2.13 Processing Gain

Data regarding processing gain has been provided on the following page from Digital Wireless.

Notes Regarding Processing Gain of CTM2000

The CTM2000 is the latest revision of a transmitter used in a one-way data link produced by Digital Wireless. The initial transmitter/receiver pair in this link was certified in 1992 under the FCC ID: I8WWRM91-50. The transmitter and receiver in this simplex system were named the WRM91 transmitter and WRM91 receiver respectively.

Since the introduction of this product, we have revamped the transmitter portion of this link twice in order to make it more useful to the customer. The first revision of the transmitter was called the CTM100 (FCC ID: I8WCTM101-50). It was certified in 1995. The spreading code, modulation format, and data framing used in the CTM100 were designed to be identical to those used in the original WRM91 transmitter. Therefore, the WRM91 receiver did not need to be modified in any way. Also, since all of the system parameters pertaining to processing gain remained unchanged during the transition from WRM91 transmitter to CTM100, the processing gain data from the original WRM91 certification was included in the CTM100 application.

We are now applying for certification for the 3rd version of the transmitter, called the CTM2000. Newer technology has been implemented in the CTM2000 to make it frequency agile, run off of lower battery voltage, and smaller in size. However, even with these changes, the spreading rate, modulation waveforms, and data framing formats are unchanged from the original WRM91 transmitter. As such, we again intend to use the WRM91 receiver in this link. Again, since none of the parameters concerning processing gain (chip rate, data rate, modulation waveform, etc.) have changed from the original WRM91 system, we are resubmitting the original WRM91 processing gain data in this application.

DIGITAL WIRELESS CORP. TRADE SECRET INFORMATION

Processing Gain

in the

WIT915 Receiver

This document contains Trade Secret and/or Company Confidential information. We request that the contents of this correspondence and all related correspondence be withheld from public inspection as provided under Section 0.459, as requested in the application for Part 15 intentional spread spectrum radiator certification for FCC ID HSW-WIT915A.

FCC Part 15.247, amended June 14, 1990, requires that direct sequence spread spectrum (DS/SS) receivers exhibit at least 10 dB processing gain. Processing gain in DS/SS systems is defined as the difference between receiver input signal to noise ratio and post-correlation signal to noise ratio. The Rules state that "processing gain shall be determined from the ratio of the signal to noise ratio with the system spreading code turned off and the signal to noise ratio with the system spreading code turned on, as measured at the demodulated output of the receiver." In many systems, including the subject WIT915 receiver, the signal to noise ratio cannot be measured with the spreading code "turned off" because the code is permanently programmed into a digital FIR filter. If the FIR filter clock is disabled to "turn off" the spreading code, the FIR filter will be disabled, making any measurement of signal noise to ratio impossible.

As an alternative, measurement of a related quantity -- jamming margin -- provides a convenient substitute measurement. Jamming margin is generally considered a valid substitute measurement of realized processing gain. Jamming margin is often a function of the nature of the jamming signal. The use of a CW jammer for jamming margin measurements is simple and straightforward and is meaningful and repeatable. Using CW jammer and measuring system bit error rate (BER) as a function of the signal to interference (S/I) ratio or its converse, the jam to signal (J/S) ratio, provides an indication of a receiver's ability to resist jamming.

Digital communications systems exhibit a BER threshold effect: they perform well in the presence of noise or jamming up to a certain point, then BER precipitously deteriorates. The theoretical 10E-5 BER threshold for BPSK systems is about 9.6 dB (see Appendix A). Most commercial systems, including the WIT915, for reasons relating to practical and economic aspects of commercial-quality circuit realization, exhibit a 10E-5 BER at approximately 12 to 14 dB S/I. Using this as a standard, a spread spectrum system that exhibits a 10E-5 BER at an input S/I ratio in the range of 2 to 4 dB has probably achieved 10 dB jamming margin and, by interference, 10 dB of processing gain. The following are the major reasons for deviation from the theoretical limits:

1) Use of a differential demodulator instead of a coherent demodulator results in a 1 to 2 dB degradation.

2) Clock recovery circuits in commercial receivers have finite bandwidths which under interference conditions introduce timing errors.

3) The fixed precision mathematics (typically 4 bits) used in the digital signal processing portion of the receiver has degraded performance when compared to the double precision mathematics (typically 64 bits) used in theoretical derivations.

