

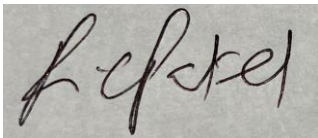

**LoRAWAN Module: P-LPWA-900****FCC ID: LDKLPWA900****IC: 2461A-LPWA900**

Against the following Specifications:  
FCC CFR47 Rule Parts 1.1307, 1.1310 & 2.1091  
ISED RSS-102 Issue 5



CERTIFICATE #1178.01

**Cisco Systems**  
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This report replaces any previously entered test report under EDCS – **23320460**. This test report has been electronically authorized and archived using the CISCO Engineering Document Control system. Test Report Template EDCS# 11644121

**Attestation Statement of Compliance**

The P-LPWA-900 in IR1100 series router has been evaluated for Maximum Permissible Exposure in compliance with 47 Code of Federal Regulations [Part 1.1307(b) (for fixed devices), Part 2.1091 (for mobile devices)]. Part 1.1307(b) refers to limits in Part 1.1310 and 2.1091. The evaluation was in accordance with methodology as referenced in KDB 447498 D01 General RF Exposure Guidance v06.

This study addresses the addition of an additional pair of transmitters using the data derived in the afore mentioned report EDCS #

- FCC/ISED LoRAWAN report - 23252260

This study also addresses the co-located transmitter. The following cellular modems was considered during simultaneous operation

- P-LTE-VZ (FCC ID: N7NWP76A & IC: 2147C-WP76A) – 13328078, 13328077
- P-LTE-US (FCC ID: N7NWP76C & IC: 2147C-WP76C) – 13327600, 13327597, 13327598, 13327599
- P-LTE-MNA (FCC ID: N7NWP7610 & IC: 2147C-WP7610) - 21581304, 21581305, 21581306

The limits used for this evaluation are in line with the recommendations of the World Health Organizations (WHO) International Committee on Non-Ionizing Radiation Protection (ICNIRP) as well as the American National Standards Institute (ANSI) C95.1.

The limits chosen are of **General Population/Uncontrolled Exposure**.

The following case scenarios were used:

- LTE
- LoRAWAN

This device must be installed to provide a separation distance of at least 22 cm for FCC and 33cm for Canada from all persons in the standalone mode. In simultaneous transmission mode, the device must be installed to provide a separation distance of at least 24 cm for FCC and 36 cm for Canada from all persons

. Installers must be provided with antenna installation and transmitter operating conditions for satisfying RF exposure compliance. Based on the study this case scenario, the General Population/Uncontrolled Exposure and the minimum recommended distance is around 36cm from the antenna.

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## EUT Description

**P-LPWA-900** LoRa radio is a low power wide area network (LPWAN) RF physical layer modulation technology that offers long-distance wireless connectivity, excellent power efficiency, very high receiver sensitivity, and robust spectrum spreading. It operates on unlicensed Industrial, Scientific, and Medical (ISM) frequencies, for which 902 - 928 MHz spectrum and spectrum subsets can be utilized in the Americas and in Asia-Pacific countries.

LoRAWAN is a MAC (Media Access Control) protocol specification defined by the LoRa Alliance that complements the LoRa physical layer. It is supported by an established ecosystem of LoRAWAN compliant devices that are available from multiple vendors, and which can be certified for interoperability by the LoRa Alliance.

### **900 MHz Lora Radio Specification:**

- Operating Frequency Band: 902 MHz – 928 MHz
- Mode: LoRa-DTS
- Nominal Bandwidth: 500kHz
- Data Rate: SF7 – SF 12 (980bps – 21.9Kbps)
- Modulation: Chirp Spread Spectrum (CSS)

### Supported Antennas – Cellular Modems

The following antennas are supported by this product series.

The data included in this report represent the worst-case data for all antennas.

