Errata

Radio Frequency Circuit Design
February 15, 2008

p. xiii Old At the end of the second to last paragraph
...simply a microwave text.

Revised
...simply a microwave text. Computer programs referred to in the body of the text may be found at http://www-ee.uta.edu/online/adavis/rfsoftware.

p. 3 Old
...since their mechanical size normally correspondings to the wavelength.

Revised
...since their mechanical size normally corresponds to the wavelength.

p. 4 Old In second full paragraph
Clearly, the more distinct time intervals $\tau$ these are in the total time span $T$, ...

Revised
Clearly, the more distinct time intervals $\tau$ there are in the total time span $T$, ...

p. 5 Old
\[ n \cdot n \cdot n \cdot n \ldots = n^{T/\tau} \] (1.1)

Revised
\[ n \cdot n \cdot n \cdot n \ldots = n^{T/\tau} \] (1.1)

p. 6 Old First paragraph in Section 1.3
...each interval that is independent from the others is $n^{T/\tau}$.

Revised
...each interval that is independent from the others is $n^{T/\tau}$.

p. 11
Revised
Table 2.1 Resistor Materials

1
<table>
<thead>
<tr>
<th>Resistor Type</th>
<th>Resistance</th>
<th>Temperature Coeff.</th>
<th>Voltage Coeff.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diffused Si</td>
<td>10 - 100 Ω/ ◦</td>
<td>1500 ppm/°C</td>
<td>200 ppm/V</td>
</tr>
<tr>
<td>Diffused GaAs</td>
<td>300 to 400 Ω/ ◦</td>
<td>3000 to 3200 ppm/°C</td>
<td>—</td>
</tr>
<tr>
<td>Polysilicon</td>
<td>30 to 200 Ω/ ◦</td>
<td>1500 ppm/°C</td>
<td>100 ppm/V</td>
</tr>
<tr>
<td>Ion Implantation</td>
<td>0.5 to 2 kΩ/ ◦</td>
<td>400 ppm/°C</td>
<td>800 ppm/V</td>
</tr>
<tr>
<td>AuGeNi (Alloyed)</td>
<td>2 Ω/ ◦</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Thin film Cr</td>
<td>13 μΩ – cm</td>
<td>3000 ppm/°C</td>
<td>—</td>
</tr>
<tr>
<td>Thin film Ti</td>
<td>55 to 135 μΩ – cm</td>
<td>2500 ppm/°C</td>
<td>—</td>
</tr>
<tr>
<td>Thin film Ta</td>
<td>180 to 220 μΩ – cm</td>
<td>-100 to +500 ppm/°C</td>
<td>—</td>
</tr>
<tr>
<td>Thin film TaN</td>
<td>280 μΩ – cm</td>
<td>-180 to -300 ppm/°C</td>
<td>—</td>
</tr>
<tr>
<td>Thin film Ni</td>
<td>7 μΩ – cm</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Thin film NiCr</td>
<td>60 to 600 μΩ – cm</td>
<td>200 ppm/°C</td>
<td>—</td>
</tr>
</tbody>
</table>

Sources: Refs. [1-3].

p. 18. below (2.16)

Old
... and $C_g$ is the static gap capacitance between the fingers.

Revised
... and $C_g$ is the static gap capacitance per unit length between the fingers.

p. 20.

Old

$$Z = \frac{R_p R_s + R_p L_s}{s^2 L C R_p + s(R_s C R_p + L) + R_s R_p}$$

Revised

$$Z = \frac{R_p R_s + R_p L_s}{s^2 L C R_p + s(R_s C R_p + L) + R_s + R_p}$$

p. 21.

Old Beginning of Section 2.4.1

The dc current flowing through a wire with a cross-sectional area, $A$, will encounter twice the resistance if the area is doubled.

Revised The dc current flowing through a wire with a cross-sectional area, $A$, will encounter half the resistance if the area is doubled.

p. 29.

Old

$$C_{qi} = C_m + C_f' + C'_f$$

Revised

$$C_{qi} = C_m + C_f + C'_f$$

p. 35.
Old

\[
\left| \frac{1}{R} + j\omega C - j\omega L \right| = \frac{\sqrt{2}}{R}
\]  

(3.7)

Revised

\[
\left| \frac{1}{R} + j\omega C - j\omega L \right| = \frac{\sqrt{2}}{R}
\]  

(3.7)

p. 35

Old

\[
\Delta f = \omega_2 - \omega_1
\]  

(3.11)

Revised

\[
\Delta \omega = \omega_2 - \omega_1
\]  

(3.11)

p. 38

Old

\[
jX'_1 = \frac{jR^2 + (\omega_0L)^2}{\omega_0L}
\]  

(3.22)

Revised

\[
jX'_1 = \frac{jR^2 + (\omega_0L)^2}{\omega_0L}
\]  

(3.22)

p. 42 Old

Table 3.3 T matching circuit design formulas.

<table>
<thead>
<tr>
<th>Step Number</th>
<th>( R'' &gt; R )</th>
<th>( R'' &lt; R )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>( Q_1 = Q_{\text{max}} )</td>
<td>( Q_2 = Q_{\text{max}} )</td>
</tr>
<tr>
<td>2</td>
<td>( R' = R(1 + Q_1^2) )</td>
<td>( R' = R''(1 + Q_2^2) )</td>
</tr>
<tr>
<td>3</td>
<td>( 1 + Q_2^2 = R'/R'' )</td>
<td>( 1 + Q_1^2 = R'/R'' )</td>
</tr>
<tr>
<td>4</td>
<td>( X_1 = Q_1R )</td>
<td>( X_1 = Q_1R )</td>
</tr>
<tr>
<td>5</td>
<td>( B_2 = (Q_1 + Q_2)/R' )</td>
<td>( B_2 = (Q_1 + Q_2)/R' )</td>
</tr>
<tr>
<td>6</td>
<td>( X_3 = Q_2/R'' )</td>
<td>( X_3 = Q_2/R'' )</td>
</tr>
</tbody>
</table>

p. 42 Revised

Table 3.3 T matching circuit design formulas.
<table>
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<tbody>
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</tr>
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</tr>
<tr>
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<td>$1 + Q_2^2 = R'/R''$</td>
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<td>6</td>
<td>$X_3 = Q_2 R''$</td>
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</tr>
</tbody>
</table>

p. 44

Old

$$Q_p = \left[ \frac{R_2}{R} (1 + Q_1^2) - 1 \right]^{1/2}$$ (3.42)

Revised

$$Q_p = \left[ \frac{R_2}{R'} (1 + Q_1^2) - 1 \right]^{1/2}$$ (3.42)

p. 45

Old Table 3.4 step number 7

$$C_1 = C_{seqv} C_2 / (C_{seqv} - C_2)$$

Revised

$$C_1 = C_{seqv} C / (C_{seqv} - C)$$

p. 48

Old

$$+ \omega_{m2} L_2' + \frac{1}{\omega_{m2} C_2'} = |Q_{2-m2}| \frac{R_G}{1 + Q_{2-m2}^2}$$ (3.59)

