

Test Report for FCC

FCC ID :2A2Q8-HH-930

Report Number		ESTRFC2109-005	
Applicant	Company name	HicareNet Inc.	
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	Contact person	Chang Yoon Lee	
Product	Product name	Hicare Hub	
	Factory address1	28, Wiryeseong-daero 22-gil, Songpa-gu, Seoul, South Korea	
	Model No.	HH-930	Manufacturer HicareNet Inc.
	Serial No.	NONE	Country of origin KOREA
Test date	06-Sep-21 ~ 14-Sep-21		Date of issue 15-Sep-21
Testing location	140-16, Eongmalli-ro, Majang-myeon, Icheon-si, Gyeonggi-do, Korea		
Standard	FCC PART 15 Subpart C (15.247), ANSI C 63.10(2013)		
Measurement facility registration number		659627	
Tested by	Senior Engineer H.G. Lee		(Signature) 
Reviewed by	Engineering Manager I.K. Hong		(Signature) 
Abbreviation	OK, Pass = Passed, Fail = Failed, N/A = not applicable		
* Note - This test report is not permitted to copy partly without our permission - This test result is dependent on only equipment to be used - This test result based on a single evaluation of one sample of the above mentioned - This test report is not related to KOLAS accreditation			

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Appendix 1. Special diagram for Bluetooth

Appendix 2. Antenna information

1. Laboratory Information

1.1 General

This EUT (Equipment Under Test) has been shown to be capable of compliance with the applicable technical standards and is tested in accordance with the measurement procedures as indicated in this report.

ESTECH Lab attests to accuracy of test data. All measurement reported herein were performed by ESTECH Co., Ltd.

ESTECH Lab assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them.

1.2 Test Lab.

Corporation Name : ESTECH Co., Ltd.

Head Office : Suite 1015 World Meridian III , 123 Gasan Digital 2-ro, Geumcheon-gu,
Seoul 153-759, R.O. Korea

EMC/Telecom/Safety Test Lab : 347-69, Jungbu-daero 147beon-gil, Majang-myeon, Icheon-si,
Gyeonggi-do 467-811, R. O. Korea

1.3 Official Qualification(s)

MSIP : Granted Accreditation from Ministry of Information & Communication for EMC, Safety and Telecommunication

KOLAS : Accredited Lab By Korea Laboratory Accreditation Schema base on CENELEC requirements

FCC : Conformity Assessment Body(CAB) with registration number 659627 under APEC TEL MRA between the RRA and the FCC

VCCI : Granted Accreditation from Voluntary Control Council for Interference from ITE

2. Description of EUT

2.1 Summary of Equipment Under Test (Bluetooth)

Modulation Type	: GFSK(FHSS) , 8DPSK
Transfer Rate	: 3 Mbps
Number of Channel	: 79
Channel Spacing	: 1 MHz
PEAK Output Power	: GFSK : 0.27 mW 8DPSK : 0.26 mW
Rating	: Input:AC 100 V ~ 240 V 50/60 Hz 0.8 A Output:DC 5 V 3 A
Receipt Date	: 19-Jul-21
X-tal list(s) or Frequencies generated	The highest operating frequency is 2480 MHz(Bluetooth) Bluetooth : 2.4 GHz

2.2 General descriptions of EUT

Category	Specification
Main MCU	ESP32 (WiFi, BT 내장)
– MCU	Single core 32 bit Microprocessor
	448 KB ROM
	520 KB SRAM
	4MB FLASH Memory
– Peripheral Interface	34 x Programmable GPIOs
	4 x SPI
	2 x I2C
	3 x UART
– WiFi	802. 11 b/g/n
	802.11 n(2.4GHz) up to 150Mbps
– BT	Compliant with Bluetooth v4.2 BDR/EDR and
	BLE Specification
	+12 dBm Transmitting power
	NZIF receiver with –94 dBm BLE sensitivity
USB Controller	USB2412
– Client	2 Ports



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Category	Specification
- Function	Table fast charging mode (1.5 A)
	(USB Host Mode)
USB Host	STM32 USB Host
-USB Host	Modem
-LAN	WiFi AP
-WAN	PPP-PSTN Modem
F/W Download	(OTA) Download
Power	AC Adapter (5V/3A)
Dimension (WDH)	280x130x25(88) mm

3. Test Standards

Test Standard : FCC PART 15 Subpart C (15.247)

This Standard sets out the regulations under which an intentional, unintentional, or incidental radiator may be operated without an individual license. It also contains the technical specifications, administrative requirements and other conditions relating to the marketing of Part 15 devices.

Test Method : ANSI C 63.10 (2013)

This standard sets forth uniform methods of measurement of radio-frequency (RF) signals and noise emitted from both unintentional and intentional emitters of RF energy in the frequency range 9 kHz to 40 GHz. Methods for the measurement of radiated and AC power-line conducted radio noise are covered and may be applied to any such equipment unless otherwise specified by individual equipment requirements. These methods cover measurement of certain devices that deliberately radiate energy, such as intentional emitters, but does not cover licensed transmitters. This standard is not intended for certification/approval of avionic equipment or for industrial, scientific, and medical (ISM) equipment. These methods apply to the measurement of individual units or systems comprised of multiple units.

Summary of Test Results

Applied Standard : 47 CFR Part 15 Subpart C				remark
FCC Standard	Test Type	Result	Remark	Limit
15.207	AC Power Conducted Emission	Pass		
15.205 & 15.209	Intentional Radiated Emission	Pass	Meet the requirement	
15.247(a)(1)	Carrier Frequency Separation & 20 Bandwidth ,99% Bandwidth	Pass	Meet the requirement	>25 kHz
15.247(b)	Maximum Peak output power	Pass	Meet the requirement	30dBm(1W)
15.247(a)(1)(ii)	Number of Hopping Frequency	Pass	Meet the requirement	>75
15.209	Transmitter Radiated Emission	Pass	Meet the requirement	
15.247(a)(1)(iii)	Time of Occupancy (Dwell Time)	Pass	Meet the requirement	<400ms
15.247(d)	Band Edge Measurement	Pass	Meet the requirement	

4. Measurement Condition

4.1 EUT Operation

a. Channel

Ch.	Frequency	Ch.	Frequency
0	2402 MHz	40	2442 MHz
1	2403 MHz	41	2443 MHz
2	2404 MHz	42	2444 MHz
3	2405 MHz	43	2445 MHz
4	2406 MHz	...	...
...	...	78	2480 MHz
38	2440 MHz		

b. Measurement Channel : Low (2402 MHz), Middle (2440 MHz), High (2480 MHz)

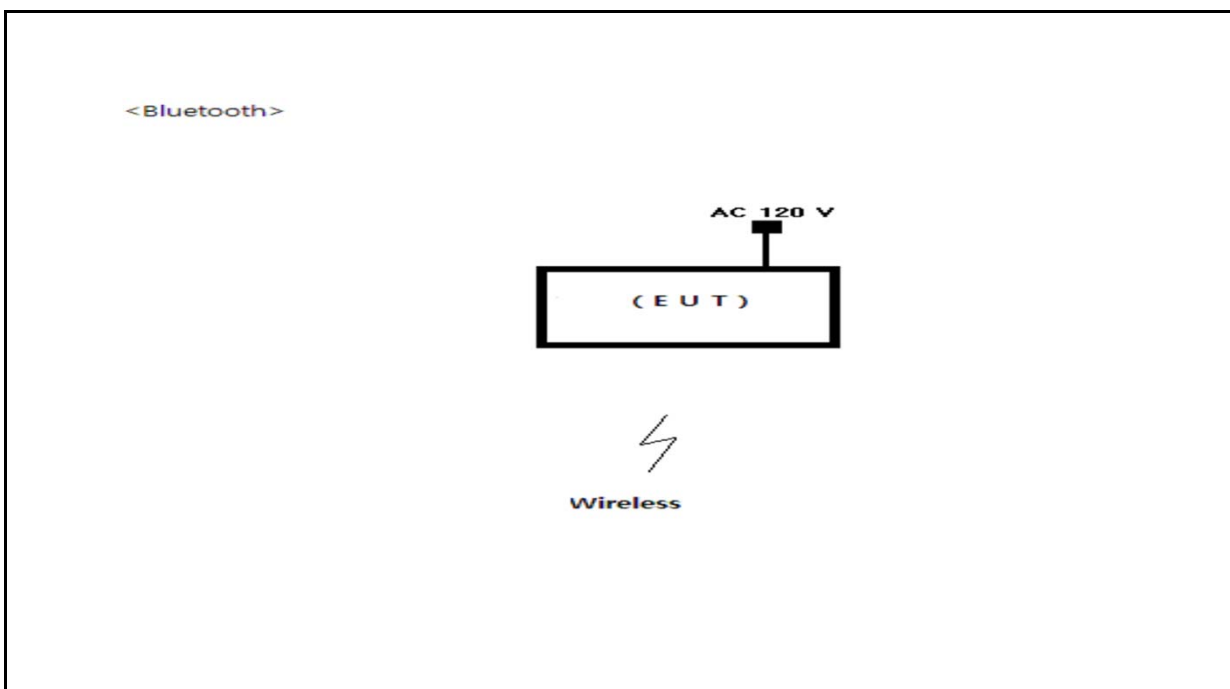
c. Test Mode : 8DPSK, GFSK (worst case)

d. Test rate : 3 Mbps

4.2 EUT Operation.

- * The EUT was in the following operation mode during all testing
- * The operational conditions of the EUT was determined by the manufacturer according to emission
- * Execute a RF test program to enable EUT under transmission/receiving condition continuously at specific channel frequency.
- * Transmit mode was each test. Each channel (low, middle, high), also set the test after
- * The EUT was measured up to tenth harmonic or 40 GHz of the highest operating frequencies.

4.3 Configuration and Peripherals



4.4 EUT and Support equipment

Equipment Name	Model Name	S/N	Manufacturer	Remark (FCC ID)
Hicare Hub	HH-930	NONE	HicareNet Inc.	EUT
Adapter	SAW30-050-3000U	NONE	VLL POWER	

4.5 Cable Connecting

Start Equipment		End Equipment		Cable Standard		Remark
Name	I/O port	Name	I/O port	Length	Shielded	
Hicare Hub	Power	Adapter	–	2.0	Unshielded	

5. Carrier Frequency Separation

5.1 Test procedure

According to §15.247(a)(1), Frequency hopping systems shall have hopping channel carrier frequencies separated by minimum of 25kHz or the 20dB bandwidth of the hopping channel, whichever is greater.

5.2 Test instruments and measurement setup

The spectrum analyzer is set to as following.

- . RBW= 30 KHz
- . VBW= 300 KHz
- . Span= 3 MHz
- . Sweep= suitable duration based on the EUT specification.

20dB Bandwidth Test Instruments

Description	Model	Serial Number	Cal. Due Date
Spectrum Analyzer	E4440A	US42041291	2021-Dec-01
-Spectrum Analyzer <=> EUT	Loss: 1 dB	–	

5.3 Measurement results

EUT	Hicare Hub	MODEL	HH-930
MODE	GFSK,8DPSK	ENVIRONMENTAL CONDITION	23 °C, 40 % R.H .
INPUT POWER	DC 5.0 V		

(GFSK)

CHANNEL	Channel Frequency (MHz)	Bandwidth at 99% (kHz)	Bandwidth at 20dB below(kHz)	Channel Separation (kHz)	Limit (kHz)	PASS/FAIL
0	2402	841	943	1000	629	PASS
38	2440	866	946	1000	631	PASS
78	2480	862	954	1000	636	PASS



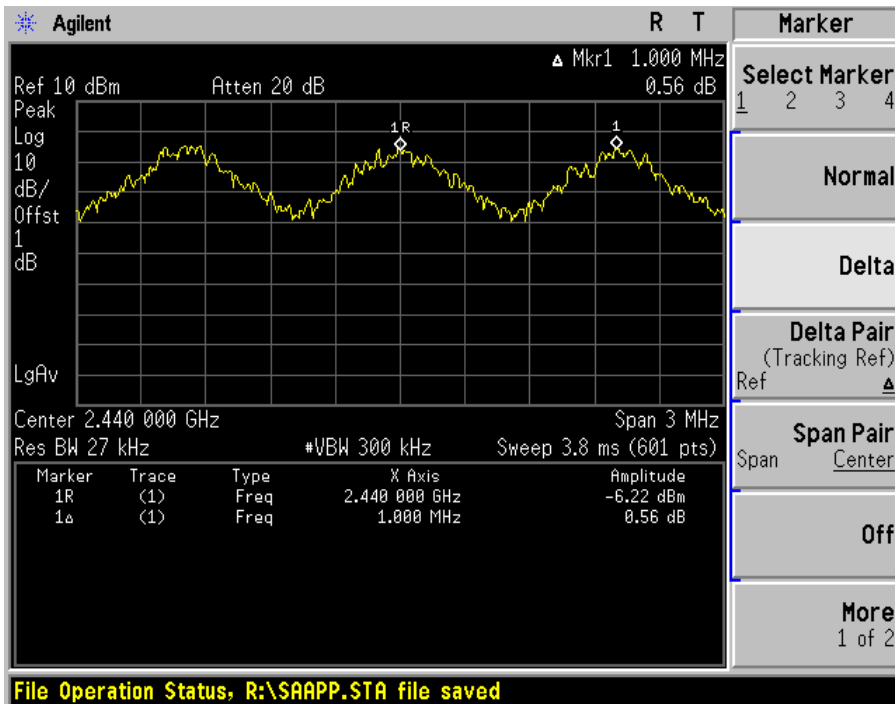
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(8DPSK)

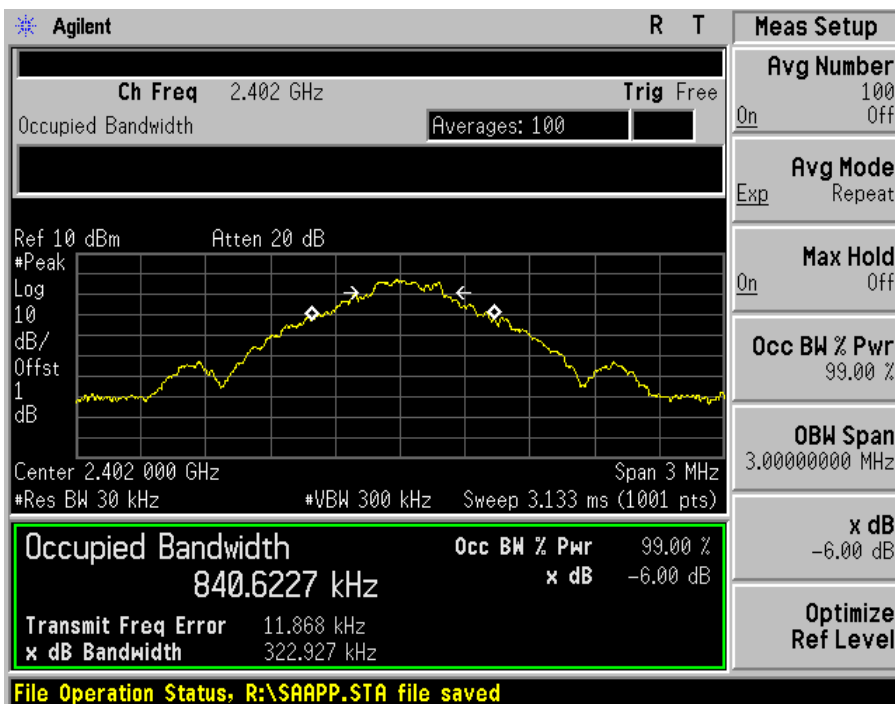
CHANNEL	Channel Frequency (MHz)	Bandwidth at 99% (MHz)	Bandwidth at 20dB below(kHz)	Channel Separation (kHz)	Limit (kHz)	PASS/FAIL
0	2402	1.080	1202	1000	801	PASS
38	2440	1.080	1225	1000	817	PASS
78	2480	1.080	1229	1000	819	PASS

5.4 Trace data (GFSK)

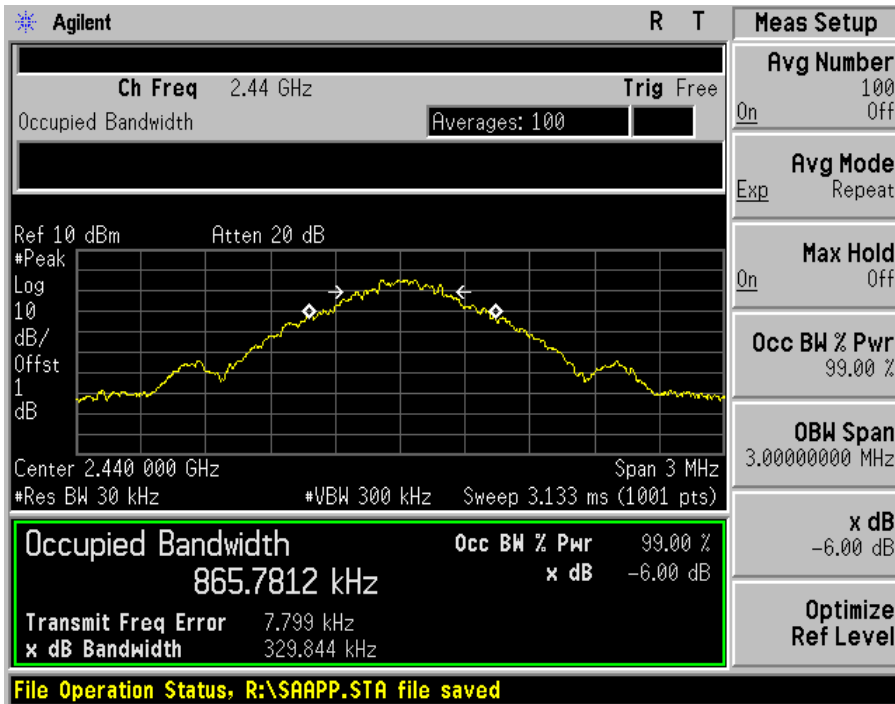
Channel Separation



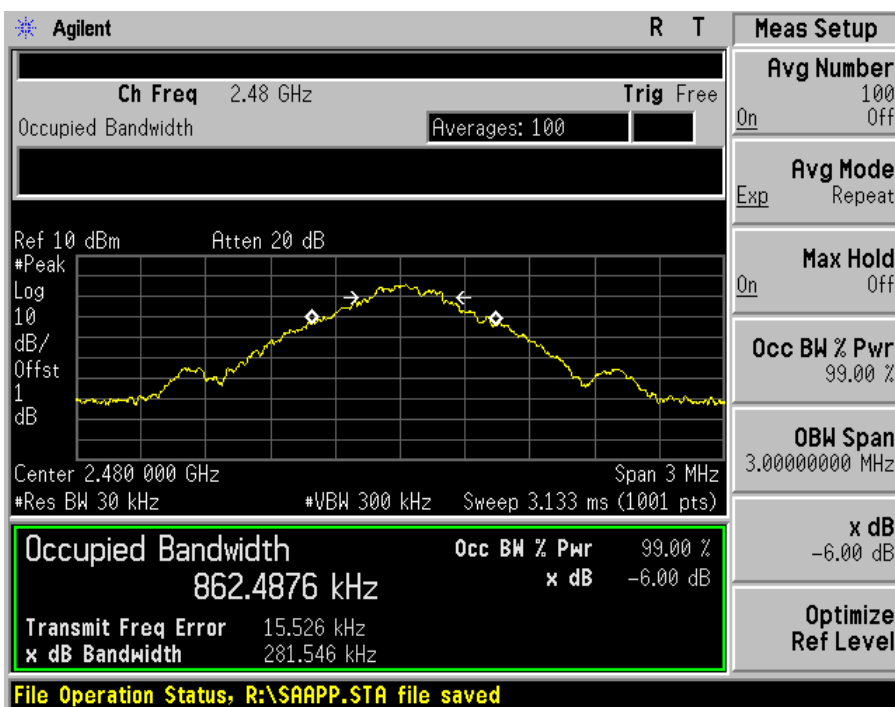
20dB bandwidth(Ch 0)



20dB bandwidth(CH 38)



20dB bandwidth(CH 78)

