

**Errata for the 4th Printing of
"Understanding Digital Signal Processing, 2/E",
by Richard Lyons**

I beg your pardon for the typographical errors in the book.
It will not take long to make these corrections. I promise.

- Rick Lyons

Page 7: In the third line below Eq. (1-7), the text:

"... indicate that $X_{\text{sum}}(n)$ has a frequency ..."

The uppercase "X" should be lowercase "x" as:

"... indicate that $x_{\text{sum}}(n)$ has a frequency ..."

[Found by Angela Livingstone, 3/30/08; [Production Error]

Page 23: Equation(2-3), ends with the text:

$$\text{"... } \sin(2\pi(f_0 + \frac{1}{32})nt_s) \text{ (2-3)}$$

The $\frac{1}{32}$ should be $\frac{m}{nt_s}$ & there is a missing "final" right parenthesis, and period, after the " nt_s ". The Eq. (2-3) should end with:

$$\text{"... } \sin(2\pi(f_0 + \frac{m}{nt_s})nt_s) \text{. (2-3)}$$

[Found by Jimmy Ceilidh, 12/30/04; & Jim Murphy, 9/14/05.][Production Error]

Page 31: In the 3rd line above EQ. (2-6), in the text:

"... and negative bands, P and Q, just butt up ..."

the letters "P" & "Q" should be swapped making it:

"... and negative bands, **Q** and **P**, just butt up ..."

[Found by Jimmy Ceilidh [12/29/04].][Author Error]

Page 34: In the 5th line down, the text:

"... where spectral replications do not butt up against each other except at zero Hz."

is confusing. Please edit it as follows:

"... where spectral replications ~~do not~~ butt up against each other ~~except~~ at zero Hz."

Page 37: The " f_s " labels, within the arrows, at the very bottom of Figure 2-13 should be " $f_s/2$ ".

[Found by Author [6/20/06].][Author Error]

Page 38: In the fifth line up from the bottom of the page,

the text:

"... where m_{odd} is an odd integer[14]."

should be changed to:

"... where m_{odd} is an odd integer greater than one[14]."

[Found by Jim Murphy [9/14/05] & Justin Reeves [6/20/06].][Author Error]

Page 40: In the 2nd line below Eq. (2-14), the text:

" $m = 2$ provide an optimum ..."

should be changed to:

" $m_{\text{even}} = 2$ provide an optimum ..."

[Found by Justin Reeves, 6/20/06.][Author Error]

Page 42: In the middle of Table 2-2, on the right side, the text:

" m_{odd} is any positive odd integer ..."

should be changed to:

" m_{odd} is an odd integer greater than one ..."

[Found by Justin Reeves, 6/20/06.][Author Error]

Page 48: The incorrect letter "v" in the third line of Eq. (3-4d) should be replaced with a "." multiplication symbol.

[Found by Uday Padmanabhan, 11/19/08.][Author Error]

Page 62: The second part of equation (3-18') printed as:

$$x(n) = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} X'(m) e^{j2\pi nm/N} \quad (3-18')$$

should have the lower limit of the summation changed to "m" instead of "n", as :

$$x(n) = \frac{1}{\sqrt{N}} \sum_{m=0}^{N-1} X'(m) e^{j2\pi nm/N} \quad (3-18')$$

[Found by Larry Ong, 2/19/08.][Author Error]

Page 63: on line 9, the text:

"..., that $X(N/2+1)$, when $m = N/2+1$ "

should be

"..., that $X(N/2)$, when $m = N/2$ "

[Found by Antoine Trux, 12/15/04.][Author Error]

Page 77: For **both** Eq. (3-29) and Eq. (3-30), the "-1" characters should be deleted from the denominator of the cosine arguments. The cosine argument, in both equations, should be:

"...cos($2\pi n/N$),"

[Found by Author, 10/26/07.][Author Error]

Page 93: The last term in Eq. 3-37 has a missing minus sign in its exponent. The last term should be:

... + $e^{-jq(K-1)}$] .

[Found by Stan Moore, 3/19/12.][Production Error]

Page 105: In Table 3-1, on the second row the 1st column text:

"Frequency in radians"

should be replaced with:

"Frequency in radians/second"

[Found by Antoine Trux, 12/15/04.][Author Error]

Page 110: In both lines of Equation (3-58) there is a missing minus sign in front of the "j" in the exponent of "e". For both lines of Eq. (3-58) the printed expression should be:

= $e^{-j(2\pi n/N)}$...

