



*COMPANY NAME:* NOKIA WIRELESS BUSINESS COMMUNICATIONS  
*EUT:* NOKIA C110 AND C111  
*CLIENT REFERENCE NUMBER:* QUOTE NUMBER  
*WORK ORDER NUMBER:* 2000156  
*FCC ID:* ORE-C110-C111

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## APPENDIX M:

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## PROCESSING GAIN REPORT

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# Measurement of Processing Gain of a Direct Sequence Spread Spectrum System

Certification Report on Compliance with Respect to FCC  
CFR 47, Paragraph 15.247(e)

Product: Nokia C110/C111 Wireless LAN Card

April 14, 2000

REPORT PREPARED BY: Rick McMurray

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## Scope

This report contains the results of the processing gain testing performed on the Nokia C110 Wireless LAN Cards. The tests were carried out in accordance with FCC CFR 47, Paragraph 15.247(e). The jamming margin method specified in 15.247(e)(2) was used to perform the processing gain testing. FCC 97-114, Guidance on Measurements for Direct Sequence Spread Spectrum Systems, was also utilized as a guiding document for the performance of the processing gain testing.

The data submitted for the Nokia C110 is also applicable for the Nokia C111. Both of these devices are identical, except for the fact that the C111 incorporates connectors for external antennas.

## FCC Requirements

The processing gain of a direct sequence system shall be at least 10dB. The processing gain shall be determined from 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, as measured at the demodulated output of the receiver.

## Test Equipment

Hewlett Packard Spectrum Analyzer, Model 8566B, 100Hz-2.5GHz/2-22GHz

Hewlett Packard Signal Generator, Model 8648C, 100kHz-3200MHz

Weinschel Broadband Resistive Power Divider, Model 1515, DC to 18.0GHz 1 Watt

Weinschel Directional Coupler, Model 1537RA-20, 0.5 to 4.0GHz

Weinschel 6dB Attenuator (quantity 2), Model 2, 0 to 18GHz 5W

IBM Laptop Computer, Model ThinkPad 600E (used with transmitter)

IBM Laptop Computer, Model ThinkPad 600 (used with receiver)

## Method of Measurement

As mentioned in the scope section, the jamming margin method was used. The following drawing titled "Processing Gain – Jamming Test Setup" illustrates a block diagram of the test setup. In this method, a signal generator was stepped in 50kHz increments across the passband of the system. At each point, the level of the signal generator required to produce the recommended Bit Error Rate (BER) was recorded. This level is the jammer level. The output power of the transmitter was also recorded at these same points. This level is the signal level. The jammer to signal ratio (J/S) was then calculated. The worst 20% of the J/S data points were discarded. The lowest remaining J/S ratio was used to calculate the processing gain for each of the channels and rates investigated. The processing gain,  $G_p$ , was calculated as follows:  $G_p = (S/N)_o + M_j + L_{sys}$ , where  $G_p$  = the processing gain of the system,  $(S/N)_o$  = signal to noise ratio required for the chosen BER,  $M_j$  = J/S ratio, and  $L_{sys}$  = system losses. Note that total system losses in a system, including intentional radiator and receiver, are assumed to be no more than 2dB as specified by the FCC.

An ideal signal to noise ratio, also referred to as  $(S/N)_o$  or  $(E_s/N_o)$ , of 13.3dB was used as specified by Intersil when calculating the processing gain when operating at 2Mbps. A value of 16.4dB was used as specified by Intersil when calculating the processing gain when operating at 11Mbps. The Nokia C110/C111 contains chip-sets from Intersil and operates at rates up to 11Mbps. Please see the enclosed documents “Theoretical BER curves for the IEEE 1 and 2 Mbps modulations” and “Testing for compliance with FCC rules 15-247e” by Carl Andren of Intersil Corporation for more information.

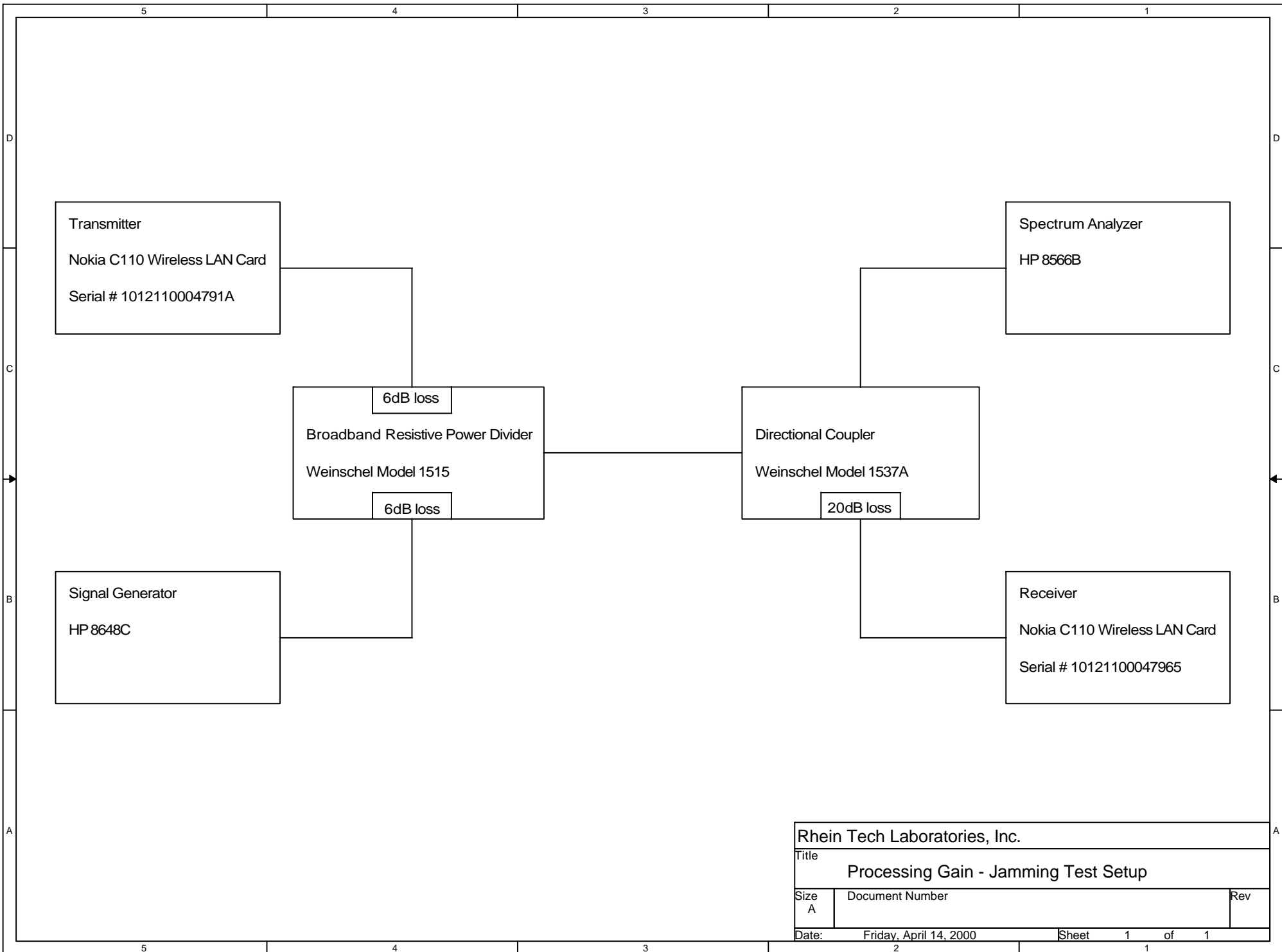
The use of 8% FER frame error rate (or PER packet error rate) as a substitute for the recommended BER bit error rate is derived in the attached document “Testing for compliance with FCC rules 15-247e” by Carl Andren of Intersil Corporation.

## Engineering Summary

Processing Gain Results Summary:

Channel	Rate (Mbps)	Gp(dB)
1	2	27.13
1	11	15.57
6	11	22.90
11	11	22.73

Following are the calculations and data for the one channel at 2Mbps and the three channels at 11Mbps that were investigated.



Rhein Tech Laboratories, Inc.		
Title		
Processing Gain - Jamming Test Setup		
Size	Document Number	Rev
A		
Date:	Friday, April 14, 2000	Sheet 1 of 1
	2	1

# Channel 1 Processing Gain

2412MHz

2 Mbps

After discarding the lowest 20% J/S data points, the lowest J/S was 11.83 dB.

$$\begin{aligned}
 G_p &= (S/N)_o + M_j + L_{sys} \\
 &= 13.3 \text{ dB} + 11.83 \text{ dB} + 2.0 \text{ dB} \\
 &= \mathbf{27.13 \text{ dB}}
 \end{aligned}$$

2Mbps Channel 1 Processing Gain						
Gp = (S/N)o + Mj + Lsys						
Frequency (MHz)	Gp (dB)	(S/N)o (dB)	Mj = J/S (dB)	Lsys (dB)	S (Tx Power) (dBm)	J (S/G Power) (dBm)
2407.00	30.14	13.3	14.84	2.0	-5.17	9.67
2407.05	30.14	13.3	14.84	2.0	-5.17	9.67
2407.10	30.14	13.3	14.84	2.0	-5.17	9.67
2407.15	29.80	13.3	14.50	2.0	-5.00	9.50
2407.20	29.63	13.3	14.33	2.0	-5.00	9.33
2407.25	29.14	13.3	13.84	2.0	-4.67	9.17
2407.30	28.97	13.3	13.67	2.0	-4.50	9.17
2407.35	28.63	13.3	13.33	2.0	-4.33	9.00
2407.40	29.46	13.3	14.16	2.0	-4.33	9.83
2407.45	29.30	13.3	14.00	2.0	-4.17	9.83
2407.50	29.97	13.3	14.67	2.0	-4.17	10.50
2407.55	29.30	13.3	14.00	2.0	-4.00	10.00
2407.60	28.63	13.3	13.33	2.0	-3.83	9.50
2407.65	28.96	13.3	13.66	2.0	-3.83	9.83
2407.70	28.96	13.3	13.66	2.0	-3.83	9.83
2407.75	28.63	13.3	13.33	2.0	-3.50	9.83
2407.80	28.30	13.3	13.00	2.0	-3.33	9.67
2407.85	28.80	13.3	13.50	2.0	-3.50	10.00
2407.90	27.80	13.3	12.50	2.0	-3.17	9.33
2407.95	27.64	13.3	12.34	2.0	-3.17	9.17
2408.00	27.13	13.3	11.83	2.0	-2.83	9.00
2408.05	27.80	13.3	12.50	2.0	-2.83	9.67
2408.10	27.80	13.3	12.50	2.0	-2.83	9.67
2408.15	27.64	13.3	12.34	2.0	-2.67	9.67
2408.20	27.47	13.3	12.17	2.0	-2.50	9.67
2408.25	27.64	13.3	12.34	2.0	-2.67	9.67
2408.30	27.30	13.3	12.00	2.0	-2.67	9.33
2408.35	27.30	13.3	12.00	2.0	-2.83	9.17
2408.40	27.97	13.3	12.67	2.0	-2.67	10.00
2408.45	27.97	13.3	12.67	2.0	-2.67	10.00
2408.50	27.96	13.3	12.66	2.0	-2.83	9.83
2408.55	27.80	13.3	12.50	2.0	-2.83	9.67
2408.60	27.47	13.3	12.17	2.0	-3.00	9.17
2408.65	27.47	13.3	12.17	2.0	-3.00	9.17
2408.70	26.97	13.3	11.67	2.0	-3.00	8.67
2408.75	26.80	13.3	11.50	2.0	-2.83	8.67
2408.80	27.13	13.3	11.83	2.0	-3.00	8.83

