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Simulation Of A Second-Order Current Generalized Immitance Structure (CGIC) Based Band Pass Biquad Filter For Fsk Telephone Communication Applications.

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Abstract: *This paper presented design and simulation of a second order CGIC Band pass Biquad filter for FSK telephone communication applications. One of the forms which this can be utilized in telephone communication is the modem. Modem is an abbreviation for Modulator-Demodulation used in transfer of data from one computer network to another through telephone lines. This technology is very fast and most used in the communications and information sector. The modem utilizes a bandpass filter both in the transmitters and receivers to enable sorting out of noise and other unwanted signals in the system. Hence the CGIC based filter was designed and simulated for this purpose. The filter used a pass band f 1200Hz to 2200Hz with a centre frequency of 1.70 kHz and a quantity factor of 50. Results from the simulation showed good agreement with the specified parameters and conclusion was made that it can be used in the implementation in modems for FSK telephone communications. Recommendations were also given.*

Keywords: CGIC, Band pass filter, FSK, Telephone, Communication

1. INTRODUCTION

The telephone line allows transmission of analogue audio frequency signals, but the digital data signal, as such cannot be passed through this reason, modems are required as interface to existing analogue transmission lines. The basic role of a modem is to convert digital logic signals “1” “0” into an analogue equivalent that can be passed through a telephone line, and vice versa.

A data signal (digital signal) from a data terminal is converted into an analogue audio signal and transmitted to the Modem of a receiving terminal utilizing the public telephone network. At the receiving end the analogue audio signal thus received is then converted by its modem into a corresponding digital signal and conveyed to the receiving data terminal. In this way, two distant data terminals can communicate for the exchange of data by means of modem (Data Pack, 1997).

Modem is abbreviation for modulator-Demodulator. Modems are used for data transfer from one computer network to another computer network through telephone lines. The computer network works digital mode, while analogue technology is used for carrying messages across phone lines. Modulator converts information from digital mode to analogue mode at the transmitting end and demodulator converts the same from analogue to digital at receiving end. This process of converting analogue signals of one computer network into digital signals of another computer network so they can be proceed by a receiving computer is referred to as digitizing. When an analogue facility is used for data communication between two digital devices called data Terminal Equipment (DTE), modems are used at each end. DTE can be a terminal or a computer.

The modem at the transmitting end converts the digital signals generated by DTE into an analogue signal by modulating a carrier. This modem at the receiving end demodulates the carrier and hand over the demodulated digital signal to the DTE.

The modem communication systems are largely divided into modes of operation. One is called the full duplex system, and the other, the half-duplex system. The telephone line is a balanced two-wire circuit, and usually is called the two-wire (2W) line. The full duplex and half duplex are terms which conform to the common use of this two – wire line which are:

a. 4 – Wire full duplex communication
b. 2 – Wire half duplex communication.
c. 2 – Wire full duplex communication

A typical modem system is presented in figure 1 and the three modem communications system is presented in figure 2.

