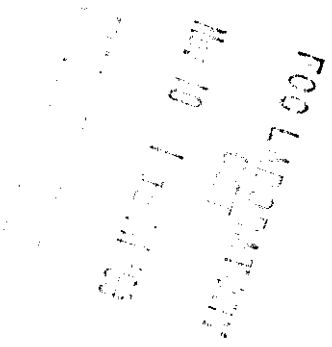
Repeater Technologies

Appendix C

Measurements of Power, Modulation and Occupied Bandwidth, Spurious, Freq. Stability

Measured Test Data

The OA850C REPEATER was tested as required by 47 CFR 2.985 through 2.997, inclusive, in accordance with §2.999.



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2.985: RF Power Output

Requirement

For the power levels expected, spurious signals including intermodulation distortion must meet industry and FCC requirements. The industry specification is published as IS-95-A and IS-97-A standards for CDMA cellular systems. The FCC requirement is governed by Title 47, CFR, part 22.917.

Industry specification, Forward Path: The power in a 30 kHz bandwidth at ± 750 kHz away from the center frequency shall be less than -45 dBc relative to the mean output power in the tuned CDMA channel. The power in a 30 kHz bandwidth at ± 1.98 MHz away from the center frequency shall be less than -60 dBc relative to the mean output power in the tuned CDMA channel (IS-95 section 7.1.4.2). These are measured at rated output power +38.5 dBm per channel and the input is an IS-97-A defined CDMA signal (see table below, IS-97 section 12.5.2) or its equivalent (e.g. synthesized CDMA waveform from HP MCSS system).

Type	Number of Channels	Fraction of Power (linear)	Fraction of Power (dB)	Comments
Pilot	1	0.2000	-7.0	Code channel 0
Sync	1	0.0471	-13.3	Code channel 32, always 1/8 rate
Paging	1	0.1882	-7.3	Code channel 1, full rate only
Traffic	6	0.09412	-10.3	Variable code channel assignments; full rate only

Industry specification, Reverse Path: In the reverse direction, the same signal is used except that Paging, Traffic, and Sync are turned off (pilot only), rated output power is +18 dBm per channel. Spurious emission levels shall not exceed -42 dBc/30-kHz at ± 885 kHz from the center frequency, and -54 dBc/30-kHz at ± 1.98 MHz.

FCC Requirement: Forward & Reverse Paths: Section 22.913 states that the spurious signal attenuation shall be at least 43 + 10log(output power), dB. The limit is -13 dBm.

Test Equipment

The following equipment was utilized:

1. HP Multi-format Communications Signal Simulator (MCSS)
2. HP 8593E Spectrum Analyzer
3. HP 438A Power Meter, with HP8481A sensor
4. 3 30 dB N type attenuators
5. 0 – 50 dB, 10 dB step attenuator
6. Weinschel Model 905 continuously adjustable attenuator, 0 to 10 dB
7. HP ThinkJet Printer

Test Notes

The repeater input power is adjusted until the rated output power is measured on the power meter. The output is then connected to the spectrum analyzer for spectral display plots. The spectrum analyzer reference level offset is entered to compensate for attenuators and cable losses.

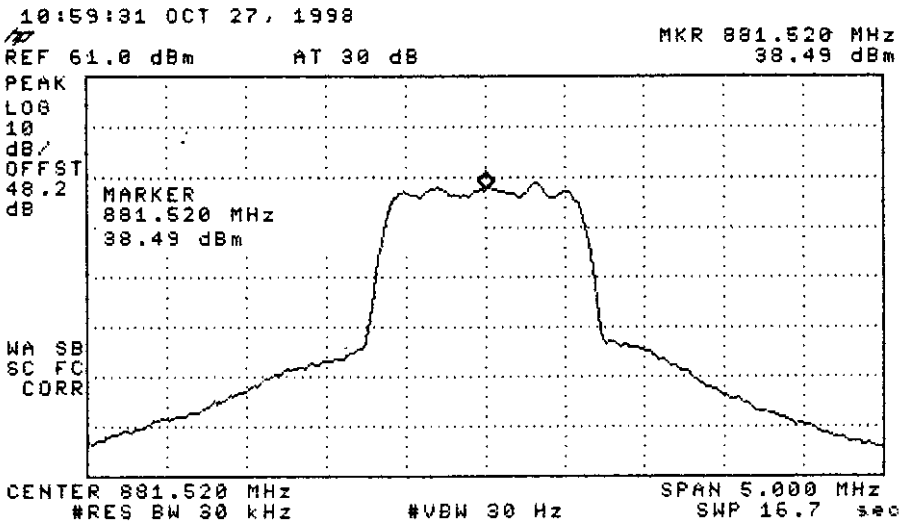
IS-95/97-A "mask" spectral plots are plotted in the industry standard resolution bandwidth (RBW) of 30-kHz. A noise-bandwidth conversion of 16 dB is added to the dBc measurement to convert the 1.25-MHz signal power bandwidth to 30-kHz.

Test Data, Output Power and Emissions

Summarized as follows:

Direction/ Channel	Figures	Rated Output Power, dBm	Requirement	Pass/Fail	Margin, dB
Forward Channel 1	C1.1	+38.5	Rated Output	PASS	Rated Output
			IS-95-A, IS-97-A:		
	C1.2		45 dBc, 750 kHz		1.3
	C1.3		60 dBc, 1.98 MHz		2.5
Forward Channel 2	C1.4	+38.5	Rated Output	PASS	Rated Output
			IS-95-A, IS-97-A:		
	C1.5		45 dBc, 750 kHz		3.9
	C1.6		60 dBc, 1.98 MHz		4.9
Forward Channel 1	C1.7	+38.5	47 CFR 22.917	PASS	5
	C1.8		< -13 dBm		>12
Forward Channel 2	C1.9	+38.5	47 CFR 22.917	PASS	5
	C1.10		< -13 dBm		>12
Reverse Channels 1&2	C1.11	+18	Rated Output	PASS	Rated Output
			IS-95-A, IS-97-A:		
	C1.12		42 dBc, 885 kHz		4.4
	C1.13		54 dBc, 1.98 MHz		2.2
	C1.14		42 dBc, 885 kHz		9.2
	C1.15		54 dBc, 1.98 MHz		3.7
Reverse Channels 1&2	C1.16	+18	47 CFR 22.917	PASS	>20
	C1.17		< -13 dBm		>20

Summary: The OA850C NR meets industry and FCC specifications for emissions, when transmitting at rated output power.



