VR Surface Reader

Antenna Panel
Test Procedure

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Revision 2.0

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	Add M6e module test, far-field test

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1 Introduction

Venture Research's manufacturing line conducts a series of tests during the build process to validate the antenna's tuning and ensure proper readability. The test results are recorded in a database along with the serial number of the unit.

Once all the RF components are put together: Antennas, RF Module, Multiplexers, and tuning capacitors or inductors, each antenna assembly is validated for proper RF tuning. Then the antenna assembly will be tested for adequate read performance before it is finished with top and bottom aesthetic plastics. Finally, the assembly will once more get tested for read performance. During each test, the VR serial number is recorded along with the test results in our Manufacturing Database via the Test Software.

Manufacturing tests include:

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

2 Definition, Acronym, Abbreviations

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

3 M6e Module Test

This test is performed to ensure the M6e module in good conditions before attaching it to the antenna assembly.

3.1 Test Equipment

- A tag board having 1 reference tag
- A test assembly board having 4 antennas, a boxed VR reader with a VR Linux board 4.4, and a M6e module holder
- A computer with the software installed: VR-Hardware Manager, Version 5.88

3.2 Test Setup

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

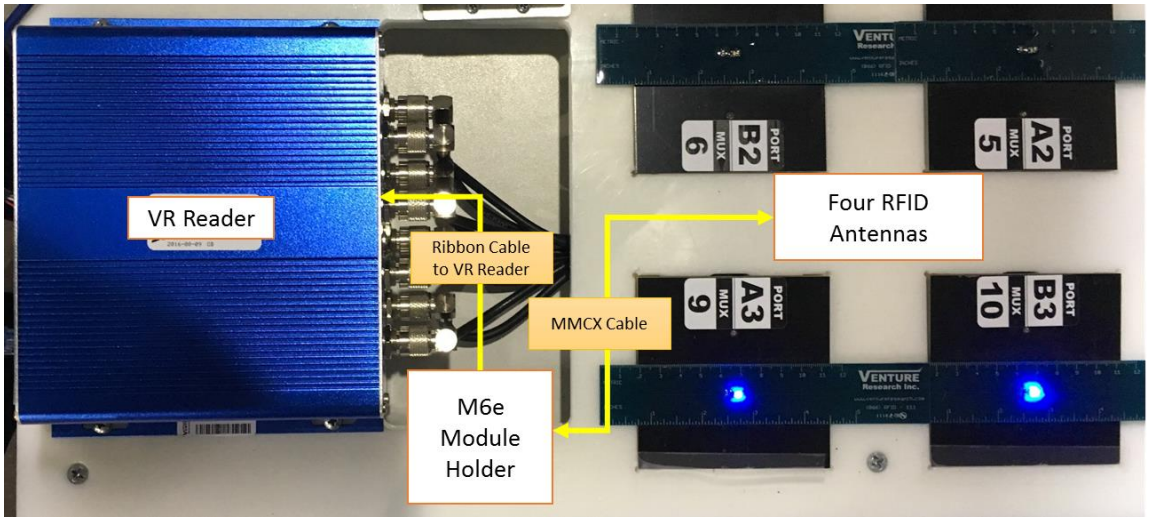


Figure 1. Test Assembly Board (To be Updated)

The reference tag board (Figure 2) is placed 20 feet away from the test assembly board. At this distance, the tag can be read by a good M6e module under the max power 30dB, while it is not readable under a lower power 27dB.

Figure 2. Reference Tag Board (To be Updated)

3.3 Test Process

The steps of the M6e module test are performed in sequence:

1. Load a M6e module to the test assembly board. Connect the ribbon cable to the VR Reader. Connect the mmc cables to the four ports of the M6e module.
2. Place the reference tag board 20 feet away from the test board.
3. At the testing computer, start the test using the software: VR Hardware Manager.
4. When the test is completed, unload the M6e module.
5. Collect the printed test label and test result.
6. If the test passes, move the M6e module to next manufacturing station.

In the VRHM, the test is performed automatically including:

- Enable port A, set the max power = 30dB, read the reference tag.
- Enable port A, set a lower power = 27dB, read the reference tag.
- Enable port B, set the max power = 30dB, read the reference tag.
- Enable port B, set a lower power = 27dB, read the reference tag.
- Enable port C, set the max power = 30dB, read the reference tag.
- Enable port C, set a lower power = 27dB, read the reference tag.
- Enable port D, set the max power = 30dB, read the reference tag.
- Enable port D, set a lower power = 27dB, read the reference tag.
- Enable port A, B, C and D, radiate with the max power = 30dB for 2 minutes, read the temperature.

3.4 Test Validation

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.

3.4.1 Equipment Used

- A good M6e module
- The equipment described in the Section 3.1

3.4.2 Data

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. There is not any damage on it.	
2	The VR reader is able to communicate with the M6e module.	
3	The VR reader is able to switch radiating antenna.	
4	The VR reader is able to change radiating power.	
5	The VR reader is able to read the temperature of the M6e module.	
6	The VRHM is able to communicate with the VR reader including sending commands and reading response/tags.	
7	The VRHM is able to request a new test ID.	
8	The VRHM is able to print test label and test result.	
9	The VRHM is able to create a new Asset ID.	
10	The VRHM is able to run the automated M6e module test a specified number of cycles.	

3.4.3 Results/Conclusion

Overall, the M6e module test equipment and software will function as designed and specified if all test cases pass.

4 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.

4.1 Test Equipment

- A computer with the software installed: VR Asset Manager [SWR], Version 4.6
- A network analyzer OBZOR TR1300
- A VR GPIO control box

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 µs 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 3 - Network Analyzer used in Manufacturing

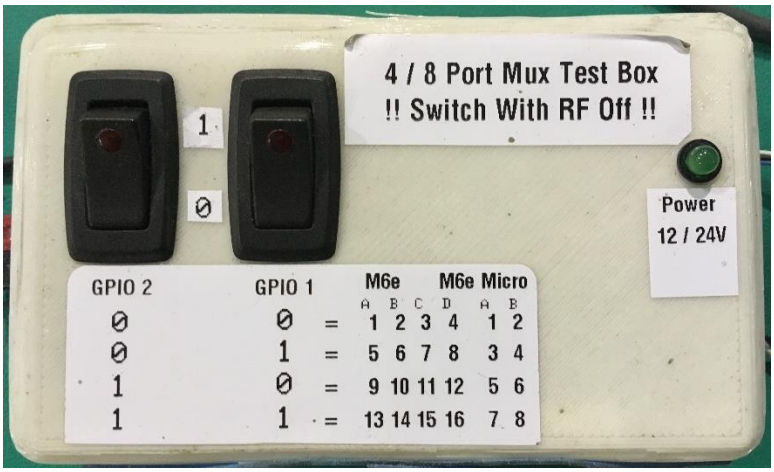


Figure 4. VR GPIO Control Box

4.2 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.

4.3 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 5 for an example of Lin Mag measurements at the three selected frequencies: 0.06 @ 902MHz, 0.19 @ 915MHz, and 0.11 @ 928MHz.

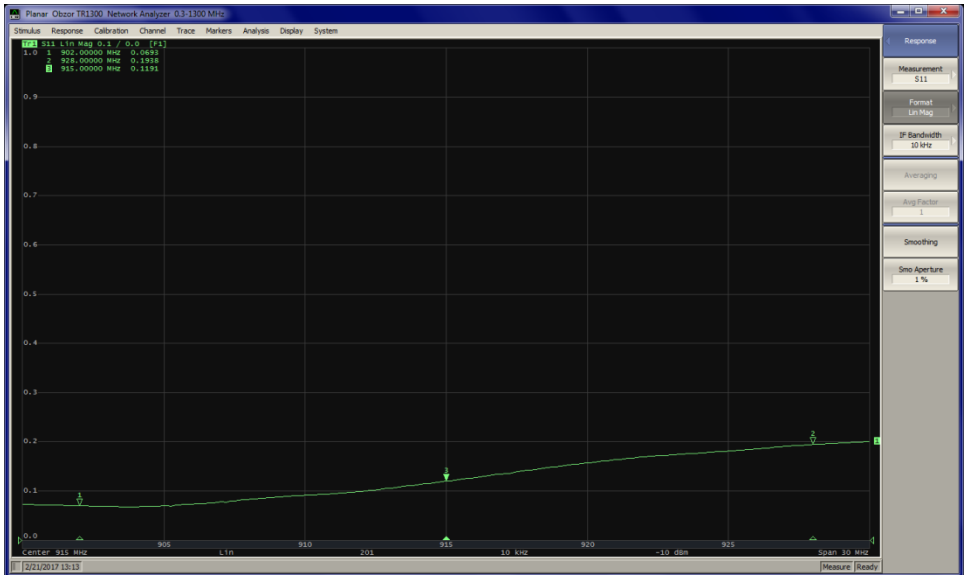


Figure 5 - Lin Mag Measurements

4.4 Test Validation

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.

4.4.1 Equipment Used

- A good unsealed antenna assembly
- The equipment described in the Section 4.1

4.4.2 Data

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 is able to switch radiating antenna.	
2	The network analyzer is able to measure VSWR and Line Magnitude values.	
6	The VRAMS is able to communicate with the network analyzer and read the measurements.	
7	The VRAMS is able to request a new test ID.	
8	The VRAMS is able to print test label and test result.	
9	The VRAMS is able to create a new Asset ID.	

4.4.3 Results/Conclusion

Overall, the far field test equipment and software will function as designed and specified if all test cases pass.

5 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.

5.1 Test Equipment

- A test fixture having 16 tags
- A boxed VR reader having a VR Linux board 4.4
- A computer with the software installed: VR-Hardware Manager, Version 5.88

5.2 Test Setup

The test fixture (Figure 6) has 16 reference RFID tags. The tags are placed at the center of each antenna patch with a certain height off the antenna surface. Thus, as to each antenna, with very small radiating power, only the tag directly above the antenna is able to be read.

Figure 6 - Test Fixture

5.3 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 reader.
3. Load the test tag fixture on the antenna assembly.
4. At the testing computer, start the test using the software: VR Hardware Manager.
5. When the test is completed, unload the test fixture and the antenna assembly.
6. Collect the printed test label and test result.

If the test passes, move the antenna assembly to next manufacturing station.

VR Hardware Manager (see Figure 7) 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 8 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”).

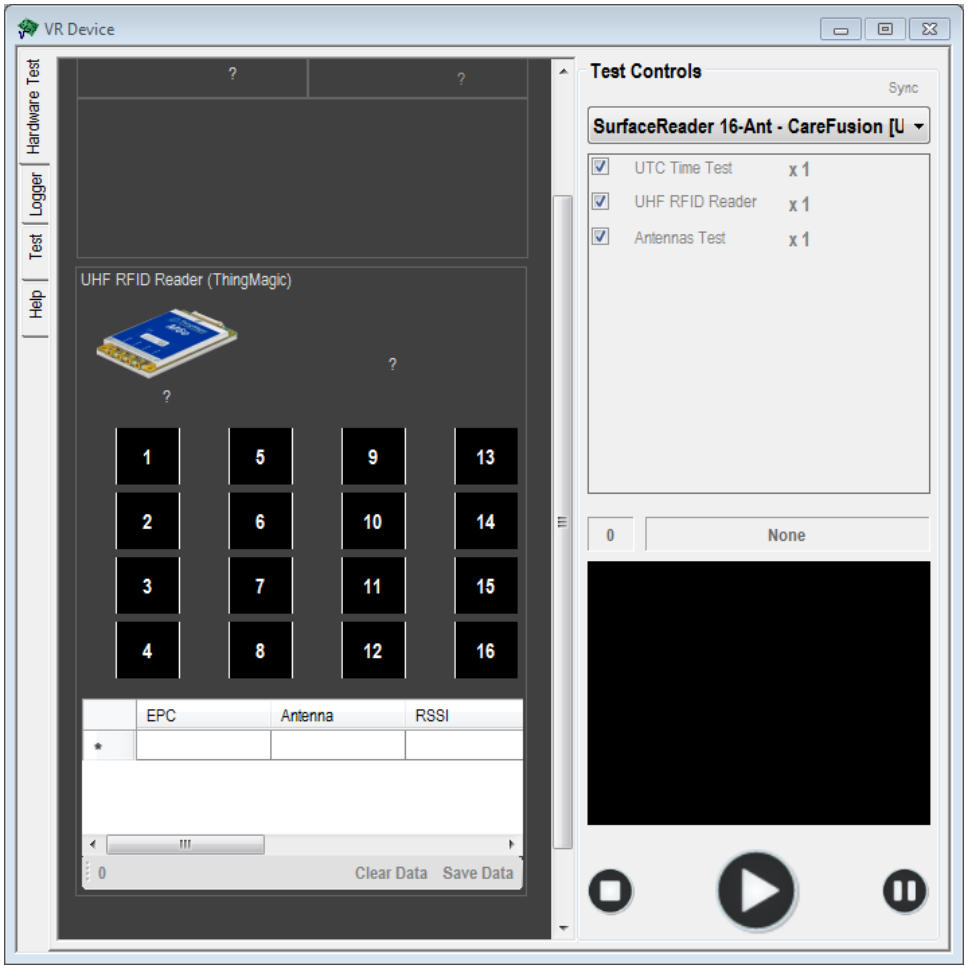


Figure 7 - VR Hardware Manager

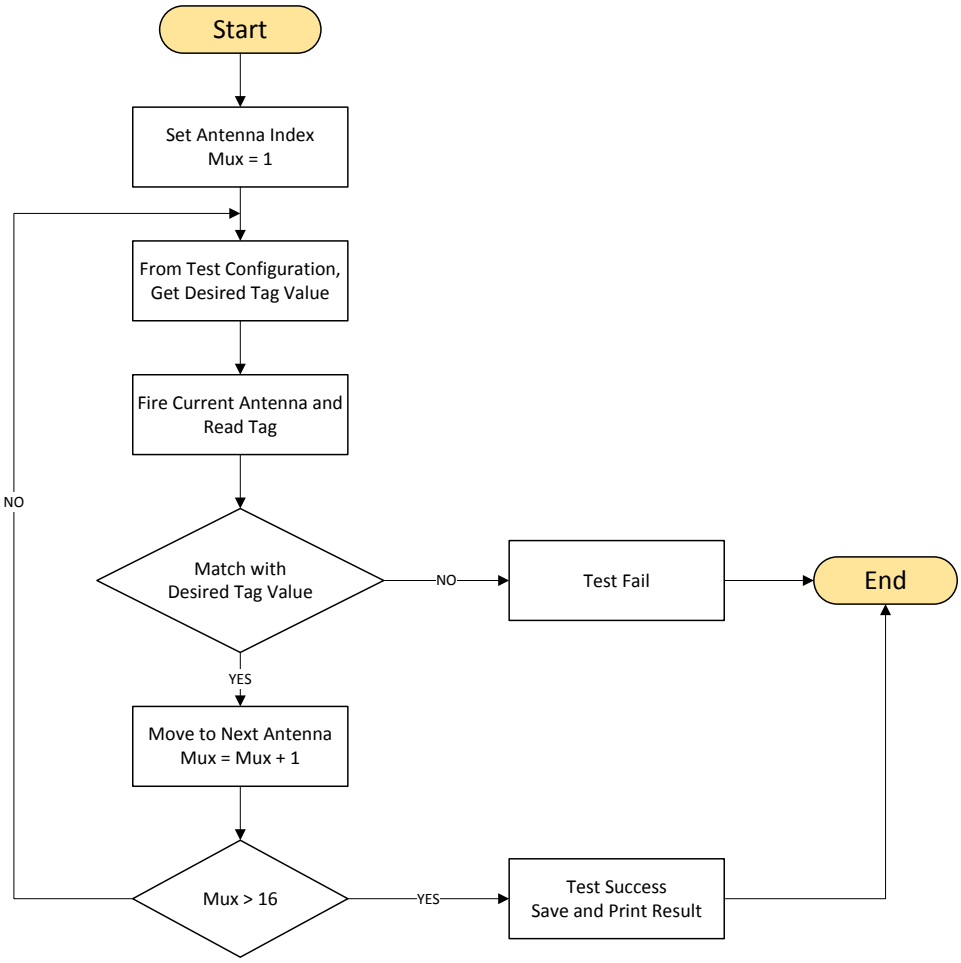


Figure 8 - Flowchart of Antenna System Test (16 Antenna Patches)

5.4 Test Validation

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.

5.4.1 Equipment Used

- A good unsealed antenna assembly having 16 antenna patches
- The equipment described in the Section 5.1

5.4.2 Data

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. There is not any damage on them.	
2	The VR reader is able to communicate with the antenna assembly.	
3	The VR reader is able to switch radiating antenna among 16 antennas.	
4	The VR reader is able to change radiating power.	
5	The VR reader is able to write/read data to the interface board through I2C bus.	
6	The VRHM is able to communicate with the VR reader including sending commands and reading response/tags.	
7	The VRHM is able to request a new test ID.	
8	The VRHM is able to print test label and test result.	
9	The VRHM is able to create a new Asset ID.	
10	The VRHM is able to run the automated antenna system test a specified number of cycles.	
11	The VRHM is able to flash production data to the interface board.	

5.4.3 Results/Conclusion

Overall, the far field test equipment and software will function as designed and specified if all test cases pass.

6 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.

6.1 Test Equipment

- A BD Tower Cabinet P1
- A test tag fixture 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: VR RFID Test Bench, Version 1.36

6.2 Test Setup

Instead of merchandise items, the far field test uses 16 paper boards with 36 tags on each board (Figure 9). In total, there are 576 tags in the tower cabinet (Figure 10), and 76 tags on each shelf.

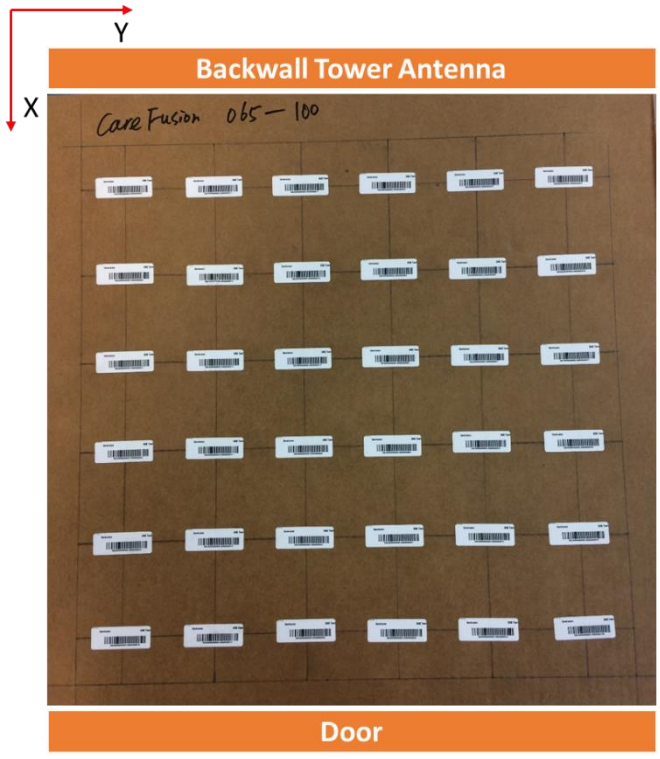


Figure 9. Tag Board

Figure 10. Tags 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.

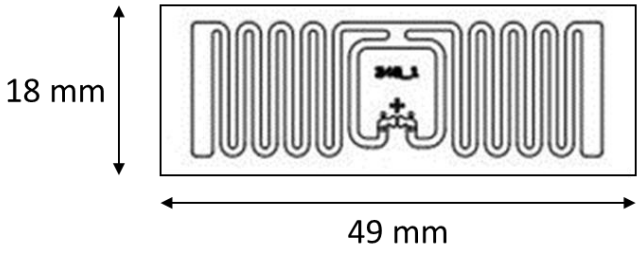


Figure 11. RFID Tag

6.3 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 12), the test is performed automatically including:

- Individually radiate each antenna patch, read tags in the cabinet (Figure 13).
- 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.

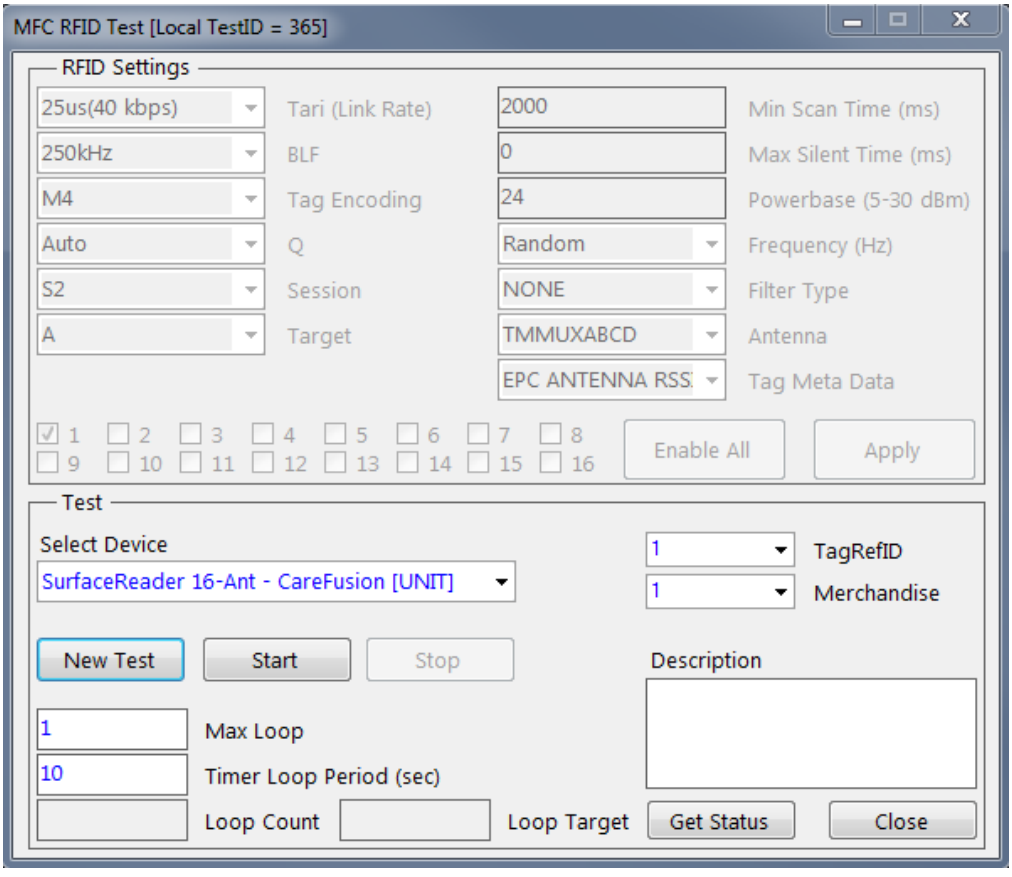


Figure 12. Test Screen of VR RFID Test Bench

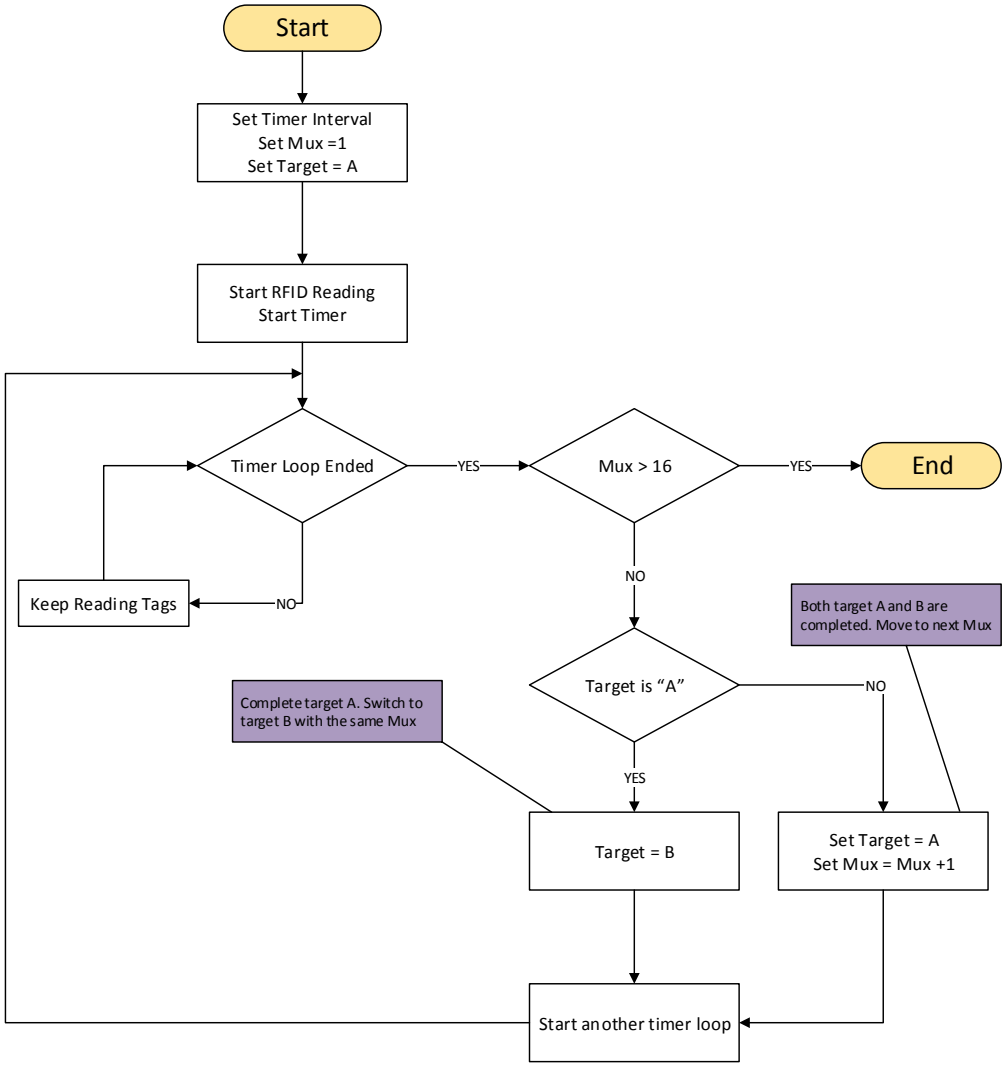


Figure 13. Flowchart of Individual Antenna Reading

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 µs 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 13 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 14.

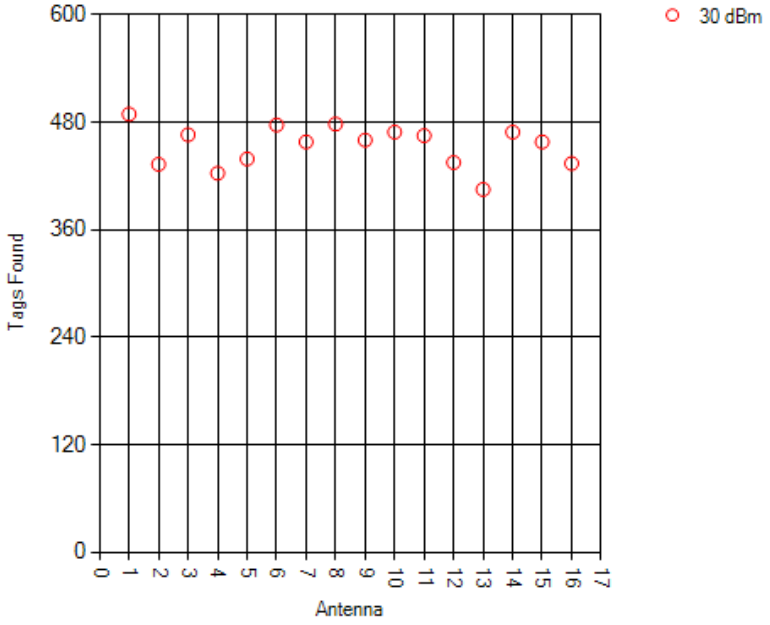


Figure 14. An Example of Tag Reading Count per Antenna Patch

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.

6.4 Test Validation

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.

6.4.1 Equipment Used

- A good antenna assembly having 16 antenna patches
- The equipment described in the Section 6.1

6.4.2 Data

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

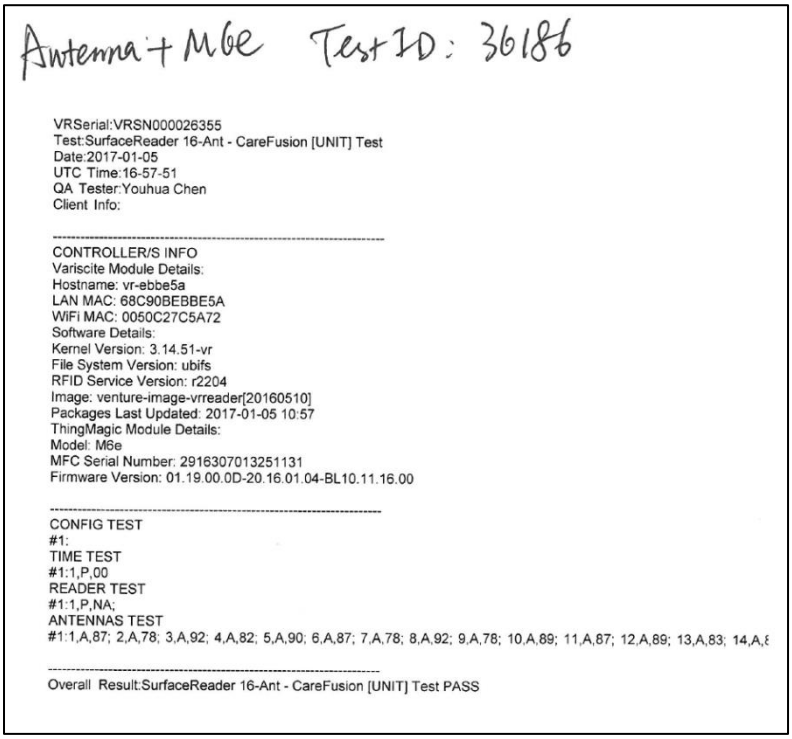
Test Case	Description	Result (PASS/FAIL)
1	All 576 reference tags are readable. There is not any damage on them.	
2	The VR reader is able to communicate with the antenna assembly.	
3	The VR reader is able to switch radiating antenna among 16 antennas.	
4	The VR reader is able to change radiating power.	
6	The VRRTB is able to communicate with the VR reader including sending commands and reading response/tags.	
7	The VRRTB is able to request a new test ID.	
8	The VRRTB is able to print test label and test result.	
9	The VRRTB is able to create a new Asset ID.	
10	The VRRTB is able to run the automated far field test a specified number of cycles.	

6.4.3 Results/Conclusion

Overall, the far field test equipment and software will function as designed and specified if all test cases pass.

7 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 5. The test result report and labels are printed and recorded with the Quality Sheet for that antenna assembly.


Antenna + M6e Test ID: 36186

VRSerial:VRSN000026355
Test:SurfaceReader 16-Ant - CareFusion [UNIT] Test
Date:2017-01-05
UTC Time:16-57-51
QA Tester:Youhua Chen
Client Info:

CONTROLLER/S INFO
Variscite Module Details:
Hostname: vr-ebbe5a
LAN MAC: 68C90BEBBE5A
WiFi MAC: 0050C27C5A72
Software Details:
Kernel Version: 3.14.51-vr
File System Version: ubifs
RFID Service Version: r2204
Image: venture-image-vrreader[20160510]
Packages Last Updated: 2017-01-05 10:57
ThingMagic Module Details:
Model: M6e
MFC Serial Number: 2916307013251131
Firmware Version: 01.19.00.0D-20.16.01.04-BL10.11.16.00

CONFIG TEST
#1:
TIME TEST
#1:1,P,00
READER TEST
#1:1,P,NA;
ANTENNAS TEST
#1:1,A,87; 2,A,78; 3,A,92; 4,A,82; 5,A,90; 6,A,87; 7,A,78; 8,A,92; 9,A,78; 10,A,89; 11,A,87; 12,A,89; 13,A,83; 14,A,

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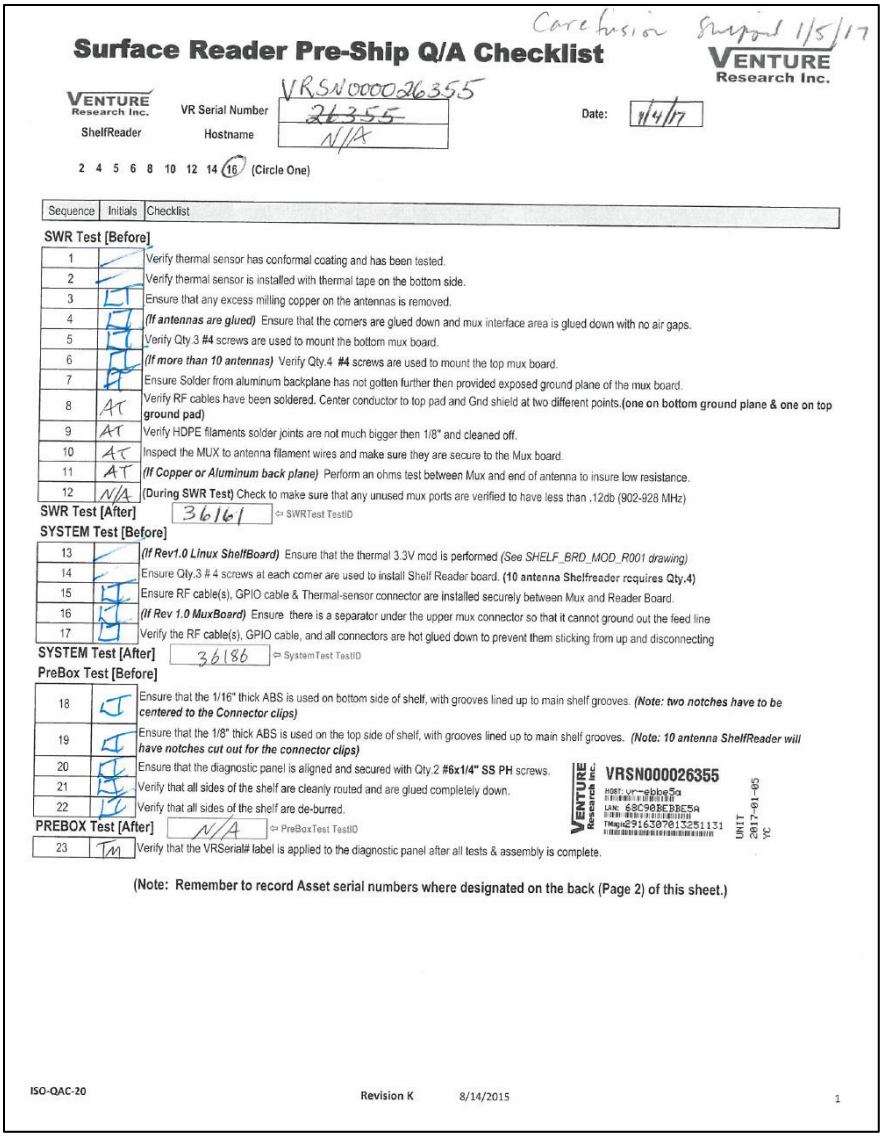
Overall Result:SurfaceReader 16-Ant - CareFusion [UNIT] Test PASS

Figure 15 - Sample of Test Result Report

Figure 16 - Sample of Final Label



Surface Reader Pre-Ship Q/A Checklist

Carefusion Shipped 1/5/17

VENTURE Research Inc.

VENTURE Research Inc. ShelfReader

VR Serial Number: VRSN000026355 — 26355

Hostname: N/A

Date: 11/4/17

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

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

VENTURE Research Inc. VRSN000026355 HOST: vr-ebbe5a LAN: 68C90BEBBE5A TM#29163070133251131 UNIT 2017-01-05 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 17 - Sample of Final Q/A Sheet