



## **Out of Band Edge Emission Test Report**

**Sirius XM ALU DTR-0200 Repeater**

**TRS-OPS-FCC-00-015-001-1000**

**January 18, 2014**



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## Out of Band Edge Emissions Test Report: Sirius XM ALU-0200

### Test Summary:

The Out of Band Emissions for the Sirius XM ALU - 200W Repeaters is compliant with the FCC 90 + 10\*Log [P]/1 MHz guideline.

The table below provides the results of worst sample measurements at the low band edge (LBE) with the power meter.

Item	ALU DTR-0200	RF Output (Watts)	Conducted Emission (dBm)	FCC Limit (dBm)	Margin (dB)
1	CA0V6885	200	-75.99	-60	15.99

The worst case conducted emission from the test sample was -75.99 dBm/1 MHz BW at rated output power at the repeater output flange.

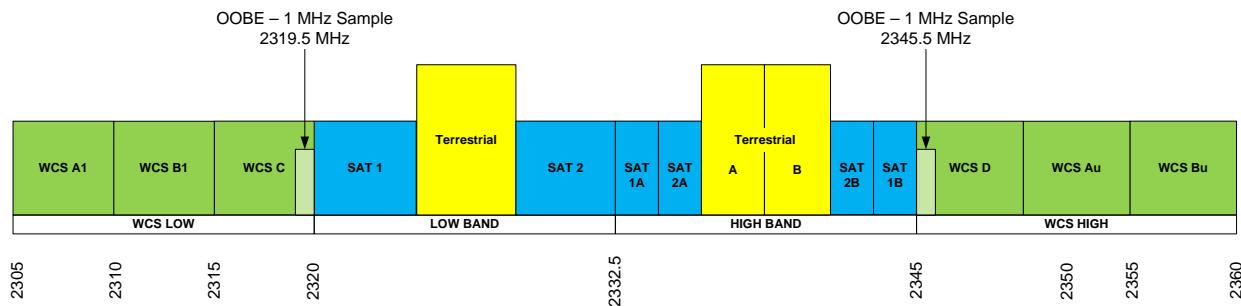
The measurement exceeds the FCC guideline with 15.99 dB of margin.



## Overview

The Sirius XM ALU DTR-0200 Repeater uses a single Coded Orthogonal Frequency Division Multiplexed (COFDM) carrier centered at 2326.25 MHz. The LB COFDM carriers occupy a bandwidth of 4.012 MHz. The repeater broadcasts a Sirius XM Low Band COFDM waveform with an RF output level of 200 Watts (53 dBm) measured at the HPA Output Flange.

Out of Band Emissions for the Sirius XM Low Band ALU 200W Repeater is measured using a 1 MHz wide band pass filter centered at 2319.5 MHz

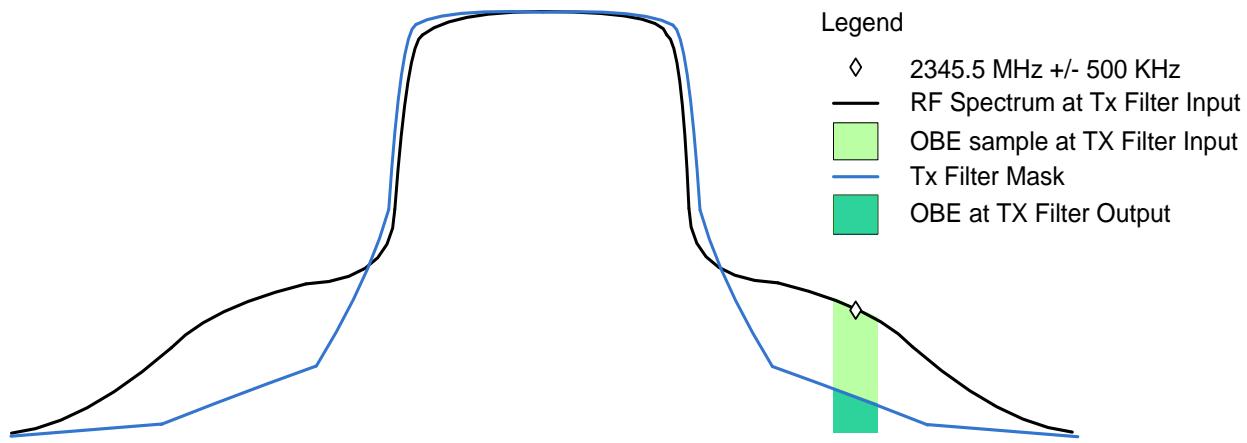


System	Signal	Center Frequency	Bandwidth	Polarization
Low Band	SAT 1 (F1)	2322.293	4.510	LHCP
Low Band	Terrestrial	2326.25	4.012	Vertical
Low Band	SAT 2 (F2)	2330.207	4.510	LHCP
High Band	SAT 1 A	2333.465	1.84	LHCP
High Band	SAT 2 A	2335.305	1.84	LHCP
High Band	Terrestrial A	2337.490	2.53	Vertical
High Band	Terrestrial B	2340.020	2.53	Vertical
High Band	SAT 2B	2342.205	1.84	LHCP
High Band	SAT 1B	2344.045	1.84	LHCP

