January 23, 1994

AirLink VF Processing Gain Measurement

1. Set-up

The Set-up shown in Figure 1 was Used. The Unit Under Test - An Airlink VF Wireless Modem has been connected as shown. The Modems were running in Simplex while the receiving modem is being interferred with by the CW signal. The transmit section of the BER Tester generated a pseudo-random sequence with a period of $2^{10}-1$ (arbitrary).
Both Airlink Modems were set to channel 5: 913.682 MHz.
The Signal Generator [SG] operated as a CW source with power resolution of 0.1 dB. It was set for frequency increment of 25 KHz. Fifty frequency steps below and 50 frequency steps above the center frequency of the receiver cover the RF bandwidth of the receiver of the Modem.

1.1 Calibration

The Adjustable attenuator was set to 25 dB. The received signal power was then -69.4 dBm. It was found that to obtain equal Signal and Jammer power, (i.e. J/S=0 dB), as measured by the Power Meter, the SG had to be set to -45.6 dBm.

1.2 Procedure

The SG frequency has then been incremented between 913.682 MHz minus 50x0.025 MHz and 913.682 MHz plus 50x0.025 MHz. For each frequency step the power of the SG was set to produce exactly BER=10^{-4}. The deviation of the SG setting from -45.6 dB has been recorded as the J/S for that frequency.

1.3 Measured Results

The measurements are shown in Figure 2 and the attached list.

2. Processing Gain Derivation

Deleting the worst 20% of the measurements, i.e. 20 measurements, (marked in the attached list) we find that the worst remaining measurement is J/s=-1 dB.

The Processing Gain is now calculated from the formula:

$$\text{Jamming Margin} = G_p - (S/N)_{out} - L_{sys} \qquad 1$$

where:

* Jamming Margin is the maximum ratio of Jammer to Signal power, which still allows the receiver to deliver the prescribed BER.

* $(S/N)_{out}$ is the signal to noise ratio required at the input of that part of an ideal receiver (of the same type), which accomplishes data demodulation, in order to obtain a prescribed BER.

* L_{sys} is the total losses of the tested receive system in comparison with an ideal (theoretical) system having the same type of Modulation/Demodulation. In our case the basic modulation scheme is Noncoherent Orthogonal Signalling. Cylink estimates that the total system losses of the Airlink VF are in access of 1.5 dB. This figure includes losses in the transmitter and the receiver. The major contributor to this total loss are the nonideal analog filters/equalizers and "corner cutting" in the Base-band Digital Processor.

* G_p is the Processing Gain.

For an explanation see: Robert C.Dixon "Spread Spectrum Systems", John Wiley & Sons, 1984 (second edition), page 10.

2.1 Calculation

The theoretical performance of noncoherent reception of orthogonal signals is given, for instance, by A. J. Viterbi, McGraw-Hill Book Company, 1966 page 207:

$$P_e = (1/2)EXP(-E/2N_o) \qquad 2$$

where E/N_o should be replaced for our purpose by $(S/N)_{out}$.

For BER=10^{-4} this formula requires (S/N) = 12.3 dB.

As said above we will take: L_{sys} = 1.5 dB

As said above, the worst remaining Jammer to Signal Power Ratio in Table 1 after omitting the "worst" 20 measurements, is -1 dB.

From formula 1 we obtain:

$$G_p = (J/S) + (S/N)_{out} + L_{sys} \qquad 3$$

Substituting the numerical values we obtain:

G_p = -1 + 12.3 + 1.5 = <u>12.8 dB</u>

Table 1: Jammer Power to Signal Power Ratio for [illegible]
Signal Power Constant at - 69.4 dBm.

	Frequency	J/S	
1	912.432	7.7	
2	912.457	8.2	
3	912.482	7.5	
4	912.507	7.6	
5	912.532	6.9	
6	912.557	6.8	
7	912.582	6.3	
8	912.607	6.5	
9	912.632	5.8	
10	912.657	4.5	
11	912.682	5.3	
12	912.707	5.3	
13	912.732	5.1	
14	912.757	4.6	
15	912.782	3.9	
16	912.807	3.8	
17	912.832	3.1	
18	912.857	3.3	
19	912.882	2.9	
20	912.907	3.3	
21	912.932	2.6	
22	912.957	2.0	
23	912.982	2.1	
24	913.007	1.9	
25	913.032	1.5	
26	913.057	1.1	
27	913.082	0.7	
28	913.107	1.0	
29	913.132	0.5	
30	913.157	0.1	
31	913.182	0.0	
32	913.207	-0.9	
33	913.232	-0.4	
34	913.257	-0.3	
35	913.282	-0.8	
36	913.307	-0.1	
37	913.332	-0.3	
38	913.357	-0.4	
39	913.382	-1.0	*
40	913.407	-2.6	*
41	913.432	-2.0	*
42	913.457	-1.5	*
43	913.482	-1.2	*
44	913.507	-2.4	*
45	913.532	-2.5	*
46	913.557	-2.0	*
47	913.582	-2.6	*
48	913.607	-3.3	*
49	913.632	-1.0	

