

Report on the RF Testing of:

HOKUBU Communication & Industrial Co., Ltd.
TX Module, Model: Model BR
FCC ID: 2AGF8-TXMBR

In accordance with FCC Part 15 Subpart C

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Document Number: JPD-TR-20166-1

SIGNATURE

NAME	JOB TITLE	RESPONSIBLE FOR	ISSUE DATE
Hiroaki Suzuki	Deputy Manager of RF Group	Approved Signatory	13 OCT 2020

Signatures in this approval box have checked this document in line with the requirements of TÜV SÜD Japan Ltd. document control rules.

EXECUTIVE SUMMARY – Result: Complied

A sample of this product was tested and the result above was confirmed in accordance with FCC Part 15 Subpart C.



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ACCREDITATION

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Contents

1	Summary of Test	3
1.1	Modification history of the test report	3
1.2	Standards	3
1.3	Test methods.....	3
1.4	Deviation from standards	3
1.5	List of applied test(s) of the EUT	3
1.6	Test set up.....	3
1.7	Test period	3
2	Equipment Under Test.....	4
2.1	EUT information	4
2.2	Modification to the EUT	5
2.3	Variation of family model(s).....	5
2.4	Operating channels and frequencies	5
2.5	Operating mode.....	6
2.6	Operating flow	6
3	Configuration of Equipment.....	7
3.1	Equipment used	7
3.2	Cable(s) used	7
3.3	System configuration.....	7
4	Test Result	8
4.1	20dB Bandwidth / Occupied Bandwidth	8
4.2	Spurious Emissions - Field Strength of Fundamental and Harmonics -	10
4.3	Restricted Band of Operation	21
4.4	AC Power Line Conducted Emissions	27
5	Antenna requirement	30
6	Measurement Uncertainty	31
7	Laboratory Information.....	32
Appendix A. Test Equipment.....		33
Appendix B. Duty Cycle		34

1 Summary of Test

1.1 Modification history of the test report

Document Number	Modification History	Issue Date
JPD-TR-20166-0	First Issue	16-September-2020
JPD-TR-20166-1	Added 20dB bandwidth test results.	Refer to the cover page

1.2 Standards

CFR47 FCC Part 15 Subpart C

1.3 Test methods

ANSI C63.10-2013

1.4 Deviation from standards

None

1.5 List of applied test(s) of the EUT

Test item section	Test item	Condition	Result	Remark
2.1049	20dB Bandwidth / Occupied Bandwidth	Conducted	PASS	-
15.249(a), (b), (c), (d), (e) 15.205 15.209 15.35(b)	Spurious Emissions (Field Strength of Fundamental and Harmonics)	Radiated	PASS	-
15.249(c), (d) 15.205 15.209	Restricted Bands of Operation	Radiated	PASS	-
15.207	AC Power Line Conducted Emissions	Conducted	PASS	-

1.6 Test set up

Table-top

1.7 Test period

27-July-2020 - 20-August-2020

2 Equipment Under Test

2.1 EUT information

Applicant	HOKUBU Communication & Industrial Co., Ltd. 27-1, Fushi-o- gami, Fukushima-shi Fukushima 960-8154, Japan Phone: +81-24-545-2237 Fax: +81-24-545-2491
Equipment Under Test (EUT)	TX Module
Model number	Model BR
Serial number	20060001 (with Occupied Bandwidth test) 20060002 (with Other tests)
Trade name	HOKUBU TSUSHIN
Number of sample(s)	2
EUT condition	Pre-Production
Power rating	DC 3.3 V
Size	(W) 29.0 × (D) 6.0 × (H) 25.0 mm
Environment	Indoor and Outdoor use
Terminal limitation	-15 °C to 65 °C
Hardware version	3.2.3
Software version	Not applicable
Firmware version	1.0.0.1
RF Specification	
Frequency range	2403 MHz-2481 MHz
Number of RF Channels	40 Channels
Modulation method/Data rate	GFSK (250 kbps)
Channel separation	2 MHz
Output power	103.3 dBuV/m
Antenna type	Internal antenna
Antenna gain	0 dBi

2.2 Modification to the EUT

The table below details modifications made to the EUT during the test project.

Modification State	Description of Modification	Modification fitted by	Date of Modification
Model: Model BR, Serial Number: 20060001, 20060002			
0	As supplied by the applicant	Not Applicable	Not Applicable

2.3 Variation of family model(s)

2.3.1 List of family model(s)

Not applicable

2.3.2 Reason for selection of EUT

Not applicable

2.4 Operating channels and frequencies

Channel	Frequency [MHz]	Channel	Frequency [MHz]
1	2403	21	2443
2	2405	22	2445
3	2407	23	2447
4	2409	24	2449
5	2411	25	2451
6	2413	26	2453
7	2415	27	2455
8	2417	28	2457
9	2419	29	2459
10	2421	30	2461
11	2423	31	2463
12	2425	32	2465
13	2427	33	2467
14	2429	34	2469
15	2431	35	2471
16	2433	36	2473
17	2435	37	2475
18	2437	38	2477
19	2439	39	2479
20	2441	40	2481

2.5 Operating mode

The EUT had been tested under operating condition.
There are three channels have been tested as following:

Tested Channel	Frequency [MHz]
Low	2403
Middle	2441
High	2481

The pre-test has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates.

Tested Channel	Modulation Type	Data Rate
Low, Middle, High	GFSK	250kbps

The field strength of spurious emissions was measured at each position of all three axis X, Y and Z to compare the level, and the maximum noise.

The worst emission was found in X-axis and the worst case recorded.

Pre-scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports.

2.6 Operating flow

[Tx mode]

- i) Test program setup to the PARAS
- ii) Select a Test mode
Operating frequency: Channel Low: 2403MHz, Channel Middle: 2441MHz, Channel High: 2481MHz, Data rate: EL-NORMAL 250kbps
- iii) Start test mode

[Rx mode]

- i) Test program setup to the PARAS
- ii) Select a Test mode
Operating frequency: Channel Low: 2403MHz, Channel Middle: 2441MHz, Channel High: 2481MHz
- iii) Start test mode

3 Configuration of Equipment

Numbers assigned to equipment on the diagram in “3.3 System configuration” correspond to the list in “3.1 Equipment used” and “3.2 Cable(s) used”.

Cabling and setup(s) were taken into consideration and test data was taken under worse case condition.

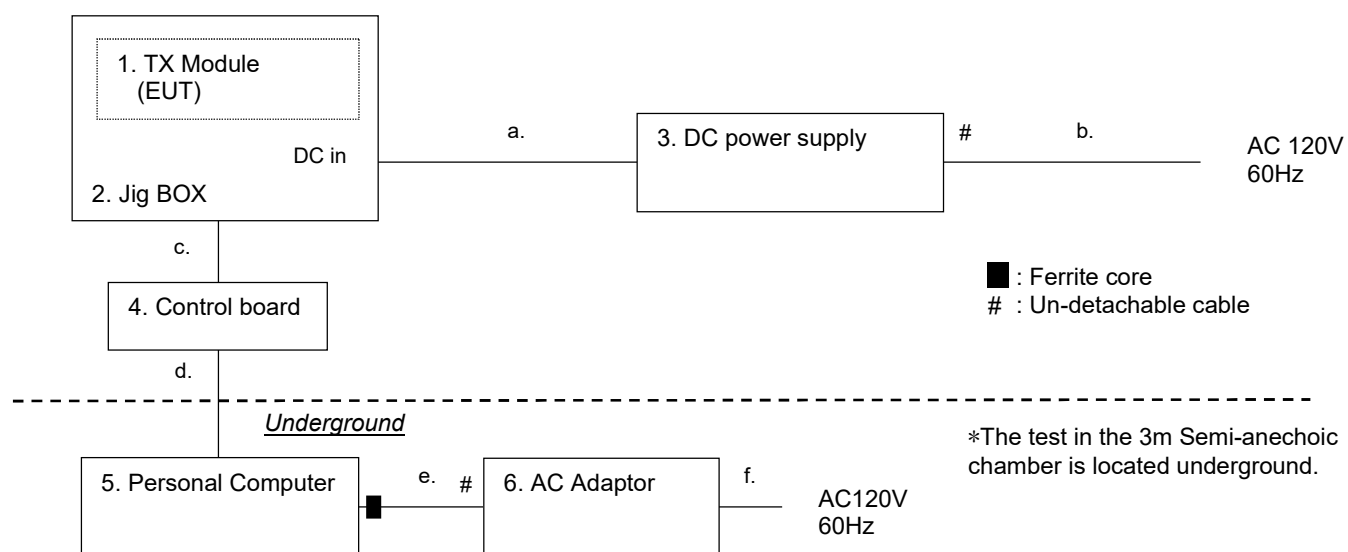
3.1 Equipment used

No.	Equipment	Company	Model No.	Serial No.	FCC ID/DoC	Comment
1	TX Module	HOKUBU TSUSHIN	Model BR	20060001 20060002	2AGF8-TXMBR	EUT
2	Jig BOX	-	-	-	-	-
3	DC power supply	KIKUSUI	PAB32-2	47306490	-	-
4	Control board	HOKUBU TSUSHIN	FT232RX	N/A	-	-
5	Personal Computer	ASUS	Eee PC 1015PEM	B30AAS254869	DoC	-
6	AC Adaptor	ASUS	ADP-40PH AB	N/A	-	-

3.2 Cable(s) used

No.	Equipment	Length[m]	Shield	Connector	Comment
a	DC cable	0.8	No	Plastic	-
b	AC power cord	2.0	No	Plastic	-
c	Signal cable	0.15	No	Plastic	-
d	USB cable	0.9	Yes	Metal	Shielded room No.4
		3.0	Yes	Metal	3m Semi-anechoic chamber
e	DC cable	1.8	No	Plastic	-
f	AC cable	0.8	No	Plastic	-

3.3 System configuration



Note1: Numbers assigned to equipment or cables on this diagram correspond to the list in “3.1 Equipment(s) used” and “3.2 Cable(s) used”.

4 Test Result

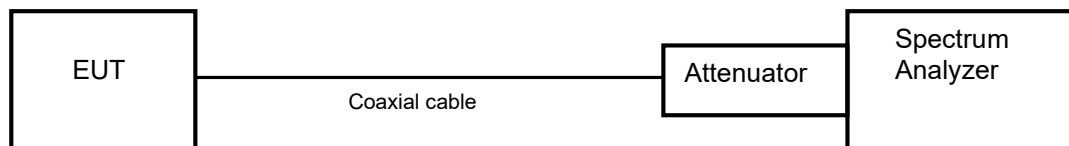
4.1 20dB Bandwidth / Occupied Bandwidth

4.1.1 Measurement procedure

[FCC 2.1049, ISSED RSS-Gen 6.6.7]

The transmitter output is connected to the spectrum analyzer. The RBW is set to 1% to 3% of the 99% bandwidth. The VBW is set to 3 times the RBW. The sweep time is coupled. The spectrum analyzer internal 99% bandwidth function is utilized.

- Test configuration



4.1.2 Limit

None

4.1.3 Measurement result

Date : 20-August-2020

Temperature : 24.8 [°C]

Humidity : 58.4 [%]

Test place : Shielded room No.4

Test engineer :

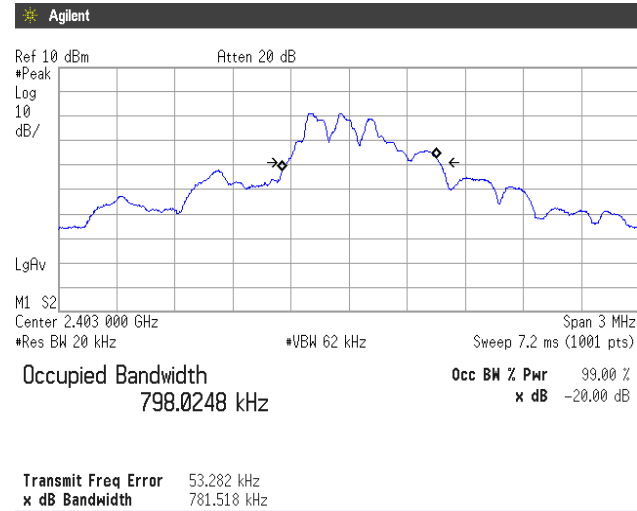
Tadahiro Seino

Band	Channel	Frequency (MHz)	Test Result (MHz)	
			20dB Bandwidth	Occupied Bandwidth
Low	1	2403	0.7815	0.7980
Middle	20	2441	0.9054	1.1037
High	40	2481	0.5673	0.5639

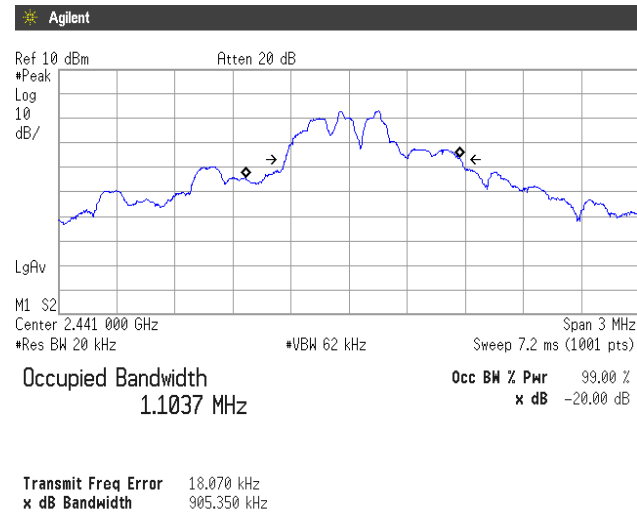
4.1.4 Trace data

[250kbps]

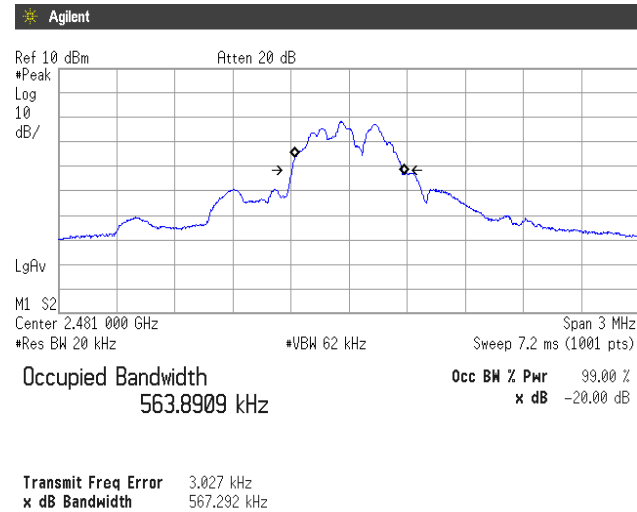
Channel: Low



Channel: Middle



Channel: High



4.2 Spurious Emissions - Field Strength of Fundamental and Harmonics -

4.2.1 Measurement procedure

[FCC 15.205, 15.209, 15.249(a), (b), (c), (d), (e), 15.35(b), ISED RSS-247 5.5, RSS-Gen 7.3, 8.9]

Test was applied by following conditions.

Test method	: ANSI C63.10
Frequency range	: 9kHz to 25GHz
Test place	: 3m Semi-anechoic chamber
EUT was placed on	: Styrofoam table / (W)0.6m × (D)0.6m × (H)0.8m (below 1GHz) Styrofoam table / (W)0.3m × (D)0.3m × (H)1.5m (above 1GHz)
Antenna distance	: 3m
Test receiver setting	Below 1GHz
- Detector	: Average (9kHz-90kHz, 110kHz-490kHz), Quasi-peak
- Bandwidth	: 200Hz, 120kHz
Spectrum analyzer setting	Above 1GHz
- Peak	: RBW=1MHz, VBW=3MHz, Span=0Hz, Sweep=auto
- Average	: Peak reading + DCF

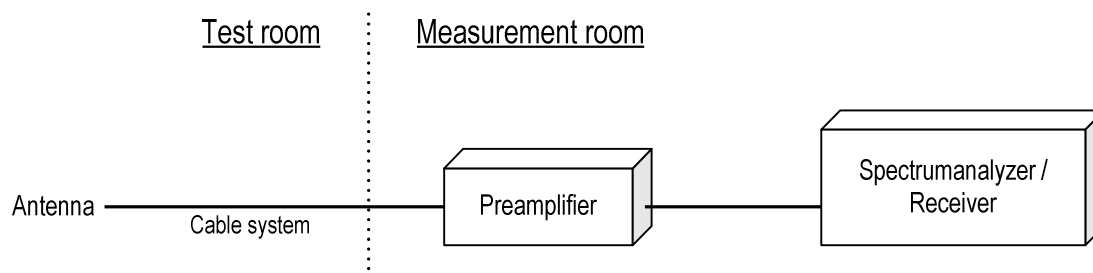
Average Measurement [DCF]

Data rate	Duty cycle (%)	T _{on} (ms)	100ms Window	1/T _{on} (kHz)	Duty cycle factor 20log (Dc %) (dB)
250kbps	12.4	1.24	10	0.806	-18.1

Although these tests were performed other than open area test site, adequate comparison measurements were confirmed against 30 m open area test site. Therefore sufficient tests were made to demonstrate that the alternative site produces results that correlate with the ones of tests made in an open field based on KDB 414788.

Radiated emission measurements are performed at 3m distance with the broadband antenna (Loop antenna, Biconical antenna, Log periodic antenna, Double ridged guide antenna and Broad-band horn Antenna). The antenna is positioned both the horizontal and vertical planes of polarization and height is varied 1m to 4m and stopped at height producing the maximum emission. As for the Loop antenna, it is positioned with its plane vertical, and the center of the Loop antenna is 1m above the ground plane. The EUT is Placed on a turntable, which is 0.8m/1.5m above ground plane. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level. The test results represent the worst case emission for each emission with manipulating the EUT, support equipment, interconnecting cables and varying the mode of operation. Sufficient time for the EUT, support equipment, and test equipment are allowed in order for them to warm up to their normal operating condition.

- Test configuration



4.2.2 Calculation method

[9kHz to 150kHz]

Emission level = Reading + (Ant factor + Cable system loss)

Margin = Limit – Emission level

[150kHz to 25GHz]

Emission level = Reading + (Ant factor + Cable system loss - Amp. Gain)

Margin = Limit – Emission level

Example:

Limit @ 4804.0MHz : 74.0dBuV/m (Peak Limit)

S.A Reading = 39.9dBuV Cable system loss = 8.3dB

Result = 39.9 + 8.3 = 48.2dBuV/m

Margin = 74.0 - 48.2 = 25.8dB

4.2.3 Limit

Fundamental Frequency [MHz]	Field strength of fundamental		Field strength of harmonics		Distance [m]
	[mV/m]	[dBuV/m]	[mV/m]	[dBuV/m]	
2400-2483.5	50	20logE [uV/m]	500	20logE [uV/m]	3

Frequency [MHz]	Field strength		Distance [m]
	[uV/m]	[dBuV/m]	
0.009-0.490	2400 / F [kHz]	20logE [uV/m]	300
0.490-1.705	24000 / F [kHz]	20logE [uV/m]	30
1.705-30	30	29.5	30
30-88	100	40.0	3
88-216	150	43.5	3
216-960	200	46.0	3
Above 960	500	54.0	3

Note:

1. The lower limit shall apply at the transition frequencies.
2. Emission level [dBuV/m] = 20log Emission [uV/m]
3. As shown in 15.35(b), for frequencies above 1000MHz, the field strength limits are based on average detector, however, the peak field strength of any emission shall not exceed the maximum permitted average limits, specified above by more than 20dB under any condition modulation.

4.2.4 Test data

Date : 27-July-2020
 Temperature : 21.8 [°C]
 Humidity : 68.8 [%]
 Test place : 3m Semi-anechoic chamber

Test engineer : Tadahiro Seino

Date : 18-August-2020
 Temperature : 20.6 [°C]
 Humidity : 67.3 [%]
 Test place : 3m Semi-anechoic chamber

Test engineer : Tadahiro Seino

<250kbps>**Channel Low
Peak**

(P)	Frequency [MHz]	Reading [dBμV/m]	c.f [dB(1/m)]	Duty cycle factor [dB(1/m)]	Result [dBμV/m]	Limit [dBμV/m]	Margin [dB]
H	2403	94.8	6.1	-	100.9	114	13.1
V	2403	89.6	6.1	-	95.7	114	18.3
H	4806	49.6	10.3	-	59.9	74	14.1
V	4806	50.3	10.3	-	60.6	74	13.4
H	7209	52.7	5.3	-	58.0	74	16.0
V	7209	52.0	5.3	-	57.3	74	16.7
H	9612	50.4	9.5	-	59.9	74	14.1
V	9612	49.7	9.5	-	59.2	74	14.8
H	12015	48.4	12.0	-	60.4	74	13.6
V	12015	46.4	12.0	-	58.4	74	15.6

Average

(P)	Frequency [MHz]	Reading [dBμV/m]	c.f [dB(1/m)]	Duty cycle factor [dB(1/m)]	Result [dBμV/m]	Limit [dBμV/m]	Margin [dB]
H	2403	94.8	6.1	18.1	82.8	94	11.2
V	2403	89.6	6.1	18.1	77.6	94	16.4
H	4806	49.6	10.3	18.1	41.8	54	12.2
V	4806	50.3	10.3	18.1	42.5	54	11.5
H	7209	52.7	5.3	18.1	39.9	54	14.1
V	7209	52.0	5.3	18.1	39.2	54	14.8
H	9612	50.4	9.5	18.1	41.8	54	12.2
V	9612	49.7	9.5	18.1	41.1	54	12.9
H	12015	48.4	12.0	18.1	42.3	54	11.7
V	12015	46.4	12.0	18.1	40.3	54	13.7

**Channel Middle
Peak**

(P)	Frequency [MHz]	Reading [dBμV/m]	c.f [dB(1/m)]	Duty cycle factor [dB(1/m)]	Result [dBμV/m]	Limit [dBμV/m]	Margin [dB]
H	2441	97.0	6.3	-	103.3	114	10.7
V	2441	91.6	6.3	-	97.9	114	16.1
H	4882	49.6	10.3	-	59.9	74	14.1
V	4882	50.8	10.3	-	61.1	74	12.9
H	7323	55.8	5.4	-	61.2	74	12.8
V	7323	53.0	5.4	-	58.4	74	15.6
H	9764	49.3	9.8	-	59.1	74	14.9
V	9764	49.5	9.8	-	59.3	74	14.7
H	12205	49.3	12.0	-	61.3	74	12.7
V	12205	50.7	12.0	-	62.7	74	11.3

Average

(P)	Frequency [MHz]	Reading [dB μ V/m]	c.f [dB(1/m)]	Duty cycle factor [dB(1/m)]	Result [dB μ V/m]	Limit [dB μ V/m]	Margin [dB]
H	2441	97.0	6.3	18.1	85.2	94	8.8
V	2441	91.6	6.3	18.1	79.8	94	14.2
H	4882	49.6	10.3	18.1	41.8	54	12.2
V	4882	50.8	10.3	18.1	43.0	54	11.0
H	7323	55.8	5.4	18.1	43.1	54	10.9
V	7323	53.0	5.4	18.1	40.3	54	13.7
H	9764	49.3	9.8	18.1	41.0	54	13.0
V	9764	49.5	9.8	18.1	41.2	54	12.8
H	12205	49.3	12.0	18.1	43.2	54	10.8
V	12205	50.7	12.0	18.1	44.6	54	9.4

Channel High Peak

(P)	Frequency [MHz]	Reading [dB μ V/m]	c.f [dB(1/m)]	Duty cycle factor [dB(1/m)]	Result [dB μ V/m]	Limit [dB μ V/m]	Margin [dB]
H	2481	92.4	6.5	-	98.9	114	15.1
V	2481	89.4	6.5	-	95.9	114	18.1
H	4962	48.6	10.5	-	59.1	74	14.9
V	4962	48.8	10.5	-	59.3	74	14.7
H	7443	51.4	5.7	-	57.1	74	16.9
V	7443	52.5	5.7	-	58.2	74	15.8
H	9924	45.2	10.2	-	55.4	74	18.6
V	9924	46.4	10.2	-	56.6	74	17.4
H	12405	47.2	11.8	-	59.0	74	15.0
V	12405	47.9	11.8	-	59.7	74	14.3

Average

(P)	Frequency [MHz]	Reading [dB μ V/m]	c.f [dB(1/m)]	Duty cycle factor [dB(1/m)]	Result [dB μ V/m]	Limit [dB μ V/m]	Margin [dB]
H	2481	92.4	6.5	18.1	80.8	94	13.2
V	2481	89.4	6.5	18.1	77.8	94	16.2
H	4962	48.6	10.5	18.1	41.0	54	13.0
V	4962	48.8	10.5	18.1	41.2	54	12.8
H	7443	51.4	5.7	18.1	39.0	54	15.0
V	7443	52.5	5.7	18.1	40.1	54	13.9
H	9924	45.2	10.2	18.1	37.3	54	16.7
V	9924	46.4	10.2	18.1	38.5	54	15.5
H	12405	47.2	11.8	18.1	40.9	54	13.1
V	12405	47.9	11.8	18.1	41.6	54	12.4

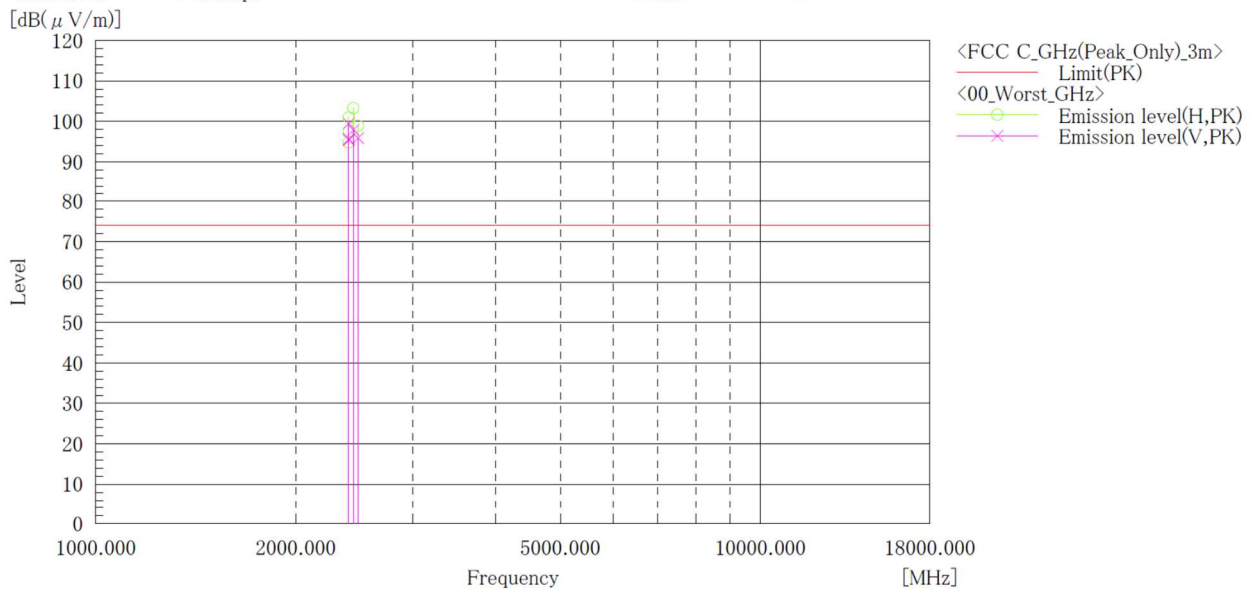
Note:

No emission was detected in the receive mode.

[Transmission mode]**Electric field strength of carrier wave***** The worst emission was found in X-axis.**

Company name : HOKUBU Communication
 EUT : TX Module
 Model No. : Model BR
 Serial No. : 20060002
 Test mode : 250kbps

Standard : FCC Part.15 subpart C
 Operator : T.Seino
 Temp,Hum,Atm : 20.6[°C] 67.3[%]
 Note1 :
 Note2 :

**Final Result**

No.	Frequency [MHz]	(P)	Reading PK [dB(μ V)]	c. f [dB(1/m)]	Result PK [dB(μ V/m)]	Limit PK [dB(μ V/m)]	Margin PK [dB]	Height [cm]	Angle [°]	Remark
1	2403.000	H	94.8	6.1	100.9	114.0	13.1	211.0	183.0	X axis_Max
2	2403.000	V	89.6	6.1	95.7	114.0	18.3	112.0	137.0	X axis
3	2403.000	H	88.7	6.1	94.8	114.0	19.2	370.0	177.0	Y axis
4	2403.000	V	93.4	6.1	99.5	114.0	14.5	117.0	134.0	Y axis
5	2403.000	H	91.5	6.1	97.6	114.0	16.4	155.0	246.0	Z axis
6	2403.000	V	89.3	6.1	95.4	114.0	18.6	155.0	178.0	Z axis
7	2441.000	H	97.0	6.3	103.3	114.0	10.7	110.0	186.0	X axis
8	2441.000	V	91.6	6.3	97.9	114.0	16.1	108.0	137.0	X axis
9	2481.000	H	92.4	6.5	98.9	114.0	15.1	200.0	188.0	X axis
10	2481.000	V	89.4	6.5	95.9	114.0	18.1	100.0	231.0	X axis

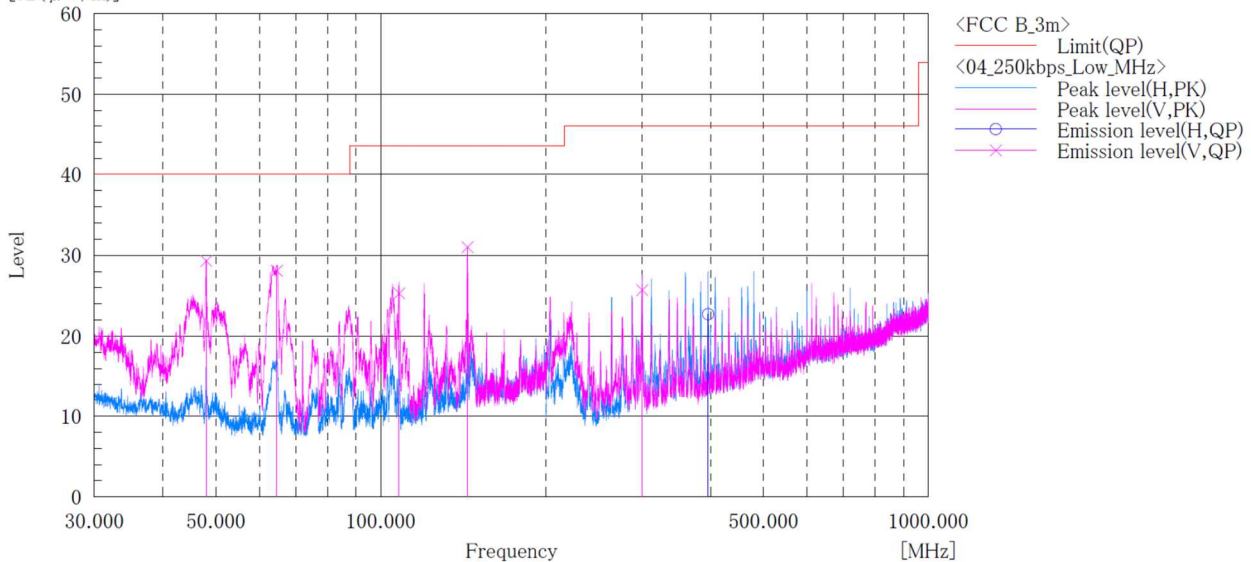
Note:Limit: 114 dB μ V/m

Channel: Low
BELOW 1 GHz

Company name : HOKUBU Communication
 EUT : TX Module
 Model No. : Model BR
 Serial No. : 20060002
 Test mode : 250kbps_Low CH (2403MHz)

Standard : FCC Part.15 subpart C
 Operator : T.Seino
 Temp,Hum,Atm : 20.6[°C] 67.3[%]
 Note1 : X axis
 Note2 :

[dB(μV/m)]



Final Result

No.	Frequency [MHz]	(P)	Reading QP [dB(μV)]	c. f [dB(1/m)]	Result QP [dB(μV/m)]	Limit QP [dB(μV/m)]	Margin QP [dB]	Height [cm]	Angle [°]
1	48.013	V	44.9	-15.6	29.3	40.0	10.7	100.0	99.0
2	64.583	V	45.1	-17.0	28.1	40.0	11.9	100.0	210.0
3	107.994	V	40.5	-15.2	25.3	43.5	18.2	100.0	155.0
4	144.001	V	44.2	-13.2	31.0	43.5	12.5	100.0	249.0
5	300.009	V	39.5	-13.8	25.7	46.0	20.3	100.0	240.0
6	396.001	H	34.3	-11.6	22.7	46.0	23.3	265.0	292.0