#### Cellular Antennas

Antenna P/N	Gain (dBi)	Gain (dBi)	Gain (dBi)	Connector	Antenna Description
	698-960MHz	1710-2690MHz	3400-3800MHz	type	
ANT-4G-OMNI-OUT-N	1.5	3.5	5.5	N-Type (Female)	Cisco outdoor omnidirectional antenna for 2G, 3G, and 4G LTE cellular
Antenna P/N	Gain (dBi)	Gain (dBi)	Gain (dBi)	Connector	Antenna Description
	617-960MHz	1450-4200MHz	4400-7125MHz	type	
ANT-5G-OMNI-OUT-N	2.5	4	4.3	N-Type (Female)	Cisco outdoor omnidirectional antenna for 2G, 3G, 4G LTE, 5G NR FR1 cellular
Antenna P/N	Gain (dBi)	Gain (dBi)	Gain (dBi)	Connector	Antenna Description
	698-960MHz	1448-1511MHz	for 1710-2700MHz	type	
ANT-2-4G2-O	3.8	4.3	5.5	TNC male	Cisco Cellular 2-in-1 Vehicle Mount and Fixed Infrastructure Antenna
Antenna P/N	Gain (dBi)	Gain (dBi)		Connector	Antenna Description
	698-960MHz	for 1710-2700MHz		type	
4G-LTE-ANTM-O-3-B	2.5	2.5		SMA-male	Cisco cellular 3-in-1- indoor and outdoor antenna
Antenna P/N	Gain (dBi)	Gain (dBi)	Gain (dBi)	Connector	Antenna Description
	698-960MHz	1448-1511MHz	1710-2700MHz	type	
ANT-3-4G2G1-O	3.8	4.3	5.5	TNC male	Cisco Cellular 2-in-1 Vehicle Mount and Fixed Infrastructure Antenna
Antenna P/N	Gain (dBi)	Gain (dBi)	Gain (dBi)	Connector	Antenna Description
	698-960MHz	for 1448-1511MHz	for 1710-2700MHz	type	
ANT-5-4G2WL2G1-O	2.9	4.8	6	TNC male	Cisco 5-in-1 Vehicle Mount and Fixed Infrastructure Antenna
Antenna P/N	Gain (dBi)	Gain (dBi)		Connector	Antenna Description
	617 -960 MHz	1710-5925MHz		type	
ANT-7-5G4WL2G1-O	2.1	6		SMA-male	4x 5G (LTE) / 2x WiFi / 1x GNSS
Antenna P/N	Gain (dBi)	Gain (dBi)	Gain (dBi)	Connector	Antenna Description
	617-960MHz	1400-2960MHz	2500-2690MHz 3400-3900MHz	type	
LTE-ANTM2-SMA-D	0	2	5	SMA connector	Cisco LTE-ANTM2-SMA-D omnidirectional dipole antenna, SMA connector, and articulating join

Antenna P/N	Gain (dBi) 617-960MHz	Gain (dBi) 1710-5925MHz	Connector type	Antenna Description
5G-ANTM-SMA-D	3.1	4.5	SMA connector	Cisco LTE-ANTM2-SMA-D omnidirectional dipole antenna, SMA connector, and articulating join

- 3.8dBi represents worst case antenna gain in the 617-960MHz frequency range
- 6dBi represents worst case antenna gain in the 1710-5925MHz frequency range
- 4.8dBi represents worst case antenna gain in the 1448-1511 frequency range

#### LoRAWAN Antennas:

P-LPWA-900 supports the following antennas:

Antenna	Frequency Supported (MHz)	Peak Gain (dBi)	Radiation Pattern	Antenna Type	Connector	Mounting Style
ANT-LPWA-SMA-D	863 – 928	0.9	Omnidirectional	Dipole	SMA(m)	Direct mount to front panel SMA(f)
ANT-WPAN-OD-OUT-N	863 – 928	1.5	Omnidirectional	Dipole	N(m)	Direct mount to bulkhead N(f)
ANT-LPWA-DB-O-N-5	863 – 928	5.6	Omnidirectional	Dipole	N(f)	Pole/mast mount

