Hummingbird 900MHz System Processing Gain

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1. Scope

This document details the results of measurement of the processing gain of a DCT FFF phone with reference to the Code of Federal Regulations, Title 47, Chapter 1, Part 15 Radio Frequency Devices, FCC. The purpose of this document is to provide conceptual background of processing gain and method of measurement.

Table 1: Abbreviations

FCC	Federal Communications Commission
SNR	Signal to Noise Ratio
JSR	Jammer to Signal Ratio
CW	Continuous wave (jammer)
HS	Handset
BS	Basestation
DBPSK	Differential Binary Phase Shift Keying

2. An Overview of the Processing Gain

Processing Gain Calculation

Theoretical processing gain limit for the 12bit Spreading BPSK system is 10.8dB.

Processing Gain = 10 Log (Spreaded data rate / Unspreaded data rate)
= 10 Log [(12 Chip/bit * 100Kbit/sec) / 100 Kbit/sec)]
= 10 Log [12]
= 10.8 dB

Processing Gain Measurement Method

Following method is specified by the FCC to measure processing gain. The detailed are in FCC documents 15.247 (e)(1). This involves transmitting a CW jammer in the RF passband of the system and measuring the jammer to signal ratio (JSR) required to achieve a certain bit error rate. The choice of the actual value of the bit error rate is left up to the tester. The jammer is stepped in 50 kHz increments across the entire passband and in each case the JSR to achieve the desired bit error rate is measured. The JSR is measured at the RF input to the system under test. The lowest 20% of the JSR data (in dB) are discarded. The processing gain can then be calculated as follows:

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

where G_p is the processing gain, the SNR is that theoretically predicted for the system under the test to achieve the desired bit error rate, the JSR is the lowest value (in dB) in the remaining data set and L_{sys} adjusts for non-ideal system losses. L_{sys} can not be greater than 2 dB.

3. Processing Gain Measurement Test Setup

The test set up is shown in Fig.1. The base station and handset are configured to measure the Bit Error Rate (BER) through serial ports of a personal computer. Conexant’s software utility program (FCC_3V3.exe) is used to configure the test modes, establish the link between the base and handset unit and monitor the results. The BER test results are displayed on the monitor. The strength of the received signal entering at the receiving antenna port of the unit under test is derived from the signal strength of the transmitting unit.

General Procedure

Step-1: Measure the output power of the base and handset units in LOW power mode. Determine attenuation and signal losses in the path to calculate the received signal strength arriving at the base station antenna port.
Step-2: Connect the serial interface of the base and handset to the serial ports of a PC.
Step-3: Connect the base and handset through attenuator, signal combiner etc components using 50 ohm SMA connectors and cables as shown in Figure 1. Thus, the BER test set up establishes link through wired connection.
Step-4: Using utility test software, select the channel frequency (904.2MHz), LOW power mode, LNA attenuation for base and handset units.
Step-5: Click on “Start S7 HS Master” button ON. The two link is established and the BER results are displayed on monitor.
Step-6: Feed jamming signal from the signal generator.
Step-7: Increase the amplitude of the jamming while monitoring BER such that the BER is ≤ 10E-3. This signal power is recorded for computing received Jammer power level J.
Step-8: Increment the Jammer signal frequency in steps of 20kHz and repeat step 7 and determine the minimum Jammer signal power to achieve BER of ≤ 10E-3. Calculate the processing gain.

