IMPLEMENTATION OF VARIOUS DIGITAL MODULATION TECHNIQUES USING LOW COST COMPONENTS

Submitted in partial fulfillment of the Degree of
Bachelor of Technology

May – 2014

Under the Supervision of

Mr. Tapan Jain

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DECLARATION

We hereby declare that the work reported in the B. Tech thesis entitled "**Implementation of various digital modulation techniques using low cost components"** submitted by "**Mr. Abhishek Rustagi , Mr. Dhruv Srow and Mr. Vivek Raj Singh"** at Jaypee University Of Information Technology, Waknaghat is an authentic record of our work carried out under the supervision of **Mr. Tapan Jain**. This work has not been submitted partially or wholly to any other university or institution for the award of this or any other degree or diploma.

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CERTIFICATE

This is to certify that the work titled **"Implementation of various digital modulation techniques using low cost components"** submitted by **"Mr. Abhishek Rustagi , Mr. Dhruv Srow and Mr. Vivek Raj Singh "** in the partial fulfillment for the award of degree of Bachelor of Technology (ECE) of Jaypee University of Information Technology, Waknaghat has been carried out under my supervision. This work has not been submitted partially or wholly to any other university or institution for the award of this or any other degree or diploma.

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Contents

LIST OF FIGURES

ACRONYMS

BSK	Binary Shift Keying
ASK	Amplitude Shift Keying
PSK	Phase Shift Keying
FSK	Frequency Shift Keying
QPSK	Quadrature Phase Shift Keying
BER	Bit Error Rate
RF	Radio Frequency
DSB	Double - Sideband Modulation
SSB	Single - Sideband Modulation
QAM	Quadrature Amplitude Modulation
DPSK	Differential Phase Shift Keying
CPSK	Coherent Phase Shift Keying
BPSK	Binary Phase Shift Keying
SNR	Signal to Noise Ratio
IF	Intermediate Frequency
DAC	Digital to Analog Conversion

ABSTRACT

Through this project report we intend to bring about an economical implementation of various digital modulation techniques for a clear demonstration in the communication laboratory. This will bring in a reduction in the expenditure made for the expensive ready-made kits for the manifestation of the various digital modulation techniques. The annual maintenance cost for the various kits will also be removed. This will help the university in an economical manner. This will bring forth each subcomponent apparently to everyone, providing a better knowledge of their individual performances and a feel of the modulation techniques. Also, as all the subcomponents will be distinctly visible it will be quite easier to repair the circuit whenever some defect comes into being. One of the limitations that can be observed with the usage of kits is that a single kit is to be shared by three to four students simultaneously as they are quite expensive. This results as a hindrance in the complete attention that should be paid by every individual student. The circuits which will prove to be quite cheaper than the individual kits, can be implemented and used by every student in an individual manner.

CHAPTER 1

INTRODUCTION

Technologically speaking ,analog and digital are two kinds of processes used for the transmission of an electric signal. An audio/video signal is translated into electronic pulses which vary in amplitude. Digital communication is about breaking the signal into binary format where the data is represented by series of 1s and 0s. The difference can refer to the method of input, data storage and transfer, the internal working of an instrument and the kind of display, the beauty of digital communication is that it knows what it should be when it reaches the end point of the transmission system. It owes its accuracy to its ability to count things rather than measure them. Desired information can be achieved out of a digital signal far easily than from an analog signal. These signals are easier to encrypt for security purposes to prevent others intercepting and deciphering them.

In Electronics ,modulation is the process of varying one or more properties of a high frequency periodic-waveform, called the carrier signal, with respect to a modulating signal. This is done in a similar fashion as a musician may modulate a tone (a periodic waveform) from a musical instrument by varying its volume, timing and pitch. The three key parameters of a periodic waveform are its amplitude ("volume"), its phase ("timing") and its frequency ("pitch"), all of which can be modified in accordance with a low frequency signal to obtain the modulated signal.

In telecommunications, modulation is the process of conveying a message signal, for example a digital bit stream or an analog audio signal, inside another signal that can be physically transmitted. Modulation of a sine waveform is used to transform a baseband message signal to a pass band signal, for example a radio-frequency signal (RF signal.)

In radio communications, cable TV systems or the public switched telephone network for instance, electrical signals can only be transferred over a limited pass band frequency spectrum, with specific (non-zero) lower and upper cut off frequencies. Modulating a sine wave carrier makes it possible to the centre frequency (typically the carrier frequency) of the pass band. When coupled with demodulation, this technique can be used to, among other things, transmit a signal through a channel which may be opaque to the baseband frequency range (for instance, when sending a telephone signal through a fiber-optic stand).
In music synthesizers, modulation may be used to synthesize waveforms with a desired overtone spectrum. In this case the carrier frequency is typically in the same order or much lower than the modulating waveform. See for example frequency modulation synthesis or ring modulation.

1.1 Need For Modulation

Modulation is needed to:

1. Increase the frequency of a signal, thereby indirectly, increasing its energy to enable it to travel a long distance.
2. Decrease antenna height. To transmit a signal of wavelength 'lambda', the height of the antenna should be 'lambda/4'.
3. Transmit signals from various sources simultaneously over a common channel by means of multiplexing. Every transmission of a signal in a bandwidth is assigned with a particular frequency which is attained by modulating the signal with the carrier frequency.
4. Limit the usage of hardware.
5. Limit the use of repeaters and antennas at regular intervals.
6. Optimize the SNR, implying less noise.
7. Ensure effective radio transmission.
8. Synthesize waveforms with a desired overtone spectrum.

1.2 Modulation Index

The modulation index (or modulation depth) of a modulation scheme describes by how much the modulated variables of the carrier signal varies around its unmodulated level. It is defined differently in each modulation scheme.

1.3 Modulation Order

The modulation order of a digital communication scheme is determined by the number of the different symbols that can be transmitted using it.

Modulation order can only be defined for digital modulations. The simplest forms of digital modulation are of second order because they can transmit only two symbols (usually denoted as "0" and "1" as "-1" and "1"). They are called binary shift keying (BSK).

Modulations which have an order of 4 and above usually are termed as higher-order modulations. Examples of these are quadrature phase shift keying (QPSK) and its generalization as m-ary quadrature amplitude modulation (m-QAM).

Because existing computers and automation systems are based on binary logic most of the modulations have an order which is power two:2,4,6,8,16 etc. In principle, however, the order of a modulation can be any integer greater than one.
When the order of a digital modulation approaches infinity its properties approach those of the respective analog modulation. Thus the analogue modulations can be viewed as extreme cases of higher-order digital modulations for which the order is equal o infinity.

1.4 Modulator

A device that performs modulation is known as a modulator and a device that performs the inverse operation of a modulation is known as a demodulator (Sometimes detector or demod). A device that can do both operations is a modem (Short for "Modulator-Demodulator"). In analog modulation, modulation is applied is continuously in response to the analog information signal. Its aim is to transfer an analog baseband(or low pass signal) over an analog pass band channel. To increasing transmitter efficiency, the carrier can be removed(suppressed) from the AM signal. A form of AM is on-off, a type of amplitude-shift keying by which the binary data is represented as the presence or absence of a carrier wave. This is used at radio frequencies to transmit Morse code, referred to as continuous wave operation.

1.5 Analog Modulation Methods

In analog modulation, the modulation is applied continuously in response to the analog information signal. Common analog modulation techniques are :

1. Amplitude modulation (AM) (here the amplitude of the carrier signal is varied in accordance to instantaneous amplitude of the modulating signal)
2. Double-sideband modulation (DSB)
3. Double-sideband modulation with carrier (DSB-WC) (used on the AM radio broadcasting band)
4. Double side-band suppressed carrier transmission (DSB-SC)
5. Double side-band reduced carrier transmission (DSB-RC)
6. Single-sideband modulation (SSB, or SSB-AM)
7. SSB with carrier (SSB-WC)
8. SSB suppressed carrier modulation (SSB-SC)
9. Vestigial side-band modulation (VSB, or VSB-AM)
10. Quadrature amplitude modulation (QAM)
11. Angle modulation

1.6 Digital Modulation Methods

In digital modulation, an analog carrier signal is modulated by a digital bit stream. Digital modulation methods can be considered as digital -to-analog conversion, and the corresponding demodulation or detection as analog-to-digital conversion. The changes in the carrier signal are chosen from a finite number of M alternative symbols (the modulation alphabet).

