TEST REPORT

Subject: Processing Gain For MF24 Wireless Transceiver

Ref.: FCC Rules 47 CFR Part 15, Section 5.247d

Report Prepared by:

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Change History:

Date	Section	Description
2001/08/01, Rev. A		Initial release.

1. Summary:

This document describes the Receiver Processing Gain verification measurements performed on the MF24 according to Ref.[1].

2. Conclusion:

The ComLink Group MF24 family of products conforms to the minimum required 10 dB processing gain, as set forth by the FCC for operation in the 2.4 GHz ISM band.

3. References:

1. Document FCC 97-114, Appendix C, Guidance on Measurements for Direct Sequence Spread Spectrum Systems.
2. Feher, Kamilo, "Wireless Digital Communications, Modulation & Spread-Spectrum Applications", Upper Saddle River, Prentice Hall PTR, 1995, page 211.

4. Measurement description:

4.1 Test introduction - FCC requirements:

Part of FCC certification for the ComLink Group MF24 wireless transceiver is a processing gain test. This test proves that the receiver of the tested product employs a true spread spectrum device receiver structure, taking full advantage of the direct sequence spread spectrum modulation technique.

This test verifies the receiver processing gain to be 10 dB or more for data rates of 192 and 384 kbps by monitoring the Bit Error Rate (BER) of the product under test for each data rate, while operating under defined received signal conditions.

Several methods of showing compliance to the rules are possible, from a stepped CW jammer to a continuous sweeping CW interferer. For this test the discrete stepped CW jammer method was chosen, as described in Ref.[1].

Therefore a receiver input signal is applied to the product under test, in the presence of a Continuous Wave (CW) interference source, also referred to as CW jammer.

The product's specified max BER is 10^{-5} (10^{-3} packet error rate with 100 bit packets) at the minimum acceptable receive signal level. To eliminate the effects of thermal noise and provide results representative of true CW jammer resistance, the tests are performed at an arbitrarily chosen level of –58 dBm.

The test criteria for meeting the minimal processing gain is such that it takes the theoretical calculated SNR for the applied modulation technique and specified product BER as a reference. The theoretical SNR is subtracted from the minimum required processing gain, yielding the minimum CW Jammer to Signal ratio J/S which the unit under test must withstand. From Ref. [2], it is determined that for a BER of 10^{-5} the SNR S/N_o equals:

10.2 dB @ 192 kbit/s

14.9 dB @ 384 kbit/s

Thus the J/S ratio for a processing gain of 10 dB that must be met is calculated as:

(10 - 10.2) = -0.2 dB @ 192 kbit/s (DBPSK)

(10 - 14.9) = -4.9 dB @ 384 kbit/s (DQPSK)

Two types of measurement corrections are allowed for, as described in Ref.[1]. The first taking into account 2 dB implementation losses, thus increasing the absolute J/S ratio by 2 dB. This sets the J/S ratio FAIL limit as follows:

(-0.2 – 2) = -2.2 dB @ 192 kbit/s (DBPSK)

(-4.9 – 2) = -6.9 dB @ 384 kbit/s (DQPSK)

The second correction allows for deleting the 20% worst-case frequencies in the processing gain test that causes the test at that CW interference to fail. This implies that for the considered 5 MHz wide measurement interval the worst case 21 CW jammer frequencies can be ignored (20% of 5 MHz * (1 MHz/50 KHz) + 1 = (20% * 100) + 1 = 21). These CW jammer frequencies are those that result in a BER > 10^{-5}.

4.2 Test procedure:
The measurements are performed at a 50 KHz CW jammer raster. For each CW jammer frequency a minimum of $10^{\wedge 6}$ bits are transmitted by the reference transmitter, and received by the product under test. For practical reasons 10000 packets are transmitted, each packet containing 100 bits. This results in 10000 * 100 = 1000000 transmitted bits, which is 10 times the minimum number of bits required to establish a 10^{-5} BER. The packet error rate (PER) is measured and converted to bit error rate (BER) by dividing it by the number of bits per packet (100). Therefore, under the selected conditions, a 10^{-3} PER translates to a 10^{-5} BER. Though it would be more elegant to measure BER directly, the fact that the MF24 product is a packet radio transceiver makes a direct BER measurement impractical. Furthermore, the PER measurement better reflects the impact of the CW jammer in a real-world application. Given the fact that a minimum of ten times the number of bits required for a 10^{-5} BER are used in the measurement, and given the fact that the CW interferer is stepped in a 50 KHz raster, covering the receiver bandwidth of 5 MHz, it is considered that the BER requirement is met with sufficient accuracy.

The measurements are performed by a qualified technician. They involve the control of the reference transmitter, CW-interference generator, receiver under test and MultiSite Network Management Software (hereinafter “MNM Software”).

The MNM Software, running on a PC, is used to configure the MF24 reference transmitter and MF24 receiver under test via an EIA232 serial connection. It also has a built-in received data error-checker/packet-counter function intended specifically for RF link diagnostic by PER testing (hereinafter “MNM Diagnostic function”). The MNM diagnostic function monitors data/packet error counters in the selected MF24 unit and displays a running count of transmitted diagnostic packets as well as the current calculated packet error rate (PER). The diagnostic window also has a “RESET” button which is used to clear the MF24 receiver’s internal data/packet error counters to start a new measurement sequence. See illustration below:

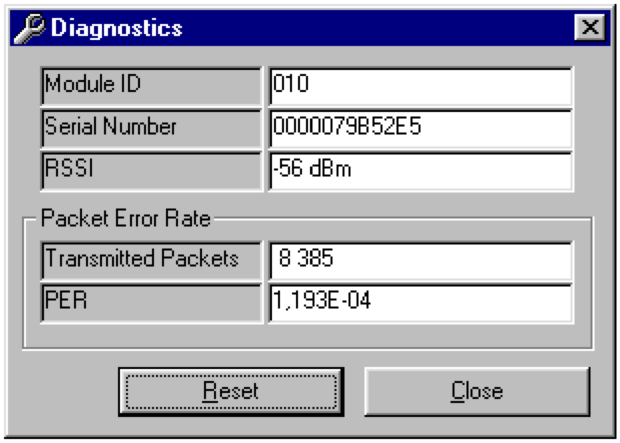

Figure 1 MNM Diagnostic function dialog

The diagnostic packets are continuously transmitted by the reference transmitter. They contain a sequence number, a data pattern known by the receiver and a CRC16 check sequence. Therefore the receiver can check for missing packets and data errors and update its internal counters accordingly. Received data errors and missing received packet counter information is retrieved by the MNM Software from the receiver under test.

The test sequence is as follows:

The test takes place at an arbitrarily chosen channel, channel seven (2442 MHz).

1. The jammer frequency is selected
2. The jammer power level is adjusted for 0 dB J/S ratio for 192 kbps (DBPSK) or for –3 dB J/S ratio for 384 kbps (DQPSK)
3. The MNM Diagnostic function is invoked at the receiver and the “RESET” button is activated to clear the data/packet error counters in the receiver
4. The packet count is monitored in the diagnostic window and the calculated PER value is recorded when the packet count shows that a minimum of 10000 packets have been transmitted by the reference transmitter
5. If the PER is greater than 10-3, the CW jammer level is reduced by 0.1dB and the test sequence is repeated from step 3. This sequence is repeated until the PER is less than 10^{-3}.

6. When the PER in step 5 is less than 10-3, the actual PER value and CW jammer level are recorded for the current CW jammer frequency.
7. The test sequence is repeated with the next CW jammer frequency until the 5MHz receiver bandwidth is covered.

5. Equipment used:

# Item needed	Description
1	PC with EIA232 serial port.
1	MultiSite Network Management (MNM) Software V1.02A, <MNM.EXE>, 251 kbytes
1	MF24 Reference Transmitter
1	MF24 Receiver under test
2	Power supply,for MF24 Receiver and reference transmitter
1	Spectrum Analyzer
1	CW jammer generator
1	Fixed attenuator, 30 dB
1	Fixed attenuator, 20 dB
2	Fixed attenuator, 6 dB
1	RF power splitter
1	Misc. RF cabling.

