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Test Report
FCC Part 25 Testing
for
AT1595-82
AT1595-83
Inmarsat GSPS Antennas
FCC ID: A6LAT1595-82

Table of Contents

1 INTRODUCTION

AT1595-82 and AT1595-83 antennas use a common power amplifier and are designed to transmit in the Inmarsat frequency band (1626.5 MHz to 1660.5 MHz).

1.1 SCOPE

Reference:	FCC Parts 2 and 25 Subpart C
Title:	Telecommunication – Code of Federal Regulations, CFR 47, Parts 2 & 25 Subpart C
Purpose of Test:	FCC Certification Authorization for Radio operating in the frequency bands 1626.5MHz-1660.5 MHz
Test Procedures:	Both conducted and radiated emission 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.

1.2 RELATED SUBMITTALS/GRANTS

None.

1.3 NORMATIVE REFERENCES

- FCC CFR Parts 2 and 25, 2013, Code of Federal Regulations – Telecommunication.
- ANSI C63.4, 2003, 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 16-1-1, 2004, Specification for Radio Disturbance and Immunity measuring apparatus and methods.
- TIA/EIA 603, Edition C, 2004, Land Mobile or PM Communications Equipment Measurement and Performance Standards.

1.4 DATE OF TESTING

- Testing date(s): June, 2013.
- Report date(s). November, 2013.

2 PERFORMANCE ASSESSMENT

2.1 APPLICANT INFORMATION

- Name: AeroAntenna Technology, Inc.

- Address: 20732 Lassen Street, Chatsworth, CA, USA, 91311
- Contact Person: William Eaton, Ph.D., Senior Engineer
- Test Engineer: Mr. Alex Sissoev, BSEE UCLA
- Phone: (818) 993-3842
- Fax: (818) 993-4525
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2.2 MANUFACTURER

- Name: AeroAntenna Technology, Inc.
- Address: 20732 Lassen Street, Chatsworth, CA, USA, 91311
- Contact Person: William Eaton, Ph.D., Senior Engineer
- Phone: (818) 993-3842
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2.3 EQUIPMENT UNDER TEST (EUT)

- FCCID: A6LAT1595-82
- Brand Name: AeroAntenna
- Product Name/Model Name: AT1595-82 and AT1595-83
- Serial Number: Production prototype
- EUT Application: Satellite Active Antenna System
- Type of Equipment: Amplifier
- Power Supply: DC 32 Volts maximum

2.4 EUT TECHNICAL SPECIFICATION

- AMPLIFIER + INTEGRAL ANTENNA
  - Equipment Type: Mobile or Fixed Base Station
  - Intended Operating Environment: Commercial, Light Industry, and Heavy Industry.
  - Power Supply Requirement: DC 32 Volts maximum.
  - RF Input Power Rating: +26.2 dBm (conducted)
  - RF Output Power Rating: +45 dBm EIRP
  - Duty Cycle: N/A
  - TX Operating Frequency Range: 1626.5 MHz – 1660.5 MHz
  - RX Operating Frequency Range: 1518.0 MHz – 1559.0 MHz
  - Channel Spacing: N/A
  - Occupied Bandwidth: 86.7325 kHz
  - Modulation: GMSK
  - Emission Designation: 86K1G1W
  - Antenna Connector Type: Integral

2.5 LIST OF EUT PORTS

- Isat RX/TX + DC Power
  - Connector: SMA, Shielded Coaxial Cable
- GPS
  - Connector: SMA, Shielded Coaxial Cable

Figure 1. Photograph of AT1595-82 and AT1595-83 antennas.
(left) AT1595-82 antenna side view.
(middle) AT1595-83 antenna side view
(right) bottom view either antenna

3 EUT OPERATING CONDITIONS AND CONFIGURATIONS DURING TESTS

3.1 CLIMATE TEST CONDITIONS

- Temperature: 23 °C
- Humidity: 50%
- Pressure: 102 kPa
- Power input source: 30 VDC

3.2 OPERATIONAL TEST CONDITIONS & ARRANGEMENT FOR TEST SIGNALS

- Operating Modes: The transmitter was operated in a continuous transmission mode with the carrier modulated as specified in the Test Data.
- Transmitter Test Antenna: The EUT was tested with the transmitter antenna port terminated into a 50 Ohm RF Load.
- Transmitter Test Signals:
  - Frequency Bands: 1626.5 MHz – 1660.5 MHz
  - Transmitter Wanted Output Test Signals:
    - Max. RF Input Power: +29.92 dBm (conducted)

- Max. RF Output Power: +40.93 dBm from power amplifier
- Normal Test Modulation: GMSK
- Modulating signal source: Signal generator

4 TESTS FOR PART 25

Part 25.129 provides the best guidance for what to test. Unfortunately, it happens to refer to "portable devices" -- devices designed to be used close (≤ 20 cm) to the operator's body. The antenna being tested, does not strictly fall into this category. However, we will use this section for guidance anyway. This was suggested by the International Bureau of the FCC.

In particular, 25.129(c) spells out which tests should be performed.

> § 25.129 Equipment authorization for portable earth-station transceivers.
>
> (a) Except as expressly permitted by §2.803 or §2.1204 of this chapter, prior authorization must be obtained pursuant to the equipment certification procedure in part 2, Subpart J of this chapter for importation, sale or lease in the United States, or offer, shipment, or distribution for sale or lease in the United States of portable earth-station transceivers subject to regulation under part 25. This requirement does not apply, however, to devices imported, sold, leased, or offered, shipped, or distributed for sale or lease before November 20, 2004.
>
> (b) For purposes of this section, an earth-station transceiver is portable if it is a "portable device" as defined in §2.1093(b) of this chapter, i.e., if its radiating structure(s) would be within 20 centimeters of the operator's body when the transceiver is in operation.
>
> (c) In addition to the information required by §1.1307(b) and §2.1033(c) of this chapter, applicants for certification required by this section shall submit any additional equipment test data necessary to demonstrate compliance with pertinent standards for transmitter performance prescribed in §25.138, §25.202(f), §25.204, §25.209, and §25.216 and shall submit the statements required by §2.1093(c) of this chapter.
>
> (d) Applicants for certification required by this section must submit evidence that the devices in question are designed for use with a satellite system that may lawfully provide service to users in the United States pursuant to an FCC license or order reserving spectrum.

Not all of the requirements of §25.129(c) are applicable to the EUT. Applicability is outlined in Table 1. Only sections §25.202(f) and §25.216 apply to the EUT.

Table 1. Applicability of §25.129(c) requirements to EUT.

section	short desc	does it apply to EUT?
25.138	18.3-18.8 GHz, 19.7-20.2 GHz	not applicable. outside band
25.202(f)	emissions limitations	***does apply***
25.204	power limits	not applicable. Iridium band is not "shared coequally with terrestrial radio communication services"
25.209	antenna performance for fixed satellite service	not applicable. mobile satellite service
25.216	limits on emissions to protect aeronautical radionavigation-satellite service.	***does apply***

5 SUMMARY OF TEST RESULTS

5.1 LOCATION OF TESTS

- AeroAntenna Technology, Inc., Chatsworth, CA, 91311, USA
  - Radiated emissions were performed at the AeroAntenna on-site Anechoic chamber, which has 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.

5.2 APPLICABILITY & SUMMARY OF EMC EMISSION TEST RESULTS

- FCC P.2.1046(a), 25.202(f), 25.216: Power Limit
- FCC P.1.1307, 1.1310, 2.1091 & 2.1093: RF Exposure Limit
- FCC P2.1049: 99% Occupied Bandwidth
- FCC P.2.1051, 25.202(f) : Emission Mask measured at antenna terminal
- FCC P.2.1051, 25.202(f) : Spurious Emissions at antenna terminal
- FCC P.2.1053, 25.202(f) : Emission Limits – Field Strength of Spurious Emissions

5.3 MODIFICATIONS TO EUT FOR COMPLIANCE PURPOSES

None.

5.4 DEVIATION FROM STANDARD TEST PROCEDURES

None.

5.5 TEST SETUP

Measurements were performed in an anechoic chamber. A diagram of the test setup is shown in Figure 2. Photographs of the side door and back door are shown in Figure 3. Lastly, a photograph of the test equipment is shown in Figure 4.

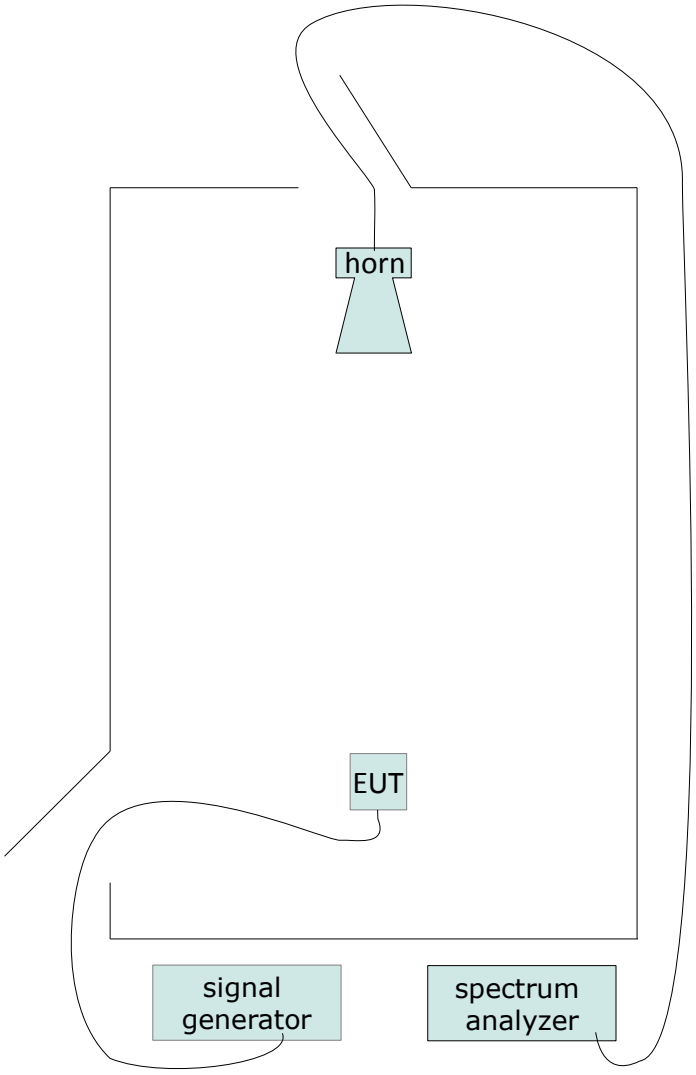


Figure 2. Diagram of test set up in anechoic chamber. Top view of anechoic chamber. Doors are closed for measurements.

