Electromagnetic Compatibility Test Report

Tests Performed on a Fybr, LLC Transceiver, Model FY5004, FybrLink

Radiometrics Document RP-8772

ACCREDITED
TESTING CERT #1495.01

Product Detail:
FCC ID: 2ALBF-5004 IC: 22374-5004 Equipment type: Low power transmitter
Test Standards:
US CFR Title 47, Chapter I, FCC Part 15 Subpart C FCC Part 15 CFR Title 47: 2016 Industry Canada RSS-247, Issue 2 This report concerns: Original Grant for Certification FCC Part 15.247

Tests Performed For:	*Test Facility:*
Fybr, LLC 640 Cepi Dr., Suite C Chesterfield, MO 63005	**Radiometrics Midwest Corporation** 12 Devonwood Avenue Romeoville, IL 60446-1349 (815) 293-0772

Test Date(s): (Month-Day-Year)
December 1, 2017 thru February 8, 2018

Document RP-8772 Revisions:

Rev.	Issue Date	Affected Sections	Revised By
0	February 12, 2018		
1	March 26, 2018	2.1, 9, 10, 11	Joseph Strzelecki

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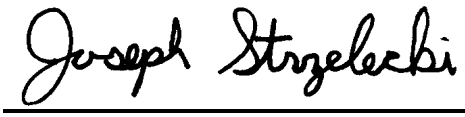
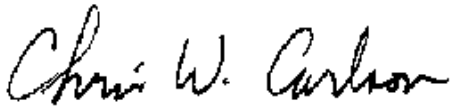
1.0 ADMINISTRATIVE DATA

Equipment Under Test: A Fybr, LLC, Transceiver Model: FY5004, FybrLink; Serial Number: None This will be referred to as the EUT in this Report	
Date EUT Received at Radiometrics: (Month-Day-Year) November 30, 2017	*Test Date(s): (Month-Day-Year)* December 1, 2017 thru February 8, 2018
Test Report Written and approved By:  Joseph Strzelecki Senior EMC Engineer NARTE EMC-000877-NE	*Test Report Authorized By:*  Chris W. Carlson Director of Engineering NARTE EMC-000921-NE
Radiometrics' Test Personnel: Joseph Strzelecki Senior EMC Engineer Richard L. Tichgelaar EMC Technician	*Test Witnessed By:* The tests were not witnessed by Fybr, LLC

2.0 TEST SUMMARY AND RESULTS

The EUT (Equipment Under Test) is a transceiver, Model FY5004, FybrLink, manufactured by Fybr, LLC. The detailed test results are presented in a separate section. The following is a summary of the test results.

Emissions Tests Results

Environmental Phenomena	Frequency Range	FCC Section	RSS- Section	Test Result
6 dB Bandwidth Test	902-928 MHz	15.247 a	RSS-247 (5.2)	Pass
20 dB Bandwidth Test	902-928 MHz	15.247 a	RSS GEN (8.8)	Pass
Peak Output Power	902-928 MHz	15.247 b	RSS-247 (5.4d)	Pass
Spurious Radiated Emissions	30 MHz to 9.5 GHz	15.247 d	RSS-247 (3.3)	Pass
Antenna Port Conducted Unwanted Emissoins	30 MHz to 9.5 GHz	15.247 d	RSS-247 (5.5)	Pass
Power Spectral Density	902-928 MHz	15.247 e	RSS-247 (5.2b)	Pass
RF Radiated Emissions (Unintential Radiation Receive mode)	30-5,000 MHz	15.209	GEN; 7.1.2	Pass

Note: The RSS-210 specification is not currently covered in Radiometrics' Scope of Accreditation. This is technically very similar to FCC, CFR 47 Part 15 which is on Radiometrics scope.

2.1 RF Exposure Compliance Requirements

Since the e.i.r.p. of the Product is 70.8 mW, and the separation distance is greater than 20 cm the EUT meets the FCC requirement for RF exposure and it is exempt from RSS-102 SAR and RF exposure evaluations. There are no power level adjustments available to the end user. The antenna is professionally installed. The detailed calculations for RF Exposure are presented in a separate document.

3.0 EQUIPMENT UNDER TEST (EUT) DETAILS

3.1 EUT Description

The EUT is a transceiver, Model FY5004, FybrLink, manufactured by Fybr, LLC. The EUT was in good working condition during the tests, with no known defects.

3.1.1 FCC Section 15.203 & RSS-GEN Antenna Requirements

The Gateway must be professionally installed. It will not be sold to the general public.

3.2 EUT Operating Modes

Environmental Phenomena	Channels Tested (MHz	Notes
Bandwidth Test	903, 915 & 927	
Peak Output Power	903, 915 & 927	
Band-edge Compliance of RF Conducted Emissions	903, 915 & 927	
RF Conducted Emissions	903, 915 & 927	
Radiated Emissions	903, 915 & 927	
Power Spectral Density	903, 915 & 927	
Conducted Emissions, AC Mains	915	Note 1

Note 1: During preliminary testing, 915 MHz was found to be worst cast for this test.

The transmit mode for all tests was continuous.

4.0 TESTED SYSTEM DETAILS

4.1 Tested System Configuration

The system was configured for testing in a typical fashion. The EUT was placed on an 80-cm high, nonconductive test stand. The testing was performed in conditions as close as possible to installed conditions. Wiring was consistent with manufacturer's recommendations.

Since the EUT is wall mounted, it was placed in an upright configuration during the tests. The EUT was tested as a stand-alone device. Power was supplied at 120 VAC, 60 Hz single-phase to its external power supply.

The identification for all equipment, plus descriptions of all cables used in the tested system, are:

Tested System Configuration List

Item	Description	Type*	Manufacturer	Model Number	Serial Number
1	Transceiver	E	Fybr, LLC	FY5004, FybrLink	None
2	19 VDC Power supply	E	Lenovo	PA-1650-52LC	11536001678ZZ4001694TG
3	Omni Directional Antenna	E	L-Com	HG906U-PRO	None
4	Patch Antenna	E	L-Com	HG908P-NF	None

* Type: E = EUT, P = Peripheral, S = Support Equipment; H = Host Computer

List of System Cables

QTY	Length (m)	Cable Description	Shielded?
1	1.2	DC Cord from external power supply	No

4.2 Special Accessories

No special accessories were used during the tests in order to achieve compliance.

4.3 Equipment Modifications

No modifications were made to the EUT at Radiometrics' test facility in order to comply with the standards listed in this report.

5.0 TEST SPECIFICATIONS

Document	Date	Title
FCC CFR Title 47	2017	Code of Federal Regulations Title 47, Chapter 1, Federal Communications Commission, Part 15 - Radio Frequency Devices
IC RSS-247 Issue 2	2017	Low Power Licence-Exempt Radiocommunication Devices (All Frequency Bands) Category I Equipment
IC RSS-Gen Issue 4	2014	General Requirements and Information for the Certification of Radiocommunication Equipment (RSS-Gen)

6.0 TEST PROCEDURE DOCUMENTS

The tests were performed using the procedures from the following specifications:

Document	Date	Title
ANSI C63.4-2014	2014	Methods of Measurement of Radio Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
ANSI C63.10-2013	2013	American National Standard for Testing Unlicensed Wireless Devices
558074 D01 DTS Meas Guidance	2016	Guidance for Performing Compliance Measurements On Digital Transmission Systems (DTS) Operating Under §15.247; v03r04

7.0 RADIOMETRICS' TEST FACILITIES

The results of these tests were obtained at Radiometrics Midwest Corp. in Romeoville, Illinois, USA. Radiometrics is accredited by A2LA (American Association for Laboratory Accreditation) to conform to ISO/IEC 17025: 2005 "General Requirements for the Competence of Calibration and Testing Laboratories". Radiometrics' Lab Code is 121191 and Certification Number is 1495.01. Radiometrics' scope of accreditation includes all of the test methods listed herein. A copy of the accreditation can be accessed on our web site (www.radiomet.com). Radiometrics accreditation status can be verified at A2LA's web site (www.a2la2.org).

The following is a list of shielded enclosures located in Romeoville, Illinois used during the tests:

Chamber E: Is a custom made anechoic chamber that measures 52' L X 30' W X 18' H. The walls and ceiling are fully lined with RF absorber. Pro-shield of Collinsville, Oklahoma manufactured the chamber. The floor has a 9' x 9' section of microwave absorber for testing above 1 GHz.

Test Station F: Is an area that measures 10' D X 12' W X 10' H. The floor and back wall are metal shielded. This area is used for conducted emissions measurements.

A separate ten-foot long, brass plated, steel ground rod attached via a 6-inch copper braid grounds each of the above chambers. Each enclosure is also equipped with low-pass power line filters.

The FCC has accepted these sites as test site number US1065. The FCC test site Registration Number is 732175. Details of the site characteristics are on file with the Industry Canada as site number IC 3124A-1.

A complete list of the test equipment is provided herein. The calibration due dates are indicated on the equipment list. The equipment is calibrated in accordance to ANSI/NCSL Z540-1 with traceability to the National Institute of Standards and Technology (NIST).

8.0 DEVIATIONS AND EXCLUSIONS FROM THE TEST SPECIFICATIONS

There were no deviations or exclusions from the test specifications.

9.0 CERTIFICATION

Radiometrics Midwest Corporation certifies that the data contained herein was taken under conditions that meet or exceed the requirements of the test specification and that the data contained herein was taken with calibrated test equipment. The results relate only to the EUT listed herein.

10.0 TEST EQUIPMENT TABLE

RMC ID	Manufacturer	Description	Model No.	Serial No.	Frequency Range	Cal Period	Cal Date
AMP-05	RMC/Celeritek	Pre-amplifier	MW110G	1001	1.0-12GHz	12 Mo.	01/09/17 01/17/18
ANT-04	Tensor	Biconical Antenna	4104	2246	20-250MHz	24 Mo.	05/16/16
ANT-07	RMC	Log-Periodic Ant.	LP1000	1001	200-1000MHz	24 Mo.	08/10/16
ANT-66	ETS-Lindgren	Horn Antenna	3115	62580	1.0-18GHz	24 Mo.	02/15/17
HPF-01	Solar	High Pass Filter	7930-100	HPF-1	0.15-30MHz	24 Mo.	03/15/16 03/14/18
HPF-07	Mini-Circuits	High Pass Filter	VHF-1500+	31121	1.7-10 GHz	24 Mo.	03/31/16
LSN-17	EMCO	LISN	3810/2NM	9602-1356	0.15 - 30MHz	24 Mo.	02/22/17
REC-11	HP / Agilent	Spectrum Analyzer	E7405A	US39110103	9Hz-26.5GHz	24 Mo	03/23/16
REC-20	HP / Agilent	Spectrum Analyzer	85460A/84562A	33330A00135 3410A00178	30Hz-6GHz	24 Mo.	07/13/16
REC-21	Agilent	Spectrum Analyzer	E7405A	MY45118341	9Hz-26.5 GHz	24 Mo.	12/22/15 01/06/18
THM-03	Fluke	Temp/Humid Meter	971	95850465	N/A	24 Mo.	02/20/17

Note: All calibrated equipment is subject to periodic checks.
All equipment was in calibration during the time it was used for the tests herein.

Software Company	Test Software Name	Version	Applicable Tests
Radiometrics	EN550XX0	02.28.17	RF Conducted Emissions (FCC Part 15 & EN 55032)
Radiometrics	REREC11D	04.19.17	RF Radiated Emissions (FCC Part 15 & EN 55032)
Agilent	PSA/ESA-E/L/EMC	2.4.0.42	Bandwidth and screen shots

11.0 TEST SECTIONS

11.1 AC Conducted Emissions

The tests and limits are in accordance with FCC section 15.207 and RSS Gen section 8.8.

A computer-controlled analyzer was used to perform the conducted emissions measurements. The frequency range was divided into 500 subranges equally spaced on a logarithmic scale. The computer recorded the peak of each subrange. This data was then plotted on a semi-log graph generated by the computer. Adjusting the positions of the cables and orientation of the test system then maximizes the highest emissions.

Mains Conducted emission measurements were performed using a 50 Ohm/50 uH Line Impedance Stabilization Network (LISN) as the pick-up device. Measurements were repeated on both leads within the power cord. If the EUT power cord exceeded 80 cm in length, the excess length of the power cord was made into a 30 to 40 cm bundle near the center of the cord. The LISN was placed on the floor at the base of the test platform and electrically bonded to the ground plane.

