

ELECTROMAGNETIC EMISSION COMPLIANCE REPORT FOR LOW-POWER, NON-LICENSED TRANSMITTER

Test Report No. : W174R-D057

AGR No. : A150A-150

Applicant : AIRO Co.,LTD.

Address : 203, Hanulteo Bldg, 464-2, Sangsam-ri, Haeryong-myeon, Suncheon-si, Jeollanam-do, South Korea, 58005

Manufacturer : AIRO Co.,LTD.

Address : 203, Hanulteo Bldg, 464-2, Sangsam-ri, Haeryong-myeon, Suncheon-si, Jeollanam-do, South Korea, 58005

Type of Equipment : Router for Aquarium Fish Robot

FCC ID : 2ALUA-MIRO-9-ROUTER

Model No. : MIRO-9-ROUTER

Serial number : N/A

Total page of Report : 24 pages (including this page)

Date of Incoming : January 29, 2016

Date of issuing : April 19, 2017

SUMMARY

The equipment complies with the regulation; *FCC PART 15 SUBPART C Section 15.231*

This test report contains only the result of a single test of the sample supplied for the examination. It is not a general valid assessment of the features of the respective products of the mass-production.

Reviewed by:



Jae-Ho Lee / Chief Engineer
ONETECH Corp.

Approved by:



Keun-Young, Choi / Vice President
ONETECH Corp.

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Revision History

Issued Report No.	Issued Date	Revisions	Effect Section
W174R-D057	April 19, 2017	Initial Issue	All

DOCUMENT HISTORY

Revision No.	Issued Date	Revisions	Effect Section
Original	April 19, 2017	Initial Issue	-
Revision 01	April 28, 2017	Add limit	5.4 Bandwidth of operating frequency
Revision 02	May 08, 2017	Add Test Plot	5.3.2 Test data for 30 MHz to 1 000 MHz
Revision 03	May 10, 2017	Revised Limits and Margin.	5.3.3 Test data for above 1 GHz

1. VERIFICATION OF COMPLIANCE

APPLICANT : AIRO Co.,LTD.
 ADDRESS : 203, Hanulteo Bldg, 464-2, Sangsam-ri, Haeryong-myeon, Suncheon-si, Jeollanam-do, South Korea, 58005
 CONTACT PERSON : Ji-hoon Kim / Manager
 TELEPHONE NO : +82-61-727-6760
 FCC ID : 2ALUA-MIRO-9-ROUTER
 MODEL NAME : MIRO-9-ROUTER

 BRAND NAME :
 DATE : April 19, 2017

EQUIPMENT CLASS	DSR- Part 15 Remote Control/Security Device Transceiver
E.U.T. DESCRIPTION	Router for Aquarium Fish Robot
THIS REPORT CONCERNS	Original Grant
MEASUREMENT PROCEDURES	ANSI C63.10: 2013
TYPE OF EQUIPMENT TESTED	Pre-Production
KIND OF EQUIPMENT AUTHORIZATION REQUESTED	Certification
EQUIPMENT WILL BE OPERATED UNDER FCC RULES PART(S)	FCC PART 15 SUBPART C Section 15.231
MODIFICATIONS ON THE EQUIPMENT TO ACHIEVE COMPLIANCE	None
FINAL TEST WAS CONDUCTED ON	3 m, Semi Anechoic Chamber

The above equipment was tested by ONETECH Corp. for compliance with the requirement set forth in the FCC Rules and Regulations. This said equipment in the configuration described in this report, shows the maximum emission levels emanating from equipment are within the compliance requirements.

2. GENERAL INFORMATION

2.1 Product Description

The AIRO Co.,LTD., Model MIRO-9-ROUTER (referred to as the EUT in this report) is a Router for Aquarium Fish Robot. The product specification described herein was obtained from product data sheet or user's manual.

CHASSIS TYPE	Plastic
OPERATING FREQUENCY	447.862 5 MHz ~ 447.987 5 MHz
MODULATION	GFSK
NUMBER OF CHANNEL	11
LIST OF EACH OSC. OR CRY. FREQ.(FREQ.>= 1 MHz)	16 MHz
ANTENNA TYPE	Helical Antenna
RATED SUPPLY VOLTAGE	DC 5 V (Adapter) / DC 3.7 V (Battery)
NUMBER OF LAYERS	2 Layers

2.2 Model Differences:

-. None

2.3 Related Submittal(s) / Grant(s)

Original submittal only

2.4 Purpose of the test

To determine whether the equipment under test fulfills the requirements of the regulation stated in FCC PART 15 SUBPART C Section 15.231

2.5 Test Methodology

Both conducted and radiated testing was performed according to the procedures in ANSI C63.10: 2013. Radiated testing was performed at a distance of 3 m from EUT to the antenna.

2.6 Test Facility

The Onetech Corp. has been designated to perform equipment testing in compliance with ISO/IEC 17025.

The Electromagnetic compatibility measurement facilities are located at 43-14, Jinsaegol-gil, Chowol-eup, Gwangju-si, Gyeonggi-do, 12735, Korea

-. Site Filing:

VCCI (Voluntary Control Council for Interference) – Registration No. R-4112/ C-4617/ G-10666 / T-1842

IC (Industry Canada) – Registration No. Site# 3736A-3

-. Site Accreditation:

KOLAS (Korea Laboratory Accreditation Scheme) - Accreditation NO. KT085

FCC (Federal Communications Commission) - Accreditation No. KR0013

RRA (Radio Research Agency) – Designation No. KR0013

3. SYSTEM TEST CONFIGURATION

3.1 Justification

This device was configured for testing in a typical way as a normal customer is supposed to be used. During the test, the following components were installed inside of the EUT.

