CHAPTER 15

Finite Wordlength Effects

Basic Problems

20.

21. (a) See plot below.

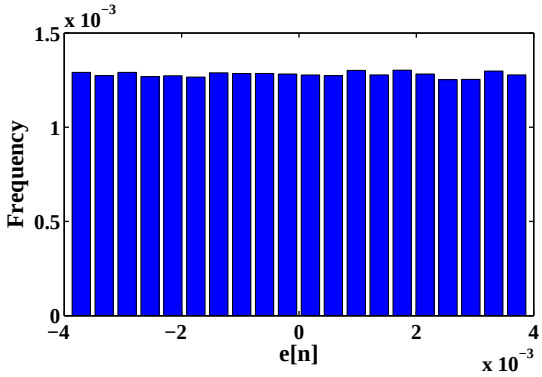

FIGURE 15.1: Plot of the histogram of $e[n]$ using 20 bins.

(b) See plot below.

(c) See plot below.

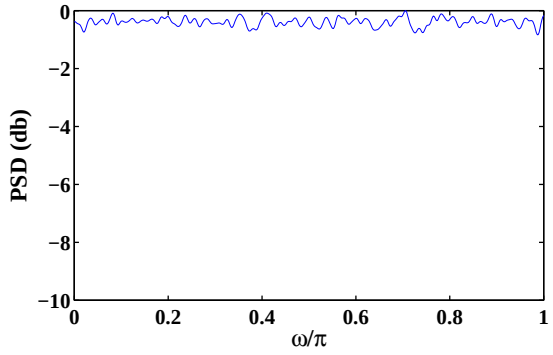

FIGURE 15.2: PSD of $e[n]$ using the `psdwelch` function for $B + 1 = 8$.

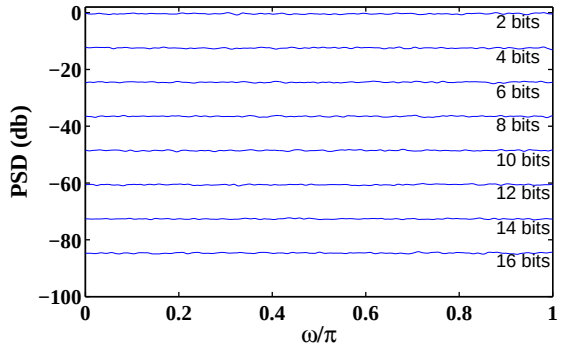

FIGURE 15.3: PSD of $e[n]$ using the `psdwelch` function for $B + 1 = 2$, 4, 6, 8, 10, 12, 14, and 16.

22. (a) Solution:

$$\text{VG} = R_0^2 + \sum_{i=1}^{2}\sum_{j=1}^{2} \frac{R_i R_j^*}{1 - p_i p_j^*}$$

where

$$R_0 = 1, \quad R_1 = \frac{2r^2 \cos\theta \, \mathrm{e}^{\mathrm{j}\theta} - r^2 - 1}{2\mathrm{j}r \sin\theta}, \quad R_2 = -\frac{2r^2 \cos\theta \, \mathrm{e}^{-\mathrm{j}\theta} - r^2 - 1}{2\mathrm{j}r \sin\theta}$$

(b) Solution:

$$\text{VG} = 10.5263$$

(c) Solution:

$$\text{VG} = 100.5025$$

(d)

23. (a)

(b) See plot below.

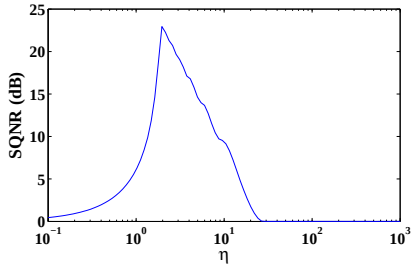

FIGURE 15.4: Plot of the noise variance as a function of η for $B + 1 = 4$ bits.

