



ANTENNA TEST REPORT

for the

STANLEY BLACK & DECKER, INC.

FCC ID: YJ7-NA091171

IC ID: 9082A-NA091171

WLL REPORT# 18681-01 REV 3

Prepared for:

Stanley Black & Decker, Inc.

701 E. Joppa Road

Towson, Maryland 21286

Prepared By:

Washington Laboratories, Ltd.

4840 Winchester Boulevard

Frederick, Maryland 21703



Testing Certificate AT-1448



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April 24, 2024

Prepared by:

Ryan Mascaro
RF Test Engineer

Reviewed by:

Steven D. Koster
President



Abstract

This report has been prepared on behalf of Stanley Black & Decker, Inc. to document the testing results of the Bluetooth Antenna that is contained as part of the applicant's transmitter assembly, seeking authorization under FCC ID: YJ7-NA091171. The information provided within this report is only applicable to the device herein documented as the EUT.

Testing was performed in the Free-space Anechoic Chamber Test-site (FACT) 3m chamber of Washington Laboratories, Ltd., located at: 4840 Winchester Boulevard, Suite #5., Frederick, MD 21703.

Revision History	Description of Change	Date
Rev 0	Initial Release	April 24, 2024
Rev 1	Minor grammatical corrections	May 21, 2024
Rev 2	Expanded the details of section 3.1.2	June 7, 2024
Rev 3	Co-sign corrections for final calculation	June 17, 2024



Table of Contents

1	Introduction.....	6
1.1	Test Scope.....	6
1.2	Contract Information.....	6
1.3	Test and Support Personnel	6
1.4	Test Location	6
1.5	Environmental Conditions	6
2	Equipment Under Test, Antenna.....	7
2.1	EUT Identification & Description	7
2.2	Test Configuration	10
2.2.1	Test Equipment Used.....	10
3	Test Results.....	11
3.1	Antenna Pattern.....	11
3.1.1	Test Procedure Summary.....	11
3.1.2	Radiated Data Reduction and Reporting.....	11
3.1.3	Complete Test Data.....	15
4	Test Setup Photographs.....	20



List of Tables

Table 1: Antenna Summary	7
Table 2: Test Equipment List and Calibration Due Dates	10
Table 3: Worst Case Orientation(s) Test Data.....	13
Table 4: NA091171 Antenna (2.44GHz) vs. Azimuth, Final Test Data.....	15

List of Figures

Figure 1: Antenna and PCB Photograph, As Tested (View #1)	8
Figure 2: Antenna and PCB Photograph, As Tested (View #2)	9
Figure 3: EUT Test Configuration.....	10
Figure 4: NA091171, Final Antenna Pattern vs Azimuth (Worst-Case Data)	14
Figure 5: Antenna Gain Testing (View #1)	20
Figure 6: Antenna Gain Testing (View #2)	21
Figure 7: Antenna Gain Testing (View #3)	22



1 Introduction

1.1 Test Scope

Testing was to determine the isotropic gain of the PCB BT antenna.

1.2 Contract Information

Customer:	Stanley Black & Decker, Inc.
Purchase Order Number:	M866023C
Quotation Number:	74621

1.3 Test and Support Personnel

Washington Laboratories, LTD	Ryan Mascaro
Customer Representative	Kirwan Magdamo

1.4 Test Location

All measurements herein were performed at Washington Laboratories, Ltd. test center in Frederick, MD. Site description and site attenuation data have been placed on file with the FCC's Sampling and Measurements Branch at the FCC laboratory in Columbia, MD. Washington Laboratories, Ltd. has been accepted by the FCC and approved by ANAB under Testing Certificate AT-1448 as an independent FCC test laboratory (ISED Canada Number 3035A).

1.5 Environmental Conditions

Environmental conditions during all testing

Ambient Temperature: 17.2 °C ($\pm 3^\circ$)

Relative Humidity: 49 % ($\pm 8.5\%$)



2 Equipment Under Test, Antenna

2.1 EUT Identification & Description

The results obtained relate only to the item(s) tested.

