R1410 Radar Frequency Stability Test Report

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Prepared for:
Washington Labs
4840 Winchester Blvd Suite 5
Frederick, MD 21703

Prepared by:
SRC
6225 Running Ridge Road
North Syracuse, NY 13212
Telephone: (315) 452-8000

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1.0 INTRODUCTION

1.1 Purpose

This document will summarize the frequency stability testing performed at the SRC, Inc facility in December 2021. The data will support the requirements of FCC part 90.213.

1.2 Overview

The R1400 is a 3-D Active Electronically Scanned Array (AESA) air surveillance radar designed specifically for the detection of small, low-flying targets.

The R1410 provides rapid, precise detection and tracking of airborne targets including small unmanned aircraft systems (sUAS), general aviation aircraft, birds, and other cooperative or non-cooperative targets of interest.

This document will summarize the frequency stability testing performed at the SRC, Inc facility in December 2021. The data will support the requirements of FCC part 90.213.

1.3 Requirements

Frequency Stability (FCC pt90.213). This is a temperature and voltage deviation test performed per FCC Part 2.1055. The R1400 radar is tested in 10° increments from -30°C to +50°C, the operational temperature range, and the deviation in frequency of the carrier is recorded. In addition, the AC input voltage is varied +/- 15% about nominal line voltage. There is no limit in this frequency range (9300-9800MHz). The results are recorded.

2.0 OVERVIEW OF TEST RESULTS

Table 1**Error! Reference source not found.** summarizes the frequency stability of the R1410 over temperature and normalized to 20°C.

Temperature (°C)	Error @ 9300 MHz (kHz)	Error @ 9800 MHz (kHz)
-30	0.036	0.703
-20	-0.156	0.406
-10	0.184	-0.039
0	-0.434	0.79
10	-0.427	0.372
20	0	0
30	0.587	-0.028
40	-0.203	-0.76
50	-0.403	-0.224

Table 1. Frequency Stability Test Results Summary

Table 2 summarizes the DC voltage variation of the GS1016 power supply over a variation in AC input voltage.

V_{AC} (V)	V_{DC} (V)
93.5	52.45
110	52.46
126.5	52.47

Table 2. DC Voltage Variation Test Results Summary

3.0 TEST SETUP

3.1 Unit Under Test

Table 3 lists the part numbers and serial numbers for the critical and relevant subcomponents of the R1410 unit under test.

Part Number	Serial Number	Description
R1410	021	R1410 Radar (Top Level)
GS1007-14-02-HW	021	R1410 Receiver / Transmitter
GS1016	022	R1410 AC/DC Power Supply
GS1029	18100004	Digital Signal Processing Board
GS1004	20360009	Receiver / Exciter Board
GS1003	087,20250021,20180002,20460001	Front End RF Array Board
GS1051	18350004,18350023,18350077,18350081	Array Mezzanine Board
GS1030-4	18140021	Active Combiner Board
GS1011	18190035	DC Power Board
GS1014	18200044	DC Power Board

Table 3. Unit Under Test Serial / Part Numbers

The radar receiver/transmitter (GS1007) and the power supply (GS1016) were placed in a temperature chamber and the ambient temperature was varied from -30°C to 50°C in 10°C increments. The radar was set to a mode to output a pulsed continuous wave (CW). The radar's output waveform was captured via a spectrum analyzer. For this portion of the test, the input voltage was 110VAC. Figure 1 is a block diagram of the set-up and Figure 2 and Figure 3 are pictures of the test equipment.

