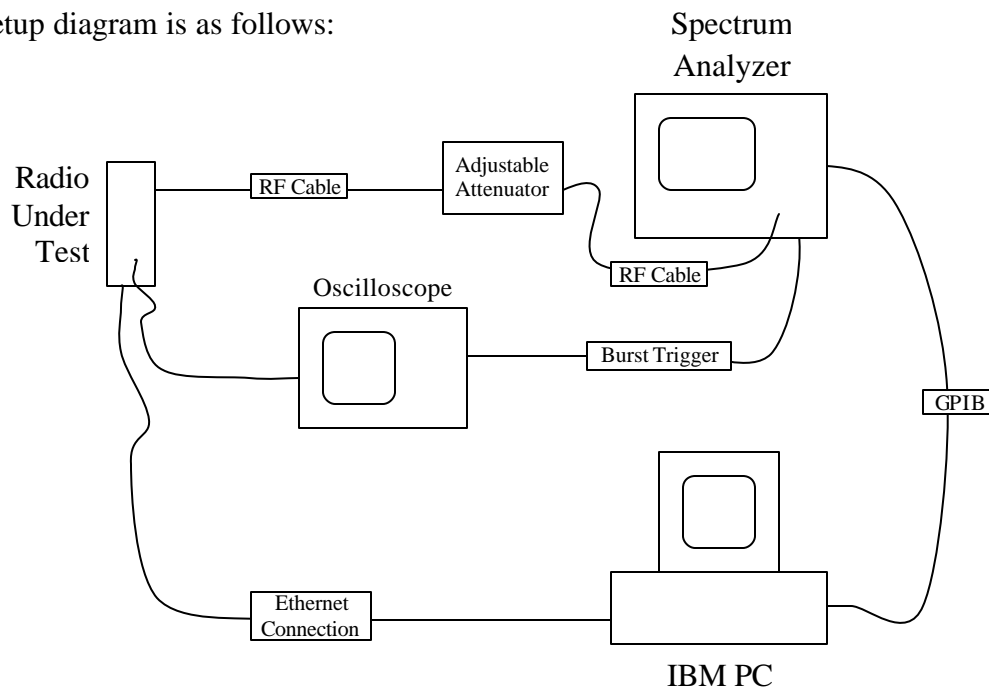


**Technical Brief**  
Canopy 5210 Conducted Test  
16 Dec 2003

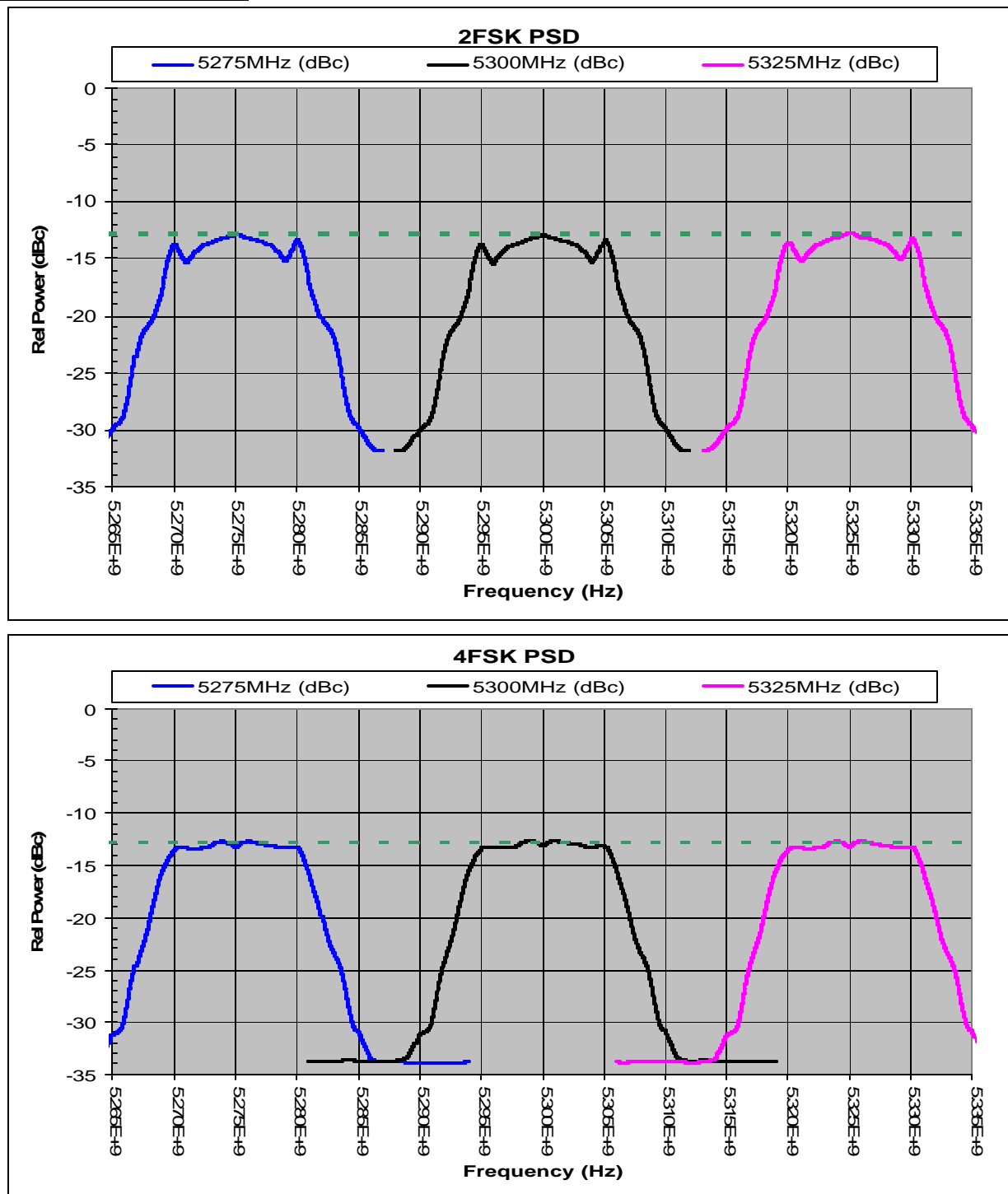
Compliance testing with FCC rules part 15.407 and RSS-210 of Industry Canada (IC) section 6.2.2 (q1) was performed in both conducted and radiated tests. The power spectral density measurement was setup on Canopy Model 5210 unit serial #0A003E0063E9 before an antenna was added. The radio was connected 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:



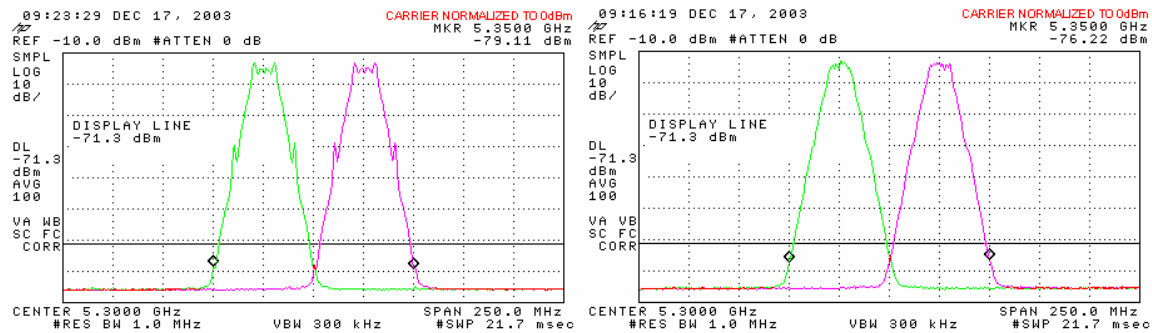
Silent carrier signal from the radio under test was used to calibrate the spectrum analyzer through the adjustable attenuator for a carrier power of 0 dBm. TX bit error test pattern was initiated to maximize the transmit duty cycle and data throughput for the radio under test. A testing program on the PC computer collected the 0Hz span power sweeps over a measurable 26 MHz 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 (+29.72dBm) and plotted as shown.

### 15.407a. Power Limits



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 less than 17dBm radiated for both 2level FSK10Mb signaling and 4 level FSK 20Mb signaling.

## 15.407b. Undesirable Emission limits



The plots above are taken directly in a 1MHz resolution bandwidth. The markers indicate the spectral power at both 5250MHz and 5350MHz. Both markers are below the display line which indicates the restricted band specification translated to a relative (dBc) output power measurement. Note: 0dBm, in the graphs above, is equivalent to 0dbc. -41.25dBm when related to the +30dBm maximum ERP results in a -71.25dBc specification. From these measurements it can be seen that the Canopy Model 5210xx radio #0A003E0063E9 passes the FCC part 15 and RSS-210 of IC section 6.2.2 (q1) specifications.

Canopy Model 5210 Radiated Test  
16 December 2003

Canopy Model 5210 unit serial #0A003E0063EC was tested in radiated fashion to check compliance with FCC requirement 15.209 and RSS-210 of IC, 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 or 7meters during the test depending on signal strength.

The FCC and RSS-210 of IC 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  $-61.78\text{dBm/m}^2$ . 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.

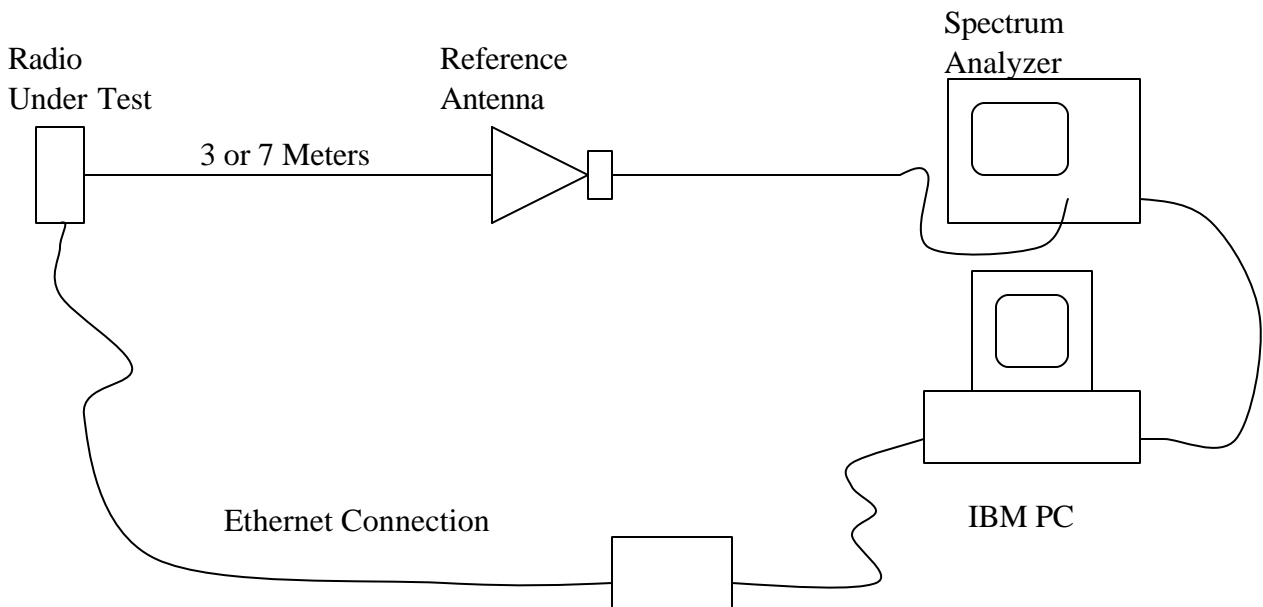
The operating frequency of the radio presented a challenge to measuring the harmonics radiated by the radio. Since the highest harmonic to be measured is 37.275GHz, finding test equipment that has reasonable noise figures and obtaining coax cables with mode-free moderate loss is difficult. The resolution 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 test antenna and test radio were mounted on adjustable tripods and placed 7 and 3 meters apart depending on signal strength.