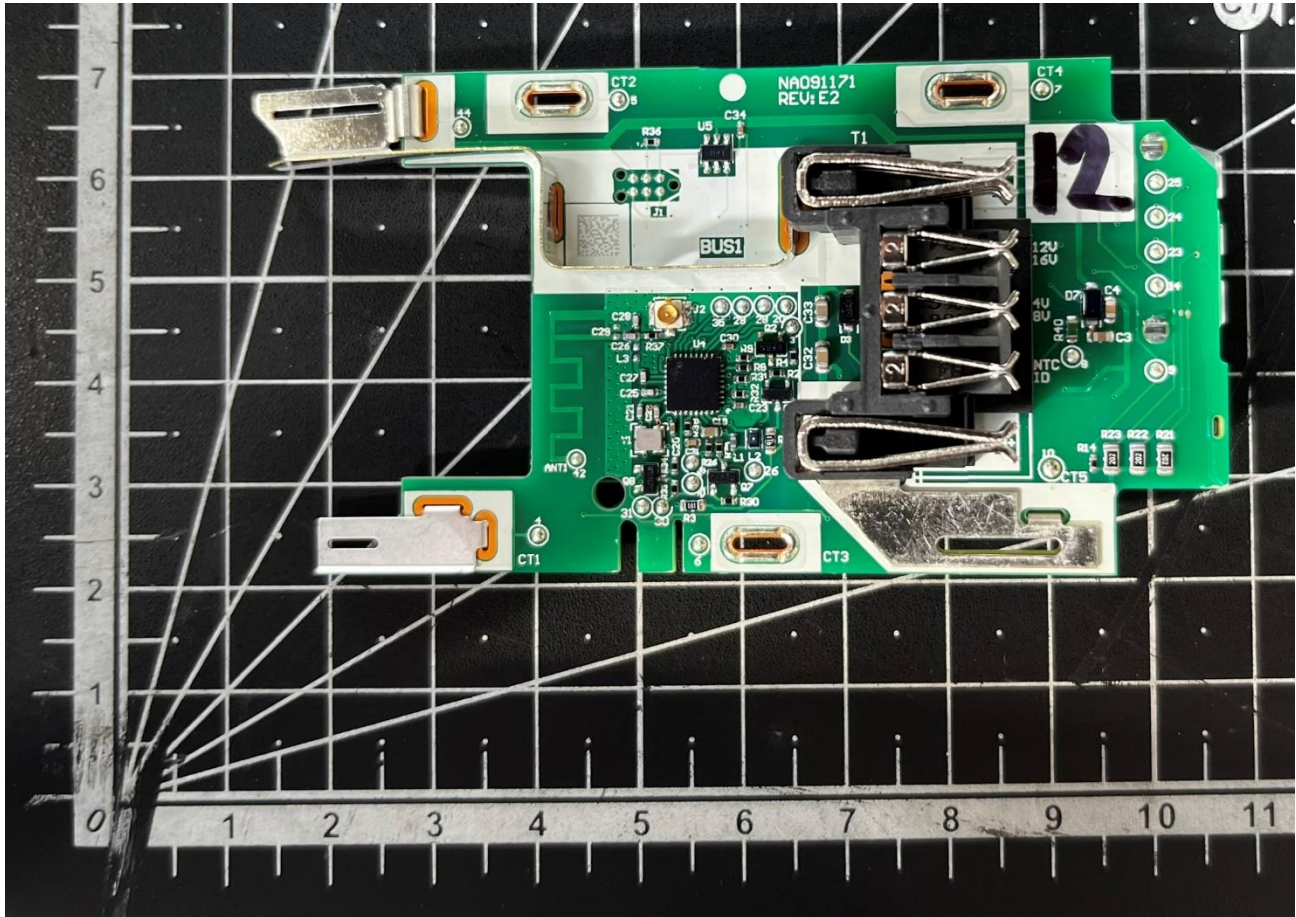
Table 1: Antenna Summary

EUT Name, Model(s) Tested:	NA091171
Manufacturer:	Stanley Black & Decker Inc.
Antenna Type:	PCB Meander Trace
Antenna Gain:	- 5.46 dBi
Testing Date(s):	4/8/2024

The Stanley Black & Decker, Inc. FCC ID: YJ7-NA091171 single limited modular transmitter employs a PCB trace antenna with -5.46 dBi of gain.

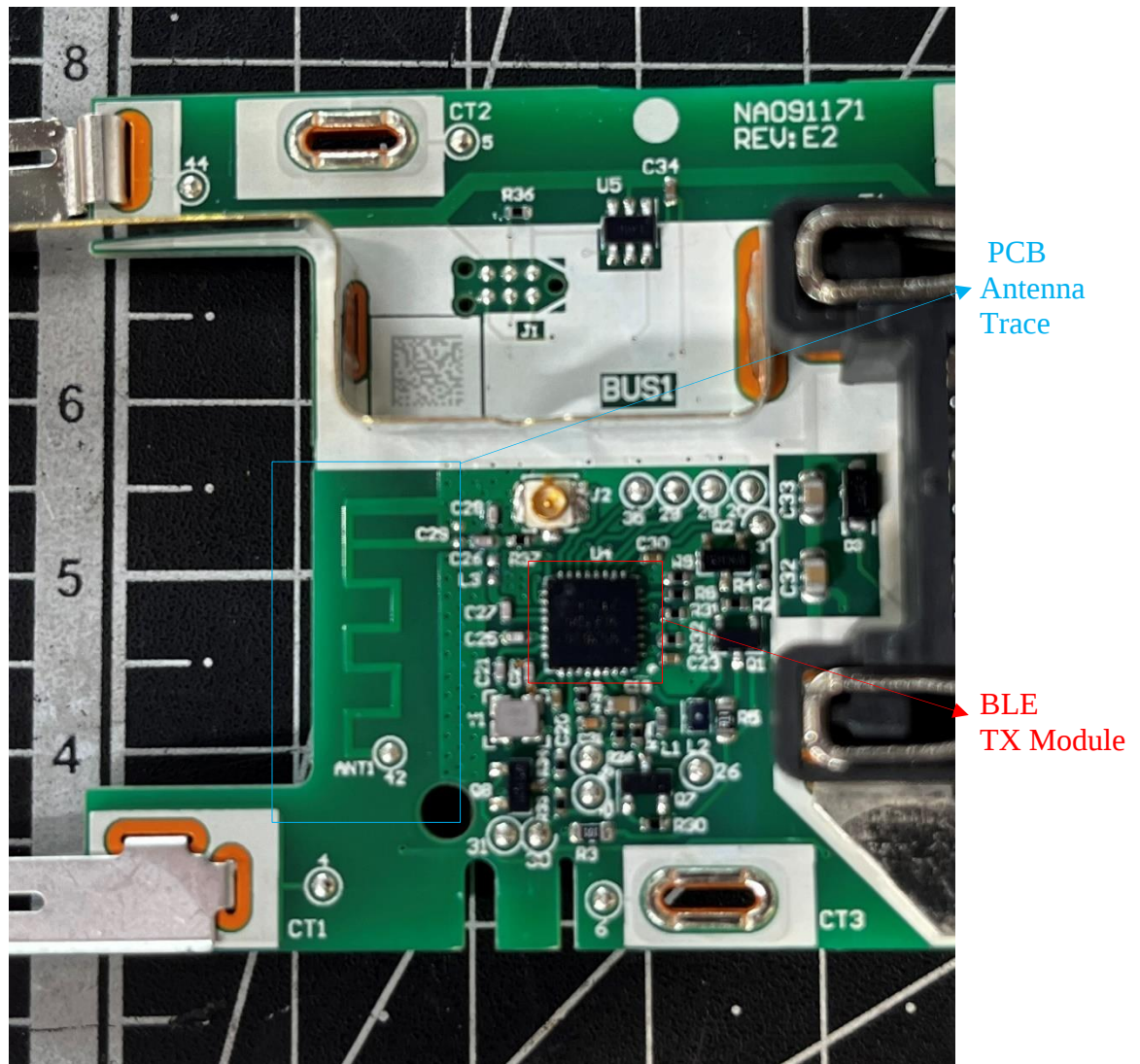
The final test data is provided below.

Figure 1: Antenna and PCB Photograph, As Tested (View #1)



* photo taken by WLL on 4/8/2024.