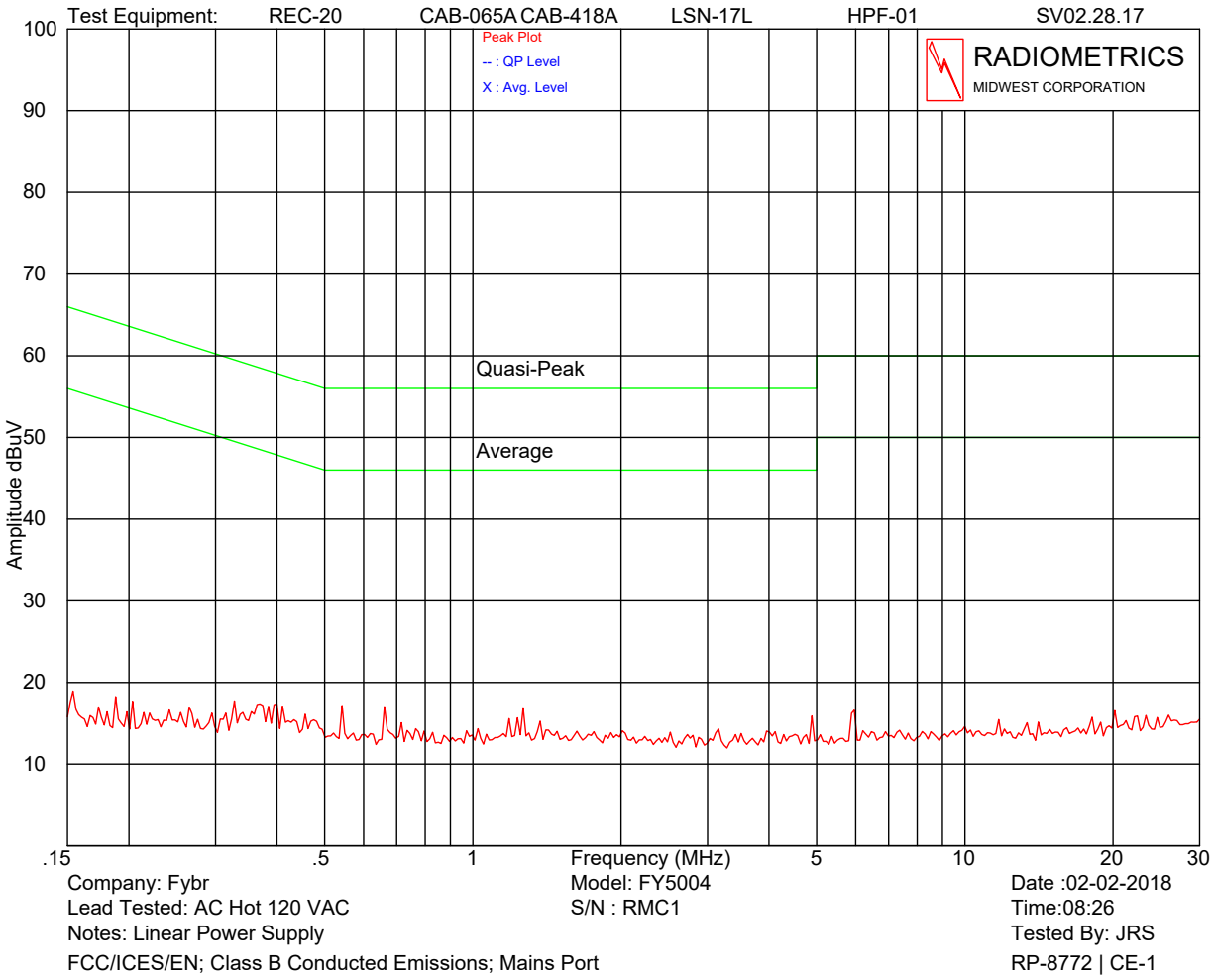
FCC Limits of Conducted Emissions at the AC Mains Ports

Frequency Range (MHz)	Class B Limits (dBuV)	
	Quasi-Peak	Average
0.150 - 0.50*	66 - 56	56 - 46
0.5 – 5.0	56	46
5.0 - 30	60	50
* The limit decreases linearly with the logarithm of the frequency in this range.		

The initial step in collecting conducted data is a peak detector scan and the plotting of the measurement range. Significant peaks are then marked as shown on the following table, and these signals are then measured with the quasi-peak detector. The following represents the worst case emissions from the power cord, after testing all modes of operation.

Test Date : February 2, 2018
The Amplitude is the final corrected value with cable and LISN Loss.
* QP readings are quasi-peak with a 9 kHz bandwidth and no video filter.

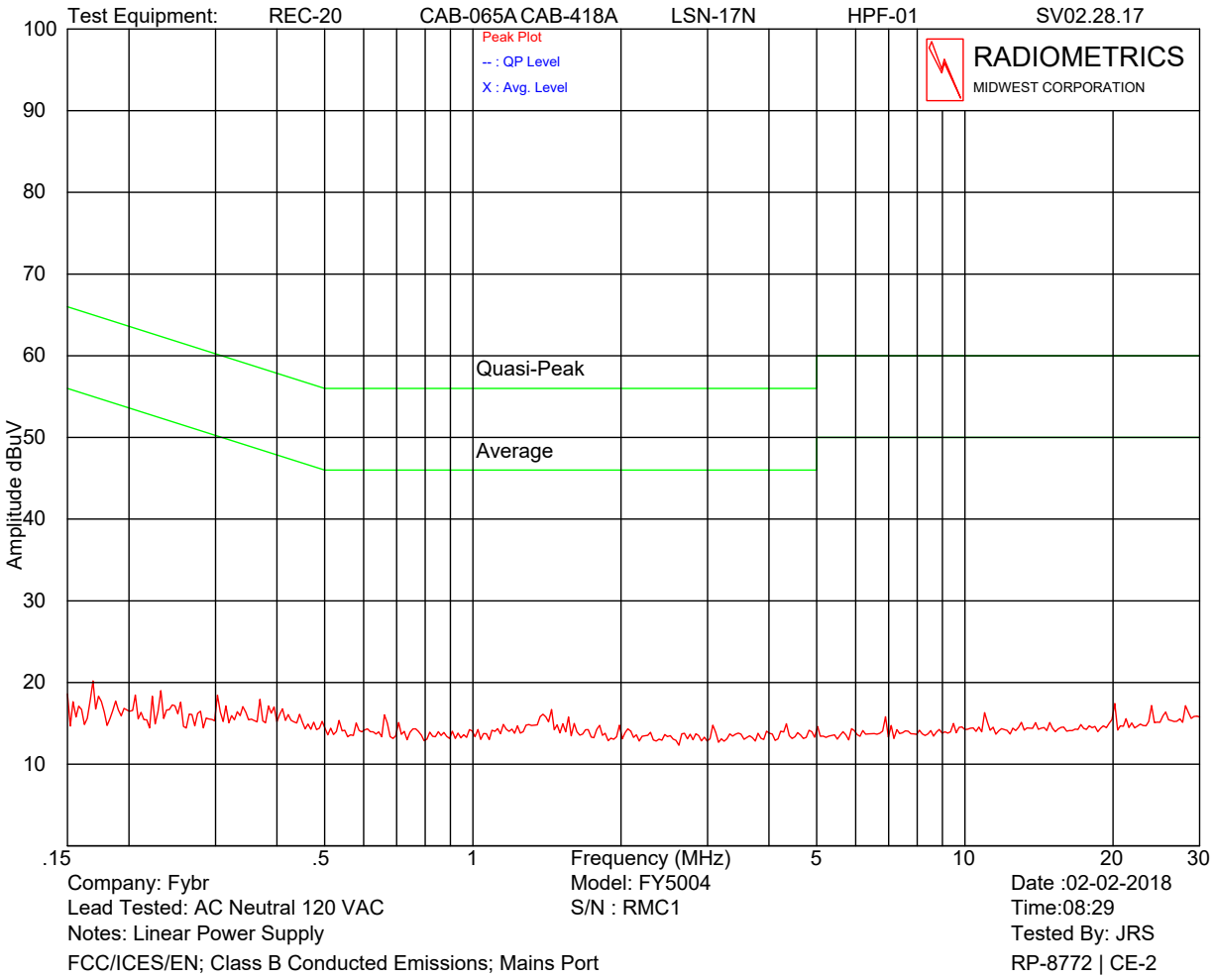
Testing of the Fybr, LLC, Model FY5004, FybrLink, Transceiver



Company: Fybr
Lead Tested: AC Hot 120 VAC
Notes: Linear Power Supply
FCC/ICES/EN; Class B Conducted Emissions; Mains Port

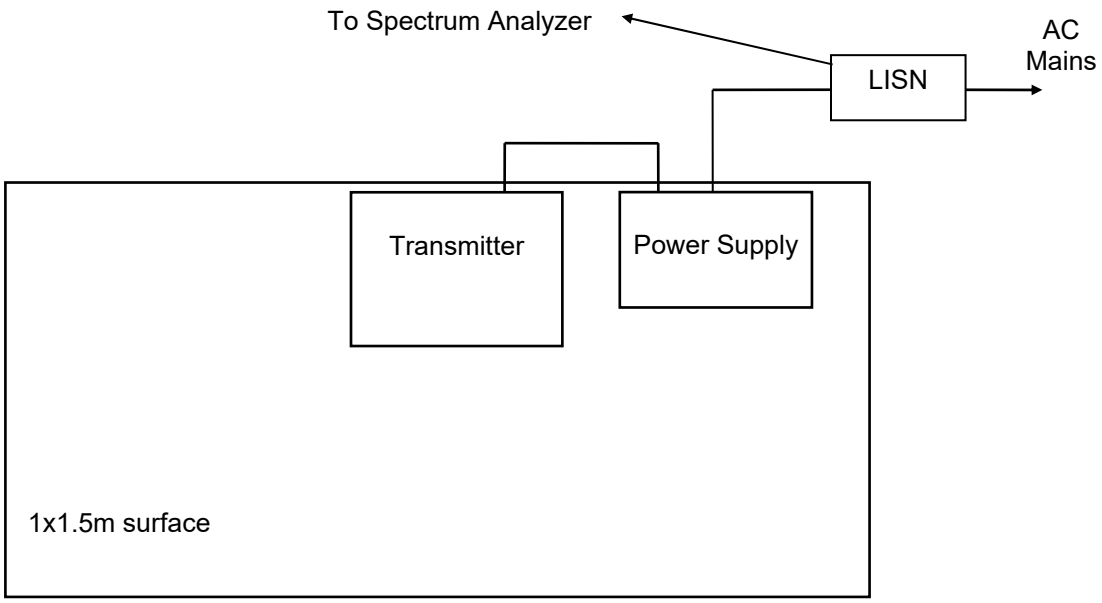
Model: FY5004
S/N : RMC1

Date :02-02-2018
Time:08:26
Tested By: JRS
RP-8772 | CE-1



Judgment: Pass by at least 10 dB

Figure 1. Conducted Emissions Test Setup



Notes:
- LISN's at least 80 cm from EUT chassis
- Vertical conductive plane 40 cm from rear of table top
- EUT power cord bundled

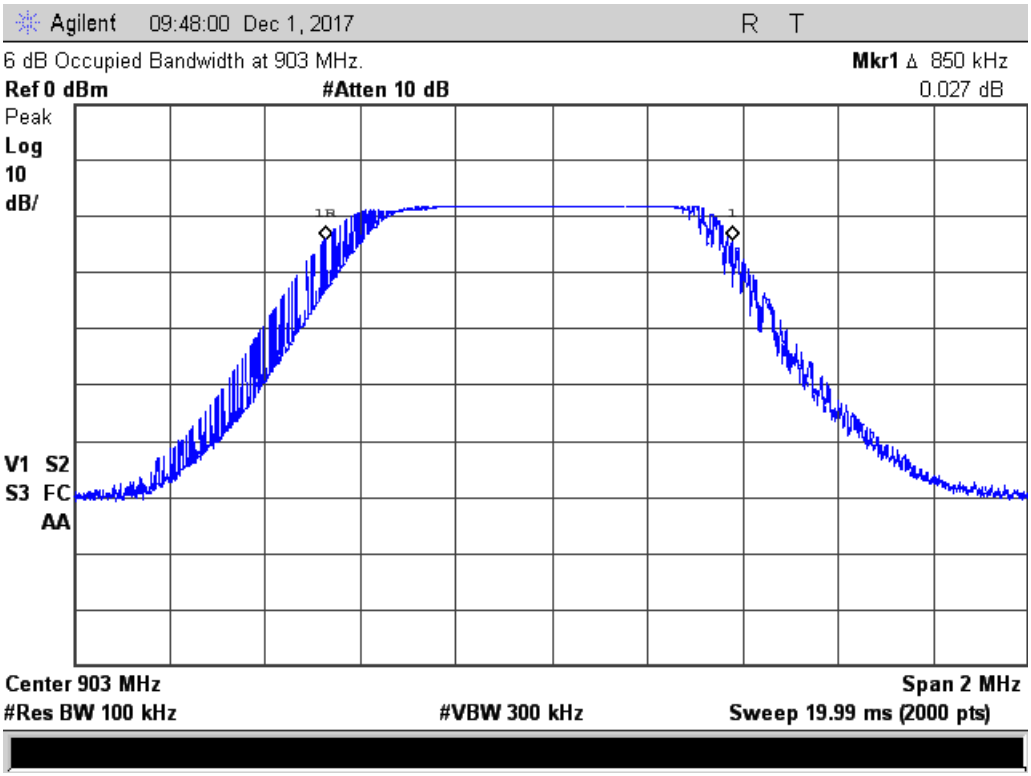
11.2 Occupied Bandwidth

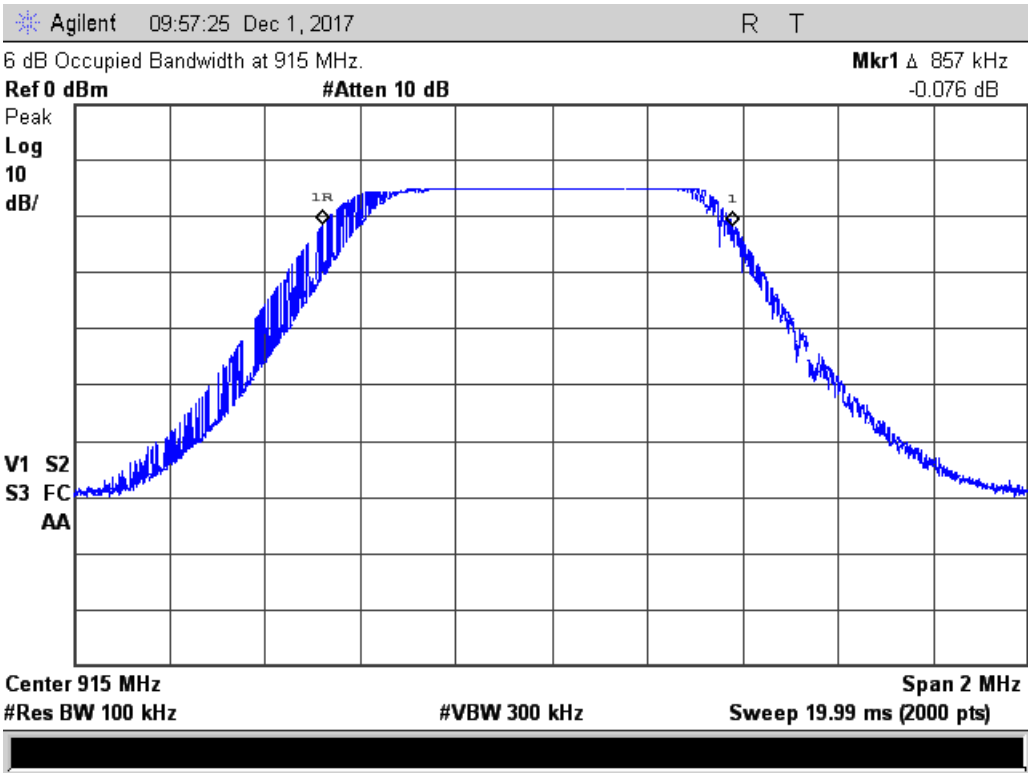
The test procedures were in accordance to FCC DTS Measurement Guideline 558074 D01, Section 8.1.

