

RF EXPOSURE REPORT

OF

Applicant: CALAMP WIRELESS NETWORKS CORPORATION
2200 Faraday Ave, Suite 220, Carlsbad, CA 92008

Product Name: LMU5541 Broadband Router/Tracker

Brand Name: CalAmp

Model No.: LMU5541LW

Model Difference: N/A

Report Number: ER/2019/C0118

FCC ID: APV-5541LW

IC: 5843C-5541LW

FCC Rule Part Part 2.1091

IC Rule: RSS-102 issue 5 Mar. 19, 2015

Issue Date: Feb. 04, 2020

We hereby certify that:

The above equipment was verified by SGS Taiwan Ltd. The evaluation in this report is in compliance with the above rule(s).

The results of this report relate only to the sample identified in this report.

John Teh

Approved By: _____
Yeh John / Asst. Manager



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f (886-2) 2298-0488

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Revision History

Report Number	Revision	Description	Issue Date	Remark
ER/2019/C0118	Rev.00	Original.	Feb. 04, 2020	Revised By: Stefanie Yu

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1 DESCRIPTION OF EQUIPMENT UNDER TEST (EUT)

1.1 General:

Product Name:	LMU5541 Broadband Router/Tracker	
Brand Name:	CalAmp	
Model No.:	LMU5541LW	
Model Difference:	N/A	
Hardware Version:	Rev E	
Software Version:	LMU,166 V4.1a	
Power Supply:	12Vdc from Car Battery & 3.7Vdc from Rechargeable Li-ion Battery	
	Battery:	Model No.: GSP633248, Supplier: N/A

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1.2 Antenna Information:

1.2.1 BT / WLAN

Antenna Type	Supplier	Antenna Part No.	Freq. (MHz)	Peak Antenna Gain (dBi)
PIFA	TAOGLAS	MA284.LBIC.001	2.4GHz	-2.21

1.2.2 WLAN 5GHz

Antenna Type	Supplier	Antenna Part No.	Frequency (MHz)	Peak Antenna Gain (dBi)
PIFA	TAOGLAS	MA284.LBIC.001	5725~5850	-2.07

1.2.3 WWAN

Antenna Type	Antenna Part No.
PIFA	MA284.LBIC.001

Operating Frequency (MHz)		Peak Antenna Gain (dBi)
GSM / GPRS / EDGE 850	824.2 ~ 848.8	3.35
GSM / GPRS / EDGE 1900	1850.2 ~ 1909.8	4.63
WCDMA / HSPA Band 2	1852.4 ~ 1907.6	4.63
WCDMA / HSPA Band 4	1712.4 ~ 1752.6	4.69
WCDMA / HSPA Band 5	826.4 ~ 846.6	3.35
LTE-Band 2	1850.7 ~ 1909.3	4.63
LTE-Band 4	1710.7 ~ 1754.3	4.69
LTE-Band 5	824.7 ~ 848.3	3.35
LTE-Band 7	2502.5 ~ 2567.5	4.22
LTE-Band 12	699.7 ~ 715.3	2.98
LTE-Band 13	779.5 ~ 784.5	2.98
LTE-Band 25	1850.7 ~ 1914.3	4.63
LTE-Band 26	824.7 ~ 848.3	3.35
LTE-Band 26 Part 90	814.7 ~ 823.3	3.35
LTE-Band 38	2572.5 ~ 2617.5	4.22
LTE-Band 41	2498.5 ~ 2687.5	4.22

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1.3 Rated Power

1.3.1 2.4GHz

Mode	Freq. Range (MHz)	Channels	Modulation Technology	Max Output Power (dBm)	Antenna Gain (dBi)	EIRP (dBm)	Worst Case
BR+EDR	2402-2480	79	GFSK + $\pi/4$ DQPSK + 8DPSK	-1.39	-2.21	-3.60	
BLE	2402-2480	40	GFSK	-3.40		-5.61	
802.11b/g/n	2412-2462	11	DSSS & OFDM	13.85		11.64	V
Modulation type:		CCK, DQPSK, DBPSK for DSSS 64QAM, 16QAM, QPSK, BPSK for OFDM					

