

# TEST REPORT

Of

## JAPAN MIC

**Product :** Bluetooth 5.0, 802.15.4 module  
**Brand:** Fanstel  
**Model:** BT840  
**Series Model:** BT840F, BT840E, BT840H  
**Model Difference:** Antenna. Please see page 5 for detail  
**Applicant:** Fanstel Corporation, Taipei  
**Address:** 10F-10, No. 79, Sec. 1, Hsin Tai Wu Rd.,  
Hsi-Chih, New Taipei City 221 Taiwan

**Test Performed by:**  
**International Standards Laboratory Corp.**

<LT Lab.>

\*Address:

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**Report No.: ISL-19LR205JAP**

**Issue Date : 2019/08/26**

Test results given in this report apply only to the specific sample(s) tested and are traceable to national or international standard through calibration of the equipment and evaluating measurement uncertainty herein.

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## VERIFICATION OF COMPLIANCE

**Applicant** Fanstel Corporation, Taipei  
**Product Name:** Bluetooth 5.0, 802.15.4 module  
**Brand Name:** Fanstel  
**Model No.:** BT840  
**Series Model:** BT840F, BT840E, BT840H  
**Model Difference:** Antenna. Please see page 5 for detail  
**Date of Test:** 2019/08/12 ~ 2019/08/21  
**Date of EUT Received:** 2019/07/29

APPLICABLE STANDARDS	
STANDARD	TEST RESULT
ARIB STD-T66	Complied

The above equipment was tested by International Standards Laboratory Corp. for compliance with the requirements in the Radio equipment stipulated in the certification ordinance article Article 2, Item (19) Appendix 43, B-1 (2). Item 19 of Article 2 Paragraph 1. The results of testing in this report apply to the product system that was tested only. Other similar equipment will not necessarily produce the same results due to production tolerance and measurement uncertainties.

<b>Test By:</b>	 <hr/> Weitin Chen / Senior Engineer	<b>Date:</b>	2019/08/26 <hr/>
<b>Prepared By:</b>	 <hr/> Elisa Chen / Senior Engineer	<b>Date:</b>	2019/08/26 <hr/>
<b>Approved By:</b>	 <hr/> Jerry Liu / Technical Manager	<b>Date:</b>	2019/08/26 <hr/>

## Version

Version No.	Date	Description
00	2019/08/26	Initial creation of document

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## 1. DESCRIPTION OF EQUIPMENT UNDER TEST (EUT)

### 1.1. GENERAL INFORMATION

General:

Product Name	Bluetooth 5.0, 802.15.4 module
Brand Name	Fanstel
Model Name	BT840
Series Model	BT840F, BT840E, BT840H
Model Difference	Antenna. Please see table below for detail.
Power Supply	5Vdc from USB (JIG)
USB port	one (JIG)

Model Summaries

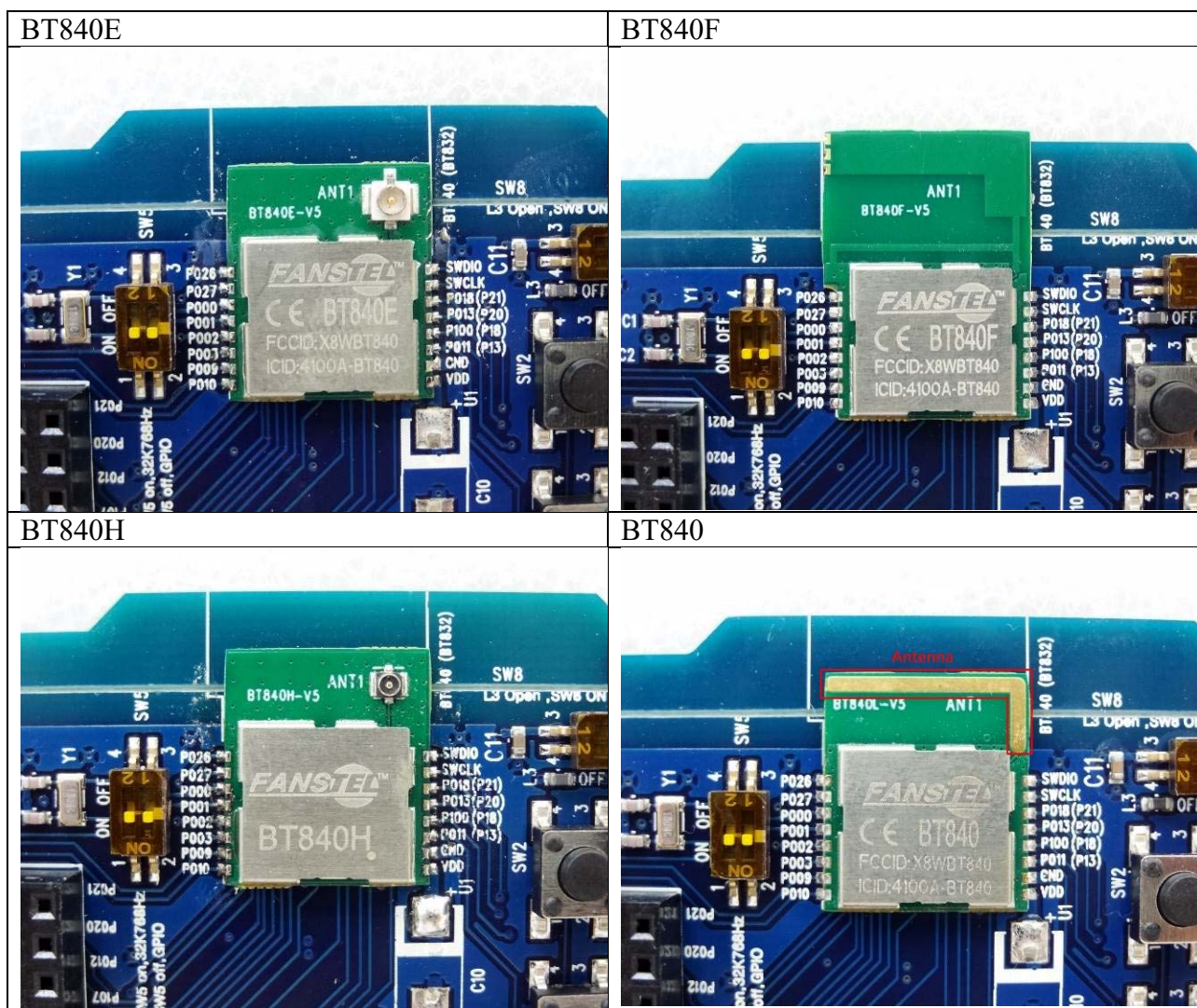
module	BT840F	BT840	BT840E	BT840H
SoC	nRF52840-QIAA	nRF52840-QIAA	nRF52840-QIAA	nRF52840-QIAA
Size	15x20.8x1.9mm	14x16x1.9mm	14x16x1.9mm	14x16x1.9mm
BT Antenna	PCB trace	PCB trace	u.FL	MHF4
BT range at 1Mbps	510 meters	180 M, estimated		
BT range at 125 Kbps	930 meters		>1000 M	>1000 M

IEEE 802.15.4 (Thread, Zigbee):

Frequency Range(MHz)	2405-2480MHz
Modulation type	OQPSK
Channel Number	16
Rated Power (mW/MHz)	6.5 mW/MHz
Antenna	BT840: PCB Antenna, -3.52dBi BT840E: Dipole Antenna, 0dBi BT840F: PCB Antenna, 0.34dBi BT840H: Dipole Antenna, 0dBi

## 1.2. Assemble

There is a shielding soldered on the module.



## 2. DESCRIPTION OF TEST MODES

The EUT has been tested at continuous TX and RX modes. And software was used to control the EUT for staying in above description test modes.

The EUT has 16 channels. Channel low, mid and High with lowest data rate was chosen for testing.

Test data of model BT840F is the worst case which is reported.

### Test channels in IEEE 802.15.4 (Thread, Zigbee) mode

	TX
Channel Low	2405MHz
Channel Mid	2445MHz
Channel High	2480MHz

### Test conditions

Temperature & humidity	Normal
Normal voltage	5 Vdc
Lower extreme voltage	4.5 Vdc
Higher extreme voltage	5.5 Vdc

## 3. GENERAL DESCRIPTION OF APPLIED STANDARDS

The EUT According to the Specifications, it must comply with the requirements of the following standards:

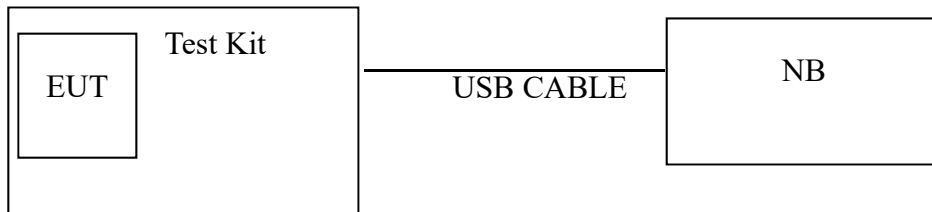
Radio equipment stipulated in the certification ordinance Article 2, Item (19) Appendix 43, B-1 (2) and Item 19 of Article 2 Paragraph 1.

## 4. TEST FACILITY

The measurement facilities used to collect the 3m Radiated Emission and AC power line conducted data are located on the address of **International Standards Laboratory Corp.** <LT Lab.> No. 120, Lane 180, Hsin Ho Rd., Lung-Tan Dist., Tao Yuan City 325, Taiwan which are constructed and calibrated to meet the FCC requirements in documents ANSI C63.4: 2014. FCC Registration Number is: TW1036, Canada Registration Number: 4067B-4.

## 5. SUPPORT EQUIPMENT

**Fig. 5-1 Configuration of Tested System**



**Table 5-1 Equipment Used in Tested System**

Item	Equipment	Mfr./Brand	Model name	Series No	Data Cable	Power Cable
1	Notebook	Lenovo	X220i	N/A	N/A	Non-shielded
2	Test Kit	N/A	N/A	N/A	N/A	N/A



## 6. SUMMARY OF TESTS

Article reference	Report reference	Parameter	Status (Note 1)
General provisions			
5	6.2	Frequency tolerance	C
6	6.3	Occupied bandwidth	C
7	6.5	Spurious emission	C
Transmitting equipment			
14	6.1	Antenna Power	C
14.2	--	SAR	N/A
15	6.2	Frequency stabilization	C
Transmitting equipment			
20	1.2	Type configuration etc of transmitting antenna	C
22	1.2	Directional pattern of transmitting antenna	C
Receiving equipment			
24	6.6	Spurious emission of receiver	C
26	1.2	Refer to all articles for transmitting antenna	C
Operating frequency 2400-2483.5MHz			
49.20(1); a	1.3	High Frequency/modulation section cannot be operated easily	C
49.20(1); b	1.1	Communication method	C
49.20(1); c	1.1	Communication method	C
49.20(1); d	1.1	Spread Spectrum method	C
49.20(1); e	6.1	Antenna Power	C
49.20(1); f(1)	1.2	Absolute gain of transmitting antenna	C
49.20(1); f(2)	6.8	Angular width of principal radiation (AWPR)	C
49.20(1); g		Number of carriers within 1MHz bandwidth in OFDM	C
49.20(1); h	6.4	Diffusion bandwidth	C
49.20(1); i	6.4	Spreading factor	C
49.20(1); j	6.7	Frequency retention time (FH employed)	C
Note 1: C=Confirm      NC=Not Confirm      NT=Not Tested      NA= Not Applicable			

## 6.1. ANTENNA POWER AND TOLERANCE

### 6.1.1. Limit:

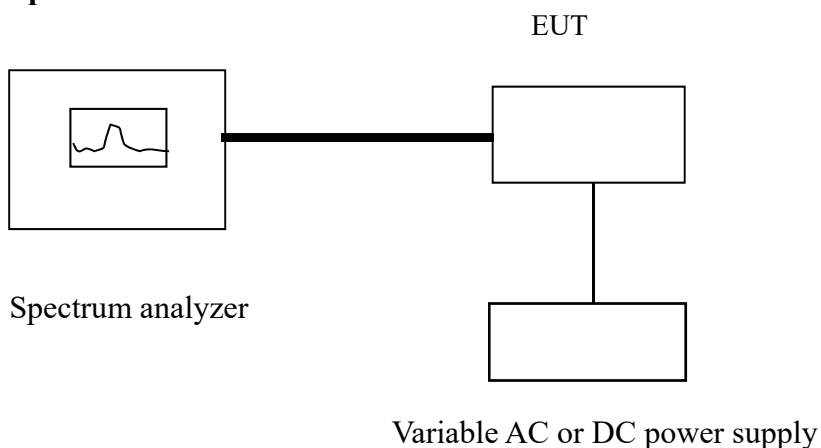
IEEE 802.15.4 (Thread, Zigbee) Antenna power: 10mW

Antenna power tolerance: + 20% to – 80%

### 6.1.2. Measurement Equipment Used:

Conducted Emission Test Site					
Equipment Type	MFR	Model Number	Serial Number	Last Cal.	Cal Due.
Power Meter 05	Anritsu	ML2495A	1116010	10/28/2018	10/27/2019
Power Sensor 05	Anritsu	MA2411B	34NKF50	10/28/2018	10/27/2019
DC Power supply	ABM	8185D	N/A	01/10/2019	01/09/2020
AC Power supply	EXTECH	CFC105W	NA	N/A	N/A
Splitter	MCLI	PS4-199	12465	12/26/2017	12/25/2019
Spectrum analyzer	keysight	N9010A	MY56070257	10/15/2018	10/14/2019
Spectrum analyzer	R&S	FSP40	100116	01/10/2019	01/09/2020

### 6.1.3. Test Setup:



### 6.1.4. Test Procedure:

1. Set the EUT at hopping off and modulation on.
2. Set the ETU operates at channel low, mid and high and normal/Upper/Lower voltage.
3. Connect the EUT to power meter.
4. Record the power level.
5. Varied input voltage to + 10% and - 10% normal voltage and repeat procedure 1 to 4 again.

### 6.1.5. Test results:

Ambient temperature: 20 °C      Relative humidity: 65%      Test Date: 2019/08/02

IEEE 802.15.4 (Thread, Zigbee) (OQPSK Modulation):

Rated Power Density(for 2405-2480) = 6.5 mW/MHz

Antenna Gain= 0.34 dBi

		Channel Low	Channel Mid	Channel High	Limit
Normal Voltage 5 V	Conducted Power (dBm/MHz)	7.830	7.880	8.130	N/A
	Conducted Power (mW/MHz)	6.067	6.138	6.501	10mW/MHz
	Power Tolerance	-6.656	-5.575	0.020	+20% to -80%
Upper Voltage 5.5 V	Conducted Power (dBm/MHz)	7.790	7.710	8.020	N/A
	Conducted Power (mW/MHz)	6.012	5.902	6.339	10mW/MHz
	Power Tolerance	-7.512	-9.200	-2.482	+20% to -80%
Lower Voltage 4.5 V	Conducted Power (dBm/MHz)	7.800	7.820	8.070	N/A
	Conducted Power (mW/MHz)	6.026	6.053	6.412	10mW/MHz
	Power Tolerance	-7.299	-6.871	-1.352	+20% to -80%

Remark:

1. Conducted Power (mW/MHz)=  $10^{(\text{Conducted Power(dBm/MHz)}/10)}$
2. P (mW/MHz) = Raw power (in mW, measured by power sensor) / [spreading bandwidth (MHz) x duty-cycle]

## 6.2. FREQUENCY TOLERANCE

### 6.2.1. Limit:

50ppm

### 6.2.2. Measurement Equipment Used:

Refer to section 6.1.2 for detail.

### 6.2.3. Test Setup:

Refer to section 6.1.3 for detail.

### 6.2.4. Test Procedure:

1. Set the EUT modulation off.
2. Set the ETU operates at channel low, mid and high and normal voltage.
3. Set the spectrum analyzer RBW = 300Hz, VBW=300Hz and Span = 20kHz
4. Max hold, View, Peak High, Mark and snap the screen and record the mark.
5. Varied input voltage to + 10% and - 10% normal voltage and repeat procedure 1 to 4 again.

### 6.2.5. Test results:

Ambient temperature: 20 °C    Relative humidity: 65 %    Test Date: 2019/08/02

## IEEE 802.15.4 (Thread, Zigbee)

### OQPSK Modulation

		Channel Low	Channel Mid	Channel High	Limit
<b>Normal Voltage</b> <b>5 V</b>	Measured Frequency (MHz)	2405.0230	2445.0210	2480.0210	+/-50ppm
	Frequency Tolerance (ppm)	9.563	8.589	8.468	
<b>Upper Voltage</b> <b>5.5 V</b>	Measured Frequency (MHz)	2405.0210	2405.0190	2480.0200	+/-50ppm
	Frequency Tolerance (ppm)	8.732	-16352.147	8.065	
<b>Lower Voltage</b> <b>4.5 V</b>	Measured Frequency (MHz)	2405.0220	2405.0220	2480.0220	+/-50ppm
	Frequency Tolerance (ppm)	9.148	-16350.920	8.871	

### **6.3. OCCUPIED BANDWIDTH**

#### **6.3.1. Limit:**

IEEE 802.15.4 (Thread, Zigbee) mode < 26MHz

#### **6.3.2. Measurement Equipment Used:**

Refer to section 6.1.2 for detail.

#### **6.3.3. Test Setup:**

Refer to section 6.1.3 for detail.

#### **6.3.4. Test Procedure:**

1. Set the EUT modulation on.
2. Set the ETU operate at channel low, mid and high and normal voltage.
3. Set the spectrum analyzer RBW = 100kHz, VBW=300kHz, center frequency = 2405MHz, 2445MHz, 2480MHz and Span = 5MHz
4. Turn on 99% spectrum OBW function on, Max hold, View, and snap the screen and record the mark.
5. Varied input voltage to + 10% and - 10% normal voltage and repeat procedure 1 to 4 again.

### 6.3.5. Test results:

Ambient temperature: 20 °C    Relative humidity: 65 %

Test Date: 2019/08/02

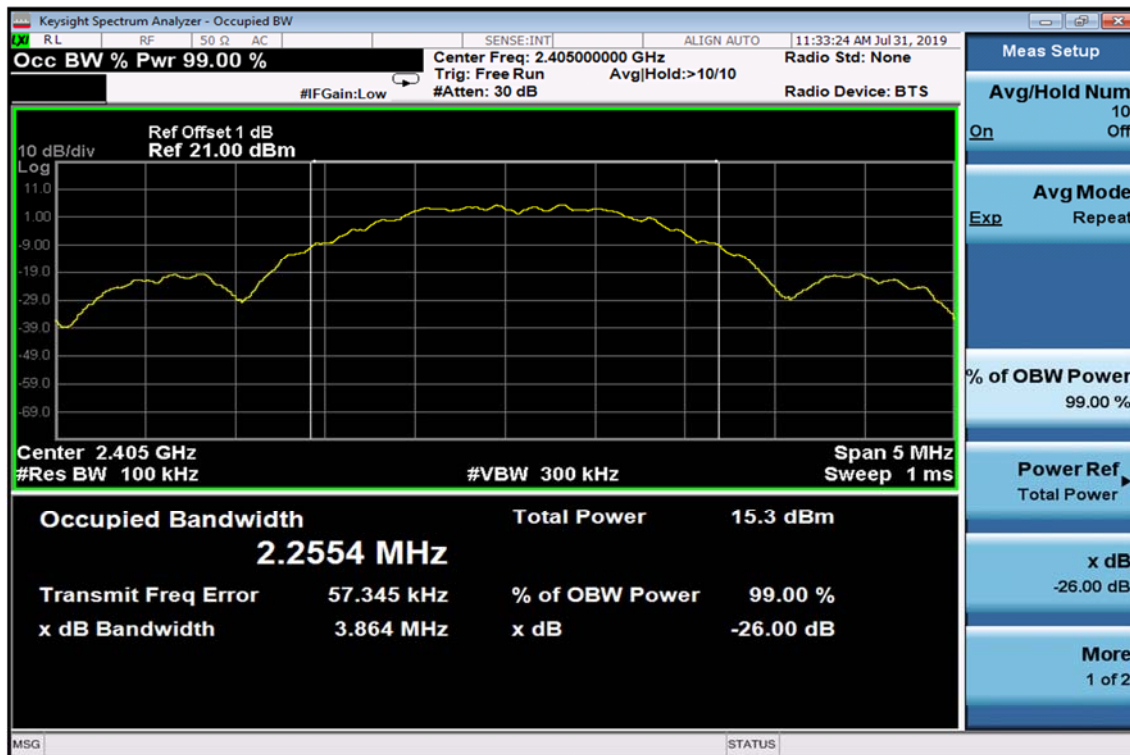
### IEEE 802.15.4 (Thread, Zigbee)

#### OQPSK Modulation

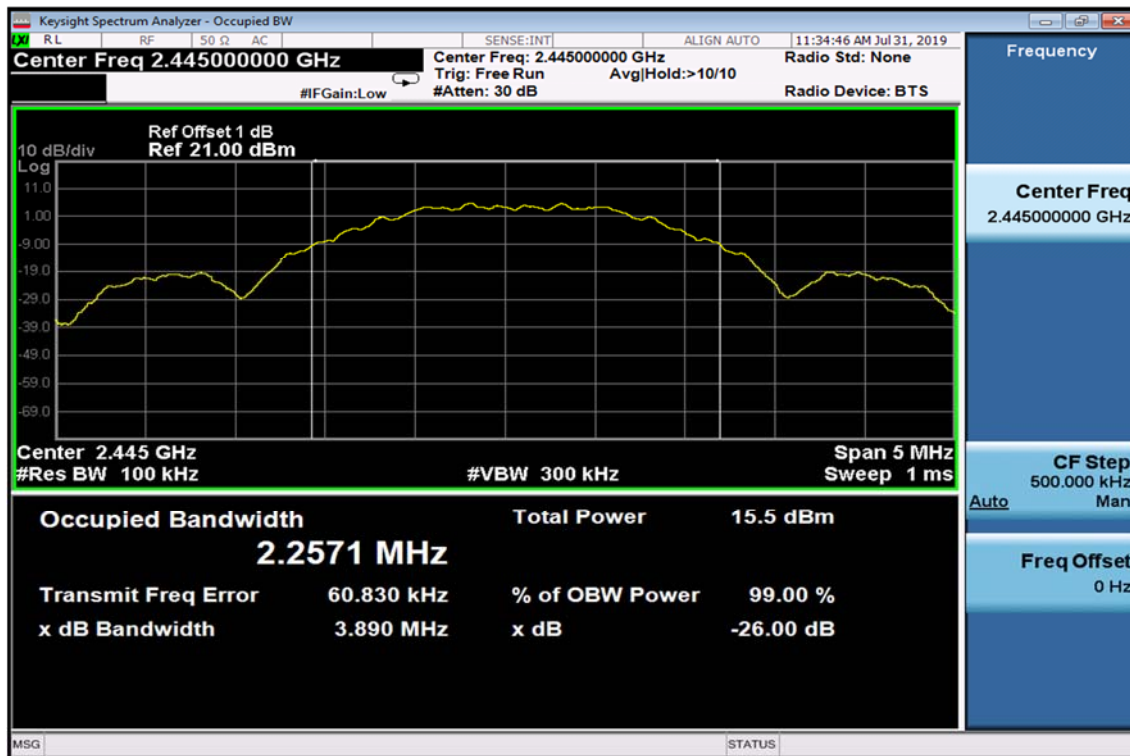
	CH Low	CH Mid	CH High	Limit	Remark
Normal Voltage 5 V	1.4689	1.4736	1.4845	<26MHz	Pass
Upper Voltage 5.5 V	1.4777	1.4784	1.4885	<26MHz	Pass
Lower Voltage 4.5 V	1.4868	1.4709	1.4870	<26MHz	Pass

## Normal voltage for IEEE 802.15.4 (Thread, Zigbee) mode

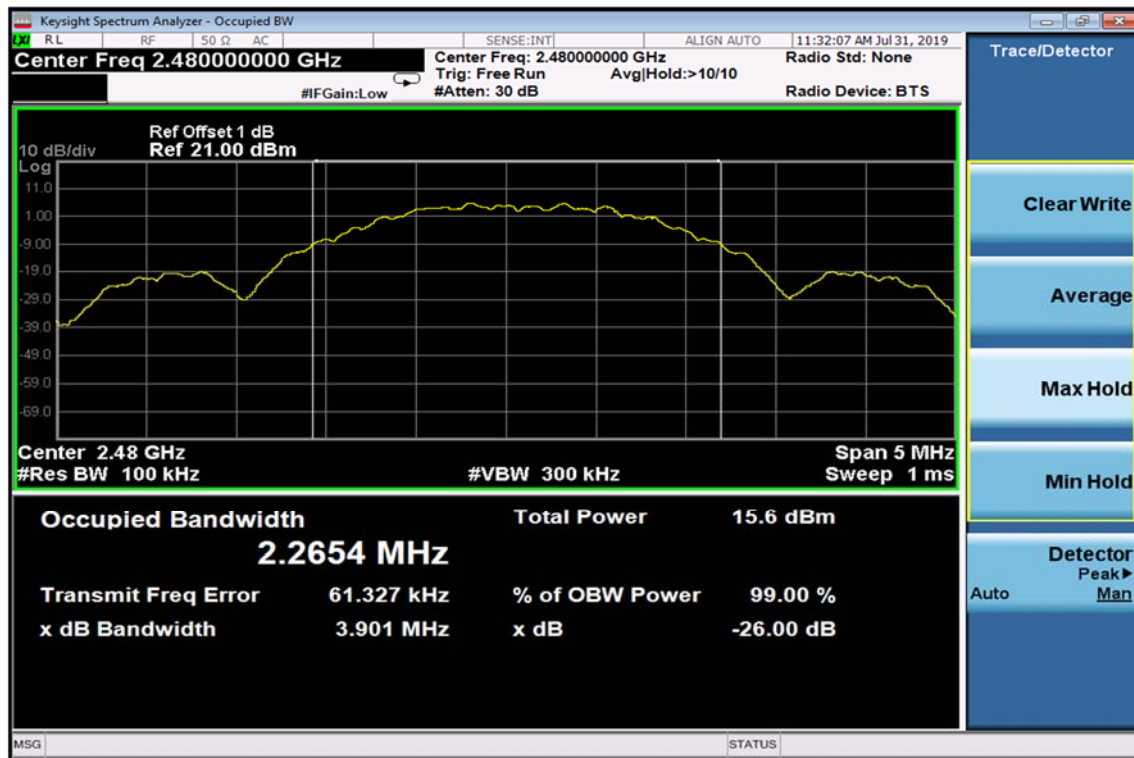
### CH2405



### CH2440



CH2480





## 6.4. SPREADING BANDWIDTH (90%)

### 6.4.1. Limit:

> 500kHz

### 6.4.2. Measurement Equipment Used:

Refer to section 6.1.2 for detail.

### 6.4.3. Test Setup:

Refer to section 6.1.3 for detail.

### 6.4.4. Test Procedure:

1. Set the EUT modulation on.
2. Set the ETU operate at channel low, mid and high and normal voltage.
3. Set the spectrum analyzer RBW = 100kHz, VBW=300kHz, center frequency =2405MHz, 2445MHz, 2480MHz and Span = 5MHz
4. Turn on 90% spectrum OBW function, Max hold, View, and snap the screen and record the mark.
5. Varied input voltage to + 10% and - 10% normal voltage and repeat procedure 1 to 4 again.

### 6.4.5. Test results:

Ambient temperature: 20 °C

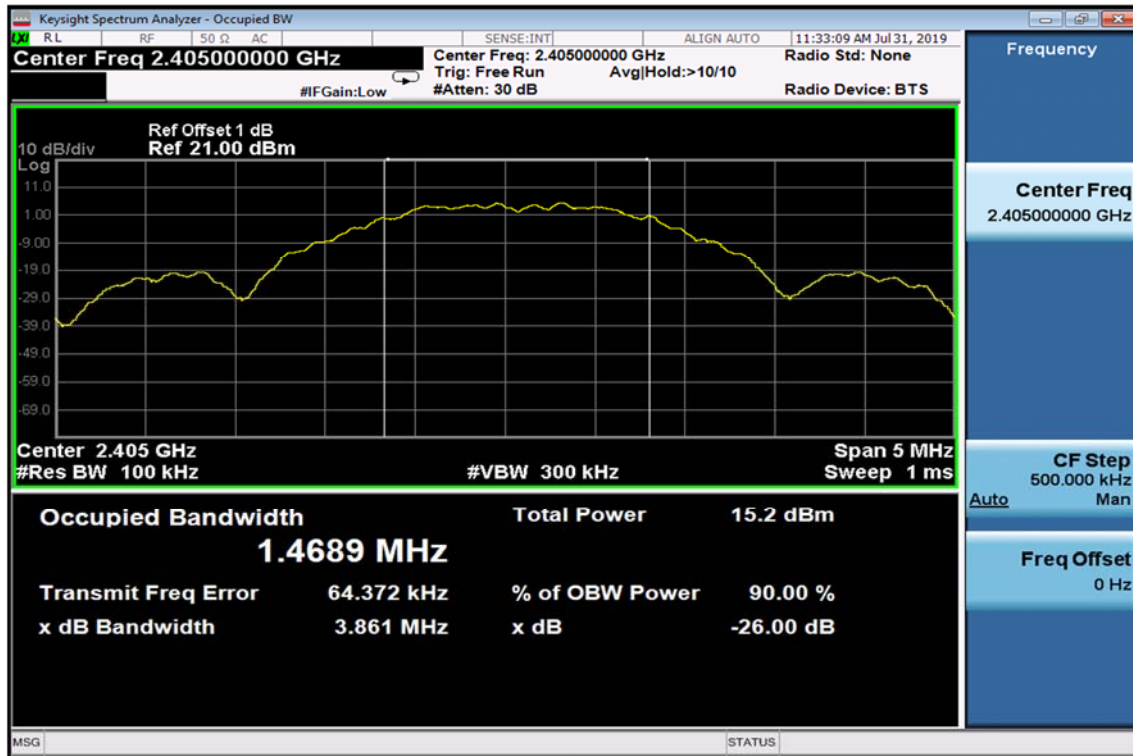
Relative humidity: 65 %

Test Date: 2019/08/02

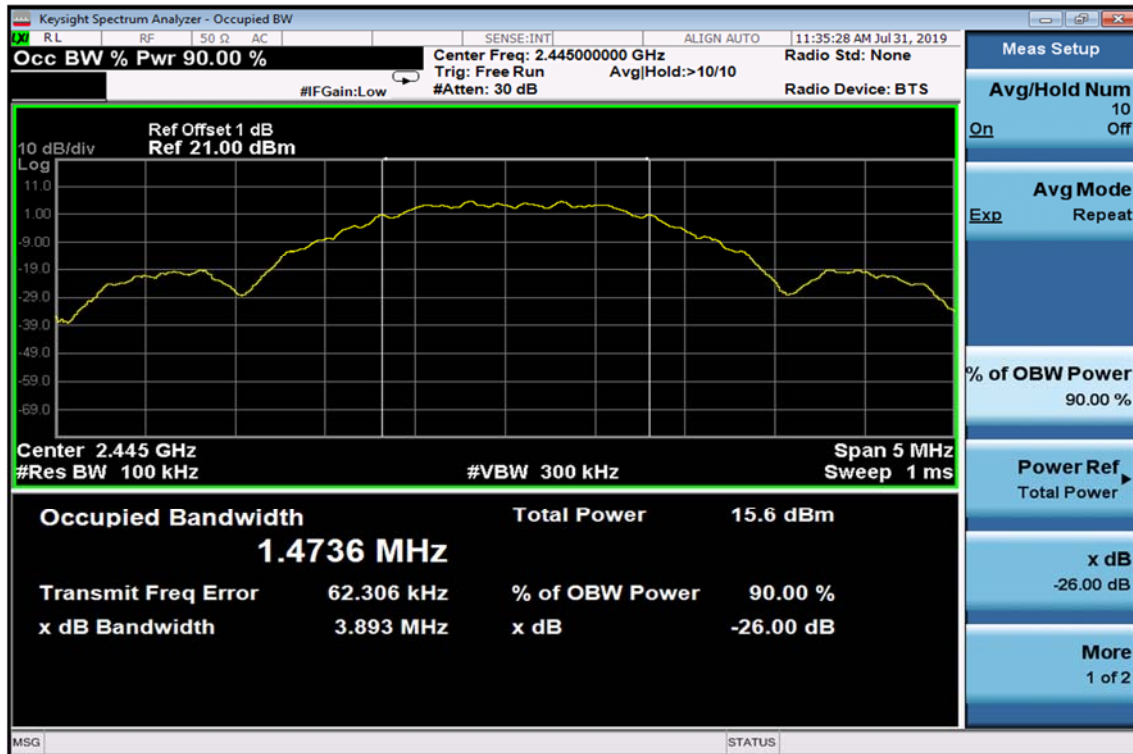
IEEE 802.15.4 (Thread, Zigbee)	CH Low	CH Mid	CH High	Limit	Symbol Rated kBd	Spread Factor Min.Value	Limit
Normal Voltage 5 V	1.4689	1.4736	1.4845	>500kHz	0.0625	26.10	>5
Upper Voltage 5.5 V	1.4777	1.4784	1.4885	>500kHz	0.0625	26.20	>5
Lower Voltage 4.5 V	1.4868	1.4709	1.487	>500kHz	0.0625	25.92	>5

## Normal voltage for IEEE 802.15.4 (Thread, Zigbee)

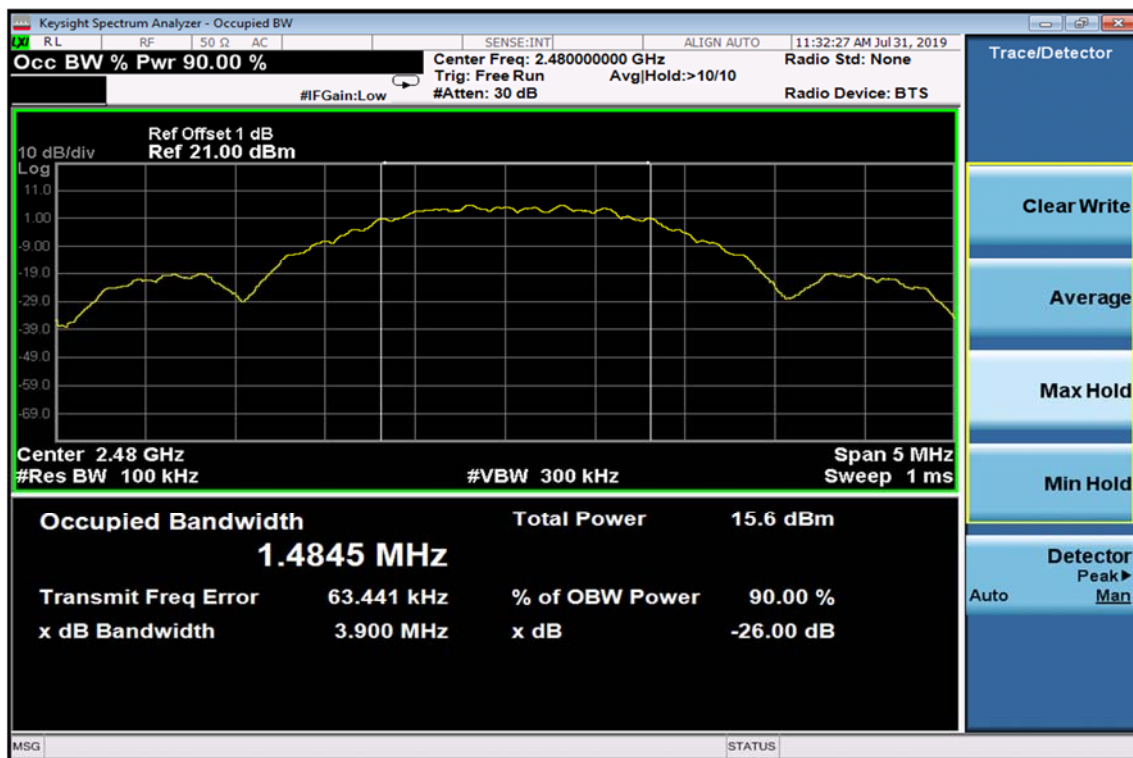
### CH 2405



### CH 2440



## CH 2480



## 6.5. TRANSMITTER SPURIOUS EMISSIONS

### 6.5.1. Limit:

Frequency below 2.387 and above 2.4965GHz :2.5uW

Frequency between 2.387 – 2.400GHz, 2.4835-2.4965GHz: 25uW

### 6.5.2. Measurement Equipment Used:

Refer to section 6.1.2 for detail.

### 6.5.3. Test Setup:

Refer to section 6.1.3 for detail.

### 6.5.4. Test Procedure:

1. Set the EUT at hopping off and modulation on.
2. Set the ETU operate at channel low, mid and high and normal voltage.
3. Set the spectrum analyzer Ref level= -10dBm; attenuation=0dB;RBW=100KHz, BW=100KHz , Sweep = auto Start=10MHz, Stop=1000MHz. Max hold view, mark highest level.
4. Set the spectrum analyzer Ref level= -10dBm; attenuation=0dB;RBW=1MHz, BW=1MHz , Sweep = auto Start=1000MHz, Stop=2387MHz. Max hold view, mark highest level.
5. Set the spectrum analyzer Ref level= -10dBm; attenuation=0dB; RBW=1MHz, RBW=1MHz, Sweep = auto, Start=2387MHz, Stop=2400MHz. Max hold view, mark highest level.
6. Set the spectrum analyzer Ref level= -10dBm; attenuation=0dB; RBW=1MHz, BW=1MHz, Sweep = auto Start=2483.5MHz, Stop=2496.5MHz. Max hold view, mark highest level.
7. Set the spectrum analyzer Ref level= -10dBm; attenuation=0dB; RBW=1MHz, BW=1MHz, Sweep = auto, Start=2496.5MHz, Stop=26GHz. Max hold view, mark highest level.
8. Varied input voltage to + 10% and - 10% normal voltage and repeat procedure 1 to 7 again.
9. The Worst data was report.

### 6.5.5. Test Results:

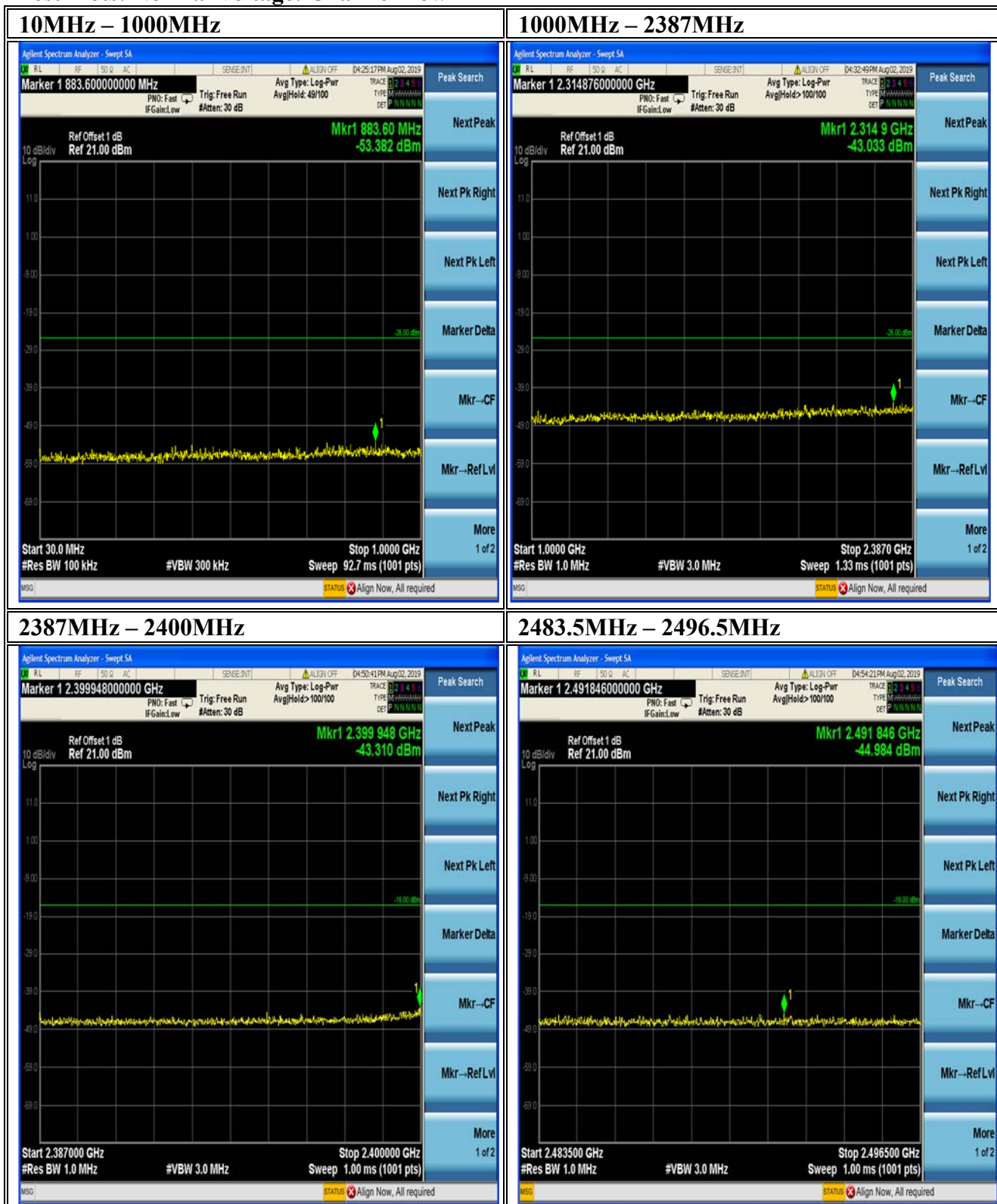
Refer to next page for plots.

Ambient temperature: 20 °C Relative humidity: 65 %

Test Date: 2019/08/02

IEEE 802.15.4 (Thread, Zigbee) (OQPSK Modulation):

Test Plots: Normal Voltage: Channel Low

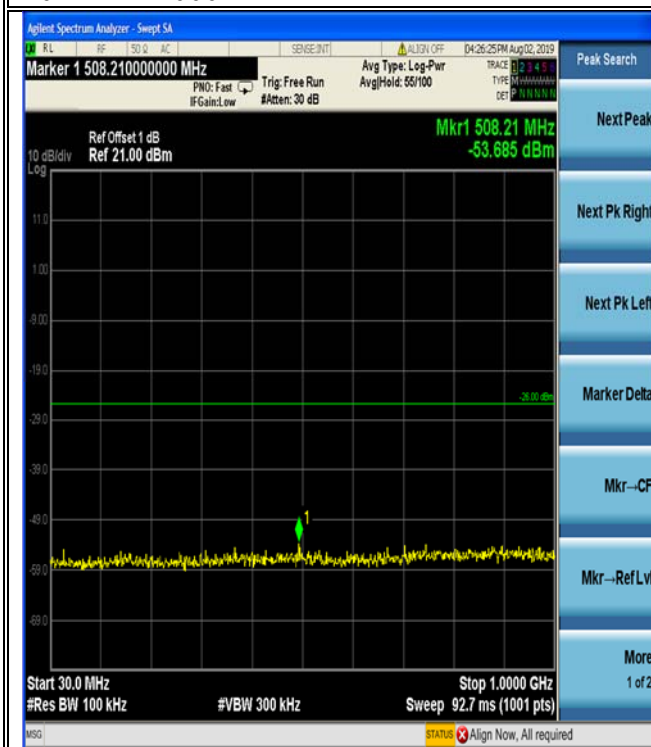




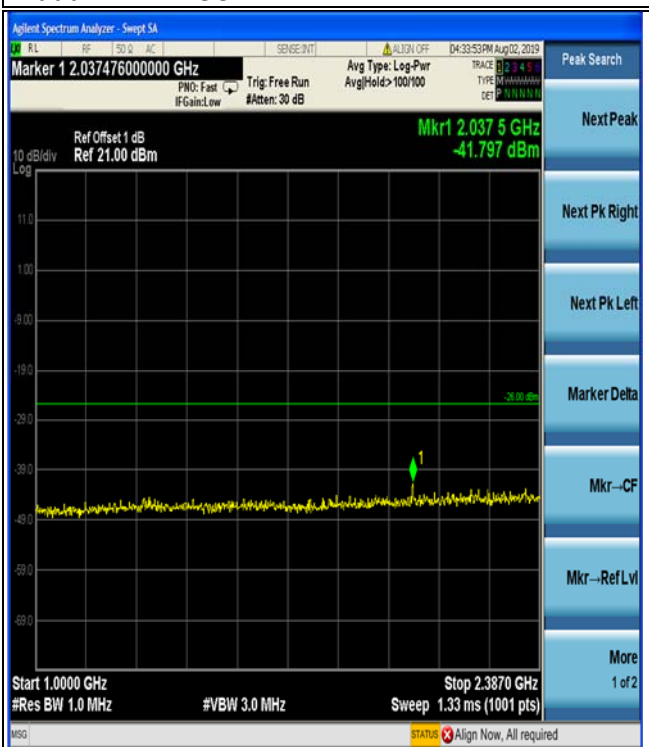


## Test Plots: Normal Voltage: Channel Mid

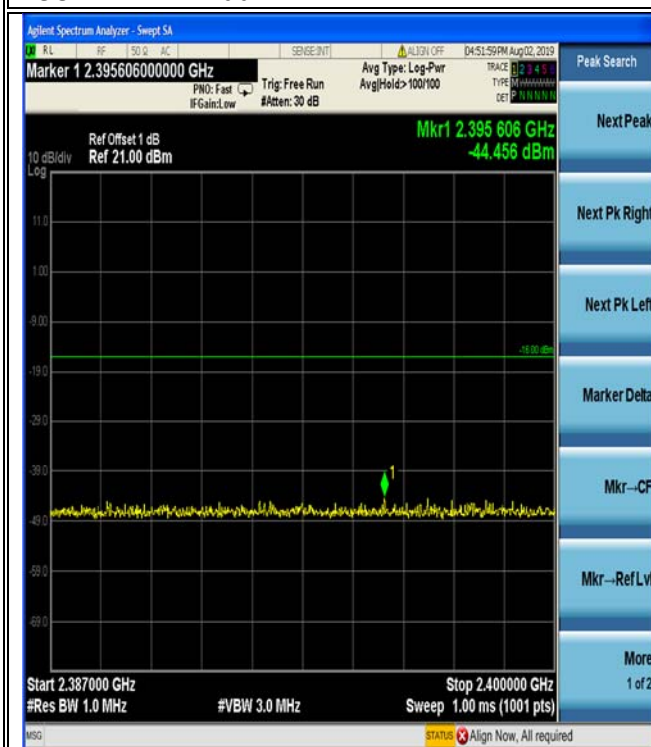
### 10MHz – 1000MHz



### 1000MHz – 2387MHz



### 2387MHz – 2400MHz



### 2483.5MHz – 2496.5MHz





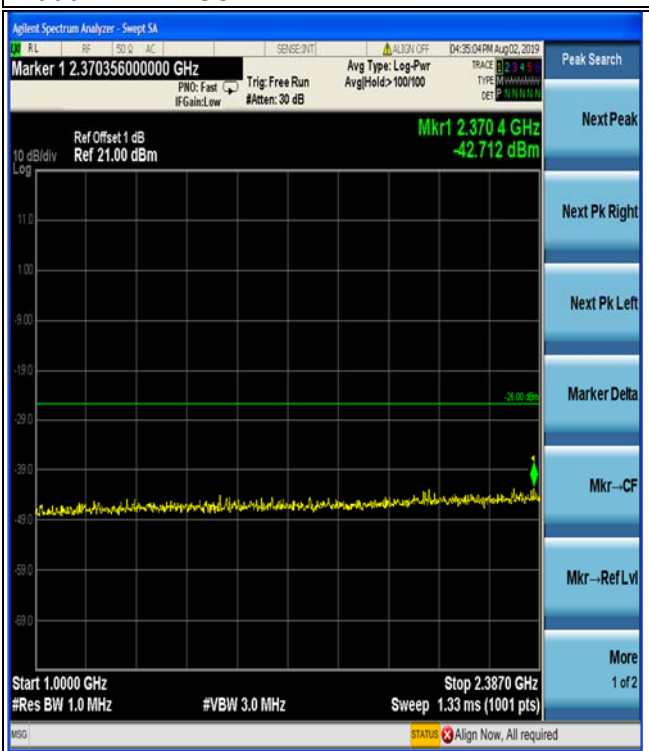


## Test Plots: Normal Voltage: Channel High

### 10MHz – 1000MHz



### 1000MHz – 2387MHz



### 2387MHz – 2400MHz



### 2483.5MHz – 2496.5MHz





## **6.6. LIMITATION OF COLLATERAL EMISSION OF RECEIVER**

### **6.6.1. Limit:**

Frequency below 1GHz : 4nW  
Frequency above 1GHz : 20nW

### **6.6.2. Measurement Equipment Used:**

Refer to section 6.1.2 for detail.

### **6.6.3. Test Setup:**

Refer to section 6.1.3 for detail.

### **6.6.4. Test Procedure:**

1. Setup the EUT at hopping off and modulation on.
2. Setup the ETU operate at channel low, mid and high and normal voltage.
3. Set the spectrum analyzer Ref level: -10dBm; attenuation=0dB;RBW=100kHz, VBW=100kHz, Sweep = auto, Start=10MHz, Stop=1GHz. Max hold view, mark highest level.
4. Set the spectrum analyzer Ref level: -10dBm, attenuation=0dB;RBW=1MHz, VBW=1MHz, Sweep = auto, Start=1GHz, Stop=13GHz. Max hold view, mark highest level
5. Varied input voltage to + 10% and - 10% normal voltage and repeat procedure 1 to 4 again.
6. The Worst data was report.

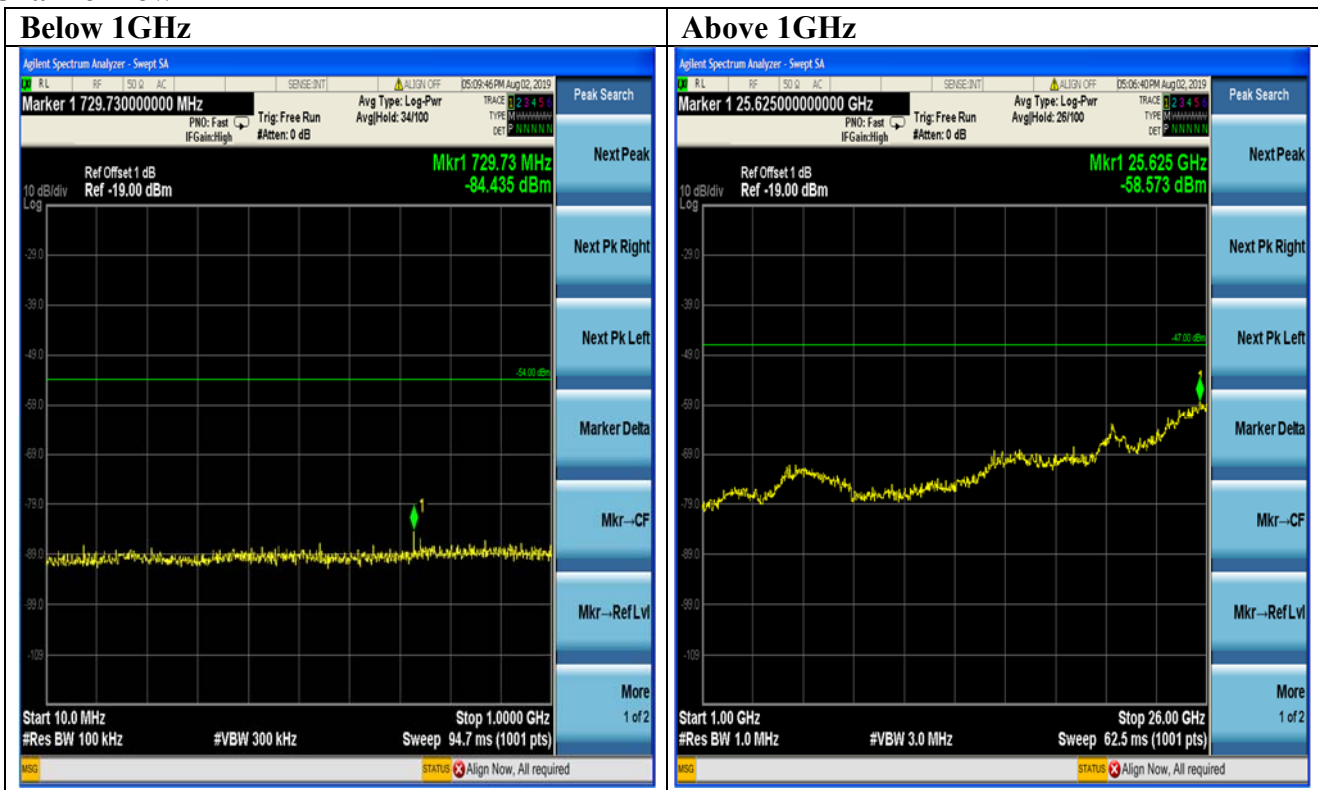
### **6.6.5. Test Results:**

Refer to next page for plots.

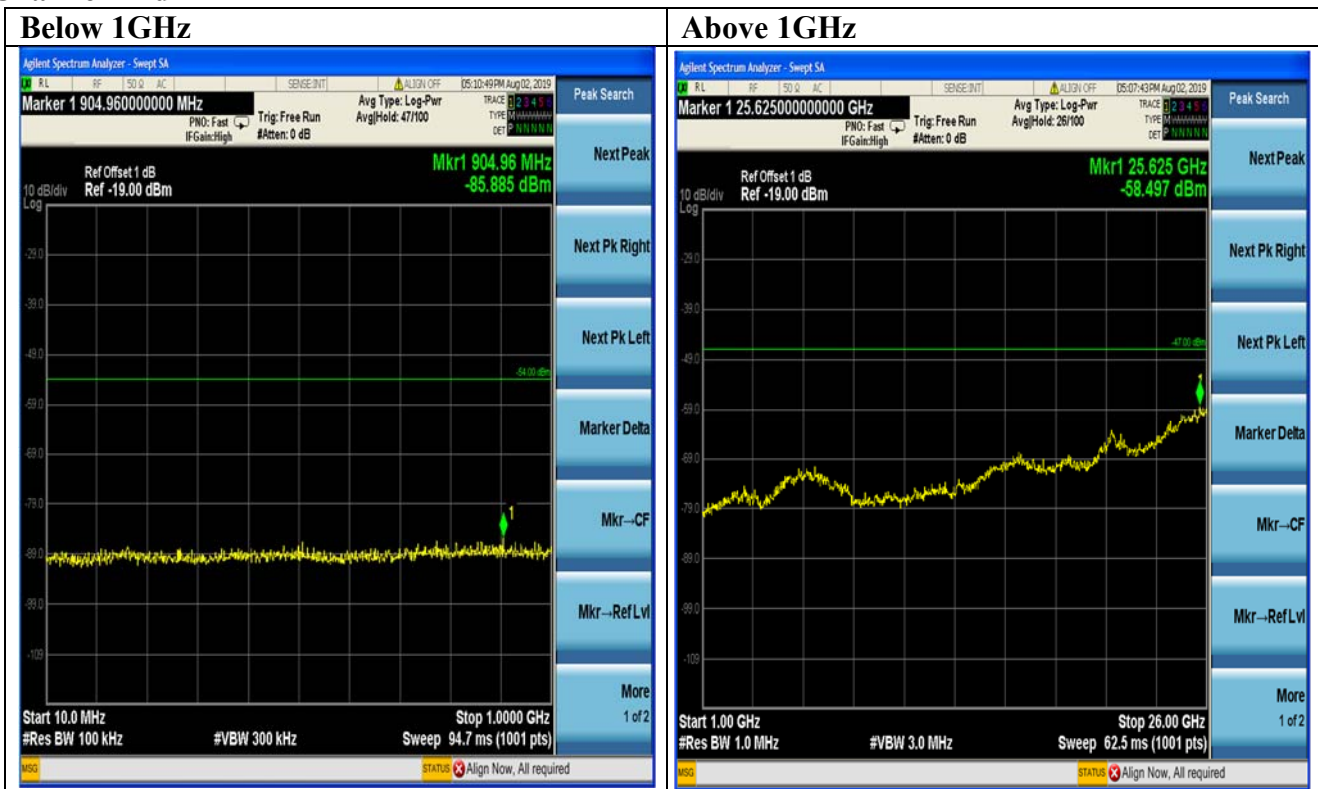
Ambient temperature: 20 °C    Relative humidity: 65 %    Test Date: 2019/08/02

Normal Voltage for IEEE 802.15.4 (Thread, Zigbee) (OQPSK Modulation):

Channel Low

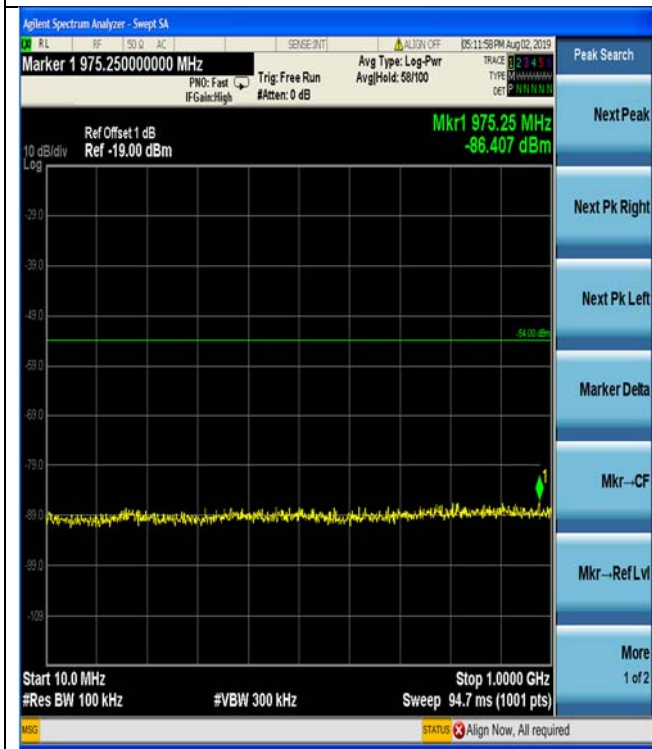


Channel Mid



## Channel High

### Below 1GHz



### Above 1GHz



## **6.7. HOPPING DWELL TIME**

### **6.7.1. Limit:**

$\leq 0.4\text{s}$  in one 28.5 sec period

### **6.7.2. Measurement Equipment Used:**

Refer to section 6.1.2 for detail.

### **6.7.3. Test Setup:**

Refer to section 6.1.3 for detail.

### **6.7.4. Test Procedure:**

1. Place the EUT on the table and set it in transmitting mode.
2. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to the spectrum analyzer.
3. Set center frequency of spectrum analyzer = operating frequency.
4. Set the spectrum analyzer as RBW, VBW=1MHz, Span = 0Hz , Adjust Sweep = 30s.
5. Repeat above procedures until all frequency measured were complete.

### **6.7.5. Test Results: N/A**

## 6.8. ANGULAR WIDTH OF PRINCIPAL RADIATION (AWPR)

The angular width of principal radiation (AWPR), which follows from the antenna pattern specifications, shall satisfy the expression  $360/A$  degree.

To be assessed:

$AWPR < 360/A$  (degree)

A represent the value determined by dividing equivalent isotropic radiated power by the value obtained by applying an antenna power with the mean power of 10mW to the transmitting antenna with its absolute gain being 2.14 dBi.

IEEE 802.15.4 (Thread, Zigbee)				
Antenna gain=		0.34 dBi		
		CH Low	CH Mid	CH High
<b>Normal Voltage</b> <b>5 V</b>	Conducted power (mW/MHz)	6.067	6.138	6.501
	Radiated power (dBm/MHz)	8.17	8.22	8.47
	Radiated power (mW/MHz)	6.561	6.637	7.031
	Constant A	6.561 /16.4<1	6.637 /16.4<1	7.031 /16.4<1
<b>Upper Voltage</b> <b>5.5 V</b>	Conducted power (mW/MHz)	6.012	5.902	6.339
	Radiated power (dBm/MHz)	8.13	8.05	8.36
	Radiated power (mW/MHz)	6.501	6.383	6.855
	Constant A	6.501 /16.4<1	6.383 /16.4<1	6.855 /16.4<1
<b>Lower Voltage</b> <b>4.5 V</b>	Conducted power (mW/MHz)	6.026	6.053	6.412
	Radiated power (dBm/MHz)	8.14	8.16	8.41
	Radiated power (mW/MHz)	6.516	6.546	6.934
	Constant A	6.516 /16.4<1	6.546 /16.4<1	6.934 /16.4<1

## 6.9. CARRIER SENSE CAPABILITY

### 6.9.1. Limit:

Shall not transmit when received signal level is above 100 mV

Automatic cessation of transmitting is required when the electric field strength is exceeding E (mV/m):

Antenna Voltage (in dBm) =  $7.88 + \max. \text{ antenna Gain} - 20 \times \log f$  ( f in MHz)

This voltage will be generated in the direction of the max. Gain.

### 2.4GHz IEEE 802.15.4 (Thread, Zigbee)

						Antenna Gain(dBi)		dBm
Channel Low	2405	MHz:	Pcs=	7.88	+	0.34	$-20\log(2405)=$	-59.40
Channel Mid	2445	MHz:	Pcs=	7.88	+	0.34	$-20\log(2445)=$	-59.55
Channel High	2480	MHz:	Pcs=	7.88	+	0.34	$-20\log(2480)=$	-59.67

### 6.9.2. Measurement Equipment Used:

Refer to section 6.1.2 for detail.

### 6.9.3. Test Setup:

Refer to section 6.1.3 for detail.

### 6.9.4. Test Procedure:

1. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port through splitter to spectrum
2. Set center frequency of spectrum analyzer = operating frequency.
3. Set the spectrum analyzer as RBW, VBW=1MHz, Span = 50MHz , Sweep = Auto.
4. EUT link to device set it in normal mode
4. used spectrum analyzer trigger function and delta mark function

### 6.9.5. Test Results:

PASS



## **Appendix 1**

### **Photographs of Setup**

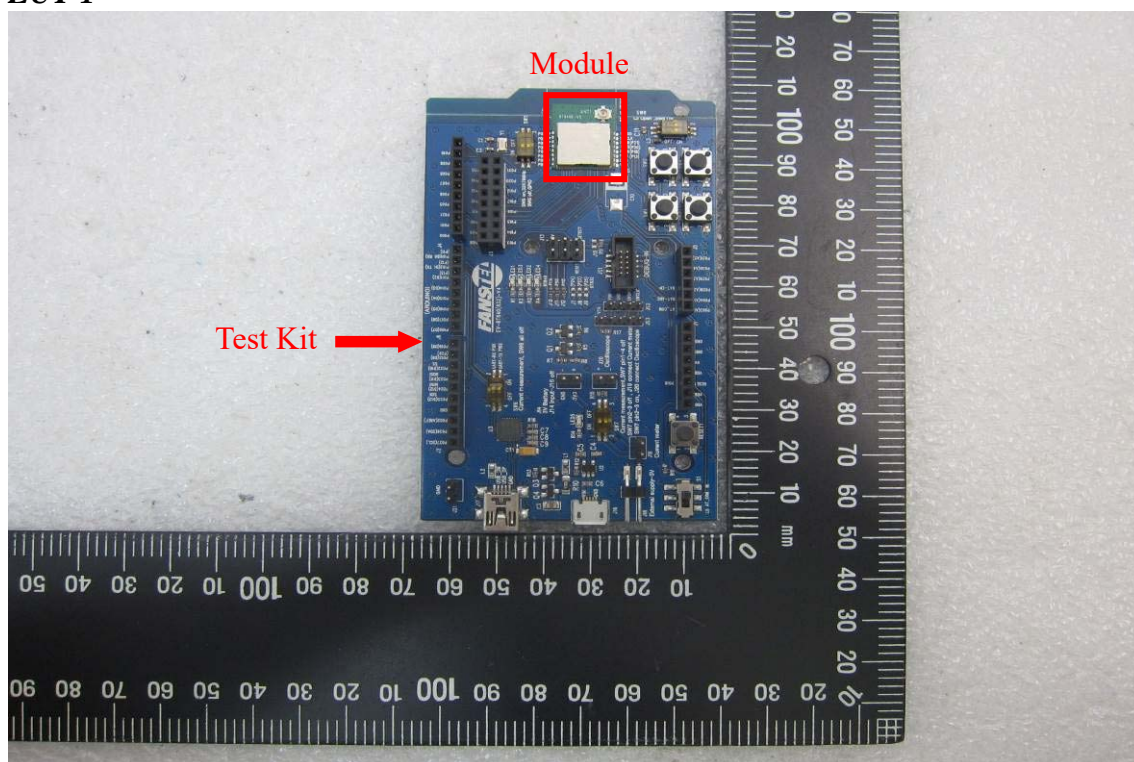
*Test Setup*



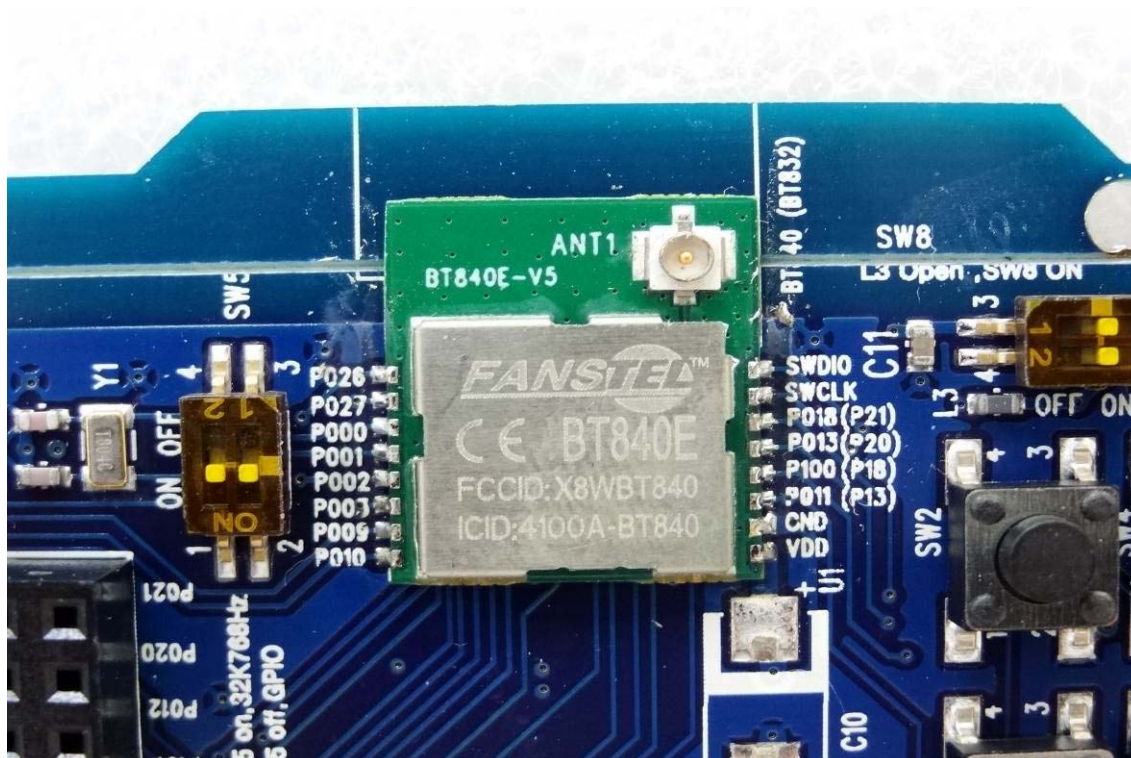
## **Appendix 2**

### **Photographs of EUT**

*EUT 1*



***EUT 2 BT840E***

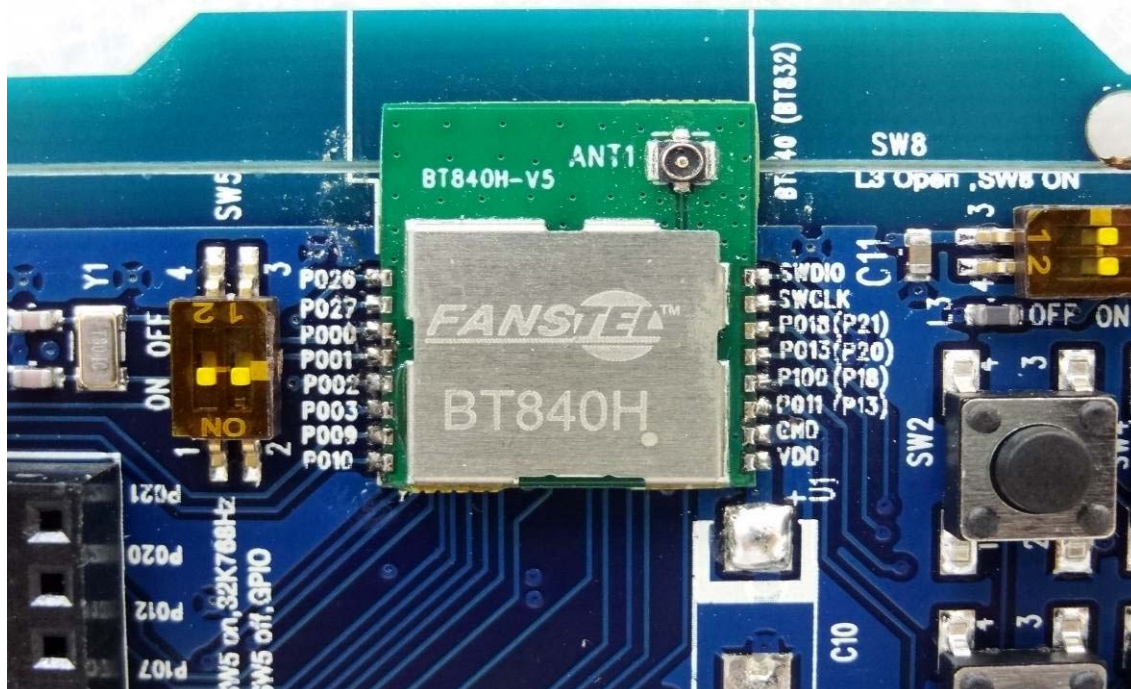




***EUT 3 BT840F***

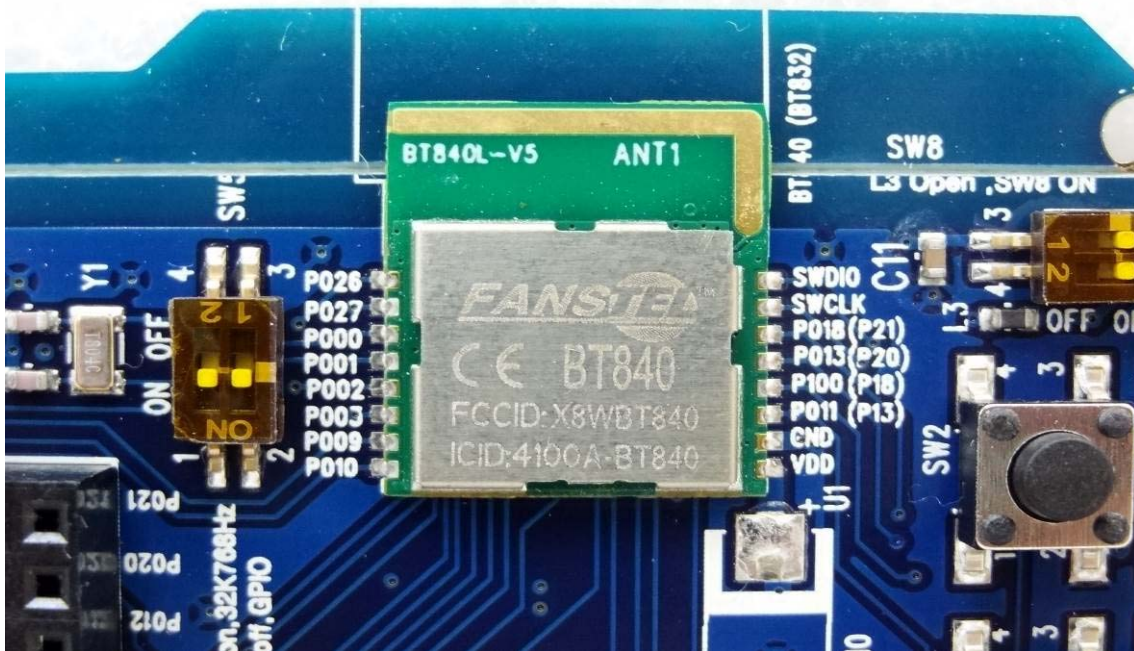


***EUT 4 BT840H***

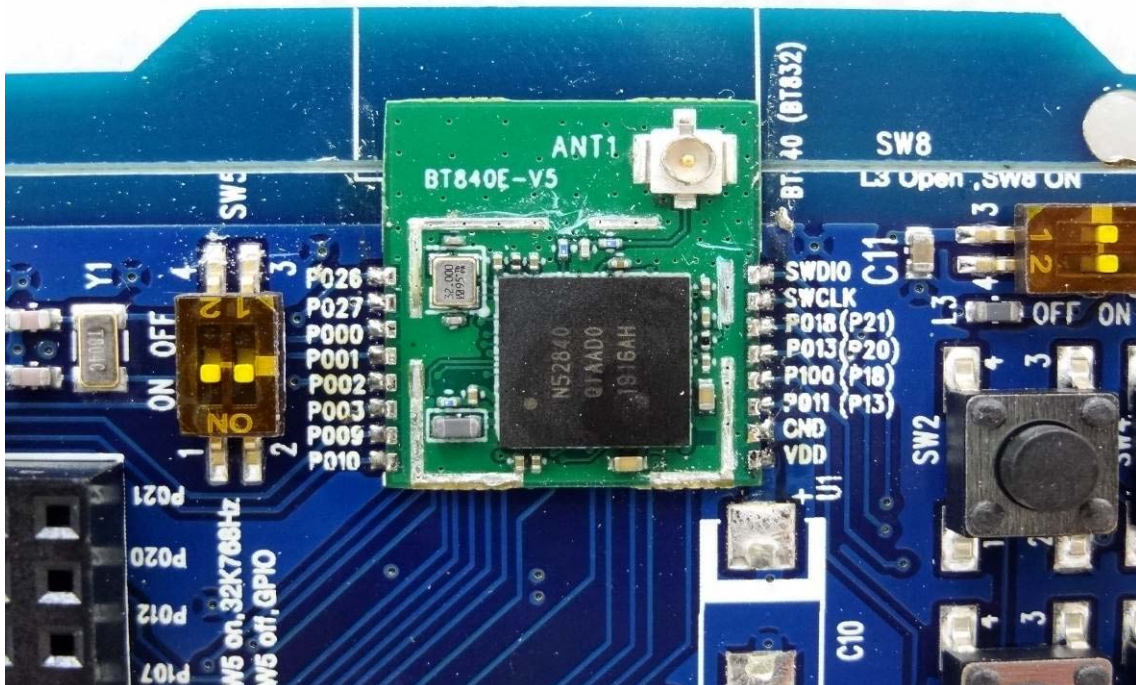




EUT 5 BT840



EUT 6 BT840E

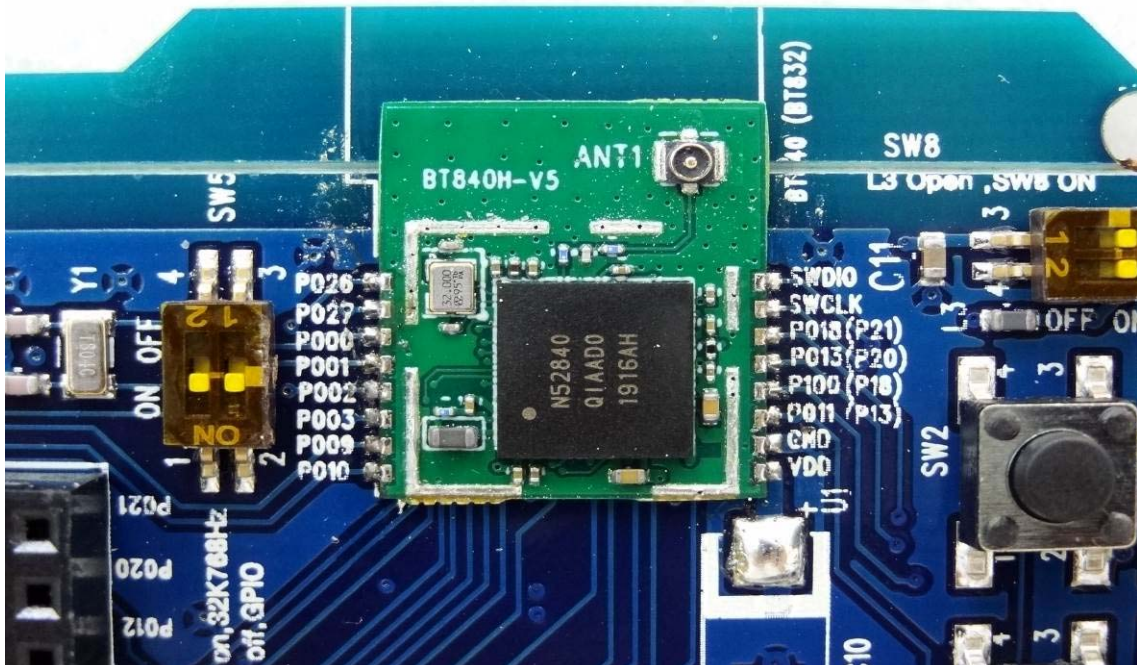




**EUT 7 BT840F**

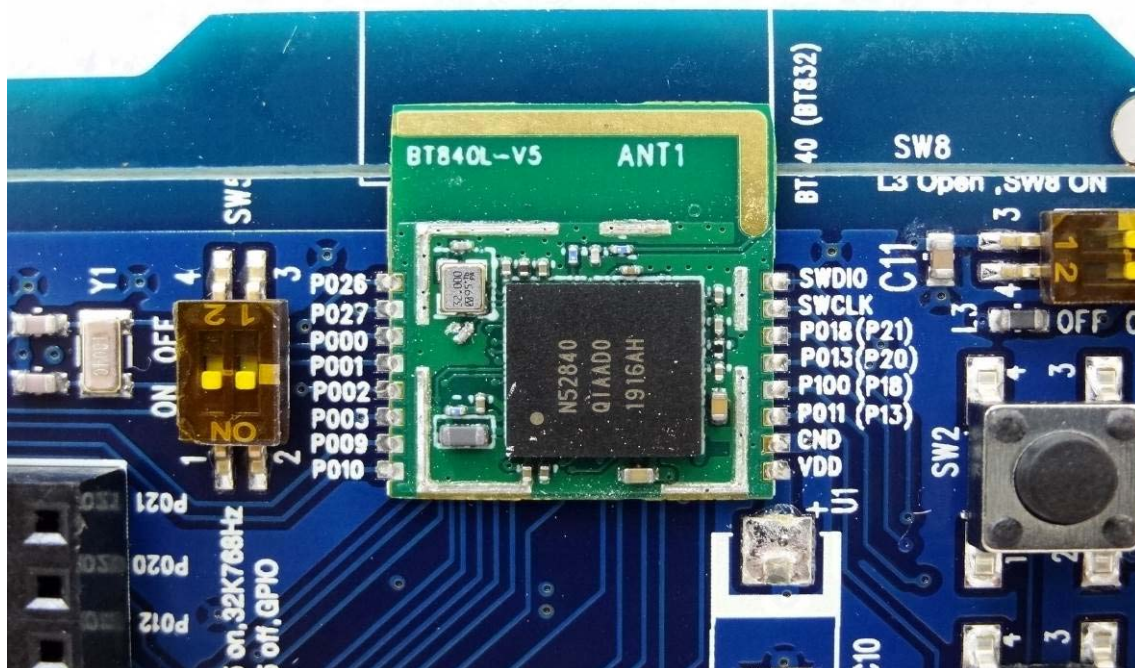


**EUT 8 BT840H**

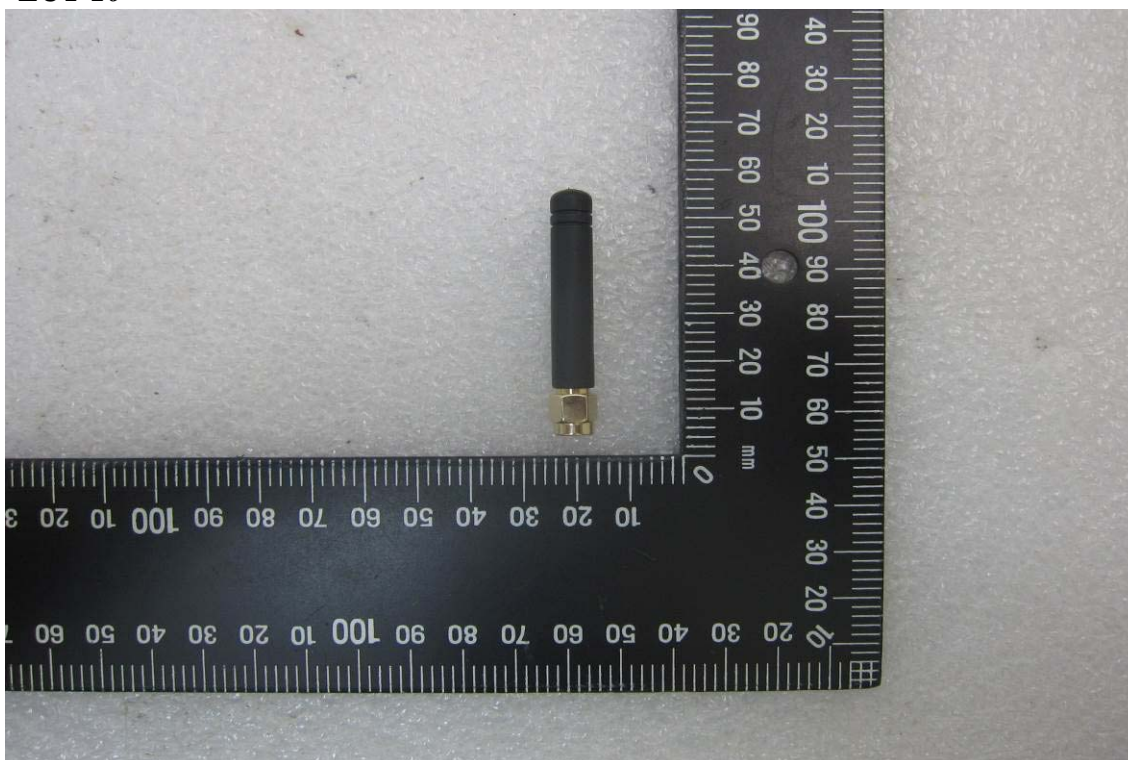




**EUT 9 BT840**



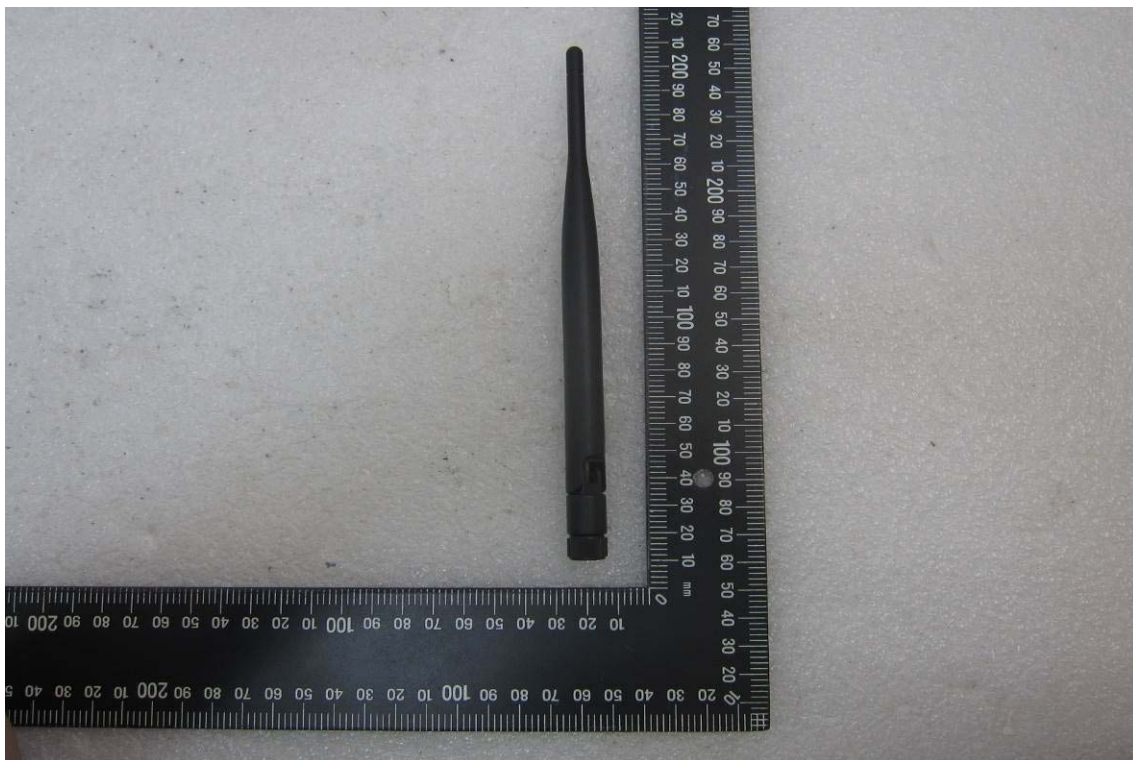
**EUT 10**







**EUT 12**





*~End of Report~*