ANT-LPWA-DB-O-N-5 represents worst case antenna gain for P-LPWA-900

## 1.0 Methodology

All calculations were made in accordance with ANSI C95.1,

### Measurement Uncertainty Values

Parameter	Max MU from standard	Declared MU
Occupied Channel Bandwidth	+/- 5%	+/-2%
RF Output Power, conducted	+/- 1,5dB	+/-1.4dB
Power Spectral Density, conducted	+/- 3dB	+/- 2dB
Unwanted emissions, conducted	+/- 3dB	+/- 2dB
All emissions, radiated	+/- 6dB	+/- 3.2dB
Temperature	+/- 3C	+/- 0.7C
Supply Voltages	+/- 3%	+/- 2.5%
Time	+/- 5%	+/-2%

## 2.0 Technical Requirements

### 2.1 Single Band Operation – Limits

#### FCC Limits for Maximum Permissible Exposure (MPE)

##### (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 <sup>2</sup> )	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 <sup>2</sup> ) *	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 <sup>2</sup> )	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 <sup>2</sup> ) *	30
30-300	27.5	0.073	0.2	30
300-1500	--	--	f/1500	30
1500-100,000	--	--	1.0	30

f = frequency in MHz    \*Plane-wave equivalent power density

NOTE 1: See Section 1 for discussion of exposure categories.

NOTE 2: The averaging time for General Population/Uncontrolled exposure to fixed transmitters is not applicable for mobile and portable transmitters. See 47 CFR §§2.1091 and 2.1093 on source-based time-averaging requirements for mobile and portable transmitters.



### 3.0 Calculations

Given

$$E = \sqrt{(30 \cdot P \cdot G)/d} \quad \text{and} \quad S = E^2/3770$$

were

E=Field Strength in Volts/meter

P=Power in Watts

G=Numeric Antenna Gain

d=Distance in meters

S=Power Density in mW/cm<sup>2</sup>

Combine equations and rearrange the terms to express the distance as a function of the remaining variables:

$$d = \sqrt{((30 \cdot P \cdot G)/(3770 \cdot S))}$$

Changing to units of power in mW and distance in cm, using:

$$P(\text{mW}) = P(\text{W})/1000 \quad d(\text{cm}) = 100 \cdot d(\text{m})$$

yields

$$d = 100 \cdot \sqrt{((30 \cdot (P/1000) \cdot G)/(3770 \cdot S))}$$

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

where

d=Distance in cm

P=Power in mW

G=Numeric Antenna Gain

S=Power Density in mW/cm<sup>2</sup>

Substituting the logarithmic form of power and gain using:

$$P(\text{mW}) = 10^{(P(\text{dBm})/10)} \quad G(\text{numeric}) = 10^{(G(\text{dBi})/10)}$$

yields

$$d = 0.282 \cdot 10^{((P+G)/20)} / \sqrt{S} \quad \text{Equation (1)}$$

and

$$s = ((0.282 \cdot 10^{((P+G)/20)} / d)^2 \quad \text{Equation (2)}$$

where

d=MPE distance in cm

P=Power in dBm

G=Antenna Gain in dBi

S=Power Density in mW/cm<sup>2</sup>

## 4.0 Results

### 4.1 FCC RF Exposure Exemption criteria:

FCC 2.1019 - (c)(1) Evaluation of compliance with the exposure limits in §1.1310, and preparation of an EA if the limits are exceeded, is necessary for mobile devices with single RF sources having either more than an available maximum time-averaged power of 1 mW or more than the ERP listed in Table 1 to §1.1307(b)(3)(i)(C), whichever is greater. For mobile devices do not exempt by §1.1307(b)(3)(i)(C) at distances from 20 centimeters to 40 centimeters and frequencies from 0.3 GHz to 6 GHz, evaluation of compliance with the exposure limits in §1.1310 of this chapter is necessary if the ERP of the device is greater than  $ERP_{20cm}$  in the formula below. If the ERP of a single RF source at distances from 20 centimeters to 40 centimeters and frequencies from 0.3 GHz to 6 GHz is not easily obtained, then the available maximum time-averaged power may be used (*i.e.*, without consideration of ERP) in comparison with the following formula only if the physical dimensions of the radiating structure(s) do not exceed the electrical length of  $\lambda/4$  or if the antenna gain is less than that of a half-wave dipole (1.64 linear value).

$$P_{th}(\text{mW}) = ERP_{20\text{ cm}}(\text{mW}) = \begin{cases} 2040f & 0.3\text{ GHz} \leq f < 1.5\text{ GHz} \\ 3060 & 1.5\text{ GHz} \leq f \leq 6\text{ GHz} \end{cases}$$

All unlicensed personal communications service (PCS) devices and unlicensed NII devices shall be subject to the limits for general population/uncontrolled exposure.

