

Prob. 1

(a) See Fig. 1

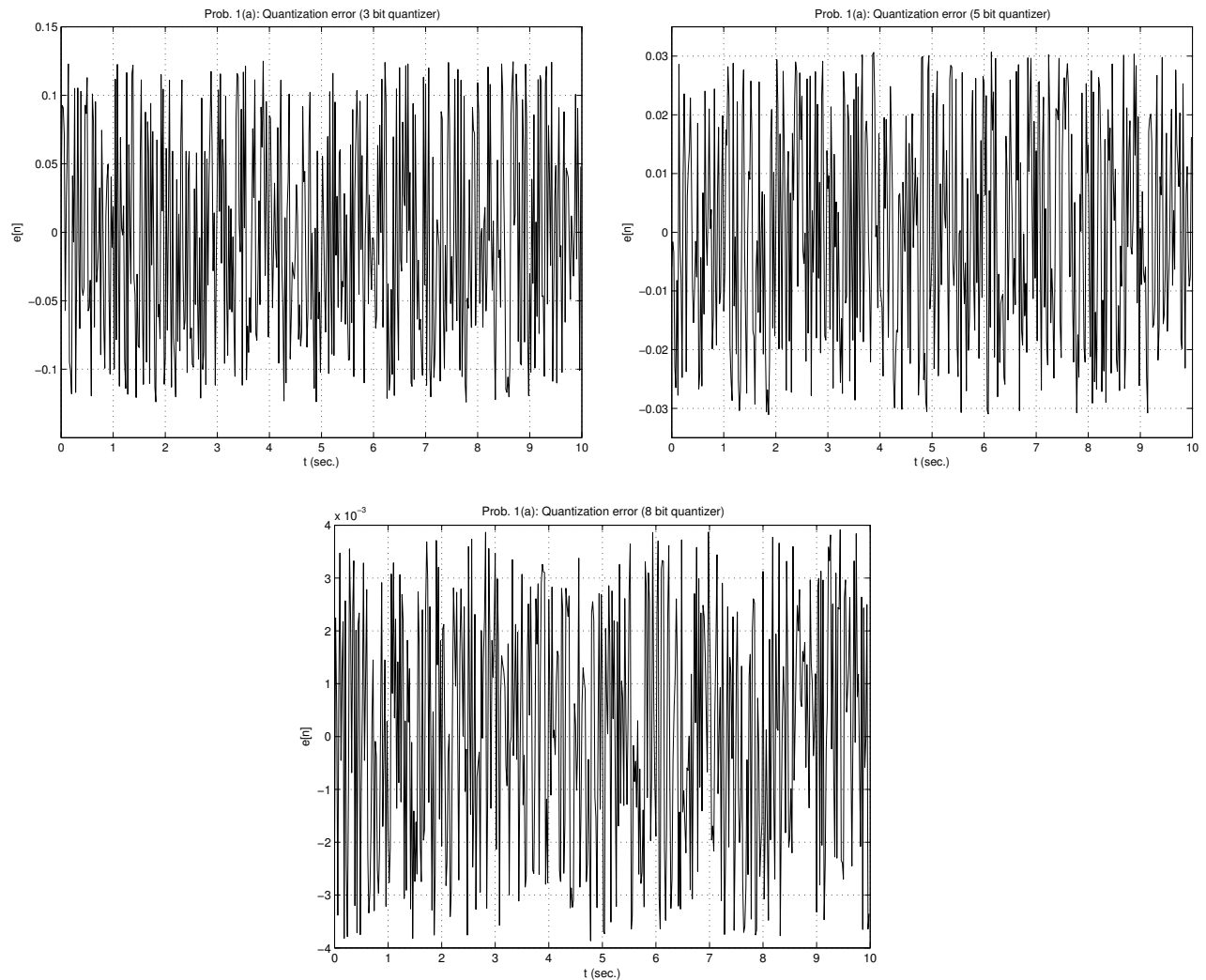


Figure 1: Prob. 1(a)

(b) SNRs are as follows: $B = 3$, $\text{SNR}=18.0589$; $B = 5$, $\text{SNR}=30.1016$; $B = 8$, $\text{SNR}= 48.1868$. As expected for a uniform quantizer designed for a uniform input pdf *and* fed samples from a uniformly-distributed random process, the values very closely follow the “6dB-per-bit rule.”

