Electromagnetic Compatibility Test Report

Tests Performed on a Takachiho Sangyo Co., Ltd

Horizontal Directional Drill Tracking System Transmitter, Model GD6-HD

Radiometrics Document RP-9656

Product Detail:	
FCC ID: 2A6WT-GD6HD IC: 28599-GD6HD Equipment type: 464.5-469.55 MHz Transmitter	
Test Standards:	
US CFR Title 47, Chapter I, FCC Part 2 and 90 FCC Parts 2, 15, and 90 CFR Title 47: 2022 IC RSS-119 Issue 12: 2015 IC RSS-GEN Issue 5: 2018 This report concerns: Original Grant for Certification; FCC part 90.217	
Tests Performed For:	*Test Facility:*
Takachiho Sangyo Co., Ltd 1-44 Namiuchi-cho Kita-ku, Nagoya Japan 462-0041	**Radiometrics Midwest Corporation** 12 Devonwood Avenue Romeoville, IL 60446-1349 (815) 293-0772
Test Date(s):	
May 13 thru June 28, 2022	

Document RP-9656 Revisions:

Rev.	Issue Date	Revised By
0	July 8, 2022	
1	July 27, 2022	Joseph Strzelecki

Table of Contents

1.0 ADMINISTRATIVE DATA

Equipment Under Test:	
A Takachiho Sangyo Co., Ltd, Horizontal Directional Drill Tracking System Model: GD6-HD Serial Number: 17121022 This will be referred to as the EUT in this Report	
Date EUT Received at Radiometrics:	*Test Date(s):*
May 10, 2022	May 13 thru June 28, 2022
Test Report Written and Authorized By:	*Test Witnessed By:*
Joseph Strzelecki Senior EMC Engineer	The tests were not witnessed by personnel from Takachiho Sangyo Co., Ltd.
Radiometrics' Personnel Responsible for Test:	*EUT Checked By:*
Joseph Strzelecki 07/27/2022 Date Joseph Strzelecki Senior EMC Engineer NARTE EMC-000877-NE Chris D'Alessio EMC Technician	Joseph Strzelecki Chris D'Alessio Radiometrics

2.0 TEST SUMMARY AND RESULTS

The EUT (Equipment Under Test) is a Horizontal Directional Drill Tracking System, Model GD6-HD, manufactured by Takachiho Sangyo Co., Ltd. The detailed test results are presented in a separate section. The following is a summary of the test results.

Transmitter Requirements

Environmental Phenomena	Frequency Range	FCC Sections	RSS 119 Section	Test Result
RF Power Output	450-470 MHz	2.1046 & 90.217	5.10	Pass
Occupied Bandwidth Test; Emissions Masks	450-470 MHz	2.1049 & 90.217	5.10	Pass
Spurious RF Conducted Emissions	1-4700 MHz	2.1051 & 90.217	5.10	Pass
Field Strength of Spurious Radiation	30-4700 MHz	2.1053 & 90.217	5.10	Pass
Frequency Stability vs. Temperature	450-470 MHz	2.1055 & 90.217	5.10	Pass
Frequency Stability vs. Voltage	450-470 MHz	2.1055 & 90.217	5.10	Pass

The Frequency stability is exempt for this transmitter. The frequency stability results are used for calculating the emissions masks of 90.217(b)

IEC 17025 Decision Rule:
The declaration of pass or fail is based on the specifications listed above. The declaration of pass or fail did not consider measurement uncertainty.

3.0 EQUIPMENT UNDER TEST (EUT) DETAILS

3.1 EUT Description

The EUT is a Horizontal Directional Drill Tracking System, Model GD6-HD, manufactured by Takachiho Sangyo Co., Ltd. The EUT was in good working condition during the tests, with no known defects.

4.0 TESTED SYSTEM DETAILS

4.1 Tested System Configuration

The system was configured for testing in a typical fashion. The EUT was placed on an 80-cm or 150 cm high, nonconductive test stand. The testing was performed in conditions as close as possible to installed conditions. Wiring was consistent with manufacturer's recommendations. The EUT was tested as a stand-alone device. Power was supplied with new batteries.

EUT Details

Item	Description	Type*	Manufacturer	Model Number	Serial Number
1	Horizontal Directional Drill Tracking System	E	Takachiho Sangyo Co., Ltd	GD6-HD	17121022

* Type: E = EUT, P = Peripheral, S = Support Equipment; H = Host Computer

4.2 EUT Operating Modes

The EUT was in a normal operating mode during the tests. All circuits were activated during the tests. Power was supplied with a new battery.

Type of modulation including the bit rate and symbol rate	FM modulation (FSK modem) 1200bps
Name and version of the test software used to exercise the device	Standard build software, not adjustable
Power settings used for the purpose of exercising the device	Standard; Not user adjustable
Firmware number of the transmitter	N/A

The EUT was in its normal FSK modulation during the tests. It was tested as a stand-alone, battery powered device, since that is the configuration in the final installation.

4.3 Special Accessories

No special accessories were used during the tests in order to achieve compliance.

4.4 Equipment Modifications

No modifications were made to the EUT at Radiometrics' test facility in order to comply with the standards listed in this report.

5.0 TEST SPECIFICATIONS

Document	Date	Title
FCC CFR Title 47	2022	Code of Federal Regulations Title 47, Chapter 1, Federal Communications Commission, Part 15 & 90 - Radio Frequency Devices
ANSI C63.4-2014	2014	Methods of Measurement of Radio Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
TIA-603-E	2016	Land Mobile FM or PM Communications Equipment – Measurement and Performance Standards
IC RSS-Gen Issue 5	2018	General Requirements and Information for the Certification of Radiocommunication Equipment (RSS-Gen)
IC RSS-119 Issue 12	2015	Radio Transmitters and Receivers Operating in the Land Mobile and Fixed Services in the Frequency Range 27.41-960 MHz

6.0 RADIOMETRICS' TEST FACILITIES

The results of these tests were obtained at Radiometrics Midwest Corp. in Romeoville, Illinois, USA. Radiometrics is accredited by A2LA (American Association for Laboratory Accreditation) to conform to ISO/IEC 17025: 2017 "General Requirements for the Competence of Calibration and Testing Laboratories". Radiometrics' Lab Code is 121191 and Certification Number is 1495.01. Radiometrics' scope of accreditation includes all of the test methods listed herein. A copy of the accreditation can be accessed on our web site (www.radiomet.com). Radiometrics accreditation status can be verified at A2LA's web site (www.a2la2.org).

The following is a list of shielded enclosures located in Romeoville, Illinois used during the tests:

Chamber E: Is a custom-made anechoic chamber that measures 52' L X 30' W X 18' H. The walls and ceiling are fully lined with RF absorber. Pro-shield of Collinsville, Oklahoma manufactured the chamber. The floor has a 9' x 9' section of microwave absorber for testing above 1 GHz.