Forward Channel 1

Figure C1.1

Rated Output Power

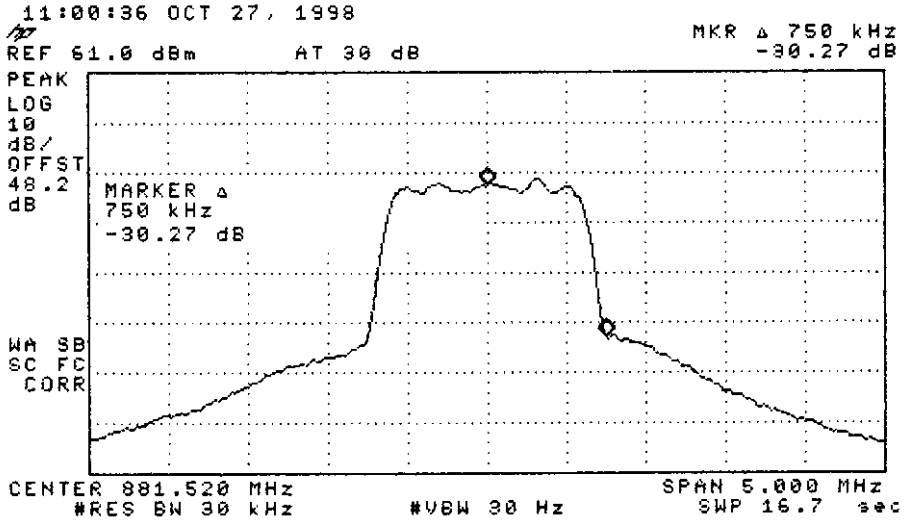


Figure C1.2

IS-95/97-A Mask

30.27

+16

46.27 dBc

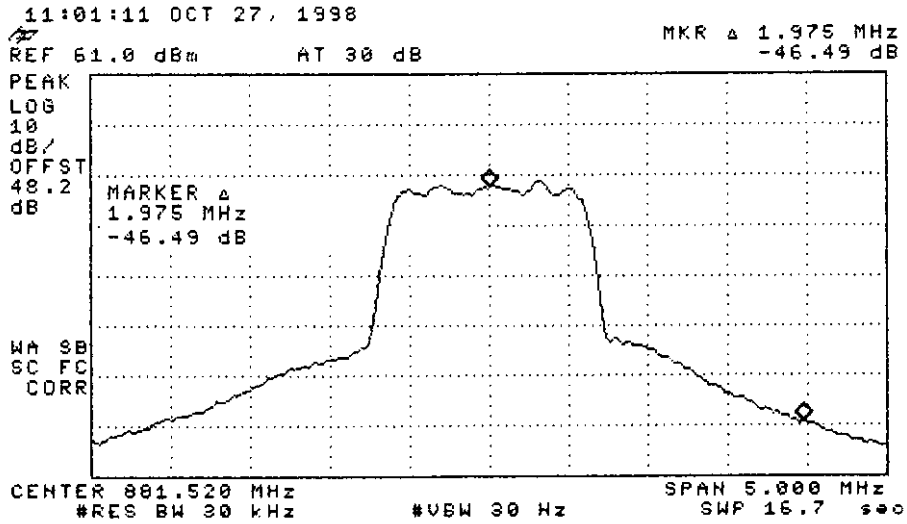


Figure C1.3

IS-95/97-A Mask

46.49

+16

62.49 dBc

Forward Channel 2

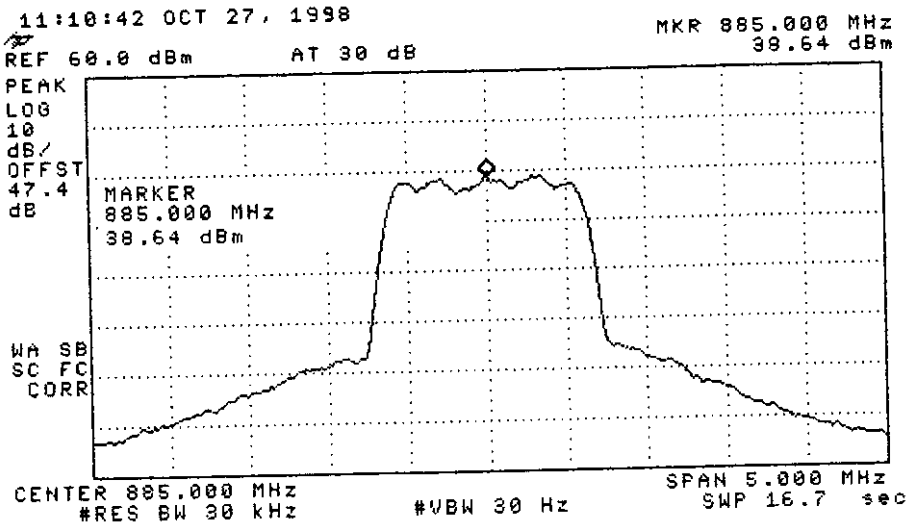


Figure C1.4

Rated Output Power

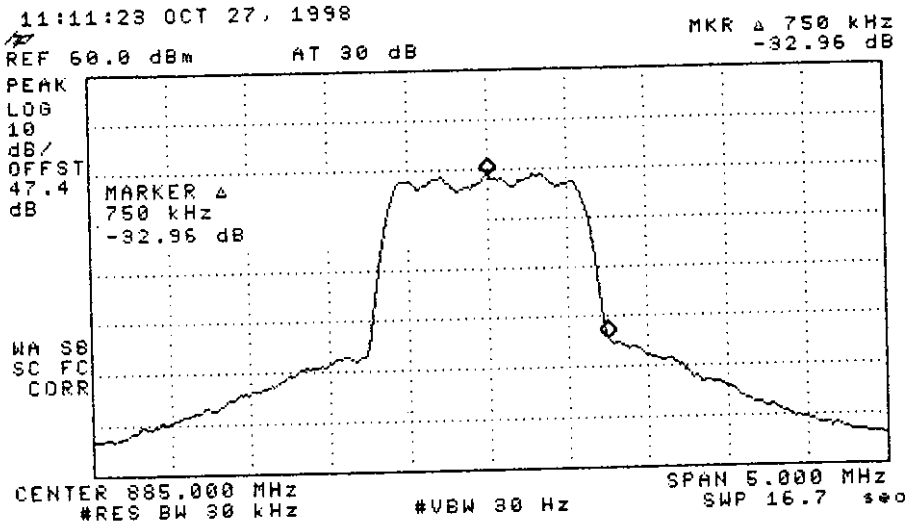


Figure C1.5

IS-95/97-A Mask

32.96

+16

48.96 dBc

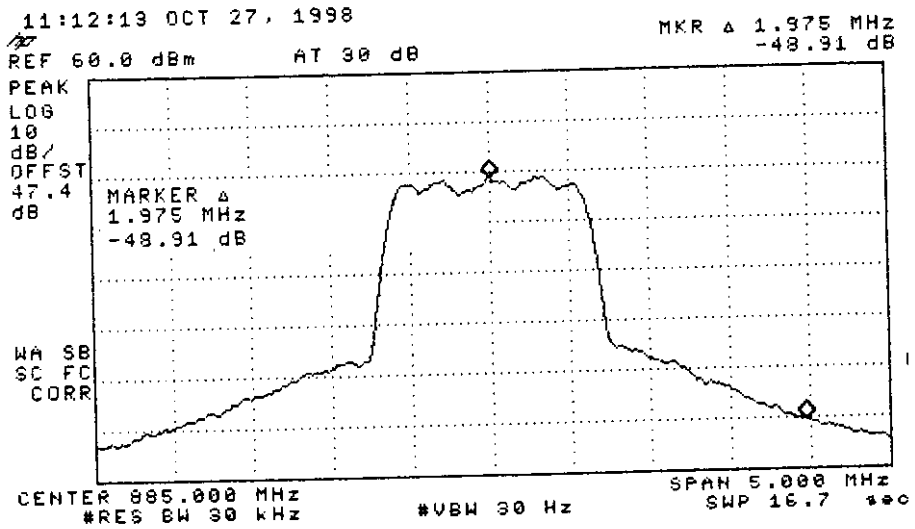


Figure C1.6

IS-95/97-A Mask

48.91

+16

64.91 dBc

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Forward Channel 1

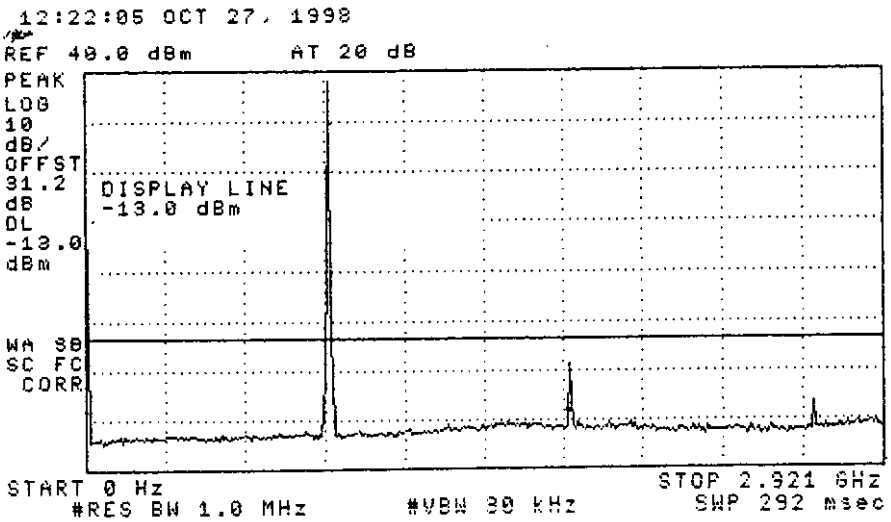


Figure C1.7

FCC limit:

-13 dBm

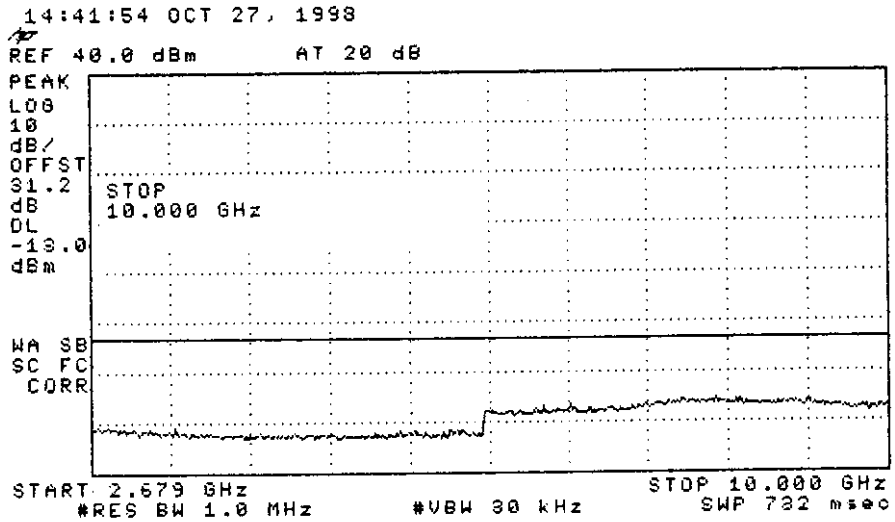
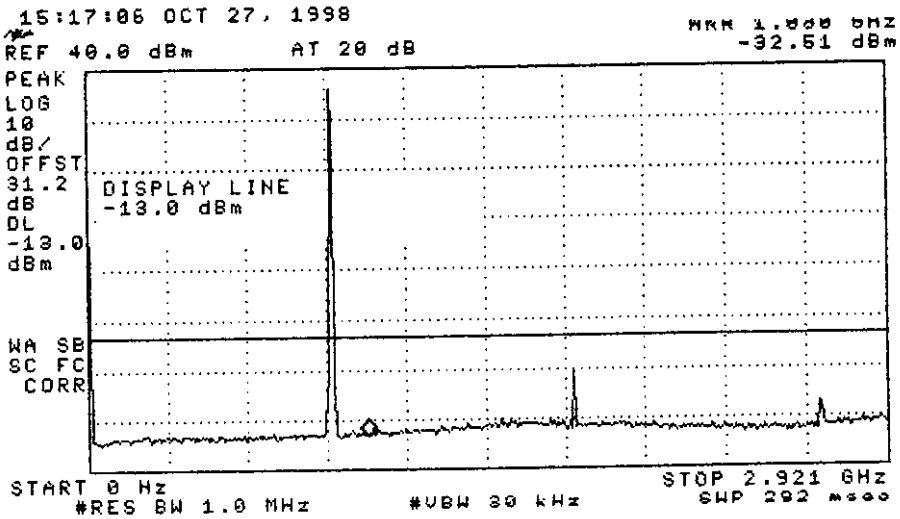


Figure C1.8

FCC limit:

-13 dBm



Forward Channel 2

Figure C1.9

FCC limit:

-13 dBm

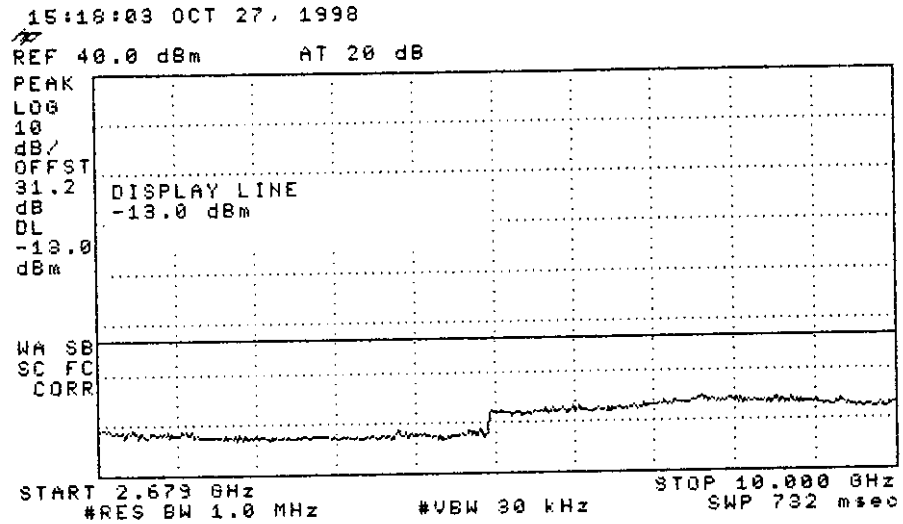
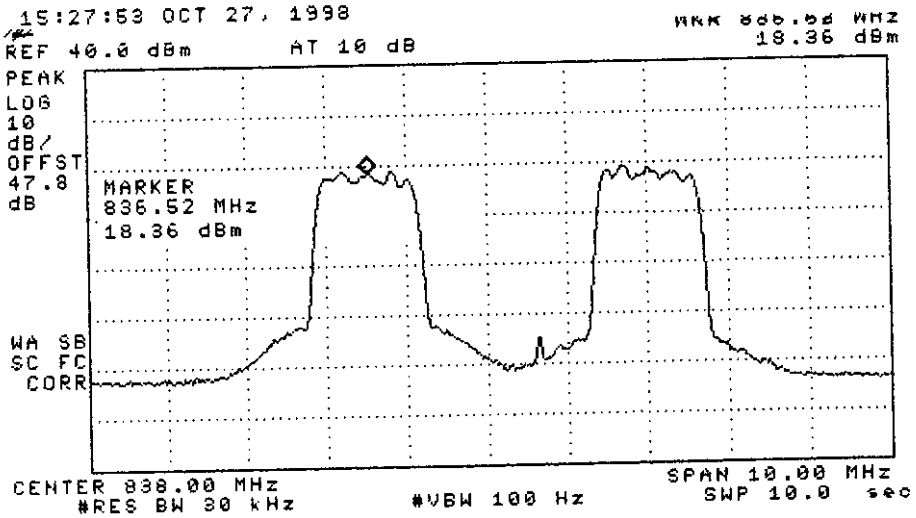


Figure C1.10

FCC limit:

-13 dBm



Reverse Channel 1 & 2

Figure C1.11

Rated Output Power

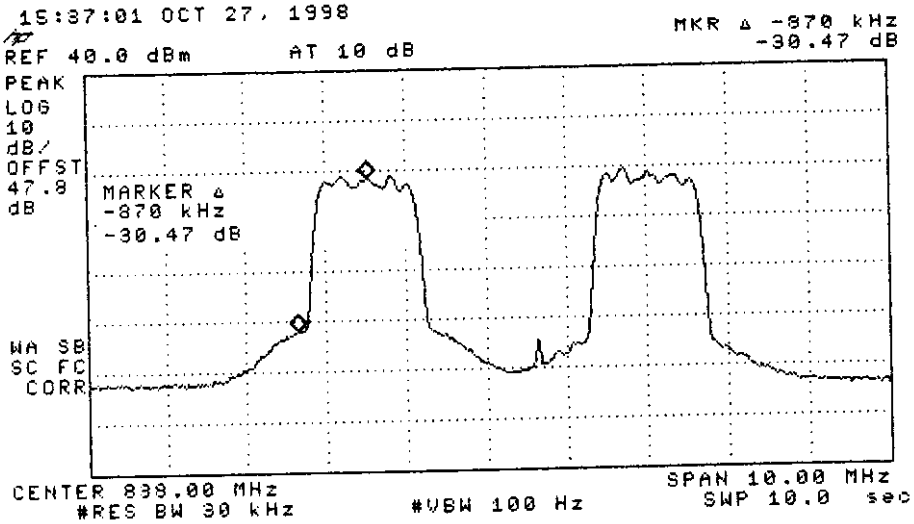


Figure C1.12

Reverse Channel 1

IS-95/97-A Mask

30.47

+16

46.42 dBc

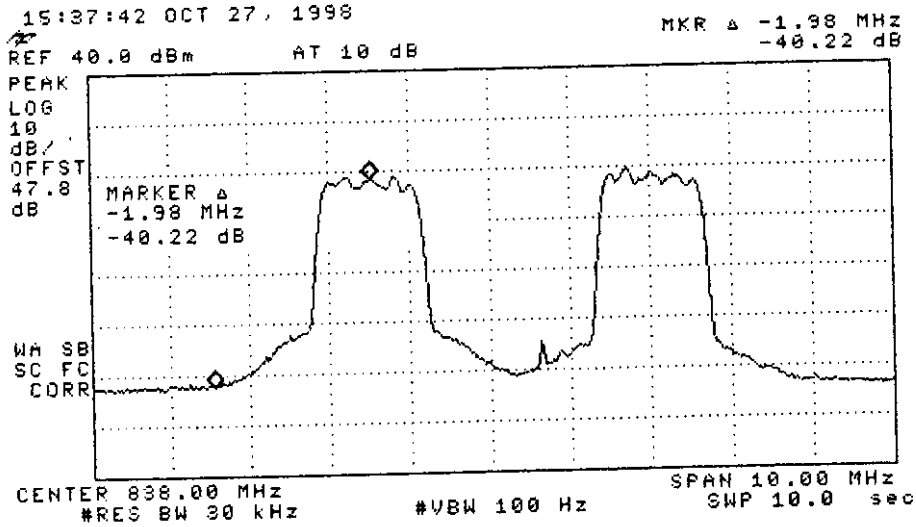


Figure C1.13

Reverse Channel 1

IS-95/97-A Mask

40.22

+16

56.22 dBc

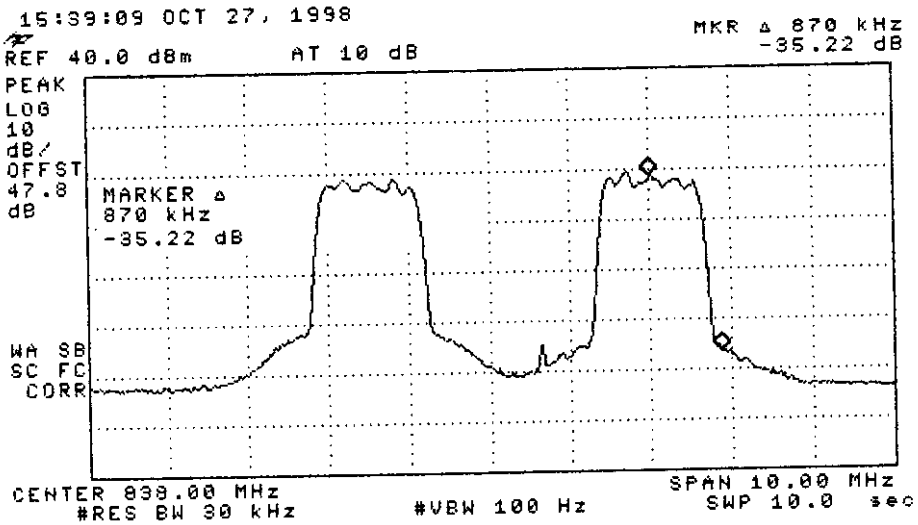


Figure C1.14
Reverse Channel 2
IS-95/97-A Mask
35.22
+16
51.22 dBc

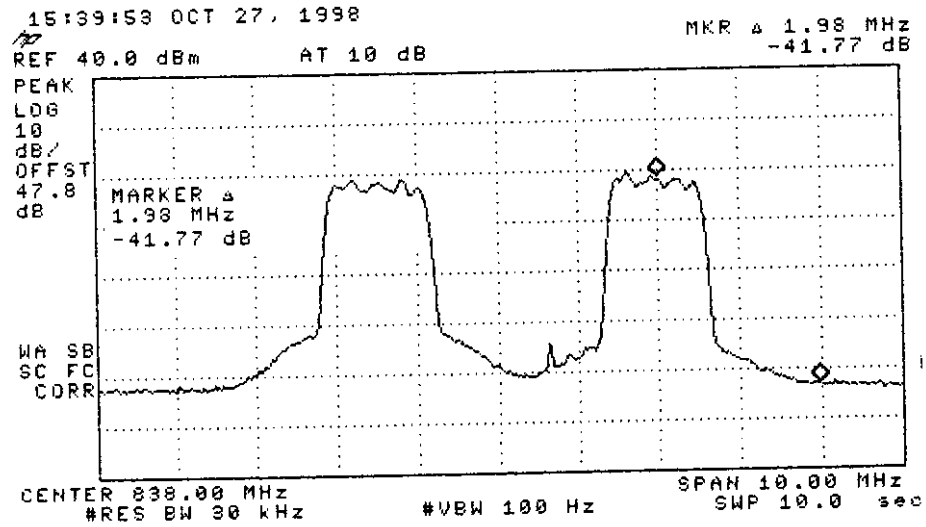


Figure C1.15
Reverse Channel 2
IS-95/97-A Mask
41.77
+16
57.77 dBc

Reverse Channel 1 & 2

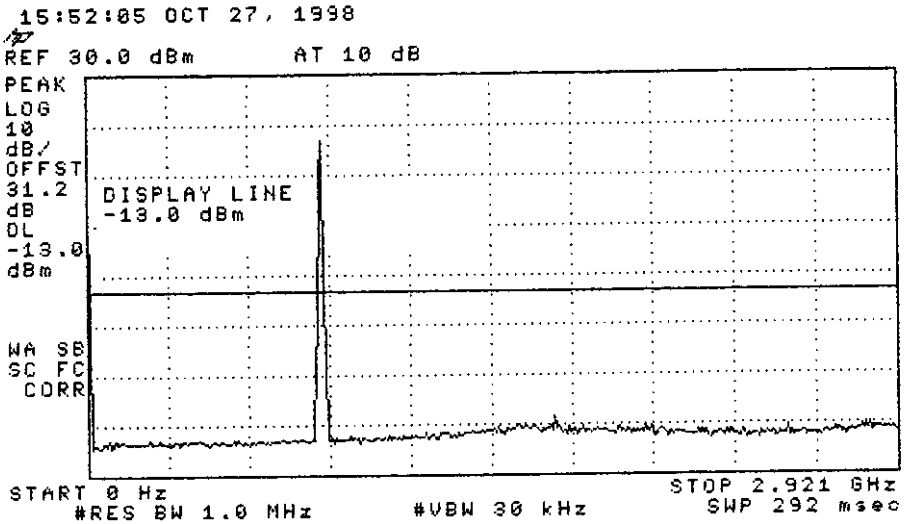


Figure C1.16

FCC limit:

-13 dBm

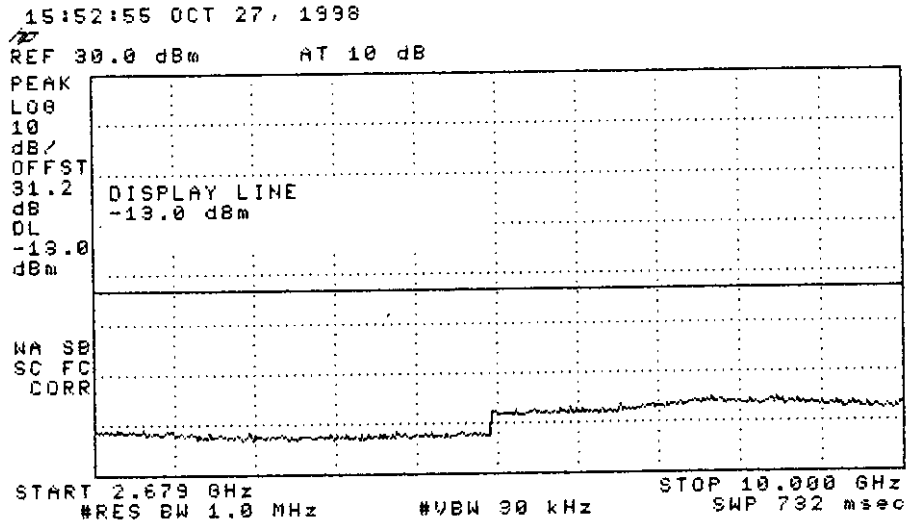


Figure C1.17

FCC limit:

-13 dBm

2.987: Modulation Characteristics
2.989: Occupied Bandwidth

Requirements

A curve or equivalent data to show that the equipment will meet the modulation requirements of the rules under which equipment is to be licensed.

Test Method

The OA850C NR repeater does not create any modulation of its own, only amplification of input signals occurs.

The test modulation used was the modulation used in Cellular CDMA base stations.

With a CDMA test signal applied to the main mobile antenna and the base antenna ports, the corresponding outputs were observed on a spectrum analyzer.

For each measurement direction, the transmitter was set to rated output power. A comparison of output spectrum to input spectrum was made.

Test Equipment

The following equipment was utilized:

1. HP Multi-format Communications Signal Simulator (MCSS)
2. HP 8593E Spectrum Analyzer
3. HP 438A Power Meter, with HP8481A sensor
4. 3 30 dB N type attenuators
5. 0 – 50 dB, 10 dB step attenuator
6. Weinschel Model 905 continuously adjustable attenuator, 0 to 10 dB
7. HP ThinkJet Printer

Test Results

The output signal spectrum as well as the input signal spectrum were recorded and compared. Within nominal measurement error, it was concluded that the OA850C NR does not change the occupied bandwidth or modulation characteristics. The output is within allowable limits.