Revised

$$+ \omega_{m2} L_2' - \frac{1}{\omega_{m2} C_2'} = |Q_{2-m2}| \frac{R_G}{1 + Q_{2-m2}^2}$$ (3.59)

p. 49

Old

$$B_{m1} = \text{Im} \left\{ \frac{1}{j \omega_{m1} L_2' + (1/G_L' + j \omega_{m1} C_2')} \right\}$$ (3.61)

$$B_{m2} = \text{Im} \left\{ \frac{1}{j \omega_{m2} L_2' + (1/G_L' + j \omega_{m2} C_2')} \right\}$$ (3.62)
Revised

\[
B_{m1} = \text{Im}\left\{\frac{1}{j\omega_1 L_2^r + 1/(G_L^r + j\omega_1 C_2^r)}\right\}
\]  
(3.61)

\[
B_{m2} = \text{Im}\left\{\frac{1}{j\omega_2 L_2^r + 1/(G_L^r + j\omega_2 C_2^r)}\right\}
\]  
(3.62)

p. 49

Old

\[
\frac{1}{\omega_2 L_{11}^r} - \omega_2 C_1 = |B_{m2}|
\]  
(3.64)

Revised

\[
\frac{1}{\omega_2 L_{11}^r} - \omega_2 C_1 = -|B_{m2}|
\]  
(3.64)

p. 61

Old

\[
I(z, t) = \frac{1}{Z_0} \left[ F_1 \left( t - \frac{z}{v} \right) + F_2 \left( t + \frac{z}{v} \right) \right]
\]  
(4.50)

Revised

\[
I(z, t) = \frac{1}{Z_0} \left[ F_1 \left( t - \frac{z}{v} \right) - F_2 \left( t + \frac{z}{v} \right) \right]
\]  
(4.50)

p. 62

Old

\[
\Gamma = \frac{V^-}{V^+} = \frac{Z_L - Z_0}{Z_L + Z_0}.
\]  
(4.56)

Revised

\[
\Gamma = \frac{V^-}{V^+} = \frac{Z_L - Z_0}{Z_L + Z_0}.
\]  
(4.56)

p. 63

Old

\[
Z_{in} = Z_0 \frac{Z_L + jZ_0 \tanh \gamma \ell}{Z_0 + jZ_L \tanh \gamma \ell}
\]  
(4.63)

Revised

\[
Z_{in} = Z_0 \frac{Z_L + Z_0 \tanh \gamma \ell}{Z_0 + Z_L \tanh \gamma \ell}
\]  
(4.63)

p. 72

Old

\[
\Delta u_a = \frac{t/h}{\pi} \ln \left[ 1 + \frac{4 \exp(1)}{t/h + \coth^2 \sqrt{6.517w/h}} \right]
\]  
(4.104)
Revised

\[ \Delta u_a = \frac{t/h}{\pi} \ln \left[ 1 + \frac{4 \exp(1)}{(t/h) \coth^2 \sqrt{6.517w/h}} \right] \]  

(4.104)

p. 72

Old

\[ f(x) = 6 + (2\pi - 6) \exp \left[ (-30.666/x)^{0.7528} \right] \]  

(4.109)

Revised

\[ f(x) = 6 + (2\pi - 6) \exp \left[ -(30.666/x)^{0.7528} \right] \]  

(4.109)

p. 73

Old

\[ \varepsilon_{eff}(w/h, t, \epsilon_r) = \varepsilon_e \left[ \frac{Z_{0a}(u_a)}{Z_{0a}(u_r)} \right]^2 \]  

(4.114)

Revised

\[ \varepsilon_{eff}(w/h, t, \epsilon_r) = \varepsilon_e(u_r, \epsilon_r) \left[ \frac{Z_{0a}(u_a)}{Z_{0a}(u_r)} \right]^2 \]  

(4.114)

Problem 4.3 p. 82

Old

...at the left-hand side of the 30 Ω line?

Revised

...at the left-hand side of the 30 Ω line at 1 GHz?

p. 87 - Sections 5.2.3 and 5.2.4

Old References to \( \omega_{c1} \) and \( \omega_{c2} \)

Revised Should be changed to \( \omega_1 \) and \( \omega_2 \) respectively. In addition the reference to \( \omega_c \) in Section 5.2.4 should be \( \omega_1 \). Consequently, the changes are as follows.

Old Section 5.2.3

...between the lower cutoff frequency, \( \omega_{c1} \), and the upper cutoff frequency, \( \omega_{c2} \). Between the lower and upper cutoff frequency is the center frequency, \( \omega \) defined by the geometric mean of \( \omega_{c1} \) and \( \omega_{c2} \).

Revised

6
... between the lower frequency, \( \omega_1 \), and the upper frequency, \( \omega_2 \). Between the lower and upper frequency is the center frequency, \( \omega_0 \), defined by the geometric mean of \( \omega_1 \) and \( \omega_2 \).

p. 88

Old

\[
H(s) = \frac{P(s)}{Q(s)} = \frac{a_0 + a_1 s + a_2 s^2 + \cdots + a_{m-1} s^{m}}{b_0 + b_1 s + b_2 s^2 + \cdots + b_{n-1} s^{n}}
\]  

(5.4)

Revised

\[
H(s) = \frac{P(s)}{Q(s)} = \frac{a_0 + a_1 s + a_2 s^2 + \cdots + a_m s^m}{b_0 + b_1 s + b_2 s^2 + \cdots + b_n s^n}
\]  

(5.4)

p. 88

Old polynomial \( m \) be equal to or less than the denominator polynomial \( n \), \( m < n \).

Revised polynomial \( m \) be equal to or less than the denominator polynomial \( n \).

p. 91

Old Since \( T_n(x) < 1 \) in the pass band, ...

Revised Since \( |T_n(x)| < 1 \) in the pass band, ...

p. 91

Old

\[
n = \frac{\text{arccosh} \left[ \frac{1}{\epsilon} \left( 10^{\alpha_{\text{max}}/10} - 1 \right)^{-1/2} \right]}{\text{arccosh} \left( \omega_s/\omega_c \right)}
\]  

(5.23)

Revised

\[
n = \frac{\text{arccosh} \left[ \frac{1}{\epsilon} \left( 10^{\alpha_{\text{min}}/10} - 1 \right)^{1/2} \right]}{\text{arccosh} \left( \omega_s/\omega_c \right)}
\]  

(5.23)

p. 93 First paragraph of Section 5.4.4

Old

\ldots [\text{arg} H(j\omega)] = -\omega T.

Revised

\ldots [\text{arg} H(j\omega)] = -\omega T.

p. 94 Middle of first paragraph of Section 5.4

Old

The elliptic function filter equal ripple response in both the pass band and in the stop band.