DEVICE TYPE	MANUFACTURER	MODEL/PART NUMBER	FCC ID
Main Board	AIRO Co.,LTD.	N/A	N/A
Battery	N/A	N/A	N/A
Module 1	Firmtech Co., Ltd	FB155BC	U8D-FB155BC
Module 2	N/A	N/A	N/A

3.2 Peripheral equipment

Model	Manufacturer	Description	Connected to
POP1770USB	Newland	Adapter	EUT

3.3 Mode of operation during the test

-. To get a maximum radiated emission from the EUT, the button on the EUT was continuously pressed to transmit the signal. To activate continuous transmission, place a small plastic block between rubber band and the push button on the EUT. To get a maximum emission levels from the EUT, the EUT was moved throughout the XY, XZ, and YZ planes. The worst case data is XY axis.

3.4 Equipment Modifications

-. None

3.5 Configuration of Test System

Line Conducted Test:

The EUT was tested in a Charging & Transmitting Mode. The EUT was connected to Adapter. All supporting equipments were connected to another LISN. Preliminary Power line Conducted Emission test was performed by using the procedure in ANSI C63.10: 2013 to determine the worse operating conditions.

Radiated Emission Test:

The EUT was tested in a charging mode and Transmitter mode. Preliminary radiated emissions test were conducted using the procedure in ANSI C63. 10: 2013 to determine the worse operating conditions. Final radiated emission tests were conducted at 3 m Semi Anechoic Chamber.

The turntable was rotated through 360 degrees and the EUT was tested by positioned three orthogonal planes to obtain the highest reading on the field strength meter. Once maximum reading was determined, the search antenna was raised and lowered in both vertical and horizontal polarization.

Occupied Bandwidth Measurement:

This measurement is performed with the antenna located close enough to give a full-scale deflection of the modulated carrier on the spectrum analyzer. The plot is taken at 20 kHz/division frequency span, 10 kHz resolution bandwidth and 10 dB/division logarithmic display from the spectrum analyzer.

3.6 Antenna Requirement

For intentional device, according to section 15.203, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device.

Antenna Construction:

The transmitter antenna of the EUT is a Helical Antenna(Reverse SMA type), so no consideration of replacement by the user.

4. PRELIMINARY TEST

4.1 AC Power line Conducted Emissions Tests

During Preliminary Tests, the following operating mode was investigated

Operation Mode	The Worse operating condition (Please check one only)
Charging & Transmitting Mode	X

4.2 Radiated Emissions Tests

During Preliminary Tests, the following operating modes were investigated

Operation Mode	The Worse operating condition (Please check one only)
Charging & Transmitting Mode	X

5. FINAL RESULT OF MEASUREMENT

Radiated emission electric field intensity, 30 MHz ~ 300 MHz : ± 4.43 dB

Radiated emission electric field intensity, 300 MHz ~ 1 000 MHz : ± 3.80 dB

Measurement uncertainty is calculated in accordance with CISPR 16-4-2. The measurement uncertainty is given with a confidence of 95 % with the coverage factor, $k = 2$.

5.1 Field Strength of the Carrier Test

The following table shows the highest levels of radiated emissions on both polarizations of horizontal and vertical.

Humidity Level : 44 % R.H. Temperature: 23 °C

Limits apply to : FCC CFR 47, PART 15, SUBPART C, SECTION 15.231(b)

Result : PASSED

EUT : Router for Aquarium Fish Robot Date: April 16, 2017

Operating Condition : Charging & Transmitting Mode

Distance : 3 m

Frequency (GHz)	Reading (dBμV)	Detector Mode	Ant. Pol. (H/V)	Ant. Factor	Cable Loss	Amp Gain	Total (dBμV/m)	Limits (dBμV/m)	Margin (dB)
Test Data for Low Channel									
447.862 5	84.82	Peak	H	16.20	5.70	33.22	73.50	101.27	27.77
	84.74	Average	H				73.42	81.27	7.85
Test Data for Middle Channel									
447.925 0	84.71	Peak	H	16.20	5.70	33.22	73.39	101.27	27.88
	84.54	Average	H				73.22	81.27	8.05
Test Data for High Channel									
447.987 5	84.33	Peak	H	16.20	5.70	33.22	73.01	101.28	28.27
	84.12	Average	H				72.80	81.28	8.48



Tested by: Min-Gu Ji / Assistant Manager

5.2 Transmitter Transmission Duration

Humidity Level : 44 % R.H.

Temperature: 23 °C

Limits apply to : FCC CFR 47, PART 15, SUBPART C, SECTION 15.231(a)