## Channel 1, 2Mbps Processing Gain

2408.85	27.30	13.3	12.00	2.0	-2.83	9.17
2408.90	26.64	13.3	11.34	2.0	-2.67	8.67
2408.95	26.64	13.3	11.34	2.0	-2.67	8.67
2409.00	26.13	13.3	10.83	2.0	-2.50	8.33
2409.05	26.80	13.3	11.50	2.0	-2.50	9.00
2409.10	27.14	13.3	11.84	2.0	-2.67	9.17
2409.15	26.97	13.3	11.67	2.0	-2.50	9.17
2409.20	26.46	13.3	11.16	2.0	-2.33	8.83
2409.25	26.80	13.3	11.50	2.0	-2.17	9.33
2409.30	26.30	13.3	11.00	2.0	-1.83	9.17
2409.35	26.46	13.3	11.16	2.0	-1.83	9.33
2409.40	26.47	13.3	11.17	2.0	-1.67	9.50
2409.45	26.30	13.3	11.00	2.0	-1.33	9.67
2409.50	26.63	13.3	11.33	2.0	-1.83	9.50
2409.55	26.47	13.3	11.17	2.0	-1.67	9.50
2409.60	25.97	13.3	10.67	2.0	-1.17	9.50
2409.65	25.97	13.3	10.67	2.0	-1.17	9.50
2409.70	25.96	13.3	10.66	2.0	-1.33	9.33
2409.75	25.80	13.3	10.50	2.0	-1.17	9.33
2409.80	25.80	13.3	10.50	2.0	-0.83	9.67
2409.85	25.63	13.3	10.33	2.0	-0.83	9.50
2409.90	25.47	13.3	10.17	2.0	-0.67	9.50
2409.95	25.30	13.3	10.00	2.0	-0.67	9.33
2410.00	25.30	13.3	10.00	2.0	-0.67	9.33
2410.05	25.47	13.3	10.17	2.0	-0.67	9.50
2410.10	25.13	13.3	9.83	2.0	-0.50	9.33
2410.15	25.13	13.3	9.83	2.0	-0.50	9.33
2410.20	24.80	13.3	9.50	2.0	-0.50	9.00
2410.25	24.97	13.3	9.67	2.0	-0.50	9.17
2410.30	25.13	13.3	9.83	2.0	-0.50	9.33
2410.35	25.30	13.3	10.00	2.0	-0.67	9.33
2410.40	25.47	13.3	10.17	2.0	-0.67	9.50
2410.45	25.80	13.3	10.50	2.0	-0.83	9.67
2410.50	25.64	13.3	10.34	2.0	-0.67	9.67
2410.55	23.13	13.3	7.83	2.0	-0.83	7.00
2410.60	25.80	13.3	10.50	2.0	-0.83	9.67
2410.65	25.30	13.3	10.00	2.0	-0.50	9.50
2410.70	25.30	13.3	10.00	2.0	-0.50	9.50
2410.75	25.30	13.3	10.00	2.0	-0.67	9.33
2410.80	25.96	13.3	10.66	2.0	-0.83	9.83
2410.85	25.64	13.3	10.34	2.0	-0.67	9.67
2410.90	24.97	13.3	9.67	2.0	0.00	9.67
2410.95	25.30	13.3	10.00	2.0	-0.50	9.50
2411.00	25.14	13.3	9.84	2.0	-0.67	9.17
2411.05	24.30	13.3	9.00	2.0	0.00	9.00
2411.10	24.63	13.3	9.33	2.0	-0.33	9.00
2411.15	24.46	13.3	9.16	2.0	-0.33	8.83
2411.20	24.80	13.3	9.50	2.0	-0.83	8.67
2411.25	24.97	13.3	9.67	2.0	-1.00	8.67
2411.30	24.97	13.3	9.67	2.0	-1.00	8.67
2411.35	25.30	13.3	10.00	2.0	-1.17	8.83

**Channel 1, 2Mbps Processing Gain**

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2411.40	25.46	13.3	10.16	2.0	-1.33	8.83
2411.45	25.97	13.3	10.67	2.0	-1.67	9.00
2411.50	26.13	13.3	10.83	2.0	-1.83	9.00
2411.55	26.63	13.3	11.33	2.0	-1.83	9.50
2411.60	27.13	13.3	11.83	2.0	-2.00	9.83
2411.65	27.80	13.3	12.50	2.0	-2.00	10.50
2411.70	28.46	13.3	13.16	2.0	-1.83	11.33
2411.75	29.14	13.3	13.84	2.0	-1.67	12.17
2411.80	30.14	13.3	14.84	2.0	-1.67	13.17
2411.85	30.30	13.3	15.00	2.0	-1.17	13.83
2411.90	30.30	13.3	15.00	2.0	-1.33	13.67
2411.95	30.47	13.3	15.17	2.0	-1.50	13.67
2412.00	29.97	13.3	14.67	2.0	-1.00	13.67
2412.05	30.14	13.3	14.84	2.0	-1.17	13.67
2412.10	30.64	13.3	15.34	2.0	-1.67	13.67
2412.15	29.46	13.3	14.16	2.0	-1.33	12.83
2412.20	28.47	13.3	13.17	2.0	-1.50	11.67
2412.25	27.97	13.3	12.67	2.0	-1.67	11.00
2412.30	27.30	13.3	12.00	2.0	-1.67	10.33
2412.35	26.80	13.3	11.50	2.0	-1.50	10.00
2412.40	26.47	13.3	11.17	2.0	-1.67	9.50
2412.45	26.13	13.3	10.83	2.0	-1.50	9.33
2412.50	25.30	13.3	10.00	2.0	-1.33	8.67
2412.55	24.97	13.3	9.67	2.0	-1.17	8.50
2412.60	24.80	13.3	9.50	2.0	-1.00	8.50
2412.65	24.30	13.3	9.00	2.0	-0.67	8.33
2412.70	24.64	13.3	9.34	2.0	-0.67	8.67
2412.75	24.64	13.3	9.34	2.0	-0.67	8.67
2412.80	24.47	13.3	9.17	2.0	0.00	9.17
2412.85	24.63	13.3	9.33	2.0	-0.33	9.00
2412.90	24.96	13.3	9.66	2.0	-0.33	9.33
2412.95	24.63	13.3	9.33	2.0	0.17	9.50
2413.00	24.80	13.3	9.50	2.0	-0.17	9.33
2413.05	24.80	13.3	9.50	2.0	0.17	9.67
2413.10	24.97	13.3	9.67	2.0	0.00	9.67
2413.15	25.30	13.3	10.00	2.0	-0.33	9.67
2413.20	25.13	13.3	9.83	2.0	0.00	9.83
2413.25	25.14	13.3	9.84	2.0	-0.17	9.67
2413.30	25.13	13.3	9.83	2.0	0.00	9.83
2413.35	24.80	13.3	9.50	2.0	0.17	9.67
2413.40	25.13	13.3	9.83	2.0	-0.33	9.50
2413.45	24.96	13.3	9.66	2.0	-0.33	9.33
2413.50	24.80	13.3	9.50	2.0	-0.33	9.17
2413.55	24.80	13.3	9.50	2.0	-0.33	9.17
2413.60	24.80	13.3	9.50	2.0	-0.50	9.00
2413.65	24.46	13.3	9.16	2.0	-0.33	8.83
2413.70	24.80	13.3	9.50	2.0	-0.67	8.83
2413.75	24.63	13.3	9.33	2.0	-0.50	8.83
2413.80	24.63	13.3	9.33	2.0	-0.33	9.00
2413.85	24.97	13.3	9.67	2.0	-0.50	9.17
2413.90	24.97	13.3	9.67	2.0	-0.50	9.17