6. Measurement setup:

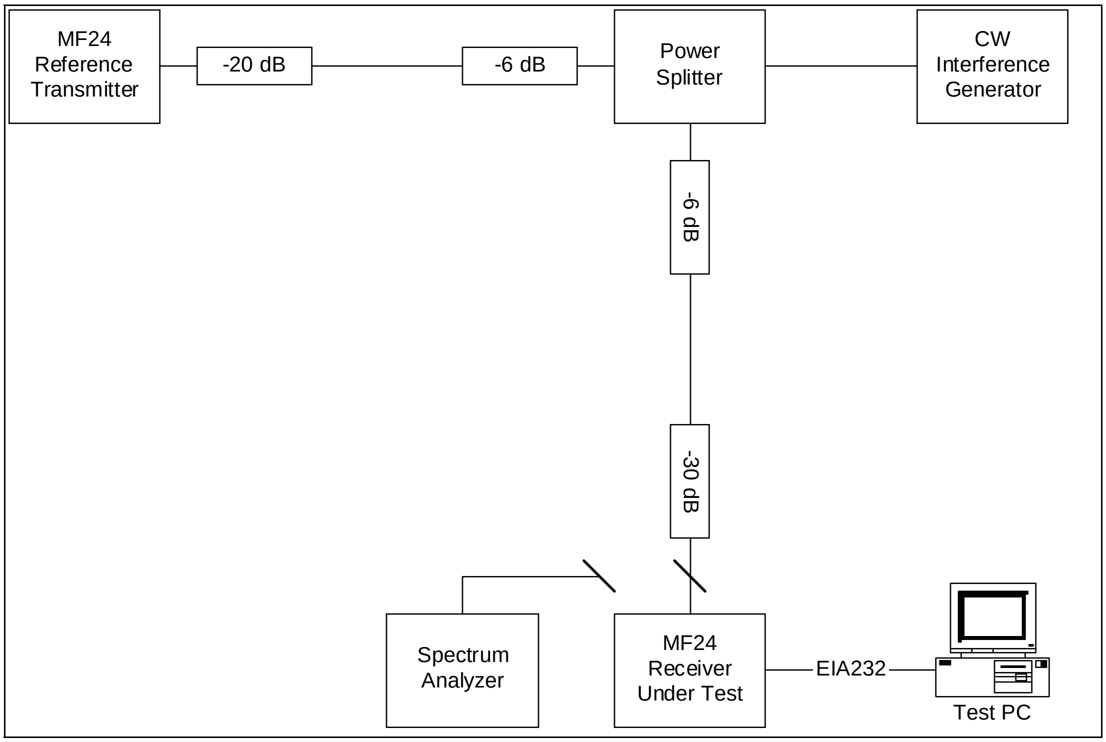

Figure 2: Processing gain measurement setup

6.1 Receiver level calibration:

The CW jammer is disabled during this calibration. Replacing the MF24 receiver under test with the spectrum analyzer, the received level at the receiver input is measured for a continuously transmitting reference transmitter.

6.2 CW level calibration:

The reference transmitter is disabled during this calibration. The CW jammer generator output level is set to 0 dBm. Replacing the MF24 receiver under test with the spectrum analyzer, the received CW jammer level at the receiver input is measured. The difference in CW output level setting and CW RF power measured at the receiver input of the device under test is the attenuation of the test set-up. This is the correction factor that needs to be applied for analysis of the measurement results.

7. Measurement results:

7.1 Calibrations:

Before measurements are started, the receiver input level and CW jammer level need to be calibrated. See Figure 2 for the test set-up.

Receiver calibration for 192 and 384 kbps: the received level at the receiver input, as measured by replacing the receiver with the spectrum analyzer, equals -58 dBm.

CW jammer generator calibration: For a 0 dBm output level at the generator the received level at the receiver input is –42 dBm. The output level at the generator is adjusted to –16 dBm for an initial 0dB J/S ratio.

7.2 Processing Gain Measurement Results:

For each CW jammer frequency between Fc ±2.5 MHz (the receiver bandwidth) a BER measurement is taken as outlined in the test sequence of para. 4.2.

For each CW measurement frequency at 192 kbps (DBPSK), the jammer level is initially set at -58 dBm at the receiver input, yielding a J/S ratio of 0 dB.

For each CW measurement frequency at 384 kbps (DQPSK), the jammer level is initially set at -61 dBm at the receiver input, yielding a J/S ratio of -3 dB.

For the 192 kbps (DBPSK) mode, several CW jammer frequencies cause the measured BER to exceed 10^{-5}. Applying a 1.8 dB margin for implementation losses, only two (2) CW jammer frequencies still cause the BER to exceed 10^{-5}. Applying the rule of discarding the 20% worst-case jamming/signal points (Ref.[1]), results in meeting the specified BER for which less than 20% of the measured CW interference frequencies were found to cause the measured BER to exceed 10^{-5}. This percentage number is 2% for 192 kbps (DBPSK).

For the 384 kbps (DQPSK) mode, no CW jammer frequencies cause the measured BER to exceed 10^{-5}. No implementation loss margin is required and no measurement points need be discarded.

7.3 Measurement Conclusion:
The tested product complies to the required Processing Gain of 10 dB for a data rate of 192 and 384 kbps as set forth in Ref.[1].