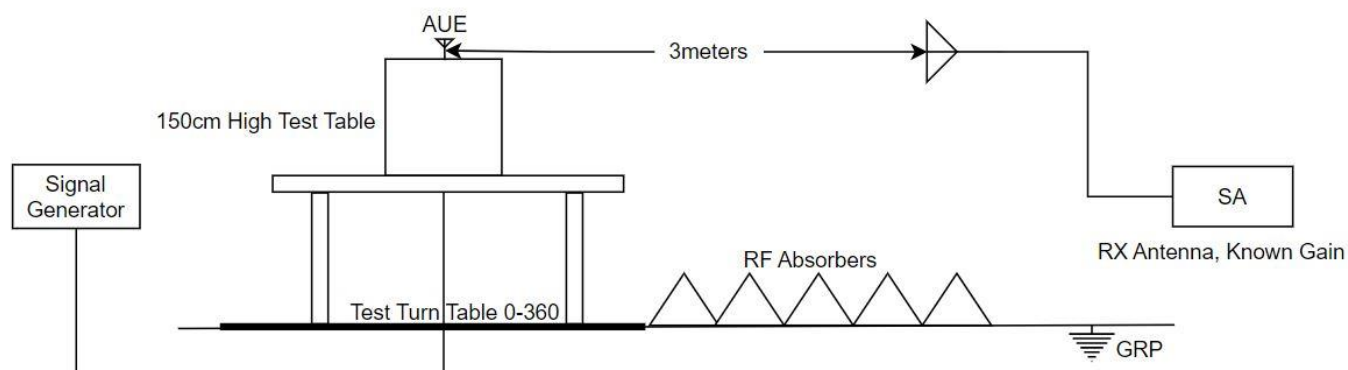
Figure 2: Antenna and PCB Photograph, As Tested (View #2)





2.2 Test Configuration

Figure 3: EUT Test Configuration



2.2.1 Test Equipment Used

Table 2: Test Equipment List and Calibration Due Dates

Test Name: Antenna Gain Testing		Test Date: 4/8/2024	
Asset #	Manufacturer/Model	Description	Cal. Due
00425	ARA, DRG-118/A	HORN ANTENNA	11/7/2024
00605	AGILENT, N1911A	POWER METER	6/21/2025
00992	KEYSIGHT, N5173B	SIGNAL GENERATOR	11/27/2024
00942	AGILENT, MXA-N9020A	SPECTRUM ANALYZER	12/19/2024
00977	JUNKOSHA MWX322-06000	ARMORED COAXIAL CABLE	12/26/2024
00806	MINI-CIRCUITS, 3061	COAXIAL CABLE, SMA	12/26/2024
00827	ASTROLAB, 16301	COAXIAL CABLE, SMA	7/17/20204



3 Test Results

3.1 Antenna Pattern

3.1.1 Test Procedure Summary

Antenna gain testing was performed on the Bluetooth meander-trace antenna. The test frequency was chosen in the center of the 2.4GHz unlicensed ISM band. A CW at 2440.0 MHz was supplied to the transmit path of the PCB trace. All measurement system losses and attenuations are accounted for. A verification/investigation was performed to determine the orientation of the PCB that produced the worst-case emissions. The worst-case orthogonal position was maintained for the remainder of the testing. The spectrum analyzer was placed in max hold mode, and the turn table was set to rotate at an RPM setting of 12%. The turn-table was rotated from 0 to 360 degrees, in 2-degree steps.

3.1.2 Radiated Data Reduction and Reporting

The following formula is a widely accepted link budget for calculating power received at the receiver:

$$P_{RX} = P_{TX} + G_{TX} - L_{TX} - FSPL - G_{RX} - L_{RX}$$

where,

P_{RX} = measured by the receive spectrum analyzer, in dBm

P_{TX} = transmit power (or drive level into the antenna feed), in dBm

G_{TX} = the final peak gain of the AUT, in dBi

L_{TX} = cable loss on the transmit side, in dB

G_{RX} = the known gain of the receive antenna, in dBi

L_{RX} = cable loss on the receive side, in dB

$$FSPL = 20 \log_{10}(d) + 20 \log_{10}(f) + 20 \log_{10} \left(\frac{4\pi}{c} \right) - G_{Tx} - G_{Rx} *$$

* *FSPL is a factor of frequency and distance only, provided the gain at either end is ignored.*



This link budget formula can be rearranged and used to calculate the gain of an unknown transmitting antenna, provided the remaining values are known.

When the above formula is rearranged to solve for the gain of the transmitter antenna:

$$G_{TX} = P_{RX} + L_{RX} - G_{RX} + FSPL - P_{TX} + L_{TX}$$

where,

G_{TX} = the final peak gain of the AUT, in dBi

P_{RX} = measured by the receive spectrum analyzer, in dBm

P_{TX} = transmit power (or drive level into the antenna feed), in dBm

G_{RX} = the known gain of the receive antenna, in dBi

L_{TX} = cable loss on the transmit side, in dB

L_{RX} = cable loss on the receive side, in dB

$$FSPL = 20 \log_{10}(d) + 20 \log_{10}(f) + 20 \log_{10}\left(\frac{4\pi}{c}\right) - G_{Tx} - G_{Rx} *$$

** FSPL is a factor of frequency and distance only, provided the gain at either end is ignored.*

Therefore,

$$G_{TX} = -49.448 + 0.55 - 9.5 + 49.76 - 0.0 + 3.20 = -5.46$$



Table 3: Worst Case Orientation(s) Test Data

RX Antenna Polarity	EUT Axis	SA Level P _{RX} (dBm)	P _{TX} (dBm)	G _{RX} (dB)	L _{TX} (dB)	FSPL (dB)	L _{RX} (dB)	Final G _{TX} (dBi)	Turn Table (Degrees)	SA Trace	Turn Table RPM (%)
V	X	-55.822	0	9.50	0.55	49.76	3.20	-11.83	0-360	Max Hold	12
V	Y	-49.448	0	9.50	0.55	49.76	3.20	-5.46	0-360	Max Hold	12
V	Z	-54.016	0	9.50	0.55	49.76	3.20	-10.03	0-360	Max Hold	12
H	X	-50.473	0	9.50	0.55	49.76	3.20	-7.58	0-360	Max Hold	12
H	Y	-49.556	0	9.50	0.55	49.76	3.20	-6.67	0-360	Max Hold	12
H	Z	-59.037	0	9.50	0.55	49.76	3.20	-16.15	0-360	Max Hold	12

