

# Digital Communications: A Discrete-Time Approach

## M. Rice

### Errata

#### Foreword

Page xiii, first paragraph, “bare witness” should be “bear witness”

Page xxi, last paragraph, “You know who you.” should be “You know who you are.”

#### Chapter 1

Page 3, second new paragraph, “Pittsburg” should be “Pittsburgh”

Page 9, The end of the second lines reads, “... signal sideband AM.” This should be “... single sideband AM.”

Page 10, the second line of Section 1.2, “information baring” should be “information bearing”

Page 12, Equation (1.1) should read

$$A(t)\cos(\omega_0 t + \theta(t)) = A(t)\cos(\theta(t))\cos(\omega_0 t) - A(t)\sin(\theta(t))\sin(\omega_0 t)$$

Page 14, Second new paragraph, “The same power/bandwidth exists with digitally modulated carriers.” should read, “The same power/bandwidth trade off exists with digitally modulated carriers.”

#### Chapter 2

Page 27, The sentence after Equation (2.14) should read

“An energy signal is a signal with finite nonzero energy whereas a power signal is a signal with finite nonzero power.”

Page 28, Equation (2.19) should read

$$u(n) = \sum_{k=-\infty}^n \delta(k) \quad \delta(n) = u(n) - u(n-1)$$

Page 28, Equation (2.20) should read

$$\sum_{n=N_1}^{N_2} x(n)\delta(n-n_0) = \begin{cases} x(n_0) & N_1 \leq n_0 \leq N_2 \\ 0 & \text{otherwise} \end{cases}$$

Page 33, Equation (2.30) should read

$$H(s) = \frac{s}{s^2 + 2s + 5} = \frac{s}{(s + 1 - j2)(s + 1 + j2)}$$

Page 36, Equation (2.36) should read

$$H(s) = \frac{s}{(s + 1 - j2)(s + 1 + j2)} = \frac{\frac{2 + j}{4}}{s + 1 - j2} + \frac{\frac{2 - j}{4}}{s + 1 + j2}$$

Page 37: Equation (2.37) should read

$$H(j\omega) = \frac{j\omega}{5 - \omega^2 + j2\omega} = \frac{j\omega}{[1 + j(\omega - 2)][1 + j(\omega + 2)]}$$

Page 40, the sixth row in Table 2.4.4 should be

$$\sum_{k=-\infty}^{\infty} a_k e^{jk\omega_0 t} \quad 2\pi \sum_{k=-\infty}^{\infty} a_k \delta(\omega - k\omega_0) \quad \sum_{k=-\infty}^{\infty} a_k \delta(f - kf_0)$$

$(\omega_0 = 2\pi f_0)$

Page 41, second line of text, “complex plain” should be “complex plane”

Page 50, Equations (2.57) and (2.58) should read

$$X[k] = \sum_{n=0}^{N-1} x(n) e^{-j\frac{2\pi}{N}nk} \quad k = 0, 1, \dots, N-1 \quad (2.57)$$

$$x(n) = \frac{1}{N} \sum_{k=0}^{N-1} X[k] e^{j\frac{2\pi}{N}nk} \quad n = 0, 1, \dots, N-1 \quad (2.58)$$

Page 56, Equation (2.72) should be

$$= \frac{1}{T} \sum_{k=-\infty}^{\infty} X_c \left( \omega - k \frac{2\pi}{T} \right)$$

Page 65, the third paragraph of Section 2.6.2. The two occurrences of  $H_c(j\Omega)$  should be  $H_c(j\omega)$

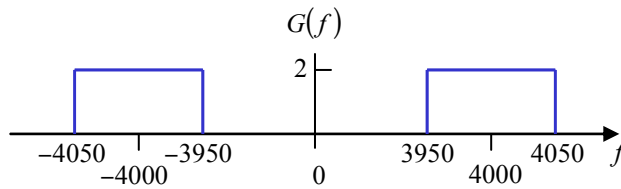
Page 75, Exercise 2.24, the equation for  $X(f)$  should be

$$X(f) = \frac{1}{2} \delta(f+2) + \frac{1}{2} \delta(f-2) + \frac{e^{j4\pi f}}{2 + j2\pi f}$$

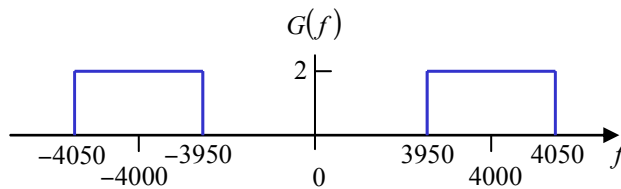
Page 76, Exercise 2.27, the line after the equation should read

“where the integral on the left is the power contained in the interval  $-B_{90\%} \leq f \leq B_{90\%} \dots$ ”

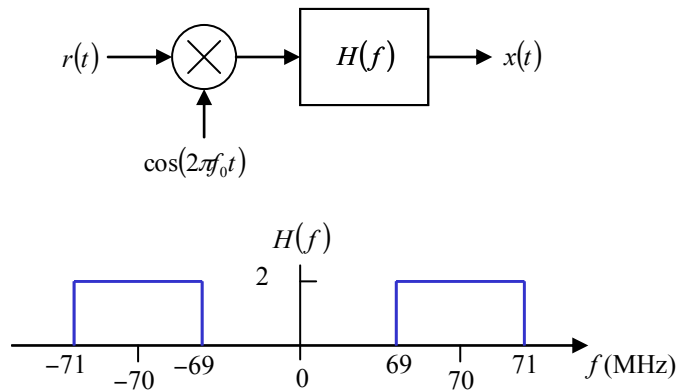
Page 83, Exercise 2.46, the plot for  $G(f)$  should be



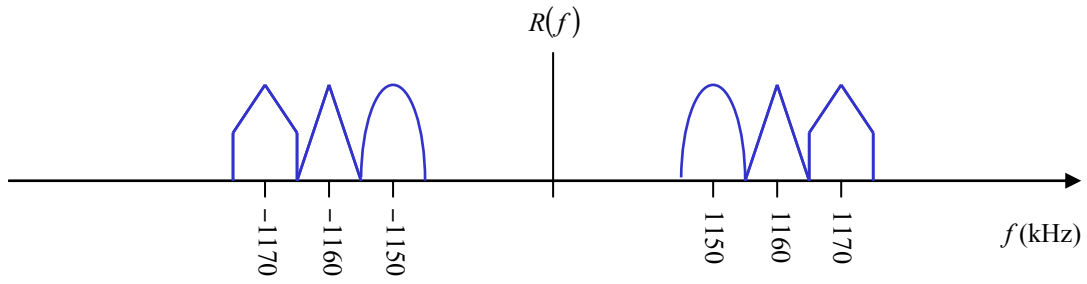
Page 83, Exercise 2.47, the plot for  $G(f)$  should be



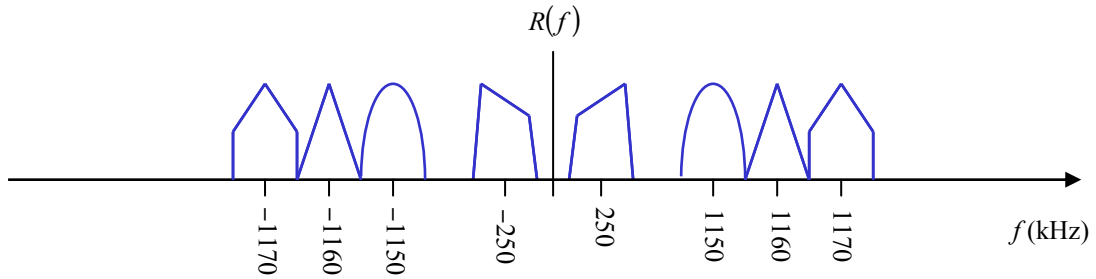
Page 84, the second figure of Exercise 2.48 should be



