

MAXIMUM PEAK POWER TEST

47 CFR FCC Part 15.247(b)(1) Maximum Peak Power Limits

The EUT shows compliance to the requirements of this section, which states the EUT employing at least 75 non-overlapping hopping channels shall not exceed 1W (30dBm). For the EUT employs other frequency hopping systems, the peak power shall not greater than 0.125W (21dBm).

47 CFR FCC Part 15.247(b)(1) Maximum Peak Power Test Instrumentation

Instrument	Model	S/No	Cal Due Date
Boonton Electronics RF Power Meter	4532	72901	26 Aug 2017
Boonton Electronics Peak Power Sensor	56218-S/1	1417	26 Aug 2017

47 CFR FCC Part 15.247(b)(1) Maximum Peak Power Test Setup

1. The EUT and supporting equipment were set up as shown in the setup photo.
2. The power supply for the EUT was connected to a filtered mains.
3. The RF antenna connector was connected to the Universal Radio Communication Tester, which set into power analyser mode via a low-loss coaxial cable.
4. All other supporting equipment were powered separately from another filtered mains.

47 CFR FCC Part 15.247(b)(1) Maximum Peak Power Test Method

1. The EUT was switched on and allowed to warm up to its normal operating condition. The EUT was then configured to operate in the test mode, non-hopping with transmitting frequency at Channel 0 (2.402GHz) (*lower ch*).
2. The maximum peak power of the transmitting frequency was detected and recorded.
3. The step 2 was repeated with the transmitting frequency was set to Channel 39 (2.441GHz) (*mid ch*) and Channel 78 (2.480GHz) (*upper ch*) respectively.



MAXIMUM PEAK POWER TEST

47 CFR FCC Part 15.247(b)(1) Maximum Peak Power Results

Test Input Power	3.7Vdc	Temperature	24°C
Antenna Gain	2.94 dBi	Relative Humidity	60%
		Atmospheric Pressure	1030mbar
		Tested By	Liau Lee Yin

Channel	Channel Frequency (GHz)	Data Rate (Mbps)	Maximum Peak Power (W)	Limit (W)
0 (lower ch)	2.402	GFSK	0.0009	1.0
39 (mid ch)	2.441		0.0010	1.0
78 (upper ch)	2.480		0.0006	1.0
0 (lower ch)	2.402	$(\pi/4)$ DQPSK	0.0009	1.0
39 (mid ch)	2.441		0.0010	1.0
78 (upper ch)	2.480		0.0006	1.0
0 (lower ch)	2.402	8DPSK	0.0009	1.0
39 (mid ch)	2.441		0.0010	1.0
78 (upper ch)	2.480		0.0006	1.0

Notes

1. Nil.

RF CONDUCTED SPURIOUS EMISSIONS TEST

47 CFR FCC Part 15.247(d) RF Conducted Spurious Emissions Limits

The EUT shows compliance to the requirements of this section, which states in any 100kHz bandwidth outside the frequency band in which the spread spectrum intentional radiator (EUT) is operating, the radio frequency power that is produced by the EUT shall be at least 20dB below that in the 100kHz bandwidth within the band that contains the highest level of desired power.

47 CFR FCC Part 15.247(d) RF Conducted Spurious Test Instrumentation

Instrument	Model	S/No	Cal Due Date
Agilent Spectrum Analyzer	E4440A	MY45304764	04 Jan 2018

47 CFR FCC Part 15.247(d) RF Conducted Spurious Emissions Test Setup

1. The EUT and supporting equipment were set up as shown in the setup photo.
2. The power supply for the EUT was connected to a filtered mains.
3. The RF antenna connector was connected to the spectrum analyser via a low-loss coaxial cable.
4. The resolution bandwidth (RBW) and the video bandwidth (VBW) of the spectrum analyser were respectively set to 100kHz and 3 times of RBW.
5. All other supporting equipment were powered separately from another filtered mains.

47 CFR FCC Part 15.247(d) RF Conducted Spurious Emissions Test Method

1. The EUT was switched on and allowed to warm up to its normal operating condition. The EUT was then configured to operate in the test mode, non-hopping with transmitting frequency at Channel 0 (2.402GHz) (*lower ch*).
2. The start and stop frequencies of the spectrum analyser were set to 30MHz and 10GHz.
3. The spectrum analyser was set to max hold to capture any spurious emissions within the span. The signal capturing was continuous until no further spurious emissions were detected.
4. The steps 2 to 3 were repeated with frequency span was set from 10GHz to 25GHz.
5. The steps 2 to 4 were repeated with the transmitting frequency was set to Channel 39 (2.441GHz) (*mid ch*) and Channel 78 (2.480GHz) (*upper ch*) respectively.



RF CONDUCTED SPURIOUS EMISSIONS TEST

47 CFR FCC Part 15.247(d) RF Conducted Spurious Emissions Results

Test Input Power	3.7Vdc	Temperature	24°C
Attached Plots	27 – 44	Relative Humidity	60%
		Atmospheric Pressure	1030mbar
		Tested By	Liau Lee Yin

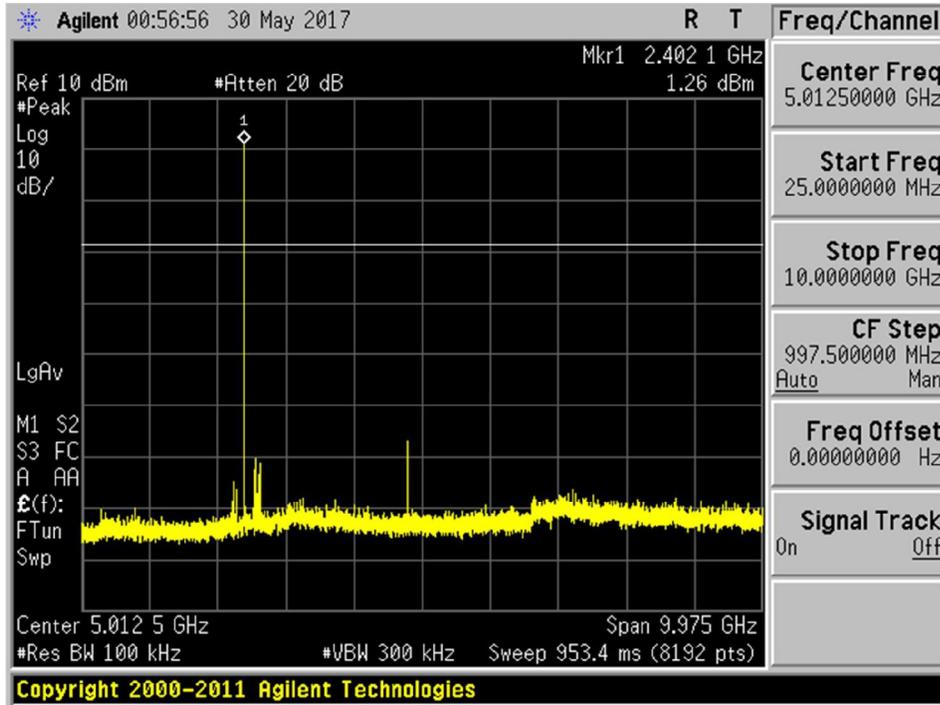
All spurious signals found were below the specified limit. Please refer to the attached plots.



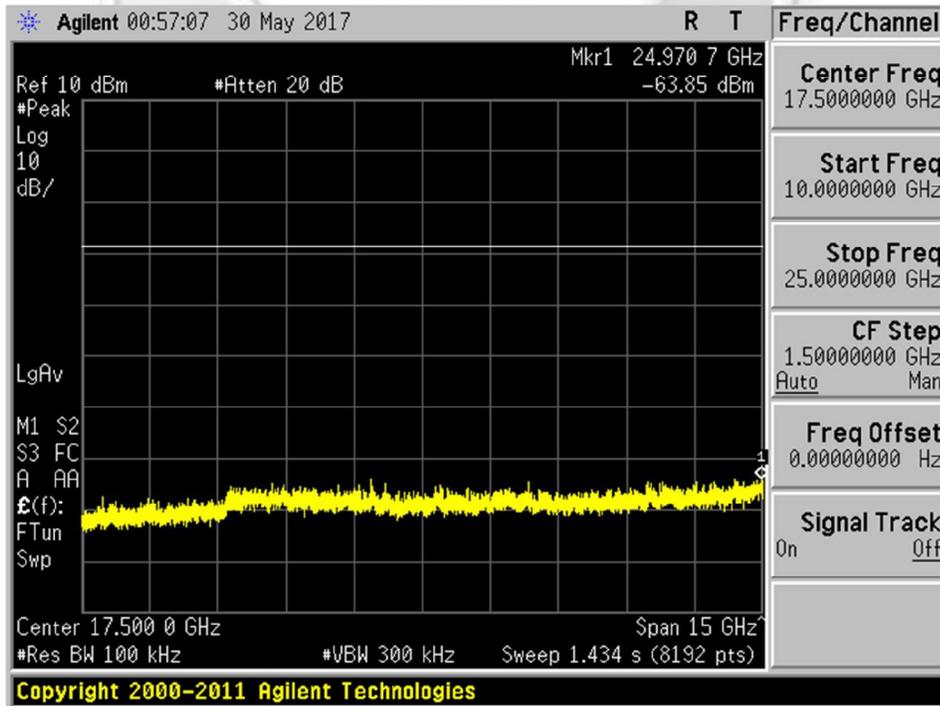


RF CONDUCTED SPURIOUS EMISSIONS TEST

RF Conducted Spurious Emissions Plots – GFSK



Plot 27 – Channel 0 (lower ch)

