UltraTech
Group of Labs

31040/SIT

C-1376

46390-2049

200093-0

00-034

SL2-IN-E-1119R

3000 Bristol Circle,
Oakville, Ontario,
Canada L6H 6G4

Tel.: (905) 829-1570
Fax.: (905) 829-8050

Website: www.ultratech-labs.com
Email: vic@ultratech-labs.com

August 5, 2003

FEDERAL COMMUNICATIONS COMMISSION
7435 Oakland Mills Road
Columbia, MD 21046
USA

Subject: **Type Acceptance Application under FCC CFR 47, Parts 2 and 90 (Subpart I) - Non-Broadcast Radio Transceivers Operating in the frequency bands 403 - 512 MHz (12.5 kHz and 25 kHz Channel Spacings).**

Applicant: **KAVAL WIRELESS TECHNOLOGIES INC.**
Product: **Bi-Directional Amplifier**
Model: **SB400**
FCC ID: **H6M-SB400**

Dear Sir/Madam,

As appointed agent for **KAVAL WIRELESS TECHNOLOGIES INC.**, we would like to submit the application to the Federal Communications Commission for certification of the above product. Please review all necessary files uploaded to FCC OET site for detailed information.

If you have any queries, please do not hesitate to contact us by our TOLL FREE number:

OUR TELEPHONE NO.: 1-877-747-6381

Yours truly,

Tri Minh Luu, P. Eng.,
V.P., Engineering

TML/DH

Encl.

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August 5,2003

KAVAL WIRELESS TECHNOLOGIES INC.
60 Gough Road
Markham, Ontario
Canada, L3R 8X7

Attn.: **Alan Aslett**

Subject: **Certification Testing in accordance with FCC CFR 47, Parts 2 and 90 (Subpart I) - Non-Broadcast Radio Transceivers Operating in the frequency bands 403 - 512 MHz (12.5 kHz and 25 kHz Channel Spacings).**

Product: **Bi-Directional Amplifier**
Model: **SB400**
FCC ID: **H6M-SB400**

Dear Aslett,

The product sample has been tested in accordance with **FCC CFR 47, Parts 2 and 90 (Subpart I) - Non-Broadcast Radio Transceivers Operating in the frequency bands 403 - 512 MHz 12.5 kHz and 25 kHz Channel Spacings),** and the results and observation were recorded in the engineering report, Our File No.: KTI-029Q

Enclosed you will find copy of the engineering report. If you have any queries, please do not hesitate to contact us.

Yours truly,

Tri Minh Luu, P.Eng
Vice President - Engineering

Encl.

ENGINEERING TEST REPORT

Bi-Directional Amplifier
Model No.: SB400
FCC ID: H6M-SB400

Applicant: **KAVAL WIRELESS TECHNOLOGIES INC.**
60 Gough Road
Markham, Ontario
Canada, L3R 8X7

Tested in Accordance With

Federal Communications Commission (FCC)
CFR 47, PARTS 2 and 90 (Subpart I)

UltraTech's File No.: KTI-029Q

This Test report is Issued under the Authority of Tri M. Luu, Professional Engineer, Vice President of Engineering UltraTech Group of Labs Date: August 5,2003	LICENSED PROFESSIONAL ENGINEER T.M. LUU PROVINCE OF ONTARIO
Report Prepared by: Dharmajit Solanki, RFI Engineer Issued Date: Aug. 05	Tested by: Hung Trinh, RFI Technician Test Dates: Jul 15 – July 30, 2003

- *The results in this Test Report apply only to the sample(s) tested, and the sample tested is randomly selected.*
- *This report must not be used by the client to claim product endorsement by NVLAP or any agency of the US Government.*

UltraTech

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Website: www.ultratech-labs.com Email: vic@ultratech-labs.com, Email: tri@ultratech-labs.com

31040/SIT C-1376 46390-2049 200093-0 SL2-IN-E-1119R 00-034

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3000 Bristol Circle, Oakville, Ontario, Canada L6H 6G4
Tel. #: 905-829-1570, Fax. #: 905-829-8050, Email: vic@ultratech-labs.com, Website: http://www.ultratech-labs.com

EXHIBIT 1. SUBMITTAL CHECK LIST

Annex No.	Exhibit Type	Description of Contents	Quality Check (OK)
--	Test Report	• Exhibit 1: Submittal check lists • Exhibit 2: Introduction • Exhibit 3: Performance Assessment • Exhibit 4: EUT Operation and Configuration during Tests • Exhibit 5: Summary of test Results • Exhibit 6: Measurement Data • Exhibit 7: Measurement Uncertainty • Exhibit 8: Measurement Methods	OK
1	Test Setup Photos	Photos # 1 to 2	OK
2	External Photos of EUT	Photos # 1 to 2	OK
3	Internal Photos of EUT	Photos # 1 to 19	
4	Cover Letters	• Letter from Ultratech for Certification Request • Letter from the Applicant to appoint Ultratech to act as an agent • Letter from the Applicant to request for Confidentiality Filing	OK
5	Attestation Statements	•	N/A
6	ID Label/Location Info	ID Label Location of ID Label	OK
7	Block Diagrams	Block diagrams # 1 to 1	OK
8	Schematic Diagrams	Schematic diagrams # 1 to 2	OK
9	Parts List/Tune Up Info	Refer to schematics	N/A
10	Operational Description	Operational Description	OK
11	RF Exposure Info	RF Exposure Info	OK
12	Users Manual	Users Manual	OK

EXHIBIT 2. INTRODUCTION

2.1. SCOPE

Reference:	FCC Parts 2 and 90
Title:	Telecommunication - Code of Federal Regulations, CFR 47, Parts 2 & 90
Purpose of Test:	To obtain FCC Certification Authorization for Radio operating in the frequency bands 403 - 512 MHz (12.5 kHz and 25 kHz Channel Spacing).
Test Procedures:	Both conducted and radiated emissions measurements were conducted in accordance with American National Standards Institute ANSI C63.4 - American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.

2.2. RELATED SUBMITAL(S)/GRANT(S)

None

2.3. NORMATIVE REFERENCES

Publication	Year	Title
FCC CFR Parts 0-19, 80-End	2002	Code of Federal Regulations – Telecommunication
ANSI C63.4	1992	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
CISPR 22 & EN 55022	1997 1998	Limits and Methods of Measurements of Radio Disturbance Characteristics of Information Technology Equipment
CISPR 16-1		Specification for Radio Disturbance and Immunity measuring apparatus and methods

EXHIBIT 3. PERFORMANCE ASSESSMENT

3.1. CLIENT INFORMATION

APPLICANT	
Name:	KAVAL WIRELESS TECHNOLOGIES INC.
Address:	60 Gough Road Markham, Ontario Canada, L3R 8X7
Contact Person:	Mr. Alan Aslett Phone #: (905) 946-3397 Fax #: (905) 946-3396 Email Address: asslet@kaval.com

MANUFACTURER	
Name:	KAVAL WIRELESS TECHNOLOGIES INC.
Address:	60 Gough Road Markham, Ontario Canada, L3R 8X7
Contact Person:	Mr. Alan Aslett Phone #: (905) 946-3397 Fax #: (905) 946-3396 Email Address: asslet@kaval.com

3.2. EQUIPMENT UNDER TEST (EUT) INFORMATION

The following information (with the exception of the Date of Receipt) has been supplied by the applicant.

Brand Name:	Kaval In-Hancer Plus
Product Name:	Bi-Directional Amplifier
Model Name or Number:	SB400
Serial Number:	Pre-Production
Type of Equipment:	Non-broadcast Radio Communication Amplifier
External Power Supply:	120V, 60 Hz
Transmitting/Receiving Antenna Type:	Non-integral
Primary User Functions of EUT:	Bi-directional amplifier for operation in UHF band.

3.3. EUT'S TECHNICAL SPECIFICATIONS

TRANSMITTER	
Equipment Type:	[√] Base station (fixed use)
Intended Operating Environment:	[√] Commercial [√] Light Industry & Heavy Industry
Power Supply Requirement:	120VAC, 60 Hz
RF Output Power Rating:	▪ 1 input/output: 6.50 Watts or 38.1 dBm ▪ 2 inputs/outputs: 0.30 Watts or 24.8 dBm ▪ 3 inputs/outputs: 0.21 Watts or 23.2 dBm
Operating Frequency Range:	403-512 MHz
RF Output Impedance:	50 Ohms
Channel Spacing:	12.5 KHz & 25 kHz
Occupied Bandwidth (99%):	Extender
Emission Designation*:	11K0F3E 16K0F3E 14K6F1D 19K6F1D
Antenna Connector Type:	N
Antenna Description:	Antenna Gain Limit = 10 dBi

* For an average case of commercial telephony, the Necessary Bandwidth is calculated as follows:

1. For FM Voice Modulation:

Channel Spacing = 12.5 KHz, D = 2.5 KHz max., K = 1, M = 3 KHz
B_n = 2M + 2DK = 2(3) + 2(2.5)(1) = **11 KHz**
emission designation: 11K0F3E

Channel Spacing = 25 KHz, D = 5 KHz max., K = 1, M = 3 KHz
B_n = 2M + 2DK = 2(3) + 2(5)(1) = **16 KHz**
emission designation: 16K0F3E

2. For FM Digital Modulation:

(a) Channel Spacing = 12.5 KHz, D = 2.5 KHz max., K = 1, M = Data Rate in kb/s / Level of FM
M = 9.6 kb/s / 2
B_n = 2M + 2DK = 2(9.6/2) + 2(2.5)(1) = **14.6 KHz**
emission designation: 14K6F1D

(a) Channel Spacing = 25 KHz, D = 2.5 KHz max., K = 1, M = Data Rate in kb/s / Level of FM
M = 9.6 kb/s / 2
B_n = 2M + 2DK = 2(9.6/2) + 2(5)(1) = **19.6 KHz**
emission designation: 19K6F1D

3.4. LIST OF EUT'S PORTS

Port Number	EUT's Port Description	Number of Identical Ports	Connector Type	Cable Type (Shielded/Non-shielded)
1	Power Port	1	3 prong	Non-shielded
2	In Port	1	N	Shielded
3	Out Port	1	N	Shielded

3.5. ANCILLARY EQUIPMENT

None

3.6. DRAWING OF TEST SETUP

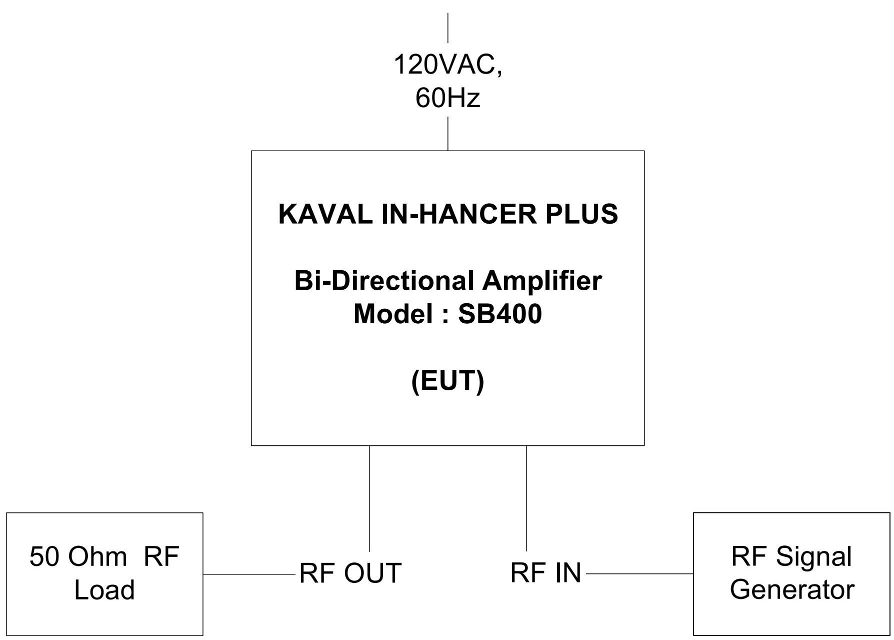


EXHIBIT 4. EUT OPERATING CONDITIONS AND CONFIGURATIONS DURING TESTS

4.1. CLIMATE TEST CONDITIONS

The climate conditions of the test environment are as follows:

Temperature:	22°C
Humidity:	45%
Pressure:	102 kPa
Power input source:	120 V 60Hz

4.2. OPERATIONAL TEST CONDITIONS & ARRANGEMENT FOR TEST SIGNALS

Operating Modes:	The amplifier was operated in a continuous transmission mode with the carrier modulated as specified in the Test Data.
Special Test Software:	N/A
Special Hardware Used:	N/A
Transmitter Test Antenna:	The EUT is tested with the transmitter antenna port terminated to a 50 Ohms RF Load.

Transmitter Test Signals	
Frequency Band(s): ▪ 403 – 512 MHz band:	Near lowest, near middle & near highest frequencies in each frequency bands that the transmitter covers: ▪ 406.1, 450 & 470 MHz
Transmitter Wanted Output Test Signals: ▪ RF Power Output (measured maximum output power): ▪ Normal Test Modulation ▪ Modulating signal source:	 ▪ 6.5 Watts ▪ FM ▪ External

EXHIBIT 5. SUMMARY OF TEST RESULTS

5.1. LOCATION OF TESTS

All of the measurements described in this report were performed at Ultratech Group of Labs located in the city of Oakville, Province of Ontario, Canada.

- AC Power Line Conducted Emissions were performed in UltraTech's shielded room, 16'(L) by 12'(W) by 12'(H).

- Radiated Emissions were performed at the Ultratech's 3 Meter Open Field Test Site (OFTS) situated in the Town of Oakville, province of Ontario.

  The above sites have been calibrated in accordance with ANSI C63.4, and found to be in compliance with the requirements of Sec. 2.948 of the FCC Rules. The descriptions and site measurement data of the Oakville Open Field Test Site has been filed with FCC office (FCC File No.: 31040/SIT 1300B3) and Industry Canada office (Industry Canada File No.: IC2049). Last Date of Site Calibration: Aug. 10, 2002.

5.2. APPLICABILITY & SUMMARY OF EMISSION TEST RESULTS

FCC PARAGRAPH.	TEST REQUIREMENTS	APPLICABILITY (YES/NO)
90.205 & 2.1046	RF Power Output & Intermodulation	Yes
1.1307, 1.1310, 2.1091 & 2.1093	RF Exposure Limit	Yes
90.213 & 2.1055	Frequency Stability	Yes
90.242(b)(8) & 2.1047(a)	Audio Frequency Response	N/A for an amplifier
90.210 & 2.1047(b)	Modulation Limiting	N/A for an amplifier
90.210 & 2.1049	Emission Limitation & Emission Mask	Yes
90.210, 2.1057 & 2.1051	Emission Limits - Spurious Emissions at Antenna Terminal	Yes
90.210, 2.1057 & 2.1053	Emission Limits - Field Strength of Spurious Emissions	Yes
90.214	Transient Frequency Behavior	N/A for amplifier
Bi-Directional Amplifier, **Model No.: SB400**, by has also been tested and found to comply with **FCC Part 15, Subpart B - Radio Receivers and Class A Digital Devices**. The engineering test report has been documented and kept in file and it is available anytime upon FCC request.		

5.3. MODIFICATIONS INCORPORATED IN THE EUT FOR COMPLIANCE PURPOSES

None

5.4. DEVIATION OF STANDARD TEST PROCEDURES

None

EXHIBIT 6. MEASUREMENTS, EXAMINATIONS & TEST DATA FOR EMC EMISSIONS

6.1. TEST PROCEDURES

This section contains test results only. Details of test methods and procedures can be found in Exhibit 8 of this report

6.2. MEASUREMENT UNCERTAINTIES

The measurement uncertainties stated were calculated in accordance with requirements of UKAS Document NIS 81 with a confidence level of 95%. Please refer to Exhibit 7 for Measurement Uncertainties.

6.3. MEASUREMENT EQUIPMENT USED:

The measurement equipment used complied with the requirements of the Standards referenced in the Methods & Procedures ANSI C63.4:1992 and CISPR 16-1.

6.4. ESSENTIAL/PRIMARY FUNCTIONS AS DECLARED BY THE MANUFACTURER:

The essential function of the EUT is to correctly communicate data to and from radios over RF link.

6.5. RF POWER OUTPUT & INTREMODULAITON @ FCC 2.1046 & 90.205

6.5.1. Limits @ FCC 90.205

Please refer to FCC CFR 47, Part 90, Subpart I, Para. 90.205 for specification details.

6.5.2. Method of Measurements

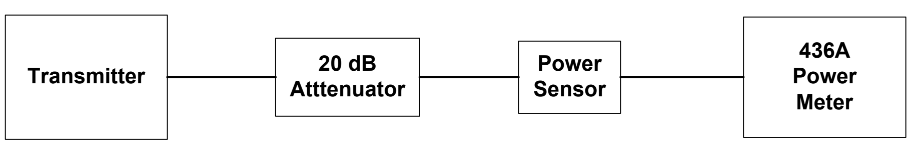
Refer to Exhibit 8, § 8.1 (Conducted) and 8.2 (Radiated) of this report for measurement details

6.5.3. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range
Spectrum Analyzer/ EMI Receiver	Hewlett Packard	HP 8546A	…	9 kHz to 5.6 GHz with built-in 30 dB Gain Pre-selector, QP, Average & Peak Detectors.
Attenuator(s)	Bird	…	…	DC – 22 GHz
Spectrum Analyzer/ EMI Receiver	Advantest	R3271	15050203	100 Hz – 26.5 GHz
Attenuator(s)	Weinschel Corp	24-20-34	BJ2357	DC – 8.5 GHz
Power Sensor	Hewlett Packard	8481A	2702A68983	10 MHz – 18 GHz
Synthesize Sweeper	Hewlett Packard	83752B	3610A00457	0.01 – 20 GHz

6.5.4. Test Arrangement

- Power at RF Power Output Terminals



6.5.5. Test Data

6.5.5.1. RF Ouptut Power with 1 Input/Output Channel

Transmitter Channel Output	Fundamental Frequency (MHz)	Measured (Average) Power (dBm)	(2) Manufacturer's Power Rating (dBm)
Near Lowest	406.1	37.9	35.0
Near Middle	450.0	38.1	35.0
Near Highest	470.0	37.8	35.0

Remarks:

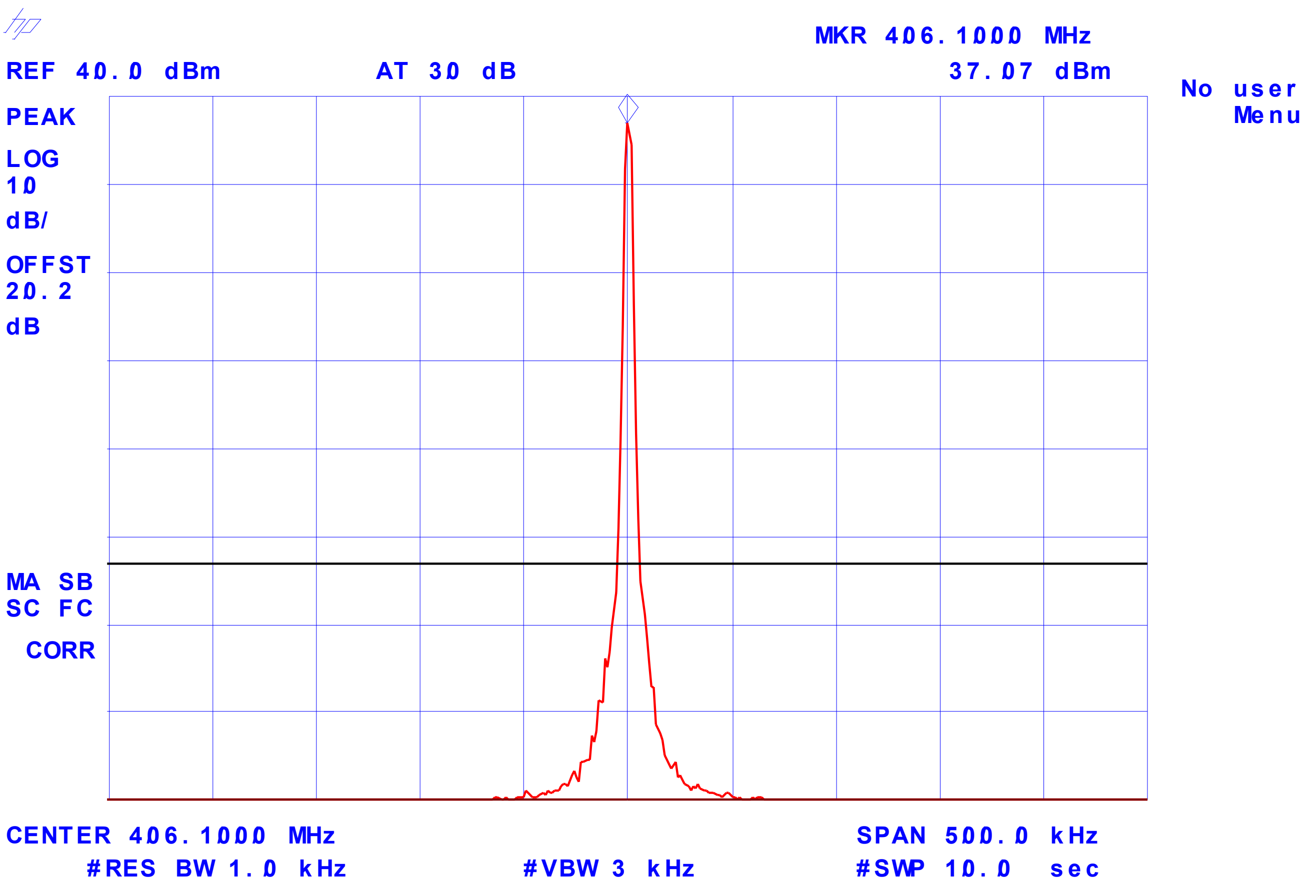
(1) Tests were performed with FM Voice and FM Data Modulations and the results were found the same as above for both 12.5KHz and 25 KHz Channel Spacing.

(2) The measured output power was measured with maximum rf input of 10 dBm . The manufacturer's rating on Page 22 of the Users Manual recommended to operate below the ratings for device's best performance.

6.5.5.2. INTERMODULATION / RF OUTPUT POWER WITH MULTI CHANNEL INPUT/OUTPUTS

Frequency (MHz)	Number of In/Out Channels	Modulation	Manufacturer's Maximum RF Input (conducted) (dBm)	Maximum RF Output (conducted) (dBm)	(2) Manufacturer's Maximum RF Output Rating (conducted) (dBm)
406.1	1	No modulation	10.0	37.1	35.0
406.1	2	No modulation	-51.8	24.7	24.0
406.1	3	No modulation	-57.2	22.9	21.0
450.0	1	No modulation	10.0	37.3	35.0
450.0	2	No modulation	-51.7	24.8	24.0
450.0	3	No modulation	-56.0	23.2	21.0
470.0	1	No modulation	10.0	36.7	35.0
470.0	2	No modulation	-51.8	24.4	24.0
470.0	3	No modulation	-55.4	22.7	21.0

Plot #1: RF Output Power with 1 RF signal input/output
Fc: 406.1 MHz, RF Input: 10 dBm

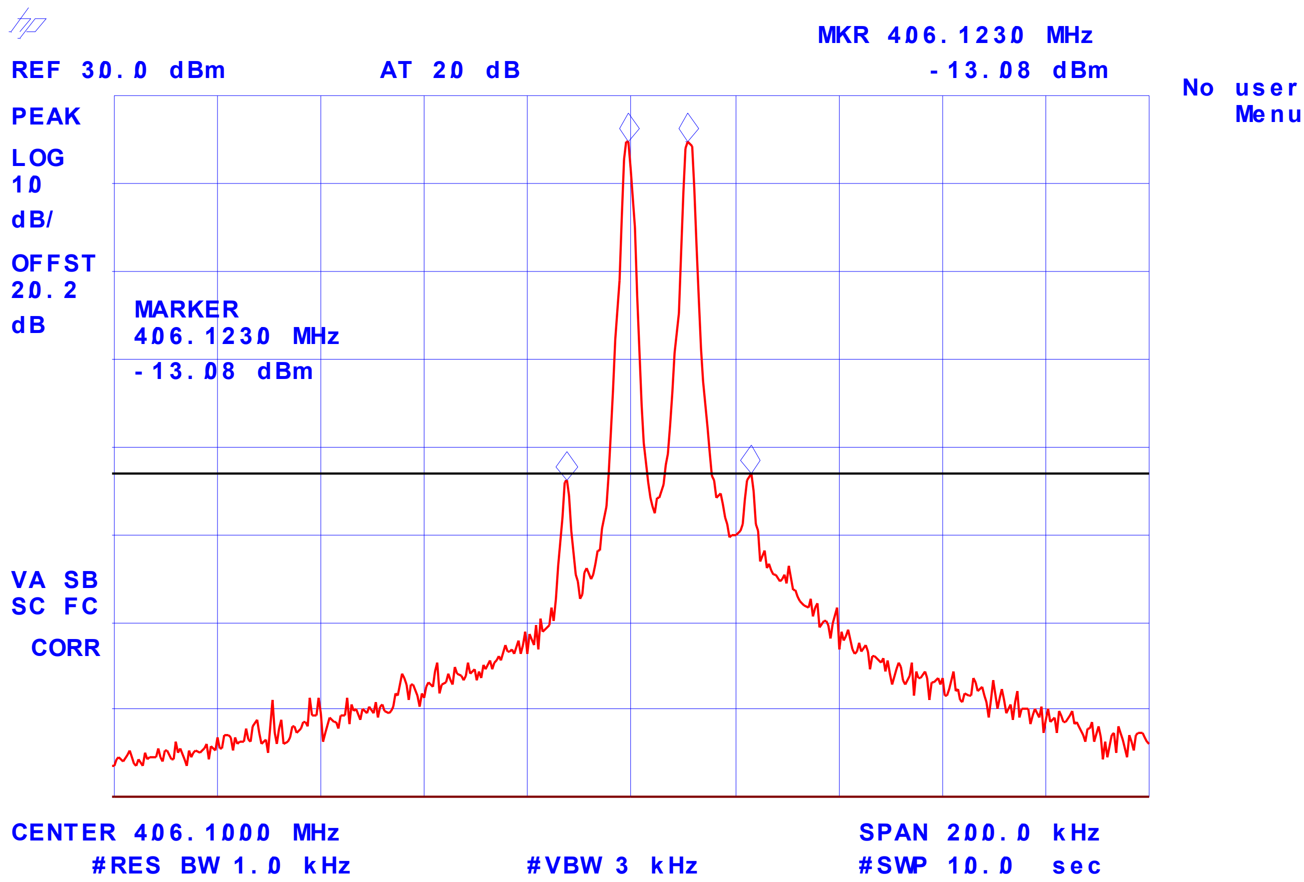


Plot #2: RF Output Power/Intermodulation with 2 RF signal inputs/outputs

Fc: 406.1 MHz, Fc+12.5 kHz

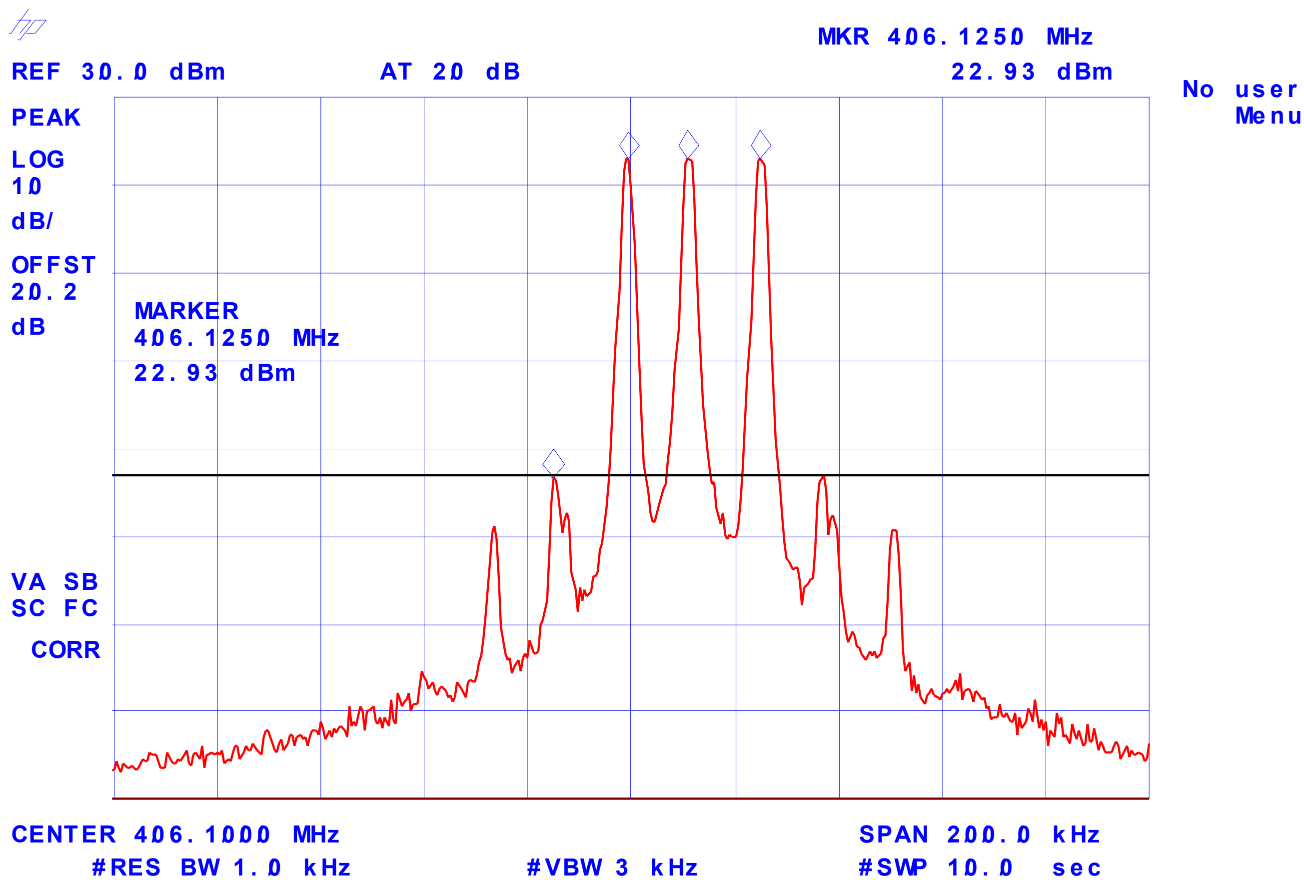
RF Input: (1) –51.83 dBm, (2) –52.01 dBm

(1) 406.0875 MHz, -13.85 dBm
(2) 406.1000 MHz, 24.69 dBm
(3) 406.1125 MHz, 24.69 dBm
(4) 406.1250 MHz, -13.08 dBm

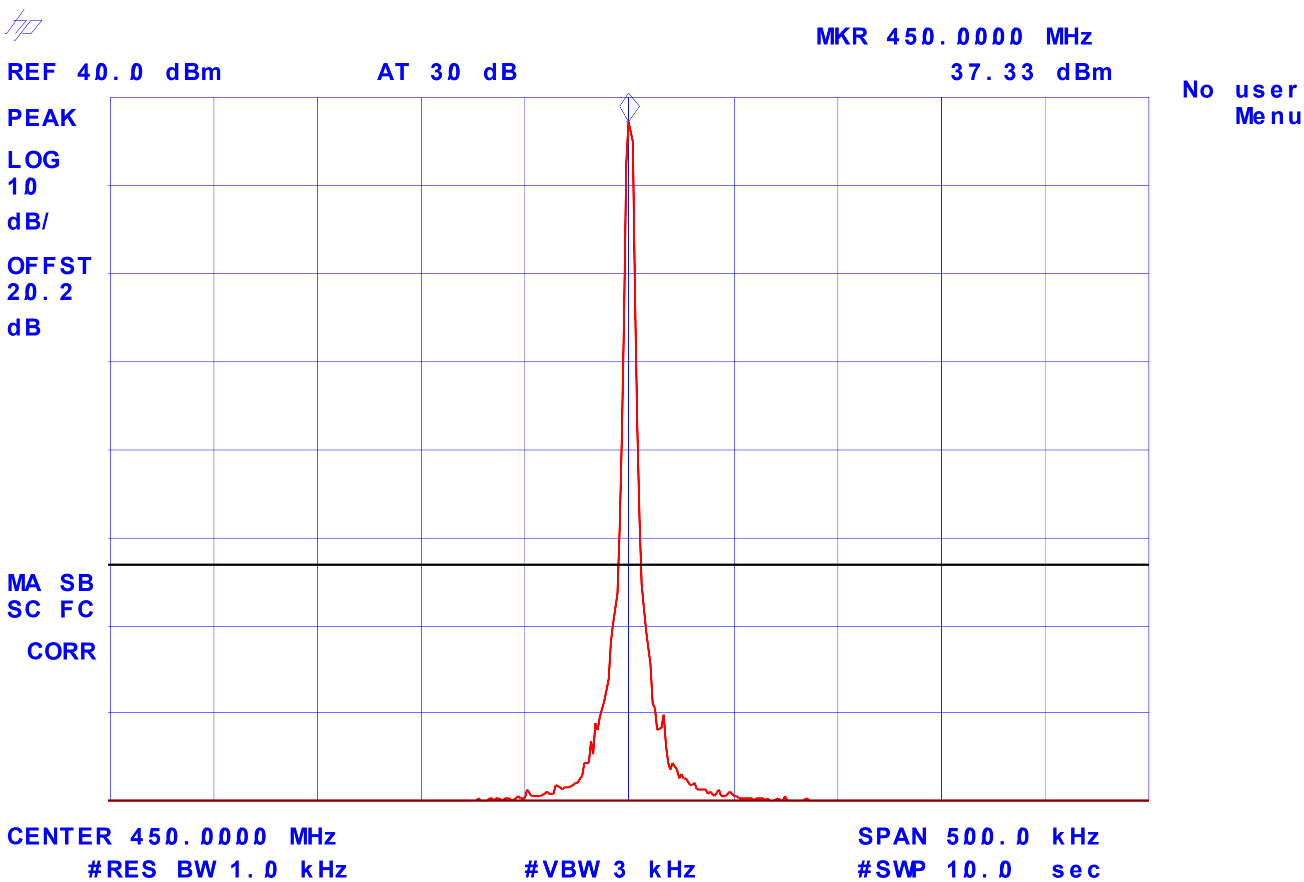


Plot #3: RF Output Power/Intermodulation with 3 RF signal inputs/outputs

Fc: 406.1 MHz, Fc+12.5 kHz, Fc+25 kHz
RF Input: (1) –57.48 dBm, (2) –56.70 dBm, (3) –57.18 dBm
(1) 406.0850 MHz, -13.40 dBm
(2) 406.0875 MHz, 22.91 dBm
(3) 406.1000 MHz, 22.93 dBm
(4) 406.1250 MHz, 22.93 dBm

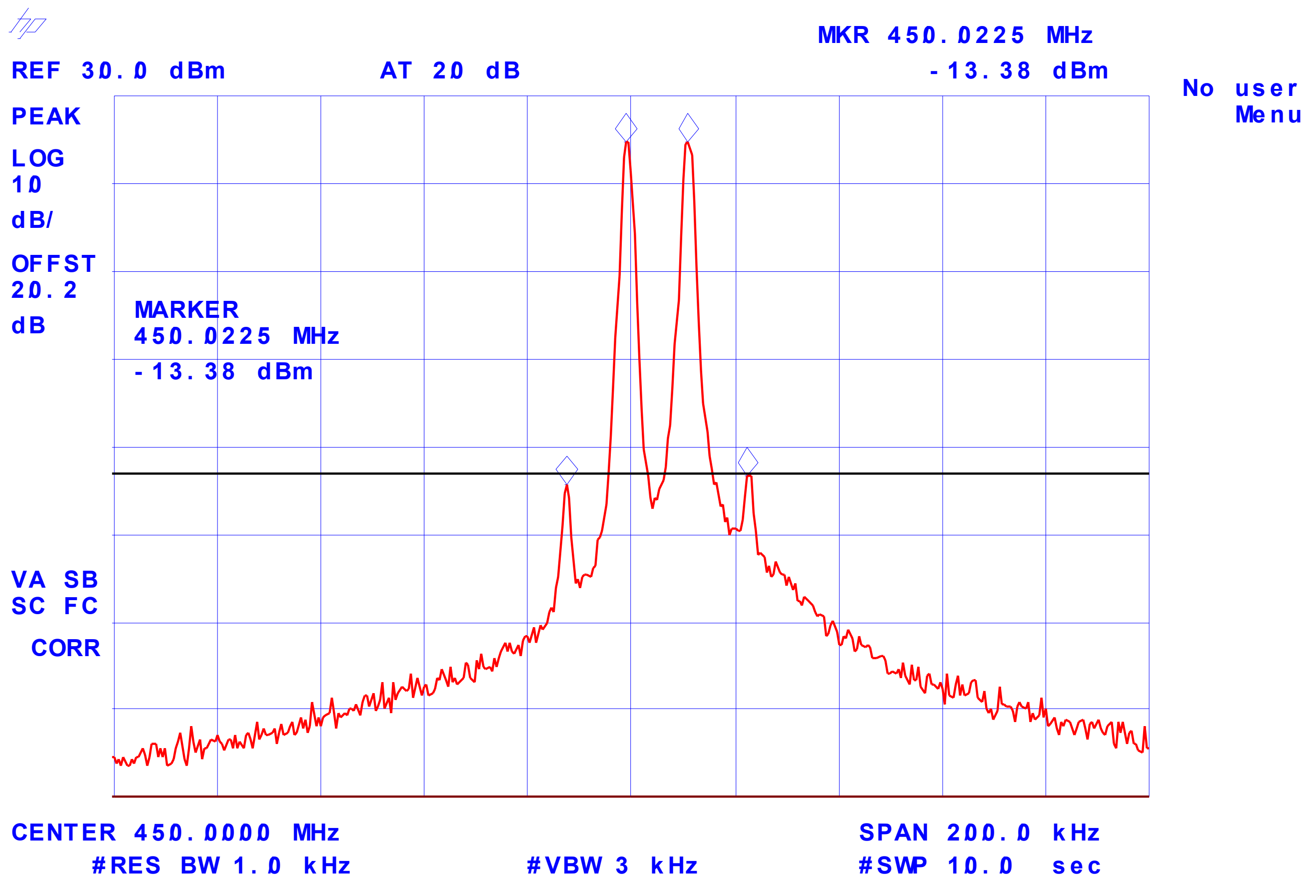


Plot #4: **RF Output Power with 1 RF signal input/output**
Fc: 450 MHz, RF Input: 10 dBm



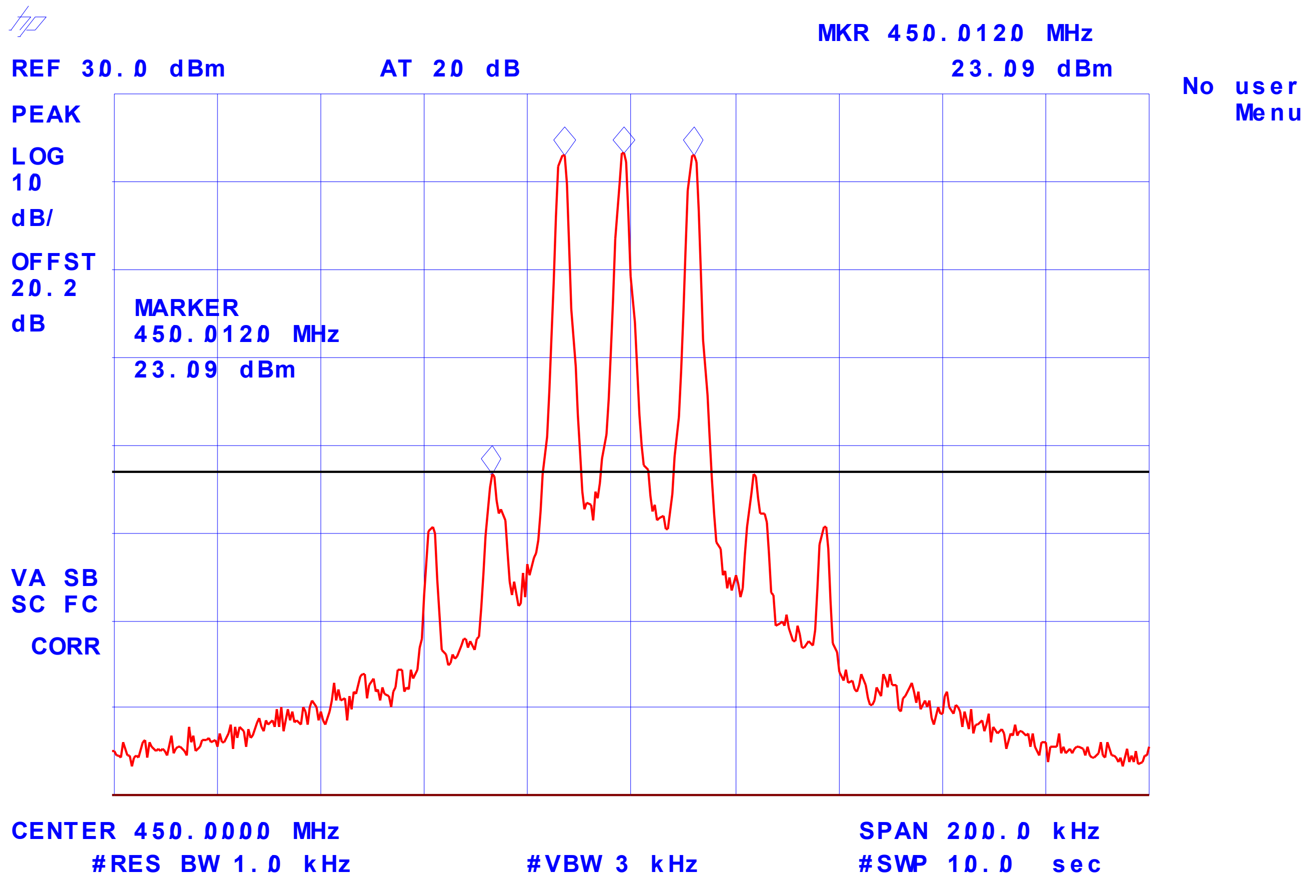
Plot #5: **RF Output Power/intermodulation with 2 RF signal input/output**

