GALTRONICS

USA Facility

Galtronics USA, Inc.
8930 S. Beck Avenue Suite #103
Tempe, Arizona 85284-2891 USA

Tel: 1-480-496-5100
Fax: 1-480-598-2766

CIG Windstream WF8181/T3280 Antenna Performance

Galtronics Embedded Antenna

8930 S. Beck Avenue Suite #103
Tempe, Arizona 85284-2891 USA
Tel: 1-480-496-5100
Fax: 1-480-598-2766

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Tel: 1-480-496-5100

Revision History (Required)

Revisions	Date	Note
S1	October 19, 2022	Initial draft

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Tel: 1-480-496-5100

Contents

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1. Antenna System Description

There are two cabled antennas (LB1_C and HB4_C) and five onboard antennas (LB2, LB3, HB1, HB2, HB3).

- 02102073-07333A1 (LB1_C): 5GHz Band WiFi Balanced PCB antenna that operates in 5150-5830 MHz Band. It provides high efficient radiation with good cost benefits. It is cable fed and can be heat-staked on the customer enclosure. The antenna has a coax cable that is terminated with U.FL-style connector.
- 02036073-7333B1 (LB2): 2.5 GHz Band WiFi Onboard antenna that operates in 2400-2500 MHz Band. It provides high efficient radiation with good cost benefits. The antenna is mounted on a PCB with corresponding footprint and a 50 ohms transmission line. A Pi matching network should be placed between the radio and antenna feed pad.
- 02036073-05853 (LB3): 2.5 GHz Band WiFi Onboard antenna that operates in 2400-2500 MHz Band. It provides high efficient radiation with good cost benefits. The antenna is mounted on a PCB with corresponding footprint and a 50 ohms transmission line. A Pi matching network should be placed between the radio and antenna feed pad.
- 02036142-05853 (HB1): 5GHz Band WiFi Onboard antenna that operates in 5150-5830 MHz Band. It provides high efficient radiation with good cost benefits. The antenna is mounted on a PCB with corresponding footprint and a 50 ohms transmission line. A Pi matching network should be placed between the radio and antenna feed pad.
- 02036142-05853 (HB2): 5GHz Band WiFi Onboard antenna that operates in 5150-5830 MHz Band. It provides high efficient radiation with good cost benefits. The antenna is mounted on a PCB with corresponding footprint and a 50 ohms transmission line. A Pi matching network should be placed between the radio and antenna feed pad.
- 02036142-05853 (HB3): 5GHz Band WiFi Onboard antenna that operates in 5150-5830 MHz Band. It provides high efficient radiation with good cost benefits. The antenna is mounted on a PCB with corresponding footprint and a 50 ohms transmission line. A Pi matching network should be placed between the radio and antenna feed pad.
- 02102142-07333 (HB4_C): 5GHz Band WiFi Balanced PCB antenna that operates in 5150-5830 MHz Band. It provides high efficient radiation with good cost benefits. The antenna is mounted using foam tape on the customer device. The antenna has a coax cable that is terminated with U.FL-style connector.

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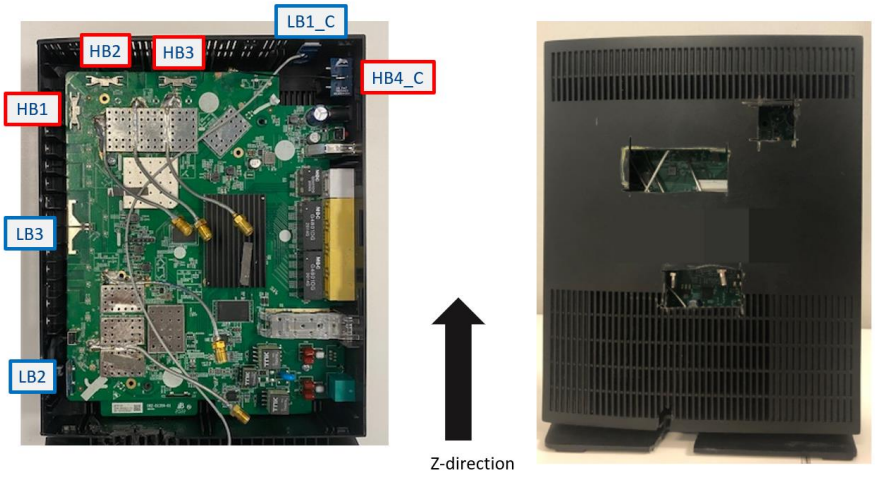

2. Measurement Quantity

The antennas were tested in full in an enclosure

- 02102073-07333A1 (LB1_C): Peak gain -- 3.47 dBi at 2500 MHz
- 02036073-7333B1 (LB2): Peak gain – 4.91 dBi at 2500 MHz
- 02036073-05853 (LB3): Peak gain – 4.23 dBi at 2500 MHz
- 02036142-05853 (HB1): Peak gain -- 4.70 dBi at 5350 MHz
- 02036142-05853 (HB2): Peak gain – 5.43 dBi at 5725 MHz
- 02036142-05853 (HB3): Peak gain – 4.61 dBi at 5725 MHz
- 02102142-07333 (HB4_C): Peak gain – 3.34 dBi at 5825 MHz

2-1. Correlated/Un-Correlated directional gain equation

Unequal antenna gains, with equal transmit powers. For antenna gains given by $G_1, G_2, \ldots, G_N$ dBi

(i) If transmit signals are *correlated*, then

Directional gain = $10 \log[(10^{G_1/20} + 10^{G_2/20} + \ldots + 10^{G_N/20})^2 / N_{ANT}]$ dBi [Note the "20"s in the denominator of each exponent and the square of the sum of terms; the object is to combine the signal levels coherently.]

(ii) If all transmit signals are *completely uncorrelated*, then

Directional gain = $10 \log[(10^{G_1/10} + 10^{G_2/10} + \ldots + 10^{G_N/10})/N_{ANT}]$ dBi

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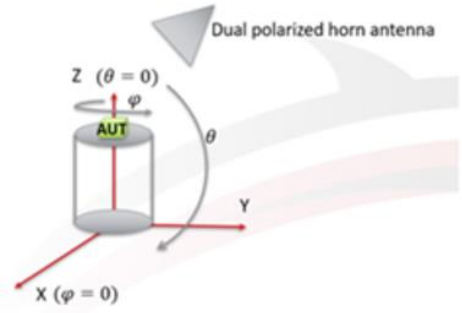
3. Measurement Method

The measurement setup is a spherical near-field scanner. The scanner system is housed in an integral/shielded anechoic chamber. The antenna under test (AUT) is mounted at the center of the chamber on an entirely foam pedestal. The pedestal rotates horizontally in the Azimuth (Phi). A wideband dual polarized horn antenna (probe) is mounted at a fixed distance away from the center of the chamber. The probe rotates along the elevation angle (Theta) and measures the radiation from the AUT. The measurement in the azimuth plane provides 360-degree of rotation whereas in the elevation plane it provides 180-degree of rotation. A software is used for post processing the measured data and calculate the far-field parameters including gain, directivity, and efficiency of the antenna.



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4. Measurement Environment

Galtronics, USA use Howland 7200S Near Field anechoic chamber designed to interface with Howland Wireless Test Lab (WTL) is used to control the chamber hardware for antenna pattern measurements. Processing measurement scan results and generation of 'Far Field' and 'Gain & Directivity' files are done using Howland Spherical N2F software. The anechoic Chamber is 14'W x 16'H x 16'D without absorbers.

The DUT is placed on an NSI turntable (Phi Axis) in the center of the anechoic Chamber and 96" from the chamber floor. A probe is mounted on the theta axis. The probe used by Galtronics, USA is a Howland QR1, broadband, dual-polarization horn antenna operating in 700MHz to 10GHz. Theta and Phi axis are controlled by the Motion Control Unit from The Howland Company

The Chamber operates from 698MHz-7.5GHz. A Rohde & Schwarz ZVB8 Vector network analyzer (VNA) is used to generate and measure the RF signal fed through the DUT and the Probe antenna. The VNA is controlled by Howland WTL software in remote control mode.

The Chamber is validated periodically to ensure accuracy in antenna pattern measurements.

Innovative Antenna Solutions

Mobile Devices | Wireless Infrastructure | **Embedded**

CIG WindStream T3280 Antenna Performance

Galtronics Project: 7333A

Prepared by Junho Cha
July 31st , 2020

Introduction

- Galtronics developed an antenna solution for CIG WindStream T3280
- Galtronics received the new Hardware from CIG
- There are two cabled antennas (LB1_C and HB4_C) and Five onboard (LB2, LB3, HB1, HB2, HB3) antennas
- LB1_C and HB4_C are PCB cabled antennas and DC-grounded antennas.
- LC matching component values:
  - LB 2 (PCB Onboard) : Add a series inductor (2.7 nH) : Existing component
  - LB 3 (Metal Onboard) : Add a shunt capacitor (1 pF) and a series inductor (1.5 nH) : Existing component
  - HB 3 (Metal Onboard) : O Ohm resistor : Updated component
- Measured return loss, isolation, peak gain, efficiency, composite gain and gain pattern of the antennas

Antenna Location

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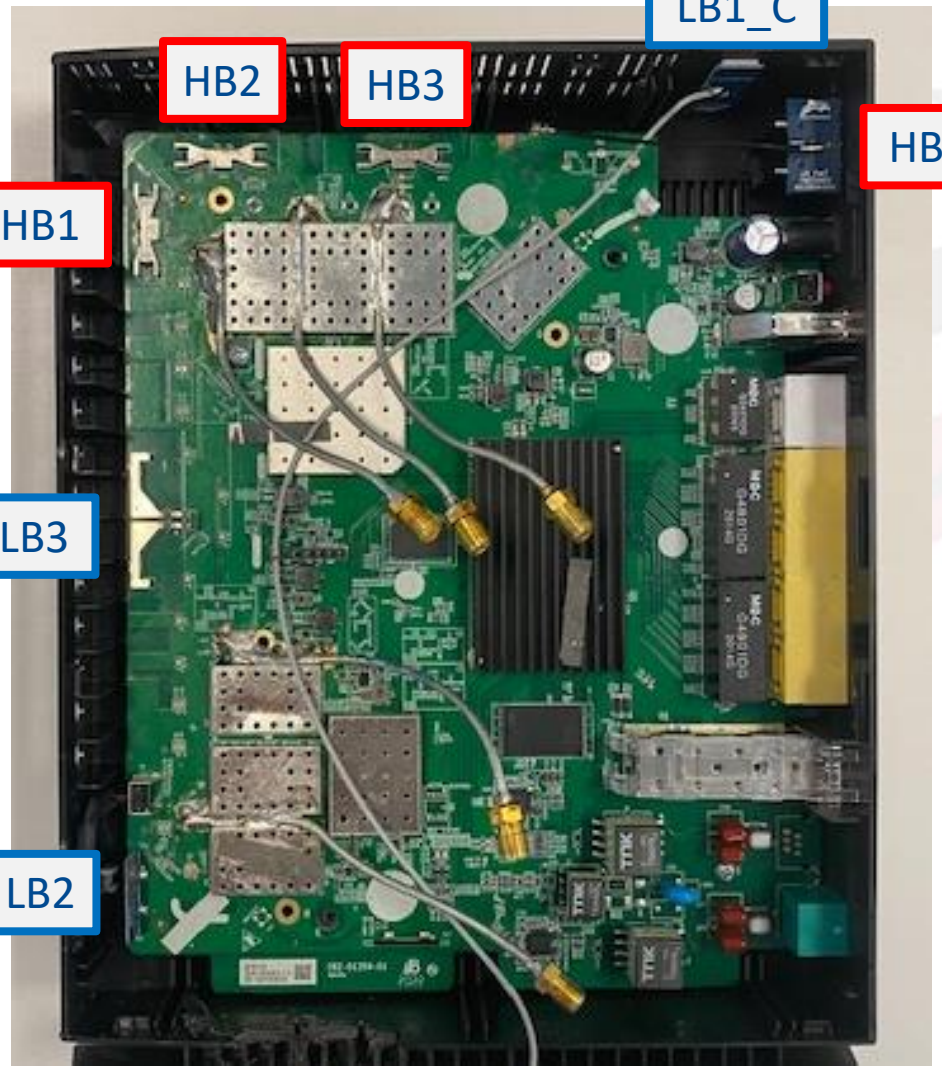

LC Matching components

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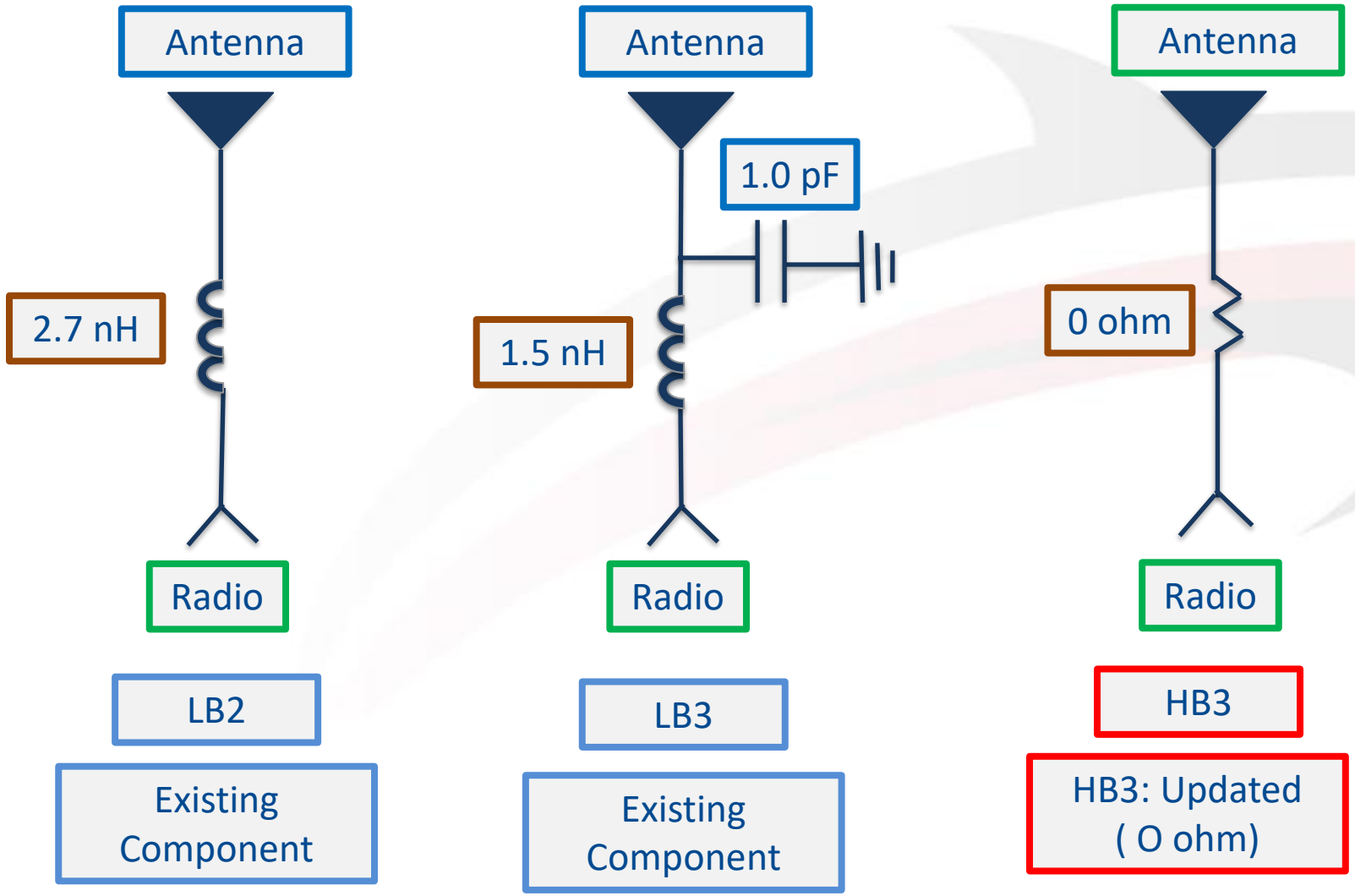

Cable Length and Orientation

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Antenna	Cable Length	orientation	Cable Color
LB1_C	310 mm	H	Black
LB2	NA	Mix	NA
LB3	NA	V	NA
HB1	NA	V	NA
HB2	NA	H	NA
HB3	NA	H	NA
HB4_C	69 mm	V	Black

Antenna Return Loss of the Low Band

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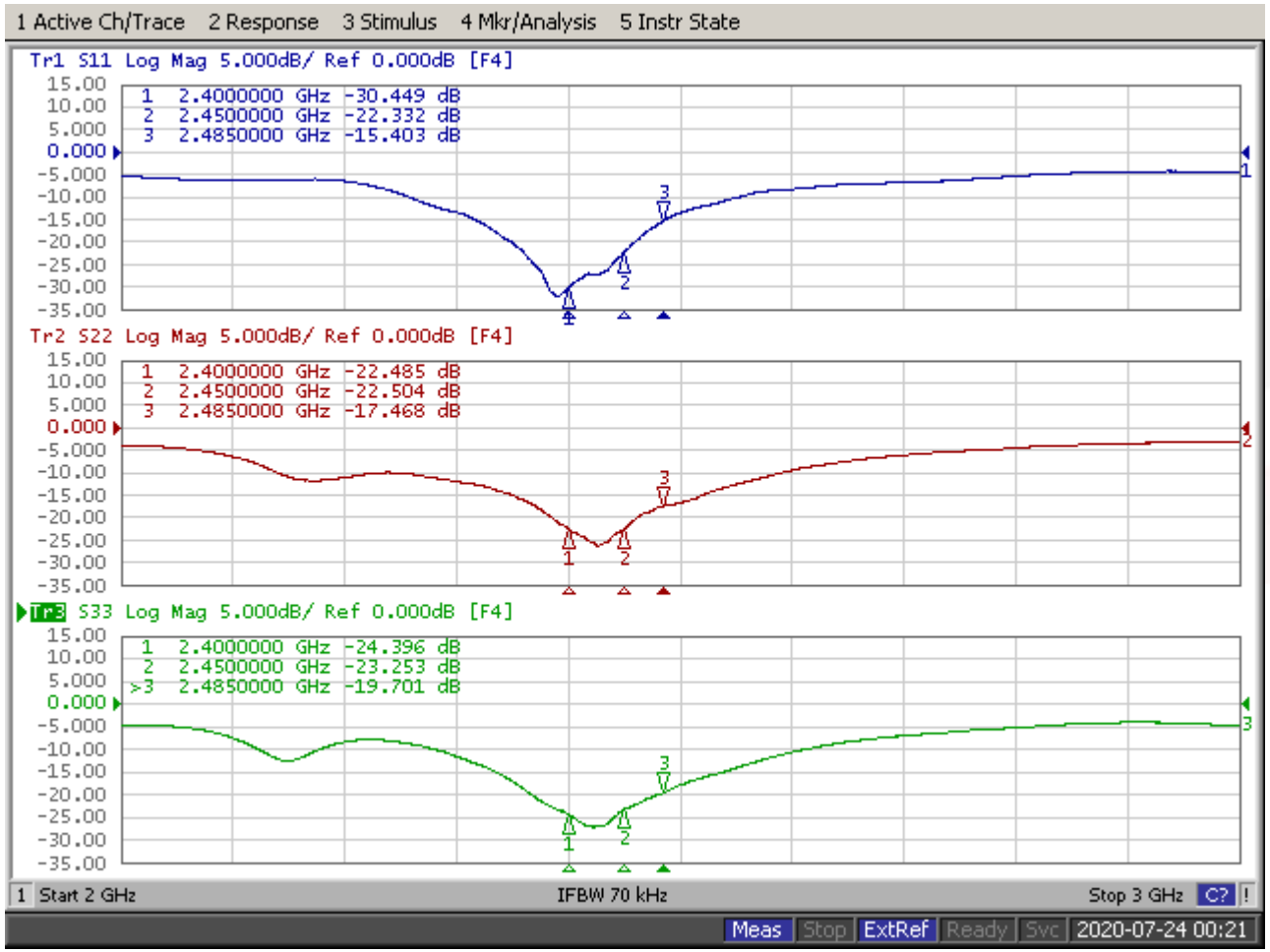
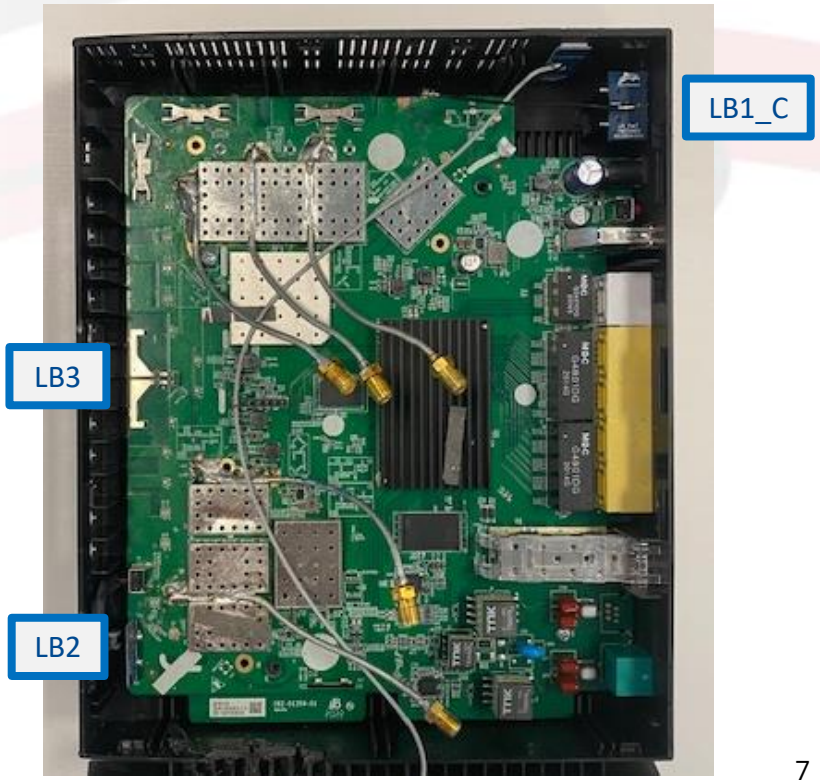


Port 1= LB1_C
Port 2= LB2
Port 3= LB



Antenna Isolation of the Low Band

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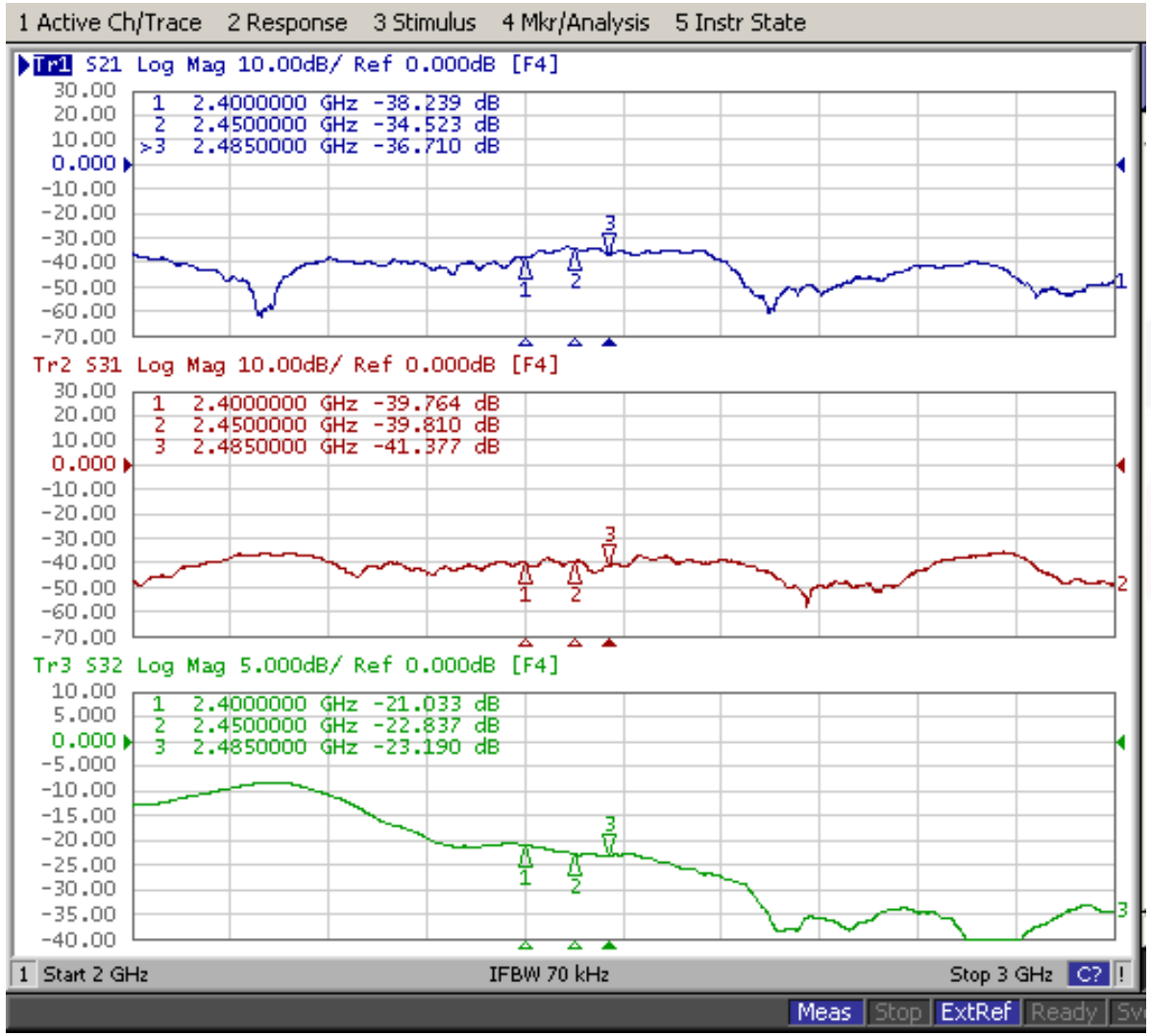
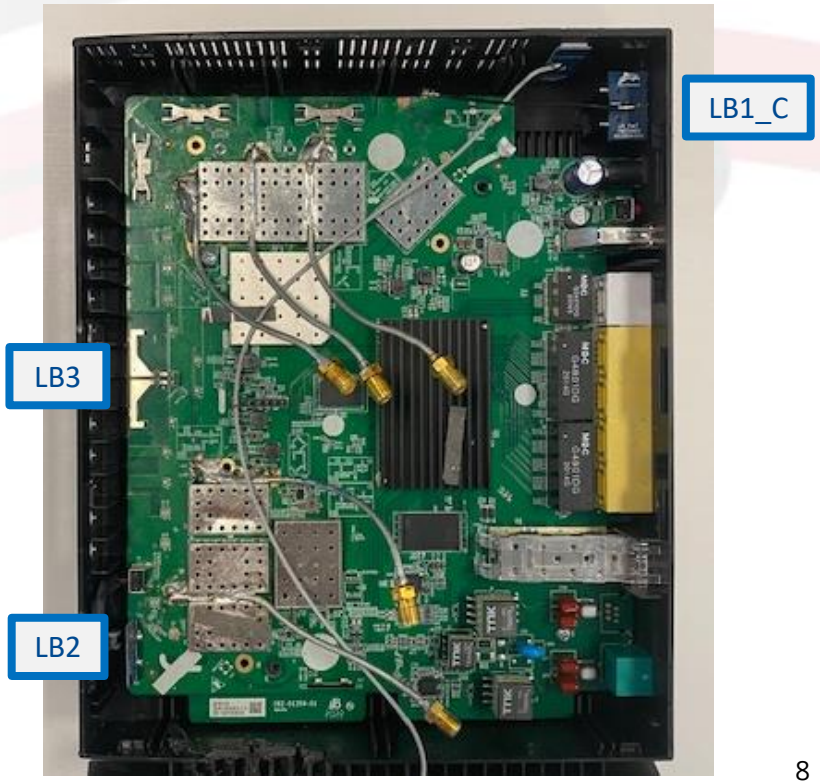


Port 1= LB1_C
Port 2= LB2
Port 3= LB



Antenna Return Loss of the High Band

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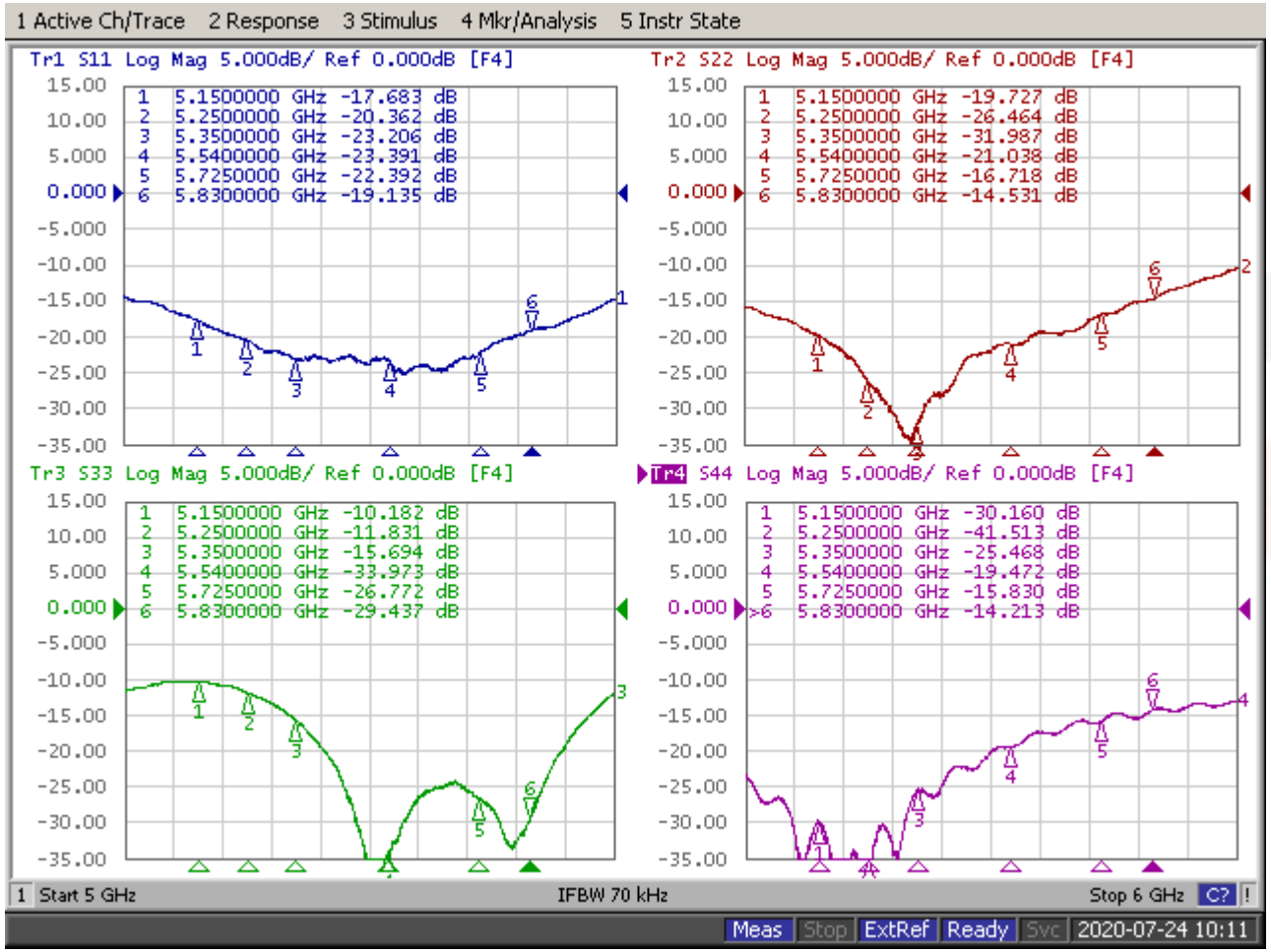

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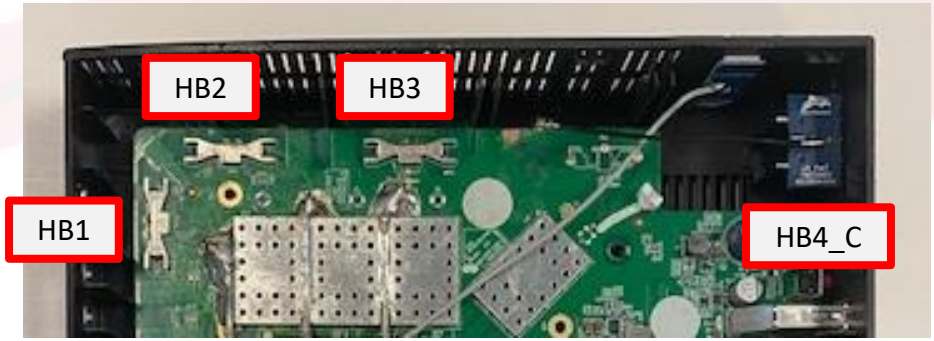
Port3= HB3	Port4= HB4_C



Antenna Isolation of the High Band

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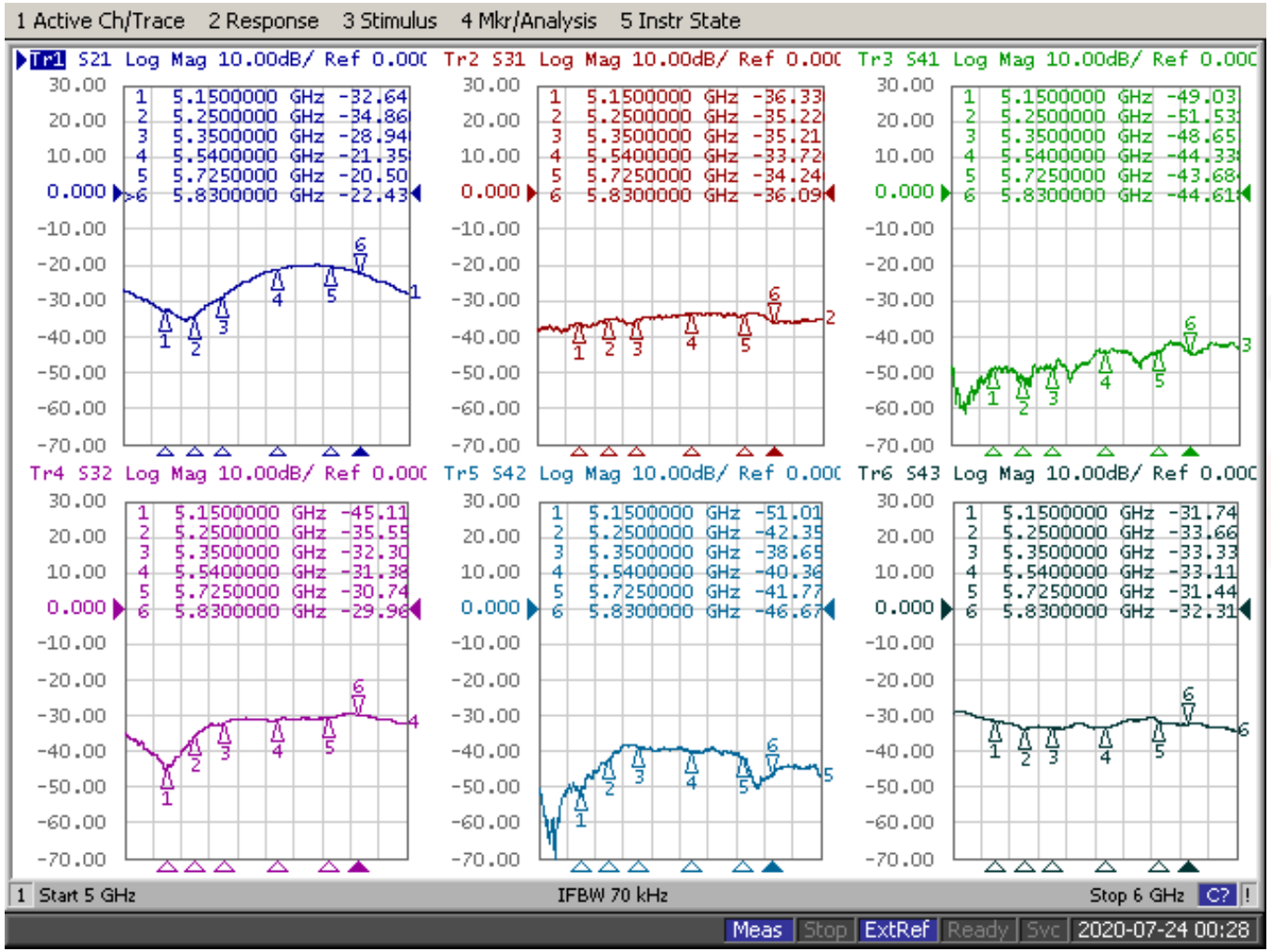
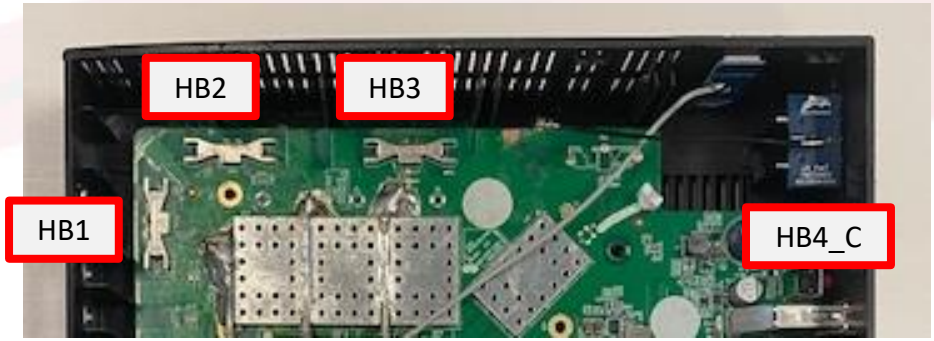


Port1= HB1	Port2= HB2
Port3= HB3	Port4= HB4_C



Antenna Isolation between LB and HB

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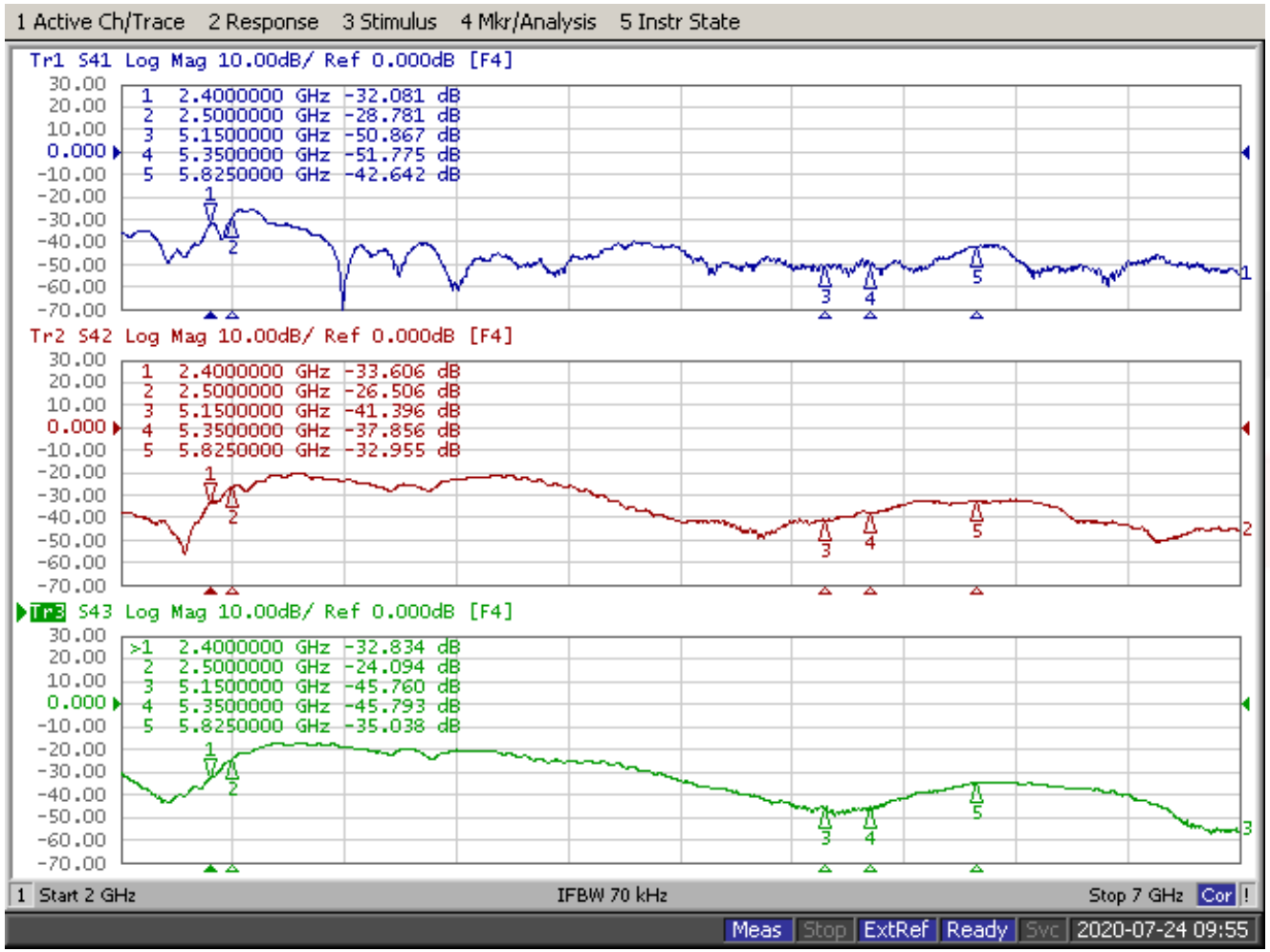
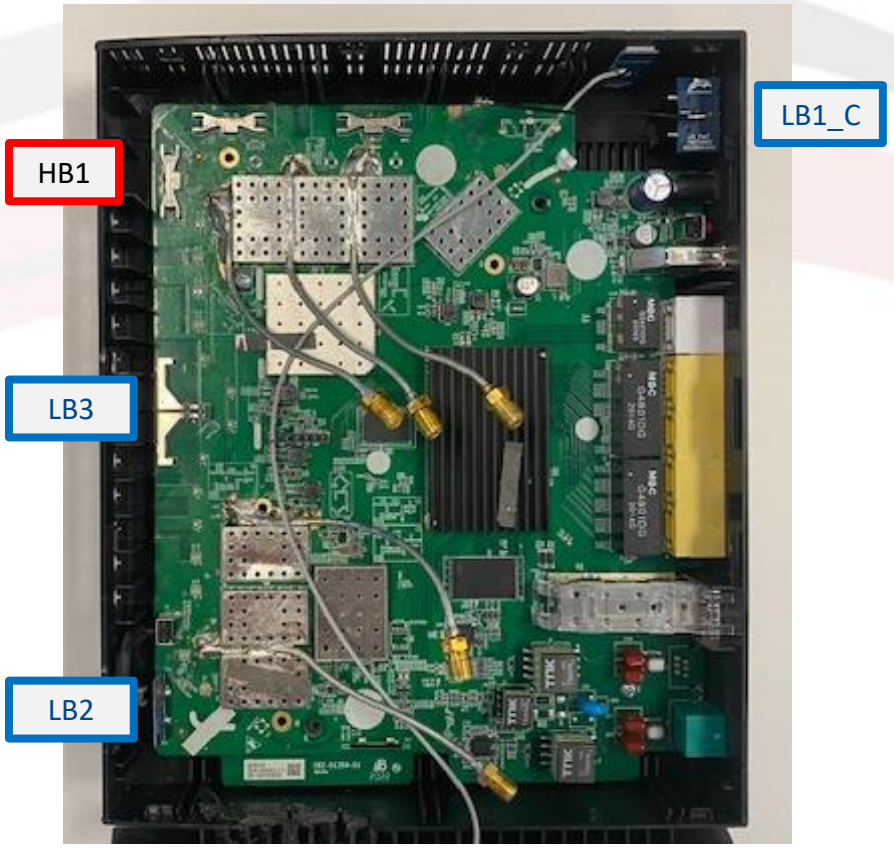