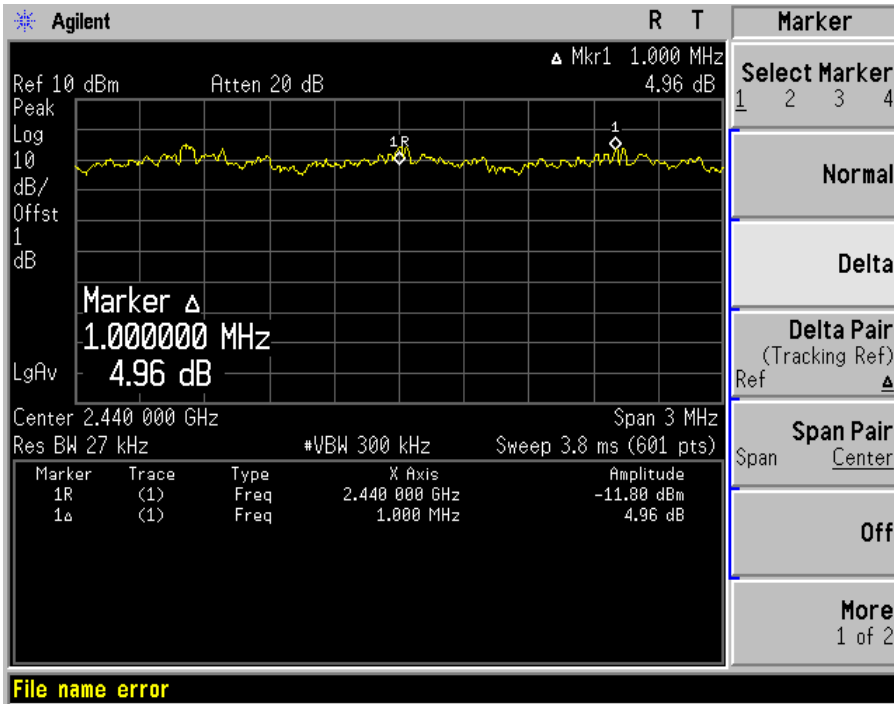




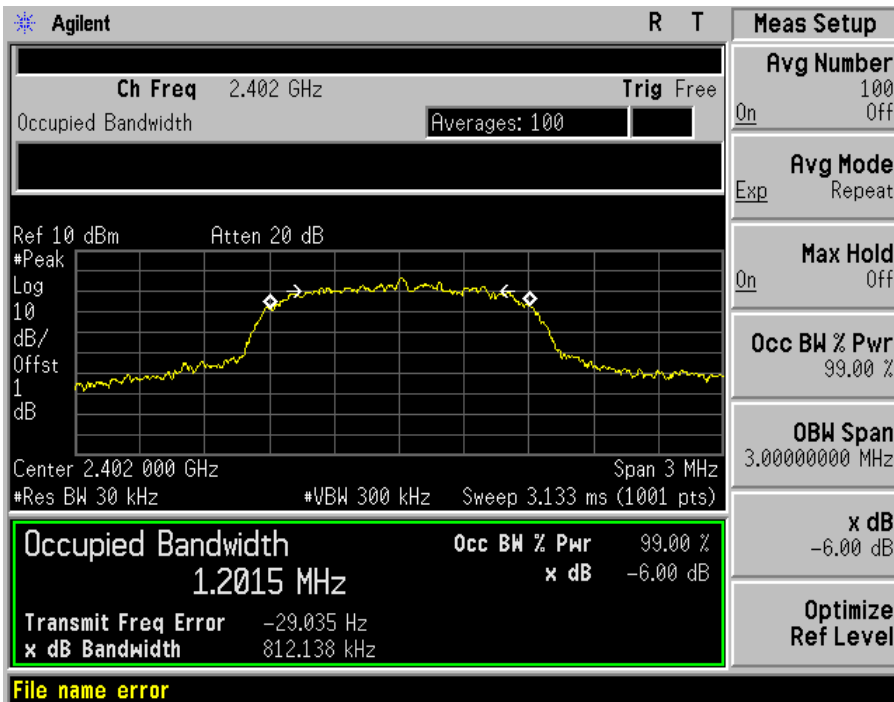
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(8DPSK)

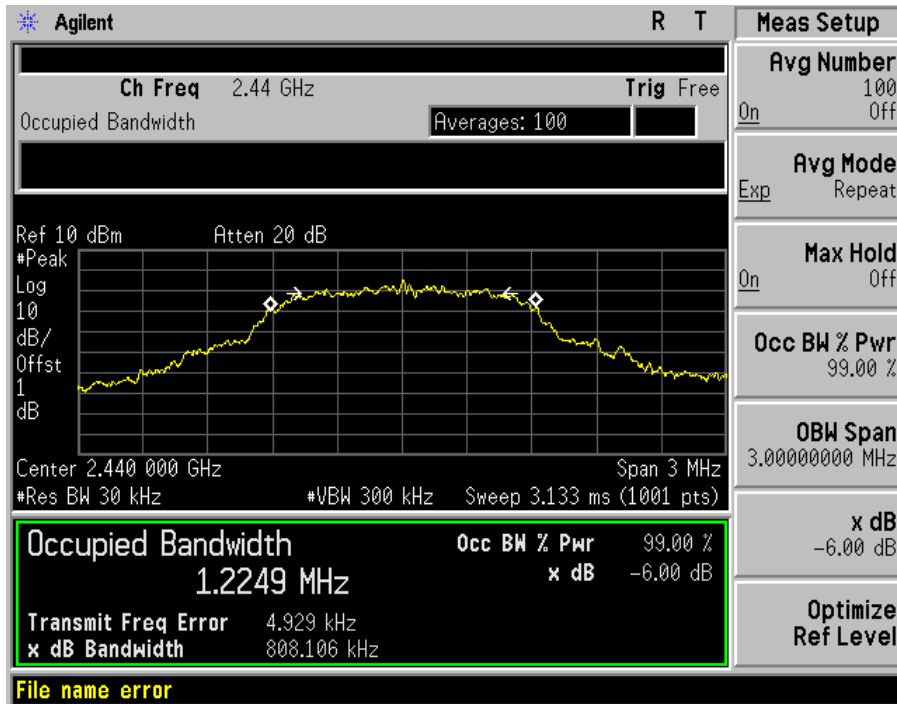
Channel Separation



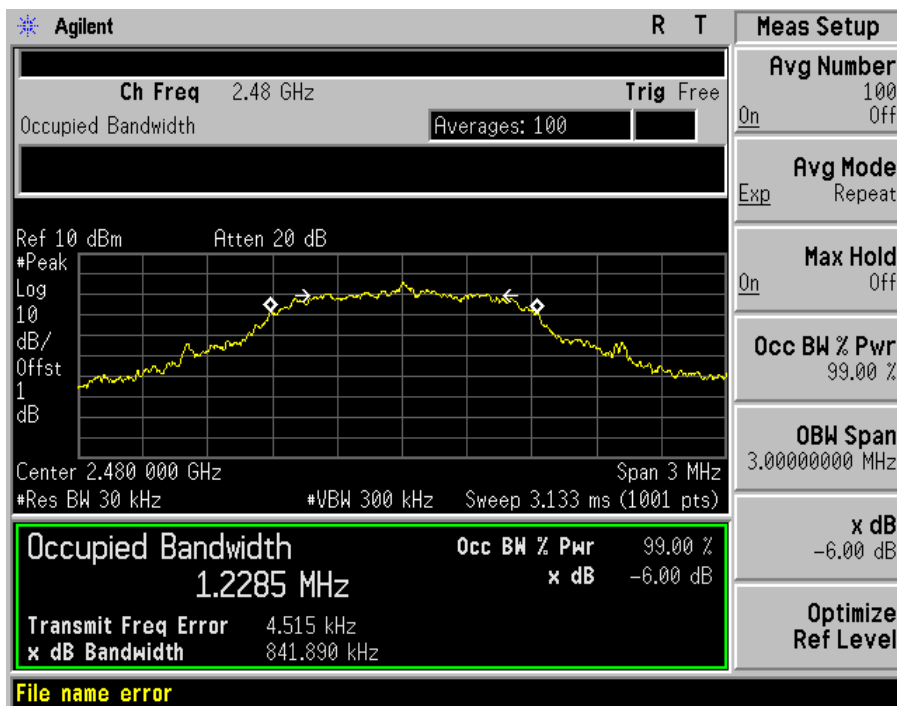
20dB bandwidth(Ch 0)



20dB bandwidth(CH 38)



20dB bandwidth(CH 78)



6. MAXIMUM PEAK OUTPUT POWER

6.1 Test procedure

The transmitter antenna terminal is connected to the input of a Power Sensor. Measurement is made while EUT is operating in transmission mode at the appropriate center frequency. The maximum peak output power measurement is 30 dBm.

Description	Model	Serial Number	Cal. Due Date
Power Meter	N1921A	MY45100570	2021-12-01
Power Sensor	N1921A	MY45240427	2021-12-01
Power Meter <=> EUT	Loss: 1 dB	–	

6.2 Measurement results

EUT	Hicare Hub	MODEL	HH-930
MODE	GFSK,8DPSK	ENVIRONMENTAL CONDITION	23 °C, 41 % R.H.
INPUT POWER	DC 5.0 V		

GFSK

CHANNEL	Channel Frequency (MHz)	Peak Power Output(dBm)		Limit[mW]	PASS/ FAIL
		(dBm)	(mW)		
0	2402	–5.70	0.27	125	PASS
38	2440	–6.00	0.25	125	PASS
78	2480	–5.80	0.26	125	PASS

8DPSK

CHANNEL	Channel Frequency (MHz)	Peak Power Output(dBm)		Limit[mW]	PASS/ FAIL
		(dBm)	(mW)		
0	2402	–5.80	0.26	125	PASS
38	2440	–5.90	0.26	125	PASS
78	2480	–6.10	0.25	125	PASS



GFSK

CHANNEL	Channel Frequency (MHz)	Average Power Output(dBm)			Limit[mW]	PASS/FAIL
		(dBm)	(mW)	factor		
0	2402	-15.40	0.03	1.20	125	PASS
38	2440	-15.70	0.03	1.20	125	PASS
78	2480	-15.30	0.03	1.20	125	PASS

8DPSK

CHANNEL	Channel Frequency (MHz)	Average Power Output(dBm)			Limit[mW]	PASS/FAIL
		(dBm)	(mW)	factor		
0	2402	-15.50	0.03	1.18	125	PASS
38	2440	-15.90	0.03	1.18	125	PASS
78	2480	-16.00	0.03	1.18	125	PASS

Note : 8DPSK mode is max power in three different modulations.

7. Number of Hopping Frequency

7.1 Test procedure

According to §15.247(a)(1)(ii), Frequency hopping systems operating in the 2 400 MHz – 2 483.5 MHz bands shall use at least 15 hopping frequencies.

7.2 Test instruments and measurement setup

The spectrum analyzer is set to as following.

- . RBW= 100 KHz
- . VBW= 100 KHz
- . Span= the frequency band of operation
- . Sweep= suitable duration based on the EUT specification.

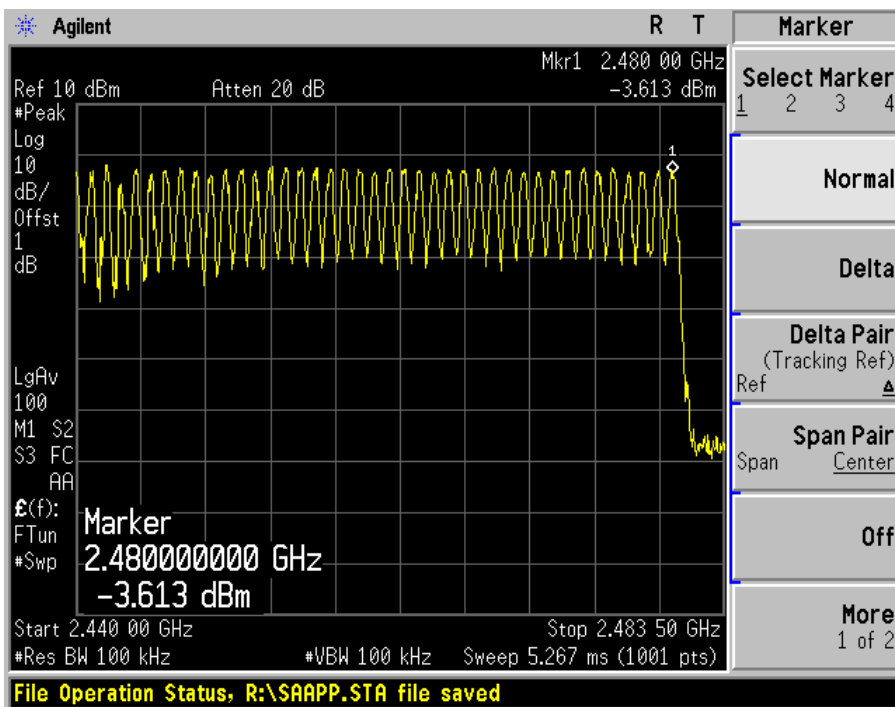
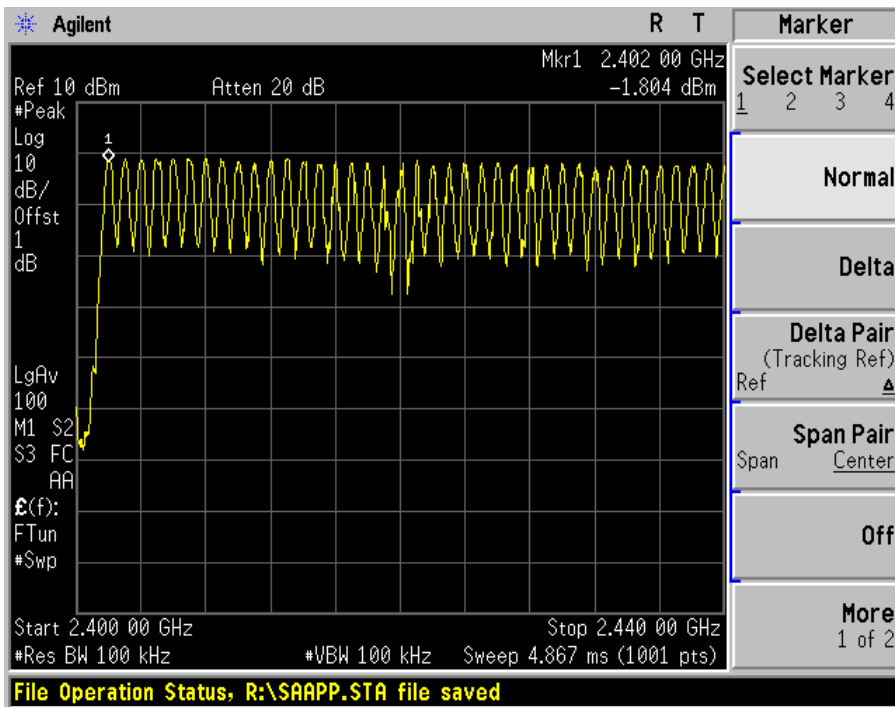
The Number of Hopping Frequency Test Instruments

Description	Model	Serial Number	Cal. Due Date
Spectrum Analyzer	E4440A	US42041291	2021-12-01
-Spectrum Analyzer <=> EUT	Loss: 1 dB		

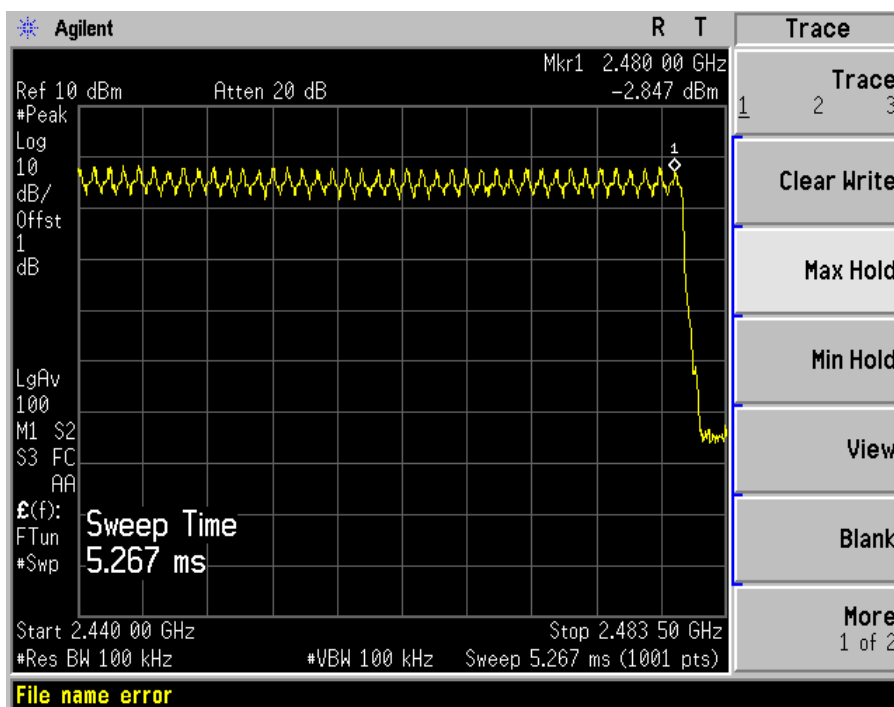
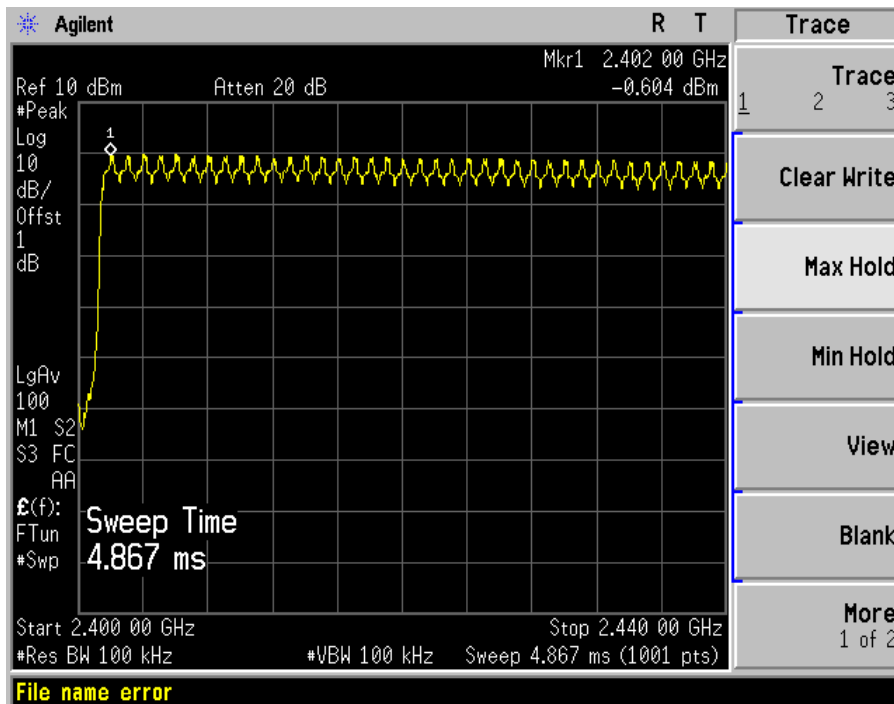
7.3 Measurement results

EUT	Hicare Hub	MODEL	HH-930
MODE	GFSK,8DPSK	ENVIRONMENTAL CONDITION	23 °C, 42 % R.H.
INPUT POWER	DC 5.0 V		
Number of CH	Limit (Number of CH)	PASS/FAIL	
79	>15	PASS	

7.4 Trace data(GFSK)



7.4 Trace data(8DPSK)



8. Time of Occupancy (Dwell Time)

8.1 Test procedure

According to §15.247(a)(1)(iii), Frequency hopping systems operating in the 2 400 MHz – 2 483.5 MHz bands. The average time of occupancy on any channels shall not greater than 0.4 s within a period 0.4 s multiplied by the number of hopping channels employed.

8.2 Test instruments and measurement setup

The spectrum analyzer is set to as following.

- . RBW= 1 MHz
- . VBW= 1 MHz
- . Span= zero span, centered on a hopping channel
- . Sweep = as necessary to capture the entire dwell time per hopping channel
- . Detector function = Peak
- . Trace = Max hold

The Time of Occupancy Test Instruments

Description	Model	Serial Number	Cal. Due Date
Spectrum Analyzer	E4440A	US42041291	2020-12-01
-Spectrum Analyzer <=> EUT	Loss: 1 dB		

8.3 Measurement results

EUT	Hicare Hub	MODEL	HH-930
MODE	GFSK,8DPSK	ENVIRONMENTAL CONDITION	23 °C, 43 % R.H.
INPUT POWER	DC 5.0 V		

A. DH1 Mode

One period for each particular channel : $0.4498 \text{ ms} \times 320.1 = 143.98 \text{ ms}$

Channel	Pulse Time(ms)	Limit(ms)	PASS/FAIL
38	91.23	400	PASS

Calculation: The Bluetooth system hops at a rate of 1600 times per second. This means there are 1600 timeslots in one second, the DH1 data rate operates on a one-slot transmission and one-slot receiving basis. Thus there are $1600/(1+1)=800$ transmissions per second. In one period for each particular channel there are $10.13 \times 31.6 = 320.1$ times of transmissions.

B. DH3 Mode

One period for each particular channel : $1.692 \text{ ms} \times 159.9 = 270.55 \text{ ms}$

Channel	Pulse Time(ms)	Limit(ms)	PASS/FAIL
38	270.55	400	PASS

Calculation: The Bluetooth system hops at a rate of 1600 times per second. This means there are 1600 timeslots in one second, the DH3 data rate operates on a three-slot transmission and one-slot receiving basis. Thus there are $1600/(3+1)=400$ transmissions per second. In one period for each particular channel there are $5.06 \times 31.6 = 159.9$ times of transmissions.

C. DH5 Mode

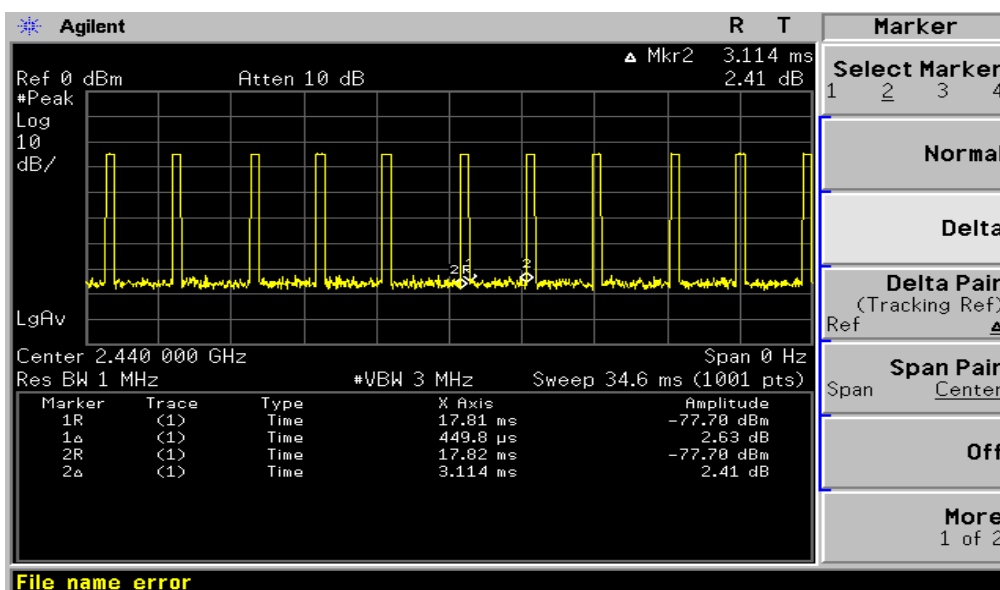
One period for each particular channel : $2.9565 \text{ ms} \times 106.81 = 315.78 \text{ ms}$

Channel	Pulse Time(ms)	Limit(ms)	PASS/FAIL
38	315.78	400	PASS

Calculation: The Bluetooth system hops at a rate of 1600 times per second. This means there are 1600 timeslots in one second, the DH5 data rate operates on a five-slot transmission and one-slot receiving basis. Thus there are $1600/(5+1)=266.7$ transmissions per second. In one period for each particular channel there are $3.38 \times 31.6 = 106.81$ times of transmissions.

8.4 Trace data

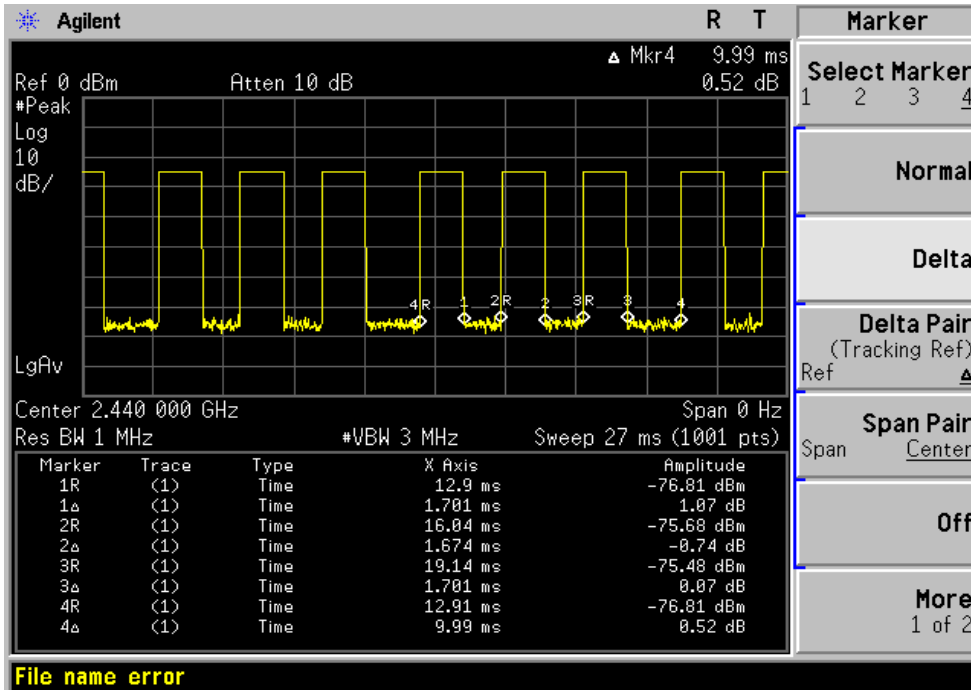
DH1



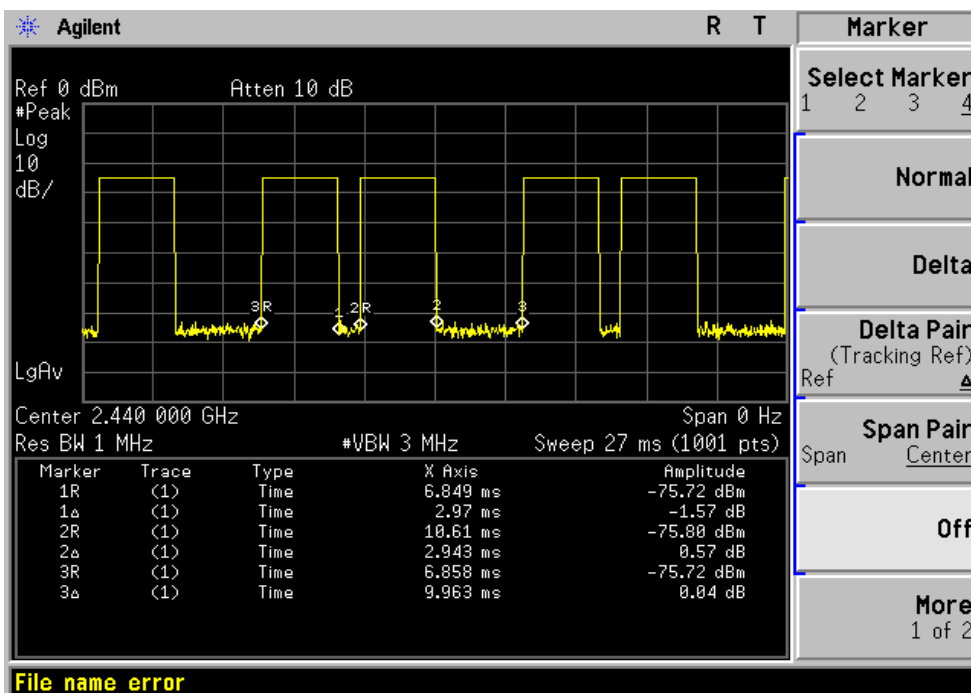


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DH3



DH5



8DPSK

A. 1DH5 Mode

One period for each particular channel : $0.516 \text{ ms} \times 320.1 = 166.13 \text{ ms}$

Channel	Pulse Time(ms)	Limit (ms)	PASS/FAIL
39	166.13	400	PASS

B. 3DH5 Mode

One period for each particular channel : $1.7533 \text{ ms} \times 159.9 = 280.35 \text{ ms}$

Channel	Pulse Time(ms)	Limit (ms)	PASS/FAIL
39	280.35	400	PASS

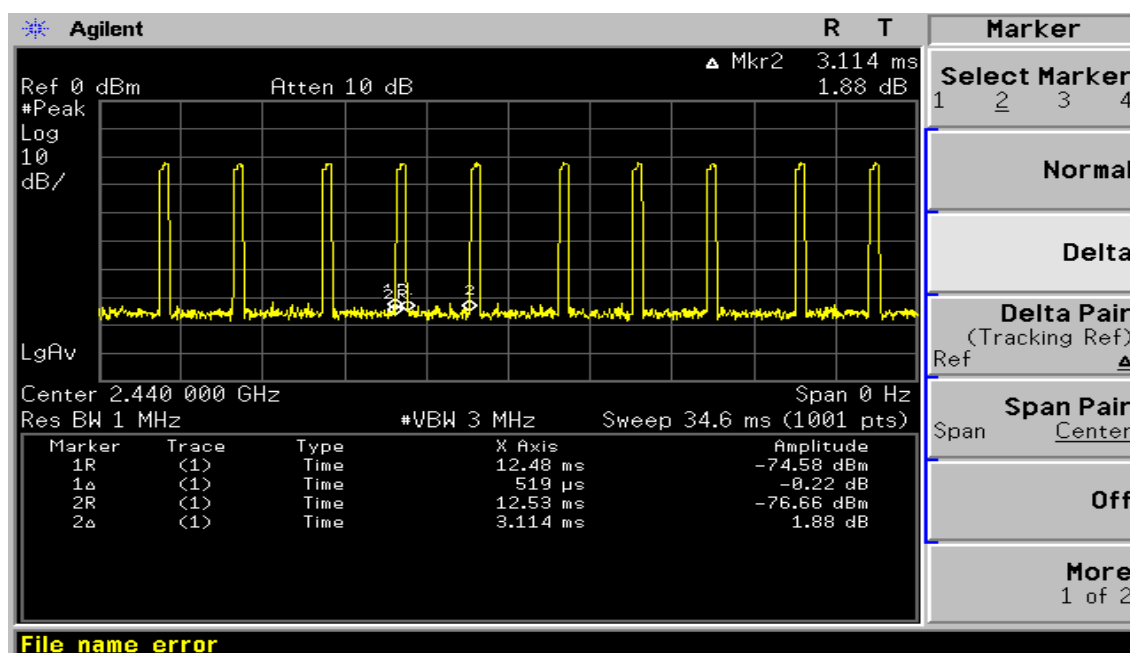
B. 3DH5 Mode

One period for each particular channel : $3.0275 \text{ ms} \times 106.81 = 323.37 \text{ ms}$

Channel	Pulse Time(ms)	Limit (ms)	PASS/FAIL
39	323.37	400	PASS

8.5 Trace data

1DH5

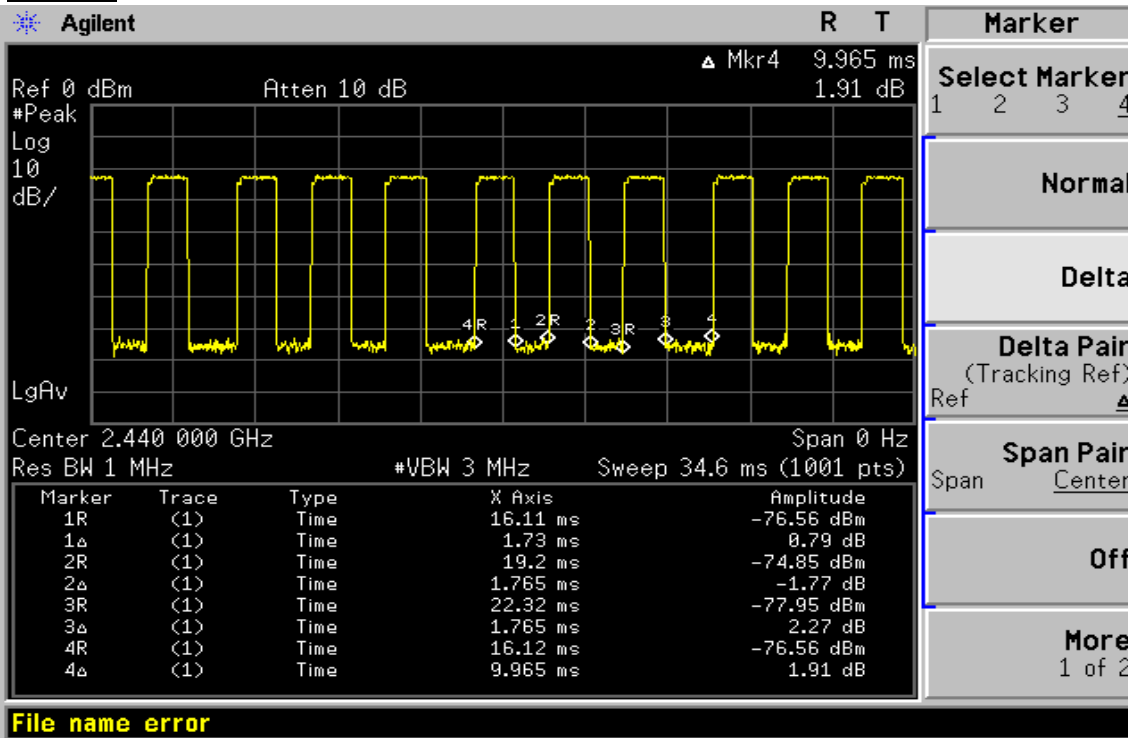




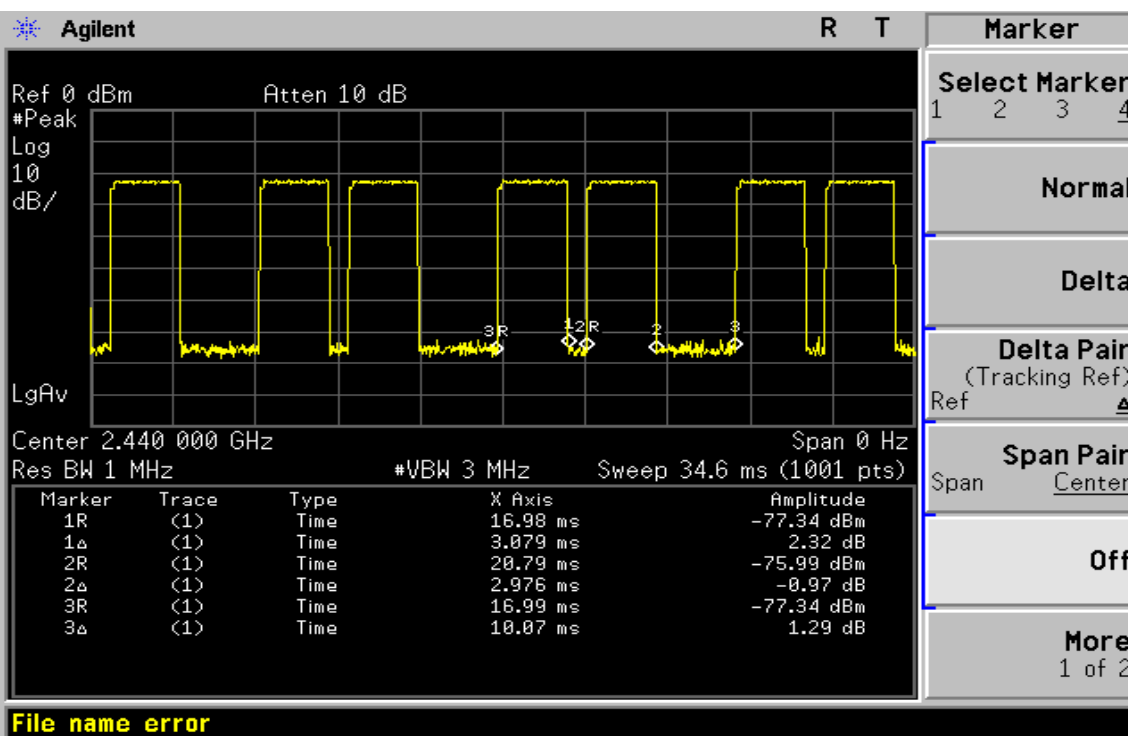
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8DPSK

2DH5



3DH5



9. band-edge and out of band emissions.

9.1 Test procedure

The radio frequency power at 20dB down from the highest inband power level is measured with a spectrum analyzer connected to the antenna terminal, while EUT is operating in transmission mode at the appropriate center frequency. The band edge&out of band emission shall be at least 20dB below of the highest inband power level.

9.2 Test instruments and measurement setup

The spectrum analyzer is set to as following.

- . RBW= 100 KHz
- . VBW= >100 KHz
- . Span= suitable frequency span
- . Sweep= suitable duration based on the EUT specification.

Band Edge&Out of Emission Test Instruments

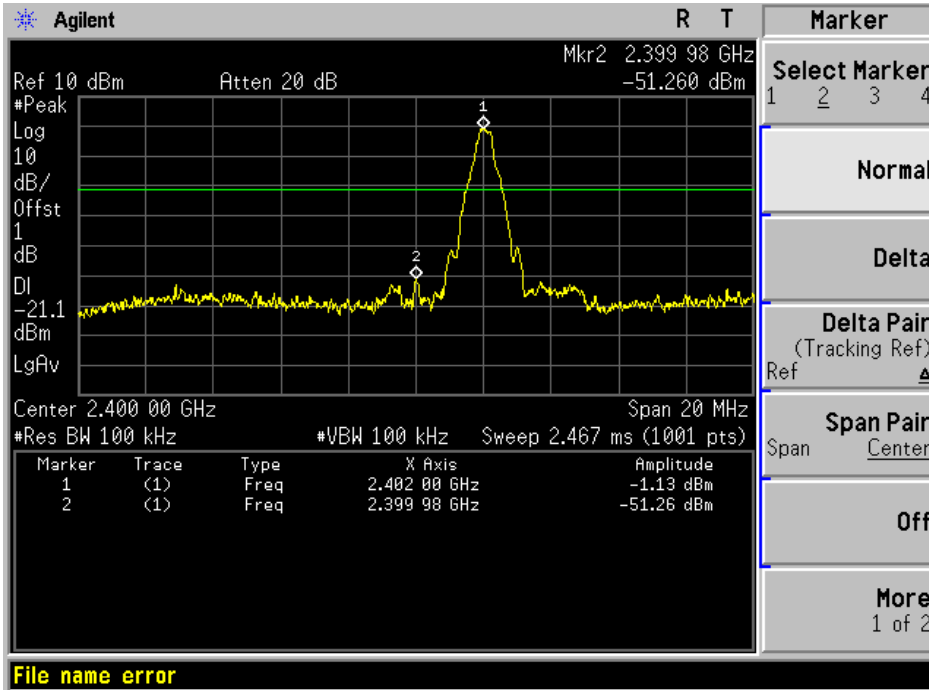
Description	Model	Serial Number	Cal. Due Date
Spectrum Analyzer	E4440A	US42041291	2021-12-01
Spectrum Analyzer	FSV40	100939	2021-12-01
-Spectrum Analyzer <=> EUT	Loss: 1 dB		

9.3 Measurement results of band-edge & out of emission

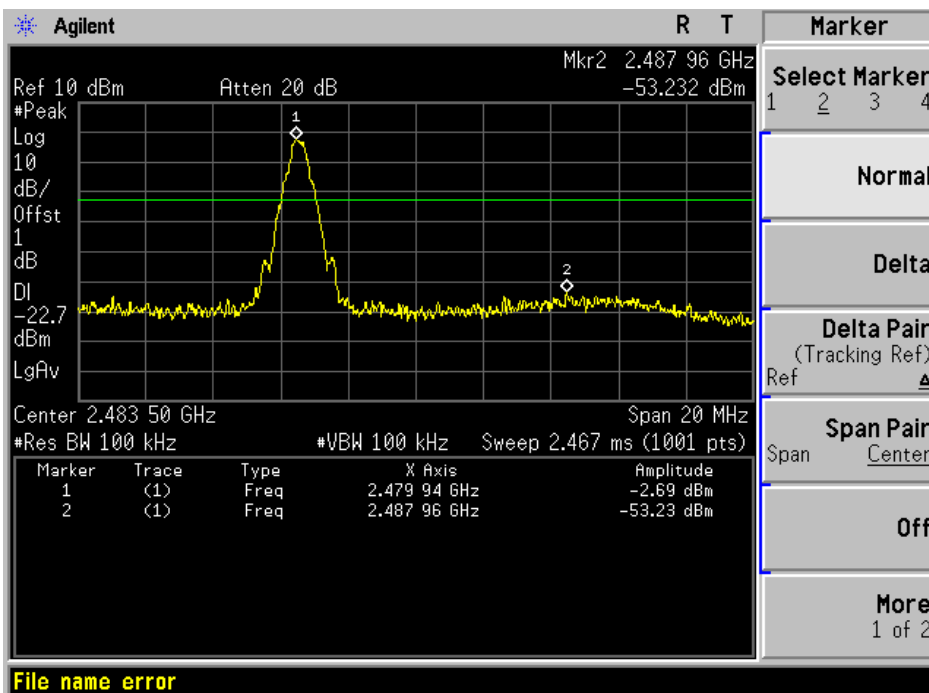
EUT	Hicare Hub	MODEL	HH-930
MODE	GFSK,8DPSK	ENVIRONMENTAL CONDITION	23 °C, 42 % R.H.
INPUT POWER	DC 5.0 V		

* Refer to attach spectrum analyzer data chart.

9.4 Trace data of band-edge & Out of Emission CH0 (GFSK)



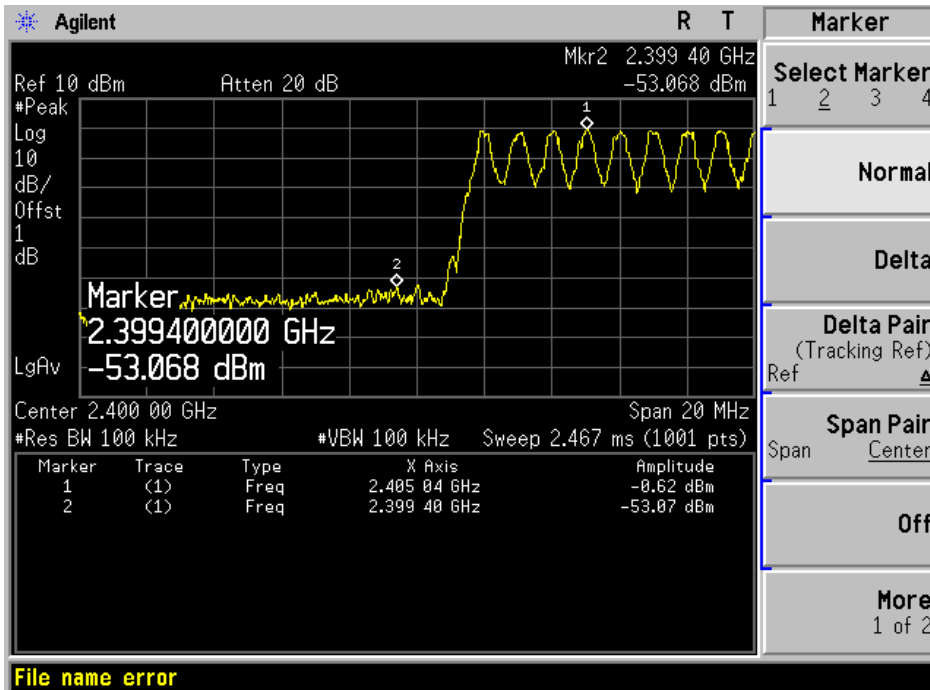
CH78



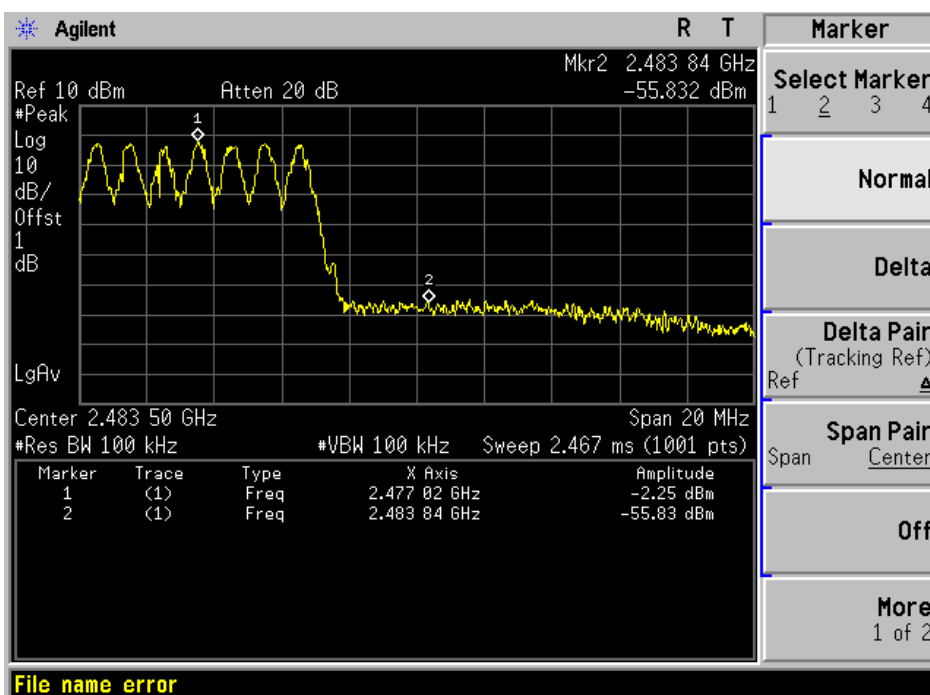


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CH0



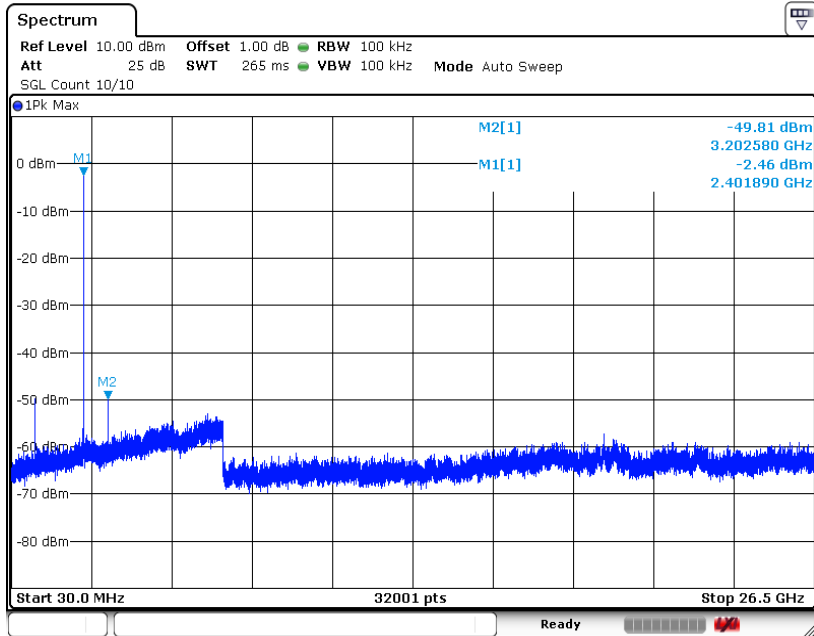
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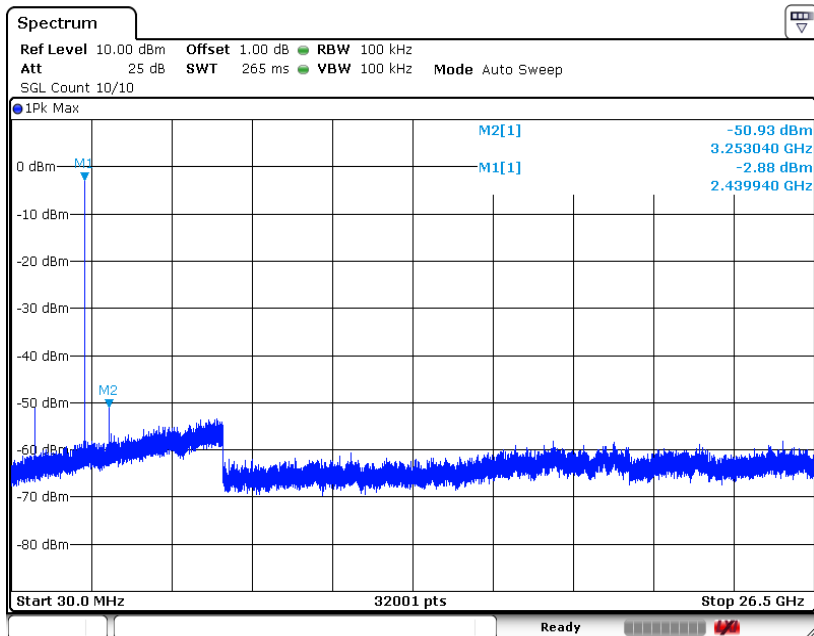
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CH0



ESTR-21-00225

CH38

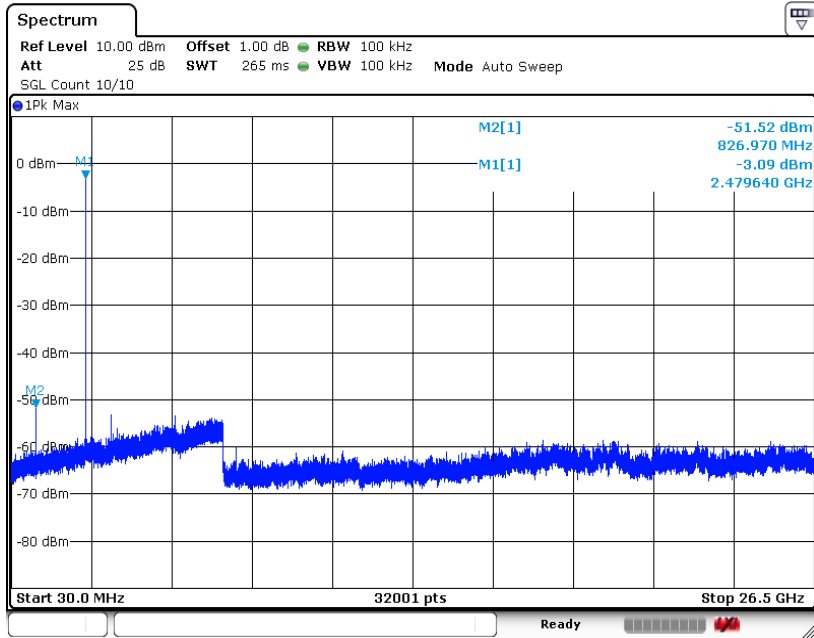


ESTR-21-00225



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CH78



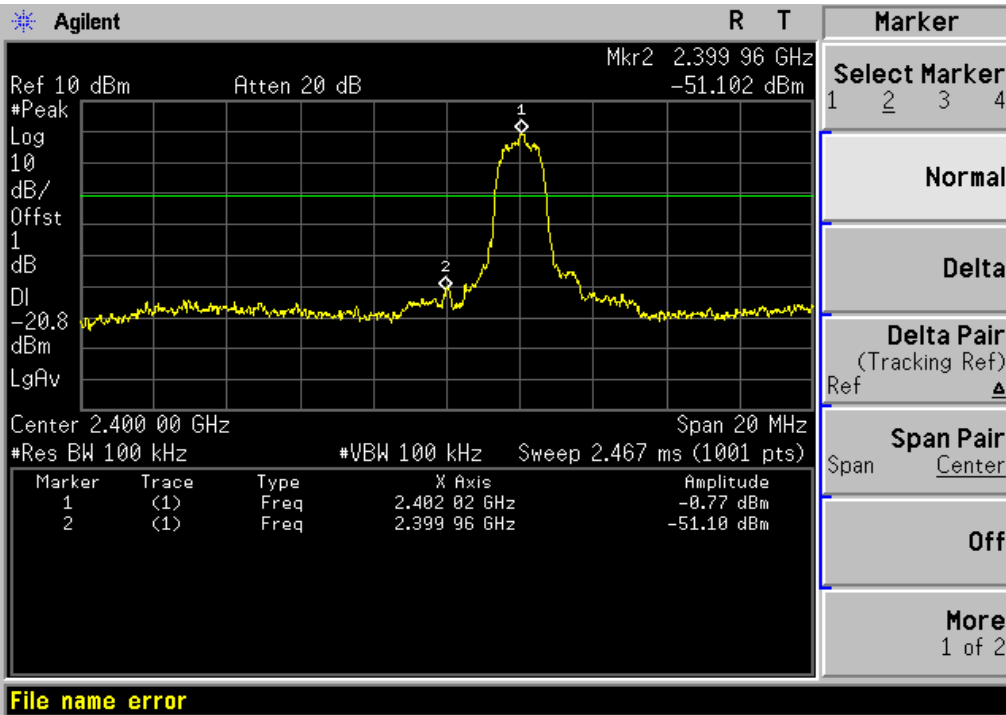
ESTR-21-00225



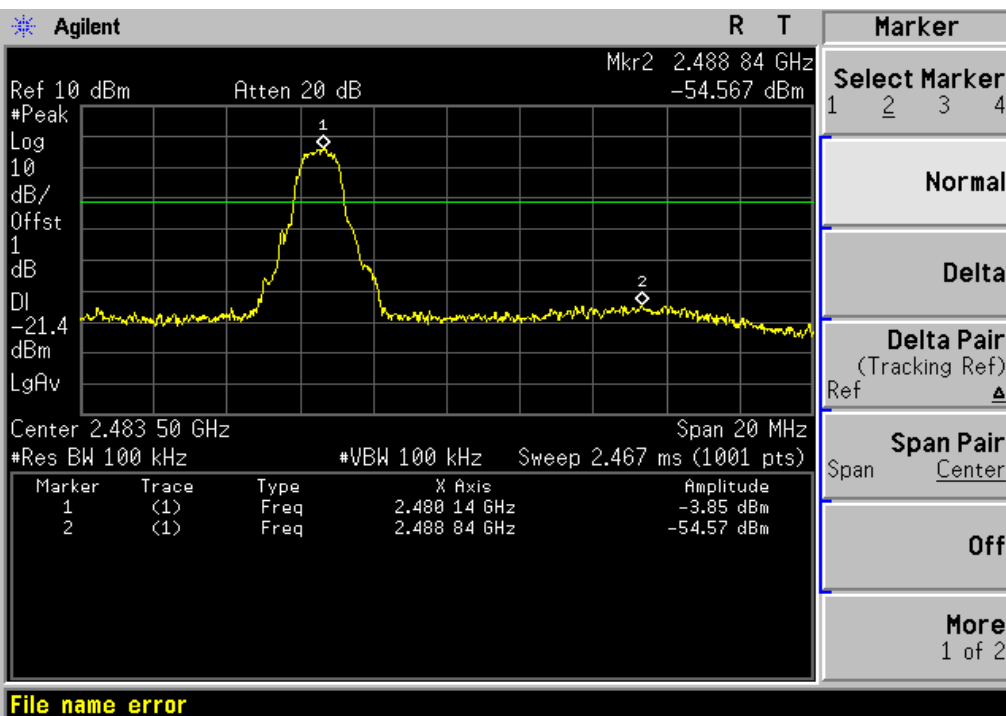
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8DPSK

