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***DN201SC - Human Exposure to RF EMF - FCC  
and ISED***

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Proprietary and Confidential

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## Version History

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<b>Issue Number</b>	<b>Author(s)</b>	<b>Version Date</b>	<b>Summary &amp; Comments</b>
1	DF	2022-03-14	Approved version
2	DF	2022-06-23	Revised exposure calculations

## Related Documents

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<b>Ref.</b>	<b>Title</b>	<b>Number</b>	<b>Version &amp; Date</b>
[1]	DN201SC user guide (FCC/ISED compliant)	<a href="#">BW-008828-SD</a>	Mar 2022
[2]	FCC - OET Bulletin 65	Edition 97-01	Aug 1997
[3]	FCC – Radio frequency radiation exposure limits	CFR Title 47 Part 1.1310	Feb 2022
[4]	Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands)	RSS-102	Issue 5, March 2015
[5]	IEEE Recommended Practice for Measurements and Computations of Electric, Magnetic, and Electromagnetic Fields with Respect to Human Exposure to Such Fields, 0 Hz to 300 GHz	IEEE Std C95.3	2021

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## Terms and Acronyms

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<i>Term / Acronym</i>	<i>Definition</i>
EIRP	Effective Isotropic Radiated Power
EM	Electromagnetic
EMF	Electromagnetic Field
PAA	Phased-Array Antenna
mmWave	Millimetre-Wave
RF	Radio-Frequency

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# 1. Overview

The DN201SC product delivers high bandwidth connectivity in two primary scenarios using mmWave technology in the 57-71 GHz radio band. The two scenarios are:

- For rail or transport use between a vehicle and static units, when combined with the vehicle unit TN201SC. In this scenario, the DN201SC is part of the static infrastructure.
- For fixed wireless systems, where the DN201SC is used at both ends of the radio link.

The DN201SC will be used in commercial and industrial applications and will be installed and mounted at a nominal height of 4.5 meters on either a pole, mast, residential or commercial property, out of reach and at a safe distance from the general public.

The DN201SC product will be installed and maintained by professional operatives who are aware of the risks of Electromagnetic (EM) Fields, and an installation manual is supplied with instructions and safety notices.

The assessment takes into consideration all intended and foreseen operating conditions that were reasonably anticipated at the time of the assessment.

This document shows the calculations of the compliance distance for DN201SC product to meet the basic restrictions as defined in CFR Title 47 Part 1.1310 (referencing OET65 Edition 97-01) for FCC regulatory domain, and RSS-102 Issue 5 Sections 3 and 4 (referencing IEEE C95.3-2021 and Safety Code 6 – 2015, respectively) for ISED regulatory domain.

## 1.1 DN201SC equipment characteristics

Each DN201SC unit has:

- Two integrated radios, each positioned in opposing sides of the product, and operating in the 60GHz band covering 57GHz – 71GHz (802.11ad channels 1 to 6), with a maximum of 2.16GHz channel bandwidth.
- Each radio has one transmit phased-array antenna (PAA) and one receive PAA.
- The Tx PAA is a 16x4 array, made up of 16 Tx RF paths and 1x4 sub-arrays.
- The Rx PAA is a 16x4 array, made up of 16 Rx RF paths and 1x4 sub-arrays.
- Each radio has 13 levels of adaptive encoding, Modulation Coding Scheme (MCS) 0 to MCS12, as per 802.11ad.
- Multi-sector horizontal coverage of 180 degrees, with each beam having 7 degrees 3dB beamwidth, and 20 degrees vertical 3dB beamwidth (fixed coverage).

## 1.2 Maximum RF transmit output power

Each of the two radios on the DN201SC have an electronically steerable beamforming PAA for transmission, with 23dBi of gain, resulting in the ability to achieve a maximum regulated transmitter power of 40dBm EIRP.

Transmitter power has been shown to comply with CFR Title 47 Part 15.255 (Operation within the band 57-71 GHz), and RSS-210 Issue 10 Annex J (Devices operating in the band 57-71 GHz), with maximum transmitted power not exceeding 40dBm EIRP.