Revised

The elliptic function filter has equal ripple response in both the pass band and in the stop band.

p. 96

Old The dc transfer function is

\[
|\Gamma(0)|^2 = 1 - H_0
\]  

(5.47)
Revised The dc reflection coefficient is

$$|\Gamma(0)|^2 = 1 - H_0$$  \hspace{1cm} (5.47)

p. 97

Old

$$|H(\omega)| = \frac{H_0}{1 + \omega^6}$$  \hspace{1cm} (5.52)

Revised

$$|H(\omega)|^2 = \frac{H_0}{1 + \omega^6}$$  \hspace{1cm} (5.52)

p. 98

Old

$$Z_{in} = 20 \frac{2s^3 + 3.687s^2 + 3.423s + 1.599}{0s^3 + 0.313s^2 + 0.577s + 0.400s}$$  \hspace{1cm} (5.57)

Revised

$$Z_{in} = 20 \frac{2s^3 + 3.687s^2 + 3.423s + 1.599}{0s^3 + 0.313s^2 + 0.577s + 0.400}$$  \hspace{1cm} (5.57)

p. 98

Old

$$\frac{0.361s}{0.868s + 1.599 \left[ \frac{0.313s^2 + 0.577s + 0.400}{0.313s^2 + 0.577s} \right]}$$

Revised

$$\frac{0.361s}{0.868s + 1.599 \left[ \frac{0.313s^2 + 0.577s + 0.400}{0.313s^2 + 0.577s} \right]}$$

p. 99 $R_L \rightarrow R_G$

Old

\ldots to be changed from 1 to $R_L$, then all inductors and resistors should should be multiplied
by $R_L$, and all capacitors should be divided by $R_L$.

Revised

\ldots to be changed from 1 to $R_G$, then all inductors and resistors should should be multiplied
by $R_G$, and all capacitors should be divided by $R_G$.

p. 99 (5.58) - (5.60)

Old

$$L = R_L L_p$$  \hspace{1cm} (5.58)

$$C = \frac{C_p}{R_L}$$  \hspace{1cm} (5.59)

$$R = R_L R_p$$  \hspace{1cm} (5.60)
Revised

\[ L = R_G L_p \]  \hspace{1cm} (5.58)
\[ C = \frac{C_p}{R_G} \]  \hspace{1cm} (5.59)
\[ R = R_G R_p \]  \hspace{1cm} (5.60)

p. 101 Below equation (5.68)
Old
To verify this expression for the \( j\omega \) axis, Eq. (5.58) is rewritten as
Revised
To verify this expression for the \( j\omega \) axis, Eq. (5.68) is rewritten as

p. 102 Fig. 5.10
Old In the Band pass column:
\[ \frac{L}{\omega_0 W} \]
\[ \frac{C}{\omega_0 W} \]
Revised In the Band pass column:
\[ \frac{L}{\omega_0 w} \]
\[ \frac{C}{\omega_0 w} \]

p. 113
Old
\[ P_o = \frac{1}{2} |I_2|^2 R_L = \frac{1}{2} \left[ \frac{|V_g|^2 (1 + \cos \theta)^2 R_L}{2R_G(1 + \cos \theta) + R_L \cos \theta} \right]^2 + \left[ (R_G R_L + Z_0^2) \right] \sin^2 \theta \]  \hspace{1cm} (6.15)

Revised
\[ P_o = \frac{1}{2} |I_2|^2 R_L = \frac{1}{2} \left[ \frac{|V_g|^2 (1 + \cos \theta)^2 R_L}{2R_G(1 + \cos \theta) + R_L \cos \theta} \right]^2 + \left[ (R_G R_L + Z_0^2) \right] \sin^2 \theta \]  \hspace{1cm} (6.15)

p. 121 Problem 6.1
Old Determine the value of \( R_{in} \) in terms of \( R_{out} \).
Revised Determine the value of \( R_{in} \) in terms of \( R_L \).

p. 130
Old
\[(\Gamma_L + m^*)(\Gamma_L^* + m) = |\Gamma_L|^2 + \Gamma_L m + \Gamma_L^* m^* + |m|^2 + \frac{|S_{11}|^2 - 1}{|S_{22}|^2 - |\Delta|^2}\] (7.36)

Revised
\[(\Gamma_L + m^*)(\Gamma_L^* + m) = |m|^2 + \frac{|S_{11}|^2 - 1}{|S_{22}|^2 - |\Delta|^2}\] (7.36)

p. 133
Old
Below (7.53). By subtracting \(|S_{12}S_{21}|\) inside the parenthesis ...

Revised
By subtracting \(|S_{12}S_{21}|^2\) inside the parenthesis ...

p. 138 After (7.79)
Old
...by setting \(b_{fb} = b_{12a} = -2.3092\).

Revised
...by setting \(b_{fb} = b_{12a} = -2.3092 \cdot 10^{-3}\).

p. 141 Section 7.8
Old
However, eventually, the large the gate periphery ...

Revised
However, eventually, the large gate periphery ...

p. 179 Section 9.3 (9.35)
Old
\[i_C(\omega t) = \begin{cases} I_C - \hat{I}_C \sin(\omega t) & -\psi \leq \omega t \leq +\psi \\ 0 & \text{otherwise} \end{cases}\] (9.35)

Revised
\[i_C(\omega t) = \begin{cases} I_C - \hat{I}_C \sin(\omega t) & \frac{3\pi}{2} - \psi \leq \omega t \leq \frac{3\pi}{2} + \psi \\ 0 & \text{otherwise} \end{cases}\] (9.35)

p. 179 Section 9.3
Old
The point where quiescent current equals the total current is ...

Revised
The point where the total current = 0 is ...

p. 200 Section 10.3
Old
\[ y_{12f} = \frac{-1}{sL} \]  
\[ y_{12f} = y_{21f} = \frac{-1}{sL} \]  
\[ \text{Revised} \]

\[ \frac{v_o}{v_{gs}} = \frac{g_m + y_{12f}}{(1/R_D) + y_{22f}} \]  
\[ \text{Revised} \]

\[ \frac{v_o}{v_{gs}} = -\frac{g_m + y_{21f}}{(1/R_D) + y_{22f}} \]  
\[ \text{p. 200 Section 10.3} \]

\[ v_{gs} = g_m + y_{12f} \]
\[ v_{gs} = -g_m + y_{21f} \]  
\[ \text{Revised} \]

\[ a = \frac{v_o}{i_i} = \frac{v_o}{-v_{gs}y_{11f}} = -\frac{g_m + y_{12f}}{y_{11f}[(1/R_D) + y_{22f}]} \]  
\[ \text{Revised} \]

\[ a = \frac{v_o}{i_i} = \frac{v_o}{-v_{gs}y_{11f}} = \frac{g_m + y_{21f}}{y_{11f}[(1/R_D) + y_{22f}]} \]  
\[ \text{p. 201 Section 10.3} \]

\[ 1 = ay_{12f} = \frac{g_m + y_{12f}}{y_{11f}[(1/R_D) + y_{22f}]} \]  
\[ \text{Revised} \]

\[ 1 = ay_{12f} = \frac{g_m + y_{21f}}{y_{11f}[(1/R_D) + y_{22f}]} \]  
\[ \text{p. 212} \]

