

Processing Gain

Compliance with direct sequence spread spectrum processing gain requirements is demonstrated using the CW jamming-margin method prescribed in FCC Part 15.247(e)(2). Spread spectrum functions in the HWN Controller, Handset, wireless phone jack, and wireless data jack are performed in a custom ASIC device, and all share a common radio transceiver design. The supporting, measured data in Appendix P was obtained from a pair of these HWN transceivers in a jamming-margin test setup that sets precise desired and jammer signal levels.

Test Setup

Tests were performed in accordance with *Guidance on Measurements for Direct Sequence Spread Spectrum Systems*, FCC 97-114, Appendix C. The test setup is illustrated in Figure P1. The CW jamming signal was generated by an HP ESG-2000A signal generator. RF Power levels of the desired and jamming signals were calibrated using a HP EPM 441A power meter. Data was recorded at 89 points, starting well below the receive passband and ending well above the receive passband, and recorded every 50 kHz. Measurements were performed at a center frequency of 920.064 MHz. The desired-signal power level into the EUT receiver was set to -49.3 dBm, approximately midway in the receiver's dynamic range and well above its thermal noise floor. Of the 89 recorded data points, 55 of these fall within the receiver passband, which is approximately 2.8 MHz. Of the 55 in-band points, the worst 20%, or 11 data points, were discarded as permitted under 15.247(e). Excluding these 11 points, the worst-case processing gain is 15.52 dB (see example below), which occurs at 921.364 MHz. The measured data is shown in both tabular and graphical formats in Appendix P.

Calculations

The processing gain required to meet Part 15.247(e) is calculated as follows.

$$G_p = (S/N)_0 + M_j + L_{sys}$$

$$(S/N)_0 = 24.54 \text{ dB}, 10^{-5} \text{ BER, DBPSK}^1, 26 \text{ bits per symbol}$$

$$M_j = J/S \text{ (-11.02 in this example)}$$

$$L_{sys} = 2.0 \text{ dB}$$

$$G_p = 24.54 + (-11.02) + 2.0 = 15.52 \text{ dB}$$

Theoretical Performance

The HWN ASIC performs the spreading function by mapping blocks of data as 26-bit symbols to a family of 31-chip spreading codes. Received spreading sequences are processed by a 31-tap reentrant correlator, which performs the logical equivalent of a parallel array of 2^{26} correlators. This process delivers the original, transmitted 26-bit data word with negligible processing delay and minimal hardware. Theoretical processing gain is $10\log 31 = 14.91 \text{ dB}$. $(S/N)_0$ for 10^{-5} BER using DBPSK is $10.4 \text{ dB}^1 + 10\log 26$ (14.14 dB) = 24.54 dB, because each 31-chip sequence represents 26 bits of data, each of which carries 1/26 of total energy.

¹ *Digital Communications*, Third Edition, 1983, John G. Proakis, McGraw-Hill, p. 277 attached

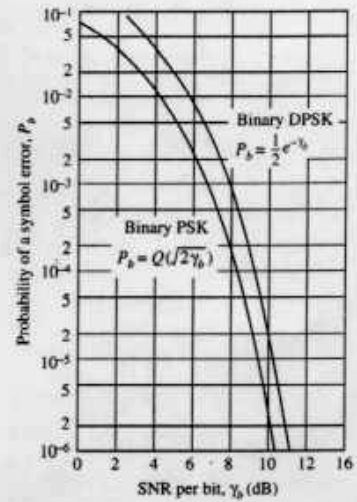


FIGURE 5-2-12 Probability of error for binary PSK and DPSK.

where $Q_1(a, b)$ is the Marcum Q function defined by (2-1-122) and (2-1-123), $I_0(x)$ is the modified Bessel function of order zero, defined by (2-1-120), and the parameters a and b are defined as

$$\begin{aligned} a &= \sqrt{2\gamma_b(1 - \sqrt{\frac{1}{2}})} \\ b &= \sqrt{2\gamma_b(1 + \sqrt{\frac{1}{2}})} \end{aligned} \quad (5-2-71)$$

Figure 5-2-13 illustrates the probability of a binary digit error for two- and

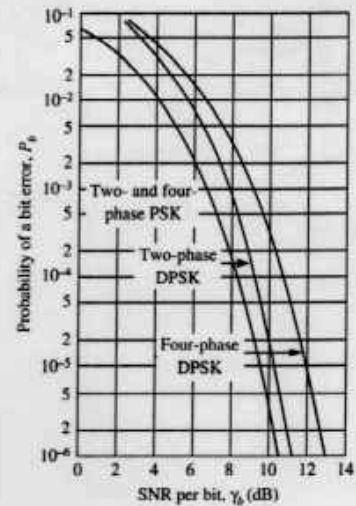


FIGURE 5-2-13 Probability of bit error for binary and four-phase PSK and DPSK.

Appendix P

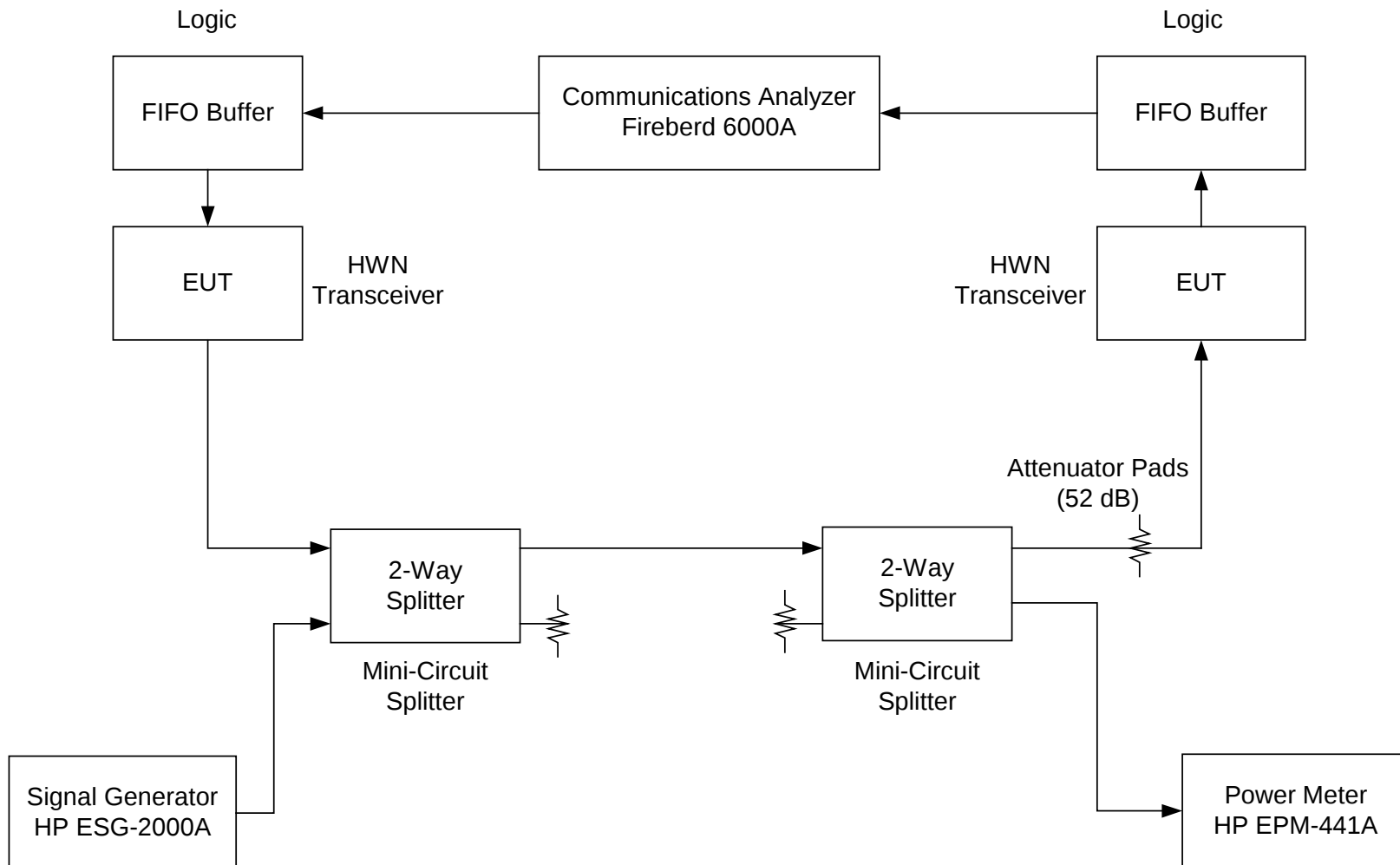


Figure P1:
Processing Gain Measurement Test Setup

HWN CONFIDENTIAL/PROPRIETARY

Frequency (MHz)	Jammer Level (dBm) at Receiver	Tx Level (dBm) at Receiver	(S/N)o (dB)	J/S (dB)	Lsys (dB)	Gp (dB)
917.864	-46.72	-49.3	24.54	2.58	2	29.12
917.914	-46.68	-49.3	24.54	2.62	2	29.16
917.964	-46.40	-49.3	24.54	2.90	2	29.44
918.014	-46.96	-49.3	24.54	2.34	2	28.88
918.064	-48.28	-49.3	24.54	1.02	2	27.56
918.114	-48.72	-49.3	24.54	0.58	2	27.12
918.164	-49.24	-49.3	24.54	0.06	2	26.60
918.214	-50.00	-49.3	24.54	-0.70	2	25.84
918.264	-50.92	-49.3	24.54	-1.62	2	24.92
918.314	-51.52	-49.3	24.54	-2.22	2	24.32
918.364	-52.28	-49.3	24.54	-2.98	2	23.56
918.414	-53.08	-49.3	24.54	-3.78	2	22.76
918.464	-53.52	-49.3	24.54	-4.22	2	22.32
918.514	-54.36	-49.3	24.54	-5.06	2	21.48
918.564	-53.92	-49.3	24.54	-4.62	2	21.92
918.614	-54.44	-49.3	24.54	-5.14	2	21.40
918.664	-57.52	-49.3	24.54	-8.22	2	18.32
Lower passband edge						