Test Station F: Is an area that measures 10' D X 12' W X 10' H. The floor and back wall are metal shielded. This area is used for conducted emissions measurements.

A separate ten-foot long, brass plated, steel ground rod attached via a 6-inch copper braid grounds each of the above chambers. Each enclosure is also equipped with low-pass power line filters.

The FCC has accepted these sites as test site number US1065. The FCC test site Registration Number is 732175. Details of the site characteristics are on file with the Industry Canada as site number IC 3124A with a CAB ID of US0224.

A complete list of the test equipment is provided herein. The calibration due dates are indicated on the equipment list. The equipment is calibrated in accordance with ANSI/NCSL Z540-1 with traceability to the National Institute of Standards and Technology (NIST).

7.0 DEVIATIONS AND EXCLUSIONS FROM THE TEST SPECIFICATIONS

There were no deviations or exclusions from the test specifications.

8.0 CERTIFICATION

Radiometrics Midwest Corporation certifies that the data contained herein was taken under conditions that meet or exceed the requirements of the test specification and the data contained herein was taken with calibrated test equipment. The results relate only to the EUT listed herein.

9.0 TEST EQUIPMENT TABLE

RMC ID	Manufacturer	Description	Model No.	Serial No.	Frequency Range	Cal Period	Cal Date
AMP-05	RMC/Celeritek	Pre-amplifier	MW110G	1001	1.0-12GHz	12 Mo.	01/04/22
ANT-06	EMCO	Log-Periodic Ant.	3146	1248	200-1000MHz	24 Mo.	01/18/22
ANT-07	RMC	Log-Periodic Ant.	LP1000	1001	200-1000MHz	24 Mo.	08/11/21
ANT-13	EMCO	Horn Antenna	3115	2502	1.0-18GHz	24 Mo.	01/29/21
ANT-66	ETS-Lindgren	Horn Antenna	3115	62580	1.0-18GHz	24 Mo.	03/11/21
ANT-79	AH Systems	Bicon Antenna	SAS-540	793	20-330MHz	24 Mo.	01/05/21
ANT-80	AH Systems	Bicon Antenna	SAS-540	294	20-330MHz	24 Mo.	01/05/21
ATT-53	Weinschel	Attenuator (20 dB)	23-20-34	CG7857	DC-18 GHz	12 Mo	12/17/21
DMM-09	Fluke	DMM	15B	12220951	DC-500 Hz	24 Mo.	01/22/21
PWM-01	Boonton	Power Meter	4230	22503	50kHz-18GHz	24 Mo.	02/12/22
REC-31	HP / Agilent	Spectrum Analyzer	E7402A	US41160415	9kHz-3GHz	24 Mo.	05/28/21
REC-21	Agilent	Spectrum Analyzer	E7405A	MY45118341	9Hz-26.5 GHz	24 Mo.	02/24/22
REC-44	Agilent	Spectrum Analyzer	E4440A	US40420673	3Hz-26.5GHz	24 Mo.	03/31/22
SIG-31	Rohde Schwarz	Vector Signal Generator	SMJ 100A	101395	100kHz-6GHz	36 Mo.	09/08/20
TC-01	GS Blue M Electric	Temperature Chamber	ETC-04S-E	0003-ETC-201	-40 to 100 Deg C	24 Mo.	10/16/20
THM-02	Fluke	Temp/Humid Meter	971	93490471	N/A	24 Mo.	11/13/20

Note: All calibrated equipment is subject to periodic checks.
NCR – No Calibration Required. Device monitored by calibrated equipment. N/A: Not Applicable.

Software Company	Test Software Name	Version	Applicable Tests
Radiometrics	REREC11D	07.16.19	RF Radiated Emissions (FCC Part 15 & EN 55032)
Agilent	PSA/ESA-E/L/EMC	2.4.0.42	Bandwidth and screen shots

10.0 TEST SECTIONS

10.1 Peak Output Power

The peak power was measured by connecting the EUT antenna port to the spectrum analyzer via a low loss coaxial cable and an appropiate power attenuator.

Model	GD6HD	Specification	FCC part 90.205 RSS-119 Section 5.4
Serial Number	17121022	Test Date	06/23/2022
Test Personnel	Joseph Strzelecki	Test Location	Chamber B
Test Equipment	Power meter (PWM-01); Attenuator (ATT-53)		

TX Freq MHz	Reading dBm	Atten & Cable	Total dBm	Peak Power milliwatts	Limit milliwatts
464.5000	-1.00	20.3	19.3	85.1	120.0
464.5500	-0.80	20.3	19.5	89.1	120.0
469.5000	-0.90	20.3	19.4	87.1	120.0
469.5500	-0.80	20.3	19.5	89.1	120.0