Please note that the highest EUT gain was recorded as -5.44 dBi. The orientation that produced this gain shall be employed for the final antenna pattern plot, which is provided on the next page. The following settings were employed:

RX Antenna = Vertical
EUT Axis = Y
SA, RBW = 1MHz
SA, VBW = 3 MHz
Detector = Peak

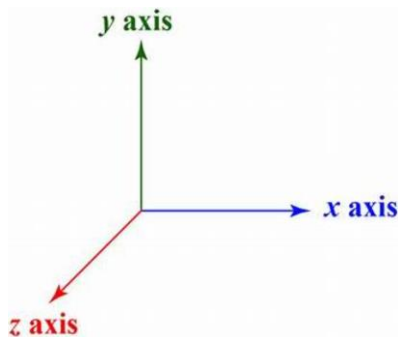
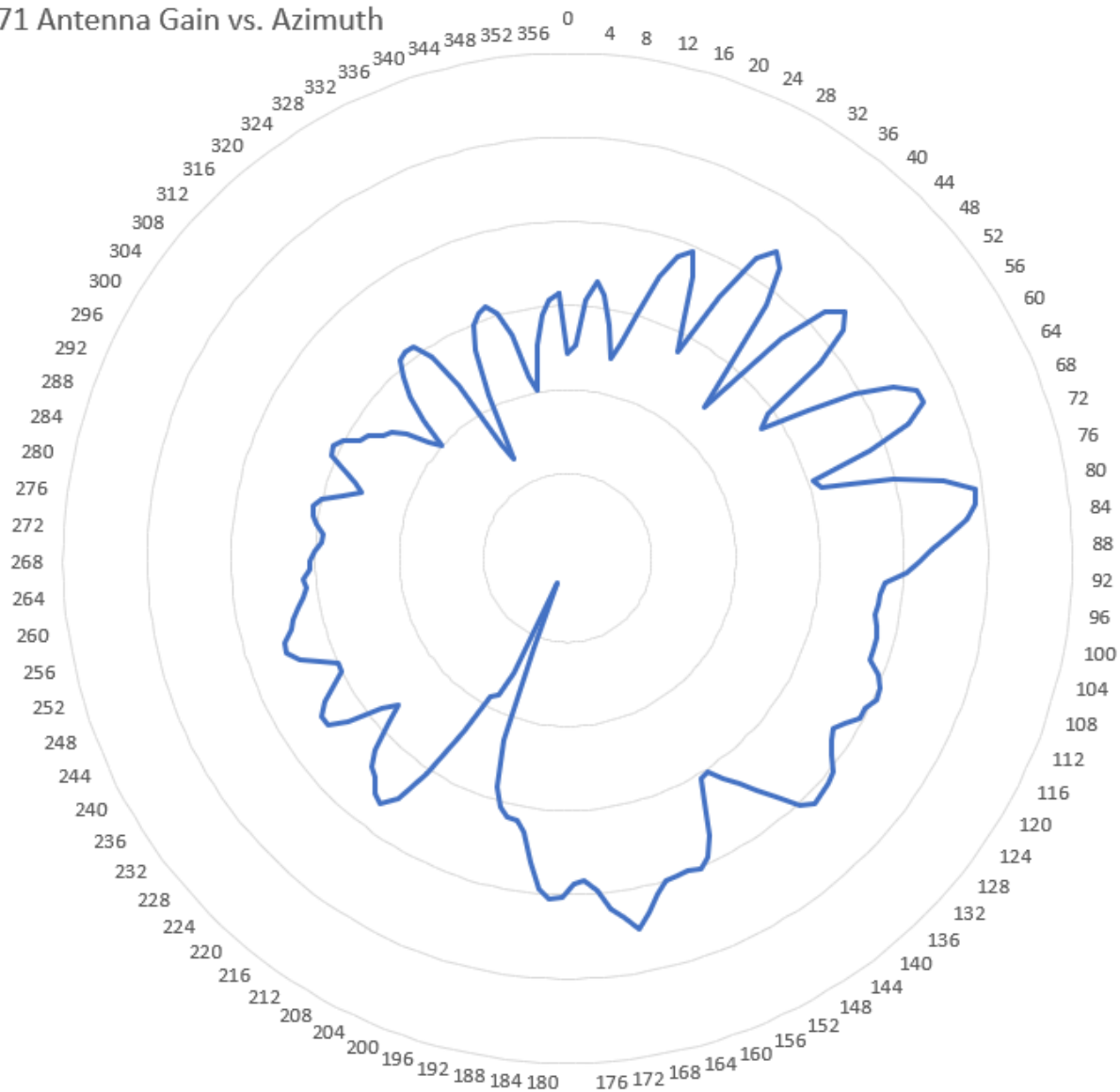




Figure 4: NA091171, Final Antenna Pattern vs Azimuth (Worst-Case Data)