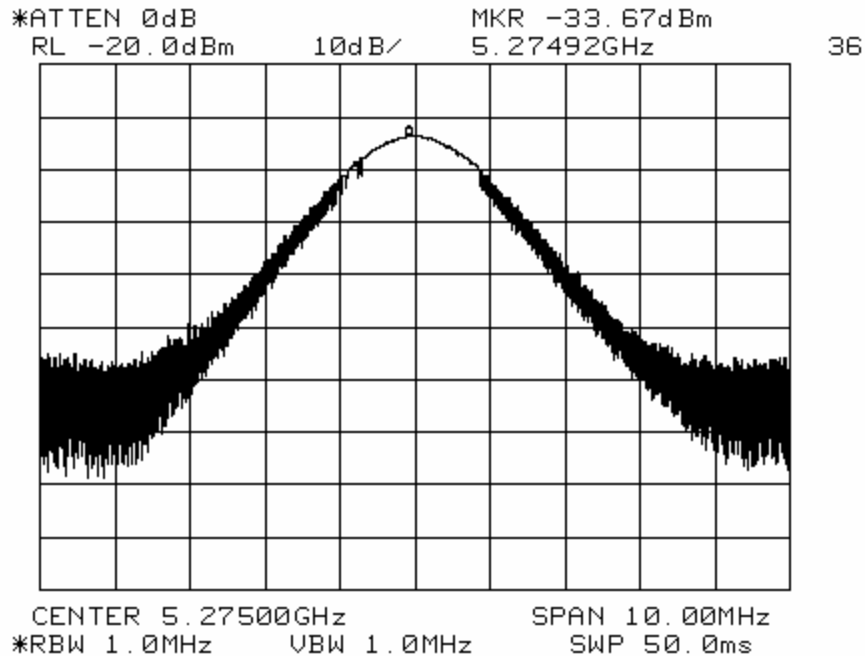
The test setup diagram is as follows:



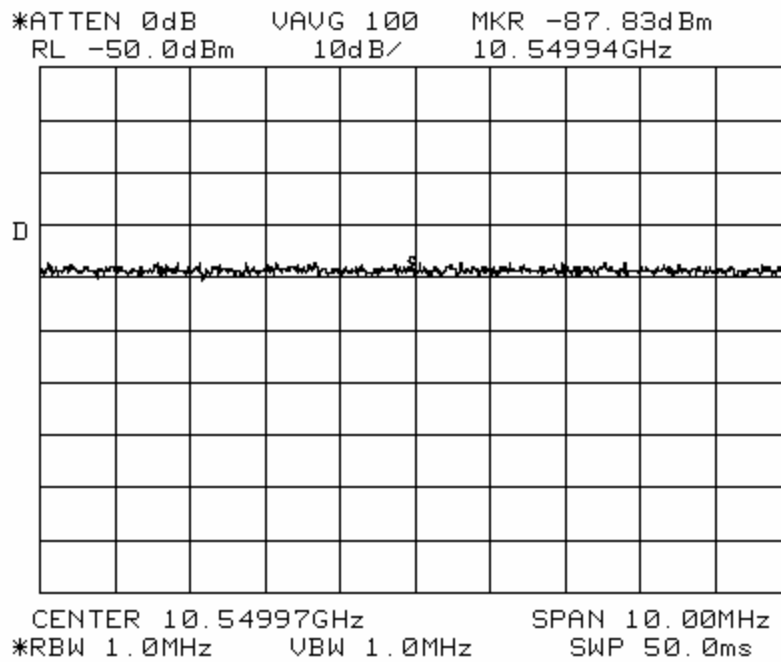
The radio has a CW mode for testing purposes and was used to measure the harmonic levels radiated from the radio. With no modulation, the measurement bandwidth could be reduced below 1MHz, allowing greater dynamic range for the test equipment. Measurements were made using multiple resolution bandwidths ranging from 300Hz to 1MHz, in order to observe radiated emissions from the unit under test. Measurements were confirmed as narrowband carrier components equated to a 1MHz bandwidth.

Measurements were performed at three frequencies across the band 5275 MHz to 5325 MHz. Data from the analyzer was transferred to the laptop computer and later processed. The raw spectral plots from the HP8564E analyzer are given below.

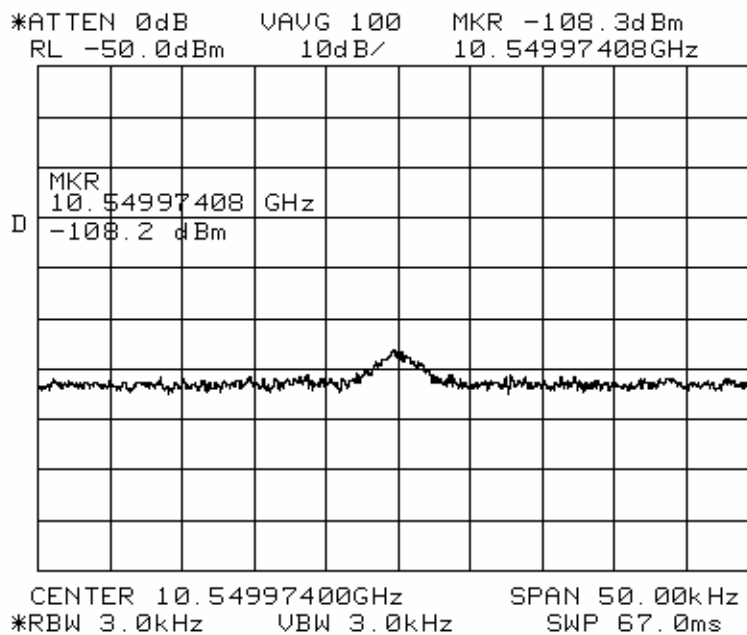
Plot 1: Low Channel Fundamental frequency: 1MHz RBW: 7m



Plot 2: Low Channel Second Harmonic: 1MHz RBW: 7m

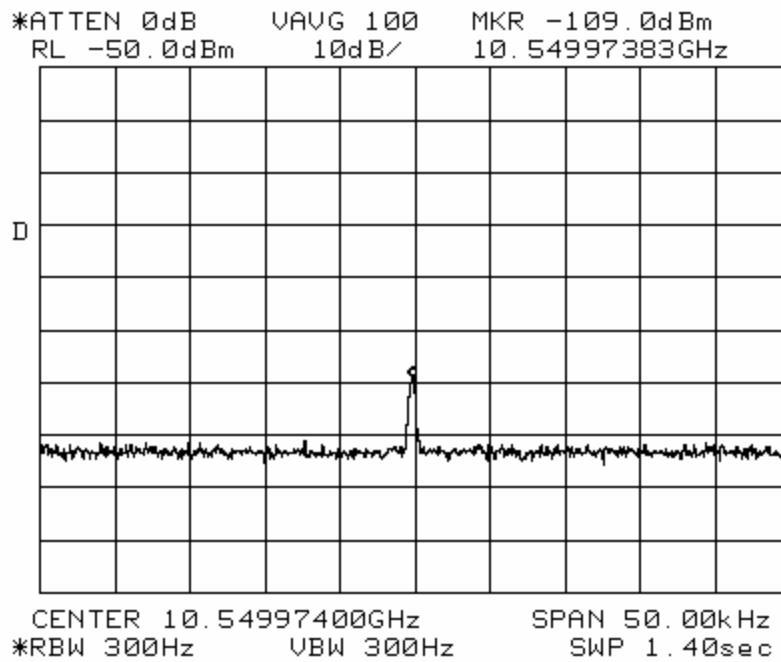


Plot 3: Low Channel Second Harmonic: 3KHz RBW: 7m

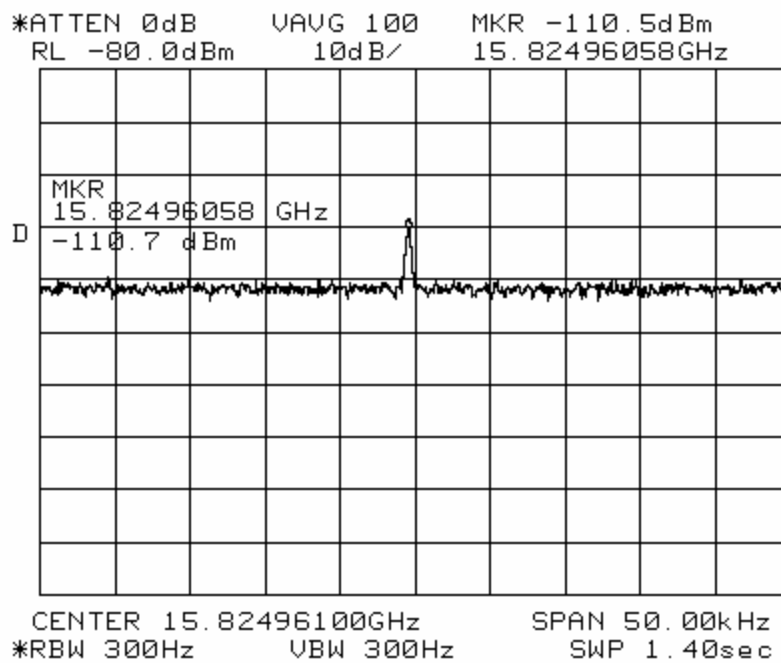




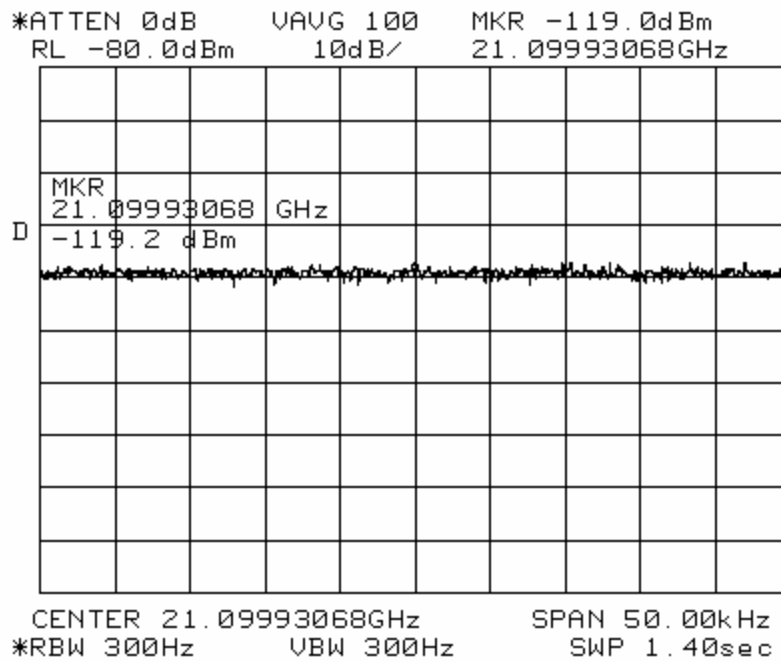
Plot 4: Low Channel Second Harmonic: 300Hz RBW: 7m



