

## 1 Constant and Units

$h = 6.625 \times 10^{-34}$  J·s,  $q = 1.6 \times 10^{-19}$  C,  $k = 1.38 \times 10^{-23}$  J/K,  $c = 3 \times 10^8$  m/s  
 1 nW =  $10^{-9}$  W, 1  $\mu$  W =  $10^{-6}$  W

## 2 Equations

$$E = hf, \quad f = c/\lambda, \quad d = v \cdot t$$

$$Q \text{ [dB]} = 10 \log(Q), \quad \log(A \cdot B/C) = \log(A) + \log(B) - \log(C)$$

$$P = V \cdot I, \quad V = R \cdot I$$

$$p = \frac{P_t}{4\pi d^2}, \quad P_r = p \cdot A_{er} = \frac{(EIRP)A_{er}}{4\pi d^2}$$

$$\text{beamwidth} = \frac{k\lambda}{L}$$

$$G = 4\pi\eta \frac{A_e}{\lambda^2}, \quad P_r = \frac{P_t G_t G_r \lambda^2}{(4\pi)^2 d^2}$$

$$P = kTB, \quad S(f) = \frac{N_0}{2}, \quad S_y(f) = |H(f)|^2 S_x(f), \quad P_y = \int_{-\infty}^{\infty} S_y(f) df$$

$$\langle v^2 \rangle = \lim_{T \rightarrow \infty} \frac{1}{T} \int_{T/2}^{T/2} v^2(t) dt, \quad v_{rms} = \sqrt{\langle v^2 \rangle}, \quad kTB = \langle v^2 \rangle / 4R, \quad \langle v^2 \rangle = 4kTRB = 4N_0RB$$

$$P_{ao} = G_0 \cdot N_0 \cdot B = \frac{N_0}{2} \int_{-\infty}^{\infty} G(f) df, \quad G(f) = \frac{1}{1 + (f/f_{3dB})^{2n}}, \quad B = \frac{\frac{\pi}{2} f_{3dB}}{n \sin(\frac{\pi}{2n})}$$

$$P_{ao} = G_0 N_0 B F = kTB G_0 F = k(T_0 + T_e) B G_0, \quad F = 1 + \frac{T_e}{T_0}, \quad T_e = T_0(F - 1)$$

$$F = F_1 + \frac{F_2 - 1}{G_{01}} + \frac{F_3 - 1}{G_{01} G_{02}}, \quad T_e = T_{e1} + \frac{T_{e1}}{G_{01}} + \frac{T_{e3}}{G_{01} G_{02}}$$

$$P_r \approx \frac{P_t G_t G_r \lambda^2}{(4\pi)^2 L_{sys}} \left( \frac{4\pi h_t h_r}{\lambda} \right)^2 \frac{1}{d^4}$$

$$Pr[P_r|_{dB} > \bar{p}_r|_{dB}] = Q\left(\frac{p_r|_{dB} - \bar{P}_r|_{dB}}{\sigma_{path}}\right)$$

$$Pr[P_r|_{dB} \leq \bar{p}_r|_{dB}] = Q\left(\frac{\bar{P}_r|_{dB} - p_r|_{dB}}{\sigma_{path}}\right)$$

$$Q(x) = 1 - Q(-x)$$

$$f_{n-n} = \frac{1}{t_2 - t_1}$$

$$f_P(p) = \frac{1}{\sigma^2} e^{-p/\sigma^2}$$

$$-be^{-x/b} = \int e^{-x/b} dx$$

## Q-Function Table

$z$	$Q(z)$	$z$	$Q(z)$
0.0	0.50000	2.0	0.02275
0.1	0.46017	2.1	0.01786
0.2	0.42074	2.2	0.01390
0.3	0.38209	2.3	0.01072
0.4	0.34458	2.4	0.00820
0.5	0.30854	2.5	0.00621
0.6	0.27425	2.6	0.00466
0.7	0.24196	2.7	0.00347
0.8	0.21186	2.8	0.00256
0.9	0.18406	2.9	0.00187
1.0	0.15866	3.0	0.00135
1.1	0.13567	3.1	0.00097
1.2	0.11507	3.2	0.00069
1.3	0.09680	3.3	0.00048
1.4	0.08076	3.4	0.00034
1.5	0.06681	3.5	0.00023
1.6	0.05480	3.6	0.00016
1.7	0.04457	3.7	0.00011
1.8	0.03593	3.8	0.00007
1.9	0.02872	3.9	0.00005

The definition of  $Q$  function is:

$$Q(z) = \int_z^{\infty} \frac{1}{\sqrt{2\pi}} e^{-y^2/2} dy$$