50	913.657	2.5	
51	913.682	34.1	
52	913.707	2.8	
53	913.732	-0.3	
54	913.757	-2.1	*
55	913.782	-2.1	*
56	913.807	-1.7	*
57	913.832	-1.9	*
58	913.857	-2.0	*
59	913.882	-1.2	*
60	913.907	-1.1	*
61	913.932	-1.6	*
62	913.957	-2.0	*
63	913.982	-1.4	*
64	914.007	-0.6	
65	914.032	-0.2	
66	914.057	-0.7	
67	914.082	-0.7	
68	914.107	-0.2	
69	914.132	-0.2	
70	914.157	-0.2	
71	914.182	0.0	
72	914.207	-0.1	
73	914.232	0.7	
74	914.257	1.4	
75	914.282	0.7	
76	914.307	1.5	
77	914.332	0.4	
78	914.357	2.2	
79	914.382	3.0	
80	914.407	2.5	
81	914.432	2.8	
82	914.457	4.0	
83	914.482	3.3	
84	914.507	3.3	
85	914.532	3.4	
86	914.557	3.8	
87	914.582	4.5	
88	914.607	4.9	
89	914.632	5.3	
90	914.657	5.2	
91	914.682	4.8	
92	914.707	5.0	
93	914.732	6.0	
94	914.757	6.8	
95	914.782	6.6	
96	914.807	6.8	
97	914.832	7.0	
98	914.857	8.0	
99	914.882	7.6	
100	914.907	8.3	
101	914.932	8.0	