Fc: 450 MHz, Fc+12.5 kHz
RF Input: (1) –51.69 dBm, (2) –51.91 dBm
(1) 449.9875 MHz, -14.25 dBm
(2) 450.0000 MHz, 24.76 dBm
(3) 450.0125 MHz, 24.74 dBm
(4) 450.0250 MHz, -13.38 dBm

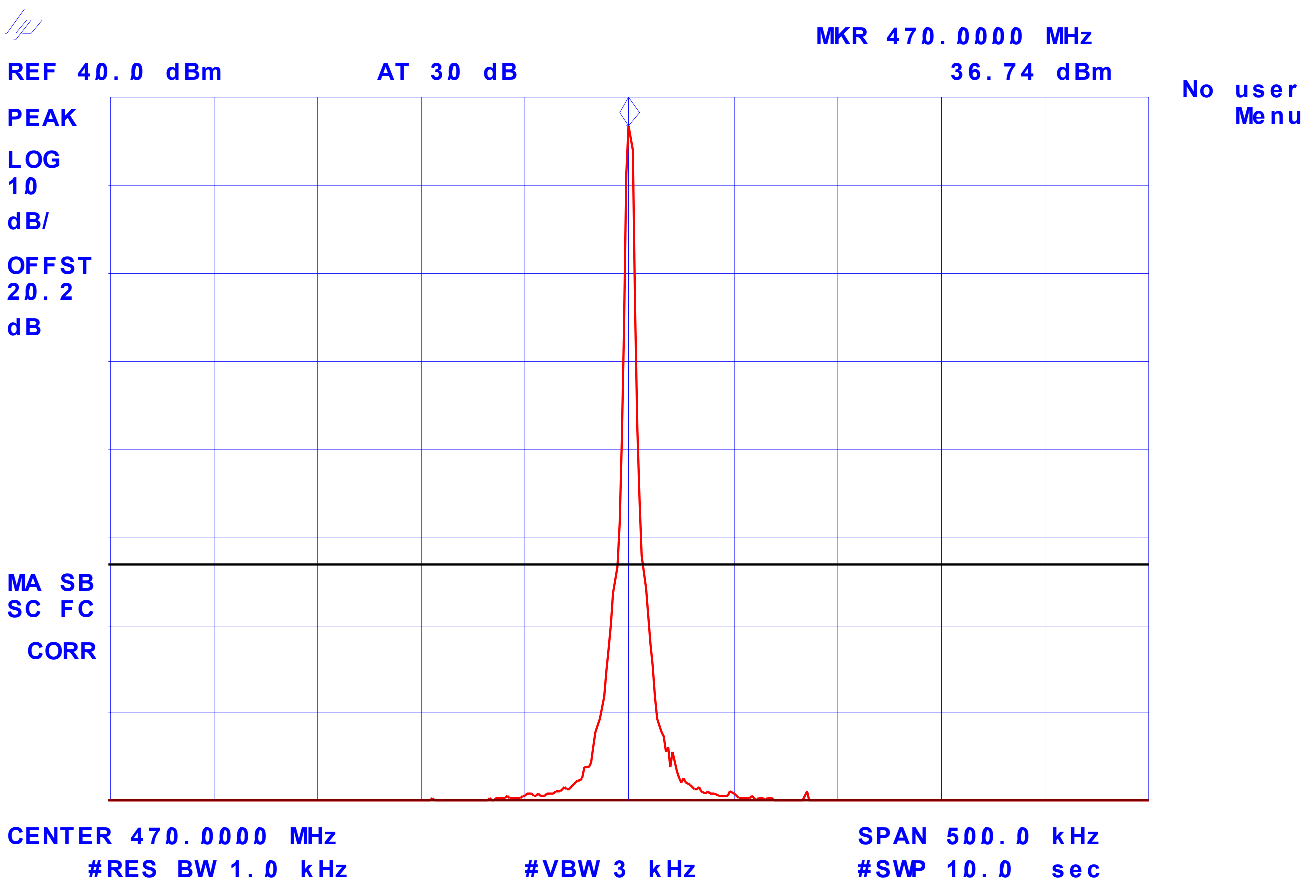


Plot #6: **RF Output Power/intermodulation with 3 RF signal input/output**

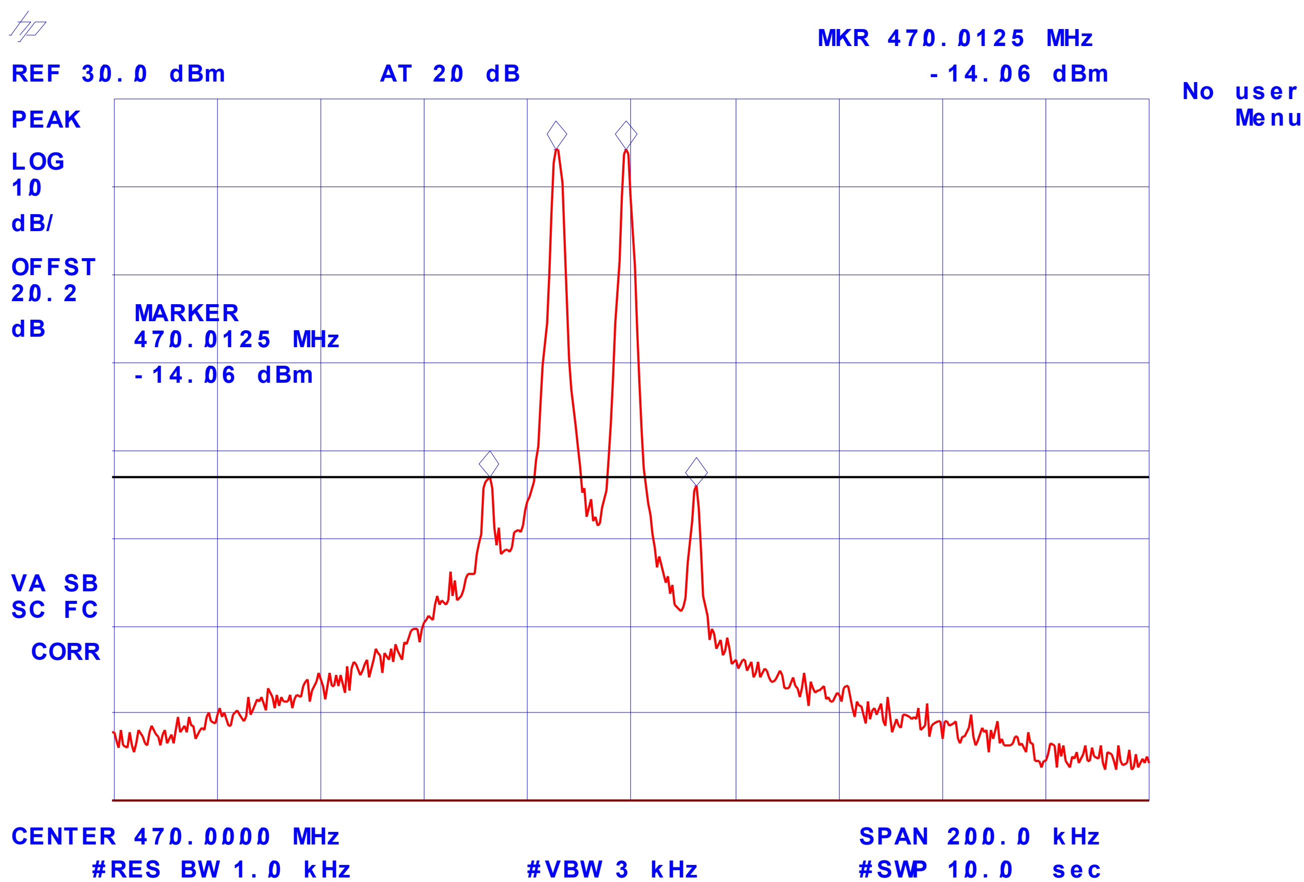
Fc: 450 MHz, Fc-12.5 kHz, Fc+12.5 kHz
RF Input: (1) –56.40 dBm, (2) –56.44 dBm, (3) –56.03 dBm
(1) 449.9750 MHz, -13.26 dBm
(2) 449.9875 MHz, 23.07 dBm
(3) 450.0000 MHz, 23.16 dBm
(4) 450.0125 MHz, 23.09 dBm



Plot #7: **RF Output Power with 1 RF signal input/output**
Fc: 470 MHz, RF Input: 10 dBm

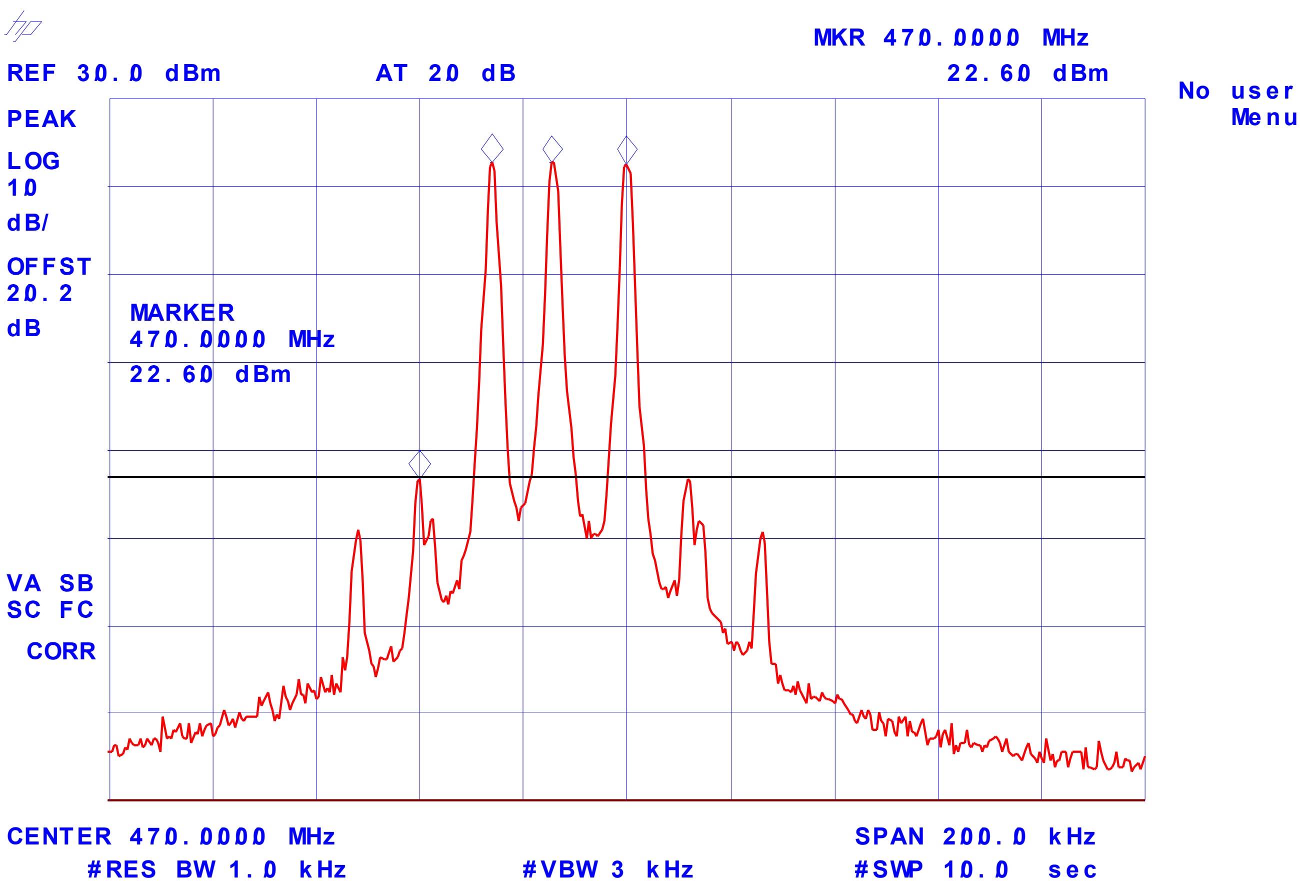


Plot #8: **RF Output Power/intermodulation with 2 RF signal input/output**
Fc: 470 MHz, Fc-12.5 kHz
RF Input: (1) –51.81 dBm, (2) –52.05 dBm
(1) 469.9725 MHz, -13.20 dBm
(2) 469.9875 MHz, 24.32 dBm
(3) 470.0000 MHz, 24.36 dBm
(4) 470.0125 MHz, -14.06 dBm



Plot #9: **RF Output Power/intermodulation with 3 RF signal input/output**

Fc: 470 MHz, Fc-12.5 kHz, Fc-25 kHz
RF Input: (1) –55.46 dBm, (2) –55.42 dBm, (3) –55.42 dBm
(1) 469.9625 MHz, -13.27 dBm
(2) 469.9750 MHz, 22.69 dBm
(3) 469.9875 MHz, 22.62 dBm
(4) 470.0000 MHz, 22.60 dBm



6.6. RF EXPOSURE REQUIRMENTS @ 1.1310 & 2.1091

6.6.1. Limits

- **FCC 1.1310:**- The criteria listed in the following table shall be used to evaluate the environmental impact of human exposure to radio-frequency (RF) radiation as specified in 1.1307(b).

LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm^2)	Average Time (minutes)
(A) Limits for Occupational/Control Exposures				
300-1500	...	...	F/300	6
(B) Limits for General Population/Uncontrolled Exposure				
300-1500	...	...	F/1500	6

F = Frequency in MHz

6.6.2. Method of Measurements

Refer to FCC @ 1.1310, 2.1091 and Public Notice DA 00-705 (March 30, 2000)

- In order to demonstrate compliance with MPE requirements (see Section 2.1091), the following information is typically needed:

(1) Calculation that estimates the minimum separation distance (20 cm or more) between an antenna and persons required to satisfy power density limits defined for free space.
(2) Antenna installation and device operating instructions for installers (professional/unskilled users), and the parties responsible for ensuring compliance with the RF exposure requirement
(3) Any caution statements and/or warning labels that are necessary in order to comply with the exposure limits
(4) Any other RF exposure related issues that may affect MPE compliance

Calculation Method of RF Safety Distance:

$S = PG/4\Pi r^2 = EIRP/4\Pi r^2$

Where: P: power input to the antenna in mW
EIRP: Equivalent (effective) isotropic radiated power.
S: power density mW/cm^2
G: numeric gain of antenna relative to isotropic radiator
r: distance to centre of radiation in cm

FCC radio frequency exposure limits may be exceeded at distances closer than r cm from the antenna of this device

$r = \sqrt{PG/4\Pi S}$

FCC radio frequency exposure limits may not be exceeded at distances closer than r cm from the antenna of this device

- For portable transmitters (see Section 2.1093), or devices designed to operate next to a person's body, compliance is determined with respect to the SAR limit (define in the body tissues) for near-field exposure conditions. If the maximum average output power, operating condition configurations and exposure conditions are comparable to those of existing cellular and PCS phones., an SAR evaluation may be required in order to determine if such a device complies with SAR limit. When SAR evaluation data is not available, and the additional supporting information cannot assure compliance, the Commission may request that an SAR evaluation be performed, as provided for in Section 1.1307(d)

6.6.3. Test Data

Antenna Gain Limit specified by Manufactuer: 10 dBi

Frequency (MHz)	Measured RF Conducted (dBm)	Calculated EIRP (dBm)	Laboratory's Recommended Minimum RF Safety Distance r (cm)
450	38.1	48.1	138

Note 1: **RF EXPOSURE DISTANCE LIMITS:** $r = (PG/4\Pi S)^{1/2} = (EIRP/4\Pi S)^{1/2}$
For worst case: $S = F/1500 = 403/1500 = 0.269\ mW/cm^2$

Evaluation of RF Exposure Compliance Requirements	
RF Exposure Requirements	**Compliance with FCC Rules**
Minimum calculated separation distance between antenna and persons required: 138 cm	Manufacturer' instruction for separation distance between antenna and persons required: 10 meters Please refer to page # 25 of the Users/ Manual and FCC RF Exposure folder
Antenna installation and device operating instructions for installers (professional/unskilled users), and the parties responsible for ensuring compliance with the RF exposure requirement	Please refer to page # 25 of the Users/ Manual and FCC RF Exposure folder
Caution statements and/or warning labels that are necessary in order to comply with the exposure limits	Please refer to page # 25 of the Users/ Manual and FCC RF Exposure folder

6.7. FREQUENCY STABILITY @ FCC 2.1055 & 90.213

6.7.1. Limits @ FCC 90.213

Please refer to FCC CFR 47, Part 90, Subpart I, Para. 90.213 for specification details.

FREQUENCY RANGE (MHz)	FIXED & BASE STATIONS (ppm)	
	12.5 kHz	25 kHz
403-512 MHz	1.5	2.5

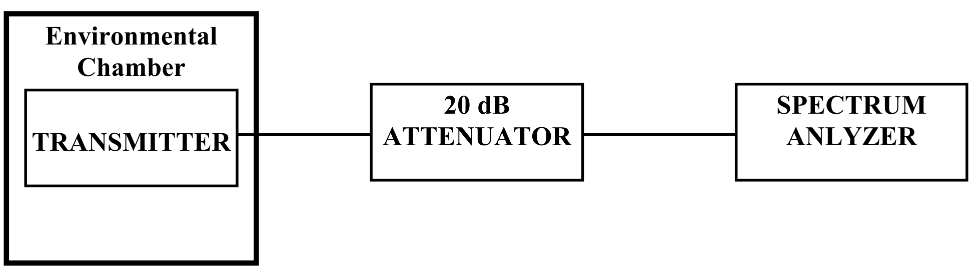
6.7.2. Method of Measurements

Refer to Exhibit 8, § 8.3 of this report for measurement details

6.7.3. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range
EMI Receiver/ EMI Receiver	Hewlett Packard	HP 8593EM	3412A00103	9 kHz – 26.5 GHz
Attenuator(s)	Bird	..	…	DC – 22 GHz
Temperature & Humidity Chamber	Tenney	T5	9723B	-40^o to $+60^o$ C range

6.7.4. Test Arrangement



6.7.5. Test Data

Product Name: **Model No.:**	**Bi-Directional Amplifier** **SB400**
Center Frequency:	403 MHz
Full Power Level:	38.1 dBm
Frequency Tolerance Limit:	±1.5 ppm (the most stringent limit for both 12.5 kHz & 25 kHz channel spacing)
Max. Frequency Tolerance Measured:	-123 Hz or –0.305 ppm
Input Voltage Rating:	120 Vac 60 Hz

CENTER FREQUENCY & RF POWER OUTPUT VARIATION			
Ambient Temperature (^oC)	**Supply Voltage (Nominal) 120 Volts AC**	**Supply Voltage (85% of Nominal) 102 Volts AC**	**Supply Voltage (115% of Nominal) 138 Volts AC**
	Hz	**Hz**	**Hz**
-30	-123	N/A	N/A
+20	-9	-8	-11
+50	-117	N/A	N/A

6.8. EMISSION MASK @ FCC 2.1049, 90.208 & 90.210

6.8.1. Limits @ FCC 90.209 & 90.210

Emissions shall be attenuated below the mean output power of the transmitter as follows:

Frequency Range (MHz)	Maximum Authorized BW (KHz)	Channel Spacing (KHz)	Recommended Frequency Deviation (KHz)	FCC Applicable Mask
403-512	20.0	25.0	5.0	• Mask B – Voice • Mask C – Data
403-512	11.25	12.5	2.5	• Mask D – Voice & Data

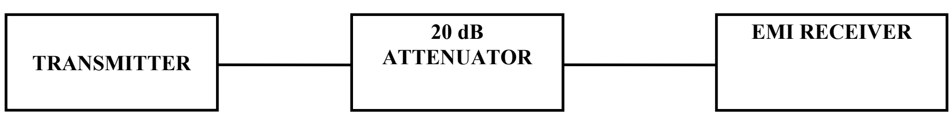
6.8.2. Method of Measurements

Refer to Exhibit 8, § 8.4 of this report for measurement details

6.8.3. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range
EMI Receiver/ EMI Receiver	Hewlett Packard	HP 8593EM	3412A00103	9 kHz – 26.5 GHz
Attenuator(s)	Bird	..	…	DC – 22 GHz
Audio Oscillator	Hewlett Packard	HP 204C	0989A08798	DC to 1.2 MHz

6.8.4. Test Arrangement



6.8.5. Test Data

Remark: Tests were performed on the RF Input and RF Output Signals for comparison purpose. The RF input signals from the signal generator are the same at all frequencies; therefore only 1 rf input signal plot is provided for review.

6.8.5.1. 20 dB Bandwidth and Gain of the Amplifier

Refer to Plot # 10-12 for detailed measurements of 20 dB and maximum gain of the Amplifier

6.8.5.2. 99% Occupied Bandwidth

Frequency (MHz)	Channel Spacing (kHz)	Modulation	Measured 99% OBW of RF Input Signal (kHz)	Measured 99% OBW of RF Output Signal (kHz)	Recommended 99% OBW (kHz)
406.1	12.5	FM Voice	10.4	10.4	11.25
450.0	12.5	FM Voice	10.4	10.4	11.25
470.0	12.5	FM Voice	10.4	10.4	11.25
▪ Refer to Plots 13 to 16 below for the details of the above measurements					
406.1	25	FM Voice	15.6	15.6	20.0
450.0	25	FM Voice	15.6	15.6	20.0
470.0	25	FM Voice	15.6	15.6	20.0
▪ Refer to Plots 17 to 20 below for the details of the above measurements					
406.1	12.5	FM Data	11.6	11.6	11.25
450.0	12.5	FM Data	11.6	11.6	11.25
470.0	12.5	FM Data	11.6	11.6	11.25
▪ Refer to Plots 21 to 24 below for the details of the above measurements					
406.1	25	FM Data	17.5	17.6	20.0
450.0	25	FM Data	17.5	17.7	20.0
470.0	25	FM Data	17.5	17.7	20.0
▪ Refer to Plots 25 to 28 below for the details of the above measurements					

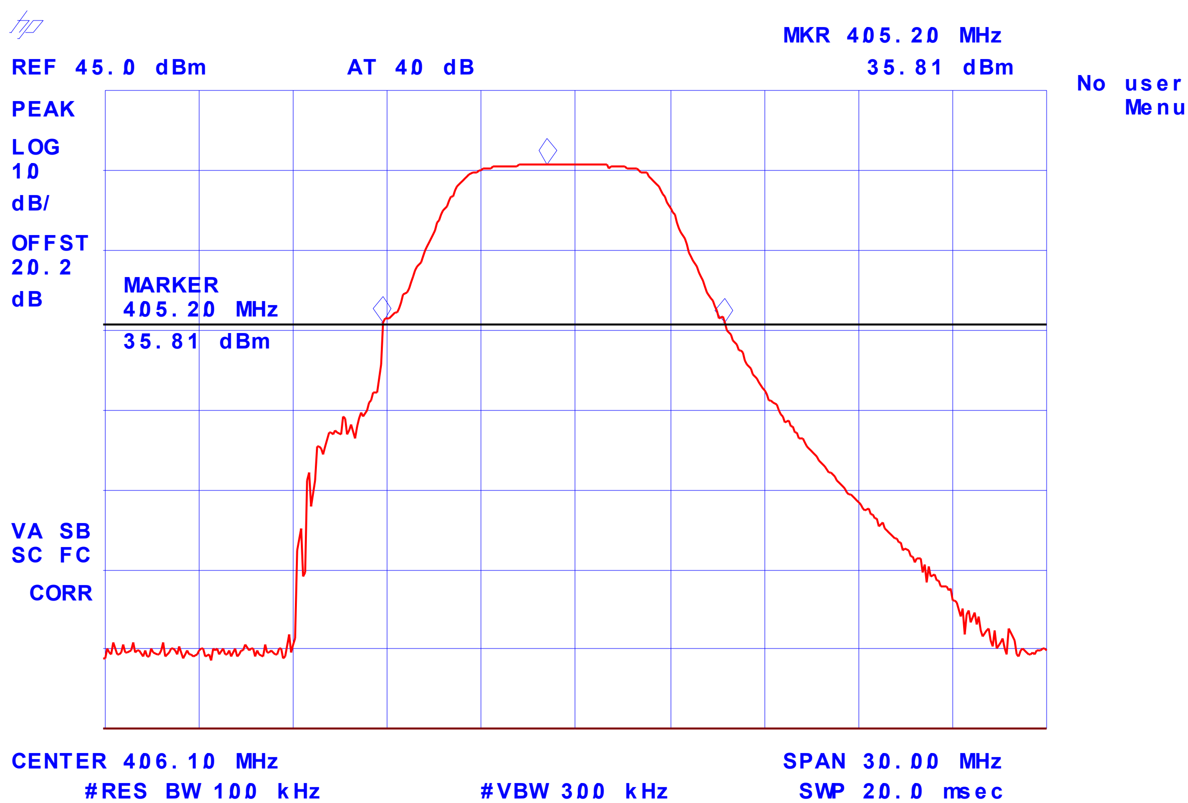
6.8.5.3. Emission Masks

Conform.

- Refer to Plots 29 to 32 for Emissions Mask D with FM Voice modulation, 12.5 kHz Channel Spacing
- Refer to Plots 33 to 36 for Emissions Mask D with FM Voice modulation, 12.5 kHz Channel Spacing
- Refer to Plots 37 to 40 for Emissions Mask B with FM Data modulation, 25 kHz Channel Spacing
- Refer to Plots 41 to 44 for Emissions Mask C with FM Data modulation, 25 kHz Channel Spacing

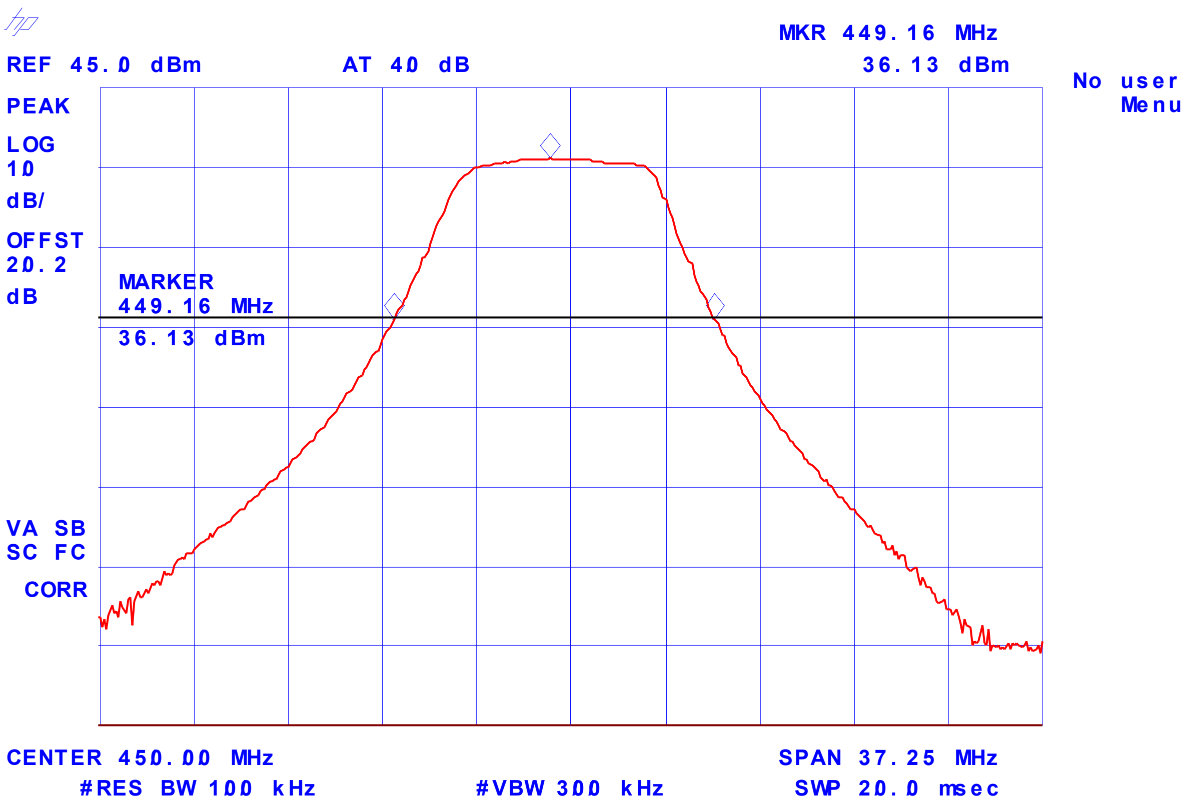
Plot# 10 : 20 dB BW of the 403 – 512 MHz band pass gain

RF Input: 10 dBm, Tracking from 400 – 600 MHz
Max. Gain: 25.8 dB
(1) 399.95 MHz, (2) 410.83 MHz

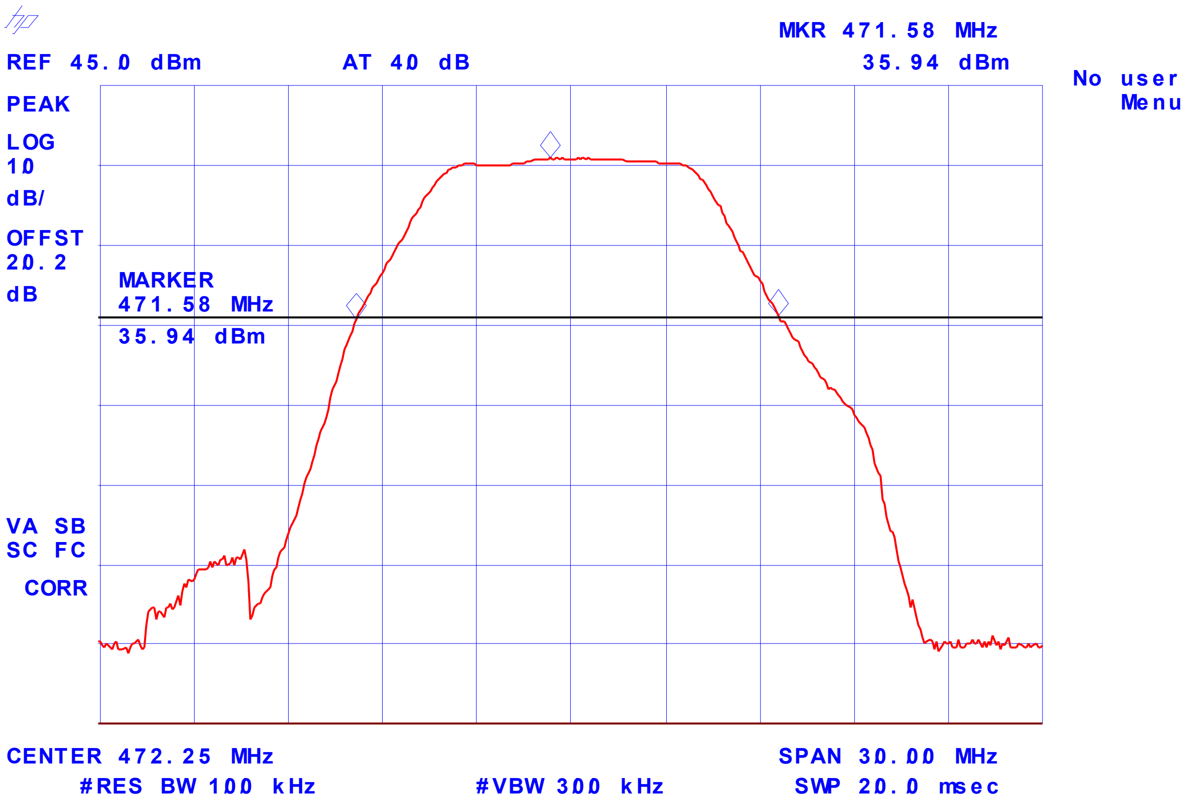


Plot# 11 : 20 dB BW of the 403 – 512 MHz band pass gain

RF Input: 10 dBm, Tracking from 400 – 600 MHz
Max. Gain: 26.1 dB
(1) 443.02 MHz, (2) 455.68 MHz

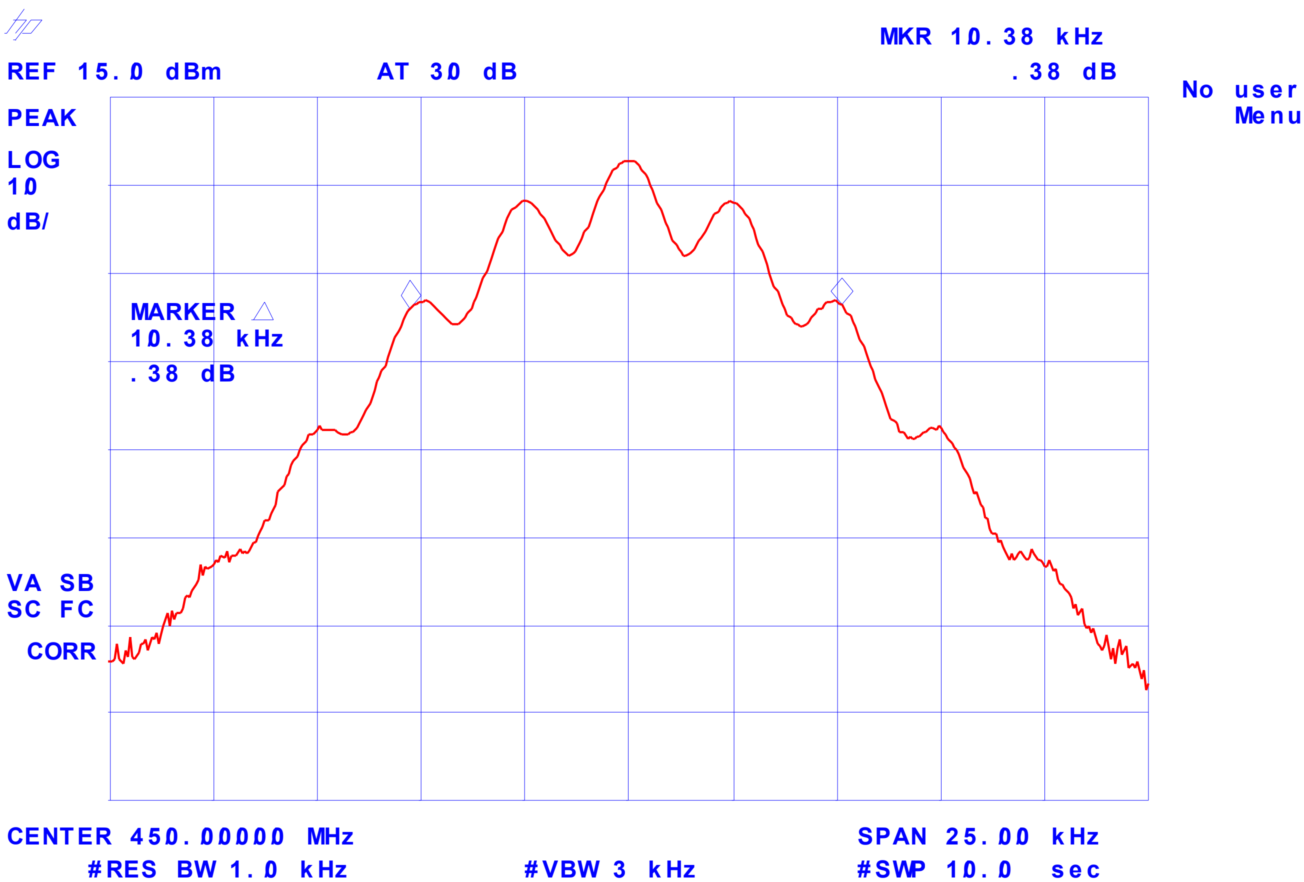


Plot# 12 : **20 dB BW of the 403 – 512 MHz band pass gain**
RF Input: 10 dBm, Tracking from 400 – 600 MHz
Max. Gain: 26 dB
(1) 465.43 MHz, (2) 478.85 MHz



Plot # 13: 99% OBW of RF Input, RF Input Level = 10 dBm as maximum rated by the manufacturer

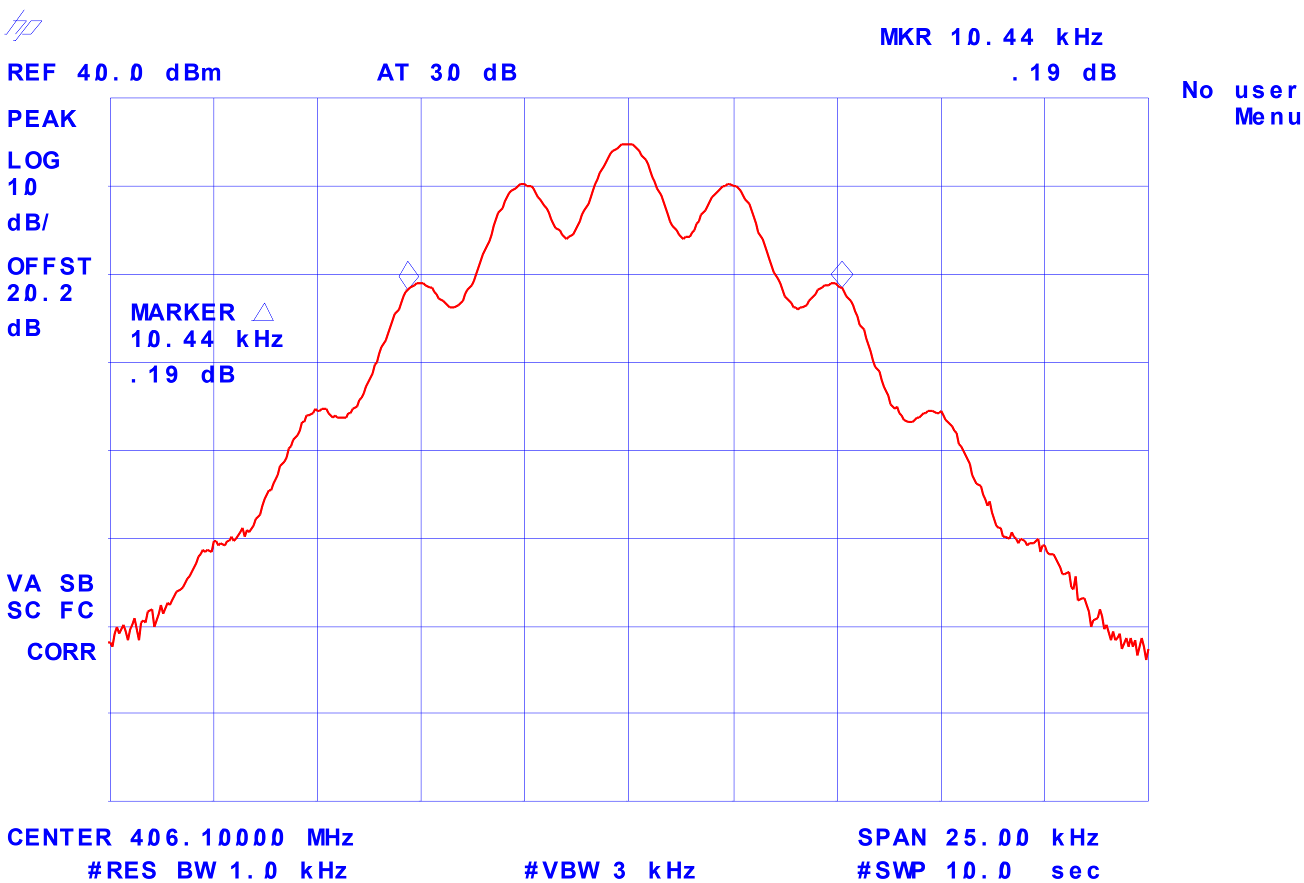
Mid Channel, 450 MHz, 12..5 kHz Channel Spacing
FM Modulation with 2.5 kHz Sine wave signal, 2.5 kHz Deviation



