# Measurement of Processing Gain of the JX-4000F

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Clarion®

## 1. A GENERAL DEFINITION OF THE PROCESSING GAIN

The nominal processing gain for a direct-sequence spread-spectrum system is simply the number of chips $N_c$ in the symbol waveform; it represents the theoretical rejection of a center-band narrowband interferer, averaged over all chip-code patterns. The practical processing gain of the system must also take into account the SNR (Signal to Noise Ratio) required for adequately low demodulation errors and the system implementation losses. The practical processing gain Gp is defined by[1]

$$Gp = (S/N)_{req} + Mj + Lsys \qquad (1)$$

(all in dB) where

- $(S/N)_{req}$ is the minimum signal-to-noise ratio after despreading at which the given modulation can provide adequate error performance,
- Mj is the maximum ratio of interference power to the signal power, measured at the system input, for which the system can provide the adequate error performance,
- Lsys is the system implementation losses in SNR due to practical implementation limitations.

## 2. CONSIDERATION OF ACTUAL PROCESSING GAIN

First, the values used for S/N and Lsys will be discussed, then the measured values of Mj will be presented.

### 2.1.REQUIRED SNR

The data modulation employed is a form of bi-orthogonal signaling in which transmission of one of 32 waveforms, these differing in the spreading code pattern, conveys five bits of information during each 16-chip data symbol. The theoretical coherent S/N performance in terms of probability of symbol error ($P_{SE}$) can be seen in the graph on page 259 in a book of Wozencraft and Jacobs[2] . This analysis is appended on page 263 of the book, which shows that the 32 channel bi-orthognal performance is approximately equal to the 16 channel orthogonal performance shown on page 259. The JX-4000F, applying to the FCC, processes In-phase and Quadrature-phase correlation channels, and then noncoherently combines the results; thus, it would be expected to perform a fraction of a dB worse (at good S/N) than the fully coherent (recovered carrier) case shown in the book. In fact, the manufacturer has performed simulation, numerical computation, and experimentation (using unfiltered, perfectly timed received waveforms) to verify this performance. The results of the numerical computation are shown in Figure 1.

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[1] Dixon, R, Spread Spectrum Systems, Chapter 1 (New York: Wiley, 1994)
[2] Wozencraft and Jacobs, Principles of Communication Engineering, John Wiley & Sons, Inc., New York, 1965

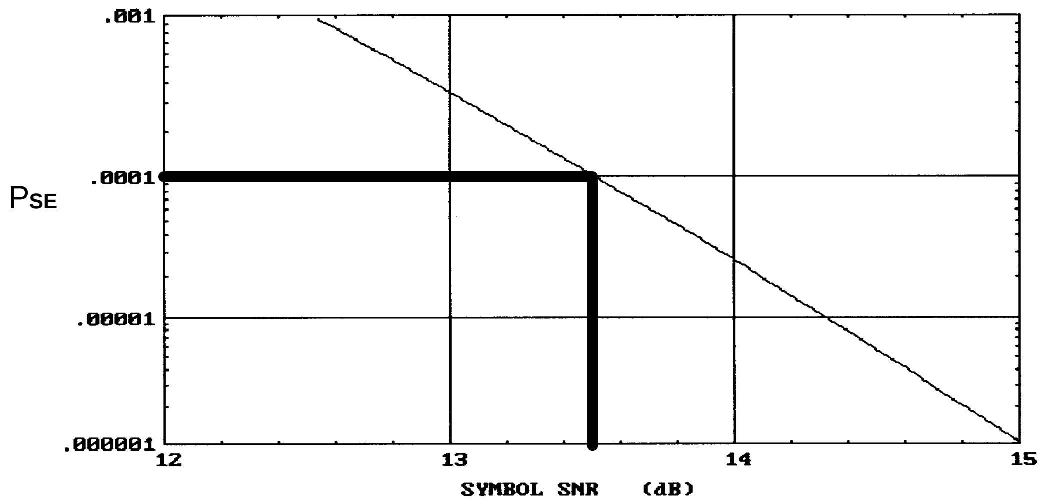



***Figure 1***

As expected, at low $P_{SE}$, these results are within 0.5 dB of the coherent performance expected from the theoretical analysis described above. It is the manufacturers view that adequate system performance is still achieved when the JX-4000F has degraded to 75% of its maximum throughput. As will be shown by calculation in the next section, this level of throughput results for a $P_{SE}$ of $10^{-4}$ (recall that each symbol consists of 5 data bits), resulting in an operating point output SNR = 13.5 dB.

The processing gain does not change rapidly with operating point. The 75% point of its maximum throughput (a loss of approximately 160 frames/sec out of 640 frames/sec) results in good measurement accuracy; Effects of the computer interface and long time averaging are minimized. Because of the proprietary re-transmission protocol that can be enabled in the JX-4000F, this level of frame loss does not render the link ineffective.

## 2.2. ANTICIPATED SYSTEM LOSS

System loss is due to a multitude of effects which include various filters, signal quantization, computation errors, timing misalignment, etc. The very tight filtering required to conform to FCC part 15 regulations (the 2400-to-2483.5-MHz band resides between two protected bands which constrain the absolute levels of signal power which may be produced, unlike the relative-power-level constraint of the part 15.247 alone) causes mismatch between the transmitted waveform and the much-less-filtered reference waveforms in the correlator bank. This causes a loss of approximately 0.8 dB loss. Signal quantization as well as round-off and truncation within the digital correlation subsystem result in approximately 0.45 dB departure from ideal. Timing error in the placement of the correlation processor relative to the received signal results in an average loss of 0.25 dB. The total implementation loss is consequently 1.5 dB.

## 3. MEASUREMENT PROCEDURE OF THE PROCESSING GAIN

The practical processing gain may be measured using the CW jamming margin method. *Figure 2* shows the test configuration . The actual test site is shown in Appendix-A.