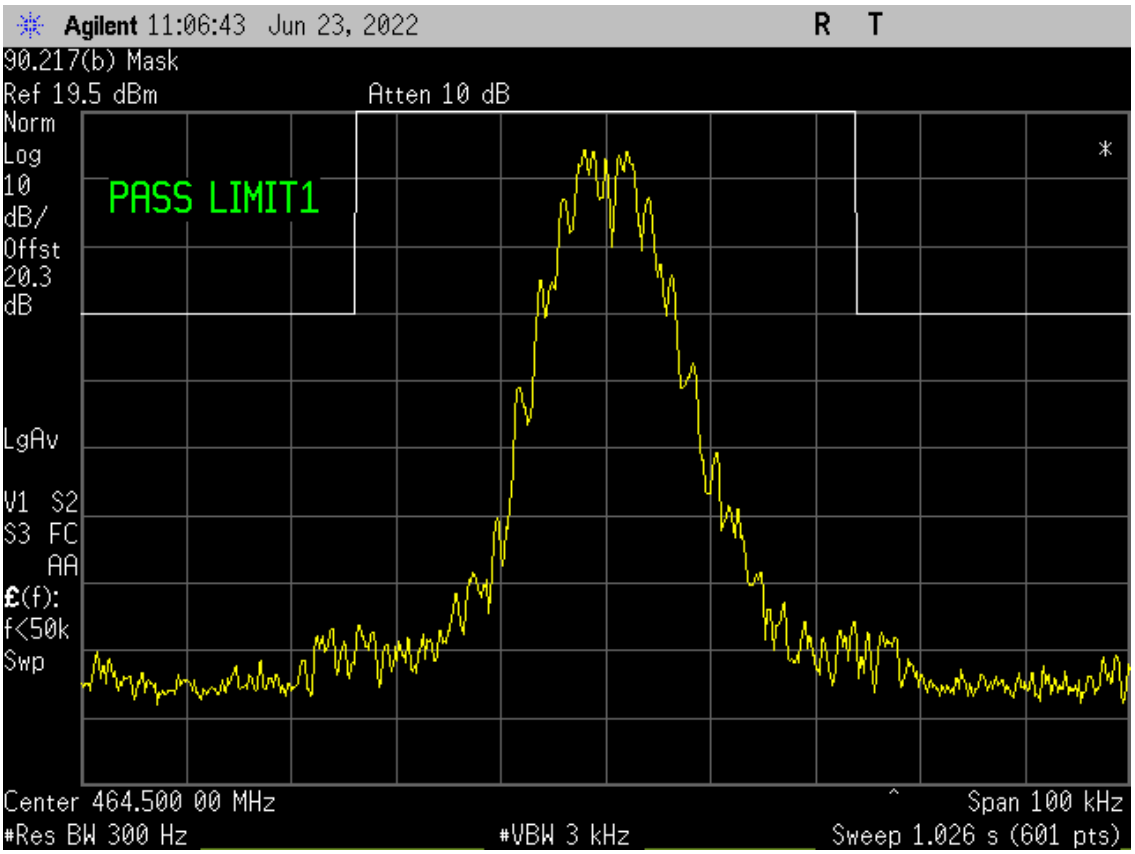
Judgement: Pass

10.2 Occupied Bandwidth; Emissions Masks

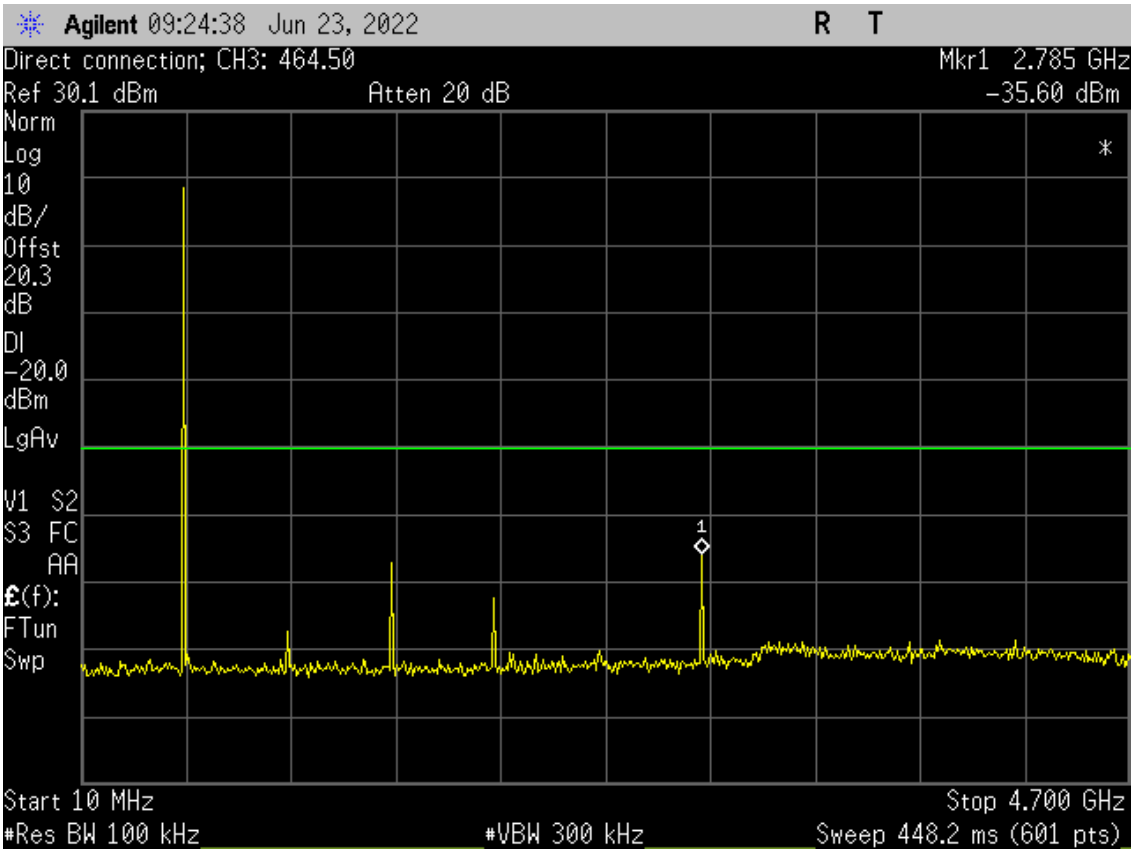
Model	GD6HD	Specification	FCC Part 90.217 RSS-119 Section 5.10
Serial Number	17121022	Test Date	06/23/2022
Test Personnel	Joseph Strzelecki	Test Location	Chamber B
Test Equipment	Spectrum Analyzer (REC-44); Attenuator (ATT-53)		

The spectrum analyzer was set to the MAX HOLD mode to record the worst case of the modulation. The EUT was transmitting at its maximum data rate. The trace was allowed to stabilize.

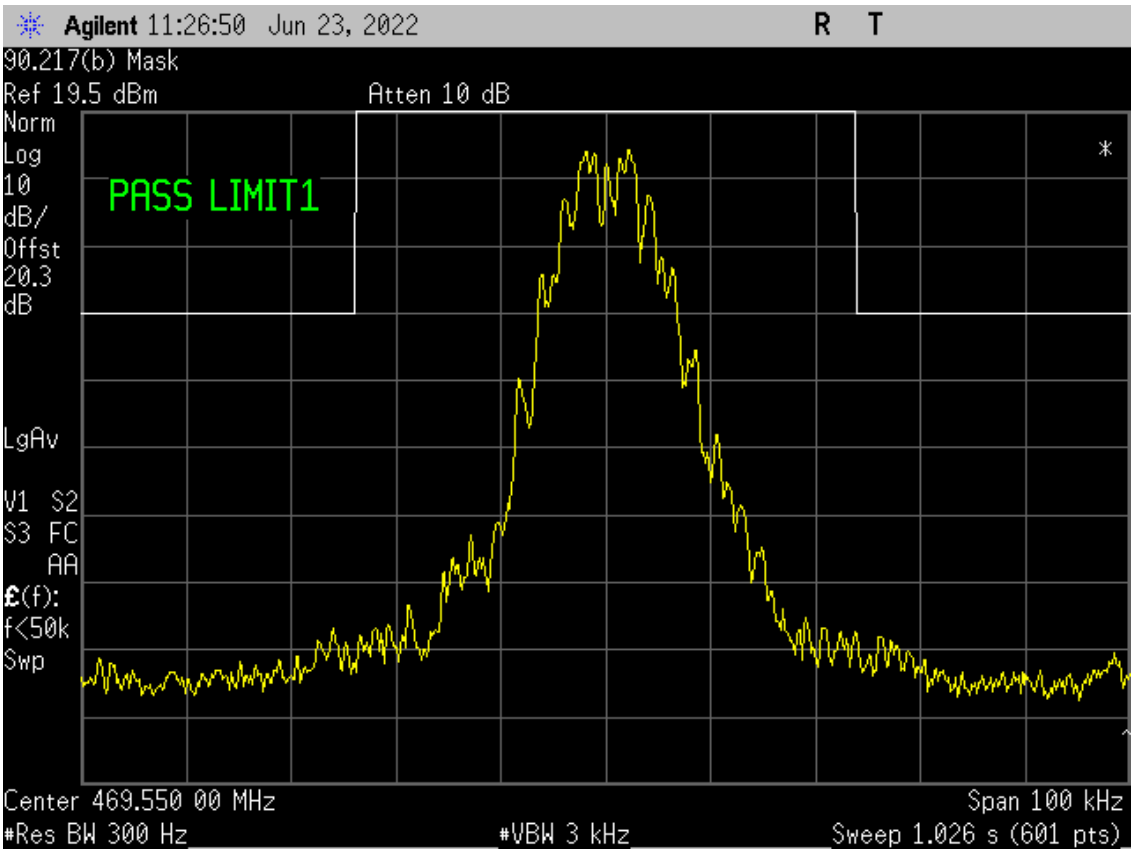
As per FCC part 90.217 (b), “For equipment designed to operate with a 12.5 kHz channel bandwidth, the sum of the bandwidth occupied by the emitted signal plus the bandwidth required for frequency stability shall be adjusted so that any emission appearing on a frequency 25 kHz or more removed from the assigned frequency is attenuated at least 30 dB below the unmodulated carrier.”



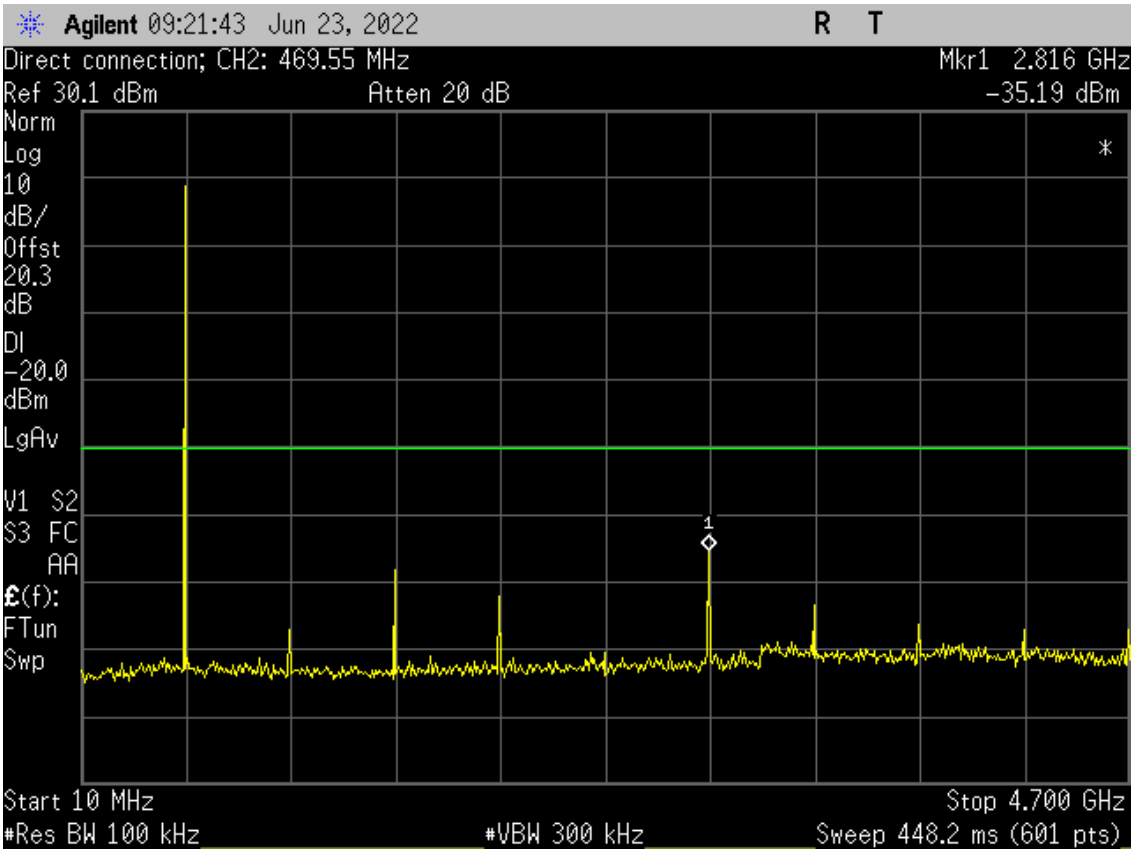
The offset of the mask is set to +/-24 instead of 25 kHz to account for Frequency Stability



The limit line was set to -20 dBm which is more stringent than the actual limit of -10.6 dBm.



The offset of the mask is set to +/-24 instead of 25 kHz to account for Frequency Stability



The limit line was set to -20 dBm which is more stringent than the actual limit of -10.6 dBm.

Judgement: Pass

10.2.1 Conducted Spurious Emissions

Model	GD6HD	Specification	FCC Part 90.210 RSS-119 Section 5.5
Serial Number	17121022	Test Date	June 23, 2022
Test Personnel	Joseph Strzelecki	Test Location	Chamber B
Test Equipment	EMI Receiver (REC-44); Attenuator (ATT-53)		

