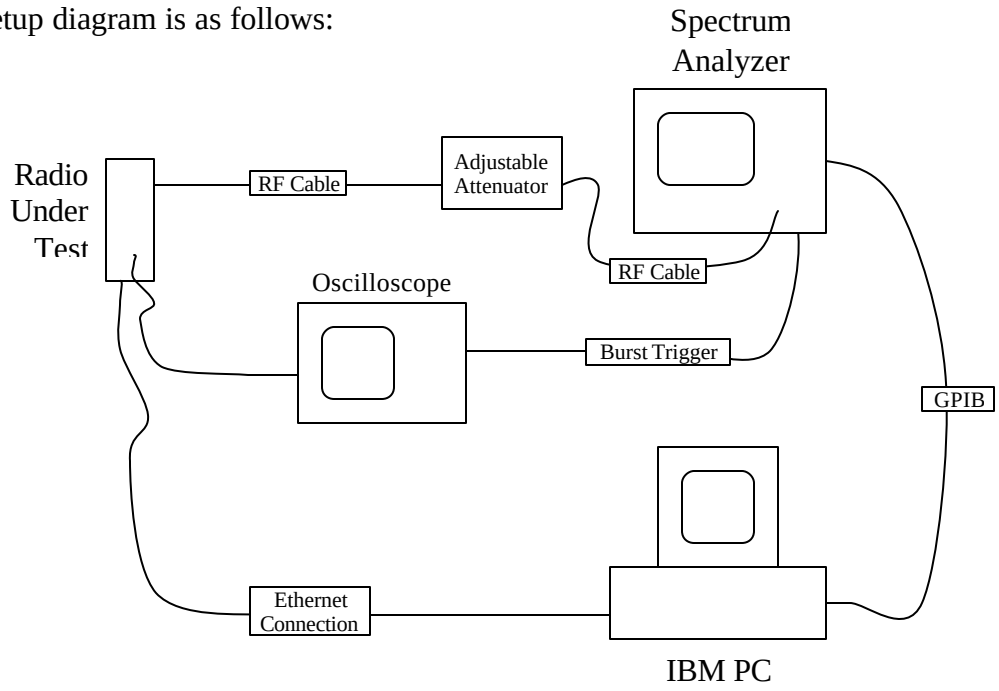
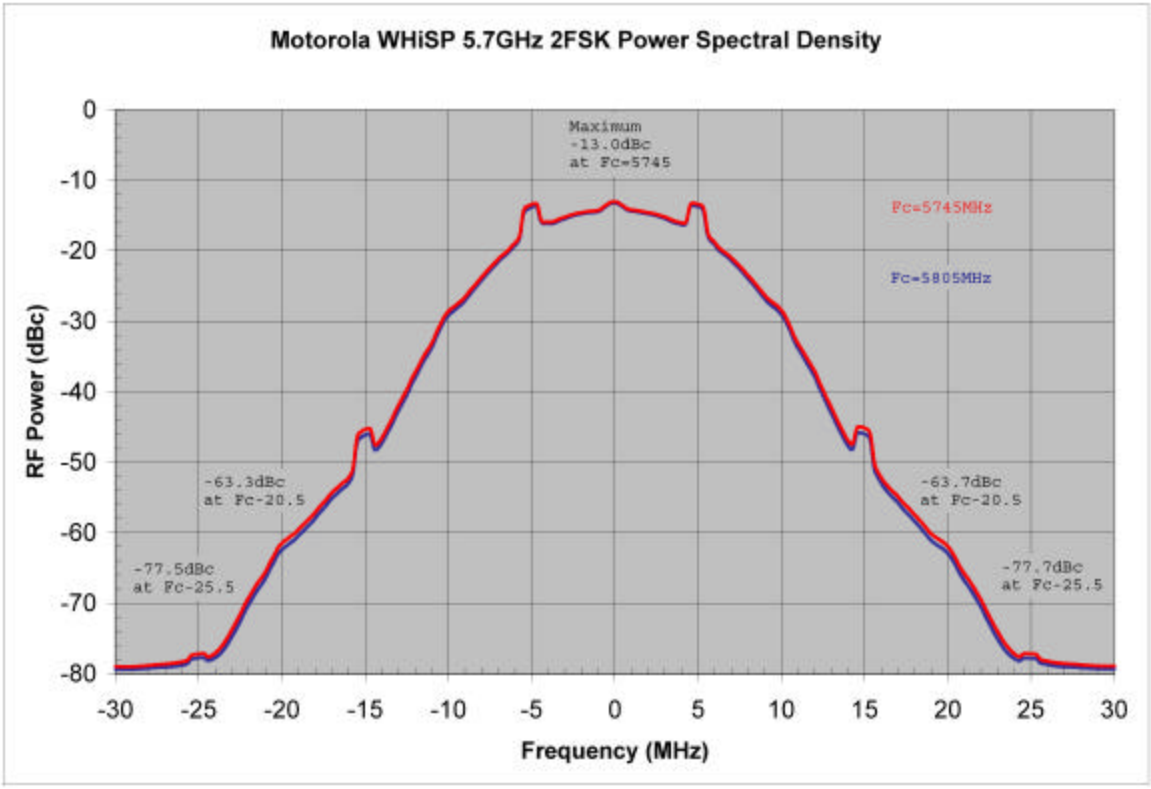
Canopy 5700 Conducted Test
16 December 2001

Compliance testing with FCC rules part 15.407 was performed in both conducted and radiated tests. The power spectral density measurement was setup on WHISP unit serial #440 before an antenna was added. The radio was connected to an HP (Agilent) 8596E Spectrum analyzer. Measurements were taken in 0Hz span with the spectrum analyzer synchronized to the transmitter's data burst. This allowed the analyzer to make time gated power measurements of the radio.

The test setup diagram is as follows:



Silent carrier signal from the radio under test was used to calibrate the spectrum analyzer through the adjustable attenuator for a carrier power of 0 dBm. TX bit error test pattern was initiated to maximize the transmit duty cycle and data throughput for the radio under test. A testing program on the PC computer collected the 0Hz span power sweeps over a 60MHz frequency band. Post processing integrated the power measurements into the 1MHz measurement bandwidths for the plotted power spectral density. The data was offset via the radiated carrier power measurement (+29.05dBm) and plotted as shown.



The plot shown above indicates the worst case results for the radio operation in the frequency band 5725-5825MHz. The results show that at the carrier frequency the maximum power in a 1MHz BW is +16.05dBm radiated. In the region +/-25 to 26MHz the maximum amplitude was –48.45dBm or 31.4dB better than the maximum bandedge power of -17dBm radiated. In the region +/-20 to 21MHz the maximum amplitude was –34.25dBm or 17.2dB better than the maximum bandedge power of -17dBm radiated. Signals > +/-31MHz were below the measurement noise floor. From these measurements it can be seen that the WHiSP radio #440 passses the FCC part 15 specifications.

Canopy 5700 Radiated Test
16 December 2001

A Canopy 5700 unit, serial #440, was tested outdoors to check compliance with FCC requirement 15.209, restricted band emissions. The testing was done using a model 3115 and a model 3116 calibrated dual-ridged waveguide-horn antennas manufactured by EMCO, Inc., an Agilent 8564EC 40GHz spectrum analyzer, and a laptop to control the DUT and take data from the spectrum analyzer. The two antennas combined allowed a frequency measurement range of 1GHz to 40GHz. The spatial separation between the EMCO horn antennas and the DUT was maintained at 1 or 3 meters during the test.

The FCC requirement for restricted band emissions is stated in terms of field strength at 500uV/m at a distance of 3 meters. Using the free space impedance of 377 ohms, the equivalent power density is –61.78dBm/m^2. This power density number was used as the pass/fail criteria for the test. Cable losses, antenna gains, and other correction factors were entered into an Excel spreadsheet along with the results of the testing.

To calculate the power density at the horn antennas, the power level received by the antenna is offset by the log ratio of the effective aperture of the antenna to one square meter. The calculation of the effective aperture is done using:

$$A_{em} = e_{cd}(?^2/4p)D_o,$$

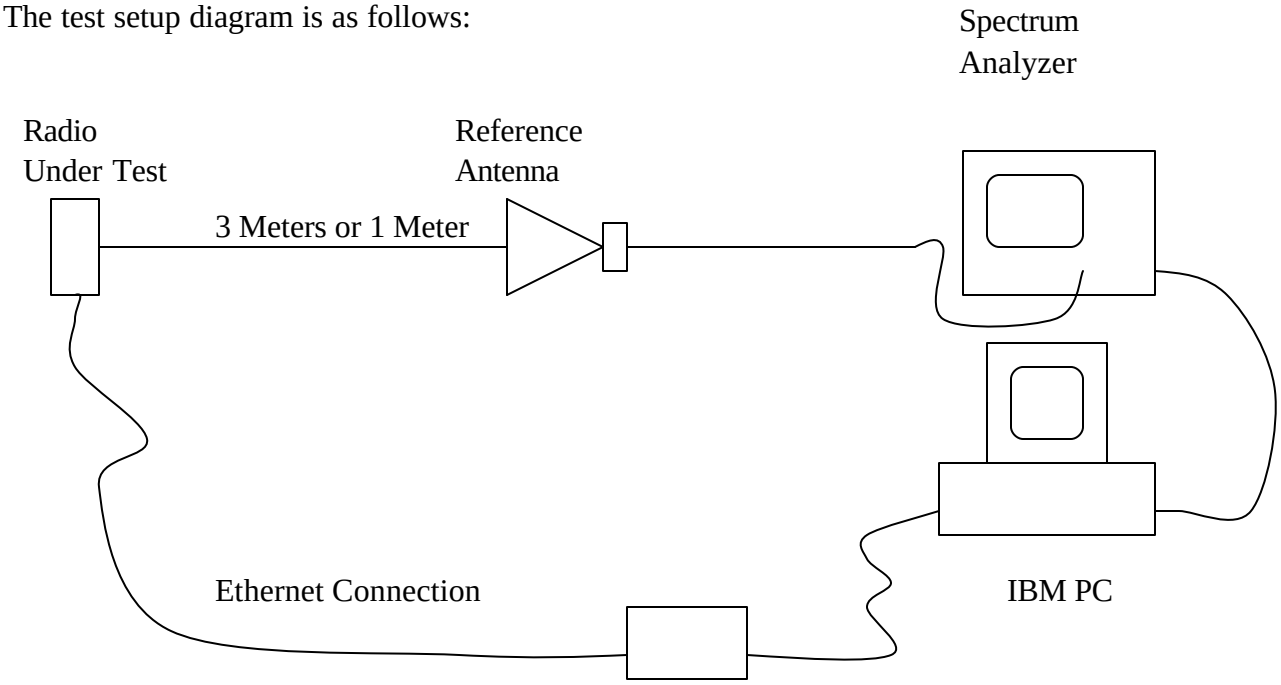
D_o is the directivity of the antenna, e_{cd} is the efficiency, and ? is the wavelength of the frequency under observation. In the equation, e_{cd} and D_o may be replaced by the numeric gain of the antenna. Using the calibration data from the manufacturer, the effective area of the antenna was computed for each measurement frequency and the appropriate dB correction factor applied.

The operating frequency of the radio presented a challenge to measuring the harmonics radiated by the radio. Since the highest harmonic to be measured is 34GHz (as the seventh harmonic exceeded the FCC frequency limit of 40GHz, it was not measured), finding test equipment that possess reasonable noise figures and obtaining coax cables with mode-free moderate loss is difficult. The resolution bandwidth of 1MHz also adds to the problem of making an effective radiated power measurement. As an aid in performing these measurements, the radio was designed with the ability to operate in continuous-wave mode (a proprietary mode of operation not available to the normal user), permitting the use of narrow bandwidths on the analyzer. In normal operation, logic in the radio will prevent the transmitter from operating in case of frequency error, and the resident firmware and hardware logic prevent transmissions when there is no data to be sent.

The picture below shows the configuration of the test set-up:

The test antennas and test radio were mounted on adjustable tripods and placed 1 or 3 meters apart, depending on the measurement antenna type. Absorbing panels were placed on the ground to reduce the effects of ground reflections.

The test setup diagram is as follows:

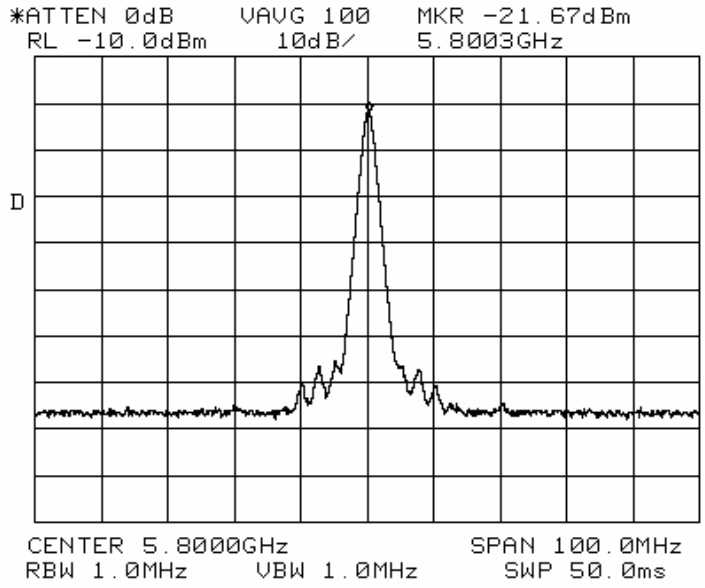


Two different antennas were used, an EMCO model 3115 ridged-waveguide horn antenna covering the 1 to 18GHz frequency range, and an EMCO model 3116 ridged-waveguide horn antenna covering the 18 to 40GHz frequency range.

