Journal of Management Engineering and Information Technology (JMEIT)
Volume 6 Issue 6, Dec 2019, Online ISSN: 2394 - 8124
Impact Factor: SJIF - 6.265 (2016) | 4.564 (2015)
Website: www.jmeit.com | E-mail: editorjmeit@outlook.com | jmeit@outlook.com

CFOA based Biquad filter realized with low pass filter and band pass filter using dual op-amp IC (THS3202) for high frequency applications

Vijay Laxmi Kalyani, Prachi Mathur, Nidhi Singhal, Nupur Makwana

Vijay Laxmi Kalyani, Assistant Professor and Former *HOD, ECE department, Govt. Women Engineering College, Ajmer, India*
vijaylaxmikalyani@yahoo.com
***Prachi Mathur**, B.Tech student, EE, Govt. Women Engineering College, Ajmer, India e-mail: prachimathur87@gmail.com*
***Nidhi Singhal**, B.Tech student, EE, Govt. Women Engineering College, Ajmer, India (e-mail:nidhigupta3555@gmail.com*
***Nupur Makwana**, B.Tech student, EE, Govt. Women Engineering College, Ajmer, India e-mail:nupur.makwana001@gmail.com*

Abstract— In this paper biquad filter has been proposed to design the band pass and low pass filter for high frequency and low frequency applications with a very high speed dual current-feedback operational amplifier IC THS3202D which has high slew rate of 9000 V/µs with low distortion. The proposed circuit has been designed at 17.8 MHz frequency range. The output results of low pass filter are obtained at 17.1MHz which is the nearest value of theoretical frequency 17.8MHz with a sharper transition region. The output of low pass filter passes all the frequencies from 20.756 KHz to 17.1MHz and it stop the other frequencies above 17.1MHz. The band pass filter output obtained at center frequency 1.023GHz which select the frequencies between two band f_H and f_L from 1.179 GHz to 874.094 MHz and reject the frequencies outside these bands. The proposed circuit is best suited for many applications such as High-Speed Signal Processing, Test and Measurement Systems, High-Voltage ADC Preamplifier, RF and IF Amplifier Stages, Professional Video etc. In this paper the output results are obtained by help of simulation software NI-MULTISIM and ULTIBOARD.

Keywords— Biquad filter, THS3202 IC, output using NI-Multisim and Ultiboard

I. INTRODUCTION

Many research has been carried out over the decade to design the biquad filter. In [1], CFOA based Biquad Filter using AD844 IC was designed for various application. In [2], the paper was presented a new current mode biquadratic filter with one input and three outputs using differential voltage

current conveyor (DVCC) and four passive components. The proposed circuit was simultaneously realized low-pass, band-pass, and high pass filter functions without changing the circuit topology and passive elements. In [3], the paper was based on a new second order multiple-input–single-output type universal filter configuration using only two DDAs along with only five passive components which can realize all the five generic filter functions from the same configuration under various conditions in terms of the four input signals.

A biquad filter is a universal filter which has a low pass and band pass filter. A second order biquadratic has a band pass and low pass filter output with three op-amps. Biquad filter can be tuned easily by varying R3, It has no effect on the voltage gain. Therefore we can vary the frequency range by varying the resistor. By adding more op-amp in the circuitry we can also obtain the output results of high pass, all pass and notch filter. To design the biquad filter using VFOA based op-amp IC there is some limitation of frequency range due to their lower slew rate. To increase the frequency range for high frequency application, there is a need of some high speed IC with faster slew rate. Therefore in this paper CFOA based dual op-amp high speed IC THS3202 is to be used to design the biquad filter for high frequency range.

The THS3202 is a dual current-feedback operational amplifier IC. This IC have a high slew rate of 9000 V/µs with low distortion. In biquad filter using 3 or more op-amp IC, the circuit draw more power, require more time to design and uses larger PCB design area. Therefore using dual op-amp IC like THS3202, the circuit require only 2 op-amp IC draw less power and requires minimum time to design circuit. The proposed circuit is best suited for many high frequency applications.

I.II. THS3202 IC: It is a dual current-feedback operational amplifier IC. This IC have a high slew rate of 9000 V/µs with low distortion.

