

FCC CERTIFICATION REPORT

for

Advanced Measurement Solutions, Inc.

FCC ID: NX4P90092

1.0 Introduction

This report has been prepared on behalf of Advanced Measurement Solutions, Inc. to support the attached Application for Equipment Authorization. The test and application are submitted for an Intentional Radiator under Section 15.247 of the FCC Rules and Regulations. The Equipment Under Test was the Advanced Measurement Solutions, Inc. P90092 Sensor Transmitter.

All measurements herein were performed according to the 1992 version of ANSI C63.4. The measurement equipment conforms to ANSI C63.2 Specifications for Electromagnetic Noise and field Strength Instrumentation. Calibration checks are made periodically to verify proper performance of the measuring instrumentation.

All measurements are performed at Washington Laboratories, Ltd. test center in Gaithersburg, MD. Site description and site attenuation data have been placed on file with the FCC's Sampling and Measurements Branch. Washington Laboratories, Ltd. has been accepted by the FCC and approved by NIST NVLAP (NVLAP Lab Code 200066-0) as an independent test laboratory.

The results of this test report relate only to the item tested. This report shall not be used to claim product endorsement by NVLAP or any agency of the US Government.

1.1 Summary

The Advanced Measurement Solutions, Inc. P90092 Sensor Transmitter complies with the limits for an Intentional Radiator under Section 15.247.

2.0 Description of Equipment Under Test (EUT)

The Advanced Measurement Solutions, Inc. P90092 Sensor Transmitter is a low power direct sequence spread spectrum transmitter that has a single channel transmitting frequency of 923.58 MHz. The battery powered transmitter is used to report the status of underground storage tank conditions. The information is transmitted to a C&K Systems FCC approved receiver (FCC ID: C2DLWSN-11-SL). The unit contains a permanently attached internal antenna (approximate gain of 1 dBi) and a 5-pin terminal block for connection of sensor signal wires.

2.1 On-board Oscillators

The Advanced Measurement Solutions, Inc. P90092 Sensor Transmitter contains a 14.66 MHz oscillator.

3.0 Test Configuration

To complete the test configuration required by the FCC, a five conductor cable was attached to the terminal block to simulate connection to external devices. The transmitter was tested in all three orthogonal planes.

3.1 Testing Algorithm

The transmitter was turned on and constantly transmitting. Worst case emissions are recorded in the data tables.

3.2 Conducted Emissions Testing

Conducted emissions testing is not required since the EUT is battery powered.

3.3 Radiated Emissions Testing

The EUT was then placed on an 80 cm high 1 x 1.5 meters non-conductive motorized turntable for radiated testing on a 3 meter open field test site. The emissions from the EUT were measured continuously at every azimuth by rotating the turntable. Biconical log periodic and horn broadband antennas were mounted on an antenna mast to determine the height of maximum emissions. The height of the antenna was varied between 1 and 4 meters. Cables were varied in position to produce maximum emissions. Both the horizontal and vertical field components were measured.

The output from the antenna was connected, via a preselector or preamplifier, to the input of the spectrum analyzer. The detector function was set to quasi-peak for frequencies below 1000 MHz and peak for frequencies above 1000 MHz. For frequencies below 1000 MHz, the measurement bandwidth on the spectrum analyzer system was set to at least 120 kHz, with all post-detector filtering no less than 10 times the measurement bandwidth. For frequencies above 1000 MHz, the resolution bandwidth on the spectrum analyzer system was set to 1 MHz and the video bandwidth on the spectrum analyzer system was set to 1 MHz for peak measurements.

No average measurements were taken above 1 GHz since the peak limit is the worst case limit. The peak limit is the worst case limit because it is 20 dB above the average limit and the duty cycle correction for this transmitter is -22.38 dB. According to Section 15.35, the average limit above 1 GHz is determined by taking the peak reading and correcting it by using the duty cycle of the pulse modulated signal (over the worst case 0.1 second interval). Therefore, when the peak reading for this transmitter is below the peak limit, the average reading will always be below the average limit by at least 2.38 dB.

3.3.1 Radiated Data Reduction and Reporting

To convert the raw spectrum analyzer radiated data into a form that can be compared with the FCC limits, it is necessary to account for various calibration factors that are supplied with the antennas and other measurement accessories. These factors are grouped into a composite antenna factor (AFc) and are supplied in the AFc column of Table 1. The AFc in dB/m is algebraically added to the Spectrum Analyzer Voltage in dBμV to obtain the Radiated Electric Field in dBμV/m.

Since the FCC limits above 1 GHz are average levels, the peak spectrum analyzer reading is corrected using the duty cycle of the pulse modulated signal (over the worst case 0.1 second interval). The duty cycle factor (AFd) is added to the spectrum analyzer level to convert the peak level to an average level (Section 15.35). This level is then compared with the FCC limit. As stated earlier, only peak measurements were taken above 1 GHz since the peak limit is the worst case limit. For emissions below 1 GHz, the FCC limits are in quasi-peak and the duty cycle factor is not used since the measurements are taken using a quasi-peak detector.

Example:

Duty Cycle: $AFd = 7.6 \text{ ms on-time} / 100 \text{ ms} = 7.6\% = -22.38 \text{ dB}$

Spectrum Analyzer Voltage: $VdB\mu V$

Composite Antenna Factor: $AFcdB/m$

Electric Field: $EdB\mu V/m = VdB\mu V + AFcdB/m$

To convert to linear units: $E\mu V/m = \text{antilog}(EdB\mu V/m/20)$

Data is recorded in Table 1.

Table 1

Radiated Emissions Test Per 15.247(c)

CLIENT: Advanced Measurement Solutions, Inc.
 FCC ID: NX4P90092
 DATE: 4/22/98
 CARRIER FREQ: 923.58 MHz
 BY: Chad Beattie/Greg Snyder
 JOB #: 4475X

FREQ	POL	Azimuth	Ant Height	SA LEVEL (QP)	AFc	E-FIELD	E-FIELD	LIMIT	MARGIN
MHz	H/V	Degree	m	dBuV	dB/m	dBuV/m	uV/m	uV/m	dB
278.56	H	180.00	1.0	15.2	15.4	30.6	33.8	200.0	-15.4
322.53	H	90.00	1.0	23.7	16.7	40.4	104.7	200.0	-5.6
613.90	V	0.00	1.0	18.2	23.8	42.0	125.5	200.0	-4.0
982.16	V	0.00	1.0	19.7	29.4	49.1	286.1	500.0	-4.8
996.83	V	180.00	1.0	20.8	29.6	50.4	331.7	500.0	-3.6
				(Peak)					
1026.23	V	180.00	1.0	68.0	-16.4	51.6	380.2	5000.0	-22.4
1231.48	V	0.00	1.0	73.5	-16.2	57.3	732.8	5000.0	-16.7
1334.11	V	0.00	1.0	52.0	-14.5	37.5	75.0	5000.0	-36.5
1436.73	V	0.00	1.0	49.6	-13.5	36.1	63.8	5000.0	-37.9
1539.36	V	0.00	1.0	60.8	-11.8	49.0	280.2	5000.0	-25.0
2770.70	H	180.00	1.0	72.4	-7.0	65.4	1862.1	5000.0	-8.6
2873.50	H	180.00	1.0	59.8	-7.0	52.8	436.5	5000.0	-21.2
3694.50	H	180.00	1.0	60.7	-5.7	55.0	562.3	5000.0	-19.0
4002.50	V	180.00	1.0	58.4	-5.0	53.4	467.7	5000.0	-20.6
4310.50	V	180.00	1.0	53.5	-4.5	49.0	281.8	5000.0	-25.0
4618.00	H	0.00	1.0	52.4	-1.5	50.9	350.8	5000.0	-23.1

3.4 Spurious Emissions At The Antenna Terminal Testing

The EUT antenna was replaced with a short piece of microwave "hard line" coaxial cable and the cable was connected into a spectrum analyzer through a 10 dB attenuator. An offset was programmed into the spectrum analyzer to compensate for the loss of the external attenuator. The spectrum analyzer resolution bandwidth was set to 100 kHz and the video bandwidth was set to 1 MHz. The amplitude of the EUT carrier frequency was measured to determine the emissions limit (20 dB below the carrier frequency amplitude). Then all of the emissions outside of the allocated frequency band were scanned up to the tenth harmonic of the carrier. At each frequency, a second external attenuator was used to confirm that the transmitter input was not overloading the spectrum analyzer input.