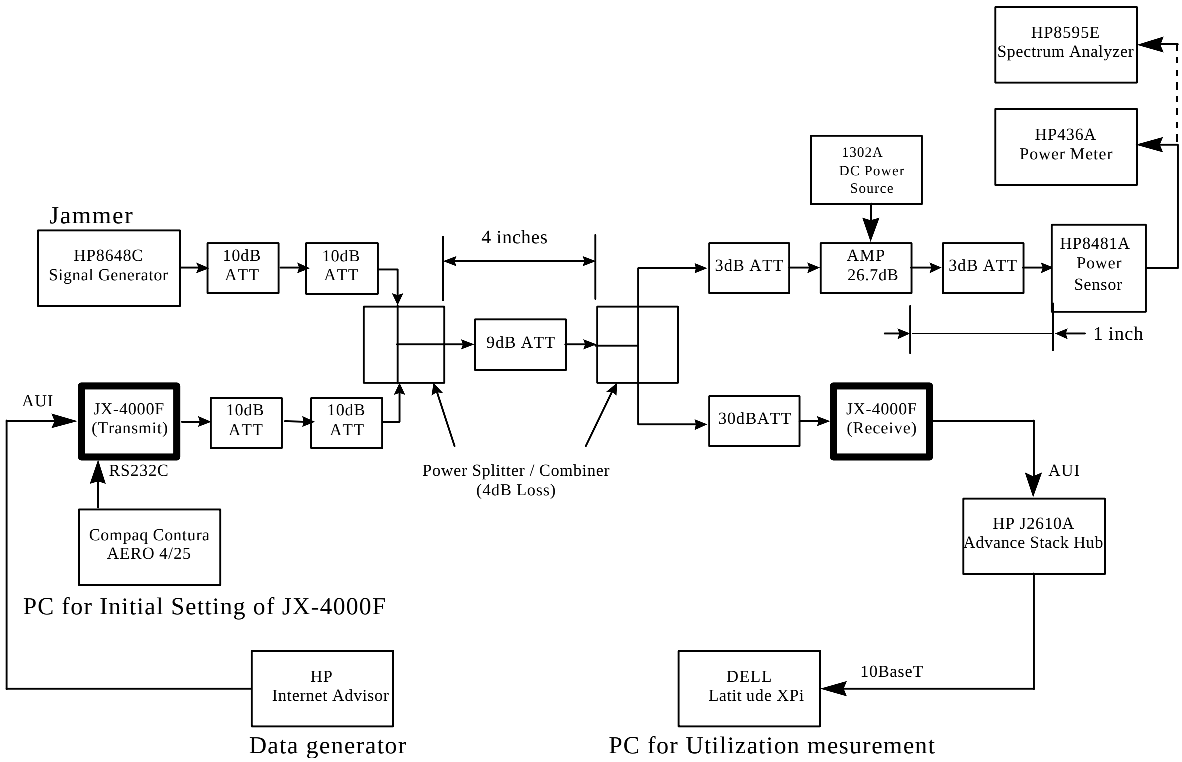



*Figure 2*

The "HP Internet advisor", a data generator, is the source of continuous Ethernet frames. The rate of frame sourcing and all frame parameters can be set. The output of the "HP Internet Advisor" is fed to the Ethernet MAU port on the JX-4000F (Transmit). A "Compaq Contura" PC is used on a local RS-232 control port on the JX-4000F for the initial setting of the transmitter. An "HP8648C" signal generator is used as a jammer (causes CW interference). The desired signal and CW jamming signal are combined and then split for observation of power and for feeding to the JX-4000F (Receive).

The Jammer-to-Signal (J/S) ratio is measured using HP 436A power meter. The power meter readout of the desired signal must be compensated using the transmit stream duty factor of the desired signal frames. The detailed compensation procedure is described in Appendix-B. The spectrum analyzer is exchanged with the power meter only to verify that operation is normal and all spectra are as anticipated.

The output signal of the receiving JX-4000F is a stream of Ethernet frames that is fed through the "HPJ2610A Stack Hub" for conversion of interface from AUI to 10BaseT because no AUI connectors are provided on the "DELL Latitude Xpi" Ethernet card. The "DELL Latitude Xpi" is running "Lanalyzer", a LAN monitoring software package supplied by Novell, used for measuring the rate of frames that are received without any errors (i.e. passed a 32-bit CRC check by the JX-4000F).

Although the data rate is actually 10 Mbps, the software that assigns frame buffers in the JX-4000F limits the overall throughput. It should be noted that all re-transmission protocol, acknowledgment protocol and error-correction coding are shut off for this measurement. The “HP Internet Advisor” is set to generate Ethernet frames at the maximum rate and maximum length that the JX-4000F will accept them. In this case, a utilization of 82% can be observed at the output without any interference. The JX-4000F will only download frames to the MAU port if the 32-bit CRC has passed. Therefore, only the percentage utilization need be noted on the “Lanalyzer.” A measured J/S (equal to jamming margin Mj) at the input of the receiving JX-4000F which results in 61.5% utilization (75% of the maximum utilization of the JX-4000F), corresponds to symbol error rate of $10^{-4}$.

## 3.1. DETAIL PROCEDURE OF THE MEASUREMENT

The processing gain Gp can be calculated by applying the system loss Lsys of 1.5 dB described above and the measured jamming margin Mj to Equation 1. The processing gain is measured across the band in the steps shown in Table 1.

***Table 1***

| Frequency Range (MHz) | Frequency Step |
|---|---|
| 2400.536 - 2425.536 | 1 MHz |
| 2425.636 - 2431.036 | 100 kHz |
| 2431.086 - 2441.136 | 50 kHz |
| 2441.236 - 2446.536 | 100 kHz |
| 2447.536 - 2483.536 | 1 MHz |

The output level of the signal generator (HP8648C) is adjusted in 0.1 dB steps. The CW source is shut off to measure the signal power with the "RF OFF" switch on the front panel of the signal generator. This is done after each measurement to account for any time variation of the power level. The signal source is shut off to measure the CW power through the RS-232 control port on the transmitting JX-4000F. This is done after each measurement to account for any variation of the CW source power at each new frequency sample. At each frequency step, the CW source power is varied with 0.1 dB resolution in order to achieve a reading of approximately 62% on the utiliztion meter. After each measurement, when turning off the CW, the utilization is verified to go back up to 82%. For the band edge measurements, additional padding is inserted in the signal line in order to preserve the accuracy of the relative-power measurements on the power meter for the high J/S values. In the case of any mechanical change to the test setup, the spectra are re-verified on the spectrum analyzer.