**Channel 1, 2Mbps Processing Gain**

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2413.95	25.30	13.3	10.00	2.0	-0.50	9.50
2414.00	24.80	13.3	9.50	2.0	-0.33	9.17
2414.05	24.97	13.3	9.67	2.0	-0.50	9.17
2414.10	25.30	13.3	10.00	2.0	-0.50	9.50
2414.15	25.14	13.3	9.84	2.0	-0.67	9.17
2414.20	25.14	13.3	9.84	2.0	-0.67	9.17
2414.25	25.47	13.3	10.17	2.0	-0.67	9.50
2414.30	25.46	13.3	10.16	2.0	-0.83	9.33
2414.35	25.63	13.3	10.33	2.0	-1.00	9.33
2414.40	25.63	13.3	10.33	2.0	-0.83	9.50
2414.45	25.63	13.3	10.33	2.0	-1.00	9.33
2414.50	25.97	13.3	10.67	2.0	-1.50	9.17
2414.55	25.80	13.3	10.50	2.0	-1.50	9.00
2414.60	25.63	13.3	10.33	2.0	-1.33	9.00
2414.65	25.63	13.3	10.33	2.0	-1.50	8.83
2414.70	25.64	13.3	10.34	2.0	-1.67	8.67
2414.75	25.80	13.3	10.50	2.0	-2.00	8.50
2414.80	25.97	13.3	10.67	2.0	-2.00	8.67
2414.85	26.30	13.3	11.00	2.0	-2.17	8.83
2414.90	26.30	13.3	11.00	2.0	-2.33	8.67
2414.95	26.13	13.3	10.83	2.0	-2.33	8.50
2415.00	26.13	13.3	10.83	2.0	-2.33	8.50
2415.05	26.47	13.3	11.17	2.0	-2.00	9.17
2415.10	27.13	13.3	11.83	2.0	-2.50	9.33
2415.15	27.13	13.3	11.83	2.0	-2.50	9.33
2415.20	26.80	13.3	11.50	2.0	-2.50	9.00
2415.25	26.97	13.3	11.67	2.0	-2.17	9.50
2415.30	26.64	13.3	11.34	2.0	-2.17	9.17
2415.35	26.30	13.3	11.00	2.0	-2.33	8.67
2415.40	26.80	13.3	11.50	2.0	-2.17	9.33
2415.45	27.13	13.3	11.83	2.0	-2.33	9.50
2415.50	27.13	13.3	11.83	2.0	-2.50	9.33
2415.55	26.80	13.3	11.50	2.0	-2.17	9.33
2415.60	26.97	13.3	11.67	2.0	-2.50	9.17
2415.65	26.64	13.3	11.34	2.0	-2.17	9.17
2415.70	26.30	13.3	11.00	2.0	-2.33	8.67
2415.75	26.47	13.3	11.17	2.0	-2.50	8.67
2415.80	26.63	13.3	11.33	2.0	-2.33	9.00
2415.85	27.30	13.3	12.00	2.0	-2.50	9.50
2415.90	26.97	13.3	11.67	2.0	-2.67	9.00
2415.95	26.63	13.3	11.33	2.0	-2.50	8.83
2416.00	26.80	13.3	11.50	2.0	-2.67	8.83
2416.05	27.47	13.3	12.17	2.0	-2.67	9.50
2416.10	27.64	13.3	12.34	2.0	-2.67	9.67
2416.15	28.13	13.3	12.83	2.0	-3.33	9.50
2416.20	27.47	13.3	12.17	2.0	-3.00	9.17
2416.25	28.97	13.3	13.67	2.0	-3.50	10.17
2416.30	28.30	13.3	13.00	2.0	-3.67	9.33
2416.35	28.14	13.3	12.84	2.0	-3.67	9.17
2416.40	28.13	13.3	12.83	2.0	-3.50	9.33
2416.45	28.64	13.3	13.34	2.0	-3.67	9.67

**Channel 1, 2Mbps Processing Gain**

**Rhein Tech Laboratories, Inc.**

2416.50	28.80	13.3	13.50	2.0	-3.83	9.67
2416.55	28.46	13.3	13.16	2.0	-3.83	9.33
2416.60	28.13	13.3	12.83	2.0	-4.00	8.83
2416.65	28.47	13.3	13.17	2.0	-4.17	9.00
2416.70	28.47	13.3	13.17	2.0	-4.00	9.17
2416.75	28.47	13.3	13.17	2.0	-4.17	9.00
2416.80	29.13	13.3	13.83	2.0	-4.50	9.33
2416.85	29.14	13.3	13.84	2.0	-4.17	9.67
2416.90	29.30	13.3	14.00	2.0	-4.50	9.50
2416.95	29.30	13.3	14.00	2.0	-4.50	9.50
2417.00	29.96	13.3	14.66	2.0	-4.83	9.83

**Channel 1, 2Mbps Processing Gain**

**Rhein Tech Laboratories, Inc.**

# Channel 1 Processing Gain

2412MHz

11Mbps

After discarding the lowest 20% J/S data points, the lowest J/S was -2.83 dB.

$$\begin{aligned}
 G_p &= (S/N)_o + M_j + L_{sys} \\
 &= 16.4\text{dB} + (-2.83\text{dB}) + 2.0\text{dB} \\
 &= \mathbf{15.57\text{dB}}
 \end{aligned}$$

11Mbps Channel 1 Processing Gain						
Gp = (S/N)o + Mj + Lsys						
Frequency (MHz)	Gp (dB)	(S/N)o (dB)	Mj = J/S (dB)	Lsys (dB)	S (Tx Power) (dBm)	J (S/G Power) (dBm)
2407.00	27.40	16.4	9.00	2.0	-1.83	7.17
2407.05	27.40	16.4	9.00	2.0	-1.67	7.33
2407.10	27.23	16.4	8.83	2.0	-1.50	7.33
2407.15	27.07	16.4	8.67	2.0	-1.50	7.17
2407.20	26.73	16.4	8.33	2.0	-1.33	7.00
2407.25	26.24	16.4	7.84	2.0	-1.17	6.67
2407.30	26.40	16.4	8.00	2.0	-1.00	7.00
2407.35	26.40	16.4	8.00	2.0	-0.83	7.17
2407.40	26.57	16.4	8.17	2.0	-1.00	7.17
2407.45	26.56	16.4	8.16	2.0	-0.83	7.33
2407.50	26.24	16.4	7.84	2.0	-0.67	7.17
2407.55	26.24	16.4	7.84	2.0	-0.67	7.17
2407.60	26.07	16.4	7.67	2.0	-0.50	7.17
2407.65	26.23	16.4	7.83	2.0	-0.50	7.33
2407.70	26.23	16.4	7.83	2.0	-0.50	7.33
2407.75	25.74	16.4	7.34	2.0	-0.17	7.17
2407.80	25.74	16.4	7.34	2.0	-0.17	7.17
2407.85	25.74	16.4	7.34	2.0	-0.17	7.17
2407.90	25.57	16.4	7.17	2.0	0.00	7.17
2407.95	25.57	16.4	7.17	2.0	-0.17	7.00
2408.00	25.57	16.4	7.17	2.0	0.00	7.17
2408.05	25.57	16.4	7.17	2.0	0.00	7.17
2408.10	25.40	16.4	7.00	2.0	0.17	7.17
2408.15	25.40	16.4	7.00	2.0	0.17	7.17
2408.20	25.40	16.4	7.00	2.0	0.17	7.17
2408.25	25.40	16.4	7.00	2.0	0.33	7.33
2408.30	25.40	16.4	7.00	2.0	0.17	7.17
2408.35	25.23	16.4	6.83	2.0	0.17	7.00
2408.40	25.07	16.4	6.67	2.0	0.50	7.17
2408.45	25.07	16.4	6.67	2.0	0.50	7.17
2408.50	25.07	16.4	6.67	2.0	0.33	7.00
2408.55	24.90	16.4	6.50	2.0	0.67	7.17
2408.60	24.90	16.4	6.50	2.0	0.67	7.17
2408.65	24.90	16.4	6.50	2.0	0.67	7.17
2408.70	24.90	16.4	6.50	2.0	0.83	7.33
2408.75	24.73	16.4	6.33	2.0	1.00	7.33
2408.80	24.90	16.4	6.50	2.0	1.00	7.50

## Channel 1, 11Mbps Processing Gain

2408.85	24.90	16.4	6.50	2.0	1.00	7.50
2408.90	24.73	16.4	6.33	2.0	1.17	7.50
2408.95	24.57	16.4	6.17	2.0	1.33	7.50
2409.00	24.57	16.4	6.17	2.0	1.33	7.50
2409.05	24.23	16.4	5.83	2.0	1.50	7.33
2409.10	24.07	16.4	5.67	2.0	1.50	7.17
2409.15	24.23	16.4	5.83	2.0	1.50	7.33
2409.20	24.23	16.4	5.83	2.0	1.67	7.50
2409.25	24.23	16.4	5.83	2.0	1.67	7.50
2409.30	23.90	16.4	5.50	2.0	1.83	7.33
2409.35	24.06	16.4	5.66	2.0	1.67	7.33
2409.40	24.06	16.4	5.66	2.0	1.67	7.33
2409.45	24.23	16.4	5.83	2.0	1.50	7.33
2409.50	24.40	16.4	6.00	2.0	1.50	7.50
2409.55	24.23	16.4	5.83	2.0	1.67	7.50
2409.60	24.07	16.4	5.67	2.0	1.83	7.50
2409.65	24.07	16.4	5.67	2.0	1.83	7.50
2409.70	23.90	16.4	5.50	2.0	2.00	7.50
2409.75	24.07	16.4	5.67	2.0	2.00	7.67
2409.80	23.90	16.4	5.50	2.0	2.00	7.50
2409.85	23.73	16.4	5.33	2.0	2.17	7.50
2409.90	23.73	16.4	5.33	2.0	2.17	7.50
2409.95	23.73	16.4	5.33	2.0	2.17	7.50
2410.00	23.90	16.4	5.50	2.0	2.17	7.67
2410.05	23.90	16.4	5.50	2.0	2.17	7.67
2410.10	23.57	16.4	5.17	2.0	2.50	7.67
2410.15	23.40	16.4	5.00	2.0	2.50	7.50
2410.20	23.90	16.4	5.50	2.0	2.67	8.17
2410.25	23.74	16.4	5.34	2.0	2.83	8.17
2410.30	23.74	16.4	5.34	2.0	2.83	8.17
2410.35	23.73	16.4	5.33	2.0	2.67	8.00
2410.40	23.57	16.4	5.17	2.0	2.83	8.00
2410.45	23.40	16.4	5.00	2.0	2.83	7.83
2410.50	23.40	16.4	5.00	2.0	2.83	7.83
2410.55	23.56	16.4	5.16	2.0	2.67	7.83
2410.60	23.56	16.4	5.16	2.0	2.67	7.83
2410.65	23.56	16.4	5.16	2.0	2.67	7.83
2410.70	23.73	16.4	5.33	2.0	2.67	8.00
2410.75	23.57	16.4	5.17	2.0	3.00	8.17
2410.80	23.90	16.4	5.50	2.0	2.83	8.33
2410.85	23.73	16.4	5.33	2.0	3.00	8.33
2410.90	23.73	16.4	5.33	2.0	3.00	8.33
2410.95	23.40	16.4	5.00	2.0	3.17	8.17
2411.00	23.57	16.4	5.17	2.0	3.00	8.17
2411.05	23.57	16.4	5.17	2.0	3.00	8.17
2411.10	23.40	16.4	5.00	2.0	3.17	8.17
2411.15	23.40	16.4	5.00	2.0	3.17	8.17
2411.20	23.40	16.4	5.00	2.0	3.17	8.17
2411.25	23.74	16.4	5.34	2.0	2.83	8.17
2411.30	23.57	16.4	5.17	2.0	3.00	8.17
2411.35	23.40	16.4	5.00	2.0	3.00	8.00

