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3-DIMENSIONAL POLAR FSK WITH IMPROVED PERFORMANCE

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Abstract - -*In this day and age there is coercion for wireless systems to provide high data rate in less bandwidth, less probability error, and least multipath interference. These goals are often conflicting, so the ideal technique is sought to offer the finest trade between them. Hence a technique titled 3-Dimensional Polar Frequency Shift Keying (3-D Polar FSK) was proposed in the year 2017 which consummate all the needs of wireless communication. As the transmitter section of this technique was implemented earlier, it has been observed that after the signal was multiplied without the use of Bandpass Filters then there existed a presence of Inter-Symbol Interference (ISI) as the side lobes also get added with the main lobe of the adjacent symbol signal. Thus, we have designed the receiver section and implemented the bandpass filters of Centre frequencies 480KHz, 560KHz, and 640KHz to separate the main lobe.*

Key Words*: *Digital modulation, 3-D FSK, Power efficiency, multi path fading, multi carrier modulation.

1. INTRODUCTION

1.1 Literature Survey

Numerous digital modulation techniques are prevailing such as Amplitude Shift Keying (ASK), Phase Shift Keying (PSK), Minimum Shift Keying (MSK), Frequency Shift Keying (FSK), and so forth. From the analysis it has been observed that in PSK, as N (number of bits/symbol) increases, bandwidth decreases but the probability of error increases. Whereas in FSK as N increases, the probability of error (Pe) decreases but bandwidth (BW) increases, and it is spectrally efficient. As in ASK, noise immunity and power efficiency are low. MSK is the combination of PSK and FSK which has less inter-symbol and inter-channel interferences but has a bandwidth of 1.5 f_b which is comparatively lower [1]. Considering cost factor and power efficient communication Orthogonal Frequency Division Multiplexing (OFDM) is not desirable [3-4]. Single carrier modulation techniques such as M-ary PSK, M-ary ASK and M-ary QASK are more vulnerable to multipath fading. However, M-ary FSK uses multiple carriers but due to its large requirement of bandwidth it is not suitable for high data rate applications [5-10].

1.2 About 3-Dimensional Polar FSK

To accomplish all the requirements of a wireless personal area network (WPAN) a new modulation technique named 3-Dimensional Frequency Shift Keying has been proposed and the modulator part has been implemented [11]. In this technique three orthogonal signals are used which leads to less frequency selective fading. Bandwidth obtained is $2f_b$ Hz, so the spectral efficiency is high. While in this technique by increasing the N, the symbol duration is increased which eliminates multipath interference.

The power spectrum of the signal is given as:

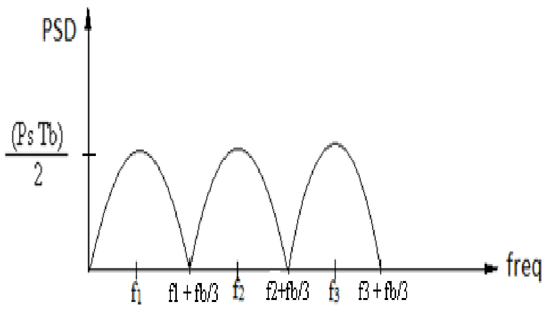

Figure 1- Bandwidth without spectral overlap [1-2]

Bandwidth = $2f_b$

Power spectral density with spectral overlap is given as:

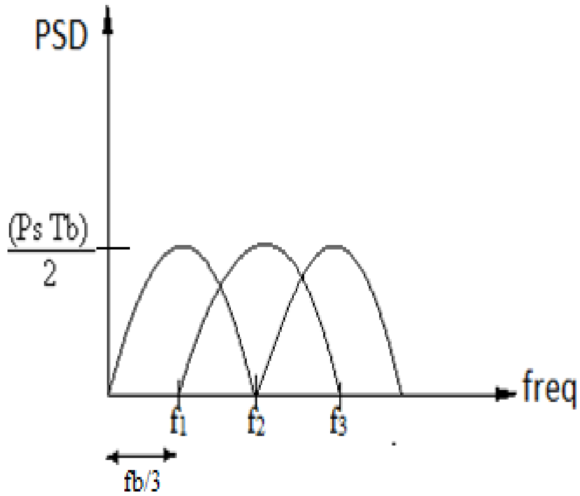

Figure 2- Bandwidth with spectral overlap [1-2]

