Application Report
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Reader Antenna Optimization for Reading the RF37S114

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NFC/RFID Applications

ABSTRACT

This application report provides performance data for the RF37S114 tag with various antenna sizes. Antenna design for a specific tag is an integral part in the NFC/RFID communication system. By maximizing antenna read range, potential hindrances, such as size and space limitations or physical dimensions, can be overcome. For example, the RF37S114 tag has a size of 4 mm × 4 mm, and by selecting the optimized antenna solution, the designer can be sure that all application requirements can be met.

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1 Test

This section summarizes the method used to determine the read range of the RF37S114 tag. It outlines tuning antennas and measuring the RF37S114 tag read range.

1.1 Equipment, Setup, and Test Method

To simulate various reader antennas encountered in NFC applications, six 3D printed antenna bobbins with different square sizes were built and copper magnet wire wrapped around them. See Figure 1 for reference.

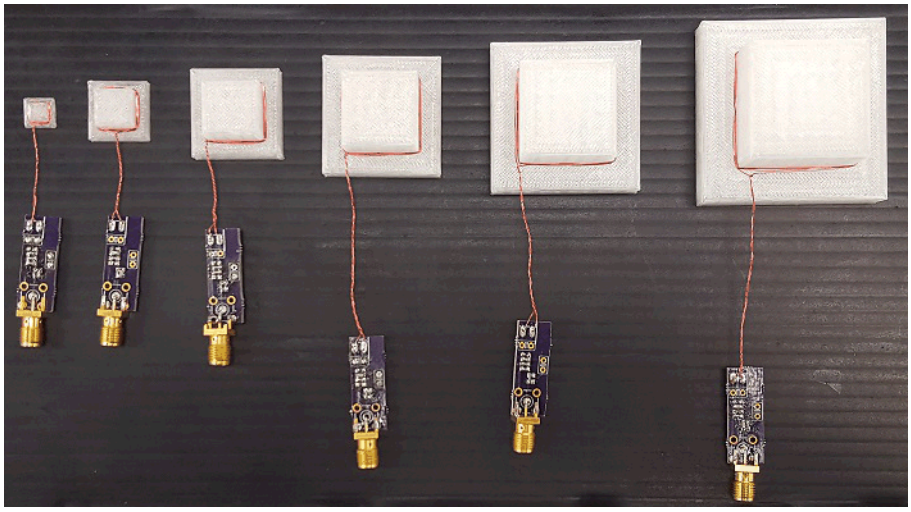

Figure 1. Tuned 3D Printed Antennas

See Table 1 for the 3D printed antenna properties. A network analyzer, Agilent Technologies E5070B, was used to measure the inductance of each antenna.

Table 1. Antenna Properties

Dimensions (mm × mm)	Wire Thickness (mm)	Number of Turns	Inductance (µH)
5 × 5	0.15	10	0.6
10 × 10	0.25	7	1.06
15 × 15	0.25	6	1.32
20 × 20	0.25	5	1.45
25 × 25	0.25	5	1.6
30 × 30	0.25	4	1.5

In order to generate maximum read range of the RF37S114 tags, the antennas should be tuned for the RF37S114 tag's protocol: ISO15693. Beginning with complex impedance being measured for each antenna with a network analyzer, the parallel capacitor, parallel resistor and series capacitor values for each antenna can be calculated.

See Table 2 for the parallel capacitor, parallel resistor and series capacitor values of the tuned antennas. For more information on antenna tuning see the *Antenna Tuning Details* section of the *TRF7960ATB, TRF7970ATB NFC/HF RFID Reader Module User's Guide*.

Table 2. Antenna Tuning Values

Dimensions (mm × mm)	Series Capacitor (pF)			Parallel Capacitor (pF)				Parallel Resistor (kΩ)
	Individual Capacitor Values		Total	Individual Capacitor Values			Total	
5 × 5	68	2	70	150	12	4	166	0.825
10 × 10	47	5	52	68		9	77	1.27
15 × 15	33	11	44	56		1	57	1.62
20 × 20	33	11	44	47		7	54	1.69
25 × 25	47		47	68	2	0.8	70.8	1.33
30 × 30	39	4	43	47	4	2.7	53.7	1.78

The bandwidth is required to calculate the Q factor of the antenna. The Q factor is an indicator of antenna performance. See Table 3 for the bandwidth and Q factor of each antenna.