918.714	-58.80	-49.3	24.54	-9.50	2	17.04
918.764	-59.24	-49.3	24.54	-9.94	2	16.60
918.814	-58.88	-49.3	24.54	-9.58	2	16.96
918.864	-59.44	-49.3	24.54	-10.14	2	16.40
918.914	-57.64	-49.3	24.54	-8.34	2	18.20
918.964	-57.96	-49.3	24.54	-8.66	2	17.88
919.014	-59.60	-49.3	24.54	-10.30	2	16.24
919.064	-59.52	-49.3	24.54	-10.22	2	16.32
919.114	-63.00	-49.3	24.54	-13.70	2	12.84
919.164	-62.88	-49.3	24.54	-13.58	2	12.96
919.214	-61.36	-49.3	24.54	-12.06	2	14.48
919.264	-55.76	-49.3	24.54	-6.46	2	20.08
919.314	-57.44	-49.3	24.54	-8.14	2	18.40
919.364	-57.32	-49.3	24.54	-8.02	2	18.52
919.414	-57.80	-49.3	24.54	-8.50	2	18.04
919.464	-57.76	-49.3	24.54	-8.46	2	18.08
919.514	-57.64	-49.3	24.54	-8.34	2	18.20
919.564	-57.64	-49.3	24.54	-8.34	2	18.20
919.614	-57.36	-49.3	24.54	-8.06	2	18.48
919.664	-57.08	-49.3	24.54	-7.78	2	18.76
919.714	-57.24	-49.3	24.54	-7.94	2	18.60
919.764	-57.24	-49.3	24.54	-7.94	2	18.60
919.814	-56.56	-49.3	24.54	-7.26	2	19.28
919.864	-56.56	-49.3	24.54	-7.26	2	19.28
919.914	-56.36	-49.3	24.54	-7.06	2	19.48
919.964	-56.56	-49.3	24.54	-7.26	2	19.28
920.014	-56.48	-49.3	24.54	-7.18	2	19.36
920.064	-56.12	-49.3	24.54	-6.82	2	19.72