Journal of Management Engineering and Information Technology (JMEIT)
Volume 6 Issue 6, Dec 2019, Online ISSN: 2394 - 8124
Impact Factor: SJIF - 6.265 (2016) | 4.564 (2015)
Website: www.jmeit.com | E-mail: editorjmeit@outlook.com | jmeit@outlook.com

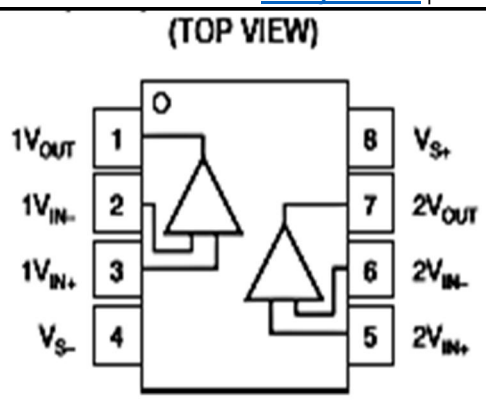

Fig.1 pin diagram of THS3202 IC

The THS3202 provides well-regulated ac performance characteristics with power supplies ranging from single supply 6.6-V operation up to a 15-V supply. The high unity gain bandwidth of up to 2 GHz is a major contributor to the excellent distortion performance. The THS3202 offers an output current drive of ±115 mA and a low differential gain and phase error that make it suitable for applications such as video line drivers. It is suitable for high speed signal processing applications [4].

II. BIQUADRATIC FILTERS

The biquadratic filter is also referred to as TT (Tow-Thomas) filter. This type of filter can be tuned by varying R_3.This has no effect on the voltage gain, which is an advantage. The biquadratic filter has low pass and band pass output.

A second order biquadratic has a band pass and low pass filter output with three op-amps. Resistors R_2 and $R_1$are used to set the voltage gain. Resistors R_3 and R'_3 have the equal value, as do R_4 and R'_4.

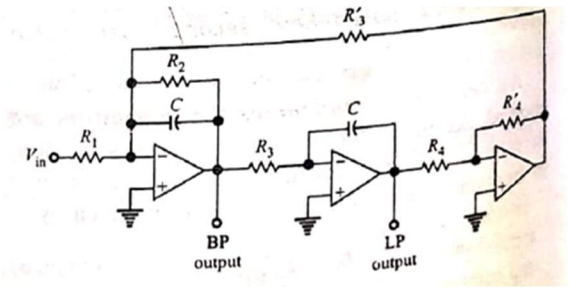

Fig.2: circuit diagram of biquad filter

To design the biquad filter, it is necessary to select the cut off frequency and choose the value of capacitor C≤1μF, find the value of R using the following formula- $f_0=1/2\pi RC$ or $R=1/2\pi fC$.

To find the voltage gain (A_V), quality factor (Q), cut off frequency (f_0) and bandwidth (BW) following formula are used:

$A_V=-R_2/R_1$, $Q=R_2/R_3$, $f_0=1/2\pi R_3C$, $BW=1/2\pi R_2C$ (1)

The biquadratic filter has another advantage. We can independently vary the voltage gain with R_1, the bandwidth with R_2 and the centre frequency with R_3. This is a major advantage and one of the reasons for the biquadratic filters, also known as **biquads.**

In biquad filter using 3 or more operational amplifier draw more power in the circuitry and require more time to design. Therefore using dual op-amp IC like THS3202 draw less power, requires minimum op-amp to design circuit and requires less time.

III. DESIGN AND SIMULATION RESULTS

Biquad filter can be tuned easily by varying R3, It has no effect on the voltage gain. It provides the BP and LP output simultaneously. To implement a biquad filter using Butterworth filter functions. In this paper the circuit has been designed at 17.8 MHz frequency range. Therefore it is best suited for many lower or higher frequency range of applications. The high cut off frequency is obtained of low pass filter in fig.7 at 17.1MHz which is the nearest result at 17.8MHz frequency with a sharper transition region. The low pass filter passes all the frequencies from 20.756 KHz to 17.1MHz and it stop the other frequencies above 17.1MHz. The output also provided by the band pass filter. The band pass filter is used to select the particular frequency range between two band f_H and f_L. In this paper the band pass filter (fig.6a and 6b) select the frequencies between two band f_H and f_L from 1.179 GHz to 874.094 MHz and reject the frequencies outside these bands. The center frequency f_C of band pass filter (fig.6) is 1.023GHz. Therefore we can use the designed circuit for high frequency applications also.

