RF Exposure Considerations for Novariant 802.11b/g Radio Module

Novariant manufactures steering and guidance systems for large vehicles used in farming and mining operations. The system, called Timaru, is designed to control the lateral steering of a vehicle combined with wireless data management and remote IP-based service/diagnostics. The system is specifically designed to be easily adapted to other new vehicles with little or no product modification.

The radio communications section of the product is located in the Roof Module assembly. Novariant will install the following radio modules in the roof module:

Novariant 802.11b/g module, FCC ID: TMN-WMIA-166AGI
Freewave 900 MHz FHSS module, FCC ID: KNY-6231812519
Intelligent Wireless Products Amplifier, FCC ID: RFK-LMSWDJH819 (CDMA)

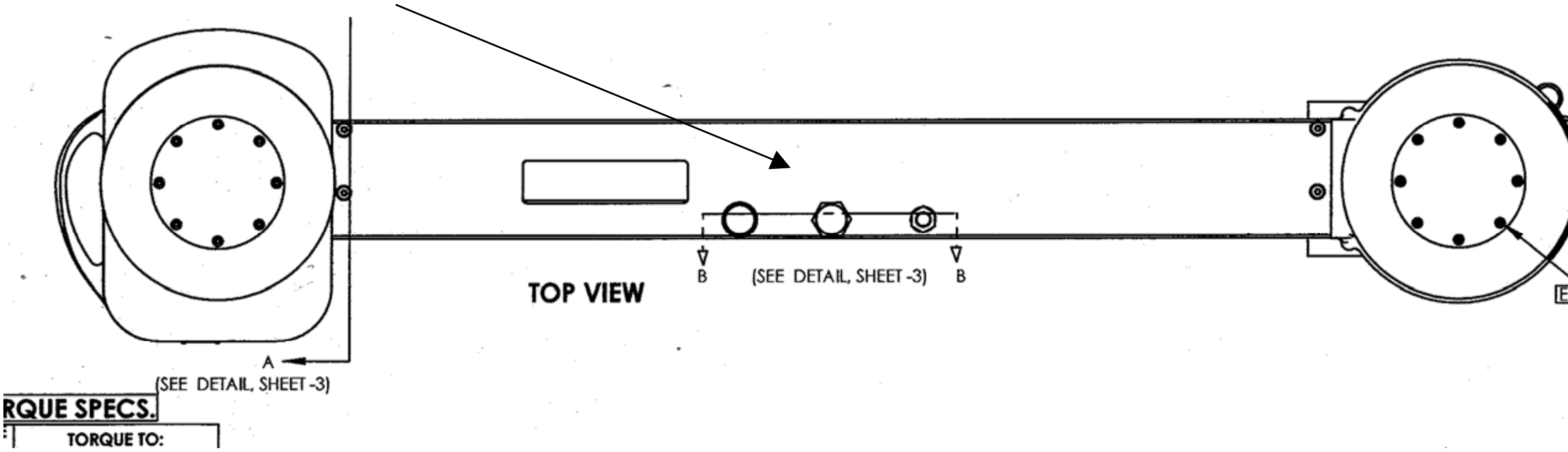
Multitech CDMA/AMPS/PSC module FCC ID: AU792U04A22750

The Multitech module drives the Intelligent Wireless Products amplifier and operates in CDMA mode only.

The roof modules will be essentially the same for all the machines Novariant will equip, therefore, the Novariant 802.11 module will always be co-located with two other radios.

Refer to attached drawing for details of roof module construction. The antennas are approximately 12 cm apart, however, to simplify worst-case RF exposure calculations, the antennas are assumed to be at zero separation.

Antenna locations



RFx CALCULATION FOR MULTIPLE CO-LOCATED TX SOURCES

Novariant 802.11b/g module, FCC ID: TMN-WMIA-166AGI
Freewave 900 MHz FHSS module, FCC ID: KNY-6231812519
Intelligent Wireless Products Cellular Amplifier, FCC ID: RFK-LMSWDJH819 (CDMA Operation)
Multitech CDMA/AMPS/PSC module FCC ID: AU792U04A22750

The Multitech module drives the Intelligent Wireless Products amplifier and operates in CDMA mode only.

The following relationships between power density (S), distance from antenna (d meters), transmitter field strength (E v/m), transmitter power (P, watts) and antenna gain (G, numeric) are used to determine MPE for each transmitter:

$E^2/3770 = S$, mW/cm^2
E, V/m = $(Pwatts*Ggain*30)^{.5}/d$, meters
MPE d,m = $((Pwatts*G*30)/3770*S))^{0.5}$
$Pwatts*Ggain = 10^{(PdBm-30+GdBi)/10)}$
$S@dist2 = S@dist1*(dist1/dist2)^2$

The antenna gains and output powersof the different radios were obtained from Novariant test report and from exhibits submitted with FCC certification applications for the Freewave 900 MHz FHSS and the Intelligent Wireless Products cell radio amplifier.