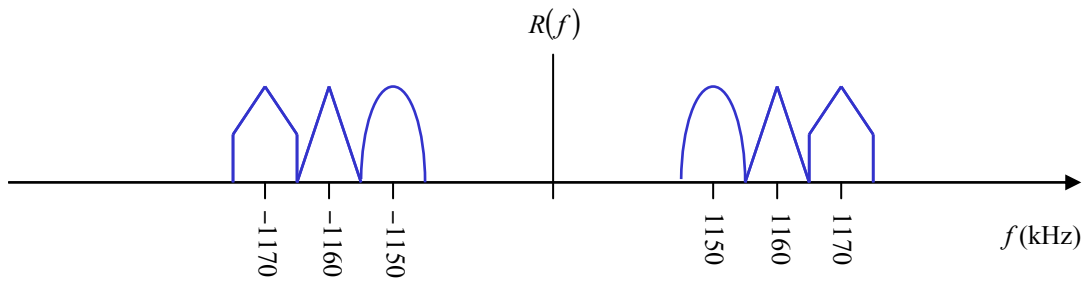
Page 85: The first figure of Exercise 2.50 should be



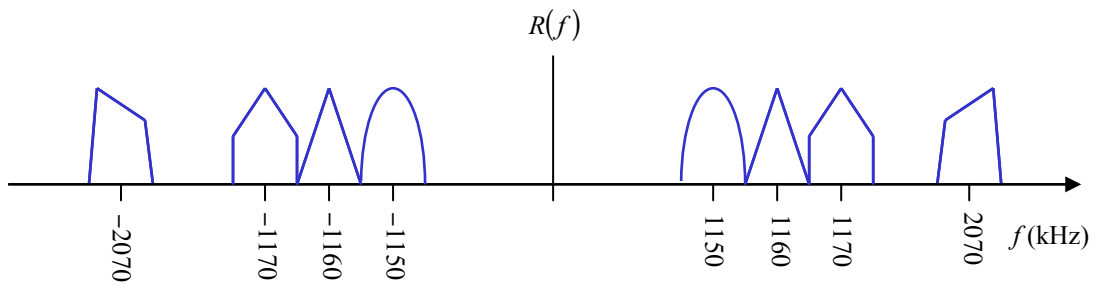
Page 86: The figure at the top of the page (Exercise 2.50) should be



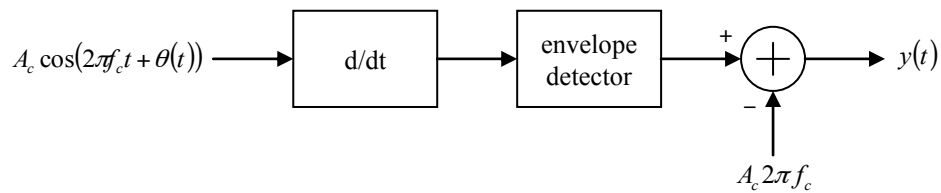
Page 86: The first Figure in Exercise 2.51 should be



Page 87, The figure at the top of the page (Exercise 2.51) should be



Page 95, The figure of Exercise 2.63 should be



Page 97, Exercise 2.67. The Fibonacci sequence is

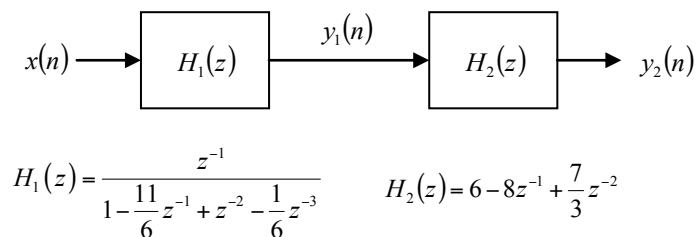
$$0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, 377, 610, 987, \dots$$

Page 98, Exercise 2.67. The initial conditions should be  $x(0) = 0$ ,  $x(1) = 1$ .

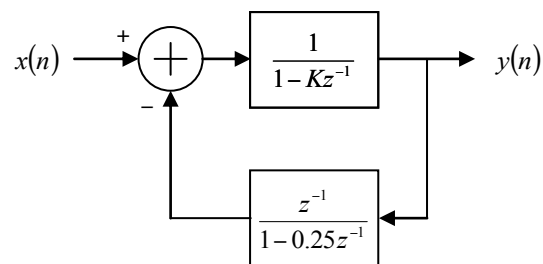
Page 98, Exercise 2.69 should begin “Consider an LTI system with input ...”

Page 99, Exercise 2.70 should begin “Consider an LTI system with input ...”

Page 99, the figure of Exercise 2.71 should be



Page 102, the figure of Exercise 2.77 should be



Page 103, Exercise 2.81 (c) should read

$$x(n) = \left(\frac{1}{2}\right)^n \cos\left(\frac{\pi}{8}n - \frac{\pi}{4}\right)u(n)$$

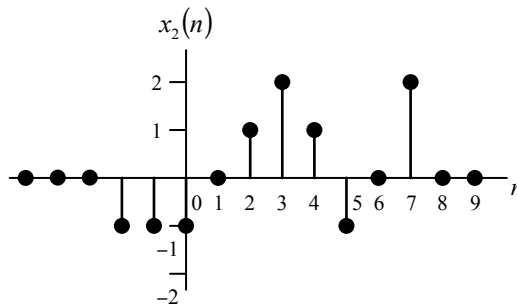
Page 103, Exercise 2.81 (f) should read

$$x(n) = \cos\left(\frac{5\pi}{3}n\right) + \sin\left(\frac{7\pi}{3}n\right)$$

Page 103, Exercise 2.82 (a) should read

$$X(e^{j\Omega}) = \begin{cases} 0 & -\pi \leq \Omega < -\frac{3\pi}{8} \\ 1 & -\frac{3\pi}{8} \leq \Omega \leq \frac{3\pi}{8} \\ 0 & \frac{3\pi}{8} < \Omega \leq \pi \end{cases}$$

Page 106, Exercise 2.90. The plot for  $x_2(n)$  should be



and the statement after the figures should read

Show that the length-4 DFT of both series have the same magnitude. (Hint: do the analysis in the time domain.)

### Chapter 3

Page 125, Forth line after equation (3.16):  $z - 1$  should be  $z^{-1}$

Page 125, Fifth line after equation (3.16):  $z - 1$  should be  $z^{-1}$

Page 132, Equation (3.23) should read

$$H_d(e^{j\Omega}) = \sum_{k=-\infty}^{\infty} H_c\left(j\left(\frac{\Omega - k2\pi}{T}\right)\right)$$

Page 133, Equation (3.24) should read

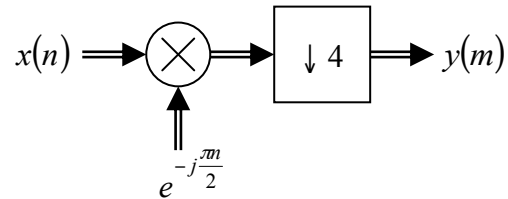
$$H_d(e^{j\Omega}) = H_c\left(j\frac{\Omega}{T}\right) \quad \text{for} \quad -\pi \leq \Omega \leq \pi$$

Page 138, second line “... Figure 3.3.8 requires three multipliers...” should read “... Figure 3.3.8 requires four multipliers...”

Page 154, Equation (3.66) should read,

$$y(nT) = y((n-1)T) + \frac{T}{2}x(nT) + \frac{T}{2}x((n-1)T)$$

Page 165, the figure for Exercise 3.15 (b) should be



Page 174, Exercise 3.33 (b) should read

Sample the impulse response at instants  $t = nT$  and scale by  $T$  to produce a discrete-time impulse response  $h_d(n) = Th_c(nT)$ .

Page 175, Exercise 3.37, The last sentence should read “Show that for small  $\Omega$ , the DTFT is approximately  $j\Omega/T$ .”

