WLAN cards WL2400-ISA, Processing Gain Performance Tests

Product Name: WL2400-ISA

FCC Requirements:

From Document 47CFR15, paragraph 15.247 (e):

- *"The processing gain of a direct sequence system shall be at least 10 dB. The processing gain represents the improvement to the received signal-to-noise ratio, after filtering to the information bandwidth, from the spreading/despreading function".*

- *". The processing gain may be determined using one of the following methods: (1) As measured at the demodulated output of the receiver: the ratio in dB of the signal-to-noise ratio with the system spreading code turned off to the signal-to-noise ratio with the system spreading code turned on.*
(2) As measured using the CW jamming margin method: a signal generator is stepped in 50 kHz increments across the passband of the system, recording at each point the generator level required to produce the recommended Bit Error Rate (BER). This level is the jammer level. The output power of the intentional radiator is measured at the same point. The jammer to signal ratio (J/S) is then calculated, discarding the worst 20% of the J/S data points. The lowest remaining J/S ratio is used to calculate the processing gain, as follows: Gp = (S/N) o + Mj + Lsys, where Gp = processing gain of the system, (S/N) o = signal to noise ratio required for the chosen BER, Mj = J/S ratio, and Lsys = system losses. Note that total losses in a system, including intentional radiator and receiver, should be assumed to be no more than 2 dB."

Test Conditions:

Test Equipment:

- Hewlett Packard Model 8562A Spectrum Analyzer
- BER Test Set: Fireberd 4000
- Signal Generator, Hewlett Packard model 8683B
- RF Power Meter, Peak Reading, Hewlett Packard model 8900
- Step Attenuators (1 dB steps) , Kay Model 839

Environmental:

Temperature and humidity : 72 degrees F +/- 2 degrees (22.2 deg C, +/- 1.1 deg C)
40% nominal relative humidity

Power:

The WLAN card was powered from the internal supply of a computer.

Measurement methodology:

The CW jamming margin technique was selected for measurement of processing gain. A block diagram of the test circuit is shown in figure 1. The test consists of stepping an interfering signal across the receiver passband. At each step, the output level of the signal generator is adjusted and recorded (the level which produces the desired system bit error rate (BER). The output level of the signal generator is the jamming level. It is then compared to the transmitted output power and from this, a jammer-to-signal ratio (J/S) is recorded (Mj in the calculation) . The calculation allows us to disregard the worst 20% of the J/S data points. The Processing Gain is is calculated from the lowest remaining Jammer to Signal ratio.

The signal to noise ratio for differential coherent detection (ideal case) of a DPSK receiver (differentially encoded) can be derived from the bit error probability (Pb) versus signal to noise ratio. See references (below) for additional information.

From the above FCC definition, we know that the following equation is used for calculation of processing gain:

$$Gp = (S/N)o + Mj + Lsys$$

Where:

- Gp = processing gain of the system
- (S/N)o = signal to noise ratio required for the chosen BER
- Mj = J/S ratio
- Lsys = system losses. Note that total losses in a system, including intentional radiator and receiver, should be assumed to be no more than 2 dB."

In the above definitions:

- $(S/N)_o$ is the level that maintains normal operation immediately before the threshold where bit errors begin to occur. A maximum error of 1e-03 is permitted in real measurements where all codes are turned off.
- The J/S ratio (Mj) is the maximum jamming to signal ratio which is measured at the specified BER

Test Results:

Compliant with FCC requirement for 10 dB minimum processing gain. See attached sheet for test data.

Tested By:

Young Design, Inc Engineering Department, Falls Church, VA

References:

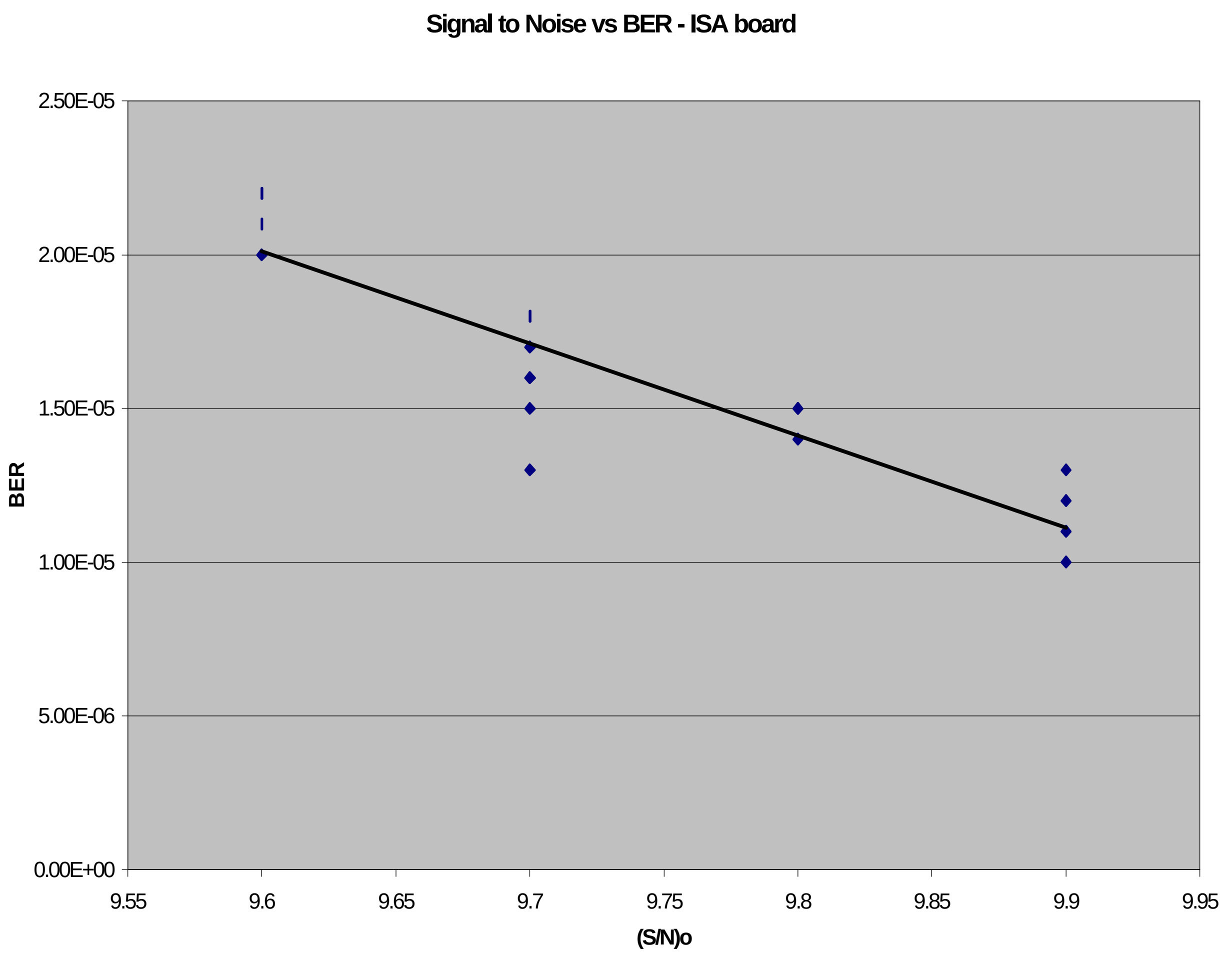
1. Andren, Carl. Testing for compliance with FCC rules 15-247e. (Intersil Corporation Tech note, January, 2000)
2. Viterbi, A.J. Principles of Coherent Communications (McGraw Hill, 1966), page 207