## 4.2 ISED RF Exposure requirements

The ISED MPE limits from RSS-102 Issue 5 are shown in the table below.

**RF Field Strength Limits for Devices Used by the General Public  
(Uncontrolled Environment)**

Frequency Range (MHz)	Electric Field (V/m rms)	Magnetic Field (A/m rms)	Power Density (W/m <sup>2</sup> )	Reference Period (minutes)
0.003-10 <sup>21</sup>	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	$3.142 f^{0.3417}$	$0.008335 f$	$0.02619 f^{0.6834}$	6
6000-15000	61.4	0.163	10	6
15000-150000	61.4	0.163	10	$616000/f^{1.2}$
150000-300000	$0.158 f^{0.5}$	$4.21 \times 10^{-4} f^{0.5}$	$6.67 \times 10^{-5} f$	$616000/f^{1.2}$
Note: $f$ is frequency in MHz. *Based on nerve stimulation (NS). **Based on specific absorption rate (SAR).				

## 4.3 ISED RF Exposure exemption requirements

RF exposure evaluation is required if the separation distance between the user and/or bystander and the device's radiating element is greater than 20 cm, except when the device operates as follows:

- below 20 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 1 W (adjusted for tune-up tolerance);
- at or above 20 MHz and below 48 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than  $22.48/f^{0.5}$  W (adjusted for tune-up tolerance), where  $f$  is in MHz;
- at or above 48 MHz and below 300 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 0.6 W (adjusted for tune-up tolerance);
- at or above 300 MHz and below 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than  $1.31 \times 10^{-2} f^{0.6834}$  W (adjusted for tune-up tolerance), where  $f$  is in MHz;
- at or above 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 5 W (adjusted for tune-up tolerance).

## 5.0 Maximum EIRP and ERP

The declared maximum output powers including tune-up tolerances are used in conjunction with the maximum antenna gains to find the maximum EIRP and ERP values

Maximum EIRP and ERP - LoRAWAN							
Radio types		Band (GHz)	Max Power (dBm)	Max Antenna Gain (dBi)	Tolerance Value (dB)	Max total EIRP (dBm)	Max total ERP (dBm)
LoRAWAN	900MHz	902-928MHz	27	5.6	3	35.6	33.46
Maximum EIRP and ERP – Cellular bands							
P-LTE-VZ	LTE Band 4 1710-1755	LTE Band 4 1710-1755	24	6	30	27.86	
	LTE Band 13 777-787	LTE Band 13 777-787	24	3.8	27.8	25.66	
P-LTE-US	LTE/WCDMA Band 2 1850-1910	LTE/WCDMA Band 2 1850-1910	24	6	30	27.86	
	LTE/WCDMA Band 4 1710-1755	LTE/WCDMA Band 4 1710-1755	24	6	30	27.86	
	LTE/WCDMA Band 5 824-849	LTE/WCDMA Band 5 824-849	24	3.8	27.8	25.66	
	LTE Band 12 699-716	LTE Band 12 699-716	24	3.8	27.8	25.66	
P-LTE-MNA	LTE/WCDMA Band 2 1850-1910	LTE/WCDMA Band 2 1850-1910	24	6	30	27.86	

	LTE/WCDMA Band 4 1710-1755	LTE/WCDMA Band 4 1710-1755	24	6	30	27.86
	LTE/WCDMA Band 5 824-849	LTE/WCDMA Band 5 824-849	24	3.8	27.8	25.66
	LTE Band 12 699-716	LTE Band 12 699-716	24	3.8	27.8	25.66
	LTE Band 13 699MHz	LTE Band 13 699MHz	24	3.8	27.8	25.66
	LTE Band 14 788MHz	LTE Band 14 788MHz	24	3.8	27.8	25.66
	LTE Band 17 704	LTE Band 17 704	24	3.8	27.8	25.66
	LTE Band 66 1710MHz	LTE Band 66 1710MHz	24	6	30	27.86