- *All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)*

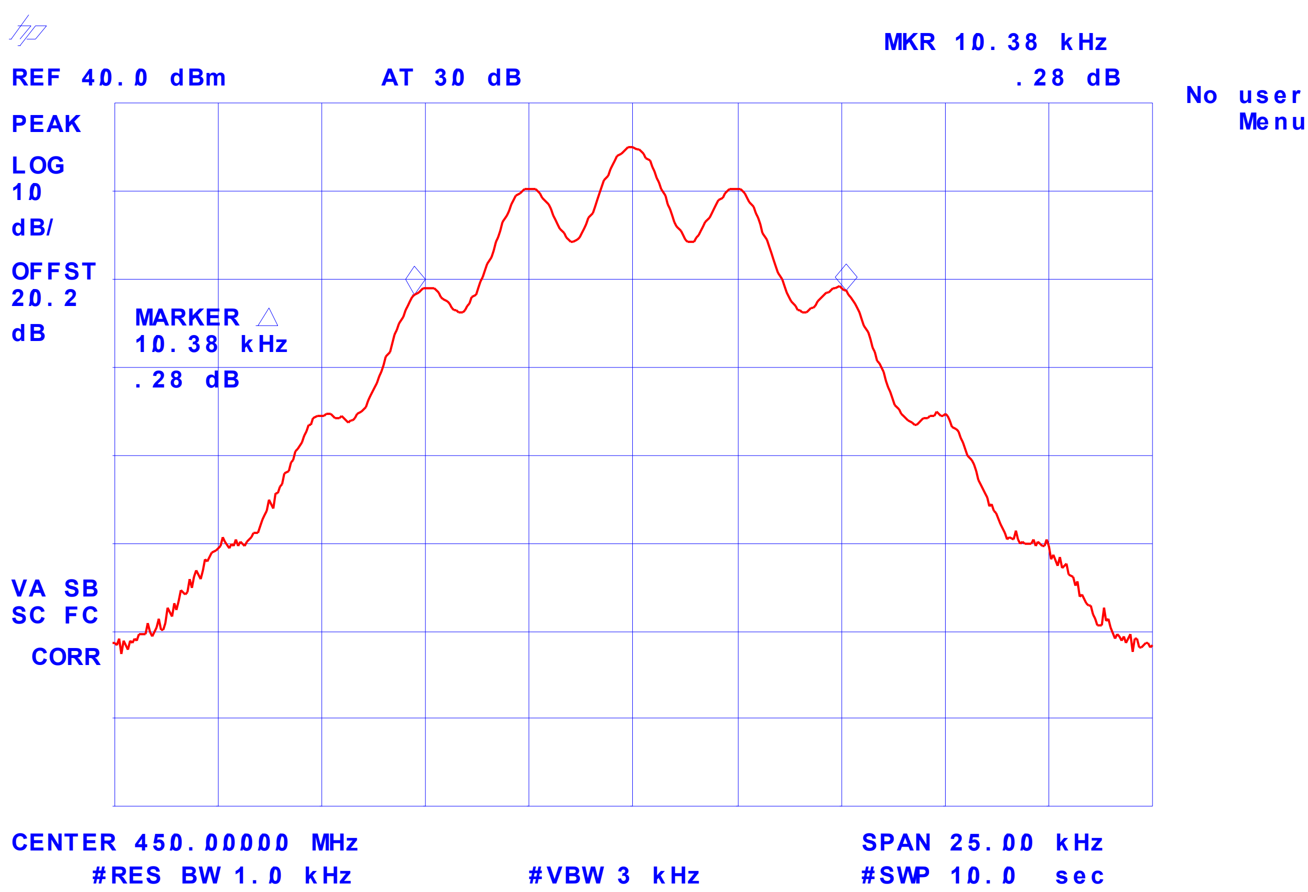
Plot # 14: 99% OBW of RF Output Signal

Low Channel, 406.1 MHz, 12.5 kHz Channel Spacing
FM Modulation with 2.5 kHz Sine wave signal, 2.5 kHz Deviation



Plot # 15: 99% OBW of RF Output Signal

Mid Channel, 450 MHz, 12.5 kHz Channel Spacing
FM Modulation with 2.5 kHz Sine wave signal, 2.5 kHz Deviation

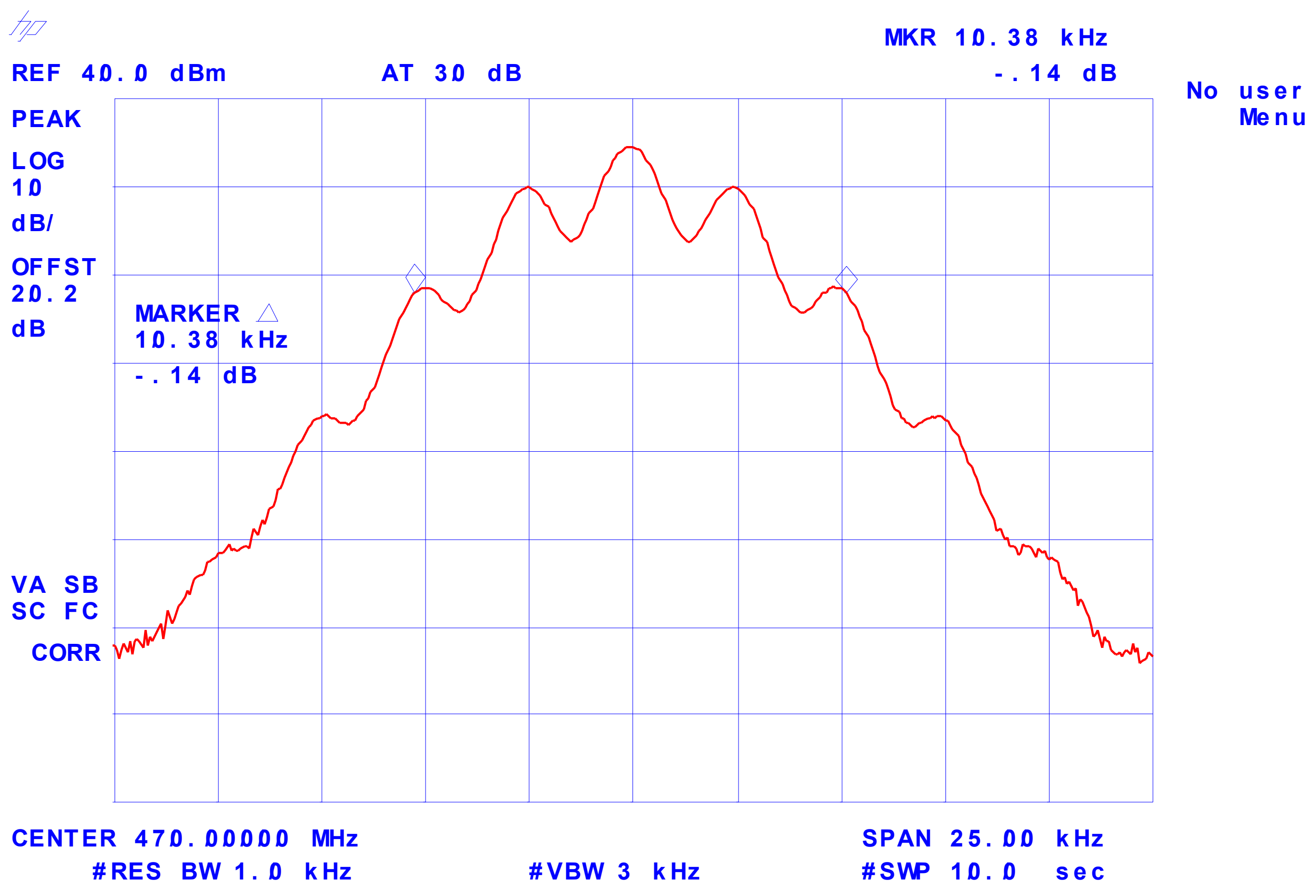


3000 Bristol Circle, Oakville, Ontario, Canada L6H 6G4
Tel. #: 905-829-1570, Fax. #: 905-829-8050, Email: vic@ultratech-labs.com, Website: http://www.ultratech-labs.com

- *All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)*

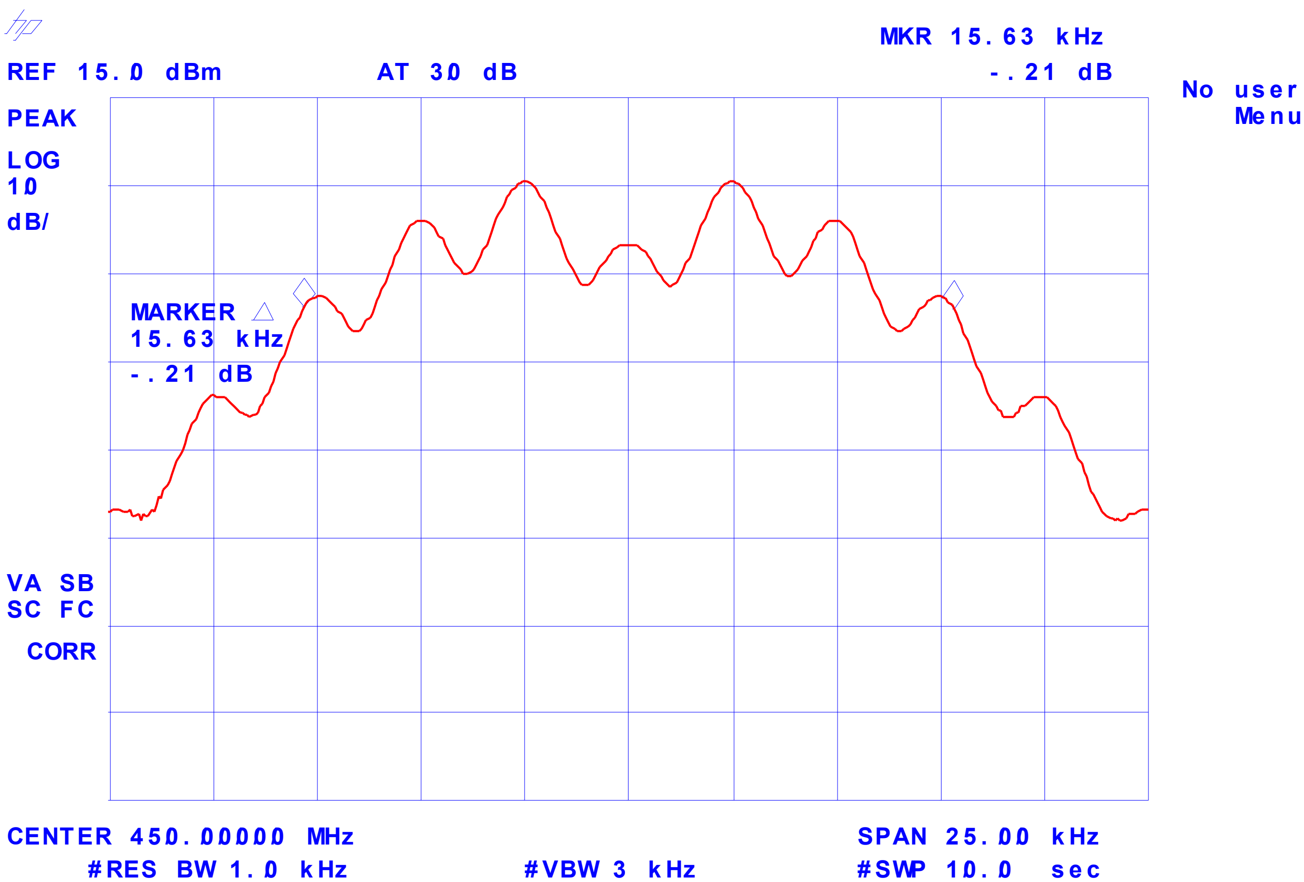
Plot # 16: 99% OBW of RF Output Signal

High Channel, 470 MHz, 12.5 kHz Channel Spacing
FM Modulation with 2.5 kHz Sine wave signal, 2.5 kHz Deviation



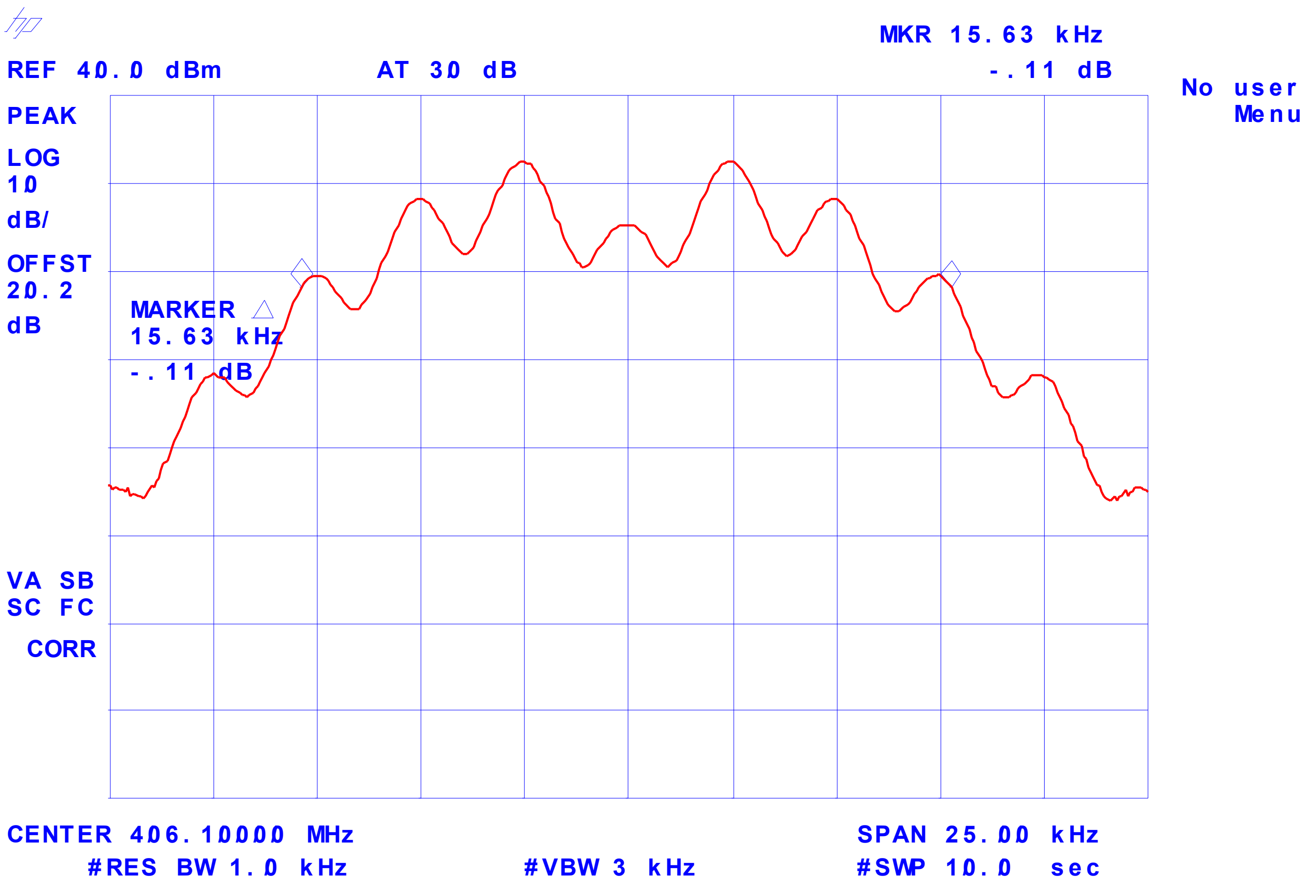
Plot # 17: 99% OBW of RF Input, RF Input Level = 10 dBm as maximum rated by the manufacturer

Mid Channel, 450 MHz, 25 kHz Channel Spacing
FM Modulation with 2.5 kHz Sine wave signal, 5 kHz Deviation



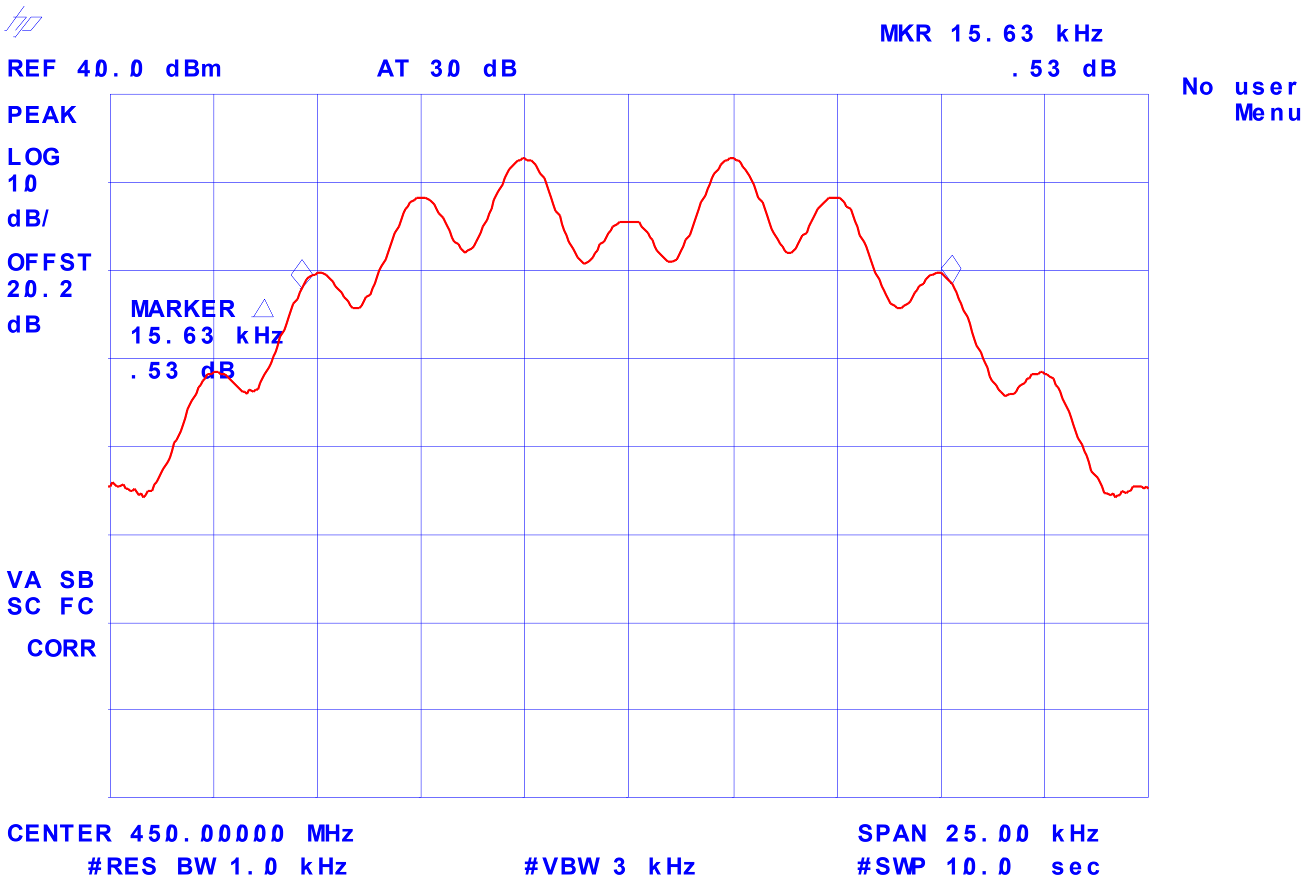
Plot # 18: 99% OBW of RF Output Signal

Low Channel, 406.1 MHz, 25 kHz Channel Spacing
FM Modulation with 2.5 kHz Sine wave signal, 5 kHz Deviation



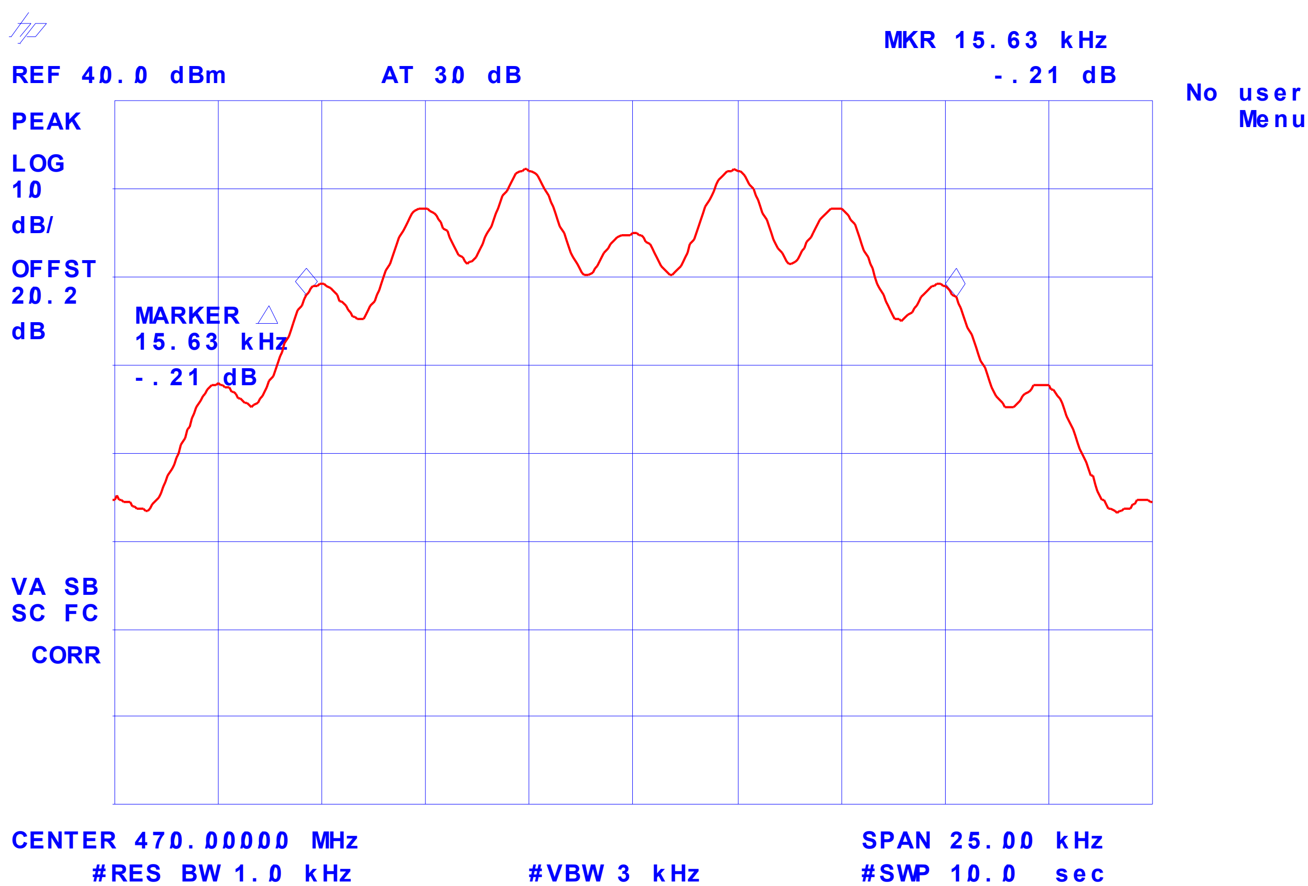
Plot # 19: 99% OBW of RF Output Signal

Mid Channel, 450 MHz, 25 kHz Channel Spacing
FM Modulation with 25 kHz Sine wave signal, 5 kHz Deviation



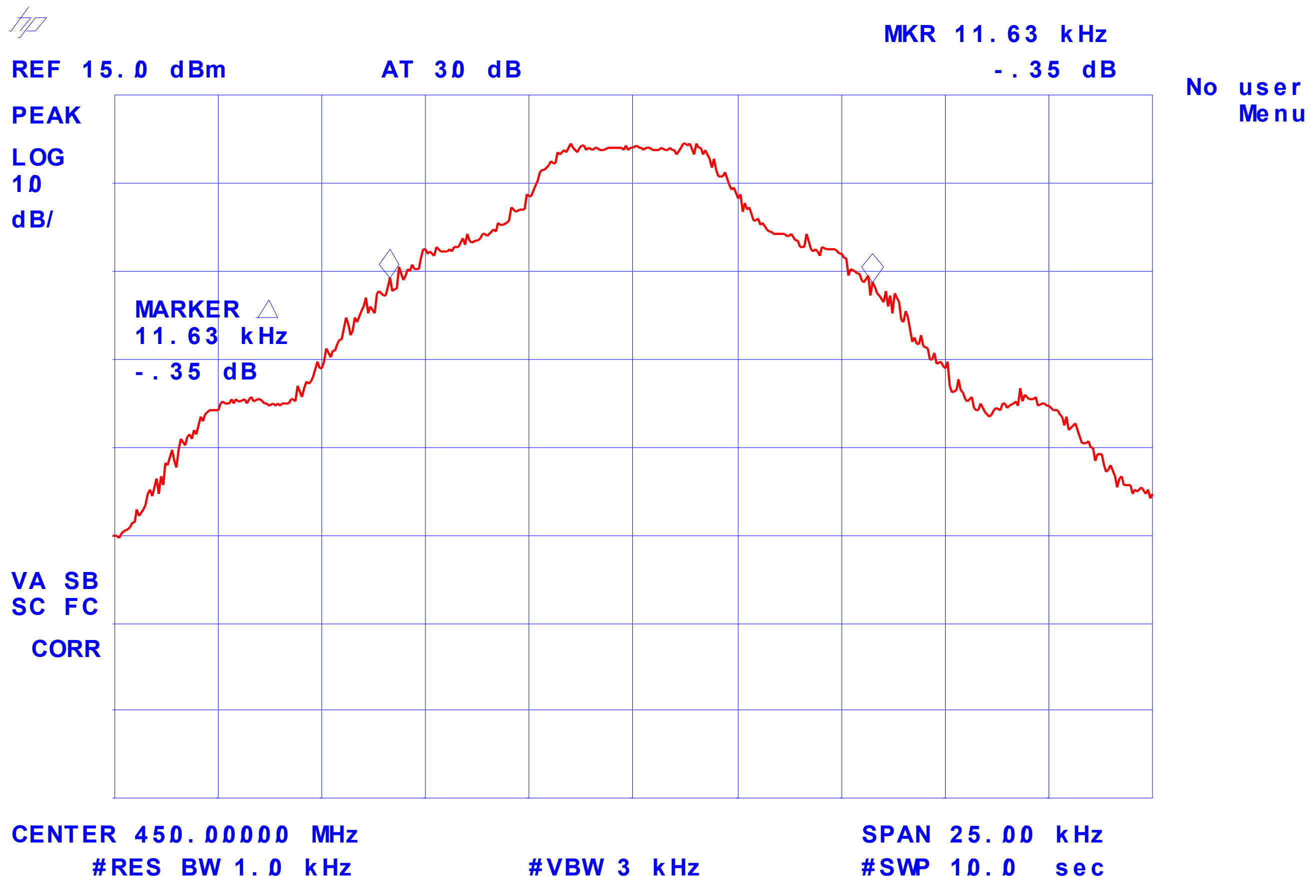
Plot # 20: 99% OBW of RF Output Signal

High Channel, 470 MHz, 25 kHz Channel Spacing
FM Modulation with 25 kHz Sine wave signal, 5 kHz Deviation



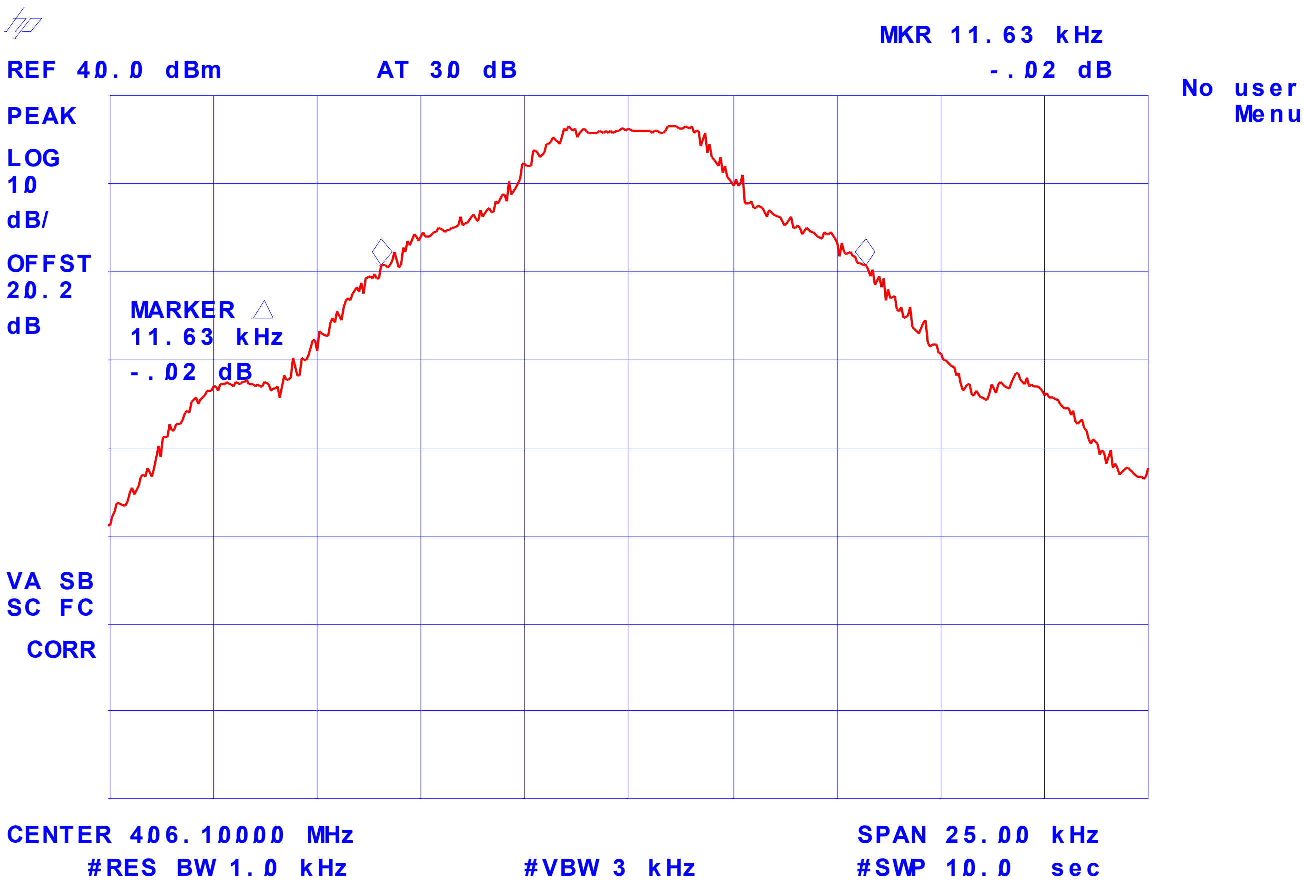
Plot # 21: 99% OBW of RF Input, RF Input Level = 10 dBm as maximum rated by the manufacturer

Mid Channel, 450 MHz, 12.5 kHz Channel Spacing
FM Modulation with 9600 b/s random data source, 2.5 kHz Deviation



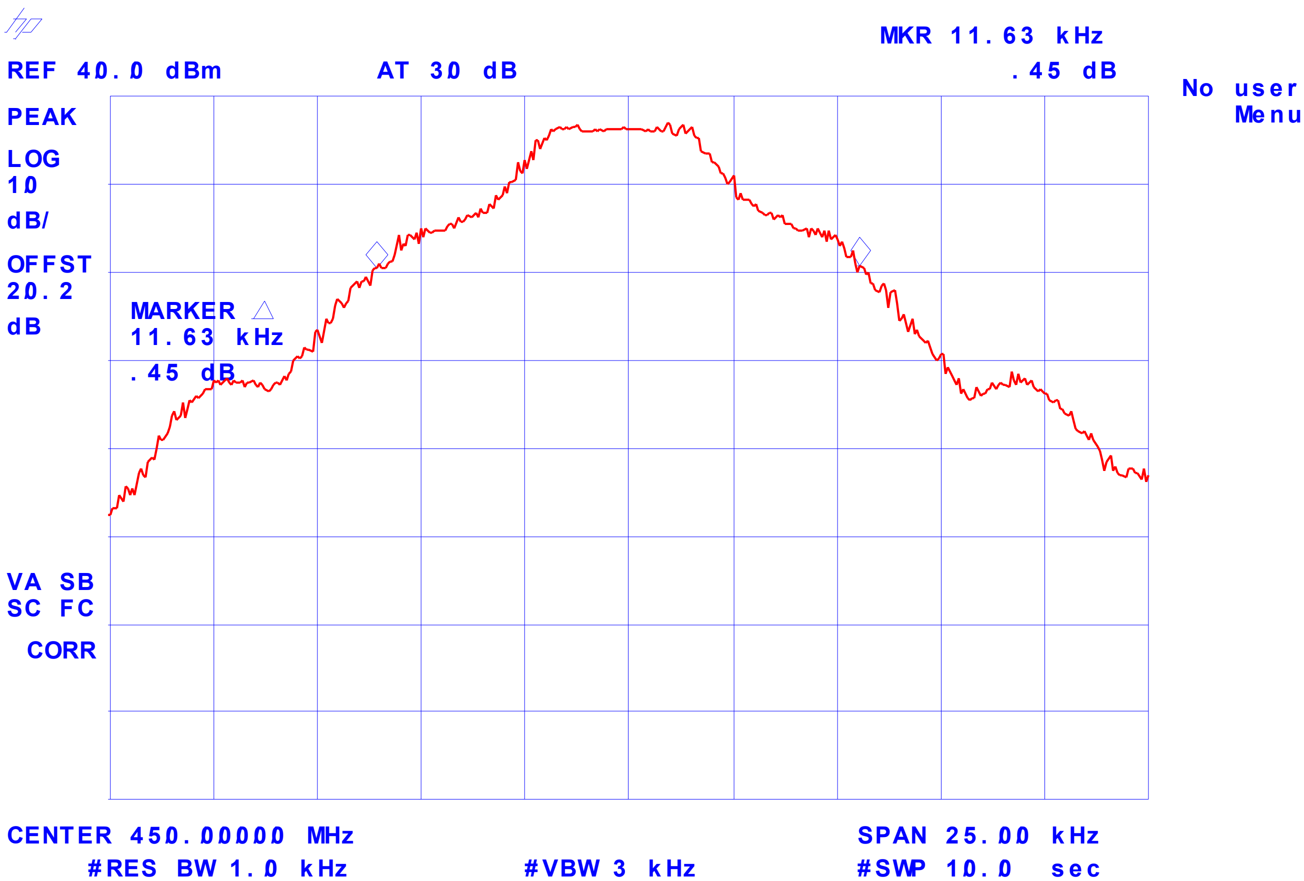
Plot # 22: 99% OBW of RF Output Signal

Low Channel, 406.1 MHz, 12.5 kHz Channel Spacing
FM Modulation with 9600 b/s random data source, 2.5 kHz Deviation



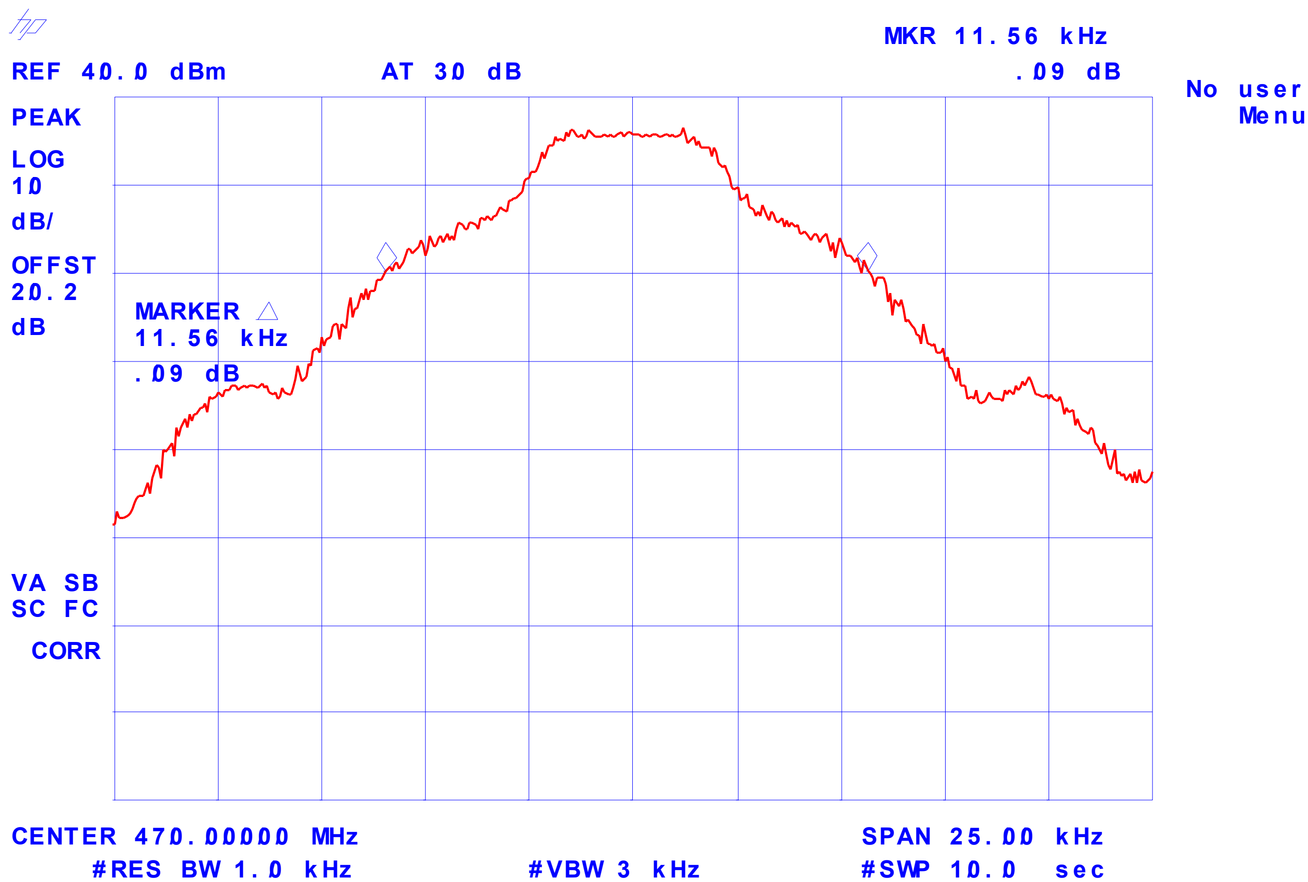
Plot # 23: 99% OBW of RF Output Signal

Mid Channel, 450 MHz, 12.5 kHz Channel Spacing
FM Modulation with 9600 b/s random data source, 2.5 kHz Deviation



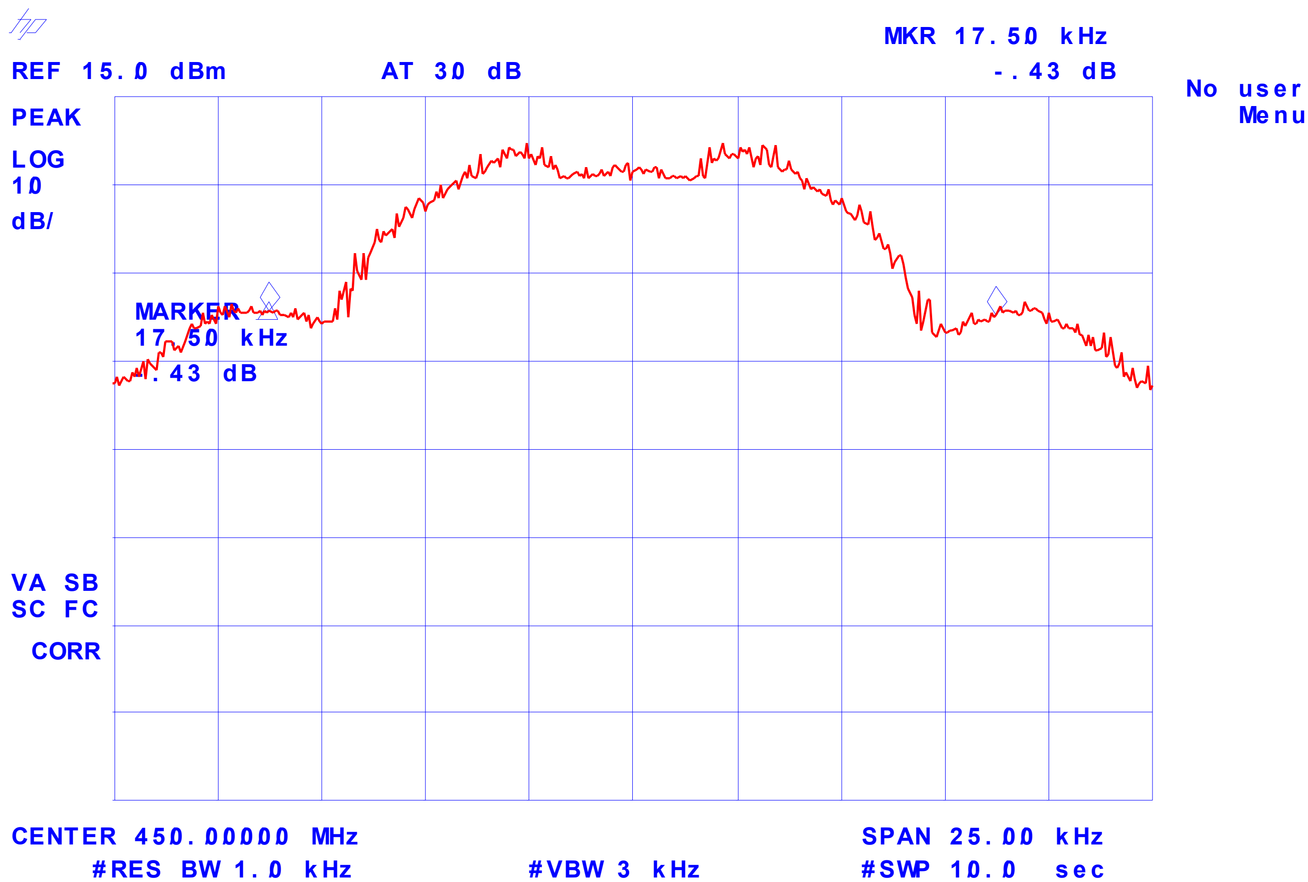
Plot # 24: 99% OBW of RF Output Signal

High Channel, 470 MHz, 12.5 kHz Channel Spacing
FM Modulation with 9600 b/s random data source, 2.5 kHz Deviation



