Processing Gain.

The purpose of this test is to show that the processing gain of the system is at least 10 dB. The test method utilized here is applicable to any direct sequence spread spectrum radio with an arbitrary jammer, where the total power of the jammer is known. The test is performed in a full duplex link configuration as shown in Figure 1. The CW jammer signal is injected through a 10 dB directional coupler in the direction of the receiver under test and monitored with the spectrum analyzer. Both the transmit high (TX hi: the higher of the two transmit frequencies) and transmit low frequency units are tested for process gain. As anticipated, test results show that, processing gain performance of the two units is very similar.

For verification of requirements, the **BER** vs. **S/N** (or **Eb/No**) curve of the 16QUAM modulation format is utilized (Figure 2). Initially the system is set for error-free operation at about mid-way in the operating range. Then the CW jamming signal is injected and is adjusted until appx. **BER=2E-5** is achieved while the carrier signal power, **S** is held constant. Then, the processing gain **Gp** is computed (CW jamming margin method per Dixon, Ref. 1):

$$Gp = (S/N) + Mj + Lsys \qquad [dB]$$

where: S/N = baseband signal-to-noise ratio (Eb/No) in dB of the 16QUAM system for a BER 2E-5.
Mj = J/S = Jamming to Signal Power ratio at RF, dB.
Lsys = system implementation loss (2dB max. allowed here; however 0 dB is used, hence, Gp = (S/N) + Mj).

Test data were taken for the following frequency bands in 100 KHz increments:

"TX HI" unit: at receive frequency range: 5752.5 ∀ 22.5 MHz
"TX LO" unit: at receive frequency range: 5822.5 ∀ 22.5 MHz

The number of test points per unit were 450, or 900 points for the system. The 100 KHz increment is considered to be adequate, since the BER vs. S/N function turned out to be a smooth curve and no irregularities were found within the measurement range. In reducing the test data, the 6 dB spectral efficiency factor, pertinent to the 16QUAM modulation, was taken into account. Here, a "bit error" as measured with the digital transmission analyzer is basically a symbol error. The 16QUAM performance curve shown in Figure 2 (from Ref. 2) is representative of this scenario; the operating point is SNR/bit (or Eb/No) = 14 dB @ Symbol Error rate = 2E-5. The representative carrier spectra are shown in figures 3a and 3b.

Based on the test data, with Gp 12 dB measured at band center, the conclusion is that the units meet the process gain requirement of 10 dB minimum.

REFERENCES. 1. Dixon, R. Spread Spectrum systems, Chapter 1 (New York, Wiley, 1984)
2. Proakis-Salahi: Communications Systems Engineering, Prentice-Hall, 1994, pp. 655-657.

