PROCESSING GAIN MEASUREMENT (Fc = 2422 MHz)

1.1 Measurement Setup

Figure 1 shows the setup for measuring the processing gain of AirEzy-2460 when its central carrier frequency is set at 2422 MHz. A Transmitting Computer A and a Receiving Computer B are used to execute a Bit Error Rate (BER) Testing Computer Program. The BER is determined by repetitively transmitting a testing data file from Computer A to Computer B. At Computer B the received data file is compared with a pre-stored version of the testing data file to compute the bit error rate. An HP 8648C Signal Generator is used to generate interference or jamming signal.

Data signal from the Transmitting Computer is sent to the Transmitting AirEzy-2460 unit for modulation. It is then combined with the interference signal from the Signal Generator through a equal power (3 dB) combiner. The combined signal is fed into a Receiving AirEzy-2460, the Device Under Test (DUT), for demodulation, and the demodulated signal is sent into the Receiving Computer for Bit Error Rate computation.

1.2 Measurement Procedure

The data signal level at the input of the Receiving AirEzy-2460, point P in Figure 1, is determined. With Attenuator A set at 53 dB attenuation, the data signal level at point P is measured to be -38.5 dBm.

Then the Signal Generator is set at a certain CW frequency between 2400 MHz and 2484 MHz. The interference level at the input of the Receiving AirEzy-2460, the DUT, can be varied by adjusting the output level of the Signal Generator.

The measurement of processing gain is carried out by adjusting the output level of the Signal Generator such that the Bit Error Rate is maintained at no higher than 10^{-5}. The interference level at the input of the DUT, the point P, is then measured. In the AirEzy-2460 receiving chain a Surface Acoustic Wave (SAW) IF filter which has a nominal 3-dB bandwidth of $\pm$7.5 MHz centered at 280 MHz (see Fig. 2) is used. Jamming signals outside the 2422$\pm$7.5 MHz frequency band will be heavily attenuated. The measurement is performed from 2414.3 MHz to 2429.75 MHz at 50 KHz interval. The measured interference power level and the signal to interference noise ratio SNRS at point P with BER $\leq 10^{-5}$ at each frequency are shown in the following:

FREQ MHz	POWER LVL(dBm)	SNRS(dB)	FREQ. MHz	POWER LVL(dBm)	SNRS(dB)
2414.3	-34.5	-4	2422.5	-39.4	0.9
2414.35	-34.6	-3.9	2422.55	-39.5	1
2414.4	-34.5	-4	2422.6	-39.4	0.9
2414.45	-34.7	-3.8	2422.65	-39.5	1
2414.5	-34.6	-3.9	2422.7	-39.4	0.9
2414.55	-34.5	-4	2422.75	-39.3	0.8
2414.6	-34.6	-3.9	2422.8	-39.2	0.7
2414.65	-34.4	-4.1	2422.85	-39.3	0.8
2414.7	-34.5	-4	2422.9	-39.3	0.8
2414.75	-34.6	-3.9	2422.95	-39	0.5
2414.8	-34.7	-3.8	2423	-38.8	0.3
2414.85	-34.8	-3.7	2423.05	-38.8	0.3
2414.9	-34.3	-4.2	2423.1	-38.7	0.2
2414.95	-34.1	-4.4	2423.15	-38.7	0.2
2415	-34.3	-4.2	2423.2	-38.3	-0.2
2415.05	-34.2	-4.3	2423.25	-38	-0.5
2415.1	-34.2	-4.3	2423.3	-37.7	-0.8
2415.15	-34.3	-4.2	2423.35	-37.6	-0.9
2415.2	-34.2	-4.3	2423.4	-38	-0.5
2415.25	-34.4	-4.1	2423.45	-38	-0.5
2415.3	-34.6	-3.9	2423.5	-38.2	-0.3
2415.35	-34.7	-3.8	2423.55	-38.6	0.1
2415.4	-35.1	-3.4	2423.6	-38.7	0.2
2415.45	-35.4	-3.1	2423.65	-39.4	0.9
2415.5	-35.6	-2.9	2423.7	-39.3	0.8
2415.55	-36.3	-2.2	2423.75	-39.7	1.2
2415.6	-36.4	-2.1	2423.8	-39.9	1.4
2415.65	-36.4	-2.1	2423.85	-39.8	1.3
2415.7	-36.5	-2	2423.9	-40	1.5
2415.75	-36.6	-1.9	2423.95	-40.2	1.7
2415.8	-36.7	-1.8	2424	-40.2	1.7
2415.85	-36.8	-1.7	2424.05	-40.3	1.8
2415.9	-36.6	-1.9	2424.1	-40	1.5
2415.95	-36.5	-2	2424.15	-40.2	1.7
2416	-36.3	-2.2	2424.2	-40.1	1.6
2416.05	-36.2	-2.3	2424.25	-40.1	1.6
2416.1	-35.9	-2.6	2424.3	-39.8	1.3
2416.15	-35.6	-2.9	2424.35	-39.8	1.3
2416.2	-35.5	-3	2424.4	-39.7	1.2
2416.25	-35.7	-2.8	2424.45	-39.6	1.1