## 6.0 MPE Calculations and Evaluation

Power densities are calculated for all radios, and sum totals are compared to the FCC and ICC limits to support the 20cm minimum device-user separation

Power density is calculated as:

$$S = \frac{EIRP}{4\pi R^2}$$

- For FCC evaluation, the WLAN band with the highest EIRP is chosen for the worst-case.
- ISED Limits for 300MHz-6GHz are calculated as (from table in section 4.2)
- For ISED in accordance with RSS-102 section 3.2, the fractions of the applicable limits are summed

Radio types	Frequency Bands	Channel (MHz)	Max total EIRP (dBm)	Max total EIRP (mW)	$S = \frac{EIRP}{4\pi r^2}$ (mW/cm <sup>2</sup> )	FCC Limit (mW/cm <sup>2</sup> )	FCC MPE Distance (cm)	ISED: S (W/m <sup>2</sup> )	ISED Limit (W/m <sup>2</sup> )	ISED Distance (cm)
LoRAWAN	902-928MHz	923.3	35.6	3630	0.722	0.616	21.65	7.22	2.78	32.21
P-LTE-VZ	LTE Band 4 1710-1755	1710	30	1000	0.199	1.0	8.92	1.99	4.24	13.69
	LTE Band 13 777-787	777	27.8	602.3	0.120	0.518	9.62	1.20	2.47	13.92
P-LTE-US	LTE/WCDMA Band 2 1850-1910	1850	30	1379.9	0.199	1.0	8.92	1.99	4.48	13.33
	LTE/WCDMA Band 4 1710-1755	1710	30	1000	0.199	1.0	8.92	1.99	4.24	13.69
	LTE/WCDMA Band 5 824-849	824	27.8	602.3	0.120	0.5493	9.34	1.20	2.58	13.64
	LTE Band 12 699-716	699	27.8	602.3	0.120	0.466	10.14	1.20	2.30	14.43

<b>P-LTE-MNA</b>	LTE/WCDMA Band 2 1850-1910	1850	30	1000	0.199	1.0	8.92	1.99	4.48	13.33
	LTE/WCDMA Band 4 1710-1755	1710	30	1000	0.199	1.0	8.92	1.99	4.24	13.69
	LTE/WCDMA Band 5 824-849	824	27.8	602.3	0.120	0.5493	9.34	1.20	2.58	13.64
	LTE Band 12 699-716	699	27.8	602.3	0.120	0.466	10.14	1.20	2.30	14.43
	LTE Band 13 777-787	777	27.8	602.3	0.120	0.518	9.62	1.20	2.47	13.92
	LTE Band 14 788-798MHz	788	27.8	602.3	0.120	0.525	9.55	1.20	2.50	13.85
	LTE Band 17 704-716MHz	704	27.8	602.3	0.120	0.469	10.10	1.20	2.31	14.69
	LTE Band 66 1710- 1780MHz	1710	30	1000	0.199	1.0	8.92	1.99	4.24	13.69

LTE Band 12 represents worst case for both FCC/IC



**Calculations with simultaneous transmitters – FCC**

	Power Density (mW/cm <sup>2</sup> )	Power Density Limit (mW/cm <sup>2</sup> )	Percent Contribution Relative to Applicable Limit (%)
LoRAWAN	0.722	0.616	117.2
LTE	0.12	0.466	25.8
			Total Percentage (%)
			143.0
			Estimated Separation Distance for Multiple Transmitter Scenario (cm)
			24

**Calculations with simultaneous transmitters – ISED**

	Power Density (W/m^2)	Power Density Limit (W/m^2)	Percent Contribution Relative to Applicable Limit (%)
LTE	1.2	2.310	51.9
LoRAWAN	7.22	2.780	259.7
			Total Percentage (%)
			311.7
			Estimated Separation Distance for Multiple Transmitter Scenario (cm)
			36