To find the value of R_2, consider $R_F=R_2=.586\ R_1$ where $R_1\leq100\Omega$

Assume $R_1=50\Omega$

Therefore $R_F=29.3\Omega$

Using above equation (1)

A_V= -0.586, Q=1.7, B.W.= 6.1MHz

Journal of Management Engineering and Information Technology (JMEIT)
Volume 6 Issue 6, Dec 2019, Online ISSN: 2394 - 8124
Impact Factor: SJIF - 6.265 (2016) | 4.564 (2015)
Website: www.jmeit.com | E-mail: editorjmeit@outlook.com | jmeit@outlook.com

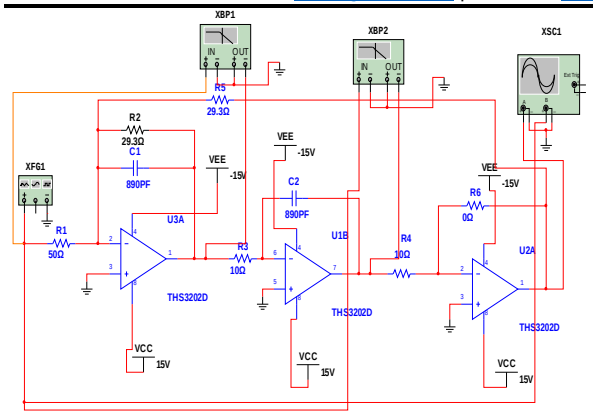

Fig.3: circuit design of biquad filter using NI-MULTISIM

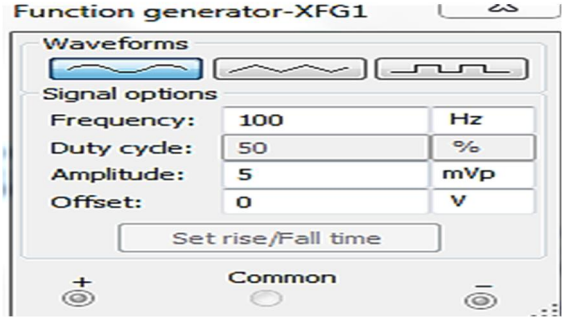

Fig.4: input frequency 100 Hz using function generator

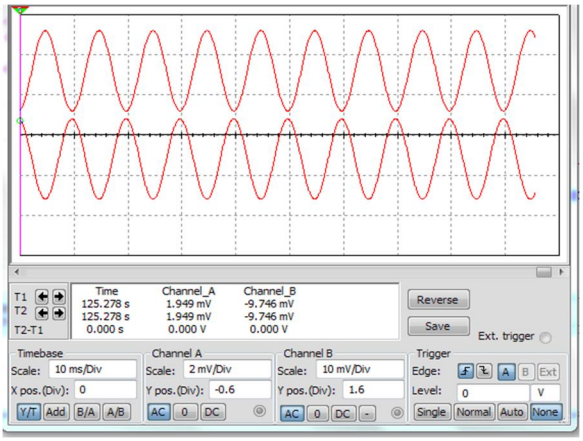

Fig.5: output waveform of biquad filter using NI-MULTISIM

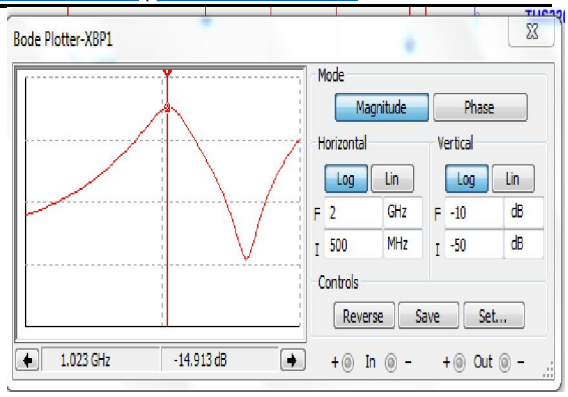

Fig.6: frequency response curve of BP filter using NI-MULTISIM

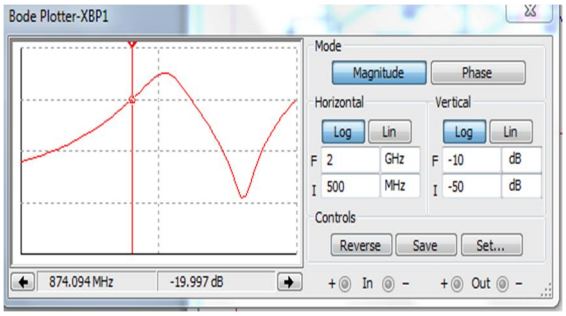

Fig.6 (a): Low cut-off frequency (f_L) of Band pass filter

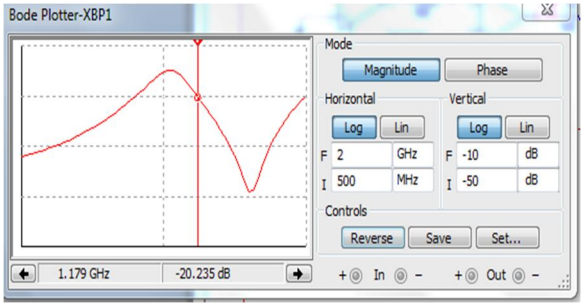

Fig.6 (b): High cut-off frequency (f_H) of Band pass filter

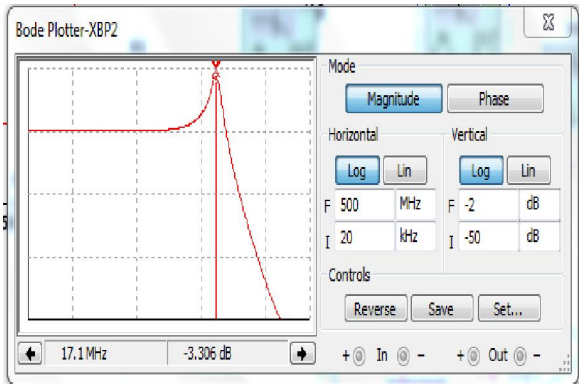

Fig.7: frequency response curve of LP filter showing high cut-off frequency f_H at 17.1MHz

Journal of Management Engineering and Information Technology (JMEIT)
Volume 6 Issue 6, Dec 2019, Online ISSN: 2394 - 8124
Impact Factor: SJIF - 6.265 (2016) | 4.564 (2015)
Website: www.jmeit.com | E-mail: editorjmeit@outlook.com | jmeit@outlook.com