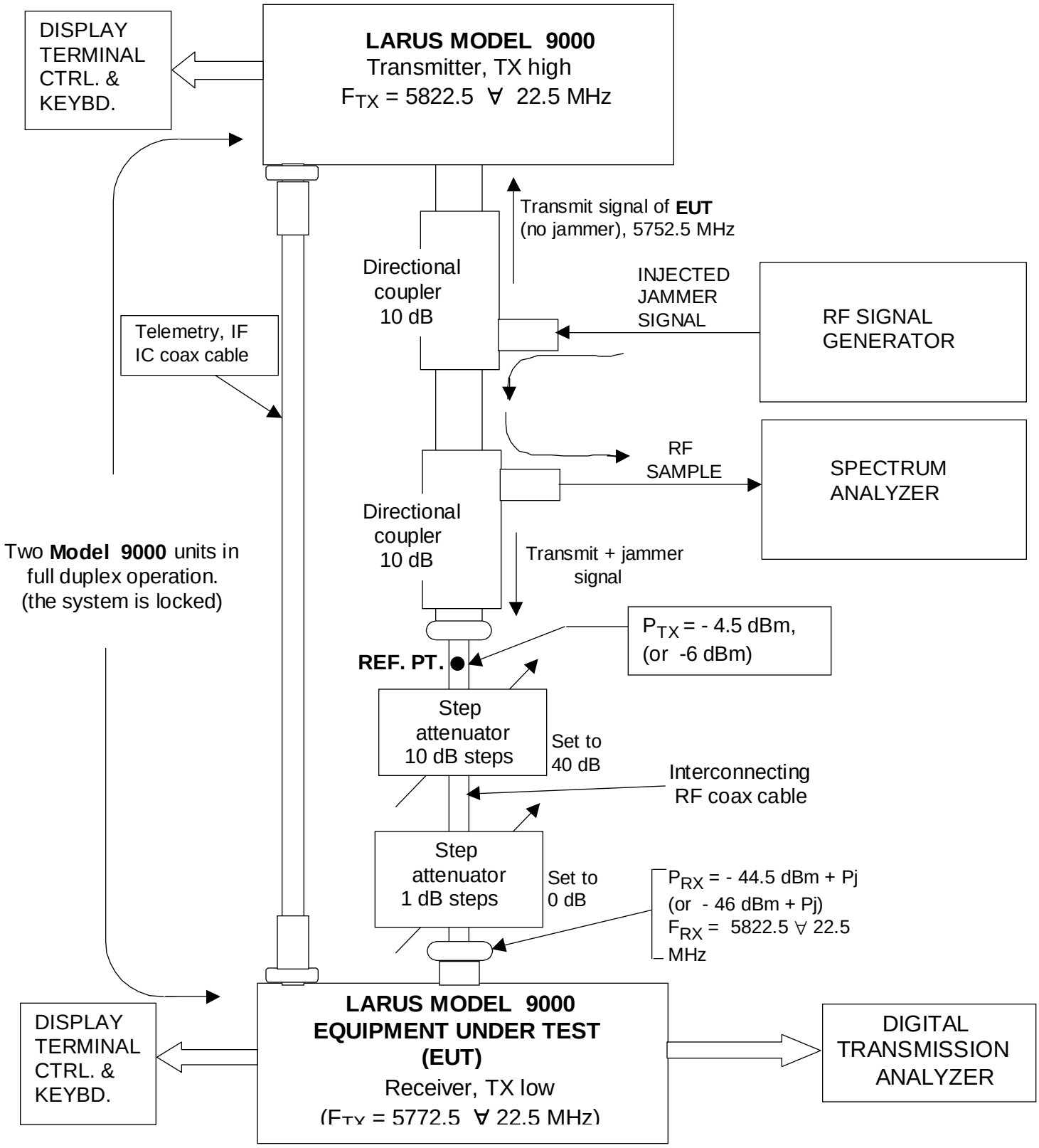

Figure 1. Full duplex setup of two LARUS model 9000 units to test for CW jamming margin. **NOTE**: in the configuration shown here, the TX low unit is tested for jamming margin. The TX high unit was also tested in identical test setup.

Required Instrumentation.