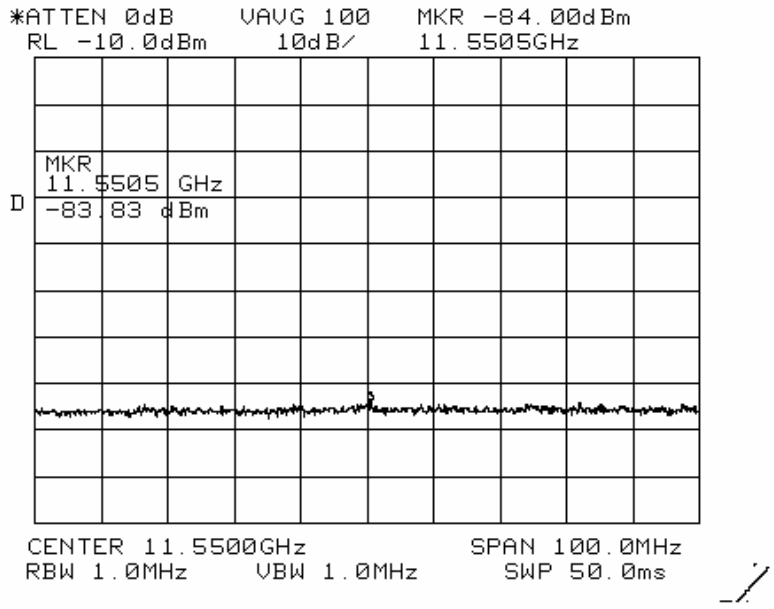
The radio has a CW mode for testing purposes and was used to measure the harmonic levels radiated from the radio. With no modulation, the measurement bandwidth could be reduced below 1MHz, allowing greater dynamic range for the test equipment. Measurements were made using a 30 kHz resolution bandwidth and a 1MHz bandwidth. Data used for calculations was taken from the 1MHz RBW measurements. Where no clearly discernable signal could be seen, the magnitude difference between signal and noise was set equal to a minimum value to avoid computational errors in the spreadsheet.

Harmonic level as a function of channel frequency was reviewed and the RF channel possessing the highest harmonic level was used. Where harmonic levels were not strongly tied to the channel frequency, a nominal frequency of 5800MHz was used. Data from the analyzer was transferred to the laptop computer and later processed. The raw spectral plots from the HP8564E analyzer are given below:

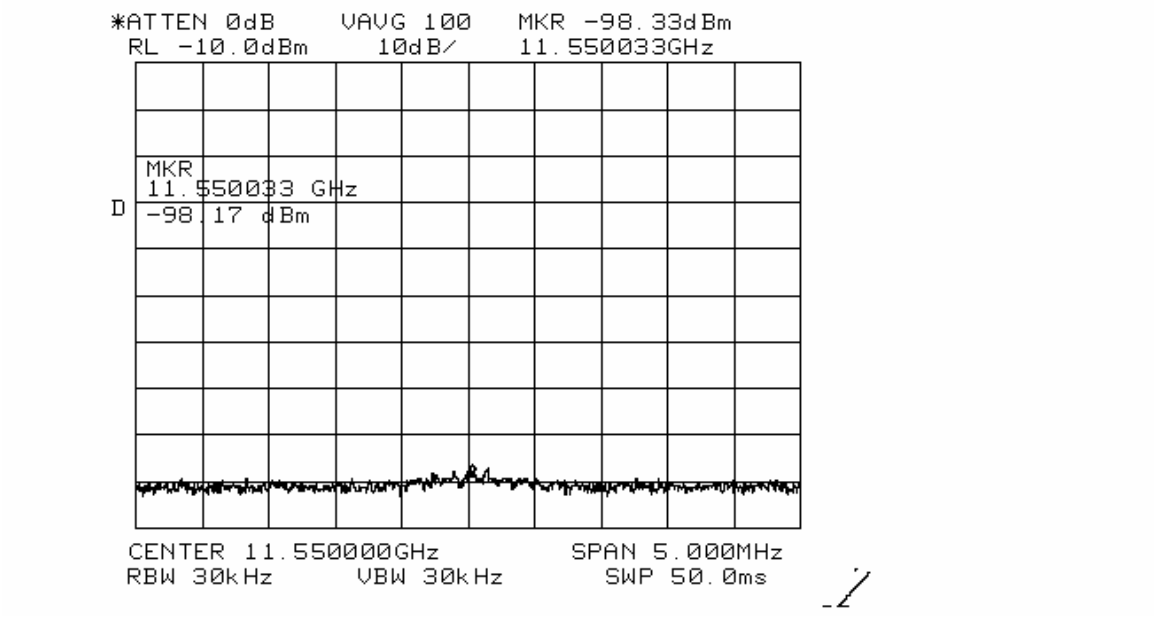
Plot 1: Fundamental frequency: 1MHz RBW:



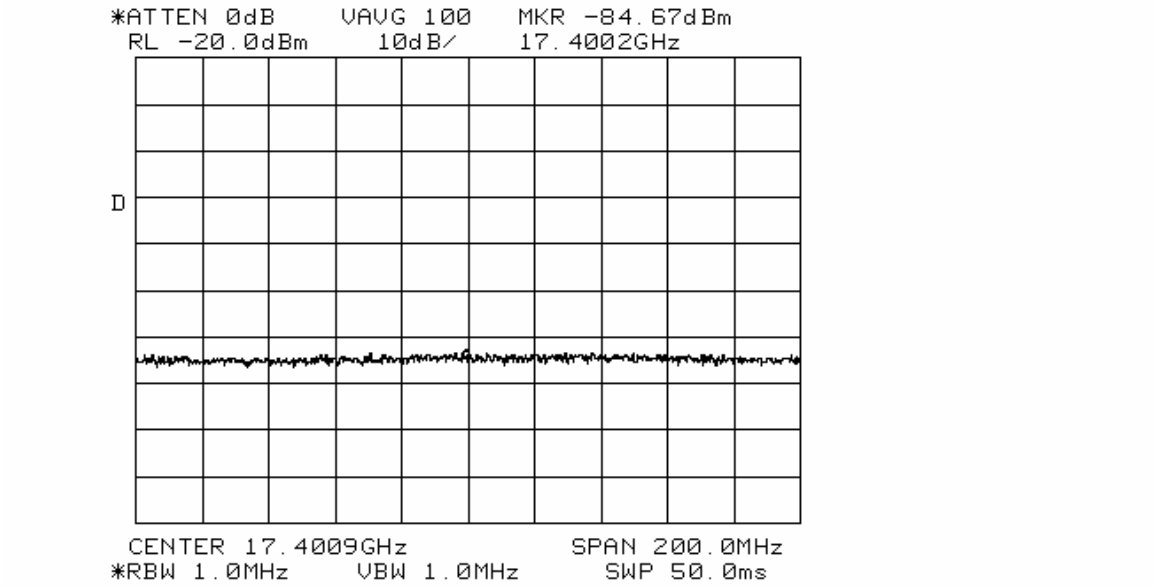
Plot 2: Second Harmonic, 1 MHz RBW:



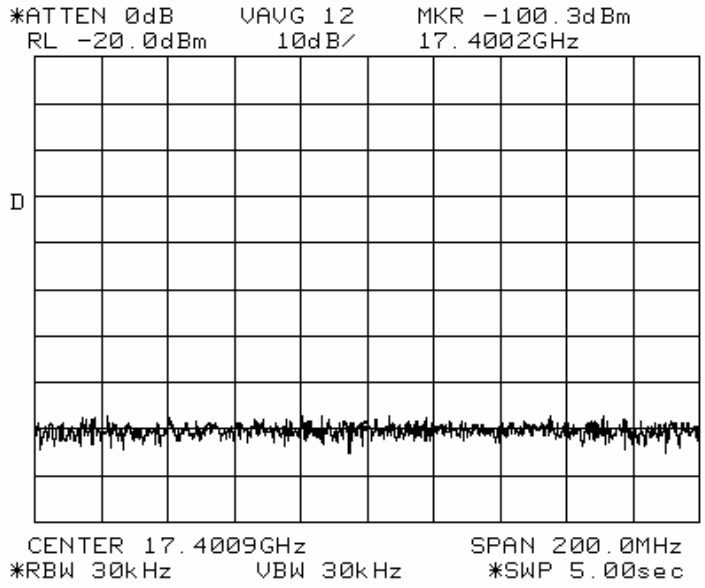
Plot 3: Second Harmonic, 30kHz RBW:



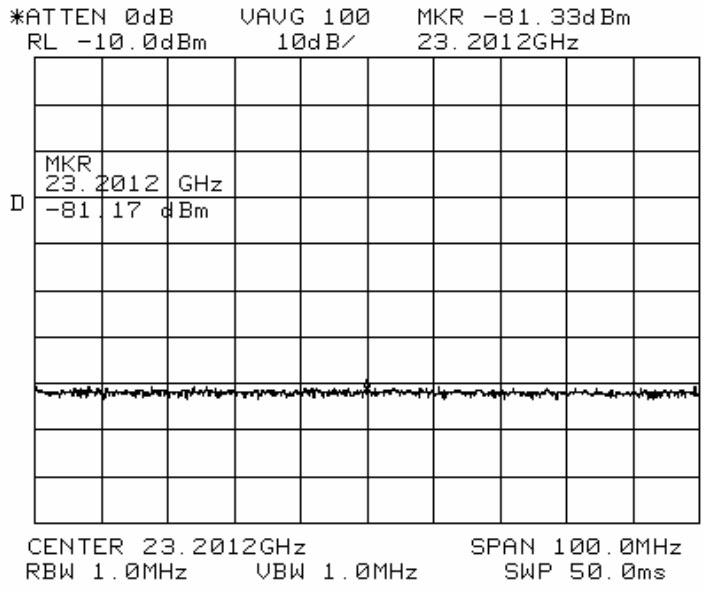
Plot 4: Third Harmonic, 1 MHz RBW:



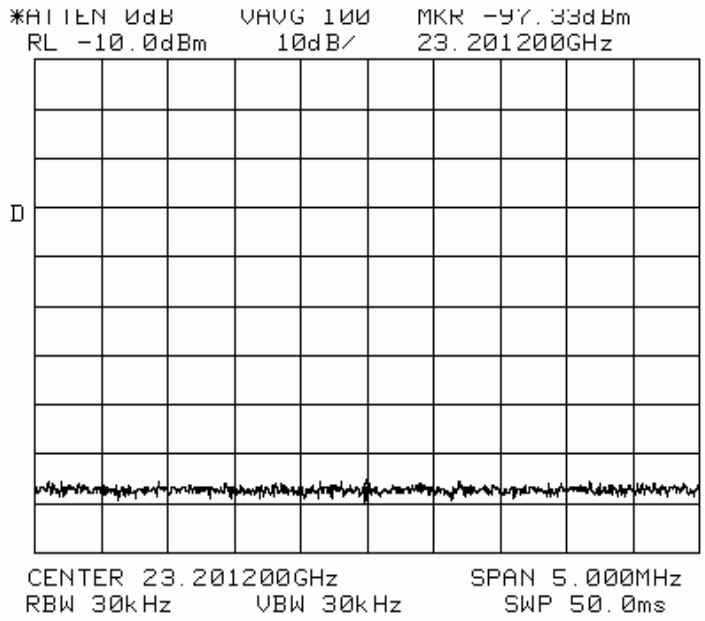
Plot 4: Third Harmonic, 30kHz RBW:



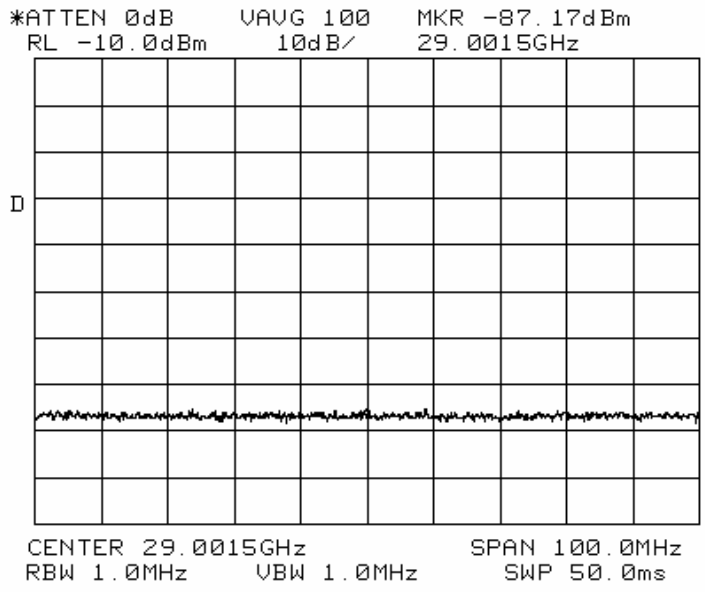
Plot 5: Fourth Harmonic, 1 meter, 1MHz RBW:



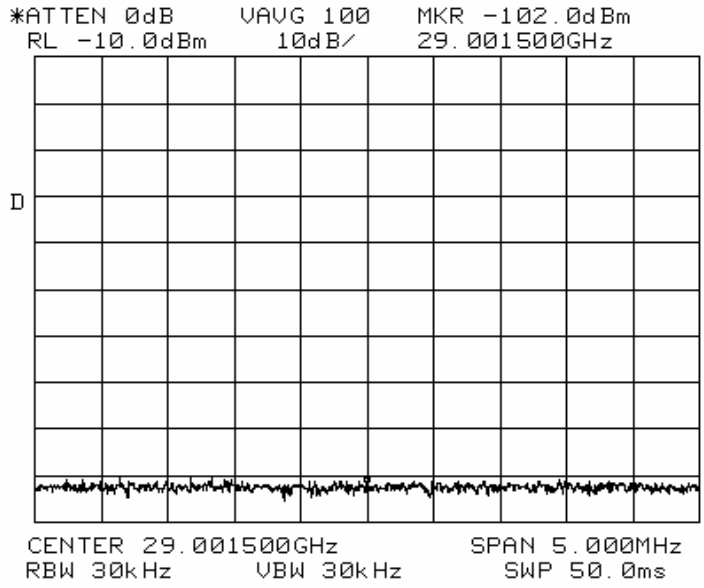
Plot 5: Fourth Harmonic, 1 meter, 30kHz RBW:



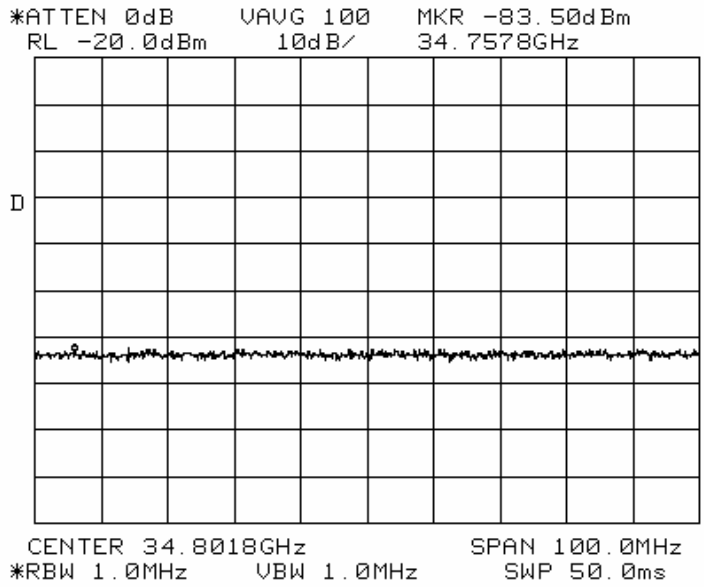
Plot 6: Fifth Harmonic, 1meter, 1MHz RBW:



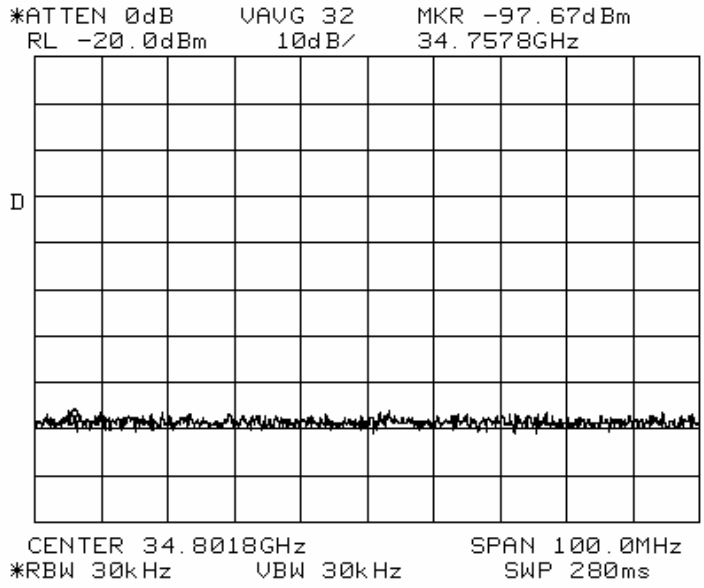
Plot 7: Fifth Harmonic, 1 meter, 30kHz RBW:



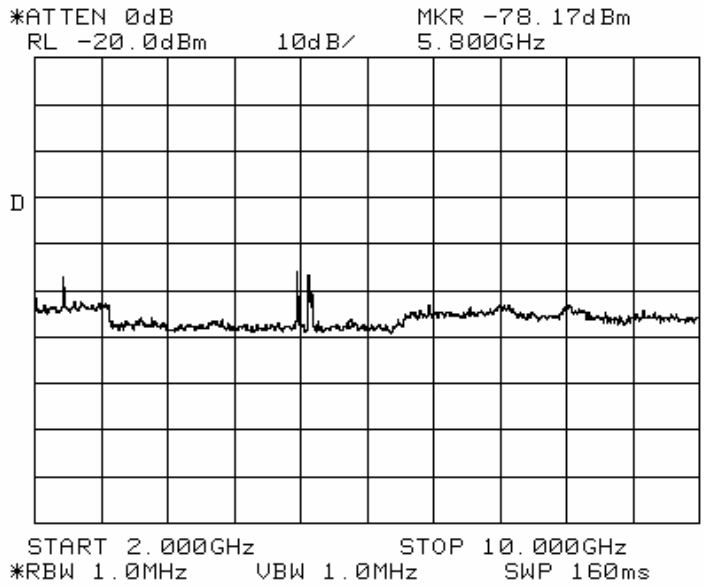
Plot 7: Sixth Harmonic, 1 meter, 1MHz RBW:



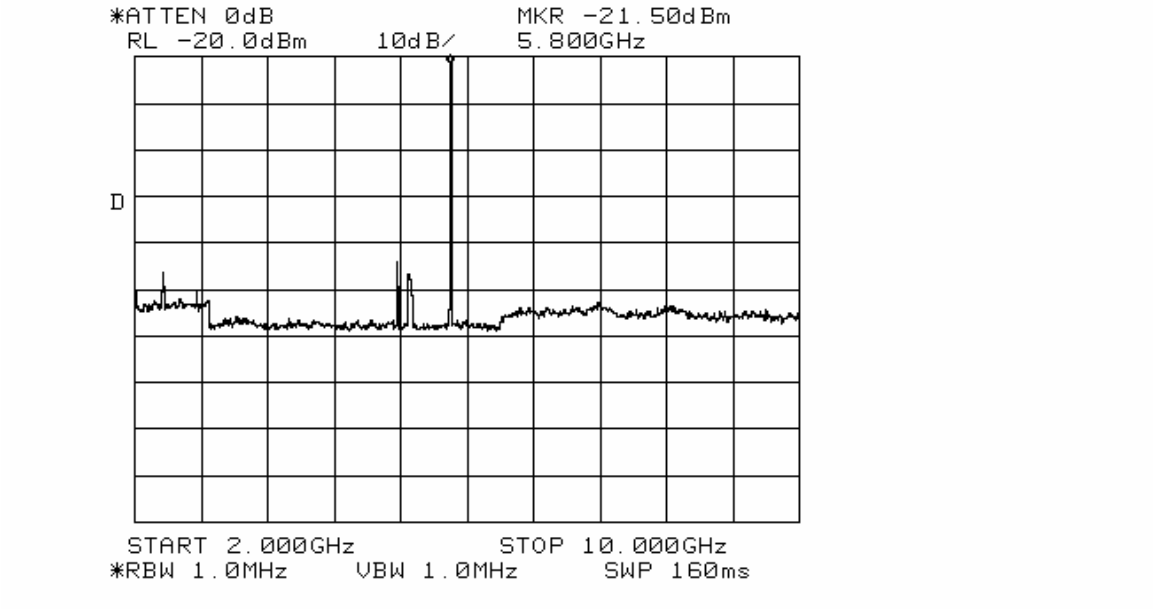
Plot 8: Sixth Harmonic, 1 meter, 30kHz RBW:



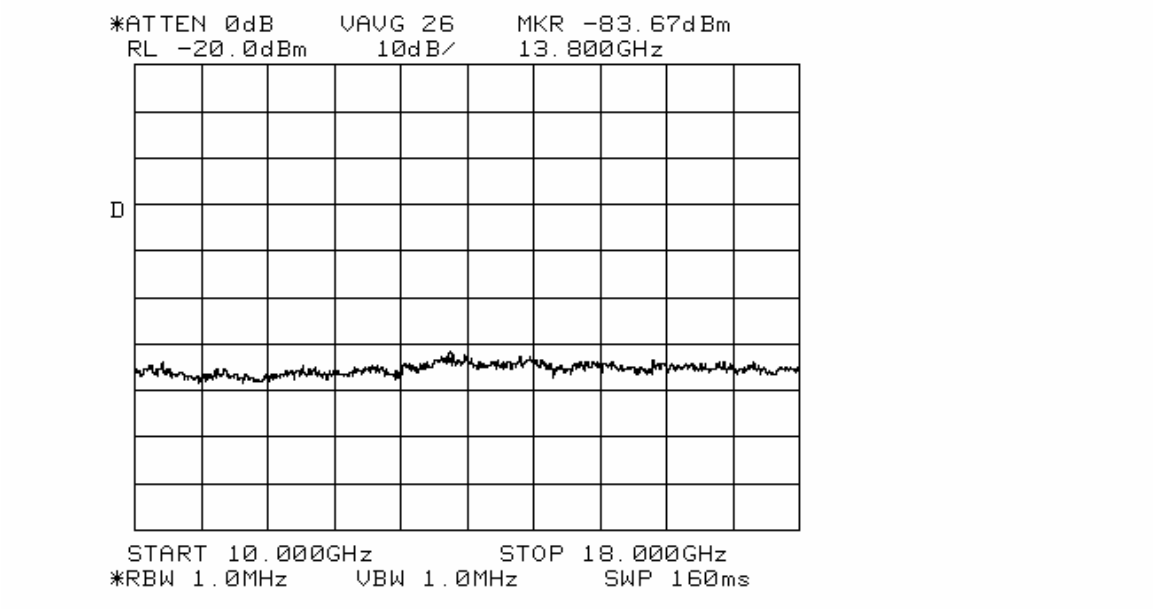
Plot 9: Frequency Sweep 2 to 10GHz, Radio turned off:



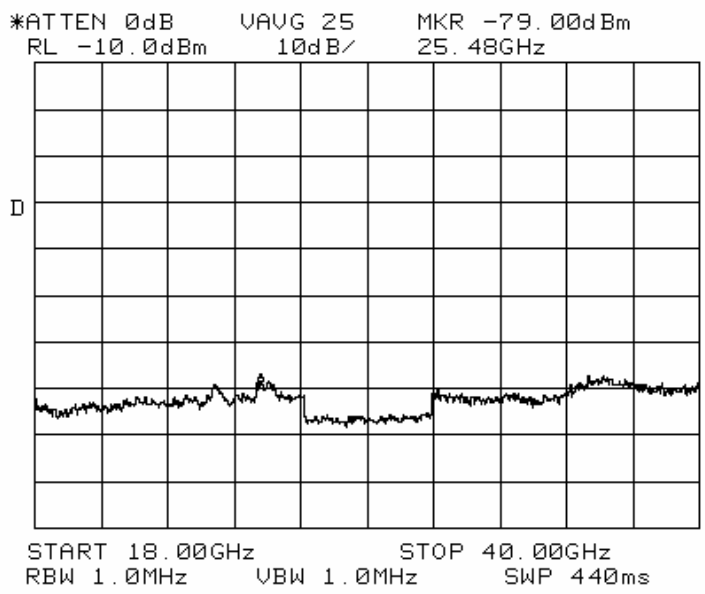
Plot 10: Frequency Sweep 2 to 10GHz, Radio turned on:



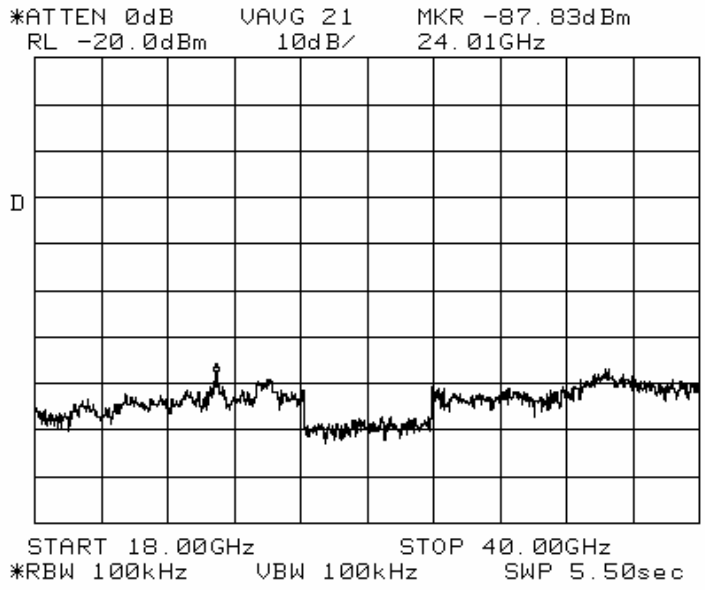
Plot 11: Frequency Sweep 10 to 18 GHz:



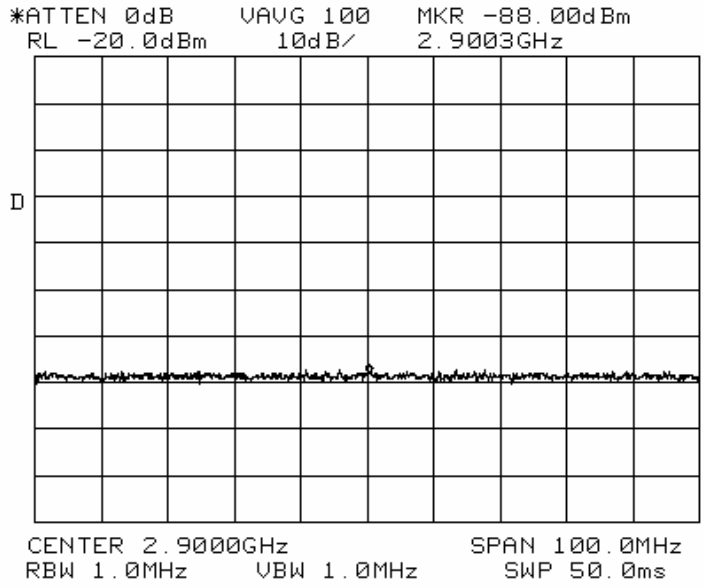
Plot 12: Frequency Sweep 18 to 40GHz, Radio off:



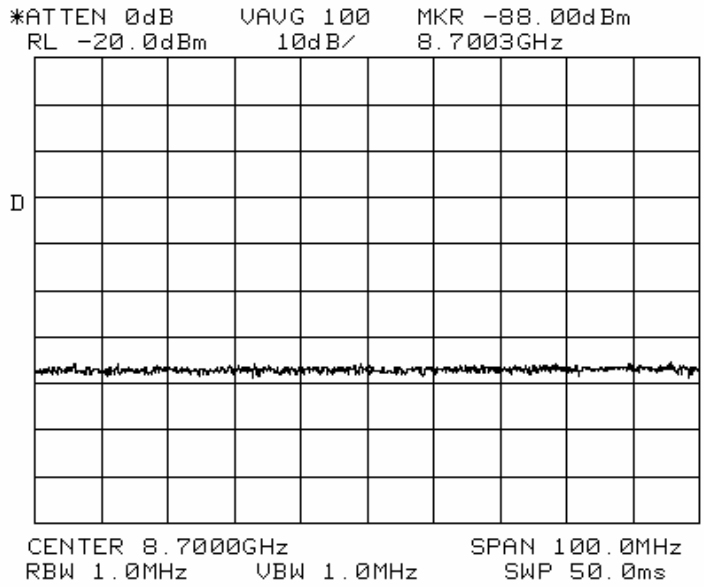
Plot 13: Frequency Sweep 18 to 40 GHz, Radio turned on:



Plot 14: VCO Feedthrough, 1MHz RBW:



Plot 15, VCO 3rd Harmonic, 30kHz RBW:



The Canopy 5700 radio can be equipped with a passive reflector to increase the ERP of the radio when setting up long distance links. The FCC rules given in part 15.407, subpart (a), paragraph (3), states that for a U-NII device employed in a fixed-point application in the 5725 to 5825MHz band, an external antenna of up to +23dBi gain (providing an ERP of up to +53dBm) may be used. A test reflector providing an additional 19 dBi gain was attached to the Canopy 5700 radio. The radio assembly was mounted on a pole with the EMCO antennas located 20 meters away to avoid near-field measurement error due to the high gain of the reflector (utilizing the relationship $2D^2/?$, with D= largest antenna dimension, the minimum distance to avoid near field errors for the fundamental frequency was 13.48meters). On-channel power and harmonic content measurements were performed and used to calculate equivalent 3 meter data.

