Waverider Communications

WRM3200

Test Report: FCC 15.247(e) Jamming Margin Test

		Rev. 2 Nov. 15, 2000.
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1.0 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 on the Waverider Communications WRM3200 Radio.

2.0 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. "HFA3860B Direct Sequence Spread Spectrum Baseband Processor" ***Harris Corporation Semiconductor Sector Preliminary Data Sheet***, Melbourne FL, June 1997.

4. " M-ary Orthogonal Keying BER Curve",

3.0 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-rate (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.

4.0 Theoretical calculations

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

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

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.

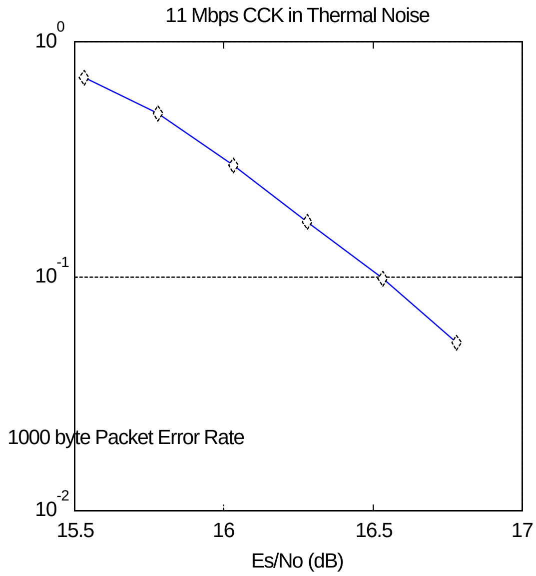
The HFA3860 direct sequence spread spectrum baseband processor uses CCK modulation which is a form of M-ary Orthogonal Keying. The BER performance curve is given by [4]:

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

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

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.

4.01 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 PER 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 HFA3860, 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 $\left(\frac{J}{S}\right) \geq -8.4\,dB$ then the equipment passes the CW jamming test.

Note:

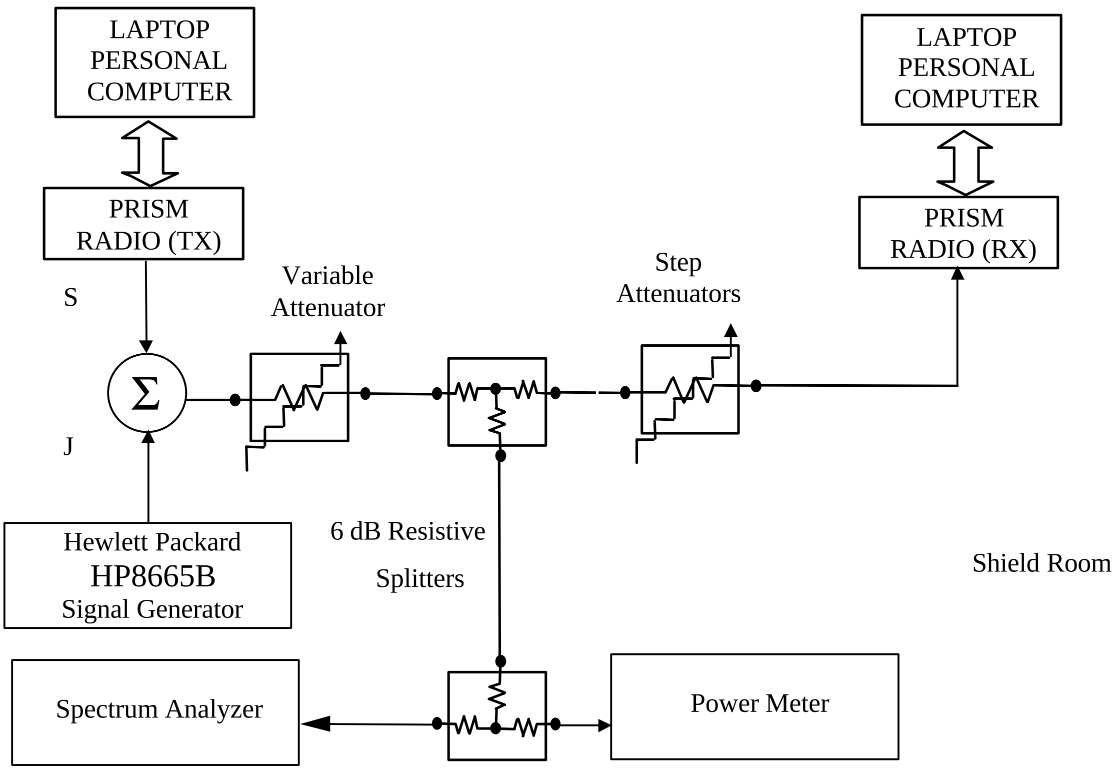
This product (WRM3200) uses a master clock that is ¼ of the clock used in the standard Prism chipset design described above. Also, it only operates at the highest data rate which means that the chip rate and data rates are ¼ of the highest rates in the standard system described above. This results in the following rates:

Chip Rate: 2.75 MCps
Data Rate: 2.75 Mbps.
Symbol Rate: 343.75 KSps.

Therefore the ratio of chip rate to symbol rate is 8:1 and the above theory for the 11 Mbps rate still applies.

5.0 Test Configuration: CW Jamming Margin (15.247) (e)

5.01 Basic Test Block Diagram



5.02 Test Procedure

Set up 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 (using high sensitivity probe) between -20 and -40 dBm for optimal linearity.

3. Use spectrum analyzer to monitor test.

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 a low power level and gradually increase the CW Jammer power until the PER is 8%. Note nominal Jammer power setting, Jn

This test is repeated for a fixed signal carrier frequency and for uniform steps in frequency increments of 50 kHz across the receiver passband with the CW Jammer. In this case the receiver passband is ±2.125 MHz. The procedure can be illustrated as follows:

For offset frequency – 2.125 MHz to carrier frequency + 2.125 MHz , Step 50 kHz.

Do:

Adjust Nominal Jammer Level setting.

Until:

Average PER is equal to reference PER.

Record Indicated Nominal Jammer Level setting.

Next offset frequency.

5.03 Data Calculation

The nominal Jammer Level settings are tabulated versus offset frequency. The J/S ratio and the processing gain are then calculated as follows:

$$\left(\frac{J}{S}\right) = -\left[\left(S_r - J_n\right) - \left(S_r - 8.6\,dB - J_r\right)\right]$$

If $J_n = J_r$ then:

$$\left(\frac{J}{S}\right) = -\left[8.6\,dB\right]$$

is the J/S ratio associated with 10 dB processing gain.

The processing gain then is determined using the J/S ratio:

$$G_p = 18.6\ dB\ + \left(\frac{J}{S}\right)$$

The number of points where the S/J fails to achieve 8.4 dB (is higher than 8.4 dB) is determined and if this is above 20% of the total, the test is failed. Otherwise it is passed.

