Processing Gain for the HWN TransPort

The radio transmitter and receiver in the Home Wireless Networks TransPort Wireless
LAN Access Point is capable of operation at over-the-air data rates of 1 MBPS, 2 MBPS,
5.5 MBPS, and 11 MBPS. The following table illustrates the differences in modulation,
data, and symbol rates for each mode:

Data Rates and Modulation HWN TransPort								
Data Rate (MBPS)	Modulation	Symbol Rate (MSPS)	Chip Rate (MCPS)	Spreading Gain (dB)	Coding Gain (dB)	Theoretical Processing Gain (dB)	Theoretical Es/No at 10e-5 BER (dB)	Minimum J/S ratio for 10 dB processing gain (dB) (with 2 dB allowable system loss)
1	BPSK	1	11	10.4	0	10.4	11	-3
2	QPSK	1	11	10.4	0	10.4	11	-3
5.5	CCK	1.375	8	9.0	2.2	11.2	16.2	-8.2
11	CCK	1.375	8	9.0	2.2	11.2	16.4	-8.4

The performance of the HWN TransPort has been tested in accordance with the CW
jamming margin test of FCC rules Part 15.247(e). Below is a summary of the theoretical
basis behind the performance of the equipment at the 5.5 and 11 MBPS modes with 8
chips/symbol. Performance of the 1 and 2 MBPS modes is based upon the calculations
given in 15.247(e) at 11 chips per symbol and does not require additional theoretical
basis.

Theoretical calculations for 5.5 and 11 MBPS Modes

The processing gain is related to the jamming margin as follows [2]:

$$G_p = \left(\frac{S}{N} \right)_{output} + \left(\frac{J}{S} \right) + L_{system}$$

Where $BER_{REFERENCE}$ is the reference bit error ratio with its corresponding, theoretical
output signal to noise ratio per symbol, $(S/N)_{output}$, (J/S) is the jamming margin (jamming
signal power relative to desired signal power), and L_{system} are the system implementation
losses. The maximum allowed total system implementation loss is 2 dB.
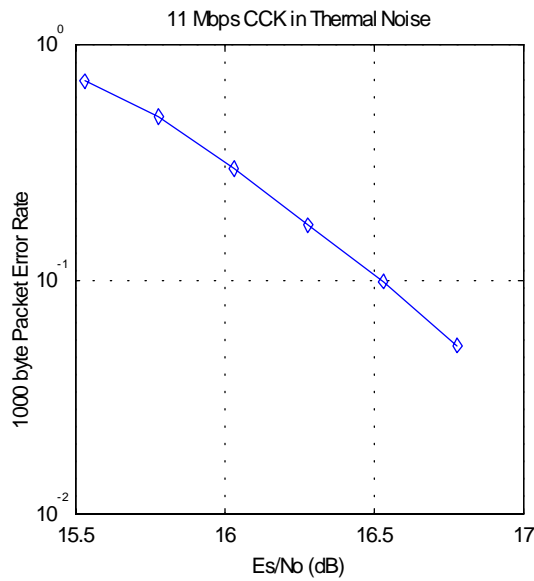
The HFA3860B direct sequence spread spectrum baseband processor uses CCK modulation for 5.5 and 11 MBPS modes, which is a form of M-ary Orthogonal Keying. The BER performance curve is given as:

" The probability of error for generalized M-ary Orthogonal signaling using coherent demodulation is given by:

$$P_e = 1 - P_{c1} = 1 - \frac{1}{\sqrt{2\pi}} \int_{-\frac{S_{01}}{N_0}}^{\infty} \left[2(1 - Q\left\{ z + \sqrt{2\frac{E_b}{\eta}} \right\}) \right]^{\frac{M}{2}-1} \exp\left\{ -\frac{z^2}{2} \right\} dz$$

This integral cannot be solved in closed form, and numerical integration must be used. There are error rate extensions for differential decoding and descrambling that are also to be accounted for. This is done in a MATHCAD environment and is displayed in graphical format below.

1.1   1000 byte PER vs. Es/No

The reference PER is specified as 8% . The corresponding Es/No (signal to noise ratio per symbol) is 16.4 dB. The Es/No required to achieve the desired BER with maximum system implementation losses is 18.4 dB. The minimum processing gain is again, 10 dB, therefore:

$$G_p = \left(\frac{E_s}{N_o}\right)_{output} + \left(\frac{J}{S}\right) + L_{system} = 16.4dB + 2.0dB + \left(\frac{J}{S}\right) \geq 10dB$$

$$G_p = 18.4\,dB + \left(\frac{J}{S}\right) \geq 10dB$$

The minimum jammer to signal ratio is as follows:

$$\left(\frac{J}{S}\right) \geq -8.4\,dB$$

For the case of the HFA3860B, the bit rates are 1, 2, 5.5, and 11 Mbps. The corresponding symbol rates are 1, 1, 1.375, and 1.375 MSps. The chip rate is always 11 MCps, so the ratio of chip rate to symbol rate is 11:1 for the 1 and 2 Mbps rates and 8:1 for the 5.5 and 11 Mbps rates. Since the symbol rate to bit rate is less than 10 for the higher rates, we supply the theoretical processing gain calculation for these cases where spread spectrum processing gain with embedded coding gain is utilized. This is reasonable in that they cannot be separated in the demodulation process. If a separable FEC coding scheme were used, we would not be comfortable making this assertion.

As can be seen from the curve of figure 1, the Es/N0 is 16.4 dB at the PER of 8%. This PER can be related to a BER of 1e-5 on 1000 byte packets. With 8 bits per symbol, the Eb/N0 is then 7.4 dB or 9 dB less than the Es/N0. It is well known that the Eb/N0 of BPSK is 9.6 dB for 1e-5 BER, so therefore the coding gain of CCK over BPSK is 2.2 dB. We add this to the processing gain of 9 dB to get 11.2 dB overall processing gain for the CW jammer test.

Taking the calculations above, if the **J/S >= -8.4 dB** then the equipment passes the CW jamming test in 11 MBPS modes. For 5.5 MBPS modes, the HFA3860B data sheet shows that the required Es/No is 0.2 dB less than that required for the 11 MBPS mode. Thus if the **J/S >= -8.2 dB** then the equipment passes the CW jamming test in 5.5 MBPS modes.