs from the low pass filters in the modem. A separate digital spreader and despreader is built in the transmit and receive section respectively .The spreader spreads the encoded data with a high data rate pseudo random codes pror to transmission. The despreader dispreads the desired signal into its band width while spreading the unwanted signals and interference. A media access control to physical layer interface (MAC-PHY) in the base band processor provides the path for data communication between transceiver and the network processor. A control module called the Clear channel assessment (CCA) monitors the channel traffic so to indicate to the external processor to transmit data when channel is clear, thus preventing channel collision and increases network throughput. There are a total of 57 configurable registers that are used to configure the chipset for various operations such as status viewing, threshold settings, A/D calibration and modem operation.

3.1.2 Quadrature Modem

The quadrature modem is a highly integrated base band converter for half duplex wireless data applications. It features all the necessary blocks for modulation and demodulation of I and Q signals Quadrature multiplexing signals. It consists of two-stage integrated limiting IF amplifiers which accept the IF signal from the RF/IF converter. The IF limiter limits the output to an appropriate constant level for phase detection. The base band signal is modulated in this section using DBPSK method and sent for transmission to the RF/IF converter, while the received signal is demodulated and sent to the base band processor. The reference signals required by the mixers can be supplied by a 600MHz local oscillator using the dual synthesizer. For transmission, it up converts the base band signal to IF signal and down coverts the IF to base band signal upon reception. A programmable 5^{th} order Butterworth low pass filter with four digitally selectable filter bandwidth at 2.2, 4.4, 8.8 and 17.6 MHz is used for pulse shaping before transmission.

3.1.3 Dual Synthesizer

The reference signals required by the mixers can be supplied by a 600MHz local oscillator using the dual synthesizer. For Transmission, it up converts the base band to IF signal and down converts the IF to base band signal upon reception .A programmable fifth order Butterworth low pass filter with four selectable filter bandwidth at 2.2,4.4,8,8 and 17.6 MHz, is used for pulse shaping before transmission.

3.1.4. Up -down Converter

The up-down converter consists of an up conversion mixer with a 15dB gain pre amplifier is used to bring up the signal to an appropriate level. The down conversion mixer with a low noise amplifier down converts the RF to IF signal .there are two external surface acoustic filters (SAW), each at the transmit and receive section. At the transmit side. The SAW filter is used to select the upper side band for transmission whereas the second filter is used to reduce image noise at the receiving end. The up-down converter has an in-built energy saving power enable control feature to provide isolation between the receive and transmit circuits in time multiplexed systems.

3.1.5 RF / IF Synthesizer

It provides a stable and low noise signal for the local oscillator with the help of digital phase lock loop technique, the dual frequency synthesizer provides a stable low noise signal for the local oscillator. It consists of a 32/33 prescalar for selecting the frequency for RF synthesizer, and an 8/9 prescalar use to d for the IF synthesizer.

3.1.6 RF Power Amplifier

This is a three stage amplifier with bias control and a transmit /receive switch. The logical-level PMOS switch in the stage bias circuit is used to control drain voltage to the power amplifier. The T/R switch allows the prism chipset to operate as a receiver for the incoming signal or a transmitter to send out a RF signal. Supply voltage used in the amplifier can be as a slow as 2.7 volts thus this a low power consumption chip.

3.1.7 Low noise Amplifier

It is an optional chip for noise figure improvement. This chip is placed before the RF/IF converter it offers a high gain of 14dB low noise figure of 1.9db and low power consumption, while operating from a 2.7 -5.5V supply.