(c) See plot below.

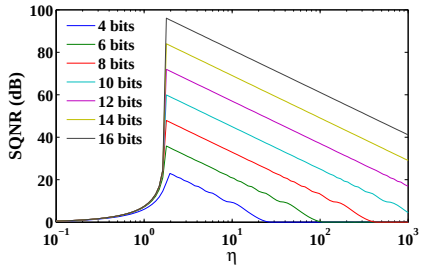

FIGURE 15.5: Plot of the noise variance as a function of η for $B + 1 = 6$, 8, 10, 12, 14, and 16 bits.

24.

25.

26. (a) See plot below.

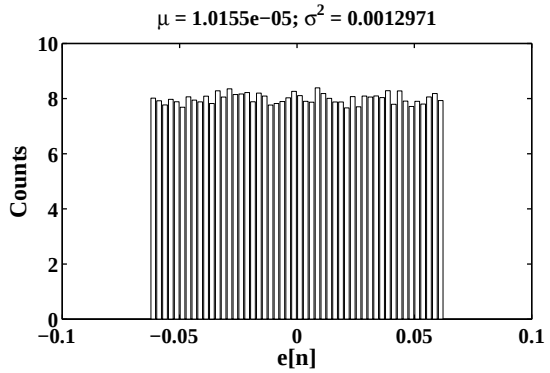

FIGURE 15.6: Plot of the quantization histogram for $B = 3$ bits.

(b) See plot below.

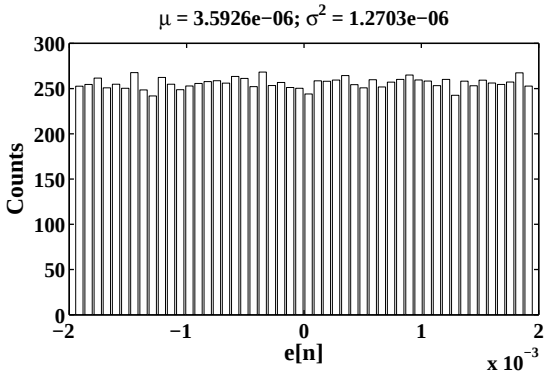

FIGURE 15.7: Plot of the quantization histogram for $B = 8$ bits.

(c) tba.

27.

28.

29.

30. (a) See plot below.

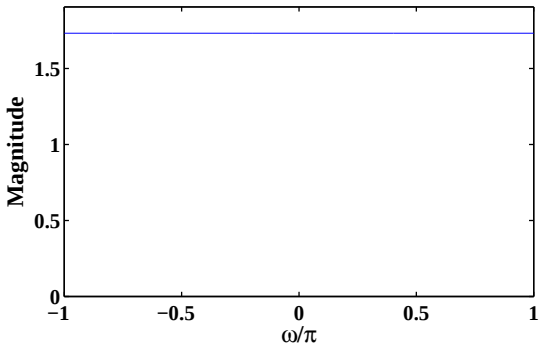

FIGURE 15.8: Plot of the magnitude response of the allpass filter.

(b) See plot below.

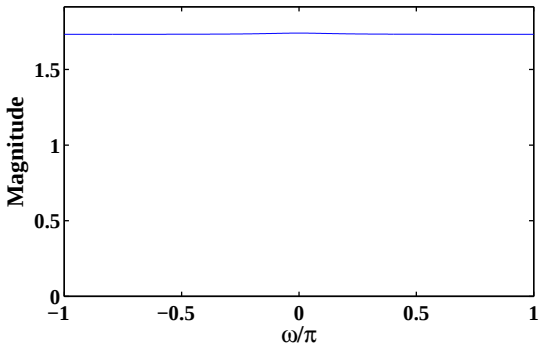

FIGURE 15.9: Plot of the magnitude response of the resulting filter by rounding the filter coefficients to $B = 8$ fraction bits.

(c) See plot below.