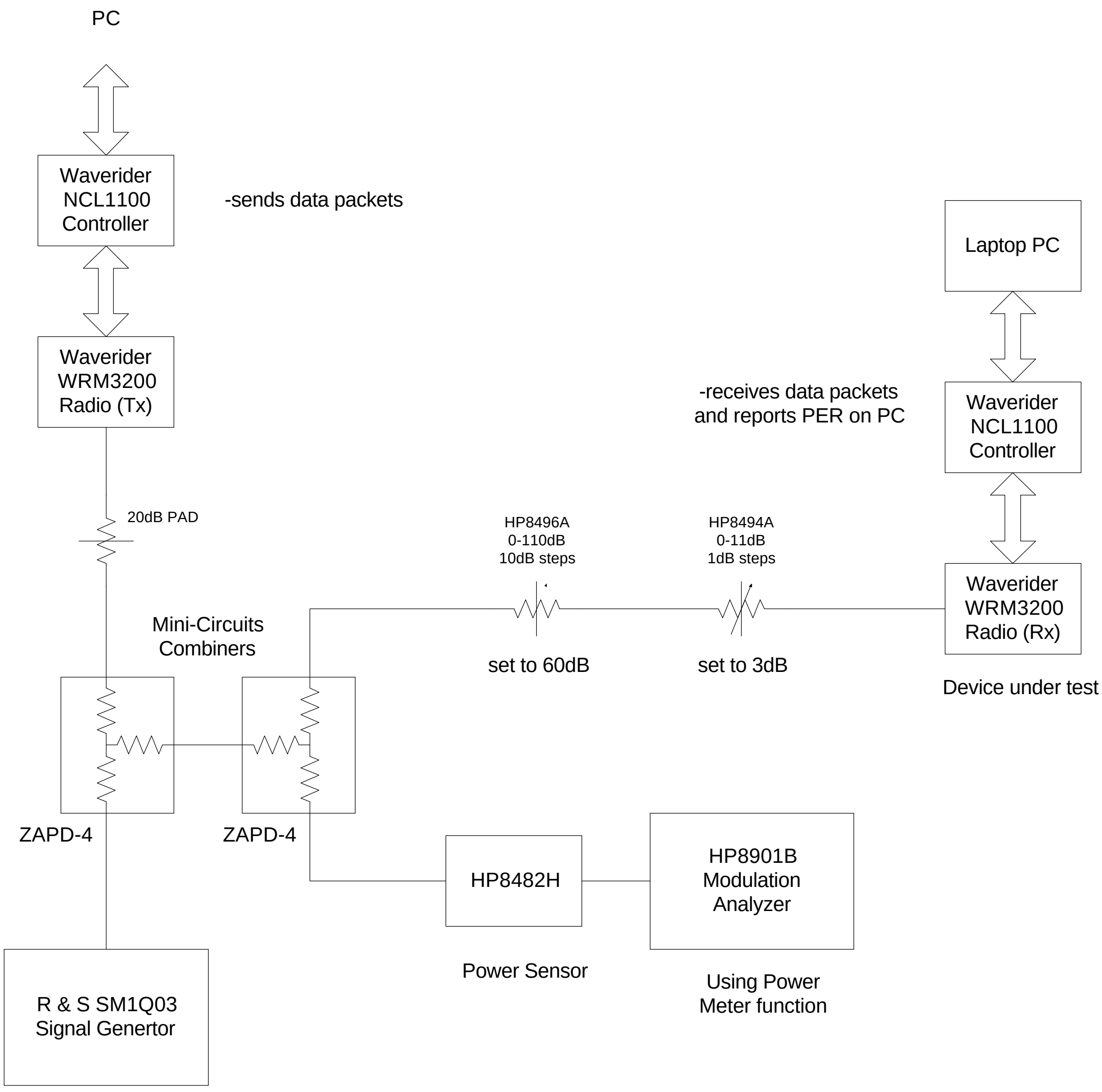
The numerical data associated with the following radio channels is tabulated and presented for:

Channel 1: 905 MHz

Channel 6: 915 MHz

Channel 11: 925 MHz

5.04 Test Configuration



5.05 Measurement Equipment List

Equipment	**Serial Number**	**Calibration**
Rhode and Scwartz SMIQ03 Signal Gen.	1084.8004.03	March 2, 1998.
HP 8482H RF Power Sensor	2704A04288	August 31, 2000.
HP 8901B Modulation Analyzer	3116A03490	N/A
HP 8496A Step Atten. 0-110 dB	1350A00108	N/A
HP 8494A Step Atten. 0-11 dB	1510A07617	N/A
Mini-Circuits ZAPD-4 Power Splitters (2)	none	N/A
Waverider NCL1100 Controller (TX)	035005	N/A
Waverider NCL1100 Controller (RX)	035148	N/A
Waverider WRM3200 Radio (TX)	013	N/A
Waverider WRM3200 Radio (RX- DUT)	1001	N/A

6.0 Test Data

6.01 Channel 1: 905 MHz

Relative signal power (Sr):	-3.5 dBm	Power meter
Reference Jamming level:	-11.9 dBm	Power meter
Reference jamming level setting (Jr):	-3.6 dBm	Sig. Gen. setting