1.3.2 WLAN 5GHz:

802.11	Freq. Range (MHz)	Max. Output Power (dBm)	Antenna Gain (dBi)	EIRP (dBm)	Worst Case
a	5725~5850	13.97	-2.07	11.90	V
n/ac_20	5725~5850	11.97	-2.07	9.90	
n/ac_40	5725~5850	11.94	-2.07	9.87	
ac_80	5725~5850	8.68	-2.07	6.61	
Modulation type		64QAM, 16QAM, QPSK, BPSK for OFDM			

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1.3.3 WCDMA / LTE:

Operating Frequency (MHz)				Max. Output Power include tolerance (dBm)	Antenna Gain (dBi)	EIRP / ERP (dBm)
GSM / GPRS / EDGE 850	824.2	~	848.8	26.25	3.35	29.60
GSM / GPRS / EDGE 1900	1850.2	~	1909.8	26.25	4.63	30.88
WCDMA / HSPA Band 2	1852.4	~	1907.6	25.00	4.63	29.63
WCDMA / HSPA Band 4	1712.4	~	1752.6	25.00	4.69	29.69
WCDMA / HSPA Band 5	826.4	~	846.6	25.00	3.35	28.35
LTE-Band 2	1850.7	~	1909.3	25.00	4.63	29.63
LTE-Band 4	1710.7	~	1754.3	25.00	4.69	29.69
LTE-Band 5	824.7	~	848.3	25.00	3.35	28.35
LTE-Band 7	2502.5	~	2567.5	25.00	4.22	29.22
LTE-Band 12	699.7	~	715.3	25.00	2.98	27.98
LTE-Band 13	779.5	~	784.5	25.00	2.98	27.98
LTE-Band 25	1850.7	~	1914.3	25.00	4.63	29.63
LTE-Band 26	824.7	~	848.3	25.00	3.35	28.35
LTE-Band 26 Part 90	814.7	~	823.3	25.00	3.35	28.35
LTE-Band 38	2572.5	~	2617.5	25.00	4.22	29.22
LTE-Band 41	2498.5	~	2687.5	25.00	4.22	29.22
A duty cycle of 0.25 is set in the output power of GSM 850 and 1900 for PD calculation.						

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FCC Worst case							
Operating Frequency (MHz)				Operation Distance (cm)	Power Density (mW/cm ²)	Margin	FCC Worst Case
GSM / GPRS / EDGE 850	824.2	~	848.8	20	0.18	0.16	
GSM / GPRS / EDGE 1900	1850.2	~	1909.8	20	0.24	0.22	V
WCDMA / HSPA Band 2	1852.4	~	1907.6	20	0.18	0.16	
WCDMA / HSPA Band 4	1712.4	~	1752.6	20	0.19	0.17	
WCDMA / HSPA Band 5	826.4	~	846.6	20	0.14	0.12	
LTE-Band 2	1850.7	~	1909.3	20	0.18	0.16	
LTE-Band 4	1710.7	~	1754.3	20	0.19	0.17	
LTE-Band 5	824.7	~	848.3	20	0.14	0.12	
LTE-Band 7	2502.5	~	2567.5	20	0.17	0.15	
LTE-Band 12	699.7	~	715.3	20	0.13	0.11	
LTE-Band 13	779.5	~	784.5	20	0.13	0.11	
LTE-Band 25	1850.7	~	1914.3	20	0.18	0.16	
LTE-Band 26	824.7	~	848.3	20	0.14	0.12	
LTE-Band 26 Part 90	814.7	~	823.3	20	0.14	0.12	
LTE-Band 38	2572.5	~	2617.5	20	0.17	0.15	
LTE-Band 41	2498.5	~	2687.5	20	0.17	0.15	

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IC Worst case							
Operating Frequency (MHz)				Operation Distance (cm)	Power Density (W/m ²)	Margin	IC Worst Case
GSM / GPRS / EDGE 850	824.2	~	848.8	20	1.82	-0.76	V
GSM / GPRS / EDGE 1900	1850.2	~	1909.8	20	2.44	-2.04	
WCDMA / HSPA Band 2	1852.4	~	1907.6	20	1.83	-2.65	
WCDMA / HSPA Band 4	1712.4	~	1752.6	20	1.85	-2.39	
WCDMA / HSPA Band 5	826.4	~	846.6	20	1.36	-1.22	
LTE-Band 2	1850.7	~	1909.3	20	1.83	-2.65	
LTE-Band 4	1710.7	~	1754.3	20	1.85	-2.39	
LTE-Band 5	824.7	~	848.3	20	1.36	-1.22	
LTE-Band 7	2502.5	~	2567.5	20	1.66	-3.84	
LTE-Band 12	699.7	~	715.3	20	1.25	-1.05	
LTE-Band 13	779.5	~	784.5	20	1.25	-1.23	
LTE-Band 25	1850.7	~	1914.3	20	1.83	-2.65	
LTE-Band 26	824.7	~	848.3	20	1.36	-1.22	
LTE-Band 26 Part 90	814.7		823.3	20	1.36	-1.19	
LTE-Band 38	2572.5	~	2617.5	20	1.66	-3.94	
LTE-Band 41	2498.5	~	2687.5	20	1.66	-3.83	

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2 FCC MAXIMUM PERMISSIBLE EXPOSURE (MPE)

2.1 FCC Standard Applicable

According to §1.1307(b)(1), systems operating under the provisions of this section shall be operated in a manner that ensure that the public is not exposed to radio frequency energy level in excess of the Commission's guideline.

This is a Mobile device, the MPE is required.

According to §1.1310 and §2.1091 RF exposure is calculated.

Limits for Maximum Permissive Exposure (MPE)

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm ²)	Averaging Time (minute)
Limits for General Population/Uncontrolled Exposure				
0.3-1.34	614	1.63	*(100)	30
1.34-30	824/f	2.19/f	*(180/f ²)	30
30-300	27.5	0.073	0.2	30
300-1500	/	/	f/1500	30
1500-15000	/	/	1.0	30

f = frequency in MHz

* = Plane-wave equipment power density

Prediction of MPE limit at a given distance

$$S = PG / 4\pi R^2$$

Where: S = Power density

P = Power input to antenna

G = Power gain of the antenna in the direction of interest relative to an isotropic radiator

R = Distance to the center of radiation of the antenna

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2.2 ISED Standard Applicable

This submittal(s) (test report) is intended to comply with RSS-102 issue 5 Radio frequency Radiation Exposure requirement.

This is a Mobile device, the MPE is required.

Limits for Maximum Permissible Exposure (MPE)

RF Field Strength Limits for Devices Used by the General Public (Uncontrolled Environment)				
Frequency Range (MHz)	Electric Field (V/m rms)	Magnetic Field Strength (A/m rms)	Power Density (W/m ²)	Reference Period (minutes)
0.003-10	83	90	-	Instantaneous*
0.1-10	-	$0.73/f$	-	6**
1.1-10	$87/f^{0.5}$	-	-	6**
10-20	27.46	0.0728	2	6
20-48	$58.07/f^{0.25}$	$0.1540/f^{0.25}$	$8.944/f^{0.5}$	6
48-300	22.06	0.05852	1.291	6
300-6000	$3.142 f^{0.3417}$	$0.008335 f^{0.3417}$	$0.02619 f^{0.6834}$	6
6000-15000	61.4	0.163	10	6
15000-150000	61.4	0.163	10	$616000/f^{1.2}$
150000-300000	$0.158 f^{0.5}$	$4.21 \times 10^{-4} f^{0.5}$	$6.67 \times 10^{-5} f$	$616000/f^{1.2}$

F = frequency in MHz

* = Based on nerve stimulation (NS).

** = Based on specific absorption rate (SAR)

Maximum Permissible Exposure (MPE) Evaluation

Prediction of MPE limit at a given distance

$$S = PG/4\pi R^2$$

Where: S = Power density

P = Power input to antenna

G = Power gain of the antenna in the direction of interest relative to an isotropic radiator

R = Distance to the center of radiation of the antenna

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台灣檢驗科技股份有限公司

t (886-2) 2299-3279

f (886-2) 2298-0488

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2.3 Power Density Calculation (Worst Case)

FCC								ISED		
Operation Mode	Evaluation Frequency (MHz)	Operation Distance (cm)	Output Power ERP / EIRP (dBm)	Output Power ERP / EIRP (mW)	Power Density (mW/cm ²)	Limit (mW/cm ²)	Pass / Fail	Power Density (W/cm ²)	Limit (W/cm ²)	Pass / Fail
BT	2402.00	20	-3.60	0.44	0.0001	1.000	Pass	0.001	5.351	Pass
WLAN	5180.00	20	13.10	20.42	0.0041	1.000	Pass	0.041	9.047	Pass
GSM 1900	1850.2	20	30.88	1224.62	0.2438	1.000	Pass	1.250	2.303	Pass
GSM 850	824.2	20	29.60	912.01	0.1815	0.549	Pass	1.815	2.576	Pass

Note: For conservativeness, the lowest uplink frequency of each band is used to determine the MPE limit of that band.

2.4 Collocated Power Density Calculation

FCC				
Operation Mode	Power Density (mW/cm ²)	Limit (mW/cm ²)	Power Density / Limit	Σ(E- Power Density / Limit)
BT	0.0001	1.000	0.0001	0.2749
WLAN	0.0041	1.000	0.0041	
GSM 1900	0.2438	1.000	0.2680	

ISED				
Operation Mode	Power Density (W/m ²)	Limit (W/m ²)	Power Density / Limit	Σ(E- Power Density / Limit)
BT	0.001	5.351	0.0002	0.7093
WLAN	0.041	9.047	0.0045	
GSM 850	1.815	2.576	0.7047	

Note:

1. $\Sigma(\text{E- Power Density} / \text{Limit})$: This is a summation of [(Power Density for each transmitter/antenna included in the simultaneous transmission) / (corresponding MPE limit)].
2. Considering the collocated transmitters, the aggregated (Power Density /limit) is smaller than 1, and MPE of collocated transmitters is compliant

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2.5 Maximum Allowable Gain

FCC

Operation Mode	Frequency (MHz)	Operation Distance (cm)	Conducted Average output power (dBm)	Max. output Power include tolerance (dBm)	Antenna Gain (dBi)	EIRP (ERP) Limit (dBm)	Max. output Power (mW)	Power Density (PD) (mW/cm ²)	Limit (mW/cm ²)	Allowable Gain according to EIRP (dBi)	Allowable Gain according to PD (dBi)	Max Allowable Gain (dBi)
GSM / GPRS / EDGE 850	824.2	20	24.05	26.25	6.38	38.45	1832.31	0.365	0.549	6.38	8.16	6.38
GSM / GPRS / EDGE 1900	1850.2	20	21.95	26.25	3.79	33.00	1009.25	0.201	1.000	3.79	10.76	3.79
WCDMA / HSPA Band 2	1852.4	20	22.58	25.00	10.42	33.00	3483.37	0.693	1.000	10.42	12.01	10.42
WCDMA / HSPA Band 4	1712.4	20	22.77	25.00	7.23	30.00	1671.09	0.333	1.000	7.23	12.01	7.23
WCDMA / HSPA Band 5	826.4	20	25.26	25.00	9.42	38.45	2767.89	0.551	0.551	13.19	9.42	9.42
LTE-Band 2	1850.7	20	21.94	25.00	11.06	33.00	4036.45	0.803	1.000	11.06	12.01	11.06
LTE-Band 4	1710.7	20	22.33	25.00	10.67	33.00	3689.78	0.734	1.000	10.67	12.01	10.67
LTE-Band 5	824.7	20	22.66	25.00	9.41	38.45	2762.20	0.550	0.550	15.79	9.41	9.41
LTE-Band 7	2502.5	20	22.54	25.00	10.46	33.00	3515.60	0.700	1.000	10.46	12.01	10.46
LTE-Band 12	699.7	20	22.67	25.00	8.70	34.77	2343.53	0.466	0.466	12.10	8.70	8.70
LTE-Band 13	779.5	20	22.27	25.00	9.17	34.77	2610.81	0.520	0.520	12.50	9.17	9.17
LTE-Band 25	1850.7	20	22.73	25.00	10.27	33.00	3365.12	0.670	1.000	10.27	12.01	10.27
LTE-Band 26	824.7	20	22.46	25.00	9.41	50.00	2762.20	0.550	0.550	27.54	9.41	9.41
LTE-Band 26 Part 90	814.7	20	22.40	25.00	9.36	38.45	2728.70	0.543	0.543	16.05	9.36	9.36
LTE-Band 38	2572.5	20	23.11	25.00	9.89	33.00	3083.19	0.614	1.000	9.89	12.01	9.89
LTE-Band 41	2498.5	20	23.05	25.00	9.95	33.00	3126.08	0.622	1.000	9.95	12.01	9.95

