

Measuring the power of the ShareWave Radio 1/10/00

The transmit power for the ShareWave radio was measured by several methods previously. Generally the average power is powered using a thermistor type probe. The peak power is measured using a peak power meter. The object of this paper is to obtain the measurement of the peak power. A similar paper was presented for our previous radio, FCC file N9PSW1-2450.

Initial measurements from Elliot Labs listed below is 17.7dBm.

The meter used by Elliot labs was an HP432 with 478A Thermistor Probe, first measured on 12//10/99, file D35037.

Elliott Laboratories Inc.
684 West Maude Ave.
Sunnyvale, CA 94086
<http://www.elliottlabs.com>
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To determine the peak power, several factors need to be considered.

- The packet duty cycle.
- The sinusoidal cresting factor.
- Multiple symbol power levels.
- Compound ringing caused by baseband filtering and turn-on overshoot.

Using 17.7 dBm (58.9 mW) as the average power over time, the average power during the transmit 'on' time can be found using the duty cycle factor. The transmit 'on' time for the above measurements is 957 uS. The time between packets (receive mode) is 337 uS. The duty cycle factor is $(957+337) / 957 = 1.35$

Given this, the power during transmit is $58.9 \text{ mW} * 1.35 = 79.5 \text{ mW}$ (19 dBm).

Using the sinusoidal cresting factor to calculate the peak power, based on the relationship of peak to average power of a sine wave, we get an additional 3 dB.

This gives a peak power of 22dBm.

The additional power due to symbol power level can be shown by the waveform pictures below. The peak to average symbol power ratio is 1.25:1 for the Harris 3760 modulator. In dB this is 1.0 dB, above the peak.

This gives a power of 23 dBm.

Conclusion

Given an average power of 17.7 dBm over many packets the peak power is 23 dBm.

A measurement using a peak power meter confirms the results to within acceptable limits as was shown in the previous ShareWave submission.

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Process Gain of a Direct Sequence Spread Spectrum. FCC CFR 47, Para 15.247(e)

Product Name:

CRESTA II, ShareWave Inc.

FCC Requirements:

The processing gain of a direct sequence system shall be at least 10 dB. The process 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.

Power Input:

Both the transmitter and the receiver obtain their 5-Volt power from the PCI bus from a PC.

Equipment:

Transmitter: ShareWave serial number 006

Output Power: 23 dBm

Tx Controller: ShareWave OspreyII (model 300-0114)

Attenuator: 40 dB, Mini Circuits MCL BW-S40W2, DC-18GHz

Coax: 1' 7805 MCX-SMA

Output Level: -47 dBm

Receiver: ShareWave serial number 038

Rx Controller: ShareWave OspreyII (model 300-0114)

Computer: Dell Dimension XPS M200s connected to the transmitter and receiver through an OspreyII PCI card.

Coax: 4' 7805 SMA-SMA

Attenuator: 20dB, InMet Model 18AH-20dB

Power Splitter: HP 11667, DC to 26.5GHz

Generator: HP ESG-D4000A, model E4433A, serial number US37040343

Coax: 3' 7805 SMA-SMA

Power Meter: Gigatronics 8541C, serial number 1834297

Power Sensor: Gigatronics 80350A, serial number 1828418

Test Method – Jamming Margin Method

The processing gain may be measured using the CW jamming margin method. Figure 1 shows the test configuration. The test consists of stepping a signal generator in 50 kHz increments across the passband of the system. At each point, the generator level required to produce the recommended Bit Error Rate (BER) is recorded. This level is the jamming level. The output power of the transmitting unit and generator are measured at the same point with the power meter. The Jammer to Signal (J/S) ratio is calculated. Discard the worst 20% of the J/S data points. The lowest remaining J/S ratio is used when calculating the Process Gain.

The signal to noise ratio for CCK modulation can be derived from the Bit Error Rate (BER).

Intersil (Harris Semiconductor) who designed the baseband processor used in the Cresta II, supplies relevant information for calculating the E_b/N_o (energy per bit over unit noise) from a specified BER. This information yields $(S/N)_0$ given a specific BER.

For the measurements of the $(S/N)_0$, a BER of $1.0E-6$ minimum was used.

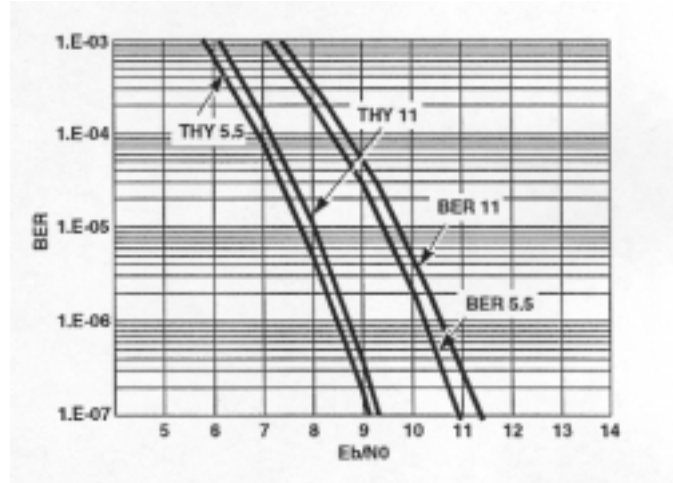


Figure 2: BER vs E_b/N_o Performance for MBOK/CCK Modes

Reading from Figure 2, for a BER level of better than $1E-6$, 10dB of E_b/N_o is necessary.

For CCK encoding, there are 8 bits per symbol. E_s/N_o (energy per symbol over unit noise) is calculated as:

$$\begin{aligned} \left(\frac{E_s}{N_o} \right)_{dB} &= \left(\frac{E_b}{N_o} \right)_{dB} + 10 \log_{10}(8 \text{ bits per symbol}) \\ &= 10dB + 9.0dB \\ &= 19dB \end{aligned}$$

Where

$\frac{E_s}{N_o}$ is the symbol energy per unit noise.

$\frac{E_b}{N_o}$ is the bit energy per unit noise.

Reference:

Andren, Carl CCK Modulation Delivers 11 Mb/s For A High-Rate 802.11 Extension (Wireless Systems Design, May 1999), pp31-39.

To determine $(S/N)_0$, the bandwidth must be accounted for.

$$\begin{aligned}\left(\frac{S}{N}\right)_0 &= 10 \log_{10} \left(\frac{\frac{E_s}{N_o}}{\frac{BW}{R}} \right) = \left(\frac{E_s}{N_o} \right)_{dB} - 10 \log_{10} \left(\frac{BW}{R} \right) \\ &= 19dB - 10 \log_{10}(2) \\ &= 16dB\end{aligned}$$

Where

$\frac{E_s}{N_o}$ is the symbol energy per unit noise.

