



VR Surface Reader SRA-16 [20x69]  
P/N: VR102601

## Qualification of Test Equipment

Venture Research Inc.  
3001 Summit Ave, Suite 100  
Plano, Texas 75074  
469-246-4000

**Revision 3.0**

Date	Revision	Author / Reviewer	Description of Change
2/21/2017	1.0	Youhua Chen / Adnan Ali	Initial revision
8/3/2017	2.0	Youhua Chen	Added M6e module test; Added Far-field test
8/21/2017	3.0	Youhua Chen / Adnan Ali	Added challenging test cases; Added pressing fixture and heating fixture calibration and testing

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## 1 Introduction

This document explains the qualification process of automated test and build equipment that's used by Venture Research's manufacturing line. This equipment is used to enhance and verify the reliability of the Antenna Panel during the build process.

This document will describe the qualification process for the following manufacturing tests:

- M6e RFID Module Test
- Antenna VSWR Test
- Antenna System Test
- Antenna Far Field Test
- Antenna Pre-Box Test

This document will describe the qualification process for the following manufacturing fixtures:

- Pressing Machine
- Heating Machine

### Definition, Acronym, Abbreviations

- **VRAMS** – VR Asset Manager [SWR]
- **VRHM** – VR Hardware Manager
- **VRRTB** – VR RFID Test Bench
- **VSWR** – Voltage Standing Wave Ratio

## 2 M6e RFID Module Test

This test is performed at the receiving of M6e RFID Modules. It ensures that each M6e module that's test is able to communicate, has the latest approved firmware revision, and 4 fully functional RF ports that are able to radiate at 30dB.

### 2.1 Test Equipment

1. A good reference tag that is able to be read by a 3dBic antenna @ 30dB from 20 ft. distance
2. A test fixture including
  - VR Controller Box
  - M6e Data Cable
  - 4 x Black Patch 3dbiC Antennas and RF Cables
  - A M6e module holder
3. A test PC with the following software installed
  - VR Hardware Manager, Version 5.88
  - VR Asset Manager, Version
4. A "Good" M6e Reader
5. A "Bad" M6e Reader with RF port 1 missing and old firmware

### 2.2 Test Setup

The test fixture (Figure 1) is connected to a computer where VR Hardware Manger is running.

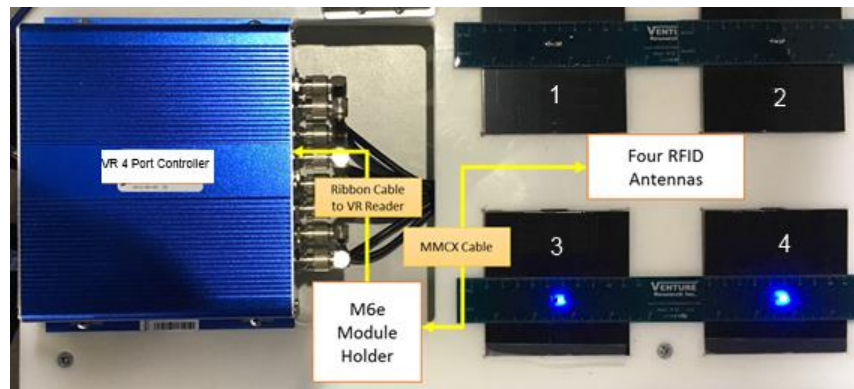


Figure 1. M6e RFID Module Test Fixture

The reference tag (Figure 2) will be placed 20 feet away from the test assembly board. At this distance, the tag can be read by a good M6e module only at the max power of 30dB and not readable at power 27dB.



Figure 2. Reference Tag

## 2.3 Test Process

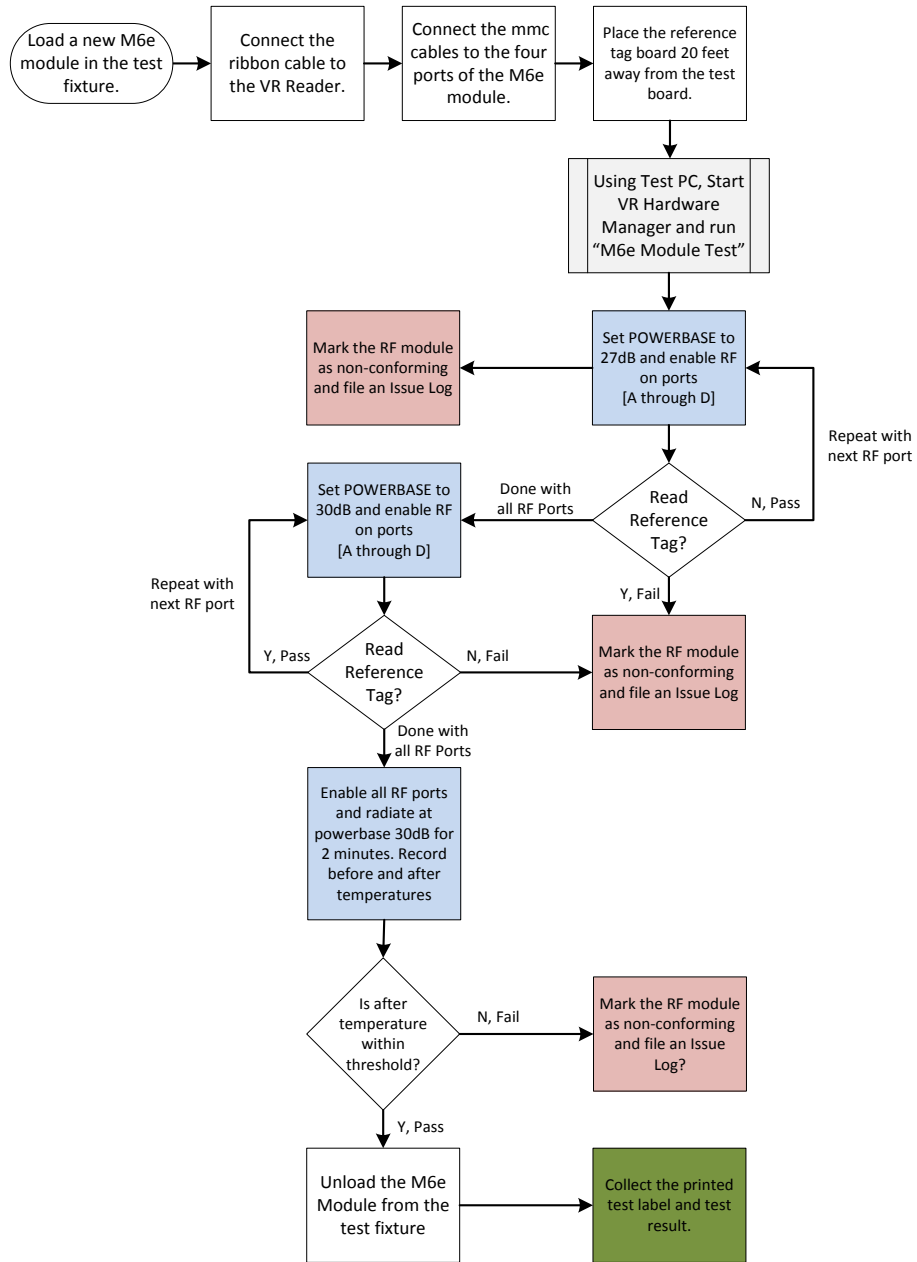


Figure 3. M6e Module Test Process Flow

## 2.4 Test Validation Report

The test validation is performed to ensure all specifications indicated above demonstrated successfully. The test validation report is required to be approved by engineers and supervisors before any change is taken effect on the M6e module test.

Additional data sheet needs to be recorded and signed in the validation test. The summary of all validation test cases is shown below.

Test Case	Description	Result (PASS/FAIL)
1	The reference tag is readable.	
2	The VRHM can request a new test ID.	
3	The VRHM alerts the user when the test is unable to request a new test ID.	
4	The VRHM can print test label and test result.	
5	The VRHM alerts the user when the test is unable to print test label and/or test result.	
6	The VRHM can create a new Asset ID.	
7	The VRHM alerts the user when the test is unable to create a new Asset ID.	
8	The VRHM can run the automated M6e module test.	
9	The VRHM can communicate with the good M6e module.	
10	The VRHM fails the test when unable to communicate with the bad M6e module.	
11	The VRHM can switch radiating antenna with the good M6e module.	
12	The VRHM fails the test when unable to switch radiating antenna with the bad M6e module.	
13	The VRHM can change radiating power with the good M6e module.	
14	The VRHM fails the test when unable to change radiating power with the bad M6e module.	
15	The VRHM can read the temperature of the good M6e module.	
16	The VRHM fails the test when unable to read the temperature of the bad M6e module.	
17	The VRHM can read the reference tag on each antenna port with the good M6e module.	
18	The VRHM fails the test when unable to read the reference tag on each antenna port with the bad M6e module.	
19	The VRHM can find the desired firmware version of the good M6e module.	
20	The VRHM fails the test when unable to find the desired firmware version of the bad M6e module.	

### 3 Antenna VSWR Test

In this test, the SWR and Lin Mag values of 16 antenna patches are measured and validated to be below the approved thresholds. This test is performed using a Network Analyzer that supports frequencies above 850MHz and below 950MHz.

#### 3.1 Test Equipment

6. A test PC with the following software installed
  - o VR Asset Manager [SWR], Version 4.6
- A network analyzer OBZOR TR1300
- A VR GPIO control box
- A good unsealed antenna assembly
- A bad unsealed antenna assembly

Sample specifications of the network analyzer:

- Frequency range: 300 kHz to 1.3 GHz
- Measured parameters: S11, S21
- Sweep types: Linear frequency, log frequency, segment, power sweep
- Dynamic range: 130 dB (10 Hz)
- Measurement speed: 150  $\mu$ s per point at 95 dB dynamic range
- Output power adjustment range: -55 dBm to +3 dBm
- Up to 16,001 measurement points per sweep



Figure 4 - Network Analyzer used in Manufacturing

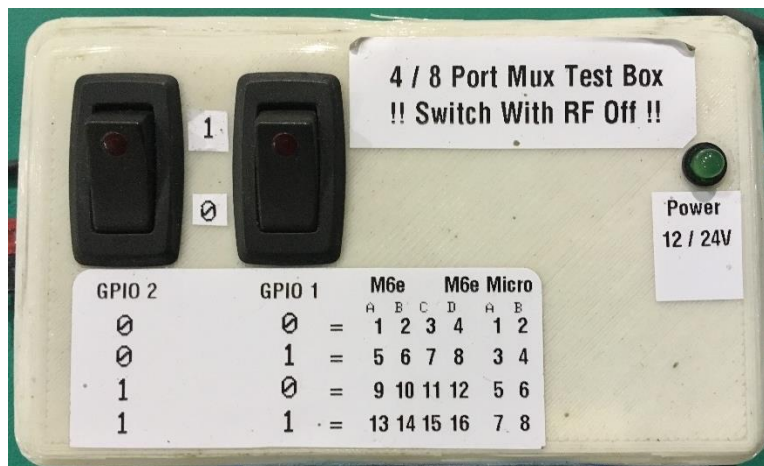


Figure 5. VR GPIO Control Box

### 3.2 Test Setup

- Set Network analyzer frequency range to 902 MHz to 928 MHz
- Set markers to take measurements at the following frequencies:
  - @ 902MHz (Low Frequency)
  - @ 915MHz (Mid Frequency)
  - @ 928MHz (High Frequency)
- Ensure that the analyzer was calibrated for Open, Short, and Through settings

For each antenna assembly, the following measurements are taken and stored in the database with the VR Serial Number.

### 3.3 Test Process

The steps of the VSWR test are performed in sequence:

1. Load the unsealed antenna assembly on the testing table.
2. Connect the network analyzer to the mux board.
3. Connect the GPIO control box to the mux board.
4. At the testing computer, start the test using the software: VR Asset Manager [SWR], where:
  - Select antenna using the GPIO control box.
  - Measure Voltage Standing-Wave Ratio: VSWR at each measurement point must be at or below 2.0.
  - Measure Line Magnitude: Lin Mag at each measurement point must be at or below 0.27.
  - Repeat the steps above till all antennas are measured.
5. When the test is completed, unload the antenna assembly.
6. Collect the printed test label and test result.
7. If the test passes, move the antenna assembly to next manufacturing station.

See Figure 6 for an example of Lin Mag measurements at the three selected frequencies: 0.06 @ 902MHz, 0.19 @ 915MHz, and 0.11 @ 928MHz.

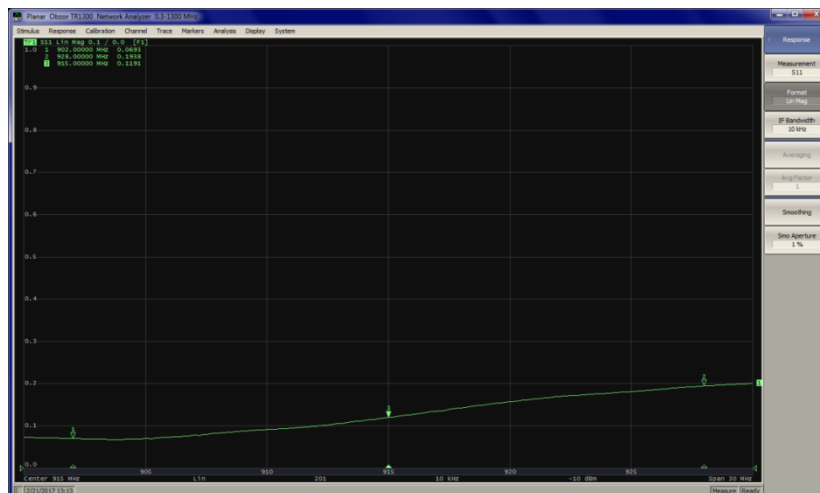


Figure 6 - Lin Mag Measurements

### 3.4 Test Validation Report

The test validation is performed to ensure all specifications indicated above demonstrated successfully. The test validation report is required to be approved by engineers and supervisors before any change is taken effect on the VSWR test.

