

Test Report TR3664-BL652A

Equipment Under Test: BL652-SC

Requirement(s): FCC 15.247
RSS-247

Test Date(s): 3/9/2023-3/22/2023

Prepared for: Laird Connectivity
Attn: Jonathan Kaye
W66 N220 Commerce Ct.
Cedarburg, WI 53012

Report Issued by: Adam Hauke, EMC Engineer

Signature: 

Date: 07/1/2023

Report Reviewed by: Adam Alger, Laboratory Manager

Signature: 

Date: 06/30/2023

Report Constructed by: Adam Hauke, EMC Engineer

Signature: 

Date: 06/29/2023

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Report: TR3664-BL652A		Model: BL652-SC
Quote: NBO-2022-005678		Serial: 1222195

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Laird Connectivity Test Services in Review

The Laird Connectivity LLC laboratory located at W66 N220 Commerce Court Cedarburg, Wisconsin, 53012 USA is recognized through the following organizations:



A2LA – American Association for Laboratory Accreditation

Accreditation based on ISO/IEC 17025:2017 with Electrical (EMC) Scope

A2LA Certificate Number: 1255.01

Scope of accreditation includes all test methods listed herein unless otherwise noted



Federal Communications Commission (FCC) – USA

Accredited Test Firm Registration Number: 953492

Recognition of two 3 meter Semi-Anechoic Chambers



Innovation, Science and Economic Development Canada

Accredited U.S. Identification Number: US0218

Recognition of two 3 meter Semi-Anechoic Chambers

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1 TEST REPORT SUMMARY

During **March 9th, 2023 to March 22nd, 2023** the Equipment Under Test (EUT), **BL652-SC**, as provided by **Laird Connectivity** was tested to the following requirements for the purpose of a Class 2 permissive change to add an antenna:

FCC 15.247

Requirements	Description	Specification	Method	Compliant
FCC: 15.247 (b)(3) ISED: RSS-247 5.4 (d)	Maximum Conducted Output Power	30 dBm	ANSI C63.10	Yes
FCC: 15.247 (d) ISED: RSS-GEN 8.10	Spurious Emissions in Restricted Frequency Bands	FCC 15.209 RSS-GEN 8.9	ANSI C63.10	Yes

Notice:

The results relate only to the item tested as configured and described in this report. Any additional configurations, modes of operation, or modifications made to the equipment under test after the specified test date(s) are at the decision of the client and may not apply to the data seen in this test report.

The decision rule for Pass / Fail assessment to the specification or standard listed in this test report has been agreed upon by the client and laboratory to be as follows:

Measurement Type	Rule
Emissions – Amplitude	1 dB below specified limit
Emissions – Frequency	1% less than the specification
Immunity	Tested at specified level

2 CLIENT INFORMATION

Company Name	Laird Connectivity
Contact Person	Jonathan Kaye
Address	W66N220 Commerce Court Cedarburg, WI, 53012

2.1 Equipment Under Test (EUT) Information

The following information has been supplied by the client

Product Name	BL652-SC
Model Number	BL652-SC
Serial Number	1222195
FCC ID	SQGBL652
IC ID	3147A-BL652

2.2 Product Description

Bluetooth Low Energy Module operating in the 2.4 GHz range.

2.3 Modifications Incorporated for Compliance

None noted at time of test

2.4 Deviations and Exclusions from Test Specifications

None noted at time of test

2.5 Additional Information

Bluetooth LE (Low Energy) 1 and 2 Mbps. Channels tested: 0 (2402 MHz), 17 (2440 MHz), and 39 (2480 MHz).

3 AAA 1.5V Batteries. Laird Connectivity Bluetooth Development Tools - 802.15.1 Dev Kit w/ BL652-SC used for programming. Dell Latitude 5480 Laptop used to program radio.

BTLRU (Bluetooth Laird Regulatory Utility) Version 10.0.0.178 utilized to control radio.

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2.6 Additional Information

This testing is for a permissive change to add the iFlex-Pifa Antenna, with an antenna gain of 3.1 dBi, to the list of antennas usable by the BL652-SC. EUT tested via Cabinet Radiation method.

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3 REFERENCES

Publication	Edition	Date	AMD 1
eCFR	-	2023	-
RSS-247	2	2017	-
RSS-GEN	5	2018	2019
ANSI C63.10	-	2013	-
KDB 178919 D01	6	2015	-

4 UNCERTAINTY SUMMARY

Using the guidance of the following publications the calculated measurement uncertainty represents an expanded uncertainty expressed at approximately the 95 % confidence level, using a coverage factor of $k = 2$.

References
CISPR 16-4-1
CISPR 16-4-2
CISPR 32
ANSI C63.23
A2LA P103
A2LA P103c
ETSI TR 100-028

Measurement Type	Configuration	Uncertainty \pm
Radiated Emissions	Biconical Antenna	5.0 dB
Radiated Emissions	Log Periodic Antenna	5.3 dB
Radiated Emissions	Horn Antenna	4.7 dB
AC Line Conducted Emissions	Artificial Mains Network	3.4 dB
Telecom Conducted Emissions	Asymmetric Artificial Network	4.9 dB
Disturbance Power Emissions	Absorbing Clamp	4.1 dB
Radiated Immunity	3 Volts/meter	2.2 dB
Conducted Immunity	CDN/EM/BCI	2.4/3.5/3.4 dB
EFT Burst/Surge	Peak pulse voltage	164 volts
ESD Immunity	15 kV level	1377 Volts

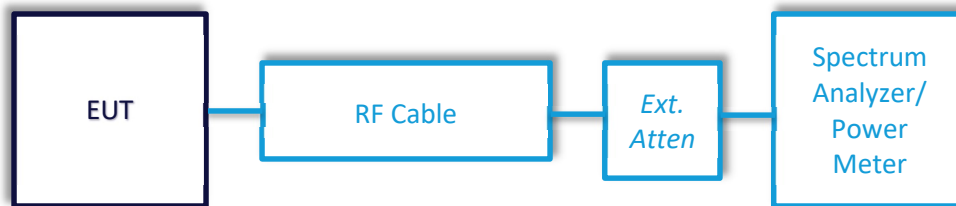
Parameter	ETSI U.C. \pm	U.C. \pm
Radio Frequency, from F0	1×10^{-7}	0.55×10^{-7}
Occupied Channel Bandwidth	5 %	2 %
RF conducted Power (Power Meter)	1.5 dB	1.2 dB
RF conducted emissions (Spectrum Analyzer)	3.0 dB	1.7 dB
All emissions, radiated	6.0 dB	5.3 dB
Temperature	1° C	0.65° C
Humidity	5 %	2.9 %
Supply voltages	3 %	1 %

5 TEST DATA

5.1 Antenna Port Conducted Emissions

Description of Measurement	<p>The direct measurement of emissions at the antenna port of the EUT is achieved by use of a RF connection to a spectrum analyzer or power meter.</p> <p>The cable and attenuator factors are loaded into the analyzer or power meter allowing for direct measurement readings without the need for further corrections.</p>
Example Calculations	<p>Measurement (dBm) + Cable factor (dB) + External Attenuator (dB) = Corrected Reading (dBm)</p> <p>Margin (dB) = Limit (dBm) – Corrected Reading (dBm)</p>

Block Diagram



5.1.1 Antenna Port Conducted Emissions – RF Output Power

Operator	Anthony Smith	QA	Adam Alger
Temperature (°C)	20.8, 22.2	R.H. %	29.0, 30.5
Test Date	3/8/2023, 3/22/2023	Location	RF Conducted Bench
Requirement	FCC 15.247 RSS-247	Method	ANSI C63.10

Limits:

<30 dBm

Test Parameters

Frequency	2.4-2.4835 GHz	Setup	Conducted
RBW	3 MHz	VBW	50 MHz
Detector(s)	Peak	Settings	Trace Max Hold

Instrumentation

Asset #	Description	Manufacturer	Model #	Serial #	Date	Due Date	Status
AA 960172	Cable	A.H. Systems, Inc.	SAC-26G-1	387	3/22/2022	3/22/2023	Active Verification
EE 960087	Analyzer - Spectrum	Agilent	N9010A	MY53400296	4/12/2022	4/12/2023	Active Calibration

EUT Parameters

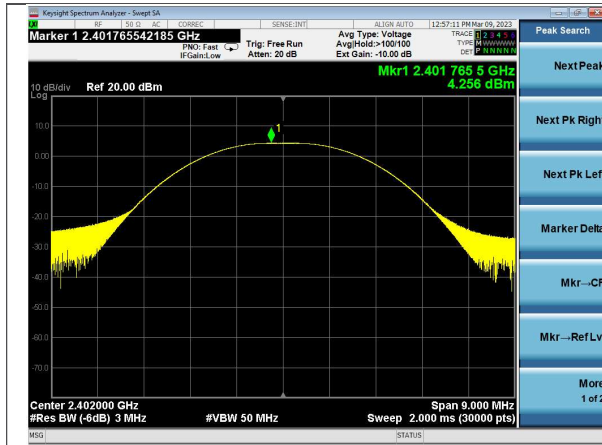
Input Power	12VDC	Mode	BLE 1Mbps, 2Mbps
Frequency (MHz)	2402, 2440, 2480	Channel	0, 17, 39

Data

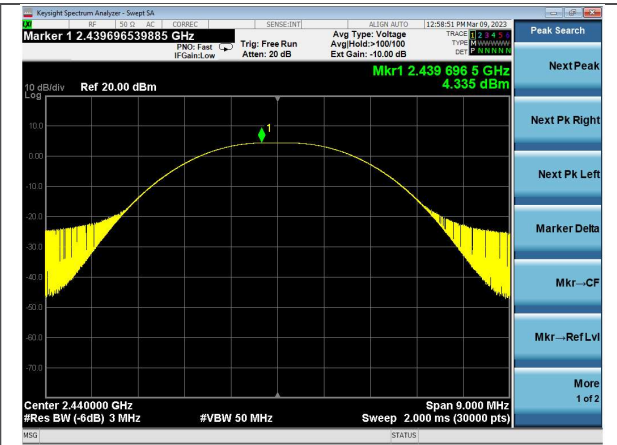
Table

Mode / Channel	Data Rate (Mbps)	Antenna Gain (dBi)	Peak Conducted Output Power (dBm)	Limit (dBm)	Margin (dB)
BLE / 0	1	3.1	4.3	30.0	25.7
BLE / 17	1	3.1	4.3	30.0	25.7
BLE / 39	1	3.1	4.3	30.0	25.7
BLE / 0	2	3.1	4.3	30.0	25.7
BLE / 17	2	3.1	4.3	30.0	25.7
BLE / 39	2	3.1	4.3	30.0	25.7

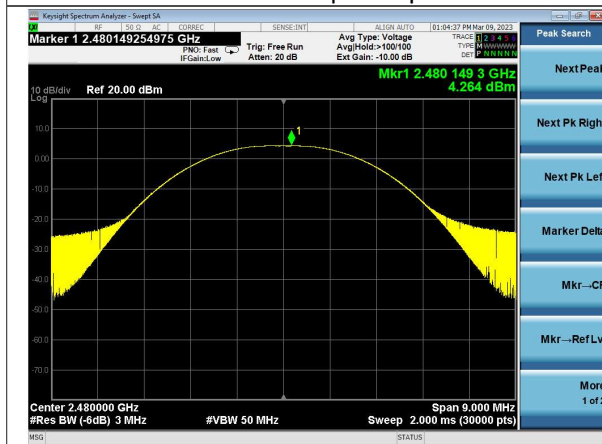
Plots



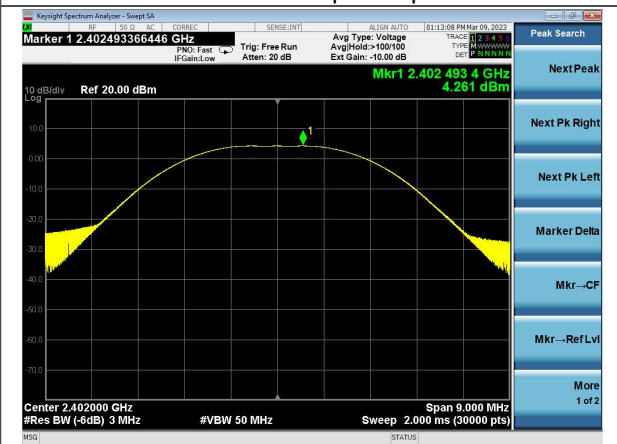
Channel 0 | 1 Mbps



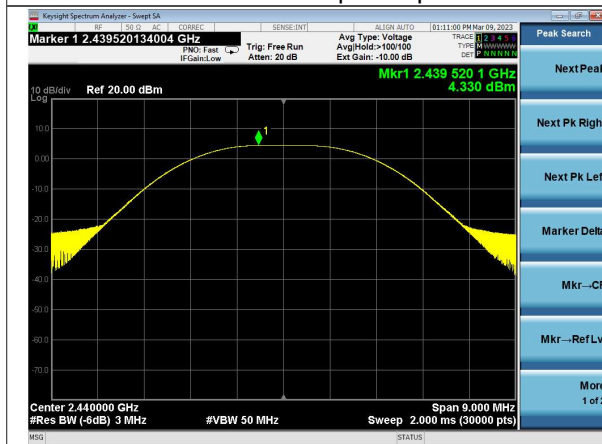
Channel 17 | 1 Mbps



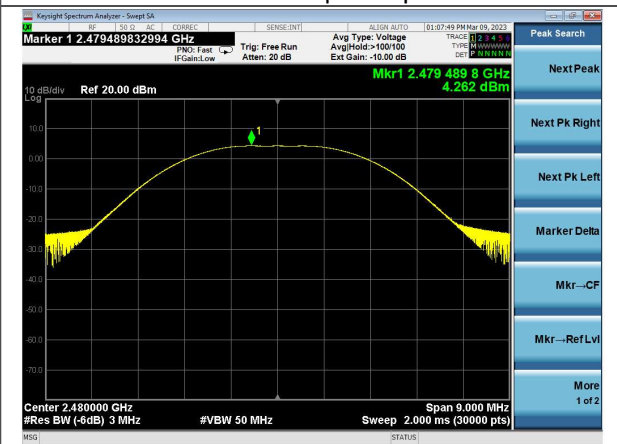
Channel 39 | 1 Mbps



Channel 0 | 2 Mbps



Channel 17 | 2 Mbps



Channel 39 | 2 Mbps

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5.1.2 Antenna Port Conducted Emissions – Emissions in Restricted Frequency Bands

Operator	Anthony Smith	QA	Adam Alger
Temperature (°C)	20.8, 22.2	R.H. %	29.0, 30.5
Test Date	3/8/2023, 03/22/2023	Location	RF Conducted Bench
Requirement	FCC 15.247 RSS-247	Method	ANSI C63.10

Restricted Band Limits:

Frequency (MHz)	Quasi Peak Limit (dBµV/m)	Average Limit (dBµV/m)	Peak Limit (dBµV/m)
30-88	40.0	-	-
88-216	43.5	-	-
216-960	46.0	-	-
960-1000	54.0	-	-
1000-25000	-	54.0	74.0

Test Parameters

Frequency	1-25 GHz	Setup	Conducted
RBW	1 MHz	VBW	470 Hz Average 3 MHz Peak
Detector(s)	Peak	Settings	Trace Max Hold
Example Calculations	54 dBµV/m – 95.2 = -41.2 dBm Conducted Average Limit 74 dBµV/m – 95.2 = -21.2 dBm Conducted Peak Limit		

Instrumentation

Asset #	Description	Manufacturer	Model #	Serial #	Date	Due Date	Status
AA 960172	Cable	A.H. Systems, Inc.	SAC-26G-1	387	3/22/2022	3/22/2023	Active Verification
EE 960087	Analyzer - Spectrum	Agilent	N9010A	MY53400296	4/12/2022	4/12/2023	Active Calibration

EUT Parameters

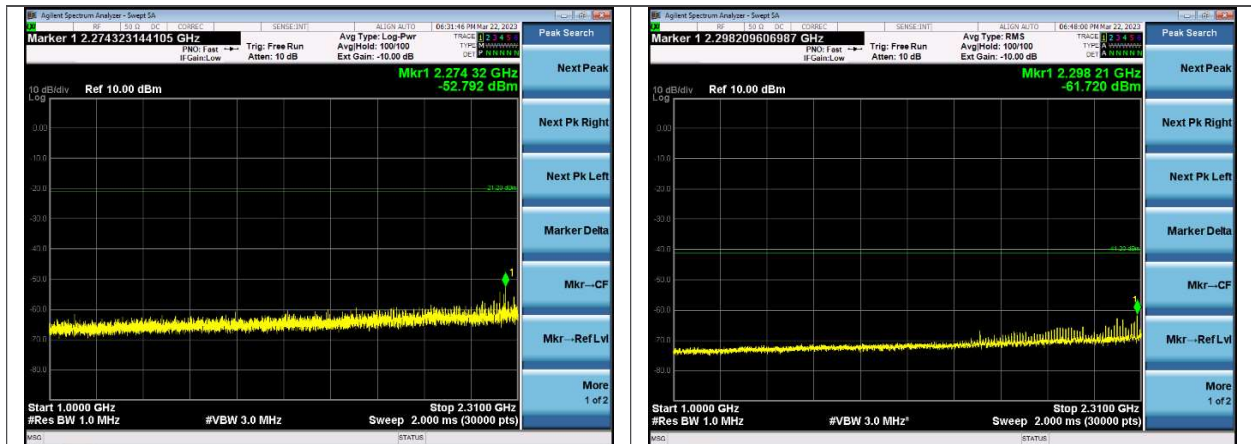
Input Power	12VDC	Mode	BLE 1 and 2 Mbps
Frequency (MHz)	2402, 2440, 2480	Channel	0, 17, 39

Data

Table

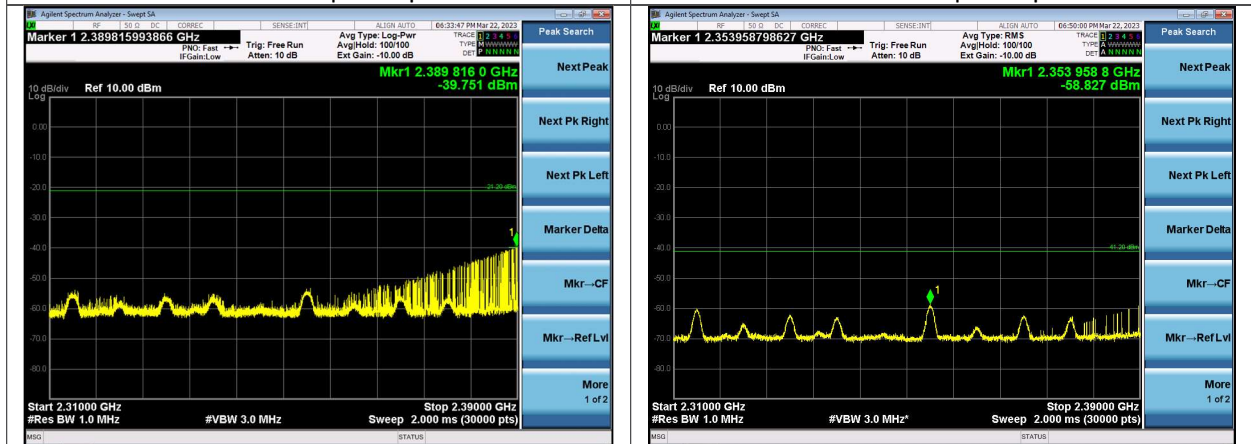
Channel	Data Rate (Mbps)	Frequency (MHz)	Measurement (dBm)	Antenna Gain (dBi)	Corrected Measurement (dBm)	Limit (dBm)	Margin (dB)	Meas.Type
0	1	2389.8	-39.8	3.1	-36.7	-21.2	15.5	Peak
0	1	2353.9	-58.8	3.1	-55.0	-41.2	13.8	Average
0	2	2389.8	-39.3	3.1	-36.2	-21.2	15.0	Peak
0	2	2388.2	-59.9	3.1	-54.4	-41.2	13.2	Average
39	1	2483.5	-29.4	3.1	-26.3	-21.2	5.1	Peak
39	1	2483.6	-48.6	3.1	-44.8	-41.2	3.6	Average
39	2	2483.5	-29.1	3.1	-26.0	-21.2	4.8	Peak
39	2	2483.6	-49.9	3.1	-44.4	-41.2	3.2	Average
0	1	4803.3	-50.9	3.1	-47.8	-21.2	26.6	Peak
0	1	4804.1	-56.8	3.1	-53.0	-41.2	11.8	Average
17	1	4880.0	-53.7	3.1	-50.6	-21.2	29.4	Peak
17	1	4879.8	-60.8	3.1	-57.0	-41.2	15.8	Average
39	1	4960.1	-50.2	3.1	-47.1	-21.2	25.9	Peak
39	1	1959.3	-59.9	3.1	-56.1	-41.2	14.9	Average
0	2	4805.6	-51.1	3.1	-48.0	-21.2	26.8	Peak
0	2	4804.1	-59.1	3.1	-53.6	-41.2	12.4	Average
17	2	4880.8	-54.1	3.1	-51.0	-21.2	29.8	Peak
17	2	4880.8	-63.3	3.1	-57.8	-41.2	15.6	Average
39	2	4960.1	-51.7	3.1	-48.6	-21.2	27.4	Peak
39	2	4960.1	-62.3	3.1	-56.8	-41.2	15.6	Average

Plots



1-2.31 GHz Peak
Channel 0 | 1 Mbps

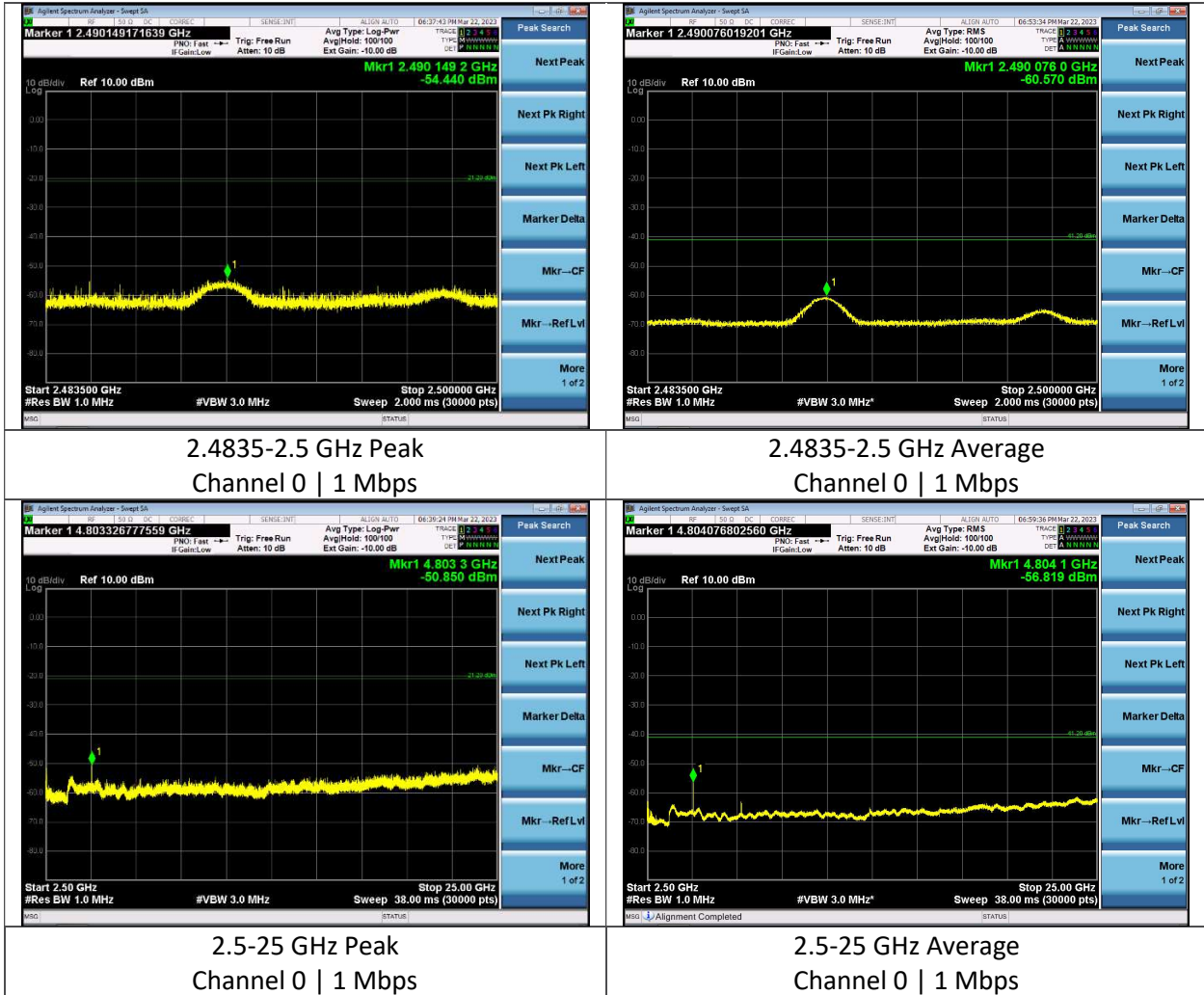
1-2.31 GHz Average
Channel 0 | 1 Mbps

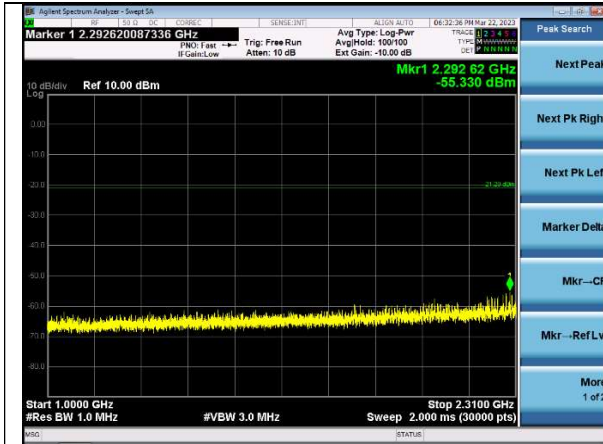


2.31-2.39 GHz Peak
Channel 0 | 1 Mbps

2.31-2.39 GHz Average
Channel 0 | 1 Mbps

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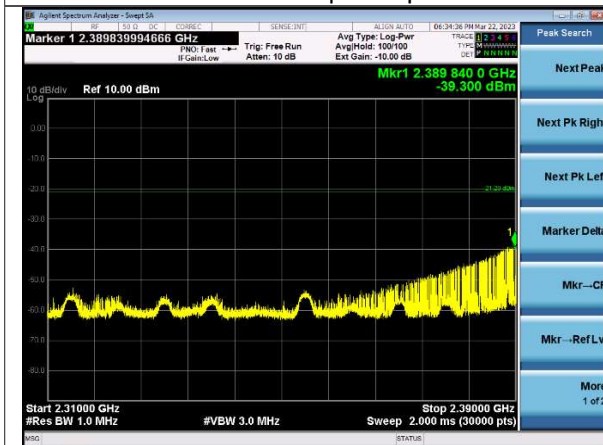




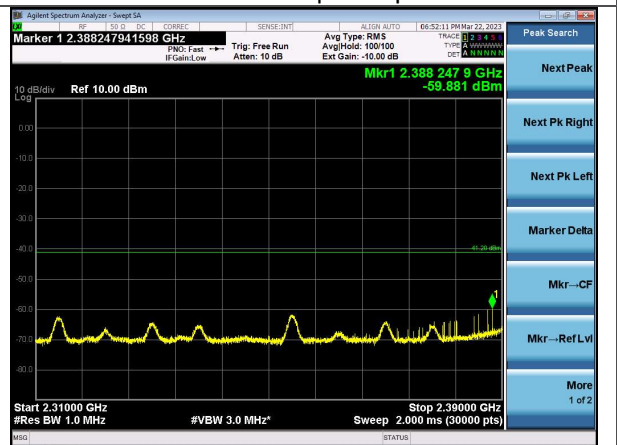
1-2.31 GHz Peak
Channel 0 | 2 Mbps



1-2.31 GHz Average
Channel 0 | 2 Mbps

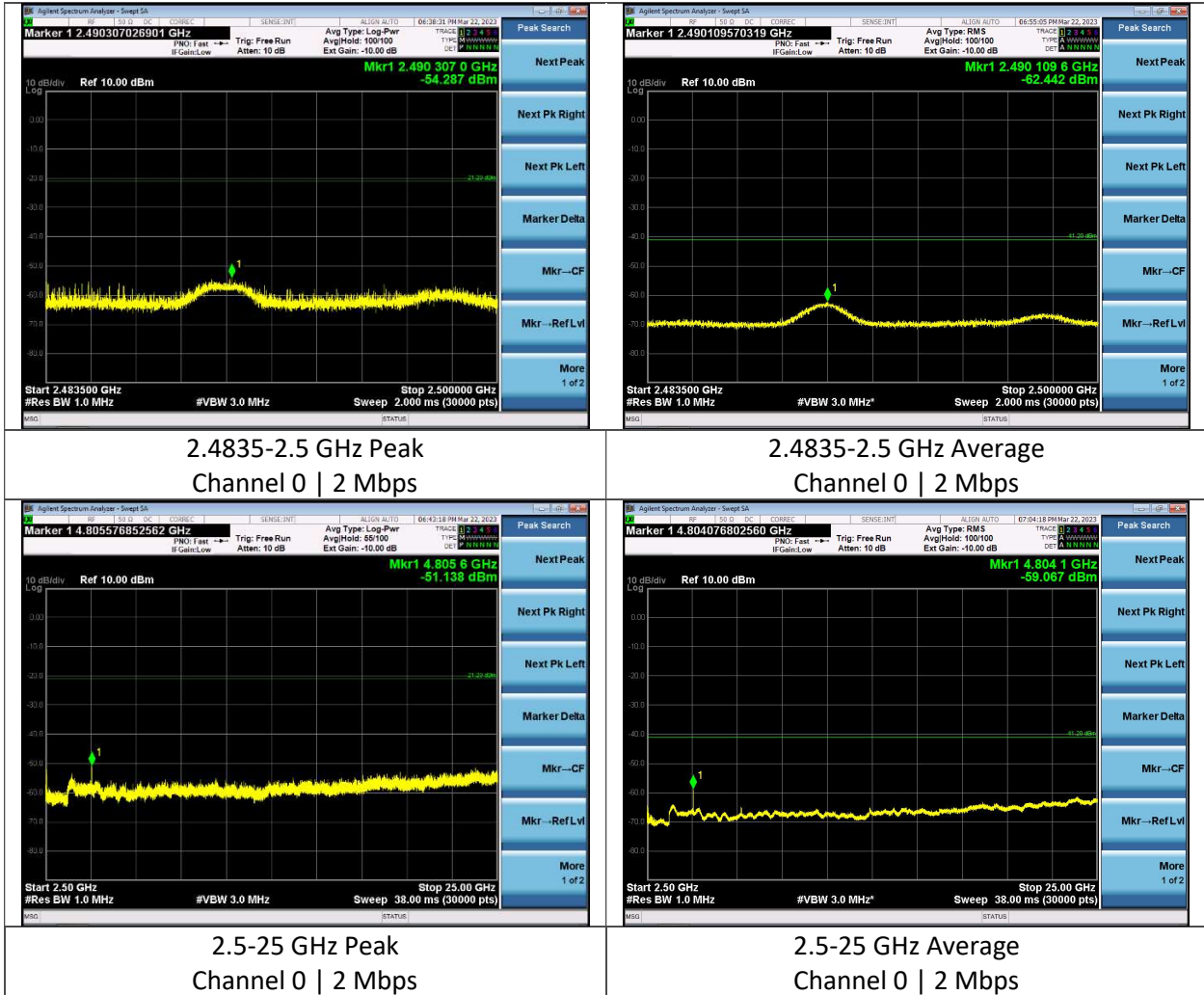


2.31-2.39 GHz Peak
Channel 0 | 2 Mbps



2.31-2.39 GHz Average
Channel 0 | 2 Mbps

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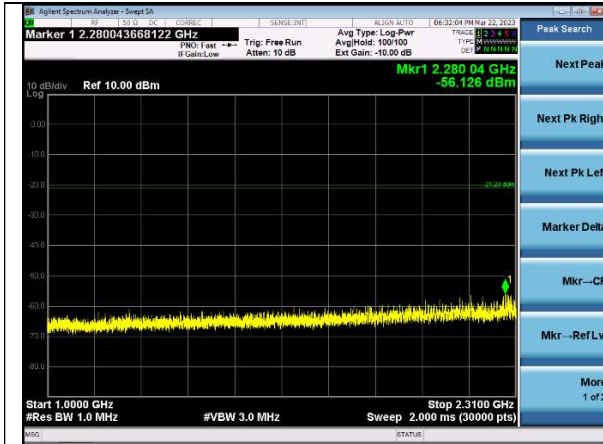


2.4835-2.5 GHz Peak
Channel 0 | 2 Mbps

2.4835-2.5 GHz Average
Channel 0 | 2 Mbps

2.5-25 GHz Peak
Channel 0 | 2 Mbps

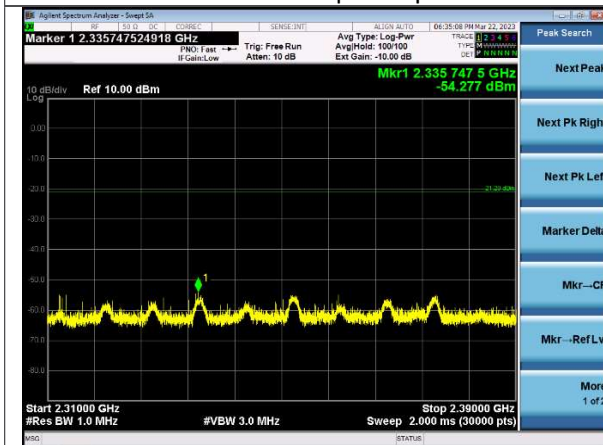
2.5-25 GHz Average
Channel 0 | 2 Mbps



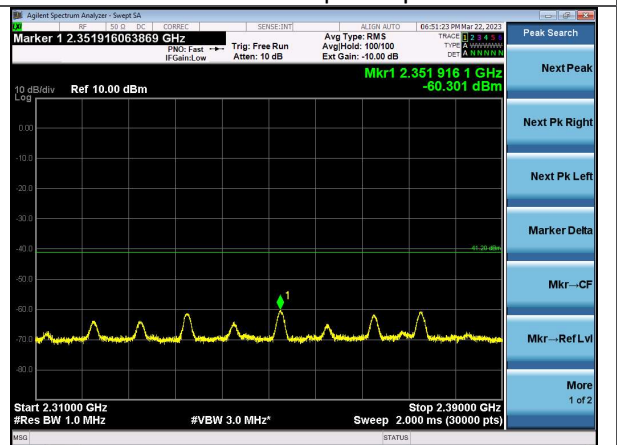
1-2.31 GHz Peak
Channel 17 | 1 Mbps



1-2.31 GHz Average
Channel 17 | 1 Mbps

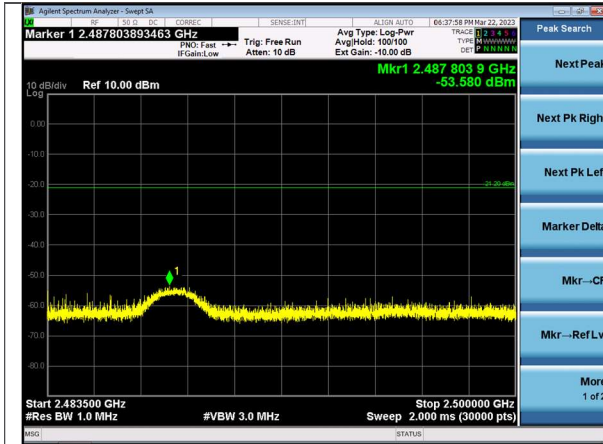


2.31-2.39 GHz Peak
Channel 17 | 1 Mbps

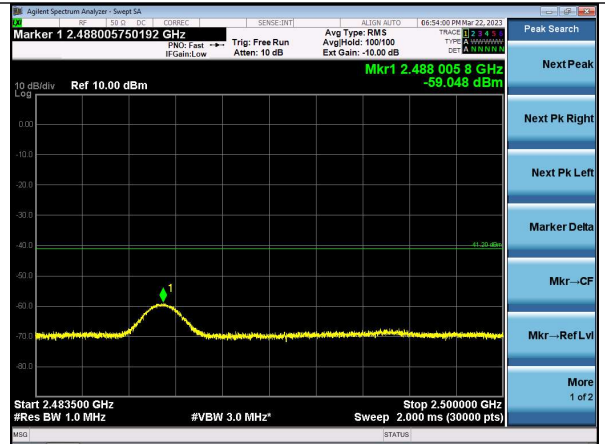


2.31-2.39 GHz Average
Channel 17 | 1 Mbps

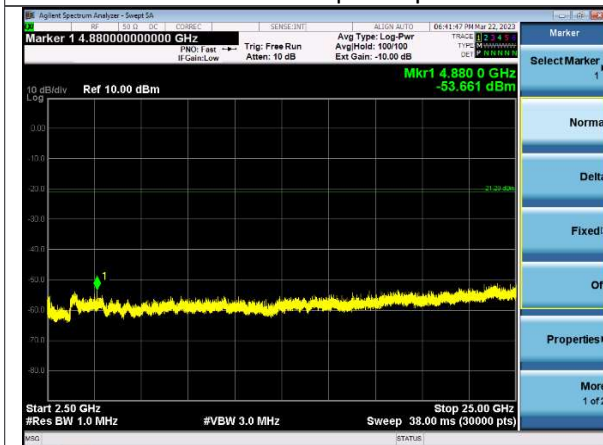
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2.4835-2.5 GHz Peak
Channel 17 | 1 Mbps



2.4835-2.5 GHz Average
Channel 17 | 1 Mbps

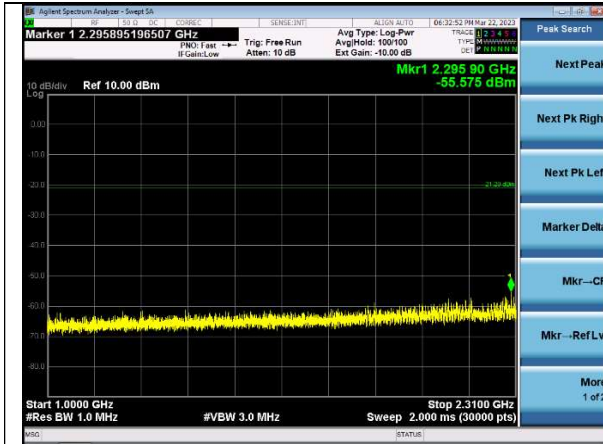


2.5-25 GHz Peak
Channel 17 | 1 Mbps



2.5-25 GHz Average
Channel 17 | 1 Mbps

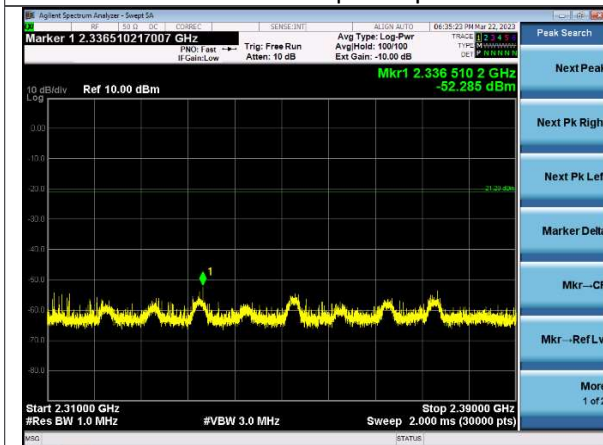
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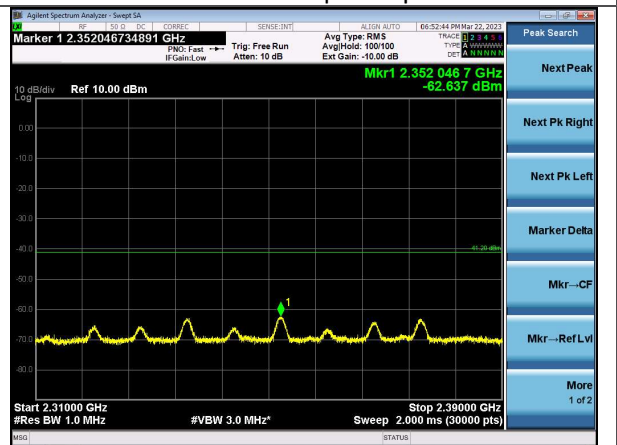
1-2.31 GHz Peak
Channel 17 | 2 Mbps



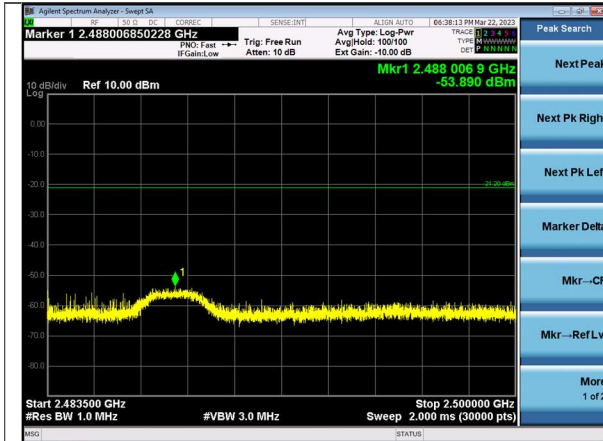
1-2.31 GHz Average
Channel 17 | 2 Mbps



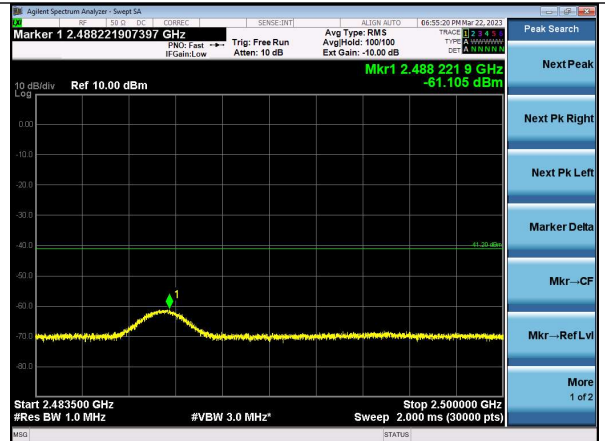
2.31-2.39 GHz Peak
Channel 17 | 2 Mbps



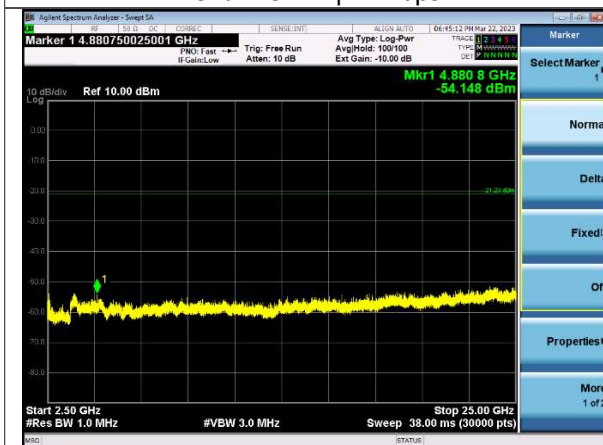
2.31-2.39 GHz Average
Channel 17 | 2 Mbps



2.4835-2.5 GHz Peak
Channel 17 | 2 Mbps



2.4835-2.5 GHz Average
Channel 17 | 2 Mbps

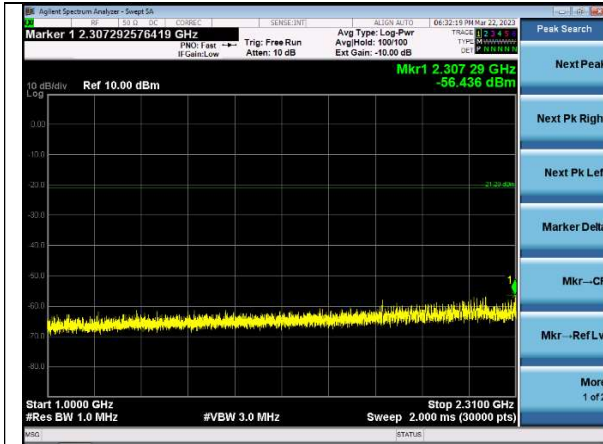


2.5-25 GHz Peak
Channel 17 | 2 Mbps



2.5-25 GHz Average
Channel 17 | 2 Mbps

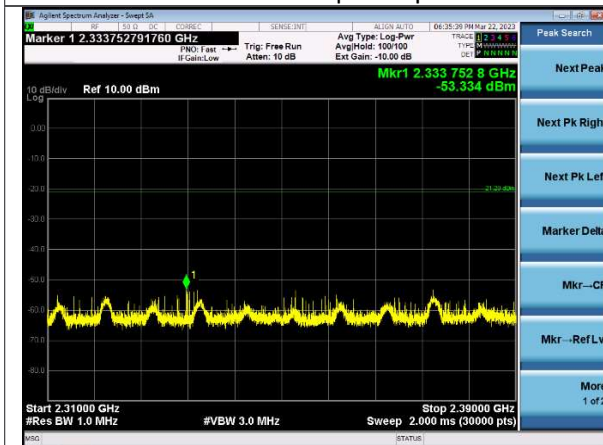
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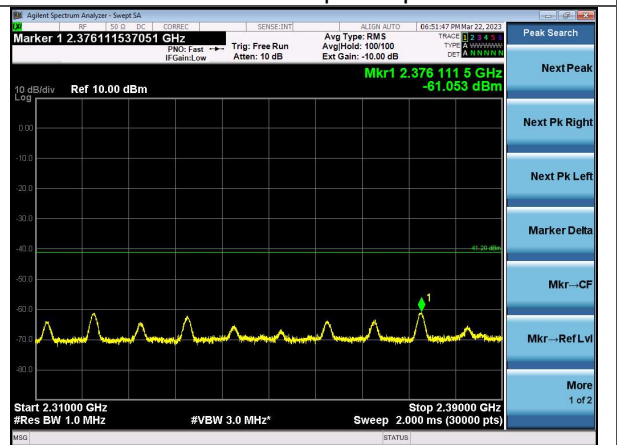
1-2.31 GHz Peak
Channel 39 | 1 Mbps



1-2.31 GHz Average
Channel 39 | 1 Mbps

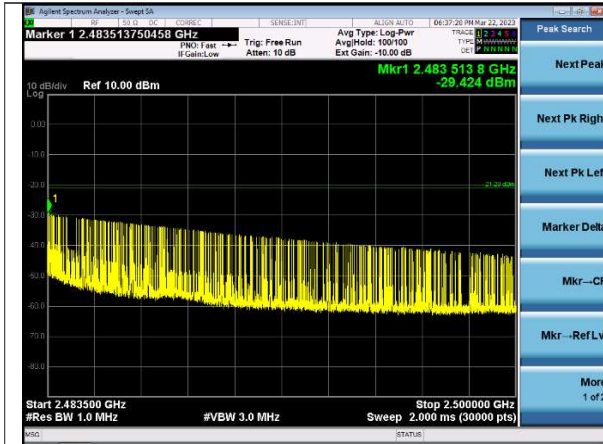


2.31-2.39 GHz Peak
Channel 39 | 1 Mbps

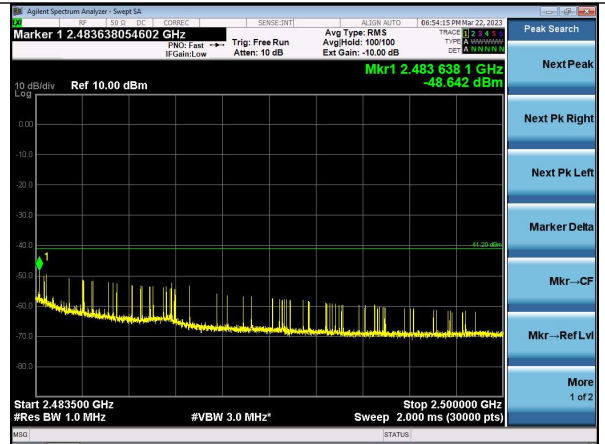


2.31-2.39 GHz Average
Channel 39 | 1 Mbps

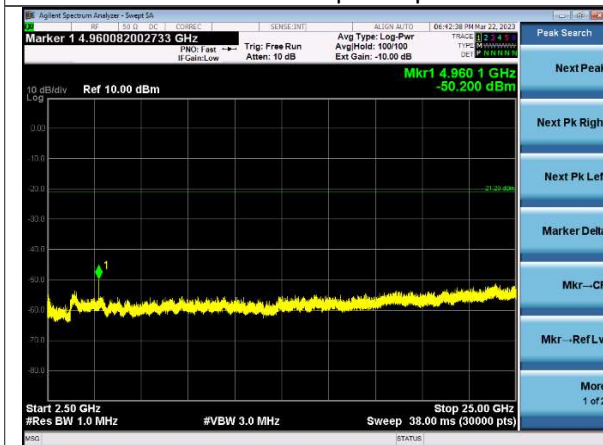
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2.4835-2.5 GHz Peak
Channel 39 | 1 Mbps



2.4835-2.5 GHz Average
Channel 39 | 1 Mbps

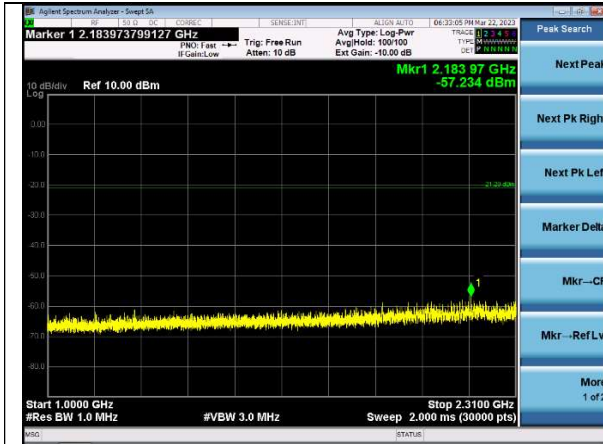


2.5-25 GHz Peak
Channel 39 | 1 Mbps



2.5-25 GHz Average
Channel 39 | 1 Mbps

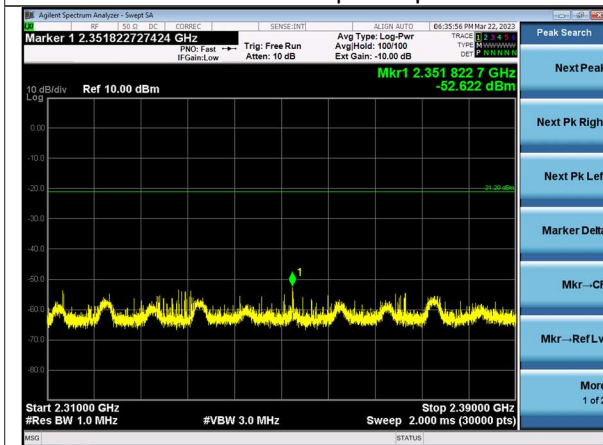
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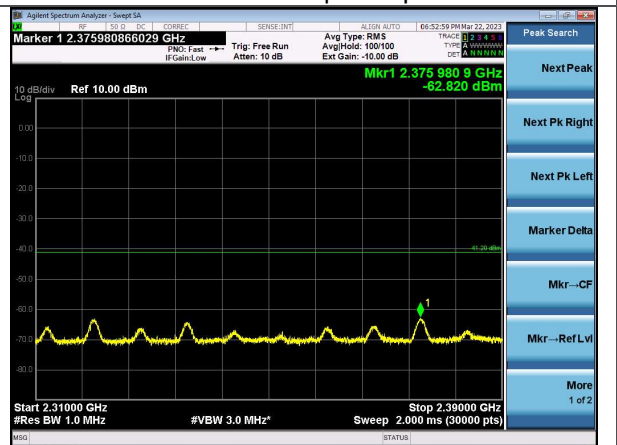
1-2.31 GHz Peak
Channel 39 | 2 Mbps



1-2.31 GHz Average
Channel 39 | 2 Mbps

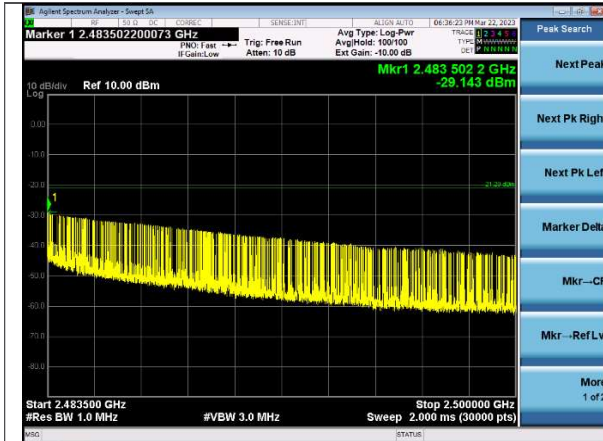


2.31-2.39 GHz Peak
Channel 39 | 2 Mbps

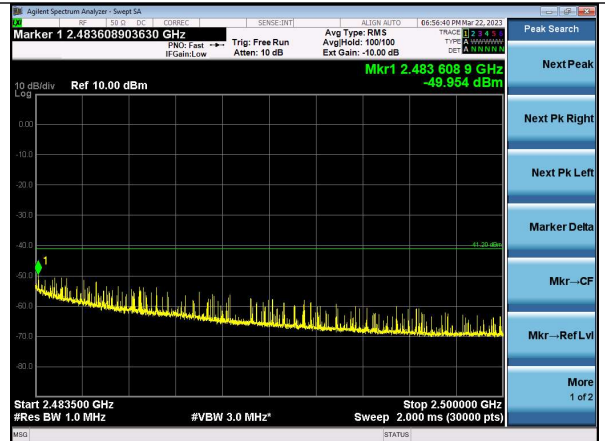


2.31-2.39 GHz Average
Channel 39 | 2 Mbps

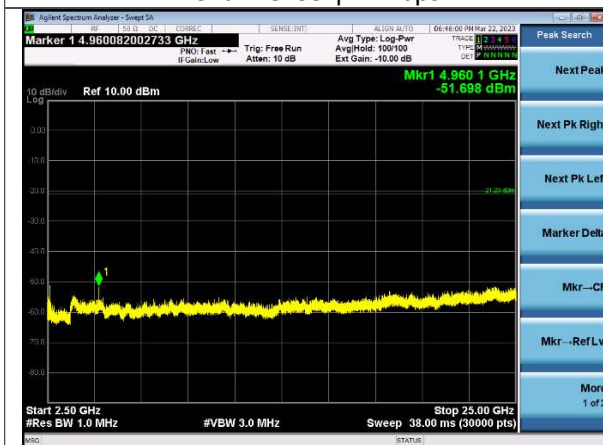
Company: Laird Connectivity	Page 25 of 27	Name: BL652-SC
Report: TR3664-BL652A		Model: BL652-SC
Quote: NBO-2022-005678		Serial: 1222195



2.4835-2.5 GHz Peak
Channel 39 | 2 Mbps



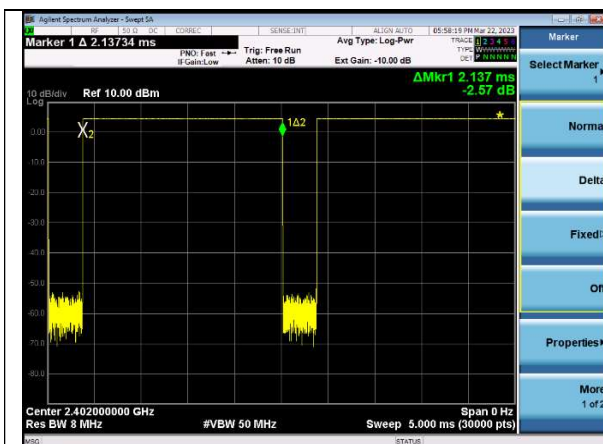
2.4835-2.5 GHz Average
Channel 39 | 2 Mbps



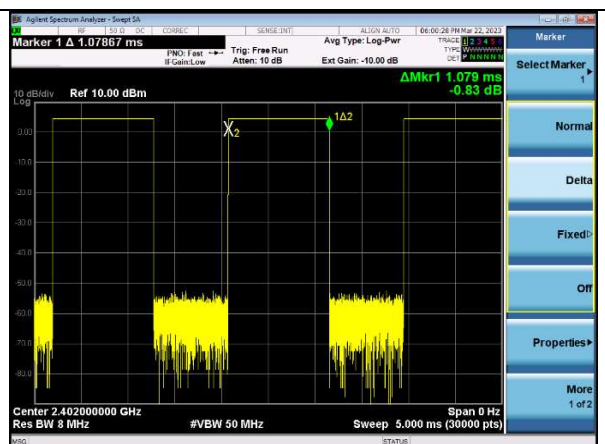
2.5-25 GHz Peak
Channel 39 | 2 Mbps



2.5-25 GHz Average
Channel 39 | 2 Mbps



1 Mbps On Time 2.137ms



2 Mbps On Time 1.079ms

6 REVISION HISTORY

Version	Date	Notes	Person
0.0	6/29/2023	Initial Draft	Adam Hauke
1.0	07/01/2023	Final Draft	Adam Hauke

END OF REPORT