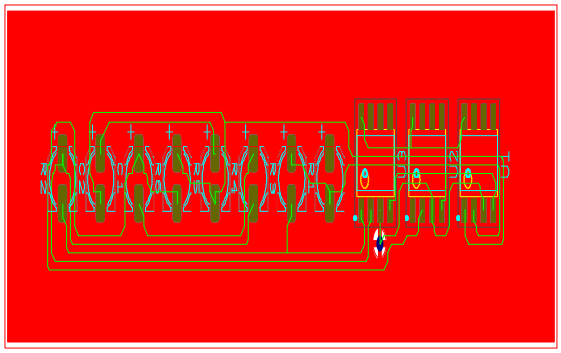

Fig.8: PCB design of biquad filter with three op-amp IC using Ultiboard

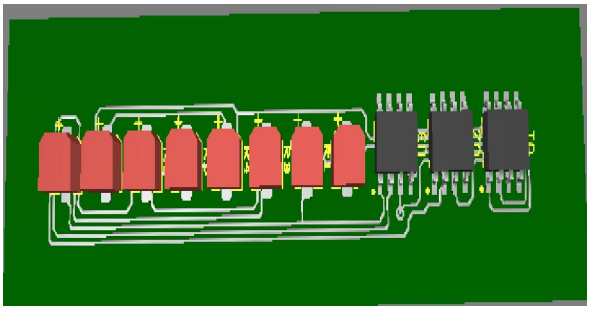

Fig.9: 3D view of biquad filter using three op-amp IC

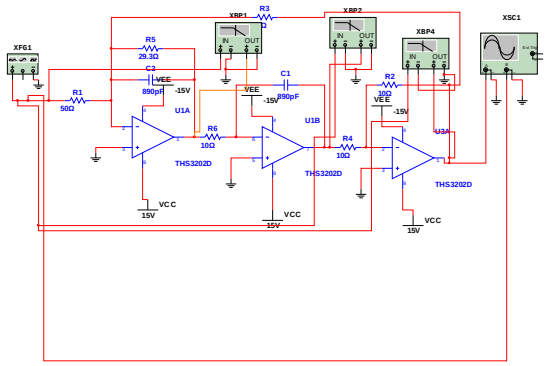

Fig.10: circuit design of biquad filter using dual op-amp IC

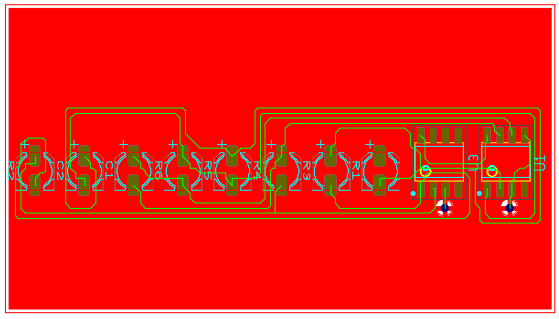

Fig.11: PCB design of biquad filter with two op-amp IC using Ultiboard

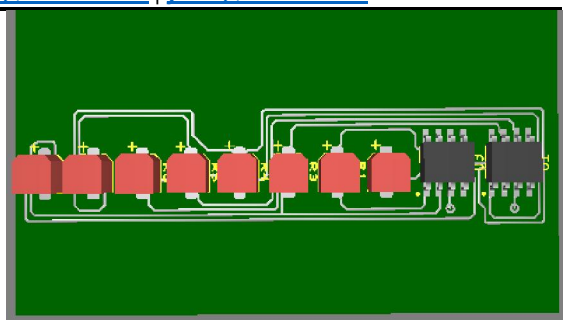

Fig.12: 3D View of biquad filter using two op-amp IC

IV. RESULTS

Biquad filter output	Results
Center frequency (f_C) of Band pass filter and gain in dB	1.023GHz and -14.913 dB
High cut-off frequency (f_H) of Low pass filter	17.1MHz which is nearest to the theoretical value 17.8MHz and gain is -3.306 dB
Voltage gain (A_V) of Biquad filter	-0.586
Quality factor (Q) of Biquad filter	1.7
Bandwidth (B.W.)	6.1MHz

V. CONCLUSION

In this paper biquad filter has been proposed to design the low pass filter and a band pass filter for high frequency application on the same circuitry with a very high speed IC THS3202D. This IC have a high slew rate of 9000 V/µs and it is well suitable for high speed signal processing applications. Because THS3202 is a dual current-feedback operational amplifier IC. So that minimum number of ICs are required in the designed circuit. Therefore, we may concluded that the smaller circuit can be designed using dual op-amp THS3202D IC at a very high frequency range with minimum distortion.

The proposed circuit has been designed at 17.8MHz frequency range. The high cut-off frequency of low pass filter is obtained at 17.1MHz which is the nearest value of theoretical frequency 17.8MHz. The frequency response curve of low pass filter provides a sharper transition region. The low pass filter passes all the frequencies from 20.756 KHz to 17.1MHz and it stop the other frequencies above 17.1MHz. The band pass filter output obtained at center