Raytheon Request for FCC Experimental License

File Number: 0431-EX-CN-2017
Date: 06/05/2017

Purpose of Operation:
Frequency authorization is being requested for X-band at frequencies between 9000 – 9200 MHz, in order to test prototype radar arrays in a relevant environment. Outdoor testing, across multiple frequencies as noted above is required to assess hardware compliance with requirements and to continue research and development.

Technical Synopsis:

- Spectrum needed: 9000 - 9200 MHz.
- A minimum of 2 frequencies separated by at least 12 MHz.
- Power levels requested: 160 W output power, 953.4 kW ERP (peak)
- Location of use: Raytheon Facility in Burlington, MA
- Direction of radiation: Boresite 288° +/- 20° with a +/- 45 degree scan angle
- Stop buzzer contacts: Nate Miller (507-421-9830) and Karen Dyberg (508-450-9236)

Test Summary:
The system will transmit pulsed Frequency Modulated (Chirp) waveforms. For all waveform types, the maximum pulse duration is 55µs and the maximum duty factor is 22%. See the detailed waveform explanation in a later section. Each operational frequency requires approximately 12 MHz of spectrum. At least 2 separate frequencies are necessary to conduct our research and development effort, however 4 frequencies are preferred. It is expected that the radars will be operated periodically, < 8 hours a day, up to 7 days a week.

RF Hazard Calculations and Site Safety Measures:
Initial calculations show that general public exposure limits will be reached at a 2.25 meters distance and occupational exposure limits at 1.0 meter, using formula (7) from FCC OET Bulletin 65 "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields", dated August 1997. These calculations take into account the highest duty factor of 22% and the raster scan pattern utilized by the radar.

Raytheon's RF safety group is involved in all testing that requires free space radiation to ensure that no personnel are subjected to RF power density levels exceeding the Maximum Permissible Exposure (MPE) limits of the Part 1.1310 of the FCC Rules and the guidelines in FCC's OET Bulletin Number 65. An RF Safety Control Plan will be in place for the tests. The Plan will define the procedures and controls required to prevent personnel exposure to levels which exceed the MPE. To verify the safety of personnel, an RF survey will be performed at the initial turn-on of the system. All measured levels, where personnel have access, must be below the MPE limits before testing can proceed.

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Spectrum Management/RF Safety
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Equipment Information:
Indicate all equipment that will be involved in this operation.

Transmitter info:

Manufacturer:	Raytheon
Model:	LPR3
Number of units:	6
Experimental (Y/N):	Y

For each frequency band:
RF output at the transmitter terminals:
160 Watts peak

Effective radiated power from the antenna (if pulsed emission, specify peak power):
The effective radiated power from the antenna, including antenna transmit gain and front-end losses, is 953.4 kW (peak power).

EIRP = Power * gain, Power = 160 W, gain = 39.9 dBi, EIRP = 160 * 9772.37 = 1563579.2 W
ERP = EIRP/1.64 = 953402 W or 953.4 kW

Frequency Tolerance:
Less than 0.001 %

List each type of emission separately for each frequency (basically list the emission designators)
The LPR3 can tune at 1 MHz intervals within the band(s) authorized.

For each tunable frequency authorized, the LPR3 has the following emission designators:
4M7Q3N - 55µsec FM-Pulsed (LP) with a 2 MHz LFM chirp, centered at Ftune – 3 MHz
7M1Q3N - 6µsec FM-Pulsed (SP) with a 2.5 MHz NLFM chirp, centered at Ftune + 3 MHz

The transmit waveform chain-pulse sequence transmits a Long Pulse (LP) then a Short Pulse (SP) for each pulse repetition interval (PRI). The PRI for a pulse sequence is 256 usec (PRF = 3906.25 Hz). The Long Pulse (LP) is 55 usec pulse length using a 2 MHz linear FM chirp at a

22% duty factor. The Short Pulse (SP) is a 6 usec pulse length using a 2.5 MHz non-linear FM chirp at a 2.3% duty factor.

IMPORTANT: The pulse sequence requires 11.9 MHz (LP necessary bandwidth/2 + SP necessary bandwidth/2 + 6.0 MHz = 4.7/2 MHz + 7.1/2 MHz + 6.0 MHz = 11.9 MHz) Therefore the emission designator is defined as 12M0Q3N.

List as appropriate for the type of modulation:
LP: Linear Frequency-Modulated Pulsed (Chirp)
SP: Non-Linear Frequency-Modulated Pulsed (Chirp)

Necessary bandwidth. Explain how determined.
The necessary bandwidth was calculated using the equations in Annex J of the NTIA Manual.

Locations:
The street address for the Raytheon location is 3 Van de Graaff Drive, Burlington, MA 01803. The ground elevation of the facility is 69 meters above sea level. The radars will be located on mounted on a rooftop at following coordinates: 42º 28' 57.61" North, 071º 11' 57.27" West.

Is a directional antenna (other than radar used)?
No.

If yes, give the following info: (Although not necessary for this application, additional antenna detail is provided below)

Width of beam in degrees at the half-power point:
1.98° Azimuth, 2.1° Elevation at boresight
Orientation in horizontal plane:
+/- 45° Electronically Scanned
Orientation in vertical plane:
0° to 30°, relative to ground horizontal, electronically scanned

Will the antenna extend more than 6 meters above ground, or if mounted on an existing building, will it extend more than 6 meters above the building, or will the proposed antenna be mounted on an existing structure other than a building?
No.

Overall height above ground to tip of antenna in meters:
About 11 meters when mounted on the rooftop.

Necessary Bandwidth Calculation Table

FM-Pulsed Radar		
Modulation	LFM	NLFM
Pulse Width (µsec)	55	6
Rise Time (µsec)	0.128	0.128
Fall Time (µsec)	0.128	0.128
Chirp BW (MHz)	2	2.5
Necessary BW (MHz)	4.7	7.1
Designator	4M7Q3N	7M1Q3N

Necessary BW Formula

Symbols:

t = Emitted pulse duration at 50% amplitude (voltage) points. The 100% amplitude point is the nominal peak level of the pulse.

t_r = Emitted pulse rise time in µsec from the 10% to the 90% amplitude points on the leading edge.

t_f = Emitted pulse fall time in µsec from the 90% to the 10% amplitude points on the trailing edge.

$$B_n = B(-20dB) = \frac{1.79}{\sqrt{t_r t}} + 2B_c$$

FM-Pulsed Radar: *If t_f is less than t_r, then t_f is to be used in place of t_r when performing the necessary bandwidth calculations.