

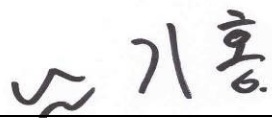
ELECTROMAGNETIC EMISSION COMPLIANCE REPORT FOR LOW-POWER, NON-LICENSED TRANSMITTER

Test Report No. : OT-185-RWD-053
AGR No. : A183A-213
Applicant : LG Innotek Co., Ltd.
Address : 26, Hanamsandan 5beon-ro Gwangsan-gu, Gwangju, 506-731, South Korea
Manufacturer : LG Innotek Co., Ltd.
Address : 26, Hanamsandan 5beon-ro Gwangsan-gu, Gwangju, 506-731, South Korea
Type of Equipment : WLAN(802.11a/b/g/n/ac) 2x2 MIMO Module
FCC ID. : YZP-TWFS-B005D
Model Name : TWFS-B005D
Multiple Model Name : N/A
Serial number : N/A
Total page of Report : 13 pages (including this page)
Date of Incoming : May 02, 2018
Date of issue : May 24, 2018

SUMMARY

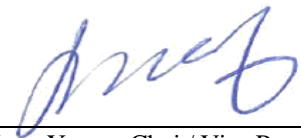
The equipment complies with the regulation; *FCC PART 15 SUBPART E Section 15.407*
 This test report only contains the result of a single test of the sample supplied for the examination.
 It is not a generally valid assessment of the features of the respective products of the mass-production.

Reviewed by:



Ki-Hong, Nam / Chief Engineer
ONETECH Corp.

Approved by:



Keun-Young, Choi / Vice President
ONETECH Corp.

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Revision History

Rev. No.	Issue Report No.	Issued Date	Revisions	Section Affected
0	OT-185-RWD-053	2018.05.24	Initial Release	All

1. VERIFICATION OF COMPLIANCE

Applicant : LG Innotek Co., Ltd.
 Address : 26, Hanamsandan 5beon-ro Gwangsan-gu, Gwangju, 506-731, South Korea
 Contact Person : Jeong Inchang / Senior Research Engineer
 Telephone No. : +82-62-950-0332
 FCC ID : YZP-TWFS-B005D
 Model Name : TWFS-B005D
 Serial Number : N/A
 Date : May 24, 2018

EQUIPMENT CLASS	Unlicensed National Information infrastructure(UNII)
E.U.T. DESCRIPTION	Modular Transmitter, WLAN(802.11a/b/g/n/ac) 2x2 MIMO Module
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 E Section 15.407 KDB 789033 D02 General UNII Test Procedures New Rules V02r01
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 LG Innotek Co., Ltd., Model TWFS-B005D (referred to as the EUT in this report) is a WLAN(802.11a/b/g/n/ac) 2x2 MIMO Module. Product specification information described herein was obtained from product data sheet or user’s manual.

DEVICE TYPE	WLAN(802.11a/b/g/n/ac) 2x2 MIMO Module		
Operating Frequency	WLAN 2.4 GHz Band	2 412 MHz ~ 2 462 MHz (802.11b/g/n(HT20))	
		2 422 MHz ~ 2 452 MHz (802.11n(HT40))	
	WLAN 5 GHz Band	5 150 MHz ~ 5 250 MHz Band	5 180 MHz ~ 5 240 MHz (802.11a/n(HT20)/ac(VHT20))
			5 190 MHz ~ 5 230 MHz (802.11n(HT40)/ac(VHT40))
		5 725 MHz ~ 5 850 MHz Band	5 210 MHz (802.11ac(VHT80))
			5 745 MHz ~ 5 825 MHz (802.11a/n(HT20)/ac(VHT20))
		5 755 MHz ~ 5 795 MHz (802.11n(HT40)/ac(VHT40))	
		5 775 MHz (802.11ac(VHT80))	
RF Output Power	WLAN 2.4 GHz Band	Antenna 0	Wi-Fi 802.11b (13.19 dBm) Wi-Fi 802.11g (12.32 dBm) Wi-Fi 802.11n(HT20) (12.08 dBm) Wi-Fi 802.11n(HT40) (11.15 dBm)
		Antenna 1	Wi-Fi 802.11b (14.07 dBm) Wi-Fi 802.11g (12.41 dBm) Wi-Fi 802.11n(HT20) (12.21 dBm) Wi-Fi 802.11n(HT40) (11.14 dBm)
		Antenna 0 + Antenna 1	Wi-Fi 802.11n(HT20) (15.08 dBm) Wi-Fi 802.11n(HT40) (14.11 dBm)