Forward Channel 1

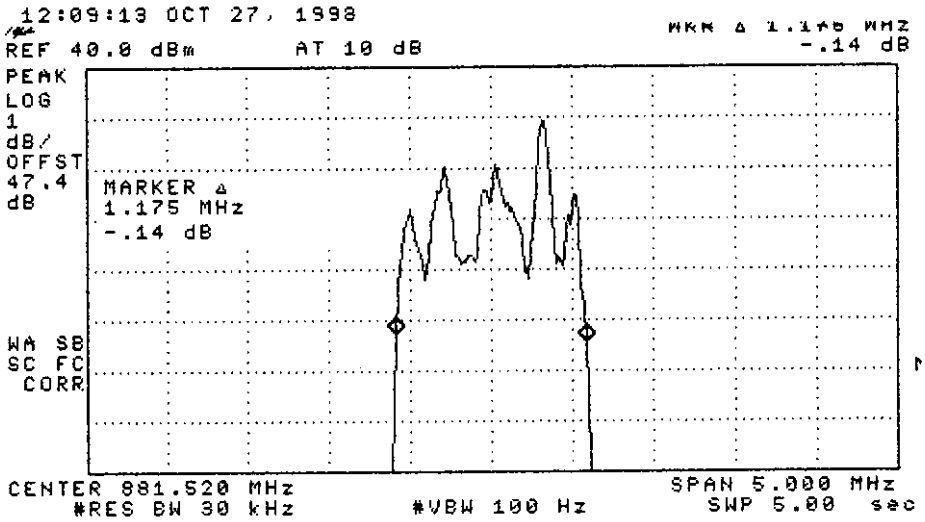


Figure C2.1
Repeater CDMA
Output
Bandwidth

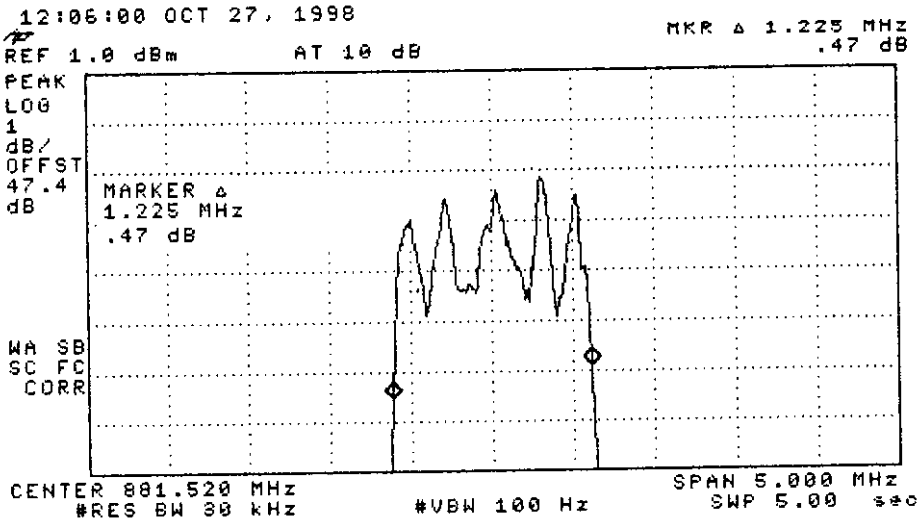


Figure C2.2
Test Source
CDMA
Output
Bandwidth

Forward Channel 2

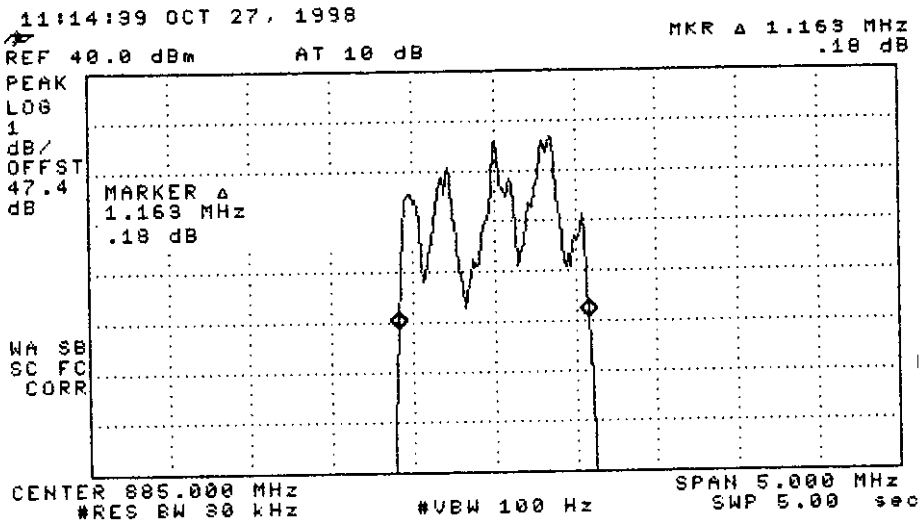


Figure C2.3
Repeater CDMA
Output
Bandwidth

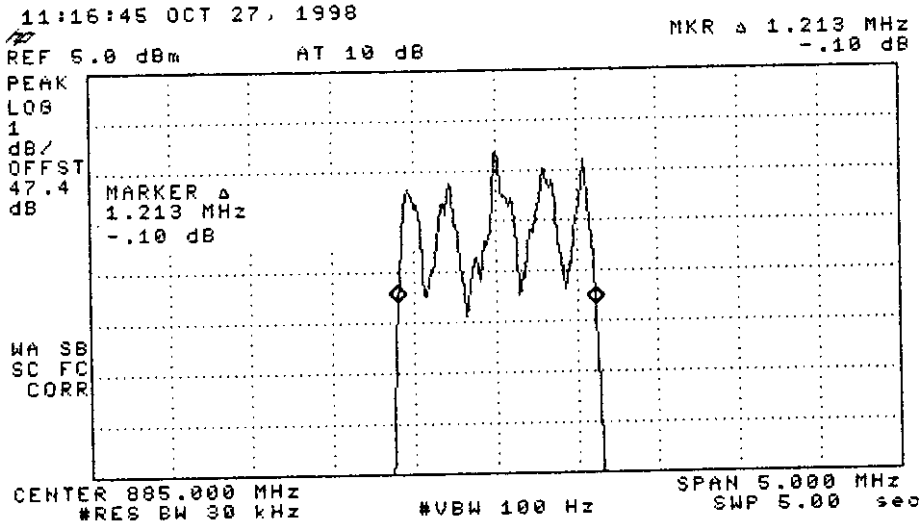


Figure C2.4
Test Source
CDMA
Output
Bandwidth

Reverse Channel 1

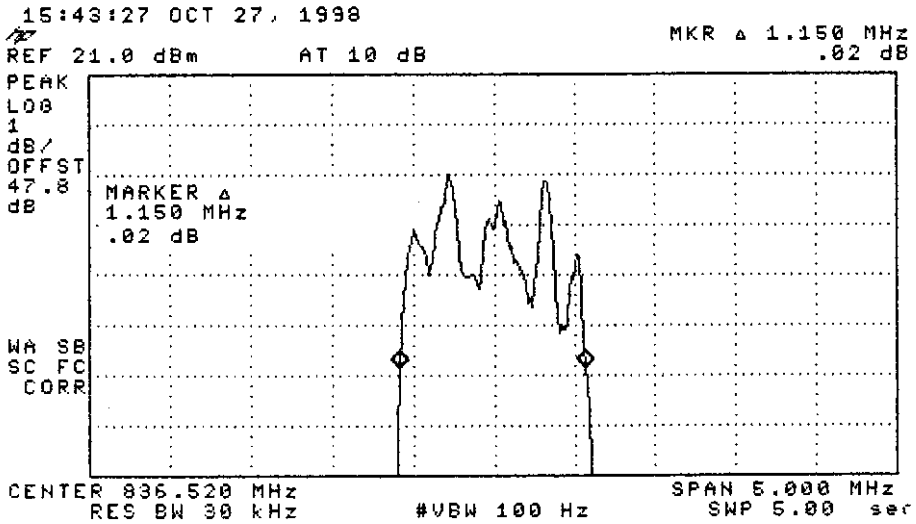


Figure C2.5
Repeater CDMA
Output
Bandwidth

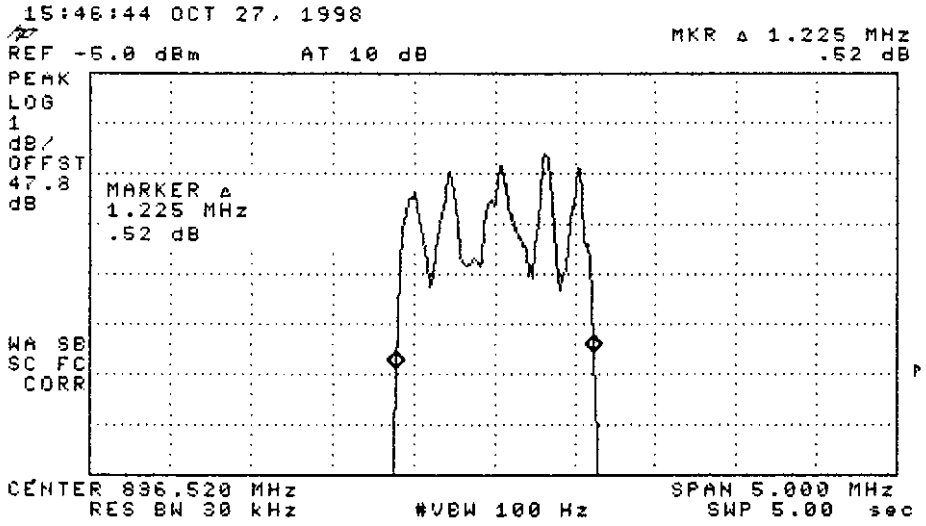


Figure C2.6
Test Source
CDMA
Output
Bandwidth

Reverse Channel 2

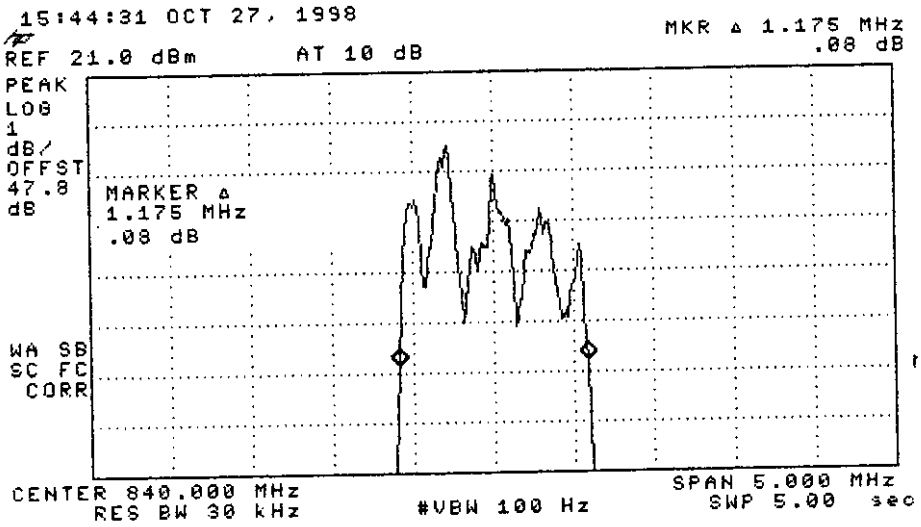


Figure C2.7
Repeater CDMA
Output
Bandwidth

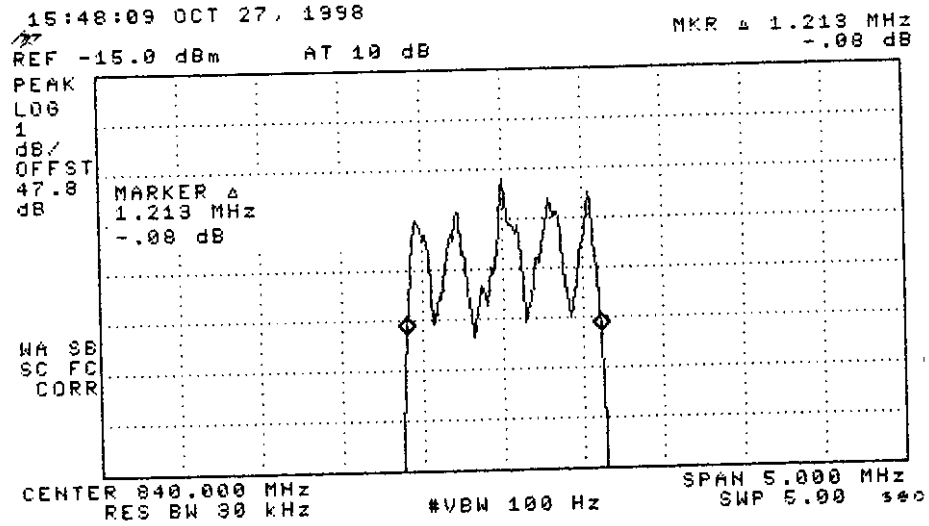


Figure C2.8
Test Source
CDMA
Output
Bandwidth

2.991: Spurious Emissions at the Antenna Terminals

Requirements

Under §2.991, the radio frequency power generated within the equipment and appearing on a spurious frequency shall be checked at the output terminals. The frequency range of the measurement is to include harmonics.

Section 22.913 states that the spurious signal attenuation shall be at least 43 + 10log(output power), dB. The limit is -13 dBm.

Test Method

The OA850C NR repeater was operated with a 30 dB dummy load at each antenna port. Thus, the transmitters were each terminated into the design load impedance of 50 Ohms.

A microwave spectrum analyzer was used to measure each output. Outputs were checked for spurious and/or harmonic signals, to a frequency of ten times the fundamental transmit frequency.

The repeater input power is adjusted until the rated output power is measured on the power meter. The output is then connected to the spectrum analyzer for spectral display plots. The spectrum analyzer reference level offset is entered to compensate for attenuators and cable losses.