2416.3	-36	-2.5	2424.5	-39.4	***0.9***
2416.35	-36.2	***-2.3***	2424.55	-39.2	***0.7***
2416.4	-36.2	***-2.3***	2424.6	-39.1	***0.6***
2416.45	-36.1	***-2.4***	2424.65	-39	***0.5***
2416.5	-36.2	***-2.3***	2424.7	-38.8	***0.3***
2416.55	-36.2	***-2.3***	2424.75	-38.6	***0.1***
2416.6	-36.3	***-2.2***	2424.8	-38.7	***0.2***
2416.65	-36.2	***-2.3***	2424.85	-38.5	***0***
2416.7	-36.3	***-2.2***	2424.9	-38.5	***0***
2416.75	-36.6	***-1.9***	2424.95	-38.3	***-0.2***
2416.8	-36.8	***-1.7***	2425	-38.2	***-0.3***
2416.85	-37	***-1.5***	2425.05	-38.1	***-0.4***
2416.9	-37.1	***-1.4***	2425.1	-37.9	***-0.6***
2416.95	-37.3	***-1.2***	2425.15	-37.8	***-0.7***
2417	-37.3	***-1.2***	2425.2	-37.7	***-0.8***
2417.05	-37.2	***-1.3***	2425.25	-37.7	***-0.8***
2417.1	-37.3	***-1.2***	2425.3	-37.5	***-1***
2417.15	-37.4	***-1.1***	2425.35	-37.6	***-0.9***
2417.2	-37.6	***-0.9***	2425.4	-37.7	***-0.8***
2417.25	-37.6	***-0.9***	2425.45	-37.9	***-0.6***
2417.3	-37.5	***-1***	2425.5	-37.9	***-0.6***
2417.35	-37.6	***-0.9***	2425.55	-38.1	***-0.4***
2417.4	-37.5	***-1***	2425.6	-38.1	***-0.4***
2417.45	-37.3	***-1.2***	2425.65	-38.2	***-0.3***
2417.5	-37.4	***-1.1***	2425.7	-38.3	***-0.2***
2417.55	-37.4	***-1.1***	2425.75	-38.4	***-0.1***
2417.6	-37.5	***-1***	2425.8	-38.5	***0***
2417.65	-37.6	***-0.9***	2425.85	-38.1	***-0.4***
2417.7	-37.7	***-0.8***	2425.9	-38.2	***-0.3***
2417.75	-37.6	***-0.9***	2425.95	-38.4	***-0.1***
2417.8	-38	***-0.5***	2426	-38.5	***0***
2417.85	-38.2	***-0.3***	2426.05	-38.6	***0.1***
2417.9	-38.5	***0***	2426.1	-38.5	***0***
2417.95	-38.7	***0.2***	2426.15	-38.2	***-0.3***
2418	-38.6	***0.1***	2426.2	-38	***-0.5***
2418.05	-38.6	***0.1***	2426.25	-37.7	***-0.8***
2418.1	-38.4	***-0.1***	2426.3	-37.8	***-0.7***
2418.15	-38.2	***-0.3***	2426.35	-37.6	***-0.9***
2418.2	-38.3	***-0.2***	2426.4	-37.7	***-0.8***
2418.25	-38.4	***-0.1***	2426.45	-37.6	***-0.9***
2418.3	-38.5	***0***	2426.5	-37.7	***-0.8***
2418.35	-38.4	***-0.1***	2426.55	-37.4	***-1.1***
2418.4	-38.1	***-0.4***	2426.6	-37.5	***-1***
2418.45	-38.2	***-0.3***	2426.65	-37.6	***-0.9***
2418.5	-38	***-0.5***	2426.7	-37.6	***-0.9***
2418.55	-37.7	***-0.8***	2426.75	-37.5	***-1***
2418.6	-37.6	***-0.9***	2426.8	-37.6	***-0.9***
2418.65	-37.6	***-0.9***	2426.85	-37.5	***-1***
2418.7	-37.5	***-1***	2426.9	-37.5	***-1***

