

Section 15.247(e): Processing Gain

Test Method

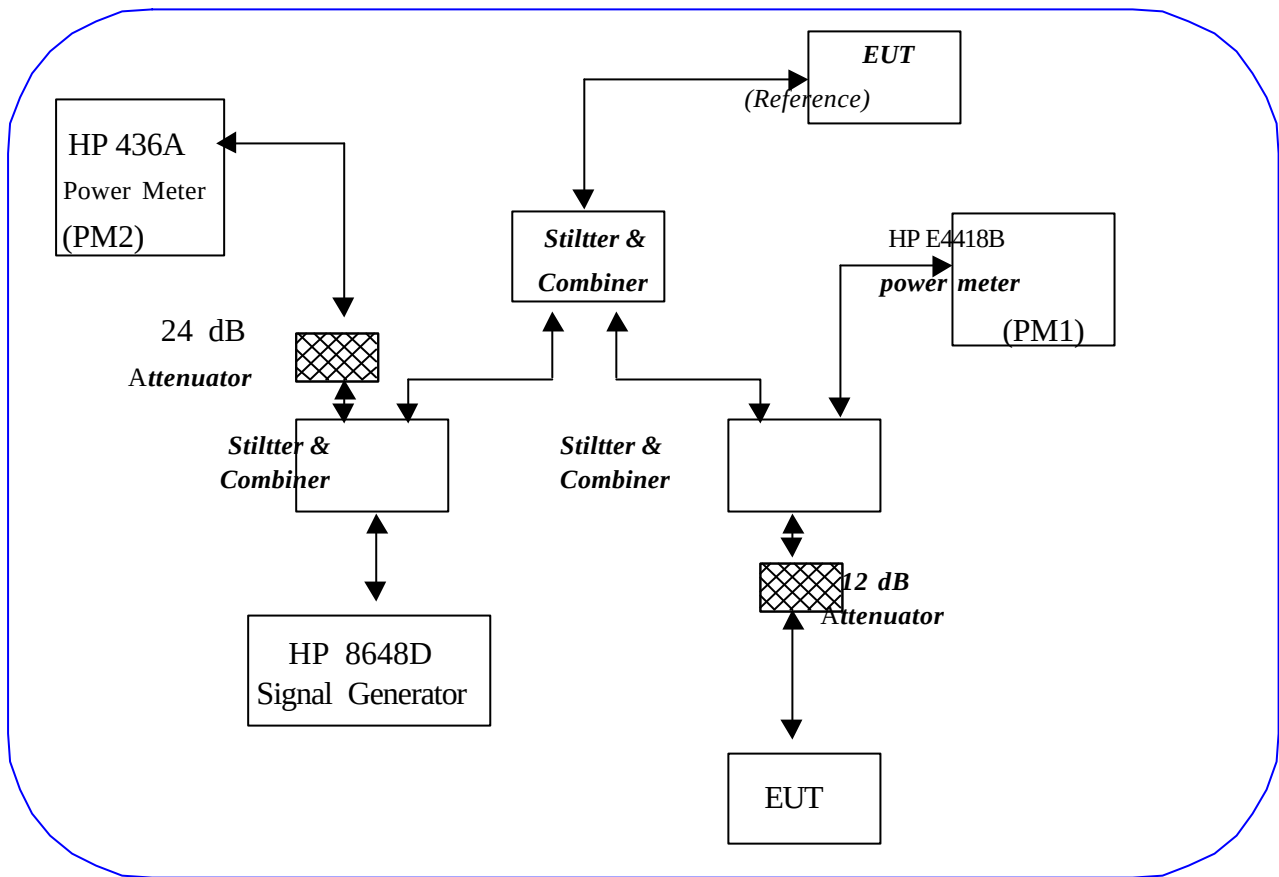
The test method attach in the docket 97-114 appendix C Jamming Test setup that we found there were couple disadvantage as list in the follow:

- (1) It can not simulate the real world condition
- (2) Most of the hand held device (include notebook computer) there is no ground connection to the earth, especially the RF front end ground.
- (3) The Coaxial and internal RF module will leak the signal that even you connect very high value attenuator .(shielding effective is low in the 2.4 GHz)
- (4) There was very high uncertainty of measurement result and it is depended how you connect EUT, testing facility, wire and cable for BER measurement, power supply... all of this can affect the testing result.
- (5) Move out the antenna is inconvenient for the testing and need more sample.

