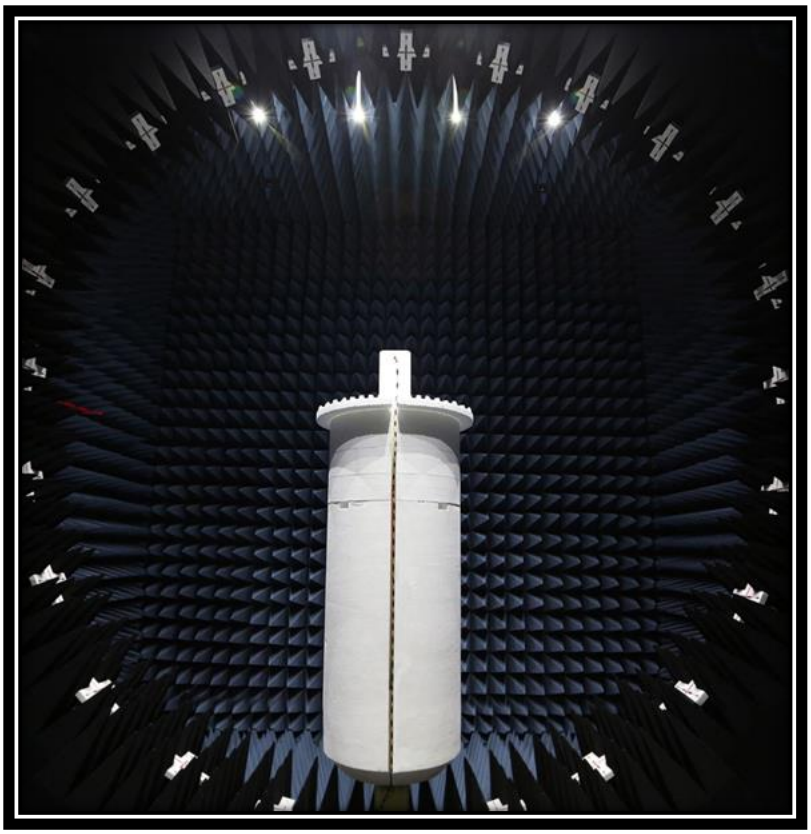
MSA Innovation, LLC

MSA LRR 900MHz Radio

Antenna Pattern Measurements

Report: F3EN0147, Issue Date: January 3, 2023



Approved by:

Eric Brandon, Department Manager

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

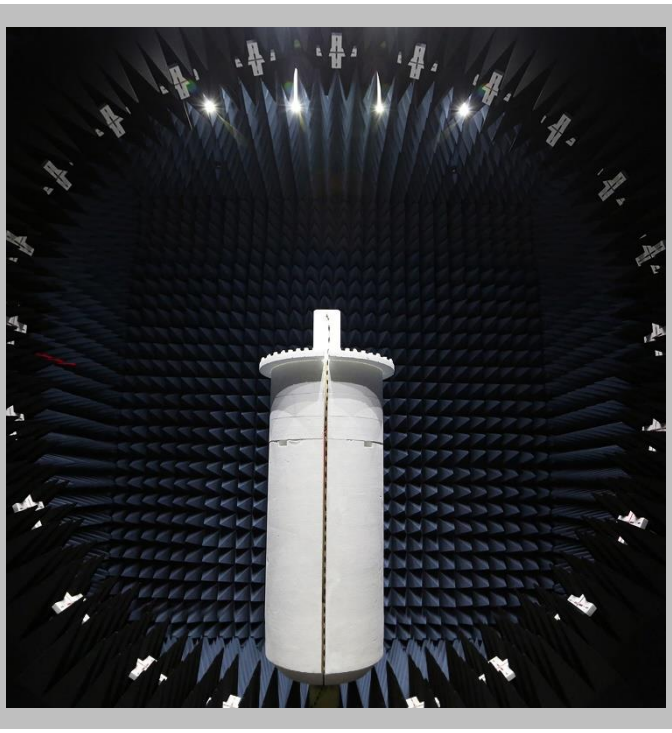
For details on the Scopes of our Accreditations, please visit:

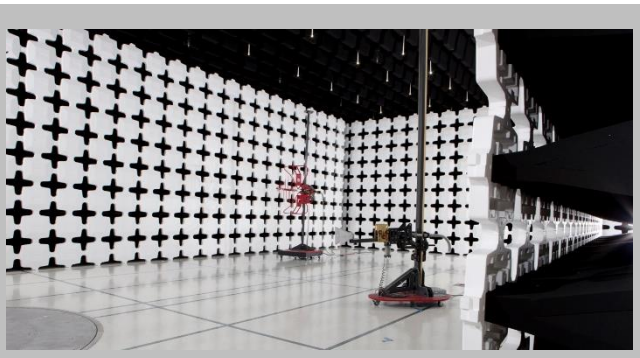
California Minnesota Oregon Texas Washington

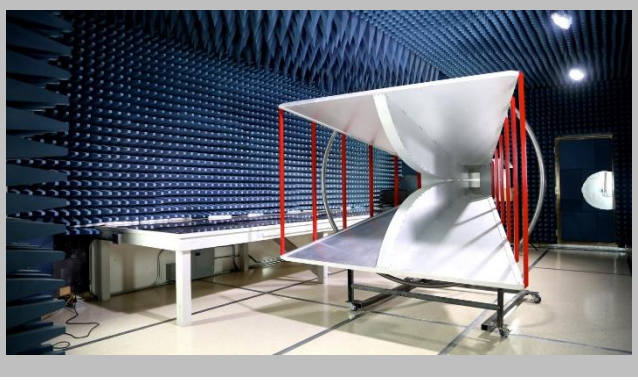
FACILITIES

element
2020.12.15

California	Minnesota	Oregon	Texas	Washington
Labs OC01-17 41 Tesla Irvine, CA 92618 (949) 861-8918	Labs MN01-11 9349 W Broadway Ave. Brooklyn Park, MN 55445 (612)-638-5136	Labs EV01-12 6775 NE Evergreen Pkwy #400 Hillsboro, OR 97124 (503) 844-4066	Labs TX01-09 3801 E Plano Pkwy Plano, TX 75074 (469) 304-5255	Labs NC01-05 19201 120th Ave NE Bothell, WA 98011 (425)984-6600
A2LA				
Lab Code: 3310.04	Lab Code: 3310.05	Lab Code: 3310.02	Lab Code: 3310.03	Lab Code: 3310.06
Innovation, Science and Economic Development Canada				
2834B-1, 2834B-3	2834E-1, 2834E-3	2834D-1	2834G-1	2834F-1
BSMI				
SL2-IN-E-1154R	SL2-IN-E-1152R	SL2-IN-E-1017	SL2-IN-E-1158R	SL2-IN-E-1153R
VCCI				
A-0029	A-0109	A-0108	A-0201	A-0110
Recognized Phase I CAB for ISED, ACMA, BSMI, IDA, KCC/RRA, MIC, MOC, NCC, OFCA				
US0158	US0175	US0017	US0191	US0157







PRODUCT DESCRIPTION

Client and Equipment under Test (EUT) Information

Company Name:	MSA Innovation, LLC
Address:	1100 Cranberry Woods Road
City, State, Zip:	Cranberry Township, PA 16066
Test Requested By:	Dustin Morris
EUT:	MSA LRR 900MHz Radio
First Date of Test:	October 5, 2021
Last Date of Test:	October 5, 2021
Receipt Date of Samples:	October 5, 2021
Equipment Design Stage:	Prototype
Equipment Condition:	No Damage
Purchase Authorization:	Verified

Information Provided by the Party Requesting the Test

Functional Description of the EUT:
900MHz Radio

Testing Objective:
To obtain 3D antenna pattern measurements and calculated antenna performance values

MODIFICATIONS

Equipment Modifications

Item	Date	Test	Modification	Note	Disposition of EUT
1	2021-10-05	Antenna Pattern Measurements	Tested as delivered to Test Station.	No EMI suppression devices were added or modified during this test.	Scheduled testing was completed.

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
Analyzer - Network Analyzer	Agilent	E5071C	NAM	11/13/2019	36 mo
Analyzer - Spectrum Analyzer	Agilent	E4443A	AAS	5/21/2021	12 mo
Chamber - OTA	ETS Lindgren	AMS-8923-195	OTA	4/19/2021	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

OTA 2018.01.04

EUT:	MSA LRR 900MHz Radio
Serial Number:	wire_tuned
Customer:	MSA Innovation, LLC
Attendees:	Dustin Morris
Customer Project:	None
Tested By:	Christopher Heintzelman
Test Run Description:	Passive - wire_tuned - Run 4

Work Order:	F3EN0091
Date:	10/5/2021
Temperature:	21.6 °C
Relative Humidity:	54.4% RH
Bar. Pressure:	1024 mbar
Job Site:	MN10

COMMENTS

None

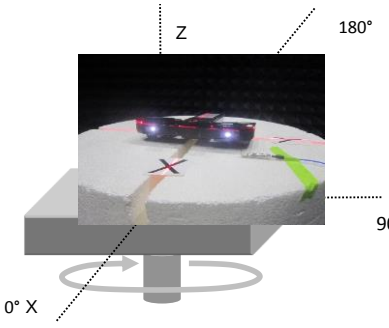
3D PATTERN DATA

Frequency (MHz)	800	805	810	815	820	825	830	835	840	845	850
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
Tot. Rad. Pwr. (dBm)	-6.10	-6.02	-5.84	-5.74	-5.54	-5.44	-5.27	-5.27	-5.14	-5.05	-4.83
Peak EIRP (dBm)	-0.34	-0.28	-0.10	-0.04	0.14	0.18	0.43	0.41	0.43	0.37	0.48
Directivity (dBi)	5.75	5.74	5.74	5.69	5.68	5.62	5.70	5.67	5.57	5.42	5.31
Efficiency (dB)	-6.10	-6.02	-5.84	-5.74	-5.54	-5.44	-5.27	-5.27	-5.14	-5.05	-4.83
Efficiency (%)	24.57	25.01	26.07	26.68	27.95	28.56	29.72	29.75	30.60	31.26	32.89
Gain (dBi)	-0.34	-0.28	-0.10	-0.04	0.14	0.18	0.43	0.41	0.43	0.37	0.48
Average Gain (dB)	-6.10	-6.02	-5.84	-5.74	-5.54	-5.44	-5.27	-5.27	-5.14	-5.05	-4.83
E-Plane 3 dB BW (°)	33.00	33.00	33.00	34.00	34.00	34.00	34.00	33.00	33.00	33.00	34.00

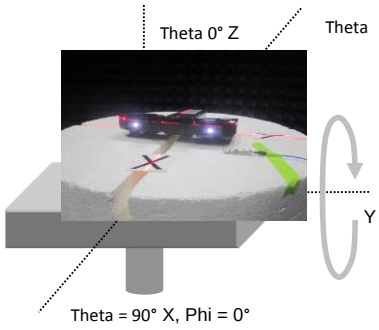
Frequency (MHz)	855	860	865	870	875	880	885	890	895	900	905
Ant. Port Input Pwr. (dBm)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tot. Rad. Pwr. (dBm)	-4.70	-4.56	-4.47	-4.41	-4.42	-4.45	-4.56	-4.60	-4.71	-4.33	-4.40
Peak EIRP (dBm)	0.53	0.57	0.58	0.61	0.61	0.56	0.46	0.36	0.18	0.50	0.41
Directivity (dBi)	5.23	5.13	5.05	5.02	5.03	5.02	5.02	4.96	4.89	4.83	4.81
Efficiency (dB)	-4.70	-4.56	-4.47	-4.41	-4.42	-4.45	-4.56	-4.60	-4.71	-4.33	-4.40
Efficiency (%)	33.90	35.01	35.76	36.22	36.15	35.88	35.00	34.64	33.82	36.88	36.33
Gain (dBi)	0.53	0.57	0.58	0.61	0.61	0.56	0.46	0.36	0.18	0.50	0.41
Average Gain (dB)	-4.70	-4.56	-4.47	-4.41	-4.42	-4.45	-4.56	-4.60	-4.71	-4.33	-4.40
E-Plane 3 dB BW (°)	34.00	1.00	1.00	1.00	1.00	1.00	33.00	54.00	63.00	64.00	64.00

Frequency (MHz)	910	915	920	925	930	935	940	945	950	955	960
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
Tot. Rad. Pwr. (dBm)	-4.38	-4.49	-4.54	-4.78	-4.93	-5.21	-5.32	-5.51	-5.41	-5.43	-5.29
Peak EIRP (dBm)	0.29	0.10	-0.10	-0.41	-0.50	-0.64	-0.66	-0.70	-0.52	-0.43	-0.27
Directivity (dBi)	4.67	4.59	4.44	4.36	4.43	4.57	4.66	4.81	4.89	5.00	5.02
Efficiency (dB)	-4.38	-4.49	-4.54	-4.78	-4.93	-5.21	-5.32	-5.51	-5.41	-5.43	-5.29
Efficiency (%)	36.47	35.55	35.16	33.29	32.15	30.15	29.37	28.13	28.80	28.62	29.57
Gain (dBi)	0.29	0.10	-0.10	-0.41	-0.50	-0.64	-0.66	-0.70	-0.52	-0.43	-0.27
Average Gain (dB)	-4.38	-4.49	-4.54	-4.78	-4.93	-5.21	-5.32	-5.51	-5.41	-5.43	-5.29
E-Plane 3 dB BW (°)	66.00	67.00	69.00	90.00	89.00	86.00	85.00	80.00	75.00	70.00	55.00

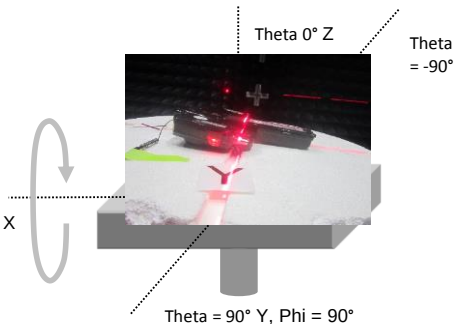
Azimuth Cut (Theta Axis = 90°)



Elevation Cut (Phi Axis = 0°)



Elevation Cut (Phi Axis = 90°)



ANTENNA PATTERN MEASUREMENTS

OTA 2018.01.04

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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 the measurement port of a spectrum analyzer. The EUT is commanded to transmit at the desired frequency and an absolute power measurement is obtained at the spectrum analyzer. 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 the measurement port of the spectrum analyzer. Another absolute power measurement is obtained at the spectrum analyzer. 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.

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ACTIVE 3D ANTENNA PATTERN MEASUREMENTS

OTA 2018.01.04

EUT:	MSA LRR 900MHz Radio
Serial Number:	wire_tuned
Customer:	MSA Innovation, LLC
Attendees:	Dustin Morris
Customer Project:	None
Tested By:	Christopher Heintzelman
Test Run Description:	TRP - wire_tuned 4

Work Order:	F3EN0091
Date:	10/5/2021
Temperature:	21.7 °C
Relative Humidity:	51.6% RH
Bar. Pressure:	1024 mbar
Job Site:	MN10

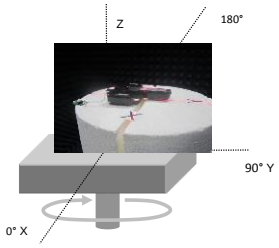
COMMENTS

27dBm APIP, 10dB attenuator in line

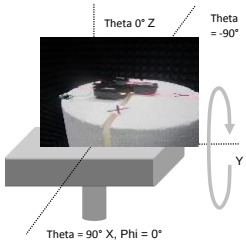
3D PATTERN DATA

Frequency (MHz)	902.2
Ant. Port Input Pwr. (dBm)	27.00
Tot. Rad. Pwr. (dBm)	24.48
Peak EIRP (dBm)	30.51
Directivity (dBi)	6.03
Efficiency (dB)	-2.52
Efficiency (%)	55.93
Gain (dBi)	3.51
Average Gain (dB)	-2.52
E-Plane 3 dB BW (°)	58.00

Azimuth Cut (Theta Axis = 90°)



Elevation Cut (Phi Axis = 0°)



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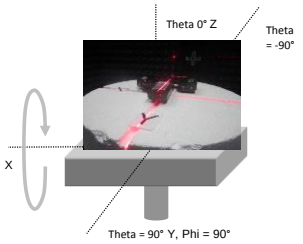
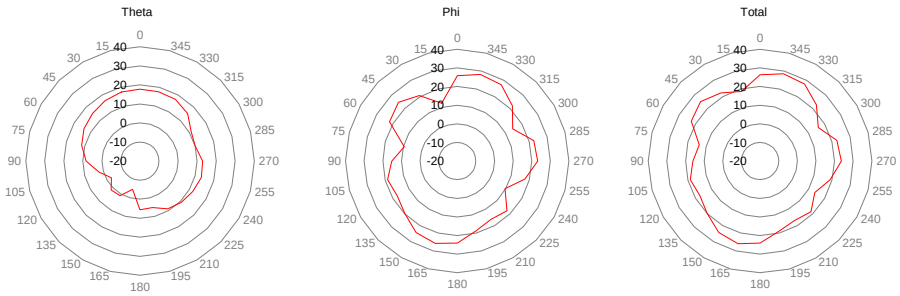
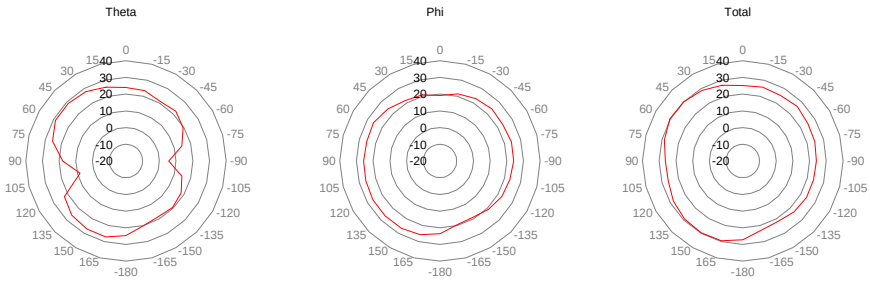


POLAR PLOTS

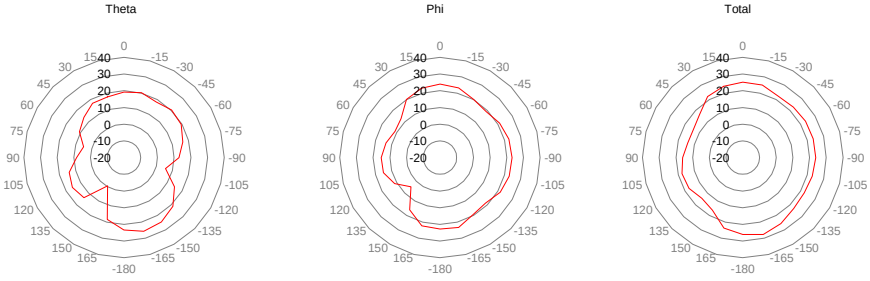
Power (dBm) — Azimuth Cut (Theta Axis = 90°)



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



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



End of Test Report