[Found by Antoine Trux, 12/15/04.][Author Error]

Page 114: The label text above the arrow in Figure 3-41 states:

" ... transform of $x(n)$..."

There is a missing "c" subscript, the arrow's label text should state:

" ... transform of $x_c(n)$..."

[Found by Jimmy Ceilidh [12/26/04.][Author Error]

Page 122: The caption to Figure 3-47 was printed as:

"DTFT magnitude $|X_o(w)|$ "

The "w" should be the Greek " ω " character, making the caption:

"DTFT magnitude $|X_o(\omega)|$ "

[Found by Author, 4/16/05.][Production Error]

Page 135: On the 3rd line from the bottom, the "1" in:

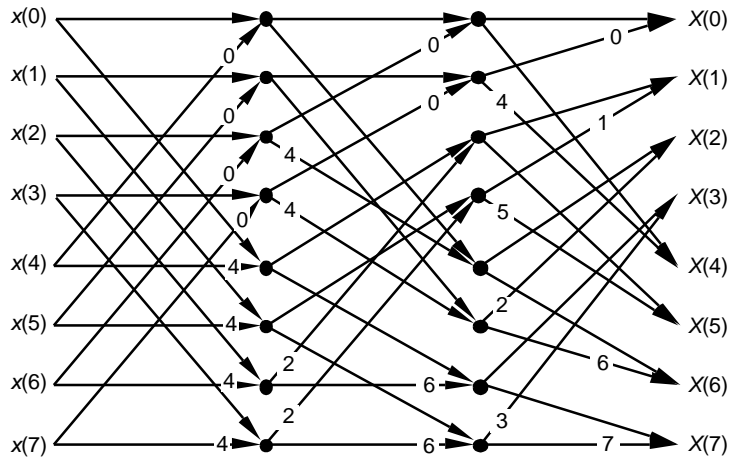
$$"e^{-j\pi} = 1"$$

should be a minus 1 as

$$"e^{-j\pi} = -1"$$

[Found by Antoine Trux, 1/2/07.][Author Error]

Page 143: In Figure 4-10, in the middle stage there is the number 4 on the 1st and 2nd (counting down from the top) southeast-pointing arrows. Those 4s should not be there. The 4s should be on the 3rd and 4th southeast-pointing arrows of the middle stage as shown below.



[Found by Antoine Trux, 1/2/07.][Author Error]

Page 163: The text on the bottom line, printed as:

"Figures 5-8(a) and 5-8(b)."

should be changed to

"Figures 5-8(b) and 5-8(c)."

[Found by Antoine Trux, 12/15/04.][Author Error]

Page 178: In the 3rd & 4th lines of the 1st paragraph the text printed as:

"... defined by 32 discrete samples, to which 480 zeros were ..."

should be

"... defined by 16 discrete samples, to which 496 zeros were ..."

[Found by Fitzgerald Sungkyung Park, 4/25/06.][Author Error]

Page 179: In the 5th line of the next to the last paragraph the text printed as:

"... by 32 discrete samples, with 480 zeros appended, ..."

should be

"... by 16 discrete samples, with 496 zeros appended, ..."

[Found by Fitzgerald Sungkyung Park, 4/25/06.][Author Error]

Page 198: On line 8, the text:

"... in Figure-34(b), ..."

Should be:

"... in Figure 5-40(b), ..."

[Found by Antoine Trux, 12/15/04.][Author Error]

Page 222: In Figure 6-7(a), the label above the arrow should be

" $\sigma = -a_0/a_1$ "

just as it is in Figure 6-8(a)

[Found by Antoine Trux, 12/15/04.][Author Error]

Page 244: The normalized-frequency labeling (radians/sample) on the frequency axis of Figures 6-24(b) and 6-24(c) should be changed as:

-2 π changed to -4 π
- π changed to -2 π
 π changed to 2 π
2 π changed to 4 π

[Found by Author, 10/17/08.][Author Error]

Page 245: On the second line the text:

"... if Figure 6-4(a) ..."

should be changed to

"... if Figure 6-24(a) ..."

