Maximum Permissible Exposure: GWS-5002 Family

19th July 2019

Author: Dr. Michael Davies

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Contents

Introduction

Radio-frequency (RF) sources (3 kHz - 300 GHz), electric and magnetic fields, are predominantly thermal hazards. The exposure limits in this range are for acute (short-term) exposures since there is no scientific evidence of adverse biological effects from chronic or cumulative exposure to electric and magnetic fields emitted at these frequencies. Exposure limits for this spectral range are based on specific absorption rates SAR (W/kg) which are the used to calculate the maximum permissible exposure (MPE).

The frequencies used by these radios are 470MHz to 698MHz and therefore the RF exposure risk is evaluated using the SAR and MPE methodology.

In the test report provided by Nemko the maximum conducted power allowed to meet all other requirements of Part 15 H is 27.73dBm/24MHz.

Given the measurement uncertainties and to be conservative we will assume that the maximum in these calculations is 29dBm/24MHz. This ensures an extra margin of permissible exposure beyond the calculations that follow.

The GWS-5002 is capable of transmitting with two spatial streams (MIMO). The GWS-5002E model variant can only transmit with on spatial stream (SISO).

RF Exposure Risk: FCC Operation

Page 18 of OET Bulletin 65, Edition 97-01

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

S=power density

P=power input

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

R=distance to the centre of radiation of the antenna.

If the antenna is directional; the power density maximum is assumed to be at the centre of the beam maximum in zenith and at the centre of the beam maximum in azimuth i.e. directly in front of the antenna.

If the antenna is omni directional; then the power density maximum is assumed to be at the centre of the beam maximum in zenith, and rotationally uniform.

MIMO

Calculated maximum power density MIMO:

Maximum peak power at radio terminal	29dBm/24MHz
Cable/connector loss/filters	1dB
Maximum peak power at each antenna input	28dBm/24MHz
Maximum peak power at each antenna input	0.631W (631mW)
Antenna gain (worst case)	12dBi
Numeric antenna gain	15.8
Number of antennas[1]	2
Prediction distance	75cm

$$S\ (mW/cm^2) = \frac{631*15.8*2}{4*\pi*75*75}$$

Calculated MPE at predicted distance & predicted frequency=0.282 mW/cm^2

The estimated power density at 75cm from the transmitting antenna is 0.282 $mWcm^2$ which is 88% of the limit (0.321mW/cm^2). We assume the device is operating continuously, the actual operation would not typically be continuous and therefore these estimates are conservative.

[1] The radio uses STBC and according to KDB 662911 D01 Multiple Transmitter Output v02r01, Section F, Part 1) on page 5, STBC transmissions are considered to be completely uncorrelated and as such there is no antenna array gain. However, to be conservative in this MPE calculation we assume that both transmitters are additive.

MPE Margin Calculation MIMO

Power density at predicted frequency	f/1500 mW/cm^2
Prediction frequency	482MHz
Power density MPE at predicted frequency	0.321mW/cm^2
Tx on time	1msecond
Tx period time	1msecond
Duty factor[2]	100%
Maximum peak power at radio terminal	26dBm
Cable/connector loss	1dB
Maximum peak power at antenna input	25dBm
Maximum peak power at antenna input	0.321W (321mW)
Number of antennas	2
Prediction distance	75cm

Maximum allowable numeric gain:

$$\frac{S * 4 * \pi * R * R}{P * 2}$$

$$G = \frac{0.321 * 4 * \pi * 75 * 75}{321}$$

Maximum numeric antenna gain allowed	35.35
Maximum antenna gain allowed	15.5dBi
Compliance margin with 12dBi antenna	3.5dB
Compliance margin numerical	2.2 times

[2] Worst case scenario

SISO

Calculated maximum power density SISO:

Maximum peak power at radio terminal	29dBm / 24MHz
Cable/connector loss	1dB
Maximum peak power at antenna input	28dBm / 24Mhz
Maximum peak power at antenna input	0.631W (631mW)
Antenna gain	
(worst case, non-congested areas)	12dBi
Numeric antenna gain	15.8
Number of antennas	1
Prediction distance	75cm

$$S\ (mW/cm^2) = \frac{631*15.8*1}{4*\pi*75*75}$$

Calculated MPE at predicted distance & predicted frequency=0.141 mW/cm^2

Power density at predicted frequency	f/1500 mW/cm^2
Prediction frequency	482MHz
Power density MPE at predicted frequency	0.321mW/cm^2

The estimated power density at 75cm from the transmitting antenna is 0.141mWcm^2 which is 44% of the limit (0.321mW/cm^2). We assume the device is operating continuously, the actual operation would not typically be continuous and therefore these estimates are conservative.