ISED

Operation Mode	Frequency (MHz)	Operation Distance (cm)	Conducted Average output power (dBm)	Max. output Power include tolerance (dBm)	Antenna Gain (dBi)	EIRP (ERP) Limit (dBm)	Max. output Power (mW)	Power Density (PD) (W/m ²)	Limit (W/m ²)	Allowable Gain according to EIRP (dBi)	Allowable Gain according to PD (dBi)	Max Allowable Gain (dBi)
GSM / GPRS / EDGE 850	824.2	20	24.05	26.25	4.87	38.45	1294.20	2.576	2.576	6.38	4.87	4.87
GSM / GPRS / EDGE 1900	1850.2	20	21.95	26.25	3.79	33.00	1009.25	2.009	4.477	3.79	7.27	3.79
WCDMA / HSPA Band 2	1852.4	20	22.58	25.00	8.52	33.00	2250.89	4.480	4.480	10.42	8.52	8.52
WCDMA / HSPA Band 4	1712.4	20	22.77	25.00	7.23	30.00	1671.09	3.326	4.246	7.23	8.29	7.23
WCDMA / HSPA Band 5	826.4	20	25.26	25.00	6.13	38.45	1296.56	2.581	2.581	13.19	6.13	6.13
LTE-Band 2	1850.7	20	21.94	25.00	8.52	33.00	2249.48	4.477	4.477	11.06	8.52	8.52
LTE-Band 4	1710.7	20	22.33	25.00	8.29	33.00	2131.75	4.243	4.243	10.67	8.29	8.29
LTE-Band 5	824.7	20	22.66	25.00	6.12	38.45	1294.74	2.577	2.577	15.79	6.12	6.12
LTE-Band 7	2502.5	20	22.54	25.00	9.42	33.00	2764.61	5.503	5.503	10.46	9.42	9.42
LTE-Band 12	699.7	20	22.67	25.00	5.63	34.77	1157.17	2.303	2.303	12.10	5.63	5.63
LTE-Band 13	779.5	20	22.27	25.00	5.95	34.77	1245.81	2.480	2.480	12.50	5.95	5.95
LTE-Band 25	1850.7	20	22.73	25.00	8.52	33.00	2249.48	4.477	4.477	10.27	8.52	8.52
LTE-Band 26	824.7	20	22.46	25.00	6.12	50.00	1294.74	2.577	2.577	27.54	6.12	6.12
LTE-Band 26 Part 90	814.7	20	22.40	25.00	6.09	38.45	1283.99	2.556	2.556	16.05	6.09	6.09
LTE-Band 38	2572.5	20	23.11	25.00	9.50	33.00	2817.23	5.608	5.608	9.89	9.50	9.50
LTE-Band 41	2498.5	20	23.05	25.00	9.41	33.00	2761.59	5.497	5.497	9.95	9.41	9.41

A duty cycle of 0.25 is set in the output power of GSM 850 and 1900 for PD calculation.

Refer to report ER/2019/C0117 for conducted average output power.

Note: For conservativeness, the lowest uplink frequency of each band is used to determine the MPE limit of that band.

The calculation maximum power density was equal to or less than the required limits for general population exposure for FCC and RSS-102 provided that the antenna chosen has a gain of equal or less than which is shown in the above table.

~ End of Report ~

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