PIVOTAL COMMWARE

Application for Experimental Authority
File No. 0995-EX-CN-2018
Call Sign: WN9XDE

Supplemental Information
Correspondence Reference Number: 45790

Question 1: Please clarify the requested frequency bands.

Applicant seeks authority to operate in the 14.5 – 15.35 GHz band. This is consistent with the STA granted by the Commission, and consistent with the applicant's supplemental information, filed October 16, 2018 (correspondence reference number 44034) to its application for an STA.

Question 2A: What is the size of the proposed antenna(s)?

13" x 13"

Question 2B: Please submit the antenna pattern performances.

See Exhibit 1 for a computer-generated antenna pattern. Applicant seeks experimental authorization to conduct "real-world" testing, and among other things, to generate real-world antenna patterns.

Question 3: Please submit a radiation hazard study for the proposed antenna(s).

See Exhibit 2.

Question 4: Notification to potentially affected earth station operators

Applicant does not seek authority to operate in the 14.4 – 14.5 GHz band. See response to Question 1 above. Therefore, notification to earth station operators is not necessary.

Question 5: Please provide a point of contact to terminate operations (aka a "stop buzzer").

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Exhibit 1

Antenna Patterns

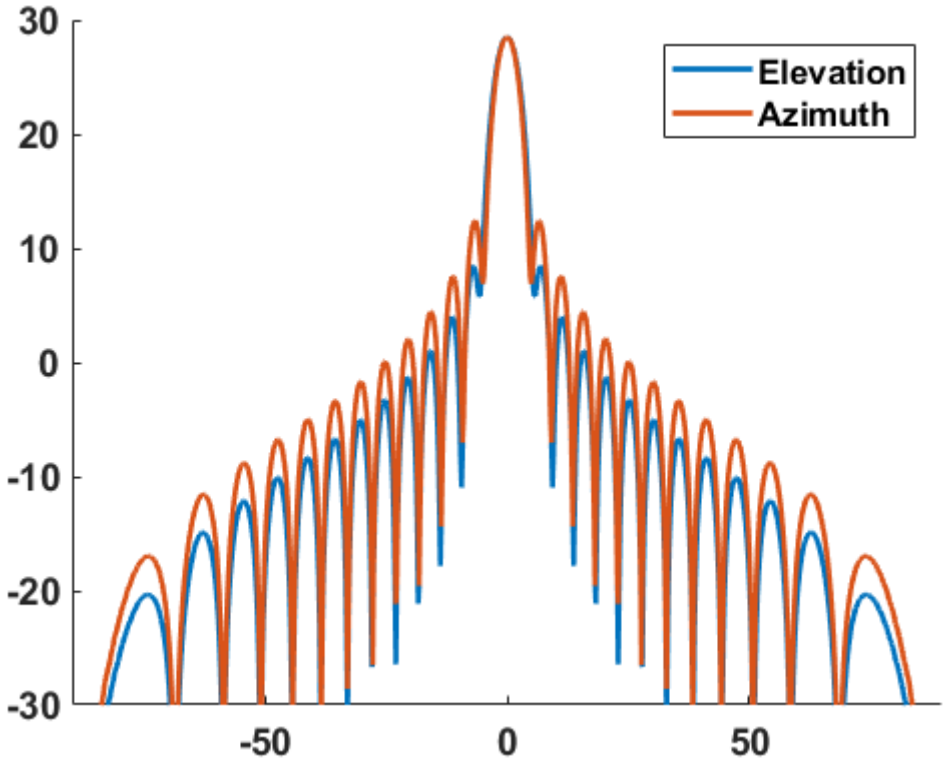

Exhibit 2

Pivotal Commware

RF Safety Analysis

October 2018

Introduction

The purpose of this report is to provide an analysis of radio frequency (RF) radiation levels for Pivotal Commware's HBF-1 device. The device will be operated on a 12-foot tower next to Pivotal's Kirkland, Washington headquarters. This area will only be accessible to trained personnel and inaccessible to the general public.

The formulas used in Sections 2 through 7 of this analysis are consistent with the guidelines provided in OET Bulletin No. 65, Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields, Edition 97-01. The FCC guidelines specify maximum permissible exposure (MPE) limits for two categories: (1) general population/uncontrolled and (2) occupational/controlled exposure limits. The general population/uncontrolled exposure limit is specified as 1 mW/cm^2 averaged over 30 minutes while the occupational/controlled limit is specified as 5 mW/cm^2 averaged over 6 minutes.

Table 1 defines the major parameters used in the analysis.

Table 1: Definition of parameters used in the analysis.

Parameter	Symbol	Value
Input power (W)	P	3
Gain (dBi)	G	28.5
Antenna area (cm^2)	A	676
Antenna diameter (cm)	D	30
Frequency (GHz)	f	15
Wavelength (cm)	λ	2
Total antenna efficiency (%)	η	35

1 Antenna Surface Region Analysis

Equation 1 defines the power density at the surface of the antenna for RF hazard assessment purposes.

$$S_{Surface} = \frac{4P}{A} = 17.75\ mW/cm^2 \qquad (1)$$

The power density at and just outside the surface of the antenna is not compliant with the controlled and uncontrolled MPE limits. Pivotal employees requiring access to this region of the antenna will be properly trained and made aware of the potential for exposure and the time-

averaging considerations specified in OET Bulletin 65 Edition 97-01, pages 9 through 11 and Appendix A, Table 1 on page 67. Antenna power will be switched off whenever maintenance requires access to this region.

2 Antenna On-Axis Near-Field Region Analysis

Equation 2 defines the near-field region from the center of the antenna.

$$R_{nf} = \frac{D^2}{4\lambda} = 1.1\ m \qquad (2)$$

$$S_{nf} = \frac{16\eta P}{\pi D^2} = 5.95\ mW/cm^2 \qquad (3)$$

Where R_{nf} represents the near-field distance from the center point of the antenna along the main beam axis.

The power density level in the near-field region is not compliant with the MPE limits for uncontrolled or controlled exposure. As indicated previously, the area around the antenna is a controlled environment that will not be accessible to the general public.

3 Antenna On-Axis Transition Region Analysis

The transition region exists between the end of the near-field region and the beginning of the far field region. The power density in this region varies inversely with distance R and is represented by Equation 4.

$$S_t = \frac{S_{nf} * R_{nf}}{R} \qquad (4)$$

Where S_t represents the power density in the transition region. Table 2 contains calculated power densities for various distances in this region.

Table 2: Power density in the transition region.

Distance R (m)	Power Density (mW/cm²)
1.1	5.95
1.5	4.36
2.24	2.98
2.5	2.62

The power density levels in the transition region are not compliant is not compliant with the MPE limits for uncontrolled exposure, but are complaint with the controlled exposure limits

except at 1.1 meters (the near field distance). As noted previously, the area around the antenna is a controlled environment that will not be accessible to the general public.

4 Antenna On-Axis Far-Field Region Analysis

Equation 5 defines the far-field region from the center of the antenna, and Equation 6 defines the power density in the far-field region.

$$R_{ff} = \frac{0.6*D^2}{\lambda} = 2.7\ m \qquad (5)$$

$$S_{ff} = \frac{P * G_{factor}}{4\pi R^2} \qquad (6)$$

Where G_{factor} is defined as $10^{(G/10)}$, R_{ff} represents the end of the transition region and the beginning of the far-field region, and S_{ff} is power density in the far-field region.

Using Equation 6, the distances for compliance with uncontrolled exposure limits are as follows:

- Distance for uncontrolled MPE Compliance = **4.1 m**

The distances for compliance with controlled exposure limits are as follows:

- Distance for controlled MPE Compliance = **1.8 m**

As indicated previously, the area around the antenna is a controlled environment that will not be accessible by the general public. Appropriate training manuals will ensure that operators and maintenance technicians will not be subject to excessive levels of RF radiation.

5 Antenna Off-Axis Near-Field and Transition Region Analysis

OET Bulletin 65 prescribes that at a point of interest about one diameter away from the main beam axis the power density level is estimated to be a factor of 100 or 20 dB lower than that of the peak of the beam. Equation 7 provides the power density level in this area.

$$S_{nf\_off-axis} = \frac{S_{nf}}{100} = 0.0595\ \text{mW/cm}^2 \qquad (7)$$

This level is compliant with controlled and uncontrolled MPE limits.

6 Antenna Off-Axis Far-Field Region Analysis

The far-field antenna radiation pattern can be used to compute power density at an off-axis angle formed between the central antenna axis and the desired point. The on-axis power

density at 2.7 m, which represents the beginning of the far-field region, is 2.42 mW/cm^2. For example, at a point about 5° away from the center line (off-axis region) while the antenna is pointed at broadside and down the horizon, the power density is reduced by about 13 dB (first sidelobe level), resulting in a power density of approximately 0.12 mW/cm^2.

This level is compliant with controlled and uncontrolled MPE limits. This RF safety analysis examines off-axis RF hazard scenarios and concludes there are no material safety concerns in the off-axis case.

7 Operational RF Safety Considerations

Pivotal employees requiring access to regions of the antenna that exceed the controlled MPE limits will be properly trained and made aware of the potential for exposure and the time-averaging considerations specified in OET Bulletin 65 Edition 97-01, pages 9 through 11 and Appendix A, Table 1 on page 67. Antenna power will be switched off whenever maintenance requires access to these region.

8 Summary

Pivotal employees requiring access to regions of the antenna that exceed the controlled MPE limits will be properly trained and made aware of the potential for exposure. Antenna power will be switched off whenever maintenance requires access to these regions.

The area around the antenna is a controlled environment on private property. Further, the antenna will be mounted at the top of a 12-foot tower. For these reasons, the general public will not have access to any regions of the antenna that exceed the uncontrolled MPE limits.