Date	Rev	Revision Record	Approved
2/1/2000	0.9	Test plan	JR
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PMP
RF Type Acceptance Test Plan and Report
For 24 GHz SUB ODU

Prepared for
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Hughes Proprietary II

Job	Approvals	Date	
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Checked:			Title: PMP RF Type Acceptance Test Plan and Report For 24 GHz SUB ODU
	Sheet 1 of 66	CAGE No. 52571	No. 1029004

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 OVERVIEW

1.1 PRODUCT DESCRIPTION

This test plan has been prepared by Hughes Network Systems to document the required RF Type Acceptance FCC101 subparts C& H (Fixed Microwave Services) on the Point to Multipoint - Aireach product (PMP). The purpose of this testing is to determine performance against the requirements for the FCC 101 subsections mentioned.
This test plan and report will demonstrate the compliance with the FCC 101 PMP-ODU SUBSCRIBER (SUB) systems. The test plan and report for the Subscriber ODU is demonstrate in HNS document 1029004

SUB (Subscriber unit) Tx (25050.-25250) MHz **HNS 1026128-0008**
HUB (HUB unit) Tx (24250-24450) MHz **HNS 1026128-0005**

In this test plan and report we are verifying the HUB, the SUB data will be in another HNS test report document #1029004

The HNS PMP provides services to carry voice and data efficiently and economically. The system is based upon multi-sector cells with TDMA/TDMA air Interface. It provides sophisticated multi-mode modulation (QPSK, 64-QAM, and 16-QAM) on a per-burst basis to efficiently handle broad ranging requirements for sector capacity and sector size.

The overall PMP network Architecture includes several elements, including the radios, the transmission equipment, and the central office equipment. The HNS portion of this system is the HNS 24 GHz Point-to Multipoint (PMP). This includes subscriber premises equipment, PMP HUB radio equipment, and interfaces to commercially available multiplexing equipment. These interfaces include the (SONET) backbone and dedicated trunks to the voice switch, as well as IP routers and other data delivery systems. The PMP product is broken into two terminals, a hub terminal (HT) and a remote Terminal (RT). The HT is responsible on routing the data/voice signals from one RT to another. The RT is at the customer premises and comprises 3 components:

(ODU): Outdoor Unit: which is an integrated 24 GHz Trasnsceiver and antenna,

(IDU) the Indoor unit that provide modem and remote multiplexers function, and finally,

The Interfacility Link (IFL) which is a single coaxial cable that interconnects the ODU and IDU.
The HT has the same main components, it supports one sector with one over-the air frequency (12.5 MHz subchannel).

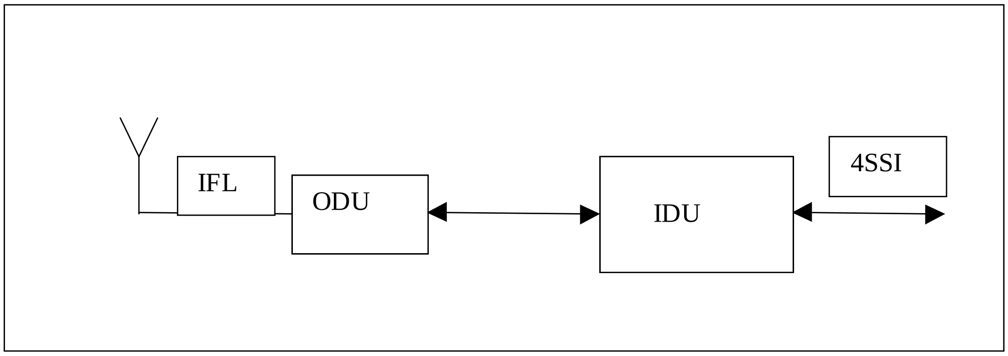
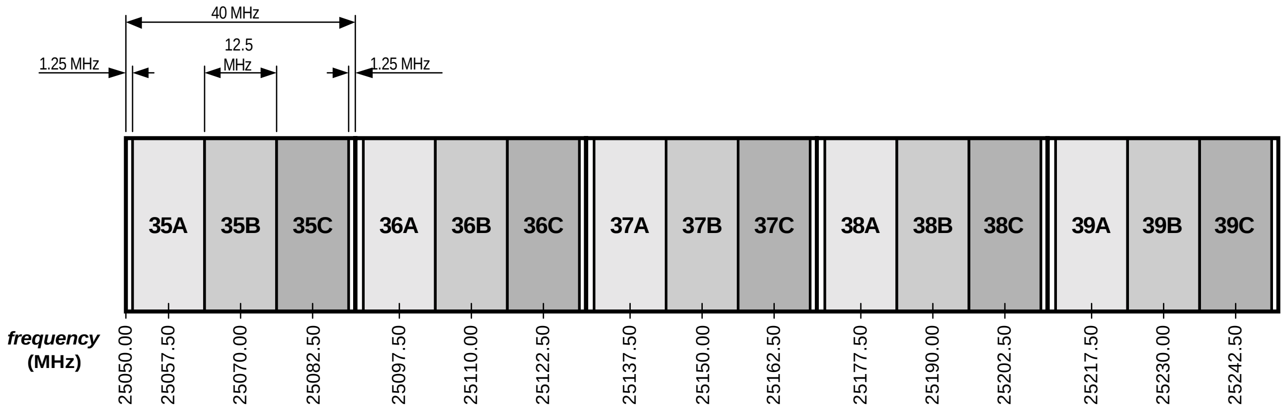


Figure 1 Basic RT/HT Terminal

Figure 1 shows a basic block diagram for the RT/HT system. The IFL cable shown carries DC power signal, reference carrier frequency, the Up-link and the Downlink IF signals and the telemetry control link signals. The IDU is installed indoors, often in a wiring closet. It includes the IF, modem, air frame formatting login, the IFL interface, and the subscriber interface multiplexes the functions in one unit. Each IDU has four multi-port SSI slots to allow for several different user interfaces. For more description of product, it's operation and functionality, please refer to the DDD (Detailed Design document) HNS – 13880.



SUBSCRIBER CHANNELS - TX CENTER FREQUENCIES

1.2 CHANNELIZATION

The channelization, taken from the FCC regulations, CFR-47& 101.147 Frequency assignments, is given in Table 1. The HNS product further divides each 40 MHz license into 3 12.5 MHz subchannels with 1.25 Mhz Guard bands (upper and Lower sides of the 40 Mhz band (see Figure below) The first number and the first letter of each designator are the FCC number for the channel. The last number is the subchannel designator. Each of these subchannel operates at a symbol rate of 10.0Msps in the TDMA mode. The QPSK Spectral Density is 20Mbps in 12.5 Mhz or 1.6 bits/s/Hz and the 64-QAM spectral density is 60Mbps in 12.5 MHz or 4.8 bits/s/Hz.

Channel No.	Tx Center Frequency (MHz)	Rx Center Frequency (MHz)
35A	25057.50	24257.50
35B	25070.00	24270.00
35C	25082.50	24282.50
36A	25097.50	24297.50
36B	25110.00	24310.00
36C	25122.50	24322.50
37A	25137.50	24337.50
37B	25150.00	24350.00
37C	25162.50	24362.50
38A	25177.50	24377.50
38B	25190.00	24390.00
38C	25202.50	24402.50
39A	25217.50	24417.50
39B	25230.00	24430.00
39C	25242.50	24442.50

Table 1: 24 GHz SUBSCRIBER (SUB) Channels

1.3 APPLICABLE STANDARDS

The considered standards are as follows:
1. FCC CFR 47 Part 101 Subparts C & H - Fixed Microwave Services
2. FCC CFR 47 Part 15 - Radio Frequency Devices
3. FCC CFR 47 Part 2 - General Rules and Regulations

1.4 REFERENCE DOCUMENTS

1. HNS-13880, 38GHz Point to Multi to point radio System Detailed Design and Requirements Documents
2 HNS 1026128, 24 GHz Radio Integrated Outdoor units for Subscribers and Hub Stations
3 ODU Detailed test data SUB Terminal ODU S/N 212.
4 HP 8564E Spectrum Analyzer Manual
5 Specification for the parts used during the type acceptance test.
6 24- 26 GHz SUBSCRIBER (SUB) Antenna Specification document # 1025231

2.0 SETUP

This section documents the RF transmit and receive test setup, parts and test equipment used. Table 2 in section 2.1 lists the EUT (Equipment Under Test) that are subject for testing for FCC 101, with part numbers and revision levels. Table 3: lists the EUT equipment was used to generate the traffic to the ODU. Table 4 lists the test equipment and their calibration dates used to support the test. Section 2.2 shows the various test configuration diagrams. The measurements will be done using a HP 8564E series Spectrum Analyzer as the final measuring device. All the data plots will be captured via HP Bench screen capture software and saved as *.GIF images which may then be inserted into test report documents digitally. The EUT is configured for transmission mode using custom software prepared by Hughes Network Systems for channel selection and simulation of the signals that are normally transmitted to the Subscriber (SUB) terminal

2.1 EQUIPMENT LIST

PART NUMBER	DESCRIPTION	SERIAL NUMBER	REVISION LEVEL
1026128-0008	Subscriber Out Door unit ODU	200	Gamma

Table 2 Equipment Under Test (EUT) that is subject to the FCC 101 filling

1028966-001	Channel and Control module (CCM) HUB Terminal HT [Indoor unit} IDU	129	B
1028966-002	Channel and Control module (CCM) SUB (Remote Terminal RT [Indoor unit} IDU	146	C
1027094-001	DS3 TDM module [Indoor unit} IDU	6	B
3003132-0002	Universal DS1 module [Indoor unit} IDU	8	12
3003132-0002	Universal DS1 module [Indoor unit} IDU	3	12
3003132-0002	Universal DS1 module [Indoor unit} IDU	56	B
1024668-0017	24-26 GHz Antenna Assembly HUB	42	A

Table 3 Equipment that were used to generate the traffic to the ODU

REF #	PART NUMBER	MANUFACTURER	DESCRIPTION	Calibration Dates	SERIAL NUMBER
1	8564E	HP	40 GHz Spectrum Analyzer	04/16/00	2500
2	8564E	HP	40 GHz Spectrum Analyzer	12/16/00	01611
3	UFB142A-0-0394-110110	Micro Coax	Low Loss 40 GHz cable	NA	99A0483
4	UFB142A-0-0394-110110	Micro Coax	Low Loss 40 GHz cable	NA	99A0483
5	UFB142A-0-0394-110110	Micro Coax	Low Loss 40 GHz cable	NA	99A0483
6	UFB142A-0-0394-110110	Micro Coax	Low Loss 40 GHz cable	NA	99A0483
7	ETS42S-28S ETS28S-19R, ET28S-12R, ET28S-8R, ET28S 5R	Custom Microwave	Waveguide transitions	NA	S0550,S0725 S0680,S0320 S0957
8	R281A	HP	Waveguide to Cable adapter 2.4mm to WR-28	NA	2687-
9	WA-42K	Dorado International	Waveguide to Cable adapter 3.5mm to WR-42	NA	-
10	3142	EMCO	BI-Log Antenna 30 to 1000 MHz	NA	9701-1120
11	3115	EMCO	Horn Antenna 1 to 18 GHz	NA	9701-5069
12	HO42S, HO28S, HO19R, HO12R, HO8R, HO5R	Custom Microwave	Standard Gain Horn Antennas Covering 18 to 220 GHz ranges	NA	S0656 S0750 S0746 S0683 NA
13	M19HW, M12HW, MO8HW, MO5HW, O/IFDIPLEXER	Oleson Microwave	Harmonic Mixers covering 40 to 220 GHz ranges	NA	U90108-2 E90108-1 F90108-1 G90222-1 OS 26805-
14	-	Antenna port to WR-28 adapters	-	NA	
15	N/A	Circular Waveguide to Rectangular wave Guide adapter	00010	NA	1
16		T- BERD 224	Metrology	06/29/00	12825
17	SS300e	SunSet T3 SS300e by Sunrise telecom	Sunrise telecom	NA	07373
18	HP 438	Power meter (HP)	Hewelt Packard	06/29/00	3513V06277
19	MDC 520028-0001	Load (Wave guide)		NA	7370
20	MDC 63660	Load (Wave guide)		NA	7791
21	NA	24-40 Ghz Waveguide transition		NA	
22	Thermotron SigminMax	Temperature chamber	Thermotron	01/18/01	13988
23	HP 8487A	Power sensor	Hewelt Packard	3/23/00	3318A03283
24	HP531521A	Frequency counter	Hewelt Packard	11/22/00	US39270189

Table 4 Test Equipment used

2.2 TEST SETUPS

This section documents the test plan, and requirements for the transmitter test.

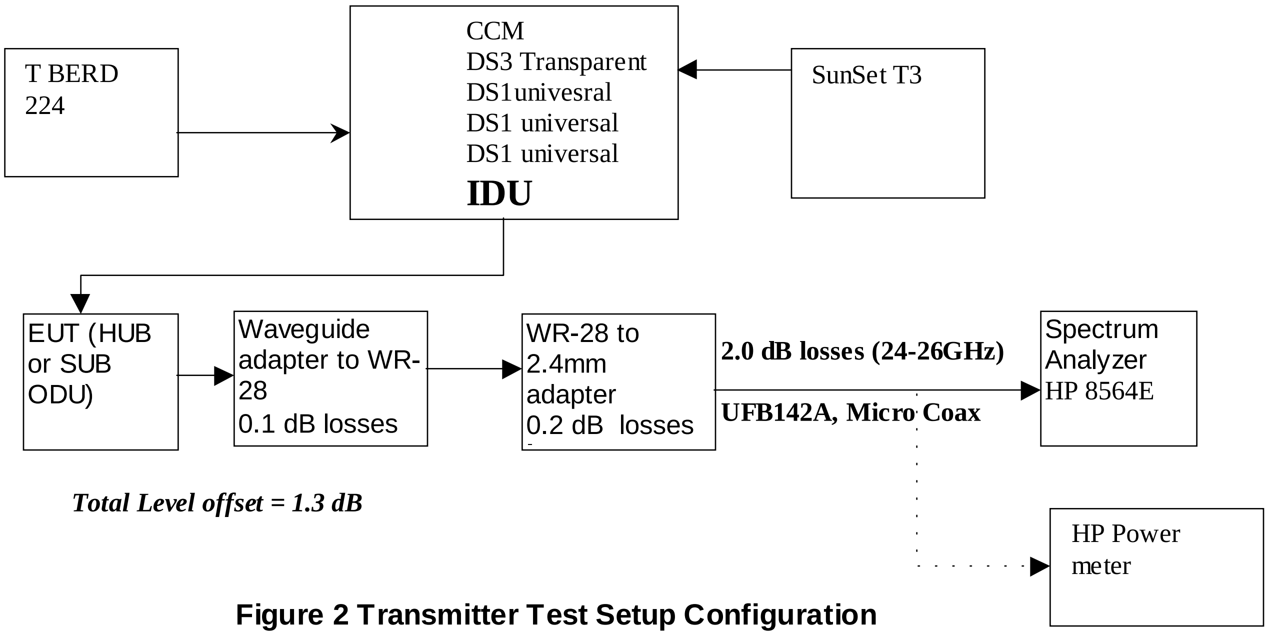


Figure 2 Transmitter Test Setup Configuration

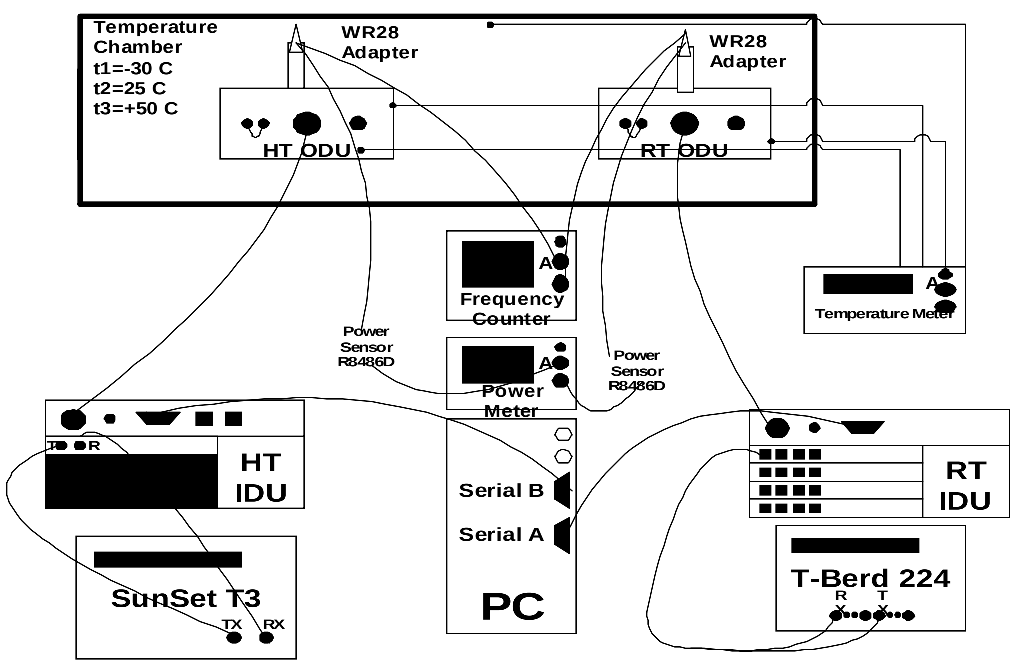


Figure 3 Frequency Stability Test Setup Configuration

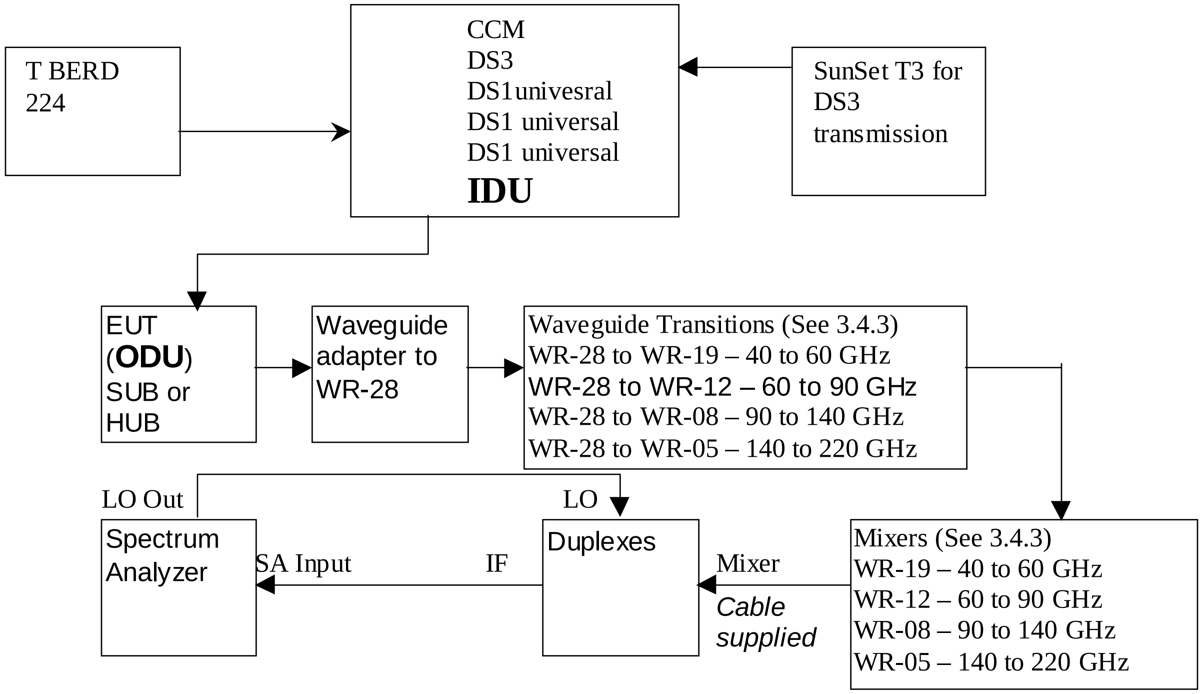


Figure 4 Transmitter Test Setup Configuration – Conducted Spurious Emissions

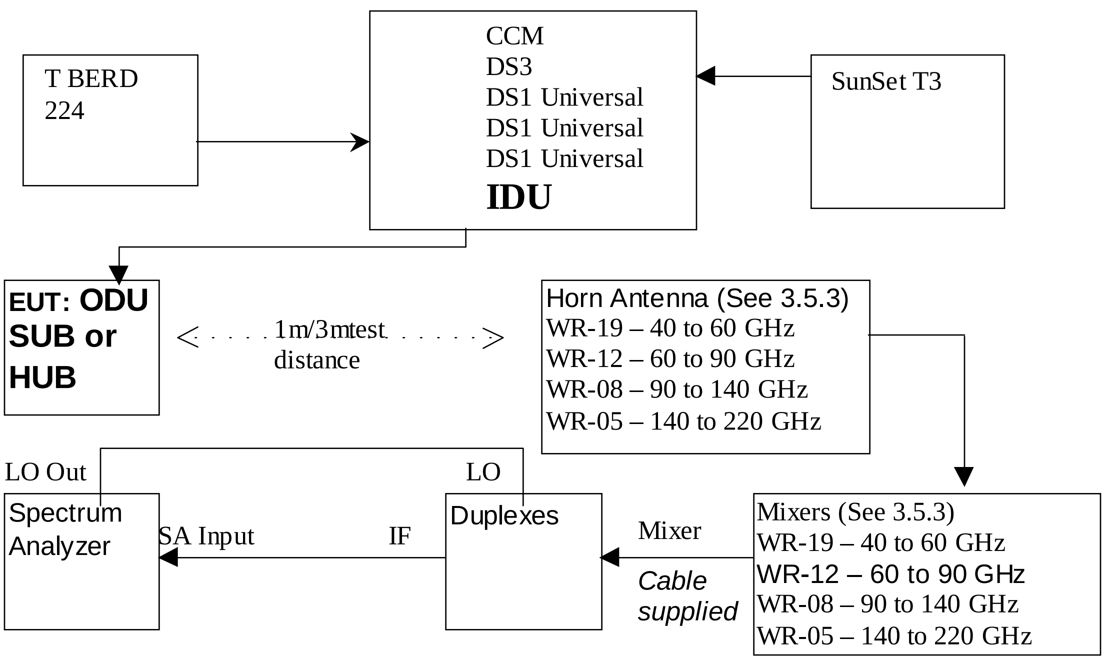


Figure 5 Transmitter Test Setup Configuration – Radiated Spurious Emissions

3.0 TRANSMITTER TESTS

3.1 THE OUTPUT POWER

This test demonstrates the maximum transmitter power level of the EUT antenna output. The maximum power transmitted will be 20.0 dBm at the Antenna port. All the measurements are with + 1dB of tolerance.

3.1.1 Performance Specifications

As per FCC CFR 47 Part 2.1046 (previously 2.985) and 101.113
EIRP Max = +55dBW after the antenna.

The maximum SUBSCRIBER (SUB) Antenna has a gain of 37 dBi in the range of 24.25 – 25.25GHz

The maximum allowable limit is
55dBw= 85 dBm
Maximum allowable transmitted power from the Antenna port is for the transmitting bands:

PTx max allowed = 85dBm- 37 dBi= 48 dBm in 1MHz Resolution Bandwidth. Our maximum power is only 20 dBm, so we are 28 dB lower than the Mask.

3.1.2 Test Procedures

The equipment under test will be operated at different frequencies across the transmit frequency band (low end, center, and high end of the FCC authorized bands. The power level is better seen on the Spectrum Analyzer when operating at CW mode. The Power level of the CW reflects what is the power level of each modulation type. The RMS power of the Tx signal is measured using an HP power meter with a power sensor adapter that ranges up to 50 GHz. We will base our reading on the power meter reading. The difference between the SA reading and the power meter reading was within 1 dB.

