Channel 11 – Radiated Emissions Data

Figures 28 –39 show data for the WiFi Module set to Channel 11, corresponding to the center frequency of 2.46 GHz.

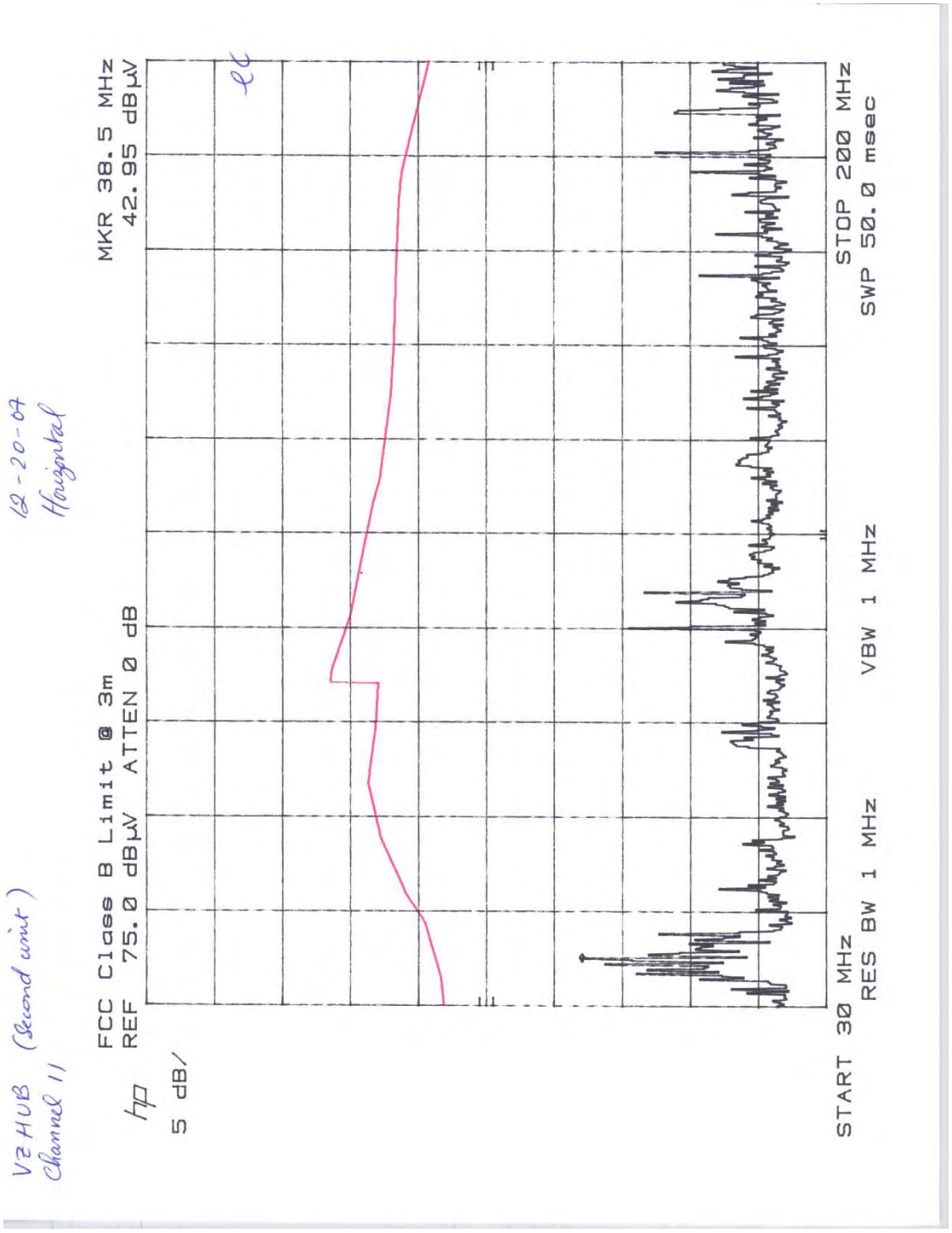


FIGURE 28: Radiated Emission 30 – 200 MHz Horizontal Polarization

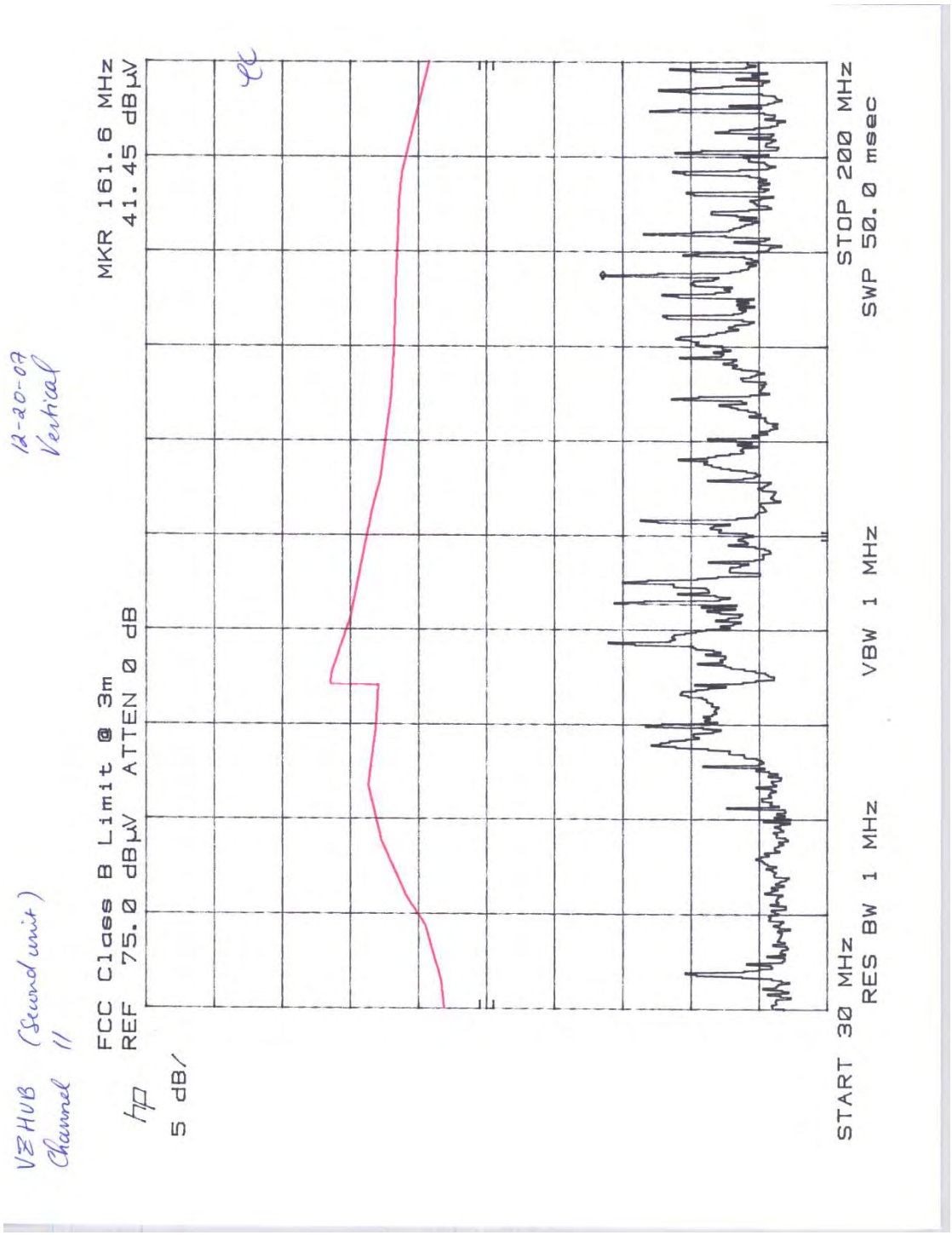


FIGURE 29: Radiated Emission 30 – 200 MHz Vertical Polarization