1.7 Fundamental Digital Modulation Methods

The most fundamental digital modulation techniques are based on keying :
In the case of PSK , a finite number of phases are used.
In the case of FSK, a finite number of frequencies are used.
In the case of ASK, a finite number of amplitudes are used.
In the case of Quadrature Amplitude Modulation , a finite number of atleast two phases and at least two amplitudes are used .
In all of the above methods, each of these phases , frequencies or amplitudes are assigned a unique pattern of binary bits. Usually, each phase, frequency or amplitude encodes an equal number of bits. This number of bits comprises the symbol that is represented by the particular phase, frequency or amplitude.
If the alphabet consists of $M = 2^n$ alternative symbols, each symbol represents a message consisting of N bits . If the symbol rate (baud rate) is f_s symbols/second , the data rate is Nf_s bit/second .
For example, with an alphabet consisting of 16 alternative symbols, each symbol represents 4 bits. Thus, the data rate is four times the baud rate .

CHAPTER 2

MODULATOR AND DETECTOR PRINCIPLES OF OPERATION

PSK and ASK, and sometimes also FSK, are often generated and detected using the principle of QAM. The I and Q signals can be combined into a complex-valued signal $I+jQ$(where j is the imaginary unit). The resulting so called equivalent lowpass signal or equivalent baseband signal is a complex-valued representation of the real-valued modulated physical signal (the so-called passband signal or RF signal).

These are the general steps used by the modulator to transmit data:
Group the incoming data bits into codewords, one for each symbol that will be transmitted.
Map the codewords to attributes, for example amplitudes of the I and Q signals (the equivalent low pass signal), or frequency or phase values.
Adapt pulse shaping or some other filtering to limit the bandwidth and form the spectrum of the equivalent low pass signal, typically using digital signal processing.
Perform digital to analog conversion (DAC) of the I and Q signals (since today all of the above is normally achieved using digital signal processing, DSP).
Generate a high frequency sine carrier waveform, and perhaps also a cosine quadrature component. Carry out the modulation, for example by multiplying the sine and cosine waveform with the I and Q signals, resulting in the equivalent low pass signal being frequency shifted to the modulated passband signal or RF signal. Sometimes this is achieved using DSP technology, for example direct digital synthesis using a waveform table, instead of analog signal processing. In that case the above DAC step should be done after this step.
Amplification and analog bandpass filtering to avoid harmonic distortion and periodic spectrum
At the receiver side, the demodulator typically performs:
Bandpass filtering.

Automatic gain control, AGC (to compensate for attenuation, for example fading).
Frequency shifting of the RF signal to the equivalent baseband I and Q signals, or to an intermediate frequency (IF) signal, by multiplying the RF signal with a local oscillator sinewave and cosine wave frequency (see the superheterodyne receiver principle).
Sampling and analog-to-digital conversion (ADC) (Sometimes before or instead of the above point, for example by means of undersampling).
Equalization filtering, for example a matched filter, compensation for multipath propagation, time spreading, phase distortion and frequency selective fading, to avoid intersymbol interference and symbol distortion.
Detection of the amplitudes of the I and Q signals, or the frequency or phase of the IF signal.
Quantization of the amplitudes, frequencies or phases to the nearest allowed symbol values.
Mapping of the quantized amplitudes, frequencies or phases to codewords (bit groups).
Parallel-to-serial conversion of the codewords into a bit stream.
Pass the resultant bit stream on for further processing such as removal of any error-correcting codes.

As is common to all digital communication systems, the design of both the modulator and demodulator must be done simultaneously. Digital modulation schemes are possible because the transmitter-receiver pair have prior knowledge of how data is encoded and represented in the communications system. In all digital communication systems, both the modulator at the transmitter and the demodulator at the receiver are structured so that they perform inverse operations.

Non-coherent modulation methods do not require a receiver reference clock signal that is phase synchronized with the sender carrier wave. In this case, modulation symbols (rather than bits, characters, or data packets) are asynchronously transferred. The opposite is coherent modulation.

2.1 List of various digital modulation techniques :

Phase-shift keying (PSK):
Binary PSK (BPSK), using M=2 symbols
Quadrature PSK (QPSK), using M=4 symbols
8PSK, using M=8 symbols
16PSK, using M=16 symbols
Differential PSK (DPSK)
Differential QPSK (DQPSK)
Offset QPSK (OQPSK)
π/4–QPSK
Frequency-shift keying (FSK):
Audio frequency-shift keying (AFSK)
Multi-frequency shift keying (M-ary FSK or MFSK)
Dual-tone multi-frequency (DTMF)
Amplitude-shift keying (ASK)
On-off keying (OOK), the most common ASK form
M-ary vestigial sideband modulation, for example 8VSB
Quadrature amplitude modulation (QAM) - a combination of PSK and ASK:
Polar modulation like QAM a combination of PSK and ASK.
Continuous phase modulation (CPM) methods:
Minimum-shift keying (MSK)
Gaussian minimum-shift keying (GMSK)
Continuous-phase frequency-shift keying (CPFSK)
Orthogonal frequency-division multiplexing (OFDM) modulation:
discrete multitone (DMT) - including adaptive modulation and bit-loading.
Wavelet modulation
Trellis coded modulation (TCM), also known as trellis modulation
Spread-spectrum techniques:
Direct-sequence spread spectrum (DSSS)
Chirp spread spectrum (CSS) according to IEEE 802.15.4a CSS uses pseudo-stochastic coding

Frequency-hopping spread spectrum (FHSS) applies a special scheme for channel release

SIM31 (SIM) New digital Mode SIM31 SIM63 tks SWL Tunisian

MSK and GMSK are particular cases of continuous phase modulation. Indeed, MSK is a particular case of the sub-family of CPM known as continuous-phase frequency-shift keying (CPFSK) which is defined by a rectangular frequency pulse (i.e. a linearly increasing phase pulse) of one symbol-time duration (total response signaling).

OFDM is based on the idea of frequency-division multiplexing (FDM), but the multiplexed streams are all parts of a single original stream. The bit stream is split into several parallel data streams, each transferred over its own sub-carrier using some conventional digital modulation scheme. The modulated sub-carriers are summed to form an OFDM signal. This dividing and recombining helps with handling channel impairments. OFDM is considered as a modulation technique rather than a multiplex technique, since it transfers one bit stream over one communication channel using one sequence of so-called OFDM symbols. OFDM can be extended to multi-user channel access method in the orthogonal frequency-division multiple access (OFDMA) and multi-carrier code division multiple access (MC-CDMA) schemes, allowing several users to share the same physical medium by giving different sub-carriers or spreading codes to different users.

Of the two kinds of RF power amplifier, switching amplifiers (Class D amplifiers) cost less and use less battery power than linear amplifiers of the same output power. However, they only work with relatively constant-amplitude-modulation signals such as angle modulation (FSK or PSK) and CDMA, but not with QAM and OFDM. Nevertheless, even though switching amplifiers are completely unsuitable for normal QAM constellations, often the QAM modulation principle are used to drive switching amplifiers with these FM and other waveforms, and sometimes QAM demodulators are used to receive the signals put out by these switching amplifiers.