## Measurement Technique

The measurement technique is based on a 1MHz BW OBE Sample at 2319.5 MHz or 2345.5 MHz. The sample is taken via an inline test coupler between the HPA flange and the transmit band pass filter. The OBE sample is attenuated by the Transmit Band Pass filter mask.

The OBE Sample power and the transmit filter rejection ratio at the frequency of interest are obtained. The resultant is the conducted OBE power at the TX Filter Output. The illustration below is provided for the High Band OBE Sample.



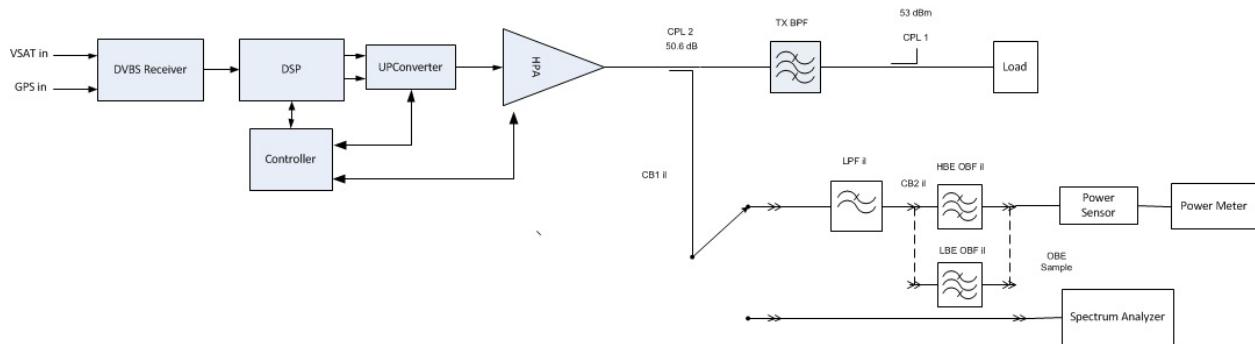


## Test Configuration

The Sirius XM ALU DTR-0200 Repeater is configured with a 50.6 dB test coupler (CPL 2) inserted between the HPA output flange and at the input of the Transmit Band Pass Filter (TX BPF).

The HPA under test is configured with 200 Watts (53.0 dBm) of RF power at the load. The power is verified by measurement at the HPA sample port with a power meter.

The Out of Band measurement is sampled at the output of the test coupler CPL 2. The measurement is made with an OBE filter centered at 2319.5 MHz with a 1 MHz Bandwidth.

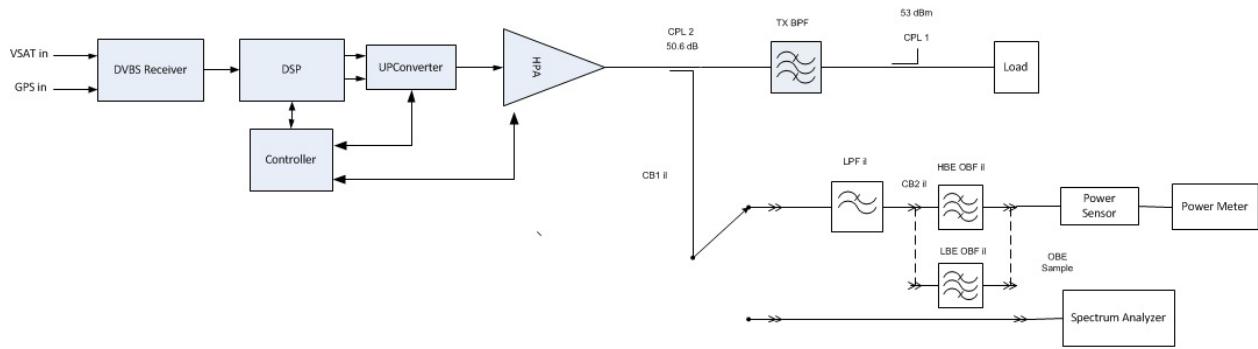


A 50 MHz spectral plot of the ALU 200W centered at 2326.25 MHz is saved for reference purposes.