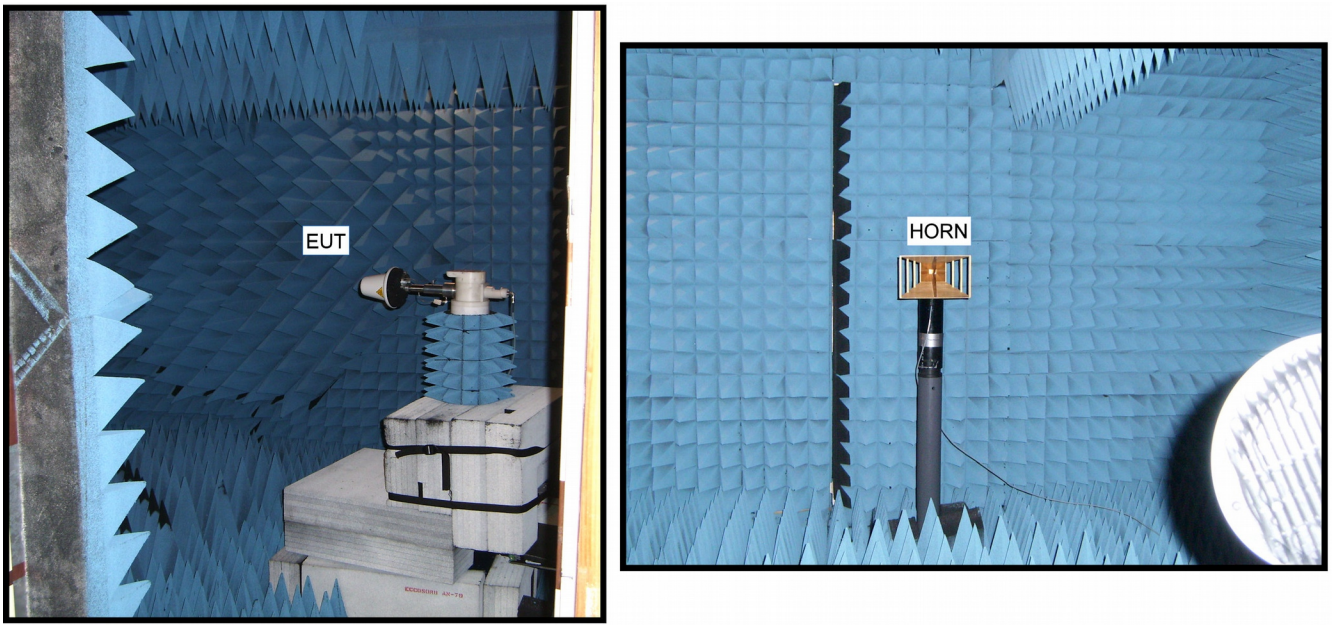


Figure 3. Photographs of anechoic chamber. (left) View is looking into side door of anechoic chamber showing equipment under test (EUT). (right) View from inside chamber just behind EUT looking towards reference horn. For actual measurements, door is closed with RF cable passing through the door to the spectrum analyzer.

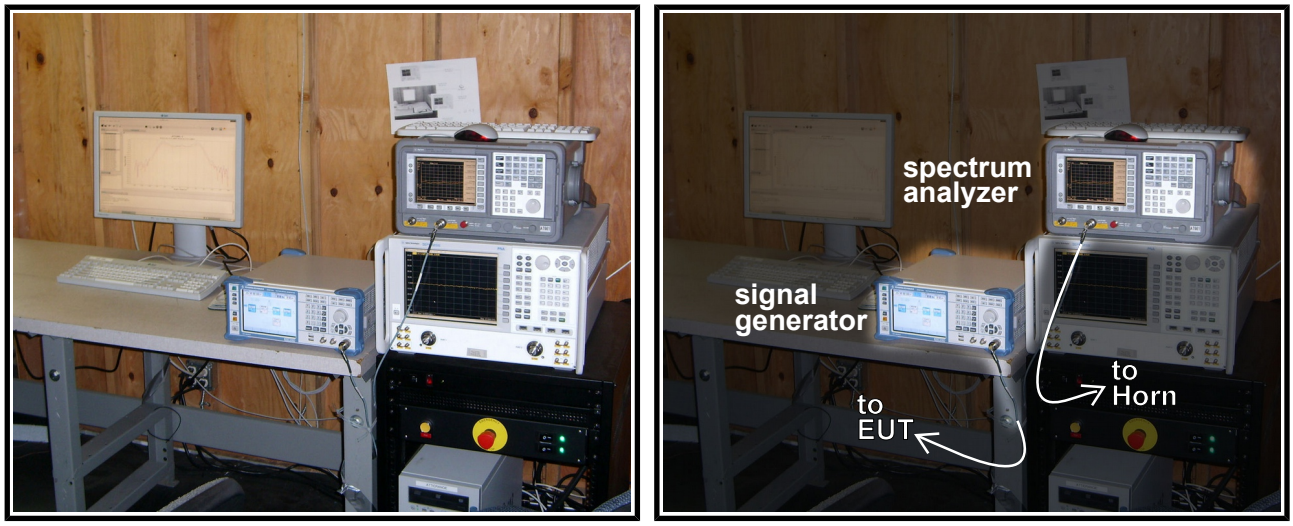


Figure 4. Photographs of test setup. (left) all test equipment. (right) test equipment used for this report highlighted.

6 EMISSIONS LIMITATIONS

6.1 BROADBAND LIMITATIONS

6.1.1 METHOD OF MEASUREMENT AND TEST ARRANGEMENT

Broadband Emissions limitations measurements were performed over a wide range of frequencies in an anechoic chamber using a Spectrum Analyzer in max hold mode. The test

arrangement is shown in Figure 2. This was performed as a radiated measurement. Recall that the AT1595-82 and AT1595-83 antenna models have the same power amplifier, but different antenna elements. For radiated measurements, the spectrum analyzer data is referred back to the output power of the power amplifier and then the maximum gain of the antenna is added back to generate EIRP plots.

6.1.2 ANTENNA ELEMENT DATA

3D antenna element data was collected for both AT1595-82 and AT1595-83 antennas. Plots of maximum gain vs. elevation angle are shown in Figure 5.

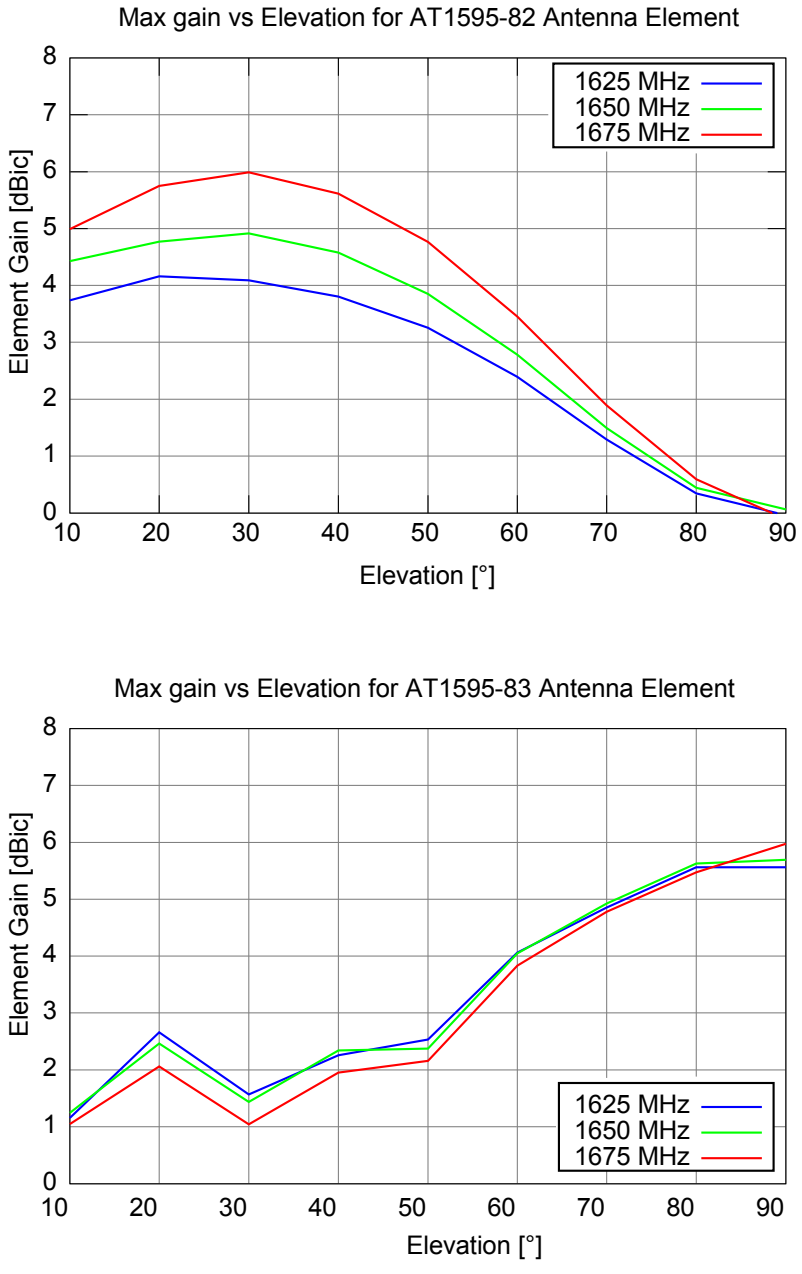


Figure 5. Max gain vs elevation for AT1595-82 (top) and AT1595-83 (bottom) antenna elements.

6.1.3 TESTED POWER LEVELS VS CERTIFIED POWER LEVELS

The data presented here for both input and output power is higher than the maximums requested for certification. Production units will not be subjected to such high input powers and will not radiate such high EIRP. A summary of tested vs certified power levels is shown in Table 2.

Table 2. Tested power levels vs certified power levels

Parameter	Tested Level	Level Requested for Certification
Max Input Power to Amplifier	29.92 dBm	26.2 dBm
Max Output Power of Amplifier	40.93 dBm	26.2 + 11 dB gain = 37.2 dBm → set production limits at 37.5 dB with ± 0.5 dB tolerance = 38 dBm
Max Antenna Element Gain	6 dBic for either AT1595-82 or AT1595-83 (see Figure 5)	6.5 dBic production limits ± 0.5 dB measurement tolerance = 7 dBic
Max Antenna EIRP		38 dBm + 7 dBic = 45 dBm

6.1.4 DERIVATION OF BROAD EMISSIONS MASK

In this part of the report, we derive a composite emissions mask in absolute power from all of the applicable sections. Measurements were performed at three input frequencies (band start, band middle, and band stop). Power values are referred to a maximum EIRP value of 45 dBm.

