

Raytheon Request for FCC Special Temporary Authorization (STA)

STA File Number: 1184-EX-ST-2015

Date: 11/3/2015

Purpose of Operation:

Frequency authorization is being requested for the period of November 20, 2015 – May 13, 2016 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. Only one unit will be tested at a time.

Technical Synopsis:

- Spectrum needed: 9.55 – 9.65 GHz
- Power levels requested: 160 W output power, 953.4 kW ERP (peak)
- Location of use: NTIA-ITS Table Mountain Antenna Fields Site in Boulder, Co and Raytheon Test Facility in Sudbury, MA
- Direction of radiation: South East with +/- 45 degree scan angle with ability to adjust mechanically about boresite pointing angle +/- 30 degs)
- Stop buzzer contact: Robert Palumbo, 978-376-7321

STA Explanation:

The Raytheon Low Power Radar 2 (LPR2) array is planned to be tested at the NTIA-ITS Table Mountain Antenna Fields Site in Boulder, Co, over the period of November 20, 2015 – May 13, 2016. 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 in parallel at the Raytheon facility in Sudbury, 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, Mon - Sat, 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: November 20, 2015
End date: May 13, 2016

Equipment Information:

Indicate all equipment that will be involved in this operation.

Transmitter info:

Manufacturer: Raytheon
Model: LPR2
Number of units: 7
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).

$\text{Power} * \text{gain} = \text{EIRP}$, $\text{gain} = 39.9 \text{ dBi}$, $\text{EIRP} = 160 * 9772.37 = 15635972 \text{ W}$
 $\text{ERP} = \text{EIRP}/1.64 = 953402 \text{ W}$ 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 LPR2 can tune at 1 MHz intervals within the band(s) authorized. For 9.6 GHz operation, Ftune is 9.6 GHz.

For each tunable frequency authorized, the LPR2 has the following emission designators:

4M7Q3N - 55µsec FM-Pulsed (LP) with a 2 MHz LFM chirp, centered at Ftune – 1.5 MHz

7M1Q3N - 6µsec FM-Pulsed (SP) with a 2.5 MHz NLFM chirp, centered at Ftune + 1.25 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 2.5MHz non-linear FM chirp at a 2.3% duty factor.

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:

1. The outdoor test facility at Table Mountain Antenna Fields Site in Boulder, Co is located at North 40°07'58", West 105°14'42" and ground elevation of 1698 meters above sea level. The approximate location of the radar will be within a 2 km radius of the location stated.
2. The Raytheon facility in Sudbury, MA, is located at North 42°21'57", West 71°25'56" and ground elevation of 50 meters above sea level. The street address is 528 Boston Post Rd, Sudbury, MA 01776. The approximate location of the radar will be at North 42°21'57.7", West 71°25'55".

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, the radar and antenna are installed on a short (< 4 meter tower) with a small cabin located at its base to house the radar processing equipment.

Overall height above ground to tip of antenna in meters:

Maximum of about 4 meters or less above the local ground level

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.

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

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.