RF Output Power	WLAN 5 GHz Band	5 150 MHz ~ 5 250 MHz Band	Antenna 0	Wi-Fi 802.11a (13.19 dBm) Wi-Fi 802.11n(HT20) (12.91 dBm) Wi-Fi 802.11n(HT40) (11.45 dBm) Wi-Fi 802.11ac(HT80) (6.48 dBm)
			Antenna 1	Wi-Fi 802.11a (13.84 dBm) Wi-Fi 802.11n(HT20) (13.71 dBm) Wi-Fi 802.11n(HT40) (12.71 dBm) Wi-Fi 802.11ac(HT80) (7.16 dBm)
			Antenna 0 + Antenna 1	Wi-Fi 802.11n(HT20) (16.34 dBm) Wi-Fi 802.11n(HT40) (15.09 dBm) Wi-Fi 802.11ac(HT80) (9.84 dBm)
		5 725 MHz ~ 5 850 MHz Band	Antenna 0	Wi-Fi 802.11a (12.52 dBm) Wi-Fi 802.11n(HT20) (12.17 dBm) Wi-Fi 802.11n(HT40) (11.45 dBm) Wi-Fi 802.11ac(HT80) (8.36 dBm)
			Antenna 1	Wi-Fi 802.11a (12.56 dBm) Wi-Fi 802.11n(HT20) (12.85 dBm) Wi-Fi 802.11n(HT40) (11.87 dBm) Wi-Fi 802.11ac(HT80) (7.14 dBm)
			Antenna 0 + Antenna 1	Wi-Fi 802.11n(HT20) (15.53 dBm) Wi-Fi 802.11n(HT40) (14.91 dBm) Wi-Fi 802.11ac(HT80) (10.80 dBm)

Modulation Type	WLAN 2.4 GHz Band	DSSS Modulation(DBPSK/DQPSK/CCK) OFDM Modulation(BPSK/QPSK/16QAM/64QAM)		
	WLAN 5 GHz Band	OFDM Modulation(BPSK/QPSK/16QAM/64QAM)		
Antenna Type	WLAN 2.4 GHz Band	Antenna 0	3.39 dBi	
		Antenna 1	3.56 dBi	
		Antenna 0 + Antenna 1	6.49 dBi	
	5 150 MHz ~ 5 250 MHz Band	Antenna 0	2.56 dBi	
		Antenna 1	2.01 dBi	
		Antenna 0 + Antenna 1	5.30 dBi	
	5 725 MHz ~ 5 850 MHz Band	Antenna 0	2.39 dBi	
		Antenna 1	1.70 dBi	
		Antenna 0 + Antenna 1	5.07 dBi	
	List of each Osc. or crystal Freq.(Freq. >= 1 MHz)	32.768 kHz, 37.4 MHz		

2.2 Alternative type(s)/model(s); also covered by this test report.

-. None

3. EUT MODIFICATIONS

-. None

4. MAXIMUM PERMISSIBLE EXPOSURE

4.1 RF Exposure Calculation

According to the FCC rule 1.1310 table 1B, the limit for the maximum permissible RF exposure for an uncontrolled environment are $f/1500 \text{ mW/cm}^2$ for the frequency range between 300 MHz and 1 500 MHz and 1.0 mW/cm^2 for the frequency range between 1 500 MHz and 100 000 MHz.

The electric field generated for a 1 mW/cm^2 exposure is calculated as follows:

$$E = \sqrt{(30 * P * G) / d}, \text{ and } S = E^2 / Z = E^2 / 377, \text{ because } 1 \text{ mW/cm}^2 = 10 \text{ W/m}^2$$

Where

S = Power density in mW/cm^2 , Z = Impedance of free space, 377Ω

E = Electric field strength in V/m, G = Numeric antenna gain, and d = distance in meter

Combining equations and rearranging the terms to express the distance as a function of the remaining variable

$$d = \sqrt{(30 * P * G) / (377 * 10 S)}$$

Changing to units of mW and cm, using $P (\text{mW}) = P (\text{W}) / 1 000$, $d (\text{cm}) = 0.01 * d (\text{m})$

$$d = 0.282 * \sqrt{(P * G) / S}$$

Where

d = distance in cm, P = Power in mW, G = Numeric antenna gain, and S = Power density in mW/cm^2

