F-22 GPS Re-Radiation (Re-Rad) System Technical Description

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Purpose for the Application

The purpose of this application is to obtain a 2-year experimental license to operate a GPS re-radiation system supporting aircraft development and testing.

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Why we are Applying for a License

The Boeing Company would like the ability to perform functional testing of receive GPS systems inside a building in order to support testing of aircraft subsystems with integrated GPS receivers.

Technical Description

This technical description shows compliance with all NTIA items in Chapter 8.3.28.

1. Individual authorization is for indoor use only, and is required for each device at a specific site. ***Operation will be conducted indoors. The device information is provided in application and specific site information provided below.***

2. Applications for frequency assignment should be applied for as an XT station class with a note indicating the device is to be used as an "Experimental RNSS Test Equipment for the purpose of testing GPS receivers" and describing how the device will be used.

3. Approved applications for frequency assignment will be entered in the GMF. ***Boeing concurs.***

4. The maximum length of the assignment will be two years, with possible renewal. ***Boeing concurs.***

5. The area of potential interference to GPS reception (e.g., military or contractor facility) has to be under the control of the user. ***The site is under Boeing's control.***

6. The maximum equivalent isotropically radiated power (EIRP) must be such that the calculated emissions are no greater than -140 dBm/24 MHz as received by an isotropic antenna at a distance of 100 feet (30 meters) from the building where the test is being conducted. The calculations showing compliance with this requirement must be provided with the application for frequency assignment and should be based on free space propagation with no allowance for additional attenuation (e.g., building attenuation.) ***Link budgets provided below and meet specified levels. Calculations do not allow for building attenuation.***

7. GPS users in the area of potential interference to GPS reception must be notified that GPS information may be impacted for periods of time. ***GPS users in area will be notified.***

8. The use is limited to activity for the purpose of testing RNSS equipment/systems. ***Use will be limited to testing RNSS equipment.***

9. A "Stop Buzzer" point of contact for the authorized device must be identified and available at all times during GPS re-radiation operation of the device under any condition. ***Stop Buzzer information provided below.***

Location

The GPS Re-Radiation systems will be installed on one building. The specific location of the system is:

38-44-53N
90-21-12W

Military Contract Numbers

The facilities identified above support work accomplished under contract. The current contract numbers are:

1) FA8611-13-D-2850 F-22 contract supporting integration testing.

Stop Buzzer

Primary Stop Buzzer:
John T. Podgajny
Work Desk: 314-563-7047
Home Phone: 618-560-3606

Backup Stop Buzzer:
Tony E. Gibson
Work Desk: 314-545-5703
Home Phone:

Technical Description

System:

Receiving and transmitting antennas with LNAs and attenuators to control radiating power.

Frequency: L1 1575.42 MHz
Emission: 24M0G1D

Frequency: L2 1227.60 MHz
Emission: 24M0G1D

Boeing F-22 Agile Integration Lab (AIL) Flying Test Bed (FTB) – Ground Laboratory
GPS Re-Radiator Design
12/10/2019

Requirements:

1. Provide range limited GPS repeater capability to the Boeing F-22 AIL FTB – Ground Laboratory, located in building 60C of the Boeing St. Louis facility at the following geodetic coordinates: 38º 44’ 53.4” N x 90º 21’ 11.9” W.
2. Within the AIL FTB Ground Lab, allow limited portability of the re-radiating antenna by providing a 30 Ft. flexible cable that extends from a wall mounted enclosure to the re-radiating antenna.
3. Use the following equipment to control the Re-radiated GPS RF power (or equivalent):
    a. Roof-top antenna with built in 40 dB LNA (Sensor Systems S67-1575-96 GPS Antenna with built in 40 dB LNA)
    b. Low Loss RF Cable – 70 Ft (Times Microwave LMR-400-DB)
    c. Additional 40 dB LNA (GPS Source A114M 40 dB In-line LNA)
    d. Fixed Attenuator – 10 dB (Pasternack PE7091-10)
    e. Variable Attenuator to further attenuate the GPS RF as needed based on GPS receiving equipment in the lab (JFW Industries 50DR-055-SMA)
    f. Flexible RF Cable – 30 Ft. (Times Microwave LMR-400-UF)
    g. GPS Re-radiating antenna (Sensor Systems S67-1575-714)
    h. See Figure 1 below for the proposed F-22 AIL FTB Ground Lab Re-Radiator System
4. Range limitation (Based on an NTIA maximum of -140 dBm/24 MHz at 100 feet):

a. L1: Total re-radiated power across a 24 MHz band centered at 1572.42 MHz shall not exceed -140 dBm at a distance of 100 Ft.
b. L2: Total re-radiated power across a 24 MHz band centered at 1227.60 MHz shall not exceed -140 dBm at a distance of 100 Ft.

Physical Design:

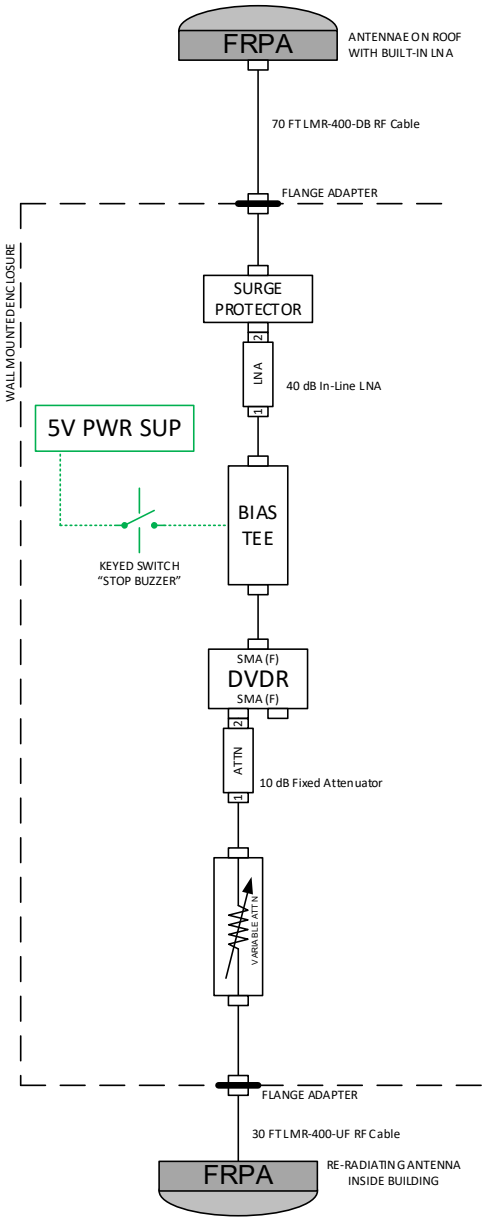

Figure 1, F-22 AIL FTB Ground Lab Re-Radiator System

Functional Description:

GPS Satellite signals received and amplified by the roof-top antenna are conducted through a 70 foot transmission line (coaxial cable) into the F-22 AIL FTB Ground Lab wall mounted junction box. The roof-top antenna will be mounted on a pole and not be higher than 2 ft from roof surface. The wall mounted junction box contains a 40 dB LNA and a Bias-T to provide DC power to the local LNA and the roof-top antenna's LNA. It also contains a 10 dB attenuator to ensure re-radiated power levels at 100 Feet are below the NTIA maximum of -140 dBm/24 MHz. There is also a variable attenuator necessary to reduce the re-radiated signal level below the target GPS receiver's maximum input. This variable attenuator will also allow the ability to lower the re-radiated signal level such that any potential multipath portions of the signal below

From the wall mounted junction box, the re-radiating antenna is tethered by a 30 foot flexible cable. This cable allows the re-radiating antenna to be semi-portable within the F-22 AIL FTB Ground Lab. However, the antenna will be ceiling mounted in a location between the most commonly used test stations requiring radiated GPS signals for the majority of required testing. With power levels at 100 foot distance from the re-radiating antenna approaching -142 dBm (-172 dBW) inside a metal enclosure (lab building) smaller than the 100 ft requirement, the likely-hood of interference with other systems beyond 100 feet is reduce to nearly zero. The target GPS receivers (most commonly, weapon system GPS receivers under test in the laboratory) to be excited by the re-radiator antenna have maximum sensitivities in the range of -140 dBm (slightly above the re-radiator signal level at 100 feet).

Below are the calculations demonstrating NTIA compliance at 100 Feet.

Part No	Description	Multiplier length (ft) attn (dB)	L1 RF Power delta (dB)	L1 RF Power (dBm)	L2 RF Power delta (dB)	L2 RF Power (dBm)
	Frequency		1575.42		1227.60	
	GPS Satellite Signal at Earth's Surface			-130.00		-133.00
S67-1575-96	GPS Active Antenna (Gain = -4.5 dBi, LNA = +40 dB)		35.5	-94.50	35.5	-97.50
LMR-400-DB	Low Loss, External, RF Cable	70	-3.71	-98.21	-3.22	-100.72
PE9276	RF Flange Adapter		-0.1	-98.31	-0.1	-100.82
PE34414-XX	RF Cable - SMA/TNC	0.5	-0.0115	-98.32	-0.0115	-100.83
PE73SP1016	RF Surge Protector		-0.1	-98.42	-0.1	-100.93
A114M	40 dB in-line LNA		40	-58.42	40	-60.93
PE34414-XX	RF Cable - SMA/TNC	0.5	-0.0115	-58.43	-0.0115	-60.94
PE1605	Bias Tee		-0.2	-58.63	-0.2	-61.14
PE34414-XX	RF Cable - SMA/TNC	1	-0.023	-58.66	-0.023	-61.17
PE2074	Power Divider		-3.4	-62.06	-3.4	-64.57
PE7091-X	RF Fixed Attenuator	10	-10	-72.06	-10	-74.57
PE34414-XX	RF Cable - SMA/TNC	1	-0.023	-72.08	-0.023	-74.59
50DR-055-SMA	Variable Attenuator	0.8	-0.8	-72.88	-0.8	-75.39
PE34414-XX	RF Cable - SMA/TNC	0.5	-0.0115	-72.89	-0.0115	-75.40
PE9276	RF Flange Adapter		-0.1	-72.99	-0.1	-75.50
LMR-400-UF	Low Loss, RF Cable	30	-1.89	-74.88	-1.65	-77.15
S67-1575-714	GPS passive antenna		-1	-75.88	-1	-78.15
	Maximum GPS Radiated Power @ 100ft = -140 dBm / 24MHz					
	Free Space Loss @ 100ft	100	-66.078		-63.91	
	Radiated Power @ 100ft			**-141.96**		**-142.06**