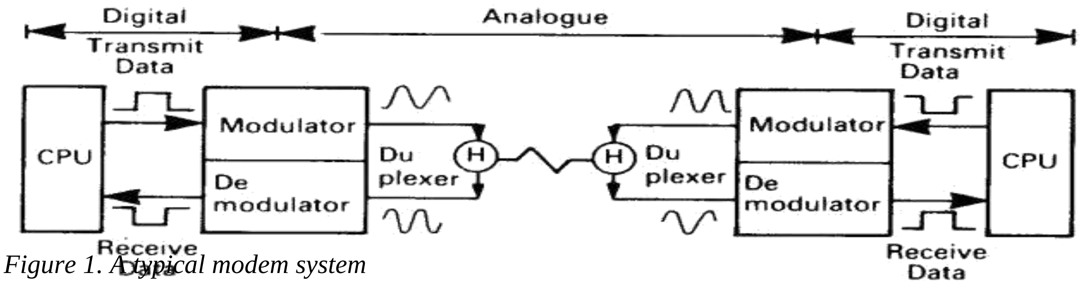

Figure 1. A typical modem system

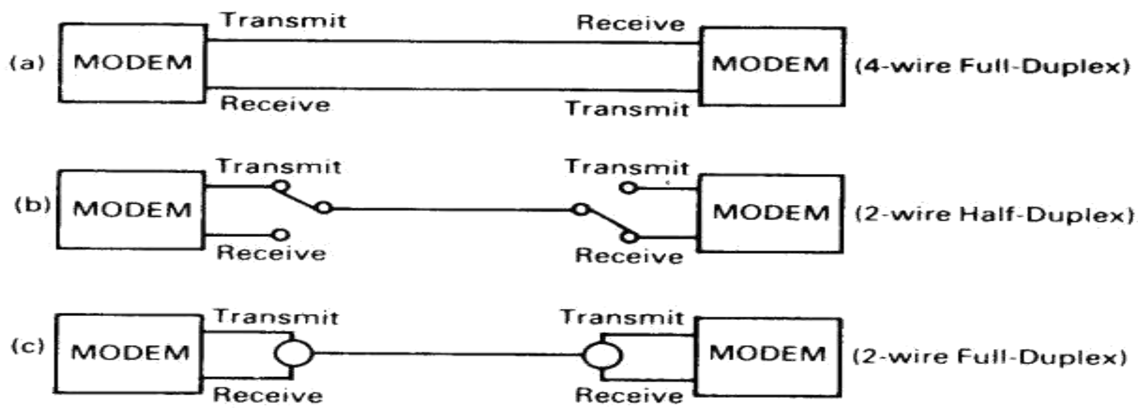

Figure 2. The three modem communications system

The basic modulation technologies used by a modem to convert digital data to analogue signals are

I. Amplitude shift keying (ASK).
II. Frequency shift keying (FSK)
III. Phase shift keying (PSK).
IV. Differential PSK (DPSK)

These techniques are known as the binary continuous wave (CW) Modulation. Modems are always used in pairs such that any system whether simplex, half duplex or full duplex requires a modem at the transmitting as well as the receiving end. Thus a modem acts as the electronic bridge between two worlds – the world of purely digital signals and the established analogue world.

This paper considers the FSK transmission techniques for modulation in the modem communication system which is presented in figure 3.

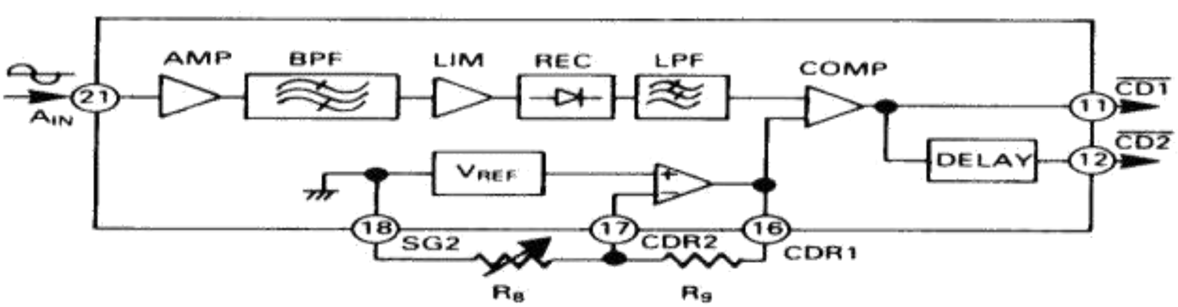

Figure 3. FSK Transmission

The active filter is an important component in both the transmitter and receiver parts of a modem which perform specific duties in the modem. In the FSK transmission, the Bandpass filter as seen in figure 3 comes after the input amplifier in the modem. In the transmitter, base band signal is generated converted to a modulated band pass signal while in the receiver part, the modulated band pass signal is demodulated back to the base band in order to read the information transmitted and carry out other functions too. (mohammad, & Abdur, 2018).

In this paper, the two-amplifier biquad band pass filter is presented to be used in modems of telephone lines applications. This is because of the advantages of this filter over others in terms of performance criteria such as stability, versatility, insensitivity to component tolerances and drift, low dependence in the op amp frequency limitation finite gain, tenability, small spread in component values and minimum total capacitance. In addition, the performance of the two-amplifier current generalised immitance (CGIC) based biquads, but does not have as many op amps outputs and consequently as many simultaneous filtering functions which makes it suitable for use in the modem transmitters and receivers systems.

DESIGN SPECIFICATION

The second-order current generalized immittance (CGIC) Bandpass Biquad filter has specifications:

Centre frequency $\omega_o = 1.70kHz$

Pass band frequency $= 1200Hz - 2200Hz$

Quality factor Q$= 50$

The transfer function for the CGIC band pass filter is given by

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

An appropriate value of a capacitor is chosen and then, the resistance values are calculated using the equation.

$$R = \frac{1}{C\omega_O} \qquad (2)$$

$$R_3 = RQ \qquad (3)$$

The circuit to be simulated is shown in Figure 4. This circuit needs to be functionally tuned to yield the specified values of the quality factor Q and the cut off frequencyω_O. The desired value of ω_O is realized by adjusting R_2 until the phase angle between the output and the input voltage equals O degrees at the sinusoidal input of the frequency ω_O. Q can be attained by adjusting R_5 until the output voltage advances the input voltage by 45 degrees when the frequency of the sinusoidal input is the lower cut off frequency $\omega_{1.}$

The capacitance value was chosen as 10nF. Equation 2 was used to determine the value of the Resistance R to be 5.71KΩ. While equation 3 was used to calculate R_5 which gave 57.14kΩ. The calculated values and the preferred values for the resistors are; $R_1 = 5.76k\Omega = R_2 = R_3 = R_4$ but preferred value for $R_2 = 2.25k\Omega$ when tuned and the commercial value of resistors used are 5.76k Ω and 57.6K Ω for R1 and R2 respectively.