2418.75	-37.6	*-0.9*	2426.95	-37.2	*-1.3*
2418.8	-37.7	*-0.8*	2427	-37.3	*-1.2*
2418.85	-37.9	*-0.6*	2427.05	-37.2	*-1.3*
2418.9	-38.1	*-0.4*	2427.1	-37.4	*-1.1*
2418.95	-38	*-0.5*	2427.15	-37.4	*-1.1*
2419	-38.2	*-0.3*	2427.2	-37.2	*-1.3*
2419.05	-38.2	*-0.3*	2427.25	-36.8	*-1.7*
2419.1	-38.4	*-0.1*	2427.3	-36.3	*-2.2*
2419.15	-38.5	*0*	2427.35	-36.1	-2.4
2419.2	-38.5	*0*	2427.4	-36.2	*-2.3*
2419.25	-38.7	*0.2*	2427.45	-36.3	*-2.2*
2419.3	-38.8	*0.3*	2427.5	-36.2	*-2.3*
2419.35	-39	*0.5*	2427.55	-36.2	*-2.3*
2419.4	-39.1	*0.6*	2427.6	-36.3	*-2.2*
2419.45	-39.2	*0.7*	2427.65	-36.2	*-2.3*
2419.5	-39.2	*0.7*	2427.7	-36	-2.5
2419.55	-39.5	*1*	2427.75	-35.9	-2.6
2419.6	-39.4	*0.9*	2427.8	-35.6	-2.9
2419.65	-39.7	*1.2*	2427.85	-35.4	-3.1
2419.7	-39.8	*1.3*	2427.9	-35.7	-2.8
2419.75	-39.9	*1.4*	2427.95	-36	-2.5
2419.8	-40.2	*1.7*	2428	-36.2	*-2.3*
2419.85	-40	*1.5*	2428.05	-36	-2.5
2419.9	-40.1	*1.6*	2428.1	-36.2	*-2.3*
2419.95	-40	*1.5*	2428.15	-36.4	*-2.1*
2420	-40.2	*1.7*	2428.2	-36.6	*-1.9*
2420.05	-40.1	*1.6*	2428.25	-36.7	*-1.8*
2420.1	-40	*1.5*	2428.3	-36.8	*-1.7*
2420.15	-39.9	*1.4*	2428.35	-36.6	*-1.9*
2420.2	-39.8	*1.3*	2428.4	-36.6	*-1.9*
2420.25	-39.8	*1.3*	2428.45	-36.5	*-2*
2420.3	-39.4	*0.9*	2428.5	-36.3	*-2.2*
2420.35	-39.3	*0.8*	2428.55	-36.4	*-2.1*
2420.4	-38.9	*0.4*	2428.6	-35.8	-2.7
2420.45	-38.6	*0.1*	2428.65	-35.5	-3
2420.5	-38.2	*-0.3*	2428.7	-35.1	-3.4
2420.55	-38.1	*-0.4*	2428.75	-34.9	-3.6
2420.6	-37.9	*-0.6*	2428.8	-34.8	-3.7
2420.65	-37.7	*-0.8*	2428.85	-34.5	-4
2420.7	-37.6	*-0.9*	2428.9	-34.2	-4.3
2420.75	-38	*-0.5*	2428.95	-34.2	-4.3
2420.8	-38.3	*-0.2*	2429	-34.3	-4.2
2420.85	-38.5	*0*	2429.05	-34.4	-4.1
2420.9	-38.6	*0.1*	2429.1	-34.8	-3.7
2420.95	-38.8	*0.3*	2429.15	-34.7	-3.8
2421	-39	*0.5*	2429.2	-34.6	-3.9
2421.05	-39.1	*0.6*	2429.25	-34.4	-4.1
2421.1	-39.3	*0.8*	2429.3	-34.5	-4
2421.15	-39.2	*0.7*	2429.35	-34.4	-4.1

