



QZSS L1 Bandwidth Frequency Filter Design for QZSS Receiver

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ABSTRACTS

We present the design of bandpass filter on the frequency of the QZSS satellite, by providing bandwidth at the cut-off frequency equally to the bandwidth of the QZSS L1 with selecting the response characteristic on Butterworth maximally flat amplitude. Bandpass filter design using frequency of the QZSS L1 with bandwidth is 24MHz. The design procedure involves two steps, the first step is to find the required order of the filter, which we use 3rd order, and the second step is to find the scale factor that must be applied to the normalized parameter values. The Band-Pass Butterworth filter is a combination between low pass and high pass. For the Butterworth filter, the value of a resistor that has been used are 50Ω. Then go to find the capacitor and inductor and by using PSpice as the tools for the simulation. The results of the output of bandpass filter at -3dB was between 1563 and 1587MHz. And was bandwidth around 24MHz. The combination of the lowpass filter and high pass filter is to perform as the bandpass filter. Therefore, there are two combinations also in designing bandpass filter. The aim of this combination is to have an influence on the performance of bandpass filter. As a conclusion, this designed filter on the frequency of QZSS L1 is to be useful by using bandpass filter.

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1. INTRODUCTION

Figure 1 shows the QZSS. QZSS is a Japanese regional satellite navigation system. The navigation system objective is to broadcast GPS-interoperable and augmentation signals. The design concept of QZSS is the requirements of the Japanese system which are quite different in terms of service, service area, and, more importantly, the policy of national space development underlying them (Inaba et al., 2009). QZSS L1, the signal frequency is equal to GPS/SBAS L1 (1575.42 MHz) and the bandwidth is 24 MHz (Sakai & Ito, 2009; Sakai et al., 2008).

Bandpass filter (BPF) for bandwidth design is used as the controllable features such as tuning frequency range, bandwidth, pass band gain, and low noise figure etc. (Jian & Chien-In, 2015). Chen concludes that a band pass filter design for tuning center frequency in a wide frequency span e.g., 1 GHz (Jian & Chien-In, 2015). The Butterworth bandpass filter is one type of signal processing filter design. It is designed to have a frequency response which is as flat as mathematically possible in the pass band (Hussin & Gauri, 2016). However, there is rarely study about QZSS L1 bandwidth frequency filter design receiver.

In this research, we studied the design of bandpass filter on the frequency of the satellite, by providing bandwidth at the cut-off frequency equally to the bandwidth of the QZSS L1 with selecting the response characteristic on Butterworth maximally flat amplitude.



Figure 1. QZSS.

2. METHODS

Figure 2 shows the circuit design method for the configuration of Butterworth bandpass filter by using PSpice as the tools for the simulation.

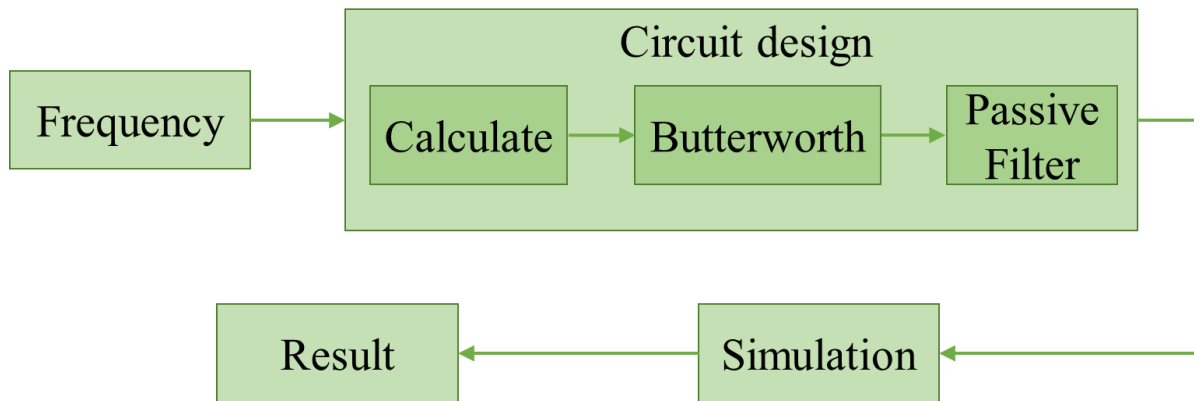


Figure 2. Circuit design method.