Data is recorded in Table 2. Spectrum analyzer plots of the emissions are in Exhibit 1.

Table 2

FCC Spurious Emissions At The Antenna Terminal Test Per Section 15.247(c)

CLIENT: Advanced Measurement Solutions, Inc.
FCC ID: NX4P90092
DATE: 4/22/98
CARRIER FREQ: 923.58 MHz
BY: Greg Snyder
JOB #: 4475X

FREQ	LEVEL	LIMIT	MARGIN
MHz	dBm	dBm	dB
616.00	-11.8	-4.9	-6.9
718.30	-13.8	-4.9	-8.9
821.00	-10.3	-4.9	-5.4
894.33	-10.4	-4.9	-5.5
923.58	15.1	N/A	N/A
928.44	-7.1	-4.9	-2.2
929.67	-10.6	-4.9	-5.7
938.55	-14.6	-4.9	-9.7
952.87	-10.6	-4.9	-5.7
996.82	-23.5	-4.9	-18.6
1026.17	-9.0	-4.9	-4.1
1128.93	-16.0	-4.9	-11.1
1231.58	-6.3	-4.9	-1.4
1541.30	-11.0	-4.9	-6.1
1850.00	-17.9	-4.9	-13.0
1951.30	-20.0	-4.9	-15.1
2055.00	-20.4	-4.9	-15.5
2157.50	-17.4	-4.9	-12.5
2465.10	-23.8	-4.9	-18.9
2771.00	-46.3	-4.9	-41.4
3085.00	-25.7	-4.9	-20.8
3392.00	-31.6	-4.9	-26.7
3706.00	-32.2	-4.9	-27.3
4617.20	-38.2	-4.9	-33.3
5541.40	-46.4	-4.9	-41.5
6465.00	-56.3	-4.9	-51.4

3.5 Transmitted Power Density Testing

The EUT antenna was replaced with a short piece of microwave "hard line" coaxial cable and the cable was connected into a spectrum analyzer through a 10 dB attenuator. An offset was programmed into the spectrum analyzer to compensate for the loss of the external attenuator. The highest peak of the carrier was centered on the analyzer display. The analyzer resolution bandwidth was set to 3 kHz, the video bandwidth was set to 30 kHz, the sweep time was set to 100 seconds, and the span was set to 300 kHz. The highest level was measured in dBm and compared to the FCC limit.

A spectrum analyzer plot of the power density is located in Exhibit 2. The measured transmitter power density was 1.52 dBm.

3.6 Carrier Bandwidth Testing

The EUT antenna was replaced with a short piece of microwave "hard line" coaxial cable and the cable was connected into a spectrum analyzer through a 6 dB attenuator. An offset was programmed into the spectrum analyzer to compensate for the loss of the external attenuator. The spectrum analyzer resolution bandwidth was set to 100 kHz and the video bandwidth was set to 1 MHz. The highest peak of the carrier was centered on the analyzer display. The 6 dB bandwidth of the modulated carrier was measured and compared to the FCC limit.

A spectrum analyzer plot of the bandwidth is located in Exhibit 3. The measured 6 dB bandwidth was 1.395 MHz.

3.7 Power Output Testing

The EUT antenna was replaced with a short piece of microwave "hard line" coaxial cable and the cable was connected to the spectrum analyzer input through a 10 dB attenuator. An offset was programmed into the spectrum analyzer to compensate for the loss of the external attenuator. The analyzer resolution bandwidth was set to 5.0 MHz and the video bandwidth was set to 3 MHz (greater than the 6 dB bandwidth). The highest peak of the carrier was centered on the analyzer display. The peak power in dBm was measured and compared to the FCC limit.

A spectrum analyzer plot of the bandwidth is located in Exhibit 4. The measured peak power was 19.92 dBm, or 98.2 mW.

Table 3

System Under Test

FCC ID: NX4P90092

EUT: Advanced Measurement Solutions, Inc. P90092 Sensor Transmitter; FCC ID: NX4P90092

Table 4

Measurement Equipment Used

The following equipment is used to perform measurements:

Hewlett-Packard Spectrum Analyzer: HP 8568B

Hewlett-Packard Spectrum Analyzer: HP 8593A

Hewlett-Packard Signal Generator: HP 8656B

Hewlett-Packard Quasi-Peak Adapter: HP 85650A

Hewlett-Packard Preselector: HP 85685A

Hewlett-Packard Preamplifier: HP 8449B

Antenna Research Associates, Inc. Biconical Log Periodic Antenna: LPB-2520

Antenna Research Associates Horn Antenna: DRG-118/A

Solar 50 Ω /50 μ H Line Impedance Stabilization Network

Washington Laboratories Portable Antenna Mast

AH Systems, Inc. Motorized Turntable

RG-214 semi-rigid coaxial cable

RG-223 double-shielded coaxial cable

WASHINGTON LABORATORIES, LTD
7560 LINDBERGH DRIVE
GAITHERSBURG, MD 20879
(301) 417-0220 FAX: (301) 417-9069

FCC CLASS B 3M AVERAGE RADIATED EMISSIONS DATA - SITE 2

CLIENT: AMS
MODEL NO: Transmitter
DATE: 4/22/98
CLK SPEED(S): 923.58 MHz TX
BY: Chad Beattie/Greg Snyder(Above 1GHz)
JOB #: 4475X

CONFIGURATION:

FREQ	Pol	Azimuth	Ant Height	SA LEVEL	AFd	AFc	E-Field (Average)	E-Field (Average)	Limit	MARGN
MHz	H/V	Degree	m	Peak dBuV	Corr	dBm	dBuV/m	uV/m	uV/m	dB
1026.23	V	180.00	1.0	68.0	-22.3	-16.4	29.3	29.2	500.0	-24.7
1231.48	V	0.00	1.0	73.5	-22.3	-16.2	35.0	56.2	500.0	-19.0
1334.11	V	0.00	1.0	52.0	-22.3	-14.5	15.2	5.8	500.0	-38.8
1436.73	V	0.00	1.0	49.6	-22.3	-13.5	13.8	4.9	500.0	-40.2
1539.36	V	0.00	1.0	60.8	-22.3	-11.8	26.7	21.5	500.0	-27.3
2771.00	V	180.00	1.0	65.4	-22.3	-7.0	36.1	63.8	500.0	-17.9
3694.66	V	180.00	1.0	60.5	-22.3	-5.7	32.5	42.2	500.0	-21.5
4002.50	V	180.00	1.0	58.4	-22.3	-5.0	31.1	35.9	500.0	-22.9
4310.50	V	180.00	1.0	53.5	-22.3	-4.5	26.7	21.6	500.0	-27.3
1026.33	H	180.00	1.0	63.5	-22.3	-16.4	24.8	17.4	500.0	-29.2
1231.15	H	0.00	1.0	65.1	-22.3	-16.2	26.6	21.4	500.0	-27.4
1539.18	H	0.00	1.0	57.2	-22.3	-11.8	23.1	14.3	500.0	-30.9
2770.70	H	180.00	1.0	72.4	-22.3	-7.0	43.1	142.9	500.0	-10.9
2873.50	H	180.00	1.0	59.8	-22.3	-7.0	30.5	33.5	500.0	-23.5
3694.50	H	180.00	1.0	60.7	-22.3	-5.7	32.7	43.2	500.0	-21.3
4002.30	H	180.00	1.0	55.0	-22.3	-5.0	27.7	24.4	500.0	-26.2
4310.15	H	180.00	1.0	52.7	-22.3	-4.5	25.9	19.7	500.0	-28.1
4618.00	H	0.00	1.0	52.4	-22.3	-1.5	28.6	26.9	500.0	-25.4