3.2 SCHEMATIC DESIGN

3.2.1. Base Band Design

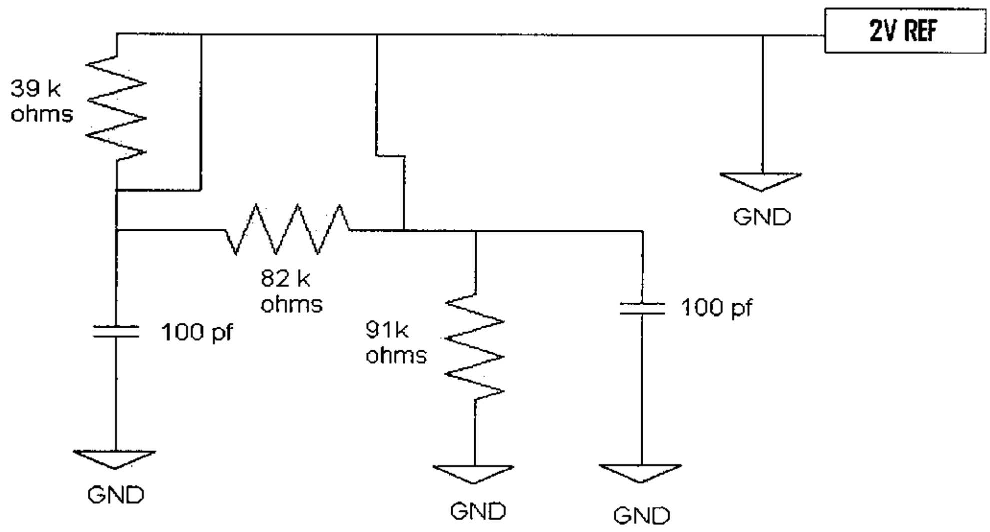


Fig 3.2 Biasing of voltage references for ADCs

The design of base band is straight forward, as most of features are built in the IC itself and the digital control signals directly interface to an external controller and the other modules of the system. The base band processor derives its power from two separate supplies, one for the digital section inside the IC and the other for the analog portion of the IC. It is recommended that the grounds for these two supplies be separated in the Printed circuit board to reduce interference Capacitors C129, C24, C41 act as decoupling capacitors for the digital supply whole the capacitors C125,C 130 C132 act as decoupling capacitors for the analog supply .The 2VREF is a DC voltage of 2V supplied by the Quadrature Modem.

This voltage level is used to set the positive reference level and the negative level for the analog to digital converters inside the base band processor using the network of resistors R13, R22 and R1 while C6 and C15 act as decoupling capacitors. The base band processor derives its clock signal (MCLK) from the 22 MHz FOX crystal oscillator (U20), which is permanently enabled by pull in.

3.2.2 Transmit Processing

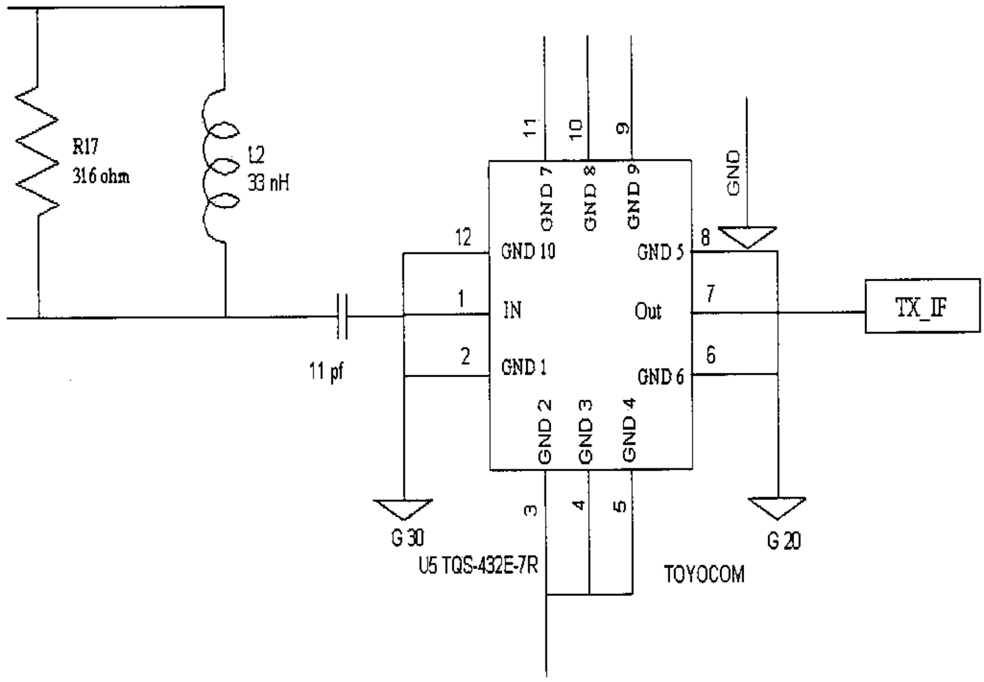


Fig 3.3 Transmit IF filtering and matching to filter

The data from the voice processor is sent to the base band processor which clocks it in. The base band processor scrambles the packet and differently encodes it before applying the SS modulation. The data can be either DBPSK modulated at 1MSPS and is base band quadrature signal with I and Q components. The spreading is an 11 chip Barker sequence that is clocked at 11MHz and is modulates with the I and Q data components .These are then output to the IF modem as CMOS logic signals. Transmit Quadrature single-bit digital inputs are applied to the Quadrature IF modem from the base band processor .These inputs are attenuated by a factor of 17 and DC coupled to the fifth order Butterworth low pass filter, which are used to provide shaping of the PSK signal. The required transmit spectral mask, at the antenna is -30dBc at the first side lobe relative to the main lobe.

The fifth order filters are tuned to an approximate 7.7MHz cutoff, using a 9 ohm resistor external to the modem .The low pass filters provide initial shaping of the PSK waveform. final shaping is provided by transmit IF filter (U7) TOYOCOM TQS-432 SAW band pass filter .The low pass filter are off-chip AC coupled to the quadrature up-down converter in the modem .As in the receive mode, the base band AC coupling time constant is approximately 25 times longer the symbol period, and is implemented with 0.01micro farad series capacitors. The same twice IF frequency local oscillator used previously is also used in this up-conversion.

The IF output of the Quadrature modem is reactively matched to U5 with a 250 ohm resistive load presented with a 316 ohm resistor is used to provide this match ,negate the effects of board and component capacitance, and provide a DC return to Vcc to prevent saturation in the IF stage of the quuadrature modem.

