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Paul Slavens
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Dear Paul,

Please find attached the inFOREmer 2000 product images you requested (product & circuit boards – both sides) in jpeg format, as well as the results of the Jamming margin / processing gain tests.

The processing gain was measured to be 11 dB using the Carrier Peak Power measurement, and 13 dB using the Carrier Avg. Power jamming margin measurement, both exceeding the 10 dB requirement. I've included a copy of the FCC Public Notice 54797 "GUIDANCE ON MEASUREMENTS FOR DIRECT SEQUENCE SPREAD SPECTRUM SYSTEMS", used to do the measurement, as well as the test results, and the jamming margin application notes from the IC supplier (Harris Semiconductor).

PUBLIC NOTICE

Federal Communications Commission
1919 M Street NW
Washington, DC 20554

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GUIDANCE ON MEASUREMENTS FOR DIRECT SEQUENCE SPREAD SPECTRUM SYSTEMS

Part 15 of the FCC Rules provides for operation of direct sequence spread spectrum transmitters. Examples of devices that operate under these rules include radio local area networks, cordless telephones, wireless cash registers, and wireless inventory tracking systems.

The Commission frequency receives requests for guidance as to how to perform measurements to demonstrate compliance with the technical standards for such systems. No formal measurement procedure has been established for determining compliance with the technical standards. Such tests are to be performed following the general guidance in Section 15.31 of the FCC Rules using good engineering practice. The following provides information on the measurement techniques the commission has accepted in the past for equipment authorization purposes. Alternative techniques may be acceptable upon the consultation and approval by the Commission staff. The information is organized according to the pertinent FCC rule sections.

Section 15.31(m): This rule specifies the number of operating frequencies to be examined for tunable equipment.

Section 15.207: Power line conducted emissions. If the unit is AC powered, an AC power line conducted test is also required per this rule.

Section 15.247(a)(2): Bandwidth. Make the measurement with the spectrum analyzer's resolution bandwidth (RBW) = 100 kHz. In order to make an accurate measurement, set the span >> RBW.

Section 15.247(b): Power output. This is an RF conducted test. Use a direct connection between the antenna port of the transmitter and the spectrum analyzer, through suitable attenuation. Set the RBW > 6 dB bandwidth of the emission or use a peak power meter.

Section 15.247(c): Spurious emissions. The following tests are required:

1. RF antenna conducted test: Set RBW = 100 kHz, Video bandwidth (VBW) > RBW, scan up through 10th harmonic. All harmonics/spurs must be at least 20 dB down from the highest emission level within the authorized band *as measured with a 100 kHz RBW.*
2. Radiated emission test: Applies to harmonics/spurs that fall in the restricted bands listed in Section 15.205. The maximum permitted average field strength is listed in Section 15.209. A pre-amp (and possibly a high-pass filter) is necessary for this measurement. For measurements above 1 GHz, set RBW = 1 MHz, VBW = 10 Hz, Sweep: Auto. If the emission is pulsed, modify the unit for continuous operation, use the settings shown above, then correct the reading by subtracting the peak-average correction factor derived from the appropriate duty cycle calculation. See Section 15.35(b) and (c).

Section 15.247(d): Power spectral density. Locate and zoom in on emission peak(s) within the passband. Set RBW = 3 kHz, VBW > RBW, sweep = (Span / 3 kHz) e.g., for a span of 1.5 MHz, the sweep should be $1.5 \times 10^6 / 3 \times 10^3 = 500$ seconds. The peak level measured must be no greater than +8 dBm. If external attenuation is used, don't forget to add this value to the reading. Use the following guidelines for modifying the power spectral density measurement procedure when necessary.

- For devices with spectrum line spacing greater than 3 kHz no change is required.
- For devices with spectrum line spacing equal to or less than 3 kHz, the resolution bandwidth must be reduced below 3 kHz until the individual lines in the spectrum are resolved. The measurement data must then be normalized to 3 kHz by summing the power of all the individual spectral lines within a 3 kHz band (in linear power units) to determine compliance.
- If the spectrum line spacing cannot be resolved on the available spectrum analyzer, the noise density function on most modern conventional spectrum analyzers will directly measure the noise power density normalized to a 1 Hz noise power bandwidth. Add 30 dB for correction to 3 kHz.
- Should all the above fail or any controversy develop regarding accuracy of measurement the Laboratory will use the HP 89440A Vector Signal Analyzer for final measurement unless a clear showing can be made for a further alternate.