This is a direct measurement from the Antenna port to the EMI Receiver

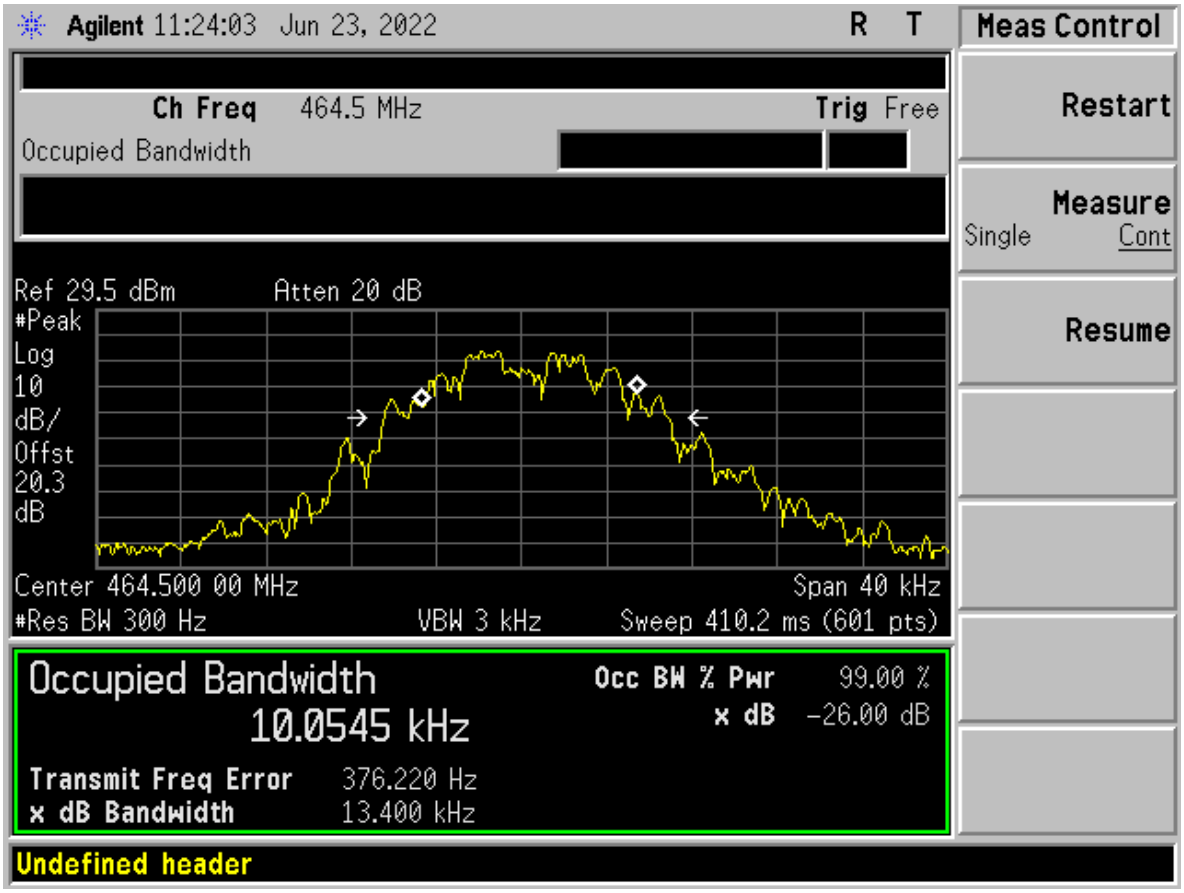
Freq. Tx	Harm	Tested Freq.	Rec Reading	Ext. Atten. Factor	Cable Loss	Total Power	Power Limit	Margin Under Limit
MHz	#	MHz	dBm	dB	dB	dBm	dBm	dB
464.500	2	929.00	-54.3	19.9	0.6	-33.8	-10.7	23.1
464.500	3	1393.50	-65.3	19.9	0.8	-44.6	-10.7	33.9
464.500	4	1858.00	-66.1	20.0	1.0	-45.1	-10.7	34.4
464.500	5	2322.50	-53.9	20.0	1.2	-32.7	-10.7	22.0
464.500	6	2787.00	-69.2	20.0	1.3	-47.9	-10.7	37.2
464.500	7	3251.50	-69.1	20.0	1.4	-47.7	-10.7	37.0
464.500	8	3716.00	-65.9	20.0	1.7	-44.2	-10.7	33.5
464.500	9	4180.50	-69.4	20.0	2.1	-47.3	-10.7	36.6
464.500	10	4645.00	-71.6	20.0	2.3	-49.3	-10.7	38.6
464.550	2	929.10	-65.7	19.9	0.6	-45.2	-10.5	34.7

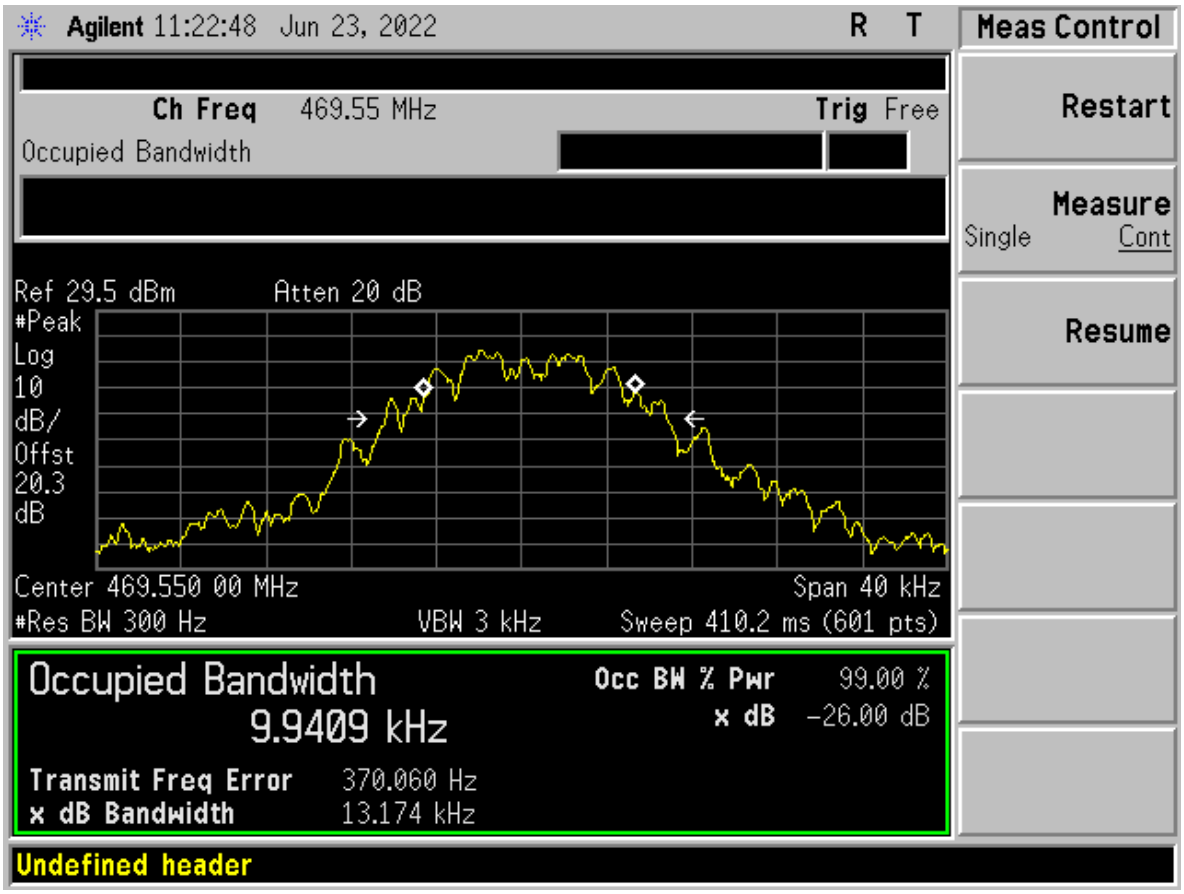
Freq. Tx	Harm	Tested Freq.	Rec Reading	Ext. Atten. Factor	Cable Loss	Total Power	Power Limit	Margin Under Limit
MHz	#	MHz	dBm	dB	dB	dBm	dBm	dB
464.550	3	1393.65	-53.9	19.9	0.8	-33.2	-10.5	22.7
464.550	4	1858.20	-61.0	20.0	1.0	-40.0	-10.5	29.5
464.550	5	2322.75	-66.3	20.0	1.2	-45.1	-10.5	34.6
464.550	6	2787.30	-52.9	20.0	1.3	-31.6	-10.5	21.1
464.550	7	3251.85	-71.8	20.0	1.4	-50.4	-10.5	39.9
464.550	8	3716.40	-68.2	20.0	1.7	-46.5	-10.5	36.0
464.550	9	4180.95	-67.5	20.0	2.1	-45.4	-10.5	34.9
464.550	10	4645.50	-69.3	20.0	2.3	-47.0	-10.5	36.5
469.500	2	939.00	-63.5	19.9	0.6	-43.0	-10.6	32.4
469.500	3	1408.50	-55.4	19.9	0.8	-34.7	-10.6	24.1
469.500	4	1878.00	-60.0	20.0	1.0	-39.0	-10.6	28.4
469.500	5	2347.50	-67.3	20.0	1.2	-46.1	-10.6	35.5
469.500	6	2817.00	-54.8	20.0	1.3	-33.5	-10.6	22.9
469.500	7	3286.50	-62.5	20.0	1.4	-41.1	-10.6	30.5
469.500	8	3756.00	-67.5	20.0	1.7	-45.8	-10.6	35.2
469.500	9	4225.50	-64.6	20.0	2.1	-42.5	-10.6	31.9
469.500	10	4695.00	-65.4	20.0	2.3	-43.1	-10.6	32.5
469.550	2	939.10	-63.0	19.9	0.6	-42.5	-10.5	32.0
469.550	3	1408.65	-54.4	19.9	0.8	-33.7	-10.5	23.2
469.550	4	1878.20	-59.7	20.0	1.0	-38.7	-10.5	28.2
469.550	5	2347.75	-66.1	20.0	1.2	-44.9	-10.5	34.4
469.550	6	2817.30	-54.9	20.0	1.3	-33.6	-10.5	23.1
469.550	7	3286.85	-62.5	20.0	1.4	-41.1	-10.5	30.6
469.550	8	3756.40	-67.5	20.0	1.7	-45.8	-10.5	35.3
469.550	9	4225.95	-65.1	20.0	2.1	-43.0	-10.5	32.5
469.550	10	4695.50	-66.2	20.0	2.3	-43.9	-10.5	33.4