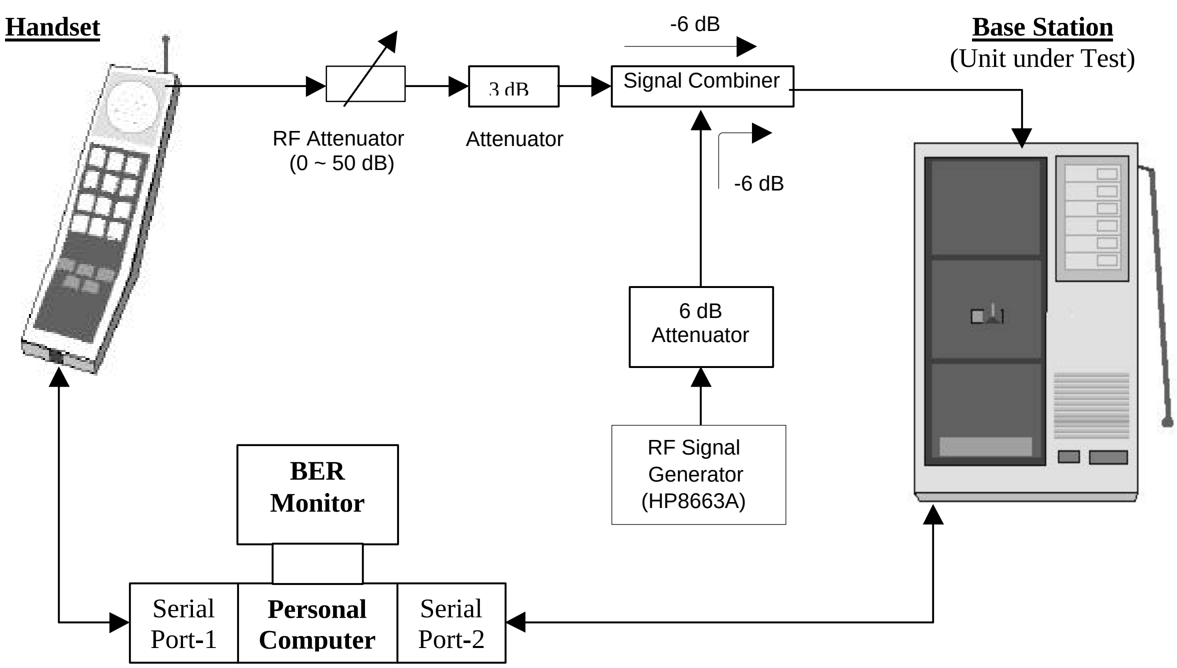

Figure –1: Bit Error Rate (BER) Test Setup

The following parameters were used in the test setup.

Table 2: Test Setup Parameters

HS Tx power (dBm)	-1.9	measured @ 50-ohm SMA-antenna port
BS LNA gain (dB)	0	
Test system losses (signal) (dB)	-61.75	-50dB (channel attenuation) -5.75 dB (attenuator & cables), -6 dB (signal combiner),
Received signal strength (dBm) at combiner output	-63.65	measured @ combiner output
Test system losses (jammer) (dB) upto the combiner output	-12.85	–6dB (attenuator), -6 dB (signal combiner), -0.85 dB (cable)

4. Results & Calculation

The following measurement results were taken at the basestation. The desired bit error rate was set at 10^{-3}.

Table 3: Test Results

Jammer Frequency (MHz)	BER (BS)	Received jammer power (dBm)	Received signal power (dBm)	Jammer/Signal ratio (dB)
913.80	9.4×10^{-4}	-59.55	-63.65	4.1
913.85	9.6×10^{-4}	-57.95	-63.65	5.7
913.90	9.6×10^{-4}	-60.15	-63.65	3.5
913.95	9.6×10^{-4}	-64.25	-63.65	-0.6
914.00	1.1×10^{-3}	-61.55	-63.65	2.1
914.05	9.8×10^{-4}	-61.55	-63.65	2.1
914.10	1.1×10^{-3}	-61.95	-63.65	1.7
914.15	9.2×10^{-4}	-62.85	-63.65	0.8
914.20	1.0×10^{-3}	-59.85	-63.65	3.8
914.25	1.0×10^{-3}	-61.15	-63.65	2.5
914.30	1.1×10^{-3}	-62.05	-63.65	1.6
914.35	1.0×10^{-3}	-57.65	-63.65	6.0
914.40	1.1×10^{-3}	-55.65	-63.65	8.0
914.45	1.0×10^{-3}	-49.35	-63.65	14.3
914.50	1.1×10^{-3}	-59.25	-63.65	4.4
914.55	1.0×10^{-3}	-62.35	-63.65	1.3
914.60	9.7×10^{-4}	-59.05	-63.65	4.6
914.65	1.0×10^{-3}	-61.05	-63.65	2.6
914.70	1.1×10^{-3}	-62.55	-63.65	1.1
914.75	9.0×10^{-4}	-61.95	-63.65	1.7
914.80	1.0×10^{-3}	-61.05	-63.65	2.6
914.85	9.9×10^{-4}	-62.35	-63.65	1.3
914.90	1.1×10^{-3}	-64.05	-63.65	-0.4
914.95	9.2×10^{-4}	-56.25	-63.65	7.4
915.00	1.0×10^{-3}	-59.85	-63.65	3.8
915.05	1.1×10^{-3}	-57.25	-63.65	6.4
915.10	9.9×10^{-4}	-58.15	-63.65	5.5

For DBPSK at 10^{-3} bit error rate the required SNR is 8.0 dB. Using the results above and the data in the table below the processing gain is calculated to be 11.3 dB.

Table 4: Processing Gain Calculation data

required SNR (dB)	8.0
system losses (dB)	2.0
J/S ratio at 80% point (dB)	1.30
FCC Processing gain (dB)	**11.3**

Conclusions

The result measured for processing gain of 11.3 dB is close to the actual processing gain due to a 12 chip spreading code of $10 \times \log_{10} (12) = 10.8$ dB