

**Electromagnetic Waves and Antennas – S. J. Orfanidis**  
**Errata List – December 10, 2020**

*The page numbers refer to the online version of the book posted on the web page:*  
<http://www.ece.rutgers.edu/~orfanidi/ewa/>

- p.73.** In text line above Eq. (2.13.12), instead of,  $k^2 = \omega^2 \mu \epsilon = \omega^2 |\mu \epsilon|^2 e^{-j(\theta_\epsilon + \theta_\mu)}$ , read,  
 $k^2 = \omega^2 \mu \epsilon = \omega^2 |\mu \epsilon| e^{-j(\theta_\epsilon + \theta_\mu)}$ .
- p.122.** In text line above Eq. (3.10.24), instead of,  $T_{\text{compr}} = 2\pi T / \dot{\omega}_0 = 1/B$ , read,  
 $T_{\text{compr}} = 2\pi / T \dot{\omega}_0 = 1/B$ .
- p.131.** In the last equation of Problem 3.18, the phase factor,  $e^{j\dot{\omega}_0 \dot{\omega}_2 t^2 / 2\dot{\omega}_1}$ , should be replaced by its complex conjugate,  $e^{-j\dot{\omega}_0 \dot{\omega}_2 t^2 / 2\dot{\omega}_1}$ .
- p.166.** In paragraph below Eq. (5.4.11), instead of “can be can be”, read, “can be”.
- p.206.** In fifth text line from top, instead of,  $(HL)^N (2L) (LH)^N$ , read,  $(LH)^N (2L) (HL)^N$ .
- p.233.** In Eq. (6.8.23), instead of,  $n_i n_{M+2-i} = n_a n_b$ , read,  $n_i n_{M+1-i} = n_a n_b$ , with a similar correction in the first line of p.234, that is, read,  $Y_i Y_{M+1-i} = Y_a Y_b$ , and,  $Z_i Z_{M+1-i} = Z_a Z_b$ .
- p.258.** Fourth text line from the bottom, instead of, “Using Eq. (7.5.5),” read,  
“Using Eq. (7.5.5) with  $\chi n^2$  replaced by  $\chi n^2 / n'^2$  in  $\rho_{TM}$ ,”
- p.267.** Eighth text line from the top, instead of,  
 $D_R = \omega^2 \mu_0 (\sin^2 \theta_c - \sin^2 \theta)$ , read,  $D_R = \omega^2 \mu_0 \epsilon (\sin^2 \theta_c - \sin^2 \theta)$ .
- p.282.** In paragraph below Eq. (7.14.3), instead of,  
“is the one the *minimizes*”, read, “is the one that *minimizes*”.
- p.283.** Sixth text line from the bottom, instead of,  $A_0 A_0$ , read,  $A_0 A'_0$ .
- p.285.** Sixth text line from the top, instead of, “we write (7.15.2)”, read, “we write (7.15.1)”.
- p.287.** In Eq. (7.15.15), the factor,  $\sin^2 \theta_a$ , should be,  $\sin \theta_a$ .
- p.308.** Third text line from the bottom, instead of,  
 $\theta_1 = \text{asin}(n_a \text{asin}(\theta_a) / n_1)$ , read,  $\theta_1 = \text{asin}(n_a \sin(\theta_a) / n_1)$
- p.315.** Text line below Eq. (8.5.3), instead of, “Sec. 7.7”, read, “Sec. 7.11”.
- p.325.** In Eq. (8.6.9), the ratios,  $\frac{1 - \rho_{TM} \Gamma}{1 - \rho_{TM}}$ ,  $\frac{-\rho_{TM} + \Gamma}{1 - \rho_{TM}}$ , should be multiplied by a factor of  $E_0$ .
- p.329.** Last text line, instead of,  $\alpha'_z = \sqrt{\alpha_z^2 + k_0(1 - n^2)}$ , read,  $\alpha'_z = \sqrt{\alpha_z^2 + k_0^2(1 - n^2)}$ .
- p.340.** Example 8.8.2, uses the values,  $n_H = 3$ ,  $n_L = 1.38$ , and,  $L_L = 0.15$ , and also instead of,  
 $[F_1, F_2] = [1.0933, 1.3891]$ , read,  $[F_1, F_2] = [1.0933, 1.3791]$ .
- p.350.** Third text line below Eq. (8.10.16), instead of, “ $\rho_{TM} = \rho_{TE}$  at all angles of incidence”, read,  
“ $\rho_{TM} = \rho_{TE}$  at all angles of incidence in the multilayer case - see for example, Eq.(8.13.3)”