**Channel 1, 11Mbps Processing Gain**

**Rhein Tech Laboratories, Inc.**

2411.40	23.40	16.4	5.00	2.0	3.00	8.00
2411.45	23.23	16.4	4.83	2.0	3.00	7.83
2411.50	23.40	16.4	5.00	2.0	3.17	8.17
2411.55	23.40	16.4	5.00	2.0	3.00	8.00
2411.60	23.73	16.4	5.33	2.0	3.00	8.33
2411.65	23.73	16.4	5.33	2.0	3.00	8.33
2411.70	23.73	16.4	5.33	2.0	3.00	8.33
2411.75	23.56	16.4	5.16	2.0	3.17	8.33
2411.80	23.57	16.4	5.17	2.0	3.00	8.17
2411.85	23.40	16.4	5.00	2.0	3.00	8.00
2411.90	23.40	16.4	5.00	2.0	3.00	8.00
2411.95	23.57	16.4	5.17	2.0	3.00	8.17
2412.00	23.73	16.4	5.33	2.0	3.00	8.33
2412.05	23.73	16.4	5.33	2.0	3.00	8.33
2412.10	23.57	16.4	5.17	2.0	3.00	8.17
2412.15	23.23	16.4	4.83	2.0	3.00	7.83
2412.20	23.23	16.4	4.83	2.0	3.00	7.83
2412.25	23.57	16.4	5.17	2.0	2.83	8.00
2412.30	23.90	16.4	5.50	2.0	2.67	8.17
2412.35	23.40	16.4	5.00	2.0	2.83	7.83
2412.40	23.40	16.4	5.00	2.0	2.83	7.83
2412.45	23.74	16.4	5.34	2.0	2.83	8.17
2412.50	23.24	16.4	4.84	2.0	3.33	8.17
2412.55	23.90	16.4	5.50	2.0	2.83	8.33
2412.60	23.40	16.4	5.00	2.0	3.17	8.17
2412.65	23.73	16.4	5.33	2.0	3.00	8.33
2412.70	23.57	16.4	5.17	2.0	3.00	8.17
2412.75	23.40	16.4	5.00	2.0	3.17	8.17
2412.80	23.40	16.4	5.00	2.0	3.00	8.00
2412.85	23.57	16.4	5.17	2.0	3.00	8.17
2412.90	23.74	16.4	5.34	2.0	2.83	8.17
2412.95	23.57	16.4	5.17	2.0	3.00	8.17
2413.00	23.73	16.4	5.33	2.0	3.00	8.33
2413.05	23.55	16.4	5.15	2.0	3.00	8.15
2413.10	24.24	16.4	5.84	2.0	2.83	8.67
2413.15	23.57	16.4	5.17	2.0	3.00	8.17
2413.20	23.24	16.4	4.84	2.0	3.33	8.17
2413.25	23.07	16.4	4.67	2.0	3.33	8.00
2413.30	23.07	16.4	4.67	2.0	3.00	7.67
2413.35	22.90	16.4	4.50	2.0	3.17	7.67
2413.40	22.57	16.4	4.17	2.0	3.33	7.50
2413.45	23.07	16.4	4.67	2.0	3.00	7.67
2413.50	23.23	16.4	4.83	2.0	3.00	7.83
2413.55	23.40	16.4	5.00	2.0	2.83	7.83
2413.60	23.06	16.4	4.66	2.0	2.67	7.33
2413.65	23.56	16.4	5.16	2.0	2.67	7.83
2413.70	23.40	16.4	5.00	2.0	2.67	7.67
2413.75	23.40	16.4	5.00	2.0	2.67	7.67
2413.80	23.57	16.4	5.17	2.0	2.50	7.67
2413.85	23.73	16.4	5.33	2.0	2.50	7.83
2413.90	23.90	16.4	5.50	2.0	2.17	7.67

**Channel 1, 11Mbps Processing Gain**

**Rhein Tech Laboratories, Inc.**

2413.95	23.57	16.4	5.17	2.0	2.50	7.67
2414.00	23.40	16.4	5.00	2.0	2.50	7.50
2414.05	23.57	16.4	5.17	2.0	2.50	7.67
2414.10	23.57	16.4	5.17	2.0	2.33	7.50
2414.15	23.73	16.4	5.33	2.0	2.17	7.50
2414.20	23.57	16.4	5.17	2.0	2.33	7.50
2414.25	23.90	16.4	5.50	2.0	2.17	7.67
2414.30	23.73	16.4	5.33	2.0	2.17	7.50
2414.35	13.90	16.4	-4.50	2.0	2.17	-2.33
2414.40	13.90	16.4	-4.50	2.0	2.00	-2.50
2414.45	14.07	16.4	-4.33	2.0	1.83	-2.50
2414.50	14.07	16.4	-4.33	2.0	1.83	-2.50
2414.55	13.90	16.4	-4.50	2.0	1.83	-2.67
2414.60	14.23	16.4	-4.17	2.0	1.67	-2.50
2414.65	14.23	16.4	-4.17	2.0	1.67	-2.50
2414.70	14.40	16.4	-4.00	2.0	1.67	-2.33
2414.75	14.23	16.4	-4.17	2.0	1.67	-2.50
2414.80	14.23	16.4	-4.17	2.0	1.67	-2.50
2414.85	14.73	16.4	-3.67	2.0	1.50	-2.17
2414.90	14.73	16.4	-3.67	2.0	1.50	-2.17
2414.95	14.40	16.4	-4.00	2.0	1.67	-2.33
2415.00	14.73	16.4	-3.67	2.0	1.50	-2.17
2415.05	14.90	16.4	-3.50	2.0	1.33	-2.17
2415.10	14.74	16.4	-3.66	2.0	1.33	-2.33
2415.15	14.57	16.4	-3.83	2.0	1.33	-2.50
2415.20	14.56	16.4	-3.84	2.0	1.17	-2.67
2415.25	14.56	16.4	-3.84	2.0	1.17	-2.67
2415.30	14.73	16.4	-3.67	2.0	1.17	-2.50
2415.35	14.73	16.4	-3.67	2.0	1.00	-2.67
2415.40	14.57	16.4	-3.83	2.0	1.00	-2.83
2415.45	14.40	16.4	-4.00	2.0	1.17	-2.83
2415.50	14.57	16.4	-3.83	2.0	1.00	-2.83
2415.55	14.40	16.4	-4.00	2.0	1.00	-3.00
2415.60	14.57	16.4	-3.83	2.0	1.00	-2.83
2415.65	14.90	16.4	-3.50	2.0	0.83	-2.67
2415.70	15.06	16.4	-3.34	2.0	0.67	-2.67
2415.75	15.40	16.4	-3.00	2.0	0.33	-2.67
2415.80	15.57	16.4	-2.83	2.0	0.33	-2.50
2415.85	15.23	16.4	-3.17	2.0	0.50	-2.67
2415.90	15.56	16.4	-2.84	2.0	0.17	-2.67
2415.95	15.07	16.4	-3.33	2.0	0.50	-2.83
2416.00	15.07	16.4	-3.33	2.0	0.33	-3.00
2416.05	14.90	16.4	-3.50	2.0	0.67	-2.83
2416.10	14.90	16.4	-3.50	2.0	0.50	-3.00
2416.15	14.90	16.4	-3.50	2.0	0.50	-3.00
2416.20	15.40	16.4	-3.00	2.0	0.00	-3.00
2416.25	15.07	16.4	-3.33	2.0	0.33	-3.00
2416.30	15.40	16.4	-3.00	2.0	0.00	-3.00
2416.35	15.57	16.4	-2.83	2.0	0.00	-2.83
2416.40	15.57	16.4	-2.83	2.0	0.00	-2.83
2416.45	15.90	16.4	-2.50	2.0	-0.17	-2.67

**Channel 1, 11Mbps Processing Gain**

**Rhein Tech Laboratories, Inc.**

2416.50	15.90	16.4	-2.50	2.0	-0.33	-2.83
2416.55	16.07	16.4	-2.33	2.0	-0.50	-2.83
2416.60	16.23	16.4	-2.17	2.0	-0.50	-2.67
2416.65	16.24	16.4	-2.16	2.0	-0.67	-2.83
2416.70	16.24	16.4	-2.16	2.0	-0.67	-2.83
2416.75	16.40	16.4	-2.00	2.0	-0.83	-2.83
2416.80	16.73	16.4	-1.67	2.0	-1.00	-2.67
2416.85	16.73	16.4	-1.67	2.0	-1.00	-2.67
2416.90	16.73	16.4	-1.67	2.0	-1.00	-2.67
2416.95	16.90	16.4	-1.50	2.0	-1.17	-2.67
2417.00	17.07	16.4	-1.33	2.0	-1.17	-2.50

**Channel 1, 11Mbps Processing Gain**

**Rhein Tech Laboratories, Inc.**

# Channel 6 Processing Gain

2437MHz

11Mbps

After discarding the lowest 20% J/S data points, the lowest J/S was 4.5 dB.

$$\begin{aligned}
 G_p &= (S/N)_o + M_j + L_{sys} \\
 &= 16.4\text{dB} + 4.5\text{dB} + 2.0\text{dB} \\
 &= \mathbf{22.9\text{ dB}}
 \end{aligned}$$

11Mbps Channel 6 Processing Gain						
Gp = (S/N)o + Mj + Lsys						
Frequency (MHz)	Gp (dB)	(S/N)o (dB)	Mj = J/S (dB)	Lsys (dB)	S (Tx Power) (dBm)	J (S/G Power) (dBm)
2432.00	26.74	16.4	8.34	2.0	-0.67	7.67
2432.05	26.40	16.4	8.00	2.0	-0.67	7.33
2432.10	26.24	16.4	7.84	2.0	-0.67	7.17
2432.15	26.24	16.4	7.84	2.0	-0.17	7.67
2432.20	25.90	16.4	7.50	2.0	-0.50	7.00
2432.25	25.07	16.4	6.67	2.0	0.33	7.00
2432.30	25.57	16.4	7.17	2.0	-0.17	7.00
2432.35	25.40	16.4	7.00	2.0	0.17	7.17
2432.40	25.40	16.4	7.00	2.0	0.50	7.50
2432.45	25.24	16.4	6.84	2.0	0.33	7.17
2432.50	25.90	16.4	7.50	2.0	-0.17	7.33
2432.55	25.07	16.4	6.67	2.0	0.33	7.00
2432.60	25.57	16.4	7.17	2.0	0.33	7.50
2432.65	25.07	16.4	6.67	2.0	0.50	7.17
2432.70	25.07	16.4	6.67	2.0	0.50	7.17
2432.75	24.40	16.4	6.00	2.0	0.83	6.83
2432.80	25.07	16.4	6.67	2.0	0.50	7.17
2432.85	24.40	16.4	6.00	2.0	0.83	6.83
2432.90	24.23	16.4	5.83	2.0	1.17	7.00
2432.95	24.74	16.4	6.34	2.0	0.83	7.17
2433.00	24.24	16.4	5.84	2.0	1.33	7.17
2433.05	24.40	16.4	6.00	2.0	1.33	7.33
2433.10	25.07	16.4	6.67	2.0	1.00	7.67
2433.15	24.23	16.4	5.83	2.0	1.00	6.83
2433.20	24.24	16.4	5.84	2.0	1.33	7.17
2433.25	24.23	16.4	5.83	2.0	1.50	7.33
2433.30	24.40	16.4	6.00	2.0	1.50	7.50
2433.35	24.07	16.4	5.67	2.0	1.50	7.17
2433.40	23.57	16.4	5.17	2.0	1.50	6.67
2433.45	24.24	16.4	5.84	2.0	1.33	7.17
2433.50	23.90	16.4	5.50	2.0	1.50	7.00
2433.55	24.07	16.4	5.67	2.0	1.50	7.17
2433.60	24.07	16.4	5.67	2.0	1.50	7.17
2433.65	24.07	16.4	5.67	2.0	1.33	7.00
2433.70	23.74	16.4	5.34	2.0	1.83	7.17
2433.75	24.23	16.4	5.83	2.0	1.67	7.50
2433.80	23.90	16.4	5.50	2.0	1.83	7.33