\[ 0 = [R(\omega) + R_d(A)] \frac{dX}{d\omega} - [X(\omega) + X_d(A)] + \left| \frac{dZ(\omega)}{d\omega} \right|^2 \frac{1}{A} \frac{dA}{dt} \]  
\[ 0 = [X(\omega) + X_d(A)] \frac{dX}{d\omega} + [R(\omega) + R_d(A)] + \left| \frac{dZ(\omega)}{d\omega} \right|^2 \frac{d\phi}{dt} \]
Revised

\[ 0 = [R(\omega) + R_d(A)] \frac{dX}{d\omega} - [X(\omega) + X_d(A)] \frac{dR}{d\omega} + \left| \frac{dZ(\omega)}{d\omega} \right|^2 \frac{1}{A} \frac{dA}{dt} \] (10.50)

\[ 0 = [X(\omega) + X_d(A)] \frac{dX}{d\omega} + [R(\omega) + R_d(A)] \frac{dR}{d\omega} + \left| \frac{dZ(\omega)}{d\omega} \right|^2 \frac{2}{d\phi}{dt} \] (10.51)

p. 212

Old

\[ R(\omega_0) + R_d(A) = R(\omega_0) + R_d(A_0) + \delta A \frac{dR_d(A)}{dA} \]
\[ = \delta A \frac{dR_d(A)}{dA} \] (10.53)

\[ X(\omega_0) + X_d(A) = \delta A \frac{dX_d(A)}{dA} \] (10.54)

Revised

\[ R(\omega_0) + R_d(A) = R(\omega_0) + R_d(A_0) + \delta A \frac{\partial R_d(A)}{\partial A} \]
\[ = \delta A \frac{\partial R_d(A)}{\partial A} \] (10.53)

\[ X(\omega_0) + X_d(A) = \delta A \frac{\partial X_d(A)}{\partial A} \] (10.54)

p. 213

Old

\[ 0 = \delta A \frac{dR_d(A)}{dA} \frac{dX(\omega)}{d\omega} - \delta A \frac{dX_d(A)}{dA} \frac{dR(\omega)}{d\omega} + \left| \frac{dZ(\omega)}{d\omega} \right|^2 \frac{1}{A_0} \frac{d\delta A}{dt} \] (10.55)

Revised

\[ 0 = \delta A \frac{\partial R_d(A)}{\partial A} \frac{dX(\omega)}{d\omega} - \delta A \frac{\partial X_d(A)}{\partial A} \frac{dR(\omega)}{d\omega} + \left| \frac{dZ(\omega)}{d\omega} \right|^2 \frac{1}{A_0} \frac{d\delta A}{dt} \] (10.55)

p. 213

Old
\[ S \triangleq \frac{\partial R_d(A)}{\partial A} \frac{dX(\omega)}{d\omega} - \frac{\partial X_d(A)}{\partial A} \frac{dR(\omega)}{d\omega} > 0 \] (10.57)

Revised

\[ S \triangleq \frac{\partial R_d(A)}{\partial A} \frac{dX(\omega)}{d\omega} - \frac{\partial X_d(A)}{\partial A} \frac{dR(\omega)}{d\omega} > 0 \] (10.57)

p. 214

Old

\[ S' \triangleq \frac{\partial X_d(\phi)}{\partial \phi} \frac{dX(\omega)}{d\omega} + \frac{\partial X_d(\phi)}{\partial \phi} \frac{dR(\omega)}{d\omega} > 0 \] (10.59)

Revised

\[ S' \triangleq \frac{\partial X_d(\phi)}{\partial \phi} \frac{dX(\omega)}{d\omega} + \frac{\partial R_d(\phi)}{\partial \phi} \frac{dR(\omega)}{d\omega} > 0 \] (10.59)

p. 214

Old

... Taylor series approximation for a change in phase.

Revised

... Taylor series approximation for a change in phase. The corresponding \( \alpha' = \alpha A_0 \).

p. 222

Old

\[ I(t) = I_s e^{V_{DC}/V_T} \left[ e^{V_p \cos \omega_p t} \cdot e^{V_1 \cos \omega_1 t} \right] \] (11.2)

Revised

\[ I(t) = I_s e^{V_{DC}/V_T} \left[ e^{V_p/V_T \cos \omega_p t} \cdot e^{V_1/V_T \cos \omega_1 t} \right] \] (11.2)

p. 223

Old
\[ I(t) = I_s e^{v_{DC}/V_T} \left[ I_0(V_p) + 2 \sum_{n=1}^{\infty} I_n(V_p) \cos n\omega_p t \right] \cdot \left[ I_0(V_1) + 2 \sum_{m=1}^{\infty} I_n(V_1) \cos m\omega_1 t \right] \]

\[ = I_D C e^{v_{DC}/V_T} I_0(V_p) I_0(V_1) + 2I_D C e^{v_{DC}/V_T} \left( I_0(V_1) \sum_{n=1}^{\infty} I_n(V_p) \cos n\omega_p t + I_0(V_p) \sum_{m=1}^{\infty} I_m(V_1) \cos m\omega_1 t \right) \]

\[ + 4I_D C e^{v_{DC}/V_T} \left[ \sum_{n=1}^{\infty} I_n(V_p) \cos n\omega_p t \right] \cdot \left[ \sum_{m=1}^{\infty} I_m(V_1) \cos m\omega_1 t \right] \quad (11.4) \]

Revised

\[ I(t) = I_s e^{v_{DC}/V_T} \left[ I_0(V_p/V_T) + 2 \sum_{n=1}^{\infty} I_n(V_p/V_T) \cos n\omega_p t \right] \cdot \left[ I_0(V_1/V_T) + 2 \sum_{m=1}^{\infty} I_n(V_1/V_T) \cos m\omega_1 t \right] \]

\[ = I_D C e^{v_{DC}/V_T} I_0(V_p/V_T) I_0(V_1/V_T) + 2I_D C e^{v_{DC}/V_T} \left( I_0(V_1/V_T) \sum_{n=1}^{\infty} I_n(V_p/V_T) \cos n\omega_p t + I_0(V_p/V_T) \sum_{m=1}^{\infty} I_m(V_1/V_T) \cos m\omega_1 t \right) \]

\[ + 4I_D C e^{v_{DC}/V_T} \left[ \sum_{n=1}^{\infty} I_n(V_p/V_T) \cos n\omega_p t \right] \cdot \left[ \sum_{m=1}^{\infty} I_m(V_1/V_T) \cos m\omega_1 t \right] \quad (11.4) \]

p. 225

Old

\[ \mathcal{F}(e^{-j\omega_a}) = 2\pi \delta(\omega - \omega_a) \quad (11.11) \]

Revised

\[ \mathcal{F}(e^{-jf_a}) = \delta(f - f_a) \quad (11.11) \]

p. 243

Old

\[ = \frac{1}{G_T} \cdot \frac{G_T(T_G + T_n)}{T_G} \]

\[ = \left(1 + \frac{T_n}{T_G}\right) \quad (11.35) \]

Revised
\[
\frac{1}{G_T} \cdot \frac{G_T(T_G + T_{in})}{T_G} = \left(1 + \frac{T_{in}}{T_G}\right)
\]

(11.35)

p. 244, three lines above (11.36)

Old
... then this will designated as \( N_{SSB} \).