## Chapter 4

Page 195, Equation (4.45) should be  $\mathbf{M} = E\{(\mathbf{x} - \boldsymbol{\mu})(\mathbf{x} - \boldsymbol{\mu})^T\}$

Page 198, Equation (4.52):  $\boldsymbol{\mu}$  should be boldface so that Equation (4.52) reads as follows:

$$\mathbf{A}E\{(\mathbf{x} - \boldsymbol{\mu})(\mathbf{x} - \boldsymbol{\mu})^T\}\mathbf{A}^T = \mathbf{A}\mathbf{M}\mathbf{A}^T$$

Page 198, Equation (4.54):  $\boldsymbol{\mu}$  should be boldface so that Equation (4.54) reads as follows:

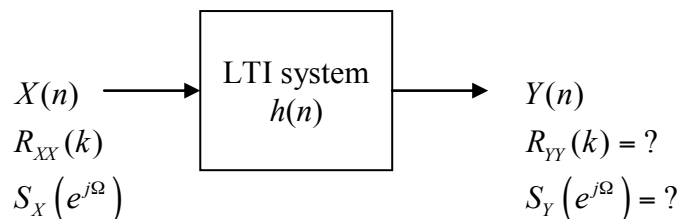
$$\boldsymbol{\mu}' = \mathbf{A}\boldsymbol{\mu}$$

Page 198, Equation (4.55):  $\mathbf{M}'$  should be boldface so that Equation (4.55) reads as follows:

$$\mathbf{M}' = \mathbf{A}\mathbf{M}\mathbf{A}^T$$

Page 200, the last equation on the page.  $R_Y(k)$  should be  $R_{YY}(k)$ .

Page 201, figure 4.4.1 should be

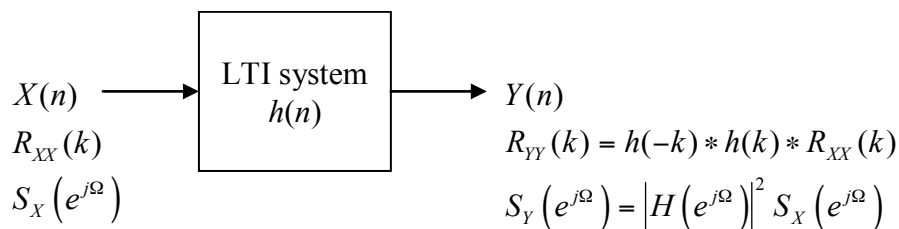


Page 201, the first line of the equation for  $S_Y(e^{j\Omega})$  should be

$$S_Y(e^{j\Omega}) = \sum_{k=-\infty}^{\infty} R_{YY}(k)e^{-j\Omega k}$$

Page 201, Example 4.4.1: In the properties of the Gaussian sequence,  $R_X(k)$  should be  $R_{XX}(k)$ .

Page 202, Figure 4.4.2 should be





Page 211, Exercise 4.19:  $\mu$  should be boldface.

Page 211, Exercise 4.20:  $\mu$  should be boldface.

Page 212, Exercise 4.23: part (b) should read

(b) Compute the probability that  $X_1 + X_2 + X_3 + X_4 > 1$ .

Page 212, Exercise 4.24: The autocorrelation function should be

$$R_{XX}(m) = (-2)^{-|m|}$$

Page 212, Exercise 4.24: part (c) should read

(c) Compute the probability that  $X_1 + X_2 + X_3 + X_4 > 1$ .

Page 212, Exercise 4.26: the impulse response should be written as follows:

$$h(n) = \frac{\sin(Wn)}{\pi n}$$

Page 213, Exercise 4.28: the impulse response should be written as follows:

$$h(n) = \begin{cases} 1 & |n| \leq N_1 \\ 0 & |n| > N_1 \end{cases}$$

## Chapter 5

Page 225, Equation (5.17) should read

$$\mathfrak{S} = \operatorname{argmin}_{s_m(t) \in \mathcal{S}} \left\{ \int_{T_1}^{T_2} r^2(t) dt - 2 \int_{T_1}^{T_2} r(t) \phi_k(t) dt + \sum_{k=0}^{K-1} \sum_{k'=0}^{K-1} a_{m,k} a_{m,k'} \int_{T_1}^{T_2} \phi_k(t) \phi_{k'}(t) dt \right\}$$

Page 229, First line after equation (5.29): 2 should be  $2A$ .

Page 234, Four lines below equation (5.40), ADC should be DAC.

Page 239, Equation (5.53) should be

$$-\frac{\sin(\omega_0(T_2 + T_1)) \sin(\omega_0(T_2 - T_1))}{\omega_0}$$

Page 239, Equation (5.54) should be

$$-\frac{1}{\omega_0} \leq \rho \leq \frac{1}{\omega_0}$$

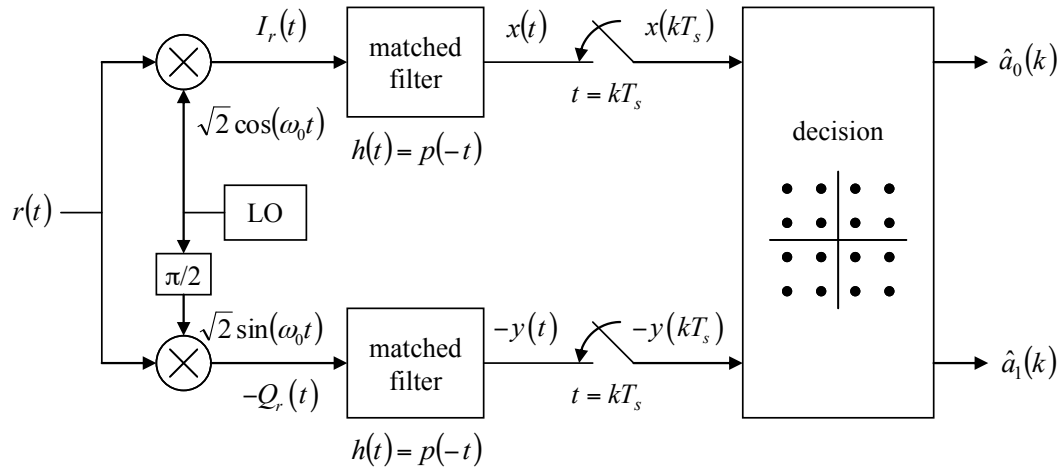
Page 239, Equation (5.56) should be

$$= - \int_{T_1}^{T_2} p^2(t) \sin(2\omega_0 t) dt$$

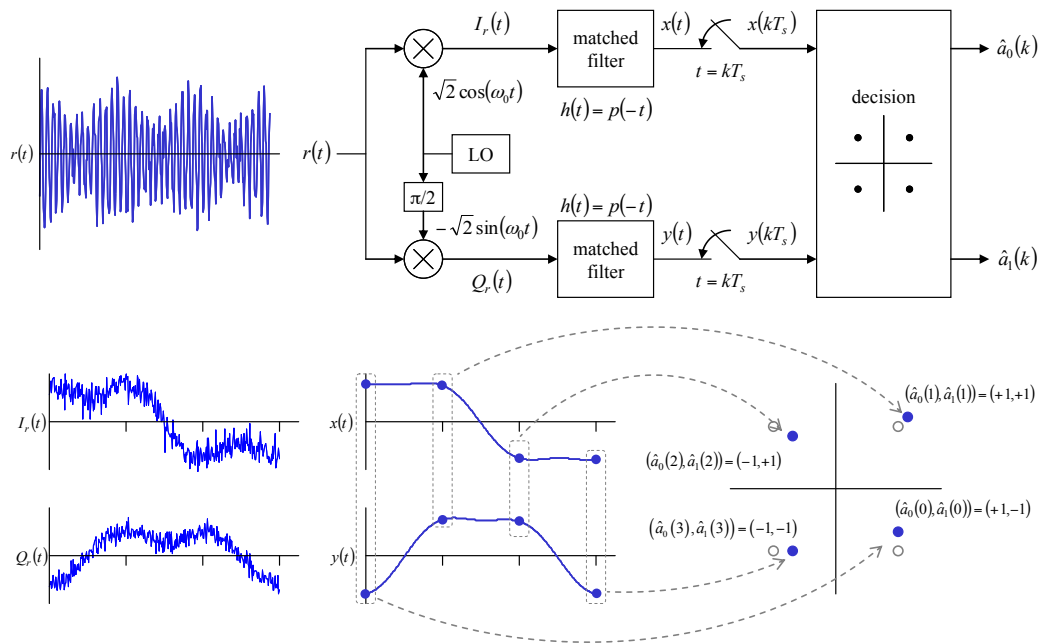
Page 241, Equation (5.62) should be

$$-\frac{p^2(T_1 + LT_0)}{\omega_0} \leq \rho \leq \frac{p^2(T_1 + LT_0)}{\omega_0}$$