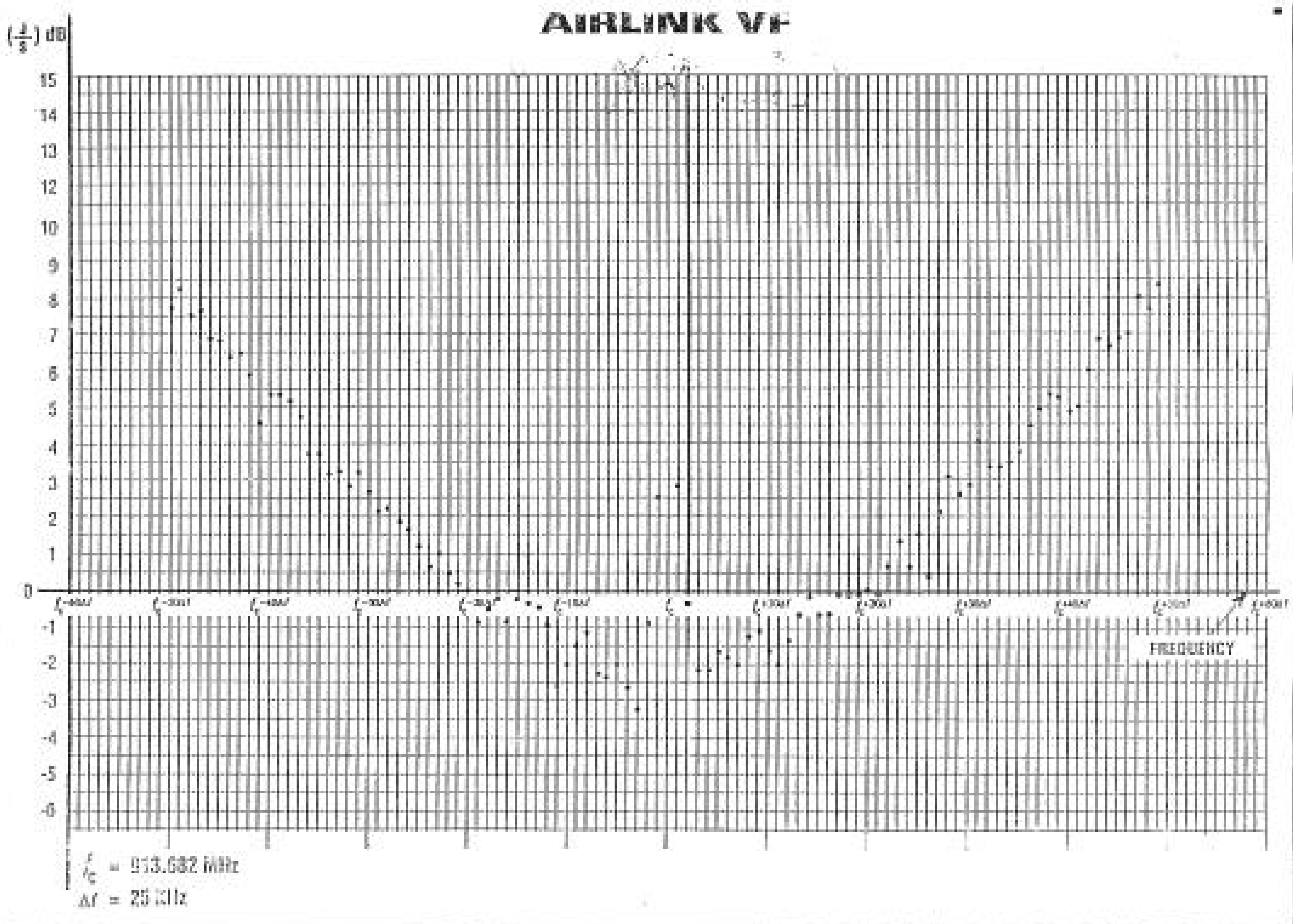

FIGURE : $(\frac{J}{S})$ dB REQUIRED FOR BER = 10^{-4}

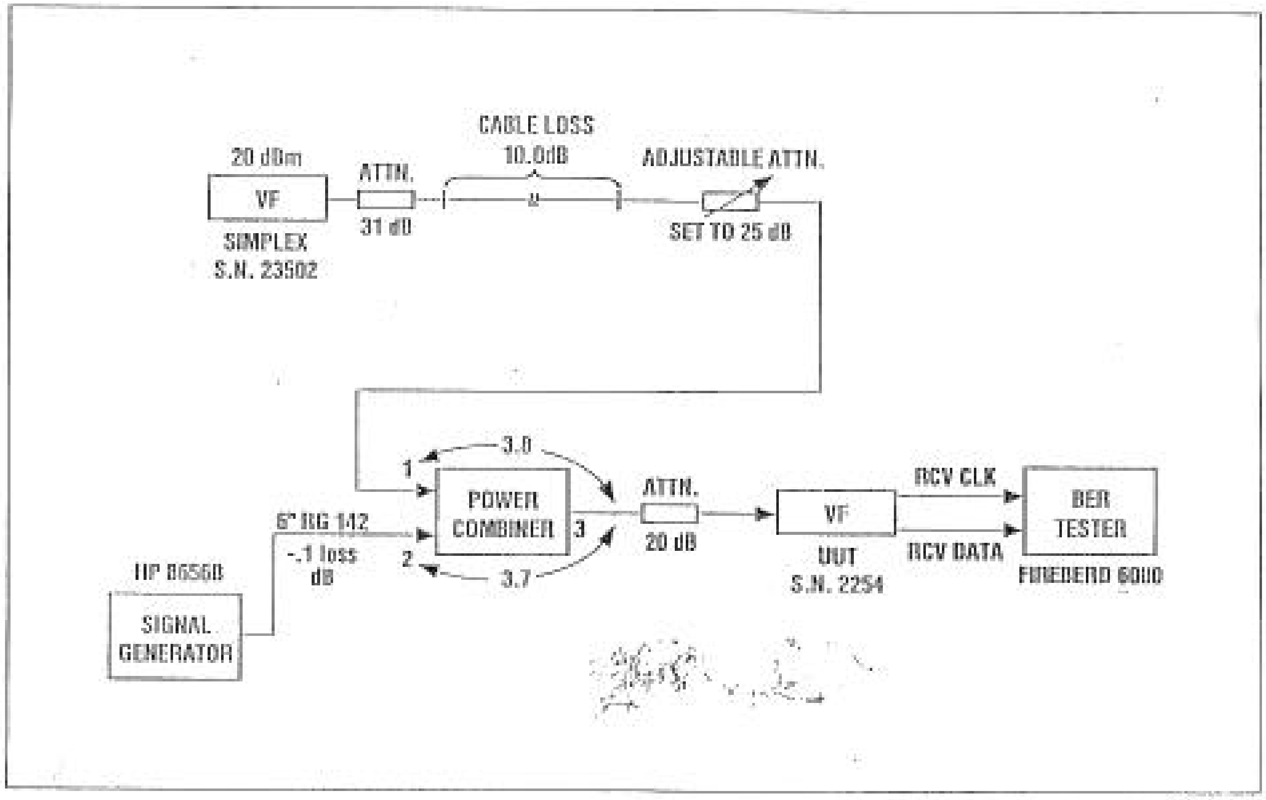

FIGURE 1: Set-up for BER versus J/S measurement. Modems running in simplex.