4.2 EUT Description

Kind of EUT	WLAN(802.11a/b/g/n/ac) 2x2 MIMO Module
Operating Frequency Band	<ul style="list-style-type: none"> ■ WLAN: 2 412 MHz ~ 2 462 MHz ■ WLAN: 2 422 MHz ~ 2 452 MHz ■ WLAN: 5 180 MHz ~ 5 240 MHz ■ WLAN: 5 190 MHz ~ 5 230 MHz ■ WLAN: 5 210 MHz ■ WLAN: 5 745 MHz ~ 5 825 MHz ■ WLAN: 5 755 MHz ~ 5 795 MHz ■ WLAN: 5 775 MHz
Device Category	<ul style="list-style-type: none"> <input type="checkbox"/> Portable (< 20 cm separation) <input type="checkbox"/> Mobile (> 20 cm separation) ■ Others
Exposure Evaluation Applied	<ul style="list-style-type: none"> ■ MPE <input type="checkbox"/> SAR <input type="checkbox"/> N/A

RF Output Power	WLAN 5 GHz Band	5 150 MHz ~ 5 250 MHz Band	Antenna 0	Wi-Fi 802.11a (13.19 dBm) Wi-Fi 802.11n(HT20) (12.91 dBm) Wi-Fi 802.11n(HT40) (11.45 dBm) Wi-Fi 802.11ac(HT80) (6.48 dBm)
			Antenna 1	Wi-Fi 802.11a (13.84 dBm) Wi-Fi 802.11n(HT20) (13.71 dBm) Wi-Fi 802.11n(HT40) (12.71 dBm) Wi-Fi 802.11ac(HT80) (7.16 dBm)
			Antenna 0 + Antenna 1	Wi-Fi 802.11n(HT20) (16.34 dBm) Wi-Fi 802.11n(HT40) (15.09 dBm) Wi-Fi 802.11ac(HT80) (9.84 dBm)
		5 725 MHz ~ 5 850 MHz Band	Antenna 0	Wi-Fi 802.11a (12.52 dBm) Wi-Fi 802.11n(HT20) (12.17 dBm) Wi-Fi 802.11n(HT40) (11.45 dBm) Wi-Fi 802.11ac(HT80) (8.36 dBm)
			Antenna 1	Wi-Fi 802.11a (12.56 dBm) Wi-Fi 802.11n(HT20) (12.85 dBm) Wi-Fi 802.11n(HT40) (11.87 dBm) Wi-Fi 802.11ac(HT80) (7.14 dBm)
			Antenna 0 + Antenna 1	Wi-Fi 802.11n(HT20) (15.53 dBm) Wi-Fi 802.11n(HT40) (14.91 dBm) Wi-Fi 802.11ac(HT80) (10.80 dBm)
Antenna Type	WLAN 2.4 GHz Band	Antenna 0	3.39 dBi	
		Antenna 1	3.56 dBi	
		Antenna 0 + Antenna 1	6.49 dBi	
	5 150 MHz ~ 5 250 MHz Band	Antenna 0	2.56 dBi	
		Antenna 1	2.01 dBi	
		Antenna 0 + Antenna 1	5.30 dBi	
	5 725 MHz ~ 5 850 MHz Band	Antenna 0	2.39 dBi	
		Antenna 1	1.70 dBi	
		Antenna 0 + Antenna 1	5.07 dBi	

4.3 Calculated MPE Safe Distance for Antenna 0

According to above equation, the following result was obtained.

Operating Freq. Band (MHz)	Operating Mode	Target Power W/tolerance	Max tune up power		Antenna Gain		Safe Distance (cm)	Power Density (mW/cm ²) @ 20 cm Separation	Limit (mW/cm ²)
		(dBm)	(dBm)	(mW)	Log	Linear			
5 150 ~ 5 250	802.11a	13.0 ± 0.5	13.50	22.39	2.56	1.80	1.79	0.008 0	1.00
	802.11n_HT20	13.0 ± 0.5	13.50	22.39			1.79	0.008 0	1.00
	802.11n_HT40	11.5 ± 0.5	12.00	15.85			1.51	0.005 7	1.00
	802.11ac80	6.5 ± 0.5	7.00	5.01			0.85	0.001 8	1.00
5 725 ~ 5 850	802.11a	12.5 ± 0.5	13.00	19.95	2.39	1.73	1.66	0.006 9	1.00
	802.11n_HT20	12.0 ± 0.5	12.50	17.78			1.57	0.006 1	1.00
	802.11n_HT40	11.5 ± 0.5	12.00	15.85			1.48	0.005 5	1.00
	802.11ac80	8.5 ± 0.5	9.00	7.94			1.05	0.002 7	1.00

According to above table, for 5 150 ~ 5 250 MHz Band, safe distance,

$$D = 0.282 * \sqrt{(22.39 * 1.80)/1.00} = 1.79 \text{ cm.}$$

For getting power density at 20 cm separation in above table, following formula was used.

$$S = P * G / (4\pi * R^2) = 22.39 * 1.80 / (4 * 3.14 * 20^2) = 0.008 0$$

Where:

S = Power Density,

P = Power input to the external antenna (Output power from the EUT antenna port (dBm) – cable loss (dB)),

G = Gain of Transmit Antenna (linear gain), R = Distance from Transmitting Antenna



Tested by: Hyung-Kwon, Oh / Assistant Manager

4.4 Calculated MPE Safe Distance for Antenna 1

According to above equation, the following result was obtained.