Port 1= LB1_C	Port 3= LB
Port 2= LB2	Port 4= HB1



Antenna Isolation between LB and HB

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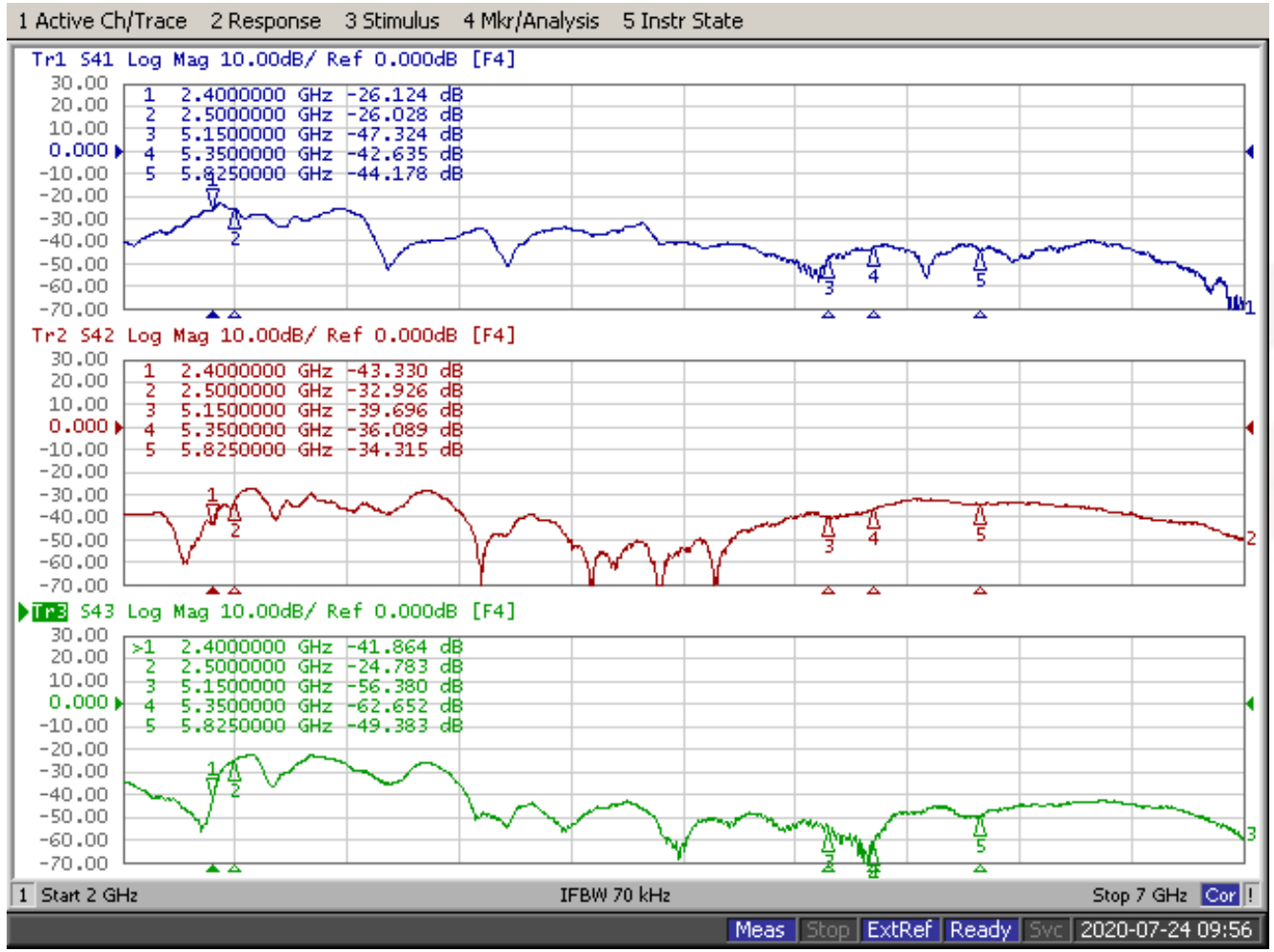
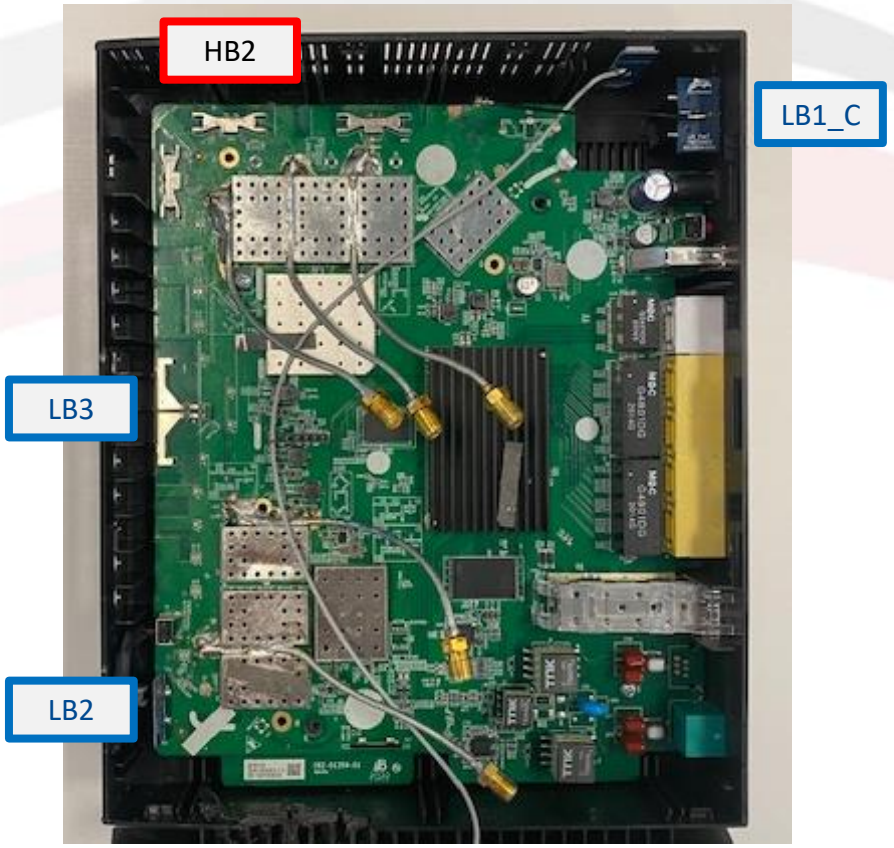
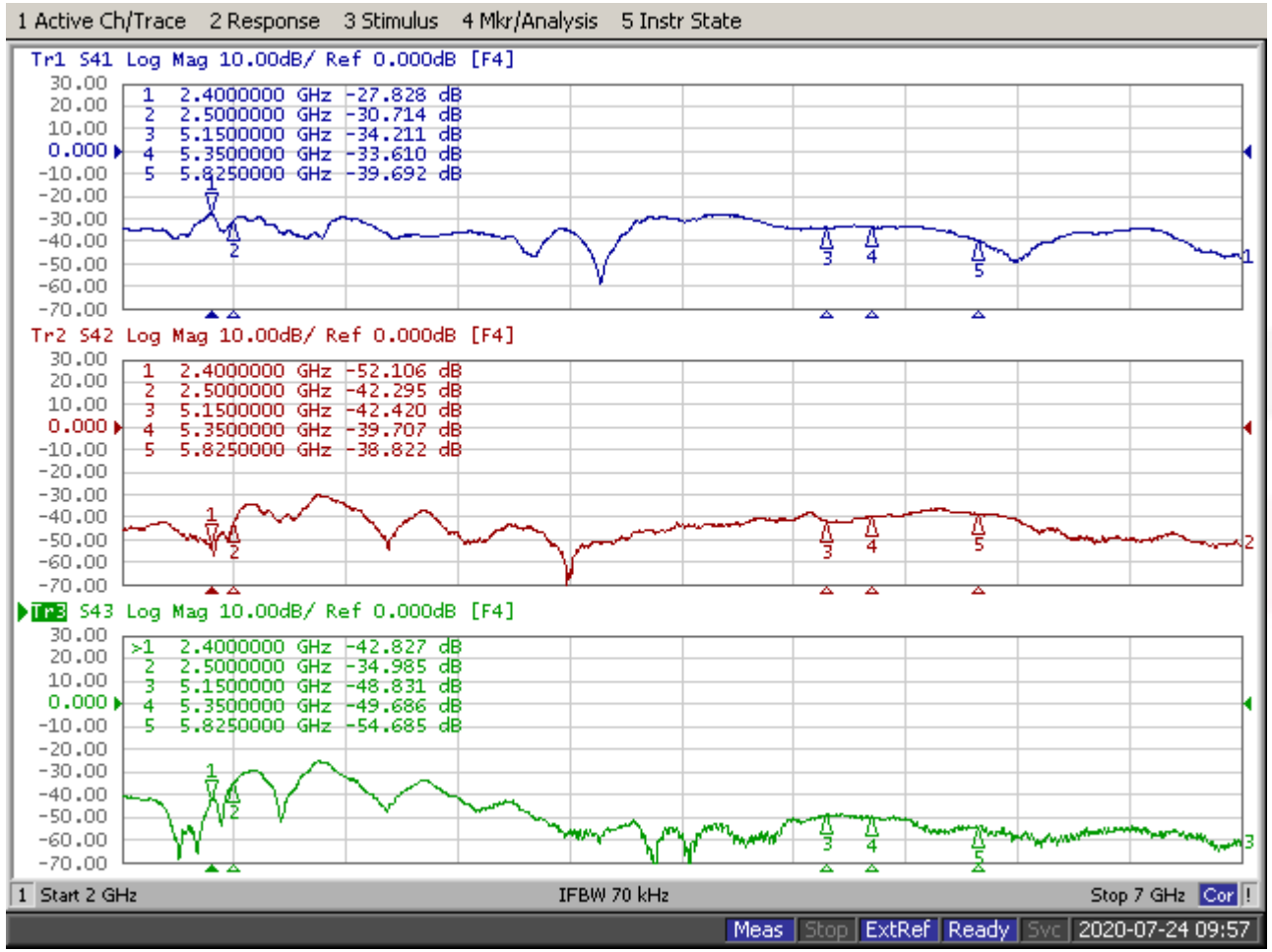


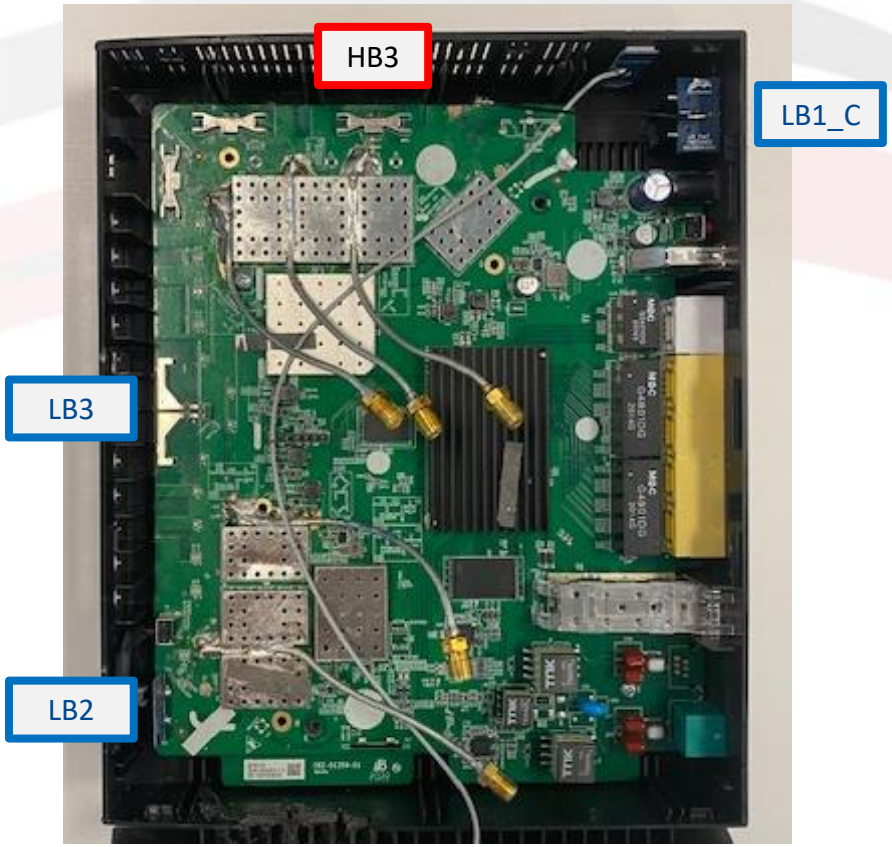
Port 1= LB1_C	Port 3= LB
Port 2= LB2	Port 4= HB2



Antenna Isolation between LB and HB



Port 1= LB1_C	Port 3= LB
Port 2= LB2	Port 4= HB3



G

Antenna Isolation between LB and HB

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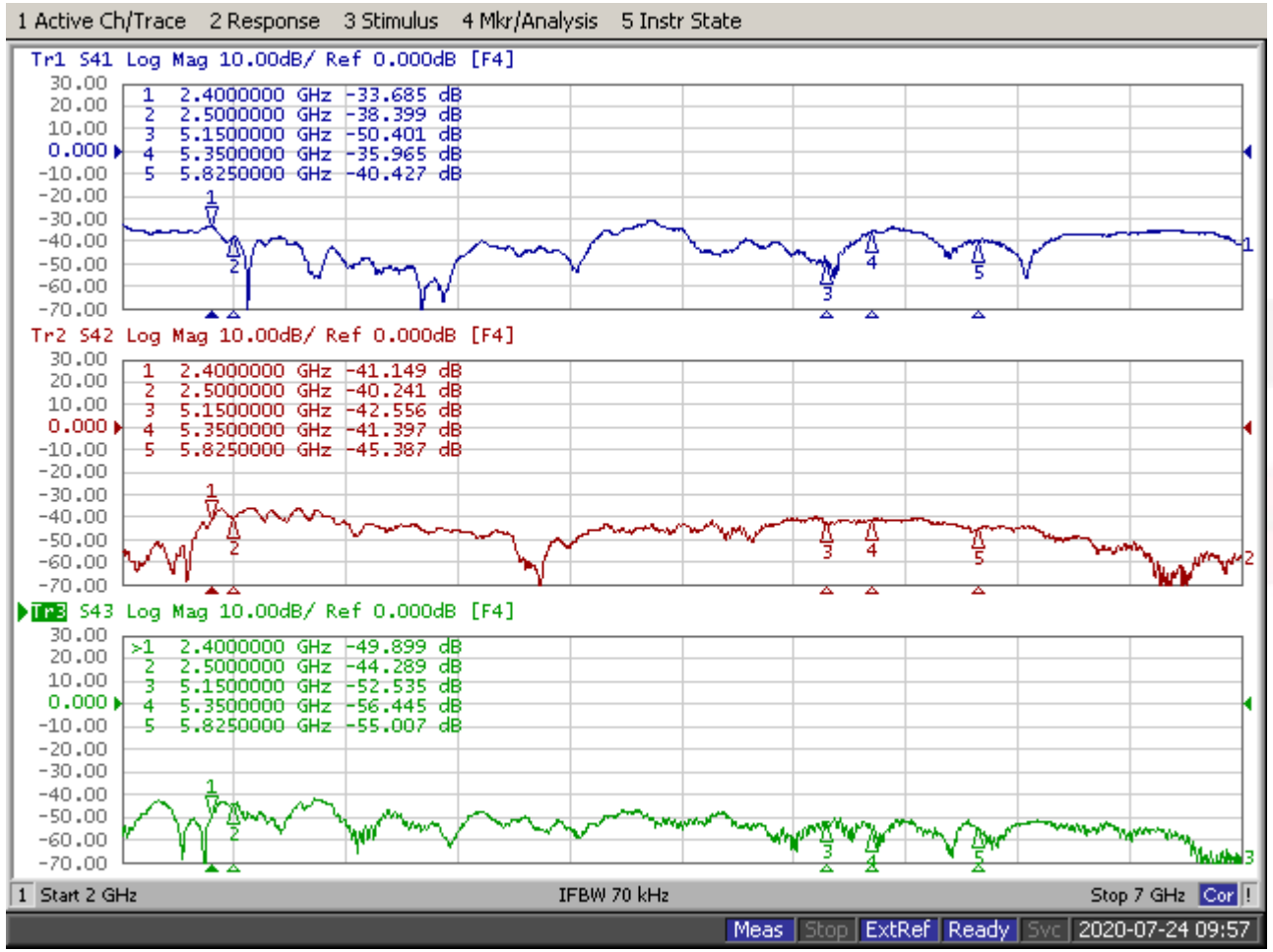
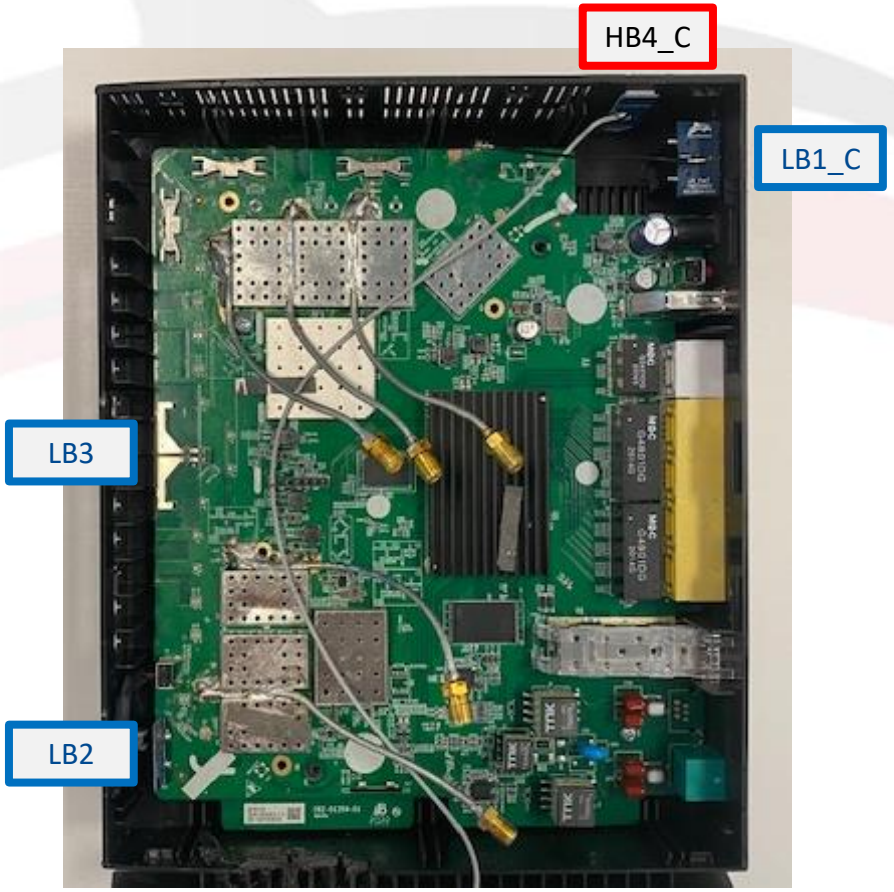


Port 1= LB1_C	Port 3= LB
Port 2= LB2	Port 4= HB4_C



Antenna with an enclosure

Front

Z-direction

The antennas were tested in full in an enclosure

Antennas Peak Gain and Efficiency

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	Freq (MHz)	Peak Gain (dBi)	Directivity (dB)	Efficiency
LB 1_C	2400	2.365	4.176	65.9 %
	2450	2.514	4.196	67.88 %
	2500	3.47	5.236	66.59 %
	Average			66.79 %

	Freq (MHz)	Peak Gain (dBi)	Directivity (dB)	Efficiency
LB 2	2400	3.885	5.209	73.73 %
	2450	4.358	5.545	76.08 %
	2500	4.911	5.907	79.51 %
	Average			76.44 %