MPE Margin Calculation SISO CPE

Allowed power density at predicted frequency	f/1500 mW/cm^2
Prediction frequency	482MHz
Power density MPE at predicted frequency (S)	0.321mW/cm^2
Tx on time	1msecond
Tx period time	1msecond
Duty factor[3]	100%
Maximum peak power allowed at antenna input	0.321W (321mW)
Number of antennas	1
Prediction distance	75cm

Maximum allowable numeric gain:

$$G = \frac{S * 4 * \pi * R * R}{P}$$

$$G = \frac{0.321 * 4 * \pi * 75 * 75}{321}$$

Maximum numeric antenna gain allowed	70.77
Maximum antenna gain allowed	18.5dBi
Compliance margin with 12dBi antenna	6.6dB
Compliance margin numerical	4.6 times

[3] Worst case scenario

Summary of RF Exposure Risk

Mode	Max Antenna Gain	Power per RF Port	Minimum distance to avoid exposure	Compliance margin numerical
MIMO	12dBi	29dBm	75cm	2.2 times
SISO	12dBi	29dBm	75cm	4.6 times

These are conservative estimates, and the actual exposure risk will be less.

Typically, these antennas are mounted on a roof which reduce exposure significantly.

In particular, the MIMO transmission scenario will occur on towers as high as 100m.

Explanation:

If a person was directly in front of the radiating antenna at a distance of 75cm then the radiation received would be 17.5% (1/4.6) of the maximum permissible exposure. This also assumes that the duty cycle is 100%, which it is not. The calculation also assumes direct line of sight, any obstructions such as a roof or wall will significantly reduce the signal strength further. Also, the MPE assumes that the person will be in place continuously for 30minutes in order to receive the MPE.

MPE Methodology

In order to calculate the maximum permissible exposure (MPE) we must know the Specific Absorption Rate (SAR) for the RF being used.

The maximum MPE (in mW/cm^2) is defined as f/1500 where f is the frequency of the RF.

Prediction of MPE at a given distance

1. Limits

The criteria listed in the following table shall be used to evaluate the environment impact of human exposure to radio frequency (RF) radiation as specified in 1.1307(b)

Frequency range (MHz)	Electric field strength (V/m rms)	Magnetic field strength (A/m rms)	Power density (mW/cm^2)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposures				
0.3-3.0	614	1.63	*(100)	6
3.0-30	1842/f	4.89/f	*(900/f2)	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				
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	30

2. Test Procedure

Equation from page 18 of OET Bulletin 65, Edition 97-01

$$S = \frac{P \times G}{4 \times \pi \times R^2}$$

Where:

S = power density

P = power input to the antenna

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

R = distance to the centre of radiation of the antenna

References

- https://en.wikipedia.org/wiki/Specific_absorption_rate
- https://www.fcc.gov/general/oet-bulletins-line#65
- https://apps.fcc.gov/kdb/GetAttachment.html?id=f8IQgJxTTL5y0oRi0cpAuA%3D%3D&desc=447498%20D01%20General%20RF%20Exposure%20Guidance%20v06&tracking_number=20676 specifically Section 4.

Expert Installer

For FCC an “expert installation” is required to ensure both electrical shock risk and RF exposure risk are minimal. In addition, the expert installer is responsible for regulatory compliance and to ensure that the radios do not cause interference.

Signature Page

Signed for and on behalf of 6Harmonics Inc

Place: Ottawa, Ontario, Canada

Date of issue: 19 July 2019

Name: Michael Davies

Function: Vice President, Business Development

Signature: