Maximum Permissible Exposure Study - Engineering Analysis

C1101-4PLTEPW
with ISR-AP1101AC-x

Router with Wave 2 802.11a/g/n/ac WLAN & LTE

FCC ID: LDKC11011757

2400-2483.5 MHz, 5150-5250 MHz,

5250-5350 MHz, 5470-5725 MHz, 5725-5850 MHz, and LTE

Against the following Specifications:
47 Code of Federal Regulations 2.1091

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This report replaces any previously entered test report under EDCS – 12649075. This test report has been electronically authorized and archived using the CISCO Doc Central. Test Report Template EDCS# 11556830.

EDCS – 12649075

Attestation Statement of Compliance

The C1101-4PLTEPW with ISR-AP1101AC-x wifi adapter has been evaluated for Maximum Permissible Exposure in compliance with 47 Code of Federal Regulations 2.1091. The evaluation was in accordance with methodology as referenced in KDB 447498 D01 General RF Exposure Guidance. This report serves as the additional technical analysis of the Cisco radio modules

This study addresses the addition of an additional pair of transmitters using the data derived in the afore mentioned report #
LTE report = info derived from the documents: AirPrime EM7455 & WP760x Product Technical Specification & Customer Design Guidelines and Cisco LTE-ANTM-D antenna)
2.4GHz DTS report : EDCS-12057781
5GHz UNII-1 report : EDCS-12062325
5GHz UNII-2 report : EDCS-12062326
5GHz UNII-2ext reports : EDCS-12062328
5GHz UNII-3 report : EDCS-12062329

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
2.4GHz WLAN
5GHz WLAN
This device must be installed to provide a separation distance of at least 20 cm 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 20cm (8 inches) from the antenna.

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EDCS – 12649075

1.0 EUT Description

C1101-4PLTEPW with ISR-AP1101AC-x is Enterprise/MSP/M2M next generation low end router with the unified platform GE WAN, next generation Wave 2 802.11a/g/n/ac WLAN, and next generation LTE WWAN on Polaris IOS XE. It supports the following WLAN modes:

2.4GHz

802.11b - Legacy CCK, One Antenna, 1 to 11 Mbps
802.11b - Legacy CCK, Two Antennas, 1 to 11 Mbps

802.11g - Non HT20, One Antenna, 6 to 54 Mbps, 1ss
802.11g - Non HT20, Two Antennas, 6 to 54 Mbps, 1ss

802.11g - Non HT20 Beam Forming, Two Antennas, 6 to 54 Mbps, 1ss

802.11n/ac - HT/VHT20, One Antenna, M0 to M7, 1ss
802.11n/ac - HT/VHT20, Two Antennas, M0 to M7, 1ss
802.11n/ac - HT/VHT20, Two Antennas, M8 to M15, 2ss

802.11n/ac - HT/VHT20 Beam Forming, Two Antennas, M0 to M7, 1ss
802.11n/ac - HT/VHT20 Beam Forming, Two Antennas, M8 to M15, 2ss

802.11n/ac - HT/VHT20 STBC, Two Antennas, M0 to M7

5GHz

802.11a - Non HT20, One Antenna, 6 to 54 Mbps, 1ss
802.11a - Non HT20, Two Antennas, 6 to 54 Mbps, 1ss

802.11a - Non HT20 Beam Forming, Two Antennas, 6 to 54 Mbps, 1ss

802.11n/ac - HT/VHT20, One Antenna, M0 to M7, M0.1 to M9.1, 1ss
802.11n/ac - HT/VHT20, Two Antennas, M0 to M7, M0.1 to M9.1, 1ss
802.11n/ac - HT/VHT20, Two Antennas, M8 to M15, M0.2, M9.2, 2ss

802.11n/ac - HT/VHT20 Beam Forming, Two Antennas, M0 to M7, M0.1 to M9.1, 1ss
802.11n/ac - HT/VHT20 Beam Forming, Two Antennas, M8 to M15, M0.2, M9.2, 2ss

802.11n/ac - HT/VHT20 STBC, Two Antennas, M0 to M7, M0.1 to M9.1, 1ss

802.11a - Non HT40, One Antenna, 6 to 54 Mbps, 1ss
802.11a - Non HT40, Two Antennas, 6 to 54 Mbps, 1ss

802.11n/ac - HT/VHT40, One Antenna, M0 to M7, M0.1 to M9.1, 1ss
802.11n/ac - HT/VHT40, Two Antennas, M0 to M7, M0.1 to M9.1, 1ss
802.11n/ac - HT/VHT40, Two Antennas, M8 to M15, M0.2, M9.2, 2ss

802.11n/ac - HT/VHT40 Beam Forming, Two Antennas, M0 to M7, M0.1 to M9.1, 1ss
802.11n/ac - HT/VHT40 Beam Forming, Two Antennas, M8 to M15, M0.2, M9.2, 2ss

802.11n/ac - HT/VHT40 STBC, Two Antennas, M0 to M7, M0.1 to M9.1, 1ss

802.11a - Non HT80, One Antenna, 6 to 54 Mbps, 1ss
802.11a - Non HT80, Two Antennas, 6 to 54 Mbps, 1ss

802.11n/ac - HT/VHT80, One Antenna, M0.1 to M9.1, 1ss
802.11n/ac - HT/VHT80, Two Antennas, M0.1 to M9.1, 1ss
802.11n/ac - HT/VHT80, Two Antennas, M0.2 to M9.2, 2ss

802.11n/ac - HT/VHT80 Beam Forming, Two Antennas, M0.1 to M9.1, 1ss
802.11n/ac - HT/VHT80 Beam Forming, Two Antennas, M0.2 to M9.2, 2ss

802.11n/ac - HT/VHT80 STBC, Two Antennas, M0.1 to M9.1

The following antennas are supported by this product series.
The data included in this report represent the worst case data for all antennas.