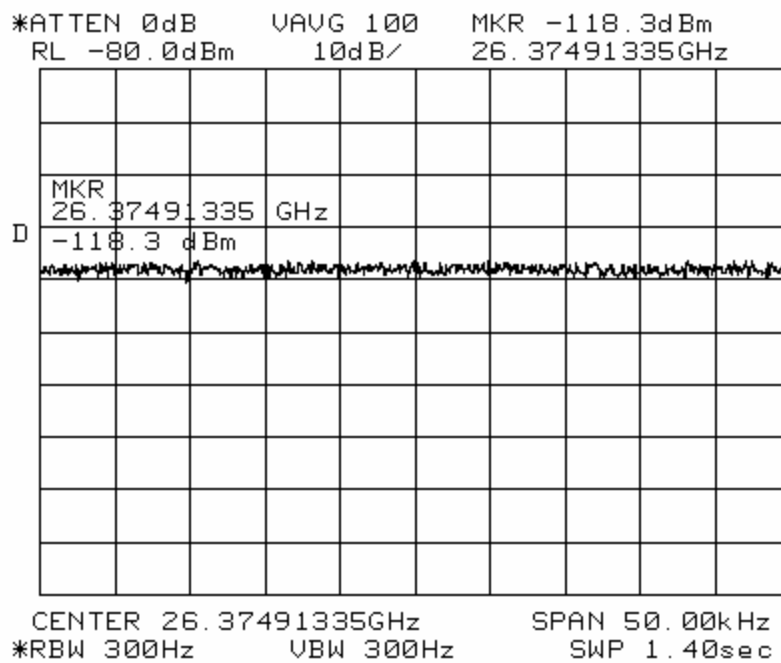
Plot 5: Low Channel Third Harmonic: 300Hz RBW: 7m



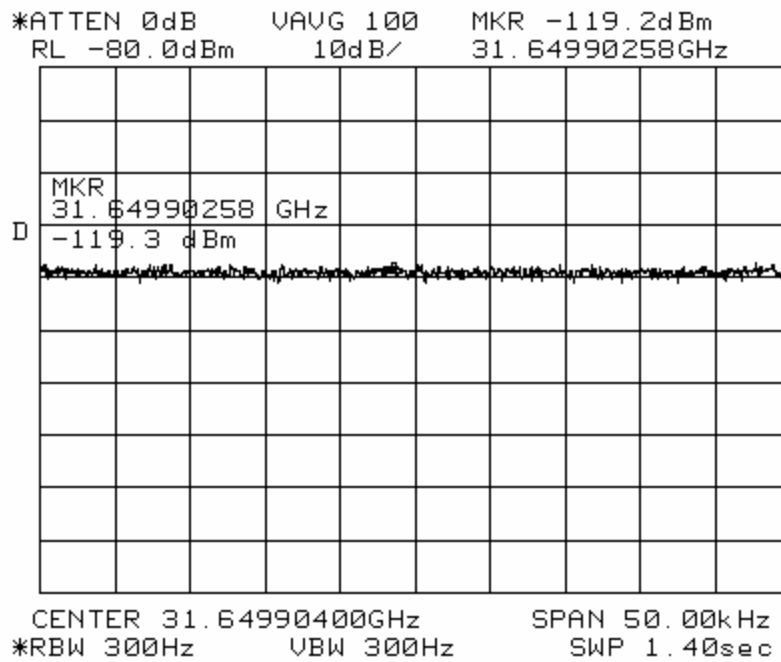
Plot 6: Low Channel Fourth Harmonic: 300Hz RBW: 7m



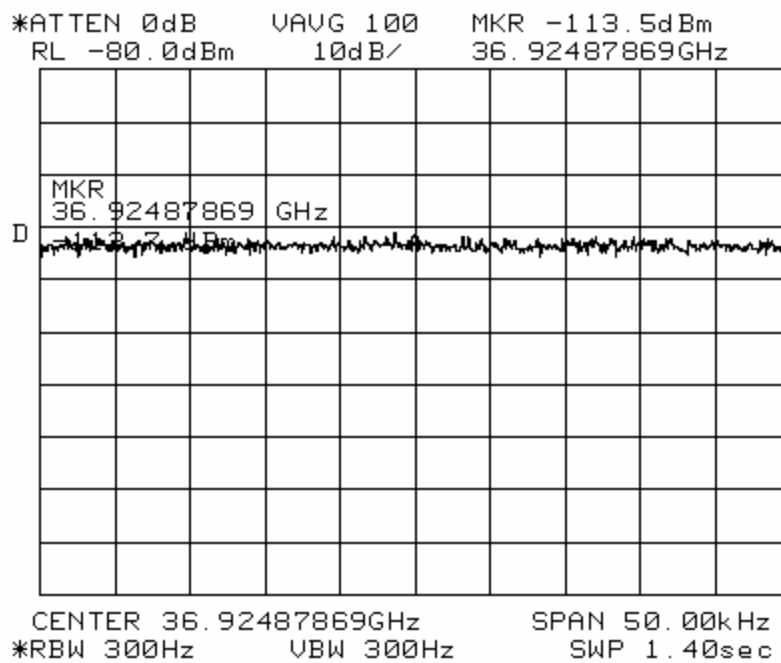
Plot 7: Low Channel Fifth Harmonic: 300Hz RBW: 7m



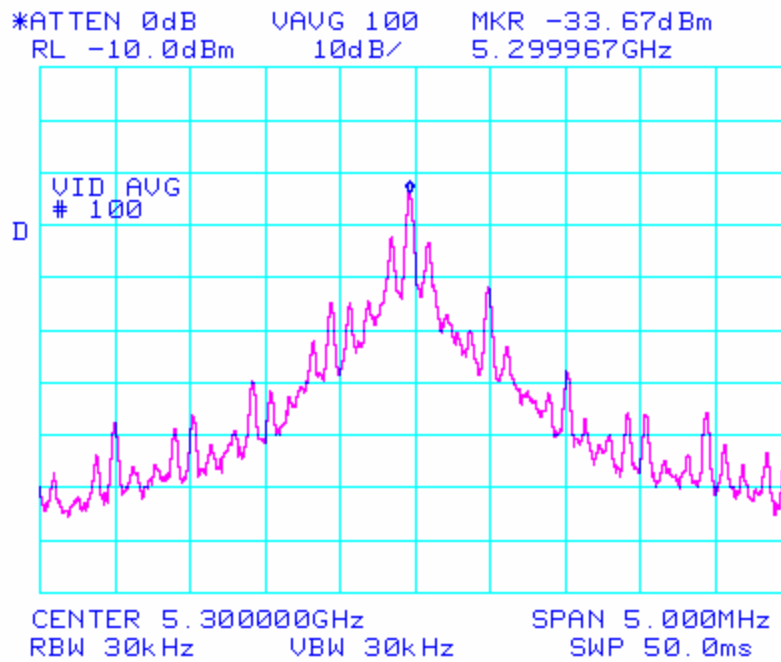
Plot 8: Low Channel Sixth Harmonic: 300Hz RBW: 7m



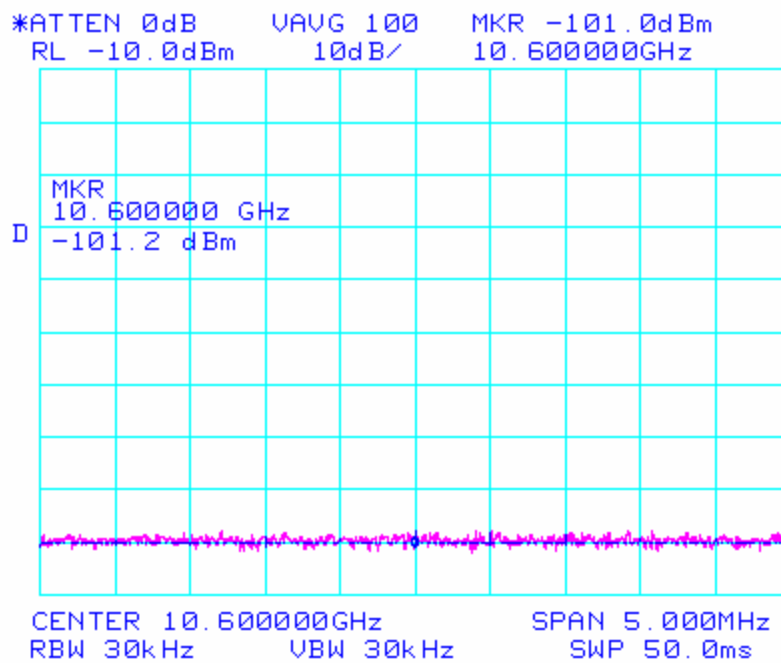
Plot 9: Low Channel Seventh Harmonic: 300Hz RBW: 7m