Table 3. Antenna Bandwidth and Q Factor Values

Dimensions (mm × mm)	Bandwidth (kHz)	Q Factor
5 × 5	785.95	17.25
10 × 10	767.82	17.66
15 × 15	762	17.80
20 × 20	743	18.25
25 × 25	774	17.52
30 × 30	726	18.68

Measuring bandwidth is done using the SWR observed on the network analyzer. Q factor is determined using Equation 1.

Resonant Frequency (13.56 MHz) / Bandwidth = Q Factor (1)

See Figure 2 for network analyzer to antenna setup.

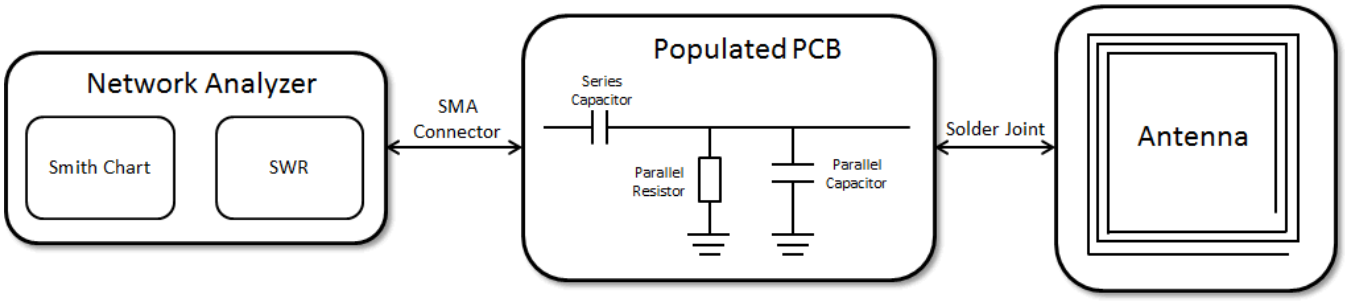

Figure 2. Antenna Calibration Setup

To measure the range of the tags, the external antennas were connected to a TRF7970AEVM. To configure the TRF7970AEVM for use with an external antenna, remove R3 to disconnect the onboard antenna. Connect the external antenna to J3. TRF7970AEVM runs on 5 V and was configured for full output power (200 mW) to collect this data. See Figure 3 for the tag distance reader setup.

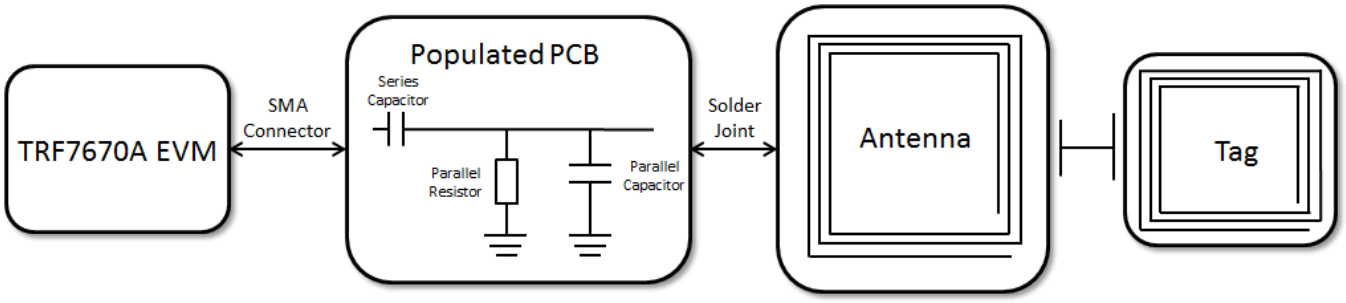

Figure 3. Tag Distance Measurement Setup

2 Results

This section contains the read distances of the tags and the Smith chart plots and standing wave ratio (SWR) screen captures of the tuned antennas.

2.1 RF37S114 Read Range

Table 4 contains the RF37S114 read range measured with the tuned antennas.

Table 4. RF37S114 Read Range Values

Dimensions (mm × mm)	RF37S114 Read Range (cm)
5 × 5	0.95
10 × 10	1.4
15 × 15	1.4
20 × 20	1.65
25 × 25	1.6
30 × 30	1.5

These measurements assume a completely parallel orientation between tag and antenna. See Figure 4 for reference for tag orientation.

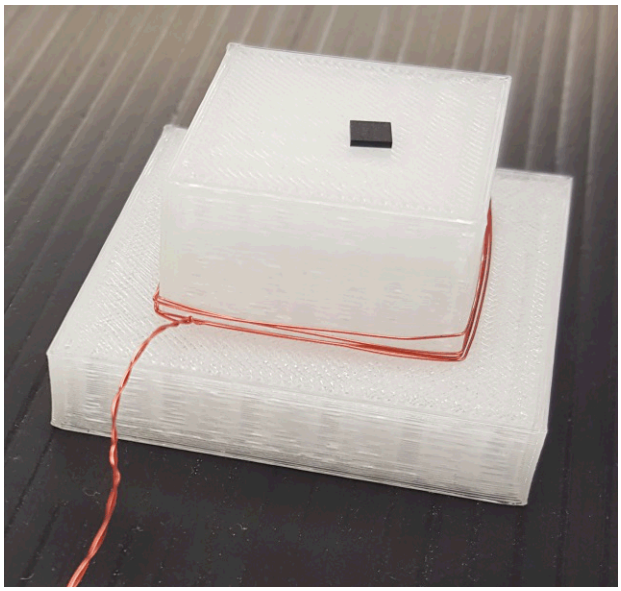

Figure 4. Antenna and Tag Parallel Orientation

2.2 Antenna Tuning Captures

This section contains the screen captures of the Smith chart and standing waveform for each tuned antenna.

2.2.1 5-mm × 5-mm Antenna

See Figure 5 for the Smith chart of the tuned 5-mm × 5-mm antenna.

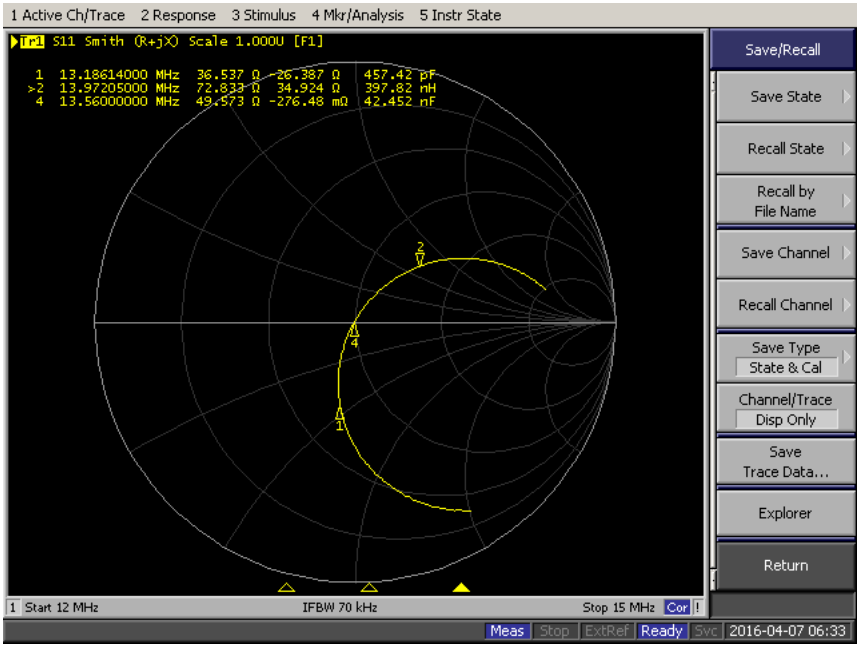

Figure 5. Tuned 5-mm × 5-mm Antenna Smith Chart

See Figure 6 for the standing wave ratio of the tuned 5-mm × 5-mm antenna.

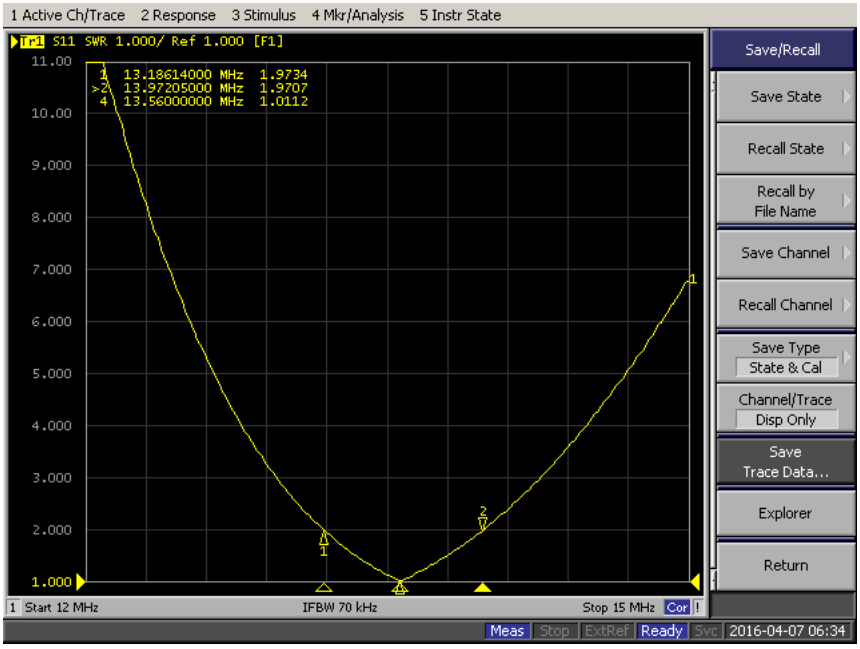

Figure 6. Tuned 5-mm × 5-mm Antenna Standing Wave Ratio

2.2.2 10-mm × 10-mm Antenna

See Figure 7 for the Smith chart of the tuned 10-mm × 10-mm antenna.

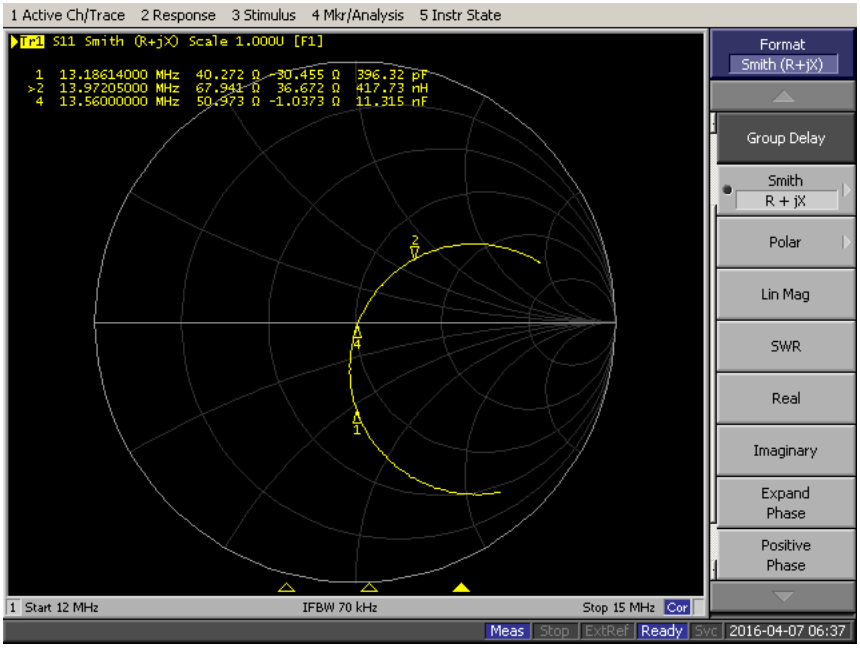

Figure 7. Tuned 10-mm × 10-mm Antenna Smith Chart

See Figure 8 for the standing wave ratio of the tuned 10-mm × 10-mm antenna

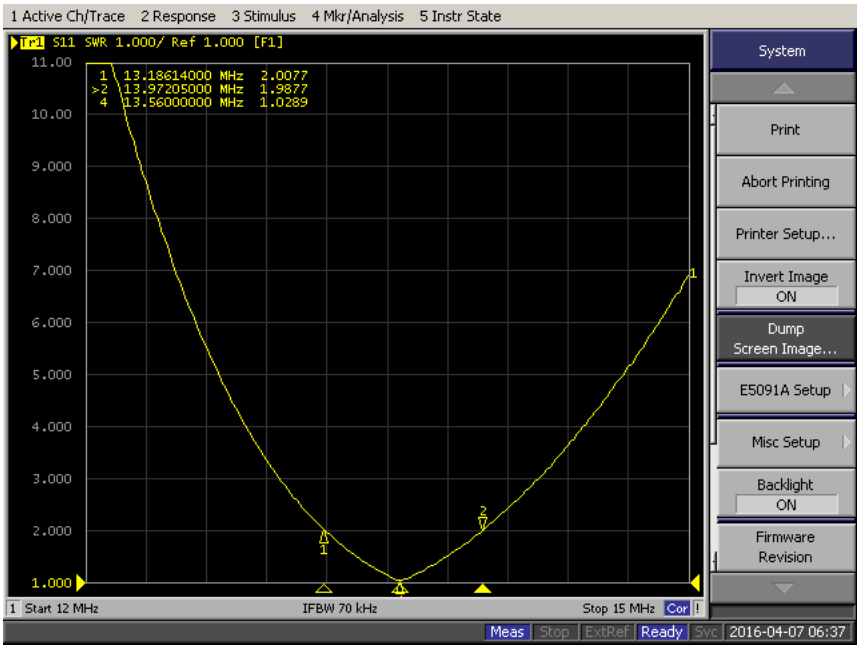

Figure 8. Tuned 10-mm × 10-mm Antenna Standing Wave Ratio

2.2.3 15-mm × 15-mm Antenna

See Figure 9 for the Smith chart of the tuned 15-mm × 15-mm antenna.

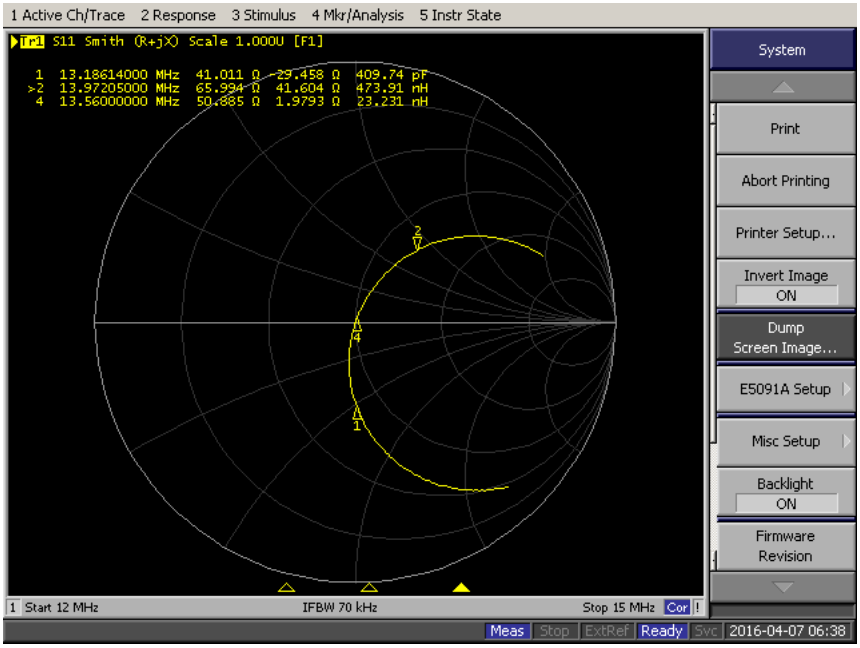

Figure 9. Tuned 15-mm × 15-mm Antenna Smith Chart

See Figure 10 for the standing wave ratio of the tuned 15-mm × 15-mm antenna.

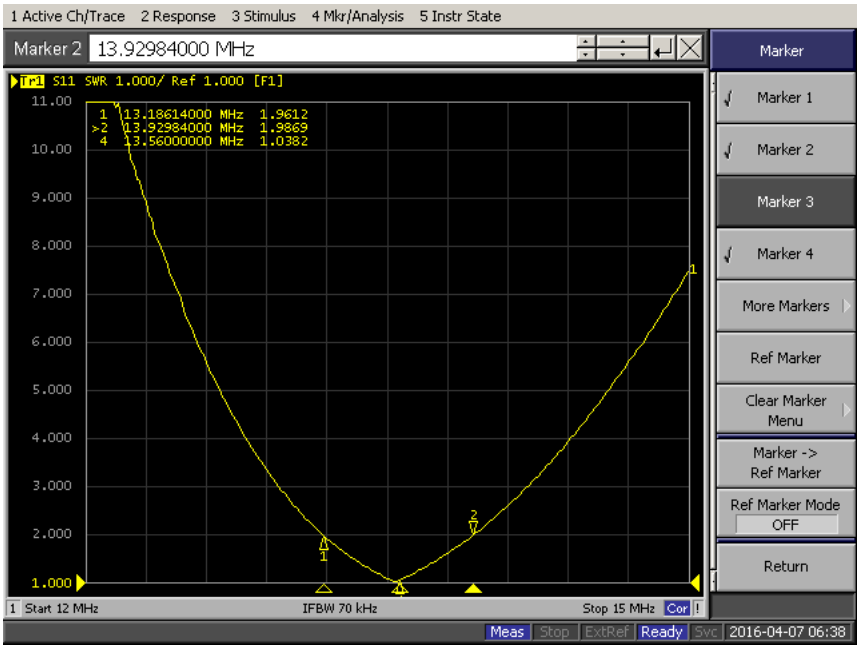

Figure 10. Tuned 15-mm × 15-mm Antenna Standing Wave Ratio

2.2.4 20-mm × 20-mm Antenna

See Figure 11 for the Smith chart of the tuned 20-mm × 20-mm antenna.

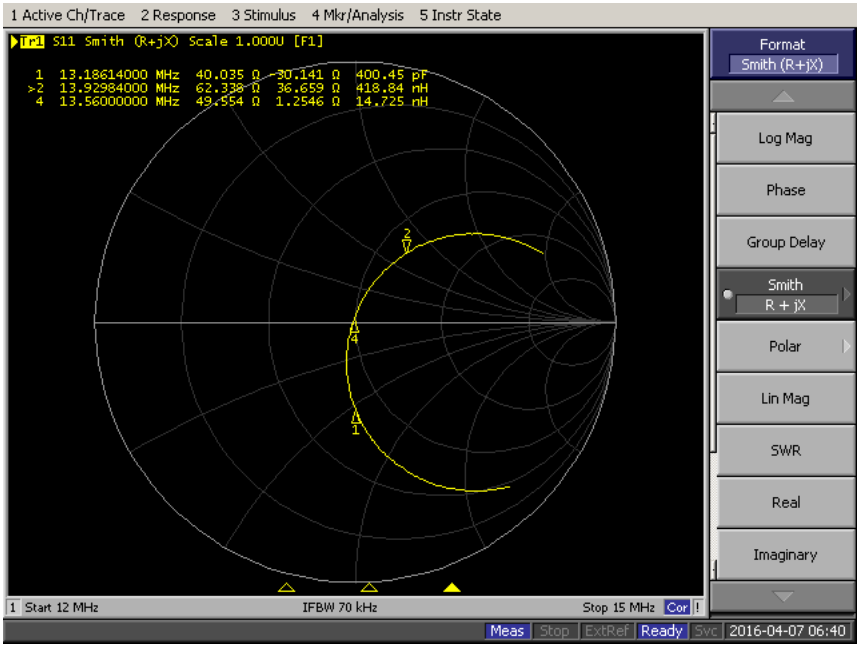

Figure 11. Tuned 20-mm × 20-mm Antenna Smith Chart

See Figure 12 for the standing wave ratio of the tuned 20-mm × 20-mm antenna.

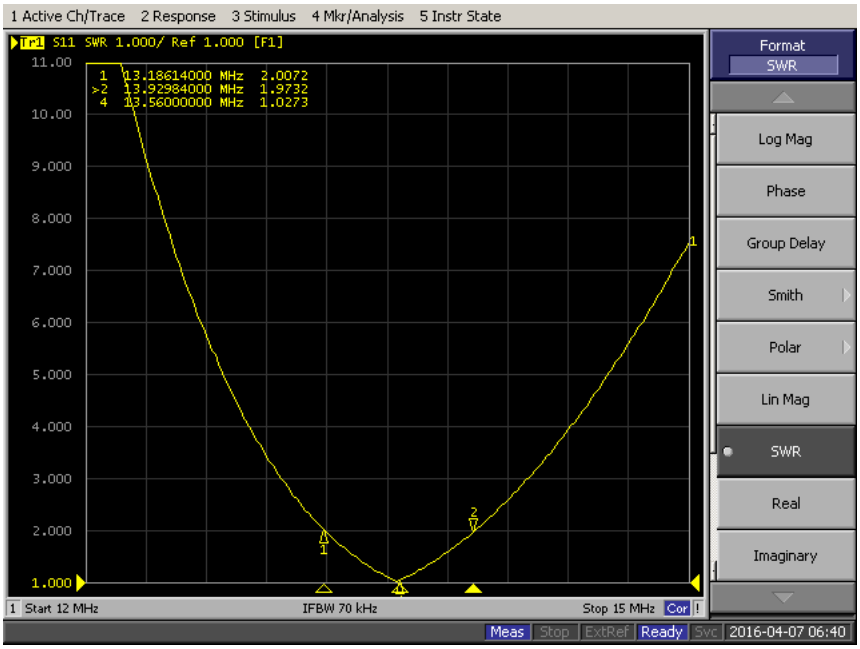

Figure 12. Tuned 20-mm × 20-mm Antenna Standing Wave Ratio

2.2.5 25-mm × 25-mm Antenna

See Figure 13 for the Smith chart of the tuned 25-mm × 25-mm antenna.

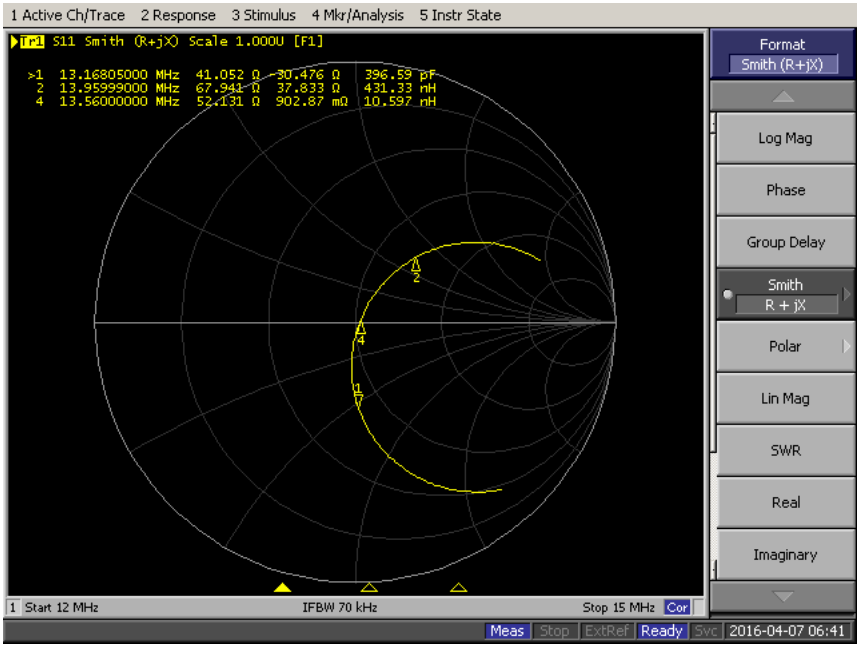

Figure 13. Tuned 25-mm × 25-mm Antenna Smith Chart

See Figure 14 for the standing wave ratio of the tuned 25-mm × 25-mm antenna.

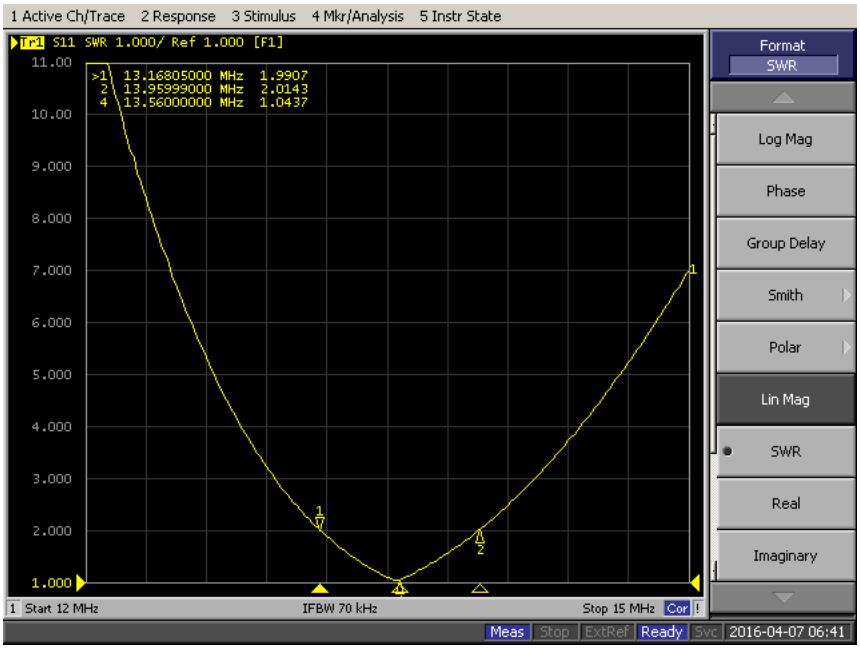

Figure 14. Tuned 25-mm × 25-mm Antenna Standing Wave Ratio

2.2.6 30-mm × 30-mm Antenna

See Figure 15 for the Smith chart of the tuned 30-mm × 30-mm antenna.

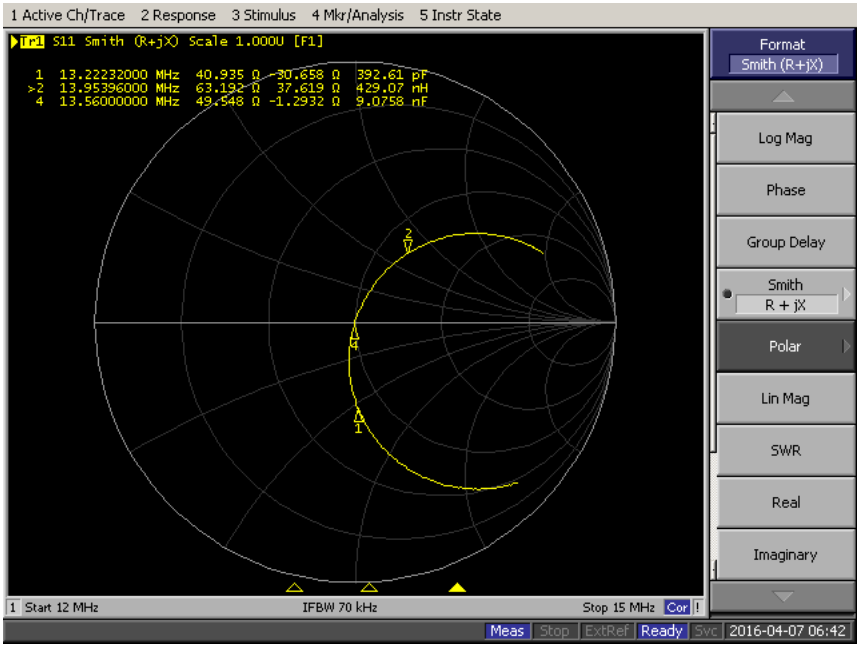

Figure 15. Tuned 30-mm × 30-mm Antenna Smith Chart

See Figure 16 for the standing wave ratio of the tuned 30-mm × 30-mm antenna.

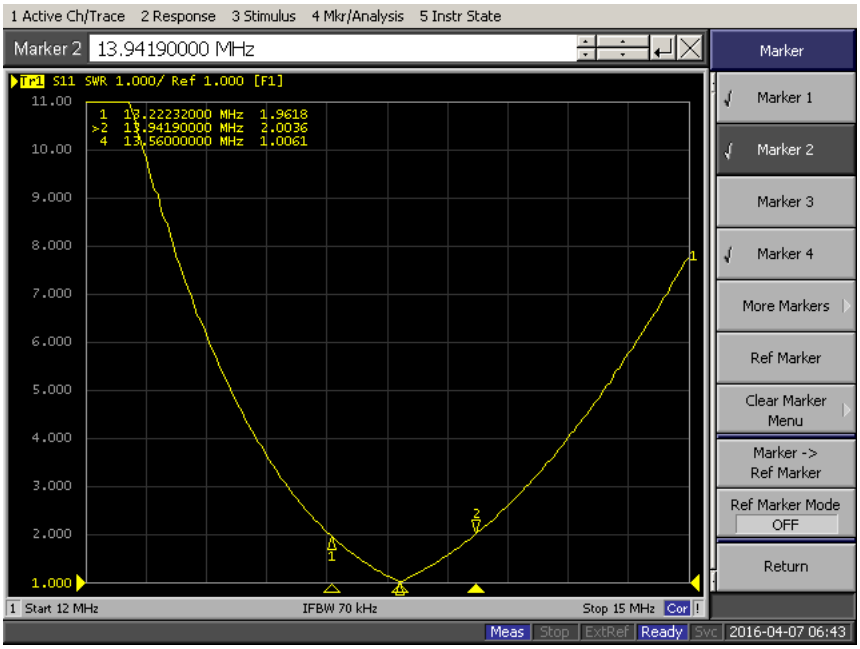

Figure 16. Tuned 30-mm × 30-mm Antenna Standing Wave Ratio

3 References

1. *TRF7960ATB, TRF7970ATB NFC/HF RFID Reader Module User's Guide*
2. RF37S114 Product Page
3. TRF7970A Product Page
4. TRF7970AEVM Product Page

Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from June 11, 2016 to July 12, 2016	Page
• Changed the title of this application report from *Antenna Tuning for RF37S114 Tag Maximum Read Range*	1

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