## Channel 6, 11Mbps Processing Gain



2433.85	24.24	16.4	5.84	2.0	1.83	7.67
2433.90	23.73	16.4	5.33	2.0	2.17	7.50
2433.95	23.90	16.4	5.50	2.0	2.00	7.50
2434.00	24.07	16.4	5.67	2.0	2.00	7.67
2434.05	23.07	16.4	4.67	2.0	2.50	7.17
2434.10	23.23	16.4	4.83	2.0	2.50	7.33
2434.15	23.07	16.4	4.67	2.0	2.33	7.00
2434.20	23.23	16.4	4.83	2.0	2.67	7.50
2434.25	23.23	16.4	4.83	2.0	2.50	7.33
2434.30	22.73	16.4	4.33	2.0	2.50	6.83
2434.35	23.24	16.4	4.84	2.0	2.33	7.17
2434.40	23.07	16.4	4.67	2.0	2.50	7.17
2434.45	22.90	16.4	4.50	2.0	2.67	7.17
2434.50	23.07	16.4	4.67	2.0	2.83	7.50
2434.55	23.57	16.4	5.17	2.0	2.50	7.67
2434.60	23.06	16.4	4.66	2.0	3.17	7.83
2434.65	22.90	16.4	4.50	2.0	2.83	7.33
2434.70	23.40	16.4	5.00	2.0	3.00	8.00
2434.75	23.57	16.4	5.17	2.0	2.50	7.67
2434.80	23.07	16.4	4.67	2.0	2.83	7.50
2434.85	22.73	16.4	4.33	2.0	3.17	7.50
2434.90	23.07	16.4	4.67	2.0	3.00	7.67
2434.95	23.24	16.4	4.84	2.0	2.83	7.67
2435.00	22.90	16.4	4.50	2.0	2.83	7.33
2435.05	22.74	16.4	4.34	2.0	3.33	7.67
2435.10	23.74	16.4	5.34	2.0	2.83	8.17
2435.15	23.23	16.4	4.83	2.0	3.17	8.00
2435.20	22.57	16.4	4.17	2.0	3.50	7.67
2435.25	23.23	16.4	4.83	2.0	3.00	7.83
2435.30	23.57	16.4	5.17	2.0	3.00	8.17
2435.35	23.24	16.4	4.84	2.0	2.83	7.67
2435.40	23.56	16.4	5.16	2.0	3.17	8.33
2435.45	22.73	16.4	4.33	2.0	3.50	7.83
2435.50	23.24	16.4	4.84	2.0	3.33	8.17
2435.55	23.06	16.4	4.66	2.0	3.17	7.83
2435.60	22.90	16.4	4.50	2.0	3.67	8.17
2435.65	23.40	16.4	5.00	2.0	3.33	8.33
2435.70	23.23	16.4	4.83	2.0	3.50	8.33
2435.75	22.90	16.4	4.50	2.0	4.00	8.50
2435.80	23.23	16.4	4.83	2.0	3.50	8.33
2435.85	23.23	16.4	4.83	2.0	3.50	8.33
2435.90	23.40	16.4	5.00	2.0	3.33	8.33
2435.95	22.90	16.4	4.50	2.0	3.50	8.00
2436.00	23.40	16.4	5.00	2.0	3.33	8.33
2436.05	22.90	16.4	4.50	2.0	3.67	8.17
2436.10	22.90	16.4	4.50	2.0	3.67	8.17
2436.15	23.24	16.4	4.84	2.0	3.33	8.17
2436.20	23.40	16.4	5.00	2.0	3.50	8.50
2436.25	23.06	16.4	4.66	2.0	3.67	8.33
2436.30	23.07	16.4	4.67	2.0	4.00	8.67
2436.35	23.07	16.4	4.67	2.0	3.50	8.17

**Channel 6, 11Mbps Processing Gain**

**Rhein Tech Laboratories, Inc.**

2436.40	23.40	16.4	5.00	2.0	3.50	8.50
2436.45	23.07	16.4	4.67	2.0	3.50	8.17
2436.50	23.23	16.4	4.83	2.0	3.50	8.33
2436.55	22.90	16.4	4.50	2.0	3.67	8.17
2436.60	23.23	16.4	4.83	2.0	3.50	8.33
2436.65	23.23	16.4	4.83	2.0	3.50	8.33
2436.70	23.23	16.4	4.83	2.0	3.67	8.50
2436.75	23.40	16.4	5.00	2.0	3.50	8.50
2436.80	23.07	16.4	4.67	2.0	3.83	8.50
2436.85	23.07	16.4	4.67	2.0	3.50	8.17
2436.90	22.74	16.4	4.34	2.0	3.83	8.17
2436.95	22.90	16.4	4.50	2.0	3.83	8.33
2437.00	23.06	16.4	4.66	2.0	3.67	8.33
2437.05	23.06	16.4	4.66	2.0	3.67	8.33
2437.10	22.74	16.4	4.34	2.0	3.83	8.17
2437.15	23.06	16.4	4.66	2.0	3.67	8.33
2437.20	23.06	16.4	4.66	2.0	3.67	8.33
2437.25	22.90	16.4	4.50	2.0	3.67	8.17
2437.30	23.57	16.4	5.17	2.0	3.50	8.67
2437.35	22.73	16.4	4.33	2.0	4.00	8.33
2437.40	22.73	16.4	4.33	2.0	4.00	8.33
2437.45	22.90	16.4	4.50	2.0	3.67	8.17
2437.50	22.73	16.4	4.33	2.0	4.00	8.33
2437.55	22.90	16.4	4.50	2.0	3.67	8.17
2437.60	22.90	16.4	4.50	2.0	3.83	8.33
2437.65	23.23	16.4	4.83	2.0	3.50	8.33
2437.70	23.40	16.4	5.00	2.0	3.33	8.33
2437.75	23.07	16.4	4.67	2.0	3.83	8.50
2437.80	23.40	16.4	5.00	2.0	3.50	8.50
2437.85	23.40	16.4	5.00	2.0	3.50	8.50
2437.90	23.23	16.4	4.83	2.0	3.67	8.50
2437.95	23.24	16.4	4.84	2.0	3.83	8.67
2438.00	22.90	16.4	4.50	2.0	3.83	8.33
2438.05	23.24	16.4	4.84	2.0	3.83	8.67
2438.10	22.73	16.4	4.33	2.0	4.00	8.33
2438.15	22.90	16.4	4.50	2.0	4.00	8.50
2438.20	23.24	16.4	4.84	2.0	3.33	8.17
2438.25	22.90	16.4	4.50	2.0	3.67	8.17
2438.30	22.73	16.4	4.33	2.0	3.67	8.00
2438.35	22.24	16.4	3.84	2.0	4.33	8.17
2438.40	22.90	16.4	4.50	2.0	3.67	8.17
2438.45	23.07	16.4	4.67	2.0	3.50	8.17
2438.50	22.73	16.4	4.33	2.0	3.67	8.00
2438.55	22.74	16.4	4.34	2.0	3.83	8.17
2438.60	22.90	16.4	4.50	2.0	3.67	8.17
2438.65	22.56	16.4	4.16	2.0	3.67	7.83
2438.70	22.73	16.4	4.33	2.0	3.50	7.83
2438.75	22.90	16.4	4.50	2.0	3.33	7.83
2438.80	23.23	16.4	4.83	2.0	3.17	8.00
2438.85	23.57	16.4	5.17	2.0	2.83	8.00
2438.90	23.07	16.4	4.67	2.0	3.33	8.00