Page 249, Figure 5.3.11 should be



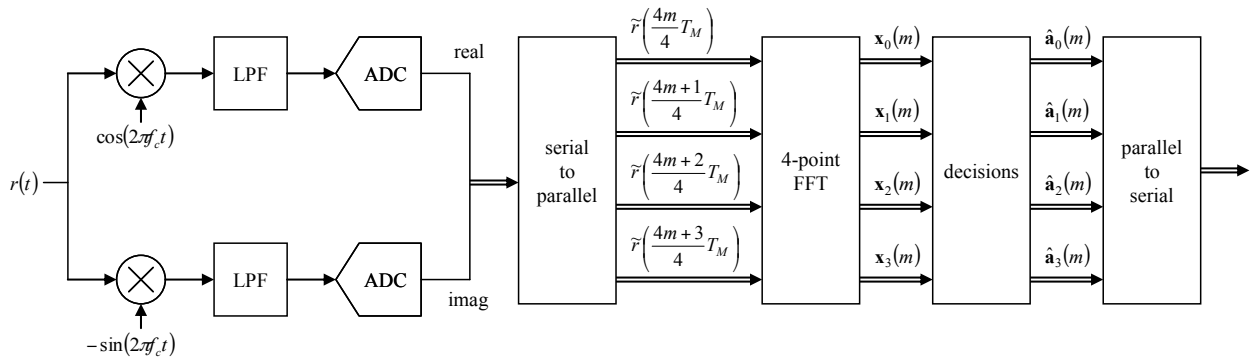
Page 253, Figure 5.3.13 should be



Page 254, The table at the end of Example 5.3.9 should be

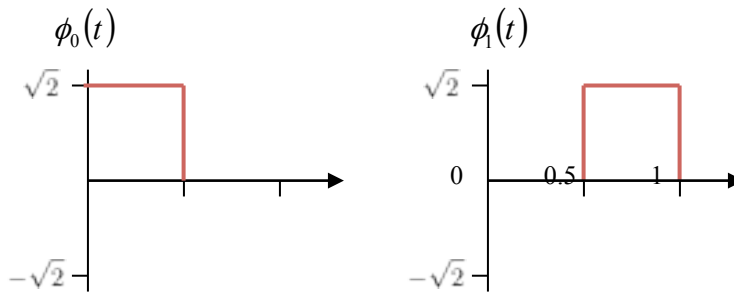
k	0	1	2	3
$x(kT_s)$	+1.00	+1.02	-0.97	-0.97
$y(kT_s)$	-0.95	+1.02	+0.98	-1.00
$\hat{a}_0(k)$	+1	+1	-1	-1
$\hat{a}_1(k)$	-1	+1	+1	-1

Page 270, Figure 5.5.2 (b) should be

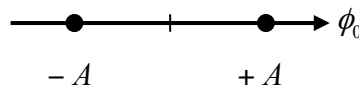


Page 273, the sentence just above Equation (5.107) should read, “Using Bayes’ rule, ...”

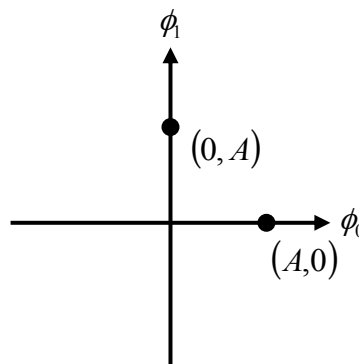
Page 286, The basis functions for Exercise 5.17 should be



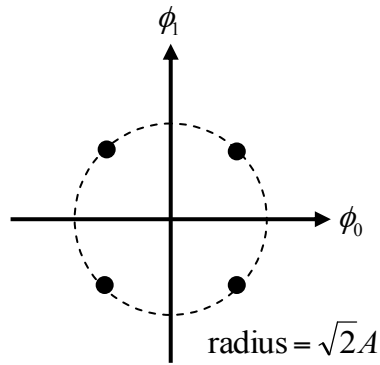
Page 286, The constellation plot in Exercise 5.17 should be



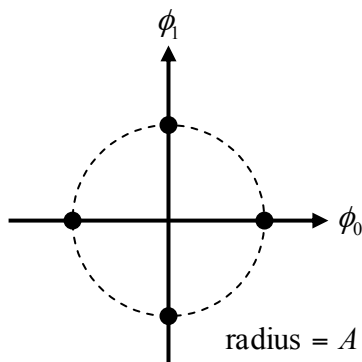
Page 286, The constellation plot of Exercise 5.18 should be



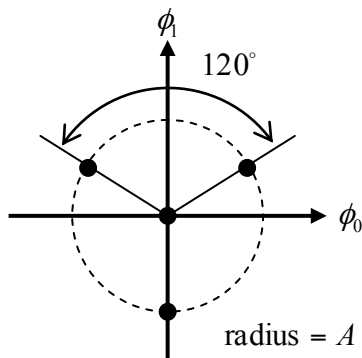
Page 286, The constellation of Exercise 5.19 should be



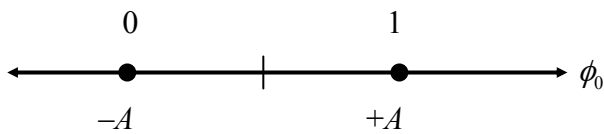
Page 286, The constellation of Exercise 5.20 should be



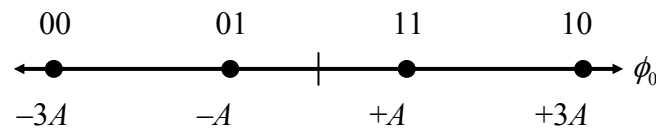
Page 287, The constellation of Exercise 5.21 should be



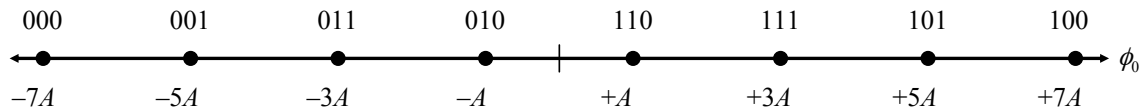
Page 291, The constellation of Exercise 5.30 should be



Page 291, The constellation of Exercise 5.31 should be



Page 291, The constellation of Exercise 5.32 should be



Page 292, Exercise 5.33 should read

Consider a binary PAM system using the SRRC pulse shape.

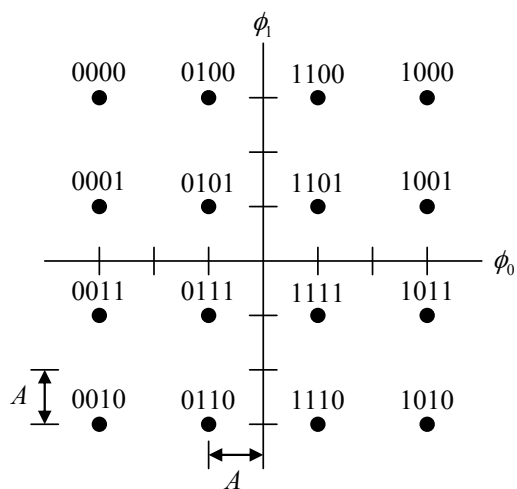
- Produce an eye diagram corresponding to 200 randomly generated symbols for a pulse shape with 100% excess bandwidth and  $L_p = 6$ . Use a sampling rate equivalent to 16 samples/symbol.
- Repeat part (a) for a pulse shape with 50% excess bandwidth and  $L_p = 12$ .
- Repeat part (a) for a pulse shape with 25% excess bandwidth and  $L_p = 200$ .
- Compare and contrast the eye diagrams from parts (a) – (c).

Page 292, Exercise 5.34 should read

Consider a 4-ary PAM system using the SRRC pulse shape.

- Produce an eye diagram corresponding to 200 randomly generated symbols for a pulse shape with 100% excess bandwidth and  $L_p = 6$ . Use a sampling rate equivalent to 16 samples/symbol.
- Repeat part (a) for a pulse shape with 50% excess bandwidth and  $L_p = 12$ .
- Repeat part (a) for a pulse shape with 25% excess bandwidth and  $L_p = 200$ .
- Compare and contrast the eye diagrams from parts (a) – (c).

Page 300, The figure for Exercise 5.46 should be



Page 301, The first line after the figure should read "... the average energy is 1.215 J ..."