Additional data sheet needs to be recorded and signed in the validation test. The summary of all validation test cases is shown below.

Test Case	Description	Result (PASS/FAIL)
1	The GPIO control box can switch radiating antenna.	
2	The network analyzer can measure VSWR and Line Magnitude values.	
3	The VRAMS can communicate with the network analyzer and read the measurements.	
4	The VRAMS can fail the VSWR test when unable to communicate with the network analyzer	
5	The VRAMS can request a new test ID.	
6	The VRAMS can fail the VSWR test when unable to request a new test ID	
7	The VRAMS can print test label and test result.	
8	The VRAMS can warn the user when unable to print test label and test result.	
9	The VRAMS can create a new Asset ID.	
10	The VRAMS can alert the user if failed to create a new Asset ID.	
11	The VRAMS can read VSWR values of all antenna patches lower than 0.27 with the good antenna assembly.	
12	The VRAMS fails on VSWR values of all antenna patches higher than 0.27 with the bad antenna assembly.	

## 4 Antenna System Test

Before the antenna panel is sealed with a top and bottom aesthetic plastic cover, a read performance test is performed. This test is performed to ensure adequate performance for each antenna.

### 4.1 Test Equipment

- An 1/8" ABS test fixture with 16 tags mounted @ 1 inch
- VR Controller Box
- A test PC with the following software installed
  - o VR-Hardware Manager, Version 5.88
- A good unsealed antenna assembly
- A bad unsealed antenna assembly

### 4.2 Test Setup

The test fixture (Figure 7) has 16 reference RFID tags. This fixture is placed above the antenna panel where each tag aligns at the center of each antenna patch at 1" distance. The reader module is setup to radiate at only 9dB of power where only the tag directly above the antenna is able to be read.



Figure 7 - Test Fixture

### 4.3 Test Process

The steps of the antenna system test are performed in sequence:

1. Load an unsealed antenna assembly on the testing table.
2. Connect the antenna assembly to the VR Controller Box.
3. Load the test tag fixture on the antenna assembly.
4. At the testing computer, start the test using the VR Hardware Manager software
5. When the test is completed, unload the test fixture and the antenna assembly
6. Collect the printed test label and test result and insert them in the traveler pouch

VR Hardware Manager (see Figure 8) reads on all antennas one at a time. The application ensures that the (designated) tag directly perpendicular to the antenna is read at or above the RSSI threshold. If all reference testing tags are read successfully, the test result is recorded as PASS in the Manufacturing database along with the VR Serial Number of the Antenna Assembly. Figure 9 presents the test flowchart. The resulting report and labels are then printed and recorded with the Quality Sheet for that antenna assembly. After that, the VRHM writes all product information data to the interface board (more details in the document: “Interface EEPROM Configure”).

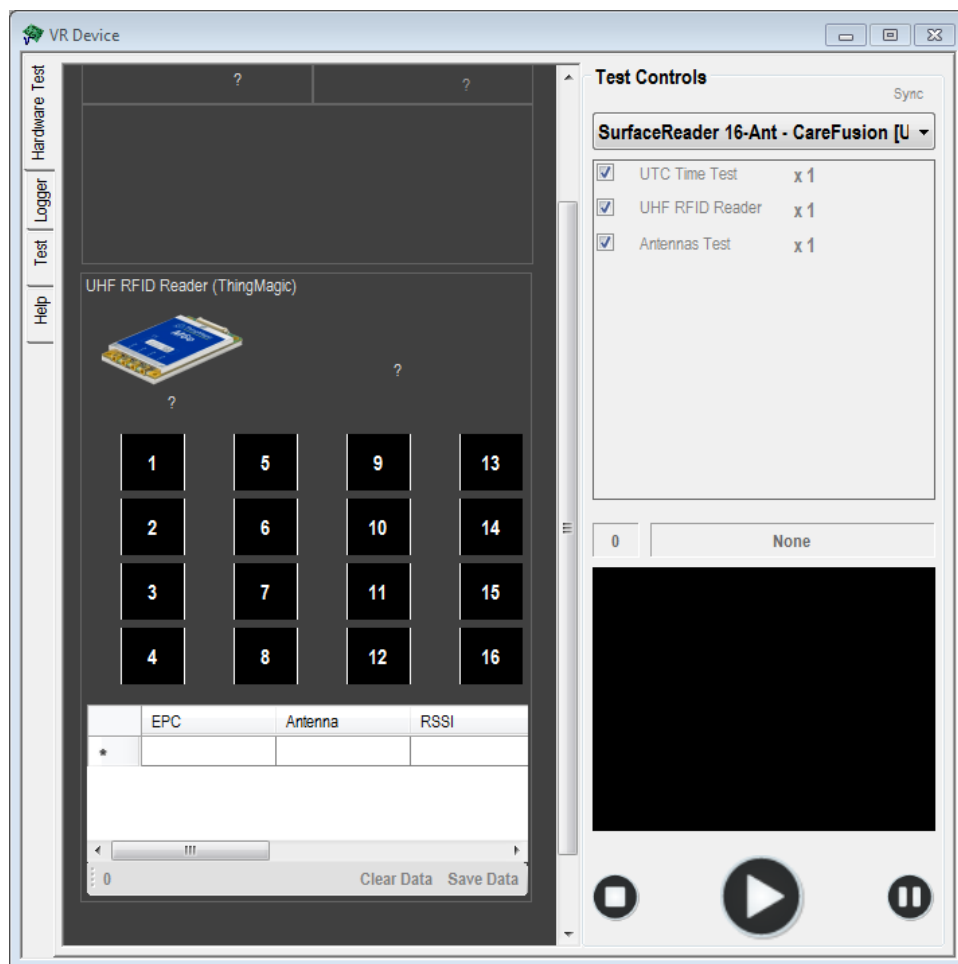


Figure 8 - VR Hardware Manager

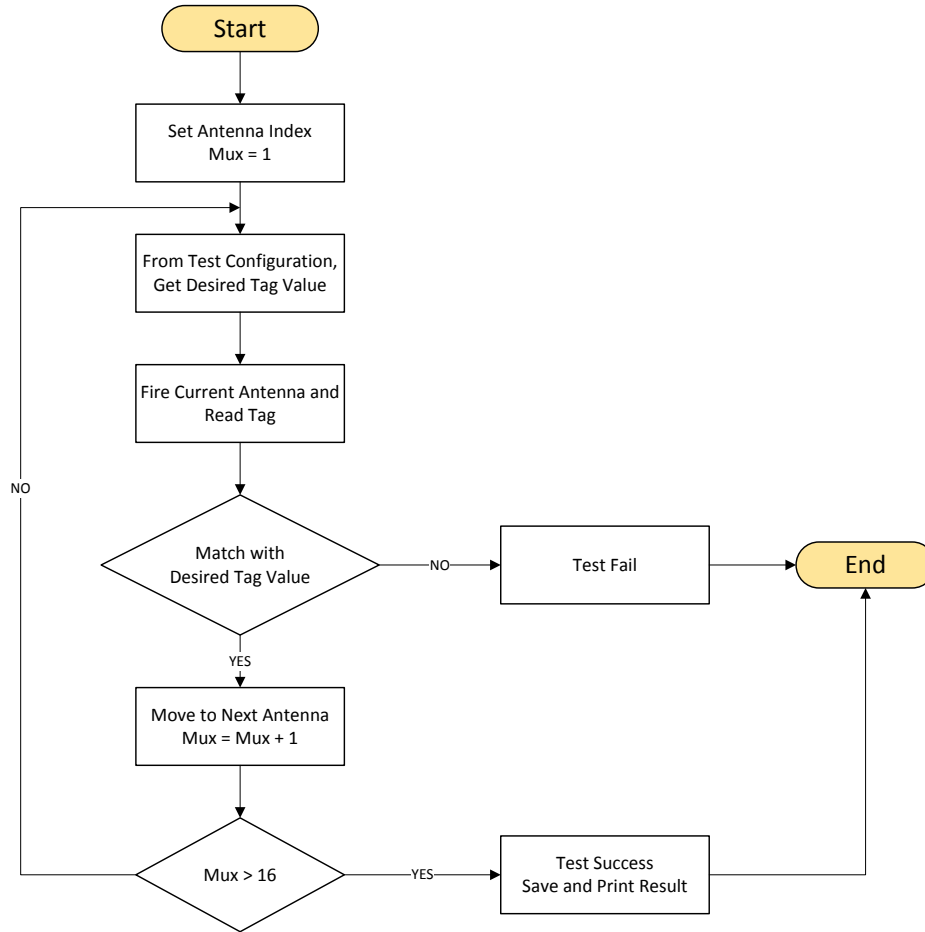


Figure 9 - Flowchart of Antenna System Test (16 Antenna Patches)

## 4.4 Test Validation Report

The test validation is performed to ensure all specifications indicated above demonstrated successfully. The test validation report is required to be approved by engineers and supervisors before any change is taken effect on the antenna system test.

Additional data sheet needs to be recorded and signed in the validation test. The summary of all validation test cases is shown below.

Test Case	Description	Result (PASS/FAIL)
1	All 16 reference tags in the test fixture are readable.	
2	The VRHM can request a new test ID.	
3	The VRHM alerts the user when the test is unable to request a new test ID.	
4	The VRHM can print test label and test result.	
5	The VRHM alerts the user when the test is unable to print test label and/or test result.	
6	The VRHM can create a new Asset ID.	
7	The VRHM alerts the user when the test is unable to create a new Asset ID.	
8	The VRHM can run the automated antenna system test a specified number of cycles.	
9	The VRHM can communicate with the good antenna assembly.	
10	The VRHM fails the test when unable to communicate with the bad antenna assembly.	
11	The VRHM can switch radiating antenna with the good antenna assembly.	
12	The VRHM fails the test when unable to switch radiating antenna with the bad antenna assembly.	
13	The VRHM can change radiating power with the good antenna assembly.	
14	The VRHM fails the test when unable to change radiating power with the bad antenna assembly.	
15	The VRHM can read the reference tag on each antenna patch with the good antenna assembly.	
16	The VRHM can fail the test when any of the 16 reference tags is unable to be read.	
17	The VRHM can find the desired firmware version of the good antenna assembly.	
18	The VRHM fails the test when unable to find the desired firmware version of the bad antenna assembly.	
19	The VRHM can flash production data to the interface board with the good antenna assembly.	
20	The VRHM fails the test when unable to flash production data to the interface board with the bad antenna assembly.	

## 5 Far Field Test

After the antenna system test passes, the top and bottom aesthetic plastics are attached and the antenna assembly is ready for far field test. The far field test is performed to check the tag reading performance of each antenna patch individually in the antenna assembly.

### 5.1 Test Equipment

- A BD Tower Cabinet P1
- RFID Tag Fixture with having 16 tag boards and 576 tags in total
- A boxed VR reader having a VR Linux board 4.4
- A computer with the software installed
  - o VR RFID Test Bench, Version 1.36
- A good antenna assembly
- A bad antenna assembly

### 5.2 Test Setup

Instead of merchandise items, the far field test uses 16 paper boards with 36 tags on each board (Figure 10). In total, there are 576 tags in the tower cabinet (Figure 11), and 76 tags on each shelf.

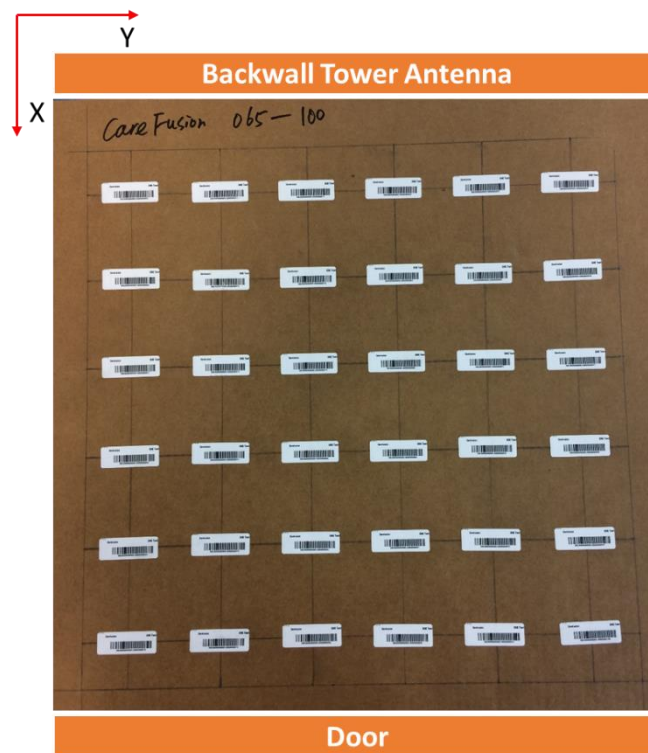


Figure 10. Tag Board



Figure 11. RFID Tag Fixture in the Tower Cabinet

The RFID tag used in all tests is Smartrac Web Lite (<https://www.smartrac-group.com/web-lite.html>) with the size 49 x 18 mm.

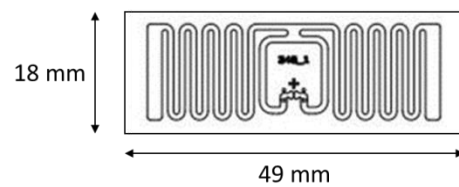


Figure 12. RFID Tag

### 5.3 Test Process

The steps of the far field test are performed in sequence:

1. Empty the testing BD tower cabinet.
2. Load an antenna assembly and connect it to the VR reader.
3. Load the test fixture and close the door of the cabinet.
4. At the testing computer, start the test using the software: VR RFID Test Bench.
5. When the test is completed, unload the test fixture and the antenna assembly.
6. Collect the printed test label and test result.
7. If the test passes, move the antenna assembly to next manufacturing station.

In the VR RFID Test Bench (Figure 13), the test is performed automatically including:

- Individually radiate each antenna patch, read tags in the cabinet (Figure 14).
- Radiate all antenna patch, read tags in the cabinet.
- Radiate all antenna patch, change reading time from 0.5 seconds to 10 seconds with the step 0.5 seconds to read tags in the cabinet.

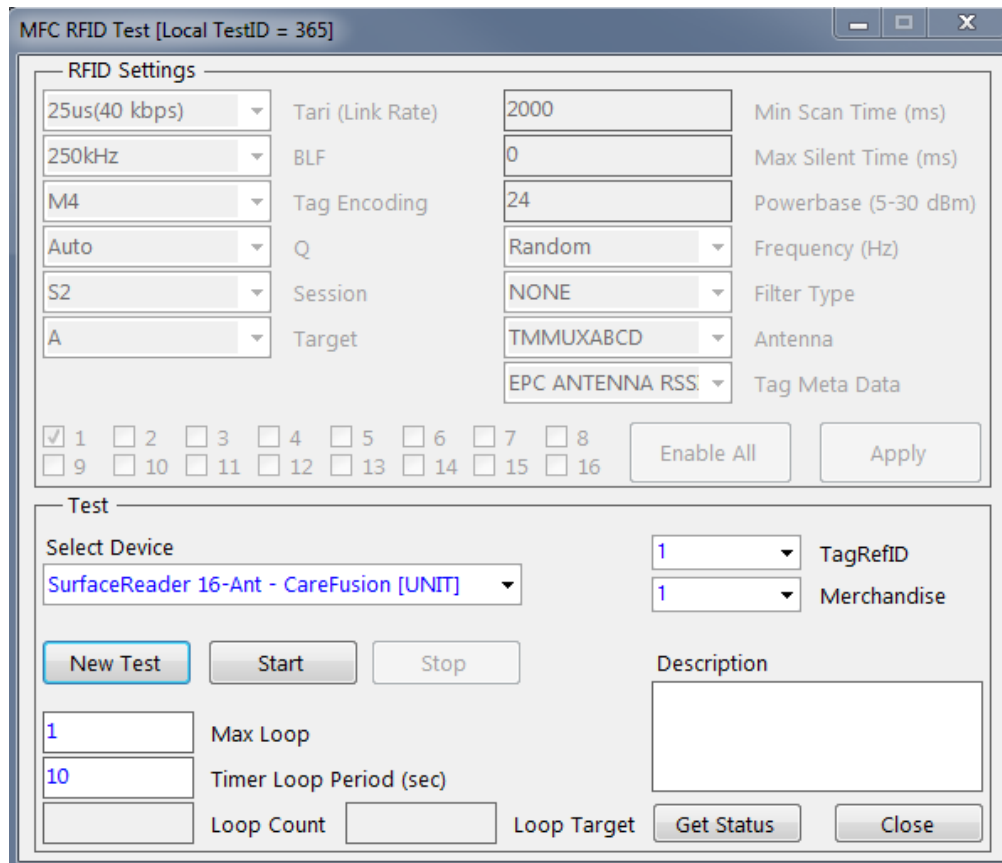


Figure 13. Test Screen of VR RFID Test Bench

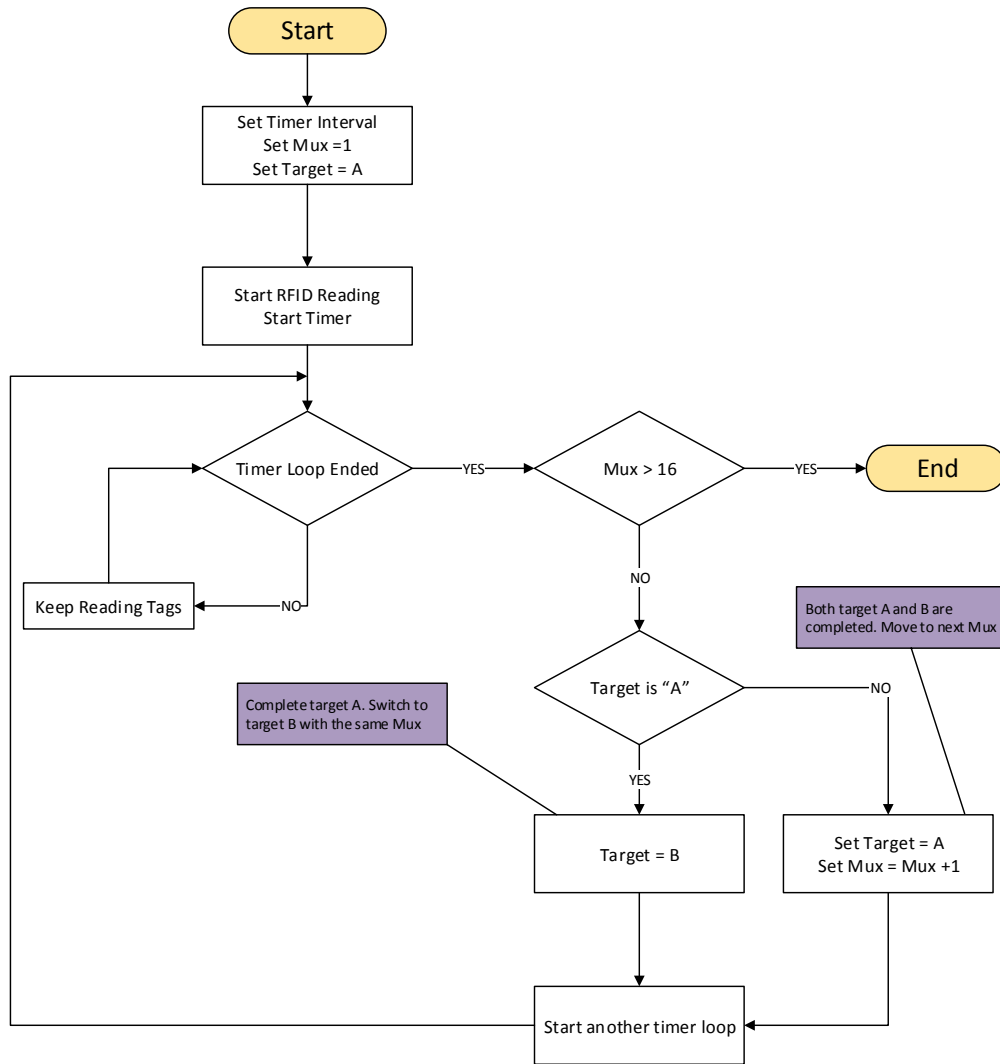


Figure 14. Flowchart of Individual Antenna Reading

The RFID settings used are:

Setup	Description
Tag	576 Smarttrac Weblite tags
Key RFID settings	Powerbase = 30 dBm Session = 2 BLF: 250 kHz Tag Encoding: M4 Readtimeout: 2000 TARI: 25 $\mu$ s Q Value: Auto Asyncofftime: 0 Frequency: Random
Test Process	The antenna is enabled one by one while reading. The detail process is presented in Figure 14 The timer interval is set as 20 seconds, which is also the reading time period

All tag readings are saved in the database. Then tags read by each antenna patch are counted like Figure 15.

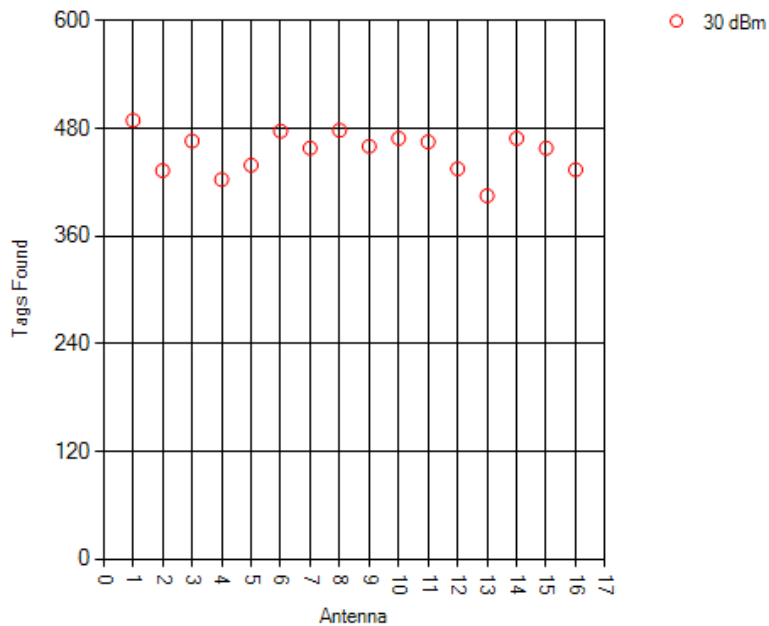


Figure 15. An Example of Tag Reading Count per Antenna Patch

In the final, each antenna patch must be able to read over 85% tags in the cabinet. Since the total tags is 576, the minimum tag amount read by each antenna patch is 490 to pass the far-field test.

## 5.4 Test Validation Report

The test validation is performed to ensure all specifications indicated above demonstrated successfully. The test validation report is required to be approved by engineers and supervisors before any change is taken effect on the far field test.

Additional data sheet needs to be recorded and signed in the validation test. The summary of all validation test cases is shown below.

Test Case	Description	Result (PASS/FAIL)
1	All 576 reference tags are readable.	
2	The VRRTB can request a new test ID.	
3	The VRRTB alerts the user when the test is unable to request a new test ID.	
4	The VRRTB can print test label and test result.	
5	The VRRTB alerts the user when the test is unable to print test label and/or test result.	
6	The VRRTB can run the automated far-field test specified number of cycles.	
7	The VRRTB can communicate with the good antenna assembly.	
8	The VRRTB fails the test when unable to communicate with the bad antenna assembly.	
9	The VRRTB can switch radiating antenna with the good antenna assembly.	
10	The VRRTB fails the test when unable to switch radiating antenna with the bad antenna assembly.	
11	The VRRTB can change radiating power with the good antenna assembly.	
12	The VRRTB fails the test when unable to change radiating power with the bad antenna assembly.	
13	The VRRTB test can radiate on individual antennas where each individual antenna is able to read 90% (518) of all tags.	
14	The VRRTB can fail the test when individual antennas aren't able to reach threshold.	
15	The VRRTB test can radiate on all antennas and read 100% of tags within 4 seconds.	
16	The VRRTB can fail the test when panel isn't able to read all tags within set threshold.	

## 6 Antenna Pre-Box Test

After the far field test passes, the unit is ready for the final test. The final (or Pre-Box) test procedure is the same as the Antenna System Test in section 4. The test result report and labels are printed and recorded with the Quality Sheet for that antenna assembly.

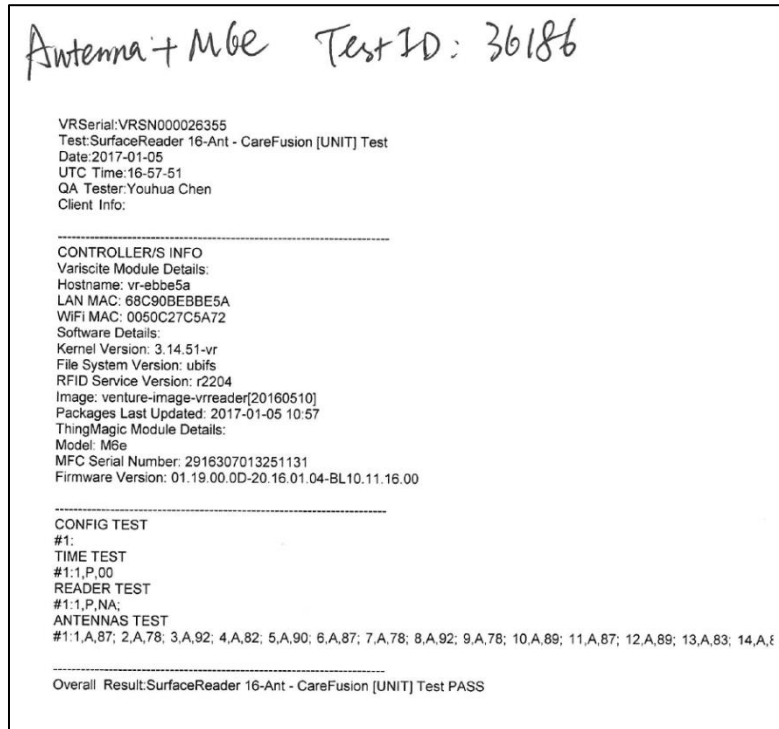


Figure 16 - Sample of Test Result Report

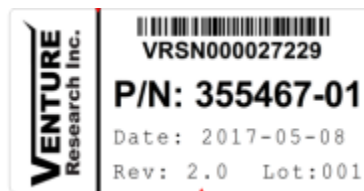


Figure 17 - Sample of Final Label

*Corevision Support 1/5/17*

### Surface Reader Pre-Ship Q/A Checklist

**VENTURE** Research Inc. VR Serial Number VRSN000026355 Date: 1/4/17  
 ShellReader Hostname N/A

2 4 5 6 8 10 12 14 **16** (Circle One)

Sequence	Initials	Checklist
<b>SWR Test [Before]</b>		
1	<input checked="" type="checkbox"/>	Verify thermal sensor has conformal coating and has been tested.
2	<input checked="" type="checkbox"/>	Verify thermal sensor is installed with thermal tape on the bottom side.
3	<input checked="" type="checkbox"/>	Ensure that any excess milling copper on the antennas is removed.
4	<input checked="" type="checkbox"/>	<i>(If antennas are glued)</i> Ensure that the corners are glued down and mux interface area is glued down with no air gaps.
5	<input checked="" type="checkbox"/>	Verify Qty. 3 #4 screws are used to mount the bottom mux board.
6	<input checked="" type="checkbox"/>	<i>(If more than 10 antennas)</i> Verify Qty. 4 #4 screws are used to mount the top mux board.
7	<input checked="" type="checkbox"/>	Ensure Solder from aluminum backplane has not gotten further than provided exposed ground plane of the mux board.
8	<u>AT</u>	Verify RF cables have been soldered. Center conductor to top pad and Grd shield at two different points <b>(one on bottom ground plane &amp; one on top ground pad)</b>
9	<u>AT</u>	Verify HDPE filaments solder joints are not much bigger than 1/8" and cleaned off.
10	<u>AT</u>	Inspect the MUX to antenna filament wires and <b>make sure</b> they are secure to the Mux board.
11	<u>AT</u>	<i>(If Copper or Aluminum back plane)</i> Perform an ohms test between Mux and end of antenna to insure low resistance.
12	<u>N/A</u>	<i>(During SWR Test)</i> Check to make sure that any unused mux ports are verified to have less than .12db (902-928 MHz)
SWR Test [After]		<u>36161</u> ⇨ SWRTest TestID
<b>SYSTEM Test [Before]</b>		
13	<input checked="" type="checkbox"/>	<i>(If Rev1.0 Linux ShelfBoard)</i> Ensure that the thermal 3.3V mod is performed <i>(See SHELF_BRD_MOD_R001 drawing)</i>
14	<input checked="" type="checkbox"/>	Ensure Qty. 3 #4 screws at each corner are used to install Shelf Reader board. <i>(10 antenna ShelfReader requires Qty. 4)</i>
15	<input checked="" type="checkbox"/>	Ensure RF cable(s), GPIO cable & Thermal-sensor connector are installed securely between Mux and Reader Board.
16	<input checked="" type="checkbox"/>	<i>(If Rev 1.0 MuxBoard)</i> Ensure there is a separator under the upper mux connector so that it cannot ground out the feed line
17	<input checked="" type="checkbox"/>	Verify the RF cable(s), GPIO cable, and all connectors are hot glued down to prevent them sticking from up and disconnecting
SYSTEM Test [After]		<u>36186</u> ⇨ SystemTest TestID
<b>PreBox Test [Before]</b>		
18	<input checked="" type="checkbox"/>	Ensure that the 1/16" thick ABS is used on bottom side of shelf, with grooves lined up to main shelf grooves. <i>(Note: two notches have to be centered to the Connector clips)</i>
19	<input checked="" type="checkbox"/>	Ensure that the 1/8" thick ABS is used on the top side of shelf, with grooves lined up to main shelf grooves. <i>(Note: 10 antenna ShelfReader will have notches cut out for the connector clips)</i>
20	<input checked="" type="checkbox"/>	Ensure that the diagnostic panel is aligned and secured with Qty. 2 #6x1/4" SS PH screws.
21	<input checked="" type="checkbox"/>	Verify that all sides of the shelf are cleanly routed and are glued completely down.
22	<input checked="" type="checkbox"/>	Verify that all sides of the shelf are de-burred.
PREBOX Test [After]		<u>N/A</u> ⇨ PreBoxTest TestID
23	<u>TM</u>	Verify that the VRSerial# label is applied to the diagnostic panel after all tests & assembly is complete.

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 UNIT 2817-91-95  
 YC

(Note: Remember to record Asset serial numbers where designated on the back (Page 2) of this sheet.)

ISO-QAC-20 Revision K 8/14/2015 1

Figure 18 - Sample of Final Q/A Sheet

## 7 Pressing Machine

This machine was designed and added to the manufacturing process in order to add reliability and consistency to the pressing process. Per manufacturing specifications, the machine needs to bond with firm pressure, 15lbs/in while warm. Once cured over 1-2 days at room temperature, the bond should require 20lbs/in of force to peel. See figure of Pressing Machine below.



Figure 19 – Pressing Machine

### 7.1 Test Equipment

1. Pressing Machine
2. Force Test Plate
  - a. Force testing sensor
  - b. Arduino Uno Board
3. Force Sensor Calibration Fixture
4. Calipers
5. Pressure Gauge
6. Display Panel
7. Test PC loaded with Single Tact software

### 7.2 Test Setup

#### 7.2.1 Force Sensor Calibration

Place the force sensor into the fixture and hang a calibrated 10lb weight.

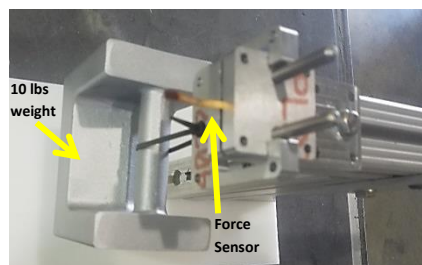


Figure 20 – Force Sensor Calibration

### 7.2.2 Pressing Machine – Press Calibration

Per manufacturer specifications:

After gluing and heating drying, at least 15 lbs/sqin of force and 1-2 days of cure time at room temperature is required to achieve 20lbs/sqin of peeling force

Per testing the roller touches .16 inches of the material

Based on the unit’s width of 20.5 inches, the total minimum force needed is:

$0.16 \text{ (roller touch width)} \times 20.5 \text{ (unit width)} \times 15 \text{ (lbs/sq in of force required)} = 49.2\text{lbs}$  or **219 newtons**



Figure 21 – Establish Roller Touch Width

### 7.2.3 Pressing Machine – Belt Speed

Ensure that the Variable speed driver that’s controlling the motor is running at 7.3 rpm. When set at 7.3 rpm, the belt speed stays at 11rpm. This measurement is displayed on the display panel located on the Pressing Machine.



Figure 22 – Variable Speed Driver

### 7.2.4 Peeling Force Required





### 7.3 Test Process

In order to measure force from the Pressing Machine, pass the Force Test Plate which contains a force sensor and microcontroller through the Pressing Machine.

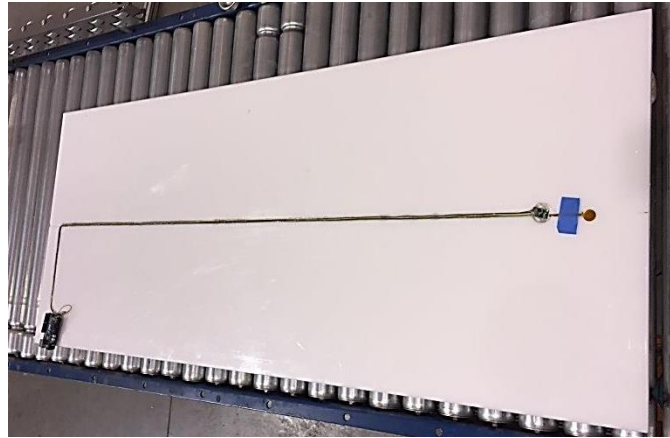


Figure 23 – Force Test Plate

While passing the Force Test Plate, monitor the pressure on the Single Tact Software and verify for it to be above 220 newton and below 300 newton.

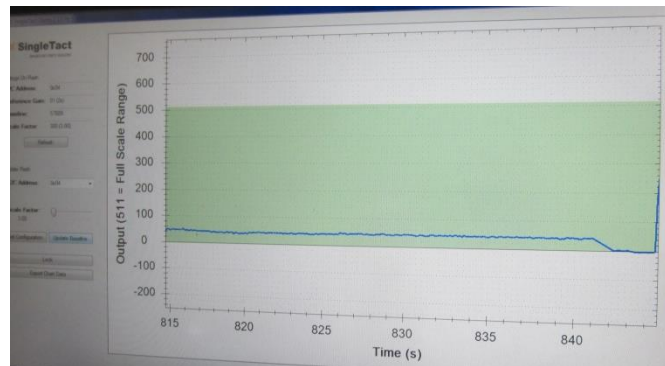


Figure 24 – Single Tact Software

If the variable speed driver is set to 7.3mph, on the display panel that the speed on the display panel is showing 11.



Figure 25 – Display Panel

If all the above variables are correct, then a test panel should be run through the pressing process and kept at room temperature for 1-2 days.

#### 7.4 Test Validation Report

Test Case	Description	Result (PASS/FAIL)
1	Force Test Plate should measure 220 newton	
2	Display panel should report belt speed of 11	

## 8 Heating Test



### 8.1 Test Equipment

### 8.2 Test Setup

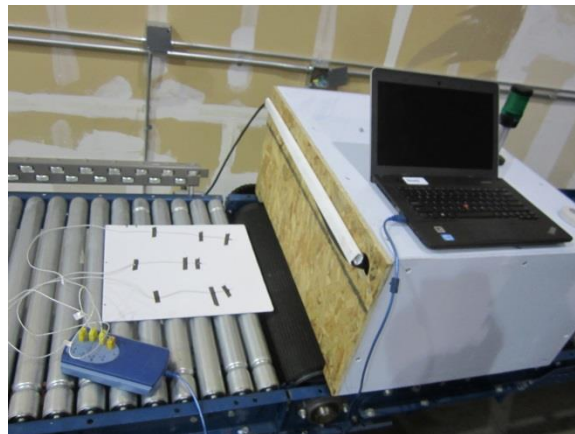


Figure 26 – Temperature Probe

### 8.3 Test Process

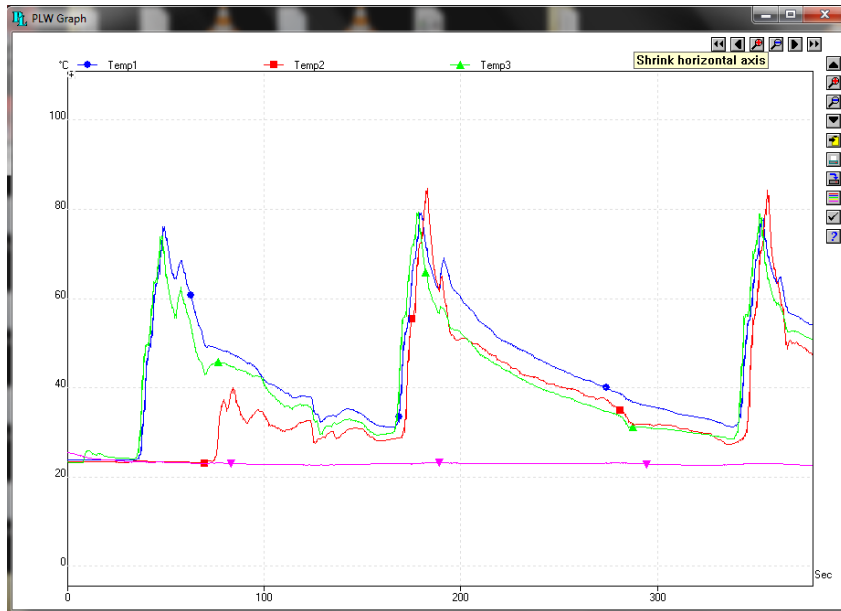


Figure 27 – Temperature Validation

### 8.4 Test Validation Report

## 9 Final QA Dimension Verification

This fixture helps speeding up the measurement validation for all Antenna assemblies. This fixture is inside out replica of our Antenna assembly. The tolerance for the outer dimension is kept at its maximum and tolerance for the mounting slots is kept at its minimum. In this way, the fixture will validate that each antenna assembly can be mounted in the BD cabinet's PEM nuts. This fixture will also validate the outer length and width dimensions to ensure that the antenna assembly will fit within the BD cabinet.

### 9.1 Test Equipment

1. Final QA Dimension Verification Fixture
2. Calipers
3. BD Antenna RFID Tower Spec Control Drawing, Rev 5.
4. Height Verification

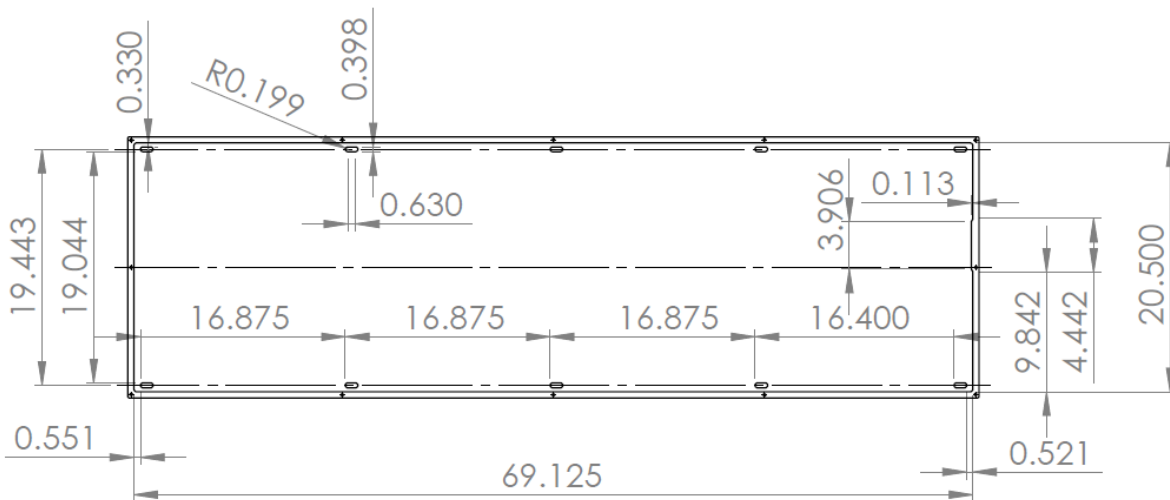


Figure 28 – Final QA Dimension Verification Fixture

### 9.2 Test Setup

1. Prepare the dimension verification fixture and place QA table and

### 9.3 Test Process

1. Place the antenna assembly inside the fixture
  - a. Ensure and validate easy alignment of all slots
  - b. Validate fit for both length and width dimensions
2. Remove the antenna assembly and place it on the QA table to measure the remaining dimensions
  - a. Validate the thickness by using calipers
  - b. Validate the flatness by using height verification

## 9.4 Test Validation Report