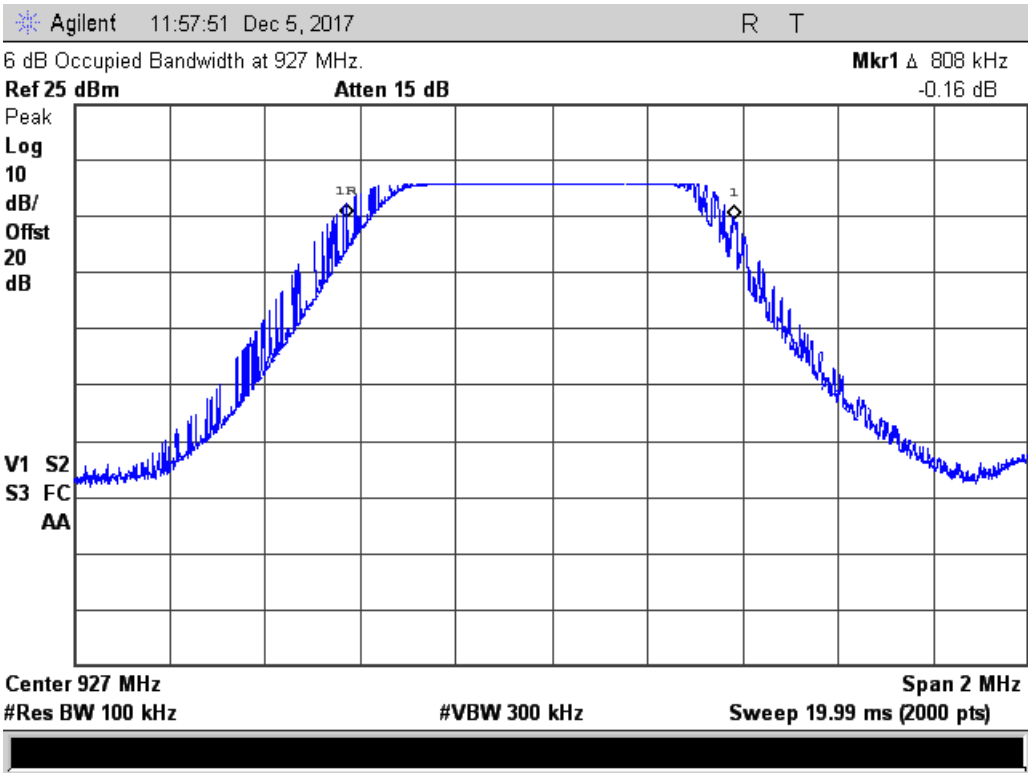
The spectrum analyzer was set to the MAX HOLD mode to record the worst case of the modulation. The EUT was transmitting at its maximum data rate. The trace was allowed to stabilize. The marker-to-peak function was set to the peak of the emission. Then the marker-delta function was used to measure 6 or 20 dB down one side of the emission. The marker-delta function was reset and then moved to the other side of the emission, until it is (as close as possible to) even with the reference marker level. The marker-delta reading at this point is the bandwidth of the emission.

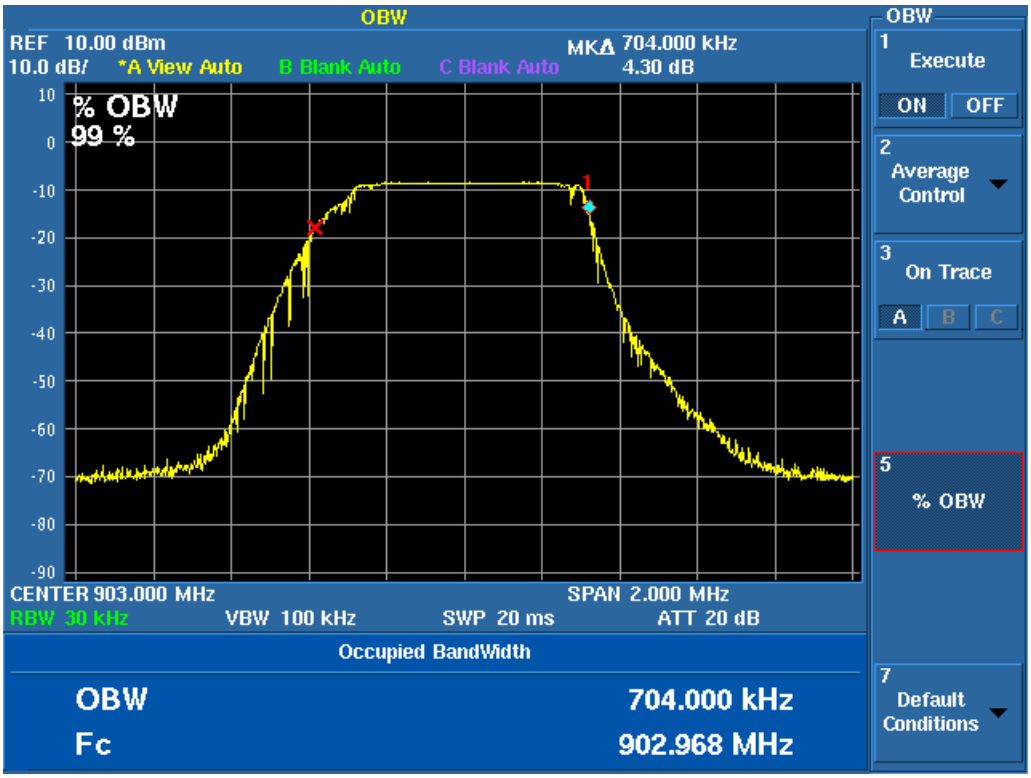
Channel	99% EBW kHz	6 dB EBW kHz
903	704	850
915	706	857
927	704	808

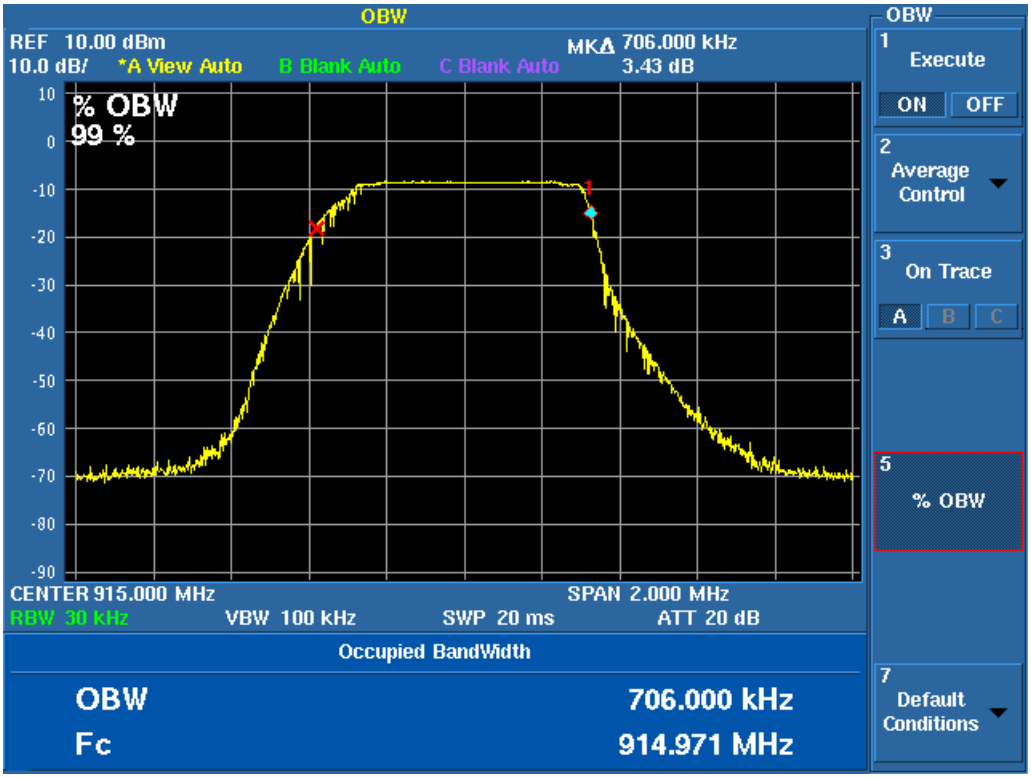
The 6 dB bandwidth is greater than 500 kHz
Judgement: Pass

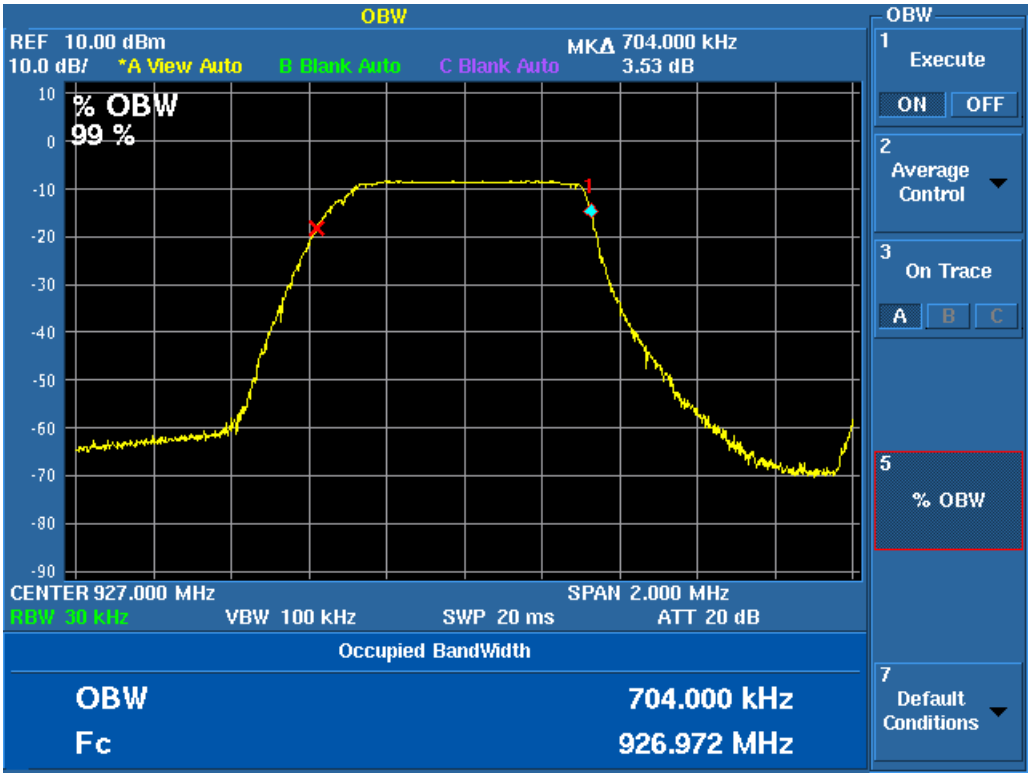

Agilent 09:48:00 Dec 1, 2017
R T
6 dB Occupied Bandwidth at 903 MHz.
Mkr1 Δ 850 kHz
Ref 0 dBm
#Atten 10 dB
0.027 dB
Peak
Log
10
dB/
V1 S2
S3 FC
AA
Center 903 MHz
Span 2 MHz
#Res BW 100 kHz
#VBW 300 kHz
Sweep 19.99 ms (2000 pts)


Agilent 09:57:25 Dec 1, 2017
R T
6 dB Occupied Bandwidth at 915 MHz.
Mkr1 Δ 857 kHz
Ref 0 dBm
#Atten 10 dB
-0.076 dB
Peak
Log
10
dB/
V1 S2
S3 FC
AA
Center 915 MHz
Span 2 MHz
#Res BW 100 kHz
#VBW 300 kHz
Sweep 19.99 ms (2000 pts)


Agilent 11:57:51 Dec 5, 2017
R T
6 dB Occupied Bandwidth at 927 MHz.
Mkr1 Δ 808 kHz
Ref 25 dBm
Atten 15 dB
-0.16 dB
Peak
Log
10
dB/
Offst
20
dB
V1 S2
S3 FC
AA
Center 927 MHz
Span 2 MHz
#Res BW 100 kHz
#VBW 300 kHz
Sweep 19.99 ms (2000 pts)


OBW
REF 10.00 dBm
10.0 dB/
*A View Auto
B Blank Auto
C Blank Auto
MKΔ 704.000 kHz
4.30 dB
% OBW
99 %
CENTER 903.000 MHz
SPAN 2.000 MHz
RBW 30 kHz
VBW 100 kHz
SWP 20 ms
ATT 20 dB
Occupied BandWidth
OBW 704.000 kHz
Fc 902.968 MHz
OBW
1 Execute
ON OFF
2 Average Control
3 On Trace
A B C
5 % OBW
7 Default Conditions


OBW
REF 10.00 dBm
10.0 dB/ *A View Auto B Blank Auto C Blank Auto
MKΔ 706.000 kHz
3.43 dB
% OBW
99 %
CENTER 915.000 MHz
SPAN 2.000 MHz
RBW 30 kHz
VBW 100 kHz
SWP 20 ms
ATT 20 dB
Occupied BandWidth
OBW 706.000 kHz
Fc 914.971 MHz
OBW
1 Execute
ON OFF
2 Average Control
3 On Trace
A B C
5 % OBW
7 Default Conditions


OBW
REF 10.00 dBm
10.0 dB/ *A View Auto B Blank Auto C Blank Auto
MKΔ 704.000 kHz
3.53 dB
% OBW
99 %
CENTER 927.000 MHz
SPAN 2.000 MHz
RBW 30 kHz
VBW 100 kHz
SWP 20 ms
ATT 20 dB
Occupied BandWidth
OBW 704.000 kHz
Fc 926.972 MHz
OBW
1 Execute
ON OFF
2 Average Control
3 On Trace
A B C
5 % OBW
7 Default Conditions

11.3 Peak Output Power

The test procedures were in accordance to FCC DTS Measurement Guideline 558074 D01, Section 9.1.1. The EUT antenna port was connected to the Spectrum analyzer Via a low loss coaxial cable.