BW is the system bandwidth(22MHz).

R is the bit rate(11Mbps).

Reference:

Intersil [HFA3860B Datasheet](#) (1999), P4-25.

Intersil Application Note 9820 (1998), P7

The value of signal to noise ratio $(S/N)_0$, derived above, and the measured J/S ratio are used in the following equation to calculate the process gain (G_p) of the system.

$$G_p = (S/N)_0 + M_j + L_{sys}$$

Where

$(S/N)_0$: The theoretical signal to noise ration required to maintain normal operation just before the limit of the BER. In real measurements the maximum error of 0.001 is allowed in an ideal system using this modulation scheme with all codes turned off (i.e., no spreading or process gain).

M_j : Maximum Jammer to Signal Ratio that was recorded at the detected BER.

L_{sys} : System losses such as non-ideal synchronization, tracking circuitry, non-optimal baseband filtering, and etc... These losses can be in excess of 3 dB for each transmitter and receiver pair. For the purpose of this processing gain calculation we assume an L_{sys} of 2 dB.

Reference: Dixon, R, [Spread Spectrum Systems](#). (New York: Wiley, 1984), Chapter

Test Results:

The minimum processing gain after the discarding the worst 20% of the data was 12.5dB

Test Personnel:

Dale Dorando

Date:

January 20, 2000

Processing gain of a direct sequence spread spectrum, FCC CFR 47,
Part 15.247 (e)

Measured Data:

Tx Power is -27.4 dBm

Sig. Gen. Freq. [MHz]	Bit error rate (BER) Less than	(S/N)o [dB]	L sys [dB]	Sig. Gen. Total Peak Power @ RX [dBm]	TX Total Peak Power @ RX [dBm]	Jammer to Signal Ratio Mj [dB]	Processing Gain (PG) [dB]
2428.750							
2428.800							
2428.850							
2428.900							
2428.950							
2429.000	1.00E-06	16	2	-30.9	-27.4	-3.5	14.5
2429.050	1.00E-06	16	2	-30.1	-27.4	-2.7	15.3
2429.100	1.00E-06	16	2	-30.1	-27.4	-2.7	15.3
2429.150	1.00E-06	16	2	-30.9	-27.4	-3.5	14.5
2429.200	1.00E-06	16	2	-31	-27.4	-3.6	14.4
2429.250	1.00E-06	16	2	-30.6	-27.4	-3.2	14.8
2429.300	1.00E-06	16	2	-30.1	-27.4	-2.7	15.3
2429.350	1.00E-06	16	2	-29.6	-27.4	-2.2	15.8
2429.400	1.00E-06	16	2	-30.3	-27.4	-2.9	15.1
2429.450	1.00E-06	16	2	-29.6	-27.4	-2.2	15.8
2429.500	1.00E-06	16	2	-29.8	-27.4	-2.4	15.6
2429.550	1.00E-06	16	2	-29.1	-27.4	-1.7	16.3
2429.600	1.00E-06	16	2	-28.9	-27.4	-1.5	16.5
2429.650	1.00E-06	16	2	-28.4	-27.4	-1	17
2429.700	1.00E-06	16	2	-28.3	-27.4	-0.9	17.1
2429.750	1.00E-06	16	2	-27.8	-27.4	-0.4	17.6
2429.800	1.00E-06	16	2	-27.6	-27.4	-0.2	17.8
2429.850	1.00E-06	16	2	-27.8	-27.4	-0.4	17.6
2429.900	1.00E-06	16	2	-27.1	-27.4	0.3	18.3
2429.950	1.00E-06	16	2	-26.9	-27.4	0.5	18.5
2430.000	1.00E-06	16	2	-26.9	-27.4	0.5	18.5
2430.050	1.00E-06	16	2	-26.5	-27.4	0.9	18.9
2430.100	1.00E-06	16	2	-26.3	-27.4	1.1	19.1
2430.150	1.00E-06	16	2	-26.2	-27.4	1.2	19.2
2430.200	1.00E-06	16	2	-26.5	-27.4	0.9	18.9
2430.250	1.00E-06	16	2	-26.7	-27.4	0.7	18.7
2430.300	1.00E-06	16	2	-26.1	-27.4	1.3	19.3
2430.350	1.00E-06	16	2	-26.5	-27.4	0.9	18.9
2430.400	1.00E-06	16	2	-27	-27.4	0.4	18.4
2430.450	1.00E-06	16	2	-27.9	-27.4	-0.5	17.5

Processing gain of a direct sequence spread spectrum, FCC CFR 47,
Part 15.247 (e)

Measured Data:

Sig. Gen. Freq. [MHz]	Bit error rate (BER)	(S/N) _o [dB]	L sys [dB]	Sig. Gen. Total Peak Power @ RX [dBm]	TX Total Peak Power @ RX [dBm]	Jammer to Signal Ratio Mj [dB]	Processing Gain (PG) [dB]
2430.500	1.00E-06	16	2	-28.4	-27.4	-1	17
2430.550	1.00E-06	16	2	-28.6	-27.4	-1.2	16.8
2430.600	1.00E-06	16	2	-28.9	-27.4	-1.5	16.5
2430.650	1.00E-06	16	2	-28.9	-27.4	-1.5	16.5
2430.700	1.00E-06	16	2	-27.4	-27.4	0	18
2430.750	1.00E-06	16	2	-26.9	-27.4	0.5	18.5
2430.800	1.00E-06	16	2	-27	-27.4	0.4	18.4
2430.850	1.00E-06	16	2	-27.9	-27.4	-0.5	17.5
2430.900	1.00E-06	16	2	-28.6	-27.4	-1.2	16.8
2430.950	1.00E-06	16	2	-29.9	-27.4	-2.5	15.5
2431.000	1.00E-06	16	2	-29.8	-27.4	-2.4	15.6
2431.050	1.00E-06	16	2	-29.8	-27.4	-2.4	15.6
2431.100	1.00E-06	16	2	-29.8	-27.4	-2.4	15.6
2431.150	1.00E-06	16	2	-29.8	-27.4	-2.4	15.6
2431.200	1.00E-06	16	2	-29.8	-27.4	-2.4	15.6
2431.250	1.00E-06	16	2	-29.8	-27.4	-2.4	15.6
2431.300	1.00E-06	16	2	-29.9	-27.4	-2.5	15.5
2431.350	1.00E-06	16	2	-30.2	-27.4	-2.8	15.2
2431.400	1.00E-06	16	2	-30.9	-27.4	-3.5	14.5
2431.450	1.00E-06	16	2	-31.5	-27.4	-4.1	13.9
2431.500	1.00E-06	16	2	-30.9	-27.4	-3.5	14.5
2431.550	1.00E-06	16	2	-31.4	-27.4	-4	14
2431.600	1.00E-06	16	2	-31.3	-27.4	-3.9	14.1
2431.650	1.00E-06	16	2	-30.9	-27.4	-3.5	14.5
2431.700	1.00E-06	16	2	-30.9	-27.4	-3.5	14.5
2431.750	1.00E-06	16	2	-30.8	-27.4	-3.4	14.6
2431.800	1.00E-06	16	2	-31.1	-27.4	-3.7	14.3
2431.850	1.00E-06	16	2	-30.9	-27.4	-3.5	14.5
2431.900	1.00E-06	16	2	-30.7	-27.4	-3.3	14.7
2431.950	1.00E-06	16	2	-31.5	-27.4	-4.1	13.9
2432.000	1.00E-06	16	2	-32.8	-27.4	-5.4	12.6
2432.050	1.00E-06	16	2	-30.5	-27.4	-3.1	14.9
2432.100	1.00E-06	16	2	-30.6	-27.4	-3.2	14.8
2432.150	1.00E-06	16	2	-29.9	-27.4	-2.5	15.5
2432.200	1.00E-06	16	2	-29.4	-27.4	-2	16