## Chapter 6

Page 306, Equation (6.2) should be

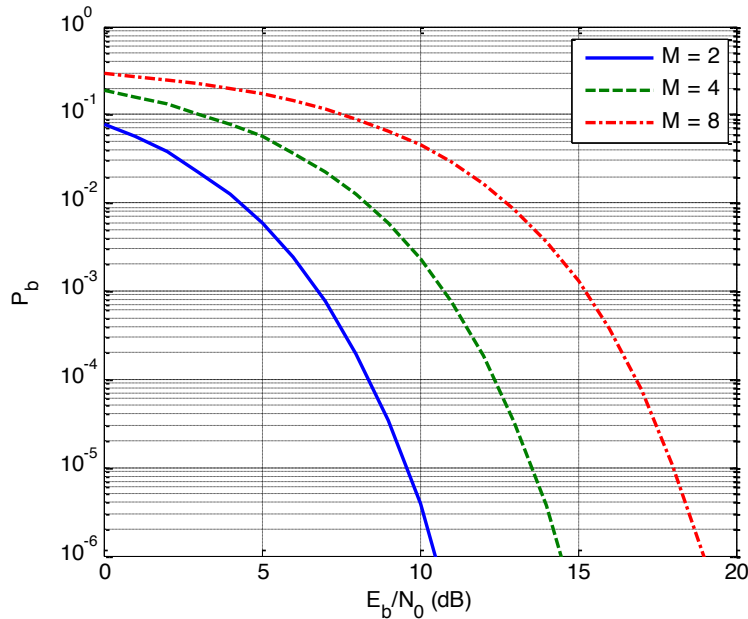
$$BW = \frac{B}{T_s} = B \times R_s = \frac{B}{\log_2(M)} \times R_b$$

Page 306, Equation (6.3) should be

$$BW = \frac{1+\alpha}{2T_s} = \frac{1+\alpha}{2} \times R_s = \frac{1+\alpha}{2\log_2(M)} \times R_b$$

Page 308, Figure 6.1.2 (b). Fix the vertical alignment of  $p(x(kT_s)|a(k) = +A)$

Page 313, The legend of Figure 6.1.3 is incorrect. Figure 6.1.3 should be as follows:



Page 314, Equation (6.30) should be

$$BW = \frac{2B}{T_s} = 2B \times R_s = \frac{2B}{\log_2(M)} \times R_b$$

Page 314, Equation (6.31) should be

$$BW = 2 \frac{1+\alpha}{2T_s} = (1+\alpha) \times R_s = \frac{1+\alpha}{\log_2(M)} \times R_b$$

Page 318, Equation (6.55) should be

$$P(E|s_0) = P(E|s_3) = P(E|s_{12}) = P(E|s_{15})$$



Page 325, the sentence just above Equation (6.87) should read, “The union bound for the conditional probabilities are”

Page 325, Equation (6.88) should be

$$P(E|\mathbf{s}_1) \leq Q\left(\sqrt{\frac{2 E_{\text{avg}}}{3 N_0}}\right) + 2\left(\sqrt{2 \frac{E_{\text{avg}}}{N_0}}\right)$$

Page 329, the caption for Figure 6.3.4 should read, “Probability of bit error versus  $E_b/N_0$  for MQAM for  $M = 4, 16, 64,$  and  $256.$ ”

Page 343, Footnote 5. The last line should read “... utility of these added features.”

Page 349, Exercise 6.10 should read as follows:

Use the union bound to upper bound the probability of bit error for the 4+12+16 APSK constellation shown in Figure 5.3.5 using  $r_1 = A$ ,  $r_2 = 2A$ ,  $r_3 = 3A$ ,  $\theta_1 = \pi/4$ ,  $\theta_2 = 0$ , and  $\theta_3 = 0$ .

Page 357-358, Exercise 6.38. The paragraph (on page 357) that begins “The other kind of repeater is the *regenerative* repeater” should be part (c). Part (d) is

Suppose a 1 Mbit/s QPSK link has  $(C/N_0)_1 = 72$  dB W/Hz and  $(C/N_0)_2 = 70$  dB W/Hz. Which type of repeater provides the lowest composite bit-error rate: the bent-pipe repeater or the regenerative repeater?

## Chapter 7

Page 375, starting with the sentence just before equations (7.35) and (7.36), the rest of the section should read as follows:

“Using  $\xi = 1/\sqrt{2}$ ,  $B_n T_s = 0.2$ ,  $N = 1$ ,  $K_0 = 16$ , and  $K_p = 2$  in (C.61), the loop filter constants are

$$K_1 = 1.6 \times 10^{-3} \quad (7.35)$$

$$K_2 = 4.3 \times 10^{-5} \quad (7.36)$$

Page 407, Equation (7.83) should read

$$\begin{aligned} \hat{b}_{2k} &= \hat{\delta}_{2k} \oplus \hat{\delta}_{2k-1} \\ \hat{b}_{2k+1} &= \hat{\delta}_{2k+1} \oplus \hat{\delta}_{2k} \end{aligned}$$

Page 464, Equation (8.53) should read

$$x(kT_l) = \sum_n x(nT) h_l(kT_l - nT)$$

Page 424, Exercise 7.7: (7.45) should be (7.44).

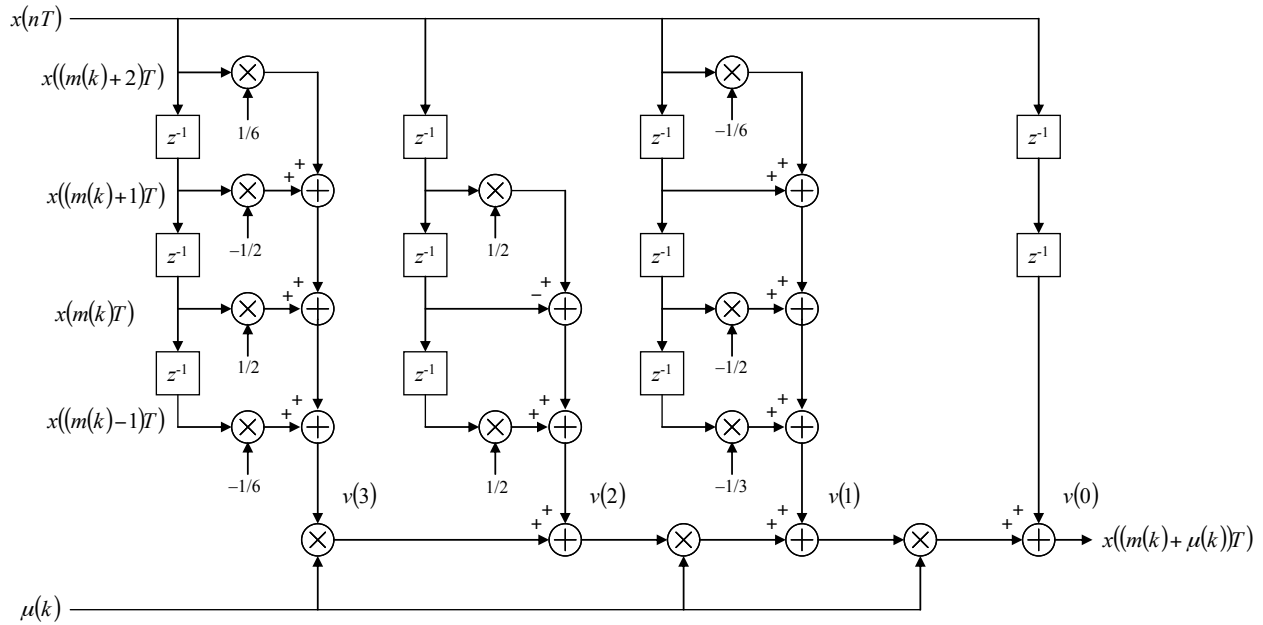
## Chapter 8

Page 445, Equation (8.20) should be as follows:

$$e(k) = |x(kT_s + \hat{\tau}(k) + \Delta T_s)| - |x(kT_s + \hat{\tau}(k) - \Delta T_s)| \\ + |y(kT_s + \hat{\tau}(k) + \Delta T_s)| - |y(kT_s + \hat{\tau}(k) - \Delta T_s)|$$

Page 488, In the caption of Figure 8.4.26, “Figure 8.4.26” should be “Figure 8.4.25”.

Page 471, The lower diagram of Figure 8.4.16 should be



Page 507, Equation (8.130) should be

$$s(nT; \mathbf{a}(k), \tau) = a_0(k)p(nT - kT_s - \tau)\sqrt{2} \cos(\Omega_0 n) - a_1(k)p(nT - kT_s - \tau)\sqrt{2} \sin(\Omega_0 n)$$

Page 507, The exponential term of the first line of equation (8.131) should be

$$\exp \left\{ -\frac{1}{2\sigma^2} \sum_{n=N(k-L_p)}^{N(k+L_p)} [r^2(nT) + p^2(nT - kT_s - \tau)] \right\}$$

Pages 517-518, Exercises 8.12-8.15 and 8.18 should be deleted. The remaining exercises should be renumbered in the obvious way.

## Chapter 9

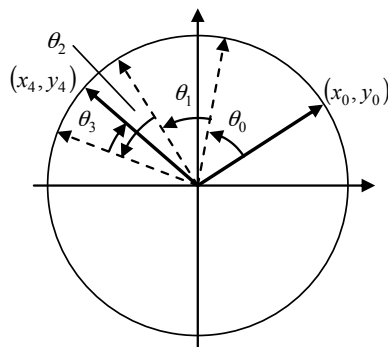
Page 560, the first line under Figure 9.3.3. Equation (9.60) should be (9.59).

Page 560, the first new paragraph the text "... a filter's transfer frequency response ..." should be "... a filter's transfer function ..."

Page 562: Equation (9.61) should be

$$H(e^{j\Omega}) = C - H(e^{j(\Omega+\pi)})$$

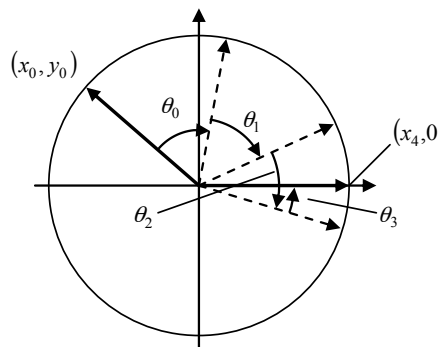
Page 579: Figure 9.4.1 should be



$$\theta = \theta_0 + \theta_1 + \theta_2 - \theta_3$$

$$\begin{bmatrix} x_4 \\ y_4 \end{bmatrix} = \begin{bmatrix} \cos \theta & -\sin \theta \\ \sin \theta & \cos \theta \end{bmatrix} \begin{bmatrix} x_0 \\ y_0 \end{bmatrix}$$

(a)



$$x_4 = \sqrt{x_0^2 + y_0^2}$$

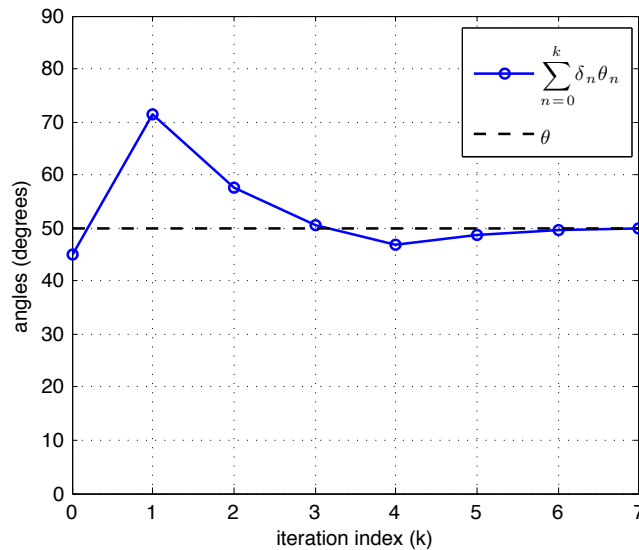
$$\tan^{-1} \left( \frac{y_0}{x_0} \right) = -(\theta_0 + \theta_1 + \theta_2 - \theta_3)$$

(b)

Page 580: Table 9.4.1 should be

k	$\theta_k$	$\sum_{n=0}^k \delta_n \theta_n$	$e_k$	$\delta_k$	$x'_k$	$y'_k$
	(degrees)	(degrees)	(degrees)			
0	45.00	45.00	+50.00	+1	+1.00	+0.00
1	26.57	71.57	+5.00	+1	+1.00	+1.00
2	14.04	57.53	-21.57	-1	+0.50	+1.50
3	7.13	50.40	-7.53	-1	+0.88	+1.38
4	3.58	46.83	-0.40	-1	+1.05	+1.27
5	1.79	48.62	+3.17	+1	+1.13	+1.20
6	0.90	49.51	+1.38	+1	+1.09	+1.24
7	0.45	49.96	+0.49	+1	+1.07	+1.25

Page 581: Figure 9.4.2 should be



Page 582: The first line of equation (9.107) should be

$$\delta_k = -\text{sgn}\{y_k\}$$

Page 587: The first line of equation (9.117) should be

$$\delta_k = -\text{sgn}\{y_k\}$$

Page 591: The last word of the last sentence should be high.

Page 596: The first word of the second sentence of the third new paragraph on the page (10 lines from the bottom of the page) should be CoRDIC.

Page 602: The first equation of Exercise 9.25 should be

$$l(n_0) = -\left(1 - \frac{1}{e}\right) \log\left(\frac{c}{R}\right)$$

Page 602: The first equation of Exercise 9.26 should be

$$x(n) = I_c(nT)e^{j\Omega_0 n} + I_c^*(nT)e^{-j\Omega_0 n}$$

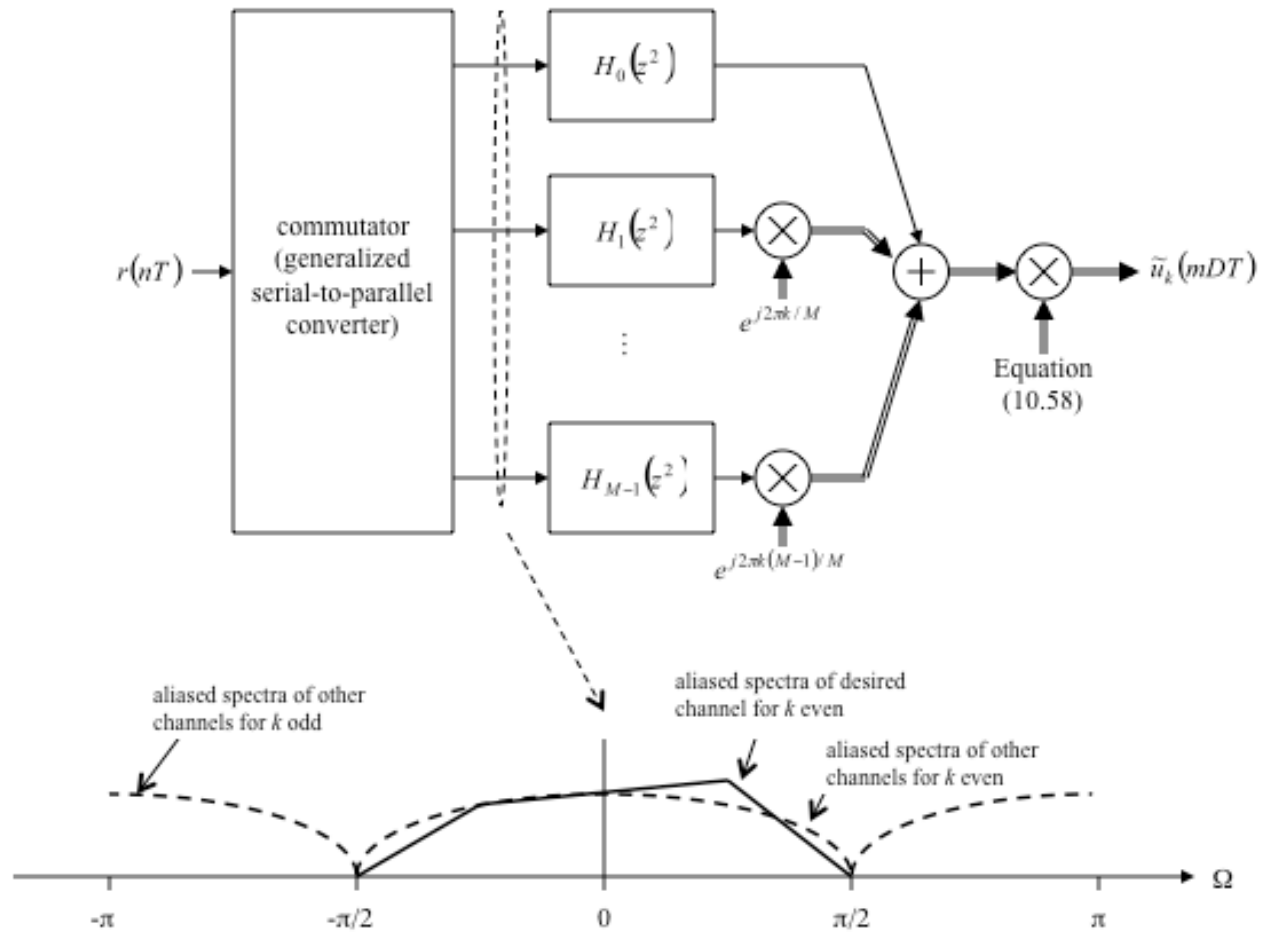
Page 603: The equation of Exercise 9.26 (c) should be

