

RF Exposure Technical Brief ASSESSMENT OF THE AAM29JQN9YA1AN (IC Model: PMUD2950AB)
MODEL 54 W MOBILE RADIO

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This Technical Brief calculates the minimum separation distance from a fixed antenna, connected to the subject mobile radio operated at a fixed station, ensuring that the power density limits listed in RSS-102,¹ Table 7 (uncontrolled environment) and Table 8 (controlled environment), are not exceeded. These Tables are reported below:

Radio Frequency (RF) Exposure Compliance of Radiocommunication
Apparatus (All Frequency Bands)

RSS-102

Table 7: RF field strength and power density limits for devices used by the general public (uncontrolled environment)

Frequency range (MHz)	Electric field (V _{RMS} /m)	Magnetic field (A _{RMS} /m)	Power density (W/m ²)	Reference period (minutes)
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	$3.142 f^{0.3417}$	$0.008335 f^{0.3417}$	$0.02619 f^{0.6834}$	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.**Table 8: RF field strength and power density limits for controlled-use devices (controlled environment)**

Frequency range (MHz)	Electric field (V _{RMS} /m)	Magnetic field (A _{RMS} /m)	Power density (W/m ²)	Reference period (minutes)
10-20	61.4	0.163	10	6
20-48	$129.8 / f^{0.25}$	$0.3444 / f^{0.25}$	$44.72 / f^{0.5}$	6
48-100	49.33	0.1309	6.455	6
100-6000	$15.60 f^{0.25}$	$0.04138 f^{0.25}$	$0.6455 f^{0.5}$	6
6000-15000	137	0.364	50	6
15000-150000	137	0.364	50	$616000 / f^{1.2}$
150000-300000	$0.354 f^{0.5}$	$9.40 \times 10^{-4} f^{0.5}$	$3.33 \times 10^{-4} f$	$616000 / f^{1.2}$

Note: f is frequency in MHz.

¹ Industry Canada (ISED) Spectrum Management and Telecommunications. Radio Standards Specification 102. Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands). Issue 6 (2023).

Within the frequency range that the subject equipment operates in (136 MHz – 174 MHz) the controlled-environment power density limit is a growing function of frequency, while the uncontrolled-environment limit is independent of the frequency.

The subject equipment is intended to operate exclusively using a set of approved antennas. Table A provides the antenna list, the associated operating frequencies, as well as the relevant electrical and physical parameters:

Table A: Approved antennas and relevant parameters

#	Part Number	Frequency range (MHz)	Antenna gain (dBi)	Length (cm)	Label
1	HAD4006A	136-144	2.15	50.3	1/4 Wave
2	HAD4007A	146.-150.8	2.15	47.3	1/4 Wave
3	HAD4008A	150.8-162	2.15	44.3	1/4 Wave
4	HAD4009A	162-174	2.15	40.8	1/4 Wave
5	RAD4218B	146-172	5.15	87.1	5/8 Wave
6	HAD4022A*	132-174	5.15	134	5/8 Wave

* Trimmable.

All the antennas are omni-directional (flexible wire) and are provided with a through-hole cable harness in order to be installed on a metallic ground structure.

Given these characteristics, the antennas can be grouped in “1/4 Wave” and “5/8 Wave” types. Consequently, the exposure assessment can be carried out for each type using the most restrictive parameters: shortest length and the frequency with the lowest power density limit.

Table B provides the exposure evaluation parameters for each antenna type and exposure tier:

Table B: Antenna Types and Exposure Limits		Power Density Limit (W/m ²)	
Antenna Type	Length (cm)	Uncontrolled Env.	Controlled Env.
1/4 Wave	40.8	1.291	7.528
5/8 Wave	87.1		

Minimum Separation Distance Calculations

The analysis is for a typical installation using a fixed antenna, assuming zero conducted RF losses between the transmitter output connector and the antenna input connector.

Furthermore, it is assumed that the antennas are installed on a large ground plane confining the RF energy emissions within one half-space, thereby providing an exposure upper bound.

The assessment proceeds by first applying a cylindrical exposure model, then verifying whether the resulting distance is within the applicability range of such a model, and then resorting to a spherical model in cases where it does not.

Tell's cylindrical exposure prediction model² is employed to produce an estimate of the spatially averaged plane-wave equivalent power density parallel to the antenna in the vertical plane, and then multiplied by 2 in order to estimate the peak power density (such an estimate being valid at least one wavelength away from the antenna),³ using Eq. (1):

$$S_{pk} = 2 \frac{P_{net}}{2\pi R h} = \frac{P_{net}}{\pi R h} \quad (1)$$

where:

S_{pk} = estimated spatial-peak power density, W/m²

P_{net} = net input RF power to the antenna, W

R = radial distance from the antenna, m

h = length of the antenna, m

The applicability range of the cylindrical propagation model is proportional to the antenna directivity and length, where the validity bound is given by the following expression:⁴

$$\rho = G_A L \quad (2)$$

where L is the antenna half-length and G_A is its gain (directivity for a lossless antenna). In both cases, the gain values are employed as directivity. Table C reports the validity bounds for both antenna types:

Table C: Antenna Types and Respective Cylindrical Propagation Model Validity Bounds

Antenna Type	L (cm)	G_A	ρ (m)
1/4 Wave	40.8	1.64	0.67
5/8 Wave	87.1	3.28	2.86

Therefore, the cylindrical model validity range exceeds one wavelength, where the largest wavelength across the operating band is 2.2 m, only for the 5/8 Wave antenna type. Instead, the 1/4 Wave antenna type will default to the spherical model:

$$S_{pk} = 2 \frac{P_{net} G_A}{4\pi R^2} = \frac{P_{net} G_A}{2\pi R^2} \quad (3)$$

where the gain is doubled because all the power is immitted in a half space.

² US Federal Communications Commission Office of Engineering & Technology, OET Bulletin 65, "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields", Edition 97-01, page 32, Tell's cylindrical model.

³ R. Cicchetti and A. Faraone, "Estimation of the Peak Power Density in the Vicinity of Cellular and Radio Base Station Antennas," IEEE Transactions on Electromagnetic Compatibility, Vol. 46, No. 2, pp. 275-290, May 2004.

⁴ Q. Balzano, A. Faraone, R. Y.-S. Tay, and K. Joyner, "Estimation of the average power density in the vicinity of cellular base-station collinear array antennas," IEEE Transactions on Vehicular Technology, vol. 49, no. 3, pp. 954-964, May 2000.

Considering that, and the best-case net RF input power is 54 W (perfect impedance match), the initial estimate of the minimum separation distances for uncontrolled and controlled environments and antenna types are estimated as follows:

Uncontrolled Environment

1/4 Wave Type

$$R = \sqrt{\frac{P_{net} G_A}{2\pi S_{pk}}} = \sqrt{\frac{54 \cdot 1.64}{2\pi \cdot 1.291}} m = 3.30 m$$

5/8 Wave Type

$$R = \max\left\{\frac{P_{net}}{\pi h S_{pk}}, 2.2 m\right\} = \max\left\{\frac{54}{\pi \cdot 0.871 \cdot 1.291}, 2.2\right\} m = 15.3 m$$

However, this distance exceeds 2.86 m; hence the spherical model gives:

$$R = \sqrt{\frac{P_{net} G_A}{2\pi S_{pk}}} = \sqrt{\frac{54 \cdot 3.28}{2\pi \cdot 1.291}} m = 4.67 m$$

Controlled Environment

1/4 Wave Type

$$R = \sqrt{\frac{P_{net} G_A}{2\pi S_{pk}}} = \sqrt{\frac{54 \cdot 1.64}{2\pi \cdot 7.528}} m = 1.37 m$$

5/8 Wave Type

$$R = \max\left\{\frac{P_{net}}{\pi h S_{pk}}, 2.2 m\right\} = \max\left\{\frac{54}{\pi \cdot 0.871 \cdot 7.528}, 2.2\right\} m = 2.62 m$$

This distance does not exceed 2.86 m.

Table D provides the final summary:

Table D: Antenna Types, Models, and Respective Minimum Compliance Distances

Antenna Type	Antenna Part Numbers	Uncontrolled Env.	Controlled Env.
1/4 Wave	HAD4006A HAD4007A	3.30 m	1.37 m

Motorola Solutions Canada, Inc.

UPN Number: 92FT7188

Company Number: 109U

Model Number: PMUD2950AB, PMUD2950AA, AAM29JQN9HA1AN, AAM29JQN9RA1AN,
AAM29JQN9GA1AN, AAM29JQC9RA1AN, AAM29JQC9GA1AN

	HAD4008A HAD4009A		
5/8 Wave	RAD4218B HAD4022A	4.67 m	2.62 m