Prob. 2

(a) See Fig. 2

(b) SNRs are as follows: $B = 3$, $\text{SNR}= 6.0609$; $B = 5$, $\text{SNR}=19.1270$; $B = 8$, $\text{SNR}=38.4869$. For $B = 3$, the 6.0609 dB SNR is expectedly low since the input is speech and the uniform quantizer is designed for

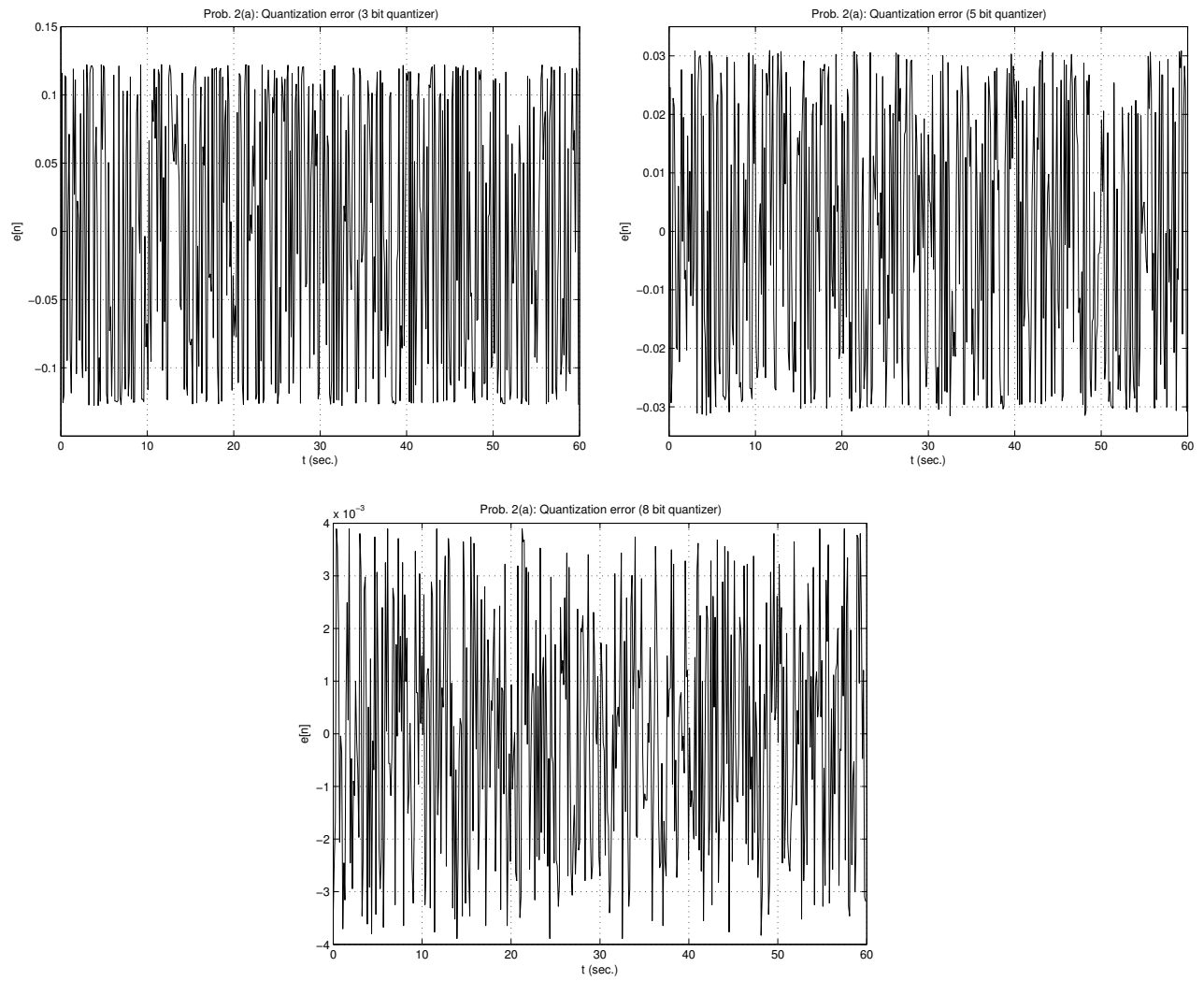


Figure 2: Prob. 2(a)

a uniform pdf. The values are lower than for a uniform quantizer designed for a Gaussian or Laplace pdf. Finally, the values are very different from a 6dB-per-bit rule since the rule assumes a uniformly-distributed input process and speech does not have that distribution.

Prob. 3

See Fig. 3.

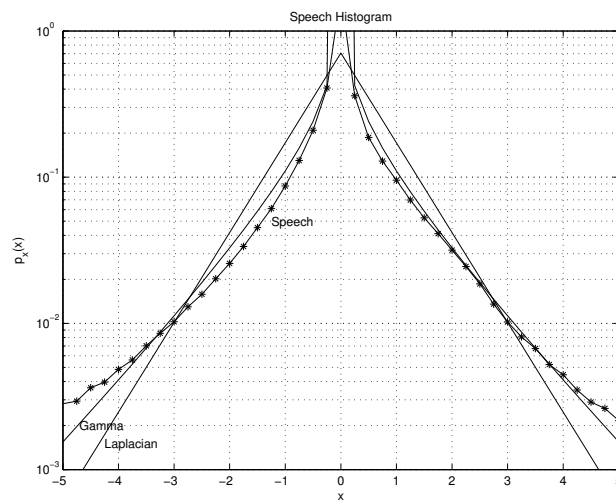


Figure 3: Prob. 3

Prob. 4

See Fig. 4. Compared to the figure for Prob. 3, we clearly see the effects of companding, i.e. a flattening of the peaked pdf into a more uniform pdf.

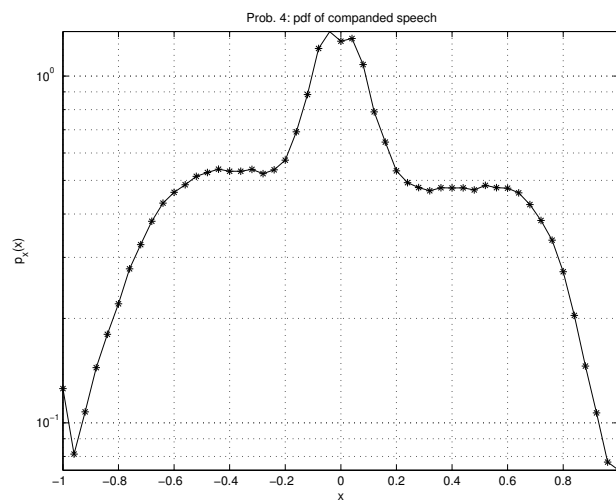


Figure 4: Prob. 4

Prob. 5

A plot of

$$e = T^{-1}\{T(x[n])\} \quad (1)$$

where T is the companding operation is given in Fig. ???. The operation is perfectly invertible (to within numerical precision limits).

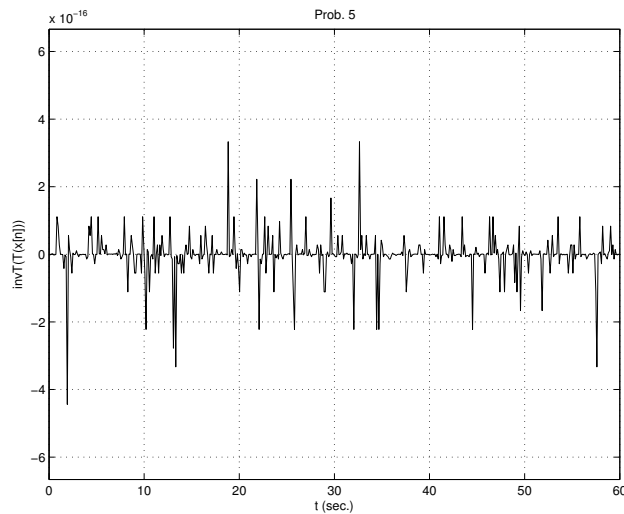


Figure 5: Prob. 5

Prob. 6

(a) See Fig. 6

(b) SNRs are as follows: $B = 3$, SNR=9.0229; $B = 5$, SNR=20.8007; $B = 8$, SNR= 39.0929. For $B = 3$, the 9.0229 dB SNR is reasonable for our μ -law compander with a uniform quantizer compared to the 9.5 dB SNR in Lecture 8 (μ -law compander with a non-uniform quantizer).

(c) Comparing SNR values, we see at least a 1 dB SNR improvement when using the μ -law compander. This is essentially a “free” improvement.

Prob. 7

(a) The reconstruction levels are given as $\{-0.8650, -0.4939, -0.2560, -0.0991, 0.0037, 0.1494, 0.3686, 0.7322\}$. Your mileage may vary.

(b) See Fig. 7.

(c) The SNR of the 3-bit non-uniform quantizer designed for speech pdf is 12.9833 dB. This compares nicely to the published result of 12.1 dB.

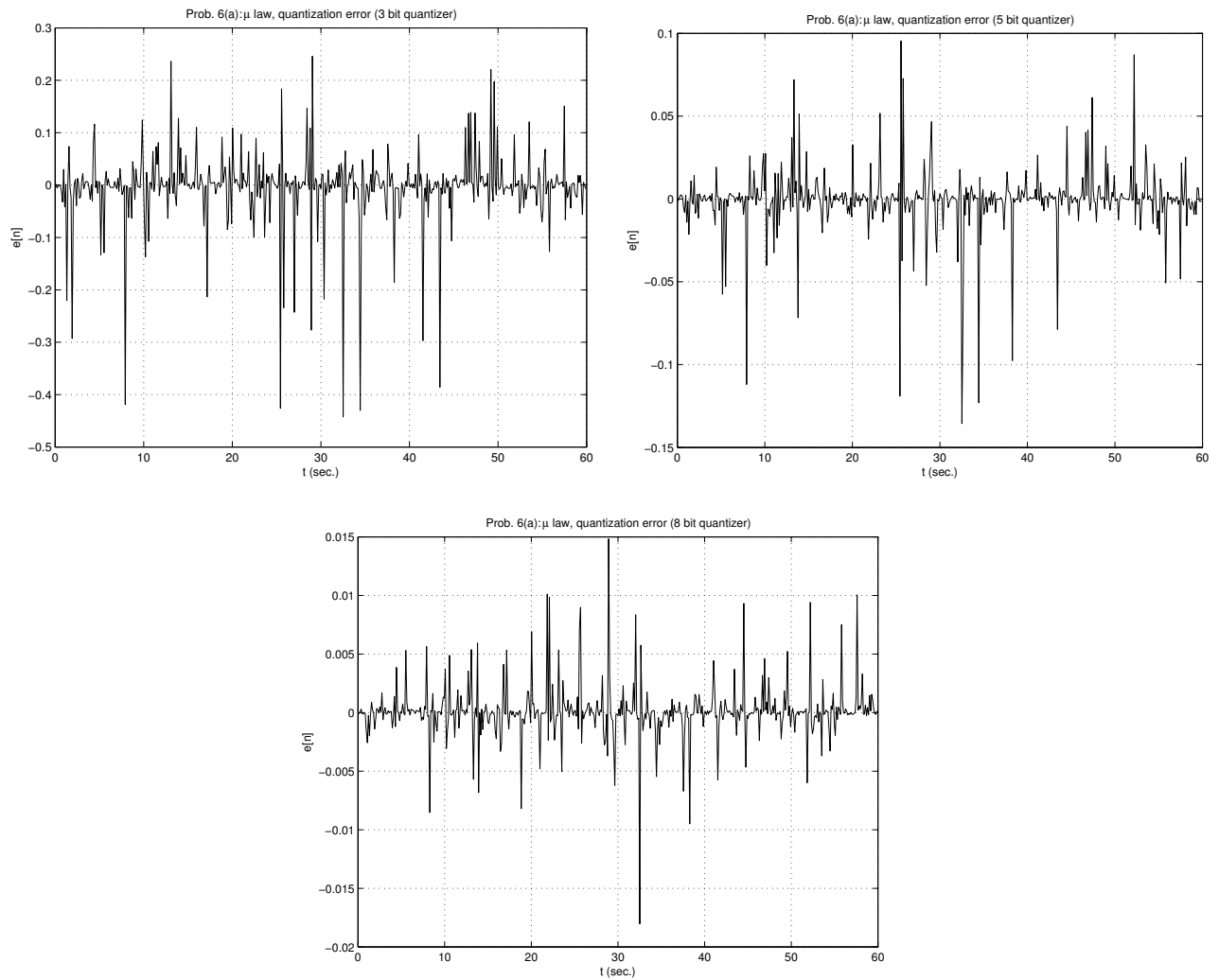


Figure 6: Prob. 6(a)

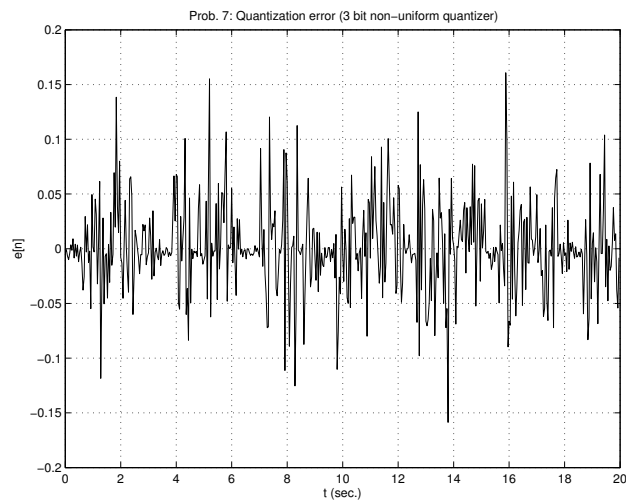


Figure 7: Prob. 7