Freq. offset (KHz)	Jammer level (Jn)	J/S	Proc. Gain	Pass/Fail
0	-6.0	-11.0	7.6	F
50	-5.7	-10.7	7.9	F
100	-2.7	-7.7	10.9	P
150	-1.6	-6.6	12.0	P
200	-2.0	-7.0	11.6	P
250	-4.6	-9.6	9.0	F
300	-4.4	-9.4	9.2	F
350	-2.8	-7.8	10.8	P
400	-1.5	-6.5	12.1	P
450	-2.0	-7.0	11.6	P
500	-3.6	-8.6	10.0	P
550	-3.4	-8.4	10.2	P
600	-2.2	-7.2	11.4	P
650	-1.5	-6.5	12.1	P
700	-1.3	-6.3	12.3	P
750	-3.0	-8.0	10.6	P
800	-2.8	-7.8	10.8	P
850	-0.8	-5.8	12.8	P
900	0.2	-4.8	13.8	P
950	0.4	-4.6	14.0	P

1000	-2.8	-7.8	10.8	P
1050	-3.0	-8.0	10.6	P
1100	0.5	-4.5	14.1	P
1150	1.4	-3.6	15.0	P
1200	1.4	-3.6	15.0	P
1250	1.4	-3.6	15.0	P
1300	2.0	-3.0	15.6	P
1350	2.0	-3.0	15.6	P
1400	2.1	-2.9	15.7	P
1450	2.7	-2.3	16.3	P
1500	2.9	-2.1	16.5	P
1550	3.1	-1.9	16.7	P
1600	3.4	-1.6	17.0	P
1650	4.1	-0.9	17.7	P
1700	4.5	-0.5	18.1	P
1750	4.9	-0.1	18.5	P
1800	5.0	0.0	18.6	P
1850	5.1	0.1	18.7	P
1900	5.5	0.5	19.1	P
1950	5.8	0.8	19.4	P
2000	6.0	1.0	19.6	P
2050	6.5	1.5	20.1	P
2100	6.7	1.7	20.3	P
2150	7.0	2.0	20.6	P
-50	-1.5	-6.5	12.1	P
-100	-1.5	-6.5	12.1	P
-150	-1.7	-6.7	11.9	P
-200	-1.7	-6.7	11.9	P
-250	-1.4	-6.4	12.2	P
-300	-1.4	-6.4	12.2	P

-350	-1.8	-6.8	11.8	P
-400	-2.0	-7.0	11.6	P
-450	-1.9	-6.9	11.7	P
-500	-2.4	-7.4	11.2	P
-550	-2.5	-7.5	11.1	P
-600	-2.4	-7.4	11.2	P
-650	-2.8	-7.8	10.8	P
-700	-2.8	-7.8	10.8	P
-750	-3.0	-8.0	10.6	P
-800	-3.2	-8.2	10.4	P
-850	-7.2	-12.2	6.4	F
-900	-6.0	-11.0	7.6	F
-950	-2.4	-7.4	11.2	P
-1000	-2.5	-7.5	11.1	P
-1050	-2.7	-7.7	10.9	P
-1100	-2.2	-7.2	11.4	P
-1150	-2.4	-7.4	11.2	P
-1200	-2.1	-7.1	11.5	P
-1250	-1.9	-6.9	11.7	P
-1300	-1.5	-6.5	12.1	P
-1350	-2.4	-7.4	11.2	P
-1400	-1.9	-6.9	11.7	P
-1450	-1.4	-6.4	12.2	P
-1500	-1.4	-6.4	12.2	P
-1550	-1.2	-6.2	12.4	P
-1600	-0.8	-5.8	12.8	P
-1650	-0.6	-5.6	13.0	P
-1700	-0.5	-5.5	13.1	P
-1750	-0.1	-5.1	13.5	P
-1800	0.3	-4.7	13.9	P
-1850	0.7	-4.3	14.3	P

-1900	1.3	-3.7	14.9	P
-1950	2.0	-3.0	15.6	P
-2000	2.4	-2.6	16.0	P
-2050	3.0	-2.0	16.6	P
-2100	3.2	-1.8	16.8	P
-2150	3.5	-1.5	17.1	P

6.02 Channel 21: 915 MHz

Relative signal power (Sr):	-4.9 dBm	Power meter
Reference Jamming level:	-13.3 dBm	Power meter
Reference jamming level setting (Jr):	-6.1 dBm	Sig. Gen. Setting