	Freq (MHz)	Peak Gain (dBi)	Directivity (dB)	Efficiency
LB 3	2400	3.762	5.505	66.94 %
	2450	4.123	5.589	71.35 %
	2500	4.238	5.667	71.96 %
	Average			70.08 %

	Freq (MHz)	Peak Gain (dBi)	Directivity (dB)	Efficiency
HB 1	5150	3.624	5.271	68.43 %
	5250	4.246	5.602	73.17 %
	5350	4.707	6.347	68.55 %
	5725	4.21	5.997	66.26 %
	5825	2.861	4.973	61.48 %
	Average			67.58 %

	Freq (MHz)	Peak Gain (dBi)	Directivity (dB)	Efficiency
HB 2	5150	3.727	5.372	68.47 %
	5250	4.453	5.87	72.16 %
	5350	4.621	6.284	68.19 %
	5725	5.439	7.296	65.2 %
	5825	4.508	6.79	59.14 %
	Average			66.63 %

	Freq (MHz)	Peak Gain (dBi)	Directivity (dB)	Efficiency
HB 3	5150	4.435	6.358	64.23 %
	5250	4.211	5.869	68.27 %
	5350	4.328	5.889	69.82 %
	5725	4.612	5.745	77.04 %
	5825	4.595	5.927	73.59 %
	Average			70.59 %

	Freq (MHz)	Peak Gain (dBi)	Directivity (dB)	Efficiency
HB 4_C	5150	3.019	4.304	74.39 %
	5250	3.34	4.318	79.84 %
	5350	3.145	4.367	75.48 %
	5725	3.303	4.479	76.27 %
	5825	3.342	4.616	74.58 %
	Average			76.11 %

Formula of Correlated & Uncorrelated Gain

Correlated Gain(each angle) $=10 \log[(10^{G1/20} + 10^{G2/20} + \ldots + 10^{GN/20})^2/N_{ANT}]$ dBi

Uncorrelated Gain(each angle)$= 10 \log[(10^{G1/10} + 10^{G2/10} + \ldots + 10^{GN/10})/N_{ANT}]$

dBi

Low Band Horizontal and Vertical Correlated directional Gain

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	Degree		Gain (dBi)			Correlated Gain (dBi) - H-Pol
Frequency (MHz)	Theta	Phi	LB1	LB2	LB3	
2400	117	150	0.58	-2.75	-9.87	1.75
2450	117	149	0.78	-2.33	-10.33	1.93
2500	117	145	0.64	-2.12	-10.12	1.97

	Degree		Gain (dBi)			Correlated Gain (dBi)-V-Pol
Frequency (MHz)	Theta	Phi	LB1	LB2	LB3	
2400	81	23	-9.17	2.55	3.61	5.34
2450	81	24	-10.56	2.76	3.77	5.37
2500	105	28	-11.12	3.90	3.93	5.90

Worst Case

Low Band Horizontal and Vertical UnCorrelated directional Gain

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	Degree		Gain (dBi)			UnCorrelated Gain (dBi) - H-Pol
Frequency (MHz)	Theta	Phi	LB1	LB2	LB3	
2400	117	153	0.63	-2.74	-10.26	-2.26
2450	119	152	0.91	-2.39	-10.88	-2.01
2500	2	5	2.95	-14.54	-26.86	-1.74

	Degree		Gain (dBi)			UnCorrelated Gain (dBi)-V-Pol
Frequency (MHz)	Theta	Phi	LB1	LB2	LB3	
2400	83	23	-9.44	2.54	3.66	1.49
2450	106	30	-15.79	3.66	3.43	1.81
2500	109	31	-13.22	4.45	3.48	2.27

Worst Case

Horizontal and Vertical Correlated directional Gain

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	Degree		Gain (dBi)				Correlated Gain (dBi) - H-Pol
Frequency (MHz)	Theta	Phi	HB1	HB2	HB3	HB4_C	
5150	23	252	-0.46	-3.29	2.27	-17.85	3.69
5250	25	250	-0.44	-4.49	2.25	-13.52	3.67
5350	29	246	-1.20	-7.28	2.25	-11.03	3.17
5725	177	163	-5.03	-2.24	-1.82	-6.74	2.29
5825	95	159	1.22	-6.36	-1.25	-16.91	2.41

	Degree		Gain (dBi)				Correlated Gain (dBi)-V-Pol
Frequency (MHz)	Theta	Phi	HB1	HB2	HB3	HB4_C	
5150	47	12	3.15	3.41	-10.97	-5.08	5.48
5250	49	11	3.85	4.12	-10.43	-4.18	6.20
5350	52	12	4.49	4.31	-8.39	-4.16	6.69
5725	56	12	2.70	4.95	-5.31	-3.99	6.66
5825	54	22	-0.41	2.81	-4.73	-2.63	5.24

Worst Case

Horizontal and Vertical UnCorrelated directional Gain

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	Degree		Gain (dBi)				UnCorrelated Gain (dBi) - H-Pol
Frequency (MHz)	Theta	Phi	HB1	HB2	HB3	HB4_C	
5150	23	255	-0.55	-2.95	2.30	-19.97	-1.11
5250	26	253	-0.61	-4.29	2.38	-14.81	-1.24
5350	30	250	-1.47	-7.24	2.54	-12.57	-1.63
5725	108	125	2.68	-16.75	-1.97	-20.54	-2.01
5825	108	126	2.56	-10.44	-2.74	-19.97	-2.15

	Degree		Gain (dBi)				UnCorrelated Gain (dBi)-V-Pol
Frequency (MHz)	Theta	Phi	HB1	HB2	HB3	HB4_C	
5150	49	11	3.25	3.39	-11.90	-5.02	0.68
5250	49	10	3.88	4.12	-10.48	-4.27	1.37
5350	51	11	4.53	4.32	-8.52	-4.31	1.80
5725	55	11	2.83	4.92	-5.63	-3.96	1.54
5825	60	12	-1.21	3.85	-4.66	-4.86	-0.17

Worst Case

Azimuth Cut - Power Sum
2.45 GHz Band Antennas

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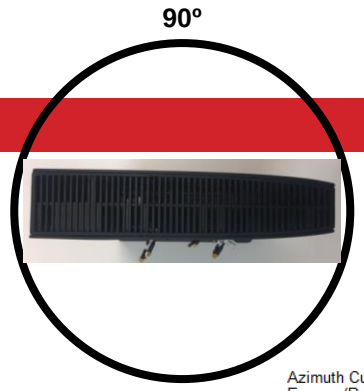
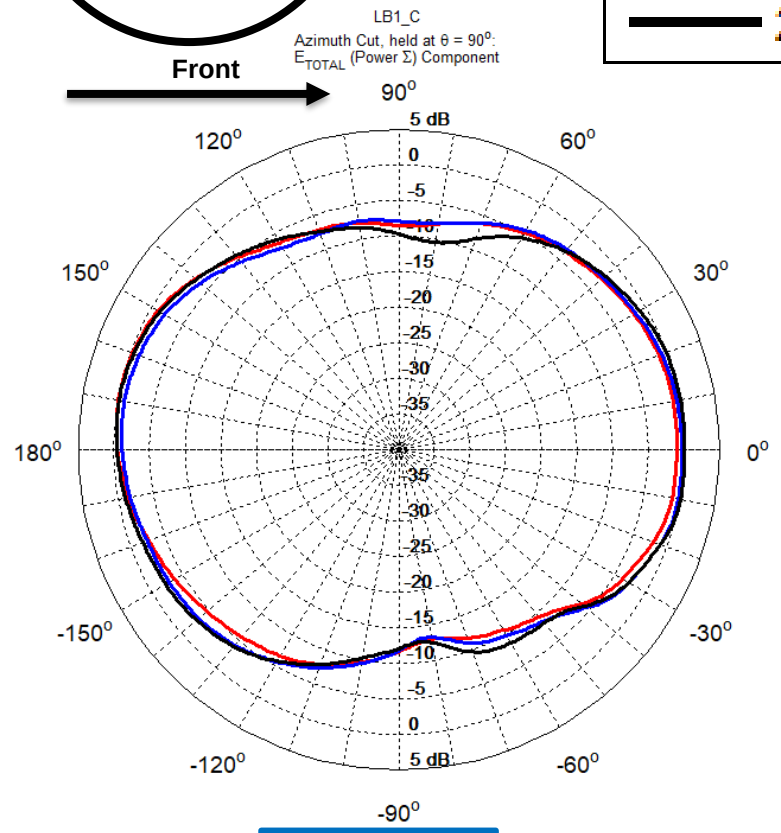
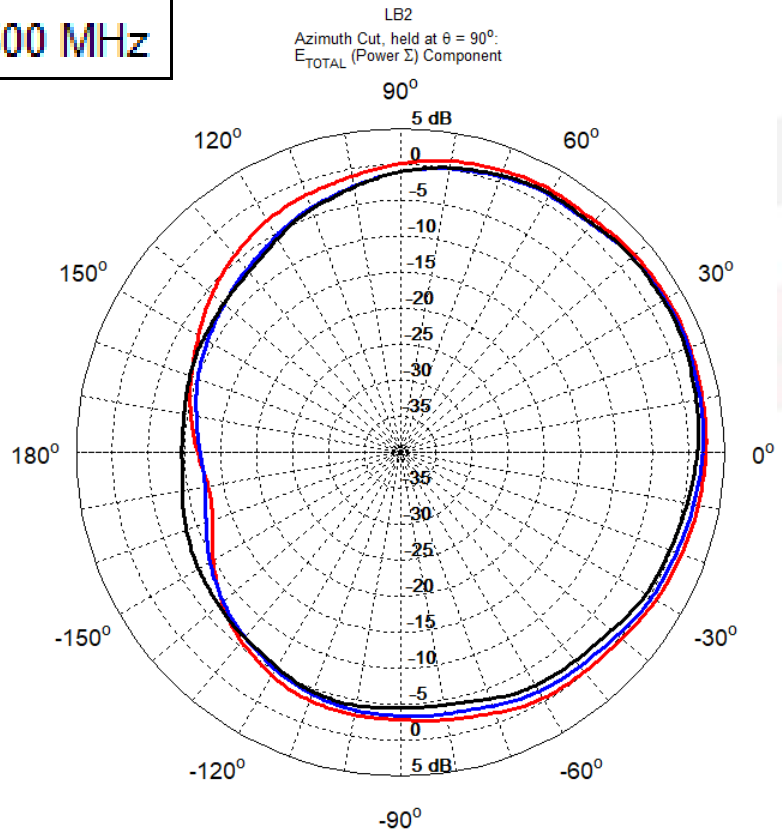


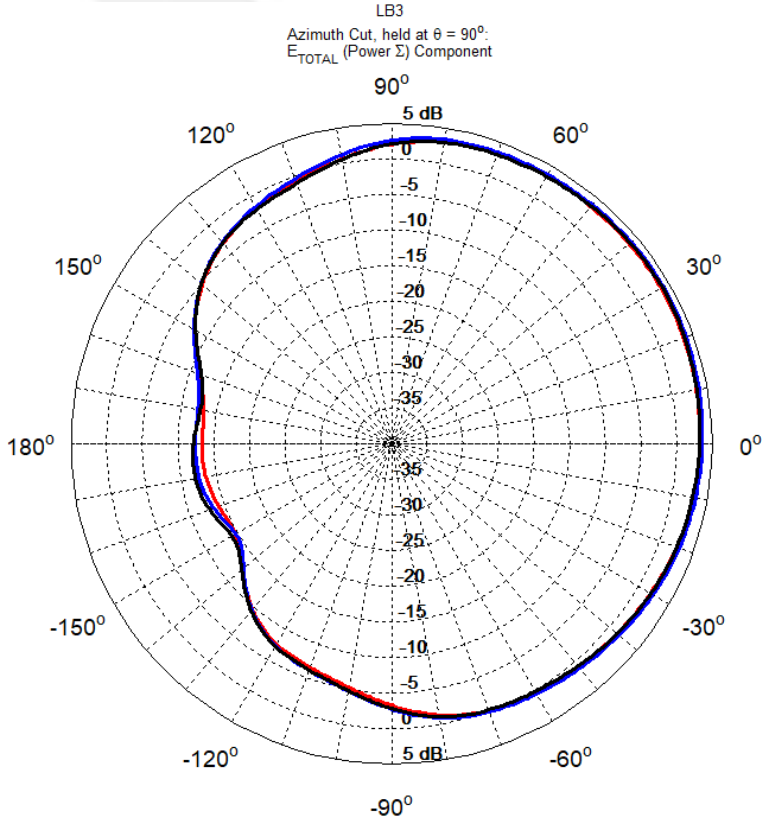
2400 MHz
2450 MHz
2500 MHz



LB1_C

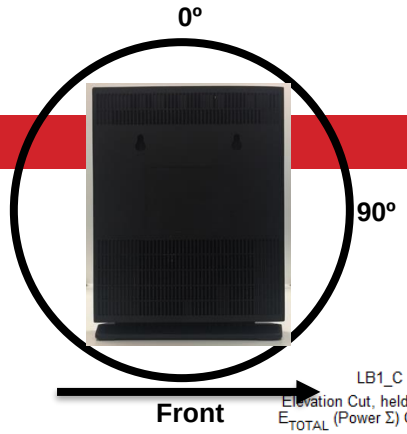


LB2

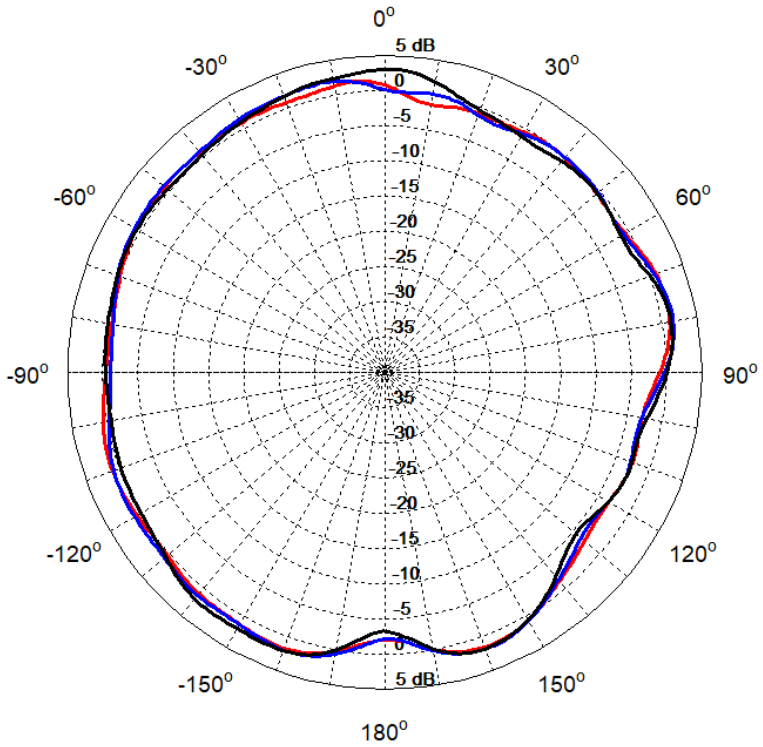


LB3

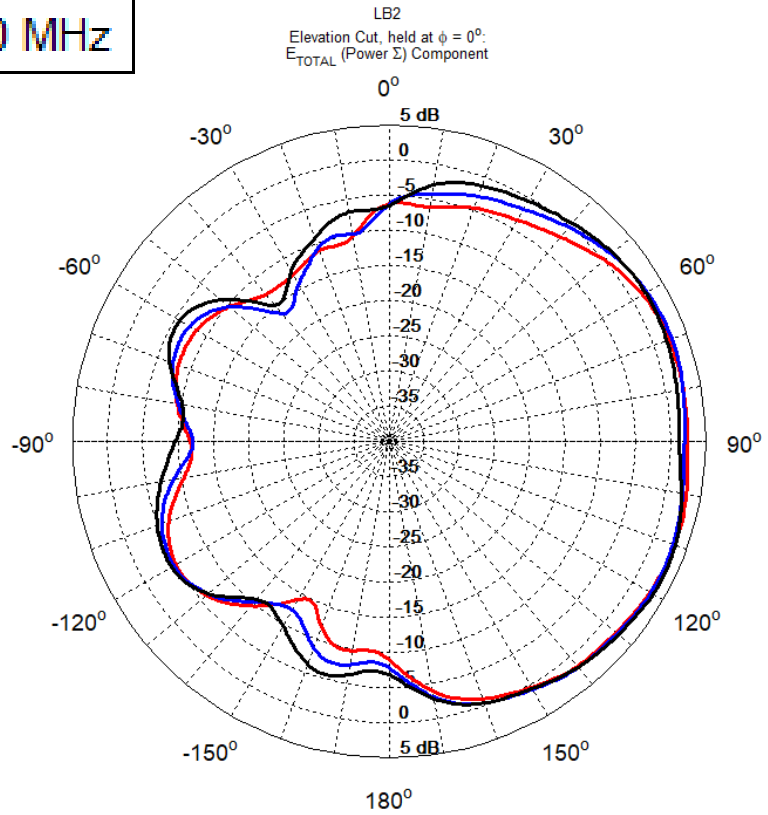
Elevation (Front to Back) Cut - Power Sum
2.45 GHz Band Antennas



2400 MHz
2450 MHz
2500 MHz



LB1_C



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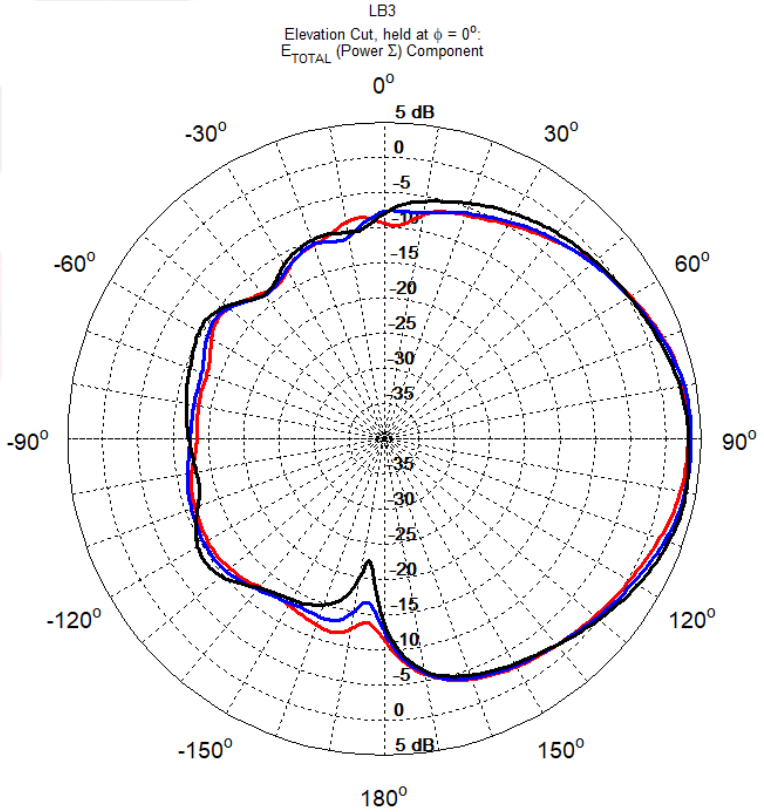
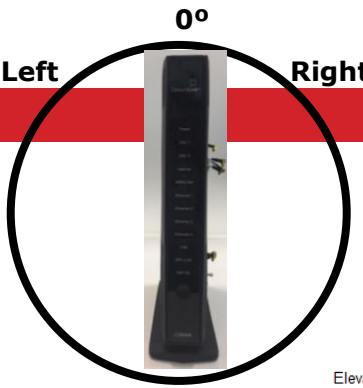


LB3

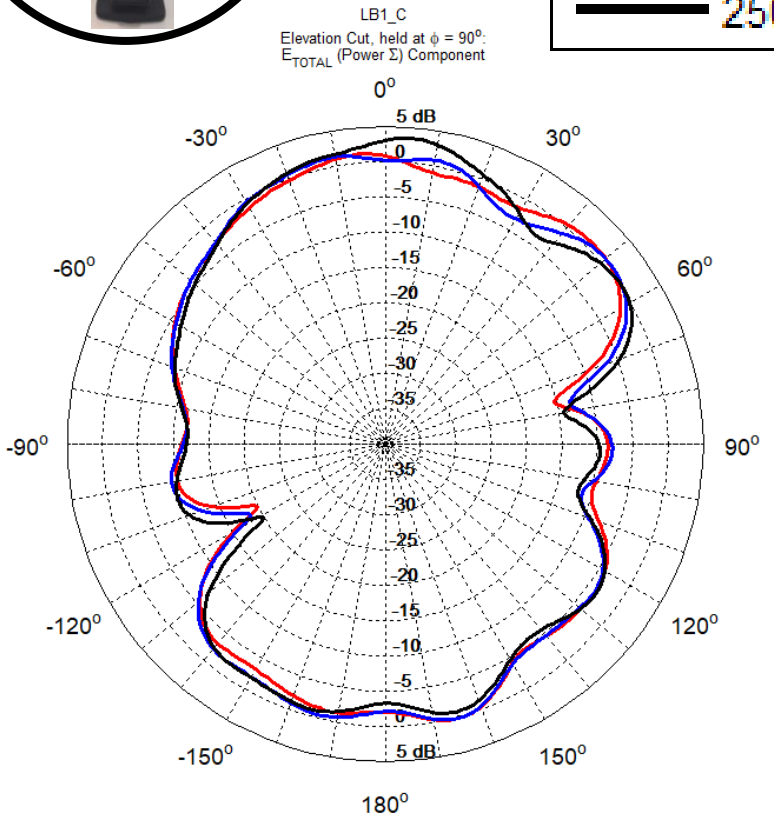
Elevation (Side to Side) Cut - Power Sum
2.45 GHz Band Antennas