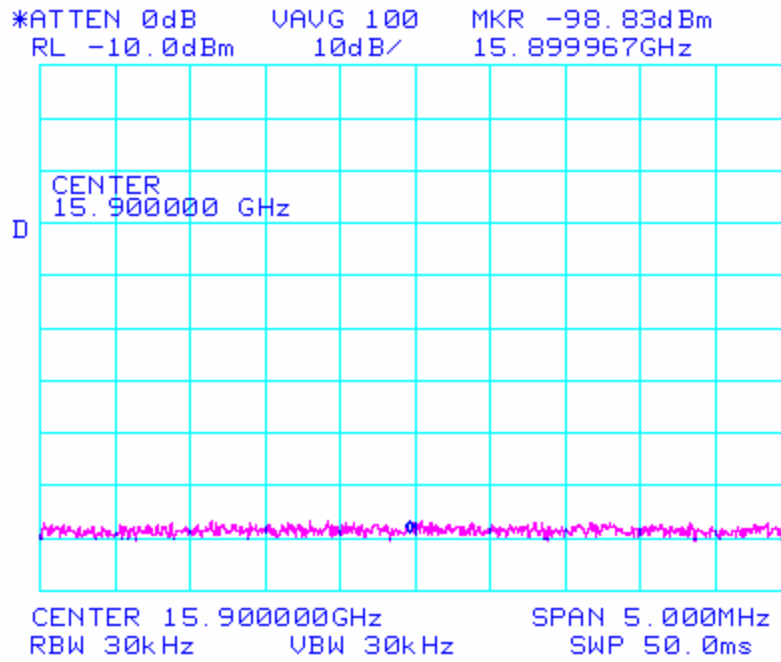
Plot 10: Mid Channel Fundamental frequency: 30KHz RBW: 7m



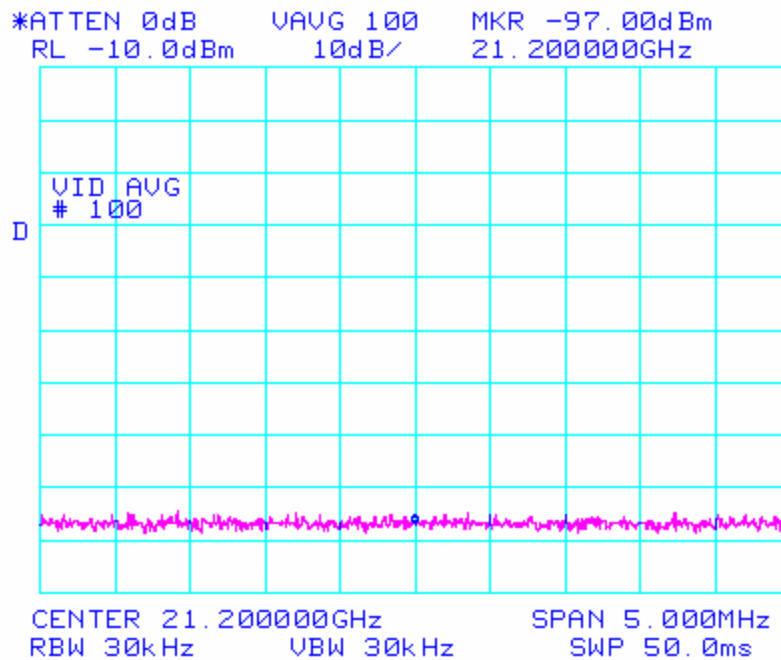
Plot 11: Mid Channel Second Harmonic, 30KHz RBW: 3m



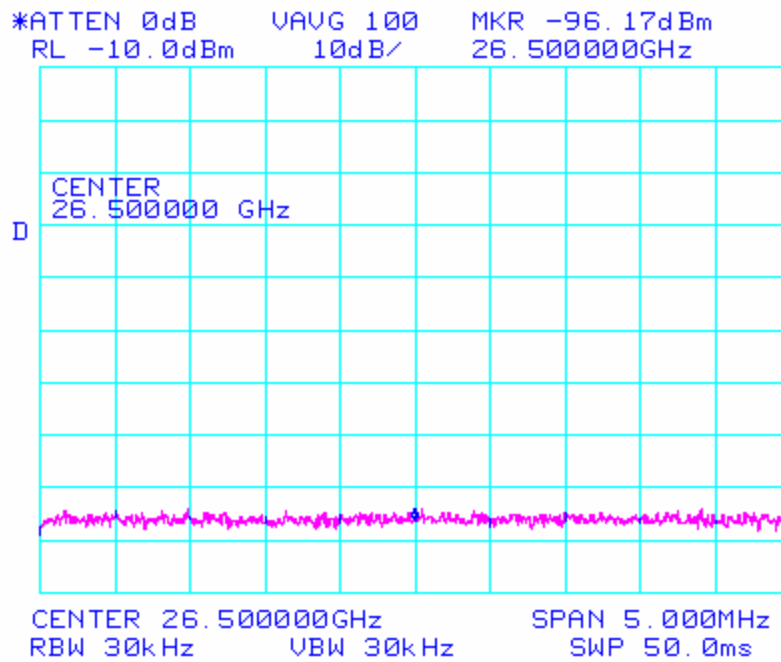
Plot 12: Mid Channel Third Harmonic, 30KHz RBW: 3m



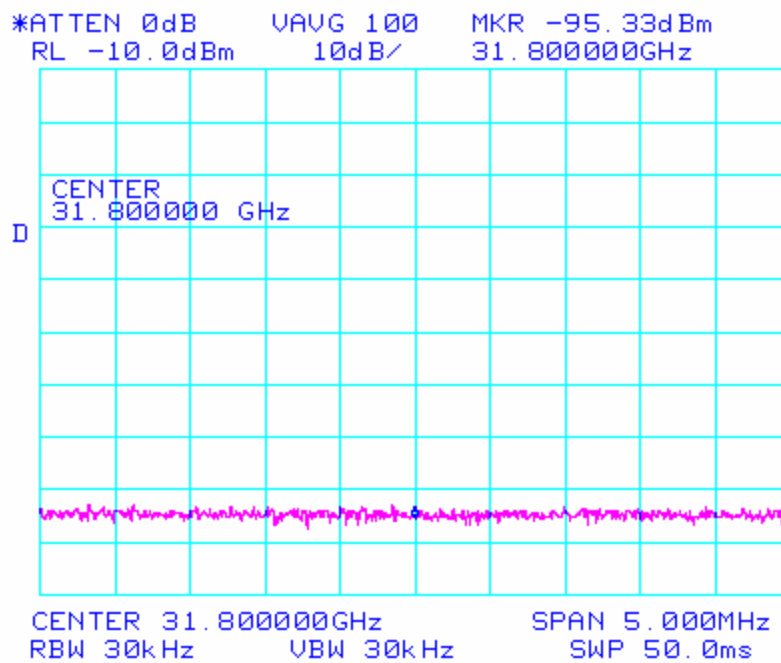
Plot 13: Mid Channel Fourth Harmonic, 30KHz RBW: 3m



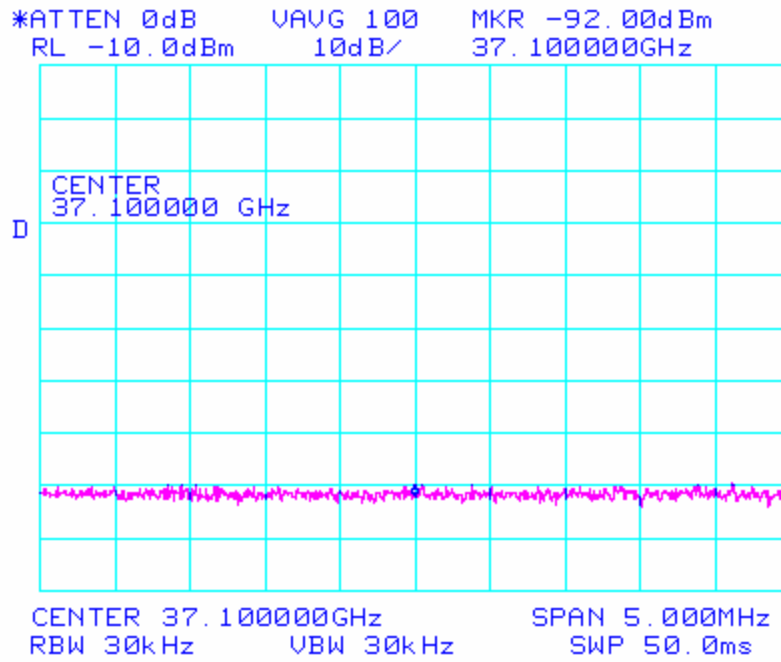
Plot 14: Mid Channel Fifth Harmonic, 30KHz RBW: 3m



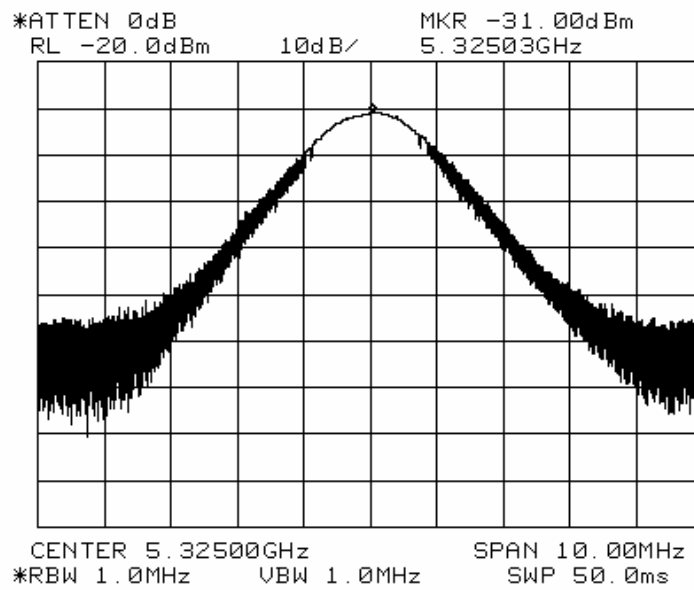
Plot 15: Mid Channel Sixth Harmonic, 30KHz RBW: 3m



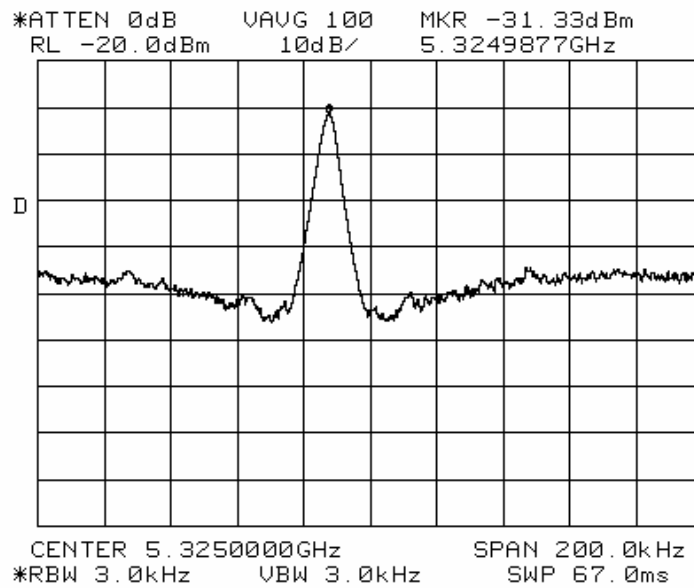
Plot 16: Mid Channel Seventh Harmonic, 30KHz RBW: 3m