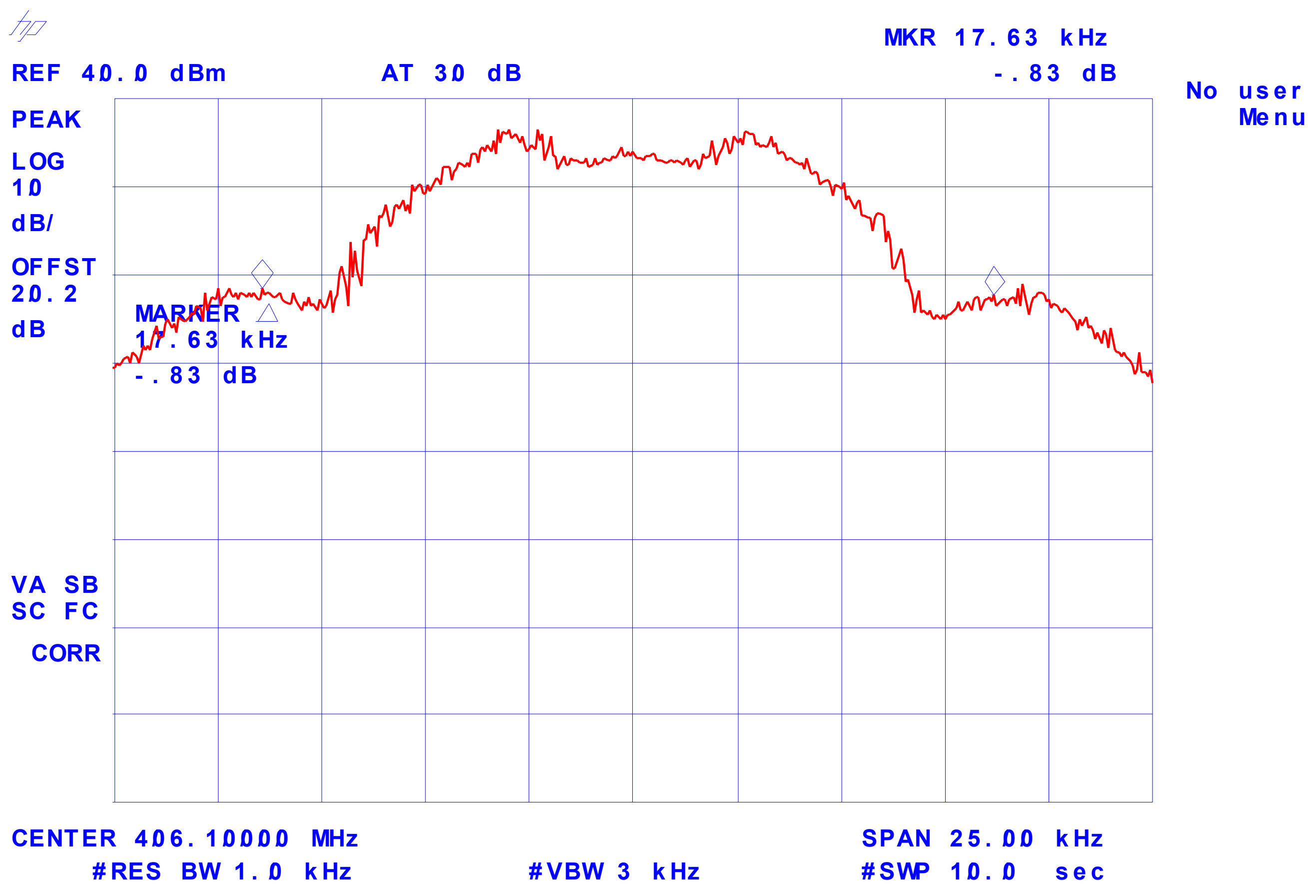
Plot # 25: 99% OBW of RF Input, RF Input Level = 10 dBm as maximum rated by the manufacturer

Mid Channel, 450 MHz, 25 kHz Channel Spacing
FM Modulation with 9600 b/s random data source, 5 kHz Deviation



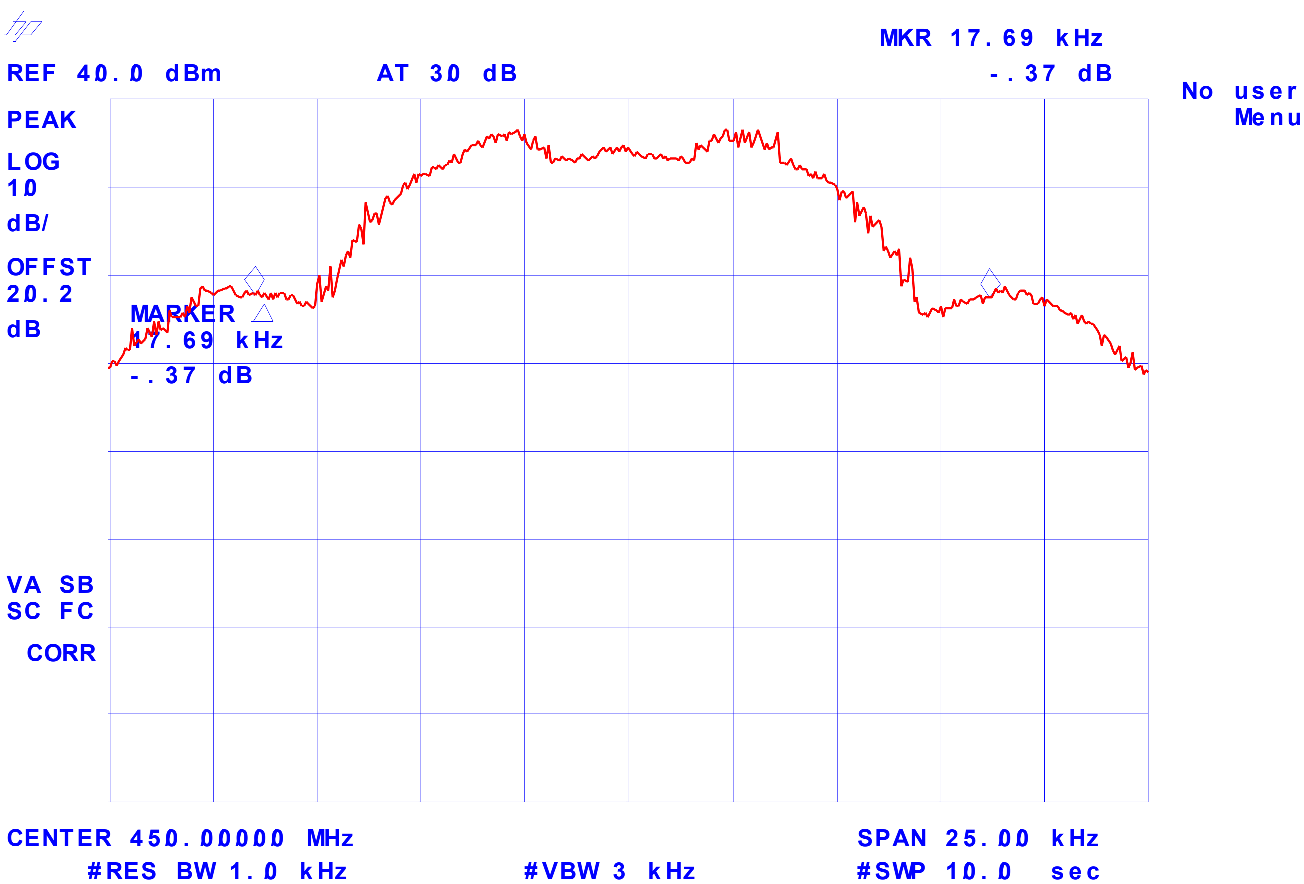
Plot # 26: 99% OBW of RF Output Signal

Low Channel, 406.1 MHz, 25 kHz Channel Spacing
FM Modulation with 9600 b/s random data source, 5 kHz Deviation



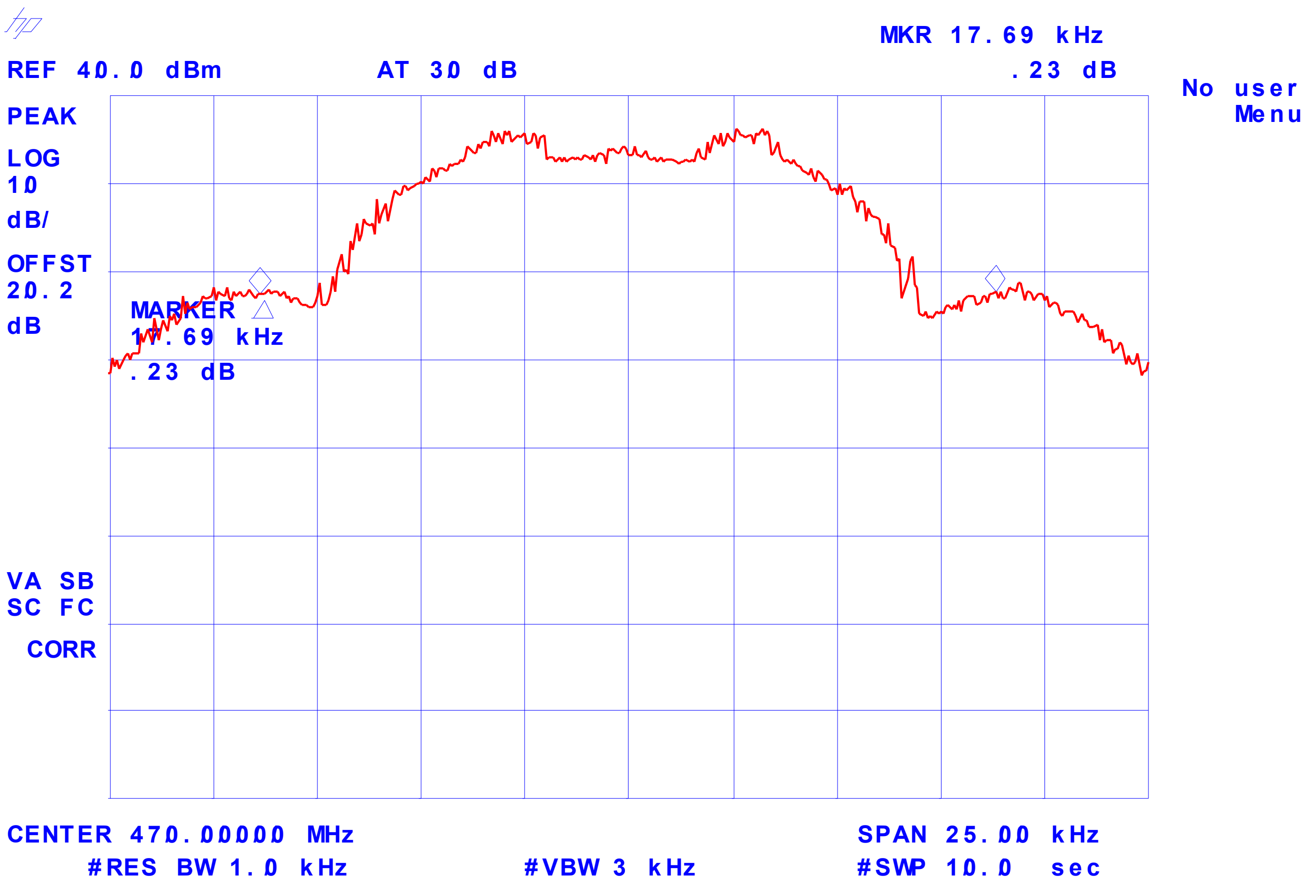
Plot # 27: 99% OBW of RF Output Signal

Mid Channel, 450 MHz, 25 kHz Channel Spacing
FM Modulation with 9600 b/s random data source, 5 kHz Deviation



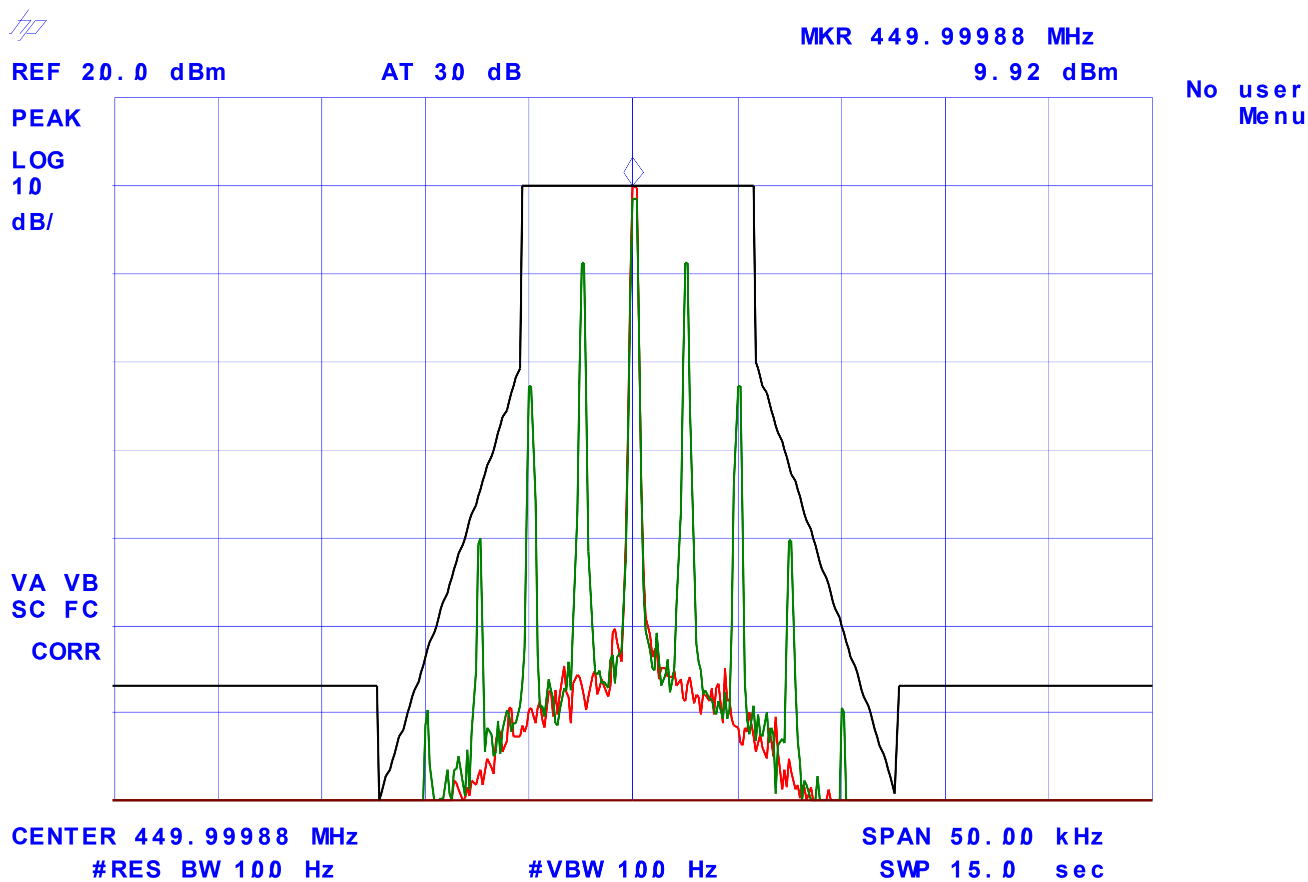
Plot # 28: 99% OBW of RF Output Signal

High Channel, 470 MHz, 25 kHz Channel Spacing
FM Modulation with 9600 b/s random data source, 5 kHz Deviation



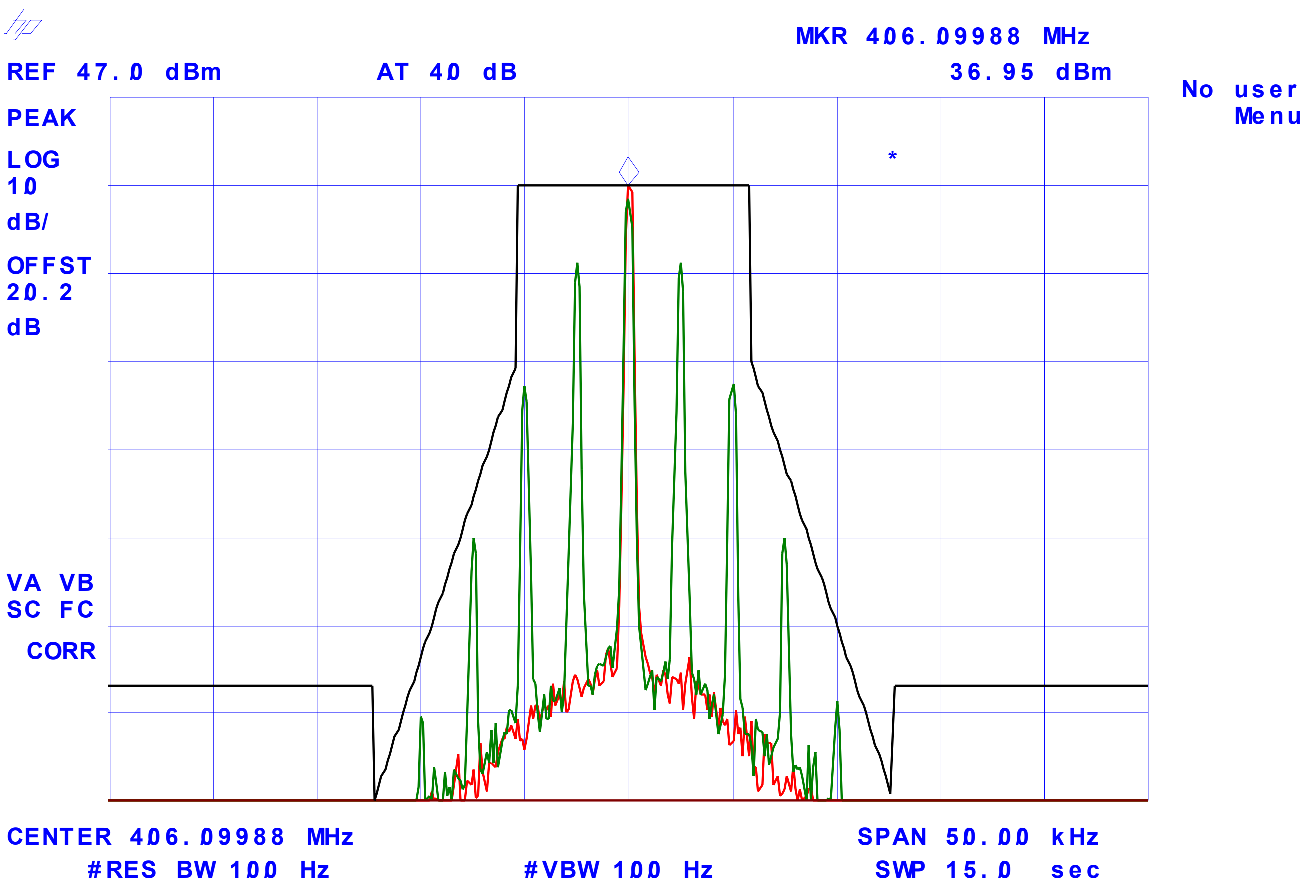
Plot # 29: Emission Mask D of RF Input Signal

RF Input Level = 10 dBm as maximum rated.
Mid Channel, 450 MHz, 12.5 kHz Channel Spacing
FM Modulation with 2.5 kHz Sine wave signal, 2.5 kHz Deviation



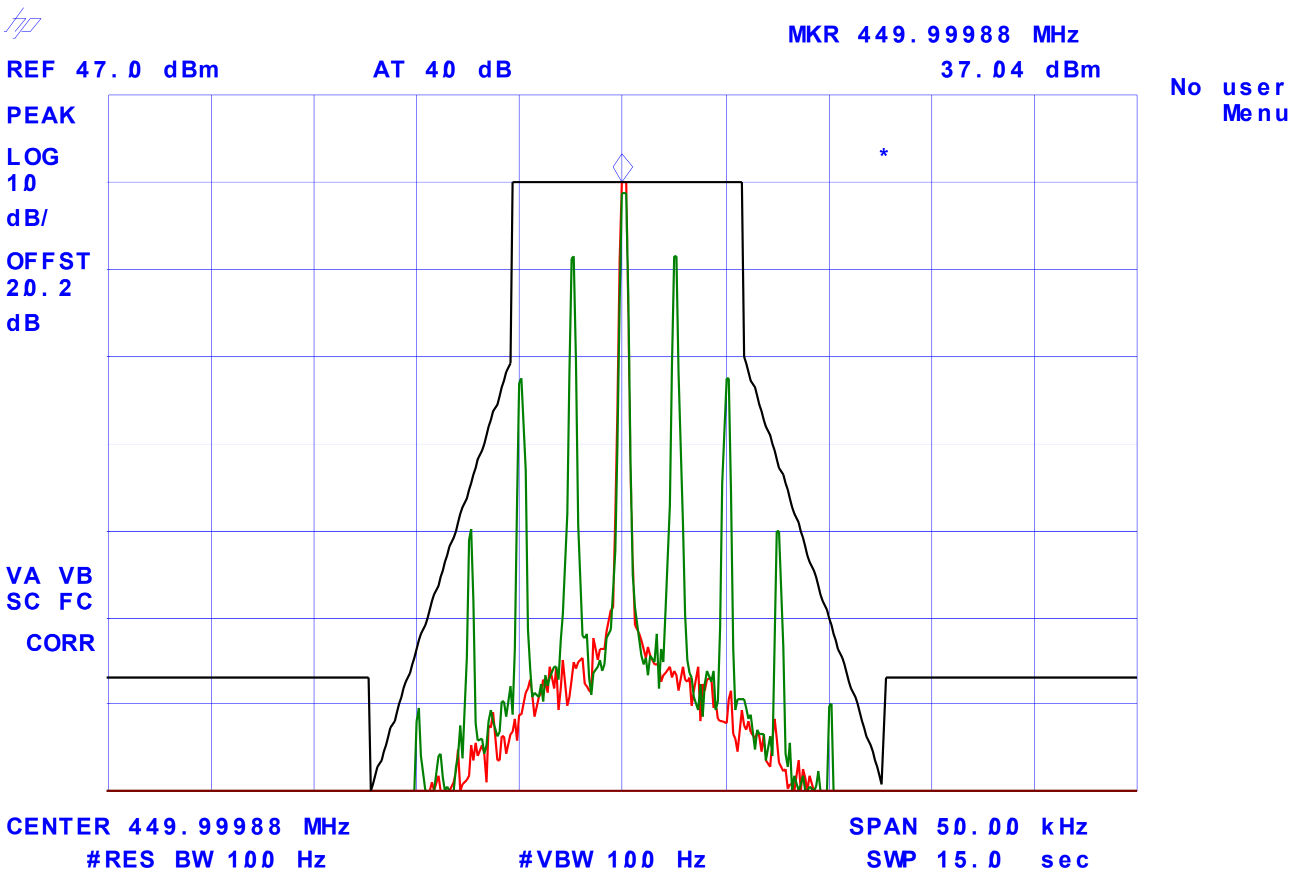
Plot # 30: Emission Mask D of RF Output Signal

Low Channel, 406.1 MHz, 12.5 kHz Channel Spacing
FM Modulation with 2.5 kHz Sine wave signal, 2.5 kHz Deviation



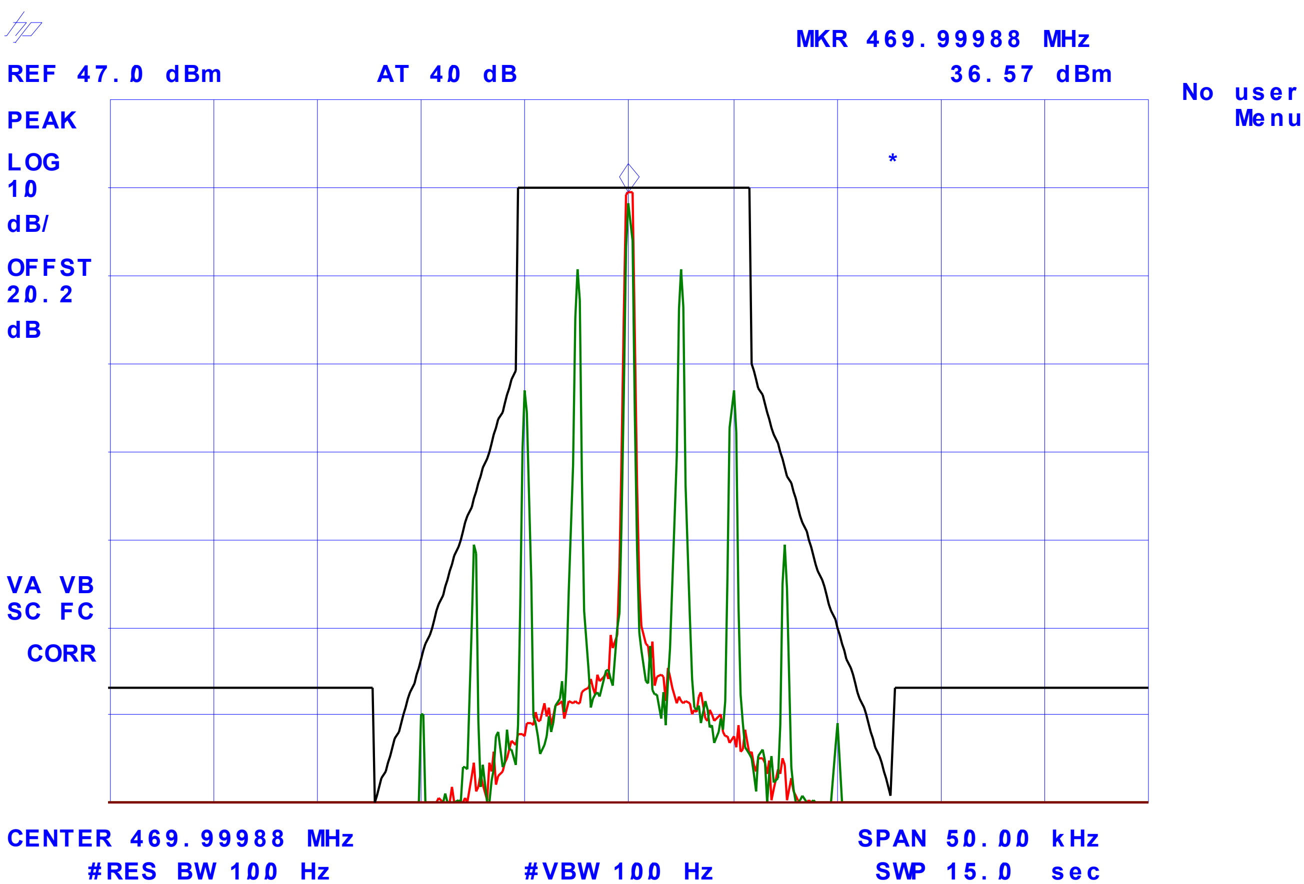
Plot # 31: Emission Mask D of RF Output Signal

Mid Channel, 450 MHz, 12.5 kHz Channel Spacing
FM Modulation with 2.5 kHz Sine wave signal, 2.5 kHz Deviation



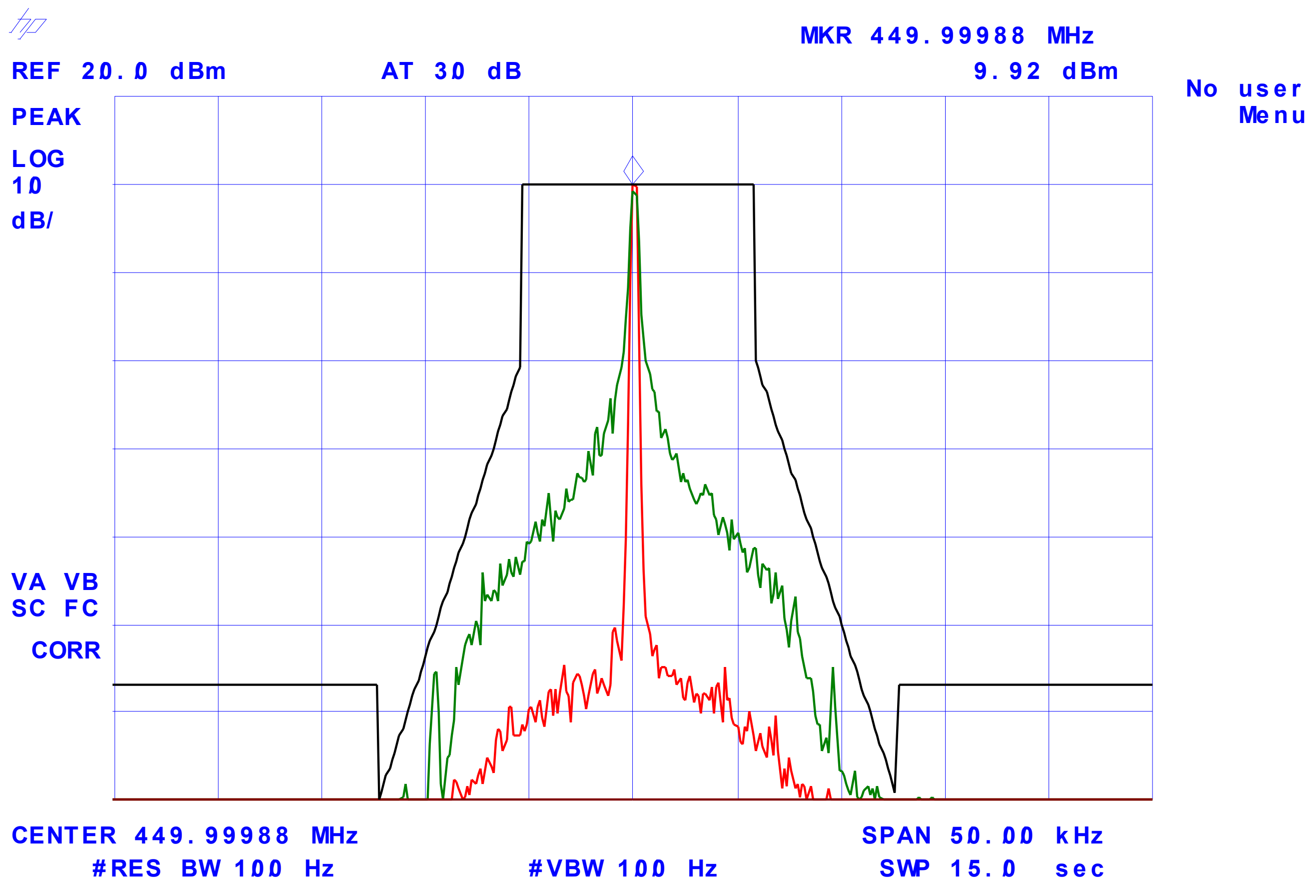
Plot # 32: Emission Mask D of RF Output Signal

High Channel, 470 MHz, 12.5 kHz Channel Spacing
FM Modulation with 2.5 kHz Sine wave signal, 2.5 kHz Deviation



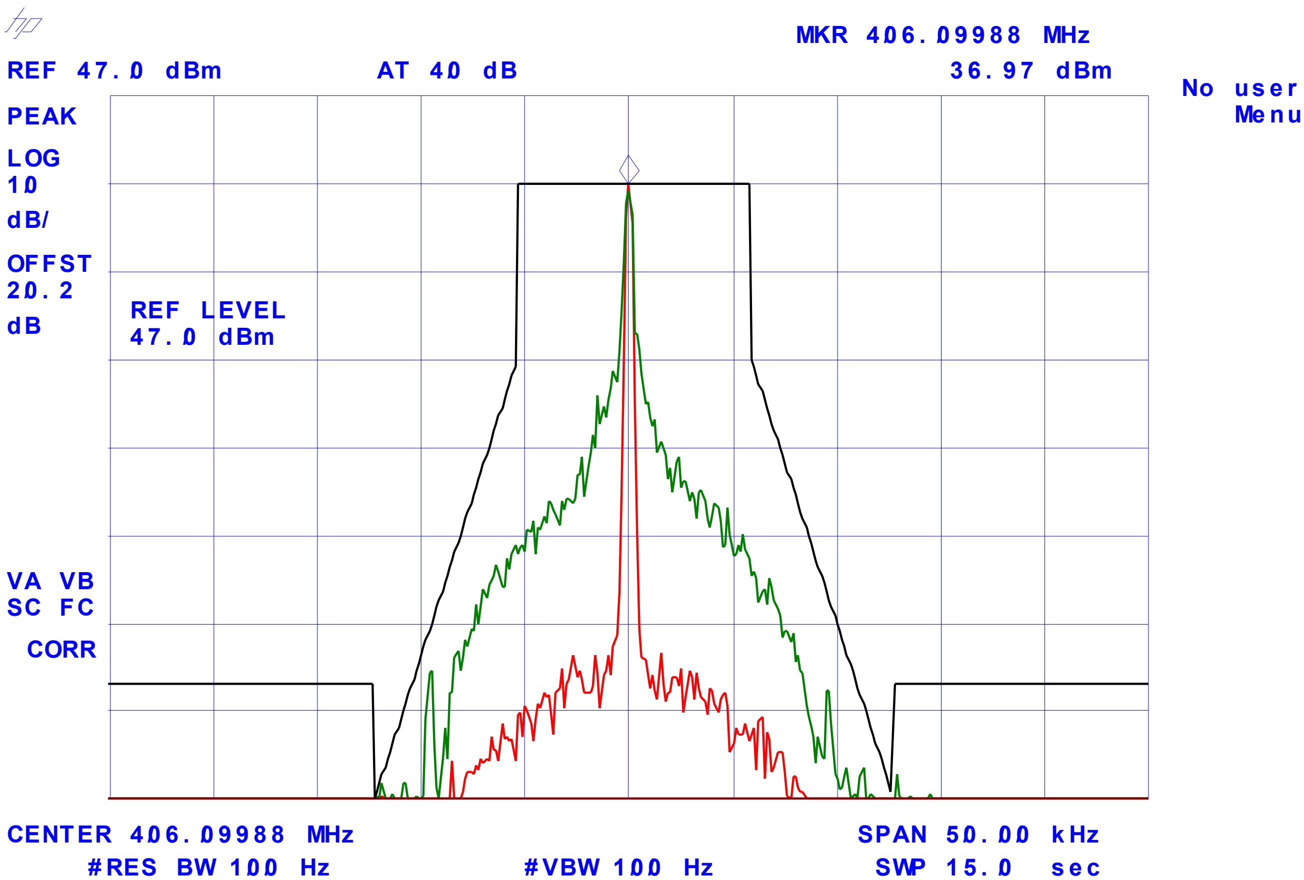
Plot # 33: Emission Mask D of RF Input Signal

RF Input Level = 10 dBm as maximum rated.
Mid Channel, 450 MHz, 12.5 kHz Channel Spacing
FM Modulation with 9600 b/s random data source, 2.5 kHz Deviation



Plot # 34: Emission Mask D of RF Output Signal

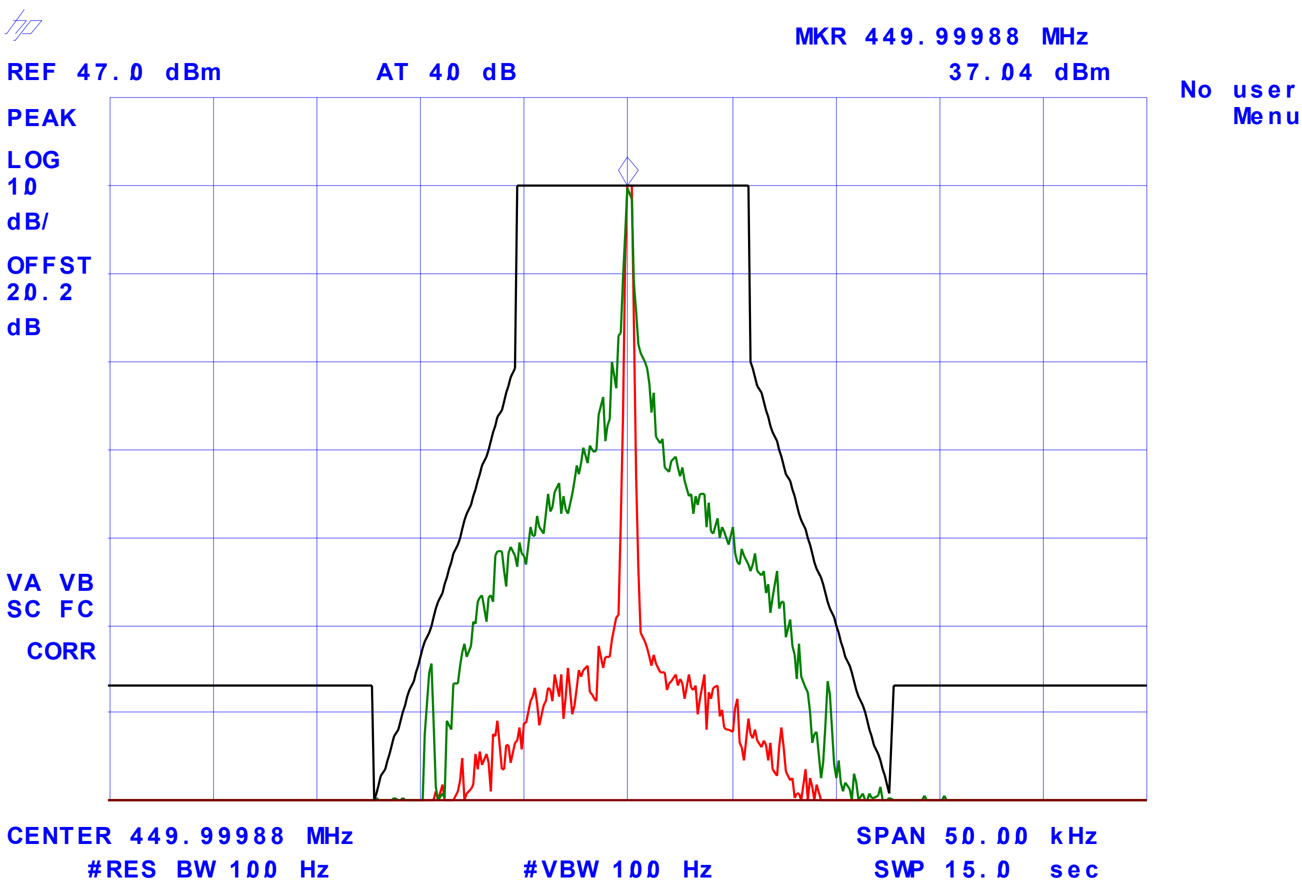
Low Channel, 406.1 MHz, 12.5 kHz Channel Spacing
FM Modulation with 9600 b/s random data source, 2.5 kHz Deviation