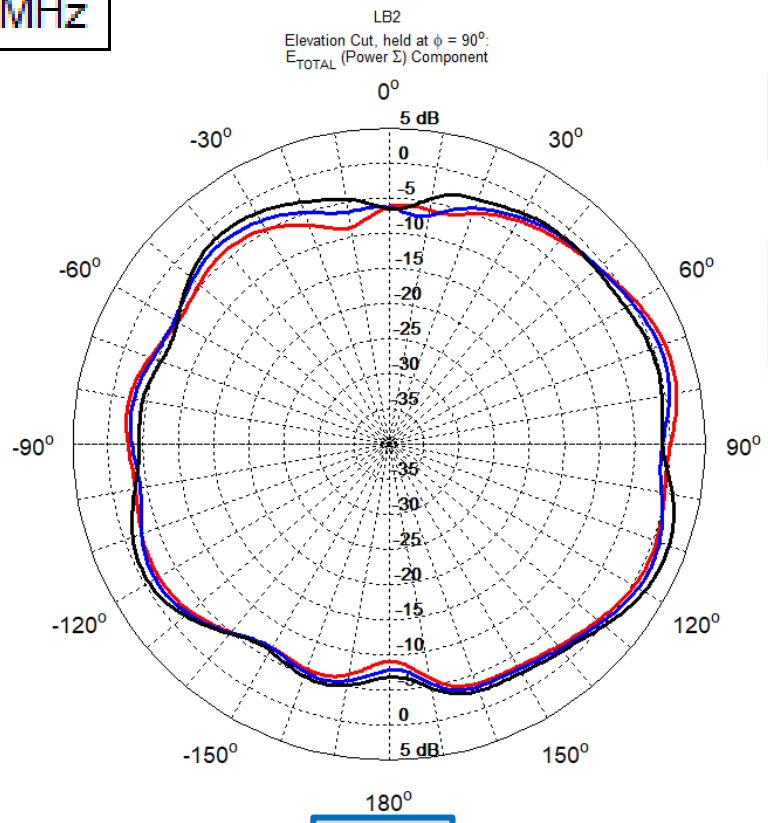
GALTRONICS

W E ' R E M A K I N G W A V E S ™

2400 MHz
2450 MHz
2500 MHz



LB1_C



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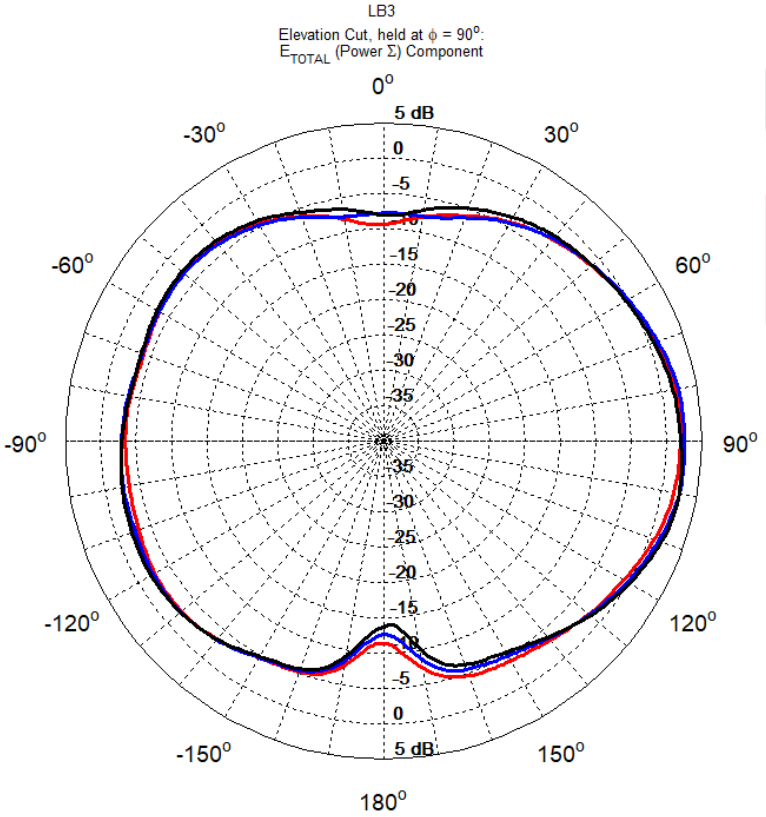
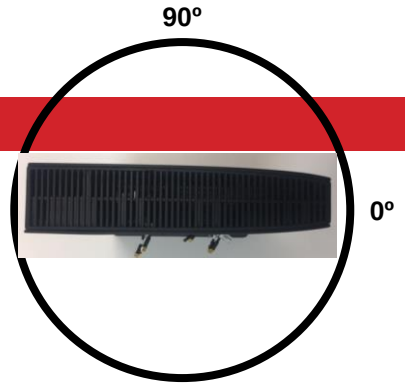


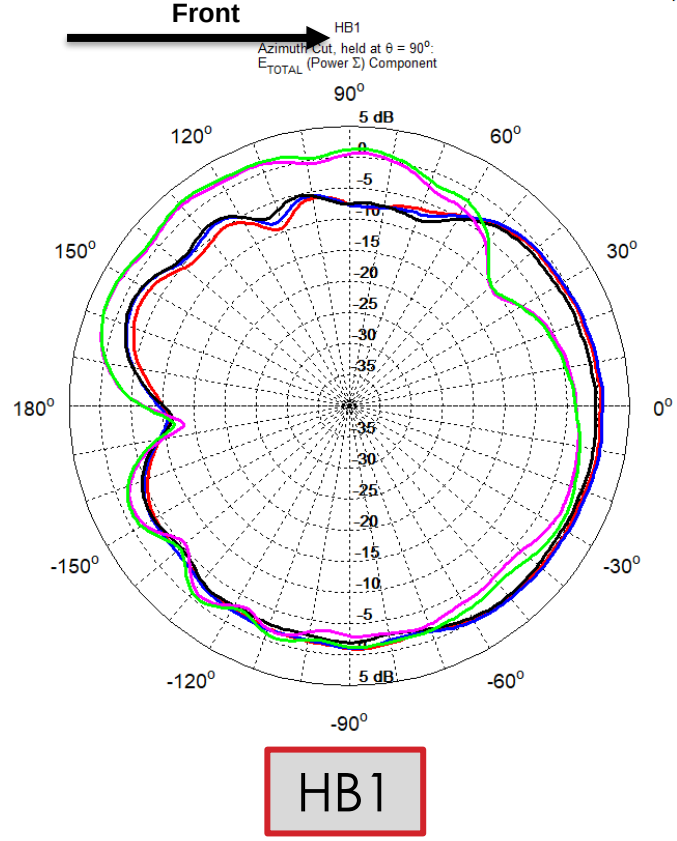
LB3

Azimuth Cut - Power Sum
5 GHz Antennas

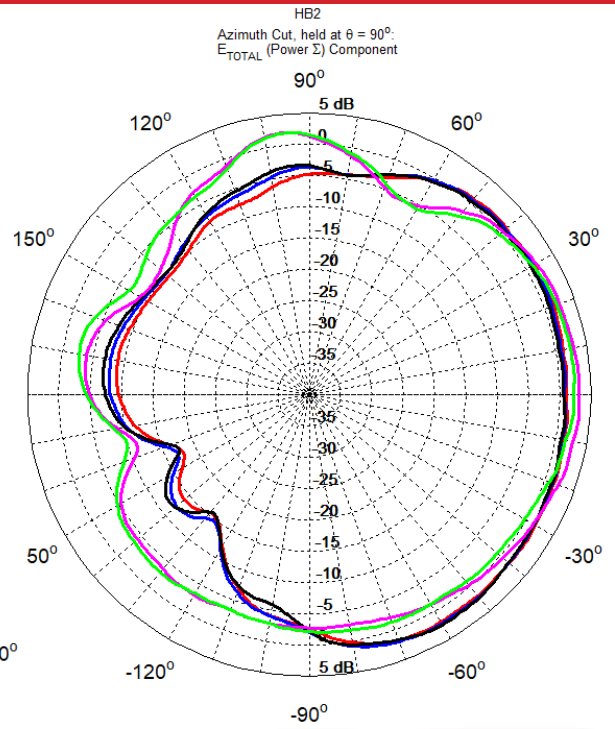
GALTRONICS

W E ' R E M A K I N G W A V E S ™





HB1



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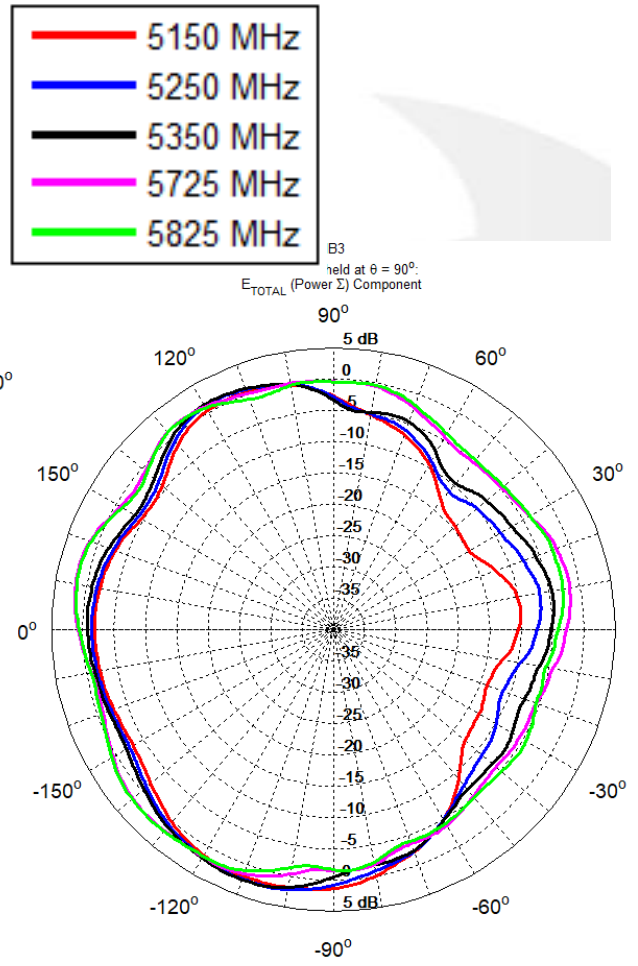
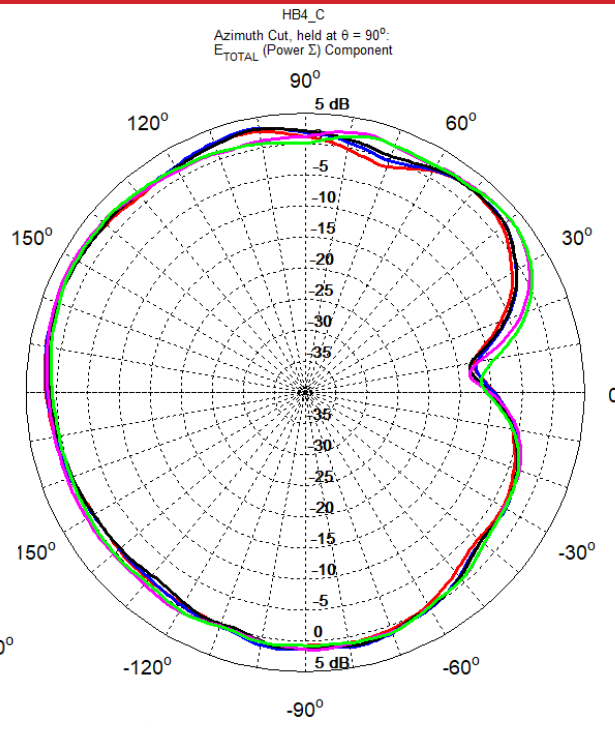


HB3

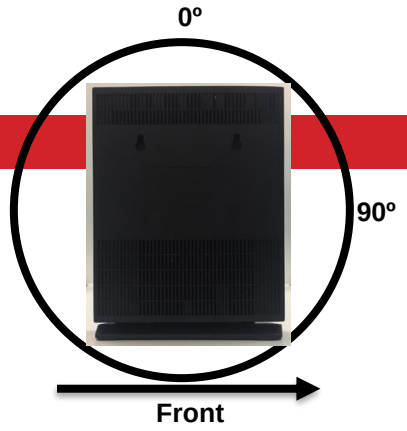


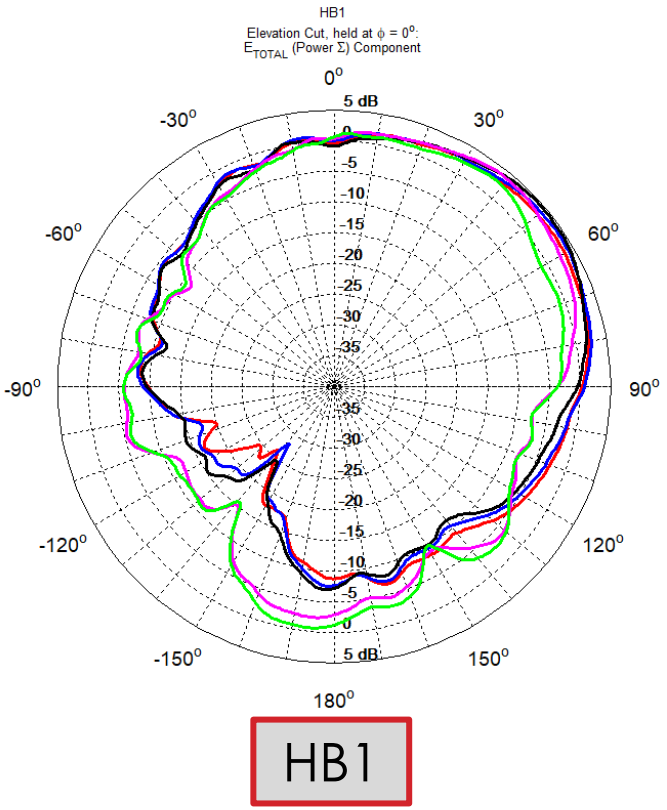
HB4

Elevation (Front to Back) Cut - Power Sum
5 GHz Antennas

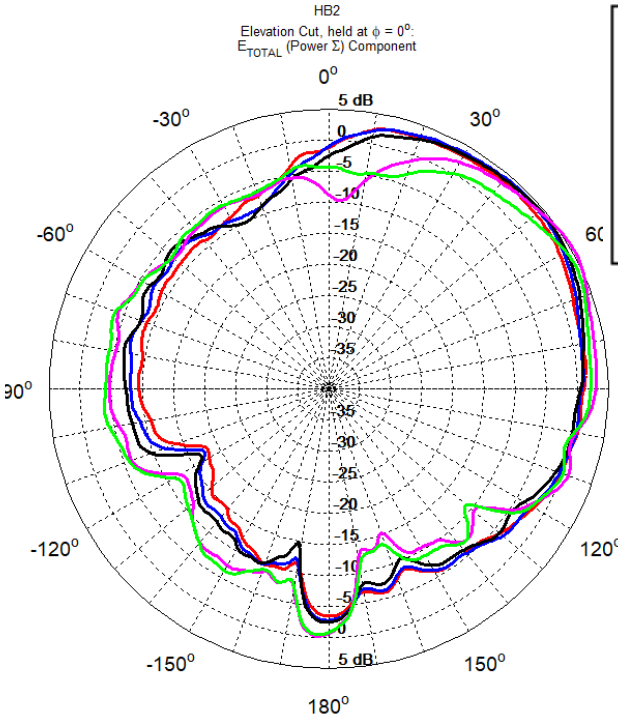
GALTRONICS

W E ' R E M A K I N G W A V E S ™

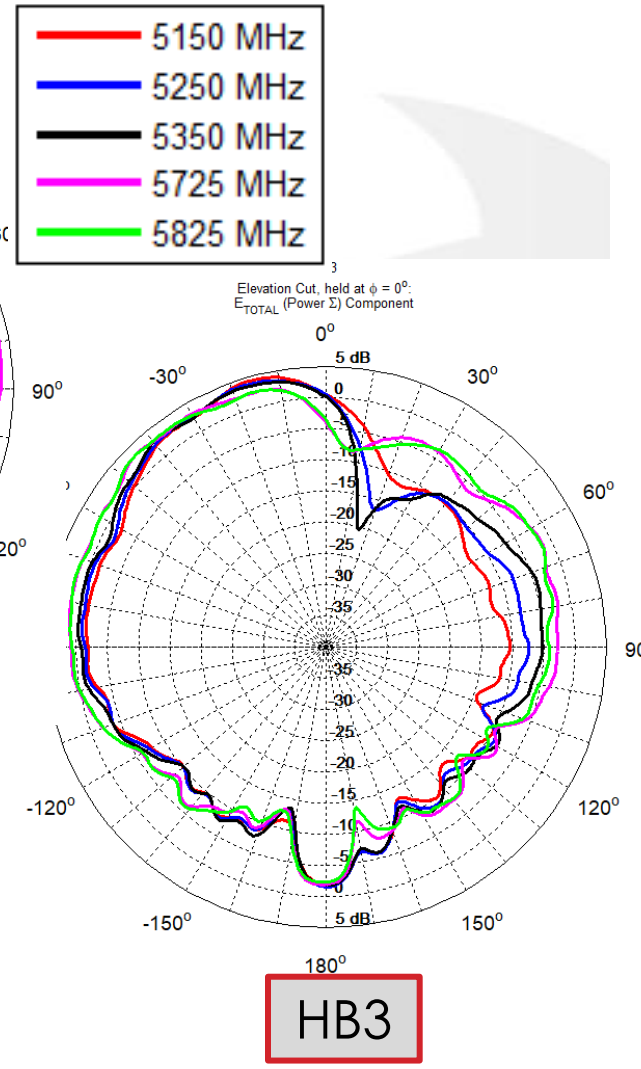




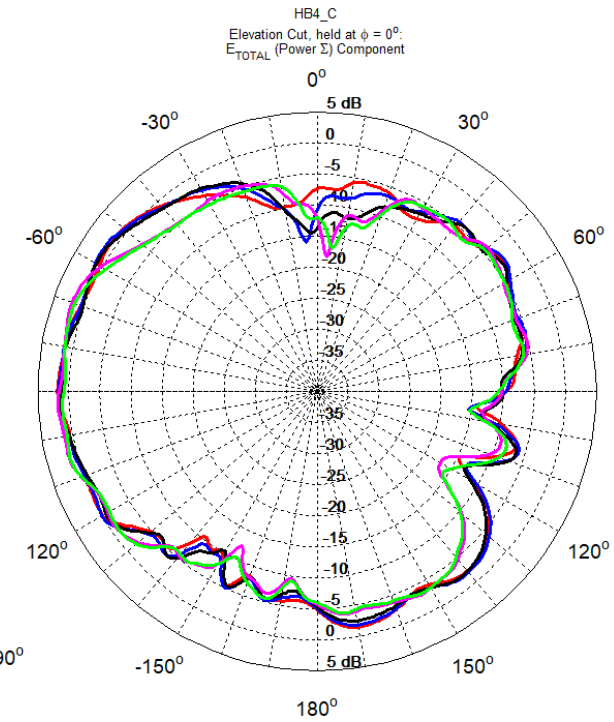
HB1



HB2

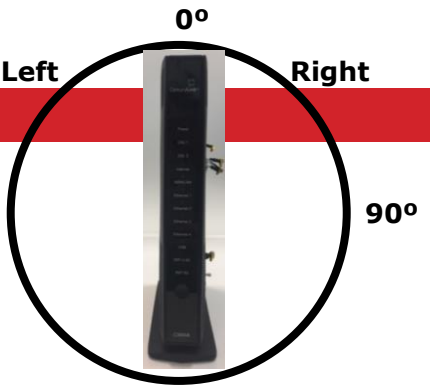


HB3



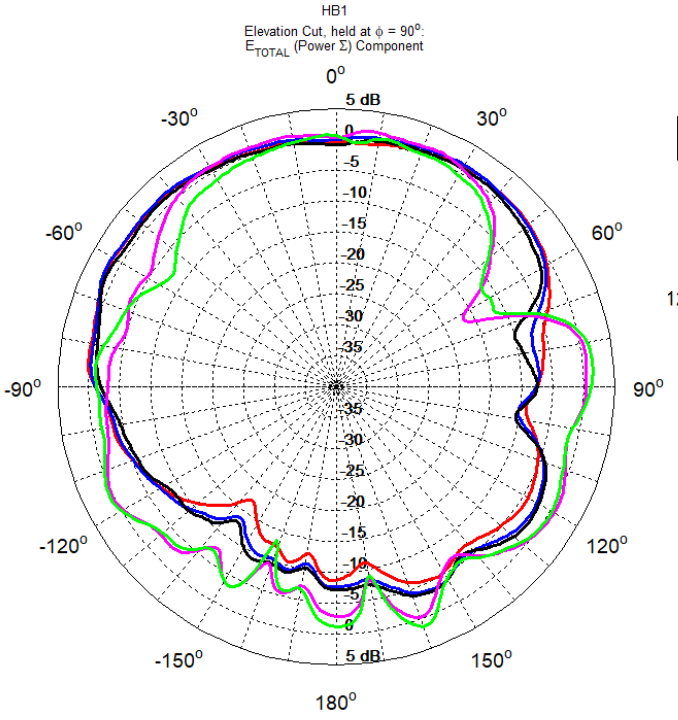
HB4

Elevation (Side to Side) Cut - Power Sum
5 GHz Antennas

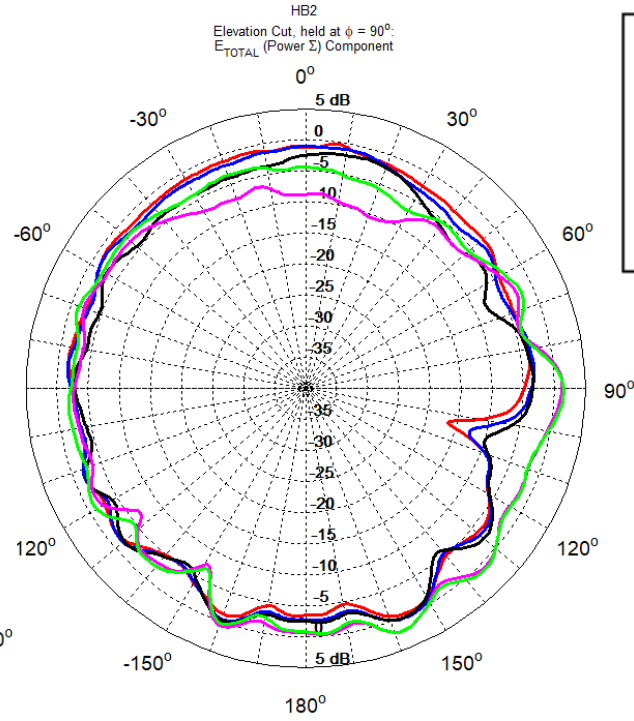


GALTRONICS

W E ' R E M A K I N G W A V E S ™



HB1



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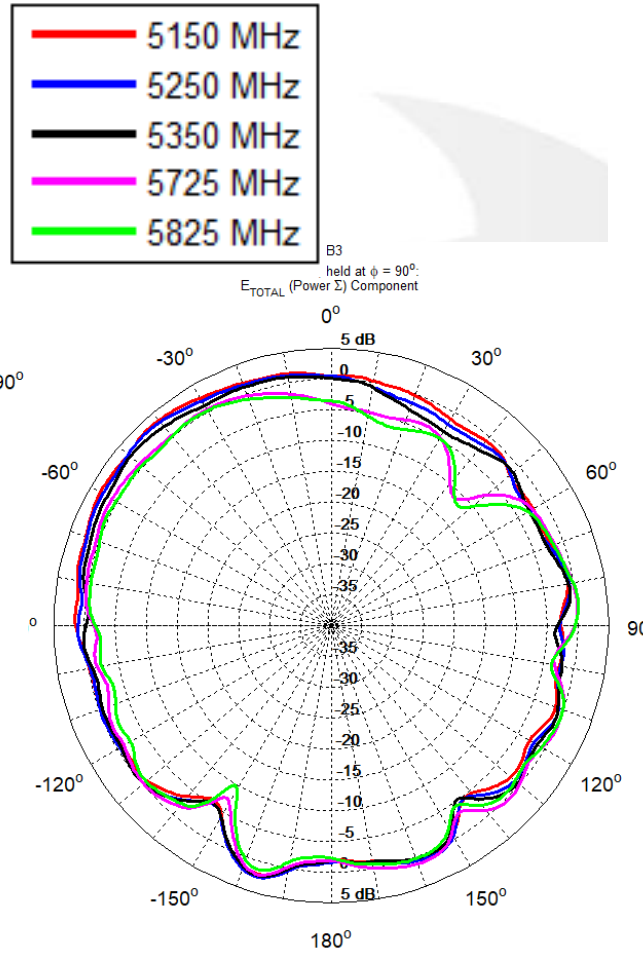
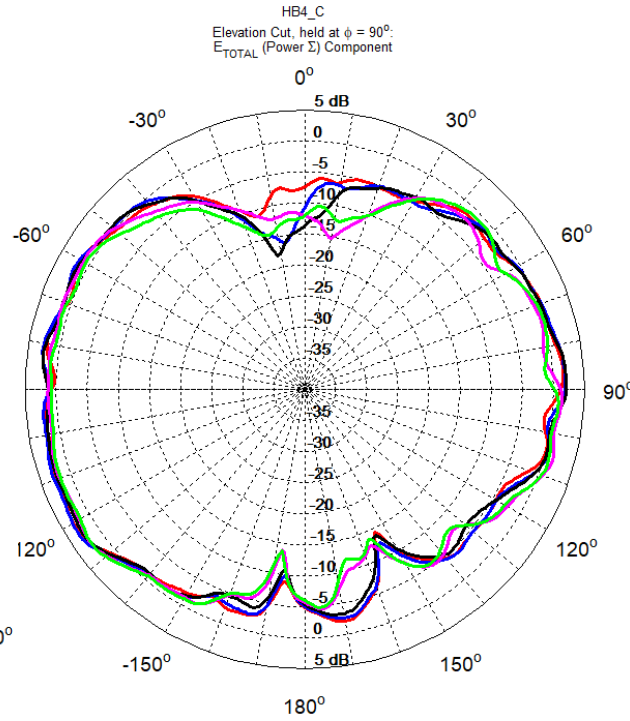