Plot 17: Hi Channel Fundamental frequency: 1MHz RBW: 7m

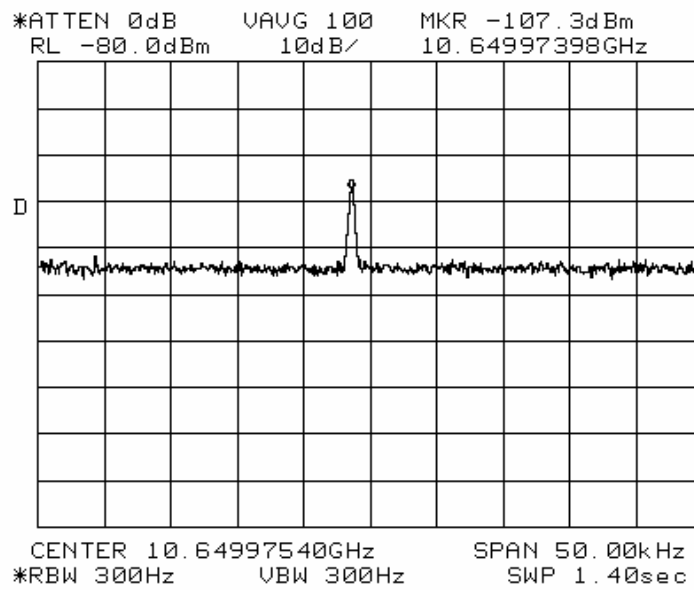


Plot 18: Hi Channel Fundamental frequency, 3kHz RBW: 7m

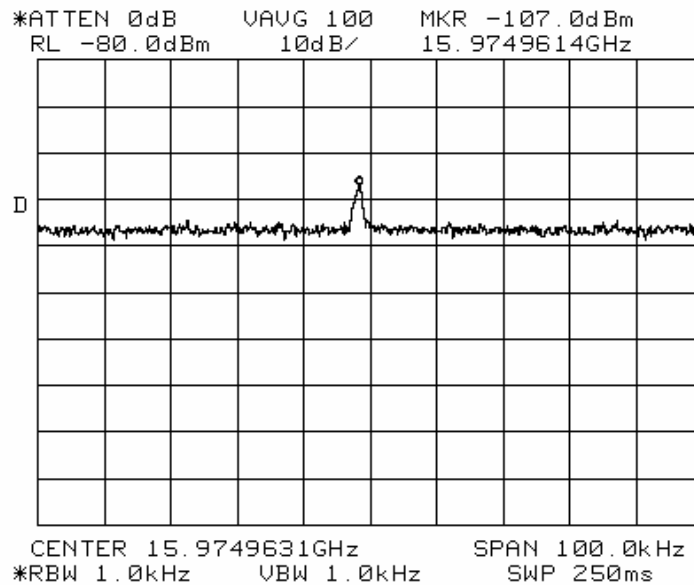




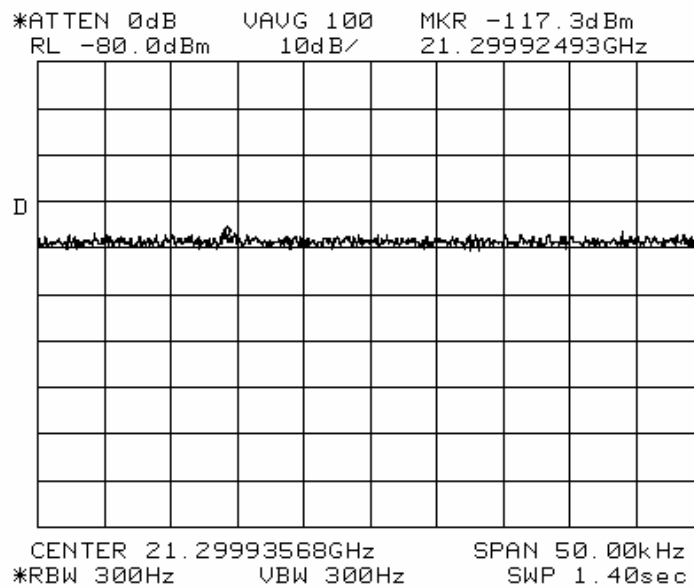
Plot 19: Hi Channel Second Harmonic, 300Hz RBW: 7m



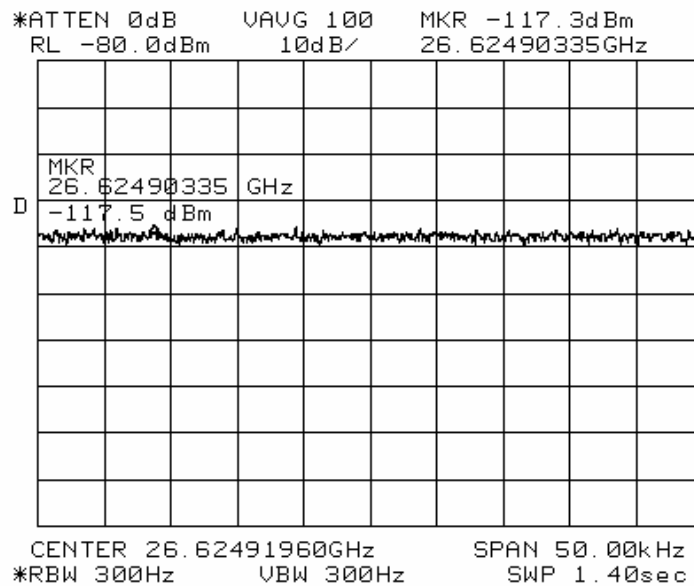
Plot 20: Hi Channel Third Harmonic, 1kHz RBW: 7m



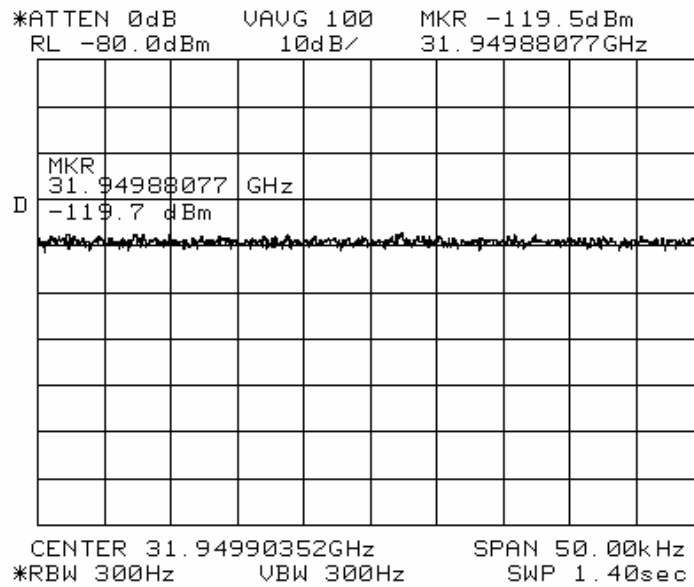
Plot 21: Hi Channel Fourth Harmonic, 300Hz RBW: 3m



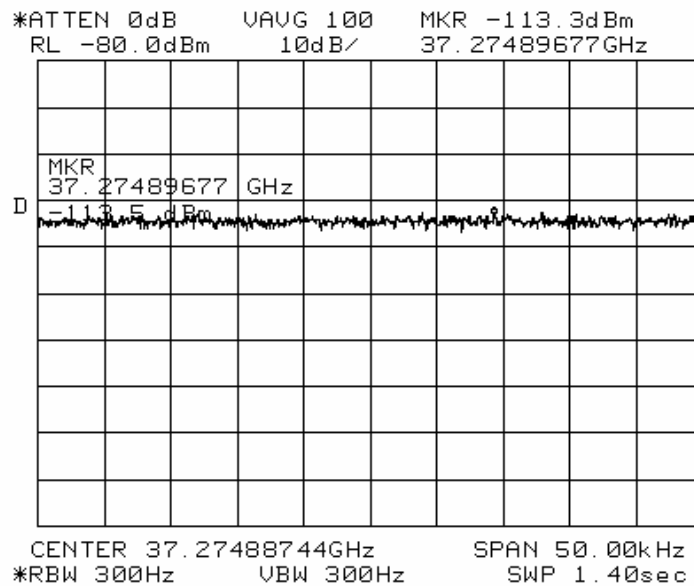
Plot 22: Hi Channel Fifth Harmonic, 300Hz RBW: 3m



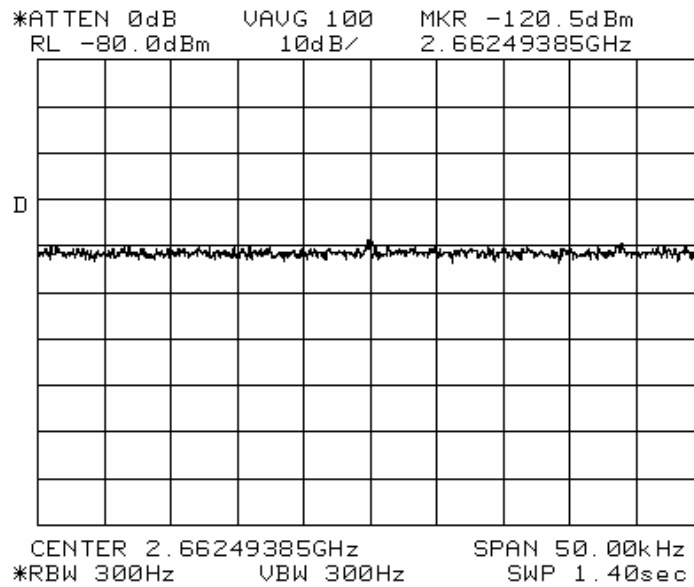
Plot 23: Hi Channel Sixth Harmonic, 300Hz RBW: 3m