The detail of test equipment is described below.:

- Signal generator (Jammer) : HP 8640C
- Data generator : HP Internet Advisor, J2522B
- Transmitter : Spread Spectrum Transceiver, JX-4000F (Equipment under test)

- Receiver : Spread Spectrum Transceiver, JX-4000F (Equipment under test)
- RF Amplifier : Mini-circuit ZHL1042J, Gain 26.7dB
- Power meter : HP426A
- Power Sensor : HP8481A
- Hub : HP J2610A, Advance Stack Hub
- Computers : Dell Latitude Xpi and Compaq Contura Aero4/25
- Spectrum analyzer : HP 8595E
- Power Splitter/Combiner : Mini-circuit 15542 ZFSC-2-2500

## 4. TEST RESULT

*Figure 3* shows actually measured and calculated result of the processing gain of the JX-4000F against CW jammer through entire frequency range of 2400.536MHz to 2483.536MHz. A table of numerical value is shown in Appendix-C.

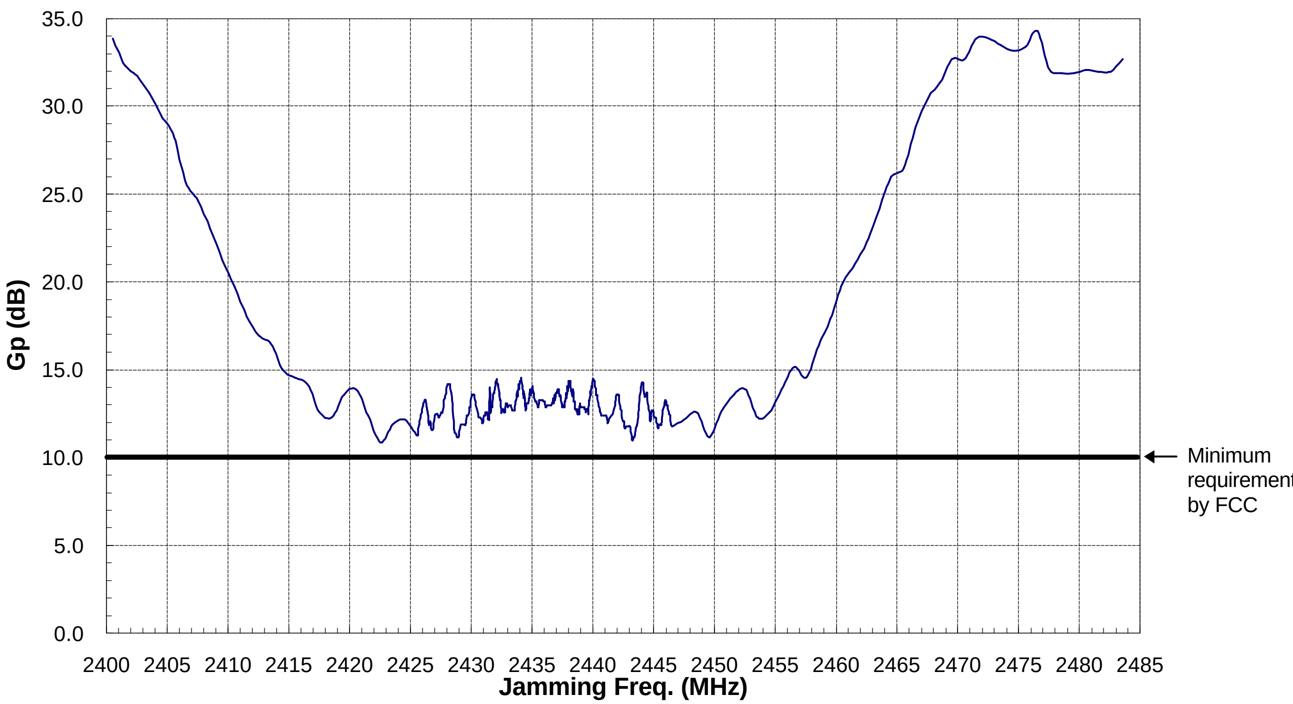


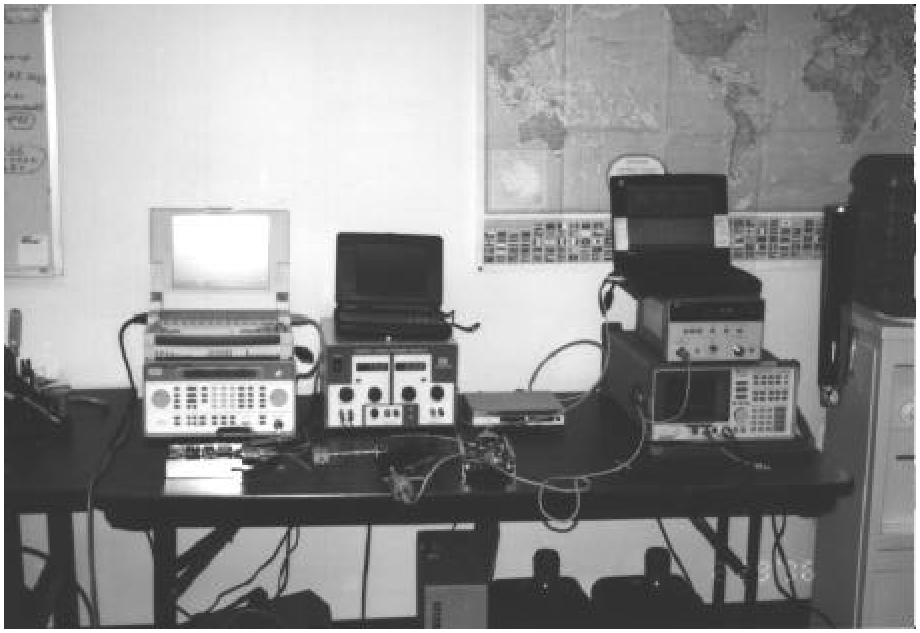

*Figure 3*

## 5. CONCLUSION

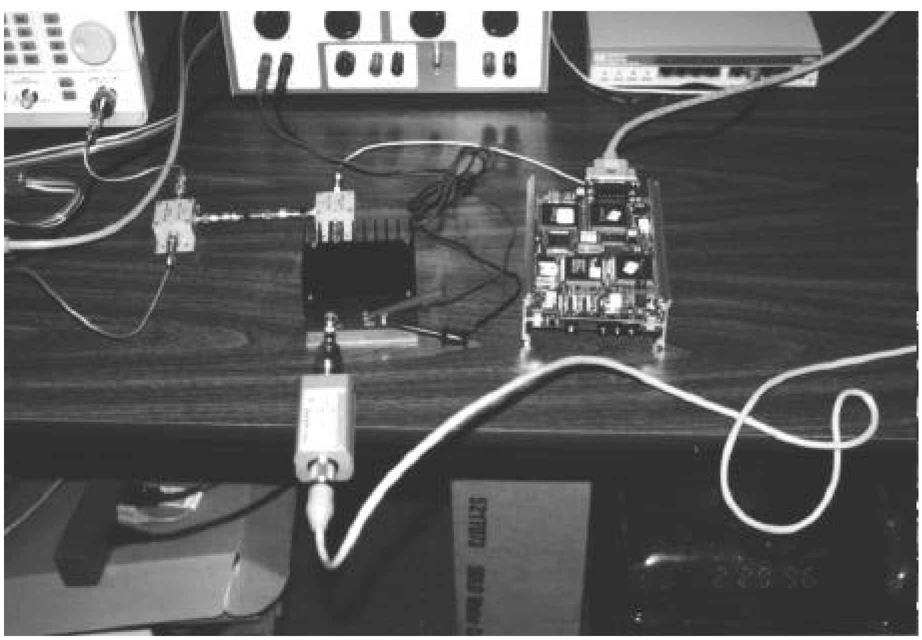
The processing gain of the JX-4000F has been measured using CW jamming margin method. The result shows that the actual processing gain of the JX-4000F exceeds 10 dB throughout the entire bandwidth of the JX-4000F. This means that the JX-4000F conforms to FCC regulation 15.247(e) prescribes that the processing gain of a direct sequence system shall be at least 10 dB.

# Appendix-A

*Test Site for Measurement of Processing Gain*



***Overall View***



***JX-4000F (Receive) and its peripheral components***

# Appendix-B

## *Compensation Procedure of Power for Desired Signal*

Readout of the power meter against desired signal should be compensated to continuous power because

