Raytheon Request for FCC Special Temporary Authorization (STA)

STA File Number: 0986-EX-ST-2016
Date: 6/29/2016

Purpose of Operation:
Frequency authorization is being requested for the period of August 1, 2016 – January 23, 2017 in X-band at frequencies between 9.55 – 9.65 GHz, 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. Up to two units will be tested over this range simultaneously.

Technical Synopsis:

- Spectrum needed: 9.55 – 9.65 GHz
- Power levels requested: 160 W output power, 953.4 kW ERP (peak)
- Location of use: Raytheon Test Facility in Marlborough, MA
- Direction of radiation:
    - Antenna 1: North West (nominally boresite 343º)
    - Antenna 2: North East (nominally boresite 73º)
    - Each antenna has a +/- 45 degree scan angle
- Stop buzzer contacts: Robert Palumbo (978-376-7321), Nate Miller (507-421-9830), and Rene Messier (774-696-3634)

STA Explanation:
The purpose of this request for Special Temporary Authorization is to test array compliance to RF performance requirements in a relevant environment. Radar development testing is planned at the Raytheon facility in Marlborough, MA.

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%. It is expected that the radars will be operated periodically during the STA period, < 8 hours a day, up to 7 days a week, for the duration of the STA.

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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Period of Use:
Start date: August 1, 2016
End date: January 23, 2017

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 = 15635972 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 – 2 MHz
7M1Q3N - 6μsec FM-Pulsed (SP) with a 2.5 MHz NLFM chirp, centered at Ftune + 2.5 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. Note: the pulse sequence requires 10.4 MHz (LP necessary bandwidth/2 + SP necessary bandwidth/2 + 4.5 MHz = 4.7/2 MHz + 7.1/2 MHz + 4.5 = 10.4 MHz

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 1001 Boston Post Road, MA 01752. The ground elevation of the facility is 70 meters above sea level. The radars will be located on Raytheon property, either on a trailer on the ground or mounted on a rooftop, within 0.4 km of the following coordinates: 42º 20' 44" North, 071º 29' 29" 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:
No more 3 meters above ground level if installed on a trailer and 14 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.

Designators

FM-Pulsed Radar

Designators (NTIA)			
Prefix	Necessary Bandwidth	##M#	Megahertz with M at decimal
Emissions	Type of Modulation Main Carrier	Q	In which the carrier is angle-modulated during the period of the pulse (i.e. chirp, FM).
Emissions	Nature of signals modulating	3	A single channel containing analogue information.
Emissions	Type of Info transmitted	N	No Information Transmitted.