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Processing Gain Document for BGB100+BlueBerry GPV2b

Preliminary Version 0.2

1. Introduction

This document presents the measured results on processing gain for the Philips Bluetooth radio BGB100 in combination with the Philips baseband processor BlueBerry GPV2b. The processing gain is measured according to FCC's CW jamming margin method as proposed by FCC for the US market, Part 15.247.

According to FCC part 15.247 the measurement procedure should be as follows:
" As measured using the CW jamming margin method: a signal generator is stepped in 50 kHz increments across the passband of the system, recording at each point the generator level required to produce the recommended Bit Error Rate (BER). This level is the jammer level. The output power of the intentional radiator is measured at the same point. The jammer to signal ratio (J/S) is then calculated, discarding the worst 20% of the J/S data points. The lowest remaining J/S ratio is used to calculate the processing gain, as follows:

$$G_p = S/N + M_j + L_{sys}, \qquad (1.1)$$

where G_p is the processing gain of the system, S/N is the signal to noise ratio required for the chosen BER, M_j is the jammer-to-signal ratio and L_{sys} are the system losses. Note that total losses in a system, including intentional radiator and receiver, should be assumed to be no more than 2dB."

The de-spreading in Bluetooth is obtained by correlation of the received bit stream with the bit pattern of the access code. Therefore, in Bluetooth the "Bit Error Rate" corresponds to a false rejection (or false acception) of the access code. Neglecting false acception, we can use the recorded Frame-Error-Rate (FER), due to errors in the access code, as a measure to find the processing gain of the system. Bluetooth is considered to be a hybrid system (combination of direct sequence (DS) and frequency hopping (FH)) in page and inquiry mode. For such systems FCC requires a minimum processing gain of 17 dB. During inquiry and paging 32 channels are used. Therefore, the processing gain from frequency hopping is $10\log_{10}$(32MHz/1MHz) = 15 dB (approx). The remaining 17-15 =2 dB should be obtained by the DS operation of the access code during paging and inquiry. In this document it will be shown that the measured processing gain from the DS operation (with FH off) is higher than 2 dB.

2. Test set-up and procedure

2.1 Test set-up

Figure 2.1 shows the test set-up that was used. The Frame-Error-Rate (FER) due to errors in the access code is measured with the Agilent Bluetooth test set E1852A, based on information provided by the BlueBerry baseband processor. The FER was measured at a single frequency f_c, arbitrary chosen from the inquiry/paging hopping sequence (f_c=2.432 GHz). The nominal signal level of the Bluetooth signal at the input of the DUT is set to –60 dBm. During the tests, the required power level of the jammer or noise source for a 0.1% FER is recorded.

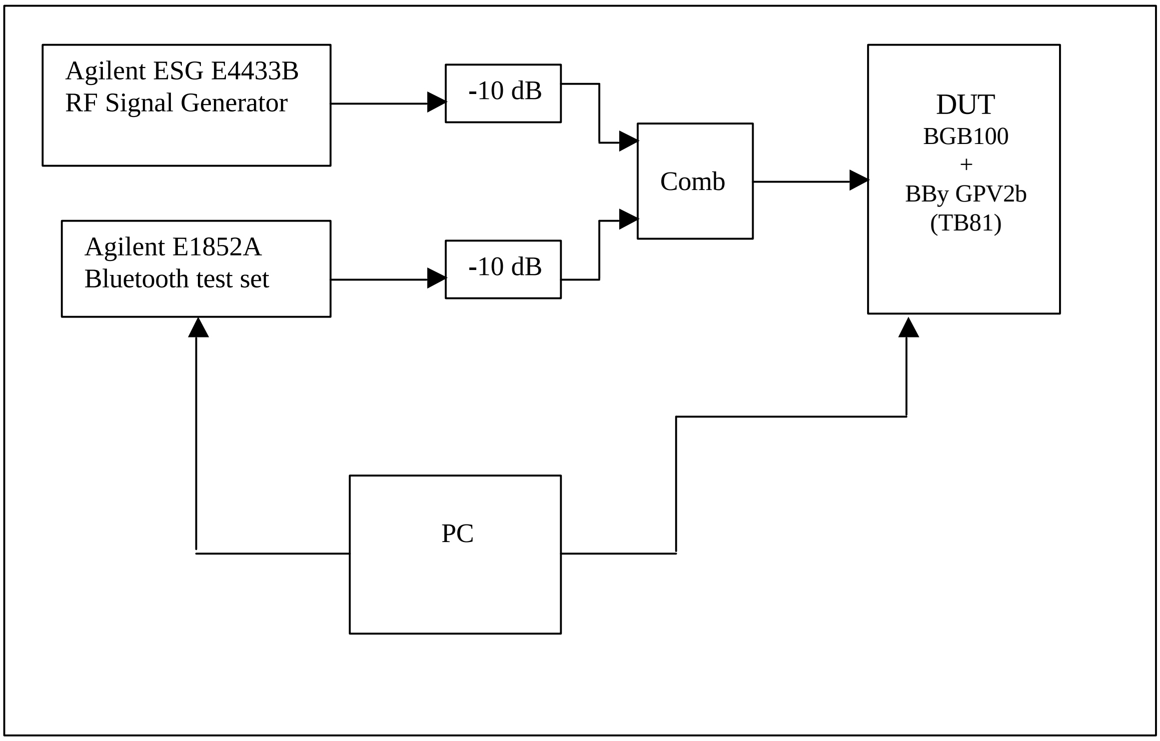

Figure 2.1: Test set-up for testing processing gain at single frequency

The Device Under Test consists of a BGB100 module (version 2) mounted on a demoboard (version 2) and a TB81 development board with the BlueBerry GP (Version 2b) baseband processor.

2.2 Test procedure

The test procedure is as follows:

1) A Bluetooth link is set-up between the Agilent Bluetooth test set (E1852A, LAP=BDBDBDBD) and the DUT at a single frequency f_c =2.432 GHz (which is one of the frequency channels used during the inquiry/paging hopping sequence). 800 access codes are send per second (poll period is set to 1, DH1 packets).
2) CW jammer signal is generated by the ESG RF signal generator and set to f_0-500 kHz.
3) The E1852A sends packets at signal level S_0.
4) The Frame Error Rate (FER) is counted by the E1825A based on the information on incorrect received frames by the BlueBerry baseband. The measured FER represents the number of incorrectly received access codes.
5) The jammer level J is increased to a level where the FER=0.1%, based on a measurement time of at least 60 seconds (60*800=48000 received access codes). This jammer level J is then recorded.
6) 3) up to 6) are repeated for jammer frequencies [f_0-450kHz,f_0+500kHz] with stepsize of 50 kHz.

3. Measurement results

3.1 Signal to Noise Ratio (S/N)

The required minimum Signal-to-Noise ratio (S/N) was measured that resulted in a FER=0.1%. This was done by adding noise to the wanted signal. The recorded S/N value is 17.5 dB.

3.2 Jammer to Signal Ratio (J/S)

Figure 3.1 shows the measured Jammer-to-Signal (J/S) level for a FER of 0.1% as measured with the test set-up as shown in figure 2.1.

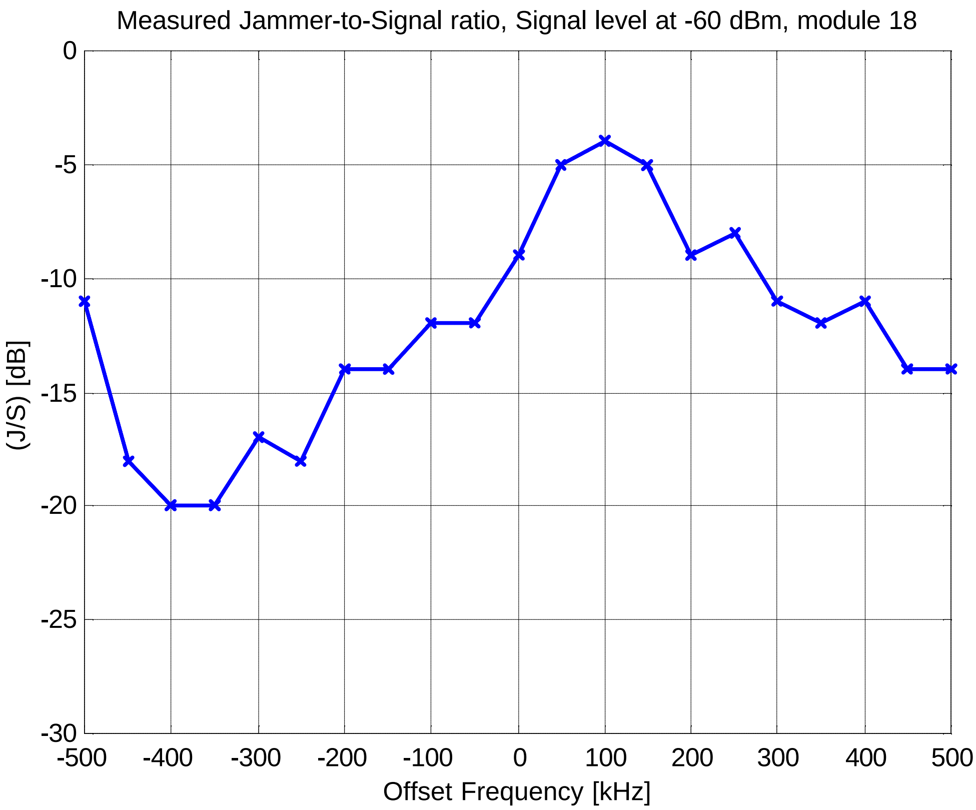

Figure 3.1: Measured Jammer-to-Signal for FER=0.1%.

Discarding the worst 20% of the data points in figure 3.1 (-450,-400,-350,-250) kHz, we find that the lowest J/S ratio is –17 dB.

3.3 Calculation of processing gain

With the data from section 3.1 and section 3.2 we find the following value for processing gain:

$$G_p^{ds} = S/N + J/S + L_{sys} = 17.5 - 17 + 2 = 2.5 dB \qquad (3.1)$$

So combined with frequency hopping the total processing gain during paging/inquiry mode is G_p=15+2.5=17.5 dB.

4. Conclusion

The device under test passes the requirements on processing gain for hybrid system as stated by FCC part 15.247.