ANTENNA GAIN
TEST REPORT

for

Z-WAVE ELECTRONIC DEADBOLT

MODEL: 450126VHC

Prepared for

SPECTRUM BRANDS, INC.
19701 DAVINCI
LAKE FOREST, CALIFORNIA 92610

Prepared by:______________

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Approved by:______________

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DATE: OCTOBER 23, 2024

	REPORT BODY	APPENDICES					TOTAL
		A	*B*	*C*	*D*	*E*	
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TESTING
NVLAP LAB CODE 200528-0

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GENERAL REPORT SUMMARY

This electromagnetic emission test report is generated by Compatible Electronics Inc., which is an independent testing and consulting firm. The test report is based on testing performed by Compatible Electronics personnel according to the measurement procedures described in the test specifications given below and in the "Test Procedures" section of this report.

The measurement data and conclusions appearing herein relate only to the sample tested and this report may not be reproduced without the written permission of Compatible Electronics, unless done so in full.

This report must not be used to claim product certification, approval or endorsement by NVLAP, NIST or any agency of the federal government.

Device Tested:	Z-Wave Electronic Deadbolt Model: 450126VHC S/N: Unit 1
Product Description:	The EUT is a Z-Wave Electronic Deadbolt.
Modifications:	The EUT was not modified to meet the specifications.
Customer:	Spectrum Brands, Inc. 19701 DaVinci Lake Forest, California 92610
Test Date(s):	May 30, 2024

SUMMARY OF TEST RESULTS

TEST	DESCRIPTION	RESULTS
1	Antenna Gain	The EUT's field strength was tested along with the Maximum Conducted Output Power to determine antenna gain

1. PURPOSE

This document is a test report to obtain the antenna gain of the antenna for the Z-Wave Electronic deadbolt. The tests were performed in order to determine the antenna gain in dBi.

1.1 Decision Rule & Risk

If a measured value exceeds a specification limit it implies non-compliance. If the value is below a specification limit it implies compliance. Measurement uncertainty of the laboratory is reported with all measurement results but generally not taken into consideration unless a standard, rule or law requires it to be considered.

Qualification test reports are only produced for products that are in compliance with the test requirements, therefore results are always in conformity. Otherwise, an engineering report or just the data is provided to the customer.

When performing a measurement and making a statement of conformity, in or out-of-specification to manufacturer's specifications or Pass/Fail against a requirement, there are two possible outcomes:

- The result is reported as conforming with the specification
- The result is reported as not conforming with the specification

The decision rule is defined below.

When the test result is found to be below the limit but within our measurement uncertainty of the limit, it is our policy that the final acceptance decision is left to the customer, after discussing the implications and potential risks of the decision.

When the test result is found to be exactly on the specification, it is our policy, in the case of unwanted emissions measurements to consider the result non-compliant, however, the final decision is left to the customer, after discussing the implications and potential risks of the decision.

When the test result is found to be over the specification limit under any condition, it is our policy to consider the result non-compliant.

In terms of uncertainty of measurement, the laboratory is a calibrated and tightly controlled environment and generally exceptionally stable, the measurement uncertainties are evaluated without the considering of the test sample. When it comes to the test sample however, as most testing is performed on a single sample rather than a sample population, and that sample is often a pre-production representation of the final product, that test sample represents a significantly higher source of measurement uncertainty. We advise our customers of this and that when in doubt (small test to limit margins), they may wish to perform statistical sampling on a population to gain a higher confidence in the results. All lab reported results are that of a single sample in any event.

2. ADMINISTRATIVE DATA

2.1 Location of Testing

The emissions tests described herein were performed at the test facility of Compatible Electronics, 114 Olinda Drive, Brea, California 92823.

2.2 Traceability Statement

The calibration certificates of all test equipment used during the test are on file at the location of the test. The calibration is traceable to the National Institute of Standards and Technology (NIST).

2.3 Cognizant Personnel

Spectrum Brands, Inc.

Thuan Nguyen	Associate Principal Engineer

Compatible Electronics Inc.

Kyle Fujimoto	Sr. Test Engineer
James Ross	Sr. Test Engineer

2.4 Date Test Sample was Received

The test sample was received on prior to the initial test date.

2.5 Disposition of the Test Sample

The test sample has not been returned to Spectrum Brands, Inc. as of the date of this test report.

2.6 Abbreviations and Acronyms

The following abbreviations and acronyms may be used in this document.

EMI	Electromagnetic Interference
EUT	Equipment Under Test
P/N	Part Number
S/N	Serial Number
FCC	Federal Communications Commission
DoC	Declaration of Conformity
N/A	Not Applicable
Tx	Transmit
Rx	Receive
Inc.	Incorporated
RF	Radio Frequency
BLE	Bluetooth Low Energy
CFR	Code of Federal Regulations
Sr.	Senior
DC	Direct Current
RSS	Radio Standards Specification

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3. APPLICABLE DOCUMENTS

The following documents are referenced or used in the preparation of this emissions Test Report.

SPEC	TITLE
FCC Title 47, Part 15 Subpart C	FCC Rules – Radio frequency devices (including digital devices) – Intentional Radiators
FCC Title 47, Part 15 Subpart B	FCC Rules – Radio frequency devices (including digital devices) – Unintentional Radiators
558074 D01 DTS Meas Guidance v05 r02	Guidance for Performing Compliance Measurements on Digital Transmissions Systems (DTS) Operating Under Section 15.247
EN 50147-2: 1997	Anechoic chambers. Alternative test site suitability with respect to site attenuation
ANSI C63.4 2014	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
ANSI C63.10 2013	American National Standard for Testing Unlicensed Wireless Devices
RSS-Gen Issue 5: 2018 + Amendment 1: 2019 + Amendment 2: 2021	General Requirements for Compliance of Radio Apparatus
RSS-247 Issue 3 August 2023	Digital Transmissions Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

4. DESCRIPTION OF TEST CONFIGURATION

The Z-Wave Electronic Deadbolt, Model: 450126VHC (EUT) was mounted on two different enclosures. The EUT was continuously transmitting Z-Wave long range at 912 MHz or 920 MHz on a continuous basis.

Two different enclosures were tested. One had a keypad enclosure and the other a touchscreen enclosure.

Note: They touchscreen enclosure is the version that had the highest field strength and was used to determine the antenna gain. The frequency of 912 MHz was used because that is the one with highest conducted output power.

The final data was taken in the mode described above. All initial investigations were performed with the EMI Receiver in manual mode scanning the frequency range continuously. The cables were bundled and routed as shown in the photographs in Appendix D.

The firmware was stored on the company's servers.

4.1 Cable Construction and Termination

The EUT had no external cables.

5. LISTS OF EUT, ACCESSORIES AND TEST EQUIPMENT

5.1 EUT and Accessory List

EQUIPMENT	MANUFACTURER	MODEL NUMBER	SERIAL NUMBER	ID
Z-WAVE ELECTRONIC DEADBOLT	SPECTRUM BRANDS, INC.	450126VHC	UNIT 1	FCC ID: NUL450126HCT IC: 3022A-450126HCT
LAPTOP*	VOSTRO	3490	DQNH703	DoC
SIMPLICITY COMMANDER TEST SOFTWARE**	SILICON LABS, INC.	Version 1v16	N/A	N/A
J-LINK BASE*	SEGGER	P/N: 8.08.00	51024137	N/A

*This equipment was used to program the EUT only and was removed from the test setup after the EUT was programmed.
**This is the software used to control the EUT during the testing.

5.2 Emissions Test Equipment

EQUIPMENT TYPE	MANU-FACTURER	MODEL NUMBER	SERIAL NUMBER	CAL. DATE	CAL. DUE DATE
TDK TestLab	TDK RF Solutions, Inc.	9.22	700145	N/A	N/A
EMI Receiver, 3 Hz – 44 GHz	Keysight Technologies, Inc.	N9038A	MY59050117	July 14, 2023	July 14, 2024
System Controller	Sunol Sciences Corporation	SC110V	112213-1	N/A	N/A
Turntable	Sunol Sciences Corporation	2011VS	N/A	N/A	N/A
Antenna-Mast	Sunol Sciences Corporation	TWR95-4	112213-3	N/A	N/A
Below 1 GHz Radiated Cable	N/A	N/A	Asset #: 0006	October 27, 2023	October 27, 2025
Computer	Hewlett Packard	p6716f	MXX1030PX0	N/A	N/A

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6. TEST SITE DESCRIPTION

6.1 Test Facility Description

Please refer to section 2.1 of this report for emissions test location.

6.2 EUT Mounting, Bonding and Grounding

For frequencies 1 GHz and below: The EUT was mounted on a 0.6 by 1.2 meter non-conductive table 0.8 meters above the ground plane.

For frequencies above 1 GHz: The EUT was mounted on a 0.6 by 1.2 meter non-conductive table 1.5 meters above the ground plane.

The EUT was not grounded.

6.3 Measurement Uncertainty

Compatible Electronics' U_{lab} value is less than U_{cispr}, thus based on this − compliance is deemed to occur if no measured disturbance exceeds the disturbance limit

$$u_c(y) = \sqrt{\sum_i c_i^2 \; u^2(x_i)}$$

Measurement		U_{cispr}	$U_{lab} = 2\,uc\,(y)$
Conducted disturbance (mains port)	(150 kHz – 30 MHz)	3.4 dB	2.72 dB
Radiated disturbance (electric field strength on an open area test site or alternative test site)	(30 MHz – 1 000 MHz)	6.3 dB	3.32 dB (Vertical) 3.30 dB (Horizontal)
Radiated disturbance (electric field strength on an open area test site or alternative test site)	(1 GHz - 6 GHz)	5.2 dB	4.06 dB
Radiated disturbance (electric field strength on an open area test site or alternative test site)	(6 GHz – 18 GHz)	5.5 dB	4.06 dB
Radiated disturbance (electric field strength on an open area test site or alternative test site)	(18 GHz – 26.5 GHz)	N/A	4.43 dB
Radiated disturbance (electric field strength on an open area test site or alternative test site)	(26.5 GHz – 40 GHz)	N/A	4.57 dB

7. CHARACTERISTICS OF THE TRANSMITTER

7.1 Channel Description and Frequencies

Z-Wave Long Range: The EUT operates at 912 MHz and 920 MHz.

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8. TEST PROCEDURES

The following sections describe the test methods and the specifications for the tests. Test results are also included in this section.

8.1 RF Emissions

8.1.1 Conducted Emissions Test

The EMI Receiver was used as a measuring meter. A quasi-peak and/or average reading was taken only where indicated in the data sheets. A 10 dB attenuator was used for the protection of the EMI Receiver input stage, and the offset was adjusted accordingly to read the actual data measured. The LISN output was measured using the EMI Receiver. The output of the second LISN was terminated by a 50-ohm termination. The effective measurement bandwidth used for this test was 9 kHz.

Please see section 6.2 of this report for mounting, bonding, and grounding of the EUT. The EUT was powered through the LISN, which was bonded to the ground plane. The LISN power was filtered and the filter was bonded to the ground plane. The EUT was set up with the minimum distances from any conductive surfaces as specified in ANSI 63:4. The excess power cord was wrapped in a figure eight pattern to form a bundle not exceeding 0.4 meters in length.

The conducted emissions from the EUT were maximized for operating mode as well as cable placement. The final data was collected under program control by computer software. The final qualification data is located in Appendix E.

Test Results:

This test was not performed because the EUT operates on battery power only.

8.1.2 Radiated Emissions Test

The EMI Receiver was used as the measuring meter. An internal preamplifier was used to increase the sensitivity of the instrument during emissions tests up to 1000 MHz. The EMI Receiver was initially used with the Analyzer mode feature activated. In this mode, the EMI receiver can then record the actual frequency to be measured. This final reading is then taken accurately in the EMI Receiver mode, which considers the cable loss, amplifier gain and antenna factors, so that a true reading is compared to the true limit. The effective measurement bandwidth used for the radiated emissions test was according to the frequency measured.

The EMI test chamber of Compatible Electronics, Inc. was used for radiated emissions testing. This test site is in full compliance with ANSI C63.4. Please see section 6.2 of this report for mounting, bonding and grounding of the EUT. The turntable supporting the EUT is remote controlled using a motor. The turntable permits EUT rotation of 360 degrees to maximize emissions. Also, the antenna mast allows height variation of the antenna from 1 meter to 4 meters. Data was collected in the worst case (highest emission) configuration of the EUT. At each reading, the EUT was rotated 360 degrees and the antenna height was varied from 1 to 4 meters (for E field radiated field strength).

The EUT was tested at a 3-meter test distance. The six highest emissions are listed in Table 1.

Radiated Emissions Test (Continued)

The measurement bandwidths and transducers used for the radiated emissions test were:

FREQUENCY RANGE	EFFECTIVE MEASUREMENT BANDWIDTH	TRANSDUCER
30 MHz to 1 GHz	1 MHz	CombiLog Antenna

Test Results:

The highest field strength was the version with the Touchscreen Enclosure.

The EUT had a conducted output power of 13.41 dBm at 912 MHz and then was placed on the Radiated Test Site at 3 Meters. When measuring the field strength at 912 MHz the field strength was 110.58 dBuV/m.

The 108.64 dBuV/m would have an EIRP of 13.41 dBm based on a 0 dBi (unity gain) antenna, based on the formula EIRP = dBuV/m – 95.2.

110.58 dBuV/m (measured) – 108.64 dBuV/m (field strength with 0 dBi) = 1.94 dBi gain for the antenna.

Also attached are the antenna radiation plots for both the Vertical and Horizontal polarizations of the receive antenna.

8.1.4 Sample Calculations

A correction factor for the antenna, cable, and a distance factor (if any) must be applied to the meter reading before a true field strength reading can be obtained. This Corrected Meter Reading is then compared to the specification limit in order to determine compliance with the limits.
Conversion to logarithmic terms: Specification limit (μV/m) log x 20 = Specification Limit in dBuV/m
To correct for distance when measuring at a distance other than the specification
For measurements below 30 MHz: (Specification distance / test distance) log x 40 = distance factor
For measurements above 30 MHz: (Specification distance / test distance) log x 20 = distance factor
Note: When using an Active Antenna, the Antenna factor shall be subtracted due to the combination of the internal amplification and antenna loss.
Corrected Meter Reading = meter reading + F – A + C
where: F = antenna factor
A= amplifier gain
C = cable loss
The correction factors for the antenna and the amplifier gain are attached in Appendix D of this report. The data sheets are attached in Appendix E.
The distance factor D is 0 when the test is performed at the required specification distance.
When the limit is in terms of magnetic field, the following equation applies:

$$H[dB(\mu A/m)] = V[dB(\mu V)] + L_C\ [dB] - G_{PA}\ [dB] + AF^H\ [dB(S/m)]$$

where: H is the magnetic field strength (to be compared with the limit),
V is the voltage level measured by the receiver or spectrum analyzer,
L_C is the cable loss,
G_{PA} is the gain of the preamplifier (if used), and
AF^H is the magnetic antenna factor.

The G_{PA} term is only included in the equation when an external preamplifier is used in the measurement chain, in front of the receiver or spectrum analyzer. An external preamplifier is not usually necessary (or even advisable, due to risk of saturating the input mixer of the receiver) when an active loop antenna is used. In that case, the antenna factor of the loop already includes the gain of its built-in preamplifier.

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Sample Calculations (Continued)

If the "electrical" antenna factor is used instead, the above equation becomes:

$H[dB(\mu A/m)] = V[dB(\mu V)] + L_C\,[dB] - G_{PA}[dB] + AF^E\,[dB(m^{-1})\,] - 51.5\,[dB\Omega]$

where: AF^E is the "electric" antenna factor, as provided by the antenna calibration laboratory.

When the limit is in terms of electric field, the following equation applies:

$E[dB(\mu V/m)] = V[dB(\mu V)] + L_C[dB] - G_{PA}[dB] + AF^E\,[dB(m^{-1})\,]$

or, if the magnetic antenna factor is used:

$E[dB(\mu V/m)] = V[dB(\mu V)] + L_C[dB] - G_{PA}[dB] + AF^H\,[dB(S/m)] + 51.5[dB\Omega]$

The display of the receiver (or spectrum analyzer) **shall not** be configured in units of current, e.g. µA or dB(µA). That conversion is calculated inside the receiver (or spectrum analyzer) using its input impedance, which is 50 Ω, while the magnetic field calculation is based on the free-space impedance of 377 Ω.

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8.2 Maximum Peak Conducted Output Power

The maximum peak conducted output power was measured using the EMI Receiver. The following steps were performed for measuring the maximum peak conducted output power.

1. Set the RBW ≥ DTS Bandwidth
2. Set the VBW ≥ [3 X RBW]
3. Set span ≥ [3 X RBW]
4. Sweep time = auto couple
5. Detector = peak
6. Trace mode = max hold
7. Allow trace to fully stabilize
8. Use the peak marker function to determine the peak amplitude level

Test Results:

The EUT complies with the relevant requirements of CFR Title 47, Part 15, Subpart C Section 15.247 (b)(3); and RSS-247.

9. REFERENCE DESIGN

From the document that contains the reference manual regarding the antenna being used.

3.3.2 Printed Antenna

The BRD4207A Radio Board includes a printed antenna tuned to have close to 50 Ohm impedance at the 863-930 MHz band.

For a detailed description of the antenna, see section 4.4 Printed Antenna.

4.4 Printed Antenna

The BRD4207A Radio Board includes a printed antenna tuned to have close to 50 Ohm impedance at the 863-930 MHz band, while the radio board is plugged into the WSTK. The antenna is not connected to the RF output by default; the RF output selector 0 Ohm resistor should be repositioned from the R2 to the R1 position in order to enable operation with the printed antenna.

The impedance and reflection of the printed antenna is shown in the following figures.

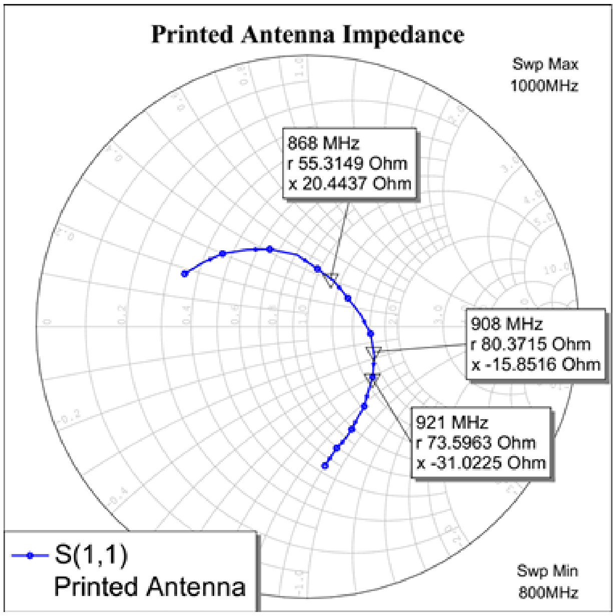


Figure 4.2. Impedance of the Printed Antenna of the BRD4207A

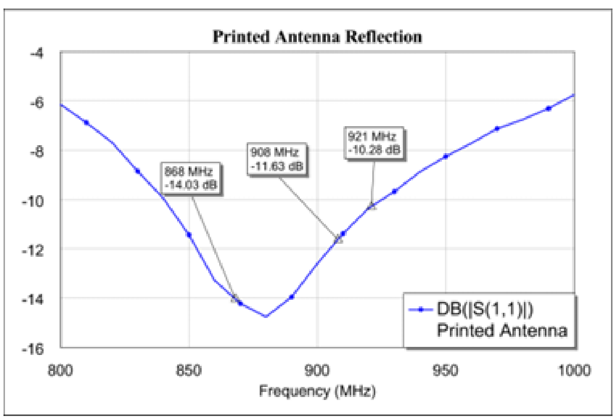


Figure 4.3. Reflection of the Printed Antenna of the BRD4207A

As it can be observed, the impedance is close to 50 Ohm at all of the marked frequencies. The reflection is better than -10 dB.

APPENDIX A

LABORATORY ACCREDITATIONS AND RECOGNITIONS

LABORATORY ACCREDITATIONS AND RECOGNITIONS

TESTING
NVLAP LAB CODE 200528-0

For US, Canada, Australia/New Zealand, Japan, Taiwan, Korea, and the European Union, Compatible Electronics is currently accredited by NVLAP to ISO/IEC 17025.
For the most up-to-date version of our scopes and certificates please visit http://celectronics.com/quality/scope/

Quote from ISO-ILAC-IAF Communiqué on 17025:
"A laboratory's fulfilment of the requirements of ISO/IEC 17025:2005 means the laboratory meets both the technical competence requirements and management system requirements that are necessary for it to consistently deliver technically valid test results and calibrations. The management system requirements in ISO/IEC 17025:2005 (Section 4) are written in language relevant to laboratory operations and meet the principles of ISO 9001:2008 Quality Management Systems — Requirements."

ISED Test Site Registration Number: 2154A

APPENDIX B

MODIFICATIONS TO THE EUT

MODIFICATIONS TO THE EUT

The modifications listed below were made to the EUT to pass FCC Subpart B and FCC 15.247; RSS-GEN and RSS-247 specifications.

All the rework described below was implemented during the test in a method that could be reproduced in all the units by the manufacturer.

No modifications were made to the EUT during the testing.

APPENDIX C

MODELS COVERED UNDER THIS REPORT

MODELS COVERED UNDER THIS REPORT

USED FOR THE PRIMARY TEST	Z-Wave Electronic Deadbolt Model: 450126VHC S/N: Unit 1

There are no additional models covered under this report.

APPENDIX D

DIAGRAMS AND CHARTS

FIGURE 1: CONDUCTED EMISSIONS TEST SETUP

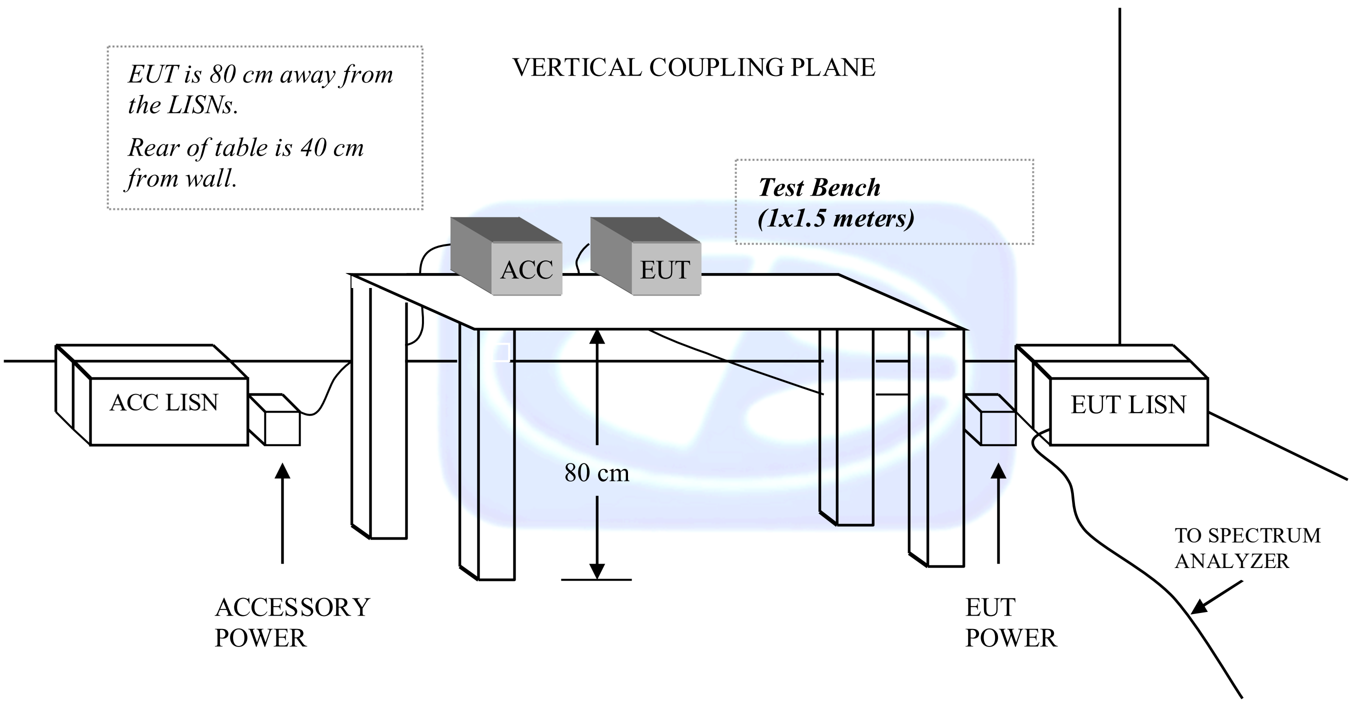
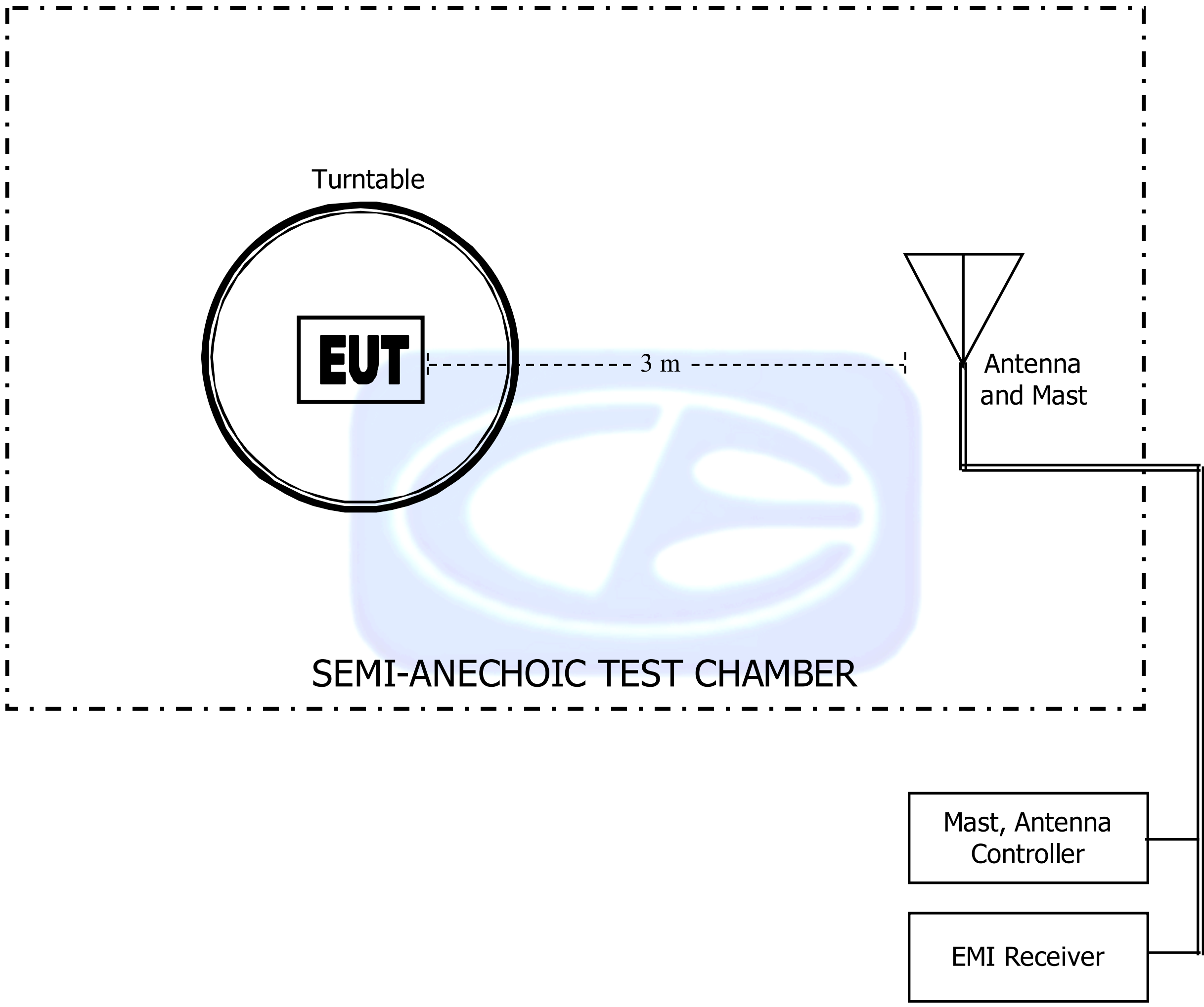


FIGURE 2: LAYOUT OF THE SEMI-ANECHOIC TEST CHAMBER



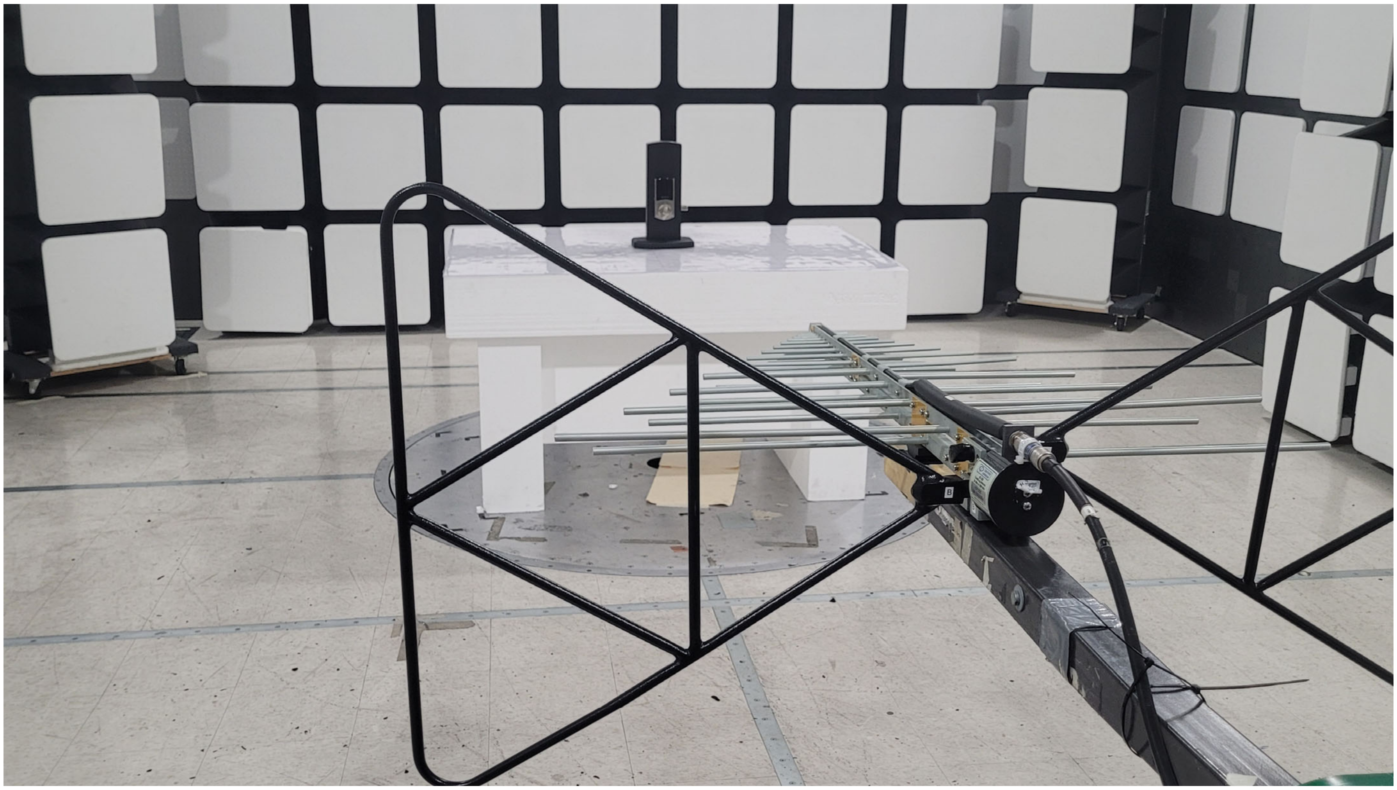
COM-POWER AC-220

COMBILOG ANTENNA

S/N: 10030004

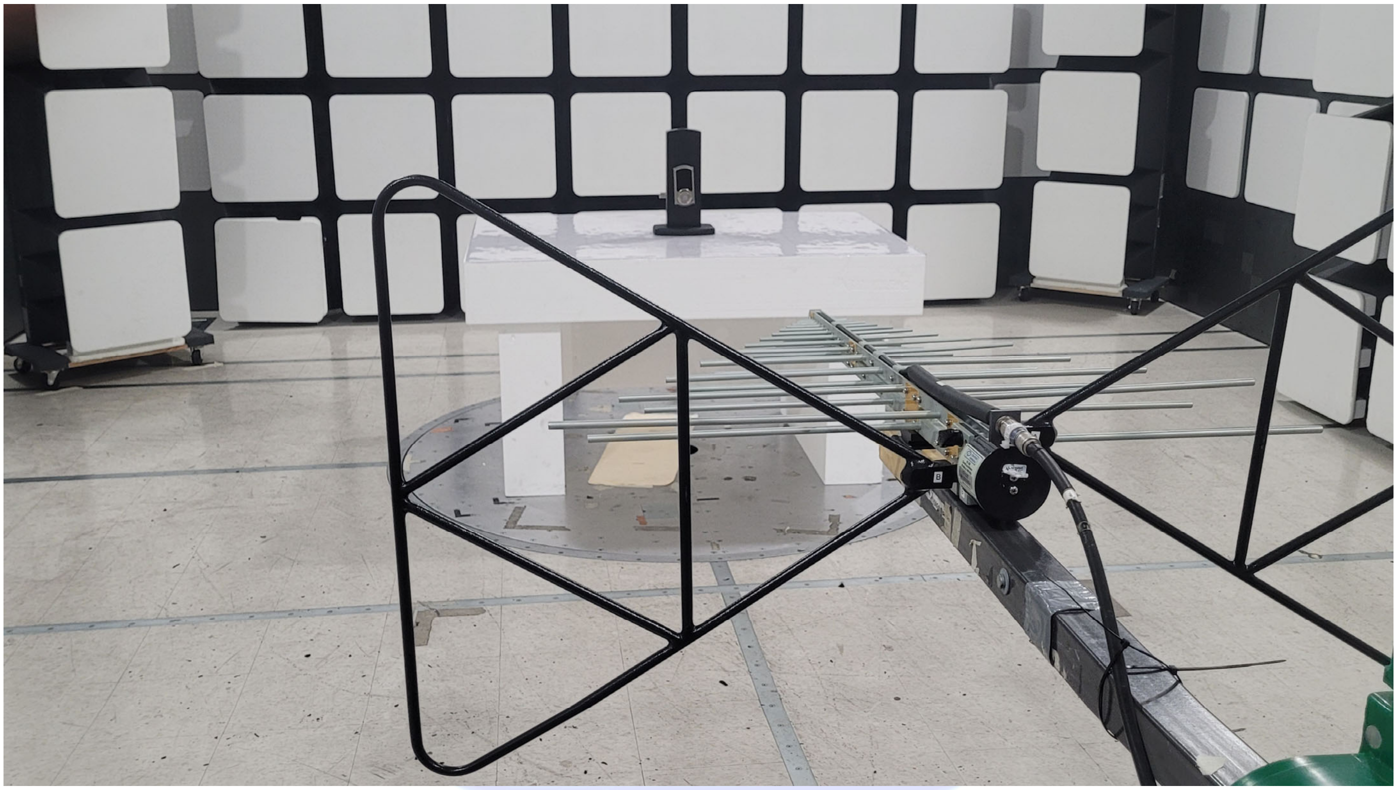
CALIBRATION DATE: NOVEMBER 22, 2023

FREQUENCY (MHz)	FACTOR (dB)	FREQUENCY (MHz)	FACTOR (dB)
30	23.10	200	16.10
35	22.00	250	17.90
40	41.30	300	19.10
45	20.50	350	20.30
50	19.30	400	21.60
60	15.40	450	22.20
70	12.40	500	23.20
80	12.40	550	23.70
90	14.10	600	25.10
100	15.50	650	25.30
120	15.90	700	25.10
125	15.90	750	26.70
140	14.80	800	26.60
150	14.60	850	27.20
160	14.80	900	28.00
175	15.90	950	29.10
180	15.50	1000	28.90



FRONT VIEW

SPECTRUM BRANDS, INC.
Z-WAVE ELECTRONIC DEADBOLT
MODEL: 450126VHC, HVIN: GED1800
FCC SUBPART B AND C; RSS-247 AND RSS-GEN – RADIATED EMISSIONS – ABOVE 1 GHz



REAR VIEW

SPECTRUM BRANDS, INC.
Z-WAVE ELECTRONIC DEADBOLT
MODEL: 450126VHC, HVIN: GED1800
FCC SUBPART B AND C; RSS-247 AND RSS-GEN – RADIATED EMISSIONS – BELOW 1 GHz

PHOTOGRAPH SHOWING
THE VIEW OF THE ANTENNA

APPENDIX E

DATA SHEETS

ANTENNA GAIN DATA SHEETS

COMPATIBLE ELECTRONICS

FCC 15.247 and RSS-247

Spectrum Brands, Inc. Date: 05/30/2024
Z-Wave Electronic Deadbolt Lab: D
Model: 450126VHC, HVIN: GED1800 Tested By: Kyle Fujimoto

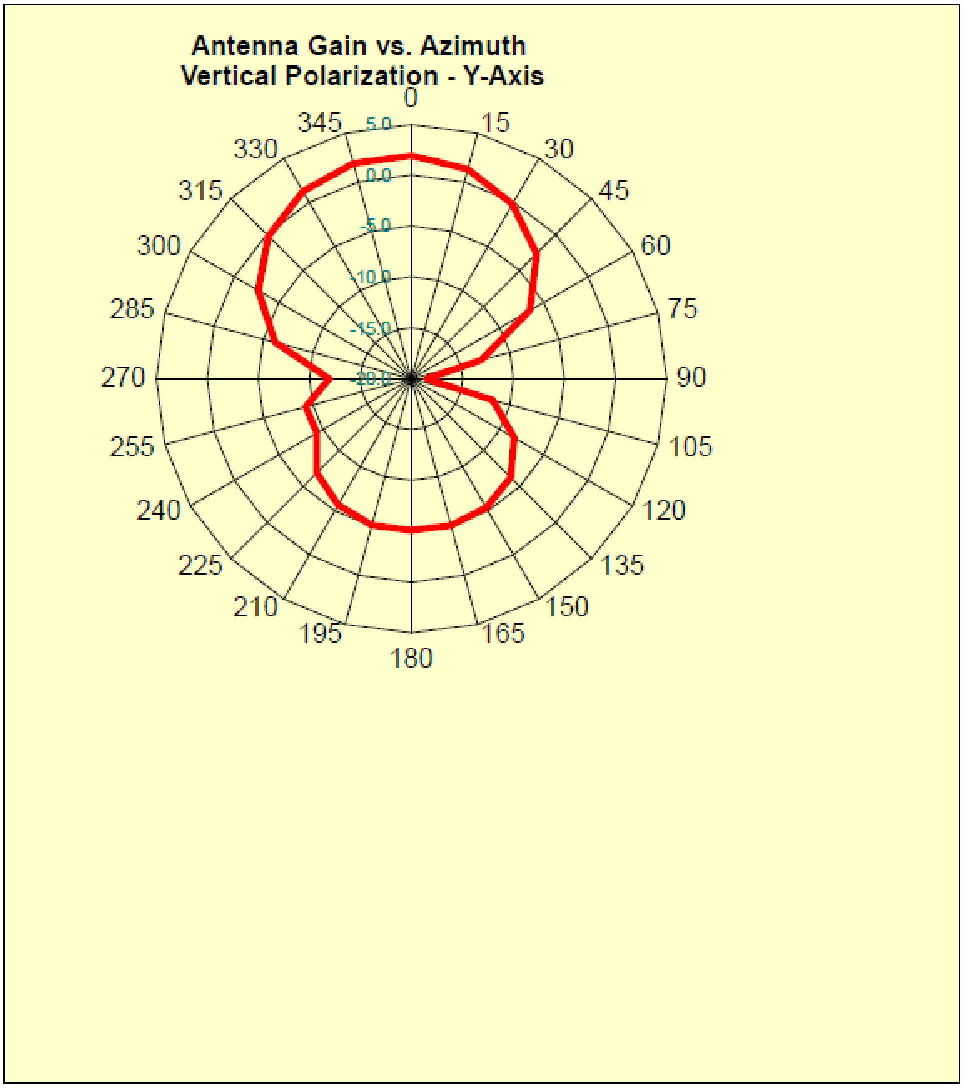
Fundamental - Low Channel
Transmit Mode - Y-Axis

Freq. (MHz)	Level (dBuV/m)	Pol (v/h)	Limit	Margin	Peak / QP / Avg	Table Angle (deg)	Ant. Height (cm)	Comments
912.00	110.55	V	--	--	Peak	0	102.26	

The 108.61 dBuV/m would have an EIRP of 13.41 dBm based on a 0 dBi (unity gain) antenna, based on the formula EIRP = dBuV/m – 95.2.
13.41 dBm = 108.61 dBuV/m – 95.2

110.55 dBuV/m (measured) – 108.61 dBuV/m (field strength with 0 dBi) = **1.94 dBi gain for the antenna**.

Antenna Pattern - Z-Wave Electronic Deadbolt - Model: 450126VHC - Vertical Polarization - Y-Axis



Degrees	Antenna Gain (dBi)
0	1.94
15	1.30
30	-0.19
45	-2.64
60	-6.59
75	-12.93
90	-18.53
105	-11.75
120	-8.38
135	-6.26
150	-5.36
165	-5.06
180	-5.08
195	-5.08
210	-5.66
225	-6.88
240	-9.31
255	-9.29
270	-11.96
285	-6.16
300	-2.66
315	-0.19
330	1.25
345	1.89

Note: The field strength that correlates to 1.94 dBi gain is 110.58 dBuV/m and is based on the formula
EIRP = dBuV/m – 95.2.
13.41 dBm = 108.61 dBuV/m – 95.2

110.55 dBuV/m (measured) – 108.61 dBuV/m (field strength with 0 dBi) = **1.94 dBi gain for the antenna**.

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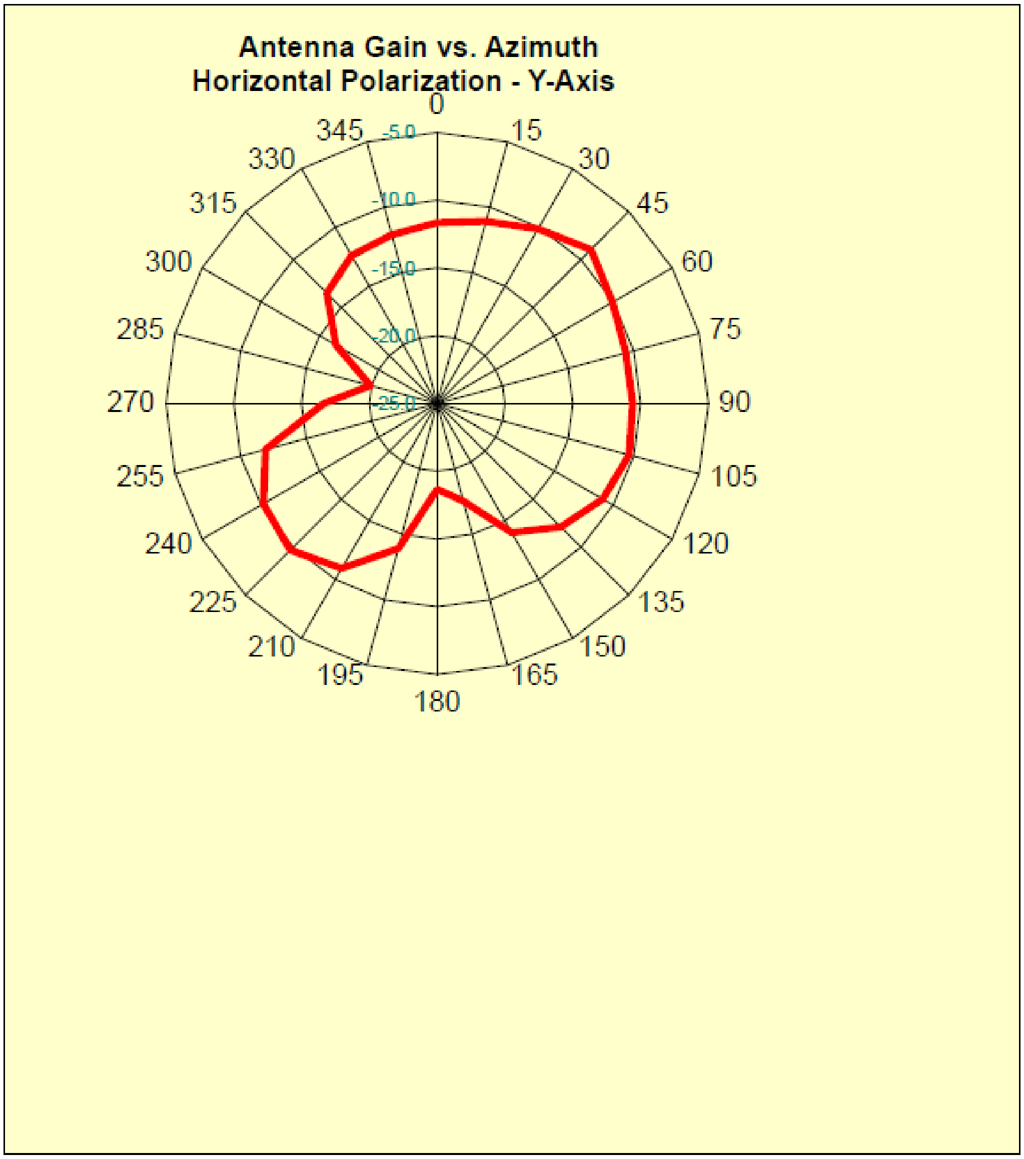
Antenna Pattern - Z-Wave Electronic Deadbolt - Model: 450126VHC - Horizontal Polarization - Y-Axis

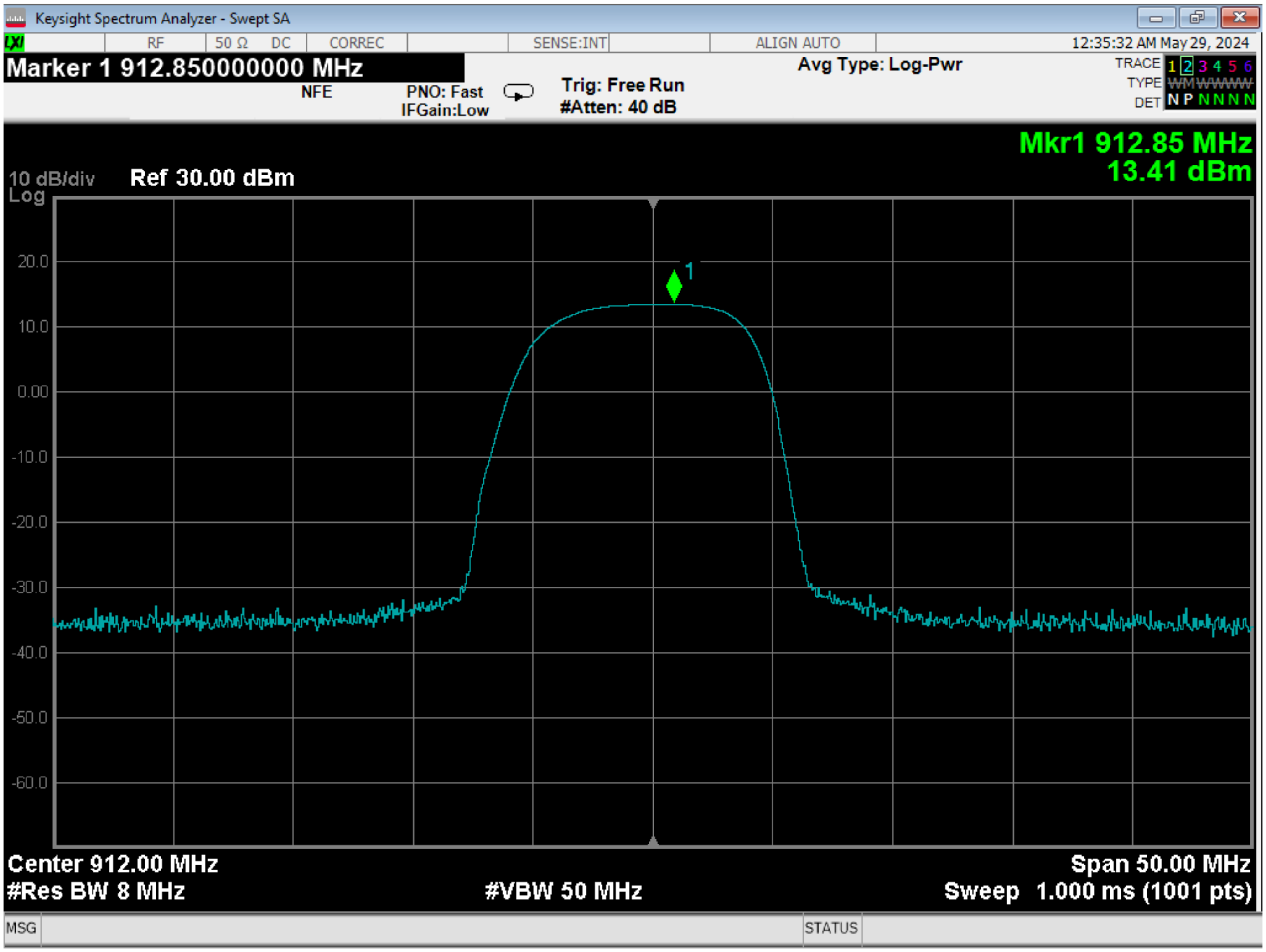


Degrees	Antenna Gain (dBi)
0	-11.67
15	-11.08
30	-10.12
45	-8.94
60	-10.08
75	-10.60
90	-10.59
105	-10.35
120	-10.91
135	-12.11
150	-14.01
165	-17.54
180	-18.66
195	-13.93
210	-10.94
225	-9.69
240	-10.19
255	-11.90
270	-16.66
285	-19.92
300	-16.37
315	-13.49
330	-12.40
345	-12.11

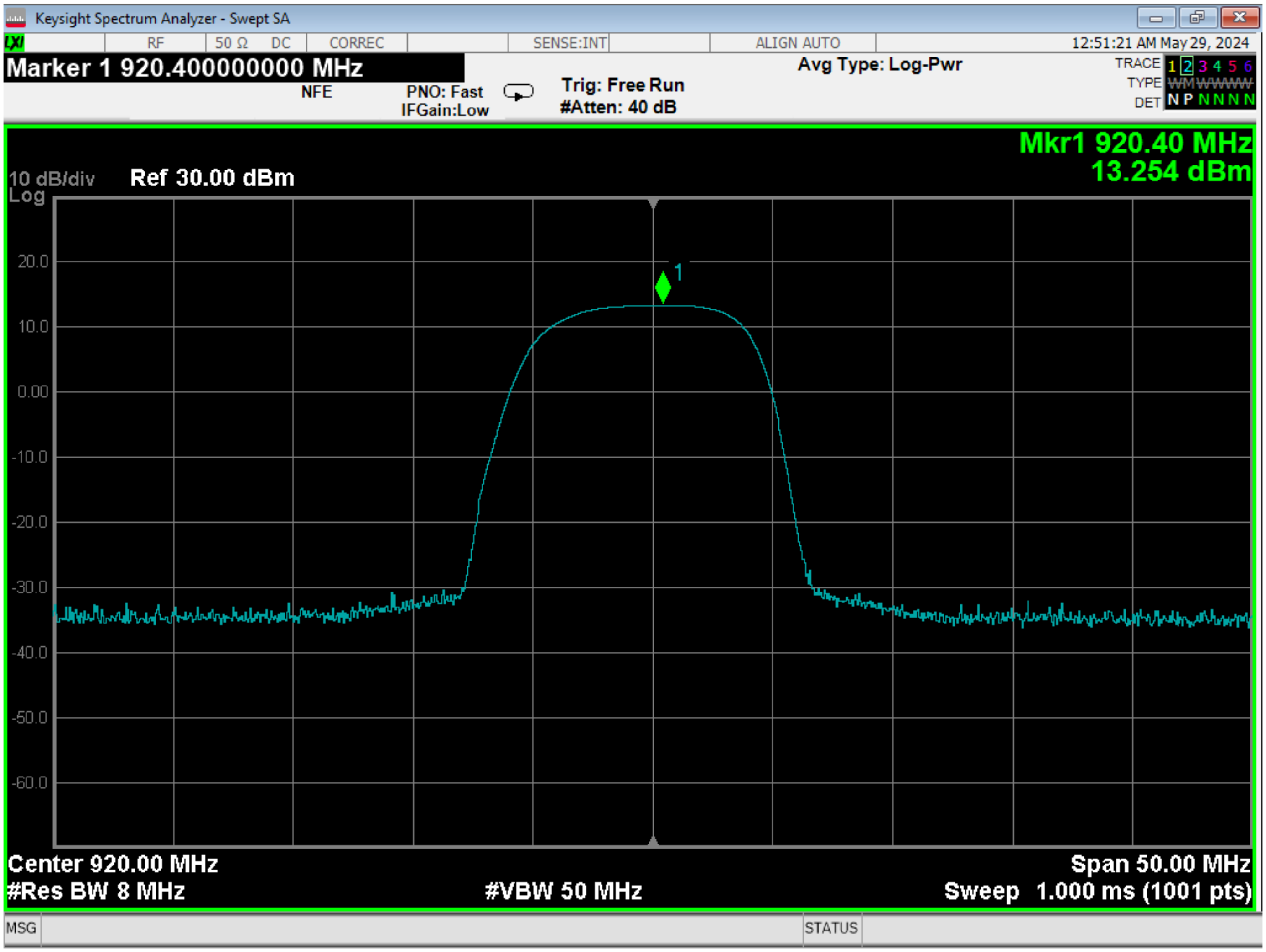
Note: The field strength that correlates to -8.94 dBi gain is 99.70 dBuV/m and is based on the formula
EIRP = dBuV/m – 95.2.
13.41 dBm = 108.61 dBuV/m – 95.2

99.67 dBuV/m (measured) – 108.61 dBuV/m (field strength with 0 dBi) = **-8.94 dBi gain in this polarization**.

PEAK POWER
DATA SHEETS



Peak Output Power – Low Channel



Peak Output Power – High Channel