Revised
... then this is designated as \( N_{SSB} \).

p. 246

Old
This illustrates the oft-stated difference between ...

Revised
This illustrates the oft-stated difference between ...

p. 246, problem 11.1

Old
11.1 Using the Fourier Transform pair, show that \( \mathcal{F}(e^{-j\omega t}) = 2\pi \delta(\omega - \omega_0) \).

Revised
11.1 Using the Fourier Transform pair, show that \( \mathcal{F}(e^{-j\omega t}) = \delta(\omega - \omega_0) \).

p. 255

Old

\[
f(t) = \frac{1}{2\pi i} \int_{\infty}^{\infty} F(s)e^{st}dt, \quad \Re s > 0
\]

(12.13)

Revised

\[
f(t) = \frac{1}{2\pi i} \lim_{\beta \to \infty} \int_{\gamma - i\beta}^{\gamma + i\beta} F(s)e^{st}dt, \quad \Re s > 0
\]

(12.13)

p. 256

Old

\[
\frac{d\phi_2(t)}{dt} = \omega_0 + \frac{K_m V_a V_b}{2} \int_{0}^{t} f(t - \mu) \cos \Delta \phi(\mu)
\]

(12.14)

Revised

\[
\frac{d\phi_2(t)}{dt} = \omega_0 + K_{vco} V_{tune-0} + \frac{K_{vco} K_m V_a V_b}{2} \int_{0}^{t} f(t - \mu) \cos \Delta \phi(\mu) d\mu
\]

(12.14)
\[ \frac{d\Delta \phi}{dt} \triangleq \frac{d\phi_1}{dt} - \omega_0 - \frac{K_m V_a V_b}{2} \int_0^t f(t - \mu) \cos \Delta \phi(\mu) d\mu \] (12.15)

Revised

\[ \frac{d\Delta \phi}{dt} \triangleq \frac{d\phi_1}{dt} - \omega_0 - K_{vco} V_{tune-0} - \frac{K_{vco} K_m V_a V_b}{2} \int_0^t f(t - \mu) \cos \Delta \phi(\mu) d\mu \] (12.15)

p. 256

Old

\[ \psi_1(t) \triangleq \phi_1(t) - \omega_0 t \] (12.16)

\[ \psi_2(t) \triangleq \phi_2(t) - \omega_0 t \] (12.17)

Revised

\[ \psi_1(t) \triangleq \phi_1(t) - (\omega_0 + K_{vco} V_{tune-0}) t \] (12.16)

\[ \psi_2(t) \triangleq \phi_2(t) - (\omega_0 + K_{vco} V_{tune-0}) t \] (12.17)

p. 256

Old

\[ \frac{d\Delta \phi}{dt} = \frac{d\psi_1}{dt} - \frac{K_m V_a V_b}{2} \int_0^t f(t - \mu) \cos \Delta \phi(\mu) d\mu \] (12.18)

Revised

\[ \frac{d\Delta \phi}{dt} = \frac{d\psi_1}{dt} - \frac{K_{vco} K_m V_a V_b}{2} \int_0^t f(t - \mu) \cos \Delta \phi(\mu) d\mu \] (12.18)

p. 256

Old

by a small amount, \( \cos(\Delta \phi + 90^\circ) \approx \Delta \phi \).

Revised

by a small amount, \( \cos(\Delta \phi - 90^\circ) \approx \Delta \phi \).
\[ K = \frac{K_m V_a V_b}{2} \]  \hspace{1cm} (12.20)

Revised

\[ K = \frac{K_{vco} K_m V_a V_b}{2} \]  \hspace{1cm} (12.20)

p. 257 after (12.23)

Old

where \( G(s) = \frac{V_a V_b K_m}{2F(s)/s} \).

Revised

where \( G(s) = KF(s)/s \).

p. 258

Old

\[ \Delta \tilde{\phi}(s) = \frac{1}{K/s} \left[ \frac{\omega - \omega_0}{s^2} + \frac{\phi_0}{s} \right] \]  \hspace{1cm} (12.28)

Revised

\[ \Delta \tilde{\phi}(s) = \frac{s}{s + K} \left[ \frac{\omega - \omega_0}{s^2} + \frac{\phi_0}{s} \right] \]  \hspace{1cm} (12.28)

p. 260

Old

\[ V_e = \frac{4}{-100} = -50 \text{ mV} \]  \hspace{1cm} (12.36)

Revised

\[ V_e = \frac{5}{-100} = -50 \text{ mV} \]  \hspace{1cm} (12.36)

p. 262 center of page

Old

... the VCO tuning voltage will now be 8 volts. With a gain of ...

Revised

... the VCO tuning voltage will now be 8 volts. This is found from \( f_{\text{ref}} = K_{vco} \cdot V_{\text{tune}} + f_0 \) where \( V_{\text{tune}0} = 5 \) gives \( f_0 = 95 \text{ MHz} \). Thus when \( f_{\text{ref}} = 103 \text{ MHz} \), \( V_{\text{tune}} \) must be 8 volts. With a gain of ...

p. 262 next paragraph

Old

This represents an angular difference of \( \Delta \phi = \arccos(V_e/0.5 \cdot 1.0) = 99.7^\circ \) in contrast to \( 95.7^\circ \) found earlier when the reference frequency was 100 MHz.
Revised

This represents an angular difference of $\Delta \phi = \arccos\left(\frac{V_e}{0.5 \cdot 1.0}\right) = 99.2^\circ$ in contrast to $95.7^\circ$ found earlier when the reference frequency was 100 MHz.

p. 265 below (12.41)

Old

In either case, when the gain, $G(s)$, is large, $|H(s)| \approx N$.

Revised

In (12.40) $G(s) = \frac{K_{pd}K_{vco}F(s)}{s}$, and for (12.41) $G(s) = -\frac{K_{pd}K_{vco}F(s)}{s}$. In either case, when the gain, $G(s)$, is large, $|H(s)| \approx N$.

p. 265

Old

For a type 1 PLL, $R_p \to \infty$ and

Revised

For a type 2 PLL, $R_p \to \infty$ and

p. 266

Old

\[
H(s) = -\frac{\frac{K_{pd}K_{vco}(R_p + sR_s)R_p}{C(R_p + R_s)}}{s^2 + s\left[\frac{1}{C(R_p + R_s)} + \frac{K_{pd}K_{vco}R_pR_s}{NR_{in}(R_p + R_s)}\right] + \frac{K_{pd}K_{vco}R_p}{NR_{in}C(R_p + R_s)}}
\]

Revised

\[
H(s) = \frac{\frac{K_{pd}K_{vco}(1 + sR_s)R_p}{R_{in}/[C(R_p + R_s)]}}{\{s^2 + s\{1 + CR_pR_sK_{pd}K_{vco}/(R_{in}N)\}/[C(R_p + R_s)]\} + K_{pd}K_{vco}R_p/[R_{in}NC(R_p + R_s)]}
\]

p. 267

Old

\[
R_p = \frac{1}{K_{pd}K_{vco}C} \left[\frac{2\zeta K_{pd}K_{vco}}{\omega_n} + \frac{K_{pd}K_{vco}F_{dc}}{N\omega_n^2} - \frac{N}{F_{dc}}\right]
\]

\[
= \frac{1}{K_tC} \left[\frac{2\zeta K_t}{\omega_n} + \frac{K_t^2F_{dc}}{N\omega_n^2} - \frac{1}{F_{dc}}\right]
\]

Revised
\[ R_p = \frac{1}{K_i C} \left[ \frac{2\zeta K_t}{\omega_n} + \frac{K_i^2 F_{dc}}{\omega_n^2} + \frac{C}{F_{dc}} \right] \] (12.55)

**p. 267 below (12.57)**

**Old**
The –3 dB gain frequency for a damping of 1.0 is 2.4 Hz. If a –3 dB frequency of 50 kHz were required with a damping of 1.0, then a natural frequency of 20.833 kHz would be chosen.