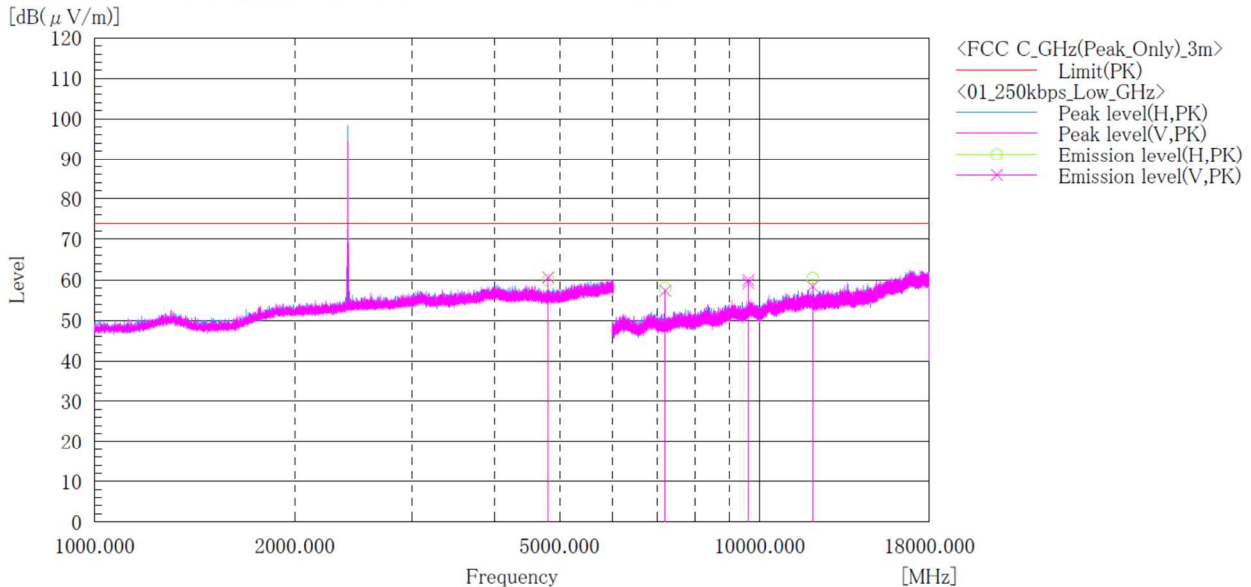
Note:

- Emission Level (Margin) = Limit - [Reading + Factor (Antenna + Cable - Amp)]
- No emission were detected in frequency range 9kHz to 30MHz at the 3 meters distance.

**Channel: Low
ABOVE 1 GHz**

Company name : HOKUBU Communication
EUT : TX Module
Model No. : Model BR
Serial No. : 20060002
Test mode : 250kbps_Low CH (2403MHz)

Standard : FCC Part.15 subpart C
Operator : T.Seino
Temp,Hum,Atm : 21.8[°C] 68.8[%]
Note1 : X axis
Note2 :


Final Result

No.	Frequency [MHz]	(P)	Reading PK [dB(μ V)]	c. f [dB(1/m)]	Result PK [dB(μ V/m)]	Limit PK [dB(μ V/m)]	Margin PK [dB]	Height [cm]	Angle [°]
1	4806.000	H	49.6	10.3	59.9	74.0	14.1	176.0	97.0
2	4806.000	V	50.3	10.3	60.6	74.0	13.4	100.0	8.0
3	7209.000	H	52.7	5.3	58.0	74.0	16.0	100.0	256.0
4	7209.000	V	52.0	5.3	57.3	74.0	16.7	100.0	322.0
5	9612.000	V	50.4	9.5	59.9	74.0	14.1	136.0	269.0
6	9612.000	V	49.7	9.5	59.2	74.0	14.8	171.0	31.0
7	12015.000	H	48.4	12.0	60.4	74.0	13.6	159.0	55.0
8	12015.000	V	46.4	12.0	58.4	74.0	15.6	159.0	112.0

Note:

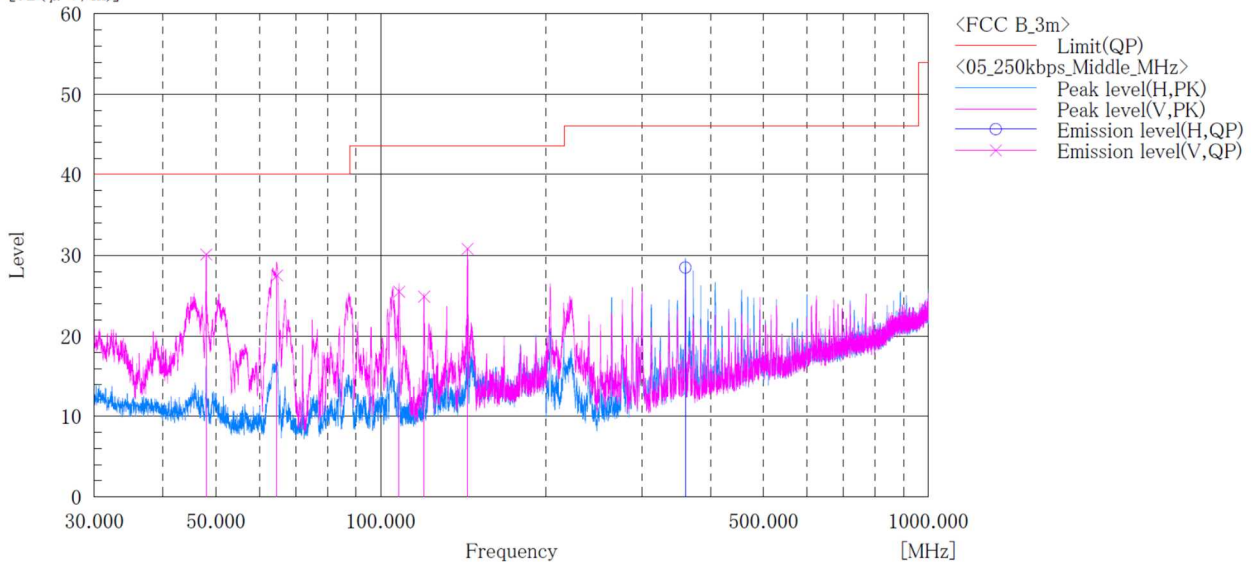
- Emission Level (Margin) = Limit - [Reading + Factor (Antenna + Cable – Amp)]
- No emission were detected in frequency range 18GHz to 25GHz at the 3 meters distance.

Channel: Middle
BELOW 1 GHz

Company name : HOKUBU Communication
 EUT : TX Module
 Model No. : Model BR
 Serial No. : 20060002
 Test mode : 250kbps_Middle CH (2441MHz)

Standard : FCC Part.15 subpart C
 Operator : T.Seino
 Temp,Hum,Atm : 20.6[°C] 67.3[%]
 Note1 : X axis
 Note2 :

[dB(μV/m)]



Final Result

No.	Frequency [MHz]	(P)	Reading QP [dB(μV)]	c. f [dB(1/m)]	Result QP [dB(μV/m)]	Limit QP [dB(μV/m)]	Margin QP [dB]	Height [cm]	Angle [°]
1	48.001	V	45.7	-15.6	30.1	40.0	9.9	100.0	58.0
2	64.614	V	44.5	-17.0	27.5	40.0	12.5	100.0	218.0
3	108.000	V	40.7	-15.2	25.5	43.5	18.0	100.0	211.0
4	120.004	V	39.5	-14.6	24.9	43.5	18.6	100.0	158.0
5	144.024	V	44.0	-13.2	30.8	43.5	12.7	100.0	245.0
6	360.005	H	40.7	-12.2	28.5	46.0	17.5	100.0	270.0

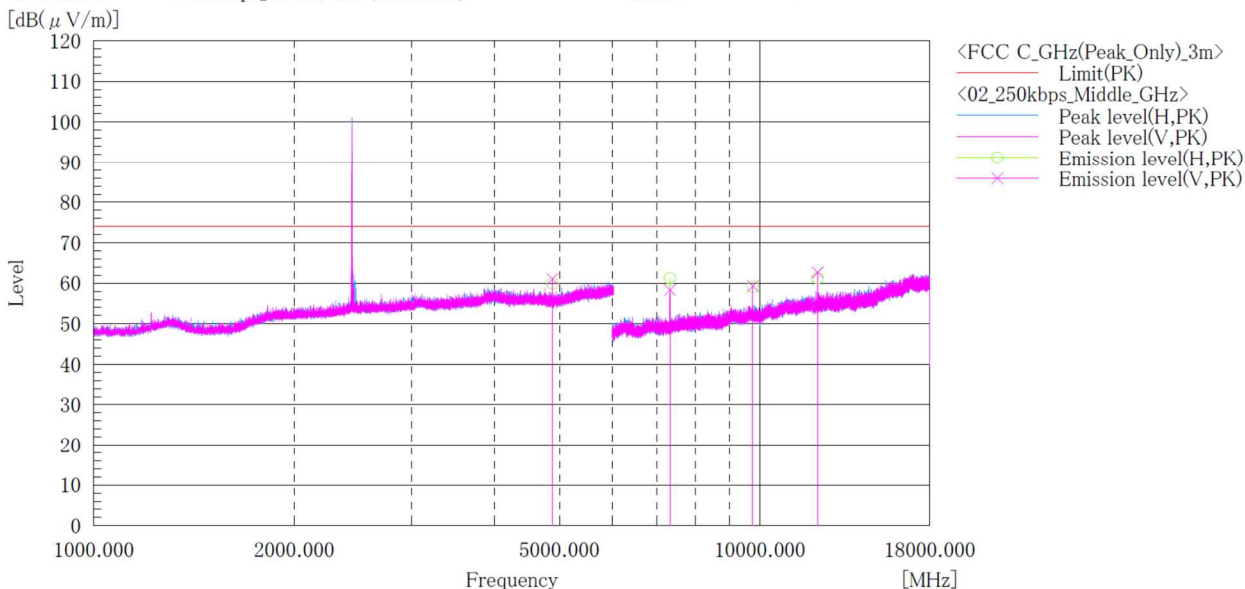
Note:

- Emission Level (Margin) = Limit - [Reading + Factor (Antenna + Cable - Amp)]
- No emission were detected in frequency range 9kHz to 30MHz at the 3 meters distance.

Channel: Middle
ABOVE 1 GHz

Company name : HOKUBU Communication
 EUT : TX Module
 Model No. : Model BR
 Serial No. : 20060002
 Test mode : 250kbps_Middle CH (2441MHz)

Standard : FCC Part.15 subpart C
 Operator : T.Seino
 Temp,Hum,Atm : 20.6[°C] 67.3[%]
 Note1 : X axis
 Note2 :


Final Result

No.	Frequency [MHz]	(P)	Reading PK [dB(μV)]	c. f [dB(1/m)]	Result PK [dB(μV/m)]	Limit PK [dB(μV/m)]	Margin PK [dB]	Height [cm]	Angle [°]
1	4882.000	H	49.6	10.3	59.9	74.0	14.1	321.0	82.0
2	4882.000	V	50.8	10.3	61.1	74.0	12.9	112.0	354.0
3	7323.000	H	55.8	5.4	61.2	74.0	12.8	104.0	101.0
4	7323.000	V	53.0	5.4	58.4	74.0	15.6	173.0	259.0
5	9764.000	H	49.3	9.8	59.1	74.0	14.9	199.0	280.0
6	9764.000	V	49.5	9.8	59.3	74.0	14.7	166.0	248.0
7	12205.000	H	49.3	12.0	61.3	74.0	12.7	214.0	348.0
8	12205.000	V	50.7	12.0	62.7	74.0	11.3	203.0	154.0

Note:

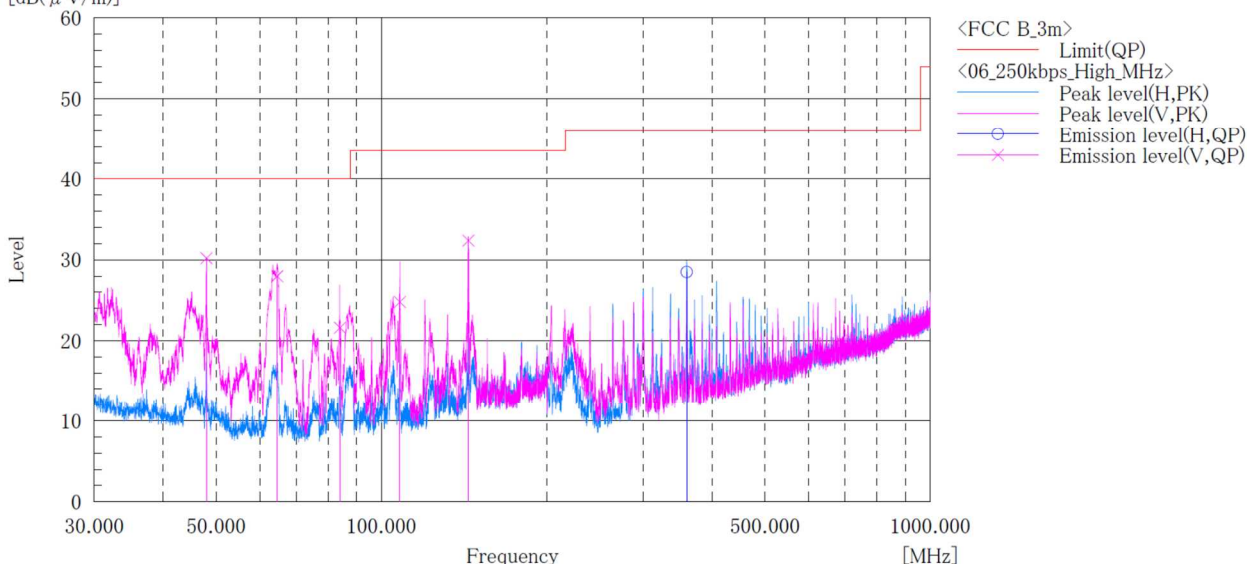
- Emission Level (Margin) = Limit - [Reading + Factor (Antenna + Cable – Amp)]
- No emission were detected in frequency range 18GHz to 25GHz at the 3 meters distance.

Channel: High
BELOW 1 GHz

Company name : HOKUBU Communication
 EUT : TX Module
 Model No. : Model BR
 Serial No. : 20060002
 Test mode : 250kbps_High CH (2481MHz)

Standard : FCC Part.15 subpart C
 Operator : T.Seino
 Temp,Hum,Atm : 20.6[°C] 67.3[%]
 Note1 : X axis
 Note2 :

[dB(μV/m)]



Final Result

No.	Frequency [MHz]	(P)	Reading QP [dB(μV)]	c. f [dB(1/m)]	Result QP [dB(μV/m)]	Limit QP [dB(μV/m)]	Margin QP [dB]	Height [cm]	Angle [°]
1	48.006	V	45.8	-15.6	30.2	40.0	9.8	100.0	139.0
2	64.590	V	45.0	-17.0	28.0	40.0	12.0	100.0	198.0
3	84.000	V	37.7	-16.1	21.6	40.0	18.4	100.0	256.0
4	108.001	V	40.0	-15.2	24.8	43.5	18.7	100.0	202.0
5	144.002	V	45.6	-13.2	32.4	43.5	11.1	100.0	244.0
6	360.003	H	40.7	-12.2	28.5	46.0	17.5	100.0	286.0

Note:

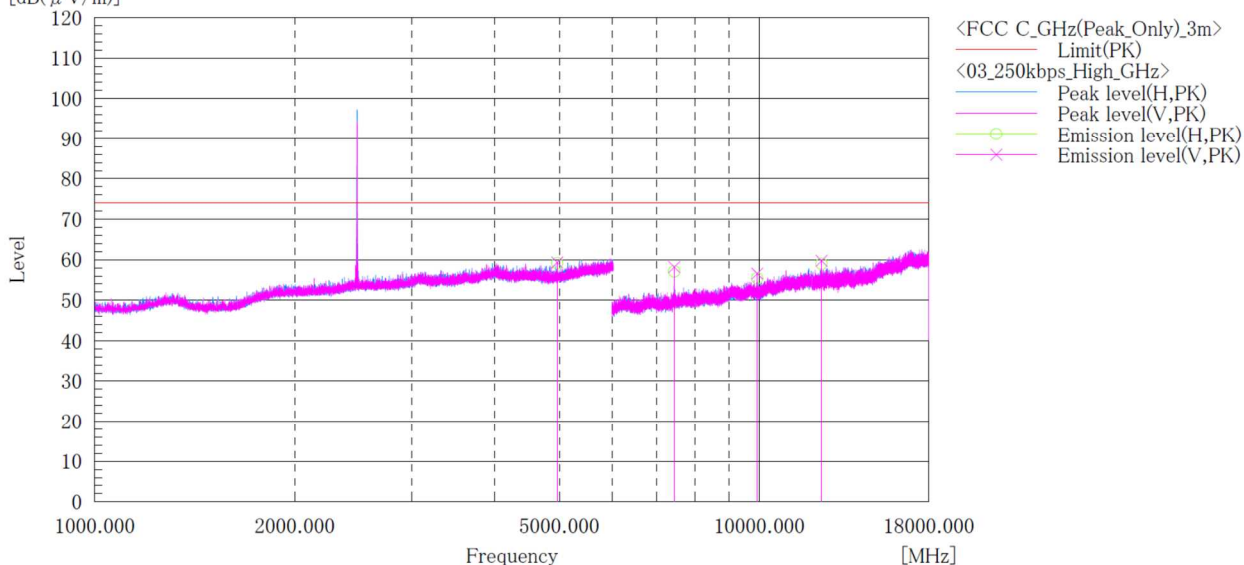
- Emission Level (Margin) = Limit - [Reading + Factor (Antenna + Cable – Amp)]
- No emission were detected in frequency range 9kHz to 30MHz at the 3 meters distance.

Channel: High
ABOVE 1 GHz

Company name : HOKUBU Communication
 EUT : TX Module
 Model No. : Model BR
 Serial No. : 20060002
 Test mode : 250kbps_High CH (2481MHz)

Standard : FCC Part.15 subpart C
 Operator : T.Seino
 Temp,Hum,Atm : 20.6[°C] 67.3[%]
 Note1 : X axis
 Note2 :

[dB(μV/m)]



Final Result

No.	Frequency [MHz]	(P)	Reading PK [dB(μV)]	c. f [dB(1/m)]	Result PK [dB(μV/m)]	Limit PK [dB(μV/m)]	Margin PK [dB]	Height [cm]	Angle [°]
1	4962.000	H	48.6	10.5	59.1	74.0	14.9	251.0	115.0
2	4962.000	V	48.8	10.5	59.3	74.0	14.7	106.0	347.0
3	7443.000	H	51.4	5.7	57.1	74.0	16.9	137.0	99.0
4	7443.000	V	52.5	5.7	58.2	74.0	15.8	100.0	212.0
5	9924.000	H	45.2	10.2	55.4	74.0	18.6	148.0	287.0
6	9924.000	V	46.4	10.2	56.6	74.0	17.4	178.0	241.0
7	12405.000	H	47.2	11.8	59.0	74.0	15.0	189.0	0.0
8	12405.000	V	47.9	11.8	59.7	74.0	14.3	196.0	155.0

Note:

- Emission Level (Margin) = Limit - [Reading + Factor (Antenna + Cable – Amp)]
- No emission were detected in frequency range 18GHz to 25GHz at the 3 meters distance.

4.3 Restricted Band of Operation

4.3.1 Measurement procedure

[FCC 15.205, 15.209, 15.249(c), (d), ISSED RSS-Gen 8.10]

Test was applied by following conditions.

Test method : ANSI C63.10
 Test place : 3m Semi-anechoic chamber
 EUT was placed on : Styrofoam table / (W)0.3m × (D)0.3m × (H)1.5m (above 1GHz)
 Antenna distance : 3m

Spectrum analyzer setting

- Peak : RBW=1MHz, VBW=3MHz, Span=10MHz, Sweep=auto
 - Delta : RBW=300kHz, VBW=300kHz, Span=40MHz, Sweep=auto
 - Average : RBW=1MHz, VBW=1kHz, Span=40MHz, Sweep=auto

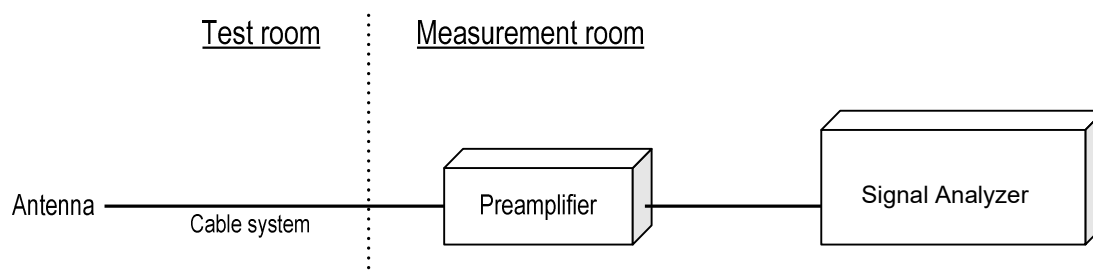
Average Measurement Setting [VBW]

Data rate	Duty Cycle (%)	T _{on} (ms)	T _{off} (ms)	1/T _{on} (kHz)	Determined VBW Setting
250kbps	12.4	1.24	8.8	0.806	1kHz

Although these tests were performed other than open area test site, adequate comparison measurements were confirmed against 30 m open area test site. Therefore sufficient tests were made to demonstrate that the alternative site produces results that correlate with the ones of tests made in an open field based on KDB 414788.

Radiated emission measurements are performed at 3m distance with the broadband antenna (Double ridged guide antenna). The antenna is positioned both the horizontal and vertical planes of polarization and height is varied 1m to 4m and stopped at height producing the maximum emission. The EUT is Placed on a turntable, which is 1.5m above ground plane. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level. The test results represent the worst case emission for each emission with manipulating the EUT, support equipment, interconnecting cables and varying the mode of operation. Sufficient time for the EUT, support equipment, and test equipment are allowed in order for them to warm up to their normal operating condition.

- Test configuration



4.3.2 Limit

Emission at the boundary of the restricted band provided by 15.205 shall be lower than 15.209 limit.

4.3.3 Measurement result

Channel	Frequency [MHz]	Results Chart	Result
Low	2403	See the Trace Data	Pass
High	2481	See the Trace Data	Pass

4.3.4 Test data

Date : 18-August-2020

Temperature : 20.6 [°C]

Humidity : 67.3 [%]

Test place : 3m Semi-anechoic chamber

Test engineer :

Tadahiro Seino

<250kbps>

Peak

(P)	Frequency [MHz]	Reading [dBμV/m]	c.f [dB(1/m)]	Marker Delta [dB]	Result [dBμV/m]	Limit [dBμV/m]	Margin [dB]
H	2390	92.93	6.1	46.57	52.46	74	21.54
V	2390	88.95	6.1	43.28	51.77	74	22.23
H	2483.5	91.10	6.5	32.23	65.37	74	8.63
V	2483.5	87.79	6.5	30.79	63.50	74	10.50

Average

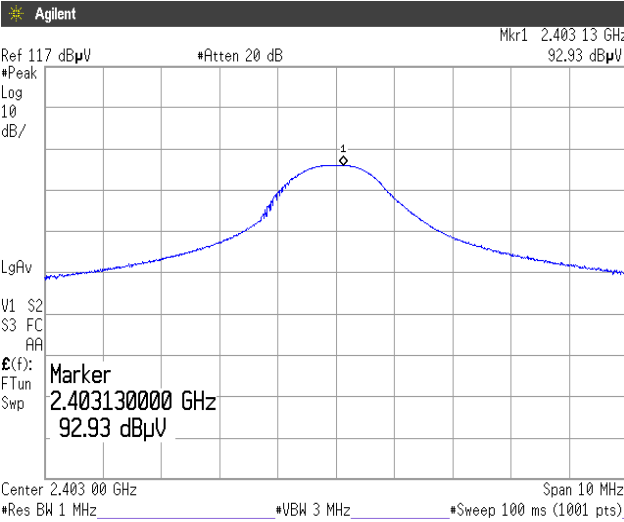
(P)	Frequency [MHz]	Reading [dBμV/m]	c.f [dB(1/m)]	Result [dBμV/m]	Limit [dBμV/m]	Margin [dB]
H	2390	38.35	6.1	44.45	54	9.55
V	2390	38.32	6.1	44.42	54	9.58
H	2483.5	39.05	6.5	45.55	54	8.45
V	2483.5	38.75	6.5	45.25	54	8.75

<250kbps>

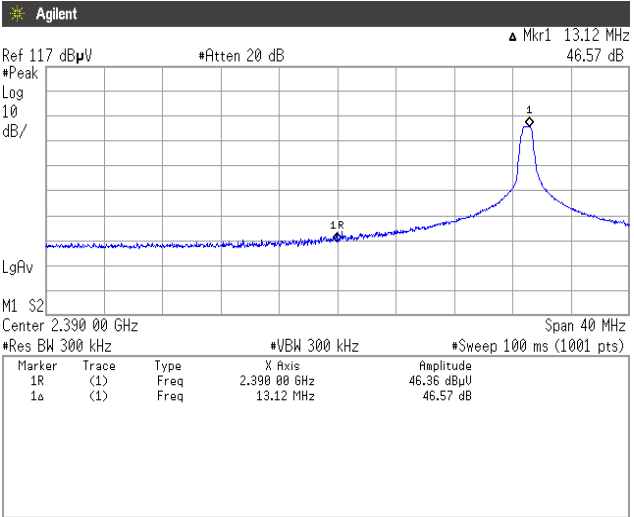
Channel Low

Horizontal

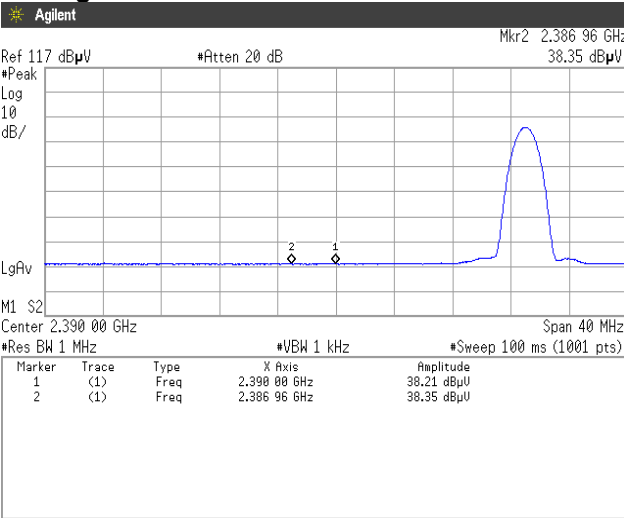
Peak



Maker Delta



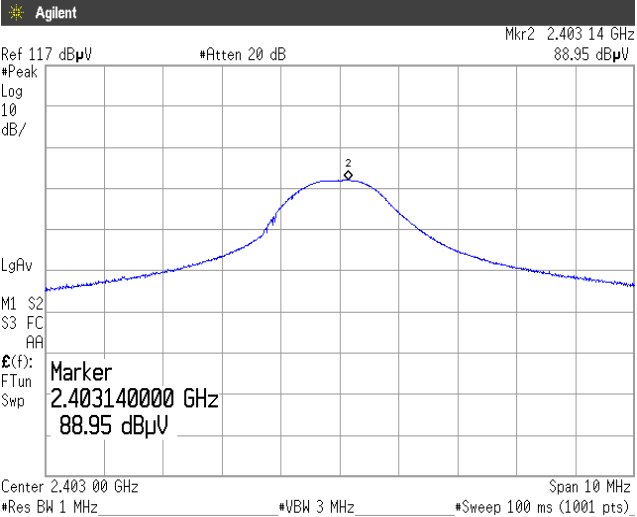
Average



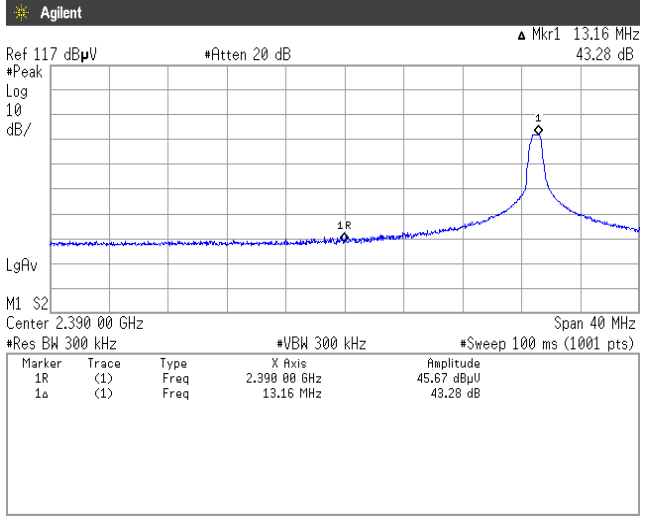


Japan

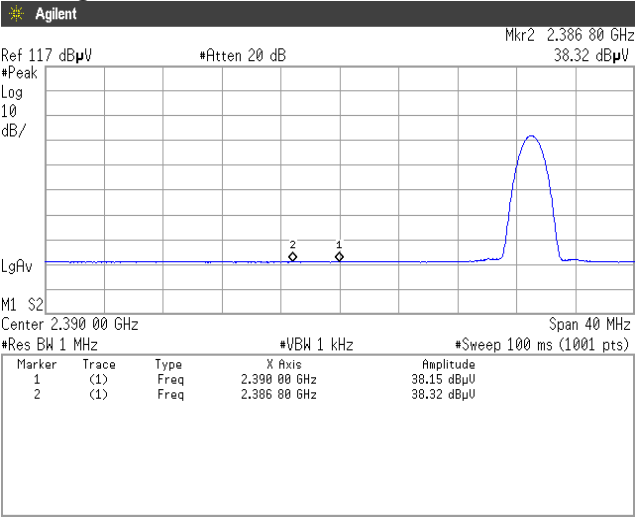
Channel Low Vertical Peak



Maker Delta



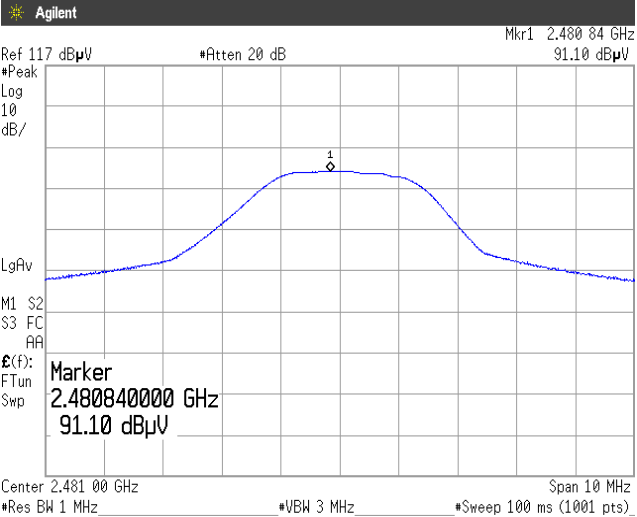
Average



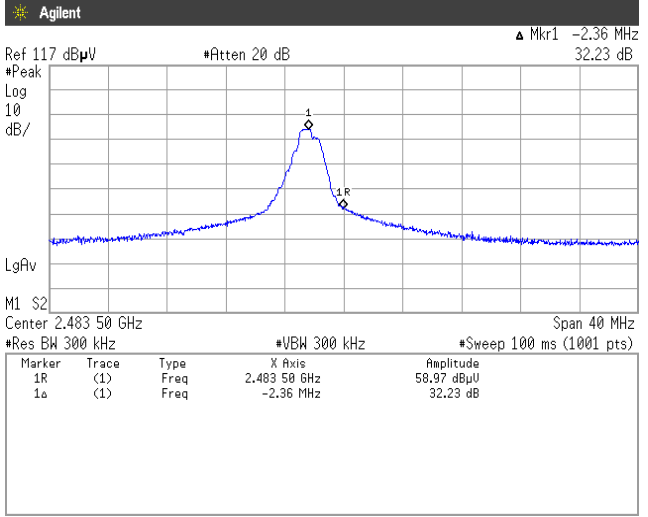


Japan

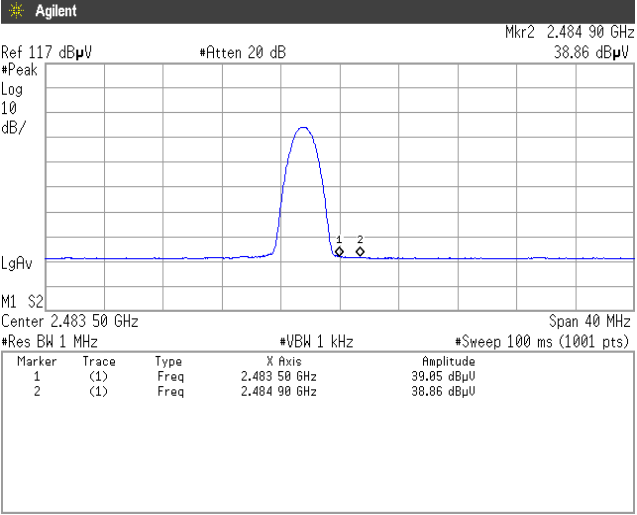
Channel High Horizontal Peak



Marker Delta



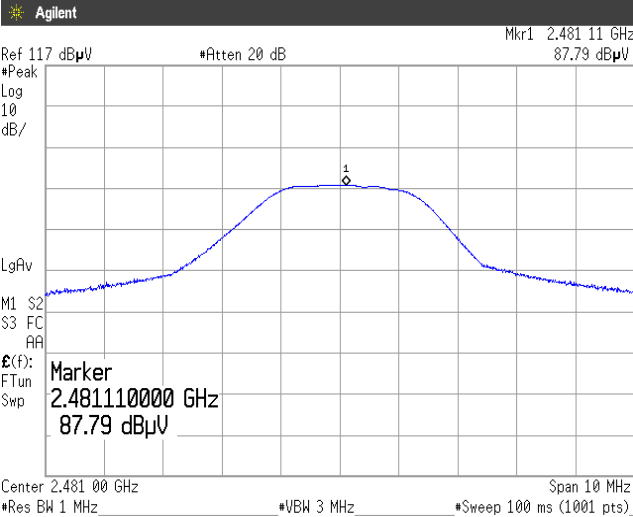
Average



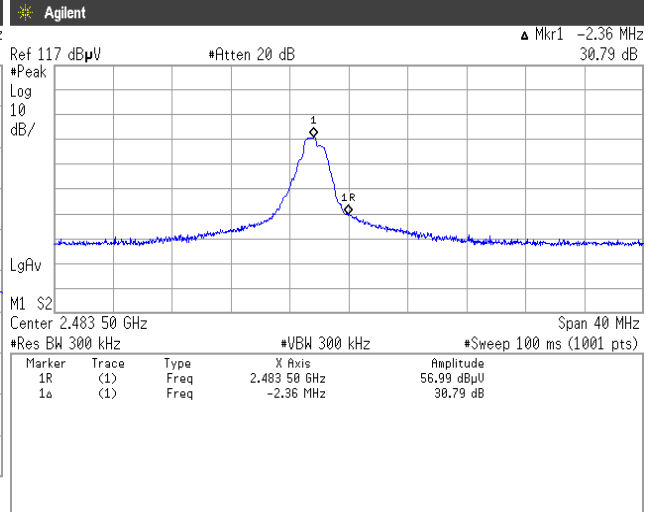


Japan

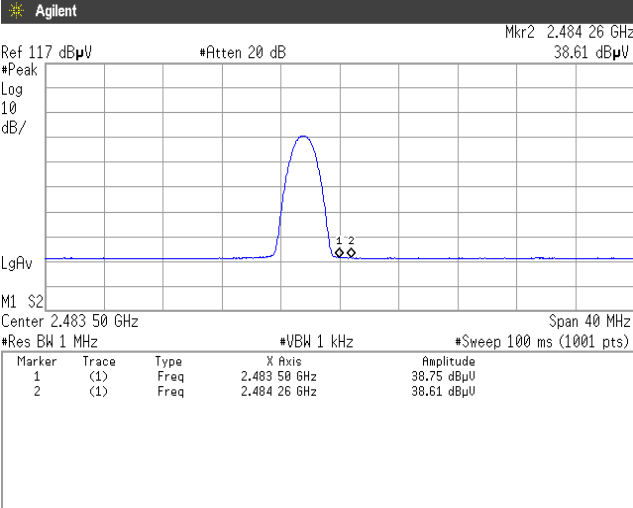
Channel High Vertical Peak



Marker Delta



Average



4.4 AC Power Line Conducted Emissions

4.4.1 Measurement procedure

[FCC 15.207, ISED RSS-Gen 8.8]

Test was applied by following conditions.

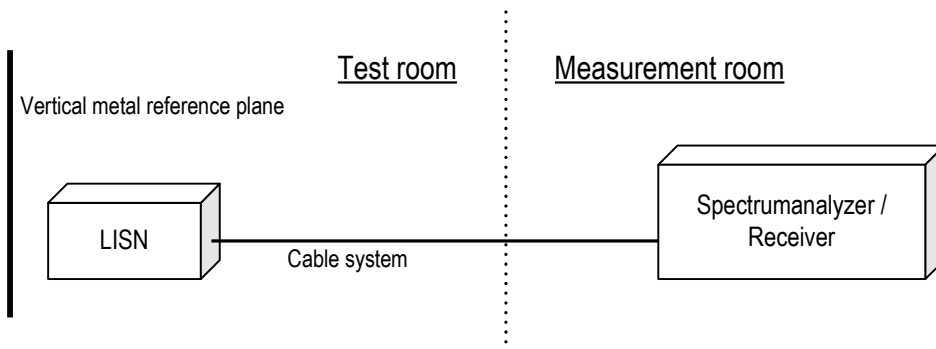
Test method	: ANSI C63.10
Frequency range	: 0.15 MHz to 30 MHz
Test place	: 3 m Semi-anechoic chamber
EUT was placed on	: FRP table / (W)2.0 m × (D)1.0 m × (H)0.8 m
Vertical Metal Reference Plane	: (W)2.0 m × (H)2.0 m 0.4 m away from EUT
Test receiver setting	
- Detector	: Quasi-peak, Average
- Bandwidth	: 9 kHz

EUT and peripherals are connected to 50Ω/50μH Line Impedance Stabilization Network (LISN) which are connected to reference ground plane, and are placed 80cm away from EUT. Excess of AC power cable is bundled in center.

LISN for peripheral is terminated in 50Ω.

EUT operating mode is selected to emit the maximum noise. Overall frequency range is investigated with spectrum analyzer using peak detector. Maximum emission configuration is determined by manipulating the EUT, peripherals, interconnecting cables. Then, emission measurements are performed with test receiver in above setting to each current-carrying conductor of the mains port. Sufficient time for EUT, peripherals and test equipment is provided in order for them to warm up to their normal operating condition. If the average limit is met when using a quasi-peak detector receiver, the EUT shall be deemed to meet both limits.

- Test configuration



4.4.2 Calculation method

Emission level = Reading + (LISN. Factor + Cable system loss)

Margin = Limit – Emission level

Example:

Limit @ 6.770 MHz : 60.0 dB μ V(Quasi-peak)

: 50.0 dB μ V(Average)

(Quasi peak) Reading = 41.2 dB μ V c.f = 10.3 dB

Emission level = 41.2 + 10.3 = 51.5 dB μ V

Margin = 60.0 – 51.5 = 8.5 dB

(Average) Reading = 35.0 dB μ V c.f = 10.3 dB

Emission level = 35.0 + 10.3 = 45.3 dB μ V

Margin = 50.0 – 45.3 = 4.7 dB

4.4.3 Limit

Frequency [MHz]	Limit	
	QP [dB μ V]	AV [dB μ V]
0.15-0.5	66-56*	56-46*
0.5-5	56	46
5-30	60	50

*: The limit decreases linearly with the logarithm of the frequency in the range 0.15MHz to 0.5MHz.

4.4.4 Test data

Date : 19-August-2020

Temperature : 21.9 [°C]

Humidity : 66.0 [%]

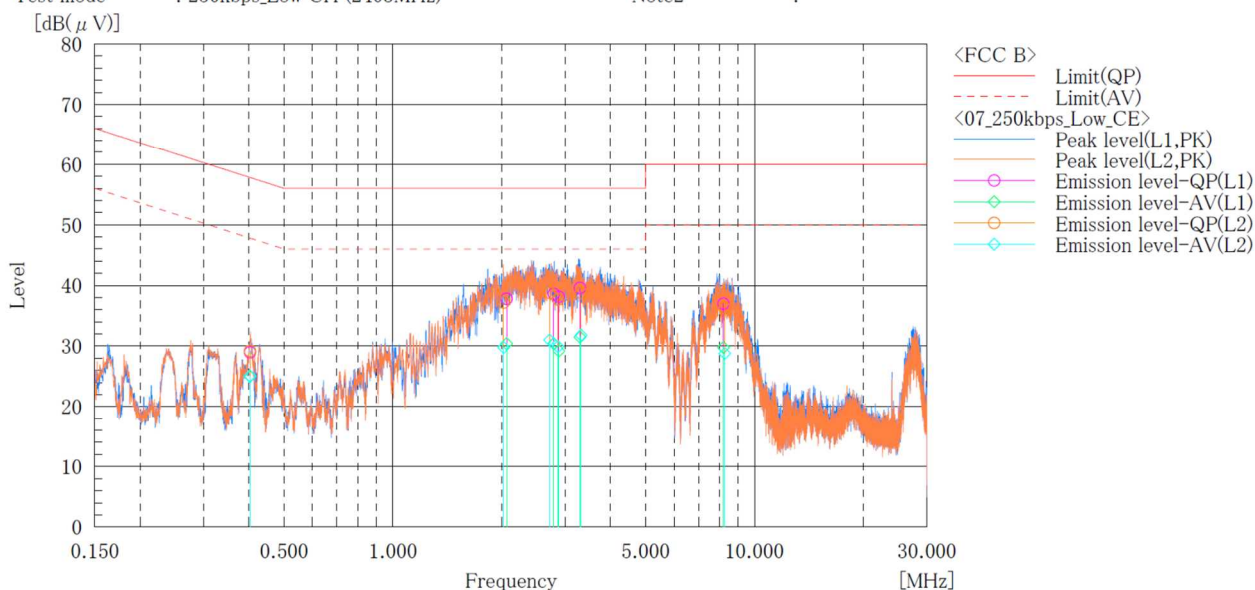
Test place : 3m Semi-anechoic chamber

Test engineer :

Tadahiro Seino

Company Name : HOKUBU Communication
 EUT : TX Module
 Model No. : Model BR
 Serial No. : 20060002
 Test mode : 250kbps_Low CH (2403MHz)

Standard : FCC Part.15 subpart C
 Operator : T.Seino
 Temp,Hum,Atm : 21.9[°C] 66.0[%]
 Note1 : X axis
 Note2 :



Final Result

--- L1 Phase ---

No.	Frequency	Reading QP	Reading AV	c. f	Result QP	Result AV	Limit QP	Limit AV	Margin QP	Margin AV
	[MHz]	[dB(μV)]	[dB(μV)]	[dB]	[dB(μV)]	[dB(μV)]	[dB(μV)]	[dB(μV)]	[dB]	[dB]
1	0.403	18.7	14.7	10.3	29.0	25.0	57.8	47.8	28.8	22.8
2	2.064	27.4	20.0	10.4	37.8	30.4	56.0	46.0	18.2	15.6
3	2.787	28.2	20.0	10.4	38.6	30.4	56.0	46.0	17.4	15.6
4	2.878	27.7	18.8	10.4	38.1	29.2	56.0	46.0	17.9	16.8
5	3.291	29.1	21.0	10.5	39.6	31.5	56.0	46.0	16.4	14.5
6	8.214	26.4	19.2	10.6	37.0	29.8	60.0	50.0	23.0	20.2

--- L2 Phase ---

No.	Frequency	Reading QP	Reading AV	c. f	Result QP	Result AV	Limit QP	Limit AV	Margin QP	Margin AV
	[MHz]	[dB(μV)]	[dB(μV)]	[dB]	[dB(μV)]	[dB(μV)]	[dB(μV)]	[dB(μV)]	[dB]	[dB]
1	0.403	18.9	14.8	10.3	29.2	25.1	57.8	47.8	28.6	22.7
2	2.025	26.8	19.4	10.4	37.2	29.8	56.0	46.0	18.8	16.2
3	2.715	28.4	20.6	10.4	38.8	31.0	56.0	46.0	17.2	15.0
4	2.861	27.3	19.5	10.4	37.7	29.9	56.0	46.0	18.3	16.1
5	3.316	28.3	21.3	10.5	38.8	31.8	56.0	46.0	17.2	14.2
6	8.274	25.7	18.2	10.6	36.3	28.8	60.0	50.0	23.7	21.2

Note: No emission were observed during Conducted testing.



Japan

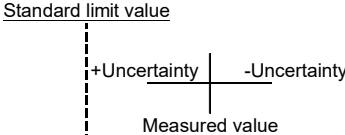
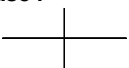
5 Antenna requirement

According to FCC section 15.203, an intentional radiator shall be designed to ensure that no antenna other than furnished by the responsible party shall be used with the device. The antenna is a special antenna mounted inside of the EUT. Therefore, the EUT complies with the antenna requirement of FCC section 15.203.

6 Measurement Uncertainty

Expanded uncertainties stated are calculated with a coverage Factor $k=2$.
Please note that these results are not taken into account when measurement uncertainty considerations contained in ETSI TR 100 028 Parts 1 and 2 determining compliance or non-compliance with test result.

Test item	Measurement uncertainty
Conducted emission, AMN (9 kHz – 150 kHz)	± 3.8 dB
Conducted emission, AMN (150 kHz – 30 MHz)	± 3.4 dB
Radiated emission (9 kHz – 30 MHz)	± 3.9 dB
Radiated emission (30 MHz – 1000 MHz)	± 4.9 dB
Radiated emission (1 GHz – 6 GHz)	± 4.6 dB
Radiated emission (6 GHz – 18 GHz)	± 4.9 dB
Radiated emission (18 GHz – 40 GHz)	± 5.8 dB
Radio Frequency	$\pm 1.4 \times 10^{-8}$
RF power, conducted	± 0.6 dB
Temperature	± 0.6 °C
Humidity	± 1.2 %
Voltage (DC)	± 0.4 %
Voltage (AC, <10kHz)	± 0.2 %

Judge	Measured value and standard limit value	
PASS	 Standard limit value Case1 +Uncertainty -Uncertainty Measured value Even if it takes uncertainty into consideration, a standard limit value is fulfilled.	
	 Case2 Although measured value is in a standard limit value, a limit value won't be fulfilled if uncertainty is taken into consideration.	
FAIL	 Case3 Although measured value exceeds a standard limit value, a limit value will be fulfilled if uncertainty is taken into consideration.	
	 Case4 Even if it takes uncertainty into consideration, a standard limit value isn't fulfilled.	

7 Laboratory Information

Testing was performed and the report was issued at:

TÜV SÜD Japan Ltd. Yonezawa Testing Center

Address: 5-4149-7 Hachimanpara, Yonezawa-shi, Yamagata, 992-1128 Japan
Phone: +81-238-28-2881
Fax: +81-238-28-2888

Accreditation and Registration

A2LA

Certificate #3686.03

VLAC

Accreditation No.: VLAC-013

BSMI

Laboratory Code: SL2-IN-E-6018, SL2-A1-E-6018

Innovation, Science and Economic Development Canada
ISED#: 4224A

VCCI Council

Registration number	Expiration date
A-0166	03-July-2021

Appendix A. Test Equipment

Antenna port conducted test

Equipment	Company	Model No.	Serial No.	Cal. Due	Cal. Date
Spectrum analyzer	Agilent Technologies	E4440A	US40420937	25-Sep-2020	26-Sep-2019
Attenuator	Weinschel	56-10	J4993	16-Dec-2020	17-Dec-2019

Radiated emission

Equipment	Company	Model No.	Serial No.	Cal. Due	Cal. Date
EMI Receiver	ROHDE&SCHWARZ	ESCI	100765	24-Sep-2020	25-Sep-2019
Spectrum analyzer	Agilent Technologies	E4447A	MY46180188	26-Mar-2021	27-Mar-2020
Spectrum analyser	Agilent Technologies	E4440A	US40420937	25-Sep-2020	26-Sep-2019
Preamplifier	SONOMA	310	372170	25-Sep-2020	26-Sep-2019
Loop antenna	ROHDE&SCHWARZ	HFH2-Z2	100515	14-Apr-2021	15-Apr-2020
Attenuator	TOYO Connector	NA-PJ-6	N/A(S507)	17-Dec-2020	18-Dec-2019
Biconical antenna	Schwarzbeck	VHBB9124/BBA9106	1344	03-Dec-2020	04-Dec-2019
Log periodic antenna	Schwarzbeck	VUSLP9111B	345	26-Aug-2020	27-Aug-2019
Attenuator	TAMAGAWA.ELEC	CFA-01/6dB	N/A(S466)	01-Oct-2020	02-Oct-2019
Attenuator	TAMAGAWA.ELEC	CFA-10/3dB	N/A(S503)	19-Jul-2021	20-Jul-2020
Preamplifier	TSJ	MLA-100M18-B02-40	1929118	07-Jan-2021	08-Jan-2020
Attenuator	AEROFLEX	26A-10	081217-08	09-Jan-2021	10-Jan-2020
Double ridged guide antenna	ETS LINDGREN	3117	00052315	07-Apr-2021	08-Apr-2020
Attenuator	HUBER+SUHNER	6803.17.B	N/A(2341)	17-Dec-2020	18-Dec-2019
Double ridged guide antenna	A.H.Systems Inc.	SAS-574	469	27-Aug-2020	28-Aug-2019
Preamplifier	TSJ	MLA-1840-B03-35	1240332	27-Aug-2020	28-Aug-2019
Notch Filter	Micro-Tronics	BRM50702	045	14-May-2021	15-May-2020
Microwave cable	HUBER+SUHNER	SUCOFLEX104/9m	MY30037/4	07-Jan-2021	08-Jan-2020
		SUCOFLEX104/1m	my24610/4	07-Jan-2021	08-Jan-2020
		SUCOFLEX104/8m	SN MY30031/4	08-Jan-2021	09-Jan-2020
		SUCOFLEX104	MY32976/4	07-Jan-2021	08-Jan-2020
		SUCOFLEX104/1.5m	MY19309/4	07-Jan-2021	08-Jan-2020
		SUCOFLEX104/7m	41625/6	07-Jan-2021	08-Jan-2020
PC	DELL	DIMENSION E521	75465BX	N/A	N/A
Software	TOYO Corporation	EP5/RE-AJ	0611193/V5.6.0	N/A	N/A
Absorber	RIKEN	PFP30	N/A	N/A	N/A
3m Semi an-echoic Chamber	TOKIN	N/A	N/A(9002-NSA)	28-May-2021	29-May-2020
3m Semi an-echoic Chamber	TOKIN	N/A	N/A(9002-SVSWR)	27-May-2021	28-May-2020

Conducted emission at mains port

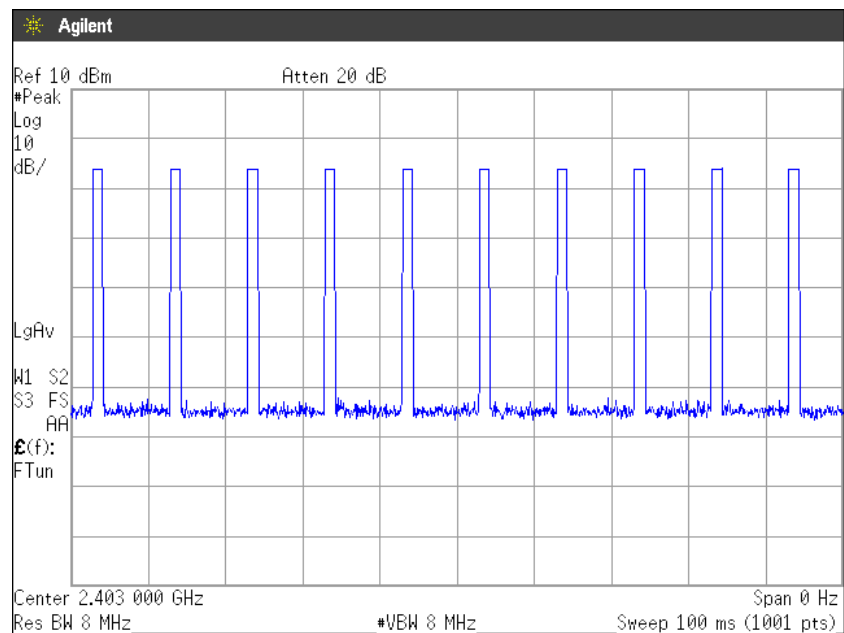
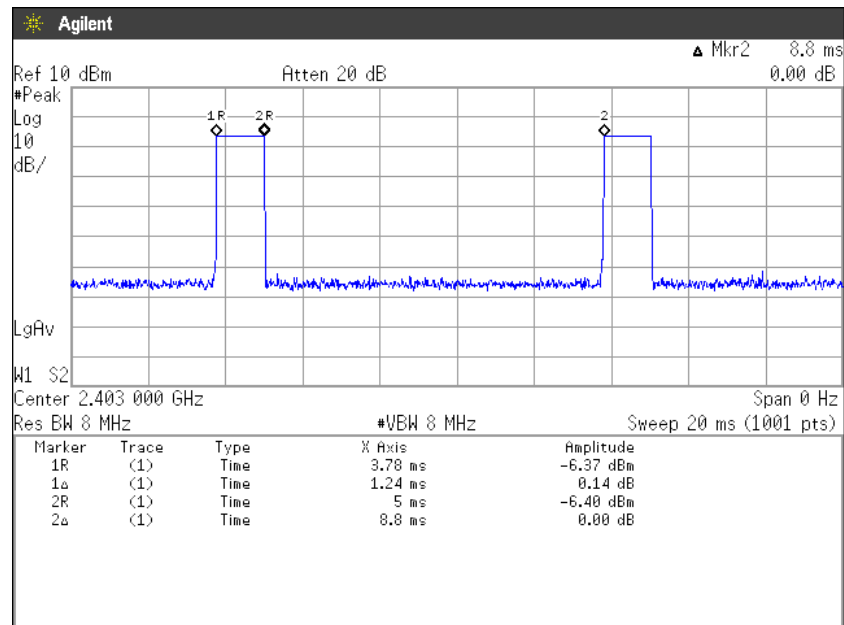
Equipment	Company	Model No.	Serial No.	Cal. Due	Cal. Date
EMI Receiver	ROHDE&SCHWARZ	ESCI	100765	24-Sep-2020	25-Sep-2019
Attenuator	HUBER+SUHNER	6810.01.A	N/A (S411)	07-Jan-2021	08-Jan-2020
Artificial mains network	Kyoritsu Electrical Works, Ltd.	TNW-407F2	12-17-110-2	02-Jun-2021	03-Jun-2020
Coaxial cable	FUJIKURA	5D-2W/4m	N/A (S350)	07-Jan-2021	08-Jan-2020
Coaxial cable	FUJIKURA	5D-2W/1m	N/A (S193)	07-Jan-2021	08-Jan-2020
Coaxial cable	HUBER+SUHNER	RG214/U/10m	N/A (S194)	07-Jan-2021	08-Jan-2020
PC	DELL	DIMENSION	75465BX	N/A	N/A
Software	TOYO Corporation	EP5/CE-AJ	0611193/V5.4.11	N/A	N/A

*: The calibrations of the above equipment are traceable to NIST or equivalent standards of the reference organizations.

Appendix B. Duty Cycle

[Plot & Calculation]

<250kbps>



Duty Cycle Factor Calculation

RF duty cycle factor: Calculation according to RF burst Para 15.35 (c)

Pulse width is 1.24ms

There are 10 pulses in 100ms window

$1.24\text{ms} \times 10 = 12.4\text{ms}$, It is 12.4ms in 100ms

Duty cycle: $12.4/100 = 0.124$

Duty cycle factor: $20\log(0.124) = -18.1\text{dB}$

Maximum is used duty cycle according to Para 15.35 (b): 20dB