From the QZSS L1 signal frequency:

$$f_i = 1563 \text{ MHz}$$

$$f_h = 1587 \text{ MHz}$$

$$f_o = 1574.95 \text{ MHz}$$

$$Z = 50\Omega$$

Calculate

$$f_0 = \sqrt{f_l \times f_h}$$

and

$$C'_1 = C'_3 = \frac{C}{FSF \times Z}$$

and

$$L'_2 = \frac{L \times Z}{FSF}$$

$$L'_1 = \frac{1}{\omega_0^2 C'_1}$$

$$C'_2 = \frac{1}{\omega_0^2 L'_2}$$

when

$$\omega_0 = 2\pi f_0$$

$$FSF = 2\pi(BW_{3dB})$$

$$Z = R_s = R_L$$

when

- f_0 = center frequency
- f_l = lower cut-off frequency
- f_h = higher cut-off frequency
- ω_0 = center angular frequency
- L = Inductor
- C = Capacitor
- R = Resistor
- FSF = frequency-scaling factor
- Z = desired impedance level

The designed circuit is as follows in **Figure 3**.

3. RESULTS AND DISCUSSION

The results of bandpass filter circuit for design were presented using PSpice. The output of bandpass filter at -3dB was between 1563 and 1587 MHz, and was bandwidth around 24 MHz is as follows in **Figure 4** and **Figure 5**.

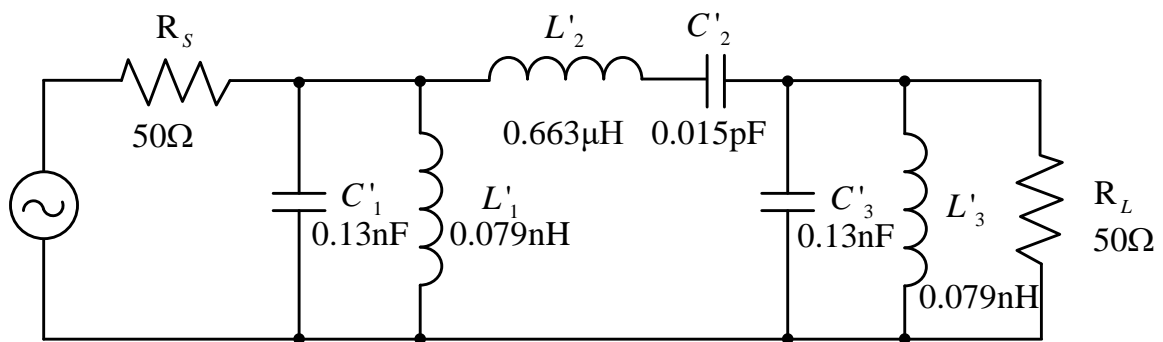


Figure 3. LC bandpass filters.

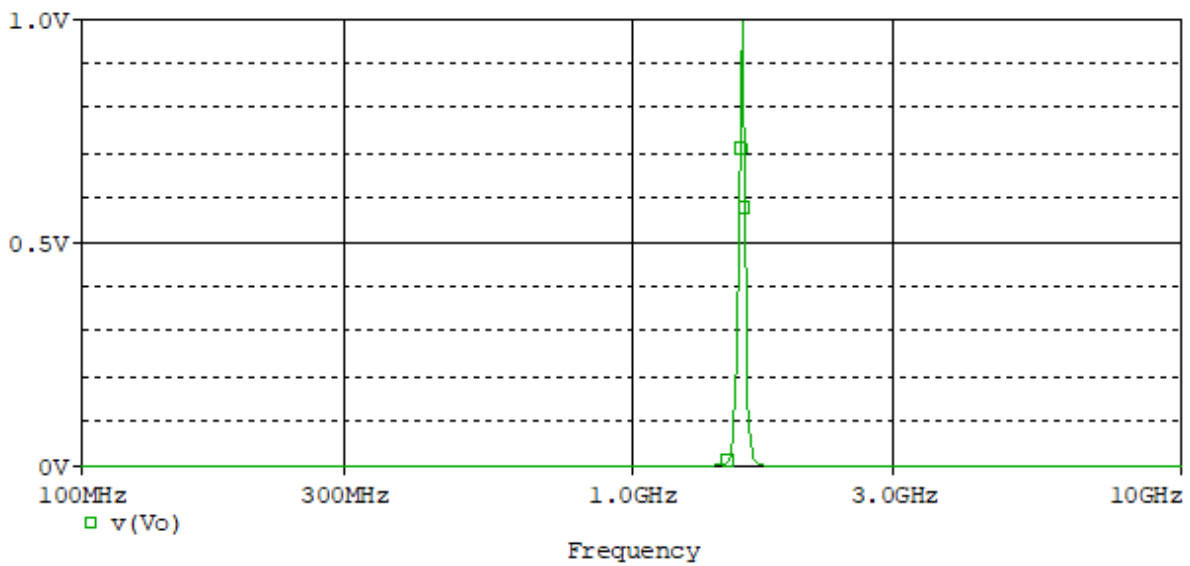


Figure 4. Amplitude-frequency response of bandpass filter.