Section 15.247(e): Processing Gain. The Processing Gain may be measured using the CW jamming margin method. Figure 1 shows the test configuration. The test consists of stepping a signal generator in 50 kHz increments across the passband of the system. At each point, the generator level required to produce the recommended Bit Error Rate (BER) is recorded. This level is the jammer level. The output power of the transmitting unit is measured at the same point. The Jammer to Signal (J/S) ratio is then calculated. Discard the worst 20% of the J/S data points. The lowest remaining J/S ratio is used when calculating the Processing Gain. In a practical system, there are always implementation losses which degrade the performance below that of an optimal theoretical system of the same type. Losses occur due to non-optimal filtering, lack of equalization, LO phase noise, "corner cutting in digital processing," etc. Total losses in a system, including transmitter and receiver, should be assumed to be no more that 2 dB.
The signal to noise for and ideal non-coherent receiver is calculated from:

(1) $Pe = 1/2e^{(-1/2(S/N)o)}$ **Where:** Pe **= probability of error (BER)**
$(S/N)o$ **= the required signal to noise ratio at the receiver output for a given received signal quality**

This is an example. You should use the equation (or curve) dictated by your demodulation scheme. Ref.: Viterbi, A. J. Principles of Coherent Communications, Pg. 207 (New York: McGraw-Hill, 1966).
Using equation (1) shown above, calculate the signal to noise ratio required for your chosen BER. This value and the measured J/S ratio are used in the following equation to calculate the Processing Gain of the system.

$Gp = (S/N)o)+Mj+Lsys$ **Where:** $(S/N)o$ **= Signal to noise ratio**
Mj **= J/S ration** $Lsys$ **= System losses.**

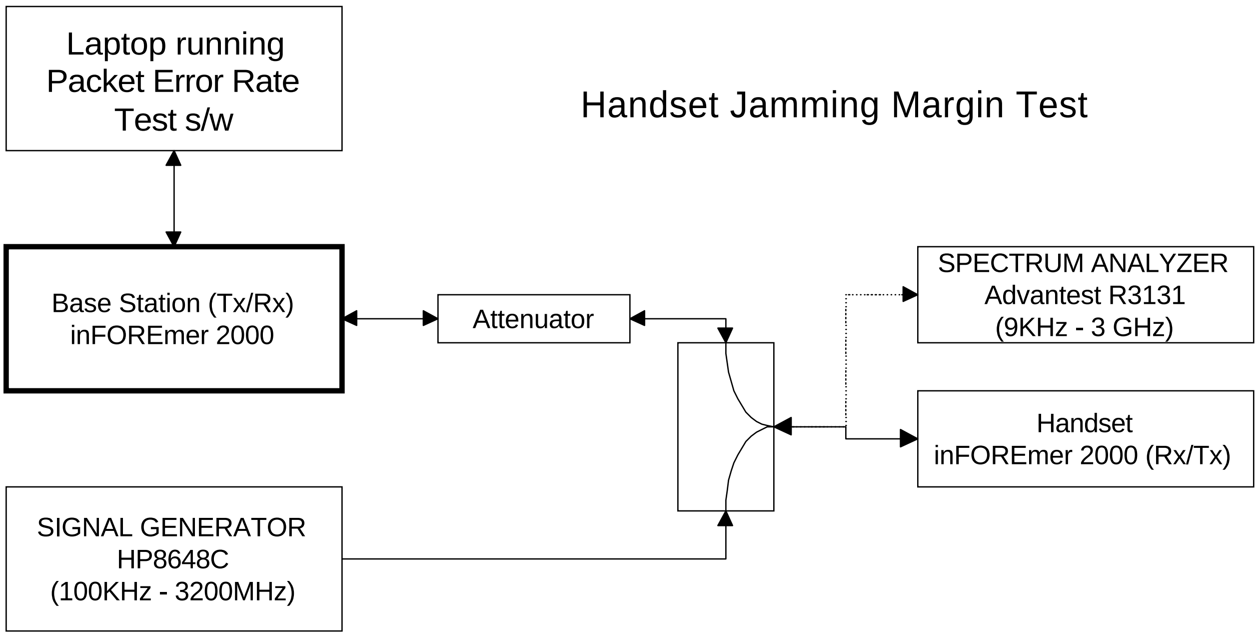
Ref.: Dixon, R. Spread Spectrum Systems, Chapter 1 (New York: Wiley, 1984)

Jamming Margin Test

InFOREmer 2000 Base Station & Handset

Background: The tests were made at Valhalla Systems by John Turner (P.Eng) & Dean Schebel.

The test setup is as shown in Fig 1.



Description:

A laptop running packet data throughput s/w was used to send a 1000 bit packet to the Handset from the Base Station. Successful packet transmission was monitored and the interfering signal's power (sig. gen.) was raised until the packets started showing errors. The last good level was used as the maximum interferer. Note that to complete the loop, the packet received by the handset was re-transmitted back to the Base Station, but in the reverse direction the interferer was significantly less than the main carrier in power.

The same test was done for the units reversed, i.e. to measure the Base Station's jamming margin. As can be seen from the tests, the results were almost identical, which makes sense, as the radios in both units are identical. In both cases the change of 1 dB resulted in a sharp BER performance, allowing for accurate jamming margin measurements

Note: The SNR for the coherent BPSK was taken from theoretical curves. The Harris Semiconductor engineers recommended adding a D-BPSK factor of 0.7 dB to the 9.6 dB to get an SNR = 10.3 dB. We left that out, as the test results measured did not seem to require this adjustment factor. Also, the jamming margin was arrived at using the "peak" envelope total power and not the avg. total power. If the avg. total power was to be used, it would result in a jamming margin 2 dB better than the peak determination.