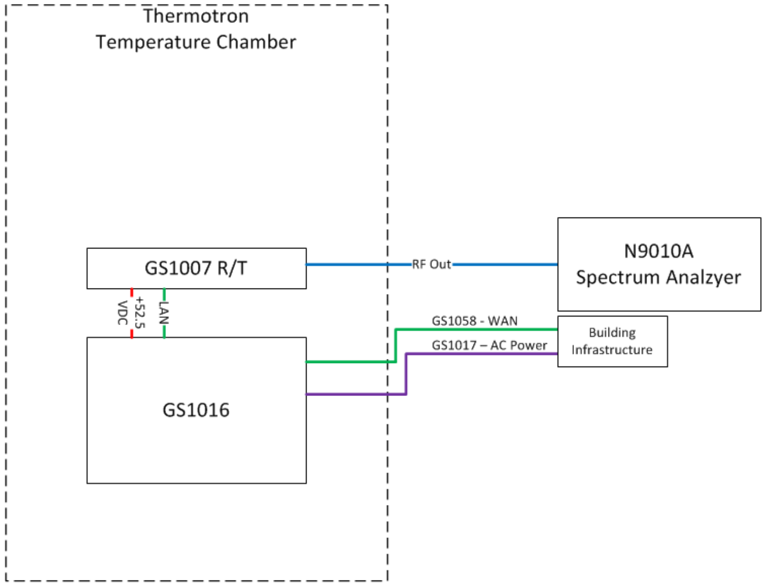

Figure 1. Frequency Stability Test Setup

Figure 2. Themotron Temperature Chamber

Figure 3. Keysight N9010A Spectrum Analyzer

The R1410's waveform, Digital to Analog conversion and frequency up-conversion from first Intermediate Frequency (IF) to final Radio Frequency (RF) at X-Band are generated entirely on the Receiver/Exciter board (REX). The REX has two possible outputs for the transmit waveform. The first output is fed to the planar arrays during tactical operation. The second is switched into a test output that is available via a SMA bulkhead on the radar chassis. The test output bypasses the arrays and is typically only used during the array calibration procedure. For the frequency stability testing, the output waveform was switched into the test output and the radar arrays were off and bypassed. This was done for several reasons:

1) It would have been difficult to sample the waveform after the radar arrays. This would require a near-field coupled probe to capture the waveform over-the-air. Also, the radar would need to be protected against reflected power as the interior of the temperature chamber is reflective metal.

2) The REX board's performance captures the frequency stability response of the system in total. The Local Oscillators and Master Oscillator are located on this board and are the single greatest contributors to frequency stability. The array will not contribute to any frequency stability over temperature.

Given the care that would need to be taken to ensure the R1410 under test would not be damaged in the chamber, and the fact that the arrays don't contribute to frequency stability, it was determined that valid data could be captured and analyzed bypassing the array via the "RF Out" test port. Figure 4 shows the radar's basic block diagram and Figure 5 highlights the test output bulkhead connector.