Base on the above reason we modify the original jamming test setup figure 1, and use two fully anechoic chambers to isolate test EUT and reference EUT.

Test procedure is simulated normal jamming setup, the block diagram as below.

Test Instruments Configuration



Test Configuration of processing gain

List of Test Instruments

Instrument Name	Model No	Brand	Serial No.	Last time	Next time
Signal Generator	8648D	HP	3613A00117	05/19/00	05/19/01
Power Meter	E4418B	HP	GB39291240	09/11/00	09/11/01
Power Meter	436A	HP	1930A05580	09/11/2000	09/11/2001
Combiner	15542 ZAPD-4	Mini Circuits	N/A	N/A	N/A
Attenuator (6dB to 18 GHz)	MCL BW-S6W2	Mini Circuits			

Bit Error Rate (BER)

(1) Test Background and procedure

According to FCC regulation, a direct sequence spread spectrum system must have processing gain, G_p of the 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 10dB)between the case where spread spectrum processes (coding, modulation) are engaged relative to the processes being bypassed. In some practical system, the spread spectrum processing cannot simply be bypassed. 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.

(2) Theoretical calculations

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

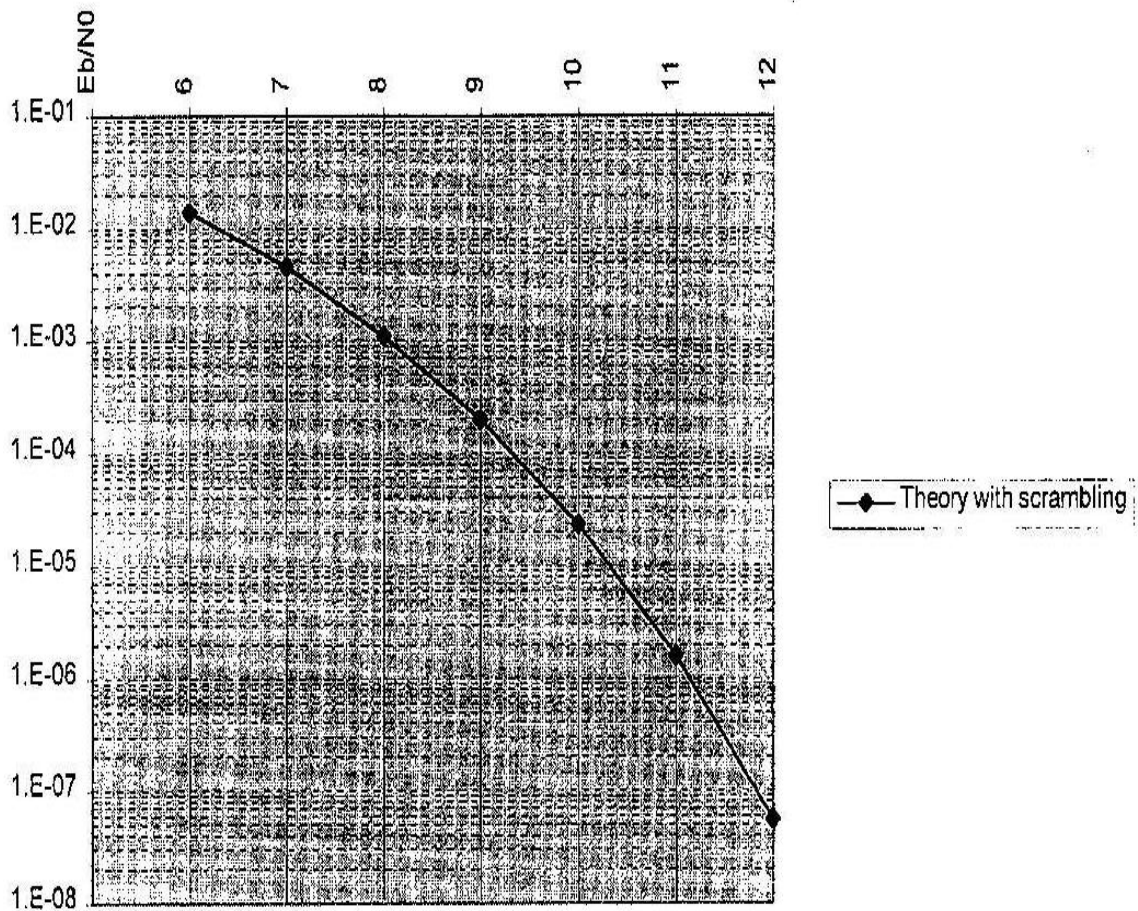
$$G_p = \left(\frac{S}{N} \right)_{\text{output}} + \left(\frac{J}{S} \right) + L_{\text{system}}$$