**Channel 6, 11Mbps Processing Gain**

**Rhein Tech Laboratories, Inc.**

2438.95	23.07	16.4	4.67	2.0	3.00	7.67
2439.00	23.23	16.4	4.83	2.0	3.17	8.00
2439.05	23.06	16.4	4.66	2.0	3.17	7.83
2439.10	23.24	16.4	4.84	2.0	2.83	7.67
2439.15	23.23	16.4	4.83	2.0	3.00	7.83
2439.20	23.23	16.4	4.83	2.0	3.00	7.83
2439.25	22.90	16.4	4.50	2.0	3.33	7.83
2439.30	23.23	16.4	4.83	2.0	3.00	7.83
2439.35	23.56	16.4	5.16	2.0	2.67	7.83
2439.40	23.24	16.4	4.84	2.0	2.83	7.67
2439.45	23.07	16.4	4.67	2.0	3.00	7.67
2439.50	23.40	16.4	5.00	2.0	2.67	7.67
2439.55	22.90	16.4	4.50	2.0	3.00	7.50
2439.60	23.73	16.4	5.33	2.0	2.50	7.83
2439.65	23.56	16.4	5.16	2.0	2.67	7.83
2439.70	23.74	16.4	5.34	2.0	2.33	7.67
2439.75	23.73	16.4	5.33	2.0	2.50	7.83
2439.80	23.73	16.4	5.33	2.0	2.50	7.83
2439.85	23.90	16.4	5.50	2.0	2.17	7.67
2439.90	23.90	16.4	5.50	2.0	2.33	7.83
2439.95	23.73	16.4	5.33	2.0	2.50	7.83
2440.00	24.24	16.4	5.84	2.0	2.33	8.17
2440.05	24.06	16.4	5.66	2.0	2.17	7.83
2440.10	23.90	16.4	5.50	2.0	2.33	7.83
2440.15	24.06	16.4	5.66	2.0	2.17	7.83
2440.20	23.73	16.4	5.33	2.0	2.50	7.83
2440.25	23.90	16.4	5.50	2.0	2.17	7.67
2440.30	23.74	16.4	5.34	2.0	2.33	7.67
2440.35	23.23	16.4	4.83	2.0	2.67	7.50
2440.40	24.23	16.4	5.83	2.0	2.00	7.83
2440.45	23.90	16.4	5.50	2.0	2.33	7.83
2440.50	24.06	16.4	5.66	2.0	2.17	7.83
2440.55	23.57	16.4	5.17	2.0	2.33	7.50
2440.60	23.57	16.4	5.17	2.0	2.50	7.67
2440.65	23.74	16.4	5.34	2.0	2.33	7.67
2440.70	23.90	16.4	5.50	2.0	2.17	7.67
2440.75	23.40	16.4	5.00	2.0	2.67	7.67
2440.80	23.73	16.4	5.33	2.0	2.50	7.83
2440.85	23.57	16.4	5.17	2.0	2.50	7.67
2440.90	23.40	16.4	5.00	2.0	2.67	7.67
2440.95	23.57	16.4	5.17	2.0	2.33	7.50
2441.00	23.07	16.4	4.67	2.0	3.00	7.67
2441.05	22.73	16.4	4.33	2.0	3.17	7.50
2441.10	22.23	16.4	3.83	2.0	3.67	7.50
2441.15	21.90	16.4	3.50	2.0	3.67	7.17
2441.20	21.57	16.4	3.17	2.0	4.33	7.50
2441.25	20.90	16.4	2.50	2.0	4.83	7.33
2441.30	21.07	16.4	2.67	2.0	4.83	7.50
2441.35	20.90	16.4	2.50	2.0	4.83	7.33
2441.40	20.23	16.4	1.83	2.0	5.67	7.50
2441.45	19.73	16.4	1.33	2.0	6.00	7.33

**Channel 6, 11Mbps Processing Gain**

**Rhein Tech Laboratories, Inc.**

2441.50	19.73	16.4	1.33	2.0	6.00	7.33
2441.55	19.23	16.4	0.83	2.0	6.50	7.33
2441.60	19.40	16.4	1.00	2.0	6.50	7.50
2441.65	18.90	16.4	0.50	2.0	7.00	7.50
2441.70	18.73	16.4	0.33	2.0	7.00	7.33
2441.75	18.90	16.4	0.50	2.0	7.33	7.83
2441.80	18.57	16.4	0.17	2.0	7.50	7.67
2441.85	18.40	16.4	0.00	2.0	7.67	7.67
2441.90	18.24	16.4	-0.16	2.0	7.83	7.67
2441.95	18.40	16.4	0.00	2.0	7.83	7.83
2442.00	18.40	16.4	0.00	2.0	7.83	7.83

**Channel 6, 11Mbps Processing Gain**

**Rhein Tech Laboratories, Inc.**

# Channel 11 Processing Gain

2462MHz

11Mbps

After discarding the lowest 20% J/S data points, the lowest J/S was 4.33 dB.

$$\begin{aligned}
 G_p &= (S/N)_o + M_j + L_{sys} \\
 &= 16.4\text{dB} + 4.33\text{dB} + 2.0\text{dB} \\
 &= \mathbf{22.73\text{ dB}}
 \end{aligned}$$

11Mbps Channel 11 Processing Gain						
Gp = (S/N)o + Mj + Lsys						
Frequency (MHz)	Gp (dB)	(S/N)o (dB)	Mj = J/S (dB)	Lsys (dB)	S (Tx Power) (dBm)	J (S/G Power) (dBm)
2457.00	26.57	16.4	8.17	2.0	-2.00	6.17
2457.05	26.24	16.4	7.84	2.0	-1.67	6.17
2457.10	26.07	16.4	7.67	2.0	-1.67	6.00
2457.15	26.23	16.4	7.83	2.0	-1.83	6.00
2457.20	26.24	16.4	7.84	2.0	-1.67	6.17
2457.25	25.90	16.4	7.50	2.0	-1.33	6.17
2457.30	25.73	16.4	7.33	2.0	-1.33	6.00
2457.35	26.57	16.4	8.17	2.0	-2.00	6.17
2457.40	25.90	16.4	7.50	2.0	-1.50	6.00
2457.45	25.23	16.4	6.83	2.0	-0.83	6.00
2457.50	25.23	16.4	6.83	2.0	-0.83	6.00
2457.55	25.40	16.4	7.00	2.0	-1.00	6.00
2457.60	25.40	16.4	7.00	2.0	-1.00	6.00
2457.65	25.40	16.4	7.00	2.0	-1.17	5.83
2457.70	25.06	16.4	6.66	2.0	-0.83	5.83
2457.75	25.07	16.4	6.67	2.0	-0.50	6.17
2457.80	25.07	16.4	6.67	2.0	-1.00	5.67
2457.85	24.73	16.4	6.33	2.0	-0.50	5.83
2457.90	24.57	16.4	6.17	2.0	-0.50	5.67
2457.95	24.90	16.4	6.50	2.0	-0.67	5.83
2458.00	24.73	16.4	6.33	2.0	-0.33	6.00
2458.05	24.90	16.4	6.50	2.0	-0.50	6.00
2458.10	24.73	16.4	6.33	2.0	0.00	6.33
2458.15	25.23	16.4	6.83	2.0	-0.50	6.33
2458.20	24.23	16.4	5.83	2.0	0.00	5.83
2458.25	24.24	16.4	5.84	2.0	0.33	6.17
2458.30	24.57	16.4	6.17	2.0	-0.17	6.00
2458.35	24.06	16.4	5.66	2.0	0.17	5.83
2458.40	24.06	16.4	5.66	2.0	0.17	5.83
2458.45	24.23	16.4	5.83	2.0	0.00	5.83
2458.50	24.06	16.4	5.66	2.0	0.17	5.83
2458.55	24.23	16.4	5.83	2.0	0.17	6.00
2458.60	23.90	16.4	5.50	2.0	0.50	6.00
2458.65	23.56	16.4	5.16	2.0	0.67	5.83
2458.70	24.23	16.4	5.83	2.0	0.50	6.33
2458.75	23.73	16.4	5.33	2.0	0.67	6.00
2458.80	24.23	16.4	5.83	2.0	0.50	6.33

## Channel 11, 11Mbps Processing Gain

2458.85	23.73	16.4	5.33	2.0	1.00	6.33
2458.90	24.06	16.4	5.66	2.0	0.67	6.33
2458.95	23.90	16.4	5.50	2.0	0.83	6.33
2459.00	23.73	16.4	5.33	2.0	1.00	6.33
2459.05	23.24	16.4	4.84	2.0	1.33	6.17
2459.10	23.07	16.4	4.67	2.0	1.33	6.00
2459.15	23.07	16.4	4.67	2.0	1.50	6.17
2459.20	23.89	16.4	5.49	2.0	0.67	6.16
2459.25	23.07	16.4	4.67	2.0	1.33	6.00
2459.30	23.23	16.4	4.83	2.0	1.17	6.00
2459.35	22.90	16.4	4.50	2.0	1.50	6.00
2459.40	23.07	16.4	4.67	2.0	1.50	6.17
2459.45	23.07	16.4	4.67	2.0	1.50	6.17
2459.50	22.90	16.4	4.50	2.0	1.67	6.17
2459.55	23.23	16.4	4.83	2.0	1.50	6.33
2459.60	22.74	16.4	4.34	2.0	1.83	6.17
2459.65	23.07	16.4	4.67	2.0	1.83	6.50
2459.70	23.23	16.4	4.83	2.0	1.67	6.50
2459.75	23.40	16.4	5.00	2.0	1.33	6.33
2459.80	22.73	16.4	4.33	2.0	2.17	6.50
2459.85	22.23	16.4	3.83	2.0	2.17	6.00
2459.90	22.74	16.4	4.34	2.0	1.83	6.17
2459.95	23.07	16.4	4.67	2.0	1.50	6.17
2460.00	23.23	16.4	4.83	2.0	1.50	6.33
2460.05	23.07	16.4	4.67	2.0	1.83	6.50
2460.10	23.07	16.4	4.67	2.0	2.00	6.67
2460.15	23.24	16.4	4.84	2.0	1.83	6.67
2460.20	22.40	16.4	4.00	2.0	2.50	6.50
2460.25	23.23	16.4	4.83	2.0	1.67	6.50
2460.30	22.57	16.4	4.17	2.0	2.33	6.50
2460.35	22.73	16.4	4.33	2.0	2.00	6.33
2460.40	22.90	16.4	4.50	2.0	2.00	6.50
2460.45	22.56	16.4	4.16	2.0	2.17	6.33
2460.50	22.57	16.4	4.17	2.0	2.33	6.50
2460.55	22.73	16.4	4.33	2.0	2.00	6.33
2460.60	22.56	16.4	4.16	2.0	2.17	6.33
2460.65	22.90	16.4	4.50	2.0	2.00	6.50
2460.70	22.57	16.4	4.17	2.0	2.50	6.67
2460.75	22.74	16.4	4.34	2.0	2.33	6.67
2460.80	23.06	16.4	4.66	2.0	2.17	6.83
2460.85	22.90	16.4	4.50	2.0	2.33	6.83
2460.90	22.90	16.4	4.50	2.0	2.33	6.83
2460.95	23.06	16.4	4.66	2.0	2.17	6.83
2461.00	22.73	16.4	4.33	2.0	2.50	6.83
2461.05	23.23	16.4	4.83	2.0	2.00	6.83
2461.10	22.73	16.4	4.33	2.0	2.67	7.00
2461.15	22.74	16.4	4.34	2.0	2.33	6.67
2461.20	23.07	16.4	4.67	2.0	2.33	7.00
2461.25	22.73	16.4	4.33	2.0	2.67	7.00
2461.30	22.74	16.4	4.34	2.0	2.33	6.67
2461.35	22.73	16.4	4.33	2.0	2.50	6.83