§25.202(f) (1)

> In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 50 percent up to and including 100 percent of the authorized bandwidth: 25 dB;

§25.202(f) (2)

> In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 100 percent up to and including 250 percent of the authorized bandwidth: 35 dB;

§25.202(f) (3)

> In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 250 percent of the authorized bandwidth: An amount equal to 43 dB plus 10 times the logarithm (to the base 10) of the transmitter power in watts;

It is worth noting that the prescribed attenuation in 25.202(f)(3) corresponds to a fixed power level of -13 dBm, which is calculated as follows:

$$\begin{aligned}
\text{Attenuation} &= 43\,dB + 10\log_{10}(\text{TX power in Watts}) \\
\text{Absolute Power level in dBm} &= 30 + 10\log_{10}(\text{TX power in Watts}) - \text{Attenuation} \\
&= 30 + \cancel{10\log_{10}(\text{TX power in Watts})} - \left(43\,dB + \cancel{10\log_{10}(\text{TX power in Watts})}\right) \\
&= -13\,dBm
\end{aligned}$$

Calculations for §25.202(f) band edges are shown in Table 1.

Table 3. §25.202(f) Calculations summary

$setDecimalPlaces(2)$ $setThousandsSeparator(\,)$ $MHz := 10^6\,Hz$		
	Band Start	Band Stop
Bandwidth	$f_L := 1626.5\,MHz$	$f_H := 1660.5\,MHz$
	$bw := f_H - f_L = 34.00\ \ MHz$	

Section		
§25.202(f)(1) 25 dB atten.	< band start lo	$f_L - bw = 1592.50\ \ MHz$
	< band start hi	$f_L - 0.5\,bw = 1609.50\ \ MHz$
	> band stop lo	$f_H + 0.5\,bw = 1677.50\ \ MHz$
	> band stop hi	$f_H + bw = 1694.50\ \ MHz$
§25.202(f)(2) 35 dB atten.	< band start lo	$f_L - 2.5\,bw = 1541.50\ \ MHz$
	< band start hi	$f_L - bw = 1592.50\ \ MHz$
	> band stop lo	$f_H + bw = 1694.50\ \ MHz$
	> band stop hi	$f_H + 2.5\,bw = 1745.50\ \ MHz$
§25.202(f)(3) ≤ -13 dBm power	< band start lo	$\leq \quad f_L - 2.5\,bw = 1541.50\ \ MHz$
	> band stop hi	$\geq \quad f_H + 2.5\,bw = 1745.50\ \ MHz$

§25.216 (a) (b) (c) apply but are superceded by (i)

(d) applies, but is encompassed by (g)

(e) frequencies don't apply

(f) superceded by (g)

(g) applies

(h) frequencies don't apply

(i) applies

(g) Mobile earth stations manufactured more than six months after Federal Register publication of the rule changes adopted in FCC 03-283 with assigned uplink frequencies in the 1610-1626.5 MHz band shall suppress the power density of emissions in the 1605-1610 MHz band-segment to an extent

determined by linear interpolation from −70 dBW/MHz at 1605 MHz to −10 dBW/MHz at 1610 MHz averaged over any 2 millisecond active transmission interval. The e.i.r.p of discrete emissions of less than 700 Hz bandwidth from such stations shall not exceed a level determined by linear interpolation from −80 dBW at 1605 MHz to −20 dBW at 1610 MHz, averaged over any 2 millisecond active transmission interval.

(i) The e.i.r.p density of carrier-off state emissions from mobile earth stations manufactured more than six months after Federal Register publication of the rule changes adopted in FCC 03-283 with assigned uplink frequencies between 1 and 3 GHz shall not exceed -80 dBW/MHz in the 1559-1610 MHz band averaged over any two millisecond interval.

for §25.216(g) the -80 dbW@1605 to -20 dBW@1610 requirement is the most stringent and was used. For §25.216(i) there is a requirement for EIRP density(dBW/MHz). We apply a much more conservative mask by ***not*** dividing by the frequency.

All of the above requirements are plotted in Figure 6. A composite mask (in red) is shown in Figure 7.

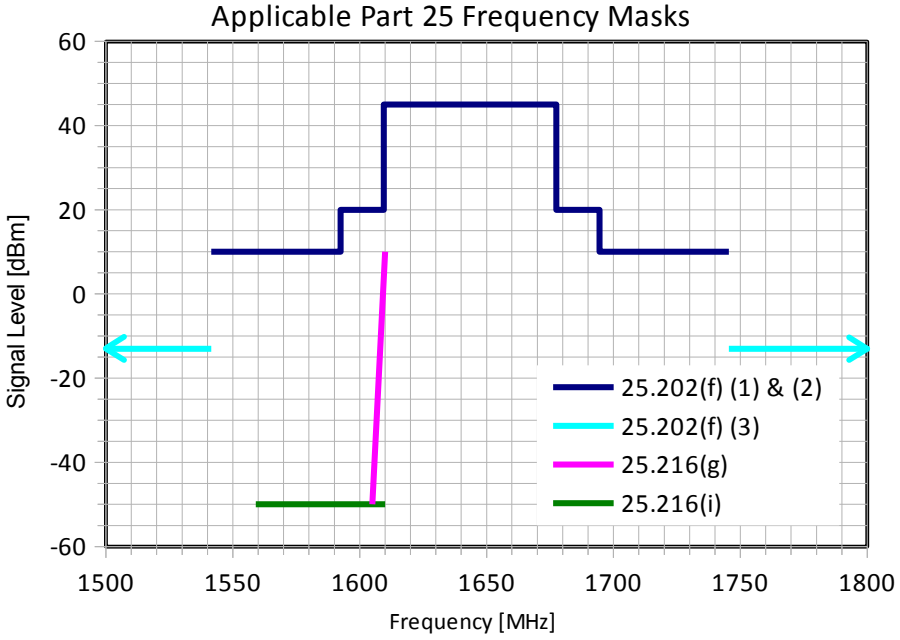


Figure 6. Frequency masks for all requirements. Arrows imply that 25.202(f) requirement extends ad infinitum

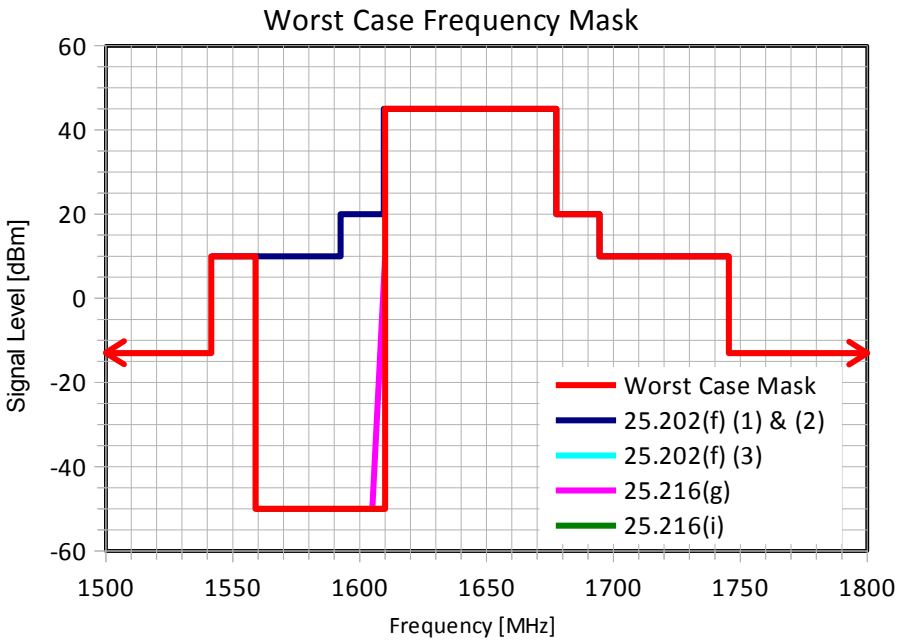


Figure 7. Worst case frequency mask (in red) Arrows imply that -13 dBm requirement extends ad infinitum.

6.1.5 BROAD TEST DATA

Maximum input power was +29.92 dBm to the EUT during test. However, for certification a maximum input power of +26.2 dBm is claimed. Raw traces for input frequencies are shown in Figures 11 through 13. Corresponding output peaks are shown in Figures 14 through 16. Out of band responses are plotted in Figures 17 through 23.

Text files were also saved for the raw data in Figures 11 through 23. These data were all plotted, along with the emissions mask (see Figure 7) in Figure 8 and Figure 9.

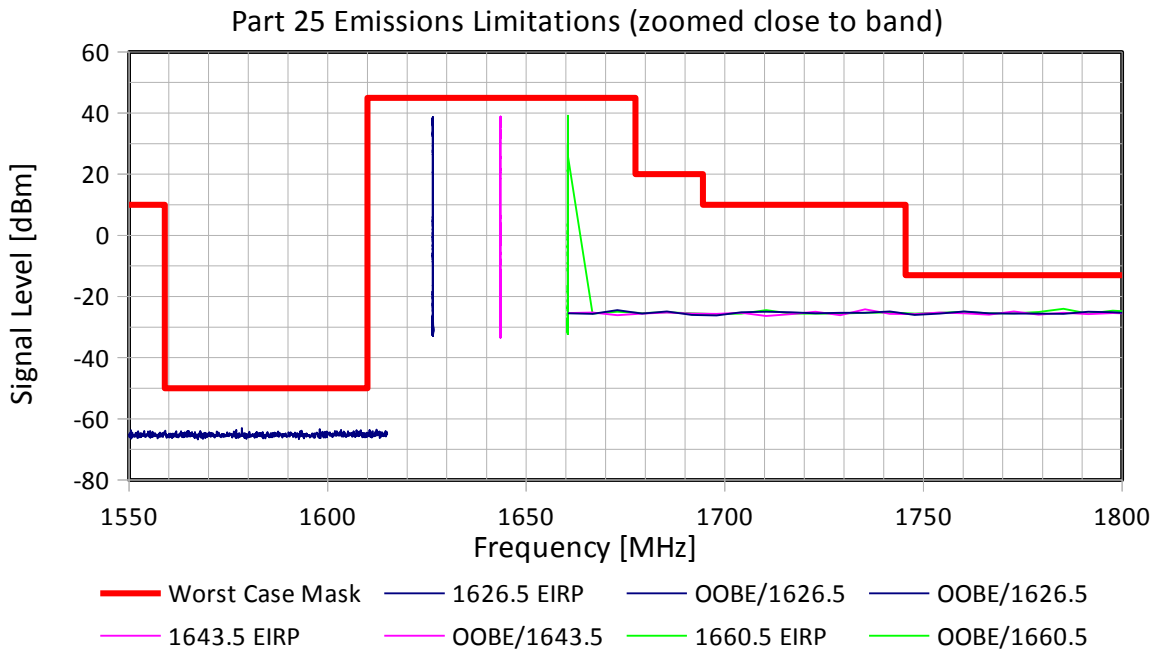


Figure 8. Data for Part 25 Emissions limitations (zoomed in close to band) assuming 7 dBic maximum antenna element gain and 42 dBm maximum power from power amplifier.