Where $BER_{\text{REFERENCE}}$ is the reference bit error ratio with its corresponding, theoretical output signal to noise ratio per symbol, $\left(\frac{S}{N} \right)_{\text{output}}$, $\left(\frac{J}{S} \right)$ 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-ray Orthogonal Keying. The BER performance curve is given by: The probability of error for generalized M-ary Orthogonal signaling using coherent demodulation is given by:

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

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

DQPSK BER curve with descrambling



The reference PER is specified as 8% . When operating DQPSK at 2Mbps, the corresponding E_s/N_o (signal to noise ratio per symbol) is 13.3 dB. The E_s/N_o required to achieve the desired BER with maximum system implementation losses is 15.3dB. The minimum processing gain is again, 10dB, therefore:

$$G_p = \left(\frac{E_s}{N_o} \right)_{\text{output}} + \left(\frac{J}{S} \right) + L_{\text{system}} = 13.3\text{dB} + 2.0\text{dB} + \left(\frac{J}{S} \right) \geq 10\text{ dB}$$

$$G_p = 15.3\text{dB} + \left(\frac{J}{S} \right) \geq 10\text{ dB}$$

The minimum jammer to signal ratio is as follow:

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

Test Procedure

The test block diagram be shown figure (→).

- (1) Install DOS Test toll into two notebook computers (E.U.T. and Reference)
- (2) Set the Reference notebook computer as DBPSK and the E.U.T. notebook computer as DBPSK. And both is link.
- (3) The signal generator RF output is disabled.
- (4) Generated the Log File in the Reference notebook computer and send the test file. And measure the power at the power meter port using the power meter (PM1). This is the relative signal power, S
- (5) Ensure that CW Jammer generator RF out put is disabled and measure the power at the power meter port using the power meter (PM2). This is the relative signal power, J .
- (6) 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 (PM2).
- (7) Disable CW Jammer generator, re-establish link. PER test should be operating essentially error-free.
- (8) Enable CW Jammer at the reference power level and verify that the PER test indicates a PER of less than 8%.
- (9) Alternatively, adjust the CW Jammer level to that which causes 8% PER and verify that the S/J is less than 8.4dB.
- (10) Repeat step 8 for uniform steps in frequency increments of 50kHz across the receiver passband with the CW Jammer. In this case the receiver passband is $\pm 5.0\text{MHz}$.

The number of points where the PER fail 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 information purposes) can be determined from the average of the remaining points' PERs scaled on the PER curve above.

7.5 Test Result of Processing Gain

Table 1 Processing Gain [Channel 6, DQPSK, 2.43205GHz to 2.43405GHz]