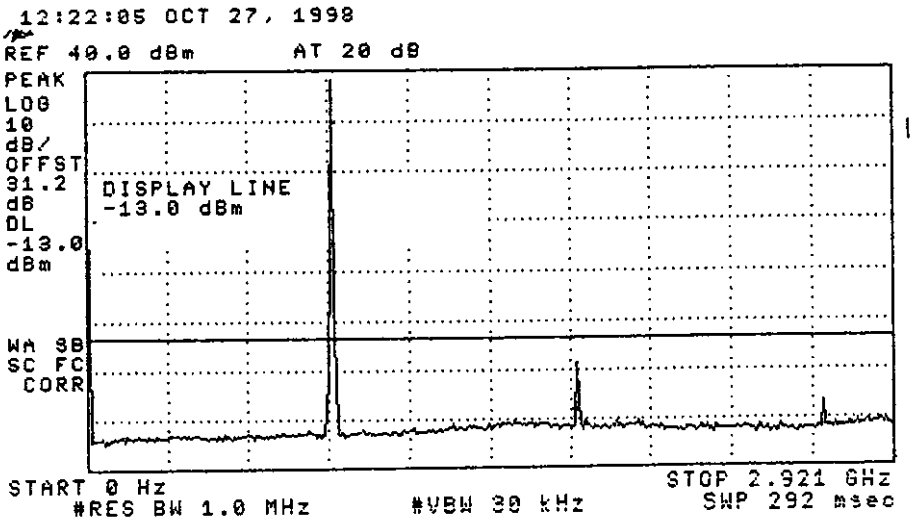
Test Equipment

The following equipment was utilized:

1. HP Multi-format Communications Signal Simulator (MCSS)
2. HP 8593E Spectrum Analyzer
3. HP 438A Power Meter, with HP8481A sensor
4. 3 30 dB N type attenuators
5. 0 – 50 dB, 10 dB step attenuator
6. Weinschel Model 905 continuously adjustable attenuator, 0 to 10 dB
7. HP ThinkJet Printer

Test Results

Refer to Figures C3.1 through 3.6. The noise floor of the spectrum analyzer and its automatic internal band changing are visible. The OA850C NR complies with FCC rules and regulations for conducted spurious emissions.



Mobile Antenna Port,

Forward Channel 1

Figure C3.1

FCC limit:

-13 dBm

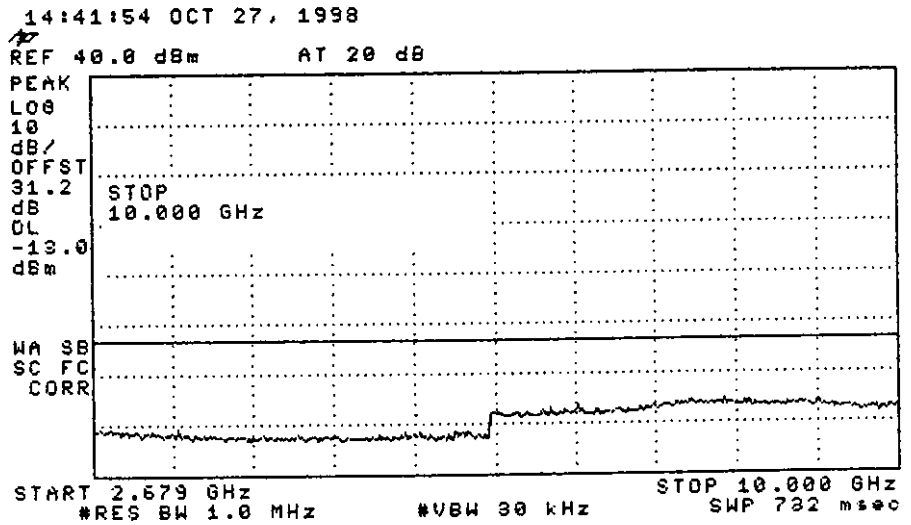


Figure C3.2

FCC limit:

-13 dBm

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Diversity Antenna Port,

Forward Channel 2

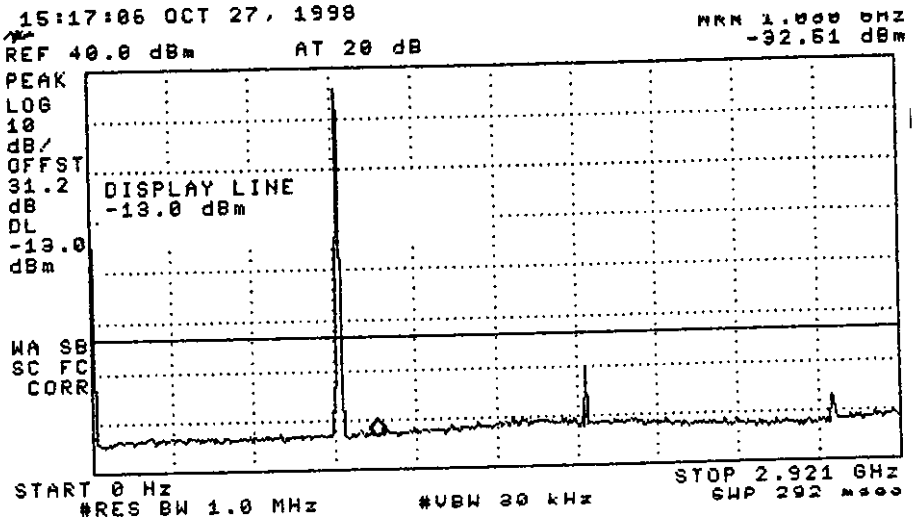

Figure C3.3

FCC limit:

-13 dBm

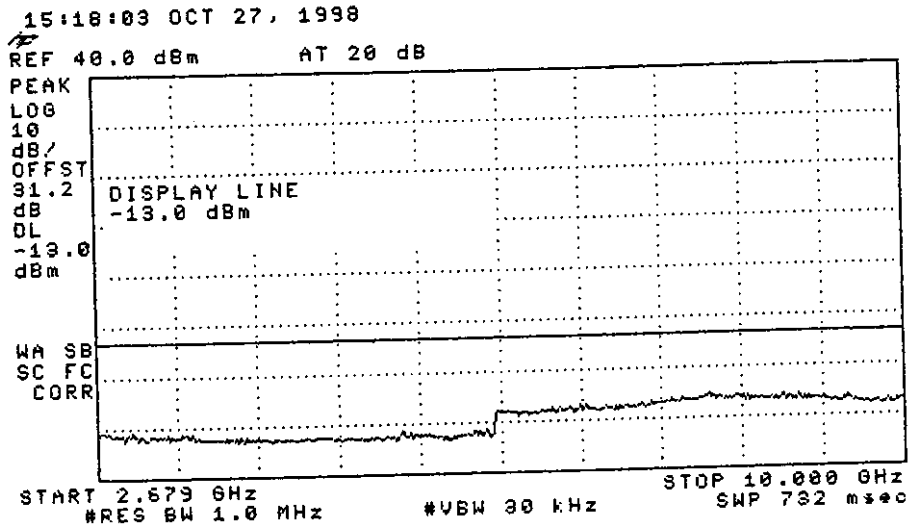

Figure C3.4

FCC limit:

-13 dBm

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Base Antenna Port,

Reverse Channels 1&2

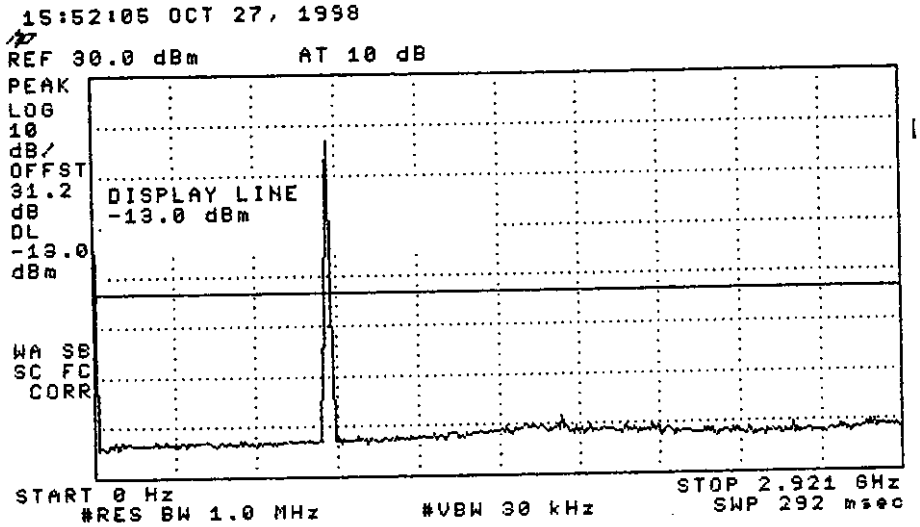

Figure C3.5

FCC limit:

-13 dBm

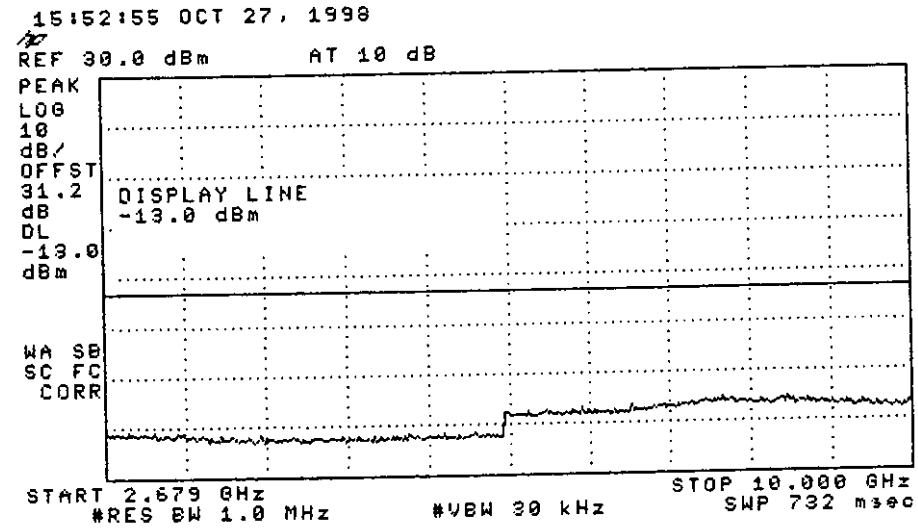

Figure C3.6

FCC limit:

-13 dBm

2.993: Field Strength of Spurious Emissions

Requirements

The OA850C NR is to be measured for spurious emissions, to a frequency of at least 10 times the rated highest output frequency (894-MHz). All spurious and harmonic signals are to be less than that which would be received by a -13 dBm transmitter into a ½ wave dipole, at the same distance as the DUT.

Test Method

The test location was an indoor open laboratory area with clear space on all sides of the equipment and test receiver. The OA850C NR REPEATER was operated with two forward channel CDMA input signals from the HP MCSS centered at 881.52 MHz and 885.00 MHz. The input signals were set to generate 7 Watts (+38.5 dBm) RF output power at repeater output antenna connectors. RF Attenuators (30 dB) were also connected to the antenna ports to provide the appropriate 50 ohm terminations.

A spectrum analyzer with suitable antennas was used as the test receiver. The antennas are listed below. Transmission line loss, between the measurement antenna and test receiver (spectrum analyzer), was entered into the spectrum analyzer as a reference level offset.

A sweep generator was used as a –13dBd signal source. A trace of the spectrum analyzer was used to record the amplitude of the substitution source across the frequency band. This result can be seen on the graphs as the wavy line above the measurement, roughly corresponding to the display line level. The display line is set to a calculated level, based on –13dBd minus path loss + RxAntennaGain – TransmissionLineLoss.

The test antenna was manually positioned with respect to DUT azimuth, elevation, and polarization, to maximize any spurious signals into the test receiver.

Test Equipment

The following equipment was utilized:

1. HP MCSS
2. HP 8593E Spectrum Analyzer
3. HP 438A Power Meter, with HP8481A sensor
4. 3 30 dB N type attenuators
5. HP 83620A Synthesized Sweeper
6. HP ThinkJet Printer
7. Transmit Antennas:

3 to 10 GHz	Coax to waveguide adapters (3)
1 to 3 GHz	Log-Periodic, Watkins Johnson
0.5 to 1 GHz	800 MHz ¼ wave whip
250 to 500 MHz	Larsen 350 MHz ¼ wave whip
60 to 250 MHz	Larsen 120 MHz ¼ wave whip
25 to 60 MHz	Lakeview 9106 ¼ wave whip

9. Receive Antennas

1 to 18 GHz	Horn, Double-ridged, Electro Metrics RGA-60
0.5 to 4 GHz	Log-Periodic, Watkins Johnson
25 to 500 MHz	Discone, with low-freq. extension whip, Diamond D-130

Test Results

See the following table for the calculation of test limits for the calculated path loss method and the substitution method.

Measurements were taken with the repeater DUT turned on, and then off, for comparison.

Each of the plots show three curves:

1. a display line at the power calculated to correspond with FCC limit of –13 dBd,
2. a stored trace that represents the substitution signal generator's received level,
3. the actual measurement from the DUT.

In all graphs, the actual measurement from the DUT is well below either of the thresholds. Therefore, radiated spurious emissions are FCC compliant.

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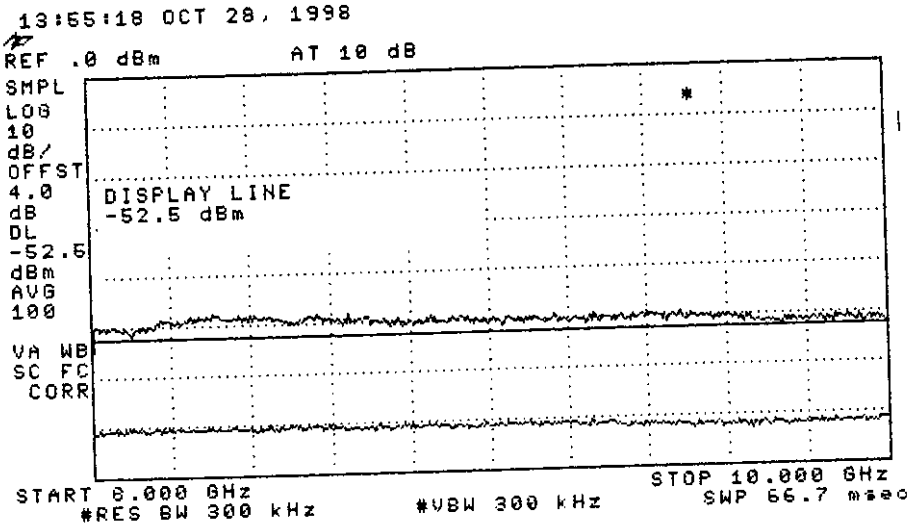
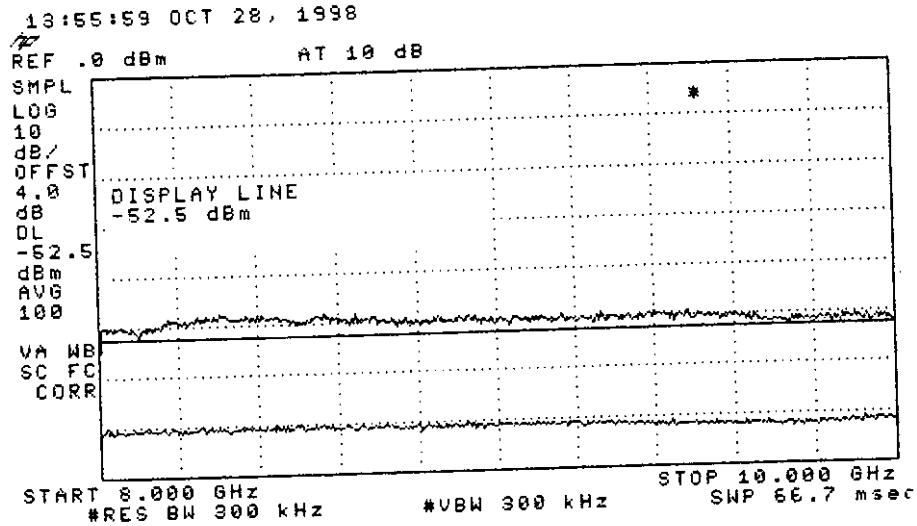
Table C4.1: Calculation of Test Limits, Spurious Emissions

Freq. Band		Calculation method, based on path loss									Substitution method				
Figure	Freq. range	Freq. for calc. of path loss, MHz	Base power level into dipole, dBm	Dist., DUT. to Rx. antenna, m.	Free Space path loss, dBi	Measurement Antenna	Rx. antenna gain, dBi	Transmission line, measurement antenna to measurement receiver	Cable loss (Spec. Analyzer Ref. Level offset), dB	Max. Allowed Rx. level, dBm (Display line setting)	Base power level into dipole, dBm	Substitution antenna type	Gain of substitution antenna, dBd	Cable loss driving substitution antenna, dB	*Tx Power into substitution antenna, dBm (sweeper out. Level)*
C4.1	8 to 10 GHz	9000	-13	1	51.5	Electro-Metrics Horn, Double-ridged, RGA-60	12	6' RG-142	4	*-52.5*	-13	Coax to waveguide transition	4	0	*-17*
C4.2	5.5 to 8 GHz	7000	-13	1	49.4	Electro-Metrics Horn, Double-ridged, RGA-60	10.9	6' RG-142	3.5	*-51.5*	-13	Coax to waveguide transition	4	0	*-17*
C4.3	4 to 5.5 GHz	5500	-13	1	47.3	Electro-Metrics Horn, Double-ridged, RGA-60	10.5	6' RG-142	3	*-49.8*	-13	Coax to waveguide transition	4	0	*-17*
C4.4	2.8 to 4 GHz	4000	-13	1	44.5	Electro-Metrics Horn, Double-ridged, RGA-60	9.4	6' RG-142	2.5	*-48.1*	-13	Watkins-Johnson Log-periodic	6	2	*-17*
C4.5	1 to 2.8 GHz	2000	-13	1	38.5	Electro-Metrics Horn, Double-ridged, RGA-60	7.5	6' RG-142	2	*-44.0*	-13	Watkins-Johnson Log-periodic	7	1.2	*-18.8*
C4.6	0.5 to 1.0 GHz	900	-13	1	31.5	Watkins-Johnson Log-periodic	5	6' RG-142	1	*-39.5*	-13	1/4 wave gnd plane cut to 0.8 GHz	0	0.6	*-12.4*
C4.7	250 to 500 MHz	400	-13	3	34	Discone, with low-freq. extension whip, Diamond D-130	4	5' RG-58	1	*-43.0*	-13	1/4 wave Larsen gnd plane cut to 350 MHz	0	2	*-11*
C4.8	60 to 250 MHz	200	-13	3	38.5	Discone, with low-freq. extension whip, Diamond D-130	2	5' RG-58	0.5	*-49.5*	-13	1/4 wave Larsen gnd plane cut to 120 MHz	0	1	*-12*
C4.9	25 to 60 MHz	38	-13	3	24	Discone, with low-freq. extension whip, Diamond D-130	-5	5' RG-58	0	*-42.0*	-13	Lakeview Co. Inc. model 9106, 1/4 wave gnd plane	-2	1	*-10*

Figure C4.1: Spurious Emissions, 8 to 10 GHz

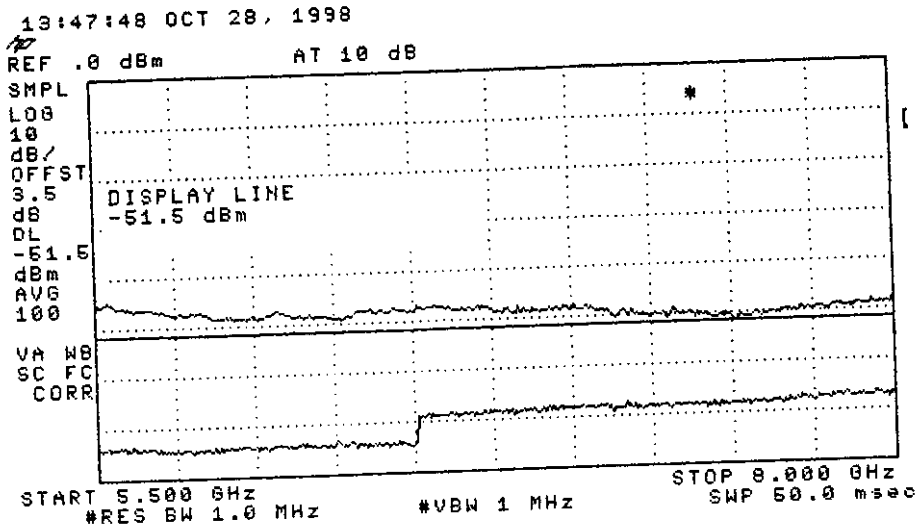


Repeater ON

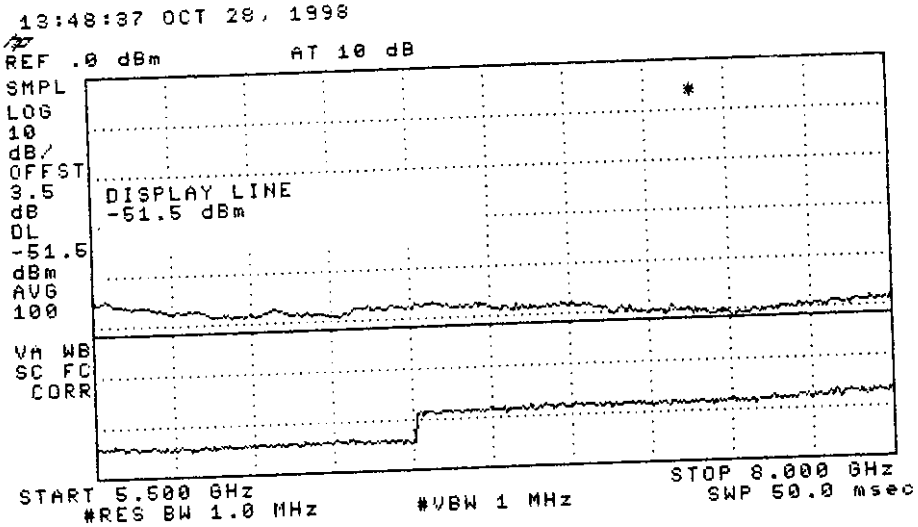


Repeater OFF

Figure C4.2: Spurious Emissions, 5.5 to 8 GHz

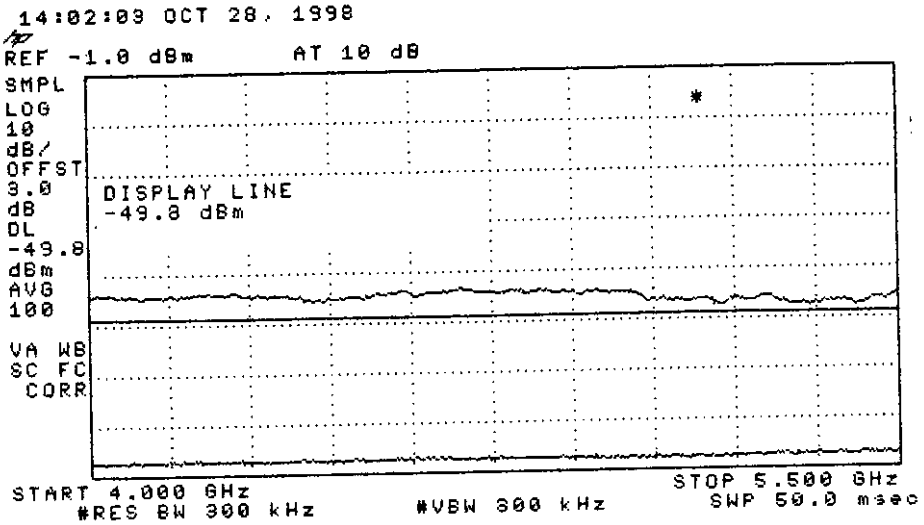


Repeater ON

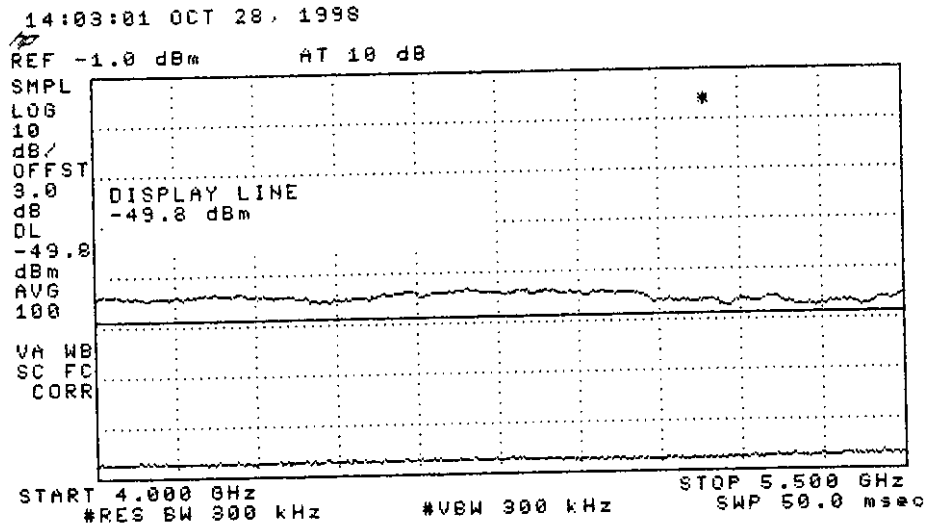


Repeater OFF

Figure C4.3: Spurious Emissions, 4 to 5.5 GHz

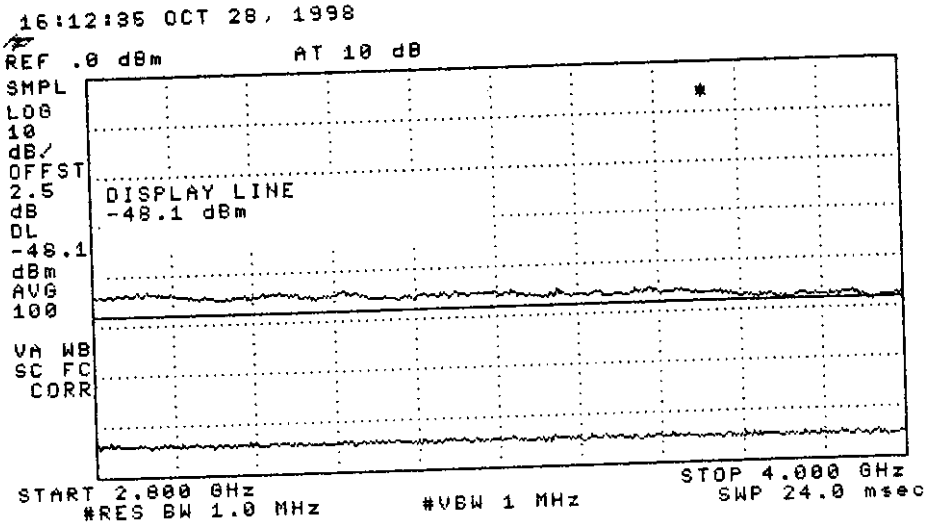


Repeater ON

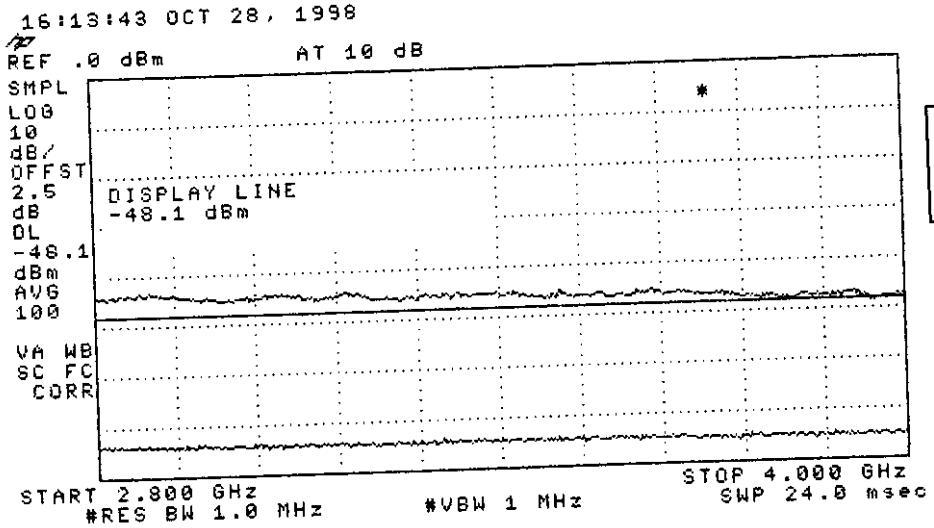


Repeater OFF

Figure C4.4: Spurious Emissions, 2.8 to 4 GHz

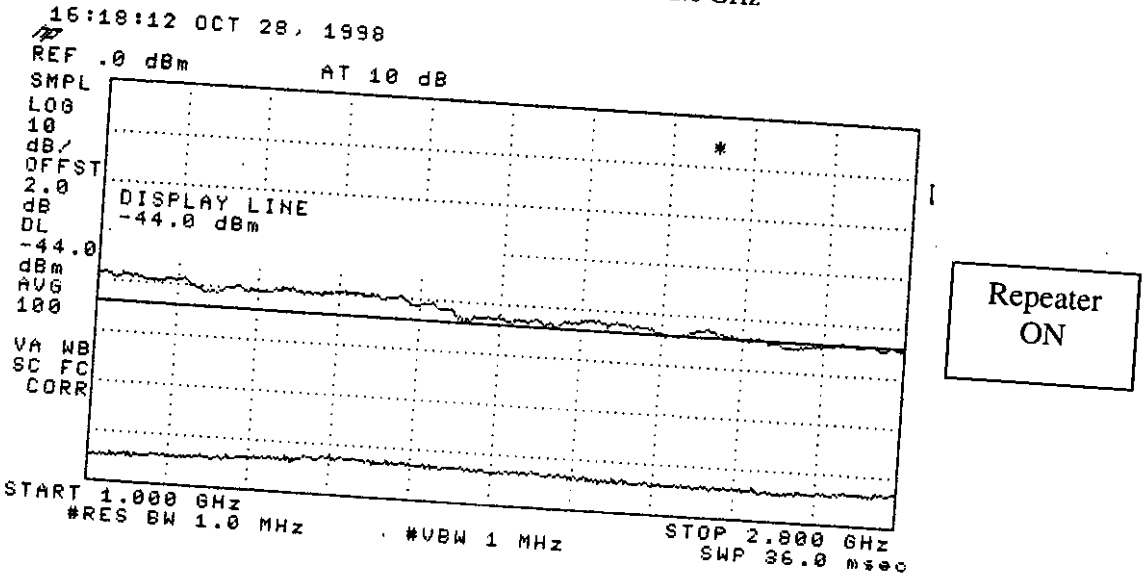


Repeater ON

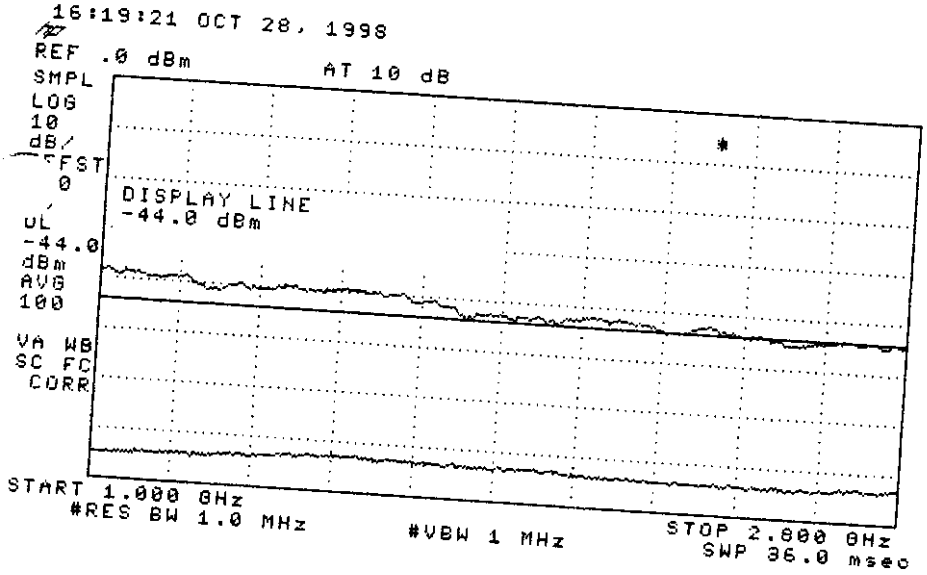


Repeater OFF

Figure C4.5: Spurious Emissions, 1 to 2.8 GHz

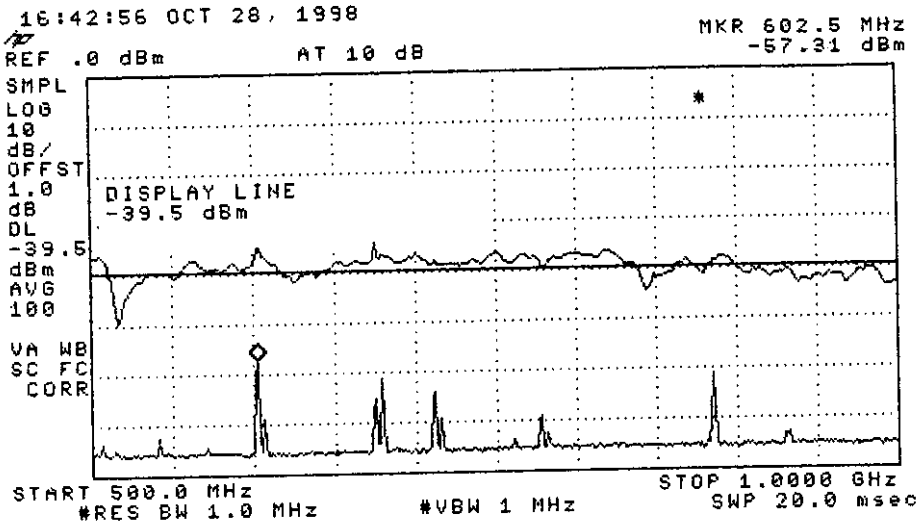


Repeater ON

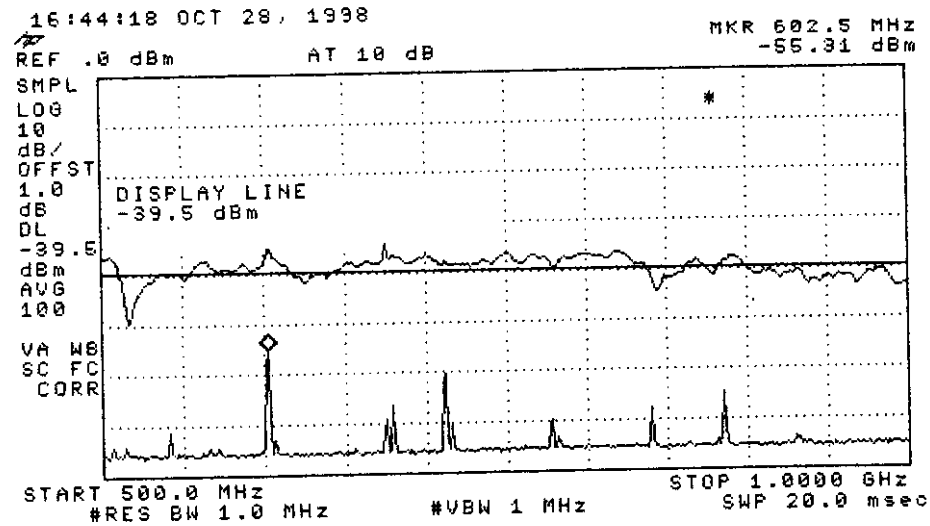


Repeater OFF

Figure C4.6: Spurious Emissions, 0.5 to 1 GHz

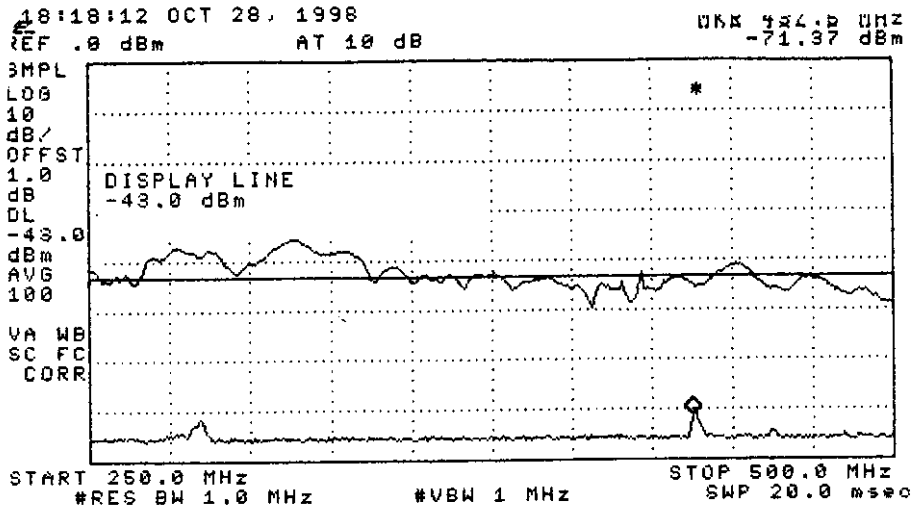


Repeater ON

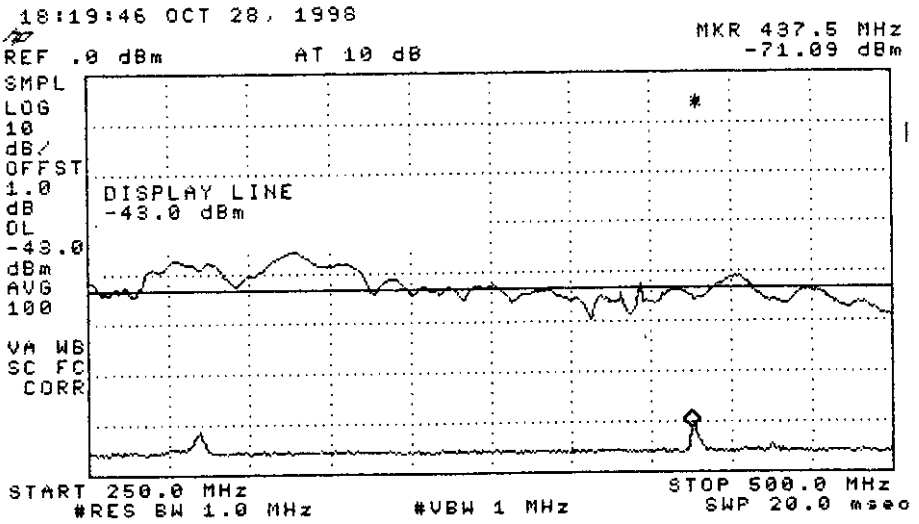


Repeater OFF

Figure C4.7: Spurious Emissions, 250 to 500 MHz

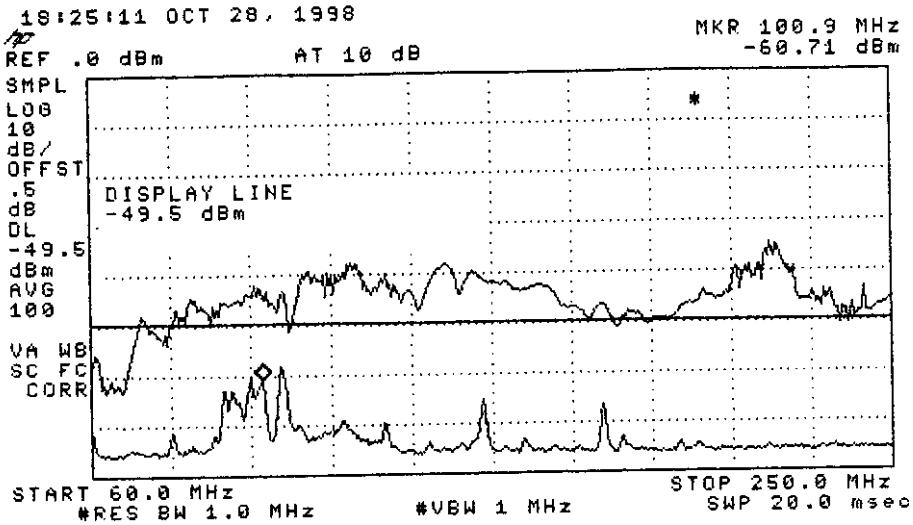


Repeater ON

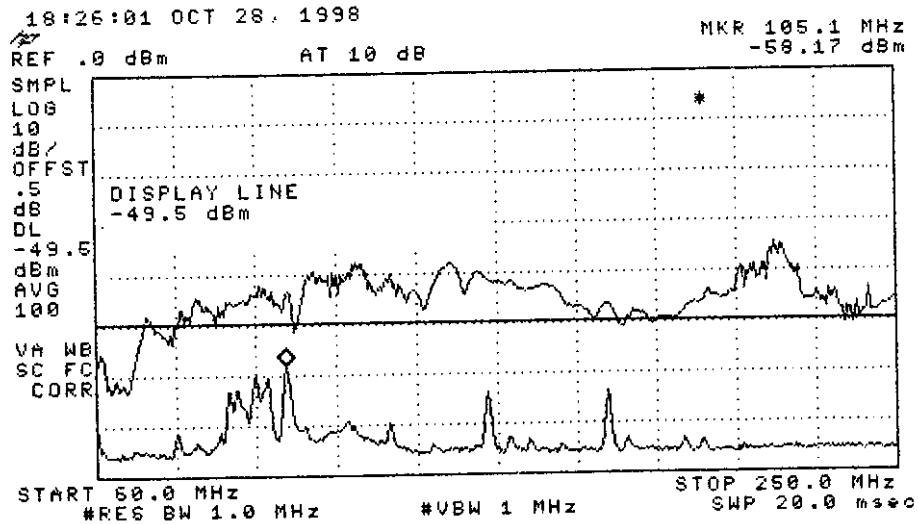


Repeater OFF

Figure C4.8: Spurious Emissions, 60 to 250 MHz

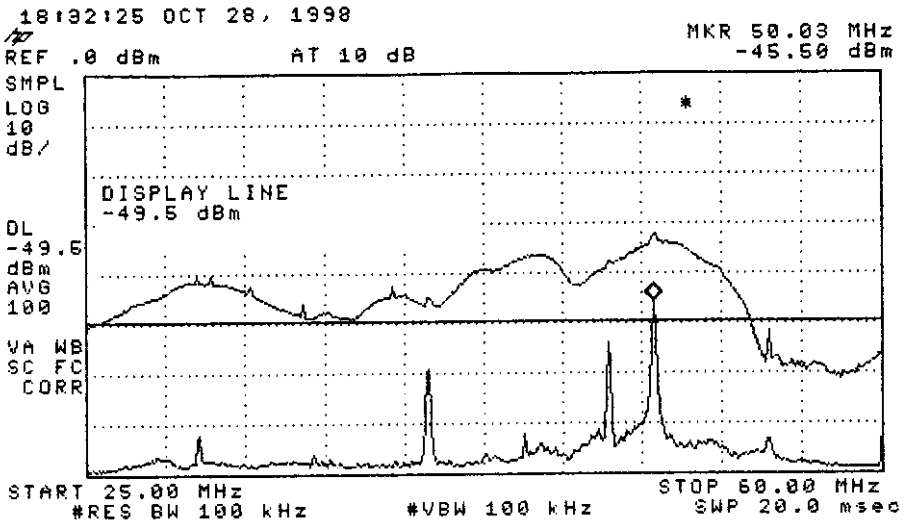


Repeater ON

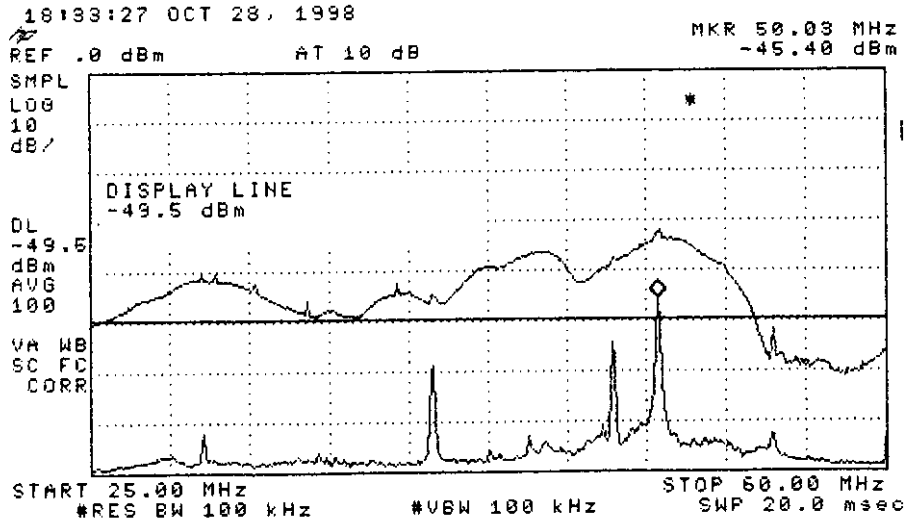


Repeater OFF

Figure C4.9: Spurious Emissions, 25 to 60 MHz



Repeater ON



Repeater OFF

2.995: Frequency Stability

Requirements

The output frequency of the OA850C NR repeater is to be measured vs. primary power supply voltage and variations in temperature. The primary power supply voltage is varied over 85 to 115 % of nominal. The temperature is varied from -30 degree C to +55 degree C.