The power output test method from ANSI C63.10 section 6.10.2.1 c) was used for this test. The spectrum analyzer was set to the following settings:

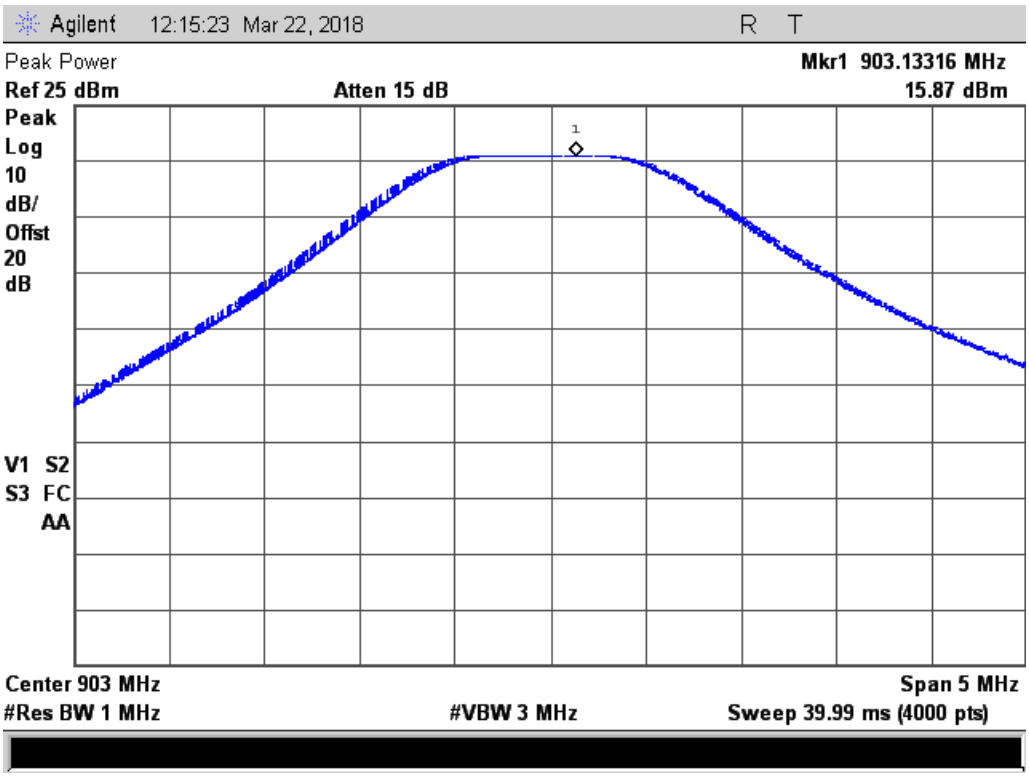
Span = 5 MHz; RBW = 1 MHz; VBW = 3 MHz; Sweep = auto
Detector function = peak; Trace = max hold

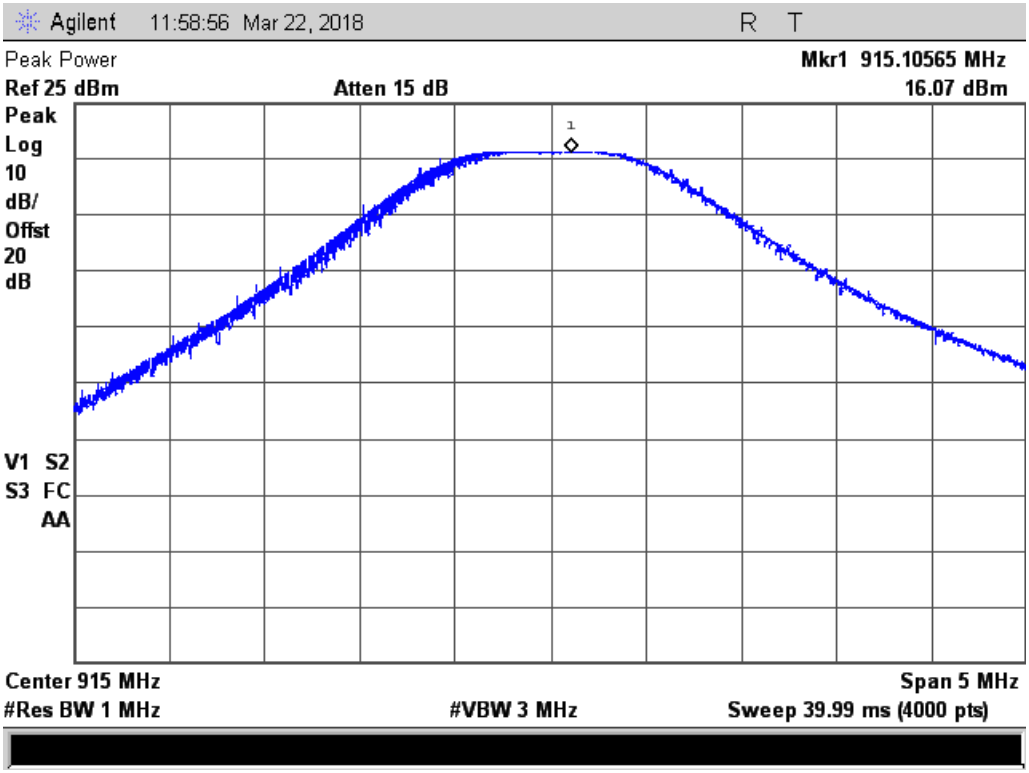
The trace was allowed to stabilize. The indicated level is the peak output power. Since the gain of the antenna is less than 6 dB, the limit is not reduced.

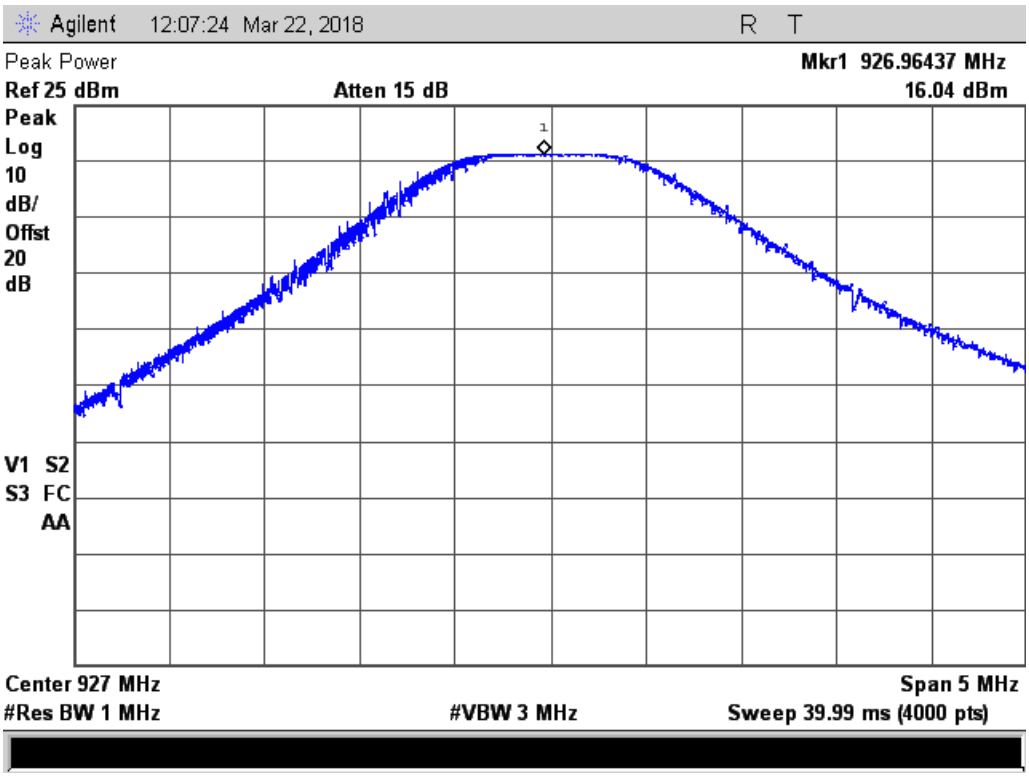
Tested by: Joseph Strzelecki
Test Date: March 22, 2018

Frequency (MHz)	Reading (dBm)	Cable Loss (dB)	Total Power (dBm)		Limit (dBm)
			dBm	Watts	
903	15.9	0.2	16.1	0.0407	30.0
915	16.1	0.2	16.3	0.0427	30.0
927	16.0	0.2	16.2	0.0417	30.0

Judgment: Passed by 13.7 dB




Agilent 11:58:56 Mar 22, 2018
R T
Peak Power
Mkr1 915.10565 MHz
Ref 25 dBm
Atten 15 dB
16.07 dBm
Peak
Log
10
dB/
Offst
20
dB
V1 S2
S3 FC
AA
Center 915 MHz
Span 5 MHz
#Res BW 1 MHz
#VBW 3 MHz
Sweep 39.99 ms (4000 pts)


Agilent 12:07:24 Mar 22, 2018
R T
Peak Power
Mkr1 926.96437 MHz
Ref 25 dBm
Atten 15 dB
16.04 dBm
Peak
Log
10
dB/
Offst
20
dB
V1 S2
S3 FC
AA
Center 927 MHz
Span 5 MHz
#Res BW 1 MHz
#VBW 3 MHz
Sweep 39.99 ms (4000 pts)

11.4 Power Spectral Density

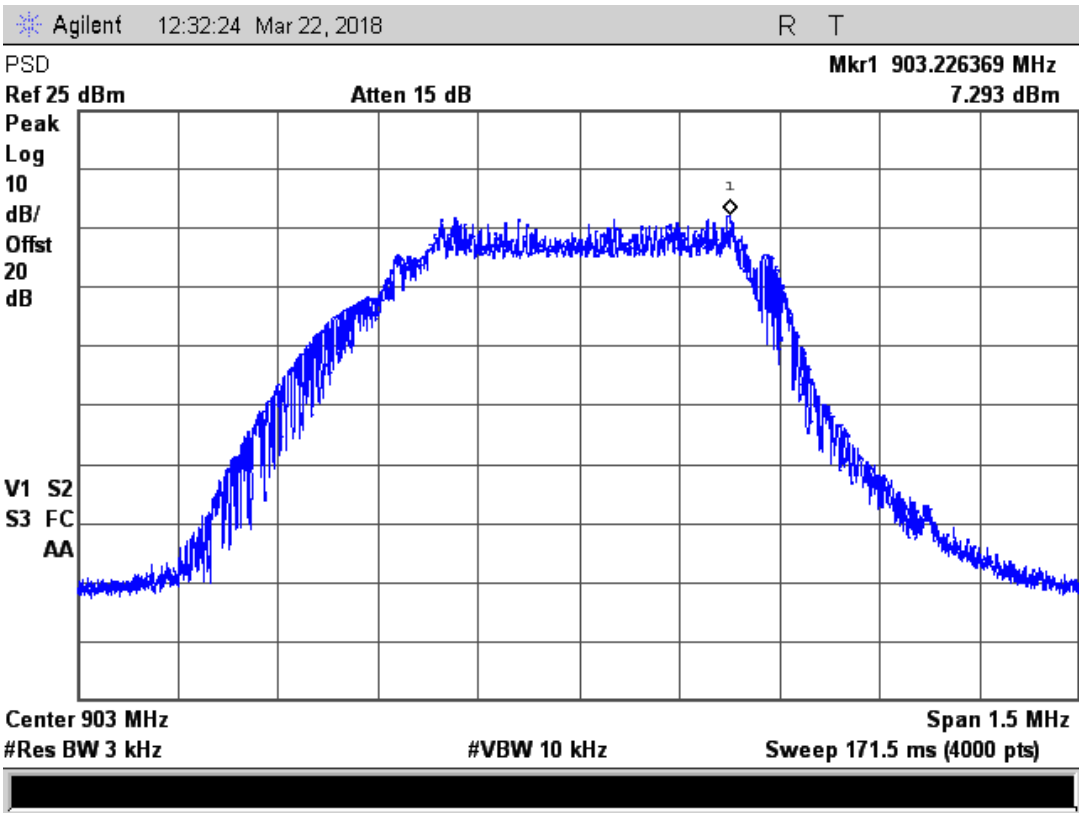
The PSD test method AVGPSD-1 from ANSI C63.10 section 11.10.3 and FCC DTS Measurement Guideline 558074 D01, Section 10.3. The spectrum analyzer was set to the following settings:

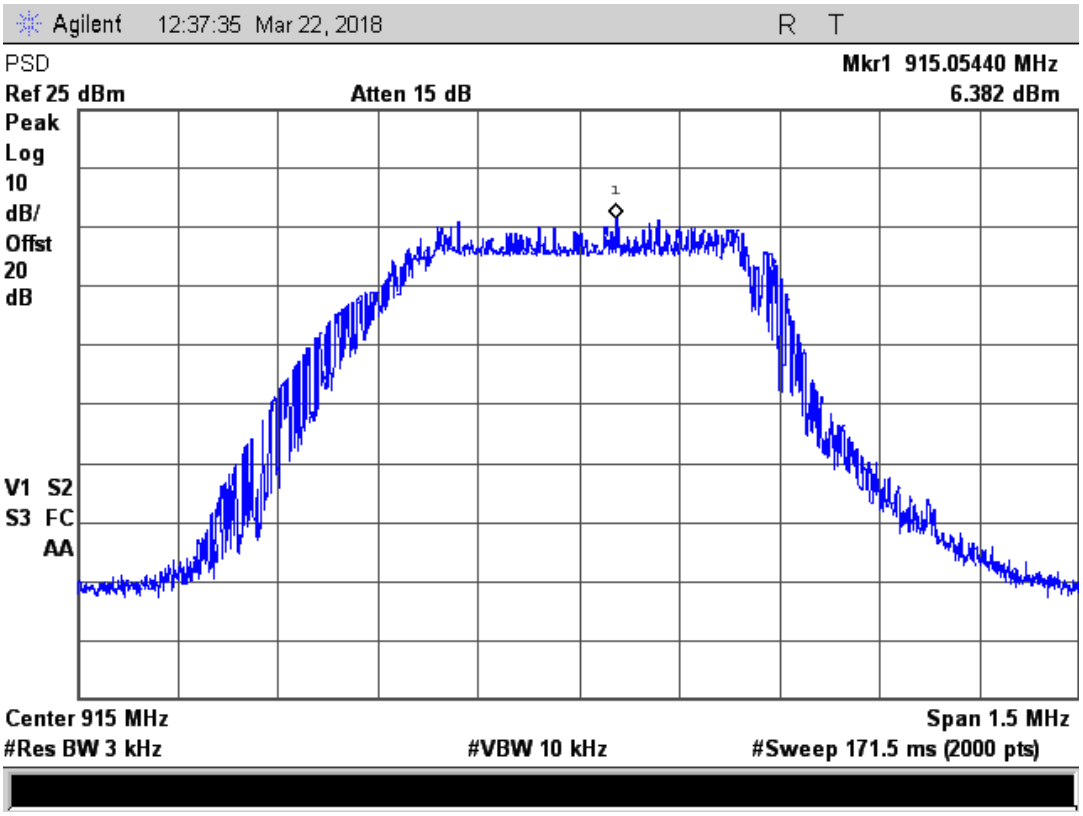
Span = 1.5 MHz; RBW = 3 kHz; VBW = 10 kHz; Power averaging

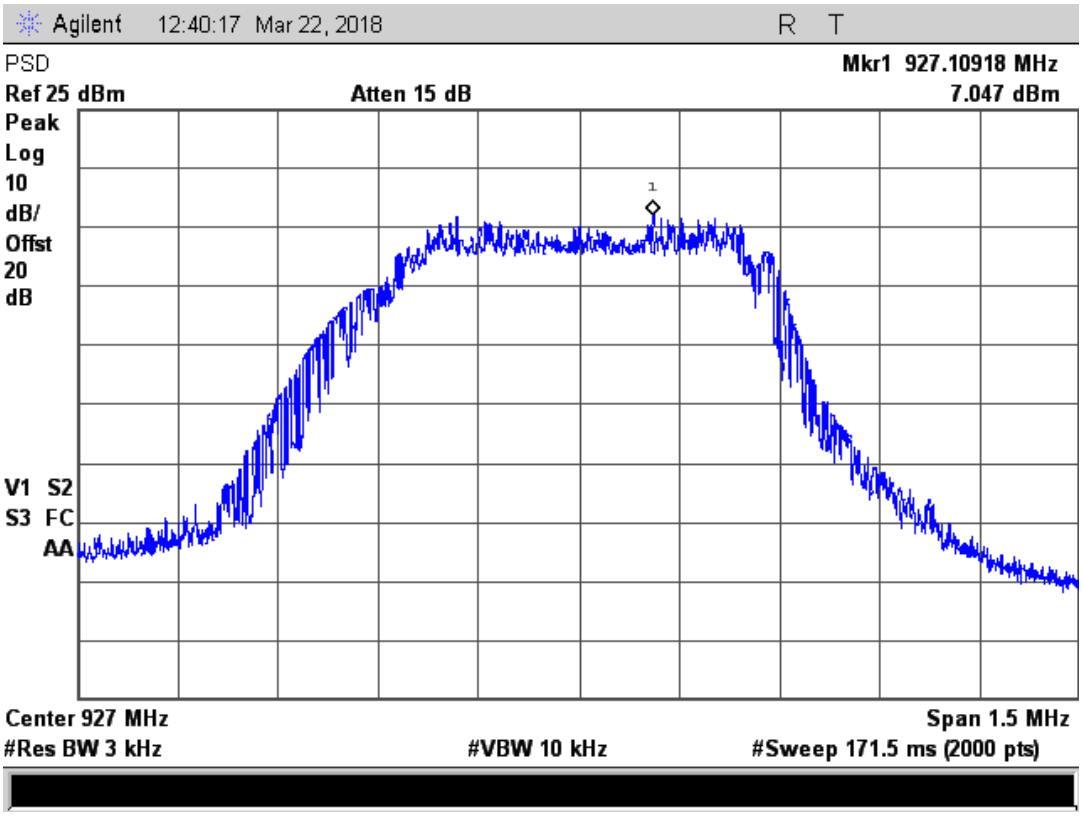
Tested by: Joseph Strzelecki
Test Date: March 22, 2018
Equipment used: REC-11

Frequency (MHz)	Reading dBm	Cable Loss (dB)	3 kHz Spectral Density (dBm)	Limit (dBm)
903	7.3	0.2	7.5	8.0
915	6.4	0.2	6.6	8.0
927	7.0	0.2	7.2	8.0

Judgment: Passed by 0.5 dB




Agilent 12:37:35 Mar 22, 2018
R T
PSD
Mkr1 915.05440 MHz
Ref 25 dBm
Atten 15 dB
6.382 dBm
Peak
Log
10
dB/
Offst
20
dB
V1 S2
S3 FC
AA
Center 915 MHz
Span 1.5 MHz
#Res BW 3 kHz
#VBW 10 kHz
#Sweep 171.5 ms (2000 pts)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R T
PSD
Mkr1 927.10918 MHz
Ref 25 dBm
Atten 15 dB
7.047 dBm
Peak
Log
10
dB/
Offst
20
dB
V1 S2
S3 FC
AA
Center 927 MHz
Span 1.5 MHz
#Res BW 3 kHz
#VBW 10 kHz
#Sweep 171.5 ms (2000 pts)

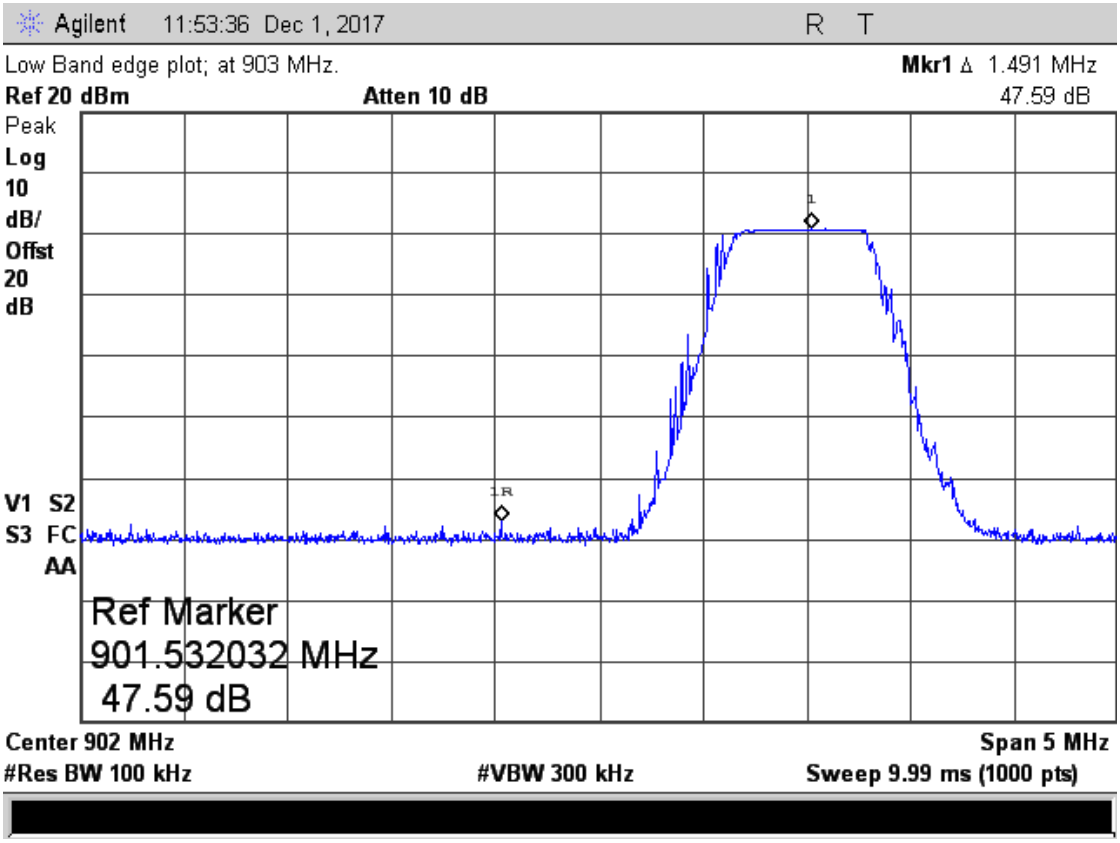
11.5 Band-edge Compliance of RF Conducted Emissions

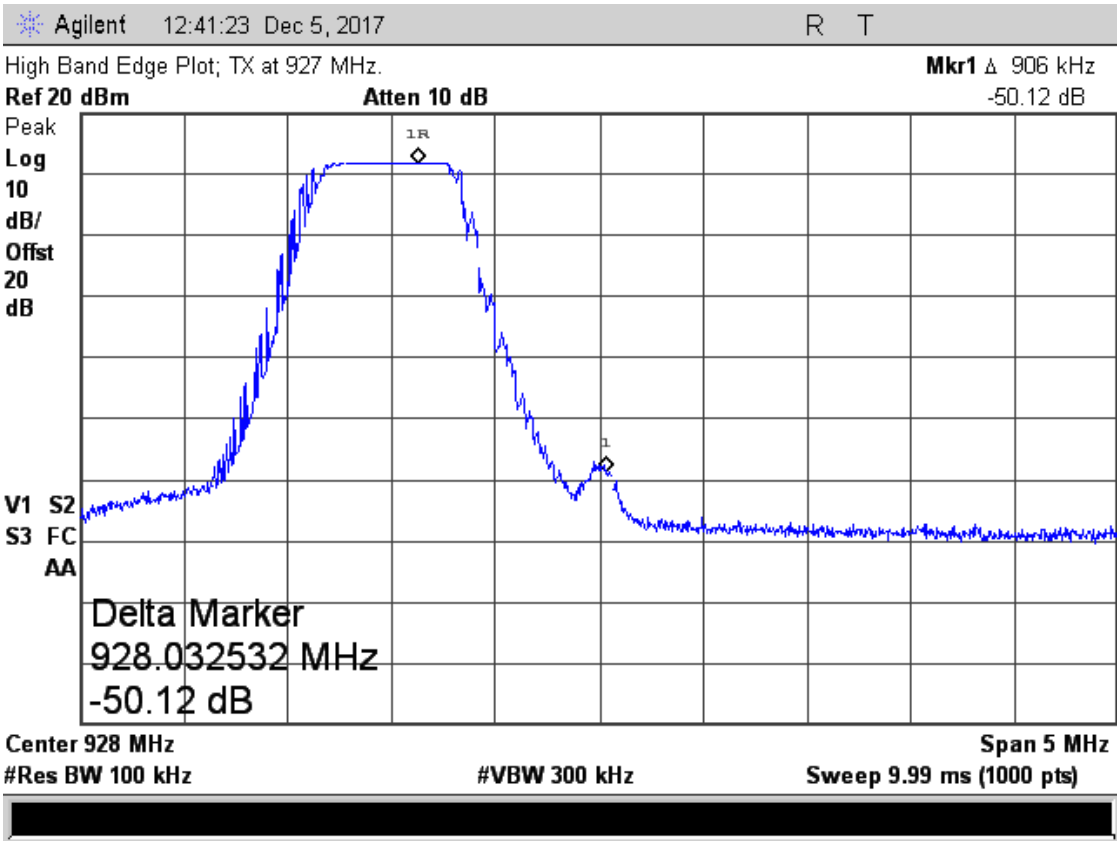
The spectrum analyzer was set to the MAX HOLD mode to record the worst case of the modulation at the band-edge, with the EUT set to the lowest frequency. The trace was allowed to stabilize.