**Revised**
The –3 dB frequency is found by setting \(|H(s)/H(0)|^2 = 1/2\) and solving for \(\omega/\omega_n\). It is assumed in doing this that only the denominator terms are frequency dependent. The –3 dB gain frequency, \(f\), for a damping of 1.0 is 0.6436 times the natural frequency. If a –3 dB frequency of 50 kHz were required with a damping of 1.0, then a natural frequency of 77.889 kHz would be chosen.

**p. 268**

**Old**
Design equations can be developed for a noninverting loop filter like that shown in Fig. 12.5.

**Revised**
Design equations can be developed for a loop filter like that shown in Fig. 12.8b.

**p. 268**

**Old**

\[
F(s) = 1 + \frac{R_p}{R_{in}} \left( R_s + \frac{1}{sC} \right) \\
= 1 + \frac{R_p}{R_{in}} + sC \left( \frac{R_p R_s}{R_{in}} + R_p + R_s \right) \\
= \frac{1 + sC(R_p + R_s)}{1 + sC(R_p + R_s)}
\] (12.58)

**Revised**

\[
F(s) = 1 + \frac{R_p}{R_{in}} \left[ R_s + \frac{1}{sC} \right] \\
= 1 + \frac{R_p}{R_{in}} \left[ R_s + \frac{R_p R_s}{R_{in}} + R_p + R_s \right] \\
= \frac{1 + R_p / R_{in} + sC[R_p R_s / R_{in} + R_p + R_s]}{1 + sC(R_p + R_s)}
\] (12.58)

**p. 268**

**Old**
The closed loop gain is found by substituting Eq. (12.58) into Eq. (12.37) while making use Eq. (12.50).
The closed loop gain is found by substituting Eq. (12.58) into Eq. (12.37) while making use of Eq. (12.43) and Eq. (12.50).

\[ H(s) = \frac{NK_t \left[ 1 + \frac{R_p}{R_s} + sC \left( \frac{R_p R_s}{R_{in}} + R_p + R_s \right) \right]}{s \left[ 1 + sC(R_p + R_s) \right] + \left[ 1 + \frac{R_p}{R_{in}} + sC \left( 1 + \frac{R_p R_s}{R_{in}} + R_p + R_s \right) \right] K_t} \]  
\[ \text{(12.59)} \]

\[ = \frac{NK_t}{C(R_p + R_s)} \left\{ 1 + \frac{R_p}{R_s} + sC \left( \frac{R_p R_s}{R_{in}} + R_p + R_s \right) \right\} \frac{1}{s^2 + s \left[ \frac{1}{C(R_p + R_s)} + \frac{R_p R_s K_t}{(R_p + R_s) R_{in}} + K_t \right] + \frac{R_{in} + R_p K_t}{R_p + R_s} C} \]  
\[ \text{(12.60)} \]

then substitution gives

\[ 0 = R_p^2 (K_t^2 - CK_t R_{in} \omega_n^2) + R_p 2K_t R_{in} (K_t \zeta - \omega_n) + R_{in}^2 (\omega_n^2 + K_t^2 - 2\zeta K_t \omega_n) \]  
\[ \text{(12.65)} \]
\[ a = K_t^2 - CK_t R_{in} \omega_n^2 \]  
(12.66)

\[ b = 2K_t R_{in}(K_t \zeta - \omega_n) \]  
(12.67)

\[ c = R_{in}^2(\omega_n^2 + K_t^2 - 2\zeta K_t \omega_n) \]  
(12.68)

Then

\[ R_p = \frac{-b + \sqrt{b^2 - 4ac}}{2a} \]  
(12.69)

Revised

\[ 0 = R_p^2(K_t^2 - CK_t R_{in} \omega_n^2) \]

\[ + R_p 2K_t R_{in}(K_t - \zeta \omega_n) + R_{in}^2(\omega_n^2 - 2\zeta K_t \omega_n) \]  
(12.65)

so that if

\[ a = K_t^2 - CK_t R_{in} \omega_n^2 \]  
(12.66)

\[ b = 2K_t R_{in}(K_t - \zeta \omega_n) \]  
(12.67)

\[ c = R_{in}^2(\omega_n^2 - 2\zeta K_t \omega_n) \]  
(12.68)

then

\[ R_p = \frac{-b + \sqrt{b^2 - 4ac}}{2a} \]  
(12.69)

p. 293

Old Table D.1 S-Parameter Conversion Chart.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>((1 + S_{11})(1 - S_{22}) + S_{12}S_{21})</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>(Z_0(1 + S_{11})(1 + S_{22}) - S_{12}S_{21})</td>
<td>(2S_{21})</td>
</tr>
<tr>
<td>C</td>
<td>(\frac{1}{Z_0}(1 - S_{11})(1 - S_{22}) - S_{12}S_{21})</td>
<td>(2S_{21})</td>
</tr>
<tr>
<td>D</td>
<td>(\frac{1}{Z_0}(1 - S_{11})(1 + S_{22}) - S_{12}S_{21})</td>
<td>(2S_{21})</td>
</tr>
</tbody>
</table>

Revised

Table D.1 S-Parameter Conversion Chart.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>((1 + S_{11})(1 - S_{22}) + S_{12}S_{21})</td>
<td></td>
</tr>
<tr>
<td>A</td>
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<td></td>
</tr>
<tr>
<td>B</td>
<td>(Z_0(1 + S_{11})(1 + S_{22}) - S_{12}S_{21})</td>
<td>(2S_{21})</td>
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<tr>
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<td>(\frac{1}{Z_0}(1 - S_{11})(1 - S_{22}) - S_{12}S_{21})</td>
<td>(2S_{21})</td>
</tr>
<tr>
<td>D</td>
<td>(\frac{1}{Z_0}(1 - S_{11})(1 + S_{22}) + S_{12}S_{21})</td>
<td>(2S_{21})</td>
</tr>
</tbody>
</table>
...\(Z_s\), \(Z_g\), or \(Z_d\). The incident and scattered waves from the three-port ...