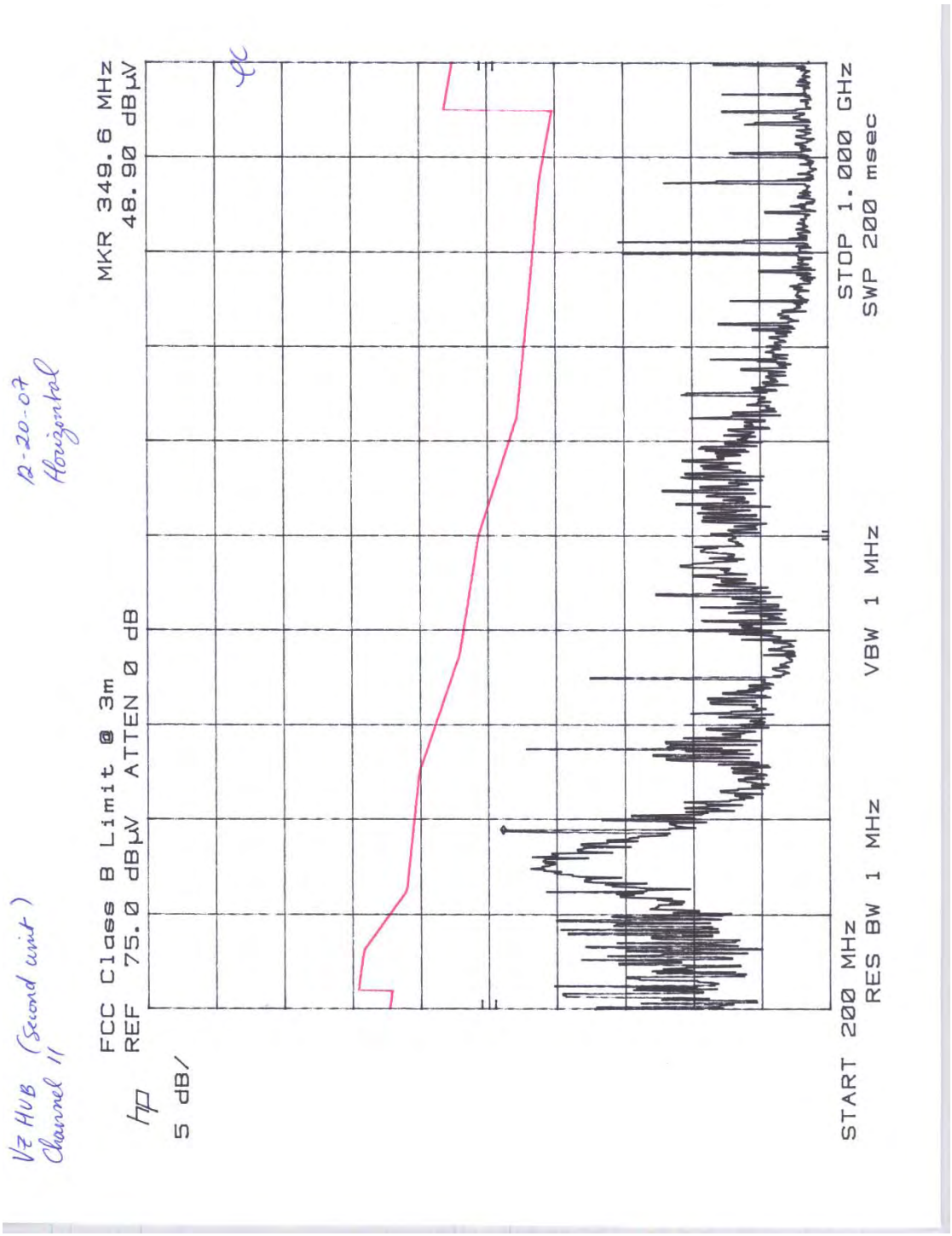


FIGURE 30: Radiated Emission 200 MHz – 1 GHz Horizontal Polarization

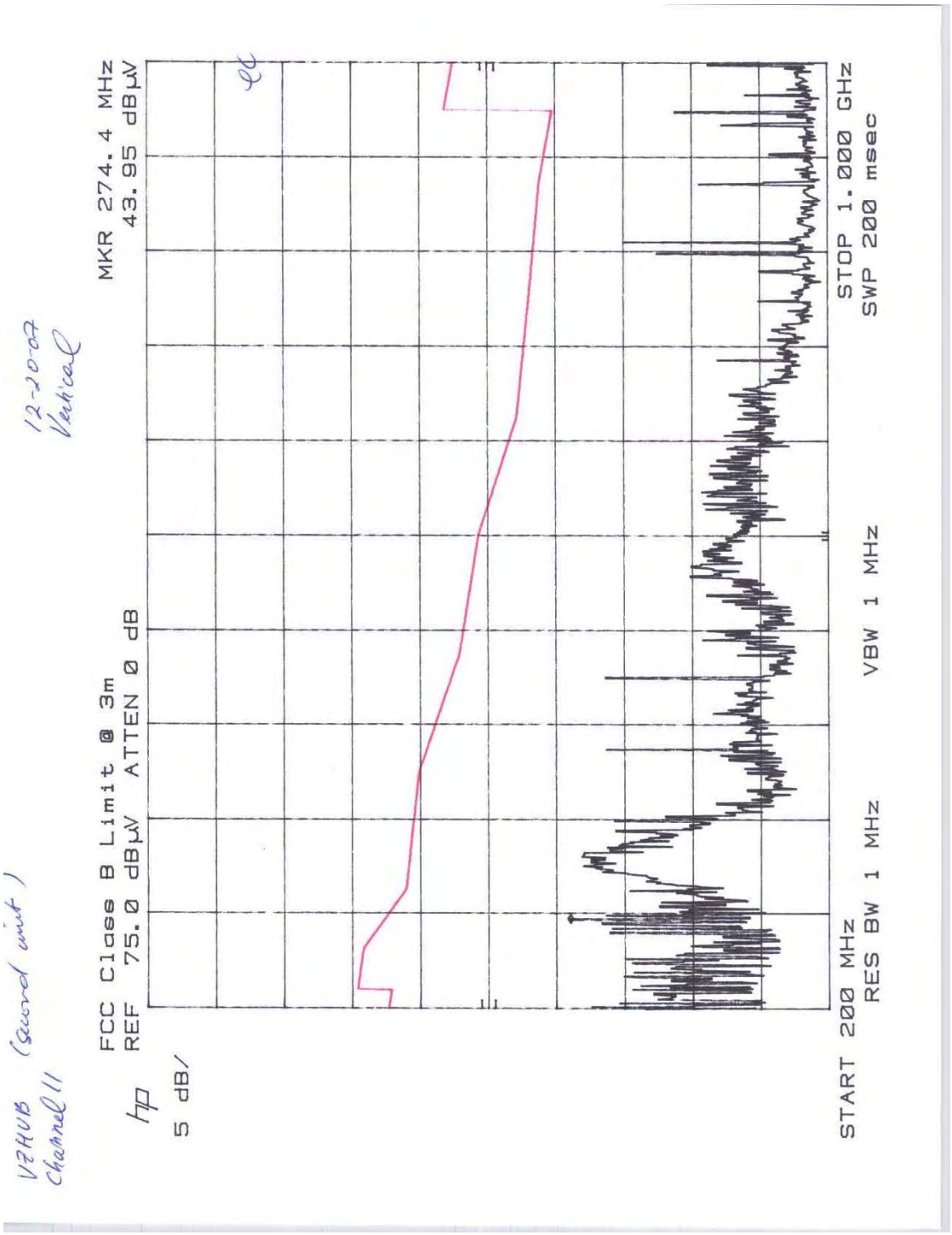


FIGURE 31: Radiated Emission 200 MHz – 1 GHz Vertical Polarization

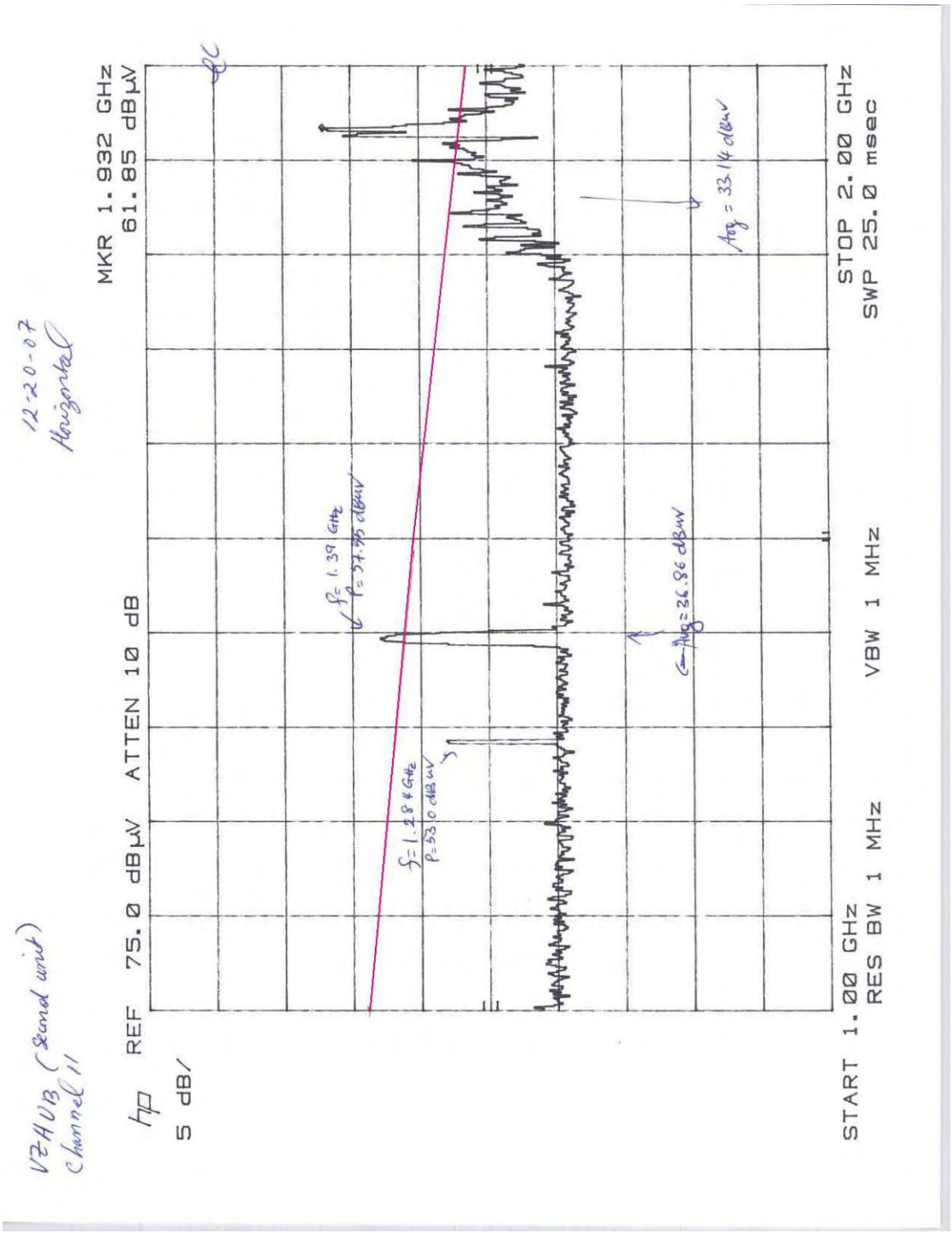


FIGURE 32: Radiated Emission 1 GHz – 2 GHz Horizontal Polarization

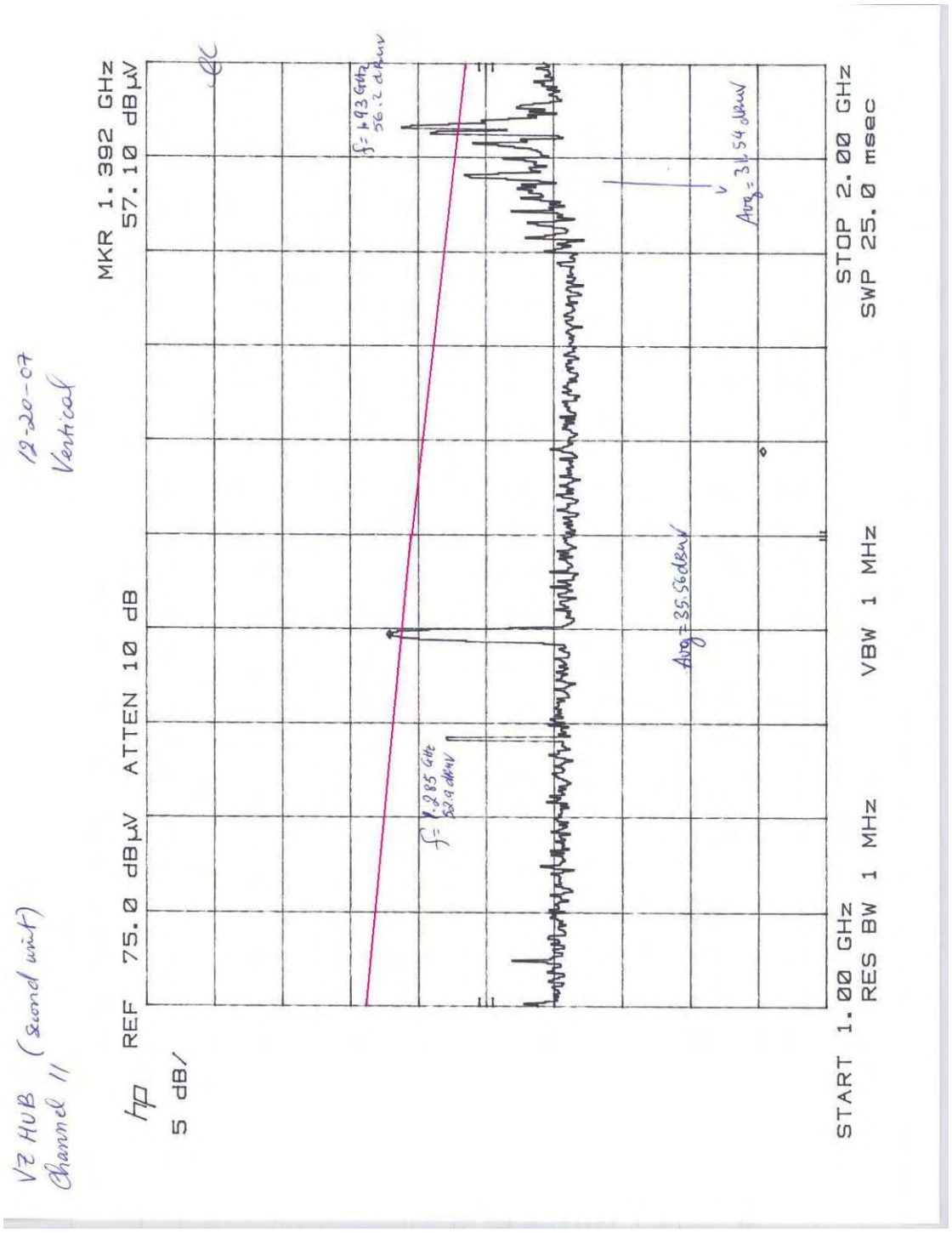