Operating Freq. Band (MHz)	Operating Mode	Target Power W/tolerance	Max tune up power		Antenna Gain		Safe Distance (cm)	Power Density (mW/cm ²) @ 20 cm Separation	Limit (mW/cm ²)
		(dBm)	(dBm)	(mW)	Log	Linear			
5 150 ~ 5 250	802.11a	14.0 ± 0.5	14.50	28.18	2.01	1.59	1.89	0.008 9	1.00
	802.11n_HT20	14.0 ± 0.5	14.50	28.18			1.89	0.008 9	1.00
	802.11n_HT40	13.0 ± 0.5	13.50	22.39			1.68	0.007 1	1.00
	802.11ac80	7.0 ± 0.5	7.50	5.62			0.84	0.001 8	1.00
5 725 ~ 5 850	802.11a	12.5 ± 0.5	13.00	19.95	1.70	1.48	1.53	0.005 9	1.00
	802.11n_HT20	13.0 ± 0.5	13.50	22.39			1.62	0.006 6	1.00
	802.11n_HT40	12.0 ± 0.5	12.50	17.78			1.45	0.005 2	1.00
	802.11ac80	7.0 ± 0.5	7.50	5.62			0.81	0.001 7	1.00

According to above table, for 5 150 ~ 5 250 MHz Band, safe distance,

$$D = 0.282 * \sqrt{(28.18 * 1.59)/1.00} = 1.89 \text{ cm.}$$

For getting power density at 20 cm separation in above table, following formula was used.

$$S = P * G / (4\pi * R^2) = 28.18 * 1.59 / (4 * 3.14 * 20^2) = 0.008 9$$

Where:

S = Power Density,

P = Power input to the external antenna (Output power from the EUT antenna port (dBm) – cable loss (dB)),

G = Gain of Transmit Antenna (linear gain), R = Distance from Transmitting Antenna



Tested by: Hyung-Kwon, Oh / Assistant Manager

4.5 Calculated MPE Safe Distance for Multiple Transmit

According to above equation, the following result was obtained.

Operating Freq. Band (MHz)	Operating Mode	Target Power W/tolerance	Max tune up power		Antenna Gain		Safe Distance (cm)	Power Density (mW/cm ²) @ 20 cm Separation	Combined Power Density (mW/cm ²) @ 20 cm Separation	Limit (mW/cm ²)
		(dBm)	(dBm)	(mW)	Log	Linear				
5 150 ~ 5 250	802.11n_HT20 Antenna 0	13.0 ± 0.5	13.50	22.39	2.56	1.80	1.79	0.008 0	0.016 9	1.00
	802.11n_HT20 Antenna 1	14.0 ± 0.5	14.50	28.18	2.01	1.59	1.89	0.008 9		1.00
	802.11n_HT40 Antenna 0	11.5 ± 0.5	12.00	15.85	2.56	1.80	1.51	0.005 7	0.012 8	1.00
	802.11n_HT40 Antenna 1	13.0 ± 0.5	13.50	22.39	2.01	1.59	1.68	0.007 1		1.00
	802.11ac80 Antenna 0	6.5 ± 0.5	7.00	5.01	2.56	1.80	0.85	0.001 8	0.003 6	1.00
	802.11ac80 Antenna 1	7.0 ± 0.5	7.50	5.62	2.01	1.59	0.84	0.001 8		1.00
5 725 ~ 5 850	802.11n_HT20 Antenna 0	12.0 ± 0.5	12.50	17.78	2.39	1.73	1.57	0.006 1	0.012 7	1.00
	802.11n_HT20 Antenna 1	13.0 ± 0.5	13.50	22.39	1.70	1.48	1.62	0.006 6		1.00
	802.11n_HT40 Antenna 0	11.5 ± 0.5	12.00	15.85	2.39	1.73	1.48	0.005 5	0.010 7	1.00
	802.11n_HT40 Antenna 1	12.0 ± 0.5	12.50	17.78	1.70	1.48	1.45	0.005 2		1.00
	802.11ac80 Antenna 0	8.5 ± 0.5	9.00	7.94	2.39	1.73	1.05	0.002 7	0.004 4	1.00
	802.11ac80 Antenna 1	7.0 ± 0.5	7.50	5.62	1.70	1.48	0.81	0.001 7		1.00



Tested by: Hyung-Kwon, Oh / Assistant Manager