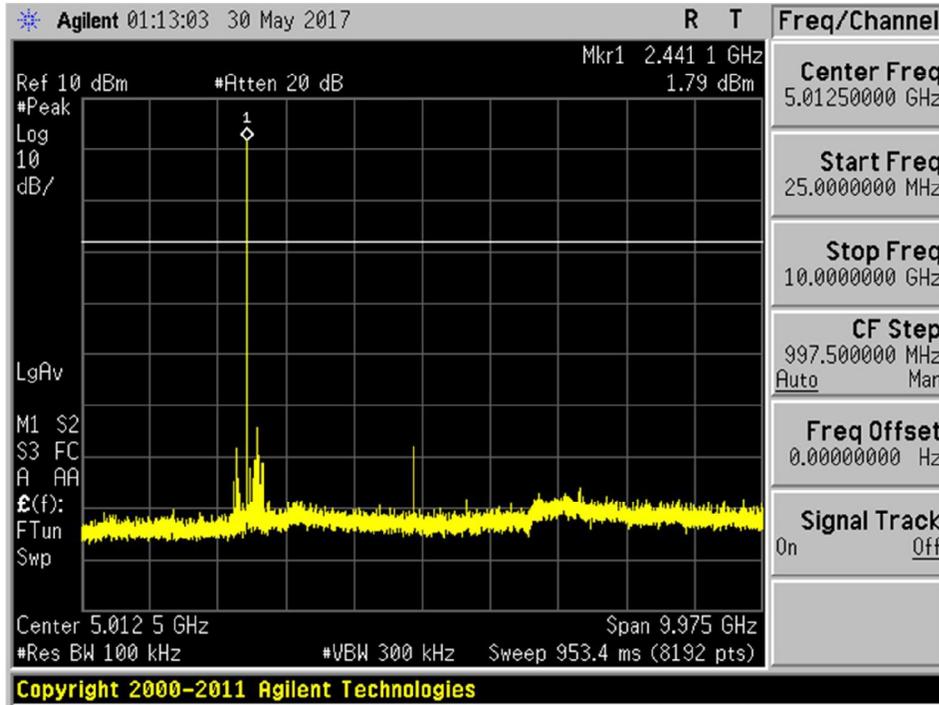


Plot 28 – Channel 0 (lower ch)

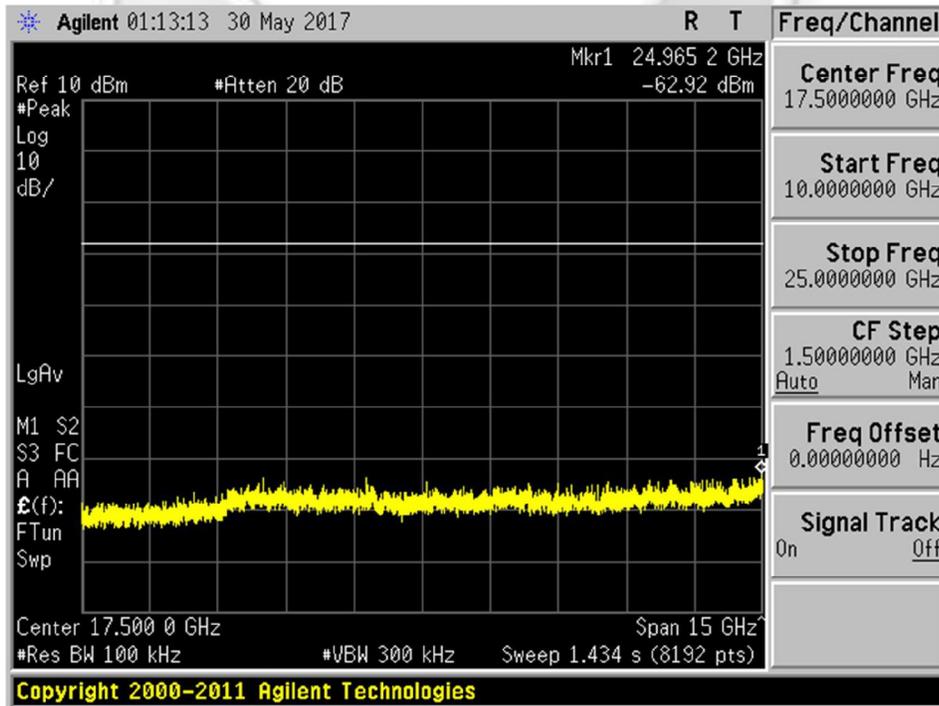


RF CONDUCTED SPURIOUS EMISSIONS TEST

RF Conducted Spurious Emissions Plots – GFSK



Plot 29 – Channel 39 (mid ch)

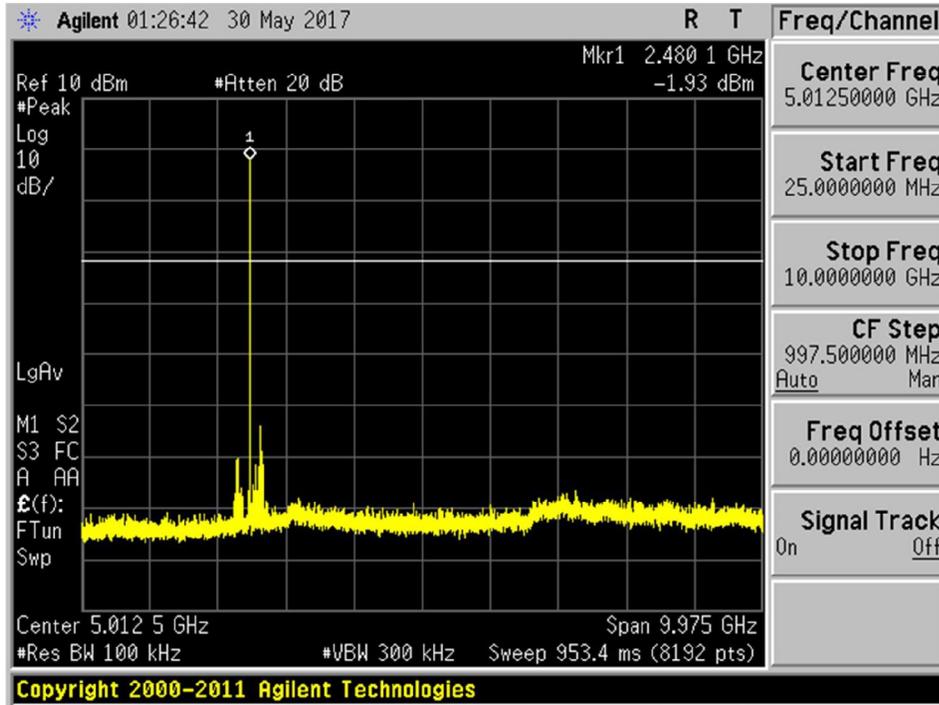


Plot 30 – Channel 39 (mid ch)

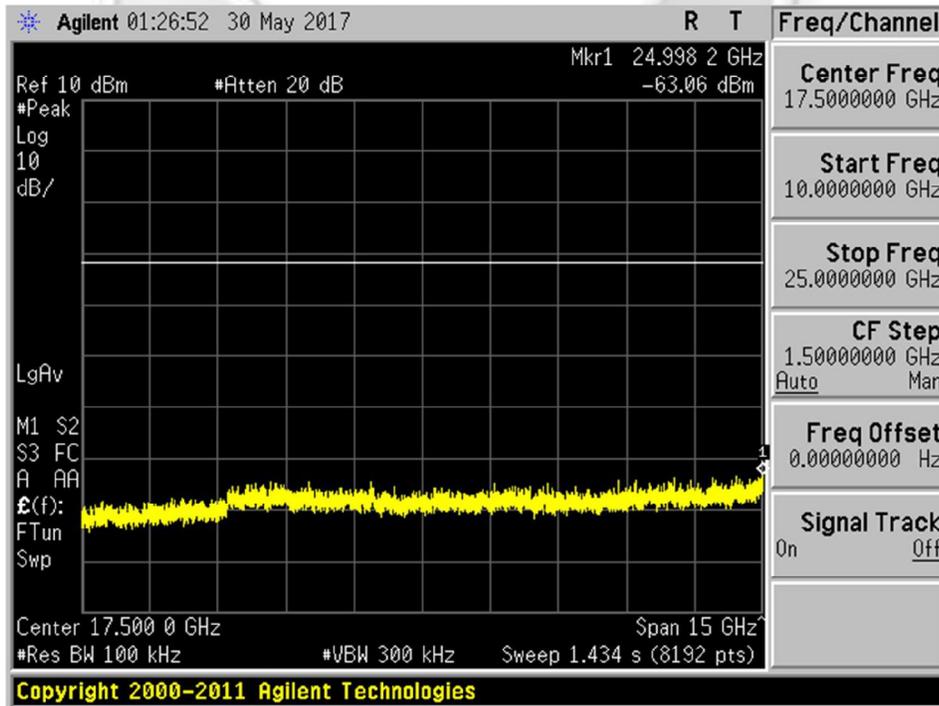


RF CONDUCTED SPURIOUS EMISSIONS TEST

RF Conducted Spurious Emissions Plots – GFSK



Plot 31 – Channel 78 (upper ch)

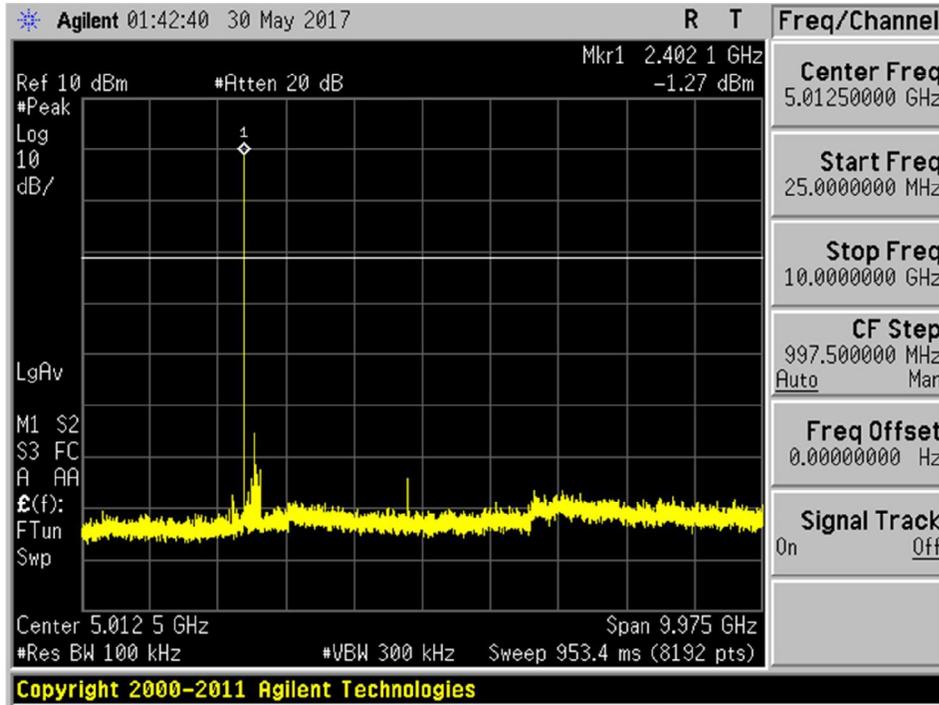


Plot 32 – Channel 78 (upper ch)

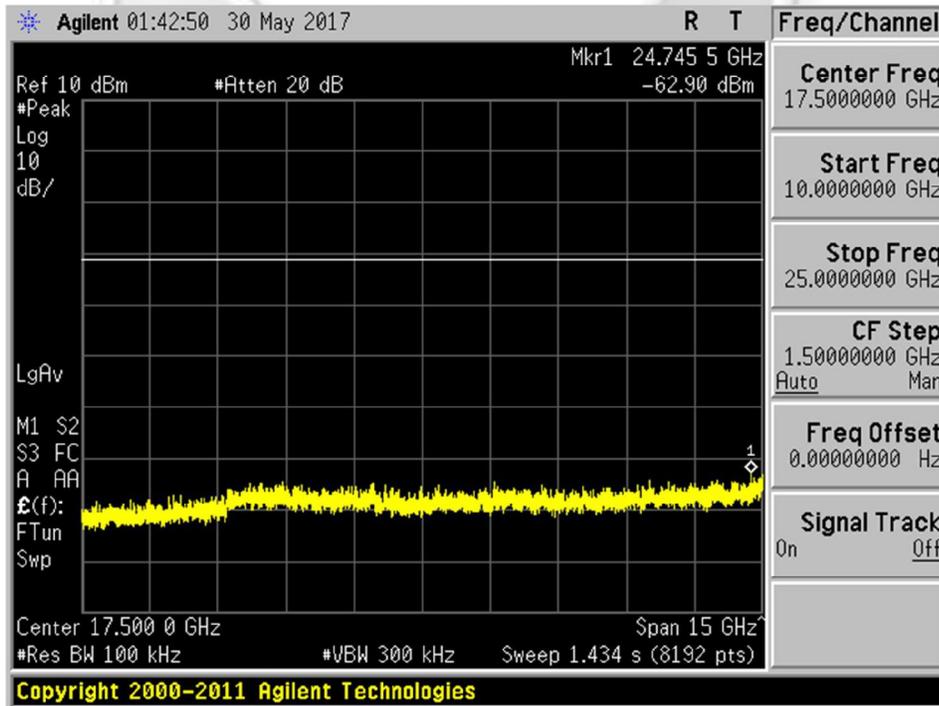


RF CONDUCTED SPURIOUS EMISSIONS TEST

RF Conducted Spurious Emissions Plots – ($\pi/4$) DQPSK



Plot 33 – Channel 0 (lower ch)

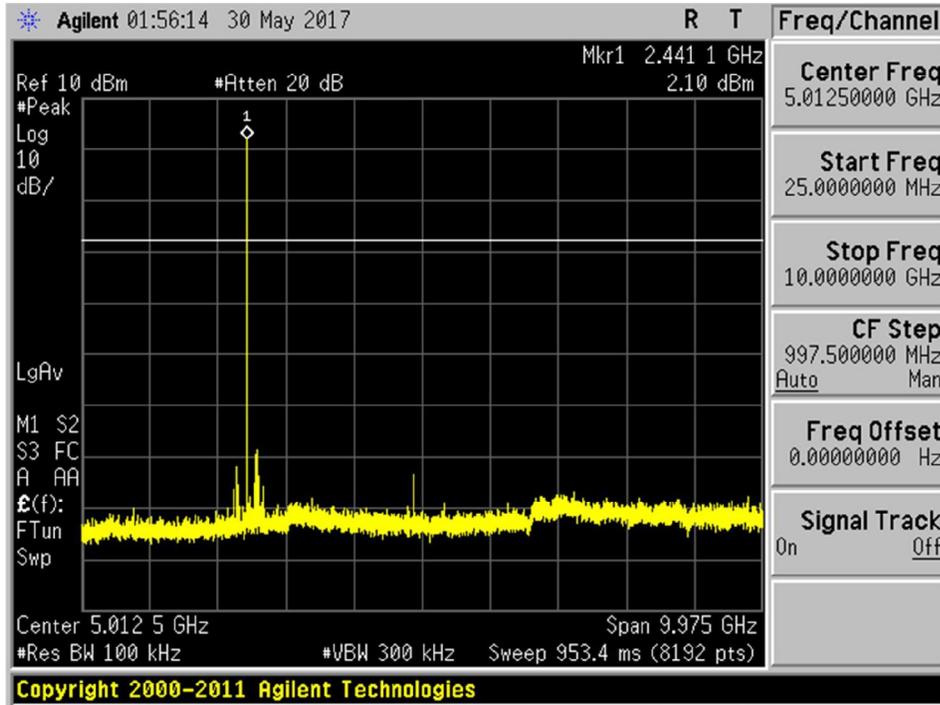


Plot 34 – Channel 0 (lower ch)

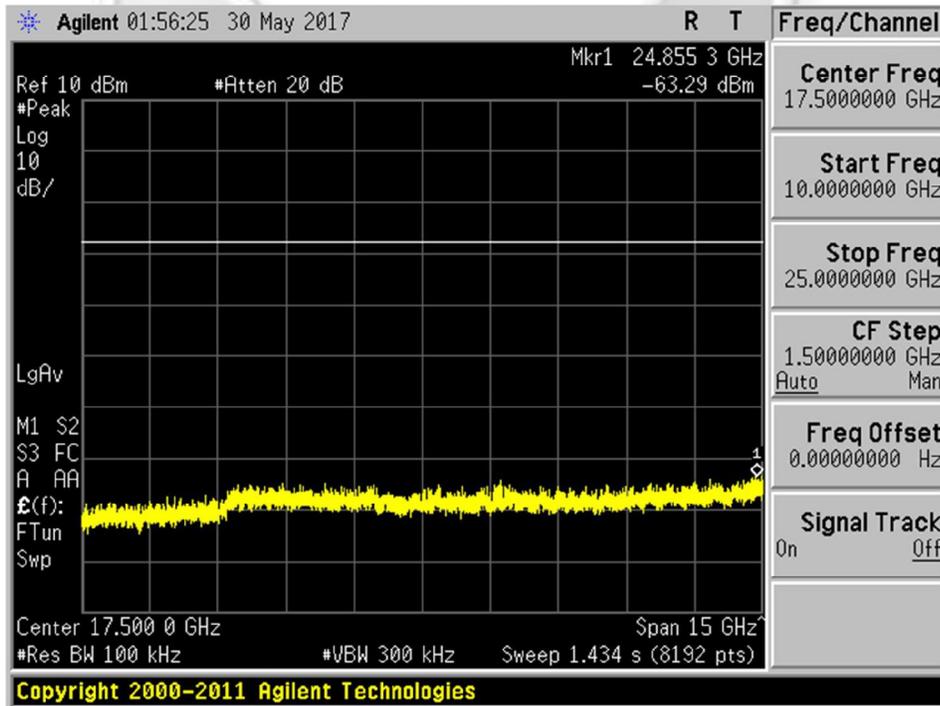


RF CONDUCTED SPURIOUS EMISSIONS TEST

RF Conducted Spurious Emissions Plots – ($\pi/4$) DQPSK



Plot 35 – Channel 39 (mid ch)

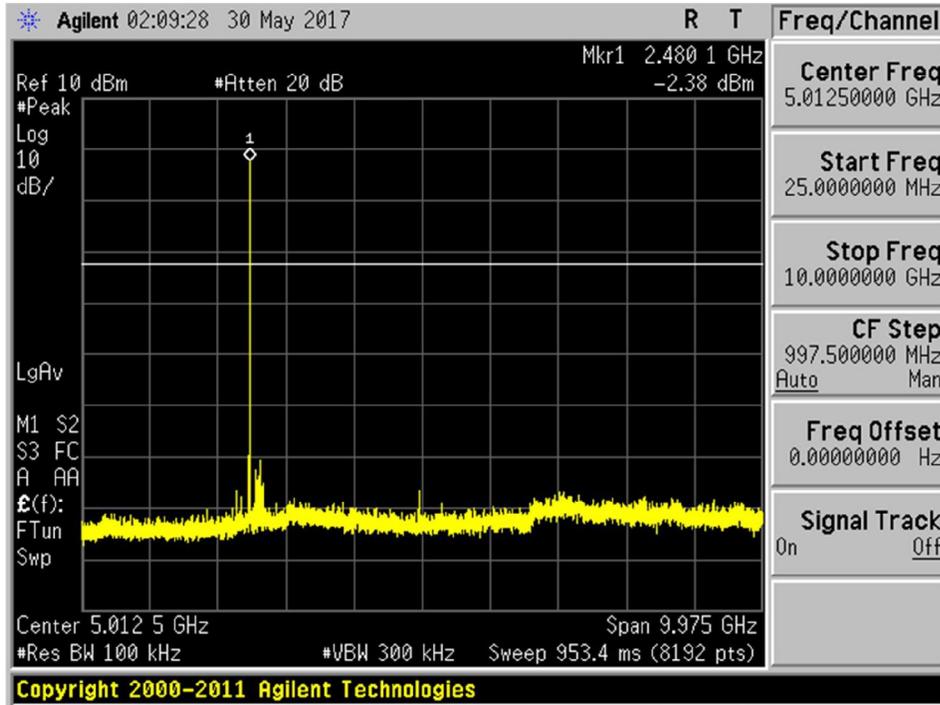


Plot 36 – Channel 39 (mid ch)

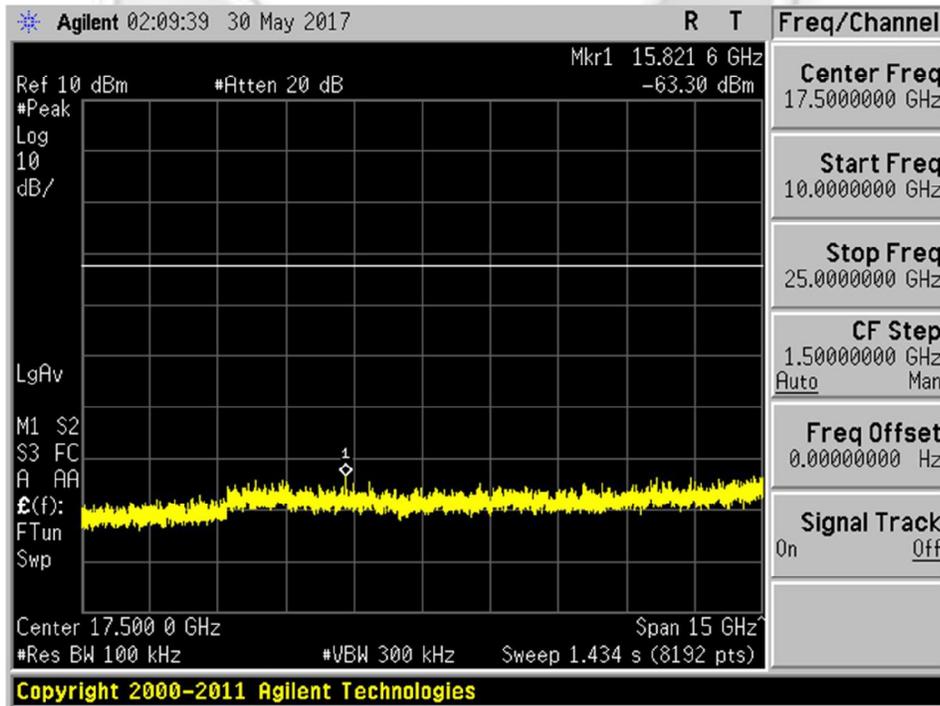


RF CONDUCTED SPURIOUS EMISSIONS TEST

RF Conducted Spurious Emissions Plots – ($\pi/4$) DQPSK



Plot 37 – Channel 78 (upper ch)

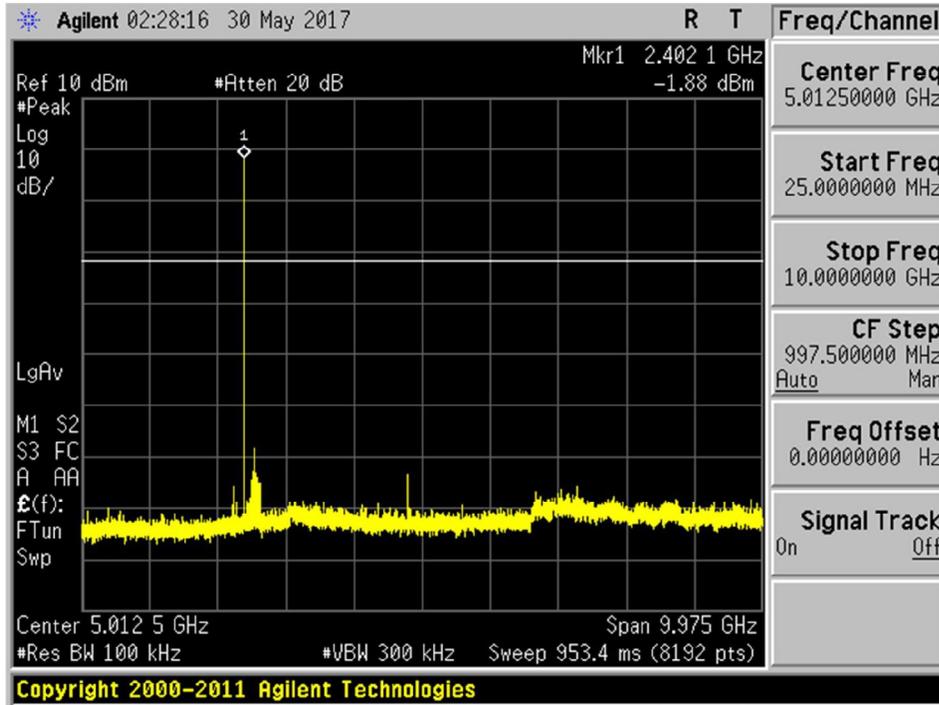


Plot 38 – Channel 78 (upper ch)

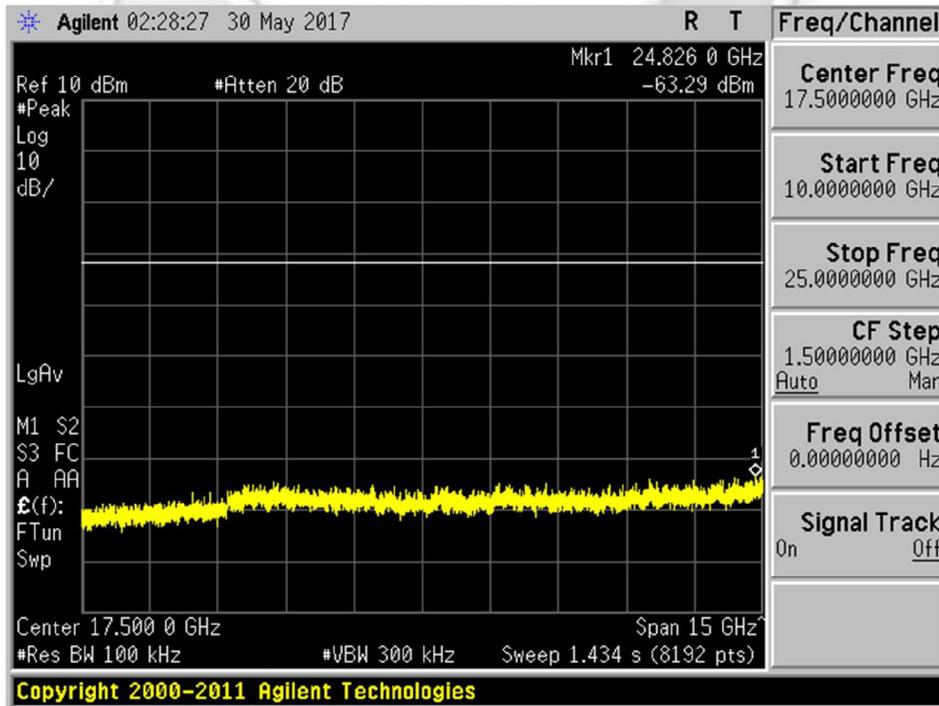


RF CONDUCTED SPURIOUS EMISSIONS TEST

RF Conducted Spurious Emissions Plots – 8DPSK



Plot 39 – Channel 0 (lower ch)

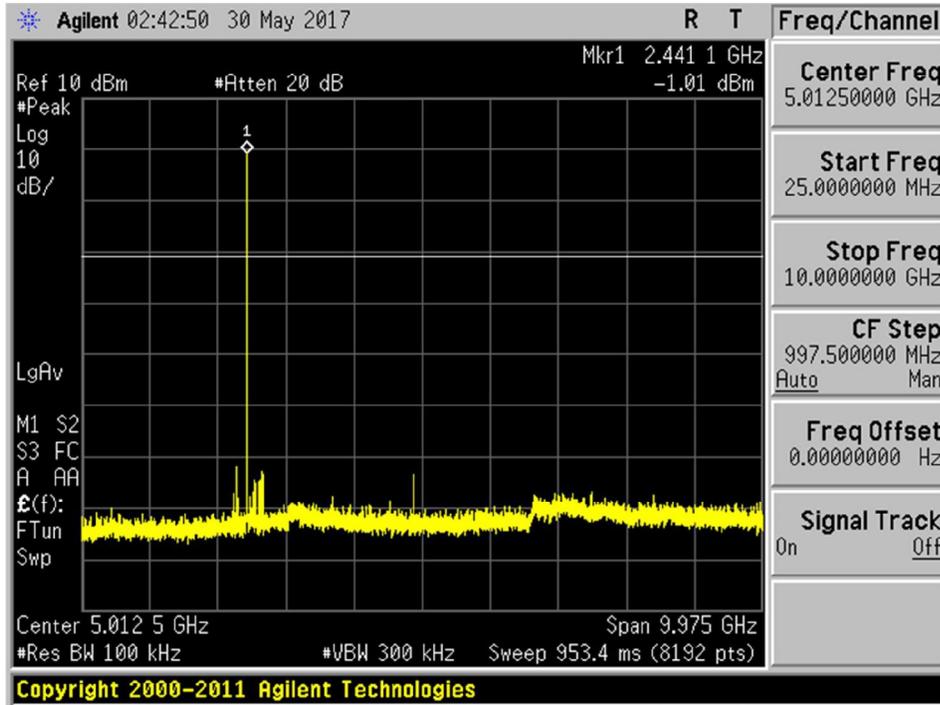


Plot 40 – Channel 0 (lower ch)

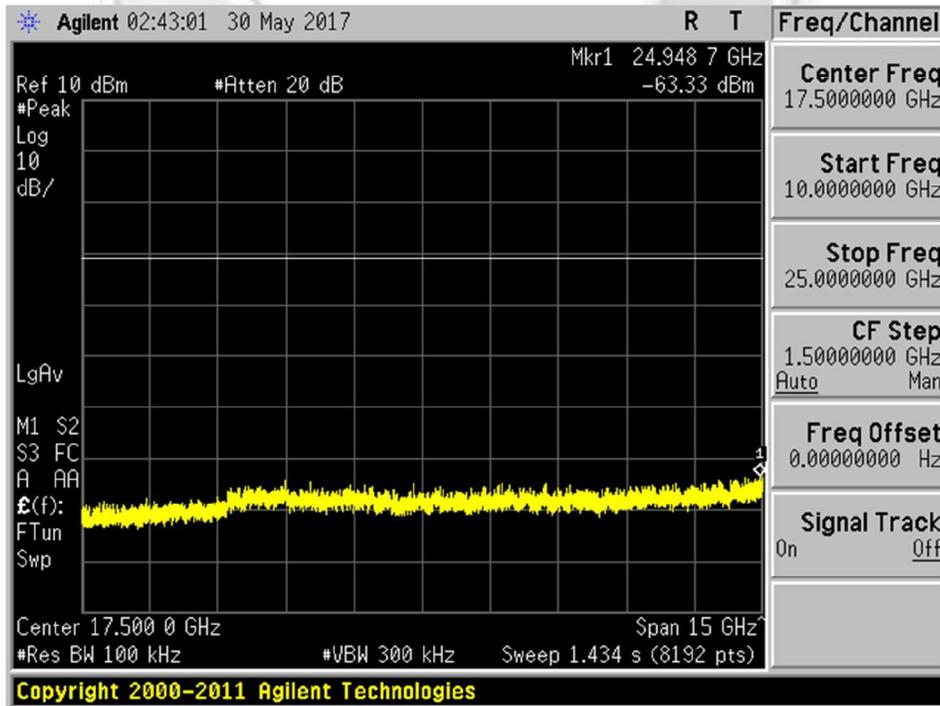


RF CONDUCTED SPURIOUS EMISSIONS TEST

RF Conducted Spurious Emissions Plots – 8DPSK



Plot 41 – Channel 39 (mid ch)

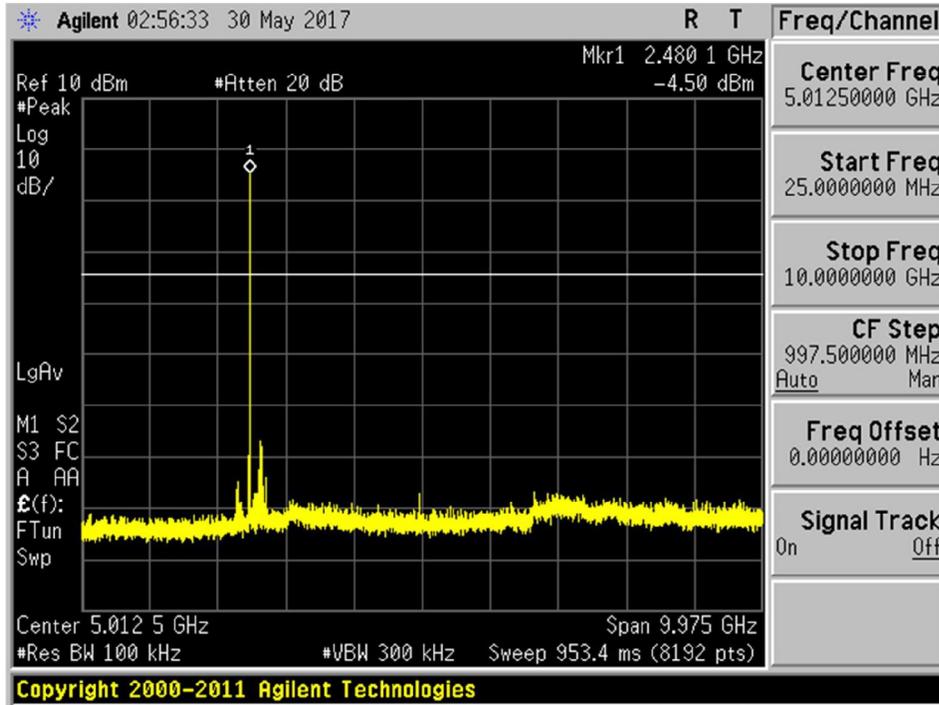


Plot 42 – Channel 39 (mid ch)

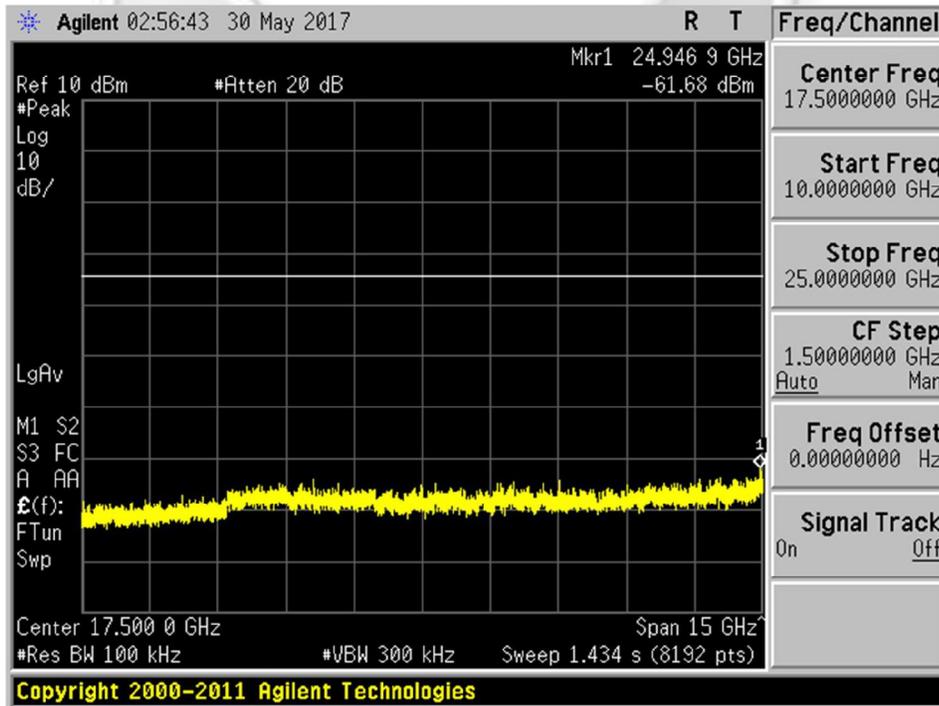


RF CONDUCTED SPURIOUS EMISSIONS TEST

RF Conducted Spurious Emissions Plots – 8DPSK



Plot 43 – Channel 78 (upper ch)



Plot 44 – Channel 78 (upper ch)

BAND EDGE COMPLIANCE (CONDUCTED) TEST

47 CFR FCC Part 15.247(d) Band Edge Compliance (Conducted) Limits

The EUT shows compliance to the requirements of this section, which states in any 100kHz bandwidth outside the frequency band in which the spread spectrum intentional radiator (EUT) is operating, the radio frequency power that is produced by the EUT shall be at least 20dB below that in the 100kHz bandwidth within the band that contains the highest level of the desired power.

47 CFR FCC Part 15.247(d) Band Edge Compliance (Conducted) Test Instrumentation

Instrument	Model	S/No	Cal Due Date
Agilent Spectrum Analyzer	E4440A	MY45304764	04 Jan 2018

47 CFR FCC Part 15.247(d) Band Edge Compliance (Conducted) Test Setup

1. The EUT and supporting equipment were set up as shown in the setup photo.
2. The power supply for the EUT was connected to a filtered mains.
3. The RF antenna connector was connected to the spectrum analyser via a low-loss coaxial cable.
4. The resolution bandwidth (RBW) and the video bandwidth (VBW) of the spectrum analyser were respectively set to 100kHz and 300kHz.
5. All other supporting equipment were powered separately from another filtered mains.

47 CFR FCC Part 15.247(d) Band Edge Compliance (Conducted) Test Method

1. The EUT was switched on and allowed to warm up to its normal operating condition. The EUT was then configured to operate in the test mode with frequency hopping sequence on.
2. The frequency span of the spectrum analyser was set to wide enough to capture the lower band edge of the transmission band, 2.400GHz and any spurious emissions at the band edge.
3. The spectrum analyser was set to max hold to capture any spurious emissions within the span. The signal capturing was continuous until no further spurious emissions were detected.
4. The steps 2 to 3 were repeated with the frequency span of the spectrum analyser was set to wide enough to capture the upper band edge frequency of the transmission band, 2.4835GHz and the any spurious emissions at the band-edge.
5. The measurements were repeated with turning off the frequency hopping sequence of the EUT.



BAND EDGE COMPLIANCE (CONDUCTED) TEST

47 CFR FCC Part 15.247(d) Band Edge Compliance (Conducted) Results

Test Input Power	3.7Vdc	Temperature	24°C
Attached Plots	45 – 56	Relative Humidity	60%
		Atmospheric Pressure	1030mbar
		Tested By	Liau Lee Yin

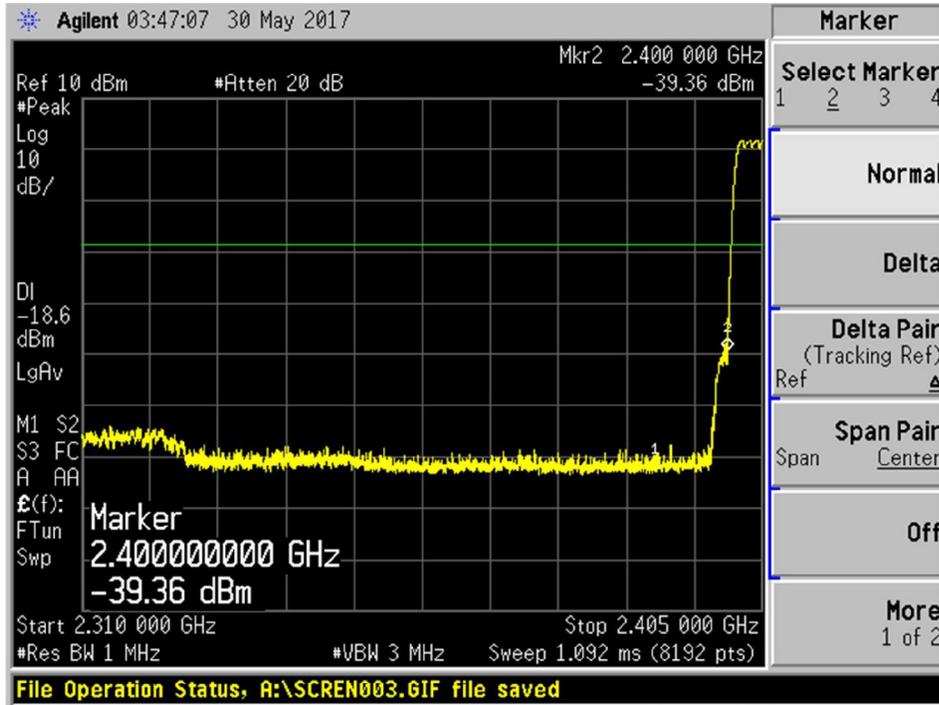
No significant signal was found and they were below the specified limit.



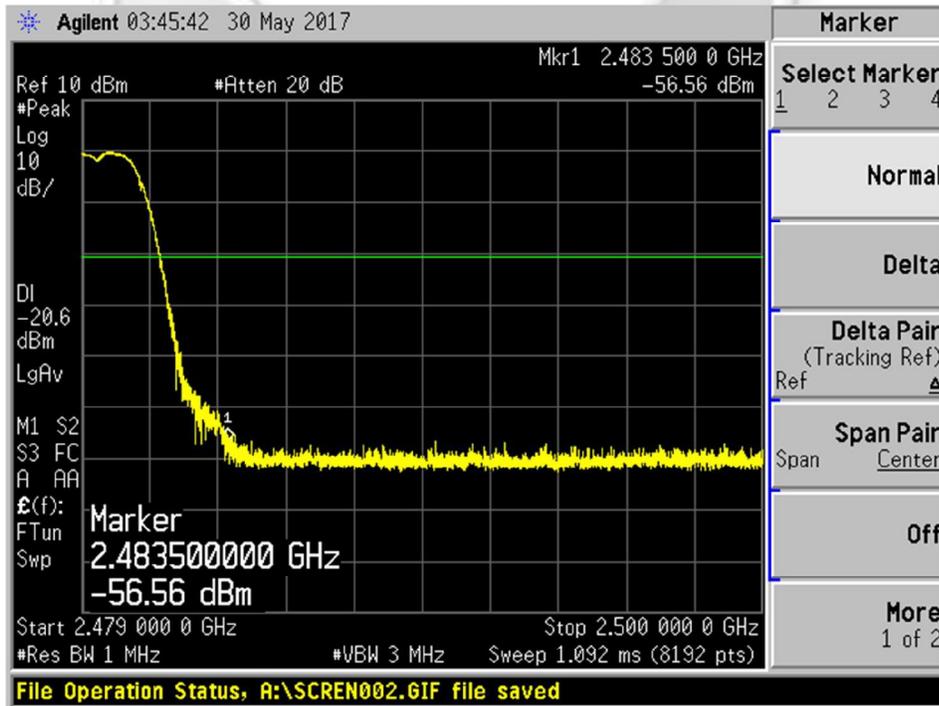


BAND EDGE COMPLIANCE (CONDUCTED) TEST

Band Edge Compliance (Conducted) Plots – Frequency Hopping On (GFSK)



Plot 45 – Lower Band Edge at 2.4000GHz

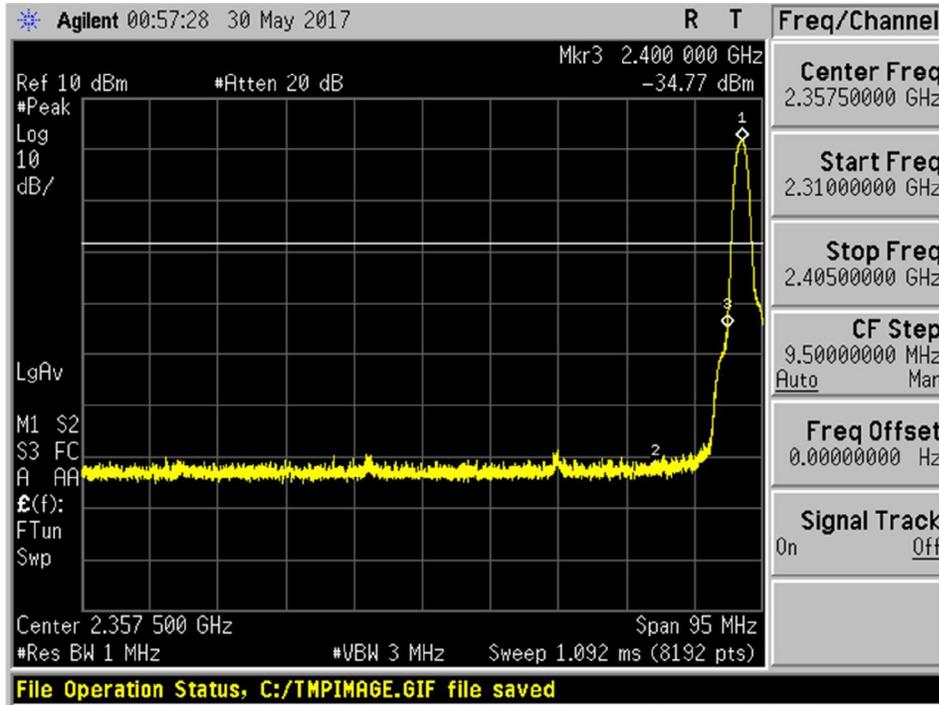


Plot 46 – Upper Band Edge at 2.4835GHz

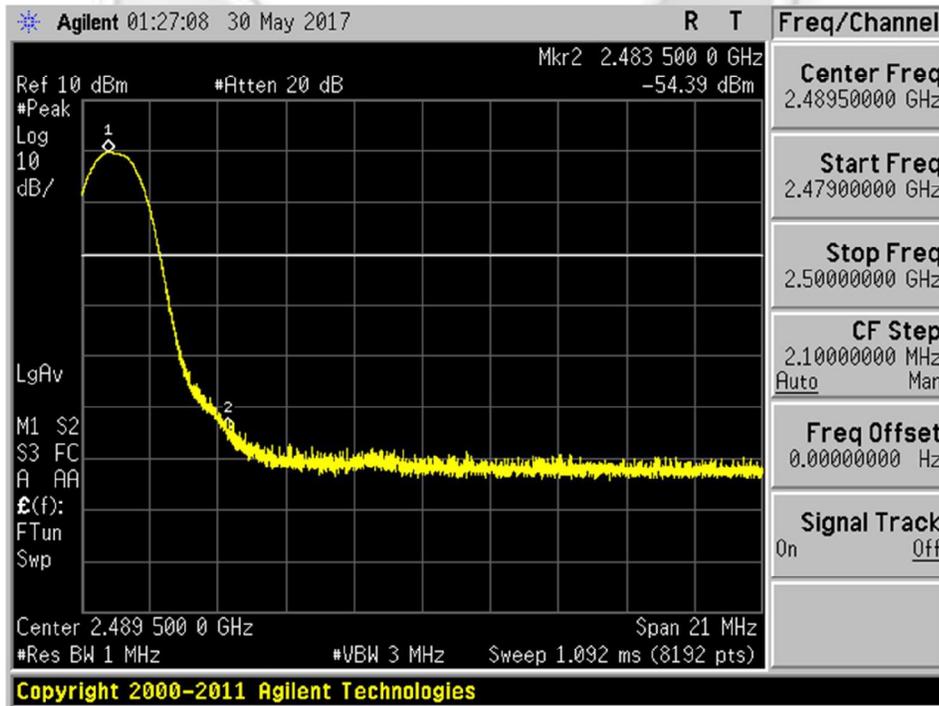


BAND EDGE COMPLIANCE (CONDUCTED) TEST

Band Edge Compliance (Conducted) Plots – Frequency Hopping Off (GFSK)



Plot 47 – Lower Band Edge at 2.4000GHz

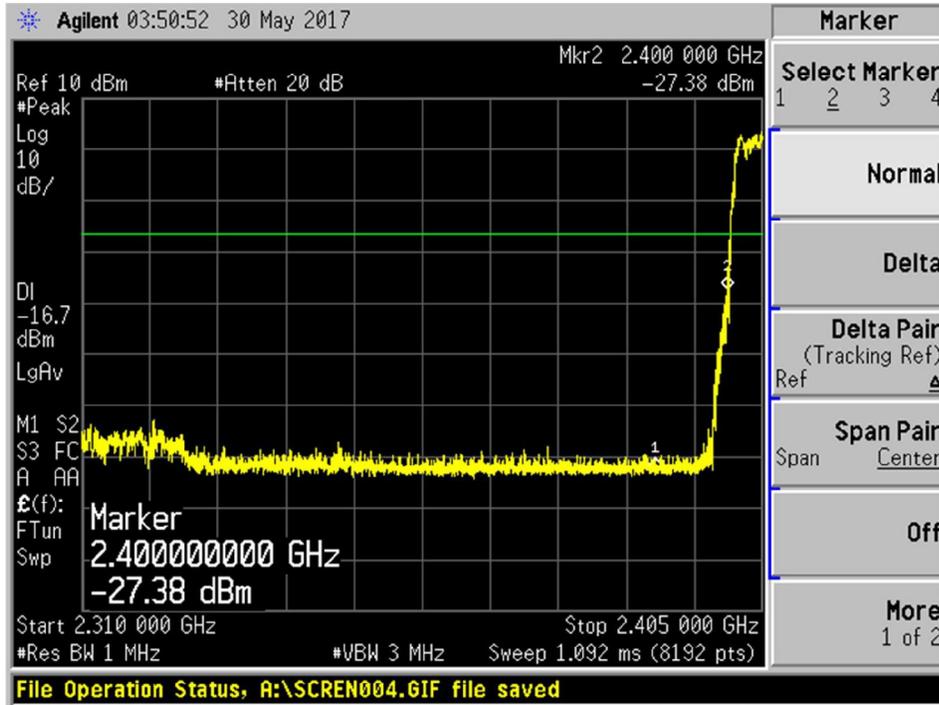


Plot 48 – Upper Band Edge at 2.4835GHz

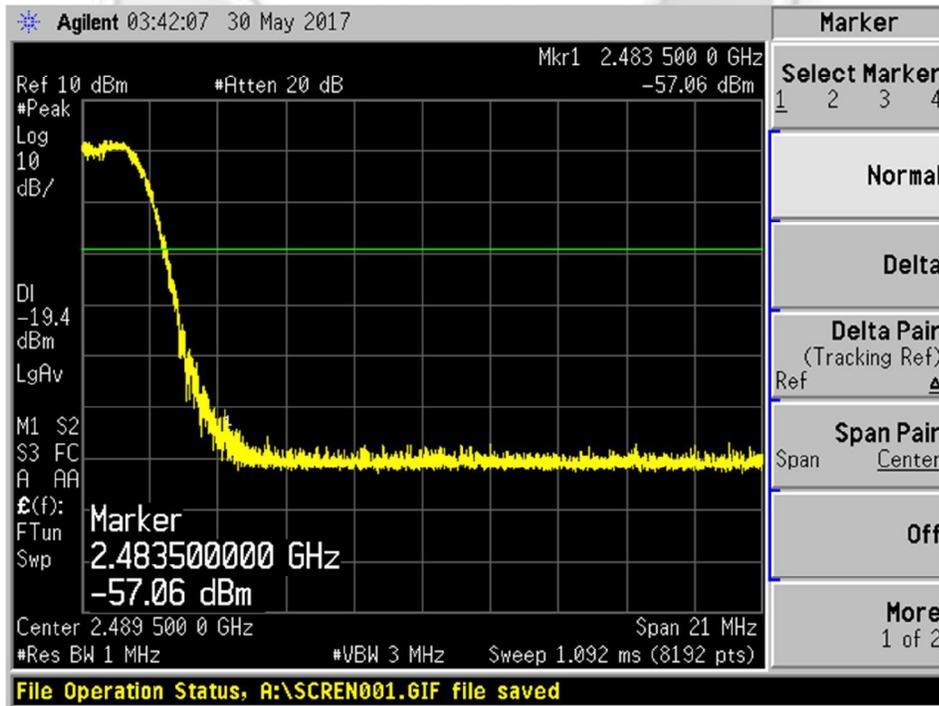


BAND EDGE COMPLIANCE (CONDUCTED) TEST

Band Edge Compliance (Conducted) Plots – Frequency Hopping On (($\pi/4$) DQPSK)