CHAPTER 3

DIGITAL MODULATION TECHNIQUES

In digital modulation, an analog carrier signal is modulated by a discrete signal. Digital modulation methods can be considered as digital-to-analog conversion, and the corresponding demodulation or detection as analog-to-digital conversion. The changes in the carrier signal are chosen from a finite number of M alternative symbols (the modulation alphabet). According to one definition of digital signal, the modulated signal is a digital signal, and according to another definition, the modulation is a form of digital-to-analog conversion. Most textbooks would consider digital modulation schemes as a form of digital transmission, synonymous to data transmission; very few would consider it as analog transmission.

3.1 Amplitude Shift Keying

Amplitude-shift keying (ASK) is a form of amplitude modulation that represents digital data as variations in the amplitude of a carrier wave. In an ASK system, the binary symbol 1 is represented by transmitting a fixed-amplitude carrier wave and fixed frequency for a bit duration of T seconds. If the signal value is 1 then the carrier signal will be transmitted; otherwise, a signal value of 0 will not be transmitted.
Any digital modulation scheme uses a finite number of distinct signals to represent digital data. ASK uses a finite number of amplitudes, each assigned a unique pattern of binary digits. Usually, each amplitude encodes an equal number of bits. Each pattern of bits forms the symbolthat is represented by the particular amplitude. The demodulator, which is designed specifically for the symbol-set used by the modulator, determines the amplitude of the received signal and maps it back to the symbol it represents, thus recovering the original data. Frequency and phase of the carrier are kept constant.
Like AM, ASK is also linear and sensitive to atmospheric noise, distortions, propagation conditions on different routes in PSTN, etc. Both ASK modulation and demodulation processes are relatively inexpensive. The ASK technique is also commonly used to transmit digital data over optical fiber . For LED transmitters, binary 1 is represented by a short pulse of light and binary 0 by the absence of light. Laser transmitters normally have a fixed "bias" current that causes the device to emit a low light level. This low level represents binary 0, while a higher-amplitude light wave represents binary 1.
The simplest and most common form of ASK operates as a switch, using the presence of a carrier wave to indicate a binary one and its absence to indicate a binary zero. This type of modulation is called on-off keying, and is used at radio frequencies to transmit Morse code (referred to as continuous wave operation),
More sophisticated encoding schemes have been developed which represent data in groups using additional amplitude levels. For instance, a four-level encoding scheme can represent two bits with each shift in amplitude; an eight-level scheme can represent three bits; and so on. These forms of amplitude-shift keying require a high signal-to-noise ratio for their recovery, as by their nature much of the signal is transmitted at reduced power.

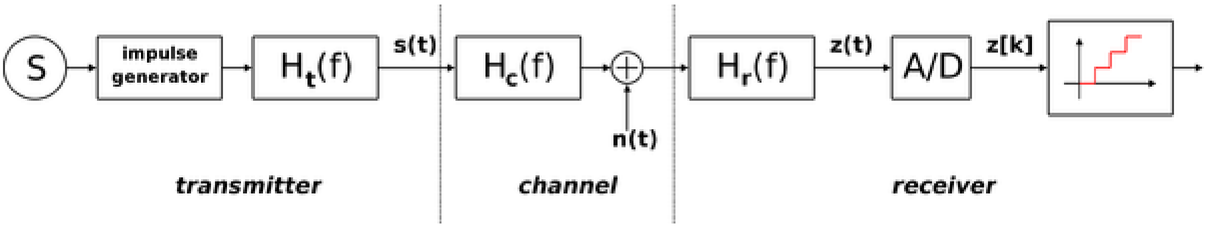

FIG. 3.1 ASK Diagram

ASK system can be divided into three blocks. The first one represents the transmitter, the second one is a linear model of the effects of the channel, the third one shows the structure of the receiver. The following notation is used:

$ht_{(f)}$ is the carrier signal for the transmission
$hc_{(f)}$ is the impulse response of the channel
$n_{(t)}$ is the noise introduced by the channel
$hr_{(f)}$ is the filter at the receiver
L is the number of levels that are used for transmission
T_s is the time between the generation of two symbols

3.2 Frequency Shift Keying

Frequency shift keying is a frequency modulation scheme in which digital information is transmitted through discrete frequency changes of a carrier. The simplest FSK is binary FSK(BFSK). BFSK literally implies using a pair of discrete frequencies to transmit binary information. With this scheme, the "1" is called the mark frequency and the "0" is called the space frequency. The time domain of an FSK modulated carrier is illustrated in the figures

Forms of FSK:

3.2.1 Minimum-Shift Keying

The MSK modulation is a constant envelope signal with continuous phase that results from modulating the instantaneous frequency with rectangular pulses. MSK is considered to be a special case of Offset QPSK (OQPSK) with half sinusoidal pulse weighting rather than rectangular. In MSK the difference between the higher and lower frequency is identical to half the bit rate. Consequently, the waveforms used to represent a 0 and a 1 bit differ by exactly half a carrier period. Thus, the maximum frequency deviation is δ = 0.25 f_m where f_m is the maximum modulating frequency. As a result, the modulation index *m* is 0.5. This is the smallest FSK modulation index that can be chosen such that the waveforms for 0 and 1 are orthogonal. A variant of MSK called GMSK is used in the GSM phone standard. In digital communication, Gaussian minimum shift keying or GMSK is a continuous-phase frequency-shift keying modulation scheme. It is similar to standard minimum-shift keying (MSK); however the digital data stream is first shaped with a Gaussian filter before being applied to a frequency modulator. This has the advantage of reducing sideband power, which in turn reduces out-of-band interference between signal carriers in adjacent frequency channels. However, the Gaussian filter increases the modulation memory in the system and causes inter symbol interference, making it more difficult to differentiate between different transmitted data values and requiring more complex channel equalization algorithms such as an adaptive equalizer at the receiver. GMSK has high spectral efficiency, but it needs a higher power level than QPSK, for instance, in order to reliably transmit the same amount of data.

FSK is most commonly used in caller ID and remote metering applications.

It is similar to standard minimum shift keying ; however the digital data stream is first shaped with a Gaussian filter before being applied to a frequency modulator.

3.2.2 Audio FSK

Audio frequency-shift keying (AFSK) is a modulation technique by which digital data is represented by changes in the frequency (pitch) of an audio tone, yielding an encoded signal suitable for transmission via radio or telephone. Normally, the transmitted audio alternates between two tones: one, the "mark", represents a binary one; the other, the "space", represents a binary zero.

AFSK differs from regular frequency-shift keying in performing the modulation at baseband frequencies. In radio applications, the AFSK-modulated signal normally is being used to modulate an RF carrier (using a conventional technique, such as AM or FM) for transmission.

AFSK is not always used for high-speed data communications, since it is far less efficient in both power and bandwidth than most other modulation modes. In addition to its simplicity, however, AFSK has the advantage that encoded signals will pass through AC-coupled links, including most equipment originally designed to carry music or speech.

AFSK is used in the U.S. based Emergency Alert System to notify stations of the type of emergency, locations affected, and the time of issue without actually hearing the text of the alert.

3.2.3 Multiple Frequency Shift Keying

Multiple frequency-shift keying (MFSK) is a variation of frequency-shift keying (FSK) that uses more than two frequencies. MFSK is a form of M-ary orthogonal modulation, where each symbol consists of one element from an alphabet of orthogonal waveforms. M, the size of the alphabet, is usually a power of two so that each symbol represents $\log_2 M$ bits.

In a M-ary signaling system like MFSK, an "alphabet" of M tones is established and the transmitter selects one tone at a time from the alphabet for transmission. M is usually a power of 2, so each tone transmission from the alphabet represents $\log_2 M$ data bits.

MFSK is classed as an M-ary orthogonal signaling scheme because each of the M tone detection filters at the receiver responds only to its tone and not at all to the others; this independence provides the orthogonality.