Jammer Frequency (MHz)	Signal Level S (dBm)	Signal Generator RF Output J (dBm)	Mj (J/S)	Process Gain (dB)
2432.05	-10.3	-6.25	4.05	19.35
2432.10	-10.3	-6.35	3.95	19.25
2432.15	-10.3	-6.55	3.75	19.05
2432.20	-10.3	-6.55	3.75	19.05
2432.25	-10.3	-6.95	3.35	18.65
2432.30	-10.3	-6.85	3.45	18.75
2432.35	-10.3	-6.85	3.45	18.75
2432.40	-10.3	-6.85	3.45	18.75
2432.45	-10.3	-6.75	3.55	18.85
2432.50	-10.3	-6.55	3.75	19.05
2432.55	-10.3	-6.55	3.75	19.05
2432.60	-10.3	-6.45	3.85	19.15
2432.65	-10.3	-6.45	3.85	19.15
2432.70	-10.3	-6.35	3.95	19.25
2432.75	-10.3	-6.55	3.75	19.05
2432.80	-10.3	-6.55	3.75	19.05
2432.85	-10.3	-6.45	3.85	19.15
2432.90	-10.3	-6.45	3.85	19.15
2432.95	-10.3	-6.35	3.95	19.25
2433.00	-10.3	-6.55	3.75	19.05
2433.05	-10.3	-6.65	3.65	18.95
2433.10	-10.3	-6.74	3.56	18.86
2433.15	-10.3	-6.94	3.36	18.66
2433.20	-10.3	-6.94	3.36	18.66
2433.25	-10.3	-6.95	3.35	18.65
2433.30	-10.3	-6.85	3.45	18.75
2433.35	-10.3	-6.85	3.45	18.75
2433.40	-10.3	-6.85	3.45	18.75
2433.45	-10.3	-6.54	3.76	19.06
2433.50	-10.3	-6.75	3.55	18.85
2433.55	-10.3	-6.65	3.65	18.95
2433.60	-10.3	-6.65	3.65	18.95
2433.65	-10.3	-6.44	3.86	19.16
2433.70	-10.3	-6.44	3.86	19.16
2433.75	-10.3	-6.55	3.75	19.05
2433.80	-10.3	-6.44	3.86	19.16
2433.85	-10.3	-6.55	3.75	19.05
2433.90	-10.3	-6.44	3.86	19.16
2433.95	-10.3	-6.34	3.96	19.26
2434.00	-10.3	-6.44	3.86	19.16
2434.05	-10.3	-6.64	3.66	18.96

Table 2 Processing Gain [Channel 6, DBPSK, 2.43410GHz to 2.43610GHz]

Jammer Frequency (MHz)	Signal Level S (dBm)	Signal Generator RF Output J (dBm)	Mj (J/S)	Process Gain (dB)
2434.10	-10.3	-6.44	3.86	19.16
2434.15	-10.3	-6.95	3.35	18.65
2434.20	-10.3	-6.95	3.35	18.65
2434.25	-10.3	-7.05	3.25	18.55
2434.30	-10.3	-7.36	2.94	18.24
2434.35	-10.3	-7.26	3.04	18.34
2434.40	-10.3	-7.10	3.20	18.50
2434.45	-10.3	-6.44	3.86	19.16
2434.50	-10.3	-6.75	3.55	18.85
2434.55	-10.3	-6.64	3.66	18.96
2434.60	-10.3	-6.54	3.76	19.06
2434.65	-10.3	-6.44	3.86	19.16
2434.70	-10.3	-6.34	3.96	19.26
2434.75	-10.3	-6.24	4.06	19.36
2434.80	-10.3	-6.24	4.06	19.36
2434.85	-10.3	-6.24	4.06	19.36
2434.90	-10.3	-6.24	4.06	19.36
2434.95	-10.3	-6.34	3.96	19.26
2435.00	-10.3	-6.34	3.96	19.26
2435.05	-10.3	-6.24	4.06	19.36
2435.10	-10.3	-6.24	4.06	19.36
2435.15	-10.3	-6.44	3.86	19.16
2435.20	-10.3	-6.85	3.45	18.75
2435.25	-10.3	-6.85	3.45	18.75
2435.30	-10.3	-7.15	3.15	18.45
2435.35	-10.3	-7.15	3.15	18.45
2435.40	-10.3	-7.46	2.84	18.14
2435.45	-10.3	-6.44	3.86	19.16
2435.50	-10.3	-7.15	3.15	18.45
2435.55	-10.3	-6.95	3.35	18.65
2435.60	-10.3	-6.75	3.55	18.85
2435.65	-10.3	-6.85	3.45	18.75
2435.70	-10.3	-6.75	3.55	18.85
2435.75	-10.3	-6.85	3.45	18.75
2435.80	-10.3	-6.65	3.65	18.95
2435.85	-10.3	-6.44	3.86	19.16
2435.90	-10.3	-6.55	3.75	19.05
2435.95	-10.3	-6.64	3.66	18.96
2436.00	-10.3	-6.55	3.75	19.05
2436.05	-10.3	-6.35	3.95	19.25
2436.10	-10.3	-6.24	4.06	19.36