- the power meter responds to average power,
- the JX-4000F transmits burst streams.

Compensation can be done using Equation A1.

$$P_{CONT} = P_{READ} / F_D \tag{A1}$$

where

$P_{CONT}$ : Continuous transmission power (W)
$P_{READ}$ : Readout of the power meter (W)
$F_D$ : Duty factor of the desired signal (sec/sec).

The duty factor $F_D$ is defined as Equation A2.

$$F_D = D_T / (D_T + D_R) \quad \text{(sec/sec)} \tag{A2}$$

where

$D_T$ : Duration of transmission (sec)
$D_R$ : Duration of receive (sec).

Figure A1 shows measurement result of $D_T$ of 1.260 ms under the same condition as processing gain measurement. Figure A2 and Figure A3 show measurement result of $D_R$ under the same condition as processing gain measurement. Two different $D_R$ of 182 µs and 282 µs are observed. This flicker of $D_R$ is caused by uncertainty of task duration of a microprocessor. Accordingly, averaged value of 232 µs may be used because probability of appearance of each value can be considered as equal throughout the response time of the power meter. $F_D$ of the system can be obtained as 0.8445 (-0.73 dB) by applying these values to Equation A2. The readout of the power meter against desired signal can be compensated by applying $F_D$ of this value to Equation A1.

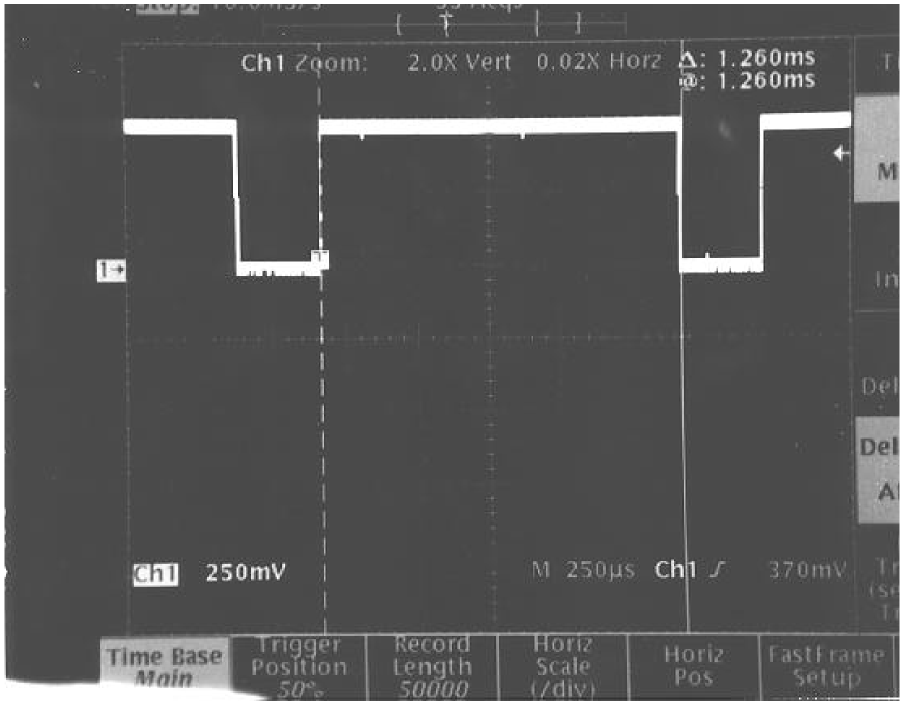

Ch1 Zoom: 2.0X Vert 0.02X Horz
Δ: 1.260ms
@: 1.260ms
Ch1 250mV
M 250µs Ch1 ∫ 370mV
Time Base Main
Trigger Position 50%
Record Length 50000
Horiz Scale (/div)
Horiz Pos
FastFrame Setup