3.3 SYSTEM SPECIFICATIONS

Table 3.1 General Specifications

Interface Connector	Surface Mount Technology
Antenna	Zb2430-100:chip antenna
Serial interface data rate	Baud rates from 1200bps to115,200 bps
Channels	16 direct sequence channels

Table 3.2 Transceiver Specifications

Frequency Band	2400-2483.5 MHz
RF Data Rate	250 kbps
RF Technology	Direct Sequence Spread Spectrum
Output Power	+2dBm to +20 dBm
Supply	3.0-3.5V

3.4 HARDWARE BLOCK DIAGRAM

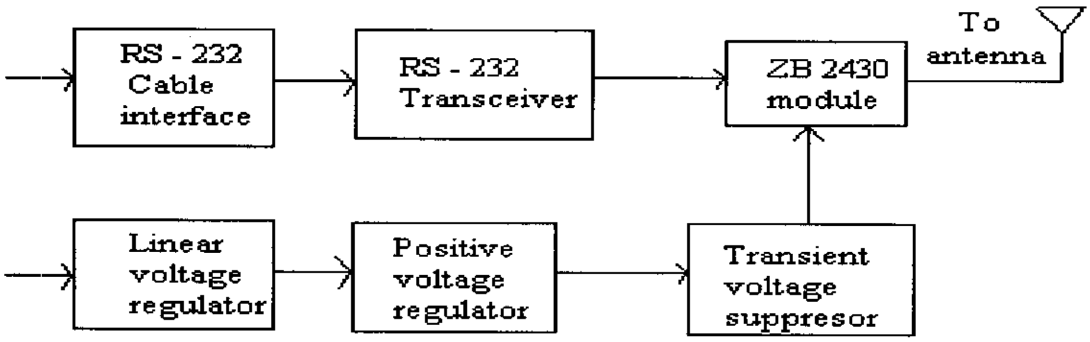


Fig 3.4 Block diagram of Hardware

3.4.1 ZB2430 Module

The module uses direct sequence spread spectrum technology featuring advanced encryption standards. This transceiver operates seamlessly serial cable replacement applications. Communications include both system and configuration data via an asynchronous TTL serial interface for OEM communication. All association and RF transmission and reception is performed by the transceiver. It also has simple interface that allows the OEM host communication with the transceiver. The ZB2430 uses ZigBee protocol stack. Which is a network layer protocol which uses small and low power digital transceivers based on IEEE 802.15.4 hardware standard? A Zigbee layer in it performs the packet routing.

3.4.2 Linear Voltage Regulator

The TPS 736XX family of low dropout linear voltage regulator uses a new technology: an NMOS pass elements in a voltage – follower configuration. This topology is stable using output capacitors with low ESR and even allows operation without a capacitor. It also provides high reverse blockage (low reverse current) and ground pin current that is nearly constant for all values of output current. The TPS 736XX uses an advanced BICMOS process to yield high precision while delivering very low dropout voltages and low ground pin current. Current consumption, when not enabled is under 1micro A and ideal for portable applications. The extremely low output noise is ideal for powering VCOS. These devices are protected by thermal shutdown and fold back current limit.

3.4.2 True RS 232 Transceiver

The MAX 3238 true RS 232 transceiver achieves a 1 micro amps supply current with maxims revolutionary auto shutdown plus feature. When the device does not sense a valid signal transition on either the receiver or transmitter inputs within 30 sec. The ON board power supply and drivers shutdown. This occurs if the RS232 cable is disconnected or if the transmitters of the connected peripheral are inactive. The system turns on again when a valid transition is applied to any RS232 receiver or transmitter input saving power to the existing BIOS or operating system. The max 3238 5 driver / 3receiver complete serial port is 3v powered EIA/TIA 232 and a V.28 / V.24 communication interface intended for notebook or sub notebook computer applications. A propriety high efficiency dual charge pump power supply and low drop out transmitter combine to deliver true RS - 232 performances from single 3V TO 5.5 supply.

3.4.3 Transient Voltage Suppressor (LC24)

This hermetically sealed component includes a rectifier diode element in series and opposite direction to achieve low capacitance performance below 100 Pf. The low level of TVS may be used for protecting higher frequency applications in inductive switching environment or electrical systems. If bipolar transient capability is required two of these capacitance TVS devices may be used in parallel in opposite directions for complete AC protection.

3.4.4 Positive Voltage Regulator (LM 2940 CS)

It has the ability to source 1A of output current with a drop out voltage of typically 0.5 V and maximum of 1V over the entire temperature range. Further more a quiescent current reduction has been included which reduces the ground current when the difference between input and output voltage is more than 3V. A quiescent current with 1A of output current and input- output differential of 5V is 30mA. Higher quiescent current exist when the regulator is in drop out mode $(V_{IN} - V_{OUT}) < 3V$.

CHAPTER 4

PRINTED CIRCUIT BOARD DESIGN

4.1 PROCEDURE FOR DESIGNING PCB

4.1.1 Schematics Editor

This is the first computer aided design package used in the PCB design. It is used to draw the circuit in the logical manner without considerations placement and routing .The most important information contained in the schematics editor are:

(1) The interconnections between (how the devices are connected to each other).