Like other M-ary orthogonal schemes, the required E_b/N_0 ratio for a given probability of error decreases as M increases without the need for multisymbol coherent detection. In fact, as M approaches infinity the required E_b/N_0 ratio decreases asymptotically to the Shannon limit of

-1.6 dB. However this decrease is slow with increasing M, and large values are impractical because of the exponential increase in required bandwidth. Typical values in practice range from 4 to 64, and MFSK is combined with another forward error correction scheme to provide additional (systematic) coding gain.

Like any other form of angle modulation that transmits a single RF tone that varies only in phase or frequency, MFSK produces a constant envelope. This significantly relaxes the design of the RF power amplifier, allowing it to achieve greater conversion efficiencies than linear amplifiers.

MFSK modes used for VHF, UHF communications:

- DTMF
- FSK441
- JT6M
- JT65
- PI4

FSK441, JT6M and JT65 are parts of the WSJT family or radio modulation systems, developed by Joe Taylor, K1JT, for long distance amateur radio VHF communications under marginal propagation conditions. These specialized MFSK modulation systems are used over troposcattering, EME (earth-moon-earth) and meteoscattering radio paths.

PI4 is a digital mode specifically designed for VUSHF beacon and propagation studies. The mode was developed as part of the Next Generation Beacons project among others used by the oldest amateur beacon in the world OZ7IGY. A decoder for PI4 is available in the PI-RX program developed by Poul-Erik Hansen, OZ1CKG.

DTMF was initially developed for telephone line signalling. It is frequently used for telecommand (remote control) applications over VHF and UHF voice channels.

The disadvantages of MFSK include the fact that the signal bandwidth for a given data speed is larger than with binary codes, and the adjustment of the receiving equipment is critical. In order for the error-reducing feature of MFSK to function, the receiver must be capable of maintaining constant frequency over long periods of time.

Even though it is a variant of a decades-old method, MFSK is considered cutting-edge by some engineers. Nowadays, it is used mainly by amateur radio experimenters. Computers with sound cards generate, decode, and display the signals. Amateur radio operators who have used MFSK16 report that it can provide reliable half-duplex communication over long distances using modest transmitters, and it can sometimes provide communications under conditions in which other modes fail.

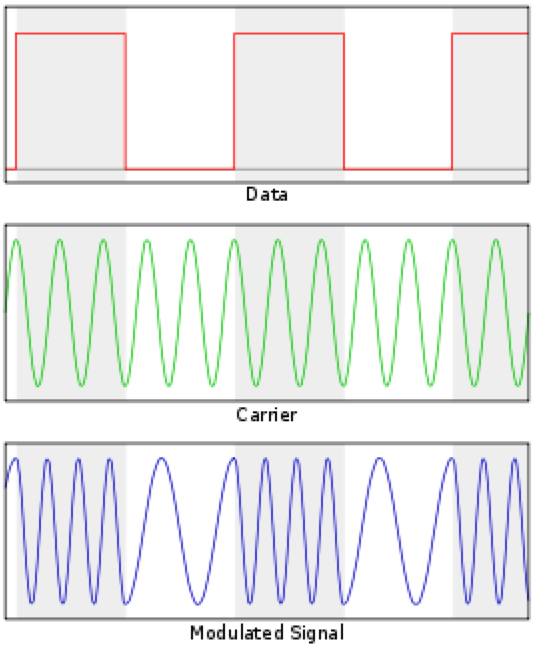

FIG 3.2 : FSK MODULATION WAVEFORM

3.3 Phase Shift Keying

Phase-shift keying (PSK) is a digital modulation scheme that conveys data by changing, or modulating, the phase of a reference signal (the carrier wave).

Any digital modulation scheme uses a finite number of distinct signals to represent digital data. PSK uses a finite number of phases, each assigned a unique pattern of binary digits. Usually, each phase encodes an equal number of bits. Each pattern of bits forms the symbol that is represented by the particular phase. The demodulator, which is designed specifically for the symbol-set used by the modulator, determines the phase of the received signal and maps it back to the symbol it represents, thus recovering the original data. This requires the receiver to be able to compare the phase of the received signal to a reference signal — such a system is termed coherent (and referred to as CPSK).

Alternatively, instead of operating with respect to a constant reference wave, the broadcast can operate with respect to itself. Changes in phase of a single broadcast waveform can be considered the significant items. In this system, the demodulator determines the changes in the phase of the received signal rather than the phase (relative to a reference wave) itself. Since this scheme depends on the difference between successive phases, it is termed differential phase-shift keying (DPSK). DPSK can be significantly simpler to implement than ordinary PSK since there is no need for the demodulator to have a copy of the reference signal to determine the exact phase of the received signal (it is a non-coherent scheme). In exchange, it produces more erroneous demodulation

3.3.1 Binary phase shift keying (BPFSK)

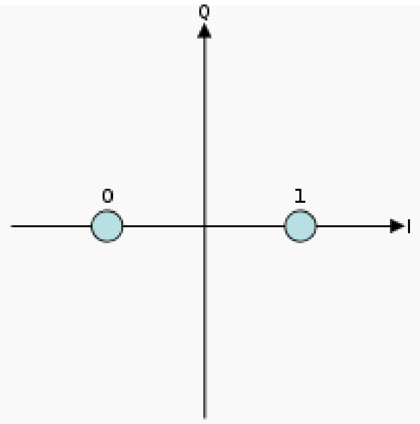

Fig 3.3 Constellation diagram example for BPSK.

BPSK (also sometimes called PRK, phase reversal keying, or 2PSK) is the simplest form of phase shift keying (PSK). It uses two phases which are separated by 180° and so can also be termed 2-PSK. It does not particularly matter exactly where the constellation points are positioned, and in this figure they are shown on the real axis, at 0° and 180°. This modulation is the most robust of all the PSKs since it takes the highest level of noise or distortion to make the demodulator reach an incorrect decision. It is, however, only able to modulate at 1 bit/symbol (as seen in the figure) and so is unsuitable for high data-rate applications.

In the presence of an arbitrary phase-shift introduced by the communications channel, the demodulator is unable to tell which constellation point is which. As a result, the data is often differentially encoded prior to modulation.

BPSK is functionally equivalent to 2-QAM modulation.

3.3.2 Quadrature Phase Shift Keying

Sometimes this is known as quadriphase *PSK*, 4-PSK, or 4-QAM. (Although the root concepts of QPSK and 4-QAM are different, the resulting modulated radio waves are exactly the same.) QPSK uses four points on the constellation diagram, equi spaced around a circle. With four phases, QPSK can encode two bits per symbol, shown in the diagram with Gray coding to minimize the bit error rate (BER) — sometimes misperceived as twice the BER of BPSK.

The mathematical analysis shows that QPSK can be used either to double the data rate compared with a BPSK system while maintaining the same bandwidth of the signal, or to maintain the data-rate of BPSK but halving the bandwidth needed. In this latter case, the BER of QPSK is exactly the same as the BER of BPSK - and deciding differently is a common confusion when considering or describing QPSK. The transmitted carrier can undergo numbers of phase changes.

Given that radio communication channels are allocated by agencies such as the Federal Communication Commission giving a prescribed (maximum) bandwidth, the advantage of QPSK over BPSK becomes evident: QPSK transmits twice the data rate in a given bandwidth compared to BPSK - at the same BER. The engineering penalty that is paid is that QPSK transmitters and receivers are more complicated than the ones for BPSK. However, with modern electronics technology, the penalty in cost is very moderate.

As with BPSK, there are phase ambiguity problems at the receiving end, and differentially encoded QPSK is often used in practice.

