1.2

(a) $f = \frac{0.01\pi}{2\pi} = \frac{1}{200} \Rightarrow$ periodic with $N_p = 200$.
(b) $f = \frac{30\pi}{105}(\frac{1}{2\pi}) = \frac{1}{7} \Rightarrow$ periodic with $N_p = 7$.
(c) $f = \frac{3\pi}{2\pi} = \frac{3}{2} \Rightarrow$ periodic with $N_p = 2$.
(d) $f = \frac{3}{2\pi} \Rightarrow$ non-periodic.
(e) $f = \frac{62\pi}{10}(\frac{1}{2\pi}) = \frac{31}{10} \Rightarrow$ periodic with $N_p = 10$.

1.3

(a) $w = \frac{2\pi k}{N}$ implies that $f = \frac{k}{N}$. Let

$$\alpha = \text{ GCD of } (k, N), \text{ i.e.,}$$

$$k = k'\alpha, N = N'\alpha.$$

Then,

$$f = \frac{k'}{N'}, \text{ which implies that}$$

$$N' = \frac{N}{\alpha}.$$

(b)

$$\begin{aligned} N &= 7 \\ k &= 0\ 1\ 2\ 3\ 4\ 5\ 6\ 7 \\ \text{GCD}(k,N) &= 7\ 1\ 1\ 1\ 1\ 1\ 1\ 7 \\ N_p &= 1\ 7\ 7\ 7\ 7\ 7\ 7\ 1 \end{aligned}$$

(c)

$$\begin{aligned} N &= 16 \\ k &= 0\ 1\ 2\ 3\ 4\ 5\ 6\ 7\ 8\ 9\ 10\ 11\ 12\ \ldots\ 16 \\ \text{GCD}(k,N) &= 16\ 1\ 2\ 1\ 4\ 1\ 2\ 1\ 8\ 1\ 2\ 1\ 4\ \ldots\ 16 \\ N_p &= 1\ 16\ 8\ 16\ 4\ 16\ 8\ 16\ 2\ 16\ 8\ 16\ 4\ \ldots\ 1 \end{aligned}$$

1.5

(a) $F_{\text{max}} = 10kHz \Rightarrow F_s \geq 2F_{\text{max}} = 20kHz$.
(b) For $F_s = 8kHz, F_{\text{fold}} = F_s/2 = 4kHz \Rightarrow 5kHz$ will alias to 3kHz.
(c) $F = 9$kHz will alias to 1kHz.

1.7

(a)

$$\begin{aligned} \text{Number of bits/sample} &= log_2 1024 = 10. \\ F_s &= \frac{[10,000 \text{ bits/sec}]}{[10 \text{ bits/sample}]} \\ &= 1000 \text{ samples/sec.} \\ F_{\text{fold}} &= 500Hz. \end{aligned}$$

(b)

$$\begin{aligned} F_{\text{max}} &= \frac{1800\pi}{2\pi} \\ &= 900Hz \\ F_N &= 2F_{\text{max}} = 1800Hz. \end{aligned}$$

(c)

$$\begin{aligned} f_1 &= \frac{600\pi}{2\pi}(\frac{1}{F_s}) \\ &= 0.3; \\ f_2 &= \frac{1800\pi}{2\pi}(\frac{1}{F_s}) \\ &= 0.9; \\ \text{But } f_2 &= 0.9 > 0.5 \Rightarrow f_2 = 0.1. \\ \text{Hence, } x(n) &= 3cos[(2\pi)(0.3)n] + 2cos[(2\pi)(0.1)n] \end{aligned}$$

(d) $\triangle = \frac{x_{\text{max}} - x_{\text{min}}}{m-1} = \frac{5-(-5)}{1023} = \frac{10}{1023}$.

1.8

$$\begin{aligned} x(n) &= x_a(nT) \\ &= 3cos\left(\frac{100\pi n}{200}\right) + 2sin\left(\frac{250\pi n}{200}\right) \end{aligned}$$

$$\begin{aligned} &= 3cos\left(\frac{\pi n}{2}\right) - 2sin\left(\frac{3\pi n}{4}\right) \\ T' &= \frac{1}{1000} \Rightarrow y_a(t) = x(t/T') \\ &= 3cos\left(\frac{\pi 1000t}{2}\right) - 2sin\left(\frac{3\pi 1000t}{4}\right) \\ y_a(t) &= 3cos(500\pi t) - 2sin(750\pi t) \end{aligned}$$

1.10

$$
\begin{aligned}
R &= (20\frac{\text{samples}}{\text{sec}}) \times (8\frac{\text{bits}}{\text{sample}}) \\
&= 160\frac{\text{bits}}{\text{sec}} \\
F_{\text{fold}} &= \frac{F_s}{2} = 10Hz. \\
\text{Resolution} &= \frac{1\text{volt}}{2^8 - 1} \\
&= 0.004.
\end{aligned}
$$

1.11

(a) for levels = 64, using truncation refer to fig 1.16-1.
for levels = 128, using truncation refer to fig 1.16-2.
for levels = 256, using truncation refer to fig 1.16-3.

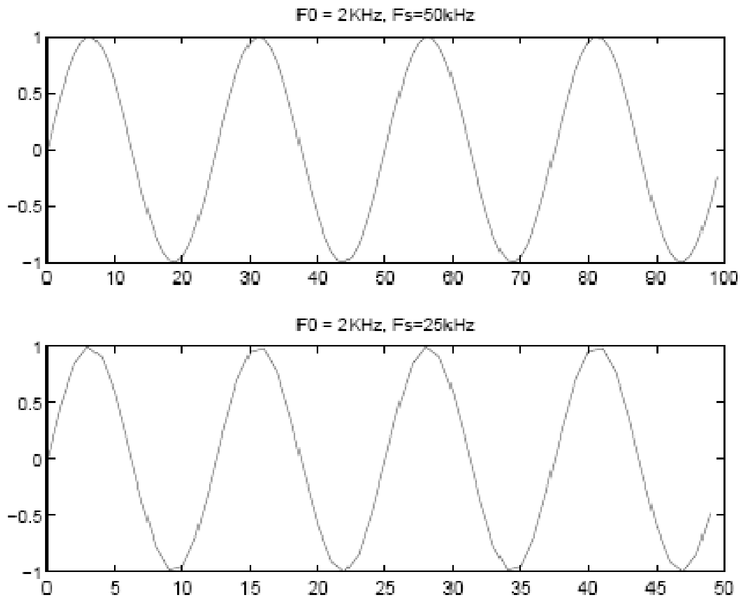


Figure 1.15-2:

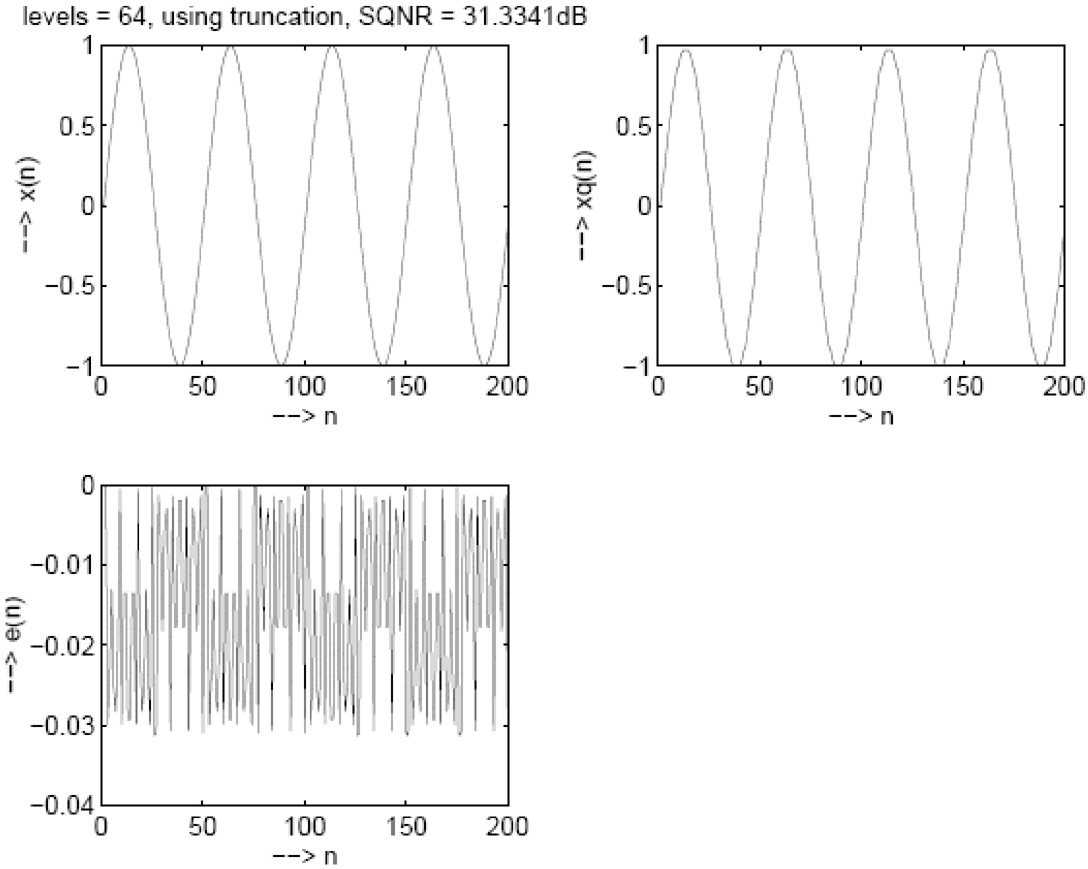


Figure 1.16-1:

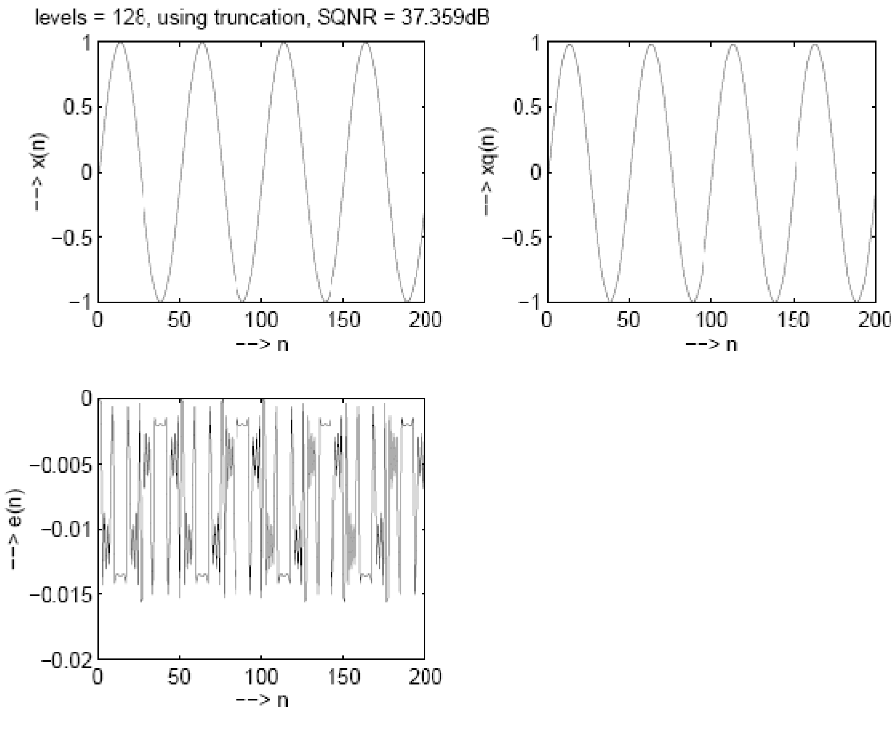
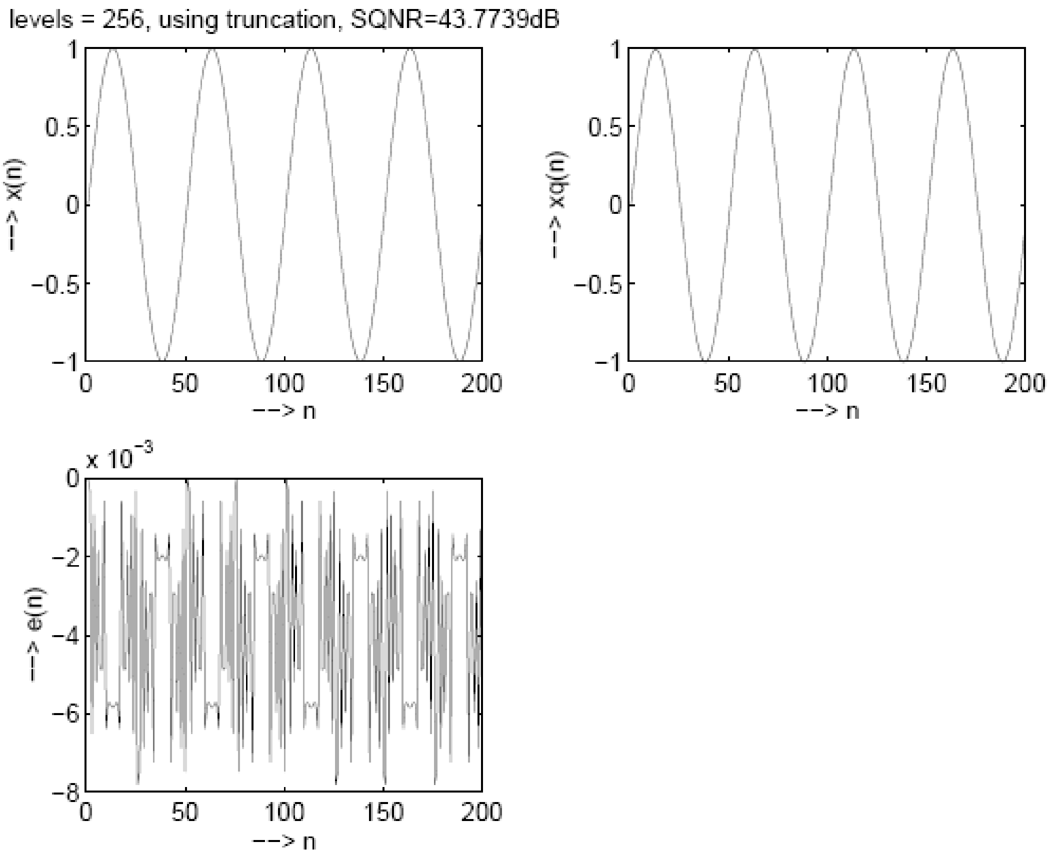


Figure 1.16-2:



levels = 256, using truncation, SQNR=43.7739dB
--> x(n)
--> xq(n)
--> e(n)
--> n
--> n
--> n
x 10^-3

Figure 1.16-3:

(b) for levels = 64, using rounding refer to fig 1.16-4.
for levels = 128, using rounding refer to fig 1.16-5.
for levels = 256, using rounding refer to fig 1.16-6.

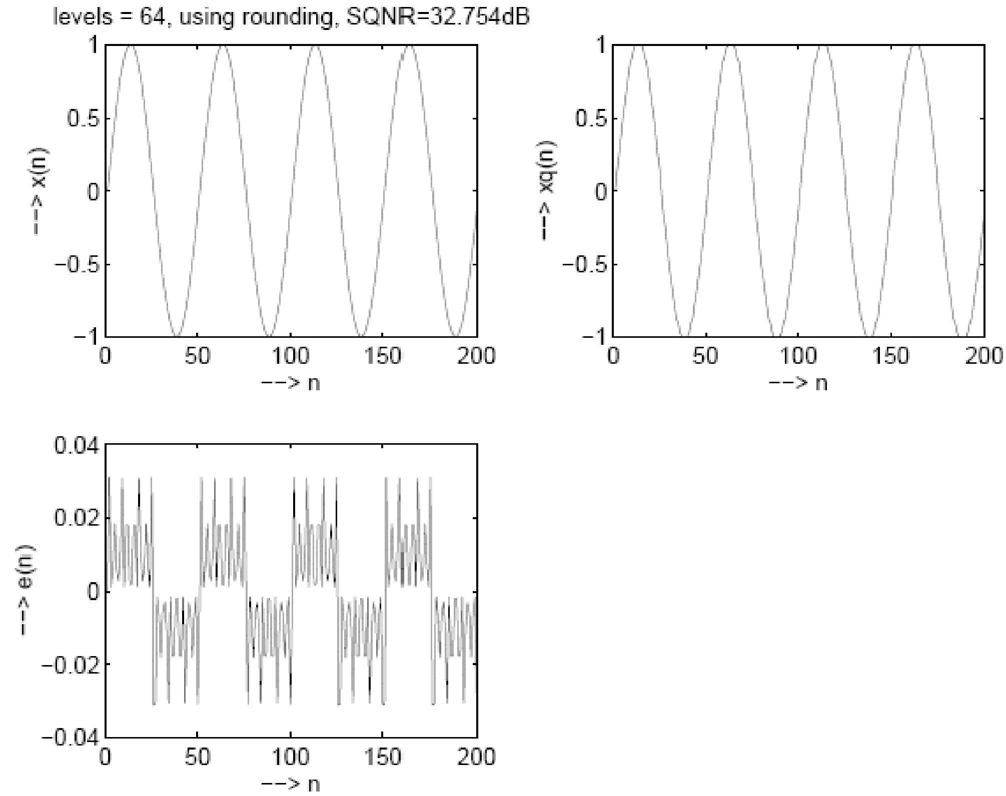


Figure 1.16-4:

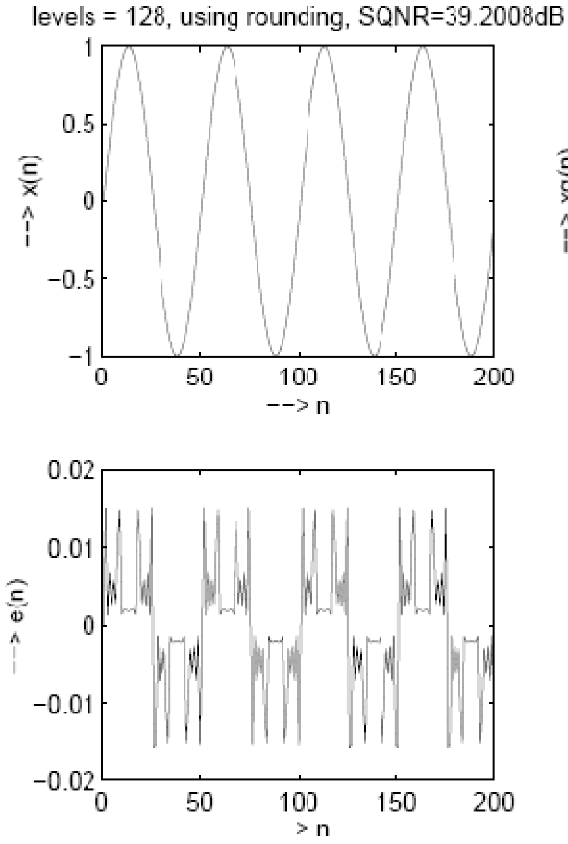


Figure 1.16-5:

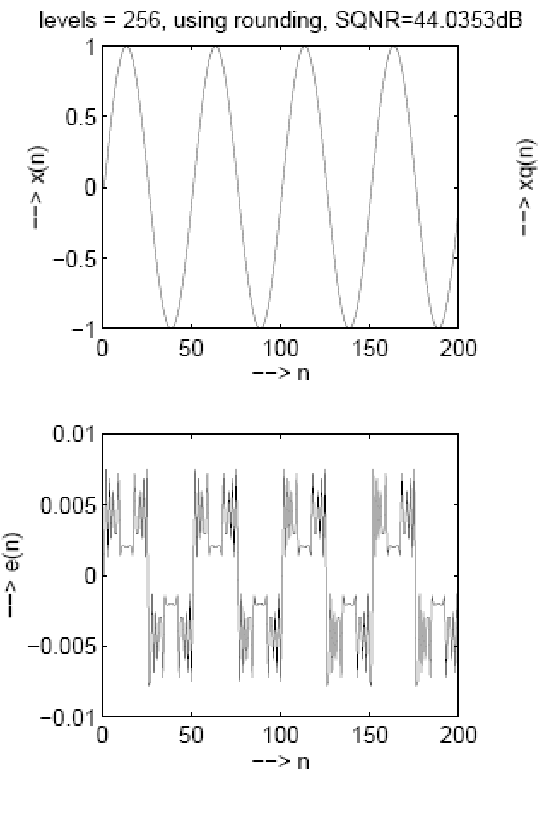


Figure 1.16-6:

(c) The sqnr with rounding is greater than with truncation. But the sqnr improves as the number of quantization levels are increased.
(d)

levels	64	128	256
theoretical sqnr	43.9000	49.9200	55.9400
sqnr with truncation	31.3341	37.359	43.7739
sqnr with rounding	32.754	39.2008	44.0353

The theoretical sqnr is given in the table above. It can be seen that theoretical sqnr is much higher than those obtained by simulations. The decrease in the sqnr is because of the truncation and rounding.