Testing Tomorrow's Technology

Application for

US Code Title 47, Part 2, Subpart J, Section 2.947, Certification
Per
Part 15, Subpart C, for Intentional Radiators, Section 15.249, Intentional Radiator Operating within the Band 2400 MHz to 2483.5 MHz.

And

US Code Title 47, Part 2, Subpart J, Section 2.902, Verification
Per
Part 15, Subpart B, for Unintentional Radiators, section 15.101, 15.107 and 15.109

For the

Estimote

Model: Rev.D3.3

Manufactured by

Estimote Polska sp. z o.o

UST Project: 14-0010
Test Date(s): January 27, 2014 and February 6, 2014
Issue Date: February 12, 2014

3505 Francis Circle Alpharetta, GA 30004
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I certify that I am authorized to sign for the test facility and that all of the statements in this report and in the Exhibits attached hereto are true and correct to the best of my knowledge and belief:

US TECH (Agent Responsible For Test):

By: 

Name: Alan Ghasiani

Title: Consulting Engineer - President

Date: February 12, 2014

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MEASUREMENT/TECHNICAL REPORT

COMPANY NAME: Estimote Polska sp. z o.o

MODEL(S): ESTIMOTE REV.D3.3
FCC ID: 2ABP2-EST0114
IC ID: 11753A-EST0114

DATE: February 12, 2014

This report concerns (check one): Original grant X
Class II change_____

Equipment type: Intentional Radiator Operating within the bands 2400-2483.5 MHz

Deferred grant requested per 47 CFR 0.457(d) (1) (ii)? yes_____ No X

If yes, defer until:_____
date

N.A. agrees to notify the Commission by N.A.
date
of the intended date of announcement of the product so that the grant can be issued on that date.

Report prepared by:

US Tech
3505 Francis Circle
Alpharetta, GA 30004

Phone Number: (770) 740-0717
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SUMMARY OF TEST REQUIREMENTS

FCC Requirement	Title	Disposition
15.205	Restricted Bands	Pass
15.207	Intentional Radiator Power Line Conducted Emissions	Pass
15.209	Intentional Radiator Radiated Emissions	Pass
15.249(a)	Fundamental Field Strength	Pass
15.107	Unintentional Radiator Power Line Conducted Emissions	N/A
15.109	Unintentional Radiator Radiated Emissions	Pass

N/A = Not applicable for this unit.

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1 General Information

1.1 Purpose of this Report

This report is prepared as a means of presenting test data to be used by a Telecom Certification Body in determination of whether this product is permitted for unlicensed dissemination to the general public according to the FCC Rules and Regulations for RF Devices Intentional Radiators.

1.2 Product Description

The Equipment under Test (EUT) is the Estimote model REV.D3.3 radio beacon. The EUT is an ISM band transceiver operating in the 2400-2483.5 MHz frequency band. Per 47 CFR Part 15.31(m) the EUT was evaluated at the low, middle and high channels for operation in this band. Test data for these channels is provided herein.

The EUT provides proximity information to mobile devices and features temperature and accelerometer sensors. The EUT uses Bluetooth Low Energy and is powered by a CR2450 coin cell battery.

1.3 Related Submittal(s)/Grant(s)

1.3.1 The EUT is subject to the following FCC authorizations:

a) Certification under section 15.249 as a transmitter.
b) Verification under 15.101 as a digital device and receiver.

1.3.2 Certification of the Transmitter

The EUT employs spread spectrum modulation, but is not being certified under CFR 15.247 because the field strength of the fundamental and its harmonics are within the limits specified in 47 CFR 15.249. Therefore the EUT is instead being presented under the requirements of CFR 15.249. The EUT will operate within the frequency band of 2400 MHz to 2483.5 MHz.

1.3.3 Verification of the Digital apparatus

The Verification requirement shares many common report elements with the Certification report. Therefore, though this report is mostly intended to provide data for the Certification process, the Verification authorization report (part 15.107 and 109) for the EUT is included herein.

2 Tests and Measurements

2.1 Configuration of Tested System

The sample was set up and tested per ANSI C63.4, Methods of Measurement from Low-Voltage Electrical and Electronic Equipment in the Frequency Range of 9 kHz to 40 GHz (2003). Conducted and radiated emissions data were taken with the EMC test receiver (or spectrum analyzer's) resolution bandwidth adjusted to 9 kHz and 120 kHz, respectively. All measurements are peak unless stated otherwise. The video filter associated with the spectrum analyzer was off throughout the evaluation process. A Block diagram of the tested system is shown in Figure 1. A listing of the EUT and its test peripherals is found in Table 1 below. Test configuration photographs for spurious and fundamental emissions measurements are in the attached appendices.

Figure 1. Test Configuration

Table 1 - EUT and Peripherals

PERIPHERAL MANUFACTURER	MODEL NUMBER	SERIAL NUMBER	FCC/IC ID:	CABLES P/D
Beacon device (EUT) Estimote	REV.D3.3	Engineering Sample	Pending: FCC ID: 2ABP2-EST0114 IC: 11753A-EST0114	N/A
Batteries	CR2450	None	None	N/A

S= Shielded, U=Unshielded, P= Power line, D= Data line

2.2 EUT Characterization

The sample used for testing was received by US Tech on January 23, 2014 in good operating condition.

2.3 Test Facility

Testing was performed at US Tech's measurement facility at 3505 Francis Circle, Alpharetta, GA. This site has been fully described and registered with the FCC under site designation number 186022. Additionally this site has also been fully described and submitted to Industry Canada (IC), and has been approved under file number 2982A-1.

2.4 Test Equipment

Table 2 describes test equipment used to evaluate this product.

Table 2 - Test Instruments used for Evaluation

TEST INSTRUMENT	MODEL NUMBER	MANUFACTURER	SERIAL NUMBER	DATE OF LAST CALIBRATION
SPECTRUM ANALYZER	8566B	HEWLETT-PACKARD	2410A00109	11/21/2012 Extended 90 days
SPECTRUM ANALYZER	E4407B	AGILENT	US41442935	11/19/2013
RF PREAMP	8447D	HEWLETT-PACKARD	2944A06291	03/14/2013
LOOP ANTENNA	SAS-200/562	AH Systems	142	09/12/2013 2 yrs
BICONICAL ANTENNA	3110B	EMCO	9307-1708	07/02/2012 2 yrs
LOG PERIODIC	3146	EMCO	9110-3236	06/05/2012 2 yrs
HORN ANTENNA	SAS-571	AH Systems	605	07/23/2013 2 yrs
HORN ANTENNA	3116	HEWLETT-PACKARD	9505-2255	08/09/2012 2 yrs
PREAMP	8449B	HEWLETT-PACKARD	3008A00480	03/04/2013
CALCULATION PROGRAM	N/A	N/A	Ver. 6.0	N/A

Note: The calibration interval of the above test instruments is 12 months unless stated otherwise, and all calibrations are traceable to NIST/USA.

2.5 Modifications to EUT

No modifications were made by US Tech to bring the EUT into compliance with FCC Part 15, Subpart B, Class B Limits for the receiver and digital portion of the EUT or the Subpart C, Transmitter requirements.

2.6 Measurement Standards (CFR 15.31)

Intentional and unintentional radiators are to use the methods of ANSI C63.4-2003. Measurements were made on an Open Area Test Site (OATS) wherever possible. For battery powered equipment, new (or fully charged) batteries are used. Section 15.31(m) indicates that if the EUT System operates over the 2400 MHz to 2483.5 MHz ISM band, measurements must be made near the bottom of the band (around 2400 MHz for example) and in the middle of the band (2440 MHz) as well as near the top of the band (2483.5 MHz).

2.7 Frequency Range of Radiated Measurements (CFR 15.33)

The frequency range is detailed below for intentional and unintentional radiators.

2.7.1 Frequency Range for Intentional Radiators

The spectrum was investigated from the lowest RF signal generated without going below 9 kHz to the 10^{th} harmonic of the highest fundamental transmitter frequency.

2.7.2 Frequency Range for Unintentional Radiators

The spectrum was investigated from the lowest RF signal generated without going below the lowest frequency for which an emissions limit is specified (30 MHz) to the 5^{th} harmonic of the highest fundamental frequency of the digital device (12.5 GHz maximum).

2.7.3 Measurement Detector Function and Bandwidth (CFR 15.35)

On any frequency below 1000 MHz, the limits shown are based upon measuring equipment employing a CISPR quasi-peak detector function and related measurement bandwidths. On frequencies above 1000 MHz, the radiation limits are based upon the use of measuring instrumentation employing an average detector function.

When average detector measurements are specified for use, including emission measurements below 1000 MHz, there is also a corresponding limit for Peak detector measurements having a limit of 20 dB above the corresponding average limit unless a different peak emission limit is specified. Measurements above 1000 MHz utilize a minimum resolution bandwidth of 1 MHz.

When radiated emissions limits are expressed in terms of the average value of the emission and pulsed operation is employed, the measurement field strength is determined by averaging over one complete pulse train (Duty Cycle) including blanking intervals for pulse trains up to 0.1 second in duration. The exact method of calculating the average field strength is included in paragraph 2.11 of this report. Refer to Figures 2 and 3 for duty cycle measurement data.

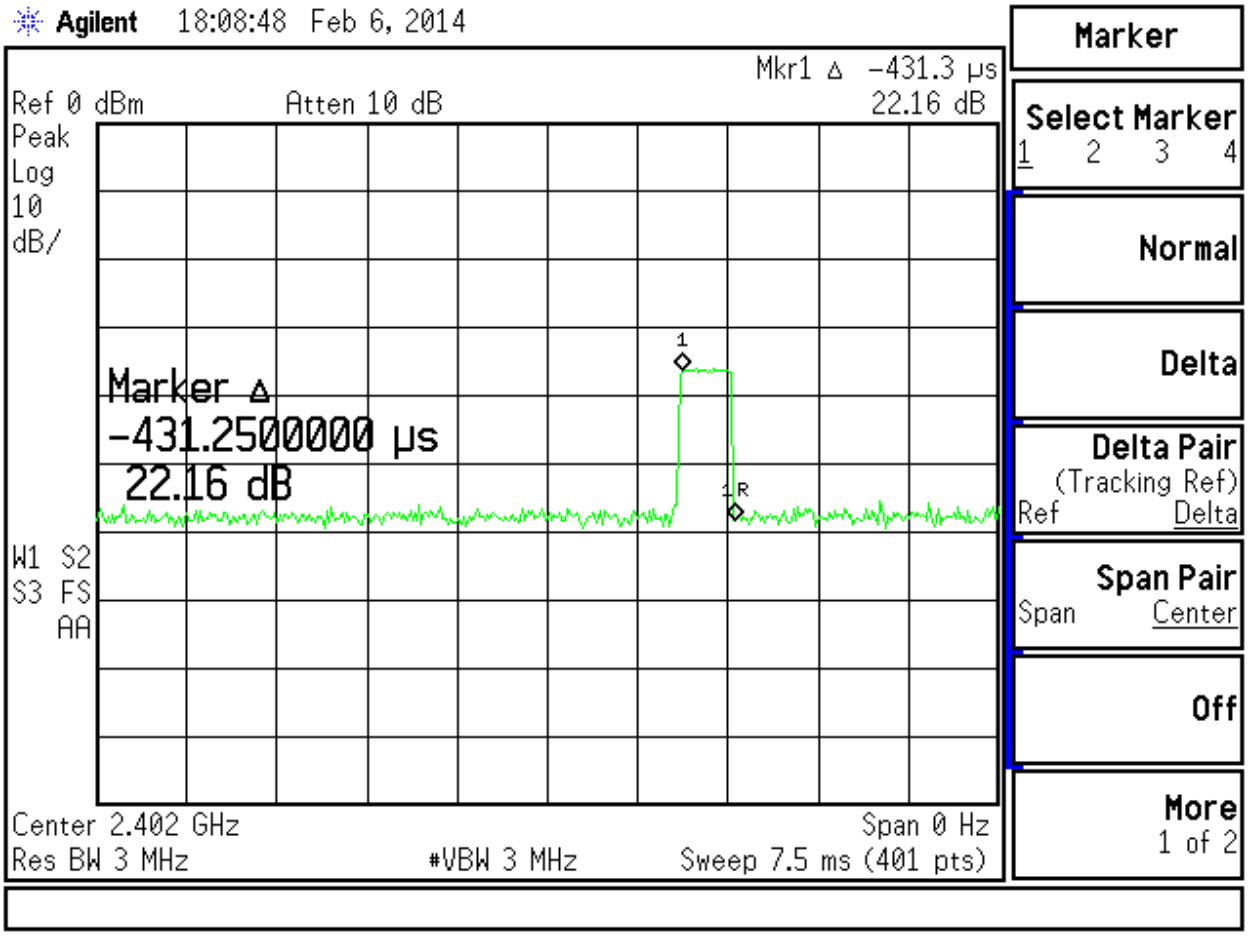

Figure 2. Transmitter Pulse Width (20ms)

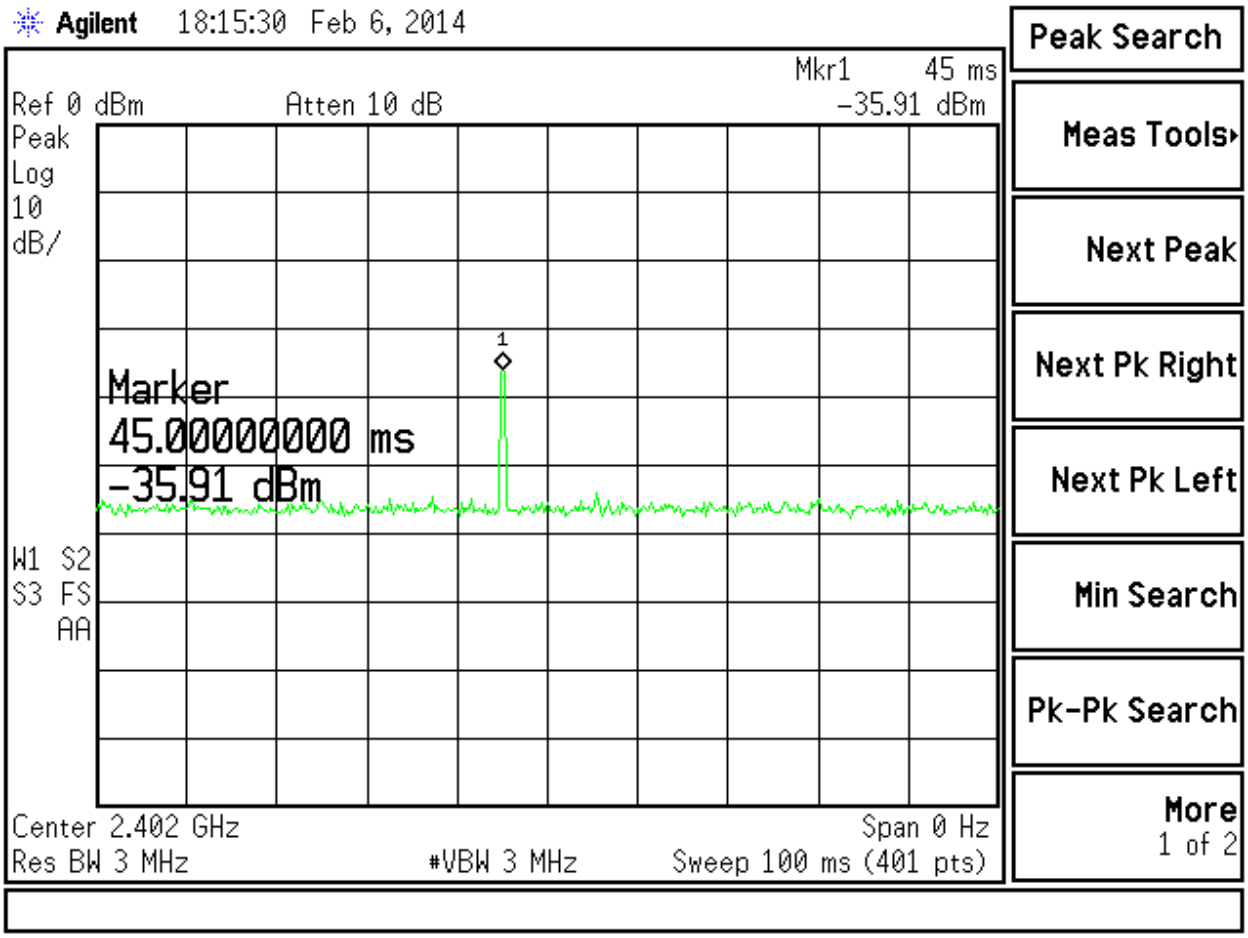

Figure 3. Transmitter Pulse Width (100ms)

(.432mS)/100mS = 0.0043 = 0.43% percent

Duty Cycle = 20 Log (0.0043) = -47.33 dB

The Duty Cycle applied in this test report is -20 dB.

2.8 Antenna Requirement (CFR 15.203)

The EUT has an internal radiator; there are no external antenna ports.

Table 3 - Allowed Antenna(s)

MANUFACTURER	TYPE OF ANTENNA	MODEL	REPORT REFERENCE	GAIN dB_i	TYPE OF CONNECTOR
Estimote	Trace Monopole	Engineering Sample	Antenna	0.0	PCB Trace Antenna

2.9 Intentional Radiator, Power Line Conducted Emissions (CFR 15.207)

The EUT requires 3.0 VDC to operate. The EUT is powered by one, CR2450 coin battery.

2.10 Intentional Radiator, Radiated Emissions (CFR 15.249 (a), (e))

The EUT was placed into a continuous transmit mode of operation. A preliminary scan was performed on the EUT to find signal frequencies that were caused by the transmitter part of the product and to obtain the worse case result the EUT tested in all X, Y and Z axis. Radiated measurements below 30 MHz were tested with a RBW = 9 kHz; emissions below 1 GHz were tested with a RBW = 120 kHz and radiated measurements above 1 GHz were measured using a RBW =1 MHz and VBW = 3 MHz.

Test data is found in Tables 4 and 5 below.

2.11 Restricted Bands of Operation (CFR 15.205)

Only radiated harmonics and other spurious signals can be permitted to fall into the restricted bands of 15.205. All signals found in paragraph 2.7 above shall be examined for this requirement. Limits are based upon the limits of paragraph 15.209. Above 1 GHz, the limits are for Average value. See Tables 4 and 5 below for peak and Average measurements. According to CFR 15.35, the peak limits can exceed the average limits by 20 dB.

Table 4 - Peak Fundamental and Harmonics, (CFR15.249 (a))

Radiated Fundamental and Harmonics Emissions								
Tested By: RN	Test: Fundamental and Harmonics CFR 15.249 (a)				Client: Estimote			
	Project: 14-0010		Class: N/A		Model: REV.D3.3			
Frequency (MHz)	**Test Data (dBuV)**	**DF+FL***	**AF+CL-PA (dB/m)**	**Corrected Results (dBuV/m)**	**Peak Limits (dBuV/m)**	**Distance / Polarity (Meters)**	**Margin (dB)**	**Det PK**
2402.00	60.16	0.0	31.88	92.04	114.0	3.0m./H	22.0	**PK**
4804.02	55.50	0.0	2.86	58.36	74.0	3.0m./H	15.6	**PK**
7206.40	51.34	0.0	10.14	61.48	74.0	3.0m./H	12.5	**PK**
9607.67	52.21	0.0	14.76	66.97	74.0	3.0m./H	7.0	**PK**
2440.30	61.21	0.0	31.98	93.19	114.0	3.0m./H	20.8	**PK**
4880.05	55.05	0.0	3.08	58.13	74.0	3.0m./H	15.9	**PK**
7316.75	51.16	0.0	11.16	62.32	74.0	3.0m./H	11.7	**PK**
9758.70	51.82	0.0	13.65	65.47	74.0	3.0m./H	8.5	**PK**
12198.72	50.77	0.0	19.79	70.56	74.0	3.0m./H	3.4	**PK**
2479.47	62.12	0.0	31.83	93.95	114.0	3.0m./H	20.0	**PK**
4959.85	58.39	0.0	2.39	60.78	74.0	3.0m./H	13.2	**PK**
7439.42	50.65	0.0	11.26	61.91	74.0	3.0m./H	12.1	**PK**
9919.42	54.79	0.0	13.35	68.14	74.0	3.0m./H	5.9	**PK**
12403.97	50.96	0.0	19.78	70.74	74.0	3.0m./H	3.3	**PK**

-Emissions were investigated up to the 10th harmonic of the highest frequency generated.
-All other emissions were at least 20 dB below the applicable limit.

SAMPLE CALCULATION: at 2402.00 MHz, = 60.16 dBuV + (31.88) dB/m = 92.04 dBuV/m @ 3m

Test Date: January 27, 2014
Tested by
Signature: Robert S. Nevels **Name: Robert Nevels**

Table 5 - Fund and Harmonics Average limits, (CFR 15.35(b), 15.249(a))

Radiated Fundamental and Harmonics Emissions								
Tested By: RN	Test: Fundamental and Harmonics CFR 15.249 (a)				Client: Estimote			
	Project: 14-0010		Class: N/A		Model: REV.D3.3			
Frequency (MHz)	**Test Data (dBuV)**	**DF+FL***	**AF+CL-PA (dB/m)**	**Corrected Results (dBuV/m)**	**Peak Limits (dBuV/m)**	**Distance / Polarity (Meters)**	**Margin (dB)**	**Det PK**
2402.00	59.57		31.78	91.35	94.0	3.0m./	2.6	**AVG**
4804.02	55.50	-20.00	2.86	38.36	54.0	3.0m./	15.6	**AVG**
7206.40	51.34	-20.00	10.14	41.48	54.0	3.0m./	12.5	**AVG**
9607.67	52.21	-20.00	14.76	46.97	54.0	3.0m./	7.0	**AVG**
2440.30	58.63		31.98	90.61	94.0	3.0m./	3.4	**AVG**
4880.05	55.05	-20.00	3.08	38.13	54.0	3.0m./	15.9	**AVG**
7316.75	51.16	-20.00	11.16	42.32	54.0	3.0m./	11.7	**AVG**
9758.70	51.82	-20.00	13.65	45.47	54.0	3.0m./	8.5	**AVG**
12198.72	50.77	-20.00	19.79	50.56	54.0	3.0m./	3.4	**AVG**
2479.47	59.69		31.83	91.52	94.0	3.0m./	2.5	**AVG**
4959.85	58.39	-20.00	2.39	40.78	54.0	3.0m./	13.2	**AVG**
7439.42	50.65	-20.00	11.26	41.91	54.0	3.0m./	12.1	**AVG**
9919.42	54.79	-20.00	13.35	48.14	54.0	3.0m./	5.9	**AVG**
12403.97	50.96	-20.00	19.78	50.74	54.0	3.0m./	3.3	**AVG**

-Emissions were investigated up to the 10th harmonic of the highest frequency generated.
-All other emissions were at least 20 dB below the applicable limit.
*duty cycle factor = -20 dB and was applied above.

SAMPLE CALCULATION: at 2402.00 MHz, = 59.57 dBuV + (31.78) dB/m = 91.35 dBuV/m @ 3m

Test Date: January 27, 2014
Tested by
Signature: Robert S. Nevels **Name: Robert Nevels**

2.13 20 dB Bandwidth Measurement per CFR 15.247, 99% Occupied Bandwidth (IC RSS 210, A8.1)

The EUT antenna port was connected to a spectrum analyzer having a 50 Ω input impedance. Measurements were performed similar to the method of FCC, KDB Publication No. 558074 for a bandwidth of 20 dB. The RBW was set to approximately 1/100 of the manufacturers claimed RBW and with the VBW ≥ RBW. The results of this test are given in Table 6 and Figures 4-6.

Table 6 - 20 dB Bandwidth and 99% Occupied Bandwidth

Frequency (MHz)	20 dB Bandwidth (MHz)	99% Occupied Bandwidth (MHz)
2401.975	1.781	1.523
2439.975	1.726	1.494
2479.975	1.699	1.514

Test Date: February 6, 2014
Tested By
Signature: _____ **Name: George Yang**

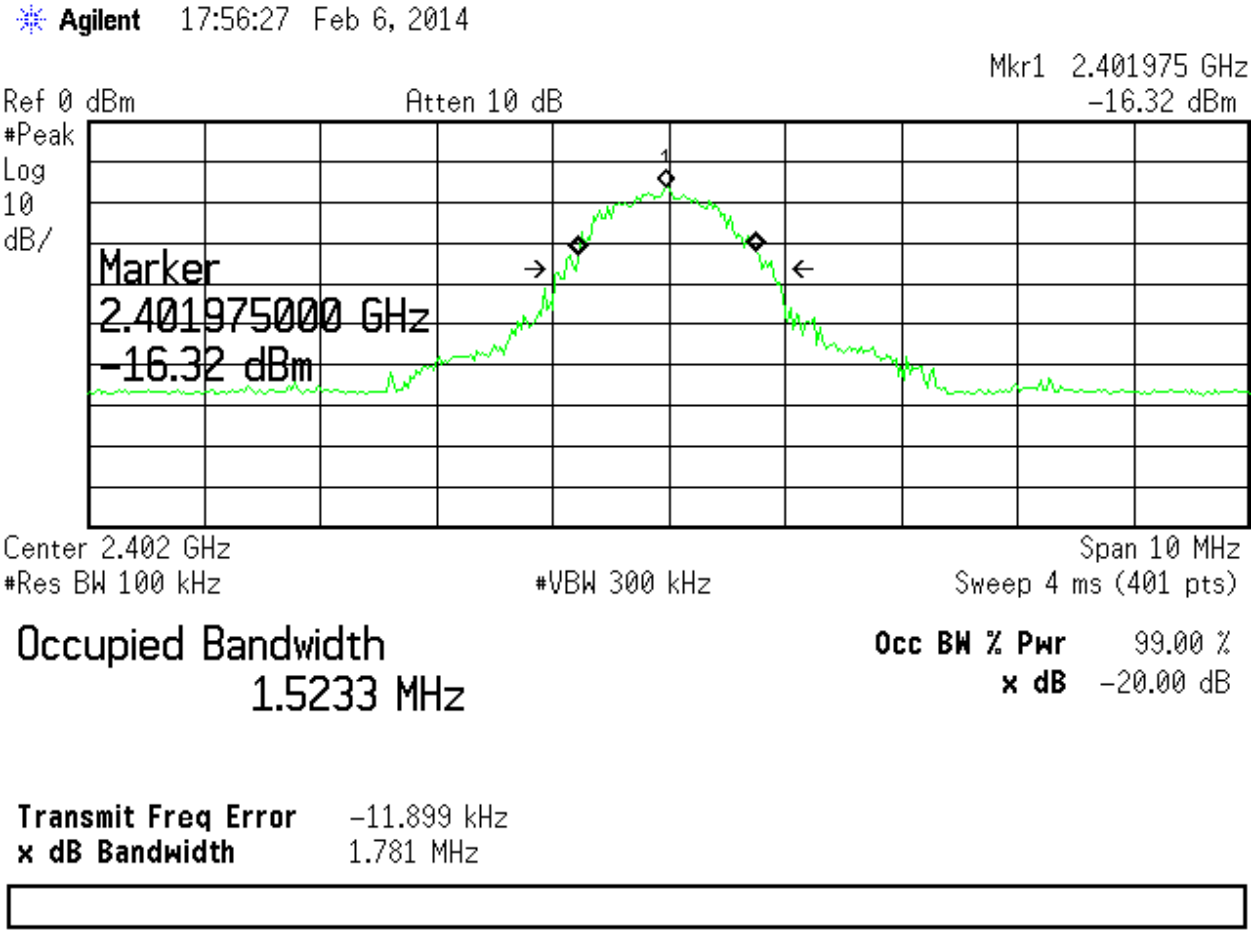

Figure 4. Low Ch Bandwidth

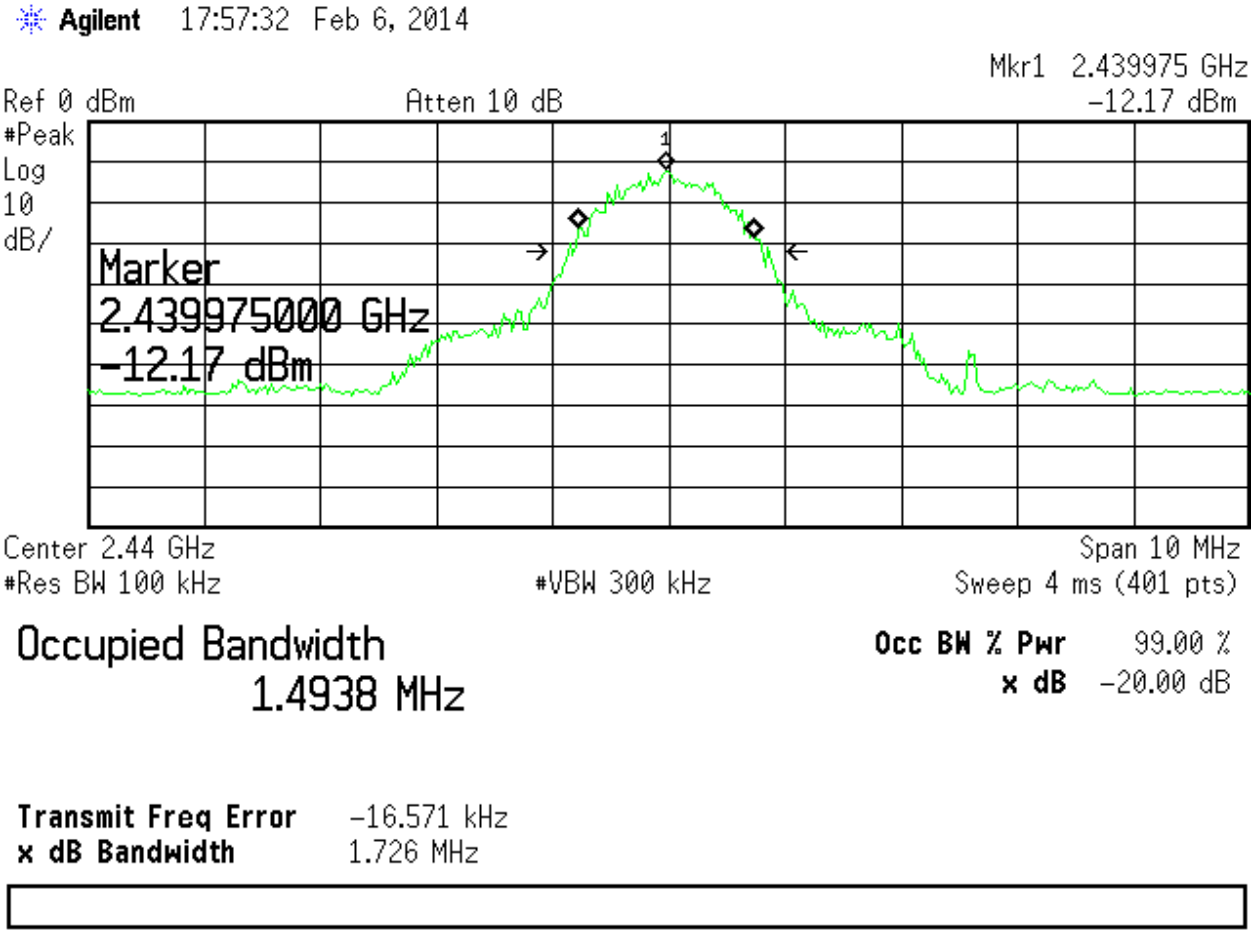

Figure 5. Mid Ch Bandwidth

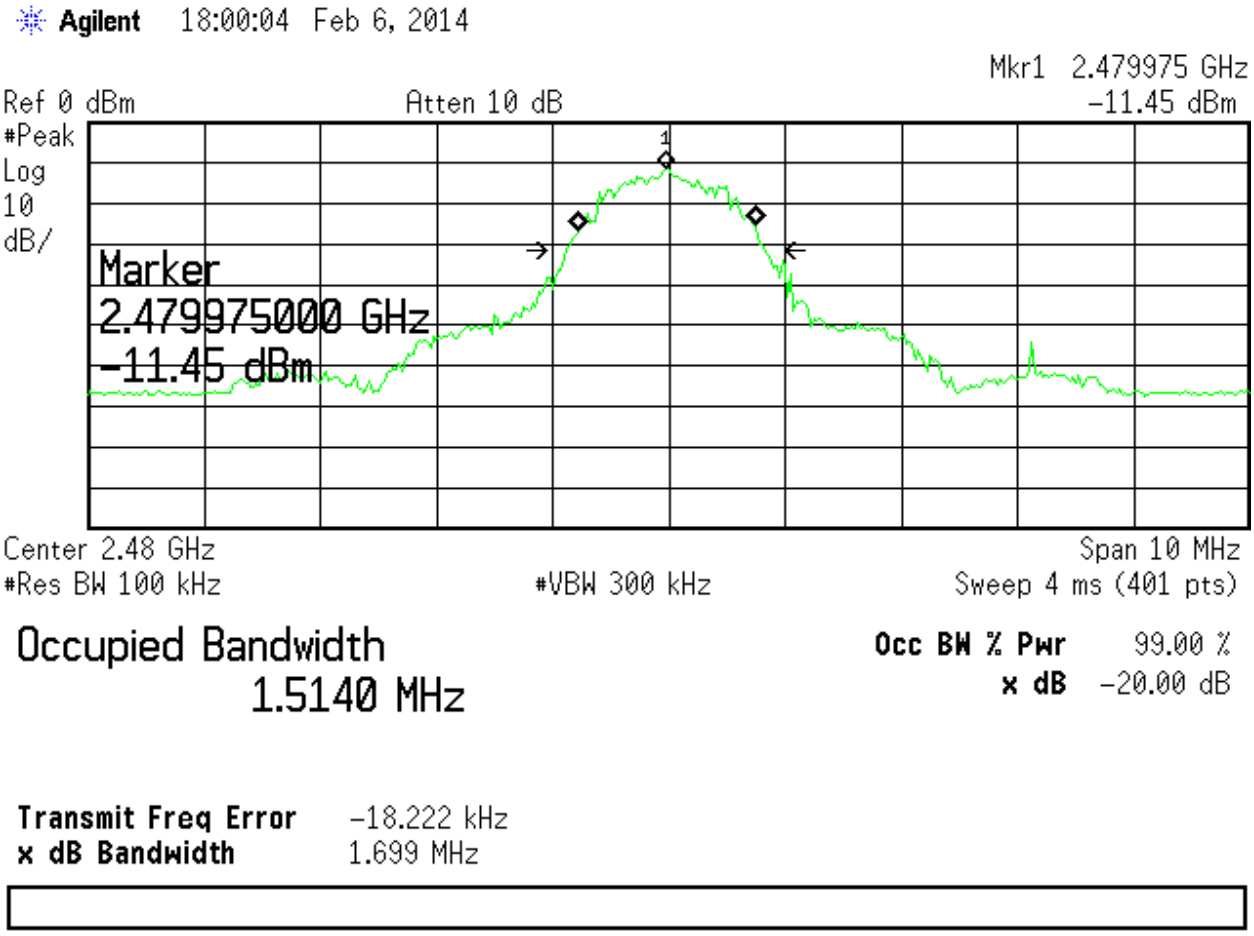

Figure 6. High Ch Bandwidth

2.12 Band Edge Measurements (CFR15.249(d))

Band Edge measurements were made at a Low Channel and High Channel peak at highest EUT related emission outside the upper and lower occupied bandwidth. A measurement was made of the fundamental and the emission was measured using a quasi peak setting. A Resolution Bandwidth of $>$ 1% of the emission bandwidth was used. This procedure was repeated for the high channel. The limits were derived as described in the following sections.

2.12.1 High Band Edge

Above 2483.5 MHz the limit per section 15.249(d) is 50 dB below the fundamental or the value expressed by CFR 15.209 (54 dBuV/m) whichever is the lesser attenuation.

The High Channel fundamental recorded in Table 4 is 93.95 dBuV/m:
93.95 -50.37 = 43.58; Passing Margin= 54.0 – 43.58 = 10.42 dB

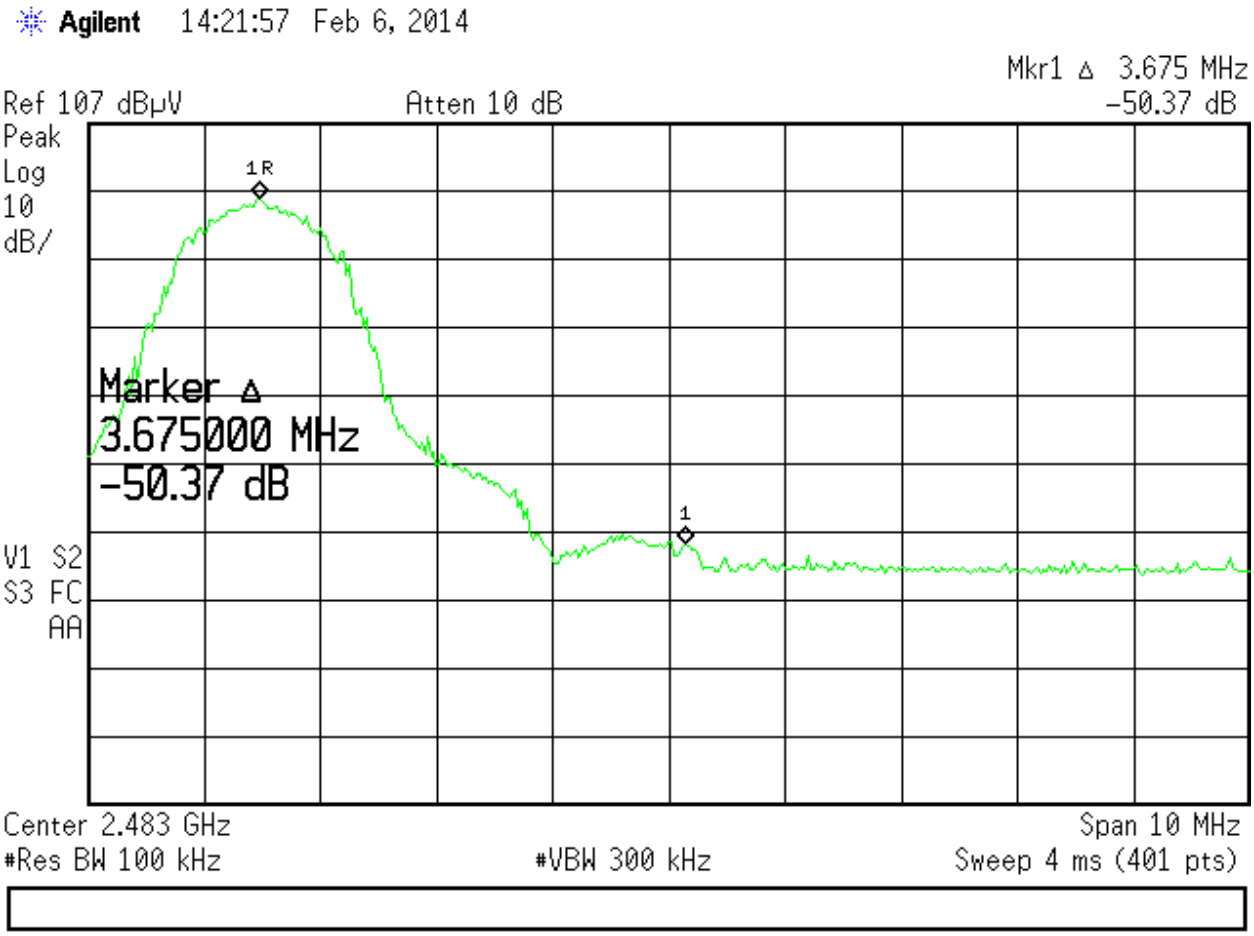

Figure 7. Radiated Band Edge – High Channel Delta

Note: All other emissions within the restricted bands of 2.31 MHz to 2.5 GHz were 20 dB or more below the limit.

Test Date: February 6, 2014
Tested By
Signature: _____ **Name: George Yang**

2.12.2 Low Band Edge

The low channel fundamental recorded in Table 4 is 91.35 dBuV/m
91.35 – 48.22 = 43.13 dB; Passing Margin= 54.0 – 43.13 = 10.87 dB

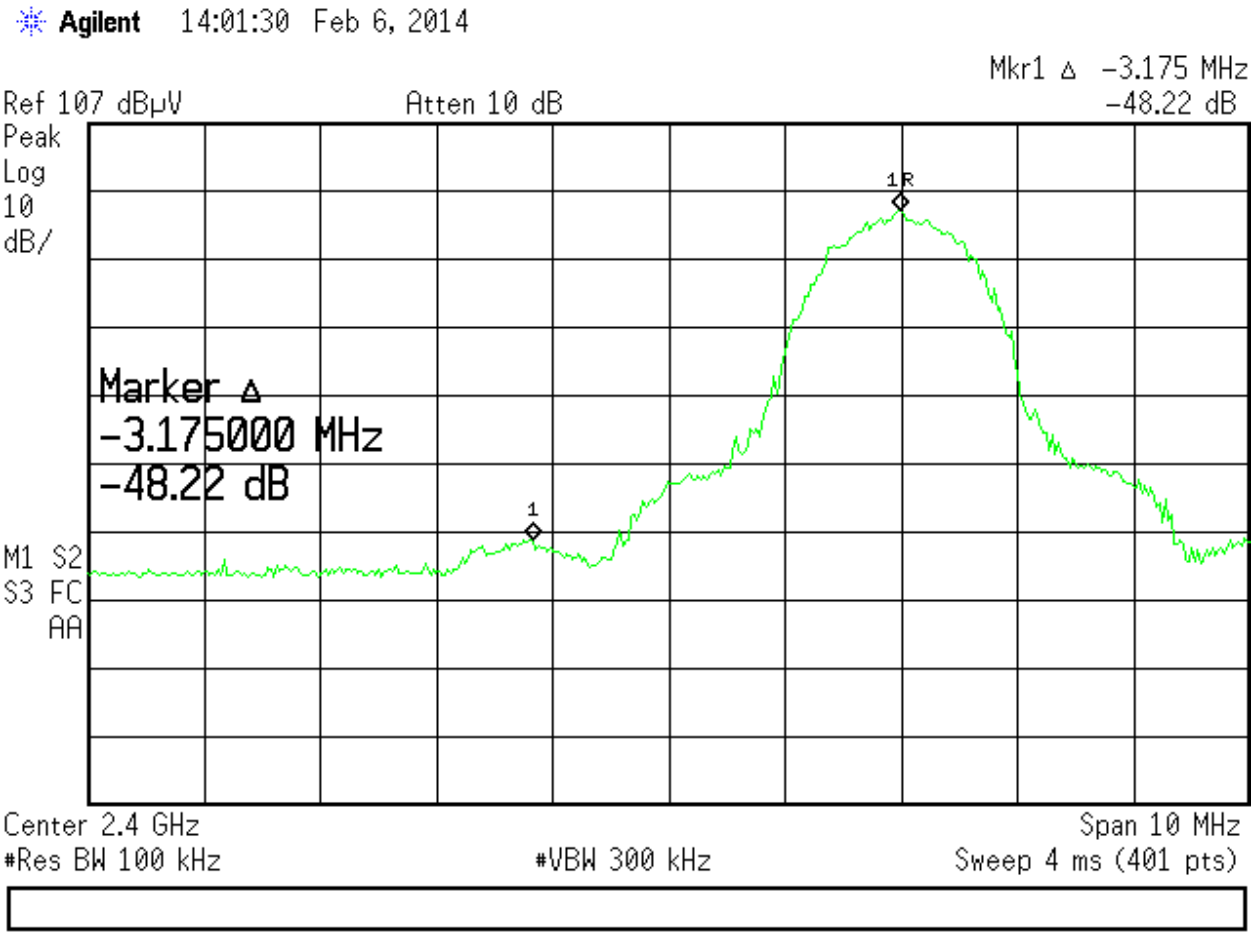

Figure 8. Radiated Band Edge – Low Channel Delta

Note: All other emissions within the restricted bands of 2.31 MHz to 2.5 GHz were 20 dB or more below the limit.

Test Date: February 6, 2014
Tested By
Signature: _____ **Name: George Yang**

2.13 Unintentional/Intentional Radiator, Power Conducted Emissions (CFR 15.107/15.207)

The EUT is battery operated.

Table 7 - Power line Conducted Emissions Data, Class B

Power Line Conducted Emissions			
Test By: GY	Test: FCC Power Line Conducted Emissions 150 KHz – 30 MHz , Hot Phase		Client: Estimote
	Project: 14-0010	Sect. 15.107/15.207 Class: A	Model: REV.D3.3

Frequency (MHz)	Test Data (dBuV)	IL+CL -PA (dB)	Results (dBuV)	AVG Limits (dBuV)	Phase /Neutral	Margin (dB)	PK / QP
EUT is battery operated and does not connect to the AC mains. This test is not applicable.							

SAMPLE CALCULATIONS:

Test Date: February 6, 2014
Tested by
Signature: _____ **Name: George Yang**

2.14 Unintentional/Intentional Radiator, Radiated Emissions (CFR 15.109/15.209)

Radiated emissions within the band 9 KHz (or lowest clock frequency of the EUT) to 30 MHz and 30 MHz to 12.5 GHz (additional intentional measurements were conducted up to 10 times the fundamental frequency, see Tables 4 and 5 above), were measured with a spectrum analyzer via a pre-amplifier by connecting the spectrum analyzer to a receiving antenna spaced three (3) meters from the EUT. The EUT was setup in a test mode which put the EUT in a continuously transmitting state, which was deemed to be the worst case state to meet both FCC Part 15.109 and 15.209 requirements. The spectrum analyzer was set for a 50 Ω input impedance with the VBW set to ≥ the RBW bandwidth. The antenna was raised and lowered over a span of 4 meters in order to maximize the signal coming from the EUT. Similarly, the turntable was rotated through 360 degrees in the same maximizing effort. Also the EUT was scanned for a maximum radiated power when placed in each of the three mutually exclusive orthogonal planes.

Radiated emissions within the band of 9 kHz to 30 MHz were investigated using a calibrated Loop Antenna and per the requirements of ANSI C63.4:2003. The resolution bandwidth was set to 9 kHz, the video bandwidth was set to three times the resolution bandwidth.

For measurements above 30 MHz the measurements were made with the analyzer's resolution bandwidth set to 120 kHz for measurements made below 1 GHz and 1 MHz for measurements made above 1 GHz. The video bandwidth was set to three times the resolution bandwidth.

All measured signals were at least 6 db below the specification limit. The results of the measurements are reported in the tables below.

Table 8 - Unintentional Radiator, Peak Radiated Emissions (CFR 15.109)

Peak Radiated Emissions, Digital Device and Receiver							
Tested By: RN	Test: Radiated Emissions- 30 kHz to 12.5 GHz			Client: Estimote			
	Project: 14-0010	Requirement 15.109 Class: B		Model: REV.D3.3			
Frequency (MHz)	**Test Data (dBuV)**	**AF+CL-PA (dB)**	**Results (dBuV/m)**	**QP Limits (dBuV/m)**	**Distance / Polarity (meters)**	**Margin (dB)**	**Detector PK / QP**
176.6000	37.78	-12.40	25.38	43.5	3m./V	18.1	**PK**
297.1200	37.48	-4.52	32.96	46.0	3m./H	13.0	**PK**
416.6500	37.66	-11.06	26.60	46.0	3m./V	19.4	**PK**
706.7000	35.84	-6.94	28.90	46.0	3m./V	17.1	**PK**
846.2500	38.36	-5.41	32.95	46.0	3m./V	13.1	**PK**
4427.9800	49.22	-7.31	41.91	54.0	3m./V	12.1	**PK**
6233.9000	49.13	-5.52	43.61	54.0	3m./V	10.4	**PK**
3532.0000	48.04	-8.20	39.84	54.0	3m./H	14.2	**PK**
8227.5000	49.05	0.79	49.84	54.0	3m./H	4.2	**PK**

Tested from 30 kHz to 12.5 GHz.
No other emissions found more than 20 dB from the limit.

SAMPLE CALCULATION: at 176.6000 MHz, = 37.78 dBuV + (-12.40) dB/m = 25.38 dBuV/m @ 3m

Test Date: January 27, 2014
Tested by
Signature: Robert S. Nevels **Name: Robert Nevels**

2.15 Measurement Uncertainty

The measurement uncertainties given were calculated using the method detailed in CISPR 16-4. A coverage factor of k=2 was used to give a level of confidence of approximately 95%.

2.15.1 Conducted Emissions Measurement Uncertainty

Measurement Uncertainty (within a 95% confidence level) for this test is ±2.8 dB.

The EUT is battery operated. This test was not applicable.

2.15.2 Radiated Emissions Measurement Uncertainty

For a measurement distance of 3 m the measurement uncertainty (with a 95% confidence level) for this test using a Biconical Antenna (30 MHz to 200 MHz) is ±5.3 dB. This value includes all elements of measurement.

The measurement uncertainty (with a 95% confidence level) for this test using a Log Periodic Antenna (200 MHz to 1000 MHz) is ±5.1 dB.

The measurement uncertainty (with a 95% confidence level) for this test using a Horn Antenna is ±2.45 dB.

The data listed in this test report does have sufficient margin to negate the effects of uncertainty. Therefore, the EUT unconditionally meets this requirement.