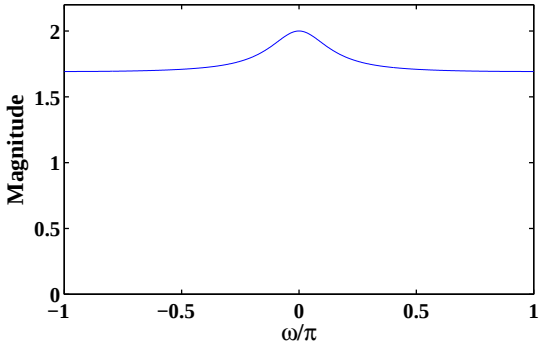

FIGURE 15.10: Plot of the magnitude response of the resulting filter by rounding the filter coefficients to $B = 4$ fraction bits.

31. (a) See plots below.

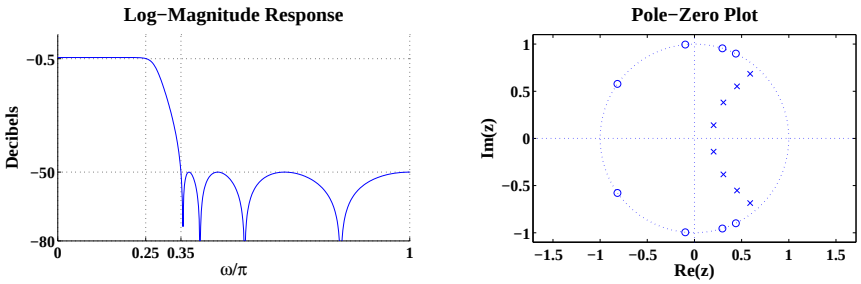

FIGURE 15.11: Plot of the magnitude response and pole-zero diagram of the filter.

(b) See plots below.

(c) See plots below.

(d) See plots below.

(e) tba

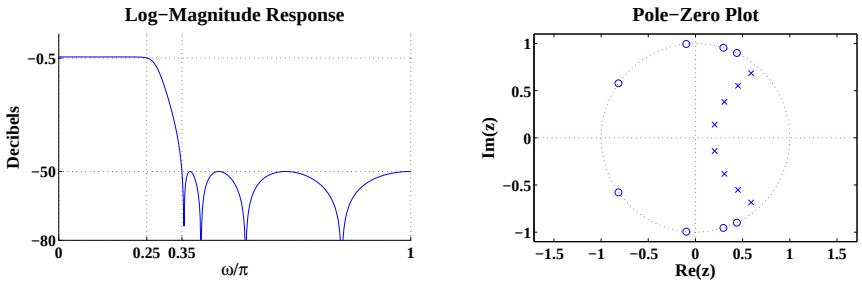

FIGURE 15.12: Plot of the magnitude response and pole-zero diagram of the filter after quantizing the cascade form coefficients to $L = 16$ bits.

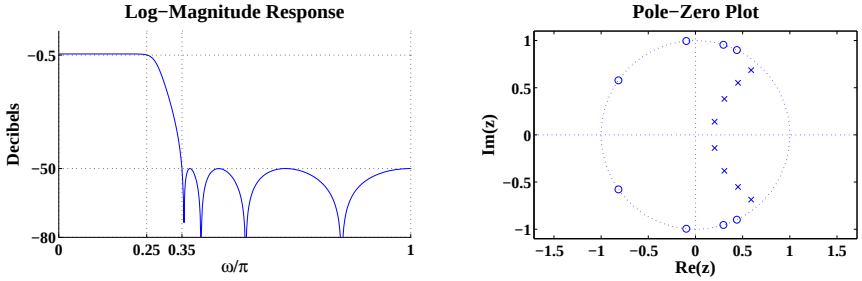

FIGURE 15.13: Plot of the magnitude response and pole-zero diagram of the filter after quantizing the cascade form coefficients to $L = 12$ bits.