Measurements of WIT915 receiver jamming margin were made using a Hewlett Packard Model 8656B UHF synthesizer as a jammer. The results are shown in the tables and graphs on the following pages. The RMS power of the jammer was measured directly on a Hewlett Packard Model 8590A spectrum analyzer. The RMS power of the signal was computed from a peak power measurement made on the spectrum analyzer (see Appendix B). It can be seen that the minimum 10 dB jamming margin requirement is met or exceeded at all frequencies. Out-of-band rejection is good, requiring a jamming (blocking) signal of +6 dBm or so to jam the desired signal.

We have submitted data on the CW jamming margin of the WIT915 receiver in-band and out-of-band in order to demonstrate that its a very robust receiver. We submit the following data and information as evidence that the WIT915 receiver does indeed possess at least 10 dB processing gain:

1) The spreading ratio of the WIT915 transmitter is 14 (11.46 dB), thus 10 dB is theoretically achievable.

2) The system exhibits less than 10E-5 BER at 1.9 dB S/I typical, 3.8 dB worst case with a CW jammer. This is indicative of a 12.1 dB typical and 10.2 dB worst case assuming that 14 dB S/N is necessary at the demod for 10E-5 BER.

3) The receiver is a well-designed, commercial-quality homodyne configuration. It uses a integrated circuit RF preamp and mixer, a high-rejection elliptic function baseband filter, insuring that it has no significant response (as is demonstrated by the out-of-band CW interference measurements) to out-of-band signals.

4) The following functions are implemented in the WIT915 receiver using digital signal processing techniques: A differential demodulator, a 35 tap FIR filter/correlator, digital integrate-and-dump bit decision circuitry, and digitally extracted AGC with a digital AGC integrator.

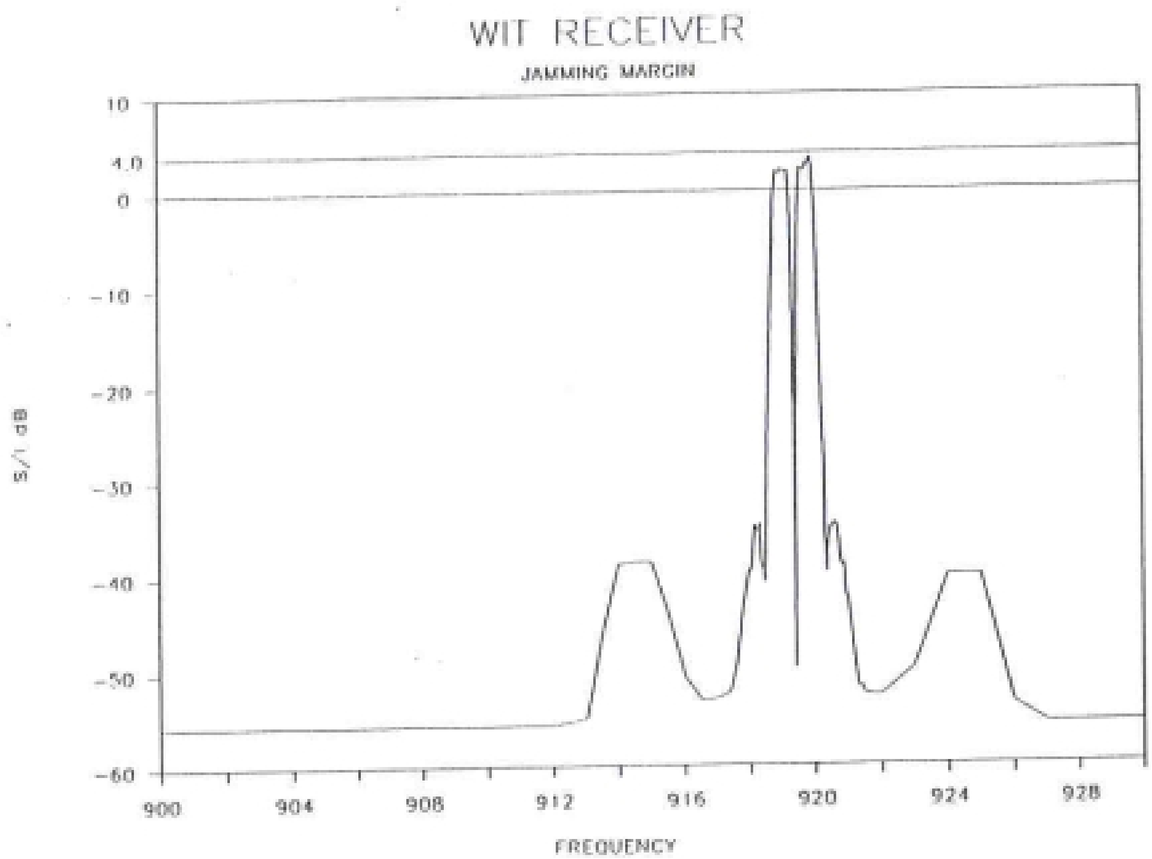
5) The system's 14-element spreading code is a permutation of the 7-element Barker sequence and was chosen for its random spectral distribution properties, 1/0 code balance, and ideal even and odd correlation characteristics.

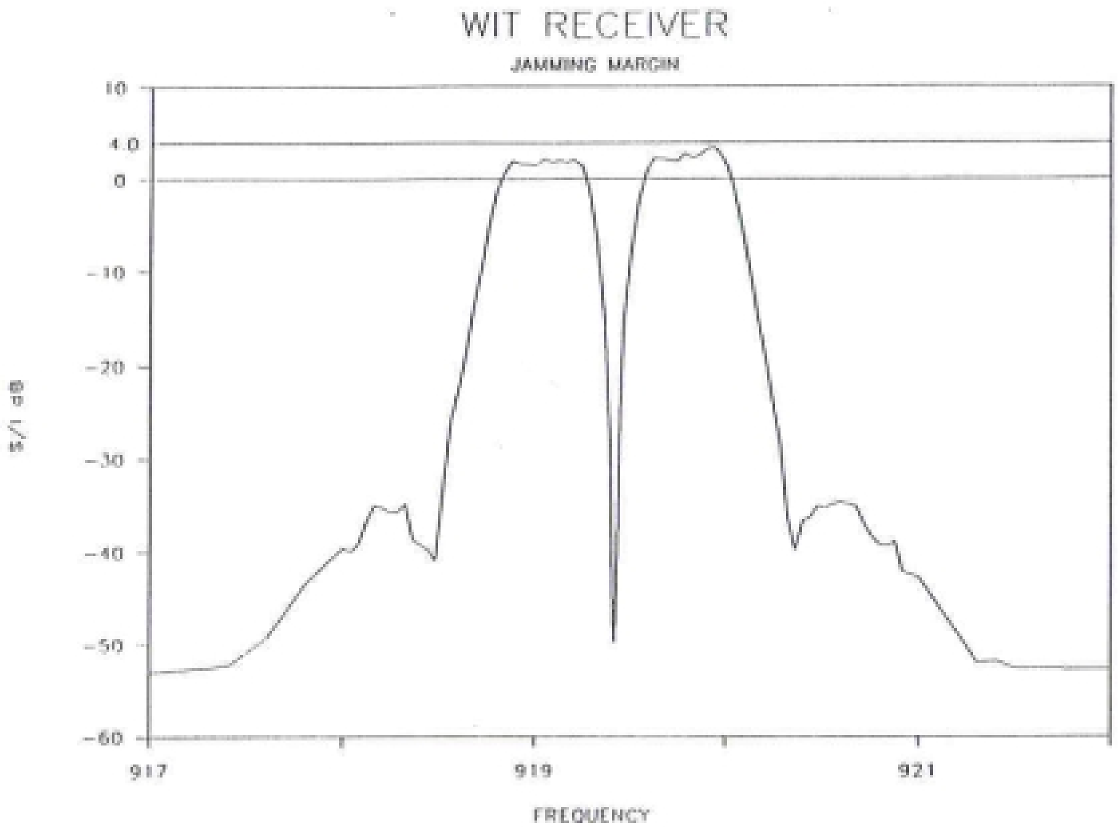
We submit that our CW jamming margin measurements are a valid demonstration of the WIT915 receiver's having met the 10 dB processing gain requirement of FCC Part 15.247, as amended June 14, 1990.