**Channel 11, 11Mbps Processing Gain**

**Rhein Tech Laboratories, Inc.**

2461.40	22.57	16.4	4.17	2.0	2.50	6.67
2461.45	23.06	16.4	4.66	2.0	2.17	6.83
2461.50	22.73	16.4	4.33	2.0	2.67	7.00
2461.55	23.40	16.4	5.00	2.0	2.00	7.00
2461.60	23.06	16.4	4.66	2.0	2.17	6.83
2461.65	23.07	16.4	4.67	2.0	2.33	7.00
2461.70	22.73	16.4	4.33	2.0	2.67	7.00
2461.75	22.73	16.4	4.33	2.0	2.50	6.83
2461.80	22.40	16.4	4.00	2.0	2.67	6.67
2461.85	22.40	16.4	4.00	2.0	2.67	6.67
2461.90	22.73	16.4	4.33	2.0	2.50	6.83
2461.95	22.07	16.4	3.67	2.0	3.00	6.67
2462.00	22.56	16.4	4.16	2.0	2.67	6.83
2462.05	22.07	16.4	3.67	2.0	3.00	6.67
2462.10	18.23	16.4	-0.17	2.0	2.50	2.33
2462.15	22.40	16.4	4.00	2.0	2.83	6.83
2462.20	22.07	16.4	3.67	2.0	3.00	6.67
2462.25	22.56	16.4	4.16	2.0	2.67	6.83
2462.30	22.57	16.4	4.17	2.0	2.33	6.50
2462.35	22.40	16.4	4.00	2.0	2.83	6.83
2462.40	22.23	16.4	3.83	2.0	3.00	6.83
2462.45	22.73	16.4	4.33	2.0	2.50	6.83
2462.50	22.06	16.4	3.66	2.0	2.67	6.33
2462.55	22.23	16.4	3.83	2.0	2.67	6.50
2462.60	22.23	16.4	3.83	2.0	2.67	6.50
2462.65	23.40	16.4	5.00	2.0	2.17	7.17
2462.70	22.40	16.4	4.00	2.0	2.67	6.67
2462.75	22.90	16.4	4.50	2.0	2.33	6.83
2462.80	22.90	16.4	4.50	2.0	2.33	6.83
2462.85	22.73	16.4	4.33	2.0	2.50	6.83
2462.90	23.40	16.4	5.00	2.0	2.17	7.17
2462.95	23.06	16.4	4.66	2.0	2.17	6.83
2463.00	22.73	16.4	4.33	2.0	2.50	6.83
2463.05	22.40	16.4	4.00	2.0	2.67	6.67
2463.10	23.07	16.4	4.67	2.0	2.33	7.00
2463.15	22.90	16.4	4.50	2.0	2.50	7.00
2463.20	21.90	16.4	3.50	2.0	3.00	6.50
2463.25	22.73	16.4	4.33	2.0	2.67	7.00
2463.30	22.57	16.4	4.17	2.0	2.50	6.67
2463.35	22.90	16.4	4.50	2.0	2.17	6.67
2463.40	22.73	16.4	4.33	2.0	2.50	6.83
2463.45	22.90	16.4	4.50	2.0	2.17	6.67
2463.50	23.06	16.4	4.66	2.0	2.17	6.83
2463.55	22.23	16.4	3.83	2.0	2.50	6.33
2463.60	22.73	16.4	4.33	2.0	2.17	6.50
2463.65	22.73	16.4	4.33	2.0	2.17	6.50
2463.70	23.40	16.4	5.00	2.0	1.67	6.67
2463.75	23.06	16.4	4.66	2.0	1.67	6.33
2463.80	22.90	16.4	4.50	2.0	2.00	6.50
2463.85	22.90	16.4	4.50	2.0	1.83	6.33
2463.90	22.74	16.4	4.34	2.0	1.83	6.17

**Channel 11, 11Mbps Processing Gain**

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2463.95	23.07	16.4	4.67	2.0	1.83	6.50
2464.00	22.73	16.4	4.33	2.0	2.00	6.33
2464.05	22.90	16.4	4.50	2.0	1.83	6.33
2464.10	22.90	16.4	4.50	2.0	1.50	6.00
2464.15	22.07	16.4	3.67	2.0	2.33	6.00
2464.20	23.06	16.4	4.66	2.0	1.67	6.33
2464.25	23.07	16.4	4.67	2.0	1.83	6.50
2464.30	23.06	16.4	4.66	2.0	1.67	6.33
2464.35	22.40	16.4	4.00	2.0	1.83	5.83
2464.40	23.40	16.4	5.00	2.0	1.50	6.50
2464.45	21.40	16.4	3.00	2.0	1.50	4.50
2464.50	22.90	16.4	4.50	2.0	1.67	6.17
2464.55	23.07	16.4	4.67	2.0	1.33	6.00
2464.60	23.56	16.4	5.16	2.0	1.17	6.33
2464.65	23.40	16.4	5.00	2.0	1.17	6.17
2464.70	23.57	16.4	5.17	2.0	0.83	6.00
2464.75	23.73	16.4	5.33	2.0	1.17	6.50
2464.80	23.07	16.4	4.67	2.0	1.50	6.17
2464.85	23.56	16.4	5.16	2.0	1.17	6.33
2464.90	23.56	16.4	5.16	2.0	1.17	6.33
2464.95	23.56	16.4	5.16	2.0	1.17	6.33
2465.00	23.56	16.4	5.16	2.0	1.17	6.33
2465.05	24.40	16.4	6.00	2.0	0.67	6.67
2465.10	23.73	16.4	5.33	2.0	1.00	6.33
2465.15	24.06	16.4	5.66	2.0	0.67	6.33
2465.20	23.90	16.4	5.50	2.0	0.83	6.33
2465.25	24.07	16.4	5.67	2.0	0.83	6.50
2465.30	24.23	16.4	5.83	2.0	0.50	6.33
2465.35	24.07	16.4	5.67	2.0	0.33	6.00
2465.40	24.57	16.4	6.17	2.0	0.33	6.50
2465.45	24.40	16.4	6.00	2.0	0.17	6.17
2465.50	23.73	16.4	5.33	2.0	0.67	6.00
2465.55	24.24	16.4	5.84	2.0	0.33	6.17
2465.60	23.90	16.4	5.50	2.0	0.33	5.83
2465.65	24.40	16.4	6.00	2.0	-0.17	5.83
2465.70	24.73	16.4	6.33	2.0	0.00	6.33
2465.75	24.74	16.4	6.34	2.0	-0.17	6.17
2465.80	24.40	16.4	6.00	2.0	0.17	6.17
2465.85	24.74	16.4	6.34	2.0	-0.17	6.17
2465.90	24.40	16.4	6.00	2.0	0.17	6.17
2465.95	24.90	16.4	6.50	2.0	-0.50	6.00
2466.00	24.57	16.4	6.17	2.0	-0.17	6.00
2466.05	24.90	16.4	6.50	2.0	-0.50	6.00
2466.10	25.06	16.4	6.66	2.0	-0.83	5.83
2466.15	24.23	16.4	5.83	2.0	0.17	6.00
2466.20	25.40	16.4	7.00	2.0	-0.83	6.17
2466.25	25.07	16.4	6.67	2.0	-0.67	6.00
2466.30	25.74	16.4	7.34	2.0	-1.17	6.17
2466.35	24.73	16.4	6.33	2.0	-0.50	5.83
2466.40	25.23	16.4	6.83	2.0	-0.83	6.00
2466.45	24.90	16.4	6.50	2.0	-0.50	6.00

**Channel 11, 11Mbps Processing Gain**

**Rhein Tech Laboratories, Inc.**



2466.50	25.73	16.4	7.33	2.0	-1.33	6.00
2466.55	26.40	16.4	8.00	2.0	-1.67	6.33
2466.60	25.40	16.4	7.00	2.0	-0.83	6.17
2466.65	25.90	16.4	7.50	2.0	-1.17	6.33
2466.70	25.57	16.4	7.17	2.0	-1.00	6.17
2466.75	26.40	16.4	8.00	2.0	-1.50	6.50
2466.80	26.23	16.4	7.83	2.0	-1.50	6.33
2466.85	26.24	16.4	7.84	2.0	-1.67	6.17
2466.90	26.73	16.4	8.33	2.0	-1.83	6.50
2466.95	26.73	16.4	8.33	2.0	-1.83	6.50
2467.00	26.90	16.4	8.50	2.0	-2.00	6.50

**Channel 11, 11Mbps Processing Gain**

**Rhein Tech Laboratories, Inc.**

## Testing for compliance with FCC rules 15-247e

**Carl Andren**  
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**407-724-7535**

### Scope

This report presents the test procedure, test configuration and test data associated with a FCC Part 15.247 (e) Jamming Margin test for the indirect measurement of processing gain.

### Applicable Reference Documents.

1. "Operation within the bands 902-928 MHz, 2400-2483.5, and 5725-5850 MHz" *Title 47 Part 15 section 247 (e) Code of Federal Regulations. (47 CFR 15.247).*
2. "Report and Order: Amendment of Parts 2 and 15 of the Commission's Rules Regarding Spread Spectrum Transmitters. Appendix C: 'Guidance on Measurements for Direct Sequence Spread Spectrum Systems" *FCC 97-114. ET Docket No. 96-8, RM-8435, RM-8608, RM-8609.*
3. "HFA3861A Direct Sequence Spread Spectrum Baseband Processor" *Harris Corporation Semiconductor Sector Preliminary Data Sheet*, Melbourne FL, July 1999.
4. "M-ary Orthogonal Keying BER Curve",

### Test Background and Procedure.

According to FCC regulations [1], a direct sequence spread spectrum system must have a processing gain,  $G_p$ , of at least 10 dB. Compliance to this requirement can be shown by demonstrating a relative bit-error-ratio (BER) performance improvement (and corresponding signal to noise ratio per symbol improvement of at least 10 dB) between the case where spread spectrum processes (coding, modulation) are engaged relative to

the processes being bypassed. In some practical systems, the spread spectrum processing cannot simply be bypassed. In these cases, the processing gain can be indirectly measured by a jamming margin test [2]. In accordance with the new NPRM 99-231, if the vendor has a system with less than 10 chips per symbol, the CW jamming results must be supported by a theoretical explanation of the system processing gain.

## Theoretical calculations

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 HFA3861A direct sequence spread spectrum baseband processor uses CCK modulation which is a form of M-ary Orthogonal Keying. The BER performance curve is given by [5]:

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

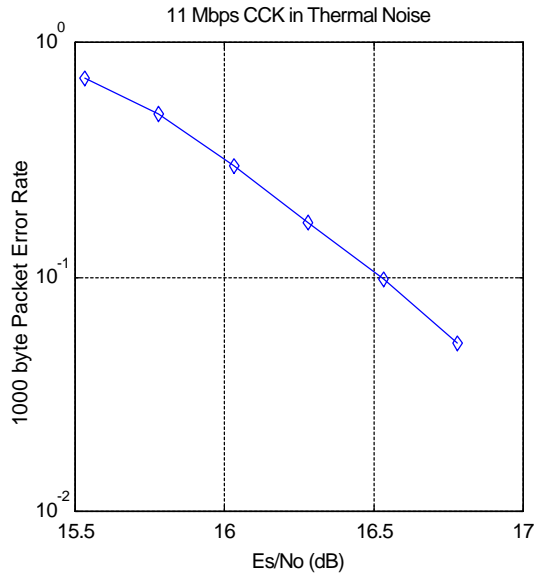
$$P_e = 1 - P_{c1} = 1 - \frac{1}{\sqrt{2p}} \int_{\frac{S_{01}}{N_0}}^{\infty} \left[ 2(1 - Q \left\{ z + \sqrt{2 \frac{E_b}{h}} \right\}) \right]^{\frac{M}{2}-1} \exp \left\{ -\frac{z^2}{2} \right\} dz$$

## intersil PRISM II radio Jamming Margin Test

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This integral cannot be solved in closed form, and numerical integration must be used. This is done in a MATHCAD environment and is displayed in graphical format.