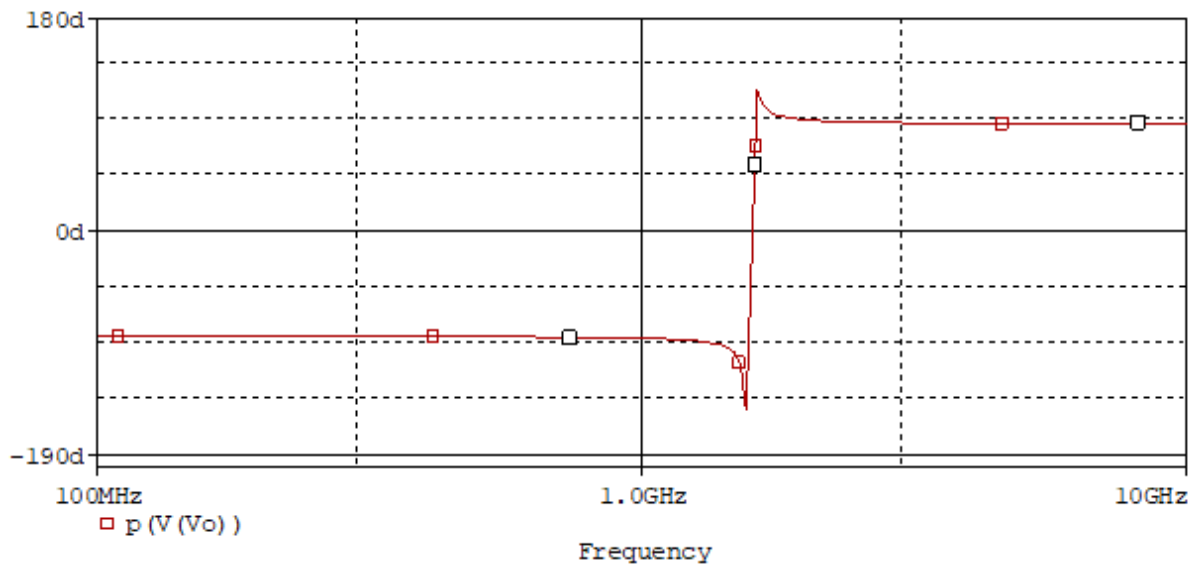


Figure 5. Phase response of bandpass filter.

The combination of the lowpass filter and high pass filter is to perform as the bandpass filter. Therefore, there are two combinations also in designing bandpass filter. The aim of this combination is to have an influence on the performance of bandpass filter.

4. CONCLUSION

Bandpass filter frequency of the QZSS L1 with bandwidth is designed in 24 MHz by using a Butterworth filter which is presented in this poster. These designed circuits are composed 3rd order. Moreover, the combination between lowpass filter and high pass filter is performed as a BPF. As a conclusion, this designed filter on the frequency of QZSS L1 is to be useful by using bandpass filter.

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6. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

7. REFERENCES

- Inaba, N., Matsumoto, A., Hase, H., Kogure, S., Sawabe, M., and Terada, K. (2009). Design concept of quasi zenith satellite system. *Acta Astronautica*, 65(7-8), 1068-1075.
- Hussin, S. F., Birasamy, G., and Hamid, Z. (2016). Design of butterworth band-pass filter. *Politeknik and Kolej Komuniti Journal of Engineering and Technology*, 1(1), 32-46.

Sakai, T., Fukushima, S., Takeichi, N., and Ito, K. (2008, January). Implementation of the QZSS L1-SAIF message generator. *Proceedings of the 2008 National Technical Meeting of The Institute of Navigation* (pp. 464-476).

Sakai, T., Fukushima, S., and Ito, K. (2009, August). Development of QZSS L1-SAIF augmentation signal. In *2009 ICCAS-SICE* (pp. 4462-4467). IEEE.

Chen, J., and Chen, C. I. H. (2015, May). 1–2 GHz tuning frequency band pass filter with controllable pass band and high stopband rejection. *2015 IEEE MTT-S International Microwave Symposium* (pp. 1-4). IEEE.

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