HB3

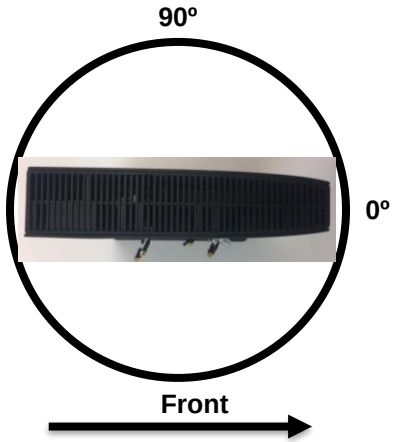


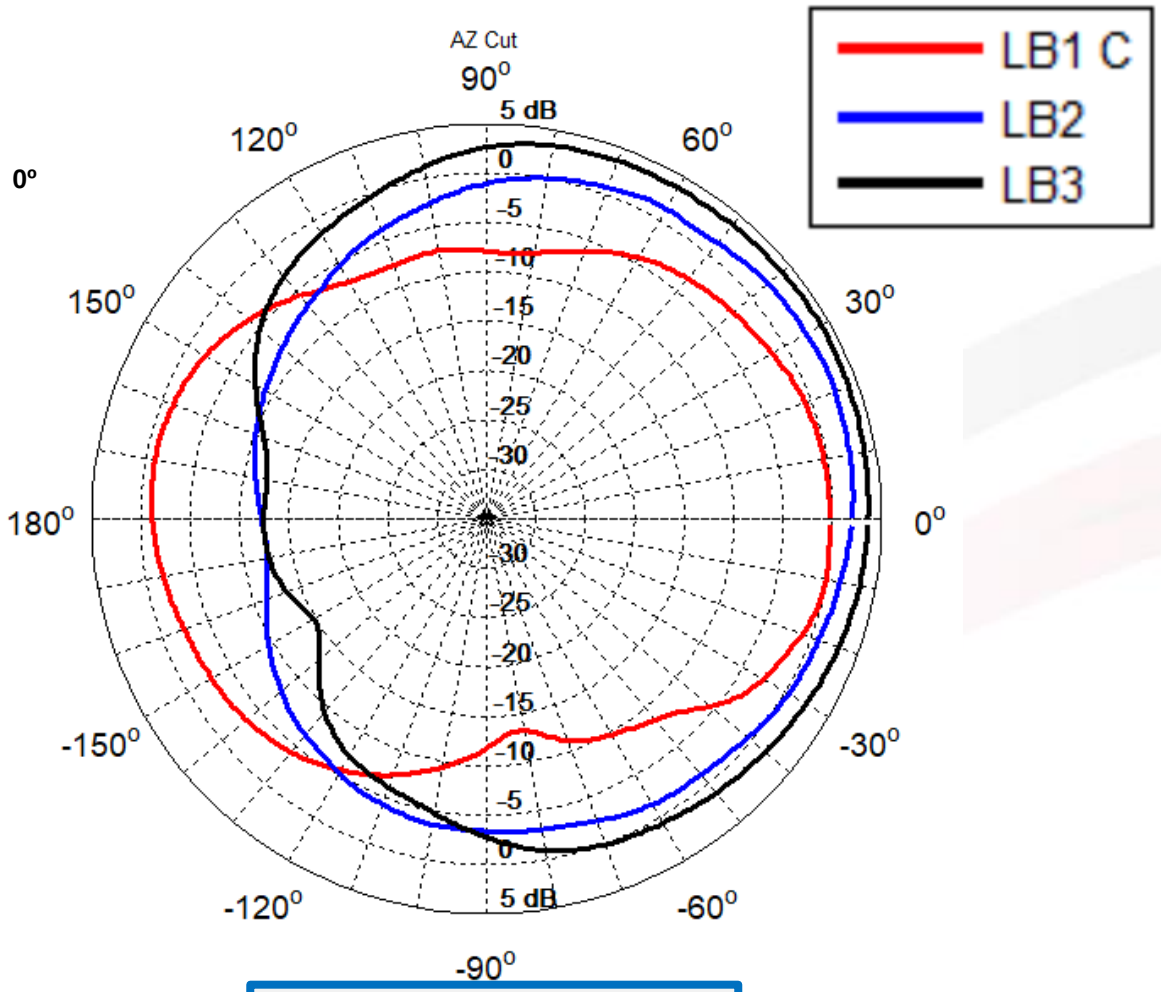
HB4

Azimuth Cut - Power Sum
System Coverage – Low Band

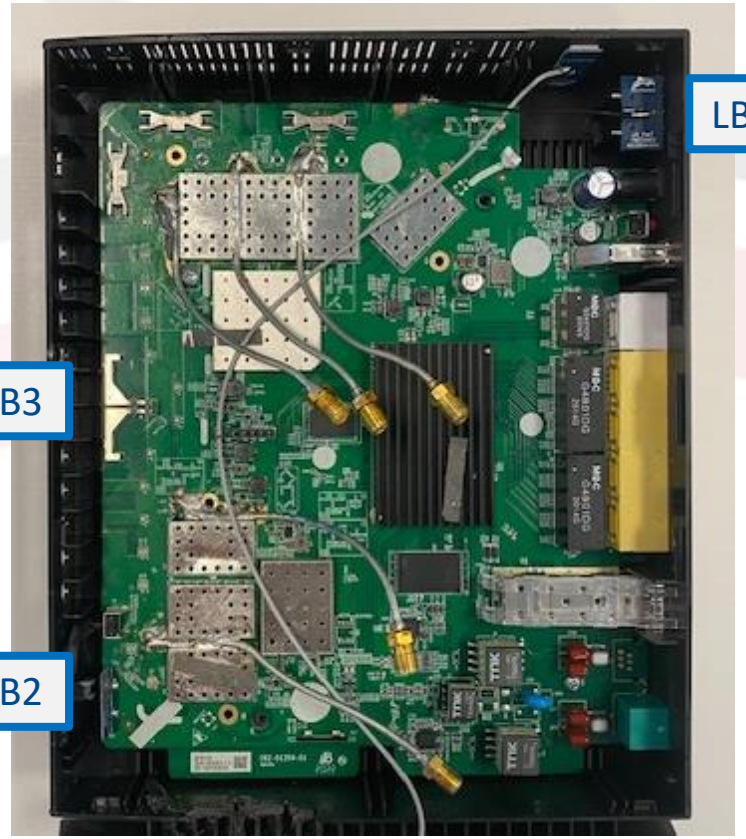
GALTRONICS

W E ' R E M A K I N G W A V E S ™





Low Band – 2.45 GHz

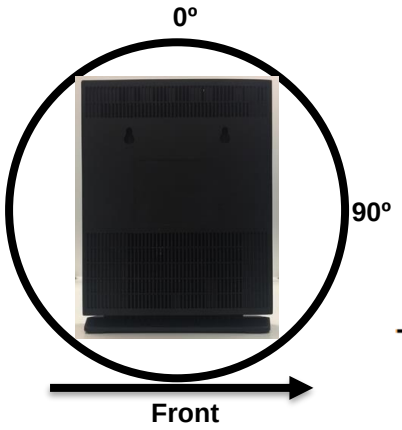


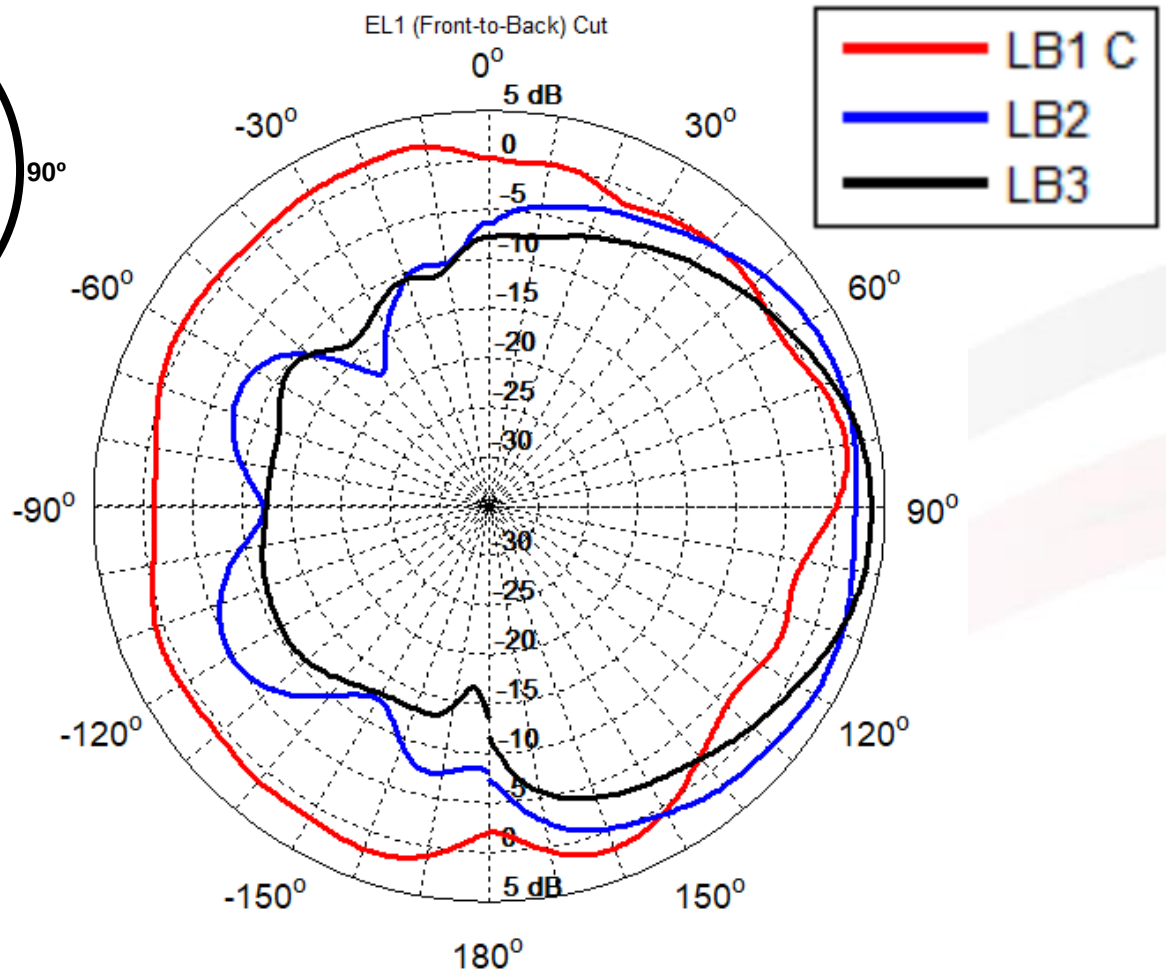
Front

Elevation (Front to Back) Cut - Power Sum System Coverage – Low Band

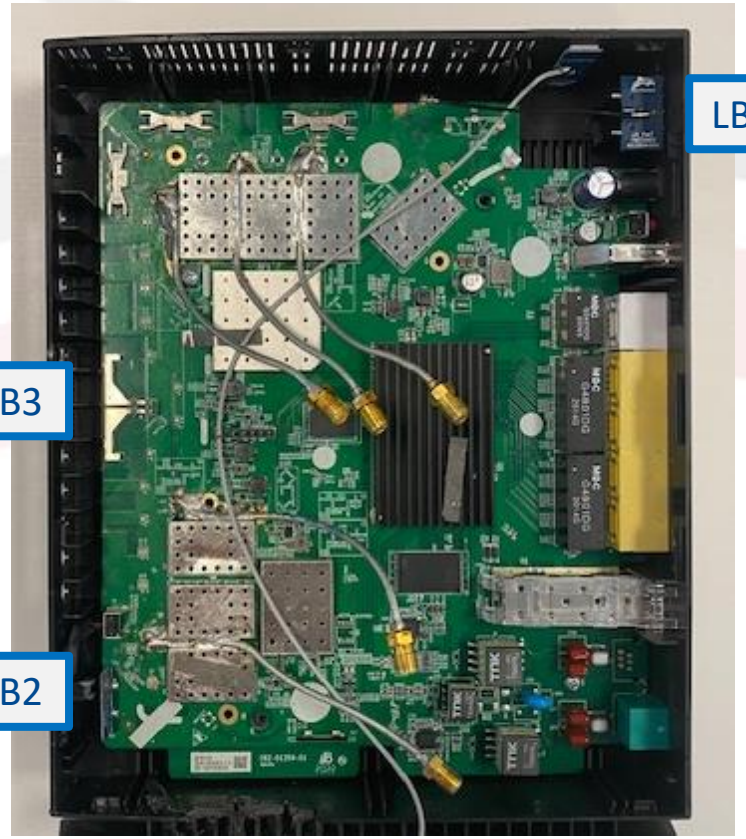
GALTRONICS

W E ' R E M A K I N G W A V E S ™





Low Band – 2.45 GHz

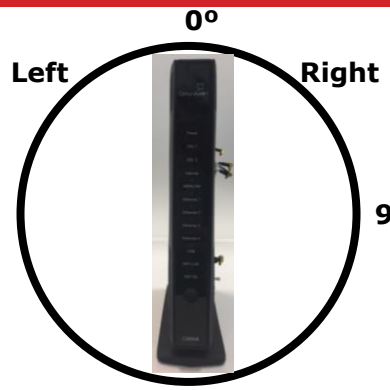


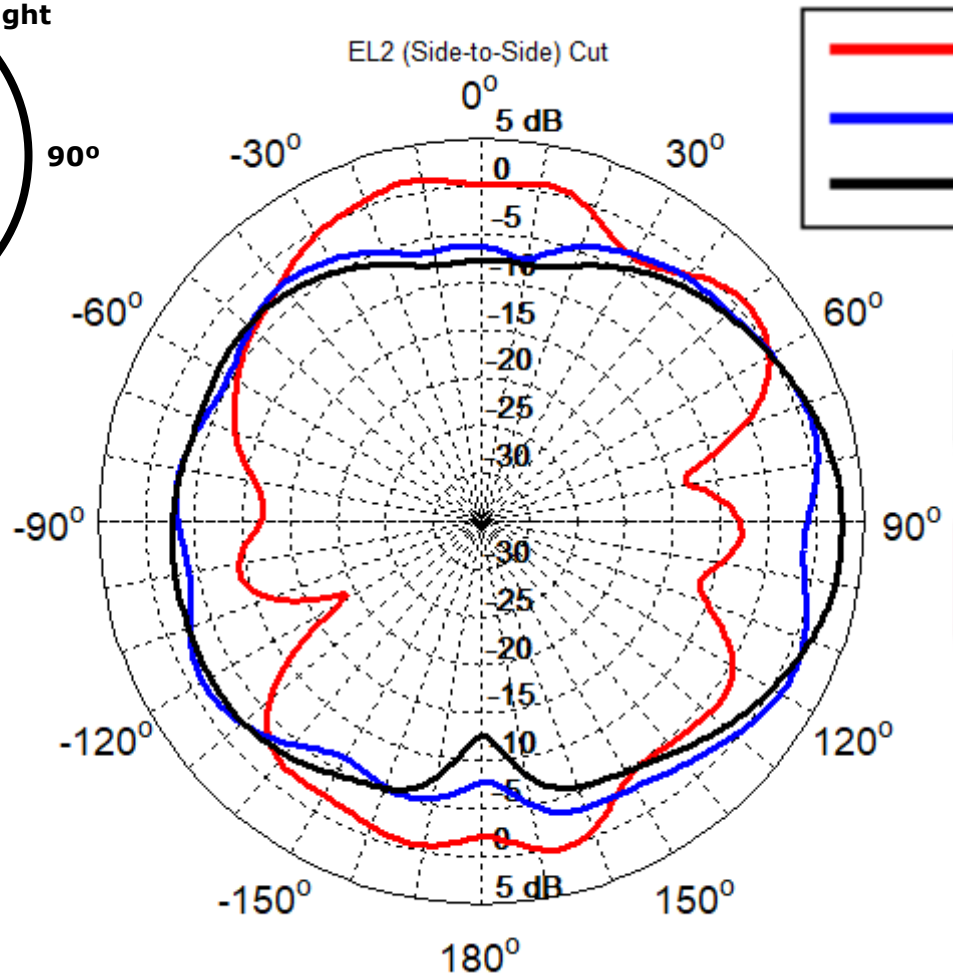
Front

Elevation (Side to Side) Cut - Power Sum System Coverage – Low Band

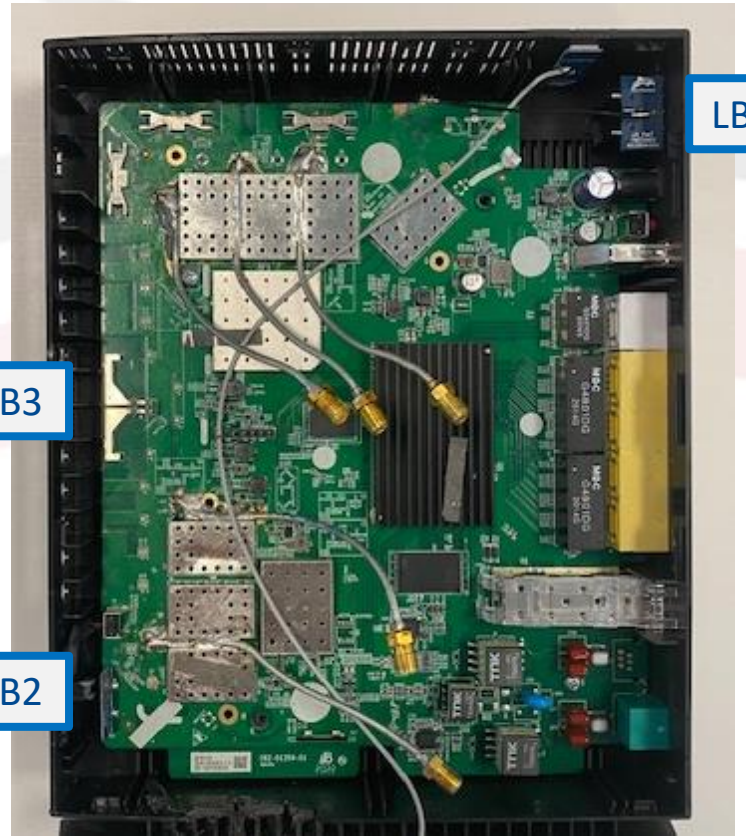
GALTRONICS

W E ' R E M A K I N G W A V E S ™





Low Band – 2.45 GHz

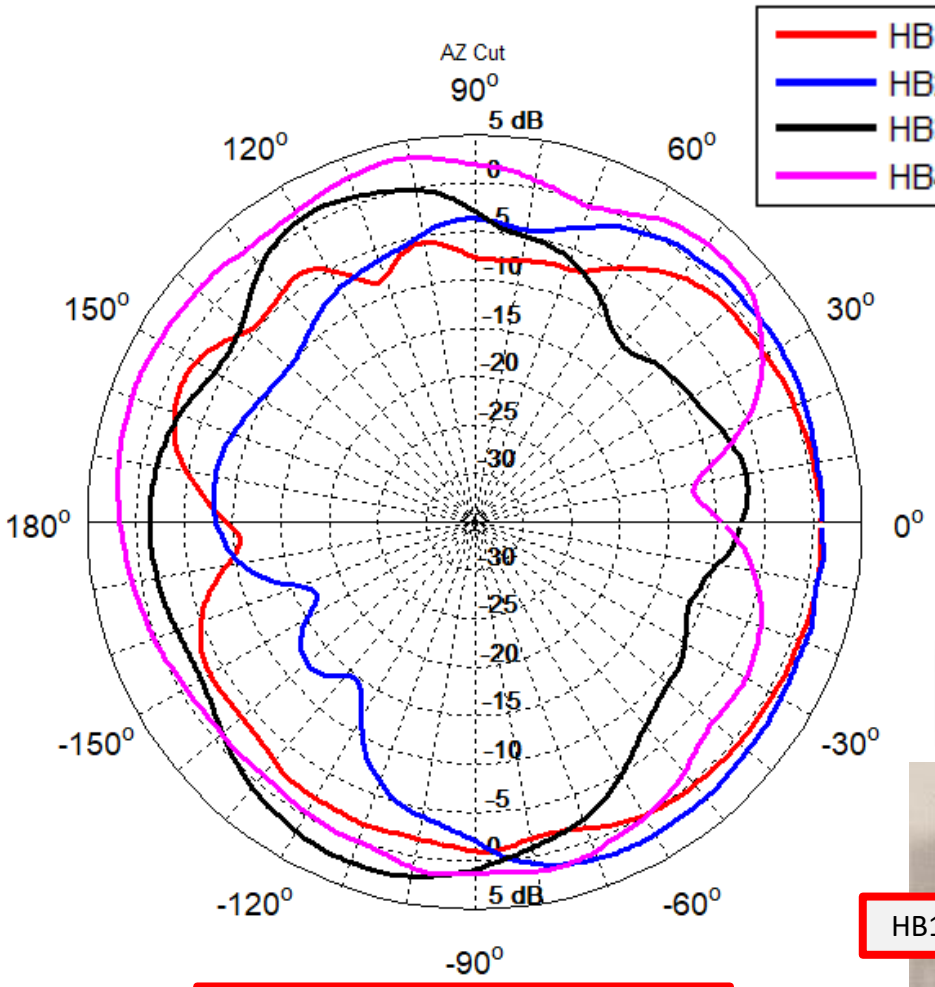


Front

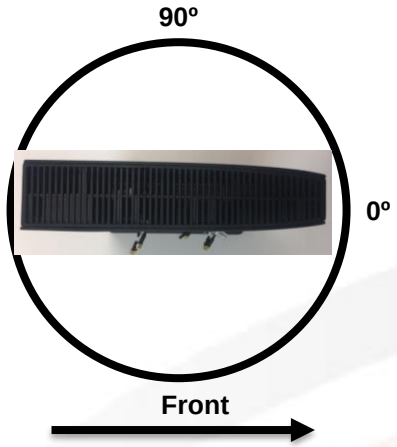
Azimuth Cut - Power Sum
System Coverage – High Band

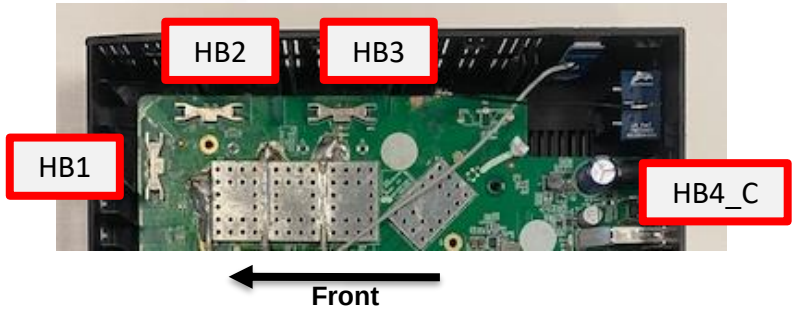
GALTRONICS

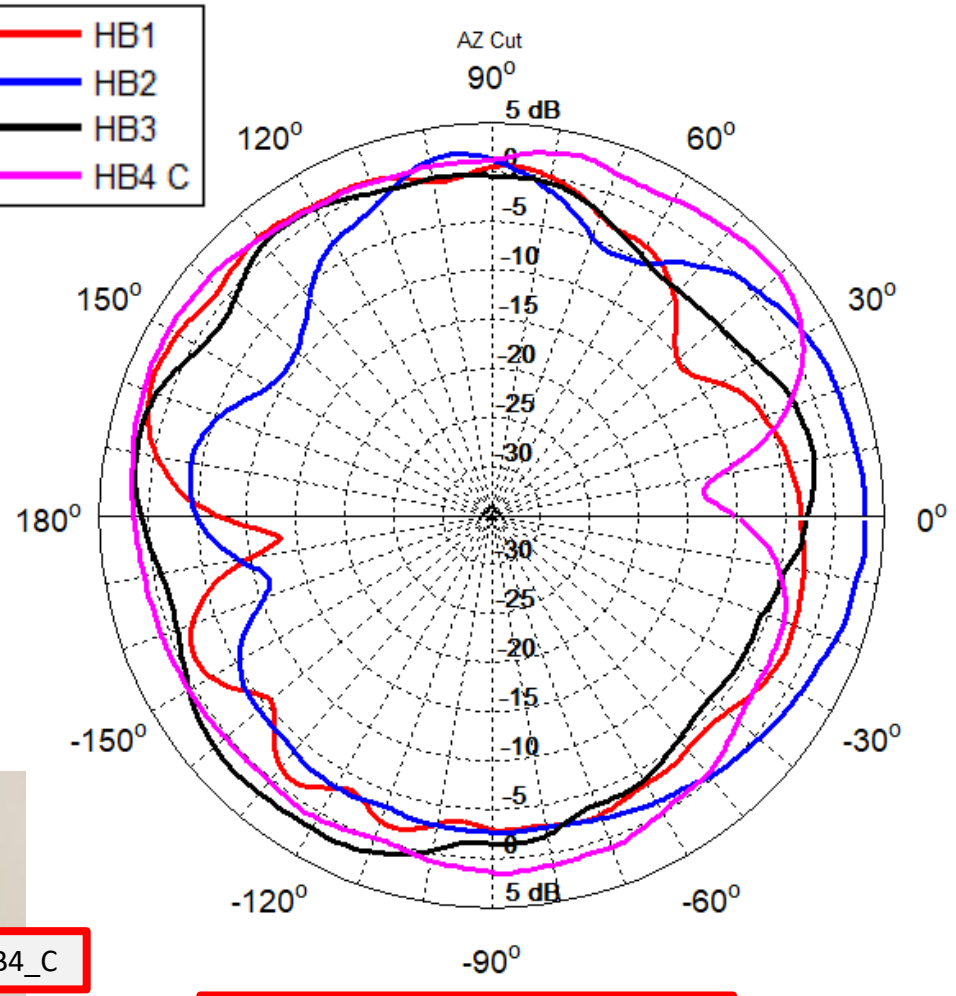
W E ' R E M A K I N G W A V E S ™



High Band – 5.25 GHz





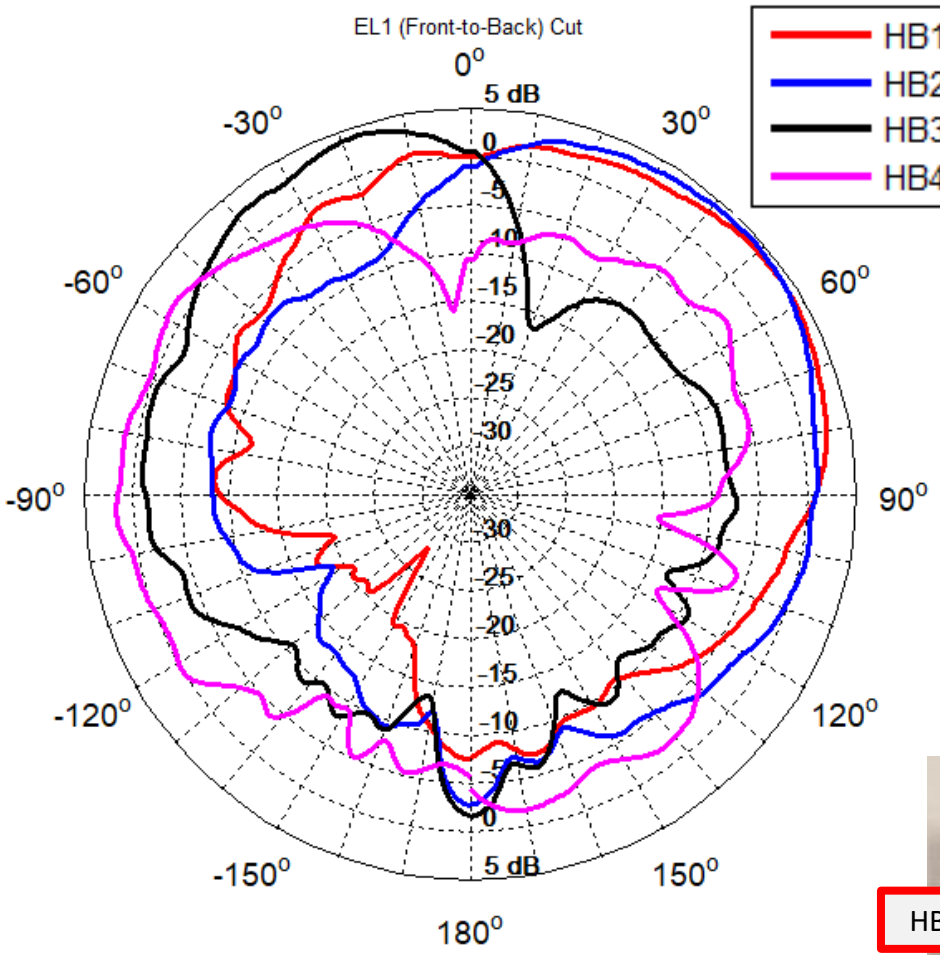


High Band – 5.725 GHz

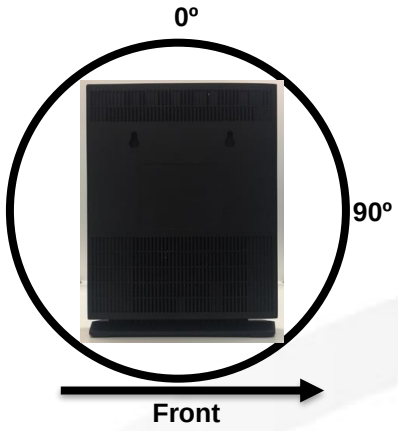
Elevation (Front to Back) Cut - Power Sum System Coverage – High Band

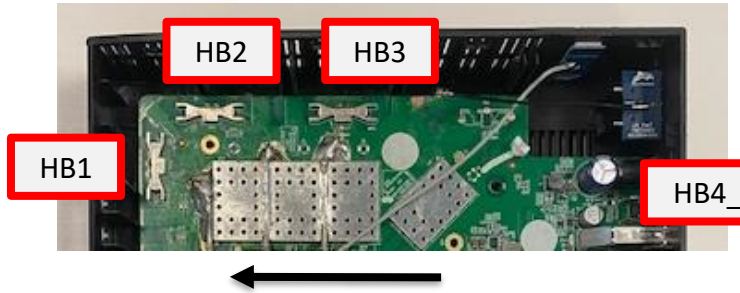
GALTRONICS

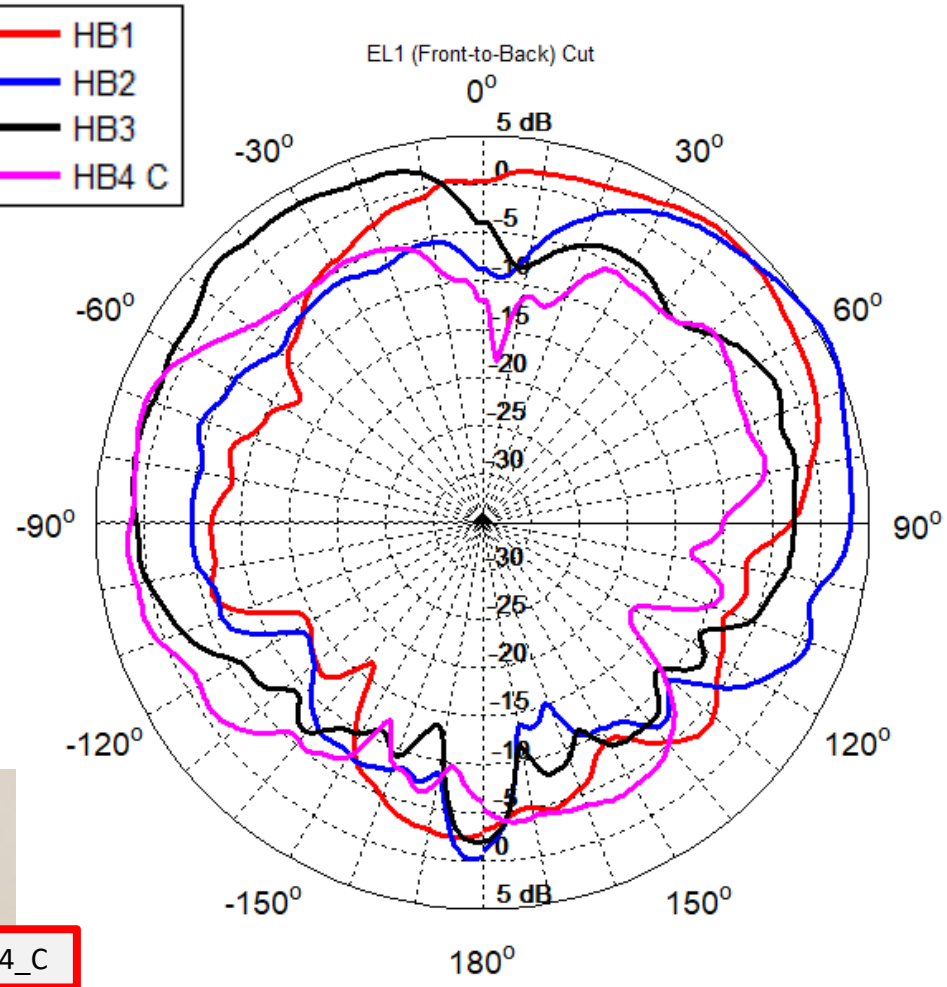
W E ' R E M A K I N G W A V E S™



High Band – 5.25 GHz





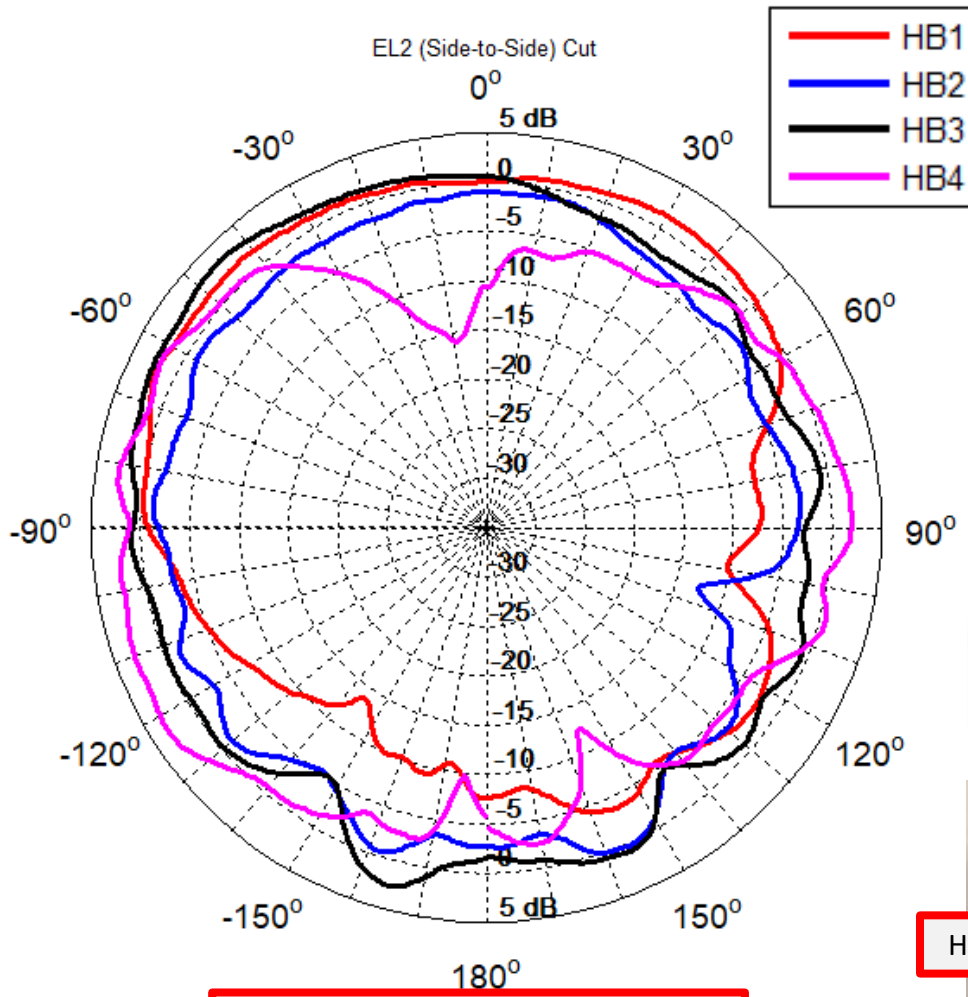


High Band – 5.725 GHz

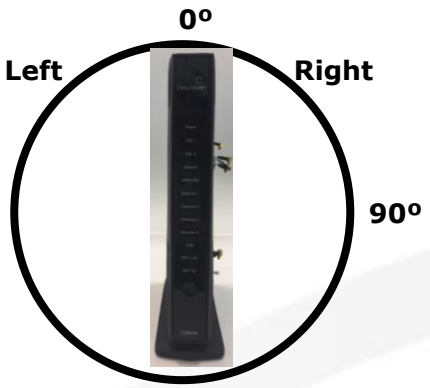
Elevation (Side to Side) Cut - Power Sum System Coverage – High Band