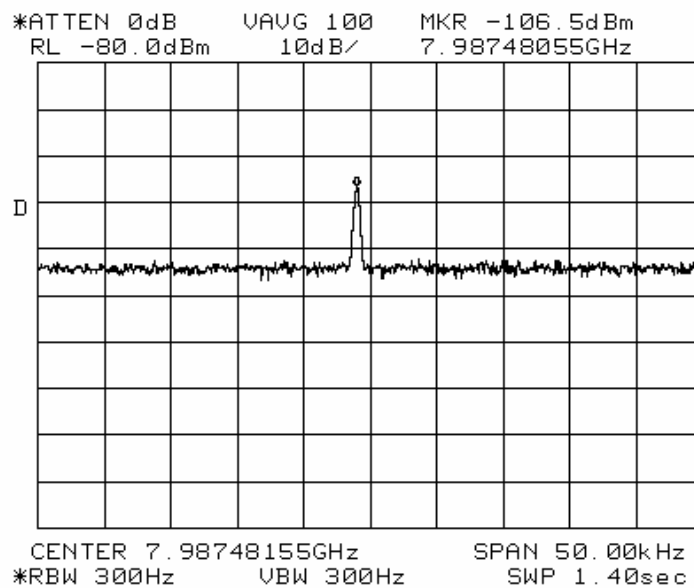
Plot 24: Hi Channel Seventh Harmonic, 300Hz RBW: 3m



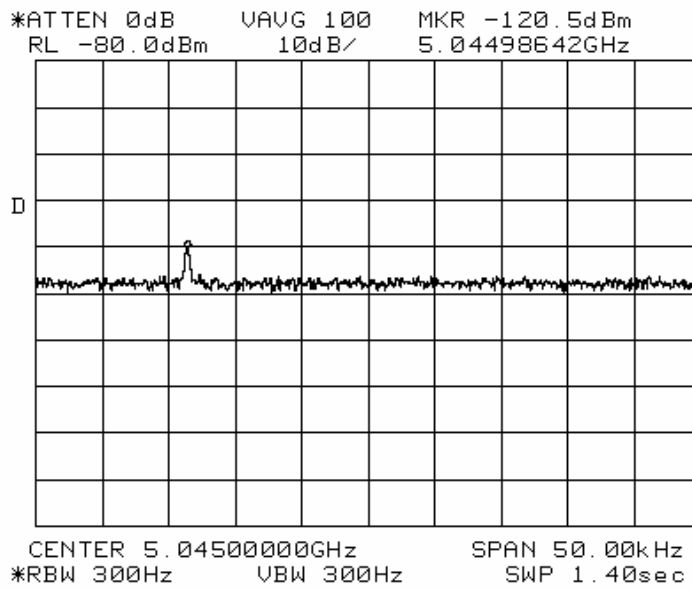
Plot 25: Tx VCO Feedthrough, 300Hz RBW: 7m



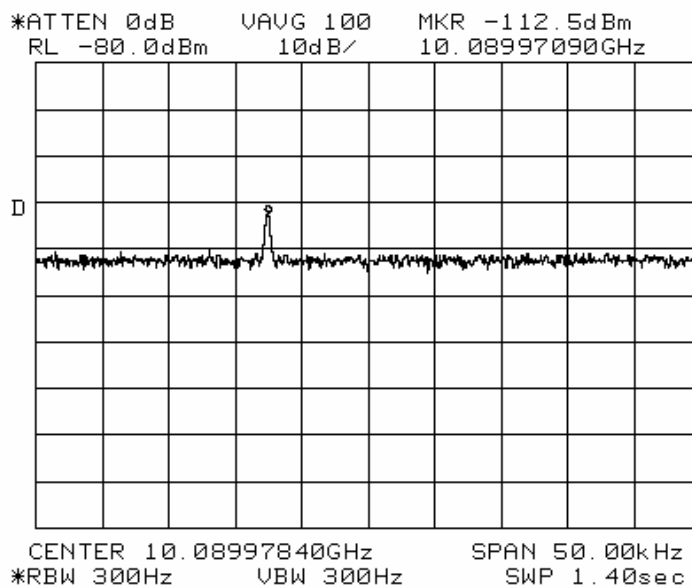
Plot 26: VCO 3<sup>rd</sup> Harmonic, 300Hz RBW: 7m