Tested by: Joseph Strzelecki/ Richard Tichgelaar
Test Date: December 1, 2017
Equipment used: REC-21

Channel	Reading at Band Edge		Minimum Allowed
	Freq. (MHz)	Delta (dB)	dB
903 Lower Band edge	901.53	47.6	20
927 Upper Band edge	928.03	50.1	20

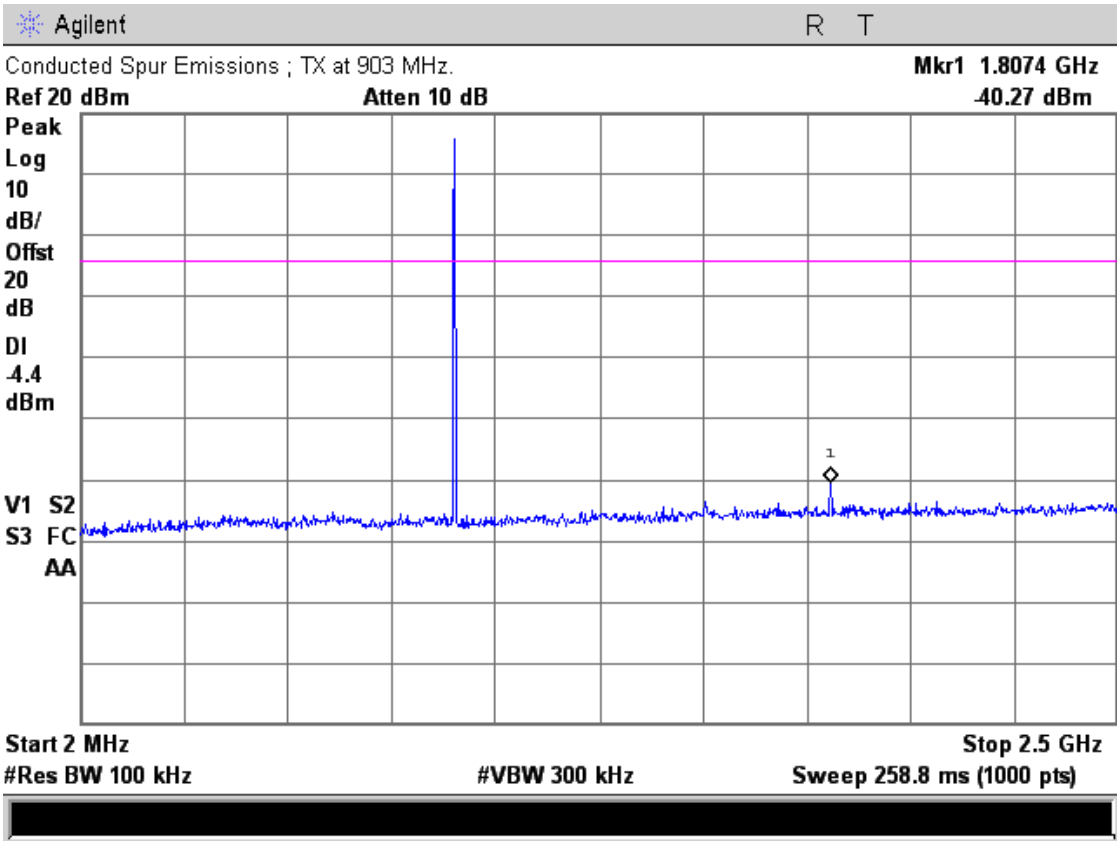
Judgment: Passed by 20.6 dB

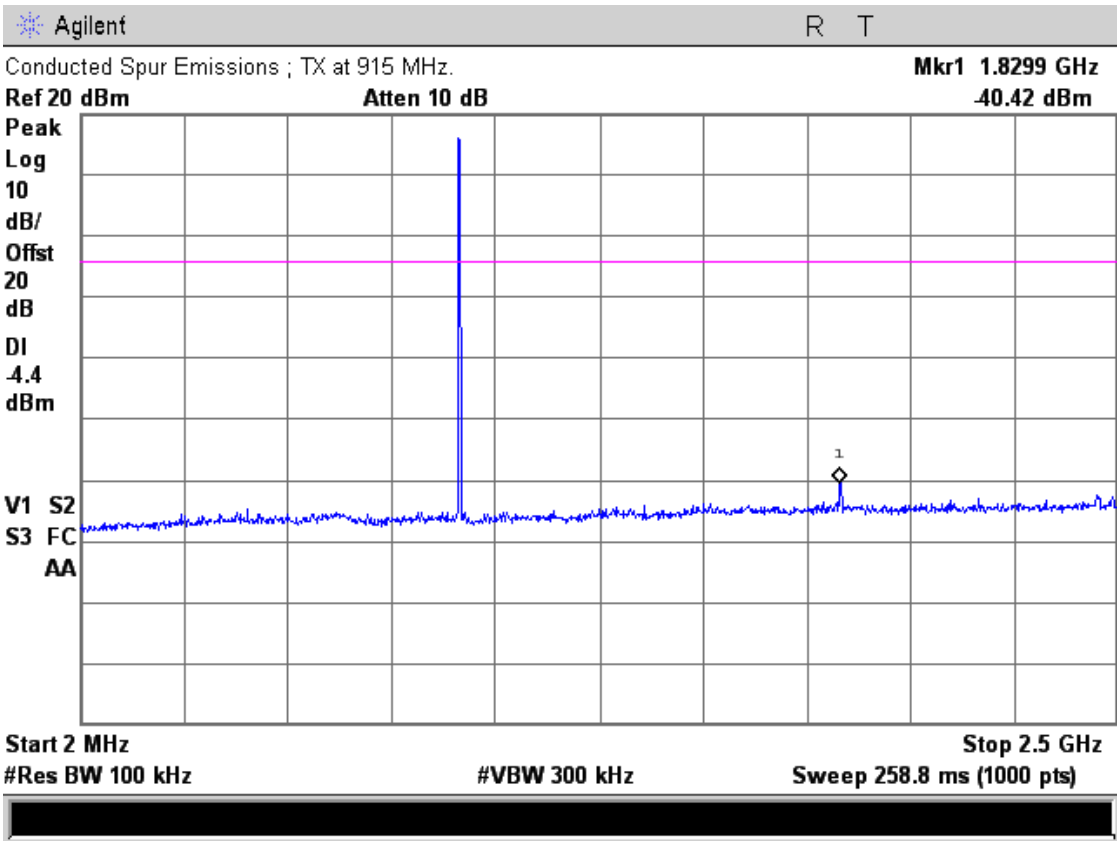


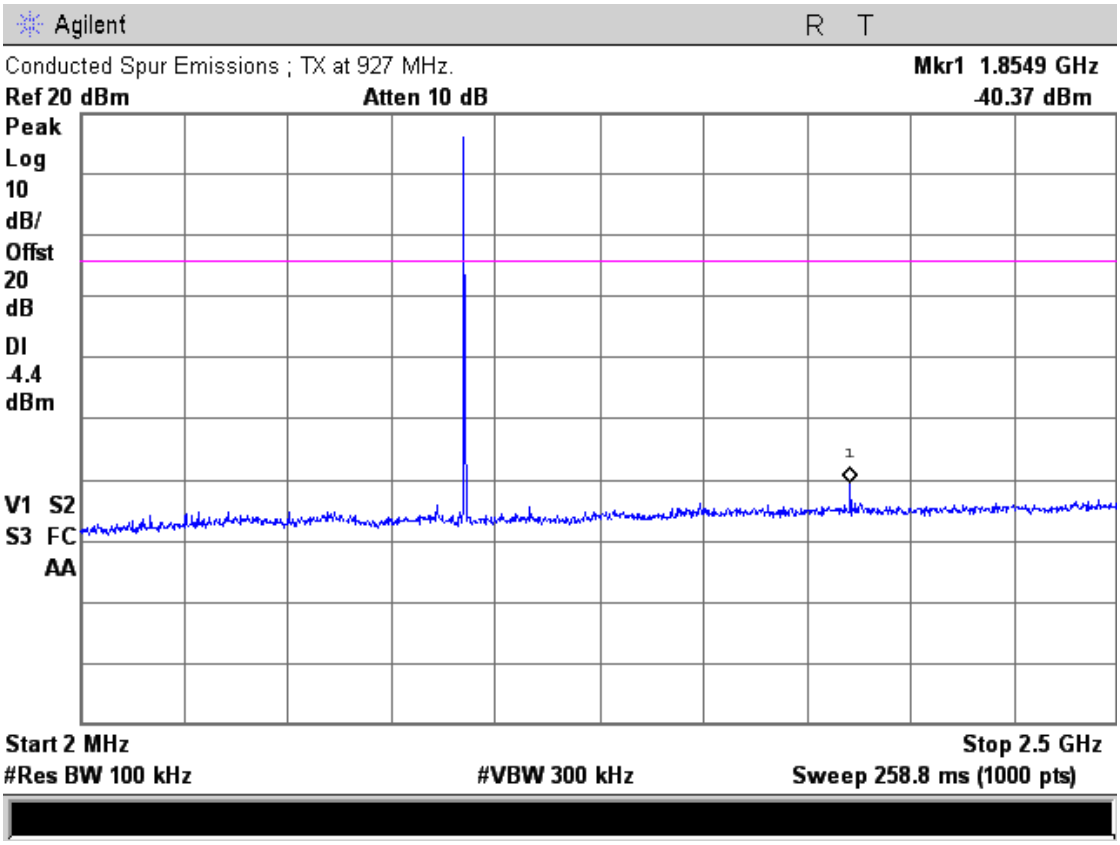


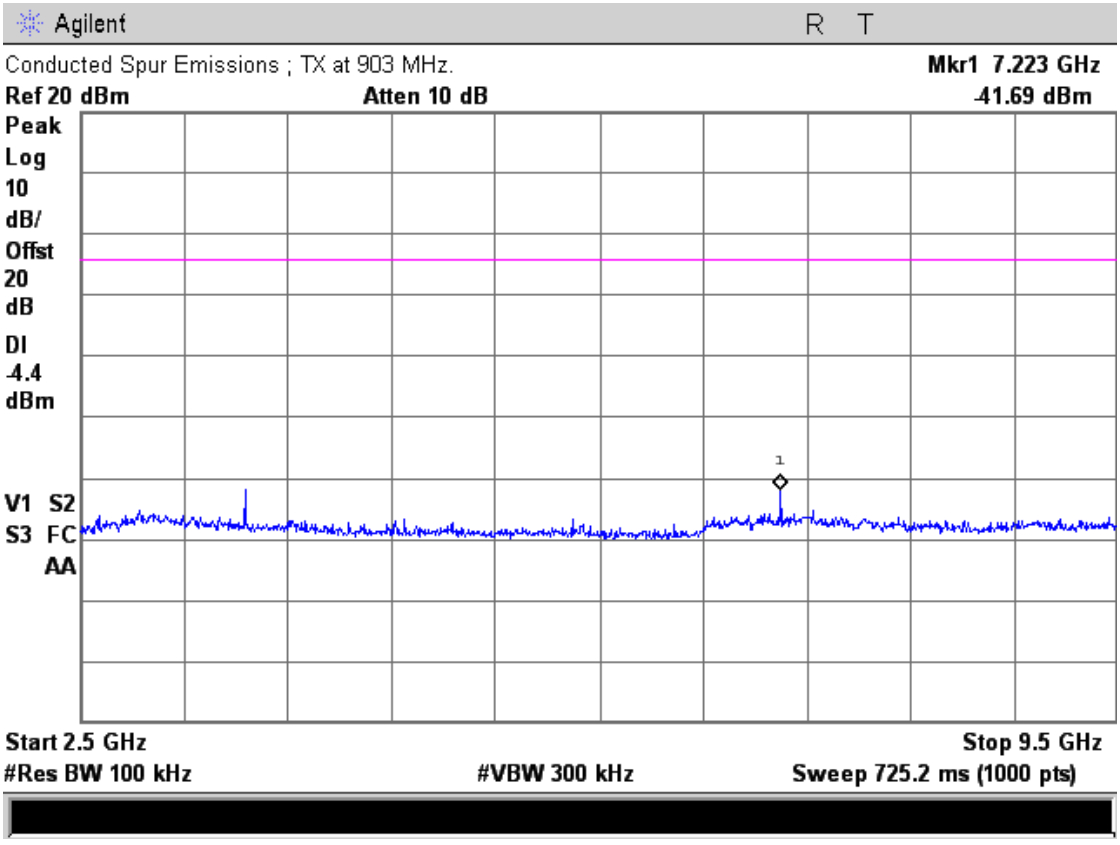
11.6 Spurious RF Conducted Emissions at Antenna Port

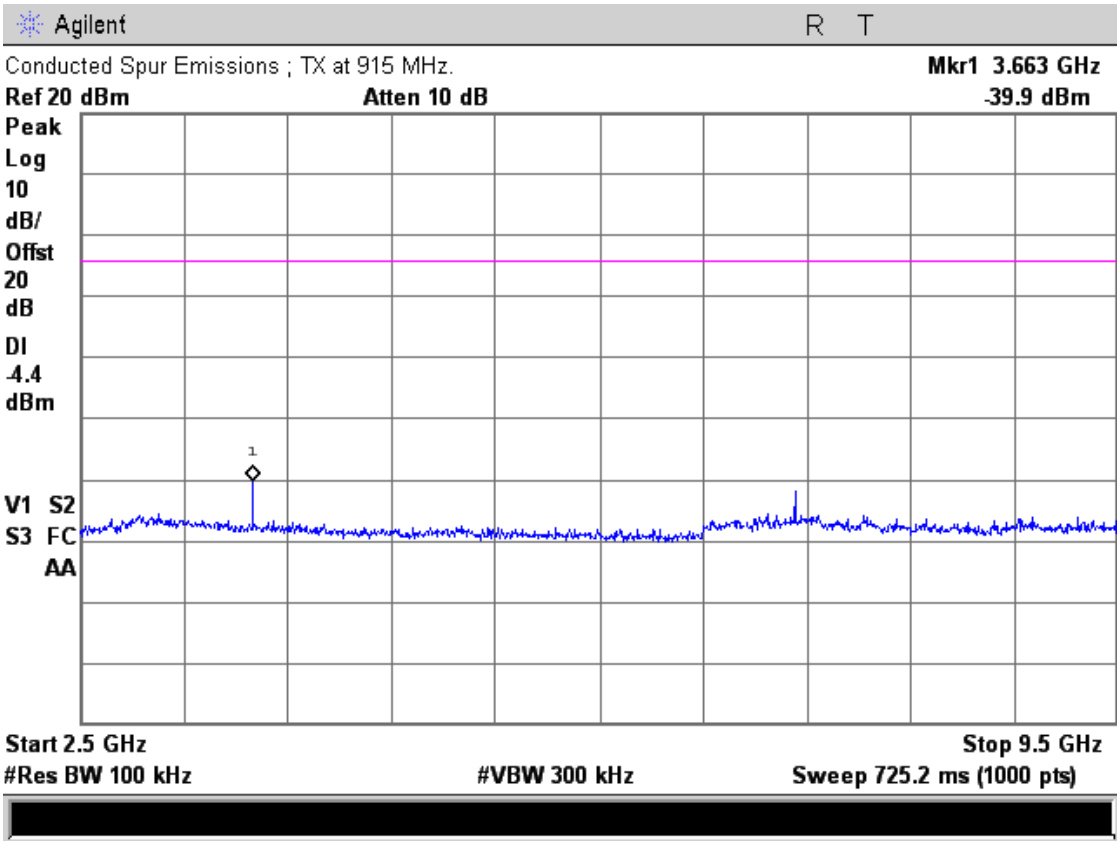
The spectrum analyzer was set to the MAX HOLD mode to record all spurious emissions from the lowest frequency generated in the EUT up through the 10th harmonic. The trace was allowed to stabilize. The first two plots were made while stepping through three frequencies (Low middle and high). Each frequency was on for 30 seconds. The red dislplay line was set to 20 dB below the level of the fundamental.