Revised

...\(Z_s\), \(Z_g\), or \(Z_d\). For example, \(r_s = a_2/b_2\) in Fig. E.1 or \(b_2 = a_2/r_s\). This is substituted in the appropriate place in the following equations. The incident and scattered waves from the three-port ...

p. 296 Appendix E

Old

When one of the ports is terminated with \(r_i\), then the circuit ...

Revised

When one of the ports is terminated with \(Z_0\), then the circuit ...

p. 301 Appendix F

Old

Thermal voltage

\[
V_T = \frac{kT}{q} = 0.259\text{ V}
\]

Revised

Thermal voltage

\[
V_T = \frac{kT}{q} = 0.0259\text{ V}
\]

p. 302 - 303 Appendix F

Old Sign of \(V_A\) should conform with Spice usage.

Junction Field Effect Transistor Parameters (JFET)

<table>
<thead>
<tr>
<th>Description</th>
<th>Formula</th>
</tr>
</thead>
</table>
| Saturated drain current           | \( \begin{align*}
I_D &= I_{DSS} \left( 1 - \frac{V_{GS}}{V_P} \right)^2 \left( 1 - \frac{V_{DS}}{V_A} \right) \\
V_{DS} &\geq V_{GS} - V_P
\end{align*} \) |
| Ohmic region drain current        | \( \begin{align*}
I_D &= G_o \left[ V_{DS} + \frac{3}{2} \left( \psi_0 + V_{GS} - V_{DS} \right)^{3/2} - \left( \psi_0 + V_{PS} \right)^{3/2} \right] \\
V_{DS} &< V_{GS} - V_P \\
G_o &= \frac{2aW}{L} \sigma_c \\
I_D &\approx K \left[ 2(V_{GS} - V_P)V_{DS} - V_{DS}^2 \right]
\end{align*} \) |
Transconductance
\[ g_m = \frac{2I_{DSS}}{V_P} \left(1 - \frac{V_{GS}}{V_P}\right) \]

Output resistance
\[ r_o = \frac{V_A}{I_D} \]

Gate source capacitance
\[ C_{gs} = \frac{C_{gs0}}{\left(1 - \frac{V_{GS}}{\psi_0}\right)^{1/3}} \]

Gate drain capacitance
\[ C_{gd} = \frac{C_{gd0}}{\left(1 - \frac{V_{GD}}{\psi_0}\right)^{1/3}} \]

Gate substrate capacitance
\[ C_{gss} = \frac{C_{gss0}}{\left(1 - \frac{V_{GSS}}{\psi_0}\right)^{1/2}} \]

N Channel JFET
\[ V_P < 0 \]

P Channel JFET
\[ V_P > 0 \]

**Metal Oxide Semiconductor Field Effect Transistor Parameters (MOSFET)**

<table>
<thead>
<tr>
<th>Description</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saturation region drain current</td>
<td>[ I_D = \frac{\mu C_{ox} W}{2L} \left(V_{GS} - V_t\right)^2 \left(1 - \frac{V_{DS}}{V_A}\right) ]</td>
</tr>
<tr>
<td>( V_{DS} \geq V_{GS} - V_t )</td>
<td></td>
</tr>
<tr>
<td>Ohmic region drain current</td>
<td>[ I_D = \frac{\mu C_{ox} W}{2L} \left[2(V_{GS} - V_t)V_{DS} - V_{DS}^2\right] \left(1 - \frac{V_{DS}}{V_A}\right) ]</td>
</tr>
<tr>
<td>( V_{DS} &lt; V_{GS} - V_t )</td>
<td></td>
</tr>
<tr>
<td>Oxide capacitance</td>
<td>[ C_{ox} = \frac{\epsilon_{ox}}{t_{ox}} ]</td>
</tr>
<tr>
<td>Transconductance</td>
<td>[ g_m = \mu C_{ox} \frac{W}{L} \left(V_{GS} - V_t\right) ]</td>
</tr>
<tr>
<td>Output resistance</td>
<td>[ r_o = \frac{</td>
</tr>
<tr>
<td>Input capacitance</td>
<td>[ C_{in} = C_{GS} + C_{GD} = C_{ox}LW ]</td>
</tr>
<tr>
<td>Transition frequency</td>
<td>[ f_c = \frac{g_m}{2\pi C_{in}} = \frac{\mu_s(V_{GS} - V_t)}{2\pi L^2} ]</td>
</tr>
<tr>
<td>Surface mobility Holes</td>
<td>( \mu_s = \frac{200cm^2}{(V - sec)} )</td>
</tr>
<tr>
<td>Surface mobility Electrons</td>
<td>( \mu_s = \frac{450cm^2}{(V - sec)} )</td>
</tr>
</tbody>
</table>

**Revised** Sign of \( V_A \) should conform with Spice usage.

**Junction Field Effect Transistor Parameters (JFET)**
### Description

<table>
<thead>
<tr>
<th>Description</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saturated drain current</td>
<td>( I_D = I_{DSS} \left( 1 - \frac{V_{GS}}{V_P} \right)^2 \left( 1 + \frac{V_{DS}}{V_A} \right) \quad V_A &gt; 0 )</td>
</tr>
<tr>
<td>Ohmic region drain current</td>
<td>( I_D = G_0 \left[ V_{DS} + \frac{3 (\psi_0 + V_{GS} - V_{DS})^{3/2} - (\psi_0 + V_{GS})^{3/2}}{(\psi_0 + V_P)^{1/2}} \right] ) ( V_{DS} &lt; V_{GS} - V_P )</td>
</tr>
<tr>
<td>Gate source capacitance</td>
<td>( C_{gs} = \frac{C_{gs0}}{(1 - \frac{V_{GS}}{\psi_0})^{1/3}} )</td>
</tr>
<tr>
<td>Gate drain capacitance</td>
<td>( C_{gd} = \frac{C_{gd0}}{(1 - \frac{V_{GD}}{\psi_0})^{1/3}} )</td>
</tr>
<tr>
<td>Gate substrate capacitance</td>
<td>( C_{gss} = \frac{C_{gss0}}{(1 - \frac{V_{GSS}}{\psi_0})^{1/2}} )</td>
</tr>
<tr>
<td>Output resistance</td>
<td>( r_o = \frac{V_A}{I_D} )</td>
</tr>
<tr>
<td>Transconductance</td>
<td>( g_m = \frac{2I_{DSS}}{V_P} \left( 1 - \frac{V_{GS}}{V_P} \right) )</td>
</tr>
<tr>
<td>N Channel JFET</td>
<td>( V_P &lt; 0 )</td>
</tr>
<tr>
<td>P Channel JFET</td>
<td>( V_P &gt; 0 )</td>
</tr>
</tbody>
</table>