Freq. offset (KHz)	Jammer level (Jn)	J/S	Proc. Gain	Pass/Fail
0	-2.5	-5.0	13.6	P
50	-2.5	-5.0	13.6	P
100	-2.5	-5.0	13.6	P
150	-2.8	-5.3	13.3	P
200	-2.6	-5.1	13.5	P
250	-2.9	-5.4	13.2	P
300	-2.9	-5.4	13.2	P
350	-2.7	-5.2	13.4	P
400	-3.5	-6.0	12.6	P
450	-3.0	-5.5	13.1	P
500	-14.0	-16.5	2.1	F
550	-3.9	-6.4	12.2	P
600	-3.5	-6.0	12.6	P
650	-3.9	-6.4	12.2	P

700	-3.0	-5.5	13.1	P
750	-2.9	-5.4	13.2	P
800	-2.8	-5.3	13.3	P
850	-2.2	-4.7	13.9	P
900	-2.5	-5.0	13.6	P
950	-2.4	-4.9	13.7	P
1000	-1.8	-4.3	14.3	P
1050	-1.7	-4.2	14.4	P
1100	-2.0	-4.5	14.1	P
1150	-1.5	-4.0	14.6	P
1200	-1.5	-4.0	14.6	P
1250	-1.6	-4.1	14.5	P
1300	-1.6	-4.1	14.5	P
1350	-0.9	-3.4	15.2	P
1400	-1.4	-3.9	14.7	P
1450	-1.4	-3.9	14.7	P
1500	0.0	-2.5	16.1	P
1550	0.2	-2.3	16.3	P
1600	0.7	-1.8	16.8	P
1650	1.2	-1.3	17.3	P
1700	1.6	-0.9	17.7	P
1750	1.7	-0.8	17.8	P
1800	2.1	-0.4	18.2	P
1850	2.7	0.2	18.8	P
1900	2.9	0.4	19.0	P
1950	3.0	0.5	19.1	P
2000	3.2	0.7	19.3	P
2050	3.7	1.2	19.8	P
2100	3.9	1.4	20.0	P
2150	4.0	1.5	20.1	P

-50	-3.0	-5.5	13.1	P
-100	-3.3	-5.8	12.8	P
-150	-2.9	-5.4	13.2	P
-200	-2.8	-5.3	13.3	P
-250	-2.8	-5.3	13.3	P
-300	-3.1	-5.6	13.0	P
-350	-3.1	-5.6	13.0	P
-400	-3.2	-5.7	12.9	P
-450	-3.5	-6.0	12.6	P
-500	-3.5	-6.0	12.6	P
-550	-3.8	-6.3	12.3	P
-600	-4.0	-6.5	12.1	P
-650	-4.0	-6.5	12.1	P
-700	-4.0	-6.5	12.1	P
-750	-4.8	-7.3	11.3	P
-800	-3.9	-6.4	12.2	P
-850	-20.0	-22.5	-3.9	F
-900	-3.7	-6.2	12.4	P
-950	-3.5	-6.0	12.6	P
-1000	-4.2	-6.7	11.9	P
-1050	-3.2	-5.7	12.9	P
-1100	-13.7	-16.2	2.4	F
-1150	-2.6	-5.1	13.5	P
-1200	-2.5	-5.0	13.6	P
-1250	-4.5	-7.0	11.6	P
-1300	-2.1	-4.6	14.0	P
-1350	-2.1	-4.6	14.0	P
-1400	-1.6	-4.1	14.5	P
-1450	-1.7	-4.2	14.4	P
-1500	-1.5	-4.0	14.6	P
-1550	-1.2	-3.7	14.9	P

-1600	-0.9	-3.4	15.2	P
-1650	-0.6	-3.1	15.5	P
-1700	-0.1	-2.6	16.0	P
-1750	0.1	-2.4	16.2	P
-1800	0.5	-2.0	16.6	P
-1850	1.0	-1.5	17.1	P
-1900	1.4	-1.1	17.5	P
-1950	1.9	-0.6	18.0	P
-2000	2.8	0.3	18.9	P
-2050	3.1	0.6	19.2	P
-2100	3.6	1.1	19.7	P
-2150	3.7	1.2	19.8	P