The TX band-pass filters are swept using an 8753E Scalar Network Analyzer. A markers are positioned at center frequency of the TX filter and the other two markers are placed at  $2319.5 \text{ MHz} \pm 0.5 \text{ MHz}$  and  $2345.5 \text{ MHz} \pm 0.5 \text{ MHz}$  of the filter rejection at the frequencies of interest. The filter plot is saved. The OBE sample measurement, associated cable losses and worst case rejection of the filters is combined to arrive at the OBE value.

## Measurement Detail

The repeater is configured to deliver its nominal RF output at the output load. In the case of the Sirius XM ALU DTR-0200 Repeater, 200 Watts or 53.0 dBm is provided at the CPL 1 sample port.



A test coupler CPL 2 is inserted between the HPA and the TX Band Pass Filter.

With the HPA output power at 53 dBm:

Two 1 MHz BW measurements are obtained via CPL 2:

- A 1 MHz BW OBE Filter measurement using a Power Meter/Sensor
- A 1 MHz BW Channel Power Measurement with an E4402B Spectrum Analyzer

The power of the Out of Band Emission at 2319.5 MHz at the TX BP Filter input is calculated as follows:

OBE Sample - (CPL 2 cf +CB1 il+ CB2 il + LPF iL + OBEF cf + OBF il + PM Acc )

**OBE Sample** is the measured value of the OBE filter output

**CPL2 cf** is the Coupling Factor of CPL2 = 50.6 dB

**CB1 il** is the insertion loss of Cable 1 = 0.3 dB

**CB2 il** is the insertion loss of Cable 2 = 0.3 dB

**LPF iL** is the insertion loss of the Low Pass Filter = 1.78 dB (worst case loss)

**OBEF cf** is the Out of Band Filter correction factor = 0.0 dB

**HBE OBF il** is the insertion loss of the Out of Band Filter = 9.37 dB (worst case loss)

**PM Acc** is the measurement accuracy of the Power Meter = 0.25 dB

$$\begin{aligned}
 -48.4 - (50.6 + 0.3 + 0.3 + 1.78 + 0.0 + 9.37 + 0.25) = \\
 -48.4 \text{ dBm} - (-62.6) = +14.20 \text{ dBm}
 \end{aligned}$$



The Transmit Band Pass Filters in the Sirius XM ALU DTR-0200 transmit path will provide a worst case rejection of 90.19 dB to the Out of Band Emission. The OBE sample measurement of 14.20 dBm will be reduced by the filter rejection at 2319.5 MHz. The conducted OBE emission at 2319.5 MHz after the TX Band Pass Filter is calculated as follows:

$$+14.20 \text{ dBm} + [-90.19] = -75.99 \text{ dBm/MHz}$$

The Transmit Filter Rejection in the spreadsheet presented in Attachment 3 is the integrated rejection over a 1 MHz Bandwidth. The worst case rejection has been used within the calculation

### FCC Limit

FCC Limit is defined as **90+10 \*Log (P)/MHz**. Where P is the output Power in Watts/MHz

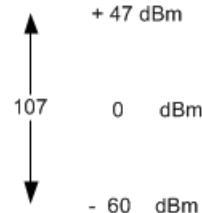
In the case of the Sirius XM ALU DTR-0200 Repeaters, the 200W or 53 dBm

$$200\text{W}/4.012\text{MHz} = 49.8\text{W/MHz}$$

$$90 + 10 \times \log (49.8) = 90 + 10 \times (1.69) = 90 + 16.9 = 106.9$$

$$49.8 \text{ Watts} = +47 \text{ dBm}$$

When the 47 dBm is applied to the FCC ratio of 107 an Out of Band Emission limit of -60 dBm/MHz is defined:



### Margin

Margin example is the conducted OBE – FCC Limit or

$$-87.0 \text{ dBm} - (-60 \text{ dBm}) = -27 \text{ dB}$$

Attachment 1 provides the measurement details for Sirius XM ALU DTR-0200 repeaters used in this test sample.



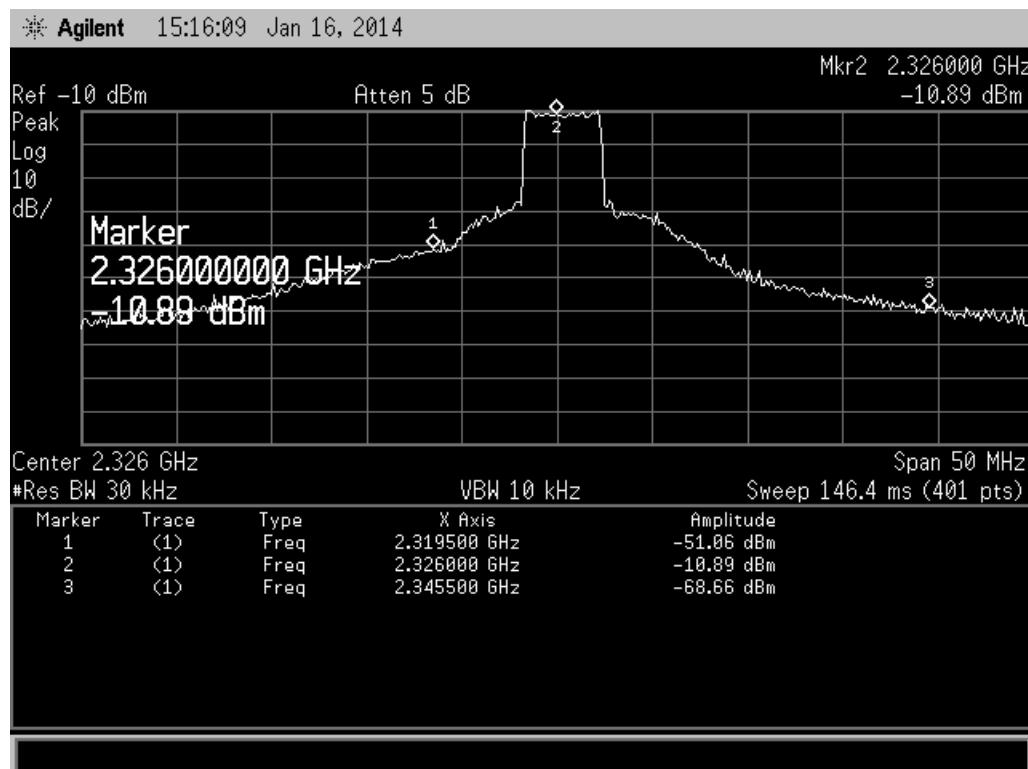
## OBE High Band Edge Measurement

The High Band edge measurement is also considered in the scope of this document and outlined in this section.

The LB OBE Filter with center frequency of 2319.5 MHz is replaced with a HB OBE filter centered at 2345.5 MHz with 1 MHz BW. The same measurements are repeated for the High Bend edge.

The measured 1 MHz samples at the HB edge are provided in tandem with the LB Edge and are provided within the body of this document. Noted is that the HB 1 MHz BW measurement are not measureable as the samples at this point are below the operating range of the measurement equipment.

A 50 MHz plot with center frequency of 2326.0 MHz is provided below and in Attachment 9 to illustrate the roll off of the high band edge at 2345.5 MHz



Plots are provided in the body of this report for back up information on the high band edge.



## List of Attachments

**Attachment 1: Sirius XM ALU 200W Repeater - Test Data**

**Attachment 2: Test Block Diagram**

**Attachment 3: Integrated Filter Rejection**

**Attachment 4: Transmit Band Pass Filter Plots**

**Attachment 5: LB TX Filter Swept Response 2315 MHz – 2365 MHz**

**Attachment 6: Out of Band Emission Filter Response**

**Attachment 7: Low Pass Filter Response**

**Attachment 8: Agilent 4402B Spectrum Analyzer - Channel Power Measurements**

**Attachment 9: Spectral Plots; Center Frequency 2326.0 MHz, SPAN = 50 MHz**

**Attachment 10: Test Equipment**



### Attachment 1: Sirius XM ALU DTR-0200 - Test Data

#### Sirius XM ALU DTR-0200 Repeater – Test Data

Item	Date	Exciter	ALU DTR-0200 Serial No	RF Output	OBE Sample	CB1 il + CB1 il	LPF il	OBE cr	HBE OBF il	PM Acc	OBE adj	CPL2 cf	OBE @ TXBPF in	TX BPF Rejection	Conducted Emission	FCC Limit	Margin
1 Low Band Edge at 2319.5 MHz OBE Filter Measurement with HP E4418B Power Meter				(Watts)	(dBm)	(dB)	(dB)	(dB)	(dB)	(dB)	(dBm)	(dB)	(dBm)	(dB)	(dBm)	(dBm)	(dB)
1.1	17-Jan-14	SPU	CA0V6885	200	-48.40	0.60	1.78	0.0	9.37	0.25	-36.40	50.60	14.20	90.19	-75.99	-60	15.99
Item	Date	Exciter	ALU DTR-0200 Serial No	RF Output	OBE Sample	CB1 il	NA	NA	NA	AS Acc	CP adj	CPL2 cf	OBE @ TXBPF in	TX BPF Rejection	Conducted Emission	FCC Limit	Margin
2 Low Band Edge Channel Power with HP E4402B Spectrum Analyzer				(Watts)	(dBm)	(dB)	(dB)	(dB)	(dB)	(dB)	(dBm)	(dB)	(dBm)	(dB)	(dBm)	(dBm)	(dB)
2.1	17-Jan-14	SPU	CA0V6885	200	-46.64	0.3	0	0	0	0.25	-46.09	50.60	4.51	90.19	-85.68	-60	25.68
Item	Date	Exciter	ALU DTR-0200 Serial No	RF Output	OBE Sample	CB1 il + CB2 il	LPF il	OBE cr	LBE OBF il	PM Acc	OBE adj	CPL2 cf	OBE @ TXBPF in	TX BPF Rejection	Conducted Emission	FCC Limit	Margin
3 High Band Edge at 2345.5 MHz OBE Filter Measurement with HP E4418B Power Meter				(Watts)	(dBm)	(dB)	(dB)	(dB)	(dB)	(dB)	(dBm)	(dB)	(dBm)	(dB)	(dBm)	(dBm)	(dB)
3.1	17-Jan-14	SPU	CA0V6885	200	-65.10	0.60	1.78	0.0	6.3	0.25	-56.17	50.60	-5.57	95.59	-101.16	-60	41.16
Item	Date	Exciter	ALU DTR-0200 Serial No	RF Output	OBE Sample	CB1 il	NA	NA	NA	AS Acc	CP adj	CPL2 cf	OBE @ TXBPF in	TX BPF Rejection	Conducted Emission	FCC Limit	Margin
4 Low Band Edge Channel Power with HP E4402B Spectrum Analyzer				(Watts)	(dBm)	(dB)	(dB)	(dB)	(dB)	(dB)	(dBm)	(dB)	(dBm)	(dB)	(dBm)	(dBm)	(dB)
4.1	17-Jan-14	SPU	CA0V6885	200	-66.35	0.3	0	0	0	0.25	-65.8	50.6	-15.2	95.59	-110.79	-60	50.79

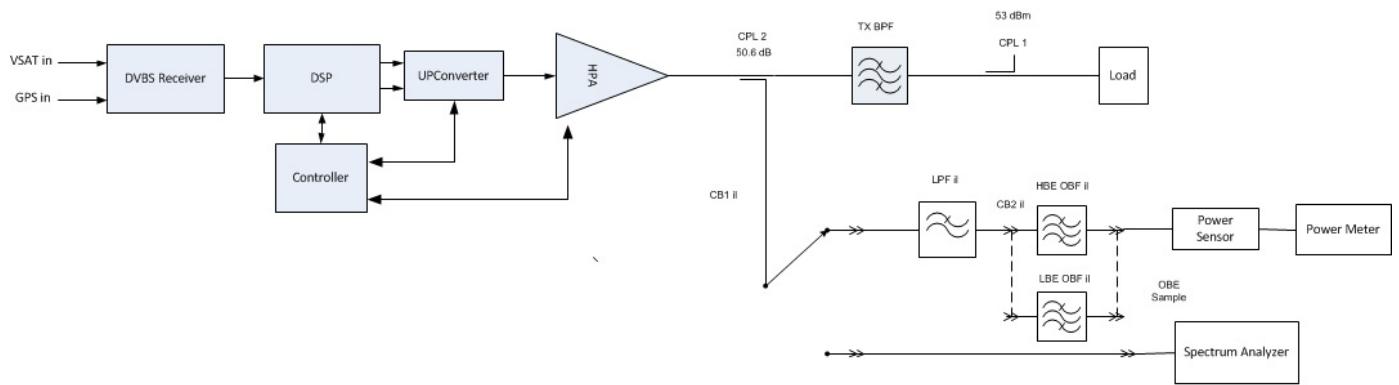


Notes:

1. Band edge measurements at 2345.5 MHz are at measurement device noise floor
  - a. Reference Measurement point 2345.5 MHz in following:
    - Attachment 2, 5, 8 and 10

## Attachment 2: Test Block Diagram

### Sirius XM ALU DTR-0200 OBE Test Diagram



#### Definitions

**OBE Sample** is the measured value of the OBE filter output

**CPL2 cf** is the Coupling Factor of CPL2 = 50.6 dB

**CB1 il** is the insertion loss of Cable 1 = 0.3 dB

**CB2 il** is the insertion loss of Cable 2 = 0.3 dB

**LPF il** is the insertion loss for the Low Pass Filter = 1.78 dB (worst case loss)

**OBF cf** is the Out of Band Filter correction factor = 0.0 dB

**LBE OBF il** is the insertion loss of the Out of Band Filters = 9.37 dB (worst case loss)

**HBE OBF il** is the insertion loss of the Out of Band Filters = 6.28 dB (worst case loss)

**PM Acc** is the measurement accuracy of the Power Meter = 0.25 dB



## Measurements with PM and OBE Filter

The table below summarized Power Measurements using an E9300A Power Sensor at band edge.

Two measurements are made at band edge 2319.5 MHz and 2345.5 MHz

1. Measurement using 1 MHz OBE filter
2. Measurement of Power Meter Noise Floor

Item	OBE Filter cF	1 MHz Power	
1	2319.5 MHz	-48.4 dBm	
2	2345.5 MHz	-65.1 dBm	*noise floor of E9300A

\*Noise measurement at band edge of 2345.5 is equivalent to noise floor of measurement device.



### Attachment 3: Integrated Filter Rejection

#### Integrated Filter Rejection

This section will detail the integrated rejection at 2319.5 MHz in a 1 MHz BW for both filter manufacturers

The Sirius XM ALU DTR-0200 Repeaters are constructed with transmits band pass filters manufactured by Trilithic.

Trilithic part no. 23402 CFB8-2326.275-IL

The worst case figures for the filters are summarized in the table below:

1. TX BP Filter Worst Case Rejection for Low Band Edge (LBE): -90.19 dB
2. TX BP Filter Worst Case Rejection for How Band Edge (HBE): -95.59 dB

#### *Transmit Band Pass Filter; Integrated Rejection*

The following table provides the TX Band Pass Filter Rejection from 2319 MHz through 2320 MHz and 2345 MHz through 2346 MHz in 250KHz steps size.

Low Band Edge-TX BF Filter		High Band Edge-TX BF Filter	
Frequency (MHz)	Rejection (dB)	Frequency (MHz)	Rejection (dB)
2319.00	-90.19	2345.00	-97.983
2319.25	-93.298	2345.25	-100.5
2319.50	-92.695	2345.50	-101.78
2319.75	-98.451	2345.75	-95.597
2320.00	-93.602	2346.00	-106.2

-90.19

-95.59

The Integrated 1 MHz rejection is the average of the measurement values expressed in the above table. The worst case rejection of the three filters is used in the final spreadsheet in attachment 1 of this document.



#### Attachment 4: Transmit Band Pass Filter Plots

##### Transmit Band Pass Filter Response – 2315 MHz through 2365 MHz

File: SCRN10.GIF

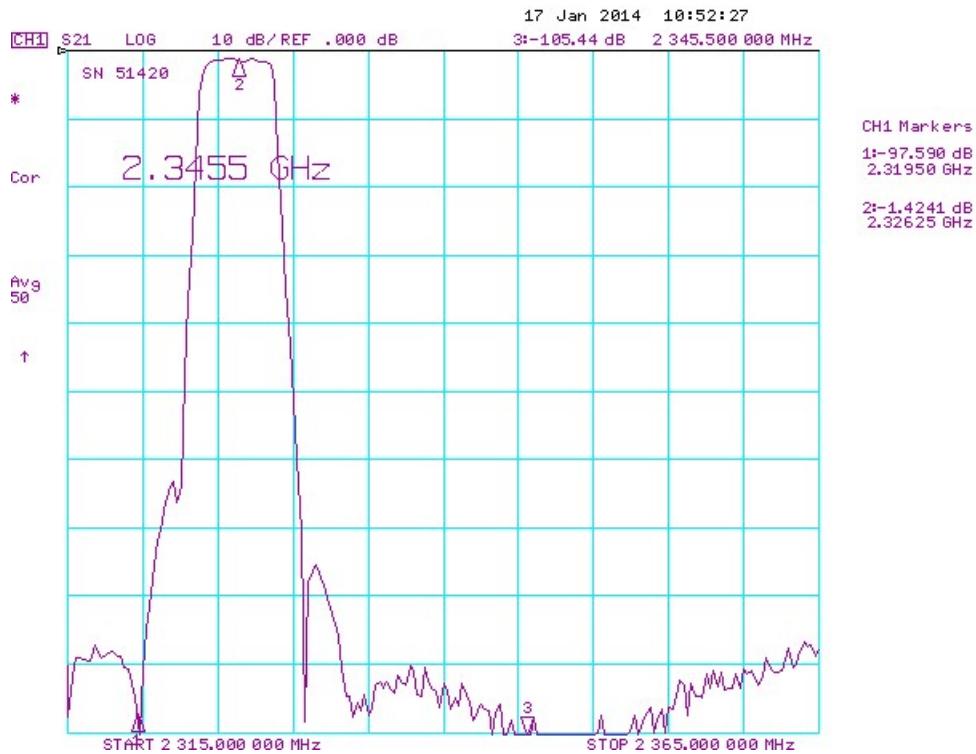
Filter: Serial No. 2007-51420

Description: Low Band Transmit Band Pass Filter

Span: 50 MHz

Start: 2315 MHz

Stop: 2365 MHz



Note: 2345.5 MHz is within noise floor of measurement device



## Attachment 5: Out of Band Emission Filter

### OBE Filter Plot

#### SCREN00.GIF



#### SCREN06.GIF

### OBE 2345.5 MHz





### Attachment 6: Low Pass Filter

Description: Low Pass Filter, Swept Response 2 GHz through 6 GHz

Mitec Low Pass Filter Part no. 626039-101MD Serial no. 6260391010430001

File: SCREN07.GIF

Marker 1 2319.5 MHz  
Marker 2 2326.0 MHz  
Marker 3 2345.5 MHz  
Marker 4 3490.1 MHz





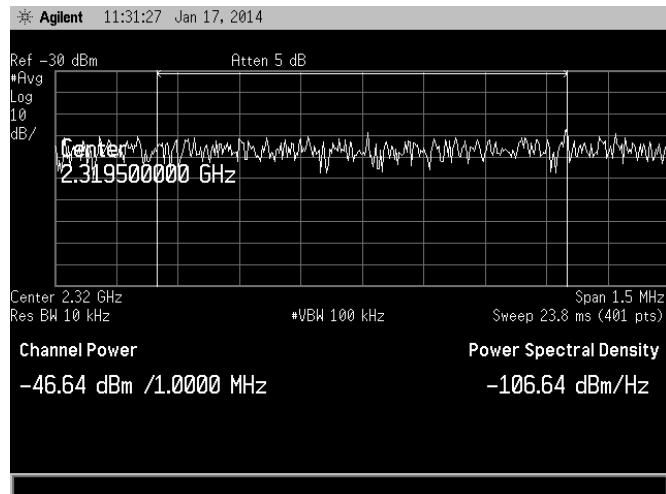
## Attachment 7: Agilent 4402B Spectrum Analyzer - Channel Power Measurements

Channel Power Measurement @ 2319.5 MHz and 2345.5 MHz  
Spectrum Analyzer E4402B

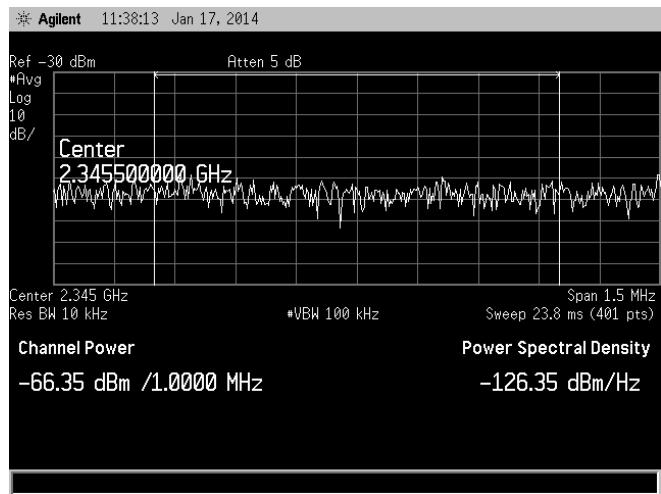
Channel Power Reference Files:

Item	Filename	Channel Power	Cf	Comment
1	SCREN363.GIF	-46.64	2319.5 MHz	-
2	SCREN364.GIF	-66.35	2345.5 MHz	Noise Floor

### SCREN363.GIF Low Side Band Edge



### SCREN364.GIF High Side Band Edge





## Attachment 8: Agilent E4418B Power Meter - Channel Power Measurements

**Low Side Band Edge**



**High Side Band Edge**





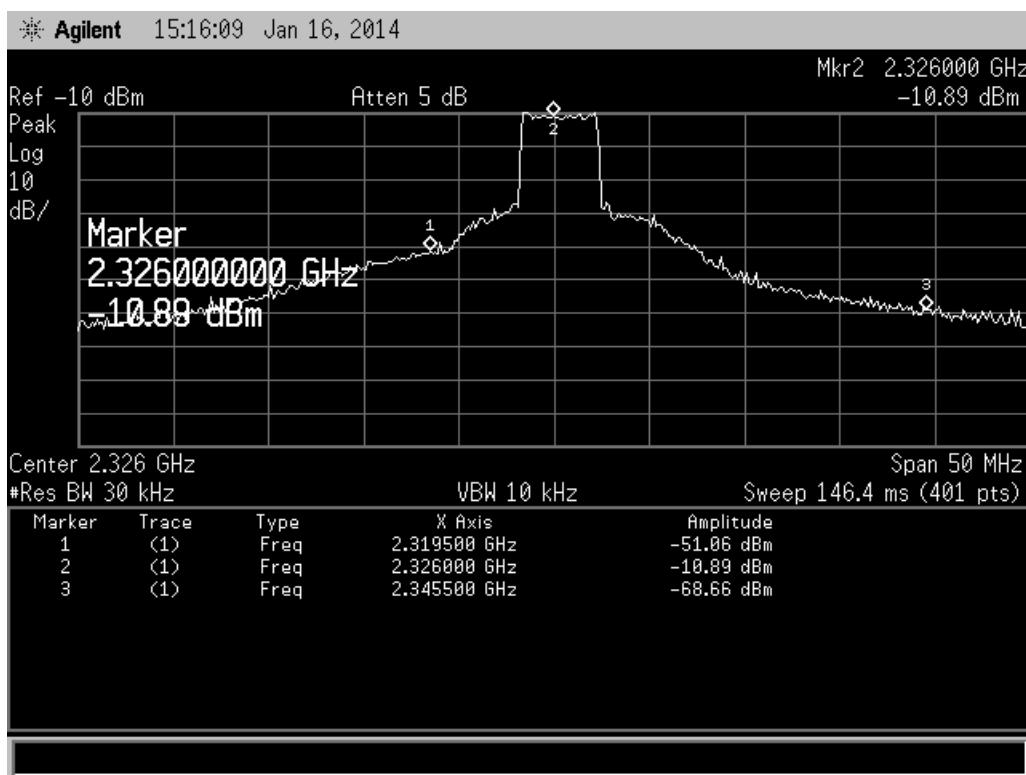
### Attachment 9: 50 MHz Spectral Plot

Spectral Plot: ALU 200W

cF = 2326.25 MHz

Span = 50 MHz

File: SCREN357.GIF





## Attachment 10: Test Equipment

### E9300A Power Sensor



#### Agilent / HP E9300A Specifications:

<b>Connector Type</b>	Type - N(m)
<b>Frequency Range</b>	10 MHz - 18GHz
<b>Min/Max Power</b>	25dBm - 35dBm

#### Agilent / HP E9304A Key Points:

- frequency range (10MHz to 18GHz) for EMC/EMI test applications such as the radiated immunity test (IEC61000-4-3).
- High sensitivity (-60 to +20dBm) and fast measurement speed to reduce the time taken to calibrate radiated field uniformity and EMC/EMI test receivers.
- Measure transmitter power and receiver sensitivity at Very Low Frequency (VLF) to microwave frequencies..
- Compatible with the EPM, EPM-P and P-series power meters..



## E4418B Power Meter



### Agilent / HP E4418B Specifications:

<b>Frequency Range</b>	100 kHz to 110 GHz, sensor dependent
<b>Power Range</b>	-70 dBm to +44 dBm (100 pW to 25 W), sensor dependent
<b>Single Sensor Dynamic Range</b>	90 dB maximum
<b>Power Output</b>	1.00 mW (0.0 dBm)
<b>Accuracy</b>	±1.2% worst case
<b>GPIB</b>	Allows communication with an external controller
<b>Input Voltage Range</b>	85 to 264 VAC, automatic selection
<b>Input Frequency Range</b>	50 to 440 Hz
<b>Power Requirement</b>	approximately 50 VA (14 Watts)
<b>Operating Temperature</b>	0 °C to 55 °C
<b>Storage Temperature</b>	-20 °C to +70 °C
<b>Dimensions</b>	212.6 mm W x 88.5 mm H x 348.3 mm D (8.5 in x 3.5 in x 13.7 in)
<b>Weight</b>	Net - 4.0 kg (8.8 lb), Shipping - 7.9 kg (17.4 lb)



## E4408B Spectrum Analyzer



### Agilent / HP E4408B Specifications:

<b>Frequency range DC coupled</b>	9KHz to 26.5GHz
<b>Accuracy</b>	±1%
<b>Video bandwidth range</b>	30Hz to 3MHz sequence :1-3-10
<b>Maximum safe input level</b>	+30 dBm (1 W)
<b>Peak pulse power</b>	+50 dBm (100 W)
<b>RF input VSWR</b>	9 kHz to 100 kHz - 2:1, 100 kHz to 3 GHz - 1.4:1
<b>RF Input</b>	50 ohms type N (f)
<b>RF out</b>	50 ohms type N (f)
<b>Probe power</b>	+ 15Vdc, -12.6Vdc at 150mA maximum (characteristic)
<b>AMPTD REF out</b>	50 ohms BNC (f) (nominal)
<b>IF INPUT (Option AYZ)</b>	50 ohms SMA (f) (nominal)
<b>LO OUTPUT (Option AYZ)</b>	50 ohms SMA (f) (nominal)
<b>Operating Temperature</b>	0 °C to + 55 °C
<b>Storage Temperature</b>	-40 °C to + 75 °C
<b>Dimensions(max.)</b>	222mm(H) x 516mm(D) x 416mm(W)
<b>Weight</b>	17.1 kg (37.7 lbs.)