[Found by Antoine Trux, 12/15/04.][Author Error]

Page 247: On the last line of the footnote, the text:

"... in Step 5."

should be changed to:

"... in Step 6."

[Found by Antoine Trux, 12/15/04.][Author Error]

Page 257: In the eleventh line below Eq. (6-87)

"... Figure 6-21(b). Knowing that ..."

should be changed to:

"... Figure 6-**22**(b). Knowing that ..."

[Found by Yancen Li (7/14/14)]; [Author Error]

Page 264: In the 6th line of the first full paragraph, the text:

"...squeezed in toward zero Hz."

should be:

"...squeezed in toward $f_s/2$ Hz."

[Found by VV (vanamali), 3/12/09.] [Author Error]

Page 264: In the next to the last line of the first full paragraph there's a missing "|" vertical bar character indicating "magnitude". The text:

"...in $|H_d(f_d)-...$ "

should be:

"...in $|H_d(f_d)|-...$ "

[Found by Author, 7/14/05.] [Author Error]

Page 265: The first line of the caption to Figure 6-32 was printed as:

"... between the f_d and f_c frequencies: ..."

The subscripted "c" should be an "a", making the text:

"... between the f_d and f_a frequencies: ..."

[Found by Author, 7/16/05.] [Author Error]

Page 267: There is a missing "x(n)" factor in Equation (6-114), the first part of that equation should be:

$$y(n) = 0.20482712 \cdot \mathbf{x(n)} + 0.40965424 \cdot x(n-1) + \dots$$

[Found by Kendall Castor-Perry, 5/3/09.] [Author Error]

Page 286: The feedback coefficient of the resonator in Figure 7-3, printed as:

$$e^{j\pi r}$$

it should be changed to:

$$e^{j\omega r}$$

[Found by Author, 7/14/09.] [Production Error]

Page 300: In Figure 7-18(b), the feedback coefficient label on the right side of the figure printed as:

$$2r \cos(2\neq k/N),$$

the " \neq " should be replaced with " π " (pi), as:

$$"2r \cos(2\pi k/N)"$$

[Found by Antoine Trux, 12/15/04.] [Author Error]

Page 339: In Figure 8-3, the last fraction on the right of the second line down printed as:

$$\frac{(j\mathbf{f})^6}{6!} \text{ should be changed to the Greek letter } \phi, \text{ as: } \frac{(j\phi)^6}{6!}.$$

[Found by Prof. Kai-Kuang Ma, 2/28/05.] [Author Error]

Page 345: On the right side of Figure 8-8 the term $e^{j2\pi f_0 t}$ should be divided by two, making it

$$e^{j2\pi f_0 t}/2.$$

[Found by John Littig, 9/24/07.] [Author Error]

Page 353: In the sentence just before Eq. (8-17), the described notion of orthogonality of $i(n)$ and $q(n)$ is only conditionally true. Because this orthogonality topic was not described in sufficient detail, I suggest you strike out both the sentence just before Eq. (8-17) as well as Eq. (8-17).

[Found by Ken Walsh, 5/9/06.] [Author Error]

Page 354: In the third line from the bottom, the text:

"... about zero Hz, not f_c Hz as in Figure 8-17(b)."

should have a comma inserted after " f_c Hz", as:

"... about zero Hz, not f_c Hz, as in Figure 8-17(b)."

(Note: The missing comma is essential because it changes the meaning of the sentence.)

[Found by Antoine Trux, 12/15/04.] [Author Error]

Page 373: In Figure 9-11, in the middle and bottom figures, the two labels within the figures printed as:

"... of $H_1(\square)$ "

should be changed to

"... of $H_1(\omega)$ "

[Found by Antoine Trux, 12/15/04.] [Author Error]

Page 379: In Item# 6, in the 2nd sentence printed as:

"In this case half the $h_{\sin}(k)$ coefficients are zeros, and all but one of the $h_{\cos}(k)$ coefficients are zeros!"

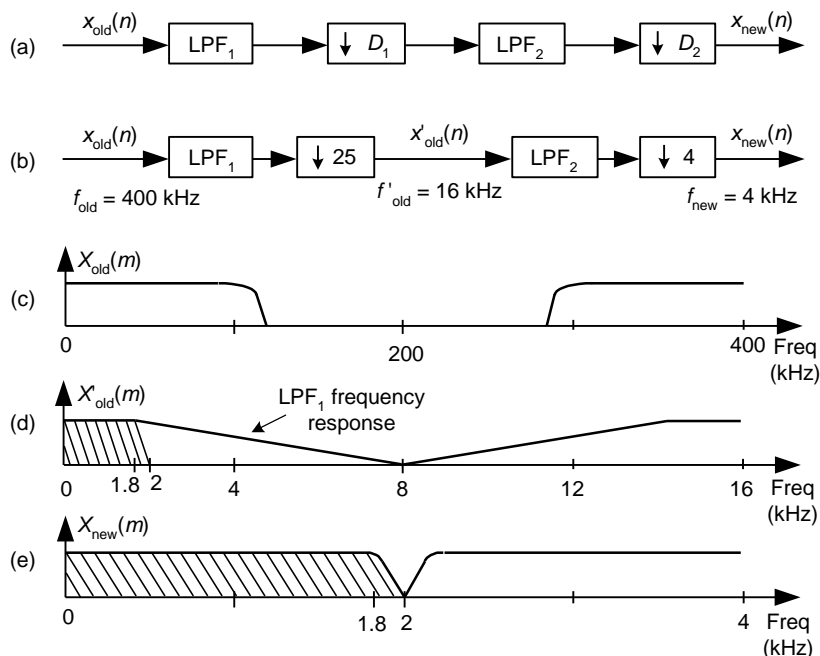
the "cos" and "sin" subscripts should be swapped making that sentence become:

"In this case half the $h_{\cos}(k)$ coefficients are zeros, and all but one of the $h_{\sin}(k)$ coefficients are zeros!"

[Found by Author 11/3/05.] [Author Error]

Page 384: The "shading" in two places at the bottom in Figure 10-3 doesn't show up in the figure.

The shading in Figure 10-3 should look like the following:



[Found by Author 11/3/05.] [Production Error]

Page 389: In the seventh line of the second paragraph, the text is printed as:

"The lower the attenuation, the ...".

Please change the word "lower" to "greater" so that the text reads:

"The **greater** the attenuation, the ...".

[Found by Mark Kolber, 1/29/08.] [Author Error]

Page 399: Equation (10-8) was printed as:

$$Y(z) = \frac{1}{D} [X(n) + X(n)z^{-1} + X(n)z^{-2} + \dots + X(n)z^{-D+1}] \quad (10-8)$$

The X(n) terms should all be X(z), so Eq. (10-8) should be

$$Y(z) = \frac{1}{D} [X(z) + X(z)z^{-1} + X(z)z^{-2} + \dots + X(z)z^{-D+1}] \quad (10-8)$$

[Found by Gурpal Gill, 4/7/05.] [Author Error]

Page 430, fourth line down in 1st paragraph of Section 11.4:

The words printed as:

"... (N-1)-tap FIR filter ..."

Should be changed to read as:

"... N-tap FIR filter ..."

Page 430: last line on the page: The words printed as:

"... through $b(N)$ coefficient ..."

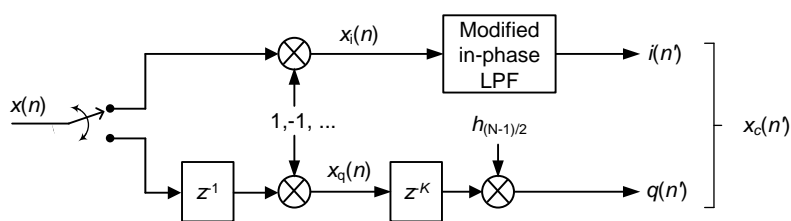
Should be changed to read as:

"... through $b(N-1)$ coefficient ..."

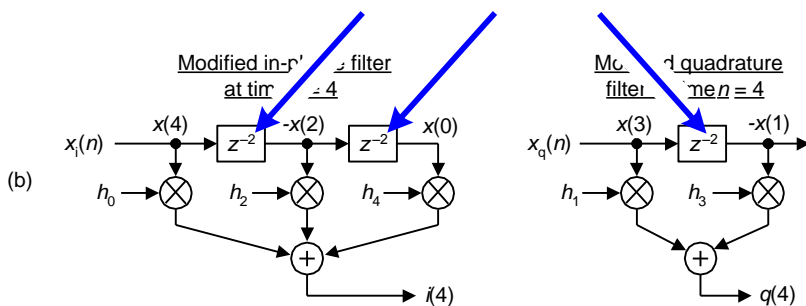
Page 478: in the fifth line down, delete the text:

"...followed by another K delay..."

