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Two Operational Amplifiers Current Generalized Immittance (CGIC) Based Low-Pass Filter for BPSK Modem Implementation.

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Abstract: *Modems in the beginning were needed mainly to communicate between data terminals and a host computer later, the use of modems was extended to communicate between end computers. Today, transmission involves data compression techniques which increase the rates, error detection and error correction for more reliability. The CGIC second order low pass filter is used in the receiver of the Binary phase shift keying (BPSK) modem for modulation of noisy signals generated in the transmitter because of its numerous advantages over other topologies in terms of stability, dynamic frequency range due to variable resistor that controls the centre frequency* ω_o*, etc. The filter designed has a centre frequency of 1.72kHz and a gain of 33dB its quality factor Q is 50. The circuit is designed to accommodate other modulation technologies since the* ω_o *and Q can be varied by tuning the filter. Therefore it is recommended that this filter be applied in other modulation techniques to ascertain its viability.*

Keywords: two-op-amps, CGIC, Low-pass filter, BPSK, modem

1. INTRODUCTION

Modem is short for "modulator – Demodulator". It is a hardware component that allows a computer or another device, such as a router or switch, to connect to the internet. It converts or "Modulates" an analogue signal from a telephone or cable wire to digital data (1's and 0's) that a computer can recognise. Similarly, it converts digital data from a computer or other devices into an analogue signal that can be sent over standard telephone lines.

The first modems were "dial-up", meaning they had to dial a phone number to connect to an ISP. These Modems operated over standard analogue phone lines and used the same frequencies as telephone calls, which limited their maximum full use of the local telephone line, meaning voice calls would interrupt the internet connection.

Modern modems are typically DSL or cable modems, which are considered "broad band" devices. DSL modems operate over standard telephone lines, but use a wilder frequency range. This allows for higher data transfer rates that dial up modems and enables them to no interfere with phone calls. Cable modems send and receive data over standard cable television lines, which are typically coaxial cables. Most modem cable modems support DOCSIS (Data over cable service interface specification) which provides and efficient way of transmitting TV; cable internet, and digital phone signals over the same cable line.

The binary phase shift keying (BPSK) is a modulation scheme for transmitting data across a wire which is based on an elementary transmitter and receiver circuits. This scheme is one of the modern modems described above. Data is generated in the transmitter and detected in the receiver. The BPSK modem contains a transmitter, a receiver, error detector and counter (Mohammad & Abdur, 2018). The simplified block diagram of a base band transmission system is shown in figure 1.

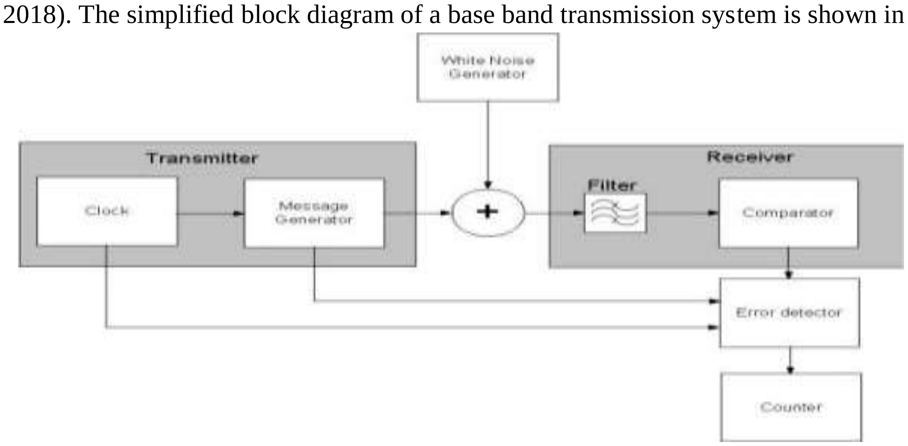

Figure 1. Simplified Base band Transceiver System

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The receiver detects the modulated band-pass signal and demodulates it back to base band to detect the information transmitted and also count the symbol error rate of the system under a variety of different signal to noise power the BPSK noisy signal through a low-pass filter. This paper therefore seeks to design and simulate a two op amps CGIC low pass filter with a cut-off frequency that can be tuned to accommodate any transmitted signal's frequency. The block diagram of a receiver system showing the low pass filter used is shown in figure 2.

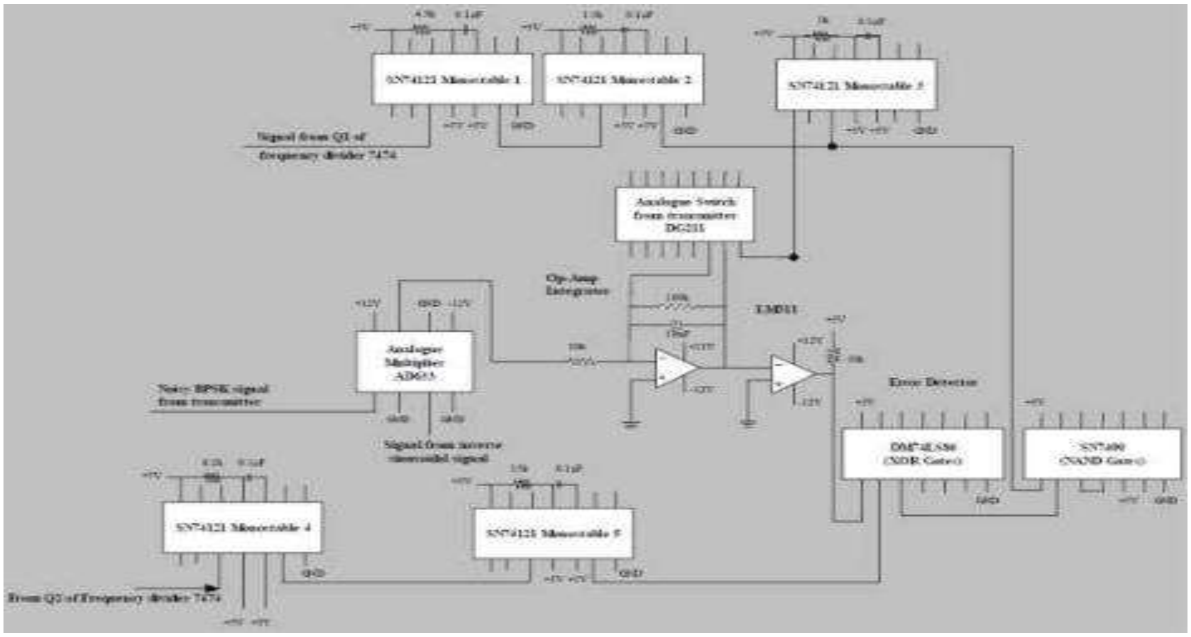

Figure 2. The receiver's circuit system.

2. MATERIALS AND METHODS

The materials used for the design of the two op amps low pass CGIC circuit are, two-op amps of NA741 – type 5 resistors $(R_1\ R_2\ R_3\ R_4\ and\ R_5)$ with R_2 and R_5 as variable resistors, two (2) capacitors of equal values of 10nF, input and the output sources, Ground connectors and NI Multisim version 14.2 software for simulation.

The values of the resistor and capacitors are determined from the equations that follow. The implied transfer function of the circuit is given by:

$$T(s) = \frac{\frac{2}{R^2C^2}}{S^2 + \frac{S}{RCQ} + \frac{1}{R^2C^2}} \qquad 1$$

The centre frequency (ω_o) of the low pass filter is determined by using the equation.

$$\omega_o = \frac{1}{RC} \qquad 2$$

For convenience, the capacitor values are carefully chosen and made equal made i.e. $C_1 = C_2 = C$ 3

The resistor values are determined using the equation

$$R = \frac{1}{C\omega_O} \qquad 4$$

$$R = R_1 = R_3 = R_4 = R_5 \qquad 5$$

$R_2 = RQ$ 6

The specification used in this research was;

Centre frequency $\omega_o = 1.70$kHz

Pass band frequency = 1200Hz – 2200Hz

Quality factor Q = 50

Input supply voltage = $\pm 12V$

Therefore we determined the value of the resistance R using equation 4 thus.

$$R = \frac{1}{10 \times 10^{-8} \times 1.70 \times 10^{3}} = 5882.35\Omega = 5.88\text{k}\Omega$$

And then we made $R = R_1 = R_3 = R_4 = R_5 = 5.88k\Omega$

We then calculate the value of R_2 $as;$

$R_2 = RQ = 5.88 \times 10^3 \times 50 = 29400 = 294K\Omega$

The low – pass filter is thus designed and simulated as shown in Figure 3 on the Multisim software.

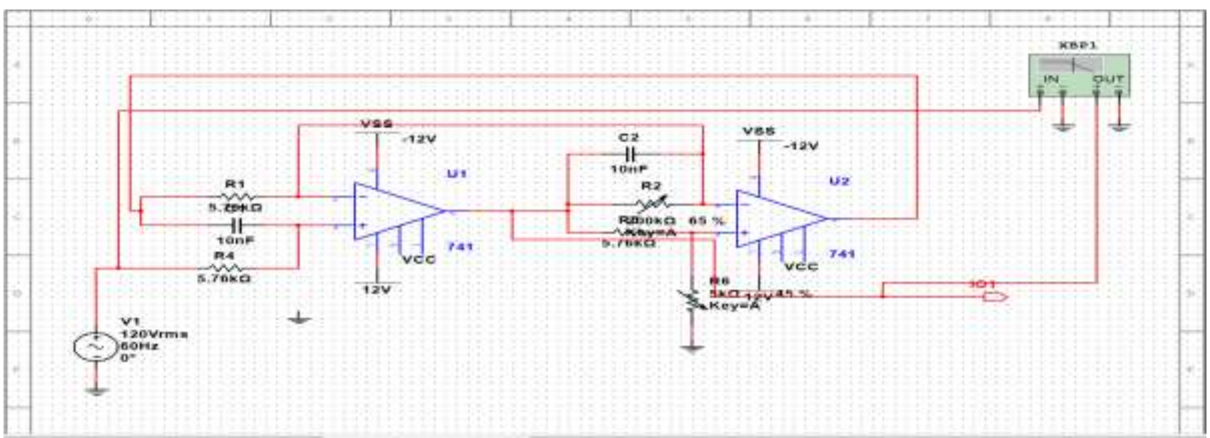

Figure 3: The Second-Order Low-Pass CGIC Filter

The Second Order Low-Pass CGIC Filter was simulated and its output obtained as shown in Figure 4, while the Output response Curve is shown in Figure 5.

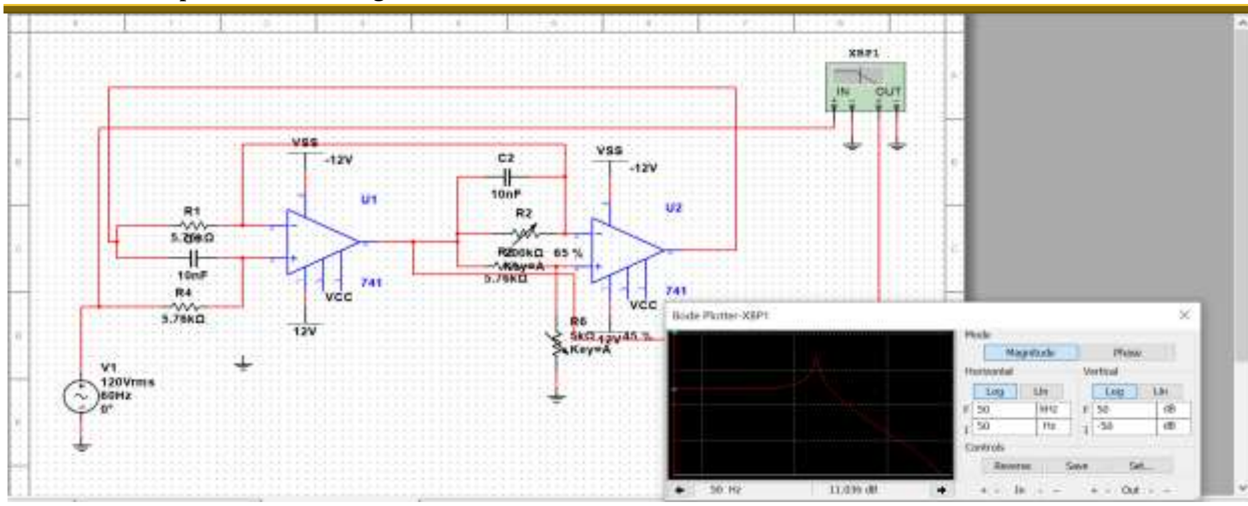

Figure 4. Shows the Circuit Diagram of the Second Order Low-Pass CGIC Filter with its Output

