$$\frac{D}{R} = \sqrt{3N} \qquad N = i^2 + ij + j^2 \qquad \frac{D}{R} = \left(M\frac{C}{I_c}\right)^{1/\alpha} \qquad S = \frac{4\pi\sigma\theta}{\lambda} \qquad v_p = \frac{\omega}{\beta}$$

$$\frac{W_r}{W_t} = G_t G_r \left(\frac{\lambda}{4\pi d}\right)^2 \left|1 + \rho e^{\theta j \Delta_\omega}\right| \qquad \frac{W_r}{W_t} = G_t G_r \left(\frac{\lambda}{4\pi d}\right)^2 \Delta_\omega^2 = G_t G_r \left(\frac{h_t h_r}{d^2}\right)^2$$

$$\alpha_0 = 20\log\left(\frac{h_t}{200\text{ m}}\right) + 10v\log\left(\frac{h_r}{3\text{ m}}\right) + G_{t(\text{dB})} + G_{r(\text{dB})} \qquad \begin{array}{l} v = 1, h_r < 3\text{ m} \\ v = 2, h_r \geq 3\text{ m} \end{array}$$

$$L = L_0 + A(f, d) - G_{area} - \alpha_0 \qquad L_0 = -20\log\left(\frac{\lambda}{4\pi d}\right) \qquad \frac{W_r}{W_t} = K\frac{G_t G_r h_t^2 h_r^v}{d^\alpha f^y}$$

$$L = 69.55 + 26.16\log f - 13.82\log h_t - A(h_r) + (44.9 - 6.55\log h_t)\log d$$

$$A(h_r) = \begin{cases} (1.1\log f - 0.7)h_r - (1.56\log f - 0.8) & \text{(small or medium city)} \\ 3.2\log^2(11.75h_r) - 4.97 & \text{(large city, f > 200 MHz)} \end{cases} \qquad R_c = \frac{N_c}{T}$$

$$\frac{W_{r_2}}{W_t} = \left(\frac{d_1}{d_0}\right)^{-\alpha_1}\left(\frac{d_2}{d_1}\right)^{-\alpha_2}\frac{W_{r_0}}{W_t} \qquad x = -h\sqrt{\frac{2}{\lambda}\left(\frac{1}{d_1} + \frac{1}{d_2}\right)} \qquad L(x) = \frac{1}{2\pi^2 x^2} \qquad x < -2.4$$

$$p(x) = \frac{1}{\sqrt{2\pi}\sigma_x}\exp-\left(\frac{(x - m_x)^2}{2\sigma_x}\right) \qquad r = \sqrt{x^2 + y^2} \qquad p(r) = \frac{r}{\sigma_x^2}e^{-\frac{r^2}{2\sigma_x^2}} \qquad m_r = \sqrt{\frac{\pi}{2}}\sigma_x$$

$$\sigma = \sqrt{2 - \frac{\pi}{2}}\sigma_x \qquad P(r \leq L) = 1 - e^{-\frac{L^2}{2\sigma_x^2}} \qquad p(r) = \frac{r}{\sigma_x^2}\exp\left(-\frac{r^2 + a^2}{2\sigma_x^2}\right)I_0\left(a\frac{r}{\sigma_x^2}\right)$$

$$v_g = \frac{d\omega}{d\beta} = \frac{v_p}{\left(1 - \frac{\omega}{v_p}\right)\left(\frac{dv_p}{d\omega}\right)} \qquad v_p' = v_p - v\cos\theta$$

$$\omega' = \beta v_p - \beta v\cos\theta = \omega - \omega_p$$

$$R_b < \frac{1}{2\pi\bar{T}} = B_c \qquad M = B\bar{T} + 1 \qquad e(t) = s(t)e^{j(\omega t + \psi_s(t) + \psi_r(t))} \qquad W_{\dot{\psi}_r} = 2\frac{v}{\lambda} = 2f_m$$