$$\frac{1}{2} A_r(nT) = |I_c(nT)e^{j\Omega_0 n}|$$

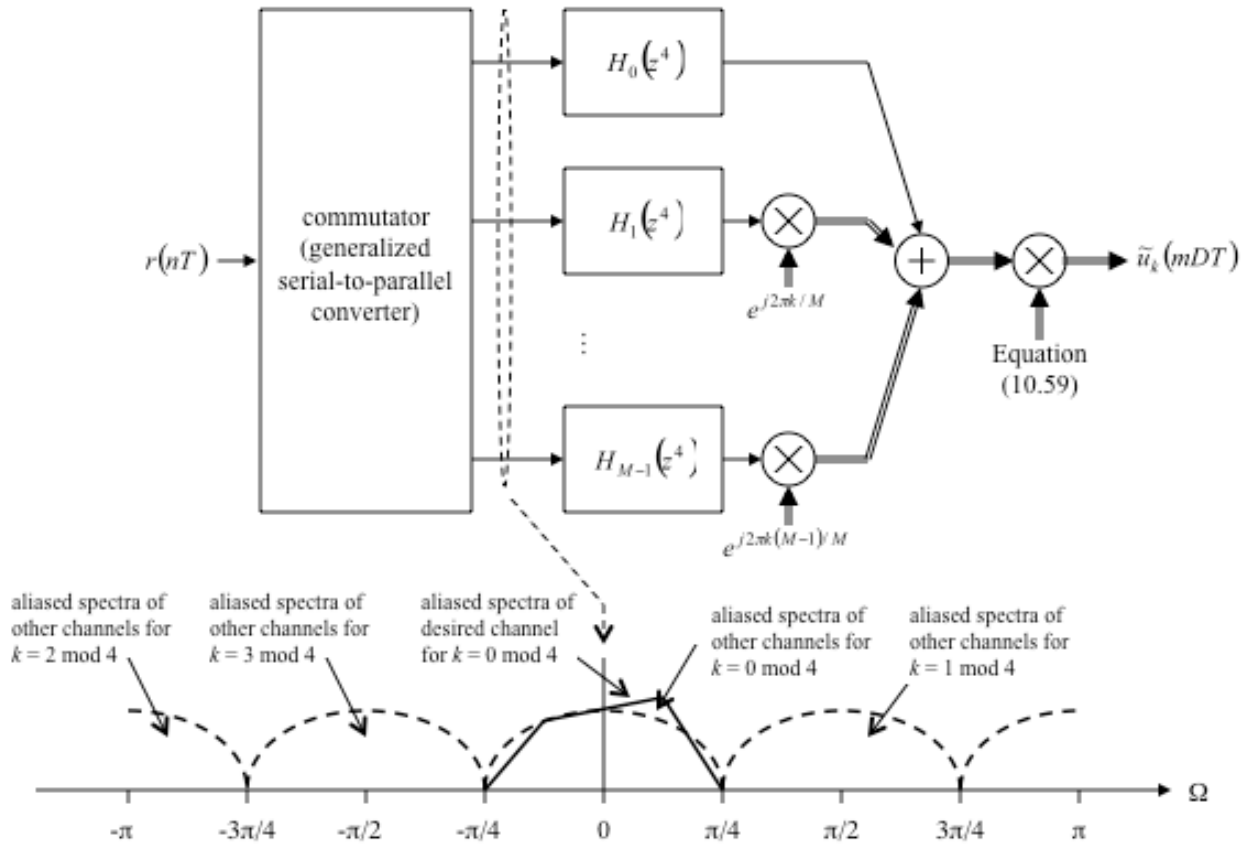
## Chapter 10

Page 652: Just below Equation (10.53),  $\Omega_0 = k \times 2\pi\Delta F / M$  should be  $\Omega_0 = k \times 2\pi\Delta F$ .

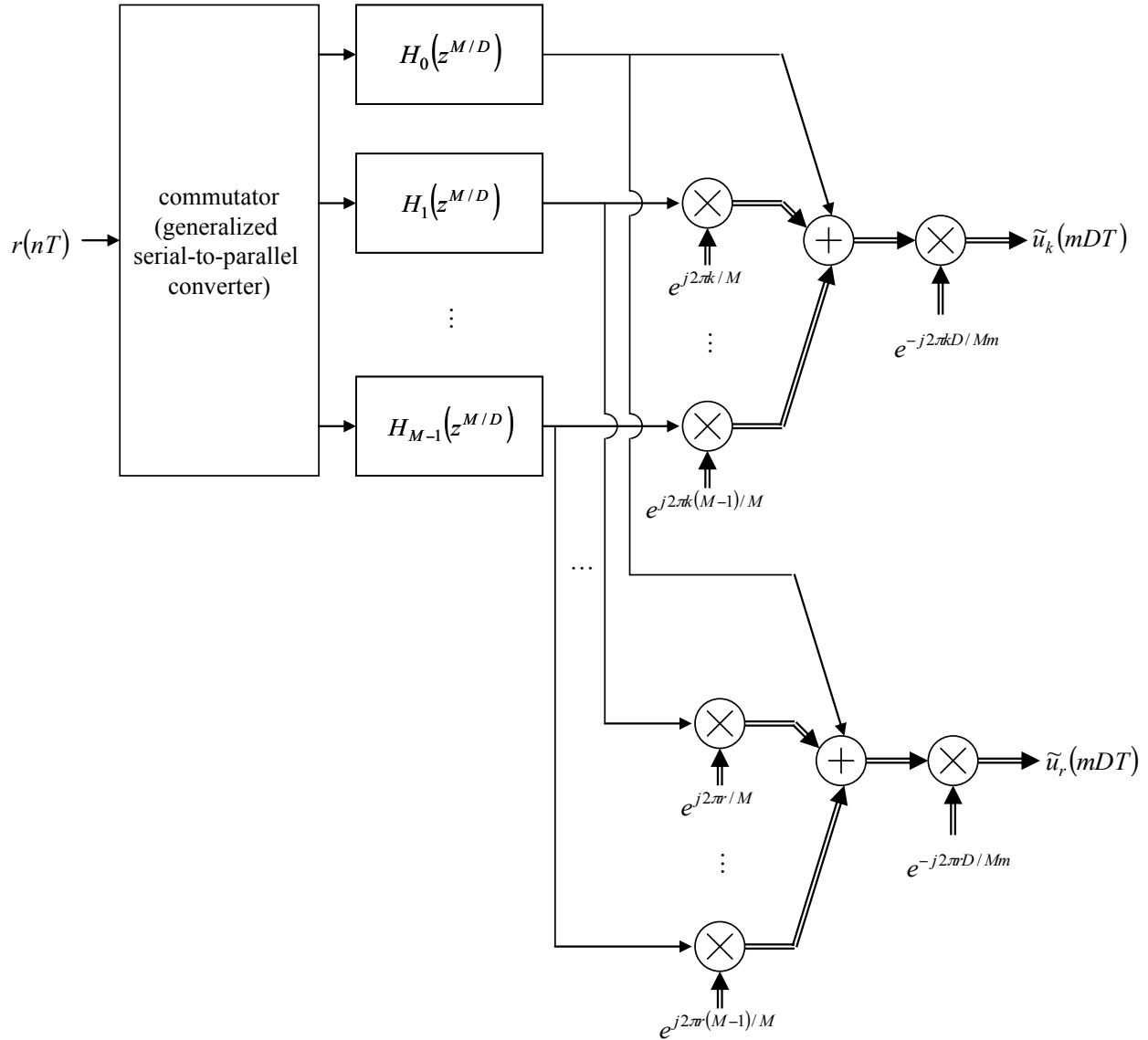
Page 658: Figure 10.2.16 should be



Page 659: Figure 10.2.17 should be



Page 660: Figure 10.2.18 should be



Page 661: line 15, the parenthetical statement should read

(ratio of RF power out to DC power in)