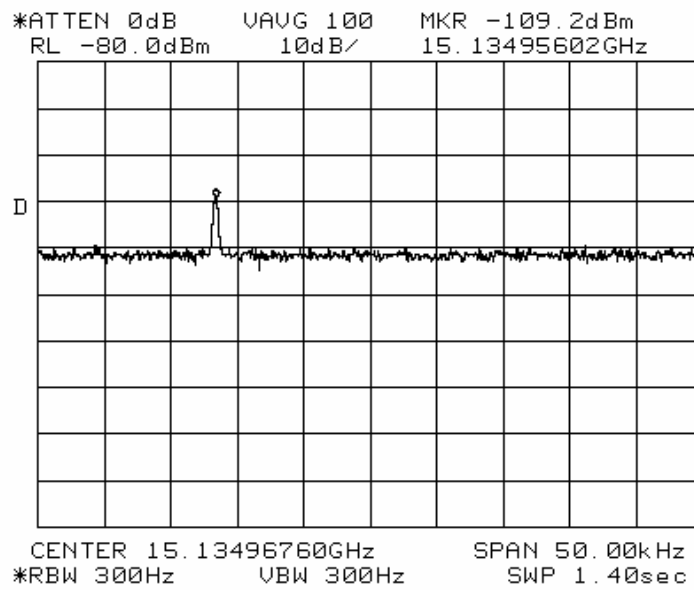
Plot 27: LO 7m



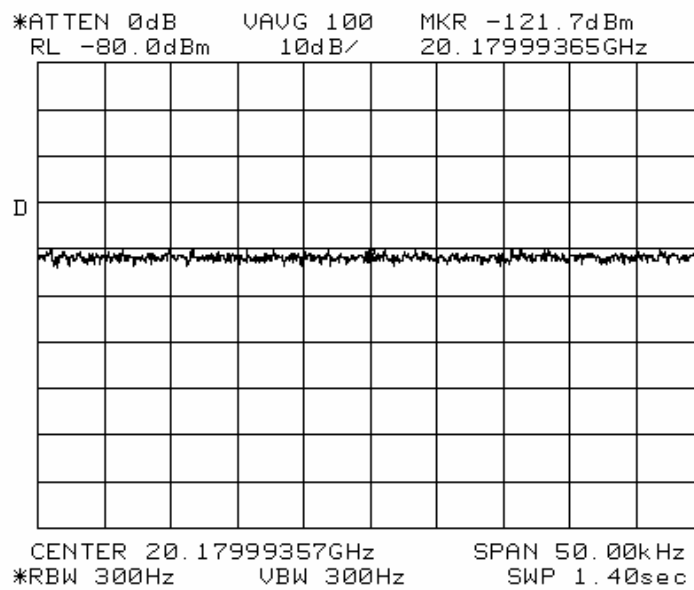
Plot 28: LO 2<sup>nd</sup> Harmonic 7m



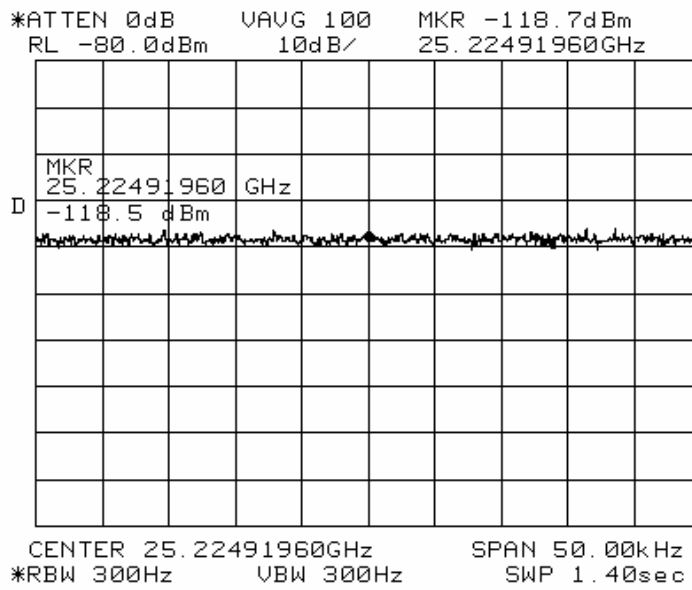
Plot 29: LO 3<sup>rd</sup> Harmonic 7m



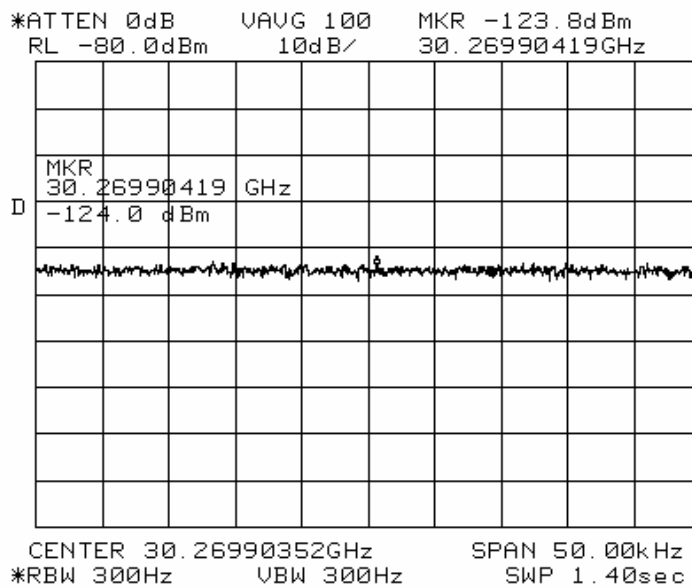
Plot 30: LO 4<sup>th</sup> Harmonic 3m



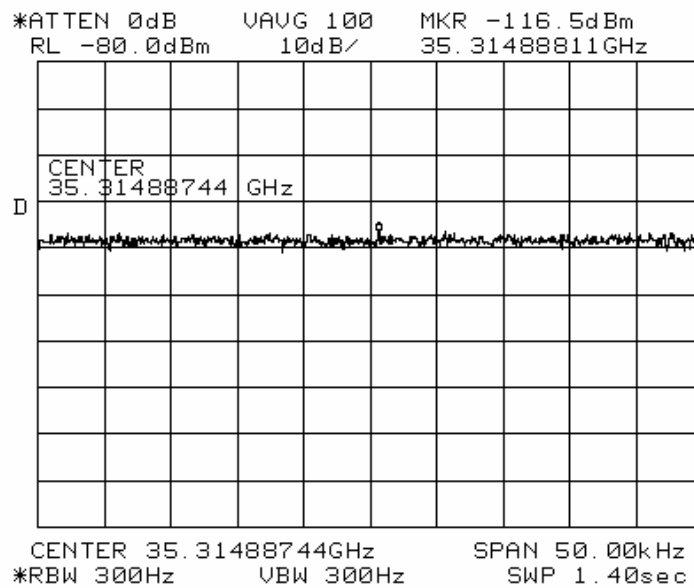
Plot 31: LO 5<sup>th</sup> Harmonic 3m



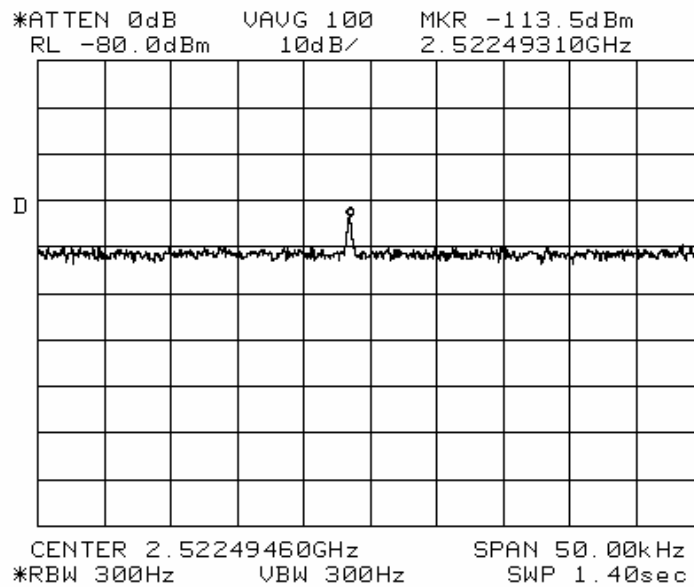
Plot 32: LO 6<sup>th</sup> Harmonic 3m



Plot 33: LO 7<sup>th</sup> Harmonic 3m

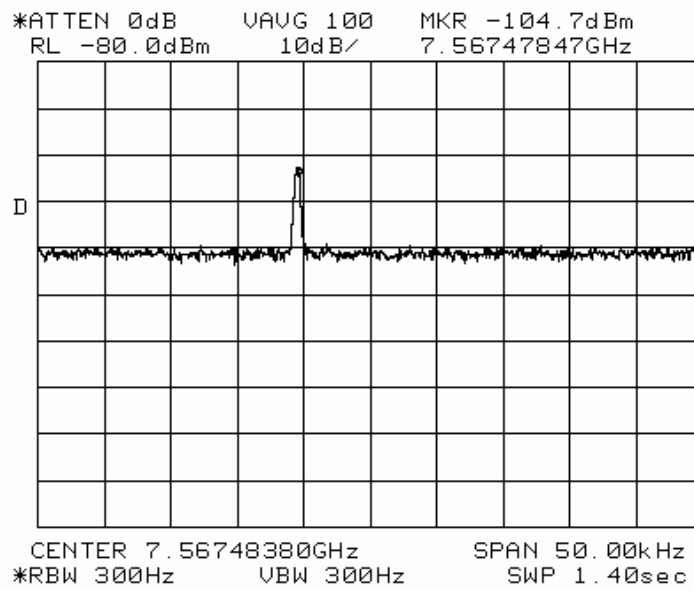


Plot 34: VCO in LO mode RX spurious 7m





Plot 35: VCO 3<sup>rd</sup> Harmonic in LO mode RX spurious 7m



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)	<b>EMCO 3115</b>	<b>EMCO 3116</b>	<b>EMCO 3116</b>
VSWR Contribution in dB	1.00	0.88	0.88
Amplitude Uncertainty	0.30	0.80	1.50
Reference Level			
<b>Total Error, Plus/Minus dB</b>	<b>1.37</b>	<b>1.48</b>	<b>1.95</b>

For a confidence level of 68%, the error budget is then  $\pm 0.93\text{dB}$ . The first sheet shows an EIRP of  $+29.7\text{ dBm} \pm 0.93\text{dB}$  when the radio was operating at 5325MHz, which is under the FCC limit of  $+30\text{dBm}$  for part 15.247 (3) devices.

<u><b>5235 MHz</b></u>	<u><b>Fund</b></u>
Analyzer Reading	-31.00
Noise floor	-89.50
cable	-6.15
antenna	9.30
path	-63.87
dBm at ref ant.	-24.85
dBm at radio	29.72

An RF frequency of 5325MHz was the frequency having the highest spurious emissions levels measured. Data is presented in the spreadsheet below.

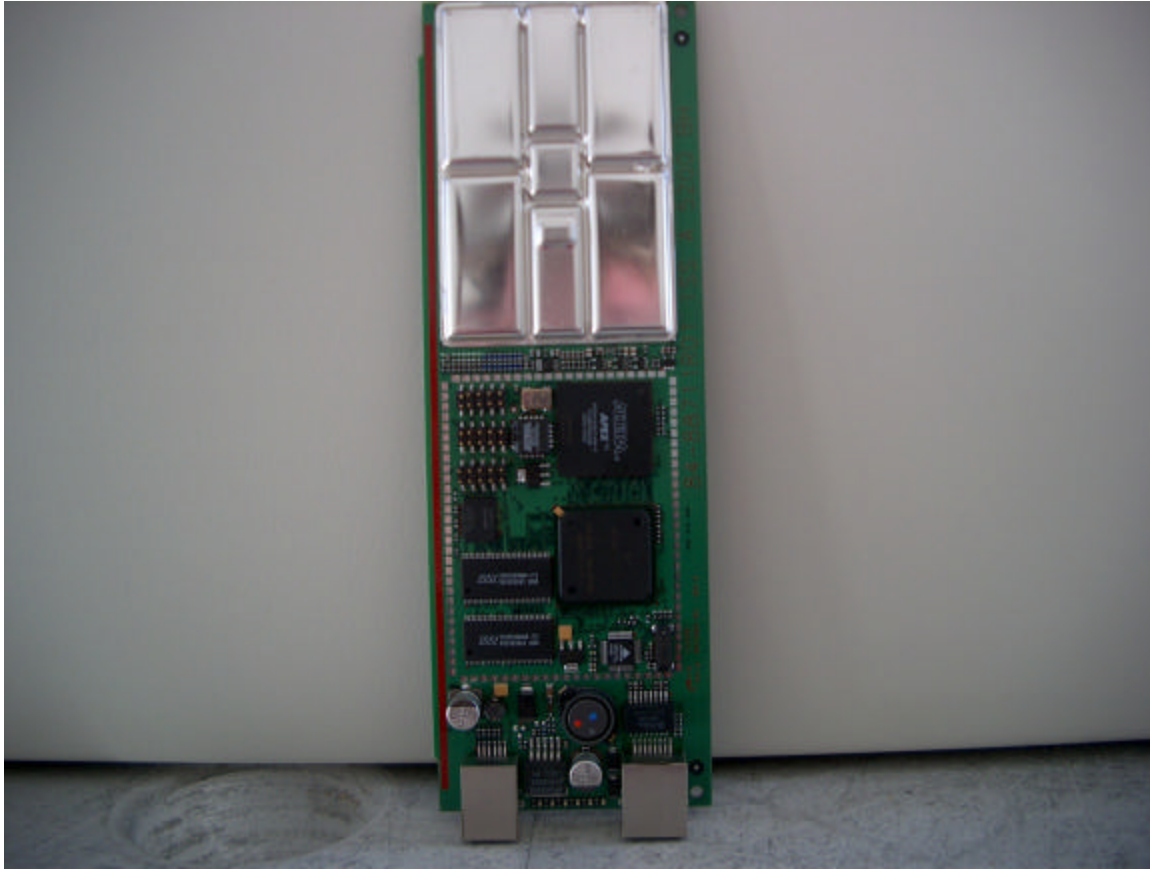
Model 5210 Worst Case Harmonic Frequency Spurious Testing Spreadsheet Summary:

Canopy 5210 Radiated Test : Unit #0A003E0063EC with Dish									
<i>CW Mode</i>	300Hz or 1MHz RBW/VBW			Agilent 8564E Analyzer					
<b>Restricted Band</b>	<b>Lg Horn Vert</b>	<b>10650.00</b>	<b>15975.00</b>	<b>21300.00</b>	<b>26625.00</b>	<b>31950.00</b>	<b>37275.00</b>	<b>2637.5</b>	<b>7912.5</b>
<b>5325.00</b>	<b>Fund</b>	<b>2nd</b>	<b>3rd</b>	<b>4th</b>	<b>5th</b>	<b>6th</b>	<b>7th</b>	<b>VCO</b>	<b>3*VCO</b>
Analyzer Reading	-31.00	-107.30	-107.00	-117.30	-117.30	-119.50	-113.30	-117.50	-106.50
Noise Floor	-89.50	-123.00	-121.50	-118.80	-119.30	-119.80	-114.70	-120.8	-123.8
Adjusted Analyzer Level	-31.00	-107.42	-107.16	-122.65	-121.63	-131.26	-118.90	-120.24	-106.58
Cable Loss	-6.15	-9.248	-11.947	-14.303	-17.00	-19.00	-21.00	-4.17	-7.75
dBm at Antenna Connector	-24.85	-98.17	-95.21	-108.34	-104.63	-112.26	-97.90	-116.07	-98.83
Conversion to dBuV	82.15	8.83	11.79	-1.34	2.37	-5.26	9.10	-9.07	8.17
Antenna Factor (dB/m)	35.50	39.50	39.50	44.40	46.40	48.00	47.00	31.00	38.20
Antenna Gain (dBi)	9.30	11.20	14.80	12.20	12.30	12.20	14.70	8.00	10.10
Free space path loss	-63.87	-69.89	-73.41	-68.55	-70.49	-72.07	-73.41	-57.77	-67.31
Corrected Antenna Connector Power Level	-34.15	-109.37	-110.01	-120.54	-116.93	-124.46	-112.60	-124.07	-108.93
Corrected Antenna dBuV Level	72.85	37.13	36.49	30.86	36.47	30.54	41.40	13.93	36.27
(Radio with Dish) ERP in dBm	<b>29.72</b>	-39.48	-36.60	-51.99	-46.44	-52.38	-39.19	-66.30	-41.62
FCC Restricted Band Emissions Limit	N/A	500.0E-6	500.0E-6	500.0E-6					
FCC Out-of-Band Emissions Limit (dBm ERP)	N/A				-27.00	-27.00	-27.00	-27.00	-27.00
Emissions Limit in dBuV	N/A	45.22	45.22	45.22	59.65	59.65	59.65	59.65	59.65
Radio Level to FCC Limit in dB(CW Mode)	N/A	8.09	8.73	14.36	23.18	29.11	18.25	45.72	23.38
CW to Modulated Mode Reduction(dB)		5	5	5	5	5	5	5	5
Radio Level to FCC Limit in dB(Modulated Mode)		13.09	13.73	19.36	28.18	34.11	23.25	50.72	28.38
Limit at antenna (watts/m <sup>2</sup> )		663.0E-12	663.0E-12	663.0E-12					
Limit at radio (watts)		75.0E-9	75.0E-9	75.0E-9					
Limit at radio (dBm)		-41.25	-41.25	-41.25					
500uV/m limit translated to Spectrum Analyzer (dBm)		-109.19	-111.81	-111.91					
<b>Margin to spec in dB</b>		<b>13.09</b>	<b>13.73</b>	<b>19.36</b>	<b>24.44</b>	<b>30.38</b>	<b>17.19</b>	<b>44.30</b>	<b>19.62</b>