Judgment: Passed by at least 10 dB.

10.3 Occupied Bandwidth

Channel	99% EBW kHz
464.500	9.94
469.550	10.05


Agilent 11:24:03 Jun 23, 2022
R T
Meas Control
Ch Freq 464.5 MHz
Trig Free
Occupied Bandwidth
Restart
Measure
Single Cont
Ref 29.5 dBm
Atten 20 dB
#Peak
Log
10
dB/
Offst
20.3
dB
Resume
Center 464.500 00 MHz
Span 40 kHz
#Res BW 300 Hz
VBW 3 kHz
Sweep 410.2 ms (601 pts)
Occupied Bandwidth
10.0545 kHz
Occ BW % Pwr 99.00 %
x dB -26.00 dB
Transmit Freq Error 376.220 Hz
x dB Bandwidth 13.400 kHz
Undefined header


Agilent 11:22:48 Jun 23, 2022
R T
Meas Control
Ch Freq 469.55 MHz
Trig Free
Occupied Bandwidth
Restart
Measure
Single Cont
Ref 29.5 dBm
Atten 20 dB
#Peak
Log
10
dB/
Offst
20.3
dB
Resume
Center 469.550 00 MHz
Span 40 kHz
#Res BW 300 Hz
VBW 3 kHz
Sweep 410.2 ms (601 pts)
Occupied Bandwidth
9.9409 kHz
Occ BW % Pwr 99.00 %
x dB -26.00 dB
Transmit Freq Error 370.060 Hz
x dB Bandwidth 13.174 kHz
Undefined header

10.4 Field Strength of Unwanted Spurious Radiation

10.4.1 Test Procedures

Radiated emission measurements in the Restricted bands were performed with linearly polarized broadband antennas. The results obtained with these antennas can be correlated with results obtained with a tuned dipole antenna. A 10 dB linearity check is performed prior to start of testing in order to determine if an overload condition exists. From 30 to 4700 MHz, a spectrum analyzer with a preselector was used for measurement. Radiated emissions measurements were performed at the anechoic chamber at a test distance of 3 meters. The entire frequency range from 30 to 4700 MHz was slowly scanned and the emissions in the restricted frequency bands were recorded. Measurements were performed using the peak detector function.

The spectrum analyzer was adjusted for the following settings:

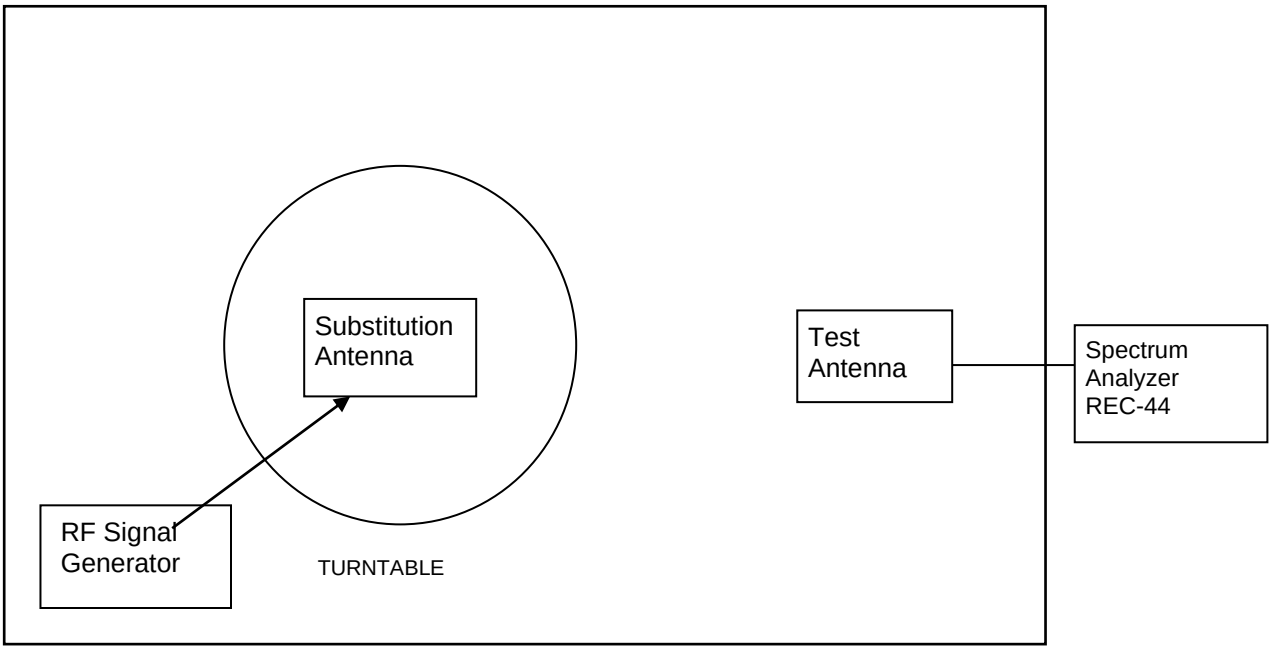
1) Resolution Bandwidth = 100 kHz for spurious emissions below 1 GHz, and 1 MHz for spurious emissions above 1 GHz.
2) Video Bandwidth = 300 kHz for spurious emissions below 1 GHz, and 3 MHz for spurious emissions above 1 GHz.
3) Sweep Speed slow enough to maintain measurement calibration.
4) Detector Mode = Positive Peak.