(2) The foot prints (pattern and size of pads required to solder the component).

4.1.2 PCB Layout And Routing

PCB layout and routing is done by NETLIST which was created in the schematics editor .This file will contain not only all the components needed along with the correct footprints but also include the nets that is interconnect components. Once when net list is created lines that interconnect components in the same nets are seen in the PCB design environment. These lines are called RASTNETS are important for PCB routing.

4.1.3 PCB Fabrication

To fabricate the PCB files which represent each layer of the board and hole locations have to be generated. These files are sent for photo – plotting onto films. The PCB manufacturer will use photographic techniques to transfer the artwork fro the onto the various layers of the board .PCB undergoes several chemical process.

4.2 MICROSTRIP LINE

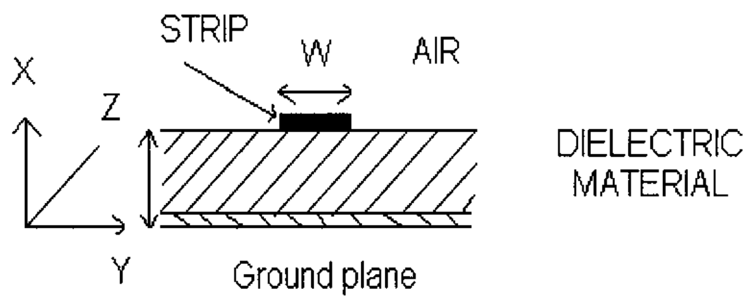


Fig 4.1 Micro Strip Line

A micro strip line is a conductor strip etched on top of the dielectric substrate of thickness H, width W, thickness T. The other side of the substrate is covered with ground plane micro strip lines are implemented as traces on printed circuit boards.

4.3 PCB PARAMETERS AND CONSIDERATIONS

4.3.1 Choice of Substrate

Substrate are dielectric material that form the interface between the micro strip line and the ground plane .There are two types of substrates they are

(i) Hard substrate
(ii) Soft substrate.

The choice of substrate depends upon various factors they are:

1. Low cost of substrate.
2. Efficient performance at high frequencies
3. Strength of substrate

4.3.2 Characteristics Impedance Of Traces

The characteristic impedance is calculated by the formula

$$Z = \underline{87 \ \ln(6h/(8w+1))} / E$$

Where, Z = Characteristic Impedance, w = width of trace, h = height of the PCB substrate, E = permittivity.

4.4 PLACEMENT AND ROUTING

4.4.1 Placement

After the net list is generated from the schematic file, it is loaded onto a PCB file, in the PROTEL PCB design software .This will give a raster, showing the connections and the footprints of components .Then the size of the PCB is demarked using the keep out layer tracks. All components must be placed manually on the PCB

The following considerations were followed for the placement of components:

1. The decoupling capacitors for each IC were placed as close to the IC as possible, to provide power fluctuations to the IC.
2. The crystal oscillators are place close to the relevant IC s.
3. The density of the components was increased to save space.
4. Most of the connectors and the jumpers were pushed to the sides of the board to increase the land space in the center of the board.
5. The components were placed such that the different modules of the system were roughly separated visibly.

4.4.2 Routing

Once the placement is finalized, the routing of all connections is done. Again the routing is done manually

The following considerations were followed:

1. All traces were confined to the top and bottom layer
2. All signal traces were kept at 9mils standard width to satisfy the 50 ohm matching requirement

CHAPTER 5
HARDWARE IMPLEMENTATION

5.1 HARDWARE IMPLEMENTATION

5.1.1 Equipment / Materials Required

5.1.1.1 Soldering Iron

A low wattage (preferably 20 W) iron with a fine tip is preferred for soldering SMT (surface mount technology) components. This will avoid over heating the components. A fine tip is required so as to be able to apply the heat at the precise point during soldering, the solder tip should be cleaned often by flux or wet sponge.

5.1.1.2 Hot Air Blower

The hot air blower is required to remove failed or incorrectly soldered components since they will extract the entire SMT component along with the solder into the sucker as well .Further more a hot air –blower is very convenient for the removal of chips with several pins as all the pins will be heated simultaneously .This enables the whole chip to be removed at one go.

5.1.1.3 Continuity Tester (Multi Meter)

This is used to ensure joints that appear to be connected visually are actually connected electrically.

5.1.1.4 Soldering Wick

This is used to remove excess solder. The wick is placed next to the excess solder before heat is applied. Due to the high affinity of solder to the wick, the excess solder will stick to the excess solder will stick when it is in the momentary molten state.

5.1.1.5 Solder

It is an alloy that has a relatively low melting point which will assume a molten state when heated by the soldering iron .The alloy is used to electrically connect the pins to the PCB and to physically hold the device on the board

5.1.1.6 Soldering Paste / Flux

Soldering paste / flux is a compound that decomposes upon heating to produce a cleaning agent .For example ammonium chloride paste will produce hydrochloric acid. The paste is usually applied to the joints before soldering is performed to ensure better contact.