Frequency	Part Number	Antenna Type	Antenna Gain (dBi)
2.4 / 5 GHz Wi-Fi	ANTS2M1-CCF34-EH	Internal PIFA	2.14/4
LTE	LTE-ANTM-D	Cisco 3G/4G LTE and LTEA Omnidirectional Dipole Antenna	3.7 (worst case for all supported LTE bands)

2.0 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%

3.0 Technical Requirements

3.1 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^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	($900/f^2$)*	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	($180/f^2$)*	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.

4.0 Calculations

Given

E=√(30*P*G)/d and S=E^2/3770

where

E=Field Strength in Volts/meter
P=Power in Watts
G=Numeric Antenna Gain
d=Distance in meters
S=Power Density in mW/cm^2

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

d=√((30*P*G)/(3770*S))

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

P(mW)=P(W)/1000 d(cm)=100*d(m)

yields

d=100*√((30*(P/1000)*G)/(3770*S))
d=0.282*√(P*G/S)

where

d=Distance in cm
P=Power in mW
G=Numeric Antenna Gain
S=Power Density in mW/cm^2

Substituting the logarithmic form of power and gain using:

P(mW)=10^(P(dBm)/10) G(numeric)=10^(G(dBi)/10)

yields

d=0.282*10^((P+G)/20)/√S Equation (1)

and

s=((0.282*10^((P+G)/20))/d)^2 Equation (2)

where

d=MPE distance in cm
P=Power in dBm
G=Antenna Gain in dBi
S=Power Density in mW/cm^2

5.0 Results

Equation (1) and the measured peak power are used to calculate the MPE distance. Note that for mobile or fixed location transmitters such as an access point, the minimum separation distance is 20 cm even if the calculations indicate that the MPE distance may be less.

S=1mW/cm^2 maximum. Using the peak power levels recorded in the test report along with Equation 1 above, the MPE distances are calculated as follows.

MPE Calculations:

Frequency (MHz)	Power Density LIMIT (mW/cm^2)	Radiated Transmit Power (dBm)	Antenna Gain (dBi)	MPE Distance (cm)	Limit (cm)	Margin (cm)
LTE	0.467	24	3.7	10.02	20	9.98
2.4GHz DTS	1.0	20	5.14*	5.63	20	14.37
UNII-1	1.0	19.4	7*	5.89	20	14.11
UNII-2	1.0	19.6	7*	6.03	20	13.97
UNII-2e	1.0	20.1	7*	6.39	20	13.61
UNII-3	1.0	20.7	7*	6.84	20	13.16

*Correlated Gain.

To maintain compliance, installations will assure a separation distance of at least 20 cm.

Using Equation 2, the MPE levels (s) at 20 cm are calculated as follows:

Frequency (MHz)	MPE Distance (cm)	Radiated Transmit Power (dBm)	Antenna Gain (dBi)	Power Density (mW/cm^2)	Limit (mW/cm^2)	Margin (mW/cm^2)
LTE	20	24	3.7	0.117	0.467	0.35
2.4GHz DTS	20	20	5.14*	0.079	1.0	0.92
UNII-1	20	19.4	7*	0.087	1.0	0.91
UNII-2	20	19.6	7*	0.091	1.0	0.91
UNII-2e	20	20.1	7*	0.102	1.0	0.90
UNII-3	20	20.7	7*	0.117	1.0	0.88

*Correlated Gain.

Calculations with additional transmitters

LTE (Highest power)
2.4GHz WLAN (Highest power)
5GHz WLAN (Highest power)

TX1 + TX2 + TX3 = % of standard
7.9% + 11.7% + 25.1% = 44.7%

D (estimate) = $20*\sqrt{\%}$

D = 13.37 cm which is less than 20 cm recommended

The configuration above co-location calculation is for **General Population/Uncontrolled exposure**. The minimum distance recommended is **20 cm (8 inches)** when all antennas are within 20 cm of each other.

References

American National Standards Institute (ANSI), "Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz," ANSI/IEEE C95.1-1992 (previously issued as IEEE C95.1-1991). Copyright 1992 by the Institute of Electrical and Electronics Engineers, Inc. (IEEE), New York, N.Y. 10017. For copies contact the IEEE: 1-800-678-4333 or 1-908-981-1393.

American National Standards Institute (ANSI), "Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields - RF and Microwave". ANSI/IEEE C95.3-1992. Copyright 1992, The Institute of Electrical and Electronics Engineers, Inc. (IEEE), New York, NY 10017. For copies contact the IEEE: 1-800-678-4333 or 1-908-981-1393.