LE/CSE 4215 Formula & Data Sheet.

1 Names, Acronyms, Structures:

AMPS: Advanced Mobile Phone System **BPSK**: Binary Phase Shift Keying **BSC**: Base Station Controller **BSS**: Base Station Subsystem **BTS**: Base Transceiver Station **CC**: Country Code **CDMA**: Code Division Multiple Access **DSSS**: Direct Sequence Spread Spectrum **EDGE**: Enhanced Data for Global Evolution **FDD**: Frequency Division Duplexing **FDMA**: Frequency Division Multiple Access **FHSS**: Frequency Hopped Spread Spectrum **FSK**: Frequency Shift Keying **GFSK**: Gaussian FSK **GGSN**: Gateway GPRS Support Node **GMSC**: Gateway MSC **GMSK**: Gaussian Minimum Shift Keying **GPRS**: General Packet Radio Service **GR**: GPRS Register **GSM**: Global System for Mobile Communication **HLR**: Home Location Register **HSCSD**: High Speed Circuit Switched Data **IMSI**: International Mobile Subscriber Identity **IS**: Intermediate System **ISDN**: Integrated Services Digital Network **MCS**: Modulation and Coding Schemes **MS**: Mobile Station **MSC**: Mobile Switching Center **MSISDN**: Mobile Station ISDN **MU**: Mobile Unit **NDC**: National Destination Code **NSS**: Network and Switching Subsystem **OFDM**: Orthogonal Frequency Division Multiplexing **OSS**: Operation Subsystem **PDN**: Packet Data Network **PSTN**: Public Switched Telephone Network **RSS**: Radio Subsystem **RTT**: Round Trip Time **SIM**: Subscriber Identity Module **SGSN**: Serving GPRS Support Node **SN**: Subscriber Number **TDD**: Time Division Duplexing **TDMA**: Time Division Multiple Access **TMSI**: Temporary MSI **USDC**: United States Digital Cellular **VLR**: Visitor Location Register

2 Constant and Units

$c = 3 \times 10^8$ m/s (in free space), $c = 2 \times 10^8$ m/s (in media)
1 Å $= 10^{-10}$ m
1 μm $= 10^{-6}$ m
1 m $= 10^{-3}$ km
1 nm $= 10^{-9}$ m
1 s $= 10^3$ ms
kbps $= 10^3$ bps
Mbps $= 10^6$ bps
Gbps $= 10^9$ bps
kBps $= 2^{10}$ Bps
MBps $= 2^{20}$ Bps

3 Equations

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

$$< v^2 >= \lim_{T\to\infty} \frac{1}{T} \int_{T/2}^{T/2} v^2(t)\mathrm{d}t, \quad v_{rms} = \sqrt{< v^2 >}, \quad kTB =< v^2 > /4R, \quad < v^2 >= 4kTRB = 4N_0RB$$

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

$$P_{ao} = G_0 N_0 BF = kTBG_0 F = k(T_0 + T_e)BG_0, \quad F = 1 + \frac{T_e}{T_0}, \quad T_e = T_0(F - 1)$$

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

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

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

$$P_{p_{sens}}(d) = Q\left(\frac{p_{sens}|_{dB} - \bar{P}_r(d)|_{dB}}{\sigma_{path}}\right), P_{p_{sens}}(d) = Q\left(\frac{p_{sens}|_{dB} - \bar{P}_r(R)|_{dB} + 10\nu \log(d/R)}{\sigma_{path}}\right)$$

$$Q(x) = 1 - Q(-x), f_{n-n} = \frac{1}{t_2 - t_1}, f_P(p) = \frac{1}{\sigma^2} e^{-p/\sigma^2}, -be^{-x/b} = \int e^{-x/b} dx$$

$$f_A(a) = \frac{a}{\sigma^2} e^{-a^2/2\sigma^2}, m_A = \sigma\sqrt{\frac{\pi}{2}}, F_A(a) = \int_0^a f_A(\alpha)d\alpha = Pr\{A \le \alpha\}, f_P(p) = \frac{1}{\sigma^2} e^{-p/\sigma^2}$$

$$\sigma_d = \sqrt{\langle t_k^2 \rangle - \langle t_k \rangle^2}, \langle t_k \rangle = \sum_{i=1}^{M} p_i t_i / \sum_{i=1}^{M} p_i, \langle t_k^2 \rangle = \sum_{i=1}^{M} p_i t_i^2 / \sum_{i=1}^{M} p_i$$

$$\rho = \frac{1}{1 + 2\pi(f_2 - f_1)\sigma_d}, B_{coh} = \frac{1}{5\sigma_d}, f_d = \frac{v}{\lambda}\cos\theta, \rho = \mathrm{J}_0^2(2\pi f_d \tau), T_{coh} = \frac{9}{16\pi f_d}$$

$$\frac{S}{I} = \frac{1}{J}\left(\frac{D}{R}\right)^{\nu}, Q = D/R, u_2 - u_1 = i, v_2 - v_1 = j, \hat{D} = \sqrt{i^2 + j^2 + ij}, D = \sqrt{3}R \cdot \hat{D}$$

$$K_{cluster} = \frac{1}{3}\left(\frac{D}{R}\right)^2, K_{cluster} = \hat{D}^2, R_2 = \sqrt{3}R_1 = \sqrt{3}D, R_3 = 2D$$

$$A = \lambda\overline{H}, \mu = \frac{1}{\overline{H}}, A_c = (1 - P_b)A, P_b = \frac{A^K}{K!} / \sum_{n=0}^{K} \frac{A^n}{n!}, \xi = \frac{A_c}{K}$$

$$y(T_s) = \int_0^{\infty} r(\tau)h(T_s - \tau)\mathrm{d}\tau, y(T_s) = \int_0^{\infty} r(\tau)s(\tau)\mathrm{d}\tau = y(T_s) = \int_0^{T_s} r(\tau)h(T_s - \tau)\mathrm{d}\tau$$

$$Y_1 = \int_0^{T_s} s_1(t)[s_1(t) - s_{-1}(t)]\mathrm{d}t, Y_{-1} = \int_0^{T_s} s_{-1}(t)[s_1(t) - s_{-1}(t)]\mathrm{d}t, Y_1 - Y_{-1} = \int_0^{T_s} [s_1 - s_{-1}]^2\mathrm{d}t = E_{diff}$$

$$\sigma_n^2 = \frac{N_0}{2}E_{diff}, P_e = Q\left(\sqrt{\frac{E_{diff}}{2N_0}}\right), P_{e,polarNRZ} = Q\left(\sqrt{\frac{2E_b}{N_0}}\right), P_{e,unipolarNRZ} = Q\left(\sqrt{\frac{E_b}{N_0}}\right)$$

$$x(t) = x_I(t)\cos(2\pi f_c t) - x_Q(t)\sin(2\pi f_c t)$$

$$p_{coll2} = \frac{1}{q}(1 + \frac{1}{N_b}), p_{coll} = 1 - (1 - p_{coll2})^{K-1}$$

$$r(t) = A_1 m(t) p_1(t)\cos(2\pi f_c t) + A_2 p_2(t - t_d)\cos[2\pi f_c(t - t_d)] + n(t)$$

$$r_4(T_b) = \pm\frac{A_1}{2}T_b + \frac{A_2}{2}\cos(2\pi f_c t_d)\int_0^{T_b} p_1(t)p_2(t - t_d)dt + n_4$$

$$SNIR = 2\frac{T_b}{T_{chip}}\frac{1}{(K-1) + \frac{N_0}{P_s T_{chip}}}$$

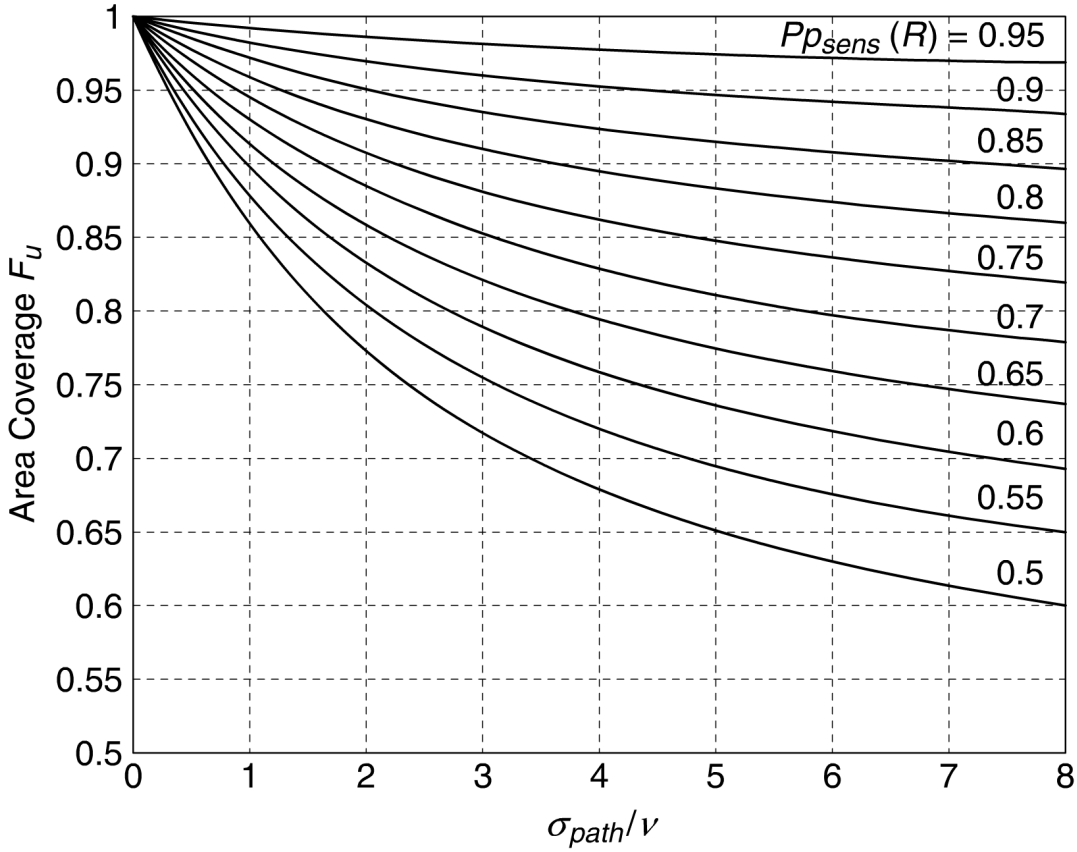
Q-Function Table

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:

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

	Grade of Service or Blocking Probability in Percent									
	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
K	A, Offered Load in Erlangs									
1	0.010	0.020	0.031	0.042	0.053	0.064	0.075	0.087		0.111
2	0.153	0.223	0.282	0.333	0.381	0.427	0.470	0.513	0.555	0.595
3	0.455	0.602	0.715	0.812	0.899	0.980	1.057	1.131	1.202	1.271
4	0.869	1.092	1.259	1.399	1.525	1.640	1.748	1.851	1.949	2.045
5	1.361	1.657	1.875	2.057	2.218	2.366	2.504	2.634	2.760	2.881
6	1.909	2.276	2.543	2.765	2.960	3.139	3.305	3.462	3.613	3.758
7	2.501	2.935	3.250	3.509	3.738	3.946	4.139	4.322	4.497	4.666
8	3.128	3.627	3.987	4.283	4.543	4.779	4.999	5.207	5.405	5.597
9	3.783	4.345	4.748	5.080	5.370	5.634	5.879	6.111	6.333	6.546
10	4.461	5.084	5.529	5.895	6.216	6.506	6.776	7.031	7.275	7.511
11	5.160	5.842	6.328	6.727	7.076	7.393	7.687	7.965	8.231	8.487
12	5.876	6.615	7.141	7.573	7.950	8.292	8.610	8.910	9.197	9.474
13	6.607	7.402	7.967	8.430	8.835	9.202	9.543	9.865	10.173	10.470
14	7.352	8.200	8.803	9.298	9.730	10.121	10.485	10.828	11.156	11.473
15	8.108	9.010	9.650	10.174	10.633	11.048	11.434	11.799	12.147	12.484
16	8.875	9.828	10.505	11.059	11.544	11.983	12.390	12.776	13.144	13.500
17	9.652	10.656	11.368	11.952	12.461	12.924	13.353	13.759	14.147	14.522
18	10.437	11.491	12.238	12.850	13.385	13.870	14.321	14.747	15.154	15.548
19	11.230	12.333	13.115	13.755	14.315	14.822	15.294	15.740	16.166	16.579
20	12.031	13.182	13.997	14.665	15.249	15.779	16.271	16.737	17.182	17.613
21	12.838	14.036	14.885	15.581	16.189	16.740	17.253	17.738	18.202	18.651
22	13.651	14.896	15.778	16.500	17.132	17.705	18.238	18.743	19.225	19.692
23	14.470	15.761	16.675	17.425	18.080	18.674	19.227	19.751	20.252	20.737
24	15.295	16.631	17.577	18.353	19.031	19.646	20.219	20.762	21.281	21.784
25	16.125	17.505	18.483	19.284	19.985	20.622	21.215	21.775	22.313	22.833
26	16.959	18.383	19.392	20.219	20.943	21.600	22.212	22.792	23.347	23.885
27	17.797	19.265	20.305	21.158	21.904	22.582	23.213	23.811	24.384	24.939
28	18.640	20.150	21.221	22.099	22.867	23.566	24.216	24.832	25.423	25.995
29	19.487	21.039	22.140	23.043	23.833	24.552	25.221	25.855	26.464	27.053
30	20.337	21.932	23.062	23.990	24.802	25.540	26.228	26.881	27.506	28.113
31	21.191	22.827	23.987	24.939	25.773	26.531	27.238	27.908	28.551	29.174
32	22.048	23.725	24.914	25.890	26.746	27.524	28.249	28.937	29.597	30.237
33	22.909	24.626	25.844	26.844	27.721	28.518	29.262	29.967	30.645	31.301
34	23.772	25.529	26.776	27.800	28.698	29.515	30.277	31.000	31.694	32.367
35	24.638	26.435	27.711	28.758	29.677	30.513	31.293	32.033	32.745	33.434
36	25.507	27.343	28.647	29.718	30.657	31.513	32.311	33.069	33.797	34.503
37	26.378	28.254	29.585	30.680	31.640	32.514	33.330	34.105	34.850	35.572
38	27.252	29.166	30.526	31.643	32.624	33.517	34.351	35.143	35.904	36.643
39	28.129	30.081	31.468	32.608	33.609	34.521	35.373	36.182	36.960	37.715
40	29.007	30.997	32.412	33.575	34.596	35.527	36.396	37.222	38.016	38.787


Area Coverage F_u
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
0.55
0.5
0
1
2
3
4
5
6
7
8
σ_{path}/ν
$Pp_{sens}(R)$ = 0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
0.55
0.5