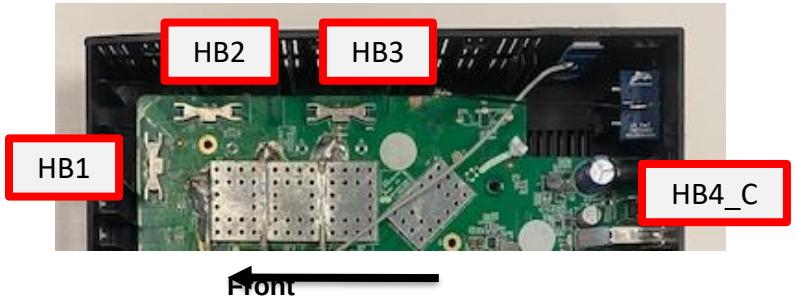
GALTRONICS

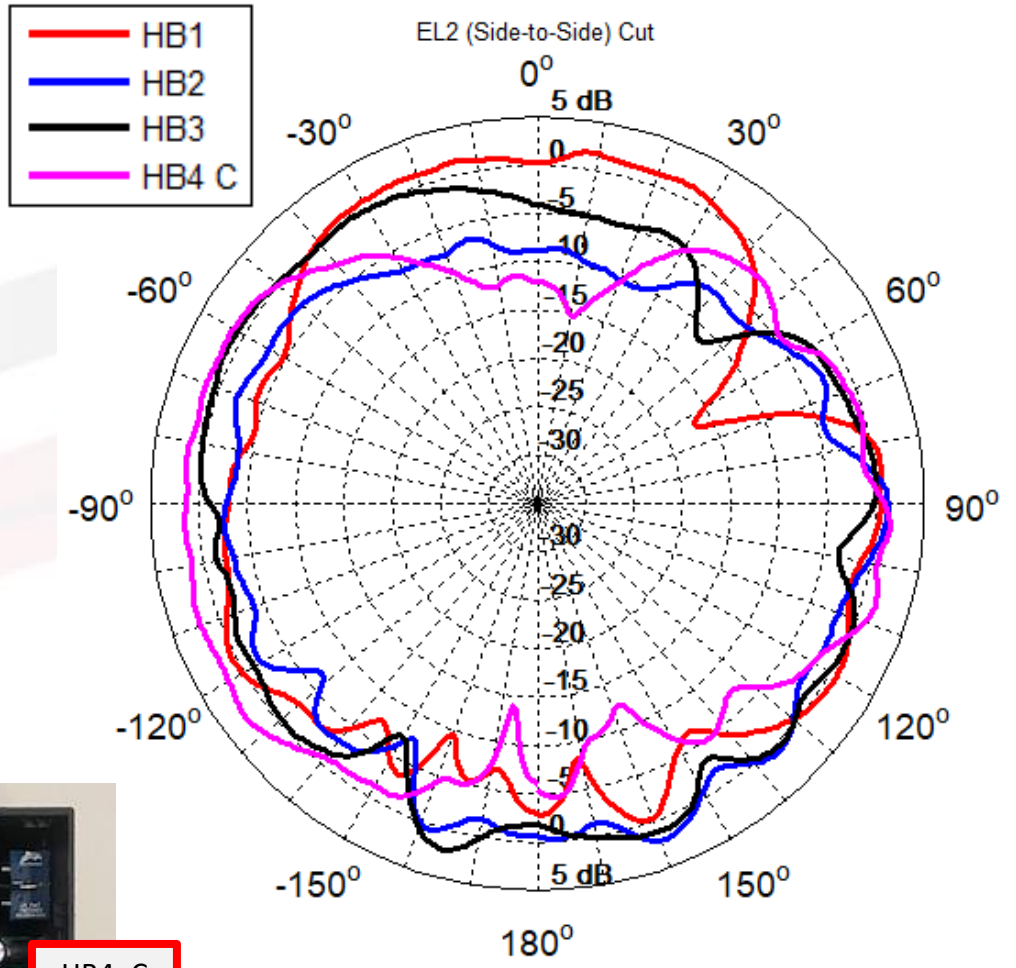
W E ' R E M A K I N G W A V E S™



High Band – 5.25 GHz







High Band – 5.725 GHz

Antenna Performance Summary

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Antenna	Worst Case Return Loss (dB) 2.45 GHz Band	Worst Case Return Loss (dB) 5 GHz Band	Average Efficiency 2.45 GHz Band (%)	Average Efficiency 5 GHz Band (%)	Highest Peak Gain 2.45 GHz Band (dBi)	Highest Peak Gain 5 GHz Band (dBi)	Mutual Isolation (dB) 2.45 GHz Band			Mutual Isolation (dB) 5 GHz Band			
							LB1_C	LB2	LB3	HB1	HB2	HB3	HB4_C
LB1_C	-15.4		66.8%		3.47					-42.6	-42.6	-33.6	-36.0
LB2	-17.5		76.4%		4.91		-34.5			-33.0	-34.3	-38.8	-41.4
LB3	-19.7		70.1%		4.24		-39.8	-21.0		-35.0	-49.4	-48.8	-52.5
HB1		-17.7		67.6%		4.71	-28.8	-26.5	-24.1				
HB2		-14.5		66.6%		5.44	-26.1	-32.9	-24.8	-20.5			
HB3		-10.2		70.6%		4.61	-27.8	-42.3	-35.0	-33.7	-30.0		
HB4_C		-14.2		76.1%		3.44	-33.7	-40.2	-44.3	-43.7	-38.7	-31.4	

GLOBAL LOCATIONS

W E ' R E M A K I N G W A V E S™

USA Design Center
Galtronics USA Inc.
8930 South Beck Avenue
Suite #103
Tempe, AZ 85284 USA
Tel: +1-480-496-5100

Korea Design Center
Galtronics Korea Co.
#B214, Innoplex Bldg.,306, Sinwon-ro,
Yeongtong-gu, Suwon-si, Gyeonggi-do,
16675 Korea
Tel: + 82-32-227-0771

Corporate Headquarters
Baylin Technologies Inc.,
60 Columbia Way
Suite 205
Markham, ON L3R 0C9 Canada

Ottawa, Canada Design Center
Galtronics Canada Inc.
200 Terence Mathews Crescent,
Unit A
Kanata, ON K2M 2C6 Canada

Suzhou, China Design Center
Galtronics Electronics (Wuxi) Co.
A05 Jinfeng Tech. Venture Park
Jinnan Rd., Jinfeng Town,
Zhangjiagang City, Jiangsu, China

China Factory
Galtronics Electronics (Wuxi) Co.
No. 1, Xishi Road,
Wuxi New District
Jiangsu Province 214028, China
Tel: +86-510-8866-5500

Vietnam Factory
Galtronics Vietnam
Lot G1 , G2, Que Vo Industrial Park,
Phuong Lieu commune, Que Vo district,
Bac Ninh province, Vietnam

Thank You

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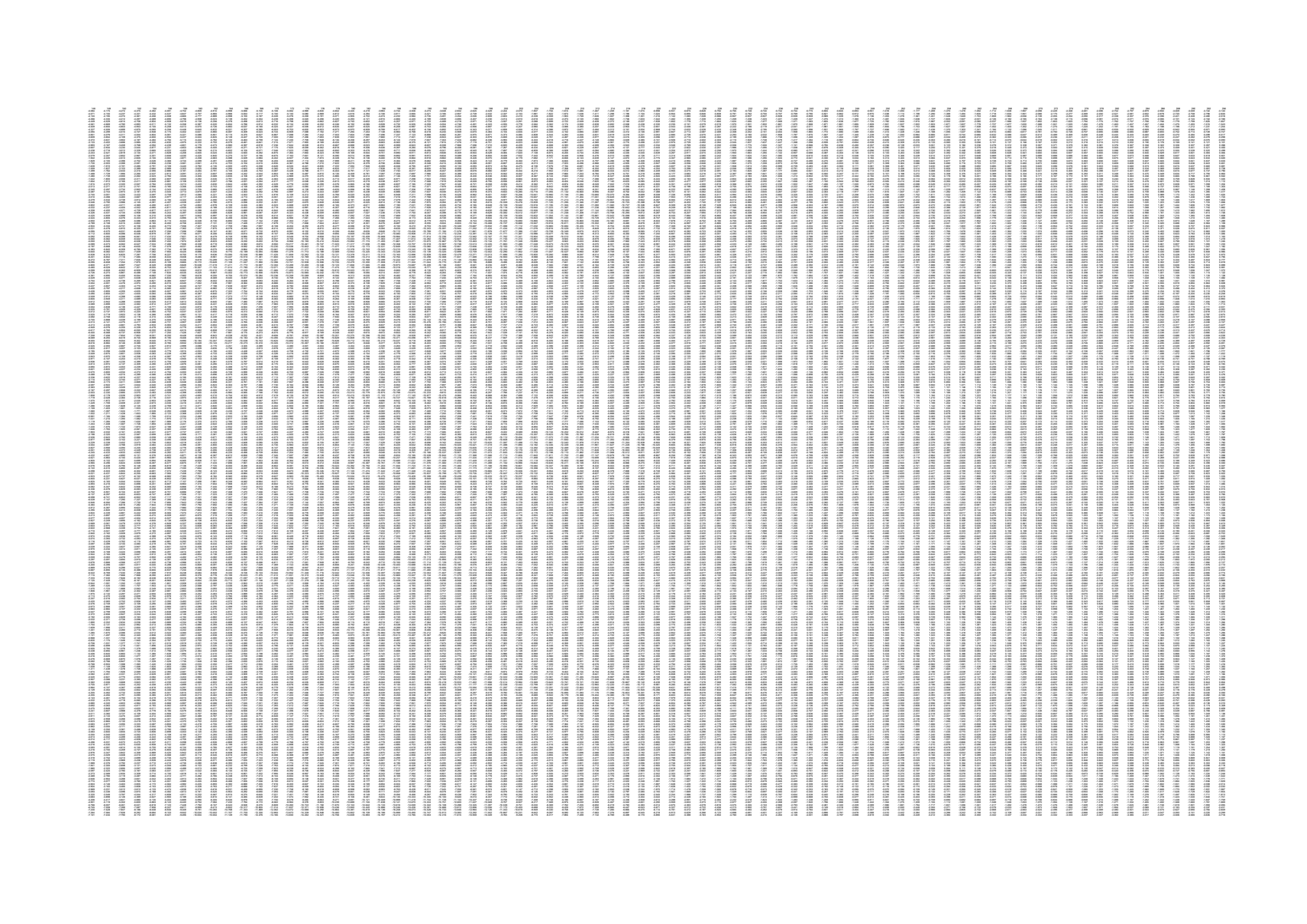
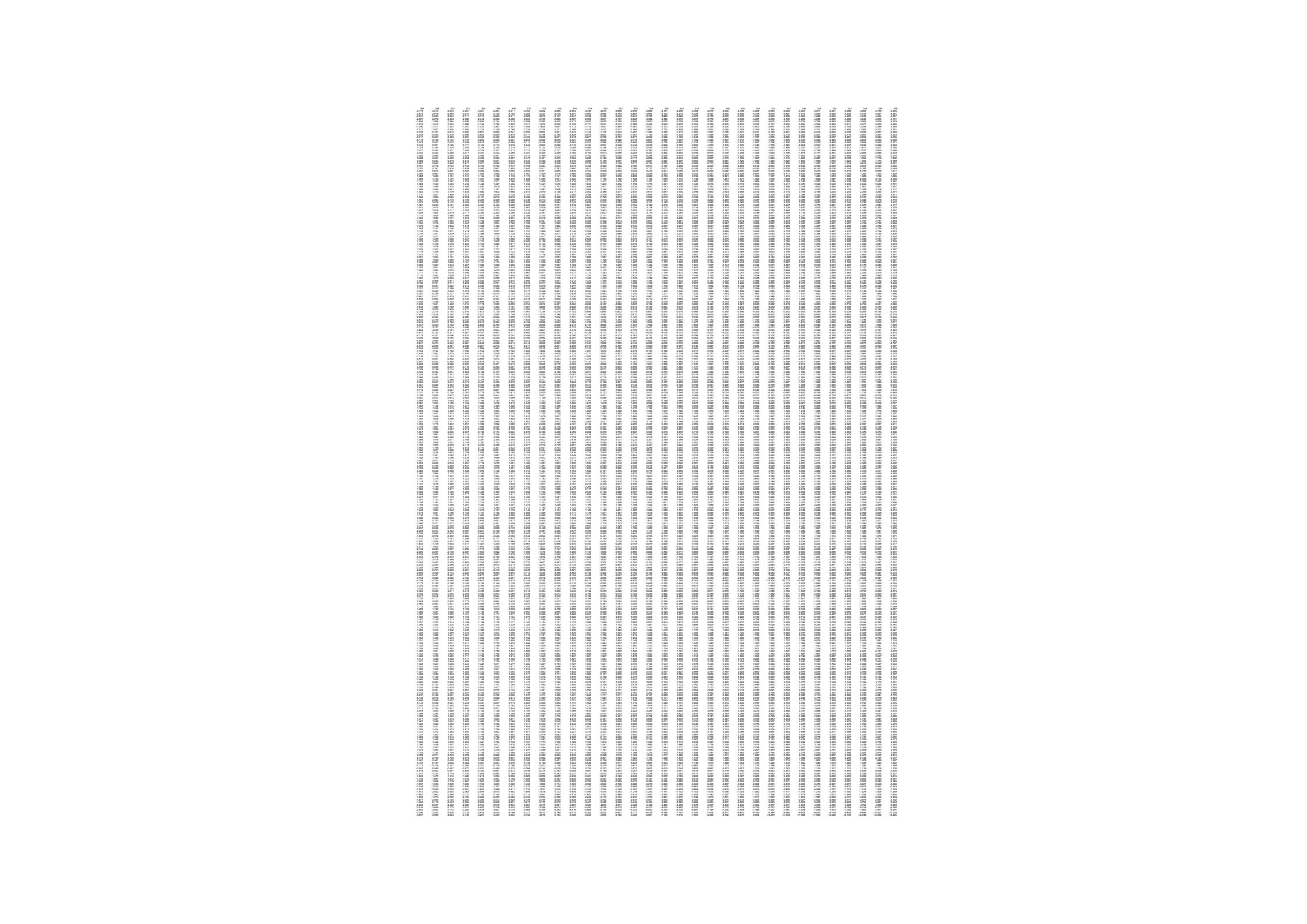
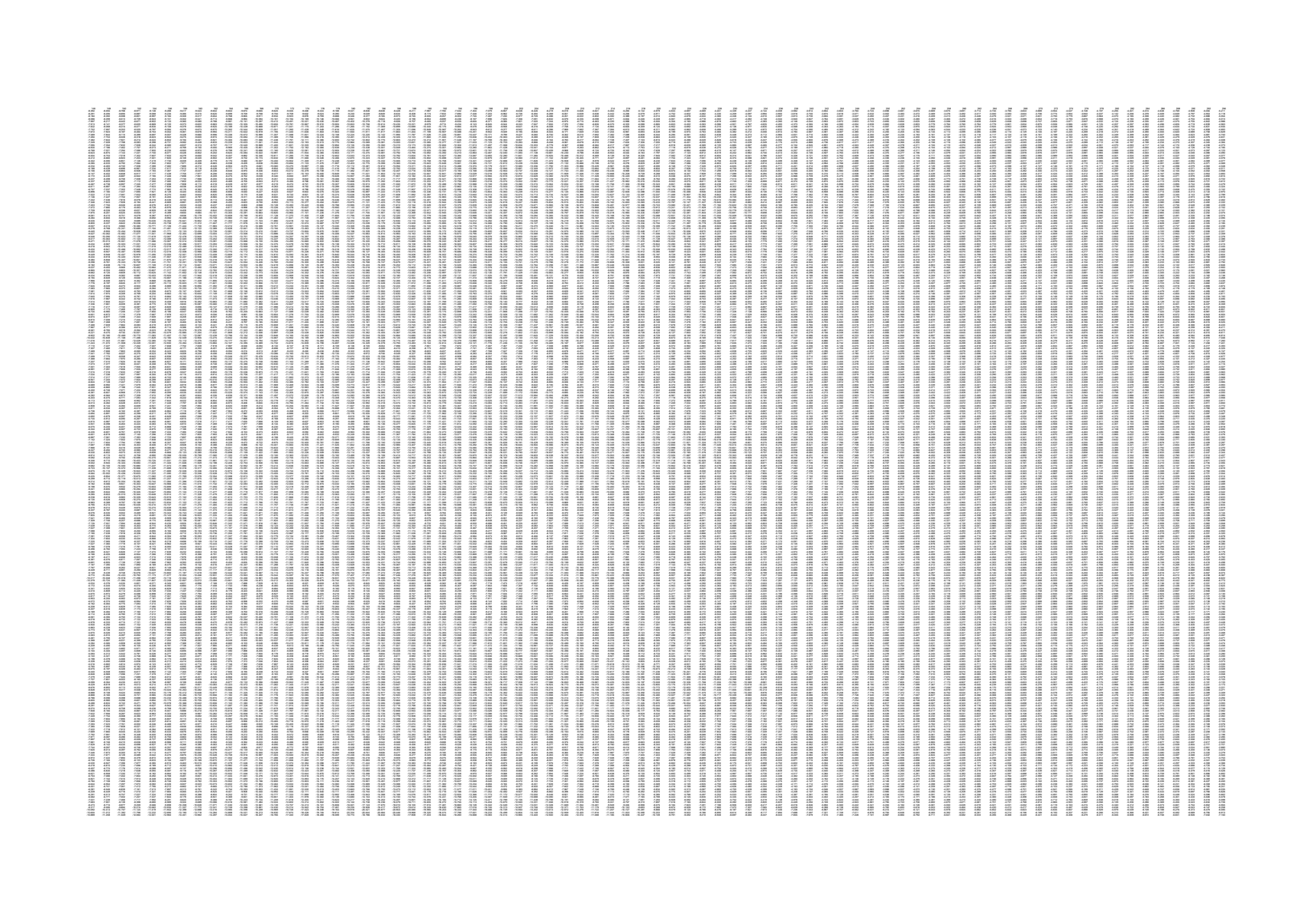
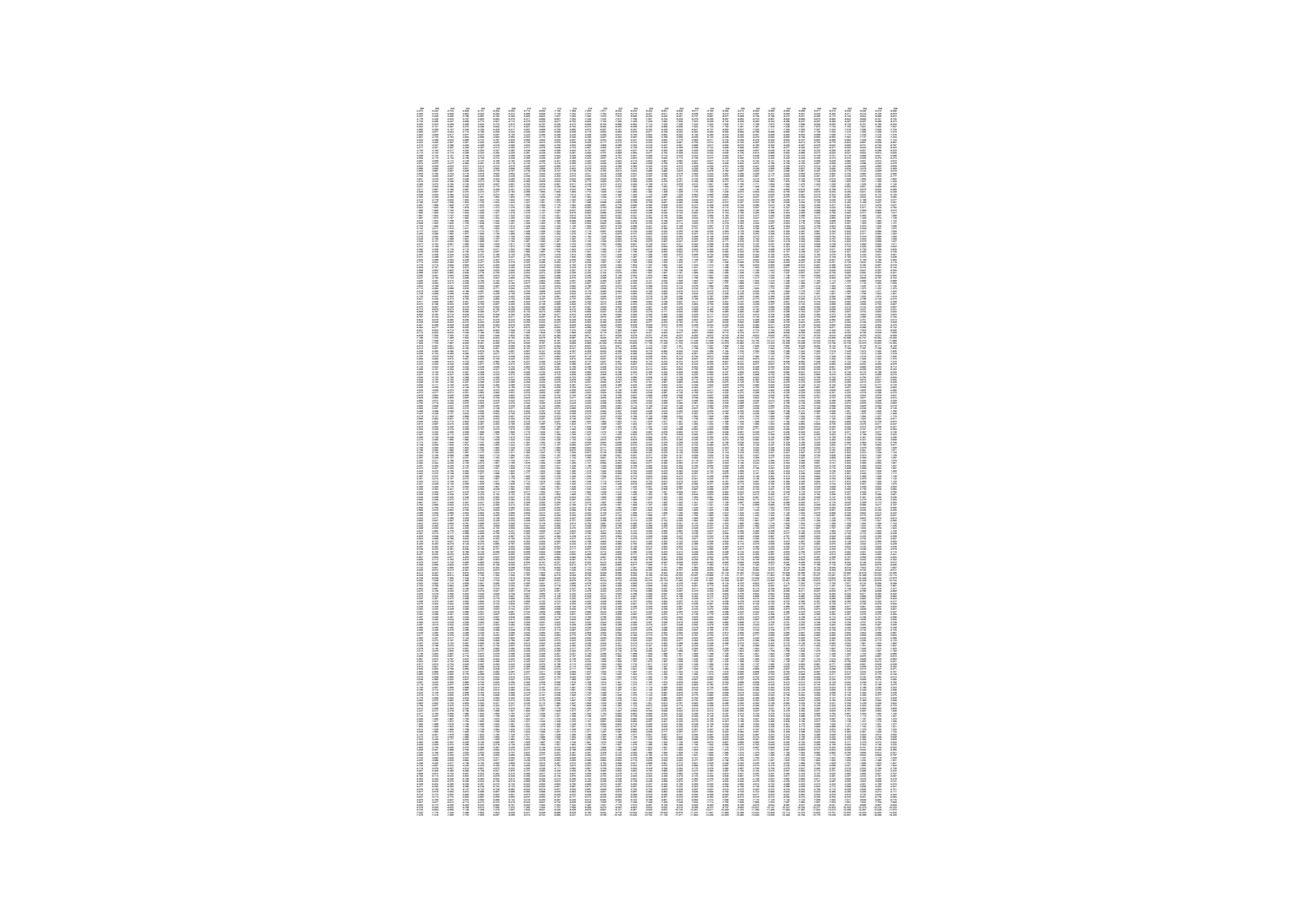
Appendix A – 2.4G Correlated and Uncorrelated Result

Freq (MHz)	2400	2450	2500
Correlated Gain	5.34	5.37	5.90
Uncorrelated Gain	1.49	1.81	2.27









Appendix A – 5G Correlated and Uncorrelated Result

Freq (MHz)	5150	5250	5350	5725	5825
Correlated Gain	5.48	6.20	6.69	6.66	5.24
Uncorrelated Gain	0.68	1.37	1.80	1.54	-0.17