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Project No: CB10411202

Maximum Permissible Exposure Report

Applicant's company	SunPower Corporation
Applicant Address	1414 Harbour Way South, Richmond, CA 94804, USA
FCC ID	YAW513407
Manufacturer's company (1)	ZyXEL Communications Corp.
Manufacturer Address	No.6, Chuangxin 2nd Rd., Baoshan Township, Hsinchu County 308, Taiwan (R.O.C.)
Manufacturer's company (2)	MitraStar Technology Corporation
Manufacturer Address	No. 6, Innovation Rd II, Hsinchu Science Park, Hsinchu 30076, Taiwan

Product Name	SunPower Monitoring System with PVS5c
Brand Name	SUNPOWER
Model Name	PVS5c
Ref. Standard(s)	47 CFR FCC Part 2 Subpart J, section 2.1091
Received Date	Oct. 16, 2015
Final Test Date	Nov. 19, 2015
Submission Type	Original Equipment

Sam Chen

SPORTON INTERNATIONAL INC.



Table of Contents

1. GENERAL DESCRIPTION.....	1
1.1. EUT General Information	1
1.2. Table for Zigbee Module	1
1.3. Table for WWAN Module	2
1.4. Testing Location.....	2
2. MAXIMUM PERMISSIBLE EXPOSURE.....	3
2.1. Limit of Maximum Permissible Exposure	3
2.2. MPE Calculation Method	3
2.3. Calculated Result and Limit.....	4

History of This Test Report

REPORT NO.	VERSION	DESCRIPTION	ISSUED DATE
FA5O1212	Rev. 01	Initial issue of report	Dec. 01, 2015

1. GENERAL DESCRIPTION

1.1. EUT General Information

RF General Information			
Evaluation Mode	Frequency Range (MHz)	Operating Frequency (MHz)	Modulation Type
2.4GHz WLAN	2400-2483.5	2412-2462	802.11b: DSSS (DBPSK, DQPSK, CCK) 802.11g/n: OFDM (BPSK, QPSK, 16QAM, 64QAM)
ZigBee	2400-2483.5	2405-2475	DSSS (O-QPSK)
Evaluation Mode: WWAN Module 1			
TX Frequency	GSM 850: 824.2 ~ 848.8 MHz PCS 1900: 1850.2 ~ 1909.8 MHz WCDMA Band V: 826.4 MHz ~ 846.6 MHz WCDMA Band II: 1852.4 MHz ~ 1907.6 MHz WCDMA Band IV: 1712.4 MHz ~ 1752.6 MHz		
RX Frequency	GSM 850: 869.2 ~ 893.8 MHz PCS 1900: 1930.2 ~ 1989.8 MHz WCDMA Band V: 871.4 MHz ~ 891.6 MHz WCDMA Band II: 1932.4 MHz ~ 1987.6 MHz WCDMA Band IV: 2112.4 MHz ~ 2152.6 MHz		
Modulation Type	GSM 850 / PCS 1900: GMSK/8PSK WCDMA : QPSK HSDPA : QPSK		
Evaluation Mode: WWAN Module 2			
TX Frequency	WCDMA Band V: 826.4 MHz ~ 846.6 MHz WCDMA Band II: 1852.4 MHz ~ 1907.6 MHz		
RX Frequency	WCDMA Band V: 871.4 MHz ~ 891.6 MHz WCDMA Band II: 1932.4 MHz ~ 1987.6 MHz		
Modulation Type	WCDMA : QPSK HSDPA : QPSK		

1.2. Table for Zigbee Module

The EUT has two Zigbee modules and their information in the following table:

Brand Name	Model No.	Remark
Ember	EM357	Zigbee module 1
Ember	EM357	Zigbee module 2

1.3. Table for WWAN Module

The EUT has two WWAN modules and their information in the following table:

Brand Name	Model No.	FCC ID	Bands	Remark
Telit	HE910-D	RI7HE910	GSM 850 GSM 1900 WCDMA Band 2 WCDMA Band 4 WCDMA Band 5	WWAN module 1
QUECTEL	UC20GA-128-NCH-STD	XMR201312UC20	WCDMA Band 2 WCDMA Band 5	WWAN module 2

1.4. Testing Location

Testing Location		
☐	HWA YA	ADD : No. 52, Hwa Ya 1st Rd., Kwei-Shan Hsiang, Tao Yuan Hsien, Taiwan, R.O.C. TEL : 886-3-327-3456 FAX : 886-3-327-0973
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2. MAXIMUM PERMISSIBLE EXPOSURE

2.1. Limit of Maximum Permissible Exposure

(A) Limits for Occupational / Controlled Exposure

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/ cm ²)	Averaging Time E ² , H ² or S (minutes)
0.3-3.0	614	1.63	(100)*	6
3.0-30	1842 / f	4.89 / f	(900 / f)*	6
30-300	61.4	0.163	1.0	6
300-1500			F/300	6
1500-100,000			5	6

(B) Limits for General Population / Uncontrolled Exposure

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/ cm ²)	Averaging Time E ² , H ² or S (minutes)
0.3-1.34	614	1.63	(100)*	30
1.34-30	824/f	2.19/f	(180/f)*	30
30-300	27.5	0.073	0.2	30
300-1500			F/1500	30
1500-100,000			1.0	30

Note: f = frequency in MHz ; *Plane-wave equivalent power density

2.2. MPE Calculation Method

The MPE was calculated at 20 cm to show compliance with the power density limit.

The following formula was used to calculate the Power Density:

$$E \text{ (V/m)} = \frac{\sqrt{30 \times P \times G}}{d} \quad \text{Power Density: } Pd \text{ (W/m}^2\text{)} = \frac{E^2}{377}$$

E = Electric field (V/m)

P = Peak RF output power (W)

G = EUT Antenna numeric gain (numeric)

d = Separation distance between radiator and human body (m)

The formula can be changed to

$$Pd = \frac{30 \times P \times G}{377 \times d^2}$$

2.3. Calculated Result and Limit

Exposure Environment: General Population / Uncontrolled Exposure

For 2.4GHz WLAN:

Antenna Type : PCB Antenna

Conducted Power for IEEE 802.11g: 26.39 dBm

Distance (cm)	Test Freq. (MHz)	Antenna Gain (dBi)	Antenna Gain (numeric)	The maximum combined Average Output Power		Power Density (S) (mW/cm ²)	Limit of Power Density (S) (mW/cm ²)	Test Result
				(dBm)	(mW)			
20	2437	3.76	2.3768	26.3893	435.4437	0.206007	1	Complies

For ZigBee:

For Zigbee module 1:

Antenna Type : PCB Antenna

Conducted Power for IEEE 802.15.4 ZigBee: 21.89 dBm

Distance (cm)	Test Freq. (MHz)	Antenna Gain (dBi)	Antenna Gain (numeric)	Average Output Power		Power Density (S) (mW/cm ²)	Limit of Power Density (S) (mW/cm ²)	Test Result
				(dBm)	(mW)			
20	2405	2.02	1.5922	21.8900	154.5254	0.048972	1	Complies

For Zigbee module 2:

Antenna Type : PCB Antenna

Conducted Power for IEEE 802.15.4 ZigBee: 21.79 dBm

Distance (cm)	Test Freq. (MHz)	Antenna Gain (dBi)	Antenna Gain (numeric)	Average Output Power		Power Density (S) (mW/cm ²)	Limit of Power Density (S) (mW/cm ²)	Test Result
				(dBm)	(mW)			
20	2405	2.89	1.9454	21.7900	151.0080	0.058472	1	Complies

For WWAN:

For WWAN module 1:

Antenna Type : Dipole Antenna

Conducted Power for WWAN: 32.20 dBm

Distance (cm)	Test Freq. (MHz)	Antenna Gain (dBi)	Antenna Gain (numeric)	Max Tune up power (dBm)	Average Output Power (mW)	The max sourced based time-averaged transmit power (mW)	Duty cycle	Calculated RF Exposure (mW/m2)	Limit (mW/m2)	Test Result
20	824.200	0.870	1.222	32.200	1659.587	2027.683	50.00	0.201697	0.550933	Complies

For WWAN module 2:

Antenna Type : Dipole Antenna

Conducted Power for WWAN: 23.50 dBm

Distance (cm)	Test Freq. (MHz)	Antenna Gain (dBi)	Antenna Gain (numeric)	Max Tune up power (dBm)	Average Output Power (mW)	The max sourced based time-averaged transmit power (mW)	Calculated RF Exposure (mW/m2)	Limit (mW/m2)	Test Result
20	826.4-846.4	0.870	1.222	23.500	223.872	273.527	0.054416	0.550933	Complies

Conclusion:

The formula of calculated the MPE is:

$$CPD1 / LPD1 + CPD2 / LPD2 +etc. < 1$$

CPD = Calculation power density

LPD = Limit of power density

The transmit simultaneously mode:

1. 2.4GHz WLAN + ZigBee (Zigbee module 1) + ZigBee (Zigbee module 2) + WWAN (WWAN module 1):

Therefore, the worst-case situation is $0.206007 / 1 + 0.048972 / 1 + 0.058472 / 1 + 0.201697 / 0.550933$
 $= 0.679552$, which is less than "1". This confirmed that the device complies.

2. 2.4GHz WLAN + ZigBee (Zigbee module 1) + ZigBee (Zigbee module 2) + WWAN (WWAN module 2):

Therefore, the worst-case situation is $0.206007 / 1 + 0.048972 / 1 + 0.058472 / 1 + 0.054416 / 0.550933$
 $= 0.41223$, which is less than "1". This confirmed that the device complies.