The Second Order CGIC Bandpass Biquad Filter is thus designed and simulated as shown in Figure 4 on the Multisim software.

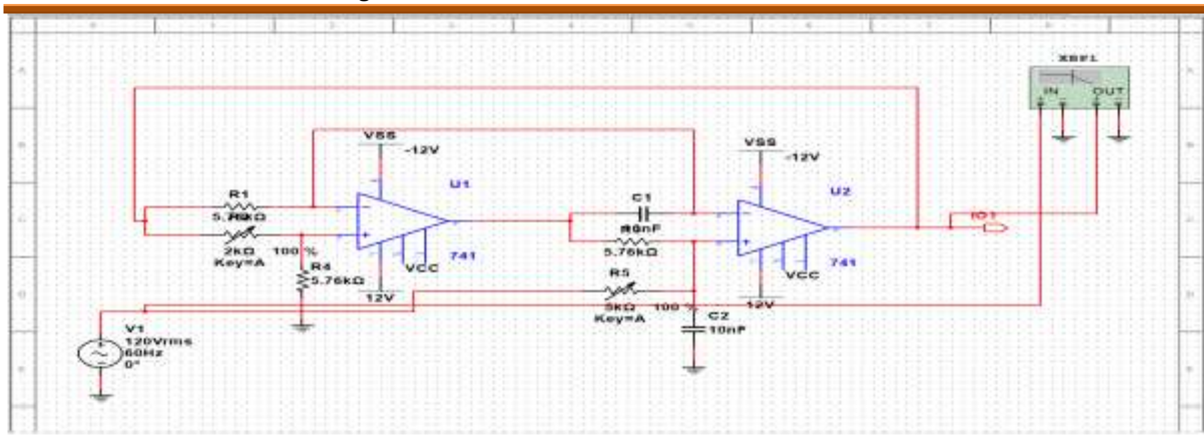

Figure 4. The Second Order CGIC Bandpass Biquad Filter

The Second Order CGIC Bandpass Biquad Filter was simulated and its output obtained as shown in Figure 5, while the Output response Curve is shown in Figure 6.

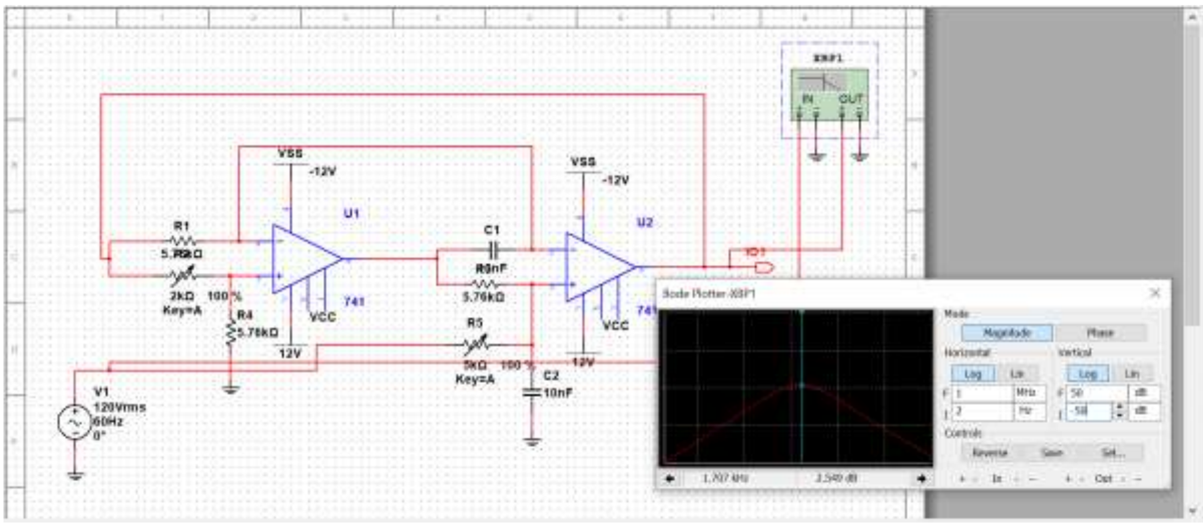

Figure 5. Shows the Circuit Diagram of the Second Order CGIC Bandpass Biquad Filter with its Output