2421.2	-39.4	*0.9*	2429.4	-34.6	-3.9
2421.25	-39.3	*0.8*	2429.45	-34.5	-4
2421.3	-39.4	*0.9*	2429.5	-34.7	-3.8
2421.35	-39.2	*0.7*	2429.55	-34.8	-3.7
2421.4	-39.4	*0.9*	2429.6	-34.8	-3.7
2421.45	-39.4	*0.9*	2429.65	-34.7	-3.8
2421.5	-39.3	*0.8*	2429.7	-34.5	-4
2421.55	-39.2	*0.7*	2429.75	-34.6	-3.9
2421.6	-39.1	*0.6*			
2421.65	-39	*0.5*			
2421.7	-38.9	*0.4*			
2421.75	-38.6	*0.1*			
2421.8	-39.5	*1*			
2421.85	-39.6	*1.1*			
2421.9	-39.7	*1.2*			
2421.95	-39.9	*1.4*			
2422	-39.6	*1.1*			
2422.05	-39.8	*1.3*			
2422.1	-40	*1.5*			
2422.15	-39.8	*1.3*			
2422.2	-39.8	*1.3*			
2422.25	-39.8	*1.3*			
2422.3	-39.7	*1.2*			
2422.35	-39.7	*1.2*			
2422.4	-39.5	*1*			
2422.45	-39.5	*1*			

1.3 Determination of Processing Gain

Let the required theoretical signal to noise ratio for achieving a certain BER, say 10^{-5}, in a non-spread-spectrum receiver be SNRN and that for achieving the same BER in a spread-spectrum receiver be SNRS, the processing gain G_p achieved by this spread-spectrum receiver can be computed using the following formula:

G_p = SNRN + L_s -SNRS (in dB),

where L_s is the system loss due to the difference between a practical system and the ideal system such as the non-ideal filter characteristic.

It is known that the theoretical signal to noise ratio required to achieve a 10^{-5} BER for a non-coherent Differential QPSK receiver such as the AirEzy-2460 is 10.3

dB[1]. The system loss L_s for AirEzy-2460 is estimated to be approximately 0.5 dB.

The signal to noise ratio required by AirEzy-2460 to achieved a BER $\leq 10^{-5}$ can be computed by the measured data listed in the preceding section. The data signal level at the input of the DUT is -38.5 dBm. There are total 310 measured data points. After the worst 20% of the data points (62 points) being discarded, the average signal to interference noise ratio for maintaining a BER of 10^{-5} is -0.25 dBm. The 248 data points used for the averaged SNRS computation are in bold italic print.

The Processing Gain is therefore

G_p = 10.3 +0.5 -(-0.25)= 11.05 dB

Reference

[1] Bernard Skalar, Digital Communications Fundamentals and Applications, pp. 166-167, Prentice Hall, 1988

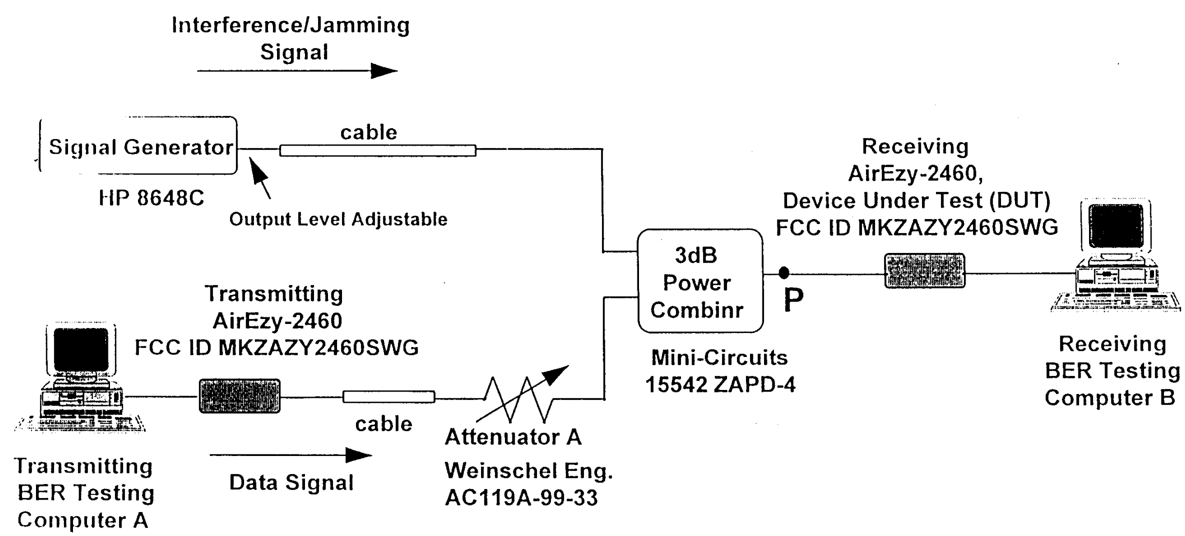

Figure 1. Processing Gain Measurement Setup for AirEzy-2460.