JAMMING MEASUREMENTS OF THE WIT915 RECEIVER

Frequency (MHz)	Signal to Interference (S/I dB)
918.000	-39.0
918.040	-36.7
918.080	-36.7
918.120	-33.3
918.160	-32.9
918.200	-33.4
918.240	-33.6
918.280	-33.6
918.320	-33.6
918.360	-33.6
918.400	-34.0
918.440	-33.4
918.480	-25.5
918.520	-19.1
918.560	-13.5
918.600	-12.7
918.640	-9.0
918.680	-6.1
918.720	-0.8
918.760	-0.1
918.800	0.7
918.840	2.2
918.880	2.8
918.920	1.9
918.960	-0.3
919.000	-0.3
919.040	0.7
919.080	0.6
919.120	1.5
919.160	1.3
919.200	1.7
919.240	1.7
919.280	-1.7
919.320	-5.2
919.360	-11.1

Frequency (MHz)	Signal to Interference (S/I dB)
919.400	-34.5
919.440	-24.6
919.480	-7.3
919.520	-2.3
919.560	1.3
919.600	3.4
919.640	3.1
919.680	1.3
919.720	1.5
919.760	3.1
919.800	2.7
919.840	1.1
919.880	0.0
919.920	3.7
919.960	3.7
920.000	2.9
920.040	0.2
920.080	1.0
920.120	1.0
920.160	-3.1
920.200	-9.3
920.240	-15.0
920.280	-17.7
920.320	-23.6
920.360	-31.4
920.400	-39.2
920.440	-38.2
920.480	-36.2
920.520	-35.4
920.560	-37.1
920.600	-36.4
920.640	-35.1
920.680	-34.7
920.720	-34.4
920.760	-40.1
920.800	-39.0
920.840	-39.0
920.880	-40.2
920.920	-42.0
920.960	-42.2
921.000	-42.3


WIT RECEIVER
JAMMING MARGIN
10
4.0
0
-10
-20
-30
-40
-50
-60
S/I dB
900
904
908
912
916
920
924
928
FREQUENCY


WIT RECEIVER
JAMMING MARGIN
10
4.0
0
-10
-20
-30
-40
-50
-60
S/I dB
917
919
921
FREQUENCY

2.14 Power Line Conducted Emissions for Transmitter FCC Section 15.207

The conducted voltage measurements have been carried out in accordance with FCC Section 15.207, with a spectrum analyzer connected to a LISN and the EUT placed into a continuous mode of transmit. The results are given in Table 8.

TABLE 8. CONDUCTED EMISSIONS DATA
CLASS B

Test Date: January 21, 1999
UST Project: CTM 2000, WRM-9201
Customer: MGP Instruments, Inc.
Product: Transmitter, CTM 2000, WRM-9201

Frequency (MHz)	Test Data (dBm) Phase Neutral	RESULTS (uV) Phase Neutral	FCC Limits (uV)
EUT is Battery Powered Therefore Conducted Emissions were deemed Not Applicable			

Tester
Signature: ____________________ Name: Tim R. Johnson

2.15 Radiated Emissions (47 CFR 15.109a)

Radiated emissions were evaluated from 30 to 5000 MHz. Measurements were made with the analyzer's bandwidth set to 120 kHz measurements made less than 1 GHz and 1 MHz are shown in Table 8a. Measurements made over 1 GHz results are shown in Table 8b.

Even thought the EUT is considered a class A device, it met with the requirements of a class B device.

TABLE 8a. RADIATED EMISSIONS DATA

CLASS B

Test Date: January 21, 1999
UST Project: CTM 2000, WRM-9201
Customer: MGP Instruments, Inc.
Product: Transmitter, CTM 2000, WRM-9201

Frequency (MHz)	Receiver Reading (dBm) @3m	Correction Factor (dB)	Corrected Reading (uV/m)	FCC Limit (uV/m) @3m
No readings were seen within 10 dB of the FCC limits				

*= Quasi Peak

Tester Signature: ___________________ **Name:** __Tim R. Johnson______

TABLE 8b. RADIATED EMISSIONS DATA

CLASS B

Test Date: January 21, 1999
UST Project: CTM 2000, WRM-9201
Customer: MGP Instruments, Inc.
Model: Transmitter, CTM 2000, WRM-9201

Measurements >1GHz

FREQ. (GHz)	TEST DATA (dBm) @ 3m	AMP GAIN (dB)	ANT. FACTOR (dB)	CABLE LOSS (dB)	RESULTS (uV/m) @ 3m	FCC LIMITS (uV/m) @ 3m
No readings seen within 10 dB of the FCC Limit						

Tested By
Signature: ____________________ Name: Tim R. Johnson