5.1.2 Soldering Considerations

There is a significant difference between soldering through the hole components and soldering SMT components further more, extra care has to be taken when dealing with RF circuits.

5.1.2.1 SMT "HEAT REFOLW" TECHNIQUE

There are several soldering processes used industrially such as wave tanks and vapour phase I which suitably hot vapour is directly over the populated board .However when soldering the components by our selves in the laboratory we have to use the conventional soldering iron .To avoid overheating the SMT components the pads to receive the components are first tinned - that is coated with a thin layer of solder .Then , soldering paste / flux is applied on the tinned surface and the component pins to be soldered .The components is held in place using a pincer before heat is applied to the pad. Upon heating, the solder will reflow and make contact with the pin of component.

5.1.2.2 Amount of Solder

It is very important to use as little solder as necessary especially when soldering components for use in the high frequency RF section. This is because excessive lumps of solder will introduce inductance to the circuit and thus modify the original circuit parameters.

5.1.2.3. Component Removal Technique

In the event of incorrect soldering or failed chip, removal is facilitated through the use of hoe air blower .It is important to remove the components using a pincer as quickly as possible once the solder assumes a molten state. Otherwise unnecessary over heating of both the components and PCB will occur with the posilibility of causing damage especially to active components.

5.1.3. Hardware Debugging

Unless the prototype has undergone several iterations of developments, there is bound to be unforeseen problems when they arise.

5.1.3.1. Incorrect Foot Path

During the soldering of the board, we discovered that some components footprints were different from that of the pads on the PCB. This can be due to last – minute changes, after the design has been completed, as certain components leads to the pads in the originally planned foot print. In such cases , fine wire – wrapping wires are used to extend the components to be soldered .After that the components are aligned over pads and the wires are trimmed to match the pad exactly .Having done that we can now proceed as usual as the components lead have now been extended to fit the pads.

5.1.3.2. Missing Track

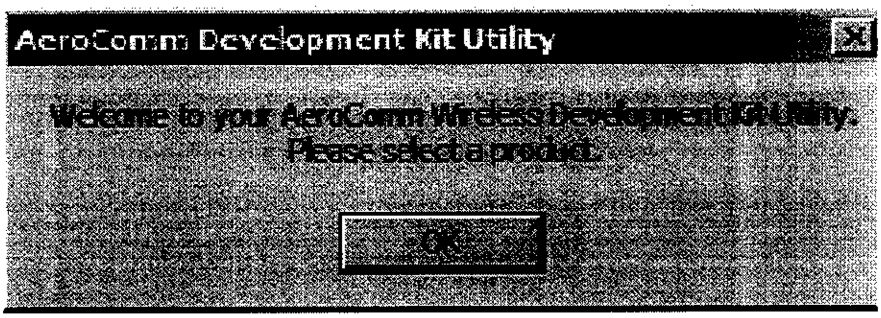
Some routes were in avertedly left out during the PCB artwork design for such problems , thin wire – wrapping wires are used as jumpers ti interconnect the points .care is taken not to remove the insulation of these jumpers except at the terminations so that they will not short components.

5.1.3.3. Unwanted Track

In the event of unexpected change in the signal assignments, some pins would have to be swapped with each other .This will create some "unwanted tracks which need to be removed.

5.2 SOFTWARE IMPLEMENTATION

Locate the OEM software on the aerocomm tools and install the development software. To install the software run setup.exe and follow the instruction prompts. During the installation the software will prompt the user to install the aerocomm USB driver. It is recommended that the user installs the driver at the same as the software .The first time the software is run the following message will be displayed.



Now click the option "ok" the software will show the port as unavailable this willm occur for one of the following reason

(1) There is other software running that has control over the COM 1 port. locate this software and shut it down while running Aerocomm OEM.exe software.
(2) The personal computer doesn't have COM1 port or the port has been disabled

5.2.1 Personal Computer (Pc) Settings Page

The PC settings page is shown below as it will appear the first time the program is run

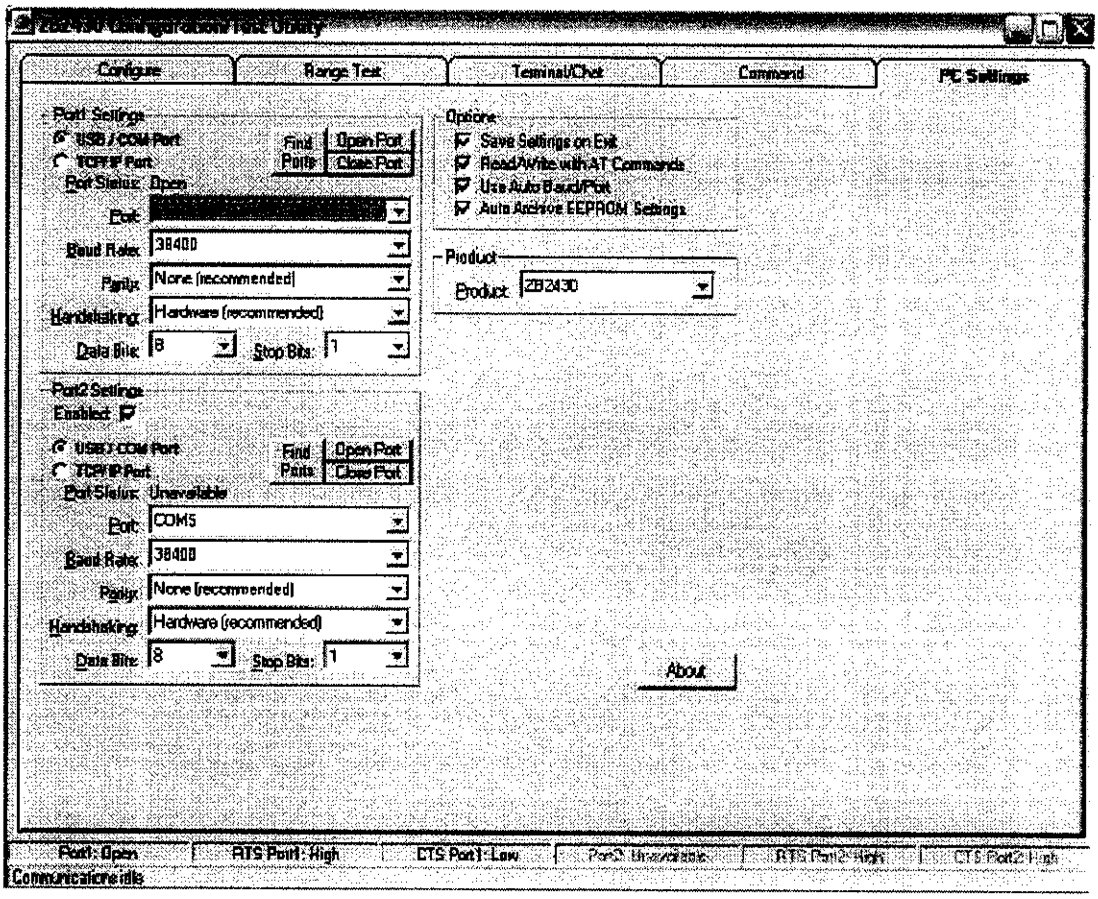


Fig 5.1 PC Settings

Then select the ZB2430 module from the product pull down menu doing this the software will choose the default baud rate of 38400. If the COM 1 port is listed unavailable a different COM 1 port will be selected in the port pull down menu .This software can use two serial ports if enabled.

5.2.2 PORT 1 / PORT 2

This software can control up to two com ports including virtual COM ports which physically map to USB or the Ethernet ports .the pull down menu allows to select COM 1 through COM 16, an error message will be displayed if the port selected is unavailable .when the port selection is made, the software will attempt to open the port and list its status as unavailable or open close .Although menus are shown for data bits, parity and stop bits, only the parity menu selection can be changed.

5.2.2 Configure Page

This is GUI representation of 256 byte EEPROM contents with in the radio the same data is shown in a full hexadecimal dump of EEPROM of the EEPROM editor view there by configure page is shown below as it will appear until a radio is successfully read.

