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RF Exposure Technical Brief

Tait Unify Vehicle

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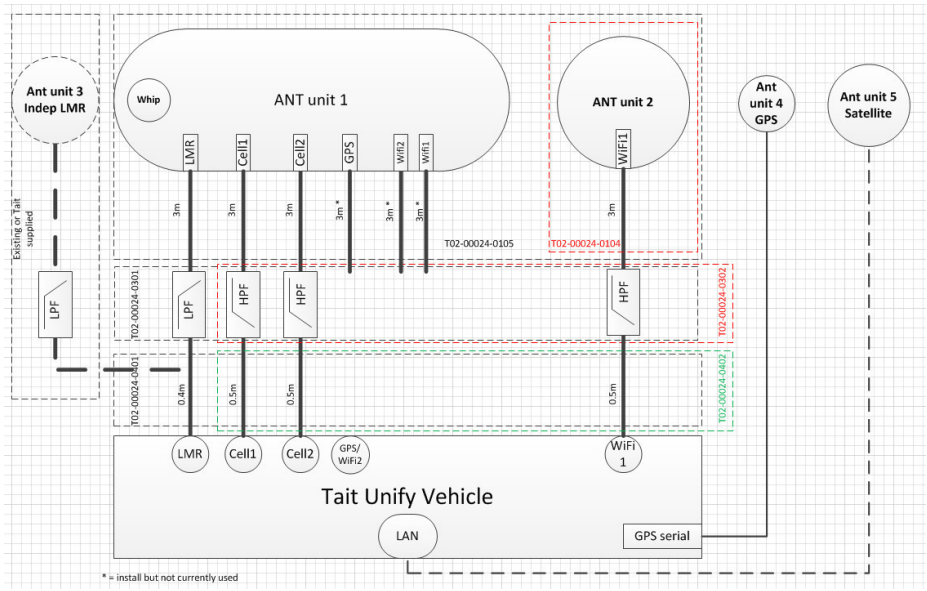
Equipment:	TUFM4B	
FCC identification	CASTUFM4B	
Rated transmit power:	23dBm (LTE), 16.5dBm (Wi-Fi), 11.7dBm (Bluetooth)	
Frequency range:	LTE	699→960MHz, 1710→2170MHz, 2500→3800MHz
	Wi-Fi	2412 → 2484 MHz, 5150 →5725 MHz
	Bluetooth	2412 → 2484 MHz
Test standards:	USA – 47CFR 1.1310	
Reference Standard:	IEEE C95.3 -2002	

Contents

Introduction

The Tait TUFM4B Unify Vehicle mobile radio contains modules to provide Wi-Fi, Bluetooth and LTE cellular radio connectivity. The Wi-Fi/Bluetooth and LTE functions use two separate antennae, spaced more than one metre apart, and can operate simultaneously. The antennas are mounted outside the vehicle.



In the above diagram “ANT unit 1” is a multi-bearer “Sharkee” antenna (GPSD-7-27-24-58-T), produced by Panorama antennas which has a gain of 4dBi. “ANT unit 2” is a PCTEL WLP2458NGP-T that has a gain of 3.9dB in the 2.4GHz band and 3.0dBi in the 5GHz band.

The LTE unit will only transmit in one band at a time.

The Wi-Fi system may operate in both the 2.4GHz and 5GHz band simultaneously.

Bluetooth transmissions are interlaced with the Wi-Fi

The MPE requirements of the attached commercial mobile radio are not dealt with in this report.

Limits: Safe Distance calculations – Uncontrolled environment

USA – 47CFR 1.1310
RF Field Strength limit for uncontrolled environments (47CFR 1310 Table1)

300MHz to 1500MHz Limit = f/1500 mW/c m^2
= f/150 W/m^2

1500MHz to 100000MHz Limit = 1 mW/cm^2
= 10 W/m^2

Result Summary

Function	Frequency	Antenna Gain (dBi)	Average output power (dBm)	Average output power (W)	System losses (dB)	Manufacturer's recommended minimum distance (m)	Power density at recommended distance (mW/cm^2)	Limit (mW/cm^2)	Ratio (level/limit)	Result
LTE	699MHz	4.0	23	0.2	-2.2	0.2	0.06	0.47	0.13	Pass
LTE	2.6GHz	4.0	23	0.2	-3.57	0.2	0.04	1.0	0.04	Pass
Wi-Fi	2.4GHz	3.9	16.5	0.045	-3.87	0.2	0.01	1.0	0.01	Pass
Wi-Fi	5.8GHz	3.0	16.5	0.045	-5.93	0.2	0.005	1.0	0.005	Pass
Bluetooth	2.4GHz	3.0	11.7	0.015	-3.87	0.2	0.03	1.0	0.003	Pass

Simultaneous transmission. - Summation of the MPE ratios for all possible transmissions.

As the LTE module may only transmit on one band at a time the highest transmission with respect to the limit is chosen.

Maximum total RF exposure = LTE (699MHz) + Wi-Fi (2.4GHz) + Wi-Fi (5.8GHz) + Bluetooth (2.4GHz)

=0.13 + 0.01 + 0.005 + 0.003

=0.148

Summation of the MPE ratios for all possible transmissions, outside the recommended safe distances from the antennae, gives a value of 0.148 of the limit, giving unconditional compliance with the RF exposure requirements.

MPE Calculation Method

Near field Calculation

Equation 39 of IEEE C95.3-2002

$$S_{near} = \frac{P}{(2\,\pi\,d\,h)}$$

Fresnel region and far field calculation

Equation 37 of IEEE C95.3-2002

$$S_{far} = \frac{P\,G}{4\,\pi\,d^2}$$

Far Field boundary calculation

The near field equation may be applied close to the antenna, but may over predict the power density at longer distances. To determine which result should be used, the crossover point where the predicted field strengths are the same is calculated.

$$S_{near} = S_{far}$$

$$\frac{P}{(2\,\pi\,d\,h)} = \frac{P\,G}{4\,\pi\,d^2}$$

Rearranged to find d

$$d = \frac{Gh}{2}$$

Where: S=power density in W/m^2
P= net power output to the antenna (W)
d = radius of a cylinder around the antenna (m)
h = aperture height of antenna (m)
G = Effective linear gain of antenna relative to an isotropic radiator
F = frequency (MHz)

Example Calculation:

Service	LTE
Frequency	699MHz
Highest Transmitter Power:	23dbm = 0.2W
Antenna Type:	Roof mount multi band
Antenna Make:	Panorama Antennas
Antenna Model:	GPSD-7-27-24-58-T
Specified Antenna Gain:	4dBi = 2.5
Antenna Length:	50mm
Antenna Coupling Loss:	2.2dB (Cables and filters)
Antenna Height:	0.05m

Effective Transmit Power

P = net power output to the antenna (W)
= Specified transmitter power - Antenna Coupling Loss
= 23 – 2.2
= 20.8 dBm
= 120mW

Far Field boundary calculation

$$d = \frac{Gh}{2}$$

$$d = \frac{2.5 \times 0.05}{2}$$

$$= 0.063m$$

For a 0.05m antenna at 699MHz, the crossover point is 0.063m.

Power density at distance requirement stated in the user manual

The minimum safe distance stated in the manual is 0.2m. This is outside the near/far field boundary so the far field occasion is appropriate to calculate the power density.

$$S_{far} = \frac{P\ G}{4\ \pi\ d^2}$$

$$= \frac{0.012\ \times 2.5}{4\ \pi \times\ 0.2^2}$$

$$= 0.60\ W/m^2$$

$$= 0.06\ mW/cm^2$$

References:

1. 47CFR 1.1310 Radiofrequency radiation exposure limits
2. IEEE Std C95.3-2002 IEEE Recommended Practice for Measurements and Computations of Radio Frequency

End