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EXHIBIT 1

EMISSIONS AT THE ANTENNA TERMINAL PLOTS

14: 50: 51 APR 22, 1998

~~14~~ 13: 52: 30 APR 22, 1998

REF 40.0 dBm #ATTEN 40 dB

MKR 823.5 MHz

-9.84 dBm

PEAK

LOG

10

dB/

OFFST

10.0

dB

DL

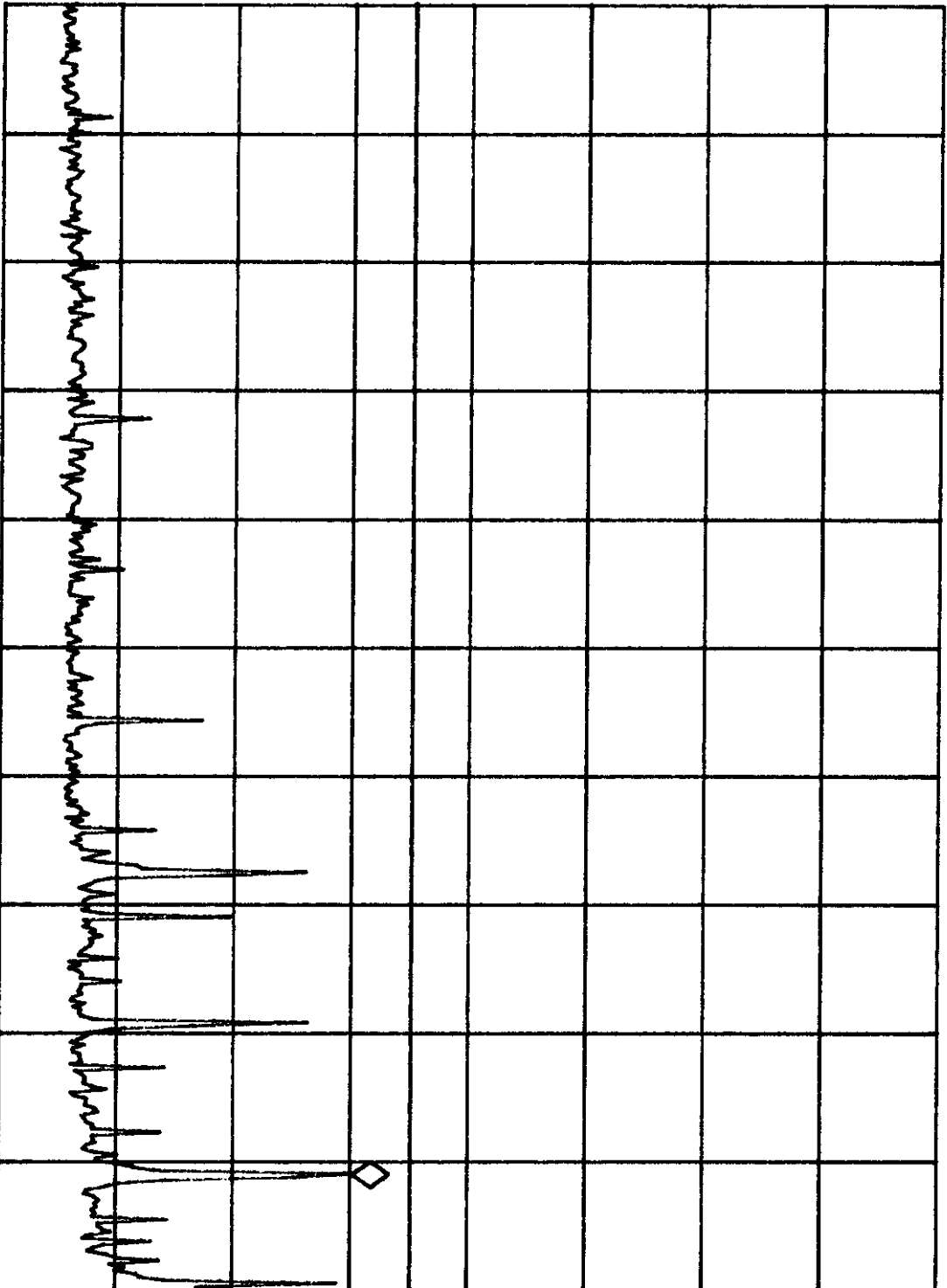
-4.9

dBm

VA SB

SC FC

CORR



START 30.0 MHz

#RES BW 100 kHz

#VBW 3 MHz

STOP 902.0 MHz

SWP 260 msec

14: 59: 47 APR 22, 1998

13: 52: 30 APR 22, 1998

MKR 928.72 MHz

REF 40.0 dBm #ATTEN 40 dB

-7.24 dBm

PEAK

LOG

10

dB/

OFFST

10.0

dB

DL

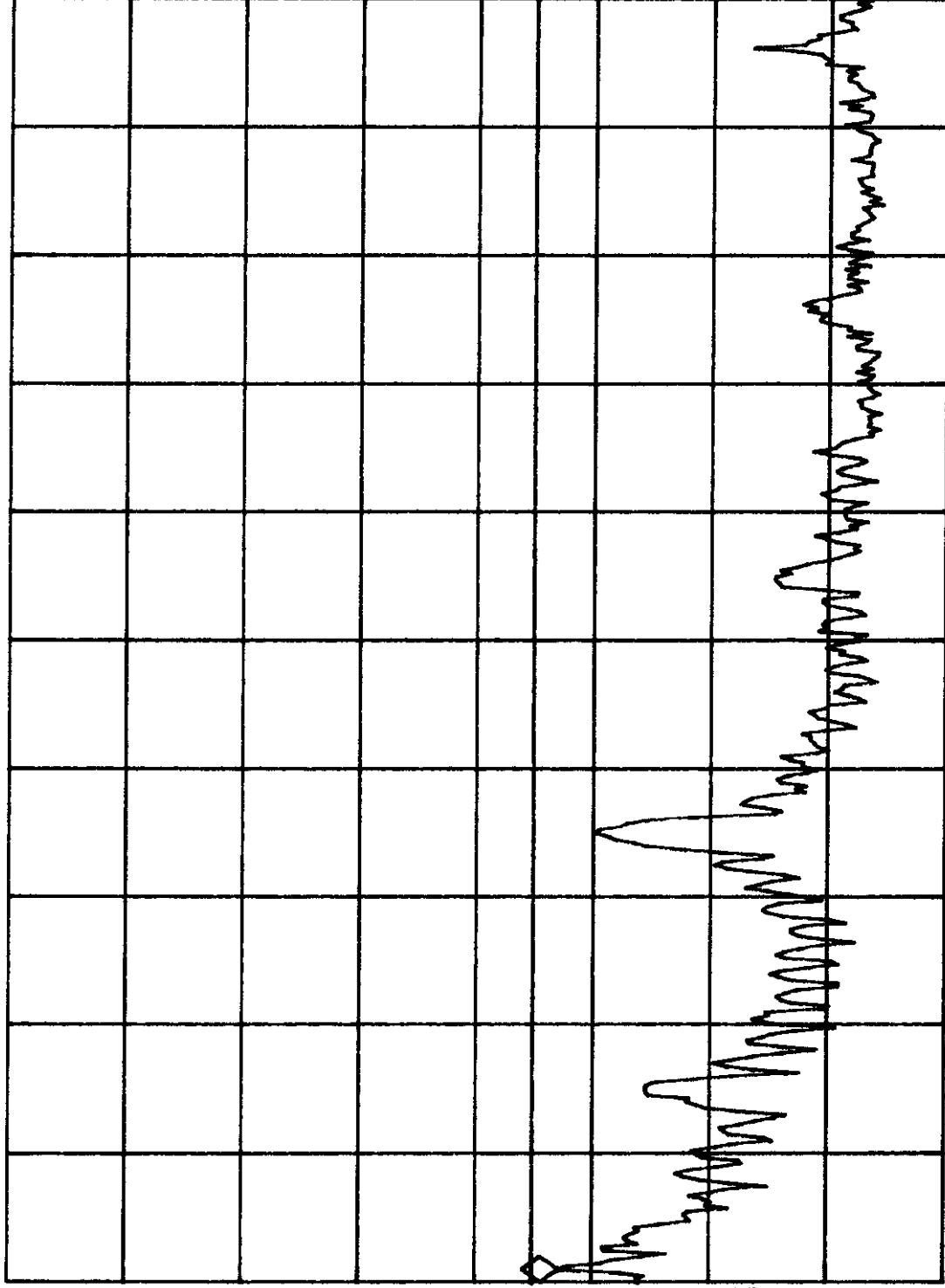
-4.9

dBm

VA SB

SC FC

CORR



START 928.00 MHz

#RES BW 100 KHZ

STOP 1.00000 GHz

#VBW 3 MHz

SWP 22 msec

15:03:37 APR 22, 1998

13:52:30 APR 22, 1998

MKR 1.235 GHz

REF 40.0 dBm #ATTEN 40 dB

-7.04 dBm

PEAK

LOG

10

dB/

OFFST

10.0

dB

DL

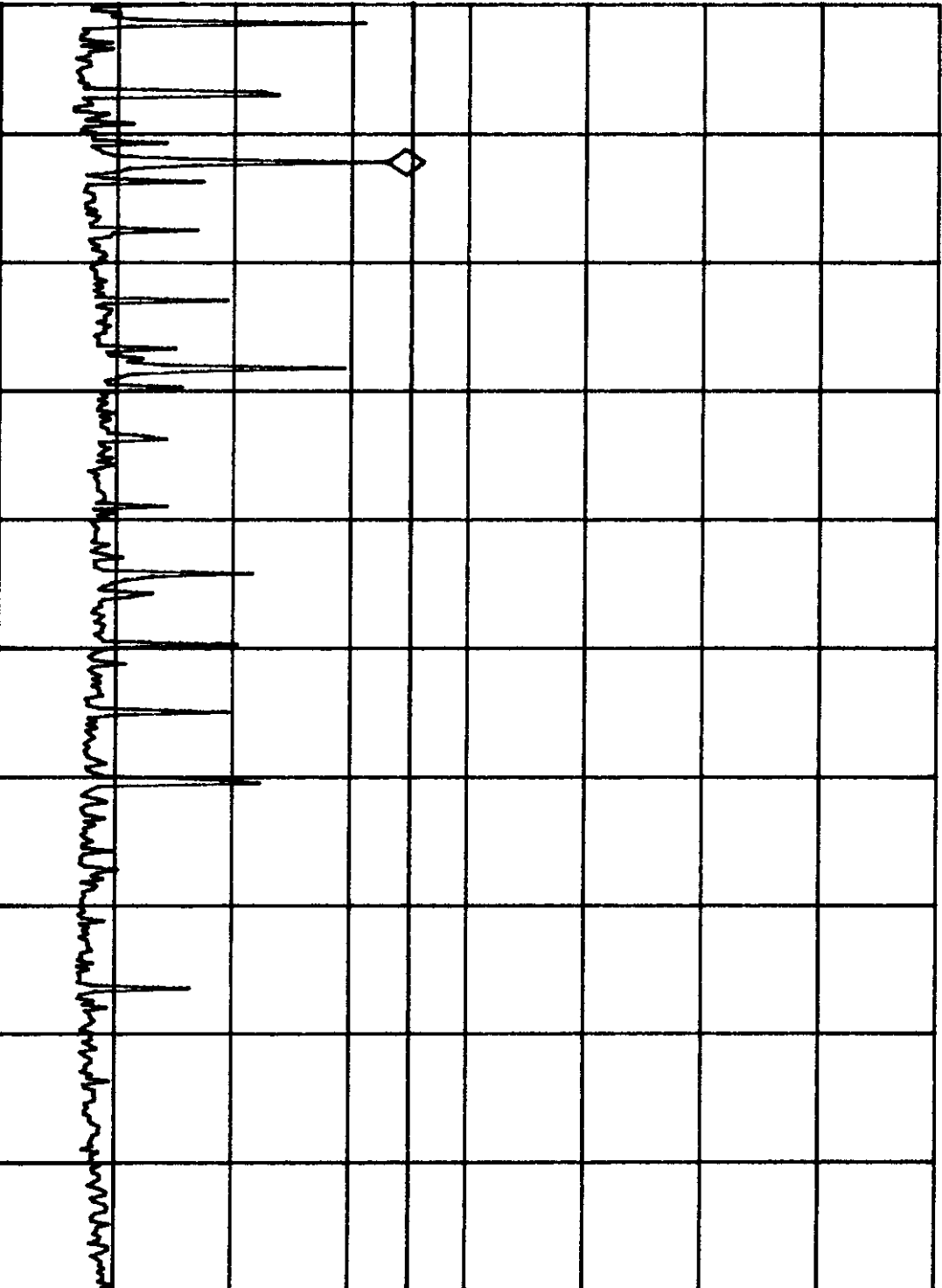
-4.9

dBm

VA SB

SC FC

CORR



START 1.000 GHz

#RES BW 100 KHz