. The following channels will be used according to the band tested.

36A, 36B, 36C, and 39C

3.1.3 Test Configuration

Please reference to Figure 1 for the test configuration used during this test.

a. Spectrum Analyzer setup:
Resolution Bandwidth - 1 Mhz
Video Bandwidth – 1 Mhz
Amplitude Units dBm
Reference level offset = 2.3 dB (Cable + Adapters losses)

b. Power meter Setup
The actual RMS transmit power = power meter reading + attenuation + coupler losses.

3.1.4 Test Results

SUB		
Channel #	**Frequency (Mhz)**	**P_{Tx}(dBm)**
36A	25057.50	20.00
36B	25110.00	20.33
39C	25242.5	20.33

Table 5 Test Results for the Output Power

Please refer to the attached plots for the output power. Graphs show the carrier in channel (36A), (36B) and high-channel (39C). The maximum output power is 20dBm. + 1dB tolerance.

PASS: X Fail: ___

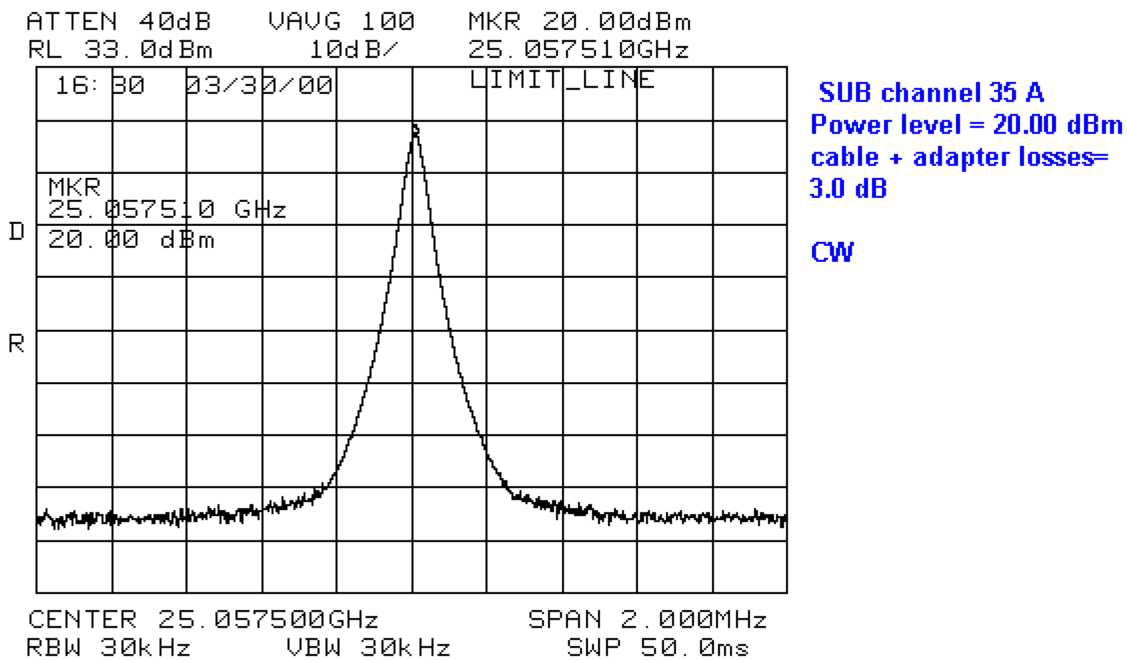
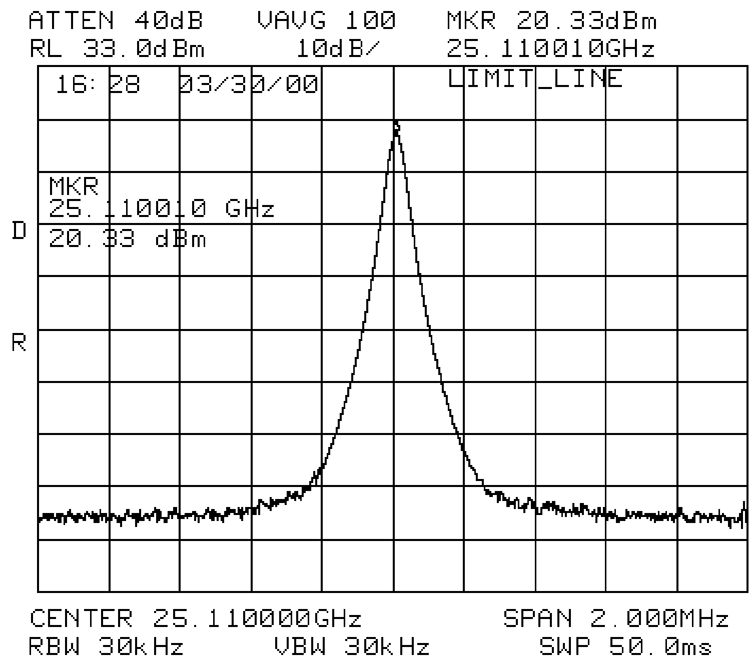


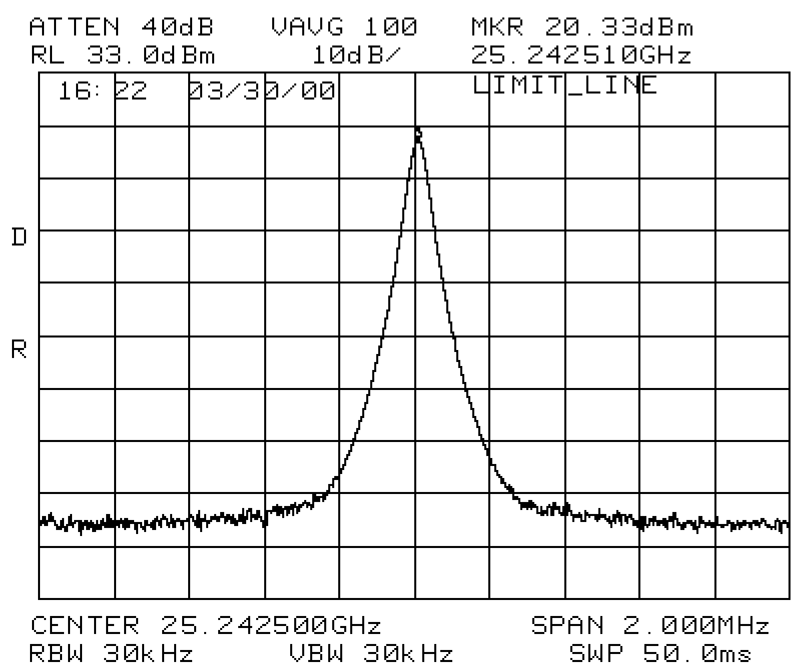
Figure 6Output Power on Ch. 36A



SUB channel 36 B
Power level = 20.33 dBm
Cable losses and adapter losses= 3.0 dB

CW.

Figure 7 Output Power for Ch. 36B



SUB Channel 39 C
Power level = 20.33 dBm

cable and adapter losses = 3.0 dB

Figure 8 Output power for 39C

3.2 MICROWAVE MODULATION:

Both the SUB ODU and the HUB ODU transmitters employ digital modulation techniques and therefore they are subject to comply with section 101.141 of the FCC 101 regulations, CFR-47& 101.141. Frequency assignments, is given in Table 1. The HNS product further divides each 40 MHz license into 3 12.5 MHz subchannels with 1.25 Mhz Guard bands. Each of these subchannel operates at a symbol rate of 10.0Msps in the TDMA mode and ATM mode. The HNS PMP system support 3 types of digital modulations. We have listed them below with there designated spectral density:

Modulation	**Bits/ Symbol**	**Spectral Density in one 12.5 Mhz**	**Bit rate in Mbps in one 12.5 Mhz band**	**Bit Rate in 40 Mhz band**	**Maximum Traffic loading (data only) in of # DS1**	**Bit Rate in 40 Mhz band (both data and overhead)**
QPSK	2	1.6bits/s/Hz	20 Mbps	60Mbps	9*3=27 DS1s	60Mbps
64-QAM	6	4.8 bits/s/Hz	60Mbps	180Mbps	28*3=84 DS1s	180Mbps
16-QAM	4	3.2 bits/s/Hz	40 Mbps	120Mbps	21*3=63 DS1	120Mbps

Table 6: System Payload Capacity and Bandwidth

From Table 6, the bit rate for the entire 40 Mhz band is 3 (3 subchannel 12.5 MHz each) * the bit rate for each subchannel = 60Mbps (QPSK), 180Mbps (64-QAM), and 120Mbps for (16-QAM). Also the table shows the maximum capacity payload in # of DS1 channels. This applied on both TDM and ATM operations. Please refer to the plots taken in section 3.3 occupied BW (Figures14-22). To show that the Bandwidth of the modulated signal occupied is always > than 50% of the maximum frequency deviation of the transmitted radio frequency carrier. Example, when sending a QPSK signal (2bit/Symbol) at 20Mbps, the symbol rate is 10Msps, which makes the BW= 10MHz, so 50% of the 10 MHz is 5 MHz. The plots clearly show that the data occupies well above 5MHz band.

3.2.1 Test Results

PASS X FAIL

3.3 OCCUPIED BANDWIDTH

This test demonstrates that occupied bandwidth of the transmitter is within the FCC 101.109 requirements.

3.3.1 Performance Specifications and Mask Determination

The Conducted, Radiated emissions and Occupied bandwidth tests were performed against the new proposed mask (NPRM doc # 99-333). Below we are showing both mask, the current and the proposed ones.

A. Current Mask

As per FCC CFR 47 Part 2.1050 (previously 2.989) and 101.109

Maximum authorized bandwidth 40MHz.Unwanted emissions must be suppressed at the aggregate channel block edges based on the same roll-off rate as specified for a single channel block in 101.111 (a) (4) (i), (ii) and (iii).

(a)(4)(i) In any 4KHz Band of any DEMS channel 50% of the DEMS channel Bandwidth up to and including 50% and 500 kHz

: A=50 +0.06(F-0.5B)+10log(N)

Where: A = Attenuation in dB below mean output power level

F = Absolute value of the difference between the center frequency of the 4Khz band measured and the center of the DEMS channel in Khz

N = Number of active channels

B: is the Bandwidth of the DEMS channel

Example calculation:

Number of active channels at one time is 1,

If your bandwidth is 40 MHz = 40'000Khz

At 50 % : A=50+ 0.06(|fc-(fc+20'000Khz|- 0.5(40'000Khz)) + 10 log(1)

A= 50 dB down from the Maximum Transmitted power (20 dBm)

Mask should be at 20-50= 30 dBm.

At 50%+ 500Khz,: A=50+0.06[|fc-(fc+20'000+500KHz)| -0.5(40'000KHz)] +10log(1).

A= 80 dB down from the Maximum Transmitted Power

Mask will be at 20dBm-80dB= -60dBm.

(4) (ii) In any 4 KHz band within the authorized DEMS band, the center frequency of which is removed from the center frequency of the DEMS channel by more than the sum of the 50% of the channel bandwidth and 500Khz, as specified by the following equation but in no event less than 80 dB.

A= 80+10log(N) = 80 dB down

Mask will be at 20dBm-80dB= -60dBm.

(a)(4)(iii)in 4kHz band outside the authorized DEMS band: at least 43+10log(output power in Watts).

Example calculation:

Outside the DEMS band:

A= 43+ 10log(0.1)=33 dB
For Power level = 20 dBm, The mask will be 20-33= -13 dBm.
Note: 4 kHz Bandwidth will be difficult to use. You may adjust the limit accordingly. We have used BW of 3 Khz. Therefore a factor of 10log(3/4) = -1.2 dB is added to the mask to compensate for the difference = -13-1.2= 14.2 dBm

The following table and plot shows a sample of the mask calculated for channels 35 and 36:

F(MHz)	f(Ghz)	A in Band	Emission limits (20 dbm)
SUB Channel 35			
25047000	25.047	31.75061263	-14.24938737
25048000	25.048	31.75061263	-14.24938737
25049000	25.049	31.75061263	-14.24938737
25050000	25.05	31.75061263	-14.24938737
25050000	25.05		20.0
25051250	25.0513		20.0
25057500	25.0575		20.0
25070000	25.07		20.0
25082500	25.0825		20.0
25088750	25.0888		20.0
25090000	25.09		20.0
25090000	25.09	50	-31.24938737
25090100	25.0901	56	-37.24938737
25090200	25.0902	62	-43.24938737
25090300	25.0903	68	-49.24938737
25090400	25.0904	74	-55.24938737
25090500	25.0905	80	-61.24938737
25090600	25.0906	80	-61.24938737
25090700	25.0907	80	-61.24938737
25090800	25.0908	80	-61.24938737
25090900	25.0909	80	-61.24938737
25091900	25.0919	80	-61.24938737

Table 7 Emission Mask for channel 35

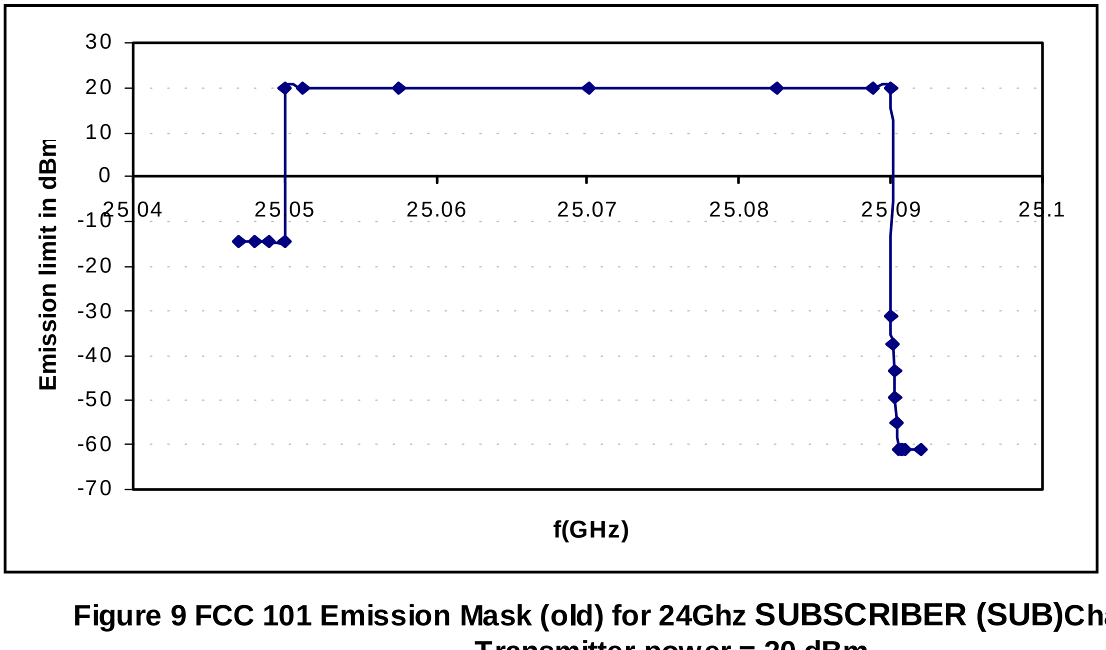


Figure 9 FCC 101 Emission Mask (old) for 24Ghz SUBSCRIBER (SUB)Channel 35 for Transmitter power = 20 dBm

SUB Channel 36

F(MHz)	f(Ghz)	A in Band	Emission limits (20 dbm)
25089500	25.0895	80	-61.24938737
25089600	25.0896	74	-55.24938737
25089700	25.0897	68	-49.24938737
25089800	25.0898	62	-43.24938737
25089900	25.0899	56	-37.24938737
25090000	25.09	50	-31.24938737
25090000	25.09		20.0
25091250	25.0913		20.0
25097500	25.0975		20.0
25110000	25.11		20.0
25122500	25.1225		20.0
25128750	25.1288		20.0
25130000	25.13		20.0
25130000	25.13	50	-31.24938737
25130100	25.1301	56	-37.24938737
25130200	25.1302	62	-43.24938737
25130300	25.1303	68	-49.24938737
25130400	25.1304	74	-55.24938737
25130500	25.1305	80	-61.24938737
25131500	25.1315	80	-61.24938737

Table 8 Emission Mask for channel 36

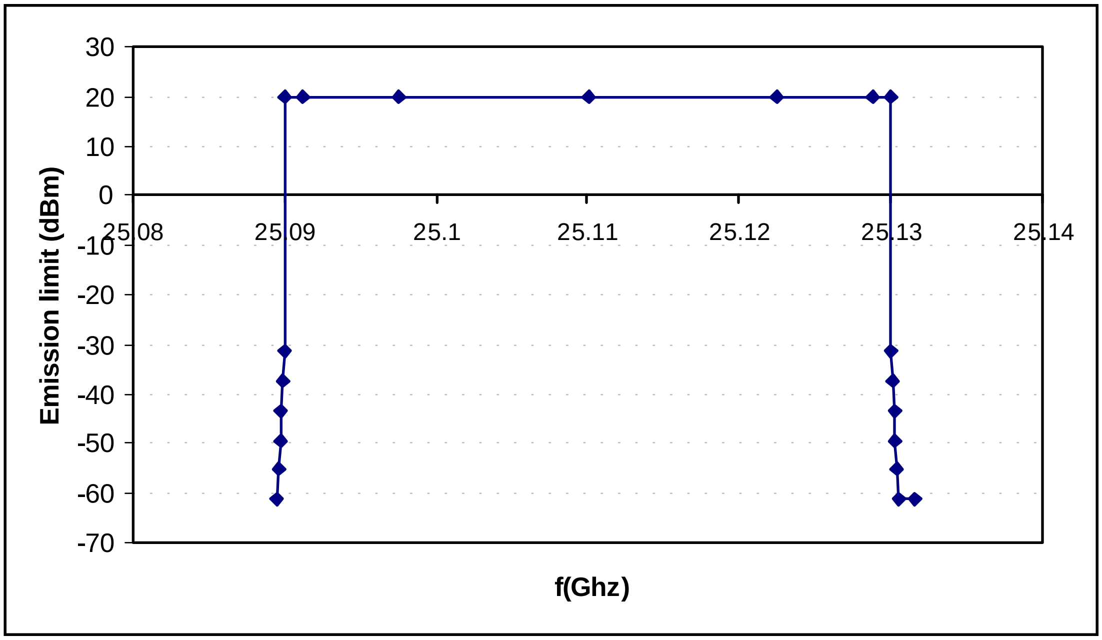


Figure 10 FCC 101 Emission Mask (old) for 24Ghz SUBSCRIBER (SUB)Channel 36 for Transmitter power = 20 dBm

The same procedure is applied on the rest of channels in the band.

Proposed FCC Emission Mask" NPRM Document # 99-333

HNS SUBSCRIBER (SUB)and HUB ODU product does not meet the Current FCC Emission Mask, therefore all the occupied Bandwidth and the Conducted Emission test was performed with respect of the new proposed Mask that is still in the process of getting released by the FCC. The mask propose the following:

For 24 GHz Service in the 24,250-25,250 MHz band:

(i) On any frequency removed from the center frequency of the 24 GHz Service channel by more than 50 percent of that channel's bandwidth:

A = 35 + 0.75(F - 0.5B) dB (in any 4 kHz channel), or
A = 11 + 0.75(F - 0.5B) dB (in any 1 MHz channel),
but in no event greater than 80 decibels;

A = attenuation (in decibels) below mean output power level contained within the 24 GHz Service channel for a given polarization
B = bandwidth of 24 GHz Service channel (in MHz)
F = absolute value of the difference between the center frequency of the measured band and the center frequency of the 24 GHz Service channel

(ii) In any 4 kHz band, the center frequency which is outside the 24 GHz Service band: At least 43 + 10 log10(mean output power in watts) decibels.
With the above Mask description, the following tables and figures were produced for Channels 35,36,and 39:

f(KHz)	f(Ghz)	A in Band	Emission limits (20 dbm)
25047000	25.047	31.75061263	**-14.24938737**
25048000	25.048	31.75061263	**-14.24938737**
25049000	25.049	31.75061263	**-14.24938737**
25050000	25.05	31.75061263	**-14.24938737**
25050000	25.05		**20**
25051250	25.0513		**20**
25057500	25.0575		**20**
25070000	25.07		**20**
25082500	25.0825		**20**
25088750	25.0888		**20**
25090000	25.09		**20**
25090000	25.09	35	**-16.24938737**
25110000	25.11	50	**-31.24938737**
25150000	25.15	80	**-61.24938737**

Table 9 Emission Mask for channel 35

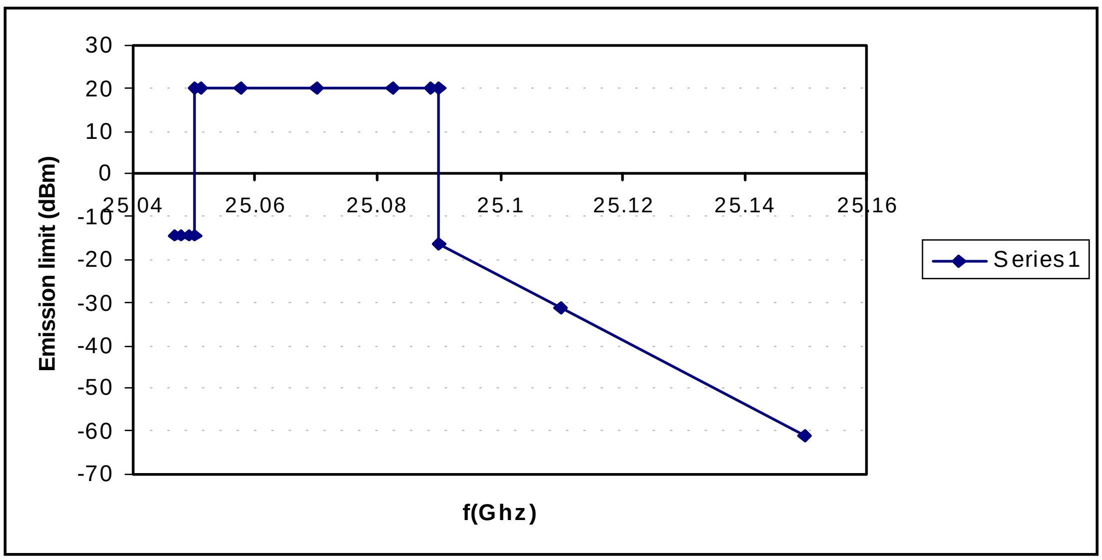


Figure 11: FCC 101 Emission Mask Proposed for 24Ghz SUBSCRIBER (SUB)Channel 35 for Transmitter power = 20 dBm

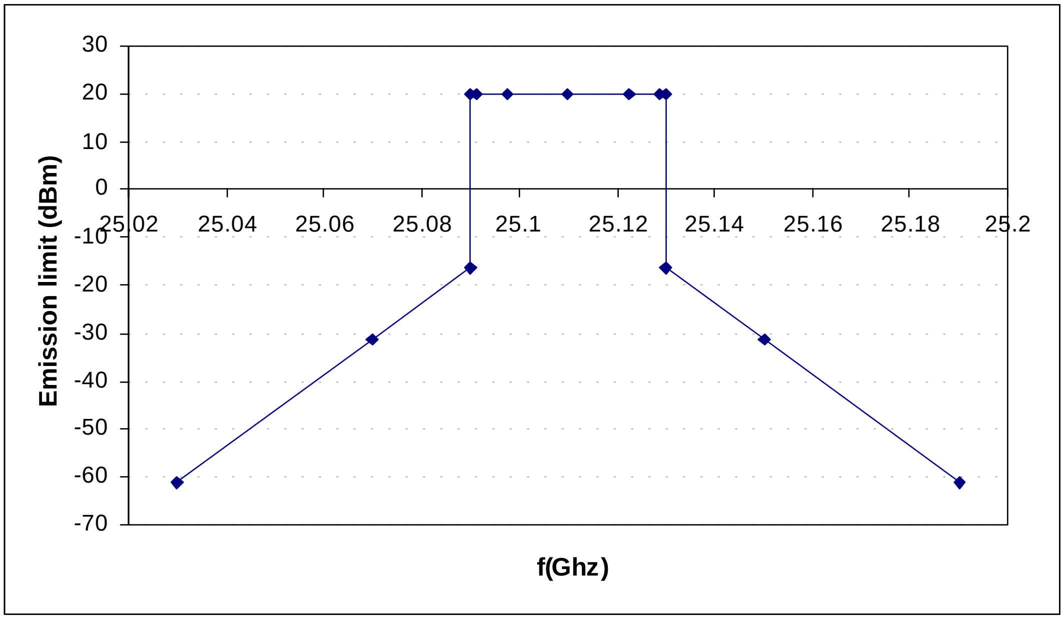


Figure 12 FCC 101 Emission Mask Proposed for 24Ghz SUBSCRIBER (SUB) Channel 36 for Transmitter power = 20 dBm

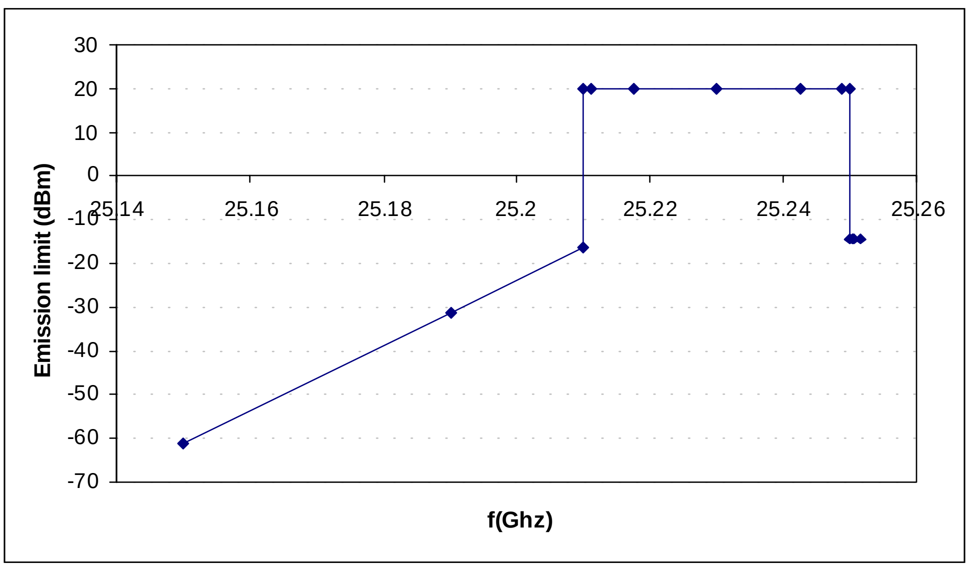


Figure 13 FCC 101 Emission Mask Proposed for 24Ghz SUBSCRIBER (SUB)Channel 39 for Transmitter power = 20 dBm

3.3.2 Test Procedures

The equipment under test will be operated at different frequencies across the transmit frequency band (low end , middle and high end). The modulated carrier will be examined and the occupied bandwidth will be viewed for compliance.