NA091171 Antenna Gain vs. Azimuth





3.1.3 Complete Test Data

Table 4: NA091171 Antenna (2.44GHz) vs. Azimuth, Final Test Data

SA Level P _{RX} (dBm)	P _{TX} (dBm)	G _{RX} (dB)	L _{TX} (dB)	FSPL (dB)	L _{RX} (dB)	Final Gain (dBi)	Turn Table (Degrees)
-61.857	0	9.50	0.55	-49.76	3.2	-17.85	0
-61.31	0	9.50	0.55	-49.76	3.2	-17.30	2
-58.651	0	9.50	0.55	-49.76	3.2	-14.64	4
-57.472	0	9.50	0.55	-49.76	3.2	-13.46	6
-58.191	0	9.50	0.55	-49.76	3.2	-14.18	8
-59.984	0	9.50	0.55	-49.76	3.2	-15.97	10
-61.839	0	9.50	0.55	-49.76	3.2	-17.83	12
-60.898	0	9.50	0.55	-49.76	3.2	-16.89	14
-58.871	0	9.50	0.55	-49.76	3.2	-14.86	16
-56.407	0	9.50	0.55	-49.76	3.2	-12.40	18
-54.885	0	9.50	0.55	-49.76	3.2	-10.88	20
-54.288	0	9.50	0.55	-49.76	3.2	-10.28	22
-55.714	0	9.50	0.55	-49.76	3.2	-11.70	24
-58.595	0	9.50	0.55	-49.76	3.2	-14.59	26
-60.077	0	9.50	0.55	-49.76	3.2	-16.07	28
-56.01	0	9.50	0.55	-49.76	3.2	-12.00	30
-52.971	0	9.50	0.55	-49.76	3.2	-8.96	32
-51.958	0	9.50	0.55	-49.76	3.2	-7.95	34
-52.636	0	9.50	0.55	-49.76	3.2	-8.63	36
-54.844	0	9.50	0.55	-49.76	3.2	-10.83	38
-59.313	0	9.50	0.55	-49.76	3.2	-15.30	40
-61.89	0	9.50	0.55	-49.76	3.2	-17.88	42
-55.811	0	9.50	0.55	-49.76	3.2	-11.80	44
-52.802	0	9.50	0.55	-49.76	3.2	-8.79	46
-51.969	0	9.50	0.55	-49.76	3.2	-7.96	48
-52.742	0	9.50	0.55	-49.76	3.2	-8.73	50
-55.081	0	9.50	0.55	-49.76	3.2	-11.07	52
-59.313	0	9.50	0.55	-49.76	3.2	-15.30	54
-60.156	0	9.50	0.55	-49.76	3.2	-16.15	56
-57.211	0	9.50	0.55	-49.76	3.2	-13.20	58



-54.327	0	9.50	0.55	-49.76	3.2	-10.32	60
-52.184	0	9.50	0.55	-49.76	3.2	-8.17	62
-50.966	0	9.50	0.55	-49.76	3.2	-6.96	64
-50.929	0	9.50	0.55	-49.76	3.2	-6.92	66
-52.235	0	9.50	0.55	-49.76	3.2	-8.23	68
-54.889	0	9.50	0.55	-49.76	3.2	-10.88	70
-58.698	0	9.50	0.55	-49.76	3.2	-14.69	72
-58.319	0	9.50	0.55	-49.76	3.2	-14.31	74
-54.055	0	9.50	0.55	-49.76	3.2	-10.05	76
-51.226	0	9.50	0.55	-49.76	3.2	-7.22	78
-49.448	0	9.50	0.55	-49.76	3.2	-5.46	80, 81
-49.575	0	9.50	0.55	-49.76	3.2	-5.57	82
-50.131	0	9.50	0.55	-49.76	3.2	-6.12	84
-51.183	0	9.50	0.55	-49.76	3.2	-7.17	86
-52.38	0	9.50	0.55	-49.76	3.2	-8.37	88
-53.089	0	9.50	0.55	-49.76	3.2	-9.08	90
-53.86	0	9.50	0.55	-49.76	3.2	-9.85	92
-55.078	0	9.50	0.55	-49.76	3.2	-11.07	94
-55.314	0	9.50	0.55	-49.76	3.2	-11.30	96
-55.363	0	9.50	0.55	-49.76	3.2	-11.35	98
-55.47	0	9.50	0.55	-49.76	3.2	-11.46	100
-55.232	0	9.50	0.55	-49.76	3.2	-11.22	102
-55.065	0	9.50	0.55	-49.76	3.2	-11.06	104
-55.083	0	9.50	0.55	-49.76	3.2	-11.07	106
-55.023	0	9.50	0.55	-49.76	3.2	-11.01	108
-54.294	0	9.50	0.55	-49.76	3.2	-10.28	110
-53.933	0	9.50	0.55	-49.76	3.2	-9.92	112
-53.77	0	9.50	0.55	-49.76	3.2	-9.76	114
-54.176	0	9.50	0.55	-49.76	3.2	-10.17	116
-54.241	0	9.50	0.55	-49.76	3.2	-10.23	118
-54.788	0	9.50	0.55	-49.76	3.2	-10.78	120
-55.232	0	9.50	0.55	-49.76	3.2	-11.22	122
-54.932	0	9.50	0.55	-49.76	3.2	-10.92	124
-54.381	0	9.50	0.55	-49.76	3.2	-10.37	126
-53.749	0	9.50	0.55	-49.76	3.2	-9.74	128
-53.549	0	9.50	0.55	-49.76	3.2	-9.54	130
-53.438	0	9.50	0.55	-49.76	3.2	-9.43	132
-53.318	0	9.50	0.55	-49.76	3.2	-9.31	134
-53.867	0	9.50	0.55	-49.76	3.2	-9.86	136
-55.118	0	9.50	0.55	-49.76	3.2	-11.11	138



-56.239	0	9.50	0.55	-49.76	3.2	-12.23	140
-57.148	0	9.50	0.55	-49.76	3.2	-13.14	142
-57.949	0	9.50	0.55	-49.76	3.2	-13.94	144
-58.833	0	9.50	0.55	-49.76	3.2	-14.82	146
-58.74	0	9.50	0.55	-49.76	3.2	-14.73	148
-57.391	0	9.50	0.55	-49.76	3.2	-13.38	150
-55.478	0	9.50	0.55	-49.76	3.2	-11.47	152
-54.417	0	9.50	0.55	-49.76	3.2	-10.41	154
-53.936	0	9.50	0.55	-49.76	3.2	-9.93	156
-54.07	0	9.50	0.55	-49.76	3.2	-10.06	158
-54.036	0	9.50	0.55	-49.76	3.2	-10.03	160
-54.002	0	9.50	0.55	-49.76	3.2	-9.99	162
-53.298	0	9.50	0.55	-49.76	3.2	-9.29	164
-52.412	0	9.50	0.55	-49.76	3.2	-8.40	166
-51.585	0	9.50	0.55	-49.76	3.2	-7.58	168
-52.365	0	9.50	0.55	-49.76	3.2	-8.36	170
-52.988	0	9.50	0.55	-49.76	3.2	-8.98	172
-54.163	0	9.50	0.55	-49.76	3.2	-10.15	174
-54.872	0	9.50	0.55	-49.76	3.2	-10.86	176
-54.622	0	9.50	0.55	-49.76	3.2	-10.61	178
-53.898	0	9.50	0.55	-49.76	3.2	-9.89	180
-53.725	0	9.50	0.55	-49.76	3.2	-9.72	182
-54.237	0	9.50	0.55	-49.76	3.2	-10.23	184
-55.797	0	9.50	0.55	-49.76	3.2	-11.79	186
-57.542	0	9.50	0.55	-49.76	3.2	-13.53	188
-58.149	0	9.50	0.55	-49.76	3.2	-14.14	190
-58.227	0	9.50	0.55	-49.76	3.2	-14.22	192
-58.71	0	9.50	0.55	-49.76	3.2	-14.70	194
-59.835	0	9.50	0.55	-49.76	3.2	-15.83	196
-62.544	0	9.50	0.55	-49.76	3.2	-18.53	198
-68.31	0	9.50	0.55	-49.76	3.2	-24.30	200
-72.424	0	9.50	0.55	-49.76	3.2	-28.41	202
-66.474	0	9.50	0.55	-49.76	3.2	-22.46	204
-64.932	0	9.50	0.55	-49.76	3.2	-20.92	206
-64.636	0	9.50	0.55	-49.76	3.2	-20.63	208
-62.013	0	9.50	0.55	-49.76	3.2	-18.00	210
-58.692	0	9.50	0.55	-49.76	3.2	-14.68	212
-56.547	0	9.50	0.55	-49.76	3.2	-12.54	214
-55.6321	0	9.50	0.55	-49.76	3.2	-11.62	216
-55.943	0	9.50	0.55	-49.76	3.2	-11.93	218



-56.689	0	9.50	0.55	-49.76	3.2	-12.68	220
-56.97	0	9.50	0.55	-49.76	3.2	-12.96	222
-57.831	0	9.50	0.55	-49.76	3.2	-13.82	224
-59.49	0	9.50	0.55	-49.76	3.2	-15.48	226
-60.701	0	9.50	0.55	-49.76	3.2	-16.69	228
-59.785	0	9.50	0.55	-49.76	3.2	-15.78	230
-57.694	0	9.50	0.55	-49.76	3.2	-13.68	232
-56.661	0	9.50	0.55	-49.76	3.2	-12.65	234
-56.596	0	9.50	0.55	-49.76	3.2	-12.59	236
-57.277	0	9.50	0.55	-49.76	3.2	-13.27	238
-58.085	0	9.50	0.55	-49.76	3.2	-14.08	240
-59.01	0	9.50	0.55	-49.76	3.2	-15.00	242
-59.012	0	9.50	0.55	-49.76	3.2	-15.00	244
-58.087	0	9.50	0.55	-49.76	3.2	-14.08	246
-56.969	0	9.50	0.55	-49.76	3.2	-12.96	248
-56.347	0	9.50	0.55	-49.76	3.2	-12.34	250
-56.44	0	9.50	0.55	-49.76	3.2	-12.43	252
-57.001	0	9.50	0.55	-49.76	3.2	-12.99	254
-57.306	0	9.50	0.55	-49.76	3.2	-13.30	256
-57.747	0	9.50	0.55	-49.76	3.2	-13.74	258
-58.11	0	9.50	0.55	-49.76	3.2	-14.10	260
-58.367	0	9.50	0.55	-49.76	3.2	-14.36	262
-58.23	0	9.50	0.55	-49.76	3.2	-14.22	264
-58.66	0	9.50	0.55	-49.76	3.2	-14.65	266
-58.725	0	9.50	0.55	-49.76	3.2	-14.72	268
-58.935	0	9.50	0.55	-49.76	3.2	-14.93	270
-59.36	0	9.50	0.55	-49.76	3.2	-15.35	272
-59.375	0	9.50	0.55	-49.76	3.2	-15.37	274
-58.925	0	9.50	0.55	-49.76	3.2	-14.92	276
-58.66	0	9.50	0.55	-49.76	3.2	-14.65	278
-58.615	0	9.50	0.55	-49.76	3.2	-14.61	280
-58.91	0	9.50	0.55	-49.76	3.2	-14.90	282
-60.181	0	9.50	0.55	-49.76	3.2	-16.17	284
-61.113	0	9.50	0.55	-49.76	3.2	-17.10	286
-60.564	0	9.50	0.55	-49.76	3.2	-16.55	288
-59.7	0	9.50	0.55	-49.76	3.2	-15.69	290
-58.742	0	9.50	0.55	-49.76	3.2	-14.73	292
-58.524	0	9.50	0.55	-49.76	3.2	-14.51	294
-58.895	0	9.50	0.55	-49.76	3.2	-14.89	296
-59.792	0	9.50	0.55	-49.76	3.2	-15.78	298



-60.135	0	9.50	0.55	-49.76	3.2	-16.13	300
-60.844	0	9.50	0.55	-49.76	3.2	-16.83	302
-61.172	0	9.50	0.55	-49.76	3.2	-17.16	304
-61.96	0	9.50	0.55	-49.76	3.2	-17.95	306
-63.278	0	9.50	0.55	-49.76	3.2	-19.27	308
-64.031	0	9.50	0.55	-49.76	3.2	-20.02	310
-62.212	0	9.50	0.55	-49.76	3.2	-18.20	312
-60.582	0	9.50	0.55	-49.76	3.2	-16.57	314
-59.492	0	9.50	0.55	-49.76	3.2	-15.48	316
-58.568	0	9.50	0.55	-49.76	3.2	-14.56	318
-58.398	0	9.50	0.55	-49.76	3.2	-14.39	320
-58.413	0	9.50	0.55	-49.76	3.2	-14.40	322
-59.572	0	9.50	0.55	-49.76	3.2	-15.56	324
-61.912	0	9.50	0.55	-49.76	3.2	-17.90	326
-66.306	0	9.50	0.55	-49.76	3.2	-22.30	328
-67.27	0	9.50	0.55	-49.76	3.2	-23.26	330
-63.26	0	9.50	0.55	-49.76	3.2	-19.25	332
-60.501	0	9.50	0.55	-49.76	3.2	-16.49	334
-59.091	0	9.50	0.55	-49.76	3.2	-15.08	336
-58.525	0	9.50	0.55	-49.76	3.2	-14.52	338
-58.344	0	9.50	0.55	-49.76	3.2	-14.33	340
-58.912	0	9.50	0.55	-49.76	3.2	-14.90	342
-60.3	0	9.50	0.55	-49.76	3.2	-16.29	344
-62.99	0	9.50	0.55	-49.76	3.2	-18.98	346
-63.905	0	9.50	0.55	-49.76	3.2	-19.90	348
-61.243	0	9.50	0.55	-49.76	3.2	-17.23	350
-59.483	0	9.50	0.55	-49.76	3.2	-15.47	352
-58.632	0	9.50	0.55	-49.76	3.2	-14.62	354
-58.31	0	9.50	0.55	-49.76	3.2	-14.30	356

4 Test Setup Photographs

Figure 5: Antenna Gain Testing (View #1)

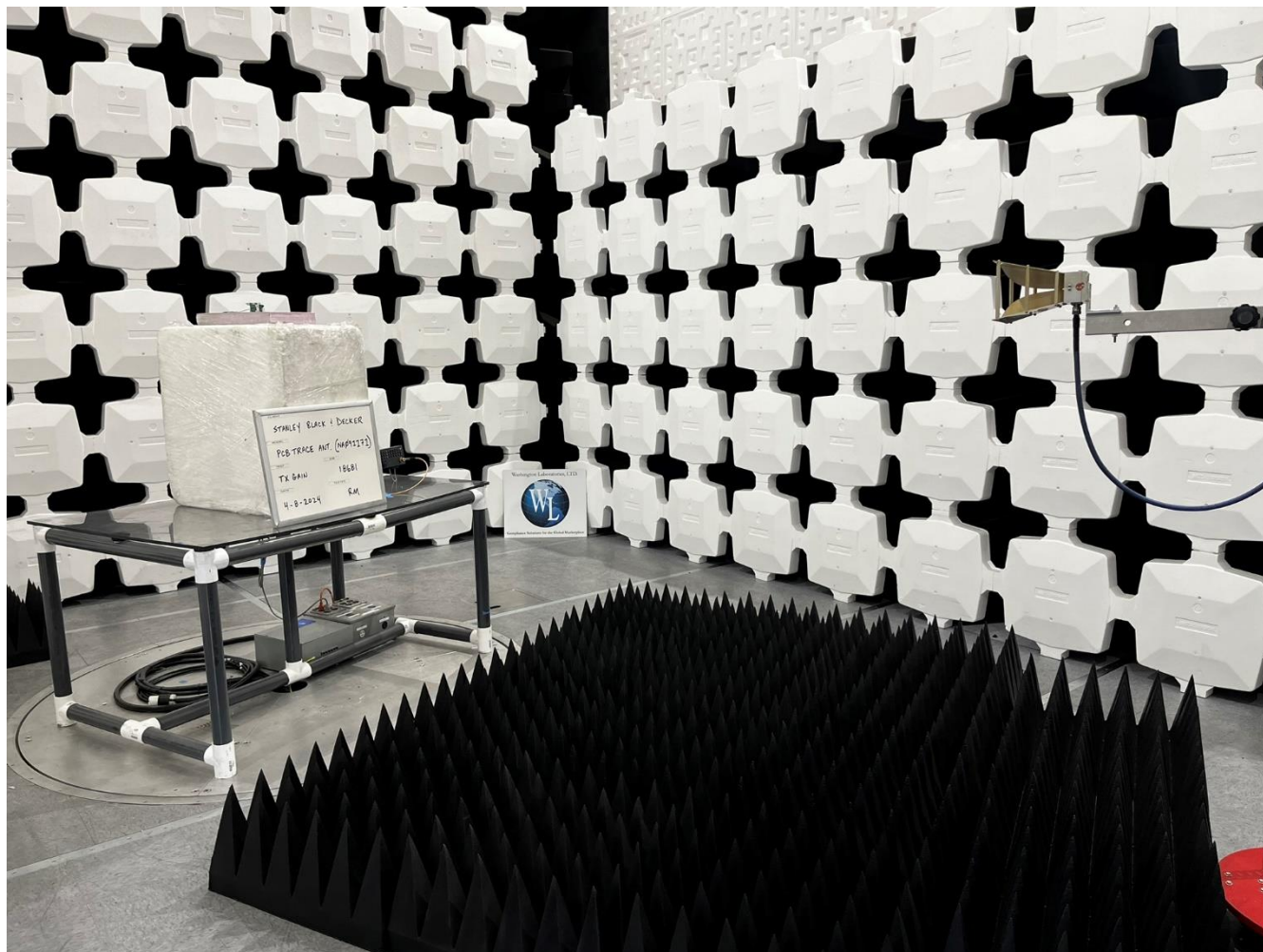


Figure 6: Antenna Gain Testing (View #2)

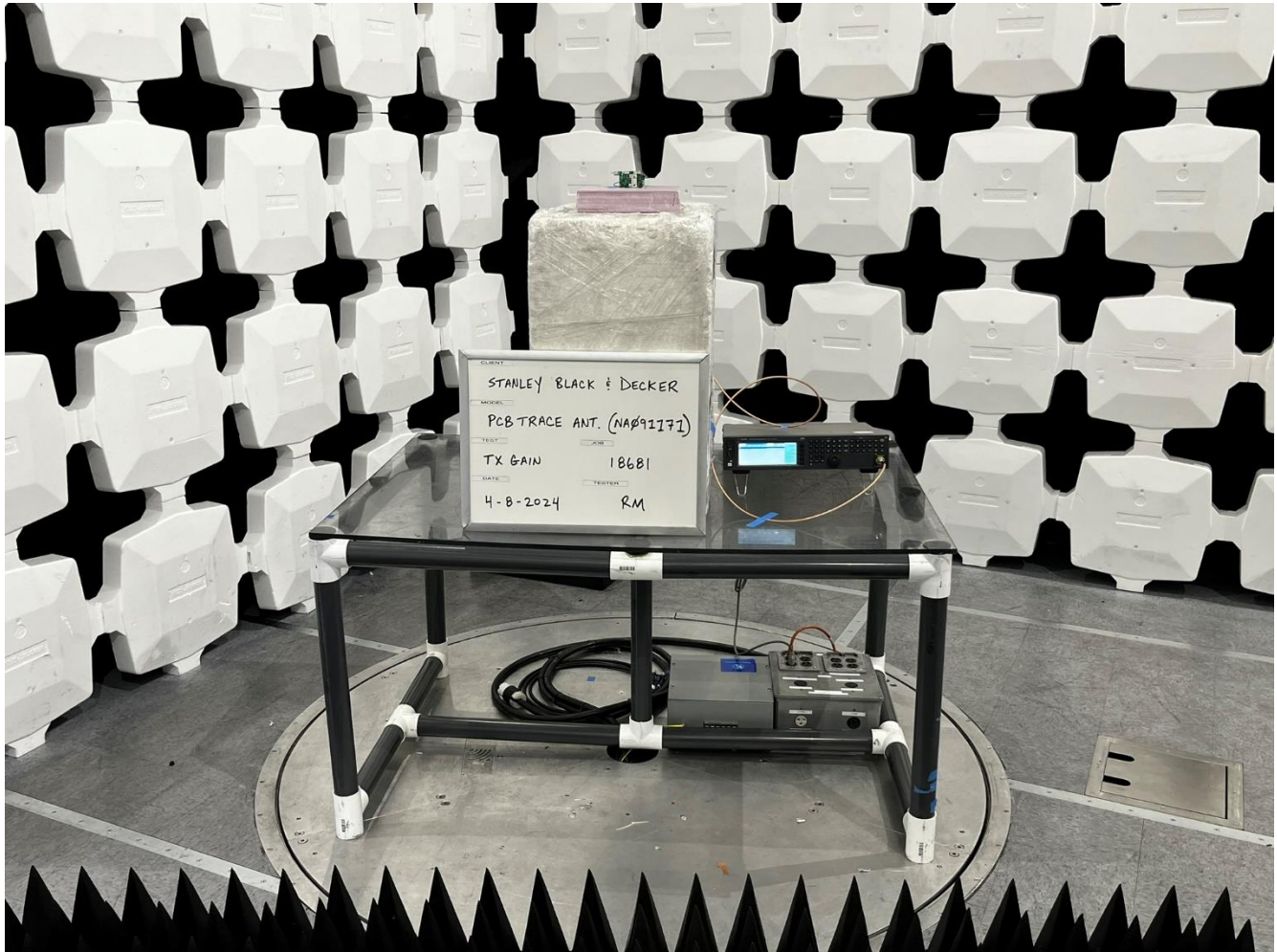
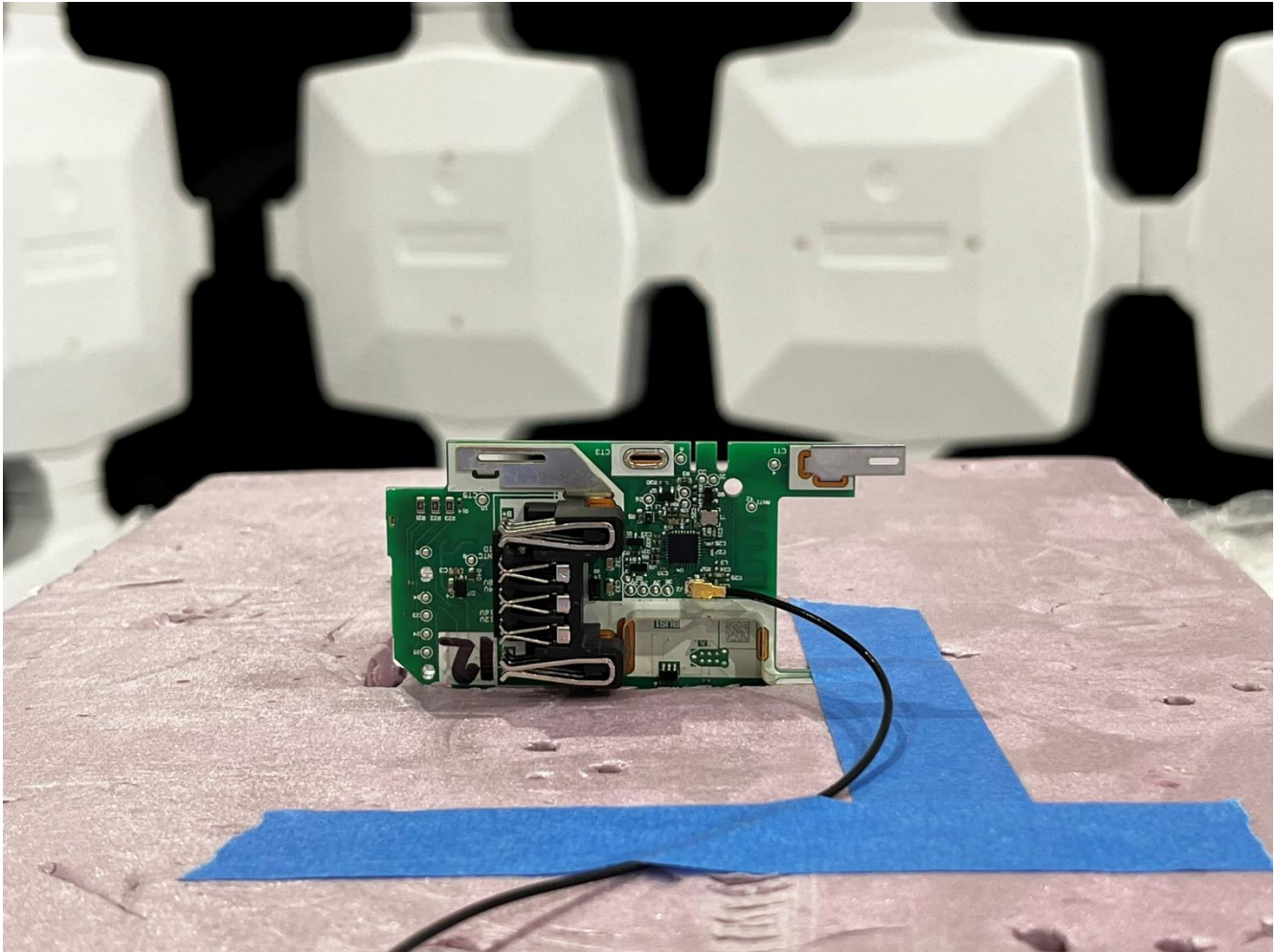


Figure 7: Antenna Gain Testing (View #3)



* Y-axis, worst-case