frequency 1.023GHz which select the frequencies between two band f_H and f_L from 1.179GHz to 874.094 MHz and reject the frequencies outside these bands. The proposed design provides a satisfactory results at output by applying very low input frequency of 100 Hz with an amplitude of 5mV. It is best suited for many high frequency applications.

REFERENCES

[1]Vijay Laxmi Kalyani, Lehar Kewalramani,"Biquad Filter Employing With Three CFOA And Its Application", Journal of Management Engineering and Information Technology ,Volume -2, Issue- 6, Dec. 2015, ISSN: 2394 - 8124

[2] Bhartendu Chaturvedi and Sudhanshu Maheshwari,"Current Mode Biquad Filter with Minimum Component Count", Hindawi Publishing Corporation Active and Passive Electronic Components, Volume 2011, Article ID 391642, 7 page,doi:10.1155/2011/391642

[3] Bhopendra Singh, Abdhesh Kumar Singh, Raj Senani,"A new universal biquad filter using differential difference amplifiers and its practical realization", Analog Integer Circle Sig Process (2013)75:293–297,DOI 10.1007/s10470-013-0048-4,Received: 16 July 2012 / Accepted: 10 February 2013 / Published online: 22 February 2013,Springer Science Business Media New York 2013

[4] http://www.ti.com/lit/ds/slos242f/slos242f.pdf

Author's Details

Vijay Lama Kalyani is currently working as an Assistant Professor in the department of ECE in GWEC, Ajmer. She has attended various workshops, conferences, FDP, STC etc. and also published many research papers in various conference proceedings, International and national Journals. She is a member of IAENG. She has guided many students of B.Tech and M.Tech for the research papers, projects etc.

Prachi Mathur is currently pursuing B.Tech (II-year) in Electrical Engineering in GWEC, Ajmer.

Nidhi Singhal is currently pursuing B.Tech (II-year) in Electrical Engineering in GWEC, Ajmer.

Nupur Makwana is currently pursuing B.Tech (II-year) in Electrical Engineering in GWEC, Ajmer.