6.03 Channel 41: 925 MHz

Relative signal power (Sr):	-3.1 dBm	Power meter
Reference Jamming level:	-11.5 dBm	Power meter
Reference jamming level setting (Jr):	-4.4 dBm	Sig. Gen. setting

Freq. offset (KHz)	Jammer level (Jn)	J/S	Proc. Gain	Pass/Fail
0	-1.3	-5.5	13.1	P
50	-1.2	-5.4	13.2	P
100	-1.5	-5.7	12.9	P
150	-1.5	-5.7	12.9	P
200	-1.5	-5.7	12.9	P
250	-1.3	-5.5	13.1	P
300	-1.4	-5.6	13.0	P
350	-1.2	-5.4	13.2	P

400	-1.0	-5.2	13.4	P
450	-1.3	-5.5	13.1	P
500	-1.3	-5.5	13.1	P
550	-7.5	-11.7	6.9	F
600	-1.6	-5.8	12.8	P
650	-1.6	-5.8	12.8	P
700	-1.6	-5.8	12.8	P
750	-1.0	-5.2	13.4	P
800	-1.3	-5.5	13.1	P
850	-1.0	-5.2	13.4	P
900	-0.1	-4.3	14.3	P
950	0.0	-4.2	14.4	P
1000	0.4	-3.8	14.8	P
1050	0.4	-3.8	14.8	P
1100	0.7	-3.5	15.1	P
1150	0.6	-3.6	15.0	P
1200	-1.3	-5.5	13.1	P
1250	1.1	-3.1	15.5	P
1300	0.5	-3.7	14.9	P
1350	0.8	-3.4	15.2	P
1400	1.7	-2.5	16.1	P
1450	1.8	-2.4	16.2	P
1500	1.0	-3.2	15.4	P
1550	2.7	-1.5	17.1	P
1600	2.7	-1.5	17.1	P
1650	3.0	-1.2	17.4	P
1700	3.6	-0.6	18.0	P
1750	4.1	-0.1	18.5	P
1800	4.7	0.5	19.1	P
1850	5.6	1.4	20.0	P
1900	6.0	1.8	20.4	P

1950	6.3	2.1	20.7	P
2000	6.7	2.5	21.1	P
2050	7.0	2.8	21.4	P
2100	7.4	3.2	21.8	P
2150	7.7	3.5	22.1	P
-50	-2.0	-6.2	12.4	P
-100	-1.3	-5.5	13.1	P
-150	-1.2	-5.4	13.2	P
-200	-1.5	-5.7	12.9	P
-250	-18.8	-23.0	-4.4	F
-300	-24.4	-28.6	-10.0	F
-350	-1.6	-5.8	12.8	P
-400	-2.2	-6.4	12.2	P
-450	-2.4	-6.6	12.0	P
-500	-14.5	-18.7	-0.1	F
-550	-23.5	-27.7	-9.1	F
-600	-2.8	-7.0	11.6	P
-650	-2.5	-6.7	11.9	P
-700	-22.5	-26.7	-8.1	F
-750	-2.6	-6.8	11.8	P
-800	-22.0	-26.2	-7.6	F
-850	-2.1	-6.3	12.3	P
-900	-2.2	-6.4	12.2	P
-950	-18.0	-22.2	-3.6	F
-1000	-1.9	-6.1	12.5	P
-1050	-2.0	-6.2	12.4	P
-1100	-1.8	-6.0	12.6	P
-1150	-1.4	-5.6	13.0	P
-1200	-1.4	-5.6	13.0	P
-1250	-1.2	-5.4	13.2	P

-1300	-1.4	-5.6	13.0	P
-1350	-0.6	-4.8	13.8	P
-1400	-0.8	-5.0	13.6	P
-1450	-0.6	-4.8	13.8	P
-1500	-0.5	-4.7	13.9	P
-1550	0.0	-4.2	14.4	P
-1600	0.1	-4.1	14.5	P
-1650	0.4	-3.8	14.8	P
-1700	1.1	-3.1	15.5	P
-1750	1.3	-2.9	15.7	P
-1800	2.0	-2.2	16.4	P
-1850	2.5	-1.7	16.9	P
-1900	3.1	-1.1	17.5	P
-1950	3.6	-0.6	18.0	P
-2000	4.2	0.0	18.6	P
-2050	4.6	0.4	19.0	P
-2100	4.7	0.5	19.1	P
-2150	5.4	1.2	19.8	P