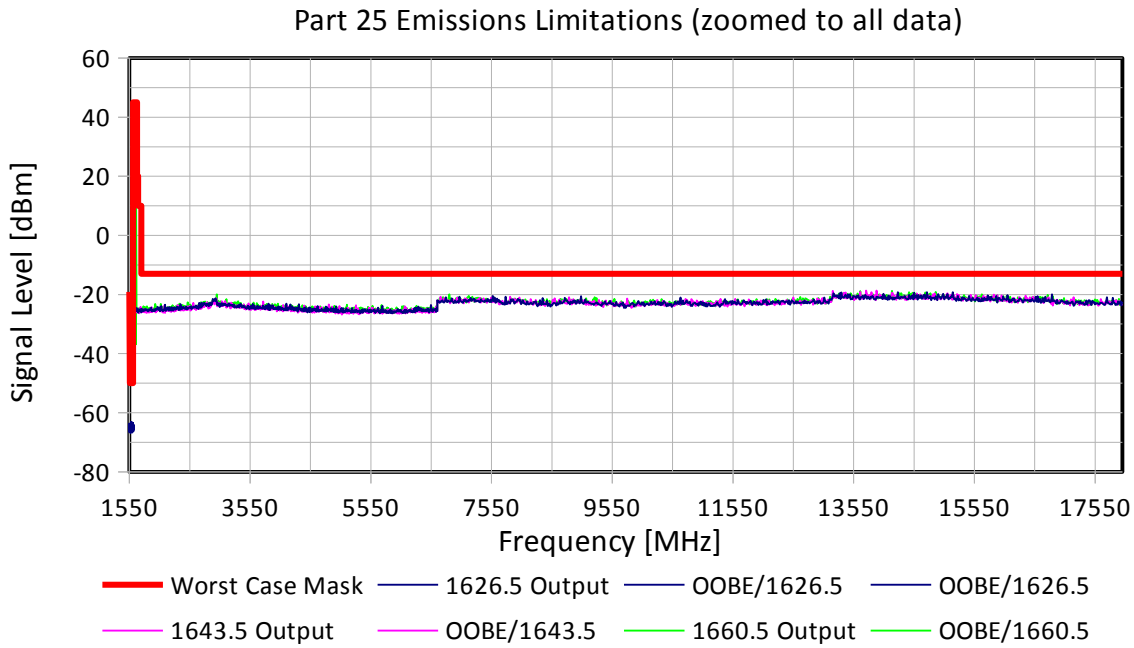


Figure 9. Data for Part 25 Emissions limitations (zoomed to all data).

6.1.6 Summary of Compliance

No notable spurs are evident in Figures 8 and 9. The minimum margin of compliance, as illustrated in Figure 10, is at least 5.6 dB.

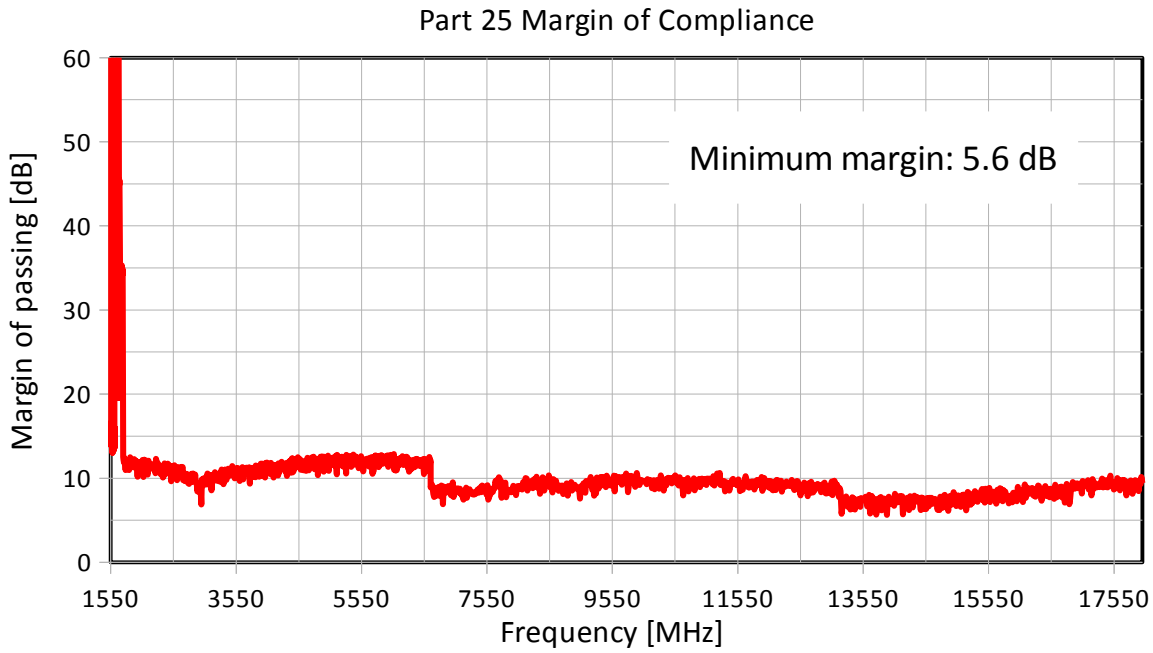


Figure 10. Margin of compliance.

6.1.7 Raw data

Raw screen shots from the spectrum analyzer are shown in this section for all data presented in Section 6.1.5. Although these were radiated measurements, the power levels were referred to the conducted output of the power amplifier. For the purposes of determining compliance with emissions masks, the plots of previous sections (Figures 6 through 10) were referred to a maximum EIRP from the antenna of 45 dBm (15 dBW). More details of tested vs certified power levels are shown in section **6.1.3 TESTED POWER LEVELS VS CERTIFIED POWER LEVELS**.

6.1.7.1 INPUT TO ANTENNA

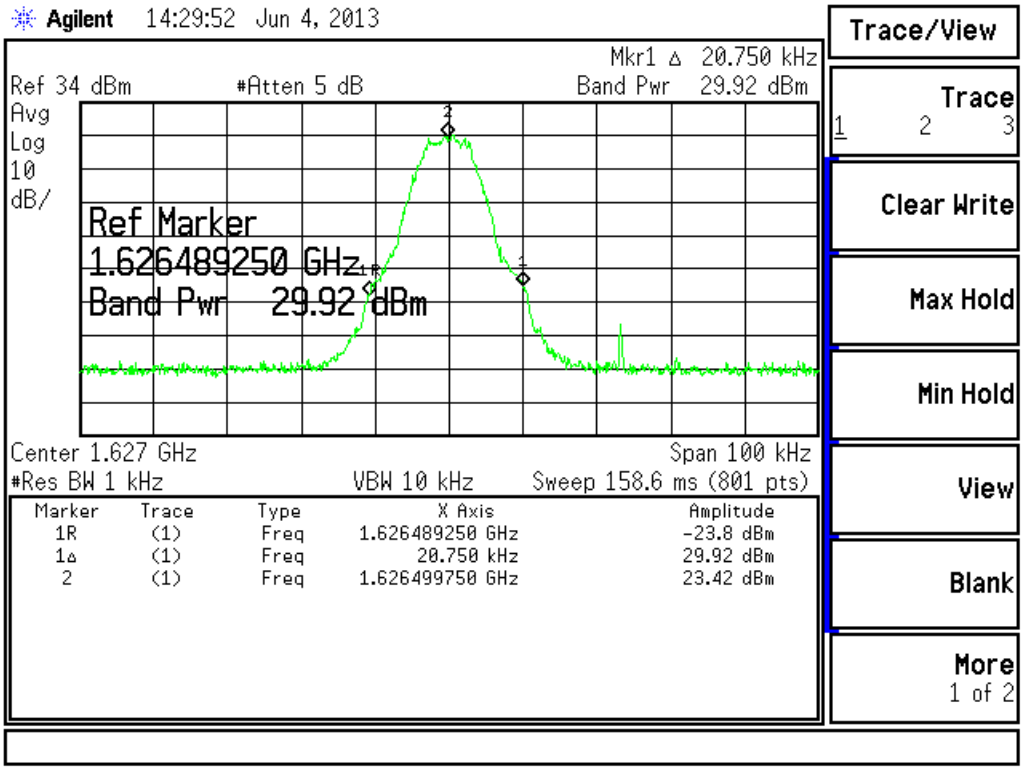


Figure 11. Input to EUT. 1626.5 MHz (band start).

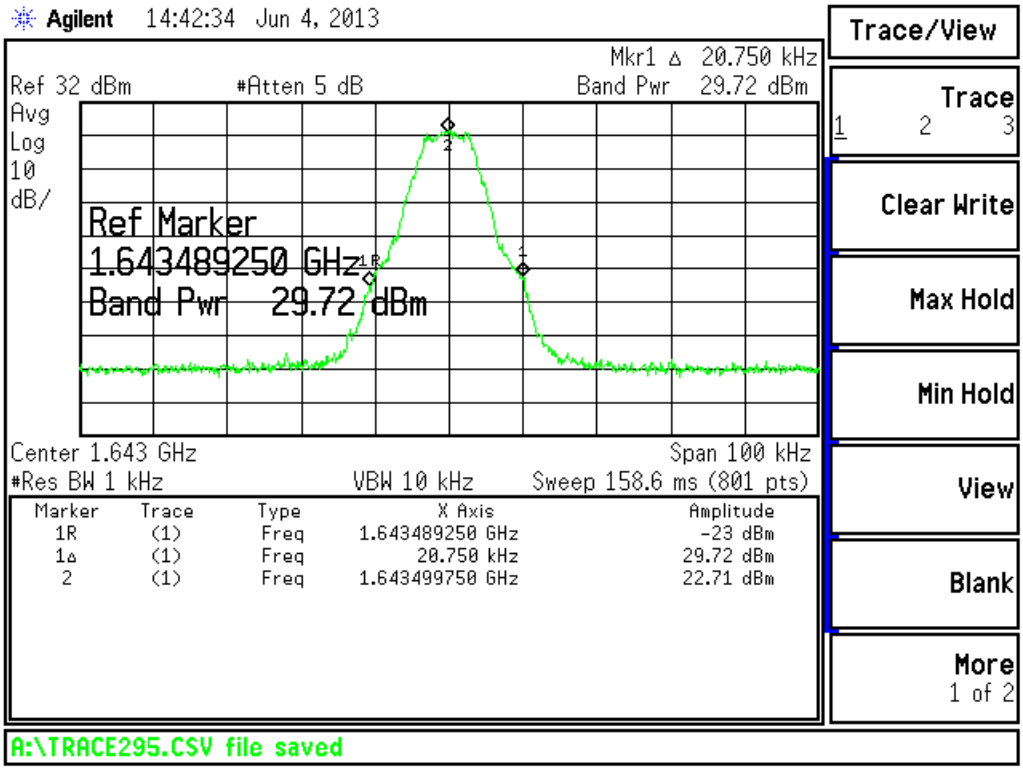


Figure 12. Input to EUT. 1643.5 MHz (band middle).