FIGURE 33: Radiated Emission 1 GHz – 2 GHz Vertical Polarization

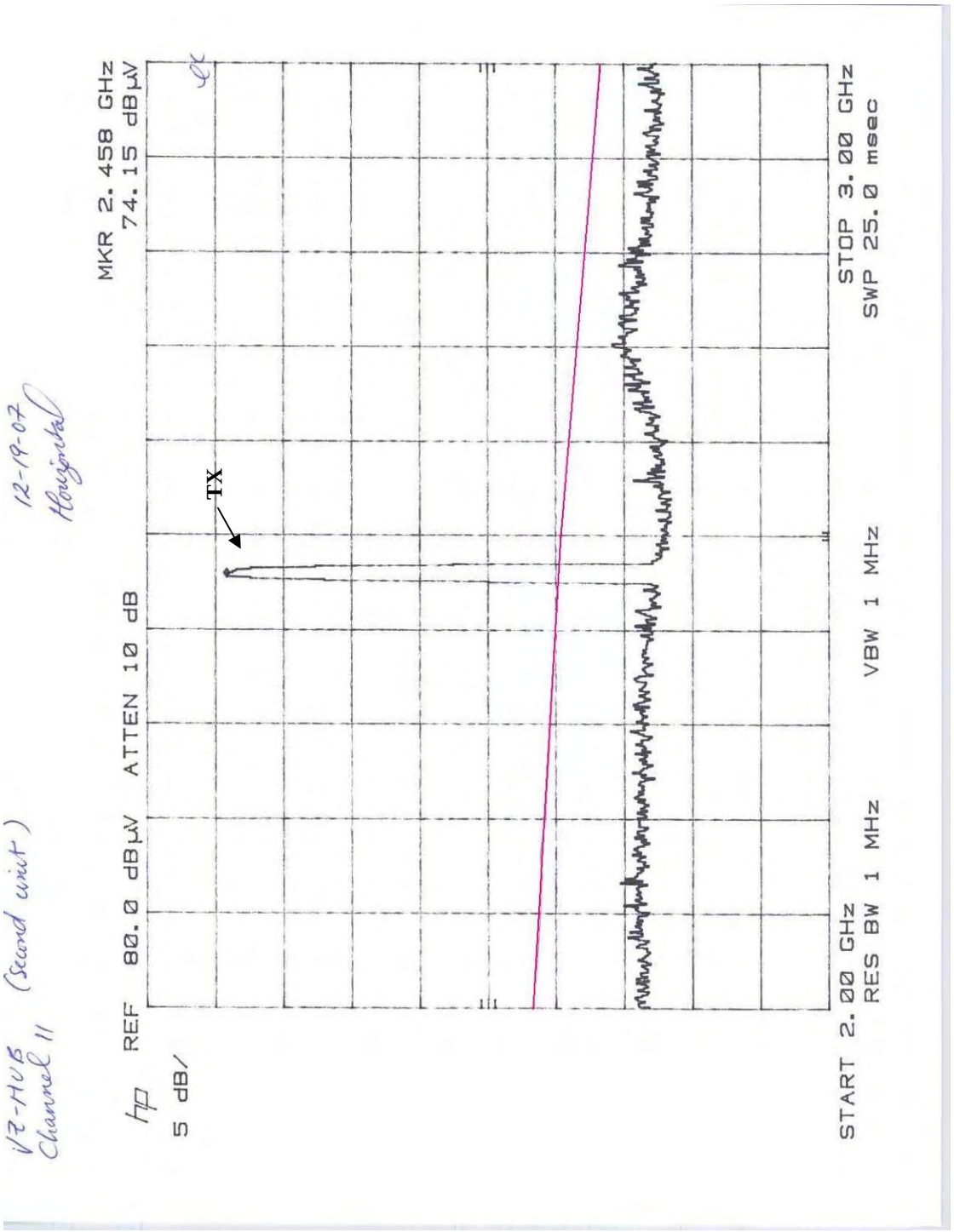


FIGURE 34: Radiated Emission 2 GHz – 3 GHz Horizontal Polarization

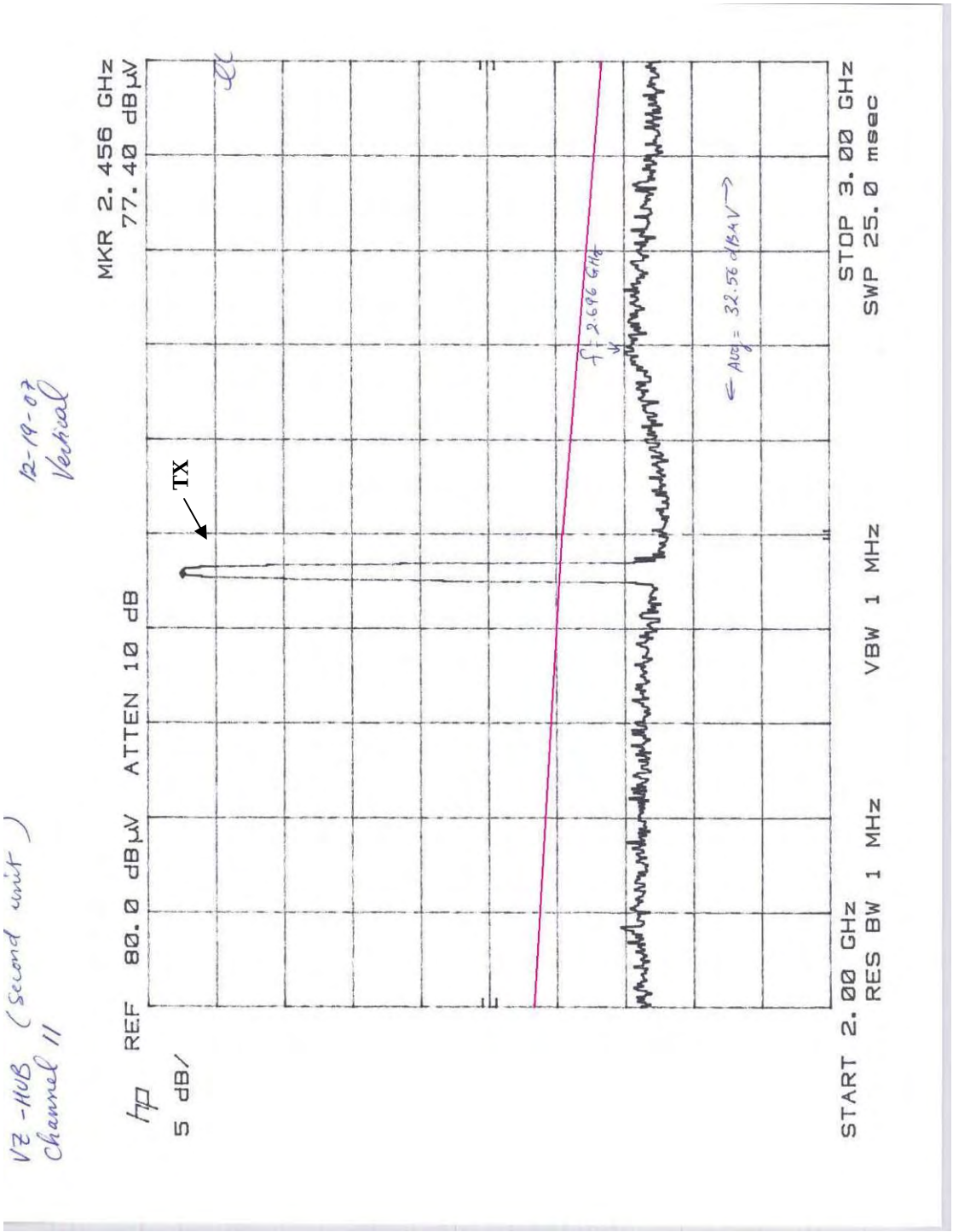


FIGURE 35: Radiated Emission 2 GHz – 3 GHz Vertical Polarization

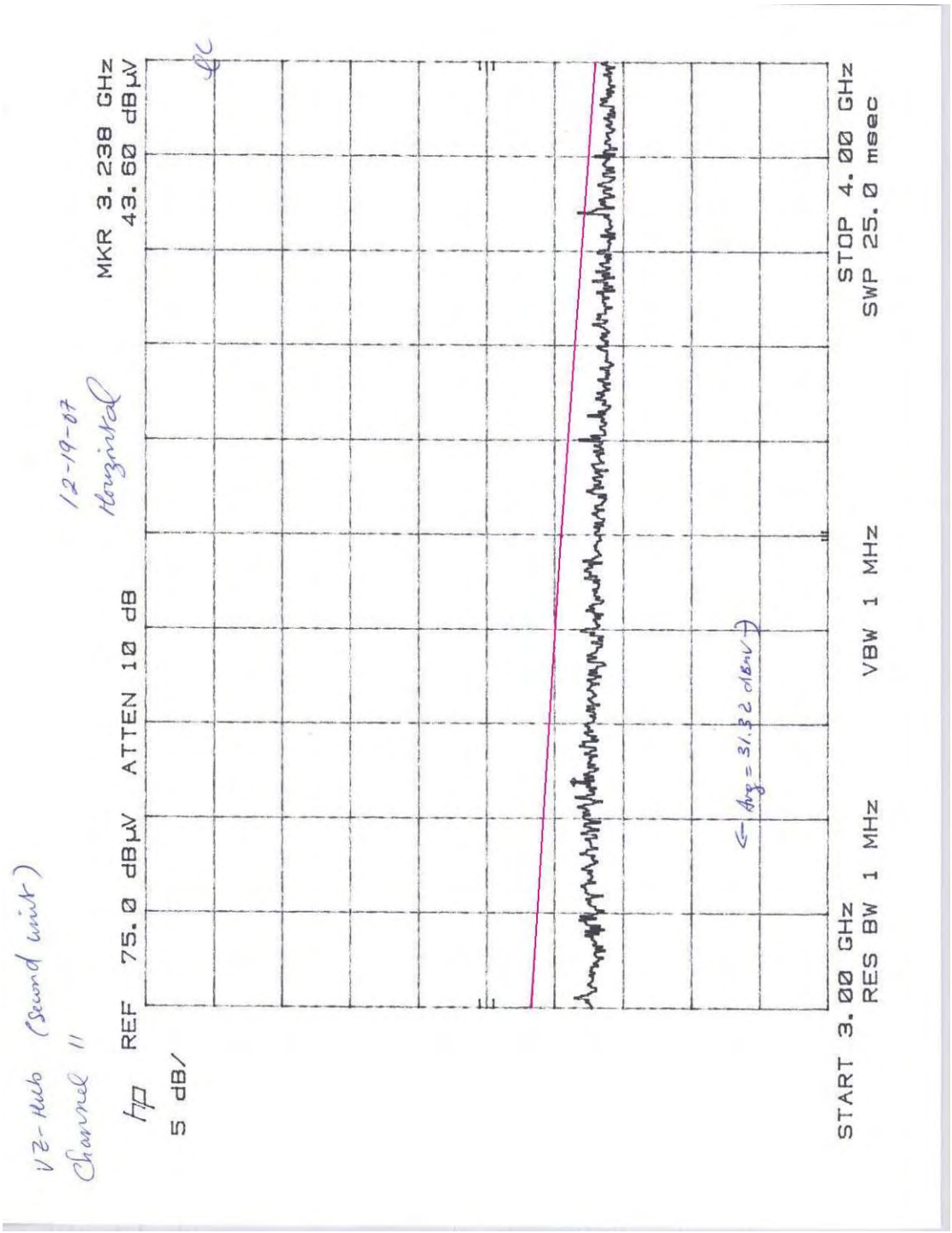


FIGURE 36: Radiated Emission 3 GHz – 4 GHz Horizontal Polarization