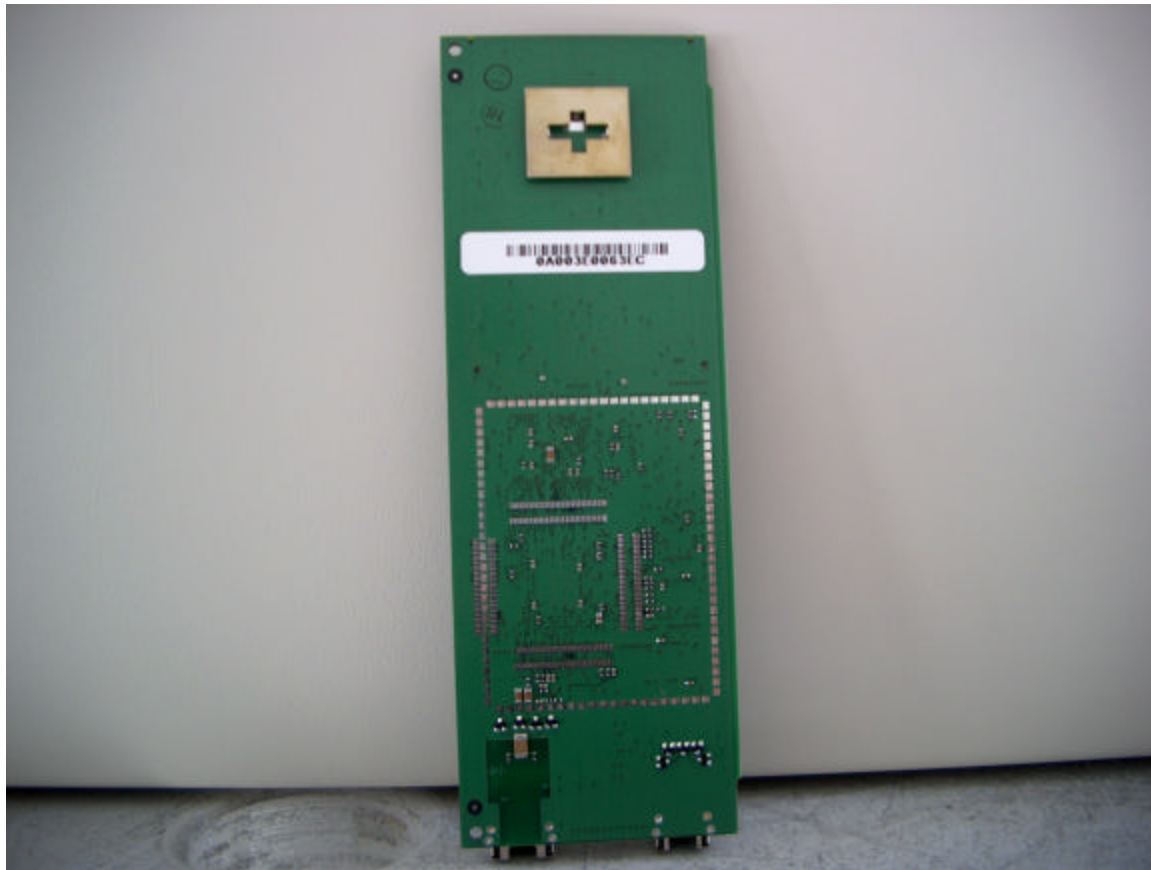
Canopy 5210 Radiated Test : Unit #0A003E0063EC with Dish								
<b>CW Mode</b>	30kHz or 1MHz RBW/VBW	30kHz or 1MHz RBW/VBW			Agilent 8564E Analyzer			
<b>Restricted Band</b>	5045.00	2522.50	10090.00	15135.00	20180.00	25225.00	30270.00	35315.00
<b>5325.00</b>	<b>LO</b>	<b>VCO</b>	<b>2*LO</b>	<b>3*LO</b>	<b>4*LO</b>	<b>5*LO</b>	<b>6*LO</b>	<b>7*LO</b>
Analyzer Reading	-120.50	-113.50	-112.50	-109.20	-121.70	-118.70	-123.00	-116.50
Noise Floor	-127.80	-122.80	-123.00	-121.50	-122.30	-120.80	-125.30	-119.20
Adjusted Analyzer Level	-121.39	-114.04	-112.91	-109.46	-130.59	-122.86	-126.86	-119.84
Cable Loss	-5.97	-4.00	-8.90	-11.57	-13.70	-16.10	-18.00	-21.00
dBm at Antenna Connector	-115.42	-110.04	-104.01	-97.89	-116.89	-106.76	-108.86	-98.84
Conversion to dBuV	-8.42	-3.04	2.99	9.11	-9.89	0.24	-1.86	8.16
Antenna Factor (dB/m)	34.90	30.30	39.60	41.90	44.40	45.90	47.20	50.00
Antenna Gain (dBi)	9.30	7.90	10.60	11.80	11.80	12.30	12.60	11.50
Free space path loss	-63.40	-57.38	-69.42	-72.94	-68.08	-70.02	-71.60	-72.94
Corrected Antenna Connector Power Level	-124.72	-117.94	-114.61	-109.69	-128.69	-119.06	-121.46	-110.34
Corrected Antenna dBuV Level	17.18	19.36	31.99	39.21	22.71	33.84	32.74	46.66
(Radio with Dish) ERP in dBm	-61.32	-60.56	-45.18	-36.75	-60.61	-49.04	-49.86	-37.40
FCC Restricted Band Emissions Limit			500.0E-6		500.0E-6			
FCC Out-of-Band Emissions Limit (dBm ERP)	-27.00	-27.00		-27.00		-27.00	-27.00	-27.00
Emissions Limit in dBuV	59.65	59.65	45.22	59.65	45.22	59.65	59.65	59.65
Radio Level to FCC Limit in dB(CW Mode)	42.47	40.29	13.22	20.44	22.51	25.81	26.91	12.99
CW to Modulated Mode Reduction(dB)	5	5	5	5	5	5	5	5
Radio Level to FCC Limit in dB(Modulated Mode)	47.47	45.29	18.22	25.44	27.51	30.81	31.91	17.99
Limit at antenna (watts)			663.0E-12		663.0E-12			
Limit at radio (watts)			75.0E-9		75.0E-9			
Limit at radio (dBm)			-41.25		-41.25			
500uV/m limit translated to Spectrum Analyzer (dBm)			-108.97		-111.23			
<b>Margin to spec in dB</b>	39.32	38.56	18.22	14.75	27.51	27.04	27.86	15.40

The results show that the radio meets the FCC and RSS-210 limits of 500uV/m on the Tx harmonics and Rx spurious. The highest level was from the 3 harmonic and had the lowest margin by being only 13.73 dB better than the limit specification. Even with the measurement uncertainty of the equipment, the radio was still 11.73dB better than the limit.

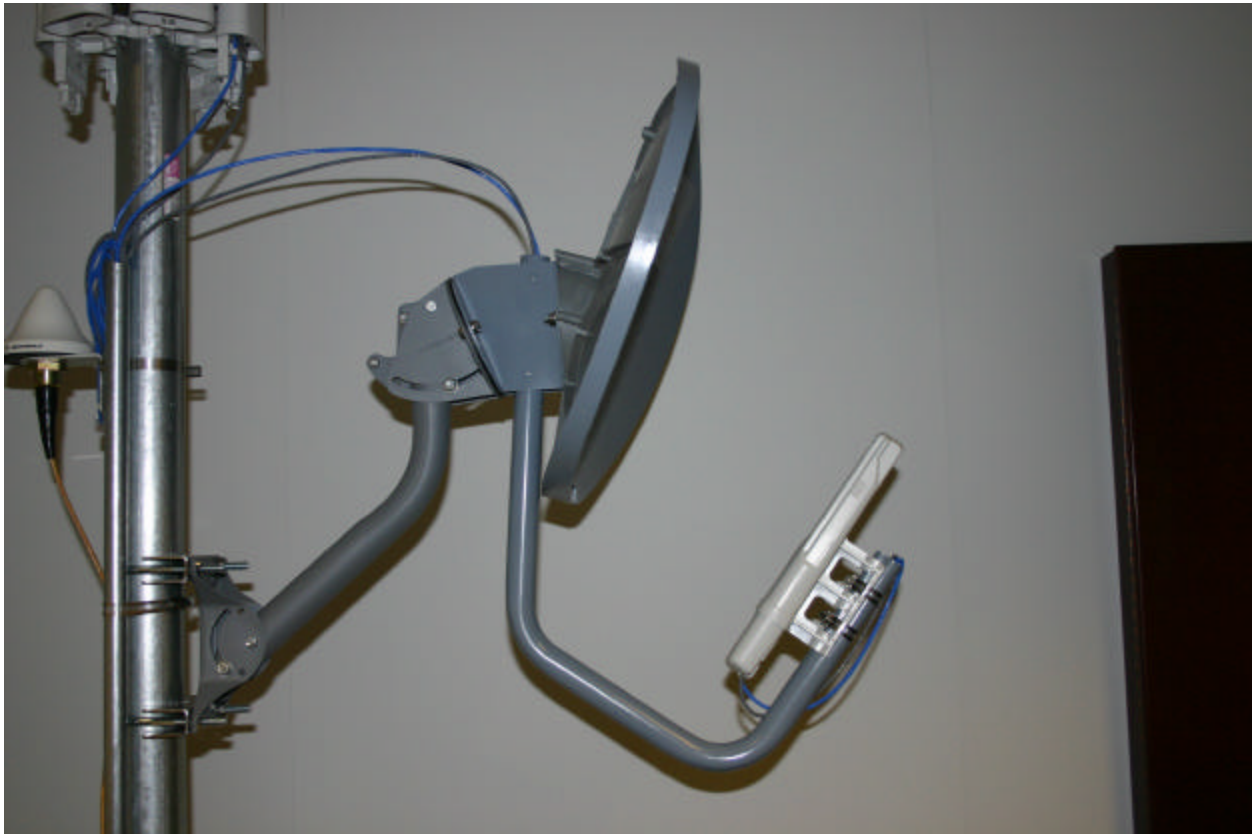
Canopy Model 5210 unit Serial #: 0A003E0063EC, Component Side:



Canopy Model 5210 Unit Serial #: 0A003E0063EC, Solder Side:



Side View Serial #: 0A003E0063EC





Front view Serial #: 0A003E0063EC



Back view  
Serial#:0A003E0063EC