Processing gain of a direct sequence spread spectrum, FCC CFR 47,
Part 15.247 (e)

Measured Data:

Sig. Gen. Freq. [MHz]	Bit error rate (BER)	(S/N)o [dB]	L sys [dB]	Sig. Gen. Total Peak Power @ RX [dBm]	TX Total Peak Power @ RX [dBm]	Jammer to Signal Ratio Mj [dB]	Processing Gain (PG) [dB]
2432.250	1.00E-06	16	2	-28.7	-27.4	-1.3	16.7
2432.300	1.00E-06	16	2	-28.9	-27.4	-1.5	16.5
2432.350	1.00E-06	16	2	-29.6	-27.4	-2.2	15.8
2432.400	1.00E-06	16	2	-30	-27.4	-2.6	15.4
2432.450	1.00E-06	16	2	-29.1	-27.4	-1.7	16.3
2432.500	1.00E-06	16	2	-30.5	-27.4	-3.1	14.9
2432.550	1.00E-06	16	2	-30.5	-27.4	-3.1	14.9
2432.600	1.00E-06	16	2	-30.3	-27.4	-2.9	15.1
2432.650	1.00E-06	16	2	-29.7	-27.4	-2.3	15.7
2432.700	1.00E-06	16	2	-29.5	-27.4	-2.1	15.9
2432.750	1.00E-06	16	2	-28.2	-27.4	-0.8	17.2
2432.800	1.00E-06	16	2	-28.7	-27.4	-1.3	16.7
2432.850	1.00E-06	16	2	-29.3	-27.4	-1.9	16.1
2432.900	1.00E-06	16	2	-29.6	-27.4	-2.2	15.8
2432.950	1.00E-06	16	2	-28.7	-27.4	-1.3	16.7
2433.000	1.00E-06	16	2	-30.3	-27.4	-2.9	15.1
2433.050	1.00E-06	16	2	-30.2	-27.4	-2.8	15.2
2433.100	1.00E-06	16	2	-30.1	-27.4	-2.7	15.3
2433.150	1.00E-06	16	2	-29.8	-27.4	-2.4	15.6
2433.200	1.00E-06	16	2	-29.8	-27.4	-2.4	15.6
2433.250	1.00E-06	16	2	-30.1	-27.4	-2.7	15.3
2433.300	1.00E-06	16	2	-30.7	-27.4	-3.3	14.7
2433.350	1.00E-06	16	2	-30.5	-27.4	-3.1	14.9
2433.400	1.00E-06	16	2	-30.9	-27.4	-3.5	14.5
2433.450	1.00E-06	16	2	-30.8	-27.4	-3.4	14.6
2433.500	1.00E-06	16	2	-31.3	-27.4	-3.9	14.1
2433.550	1.00E-06	16	2	-31.7	-27.4	-4.3	13.7
2433.600	1.00E-06	16	2	-32.1	-27.4	-4.7	13.3
2433.650	1.00E-06	16	2	-31.7	-27.4	-4.3	13.7
2433.700	1.00E-06	16	2	-31.5	-27.4	-4.1	13.9
2433.750	1.00E-06	16	2	-30.7	-27.4	-3.3	14.7
2433.800	1.00E-06	16	2	-31.4	-27.4	-4	14
2433.850	1.00E-06	16	2	-32.4	-27.4	-5	13
2433.900	1.00E-06	16	2	-32.2	-27.4	-4.8	13.2
2433.950	1.00E-06	16	2	-31.5	-27.4	-4.1	13.9

Processing gain of a direct sequence spread spectrum, FCC CFR 47,
Part 15.247 (e)

Measured Data:

Sig. Gen. Freq. [MHz]	Bit error rate (BER)	(S/N) _o [dB]	L sys [dB]	Sig. Gen. Total Peak Power @ RX [dBm]	TX Total Peak Power @ RX [dBm]	Jammer to Signal Ratio Mj [dB]	Processing Gain (PG) [dB]
2434.000	1.00E-06	16	2	-31.9	-27.4	-4.5	13.5
2434.050	1.00E-06	16	2	-31.5	-27.4	-4.1	13.9
2434.100	1.00E-06	16	2	-30.2	-27.4	-2.8	15.2
2434.150	1.00E-06	16	2	-30.2	-27.4	-2.8	15.2
2434.200	1.00E-06	16	2	-30.1	-27.4	-2.7	15.3
2434.250	1.00E-06	16	2	-29.4	-27.4	-2	16
2434.300	1.00E-06	16	2	-29.3	-27.4	-1.9	16.1
2434.350	1.00E-06	16	2	-29.3	-27.4	-1.9	16.1
2434.400	1.00E-06	16	2	-29.6	-27.4	-2.2	15.8
2434.450	1.00E-06	16	2	-29.6	-27.4	-2.2	15.8
2434.500	1.00E-06	16	2	-29.6	-27.4	-2.2	15.8
2434.550	1.00E-06	16	2	-29.7	-27.4	-2.3	15.7
2434.600	1.00E-06	16	2	-30.1	-27.4	-2.7	15.3
2434.650	1.00E-06	16	2	-30.1	-27.4	-2.7	15.3
2434.700	1.00E-06	16	2	-29.9	-27.4	-2.5	15.5
2434.750	1.00E-06	16	2	-29.9	-27.4	-2.5	15.5
2434.800	1.00E-06	16	2	-30.4	-27.4	-3	15
2434.850	1.00E-06	16	2	-31	-27.4	-3.6	14.4
2434.900	1.00E-06	16	2	-31.9	-27.4	-4.5	13.5
2434.950	1.00E-06	16	2	-32	-27.4	-4.6	13.4
2435.000	1.00E-06	16	2	-32.3	-27.4	-4.9	13.1
2435.050	1.00E-06	16	2	-33.1	-27.4	-5.7	12.3
2435.100	1.00E-06	16	2	-33.2	-27.4	-5.8	12.2
2435.150	1.00E-06	16	2	-32.8	-27.4	-5.4	12.6
2435.200	1.00E-06	16	2	-32.6	-27.4	-5.2	12.8
2435.250	1.00E-06	16	2	-32.6	-27.4	-5.2	12.8
2435.300	1.00E-06	16	2	-32.8	-27.4	-5.4	12.6
2435.350	1.00E-06	16	2	-32.6	-27.4	-5.2	12.8
2435.400	1.00E-06	16	2	-32.3	-27.4	-4.9	13.1
2435.450	1.00E-06	16	2	-32.2	-27.4	-4.8	13.2
2435.500	1.00E-06	16	2	-32.3	-27.4	-4.9	13.1
2435.550	1.00E-06	16	2	-31.9	-27.4	-4.5	13.5
2435.600	1.00E-06	16	2	-32.1	-27.4	-4.7	13.3
2435.650	1.00E-06	16	2	-31.2	-27.4	-3.8	14.2
2435.700	1.00E-06	16	2	-31	-27.4	-3.6	14.4

Processing gain of a direct sequence spread spectrum, FCC CFR 47,
Part 15.247 (e)

Measured Data:

Sig. Gen. Freq. [MHz]	Bit error rate (BER)	(S/N)o [dB]	L sys [dB]	Sig. Gen. Total Peak Power @ RX [dBm]	TX Total Peak Power @ RX [dBm]	Jammer to Signal Ratio Mj [dB]	Processing Gain (PG) [dB]
2435.750	1.00E-06	16	2	-30.3	-27.4	-2.9	15.1
2435.800	1.00E-06	16	2	-30.4	-27.4	-3	15
2435.850	1.00E-06	16	2	-29.8	-27.4	-2.4	15.6
2435.900	1.00E-06	16	2	-30	-27.4	-2.6	15.4
2435.950	1.00E-06	16	2	-30.43	-27.4	-3.03	14.97
2436.000	1.00E-06	16	2	-31.4	-27.4	-4	14
2436.050	1.00E-06	16	2	-31.2	-27.4	-3.8	14.2
2436.100	1.00E-06	16	2	-31.8	-27.4	-4.4	13.6
2436.150	1.00E-06	16	2	-31	-27.4	-3.6	14.4
2436.200	1.00E-06	16	2	-31.1	-27.4	-3.7	14.3
2436.250	1.00E-06	16	2	-30.1	-27.4	-2.7	15.3
2436.300	1.00E-06	16	2	-31	-27.4	-3.6	14.4
2436.350	1.00E-06	16	2	-31.8	-27.4	-4.4	13.6
2436.400	1.00E-06	16	2	-31.6	-27.4	-4.2	13.8
2436.450	1.00E-06	16	2	-31.6	-27.4	-4.2	13.8
2436.500	1.00E-06	16	2	-32.7	-27.4	-5.3	12.7
2436.550	1.00E-06	16	2	-31.9	-27.4	-4.5	13.5
2436.600	1.00E-06	16	2	-32	-27.4	-4.6	13.4
2436.650	1.00E-06	16	2	-31.6	-27.4	-4.2	13.8
2436.700	1.00E-06	16	2	-31	-27.4	-3.6	14.4
2436.750	1.00E-06	16	2	-31.1	-27.4	-3.7	14.3
2436.800	1.00E-06	16	2	-31	-27.4	-3.6	14.4
2436.850	1.00E-06	16	2	-31.5	-27.4	-4.1	13.9
2436.900	1.00E-06	16	2	-32.3	-27.4	-4.9	13.1
2436.950	1.00E-06	16	2	-32.2	-27.4	-4.8	13.2
2437.000	1.00E-06	16	2	-33.4	-27.4	-6	12
2437.050	1.00E-06	16	2	-33.1	-27.4	-5.7	12.3
2437.100	1.00E-06	16	2	-32.9	-27.4	-5.5	12.5
2437.150	1.00E-06	16	2	-32.7	-27.4	-5.3	12.7
2437.200	1.00E-06	16	2	-32.6	-27.4	-5.2	12.8
2437.250	1.00E-06	16	2	-33	-27.4	-5.6	12.4
2437.300	1.00E-06	16	2	-33.1	-27.4	-5.7	12.3
2437.350	1.00E-06	16	2	-33.1	-27.4	-5.7	12.3
2437.400	1.00E-06	16	2	-33.2	-27.4	-5.8	12.2
2437.450	1.00E-06	16	2	-33	-27.4	-5.6	12.4

Processing gain of a direct sequence spread spectrum, FCC CFR 47, Part 15.247 (e)

Measured Data:

Sig. Gen. Freq. [MHz]	Bit error rate (BER)	(S/N)_o [dB]	L sys [dB]	Sig. Gen. Total Peak Power @ RX [dBm]	TX Total Peak Power @ RX [dBm]	Jammer to Signal Ratio Mj [dB]	Processing Gain (PG) [dB]
2437.500	1.00E-06	16	2	-32.9	-27.4	-5.5	12.5
2437.550	1.00E-06	16	2	-33.1	-27.4	-5.7	12.3
2437.600	1.00E-06	16	2	-32.8	-27.4	-5.4	12.6
2437.650	1.00E-06	16	2	-32.7	-27.4	-5.3	12.7
2437.700	1.00E-06	16	2	-32.7	-27.4	-5.3	12.7
2437.750	1.00E-06	16	2	-32.7	-27.4	-5.3	12.7
2437.800	1.00E-06	16	2	-32.6	-27.4	-5.2	12.8
2437.850	1.00E-06	16	2	-31.7	-27.4	-4.3	13.7
2437.900	1.00E-06	16	2	-31.5	-27.4	-4.1	13.9
2437.950	1.00E-06	16	2	-31.5	-27.4	-4.1	13.9
2438.000	1.00E-06	16	2	-31.8	-27.4	-4.4	13.6
2438.050	1.00E-06	16	2	-31.7	-27.4	-4.3	13.7
2438.100	1.00E-06	16	2	-31.4	-27.4	-4	14
2438.150	1.00E-06	16	2	-30.1	-27.4	-2.7	15.3
2438.200	1.00E-06	16	2	-29.7	-27.4	-2.3	15.7
2438.250	1.00E-06	16	2	-29.6	-27.4	-2.2	15.8
2438.300	1.00E-06	16	2	-30	-27.4	-2.6	15.4
2438.350	1.00E-06	16	2	-32	-27.4	-4.6	13.4
2438.400	1.00E-06	16	2	-31.5	-27.4	-4.1	13.9
2438.450	1.00E-06	16	2	-31.1	-27.4	-3.7	14.3
2438.500	1.00E-06	16	2	-30.3	-27.4	-2.9	15.1
2438.550	1.00E-06	16	2	-30.4	-27.4	-3	15
2438.600	1.00E-06	16	2	-30.4	-27.4	-3	15
2438.650	1.00E-06	16	2	-29.2	-27.4	-1.8	16.2
2438.700	1.00E-06	16	2	-29.3	-27.4	-1.9	16.1
2438.750	1.00E-06	16	2	-28.9	-27.4	-1.5	16.5
2438.800	1.00E-06	16	2	-30.1	-27.4	-2.7	15.3
2438.850	1.00E-06	16	2	-30.8	-27.4	-3.4	14.6
2438.900	1.00E-06	16	2	-31.7	-27.4	-4.3	13.7
2438.950	1.00E-06	16	2	-31.8	-27.4	-4.4	13.6
2439.000	1.00E-06	16	2	-32.8	-27.4	-5.4	12.6
2439.050	1.00E-06	16	2	-32.6	-27.4	-5.2	12.8
2439.100	1.00E-06	16	2	-33.5	-27.4	-6.1	11.9
2439.150	1.00E-06	16	2	-32.9	-27.4	-5.5	12.5
2439.200	1.00E-06	16	2	-32.2	-27.4	-4.8	13.2

Processing gain of a direct sequence spread spectrum, FCC CFR 47,
Part 15.247 (e)

Measured Data:

Sig. Gen. Freq. [MHz]	Bit error rate (BER)	(S/N) _o [dB]	L sys [dB]	Sig. Gen. Total Peak Power @ RX [dBm]	TX Total Peak Power @ RX [dBm]	Jammer to Signal Ratio Mj [dB]	Processing Gain (PG) [dB]
2439.250	1.00E-06	16	2	-32.3	-27.4	-4.9	13.1
2439.300	1.00E-06	16	2	-33.6	-27.4	-6.2	11.8
2439.350	1.00E-06	16	2	-34.5	-27.4	-7.1	10.9
2439.400	1.00E-06	16	2	-34.2	-27.4	-6.8	11.2
2439.450	1.00E-06	16	2	-34.4	-27.4	-7	11
2439.500	1.00E-06	16	2	-34.3	-27.4	-6.9	11.1
2439.550	1.00E-06	16	2	-34.6	-27.4	-7.2	10.8
2439.600	1.00E-06	16	2	-34.4	-27.4	-7	11
2439.650	1.00E-06	16	2	-35.1	-27.4	-7.7	10.3
2439.700	1.00E-06	16	2	-35.3	-27.4	-7.9	10.1
2439.750	1.00E-06	16	2	-35.4	-27.4	-8	10
2439.800	1.00E-06	16	2	-35.5	-27.4	-8.1	9.9
2439.850	1.00E-06	16	2	-35.4	-27.4	-8	10
2439.900	1.00E-06	16	2	-35.4	-27.4	-8	10
2439.950	1.00E-06	16	2	-36.3	-27.4	-8.9	9.1
2440.000	1.00E-06	16	2	-20	-27.4	7.4	25.4
2440.050	1.00E-06	16	2	-35	-27.4	-7.6	10.4
2440.100	1.00E-06	16	2	-35.3	-27.4	-7.9	10.1
2440.150	1.00E-06	16	2	-35.4	-27.4	-8	10
2440.200	1.00E-06	16	2	-35.2	-27.4	-7.8	10.2
2440.250	1.00E-06	16	2	-35.1	-27.4	-7.7	10.3
2440.300	1.00E-06	16	2	-35	-27.4	-7.6	10.4
2440.350	1.00E-06	16	2	-34.9	-27.4	-7.5	10.5
2440.400	1.00E-06	16	2	-34.5	-27.4	-7.1	10.9
2440.450	1.00E-06	16	2	-34.3	-27.4	-6.9	11.1
2440.500	1.00E-06	16	2	-34.3	-27.4	-6.9	11.1
2440.550	1.00E-06	16	2	-33.9	-27.4	-6.5	11.5
2440.600	1.00E-06	16	2	-33.6	-27.4	-6.2	11.8
2440.650	1.00E-06	16	2	-33.6	-27.4	-6.2	11.8
2440.700	1.00E-06	16	2	-33.4	-27.4	-6	12
2440.750	1.00E-06	16	2	-32.5	-27.4	-5.1	12.9
2440.800	1.00E-06	16	2	-33.3	-27.4	-5.9	12.1
2440.850	1.00E-06	16	2	-32.5	-27.4	-5.1	12.9
2440.900	1.00E-06	16	2	-32.4	-27.4	-5	13
2440.950	1.00E-06	16	2	-31	-27.4	-3.6	14.4

Processing gain of a direct sequence spread spectrum, FCC CFR 47,
Part 15.247 (e)

Measured Data:

Sig. Gen. Freq. [MHz]	Bit error rate (BER)	(S/N) _o [dB]	L sys [dB]	Sig. Gen. Total Peak Power @ RX [dBm]	TX Total Peak Power @ RX [dBm]	Jammer to Signal Ratio Mj [dB]	Processing Gain (PG) [dB]
2441.000	1.00E-06	16	2	-31	-27.4	-3.6	14.4
2441.050	1.00E-06	16	2	-31.3	-27.4	-3.9	14.1
2441.100	1.00E-06	16	2	-31	-27.4	-3.6	14.4
2441.150	1.00E-06	16	2	-31.1	-27.4	-3.7	14.3
2441.200	1.00E-06	16	2	-30.4	-27.4	-3	15
2441.250	1.00E-06	16	2	-30.1	-27.4	-2.7	15.3
2441.300	1.00E-06	16	2	-29.7	-27.4	-2.3	15.7
2441.350	1.00E-06	16	2	-30.2	-27.4	-2.8	15.2
2441.400	1.00E-06	16	2	-30.8	-27.4	-3.4	14.6
2441.450	1.00E-06	16	2	-30.5	-27.4	-3.1	14.9
2441.500	1.00E-06	16	2	-30.6	-27.4	-3.2	14.8
2441.550	1.00E-06	16	2	-33.4	-27.4	-6	12
2441.600	1.00E-06	16	2	-33	-27.4	-5.6	12.4
2441.650	1.00E-06	16	2	-32.3	-27.4	-4.9	13.1
2441.700	1.00E-06	16	2	-31.5	-27.4	-4.1	13.9
2441.750	1.00E-06	16	2	-31	-27.4	-3.6	14.4
2441.800	1.00E-06	16	2	-32	-27.4	-4.6	13.4
2441.850	1.00E-06	16	2	-32.5	-27.4	-5.1	12.9
2441.900	1.00E-06	16	2	-32.9	-27.4	-5.5	12.5
2441.950	1.00E-06	16	2	-33.1	-27.4	-5.7	12.3
2442.000	1.00E-06	16	2	-32.9	-27.4	-5.5	12.5
2442.050	1.00E-06	16	2	-32.9	-27.4	-5.5	12.5
2442.100	1.00E-06	16	2	-33.1	-27.4	-5.7	12.3
2442.150	1.00E-06	16	2	-33.3	-27.4	-5.9	12.1
2442.200	1.00E-06	16	2	-33.7	-27.4	-6.3	11.7
2442.250	1.00E-06	16	2	-33.9	-27.4	-6.5	11.5
2442.300	1.00E-06	16	2	-34	-27.4	-6.6	11.4
2442.350	1.00E-06	16	2	-34.2	-27.4	-6.8	11.2
2442.400	1.00E-06	16	2	-33.9	-27.4	-6.5	11.5
2442.450	1.00E-06	16	2	-34.3	-27.4	-6.9	11.1
2442.500	1.00E-06	16	2	-34	-27.4	-6.6	11.4
2442.550	1.00E-06	16	2	-34	-27.4	-6.6	11.4
2442.600	1.00E-06	16	2	-34	-27.4	-6.6	11.4
2442.650	1.00E-06	16	2	-34	-27.4	-6.6	11.4
2442.700	1.00E-06	16	2	-34.3	-27.4	-6.9	11.1

Processing gain of a direct sequence spread spectrum, FCC CFR 47,
Part 15.247 (e)

Measured Data:

Sig. Gen. Freq. [MHz]	Bit error rate (BER)	(S/N) _o [dB]	L sys [dB]	Sig. Gen. Total Peak Power @ RX [dBm]	TX Total Peak Power @ RX [dBm]	Jammer to Signal Ratio Mj [dB]	Processing Gain (PG) [dB]
2442.750	1.00E-06	16	2	-34.1	-27.4	-6.7	11.3
2442.800	1.00E-06	16	2	-33.7	-27.4	-6.3	11.7
2442.850	1.00E-06	16	2	-33.1	-27.4	-5.7	12.3
2442.900	1.00E-06	16	2	-32.4	-27.4	-5	13
2442.950	1.00E-06	16	2	-32.5	-27.4	-5.1	12.9
2443.000	1.00E-06	16	2	-32.6	-27.4	-5.2	12.8
2443.050	1.00E-06	16	2	-32.5	-27.4	-5.1	12.9
2443.100	1.00E-06	16	2	-33.7	-27.4	-6.3	11.7
2443.150	1.00E-06	16	2	-32.9	-27.4	-5.5	12.5
2443.200	1.00E-06	16	2	-32.6	-27.4	-5.2	12.8
2443.250	1.00E-06	16	2	-32.2	-27.4	-4.8	13.2
2443.300	1.00E-06	16	2	-32.4	-27.4	-5	13
2443.350	1.00E-06	16	2	-33.1	-27.4	-5.7	12.3
2443.400	1.00E-06	16	2	-32.1	-27.4	-4.7	13.3
2443.450	1.00E-06	16	2	-32.7	-27.4	-5.3	12.7
2443.500	1.00E-06	16	2	-32.7	-27.4	-5.3	12.7
2443.550	1.00E-06	16	2	-33.8	-27.4	-6.4	11.6
2443.600	1.00E-06	16	2	-33.2	-27.4	-5.8	12.2
2443.650	1.00E-06	16	2	-32.1	-27.4	-4.7	13.3
2443.700	1.00E-06	16	2	-31.6	-27.4	-4.2	13.8
2443.750	1.00E-06	16	2	-30.9	-27.4	-3.5	14.5
2443.800	1.00E-06	16	2	-32.1	-27.4	-4.7	13.3
2443.850	1.00E-06	16	2	-32.2	-27.4	-4.8	13.2
2443.900	1.00E-06	16	2	-32.2	-27.4	-4.8	13.2
2443.950	1.00E-06	16	2	-30.9	-27.4	-3.5	14.5
2444.000	1.00E-06	16	2	-32.3	-27.4	-4.9	13.1
2444.050	1.00E-06	16	2	-32.4	-27.4	-5	13
2444.100	1.00E-06	16	2	-32.2	-27.4	-4.8	13.2
2444.150	1.00E-06	16	2	-32.2	-27.4	-4.8	13.2
2444.200	1.00E-06	16	2	-32.5	-27.4	-5.1	12.9
2444.250	1.00E-06	16	2	-32.6	-27.4	-5.2	12.8
2444.300	1.00E-06	16	2	-32.9	-27.4	-5.5	12.5
2444.350	1.00E-06	16	2	-32.9	-27.4	-5.5	12.5
2444.400	1.00E-06	16	2	-33	-27.4	-5.6	12.4
2444.450	1.00E-06	16	2	-32.7	-27.4	-5.3	12.7

Processing gain of a direct sequence spread spectrum, FCC CFR 47,
Part 15.247 (e)

Measured Data:

Sig. Gen. Freq. [MHz]	Bit error rate (BER)	(S/N)o [dB]	L sys [dB]	Sig. Gen. Total Peak Power @ RX [dBm]	TX Total Peak Power @ RX [dBm]	Jammer to Signal Ratio Mj [dB]	Processing Gain (PG) [dB]
2444.500	1.00E-06	16	2	-32.4	-27.4	-5	13
2444.550	1.00E-06	16	2	-33	-27.4	-5.6	12.4
2444.600	1.00E-06	16	2	-33.9	-27.4	-6.5	11.5
2444.650	1.00E-06	16	2	-32.8	-27.4	-5.4	12.6
2444.700	1.00E-06	16	2	-32.4	-27.4	-5	13
2444.750	1.00E-06	16	2	-32.3	-27.4	-4.9	13.1
2444.800	1.00E-06	16	2	-33.2	-27.4	-5.8	12.2
2444.850	1.00E-06	16	2	-32.5	-27.4	-5.1	12.9
2444.900	1.00E-06	16	2	-33.6	-27.4	-6.2	11.8
2444.950	1.00E-06	16	2	-32.4	-27.4	-5	13
2445.000	1.00E-06	16	2	-32.6	-27.4	-5.2	12.8
2445.050	1.00E-06	16	2	-32.5	-27.4	-5.1	12.9
2445.100	1.00E-06	16	2	-32.3	-27.4	-4.9	13.1
2445.150	1.00E-06	16	2	-32	-27.4	-4.6	13.4
2445.200	1.00E-06	16	2	-31.9	-27.4	-4.5	13.5
2445.250	1.00E-06	16	2	-31.5	-27.4	-4.1	13.9
2445.300	1.00E-06	16	2	-31.1	-27.4	-3.7	14.3
2445.350	1.00E-06	16	2	-31	-27.4	-3.6	14.4
2445.400	1.00E-06	16	2	-31.3	-27.4	-3.9	14.1
2445.450	1.00E-06	16	2	-31.2	-27.4	-3.8	14.2
2445.500	1.00E-06	16	2	-30.6	-27.4	-3.2	14.8
2445.550	1.00E-06	16	2	-30.5	-27.4	-3.1	14.9
2445.600	1.00E-06	16	2	-31.2	-27.4	-3.8	14.2
2445.650	1.00E-06	16	2	-31.4	-27.4	-4	14
2445.700	1.00E-06	16	2	-31.2	-27.4	-3.8	14.2
2445.750	1.00E-06	16	2	-31.7	-27.4	-4.3	13.7
2445.800	1.00E-06	16	2	-31.7	-27.4	-4.3	13.7
2445.850	1.00E-06	16	2	-32.1	-27.4	-4.7	13.3
2445.900	1.00E-06	16	2	-32.4	-27.4	-5	13
2445.950	1.00E-06	16	2	-32.5	-27.4	-5.1	12.9
2446.000	1.00E-06	16	2	-32.3	-27.4	-4.9	13.1
2446.050	1.00E-06	16	2	-33.1	-27.4	-5.7	12.3
2446.100	1.00E-06	16	2	-33.6	-27.4	-6.2	11.8
2446.150	1.00E-06	16	2	-33.9	-27.4	-6.5	11.5
2446.200	1.00E-06	16	2	-32.9	-27.4	-5.5	12.5

Processing gain of a direct sequence spread spectrum, FCC CFR 47,
Part 15.247 (e)

Measured Data:

Sig. Gen. Freq. [MHz]	Bit error rate (BER)	(S/N) _o [dB]	L sys [dB]	Sig. Gen. Total Peak Power @ RX [dBm]	TX Total Peak Power @ RX [dBm]	Jammer to Signal Ratio Mj [dB]	Processing Gain (PG) [dB]
2446.250	1.00E-06	16	2	-32.8	-27.4	-5.4	12.6
2446.300	1.00E-06	16	2	-33	-27.4	-5.6	12.4
2446.350	1.00E-06	16	2	-33.4	-27.4	-6	12
2446.400	1.00E-06	16	2	-33.5	-27.4	-6.1	11.9
2446.450	1.00E-06	16	2	-33.4	-27.4	-6	12
2446.500	1.00E-06	16	2	-32.8	-27.4	-5.4	12.6
2446.550	1.00E-06	16	2	-32.3	-27.4	-4.9	13.1
2446.600	1.00E-06	16	2	-32.7	-27.4	-5.3	12.7
2446.650	1.00E-06	16	2	-31.8	-27.4	-4.4	13.6
2446.700	1.00E-06	16	2	-31.7	-27.4	-4.3	13.7
2446.750	1.00E-06	16	2	-31.6	-27.4	-4.2	13.8
2446.800	1.00E-06	16	2	-31.5	-27.4	-4.1	13.9
2446.850	1.00E-06	16	2	-31.1	-27.4	-3.7	14.3
2446.900	1.00E-06	16	2	-31.1	-27.4	-3.7	14.3
2446.950	1.00E-06	16	2	-30.4	-27.4	-3	15
2447.000	1.00E-06	16	2	-30.7	-27.4	-3.3	14.7
2447.050	1.00E-06	16	2	-31.6	-27.4	-4.2	13.8
2447.100	1.00E-06	16	2	-32	-27.4	-4.6	13.4
2447.150	1.00E-06	16	2	-31.2	-27.4	-3.8	14.2
2447.200	1.00E-06	16	2	-30.6	-27.4	-3.2	14.8
2447.250	1.00E-06	16	2	-30.7	-27.4	-3.3	14.7
2447.300	1.00E-06	16	2	-30.7	-27.4	-3.3	14.7
2447.350	1.00E-06	16	2	-32	-27.4	-4.6	13.4
2447.400	1.00E-06	16	2	-31.5	-27.4	-4.1	13.9
2447.450	1.00E-06	16	2	-31.8	-27.4	-4.4	13.6
2447.500	1.00E-06	16	2	-31.4	-27.4	-4	14
2447.550	1.00E-06	16	2	-31.7	-27.4	-4.3	13.7
2447.600	1.00E-06	16	2	-32.2	-27.4	-4.8	13.2
2447.650	1.00E-06	16	2	-31	-27.4	-3.6	14.4
2447.700	1.00E-06	16	2	-31.1	-27.4	-3.7	14.3
2447.750	1.00E-06	16	2	-31	-27.4	-3.6	14.4
2447.800	1.00E-06	16	2	-31.1	-27.4	-3.7	14.3
2447.850	1.00E-06	16	2	-31	-27.4	-3.6	14.4
2447.900	1.00E-06	16	2	-31.7	-27.4	-4.3	13.7
2447.950	1.00E-06	16	2	-32	-27.4	-4.6	13.4