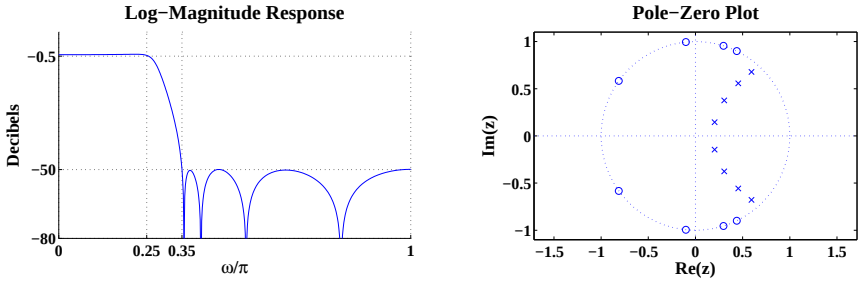

FIGURE 15.14: Plot of the magnitude response and pole-zero diagram of the filter after quantizing the cascade form coefficients to $L = 8$ bits.

32. (a) See plots below.

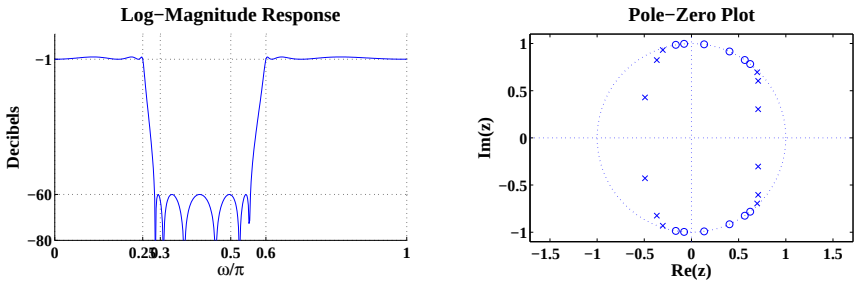

FIGURE 15.15: Plot of the magnitude response and pole-zero diagram of the filter.

(b) See plots below.

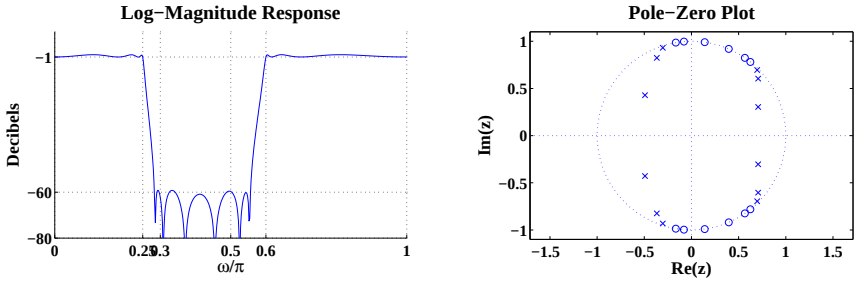

FIGURE 15.16: Plot of the magnitude response and pole-zero diagram of the filter after quantizing the direct form coefficients to $L = 16$ bits.

(c) See plots below.

(d) See plots below.

(e) tba.

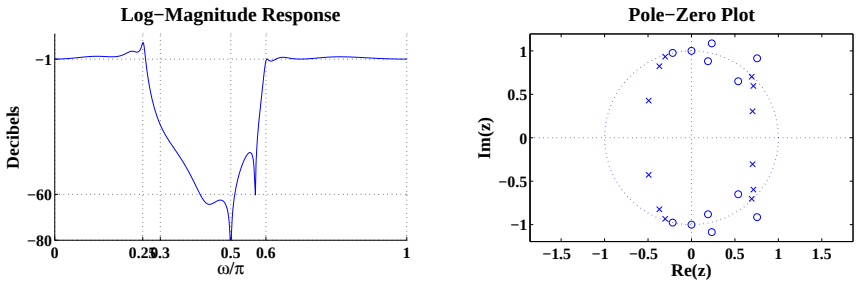

FIGURE 15.17: Plot of the magnitude response and pole-zero diagram of the filter after quantizing the direct form coefficients to $L = 10$ bits.