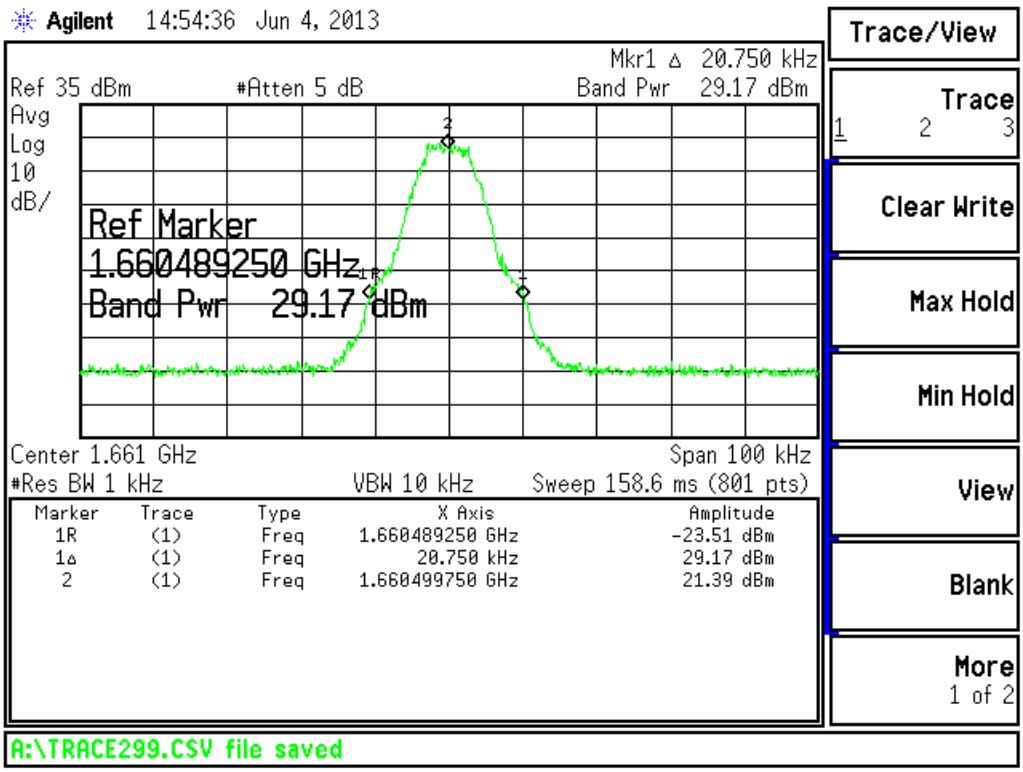


Figure 13. Input to EUT. 1660.5 MHz (band stop).

6.1.7.2 OUTPUT FROM POWER AMPLIFIER IN ASSIGNED BANDWIDTH

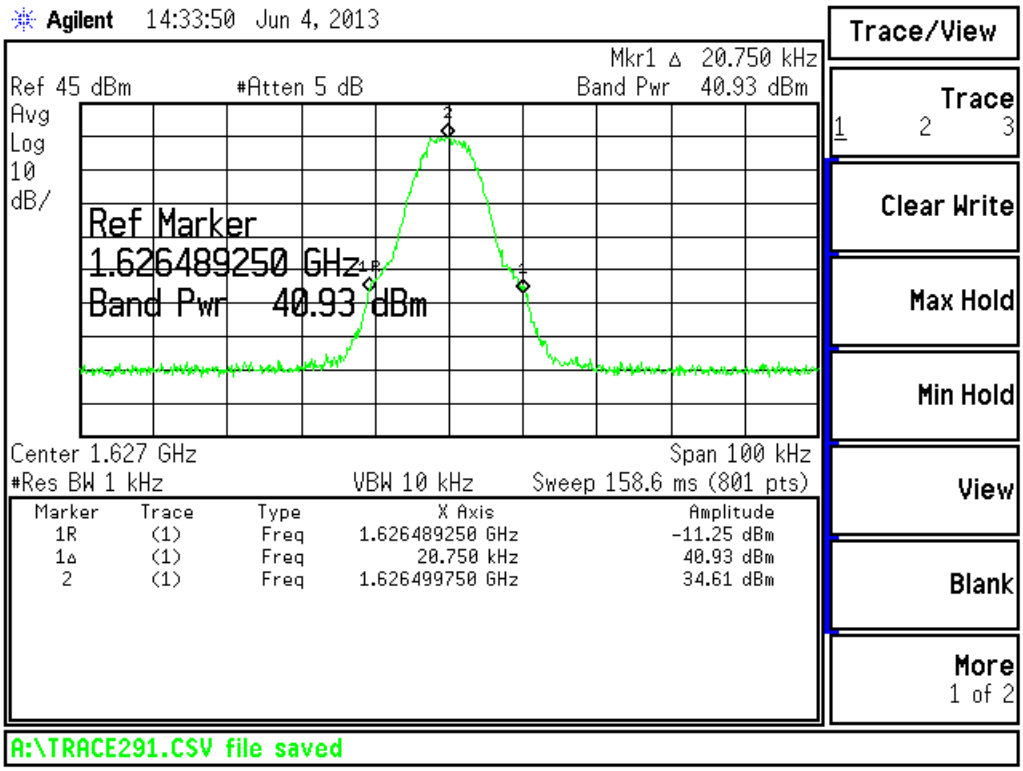


Figure 14. Output of power amplifer for input of Figure 23 (i.e. 1626.5 MHz).

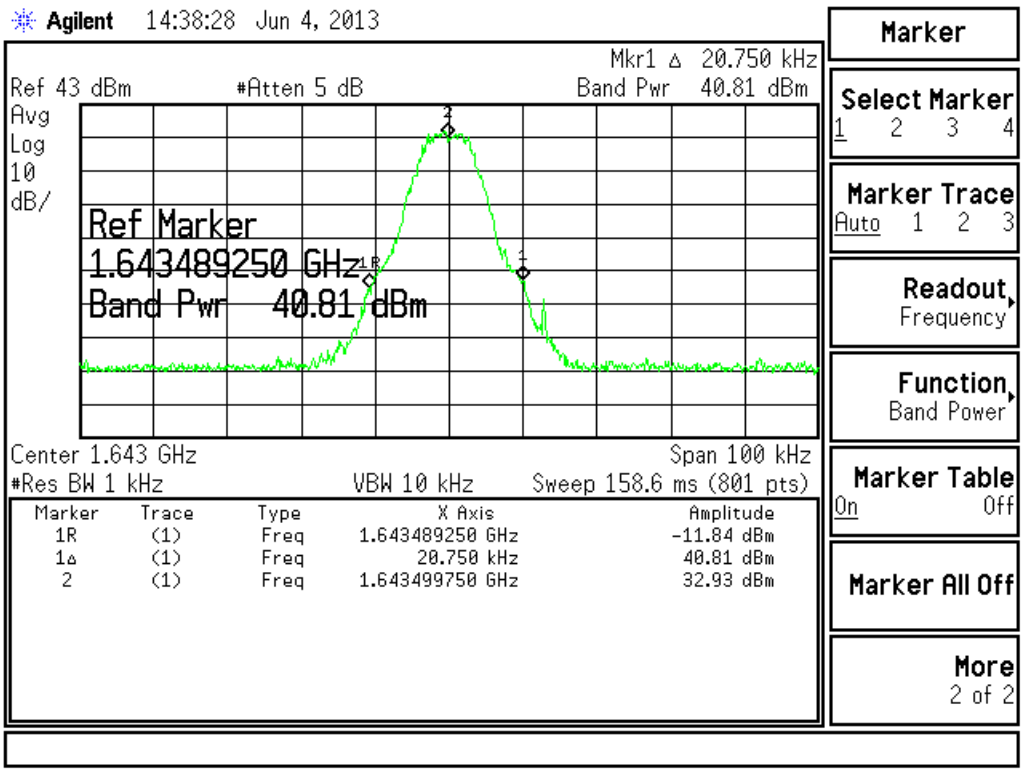


Figure 15. Output of power amplifer for input of Figure 12 (i.e. 1643.5 MHz).

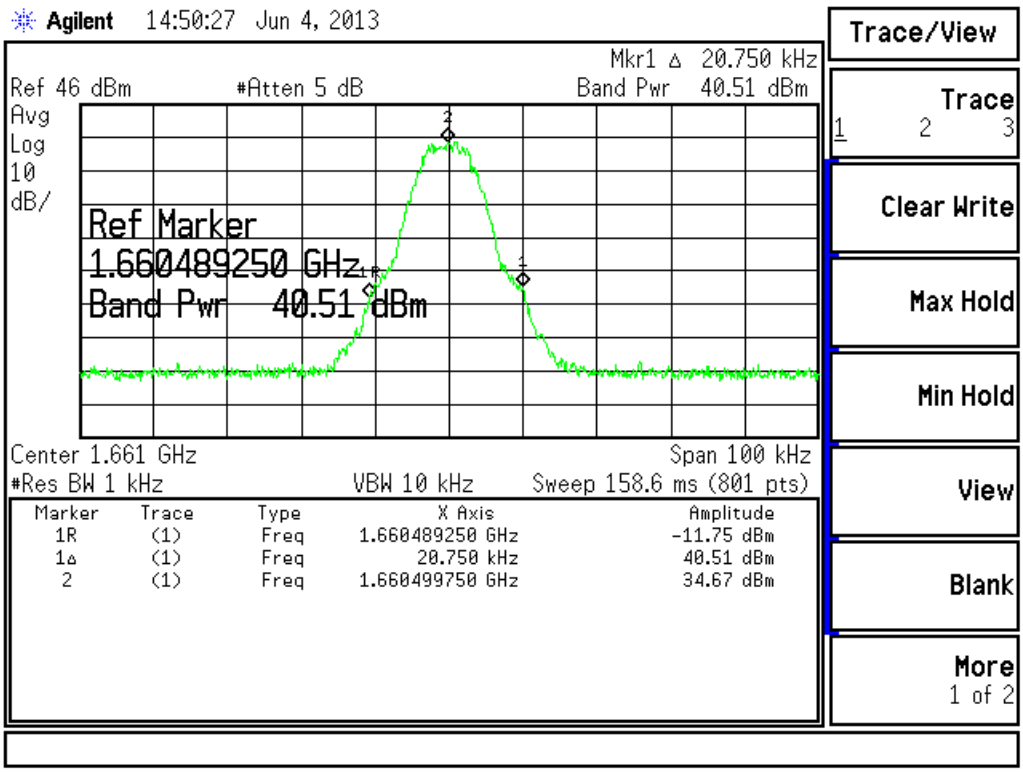


Figure 16. Output of power amplifer for input of Figure 11 (i.e. 1660.5 MHz).

6.1.7.3 OUTPUT FROM POWER AMPLIFIER OUT OF BAND

6.1.7.3.1 1550 MHz to 1610 MHz

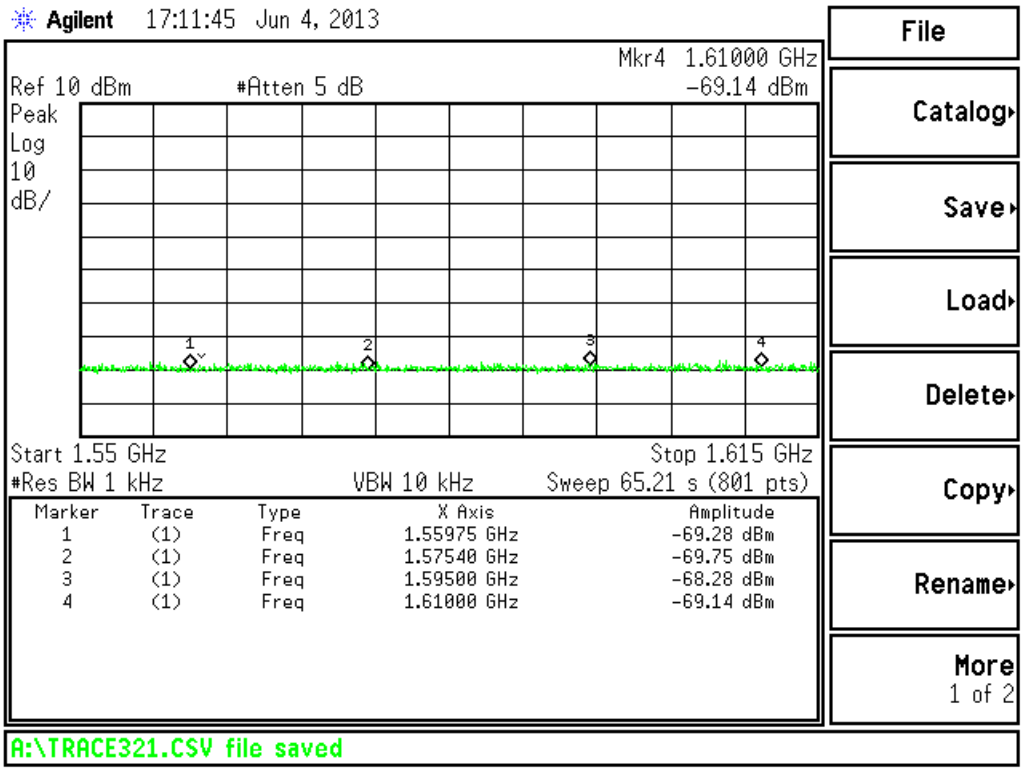


Figure 17. Output of power amplifer from 1550 MHz to 1615 MHz with input signal at band start (1626.5 MHz).

6.1.7.3.2 1.61 to 6.5 GHz

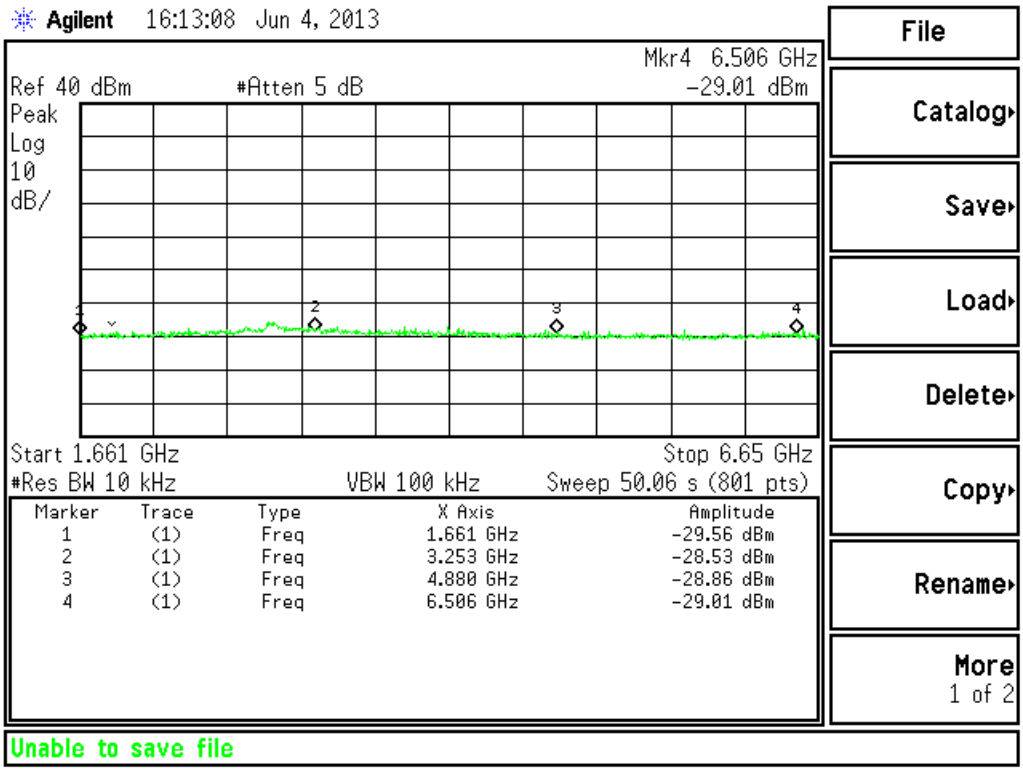


Figure 18. Out of band response of power amplifer from 1.661 to 6.65 GHz for input @ 1626.5 MHz.

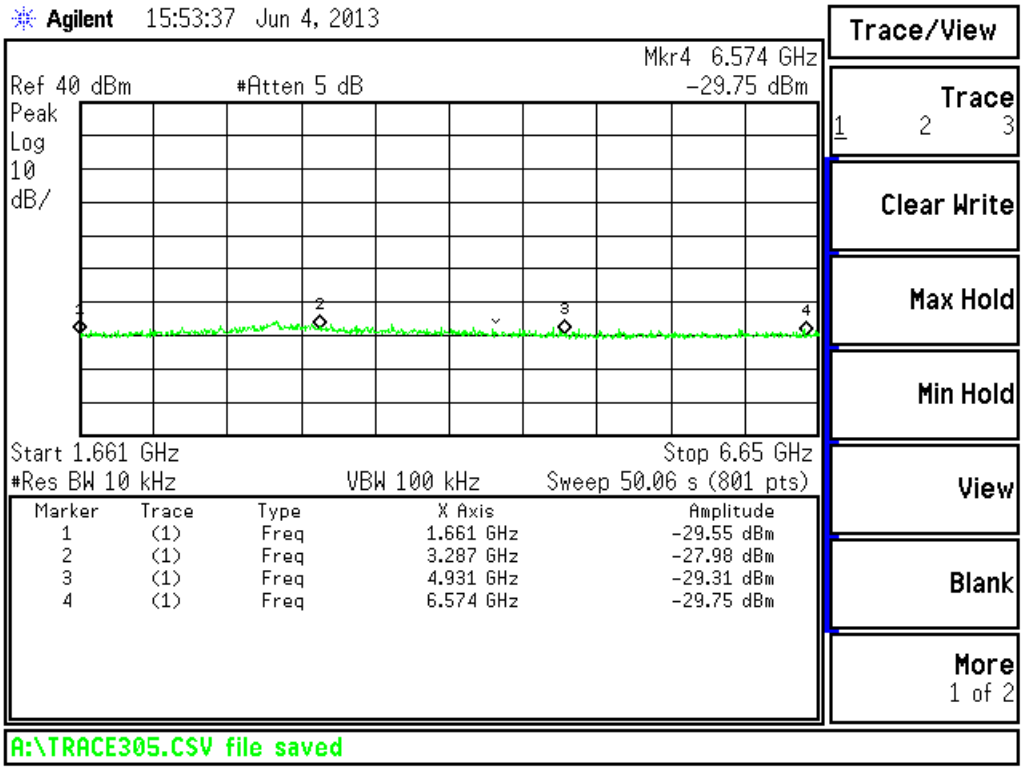


Figure 19. Out of band response of power amplifer from 1.661 to 6.650 GHz for input @ 1643.5 MHz.

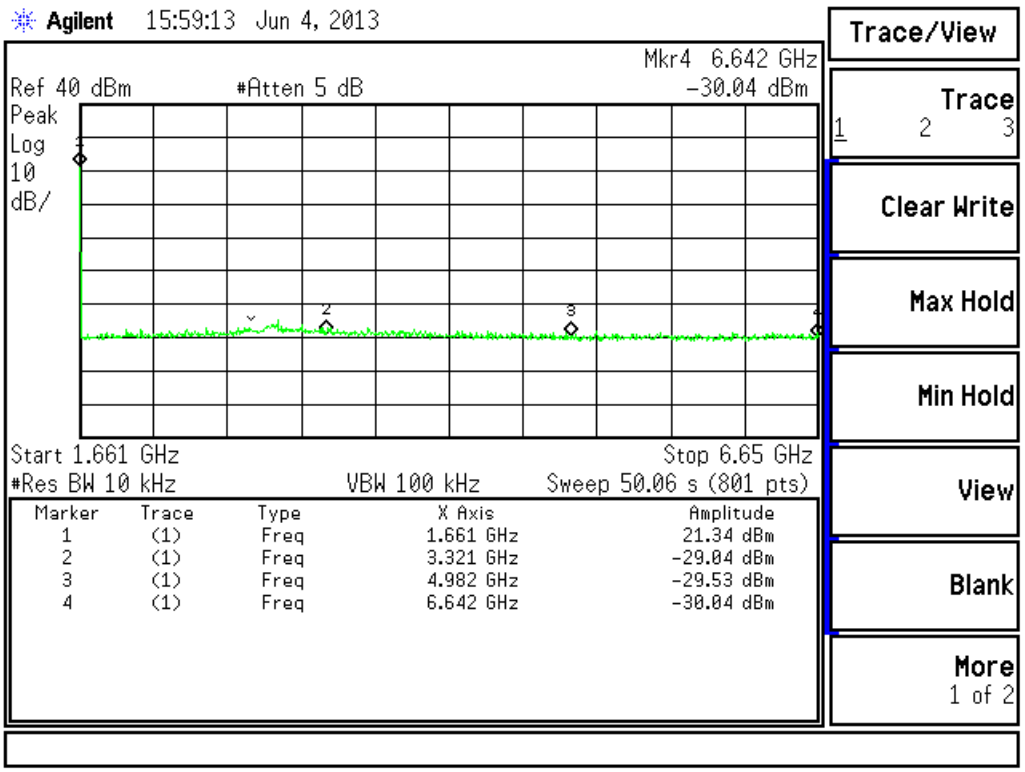


Figure 20. Out of band response of power amplifer from 1.661 to 6.650 GHz for input @ 1660.5 MHz.