p.368. Eq. (9.1.24) should read,

$$\begin{array}{l} E_\rho = -\frac{j\beta}{k_c^2}(\partial_\rho E_z + \eta_{TE}\frac{1}{\rho}\partial_\phi H_z) \\ E_\phi = -\frac{j\beta}{k_c^2}(\frac{1}{\rho}\partial_\phi E_z - \eta_{TE}\partial_\rho H_z) \end{array}, \quad \begin{array}{l} H_\rho = -\frac{j\beta}{k_c^2}(\partial_\rho H_z - \frac{1}{\eta_{TM}\rho}\partial_\phi E_z) \\ H_\phi = -\frac{j\beta}{k_c^2}(\frac{1}{\rho}\partial_\phi H_z + \frac{1}{\eta_{TM}}\partial_\rho E_z) \end{array}$$

p.377. In line 4 below Eq. (9.5.8), instead of  $\sin k_x$ , read,  $\sin k_x x$ . And, in the last equation below Eq. (9.5.9), the expression for  $H_2$  should be corrected to read,

$$H_2 = \frac{1}{\eta_{TM}} E_1 = -\frac{j\omega k_x}{\omega_c k_c} \frac{1}{\eta} E_0$$

p.396. In Eq. (9.11.37), instead of  $\sin \theta_c^2$ , read,  $\sin^2 \theta_c$ .

p.594. In bottom paragraph, please note that once coupling is introduced, the parameters  $C_i, L_i$  are no longer the values for the isolated lines.

p.600. Replace  $\zeta^{-2}$  by  $\zeta^{-2}$  in the denominator of the second term of the first equation in Eq. (12.2.1).

p.602. In Example 12.2.1, the equation,  $K_f = 0.05$ , should be replaced by,  $K_f = -0.05$ .

p.606. Eq. (12.4.6) should read,

$$\begin{bmatrix} a_1(z) \\ a_2(z) \end{bmatrix} = e^{-j\beta z} \begin{bmatrix} \cos \sigma z - j \frac{\delta}{\sigma} \sin \sigma z & -j \frac{\kappa}{\sigma} \sin \sigma z \\ -j \frac{\kappa}{\sigma} \sin \sigma z & \cos \sigma z + j \frac{\delta}{\sigma} \sin \sigma z \end{bmatrix} \begin{bmatrix} a_1(0) \\ a_2(0) \end{bmatrix}$$

p.609. The factor  $U_{12}$  in the numerator of Eq. (12.5.12) should be conjugated,  $U_{12}^*$ .

p.647. In the third formula from the top, the right-hand-side should be,  $g_L^2(e_{\max}/e - 1)$ . Similarly, the right-hand-side of Eq.(13.10.6) should be,  $g_L^2(e_{\max}/e_{\min} - 1)$ . And, the expression for  $b$  in Eq.(13.10.7) should be,

$$b = \cot \beta l_2 \pm g_L \sqrt{\left(\frac{e_{\max}}{e_{\min}} - 1\right)}$$

p.650. In the penultimate paragraph of Example 13.11.1,  $X_2 = 1/j\omega C$  and  $X_1 = j\omega L$ , should be replaced by,  $X_2 = -1/\omega C$  and  $X_1 = \omega L$ .

And in the last paragraph,  $X_2 = j\omega L$  and  $X_1 = 1/j\omega C$ , should be replaced by,  $X_2 = \omega L$  and  $X_1 = -1/\omega C$ .

p.656. In Example 13.12.3, the solution for  $Q_{\min}$  should be,  $Q_{\min} = \sqrt{200/50 - 1} = 1.73$ .

p.670. In Eq. (14.4.5), the expression,  $S_{22}a_1 + S_{22}\Gamma_L b_2$ , should read,  $S_{21}a_1 + S_{22}\Gamma_L b_2$ .

p.672. In Eq.(14.5.8), the bottom equation should be corrected to read,

$$\Gamma_{\text{out}} = S_{22} + \frac{S_{12}S_{21}\Gamma_G}{1 - S_{11}\Gamma_G} = \frac{S_{22} - \Delta\Gamma_G}{1 - S_{11}\Gamma_G}$$

The same correction also applies to Eq.(14.8.1) on p.687.