Test Frequencies	
Channel	**Frequency MHz**
35A	24257.5
36A	24282.
39C	24442.5

Table 10 Occupied Bandwidth Test Frequencies

3.3.3 Test Configuration

Please reference to Figure 3 for the test configuration used during this test.

Spectrum Analyzer setup:
Resolution Bandwidth – 3 KHz
Video Bandwidth – 3 KHz

3.3.4 Test Results

The graphs for the occupied bandwidth signals are shown in the following pages. The output transmitted channel power is 20 dBm. All the modulation schemes (QPSK, 64-QAM, 16-QAM, and mix modulation (QPSK, 16-Qam, and 64-QAM) foe channels 35A, 36B, 39C are investigated.

PASS: _X_ Fail:___

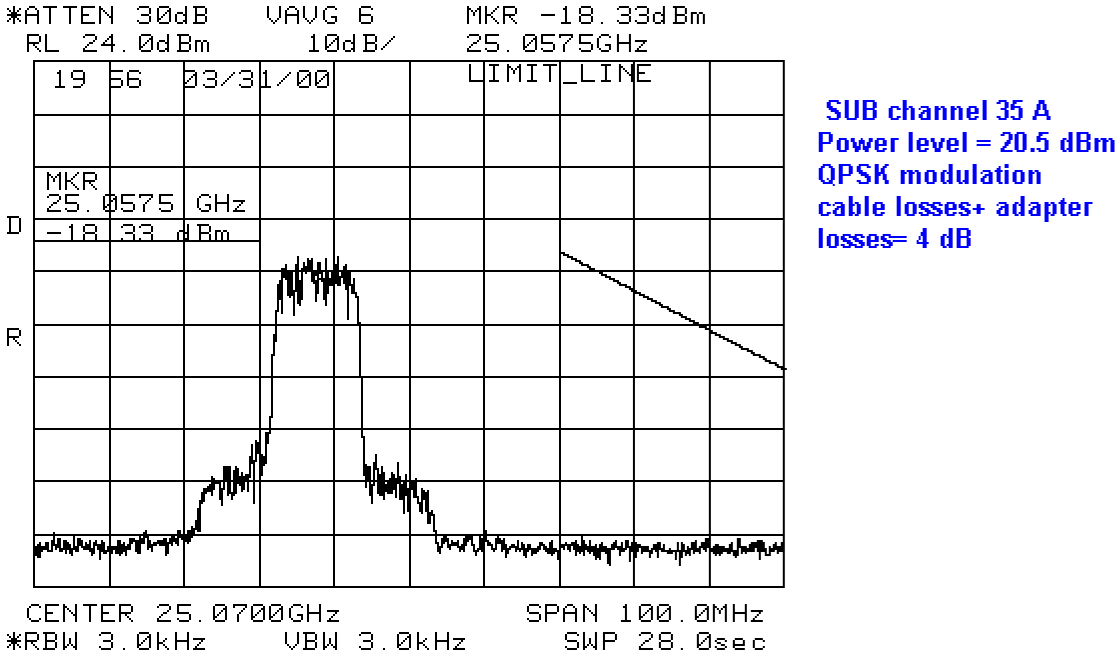


Figure 14 Bandwidth for QPSK modulated signal on channel 35A, Power=20dBm

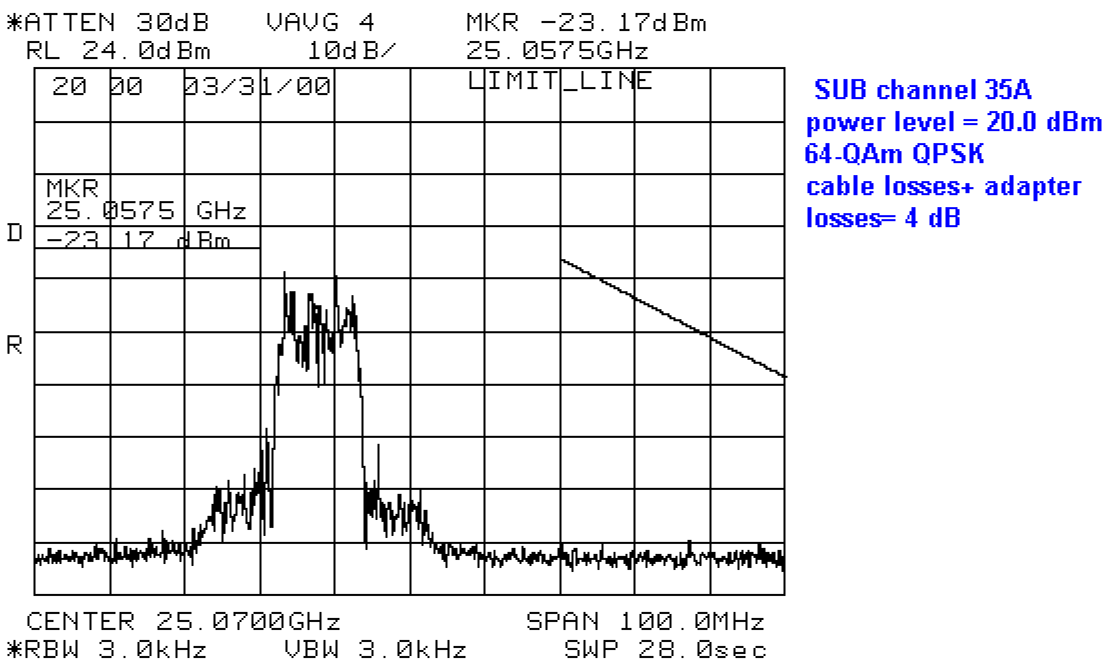
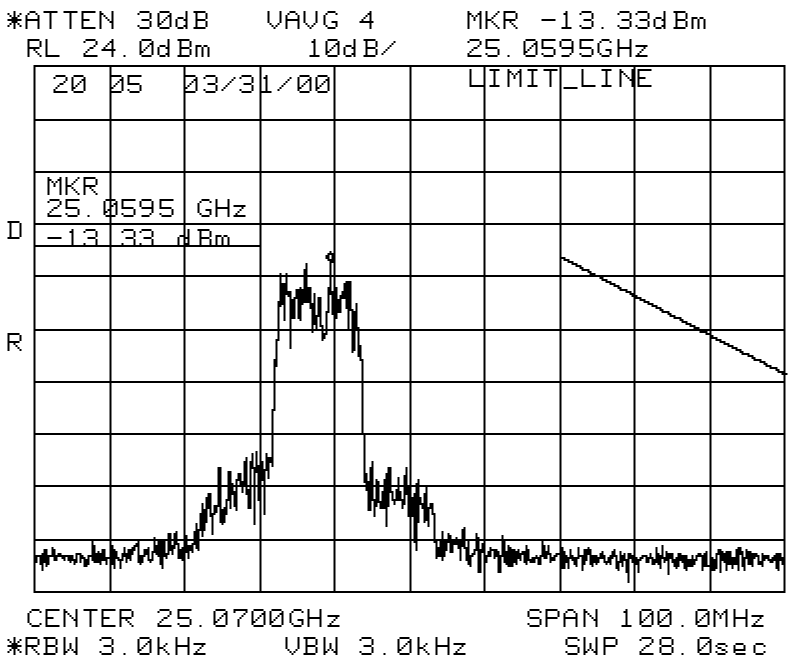


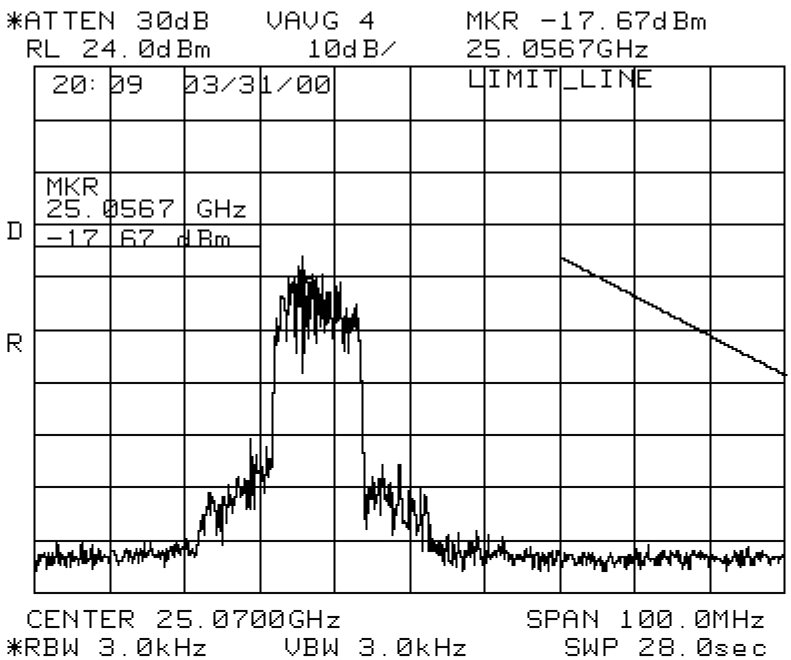
Figure 15 Bandwidth for 64-QAM modulated signal on channel 35A, Power=20dBm



SUB channel 35A
power level = 20.8 dBm
16-QAM modulation

cable losses+ adapter losses= 4.0 dB

Figure 16 Bandwidth for 16-QAM modulated signal on channel 35A, Power=20dBm



SUB channel 35A
power level = 20.9 dBm
All modulation (QPSK, 16-QAM, 64-QAM)
cable + adapters losses= 4.0 dB

Figure 17 Bandwidth for Mixed modulation Modulated signal on channel 35A, Power=20dBm

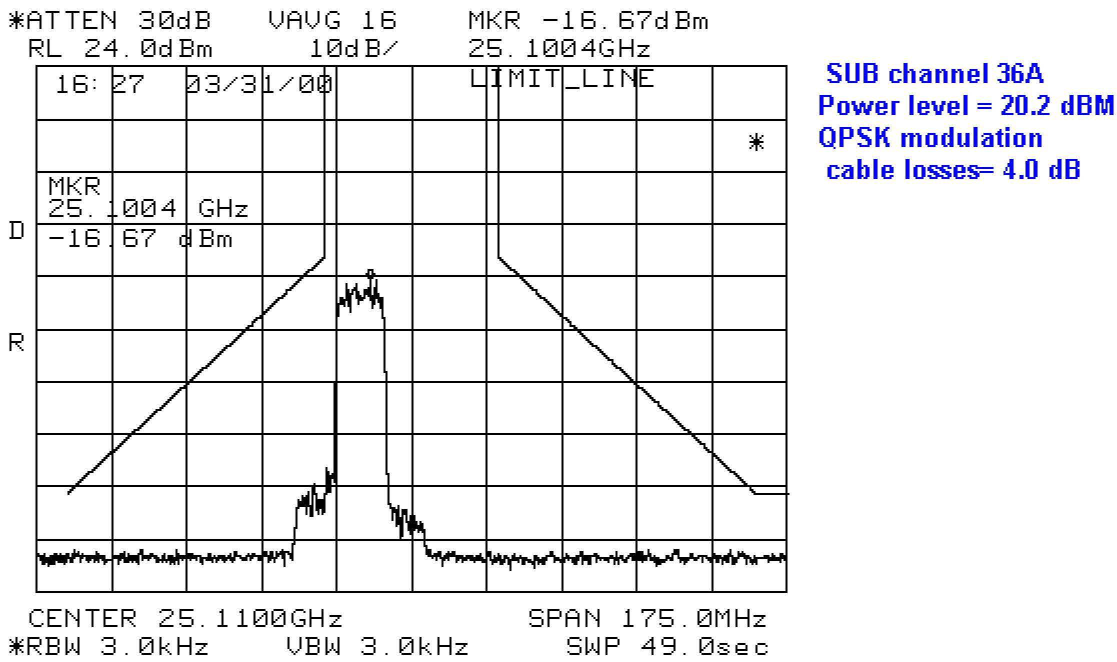


Figure 18 Bandwidth for QPSK modulated signal on channel 36A, Power=20dBm

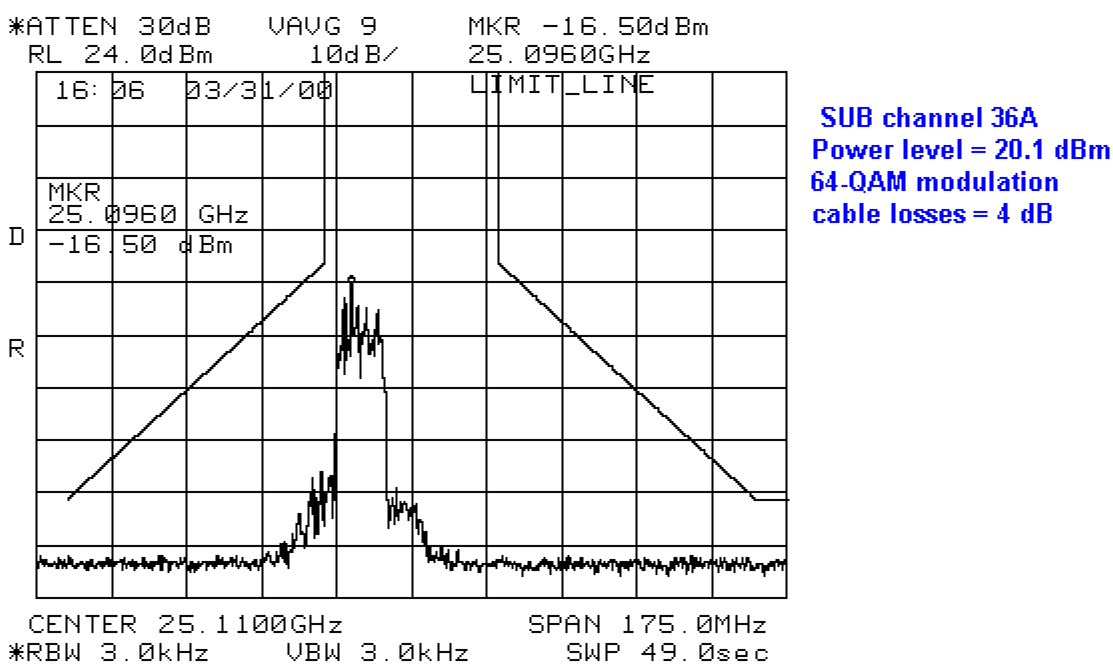
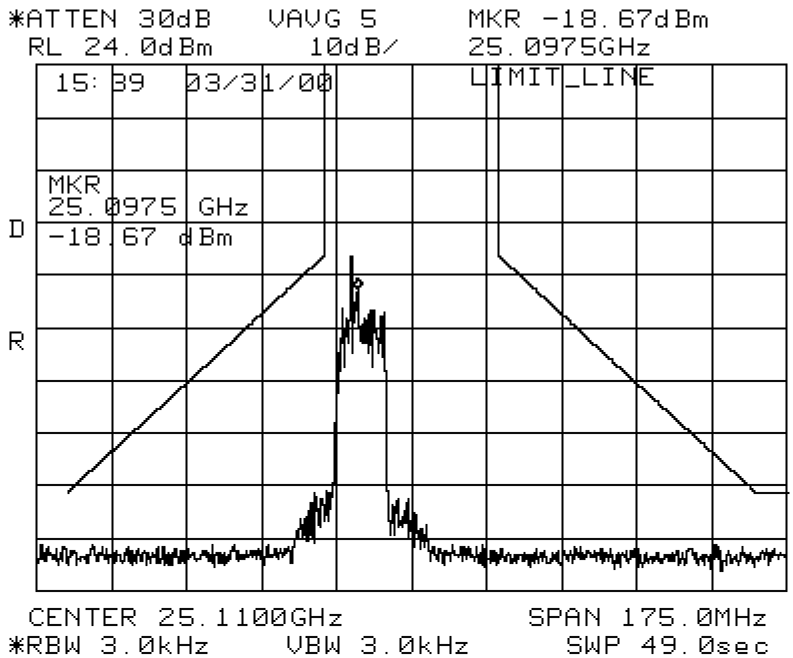
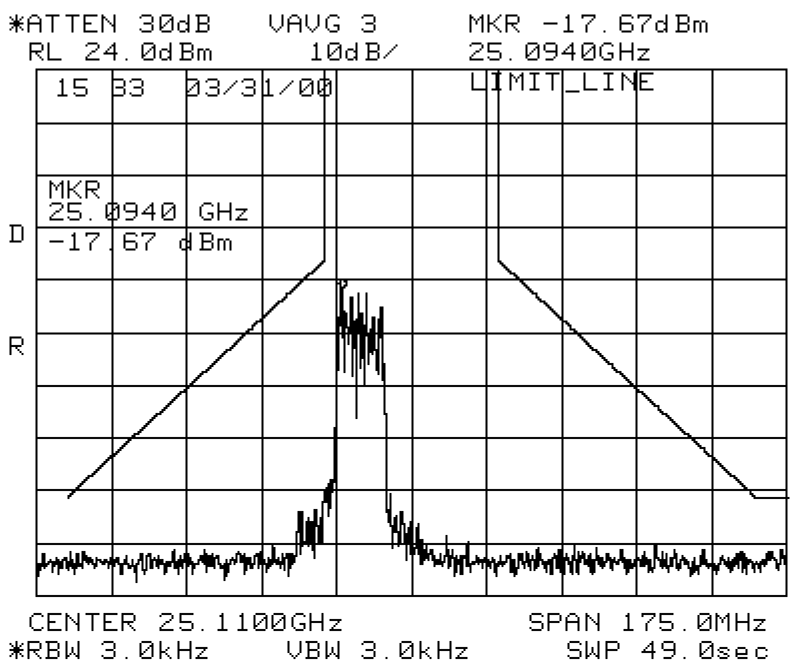


Figure 19 Bandwidth for 64-QAM modulated signal on channel 36A, Power=20dBm



SUB channel 36 A
Power level = 20.2 dBM
16-QAM modulation
Cable losses + adapters = 4.0 dB

Figure 20 Bandwidth for 16-QAM modulated signal on channel 36A, Power=20dBm



SUB channel 36A
Power level = 20.2 dBm
All modulation (QPSK, 16-QAM, 64-QAM)