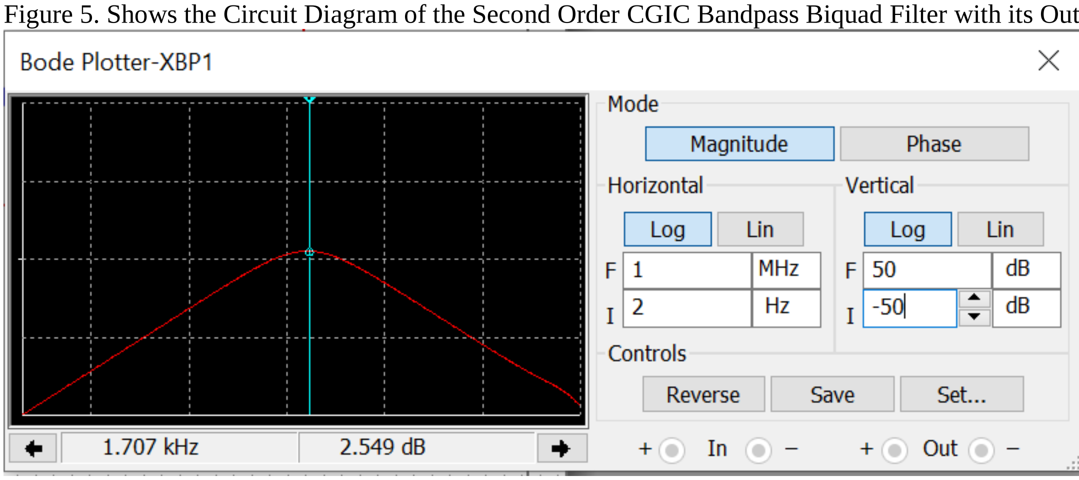

Figure 6. Shows the Frequency Response Curve using Bode Plotter

RESULT AND DISCUSSION

The circuit in Figure 5 was simulated and plots generated as shown in Figure 7 and the phase response in Figure 8.

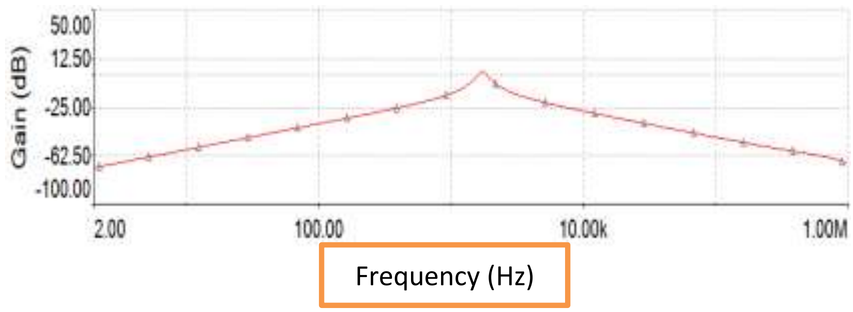

Figure 7. Magnitude Response for Second Order CGIC Band-pass Filter

Figure 8. Phase Response for Second Order CGIC Band-pass Filter

The result shows that the centre frequency ω_o gave 1.707 kHz with a mid-band gain of 2.549dB. The – 3dB gain is -0.43 dB, while the lower cut-off frequency gave a value of 1.55 kHz the higher cut-off frequency was 1.88 kHz. While the bandwidth gave 330Hz. The roll off approached -34.71dB/decade.

From the results presented, the centre frequency ω_o is slightly shifted about 2.3% of the original centre frequency which is within the range of $\pm 8.0\%$ for modems. The gain is high and sufficient for implementation in modern communication systems, while the bandwidth is also sufficient. The roll-off approached a second order double pole filter which has a normal roll-off of -40dB/decade.

CONCLUSION

The second order CGIC Bandpass Biquad Filter has been designed and simulated and studied using filter parameters of centre frequency, ω_o, Quality factor Q, midband gain, Band width and roll off rate. All filter parameters were found to confirm to theory and as such could be used in the implementation in modem systems. The CGIC was chosen because of its numerous advantages over other already implemented filter in terms of performance Criteria such as stability, sensitivity to component 5n the circuits, low dependence on op-amps frequency limitations finite gain, etc. the circuit is also suited for modem implementation because it can be tuned to obtain the required cut off frequency and quality factor which in modem communications are key factors that are required. Further works are recommended to be carried out to improve on the lapses encountered in the course of implementation techniques too, could be applied to ascertain the functionality of the CGIC filter in them.

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