Table 3 Processing Gain [Channel 6, BPSK, 2.43615GHz to 2.43815GHz]

Jammer Frequency (MHz)	Signal Level S (dBm)	Signal Generator RF Output J (dBm)	Mj (J/S)	Process Gain (dB)
2436.15	-10.3	-6.65	3.65	18.95
2436.20	-10.3	-6.05	4.25	19.55
2436.25	-10.3	-6.95	3.35	18.65
2436.30	-10.3	-6.95	3.35	18.65
2436.35	-10.3	-6.75	3.55	18.85
2436.40	-10.3	-6.75	3.55	18.85
2436.45	-10.3	-6.35	3.95	19.25
2436.50	-10.3	-6.24	4.06	19.36
2436.55	-10.3	-6.14	4.16	19.46
2436.60	-10.3	-6.24	4.06	19.36
2436.65	-10.3	-7.15	3.15	18.45
2436.70	-10.3	-7.95	2.35	17.65
2436.75	-10.3	-8.06	2.24	17.54
2436.80	-10.3	-7.86	2.44	17.74
2436.85	-10.3	-7.45	2.85	18.15
2436.90	-10.3	-6.65	3.65	18.95
2436.95	-10.3	-6.55	3.75	19.05
2437.00	-10.3	-6.65	3.65	18.95
2437.05	-10.3	-7.35	2.95	18.25
2437.10	-10.3	-7.86	2.44	17.74
2437.15	-10.3	-8.26	2.04	17.34
2437.20	-10.3	-8.46	1.84	17.14
2437.25	-10.3	-7.35	2.95	18.25
2437.30	-10.3	-6.74	3.56	18.86
2437.35	-10.3	-6.44	3.86	19.16
2437.40	-10.3	-6.64	3.66	18.96
2437.45	-10.3	-6.44	3.86	19.16
2437.50	-10.3	-7.05	3.25	18.55
2437.55	-10.3	-7.15	3.15	18.45
2437.60	-10.3	-7.05	3.25	18.55
2437.65	-10.3	-7.15	3.15	18.45
2437.70	-10.3	-7.25	3.05	18.35
2437.75	-10.3	-6.75	3.55	18.85
2437.80	-10.3	-6.65	3.65	18.95
2437.85	-10.3	-6.52	3.78	19.08
2437.90	-10.3	-6.43	3.87	19.17
2437.95	-10.3	-6.35	3.95	19.25
2438.00	-10.3	-6.24	4.06	19.36
2438.05	-10.3	-6.36	3.94	19.24
2438.10	-10.3	-6.40	3.90	19.20
2438.15	-10.3	-6.45	3.85	19.15

Table 4 Processing Gain [Channel 6, BPSK, 2.43820GHz to 2.44020GHz]

Jammer Frequency (MHz)	Signal Level S (dBm)	Signal Generator RF Output J (dBm)	Mj (J/S)	Process Gain (dB)
2438.20	-10.3	-6.72	3.58	18.88
2438.25	-10.3	-6.85	3.45	18.75
2438.30	-10.3	-7.11	3.19	18.49
2438.35	-10.3	-7.37	2.93	18.23
2438.40	-10.3	-7.57	2.73	18.03
2438.45	-10.3	-7.76	2.54	17.84
2438.50	-10.3	-7.86	2.44	17.74
2438.55	-10.3	-7.86	2.44	17.74
2438.60	-10.3	-7.81	2.49	17.79
2438.65	-10.3	-7.76	2.54	17.84
2438.70	-10.3	-7.76	2.54	17.84
2438.75	-10.3	-7.56	2.74	18.04
2438.80	-10.3	-7.46	2.84	18.14
2438.85	-10.3	-7.35	2.95	18.25
2438.90	-10.3	-7.05	3.25	18.55
2438.95	-10.3	-7.25	3.05	18.35
2439.00	-10.3	-6.65	3.65	18.95
2439.05	-10.3	-6.65	3.65	18.95
2439.10	-10.3	-6.51	3.79	19.09
2439.15	-10.3	-6.40	3.90	19.20
2439.20	-10.3	-6.40	3.90	19.20
2439.25	-10.3	-6.35	3.95	19.25
2439.30	-10.3	-6.45	3.85	19.15
2439.35	-10.3	-6.65	3.65	18.95
2439.40	-10.3	-6.64	3.66	18.96
2439.45	-10.3	-6.85	3.45	18.75
2439.50	-10.3	-7.05	3.25	18.55
2439.55	-10.3	-7.06	3.24	18.54
2439.60	-10.3	-7.06	3.24	18.54
2439.65	-10.3	-7.10	3.20	18.50
2439.70	-10.3	-7.10	3.20	18.50
2439.75	-10.3	-7.20	3.10	18.40
2439.80	-10.3	-7.20	3.10	18.40
2439.85	-10.3	-7.20	3.10	18.40
2439.90	-10.3	-7.16	3.14	18.44
2439.95	-10.3	-7.05	3.25	18.55
2440.00	-10.3	-7.05	3.25	18.55
2440.05	-10.3	-7.06	3.24	18.54
2440.10	-10.3	-7.06	3.24	18.54
2440.15	-10.3	-7.06	3.24	18.54
2440.20	-10.3	-7.06	3.24	18.54

Table 5 Processing Gain [Channel 6, BPSK, 2.44025GHz to 2.44200GHz]

Jammer Frequency (MHz)	Signal Level S (dBm)	Signal Generator RF Output J (dBm)	Mj (J/S)	Process Gain (dB)
2440.25	-10.3	-7.05	3.25	18.55
2440.30	-10.3	-7.16	3.14	18.44
2440.35	-10.3	-7.45	2.85	18.15
2440.40	-10.3	-7.25	3.05	18.35
2440.45	-10.3	-7.71	2.59	17.89
2440.50	-10.3	-7.36	2.94	18.24
2440.55	-10.3	-7.24	3.06	18.36
2440.60	-10.3	-7.30	3.00	18.30
2440.65	-10.3	-7.11	3.19	18.49
2440.70	-10.3	-7.36	2.94	18.24
2440.75	-10.3	-7.76	2.54	17.84
2440.80	-10.3	-7.36	2.94	18.24
2440.85	-10.3	-7.25	3.05	18.35
2440.90	-10.3	-7.05	3.25	18.55
2440.95	-10.3	-7.46	2.84	18.14
2441.00	-10.3	-6.85	3.45	18.75
2441.05	-10.3	-7.32	2.98	18.28
2441.10	-10.3	-7.32	2.98	18.28
2441.15	-10.3	-7.34	2.96	18.26
2441.20	-10.3	-7.36	2.94	18.24
2441.25	-10.3	-7.26	3.04	18.34
2441.30	-10.3	-7.26	3.04	18.34
2441.35	-10.3	-7.05	3.25	18.55
2441.40	-10.3	-7.30	3.00	18.30
2441.45	-10.3	-7.15	3.15	18.45
2441.50	-10.3	-7.16	3.14	18.44
2441.55	-10.3	-7.51	2.79	18.09
2441.60	-10.3	-7.66	2.64	17.94
2441.65	-10.3	-7.67	2.63	17.93
2441.70	-10.3	-7.67	2.63	17.93
2441.75	-10.3	-7.44	2.86	18.16
2441.80	-10.3	-7.44	2.86	18.16
2441.85	-10.3	-7.02	3.28	18.58
2441.90	-10.3	-7.03	3.27	18.57
2441.95	-10.3	-7.21	3.09	18.39
2442.00	-10.3	-6.83	3.47	18.77

Test Result: Processing Gain: 18.14 dB

**Note: GP = (S/No) + Mj + Lsys
= 13.3dB + Mj + 2.0dB**

Appendix A

Setting up Procedure

1. Using the PCMCIA port of Notebook PC and software to control the PCMCIA wireless lan card of EUT.
2. Use the software that is given by the customer and operated in the windows to control the EUT's continuous transmission.
3. Then making access to the mode of continuous transmission and set testing channel. Also, it is removed from PC and insert the card into pc card slot of the access point.