CH 0



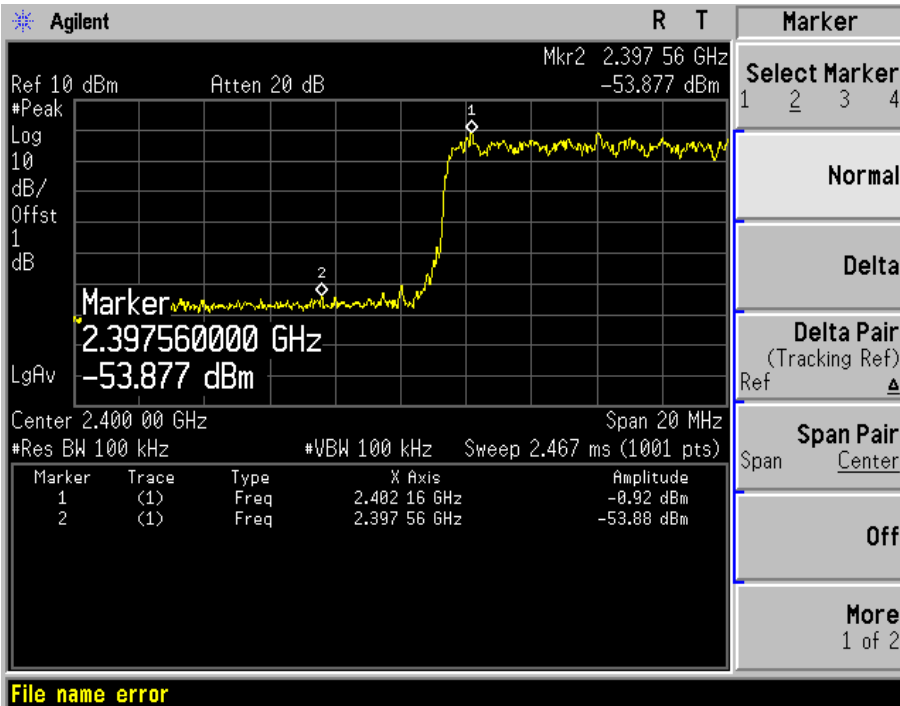
CH78



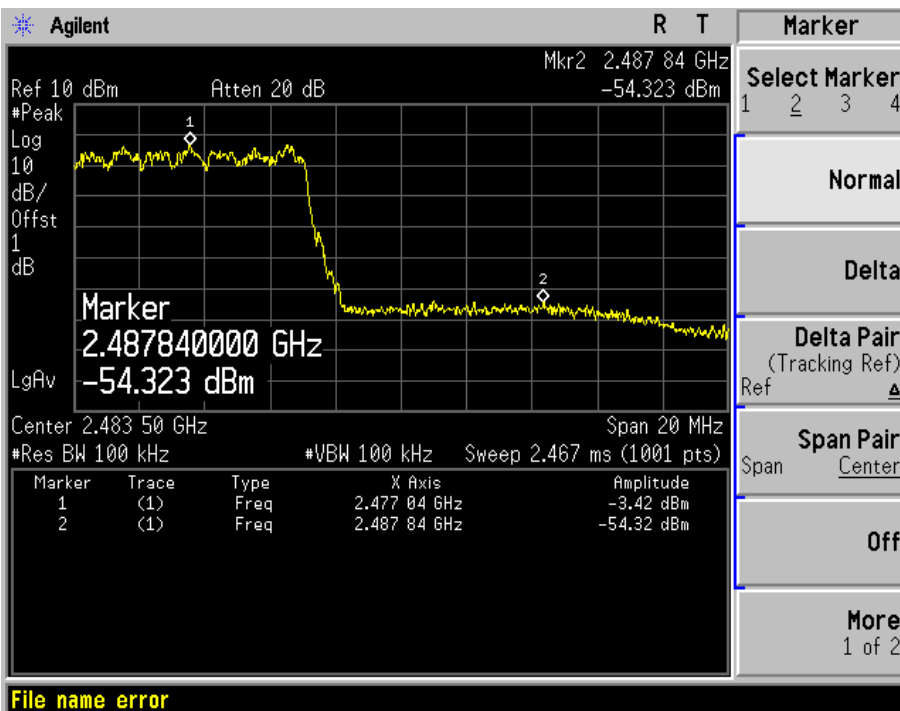


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CH 0



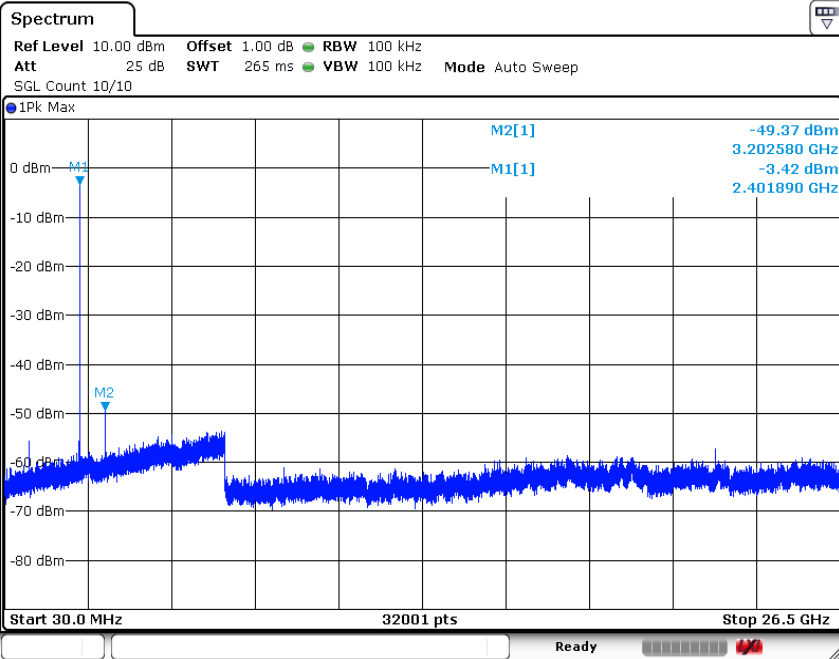
CH78





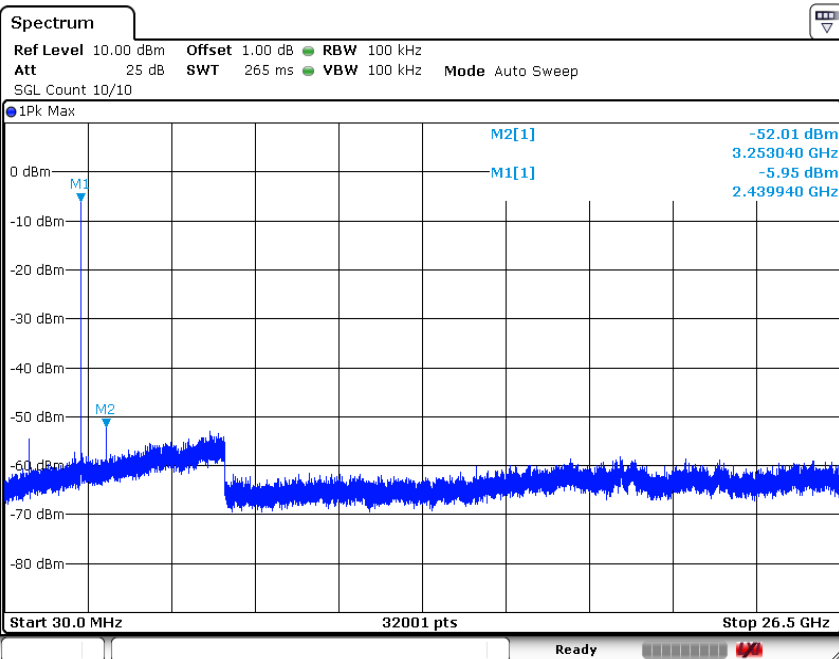
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CH 0



ESTR-21-00225

CH38

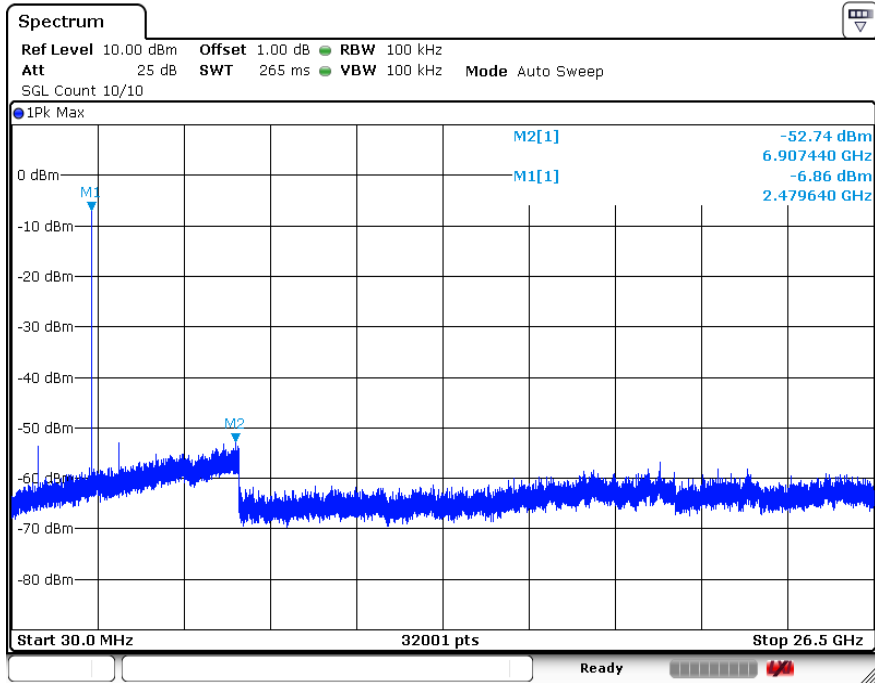


ESTR-21-00225



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CH78



ESTR-21-00225

10. Measurement of radiated disturbance

Above 30 MHz Electric Field strength was measured in accordance with FCC PART 15.205, 15.209. The test setup was made according to ANSI C 63.10 (2013) Semi-anechoic chamber, which allows a 3 m distance measurement. The EUT was placed in the center of styrofoam turntable. The height of this table was 0.8 m. The measurement was conducted with both horizontal and vertical antenna polarization. The turntable has fully rotated. For further description of the configuration refer to the picture of the test setup.

10.1 Measurement equipments

Equipment Name	Type	Manufacturer	Serial No.	Next Calibration date
TEST Receiver	ESCI7	ROHDE & SCHWARZ	100916	19-Jul-22
Logbicon Antenna	VULB 9168	SCHWARZBECK	193	14-Jan-22
Turn Table	DT3000-2t	Innco System GmbH	N/A	-
Antenna Mast	MA4000-EP	Innco System GmbH	N/A	-
PREAMPLIFIER	8449B	AGILENT	3008A00581	20-Jul-22
Horn Antenna	BBHA9120D	SCHWARZBECK	469	24-Dec-21
Signal Analyzer	FSV40	ROHDE & SCHWARZ	100393	1-Dec-21
Turn Table	DT1500-S	Innco System GmbH	N/A	-
Antenna Mast	MA4000-EP	Innco System GmbH	N/A	-
Horn Antenna	BBHA 9170	SCHWARZBECK	752	15-Oct-21
Antenna Master & Turn table controller	CO2000-P	Innco System GmbH	CO2000/642 /28051111/L	-

10.2 Environmental Condition

Below 1 GHz –Test Place : 10 m Semi-anechoic chamber

BT Basic Rate Mode

Temperature (°C) : 23.6 °C
Humidity (% R.H.) : 44.5 % R.H.

BT EDR Mode

Temperature (°C) : 23.4 °C
Humidity (% R.H.) : 43.0 % R.H.

Above 1 GHz–Test Place : 3 m Semi-anechoic chamber

BT Basic Rate Mode

Temperature (°C) : 23.1 °C
Humidity (% R.H.) : 46.0 % R.H.

BT EDR Mode

Temperature (°C) : 23.4 °C
Humidity (% R.H.) : 47.5 % R.H.

10.3 Test Data for Bluetooth (Basic Rate)

Test Date : 6-Sep-21

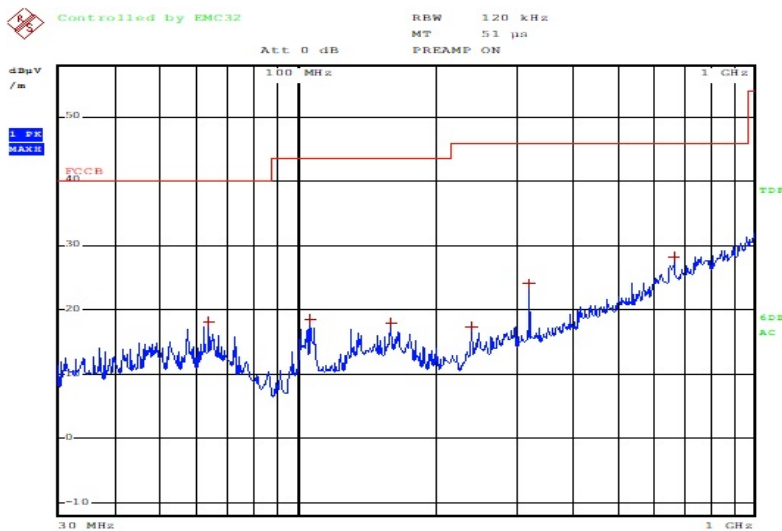
Measurement Distance : 3 m

Frequency (MHz)	Reading (dB μ V)	Position (V/H)	Height (m)	Correction Factor		Result Value		
				Ant Factor (dB)	Cable (dB)	Limit (dB μ V/m)	Result (dB μ V/m)	Margin (dB)
48.60	17.85	V	1.0	13.19	0.95	40.00	31.99	8.01
62.50	18.73	V	1.0	10.02	2.16	40.00	30.91	9.09
106.70	4.42	V	1.0	15.63	3.16	43.50	23.21	20.29
136.70	8.72	V	1.2	19.72	3.93	43.50	32.37	11.13
320.00	0.54	H	1.4	22.43	4.63	46.00	27.60	18.40
665.00	0.37	H	1.0	24.40	5.23	46.00	30.00	16.00
Remark	H : Horizontal, V : Vertical Bluetooth (Basic Rate , 38 CH , 2 440 MHz) *CL = Cable Loss (In case of below 1 000 MHz) *The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120 kHz for Quasi-peak detection at frequency below 1 GHz. *Result Value = Reading + Ant Factor + Cable loss *Margin = Limit - Result							

10.3-1 Restricted Band Edges for BT(Basic Rate)

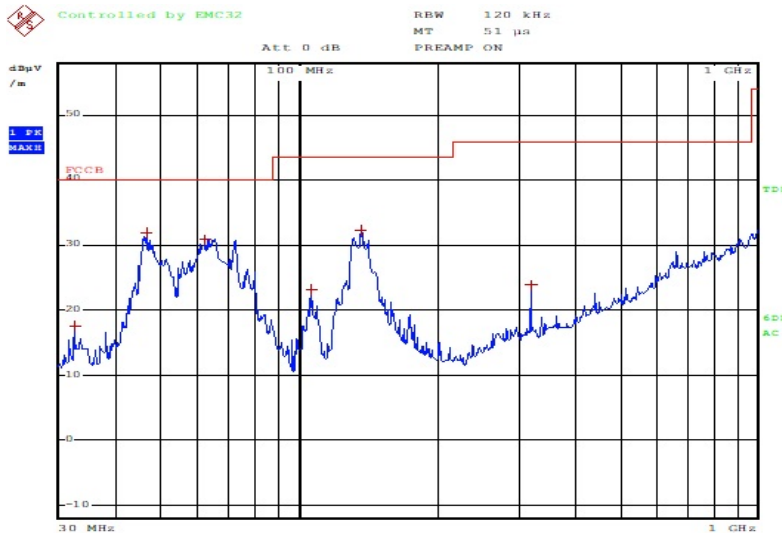
Band Edges(CH Middle)

Polarity:Horizontal



ESTR-21-00238

Polarity:Vertical

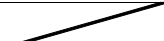
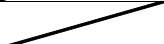


ESTR-21-00238

10.3-2 Test Data for Bluetooth(Basic Rate)

Test Date : 9-Sep-21

Measurement Distance : 3 m

Frequency (MHz)	Reading (dBμV)	Position (V/H)	Height (m)	Correction Factor		Duty Cycle Correction (dB)	Result Value		
				Ant Factor (dB)	Cable (dB)		Limit (dBμV/m)	Result (dBμV/m)	Margin (dB)
PEAK(RBW:1 MHz VBW:3 MHz)									
2390.00	44.92	H	1.5	27.89	-29.82		74.00	42.99	31.01
2390.00	42.90	V	1.5	27.89	-29.82		74.00	40.97	33.03
3220.00	54.12	H	1.5	28.68	-29.19		74.00	53.61	20.39
3220.00	51.10	V	1.5	28.68	-29.19		74.00	50.59	23.41
4804.00	53.00	H	1.5	31.50	-27.28		74.00	57.22	16.78
4804.00	50.10	V	1.5	31.50	-27.28		74.00	54.32	19.68
Average (RBW:1 MHz VBW:3 MHz)									
2390.00	33.14	H	1.5	27.89	-29.82	1.20	54.00	32.41	21.59
2390.00	32.75	V	1.5	27.89	-29.82	1.20	54.00	32.02	21.98
3220.00	46.00	H	1.5	28.68	-29.19	1.20	54.00	46.69	7.31
3220.00	43.10	V	1.5	28.68	-29.19	1.20	54.00	43.79	10.21
4804.00	45.00	H	1.5	31.50	-27.28	1.20	54.00	50.42	3.58
4804.00	43.10	V	1.5	31.50	-27.28	1.20	54.00	48.52	5.48
Remark	H : Horizontal, V : Vertical TEST MODE : Bluetooth Basic Rate-CH0 (2 402 MHz) *This test was radiated up to 26.5 GHz but no noise was measured. *The TX signal wasn't detected from 3th harmonics. *Result Value = Reading + Ant Factor + Cable loss - Amplifier Gain + Duty Cycle Correction Factor *Margin = Limit - Result *The resolution bandwidth and video bandwidth of spectrum analyzer is 1 MHz and 1 kHz for average detection at frequency above 1 GHz. FYI : Duty Cycle Correction Factor (79 channel hopping) a. Time to cycle through all channels= Δ t= τ [ms] x 79 channels = 295.934 ms, where τ = pulse width b. 100 ms/ Δ t [ms] = H → Round up to next highest integer, H ' =1 c. Worst Case Dwell Time = τ [ms] x H ' = 3.746 ms d. Duty Cycle Correction = 20log (Worst Case Dwell Time/ 100ms) dB = -28.528 dB								

10.3-3 Test Data for Bluetooth(Basic Rate)

Test Date : 9-Sep-21

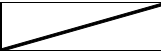
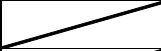
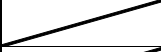
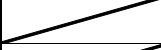
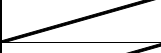
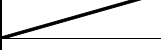
Measurement Distance : 3 m

Frequency (MHz)	Reading (dBμV)	Position (V/H)	Height (m)	Correction Factor		Duty Cycle Correction (dB)	Result Value		
				Ant Factor (dB)	Cable (dB)		Limit (dBμV/m)	Result (dBμV/m)	Margin (dB)
PEAK(RBW:1 MHz VBW:3 MHz)									
3233.00	52.60	H	1.5	28.60	-29.16		74.00	52.04	21.96
3233.00	51.10	V	1.5	28.60	-29.16		74.00	50.54	23.46
4880.00	52.50	H	1.5	31.58	-27.24		74.00	56.84	17.16
4880.00	50.10	V	1.5	31.58	-27.24		74.00	54.44	19.56
Average (RBW:1 MHz VBW:3 MHz)									
3233.00	45.52	H	1.5	28.60	-29.16	1.20	54.00	46.16	7.84
3233.00	43.52	V	1.5	28.60	-29.16	1.20	54.00	44.16	9.84
4880.00	44.10	H	1.5	31.58	-27.24	1.20	54.00	49.64	4.36
4880.00	42.30	V	1.5	31.58	-27.24	1.20	54.00	47.84	6.16
Remark	H : Horizontal, V : Vertical TEST MODE : Bluetooth Basic Rate-CH38 (2 440 MHz) *This test was radiated up to 26.5 GHz but no noise was measured. *The TX signal wasn't detected from 3th harmonics. *Result Value = Reading + Ant Factor + Cable loss - Amplifier Gain + Duty Cycle Correction Factor *Margin = Limit - Result *The resolution bandwidth and video bandwidth of spectrum analyzer is 1 MHz and 1 kHz for average detection at frequency above 1 GHz. FYI : Duty Cycle Correction Factor (79 channel hopping) a. Time to cycle through all channels= Δ t= τ [ms] x 79 channels = 295.934 ms, where τ = pulse width b. 100 ms/ Δ t [ms] = H → Round up to next highest integer, H ' =1 c. Worst Case Dwell Time = τ [ms] x H ' = 3.746 ms d. Duty Cycle Correction = 20log (Worst Case Dwell Time/ 100ms) dB = -28.528 dB								

10.3-4 Test Data for Bluetooth(Basic Rate)

Test Date : 9-Sep-21

Measurement Distance : 3 m

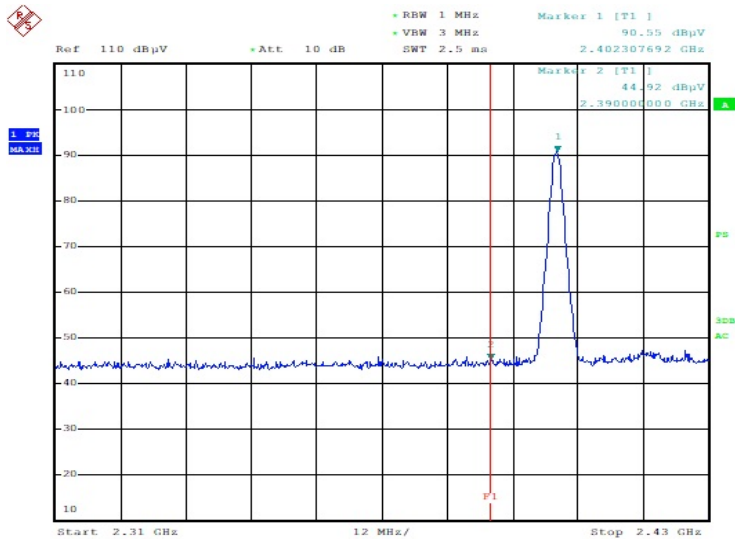
Frequency (MHz)	Reading (dBμW)	Position (V/H)	Height (m)	Correction Factor		Duty Cycle Correction (dB)	Result Value		
				Ant Factor (dB)	Cable (dB)		Limit (dBμW/m)	Result (dBμW/m)	Margin (dB)
PEAK(RBW:1 MHz VBW:3 MHz)									
2483.50	50.63	H	1.5	27.48	-29.75		74.00	48.36	25.64
2483.50	49.37	V	1.7	27.48	-29.75		74.00	47.10	26.90
3288.00	53.20	H	1.5	28.27	-29.06		74.00	52.41	21.59
3288.00	51.60	V	1.7	28.27	-29.06		74.00	50.81	23.19
4960.00	51.30	H	1.5	31.66	-27.17		74.00	55.79	18.21
4960.00	50.90	V	1.7	31.66	-27.17		74.00	55.39	18.61
Average (RBW:1 MHz VBW:3 MHz)									
2483.50	42.25	H	1.5	27.48	-29.75	1.20	54.00	41.18	12.82
2483.50	40.98	V	1.7	27.48	-29.75	1.20	54.00	39.91	14.09
3288.00	46.20	H	1.5	28.27	-29.06	1.20	54.00	46.61	7.39
3288.00	43.20	V	1.7	28.27	-29.06	1.20	54.00	43.61	10.39
4960.00	44.30	H	1.5	31.66	-27.17	1.20	54.00	49.99	4.01
4960.00	42.00	V	1.7	31.66	-27.17	1.20	54.00	47.69	6.31
Remark	H : Horizontal, V : Vertical TEST MODE : Bluetooth Basic Rate-CH78 (2 480 MHz) *This test was radiated up to 26.5 GHz but no noise was measured. *The TX signal wasn't detected from 3th harmonics. *Result Value = Reading + Ant Factor + Cable loss - Amplifier Gain + Duty Cycle Correction Factor *Margin = Limit - Result *The resolution bandwidth and video bandwidth of spectrum analyzer is 1 MHz and 1 kHz for average detection at frequency above 1 GHz. FYI : Duty Cycle Correction Factor (79 channel hopping) a. Time to cycle through all channels= Δ t= τ [ms] x 79 channels = 295.934 ms, where τ = pulse width b. 100 ms/ Δ t [ms] = H → Round up to next highest integer, H ' =1 c. Worst Case Dwell Time = τ [ms] x H ' = 3.746 ms d. Duty Cycle Correction = 20log (Worst Case Dwell Time/ 100ms) dB = -28.528 dB								

10.4 Restricted Band Edges for BT(Basic Rate)

Band Edges(CH Low)

Detector mode:Peak

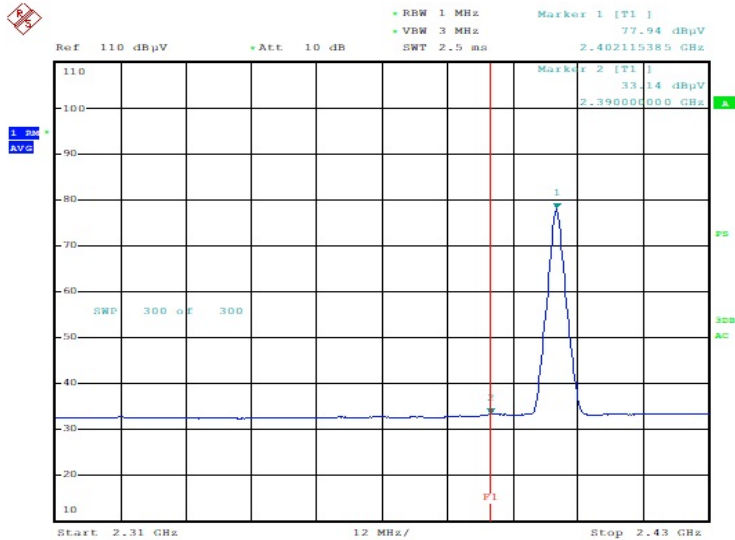
Polarity:Horizontal



ESTR-21-00288

Detector mode:Average

Polarity:Horizontal

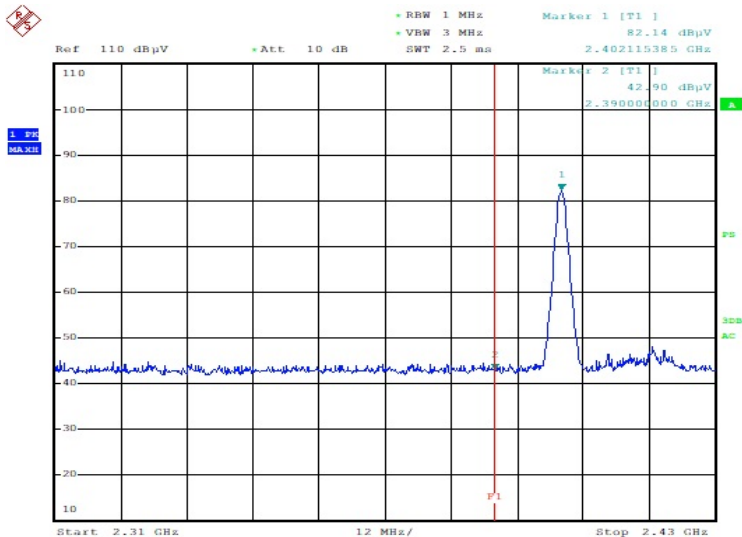


ESTR-21-00288

Band Edges(CH Low)

Detector mode:Peak

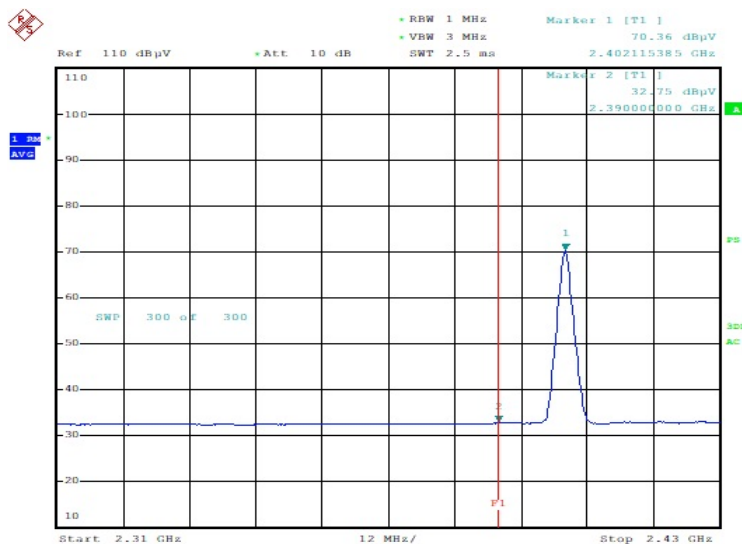
Polarity:Vertical



ESTR-21-00238

Detector mode:Average

Polarity:Vertical

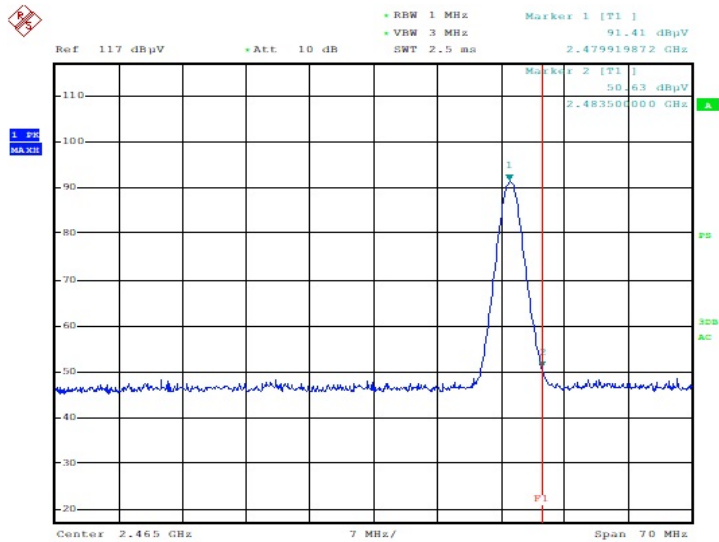


ESTR-21-00238

Band Edges(CH High)

Detector mode:Peak

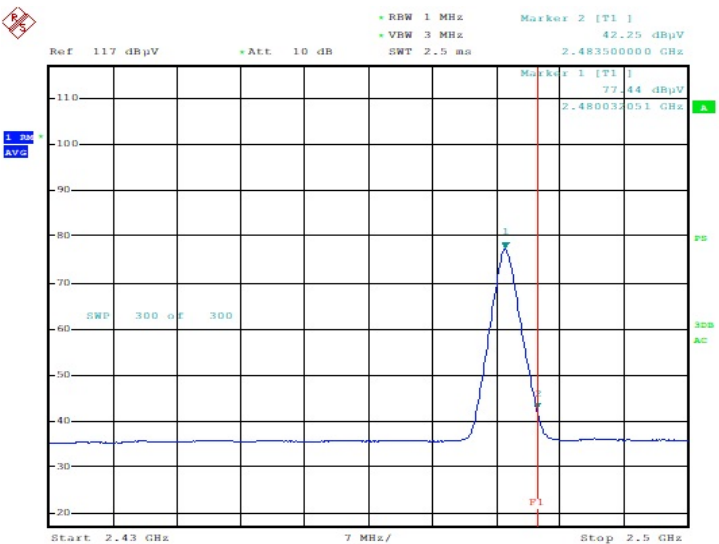
Polarity:Horizontal



ESTR-21-00238

Detector mode:Average

Polarity:Horizontal

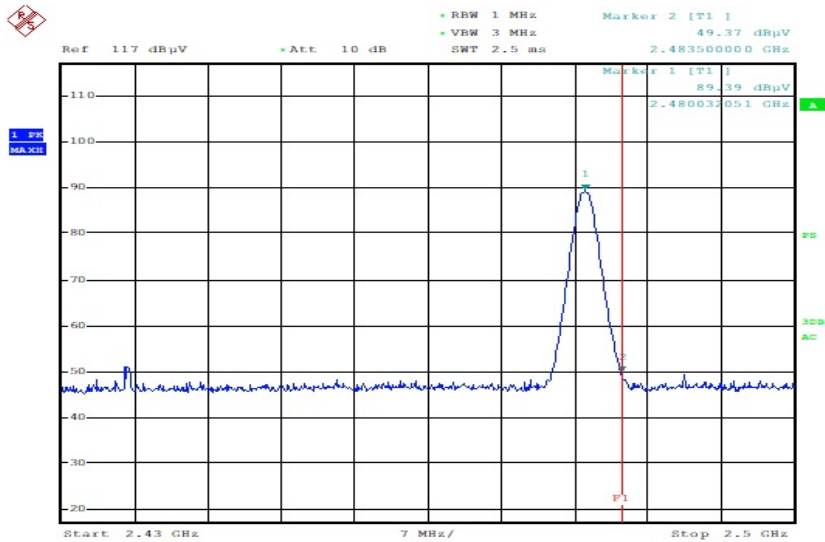


ESTR-21-00238

Band Edges(CH High)

Detector mode:Peak

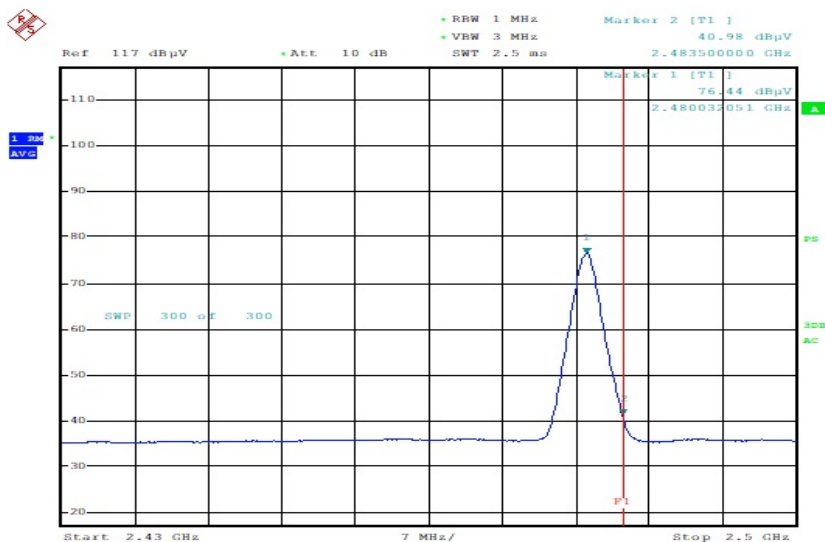
Polarity:Vertical



ESTR-21-00238

Detector mode:Average

Polarity:Vertical

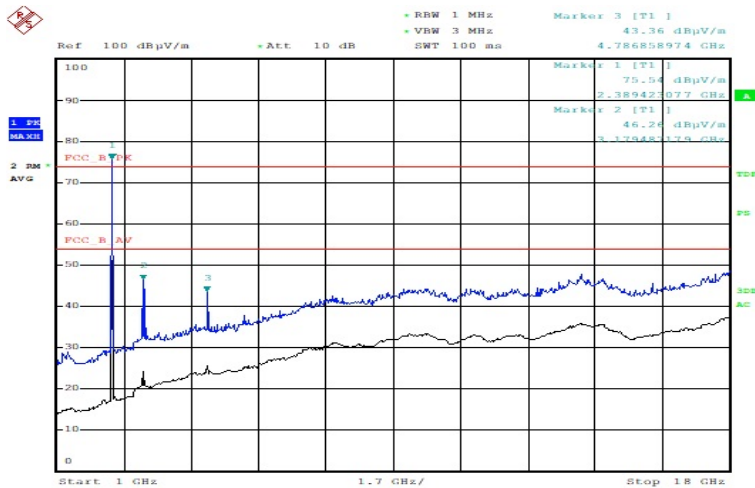


ESTR-21-00238

10.4-1 Restricted Band Edges for BT(Basic Rate)

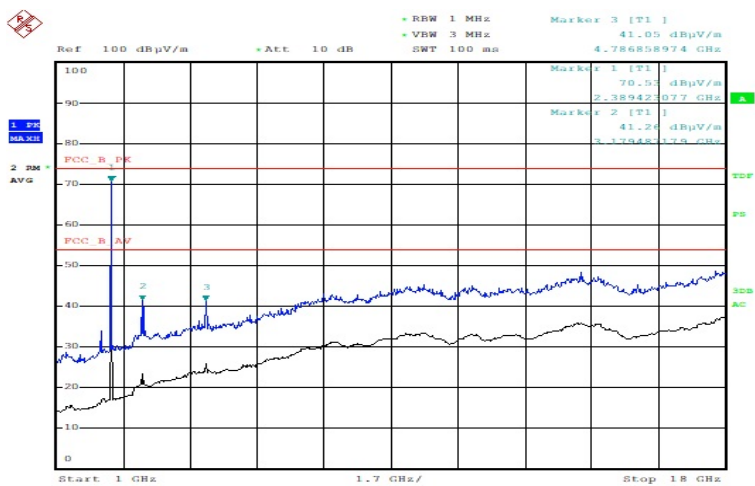
Band Edges(CH Low)

Polarity:Horizontal



ESTR-21-00238

Polarity:Vertical



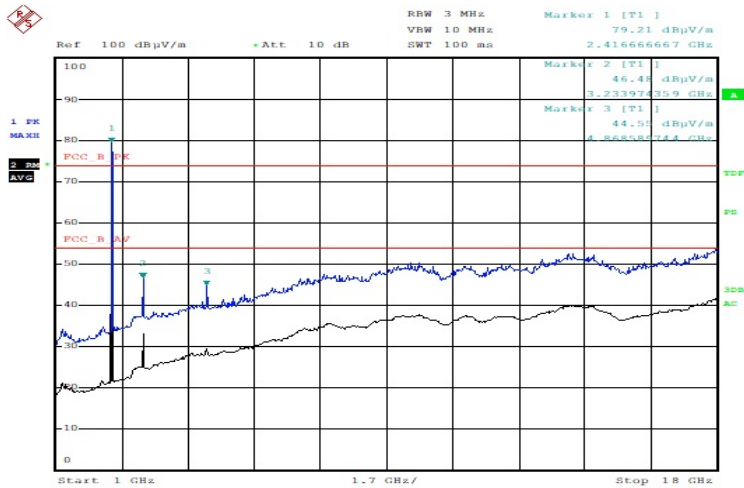
ESTR-21-00238



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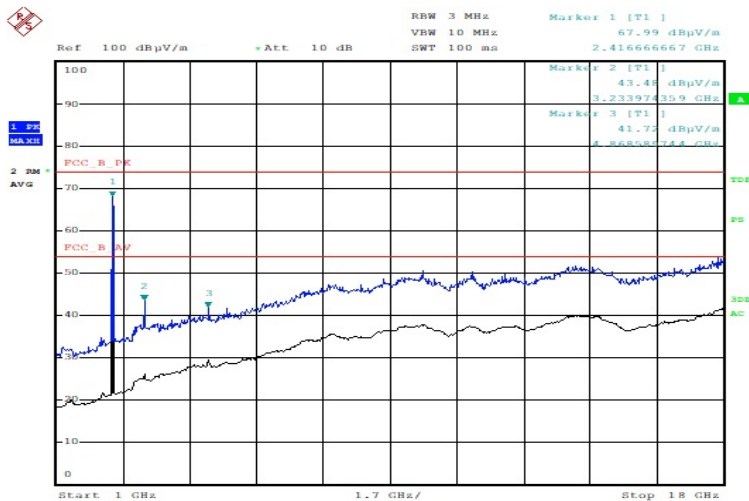
Band Edges(CH Middle)

Polarity:Horizontal



ESTR-21-00238

Polarity:Vertical



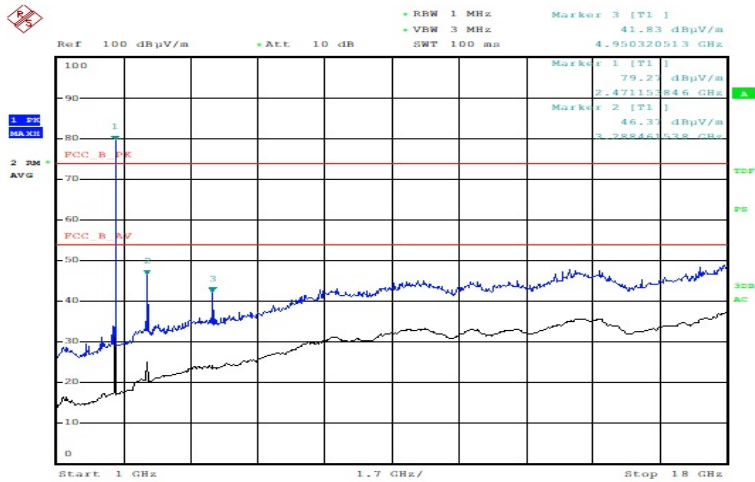
ESTR-21-00238



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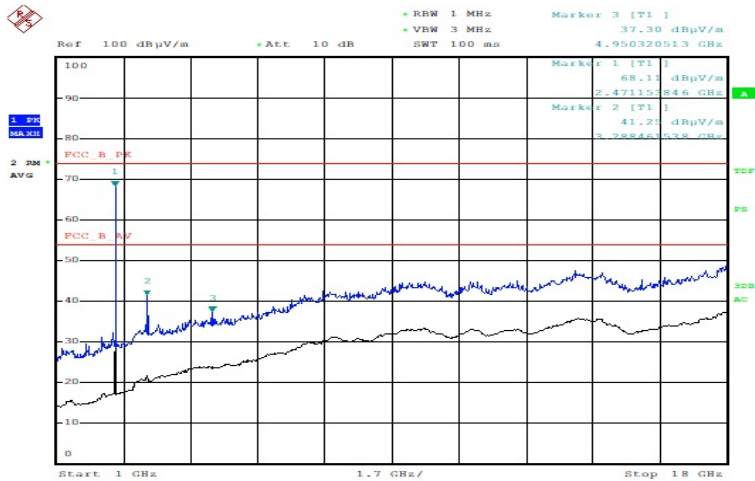
Band Edges(CH High)

Polarity:Horizontal



ESTR-21-00298

Polarity:Vertical



ESTR-21-00298

10.5 Test Data for Bluetooth (EDR)

Test Date : 6-Sep-21

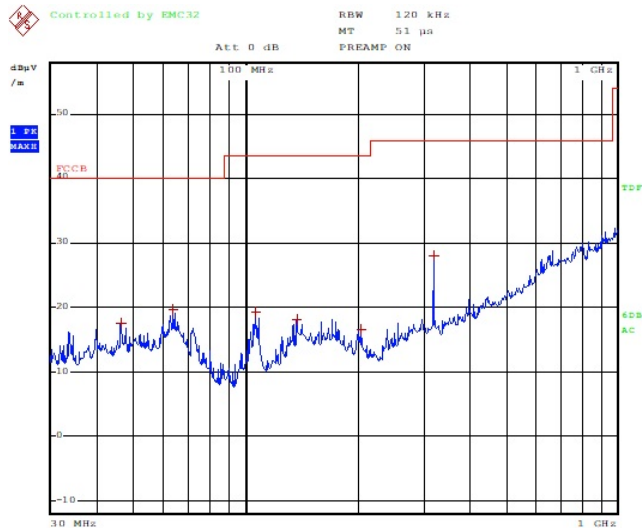
Measurement Distance : 3 m

Frequency (MHz)	Reading (dB μ W)	Position (V/H)	Height (m)	Correction Factor		Result Value		
				Ant Factor (dB)	Cable (dB)	Limit (dB μ W/m)	Result (dB μ W/m)	Margin (dB)
46.20	17.52	V	1.0	13.19	0.95	40.00	31.66	8.34
73.00	18.87	V	1.0	10.02	2.16	40.00	31.05	8.95
80.00	9.72	V	1.2	15.63	3.16	40.00	28.51	11.49
106.70	4.51	V	1.3	19.72	3.93	43.50	28.16	15.34
138.10	5.15	V	1.3	22.43	4.63	43.50	32.21	11.29
320.00	0.37	H	1.4	24.40	5.23	46.00	30.00	16.00
Remark	H : Horizontal, V : Vertical Bluetooth (EDR , 38 CH , 2 440 MHz) *CL = Cable Loss(In case of below 1 000 MHz) *The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120 kHz for Quasi-peak detection at frequency below 1 GHz. *Result Value = Reading + Ant Factor + Cable loss *Margin = Limit - Result							

10.5-1 Restricted Band Edges for BT(Basic Rate)

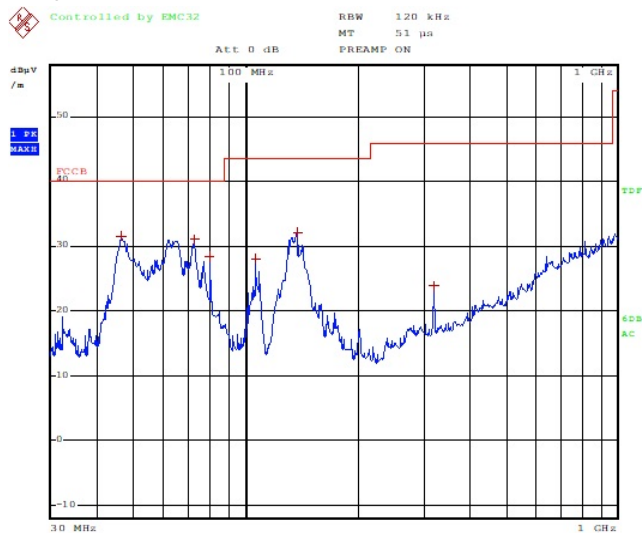
Band Edges(CH Middle)

Polarity:Horizontal



ESTR-21-00238

Polarity:Vertical



ESTR-21-00238

10.5-2 Test Data for Bluetooth(EDR)

Test Date : 10-Sep-21

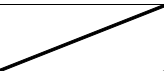
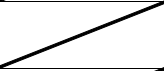
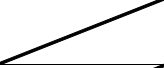
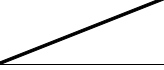
Measurement Distance : 3 m

Frequency (MHz)	Reading (dBμV)	Position (V/H)	Height (m)	Correction Factor		Duty Cycle Correction (dB)	Result Value		
				Ant Factor (dB)	Cable (dB)		Limit (dBμV/m)	Result (dBμV/m)	Margin (dB)
PEAK(RBW:1 MHz VBW:3 MHz)									
2390.00	43.89	H	1.6	27.89	-29.82		74.00	41.96	32.04
2390.00	43.15	V	1.5	27.89	-29.82		74.00	41.22	32.78
3179.00	49.23	H	1.6	28.78	-29.27		74.00	48.74	25.26
3179.00	47.12	V	1.5	28.78	-29.27		74.00	46.63	27.37
4804.00	52.90	H	1.6	31.50	-27.28		74.00	57.12	16.88
4804.00	49.90	V	1.5	31.50	-27.28		74.00	54.12	19.88
Average (RBW:1 MHz VBW:3 MHz)									
2390.00	33.14	H	1.6	27.89	-29.82	1.18	54.00	32.39	21.61
2390.00	32.79	V	1.5	27.89	-29.82	1.18	54.00	32.04	21.96
4804.00	44.90	H	1.6	31.50	-27.28	1.18	54.00	50.30	3.70
4804.00	43.80	V	1.5	31.50	-27.28	1.18	54.00	49.20	4.80
Remark	H : Horizontal, V : Vertical TEST MODE : Bluetooth EDR-CH0 (2 402 MHz) *This test was radiated up to 26.5 GHz but no noise was measured. *The TX signal wasn't detected from 3th harmonics. *Result Value = Reading + Ant Factor + Cable loss - Amplifier Gain + Duty Cycle Correction Factor *Margin = Limit - Result *The resolution bandwidth and video bandwidth of spectrum analyzer is 1 MHz and 1 kHz for average detection at frequency above 1 GHz.								
	FYI : Duty Cycle Correction Factor (79 channel hopping) a. Time to cycle through all channels= Δ t= τ [ms] x 79 channels = 296.25 ms, where τ = pulse width b. 100 ms/ Δ t [ms] = H → Round up to next highest integer, H ´ =1 c. Worst Case Dwell Time = τ [ms] x H ´ = 3.79ms d. Duty Cycle Correction = 20log (Worst Case Dwell Time/ 100ms) dB = - 28.427 dB								

10.5-3 Test Data for Bluetooth(EDR)

Test Date : 10-Sep-21

Measurement Distance : 3 m

Frequency (MHz)	Reading (dB μ V)	Position (V/H)	Height (m)	Correction Factor		Duty Cycle Correction (dB)	Result Value		
				Ant Factor (dB)	Cable (dB)		Limit (dB μ V/m)	Result (dB μ V/m)	Margin (dB)
PEAK(RBW:1 MHz VBW:3 MHz)									
3233.00	49.32	H	1.5	28.60	-29.16		74.00	48.76	25.24
3233.00	48.21	V	1.7	28.60	-29.16		74.00	47.65	26.35
4880.00	53.40	H	1.5	31.58	-37.26		74.00	47.72	26.28
4880.00	50.60	V	1.7	31.58	-37.26		74.00	44.92	29.08
Average (RBW:1 MHz VBW:3 MHz)									
4880.00	44.70	H	1.5	31.58	-37.26	1.18	54.00	40.20	13.80
4880.00	43.20	V	1.7	31.58	-37.26	1.18	54.00	38.70	15.30
Remark	H : Horizontal, V : Vertical TEST MODE : Bluetooth EDR-CH38 (2 440 MHz) *This test was radiated up to 26.5 GHz but no noise was measured. *The TX signal wasn't detected from 3th harmonics. *Result Value = Reading + Ant Factor + Cable loss – Amplifier Gain + Duty Cycle Correction Factor *Margin = Limit – Result *The resolution bandwidth and video bandwidth of spectrum analyzer is 1 MHz and 1 kHz for average detection at frequency above 1 GHz. FYI : Duty Cycle Correction Factor (79 channel hopping) a. Time to cycle through all channels= $\Delta t = \tau$ [ms] x 79 channels = 296.25 ms, where τ = pulse width b. 100 ms/ Δt [ms] = H $\rightarrow$ Round up to next highest integer, H ' =1 c. Worst Case Dwell Time = τ [ms] x H ' = 3.79ms d. Duty Cycle Correction = 20log (Worst Case Dwell Time/ 100ms) dB = – 28.427 dB								

10.5-4 Test Data for Bluetooth(EDR)

Test Date : #####

Measurement Distance : 3 m

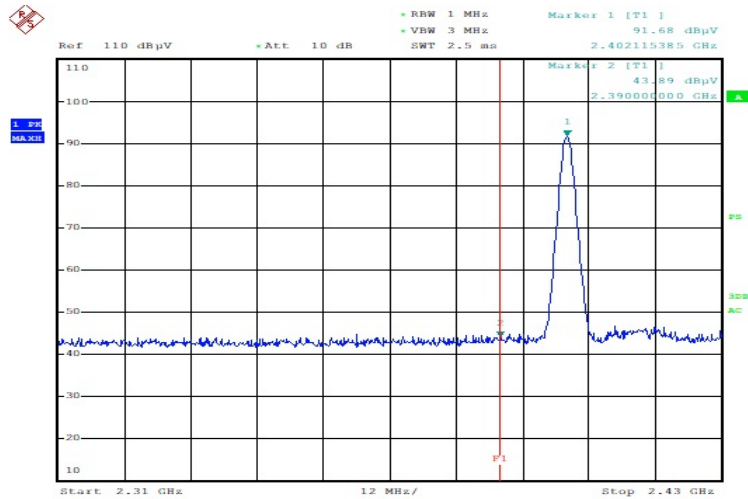
Frequency (MHz)	Reading (dBμV)	Position (V/H)	Height (m)	Correction Factor		Duty Cycle Correction (dB)	Result Value		
				Ant Factor (dB)	Cable (dB)		Limit (dBμV/m)	Result (dBμV/m)	Margin (dB)
PEAK(RBW:1 MHz VBW:3 MHz)									
2483.50	51.20	H	1.5	27.48	-29.75		74.00	48.93	25.07
2483.50	50.49	V	1.7	27.48	-29.75		74.00	48.22	25.78
3288.00	48.22	H	1.5	28.27	-29.06		74.00	47.43	26.57
3288.00	48.00	V	1.7	28.27	-29.06		74.00	47.21	26.79
4960.00	54.00	H	1.5	31.66	-27.17		74.00	58.49	15.51
4960.00	51.60	V	1.7	31.66	-27.17		74.00	56.09	17.91
Average (RBW:1 MHz VBW:3 MHz)									
2483.50	42.01	H	1.5	27.48	-29.75	1.18	54.00	40.92	13.08
2483.50	42.04	V	1.7	27.48	-29.75	1.18	54.00	40.95	13.05
4960.00	45.00	H	1.5	31.66	-27.17	1.18	54.00	50.67	3.33
4960.00	43.20	V	1.7	31.66	-27.17	1.18	54.00	48.87	5.13
Remark	H : Horizontal, V : Vertical TEST MODE : Bluetooth EDR-CH78 (2 480 MHz) *This test was radiated up to 26.5 GHz but no noise was measured. *The TX signal wasn't detected from 3th harmonics. *Result Value = Reading + Ant Factor + Cable loss - Amplifier Gain + Duty Cycle Correction Factor *Margin = Limit - Result *The resolution bandwidth and video bandwidth of spectrum analyzer is 1 MHz and 1 kHz for average detection at frequency above 1 GHz.								
	FYI : Duty Cycle Correction Factor (79 channel hopping) a. Time to cycle through all channels= Δ t= τ [ms] x 79 channels = 296.25 ms, where τ = pulse width b. 100 ms/ Δ t [ms] = H → Round up to next highest integer, H ' =1 c. Worst Case Dwell Time = τ [ms] x H ' = 3.79ms d. Duty Cycle Correction = 20log (Worst Case Dwell Time/ 100ms) dB = - 28.427 dB								

10.6 Restricted Band Edges for BT(EDR)

Band Edges(CH Low)

Detector mode:Peak

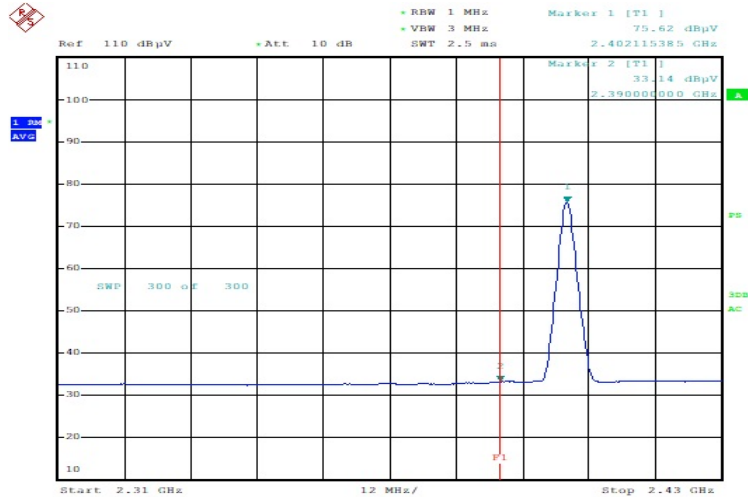
Polarity:Horizontal



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Detector mode:Average

Polarity:Horizontal

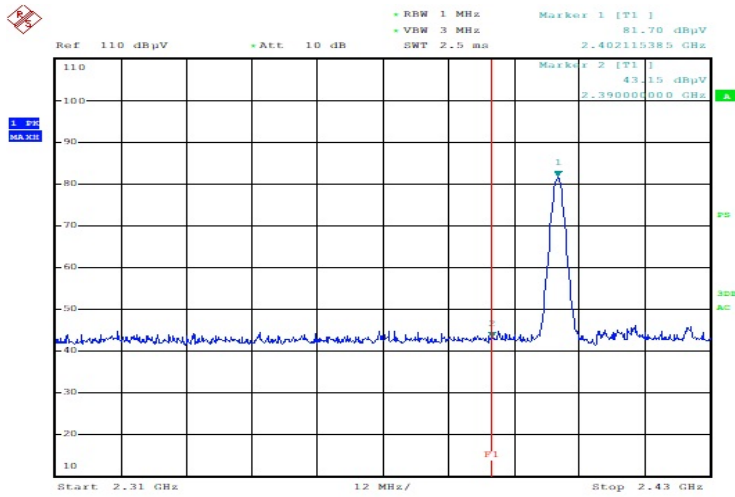


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Band Edges(CH Low)

Detector mode:Peak

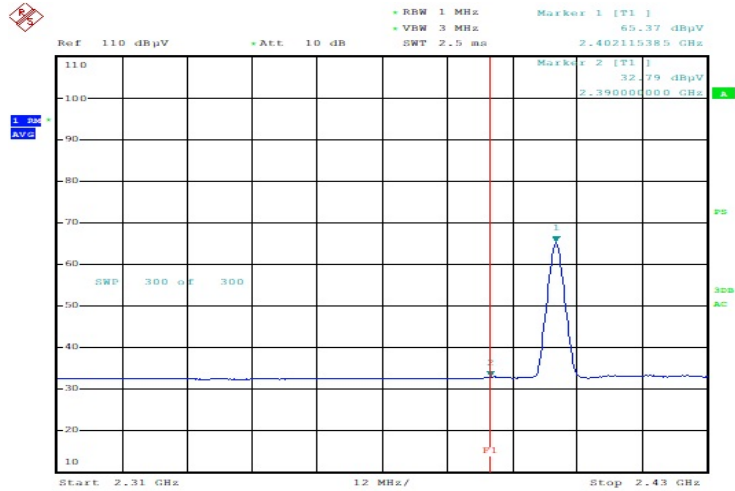
Polarity:Vertical



ESTR-21-00238

Detector mode:Average

Polarity:Vertical

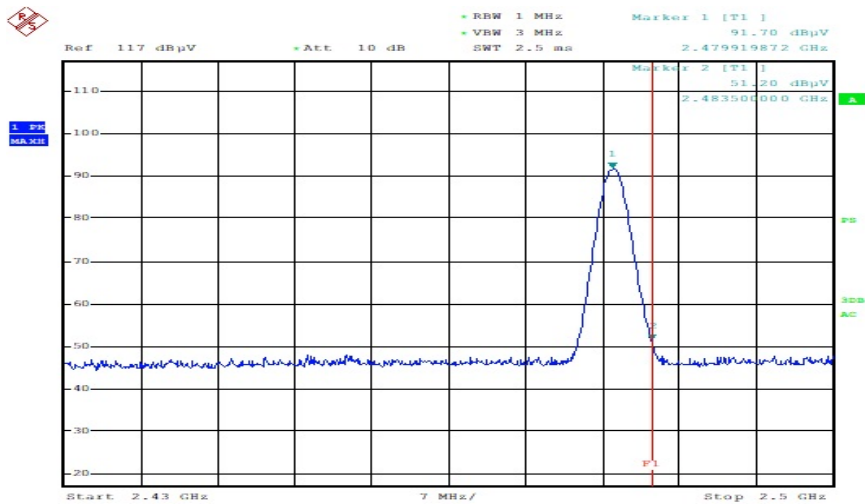


ESTR-21-00238

Band Edges(CH High)

Detector mode:Peak

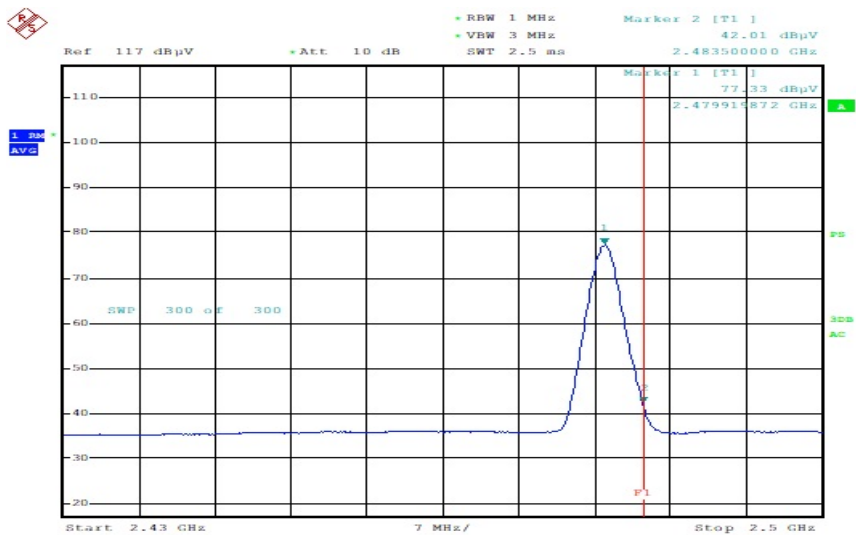
Polarity:Horizontal



ESTR-21-00238

Detector mode:Average

Polarity:Horizontal

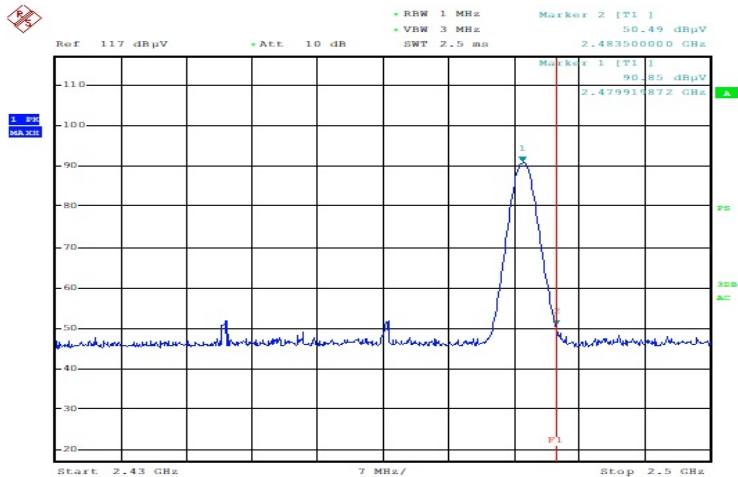


ESTR-21-00238

Band Edges(CH High)

Detector mode:Peak

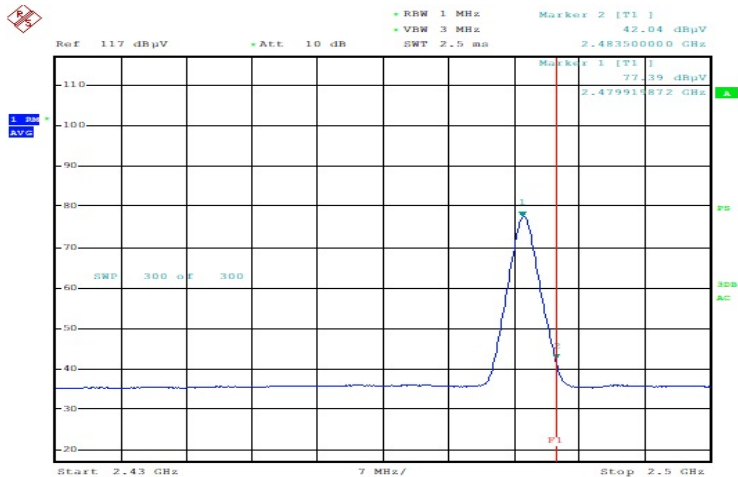
Polarity:Vertical



ESTR-21-00238

Detector mode:Average

Polarity:Vertical

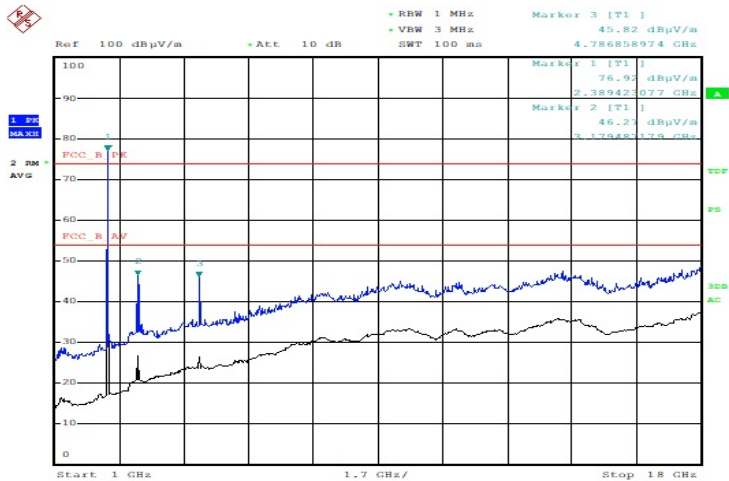


ESTR-21-00238

10.6-1 Restricted Band Edges for BT(EDR Rate)

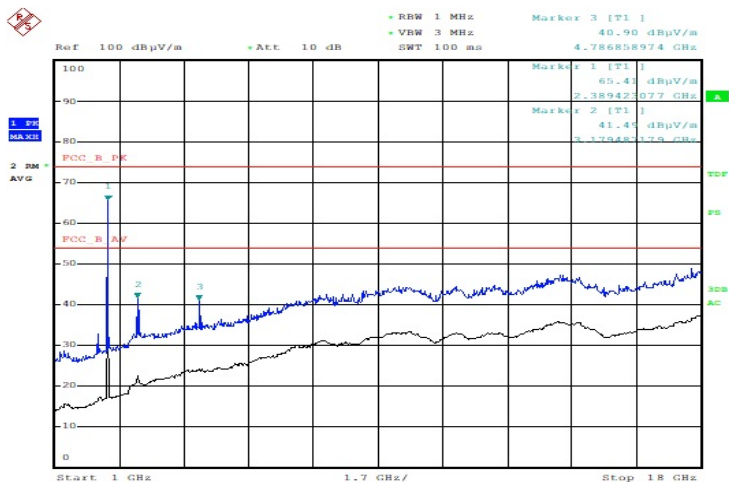
Band Edges(CH Low)

Polarity:Horizontal



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Polarity:Vertical



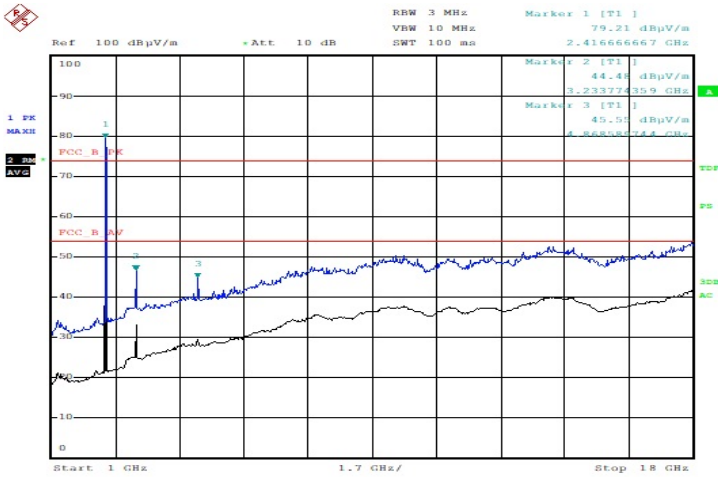
ESTR-21-00228



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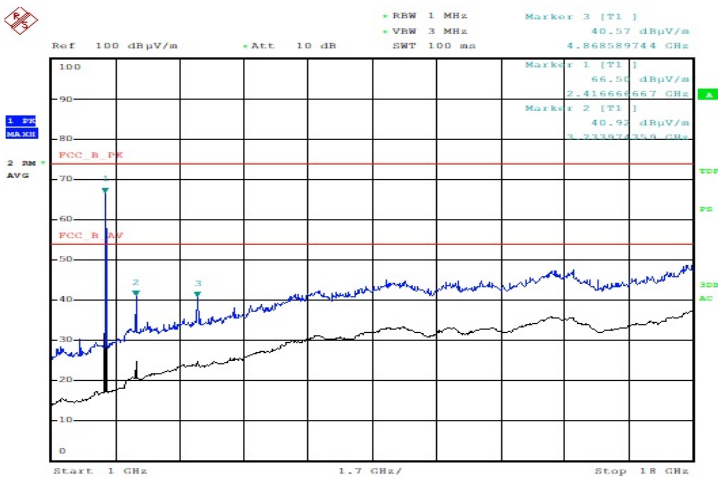
Band Edges(CH Middle)

Polarity:Horizontal



ESTR-21-00238

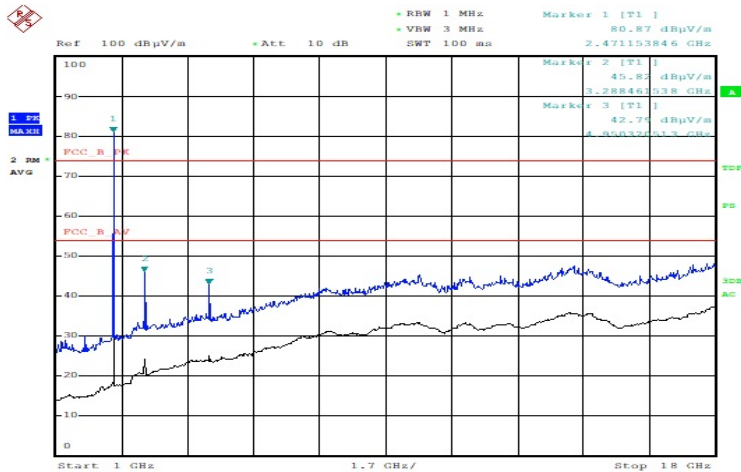
Polarity:Vertical



ESTR-21-00238

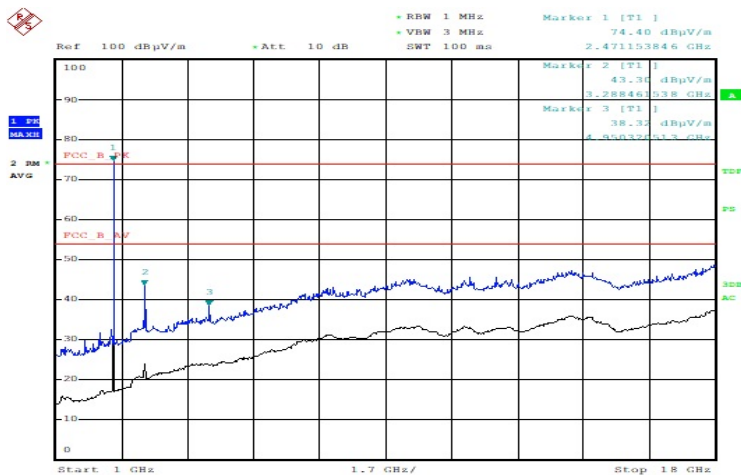
Band Edges(CH High)

Polarity:Horizontal



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Polarity:Vertical



ESTR-21-00238

11. Measurement of conducted disturbance

The continuous disturbance voltage of AC Mains in the frequency from 0.15 MHz to 30 MHz was measured in accordance to FCC PART 15.207. The test setup was made according to ANSI C 63.4 (2009) in a shielded room. The EUT was placed on a non-conductive table at least 0.8 m above the ground plan. A grounded vertical reference plane was positioned in a distance of 0.4 m from the EUT. The distance from the EUT to other metal surfaces was at least 0.8 m. The EUT was only earthen by its power cord through the line impedance stabilizing network. The power cord has been bundled to a length of 1.0 m. The test receiver with Quasi Peak detector complies with CISPR 16.

11.1 Measurement equipments

Equipment Name	Type	Manufacturer	Serial No.	Next Calibration date
TEST RECEIVER	ESPI	Rohde & Schwarz	100005	15-Aug-21
LISN	ESH3-Z5	Rohde & Schwarz	836679/025	15-Aug-21
Pulse Limiter	ESH3Z2	Rohde & Schwarz	NONE	15-Aug-21

11.2 Environmental Condition

Test Place : Shielded Room

BT Basic Mode

Temperature (°C) : 21.5 °C

Humidity (% R.H.) : 44.6 % R.H.

BT EDR Mode

Temperature (°C) : 21.5 °C

Humidity (% R.H.) : 44.6 % R.H.

11.3 Test Data for Bluetooth (Basic Rate)

Test Date : 7-Sep-21

Frequency (MHz)	Correction Factor		Line (H/N)	Quasi-peak Value			Average Value		
	Lisn (dB)	Cable (dB)		Limit (dB μ V)	Reading (dB μ V)	Result (dB μ V)	Limit (dB μ V)	Reading (dB μ V)	Result (dB)
0.17	0.06	0.17	N	65.06	31.14	31.37	55.06	26.76	26.99
0.18	0.05	0.18	H	64.35	30.14	30.37	54.35	25.31	25.54
0.25	0.05	0.18	N	61.69	30.25	30.48	51.69	25.71	25.94
0.43	0.05	0.19	N	57.27	30.94	31.18	47.27	25.98	26.22
0.49	0.04	0.32	H	56.18	35.82	36.18	46.18	30.70	31.06
0.79	0.04	0.32	H	56.00	30.89	31.25	46.00	25.92	26.28
Remark	H : Hot Line, N : Neutral Line TEST MODE : *Correction Factor = Lisn + Cable *Result = Correction Factor + Reading								

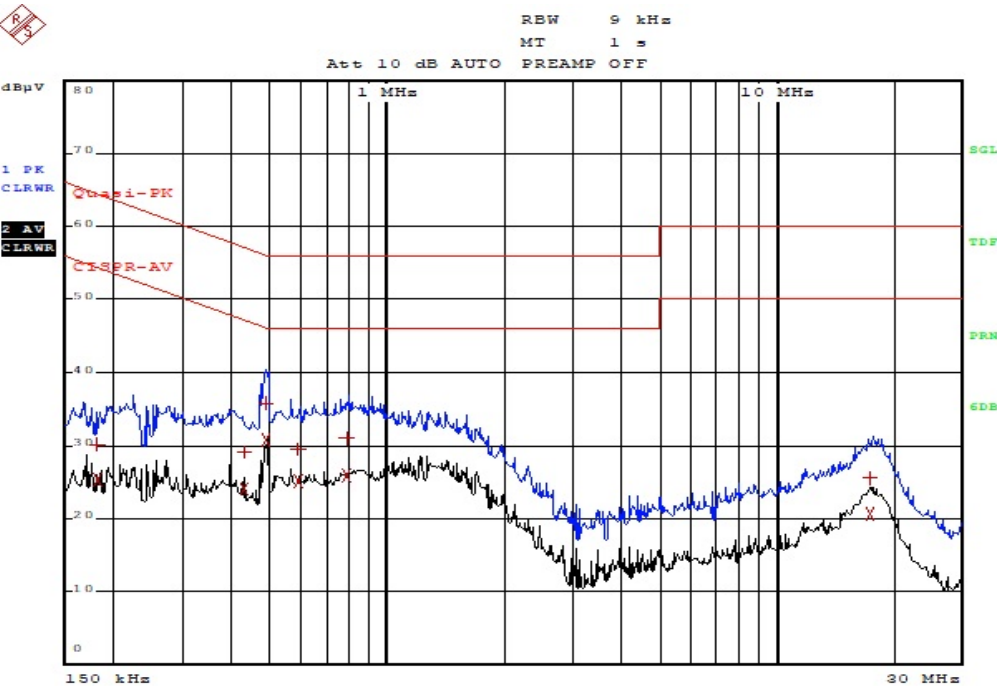
11.3-1 Test Data for Bluetooth (EDR)

Test Date : 7-Sep-21

Frequency (MHz)	Correction Factor		Line (H/N)	Quasi-peak Value			Average Value		
	Lisn (dB)	Cable (dB)		Limit (dB μ V)	Reading (dB μ V)	Result (dB μ V)	Limit (dB μ V)	Reading (dB μ V)	Result (dB)
0.17	0.06	0.17	N	65.06	31.14	31.37	55.06	26.71	26.94
0.18	0.05	0.18	H	64.35	30.11	30.34	54.35	25.31	25.54
0.25	0.05	0.18	N	61.69	30.30	30.53	51.69	25.76	25.99
0.43	0.05	0.19	N	57.27	30.84	31.08	47.27	25.96	26.20
0.49	0.04	0.32	H	56.18	35.82	36.18	46.18	30.74	31.10
0.79	0.04	0.32	H	56.00	30.86	31.22	46.00	25.82	26.18
Remark	H : Hot Line, N : Neutral Line TEST MODE : *Correction Factor = Lisn + Cable *Result = Correction Factor + Reading								

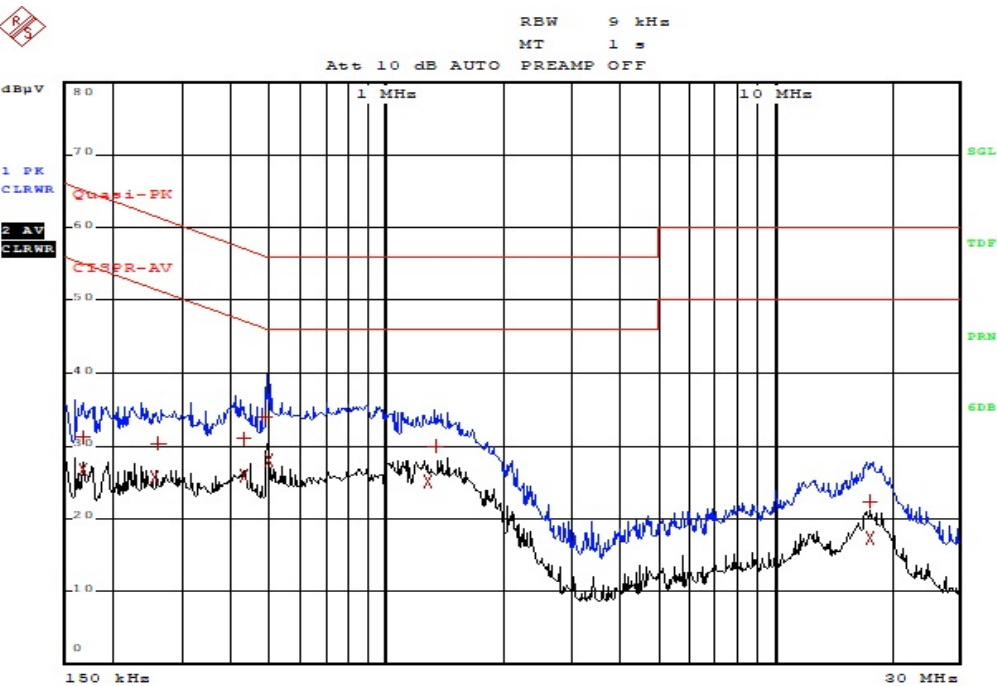
Appendix 1. Special diagram for Bluetooth (Basic Rate)

*HOT



Comment: ESTR-21-00238

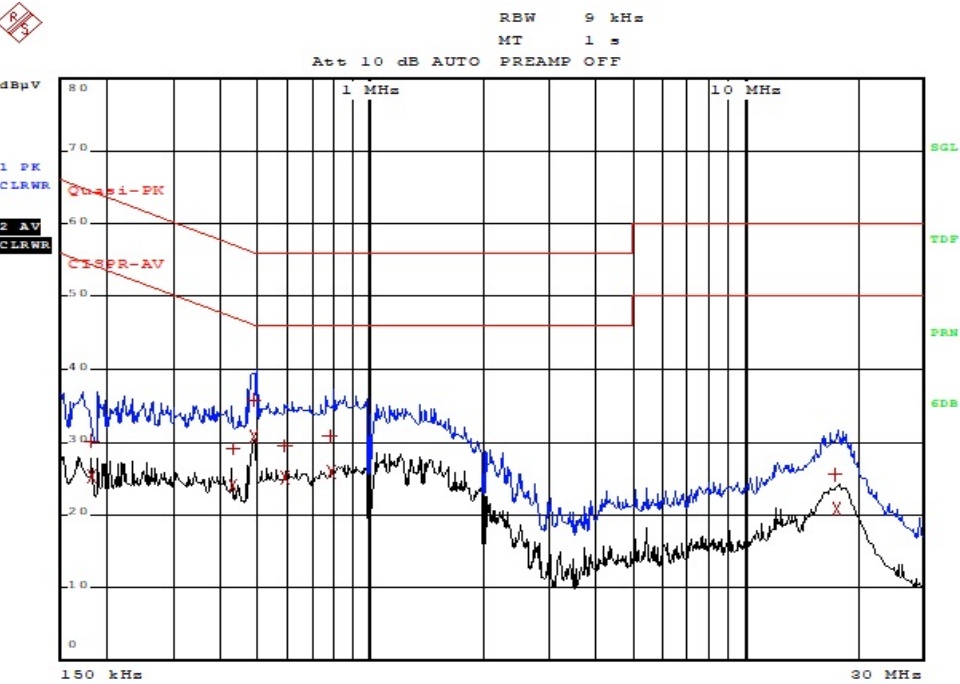
*NEUTRAL



Comment: ESTR-21-00238

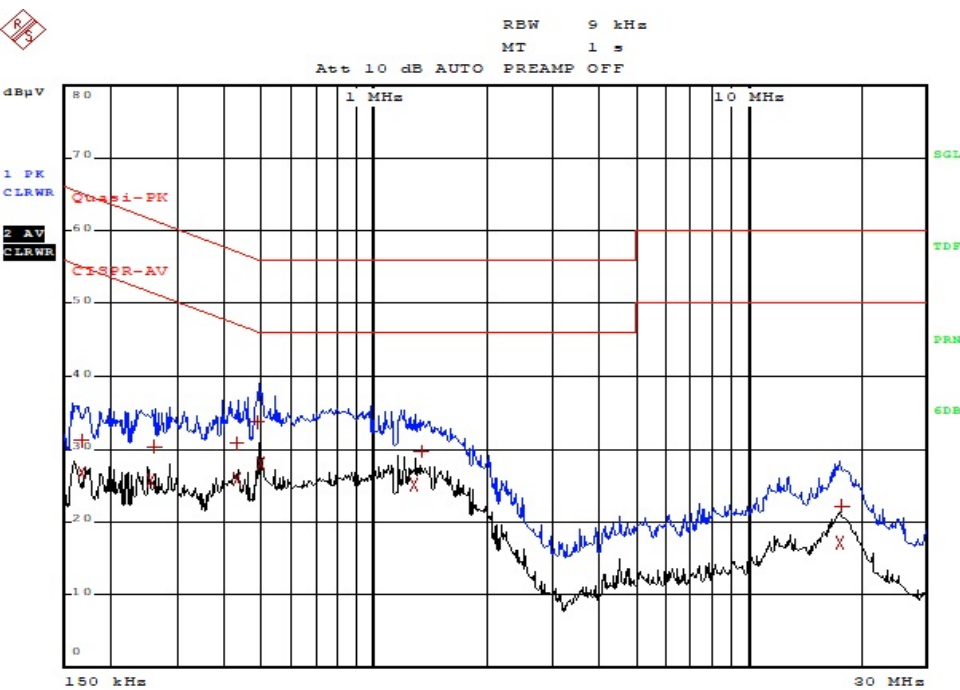
Special diagram for Bluetooth (EDR)

*HOT



Comment: ESTR-21-00238

*NEUTRAL



Comment: ESTR-21-00238

Appendix 2. Antenna information

1. Antenna information

antenna type : Dielectric Chip Antenna.

antenna location : Integral

antenna gain : 0.5 dBi

No temporary RF connector provided