1. MPE for Novariant 802.11b/g operation:
Maximum output power: 23.4 dBm
Source based duty cycle: 100%
Antenna gain : 7.4 dBi
Maximum eirp = 23.4+7.4 = 30.8 dBm eirp
Maximum allowed RF exposure, general exposure limit, 824 MHz, from Table1 OET 65: 1.0 mW/cm^2
MPE : 9.8 cm
S at 20 cm: 0.24 mW/cm^2

2. MPE for Intelligent Wireless Products 824-848 MHz amplifier operation:
Maximum output power: 27.44 dBm
Source based duty cycle: 100% = 0 dB
Antenna gain : 4 dBi effective antenna gain
Maximum eirp = 27.44 + 4 = 31.44 dBm eirp
Maximum allowed RF exposure, general exposure limit, 824 MHz, from Table1 OET 65: 0.55 mW/cm^2
MPE : 14.2 cm
S at 20 cm: 0.28 mW/cm^2

3. MPE for 902 MHz Freewave FHSS transmitter:
Maximum output power: 29.8 dBm
Source based duty cycle: 100% = 0 dB
(Note: Power and duty cycle information obtained from Silver Spring Networks certification application)
Antenna gain : 5 dBi
Maximum eirp = 29.8 +5 = 34.8 dBm eirp
Maximum allowed RF exposure, general exposure limit, 902 MHz, from Table1 OET 65: 0.6 mW/cm^2
MPE : 20.1 cm
S at 20 cm: 0.61 mW/cm^2

Per OET 65, the allowed cumulative exposure limit at a given point from three transmitters operating at different frequencies is

$S_{f1}/S_{f1limit} + S_{f2}/S_{f2limit} + S_{f3}/S_{f3limit} < 1$, where

S_{f1} = power density at a given point for transmitter operating at F1 MHz
S_{f2} = power density at a given point for transmitter operating at F2 MHz
S_{f3} = power density at a given point for transmitter operating at F3 MHz

$S_{f1limit}$ = power density limit at frequency F1 (from Table 1 in Appendix A of OET 65)
$S_{f2limit}$ = power density limit at frequency F2 (from Table 1 in Appendix A of OET 65)
$S_{f3limit}$ = power density limit at frequency F3 (from Table 1 in Appendix A of OET 65)

From calculations above, at 20 cm, and limits from Table 1

$S_{824\ MHz} = 0.28\ mW/cm^2$ $S_{824MHzlimit} = 0.55\ mW/cm^2$
$S_{902MHz} = 0.61\ mW/cm^2$ $S_{902MHzlimit} = 0.6\ mW/cm^2$
$S_{2.4\ GHz} = 0.24\ mW/cm^2$ $S_{1850MHzlimit} = 1.0\ mW/cm^2$

Frequency weighted combined exposure at 20cm:

0.28/.55 + .61/.6 + .24/1 = .51 + 1.016 + .24 = 1.766 > 1 **Worst case**

Solving for separation distance that will result in frequency weighted combined exposure =1
From above:

$S@dist2 = S@dist1*(dist1/dist2)^2$ dist1= 20cm, dist2 = distance at which combined exposure =1

$dist2 = 20cm * (1.766 / 1)^{0.5}$

= 20 * 1.33

= 26.6 cm MPE distance for simultaneous operation

Spread sheet used to calculate RFx is attached.

Novariant Inc.											
FCC ID:	TMN-WMIA-166AGI										
IC:	8490A-WMIA166AGI										
802,.11b/g radio nodule co-located with 900 MHz FHSS module and cellular module w/booster							Calculate mW/cm2 here. Enter frequency in MHz:				
FHSS ID											
Cell ID											
Booster ID											
							Calculation of Limits from 1.1310 Table 1				
S1 for 2.4 GHz		1.00	maximum							Controlled	Uncontrolled
S2 for 902 MHz		0.60	maximum							Ave 6 min	Ave 30 min
S3 for 824 MHz		0.55	maximum				F(MHz)	Actual F, MHz		Occ, mW/c2	Gen, mW/cm2
							0.3-3	0.5		100.0	100.0
Max RF Power	TX Antenna	MPE distance	S, mW/cm2	S, mW/cm2	Comment	Radio Identification	*3.0 - 30.0*	*5*		*180.0*	*36.0*
P, dBm	G, dBi	cm	at 20 cm dist	at 21.4 cm dist			**30.0-300**	**55**		**1.0**	**0.2**
							300-1500	*824*		*2.7*	*0.55*
23.4	7.40	9.8	0.24	0.21	2.4 GHz Duty Cycle = 100%	Novariant FCC ID: TMN-WMIA-166AGI	1500-100000	5555		5.0	1.0
29.8	5.0	20.1	0.61	0.53	902MHz Duty Cycle = 100%	Freewave FCC ID:KNY-6231812519					
27.4	4.0	14.2	0.28	0.24	824 MHz Duty Cycle 100%	IDW FCC ID: RFK-LMSWDJH819					
							Enter P(mW)	Equivalent dBm	**Enter dBm**	Equivalent Watts	
Basis of Calculations:							*555*	**27.44**	*29.52*	895.4	
E^2/3770 = S, mW/cm2											
E, V/m = (Pwatts*Ggain*30)^.5/d, meters											
d = ((Pwatts*G*30)/3770*S))^0.5			Pwatts*Ggain = 10^(PdBm-30+GdBi)/10)								
S@dist2 = S@MPEdist(MPE/dist2)^2											
NOTE: For mobile or fixed location transmitters, minimum separation distance is for FCC compliance is 20 cm,											
even if calculations indicate MPE distance is less											