### Metal Oxide Semiconductor Field Effect Transistor Parameters (MOSFET)

<table>
<thead>
<tr>
<th>Description</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saturation region drain current</td>
<td>( I_D = \frac{\mu C_{ox} W}{2L} (V_{GS} - V_t)^2 \left( 1 + \frac{V_{DS}}{V_A} \right) \quad V_A &gt; 0 )</td>
</tr>
<tr>
<td>Ohmic region drain current</td>
<td>( I_D = \frac{\mu C_{ox} W}{2L} \left[ 2(V_{GS} - V_t)V_{DS} - V_D^2 \right] \left( 1 + \frac{V_{DS}}{V_A} \right) ) ( V_{DS} &lt; V_{GS} - V_t )</td>
</tr>
<tr>
<td>Oxide capacitance</td>
<td>( C_{ox} = \frac{\varepsilon_{ox}}{l_{ox}} )</td>
</tr>
<tr>
<td>Transconductance</td>
<td>( g_m = \mu C_{ox} \frac{W}{L} (V_{GS} - V_t) )</td>
</tr>
</tbody>
</table>

24
Output resistance \[ r_o = \frac{|V_A|}{I_{D0}} \]

Input capacitance \[ C_{in} = C_{GS} + C_{GD} = C_{ox}LW \]

Transition frequency \[ f_c = \frac{g_m}{2\pi C_{in}} = \frac{\mu_s(V_{GS} - V_t)}{2\pi L^2} \]

Surface mobility Holes \[ \mu_s = 200 cm^2/(V - sec) \]
Surface mobility Electrons \[ \mu_s = 450 cm^2/(V - sec) \]

p. 304 Appendix F

Old
The word “Common” misspelled and some equations revised.

Revised
MOSFET

Common Source
\[ R_{in} = R_B = R_1 || R_2 \]
\[ R_{out} = R_D || r_0 \]
\[ A_V = -g_m (r_0 || R_D || R_L) \propto \frac{1}{\sqrt{A_D}} \]

Source Degeneration
\[ R_{in} = R_B = R_1 || R_2 \]
\[ R_{out} = r_0 \left[ 1 + (g_m + g_{mb}) R_S \right] + R_S \]
\[ G_m = \frac{g_m}{1 + (g_m + g_{mb}) R_S + R_S/r_0} \]

Common Gate
\[ R_{in} = \frac{r_0 + R_D || R_L}{1 + (g_m + g_{mb}) r_0} \]
\[ \approx \frac{1}{g_m + g_{mb}} + \frac{R_D || R_L}{(g_m + g_{mb}) r_0} \]
\[ R_{out} = R_D || \left[ r_0 + R_S + R_S r_0 (g_m + g_{mb}) \right] \]
\[ G_m = g_m + g_{mb} \]

Common Drain (Source Follower)
\[ R_{in} = R_1 || R_2 \]
\[ R_{out} = \frac{r_0}{1 + r_0 (g_m + g_{mb})} \approx \frac{1}{g_m + g_{mb}} \]
\[ A_V = \frac{g_m r_0}{1 + r_0 (g_m + g_{mb}) + r_0/R_L} \]
\[ \approx \frac{1}{1 + g_{mb}/g_m} \approx 1 \]

BJT

Common Emitter
\[ R_{in} = (r_\pi + r_b) || R_B \approx r_\pi \]
\[ R_{out} = R_c || r_0 \]
\[ A_V = -g_m (R_c || r_0 || R_L) \]

Emitter Degeneration
\[ R_{in} = R_B || [r_\pi + R_E (\beta + 1)] \]
\[ \approx r_\pi (1 + g_m R_E) \]
\[ R_{out} = R_E || r_\pi + r_0 \left[ 1 + g_m (r_\pi || R_E) \right] \]
\[ \approx r_\pi (1 + g_m R_E) \]
\[ G_m = \frac{g_m}{1 + g_m R_E (1 + 1/\beta)} \]

Common Base
\[ R_{in} = \frac{r_0 + R_C || R_L}{1 + \frac{g_m}{g_0} \left[ R_C || R_L + (\beta_0 + 1) r_0 \right]} \]
\[ \approx \frac{\alpha_0}{g_m} + \frac{\alpha_0 R_C || R_L}{g_m r_0} \]
\[ R_{out} = R_C || \left[ \frac{r_0 + R_{gen} (1 + r_0 g_m / \alpha_0)}{1 + R_{gen} / r_\pi} \right] \]
\[ G_m = g_m \left( \frac{1}{1 + r_b / r_\pi} \right) \approx g_m \]
\[ A_V = g_m (R_C || R_L) \]
\[ A_I = \frac{g_m R_C}{R_C + R_L} \frac{R_{gen}}{1 + g_m R_{gen}} \approx g_m r_e = \alpha_0 \]

Common Collector (Emitter Follower)
\[ R_{in} = R_B || [r_\pi + r_b + (\beta + 1) (r_0 || R_E)] \]
\[ R_{out} = \frac{r_\pi + R_{gen} + r_b}{1 + \beta} \approx \frac{1}{g_m} + \frac{R_{gen} + r_b}{1 + \beta} \]
\[ A_V = \frac{1}{1 + \frac{R_{gen} + r_b + r_\pi}{(R_E || r_0)(\beta + 1)}} \approx 1 \]
Analysis of a circuit for S11 and S21
*
* R01 and R02 are input and output resistance levels.
* RL is the load resistance. The load may be supplemented
* with additional elements.
.PARAM R01=50, R02=50. RLOAD=50. IIN=-1/R01
.FUNC N(R01,R02) SQRT(R02/R01)
R01 1 0 R01
VIN 10 11 AC 1
*GI1 1 0 VALUE=-V(10,11)/R01
*GI1 1 0 10 11 "-1/R01"
E11 10 0 1 0 2
R11 11 0 1
Xcircuit 1 2 netname
RL 2 0 RLOAD
E21 21 0 VALUE=V(2)*2/N(R01,R02)
* n = SQRT(R02/R01)
*E21 21 0 2 0 "2/n"
R21 21 0 1
*
.SUBCKT netname "first_node" "last_node"
* Input side
* * *
* *
* Output side
.ENDS netname
* Code for S11 and S21
*.AC DEC "num" "f1" "f2"
.PROBE V(11) V(21)
.END

Revised

Include {...}

Analysis of a circuit for S11 and S21
*
* R01 and R02 are input and output resistance levels.
* RL is the load resistance. The load may be supplemented
* with additional elements.
.PARAM R01=50, R02=50. RLOAD=50. IIN={-1/R01}
.FUNC N(R01,R02) {SQRT(R02/R01)}
R01  1  0  {R01}
VIN  10  11  AC  1
GI1  1  0  VALUE={-V(10,11)/R01}
*GI1  1  0  10  11  "-1/R01"
E11  10  0  1  0  2
R11  11  0  1
Xcircuit  1  2  netname
RL  2  0  {RLOAD}
E21  21  0  VALUE={V(2)*2/N(R01,R02)}
*  n = SQRT(R02/R01)
*E21  21  0  2  0  "2/n"
R21  21  0  1
*  .SUBCKT netname  "first_node"  "last_node"
*  Input side
*  *
*  *
*  *
*  Output side
*  .ENDS  netname
*  Code for S11 and S21
*  .AC DEC "num"  "f1"  "f2"
*  .PROBE V(11)  V(21)
*  .END