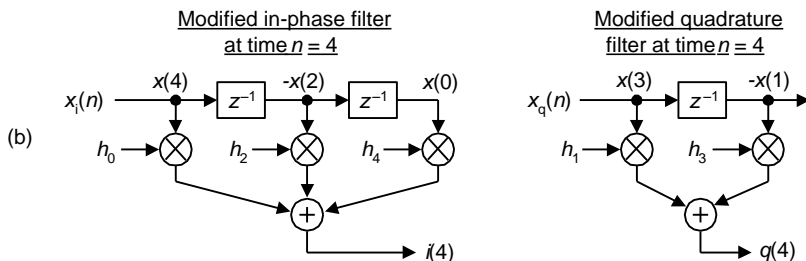
In Figure 13-6(c) the final z^{-K} delay block should be deleted making that figure look as follows:



Page 479: In Figure 13-6(b) the superscripted "-2" characters shown by the large arrows below:



Should be changed from "-2" to "-1" making Figure 13-6(b) become:



Page 484: Equation (13-10) has suffered a series of "foul-ups" in different Printings of the book. Eq. (13-10) should be:

$$\begin{aligned}
W(m) &= \sum_{n=0}^{N-1} \alpha e^{-j2\pi nm/N} - \frac{\beta}{2} \sum_{n=0}^{N-1} e^{j2\pi n/N} e^{-j2\pi nm/N} - \frac{\beta}{2} \sum_{n=0}^{N-1} e^{-j2\pi n/N} e^{-j2\pi nm/N} \\
&= \alpha \sum_{n=0}^{N-1} e^{-j2\pi nm/N} - \frac{\beta}{2} \sum_{n=0}^{N-1} e^{j2\pi n(m-1)/N} - \frac{\beta}{2} \sum_{n=0}^{N-1} e^{-j2\pi n(m+1)/N}. \quad (13-10)
\end{aligned}$$

[Found by Author, 3/22/04.][Author Error]

Page 488: Equation (13-18) has minus signs where equal signs should be. Equation (13-18) should be:

$$\begin{aligned}
x(0) &= a(0) + jb(0) \\
x(1) &= a(1) + jb(1) \\
x(2) &= a(2) + jb(2) \\
&\vdots \\
&\vdots \\
x(N-1) &= a(N-1) + jb(N-1) \quad (13-18)
\end{aligned}$$

[Found by Author [1/11/07].][Production Error. Wierd. This error was NOT in the 1st Edition!]

Page 489: In the 3rd line below Eq. (13-22) change the text from:

"... in Eq. (13-40) , ...

to:

"... in Eq. (13-**20**) , ...

[Found by Antoine Trux, 1/11/07.][Author Error]

Page 496: In the 6th and 7th lines below Eq. (13-40) change the text from:

"... real, $X_a(N)$ through $X_a(2N-1)$ are merely the complex conjugates of their $X_a(0)$ through $X_a(N-1)$ counterparts ..."

to:

"... real, $X_a(N+**1**)$ through $X_a(2N-1)$ are merely the complex conjugates of their $X_a(N-**1**)$ through $X_a(**1**)$ counterparts ..."

[Found by Antoine Trux, 1/11/07.][Author Error]

I (the author) suggest you write the following in the book's margin:

$$\begin{aligned}
&"X_{a,\text{real}}(N) = X_r(0) - X_i(0)" \\
&"X_{a,\text{imag}}(N) = 0"
\end{aligned}$$

Page 518: For more accurate results, the "12/M" factor at the beginning of Eq. (13-70) should be changed to sqrt(12/M). Thus Eq. (13-70) should be:

$$y_{\text{desired}}(n) = \sqrt{\frac{12}{M}} \cdot \sigma' \cdot \left[\left(\sum_{k=1}^M x_k(n) \right) - \frac{M}{2} \right] + \mu' . \quad (13-70)$$

[Found by Bharat Pathak, 7/13/07.][Author Error]

Page 519: Under Section 13.13, Sharpened FIR Filters, the third sentence in the opening paragraph is printed as:

"Actually, we can a filter's double stopband ..."

Please move the word "double" in front of the "a", resulting in:

"Actually, we can double a filter's stopband ..."

[Found by Chris Frailey, 12/8/04.][Author Error]

Page 544: In the exponent of Eq. (13-104), originally printed as:

$$X(k) = \sum_{n=0}^{M-1} x(n) e^{-j2\pi nk/N} . \quad (13-104)$$

The "N" should be changed to an "M", making the equation print as:

$$X(k) = \sum_{n=0}^{M-1} x(n) e^{-j2\pi nk/M} . \quad (13-104)$$

[Found by Author 3/13/06.][Author Error]

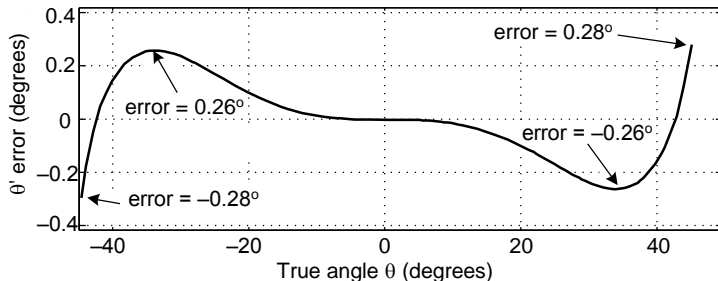
Page 548: 4th line below Eq. (13-107), change the text:

"... 0.26° using ..."

to

"... 0.28° using ...".

For preciseness, you might note on Figure 13-59 that the error is -0.28° at True $\theta = -45^\circ$, and the error is $+0.28^\circ$ at True $\theta = +45^\circ$, as shown in the following figure.



[Found by Chris Zarowski, 4/27/06.][Author Error]

Page 549: 4th line below Eq. (13-109'), change the text:

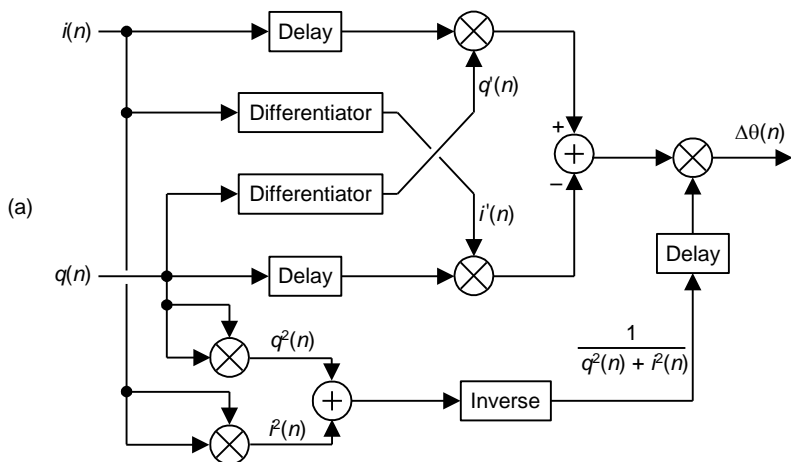
"... error is 0.26° for ..."

to

"...error is 0.28° for ...".

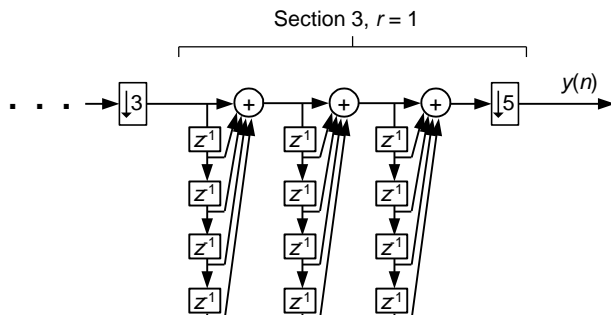
[Found by Chris Zarowski, 4/27/06.][Author Error]

Page 551: In Figure 13-61(a) there needs to be a Delay element inserted just after the "Inverse" operation as shown below. The length of that (missing) Delay element should be the same length as the Delays in the I and Q input paths.



