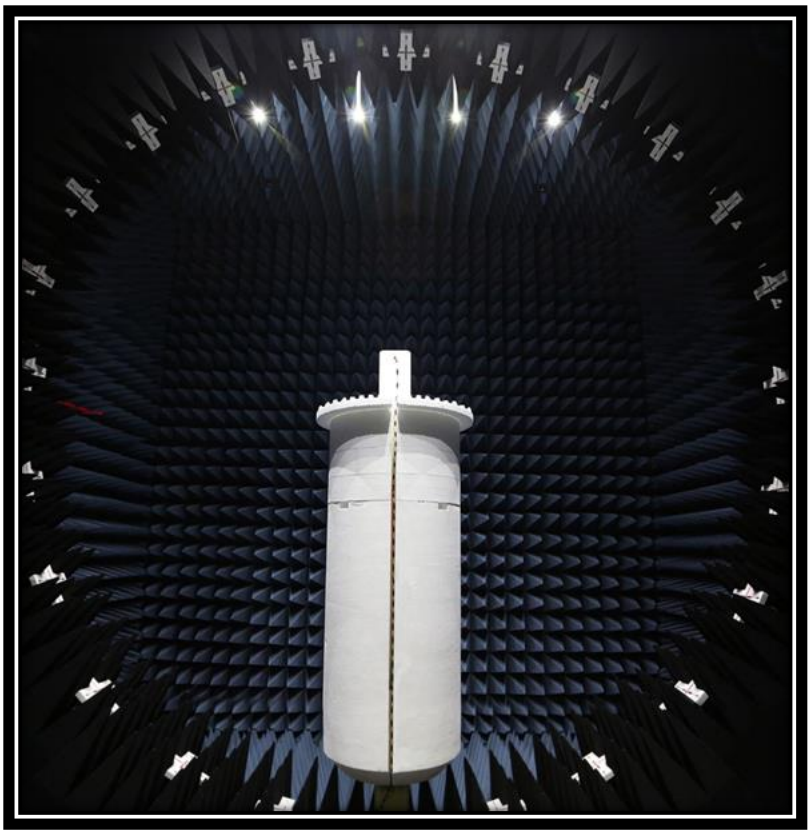
# IrriGreen, Inc.

## Controller 3, Model 705101

## Antenna Pattern Measurements

**Report: IRRI0024.0 Rev. 0, Issue Date: August 5, 2024**



Approved by:

*Trevor Buls, Principal EMC Test Engineer*
*Signed for and on behalf of Element*

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element
2023.04.17

| Section | Page Number |
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# REVISION HISTORY

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

# ACCREDITATIONS AND AUTHORIZATIONS

element
2021.09.01

## 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.

## 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.

## Vietnam

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

## SCOPE

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

California Minnesota Oregon Texas Washington

# FACILITIES

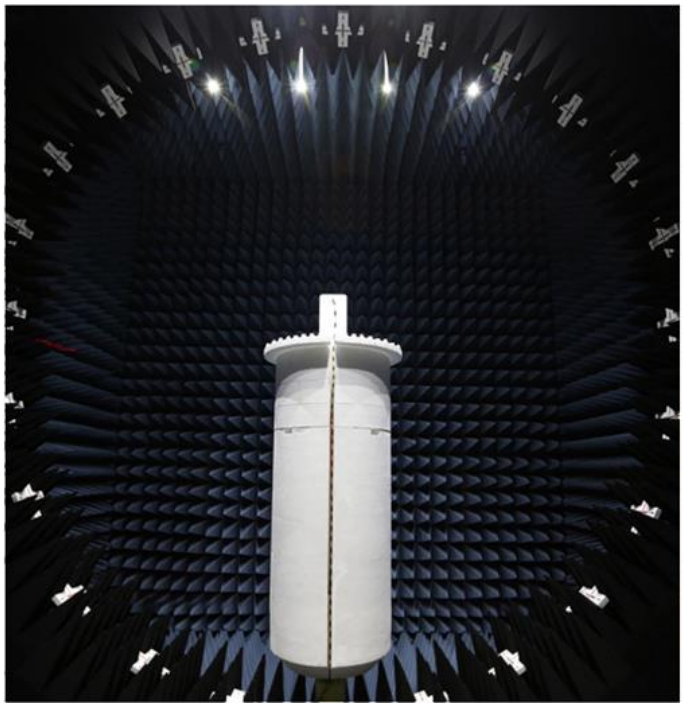
element
2024.07.18

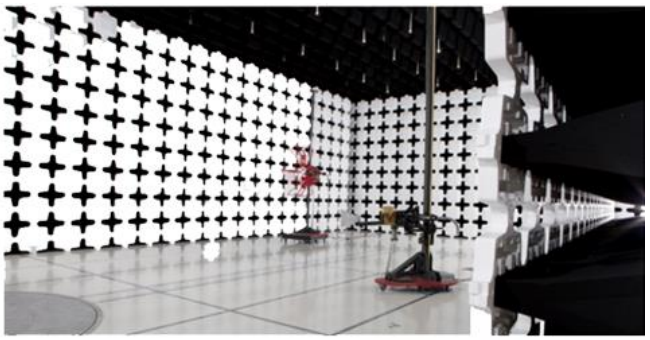
Testing was performed at the following location(s)

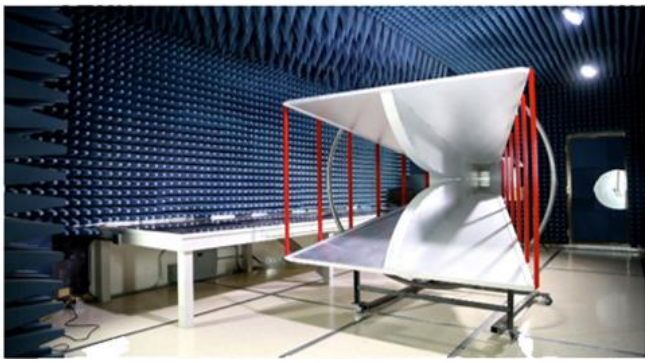
| | Location | Labs (1) | Address | A2LA (2) | ISED (3) | BSMI (4) | VCCI (5) | CAB (6) | FDA (7) |
|---|---|---|---|---|---|---|---|---|---|
| ☐ | California | OC01-17 | 41 Tesla<br>Irvine, CA 92618<br>(949) 861-8918 | 3310.04 | 2834B | SL2-IN-E-1154R | A-0029 | US0158 | TL-55 |
| ☒ | Minnesota | MN01-11 | 9349 W Broadway Ave.<br>Brooklyn Park, MN 55445<br>(612) 638-5136 | 3310.05 | 2834E | SL2-IN-E-1152R | A-0109 | US0175 | TL-57 |
| ☐ | Oregon | EV01-12 | 6775 NE Evergreen Pkwy #400<br>Hillsboro, OR 97124<br>(503) 844-4066 | 3310.02 | 2834D | SL2-IN-E-1017 | A-0108 | US0017 | TL-56 |
| ☐ | Plano Texas | PT01-15 | 1701 E Plano Pkwy, Ste 150<br>Plano, TX 75074<br>(972) 509-2566 | 214.19 | 32637 | SL2-IN-E-057R | N/A | US0054 | N/A |
| ☐ | Texas | TX01-09 | 3801 E Plano Pkwy<br>Plano, TX 75074<br>(469) 304-5255 | 3310.03 | 2834G | SL2-IN-E-1158R | N/A | US0191 | TL-54 |
| ☐ | Washington | NC01-05 | 19201 120th Ave NE<br>Bothell, WA 98011<br>(425) 984-6600 | 3310.06 | 2834F | SL2-IN-E-1153R | A-0110 | US0157 | TL-67 |
| ☐ | 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/RRA, MIC, MOC, NCC, OFCA
(7) FDA ASCA No.







# PRODUCT DESCRIPTION

## Client and Equipment under Test (EUT) Information

| | |
|---|---|
| **Company Name:** | IrriGreen, Inc. |
| **Address:** | 5250 West 73rd Street |
| **City, State, Zip:** | Edina, MN 55439 |
| **Test Requested By:** | Gary Klinefelter |
| **EUT:** | Controller 3 |
| **First Date of Test:** | July 16, 2024 |
| **Last Date of Test:** | July 16, 2024 |
| **Receipt Date of Samples:** | July 16, 2024 |
| **Equipment Design Stage:** | Prototype |
| **Equipment Condition:** | No Damage |
| **Purchase Authorization:** | Verified |

## Information Provided by the Party Requesting the Test

| **Functional Description of the EUT:** |
|---|
| The controller is labeled as a "Controller 3" with an Irrigreen sprinkler model 400104. |

| **Testing Objective:** |
|---|
| To obtain 3D antenna pattern measurements and calculated antenna performance values (gain, efficiency, TRP, etc) |

# CONFIGURATIONS

## Configuration IRRI0024-7

| EUT | | | |
|---|---|---|---|
| **Description** | **Manufacturer** | **Model/Part Number** | **Serial Number** |
| Sprinkler Controller | Irrigreen Inc | Controller 3, Model 705101 | 900636 Rev A1 Unit B |

# MODIFICATIONS

## Equipment Modifications

| Item | Date | Test | Modification | Note | Disposition of EUT |
|---|---|---|---|---|---|
| 1 | 2024-07-16 | Passive 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. |

# PASSIVE 3D ANTENNA PATTERN MEASUREMENTS

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 |
|---|---|---|---|---|---|
| Antenna - Dipole | ETS Lindgren | 3126-2450 | OTF2 | 4/18/2024 | 36 mo |
| Chamber - OTA | ETS Lindgren | AMS-8923-195 | OTA | 5/15/2024 | 36 mo |
| Analyzer - Network Analyzer | Agilent | E5071C | NAM | 11/19/2022 | 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.

A measurement uncertainty estimation has been performed for this testing. When a measurement is made, the result will be different from the true or theoretically correct value. The difference is the result of tolerances in the measurement system that cannot be completely eliminated. To the extent that technology allows us, it has been our aim to minimize this error. Measurement uncertainty is a statistical expression of measurement error qualified by a probability distribution. The expanded measurement uncertainty, 95% confidence level (K=2), for Maximum Gain / Efficiency for 2400-2483.5 MHz on active measurements is +/-1.08 dB. The expanded measurement uncertainty, 95% confidence level (K=2), for Maximum Gain / Efficiency for 2400-2483.5 MHz on passive measurements is +/-1.29. The calculations for estimating measurement uncertainty are available upon request.

# PASSIVE 3D ANTENNA PATTERN MEASUREMENTS

OTA 2018.01.04

| | |
|---|---|
| EUT: | Controller 3 |
| Serial Number: | 900636 Rev A1 Unit B |
| Customer: | IrriGreen, Inc. |
| Attendees: | Seth Hammond |
| Customer Project: | None |
| Tested By: | Christopher Heintzelman |
| Test Run Description: | Passive_1 |

| | |
|---|---|
| Work Order: | IRRI0024 |
| Date: | 7/16/2024 |
| Temperature: | 22 °C |
| Relative Humidity: | 54.3% RH |
| Bar. Pressure: | 1015 mbar |
| Job Site: | MN10 |

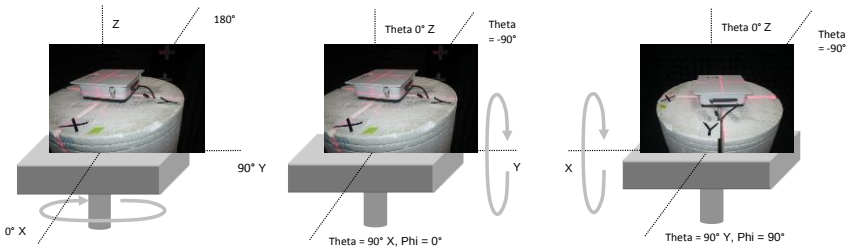
**COMMENTS**

The maximum gain found in this measurement is 5.92 dBi at 2440 MHz.

**3D PATTERN DATA**

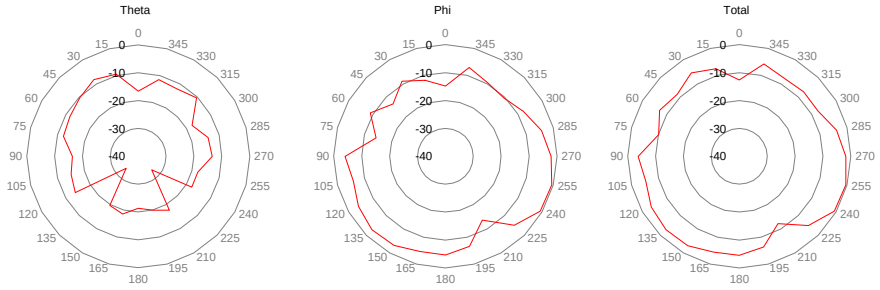
| Frequency (MHz) | 2400 | 2410 | 2420 | 2430 | 2440 | 2450 | 2460 | 2470 | 2480 | 2484 |
|---|---|---|---|---|---|---|---|---|---|---|
| Ant. Port Input Pwr. (dBm) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Tot. Rad. Pwr. (dBm) | -2.91 | -2.80 | -2.67 | -2.57 | -2.44 | -2.40 | -2.40 | -2.53 | -2.64 | -2.63 |
| Peak EIRP (dBm) | 5.43 | 5.56 | 5.74 | 5.86 | 5.92 | 5.83 | 5.61 | 5.30 | 5.14 | 5.18 |
| Directivity (dBi) | 8.33 | 8.36 | 8.42 | 8.43 | 8.36 | 8.23 | 8.00 | 7.83 | 7.78 | 7.82 |
| Efficiency (dB) | -2.91 | -2.80 | -2.67 | -2.57 | -2.44 | -2.40 | -2.40 | -2.53 | -2.64 | -2.63 |
| Efficiency (%) | 51.18 | 52.50 | 54.04 | 55.28 | 56.99 | 57.49 | 57.55 | 55.81 | 54.44 | 54.52 |
| Gain (dBi) | 5.43 | 5.56 | 5.74 | 5.86 | 5.92 | 5.83 | 5.61 | 5.30 | 5.14 | 5.18 |
| Average Gain (dB) | -2.91 | -2.80 | -2.67 | -2.57 | -2.44 | -2.40 | -2.40 | -2.53 | -2.64 | -2.63 |
| E-Plane 3 dB BW (°) | 39.00 | 40.00 | 39.00 | 41.00 | 42.00 | 42.00 | 47.00 | 48.00 | 53.00 | 53.00 |

**Azimuth Cut (Theta Axis = 90°)** **Elevation Cut (Phi Axis = 0°)** **Elevation Cut (Phi Axis = 90°)**

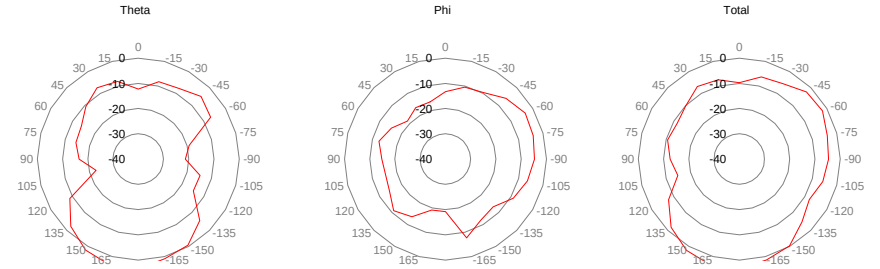



**POLAR PLOTS** **Frequency (MHz):** 2400

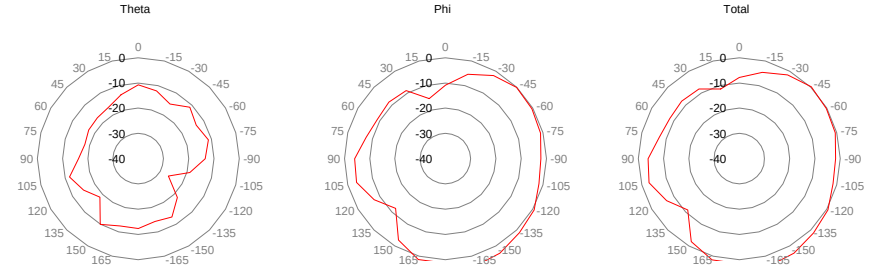
Power (dBm) — Azimuth Cut (Theta Axis = 90°)




Power (dBm) — Elevation Cut (Phi Axis = 0°)




Power (dBm) — Elevation Cut (Phi Axis = 90°)



# PASSIVE 3D ANTENNA PATTERN MEASUREMENTS

OTA 2018.01.04

| | |
|---|---|
| EUT: | Controller 3 |
| Serial Number: | 900636 Rev A1 Unit B |
| Customer: | IrriGreen, Inc. |
| Attendees: | Seth Hammond |
| Customer Project: | None |
| Tested By: | Christopher Heintzelman |
| Test Run Description: | Passive_2 |

| | |
|---|---|
| Work Order: | IRRI0024 |
| Date: | 7/16/2024 |
| Temperature: | 22 °C |
| Relative Humidity: | 54.3% RH |
| Bar. Pressure: | 1015 mbar |
| Job Site: | MN10 |

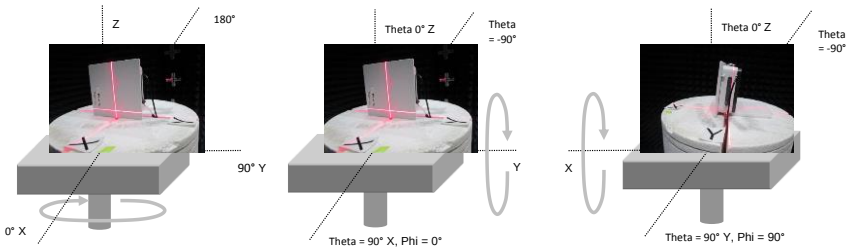
**COMMENTS**

The EUT was rotated on its side to prove that previous emissions along the -Z axis were not related to the feed cable. The table height was not adjusted to account for the difference in height. Configuration 7.

**3D PATTERN DATA**

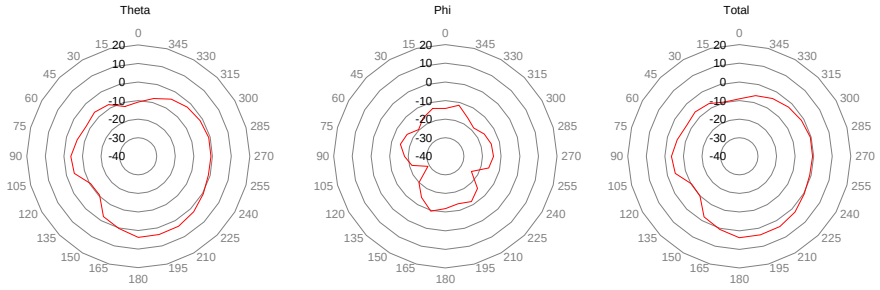
| Frequency (MHz) | 2400 | 2410 | 2420 | 2430 | 2440 | 2450 | 2460 | 2470 | 2480 | 2484 |
|---|---|---|---|---|---|---|---|---|---|---|
| Ant. Port Input Pwr. (dBm) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Tot. Rad. Pwr. (dBm) | -2.88 | -2.74 | -2.56 | -2.43 | -2.29 | -2.25 | -2.26 | -2.41 | -2.50 | -2.51 |
| Peak EIRP (dBm) | 3.85 | 4.06 | 4.22 | 4.49 | 4.84 | 4.99 | 5.07 | 5.02 | 4.98 | 5.01 |
| Directivity (dBi) | 6.73 | 6.79 | 6.78 | 6.92 | 7.12 | 7.24 | 7.33 | 7.43 | 7.48 | 7.52 |
| Efficiency (dB) | -2.88 | -2.74 | -2.56 | -2.43 | -2.29 | -2.25 | -2.26 | -2.41 | -2.50 | -2.51 |
| Efficiency (%) | 51.51 | 53.23 | 55.40 | 57.10 | 59.05 | 59.55 | 59.47 | 57.47 | 56.19 | 56.15 |
| Gain (dBi) | 3.85 | 4.06 | 4.22 | 4.49 | 4.84 | 4.99 | 5.07 | 5.02 | 4.98 | 5.01 |
| Average Gain (dB) | -2.88 | -2.74 | -2.56 | -2.43 | -2.29 | -2.25 | -2.26 | -2.41 | -2.50 | -2.51 |
| E-Plane 3 dB BW (°) | 62.00 | 62.00 | 53.00 | 53.00 | 52.00 | 52.00 | 52.00 | 51.00 | 52.00 | 51.00 |

**Azimuth Cut (Theta Axis = 90°)** **Elevation Cut (Phi Axis = 0°)** **Elevation Cut (Phi Axis = 90°)**

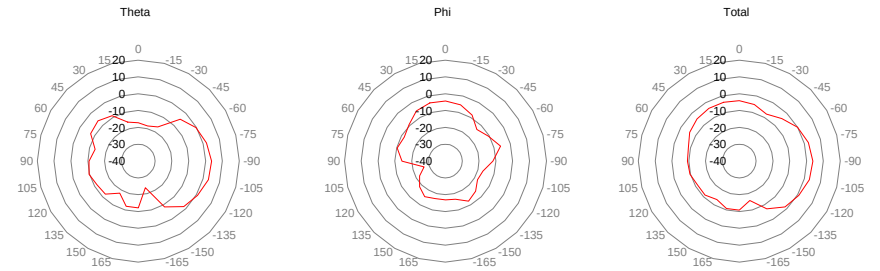



**POLAR PLOTS** **Frequency (MHz):** 2400

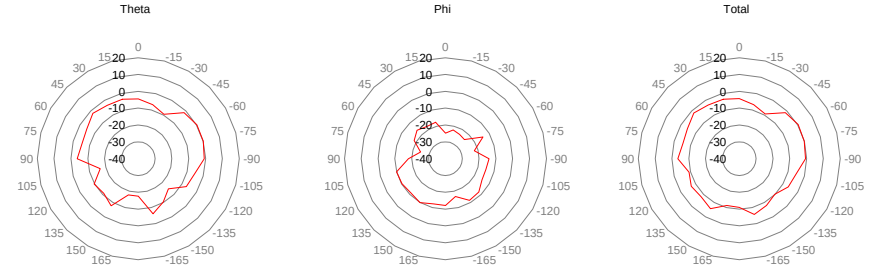
Power (dBm) — Azimuth Cut (Theta Axis = 90°)




Power (dBm) — Elevation Cut (Phi Axis = 0°)




Power (dBm) — Elevation Cut (Phi Axis = 90°)



End of Test Report