### 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:

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

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

The minimum jammer to signal ratio is as follows:

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

For the case of the HFA3861A, 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

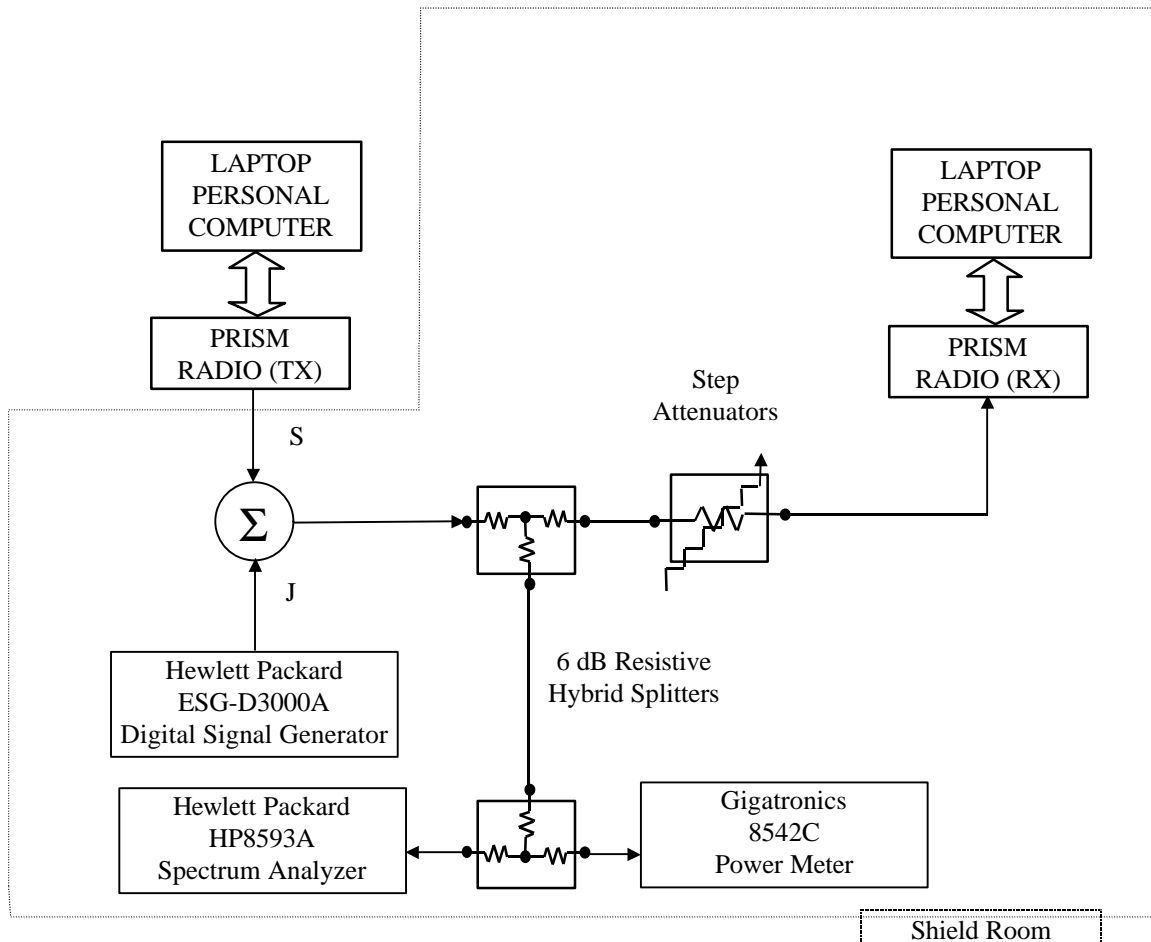
always 11 MCps, so the ratio of chip rate to symbol rate is 11:1 for the 1 and 2 Mbps rates and 8:1 for the 5.5 and 11 Mbps rates. Since the symbol rate to bit rate is less than 10 for the higher rates, we supply the theoretical processing gain calculation for these cases where both spread spectrum processing gain and coding gain are 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  $E_s/N_0$  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  $E_b/N_0$  is then 7.4 dB or 9 dB less than the  $E_s/N_0$ . It is well known that the  $E_b/N_0$  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  $\left(\frac{J}{S}\right) \geq -8.4 dB$  then the equipment passes the CW jamming test.

### **Test Configuration: CW Jamming Margin (15.247) (e)**

### Basic Test Block Diagram



### Test Procedure

Obtain the simplex link shown. Perform all independent instrumentation calibrations prior to this procedure. Set operating power levels using fixed and variable attenuators in system to meet the following objectives:

1. Signal Power at receiver approximately -60 dBm (above thermal sensitivity such that thermal noise does not cause bit errors).
2. Signal Power at power meter between -20 and -30 dBm for optimal linearity.
3. Use spectrum analyzer to monitor test.

## intersil PRISM II radio Jamming Margin Test

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4. Ensure that CW Jammer generator RF output is disabled and measure the power at the power meter port using the power meter. This is the relative signal power,  $S_r$ .
5. Disable Transmitter, and set CW Jammer generator RF output frequency equal to the carrier frequency and enable generator output. Set reference CW Jammer power level at power meter port 8.4 dB below  $S_r$  (minimum J/S, or 10 dB processing gain reference level). Note the power level setting on the generator, this is the reference CW Jammer power setting,  $J_r$ .
6. Disable CW Jammer, re-establish link. PER test should be operating essentially error-free.
7. Enable CW Jammer at the reference power level and verify that the PER test indicates a PER of less than 8%.
8. Alternatively, adjust the CW Jammer level to that which causes 8% PER and verify that the S/J is less than 8.4 dB.
9. Repeat step 7 for uniform steps in frequency increments of 50 kHz across the receiver passband with the CW Jammer. In this case the receiver passband is  $\pm 8.5$  MHz.

The number of points where the PER fails to achieve 8% (is higher than 8%) is determined and if this is above 20% of the total, the test is failed otherwise it is passed.

The margin by which the radio passes the test (for informational purposes) can be determined from the average of the remaining points' PERs scaled on the PER curve above.

The numerical data associated with the following radio channels is tabulated and presented for:

Channel 1: 2412 MHz  
Channel 6: 2437 MHz  
Channel 11: 2462 MHz

# Theoretical BER curves for the IEEE 1 and 2 Mbps modulations

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The expected BER versus  $E_b/N_0$  curves for these cases may be determined as follows.

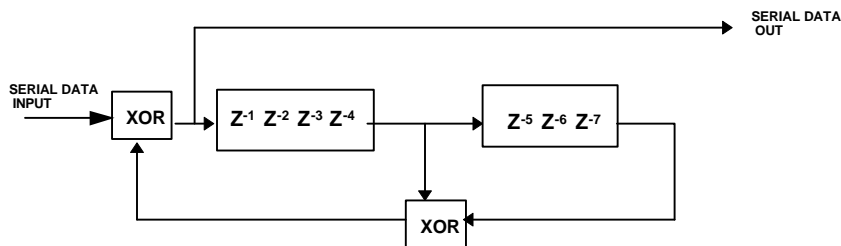
## Differential error extension.

The modulation is either DBPSK or DQPSK for 1 and 2 Mbps. With differential coding, there is an error extension factor of 2 which comes from the fact that if one symbol is in error, then the next will be demodulated in error too since its phase is dependent on the change of phase from symbol to symbol. In DBPSK, this results in a simple factor of two in BER. With QDQPSK, the picture is a little muddled in that a symbol error may cause one or two bit errors since two bits are carried per symbol. The IEEE 802.11 modulations use Grey coding of the phase so that usually only one bit error occurs with a symbol error. Sometimes, two bit errors occur, but this is infrequent at the BER considered. The bit error pattern can be adjacent, separated by one or separated by two for the two error case. This will be shown to be important in descrambling.

## De-Scrambling Error Extension

The IEEE 802.11 modulation is scrambled with a self synchronizing scrambler. This scrambler implements a polynomial multiply operation using a feed back shift register configuration as shown in figure 1.

Scrambler Polynomial;  $G(z) = Z^{-7} + Z^{-4} + 1$



It mixes two taps out of a 7 bit shift register with the data stream. The shift register is fed the received data and any error will propagate through the register for the next 7 clocks. As the error bit passes each of the taps, it will contaminate the output data. Thus each input error can produce several errors on the output. The bit error rate has to be adjusted to account for this effect. For the IEEE 802.11 modulation, taps at registers 4 and 7 are used. In BPSK mode, this produces an error extension of 3. Thus, for an output rate of  $10^{-5}$ , the input rate must be  $0.33 * 10^{-6}$  which requires that the  $E_b/N_0$  be increased by 0.5 dB. In QPSK mode, the errors can be non adjacent since they are symbol errors and the bit in error can be either the first or second of the dibits. This makes it possible for some errors to cancel in the de-scrambler. Therefore the error extension can be either 2 or 3 in this case.

What we see when running the BER test is that the errors generally occur in groups of 6 with occasional 4s.

The overall effect is to move where we operate on the BER curve. The curve below shows the resulting BER versus  $E_b/N_0$  curve. It is well known that a simple BPSK link operates at 9.6 dB for  $1e-5$  BER. With the error extension effect, we see that at that  $E_b/N_0$ , the error rate is  $6e-5$ . Or, conversely, we must operate at 10.3 dB to get  $1e-5$ .



When operating DQPSK at 2 Mbps, the  $E_b/N_0$  remains essentially the same, but the  $E_s/N_0$  goes up by 3 dB. For the purposes of the FCC testing for CW jamming, we add the allowed 2 dB for implementation loss to get a net  $E_s/N_0$  of 15.3 dB.

**DQPSK BER curve with descrambling**