Cable losses and adapter = 4.0 dB

Figure 21 Bandwidth for mixed modulated signal on channel 36A, Power=20dBm

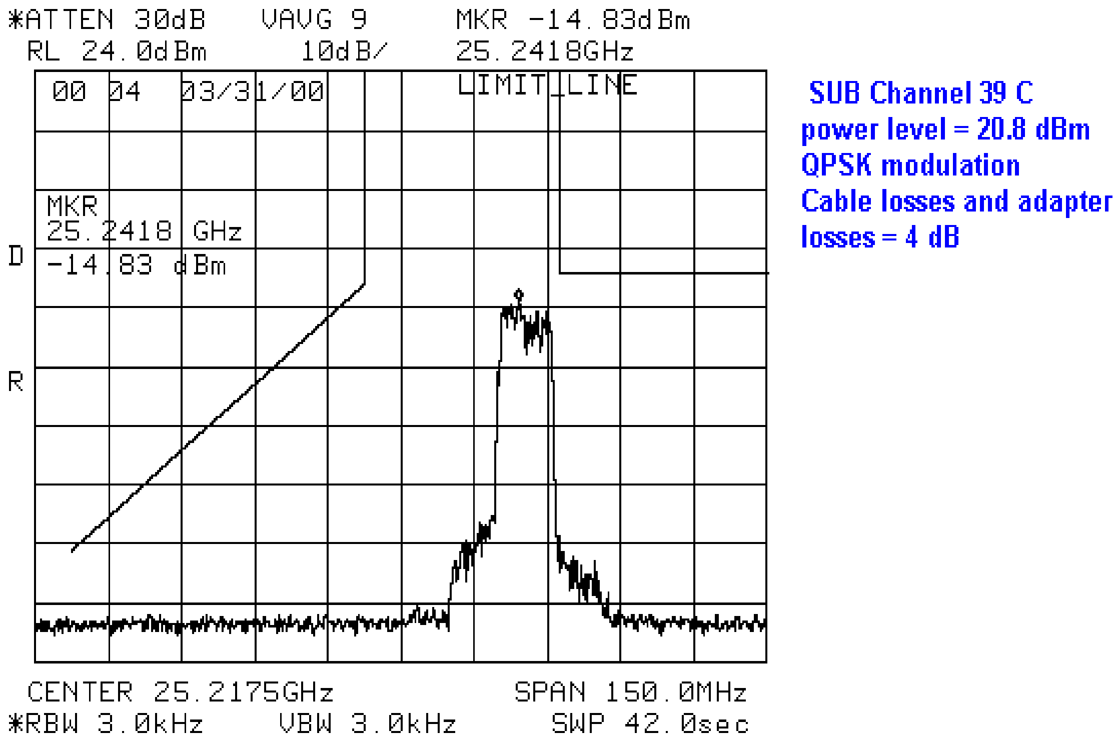


Figure 22 Bandwidth for QPSK modulated signal on channel 39C, Power=20dBm

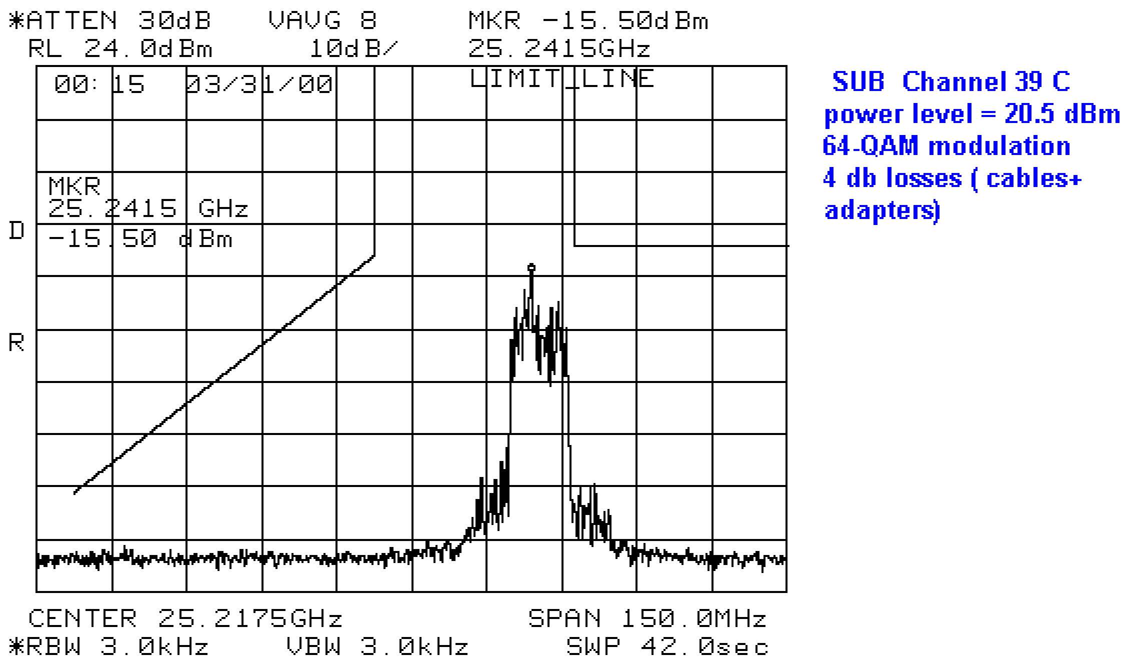


Figure 23 Bandwidth for 64-QAM modulated signal on channel 39C, Power=20dBm

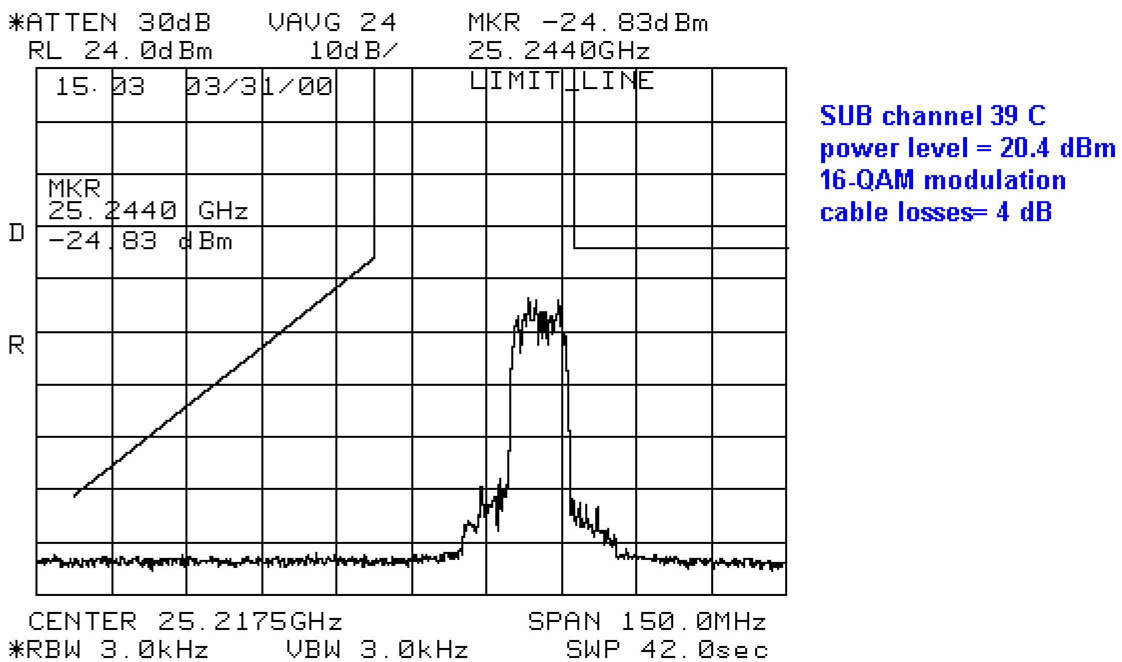


Figure 24 Bandwidth for 16-QAM modulated signal on channel 39C, Power=20dBm

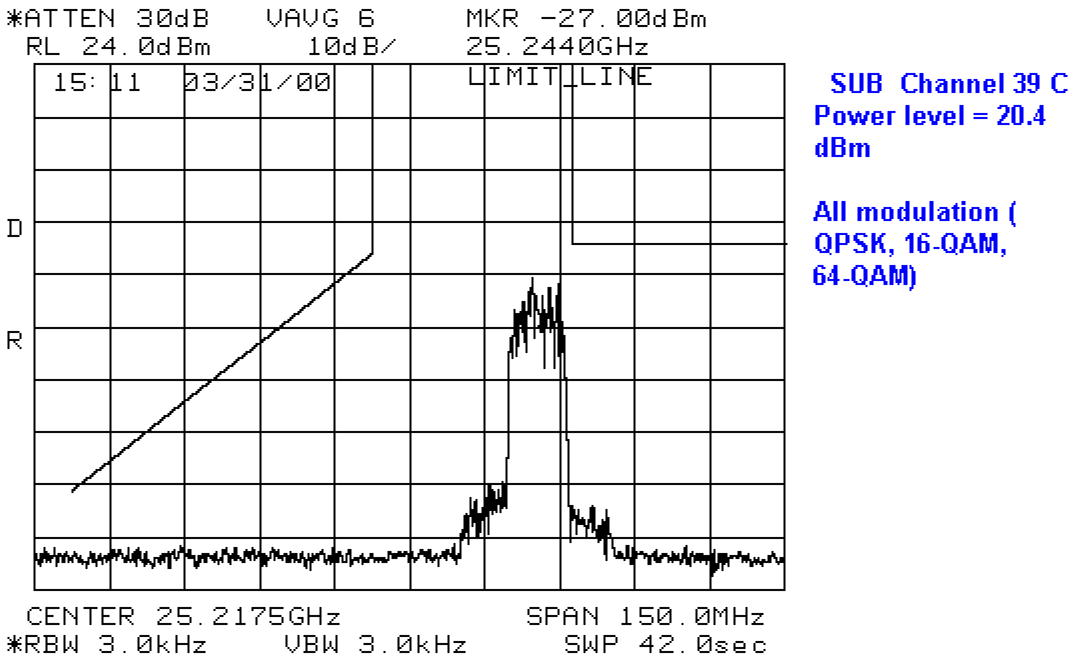


Figure 25 Bandwidth for mixed Modulation modulated signal on channel 39C, Power=20dBm

3.4 CONDUCTED SPURIOUS EMISSIONS FROM THE TRANSMITTER

These tests demonstrate the spurious emission levels, which are produced by EUT at the antenna terminals. The tests for the conducted emissions document the spurious levels conducted from the transmit filter output port (antenna connector), which connects to the transmit antenna.

3.4.1 Performance Specifications

The Conducted, Radiated emissions and Occupied bandwidth tests were performed against the new proposed mask (NPRM doc # 99-333)

Proposed FCC Emission Mask NPRM Document # 99-333

HNS HUB and Subscriber ODU product does not meet the Current FCC Emission Mask, therefore all the occupied Bandwidth and the Conducted Emission test was performed with respect of the new proposed Mask that is still in the process of getting released by the FCC. The mask propose the following:

For 24 GHz Service in the 24,250-25,250 MHz band:

(i) On any frequency removed from the center frequency of the 24 GHz Service channel by more than 50 percent of that channel's bandwidth:

A = 35 + 0.75(F - 0.5B) dB (in any 4 kHz channel), or
A = 11 + 0.75(F - 0.5B) dB (in any 1 MHz channel),
but in no event greater than 80 decibels;

A = attenuation (in decibels) below mean output power level contained within the 24 GHz Service channel for a given polarization
B = bandwidth of 24 GHz Service channel (in MHz)
F = absolute value of the difference between the center frequency of the measured band and the center frequency of the 24 GHz Service channel

(ii) In any 4 kHz band, the center frequency which is outside the 24 GHz Service band: At least 43 + 10 log10(mean output power in watts) decibels.
With the above Mask description, the following tables and figures were produced for Channels 35,36,and 39:

f(KHz)	f(MHz)	f(Ghz)	A in Band	Emission limits (20 dbm)
25047000	25047	25.047	33	**-14.24938737**
25048000	25048	25.048	33	**-14.24938737**
25049000	25049	25.049	33	**-14.24938737**
25050000	25050	25.05	33	**-14.24938737**
25050000	25050	25.05		**20**
25051250	25051.25	25.0513		**20**
25057500	25057.5	25.0575		**20**
25070000	25070	25.07		**20**
25082500	25082.5	25.0825		**20**
25088750	25088.75	25.0888		**20**
25090000	25090	25.09		**20**
25090000	25090	25.09	35	**-16.24938737**
25110000	25110	25.11	50	**-31.24938737**
25150000	25150	25.15	80	**-61.24938737**
25030000	25030	25.03	80	**-61.24938737**
25070000	25070	25.07	50	**-31.24938737**
25090000	25090	25.09	35	**-16.24938737**
25090000	25090	25.09	22.7712	**20**
25091250	25091.25	25.0913	22.7712	**20**
25097500	25097.5	25.0975	22.7712	**20**
25110000	25110	25.11	22.7712	**20**
25122500	25122.5	25.1225	22.7712	**20**
25128750	25128.75	25.1288	22.7712	**20**
25130000	25130	25.13	22.7712	**20**
25130000	25130	25.13	35	**-16.24938737**
25150000	25150	25.15	50	**-31.24938737**
25190000	25190	25.19	80	**-61.24938737**
25150000	25150	25.15	80	**-61.24938737**
25190000	25190	25.19	50	**-31.24938737**
25210000	25210	25.21	35	**-16.24938737**
25210000	25210	25.21		**20**
25211250	25211.25	25.2113		**20**
25217500	25217.5	25.2175		**20**
25230000	25230	25.23		**20**
25242500	25242.5	25.2425		**20**
25248750	25248.75	25.2488		**20**
25250000	25250	25.25		**20**
25250000	25250	25.25	31.7506	**-14.24938737**
25250100	25250.1	25.2501	31.7506	**-14.24938737**
25250200	25250.2	25.2502	31.7506	**-14.24938737**
25250300	25250.3	25.2503	31.7506	**-14.24938737**
25250400	25250.4	25.2504	31.7506	**-14.24938737**
25250500	25250.5	25.2505	31.7506	**-14.24938737**
25251500	25251.5	25.2515	31.7506	**-14.24938737**

Table 11 Emission Mask for channel 36

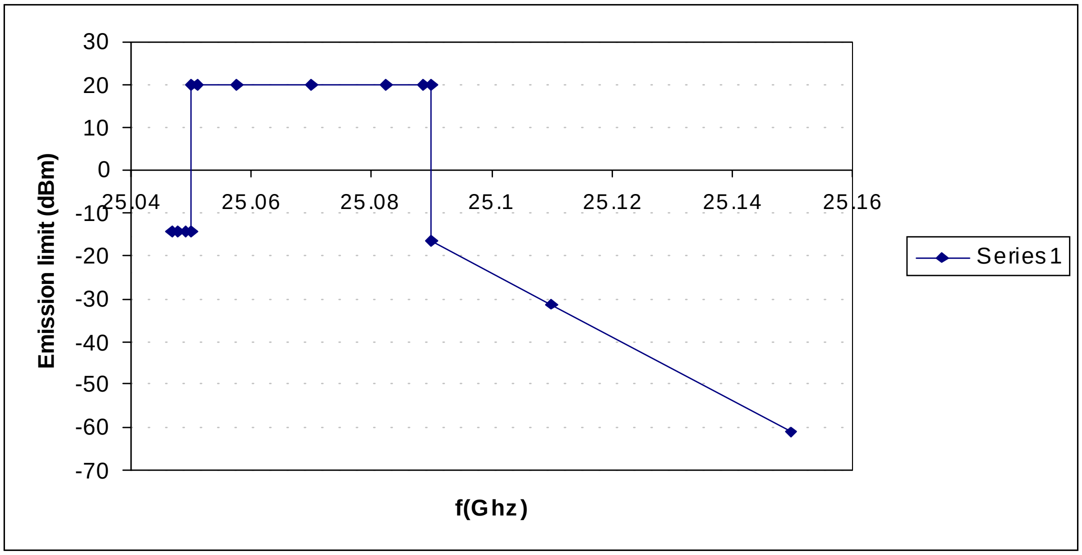


Figure 26: FCC 101 Emission Mask Proposed for 24Ghz SUBSCRIBER (SUB) Channel 35 for Transmitter power = 20 dBm

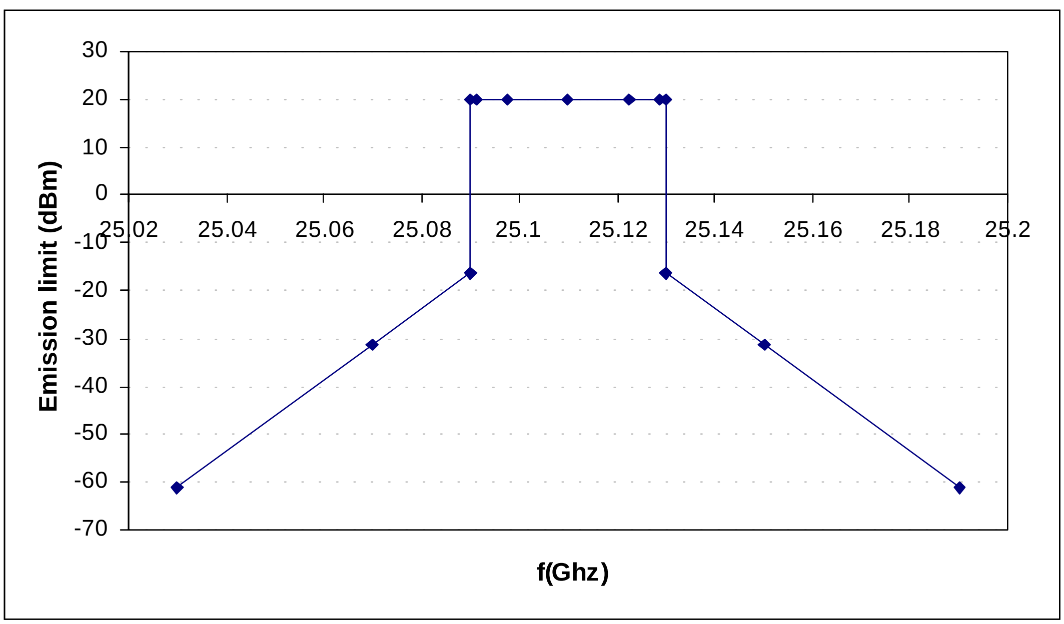


Figure 27 FCC 101 Emission Mask Proposed for 24Ghz Subchannel 36 for Transmitter power = 20 dBm

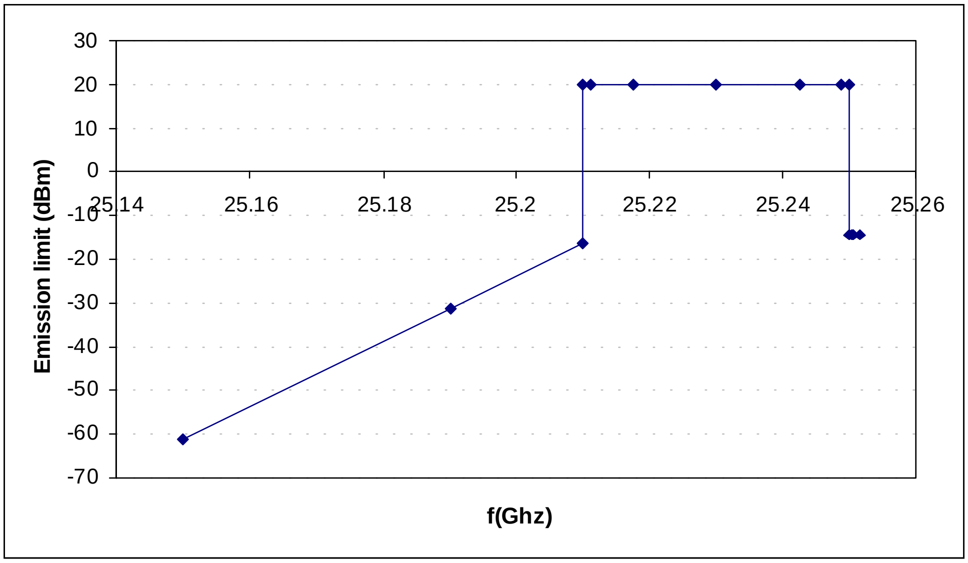


Figure 28 FCC 101 Emission Mask Proposed for 24Ghz Subchannel 39 for Transmitter power = 20 dBm

3.4.2 Test Configuration

Refer to Fig. 4 for the Basic Test configuration.

Transitions and Waveguide adapters will need to be used to connect the EUT transmit port to the various harmonic mixers. The mixers along with a Duplexes will be used to connect the signal to the spectrum analyzer and mix it down to a frequency range that can be measured. This must be done since the analyzer used only goes to 40 GHz and signals must be measured up to 220 GHz. Please refer to the documentation supplied with the mixers for instructions on how to make measurements. Also note that any measurements made over 40 GHz will not be calibrated, they will only be referenced upon the factors supplied by the mixer manufacturer. There are no NIST traceable measurements above 75GHz (they may be up to 97GHz now). Therefore, we must use engineering judgment when taking these measurements. Care must be taken to not overload the mixers. Also care must be taken when connecting and disconnecting the Waveguide pieces. Refer to Figure 29 for EUT under testing.

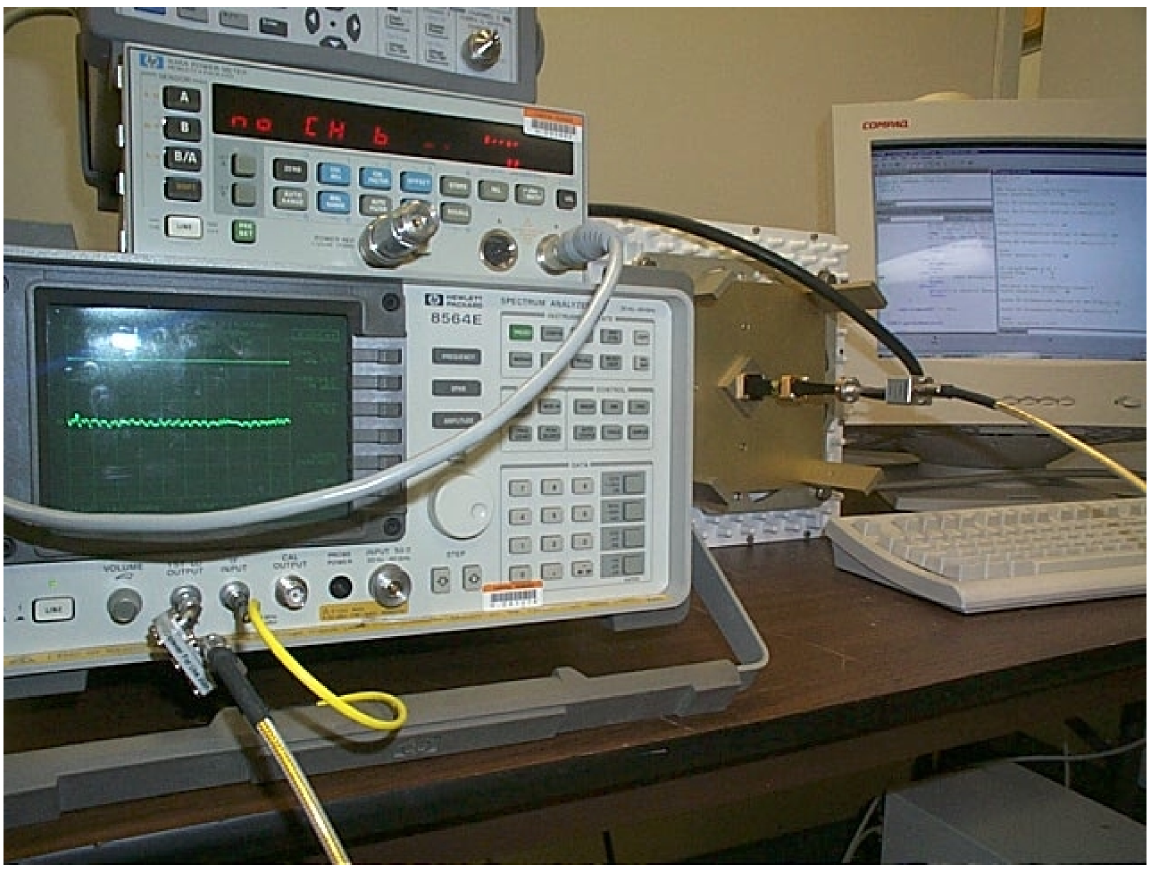


Figure 29: EUT during conducted emission testing (40Ghz-220Ghz)

The following connections will need to be made:
EUT has WR-28

Adapter	Cable	Frequency Range
WR-28 to 2.4mm connector	Low loss to 40 GHz	0 to 40 GHz
Transition	**Mixer**	**Frequency Range**
WR-28 to WR-19	WR-19	40 to 60 GHz
WR-28 to WR-12	WR-12	60 to 90 GHz
WR-28 to WR-08	WR-08	90 to 140 GHz
WR-28 to WR-05	WR-05	140 to 220 GHz

Table 12 List of the adapters used and their frequency range

3.4.3 Test Results

The following Figures show the conducted spurious emissions, when the ODU is transmitting power 20dBm. Measurements are performed while transmitting on two channels (low end 35A, Middle channel 36, and High channel 39C). The frequency of consideration is from 30MHz to 220GHz.
PASS: _X_ Fail:___

3.4.3.1 Test results (30Mhz-24GHz) Channel 35A

The graphs below show the actual Transmitting signal while measuring the Conducted Emission in the band of interest.