*Figure A1*

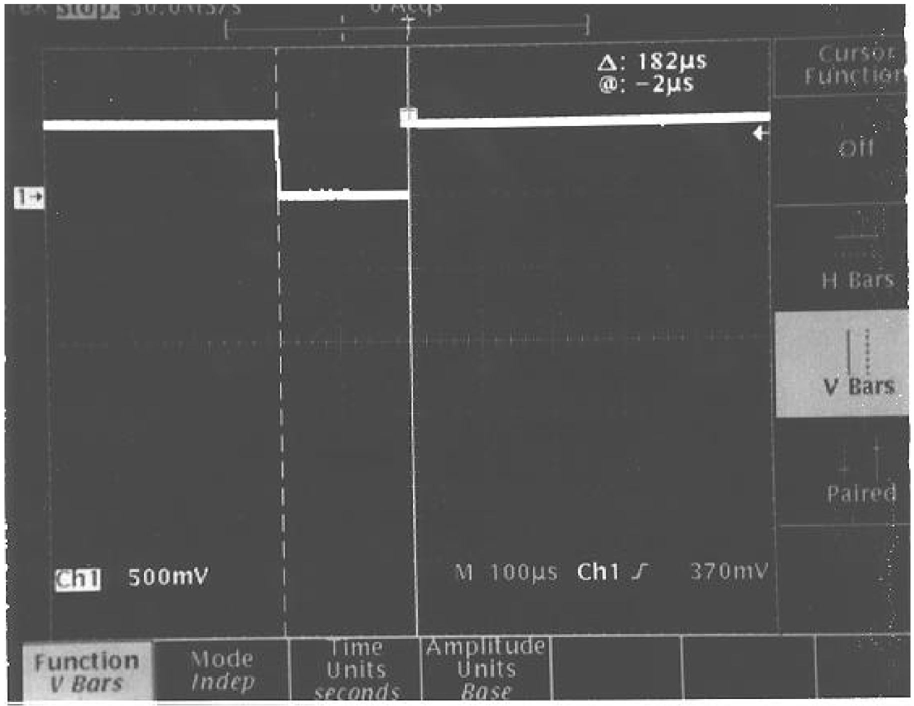



***Figure A2***

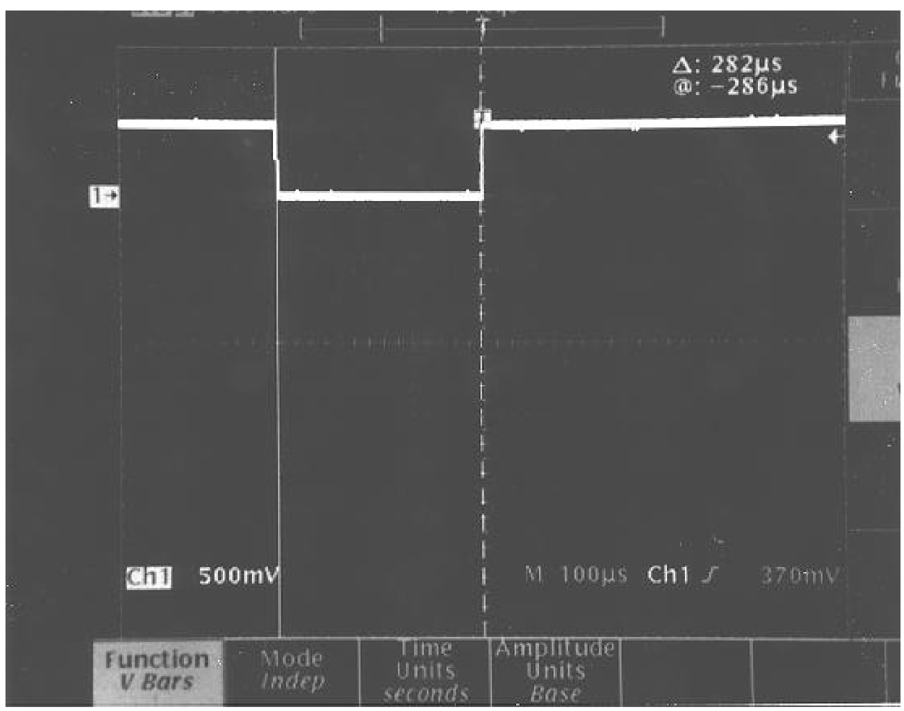



***Figure A3***

# Appendix-C

*Numerical Value of Measured Processing Gain*

| Jamming frequency (MHz) | J/S (dB) | **Gp (dB)** | Jamming frequency (MHz) | J/S (dB) | **Gp (dB)** | Jamming frequency (MHz) | J/S (dB) | **Gp (dB)** | Jamming frequency (MHz) | J/S (dB) | **Gp (dB)** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2400.536 | 18.8 | **33.8** | 2427.736 | -1.7 | **13.3** | 2431.736 | -2.1 | **12.9** | 2434.086 | -0.6 | **14.4** |
| 2401.536 | 17.3 | **32.3** | 2427.836 | -1.6 | **13.4** | 2431.786 | -1.5 | **13.5** | 2434.136 | -0.4 | **14.6** |
| 2402.536 | 16.7 | **31.7** | 2427.936 | -1.3 | **13.7** | 2431.836 | -1.3 | **13.7** | 2434.186 | -1.0 | **14.0** |
| 2403.536 | 15.7 | **30.7** | 2428.036 | -0.8 | **14.2** | 2431.886 | -1.3 | **13.7** | 2434.236 | -0.9 | **14.1** |
| 2404.536 | 14.4 | **29.4** | 2428.136 | -0.8 | **14.2** | 2431.936 | -1.1 | **13.9** | 2434.286 | -1.6 | **13.4** |
| 2405.536 | 13.3 | **28.3** | 2428.236 | -0.8 | **14.2** | 2431.986 | -0.7 | **14.3** | 2434.336 | -1.2 | **13.8** |
| 2406.536 | 10.6 | **25.6** | 2428.336 | -1.3 | **13.7** | 2432.036 | -0.7 | **14.3** | 2434.386 | -1.7 | **13.3** |
| 2407.536 | 9.6 | **24.6** | 2428.436 | -1.9 | **13.1** | 2432.086 | -0.5 | **14.5** | 2434.436 | -1.7 | **13.3** |
| 2408.536 | 8.0 | **23.0** | 2428.536 | -2.7 | **12.3** | 2432.136 | -0.6 | **14.4** | 2434.486 | -2.3 | **12.7** |
| 2409.536 | 6.2 | **21.2** | 2428.636 | -3.5 | **11.5** | 2432.186 | -0.9 | **14.1** | 2434.536 | -1.9 | **13.1** |
| 2410.536 | 4.7 | **19.7** | 2428.736 | -3.6 | **11.4** | 2432.236 | -0.8 | **14.2** | 2434.586 | -1.9 | **13.1** |
| 2411.536 | 3.0 | **18.0** | 2428.836 | -3.8 | **11.2** | 2432.286 | -1.4 | **13.6** | 2434.636 | -1.9 | **13.1** |
| 2412.536 | 1.9 | **16.9** | 2428.936 | -3.8 | **11.2** | 2432.336 | -1.3 | **13.7** | 2434.686 | -1.9 | **13.1** |
| 2413.536 | 1.5 | **16.5** | 2429.036 | -3.4 | **11.6** | 2432.386 | -1.7 | **13.3** | 2434.736 | -1.6 | **13.4** |
| 2414.536 | 0.0 | **15.0** | 2429.136 | -3.1 | **11.9** | 2432.436 | -1.7 | **13.3** | 2434.786 | -1.6 | **13.4** |
| 2415.536 | -0.4 | **14.6** | 2429.236 | -3.1 | **11.9** | 2432.486 | -2.4 | **12.6** | 2434.836 | -1.1 | **13.9** |
| 2416.536 | -0.8 | **14.2** | 2429.336 | -3.1 | **11.9** | 2432.536 | -2.2 | **12.8** | 2434.886 | -1.4 | **13.6** |
| 2417.536 | -2.4 | **12.6** | 2429.436 | -3.1 | **11.9** | 2432.586 | -2.3 | **12.7** | 2434.936 | -1.2 | **13.8** |
| 2418.536 | -2.7 | **12.3** | 2429.536 | -3.1 | **11.9** | 2432.636 | -2.2 | **12.8** | 2434.986 | -1.2 | **13.8** |
| 2419.536 | -1.4 | **13.6** | 2429.636 | -2.6 | **12.4** | 2432.686 | -2.4 | **12.6** | 2435.036 | -0.9 | **14.1** |
| 2420.536 | -1.1 | **13.9** | 2429.736 | -2.6 | **12.4** | 2432.736 | -2.4 | **12.6** | 2435.086 | -1.3 | **13.7** |
| 2421.536 | -2.6 | **12.4** | 2429.836 | -2.1 | **12.9** | 2432.786 | -2.4 | **12.6** | 2435.136 | -1.3 | **13.7** |