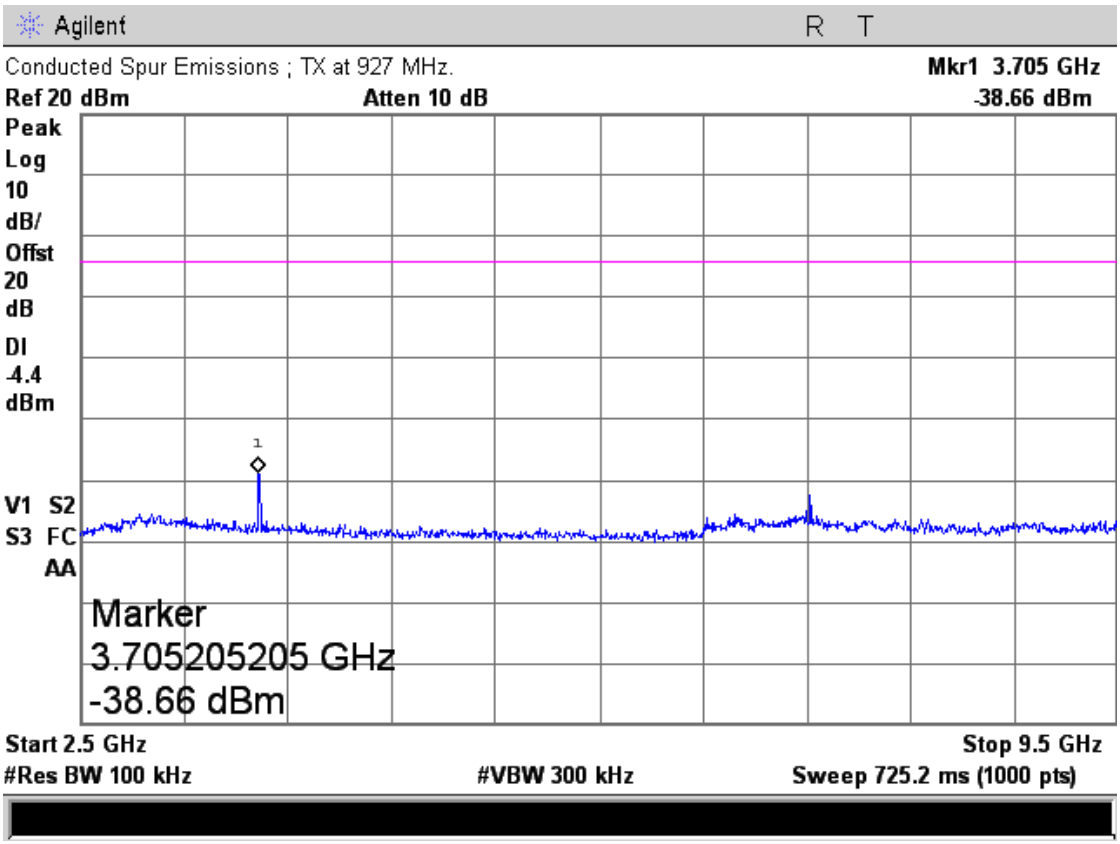

Agilent
R T
Conducted Spur Emissions ; TX at 903 MHz.
Mkr1 1.8074 GHz
Ref 20 dBm
Atten 10 dB
-40.27 dBm
Peak
Log
10
dB/
Offst
20
dB
Dl
-4.4
dBm
V1 S2
S3 FC
AA
Start 2 MHz
Stop 2.5 GHz
#Res BW 100 kHz
#VBW 300 kHz
Sweep 258.8 ms (1000 pts)


Agilent
R T
Conducted Spur Emissions ; TX at 915 MHz.
Mkr1 1.8299 GHz
Ref 20 dBm
Atten 10 dB
-40.42 dBm
Peak
Log
10
dB/
Offst
20
dB
Dl
-4.4
dBm
V1 S2
S3 FC
AA
Start 2 MHz
Stop 2.5 GHz
#Res BW 100 kHz
#VBW 300 kHz
Sweep 258.8 ms (1000 pts)


Agilent
R T
Conducted Spur Emissions ; TX at 927 MHz.
Mkr1 1.8549 GHz
Ref 20 dBm
Atten 10 dB
-40.37 dBm
Peak
Log
10
dB/
Offst
20
dB
Dl
-4.4
dBm
V1 S2
S3 FC
AA
Start 2 MHz
Stop 2.5 GHz
#Res BW 100 kHz
#VBW 300 kHz
Sweep 258.8 ms (1000 pts)


Agilent
R T
Conducted Spur Emissions ; TX at 903 MHz.
Mkr1 7.223 GHz
Ref 20 dBm
Atten 10 dB
-41.69 dBm
Peak
Log
10
dB/
Offst
20
dB
Dl
-4.4
dBm
V1 S2
S3 FC
AA
Start 2.5 GHz
Stop 9.5 GHz
#Res BW 100 kHz
#VBW 300 kHz
Sweep 725.2 ms (1000 pts)





Judgement: Pass by at least 10 dB

11.7 Spurious Radiated Emissions (Restricted Band)

The procedures were in accordance to FCC DTS Measurement Guideline 558074 D01, Section 12.1 and ANSI C63.10.

Radiated emission measurements were performed with linearly polarized broadband antennas. The results obtained with these antennas can be correlated with results obtained with a tuned dipole antenna. The radiated emission measurements were performed with a spectrum analyzer. The bandwidth used from 150 kHz to 30 MHz is 9 or 10 kHz and the bandwidth from 30 MHz to 1000 MHz is 100 or 120 kHz. Above 1 GHz, a 1 MHz bandwidth is used. A 10 dB linearity check is performed prior to start of testing in order to determine if an overload condition exists. Figure 4 herein lists the details of the test equipment used during radiated emissions tests.

For tests from 1 to 10 GHz, a high pass filter was used to reduce the fundamental emission. High pass filters were not needed above 10 GHz, since the preamplifiers attenuated the fundamental emission. Figure 4 herein lists the details of the test equipment used during radiated emissions tests.

Final radiated emissions measurements were performed inside of an anechoic chamber at a test distance of 3 meters. The anechoic chamber is designated as Chamber E. This Chamber meets the Site Attenuation requirements of ANSI C63.4. Chamber E is located at 12 East Devonwood Ave. Romeoville, Illinois EMI test lab.

The entire frequency range from 30 to 9500 MHz was slowly scanned with particular attention paid to those frequency ranges which appeared high. Measurements were performed using two antenna polarizations, (vertical and horizontal). The worst case emissions were recorded. All measurements may be performed using either the peak, average or quasi-peak detector functions. If the peak detector data exceeds or is marginally close to the limits, the measurements are repeated using a quasi-peak detector or average function as required by the specification for final determination of compliance.

The detected emission levels were maximized by rotating the EUT, adjusting the positions of all cables, and by scanning the measurement antenna from 1 to 4 meters above the ground.

11.7.1 Radiated Emissions Field Strength Sample Calculation

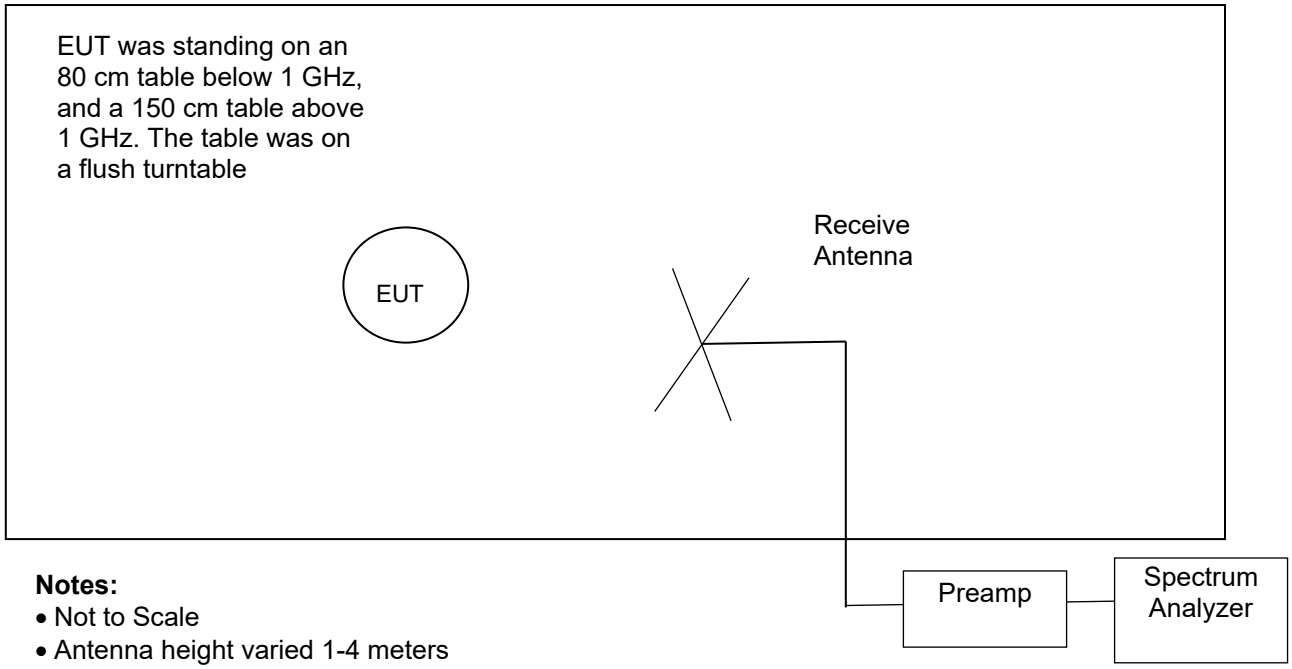
The field strength is calculated by adding the Antenna Factor and Cable Loss, and by subtracting the Amplifier Gain from the measured reading. The basic equation is as follows:

FS = RA + AF + CF - AG

Where: FS = Field Strength
RA = Receiver Amplitude
AF = Antenna Factor
CF = Cable Attenuation Factor
AG = Amplifier Gain
HPF = High pass Filter Loss

Figure 2. Drawing of Radiated Emissions Setup

Chamber E, anechoic



Notes:
- Not to Scale
- Antenna height varied 1-4 meters
- Distance from antenna to tested system is 3 meters
- AC cords not shown. They are connected to AC outlet with low-pass filter on turntable

Frequency Range	Receive Antenna	Pre-Amplifier	Spectrum Analyzer	High Pass Filter
30 to 200 MHz	ANT-04	Internal	REC-21	None*
200 to 1000 MHz	ANT-07	Internal	REC-21	None*
1 to 10 GHz	ANT-66	AMP-05	REC-21	HPF-07

* A high pass filter is not needed since the fundamental frequency was outside of the amplifiers pass band.

11.7.2 Spurious Radiated Emissions Test Results (Restricted Band)

The following spectrum analyzer settings were used.

Span = wide enough to fully capture the emission being measured
RBW = 1 MHz for f ≥ 1 GHz, 100 kHz for f < 1 GHz
VBW ≥ RBW
Sweep = auto
Detector function = peak
Trace = max hold

A Video Bandwidth of 10 Hz was used for Average measurements above 1 GHz.