**p.673.** The first line of the equation below Eq. (14.5.9) should read,

$$1 - |\Gamma_{\text{in}}|^2 = 1 - \left| \frac{S_{11} - \Delta\Gamma_L}{1 - S_{22}\Gamma_L} \right|^2 = \frac{|1 - S_{22}\Gamma_L|^2 - |S_{11} - \Delta\Gamma_L|^2}{|1 - S_{22}\Gamma_L|^2}$$

**p.694.** In Example 14.10.1, the numerical values of  $Z_G$  and  $Z_L$  should be interchanged, that is,

$$Z_L = 69.21 + 14.42j \Omega, \quad Z_G = 23.15 - 24.02j \Omega$$

**p.698.** In second paragraph from the top, instead of “corresponding matched load”, read, “corresponding matched generator”.

**p.704.** The two-line MATLAB code above Fig. 14.12.2 should read,

```
gG = smatch(S);
F = nfig(Fmin, rn, gGopt, gG);
```

**p.723.** In lines 3 & 4 below Eq. (15.6.2), the term,  $k_x \hat{z}$ , should be changed to,  $k_x \hat{x}$ .

**p.755.** After Eq. (16.7.1), the Boltzmann constant should read,  $k = 1.3806 \times 10^{-23}$  W/Hz K.

**p.765.** In the last line of Example 16.8.3, the calculated value of  $G/T$  should be, 24.2082 dB.

**p.782.** In line 3 from the top, instead of “Appendix F”, read, “Appendix G”.

**p.852.** The last equation should have a double integral, i.e.,

$$E(x, y, z) \approx 2jk \cos \theta \frac{e^{-jkr}}{4\pi r} \iint_{-\infty}^{\infty} E(x', y', 0) e^{k_x x' + k_y y'} dx' dy'$$

**p.855.** The first of Eqs. (19.4.7) should read,  $\hat{E}(k_x) = \int_{-\infty}^{\infty} E(x, 0) e^{jk_x x} dx$ .

**p.869.** And in p.870, a minus sign should be inserted in the right-hand sides of Eqs. (19.8.19) and (19.8.25) for the quantities,  $F_x, F_y$  and  $A_x, A_y$ .

**p.887.** In the top equation, instead of  $-3\pi/2$ , read  $-\pi/2$ , and in the line below it, instead of, “shadow region”, read, “transmission region”.

**p.888.** And in p.889, replace all instances of,  $\cosh(\theta + jt)$ , by,  $\cos(\theta + jt)$ .

**p.897.** Multiply the right-most side of Eq. (19.11.23) by a factor of 2.

**p.899.** In the 2nd text line above Eq. (19.11.36), instead of, (19.11.32), read, (19.11.34).

**p.901.** In Eq. (19.11.46), third equation, instead of,  $\mathbf{E}_{\text{rad}} = -2jk \hat{\mathbf{r}} \times \mathbf{F}_{\text{rad}}^i = \dots$ , read,  $\mathbf{E}_{\text{rad}} = -jk \hat{\mathbf{r}} \times \mathbf{F}_{\text{rad}}^i = \dots$ , also in the second line below Eq. (19.11.48), instead of, (19.11.49), read, (19.11.48).

