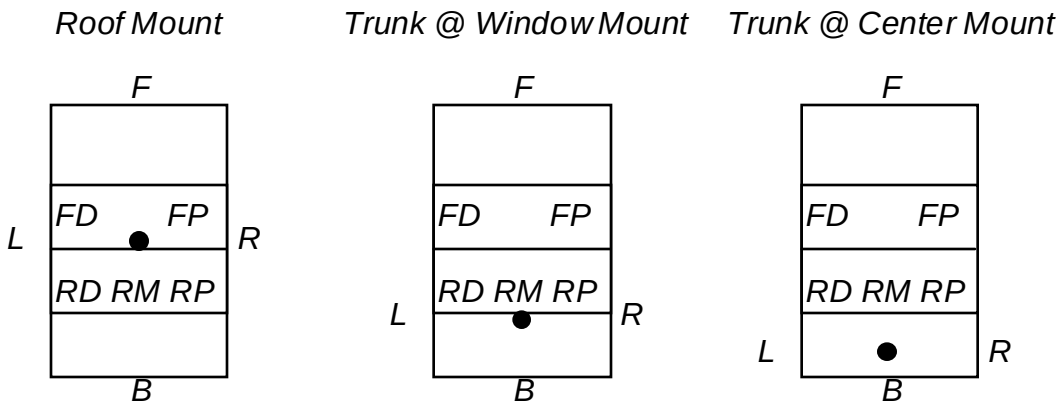
10.0 RF Exposure

FCC §2.1091, §2.1093

10.1 Test Procedure

The EUT was activated at full power, and connected to the five antennas that will be provided for use with it. Each antenna was placed at three different positions on a test vehicle, the center of the roof, the center of the trunk, and centered on the trunk at the back window, excepting the puck and transit style antennas, which were placed at the roof and center of the trunk. These are typical mounting points. A measurement antenna was connected to a spectrum analyzer, and peak readings of the field strength were taken at various test points outside and inside of the vehicle. Measurement antenna height and polarization were varied at each point to produce the worst-case value. Below are diagrams showing the transmit antenna mounting point and the corresponding test point locations and designations.



F = Front FD = Front Driver Side RP = Rear Passenger Side
L = Left FP = Front Passenger Side ● = Transmit Antenna
R = Right RD = Rear Driver Side
B = Back RM = Rear Middle

The readings at the spectrum analyzer are in dBuV/m. The limits are expressed in mW/cm^2. An equation that relates these two values is

$E = 20 \text{ LOG } (1x10^6 (377*10*P)^{1/2})$

where E is the measured voltage in dBuV/m, and P is the power density in mW/cm^2. The factor 377 is the impedance of free space, a constant. The obtained power density can then be compared to the limits. The power density limit for uncontrolled exposure is f/1500, where f is the transmit frequency. The worst case limits are at the lowest transmit frequency, and the measured RF output power of the EUT at the antenna port was maximum at the lowest transmit frequency. Therefore the lowest transmit frequency of 806.0125 MHz was selected as the worst case frequency and the limit for Maximum Permissible Exposure (MPE) was determined to be 0.537 mW/cm^2.

The distance between the transmit antenna and the test points is measured, and compared to a calculated Minimum Safe Distance (MSD). The MSD is determined by taking the maximum power output at the antenna terminals and adding the gain of the transmit antenna to determine the Effective Isotropic Radiated Power (EIRP). The EIRP assumed to radiate spherically from the transmit antenna and the Minimum Safe Distance is the radius of a sphere large enough that the radiated power density at the surface is equal to the limits for Maximum Permissible Exposure (MPE). The following equation relates the EIRP (mW) of the transmitter and P (mW/cm^2), the power density at radius r (cm):

$EIRP = P*4*Pi*r^2$

VRM:
$EIRP_{3dB}$ = maximum radio output (42.5 dBm) + maximum antenna gain (3 dB) = 45.5 dBm

$EIRP_{0dB}$ = maximum radio output (42.5 dBm) + maximum antenna gain (0 dB) = 42.5 dBm

VRB:
$EIRP_{3dB}$ = maximum radio output (41 dBm) + maximum antenna gain (3 dB) = 44 dBm
$EIRP_{0dB}$ = maximum radio output (41 dBm) + maximum antenna gain (0 dB) = 41 dBm

Therefore,

$MSD_{3dB} = [(EIRP1 + EIRP2)/(4*Pi*P)]^{1/2}$ = 95 cm
$MSD_{0dB} = [(EIRP1 + EIRP2)/(4*Pi*P)]^{1/2}$ = 67 cm

Roof Mounting on Test Vehicle


Trunk @ Window Mounting on Test Vehicle

Trunk @ Center Mounting on Test Vehicle

10.2 Test Results

Data fields in the format (low frequency data)/(high frequency data).

Antenna Specialists ASPSA912M 3dB Gain Roof Mount

Test Point	Field Strength Reading (dBuV/m)	Field Strength Reading (mW/cm^2)	Total Field Strength (mW/cm^2)	MPE Limit (mW/cm^2)	Test Point Distance (cm)	MSD Limit (cm)
Front	140.11 / 139.36	0.027 / 0.023	0.050	0.537	294.0	95
Back	141.80 / 142.45	0.040 / 0.047	0.087	0.537	203.0	95
Left	156.25 / 146.06	0.112 / 0.107	0.219	0.537	97.0	95
Right	148.14 / 147.90	0.173 / 0.164	0.336	0.537	110.0	95
Front Driver	136.80 / 130.31	0.013 / 0.003	0.016	0.537	55.0	95
Front Passenger	135.11 / 131.26	0.009 / 0.004	0.012	0.537	54.0	95
Rear Driver	135.22 / 130.83	0.009 / 0.003	0.012	0.537	55.0	95
Rear Middle	132.02 / 129.10	0.004 / 0.002	0.006	0.537	48.0	95
Rear Passenger	135.80 / 135.57	0.010 / 0.010	0.020	0.537	60.0	95

Antenna Specialists ASPSA912M 3dB Gain Trunk @ Window Mount

Test Point	Field Strength Reading (dBuV/m)	Field Strength Reading (mW/cm^2)	Total Field Strength (mW/cm^2)	MPE Limit (mW/cm^2)	Test Point Distance (cm)	MSD Limit (cm)
Front	136.48 / 135.81	0.012 / 0.010	0.022	0.537	429.0	95
Back	***151.23 / 150.69***	***0.352 / 0.311***	***0.663***	0.537	73.0	95
Left	147.81 / 147.63	0.160 / 0.154	0.314	0.537	100.0	95
Right	149.63 / 149.19	0.244 / 0.220	0.464	0.537	100.0	95
Front Driver	141.26 / 139.81	0.035 / 0.025	0.061	0.537	165.0	95
Front Passenger	143.13 / 139.30	0.055 / 0.025	0.077	0.537	165.0	95
Rear Driver	145.42 / 144.34	0.092 / 0.072	0.164	0.537	85.0	95
Rear Middle	144.51 / 143.30	0.075 / 0.057	0.132	0.537	75.0	95
Rear Passenger	145.11 / 143.57	0.086 / 0.060	0.146	0.537	85.0	95

Antenna Specialists ASPSA912M 3dB Gain Trunk @ Center Mount

Test Point	Field Strength Reading (dBuV/m)	Field Strength Reading (mW/cm^2)	Total Field Strength (mW/cm^2)	MPE Limit (mW/cm^2)	Test Point Distance (cm)	MSD Limit (cm)
Front	135.30 / 134.95	0.009 / 0.008	0.017	0.537	454.0	95
Back	***153.02 / 152.08***	***0.532 / 0.428***	***0.960***	0.537	47.0	95
Left	147.21 / 147.83	0.140 / 0.161	0.300	0.537	100.0	95
Right	147.22 / 147.83	0.140 / 0.161	0.301	0.537	100.0	95
Front Driver	141.35 / 142.03	0.036 / 0.042	0.079	0.537	185.0	95
Front Passenger	142.72 / 142.76	0.050 / 0.050	0.100	0.537	185.0	95
Rear Driver	146.62 / 144.31	0.122 / 0.072	0.193	0.537	105.0	95
Rear Middle	144.85 / 145.04	0.081 / 0.085	0.166	0.537	100.0	95

Rear Passenger	145.78 / 144.47	0.100 / 0.074	0.175	0.537	105.0	95

Antenna Specialists ASPA1850M 3dB Gain Roof Mount

Test Point	Field Strength Reading (dBuV/m)	Field Strength Reading (mW/cm^2)	Total Field Strength (mW/cm^2)	MPE Limit (mW/cm^2)	Test Point Distance (cm)	MSD Limit (cm)
Front	136.54 / 139.00	0.012 / 0.021	0.033	0.537	294.0	95
Back	139.99 / 142.31	0.026 / 0.045	0.072	0.537	203.0	95
Left	***149.58 / 150.66***	***0.241 / 0.309***	***0.550***	0.537	97.0	95
Right	147.71 / 149.82	0.157 / 0.254	0.411	0.537	110.0	95
Front Driver	133.58 / 138.1	0.006 / 0.017	0.023	0.537	55.0	95
Front Passenger	137.86 / 136.22	0.016 / 0.011	0.027	0.537	54.0	95
Rear Driver	139.23 / 138.56	0.022 / 0.019	0.041	0.537	55.0	95
Rear Middle	137.18 / 139.24	0.014 / 0.022	0.036	0.537	48.0	95
Rear Passenger	138.64 / 138.80	0.019 / 0.020	0.040	0.537	60.0	95

Antenna Specialists ASPA1850M 3dB Gain Trunk @ Window Mount

Test Point	Field Strength Reading (dBuV/m)	Field Strength Reading (mW/cm^2)	Total Field Strength (mW/cm^2)	MPE Limit (mW/cm^2)	Test Point Distance (cm)	MSD Limit (cm)
Front	134.79 / 136.76	0.008 / 0.013	0.020	0.537	429.0	95
Back	***150.84 / 151.38***	***0.322 / 0.364***	***0.686***	0.537	73.0	95
Left	147.66 / 147.54	0.155 / 0.151	0.305	0.537	100.0	95
Right	146.97 / 147.11	0.132 / 0.136	0.268	0.537	100.0	95
Front Driver	144.74 / 144.29	0.079 / 0.071	0.150	0.537	165.0	95
Front Passenger	147.34 / 145.82	0.144 / 0.101	0.245	0.537	165.0	95
Rear Driver	***150.99 / 151.82***	***0.333 / 0.403***	***0.736***	0.537	85.0	95
Rear Middle	148.37 / 148.43	0.182 / 0.185	0.367	0.537	75.0	95
Rear Passenger	149.17 / 149.07	0.219 / 0.214	0.433	0.537	85.0	95

Antenna Specialists ASPA1850M 3dB Gain Trunk @ Center Mount

Test Point	Field Strength Reading (dBuV/m)	Field Strength Reading (mW/cm^2)	Total Field Strength (mW/cm^2)	MPE Limit (mW/cm^2)	Test Point Distance (cm)	MSD Limit (cm)
Front	136.09 / 138.85	0.011 / 0.020	0.031	0.537	454.0	95
Back	***151.92 / 153.71***	***0.413 / 0.623***	***1.036***	0.537	47.0	95
Left	146.38 / 147.03	0.115 / 0.134	0.249	0.537	100.0	95
Right	145.74 / 145.92	0.099 / 0.104	0.203	0.537	100.0	95
Front Driver	141.63 / 142.13	0.039 / 0.043	0.082	0.537	185.0	95
Front Passenger	142.13 / 144.01	0.043 / 0.067	0.110	0.537	185.0	95
Rear Driver	143.89 / 147.06	0.065 / 0.135	0.200	0.537	105.0	95
Rear Middle	147.89 / 149.19	0.163 / 0.220	0.383	0.537	100.0	95
Rear Passenger	146.93 / 148.45	0.131 / 0.186	0.316	0.537	105.0	95

Maxrad Z322 0dB Gain Roof Mount

Test Point	Field Strength Reading (dBuV/m)	Field Strength Reading (mW/cm^2)	Total Field Strength (mW/cm^2)	MPE Limit (mW/cm^2)	Test Point Distance (cm)	MSD Limit (cm)
Front	135.53 / 136.06	0.009 / 0.010	0.020	0.537	294.0	67
Back	137.13 / 137.34	0.014 / 0.014	0.028	0.537	203.0	67
Left	148.29 / 148.86	0.179 / 0.204	0.383	0.537	97.0	67
Right	144.41 / 145.84	0.073 / 0.102	0.175	0.537	110.0	67
Front Driver	131.51 / 132.25	0.003 / 0.004	0.008	0.537	55.0	67
Front Passenger	130.76 / 133.21	0.003 / 0.006	0.009	0.537	54.0	67
Rear Driver	136.63 / 136.37	0.012 / 0.011	0.024	0.537	55.0	67
Rear Middle	135.07 / 139.07	0.009 / 0.021	0.030	0.537	48.0	67
Rear Passenger	137.05 / 135.73	0.013 / 0.010	0.023	0.537	60.0	67

Maxrad Z322 0dB Gain Trunk @ Window Mount

Test Point	Field Strength Reading (dBuV/m)	Field Strength Reading (mW/cm^2)	Total Field Strength (mW/cm^2)	MPE Limit (mW/cm^2)	Test Point Distance (cm)	MSD Limit (cm)
Front	136.25 / 134.45	0.011 / 0.007	0.019	0.537	429.0	67
Back	149.00 / 149.07	0.211 / 0.214	0.425	0.537	73.0	67
Left	145.05 / 142.25	0.085 / 0.045	0.129	0.537	100.0	67
Right	145.70 / 145.61	0.099 / 0.097	0.195	0.537	100.0	67
Front Driver	145.18 / 143.36	0.087 / 0.057	0.145	0.537	165.0	67
Front Passenger	144.98 / 139.93	0.083 / 0.026	0.110	0.537	165.0	67
Rear Driver	150.44 / 147.51	0.294 / 0.150	0.443	0.537	85.0	67

Rear Middle	146.81 / 145.98	0.127 / 0.105	0.232	0.537	75.0	67
Rear Passenger	148.90 / 144.17	0.206 / 0.069	0.275	0.537	85.0	67

Maxrad Z322 0dB Gain Trunk @ Center Mount

Test Point	Field Strength Reading (dBuV/m)	Field Strength Reading (mW/cm^2)	Total Field Strength (mW/cm^2)	MPE Limit (mW/cm^2)	Test Point Distance (cm)	MSD Limit (cm)
Front	135.94 / 136.63	0.010 / 0.012	0.023	0.537	454.0	67
Back	***151.48 / 152.12***	***0.373 / 0.432***	***0.805***	0.537	47.0	67
Left	147.29 / 146.48	0.142 / 0.118	0.260	0.537	100.0	67
Right	146.45 / 146.49	0.117 / 0.118	0.235	0.537	100.0	67
Front Driver	139.79 / 139.94	0.025 / 0.026	0.051	0.537	185.0	67
Front Passenger	140.89 / 141.81	0.033 / 0.040	0.073	0.537	185.0	67
Rear Driver	143.39 / 143.17	0.058 / 0.055	0.113	0.537	105.0	67
Rear Middle	147.08 / 146.07	0.135 / 0.107	0.243	0.537	100.0	67
Rear Passenger	144.60 / 145.38	0.076 / 0.092	0.168	0.537	105.0	67

Antenna Specialists Transit Antenna ASP930 0dB Gain Roof Mount

Test Point	Field Strength Reading (dBuV/m)	Field Strength Reading (mW/cm^2)	Total Field Strength (mW/cm^2)	MPE Limit (mW/cm^2)	Test Point Distance (cm)	MSD Limit (cm)
Front	138.25 / 137.54	0.018 / 0.015	0.033	0.537	294.0	67
Back	144.02 / 143.15	0.067 / 0.055	0.122	0.537	203.0	67
Left	149.47 / 148.24	0.235 / 0.177	0.412	0.537	97.0	67
Right	148.08 / 147.22	0.170 / 0.140	0.310	0.537	110.0	67
Front Driver	134.74 / 133.51	0.008 / 0.006	0.014	0.537	55.0	67
Front Passenger	137.82 / 136.28	0.016 / 0.011	0.027	0.537	54.0	67
Rear Driver	138.44 / 135.98	0.019 / 0.011	0.029	0.537	55.0	67
Rear Middle	138.75 / 135.07	0.020 / 0.009	0.028	0.537	48.0	67
Rear Passenger	138.91 / 135.86	0.021 / 0.010	0.031	0.537	60.0	67

Antenna Specialists Transit Antenna ASP930 0dB Gain Trunk @ Center Mount

Test Point	Field Strength Reading (dBuV/m)	Field Strength Reading (mW/cm^2)	Total Field Strength (mW/cm^2)	MPE Limit (mW/cm^2)	Test Point Distance (cm)	MSD Limit (cm)
Front	135.51 / 135.93	0.009 / 0.010	0.020	0.537	454.0	67
Back	***152.28 / 150.07***	***0.448 / 0.270***	***0.718***	0.537	47.0	67
Left	149.88 / 147.99	0.258 / 0.167	0.425	0.537	100.0	67
Right	148.81 / 146.90	0.202 / 0.130	0.332	0.537	100.0	67
Front Driver	144.98 / 142.66	0.083 / 0.049	0.132	0.537	185.0	67
Front Passenger	144.38 / 141.67	0.073 / 0.039	0.112	0.537	185.0	67
Rear Driver	147.66 / 144.77	0.155 / 0.080	0.234	0.537	105.0	67
Rear Middle	148.16 / 146.71	0.174 / 0.124	0.298	0.537	100.0	67
Rear Passenger	148.25 / 147.84	0.177 / 0.161	0.339	0.537	105.0	67

Antenna Plus Puck Antenna AP8000B 3dB Gain Roof Mount

Test Point	Field Strength Reading (dBuV/m)	Field Strength Reading (mW/cm^2)	Total Field Strength (mW/cm^2)	MPE Limit (mW/cm^2)	Test Point Distance (cm)	MSD Limit (cm)
Front	131.86 / 136.69	0.004 / 0.012	0.016	0.537	294.0	95
Back	136.87 / 138.44	0.013 / 0.019	0.031	0.537	203.0	95
Left	142.30 / 140.05	0.045 / 0.026	0.072	0.537	97.0	95
Right	145.06 / 145.11	0.085 / 0.086	0.171	0.537	110.0	95
Front Driver	135.11 / 136.60	0.009 / 0.012	0.021	0.537	55.0	95
Front Passenger	136.40 / 131.52	0.012 / 0.004	0.015	0.537	54.0	95
Rear Driver	137.75 / 137.05	0.016 / 0.013	0.029	0.537	55.0	95
Rear Middle	137.23 / 136.44	0.014 / 0.012	0.026	0.537	48.0	95
Rear Passenger	139.14 / 137.88	0.022 / 0.016	0.038	0.537	60.0	95

Antenna Plus Puck Antenna AP8000B 3dB Gain Trunk @ Center Mount

Test Point	Field Strength Reading (dBuV/m)	Field Strength Reading (mW/cm^2)	Total Field Strength (mW/cm^2)	MPE Limit (mW/cm^2)	Test Point Distance (cm)	MSD Limit (cm)
Front	131.47 / 130.27	0.004 / 0.003	0.007	0.537	454.0	95
Back	***151.24 / 149.55***	***0.353 / 0.239***	***0.592***	0.537	47.0	95
Left	146.74 / 140.73	0.125 / 0.031	0.157	0.537	100.0	95
Right	147.35 / 143.09	0.144 / 0.054	0.198	0.537	100.0	95
Front Driver	140.21 / 136.31	0.028 / 0.011	0.039	0.537	185.0	95
Front Passenger	141.42 / 136.65	0.037 / 0.012	0.049	0.537	185.0	95
Rear Driver	144.91 / 141.14	0.082 / 0.034	0.117	0.537	105.0	95

Rear Middle	144.48 / 138.65	0.074 / 0.019	0.094	0.537	100.0	95
Rear Passenger	143.66 / 141.9	0.061 / 0.041	0.103	0.537	105.0	95

It can be seen from the above tables that all of the field strength readings (bolded italicized readings) that exceeded the MPE limit are within the MSD. Additionally, those readings that exceeded the MPE limit all had a direct line-of-sight between the EUT transmit antenna and the field strength measurement antenna.

The EUT's transmitter is activated by bursty data transmissions and the operator keying a microphone which classifies the device as a Push-To-Talk (PTT) device. PTT allows a 50% averaging power factor reduction that corresponds to a 3 dB reduction in the measured field strength reading. The table below applies the power factor reduction for those test points that exceeded the MPE limit.

Over limit reading adjustment for Push to Talk 50% averaging factor

Test Point	Field Strength Reading – 3 dB PTT AVG Factor (dBuV/m)	Field Strength Reading – 3 dB PTT AVG Factor (mW/cm^2)	Test Point Distance (cm)	Limit (mW/cm^2)	Antenna	Mounting
Back	148.23 / 147.69	0.176 + 0.156 = 0.332	100	0.537	Antenna Specialists ASPSA912M	Trunk @ Window
Back	150.02 / 149.08	0.266 + 0.215 = 0.481	100	0.537	Antenna Specialists ASPSA912M	Trunk @ Center
Left	146.58 / 147.66	0.121 + 0.155 = 0.275	97	0.537	Antenna Specialists ASPA1850M	Roof
Back	147.84 / 148.38	0.161 + 0.183 = 0.344	100	0.537	Antenna Specialists ASPA1850M	Trunk @ Window
Rear Driver	147.99 / 148.82	0.167 + 0.202 = 0.369	85	0.537	Antenna Specialists ASPA1850M	Trunk @ Window
Back	148.92 / 150.71	0.207 + 0.312 = 0.519	100	0.537	Antenna Specialists ASPA1850M	Trunk @ Center
Back	148.48 / 149.12	0.187 + 0.217 = 0.404	100	0.537	Maxrad Z322	Trunk @ Center
Back	149.28 / 147.07	0.225 + 0.135 = 0.360	100	0.537	Antenna Specialists ASP930	Trunk @ Center
Back	148.24 / 146.55	0.177 + 0.120 = 0.297	100	0.537	Antenna Plus AP8000B	Trunk @ Center

There are two possible types of usage of this radio system, designated as "Scene of Incidence" and "Coverage Extension". In Scene of Incidence mode, the VRB only will be transmitting full duty cycle when nearby radios are keyed up. This allows use of the Push-To-Talk averaging factor. In the Coverage Extension mode, there are two further possibilities. Either the the radio user is keying up the radio, in which case both the VRM and VRB will be operating simultaneously in full duplex mode (50% duty cycle). In this full duplex mode, both the VRM and VRB are initiated by keying by the user or by keying of nearby radios, respectively, and therefore can use the Push-To-Talk average factor. When the user does not key the VRM, the VRB will continue to operate, this time with a 100% duty cycle, but still responding to keying of nearby radios, falling once again into the category of a Push-To-Talk device. Having adjusted the over limit values for the Push to Talk average factor, it can be seen that the transmitters comply with the requirements for RF exposure levels with both transmitting at 100% duty cycle simultaneously.

This radio has been tested and complies with the FCC RF exposure limits for Uncontrolled Exposure and Occupational exposure. The difference is in the minimum safe distance that people must be away from the antenna when transmitting RF energy. To assure optimal radio performance and that human exposure to RF electromagnetic energy is within the guidelines, transmit only when people are at least the minimum distance away from a properly installed antenna. The following table lists the minimal distances.

Measured Power of OpenSky Mobile Radio	Antenna Gain	MSD from Transmitting Antenna, General Population / Uncontrolled Exposure	MSD from Transmitting Antenna, Occupational / Controlled Exposure
42 dBm VRB and 41 dBm VRM	0 dB	70 cm (27.5 inches)	30.6 cm (12 inches)
42 dBm VRB and 41 dBm VRM	3 dB	1 meter (39.4 inches)	43.2 cm (17 inches)
Results: Passed			