- *All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)*

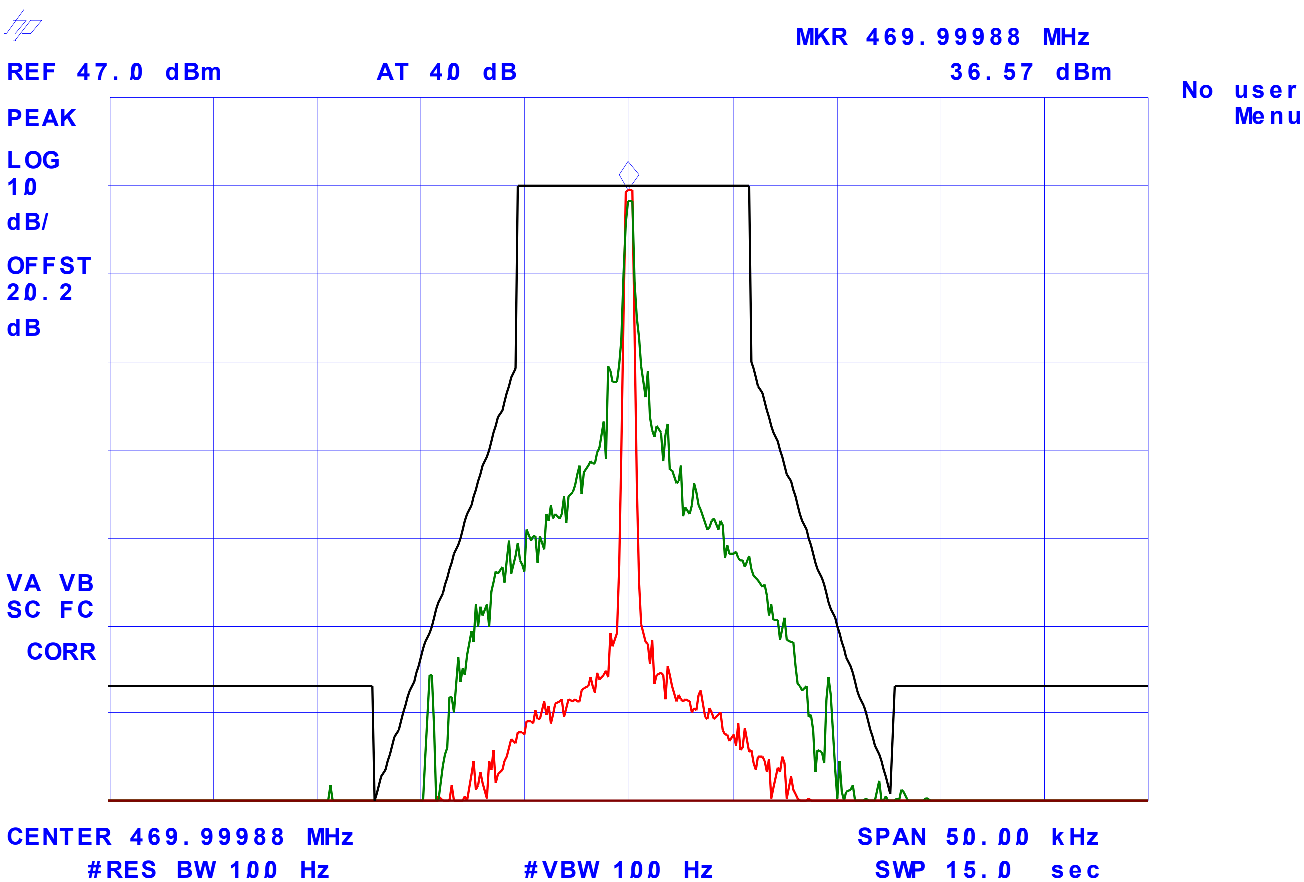
Plot # 35: Emission Mask D of RF Output Signal

Mid Channel, 450 MHz, 12.5 kHz Channel Spacing
FM Modulation with 9600 b/s random data source, 2.5 kHz Deviation



Plot # 36: Emission Mask D of RF Output Signal

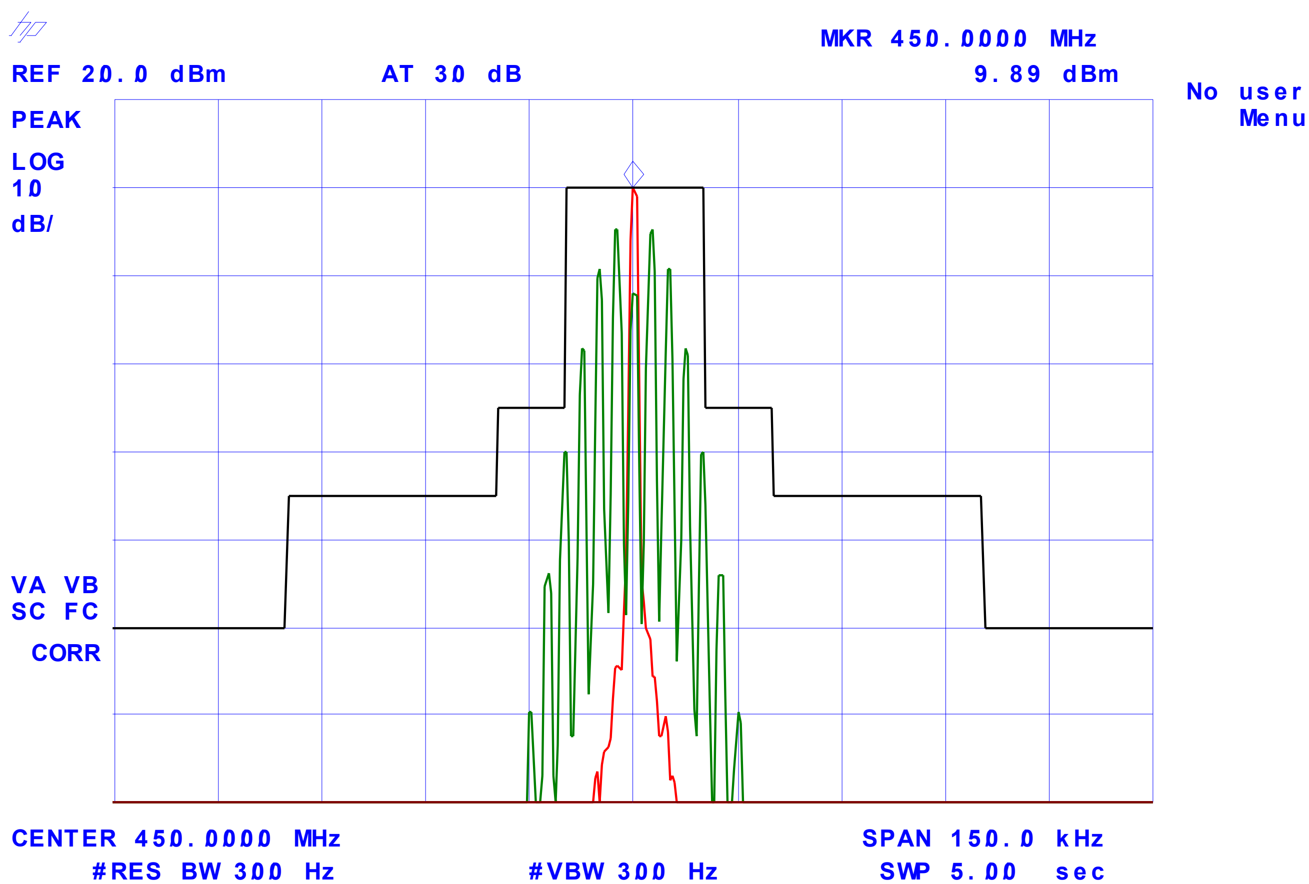
High Channel, 470 MHz, 12.5 kHz Channel Spacing
FM Modulation with 9600 b/s random data source, 2.5 kHz Deviation



- *All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)*

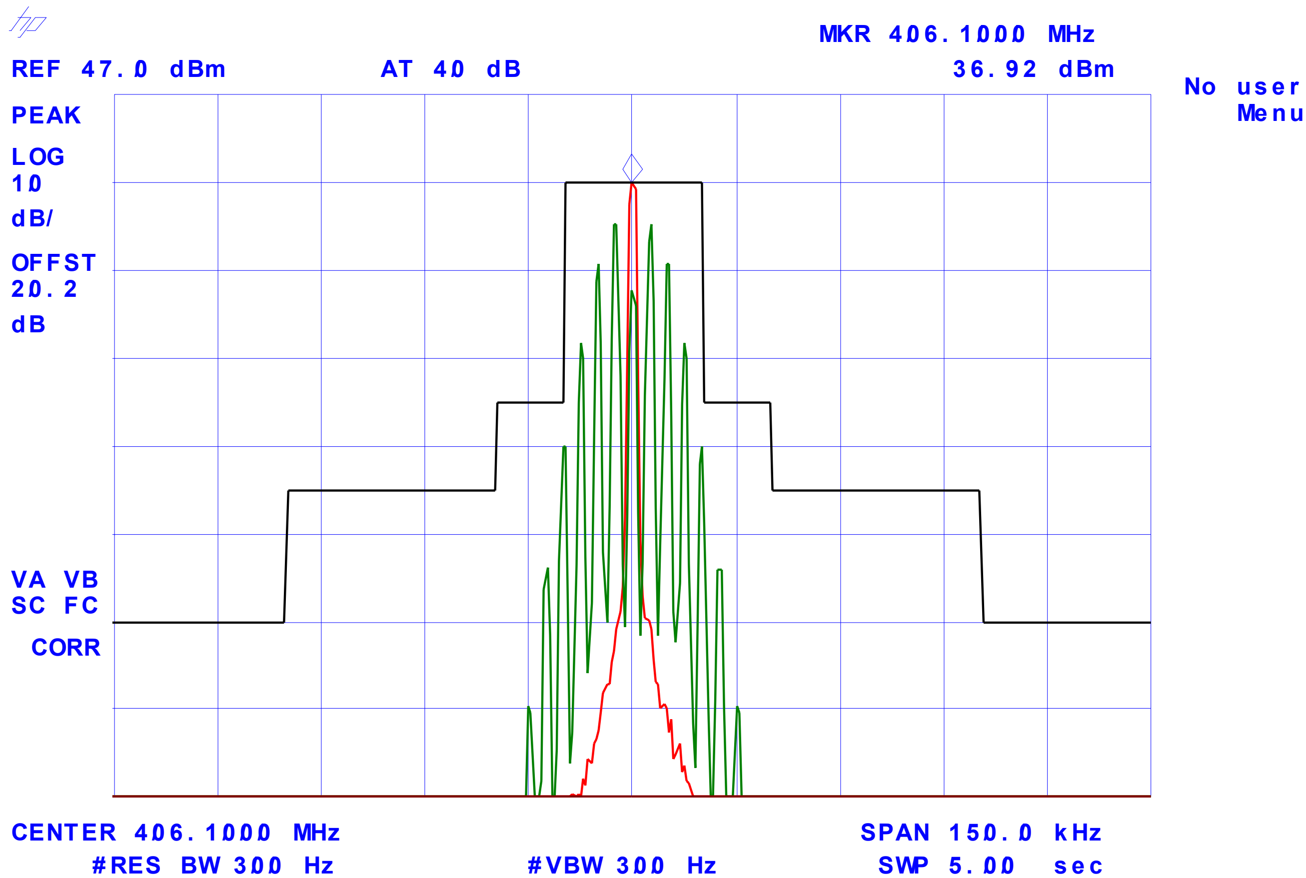
Plot # 37: Emission Mask B of RF Input Signal

RF Input Level = 10 dBm as maximum rated.
Mid Channel, 450 MHz, 25 kHz Channel Spacing
FM Modulation with 2.5 kHz Sine wave signal, 5 kHz Deviation



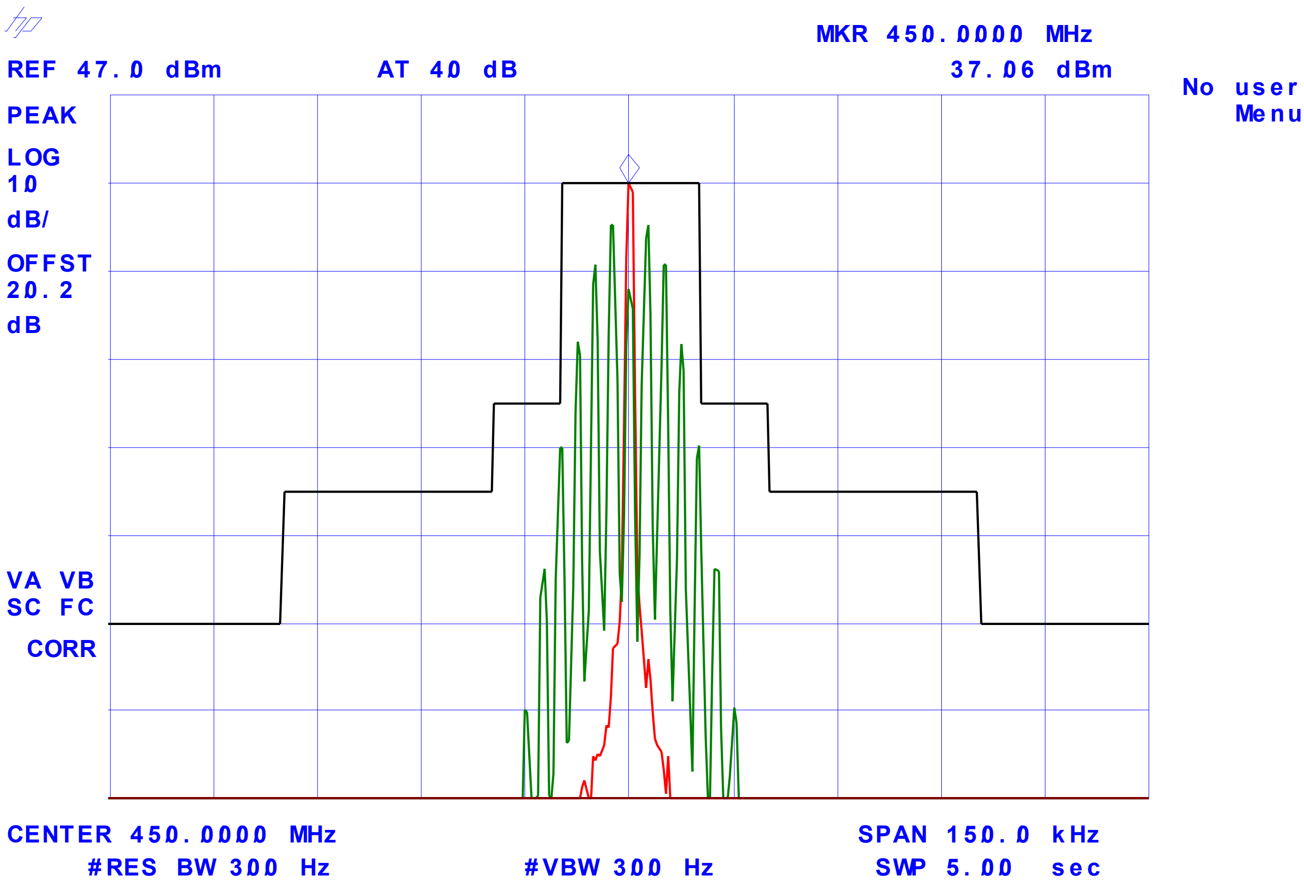
Plot # 38: Emission Mask B of RF Output Signal

Low Channel, 406.1 MHz, 25 kHz Channel Spacing
FM Modulation with 2.5 kHz Sine wave signal, 5 kHz Deviation



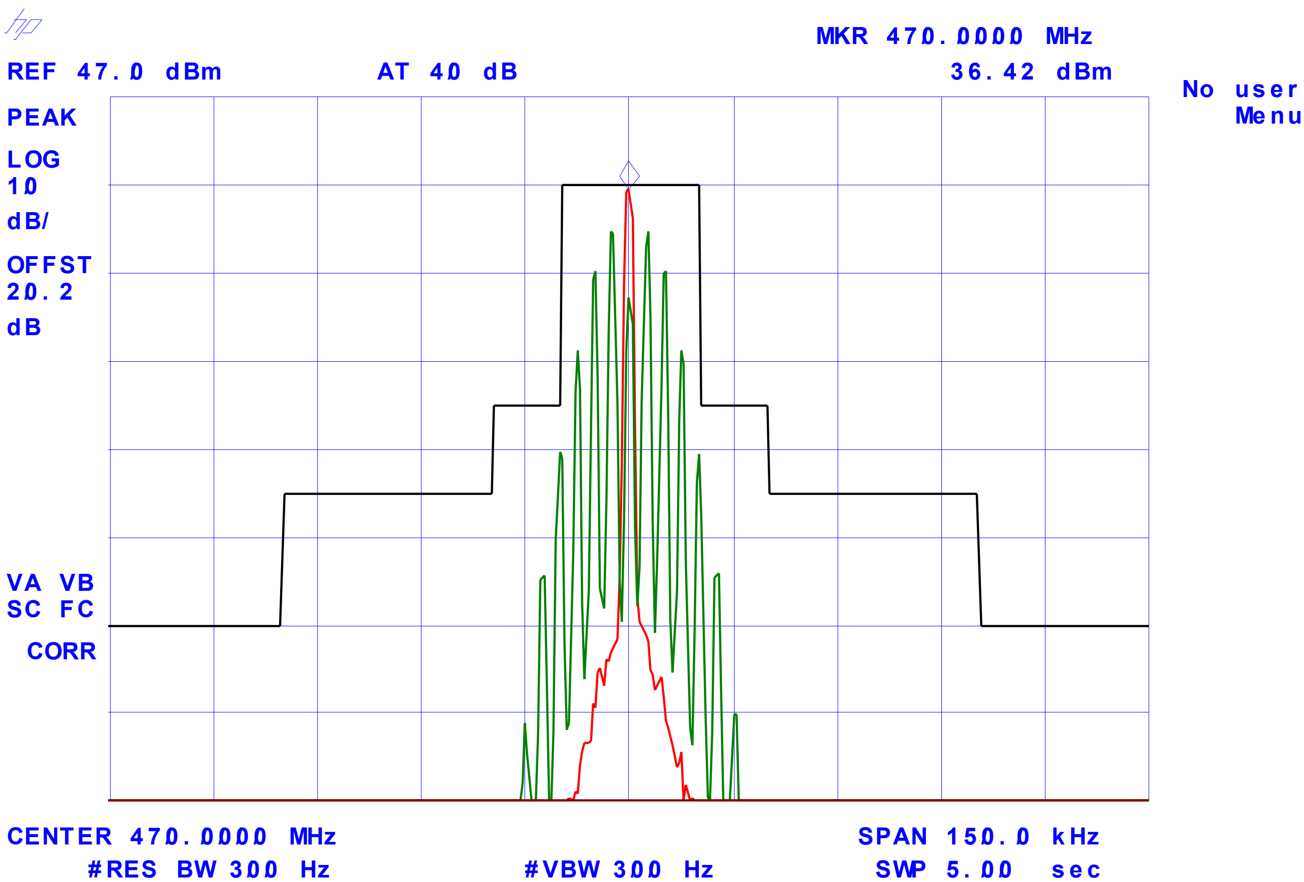
Plot # 39: Emission Mask B of RF Output Signal

Mid Channel, 450 MHz, 25 kHz Channel Spacing
FM Modulation with 2.5 kHz Sine wave signal, 5 kHz Deviation



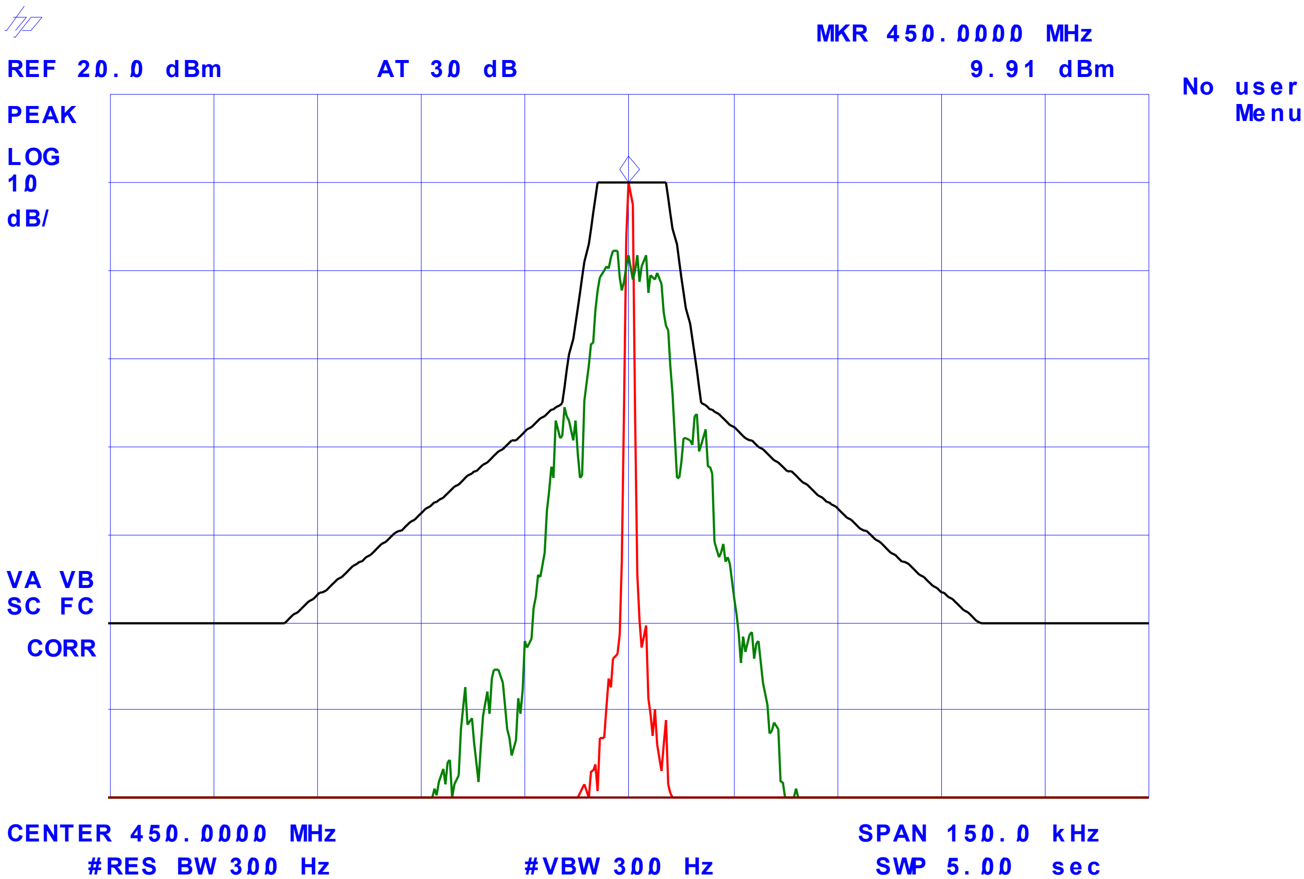
Plot # 40: Emission Mask B of RF Output Signal

High Channel, 470 MHz, 25 kHz Channel Spacing
FM Modulation with 2.5 kHz Sine wave signal, 5 kHz Deviation



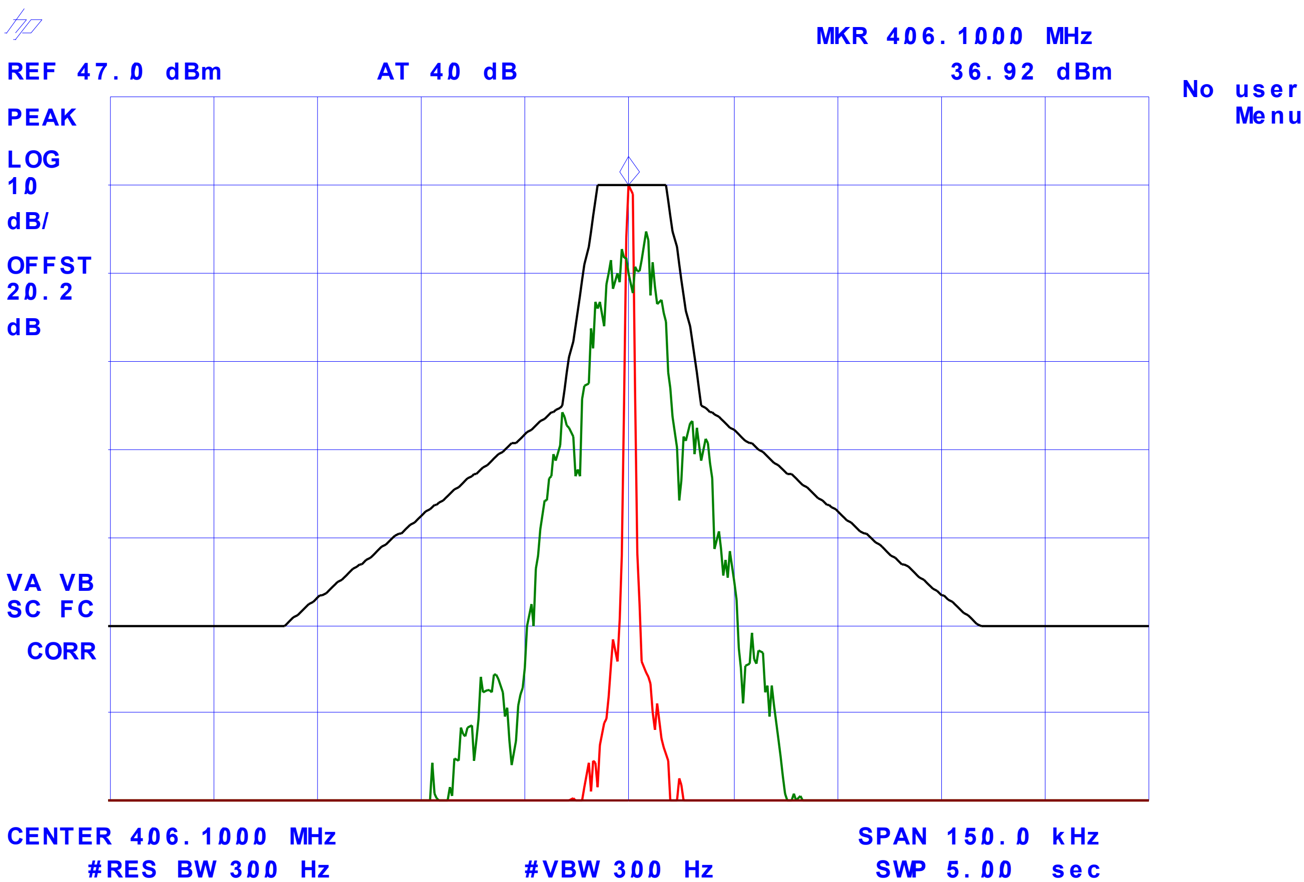
Plot # 41: Emission Mask C of RF Input Signal

RF Input Level = 10 dBm as maximum rated.
Mid Channel, 450 MHz, 25 kHz Channel Spacing
FM Modulation with 9600 b/s random data source, 5 kHz Deviation



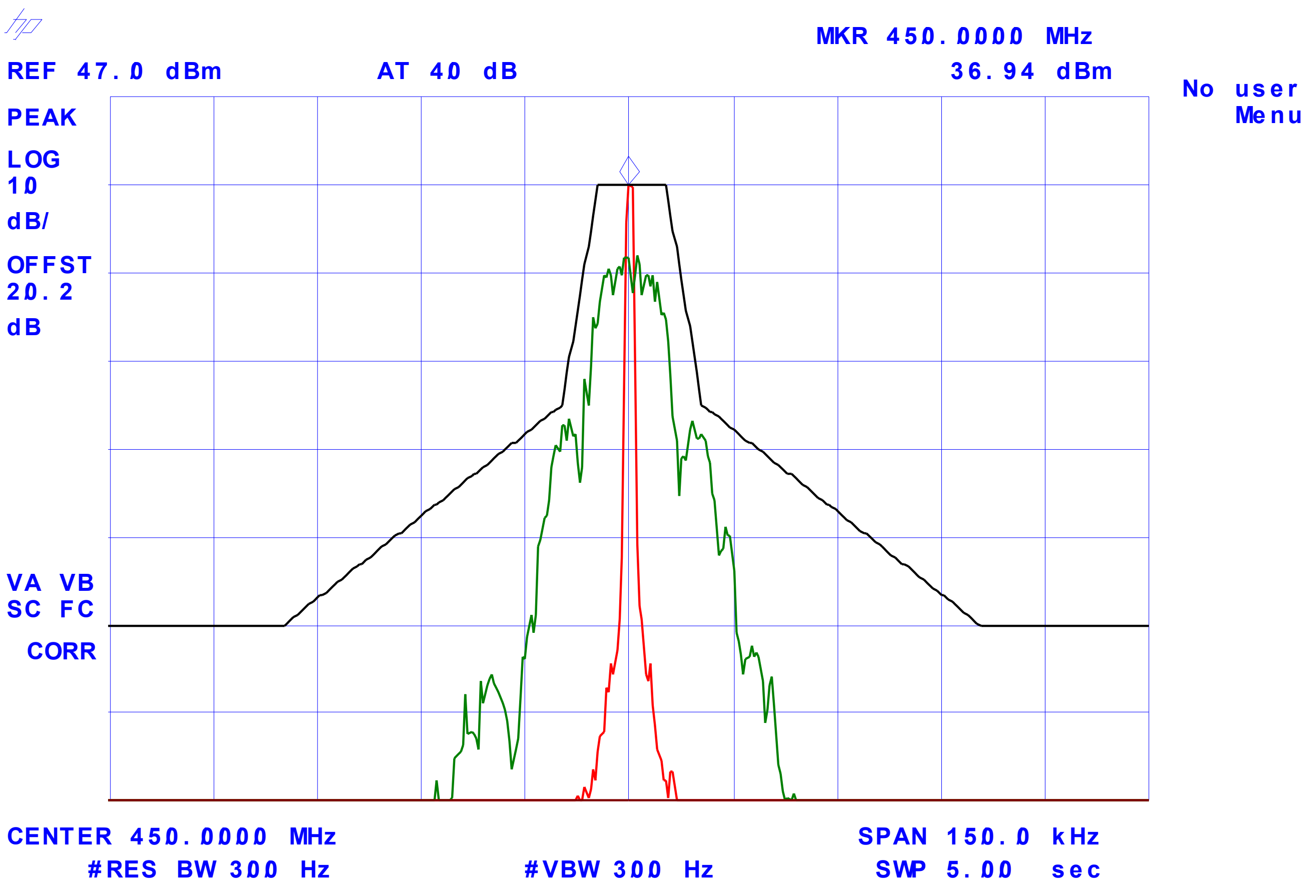
Plot # 42: Emission Mask C of RF Output Signal

Low Channel, 406.1 MHz, 25 kHz Channel Spacing
FM Modulation with 9600 b/s random data source, 5 kHz Deviation



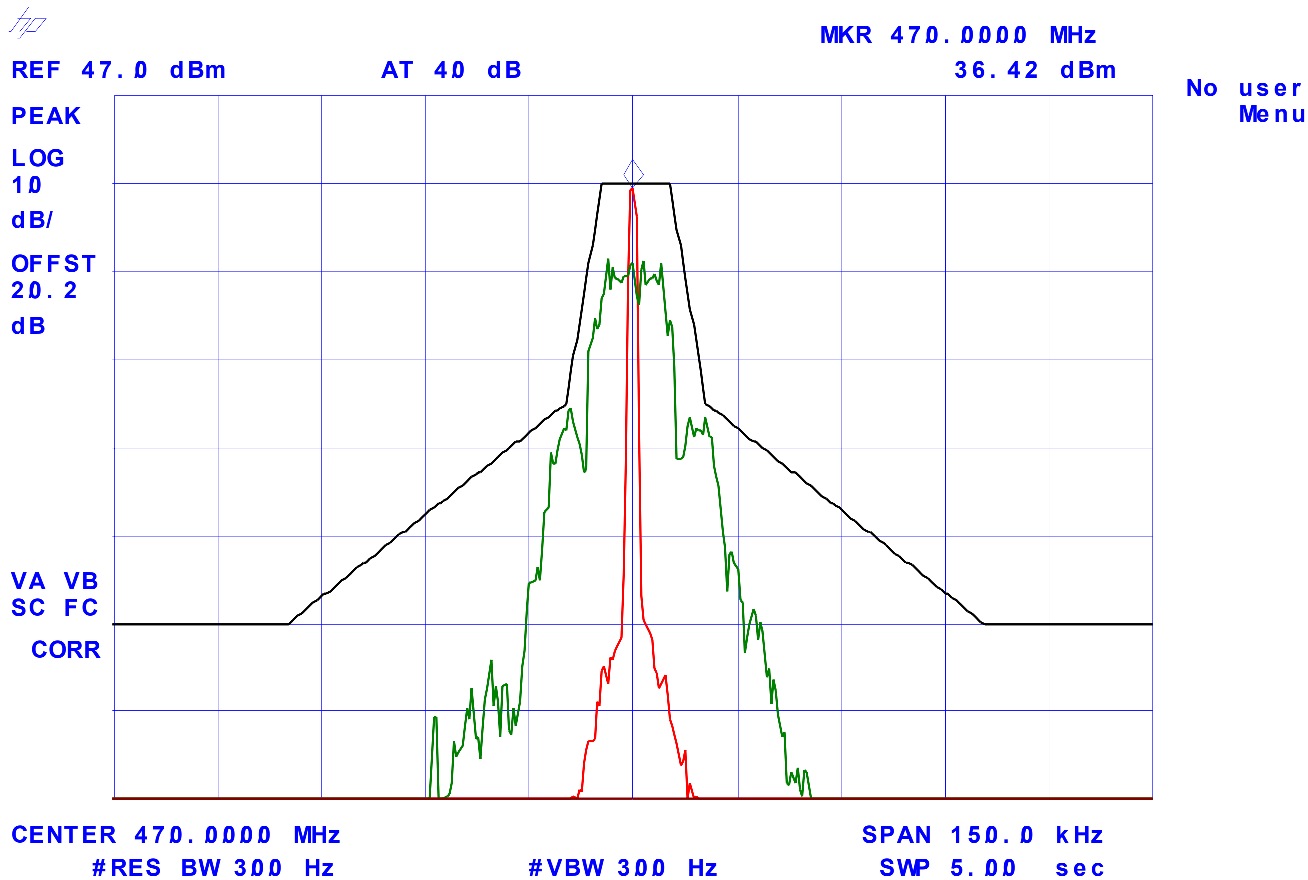
Plot # 43: Emission Mask C of RF Output Signal

Mid Channel, 450 MHz, 25 kHz Channel Spacing
FM Modulation with 9600 b/s random data source, 5 kHz Deviation



Plot # 44: Emission Mask C of RF Output Signal

High Channel, 470 MHz, 25 kHz Channel Spacing
FM Modulation with 9600 b/s random data source, 5 kHz Deviation



6.9. TRANSMITTER ANTENNA POWER SPURIOUS/HARMONIC CONDUCTED EMISSIONS @ FCC 90.210

6.9.1. Limits @ 90.210

Emissions shall be attenuated below the mean output power of the transmitter as follows:

FCC Rules	Frequency Range	Attenuation Limit (dBc)
90.210(b)&(c) – Voice & data	10 MHz to Lowest frequency of the radio to 10th harmonic of the highest frequency of the radio	43+10*log(P)
90.210(d) – Voice & data	10 MHz to Lowest frequency of the radio to 10th harmonic of the highest frequency of the radio	50+10*log(P) or 70 dBc whichever is less

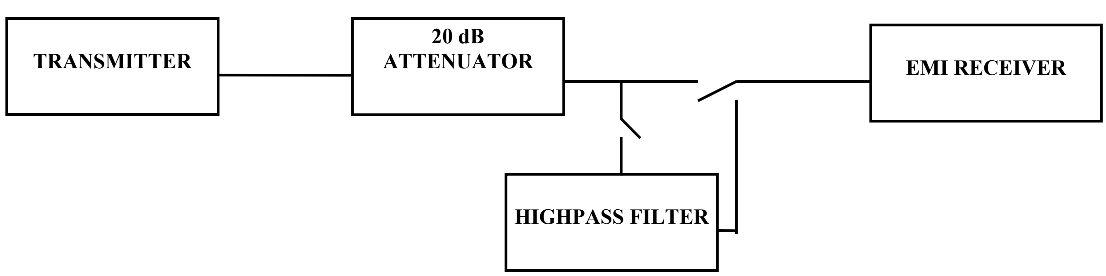
6.9.2. Method of Measurements

Refer to Exhibit 8 § 8.5 of this report for measurement details

6.9.3. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range
EMI Receiver/ EMI Receiver	Hewlett Packard	HP 8593EM	3412A00103	9 kHz – 26.5 GHz
Attenuator(s)	Bird	..	…	DC – 22 GHz
Audio Oscillator	Hewlett Packard	HP 204C	0989A08798	DC to 1.2 MHz
Highpass Filter, Microphase	Microphase	CR220HID	IITI11000AC	Cut-off Frequency at 600 MHz, 1.3 GHz or 4 GHz

6.9.4. Test Arrangement



6.9.5. Test Data

Remarks: Based on the pre-scan, the RF spurious/harmonic emissions are the same for both 12.5 kHz and 25 kHz Channel Spacing Operation and Data or Voice modulation; therefore, the 12.5 kHz channel spacing operation with FM modulation (2.5 kHz sine wave signal) was chosen for final tests with the most stringent limit of 50+10*log(P in Watts).

6.9.5.1. Near Lowest Frequency (406.1 MHz)

Fundamental Frequency: 406.1 MHz (1 input)
RF Output Power: 37.9 dBm (conducted)
Modulation: FM modulation with 2.5 kHz Sine Wave Signal

FREQUENCY (MHz)	TRANSMITTER CONDUCTED ANTENNA EMISSIONS (dBm)	TRANSMITTER CONDUCTED ANTENNA EMISSIONS (dBc)	LIMIT (dBc)	MARGIN (dB)	PASS/ FAIL
1218.3	-43.2	-81.1	-57.9	-23.2	PASS

- The emissions were scanned from 10 MHz to 5 GHz and all emissions less than 20 dB below the limits were recorded.
- Refer to Plots 45 to 47 for details of measurements

Fundamental Frequency: Fc=406.1 MHz & Fc+12.5 kHz (2 inputs)
RF Output Power: 24.7 dBm (conducted)
Modulation: umodulated

FREQUENCY (MHz)	TRANSMITTER CONDUCTED ANTENNA EMISSIONS (dBm)	TRANSMITTER CONDUCTED ANTENNA EMISSIONS (dBc)	LIMIT (dBc)	MARGIN (dB)	PASS/ FAIL
812.2	-58.6	-83.3	-44.7	-38.6	PASS

- The emissions were scanned from 10 MHz to 5 GHz and all emissions less than 20 dB below the limits were recorded.
- Refer to Plots 48 to 50 for details of measurements

Fundamental Frequency: Fc=406.1 MHz, Fc+12.5 kHz & Fc+25 kHz (3 inputs)
RF Output Power: 22.9 dBm (conducted)
Modulation: unmodulated

FREQUENCY (MHz)	TRANSMITTER CONDUCTED ANTENNA EMISSIONS (dBm)	TRANSMITTER CONDUCTED ANTENNA EMISSIONS (dBc)	LIMIT (dBc)	MARGIN (dB)	PASS/ FAIL
812.2	-55.9	-78.8	-42.9	-35.9	PASS

- The emissions were scanned from 10 MHz to 5 GHz and all emissions less than 20 dB below the limits were recorded.
- Refer to Plots 51 to 53 for details of measurements

6.9.5.2. Near Middle Frequency (450.0 MHz)

Fundamental Frequency: 450.0 MHz
RF Output Power: 38.1 dBm (conducted)
Modulation: FM modulation with 2.5 kHz Sine Wave Signal

FREQUENCY (MHz)	TRANSMITTER CONDUCTED ANTENNA EMISSIONS (dBm)	TRANSMITTER CONDUCTED ANTENNA EMISSIONS (dBc)	LIMIT (dBc)	MARGIN (dB)	PASS/ FAIL
900	-37.9	-76.0	-58.1	-17.9	PASS

- The emissions were scanned from 10 MHz to 5 GHz and all emissions less than 20 dB below the limits were recorded
- Refer to Plots 54 to 56 for details of measurements

Fundamental Frequency: Fc=450. MHz & Fc+12.5 kHz (2 inputs)
RF Output Power: 24.8 dBm (conducted)
Modulation: unmodulated

FREQUENCY (MHz)	TRANSMITTER CONDUCTED ANTENNA EMISSIONS (dBm)	TRANSMITTER CONDUCTED ANTENNA EMISSIONS (dBc)	LIMIT (dBc)	MARGIN (dB)	PASS/ FAIL
900	-49.1	-73.9	-44.8	-29.1	PASS

- The emissions were scanned from 10 MHz to 5 GHz and all emissions less than 20 dB below the limits were recorded
- Refer to Plots 57 to 59 for details of measurements

Fundamental Frequency: Fc=450 MHz, Fc-12.5 kHz & Fc+12.5 kHz (3 inputs)
RF Output Power: 23.2 dBm (conducted)
Modulation: unmodulated

FREQUENCY (MHz)	TRANSMITTER CONDUCTED ANTENNA EMISSIONS (dBm)	TRANSMITTER CONDUCTED ANTENNA EMISSIONS (dBc)	LIMIT (dBc)	MARGIN (dB)	PASS/ FAIL
900	-49.6	-72.8	-43.2	-29.6	PASS

- The emissions were scanned from 10 MHz to 5 GHz and all emissions less than 20 dB below the limits were recorded
- Refer to Plots 60 to 62 for details of measurements

6.9.5.3. Near Highest Frequency (470.0 MHz)

Fundamental Frequency: 470.0 MHz
RF Output Power: 37.8 dBm (conducted)
Modulation: FM modulation with 2.5 kHz Sine Wave Signal

FREQUENCY (MHz)	TRANSMITTER CONDUCTED ANTENNA EMISSIONS (dBm)	TRANSMITTER CONDUCTED ANTENNA EMISSIONS (dBc)	LIMIT (dBc)	MARGIN (dB)	PASS/ FAIL
940	-30.1	-67.9	-57.8	-10.1	PASS

- The emissions were scanned from 10 MHz to 5 GHz and all emissions less than 20 dB below the limits were recorded
- Refer to Plots 63 to 65 for details of measurements

Fundamental Frequency: Fc=470. MHz & Fc-12.5 kHz (2 inputs)
RF Output Power: 24.3 dBm (conducted)
Modulation: unmodulated

FREQUENCY (MHz)	TRANSMITTER CONDUCTED ANTENNA EMISSIONS (dBm)	TRANSMITTER CONDUCTED ANTENNA EMISSIONS (dBc)	LIMIT (dBc)	MARGIN (dB)	PASS/ FAIL
940	-42.7	-67.0	-44.3	-22.7	PASS

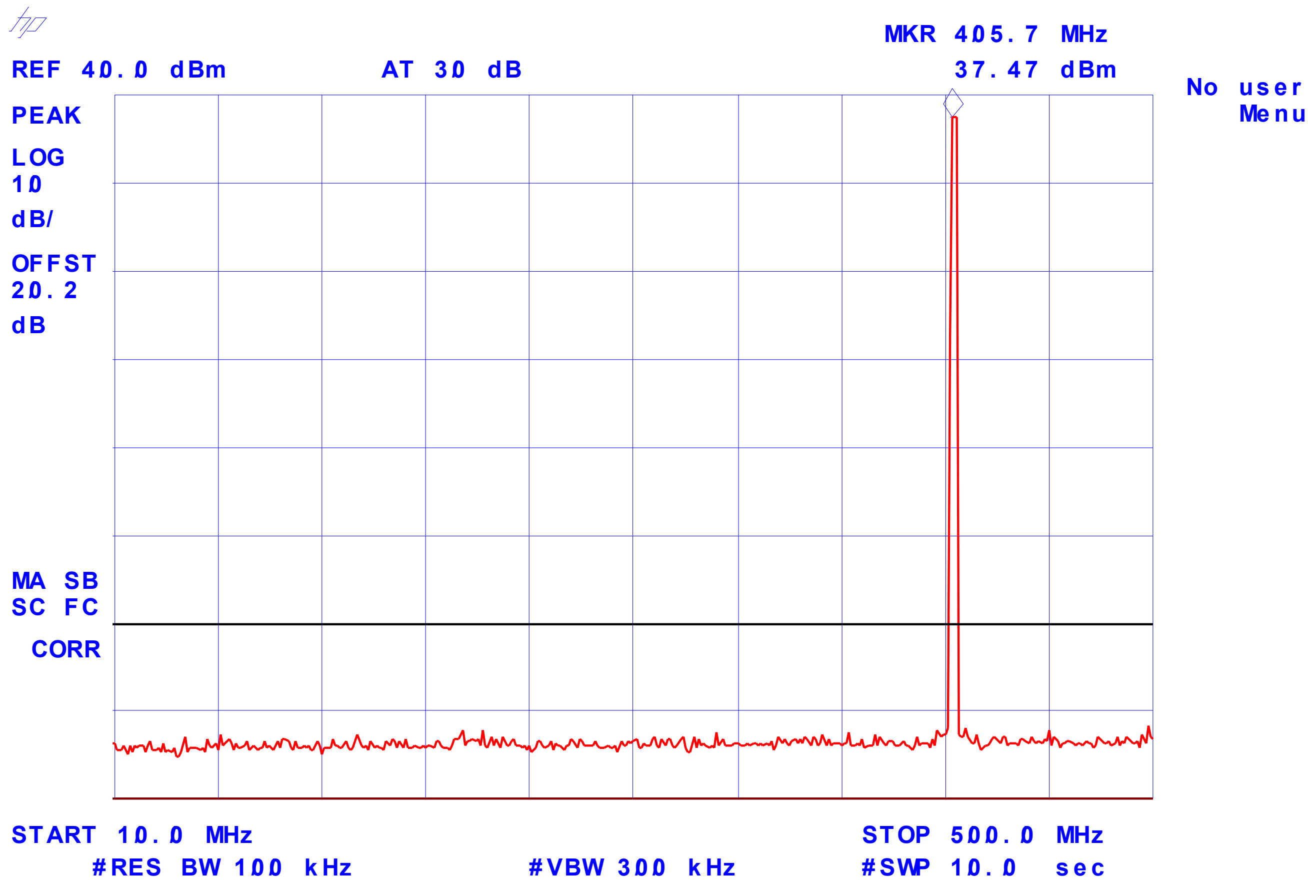
- The emissions were scanned from 10 MHz to 5 GHz and all emissions less than 20 dB below the limits were recorded
- Refer to Plots 66 to 68 for details of measurements

Fundamental Frequency: Fc=470 MHz, Fc-12.5 kHz & Fc-25 kHz (3 inputs)
RF Output Power: 22.7 dBm (conducted)
Modulation: unmodulated

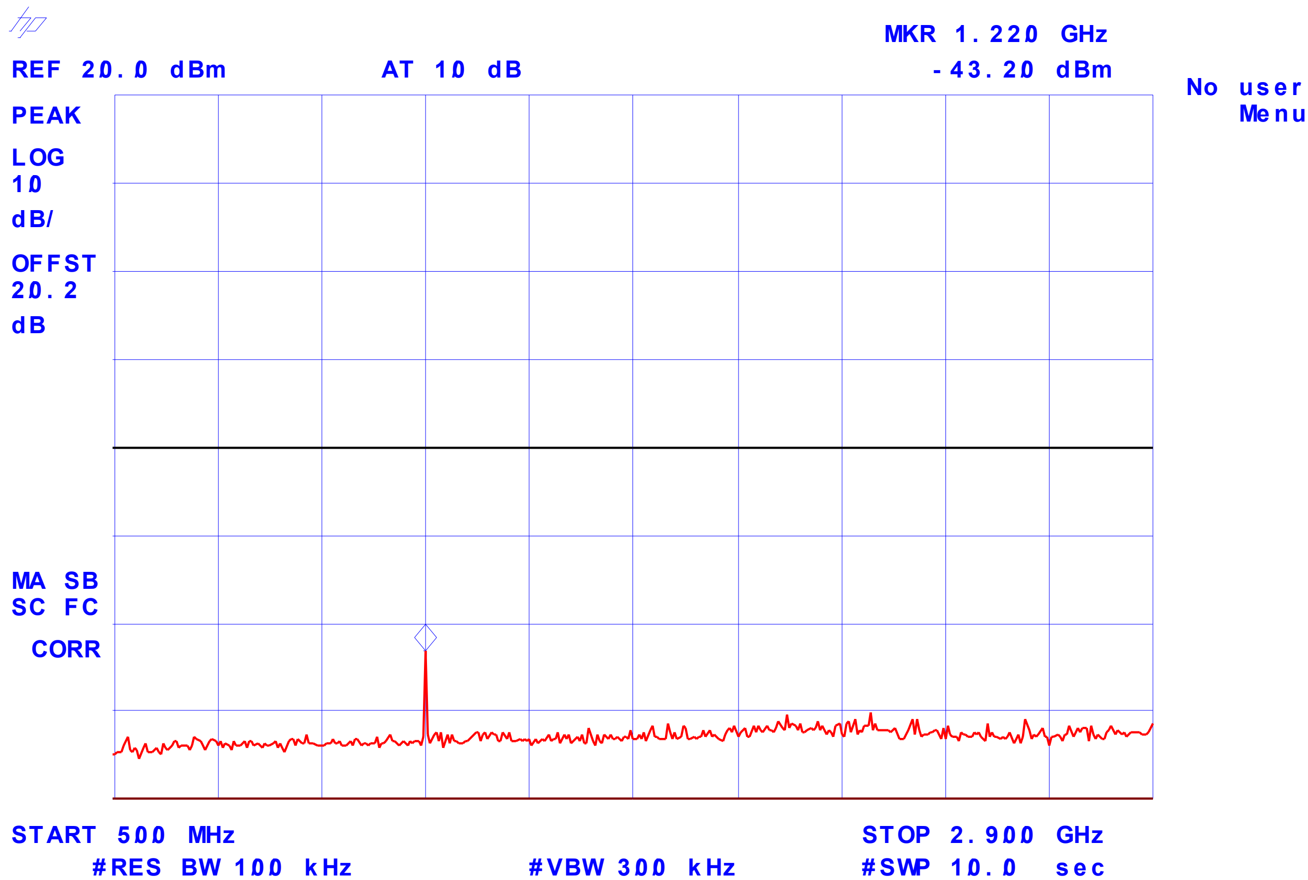
FREQUENCY (MHz)	TRANSMITTER CONDUCTED ANTENNA EMISSIONS (dBm)	TRANSMITTER CONDUCTED ANTENNA EMISSIONS (dBc)	LIMIT (dBc)	MARGIN (dB)	PASS/ FAIL
940	-38.9	-61.6	-42.7	-18.9	PASS

- The emissions were scanned from 10 MHz to 5 GHz and all emissions less than 20 dB below the limits were recorded
- Refer to Plots 69 to 71 for details of measurements

Plot # 45: - Spurious Emissions Conducted with 1 RF signal input, Fc: 406.1 MHz

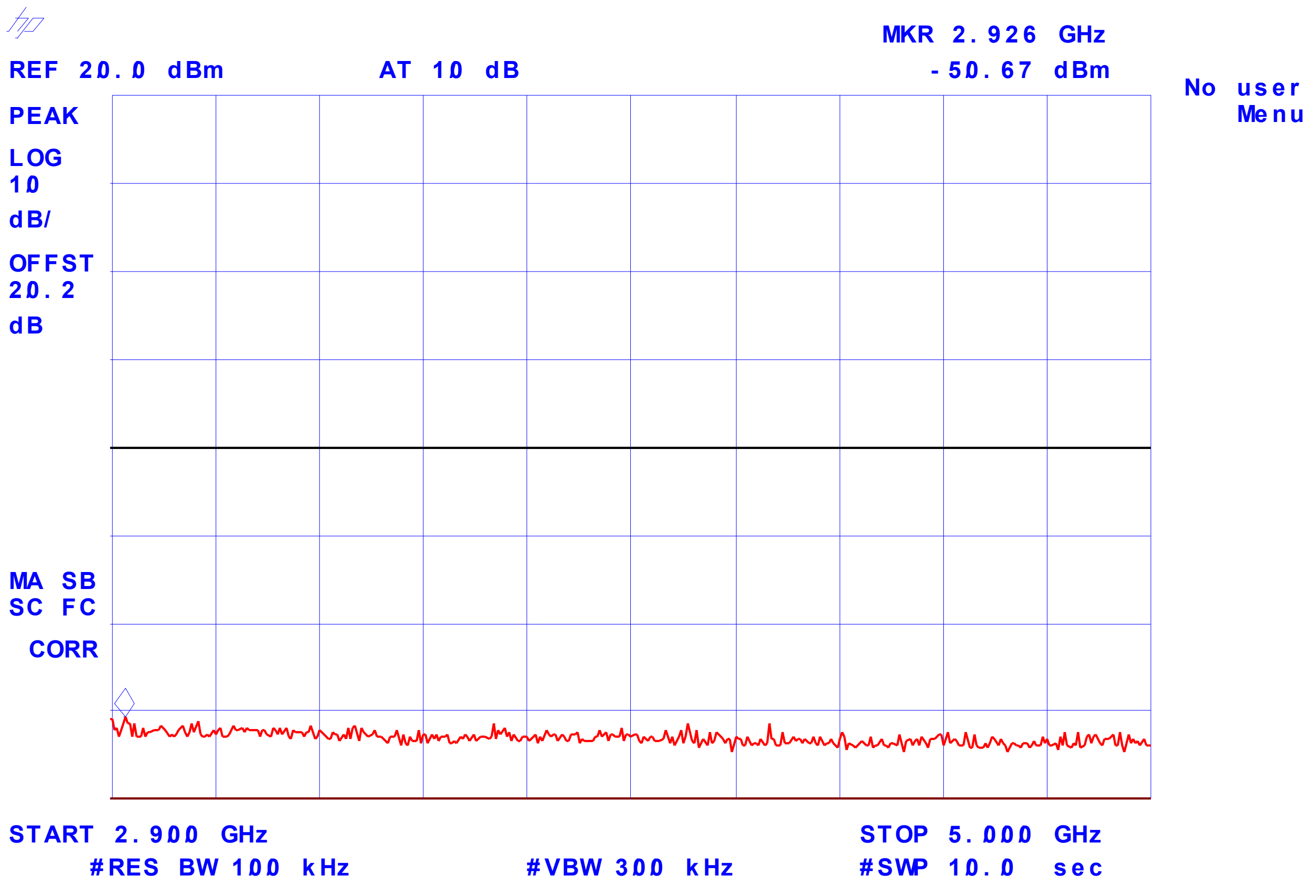


Plot # 46: - Spurious Emissions Conducted with 1 RF signal input, Fc: 406.1 MHz



- *All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)*

Plot # 47: - Spurious Emissions Conducted with 1 RF signal input, Fc: 406.1 MHz



3000 Bristol Circle, Oakville, Ontario, Canada L6H 6G4
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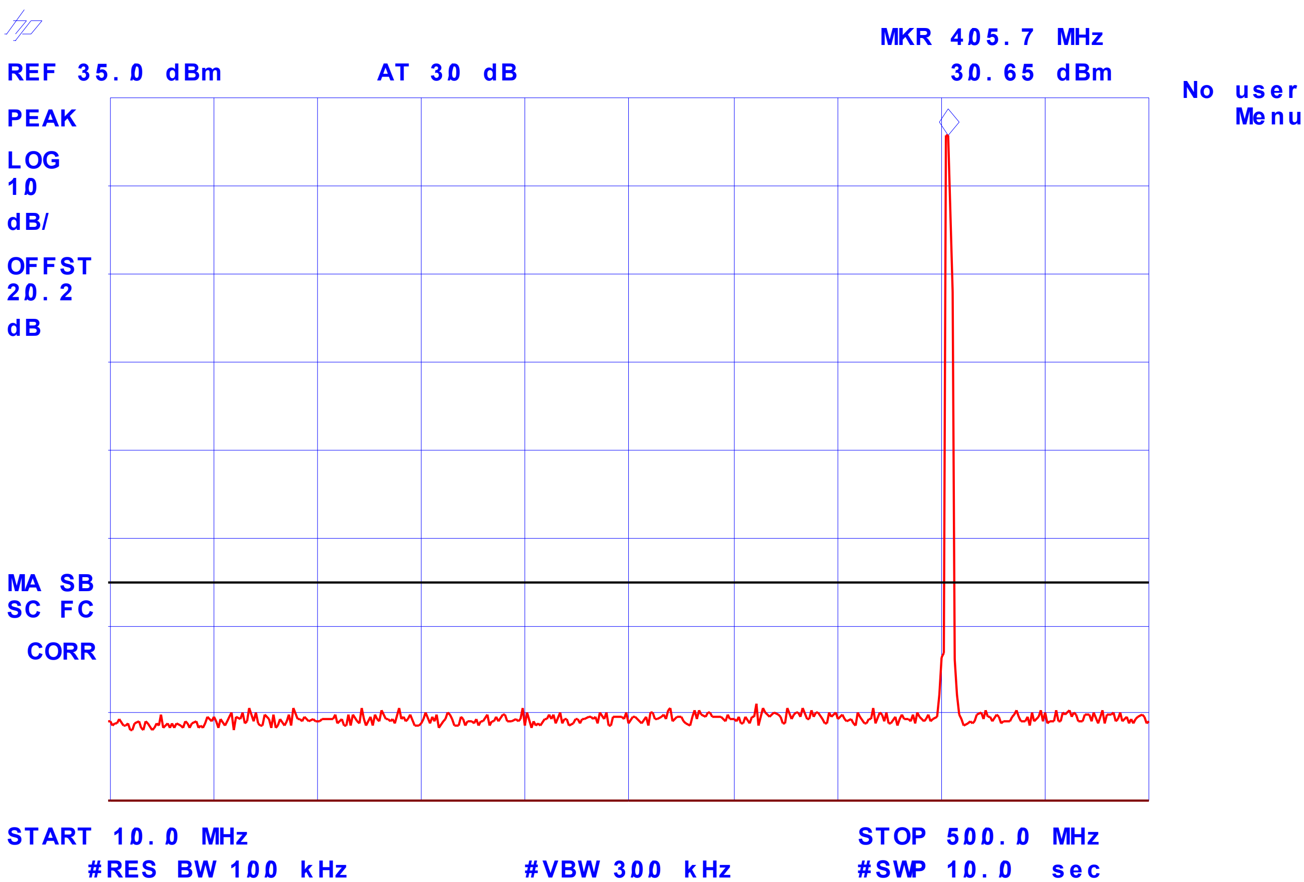
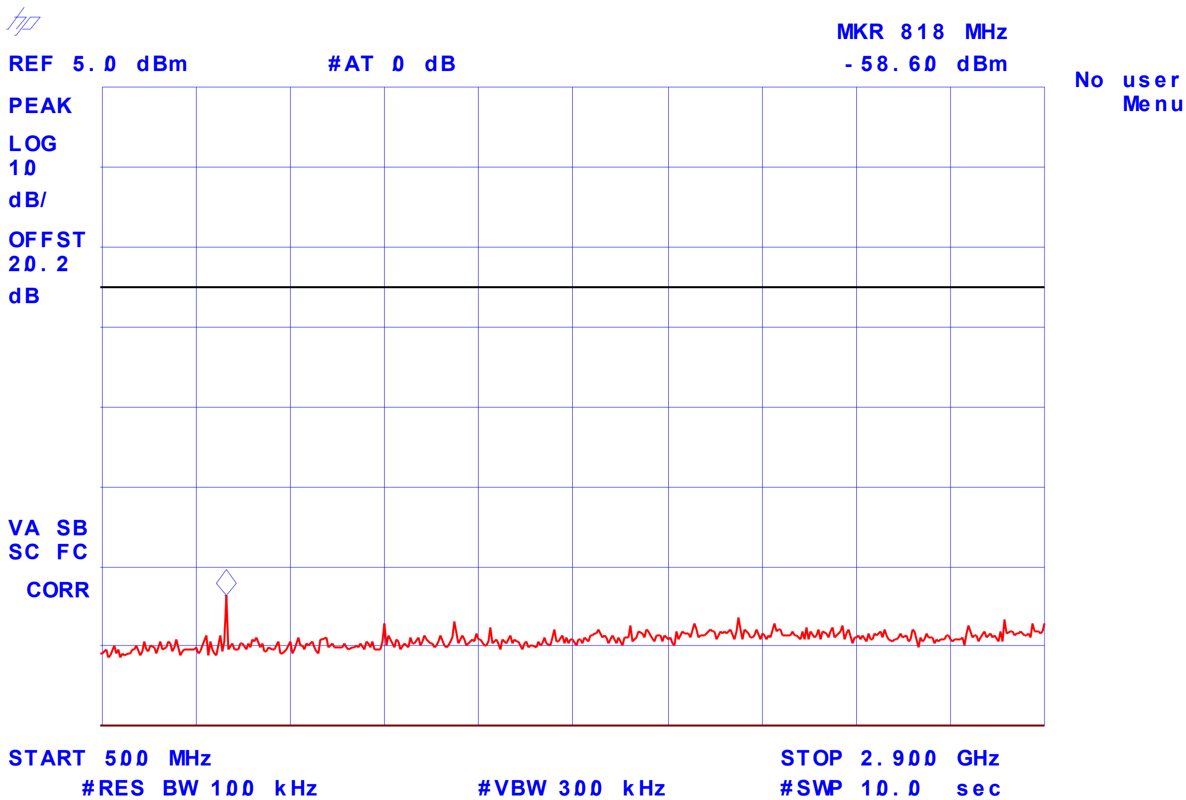
- *All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)*

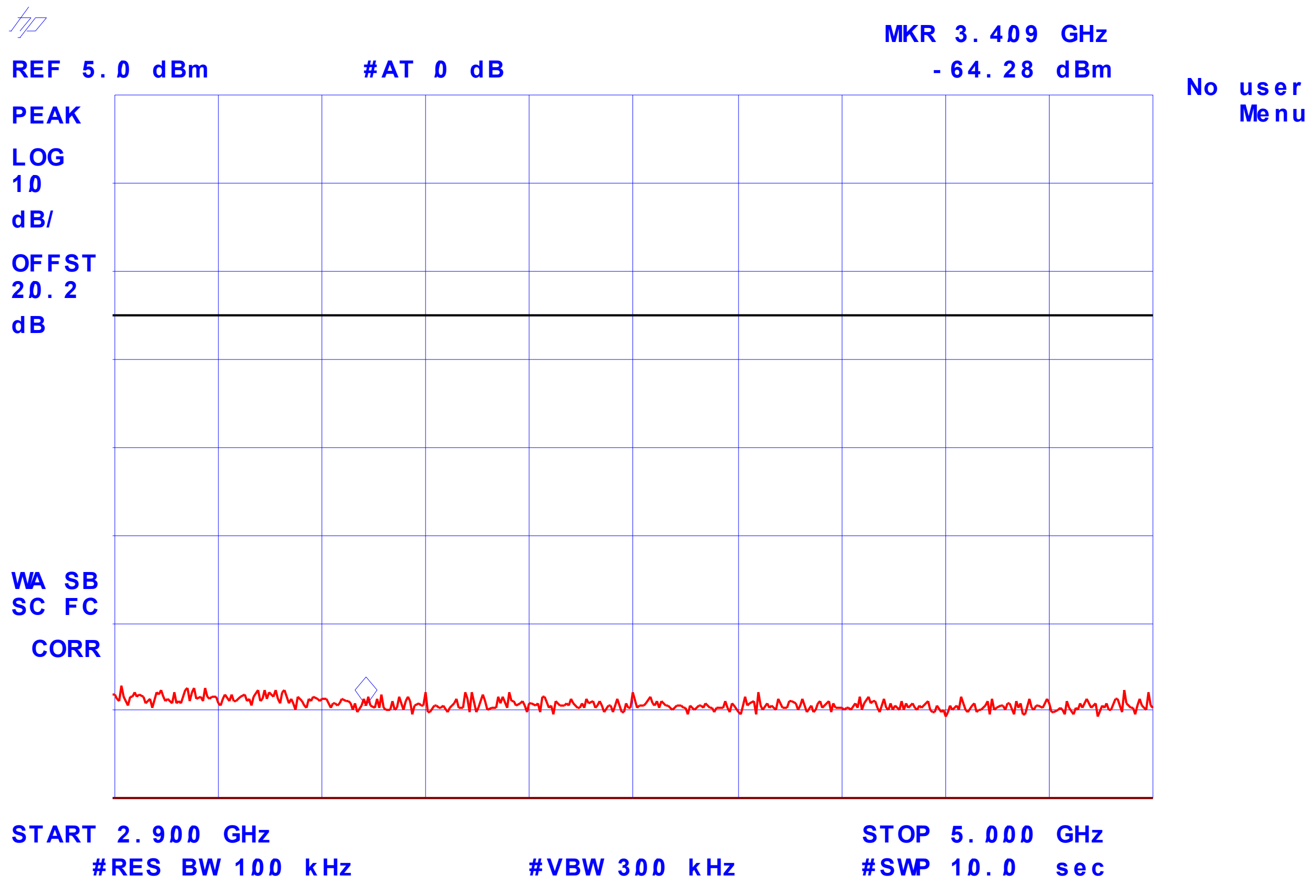
Plot # 48: - Spurious Emissions Conducted with 2 RF signal input, Fc: 406.1 MHz



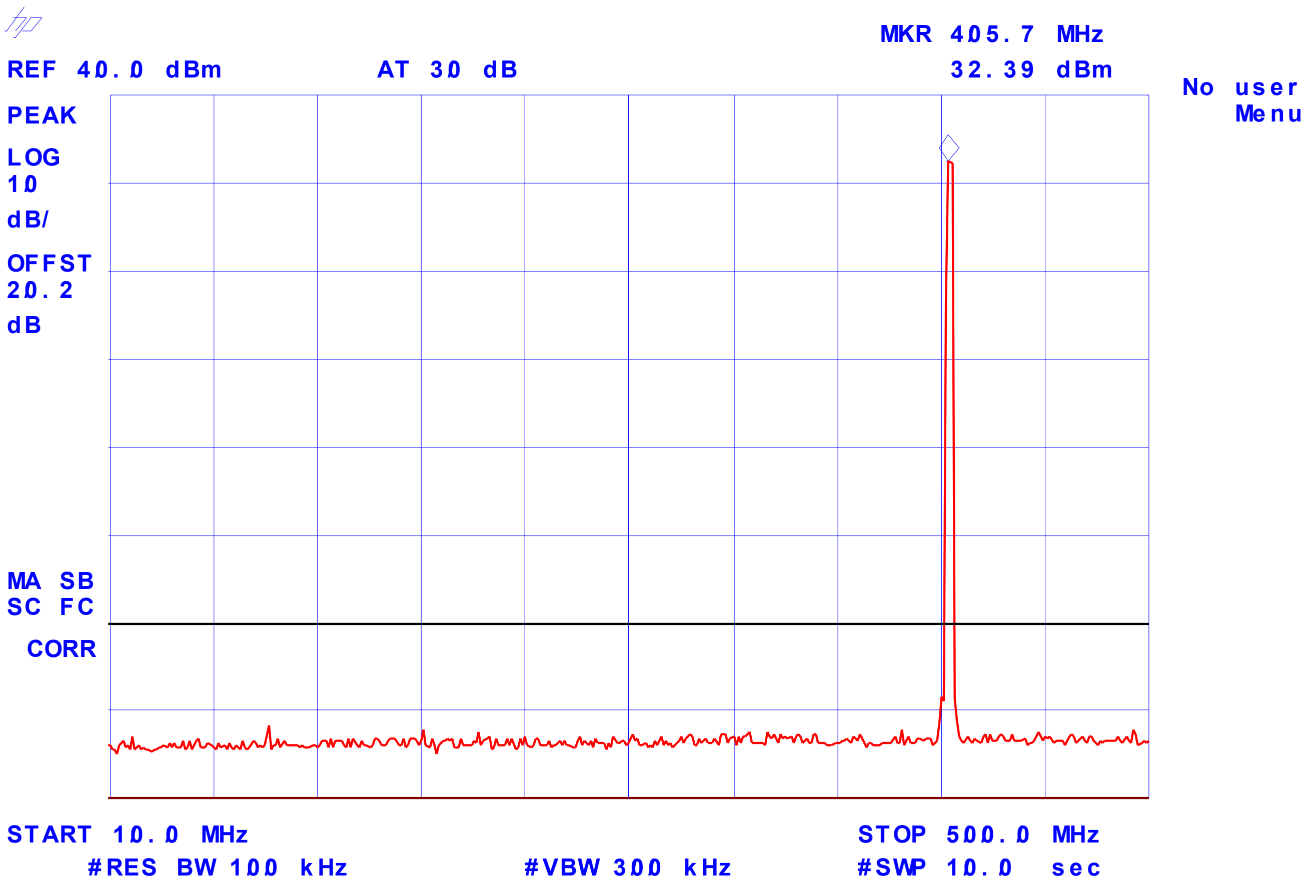
Plot # 49: - Spurious Emissions Conducted with 2 RF signal input, Fc: 406.1 MHz



Plot # 50: - Spurious Emissions Conducted with 2 RF signal input, Fc: 406.1 MHz

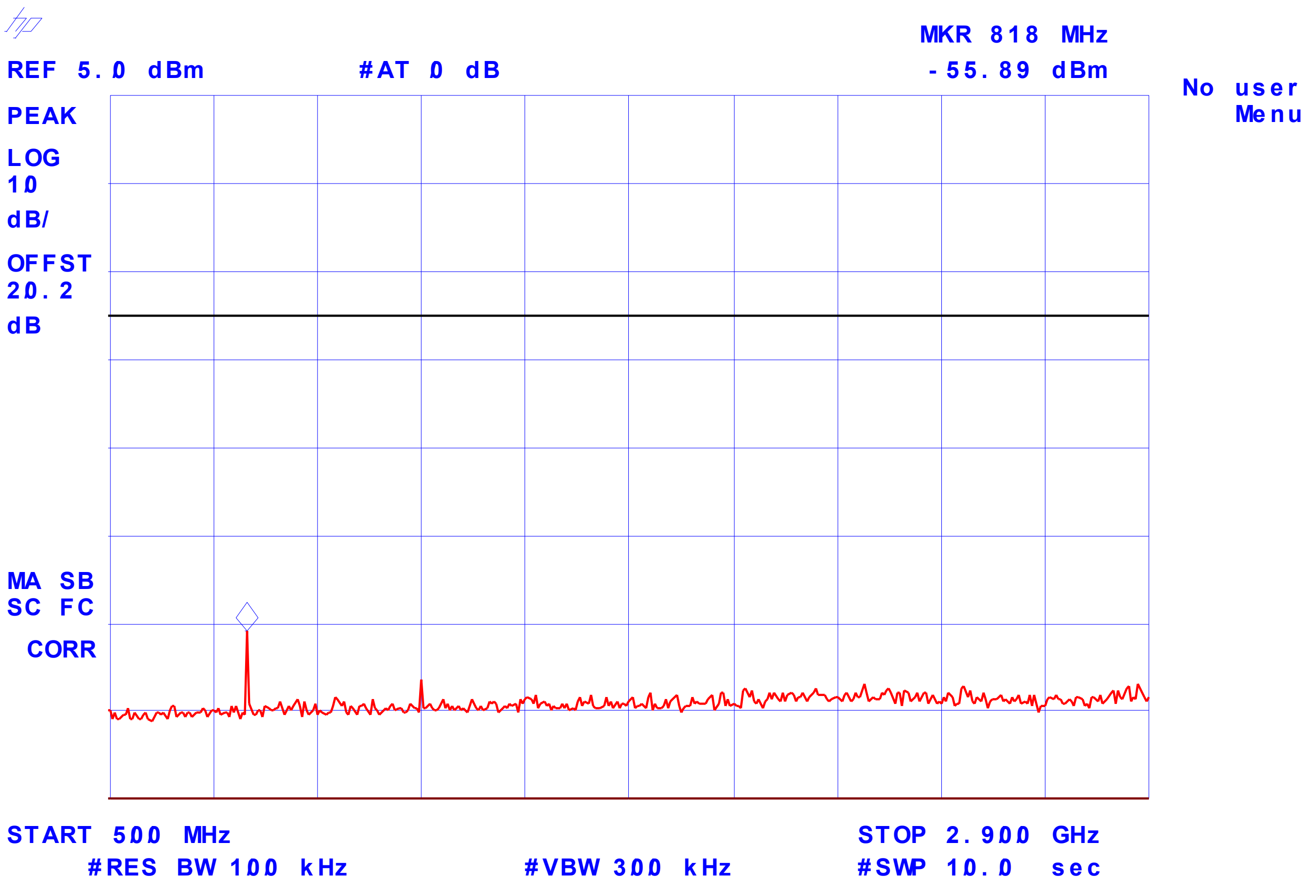


Plot # 51: - Spurious Emissions Conducted with 3 RF signal input, Fc: 406.1 MHz

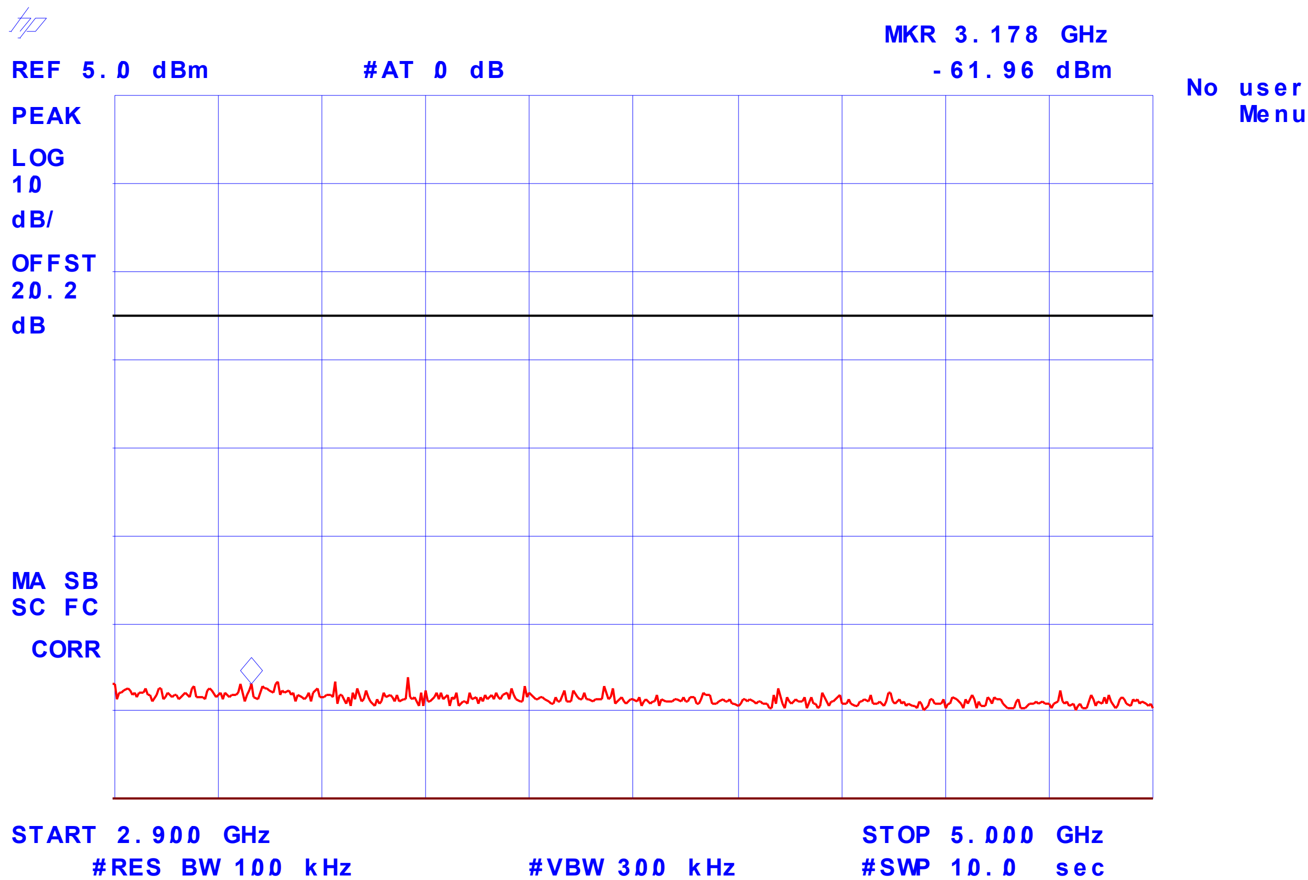


- *All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)*

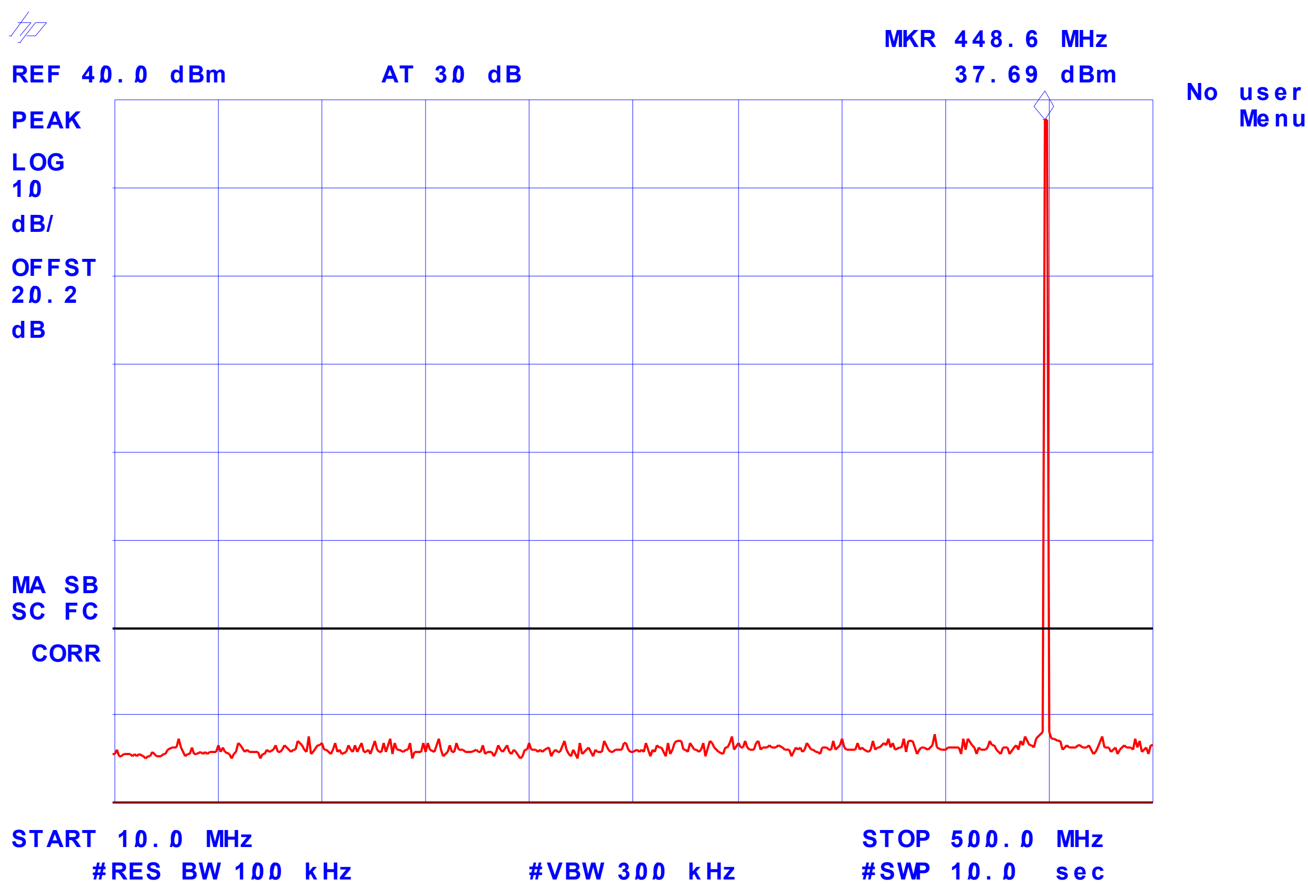
Plot # 52: - Spurious Emissions Conducted with 3 RF signal input, Fc: 406.1 MHz



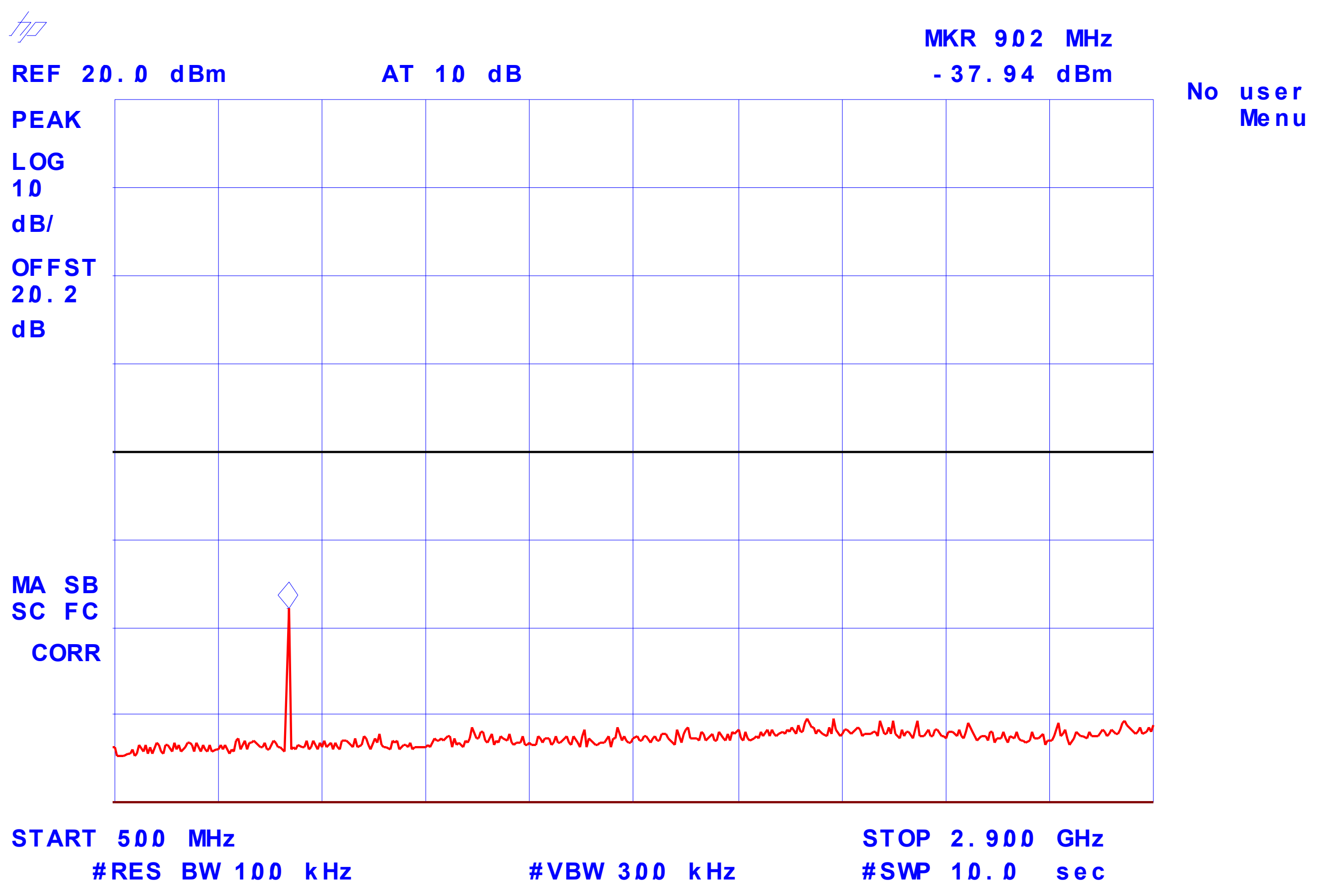
Plot # 53: - Spurious Emissions Conducted with 3 RF signal input, Fc: 406.1 MHz



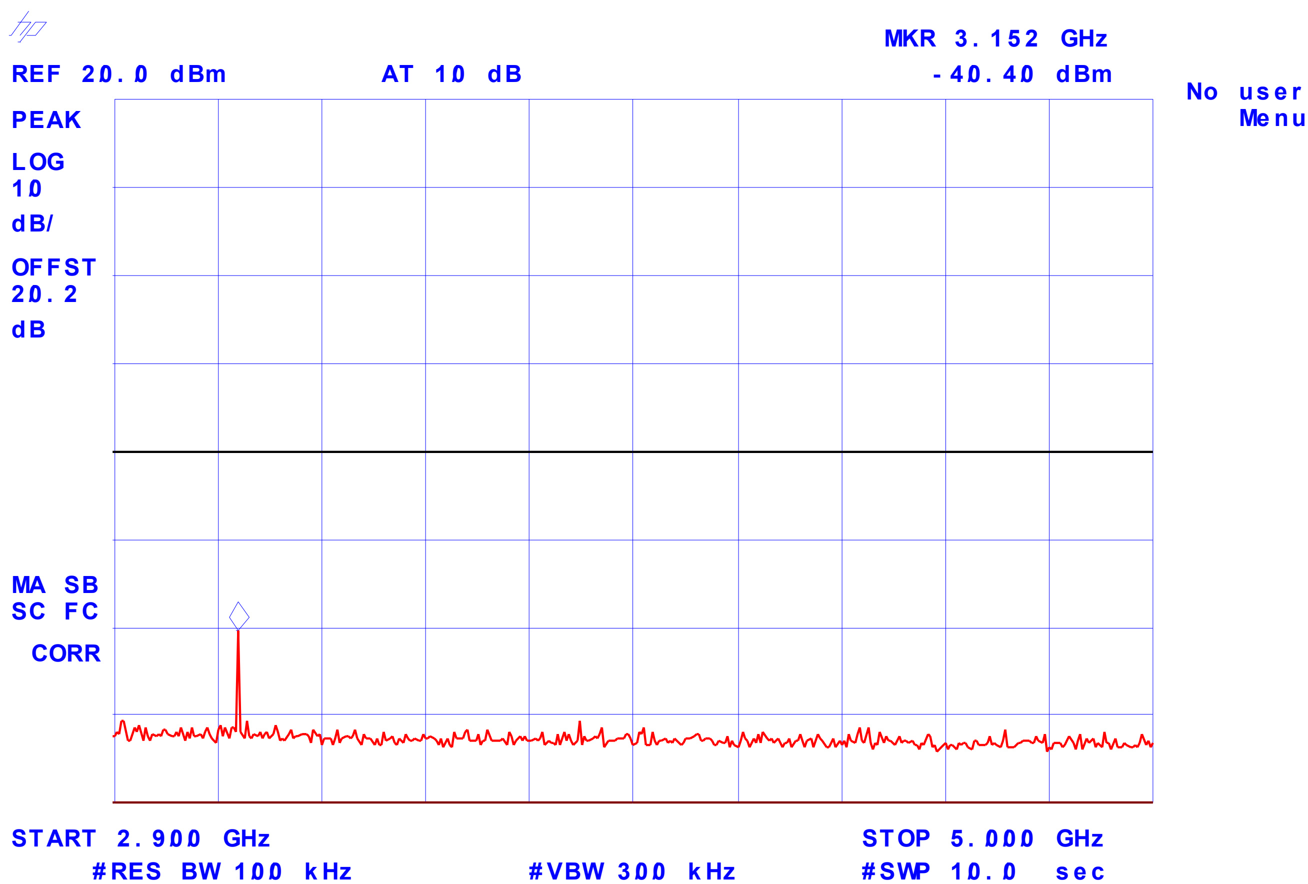
Plot # 54: - Spurious Emissions Conducted with 1 RF signal input, Fc: 450.0MHz



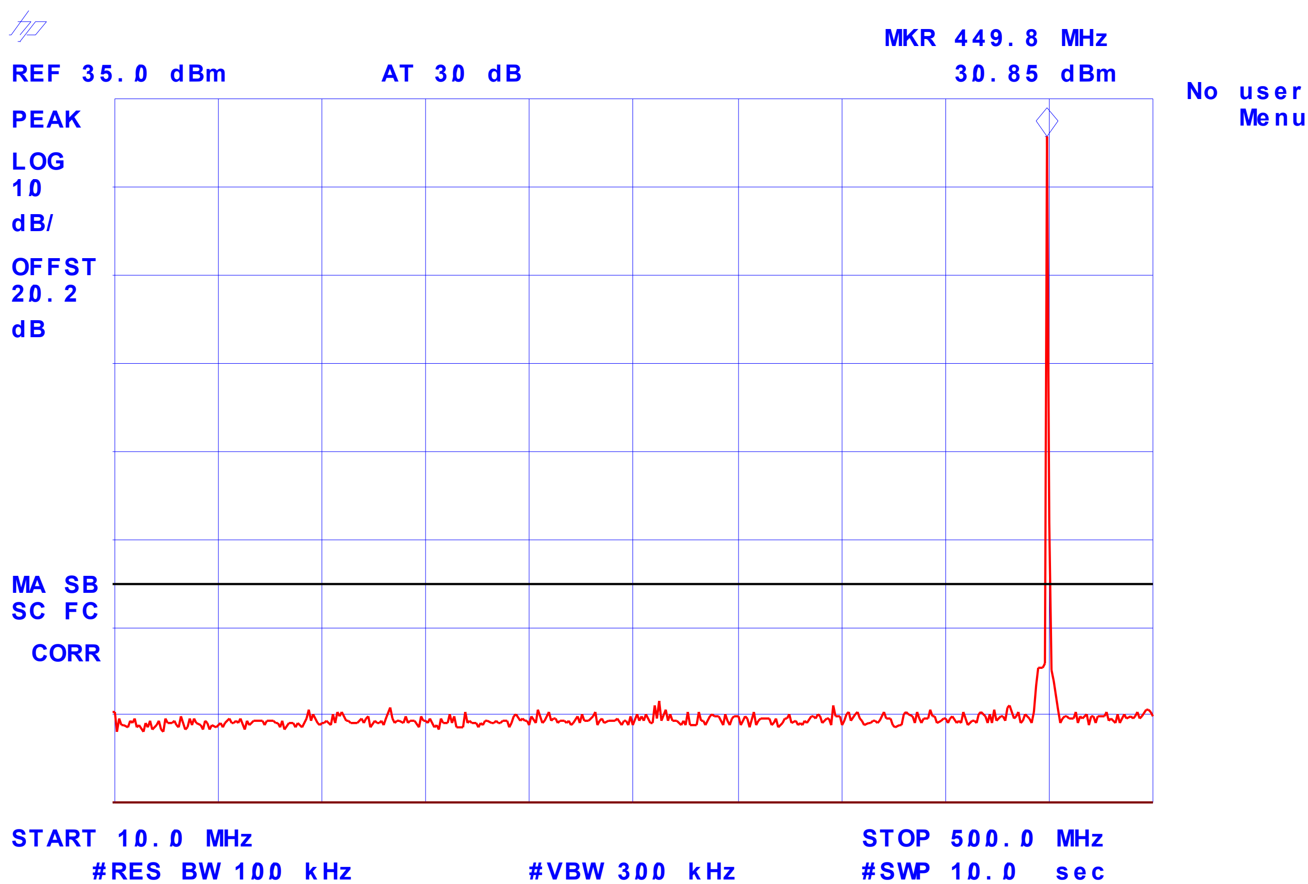
Plot # 55: - Spurious Emissions Conducted with 1 RF signal input, Fc: 450.0MHz



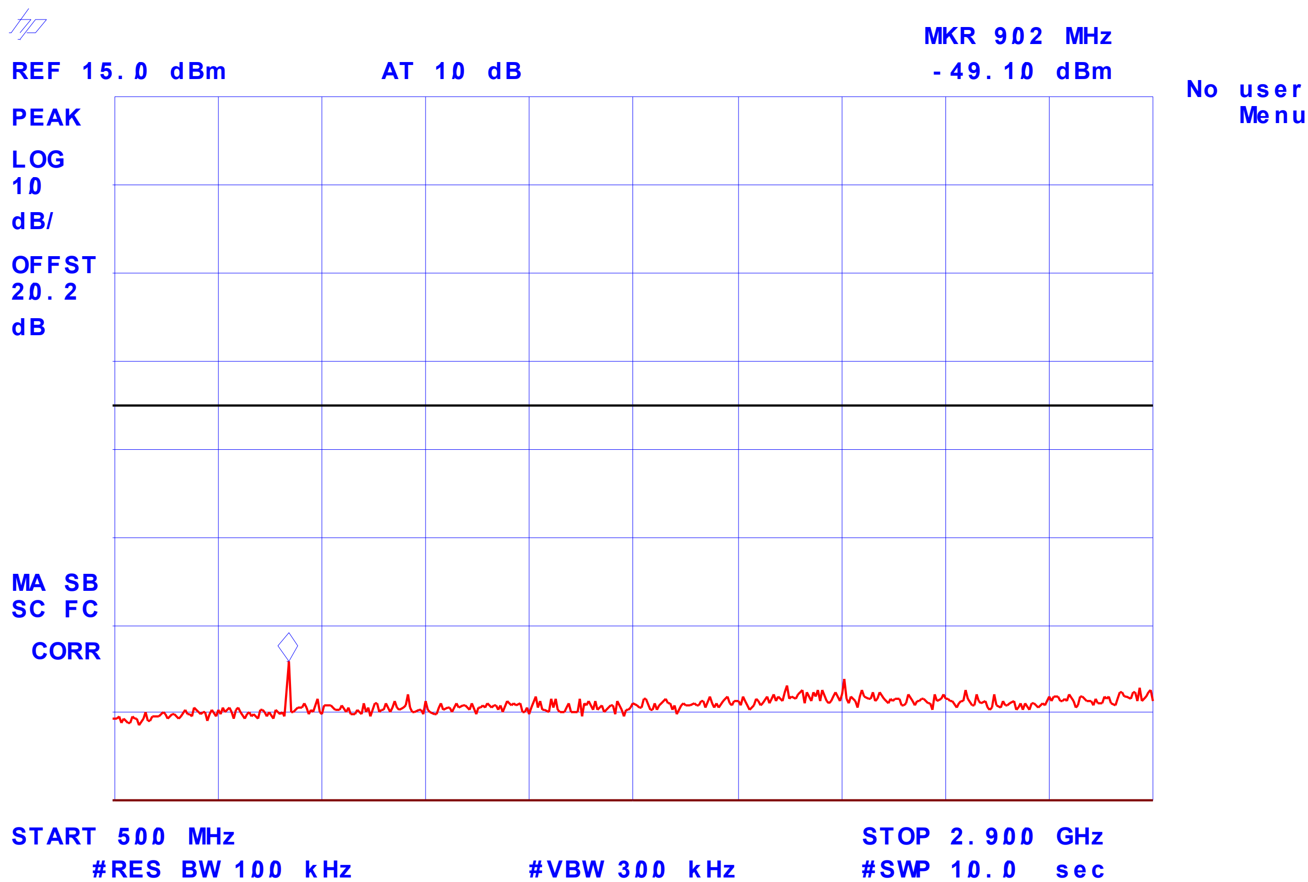
Plot # 56: - Spurious Emissions Conducted with 1 RF signal input, Fc: 450.0MHz



Plot # 57: - Spurious Emissions Conducted with 2 RF signal input, Fc: 450.0MHz

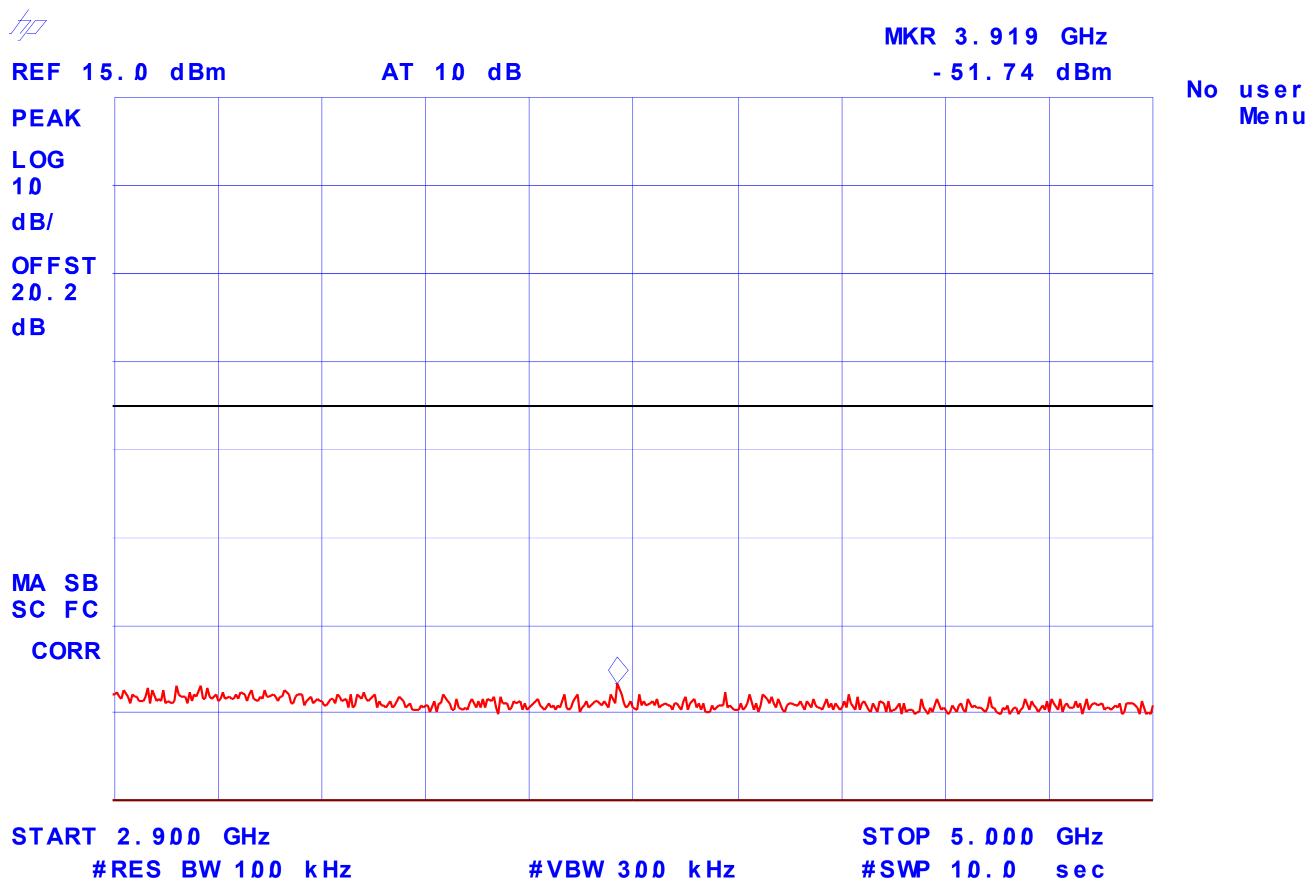


Plot # 58: - Spurious Emissions Conducted with 2 RF signal input, Fc: 450.0MHz

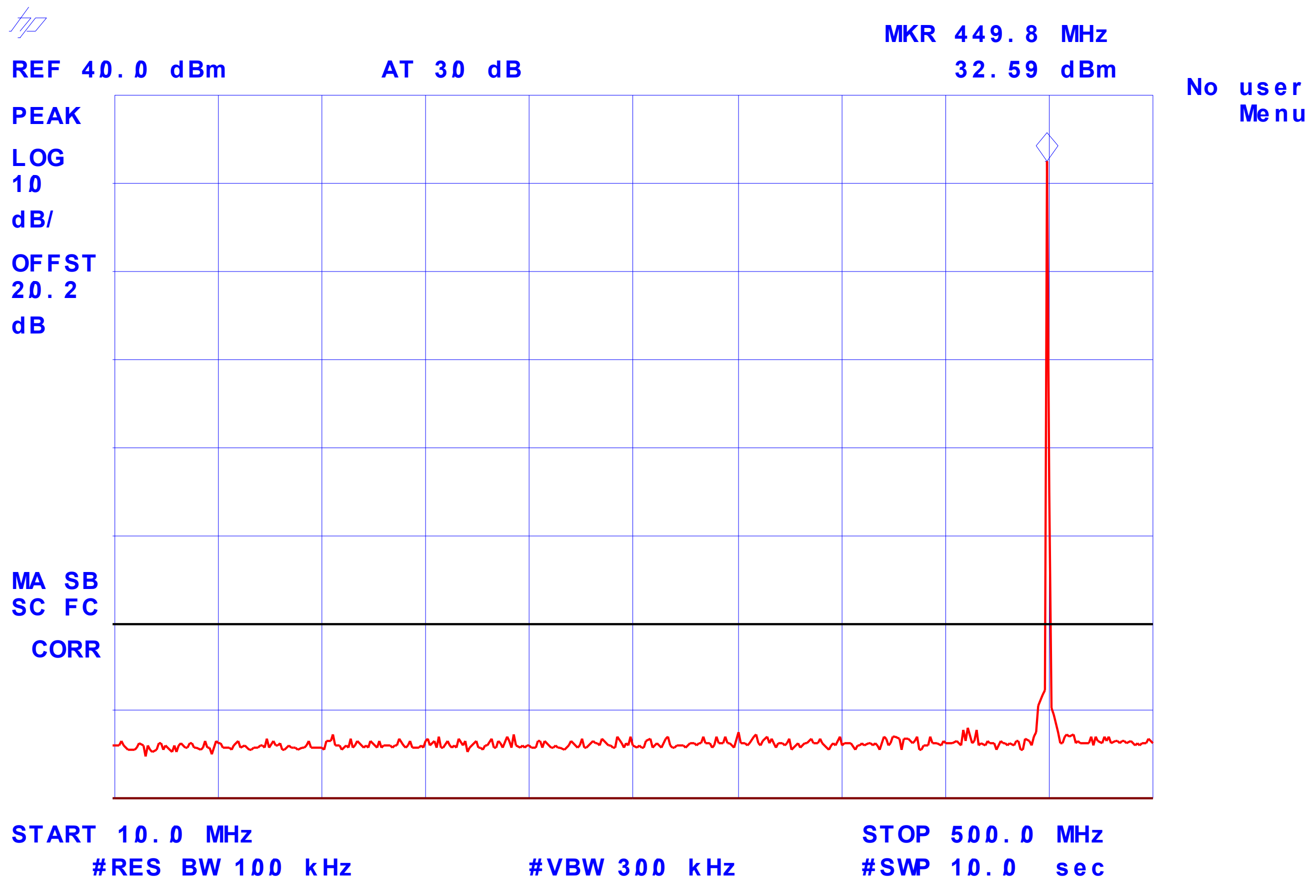


- *All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)*

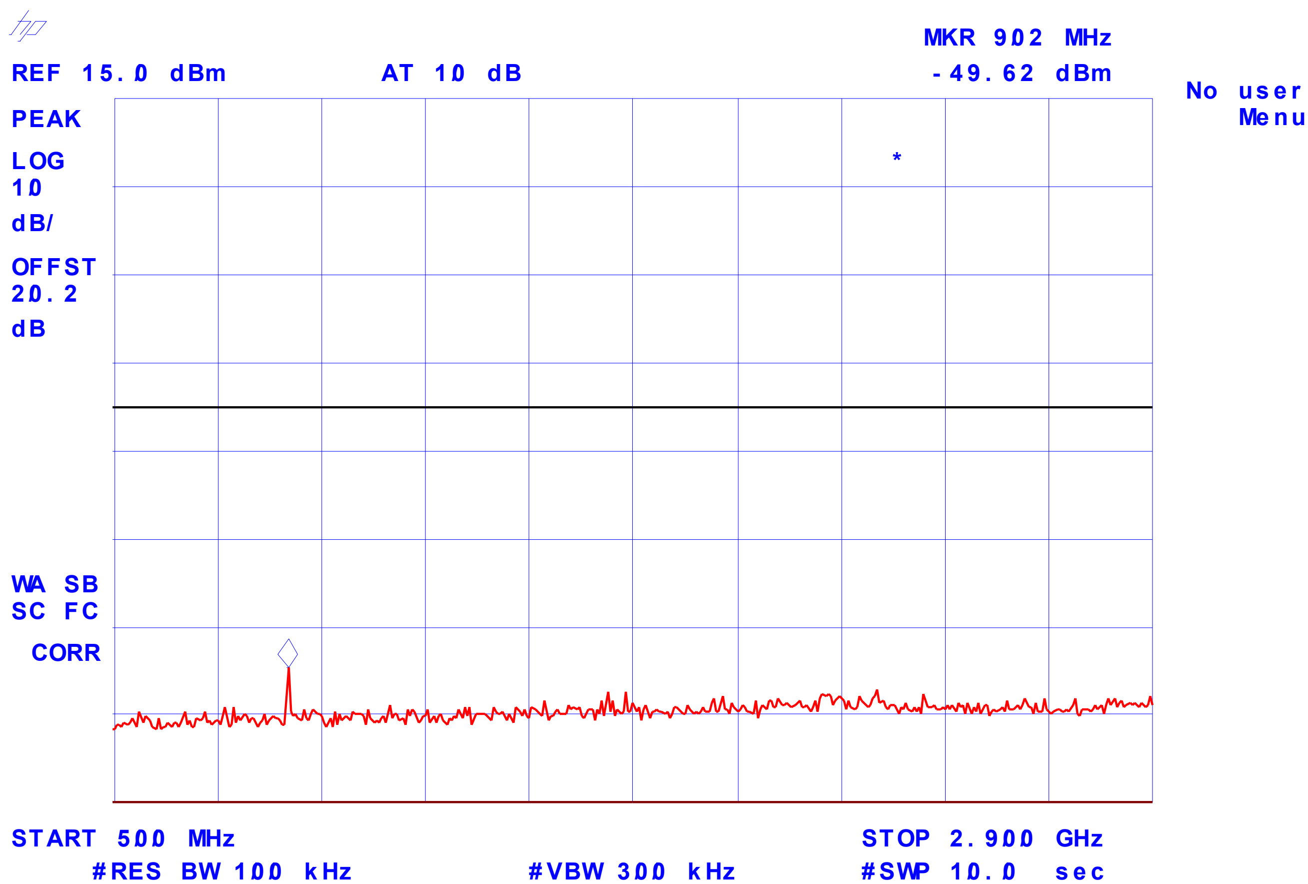
Plot # 59: - Spurious Emissions Conducted with 2 RF signal input, Fc: 450.0MHz



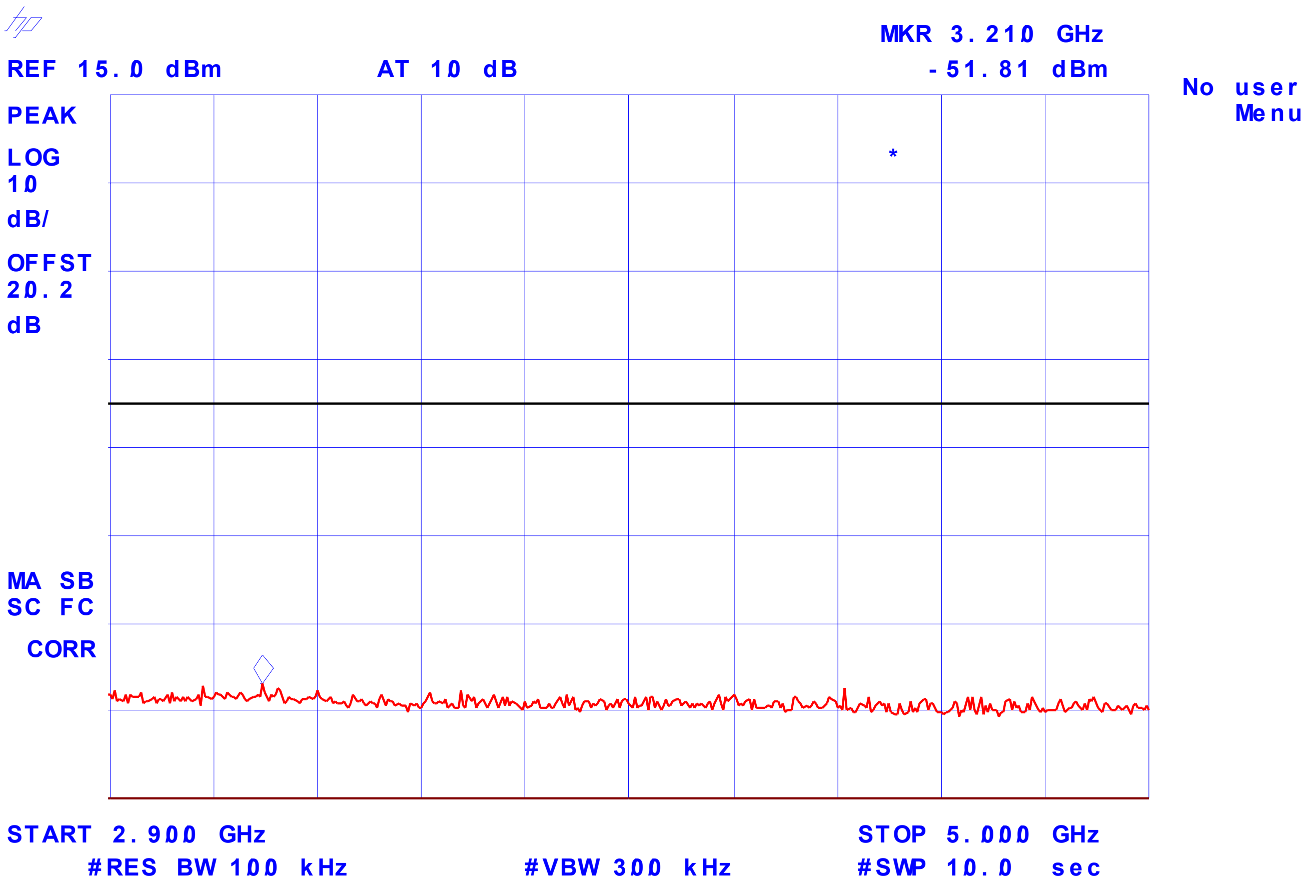
Plot # 60: - Spurious Emissions Conducted with 3 RF signal input, Fc: 450.0MHz



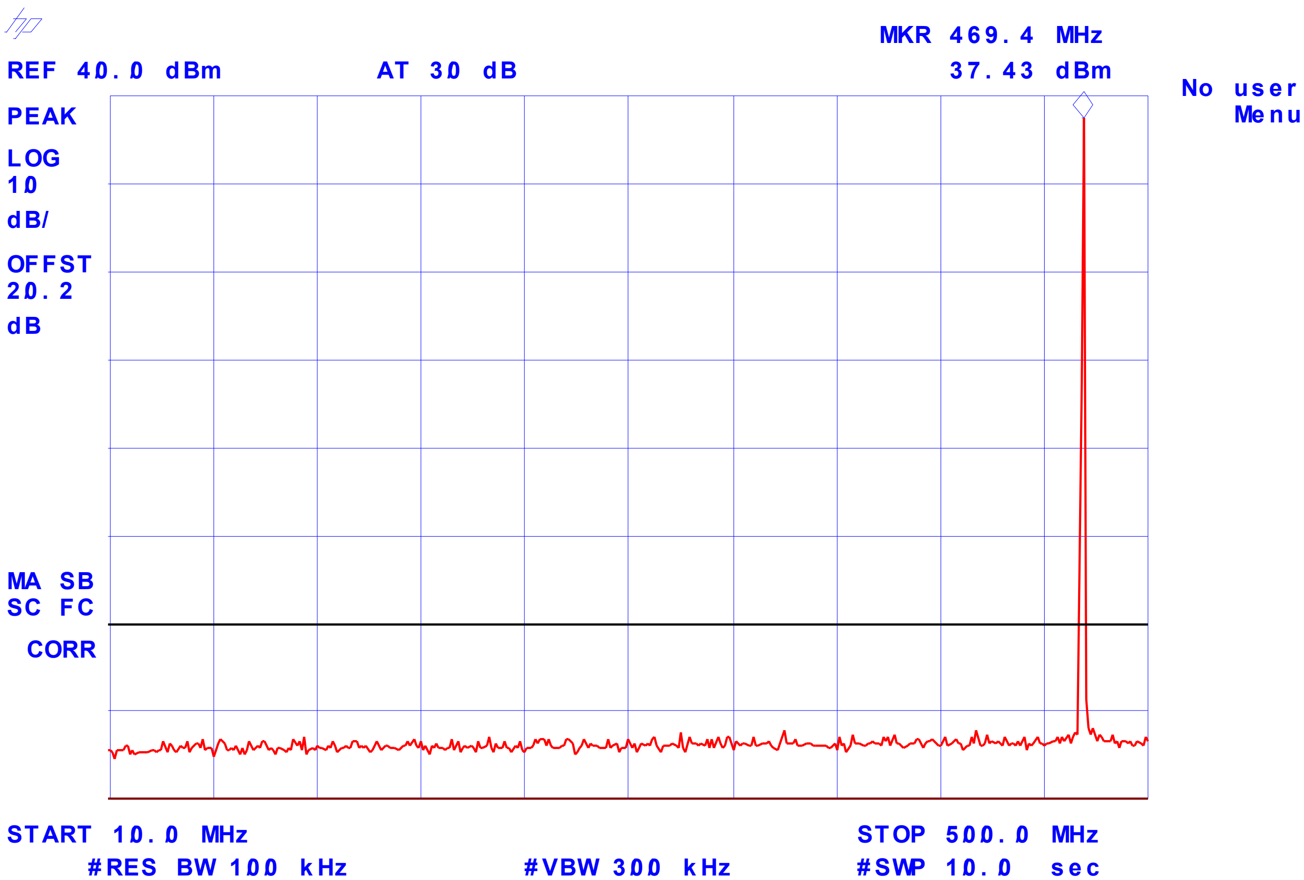
Plot # 61: - Spurious Emissions Conducted with 3 RF signal input, Fc: 450.0MHz



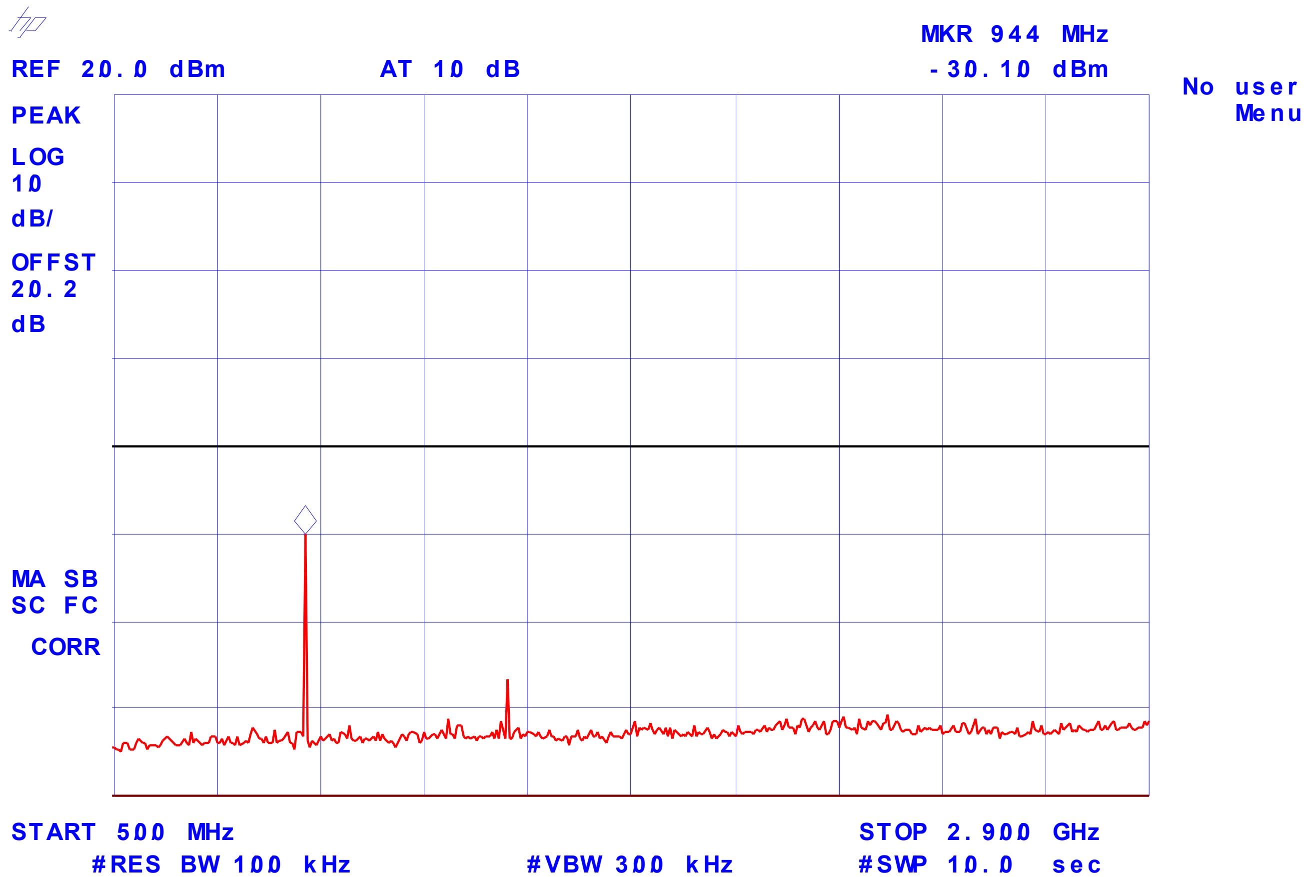
Plot # 62: - Spurious Emissions Conducted with 3 RF signal input, Fc: 450.0MHz



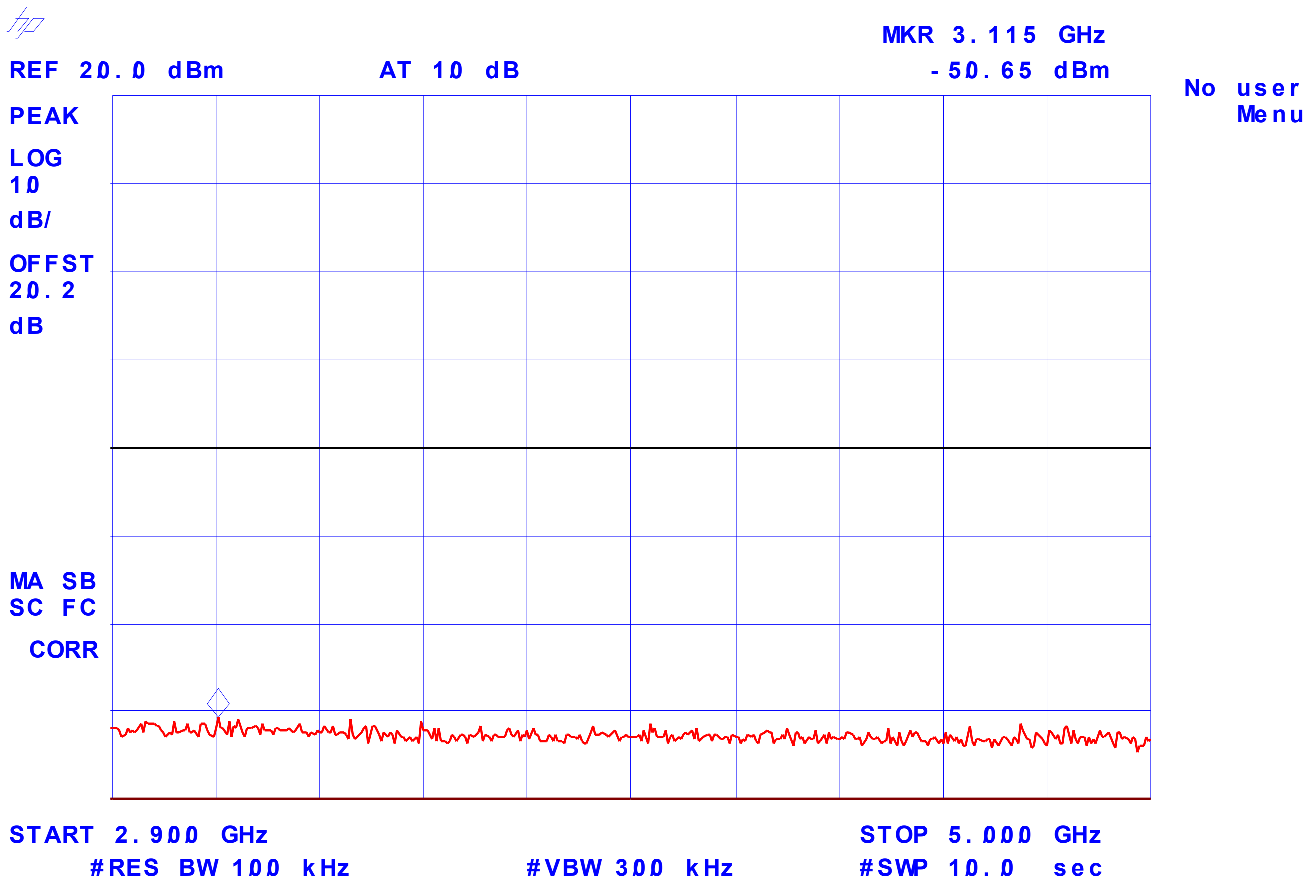
Plot # 63: - Spurious Emissions Conducted with 1 RF signal input, Fc: 470.0MHz



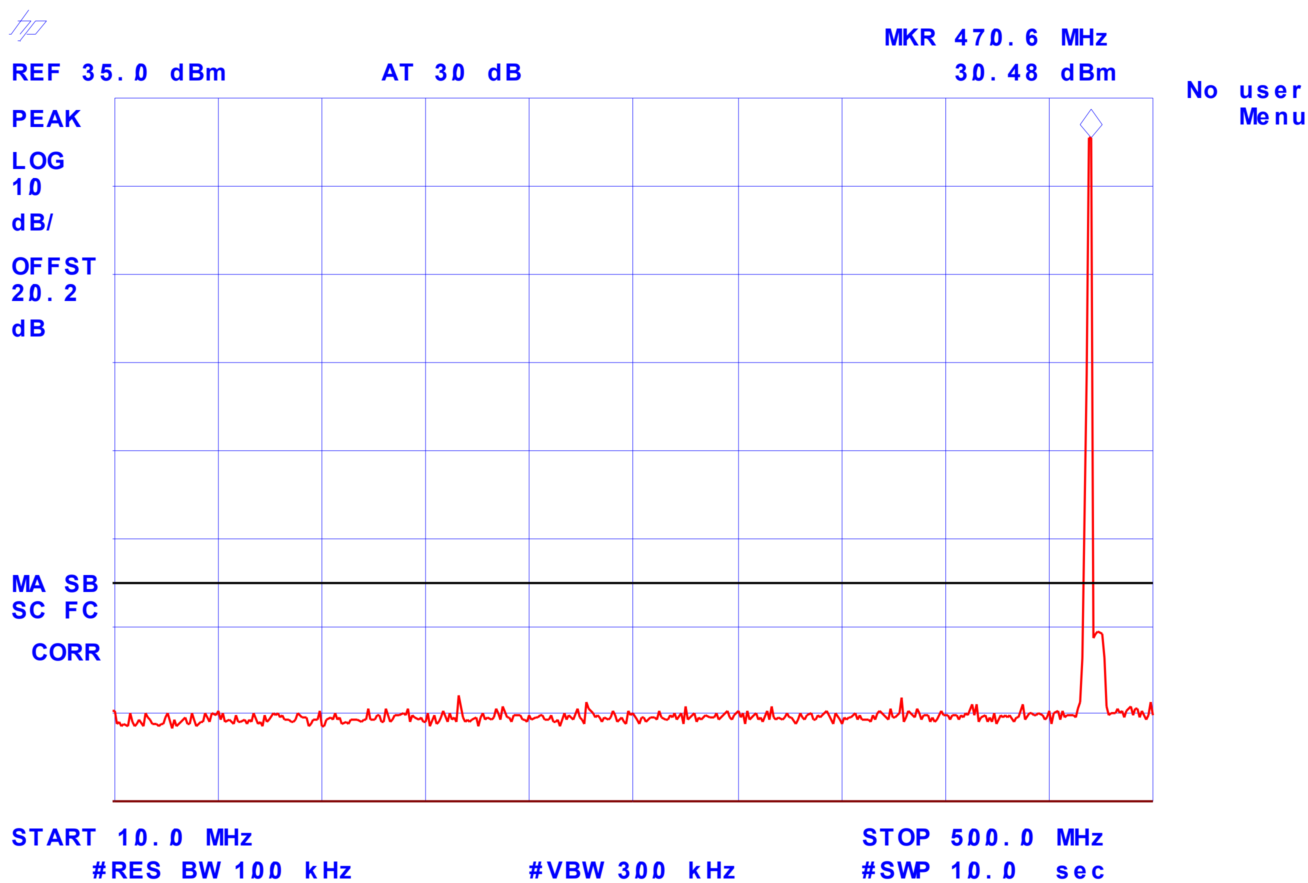
Plot # 64: - Spurious Emissions Conducted with 1 RF signal input, Fc: 470.0MHz