1. HP 3784A digital transmission analyzer for BER measurement.

2. HP70001 spectrum analyzer/power meter to monitor/measure spectrum and to calibrate values at the reference point.

3. HP 84965B 10 dB step attenuator

4. HP 84964B 1 dB step attenuator

5. Mac Technology 10 dB directional coupler, 2 ea.

6. HP 83712A 10 MHz – 2 GHz synthesized CW signal generator (to provide jammer power Pj).

7. LARUS Model 9000 unit to provide full duplex operation for the Unit Under Test.

8. Two -48 VDc power supplies (not shown in Figure 1) tp provide DC power for the system.

9. Miscellaneous cables, transitions and connectors.

10. Printer-plotter for plotting the RF spectrum and CW jammer.

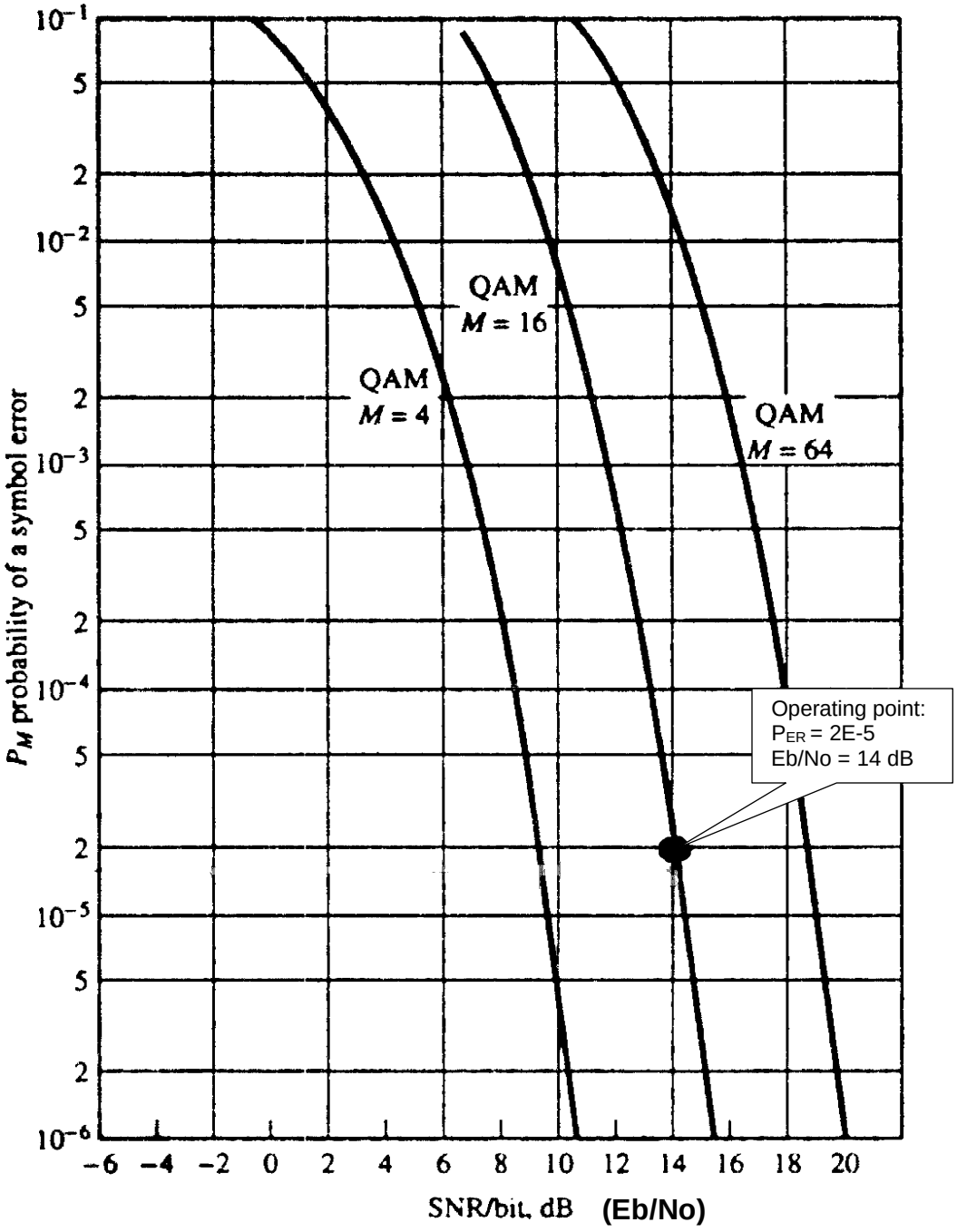

Figure 2. Eb/No vs. symbol error rate. The operating point used for process gain testing is shown on the curve. (From Reference 2).