#VBW 3 MHz

STOP 2.921 GHz

SWP 580 msec

08: 25: 43 APR 23, 1998

MKR 3.396 GHz

REF 20.0 dBm #ATTEN 20 dB

-32.17 dBm

PEAK

LOG

10

dB/

OFFST

10.0

dB

DL

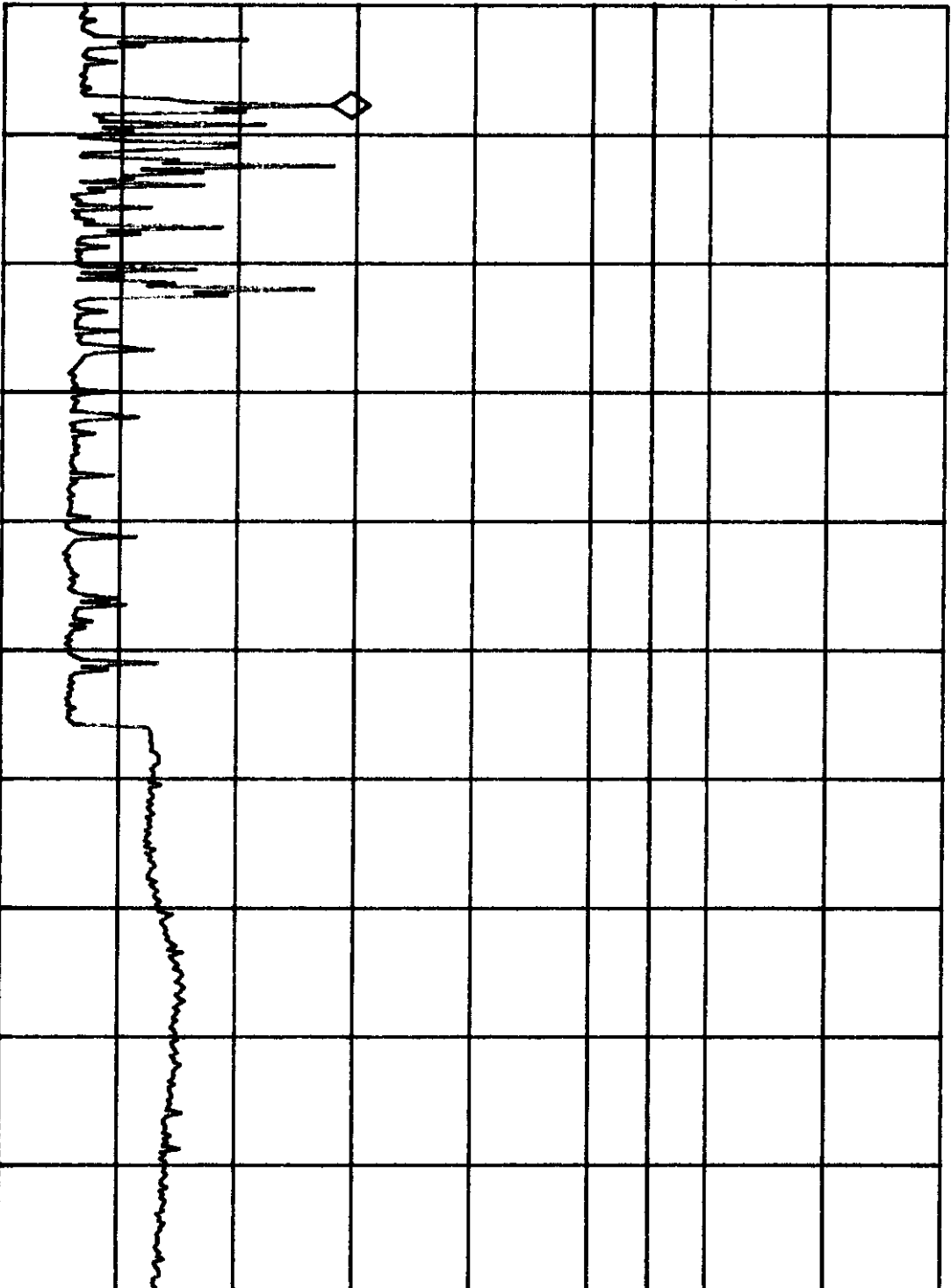
-4.9

dBm

VA SB

SC FC

CORR



START 2.900 GHz

STOP 9.300 GHz

#RES BW 100 KHz

VBW 30 KHz

SWP 6.4 sec

EXHIBIT 2

TRANSMITTED POWER DENSITY PLOT

15: 19: 41 APR 22, 1998

~~13~~ 13: 52: 30 APR 22, 1998

MKR 923.7330 MHz

REF 40.0 dBm #ATTEN 40 dB

1.52 dBm

PEAK

LOG

10

dB/

OFFST

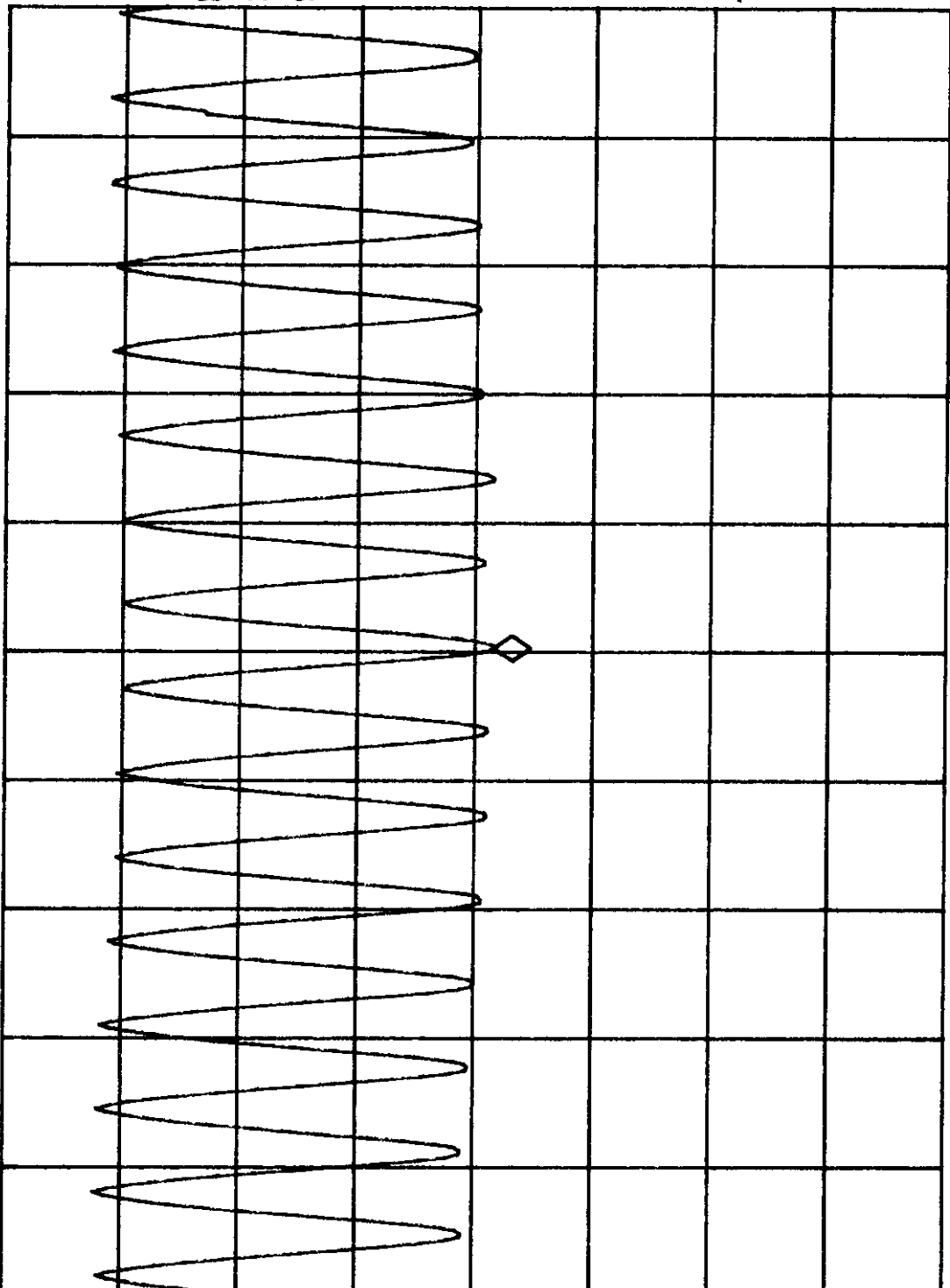
10.0

dB

VA SB

SC FC

CORR



CENTER 923.7337 MHz

#RES BW 3.0 KHz

#VBW 30 KHz

SPAN 300.0 KHz

#SWP 100 sec

EXHIBIT 3

CARRIER BANDWIDTH PLOT

13:54:45 APR 22, 1998

~~13~~ 13:52:30 APR 22, 1998

REF 36.0 dBm ATTEN 40 dB

MKR Δ 1.395 MHz

-.08 dB

PEAK

LOG

10

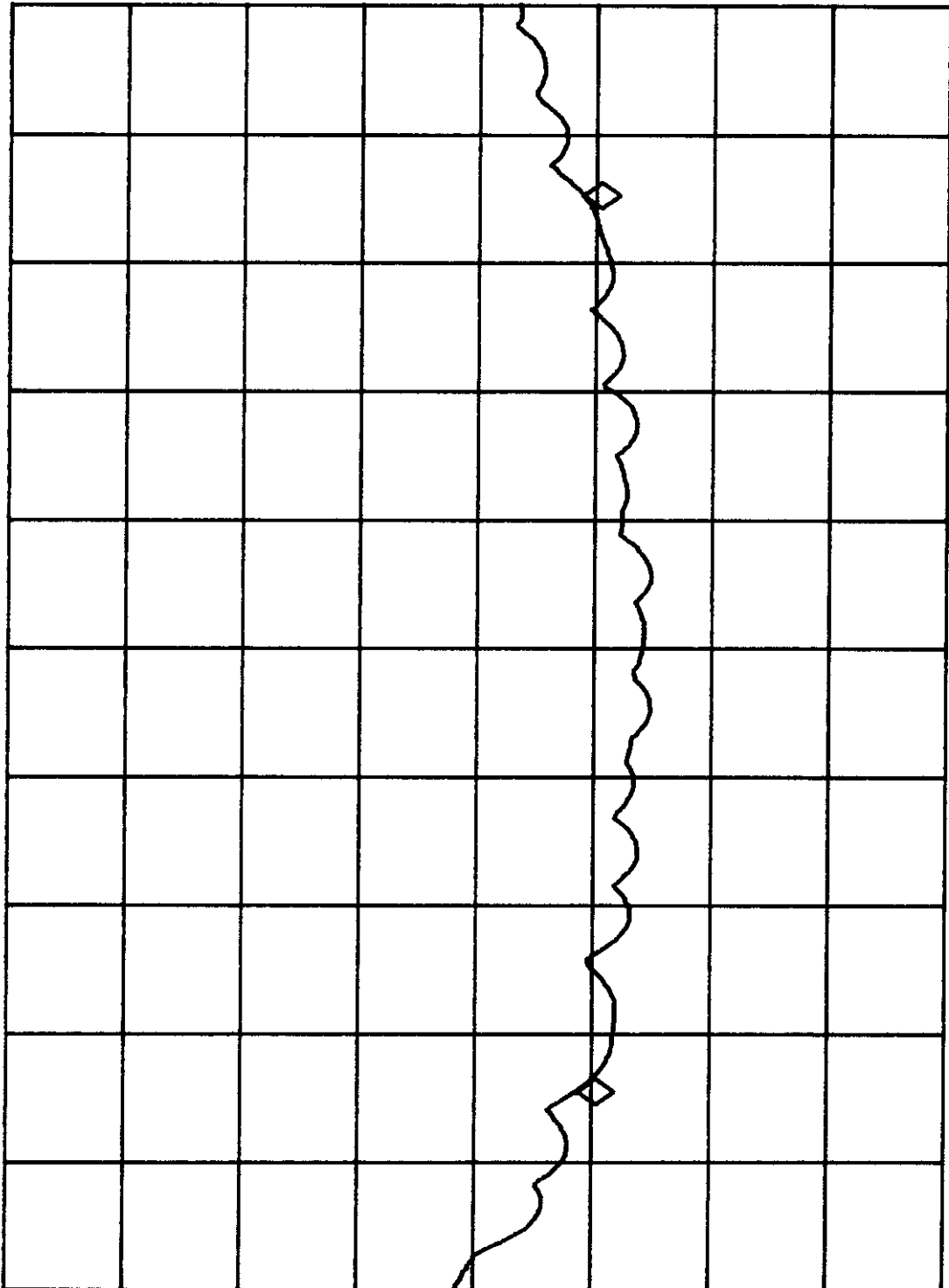
dB/

OFFST

6.0

dB

VA SB
SC FC
CORR



CENTER 923.580 MHz

#RES BW 100 KHz

#VBW 1 MHz

SPAN 2.000 MHz

SWP 20 msec

EXHIBIT 4

POWER OUTPUT PLOT

13: 59: 44 APR 22, 1998

13: 52: 30 APR 22, 1998

MKR 924.70 MHz

REF 37.0 dBm ATTEN 40 dB

19.92 dBm

PEAK

LOG

10

dB/

OFFST

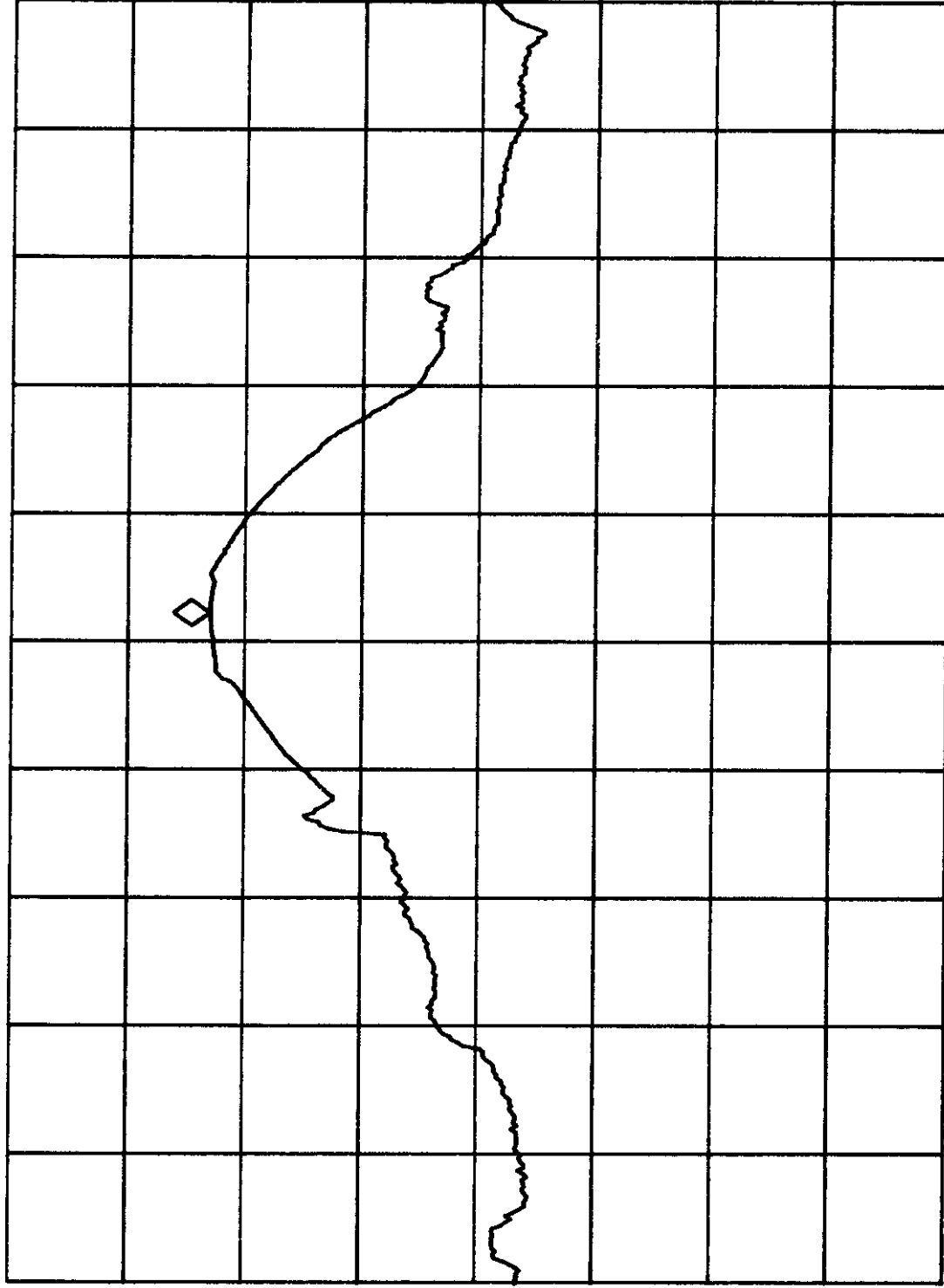
10.0

dB

VA SB

SC FC

CORR



CENTER 923.58 MHz

#RES BW 5.0 MHz

SPAN 50.00 MHz

SWP 20 msec

#VBW 3 MHz

EXHIBIT 10

PROCESSING GAIN

TESTING:

Methodology

The receiver utilizes a Signetics NE604A Received Signal Strength Indication (RSSI) integrated circuit for demodulation. The NE604 RSSI output, when connected to the integrator circuit on the digital board, produces a 500 mV per 10 dB change in signal strength output. Since this signal is the one actually used for demodulation by the receiver, the last test will show that a voltage differential of at least 12 dB is experienced when the system spreading code is turned on and off. The spreading code will be manipulated at the transmission end of the system to facilitate the testing as the 1496 demodulator does not support CW operation as configured in the circuit. The NE604 detector transfer function is not linear over the dynamic range of the device, however. Because of this, we thought that a more representative view of the processing gain of the system should be measured at the correlator's output first wide band, and then with the 110 kHz filter applied (ie. as the detector "sees" it). Another test is included at this point to show the jamming margin of the system for completeness.

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TEST #1

This test shows the output of the 1496 decorrelator with a RF spread spectrum input signal that is decorrelated versus a CW input signal of the same power.

NOTE: These signals are not band limited by the 110 kHz bandwidth filter. These photographs show just the difference in demodulator output with the two types of signals. Test Configuration #2.

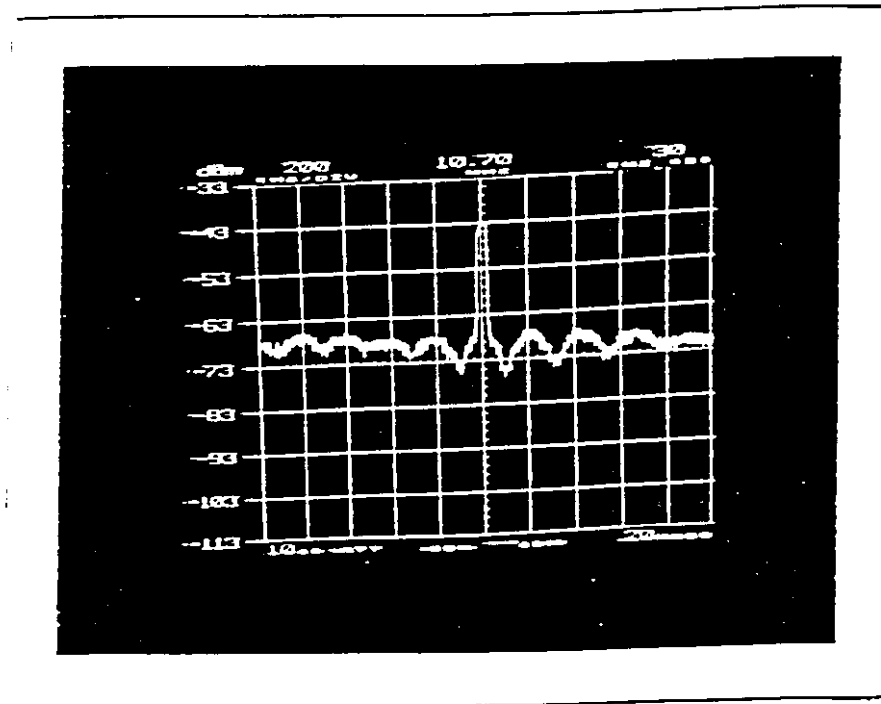


Exhibit IX, Illustration IX-B
Spread spectrum signal input at 900 MHz, 10.7 MHz IF output after decorrelation.

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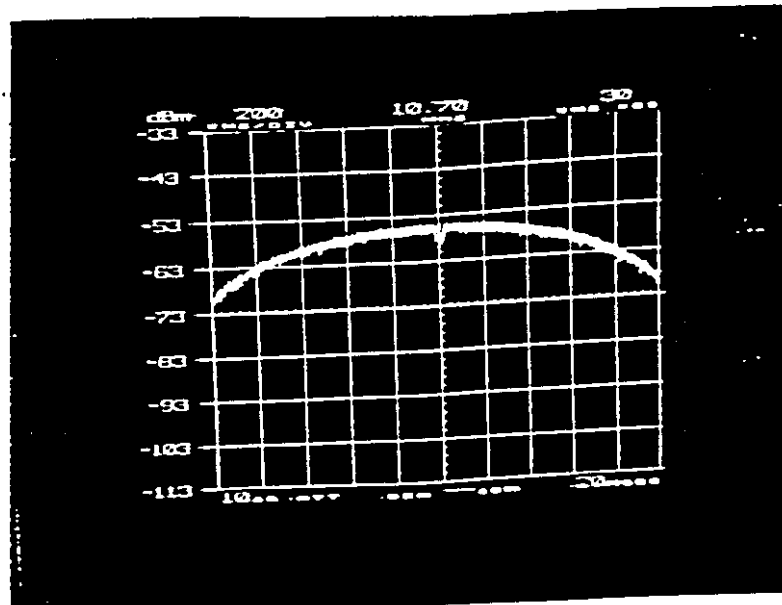


Exhibit IX, Illustration IX-C
CW signal input at 900 MHz, 10.7 MHz IF output after decorrelator.

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Testing Performed By:


Robert J. Davis, Senior RF Engineer
Life Point Systems

6-23-98

Date

C & K Systems SN912-RCV

TEST #2

Same as Test #1, with the exception that a 110 kHz bandpass filter is following the decorrelator. Test Configuration #1.

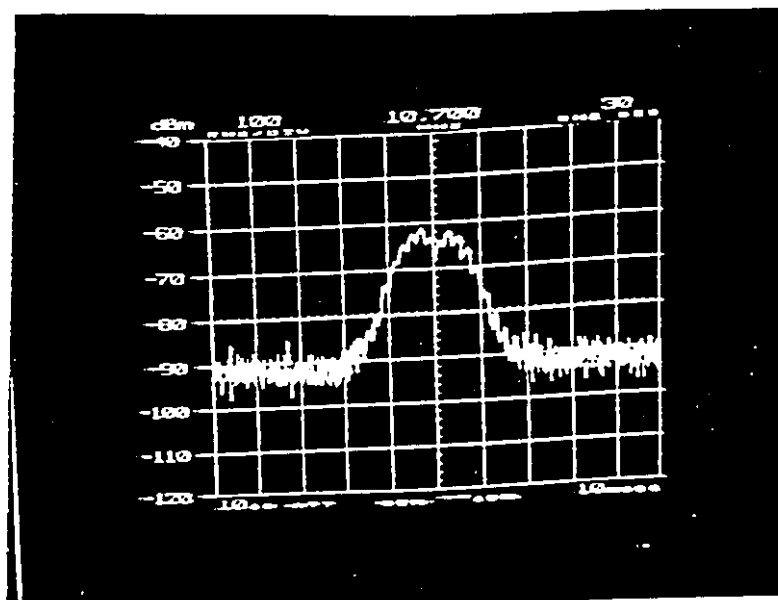


Exhibit IX, Illustration IX-D

Spread spectrum signal input at 900 MHz, 10.7 MHz output after decorrelator band limited to 110 kHz.

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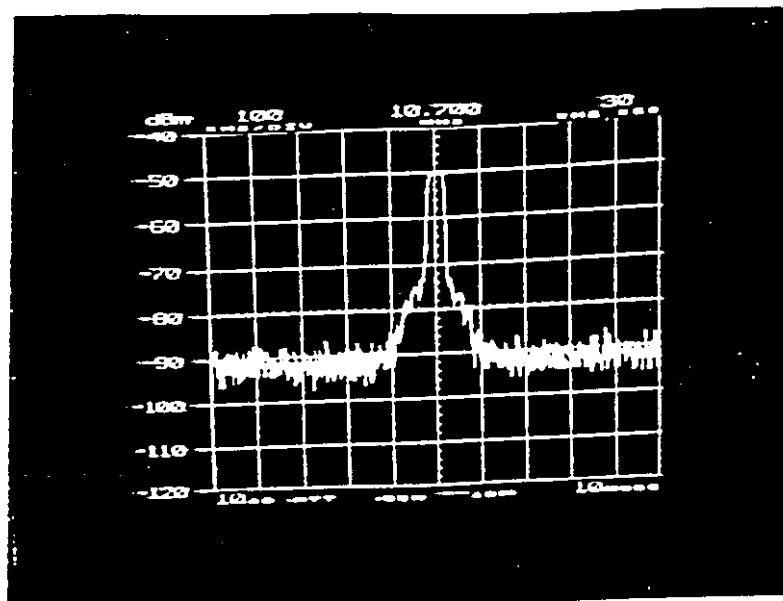


Exhibit IX, Illustration E
CW signal input at 900 MHz, 10.7 MHz output after decorrelator band limited to 110 kHz.

NOTE: Process gain of at least 12 dB.

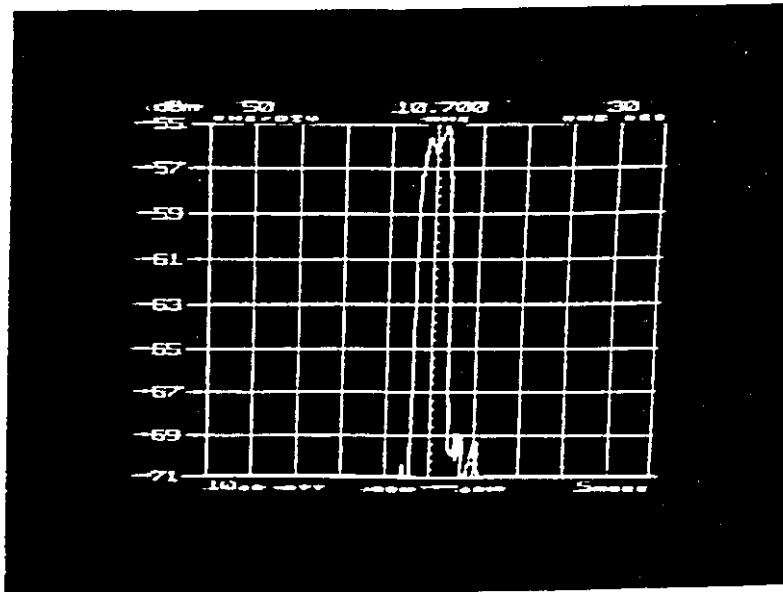


Exhibit IX, Illustration IX-F
Same as Illustration IX-D, with the exception of spectrum analyzer dB scale set to 2 dB per division to show finer amplitude resolution. SNR = 13 dB.

