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# Calculated Radio Frequency Exposure Report

Orono 2 ME

36 Oak Street, Orono, ME 04473

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## 1. Introduction

The purpose of this report is to investigate compliance with applicable FCC regulations for the installation of Verizon Wireless antenna arrays within the steeple of the Orono United Methodist Church located at 36 Oak Street in Orono, ME. The coordinates of the site are 44-53-02.81 N, 68-40-13.47 W.

Verizon Wireless is proposing to install eight (8) multi-band antennas to support their LTE network (two per sector).

This report uses the planned antenna configuration for Verizon Wireless' proposed installation to derive the resulting % MPE.

## 2. FCC Guidelines for Evaluating RF Radiation Exposure Limits

In 1985, the FCC established rules to regulate radio frequency (RF) exposure from FCC licensed antenna facilities. In 1996, the FCC updated these rules, which were further amended in August 1997 by OET Bulletin 65 Edition 97-01. These new rules include Maximum Permissible Exposure (MPE) limits for transmitters operating between 300 kHz and 100 GHz. The FCC MPE limits are based upon those recommended by the National Council on Radiation Protection and Measurements (NCRP), developed by the Institute of Electrical and Electronics Engineers, Inc., (IEEE) and adopted by the American National Standards Institute (ANSI).

The FCC general population/uncontrolled limits set the maximum exposure to which most people may be subjected. General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or cannot exercise control over their exposure.

Public exposure to radio frequencies is regulated and enforced in units of milliwatts per square centimeter ($mW/cm^2$). The general population exposure limits for the various frequency ranges are defined in the attached "FCC Limits for Maximum Permissible Exposure (MPE)" in Attachment B of this report.

Higher exposure limits are permitted under the occupational/controlled exposure category, but only for persons who are exposed as a consequence of their employment and who have been made fully aware of the potential for exposure, and they must be able to exercise control over their exposure. General population/uncontrolled limits are five times more stringent than the levels that are acceptable for occupational, or radio frequency trained individuals. Attachment B contains excerpts from OET Bulletin 65 and defines the Maximum Exposure Limit.

Finally, it should be noted that the MPE limits adopted by the FCC for both general population/uncontrolled exposure and for occupational/controlled exposure incorporate a substantial margin of safety and have been established to be well below levels generally accepted as having the potential to cause adverse health effects.

## 3. RF Exposure Calculation Methods

The calculated ground-level power density results displayed in the following figures were generated using the following formula as outlined in FCC bulletin OET 65:

$$\text{Power Density} = \left(\frac{\text{EIRP}}{\pi \times R^2}\right) \text{ X Off Beam Loss}$$

Where:

EIRP = Effective Isotropic Radiated Power

R = Radial Distance = $\sqrt{(H^2 + V^2)}$

H = Horizontal Distance from antenna

V = Vertical Distance from radiation center of antenna

Off Beam Loss is determined by the selected antenna patterns

Ground reflection factor of 2.0

These calculations assume that the antennas are operating at full power and 100 percent capacity, and that all antenna channels are transmitting simultaneously. Obstructions (trees, buildings, etc.) that would normally attenuate the signal are not taken into account. The calculations also assume even terrain in the area of study and do not take consider terrain elevations which could further attenuate the signal. As a result, the calculated power density and corresponding % MPE levels reported below are much higher than the actual signal levels will be from the final antenna configuration.

The percent of MPE values presented in this report reflect levels that one may encounter from one sector of a carrier's antennas. Most carriers use multiple sectors per site with azimuths approximately 90-120 degrees apart; therefore, one could not be standing in the main beam of any two different sectors at the same time. In cases where antenna models and downtilts are not uniform across all sectors, the antenna model with the highest gain and downtilt was used for the calculations. This results in a conservative or "worst case" assumption for percent of MPE calculations.

## 4. Proposed Antenna Inventory

Table 1 below outlines Verizon's proposed antenna configuration on the subject site. The associated data sheets and antenna patterns for these specific antenna models are included in Attachment C.

| Operator | Sector | TX Freq (MHz) | Power at Antenna (Watts) | Ant Gain (dBi) | Power EIRP (Watts) | Antenna Model | Beam Width | Mech. Downtilt | Length (ft) | Antenna Centerline Height (ft) |
|---|---|---|---|---|---|---|---|---|---|---|
| Verizon | Alpha | 751 | 80 | 13.4 | 1750 | NHH-65A-R2B | 66 | 0 | 4.6 | 51 |
| | | 885 | 80 | 13.5 | 1791 | | 61 | | | |
| | | 2100 | 120 | 17.1 | 6154 | | 61 | | | |
| | | 751 | 80 | 13.4 | 1750 | NHH-65A-R2B | 66 | 0 | 4.6 | 51 |
| | | 885 | 80 | 13.5 | 1791 | | 61 | | | |
| | | 2100 | 120 | 17.1 | 6154 | | 61 | | | |
| | Beta | 751 | 80 | 13.4 | 1750 | NHH-65A-R2B | 66 | 0 | 4.6 | 51 |
| | | 885 | 80 | 13.5 | 1791 | | 61 | | | |
| | | 2100 | 120 | 17.1 | 6154 | | 61 | | | |
| | | 751 | 80 | 13.4 | 1750 | NHH-65A-R2B | 66 | 0 | 4.6 | 51 |
| | | 885 | 80 | 13.5 | 1791 | | 61 | | | |
| | | 2100 | 120 | 17.1 | 6154 | | 61 | | | |
| | Gamma | 751 | 80 | 13.4 | 1750 | NHH-65A-R2B | 66 | 0 | 4.6 | 51 |
| | | 885 | 80 | 13.5 | 1791 | | 61 | | | |
| | | 2100 | 120 | 17.1 | 6154 | | 61 | | | |
| | | 751 | 80 | 13.4 | 1750 | NHH-65A-R2B | 66 | 0 | 4.6 | 51 |
| | | 885 | 80 | 13.5 | 1791 | | 61 | | | |
| | | 2100 | 120 | 17.1 | 6154 | | 61 | | | |
| | Delta | 751 | 80 | 13.4 | 1750 | NHH-65A-R2B | 66 | 0 | 4.6 | 51 |
| | | 885 | 80 | 13.5 | 1791 | | 61 | | | |
| | | 2100 | 120 | 17.1 | 6154 | | 61 | | | |
| | | 751 | 80 | 13.4 | 1750 | NHH-65A-R2B | 66 | 0 | 4.6 | 51 |
| | | 885 | 80 | 13.5 | 1791 | | 61 | | | |
| | | 2100 | 120 | 17.1 | 6154 | | 61 | | | |

**Table 1: Proposed Antenna Inventory[1] [2]**

[1] Transmit power assumes 0 dB of cable loss.

[2] Antenna heights are in reference to the NEXIUS construction drawings, dated December 20, 2019.

## 5. Calculated % MPE Results

The calculated % MPE results for the proposed antenna configuration are shown in Figure 1 below. Each frequency band and technology is calculated as well as the resulting cumulative percent of MPE. For completeness, the calculations for this analysis range from 0 feet horizontal distance (directly below the antennas) to a value of 2,000 feet horizontal distance from the antennas. In addition to the other worst-case scenario considerations that were previously mentioned, the % MPE calculations to each horizontal distance point away from the antennas were completed using a local maximum off beam antenna gain (within ± 3 degrees of the true mathematical angle) to incorporate a realistic worst-case scenario.

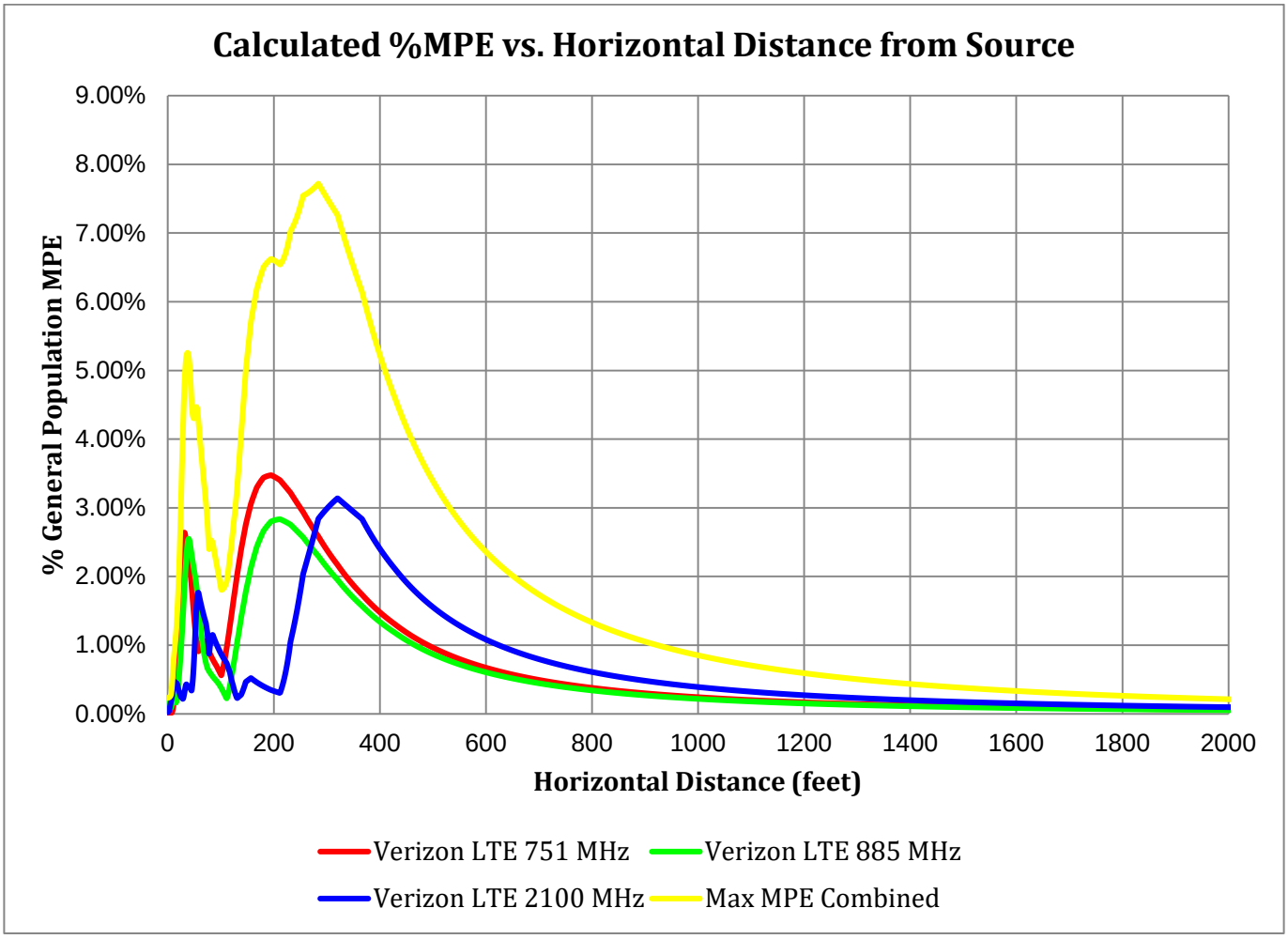



**Figure 1: Graph of Percent of MPE vs. Distance**

The highest percent of MPE (7.72%) is calculated to occur at a horizontal distance of 284 feet from the antennas. Please note that the percent of MPE calculations close to the site take into account off beam loss, which is determined from the vertical pattern of the antennas used. Therefore, RF power density levels may increase as the distance from the site increases. At distances of approximately 300 feet and beyond, one would now be in the main beam of most antenna patterns and off beam loss is no longer considered. Beyond this point, RF levels become calculated solely on distance from the site, and the percent of MPE decreases significantly as distance from the site increases.

Table 2 below lists the calculated percent of MPE values as well as the associated parameters that were included in the calculations. As stated in Section 3, all calculations assume that the antennas are operating at full power and 100 percent capacity, and that all antenna channels are transmitting simultaneously. Obstructions (trees, buildings, etc.) that would normally attenuate the signal are not taken into account. Additionally, a six-foot height offset was considered in this analysis to account for average human height standing at ground level. As a result, the calculated % MPE levels are significantly higher than the actual levels will be from the final installation. The results presented in Figure 1 and Table 2 assume level ground elevation from the base of the building out to the horizontal distances calculated.

| Carrier | Power out of Base Station Per Transmitter (Watts) | Antenna Height (Feet) | Distance to the Base of Antennas (Feet) | Power Density ($mW/cm^2$) | Limit ($mW/cm^2$) | %MPE |
|---|---|---|---|---|---|---|
| Verizon LTE 2100 MHz | 240.0 | 51.0 | 284 | 0.028383 | 1.000 | 2.84% |
| Verizon LTE 751 MHz | 160.0 | 51.0 | 284 | 0.012933 | 0.501 | 2.58% |
| Verizon LTE 885 MHz | 160.0 | 51.0 | 284 | 0.013402 | 0.583 | 2.30% |
| | | | | | **Total** | **7.72%** |

**Table 2: Maximum Percent of Exposure Values[3] [4] [5]**

[3] Transmit power assumes 0 dB of cable loss.

[4] Frequencies listed in Table 2 are representative of the operating band of Verizon Wireless and are not the carriers' specific operating frequency.

[5] The total % MPE listed is a summation of each unrounded contribution. Therefore, summing each rounded value may not reflect the total value listed in the table.

In order to factor in any ground elevation variations around the proposed site, % MPE levels were also calculated at selected points with consideration to each location's ground elevation relative to that of the proposed site. Table 3 below lists the % MPE calculated at these selected points around the proposed site. The highest % MPE calculated was **9.86%** of the **FCC General Population/Uncontrolled limit**, and is calculated to occur at Location 19, approximately 284 feet south of the proposed site. These calculated values incorporate the antenna pattern of the particular antenna models listed in Table 1 to determine the "Off Beam Loss" factor shown in the power density formula from Section 3. All % MPE values are in reference to the FCC General Population/Uncontrolled exposure limit

| Location | Latitude | Longitude | Dist. From Site (feet) | Ground Elevation Difference | Composite % MPE (Uncontrolled / General) |
|---|---|---|---|---|---|
| 1 | 44.8844 | -68.6707 | 140 | 10.7 | 1.32% |
| 2 | 44.8846 | -68.6712 | 255 | 12.8 | 4.00% |
| 3 | 44.8840 | -68.6715 | 275 | 2.1 | 6.91% |
| 4 | 44.8836 | -68.6716 | 374 | -11.7 | 6.06% |
| 5 | 44.8833 | -68.6711 | 328 | -9.8 | 7.82% |
| 6 | 44.8831 | -68.6696 | 431 | 2.1 | 4.52% |
| 7 | 44.8838 | -68.6694 | 288 | 8.1 | 5.19% |
| 8 | 44.8828 | -68.6678 | 821 | 21.1 | 1.26% |
| 9 | 44.8824 | -68.6701 | 620 | -1.4 | 2.21% |
| 10 | 44.8829 | -68.6706 | 452 | -6.1 | 4.15% |
| 11 | 44.8827 | -68.6716 | 594 | -8.3 | 2.41% |
| 12 | 44.8832 | -68.6727 | 685 | -24.7 | 1.82% |
| 13 | 44.8842 | -68.6725 | 547 | -14.9 | 2.85% |
| 14 | 44.8843 | -68.6692 | 319 | 28.1 | 2.51% |
| 15 | 44.8839 | -68.6698 | 161 | 4.0 | 4.27% |
| 16 | 44.8840 | -68.6703 | 50 | 0.8 | 4.15% |
| 17 | 44.8841 | -68.6707 | 82 | 3.3 | 2.25% |
| 18 | 44.8845 | -68.6701 | 175 | 16.1 | 1.69% |
| **19** | **44.8834** | **-68.6706** | **284** | **-8.33** | **9.86%** |
| 20 | 44.8832 | -68.6701 | 346 | -2.8 | 6.90% |

**Table 3: Calculated Results at Selected Points**[6]

[6] A positive ground elevation difference indicates the selected point's ground elevation is lower than that of the proposed site; negative values indicate the selected point is higher than that of the proposed site.

Figure 2 below is an aerial view of the proposed 36 Oak Street facility and the surrounding area. Labeled points indicate the selected locations analyzed in the % MPE calculations listed above in Table 3.


**Figure 2: Aerial View of Selected Locations (Image courtesy Google Earth, ©2020)**

## 6. Conclusion

The above analysis concludes that RF exposure at ground level from the proposed site will be below the maximum permissible levels as outlined by the FCC in the OET Bulletin 65 Ed. 97-01. Using the conservative calculation methods and parameters detailed above and assuming level ground around the proposed site, the maximum cumulative percent of MPE is calculated to be **7.72% of the FCC limit (General Population/Uncontrolled)**. This maximum percent of MPE value is calculated to occur 284 feet away from the site.

The maximum cumulative percent of MPE of the selected points around the proposed site, with consideration to any ground elevation differences, is calculated to be **9.86% of the FCC limit (General Population/Uncontrolled).** This maximum percent of MPE value is calculated to occur at Location 19, approximately 284 feet south of the proposed site.

## 7. Statement of Certification

I certify to the best of my knowledge that the statements in this report are true and accurate. The calculations follow guidelines set forth in FCC OET Bulletin 65 Edition 97-01, IEEE Std. C95.1, and IEEE Std. C95.3.

Marc Salas — June 09, 2020

Report Prepared By: Marc Salas, RF Engineer, C Squared Systems, LLC — Date

Keith Vellante — June 09, 2020

Reviewed/Approved By: Keith Vellante, Director – RF Services, C Squared Systems, LLC — Date

## Attachment A: References

OET Bulletin 65 - Edition 97-01 - August 1997 Federal Communications Commission Office of Engineering & Technology

IEEE C95.1-2005, IEEE Standard Safety Levels With Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz IEEE-SA Standards Board

IEEE Std C95.3-2002 (R2008), IEEE Recommended Practice for Measurements and Computations of Radio Frequency Electromagnetic Fields With Respect to Human Expsoure to Such Fields, 100 kHz-300 GHz IEEE-SA Standards Board

## Attachment B: FCC Limits for Maximum Permissible Exposure (MPE)

### (A) Limits for Occupational/Controlled Exposure[7]

| Frequency Range (MHz) | Electric Field Strength (E) (V/m) | Magnetic Field Strength (E) (A/m) | Power Density (S) ($mW/cm^2$) | Averaging Time $\|E\|^2$, $\|H\|^2$ or S (minutes) |
|---|---|---|---|---|
| 0.3-3.0 | 614 | 1.63 | (100)* | 6 |
| 3.0-30 | 1842/f | 4.89/f | ($900/f^2$)* | 6 |
| 30-300 | 61.4 | 0.163 | 1.0 | 6 |
| 300-1500 | - | - | f/300 | 6 |
| 1500-100,000 | - | - | 5 | 6 |

### (B) Limits for General Population/Uncontrolled Exposure[8]

| Frequency Range (MHz) | Electric Field Strength (E) (V/m) | Magnetic Field Strength (E) (A/m) | Power Density (S) ($mW/cm^2$) | Averaging Time $\|E\|^2$, $\|H\|^2$ or S (minutes) |
|---|---|---|---|---|
| 0.3-1.34 | 614 | 1.63 | (100)* | 30 |
| 1.34-30 | 824/f | 2.19/f | ($180/f^2$)* | 30 |
| 30-300 | 27.5 | 0.073 | 0.2 | 30 |
| 300-1500 | - | - | f/1500 | 30 |
| 1500-100,000 | - | - | 1.0 | 30 |

f = frequency in MHz * Plane-wave equivalent power density

**Table 4: FCC Limits for Maximum Permissible Exposure**

[7] Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

[8] General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or cannot exercise control over their exposure.

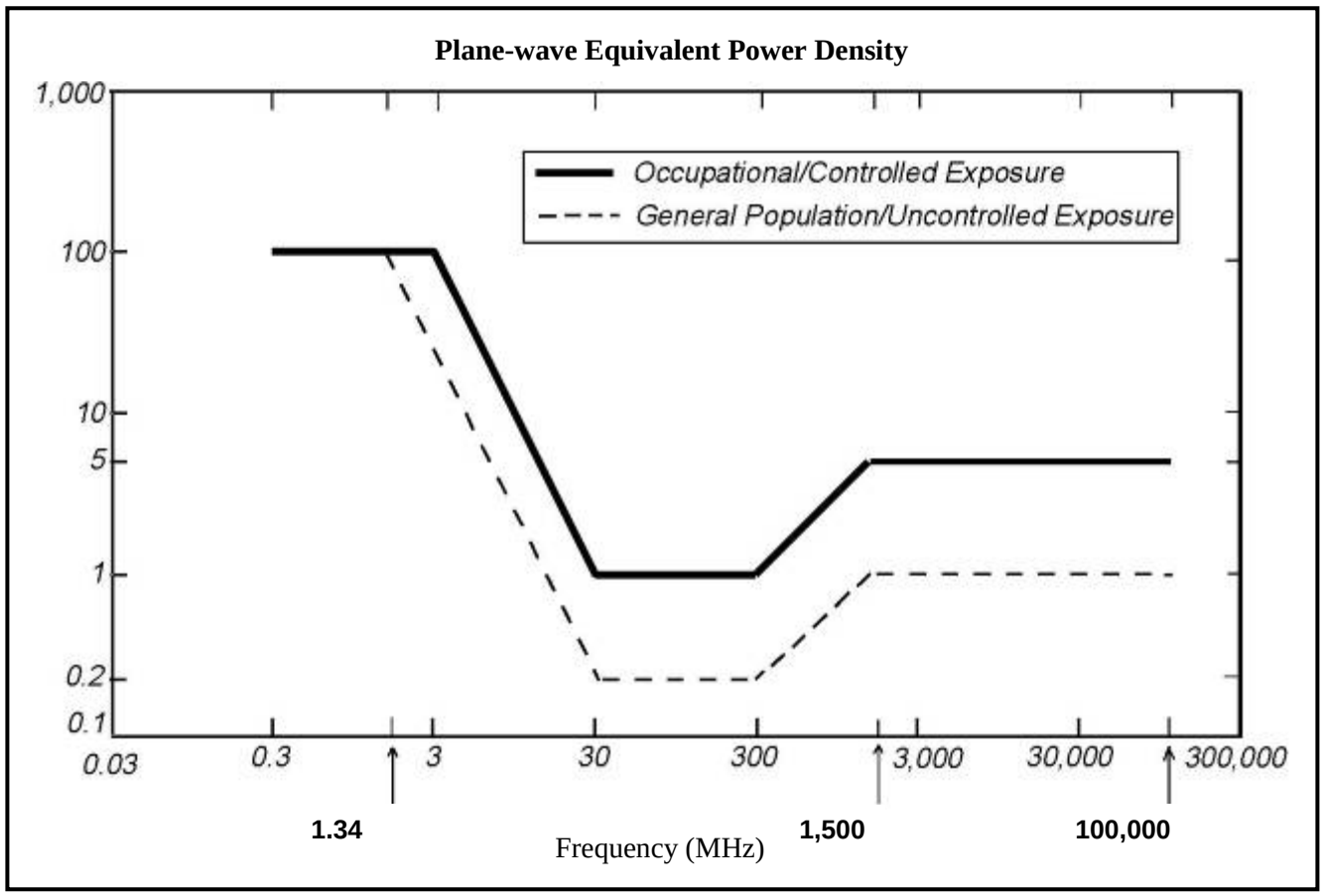
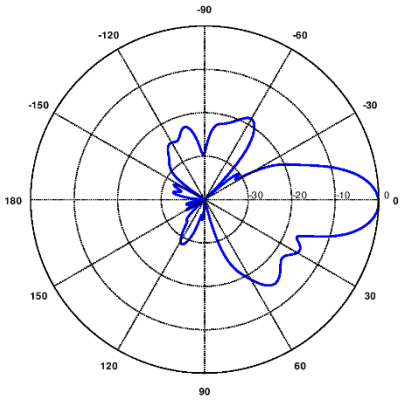
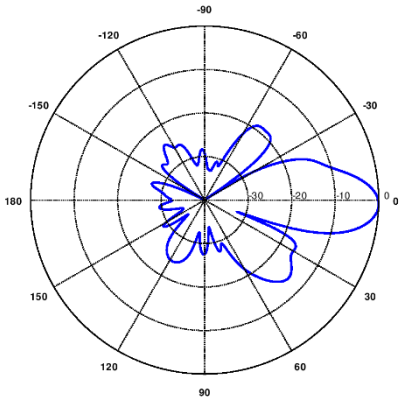
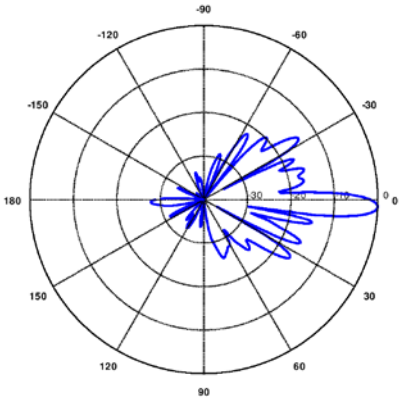



**Figure 3: Graph of FCC Limits for Maximum Permissible Exposure (MPE)**

## Attachment C: Antenna Model Data Sheets and Electrical Patterns

| | |
|---|---|
| **751 MHz**<br>Manufacturer: Commscope<br>Model #: NHH-65A-R2B<br>Frequency Band: 698 - 806 MHz<br>Gain: 13.4 dBi<br>Vertical Beamwidth: 17.8°<br>Horizontal Beamwidth: 66°<br>Polarization: ±45°<br>Size L x W x D: 55.6” x 11.9” x 7.1” |  |
| **885 MHz**<br>Manufacturer: Commscope<br>Model #: NHH-65A-R2B<br>Frequency Band: 806–896 MHz<br>Gain: 13.5 dBi<br>Vertical Beamwidth: 16.2°<br>Horizontal Beamwidth: 61°<br>Polarization: ±45°<br>Size L x W x D: 55.6” x 11.9” x 7.1” |  |
| **2100 MHz**<br>Manufacturer: Commscope<br>Model #: NHH-65A-R2B<br>Frequency Band: 1920 - 2200 MHz<br>Gain: 17.1 dBi<br>Vertical Beamwidth: 6.1°<br>Horizontal Beamwidth: 61°<br>Polarization: ±45°<br>Size L x W x D: 55.6” x 11.9” x 7.1” |  |