## 2. FCC regulatory domain – Electromagnetic fields exposure

The far field (spherical wave) calculation method, defined in OET65 (equation 6), was used to define the compliance boundary, using the maximum EIRP noted in section 1.2 of this document. This calculation yields a “truly worst-case” or conservative prediction of the near field (overestimation of the field strength), as well as accounting for 100% reflection on a nearby surface, as is referenced in OET65 (Section 2). Accounting for this worst-case assumption was deemed appropriate, given the possibility of the product being mounted on structures that could have nearby metal surfaces, therefore a source of possible reflections. Thus, the exposure at distances calculated below will be well within safe limits.

### 2.1 General Population/Uncontrolled Exposure

#### 2.1.1 Compliance limits

The limit for general population/uncontrolled exposure according to CFR Title 47 Part 1.1310 (e)(1) (referencing OET65 Edition 97-01 Table 1B) is  $1\text{mW/cm}^2$  ( $10\text{W/m}^2$ ).

#### 2.1.2 Safe distance calculation

The two radios on the DN201SC unit are located in opposing sides of the chassis, the PAAs radiate towards distinct volumes, and the radiated signals are also uncorrelated. The maximum transmitted power level used in this calculation will be considered as that of a single radio, which is 40dBm (10W) EIRP.

Considering:

$$S = \text{power density } (\text{W/m}^2) = 10\text{W/m}^2$$

$$R = \text{compliance boundary distance from the product } (\text{m})$$

$$EIRP = \text{effective isotropically radiated power } (\text{W}) = 10\text{W}$$

With:

$$S = EIRP / (\pi R^2)$$

$$R = \sqrt{EIRP / (\pi S)}$$

Therefore:

$$R = \sqrt{10 / (\pi \times 10)}$$

### 2.1.3 Required distance for general population exposure compliance

<b>Product</b>	<b>General population required distance</b>	<b>CFR Title 47 Part 1.1310 (e)(1) power density limit</b>
DN201SC	56.42cm	1mW/cm <sup>2</sup> (10W/m <sup>2</sup> )

## 2.2 Occupational/Controlled exposure

### 2.2.1 Compliance limits

The DN201SC product will be installed and maintained by professional operatives who are aware of the risks of EM exposure. The limit for occupational/controlled exposure according to CFR Title 47 Part 1.1310 (e)(1) (referencing OET65 Edition 97-01 Table 1A) is 5mW/cm<sup>2</sup> (50W/m<sup>2</sup>).

### 2.2.2 Safe distance calculation

The two radios on the DN201SC unit are located in opposing sides of the chassis, the PAAs radiate towards distinct volumes, and the radiated signals are also uncorrelated. The maximum transmitted power level used in this calculation will be considered as that of a single radio, which is 40dBm (10W) EIRP.

Considering:

$$S = \text{power density (W/m}^2\text{)} = 50\text{W/m}^2$$

$$R = \text{compliance boundary distance from the product (m)}$$

$$EIRP = \text{effective isotropically radiated power (W)} = 10\text{W}$$

With:

$$S = EIRP / (\pi R^2)$$

$$R = \sqrt{EIRP / (\pi S)}$$

Therefore:

$$R = \sqrt{10 / (\pi \times 50)}$$

### 2.2.3 Required distance for occupational exposure compliance

<b>Product</b>	<b>Workers required distance</b>	<b>CFR Title 47 Part 1.1310 (e)(1) power density limit</b>
DN201SC	25.23cm	5mW/cm <sup>2</sup> (50W/m <sup>2</sup> )

## 3. ISED regulatory domain – Electromagnetic fields exposure

From RSS-102 Issue 5 Section 3, the RF exposure evaluations should be performed according to IEEE C95.3-2021. In accordance with IEEE C95.3-2021, section A.5.1, and assuming typical use cases for the DN201SC product (as previously described in this document), the source-environment plane regions considered for the compliance distance calculations are II – 0, II – 1, III – 0 and III – 1. From Table D.1 in Annex D of the same document, it is determined the equation in Table D.2 and Table D.6 to be appropriate for the calculations, as it can be assumed worst-case scenario being exposed to EM fields along the main beam axis of the PAA radiating elements, as well as accounting for reflections in the surrounding environment. The far field (spherical wave) calculation method used herein is considered to yield a conservative prediction of the near field (overestimation of the power density), as is indicated in section D.4.2 of IEEE C95.3-2021. Thus, the exposure at distances calculated below will be well within safe limits.