**p.903.** In Eq. (19.11.58), the right-hand side of  $\mathcal{P}_y$  should be multiplied by  $(-1)$ .

**p.904.** In Eq. (19.11.65) and in the equation preceding it, instead of,  $e^{k_y y'}$ , read,  $e^{jk_y y'}$ .

**p.909.** The summation in Eq. (19.12.24) should be,  $\sum_{n=-\infty}^{\infty}$

**p.926.** In the first integral above Eq. (20.1.15), replace  $dz$  by  $dy$ .

- p.927.** In the last integral of Eq. (20.1.16), replace  $dx$  by  $dx'$ .
- p.927.** The right-hand sides of Eq. (20.1.17), Eq. (20.1.18), and of the equation below Eq. (20.1.18), should be multiplied by a factor of  $E_0$ .
- p.931.** In Eq. (20.2.2), the exponential,  $e^{-nk_d x}$ , should be changed to,  $e^{-jnk_d x}$ . And, at the bottom equation, instead of,  $e^{j\pi n^2 z/z_T} \big|_{z=z_T}$ , read,  $e^{j\pi n^2 z/z_T} \big|_{z=2z_T}$ .
- p.935.** In the third line of Example 20.2.2, instead of,  $|E(x, z_{pq})|$ , read,  $|E(x, z_{pq})|$
- p.953.** In the second line from the top, instead of,  $k_{\perp} = |\mathbf{k}_{\perp}|$ , read,  $k_{\perp} = |\mathbf{k}_{\perp}|$ .
- p.967.** In the fourth line of Example 20.11.2, replace both instances of  $\mathbf{u}_{\perp}$  by  $\mathbf{v}_{\perp}$ .
- p.984.** Eq. (20.15.8) should read,  $\sigma = \frac{\tilde{n}}{\sqrt{A^2 + (\tilde{n} - \frac{1}{2})^2}}$ . The square root in the denominator is also missing in Eq. (20.19.6) on p.998.
- p.1001.** The  $m$ -summations in Eqs. (20.20.3) and (20.20.4) should be,  $\sum_{m=-\infty}^{\infty}$
- p.1001.** All the phase exponentials,  $e^{j\pi m/N}$ ,  $e^{2\pi jnm/N}$ ,  $e^{2\pi jm/N}$ ,  $e^{j\pi p}$ , in Eq. (20.20.5), and Eqs. (20.20.6) and (20.20.7) on p.1002, should be complex conjugated.
- p.1002.** The  $p$ -summation in Eq. (20.20.7) should be,  $\sum_{p \neq 0}$ . And, in the first line below Eq. (20.20.7), instead of, “the  $p \geq 1$  terms”, read, “the  $p \neq 0$  terms”
- p.1021.** In the text line before Eq (20.22.13), instead of,  $\lambda_0 \leq \lambda_1 \leq \dots \leq \lambda_M$ , read,  $\lambda_0 \geq \lambda_1 \geq \dots \geq \lambda_M$ .
- p.1032.** In the fourth line of the section **Focusing of Plane Waves**, instead of “low-frequency evanescent modes”, read, “higher-frequency evanescent modes”.
- p.1049.** In line 1 below Eq. (21.3.3), instead of,  $F_1(v, s)$ , read,  $F_1(v, \sigma)$ .
- p.1050.** Inside the integral of the equation preceding Eq. (21.3.5), instead of,  $e^{j\pi v \xi}$ , read,  $e^{j\pi v_x \xi}$ .
- p.1051.** In Eq. (21.3.15), instead of,  $f_0(v_y, \sigma_a)$ , read,  $f_0(v_y, \sigma_b)$ .
- p.1062.** In the second equation of Eq. (21.6.5), instead of,  $\pm$ , read,  $\mp$ . And, in the equation below the fourth text paragraph, instead of,  $F_{m,24} = \hat{\mathbf{x}} \dots$ , read,  $F_{m,24} = -\hat{\mathbf{x}} \dots$ . Moreover, in Eq. (21.6.7), instead of  $F_{m,12}$ , read,  $F_{m,13}$ .
- p.1071.** In last line of third paragraph of Section 21.9, instead of,  $\hat{\mathbf{x}}' = -\hat{\mathbf{z}}$ , read,  $\hat{\mathbf{z}}' = -\hat{\mathbf{z}}$ .
- p.1100.** Line 2 of Sec. 22.4, instead of “see Fig. 22.3.4”, read, “see Fig. 22.1.1”.
- p.1138.** In text line before Eq. (23.6.21), instead of ‘is is defined’, read, ‘is defined’.
- p.1143.** The first line of the MATLAB code at the bottom of the page should be,  
`[a, dph] = binomial(0.5, 90, 7);`
- p.1148.** Example 23.9.1 shows the case of a 5-element array. The 7-element case corresponds to the following changes in the code, table, and weights,

$$[a, dph] = dolph(0.5, 90, 7, 20);$$

| $i$ | $x_i$   | $\psi_i$ | $Z_i$               |
|-----|---------|----------|---------------------|
| 1   | 0.9659  | 1.0826   | $0.4691 + 0.8832j$  |
| 2   | 0.7071  | 1.7852   | $-0.2127 + 0.9771j$ |
| 3   | 0.2588  | 2.6782   | $-0.8945 + 0.4470j$ |
| 4   | -0.2588 | 3.6050   | $-0.8945 - 0.4470j$ |
| 5   | -0.7071 | 4.4980   | $-0.2127 - 0.9771j$ |
| 6   | -0.9659 | 5.2006   | $0.4691 - 0.8832j$  |

$$x_0 = 1.1270, \quad \mathbf{w} = [1, 1.2764, 1.6837, 1.8387, 1.6837, 1.2764, 1]$$

In penultimate line of Example 23.9.2, instead of  $R = 20$ , read,  $R = 25$ .