6.04 Sorted Processing Gain Data

The processing gain data from sections 6.01, 6.02, and 6.03 were sorted from lowest to highest value and are shown in order below. The worst 20% of the data are highlighted. These points are discarded and the remaining worst data point from each channel is used to define a pass or fail. These values are:

Channel 1: 10.9 dB

Channel 21: 12.6 dB

Channel 41: 12.5 dB

Point no.	Chan. 1 sorted Proc. Gain	Chan. 21 sorted Proc. Gain	Chan. 41 sorted Proc. Gain
1	6.4	-3.9	-10.0
2	7.6	2.1	-9.1
3	7.6	2.4	-8.1
4	7.9	11.3	-7.6
5	9.0	11.6	-4.4
6	9.2	11.9	-3.6
7	10.0	12.1	-0.1
8	10.2	12.1	6.9
9	10.4	12.1	11.6
10	10.6	12.2	11.8
11	10.6	12.2	11.9
12	10.6	12.2	12.0
13	10.8	12.3	12.2
14	10.8	12.4	12.2
15	10.8	12.6	12.3
16	10.8	12.6	12.4
17	10.8	12.6	12.4
18	10.9	12.6	12.5

19	10.9	12.6	12.6
20	11.1	12.8	12.8
21	11.1	12.9	12.8
22	11.2	12.9	12.8
23	11.2	13.0	12.8
24	11.2	13.0	12.9
25	11.2	13.1	12.9
26	11.2	13.1	12.9
27	11.4	13.1	12.9
28	11.4	13.2	13.0
29	11.5	13.2	13.0
30	11.6	13.2	13.0
31	11.6	13.2	13.0
32	11.6	13.3	13.1
33	11.7	13.3	13.1
34	11.7	13.3	13.1
35	11.7	13.3	13.1
36	11.8	13.4	13.1
37	11.9	13.5	13.1
38	11.9	13.5	13.1
39	12.0	13.6	13.2
40	12.1	13.6	13.2
41	12.1	13.6	13.2
42	12.1	13.6	13.2
43	12.1	13.6	13.4
44	12.1	13.7	13.4
45	12.2	13.9	13.4
46	12.2	14.0	13.6
47	12.2	14.0	13.8
48	12.2	14.1	13.8
49	12.3	14.3	13.9

50	12.4	14.4	14.3
51	12.8	14.4	14.4
52	12.8	14.5	14.4
53	13.0	14.5	14.5
54	13.1	14.5	14.8
55	13.5	14.6	14.8
56	13.8	14.6	14.8
57	13.9	14.6	14.9
58	14.0	14.7	15.0
59	14.1	14.7	15.1
60	14.3	14.9	15.2
61	14.9	15.2	15.4
62	15.0	15.2	15.5
63	15.0	15.5	15.5
64	15.0	16.0	15.7
65	15.6	16.1	16.1
66	15.6	16.2	16.2
67	15.6	16.3	16.4
68	15.7	16.6	16.9
69	16.0	16.8	17.1
70	16.3	17.1	17.1
71	16.5	17.3	17.4
72	16.6	17.5	17.5
73	16.7	17.7	18.0
74	16.8	17.8	18.0
75	17.0	18.0	18.5
76	17.1	18.2	18.6
77	17.7	18.8	19.0
78	18.1	18.9	19.1
79	18.5	19.0	19.1
80	18.6	19.1	19.8

81	18.7	19.2	20.0
82	19.1	19.3	20.4
83	19.4	19.7	20.7
84	19.6	19.8	21.1
85	20.1	19.8	21.4
86	20.3	20.0	21.8
87	20.6	20.1	22.1

7.0 Conclusions

The system passes the CW jamming margin test on all three channels with the results shown below:

Channel	Min. Processing Gain (after 20% discarded)
1	10.9 dB
21	12.6 dB
41	12.5 dB