Note that average measurements using a video bandwidth of 10 Hz reduces the emissions to a maximum reading of 31.32 dBµV.

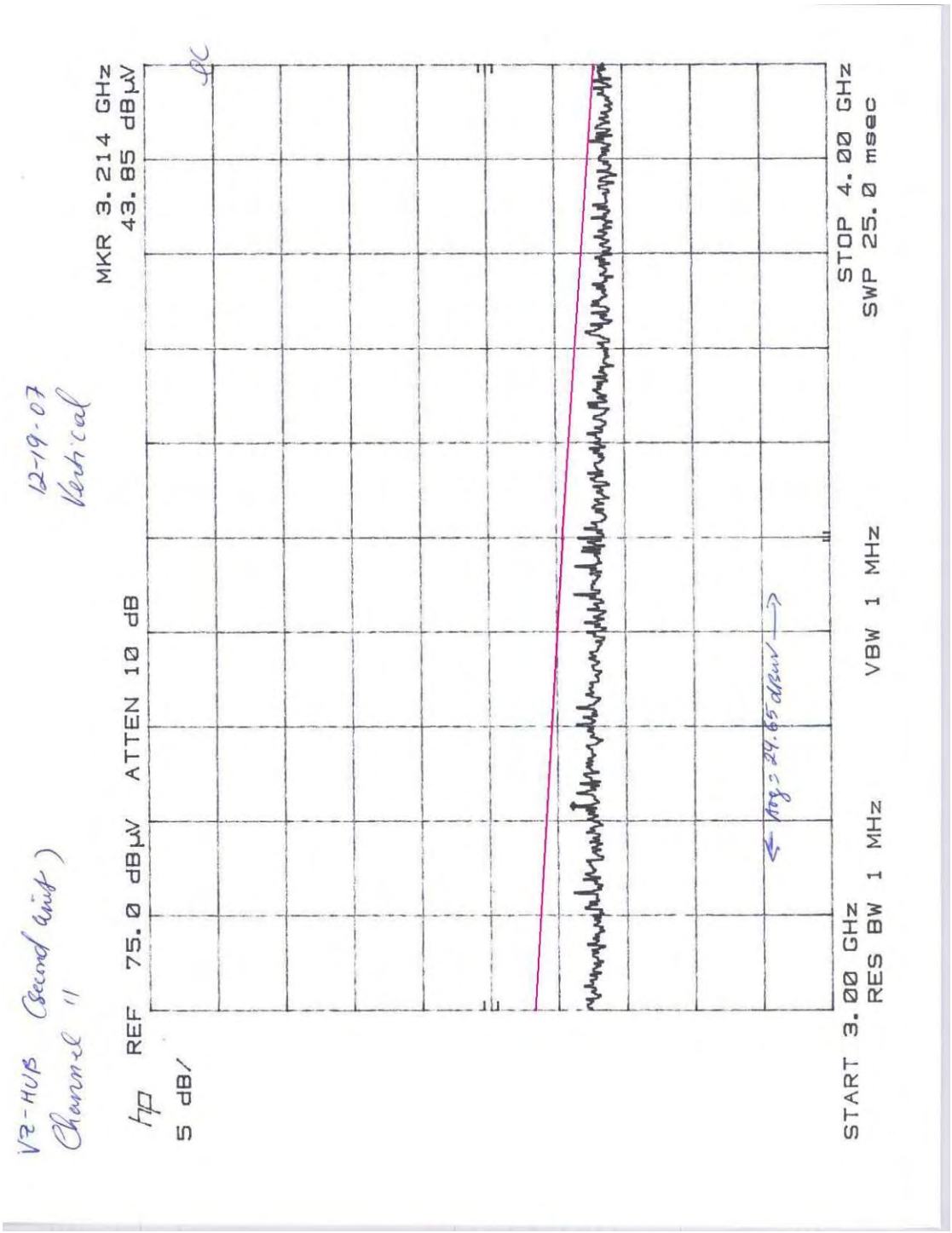


FIGURE 37: Radiated Emission 3 GHz – 4 GHz Vertical Polarization

Note that average measurements using a video bandwidth of 10 Hz reduces the emissions to a maximum reading of 29.65 dBµV.

