

1 Constant and Units

$c = 3 \times 10^8$ m/s (in free space), $c = 2 \times 10^8$ m/s (in media)

$1 \text{ \AA} = 10^{-10}$ m

$1 \text{ \mu m} = 10^{-6}$ m

$1 \text{ m} = 10^{-3}$ km

$1 \text{ s} = 10^3$ ms

kbps = 10^3 bps

Mbps = 10^6 bps

KBps = 10^3 Bps (the simplifying relation we will use unless otherwise specified)

MBps = 10^6 Bps (the simplifying relation we will use unless otherwise specified)

2 Equations

2.1 Fourier Stuff

$$x(t) = \int_{-\infty}^{\infty} X(f)e^{j2\pi ft}df, X(f) = \int_{-\infty}^{\infty} x(t)e^{-j2\pi ft}dt$$

$$\mathcal{F}\{\text{rect}(t/T)\} = T\text{sinc}(fT) = T \sin(\pi fT)/\pi fT$$

$$\mathcal{F}\{\text{sinc}(t/T)\} = T\text{rect}(fT)$$

$$\mathcal{F}\{1 - |\tau|/T\} = T\text{sinc}^2(fT)$$

$$x(t) = \sum_{n=-\infty}^{\infty} c_n e^{j2\pi n f_o t}, c_n = \int_{-\infty}^{\infty} x(t) \exp(-j2\pi n f_o t) dt$$

2.2 Basic Signals and Systems Stuff

$$\int_{-\infty}^{\infty} x^2(t)dt = \int_{-\infty}^{\infty} |X(f)|^2 df$$

$$\psi_x(f) = |X(f)|^2, G_x(f) = \sum |c_n|^2 \delta(f - n f_o), G_x(f) = \lim_{T \rightarrow \infty} \frac{1}{T} |X_T(f)|^2$$

$$R_x(\tau) = \int_{-\infty}^{\infty} x(t)x(t+\tau)dt, R_x(\tau) = \lim_{T \rightarrow \infty} \frac{1}{T} \int_{-\infty}^{\infty} x(t)x(t+\tau)dt$$

$$\text{sinc}(1.4/\pi) \approx 0.707, \int_{-\infty}^{\infty} \text{sinc}(x)dx = 1$$

$$y(t) = x(t) * h(t) = \int_{-\infty}^{\infty} x(t-\tau)h(\tau)d\tau$$

$$H_{RC}(f) = \frac{1}{1 + j2\pi fRC}, f_{3dB} = 1/2\pi RC$$

$$z(mT) = \sum_{n=-N}^{n=N} c_n x(mT - nT)$$

2.3 Trig.

$$\sin(a+b) = \sin a \cos b + \cos a \sin b, \cos(a+b) = \cos a \cos b - \sin a \sin b$$

$$\sin(a \pm b) = \sin a \cos b \pm \cos a \sin b, \cos(a \pm b) = \cos a \cos b \mp \sin a \sin b$$

$$\sin 2a = 2 \sin a \cos a, \cos 2a = \cos^2 a - \sin^2 a = 2 \cos^2 a - 1, \cos^2 a = 0.5 + 0.5 \cos(2a)$$

$$\cos a = (e^{ja} + e^{-ja})/2, \sin a = (e^{ja} - e^{-ja})/j2, \tan a = \sin a / \cos a$$

2.4 Analog-to-Digital

$$\text{SNR [dB]} = 10 \log(\text{SNR})$$

$$\text{SNR}_q = \sigma_x^2 / (q^2/12), \text{SNR}_{q,dB} = 6.02b + 10.8 + 10 \log(\sigma_x^2 / V_{pp}^2), \text{SNR}_j = 3 / (\sigma_t^2 + f_H^2)$$

2.5 Probability

$$\begin{aligned}
 p_X(x) &= dF_X(x)/dx \\
 p_n(x) &= \frac{\exp\{-[(x-\mu)^2]/2\sigma^2\}}{\sqrt{2\pi\sigma^2}}, F_n(X > a) = Q((a-\mu)/\sigma) \\
 E[X^n] &= \int_{-\infty}^{\infty} x^n p(x) dx, \sigma_x^2 = E[(X-m_x)^2] = E[X^2] - m_x^2 \\
 G_x(f) &= \int_{-\infty}^{\infty} R_x(\tau) \exp[-j2\pi f\tau] d\tau, \sigma_x^2 = R_x(0) - m_x^2 \\
 &-(z-a_1)^2/2\sigma_o^2 + \ln P(s_1) \underset{H_2}{\overset{H_1}{\gtrless}} -(z-a_2)^2/2\sigma_o^2 + \ln P(s_2) \\
 P_B &= P(H_2|s_1)P(s_1) + P(H_1|s_2)P(s_2), P_B = Q\left(\sqrt{\frac{E_d}{2N_0}}\right)
 \end{aligned}$$

2.6 And All the Rest

$$\begin{aligned}
 SNR_T &= \frac{2}{N_0} \int_{-\infty}^{\infty} |S_f|^2 df, SNR_T = \frac{(a_1 - a_2)^2}{\sigma_0^2} \\
 \sum_{k=-\infty}^{k=\infty} P_r \left(f + \frac{k}{T} \right) &= T, P_{RC} = T \text{ for } 0 \leq |f| < (1-r)/2T \\
 P_{RC} &= \frac{T}{2} \left\{ 1 + \cos \left[\frac{\pi T}{r} \left(|f| + \frac{1-r}{2T} \right) \right] \right\} \text{ for } (1-r)/2T < |f| \leq (1+r)/2T \\
 P_{RC} &= 0 \text{ for } (1+r)/2T < |f|, p_{RC}(t) = \text{sinc}(t/T) \frac{\cos(\pi r t/T)}{1 - (2r t/T)^2} \\
 |H_r| &= \frac{k|P_r|^{0.5}}{G_n^{0.25}|H_c|^{0.5}}, |H_t| = \frac{(A/k)|P_r|^{0.5}G_n^{0.25}}{|H_c|^{0.5}} \\
 P_B &= Q \left\{ \sqrt{E_T} \left[\int_{-\infty}^{\infty} \frac{G_n^{0.5}|P_r|}{|H_c|} \right]^{-1} \right\}, E_T = \int_{-\infty}^{\infty} |H_t|^2 df \\
 1.21 &\approx \int_0^1 [1 + \cos(\pi x)][1 + (2x)^2]^{0.5} dx \\
 c &= (X^T X)^{-1} X^T z, c = \left(\frac{I}{SNR} + X^T X^{-1} \right) X^T z \\
 B_k(i, j) &= |z_k - s^{(i,j)}|^2 \\
 s_i(t) &= \sum_{j=1}^N a_{ij} \psi_j(t), a_{ij} = \int_{T_i}^{T_f} s_i \psi_j dt, \int_{T_i}^{T_f} \psi_i \psi_j dt = \delta_{ij} \\
 Q(x) &\approx \frac{1}{x\sqrt{2\pi}} \exp(-x^2/2) \text{ for } x > 3
 \end{aligned}$$

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