The transmitter to be tested was placed on the turntable in the standard test site, or an FCC listed site compliant with ANSI C63.4. The transmitter is transmitting into a non-radiating load that is placed on the turntable. Measurements were made from the lowest radio frequency generated in the equipment to the tenth harmonic of the carrier. The transmitter was keyed during the tests.

For each spurious frequency, the test antenna was raised and lowered from 1 m to 4m to obtain a maximum reading on the spectrum analyzer with the test antenna at horizontal polarity. Then the turntable was rotated 360°to determine the maximum reading. This procedure was repeated to obtain the highest possible reading. This maximum reading was recorded.

Each measurement was repeated for each spurious frequency with the test antenna polarized vertically.

Figure 1. Drawing of Radiated Emissions Setup



ANSI C63.4 Listed Test Site

Notes:
- Test Antenna height varied from 1 to 4 meters
- Distance from antenna to tested system is 3 meters
- Not to Scale

Frequency MHz	Test Antenna	Substitution Antenna	Receiver to Coupler	Signal Generator
30 - 200	ANT-80	ANT-79	REC-44	SIG-31
200 - 1000	ANT-07	ANT-06	REC-44	SIG-31
1000-5000	ANT-66	ANT-13	REC-44	SIG-31

The transmitter was removed and replaced with a broadband substitution antenna. The substitution antenna is calibrated so that the gain relative to a dipole is known. The center of the substitution antenna was approximately at the same location as the center of the transmitter.

The substitution antenna was fed at the transmitter end with a signal generator connected to the antenna by means of a non-radiating cable. With the antennas at both ends horizontally polarized, and with the signal generator tuned to a particular spurious frequency, the test antenna was raised and lowered to obtain a maximum reading at the spectrum analyzer. The level of the signal generator output was adjusted until the previously recorded maximum reading for this set of conditions was obtained.

The measurements were repeated with both antennas horizontally and vertically polarized for each spurious frequency.

The power in dBm into a was calculated by reducing the substitution readings obtained above by the loss in the cable between the generator and the antenna, and further corrected for the gain of the substitution antenna used relative to an ideal half-wave dipole antenna by the following formula:

Pd(dBm) = *Pg*(dBm) – *cable loss* (dB) + *antenna gain* (dB)

where:
Pd is the dipole equivalent power and
Pg is the generator output power into the substitution antenna.

10.4.2 Test Limits

Any emission must be attenuated below the power (P) of the highest emission contained within the authorized bandwidth as follows:

On any frequency removed from the center by more than 25 kHz, 30 dB.

10.4.3 Spurious Radiated Emissions Test Results

Model	GD6HD	Specification	FCC Part 90.217 RSS-119 Section 5.10
Serial Number	17121022	Test Date	06/28/2022
Test Distance	3 Meters	Notes	Transmit Mode
Test Personnel	Chris Dalessio		

	Tx							EUT	EUT		Margin
hrm	Freq	Equivalent Radiated power into Dipole (dBm)						Emission	Power	Limit	Under
#	MHz	X	Y	Z	X	Y	Z	MHz	dBm	dBm	Limit
1	464.55	7.3	16.3	19.7	15.8	17.9	10.2	464.6	19.7	20.8	1.1
2	464.55	-35.5	-39.9	-37.2	-36.8	-38.4	-40.1	929.1	-35.5	-10.3	25.2
3	464.55	-35.6	-32.2	-36.9	-36.6	-37.1	-40.9	1393.7	-32.2	-10.3	21.9
4	464.55	-41.5	-36.4	-44.8	-44.7	-39.6	-44.8	1858.2	-36.4	-10.3	26.1
5	464.55	-44.8	-43.0	-50.1	-46.8	-47.7	-48.8	2322.8	-43.0	-10.3	32.7
6	464.55	-34.1	-46.4	-25.2	-28.6	-25.3	-31.3	2787.3	-25.2	-10.3	14.9
7	464.55	-41.8	-24.3	-44.3	-47.0	-45.9	-43.9	3251.9	-24.3	-10.3	14.0
8	464.55	-42.0	-39.7	-41.3	-40.9	-44.7	-44.0	3716.4	-39.7	-10.3	29.4
9	464.55	-48.5	-43.0	-48.1	-49.2	-50.5	-51.7	4181.0	-43.0	-10.3	32.7
10	464.55	-45.3	-48.6	-45.2	-44.8	-45.5	-46.9	4645.5	-44.8	-10.3	34.5
1	469.50	3.7	15.2	19.4	15.8	18.0	11.1	469.5	19.4	20.8	1.4
2	469.50	-39.0	-38.3	-36.8	-36.8	-38.7	-39.4	939.0	-36.8	-10.6	26.2
3	469.50	-35.6	-32.8	-30.9	-31.4	-31.9	-36.2	1408.5	-30.9	-10.6	20.3
4	469.50	-45.9	-46.8	-44.7	-46.5	-41.5	-47.2	1878.0	-41.5	-10.6	30.9
5	469.50	-41.6	-42.1	-41.0	-39.2	-40.5	-42.1	2347.5	-39.2	-10.6	28.6
6	469.50	-27.1	-27.1	-24.1	-25.1	-24.4	-29.3	2817.0	-24.1	-10.6	13.5
7	469.50	-37.6	-37.3	-41.1	-40.8	-39.3	-39.5	3286.5	-37.3	-10.6	26.7
8	469.50	-46.3	-45.3	-42.9	-42.1	-46.8	-46.6	3756.0	-42.1	-10.6	31.5
9	469.50	-46.7	-47.6	-47.2	-45.9	-47.0	-50.7	4225.5	-45.9	-10.6	35.3
10	469.50	-38.4	-42.9	-37.5	-33.6	-40.3	-39.5	4695.0	-33.6	-10.6	23.0
Column Numbers											
1	2	3	4	5	6	7	8	9	10	11	12

Column #1. hrm = Harmonic
Column #2. Frequency of Transmitter.
Column #3. Equivalent power with First Axis Rotation (Vertical Receive Antenna).
Column #4. Equivalent power with Second Axis Rotation (Vertical Receive Antenna).
Column #5. Equivalent power with Third Axis Rotation (Vertical Receive Antenna).
Column #6. Equivalent power with First Axis Rotation (Horizontal Receive Antenna).
Column #7. Equivalent power with Second Axis Rotation (Horizontal Receive Antenna).

Column #8. Equivalent power with Third Axis Rotation (Horizontal Receive Antenna).
Column #9. Frequency of Tested Emission
Column #10. Highest peak power at listed frequency.
Column #11. Power Limit.
Column #13. The margin (last column) is the worst-case margin for that row.

Note that the fundamental is for reference only. The fundamental passed the direct conducted emissions limits as shown in section 10.1 herein.

Non-Harmonic frequencies

Freq MHz	Detector	Ant Pol	EUT dBm	Limit dBm	Margin dB
33.9	P	H	-55.4	-10.6	44.8
95.2	P	H	-54.4	-10.6	43.8
133.9	P	H	-54.3	-10.6	43.7
149.9	P	H	-50.6	-10.6	40.0
196.9	P	H	-50.7	-10.6	40.1
202.4	P	H	-54.5	-10.6	43.9
397.5	P	H	-57.4	-10.6	46.8
488.9	P	H	-55.1	-10.6	44.5
543.8	P	H	-55.0	-10.6	44.4
760.0	P	H	-51.6	-10.6	41.0
973.8	P	H	-47.8	-10.6	37.2
2156.8	P	H	-55.7	-10.6	45.1
2527.0	P	H	-54.0	-10.6	43.4
3274.8	P	H	-49.3	-10.6	38.7
3752.3	P	H	-46.7	-10.6	36.1
4385.3	P	H	-47.1	-10.6	36.5
35.5	P	V	-54.2	-10.6	43.6
93.0	P	V	-54.5	-10.6	43.9
121.7	P	V	-57.4	-10.6	46.8
187.5	P	V	-56.9	-10.6	46.3
247.1	P	V	-55.2	-10.6	44.6
390.6	P	V	-57.1	-10.6	46.5
638.8	P	V	-53.3	-10.6	42.7
703.8	P	V	-52.1	-10.6	41.5
787.5	P	V	-51.2	-10.6	40.6
982.5	P	V	-48.2	-10.6	37.6
1847.7	P	V	-56.5	-10.6	45.9
2300.1	P	V	-55.7	-10.6	45.1
3747.5	P	V	-47.2	-10.6	36.6
4570.7	P	V	-48.8	-10.6	38.2

No other radiated emissions were detected within 15 dB of the limits from 30 MHz to 4.7 GHz.

Judgment: Passed by at least 13 dB.

10.5 Frequency Stability

10.5.1 Frequency Stability Vs Temperature

The chamber was then set to the lowest temperature. The transmitter was in the chamber and allowed to stabilize for 15 minutes. The transmitter was then keyed, and the frequency was recorded. The chamber was then incremented in 10°C steps with a minimum of 15-minute stabilization period for each temperature measurement. The transmitter was off during the temperature transitions.

10.5.2 Frequency Stability Vs Supply Voltage

The EUT was allowed to stabilize with the nominal primary power supply voltage applied. The primary input voltage was varied from the lowest to the highest rated levels specified by the manufacturer. Frequency readings were taken at increments of 0.2 VDC, tested to Battery End point.

10.5.3 Test Results for Frequency Stability

Model	GD6HD	Specification	FCC Part 90.213 RSS-119 Section 5.3
Serial Number	17121022	Test Date	6/22/2022
Test Personnel	Joseph Strzelecki	Test Location	Station F
Test Equipment	Spectrum Analyzer (REC-44); Temperature Chamber TC-01; Digital Multimeter (DMM-09)		
Notes	15 minutes at each Temperature; 1 min at each voltage		
Nominal Frequency	460.000 MHz		

Volts	Freq.	Nominal Freq:	Deviation	
VDC	(MHz)	at 9 VDC	Hz	PPM
10.0	469.550156	469.550154	2	0.004
9.5	469.550155	469.550154	1	0.002
9.0	469.550154	469.550154	0	0.000
8.5	469.550153	469.550154	-1	-0.002
8.0	469.550147	469.550154	-7	-0.015
7.5	469.550140	469.550154	-14	-0.030
7.0	469.550125	469.550154	-29	-0.062
6.5	469.550120	469.550154	-34	-0.07
6.4	469.550100	469.550154	-54	-0.12
6.0	469.550449	469.550154	295	0.63

Temp	Measured Freq	Nominal Freq:	Deviation	
Deg C	(MHz)	at 20 Deg C	Hz	PPM
50	469.550476	469.550154	322	0.69
40	469.550278	469.550154	124	0.26
30	469.550140	469.550154	-14	-0.03
22.2	469.550154	469.550154	0	0.00
20	469.550126	469.550154	-28	-0.06
10	469.550111	469.550154	-43	-0.09
0	469.550274	469.550154	120	0.26
-10	469.550260	469.550154	106	0.23
-20	469.550254	469.550154	100	0.21

Test Requirements: None

These tests were performed in order to know the frequency stability for the Emissions mask requirement. Since the total of both results is less than 1000 Hz, 1 kHz was subtracted from each side the emissions mask as shown in section 10.2 herein. This made the mask more stringent.

Judgement: Pass

10.5.4 Measurement Instrumentation Uncertainty

Measurement	Uncertainty
Radiated Emissions, E-field, 3 meters, 30 to 200 MHz	4.7 dB
Radiated Emissions, E-field, 3 meters, 200 to 1000 MHz	6.2 dB
Radiated Emissions, E-field, 3 meters, 1 to 6 GHz	5.0 dB
99% Occupied Bandwidth	1% of frequency span
Conducted power REC-44 at 460 MHz	0.8 dB
Amplitude measurement 1-5000 MHz	1.5 dB
Temperature THM-02	0.6 Deg C

The uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k=2 in accordance with CISPR 16-4-2.

11.0 REVISION HISTORY

Document RP-9656 Revisions:			
Rev.	Affected Sections	Description	Rationale
1	Cover	Update address	Address must match FCC's records
1	Cover, 1, 2, 3, 4.1	Change Boring Head Locator to Horizontal Directional Drill Tracking System	Corrected name of EUT