MEASUREMENT DATA:

SIG.GEN. FREQ. (MHz)	BER	Signal Gen. total Peak Power at Rcvr (dBm)	TX Total Peak Power at Rcvr (dBm)	$(S/N)_0$ (db)	Lsys (db)	Mj (dB)	Processing Gain (dB)
fc - 1.00	1.70E-05	-25.4	-27.6	9.7	2.0	-0.80	10.9
fc - 0.90	1.50E-05	-28.1	-27.6	9.8	2.0	1.40	13.2
fc - 0.70	1.00E-05	-27.1	-27.6	9.9	2.0	1.30	13.2
fc - 0.50	1.10E-05	-27.8	-27.6	9.9	2.0	1.70	13.6
fc - 0.45	2.10E-05	-29.2	-27.6	9.6	2.0	2.90	14.5
fc - 0.40	1.60E-05	-28.2	-27.6	9.7	2.0	2.00	13.7
fc - 0.35	1.80E-05	-26.7	-27.6	9.7	2.0	1.50	13.2
fc - 0.30	1.20E-05	-26.1	-27.6	9.9	2.0	2.00	13.9
fc - 0.25	1.30E-05	-29.1	-27.6	9.7	2.0	1.00	12.7
fc - 0.20	1.70E-05	-26.7	-27.6	9.7	2.0	-0.10	11.6
fc - 0.15	1.10E-05	-28.5	-27.6	9.9	2.0	3.00	14.9
fc - 0.10	1.00E-05	-28.4	-27.6	9.9	2.0	2.40	14.3
fc - 0.05	1.60E-05	-28.8	-27.6	9.7	2.0	2.90	14.6
fc	1.40E-05	-28.2	-27.6	9.8	2.0	-1.00	10.8
fc + 0.05	1.60E-05	-27.5	-27.6	9.7	2.0	1.20	12.9
fc + 0.10	1.50E-05	-25.3	-27.6	9.8	2.0	2.90	14.7
fc + 0.15	1.30E-05	-24.5	-27.6	9.9	2.0	1.70	13.6
fc + 0.20	1.10E-05	-25.2	-27.6	9.9	2.0	2.40	14.3
fc + 0.25	1.50E-05	-28.2	-27.6	9.7	2.0	2.40	14.1
fc + 0.30	1.70E-05	-26.1	-27.6	9.7	2.0	2.40	14.1
fc + 0.35	2.20E-05	-24.7	-27.6	9.6	2.0	1.30	12.9
fc + 0.40	1.20E-05	-25	-27.6	9.9	2.0	1.70	13.6
fc + 0.45	1.50E-05	-26	-27.6	9.8	2.0	2.40	14.2
fc + 0.50	1.40E-05	-25.3	-27.6	9.8	2.0	2.70	14.5
fc + 0.70	1.80E-05	-24.5	-27.6	9.7	2.0	1.00	12.7
fc + 0.90	2.00E-05	-24.9	-27.6	9.6	2.0	1.50	13.1
fc + 1.00	2.20E-05	-25.5	-27.6	9.6	2.0	-0.10	11.5
							WORST CASE PROCESSING GAIN = 10.8 dB

Notes: 1) Refer to attached curves for BER versus $(S/N)_0$

2) Processing gain $Gp = (S/N)_0 + Lays + Mj = (S/N)_0 + 2\ Mj$


Signal to Noise vs BER - ISA board
BER
2.50E-05
2.00E-05
1.50E-05
1.00E-05
5.00E-06
0.00E+00
9.55
9.6
9.65
9.7
9.75
9.8
9.85
9.9
9.95
(S/N)o

Test Block Diagram