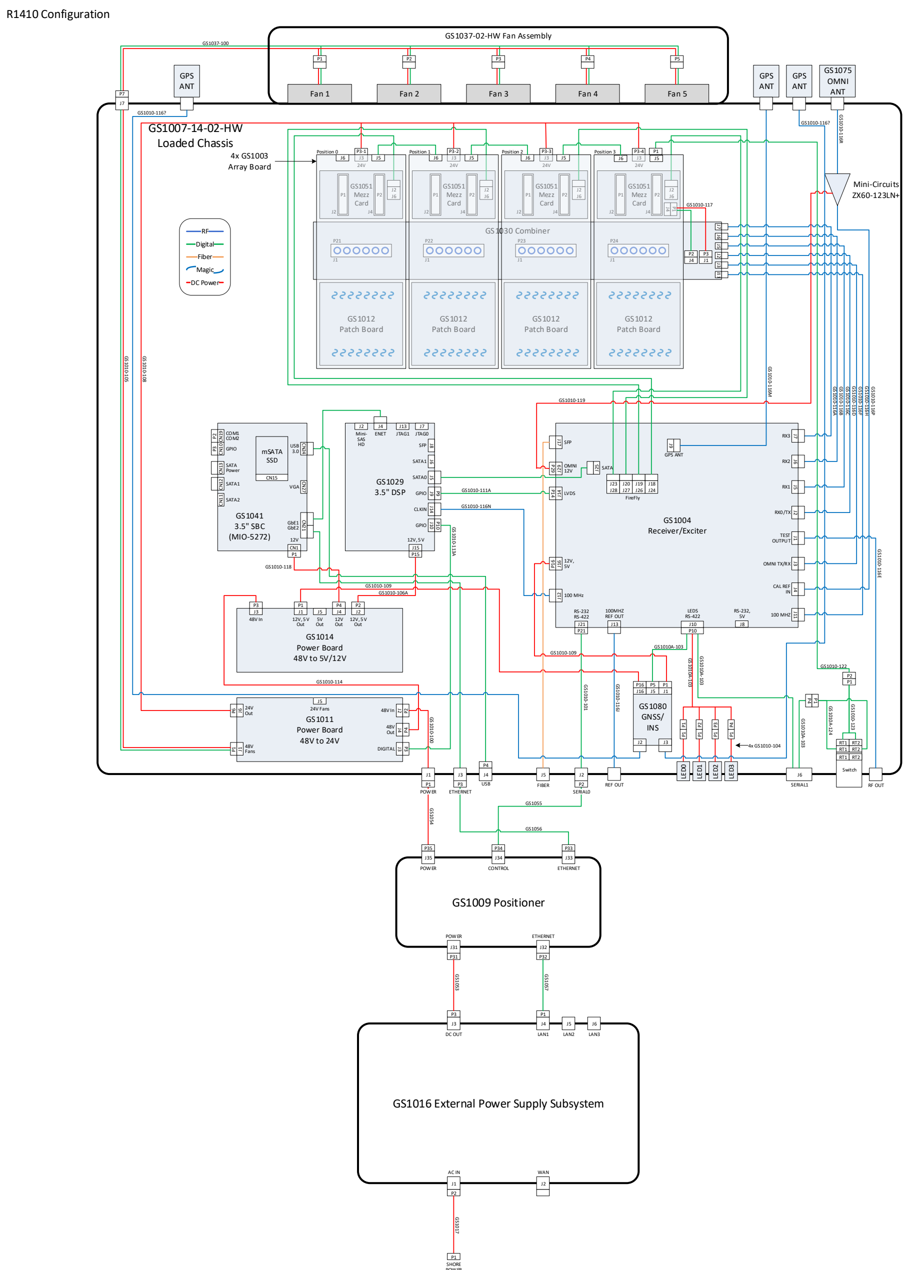

Figure 4. R1410 Functional Block Diagram

Figure 5. R1410 Back Panel / RF Out Port

Following temperature testing, the GS1016 power supply was tested at room temperature, 21°C, over the required voltage deviation of +/-15%. Variation of the input voltage was achieved with a variable autotransformer, or “VARIAC”. The autotransformer can provide sufficient current to run the power supply in a quiescent mode but cannot provide enough power for the entire radar assembly. As such, voltage deviation was tested on a standalone power supply and the radar’s frequency deviation was analyzed from those results and the system’s design. Figure 6 is a picture of the autotransformer used for testing. Figure 7 is a block diagram of the setup for the voltage deviation test.

Figure 6. Autotransformer

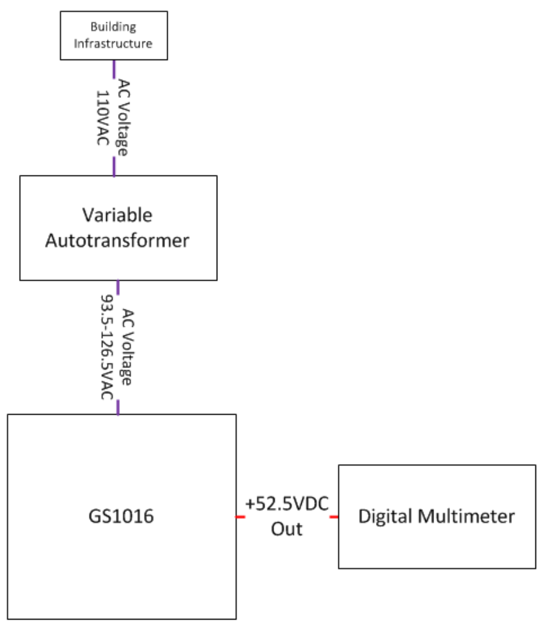

Figure 7. Input Voltage Deviation Block Diagram

4.0 DETAILED TEST RESULTS

The R1410 waveform under test was a pulsed CW waveform. The CW's amplitude response, in the spectral domain, has a defined peak at the carrier frequency. Figure 8 is an example capture of the R1410 spectrum.

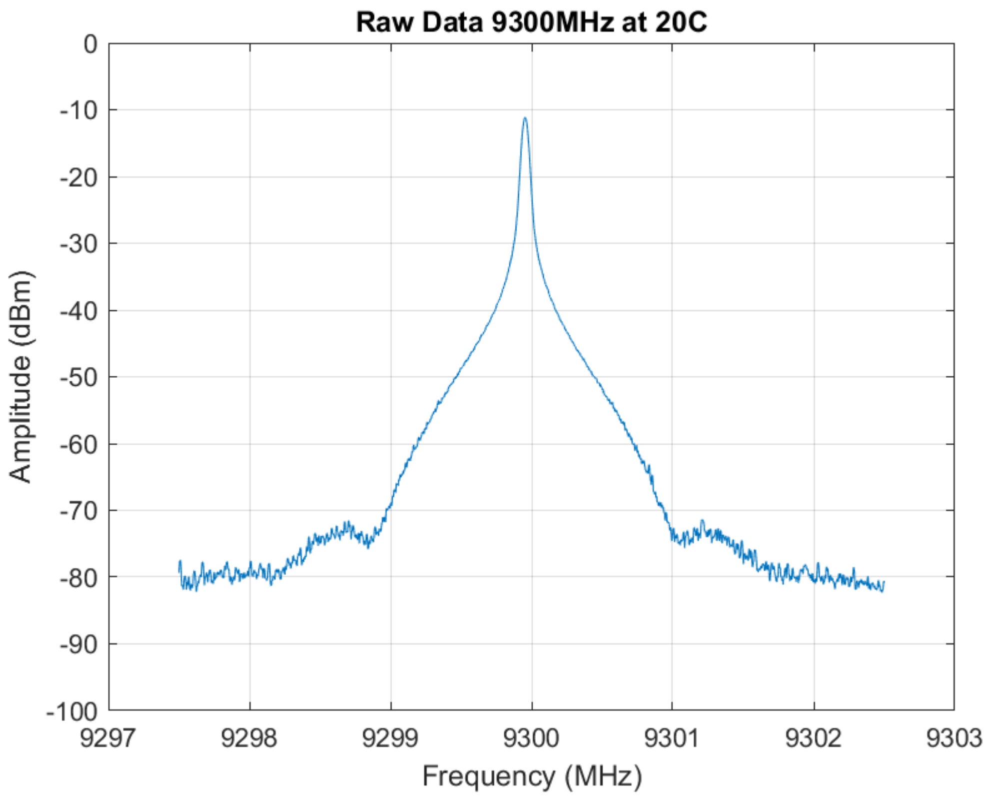

Figure 8. R1410 Spectrum at 9300 MHz, 20°C

The carrier frequency was calculated from the spectral data by finding the maximum point of the spectrum. A max hold operation was performed on the spectrum analyzer in order to capture the pulsed waveform.

Figure 9 and Figure 10 are the resulting plots of carrier offset versus temperature. Data was gathered at 9300 MHz and 9800 MHz for each temperature step. All frequencies between 9300 MHz and 9800 MHz have frequency stability that lies between the measured extremes.

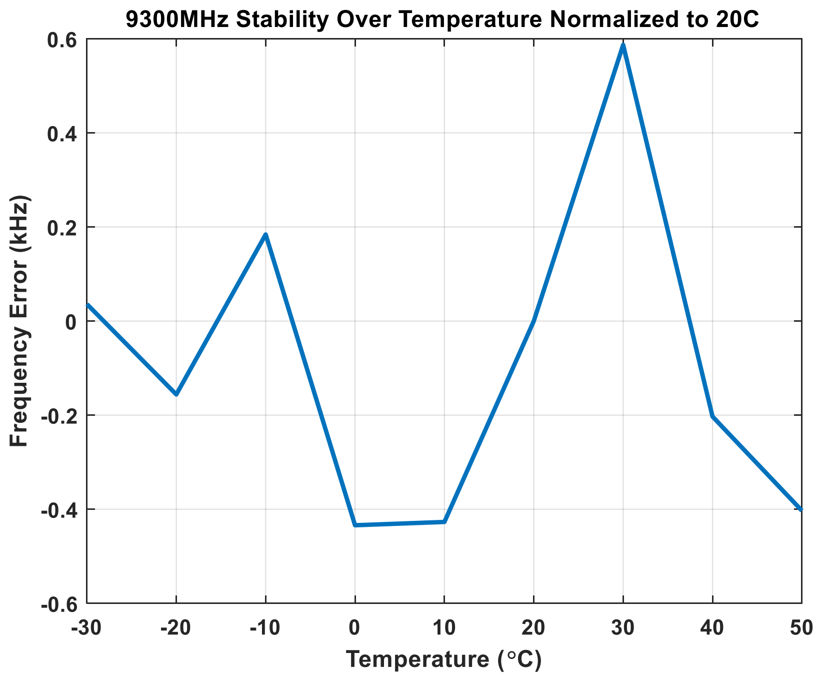

Figure 9. Frequency Deviation Over Temperature at 9300 MHz

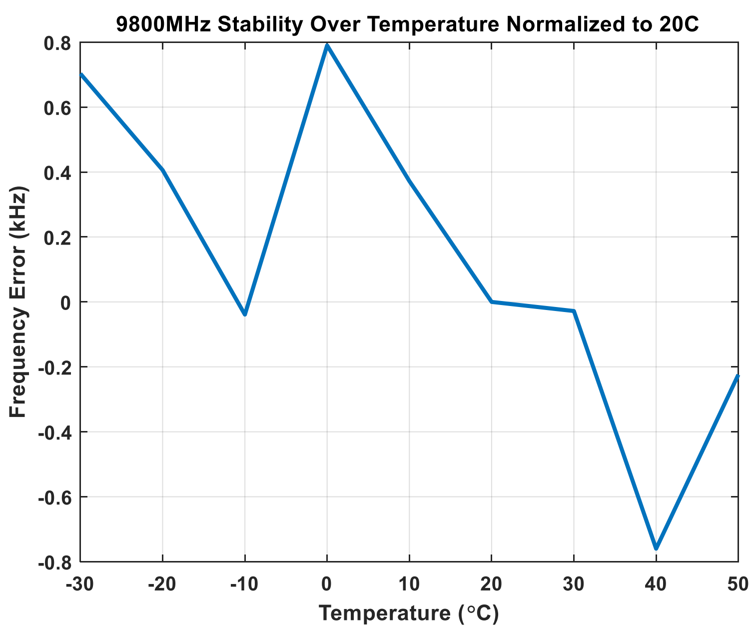

Figure 10 Frequency Deviation Over Temperature at 9800 MHz

The second portion of the testing measured the GS1016 power supply's DC output, 52.5VDC nominal, over AC voltage input deviations. As described in the previous section, this was done at room temperature and over temperature performance was extrapolated. Table 2 summarizes the DC output voltage change versus AC input deviation.

The AC/DC voltage conversion bricks are specified from 90 to 265VAC and 47 to 63Hz over -45 to +85°C base plate temperatures; the performance exhibited in Table 2 is expected based on these specifications. The accuracy of the final carrier frequency is driven by deviations in the input prime voltage. Since the prime voltage is stable, the accuracy of the carrier will also be stable over the AC input deviations. By design, the power supply will operate at both low and high temperatures with the same stability. The carrier frequency will exhibit the same performance shown in Figure 9 and Figure 10 at all frequencies and all AC Input deviations required for FCC part 90.213.