Processing gain of a direct sequence spread spectrum, FCC CFR 47,
Part 15.247 (e)

Measured Data:

Sig. Gen. Freq. [MHz]	Bit error rate (BER)	(S/N)o [dB]	L sys [dB]	Sig. Gen. Total Peak Power @ RX [dBm]	TX Total Peak Power @ RX [dBm]	Jammer to Signal Ratio Mj [dB]	Processing Gain (PG) [dB]
2448.000	1.00E-06	16	2	-32.1	-27.4	-4.7	13.3
2448.050	1.00E-06	16	2	-32.9	-27.4	-5.5	12.5
2448.100	1.00E-06	16	2	-32.3	-27.4	-4.9	13.1
2448.150	1.00E-06	16	2	-33	-27.4	-5.6	12.4
2448.200	1.00E-06	16	2	-32.4	-27.4	-5	13
2448.250	1.00E-06	16	2	-32.7	-27.4	-5.3	12.7
2448.300	1.00E-06	16	2	-33	-27.4	-5.6	12.4
2448.350	1.00E-06	16	2	-32.3	-27.4	-4.9	13.1
2448.400	1.00E-06	16	2	-32.8	-27.4	-5.4	12.6
2448.450	1.00E-06	16	2	-33.4	-27.4	-6	12
2448.500	1.00E-06	16	2	-33.2	-27.4	-5.8	12.2
2448.550	1.00E-06	16	2	-32.7	-27.4	-5.3	12.7
2448.600	1.00E-06	16	2	-32.5	-27.4	-5.1	12.9
2448.650	1.00E-06	16	2	-32.4	-27.4	-5	13
2448.700	1.00E-06	16	2	-32.1	-27.4	-4.7	13.3
2448.750	1.00E-06	16	2	-31.9	-27.4	-4.5	13.5
2448.800	1.00E-06	16	2	-32.1	-27.4	-4.7	13.3
2448.850	1.00E-06	16	2	-32.1	-27.4	-4.7	13.3
2448.900	1.00E-06	16	2	-32.1	-27.4	-4.7	13.3
2448.950	1.00E-06	16	2	-31.9	-27.4	-4.5	13.5
2449.000	1.00E-06	16	2	-31.4	-27.4	-4	14
2449.050	1.00E-06	16	2	-31.1	-27.4	-3.7	14.3
2449.100	1.00E-06	16	2	-31.2	-27.4	-3.8	14.2
2449.150	1.00E-06	16	2	-30.2	-27.4	-2.8	15.2
2449.200	1.00E-06	16	2	-29.9	-27.4	-2.5	15.5
2449.250	1.00E-06	16	2	-29.1	-27.4	-1.7	16.3
2449.300	1.00E-06	16	2	-28.7	-27.4	-1.3	16.7
2449.350	1.00E-06	16	2	-30.4	-27.4	-3	15
2449.400	1.00E-06	16	2	-29.8	-27.4	-2.4	15.6
2449.450	1.00E-06	16	2	-29.3	-27.4	-1.9	16.1
2449.500	1.00E-06	16	2	-29	-27.4	-1.6	16.4
2449.550	1.00E-06	16	2	-28.8	-27.4	-1.4	16.6
2449.600	1.00E-06	16	2	-29.1	-27.4	-1.7	16.3
2449.650	1.00E-06	16	2	-29	-27.4	-1.6	16.4
2449.700	1.00E-06	16	2	-28.2	-27.4	-0.8	17.2

Processing gain of a direct sequence spread spectrum, FCC CFR 47,
Part 15.247 (e)

Measured Data:

Sig. Gen. Freq. [MHz]	Bit error rate (BER)	(S/N) _o [dB]	L sys [dB]	Sig. Gen. Total Peak Power @ RX [dBm]	TX Total Peak Power @ RX [dBm]	Jammer to Signal Ratio Mj [dB]	Processing Gain (PG) [dB]
2449.750	1.00E-06	16	2	-27.9	-27.4	-0.5	17.5
2449.800	1.00E-06	16	2	-29.3	-27.4	-1.9	16.1
2449.850	1.00E-06	16	2	-28.8	-27.4	-1.4	16.6
2449.900	1.00E-06	16	2	-28.4	-27.4	-1	17
2449.950	1.00E-06	16	2	-30.4	-27.4	-3	15
2450.000	1.00E-06	16	2	-30.6	-27.4	-3.2	14.8
2450.050	1.00E-06	16	2	-30.4	-27.4	-3	15
2450.100	1.00E-06	16	2	-30.6	-27.4	-3.2	14.8
2450.150	1.00E-06	16	2	-30.9	-27.4	-3.5	14.5
2450.200	1.00E-06	16	2	-30.6	-27.4	-3.2	14.8
2450.250	1.00E-06	16	2	-30.8	-27.4	-3.4	14.6
2450.300	1.00E-06	16	2	-30.9	-27.4	-3.5	14.5
2450.350	1.00E-06	16	2	-31.4	-27.4	-4	14
2450.400	1.00E-06	16	2	-32	-27.4	-4.6	13.4
2450.450	1.00E-06	16	2	-31.8	-27.4	-4.4	13.6
2450.500	1.00E-06	16	2	-32.2	-27.4	-4.8	13.2
2450.550	1.00E-06	16	2	-32.2	-27.4	-4.8	13.2
2450.600	1.00E-06	16	2	-31.8	-27.4	-4.4	13.6
2450.650	1.00E-06	16	2	-32.2	-27.4	-4.8	13.2
2450.700	1.00E-06	16	2	-31.6	-27.4	-4.2	13.8
2450.750	1.00E-06	16	2	-32	-27.4	-4.6	13.4
2450.800	1.00E-06	16	2	-31.3	-27.4	-3.9	14.1
2450.850	1.00E-06	16	2	-31.8	-27.4	-4.4	13.6
2450.900	1.00E-06	16	2	-31.4	-27.4	-4	14
2450.950	1.00E-06	16	2	-31.8	-27.4	-4.4	13.6
2451.000	1.00E-06	16	2	-31.4	-27.4	-4	14
2451.050	1.00E-06	16	2	-32	-27.4	-4.6	13.4
2451.100	1.00E-06	16	2	-32	-27.4	-4.6	13.4
2451.150				-31.5			
2451.200				-30.9			
2451.250				-31			
2451.300				-30.4			
2451.350				-30.1			
2451.400				-29.1			
2451.450							