HWN CONFIDENTIAL/PROPRIETARY

920.114	-56.32	-49.3	24.54	-7.02	2	19.52
920.164	-56.24	-49.3	24.54	-6.94	2	19.60
920.214	-56.28	-49.3	24.54	-6.98	2	19.56
920.264	-56.32	-49.3	24.54	-7.02	2	19.52
920.314	-56.28	-49.3	24.54	-6.98	2	19.56
920.364	-56.28	-49.3	24.54	-6.98	2	19.56
920.414	-56.28	-49.3	24.54	-6.98	2	19.56
920.464	-56.28	-49.3	24.54	-6.98	2	19.56
920.514	-56.44	-49.3	24.54	-7.14	2	19.40
920.564	-56.76	-49.3	24.54	-7.46	2	19.08
920.614	-58.12	-49.3	24.54	-8.82	2	17.72
920.664	-58.36	-49.3	24.54	-9.06	2	17.48
920.714	-58.48	-49.3	24.54	-9.18	2	17.36
920.764	-58.56	-49.3	24.54	-9.26	2	17.28
920.814	-56.48	-49.3	24.54	-7.18	2	19.36
920.864	-59.84	-49.3	24.54	-10.54	2	16.00
920.914	-62.84	-49.3	24.54	-13.54	2	13.00
920.964	-61.88	-49.3	24.54	-12.58	2	13.96
921.014	-63.12	-49.3	24.54	-13.82	2	12.72
921.064	-61.32	-49.3	24.54	-12.02	2	14.52
921.114	-61.24	-49.3	24.54	-11.94	2	14.60
921.164	-60.28	-49.3	24.54	-10.98	2	15.56
921.214	-60.00	-49.3	24.54	-10.70	2	15.84
921.264	-60.40	-49.3	24.54	-11.10	2	15.44
921.314	-60.36	-49.3	24.54	-11.06	2	15.48
921.364	-60.32	-49.3	24.54	-11.02	2	15.52
921.414	-61.20	-49.3	24.54	-11.90	2	14.64
921.464	-59.16	-49.3	24.54	-9.86	2	16.68
Upper passband edge						
921.514	-56.04	-49.3	24.54	-6.74	2	19.80
921.564	-56.24	-49.3	24.54	-6.94	2	19.60
921.614	-55.40	-49.3	24.54	-6.10	2	20.44
921.664	-52.28	-49.3	24.54	-2.98	2	23.56
921.714	-55.84	-49.3	24.54	-6.54	2	20.00
921.764	-54.24	-49.3	24.54	-4.94	2	21.60
921.814	-54.92	-49.3	24.54	-5.62	2	20.92
921.864	-52.76	-49.3	24.54	-3.46	2	23.08
921.914	-51.96	-49.3	24.54	-2.66	2	23.88
921.964	-51.84	-49.3	24.54	-2.54	2	24.00
922.014	-49.08	-49.3	24.54	0.22	2	26.76
922.064	-48.16	-49.3	24.54	1.14	2	27.68
922.114	-47.84	-49.3	24.54	1.46	2	28.00
922.164	-46.08	-49.3	24.54	3.22	2	29.76
922.214	-46.12	-49.3	24.54	3.18	2	29.72
922.264	-46.24	-49.3	24.54	3.06	2	29.60

Note: Shaded data contains 20% worst case J/S points within passband.

Processing Gain vs Frequency