| 2422.536 | -4.1 | **10.9** | 2429.936 | -2.1 | **12.9** | 2432.836 | -1.9 | **13.1** | 2435.186 | -1.5 | **13.5** |
| 2423.536 | -3.1 | **11.9** | 2430.036 | -1.4 | **13.6** | 2432.886 | -1.9 | **13.1** | 2435.236 | -1.8 | **13.2** |
| 2424.536 | -2.8 | **12.2** | 2430.136 | -1.4 | **13.6** | 2432.936 | -1.9 | **13.1** | 2435.286 | -1.8 | **13.2** |
| 2425.536 | -3.7 | **11.3** | 2430.236 | -1.4 | **13.6** | 2432.986 | -2.1 | **12.9** | 2435.336 | -1.8 | **13.2** |
| 2425.636 | -3.3 | **11.7** | 2430.336 | -1.8 | **13.2** | 2433.036 | -2.0 | **13.0** | 2435.386 | -1.8 | **13.2** |
| 2425.736 | -3.1 | **11.9** | 2430.436 | -2.2 | **12.8** | 2433.086 | -2.0 | **13.0** | 2435.436 | -2.1 | **12.9** |
| 2425.836 | -2.7 | **12.3** | 2430.536 | -2.5 | **12.5** | 2433.136 | -2.0 | **13.0** | 2435.486 | -2.1 | **12.9** |
| 2425.936 | -2.4 | **12.6** | 2430.636 | -2.7 | **12.3** | 2433.186 | -2.0 | **13.0** | 2435.536 | -2.1 | **12.9** |
| 2426.036 | -2.0 | **13.0** | 2430.736 | -2.7 | **12.3** | 2433.236 | -2.0 | **13.0** | 2435.586 | -1.7 | **13.3** |
| 2426.136 | -1.8 | **13.2** | 2430.836 | -2.8 | **12.2** | 2433.286 | -2.0 | **13.0** | 2435.636 | -1.7 | **13.3** |
| 2426.236 | -1.7 | **13.3** | 2430.936 | -3.0 | **12.0** | 2433.336 | -2.3 | **12.7** | 2435.686 | -1.7 | **13.3** |
| 2426.336 | -2.2 | **12.8** | 2431.036 | -2.6 | **12.4** | 2433.386 | -2.3 | **12.7** | 2435.736 | -1.7 | **13.3** |
| 2426.436 | -2.4 | **12.6** | 2431.086 | -2.6 | **12.4** | 2433.436 | -2.3 | **12.7** | 2435.786 | -1.7 | **13.3** |
| 2426.536 | -3.1 | **11.9** | 2431.136 | -2.6 | **12.4** | 2433.486 | -2.3 | **12.7** | 2435.836 | -1.7 | **13.3** |
| 2426.636 | -2.9 | **12.1** | 2431.186 | -2.4 | **12.6** | 2433.536 | -2.3 | **12.7** | 2435.886 | -1.7 | **13.3** |
| 2426.736 | -3.4 | **11.6** | 2431.236 | -2.4 | **12.6** | 2433.586 | -2.3 | **12.7** | 2435.936 | -1.8 | **13.2** |
| 2426.836 | -3.4 | **11.6** | 2431.286 | -2.4 | **12.6** | 2433.636 | -1.8 | **13.2** | 2435.986 | -1.8 | **13.2** |
| 2426.936 | -2.9 | **12.1** | 2431.336 | -2.4 | **12.6** | 2433.686 | -1.7 | **13.3** | 2436.036 | -1.8 | **13.2** |
| 2427.036 | -2.5 | **12.5** | 2431.386 | -2.8 | **12.2** | 2433.736 | -1.5 | **13.5** | 2436.086 | -2.1 | **12.9** |
| 2427.136 | -2.5 | **12.5** | 2431.436 | -2.7 | **12.3** | 2433.786 | -1.2 | **13.8** | 2436.136 | -2.1 | **12.9** |
| 2427.236 | -2.5 | **12.5** | 2431.486 | -2.8 | **12.2** | 2433.836 | -1.5 | **13.5** | 2436.186 | -2.0 | **13.0** |
| 2427.336 | -2.7 | **12.3** | 2431.536 | -1.0 | **14.0** | 2433.886 | -0.8 | **14.2** | 2436.236 | -2.0 | **13.0** |
| 2427.436 | -2.6 | **12.4** | 2431.586 | -2.4 | **12.6** | 2433.936 | -1.1 | **13.9** | 2436.286 | -2.0 | **13.0** |
| 2427.536 | -2.4 | **12.6** | 2431.636 | -2.2 | **12.8** | 2433.986 | -0.6 | **14.4** | 2436.336 | -2.0 | **13.0** |
| 2427.636 | -2.4 | **12.6** | 2431.686 | -2.0 | **13.0** | 2434.036 | -0.6 | **14.4** | 2436.386 | -2.0 | **13.0** |

| Jamming frequency (MHz) | J/S (dB) | **Gp (dB)** | Jamming frequency (MHz) | J/S (dB) | **Gp (dB)** | Jamming frequency (MHz) | J/S (dB) | **Gp (dB)** | Jamming frequency (MHz) | J/S (dB) | **Gp (dB)** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2436.436 | -2.0 | **13.0** | 2438.786 | -2.5 | **12.5** | 2441.136 | -2.7 | **12.3** | 2445.836 | -2.1 | **12.9** |
| 2436.486 | -2.0 | **13.0** | 2438.836 | -2.5 | **12.5** | 2441.236 | -3.0 | **12.0** | 2445.936 | -1.7 | **13.3** |
| 2436.536 | -2.0 | **13.0** | 2438.886 | -2.5 | **12.5** | 2441.336 | -2.8 | **12.2** | 2446.036 | -2.0 | **13.0** |
| 2436.586 | -2.0 | **13.0** | 2438.936 | -1.9 | **13.1** | 2441.436 | -2.7 | **12.3** | 2446.136 | -2.0 | **13.0** |
| 2436.636 | -1.9 | **13.1** | 2438.986 | -2.1 | **12.9** | 2441.536 | -2.6 | **12.4** | 2446.236 | -2.4 | **12.6** |
| 2436.686 | -1.9 | **13.1** | 2439.036 | -2.1 | **12.9** | 2441.636 | -2.5 | **12.5** | 2446.336 | -2.6 | **12.4** |
| 2436.736 | -1.6 | **13.4** | 2439.086 | -2.1 | **12.9** | 2441.736 | -2.2 | **12.8** | 2446.436 | -3.1 | **11.9** |
| 2436.786 | -1.9 | **13.1** | 2439.136 | -2.1 | **12.9** | 2441.836 | -1.8 | **13.2** | 2446.536 | -3.2 | **11.8** |
| 2436.836 | -1.4 | **13.6** | 2439.186 | -2.1 | **12.9** | 2441.936 | -1.4 | **13.6** | 2447.536 | -2.8 | **12.2** |
| 2436.886 | -1.7 | **13.3** | 2439.236 | -2.1 | **12.9** | 2442.036 | -1.4 | **13.6** | 2448.536 | -2.4 | **12.6** |
| 2436.936 | -1.3 | **13.7** | 2439.286 | -2.1 | **12.9** | 2442.136 | -1.4 | **13.6** | 2449.536 | -3.8 | **11.2** |
| 2436.986 | -1.3 | **13.7** | 2439.336 | -2.2 | **12.8** | 2442.236 | -2.1 | **12.9** | 2450.536 | -2.4 | **12.6** |
| 2437.036 | -1.3 | **13.7** | 2439.386 | -2.2 | **12.8** | 2442.336 | -2.3 | **12.7** | 2451.536 | -1.4 | **13.6** |
| 2437.086 | -1.1 | **13.9** | 2439.436 | -2.4 | **12.6** | 2442.436 | -2.9 | **12.1** | 2452.536 | -1.1 | **13.9** |
| 2437.136 | -1.1 | **13.9** | 2439.486 | -2.2 | **12.8** | 2442.536 | -2.9 | **12.1** | 2453.536 | -2.7 | **12.3** |
| 2437.186 | -1.1 | **13.9** | 2439.536 | -2.2 | **12.8** | 2442.636 | -3.3 | **11.7** | 2454.536 | -2.4 | **12.6** |
| 2437.236 | -1.5 | **13.5** | 2439.586 | -2.2 | **12.8** | 2442.736 | -3.2 | **11.8** | 2455.536 | -1.1 | **13.9** |
| 2437.286 | -1.4 | **13.6** | 2439.636 | -2.5 | **12.5** | 2442.836 | -3.2 | **11.8** | 2456.536 | 0.2 | **15.2** |
| 2437.336 | -1.6 | **13.4** | 2439.686 | -1.7 | **13.3** | 2442.936 | -3.2 | **11.8** | 2457.536 | -0.4 | **14.6** |
| 2437.386 | -1.6 | **13.4** | 2439.736 | -1.7 | **13.3** | 2443.036 | -3.2 | **11.8** | 2458.536 | 1.4 | **16.4** |
| 2437.436 | -2.1 | **12.9** | 2439.786 | -1.2 | **13.8** | 2443.136 | -3.6 | **11.4** | 2459.536 | 2.9 | **17.9** |
| 2437.486 | -1.9 | **13.1** | 2439.836 | -1.4 | **13.6** | 2443.236 | -4.0 | **11.0** | 2460.536 | 5.0 | **20.0** |