Bandwidth = $4\frac{f_b}{3}$

1.3 About 3-Dimensional Polar FSK Receiver

The receiver section is coherent. Seeing that receiver is coherent complexity increases but the probability of error decreases. The three carriers are multiple of $f_b/3$ that is a carrier is orthogonal. So orthogonal 3-D Polar FSK is generated without any discontinuity of the signal due to which high-frequency generation will be less which helps in reducing inter- channel interference (ICI). The receiver output of 3-D polar FSK is=$b_1(t)$ $b_2(t)$ $b_3(t)$.

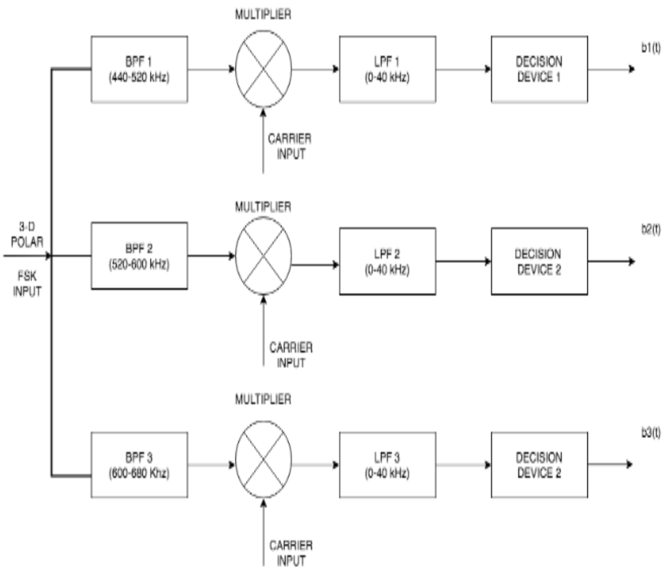

Figure 3- 3-Dimensional polar FSK Receiver

2. Design and Simulation

Bandpass filter has been designed first with the help of circuit concepts and then simulated with a help of NI Multisim. Multisim software provides an interactive schematic environment to visualize and analyze electronic circuit behavior [12].

The Bandpass filter is an electronic device that allows all the frequencies within a specified band of frequencies and eliminates all other frequencies outside the specified frequency band. Bandpass filters for three band of frequencies have been designed. The lower and higher cut-off frequencies are as follows:

i. Bandpass filter 1:440-520 kHz.
ii. Bandpass filter 2:520-600 kHz.
iii. Bandpass filter 3:600-680 kHz.

Their center frequencies are 480,560,640 kHz respectively and each with a bandwidth of 80 kHz.

Bandpass Filter 1 (440-520 kHz):

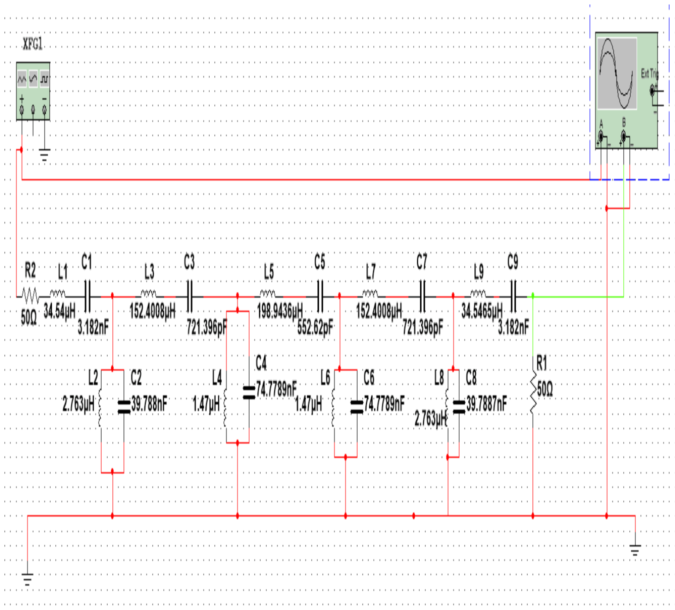

Figure 4- Bandpass filter 1 design

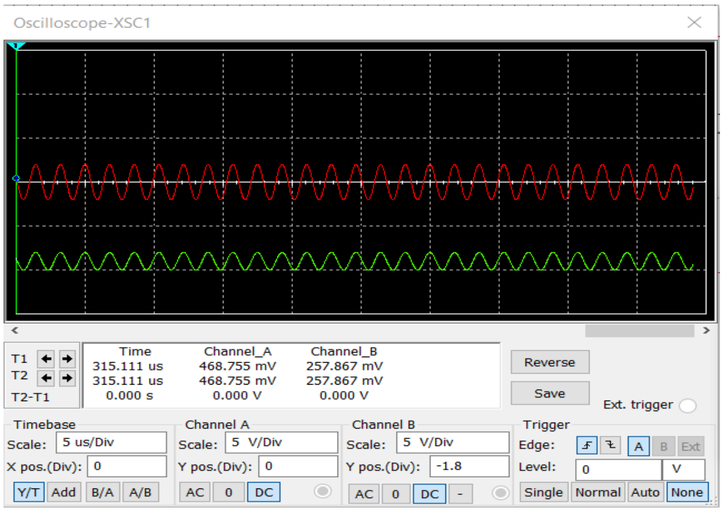

Figure 5- Bandpass filter 1 simulation output

Bandpass Filter 2 (520-600 kHz):

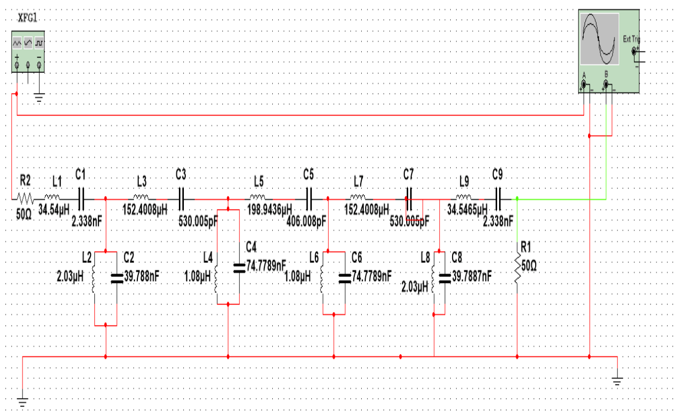

Figure 6- Bandpass filter 2 design

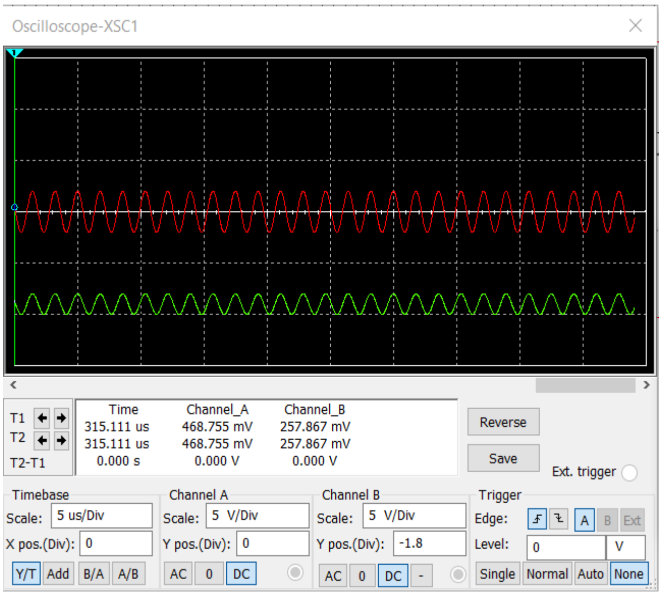

Figure 7- Bandpass filter 2 simulation output

Bandpass Filter 3 (600-680 kHz):

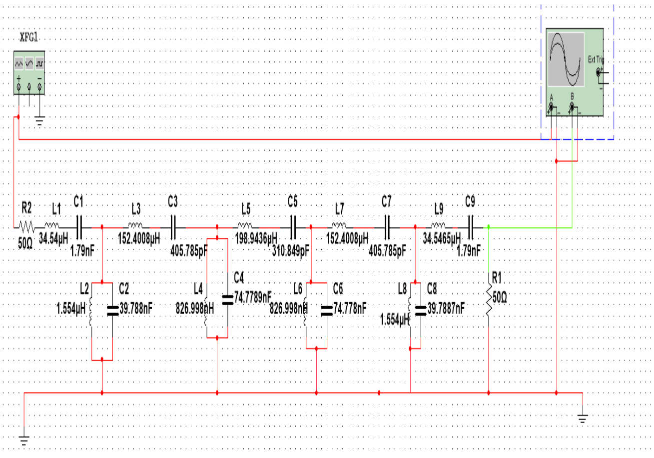

Figure 8- Bandpass filter 3 design

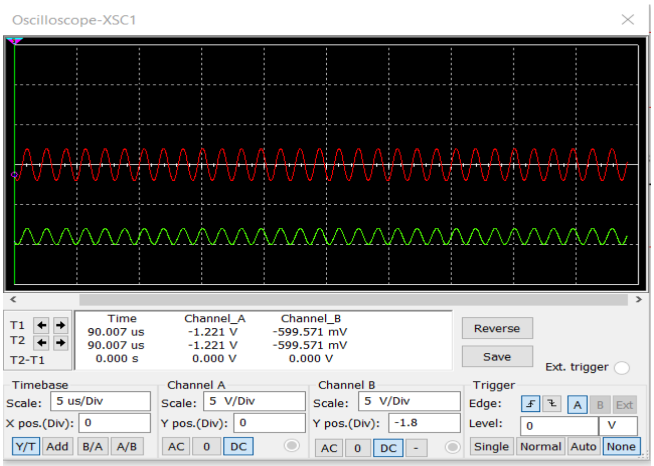

Figure 9- Bandpass filter 3 simulation output

IC MC1496 has been used in multiplier which is capable of operation at 80MHz.It can suppress carrier of 65 dB at 0.5 MHz and -50 dB at 10 MHz.MC146 is configured to operate as a balanced modulator [11].

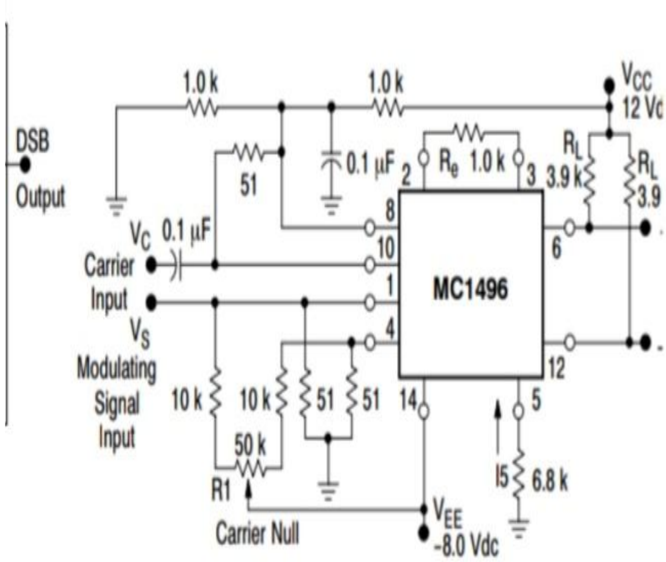

Figure 10 - Multiplier circuit diagram

To get the required waveform, the multiplier output is given as input to a Low pass Filter as the sinusoidal waveform is generated.

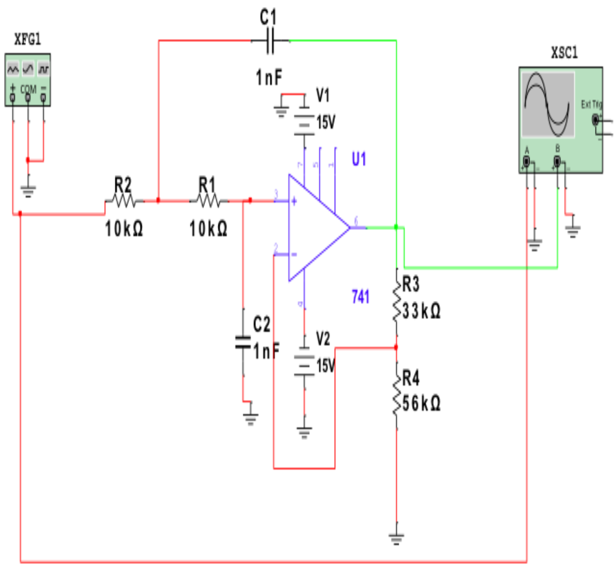

Figure 11- Low pass filter design

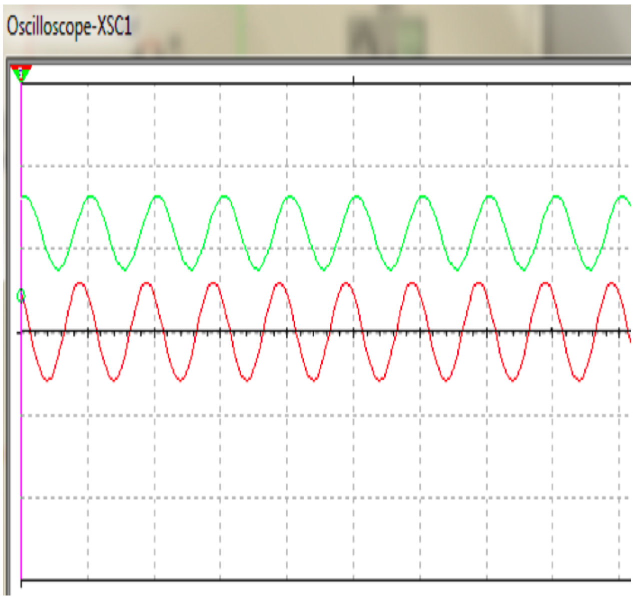

Figure 12 -Low pass filter simulation output

Low Pass Filter (LPF) output is given as input to a comparator to get the demodulated output [13].

Comparator is generally used to compare the inputs applied and produces an output. The output value from the comparator specifies which input is higher and lower. Here zero-crossing detector has been used as comparator. The reference voltage (Vref) has been set to 0v. If the input is greater than Vref then the output will be positive half cycle while it is less than Vref it will be a negative half cycle. It used as a non-inverting comparator [14-20].

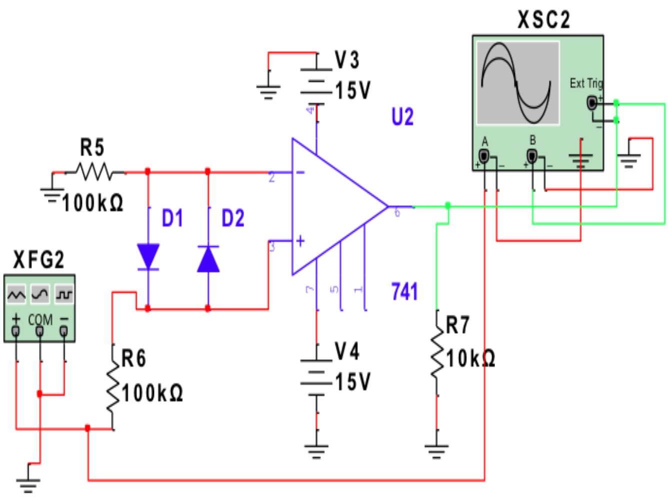

Figure 13- Comparator design

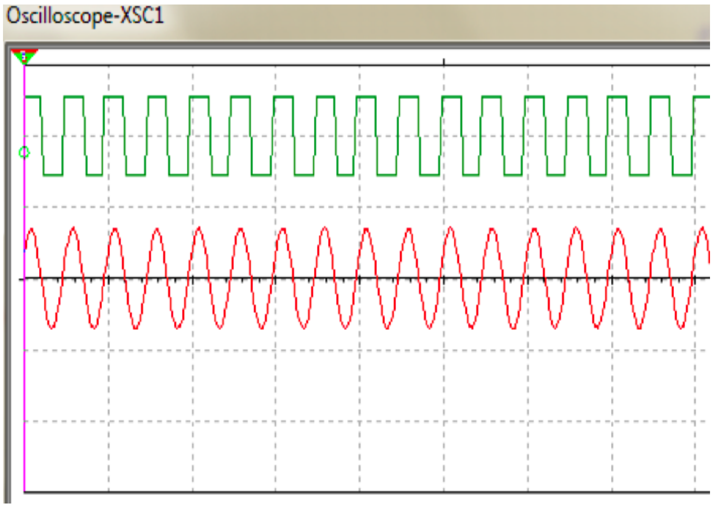

Figure 14- Comparator simulation output

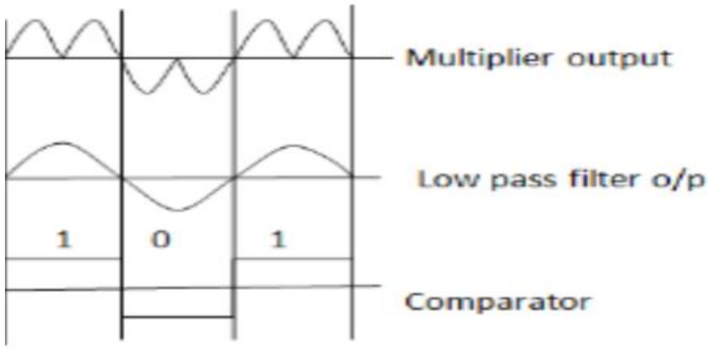

Figure 15-Graph

Figure 15 shows the waveforms obtained after each stage from multiplier to comparator.

After connecting the transmitter with the receiver section, the complete demodulated output would be:

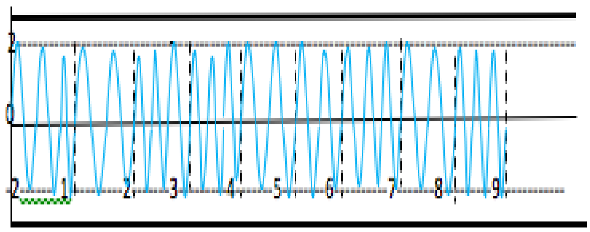

Figure 16- Modulated signal

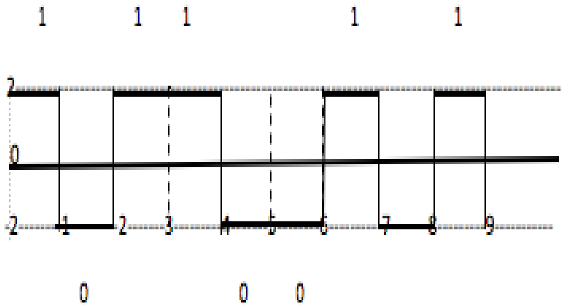

Figure 17- Demodulated signal

3. CONCLUSION AND FUTURE SCOPE

This paper has put forward an ideal implementation for the receiver part of 3-D Polar FSK digital modulation. This technique is extremely beneficial in Wireless Personal Area Network (WPAN) where multipath interference is common by increasing the width of the symbol. Therefore, the probability of error is less, and the information is secure as it is a multicarrier technique. In addition to the above-mentioned advantages it also provides spectral efficiency, less frequency selective fading, and power efficiency. This modulation technique can be used in PAN networks like WIFI, Bluetooth, Wireless Universal Serial Bus (USB), Wireless computer network, Asymmetric digital subscriber line, and Very high-speed digital subscriber line broadband access and Terrestrial digital TV system and many more.

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