### 3.1 General Population/Uncontrolled Exposure

#### 3.1.1 Compliance limits

The limit for general population/uncontrolled exposure according to RSS-102 Issue 5 Section 4 (referencing Safety Code 6 – 2015 Table 5) is 10W/m<sup>2</sup>.

#### 3.1.2 Safe distance calculation

The two radios on the DN201SC unit are located in opposing sides of the chassis, the PAAs radiate towards distinct volumes, and the radiated signals are also uncorrelated. The maximum transmitted power level used in this calculation will be considered as that of a single radio, which is 40dBm (10W) EIRP. For a theoretical worst case of a perfectly conducting ground plane, the reflection coefficient should be set to 1.

Considering:

$$S = \text{power density including reflection (W/m}^2\text{)} = 10\text{W/m}^2$$

$$S_d = \text{power density of the direct ray (W/m}^2\text{)}$$

$$|\Gamma| = \text{modulus of the absolute value of the reflection coefficient}$$

$$S_{FF} = \text{far-field power density (W/m}^2\text{)}$$

$$S_{FF} = S_d$$

$$D = \text{compliance distance from the product (m)}$$

$$G_i = \text{far-field antenna gain (power ratio)}$$

$$P_{in} = \text{power into the antenna (W)}$$

*EIRP* = effective isotropically radiated power (W)

Approximating:

$$EIRP = G_t P_{in} = 10W$$

With:

$$S = (1 + |\Gamma|)^2 S_{FF}$$

$$S_{FF} = EIRP / (4\pi D^2)$$

$$D = \sqrt{EIRP / (4\pi (S / (1 + |\Gamma|)^2))}$$

Therefore:

$$D = \sqrt{10 / (4\pi \times (10 / (1 + 1)^2))}$$

### 3.1.3 Required distance for general population exposure compliance

<b>Product</b>	<b>General population required distance</b>	<b>RSS-102 Issue 5 Section 4 power density limit</b>
DN201SC	56.42cm	10W/m <sup>2</sup>

## 3.2 Occupational/Controlled exposure

### 3.2.1 Compliance limits

The DN201SC product will be installed and maintained by professional operatives who are aware of the risks of EM exposure. The limit for occupational/controlled exposure according to RSS-102 Issue 5 Section 4 (referencing Safety Code 6 – 2015 Table 6) is 50W/m<sup>2</sup>.

### 3.2.2 Safe distance calculation

The two radios on the DN201SC unit are located in opposing sides of the chassis, the PAAs radiate towards distinct volumes, and the radiated signals are also uncorrelated. The maximum transmitted power level used in this calculation will be considered as that of a single radio, which is 40dBm (10W) EIRP. For a theoretical worst case of a perfectly conducting ground plane, the reflection coefficient should be set to 1.

Considering:

$$S = \text{power density including reflection (W/m}^2\text{)} = 50W/m^2$$

$$S_d = \text{power density of the direct ray (W/m}^2\text{)}$$

$$|\Gamma| = \text{modulus of the absolute value of the reflection coefficient}$$

$$S_{FF} = \text{far-field power density (W/m}^2\text{)}$$

$$S_{FF} = S_d$$

$D$  = compliance distance from the product (m)

$G_i$  = far-field antenna gain (power ratio)

$P_{in}$  = power into the antenna (W)

$EIRP$  = effective isotropically radiated power (W)

Approximating:

$$EIRP = G_i P_{in} = 10W$$

With:

$$S = (1 + |\Gamma|)^2 S_{FF}$$

$$S_{FF} = EIRP / (4\pi D^2)$$

$$D = \sqrt{EIRP / (4\pi (S / (1 + |\Gamma|)^2))}$$

Therefore:

$$D = \sqrt{10 / (4\pi \times (50 / (1 + 1)^2))}$$

### 3.2.3 Required distance for occupational exposure compliance

<b>Product</b>	<b>Workers required distance</b>	<b>RSS-102 Issue 5 Section 4 power density limit</b>
DN201SC	25.23cm	50W/m <sup>2</sup>