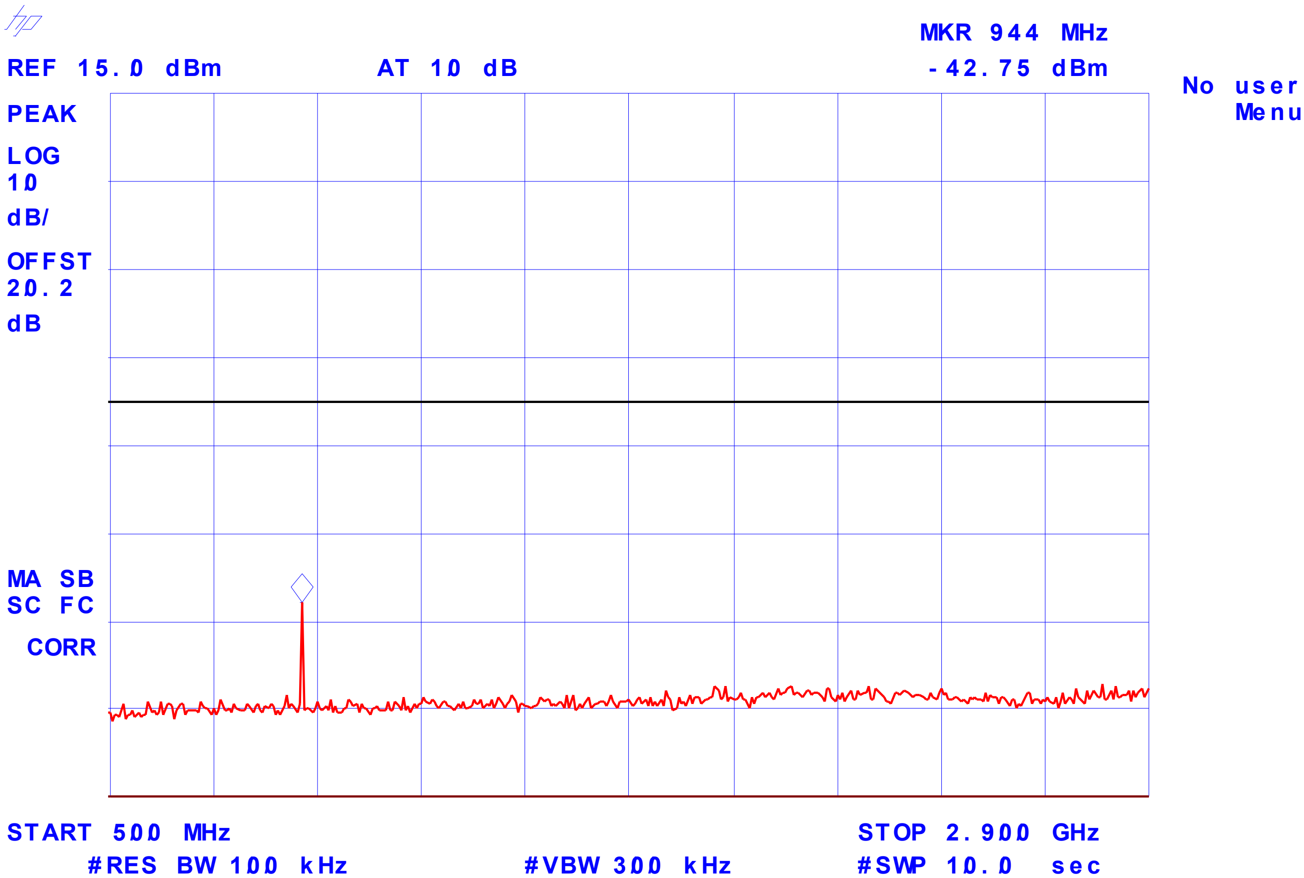
Plot # 65: - Spurious Emissions Conducted with 1 RF signal input, Fc: 470.0MHz



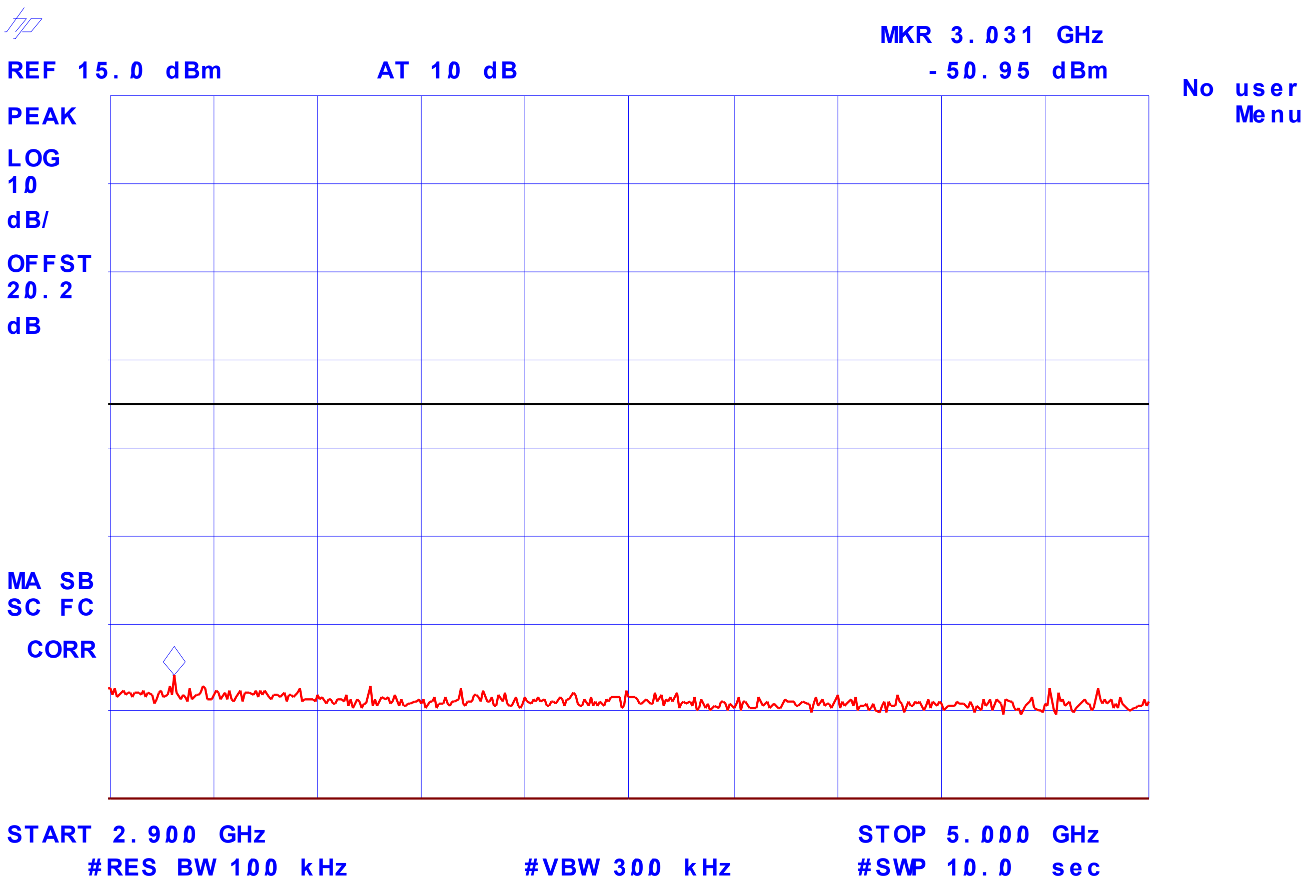
Plot # 66: - Spurious Emissions Conducted with 2 RF signal input, Fc: 470.0MHz



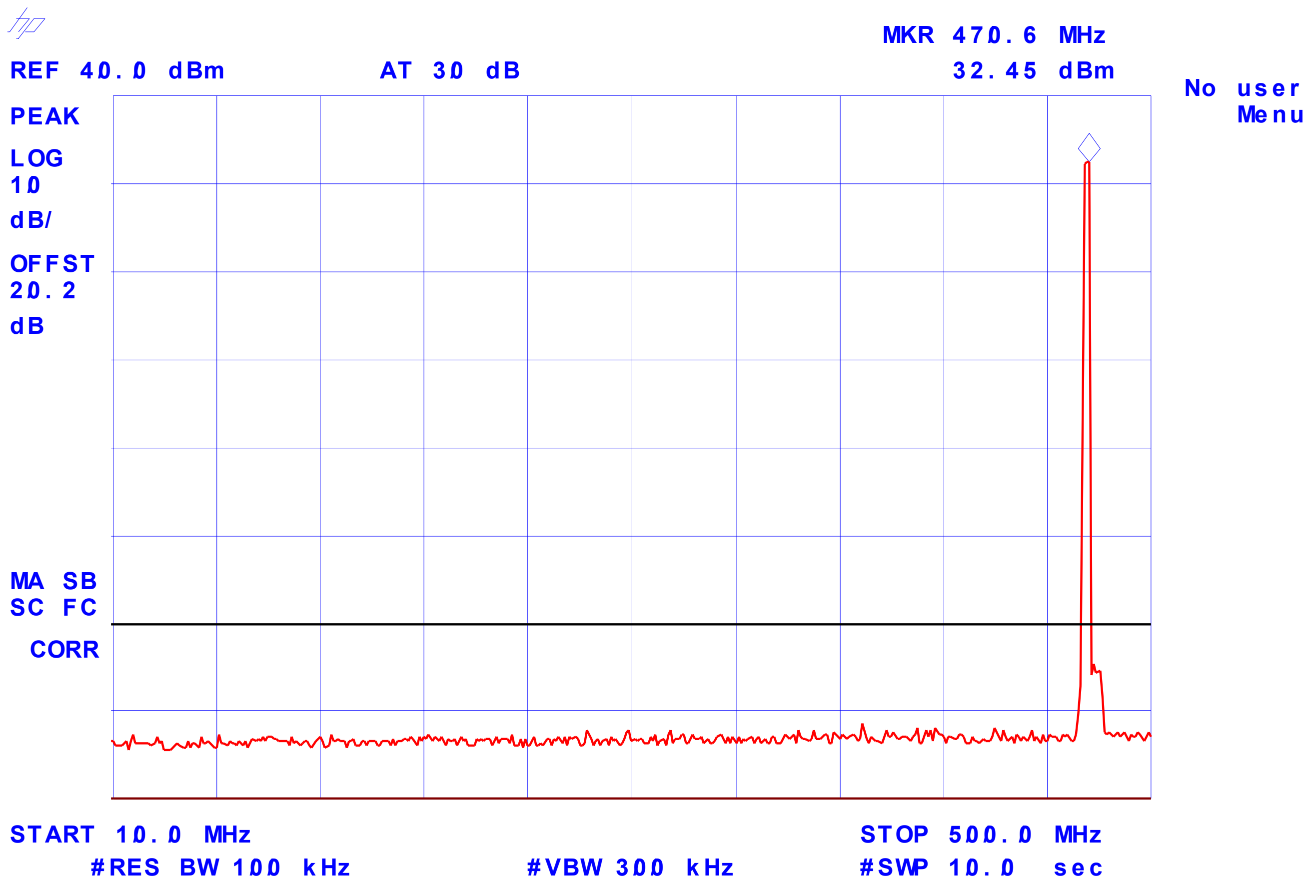
Plot # 67: - Spurious Emissions Conducted with 2 RF signal input, Fc: 470.0MHz



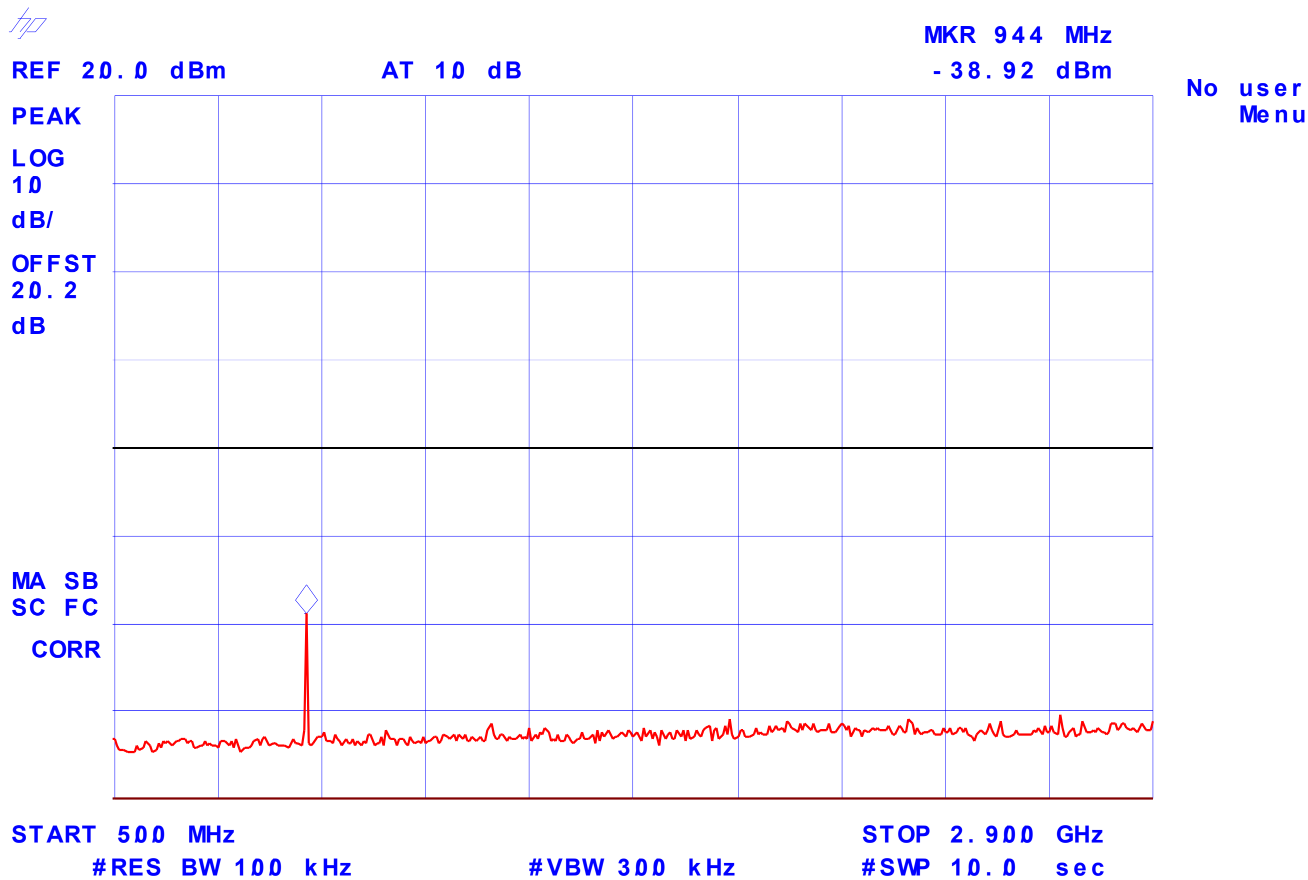
Plot # 68: - Spurious Emissions Conducted with 2 RF signal input, Fc: 470.0MHz



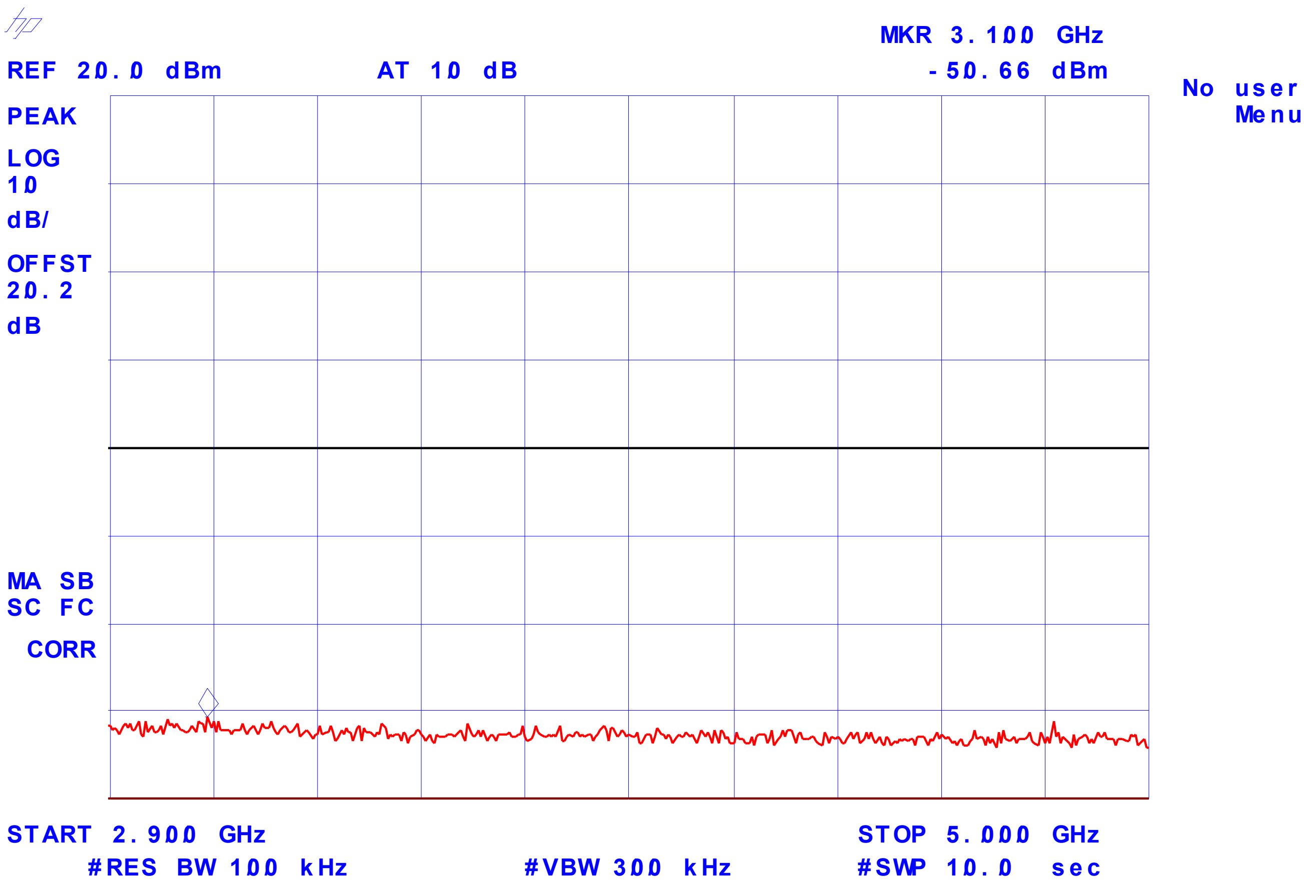
Plot # 69: - Spurious Emissions Conducted with 3 RF signal input, Fc: 470.0MHz



Plot # 70: - Spurious Emissions Conducted with 3 RF signal input, Fc: 470.0MHz



Plot # 71: - Spurious Emissions Conducted with 3 RF signal input, Fc: 470.0MHz



- *All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)*

6.10. TRANSMITTER SPURIOUS/HARMONIC RADIATED EMISSIONS @ FCC 90.210

6.10.1. Limits @ FCC 90.210

Emissions shall be attenuated below the mean output power of the transmitter as follows:

FCC Rules	Frequency Range	Attenuation Limit (dBc)
90.210(b)&(c) – Voice & data	10 MHz to Lowest frequency of the radio to 10^{th} harmonic of the highest frequency of the radio	43+10*log(P) or -13 dBm
90.210(d) – Voice & data	10 MHz to Lowest frequency of the radio to 10^{th} harmonic of the highest frequency of the radio	50+10*log(P) or -20 dBm or 70 dBc whichever is less

6.10.2. Method of Measurements

The spurious/harmonic ERP measurements are using substitution method specified in Exhibit 8, § 8.2 of this report and its value in dBc is calculated as follows:

(1) If the transmitter's antenna is an integral part of the EUT, the ERP is measured using substitution method.
(2) If the transmitter's antenna is non-integral and diverse, the lowest ERP of the carrier with 0 dBi antenna gain is used for calculation of the spurious/harmonic emissions in dBc:
Lowest ERP of the carrier = EIRP – 2.15 dB = Pc + G - 2.15 dB = xxx dBm (conducted) + 0 dBi – 2.15 dB
(3) Spurious /harmonic emissions levels expressed in dBc (dB below carrier) are as follows:

ERP of spurious/harmonic (dBc) = ERP of carrier (dBm) – ERP of spurious/harmonic emission (dBm)

6.10.3. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range
Spectrum Analyzer/ EMI Receiver	Hewlett Packard	HP 8546A	…	9 kHz to 5.6 GHz with built-in 30 dB Gain Pre-selector, QP, Average & Peak Detectors.
RF Amplifier	Com-Power	PA-102		1 MHz to 1 GHz, 30 dB gain nominal
Microwave Amplifier	Hewlett Packard	HP 83017A		1 GHz to 26.5 GHz, 30 dB nominal
Biconilog Antenna	EMCO	3142	10005	30 MHz to 2 GHz
Dipole Antenna	EMCO	3121C	8907-434	30 GHz – 1 GHz
Dipole Antenna	EMCO	3121C	8907-440	30 GHz – 1 GHz
Horn Antenna	EMCO	3155	9701-5061	1 GHz – 18 GHz
Horn Antenna	EMCO	3155	9911-5955	1 GHz – 18 GHz
RF Signal Generator	Hewlett Packard	HP 83752B	3610A00457	0.01 – 20 GHz

6.10.4. Test Setup

Please refer to Photo # 1 and 2 in Annex 1 for detailed of test setup.

6.10.5. Test Data

Remarks:

- Based on the prescans, the rf spurious/harmonic emissions are the same for both 12.5 kHz and 25 kHz Channel Spacing Operation and Data or Voice modulation; therefore, the 12.5 kHz channel spacing operation with FM modulation (2.5 kHz sine wave signal) was chosen for final tests with the most stringent limit of 50+10*log(P in Watts).
- The Radiated emissions were performed at 3 meters distance.

6.10.5.1. Near Lowest Frequency (406.1 MHz)

Fundamental Frequency: 406.1 MHz
RF Output Power: 37.9 dBm (conducted)
Modulation: FM modulation with 2.5 kHz sine wave signal

FREQUENCY (MHz)	E-FIELD @3m (dBuV/m)	ERP measured by Substitution Method (dBm)	ERP measured by Substitution Method (dBc)	EMI DETECTOR (Peak/QP)	ANTENNA POLARIZATION (H/V)	LIMIT (dBc)	MARGIN (dB)	PASS/ FAIL
**	**	**	**	PEAK	V	-57.9	**	PASS

- The emissions were scanned from 10 MHz to 5 GHz and no rf emissions less than 20 dB below the limits were found.

6.10.5.2. Near Middle Frequency (450.0 MHz)

Fundamental Frequency: 450 MHz
RF Output Power: 38.1 dBm (conducted)
Modulation: FM modulation with 2.5 kHz sine wave signal

FREQUENCY (MHz)	E-FIELD @3m (dBuV/m)	ERP measured by Substitution Method (dBm)	ERP measured by Substitution Method (dBc)	EMI DETECTOR (Peak/QP)	ANTENNA POLARIZATION (H/V)	LIMIT (dBc)	MARGIN (dB)	PASS/ FAIL
**	**	**	**	PEAK	V	-58.1	**	PASS

- The emissions were scanned from 10 MHz to 5 GHz and no rf emissions less than 20 dB below the limits were found.

6.10.5.3. Near Highest Frequency (470.0 MHz)

Fundamental Frequency:	470 MHz
RF Output Power:	37.8 dBm (ERP)
Modulation:	FM modulation with 2.5 kHz sine wave signal

FREQUENCY (MHz)	E-FIELD @3m (dBuV/m)	ERP measured by Substitution Method (dBm)	ERP measured by Substitution Method (dBc)	EMI DETECTOR (Peak/QP)	ANTENNA POLARIZATION (H/V)	LIMIT (dBc)	MARGIN (dB)	PASS/ FAIL
**	**	**	**	PEAK	V	-57.8	**	PASS

- The emissions were scanned from 10 MHz to 5 GHz and no rf emissions less than 20 dB below the limits were.

EXHIBIT 7. MEASUREMENT UNCERTAINTY

The measurement uncertainties stated were calculated in accordance with the requirements of NIST Technical Note 1297 and NIS 81 (1994)

7.1. RADIATED EMISSION MEASUREMENT UNCERTAINTY

CONTRIBUTION (Radiated Emissions)	PROBABILITY DISTRIBUTION	UNCERTAINTY (± dB)	
		3 m	10 m
Antenna Factor Calibration	Normal (k=2)	±1.0	±1.0
Cable Loss Calibration	Normal (k=2)	±0.3	±0.5
EMI Receiver specification	Rectangular	±1.5	±1.5
Antenna Directivit	Rectangular	+0.5	+0.5
Antenna factor variation with height	Rectangular	±2.0	±0.5
Antenna phase center variation	Rectangular	0.0	±0.2
Antenna factor frequency interpolation	Rectangular	±0.25	±0.25
Measurement distance variation	Rectangular	±0.6	±0.4
Site imperfections	Rectangular	±2.0	±2.0
Mismatch: Receiver VRC $\Gamma_1 = 0.2$ Antenna VRC $\Gamma_R = 0.67$(Bi) 0.3 (Lp) Uncertainty limits $20\text{Log}(1 \pm \Gamma_1 \Gamma_R)$	U-Shaped	+1.1 -1.25	±0.5
System repeatability	Std. Deviation	±0.5	±0.5
Repeatability of EUT		-	-
Combined standard uncertainty	Normal	+2.19 / -2.21	+1.74 / -1.72
Expanded uncertainty U	Normal (k=2)	+4.38 / -4.42	+3.48 / -3.44

Calculation for maximum uncertainty when 3m biconical antenna including a factor of k=2 is used:

$U = 2u_c(y) = 2x(+2.19) = +4.38$ dB And $U = 2u_c(y) = 2x(-2.21) = -4.42$ dB

EXHIBIT 8. MEASUREMENT METHODS

8.1. CONDUCTED POWER MEASUREMENTS

- The following shall be applied to the combination(s) of the radio device and its intended antenna(e).
- I f the RF level is user adjustable, all measurements shall be made with the highest power level available to the user for that combination.
- The following method of measurement shall apply to both conducted and radiated measurements.
- The radiated measurements are performed at the Ultratech Calibrated Open Field Test Site.
- The measurement shall be performed using normal operation of the equipment with modulation.

Test procedure shall be as follows:

Step 1: Duty Cycle measurements if the transmitter's transmission is transient

- Using a EMI Receiver with the frequency span set to 0 Hz and the sweep time set at a suitable value to capture the envelope peaks and the duty cycle of the transmitter output signal;
- The duty cycle of the transmitter, x = Tx on / (Tx on + Tx off) with $0<x<1$, is measure and recorded in the test report. For the purpose of testing, the equipment shall be operated with a duty cycle that is equal or more than 0.1.

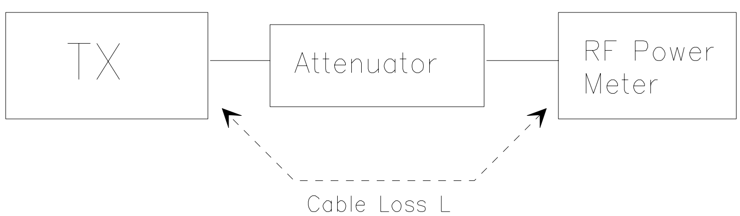
Step 2: Calculation of Average EIRP. See Figure 1

- The average output power of the transmitter shall be determined using a wideband, calibrated RF average power meter with the power sensor with an integration period that exceeds the repetition period of the transmitter by a factor 5 or more. The observed value shall be recorded as "A" (in dBm);
- The e.i.r.p. shall be calculated from the above measured power output "A", the observed duty cycle x, and the applicable antenna assembly gain "G" in dBi, according to the formula:

  EIRP = A + G + 10log(1/x)

  { X = 1 for continuous transmission => 10log(1/x) = 0 dB }

  Figure 1.



8.2. RADIATED POWER MEASUREMENTS (ERP & EIRP) USING SUBSTITUTION METHOD

8.2.1. Maximizing RF Emission Level (E-Field)

(a) The measurements was performed with full rf output power and modulation.
(b) Test was performed at listed 3m open area test site (listed with FCC, IC, ITI, NVLAP, ACA & VCCI).
(c) The transmitter under test was placed at the specified height on a non-conducting turntable (80 cm height)
(d) The BICONILOG antenna (20 MHz to 1 GHz) or HORN antenna (1 GHz to 18 GHz) was used for measuring.
(e) Load an appropriate correction factors file in EMI Receiver for correcting the field strength reading level

Total Correction Factor recorded in the EMI Receiver = Cable Loss + Antenna Factor
E (dBuV/m) = Reading (dBuV) + Total Correction Factor (dB/m)

(f) Set the EMI Receiver and #2 as follows:

Center Frequency:	test frequency
Resolution BW:	100 kHz
Video BW:	same
Detector Mode:	positive
Average:	off
Span:	3 x the signal bandwidth

(g) The test antenna was lowered or raised from 1 to 4 meters until the maximum signal level was detected.
(h) The transmitter was rotated through 360^{o} about a vertical axis until a higher maximum signal was received.
(i) The test antenna was lowered or raised again from 1 to 4 meters until a maximum was obtained. This level was recorded.
(j) The recorded reading was corrected to the true field strength level by adding the antenna factor, cable loss and subtracting the pre-amplifier gain.
(k) The above steps were repeated with both transmitters' antenna and test receiving antenna placed in vertical and horizontal polarization. Both readings with the antennas placed in vertical and horizontal polarization shall be recorded.
(l) Repeat for all different test signal frequencies

8.2.2. Measuring the EIRP of Spurious/Harmonic Emissions using Substitution Method

(a) Set the EMI Receiver (for measuring E-Field) and Receiver #2 (for measuring EIRP) as follows:

Center Frequency:	equal to the signal source
Resolution BW:	10 kHz
Video BW:	same
Detector Mode:	positive
Average:	off
Span:	3 x the signal bandwidth

(b) Load an appropriate correction factors file in EMI Receiver for correcting the field strength reading level

Total Correction Factor recorded in the EMI Receiver = Cable Loss + Antenna Factor
E (dBuV/m) = Reading (dBuV) + Total Correction Factor (dB/m)

(c) Select the frequency and E-field levels obtained in the Section 8.2.1 for ERP/EIRP measurements.
(d) Substitute the EUT by a signal generator and one of the following transmitting antenna (substitution antenna):
- ♦ DIPOLE antenna for frequency from 30-1000 MHz or
- ♦ HORN antenna for frequency above 1 GHz }.

(e) Mount the transmitting antenna at 1.5 meter high from the ground plane.
(f) Use one of the following antenna as a receiving antenna:
- ♦ DIPOLE antenna for frequency from 30-1000 MHz or
- ♦ HORN antenna for frequency above 1 GHz }.

(g) If the DIPOLE antenna is used, tune it's elements to the frequency as specified in the calibration manual.
(h) Adjust both transmitting and receiving antenna in a VERTICAL polarization.
(i) Tune the EMI Receivers to the test frequency.
(j) Lower or raise the test antenna from 1 to 4 meters until the maximum signal level was detected.
(k) The transmitter was rotated through 360^o about a vertical axis until a higher maximum signal was received.
(l) Lower or raise the test antenna from 1 to 4 meters until the maximum signal level was detected.
(m) Adjust input signal to the substitution antenna until an equal or a known related level to that detected from the transmitter was obtained in the test receiver.
(n) Record the power level read from the Average Power Meter and calculate the ERP/EIRP as follows:

P = P1 - L1 = (P2 + L2) – L1 = P3 + A + L2 - L1
EIRP = P + G1 = P3 + L2 - L1 + A + G1
ERP = EIRP – 2.15 dB
Total Correction factor in EMI Receiver # 2 = L2 – L1 + G1

Where:		
	P:	Actual RF Power fed into the substitution antenna port after corrected.
	P1:	Power output from the signal generator
	P2:	Power measured at attenuator A input
	P3:	Power reading on the Average Power Meter
	EIRP:	EIRP after correction
	ERP:	ERP after correction

(o) Adjust both transmitting and receiving antenna in a HORIZONTAL polarization, then repeat step (k) to (o)
(p) Repeat step (d) to (o) for different test frequency
(q) Repeat steps (c) to (j) with the substitution antenna oriented in horizontal polarization.
(r) Actual gain of the EUT's antenna is the difference of the measured EIRP and measured RF power at the RF port. Correct the antenna gain if necessary.:

Figure 2

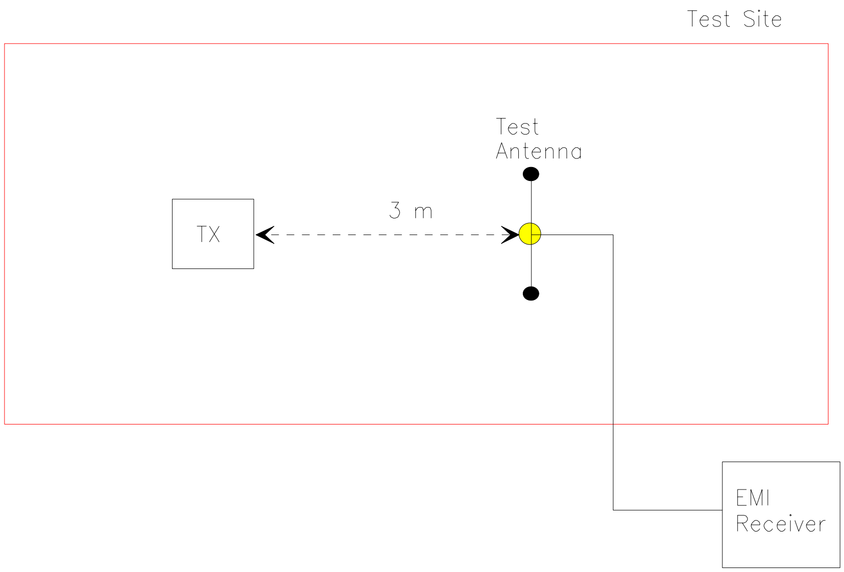
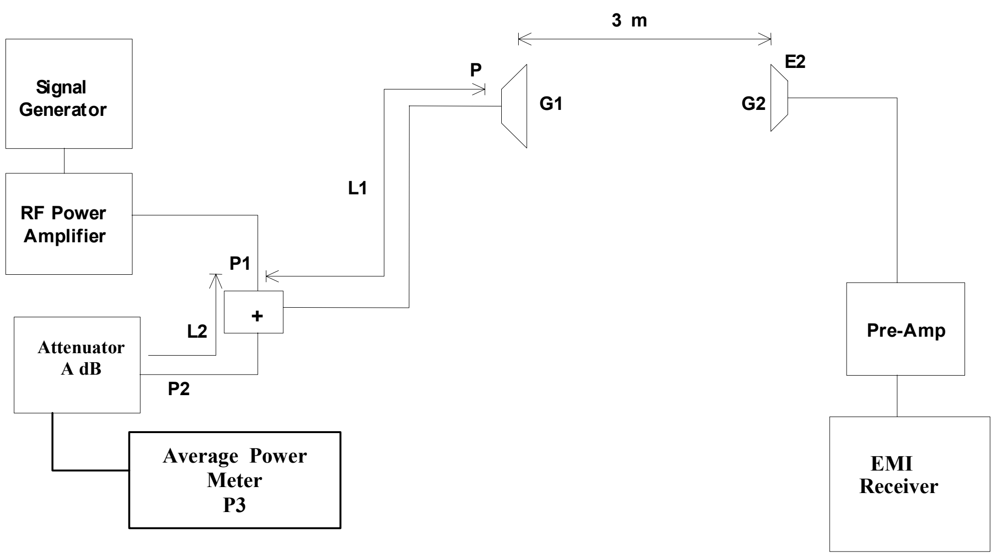


Figure 3



8.3. FREQUENCY STABILITY

Refer to FCC @ 2.1055.

(a) The frequency stability shall be measured with variation of ambient temperature as follows: From -30 to +50 centigrade except that specified in subparagraph (2) & (3) of this paragraph.

(b) Frequency measurements shall be made at extremes of the specified temperature range and at intervals of not more than 10 centigrade through the range. A period of time sufficient to stabilize all of the components of the oscillator circuit at each temperature level shall be allowed prior to frequency measurement. The short-term transient effects on the frequency of the transmitter due to keying (except for broadcast transmitters) and any heating element cycling normally occurring at each ambient temperature level also shall be shown. Only the portion or portions of the transmitter containing the frequency determining and stability circuitry need be subjected to the temperature variation test.

(d) The frequency stability supply shall be measured with variation of primary supply voltage as follows:

(1) Vary primary supply voltage from 85 to 115 percent of the nominal value for other than hand carried battery equipment.

(2) For hand carried, battery powered equipment, reduce primary supply voltage to the battery operating end point which shall be specified by the manufacturer.

(3) The supply voltage shall be measured at the input to the cable normally provide with the equipment, or at the power supply terminals if cables are not normally provided. Effects on frequency of transmitter keying (except for broadcast transmitters) and any heating element cycling at the nominal supply voltage and at each extreme also shall be shown.

(e) When deemed necessary, the Commission may require tests of frequency stability under conditions in addition to those specifically set out in paragraphs (a), (b), (c) and (d) of this section. (For example, measurements showing the effect of proximity to large metal objects, or of various types of antennas, may be required for portable equipment).

8.4. EMISSION MASK

Voice or Digital Modulation Through a Voice Input Port @ 2.1049(c)(i):- The transmitter was modulated by a 2.5 KHz tone signal at an input level 16 dB greater than that required to produce 50% modulation (e.g.: ±2.5 KHz peak deviation at 1 KHz modulating frequency). The input level was established at the frequency of maximum response of the audio modulating circuit.

Digital Modulation Through a Data Input Port @ 2.1049(h):- Transmitters employing digital modulation techniques - when modulated by an input signal such that its amplitude and symbol rate represent the maximum rated conditions under which the equipment will be operated. The signal shall be applied through any filter networks, pseudo-random generators or other devices required in normal service. Additionally, the Emission Masks shall be shown for operation with any devices used for modifying the spectrum when such devices are operational at the discretion of the user.

The following EMI Receiver bandwidth shall be used for measurement of Emission Mask/Out-of-Band Emission Measurements:

(1) For 25 kHz Channel Spacing: RBW = 300 Hz
(2) For 12.5 kHz or 6.25 kHz Channel Spacings: RBW = 100 Hz

The all cases the Video Bandwidth shall be equal or greater than the measuring bandwidth.

8.5. SPURIOUS EMISSIONS (CONDUCTED)

With transmitter modulation characteristics described in Out-of-Band Emissions measurements @ 2.1049, the transmitter spurious and harmonic emissions were scanned. The spurious and harmonic emissions were measured with the EMI Receiver controls set as RBW = 30 kHz minimum , VBW ≥ RBW and SWEEP TIME = AUTO). The transmitter was operated at a full rated power output, and modulated as follows:

FCC CFR 47, Para. 2.1057 - Frequency spectrum to be investigated:- The spectrum was investigated from the lowest radio generated in the equipment up to at least the 10^{th} harmonic of the carrier frequency or to the highest frequency practicable in the present state of the art of measuring techniques, whichever is lower. Particular attention should be paid to harmonics and subharmonics of the carrier frequency. Radiation at the frequencies of multiplier stages should be checked. The
amplitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be reported.

FCC CFR 47, Para. 2.1051 - Spurious Emissions at Antenna Terminal:- The radio frequency voltage or powers generated within the equipment and appearing on a spurious frequency shall be checked at the equipment output terminals when properly loaded with a suitable artificial antenna. Curves or equivalent data shall show the magnitude of the harmonic and other spurious emission that can be detected when the equipment is operated under the conditions specified in 2.1049 as appropriate. The magnitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be specified.