Manufacturer	Fybr, LLC	Specification	FCC Part 15 Subpart C & RSS-210
Model	FY5004, FybrLink	Test Date	12/1 to 12/4/2017 and 02/07/18
Serial Number	None	Test Distance	3 Meters
Abbreviations	Pol = Antenna Polarization; V = Vertical; H = Horizontal; P = peak; Q = QP		
Configuration	Biconical (ANT-04, 30-200 MHz) Log-Periodic (ANT-07; 200-1000 MHz); Horn (ANT-66; 1-10 GHz) REC-21		

Emissions below 1 GHz

Freq. MHz	Meter Reading dBuV	Dect.	Ant. Pol.	Ant Factor dB/m	Cable Loss dB	Dist Fact dB	EUT dBuV/m	Limit dBuV/m	Margin Under Limit dB
30.0	7.0	P	H	11.1	0.5	0.0	18.6	40.0	21.4
34.7	9.2	P	H	11.5	0.5	0.0	21.2	40.0	18.8
42.5	14.5	P	H	12.0	0.5	0.0	27.0	40.0	13.0
46.8	13.3	P	H	11.8	0.6	0.0	25.7	40.0	14.3
50.6	10.4	P	H	11.3	0.6	0.0	22.2	40.0	17.8
82.0	13.4	P	H	7.4	0.8	0.0	21.6	40.0	18.4
122.0	9.9	P	H	12.3	0.9	0.0	23.1	43.5	20.4
136.2	10.0	P	H	11.6	1.0	0.0	22.6	43.5	20.9
165.4	10.2	P	H	15.6	1.1	0.0	26.9	43.5	16.6
200.7	8.4	P	H	16.3	1.2	0.0	25.9	43.5	17.6
304.9	10.6	P	H	15.3	1.5	0.0	27.3	46.0	18.7
388.8	10.9	P	H	15.2	1.7	0.0	27.8	46.0	18.2
472.6	10.5	P	H	17.9	1.9	0.0	30.2	46.0	15.8
496.7	11.2	P	H	18.3	1.9	0.0	31.4	46.0	14.6
560.0	10.2	P	H	18.7	2.0	0.0	31.0	46.0	15.0
728.8	8.2	P	H	21.7	2.3	0.0	32.3	46.0	13.7
778.8	9.1	P	H	20.6	2.4	0.0	32.2	46.0	13.8
842.5	9.7	P	H	21.1	2.5	0.0	33.4	46.0	12.6
933.8	9.2	P	H	23.5	2.7	0.0	35.3	46.0	10.7
1000.0	9.7	P	H	22.8	2.8	0.0	35.3	54.0	18.7
30.0	7.3	P	V	11.1	0.5	0.0	18.9	40.0	21.1
44.2	11.3	P	V	12.0	0.5	0.0	23.8	40.0	16.2
56.7	10.7	P	V	10.0	0.6	0.0	21.4	40.0	18.6
66.6	10.5	P	V	7.5	0.7	0.0	18.7	40.0	21.3
83.8	10.8	P	V	8.0	0.8	0.0	19.6	40.0	20.4
87.2	13.7	P	V	9.0	0.8	0.0	23.5	40.0	16.5
115.1	8.7	P	V	12.5	0.9	0.0	22.1	43.5	21.4
148.7	8.5	P	V	13.0	1.0	0.0	22.5	43.5	21.0
180.9	9.4	P	V	17.0	1.1	0.0	27.6	43.5	15.9
202.0	9.1	P	V	16.2	1.2	0.0	26.4	43.5	17.1
212.8	8.6	P	V	10.8	1.2	0.0	20.6	43.5	22.9
293.6	9.2	P	V	14.4	1.4	0.0	25.0	46.0	21.0
353.3	9.5	P	V	14.3	1.6	0.0	25.4	46.0	20.6
369.9	11.3	P	V	14.6	1.6	0.0	27.5	46.0	18.5
415.9	9.8	P	V	15.9	1.7	0.0	27.4	46.0	18.6
459.0	10.0	P	V	16.9	1.8	0.0	28.7	46.0	17.3
502.0	10.5	P	V	18.8	1.9	0.0	31.2	46.0	14.8
518.8	7.6	P	V	17.4	1.9	0.0	26.9	46.0	19.1
536.3	9.9	P	V	17.3	2.0	0.0	29.2	46.0	16.8
597.5	10.0	P	V	18.4	2.1	0.0	30.5	46.0	15.5
673.8	9.8	P	V	20.4	2.3	0.0	32.5	46.0	13.5
743.8	10.4	P	V	20.5	2.4	0.0	33.3	46.0	12.7
820.0	8.5	P	V	21.3	2.6	0.0	32.4	46.0	13.6
890.0	10.7	P	V	22.3	2.6	0.0	35.6	46.0	10.4
983.8	10.0	P	V	22.8	2.7	0.0	35.6	54.0	18.4

Restricted band Emissions above 1 GHz

Configuration	REC-21

		Spectrum Analyzer Readings									EUT	Peak	Ave	Peak	Ave	Margin
hrm	Tx	Peak			Ave	Peak			Ave	Corr.	Emission	Tot. FS		Limit		Under
#	Freq MHz	Vertical Polarization				Horizontal Polarization				Fact. dB	Freq MHz	dBuV/m		dBuV/m		Limit dB
		X	Y	Z	Max	X	Y	Z	Max							
3	903	49.1	51.7	49.0	45.7	47.9	46.8	49.5	43.5	-4.6	2709.0	47.1	41.1	74	54	12.9
4	903	43.5	45.5	44.7	38.5	46.9	44.5	49.1	43.1	0.6	3612.0	49.7	43.7	74	54	10.3
5	903	40.2	42.1	40.4	35.1	40.6	42.2	42.6	36.6	3.4	4515.0	46.0	40.0	74	54	14.0
6	903	38.1	41.1	39.5	34.1	39.1	39.4	39.9	33.9	6.2	5418.0	47.3	40.3	74	54	13.7
8	903	43.1	44.2	45.9	35.9	44.6	45.6	46.4	37.4	11.5	7224.0	57.9	48.9	74	54	5.1
9	903	38.0	38.2	40.1	29.1	38.1	39.6	39.9	31.9	12.2	8127.0	52.3	44.1	74	54	9.9
10	903	37.1	37.8	37.4	26.8	38.0	39.5	39.2	30.5	15.3	9030.0	54.8	45.8	74	54	8.2
3	915	46.0	47.7	47.1	41.7	45.7	48.2	49.3	43.3	-2.2	2745.0	47.1	41.1	74	54	12.9
4	915	42.8	48.3	47.1	42.3	49.7	46.9	46.2	43.7	4.1	3660.0	53.8	47.8	74	54	6.2
5	915	33.8	39.8	42.2	36.2	42.4	42.1	42.3	36.4	6.8	4575.0	49.2	43.2	74	54	10.8
8	915	41.6	44.7	45.2	37.2	39.5	44.5	43.9	36.5	11.2	7320.0	56.4	48.4	74	54	5.6
9	915	38.5	40.5	38.7	34.5	38.2	37.8	40.3	34.3	12.4	8235.0	52.9	46.9	74	54	7.1
10	915	37.6	38.8	37.0	30.8	37.9	37.0	37.4	30.9	14.6	9150.0	53.4	45.5	74	54	8.5
3	927	52.8	54.4	52.9	48.4	52.1	53.0	53.8	47.8	-4.4	2781.0	50.0	44.0	74	54	10.0
4	927	45.2	48.8	43.8	42.8	47.6	49.5	50.9	44.9	0.9	3708.0	51.8	45.8	74	54	8.2
5	927	38.1	39.8	38.8	33.8	40.0	40.7	41.3	35.3	4.2	4635.0	45.5	39.5	74	54	14.5
8	927	43.4	42.7	42.9	37.4	43.4	45.2	48.2	38.3	10.6	7416.0	58.8	48.9	74	54	5.1
9	927	38.6	39.2	39.5	33.5	38.4	39.7	40.4	32.4	12.7	8343.0	53.1	46.2	74	54	7.8
Column numbers (see below for explanations)																
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

Judgment: Passed by 5.1 dB
No other emissions were detected from 1 to 9.5 GHz.

Column #1. hrm = Harmonic; BE = Band Edge emissions
Column #2. Frequency of Transmitter.
Column #3. Uncorrected readings from the spectrum analyzer with First Axis Rotation.
Column #4. Uncorrected readings from the spectrum analyzer with Second Axis Rotation.
Column #5. Uncorrected readings from the spectrum analyzer with Third Axis Rotation.
Column #6. Average Reading based on peak reading reduced by the Duty cycle correction
Column #7. Uncorrected readings from the spectrum analyzer with First Axis Rotation.
Column #8. Uncorrected readings from the spectrum analyzer with Second Axis Rotation.
Column #9. Uncorrected readings from the spectrum analyzer with Third Axis Rotation.
Column #10. Average Reading based on peak reading reduced by the Duty cycle correction
Column #11. Corr. Factors = Cable Loss – Preamp Gain + Antenna Factor
Column #12. Frequency of Tested Emission
Column #13. Highest peak field strength at listed frequency.
Column #14. Highest Average field strength at listed frequency.
Column #15. Peak Limit.
Column #16. Average Limit.
Column #17. The margin (last column) is the worst case margin under the peak or average limits for that row.

11.8 Unintentional Emissions (Receive Mode)

Manufacturer	Fybr, LLC	Specification	FCC Part 15.209 & RSS-GEN
Model	FY5004, FybrLink	Test Date	12/04/2017
Serial Number	None	Test Distance	3 Meters
Abbreviations	Pol = Antenna Polarization; V = Vertical; H = Horizontal; P = peak; Q = QP		
Configuration	Receive mode		

Freq. MHz	Meter Reading dBuV	Dect. Type	Antenna		Cable Loss Factors dB	Field Strength dBuV/m		Margin Under Limit dB
			Factor dB	Polarity		EUT	Limit	
30.0	7.7	P	H	11.1	0.5	19.3	40.0	20.7
34.3	8.3	P	H	11.4	0.5	20.2	40.0	19.8
41.2	10.4	P	H	12.0	0.5	22.9	40.0	17.1
44.2	16.0	P	H	12.0	0.5	28.6	40.0	11.4
45.9	12.9	P	H	11.9	0.6	25.3	40.0	14.7
54.9	7.7	P	H	10.4	0.6	18.7	40.0	21.3
58.0	13.4	P	H	9.6	0.6	23.6	40.0	16.4
82.5	8.6	P	H	7.6	0.8	16.9	40.0	23.1
121.2	8.2	P	H	12.3	0.9	21.4	43.5	22.1
148.7	10.1	P	H	13.0	1.0	24.1	43.5	19.4
175.3	8.7	P	H	16.6	1.1	26.4	43.5	17.1
199.9	8.7	P	H	16.4	1.2	26.3	43.5	17.2
211.3	7.7	P	H	10.9	1.2	19.8	43.5	23.7
311.7	9.2	P	H	14.6	1.5	25.3	46.0	20.7
358.5	10.2	P	H	14.5	1.6	26.3	46.0	19.7
394.0	11.0	P	H	15.0	1.7	27.7	46.0	18.3
452.9	10.4	P	H	16.7	1.8	28.9	46.0	17.1
500.0	7.5	P	H	18.8	1.9	28.2	46.0	17.8
502.0	10.3	P	H	18.8	1.9	31.1	46.0	14.9
633.8	10.2	P	H	19.6	2.2	31.9	46.0	14.1
655.0	10.9	P	H	20.2	2.2	33.4	46.0	12.6
806.3	10.4	P	H	20.8	2.6	33.8	46.0	12.2

Freq. MHz	Meter Reading dBuV	Dect. Type	Antenna Factor dB	Antenna Polarity	Cable Loss Factors dB	Field Strength dBuV/m EUT	Field Strength dBuV/m Limit	Margin Under Limit dB
891.3	10.0	P	H	22.3	2.6	34.9	46.0	11.1
1000.0	8.8	P	H	22.8	2.8	34.4	54.0	19.6
30.0	7.6	P	V	11.1	0.5	19.2	40.0	20.8
42.5	11.5	P	V	12.0	0.5	24.1	40.0	15.9
71.7	10.9	P	V	6.5	0.7	18.1	40.0	21.9
84.6	11.5	P	V	8.3	0.8	20.5	40.0	19.5
87.2	13.3	P	V	9.0	0.8	23.1	40.0	16.9
147.4	9.5	P	V	12.7	1.0	23.2	43.5	20.3
179.2	8.3	P	V	16.9	1.1	26.3	43.5	17.2
184.4	10.3	P	V	17.2	1.1	28.6	43.5	14.9
191.3	10.8	P	V	17.0	1.1	29.0	43.5	14.5
202.0	8.4	P	V	16.2	1.2	25.8	43.5	17.7
203.0	7.6	P	V	11.2	1.2	20.0	43.5	23.5
238.5	8.4	P	V	11.0	1.3	20.7	46.0	25.3
304.9	9.2	P	V	15.3	1.5	26.0	46.0	20.0
335.1	10.2	P	V	14.3	1.5	26.0	46.0	20.0
382.7	9.8	P	V	15.4	1.7	26.8	46.0	19.2
426.5	10.9	P	V	16.1	1.8	28.8	46.0	17.2
452.9	11.7	P	V	16.7	1.8	30.2	46.0	15.8
502.0	10.3	P	V	18.8	1.9	31.0	46.0	15.0
510.0	8.0	P	V	18.3	1.9	28.2	46.0	17.8
611.3	9.6	P	V	18.9	2.1	30.7	46.0	15.3
770.0	8.5	P	V	21.6	2.4	32.5	46.0	13.5
868.8	9.6	P	V	22.9	2.6	35.1	46.0	10.9

Judgment: Passed by 11.1 dB.

No other emissions were detected from 1 to 5 GHz within 10 dB of the limits.

11.8.1 Measurement Instrumentation Uncertainty

Measurement	Uncertainty
Conducted Emissions, LISN method, 150 kHz to 30 MHz	2.7 dB
Radiated Emissions, E-field, 3 meters, 30 to 200 MHz	3.3 dB
Radiated Emissions, E-field, 3 meters, 200 to 1000 MHz	4.9 dB
Radiated Emissions, E-field, 3 meters, 1 to 18 GHz	4.8 dB
Bandwidth using marker delta method at a span of 10 MHz	4 kHz
99% Occupied Bandwidth using REC-43	1% of frequency span
Conducted power REC-11/21 at 915 MHz	0.8 dB
Amplitude measurement 1-10,000 MHz; REC-21	1.5 dB
Temperature THM-02	0.6 Deg C

The uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k=2 in accordance with CISPR 16-4-2.