



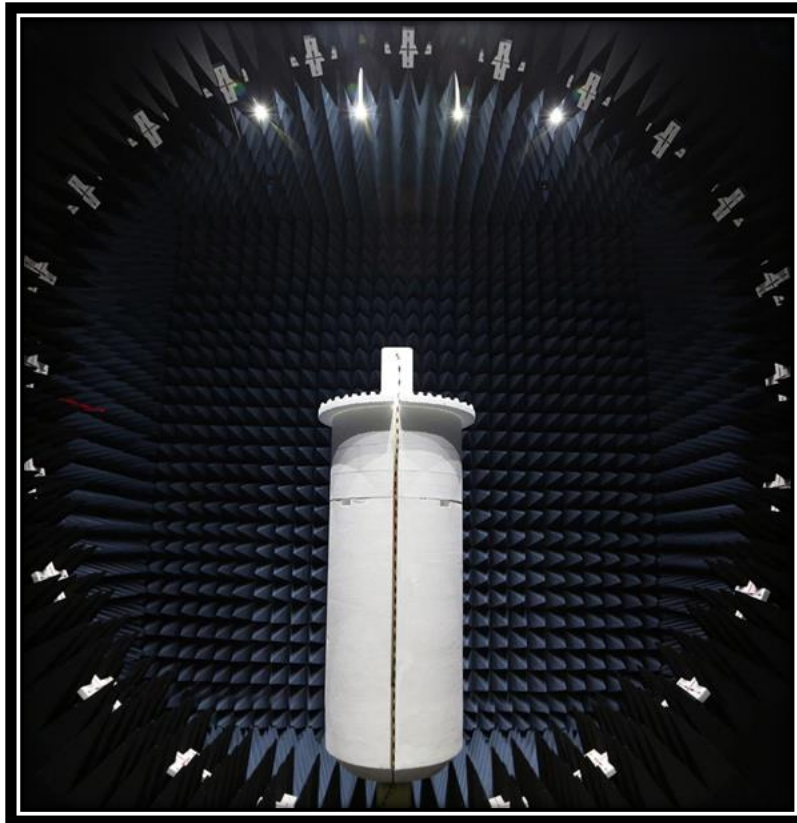
element

The Toro Company

RFID antenna testing

Antenna Pattern Measurements

Report: THET0023.0 Rev. 0, Issue Date: July 9, 2025



Approved by:

Johnny Candelas, Operations Manager

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TABLE OF CONTENTS



Section	Page Number
Revision History	3
Accreditations.....	4
Facilities	5
Product Description.....	6
Modifications	7
Antenna Pattern Measurements.....	8
End of Report.....	10

REVISION HISTORY



Revision Number	Description	Date (yyyy-mm-dd)	Page Number
00	None		

ACCREDITATIONS AND AUTHORIZATIONS



United States

FCC - Designated by the FCC as a Telecommunications Certification Body (TCB). Certification chambers, Open Area Test Sites, and conducted measurement facilities are listed with the FCC.

A2LA - Each laboratory is accredited by A2LA to ISO / IEC 17025, and as a product certifier to ISO / IEC 17065 which allows Element to certify transmitters to FCC and IC specifications.

FDA - Recognized by the FDA as an Accreditation Scheme for Conformity Assessment (ASCA)-accredited testing laboratory for basic safety and essential performance.

Canada

ISED - Recognized by Innovation, Science and Economic Development Canada as a Certification Body (CB) and as a CAB for the acceptance of test data.

European Union

European Commission – Recognized as an EU Notified Body validated for the EMCD and RED Directives.

United Kingdom

BEIS – Recognized by the UK as an Approved Body under the UK Radio Equipment and UK EMC Regulations.

Australia/New Zealand

ACMA - Recognized by ACMA as a CAB for the acceptance of test data.

Korea

MSIT / RRA - Recognized by KCC's RRA as a CAB for the acceptance of test data.

Japan

VCCI - Associate Member of the VCCI. Conducted and radiated measurement facilities are registered.

Taiwan

BSMI – Recognized by BSMI as a CAB for the acceptance of test data.

NCC - Recognized by NCC as a CAB for the acceptance of test data.

Singapore

IDA – Recognized by IDA as a CAB for the acceptance of test data.

Israel

MOC – Recognized by MOC as a CAB for the acceptance of test data.

Hong Kong

OFCA – Recognized by OFCA as a CAB for the acceptance of test data.

SCOPE

For details on the Scopes of our Accreditations, please visit:

[California](#)

[Minnesota](#)

[Oregon](#)

[Washington](#)

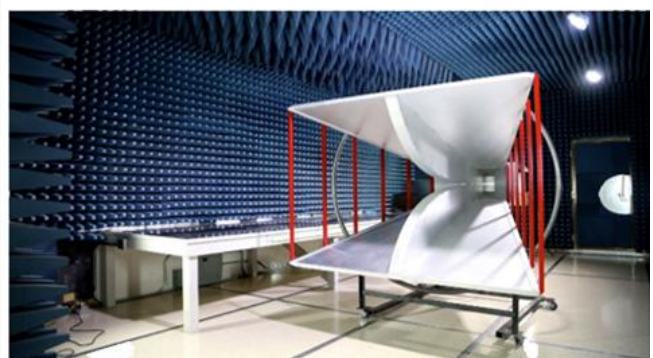
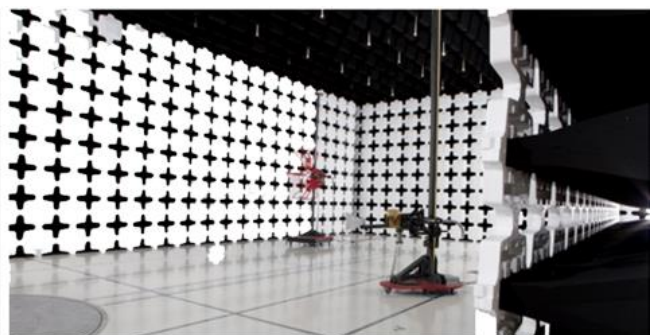
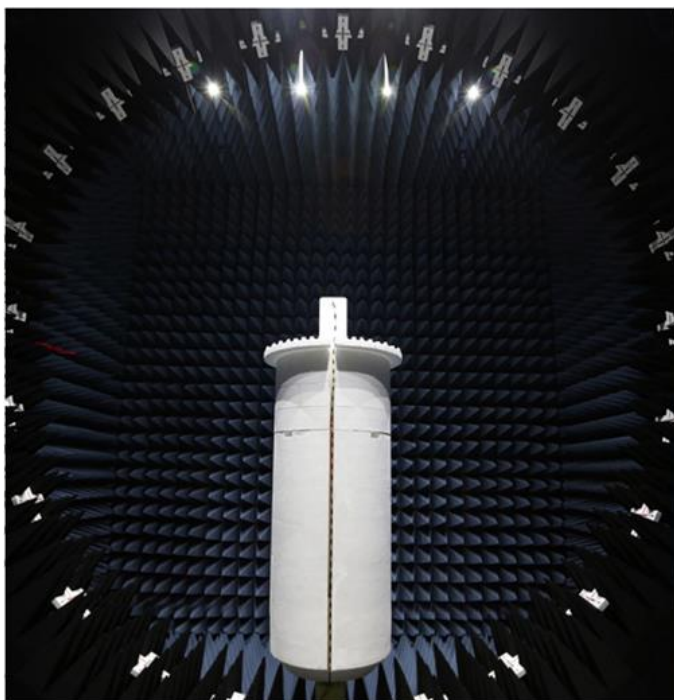
FACILITIES

Testing was performed at the following location(s)

	Location	Labs ⁽¹⁾	Address	A2LA ⁽²⁾	ISED ⁽³⁾	BSMI ⁽⁴⁾	VCCI ⁽⁵⁾	CAB ⁽⁶⁾	FDA ⁽⁷⁾
<input type="checkbox"/>	California	OC01-17	41 Tesla Irvine, CA 92618 (949) 861-8918	3310.04	2834B	SL2-IN-E-1154R	A-0029	US0158	TL-55
<input checked="" type="checkbox"/>	Minnesota	MN01-11	9349 W Broadway Ave. Brooklyn Park, MN 55445 (612) 638-5136	3310.05	2834E	SL2-IN-E-1152R	A-0109	US0175	TL-57
<input type="checkbox"/>	Oregon	EV01-12	6775 NE Evergreen Pkwy #400 Hillsboro, OR 97124 (503) 844-4066	3310.02	2834D	SL2-IN-E-1017	A-0108	US0017	TL-56
<input type="checkbox"/>	Washington	NC01-05	19201 120th Ave NE Bothell, WA 98011 (425) 984-6600	3310.06	2834F	SL2-IN-E-1153R	A-0110	US0157	TL-67
<input type="checkbox"/>	Offsite	N/A	See Product Description	N/A	N/A	N/A	N/A	N/A	N/A

See data sheets for specific labs

- (1) The lab designations denote individual rooms within each location. (OC01, OC02, OC03, etc.)
- (2) A2LA Certificate No.
- (3) ISED Company No.
- (4) BSMI No.
- (5) VCCI Site Filing No.
- (6) CAB Identifier. Recognized Phase I CAB for ISED, ACMA, BSMI, IDA, KCC/RRR, MOC, NCC, OFCA
- (7) FDA ASCA No.



PRODUCT DESCRIPTION



Client and Equipment under Test (EUT) Information

Company Name:	The Toro Company
Address:	8111 Lyndale Ave South
City, State, Zip:	Bloomington, MN 55429=0
Test Requested By:	Peter Maciel
EUT:	RFID Antenna Testing
First Date of Test:	August 16, 2022
Last Date of Test:	August 16, 2022
Receipt Date of Samples:	August 16, 2022
Equipment Design Stage:	Production
Equipment Condition:	No Damage
Purchase Authorization:	Verified

Information Provided by the Party Requesting the Test

Functional Description of the EUT:
Antennas
Testing Objective:
To obtain 3D antenna pattern measurements and calculated antenna performance values (gain, efficiency, TRP, etc)

MODIFICATIONS



Equipment Modifications

Item	Date	Test	Modification	Note	Disposition of EUT
1	2022-08-16	Active 3D Antenna Pattern Measurements	Tested as delivered to test Station.	No EMI suppression devices were added or modified during this test.	Scheduled testing was completed.

OTA TEST DESCRIPTION



OTA 2018.01.04

Testing was performed using the mode(s) of operation and configuration(s) noted within the report. The individuals and/or the organization requesting the test provided the modes, configurations and settings used to complete the evaluation. The actual test parameters are specified in the test data, this includes items such as investigated frequency range (scanned) and test levels. The testing methods and performance specifications, as well as the test site used for the evaluation are indicated in the test data. The test data represents the configuration / operating mode/ model that produced the highest emission levels as compared to the specification limit.

TEST EQUIPMENT

Description	Manufacturer	Model	ID	Last Cal.	Interval
Network Analyzer	Agilent	E5071C	NAM	11/13/2019	36 mo
Analyzer - Spectrum Analyzer	Agilent	E4443A	AAS	6/6/2022	12 mo
Antenna - Dipole	ETS Lindgren	3126-950	OTK	11/10/2022	36 mo
Antenna - Dipole	ETS Lindgren	3126-900	OTI	1/30/2020	36 mo
Antenna - Dipole	ETS Lindgren	3126-800	OTD	1/29/2020	36 mo
Antenna - Dipole	ETS Lindgren	3126-700	OTH	4/6/2020	36 mo

TEST DESCRIPTION

Using the modes of operation and configurations noted within this report, a radiated pattern measurement test was performed. The frequency ranges investigated (scanned), are also noted in this report.

The EUT was placed on a low dielectric constant support structure (Phi Axis Positioner) in the 3D center of the measurement zone using a laser alignment system. The antenna port of the EUT is connected to an RF feed cable which is connected to a Vector Network Analyzer (VNA) at its opposite end.

The test begins with a measurement path configured (via ETS-Lindgren EMQuest Data Acquisition and Analysis Software) such that an electrical path is present from the Theta polarization element of the -165° detector antenna, to port 2 of the VNA. The VNA drives the EUT through the desired frequency range at the desired IFBW and an insertion loss measurement is obtained. The measurement path is then reconfigured (again via EMQuest) such that an electrical path is present from the Phi polarization element of the -165° detector antenna, to port 2 of the VNA. The VNA drives the EUT through the desired frequency range at the desired IFBW and an insertion loss measurement is obtained. This process is repeated at each of the 23 detector antennas in turn. This process is repeated for every rotation of the Phi Axis Positioner up to 180° - Phi Axis Resolution. When this process is complete, EMQuest applies factors from a Range Calibration and Normalization to produce a final data set with 1D/2D/3D patterns and tabular values such as antenna efficiency, Equivalent Isotropic Radiated Power (EIRP), Total Radiated Power (TRP), etc.

Procedures for the Range Calibration and Normalization can be found in Element Materials Technology document: WP Antenna Pattern Measurements (3D)

PASSIVE 3D ANTENNA PATTERN MEASUREMENTS



EUT:	RFID antenna testing
Serial Number:	Optimus Tuned Matched
Customer:	The Toro Company
Attendees:	Colin
Customer Project:	None
Tested By:	Christopher Heintzelman
Test Run Description:	Optimus Tuned Matched (2)

Work Order:	THET0017
Date:	8/16/2022
Temperature:	22.6 °C
Relative Humidity:	49.3% RH
Bar. Pressure:	1020 mbar
Job Site:	MN10

COMMENTS

Axes are reversed from what is shown in picture - turntable was at 180 degrees when labels were placed. No serial number was provided at time of test.

3D PATTERN DATA

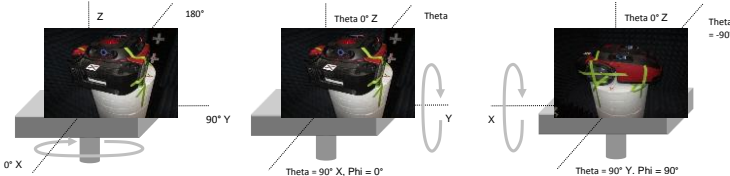
Frequency (MHz)	800	805	810	815	820	825	830	835	840	845	850	855
Ant. Port Input Pwr. (dBm)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tot. Rad. Pwr. (dBm)	-5.79	-5.81	-5.77	-5.83	-5.76	-5.70	-5.51	-5.35	-5.13	-4.93	-4.65	-4.42
Peak EIRP (dBm)	1.15	1.25	1.51	1.85	2.24	2.45	2.63	2.59	2.57	2.47	2.46	2.50
Directivity (dBi)	6.94	7.05	7.28	7.69	8.00	8.15	8.13	7.94	7.70	7.40	7.11	6.92
Efficiency (dB)	-5.79	-5.81	-5.77	-5.83	-5.76	-5.70	-5.51	-5.35	-5.13	-4.93	-4.65	-4.42
Efficiency (%)	26.34	26.27	26.49	26.09	26.56	26.89	28.14	29.19	30.66	32.14	34.30	36.14
Gain (dBi)	1.15	1.25	1.51	1.85	2.24	2.45	2.63	2.59	2.57	2.47	2.46	2.50
Average Gain (dB)	-5.79	-5.81	-5.77	-5.83	-5.76	-5.70	-5.51	-5.35	-5.13	-4.93	-4.65	-4.42
E-Plane 3 dB BW (°)	51.00	51.00	51.00	35.00	35.00	34.00	33.00	30.00	31.00	32.00	31.00	31.00

860	865	870	875	880	885	890	895	900	905	910	915	920
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-4.21	-4.06	-3.96	-3.88	-3.82	-3.83	-3.78	-3.78	-4.17	-4.14	-4.02	-3.92	-3.82
2.57	2.56	2.48	2.69	2.78	2.62	2.32	2.12	1.58	1.45	1.87	2.46	2.77
6.78	6.62	6.44	6.57	6.60	6.45	6.09	5.91	5.74	5.59	5.90	6.38	6.60
-4.21	-4.06	-3.96	-3.88	-3.82	-3.83	-3.78	-3.78	-4.17	-4.14	-4.02	-3.92	-3.82
37.97	39.25	40.18	40.93	41.50	41.42	41.91	41.86	38.31	38.56	39.59	40.52	41.45
2.57	2.56	2.48	2.69	2.78	2.62	2.32	2.12	1.58	1.45	1.87	2.46	2.77
-4.21	-4.06	-3.96	-3.88	-3.82	-3.83	-3.78	-3.78	-4.17	-4.14	-4.02	-3.92	-3.82
31.00	31.00	65.00	63.00	64.00	67.00	71.00	31.00	32.00	32.00	32.00	28.00	28.00
825	830	835	840	845	850	855	860	865	870	875	880	
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-3.89	-3.98	-4.14	-4.22	-4.27	-4.19	-4.04	-3.81	-3.63	-3.59	-3.67	-3.91	
2.65	2.42	2.28	2.21	1.99	1.85	1.85	1.78	1.58	1.33	1.34	1.62	
6.55	6.40	6.41	6.42	6.26	6.04	5.88	5.59	5.21	4.92	5.01	5.53	
-3.89	-3.98	-4.14	-4.22	-4.27	-4.19	-4.04	-3.81	-3.63	-3.59	-3.67	-3.91	
40.80	39.97	38.59	37.89	37.44	38.10	39.47	41.55	43.32	43.76	42.97	40.65	
2.65	2.42	2.28	2.21	1.99	1.85	1.85	1.78	1.58	1.33	1.34	1.62	
-3.89	-3.98	-4.14	-4.22	-4.27	-4.19	-4.04	-3.81	-3.63	-3.59	-3.67	-3.91	
29.00	25.00	25.00	25.00	25.00	53.00	55.00	61.00	59.00	59.00	59.00	55.00	

Azimuth Cut (Theta Axis = 90°)

Elevation Cut (Phi Axis = 0°)

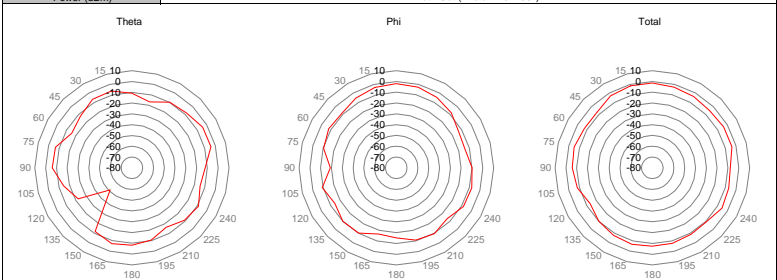
Elevation Cut (Phi Axis = 90°)



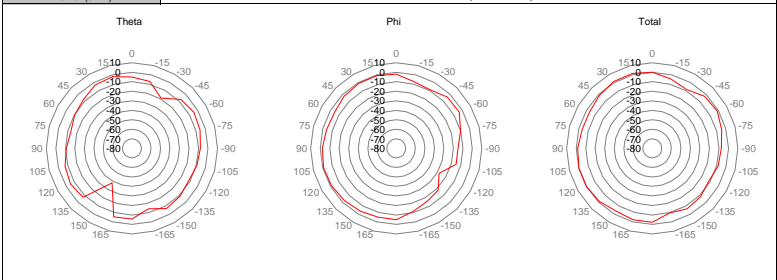
POLAR PLOTS

Frequency (MHz): 915

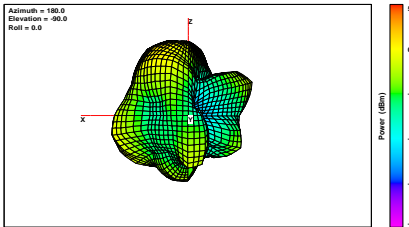
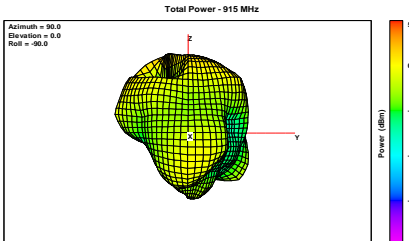
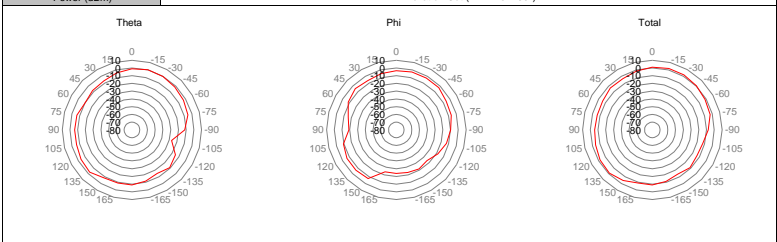
Azimuth Cut (Theta Axis = 90°)



Elevation Cut (Phi Axis = 0°)



Elevation Cut (Phi Axis = 90°)



End of Test Report