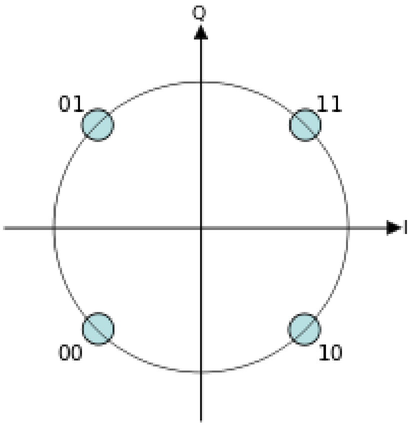

Fig 3.4: Constellation diagram of QPSK with gray

Chapter 4

Output Using Pspice

4.1 Amplitude Shift Keying

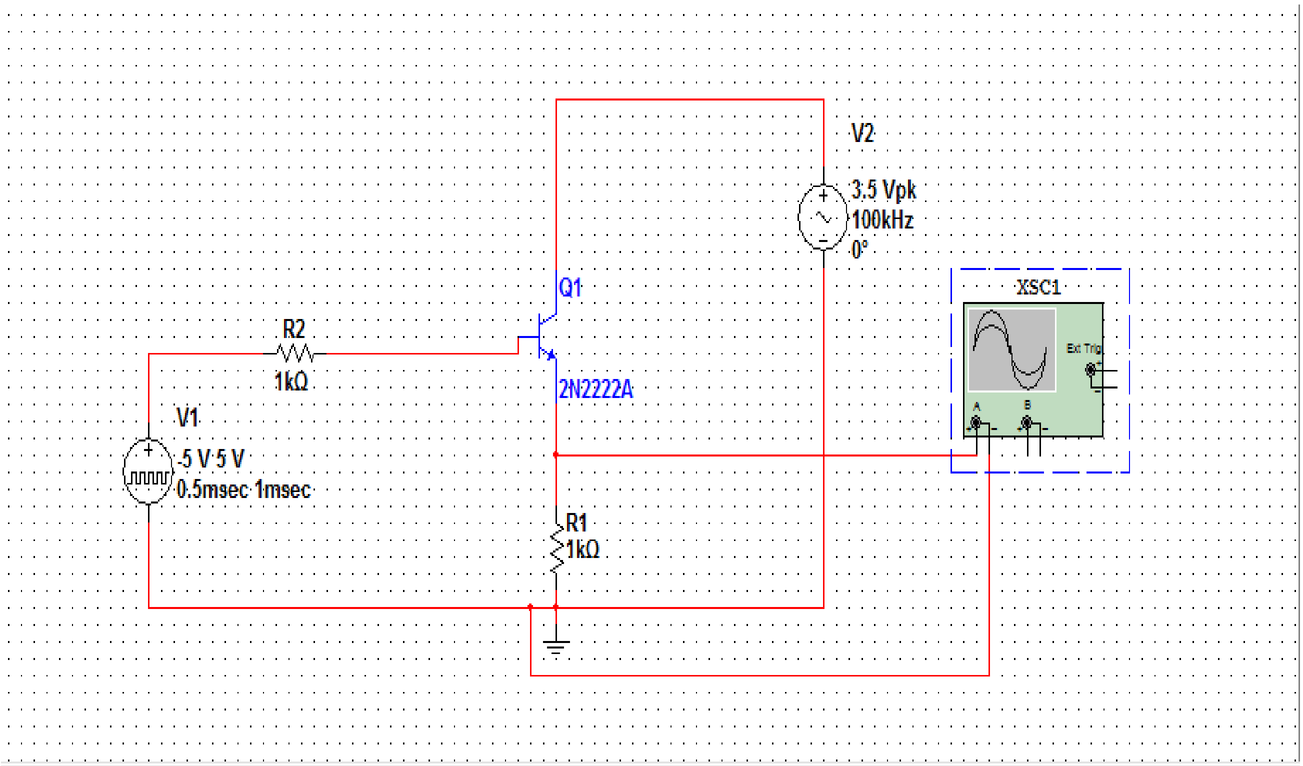

Fig. 4.1 : ASK Circuit Diagram

4.1.1 Component used :

R_1 = 1 kΩ

R_2 = 1 kΩ

V1 = 5 V

V2 = 3.5 Vpk

4.1.2 Output

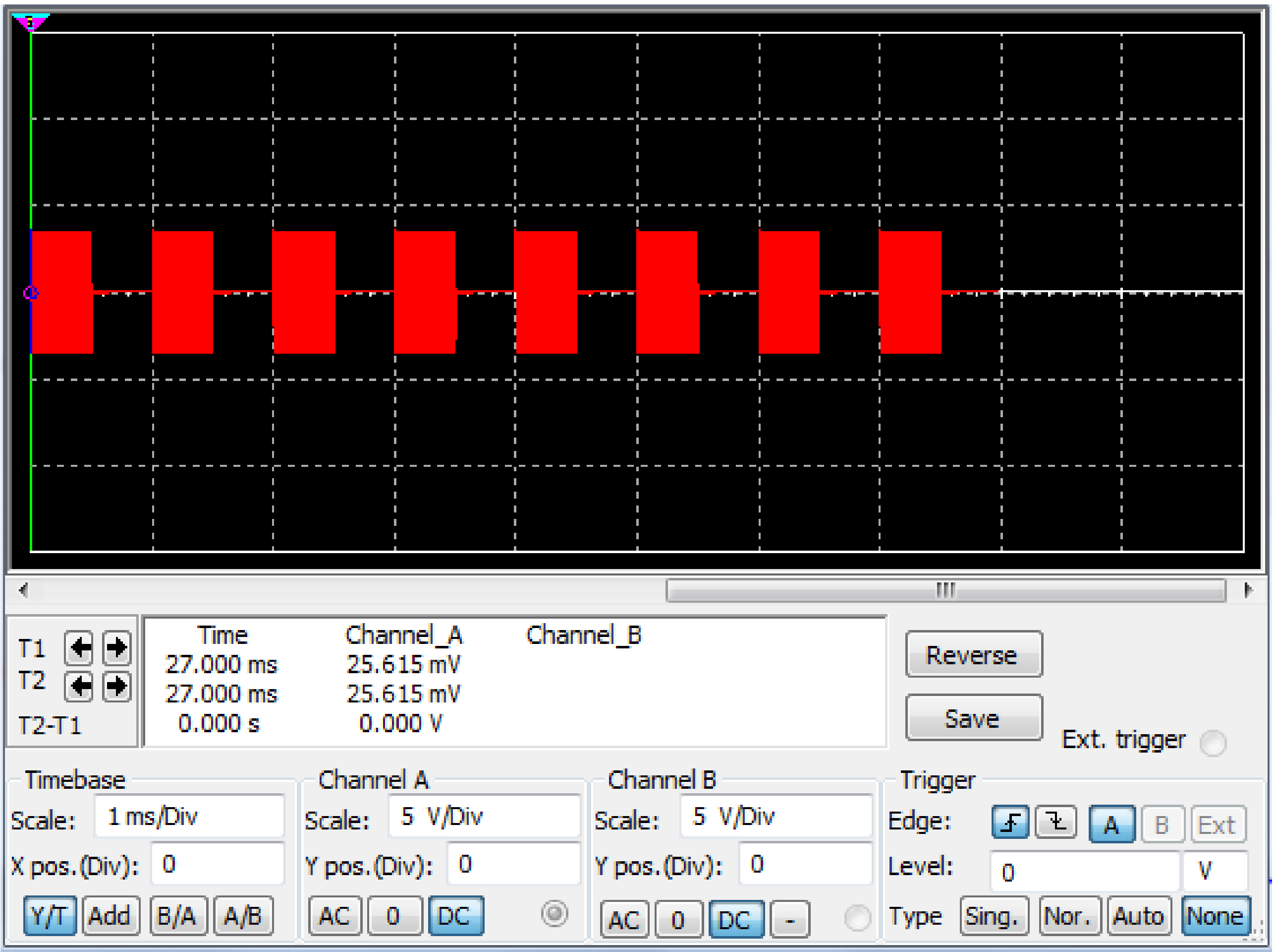

Fig 4.2 : ASK OUTPUT

4.2 Frequency Shift Keying

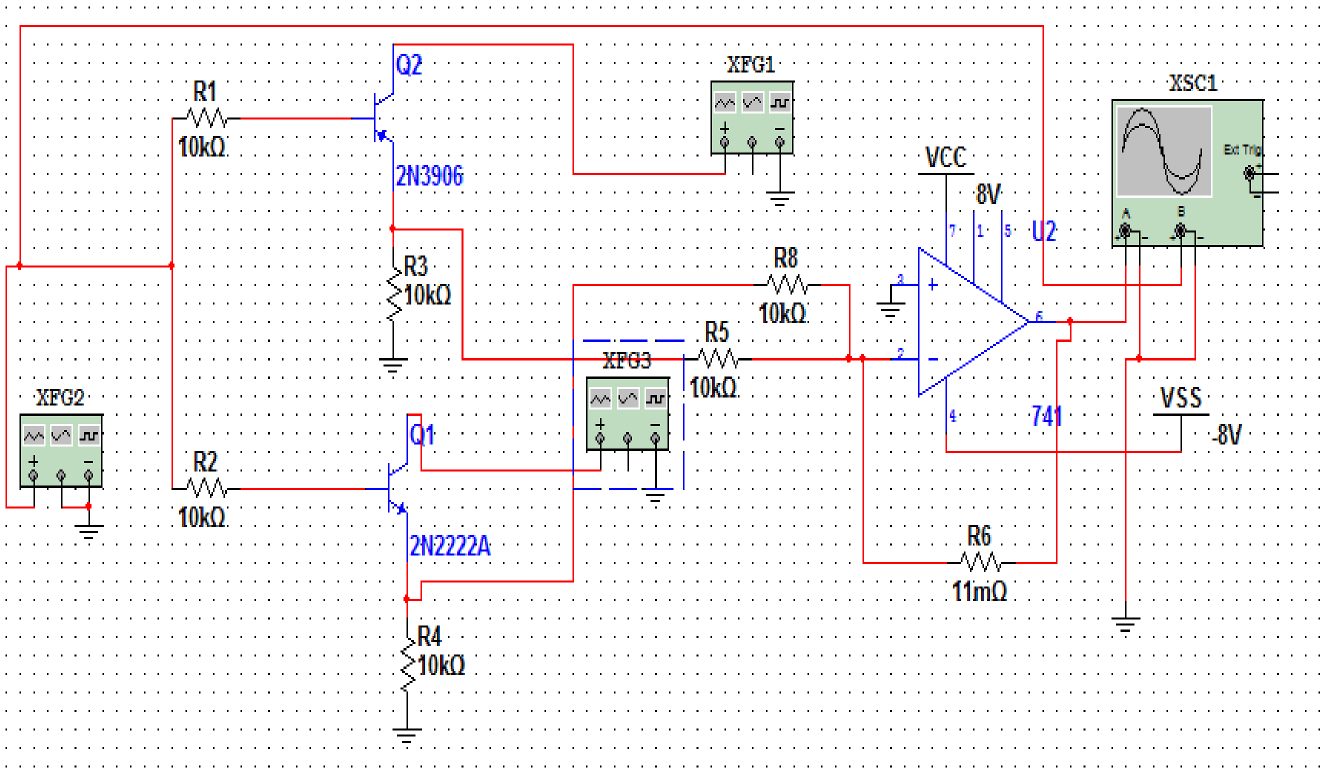

Fig 4.3 : FSK Circuit Diagram

4.2.1 Component used :

R_1 = 10 kΩ

R_2 = 10 kΩ

R_3 = 10 kΩ

R_4 = 10 kΩ

R_5 = 10 kΩ

R_6 = 11 mΩ

R_7 = 10 kΩ

R_8 = 10 kΩ

4.2.2 Output

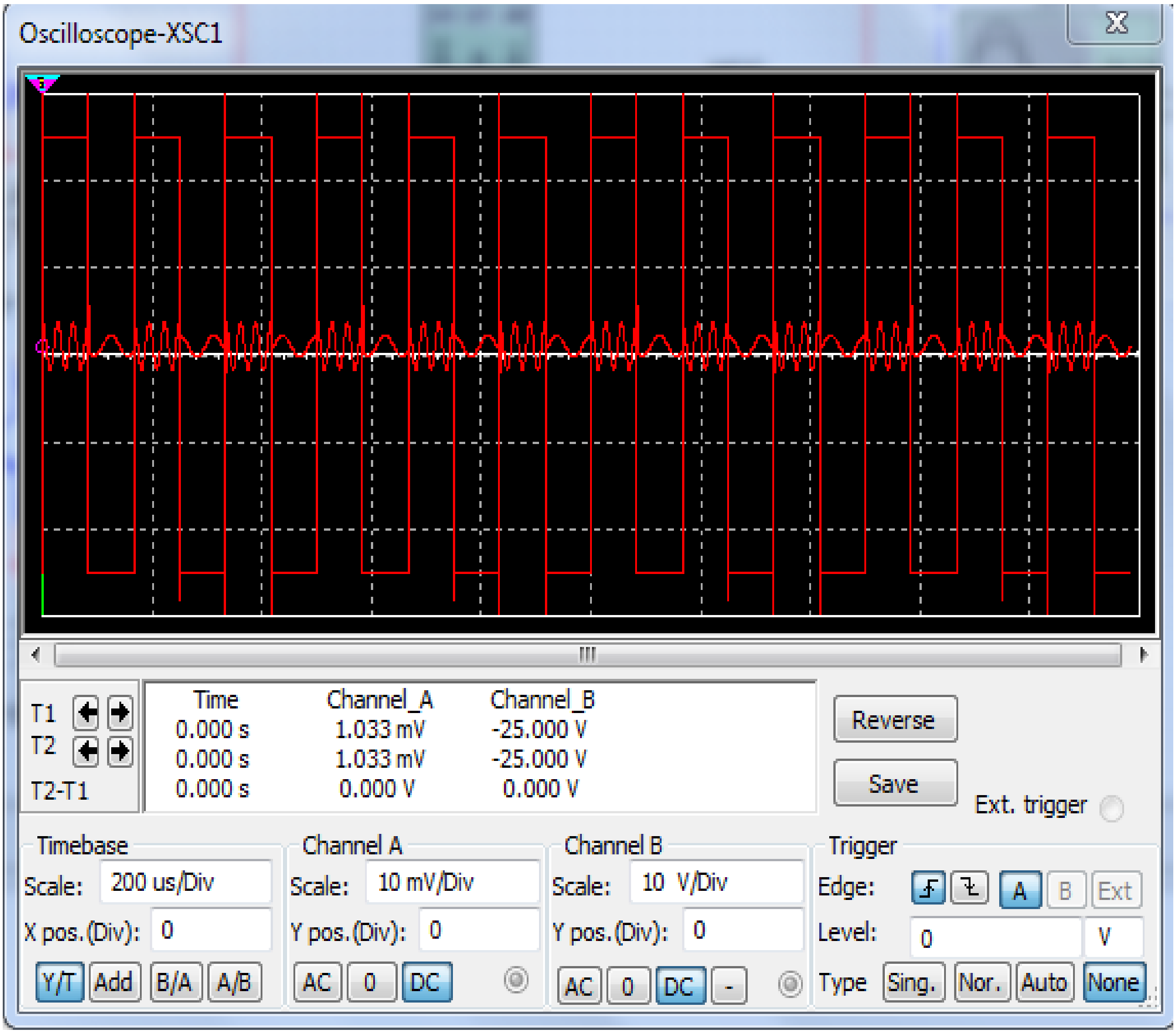

Fig 4.4 : FSK OUTPUT

4.3 Phase Shift Keying

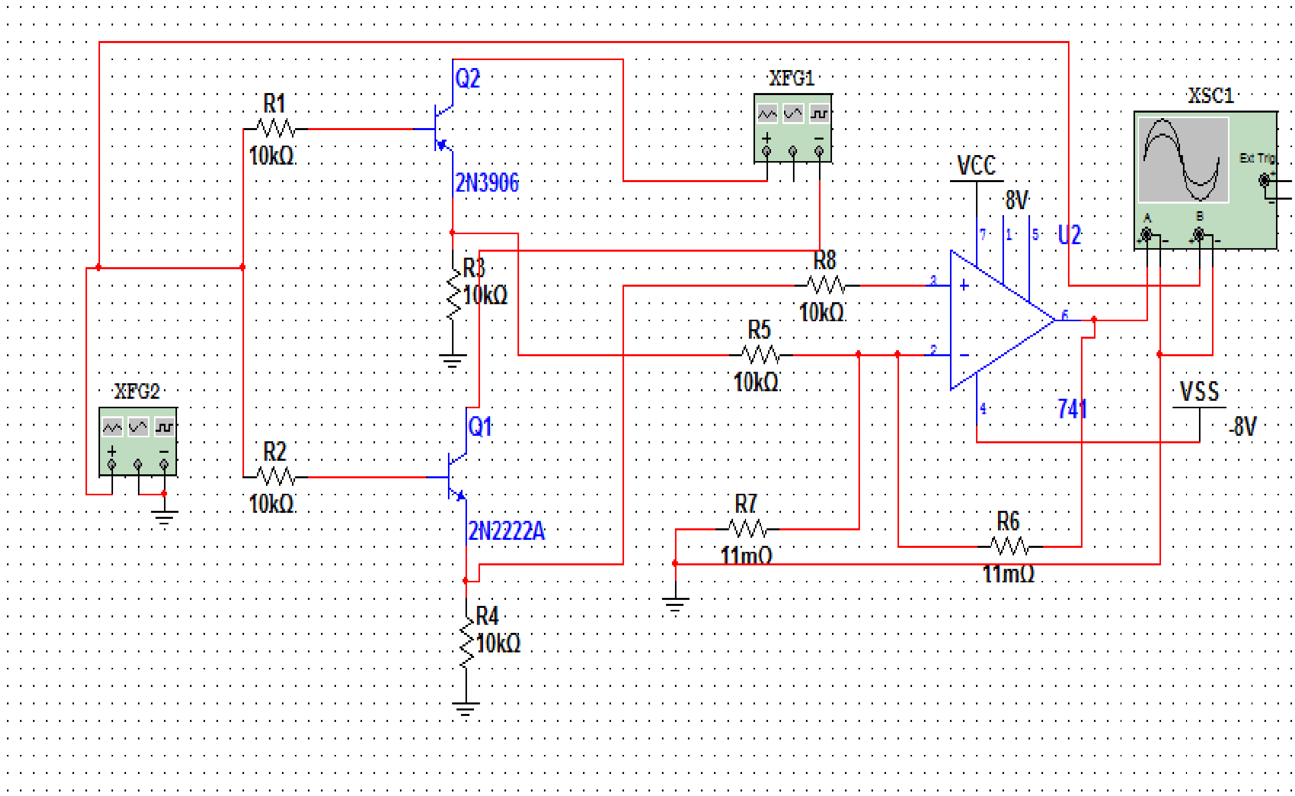

Fig 4.5: PSK Circuit Diagram

4.3.1 Components used :

R_1 = 10 kΩ

R_2 = 10 kΩ

R_3 = 10 kΩ

R_4 = 10 kΩ

R_5 = 10 kΩ

R_6 = 11 mΩ

R_7 = 11 mΩ

R_8 = 10 kΩ

4.3.2 Output

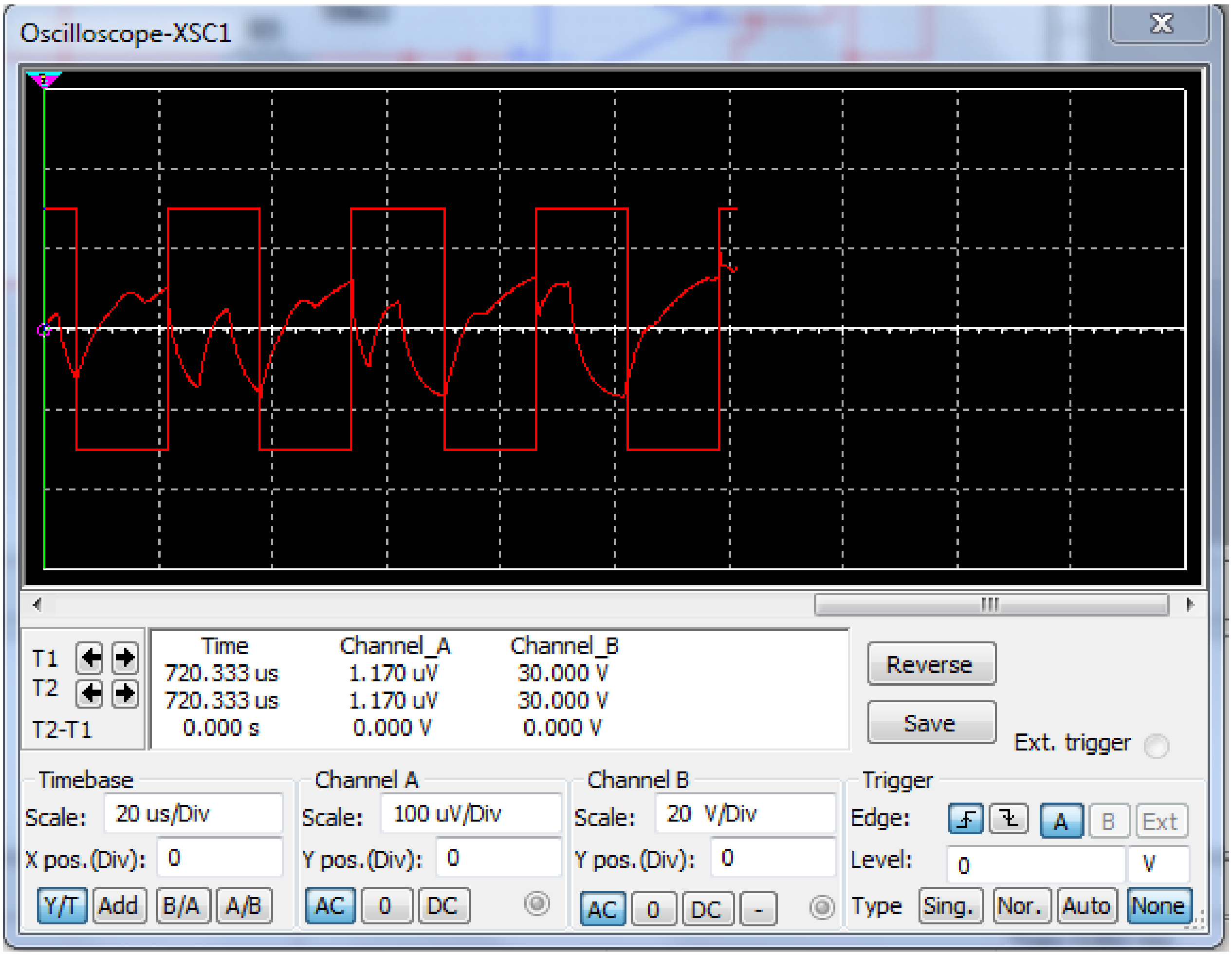

Fig 4.6 : PSK OUTPUT

CHAPTER 6

FUTURE WORK

Science and technology is the main force driving change. And if humanity is to keep pace with this change, innovation and reform are essential. The insatiable and an innate need of technological reforms and developments in the field of technology is the very need of the hour. The existing designs and systems strive for betterment. Hence, we hereby propose some of the expansions and improvements in both functions and technology of our design to make the product all the more convenient and easy to use with add on features. Also, the various other phase shift keyings can also be implemented in a similar manner.