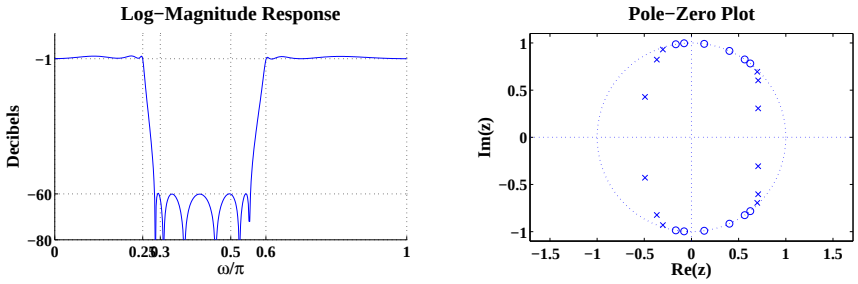

FIGURE 15.18: Plot of the magnitude response and pole-zero diagram of the filter after quantizing the cascade form coefficients to $L = 10$ bits.

33. (a) See plots below.

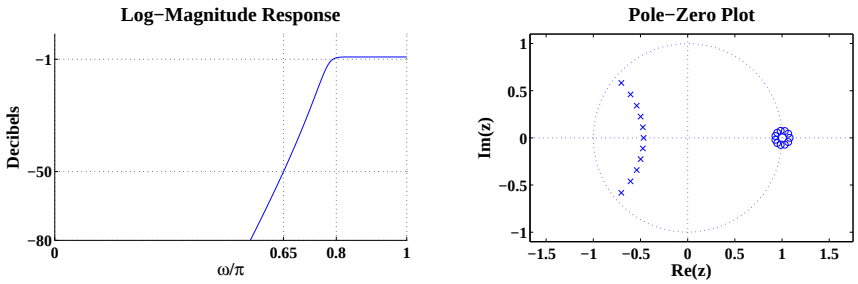

FIGURE 15.19: Plot of the magnitude response and pole-zero diagram of the filter.

(b) See plots below.

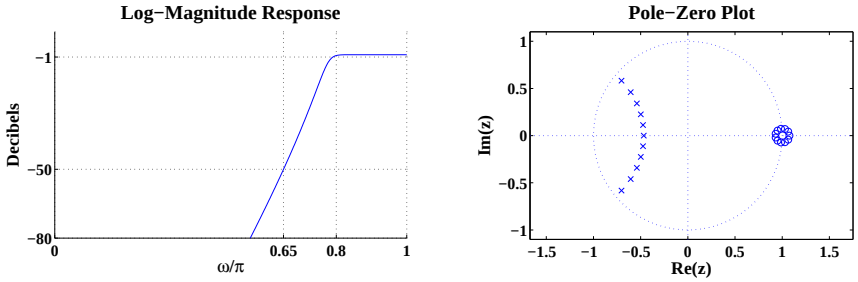

FIGURE 15.20: Plot of the magnitude response and pole-zero diagram of the filter after quantizing the cascade form coefficients to $L = 16$ bits.

(c) See plots below.

(d) See plots below.

(e) tba

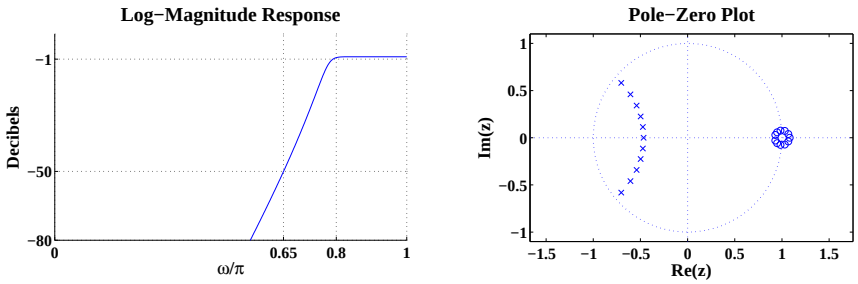

FIGURE 15.21: Plot of the magnitude response and pole-zero diagram of the filter after quantizing the cascade form coefficients to $L = 12$ bits.

