FCC PART 15.247
TEST REPORT

For

ESPRESSIF SYSTEMS (SHANGHAI) PTE LTD

456 Bibo Road Room A201, Shanghai, China

FCC ID: 2AC7Z-ESPWROOM32

Report Type:	**Product Type:**
Original Report	WIFI &Bluetooth Module

Test Engineer:	Peter Jiang
Report Number:	RKS161017001-00A
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Reviewed By:	Jesse Huang EMC Manager
Prepared By:	Bay Area Compliance Laboratories Corp. (Kunshan) Chenghu Road,Kunshan Development Zone No.248,Kunshan, Jiangsu, China Tel: +86-0512-86175000 Fax: +86-0512-88934268 www.baclcorp.com.cn

Note: This test report is prepared for the customer shown above and for the equipment described herein. It may not be duplicated or used in part without prior written consent from Bay Area Compliance Laboratories Corp.

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GENERAL INFORMATION

Product Description for Equipment under Test (EUT)

The ESPRESSIF SYSTEMS (SHANGHAI) PTE LTD's product, model number: ESP-WROOM-32 (FCC ID: 2AC7Z-ESPWROOM32) or the "EUT" in this report was a WIFI &Bluetooth Module, which was measured approximately:18mm(L)×25.5mm(W)×2.8 mm(H), rated input voltage: DC 3.3V.

** All measurement and test data in this report was gathered from production sample serial number: 20161012001.*

(Assigned by BACL, Kunshan). The EUT was received on 2016-10-12.

Objective

This test report is prepared on behalf of ESPRESSIF SYSTEMS (SHANGHAI) PTE LTD in accordance with Part 2-Subpart J, Part 15-Subparts A, B and C of the Federal Communication Commissions rules.

The tests were performed in order to determine compliance with FCC Part 15, Subpart C, section 15.203, 15.205, 15.207, 15.209 and 15.247 rules.

Related Submittal(s)/Grant(s)

Part 15.247 DTS submissions with FCC ID: 2AC7Z-ESPWROOM32.

Test Methodology

All measurements contained in this report were conducted with ANSI C63.10-2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices and DA 00-705 March 30, 2000.

All emissions measurement was performed and Bay Area Compliance Laboratories Corp. (Kunshan). The radiated testing was performed at an antenna-to-EUT distance of 3 meters.

Measurement uncertainty with radiated emission is 5.91 dB for 30MHz-1GHz, and 4.92 dB for above 1GHz, 1.85dB for conducted measurement.

Test Facility

The test site used by Bay Area Compliance Laboratories Corp. (Kunshan) to collect test data is located on the Chenghu Lake Road, Kunshan Development Zone No.248,Kunshan, Jiangsu, China

Test site at Bay Area Compliance Laboratories Corp. (Kunshan) has been fully described in reports submitted to the Federal Communication Commission (FCC). The details of these reports have been found to be in compliance with the requirements of Section 2.948 of the FCC Rules on November 06, 2014. The facility also complies with the radiated and AC line conducted test site criteria set forth in ANSI C63.4.

The Federal Communications Commission has the reports on file and is listed under FCC Registration No.: 815570. The test site has been approved by the FCC for public use and is listed in the FCC Public Access Link (PAL) database.

SYSTEM TEST CONFIGURATION

Description of Test Configuration

The system was configured for testing in an engineering mode which was controlled by the software.

EUT Exercise Software

SecureCRT

GFSK :Power level 8
π /4-DQPSK :Power level 8
8DPSK :Power level 8

Special Accessories

No special accessory.

Equipment Modifications

No modification was made to the EUT tested.

Support Equipment List and Details

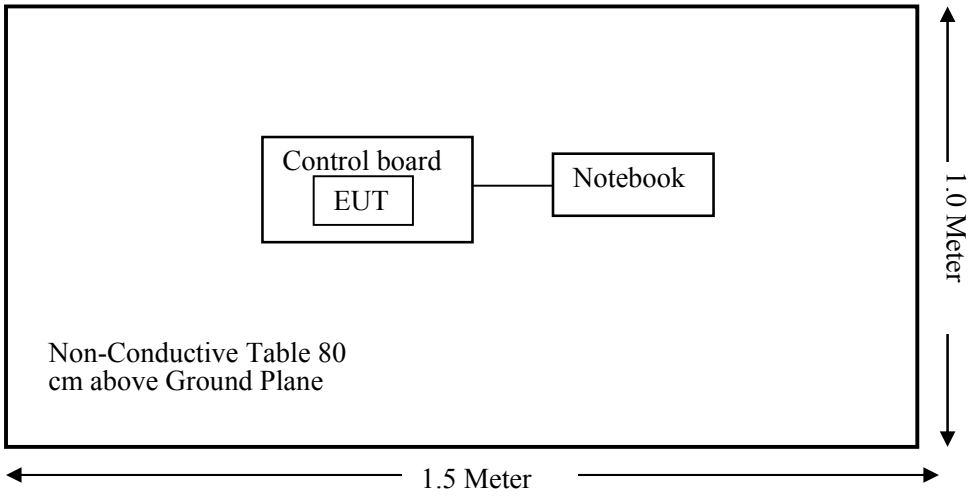
Manufacturer	Description	Model	Serial Number
/	Controlboard	ESP-WROOM-32	/
DELL	Notebook	GX620	D65874152

External I/O Cable

Cable Description	Shielding Type	Length (m)	From Port	To
Power Cable	Un-shielding	1.0	EUT	Notebook

Block Diagram of Test Setup

For Radiated Emissions (Below 1 GHz):



SUMMARY OF TEST RESULTS

FCC Rules	Description of Test	Result
§15.247 (i), §1.1310 & §2.1091	MAXIMUM PERMISSIBLE EXPOSURE (MPE)	Compliance
§15.203	Antenna Requirement	Compliance
§15.207(a)	AC Line Conducted Emissions	Compliance
§15.205, §15.209 & §15.247(d)	Radiated Emissions	Compliance
§15.247(a)(1)	20 dB Emission Bandwidth	Compliance
§15.247(a)(1)	Channel Separation Test	Compliance
§15.247(a)(1)(iii)	Time of Occupancy (Dwell Time)	Compliance
§15.247(a)(1)(iii)	Quantity of hopping channel Test	Compliance
§15.247(b)(1)	Peak Output Power Measurement	Compliance
§15.247(d)	Band edges	Compliance

FCC§15.247 (i), §1.1310& §2.1091 –MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Applicable Standard

According to subpart 15.247(i)and subpart §1.1310, systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy level in excess of the Commission's guidelines.

Limits for Maximum Permissible Exposure (MPE) (§1.1310, §2.1091)

(B) Limits for General Population/Uncontrolled Exposure				
Frequency Range (MHz)	**Electric Field Strength (V/m)**	**Magnetic Field Strength (A/m)**	**Power Density (mW/cm²)**	**Averaging Time (minutes)**
0.3-1.34	614	1.63	*(100)	30
1.34-30	824/f	2.19/f	*(180/f²)	30
30-300	27.5	0.073	0.2	30
300-1500	/		f/1500	30
1500-100,000	/		1.0	30

f = frequency in MHz; * = Plane-wave equivalent power density;

According to §1.1310 and §2.1091 RF exposure is calculated.

Calculated Formulary:
Predication of MPE limit at a given distance
$S = PG/4\pi R^2$ = power density (in appropriate units, e.g. mW/cm^2);
P = power input to the antenna (in appropriate units, e.g., mW);
G = power gain of the antenna in the direction of interest relative to an isotropic radiator, the power gain factor, is normally numeric gain;
R = distance to the center of radiation of the antenna (appropriate units, e.g., cm);

Measurement Result

Worst case EDR(8DPSK):

Model	Frequency (MHz)	Antenna Gain		Output Power		Distance (cm)	Power Density (mW/cm^2)	MPE Limit (mW/cm^2)
		(dBi)	(numeric)	(dBm)	(mW)			
EDR (8DPSK)	2441	2.0	1.58	8.00	6.31	20	0.0020	1.0

Note: The target power :6±2dBm, which declared by the Manufacturer.

Result: The device meet FCC MPE at 20 cm distance.

FCC §15.203 – ANTENNA REQUIREMENT

Applicable Standard

According to FCC § 15.203, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this Section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

Antenna Connector Construction

The EUT has a PCB antenna arrangement for Bluetooth, which the antenna gain is 2 dBi, fulfill the requirement of this section. Please refer to the EUT photos.

Result: Compliance.

FCC §15.207 (a) – AC LINE CONDUCTED EMISSIONS

Applicable Standard

FCC §15.207(a)

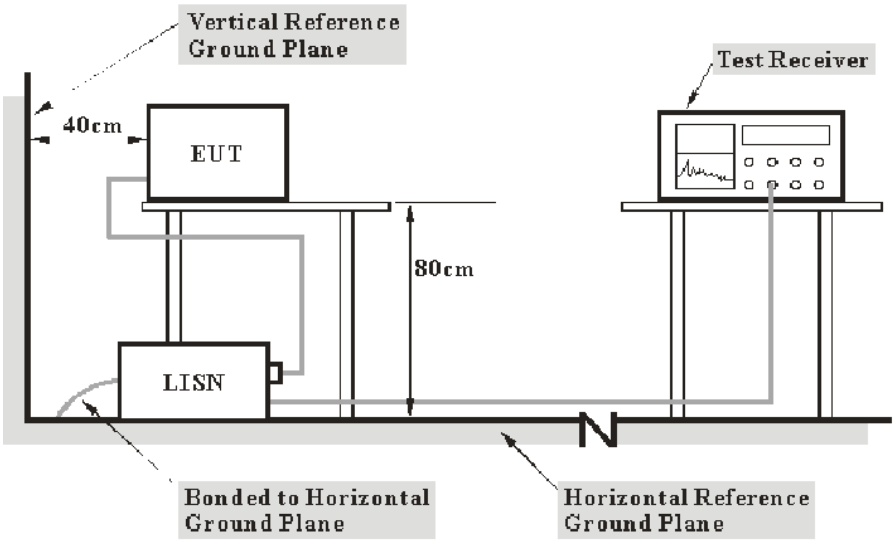
Measurement Uncertainty

Input quantities to be considered for conducted disturbance measurements maybe receiver reading, attenuation of the connection between LISN and receiver, LISN voltage division factor, LISN VDF frequency interpolation and receiver related input quantities, etc.

Based on CISPR 16-4-2, the expended combined standard uncertainty of conducted disturbance test at Bay Area Compliance Laboratories Corp. (Kunshan) is shown as below. And the uncertainty will not be taken into consideration for the test data recorded in the report.

Port	Expanded Measurement uncertainty
AC Mains	3.26 dB (k=2, 95% level of confidence)
CAT 3	3.70 dB (k=2, 95% level of confidence)
CAT 5	3.86 dB (k=2, 95% level of confidence)
CAT 6	4.64 dB (k=2, 95% level of confidence)

EUT Setup



Note: 1. Support units were connected to second LISN.
2. Both of LISNs (AMN) 80 cm from EUT and at the least 80 cm from other units and other metal planes support units.

The measurement procedure of EUT setup is according with ANSI C63.10-2013. The related limit was specified in FCC Part 15.207.

The adapter was connected to a 120 VAC/60 Hz power source.

EMI Test Receiver Setup

The EMI test receiver was set to investigate the spectrum from 150 kHz to 30 MHz.

During the conducted emission test, the EMI test receiver was set with the following configurations:

Frequency Range	IF B/W
150 kHz – 30 MHz	9 kHz

Test Procedure

During the conducted emission test, the adapter was connected to the outlet of the LISN.

Maximizing procedure was performed on the six (6) highest emissions of the EUT.

All final data was recorded in the Quasi-peak and average detection mode.

Test Equipment List and Details

Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Due Date
Rohde & Schwarz	EMI Test Receiver	ESCS30	934115/007	2015-11-12	2016-11-11
Rohde & Schwarz	LISN	ESH3-Z5	862770/011	2015-11-12	2016-11-11
Rohde & Schwarz	LISN	ESH3-Z5	892239/018	2016-07-04	2017-07-03
Rohde & Schwarz	Pulse limiter	ESH3-Z2	879940/005 8	2016-06-19	2017-06-18
HP	Current probe	8710-1744	636	2016-06-19	2017-06-18
FCC	ISN	FCC-TLISN-T8-02	20376	2016-06-23	2017-06-22
MICRO-COAX	Coaxial line	UFB-293B-1-0480-50X50	97F0173	2016-10-01	2017-10-01
Rohde & Schwarz	CE Test software	EMC 32	V 09.10.0	--	--

*** Statement of Traceability:** Bay Area Compliance Laboratories Corp. (Kunshan) attests that all calibrations have been performed in accordance to requirements that traceable to National Primary Standards and International System of Units (SI).

Corrected Factor & Margin Calculation

The Corrected factor is calculated by adding LISN VDF (Voltage Division Factor), Cable Loss and Transient Limiter Attenuation. The basic equation is as follows:

Correction Factor = LISN VDF + Cable Loss + Transient Limiter Attenuation

The "**Margin**" column of the following data tables indicates the degree of compliance with the applicable limit. For example, a margin of 7 dB means the emission is 7 dB below the limit. The equation for margin calculation is as follows:

Margin = Limit – Corrected Amplitude

Test Results Summary

According to the recorded data in following table, the EUT complied with the FCC Part 15.207, the worst margin reading as below:

13.70dB at 0.185000MHz in the **Neutral** conducted mode

Refer to CISPR16-4-2and CISPR 16-4-1, the measured level complies with the limit if

$$L_m + U_{(Lm)} \leq L_{lim} + U_{cispr}$$

In BACL, $U_{(Lm)}$ is less than U_{cispr}, if L_m is less than L_{lim}, it implies that the EUT complies with the limit.

Test Data

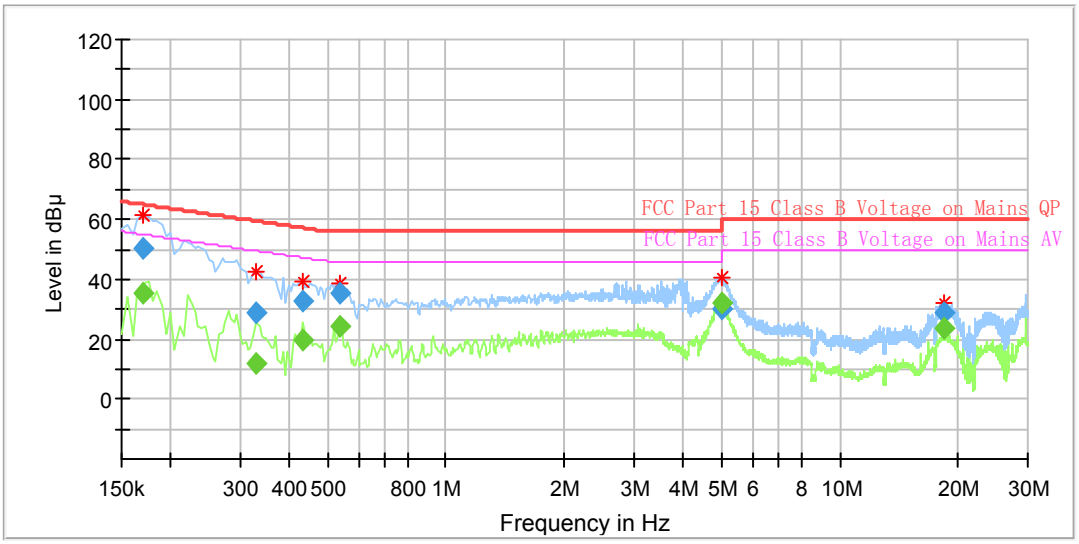
Environmental Conditions

Temperature:	27 ℃
Relative Humidity:	56 %
ATM Pressure:	101.0 kPa

The testing was performed by Peter Jiang on 2016-11-09.

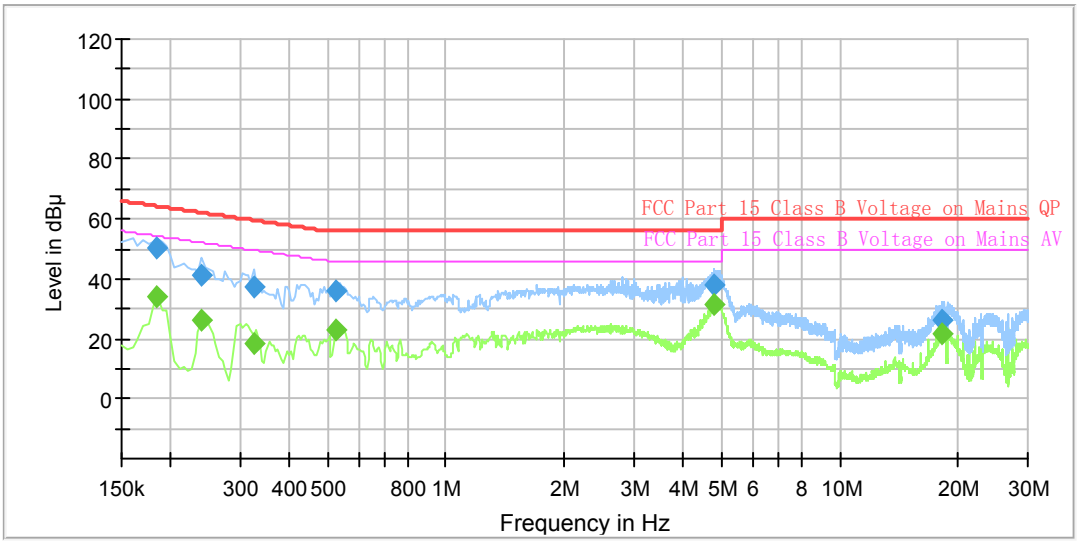
EUT operation mode: Transmitting (Worst case)

AC 120V/60 Hz, Line



Frequency (MHz)	QuasiPeak (dBµV)	Average (dB µ V)	Bandwidth (kHz)	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)	Comment
0.170000	---	35.04	9.000	L1	10.3	19.92	54.96	Compliance
0.170000	50.56	---	9.000	L1	10.3	14.40	64.96	Compliance
0.330000	---	11.80	9.000	L1	10.3	37.65	49.45	Compliance
0.330000	29.04	---	9.000	L1	10.3	30.41	59.45	Compliance
0.435000	---	19.65	9.000	L1	10.3	27.51	47.16	Compliance
0.435000	33.06	---	9.000	L1	10.3	24.10	57.16	Compliance
0.535000	---	24.47	9.000	L1	10.3	21.53	46.00	Compliance
0.535000	35.50	---	9.000	L1	10.3	20.50	56.00	Compliance
4.990000	---	32.07	9.000	L1	10.5	13.93	46.00	Compliance
4.990000	29.82	---	9.000	L1	10.5	26.18	56.00	Compliance
18.340000	---	23.95	9.000	L1	10.5	26.05	50.00	Compliance
18.340000	28.53	---	9.000	L1	10.5	31.47	60.00	Compliance

AC 120V/60 Hz, Neutral



Frequency (MHz)	QuasiPeak (dBµV)	Average (dB µ V)	Bandwidth (kHz)	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)	Comment
0.185000	---	34.14	9.000	N	10.3	20.12	54.26	Compliance
0.185000	50.56	---	9.000	N	10.3	13.70	64.26	Compliance
0.240000	---	26.55	9.000	N	10.3	25.55	52.10	Compliance
0.240000	41.22	---	9.000	N	10.3	20.88	62.10	Compliance
0.325000	---	18.36	9.000	N	10.3	31.22	49.58	Compliance
0.325000	37.07	---	9.000	N	10.3	22.51	59.58	Compliance
0.525000	---	23.02	9.000	N	10.3	22.98	46.00	Compliance
0.525000	36.19	---	9.000	N	10.3	19.81	56.00	Compliance
4.805000	---	31.38	9.000	N	10.6	14.62	46.00	Compliance
4.805000	37.70	---	9.000	N	10.6	18.30	56.00	Compliance
18.080000	---	21.74	9.000	N	10.5	28.26	50.00	Compliance
18.080000	26.19	---	9.000	N	10.5	33.81	60.00	Compliance

Note:
1) Corr.=LISN VDF (Voltage Division Factor) + Cable Loss
2) Corrected Amplitude = Reading + Corr.
3) Margin = Limit –Corrected Amplitude

FCC §15.205, §15.209 & §15.247(d) – RADIATED EMISSIONS

Applicable Standard

FCC §15.205; §15.209; §15.247(d)

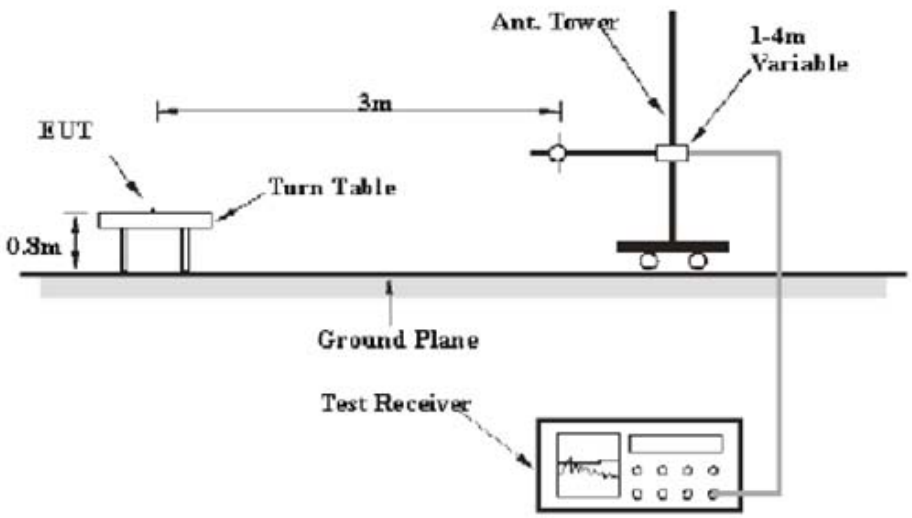
Measurement Uncertainty

All measurements involve certain levels of uncertainties, especially in field of EMC. The factors contributing to uncertainties are spectrum analyzer, cable loss, antenna factor calibration, antenna directivity, antenna factor variation with height, antenna phase center variation, antenna factor frequency interpolation, measurement distance variation, site imperfections, mismatch (average), and system repeatability.

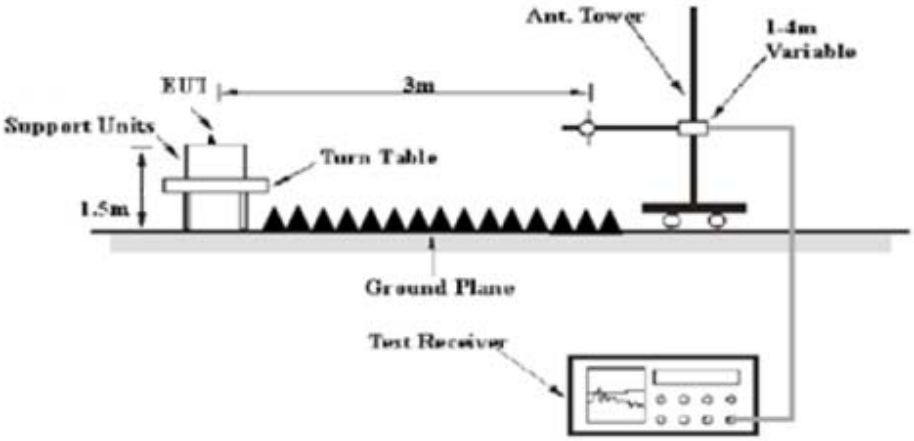
Based on CISPR 16-4-2, the expended combined standard uncertainty of radiation emissions at Bay Area Compliance Laboratories Corp. (Kunshan) is 5.91 dB for 30MHz-1GHz, and 4.92 dB for above 1GHz. And this uncertainty will not be taken into consideration for the test data recorded in the report.

EUT Setup

Below 1 GHz:



Above 1GHz:



The radiated emission tests were performed in the 3 meters, using the setup accordance with the ANSI C63.10-2013. The specification used was the FCC 15.209 and FCC 15.247 limits.

The adapter was connected to a 120 VAC/60 Hz power source.

EMI Test Receiver & Spectrum Analyzer Setup

The system was investigated from 30 MHz to 25 GHz.

During the radiated emission test, the EMI test receiver & Spectrum Analyzer Setup were set with the following configurations:

Frequency Range	RBW	Video B/W	IF B/W	Detector
30 MHz – 1000 MHz	100 kHz	300 kHz	120 kHz	QP
Above 1 GHz	1 MHz	3 MHz	/	PK
	1 MHz	10 Hz	/	Ave.

Test Procedure

Maximizing procedure was performed on the highest emissions to ensure that the EUT complied with all installation combinations.

All final data was recorded in Quasi-peak detection mode for frequency range of 30 MHz -1 GHz and peak and Average detection modes for frequencies above 1 GHz.

Corrected Amplitude & Margin Calculation

The Corrected Amplitude is calculated by adding the Antenna Factor and Cable Loss, and subtracting the Amplifier Gain from the Meter Reading. The basic equation is as follows:

Corrected Amplitude = Meter Reading + Antenna Factor + Cable Loss - Amplifier Gain

The "**Margin**" column of the following data tables indicates the degree of compliance with the applicable limit. For example, a margin of 7dB means the emission is 7dB below the limit. The equation for margin calculation is as follows:

Margin = Limit – Corrected Amplitude

Test Equipment List and Details

Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Due Date
Sonoma Instrunent	Amplifier	330	171377	2016-10-21	2017-10-21
Rohde & Schwarz	EMI Test Receiver	ESCI	100195	2016-11-12	2017-11-11
Sunol Sciences	Broadband Antenna	JB3	A090314-2	2016-01-09	2019-01-08
ETS	Horn Antenna	3115	6229	2016-11-07	2017-11-06
EMCO	Horn Antenna	3116	9510-2384	2016-11-07	2017-11-06
Rohde & Schwarz	Signal Analyzer	FSV40	101116	2016-07-04	2017-07-03
Mini	Pre-amplifier	ZVA-183-S+	857001418	2016-09-16	2017-09-15
DUCOMMUN	Pre-amplifier	ALN-22093530-01	990147	2016-09-17	2017-09-16
champrotek	Chamber	Chamber A	1#	/	/
R&S	Auto test Software	EMC32	V 09.10.0	2015-12-16	2016-12-15
BACL	RF cable	KS-LAB-012	KS-LAB-012	2015-12-16	2016-12-15
BACL	RF cable	KS-LAB-010	KS-LAB-010	2016-09-16	2017-09-15

*** Statement of Traceability:** Bay Area Compliance Laboratories Corp. (Kunshan) attests that all calibrations have been performed in accordance to requirements that traceable to National Primary Standards and International System of Units (SI).

Test Results Summary

According to the recorded data in following table, the EUT complied with the FCC Title 47, Part 15, Subpart C, section 15.205, 15.209 and 15.247.

6.52dB at **559.988250 MHz** in the **Horizontal** polarization

Refer to CISPR16-4-2 and CISPR 16-4-1, the measured level complies with the limit if

$$L_m ++ \ U_{(Lm)} \leq L_{lim} ++ \ U_{cispr}$$

In BACL, $U_{(Lm)}$ is less than + U_{cispr}, if L_m is less than L_{lim}, it implies that the EUT complies with the limit.

Test Data

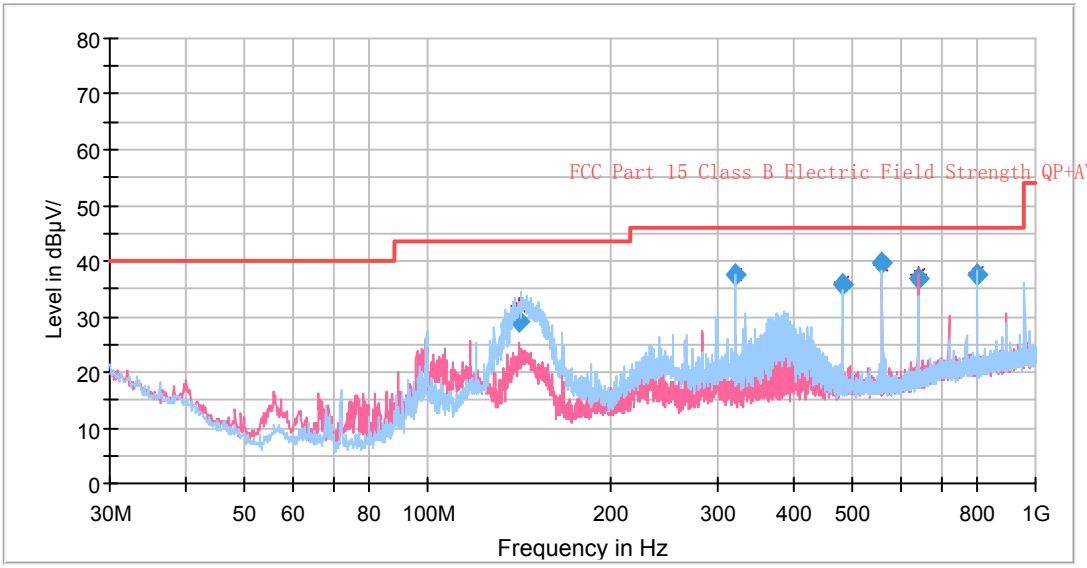
Environmental Conditions

Temperature:	27 ℃
Relative Humidity:	56 %
ATM Pressure:	101.0 kPa

The testing was performed by Peter Jiang on 2016-11-09.

EUT operation mode: Normal operation

30MHz-1GHz:



Frequency (MHz)	Receiver		Turntable Degree	Rx Antenna		Corrected Factor (dB)	Corrected Amplitude (dBµV/m)	FCC Part 15.247/205/209	
	Reading (dBµV)	Detector (PK/QP/Ave.)		Height (cm)	Polar (H/V)			Limit (dB µ V/m)	Margin (dB)
141.745850	41.26	QP	269	199	H	-12.0	29.26	43.5	14.24
320.000300	47.40	QP	110	101	H	-10.0	37.4	46	8.6
479.987600	41.85	QP	99	101	H	-6.2	35.65	46	10.35
559.988250	44.78	QP	218	199	H	-5.3	39.48	46	6.52
640.006650	40.79	QP	234	101	V	-4.1	36.69	46	9.31
799.989150	39.14	QP	349	101	H	-1.7	37.44	46	8.56

EUT operation mode: Transmitting

1GHz -25 GHz: (*Scan with GFSK, π/4-DQPSK, 8-DPSK mode, the worst case is BDR Mode (GFSK)*)

Frequency (MHz)	Receiver		Turntable Degree	Rx Antenna		Corrected Factor (dB)	Corrected Amplitude (dBμV/m)	FCC Part 15.247/205/209	
	Reading (dBμV)	Detector (PK/QP/Ave.)		Height (cm)	Polar (H/V)			Limit (dB μ V/m)	Margin (dB)
Low Channel (2402 MHz)									
2402.0	101.17	PK	91	102	V	-3.0	98.17	/	/
2402.0	96.62	Ave	91	102	V	-3.0	93.62	/	/
2402.0	97.98	PK	105	129	H	-3.0	94.98	/	/
2402.0	93.70	Ave	105	129	H	-3.0	90.70	/	/
2390.0	44.91	PK	141	124	V	-3.0	41.91	74	32.09
2390.0	33.83	Ave	141	124	V	-3.0	30.83	54	23.17
2400.0	46.95	PK	157	183	V	-3.0	43.95	74	30.05
2400.0	37.49	Ave	157	183	V	-3.0	34.49	54	19.51
1613.7	34.70	PK	70	212	H	-6.0	28.69	74	45.31
1613.7	30.66	Ave	70	212	H	-6.0	24.65	54	29.35
4804.0	31.85	PK	1	166	V	7.2	39.01	74	34.99
4804.0	23.94	Ave	1	166	V	7.2	31.10	54	22.90
7236.0	26.95	PK	326	137	H	16.0	42.95	74	31.05
7236.0	22.35	Ave	326	137	H	16.0	38.35	54	15.65
Frequency (MHz)	Receiver		Turntable Degree	Rx Antenna		Corrected Factor (dB)	Corrected Amplitude (dBμV/m)	FCC Part 15.247/205/209	
	Reading (dBμV)	Detector (PK/QP/Ave.)		Height (cm)	Polar (H/V)			Limit (dB μ V/m)	Margin (dB)
Middle Channel (2441MHz)									
2441.0	104.20	PK	215	128	V	-3.0	101.18	/	/
2441.0	99.54	Ave	215	128	V	-3.0	96.52	/	/
2441.0	98.20	PK	294	138	H	-3.0	95.18	/	/
2441.0	94.16	Ave	294	138	H	-3.0	91.14	/	/
1477.0	42.16	PK	53	218	V	-7.0	35.18	74	38.82
1477.0	33.41	Ave	53	218	V	-7.0	26.43	54	27.57
1696.0	42.17	PK	197	156	H	-5.4	36.74	74	37.26
1696.0	35.49	Ave	197	156	H	-5.4	30.06	54	23.94
4882.0	34.07	PK	170	174	V	7.3	41.33	74	32.67
4882.0	29.98	Ave	170	174	V	7.3	37.24	54	16.76
6677.0	30.24	PK	299	133	H	13.8	44.03	74	29.97
6677.0	21.58	Ave	299	133	H	13.8	35.37	54	18.63
7323.0	27.87	PK	215	221	H	16.3	44.20	74	29.80
7323.0	22.99	Ave	215	221	H	16.3	39.32	54	14.68

Frequency (MHz)	Receiver		Turntable Degree	Rx Antenna		Corrected Factor (dB)	Corrected Amplitude (dBμV/m)	FCC Part 15.247/205/209	
	Reading (dBμV)	Detector (PK/QP/Ave.)		Height (cm)	Polar (H/V)			Limit (dB μ V/m)	Margin (dB)
High Channel (2480 MHz)									
2480.0	103.61	PK	91	203	V	-3.0	100.62	/	/
2480.0	99.45	Ave	91	203	V	-3.0	96.46	/	/
2480.0	99.03	PK	277	220	H	-3.0	96.04	/	/
2480.0	94.14	Ave	277	220	H	-3.0	91.15	/	/
2483.5	44.86	PK	1	197	V	-3.0	41.87	74	32.13
2483.5	31.53	Ave	1	197	V	-3.0	28.54	54	25.46
2563.0	46.11	PK	11	198	V	-2.6	43.51	74	30.49
2563.0	34.71	Ave	11	198	V	-2.6	32.11	54	21.89
4960.0	34.97	PK	281	221	H	14.0	48.97	74	25.03
4960.0	29.50	Ave	281	221	H	14.0	43.50	54	10.50
6681.0	29.78	PK	53	188	H	7.4	37.18	74	36.82
6681.0	23.86	Ave	53	188	H	7.4	31.26	54	22.74
7386.0	28.02	PK	120	206	H	19.8	47.82	74	26.18
7386.0	22.40	Ave	120	206	H	19.8	42.20	54	11.80

Note:
Corrected Factor = Antenna factor (RX) + Cable Loss – Amplifier Factor
Corrected Amplitude = Corrected Factor + Reading
Margin = Limit - Corrected. Amplitude

FCC §15.247(a) (1)-CHANNEL SEPARATION TEST

Applicable Standard

Frequency hopping systems shall have hoping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater provided the systems operate with an output power no greater than 125 mW.

Test Procedure

1. Set the EUT in transmitting mode, maxhold the channel.
2. Set the adjacent channel of the EUT and maxhold another trace.
3. Measure the channel separation.

Test Equipment List and Details

Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Due Date
Rohde & Schwarz	Signal Analyzer	FSV40	101116	2016-07-04	2017-07-03
BACL	RF cable	KS-LAB-012	KS-LAB-012	2015-12-16	2016-12-15

*** Statement of Traceability:** Bay Area Compliance Laboratories Corp. (Kunshan) attests that all calibrations have been performed in accordance to requirements that traceable to National Primary Standards and International System of Units (SI).

Test Data

Environmental Conditions

Temperature:	26 ℃
Relative Humidity:	55 %
ATM Pressure:	101.0 kPa

The testing was performed by Peter Jiang on 2016-11-09.

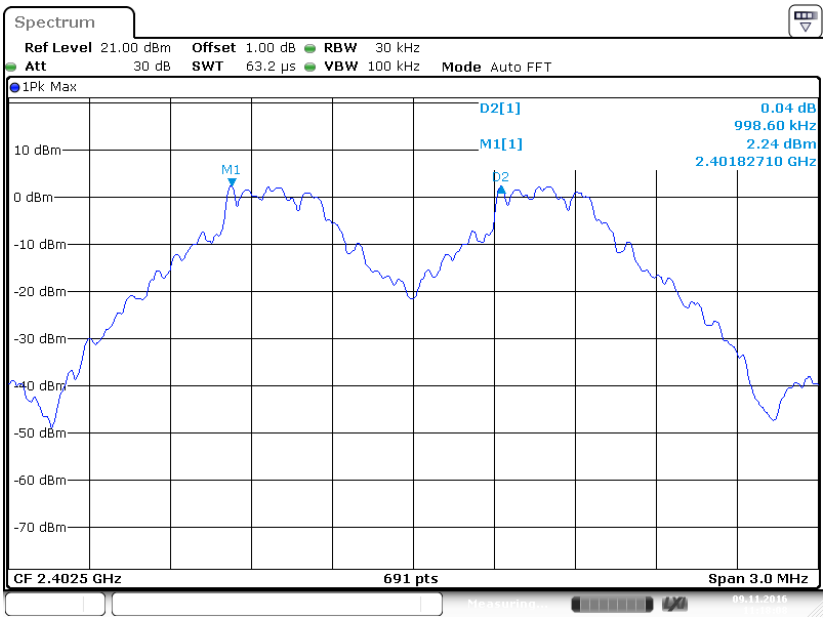
EUT operation mode: Transmitting

Test Result: Compliance. Please refer to following tables and plots

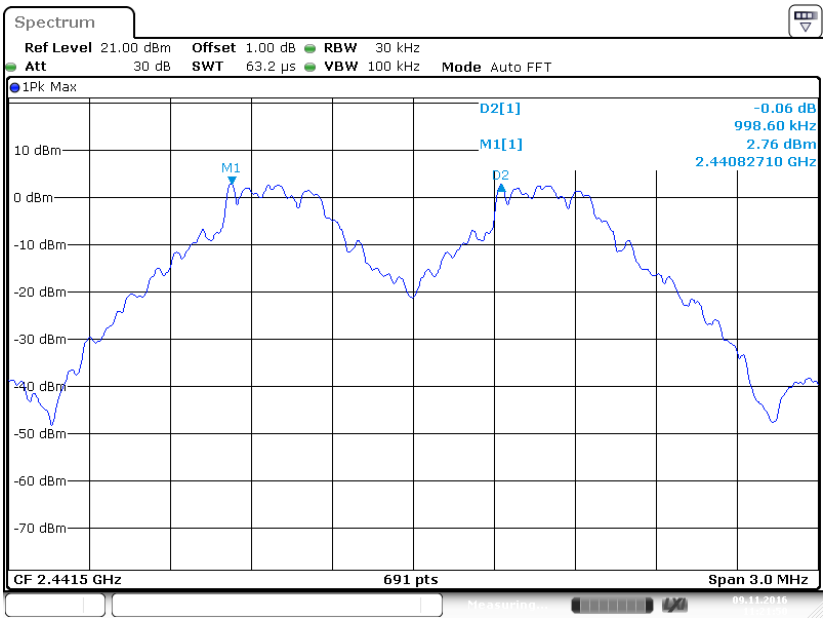
Mode	Channel	Frequency (MHz)	Channel Separation (MHz)	≥Limit (MHz)	Result
BDR (GFSK)	Low	2402	0.999	0.617	Pass
	Adjacent	2403			
	Middle	2441	0.999	0.619	Pass
	Adjacent	2442			
	High	2480	0.999	0.619	Pass
	Adjacent	2479			
EDR (π/4-DQPSK)	Low	2402	0.999	0.848	Pass
	Adjacent	2403			
	Middle	2441	0.999	0.854	Pass
	Adjacent	2442			
	High	2480	0.999	0.854	Pass
	Adjacent	2479			
EDR (8DPSK)	Low	2402	0.999	0.839	Pass
	Adjacent	2403			
	Middle	2441	0.999	0.839	Pass
	Adjacent	2442			
	High	2480	0.999	0.839	Pass
	Adjacent	2479			

Note: Limit = 20 dB bandwidth *2/3

BDR (GFSK): Low Channel

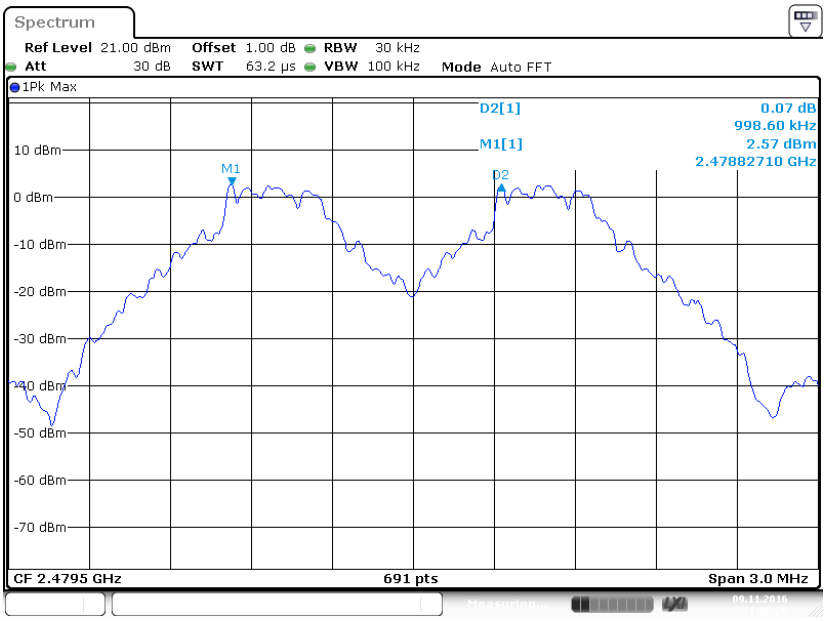


BDR (GFSK): Middle Channel



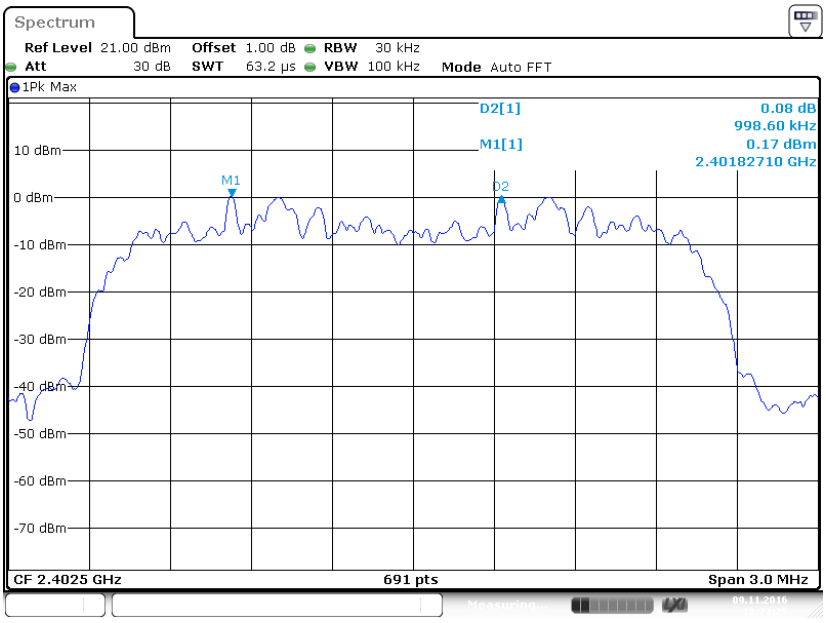
Date:9.NOV.2016 11:21:50

BDR (GFSK): High Channel



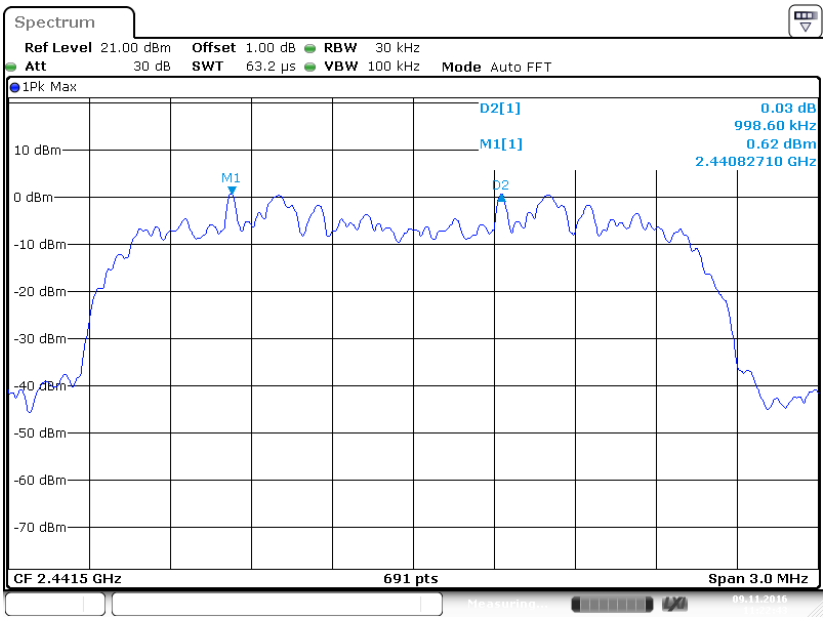
Date:9.NOV.2016 11:20:20

EDR (π/4-DQPSK): Low Channel



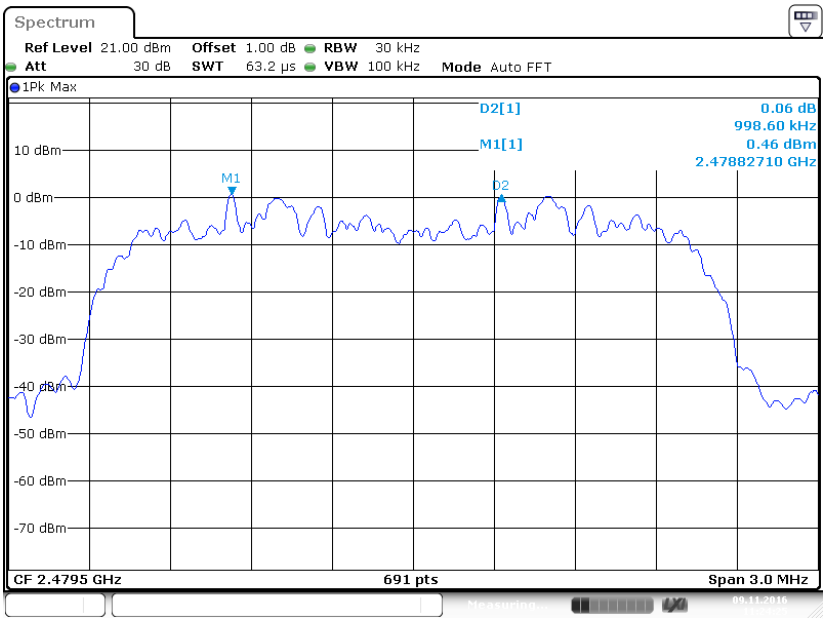
Date:9.NOV.2016 11:23:26

EDR (π/4-DQPSK): Middle Channel



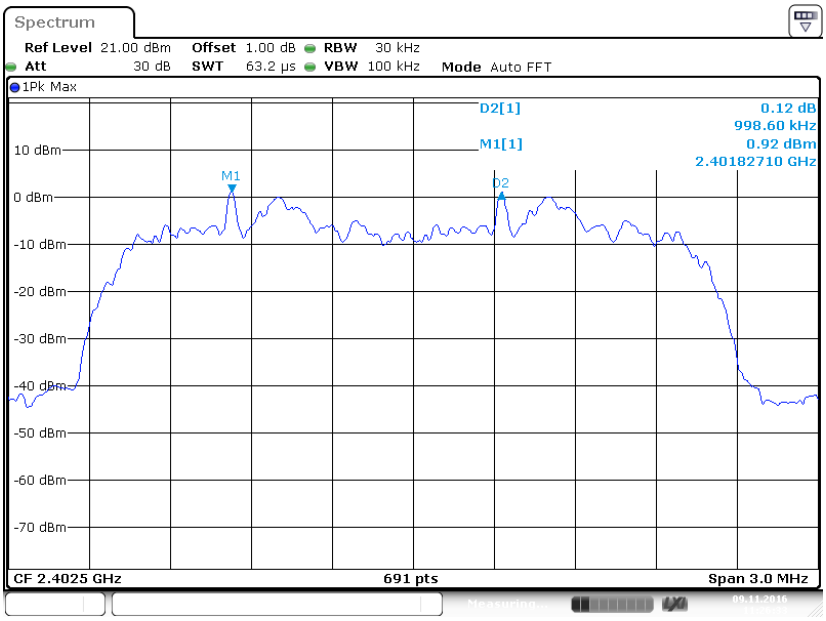
Date:9.NOV.2016 11:22:43

EDR (π/4-DQPSK): High Channel



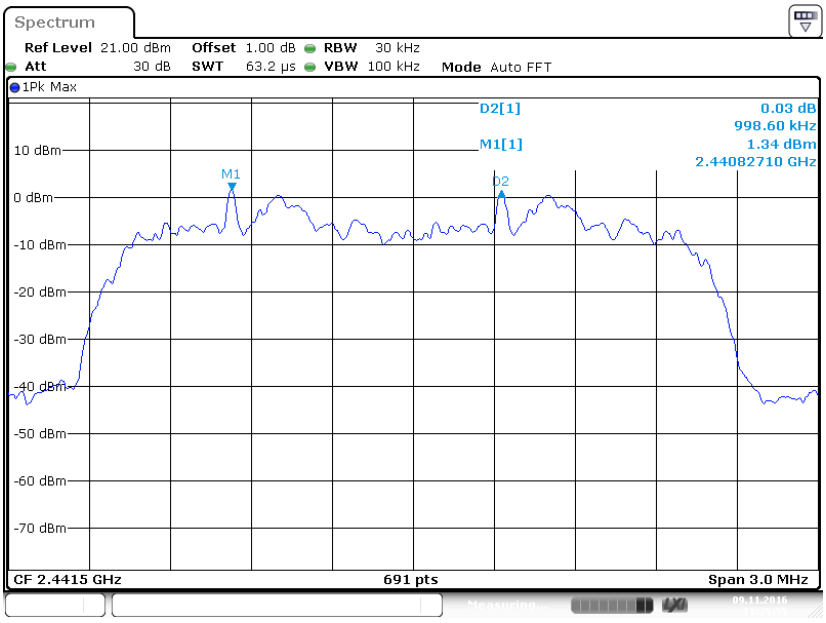
Date:9.NOV.2016 11:24:25

EDR (8DPSK): Low Channel



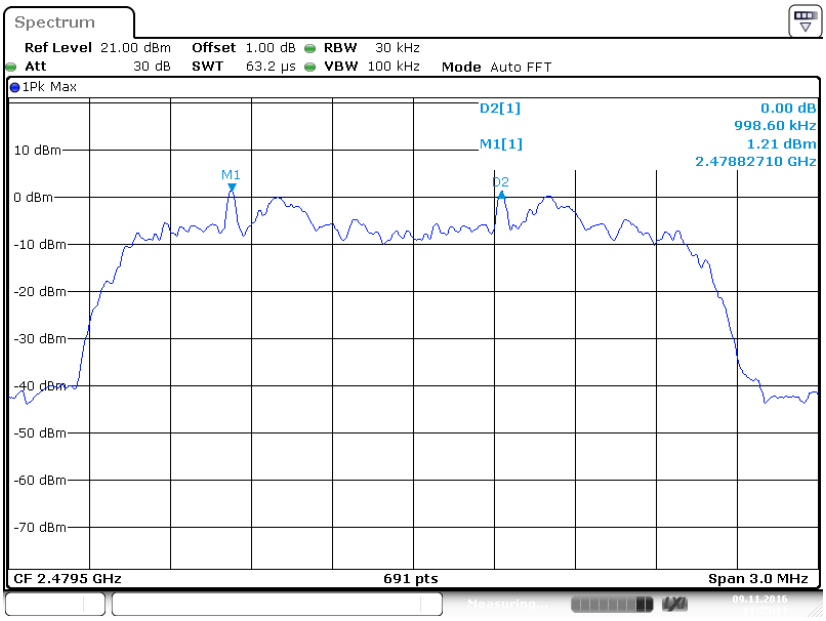
Date:9.NOV.2016 11:26:34

EDR (8DPSK): Middle Channel



Date:9.NOV.2016 11:25:54

EDR (8DPSK): High Channel



Date:9.NOV.2016 11:25:11

FCC §15.247(a) (1) – 20 dB EMISSION BANDWIDTH

Applicable Standard

Alternatively, frequency hopping systems operating in the 2400–2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

Test Procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Position the EUT without connection to measurement instrument. Turn on the EUT and connect it to measurement instrument. Then set it to any one convenient frequency within its operating range. Set a reference level on the measuring instrument equal to the highest peak value.
3. Measure the frequency difference of two frequencies that were attenuated 20 dB from the reference level. Record the frequency difference as the emission bandwidth.
4. Repeat above procedures until all frequencies measured were complete.

Test Equipment List and Details

Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Due Date
Rohde & Schwarz	Signal Analyzer	FSV40	101116	2016-07-04	2017-07-03
BACL	RF cable	KS-LAB-012	KS-LAB-012	2015-12-16	2016-12-15

*** Statement of Traceability:** Bay Area Compliance Laboratories Corp. (Kunshan) attests that all calibrations have been performed in accordance to requirements that traceable to National Primary Standards and International System of Units (SI).

Test Data

Environmental Conditions

Temperature:	26 ℃
Relative Humidity:	56 %
ATM Pressure:	101.0 kPa

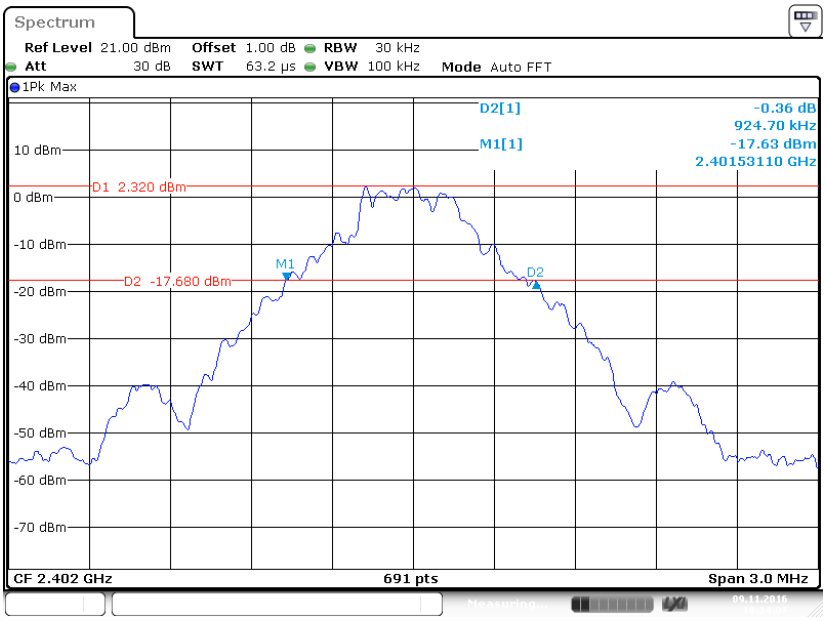
The testing was performed by Peter Jiang on 2016-11-09.

EUT operation mode: Transmitting

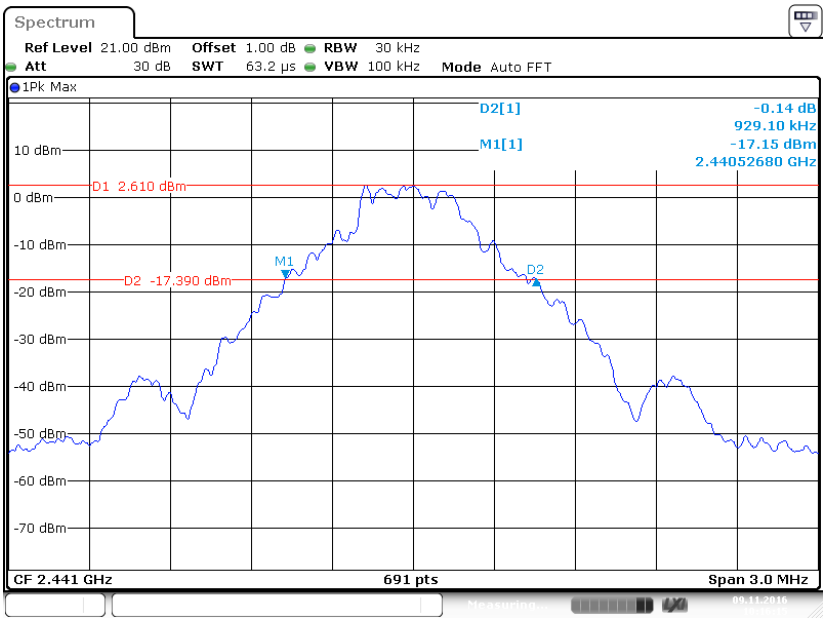
Test Result: Compliance. Please refer to following tables and plots

Mode	Channel	Frequency (MHz)	20 dB Emission Bandwidth (MHz)
BDR (GFSK)	Low	2402	0.925
	Middle	2441	0.929
	High	2480	0.929
EDR (π/4-DQPSK)	Low	2402	1.272
	Middle	2441	1.281
	High	2480	1.281
EDR (8DPSK)	Low	2402	1.259
	Middle	2441	1.259
	High	2480	1.259

BDR (GFSK): Low Channel

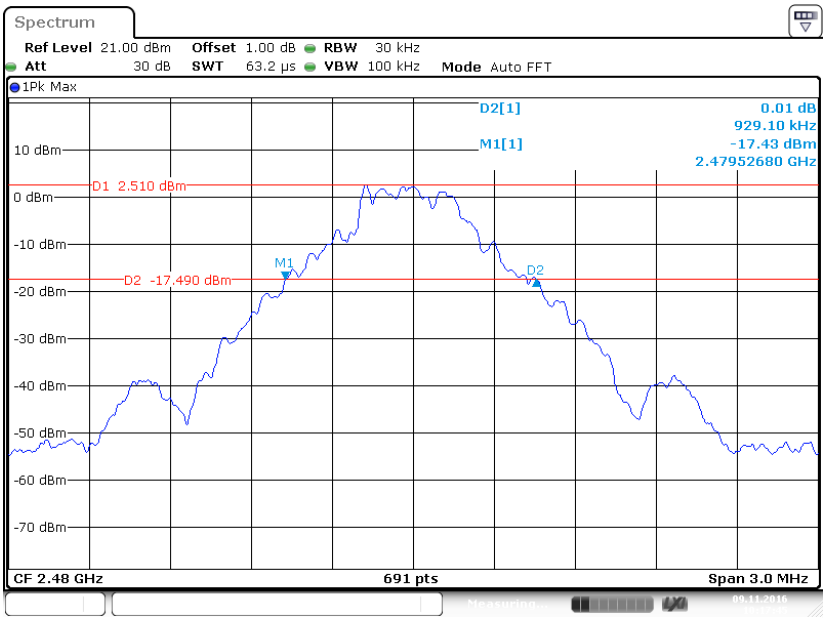


BDR (GFSK): Middle Channel



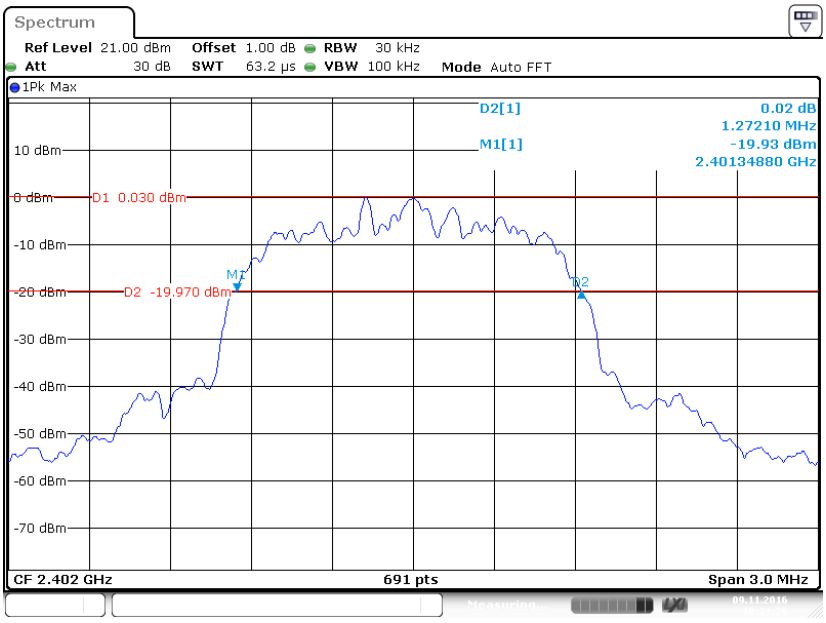
Date:9.NOV.2016 10:16:15

BDR (GFSK): High Channel



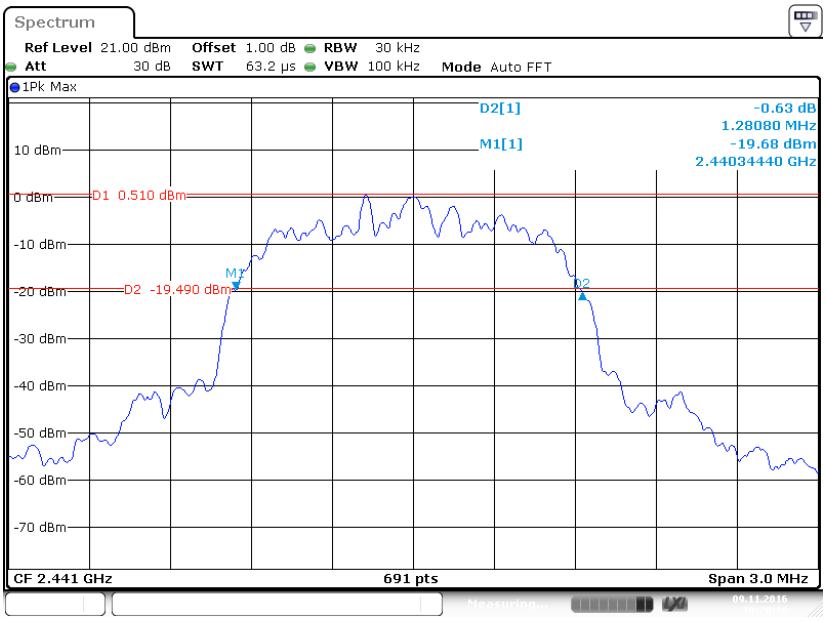
Date:9.NOV.2016 10:17:45

EDR (π/4-DQPSK): Low Channel



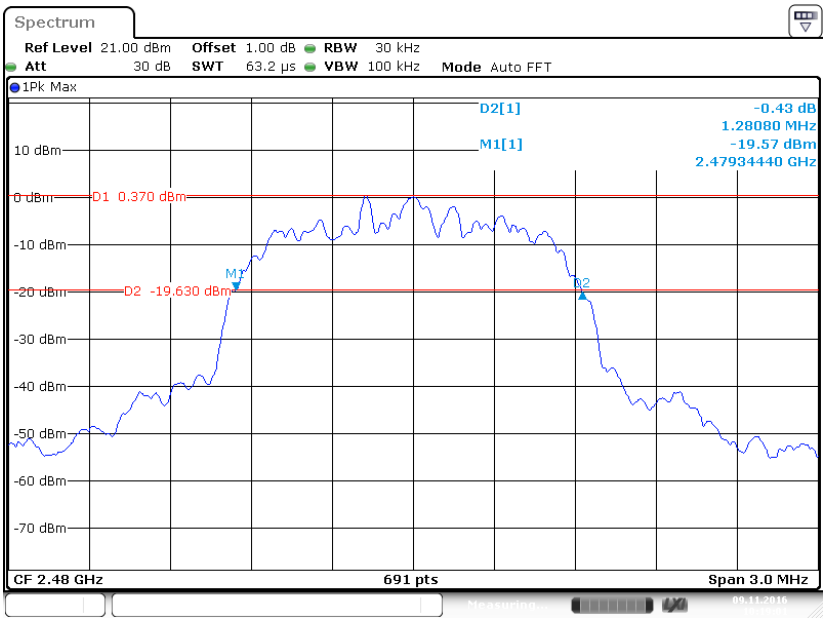
Date:9.NOV.2016 10:21:26

EDR(π/4-DQPSK): Middle Channel



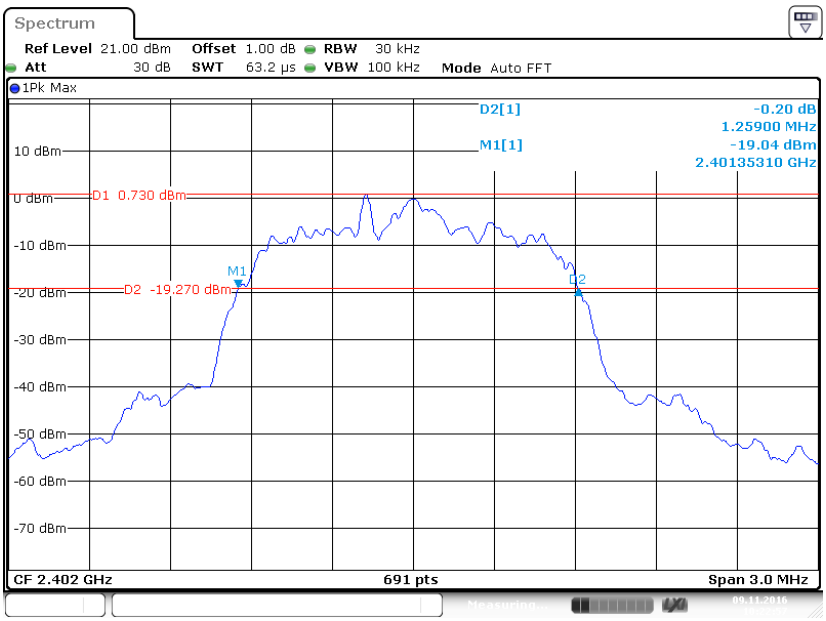
Date:9.NOV.2016 10:20:16

EDR (π/4-DQPSK): High Channel



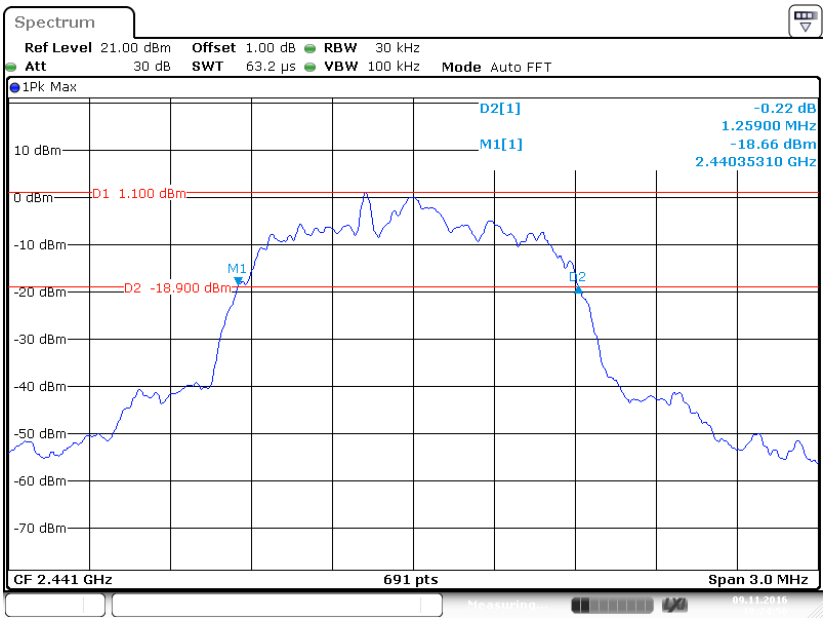
Date:9.NOV.2016 10:19:01

EDR (8DPSK): Low Channel



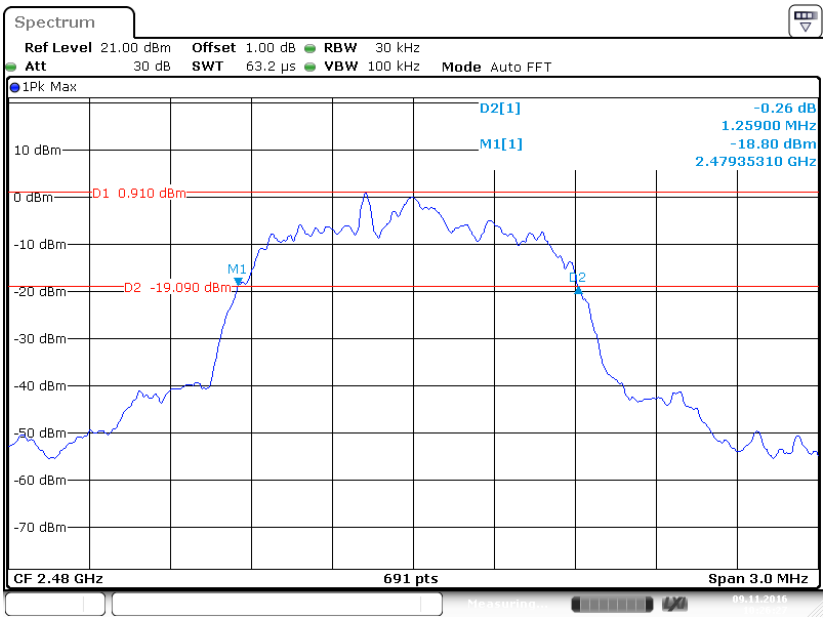
Date:9.NOV.2016 10:22:57

EDR (8DPSK): Middle Channel



Date:9.NOV.2016 10:24:56

EDR (8DPSK): High Channel



Date:9.NOV.2016 10:26:27

FCC §15.247(a) (1) (iii)-QUANTITY OF HOPPING CHANNEL TEST

Applicable Standard

Frequency hopping systems in the 2400–2483.5 MHz band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

Test Procedure

1. Check the calibration of the measuring instrument (SA) using either an internal calibrator or a known signal from an external generator.

2. Set the EUT in hopping mode from first channel to last.

3. By using the max-hold function record the quantity of the channel.

Test Equipment List and Details

Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Due Date
Rohde & Schwarz	Signal Analyzer	FSV40	101116	2016-07-04	2017-07-03
BACL	RF cable	KS-LAB-012	KS-LAB-012	2015-12-16	2016-12-15

*** Statement of Traceability:** Bay Area Compliance Laboratories Corp. (Kunshan) attests that all calibrations have been performed in accordance to requirements that traceable to National Primary Standards and International System of Units (SI).

Test Data

Environmental Conditions

Temperature:	26 ℃
Relative Humidity:	55 %
ATM Pressure:	101.0 kPa

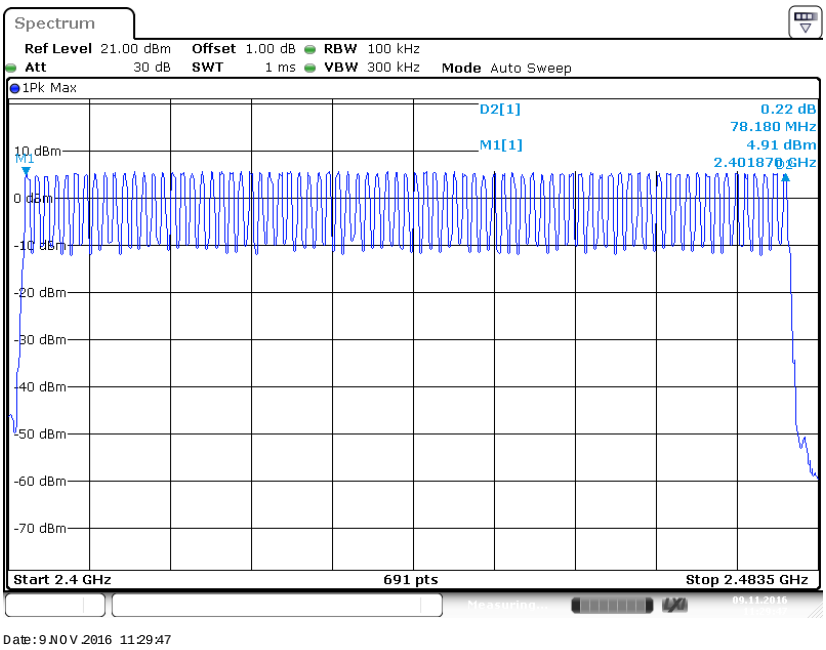
The testing was performed by Peter Jiang on 2016-11-09.

EUT operation mode: Transmitting

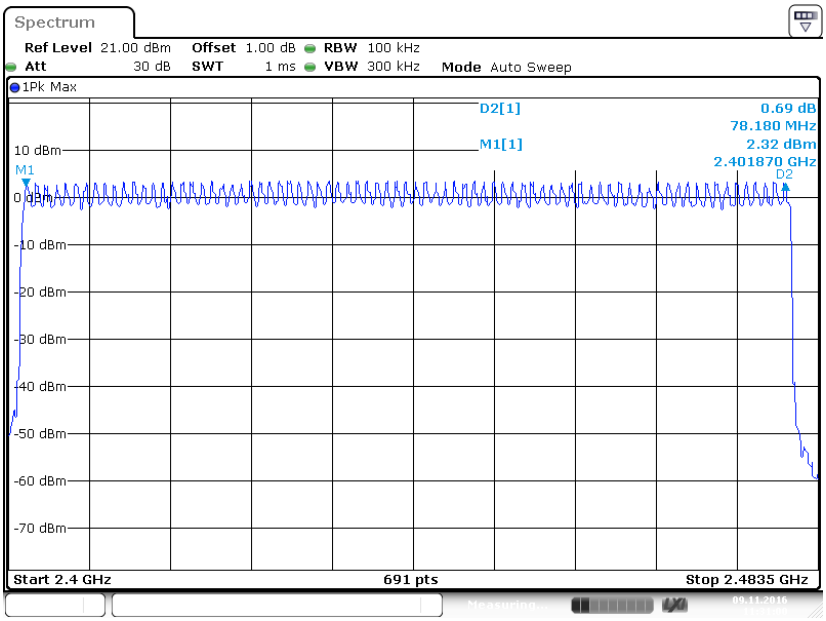
Test Result: Compliance. Please refer to following tables and plots

Mode	Frequency Range (MHz)	Number of Hopping Channel (CH)	Limit (CH)
BDR (GFSK)	2400-2483.5	79	⩾15
EDR (π/4-DQPSK)	2400-2483.5	79	⩾15
EDR (8DPSK)	2400-2483.5	79	⩾15

BDR (GFSK): Number of Hopping Channels

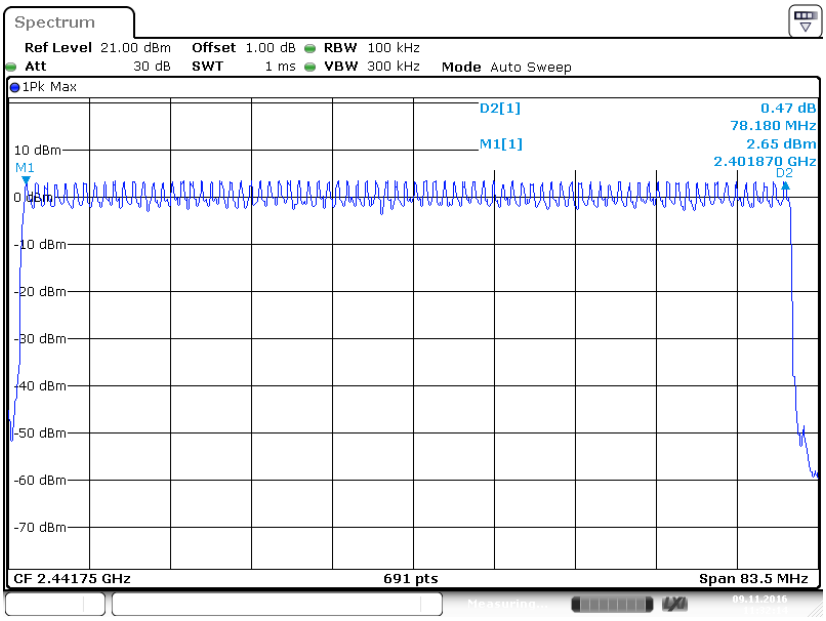


EDR (π/4-DQPSK): Number of Hopping Channels



Date:9.NOV.2016 11:31:00

EDR (8DPSK): Number of Hopping Channels



Date:9.NOV.2016 11:32:14

FCC §15.247(a) (1) (iii) - TIME OF OCCUPANCY (DWELL TIME)

Applicable Standard

Frequency hopping systems in the 2400-2483.5 MHz shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

Test Procedure

The EUT was worked in channel hopping; Spectrum SPAN was set as 0. Sweep was set as 0.4 X channel no. (s), the quantity of pulse was get from single sweep. In addition, the time of single pulses was tested.

Test Equipment List and Details

Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Due Date
Rohde & Schwarz	Signal Analyzer	FSV40	101116	2016-07-04	2017-07-03
BACL	RF cable	KS-LAB-012	KS-LAB-012	2015-12-16	2016-12-15

*** Statement of Traceability:** Bay Area Compliance Laboratories Corp. (Kunshan) attests that all calibrations have been performed in accordance to requirements that traceable to National Primary Standards and International System of Units (SI).

Test Data

Environmental Conditions

Temperature:	26 ℃
Relative Humidity:	55 %
ATM Pressure:	101.0 kPa

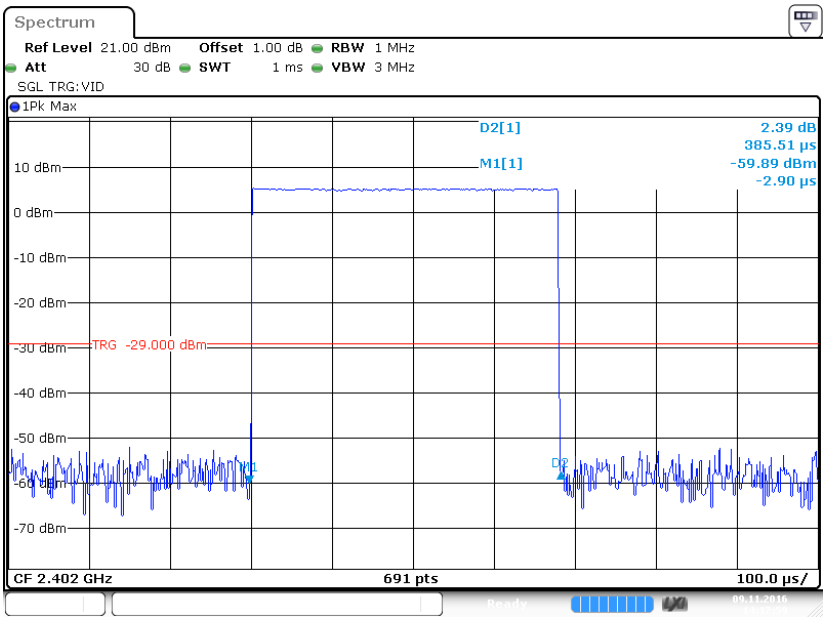
The testing was performed by Peter Jiang on 2016-11-09.

EUT operation mode: Transmitting

Test Result: Compliance. Please refer to following tables and plots

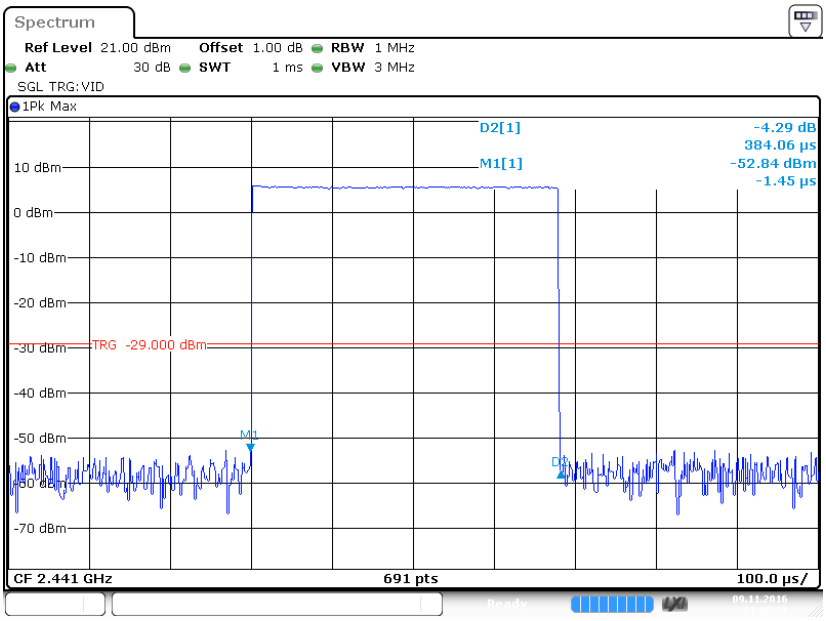
Mode		Channel	Pulse Width (ms)	Dwell Time (S)	Limit (S)	Result
BDR (GFSK)	DH 1	Low	0.386	0.124	0.4	Pass
		Middle	0.384	0.123	0.4	Pass
		High	0.386	0.124	0.4	Pass
		Note: DH1:Dwell time = Pulse time*(1600/2/79)*31.6S				
	DH 3	Low	1.648	0.264	0.4	Pass
		Middle	1.648	0.264	0.4	Pass
		High	1.648	0.264	0.4	Pass
		Note: DH3:Dwell time = Pulse time*(1600/4/79)*31.6S				
	DH 5	Low	2.904	0.310	0.4	Pass
		Middle	2.904	0.310	0.4	Pass
		High	2.904	0.310	0.4	Pass
		Note: DH5:Dwell time = Pulse time*(1600/6/79)*31.6S				
EDR (π/4-DQPSK)	DH 1	Low	0.399	0.128	0.4	Pass
		Middle	0.397	0.127	0.4	Pass
		High	0.399	0.128	0.4	Pass
		Note: DH1:Dwell time = Pulse time*(1600/2/79)*31.6S				
	DH 3	Low	1.657	0.265	0.4	Pass
		Middle	1.657	0.265	0.4	Pass
		High	1.657	0.265	0.4	Pass
		Note: DH3:Dwell time = Pulse time*(1600/4/79)*31.6S				
	DH 5	Low	2.916	0.311	0.4	Pass
		Middle	2.916	0.311	0.4	Pass
		High	2.916	0.311	0.4	Pass
		Note: DH5:Dwell time = Pulse time*(1600/6/79)*31.6S				
EDR (8DPSK)	DH 1	Low	0.397	0.127	0.4	Pass
		Middle	0.400	0.128	0.4	Pass
		High	0.399	0.128	0.4	Pass
		Note: DH1:Dwell time = Pulse time*(1600/2/79)*31.6S				
	DH 3	Low	1.657	0.265	0.4	Pass
		Middle	1.657	0.265	0.4	Pass
		High	1.657	0.265	0.4	Pass
		Note: DH3:Dwell time = Pulse time*(1600/4/79)*31.6S				
	DH 5	Low	2.916	0.311	0.4	Pass
		Middle	2.916	0.311	0.4	Pass
		High	2.916	0.311	0.4	Pass
		Note: DH5:Dwell time = Pulse time*(1600/6/79)*31.6S				

BDR (GFSK):
Pulse time, Low Channel, DH1



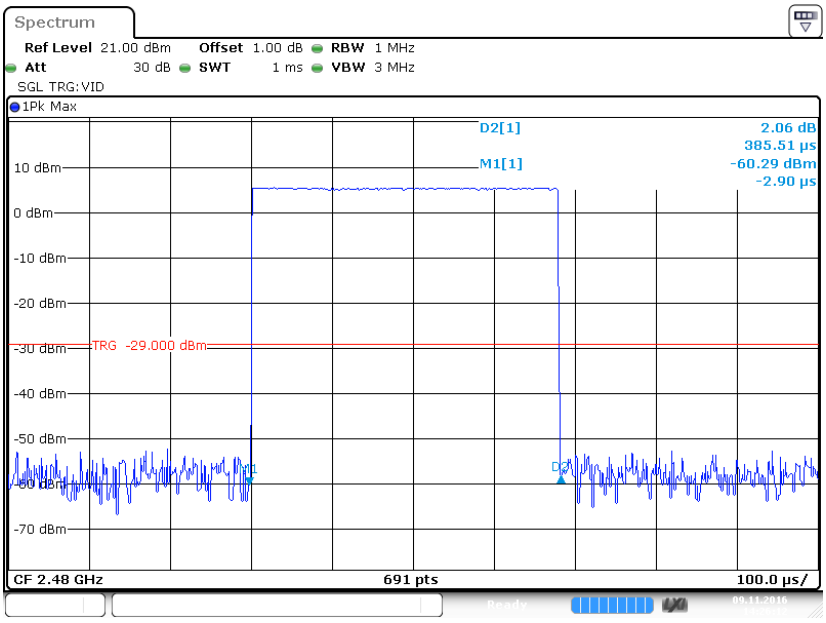
Date:9.NOV.2016 14:18:00

Pulse time, Middle Channel, DH1



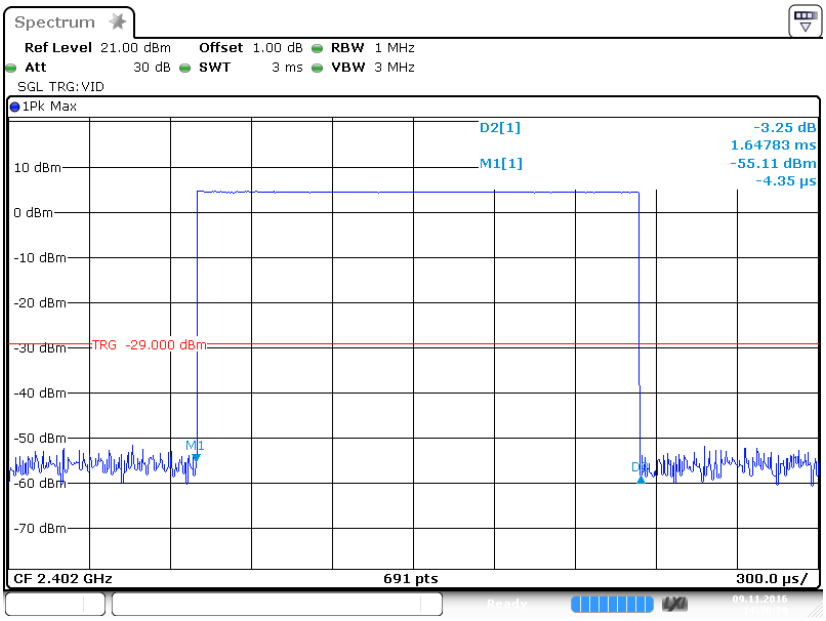
Date:9.NOV.2016 14:20:28

Pulse time, High Channel, DH1



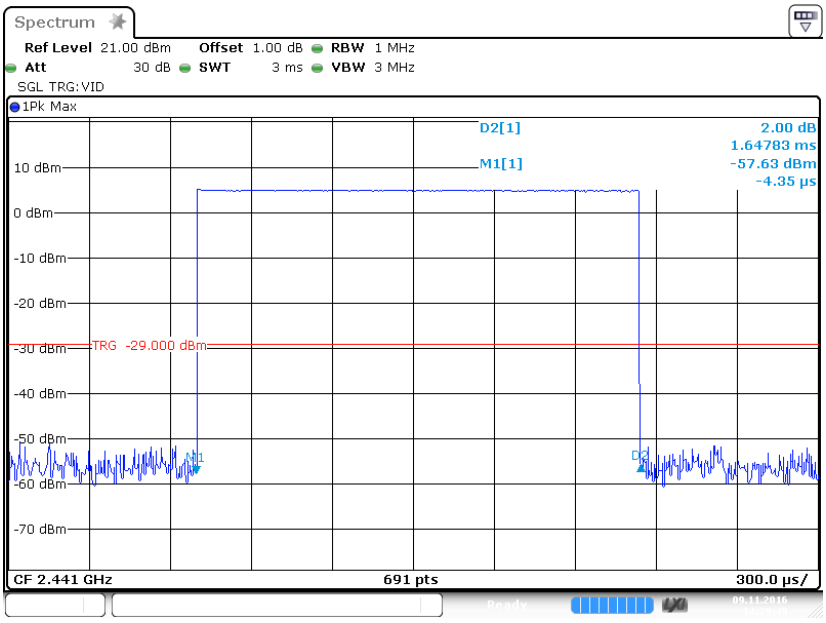
Date:9.NOV.2016 14:26:12

Pulse time, Low Channel, DH3



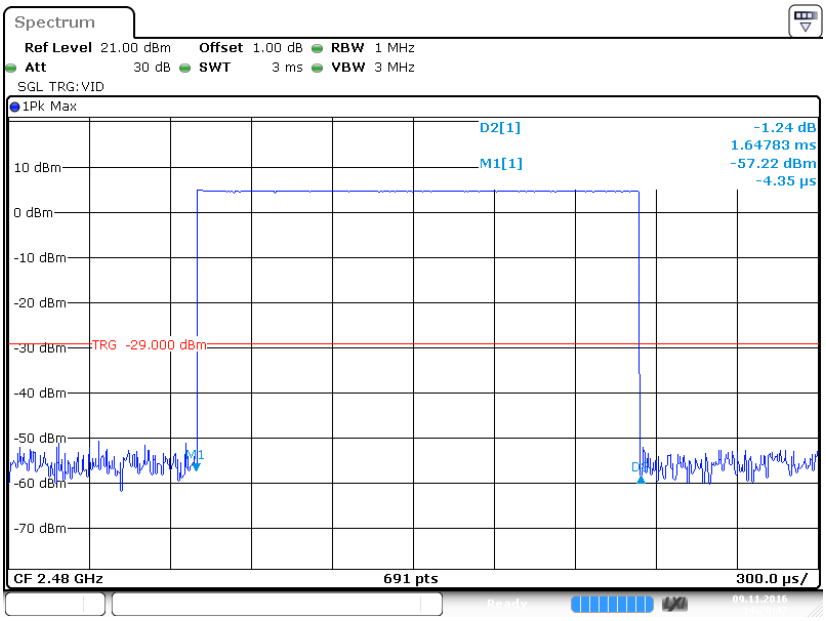
Date:9.NOV.2016 14:30:39

Pulse time, Middle Channel, DH3



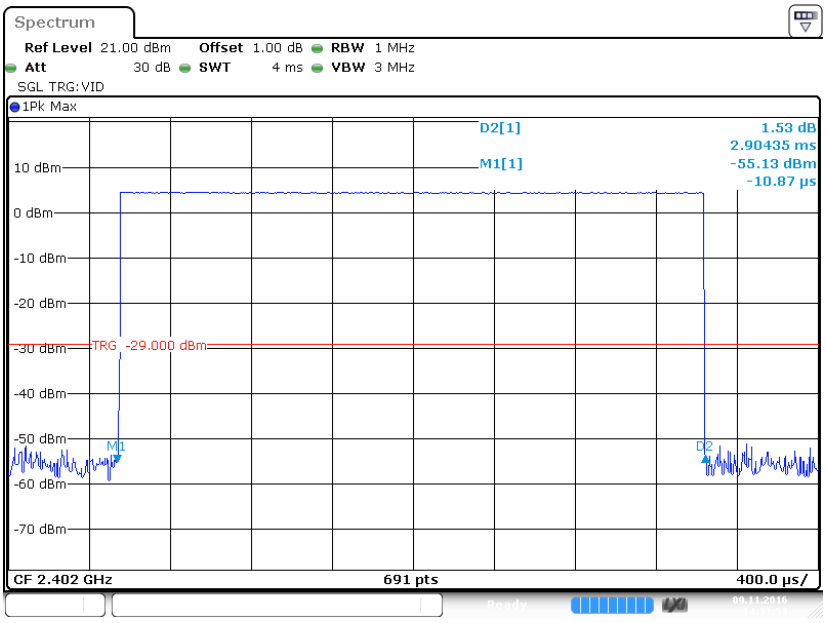
Date:9.NOV.2016 14:29:49

Pulse time, High Channel, DH3



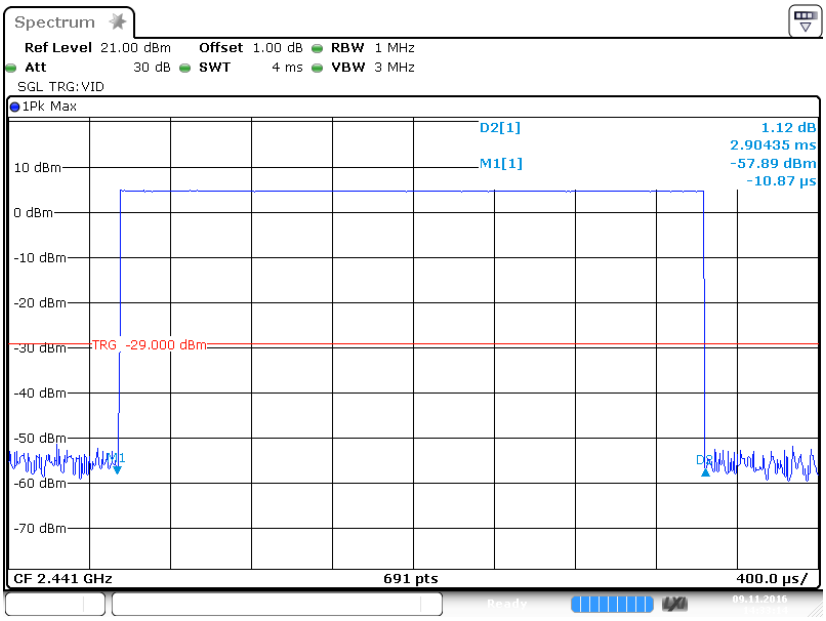
Date:9.NOV.2016 14:28:47

Pulse time, Low Channel, DH5



Date:9.NOV.2016 14:31:53

Pulse time, Middle Channel, DH5



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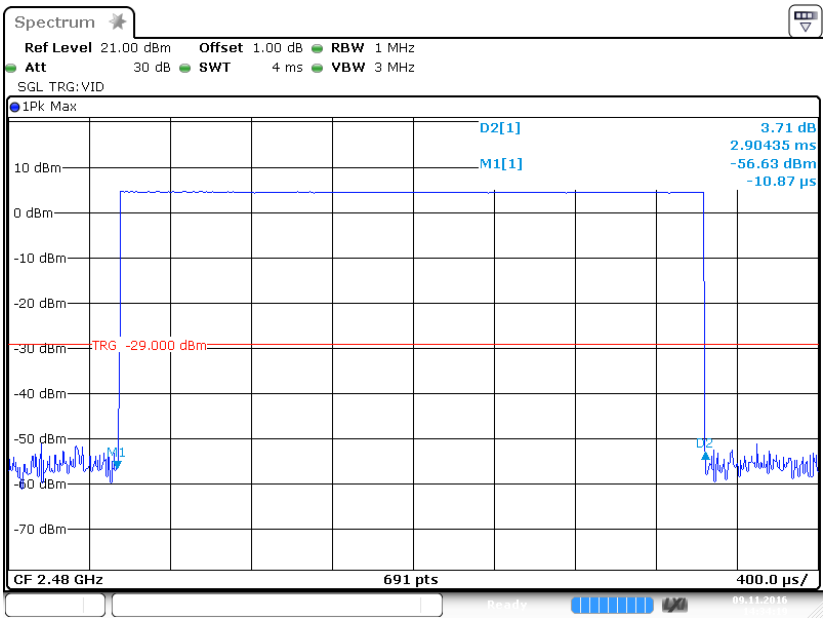
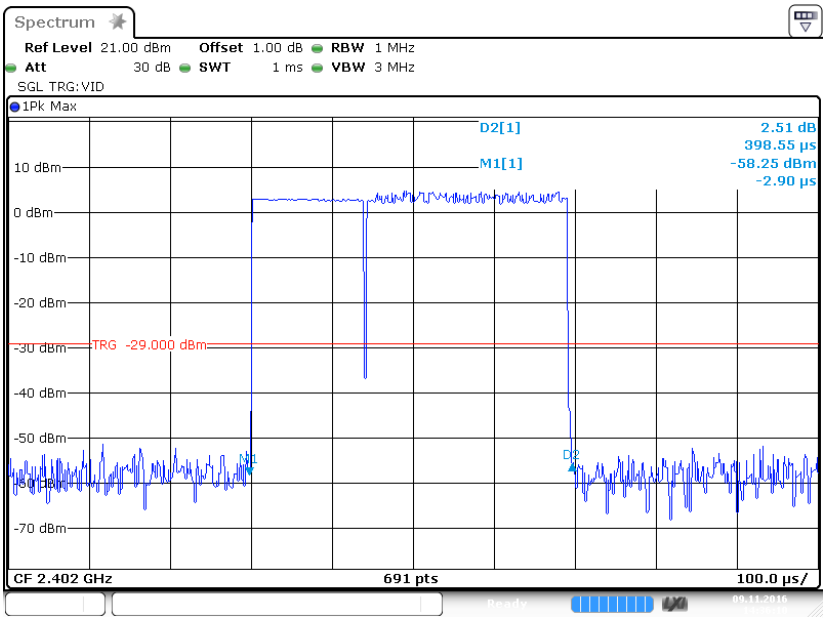
Pulse time, High Channel, DH5



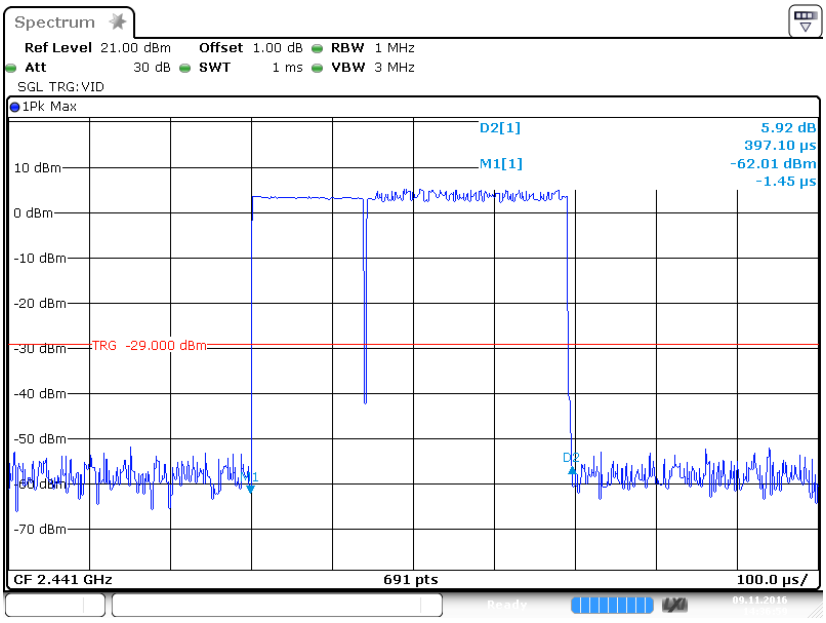
Date:9.NOV.2016 14:34:19

EDR (π/4-DQPSK):
Pulse time, Low Channel, DH1



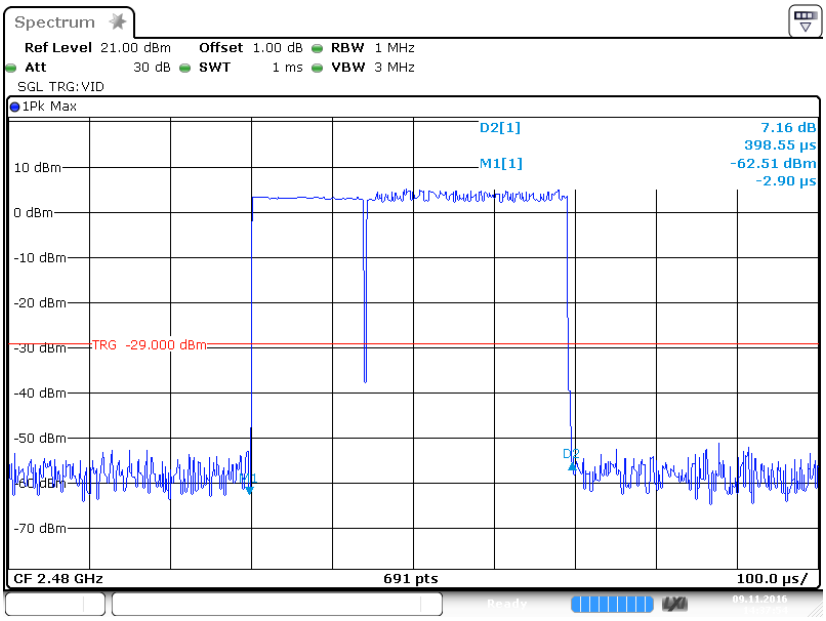
Date:9.NOV.2016 14:36:10

Pulse time, Middle Channel, DH1



Date:9.NOV.2016 14:37:00

Pulse time, High Channel, DH1



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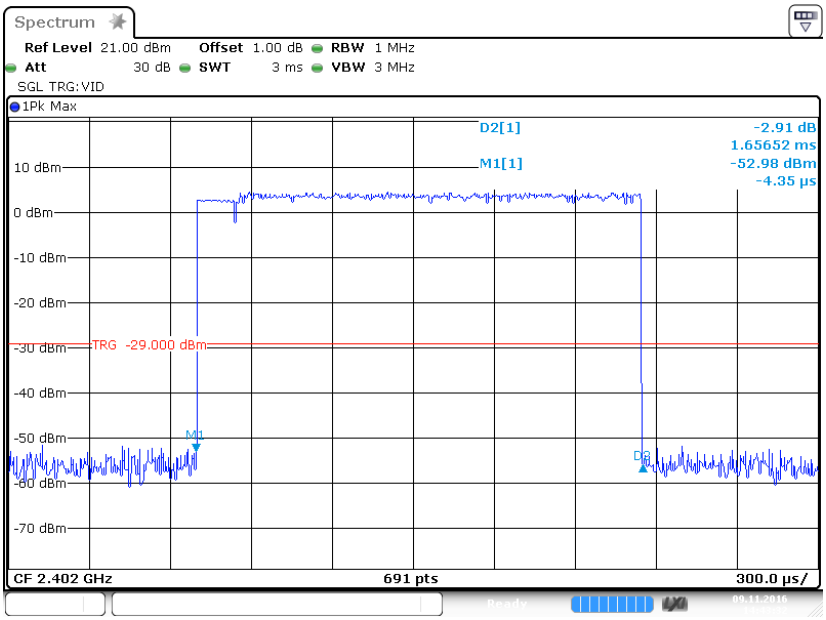
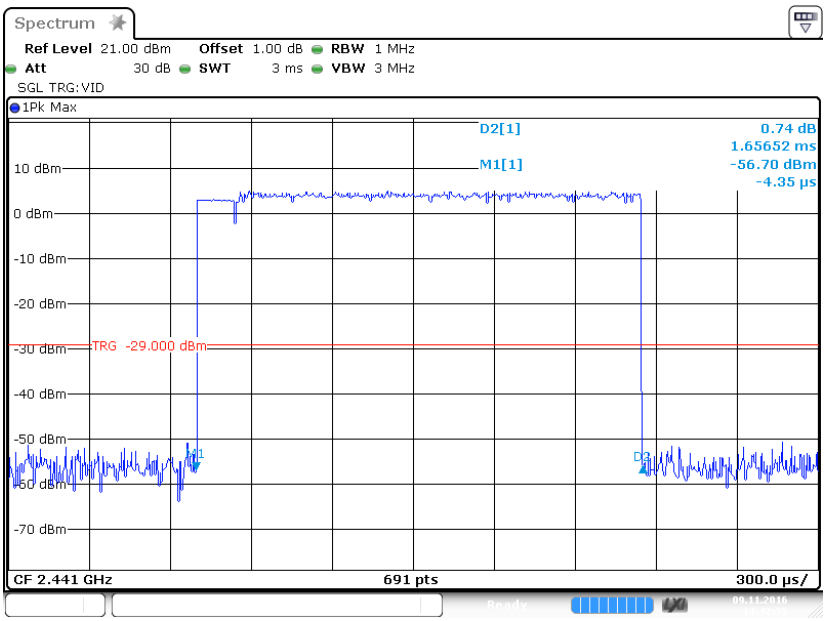
Pulse time, Low Channel, DH3



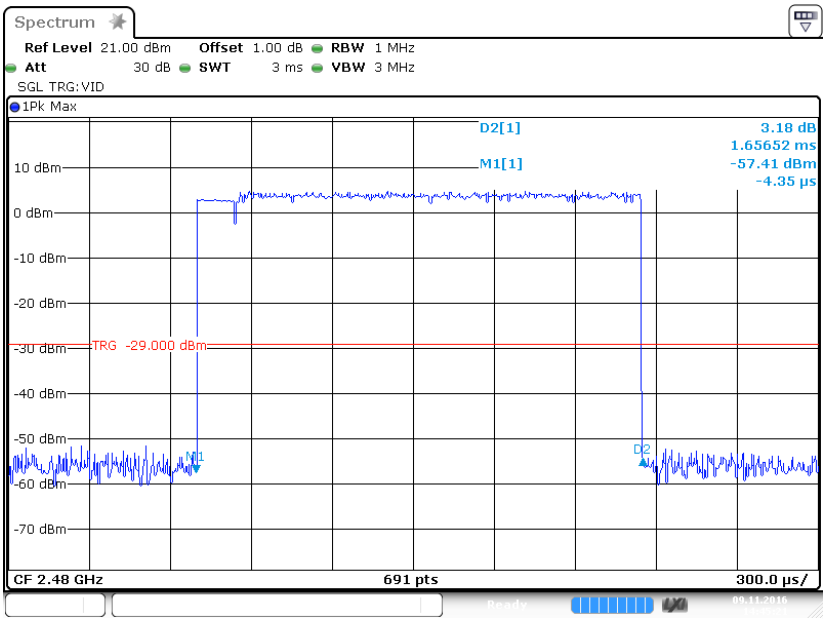
Date: 9.NOV.2016 14:43:33

Pulse time, Middle Channel, DH3



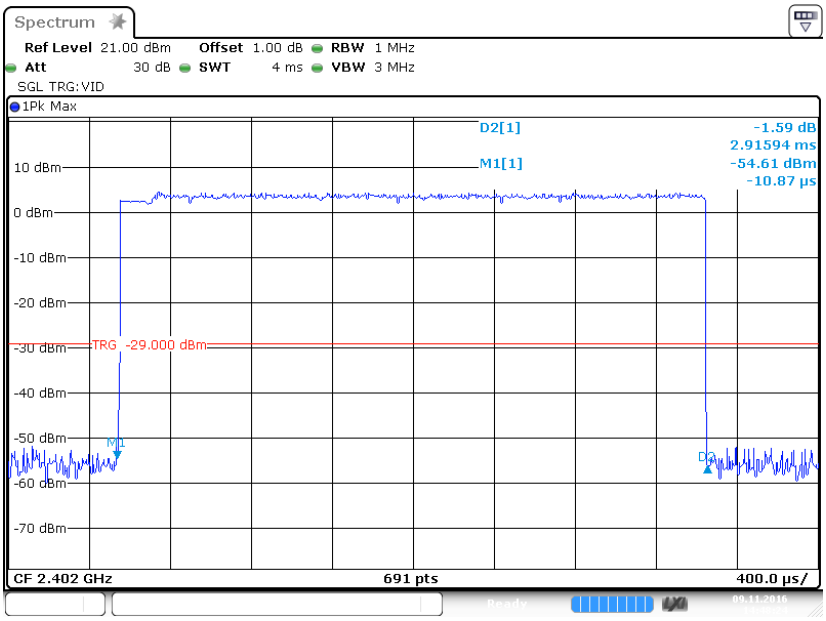
Date: 9.NOV.2016 14:42:34

Pulse time, High Channel, DH3



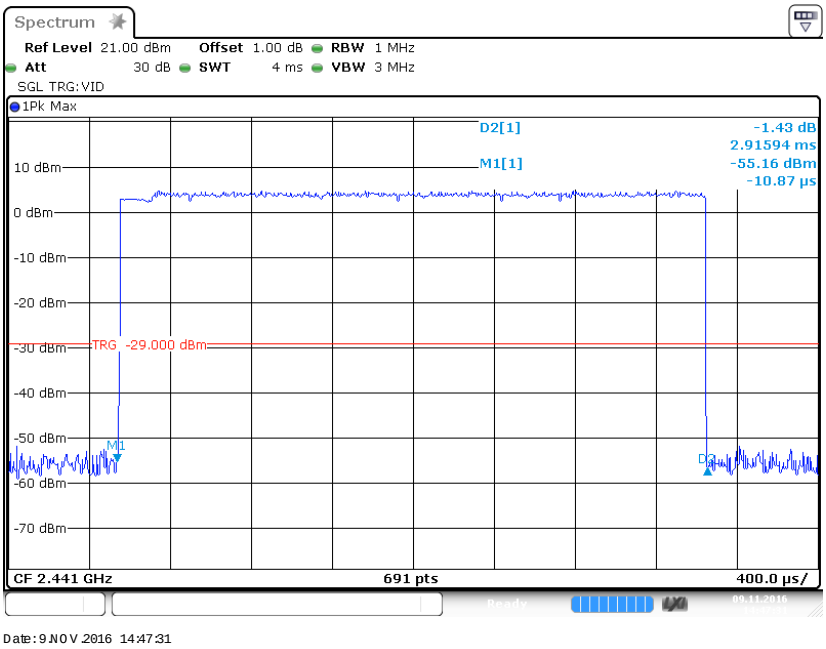
Date:9.NOV.2016 14:45:21

Pulse time, Low Channel, DH5



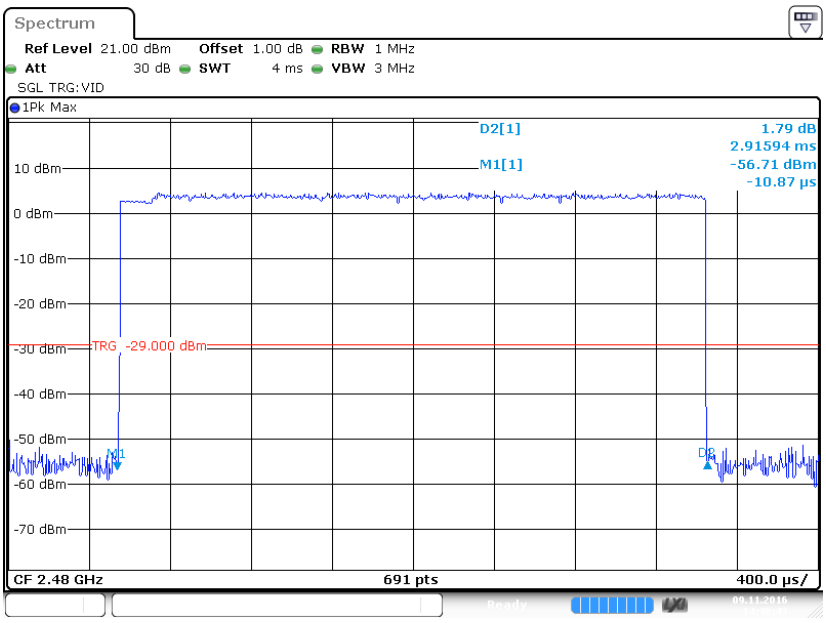
Date:9.NOV.2016 14:48:24

Pulse time, Middle Channel, DH5



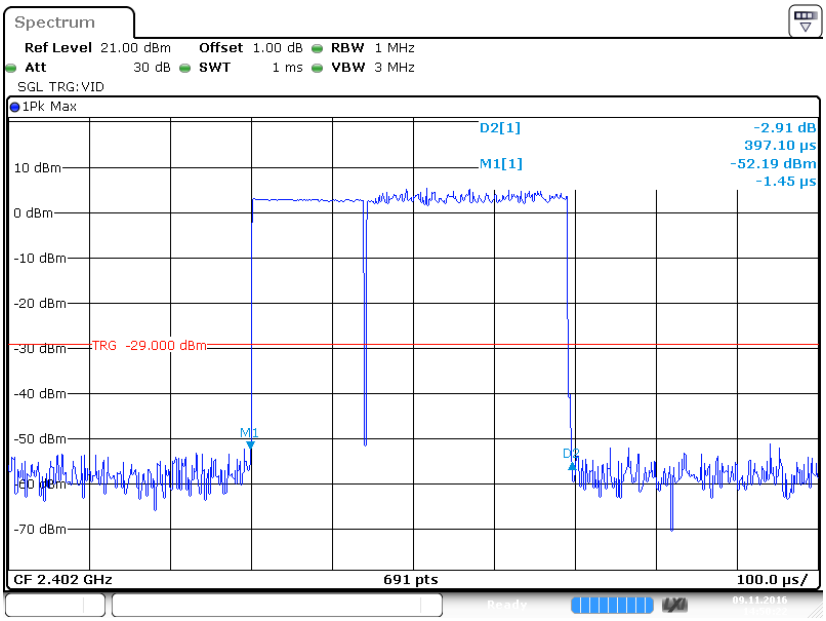
Date: 9.NOV.2016 14:47:31

Pulse time, High Channel, DH5



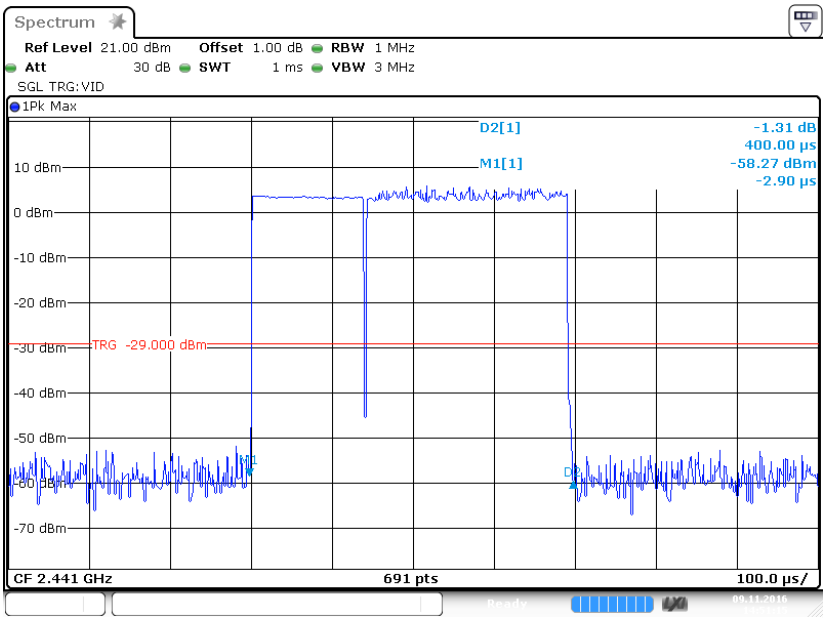
Date: 9.NOV.2016 14:46:43

EDR (8DPSK):
Pulse time, Low Channel, DH1



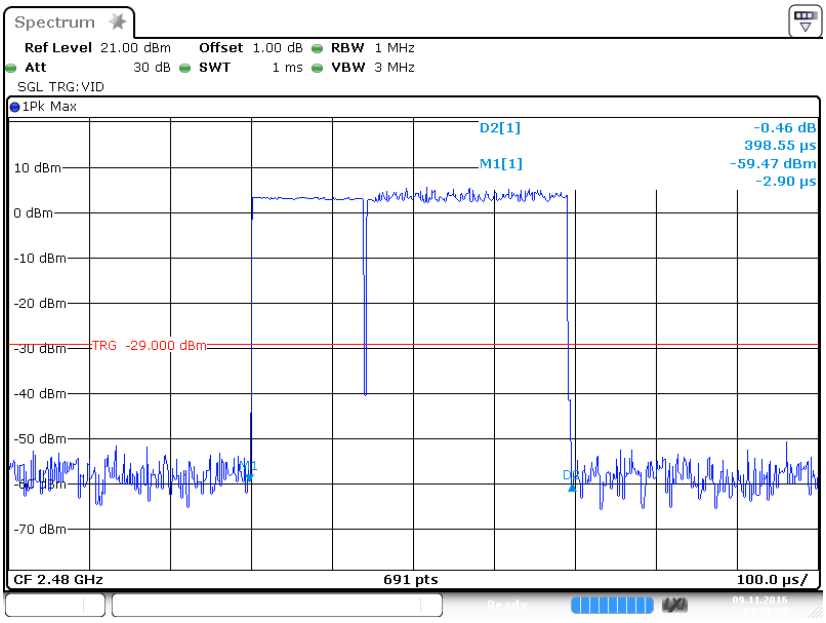
Date:9.NOV.2016 14:50:22

Pulse time, Middle Channel, DH1



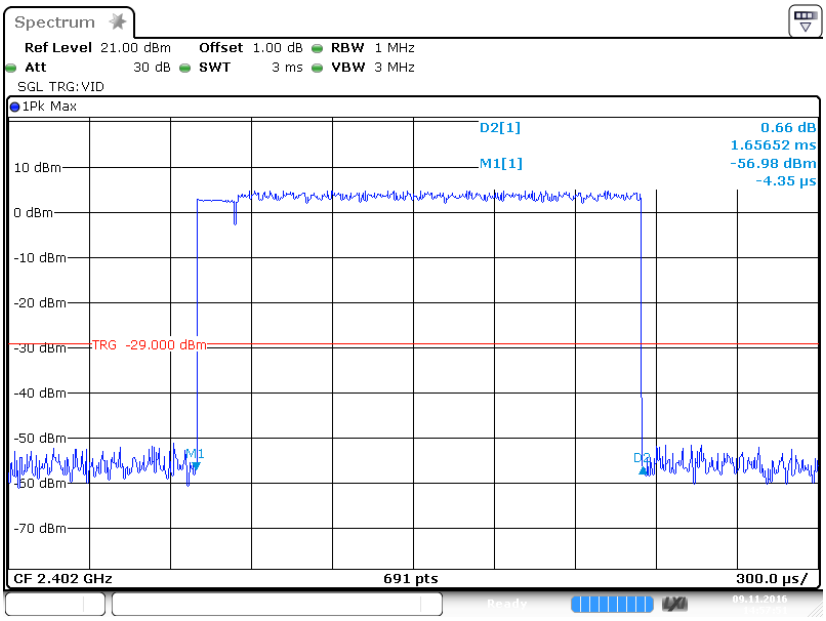
Date:9.NOV.2016 14:51:15

Pulse time, High Channel, DH1



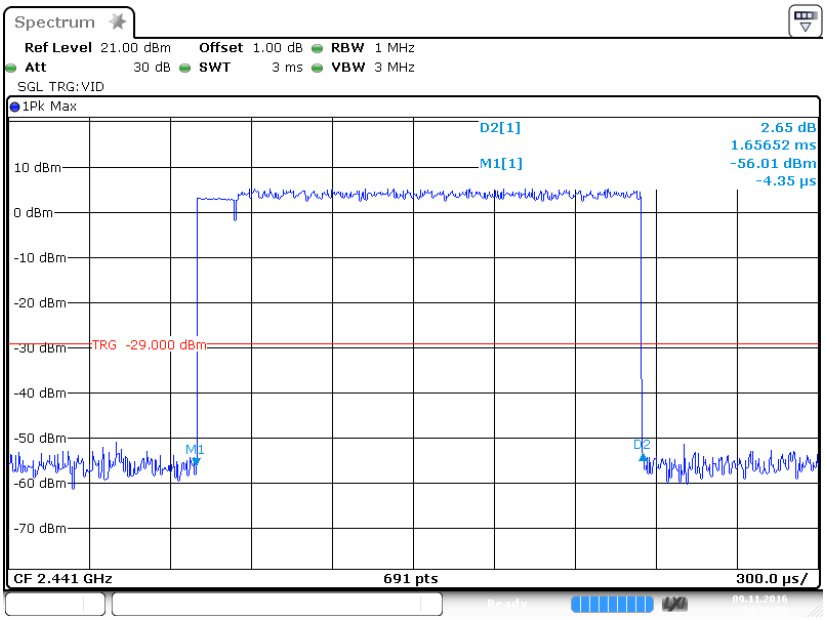
Date:9.NOV.2016 14:51:59

Pulse time, Low Channel, DH3



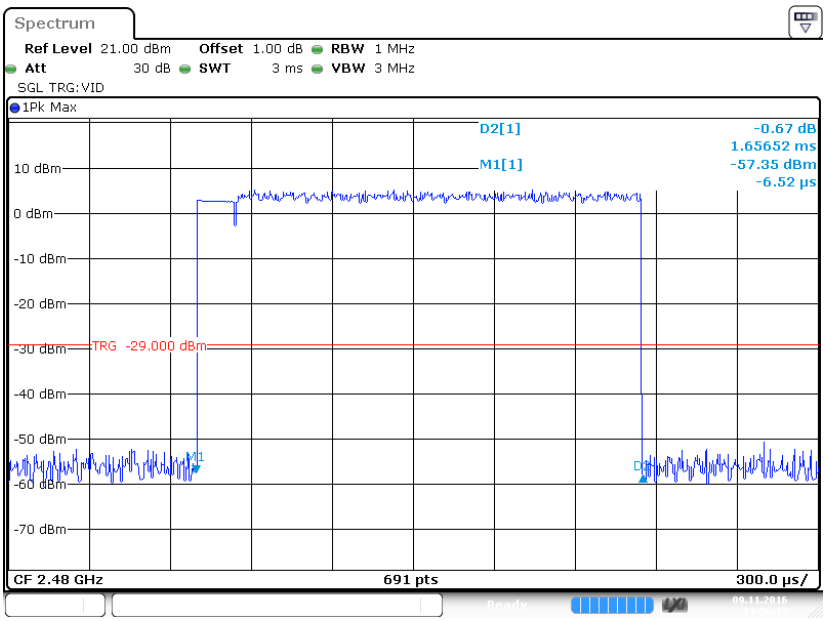
Date:9.NOV.2016 14:57:51

Pulse time, Middle Channel, DH3



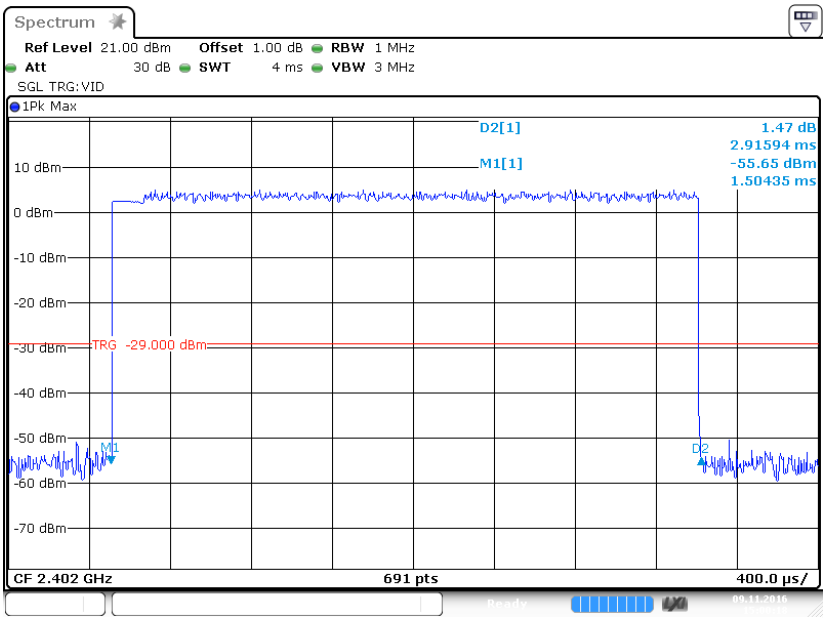
Date: 9.NOV.2016 14:57:00

Pulse time, High Channel, DH3

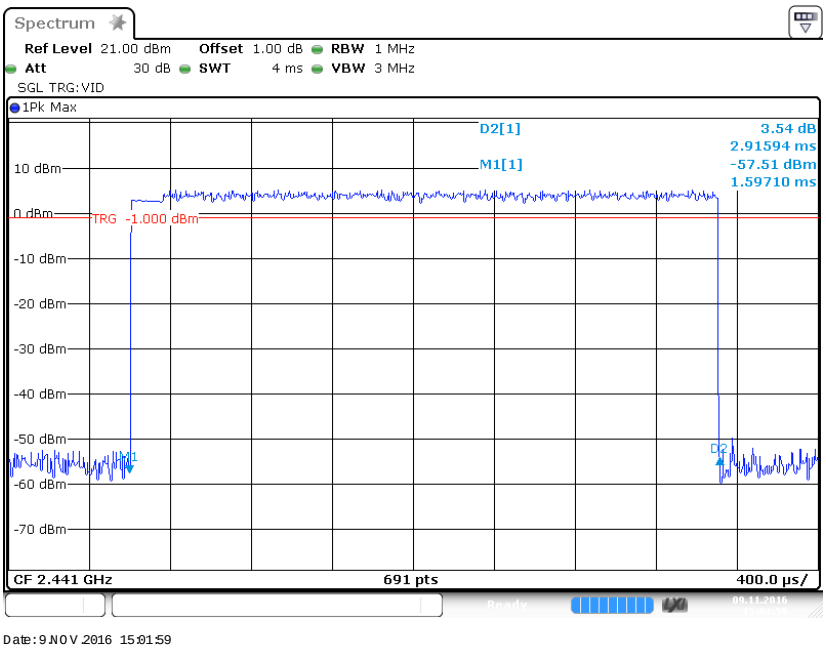


Date: 9.NOV.2016 14:56:13

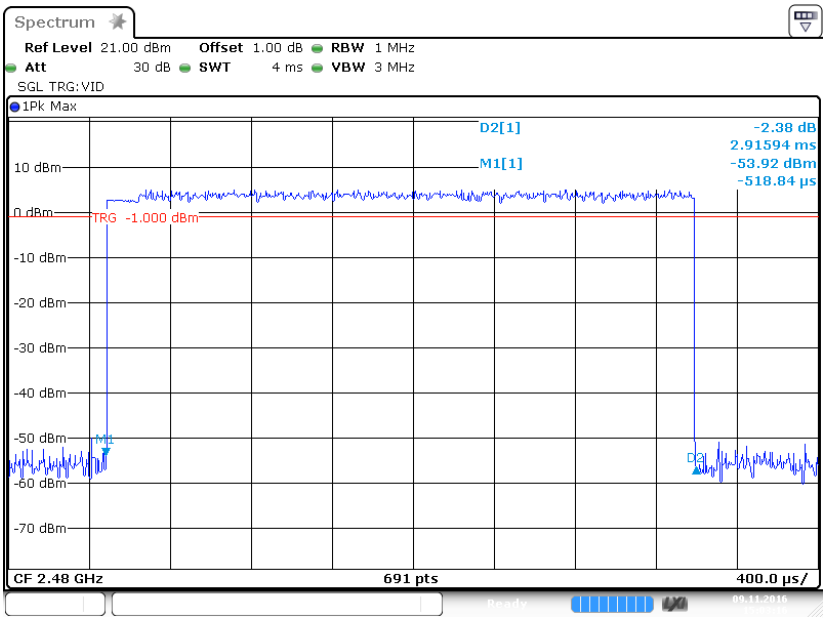
Pulse time, Low Channel, DH5



Pulse time, Middle Channel, DH5



Pulse time, High Channel, DH5



FCC §15.247(b) (1) - PEAK OUTPUT POWER MEASUREMENT

Applicable Standard

According to §15.247(b) (1), for frequency hopping systems operating in the 2400–2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt. And for all other frequency hopping systems in the 2400–2483.5 MHz band: 0.125 watts.

Test Procedure

1. Place the EUT on a bench and set in transmitting mode.
2. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to one test equipment.
3. Add a correction factor to the display.

Test Equipment List and Details

Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Due Date
Rohde & Schwarz	Signal Analyzer	FSV40	101116	2016-07-04	2017-07-03
BACL	RF cable	KS-LAB-012	KS-LAB-012	2015-12-16	2016-12-15

*** Statement of Traceability:** Bay Area Compliance Laboratories Corp. (Kunshan) attests that all calibrations have been performed in accordance to requirements that traceable to National Primary Standards and International System of Units (SI).

Test Data

Environmental Conditions

Temperature:	26 ℃
Relative Humidity:	55 %
ATM Pressure:	101.0 kPa

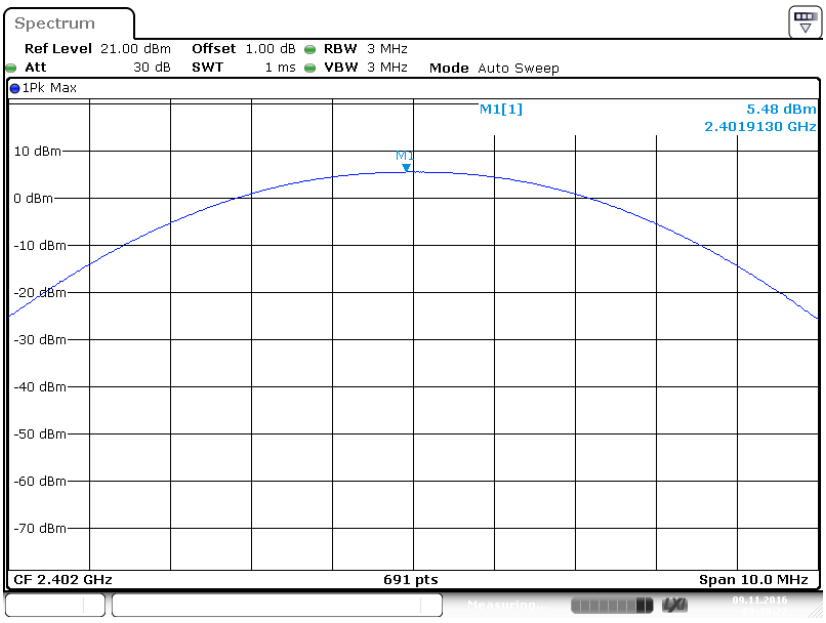
The testing was performed by Peter Jiang on 2016-11-09.

EUT operation mode: Transmitting

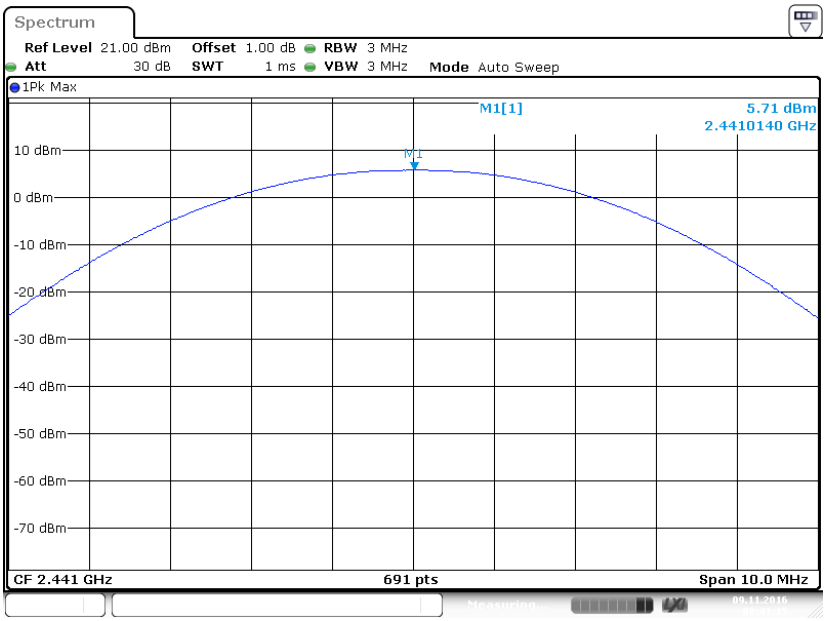
Test Result: Compliance. Please refer to following tables and plots

Mode	Channel	Frequency (MHz)	Output Power		Limit (mW)
			(dBm)	(mW)	
BDR (GFSK)	Low	2402	5.48	3.53	1000
	Middle	2441	5.71	3.72	1000
	High	2480	5.58	3.61	1000
EDR (π/4-DQPSK)	Low	2402	5.50	3.55	1000
	Middle	2441	5.95	3.94	1000
	High	2480	5.79	3.79	1000
EDR (8DPSK)	Low	2402	6.08	4.06	1000
	Middle	2441	6.42	4.39	1000
	High	2480	6.18	4.15	1000

BDR (GFSK): Low Channel

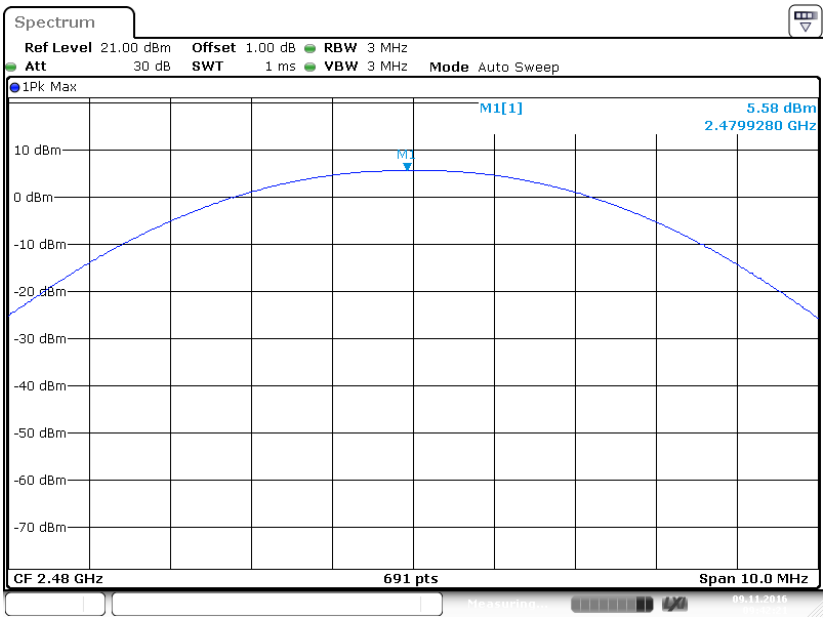


BDR (GFSK): Middle Channel



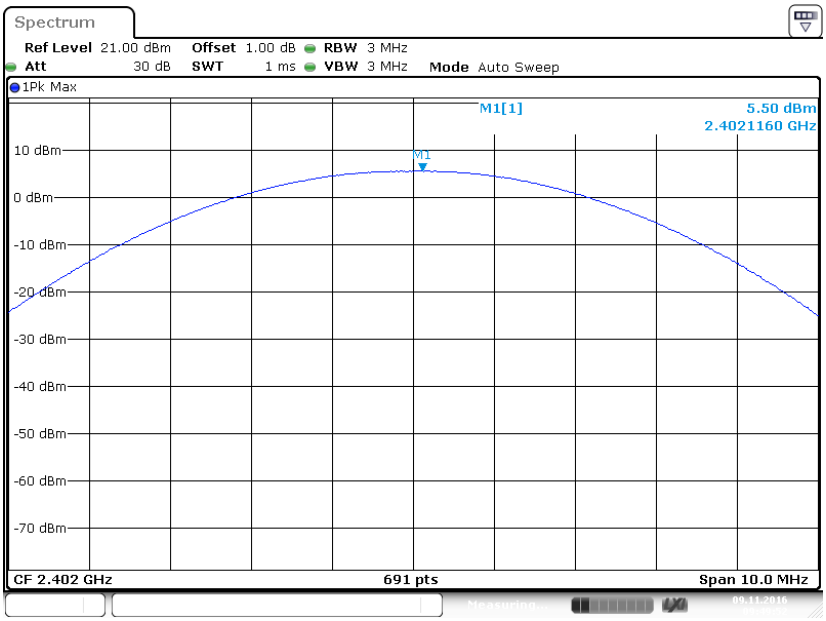
Date:9.NOV.2016 09:41:15

BDR (GFSK): High Channel



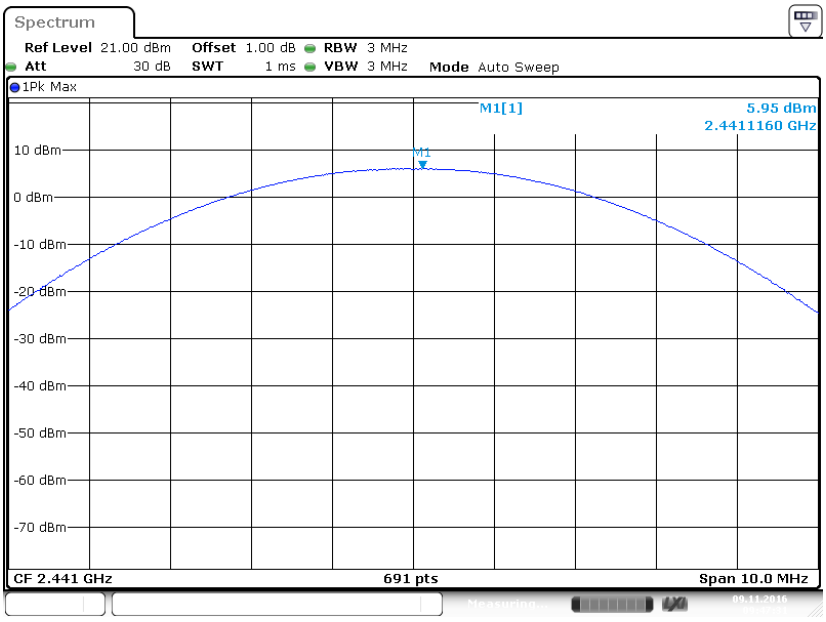
Date:9.NOV.2016 09:42:21

EDR(π/4-DQPSK): Low Channel



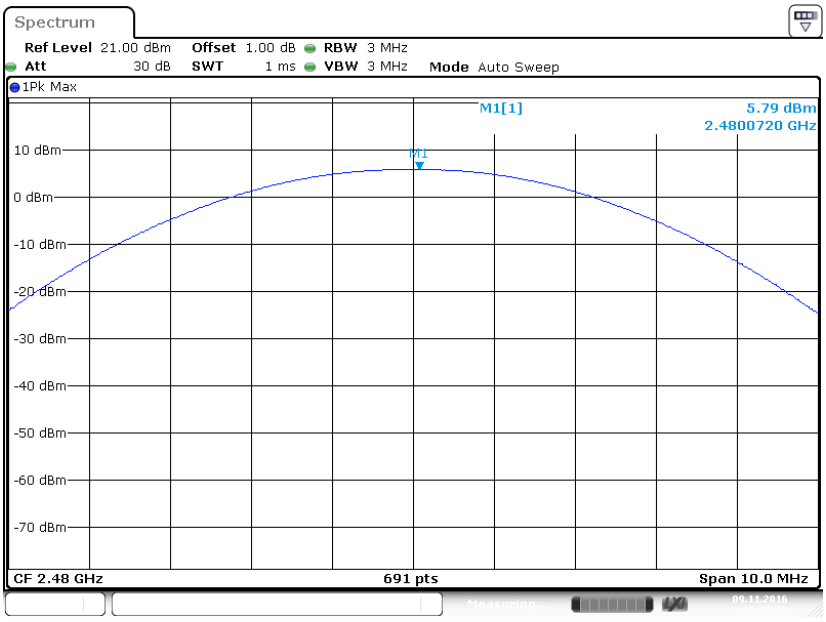
Date:9.NOV.2016 09:49:52

EDR(π/4-DQPSK): Middle Channel



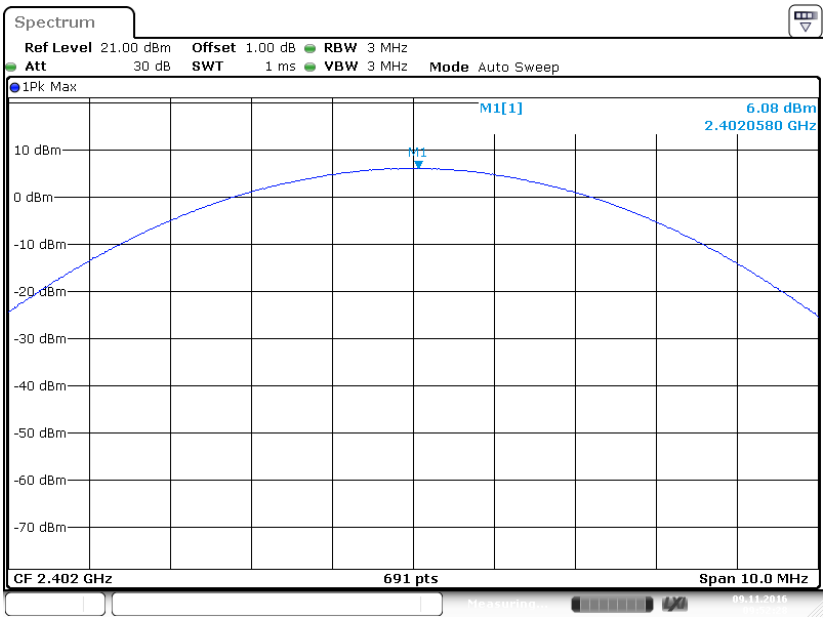
Date:9.NOV.2016 09:47:32

EDR(π/4-DQPSK): High Channel



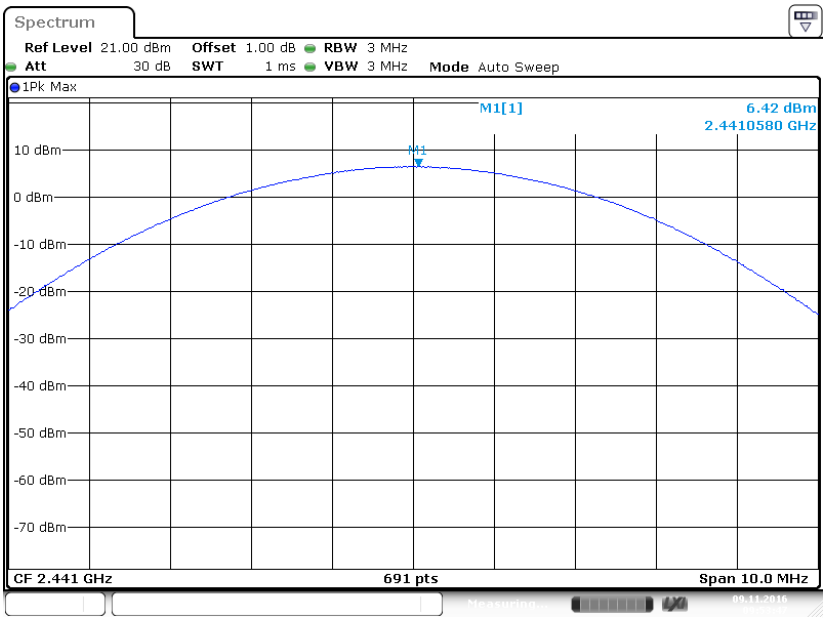
Date:9.NOV.2016 09:45:41

EDR(8DPSK): Low Channel



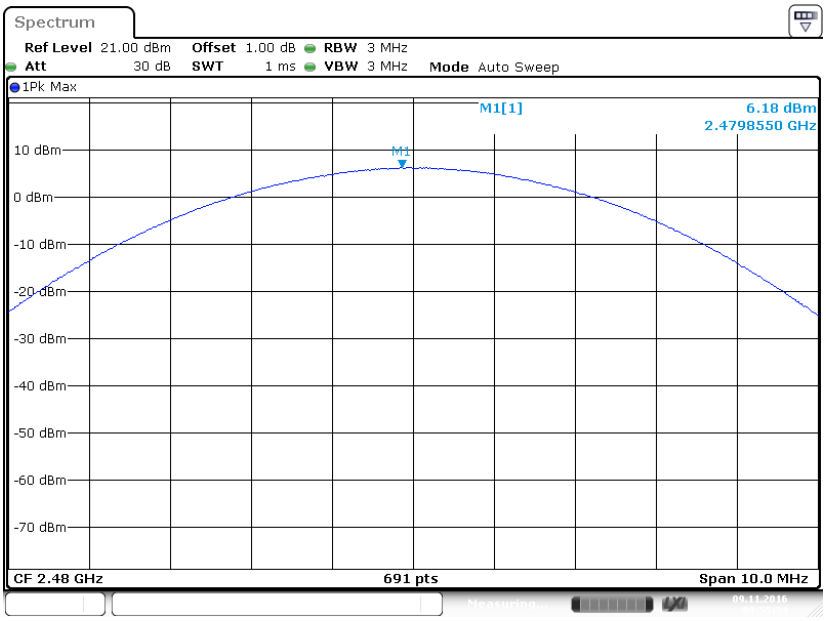
Date:9.NOV.2016 09:52:28

EDR(8DPSK): Middle Channel



Date:9.NOV.2016 09:53:47

EDR(8DPSK): High Channel



Date:9.NOV.2016 09:55:34

FCC §15.247(d) - BAND EDGES TESTING

Applicable Standard

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

Test Procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Remove the antenna from the EUT and then connect to a low loss RF cable from the antenna port to a EMI test receiver, then turn on the EUT and make it operate in transmitting mode. Then set it to Low Channel and High Channel within its operating range, and make sure the instrument is operated in its linear range.
3. Set RBW of spectrum analyzer to 100 kHz with a convenient frequency span including 100 kHz bandwidth from band edge.
4. Measure the highest amplitude appearing on spectral display and set it as a reference level. Plot the graph with marking the highest point and edge frequency.
5. Repeat above procedures until all measured frequencies were complete.

Test Equipment List and Details

Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Due Date
Rohde & Schwarz	Signal Analyzer	FSV40	101116	2016-07-04	2017-07-03
BACL	RF cable	KS-LAB-012	KS-LAB-012	2015-12-16	2016-12-15

*** Statement of Traceability:** Bay Area Compliance Laboratories Corp. (Kunshan) attests that all calibrations have been performed in accordance to requirements that traceable to National Primary Standards and International System of Units (SI).

Test Data

Environmental Conditions

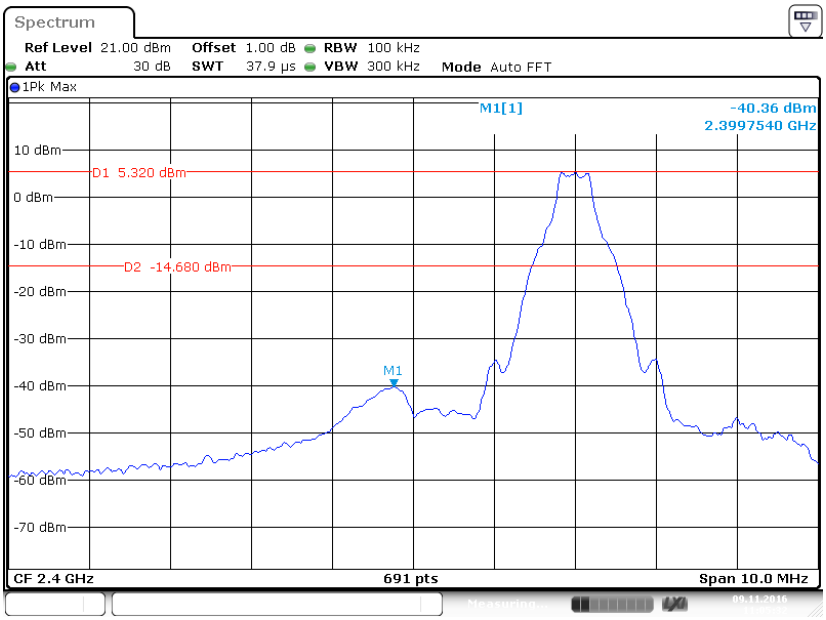
Temperature:	26 ℃
Relative Humidity:	55 %
ATM Pressure:	101.0 kPa

The testing was performed by Peter Jiang on 2016-11-09.

EUT operation mode: Transmitting

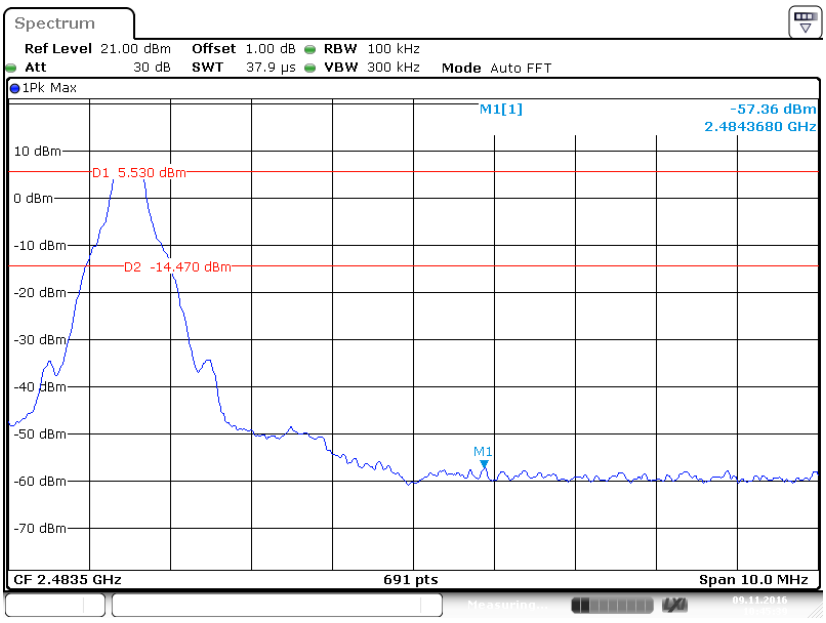
Test Result: Compliance. Please refer to following plots.

BDR (GFSK): Band Edge-Left Side



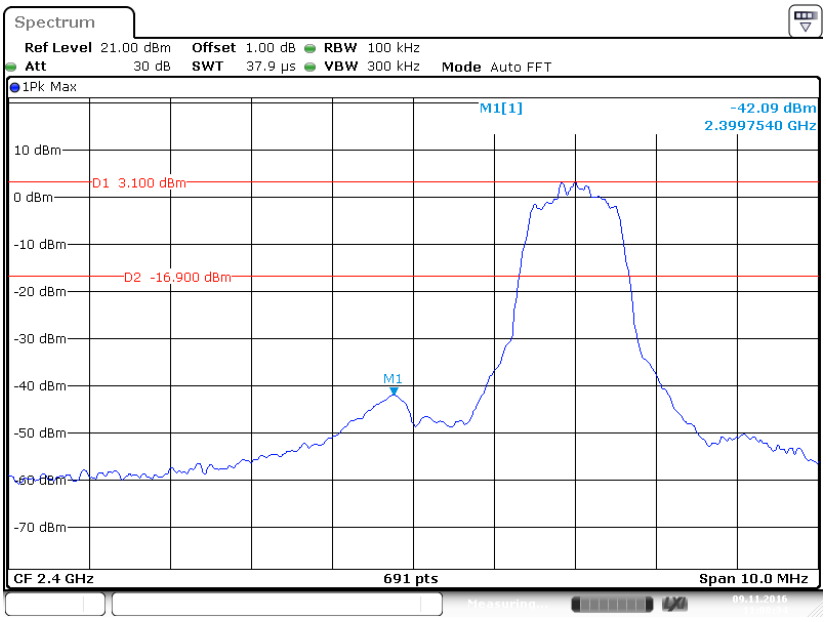
Date:9.NOV.2016 11:05:32

BDR (GFSK): Band Edge-Right Side



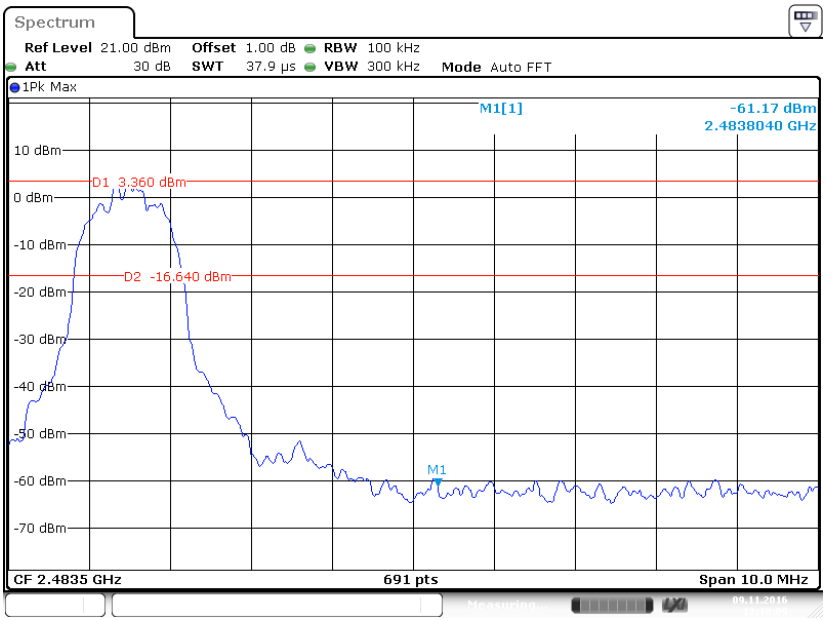
Date:9.NOV.2016 10:45:39

EDR (π/4-DQPSK): Band Edge-Left Side



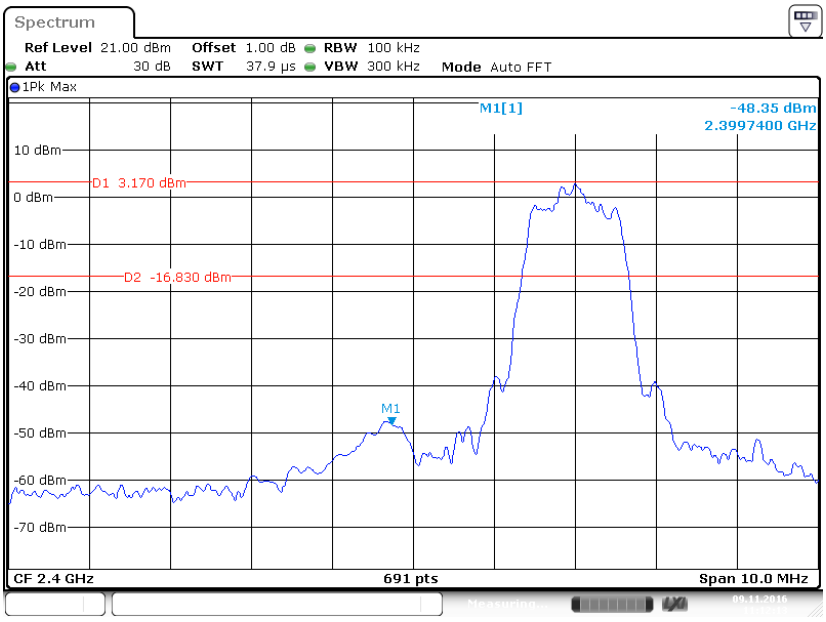
Date:9.NOV.2016 11:08:34

EDR (π/4-DQPSK): Band Edge-Right Side



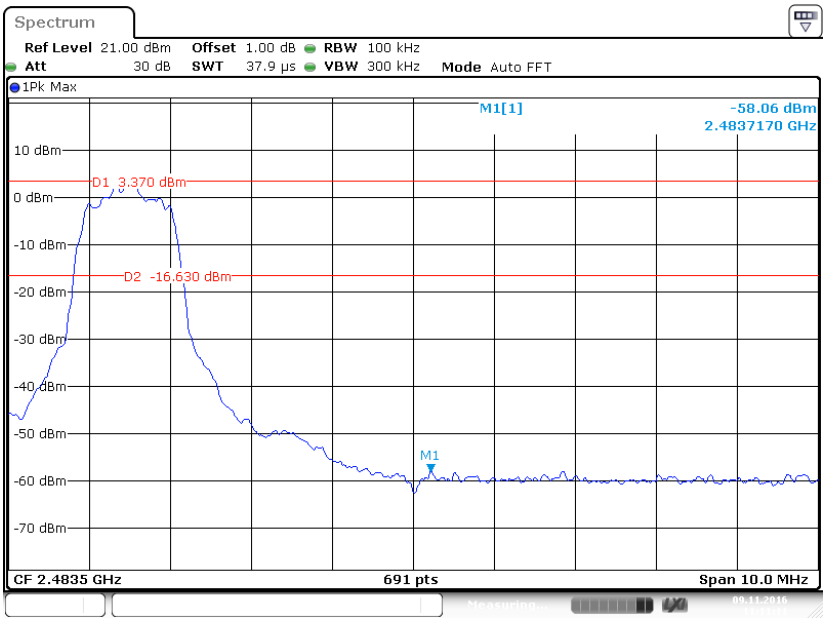
Date:9.NOV.2016 11:10:09

EDR (8DPSK): Band Edge-Left Side



Date:9.NOV.2016 11:12:13

BDR (8DPSK): Band Edge-Right Side



Date:9.NOV.2016 11:11:11

******* END OF REPORT *******