[Found by "Jerry W." on comp.dsp, 8/25/05.][Author Error]

Page 560: In Figure 13-70(b), on the right side in the "Section 3, r = 1" part of the figure, there should be three stages of delay lines instead of only two stages as shown in the figure. That "Section 3, r = 1" part of the figure should look like the following:



[Found by Mike Totham, 8/31/07.][Author Error]

Page 561: Equation (13-123) has a missing 1/N scale factor in front of the summation. That equation should be:

$$M(q) = \frac{1}{N} \sum_{k=qN}^{(q+1)N-1} x(n) \quad (13-123)$$

[Found by Author, 8/24/08.][Production Error]

Page 569: In the right $X_{int}(m)$ column of Table 13-8, the underline character associated with row $m = 9$ should be a zero "0" value as follows:

m	$X_{int}(m)$
...	...
9	0
...	...

[Found by Author, 3/21/09.][Production Error]

Page 574: In Figure 13-77(a), the "log(R)" factor applied to the adder should be two times the log of R as:

$$2\log(R).$$

[Found by Mark Borgerding, 6/8/05.][Author Error]

Page 575: The two labels in Figure 13-78(c) were strangely messed up during the typesetting process. The

$$\alpha = 0.7 \quad \text{and the} \quad \alpha = 0.09$$

labels above the graphs should be changed to

$$\alpha = 0.2 \quad \text{and the} \quad \alpha = 0.05$$

The bottom line in the figure caption is printed as:

"... (c) $E(n)$ for $\alpha = 0.7$ and $\alpha = 0.9$."

That caption text should be changed to:

"... (c) $E(n)$ for $\alpha = 0.2$ and $\alpha = 0.05$."

[Found by Author, 3/24/05.][Production Error]

Page 607: Two corrections: In the second line of Eq. (D-7), the term:

"... $-\cos(\omega t)$] ...

should be:

"... $-\cos(2\omega t)$] ...

In the third line of Eq. (D-7), the term:

"... $-\frac{1}{2}(\sin(\omega t))$..."

should be:

"... $-\frac{1}{4}(\sin(2\omega t))$..."

[Found by Julian Vrbancich, 10/23/12; [Author Error]

Page 610: The final ratio at the end of Eq. (D-12) **MAY** be printed as:

$$\frac{(b-a)^2}{12}.$$

Make sure the numerator looks like (with a PLUS sign):

$$\frac{(b+a)^2}{12}.$$

[Found by Author, 1/15/05.][Author Error]

Page 614: In the sentence just following Eq. (E-2), there is a missing "P₁/P₂" ratio. That sentence should read as:

"The logarithmic function $10 \cdot \log_{10}(P_1/P_2)$, plotted in ..."

[Found by Nikhil Sarma, 5/18/05.] [Author Error]

Page 623: Under the "Chebyshev Function": the fifth line down is printed as:

"...ripples in the passband and flat passbands..."

It should be printed as:

"...ripples in the passband and **a flat stopband...**"

[Found by Mike Beliard, 1/29/05.][Author Error]

Page 627: The minus sign before the "0.04" value in Eq. (F-5) should be deleted, making Eq. (F-5) end with:

$$"... = \frac{0.25}{2\pi} = 0.04 \text{ seconds.} \quad (\text{F-5})"$$

[Found by Author, 4/22/05.][Author Error]

Page 657, Right Column:

The top-level Index entry "Averaging" is missing. The following lines:

Automatic gain control (AGC), 548, 571
block, 561
coherent, 412
...

should be:

Automatic gain control (AGC), 548, 571
Averaging
block, 561
coherent, 412
...

Page 657, Right Column: In the following lines:

Averaging
...
...
moving, 152, 398

the page numbers 430 & 578 should be added making the line:

Averaging
...
...
moving, **152, 398, 430, 578**

Page 660, Left Column: In the following lines:

```
Filtering/filters (cont.)  
...  
...  
moving average, 152, 398
```

the page numbers 430 & 578 should be added making the line:

```
Filtering/filters (cont.)  
...  
...  
moving average, 152, 398, 430, 578
```

Dear Reader, if you find any additional errors, no matter how trivial,
please notify me at:

R.Lyons@ieee.org

I'd sure appreciate hearing from you and I promise I'll

reply to your E-mail.

Thanks,
[-Rick Lyons-]