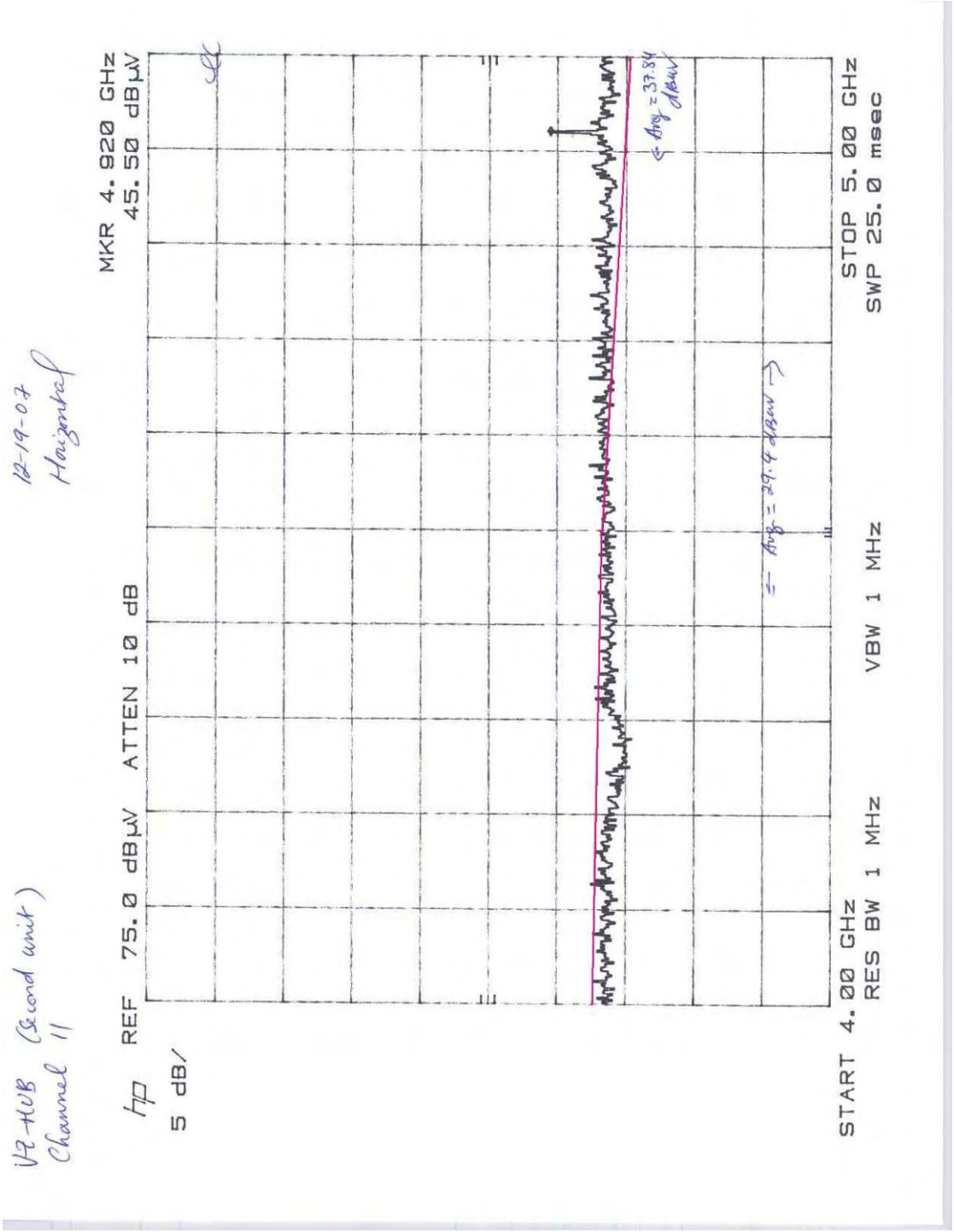


FIGURE 38: Radiated Emission 4 GHz – 5 GHz Horizontal Polarization

Note that average measurements using a video bandwidth of 10 Hz reduces the emissions to a maximum reading of 37.84 dBµV.

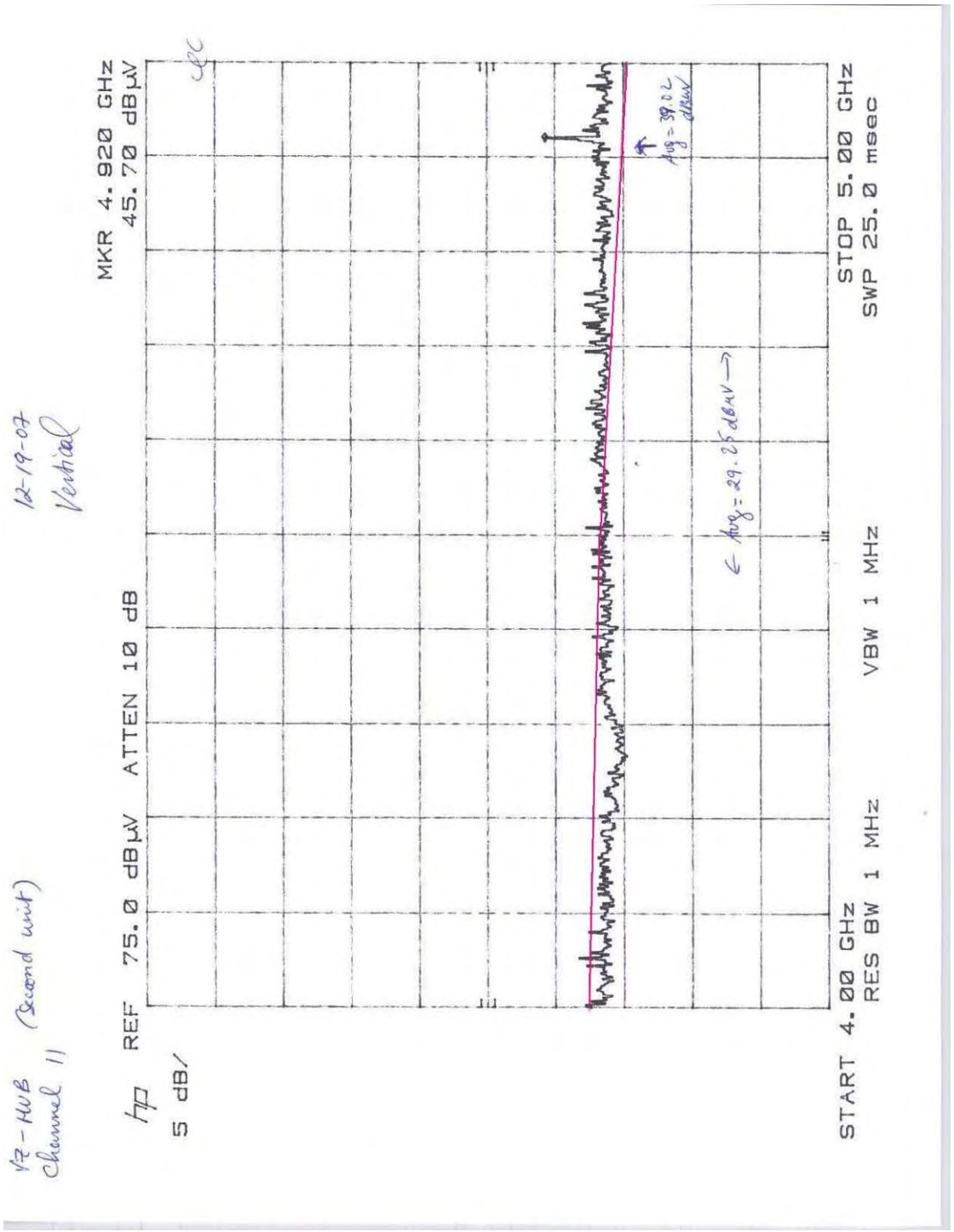


FIGURE 39: Radiated Emission 4 GHz – 5 GHz Vertical Polarization

Note that average measurements using a video bandwidth of 10 Hz reduces the emissions to a maximum reading of 39.02 dBµV.

From Figures 28-39, the unintentional peak emissions that exceeded or were within 5 dB of the limit are reported in Table 4. Note that the average measurements were obtained by reducing the video bandwidth of the HP 8566B spectrum analyzer to 10 Hz and increasing the sweep time to 20 sec.

Figure No.	Frequency (MHz)	Measured Peak (dBµV)	Quasi Peak (dBµV)	Average (dBµV)	Correction Factor (dB/m)	E- Field* (dBµV/m)	FCC Limit (dBµV/m)	Margin to limit (dB)
32	1284	53.00			3.23	49.77	54	4.23
	1390	57.55		36.86	2.51	34.35	54	19.65
	1932	61.85		33.14	-1.72	34.86	54	19.14
33	1285	52.90			3.23	49.67	54	4.33
	1392	57.10		35.56	2.49	33.07	54	20.93
	1390	56.20		31.54	-1.70	33.24	54	20.76
34	2712	45.70			-5.40	51.10	54	2.90
35	2696	44.90		32.56	-5.32	37.88	54	16.12
36	3238	43.60		31.32	-8.21	39.53	54	14.47
37	3214	43.85		29.65	-8.10	37.75	54	16.25
38	4920	45.50		37.84	-13.74	51.58	54	2.42
39	4920	45.70		39.02	-13.74	52.76	54	1.24

Table 4: Peak Measurement Results

Note that the filters' insertion losses are included in the correction factor data.

* E-field (dBµV/m) = the measured value (either Peak, Quasi Peak or Average) in dBµV - Correction Factor (dB/m)

It can be seen from the previous figures and Table 4 that the unintentional radiated emissions are below limit. Hence the unit is in compliance.

4.1.1 BAND EDGE MEASUREMENTS

Compliance of the Open Peak VZHUB WiFi module was investigated at the lower (Channel 1) and upper (Channel 11) edges of the frequency band of 2400 to 2483.5 MHz. For the evaluation, an EMCO double ridged horn antenna (Serial No. 3115) was used at the receiver, and the filters were removed from the input of the microwave amplifier. The measurement configuration and procedures were undertaken as per the guidelines presented in the FCC procedures for the measurement of digital transmission systems operating under Section 15.247.

The resolution and video bandwidths of the spectrum analyzer were set to 1 MHz. The emissions were maximized using the procedure described in the previous sections. When the maximum peak emissions were located, the average value was measured by reducing the video bandwidth to 10 Hz. Where applicable, the Delta-Marker Method was used to measure the correct value of the emissions at the edge. Figures 40 to 43 show the results for Channel 1 and Channel 11 for both vertical and horizontal polarizations of the receiving antenna.

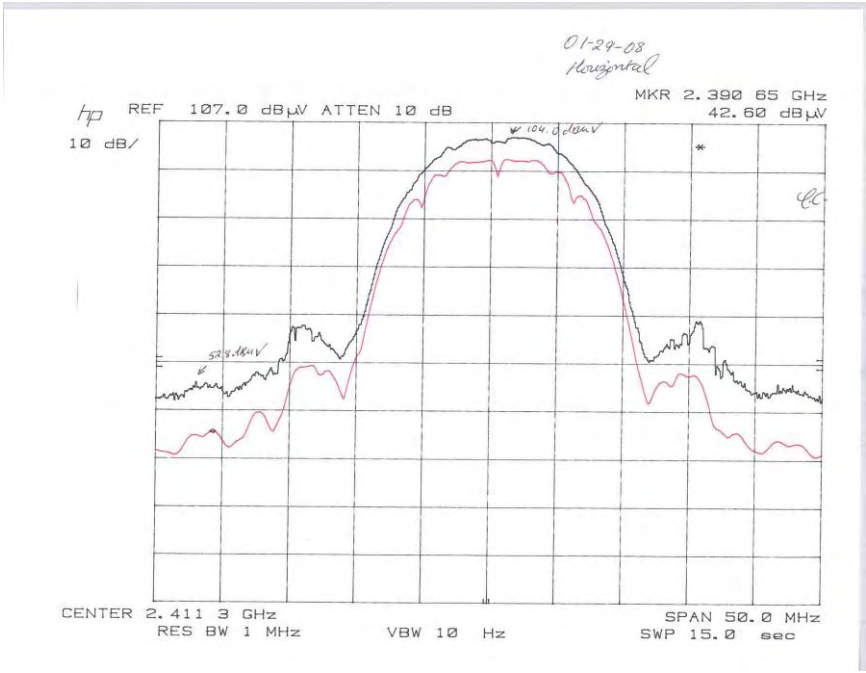


Figure 40: Edge Emissions Measurements for the VZHUB WiFi Module Set to Channel 1 (Horizontal Polarization)

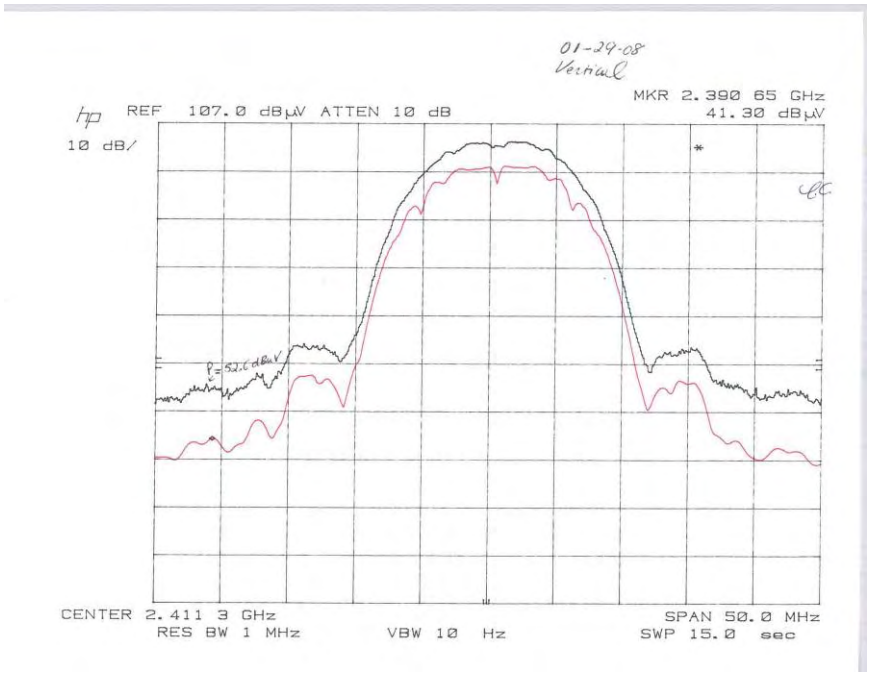


Figure 41: Edge Emissions Measurements for the VZHUB WiFi Module Set to Channel 1 (Vertical Polarization)

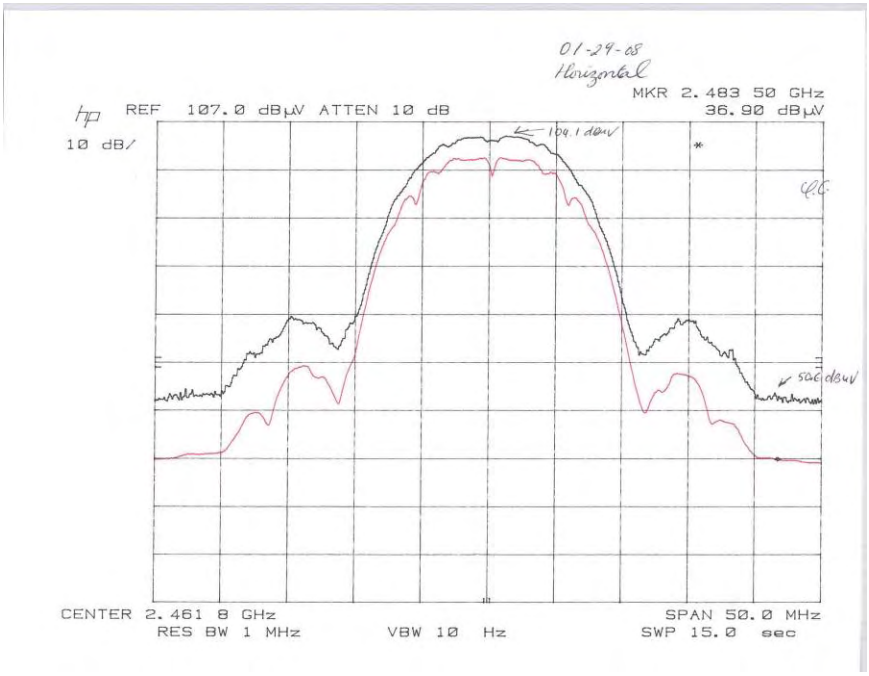


Figure 42: Edge Emissions Measurements for the VZHUB WiFi Module Set to Channel 11 (Horizontal Polarization)

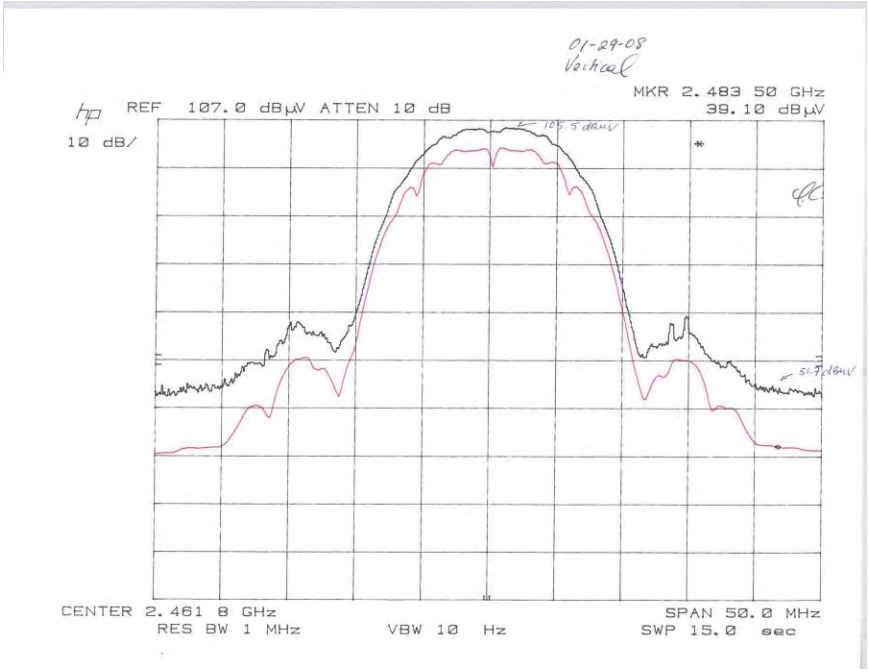


Figure 43: Edge Emissions Measurements for the VZHUB WiFi Module Set to Channel 11 (Vertical Polarization)

The field strengths of the emissions at the edges of the band of 2400 to 2483.5 MHz are computed using the delta recorded in the above figures.

Figure No.	Frequency (MHz)	Measured Peak (dBµV)	Quasi Peak (dBµV)	Average (dBµV)	Correction Factor (dB/m)	E- Field* (dBµV/m)	FCC Limit (dBµV/m)	Margin to limit (dB)
40	2.39	52.80		42.60	-3.84	46.44	54	7.56
41	2.39	52.60		41.30	-3.84	45.14	54	8.86
42	2.4835	50.60		36.90	-4.23	41.13	54	12.87
43	2.4835	51.70		39.10	-4.23	43.33	54	10.67

Table 5: Band Edge Emission Measurement

*E-field at Edge (dBµV/m) = E-field at Fundamental (dBµV/m) - Delta (dB)

Note that the average emissions at the edges of the band of 2400 to 2483.5 MHz are below the limit. Hence the Delta-Marker Method is not necessary for these measurements.

From the previous figures and Table 5, it can be seen that the emissions meet the requirements the FCC limit of Section 15.209. Hence, the unit does not operate outside of the band of 2400 to 2483.5 GHz.

4.1.2 SPURIOUS EMISSION MEASUREMENTS

Compliance for spurious emissions was investigated only for the VZHUB module set to Channel 6 (mid-band). The spurious emissions up to the 10th harmonic frequencies of the VZHUB WiFi module were measured on the HP 8566B spectrum analyzer with the bypass instrument function of the quasi peak adapter enabled. For the emissions below 18 GHz, a double rigged horn antenna (EMCO 3115) was used at the receiver. For measurements above 18 GHz, the double ridged horn antenna was replaced by a Com-Power Corporation horn antenna (Model No.: AH-826). The data was recorded with RBW and VBW set to 1 MHz for peak measurements. The VBW was then reduced to 10 Hz for average measurements. A Trilithic high pass filter (6HC3000/19500-3-KK) was connected to the input of the microwave amplifier up to the 8th harmonic. The filter was removed for the measurements above 20 GHz.

To improve the sensitivity of the receiving system for emissions above 9 GHz, the measurement distance was reduced to 1m and the corresponding antenna factors were used in the computation of the conversion factor. Then the readings were extrapolated back to 3m using the distance factor relation of 20*log(1/3). For measurements above 22 GHz (SA limitations), an HP 11971K Harmonic Mixer (Serial No. 2332A01214) was used which expanded the spectrum analyzer capability to to26.5 GHz.

The emissions were maximized by rotating the turntable, and moving the antenna up and down as previously described. The harmonic frequencies falling within the restricted bands reported in Section 15.205 were evaluated as per the limits listed in Section 15.209. It was also verified that the harmonic frequencies falling outside of the restricted band were at least 20 dB below the fundamental carrier, or met the requirements of section 15.209.

The limits for the emissions falling outside of the restricted bands are reported in Table 6.

Polarization	Frequency (GHz)	Peak Reading @ 3m (dBµV)	Correction Factor (dB/m)	E-field (dBµV/m)	Spurious Emissions Limit (dBµV/m)
Horizontal	2.437	105.50	-4.04	109.54	89.54
vertical	2.437	105.40	-4.04	109.44	89.44

Table 6: Limits for Spurious Emissions falling outside of the Restricted Bands (Channel 6)

Polarization	Frequency (GHz)	Peak Reading @ 3m (dBµV)	Average Reading @ 3m (dBµV)	Correction Factor (dB/m)	E-field* (dBµV/m)	Limit (dBµV/m)	Margin to limit (dB)
Horizontal	4.874	43.40	38.73	-13.57	52.30	54.00	1.70
	7.311	42.26	28.03	-21.01	49.04	54.00	4.96
	9.748*	34.16	22.51	-12.65	35.16	89.54	54.38
	12.184	42.71	36.46	-13.80	50.25	54.00	3.75
	14.621*	36.46	22.46	-15.67	38.13	89.54	51.41
	17.058*	35.96	23.11	-15.35	38.46	89.54	51.08
	19.495	39.76	28.56	-5.35	33.91	54.00	20.09
	21.932	39.71	26.46	-7.72	34.17	54.00	19.83
	24.369*	31.56	18.96	-9.51	28.47	89.54	61.07
Vertical	4.874	45.57	36.37	-13.57	49.94	54.00	4.06
	7.311	41.30	28.14	-21.01	49.15	54.00	4.85
	9.748*	34.51	23.41	-12.65	36.06	89.44	53.38
	12.184	40.01	33.06	-13.80	46.85	54.00	7.15
	14.621*	35.91	22.61	-15.67	38.28	89.44	51.16
	17.058*	36.46	23.06	-15.35	38.41	89.44	51.03
	19.495	40.96	31.81	-5.35	37.16	54.00	16.84
	21.932	39.51	26.41	-7.72	34.12	54.00	19.88
	24.369*	31.26	18.96	-9.51	28.47	89.44	60.97

Table 7: Spurious Emission Measurement Results

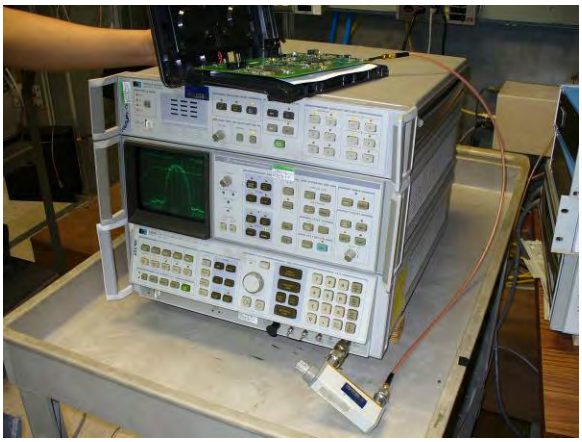
Where * noted, the spurious harmonic frequencies fall outside of the restricted bands. It should also be noted that, with the exception of the second and fifth harmonic frequencies, the spurious emissions are at the noise floor level.

The harmonic frequencies did not exceed the limit. Hence, the system is in compliance.

4.1.3 OCCUPIED BANDWIDTH TEST RESULTS

The Open Peak, VZHUB module was programmed to transmit simultaneously within the 1920 to 1930 MHz and 2400 to 2483.5 MHz bands (Channel 6). For the measurements, the antenna of the Open Peak VZHUB WiFi module was disconnected and an SMA cable was soldered at the antenna output port (direct connect). The other end of the cable was connected to the input of the spectrum analyzer in series with an HP 8495B variable attenuator set to 40 dB (Photographs 5 and 6).

The bypass instrument function of the quasi peak adapter was enabled and the resolution bandwidth of the spectrum analyzer was reduced to 100 kHz. Figures 44 shows the occupied bandwidth using 6 dB criteria for the VZHUB WiFi module set to Channel 6, corresponding to the carrier frequencies of 2.436 GHz. The measurement configuration and procedures were undertaken as per the guidelines presented in the FCC procedures for the measurement of digital transmission systems operating under 15.247.



Photographs 5 and 6: Occupied Bandwidth and Power Spectral Density Setup

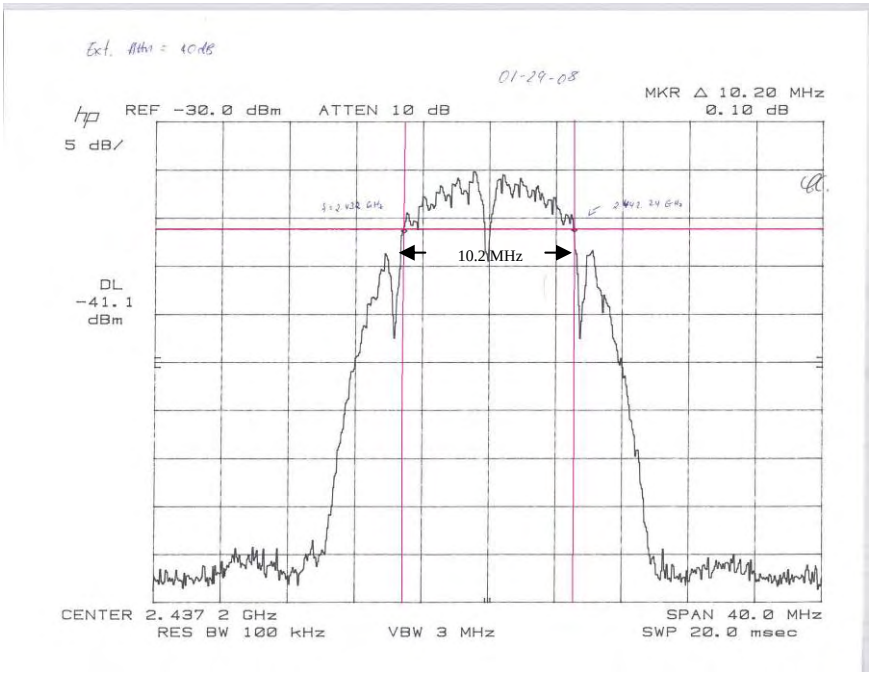


Figure 44: Occupied Bandwidth WiFi Carrier Set to Channel 6

The 6 dB bandwidth of the VZHUB WiFi Module was measured to be 10.2 MHz. Hence, the unit satisfies the minimum 500 kHz bandwidth requirement of the section 15.247.

4.1.4 POWER SPECTRAL DENSITY

The power spectral density of the Open Peak, VZHUB, WiFi Module was measured on the HP 8566B Spectrum analyzer using the setup depicted in Section 4.3.4. The resolution and the video bandwidths of SA were initially set to 3 MHz. Then, the resolution bandwidth was reduced to 3 kHz. The span was set to 1 MHz and the sweep time was adjusted to be equal or larger to the ratio of the span to the resolution bandwidth.

Sweep time ≥ span/(3 kHz) = 334 sec.

The measurement configuration and procedures were undertaken as per the guidelines presented in the FCC procedures for the measurement of digital transmission systems operating under 15.247. The results are presented in Figure 45 and Table 8.

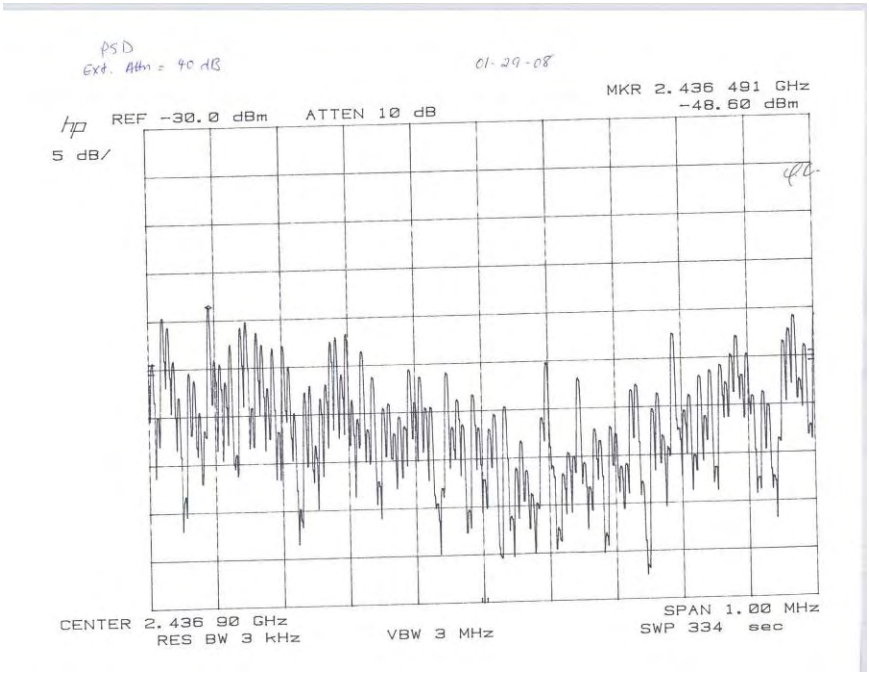


Figure 45: Power Spectral Density with WiFi Module Set to Channel 6

Frequency (GHz)	Measured Peak (dBm)	Attenuator+ Cable Loss (dB)	Peak PSD (dBm)	FCC Limit (dBm)	Margin to Limit (dBm)
2.436	-48.6	40.7	-7.9	8	15.9

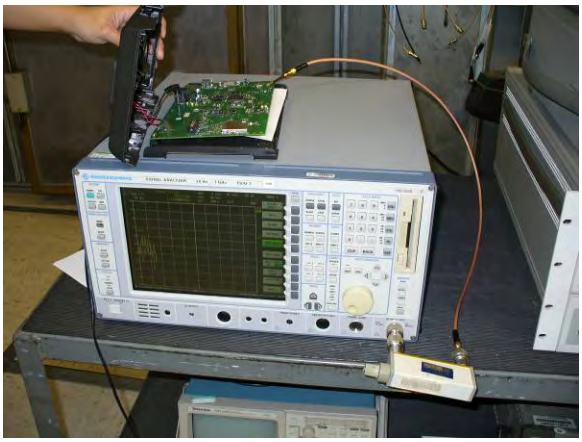
Table 8: Power Spectral Density Measurement Results

It can be observed form Table 8 and Figure 45 that the power spectral density of the VZHUB module is below +8 dBm. Hence the unit satisfies the power spectral density requirements of Section 15.247.

4.1.5 POWER OUTPUT

Because of the limitations of the HP 8566B spectrum analyzer which allows maximum resolution and video bandwidths of only 3 MHz, the conducted output power of the VZHUB WiFi module was measured on a Rohde & Schwarz, FSIQ 7 which provides maximum resolution and video bandwidths equal to 10 MHz. The spectrum analyzer was set to the peak detector mode, VBW and RBW of 10 MHz, automatic sweep time and span of 50 MHz.

For the measurements, the patch antenna of the Open Peak VZHUB WiFi module was disconnected and an SMA cable was soldered at the feed point. The other end of the cable was connected to the input of the spectrum analyzer in series with an HP 8495B variable attenuator set to 40 dB (Photographs 7 and 8).



Photographs 7 & 8: Conducted Power Setup

The measurement was undertaken for Channel 6 only. Figure 46 show the conducted output power results.

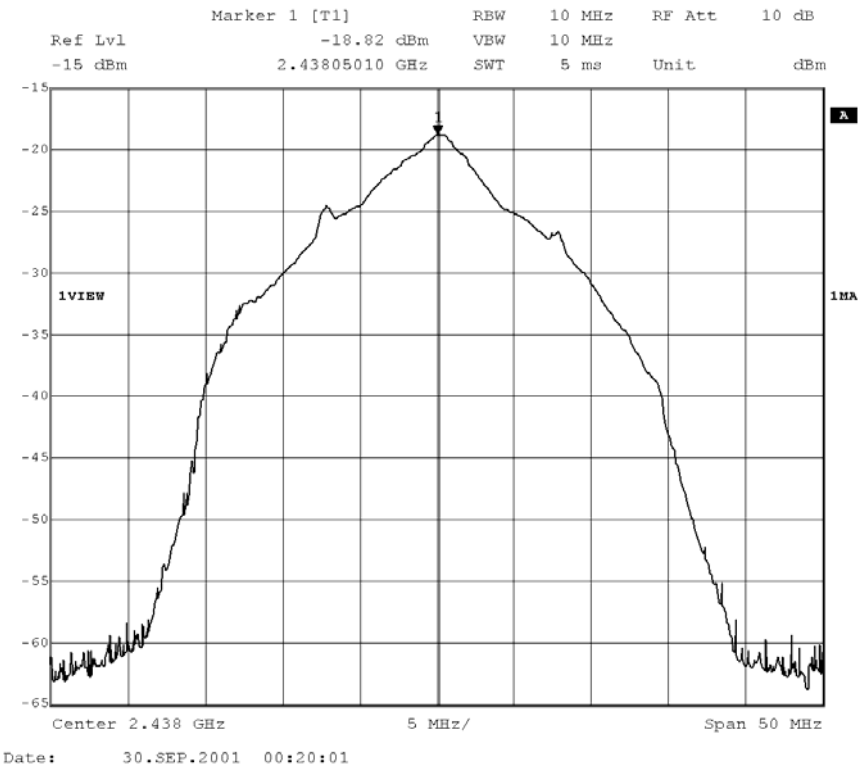


Figure 46: Peak Conducted Power with WiFi Module Set to Channel 6

Frequency (GHz)	Measured Peak (dBm)	Attenuator + Cable Loss (dB)	Peak Power (dBm)	Peak Power (mW)
2.438	-18.82	40.7	21.88	154.17

Table 9: Peak Measurement Results

It can be seen from Table 9 that the output power is 0.15 watt and did not exceed the 1 watt limit. Hence the system is in compliance.

Appendix

Filters' Insertion Loss from 1 GHz to 3 GHz

Figures A.1 show the insertion loss of the Lorch Microwave 1.9 GHz notch filter (3NF-1000/2000-N) from 1 GHz to 2 GHz.

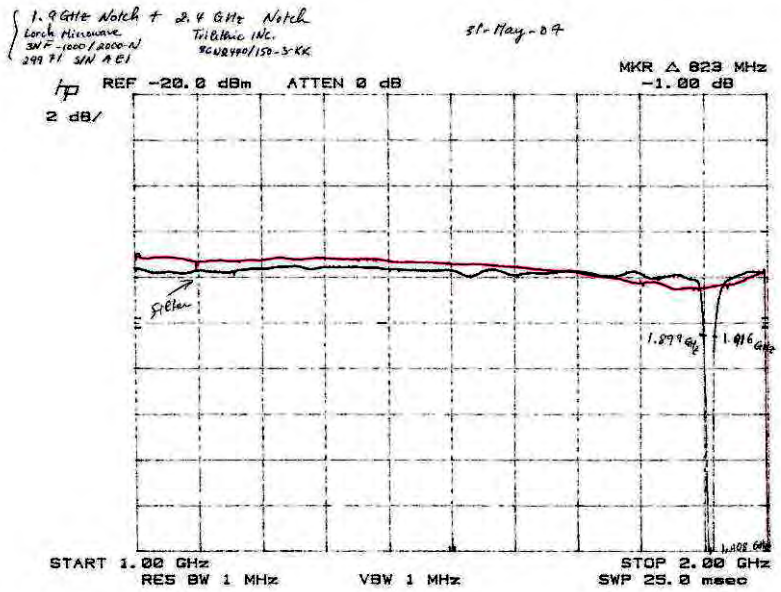


Figure A.1: Filter Insertion Loss from 1 GHz to 2 GHz

MAJOR TEST EQUIPMENT

FAU EMI R&D LABORATORY TEST EQUIPMENT						
Equipment Type	**Manufacturer**	**Description**	**Model**	**Serial No.**	**Calibration Date**	**Calibration Interval (Years)**
Spectrum Analyzer	Hewlett Packard	RF Section	8566B	2403A06381	Aug-22-06	2
Spectrum Analyzer	Hewlett Packard	Display	85662A	2407A06381	Aug-22-06	2
Spectrum Analyzer	Hewlett Packard	Quasi Peak Adapter	85650A	2430A00559	Aug-22-06	2
RF Preselector	Hewlett Packard	Preselector	85685A	2510A00151	Feb-8-06	2
LISN	EMCO	LISN	3825/2R	1095	March-10-06	2
Antenna	EMCO	Biconical	3108	2147	Feb-24-06	2
Antenna	EMCO	Log Periodic	3146	1385	Feb-24-06	2
Amplifier	Hewlett Packard	Amplifier	8447D	2443A03952	Dec-01-06	2
Amplifier	Hewlett Packard	Microwave Amplifier	83017A	3123A00324	Nov-27-06	2
Spectrum Analyzer	Rohde & Schwarz	Spectrum Analyzer	FSIQ 7	DE 35471	Apr-27-07	1

FILTER TABLE			
Model	**Manufacturer**	**Description**	**Application**
3NF-1000/2000-N	Lorch Microwave	Variable Notch	1 - 2 GHz
6HC3000/19500-3-KK	Trilithic	High Pass	2.75 GHz

TEST FACILITY

EMI Research and Development Laboratory
Department of Electrical Engineering
Florida Atlantic University
Boca Raton, Florida 33431
(561) 361-4390

A2LA Certification No. 2129.01
FCC Registration: 90599
Industry of Canada: IC46405-4076

Description	The 3m semi-anechoic chamber and Power Line Conducted Spurious Voltage test setup are constructed and calibrated to meet the FCC requirements of Section 2.948, as well as Industry Canada RSS 212 Issue 1.
Site Filing	A site description is on file with the Federal Communications Commission, 7435 Oakland Mills Road, Columbia, MD 21046, and with the Industry Canada, Certification and Engineering Bureau, 3701 Carling Ave., Building 94, P.O. Box 11490, Station "H", Ottawa Ontario, K2H 8S2.
Instrument	All measuring equipment is in accord with ANSI C63.4 and CISPR 22 requirements.

End of Report