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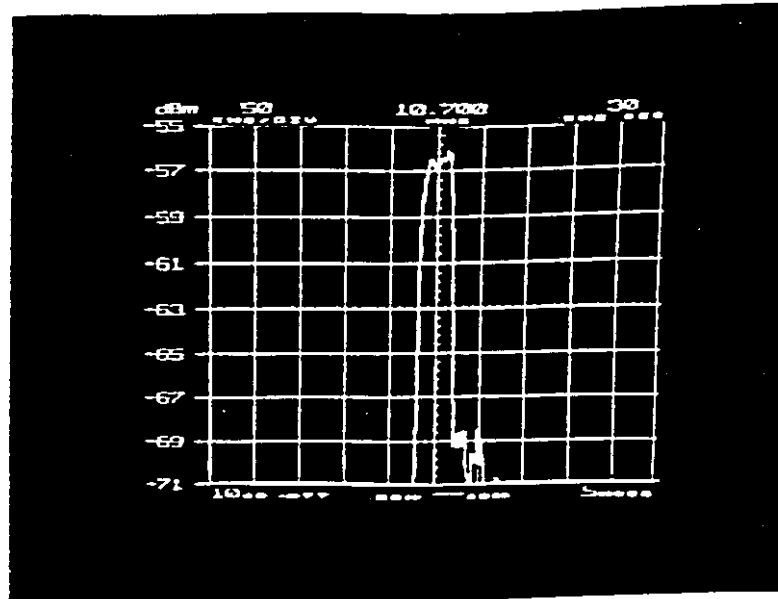


Exhibit IX, Illustration IX-G

Same as Illustration IX-F, with the exception that the receiver pseudo-random codes are purposely offset by 1/8 chip delayed from the transmitter (ie. worse case offset due to system implementation), showing roughly 1 dB delta in SNR.

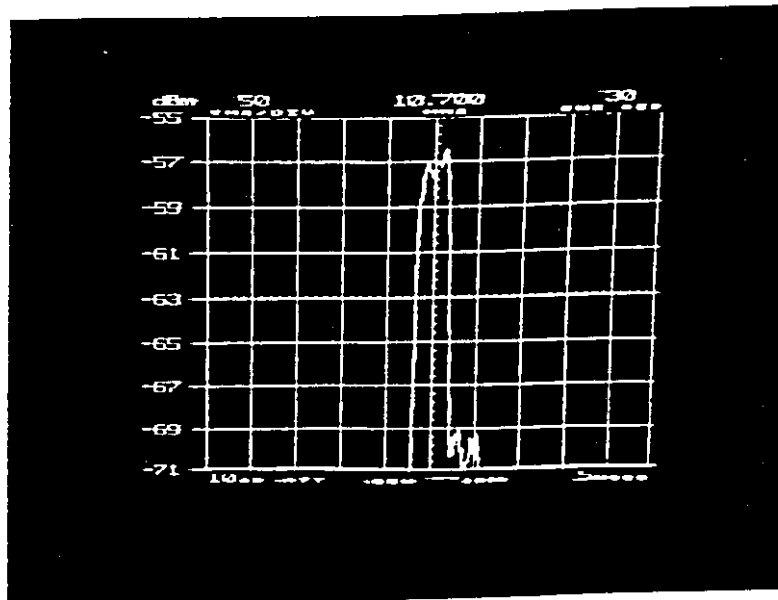


Exhibit IX, Illustration IX-H

Same as Illustration IX-G, with the exception that receiver pseudo-random codes are advanced 1/8 chip, showing roughly 1 dB delta in SNR.

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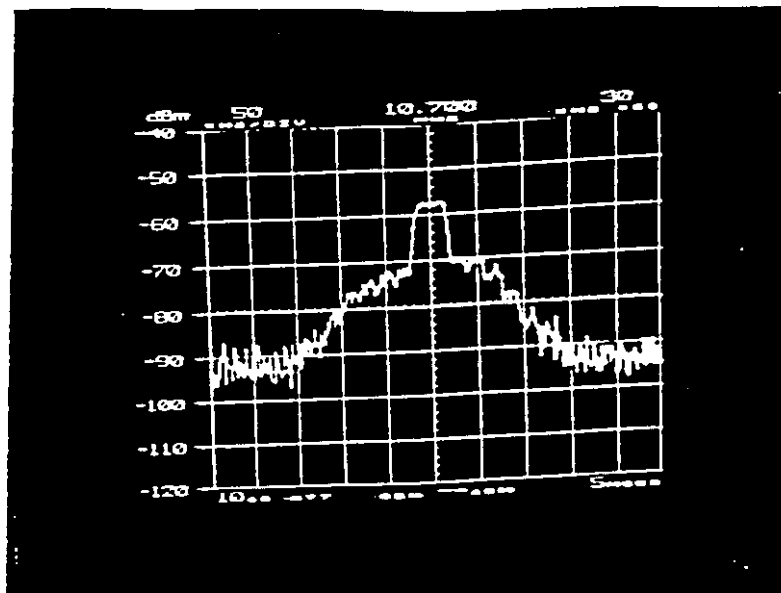


Exhibit IX, Illustration IX-I

Same setup as Illustration IX-H with the exception that the Mini Circuits RF switch at 900 MHz has been replaced with a 3 dB splitter/combiner to apply both spread spectrum and CW signals to the receiver input at the same power. Jamming SNR = 12 dB.

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Testing Performed By:

Robert J. Davis

Robert J. Davis, Senior RF Engineer
Life Point Systems

6-23-92

Date

C & K Systems SN912-RCV

TEST #3

Test Configuration #3. The 1496 output is connected to the NE604A through the Murata 110 kHz bandpass filter (normal operating condition). The integrated RSSI signal is probed with the LeCroy scope at the A to D input of the master processor. This signal will change 500 mV for each 10 dB change in signal strength input to the NE604A (100 mV for 2 dB, 50 mV for 1 dB, etc.). The Mini Circuits RF switch is switched between CW and correlated spread spectrum output (ie. the selected spread spectrum output signal from the Mini Circuits mixer generated by the chipping code from the PRC generator is in synchronization with the chipping signal presented to the receiver's 1496 decorrelator). This produces a voltage change at the A to D input of the master processor (via the integrator circuit) whose peak to peak voltage will show the processing gain of the receiver, as the master processor encounters it. This RSSI signal is used for all system acquisition and data demodulation functions and is the correct "demodulator output" to measure in our system to show compliance with 15.247(e) when the peak to peak voltage excursion is scaled with the 500 mV per 10 dB factor mentioned above (ie. 13 dB of process gain would produce a 650 mV peak to peak signal.).

The following Illustration IX-J shows the oscilloscope readings of RSSI (signal) detector change at input to master processor A to D converter for three receiver signal strength inputs at 900 MHz showing minimal indication of process gain at 12 dB.

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Integrated RSSI Voltage Readings vs. Signal Strength Input
for the C & K SN912-RCV Receiver with
A Spread Spectrum Input Signal vs.
A CW Input Signal of the Same Magnitude

SIGNAL LEVEL at 900 MHz (dBm)	RSSI LEVEL (mV)		DELTA (mV)
	CW	SPREAD SPECTRUM	
-90.0	895	1535	640
-80.0	1365	2100	735
-70.0	1960	2755	795
-60.0	2590	3225	635
-50.0	3050	3600	550

Exhibit IX, Illustration IX-J

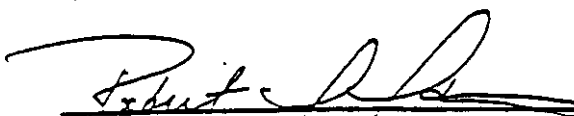
NOTE: Although the RSSI delta value indicates that the process gain exceeds 12 dB in some cases, this is caused by the non-monotonic nature of the NE604 detector in its mid-band region. The readings that show the smallest deltas are the most accurate.

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Testing Performed By:


Robert J. Davis, Senior RF Engineer
Life Point Systems

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Date
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