Result : PASSED

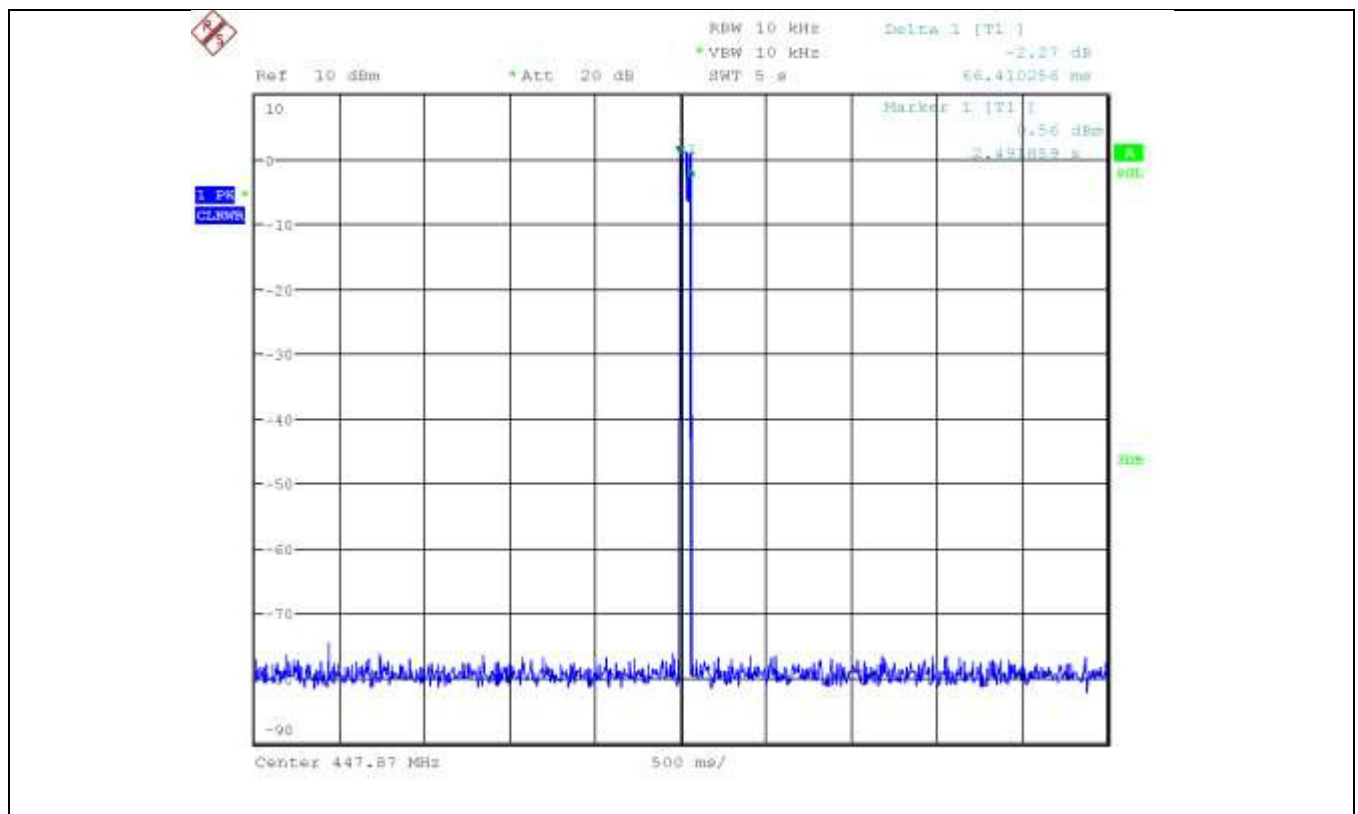
EUT : Router for Aquarium Fish Robot

Date: April 16, 2017

Operating Condition : Charging & Transmitting Mode

Distance : 3 m

Manually Activated Duration (s)	Limit (s)	Margin (s)	Result
0.07	5.00	4.93	Pass




 Tested by: Min-Gu Ji / Assistant Manager

5.3 Spurious Emission Test

Radiated emission electric field intensity, 30 MHz ~ 300 MHz : ± 4.43 dB

Radiated emission electric field intensity, 300 MHz ~ 1 000 MHz : ± 3.80 dB

Measurement uncertainty is calculated in accordance with CISPR 16-4-2. The measurement uncertainty is given with a confidence of 95 % with the coverage factor, $k = 2$.

5.3.1 Test data for Blow 30 MHz

The following table shows the highest levels of radiated emissions on both polarizations of horizontal and vertical.

Humidity Level : 44 % R.H. Temperature: 23 °C

Limits apply to : FCC CFR 47, PART 15, SUBPART C, SECTION 15.231(b)

Measurement Freq. Range : 9 kHz ~ 30 MHz

Result : PASSED

EUT : Router for Aquarium Fish Robot Date: April 16, 2017

Operating Condition : Charging & Transmitting Mode

Distance : 3 m

Frequency (MHz)	Reading (dB μ V)	Ant. Pol. (H/V)	Ant. Height (m)	Angle (°)	Ant. Factor (dB/m)	Cable Loss	Emission Level(dB μ V/m)	Limits (dB μ V/m)	Margin (dB)
Any emissions less than 20 dB below the limit were not observed.									

5.3.2 Test data for 30 MHz to 1 000 MHz

The following table shows the highest levels of radiated emissions on both polarizations of horizontal and vertical.

Humidity Level : 44 % R.H.

Temperature: 23 °C

Limits apply to : FCC CFR 47, PART 15, SUBPART C, SECTION 15.231(b)

Measurement Freq. Range : 30 MHz ~ 1 000 MHz

Result : PASSED

EUT : Router for Aquarium Fish Robot

Date: April 16, 2017

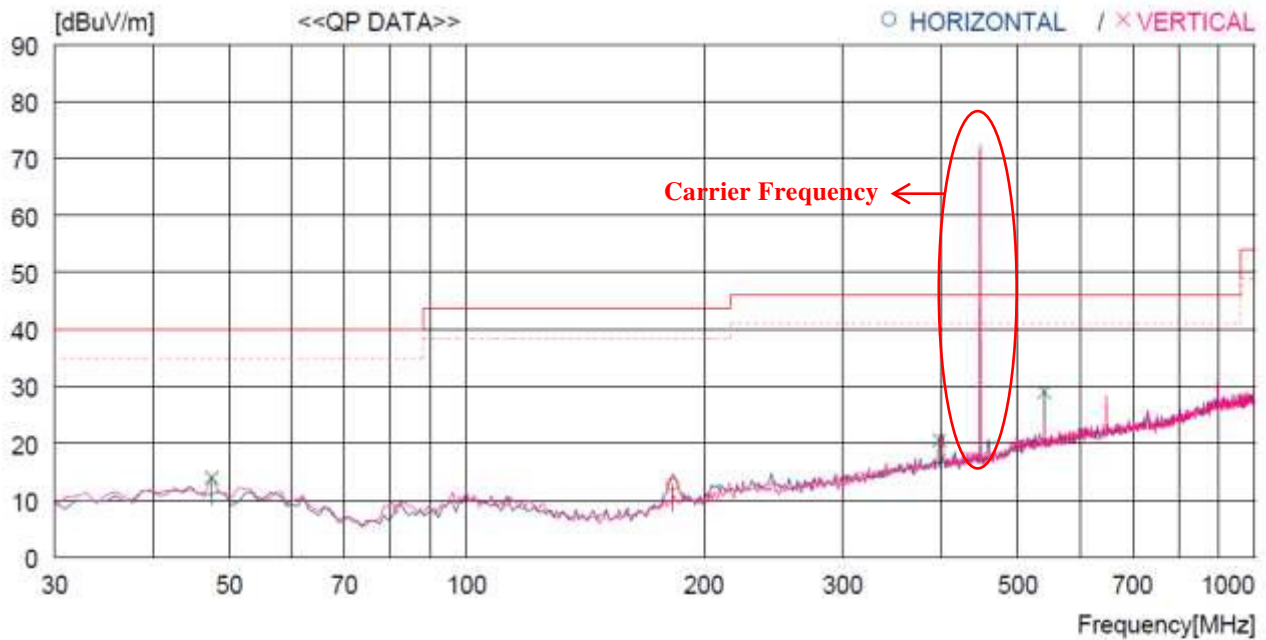
Operating Condition : Charging & Transmitting Mode

Distance : 3 m

Frequency (GHz)	Reading (dBμV)	Detector Mode	Ant. Pol. (H/V)	Ant. Factor	Cable Loss	Amp Gain	Total (dBμV/m)	Limits (dBμV/m)	Margin (dB)
Test Data for Low Channel									
895.725	52.60	Peak	H	22.00	8.30	32.50	50.40	81.27	30.87
	39.84	Average	H				37.64	61.27	23.63
Test Data for Middle Channel									
895.850	53.36	Peak	H	22.00	8.30	32.50	51.16	81.27	30.11
	53.36	Peak	H				36.98	61.27	24.29
Test Data for High Channel									
895.975	52.83	Peak	H	22.00	8.30	32.50	50.63	81.28	30.65
	39.76	Average	H				37.56	61.28	23.72


 Tested by: Min-Gu Ji / Assistant Manager

- Test Plot (Worst Case)



No.	FREQ	READING	ANT	LOSS	GAIN	RESULT	LIMIT	MARGIN	ANTENNA	TABLE
	[MHz]	[dBuV]	FACTOR	[dB]	[dB]	[dBuV/m]	[dBuV/m]	[dB]	[cm]	[DEG]
----- Horizontal -----										
1	182.290	32.2	10.0	3.6	33.0	12.8	43.5	30.7	400	0
----- Vertical -----										
2	47.460	30.6	14.3	2.0	33.0	13.9	40.0	26.1	100	0
3	397.630	32.6	15.8	5.3	33.2	20.5	46.0	25.5	300	0
4	540.220	37.6	17.9	6.8	33.3	29.0	46.0	17.0	200	135

Signature

Tested by: Min-Gu Ji / Assistant Manager

5.3.3 Test data for above 1 GHz

The following table shows the highest levels of radiated emissions on both polarizations of horizontal and vertical.

Humidity Level : 44 % R.H.

Temperature: 23 °C

Limits apply to : FCC CFR 47, PART 15, SUBPART C, SECTION 15.209

Measurement Freq. Range : 1 GHz ~ 4 GHz

Result : PASSED

EUT : Router for Aquarium Fish Robot

Date: April 16, 2017

Operating Condition : Charging & Transmitting Mode

Distance : 3 m

Frequency (GHz)	Reading (dBμV)	Detector Mode	Ant. Pol. (H/V)	Ant. Factor	Cable Loss	Amp Gain	Total (dBμV/m)	Limits (dBμV/m)	Margin (dB)
1 343.587 5	36.47	Peak	H	25.05	7.20	40.03	28.69	74.00	45.31
	33.28	Average	H				25.50	54.00	28.50
1 791.450 0	43.51	Peak	H	25.50	8.70	40.22	37.49	74.00	36.51
	42.13	Average	H				36.11	54.00	17.89
1 343.775 0	36.43	Peak	H	25.05	7.20	40.03	28.65	74.00	45.35
	32.75	Average	H				24.97	54.00	29.03
1 791.700 0	43.13	Peak	H	25.50	8.70	40.22	37.11	74.00	36.89
	42.13	Average	H				36.11	54.00	17.89
1 343.962 5	36.36	Peak	H	25.05	7.20	40.03	28.58	74.00	45.42
	33.62	Average	H				25.84	54.00	28.16
1791.950 0	42.94	Peak	H	25.50	8.70	40.22	36.92	74.00	37.08
	42.13	Average	H				36.11	54.00	17.89

Tabulated test data for Restricted Band

Remark : “H”: Horizontal, “V”: Vertical

5.3.4 Limit

Frequency Range (MHz)	Limit @ 3 m
447.862 5	$41.6667(447.862\ 5) - 7083.3333 = 11577.6\ \mu\text{V/m} = 81.27\ \text{dBuV/m}$ (Average) 101.27 dBuV/m (Peak)
Harmonics	61.27 dBuV/m (The maximum permitted unwanted emission level is 20 dB below the maximum permitted fundamental level.)



Tested by: Min-Gu Ji / Assistant Manager

5.4 Bandwidth of the operating frequency

5.4.1 Test Data

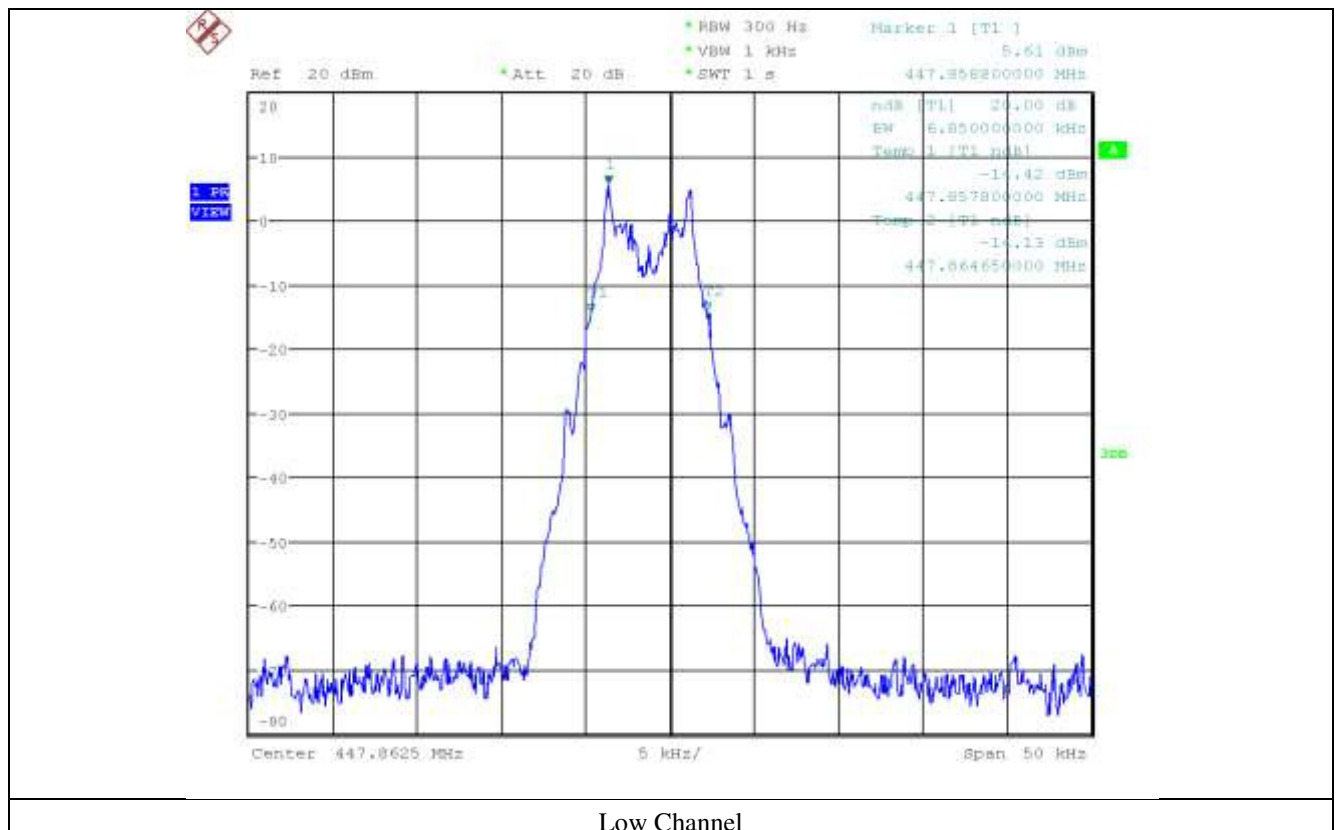
Humidity Level	: 44 % R.H.	Temperature: 23 °C
Limits apply to	: FCC CFR 47, PART 15, SUBPART C, SECTION 15.231(c)	
Result	: PASSED	
EUT	: Router for Aquarium Fish Robot	Date: April 16, 2017
Operating Condition	: Charging & Transmitting Mode	
Minimum Resolution		
Bandwidth	: 10 kHz	

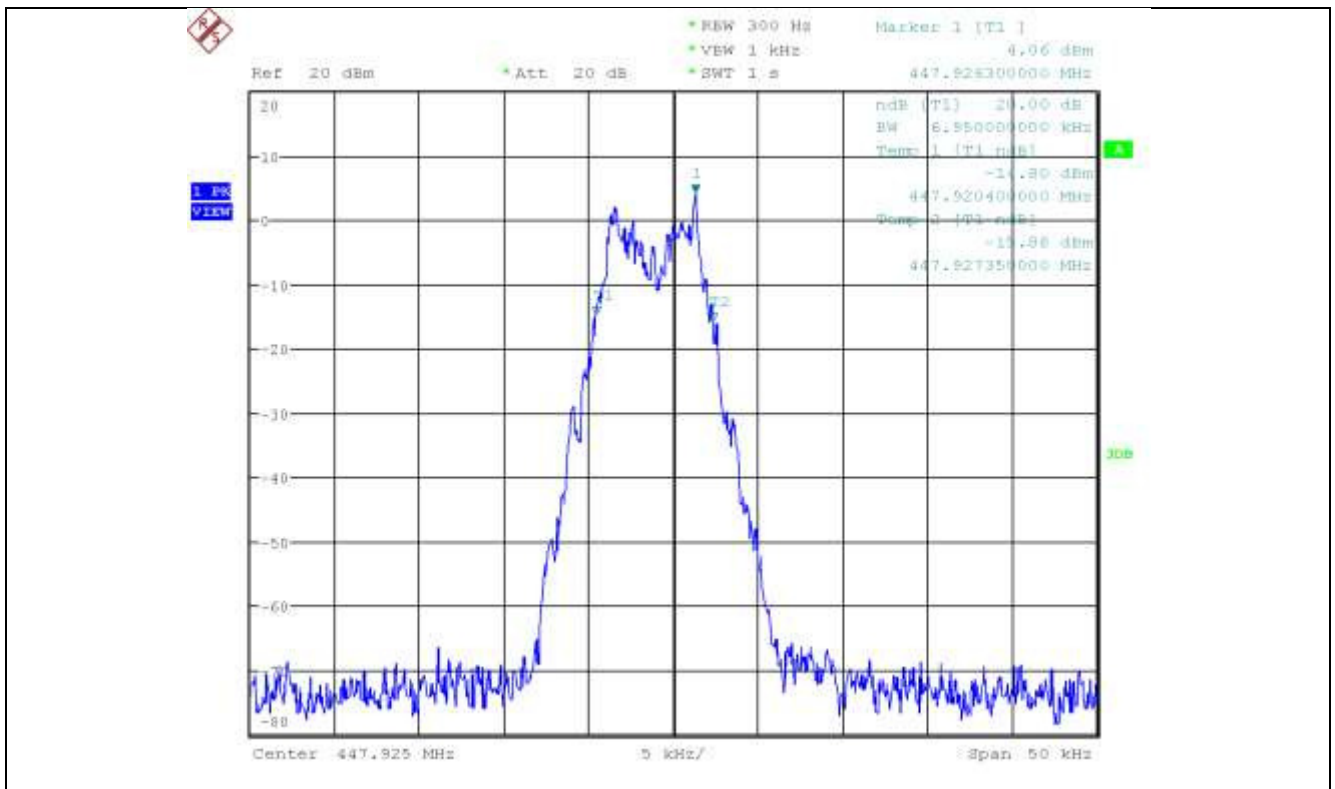
CHANNEL	FREQUENCY (MHz)	20 dB Bandwidth (kHz)	Limit
Low	447.862 5	6.85	111.97
Middle	447.925 0	6.95	111.98
High	447.987 5	6.80	112.00

Remark: Please refer to photo data for bandwidth for test data.

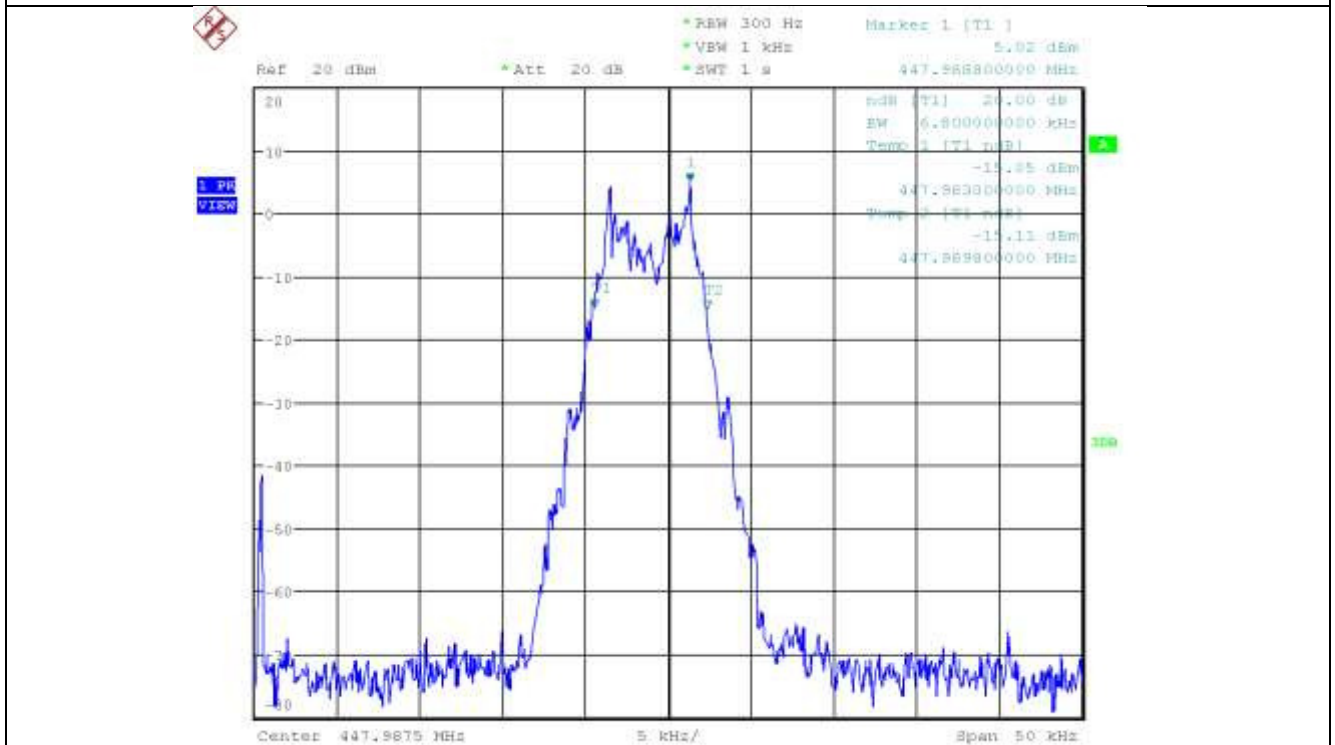


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Middle Channel



High Channel

5.4.2 Limit

The bandwidth of the emission shall be no wider than 0.25% of the center frequency for devices operating above 70 MHz and below 900 MHz. For devices operating above 900 MHz, the emission shall be no wider than 0.5% of the center frequency. Bandwidth is determined at the points 20 dB down from the modulated carrier.



Tested by: Min-Gu Ji / Assistant Manager

5.5 Conducted Emission Test

5.5.1 Operating environment

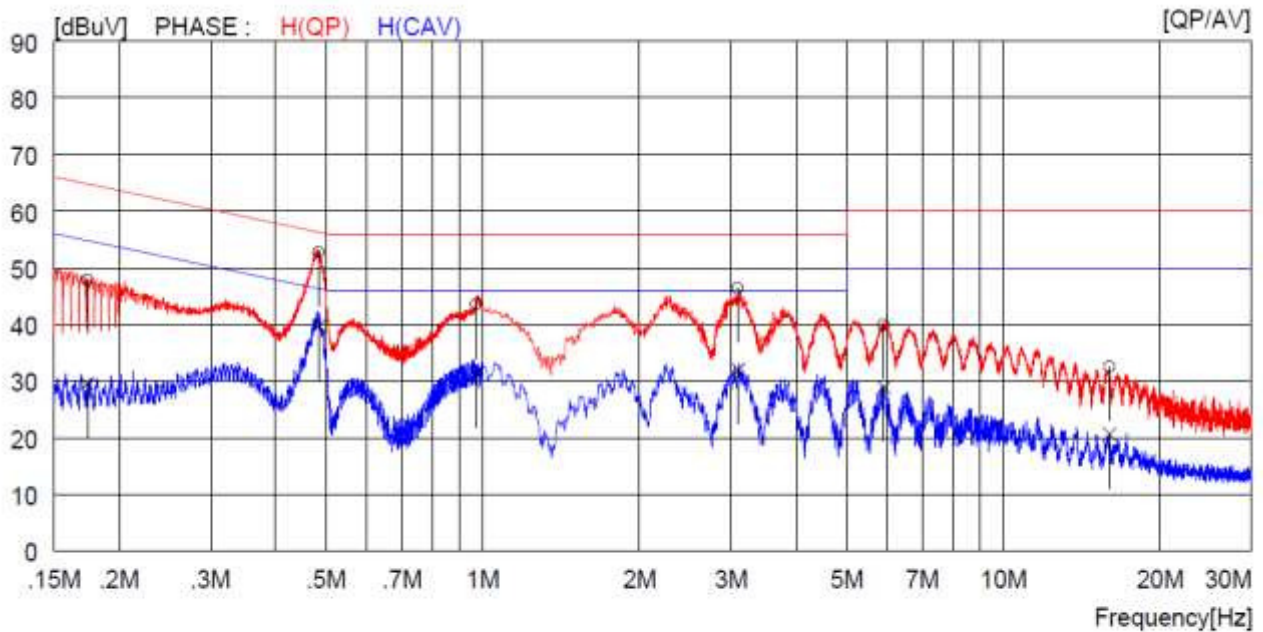
Temperature : 23 °C
Relative humidity : 44 % R.H.

5.5.2 Test set-up

The EUT was placed on a wooden table, 0.8 m height above the floor. Power was fed to the EUT through a $50\ \Omega$ / $50\ \mu\text{H}$ + $5\ \Omega$ Artificial Mains Network (AMN). The ground plane was electrically bonded to the reference ground system and all power lines were filtered from ambient.

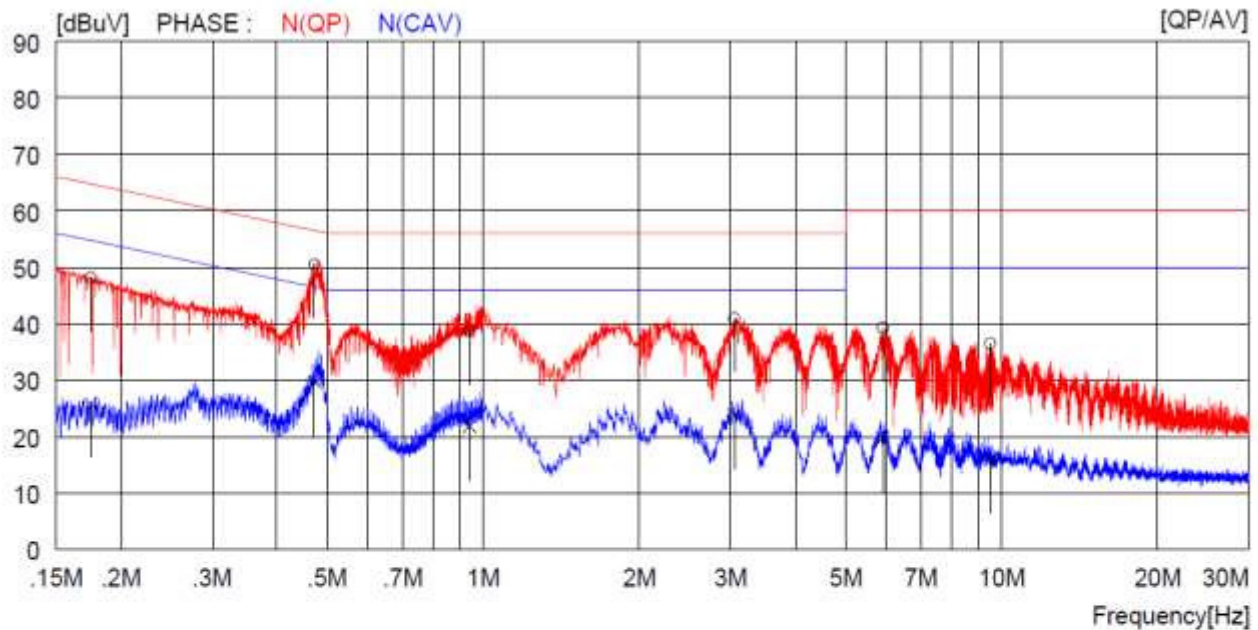
5.5.3 Test data

- . Test Date : April 16, 2017
- . Resolution bandwidth : 9 kHz
- . Frequency range : 0.15 MHz ~ 30 MHz
- . Tested Line : HOT LINE



NO	FREQ [MHz]	READING		C.FACTOR [dB]	RESULT		LIMIT		MARGIN		PHASE
		QP [dBuV]	AV [dBuV]		QP [dBuV]	AV [dBuV]	QP [dBuV]	AV [dBuV]	QP [dBuV]	AV [dBuV]	
1	0.17400	37.8	----	10.1	47.9	----	64.8	----	16.9	----	H (QP)
2	0.48400	42.8	----	10.0	52.8	----	56.3	----	3.5	----	H (QP)
3	0.97200	33.5	----	10.0	43.5	----	56.0	----	12.5	----	H (QP)
4	3.09200	36.3	----	10.1	46.4	----	56.0	----	9.6	----	H (QP)
5	5.89500	29.8	----	10.1	39.9	----	60.0	----	20.1	----	H (QP)
6	16.00000	22.3	----	10.2	32.5	----	60.0	----	27.5	----	H (QP)
7	0.17400	----	19.4	10.1	----	29.5	----	54.8	----	25.3	H (CAV)
8	0.48400	----	29.8	10.0	----	39.8	----	46.3	----	6.5	H (CAV)
9	0.97200	----	21.4	10.0	----	31.4	----	46.0	----	14.6	H (CAV)
10	3.09200	----	21.9	10.1	----	32.0	----	46.0	----	14.0	H (CAV)
11	5.89500	----	18.8	10.1	----	28.9	----	50.0	----	21.1	H (CAV)
12	16.00000	----	10.4	10.2	----	20.6	----	50.0	----	29.4	H (CAV)

-. Tested Line : NEUTRAL LINE



NO	FREQ [MHz]	READING		C.FACTOR [dB]	RESULT		LIMIT		MARGIN		PHASE
		QP [dBuV]	AV [dBuV]		QP [dBuV]	AV [dBuV]	QP [dBuV]	AV [dBuV]	QP [dBuV]	AV [dBuV]	
1	0.17500	38.0	----	10.1	48.1	----	64.7	----	16.6	----	N (QP)
2	0.47300	40.5	----	10.0	50.5	----	56.5	----	6.0	----	N (QP)
3	0.94100	28.7	----	10.0	38.7	----	56.0	----	17.3	----	N (QP)
4	3.05200	30.8	----	10.1	40.9	----	56.0	----	15.1	----	N (QP)
5	5.90000	29.1	----	10.1	39.2	----	60.0	----	20.8	----	N (QP)
6	9.52500	26.4	----	10.1	36.5	----	60.0	----	23.5	----	N (QP)
7	0.17500	----	15.7	10.1	----	25.8	----	54.7	----	28.9	N (CAV)
8	0.47300	----	19.6	10.0	----	29.6	----	46.5	----	16.9	N (CAV)
9	0.94100	----	11.9	10.0	----	21.9	----	46.0	----	24.1	N (CAV)
10	3.05200	----	13.7	10.1	----	23.8	----	46.0	----	22.2	N (CAV)
11	5.90000	----	9.6	10.1	----	19.7	----	50.0	----	30.3	N (CAV)
12	9.52500	----	5.9	10.1	----	16.0	----	50.0	----	34.0	N (CAV)

Remark: Margin (dB) = Limit – Level (Result)

The emission level in above table is included the transducer factor that means insertion loss (LISN), cable loss and attenuator.

Signature

Tested by: Min-Gu Ji / Assistant Manager

6. FIELD STRENGTH CALCULATION

Meter readings are compared to the specification limit correcting for antenna and cable losses

+	Meter reading	(dB μ V)
+	Cable Loss	(dB)
+	Antenna Factor (Loss)	(dB/m)
-	Amplifier Gain	(dB)
=	Corrected Reading	(dB μ V/m)
-	Specification Limit	(dB μ V/m)
=	dB Relative to Spec	($\pm$ dB)

7. LIST OF TEST EQUIPMENT

No.	EQUIPMENTS	MFR.	MODEL	SER. NO.	LAST CAL	DUE CAL	USE
1.	Test receiver	R/S	ESCI	101013	Apr. 04, 2017	12MONTH	■
2.	Test Receiver	R/S	ESR	101470	Feb. 08, 2017	12MONTH	■
3.	SPECTRUM ANALYZER	R/S	FSU26	200319	Apr. 04, 2017	12MONTH	■
4.	Amplifier	Sonoma Instrument	310N	312544	Apr. 04, 2017	12MONTH	■
7.	TRILOG Broadband Antenna	Schwarzbeck	VULB9163	9163-419	Aug. 05, 2016	24MONTH	■
8.	Controller	Innco System	CO3000	CO3000/904/ 37211215/L	N/A	N/A	■
9.	Turn Table	Innco System	DT3000	930611	N/A	N/A	■
10.	Antenna Master	Innco System	MA-4000XPET	MA4000/509/ 37211215/L	N/A	N/A	■
12.	Pre-Amplifier	R/S	SCU-18	102209	May 31, 2016	12MONTH	■
13.	Horn Antenna	Schwarzbeck	BBHA9120D	BBHA9120D295	Aug. 31, 2015	24MONTH	■
14.	LOOP ANTENNA	Schwarzbeck	FMZB 1513	1513-235	Jun. 10, 2016	24MONTH	■