The test layout was configured as below:

Radiated data was analyzed to determine the RF channel with the highest harmonic level. Where harmonic levels were the same regardless of operating frequency, data from the nominal (5800MHz) frequency was used. The resulting plots are shown as follows:

Figure 16: On-channel power at 20 meters:

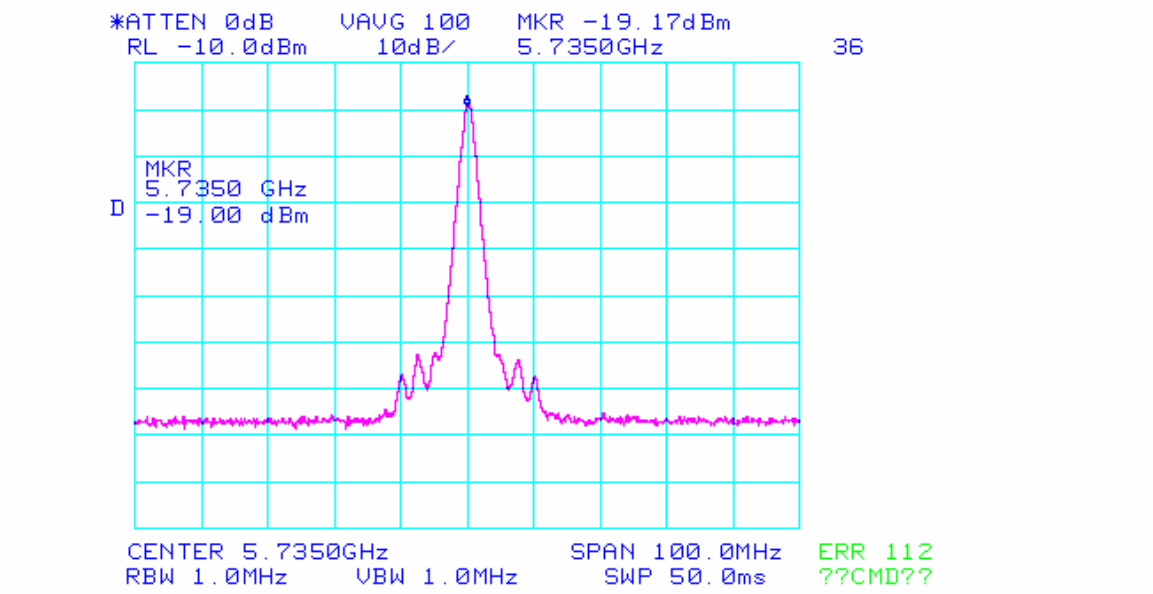


Figure 17: Second harmonic at 20 meters:

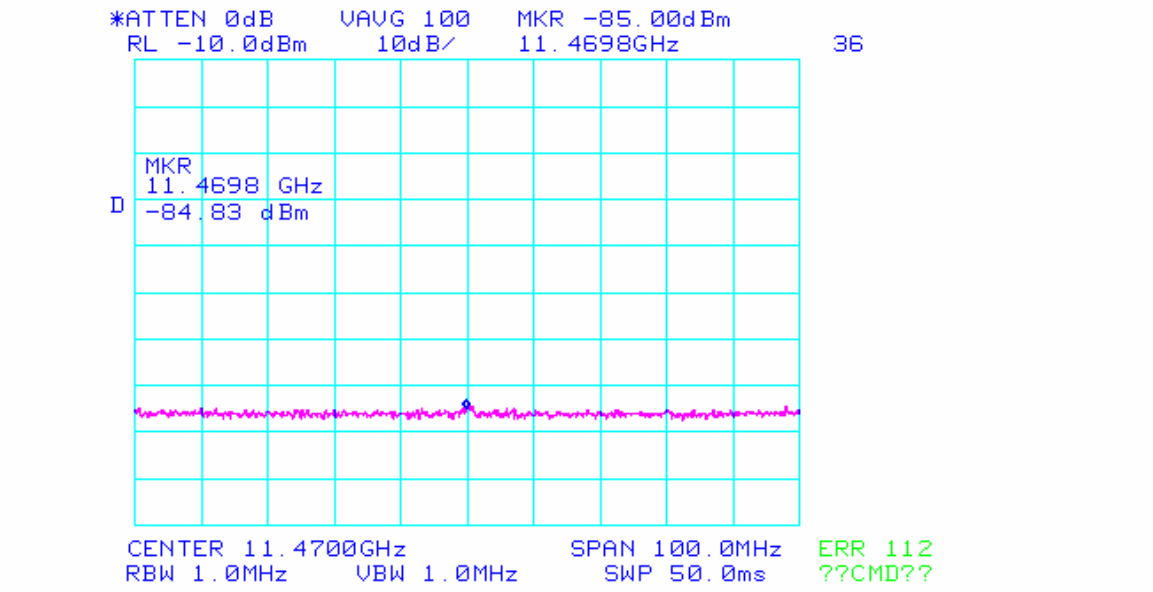


Figure 18: Third harmonic at 20 meters:

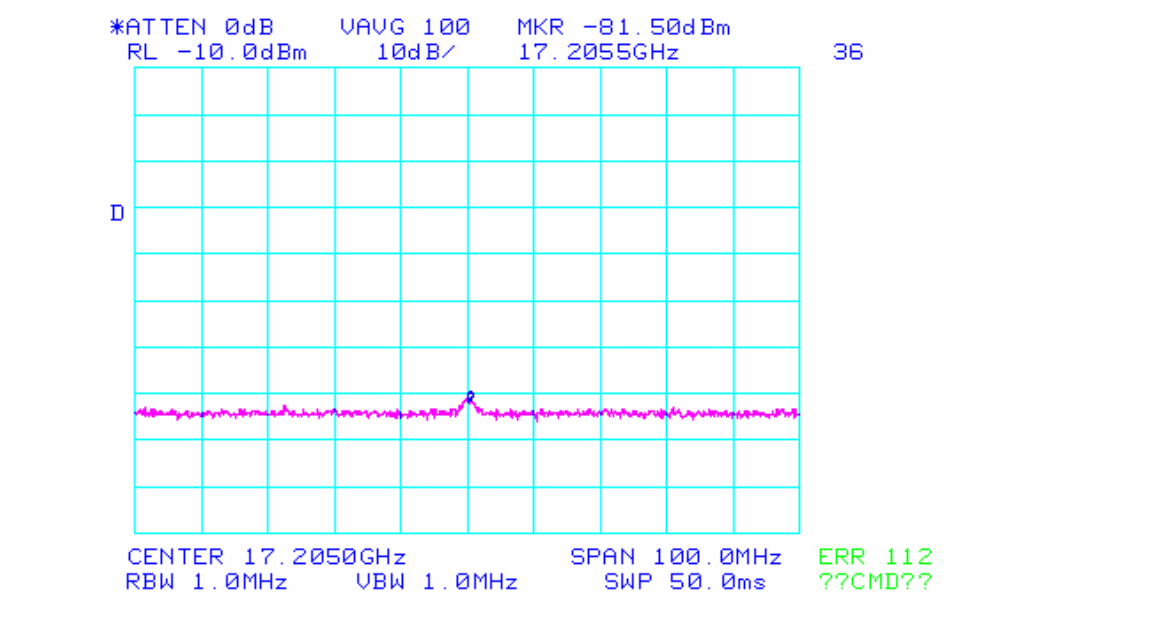


Figure 19: Fourth Harmonic at 20 meters:

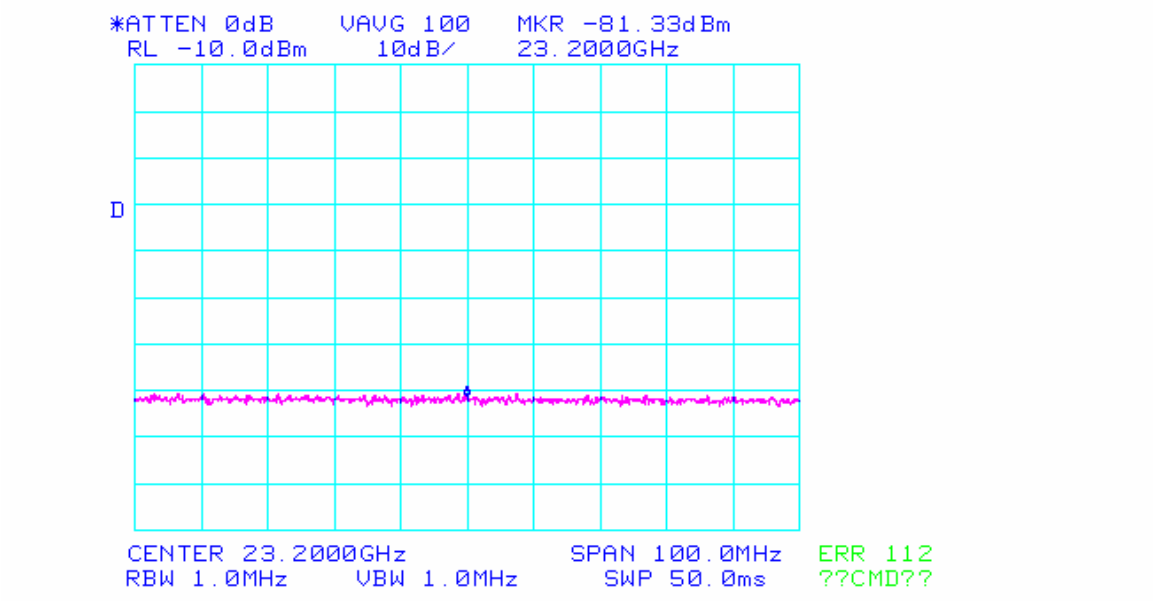


Figure 20: Fifth Harmonic at 20 meters:

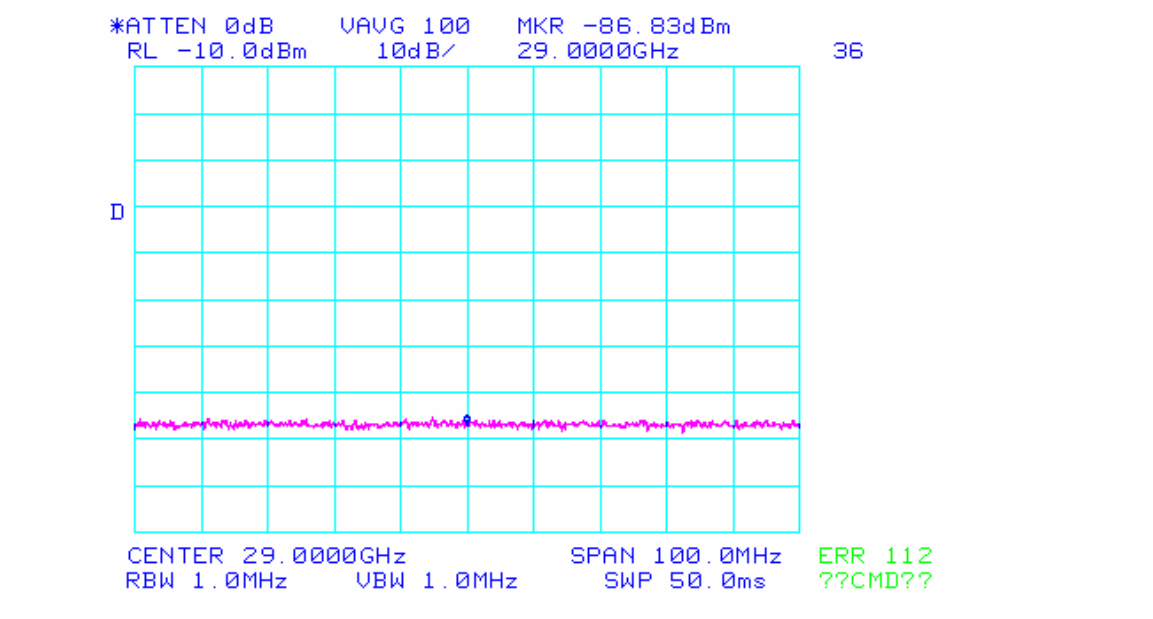


Figure 21: Sixth Harmonic at 20meters:

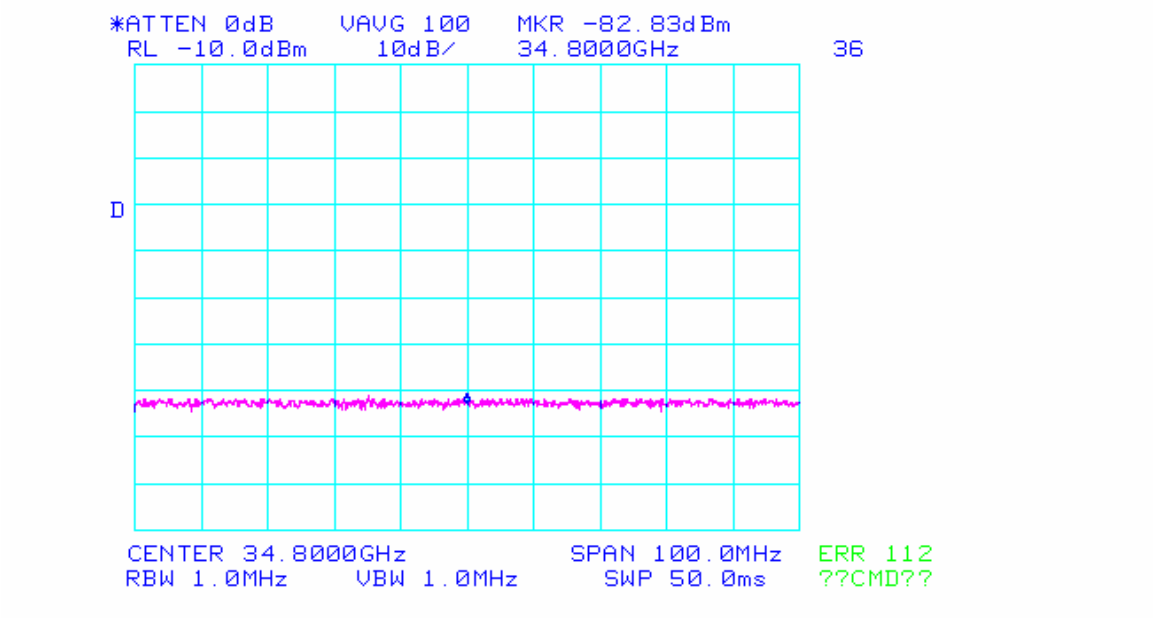
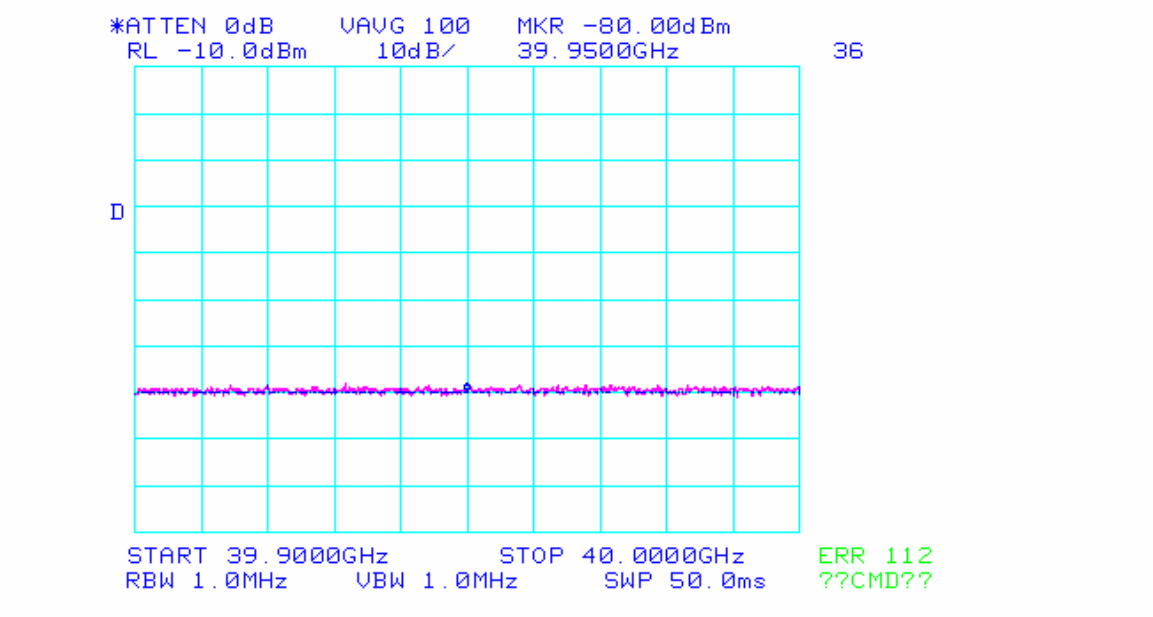


Figure 22:Near 7th Harmonic:



However, even with the best test set-ups, bugs kept creeping in, as shown below:

A sample of the error budgeting is shown below. The total error is given in the last row, and shows that the error spread does not exceed +/- 2dB over the frequency range. Although not shown in the sample below, the error terms for the coax cable and the spectrum analyzer are included in the final error terms of the bottom row.

Measurement Error Budget	1-18GHz	18-30GHz	30-40GHz
Error Contribution (dB)	**EMCO 3115**	**EMCO 3116**	**EMCO 3116**
VSWR Contribution in dB	1.00	0.88	0.88
Amplitude Uncertainty	0.30	0.80	1.50
Reference Level			
Total Error, Plus/Minus dB	***1.37***	***1.48***	***1.95***

For a confidence level of 68%, the error budget is then ±0.93dB.

The following Excel spreadsheet cells show the corrected power levels of the internal-antenna radio. The data gives an ERP of +29.05 dBm when the radio was operating at 5800MHz.

CW Mode	1MHz RBW/VBW
	Freq:=>
5800.00	**Fund**
Analyzer Reading	-21.70
Noise Floor	-87.50
Adjusted Analyzer Level	-21.70
Cable Loss	-3.30
dBm at Antenna Connector	-18.40
Antenna Gain (dBi)	9.80
3 meter path loss	-57.25
3meter Antenna Power Level	-28.20
Radio ERP in dBm	29.05

The ERP of the reflector-equipped radio is given as follows:

Canopy 5700 Radiated Test : Unit 440 with External Reflector

CW Mode	1MHz RBW/VBW
	Freq:=>
5800.00	**Fund**
Analyzer Reading	-18.67
Noise Floor	-87.50
Adjusted Analyzer Level	-18.67
Cable Loss	-3.30
dBm at Antenna Connector	-15.37
Antenna Gain (dBi)	9.80
20meter Path Loss	-73.73
3 meter path loss	-57.25
Path Loss Correction(20m to 3m)	-16.48
Equivalent 3meter Antenna Power Level	-8.69
Radio ERP in dBm	48.56

Harmonic Frequency Testing Spreadsheet Summary for the Internal-Antenna Radio:

Canopy 5700 Radiated Test : Unit 440

CW Mode	1MHz RBW/VBW					Agilent 8564EC Analyzer				
	Freq:=>	2900.00	8700.00	11600.00	17400.00	23200.00	29000.00	34800.00	40000.00	Restricted Band
5800.00	**Fund**	**VCO**	**3*LO**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	
Analyzer Reading	-21.70	-88.00	-88.00	-84.00	-84.67	-81.33	-87.17	-83.50	-80.00	
Noise Floor	-87.50	-89.00	-88.17	-85.17	-84.83	-81.50	-87.33	-83.67	-80.05	
Adjusted Analyzer Level	-21.70	-94.87	-102.16	-90.27	-99.09	-95.49	-101.59	-97.66	-99.41	
Cable Loss	-3.30	-2.20	-4.10	-4.80	-6.30	-7.50	-8.05	-9.07	-10.10	
dBm at Antenna Connector	-18.40	-92.67	-98.06	-85.47	-92.79	-87.99	-93.54	-88.59	-89.31	
Antenna Gain (dBi)	9.80	8.20	10.50	10.90	9.00	12.20	12.90	11.00	15.10	
3 meter path loss	-57.25	-51.23	-60.77	-63.27	-66.80	-69.29	-71.23	-72.82	-74.15	
3meter Antenna Power Level	-28.20	-100.87	-108.56	-96.37	-101.79	-100.19	-106.44	-99.59	-104.41	
Radio ERP in dBm	29.05	-49.64	-47.78	-33.09	-34.99	-30.89	-35.20	-26.77	-30.26	
Antenna Effective Aperture(square meters)	2.03E-03	5.63E-03	1.06E-03	6.55E-04	1.88E-04	2.21E-04	1.66E-04	7.45E-05	1.41E-04	
Aperture Ratio to 1 sq. meter in dB	26.92	22.50	29.74	31.84	37.26	36.56	37.80	41.28	38.52	
Power Density(dBm/m^2) at 3 meters	-1.28	-78.37	-78.82	-64.53	-64.53	-63.63	-68.64	-58.31	-65.89	
FCC Restricted Band Emissions Limit(uV)	N/A	500.00		500.00		500.00				
FCC Out-of-Band Emssions Limit (dBm ERP)	N/A		-27.00		-27.00		-27.00	-27.00	-27.00	
Restricted Band Emissions Limit in dBm/m^2	N/A	-61.78		-61.78		-61.78				
Radio Level to FCC Limit in dB(CW Mode)	N/A	16.59	51.82	2.75	37.53	1.84	41.64	31.31	38.89	
Transmit Duty Cycle Reduction(dB)		0.00	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	
CW to Modulated Mode Power Reduction(dB)		-13	-13	-13	-13	-13	-13	-13	-13	
Radio Level to FCC Limit in dB(Modulated Mode)		29.59	66.07	16.99	51.78	16.09	55.89	45.56	53.14	

The results show that the radio meets the FCC limit of 500uV/m on the harmonics. The highest level was from the VCO fundamental frequency and had the lowest margin by being only 2.75 dB better than the limit specification when the radio was set to the CW test mode. In normal operation, the transmitted signal is a wideband, pulsed FSK carrier. Conducted measurements of the amplitude difference between the CW mode and modulated mode were performed and used to provide a correction factor to better estimate the actual harmonic level when the radio was in normal operation. Additionally, since the unit is a time-division duplex design, there is a second correction to reflect the fact that the transmitter is periodically turned off (this correction was not applied to the VCO since the VCO, while modulated in transmit mode, is not pulsed). Adding these corrections to the spreadsheet shows the dB margin between the FCC limit and the emissions level of the radio. As expected, restricted band harmonics had the lowest margin, but were still better than the FCC limit by a comfortable amount (positive numbers showing that the radio emissions are lower than the FCC limit).

The reflector-equipped radio emissions data was similarly processed. The main differences are the higher harmonic levels due the gain of the solid reflector. The test reflector used has a gain of +19dBi at the fundamental. Results of the radiated tests for the unit equipped with an external reflector are given below:

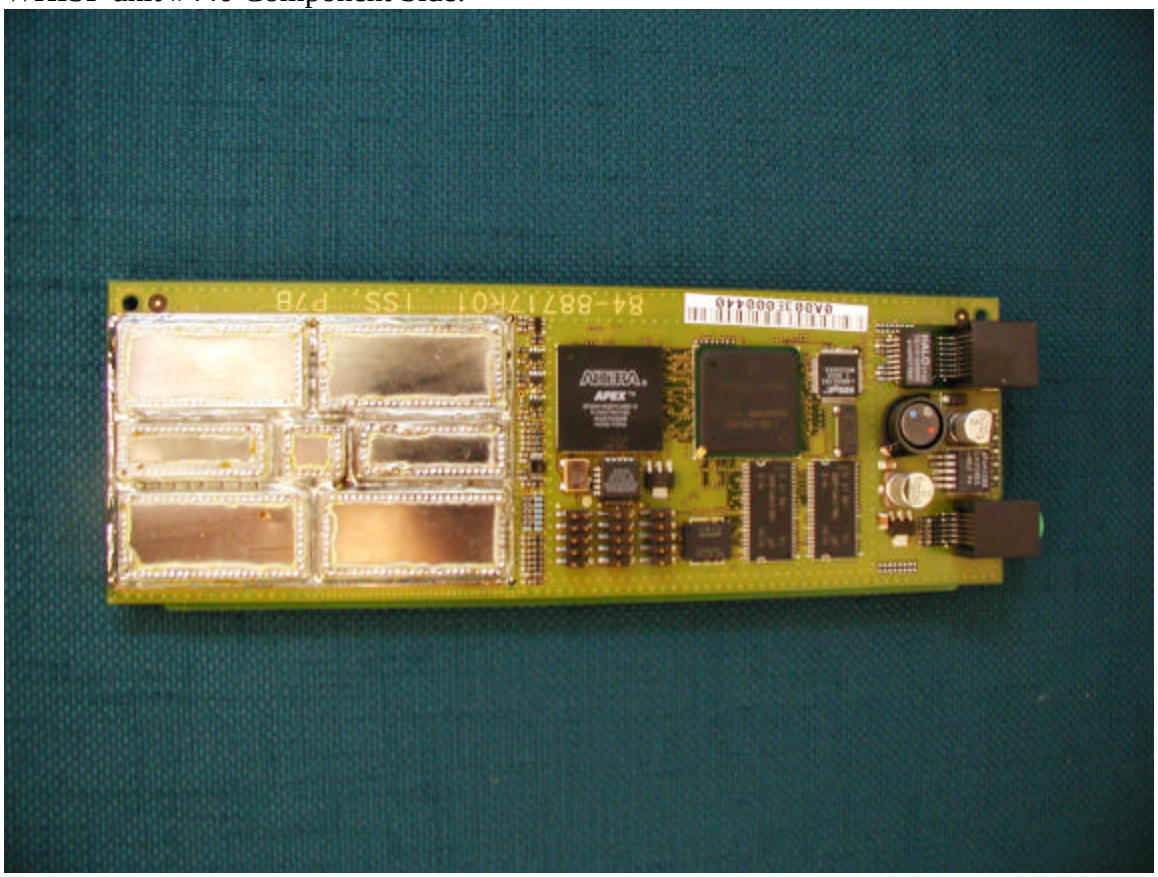
Canopy 5700 Radiated Test : Unit 440 with External Reflector

CW Mode	1MHz RBW/VBW					Agilent 8564EC Analyzer				
	Freq:=>	2900.00	8700.00	11600.00	17400.00	23200.00	29000.00	34800.00	40000.00	Restricted Band
5800.00	**Fund**	**VCO**	**3*LO**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	
Analyzer Reading	-18.67	-86.33	-85.67	-85.00	-81.50	-82.17	-86.83	-82.83	-80.00	
Noise Floor	-87.50	-87.00	-86.33	-86.50	-84.17	-82.18	-87.83	-83.17	-80.05	
Adjusted Analyzer Level	-18.67	-94.78	-94.18	-90.35	-84.88	-111.56	-93.70	-94.06	-99.41	
Cable Loss	-3.30	-2.20	-4.10	-4.80	-6.30	-7.50	-8.05	-9.07	-10.10	
dBm at Antenna Connector	-15.37	-92.58	-90.08	-85.55	-78.58	-104.06	-85.65	-84.99	-89.31	
Antenna Gain (dBi)	9.80	8.20	10.50	10.90	9.00	12.20	12.90	11.00	15.10	
20meter Path Loss	-73.73	-67.71	-77.25	-79.75	-83.27	-85.77	-87.71	-89.29	-90.63	
3 meter path loss	-57.25	-51.23	-60.77	-63.27	-66.80	-69.29	-71.23	-72.82	-74.15	
Path Loss Correction(20m to 3m)	-16.48	-16.48	-16.48	-16.48	-16.48	-16.48	-16.48	-16.48	-16.48	
Equivalent 3meter Antenna Power Level	-8.69	-84.30	-84.10	-79.97	-71.10	-99.78	-82.07	-79.51	-87.93	
Radio ERP in dBm	48.56	-33.07	-23.33	-16.69	-4.31	-30.49	-10.84	-6.70	-13.78	
Antenna Effective Aperture(square meters)	2.03E-03	5.63E-03	1.06E-03	6.55E-04	1.88E-04	2.21E-04	1.66E-04	7.45E-05	1.41E-04	
Aperture Ratio to 1 sq. meter in dB	26.92	22.50	29.74	31.84	37.26	36.56	37.80	41.28	38.52	
Power Density(dBm/m^2) at 3 meters	18.23	-61.80	-54.36	-48.13	-33.84	-63.22	-44.27	-38.23	-49.41	
FCC Restricted Band Emissions Limit(uV)	N/A	500.00		500.00		500.00				
FCC Out-of-Band Emssions Limit (dBm ERP)	N/A		-27.00		-27.00		-27.00	-27.00	-27.00	
Restricted Band Emissions Limit in dBm/m^2	N/A	-61.78		-61.78		-61.78				
Radio Level to FCC Limit in dB(CW Mode)	N/A	0.02	27.36	-13.66	6.84	1.44	17.27	11.23	22.41	
Transmit Duty Cycle Reduction(dB)		0.00	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	
CW to Modulated Mode Power Reduction(dB)		-13	-13	-13	-13	-13	-13	-13	-13	
Radio Level to FCC Limit in dB(Modulated Mode)		13.02	41.61	0.59	21.09	15.69	31.52	25.48	36.66	