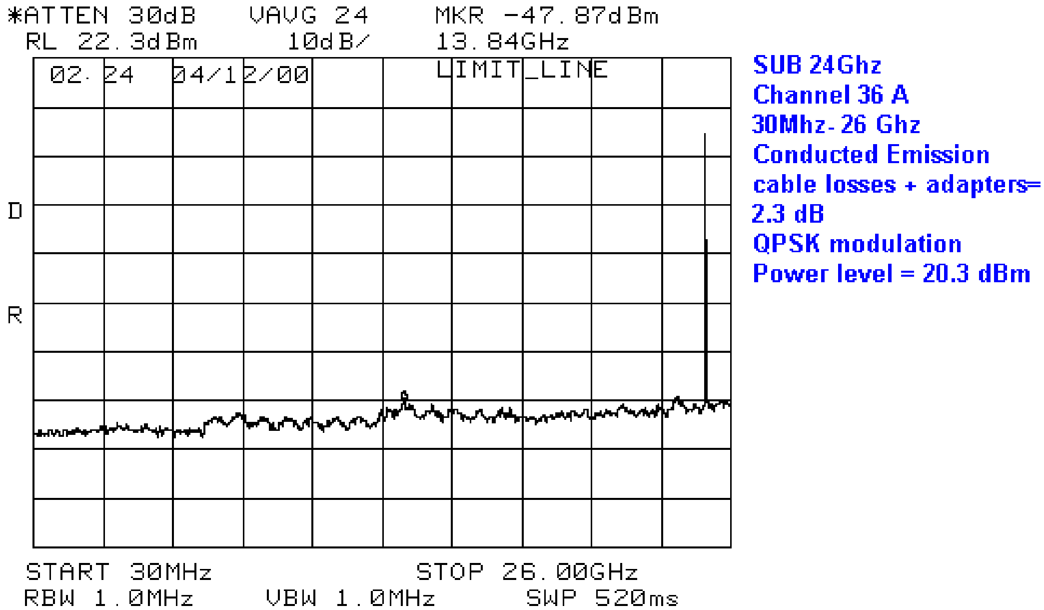


Figure 30 Conducted Emission for 30Mhz-26Ghz band Tx Power=20dBm

3.4.3.2 Test results 25Ghz- 40Ghz channel 39 C

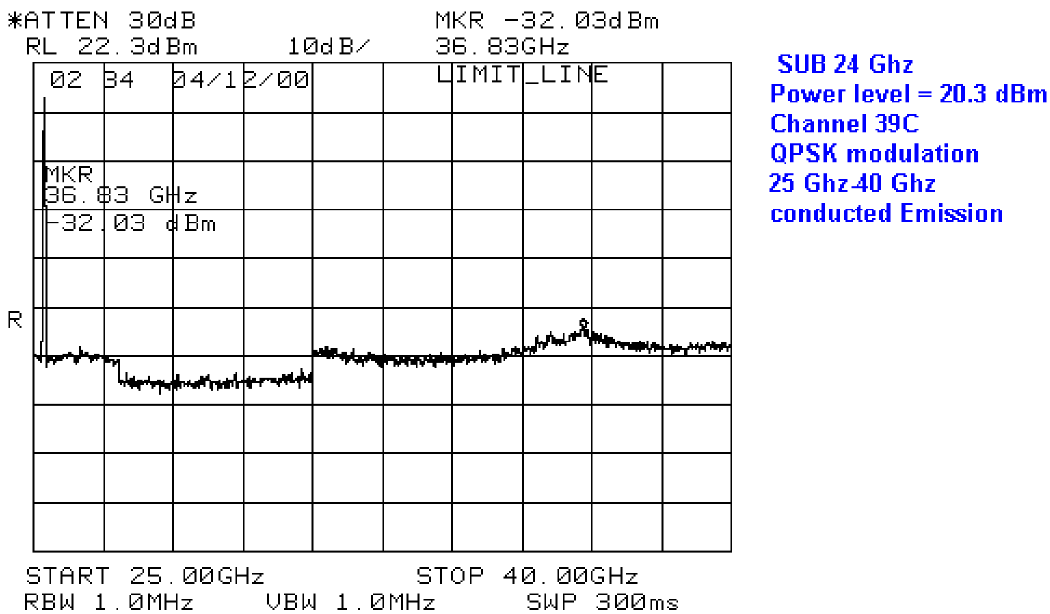


Figure 30 Conducted Emission for 25Mhz-40Ghz band Tx Power=20dBm

3.4.3.3 DEMS band Conducted Emission

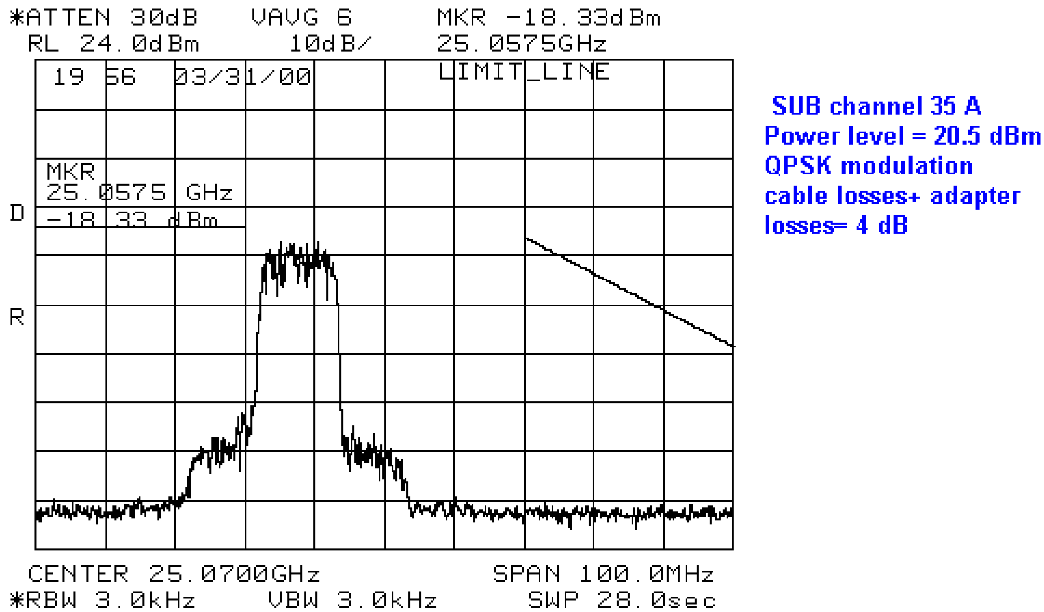


Figure 31 Conducted Emission DEMS band QPSK modulation channel 35A Tx Power=20dBm

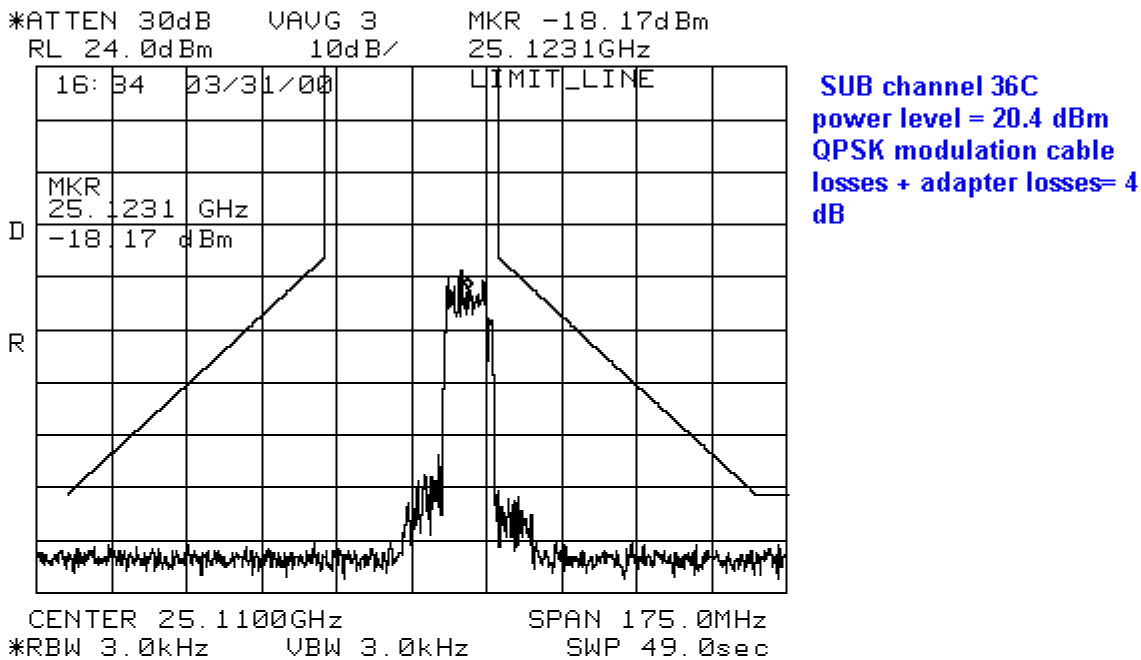


Figure 32 Conducted Emission DEMS band channel 36C Tx Power=20dBm

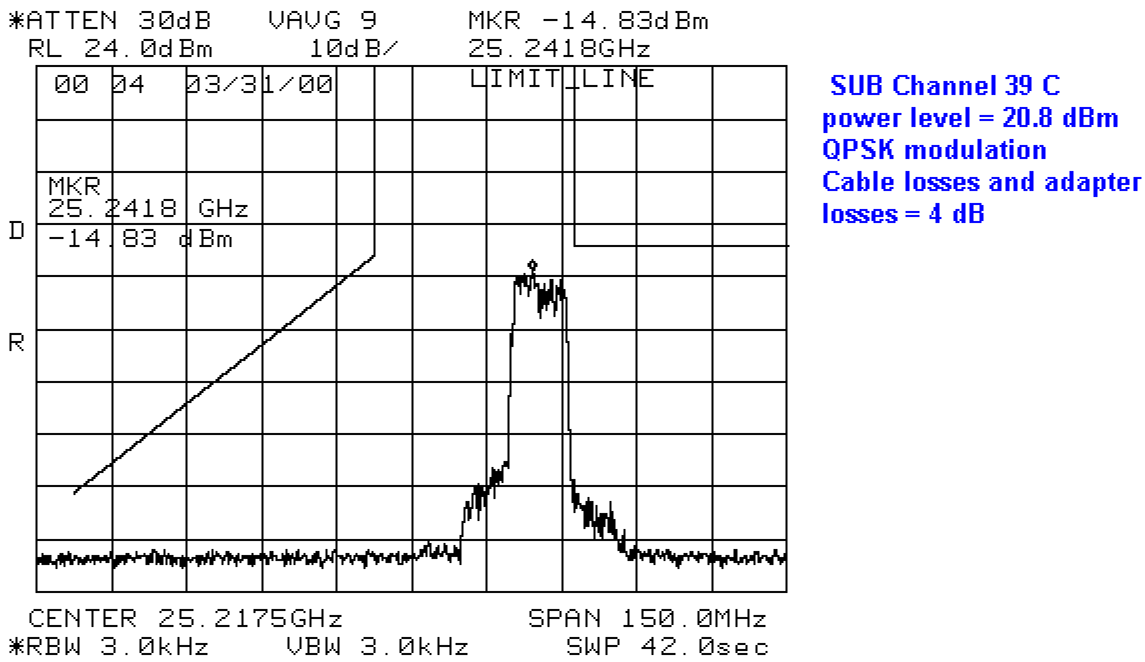


Figure 33 Conducted Emission DEMS band channel 39C Tx Power=20dBm

3.4.3.4 Conducted Emission for 40-60 GHz

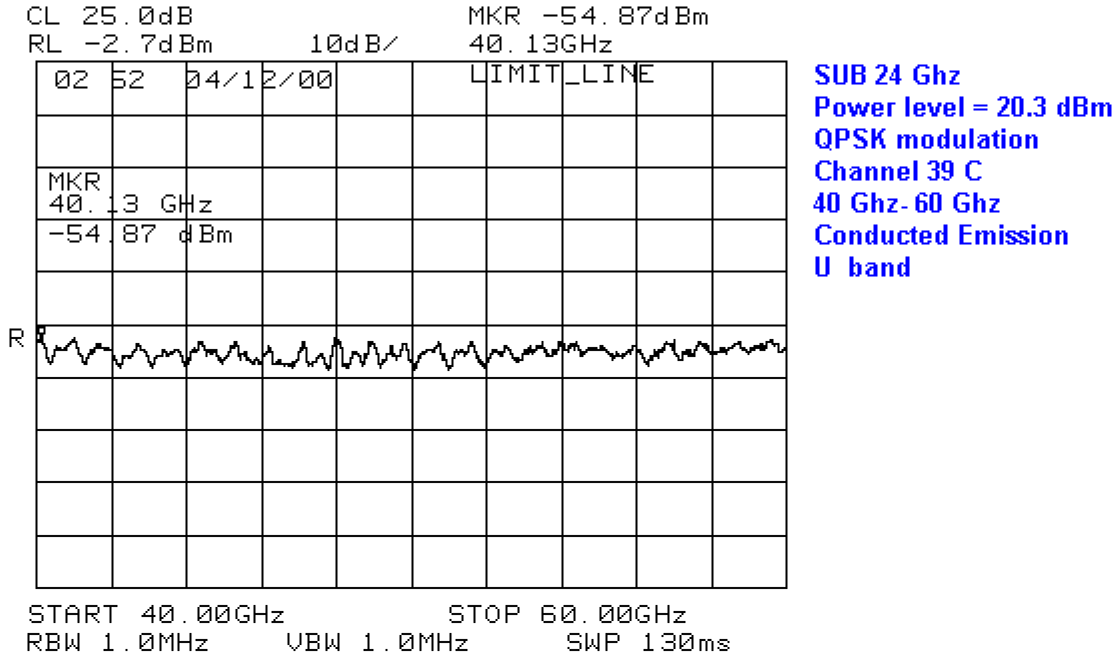


Figure 34 Conducted Emission 40-60Ghz band channel 39C Tx Power=20dBm

3.4.3.5 Conducted Emission 60-90 GHz

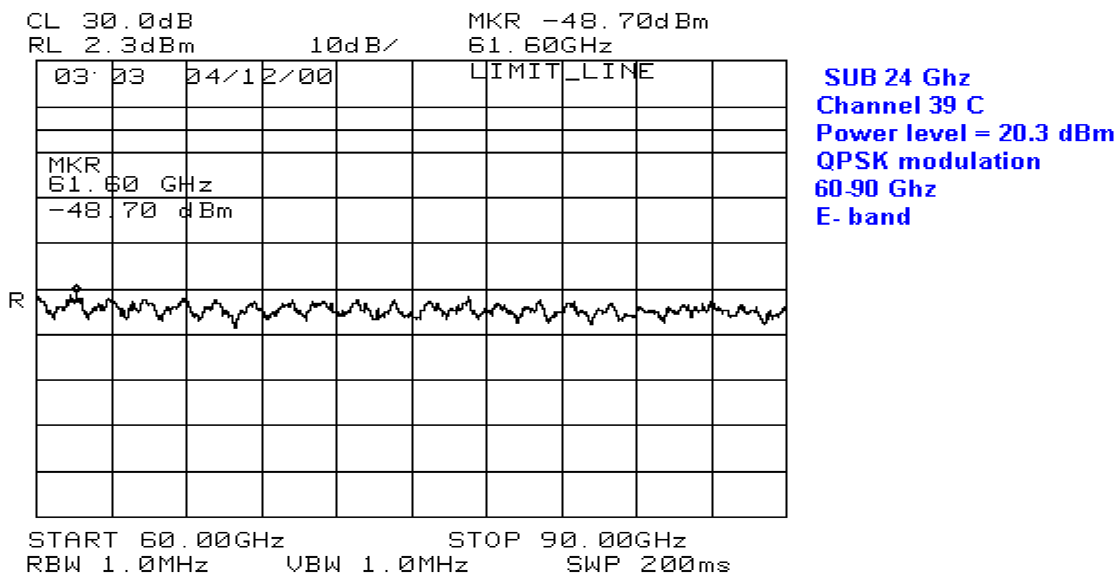


Figure 35 Conducted Emission 60-90Ghz band channel 39C Tx Power=20dBm

3.4.3.6 Conducted Emission 90-140Ghz

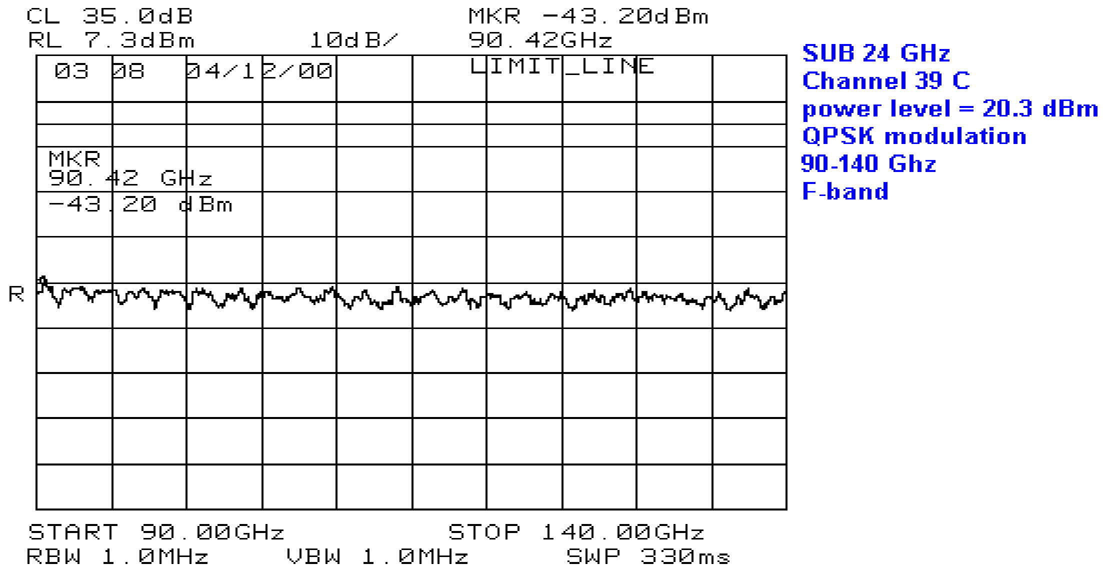


Figure 36 Conducted Emission 90-140Ghz band channel 39C Tx Power=20dBm

3.4.3.7 Conducted Emission 140-220 Ghz

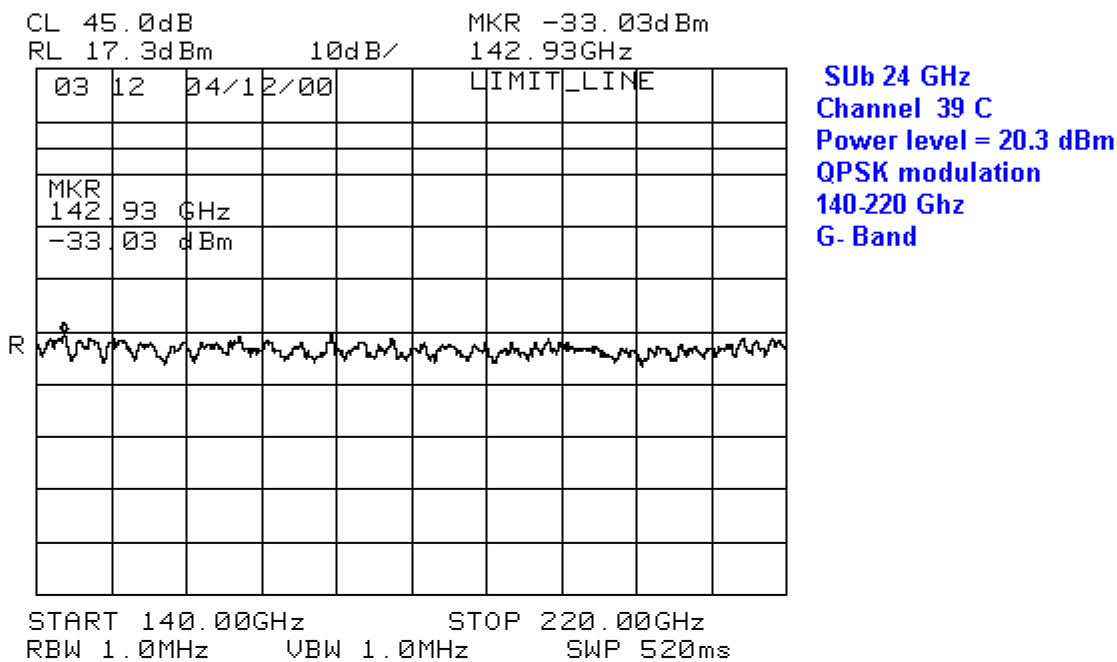


Figure 37 Conducted Emission 140-220 Ghz band channel 39C Tx Power=20dBm

3.5 RADIATED SPURIOUS EMISSIONS FROM THE TRANSMITTER

These tests demonstrate the spurious emission levels, which are produced by EUT. The tests for the radiated emissions document the spurious levels radiated from the EUT enclosure and cables, while the transmit output port (antenna connector) will be terminated by a "dummy load".

3.5.1 Performance Specifications

The Conducted, Radiated emissions and Occupied bandwidth tests were performed against the new proposed mask (NPRM doc # 99-333) as described in section 3.3.3.1

3.5.2 Test Procedures

The Both EUTs (HUB and SUB) were initialized in the transmit mode with QPSK modulation. The ODUs transmitter output will be terminated by "dummy waveguided loads" Spurious emissions measurements will be done in the frequency bands detailed below. One channel was selected that is channel 39C. The frequency spectrum from 30Mhz to 220 GHz shall be investigated and any spur or emission shall be documented.

Test Frequencies	
Channel	**Center-Frequency MHz**
39C	24447.5

Table 13 Radiated Spurious Emissions Test Frequencies

3.5.3 Test Configuration

Refer to Fig. 4 for the Basic Test configuration for frequency band (18Ghz-220Ghz) And to Figures 41,42 for 30Mhz-18Ghz the actual units under test

Standard gain horn antennas and harmonic mixers will be used to take the measurements. The mixers along with a Duplexes will be used to connect the signal to the spectrum analyzer and mix it down to a frequency range that can be measured. This must be done since the analyzer used only goes to 40 GHz and signals must be measured up to 220 GHz. Please refer to the documentation supplied with the mixers for instructions on how to make measurements. Also note that any measurements made over 40 GHz will not be calibrated, they will only be referenced upon the factors supplied by the mixer manufacturer. There are no NIST traceable measurements above 75GHz(they may be up to 97GHz now). Therefore, we must use engineering judgment when taking these measurements. Care must be taken to not overload the mixers. Also care must be taken when connecting and disconnecting the Waveguide pieces and horn antennas. The following connections will need to be made:

Antenna	Connector	Adapter	Frequency Range
Bi-Log	Type N	N/A	30 to 1000 MHz
Horn	Type N	N/A	1 to 18 GHz
Standard Gain Horn	WR-42	WR-42 to 3.5mm connector	18 to 26.5GHz
Standard Gain Horn	WR-28	WR-28 to 2.4mm connector	26.5 to 40 GHz
Antenna	**Connector**	**Mixer**	**Frequency Range**
Standard Gain Horn	WR-19	WR-19	40 to 60 GHz
Standard Gain Horn	WR-12	WR-12	60 to 90 GHz
Standard Gain Horn	WR-08	WR-08	90 to 140 GHz
Standard Gain Horn	WR-05	WR-05	140 to 220 GHz

Table 14 Equipment for Radiated Emissions Test

Recommend that test distance be 3m below 18Ghz and 1m above. In the case of the 30Mhz-18 Ghz, the unit was tested in an open test site at Washington labs. In case the frequency band 18Ghz-220Ghz, the unit was tested in our fully enechoc chamber with a turning table rotating the unit by 360 in both directions clock wise and anti-clock wise.