| 2437.536 | -2.1 | **12.9** | 2439.886 | -0.9 | **14.1** | 2443.336 | -3.8 | **11.2** | 2461.536 | 6.0 | **21.0** |
| 2437.586 | -2.1 | **12.9** | 2439.936 | -0.9 | **14.1** | 2443.436 | -3.8 | **11.2** | 2462.536 | 7.3 | **22.3** |
| 2437.636 | -2.1 | **12.9** | 2439.986 | -0.5 | **14.5** | 2443.536 | -3.3 | **11.7** | 2463.536 | 9.2 | **24.2** |
| 2437.686 | -1.8 | **13.2** | 2440.036 | -0.5 | **14.5** | 2443.636 | -3.1 | **11.9** | 2464.536 | 11.0 | **26.0** |
| 2437.736 | -1.8 | **13.2** | 2440.086 | -0.6 | **14.4** | 2443.736 | -2.5 | **12.5** | 2465.536 | 11.5 | **26.5** |
| 2437.786 | -1.3 | **13.7** | 2440.136 | -0.6 | **14.4** | 2443.836 | -1.5 | **13.5** | 2466.536 | 13.8 | **28.8** |
| 2437.836 | -1.6 | **13.4** | 2440.186 | -0.9 | **14.1** | 2443.936 | -1.0 | **14.0** | 2467.536 | 15.5 | **30.5** |
| 2437.886 | -0.9 | **14.1** | 2440.236 | -1.1 | **13.9** | 2444.036 | -0.7 | **14.3** | 2468.536 | 16.4 | **31.4** |
| 2437.936 | -1.2 | **13.8** | 2440.286 | -1.4 | **13.6** | 2444.136 | -0.7 | **14.3** | 2469.536 | 17.7 | **32.7** |
| 2437.986 | -0.6 | **14.4** | 2440.336 | -1.4 | **13.6** | 2444.236 | -1.5 | **13.5** | 2470.536 | 17.7 | **32.7** |
| 2438.036 | -0.6 | **14.4** | 2440.386 | -1.5 | **13.5** | 2444.336 | -1.5 | **13.5** | 2471.536 | 18.9 | **33.9** |
| 2438.086 | -0.6 | **14.4** | 2440.436 | -2.0 | **13.0** | 2444.436 | -1.3 | **13.7** | 2472.536 | 18.9 | **33.9** |
| 2438.136 | -0.6 | **14.4** | 2440.486 | -2.0 | **13.0** | 2444.536 | -2.1 | **12.9** | 2473.536 | 18.5 | **33.5** |
| 2438.186 | -1.2 | **13.8** | 2440.536 | -2.1 | **12.9** | 2444.636 | -2.4 | **12.6** | 2474.536 | 18.2 | **33.2** |
| 2438.236 | -1.1 | **13.9** | 2440.586 | -2.3 | **12.7** | 2444.736 | -2.9 | **12.1** | 2475.536 | 18.4 | **33.4** |
| 2438.286 | -1.5 | **13.5** | 2440.636 | -2.4 | **12.6** | 2444.836 | -2.3 | **12.7** | 2476.536 | 19.3 | **34.3** |
| 2438.336 | -1.1 | **13.9** | 2440.686 | -2.6 | **12.4** | 2444.936 | -2.3 | **12.7** | 2477.536 | 17.1 | **32.1** |
| 2438.386 | -1.5 | **13.5** | 2440.736 | -2.6 | **12.4** | 2445.036 | -2.7 | **12.3** | 2478.536 | 16.9 | **31.9** |
| 2438.436 | -1.8 | **13.2** | 2440.786 | -2.6 | **12.4** | 2445.136 | -2.7 | **12.3** | 2479.536 | 16.9 | **31.9** |
| 2438.486 | -1.8 | **13.2** | 2440.836 | -2.6 | **12.4** | 2445.236 | -3.0 | **12.0** | 2480.536 | 17.1 | **32.1** |
| 2438.536 | -2.2 | **12.8** | 2440.886 | -2.6 | **12.4** | 2445.336 | -3.3 | **11.7** | 2481.536 | 17.0 | **32.0** |
| 2438.586 | -2.2 | **12.8** | 2440.936 | -2.6 | **12.4** | 2445.436 | -3.1 | **11.9** | 2482.536 | 17.0 | **32.0** |
| 2438.636 | -2.2 | **12.8** | 2440.986 | -2.6 | **12.4** | 2445.536 | -3.1 | **11.9** | 2483.536 | 17.7 | **32.7** |
| 2438.686 | -2.5 | **12.5** | 2441.036 | -2.6 | **12.4** | 2445.636 | -3.1 | **11.9** | | | |
| 2438.736 | -2.2 | **12.8** | 2441.086 | -2.6 | **12.4** | 2445.736 | -2.3 | **12.7** | | | |