- p.1149.** Line 4 below the table, instead of  $kd < \pi/2$ , read,  $kd < \pi$ .
- p.1158.** Line 6 above Eq. (23.10.10), instead of  $y = \sinh(x)x$ , read,  $y = \sinh(x)/x$ .  
Line 2 above Eq. (23.10.11), instead of “is  $\psi$ -space”, read, “in  $\psi$ -space”.
- p.1168.** and p.1169, the MATLAB function, `multbeam`, should be, `multibeam`.
- p.1197.** Line 5 from bottom, “Then, Eq. (24.9.3)”, should read, “Then, Eq. (24.8.9)”.
- p.1210.** In the bottom integral of Eq. (24.12.15), instead of  $dy$ , read  $dz$ .
- p.1237.** Line 2, instead of, Appendix F, read, Appendix G.  
Line 4, instead of, range  $[-h_1, h_1]$ , read, range  $[-h_2, h_2]$ .  
Upper limit of the integral in Eq. (25.3.14) should be  $h_2$  instead of  $h_1$ .  
In the equation below Eq. (25.3.14),  $u_1$  should read,

$$u_1 = k \left[ \sqrt{d^2 + (h_2 - z_0)^2} + s(h_2 - z_0) \right]$$

Eq. (25.3.16) should be read,

$$\int_{-h_2}^{h_2} F(z) dz = \sum_{i=1}^{12} c_i G(z_i, s_i)$$

and the table below it should read,

| $i$ | $Z_i$      | $S_i$ | $c_i$             | $i$ | $Z_i$      | $S_i$ | $c_i$               |
|-----|------------|-------|-------------------|-----|------------|-------|---------------------|
| 1   | $h_1 - b$  | 1     | $c_1$             | 7   | $h_1 - b$  | -1    | $c_1^*$             |
| 2   | $-h_1 + b$ | 1     | $c_1$             | 8   | $-h_1 + b$ | -1    | $c_1^*$             |
| 3   | $-h_1 - b$ | 1     | $c_1$             | 9   | $-h_1 - b$ | -1    | $c_1^*$             |
| 4   | $h_1 + b$  | 1     | $c_1$             | 10  | $h_1 + b$  | -1    | $c_1^*$             |
| 5   | $b$        | 1     | $-2c_1 \cos kh_1$ | 11  | $b$        | -1    | $-2c_1^* \cos kh_1$ |
| 6   | $-b$       | 1     | $-2c_1 \cos kh_1$ | 12  | $-b$       | -1    | $-2c_1^* \cos kh_1$ |

The function **imped2.m** contained in **ewa.zip** has been updated accordingly.

- p.1244.** In the three equations between Eq. (25.5.8) and (25.5.9),  $\cos(kh_p \cos \theta)$ , should read,  $\cos(kh_p \cos \theta)$ .
- p.1273.** Eq. (D.6) in Appendix D should read,

$$\nabla \times \nabla \times [\mathbf{p} G(\mathbf{r})] = \frac{2}{3} \mathbf{p} \delta^{(3)}(\mathbf{r}) + \left[ \left( jk + \frac{1}{r} \right) \frac{3\hat{\mathbf{r}}(\hat{\mathbf{r}} \cdot \mathbf{p}) - \mathbf{p}}{r} + k^2 \hat{\mathbf{r}} \times (\mathbf{p} \times \hat{\mathbf{r}}) \right] G(\mathbf{r})$$

- p.1285.** In Eq. (F.28) of Appendix F, the quantity  $I(\phi, k\rho)$  should be replaced by  $I(\phi)$ .
- p.1304.** In Eq. (J.33) of Appendix J, the lower limit of the first integral should be  $-t_0$ .