3.5.4 Test Results

The following Figures show the plots for the horizontal polarization (HP) for the frequency range of 1GHz-220GHz. and for the vertical polarization (VP) for the same frequency range.
PASS: _X_ Fail:___

3.5.4.1 30Mhz -18GHz Open field test site

(301) 417-0220 FAX: (301) 417-9069										
TABLE 2										
FCC CLASS B 3M RADIATED EMISSIONS DATA - SITE 2										
CLIENT:		HNS								
MODEL NO:		24 GHz ODU Sub and Hub								
DATE:		5 Apr 00								
CLK SPEED(S):		clock								
BY:		Chad M. Beattie								
JOB #:		5793B								
CONFIGURATION:										
24.4225 GHz TX										
25.05756 GHz TX										
FREQ	POL	Azimuth	Ant	SA LEVEL	AFc	E-FIELD	E-FIELD	LIMIT	MRGN	
			Height	(QP)						
MHz	H/V	Degree	M	dBuV	dB/m	dBuV/m	uV/m	uV/m	dB	
30.00	V	0.00	1.0	20.9	18.4	39.3	92.3	100.0	-0.7	ambient
50.00	V	180.00	1.0	17.0	14.5	31.5	37.8	100.0	-8.5	AE
55.57	V	180.00	1.0	29.5	12.8	42.3	130.6	100.0	2.3	ambient
85.81	V	90.00	1.0	11.5	10.2	21.7	12.1	100.0	-18.3	ambient
94.95	V	0.00	1.0	2.5	11.8	14.3	5.2	150.0	-29.2	ambient
100.00	V	270.00	1.0	9.6	12.6	22.2	12.9	150.0	-21.3	AE
140.00	V	180.00	1.0	16.4	10.7	27.1	22.6	150.0	-16.4	AE
143.00	V	180.00	1.0	14.2	10.4	24.6	16.9	150.0	-19.0	AE
160.00	V	180.00	1.0	16.0	10.2	26.2	20.4	150.0	-17.3	AE
170.00	V	180.00	1.0	13.0	11.4	24.4	16.6	150.0	-19.1	AE
180.00	V	180.00	1.0	30.8	10.8	41.6	120.2	150.0	-1.9	AE
190.00	V	270.00	1.0	14.1	11.5	25.6	19.1	150.0	-17.9	AE
190.69	V	270.00	1.0	23.2	11.6	34.8	54.6	150.0	-8.8	ambient
192.00	V	0.00	1.0	3.0	11.6	14.6	5.4	150.0	-28.9	AE
200.23	V	180.00	1.0	25.6	12.2	37.8	77.5	150.0	-5.7	ambient
209.76	V	0.00	1.0	20.7	12.8	33.5	47.3	150.0	-10.0	ambient
219.30	V	0.00	1.0	20.0	13.7	33.7	48.4	200.0	-12.3	ambient
228.84	V	0.00	1.0	22.5	14.2	36.7	68.6	200.0	-9.3	ambient
238.38	V	0.00	1.0	15.7	14.3	30.0	31.6	200.0	-16.0	ambient
266.98	V	180.00	1.0	13.5	15.0	28.5	26.6	200.0	-17.5	AE

160.00	H	180.00	4.0	18.3	10.2	28.5	26.6	150.0	-15.0	AE
1100.00	V	0.00	1.0	33.0	-11.9	21.1	11.4	500.0	-32.9	ambient
10000.00	V	0.00	1.0	33.7	3.4	37.1	71.7	500.0	-16.9	ambient
17500.00	V	0.00	1.0	36.0	11.0	47.0	223.1	500.0	-7.0	ambient
1400.00	H	0.00	1.0	28.0	-9.6	18.4	8.3	500.0	-35.6	ambient
11000.00	H	0.00	1.0	30.1	4.5	34.6	53.8	500.0	-19.4	ambient
16000.00	H	0.00	1.0	34.0	7.1	41.1	113.6	500.0	-12.9	ambient

Table 15 Radiated Spurious Emissions from 1-18GHz

Radiated spurious emissions from 1GHz to 18GHz were evaluated at Washington Laboratories, Ltd. The results were enclosed above. Both the horizontal and vertical polarization were tested. There were no spurs found

Figure 38 Both Hub an SUB units while doing FCC 15 radiated Emission testing for class B (Front)

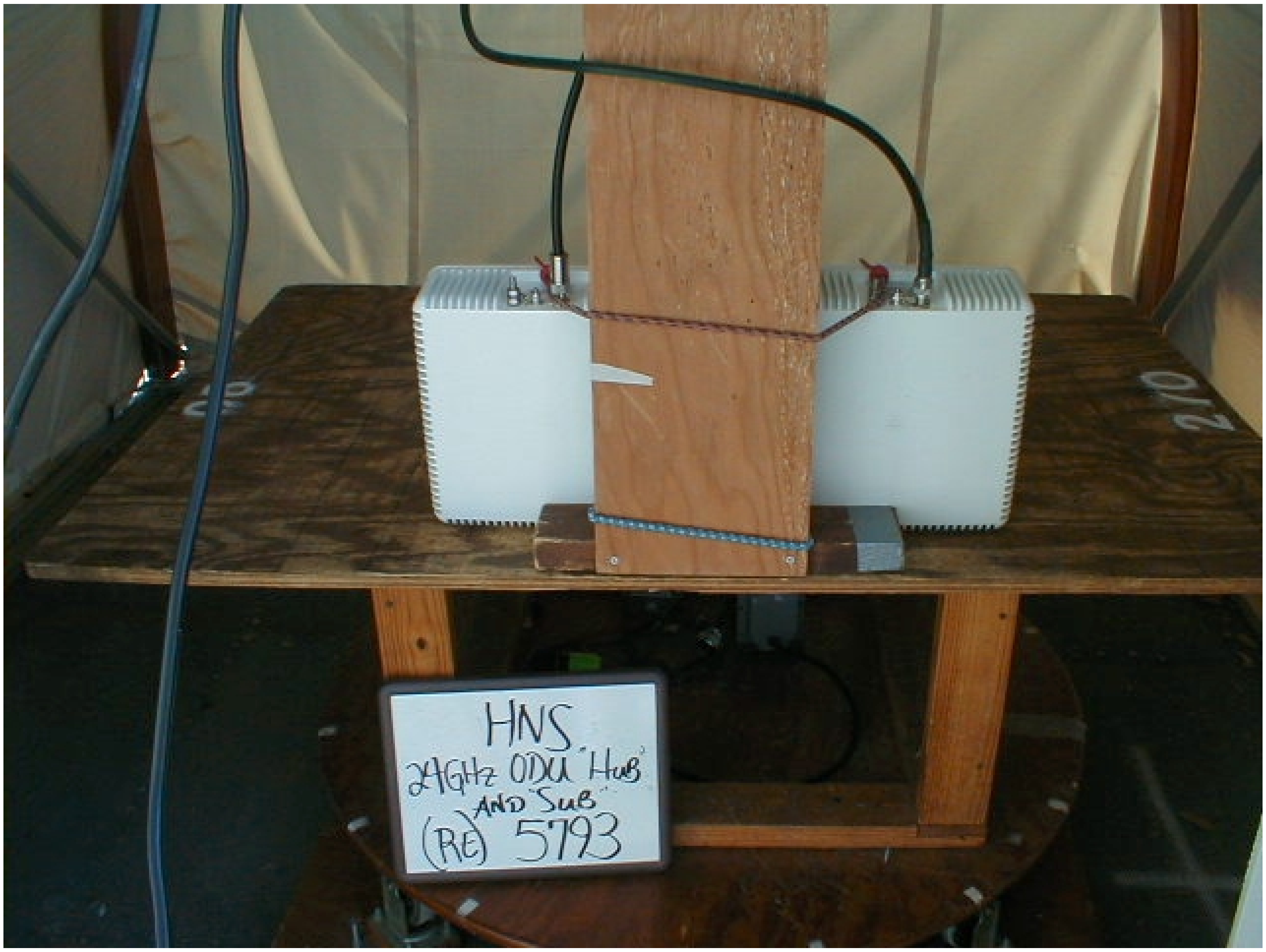


Figure 39 Both Hub an SUB units while doing FCC 15 radiated Emission testing (3m) for class B (Back)

Figure 40 Spurious radiated Emission for 18Ghz-220 Ghz (1m)

3.4.4.2 Horizontal Polarization: 18GHz-220Ghz

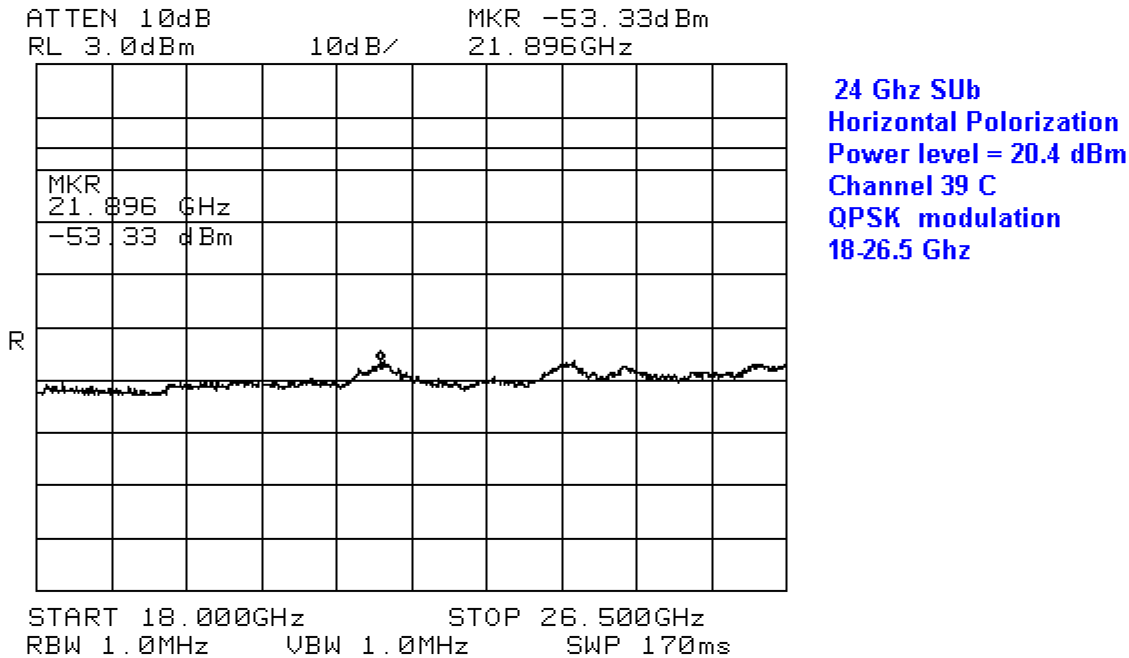


Figure 41 Radiated Emissions in 18-26.5GHz, HP, for transmitting 20dBm QPSK on Channel 39C

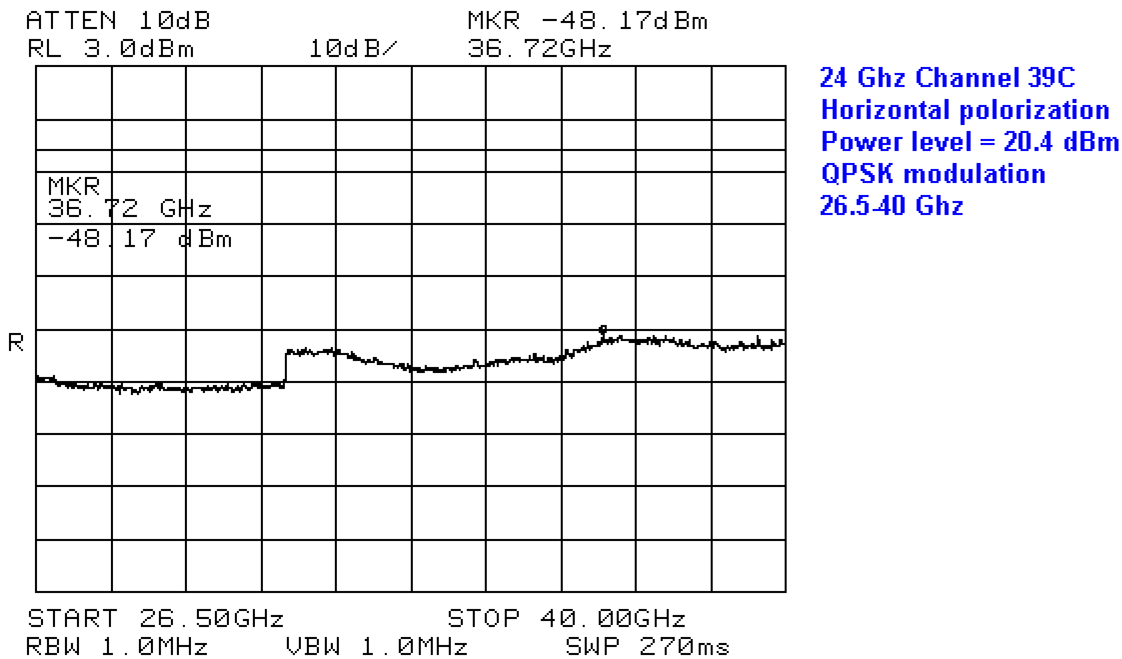


Figure 42 Radiated Emissions in 26.5-40GHz, HP, for transmitting 20dBm QPSK on Channel 39C

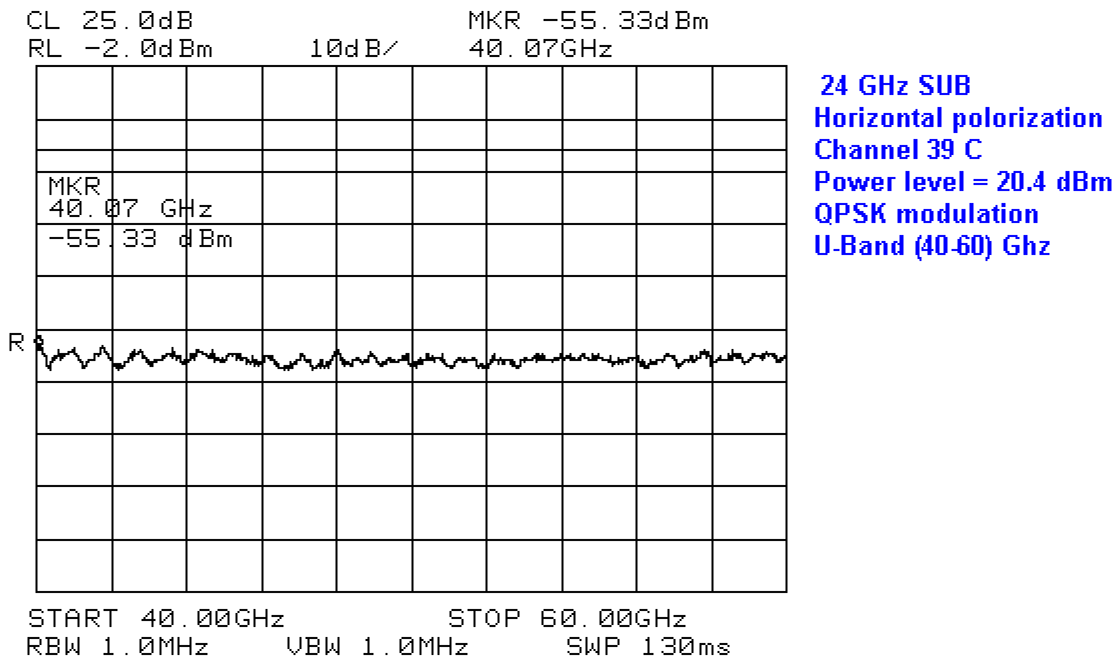


Figure 43 Radiated Emissions in 40-60GHz, HP, for transmitting 20dBm QPSK on Channel 39C

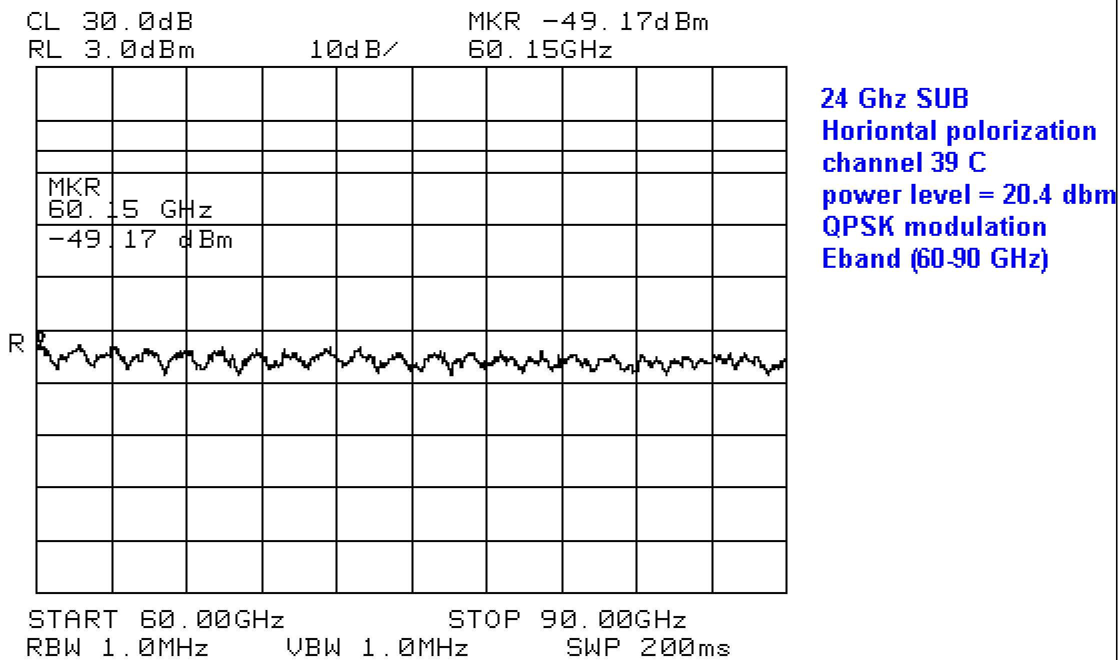


Figure 44 Radiated Emissions in 60-90GHz, HP, for transmitting 20dBm QPSK on Channel 39C

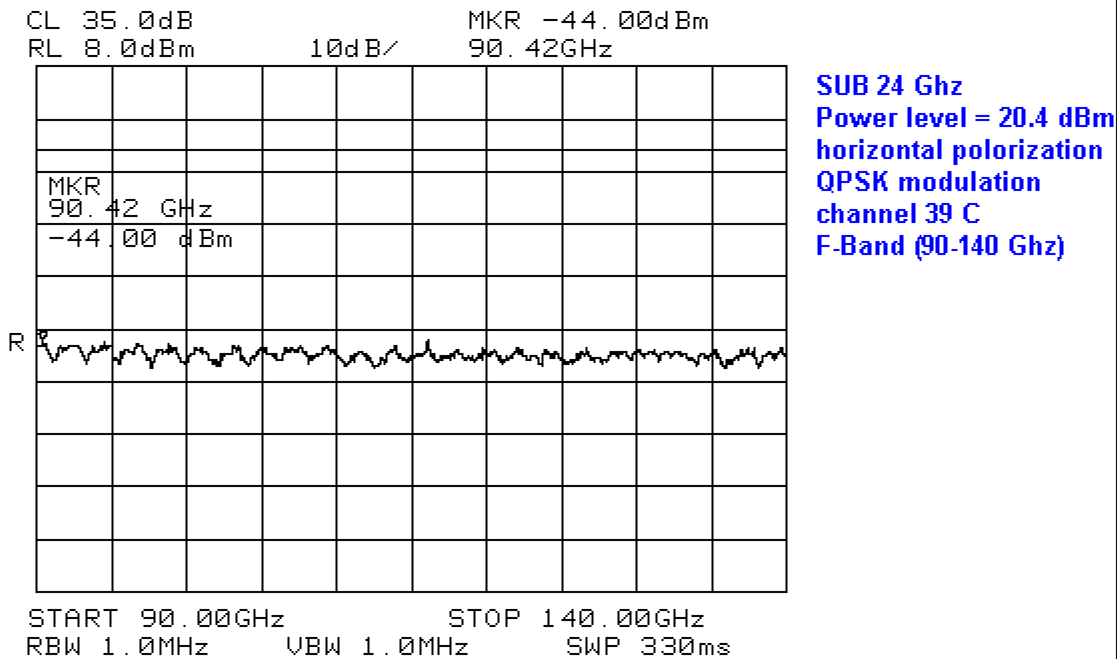


Figure 45 Radiated Emissions in 90-140GHz, HP, for transmitting 20dBm QPSK on Channel 39C

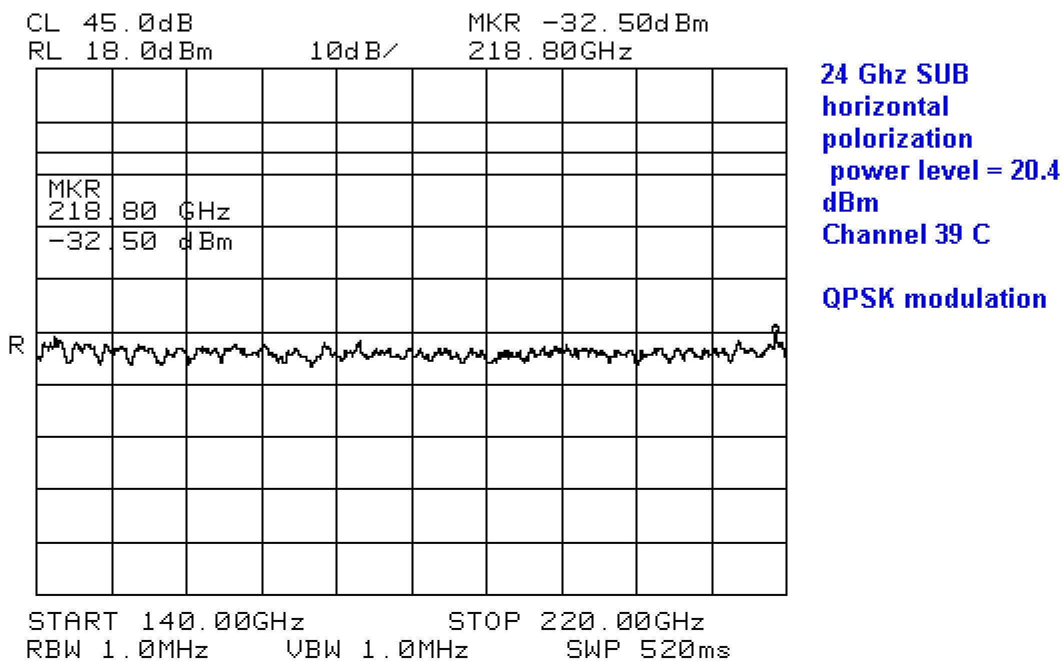


Figure 46 Radiated Emissions in 140-220 GHz, HP, for transmitting 20dBm QPSK on Channel 39C

3.5.4.2 Vertical Polarization, 18-220GHz

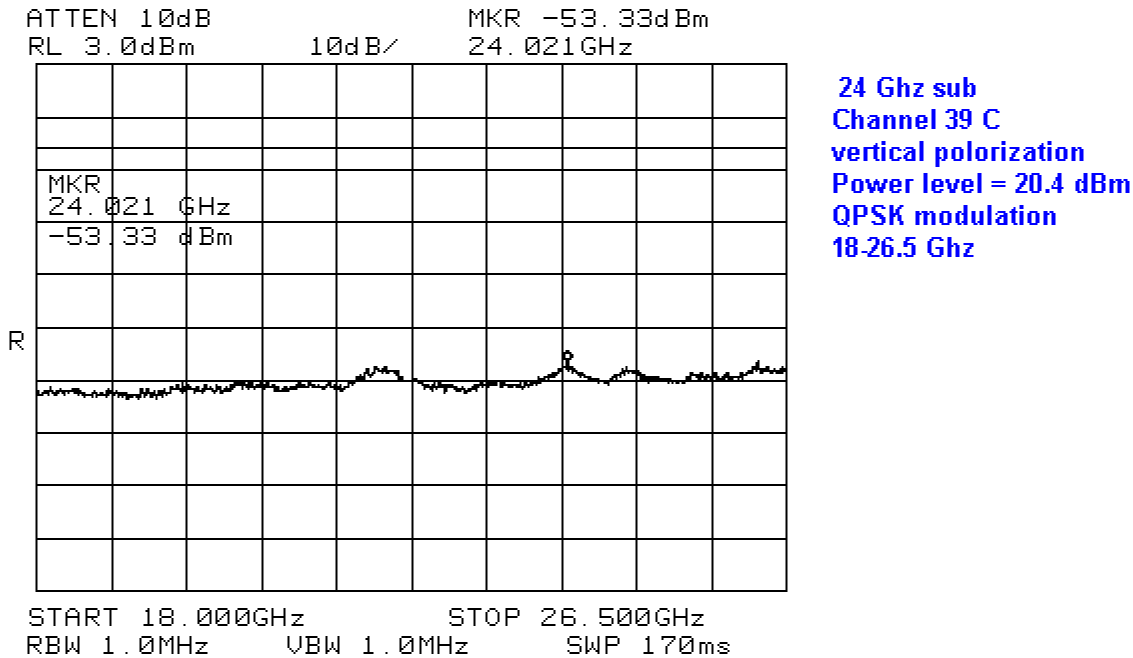


Figure 47 Radiated Emissions in 18-26.5GHz, VP, for transmitting 20dBm QPSK on Channel 39C

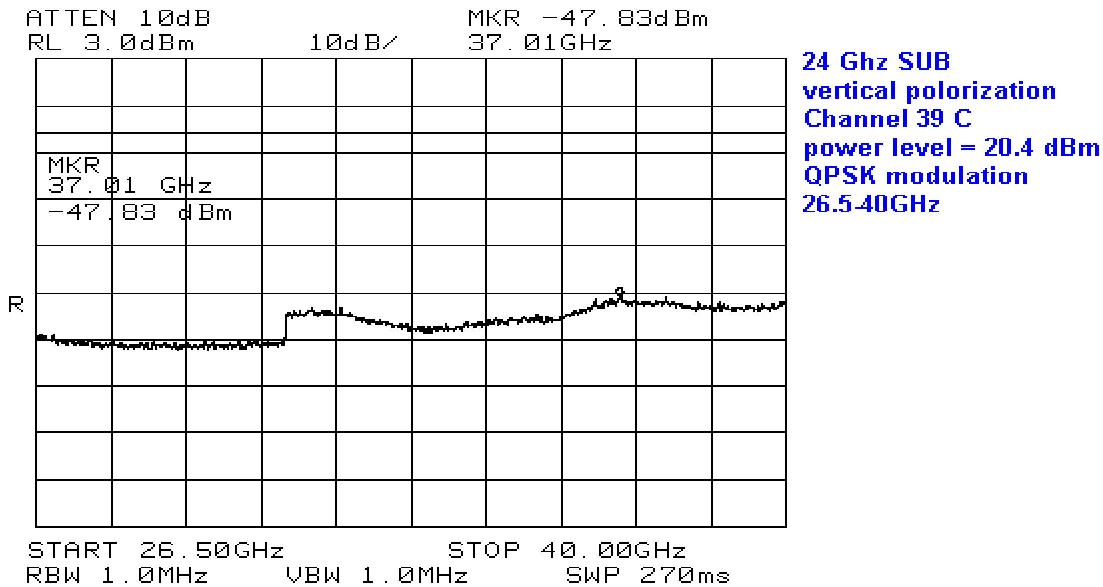


Figure 48 Radiated Emissions in 26.5-40GHz, VP, for transmitting 20dBm QPSK on Channel 39C

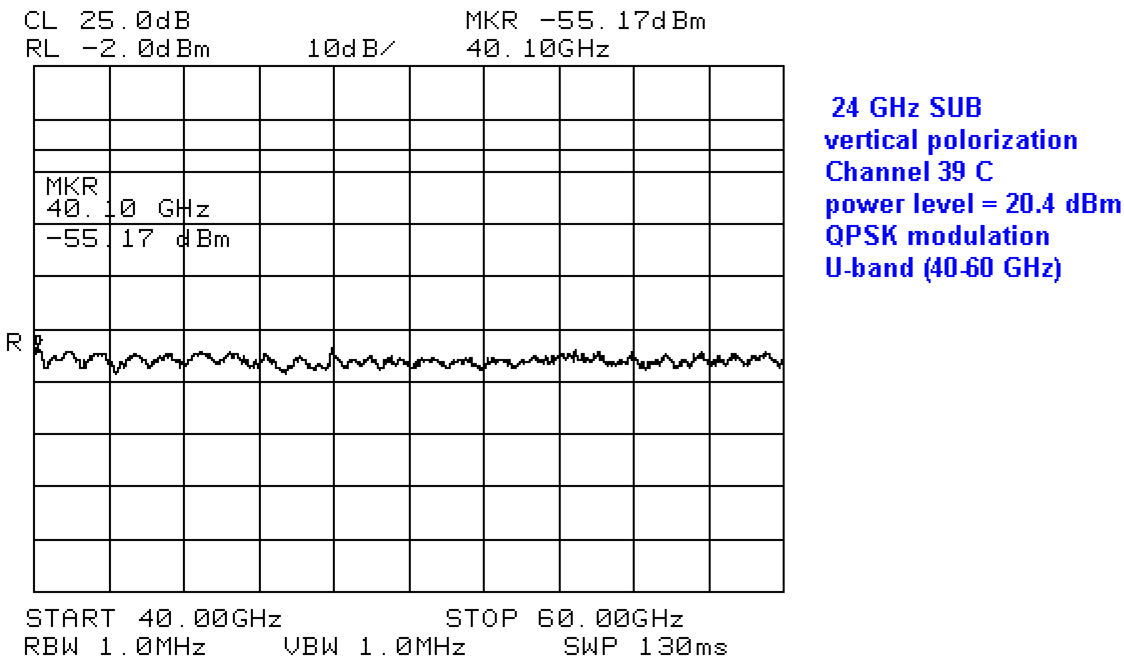


Figure 49 Radiated Emissions in 40-60GHz, VP, for transmitting 20dBm QPSK on Channel 39C

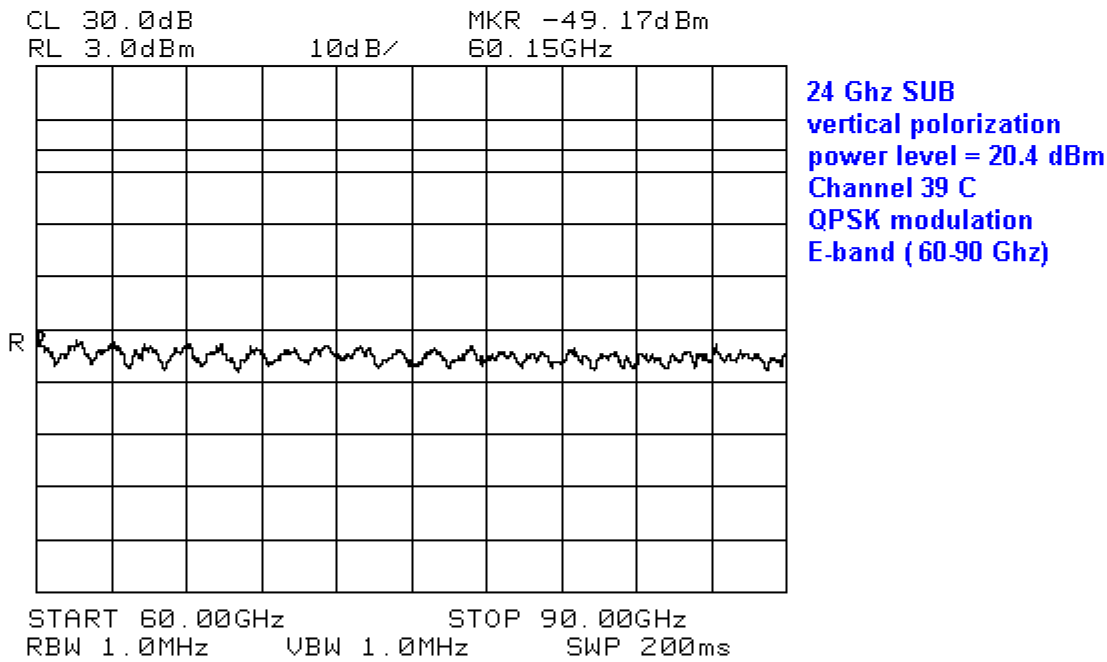


Figure 50 Radiated Emissions in 60-90GHz, VP, for transmitting 20dBm QPSK on Channel 39C

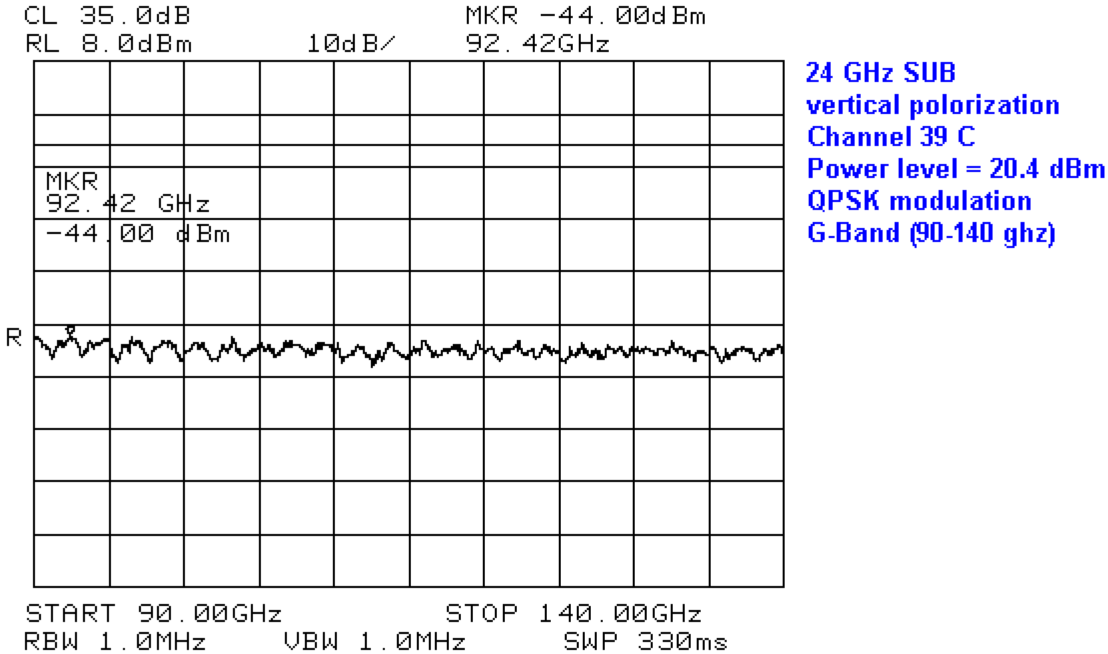


Figure 51 Radiated Emissions in 90-140GHz, VP, for transmitting 20dBm QPSK on Channel 39C

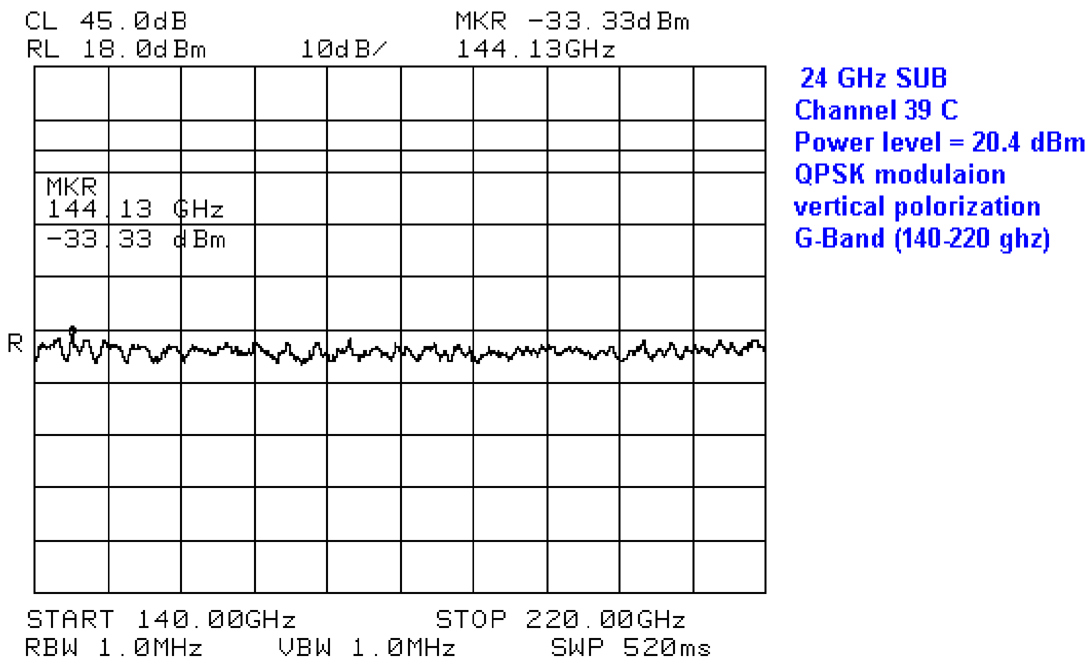


Figure 52 Radiated Emissions in 140-220GHz, VP, for transmitting 20dBm QPSK on Channel 39C

3.6 FREQUENCY STABILITY

This test demonstrates the frequency stability or tolerance of both EUTs (SUB and HUB) over the temperature ranges and different input voltage levels.

3.6.1 Performance Specifications

The test was performed against the FCC 101 requirement section 101.107. For Systems operating in the 19.700Ghz to 28.5Ghz the frequency tolerance should be within 0.03 %= 0.0003= 3E-04.

3.6.2 Test Procedures

The test was performed when considering a worst case system operation; that is when the system losses it's satellite GPS signal (10Mhz), the System become dependent on it's internal clocking (80Mhz) timing. The test for the frequency tolerance was performed when the systems are NOT referenced to the GPS 10MHz signal.

The transmitter equipment (ODU) both HUB and SUB were placed in an environmental chamber (Thermotron Sigminmax S/N 13988, calibration due date is 18 Jan 2001 as listed in table 4 page 24. While the test equipment will be outside of the chamber. The chamber temperature will be set at 4 temperatures: -30°C, 0 °C, 25 °C and 50°C. The equipment under test will be allowed to soak in those temperature condition for 5hrs before measurements will be performed. In each temperature case the frequency reading of each transmitter ODU will be taken for 3 different input voltage levels: -42Volts, -48 volts, and –54 volts. The test was performed when the units were operating in two modes: 1) Unmodulated carrier (CW), 2) Modulated QPSK Carrier. Since the deviation in frequency was only noticeable while operating in CW mode, we have shown only the CW mode data. The QPSK modulated carrier data is available if it is requested. The spectrum analyzer is used to view the CW signal for both HUB and SUB EUTs and to capture the plots, while the frequency counter is used to take the actual reading of the frequency. Measurements are taken for only one operating channel 36A for both units

3.6.3 Test Configuration

Please reference to Figure 4 for the test configuration used during this test. Figure 56, 57and 58 show the actual EUT units while performing Frequency stability.
The Spectrum analyzer and the Power meter readings were offsetted by 6 dB for the HUB, and 5.5 dB for the SUB, since we used two cables with 4 necessary adapters to convert from Female 2.4 mm/2.9mm – Male2.4mm/2.9mm or Vise-Versa. Total losses for the two-cable assembly were 6 dB for the HUB unit and 5.5 dB for the SUB unit.

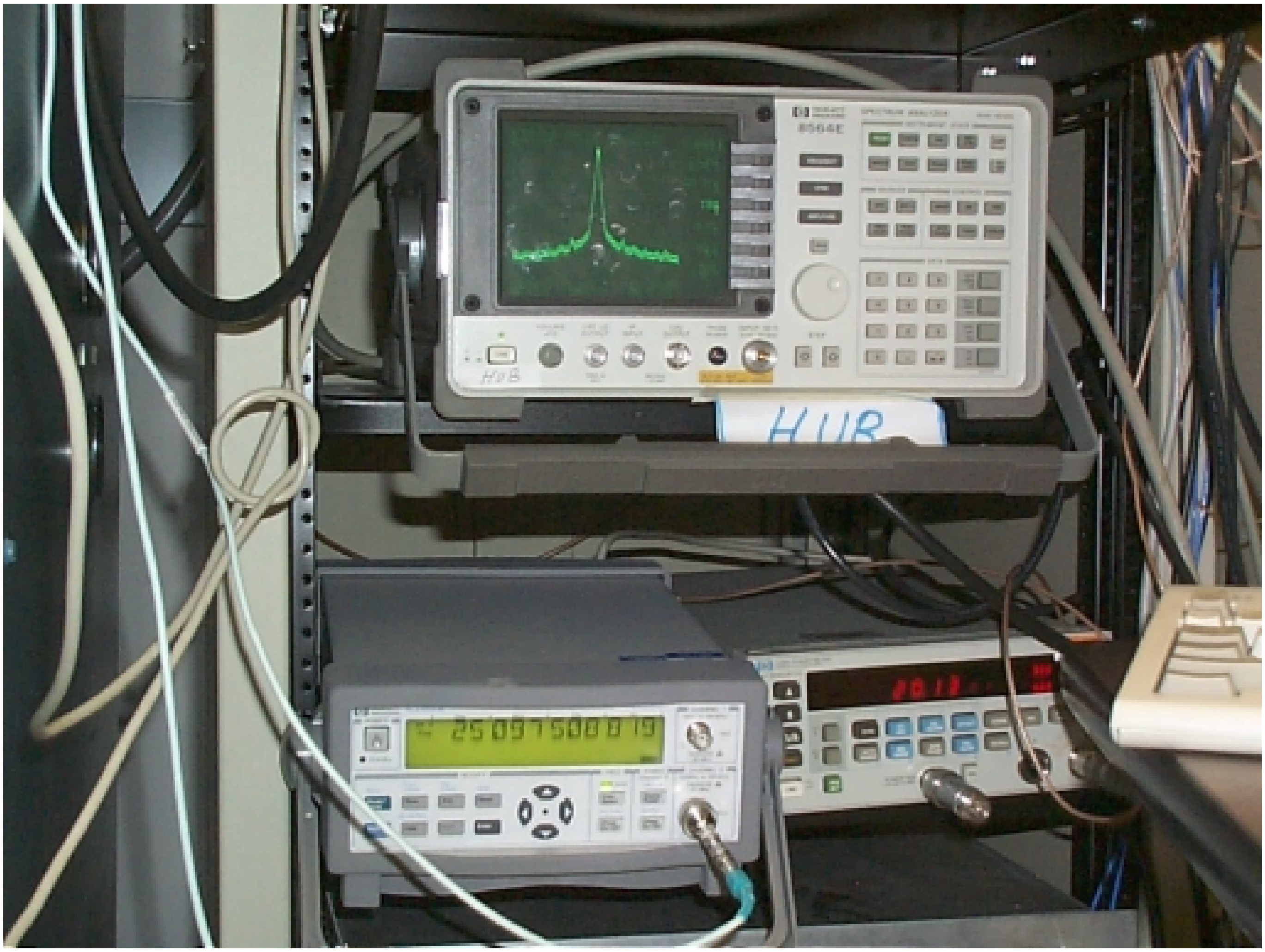


Figure 53: Frequency stability testing equipment during the Subscriber and HUB testing

Figure 54: Frequency stability testing EUTs (SUB and HUB) in the Temperature chamber.

Figure 55: Frequency stability temperature reading acquisition

3.6.4 Test Results

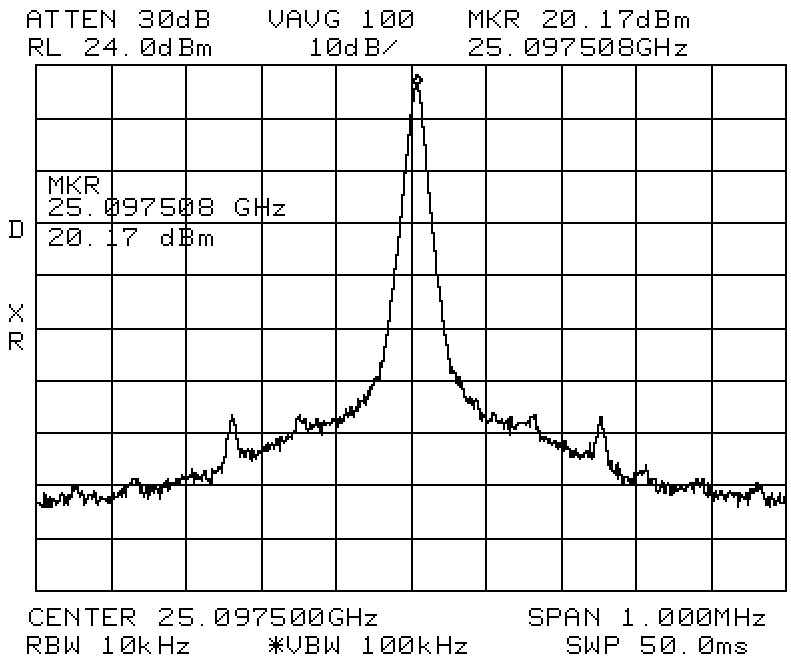
Please refer to the Table 16 for the test results, and figures 57 through 68 for the CW plots in different temperature and voltage values. All the frequency deviation readings show that it is within the allowable level.

PASS X Fail

Chamber ambient Temperature °C	ODU SUB (EUT) Internal Ambient Temp °C	ODU-SUB (EUT) input DC Voltage (V)	ODU-SUB (EUT) transmitting Frequency fc (KHz) Channel # 36A	Δf Deviation Frequency Counter Reading (Khz)	Power meter reading (dBm)	Tolerance %: Δf/fc*100 %	Temperature
-36.5	-30.4	-42	25097500.0	7.449	20.18	2.96802E-05	-30°C
-35.9	-33.7	-48	25097500.0	7.822	20.83	3.11665E-05	-30°C
-35.1	-33.7	-54	25097500.0	7.822	20.33	3.11665E-05	-30°C
-4.5	-0.2	-42	25097500.0	8.275	20.33	3.29714E-05	0 °C
-4.0	0.6	-48	225097500.0	8.882	20.17	3.94585E-06	0 °C
-6.8	-0.2	-54	25097500.0	9.005	20.17	3.58801E-05	0 °C
21.6	26.5	-42	25097500.0	9.588	20.17	3.8203E-05	25 °C
21.8	27.5	-48	25097500.0	9.103	20.50	3.62705E-05	25 °C
21.6	28	-54	25097500.0	7.861	20.67	3.13218E-05	25 °C
51.7	50.5	-42	25097500.0	5.079	20.33	2.02371E-05	50 °C
50.4	50.9	-48	25097500.0	5.086	20.67	2.0265E-05	50 °C
50.4	50.7	-54	25097500.0	5.1	20.17	2.03207E-05	50 °C

Table 16 Test results for the Frequency stability

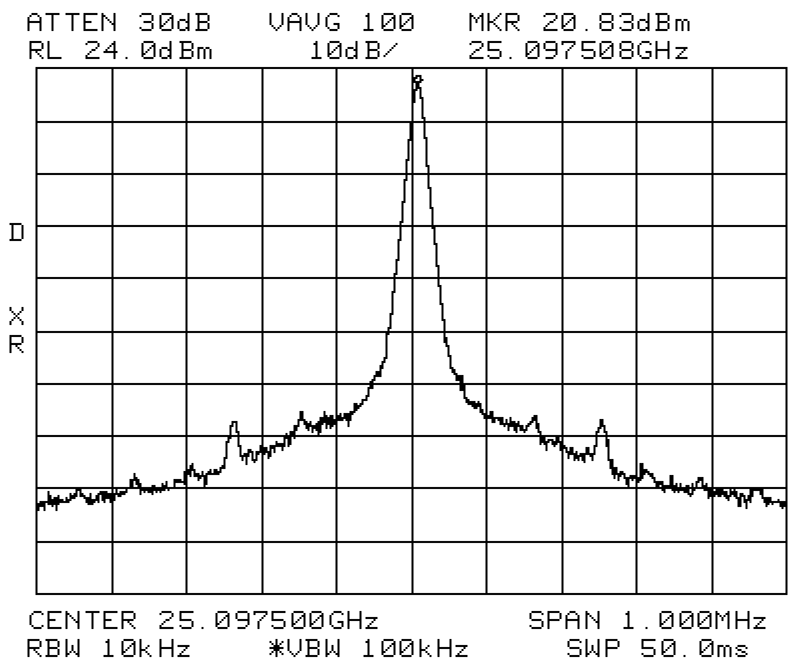
3.6.4.1 T=-30 °C



channel 36A SUB
power level = 20.17 dBm
Fc= 25.0750 Ghz
FDelta= 7.449 Khz
ODU input voltage = -42.0 vDC

temp= -31.3 C
Cable losses= 5.5 dB

Figure 56: T=-30 °C –42VDC, Tx Power = 20.0 dBm



Channel 36 A SUB
Fc= 25.0975 Ghz
Power level = 20.83 dBm.
Temp= -31.2 C (inside the ODU)
Frequency Delta = 7.822 Khz
cables losses = 4 dB

ODU input voltage = -48VDC

Figure 57: T=-30 °C –48VDC, Tx Power = 20.0 dBm

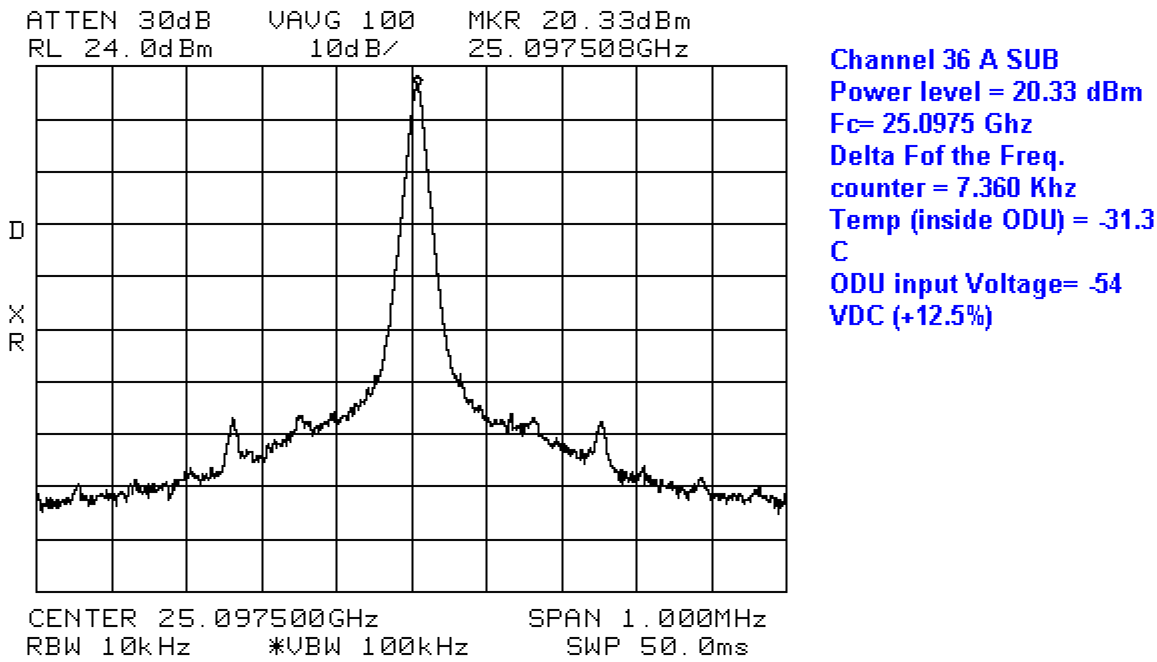


Figure 58: T=-30 °C –54VDC, Tx Power = 20.0 dBm

3.6.4.2 T= 0.0 °C:

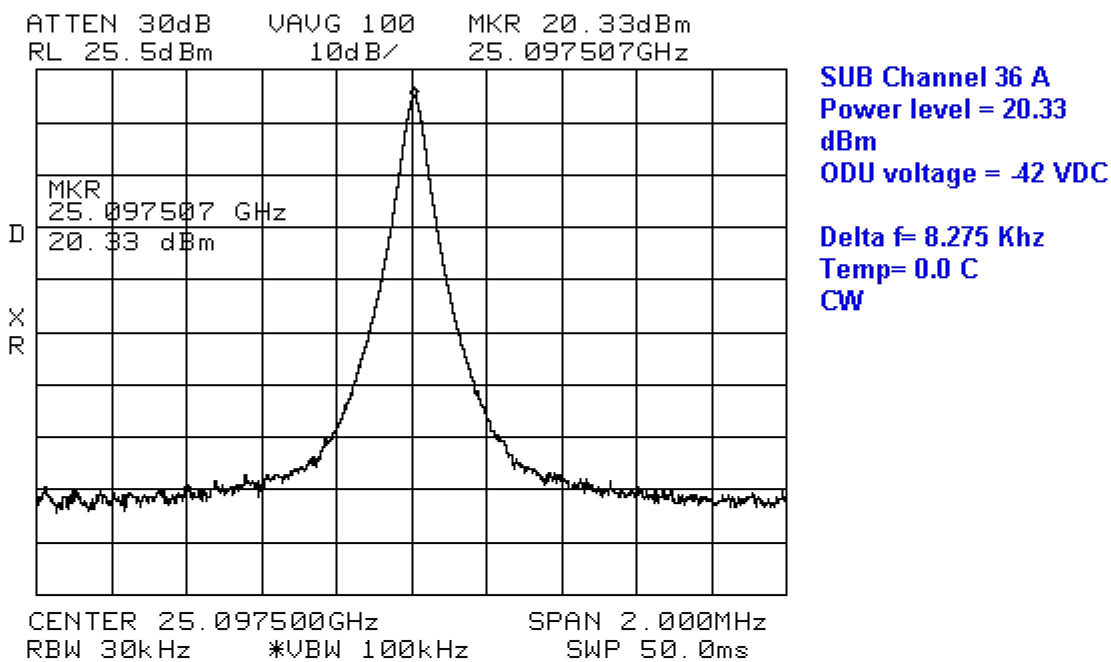


Figure 59: T=0 °C –42VDC, Tx Power = 20.0 dBm

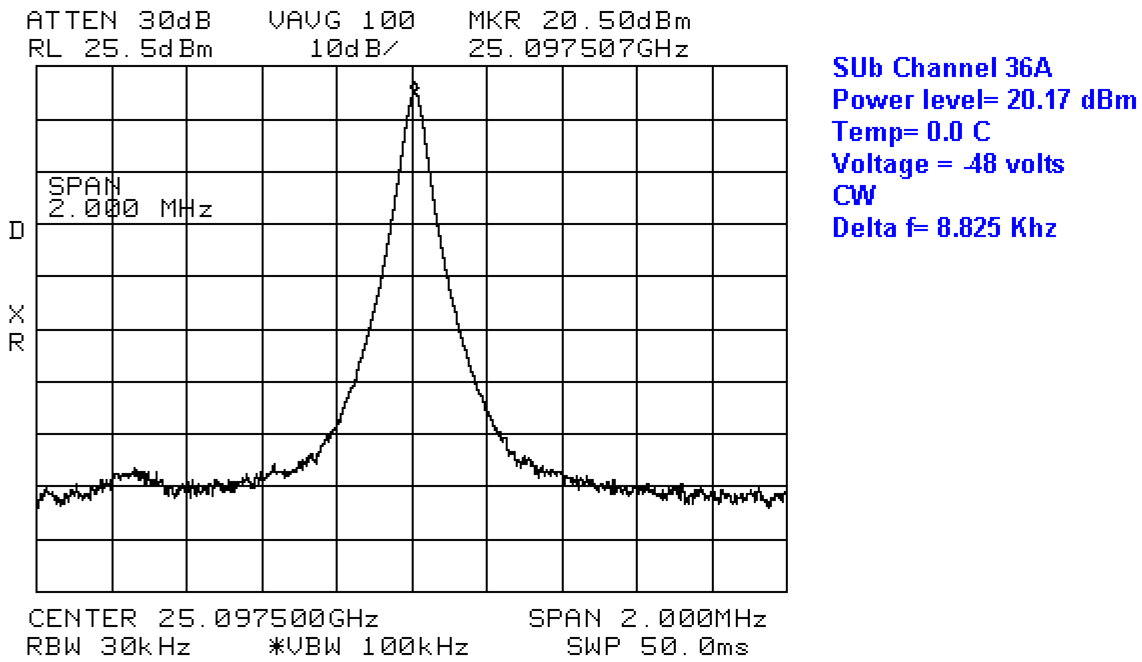


Figure60: T=0 °C –48VDC, Tx Power = 20.0 dBm

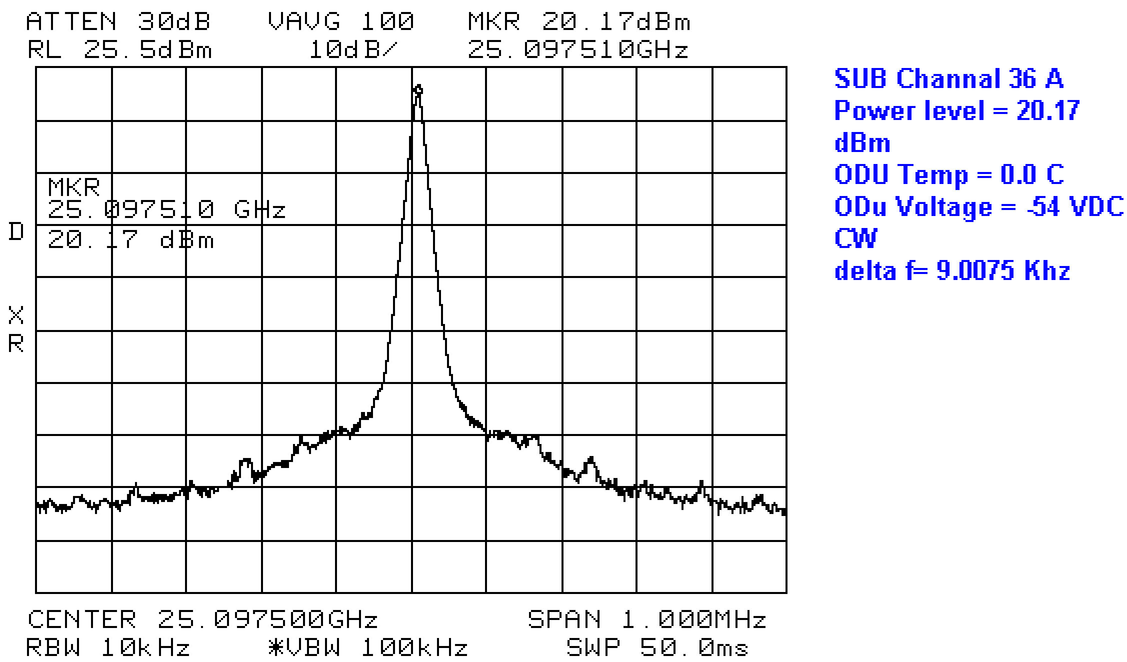
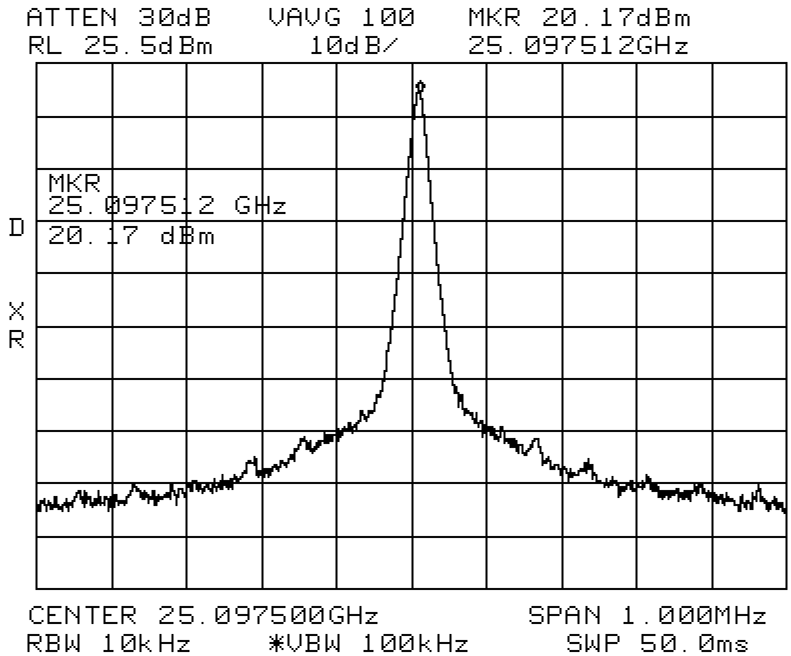


Figure 61: T=0 °C –54VDC, Tx Power = 20.0 dBm

3.6.4.3 T= 25C



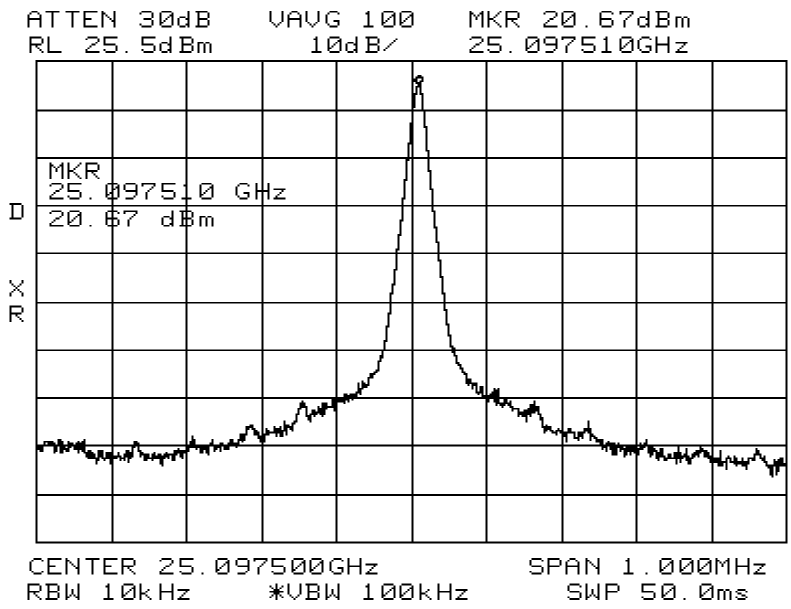
SUB channel 36 A
Power level = 20.17 dBm

ODU temp= 25 C
ODU voltage = -42 VDC

CW

Delta f= 9.588 Khz

Figure 62: T=+25°C –42VDC, Tx Power = 20.0 dBm

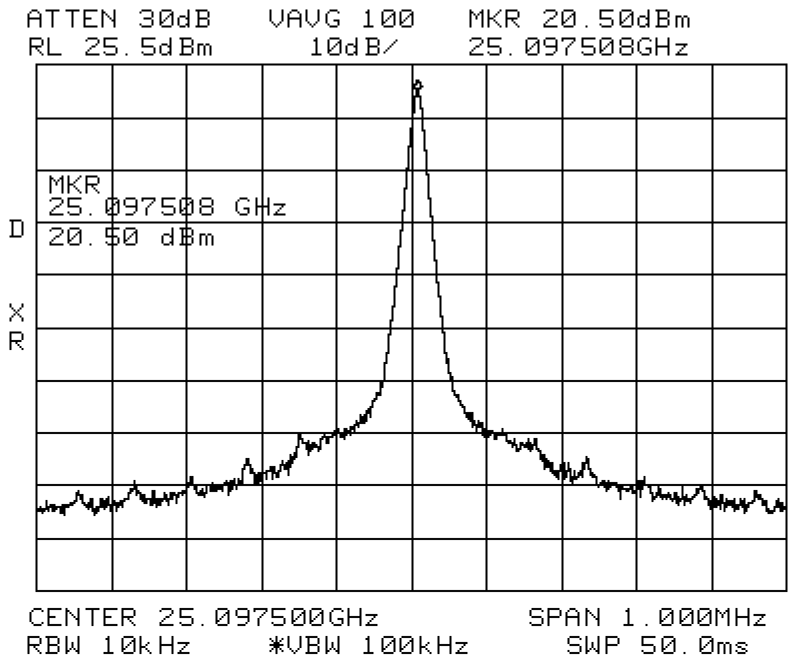


SUB Channel 36 A
power level = 20.67 dBm
ODU voltage = -48 volts
ODu temp=25 C

Delta f=9.103 Khz

CW

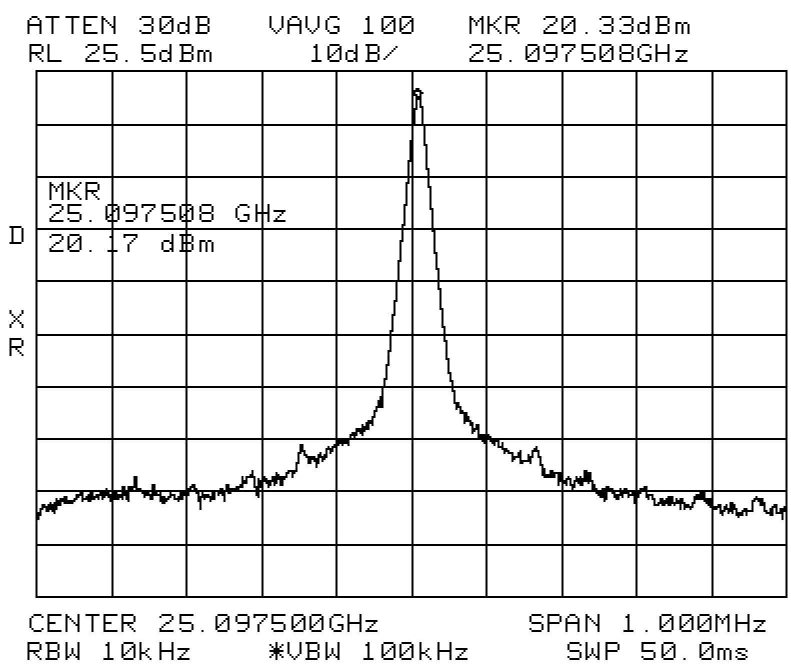
Figure 63: T=+25°C –48VDC, Tx Power = 20.0 dBm



SUB Channel 36A
Power level = 20.50 dBm
ODU voltage =-54 Vdc
Temp= 25C
Delta f= 7.861 Khz
CW

Figure 64: T=25 °C –54VDC, Tx Power = 20.0 dBm

3.6.4.4 T= 50 °C:



SUB Channel 36 A
Power level = 20.33 dBm
ODU voltage = -42 volts
ODU temp = 50.0 C
delta f= 8.928 Khz

Figure 65: T=50 °C –42VDC, Tx Power = 20.0 dBm

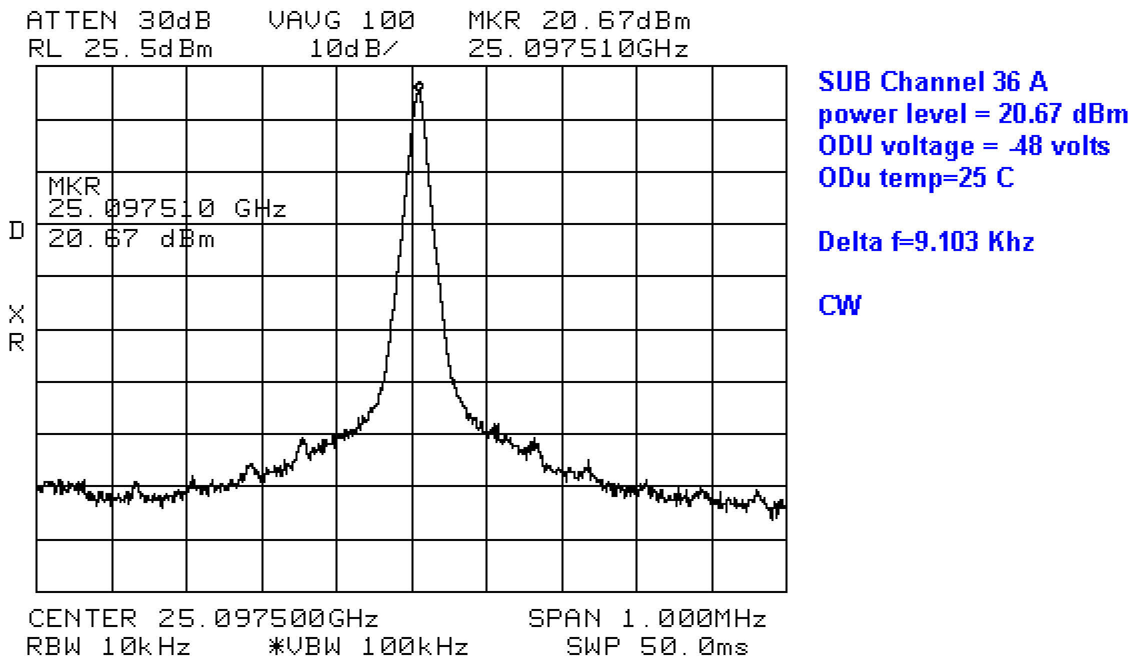


Figure 66: T=+50 °C –48VDC, Tx Power = 20.0 dBm

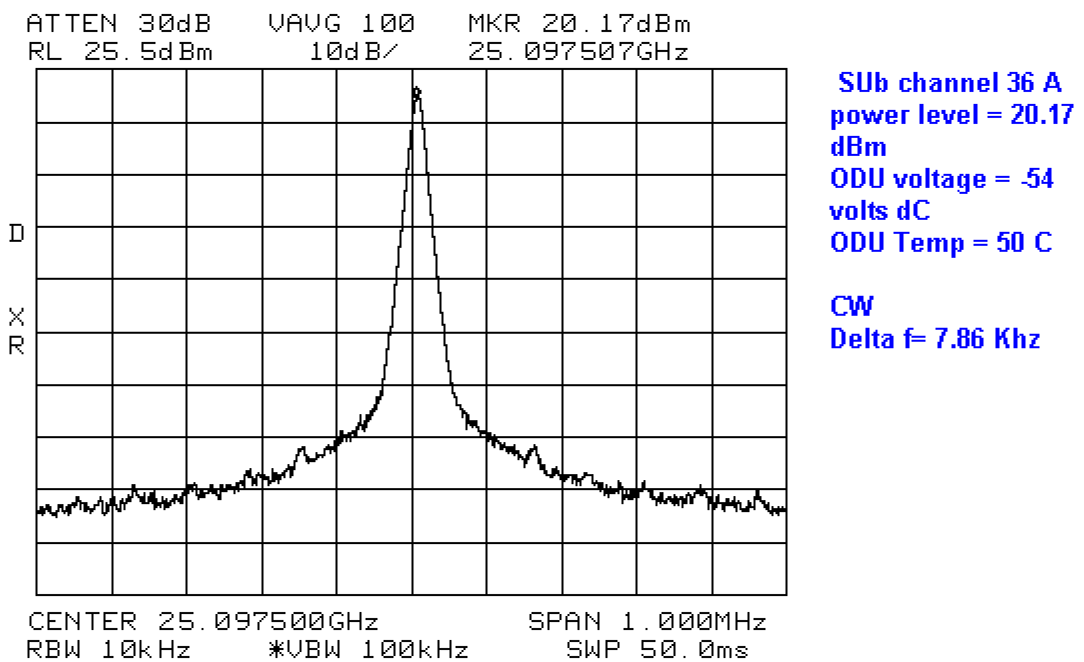


Figure 67: T= +50 °C -54VDC, Tx Power = 20.0 dBm