Testing Results

	BS	HS
Actual Signal Power (Peak)	-34.0	-34.0 dBm
Actual Signal Power (Avg)	-36.0	-36.0 dBm
Lowest Interferer after 20% of worst case measurements removed		-35.0 dBm
SN o (Theretical Coherent DBPSK required Signal to Noise Ratio)		9.6 dB
Li (Implementation efficiency of the Denodulator) (2 dB max as per FCC guidelines)	2.0	2.0 dB
Pg (Theoretical Processing Gain 16 bit spreading code)	12.0	12.0 dB
Predicted Jamming Margin =Pg -SN o - Li	0.4	0.4 dB

Thus a signal greater than 0.4 dB above the desired signal will jam the receiver.

Actual Results		BS	HS
	Actual Signal Power	-34.0	-34.0 dBm
	Actual Interferer Power	-35.0	-35.0 dBm
	Measured Jamming Margin:	1.0	1.0 dBm
	Therefore Measured Processing Gain:	12.6	12.6 dB

Freq. Range:

Freq MHz	BS to HS	HS to BS
2453.00	-24	-25
2453.05	-24	-25
2453.10	-24	-25
2453.15	-24.5	-25
2453.20	-24.5	-25
2453.25	-25	-26
2453.30	-25	-26
2453.35	-25.5	-27
2453.40	-26.5	-27
2453.45	-27	-28
2453.50	-28	-28
2453.55	-28.5	-29
2453.60	-29.5	-30
2453.65	-29.5	-31
2453.70	-30.5	-32
2453.75	-32	-32.5
2453.80	-32	-33
2453.85	-32	-33
2453.90	-33	-33
2453.95	-33	-33
2454.00	-33	-33
2454.05	-35	-33

2454.10	-33.5	-33
2454.15	-34	-33
2454.20	-34.5	-34
2454.25	-34.5	-33
2454.30	-34.5	-34
2454.35	-34.5	-33
2454.40	-35	-33
2454.45	-35	-33
2454.50	-35	-34
2454.55	-35	-34
2454.60	-35	-34
2454.65	-35	-34
2454.70	-34.5	-34
2454.75	-34.5	-34
2454.80	-34.5	-34
2454.85	-34.5	-34
2454.90	-34.5	-34
2454.95	-34.5	-34
2455.00	-34.5	-34
2455.05	-34.5	-34
2455.10	-34.5	-34
2455.15	-34.5	-34
2455.20	-34.5	-34
2455.25	-34.5	-34
2455.30	-34.5	-34
2455.35	-34.5	-34
2455.40	-34.5	-35
2455.45	-34.5	-35
2455.50	-34.5	-35
2455.55	-34.5	-35
2455.60	-34.5	-35
2455.65	-34	-35
2455.70	-33.5	-35
2455.75	-33.5	-35
2455.80	-34	-35
2455.85	-35	-35
2455.90	-34	-35
2455.95	-34	-35.5 *
2456.00	-34.5	-35 *
2456.05	-34.5	-35.5 *
2456.10	-34.5	-35.5 *
2456.15	-35.5 *	-35.5 *
2456.20	-35	-35.5 *
2456.25	-35	-35 *
2456.30	-35 *	-35 *
2456.35	-35 *	-35 *
2456.40	-35 *	-35 *
2456.45	-35.5 *	-35 *
2456.50	-35.5 *	-35 *
2456.55	-35.5 *	-35 *
2456.60	-35.5 *	-35 *
2456.65	-35.5 *	-35 *
2456.70	-35.5 *	-35 *
2456.75	-35.5 *	-35 *
2456.80	-35.5 *	-35 *
2456.85	-35.5 *	-35 *
2456.90	-35.5 *	-35 *

2456.95	-35.5 *	-35 *
2457.00	-35.5 *	-35 *
2457.05	-35.5 *	-34
2457.10	-35.5 *	-34.5
2457.15	-35.5 *	-34.5
2457.20	-35.5 *	-34.5
2457.25	-35 *	-35 *
2457.30	-35 *	-35 *
2457.35	-35 *	-34.5
2457.40	-35 *	-34.5
2457.45	-35	-34.5
2457.50	-34.5	-34.5
2457.55	-34.5	-34.5
2457.60	-34.5	-34.5
2457.65	-34	-34.5
2457.70	-34	-34.5
2457.75	-33.5	-34.5
2457.80	-33	-34
2457.85	-32.5	-33.5
2457.90	-32.5	-33
2457.95	-33	-33.5
2458.00	-32	-33.5
2458.05	-31.5	-33
2458.10	-32	-33
2458.15	-31	-32
2458.20	-30.5	-32
2458.25	-31	-32
2458.30	-29.5	-31.5
2458.35	-29	-30
2458.40	-29	-30
2458.45	-28.5	-29
2458.50	-28	-28.5
2458.55	-27.5	-28.5
2458.60	-27	-28
2458.65	-26.5	-27.5
2458.70	-26	-27
2458.75	-25.5	-26
2458.80	-25.5	-26
2458.85	-25.5	-26
2458.90	-25.5	-26
2458.95	-25	-26
2459.00	-25	-26

* indicates 20% rejected measurement as per FCC test outline