Test method

The repeater under test was put in a temperature chamber and a variable power source was used to power the DUT. The RF input signal was from a signal generator, whose 10 MHz reference input was supplied by the high stability timebase of the counter. Over the temperature and line voltage ranges of interest, frequency error was calculated from input and output frequency measurements. Both forward and reverse measurements were made, and channel one and two measurements.

Because the OA850C NR Off-Air repeater is a linear amplifying device, exactly zero Hertz frequency error is expected. This is always true because the same Local Oscillator that mixes the input RF down to IF is also used to mix the IF back up to the output RF frequency.

Test Equipment

Signal Generator:	HP 83620A
Frequency Counter:	EIP 545
30 dB Attenuators	
Variable AC power source:	B&K Precision 1655 AC Power Supply
AC Voltmeter	Fluke 8060A multimeter with true rms
Temperature Chamber	Thermotron S-32

Test Signals

For the forward test, a CW signal of 881.500000 MHz was used. For the reverse test, a CW signal of 836.500000 MHz was used.

Test Data

Refer to Table C5.1 for test results.

The OA850C NR Repeater exhibits 0 Hz. freq. error and meets FCC requirement.

Table C5.1: Frequency Error, Hertz, vs. Line voltage and Ambient Temperature

Reduced measured test data for channel one and two, and forward and reverse paths shown.

Ambient Temp. °c	AC Line Voltage, Vrms					
	95	100	110	117	125	135
-30	0	0	0	0	0	0
-20	0	0	0	0	0	0
-10	0	0	0	0	0	0
0	0	0	0	0	0	0
10	0	0	0	0	0	0
20	0	0	0	0	0	0
30	0	0	0	0	0	0
40	0	0	0	0	0	0
50	0	0	0	0	0	0
55	0	0	0	0	0	0