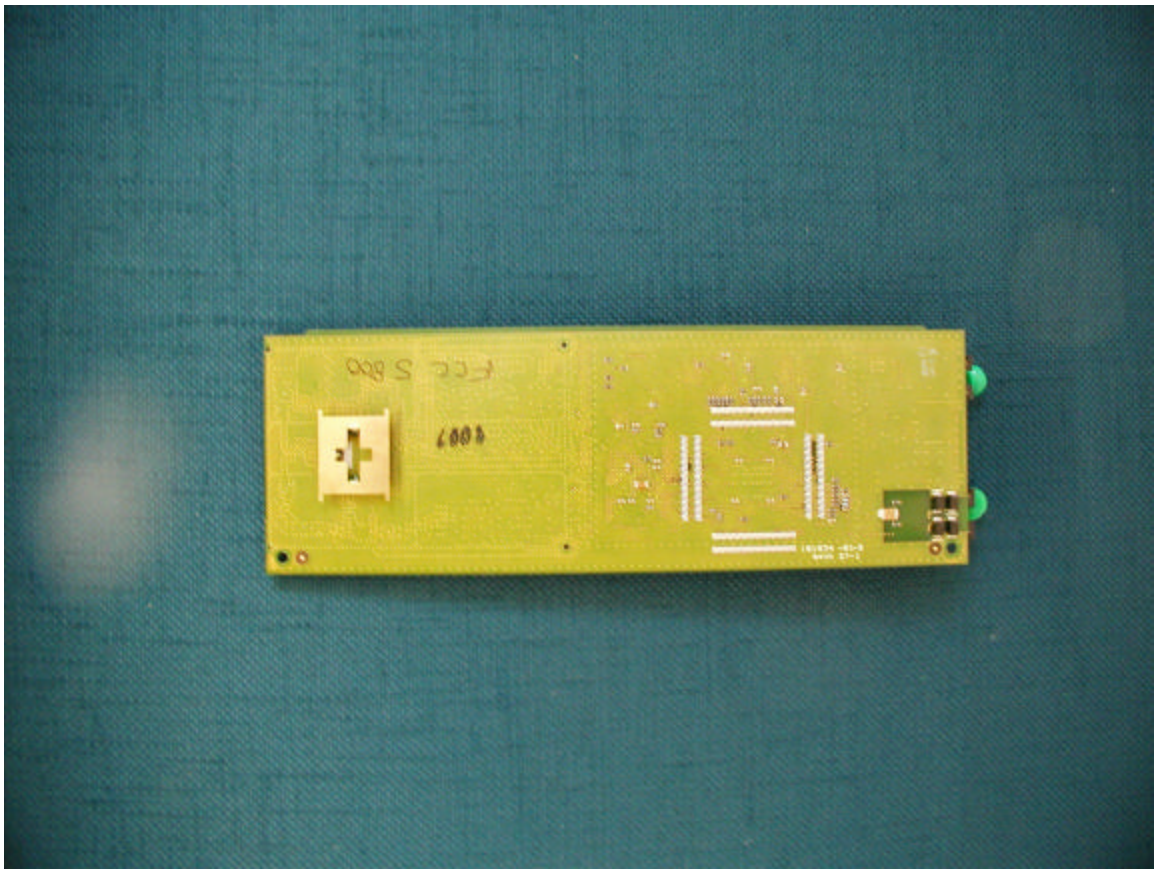
As can be seen from the spreadsheet, the radio meets the FCC limits when operating in normal mode with the +19dBi gain antenna.

The following two photographs shows the solder and component sides of the radio.

WHISP unit #440 Component Side:



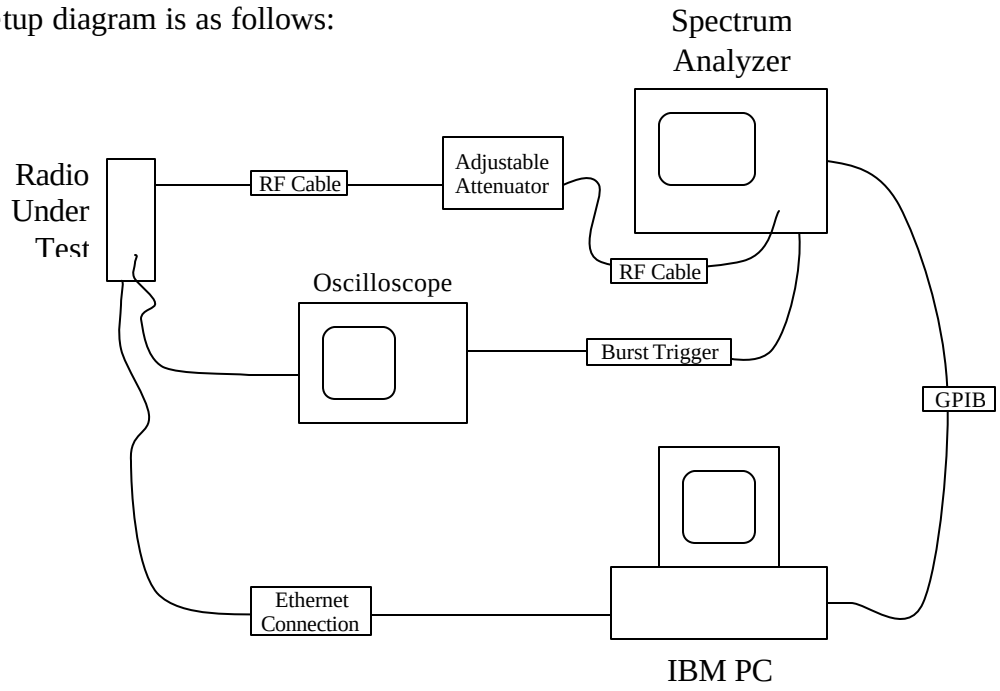
WHISP Unit #440, Solder Side:



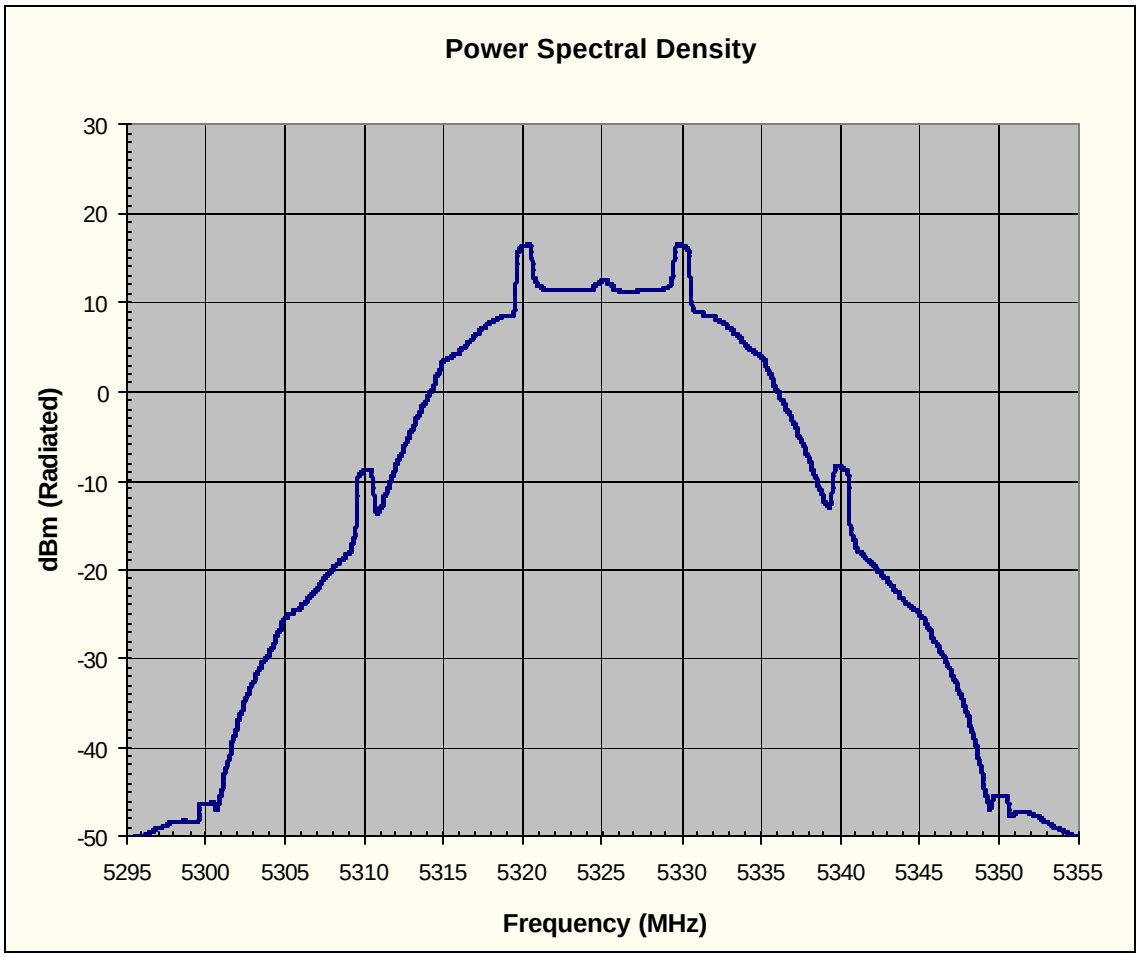
WHISP Radiated Test
19 July 2001

Compliance testing with FCC rules part 15.407 was performed in both conducted and radiated tests. The power spectral density measurement was setup on WHISP unit serial #170 before an antenna was added. The radio was connected to an HP (Agilent) 8596E Spectrum analyzer. Measurements were taken in 0Hz span with the spectrum analyzer synchronized to the transmitter's data burst. This allowed the analyzer to make time gated power measurements of the radio.

The test setup diagram is as follows:



Silent carrier signal from the radio under test was used to calibrate the spectrum analyzer through the adjustable attenuator for a carrier power of 0 dBm. TX bit error test pattern was initiated to maximize the transmit duty cycle and data throughput for the radio under test. A testing program on the PC computer collected the 0Hz span power sweeps over a 60MHz frequency band. Post processing integrated the power measurements into the 1MHz measurement bandwidths for the plotted power spectral density. The data was offset via the radiated carrier power measurement (+29.41dBm) and plotted as shown.



The plot shown above indicates the worst case results for the radio operation in the frequency band 5250-5350MHz. The results show that at +/-5MHz from the carrier frequency the maximum power in a 1MHz BW is +16.65dBm radiated. In the region +/-25 to 26MHz the maximum amplitude was –45.39dBm or 3.8dB better than the maximum restricted band power of -41.5dBm radiated. From these measurements it can be seen that the WHiSP radio #170 passses the FCC part 15 specifications.

WHISP Radiated Test

19 July 2001

WHISP unit serial #170 was tested outdoors to check compliance with FCC requirement 15.209, restricted band emissions. The testing was done using a model 3115 and a model 3116 calibrated dual-ridged waveguide-horn antennas manufactured by EMCO, Inc., an Agilent 8564EC 40GHz spectrum analyzer, and a laptop to control the DUT and take data from the spectrum analyzer. The two antennas combined allowed a frequency measurement range of 1GHz to 40GHz. The spatial separation between the EMCO horn antennas and the DUT was maintained at 3 meters during the test.

The FCC requirement for restricted band emissions is stated in terms of field strength and is 500uV/m at 3 meters. Using the free space impedance of 377 ohms, the equivalent power density is –61.78dBm/m^2. This power density number was used as the pass/fail criteria for the test. Cable losses, antenna gains, and other correction factors were entered into an Excel spreadsheet along with the results of the testing.

To calculate the power density at the horn antennas, the power level received by the antenna is offset by the log ratio of the effective aperture of the antenna to one square meter. The calculation of the effective aperture is done using:

$$A_{em} = e_{cd}(?^2/4p)D_o,$$

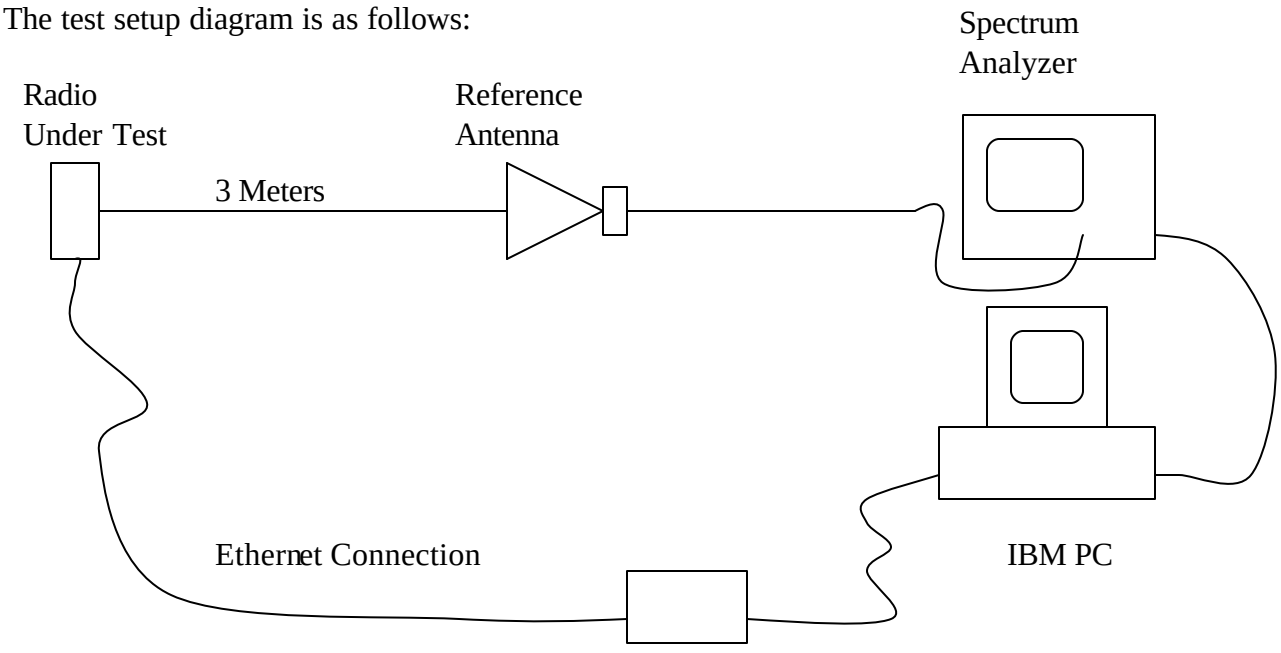
D_o is the directivity of the antenna, e_{cd} is the efficiency, and ? is the wavelength of the frequency under observation. In the equation, e_{cd} and D_o may be replaced by the numeric gain of the antenna. Using the calibration data from the manufacturer, the effective area of the antenna was computed for each measurement frequency and the appropriate dB correction factor applied.