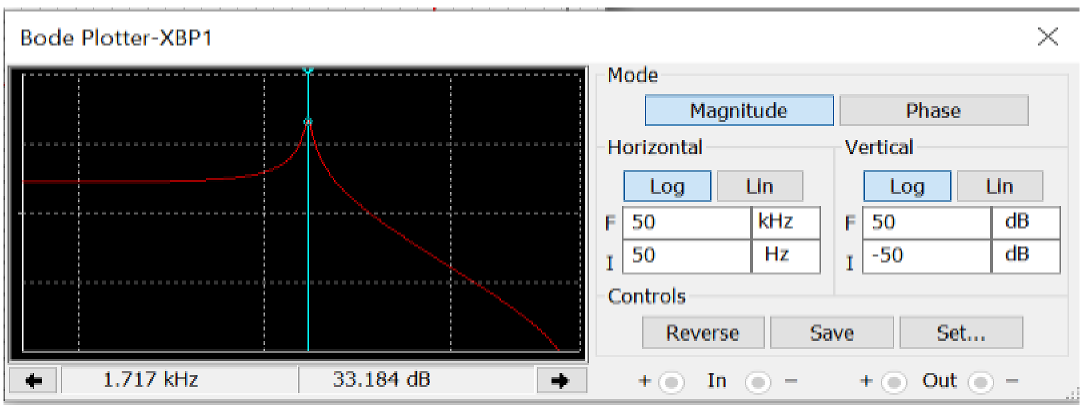

Figure 5. Shows the Frequency Response Curve using Bode Plotter

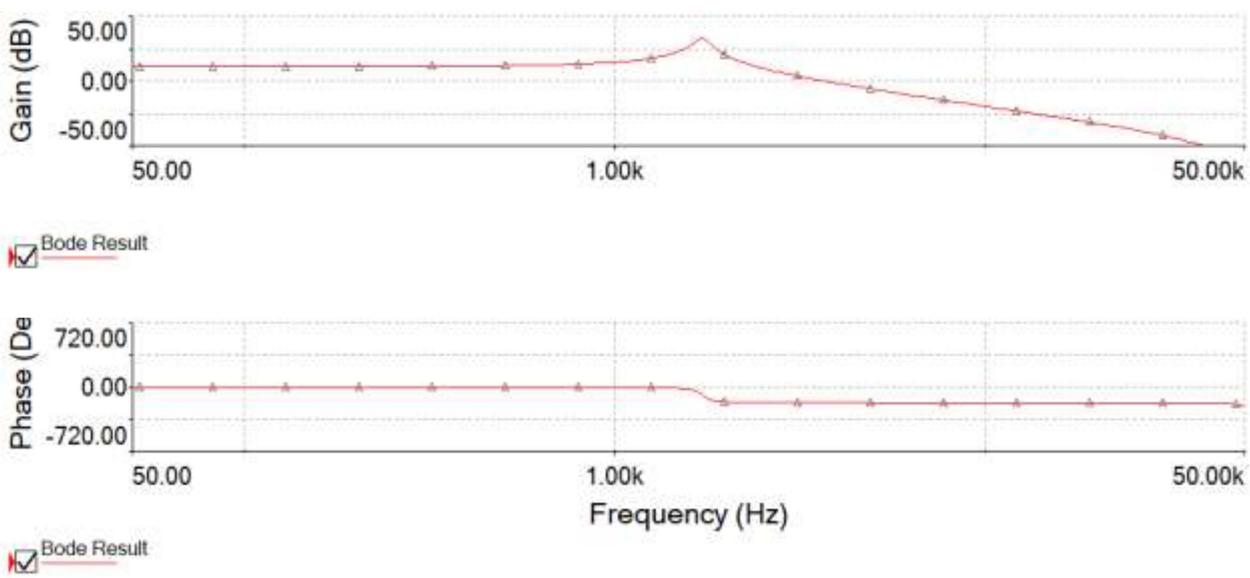

Figure 6. Magnitude and Phase Response of Second Order CGIC Low pass Filter

3. RESULT AND DISCUSSION

The simulated filter shown in figure 3 produced output response as shown in Figures4 and 5 while the Magnitude and Phase response curves as a result of the Simulation is presented in Figure 6. The results of centre frequency $\omega_o = 1.717kHz$ when variable resistor R_5 was turned to 45% and a gain of H=33.184dB which can be increased when R_2 is turned to get any desired gain. The centre frequency is slightly shifted but within the range allowed. Therefore, the CGIC low pass filter is suited for BPSK modem because of its numerous advantages of stability, insensitivity to components, dynamic range of frequencies from the variable resistor, low dependence on op amps limitations etc. consequently, this filter can be applied to other communications systems.

4. CONCLUSION

The second order CGIC low pass filter was designed and found to adhere to specification to be used in the BPSK modem for modulation of signals from telephone wires or computer networks. This filter has numerous advantages over other filters that have been dynamic range of frequencies, sensitivity to component values in the circuit, etc.

5. ACKNOWLEDGEMENT

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6. Declaration of Interest

I would like to state that there is no clash of interest from anywhere since this research is a privately sponsored one by one my humble self and family.

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Mohammad, L.H., and Abdur, R. (2018). Design and implementation of a BPSK modem and BER measurement in AWGN channel int. scientific and research publications, 8(5), 117-123.