6.1 Ring Modulation

Ring modulation is a signal-processing function in electronics, an implementation of amplitude modulation or frequency mixing, performed by multiplying two signals, where one is typically a sine-wave or another simple waveform. It is referred to as "ring" modulation because the analog circuit of diodes originally used to implement this technique took the shape of a ring. This circuit is similar to a bridge rectifier, except that instead of the diodes facing "left" or "right", they go "clockwise" or "anti-clockwise”.

The carrier, which is AC, at a given time, makes one pair of diodes conduct, and reverse-biases the other pair. The conducting pair carry the signal from the left transformer secondary to the primary of the transformer at the right. If the left carrier terminal is positive, the top and bottom diodes conduct. If that terminal is negative, then the "side" diodes conduct, but create a polarity inversion between the transformers. This action is much like that of a DPDT switch wired for reversing connections.

6.1.1 Operation

Ring modulators frequency mix or heterodyne two waveforms, and output the sum and difference of the frequencies present in each waveform. This process of ring modulation produces a signal rich in partials. As well, neither the carrier nor the incoming signal are prominent in the outputs, and ideally, not at all.

Two oscillators, whose frequencies were harmonically related and ring modulated against each other, produce sounds that still adhere to the harmonic partials of the notes, but contain a very different spectral make up. When the oscillators' frequencies are not harmonically related, ring modulation creates inharmonics, often producing bell-like or otherwise metallic sounds.

If the same signal is sent to both inputs of a ring modulator, the resultant harmonic spectrum is the original frequency domain doubled (if $f_1 = f_2 = f$, then $f_2 - f_1 = 0$ and $f_2 + f_1 = 2f$). Regarded as multiplication, this operation amounts to squaring. However, some distortion occurs due to the forward voltage drop of the diodes.

Some modern ring modulators are implemented using digital signal processing techniques by simply multiplying the time domain signals, producing a nearly-perfect signal output. Before digital music synthesizers became common, at least some analog synthesizers (such as the ARP 2600) used analog multipliers for this purpose; they were closely related to those used in electronic analog computers. (The "ring modulator" in the ARP 2600 could multiply control voltages; it could work at DC.)

Multiplication in the time domain is the same as convolution in the frequency domain, so the output waveform contains the sum and difference of the input frequencies. Thus, in the basic case where two sine waves of frequencies f_1 and f_2 ($f_1 < f_2$) are multiplied, two new sine waves are created, with one at $f_1 + f_2$ and the other at $f_2 - f_1$. The two new waves are unlikely to be harmonically related and (in a well designed ring modulator) the original signals are not present. It is this that gives the ring modulator its unique tones.

Intermodulation products can be generated by carefully selecting and changing the frequency of the two input waveforms. If the signals are processed digitally, the frequency-domain convolution becomes circular convolution. If the signals are wideband, this will cause aliasing distortion, so it is common to oversample the operation or low-pass filter the signals prior to ring modulation.

One application is spectral inversion, typically of speech; a carrier frequency is chosen to be above the highest speech frequencies (which are low-pass filtered at, say, 3 kHz, for a carrier of perhaps 3.3 kHz), and the sum frequencies from the modulator are removed by more low-pass filtering. The remaining difference frequencies have an inverted spectrum—High frequencies become low, and vice versa.

6.1.2 Integration Circuit Methods of Ring Modulation

On the C64 SID chip, ring modulation multiplies a triangle wave with a square wave.

On an ARP Odyssey synthesizer (and a few others from that era as well) the ring modulator is an XOR function (formed from two NAND gates) fed from the square wave outputs of the two oscillators. For the limited case of square or pulse wave signals, this is identical to true ring modulation.

Analog multiplier ICs (such as those made by Analog Devices) would work as ring modulators, of course with regard to such matters as their operating limits and scale factors.

Use of multiplier ICs means that the modulation products are largely confined to sum and difference frequency of inputs (unless the circuit is overdriven), rather than the much more complicated products of the rectifier circuit.

6.1.3 Use in Music

One of the earliest musical instruments utilizing a ring modulator may be the Melochord (1947) built by Harald Bode. It was a two-tone melody keyboard instrument with foot controllers and later added a second keyboard for timbre control, featuring a white-noise generator, envelope controller, formant filters and ring modulators for harmonics. The early Melochord was extensively used by Werner Meyer-Eppler in the early days of the electronic music studio at Bonn University.

Werner Meyer-Eppler mentioned the musical application of ring modulator in his book "Elektrische Klangerzeugung", published in 1949 (also described in Elena Ungeheuer's book). In 1951, he joined to the successive proposal on establishment of WDR Studio for Electronic Music in Cologne, and at the beginning of the studio, already ring modulator was equipped along with the sound sources and audio gadget including sine wave oscillators, noise generator, *etc*. Then in 1953, the above-mentioned Melochord by Harald Bode, along with the Electronic Monochord by Friedrich Trautwein, was specifically commissioned by the WDR Studio to upgrade their synthesis modules, and used by the Elektronische Musik group especially in the first half of 1950s. Also Meyer-Eppler demonstrated his experiments in June 1953 in Delft. A ring-modulator was the major component used in Louis and Bebe Barron's music for the film Forbidden Planet (1956).

Meyer-Eppler's student, Stockhausen also used ring modulation in 1956 for some sounds in Gesang der Jünglinge and his realization score for Telemusik (1966) also calls for it. Indeed, whole compositions are based around it, such as Mixtur (1964), one of the first compositions for orchestra and live electronics, Mikrophonie II (1965, where the sounds of choral voices are modulated with a Hammond organ), Mantra (1970, where the sounds from two pianos are routed through ring modulators), and Licht-Bilder (2002) from Sonntag aus Licht, which ring-modulates flute and trumpet.

On Miles Davis' 1975 live album Agharta, guitarist Pete Cosey ran the sounds he played through a ring modulator.

One of the first products dedicated for music was the Bode Ring Modulator developed in 1961 by Harald Bode. Also in 1964 he developed the Bode Frequency Shifter, which produced a clearer sound by eliminating a side band These devices were designed to be controlled by voltage, for today's modern modular synthesizer architecture also advocated by him, and these modules were licensed to R.A. Moog for their Moog modular synthesizers started in 1963-1964. In 1963, Don Buchla included an optional ring modulator in his first modular synthesizer, the Model 100. Also Tom Oberheim built a ring modulator unit for his musician friend in the late 1960s, and it became an origin of Oberheim Electronics Music Modulator and Maestro Ring Modulator, one of the earliest ring modulator effect products for guitarists. The EMS VCS3, Synthi A and Yamaha CS-80 synthesizers also featured built-in ring modulators.

One of the best-known applications of the ring modulator may be its use by Brian Hodgson of the BBC Radiophonic Workshop to produce the distinctive voice of the Daleks in the television series Doctor Who, starting in 1963.

CHAPTER 7

CONCLUSION

The Printed Circuit Board replacement of the conventional shift-keying kits will invite the drastic reduction in the miscellaneous expenditures incurred annually. The boxes that are used for the implementation of the various kits involve the use of significant amount of wood. In these difficult times where we are heading towards environmental crisis, this would lead to a drastic reduction in hazards that being posed to our environment by continuous chopping off the trees.

As far as engineering knowledge is concerned, it will bring about a clearer perception of the various digital modulation techniques which will be quite useful for the student in various other practical applications. One of the most important factors in human life which is time will be saved as each and every student will able to work on individual circuits and will not have to share the rather expensive kits among themselves. It will enhance the use of logic in the ameliorated application of various components involved.

Hence, this work will bring in far better alternative of the practical application of the engineering erudition.

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