6.1.7.3.3 6.5 to 18 GHz

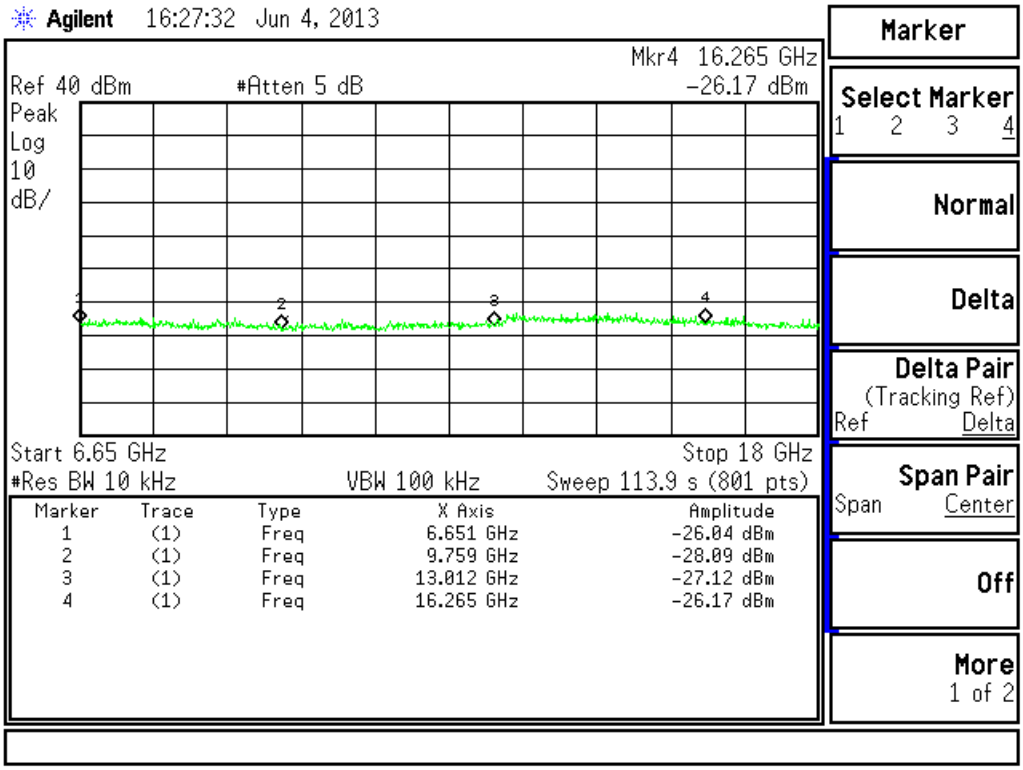


Figure 21. Out of band response of power amplifer from 6.65 to 18 GHz for input @ 1626.5 MHz.

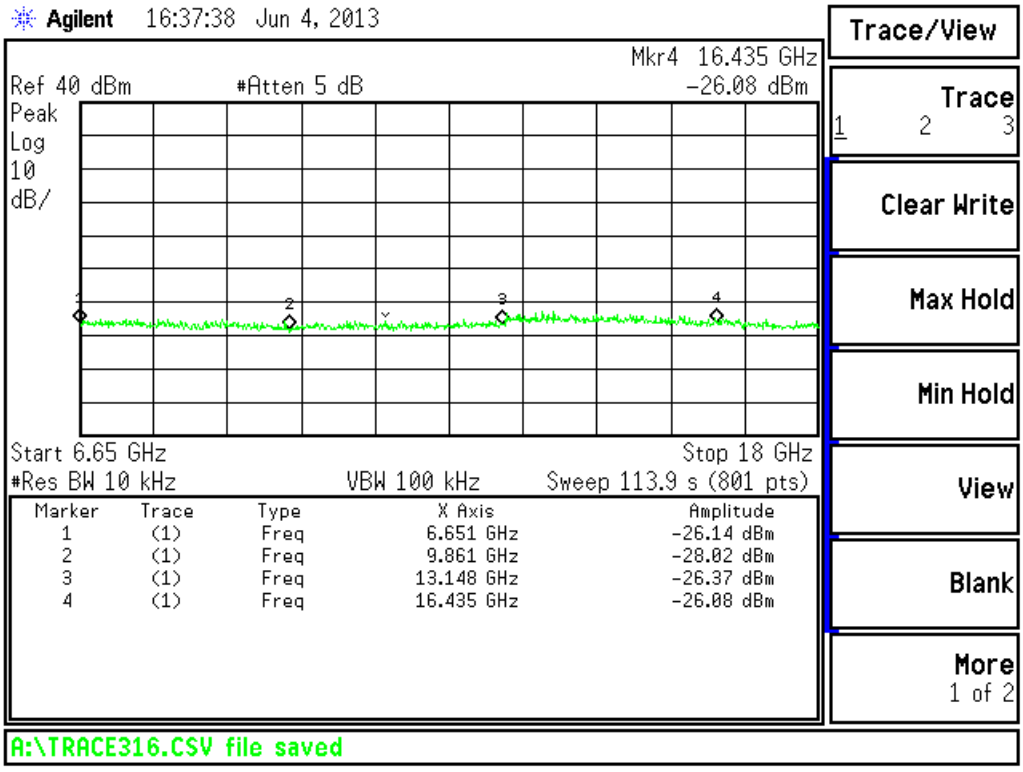


Figure 22. Out of band response of power amplifer from 6.65 to 18 GHz for input @ 1643.5 MHz.

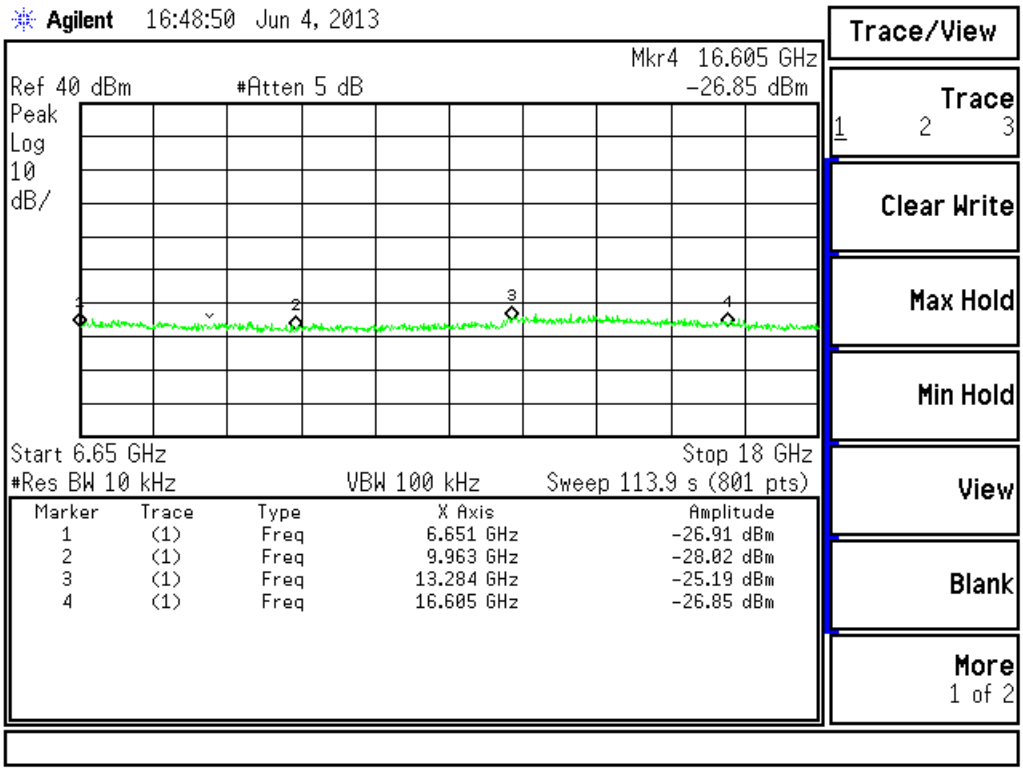


Figure 23. Out of band response of power amplifer from 6.65 to 18 GHz for input @ 1660.5 MHz.

6.2 CHANNELIZED LIMITATIONS

6.2.1 METHOD OF MEASUREMENT AND TEST ARRANGEMENT

Channelized Emissions limitations measurements were performed as conducted power measurements on a Spectrum Analyzer in max hold mode. The test arrangement is shown in Figure 24.

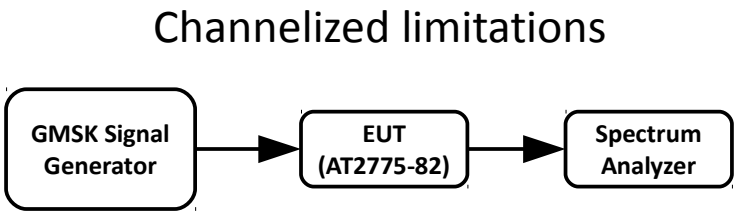


Figure 24. Block diagram for channelized emissions limitation test arrangement.

6.2.2 CHANNELIZED EMISSIONS MASK

Assuming a 25 ksymbol/sec modulation and 31.5 kHz authorized bandwidth per channel, the emissions limitations of §25.202(f) become as tabulated in Table 4.

Table 4. §25.202(f) Calculations summary for individual channel at center frequency 1621.25 MHz

$setDecimalPlaces(5)$		
	Band Start	Band Stop
Bandwidth	$f_L := 1626.5\,MHz - \frac{31.5\,kHz}{2}$ $f_L = 1626.48425\ \ MHz$	$f_H := 1626.5\,MHz + \frac{31.5\,kHz}{2}$ $f_H = 1626.51575\ \ MHz$
	$bw := f_H - f_L = 31.50000\ \ kHz$	

Section		
§25.202(f)(1) 25 dB atten.	< band start lo	$f_L - bw = 1626.45275\ \ MHz$
	< band start hi	$f_L - 0.5\,bw = 1626.46850\ \ MHz$
	> band stop lo	$f_H + 0.5\,bw = 1626.53150\ \ MHz$
	> band stop hi	$f_H + bw = 1626.54725\ \ MHz$
§25.202(f)(2) 35 dB patten.	< band start lo	$f_L - 2.5\,bw = 1626.40550\ \ MHz$
	< band start hi	$f_L - bw = 1626.45275\ \ MHz$
	> band stop lo	$f_H + bw = 1626.54725\ \ MHz$
	> band stop hi	$f_H + 2.5\,bw = 1626.59450\ \ MHz$
§25.202(f)(3) ≤ -13 dBm power	< band start lo	$\leq \quad f_L - 2.5\,bw = 1626.40550\ \ MHz$
	> band stop hi	$\geq \quad f_H + 2.5\,bw = 1626.59450\ \ MHz$

6.2.3 CHANNELIZED TEST DATA

Data was taken in the of the Inmarsat transmit band at 1626.5 MHz. The input to the amplifier is shown in Figure 25 and the output from the amplifier is shown in Figure 26. The text data from Figure 26 was plotted with a superimposed mask in Figure 27.

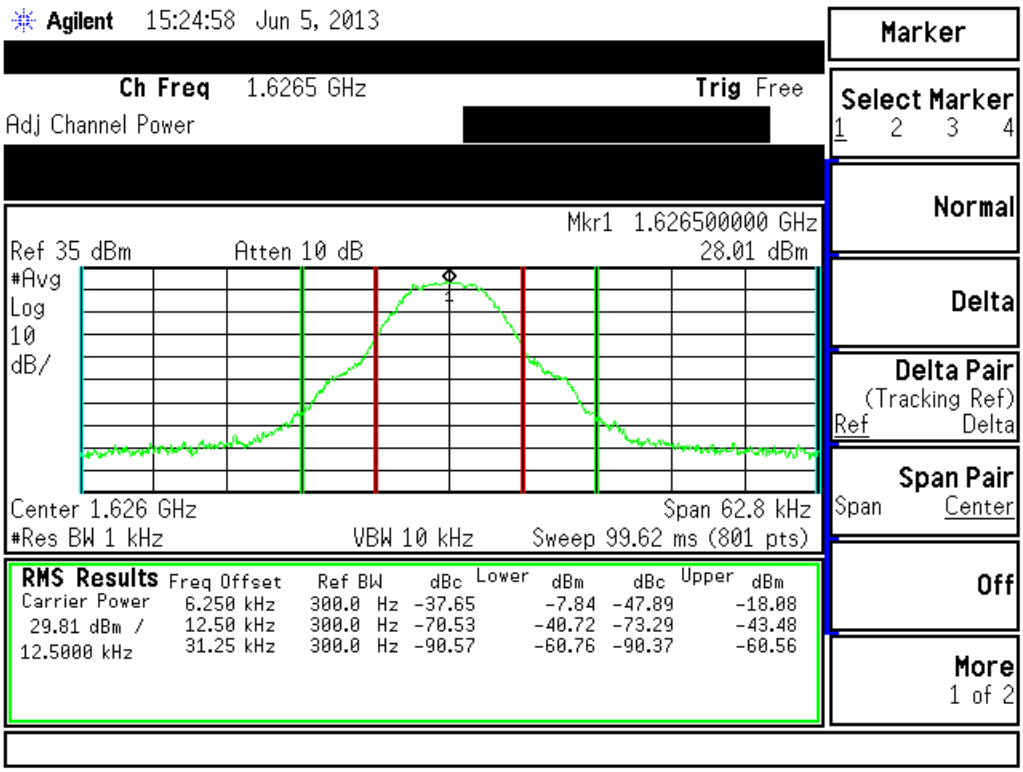


Figure 25. Input signal for channelized emissions data.

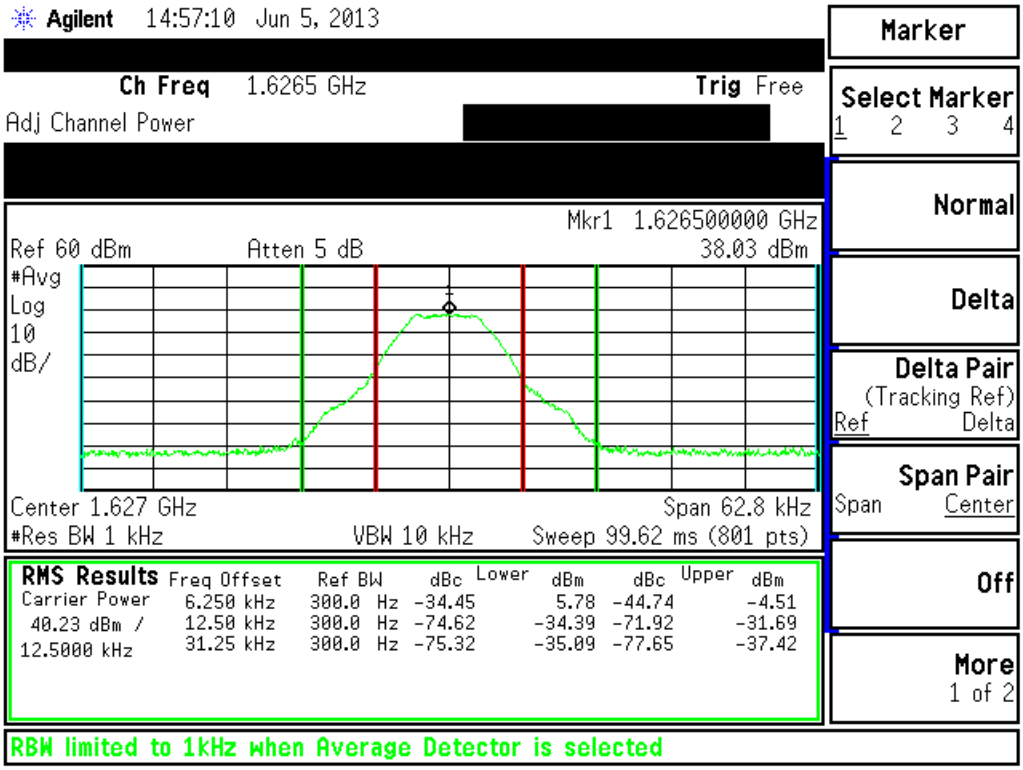


Figure 26. Output signal for channelized emissions data.

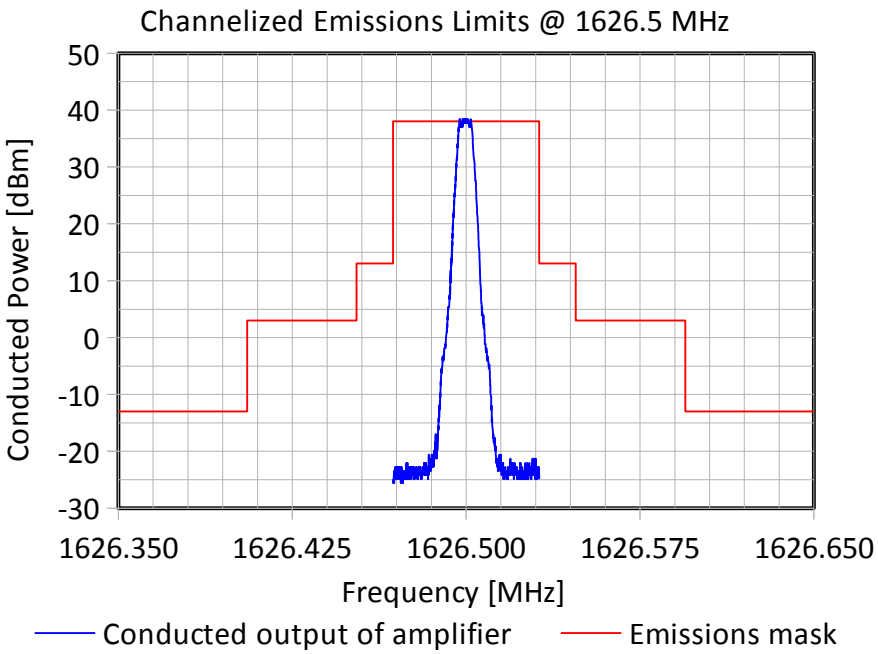


Figure 27. Output signal for channelized emissions data with superimposed emissions mask.

7 99% OCCUPIED BANDWIDTH

Per FCC P.2.1049

7.1 LIMITS

Not specified.

7.2 METHOD OF MEASUREMENTS

The 99% occupied bandwidth is measured using spectrum analyzer with RBW = 1% of 99% OBW and VBW≥RBW. Input signal was 25 ksymbols/sec GMSK at a center frequency of 1626.5 MHz.

7.3 TEST ARRANGEMENT

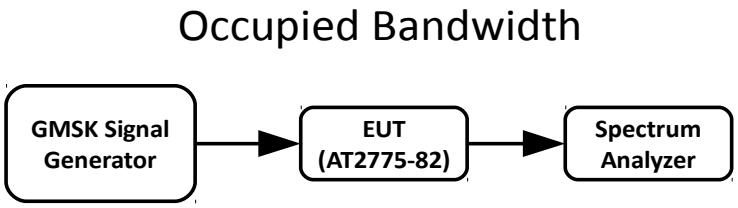
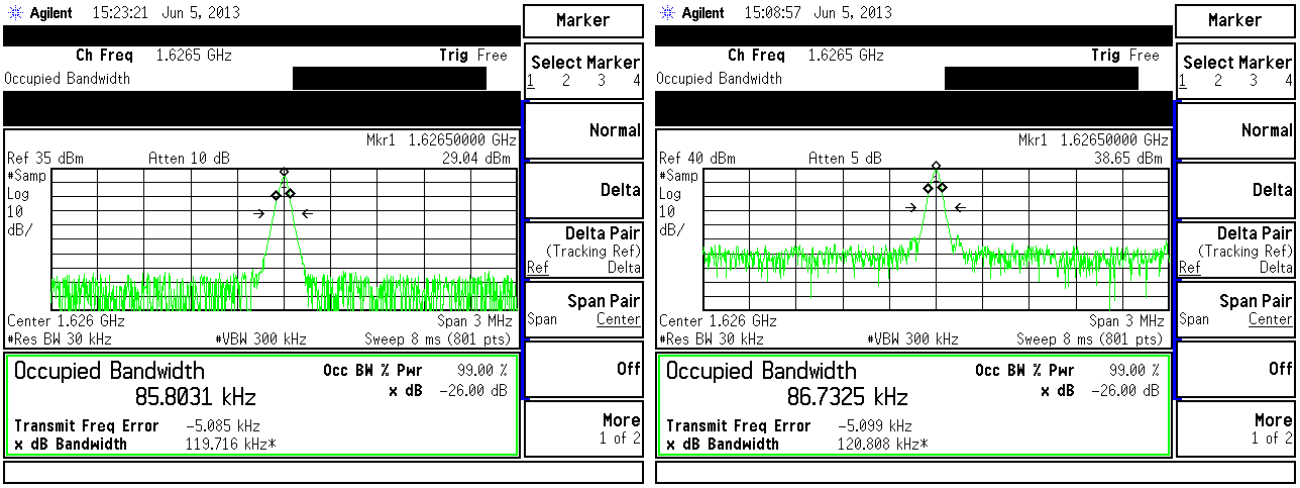


Figure 28. Block diagram of test arrangement for 99% occupied bandwidth measurements.

7.4 TEST DATA



INPUT OUTPUT

Figure 29. Measurement results for 99% occupied bandwidth @ 1621.25 MHz.

7.5 SUMMARY OF 99% OBW RESULTS

Fundamental (MHz)	Input 99% OBW [kHz]	Output 99% OBW [kHz]
1626.5	85.8	86.7

8 TEST INSTRUMENT LIST

8.1 SPECTRUM ANALYZER

- Agilent E4407B
- Serial Number: MY45103513
- Calibration Due: 05/18/2015

8.2 GMSK SIGNAL GENERATOR

- Rohde & Schwarz SMBV100A
- Serial Number: 5000-309001204
- Calibration Due: 4/23/2014

8.3 STANDARD HORN ANTENNA

- A.H. Systems Inc.
- 9710 Cozycroft Ave., Chatsworth, CA 91311
- Model: SAS-571
- Serial Number: 1464
- Calibration Due: 08/14/2014