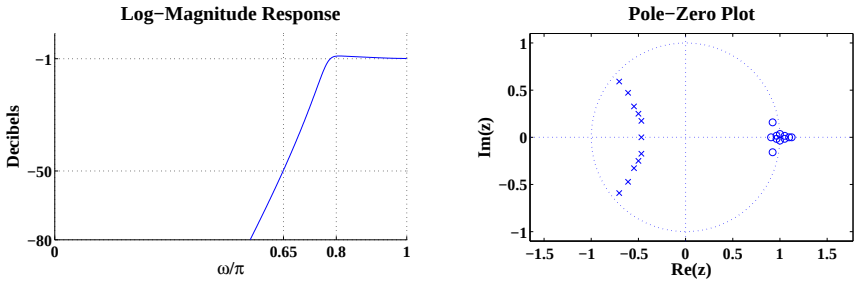

FIGURE 15.22: Plot of the magnitude response and pole-zero diagram of the filter after quantizing the cascade form coefficients to $L = 8$ bits.

34. (a) See plots below.

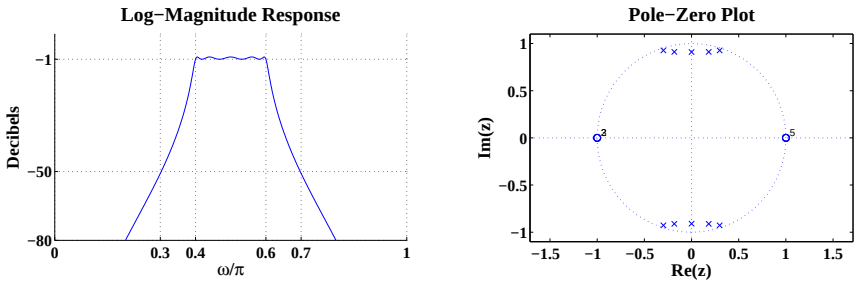

FIGURE 15.23: Plot of the magnitude response and pole-zero diagram of the filter.

(b) See plots below.

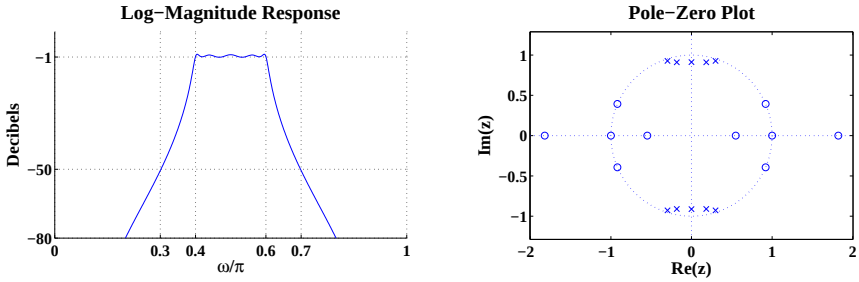

FIGURE 15.24: Plot of the magnitude response and pole-zero diagram of the filter after quantizing the direct form coefficients to $L = 16$ bits.

(c) See plots below.

(d) See plots below.

(e) tba.

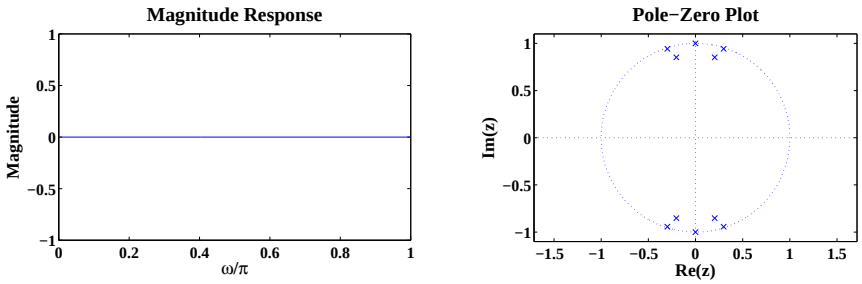

FIGURE 15.25: Plot of the magnitude response and pole-zero diagram of the filter after quantizing the direct form coefficients to $L = 10$ bits.

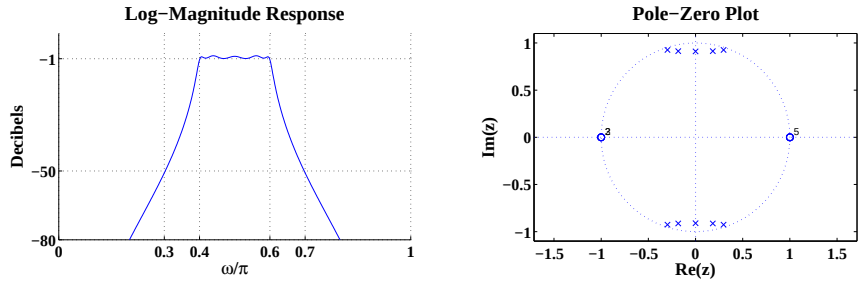

FIGURE 15.26: Plot of the magnitude response and pole-zero diagram of the filter after quantizing the cascade form coefficients to $L = 10$ bits.

35. (a) See plot below.

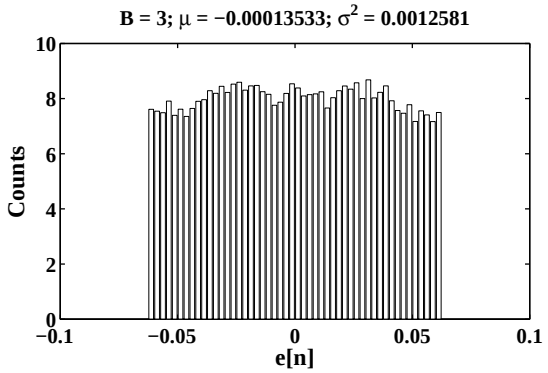

FIGURE 15.27: Plot of the histogram of the resulting error sequence when $ax[n]$ is quantized to $B = 3$.

(b) See plot below.

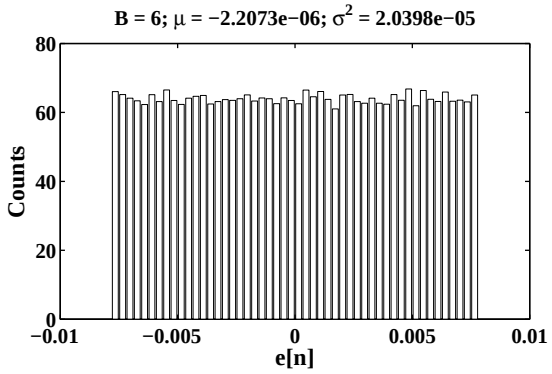

FIGURE 15.28: Plot of the histogram of the resulting error sequence when $ax[n]$ is quantized to $B = 6$.

(c) See plot below.

(d) tba

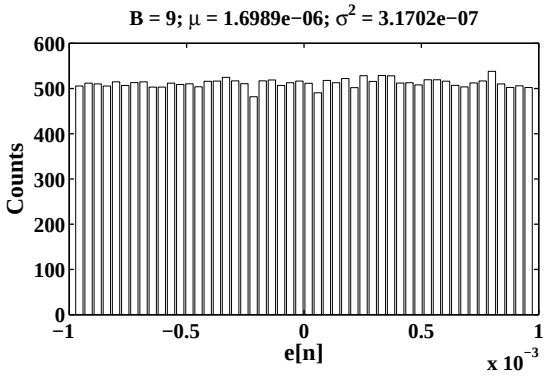

FIGURE 15.29: Plot of the histogram of the resulting error sequence when $ax[n]$ is quantized to $B = 9$.

36. (a)

(b) See plot below.

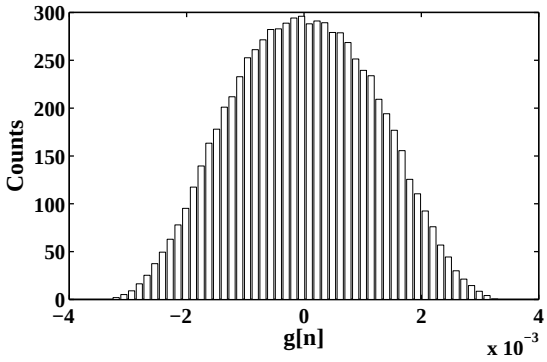

FIGURE 15.30: Plot of the histogram of the resulting error sequence $g[n]$ using all three B bit multipliers in the filter implementation.

(c) See plot below.

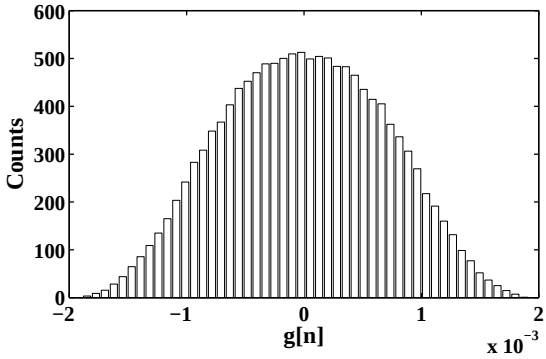

FIGURE 15.31: Plot of the histogram of the resulting error sequence $g[n]$ using only one B bit multiplier in the filter implementation.

37. (a) Solution:
The output display oscillation and the amplitude is 0.125 and frequency is one sample.

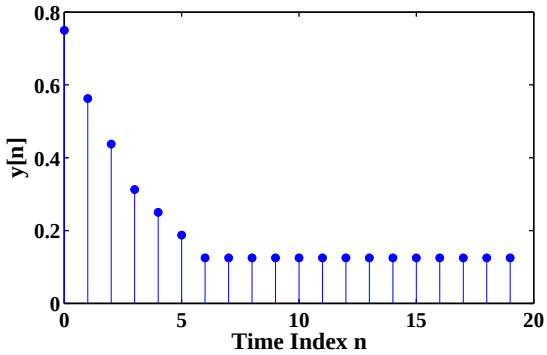

FIGURE 15.32: Plot of the first 20 samples of $y[n]$ when two's-complement overflow is used in the addition.

(b) Solution:
The output display oscillation and the amplitude is 0.125 and frequency is one sample.

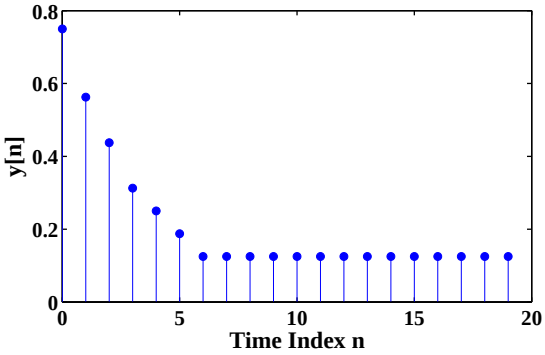

FIGURE 15.33: Plot of the first 20 samples of $y[n]$ when saturation characteristics is used in the addition.

38. tba