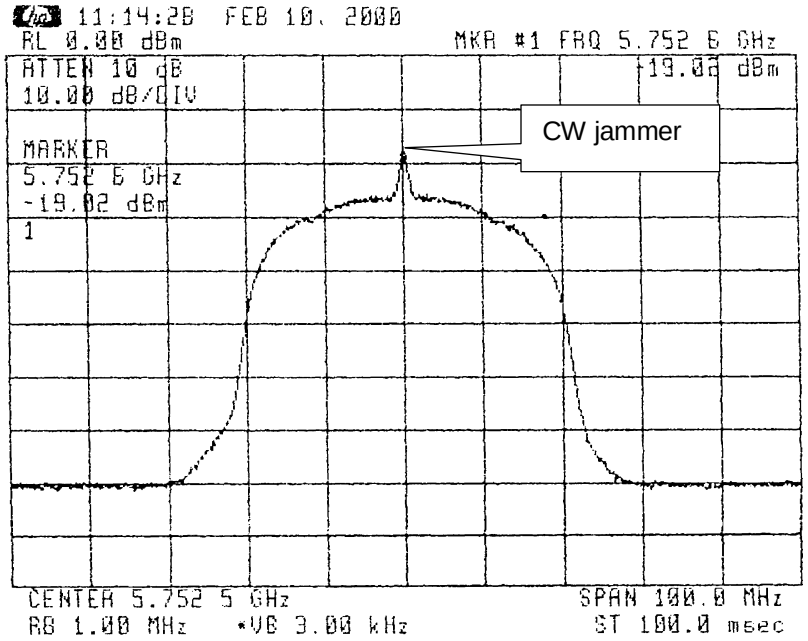

Figure 3 a. **TX HI** unit under test: spectrum of the carrier and injected jammer (tuned to receive center frequency of 5752.5 MHz).

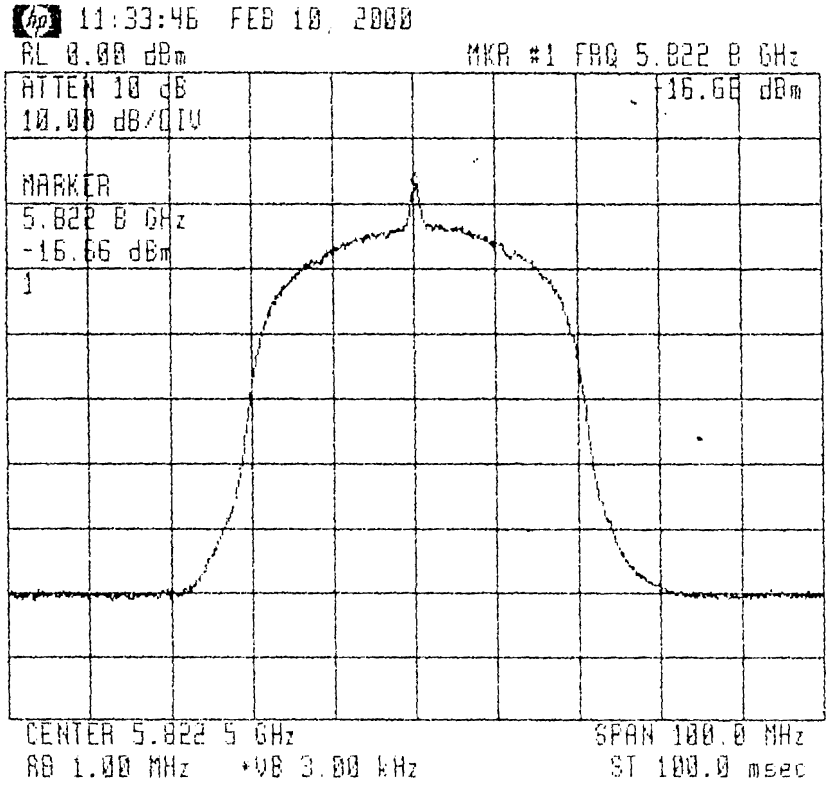

Figure 3 b. **TX LOW** unit under test: spectrum of the carrier and injected jammer (tuned to receive center frequency of 5822.5 MHz).