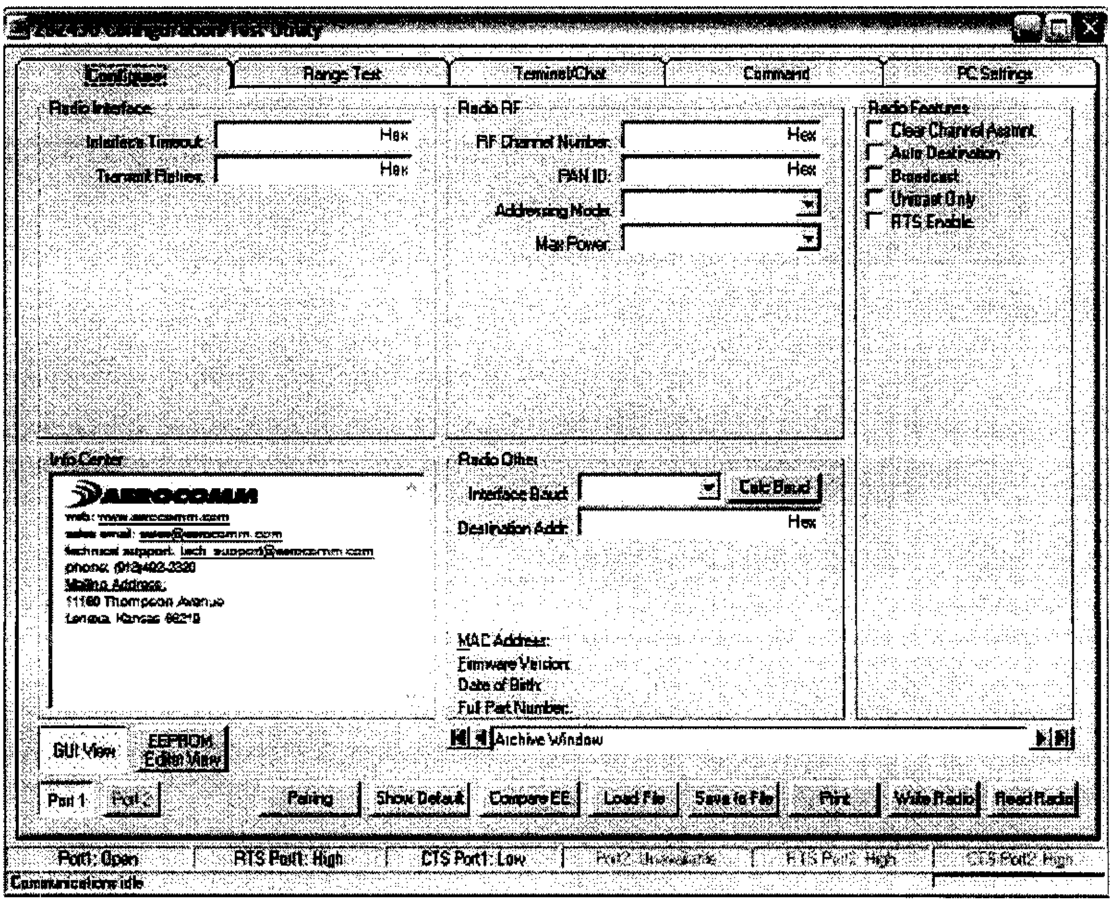


Fig 5.2 A Configuration utility

5.2.4. Read Radio Button

To update the configure and EEPROM edit to view the pages with the EEPROM contents of a radio currently connected to the proper port on the PC click the read radio button an example of the configure page after a transmitter has been fully read is shown below.

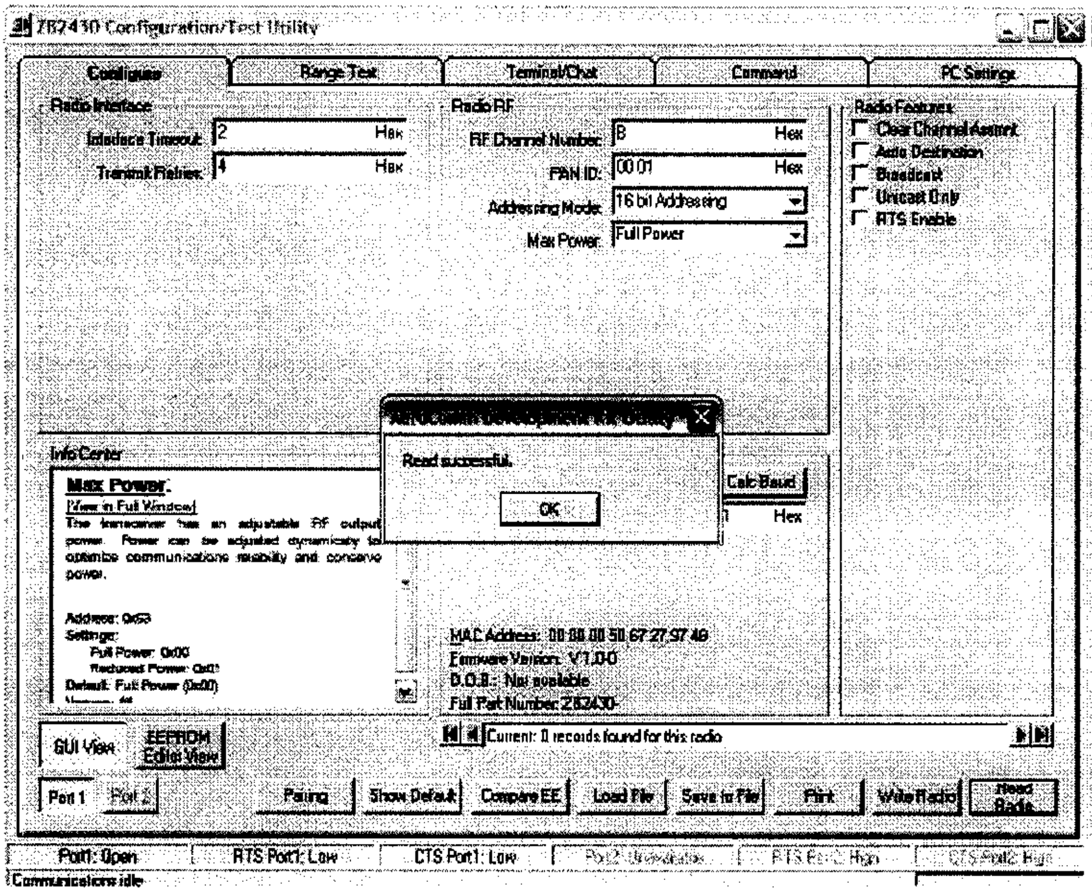


Fig 5.2B Configuration utility

CHAPTER 6
RESULTS

6.1 INTRODUCTION

The simulation of the transceiver systems provides advantages in the design process by allowing various options to be tried out before the hardware is built. To validate the feasibility of the proposed approach, a virtual implementation of the Transceiver is done using the Simulink.MATLAB is a software package for high performance numerical computation and a visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. The name MATLAB stands for MATRIX LABORATORY .There are several optional toolboxes available from the developers of MATLAB .These toolboxes are collection of functions written for special application MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation.

Typical uses include Math and computation Algorithm development Data acquisition Modelling, simulation, and prototyping Data analysis, exploration, and visualization Scientific and engineering graphics Application development, including graphical user interface building MATLAB is an interactive system whose basic data element is an array that does not require dimensioning. This allows you to solve many technical computing problems, especially those with matrix and vector formulations, in a fraction of the time it would take to write a program in a scalar non-interactive language such as C or FORTRAN.

MATLAB was originally written to provide easy access to matrix software developed by the LINPACK and EISPACK projects. Today, MATLAB engines incorporate the LAPACK and BLAS libraries, embedding the state of the art in software for matrix computation. MATLAB has evolved over a period of years with input from many users. In university environments, it is the standard instructional tool for introductory and advanced courses in mathematics, engineering, and science.

In industry, MATLAB is the tool of choice for high-productivity research, development, and analysis. MATLAB features a family of add-on application-specific solutions called toolboxes. Very important to most users of MATLAB, toolboxes allow you to learn and apply specialized technology. Toolboxes are comprehensive collections of MATLAB functions (M-files) that extend the MATLAB environment to solve particular classes of problems. Areas in which toolboxes are available include signal processing, control systems, neural networks, fuzzy logic, wavelets, simulation, and many others.

6.2 SIMULINK MODEL FOR CDMA WIRELESS TRANSCEIVER

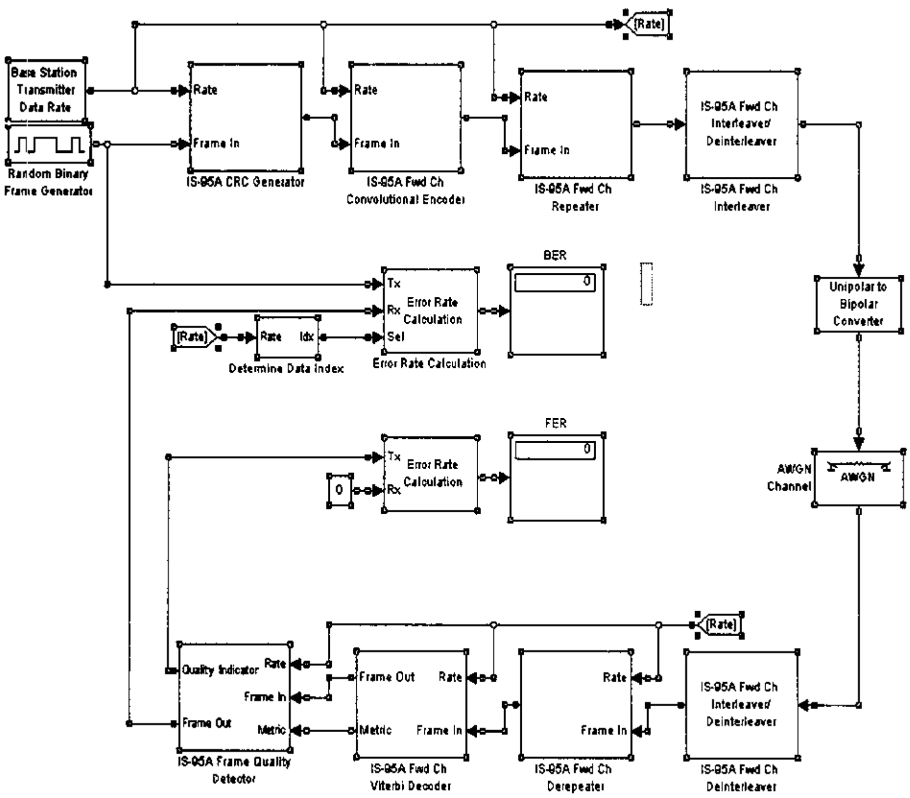


Fig 6.1 Model for CDMA Wireless Transceiver

6.2.1 Data Source

It is the subsystem for base station transmitter data rate and random binary frame generator.

CHAPTER 7

CONCLUSION

A CDMA Wireless Transmitter for generic wireless applications has been designed and developed in this project. The transmitter system consists of RS –232 cable interfaces, RS - 232 Transceiver, ZB 2430 module, linear voltage and positive regulator and transient voltage suppressor. The transmitter modules are tested and found to be functional .Also the system simulation using MATLAB is done to predict the system performance .The data was generated using a computer transmitted through the CDMA transmitter and was received without error at the computer.

8. REFERENCES

[1] Isaac Sever, et al., "A Dual Antenna Phase Array ultra –wide band CMOS Transceiver" IEEE communications August 2006 Vol 44, No .8 pp 102-110.

[2] Michel Zorzi,et al., "Cross layer issues in MAC protocol design for MIMO Ad Hoc Networks" IEEE wireless communications, August 2006 Vol 13, No. 4, pp 62-73