$$\rho_r(\tau, \Delta_\omega) = \frac{J_0^2(\omega_m\tau)}{1 + (\Delta_\omega\bar{T})^2} \qquad \rho_{eh}(\tau, \Delta_\omega) = \frac{J_1^2(\omega_m\tau)}{1 + (\Delta_\omega\bar{T})^2} \qquad R_c = \sqrt{2\pi}f_m\frac{R}{\sqrt{2}\sigma}e^{-\left(\frac{R}{\sqrt{2}\sigma}\right)^2}$$

$$\tau_{E_z} = \frac{1}{\sqrt{2\pi}f_m\left(\frac{R}{\sqrt{2}\sigma}\right)}\left[e^{\left(\frac{R}{\sqrt{2}\sigma}\right)^2} - 1\right] \qquad S_{E_z} = \frac{y}{\sqrt{1 - x^2}} \qquad y = 3\frac{W_0}{\omega_m} \qquad x = \frac{\omega - \omega_c}{\omega_m}$$

$p = 0.5e^{-\alpha\gamma_b}$ non-coherent $\quad p = 0.5\mathrm{erfc}(\sqrt{\alpha\gamma_b})$ coherent $\quad$ where $\alpha = 1$ PSK or $\alpha = 0.5$ FSK

$p = \frac{1}{2(1+\alpha\gamma_{b0})}$ non-coherent $\quad p = \frac{1}{2}\left[1 - \sqrt{\frac{\gamma_{b0}}{1+\gamma_{b0}}}\right]$ PSK $\quad p = \frac{1}{2}\left[1 - \sqrt{\frac{\gamma_{b0}}{2+\gamma_{b0}}}\right]$ FSK $\quad p = \frac{(M/2)^M}{2(\alpha\gamma_{b0})^M M!}$ coherent

$$p(N,m) = \binom{N}{m}(1-p)^{N-m}p^m \qquad p_{eM} = \sum_{m=t+1}^{N} p(N,m) = 1 - \sum_{m=0}^{t} p(N,m)$$

$$p_f = (1-p)^{N-d}p^d \qquad p' = \sum_{i=t+1}^{s} p(s,i) = \sum_{i=\frac{(s+1)}{2}}^{s} \binom{s}{i} p^i (1-p)^{s-i}$$

$$\mathrm{RFL} = \left(\frac{K}{0.3}\right)\log_{10}\left(\frac{f_2}{f_1}\right) \quad \mathrm{PL} = 10\log_{10}\left(\frac{d_1}{d_2}\right)^{\alpha} \quad \cos x \cos y = 0.5(\cos(x+y) + \cos(x-y))$$

$$\mathrm{ISIL} = 20\log_{10}\left(\frac{A}{a}\right) \quad \frac{a}{2} = \left(\frac{A}{2}\right)\cos(\pi\bar{T}R_b) \quad \hat{S}_n = \sum_{k=1}^{M} h_k S_{n-k} \quad \varepsilon_n = S_n - \hat{S}_n$$

$$S_n = \varepsilon_n + \sum_{k=1}^{M} h_k S_{n-k} \quad \tau_g = \tau_p + \bar{T} + \Delta_{\tau_g} + \tau_d \quad \eta = \frac{D}{D+P} \quad G_p = \frac{SNR_O}{SNR_I} = \frac{B_s}{B_u}$$

$$\frac{S}{I+N} = \frac{S}{(M-1)S+N} = \frac{S/N}{(M-1)(S/N)+1} = \frac{SNR_I}{(M-1)SNR_I+1} \qquad t \le \left\lfloor \frac{d_{min}-1}{2} \right\rfloor$$

$\mathbf{c = UG}$ $\quad$ $\mathbf{G = [P\ I_k]}$ $\quad$ $\mathbf{r = c + e}$ $\quad$ $\mathbf{H = [I_{n\text{-}k}\ P^T]}$ $\quad$ $\mathbf{e_i H^T = s}$ $\quad$ $\mathbf{e} = \min(\mathbf{w(e_i)})$

$\mathbf{s = rH^T = (c + e)H^T = (uG + e)H^T = eH^T}$