The operating frequency of the radio presented a challenge to measuring the harmonics radiated by the radio. Since the highest harmonic to be measured is 37GHz, finding test equipment that possess reasonable noise figures and obtaining coax cables with mode-free moderate loss is difficult. The resolution bandwidth of 1MHz also adds to the problem of making an effective radiated power measurement. As an aid in performing these measurements, the radio was designed with the ability to operate in continuous-wave mode, permitting the use of narrow bandwidths on the analyzer.

The picture below shows the configuration of the test set-up:

The test antenna and test radio were mounted on adjustable tripods and placed 3 meters apart. Absorbing panels were placed on the ground to reduce the effects of ground reflections.

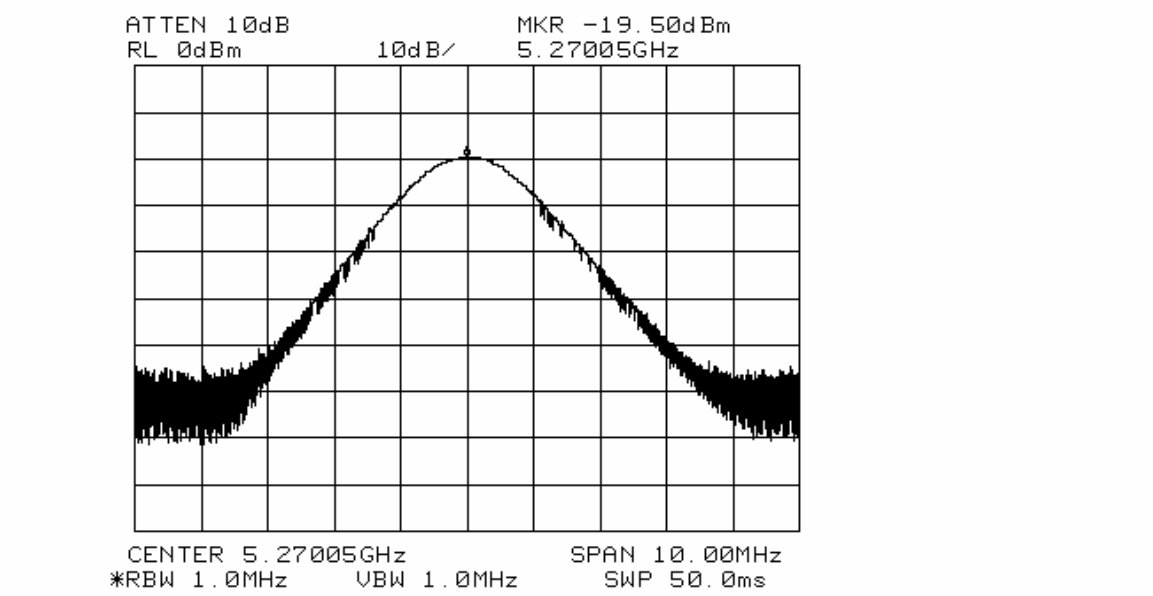
The test setup diagram is as follows:



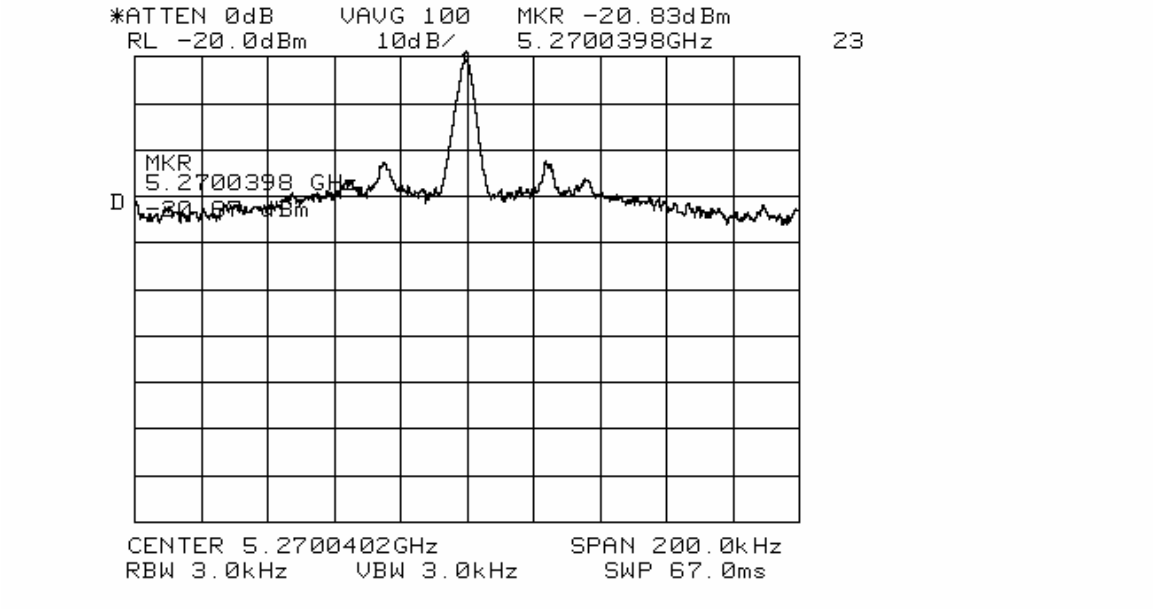
The radio has a CW mode for testing purposes and was used to measure the harmonic levels radiated from the radio. With no modulation, the measurement bandwidth could be reduced below 1MHz, allowing greater dynamic range for the test equipment. Measurements were made using 300Hz and 3 kHz resolution bandwidths and, when signal levels permitted, a 1MHz bandwidth.

An RF frequency of 5270MHz was chosen for this test since this was the frequency having the highest spurious emissions levels. Data from the analyzer was transferred to the laptop computer and later processed. The raw spectral plots from the HP8593E analyzer are given below:

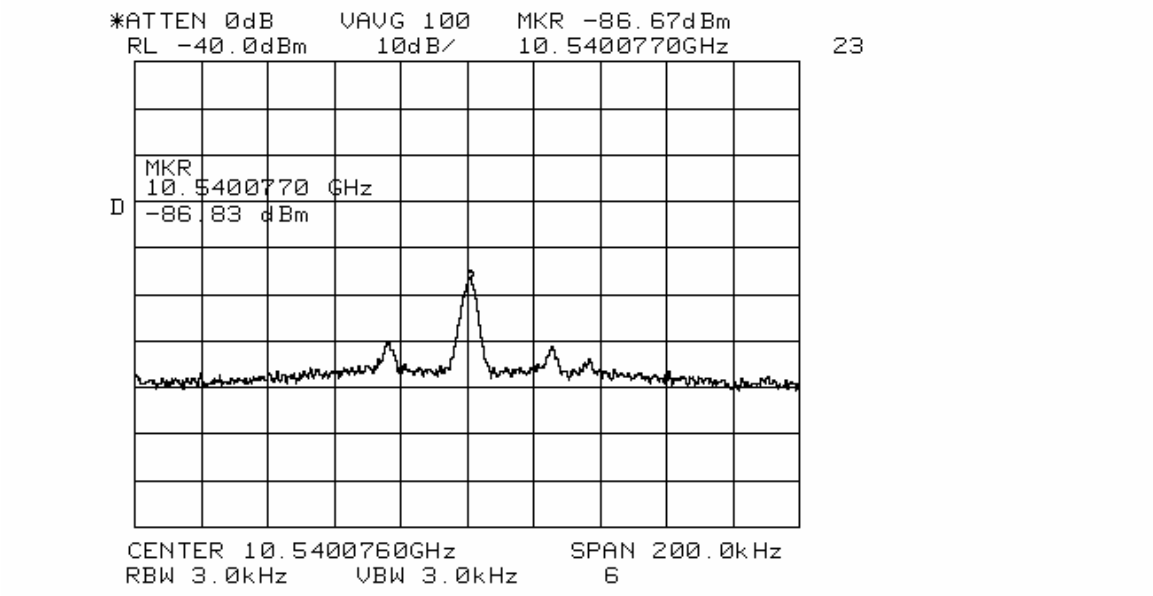
Plot 1: Fundamental frequency: 1MHz RBW:



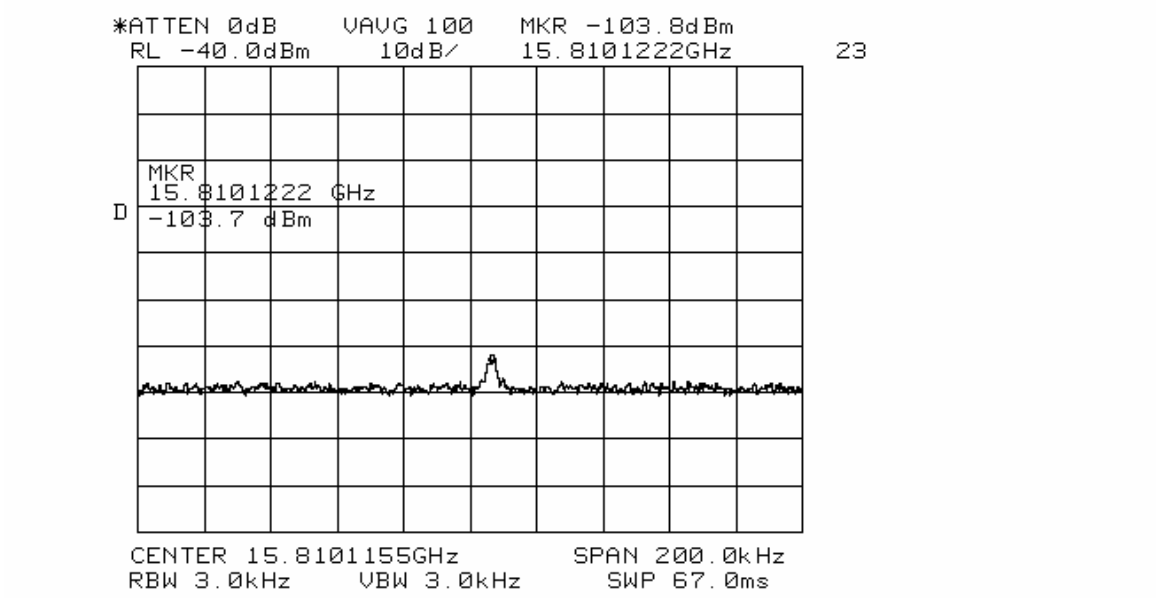
Plot 2: Fundamental frequency, 3kHz RBW:



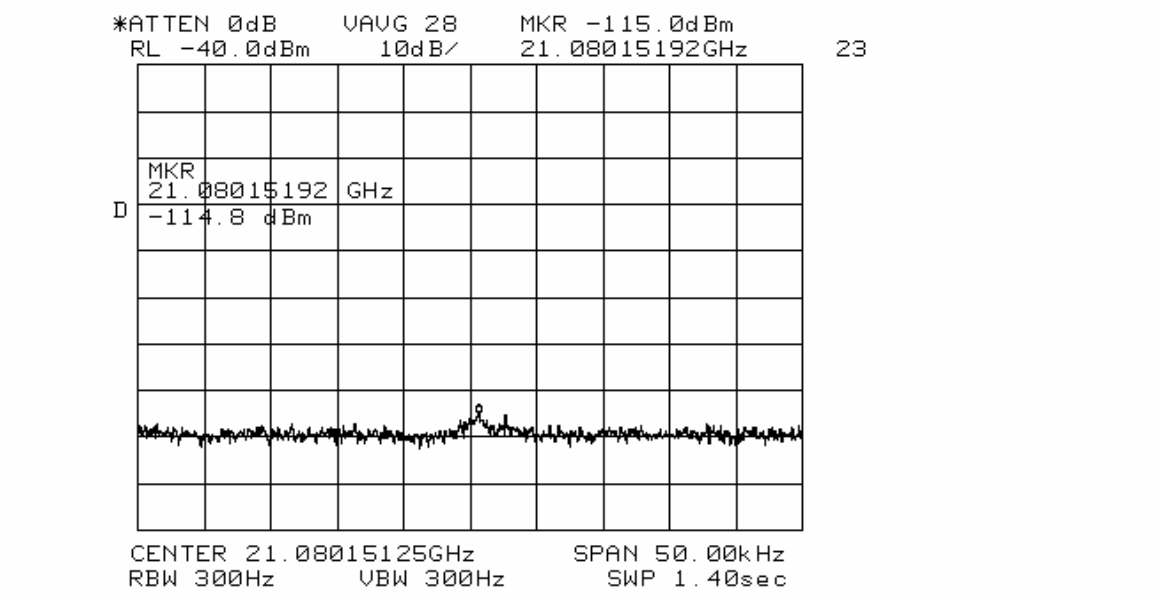
Plot 3: Second Harmonic, 3kHz RBW:



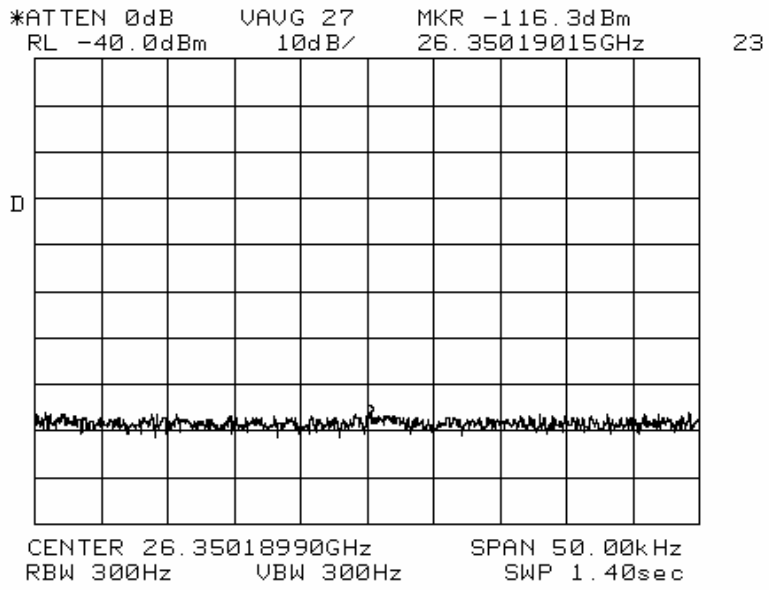
Plot 4: Third Harmonic, 3kHz RBW:



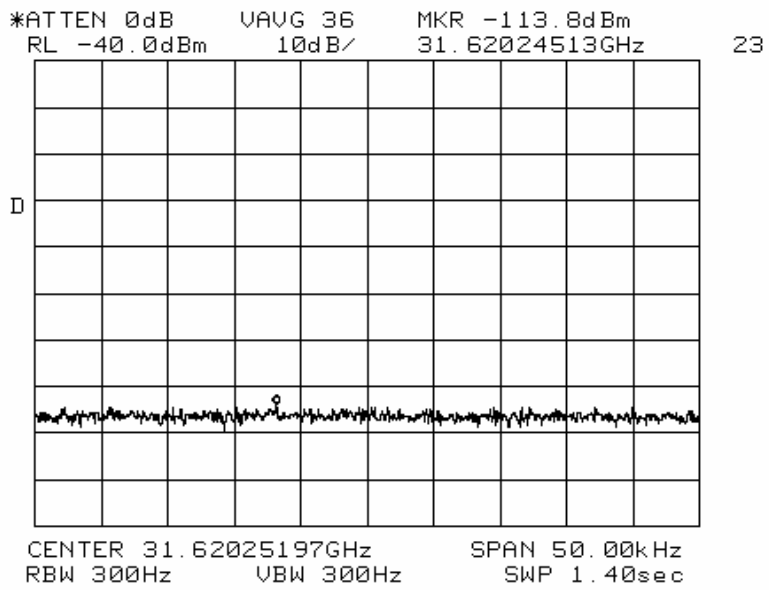
Plot 5: Fourth Harmonic, 300Hz RBW:



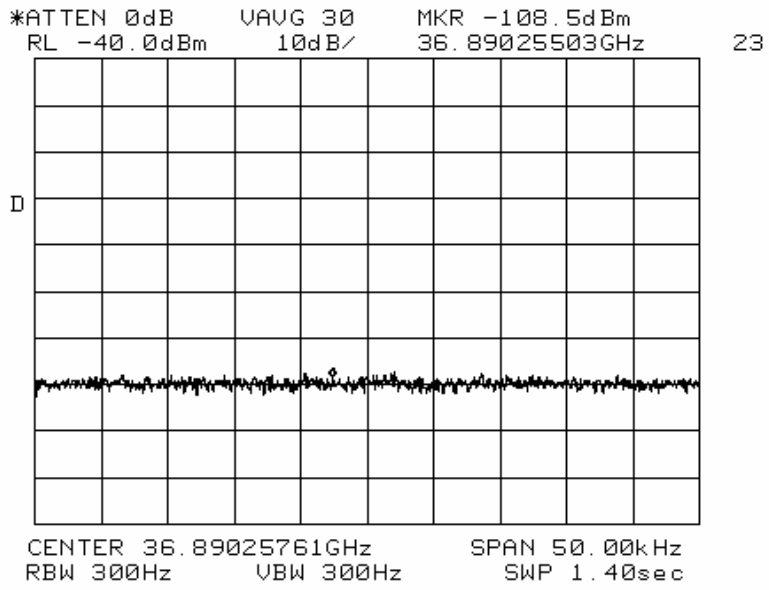
Plot 6: Fifth Harmonic, 300Hz RBW:



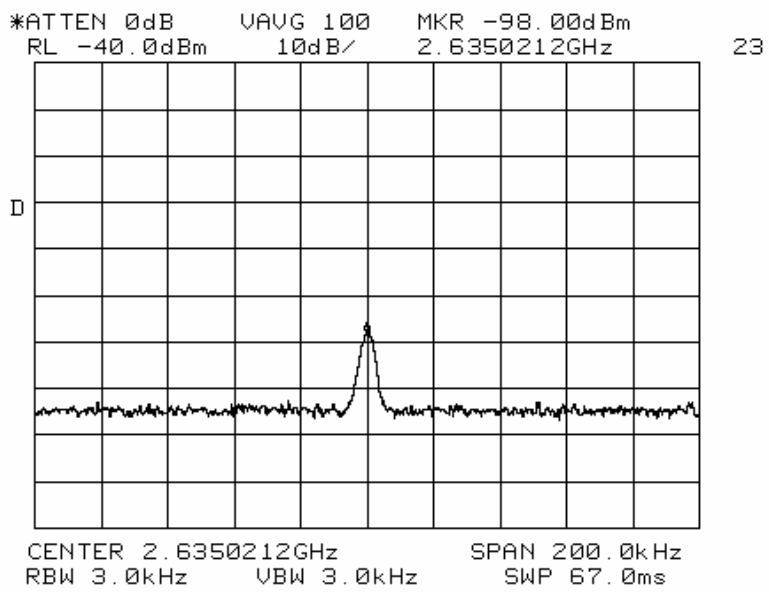
Plot 7: Sixth Harmonic, 300Hz RBW:



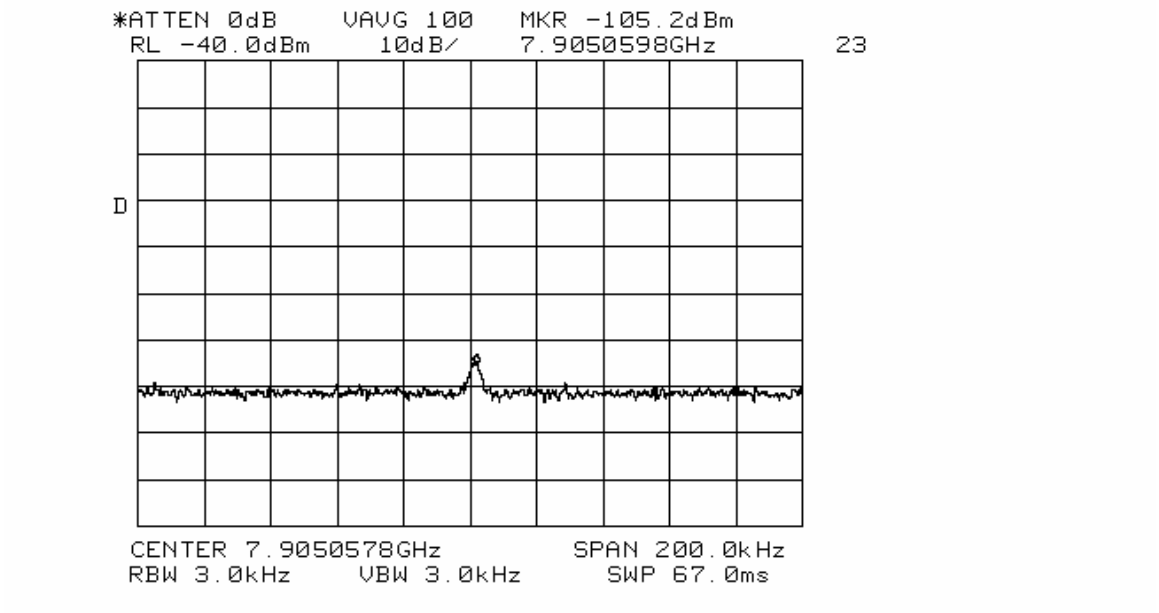
Plot 8: Seventh Harmonic, 300Hz RBW:



Plot 9: VCO Feedthrough, 3kHz RBW:



Plot 10, VCO 3rd Harmonic, 3kHz RBW:



A sample of the error budgeting is shown below. The total error is given in the last row, and shows that the error spread does not exceed +/- 2dB over the frequency range. Although not shown in the sample below, the error terms for the coax cable and the spectrum analyzer are included in the final error terms of the bottom row.

Measurement Error Budget	1-18GHz	18-30GHz	30-40GHz
Error Contribution (dB)	**EMCO 3115**	**EMCO 3116**	**EMCO 3116**
VSWR Contribution in dB	1.00	0.88	0.88
Amplitude Uncertainty	0.30	0.80	1.50
Reference Level			
Total Error, Plus/Minus dB	***1.37***	***1.48***	***1.95***

The following Excel spreadsheet cells show the corrected power levels of the radio. The first sheet shows an ERP of +29.4dBm when the radio was operating at 5270MHz.

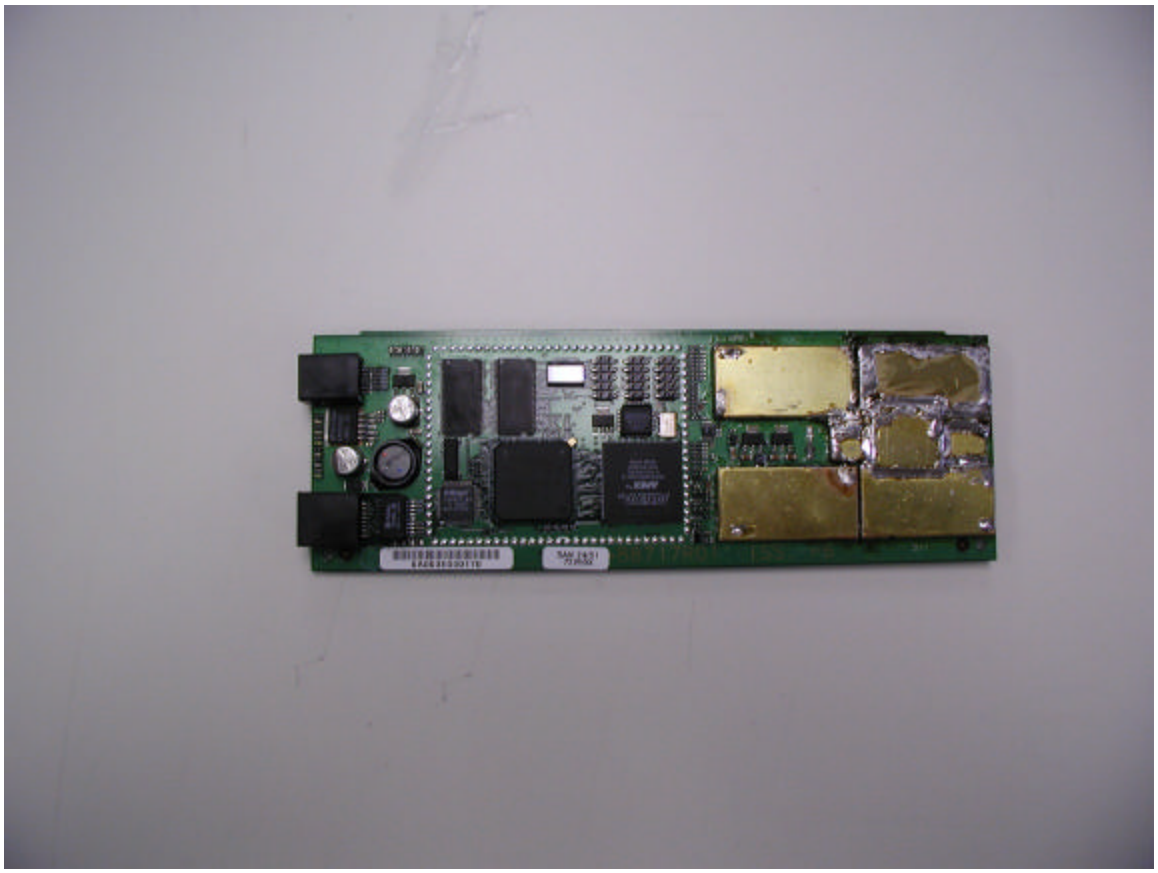
5270.003	**Fund**
rssi	-20.83
preamp	
cable	-3.023
antenna	9.2
path	-56.42041438
dBm at ref ant.	-27.007
dBm at radio	29.41341438

Harmonic Frequency Testing Spreadsheet Summary:

CW Mode	3kHz or 300Hz RBW/VBW				37101.00	Agilent 8564EC Analyzer			
	Freq:=>	2635.00	7905.00	10540.01	15810.01	21080.01	26350.02	31620.02	36890.02
5270.00	**Fund**	**VCO**	**3*LO**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**
Analyzer Level	-20.83	-98.00	-105.20	-86.67	-103.80	-115.00	-116.30	-113.80	-108.50
Cable Loss	-3.02	-2.00	-3.90	-4.46	-6.03	-7.00	-8.05	-9.07	-10.10
Antenna Gain	9.20	7.70	10.00	13.90	15.40	12.30	12.20	12.20	15.30
Path Loss	-56.42	-50.40	-59.94	-62.44	-65.96	-68.46	-70.40	-71.98	-73.32
Power Level at Antenna (dBm)	-27.01	-103.70	-111.30	-96.11	-113.17	-120.30	-120.45	-116.93	-113.70
Power Level at radio (dBm)	29.41	-53.30	-51.36	-33.67	-47.21	-51.84	-50.05	-44.95	-40.38
Level relative to Carrier, dB		82.71	80.77	63.08	76.62	81.25	-3.25	-6.41	6.71
calculated antenna aperture	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
antenna correction to sq. meter in dB	26.69	22.17	29.41	28.01	30.03	35.63	37.67	39.25	37.49
power density at 3 meters (dBm/m^2)	-0.32	-81.53	-81.89	-68.10	-83.14	-84.67	-82.78	-77.68	-76.21
FCC Limit of 500uV/m @ 3meter in dBm	-61.78								
dB better or worse than FCC limit		19.75	20.11	6.32	21.36	22.89	21.00	15.90	14.43

The results show that the radio meets the FCC limit of 500uV/m on the harmonics. The highest level was from the second harmonic and had the lowest margin by being only 6.3 dB better than the limit specification. Even with the measurement uncertainty of the equipment, the radio was still 4.37dB better than the limit.

WHISP unit #170 Component Side:



WHISP Unit #170, Solder Side: