EDCS – Radio Test Report No: EDCS – **12441001**
FCC ID: LDK- CGMOFDM

Maximum Permissible Exposure Study - Engineering Analysis

902-928 MHz Radio
FHSS/HYBRID

For
CGM-WPAN-OFDM-FCC in CGR1240/K9

FSK/OQPSK/OFDM
802.15.4g/e

FCC ID: LDK-CGMOFDM

Against the following Specifications:
47 Code of Federal Regulations 2.1091

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Version:	See Doc Central
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This report replaces any previously entered test report under EDCS # **12441001**. This test report has been electronically authorized and archived using the CISCO Doc Central. Test Report Template EDCS# 11556830.

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Attestation Statement of Compliance

The **CGM-WPAN-OFDM-FCC in CGR1240/K9** radio 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 FCC Bulletin OET 65C (rev 01-01) along with 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 #

2.4GHz DTS report - **EDCS # 1104807**
902-928MHz 802.15.4 Report – **EDCS # 12438497**

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:

CGM-WPAN-OFDM-FCC: FCC ID: LDK- CGMOFDM **IC ID:** 2461N-CGMOFDM
CGR 1240 WLAN: FCC ID: LDKALTMT0556, **IC ID:** 2461B-ALTMT0556

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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1.0 EUT Description

The WPAN module provides IEEE 802.15.4 g/e-compliant, and highly secure wireless connectivity for the Cisco 1000 Series Connected Grid Routers to enable Field Area Network (FAN) applications.
The module is ideal for multi-hop mesh networks and long-reach solutions and helps enable a high ratio of endpoints to the Field Area Router (FAR)

CGM is the next generation Field Area Network solution to meet the demands of Smart Grid applications such as distribution automation, distributed generation, renewable energy, PEV charging stations, generic SCADA telemetry applications and water, oil & gas applications.

CGM includes solution requirements such as higher bandwidth, lower latency, higher availability, improved security, fog computing, and Wi-SUN compliance for CG-Mesh.

CGM-WPAN-OFDM-FCC Card supports following Modes

Test Mode	Modulation Type	Rate	Spacing	Mode
A	2FSK	50kbps	200kHz	64
B	2FSK	150kbps	400kHz	66
C	2FSK	150kbps	400kHz	98
D	OFDM	50kbps	800kHz	144
E	OFDM	200kbps	800kHz	146
F	OFDM	400kbps	800kHz	147
G	OFDM	800kbps	800kHz	149
H	OFDM	1200kbps	800kHz	150
I	OQPSK	6.25kbps	200kHz	192
Note1: Table above represents the worst-case scenarios for all modulation and data packet type combinations.				

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

Antenna Supported by CGR1240 2.4GHz Wi-Fi

Frequency	Part Number	Antenna Type	Antenna Gain (dBi)
2.4 GHz	**ANT-MP-INT-OUT-M**	Dipole	4

Antenna Supported by CGM-WPAN-OFDM 902-928MHz

Frequency	Part Number	Antenna Type	Antenna Gain (dBi)
863 – 928MHz	**ANT-LPWA-DB-O-N-5**	**Omnidirectional collinear dipole, 24 - 28° vertical HPBW**	**5.6**
863 – 928MHz	**ANT-MP2-I-OUT-M**	**Omnidirectional dipole, 84° vertical HPBW**	**2.6**

2.0 Methodology

All calculations were made in accordance with ANSI C95.1, and FCC OET 65C.

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)/dand 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:

MPE Calculations for CGR1240 (Wi-Fi 2.4GHz)
MPE Calculations:

Frequency (MHz)	Power Density (mW/cm^2)	Conducted Transmit Power (dBm)	Antenna Gain (dBi)	MPE Distance (cm)	Limit (cm)	Margin (cm)
2.4GHz DTS	0.007	11.3	4	1.64	20	18.36

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)	Conducted Transmit Power (dBm)	Antenna Gain (dBi)	Power Density (mW/cm^2)	Limit (mW/cm^2)	Margin (mW/cm^2)
2.4GHz DTS	1.64	11.3	4	0.007	1.0	0.99

MPE Calculations for CGM-WPAN-OFDM (902-928MHz)
MPE Calculations:

Modulation	Frequency (MHz)	Power Density (mW/cm^2)	Conducted Transmit Power (dBm)	Antenna Gain (dBi)	MPE Distance (cm)	Limit (cm)	Margin (cm)
2FSK	**902.4**	**0.597**	**29.172**	**5.6**	**19.92**	**20**	**0.08**
OQPSK	902.2	0.586	29.094	5.6	19.74	20	0.26
OFDM	914.8	0.377	27.18	5.6	15.73	20	4.27

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:

Modulation	Frequency (MHz)	MPE Distance (cm)	Conducted Transmit Power (dBm)	Antenna Gain (dBi)	Power Density (mW/cm^2)	Limit (mW/cm^2)	Margin (mW/cm^2)
2FSK	**902.4**	**19.92**	**29.172**	**5.6**	**0.597**	**0.6016**	**0.0046**
OQPSK	902.2	19.74	29.94	5.6	0.586	0.6014	0.0154
OFDM	914.8	15.73	27.18	5.6	0.377	0.6098	0.23

Calculations with additional transmitters

WLAN + WPAN Colocated MPE Calculations

WLAN/WPAN	WLAN PSD (mW/cm^2)	WPAN PSD (mW/cm^2)	WLAN PSD + WPAN PSD + (mW/cm^2)	Limit	Pass/fail
2400 – 2483.5MHz- WLAN 902-928MHz – WPAN	0.007	0.597	0.604	1.000	Pass

D (estimate) = $20*\sqrt{0.604}$

D = 15.543 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.

FCC OET 65C Evaluating Compliance with FCC Guidelines for Human Exposure to RF Fields from 9KHz to 40 Ghz