Page 662: The matrix equation for Exercise 10.1 (a) should be

$$\begin{bmatrix} \tilde{I}(t) \\ \tilde{Q}(t) \end{bmatrix} = \begin{bmatrix} 1 & -(1 + \epsilon) \sin(\phi) \\ 0 & (1 + \epsilon) \cos(\phi) \end{bmatrix} \begin{bmatrix} I(t) \\ Q(t) \end{bmatrix}$$



Page 663: The matrix equation for Exercise 10.3 (a) should be

$$\begin{bmatrix} \tilde{x}(t) \\ \tilde{y}(t) \end{bmatrix} = \begin{bmatrix} 1 & -(1 + \epsilon) \sin(\phi) \\ 0 & (1 + \epsilon) \cos(\phi) \end{bmatrix} \begin{bmatrix} x(t) \\ y(t) \end{bmatrix}$$

Page 664: The second line of Exercise 10.6 should reference Figure 10.1.2 (d).

Page 665: Exercise 10.8 should read

The QAM modulator of Exercise 10.6 was derived from the QAM modulator of Figure 10.1.2 (d) by using polyphase partitions of  $p_c(nT)$  and  $p_s(nT)$ . The QAM modulator of Exercise 10.7 was derived from the QAM modulator of Figure 10.1.4 by using a polyphase partition of  $g(nT)$ . Show that the filterbanks in these two modulators are exactly identical.

Page 668: The second line of Exercise 10.20 should begin “consists of 124 channels ...”

Page 669: The second line of Exercise 10.22 should begin “consists of 124 channels...”

Page 669, Exercise 10.26: the last sentence above the figure should read

Assume  $f_1 < f_c$  and  $f_2 < (f_c - f_1)$ .

Page 669, Exercise 10.26 (b) should read

Derive an expression for  $f_{IF}$  in terms of  $f_c$ ,  $f_1$ , and  $f_2$ .

Page 670, Exercise 10.28 (a) should read

Express the product of  $r(t)$  and the LO in terms of baseband signals and double frequency signals (centered at  $2\omega_c$  rads/s).

## Appendix A

Page 677: Three of the equation numbers in the paragraph after Equation (A.8) are wrong. The paragraph should read

Assuming  $r_p(t)$  satisfies the no-ISI condition (A.6), the right-hand side of (A.8) reduces to the  $k = 0$  term, which proves that the right-hand side of (A.7) is a sufficient condition. Assuming the right-hand side of (A.7) is true, the Poisson sum formula is satisfied when  $r_p(t)$  satisfies the no-ISI condition (A.6). This proves that the right-hand side of (A.7) is necessary and the proof is complete. This proof relies on the Poisson sum formula. The derivation of the Poisson sum formula is explored in Exercise A.4.

Page 677, Equation (A.9) should read

$$R_p(f) = \begin{cases} T_s & |f| < B \\ 0 & |f| > B \end{cases}$$

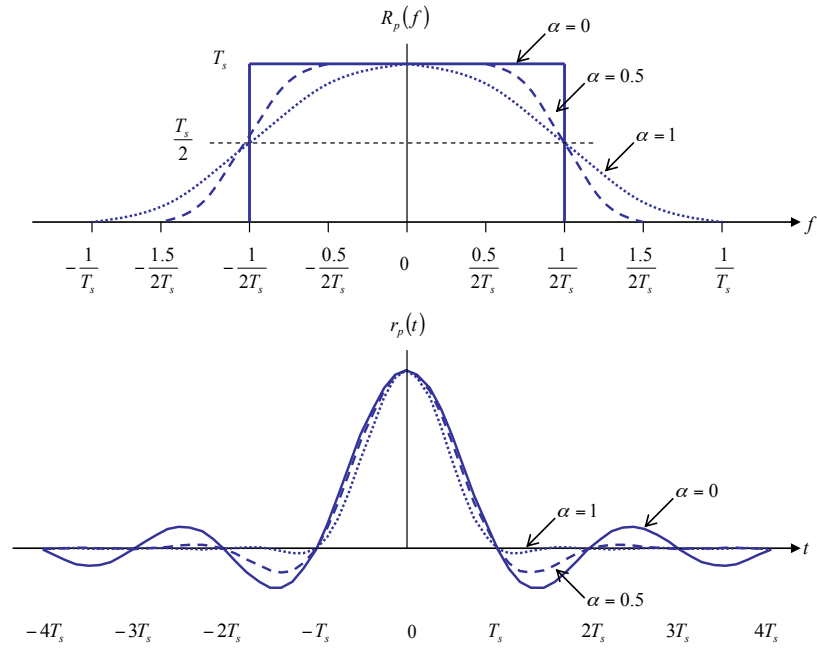
Page 679, Equation (A.11) should read

$$r_p(t) = \frac{\sin\left(\frac{\pi t}{T_s}\right)}{\frac{\pi t}{T_s}} \times \phi(t)$$

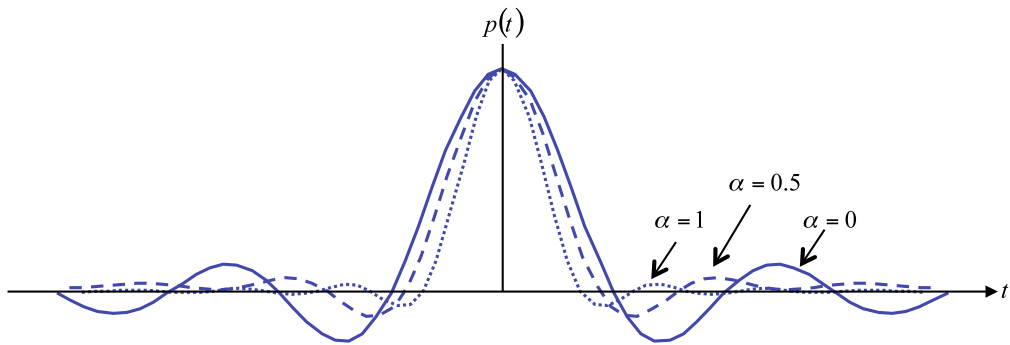
Page 682, the sentence on the last line of the page should read

The absolute bandwidth of  $R_p(f)$  is  $B_{\text{abs}} = \frac{1 + \alpha}{2T_s}$ .

Page 684, Figure A.2.4 should be



Page 685, Figure A.2.5 should be



## Appendix B

Page 715, the equation below the first line of Exercise B.18 should be

$$r(t) = I_r(t)\sqrt{2} \cos(\omega_0 t) - Q_r(t)\sqrt{2} \sin(\omega_0 t)$$

Page 715, the equation below the first line of Exercise B.18 (b) should be

$$r(t) = \operatorname{Re} \left\{ \sqrt{2} [I_r(t) + jQ_r(t)] e^{j\omega_0 t} \right\}$$

## Bibliography

Page 752. Ref. 23 should be

T. Cover and J. Thomas, *Elements of Information Theory*, John Wiley & Sons, New York, 1991.

Page 758: Ref.182 should be

C. Dick and f. harris, "On the structure, performance, and applications of recursive all-pass filters with adjustable and linear group delay," *Proceedings of the IEEE International Conference on Acoustics, Speech, and Signal Processing*, Orlando, FL, May 14-17, 2002, pp. 1517-1520.