Plot 49 – Lower Band Edge at 2.4000GHz

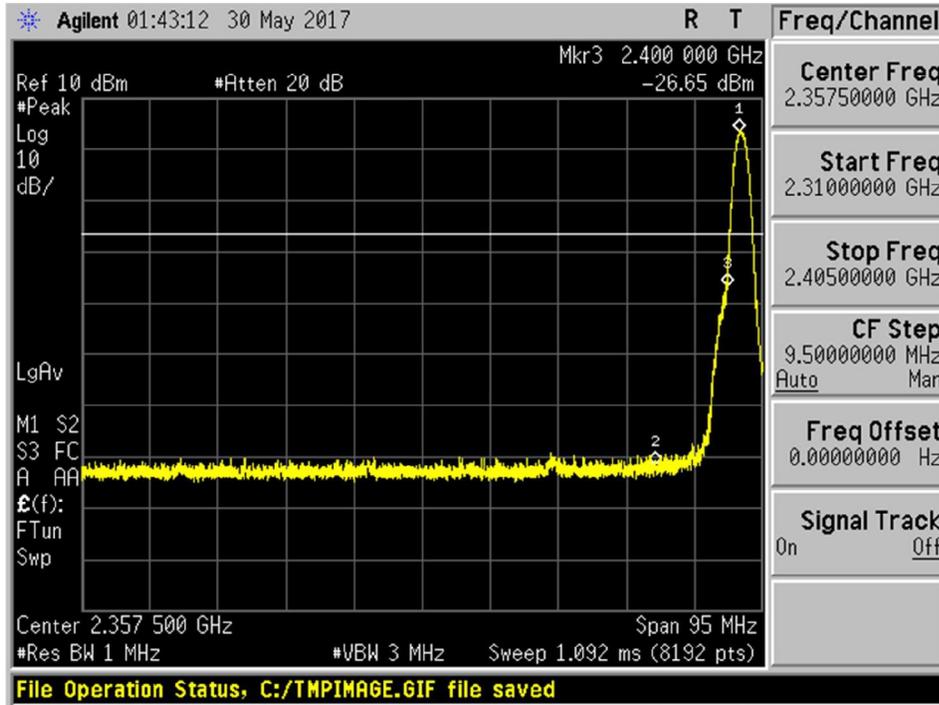


Plot 50 – Upper Band Edge at 2.4835GHz

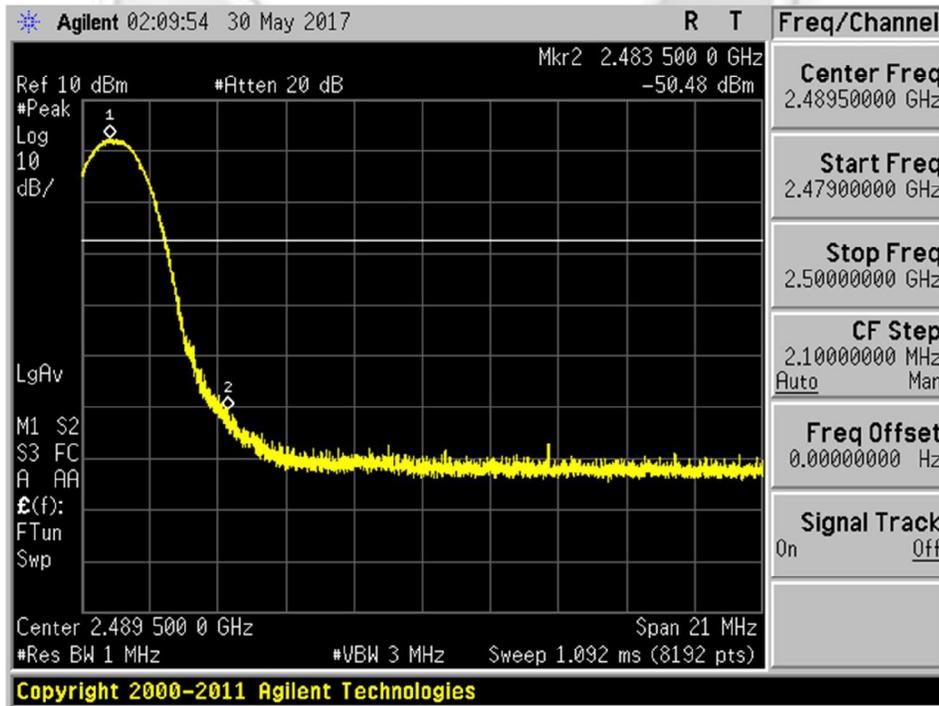


BAND EDGE COMPLIANCE (CONDUCTED) TEST

Band Edge Compliance (Conducted) Plots – Frequency Hopping Off (($\pi/4$) DQPSK)



Plot 51 – Lower Band Edge at 2.4000GHz

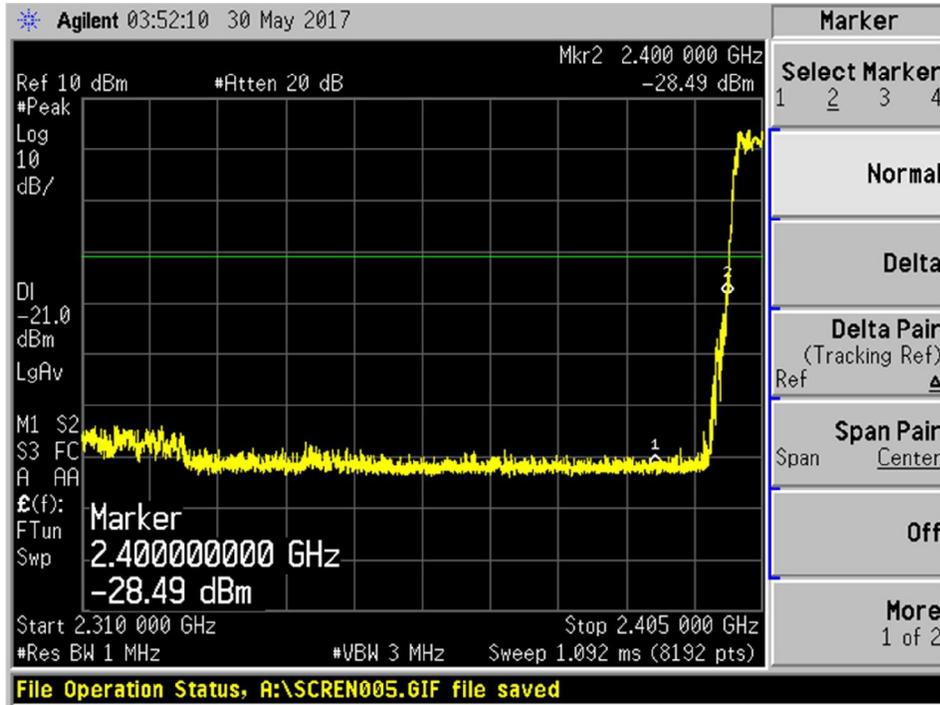


Plot 52 – Upper Band Edge at 2.4835GHz

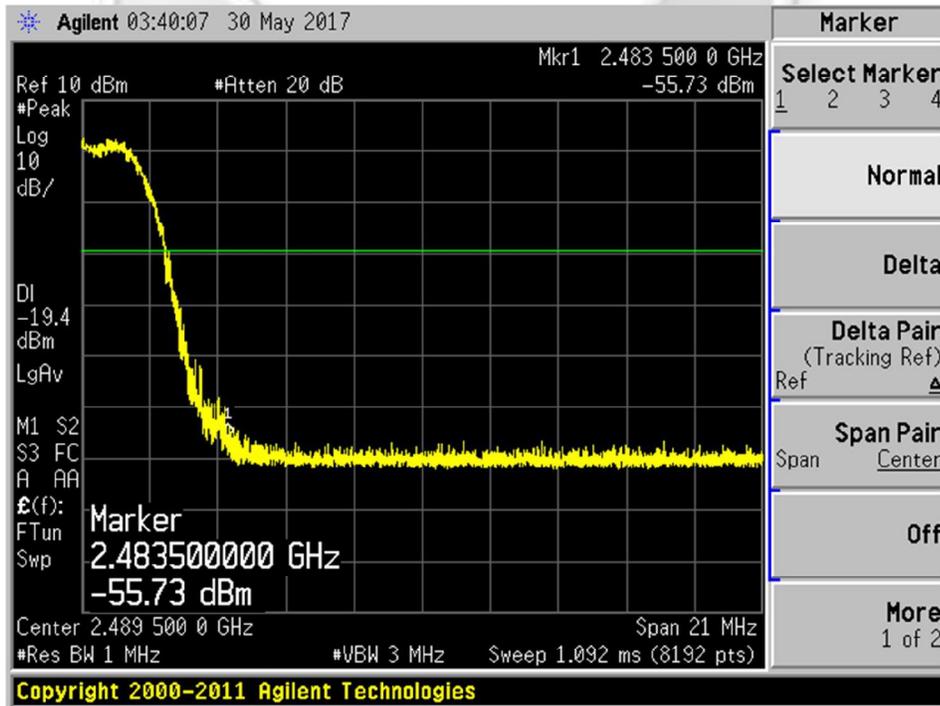


BAND EDGE COMPLIANCE (CONDUCTED) TEST

Band Edge Compliance (Conducted) Plots – Frequency Hopping On (8DPSK)



Plot 53 – Lower Band Edge at 2.4000GHz

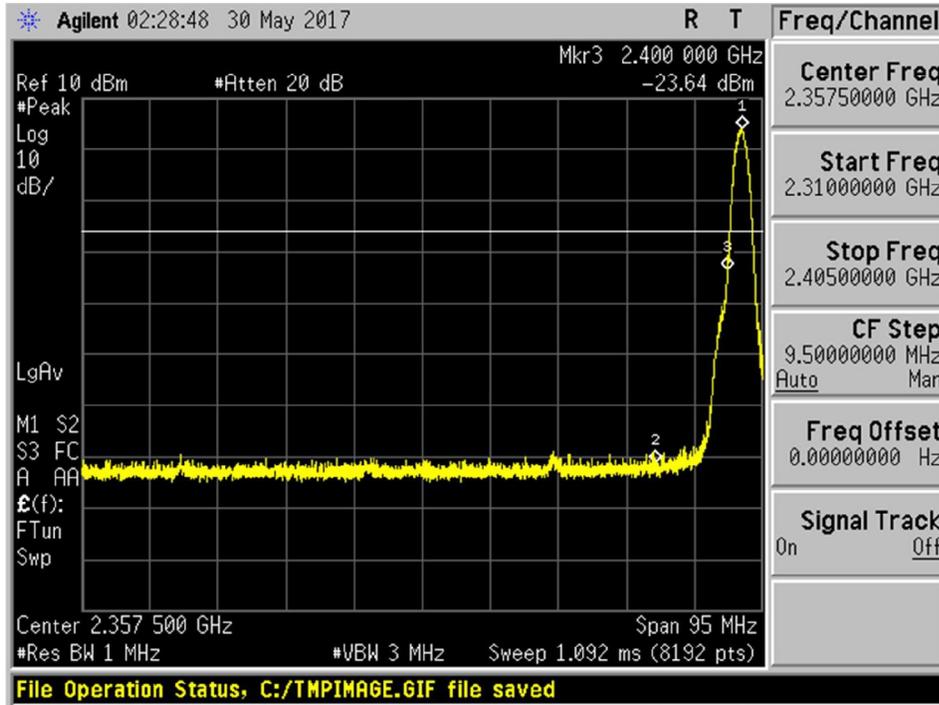


Plot 54 – Upper Band Edge at 2.4835GHz

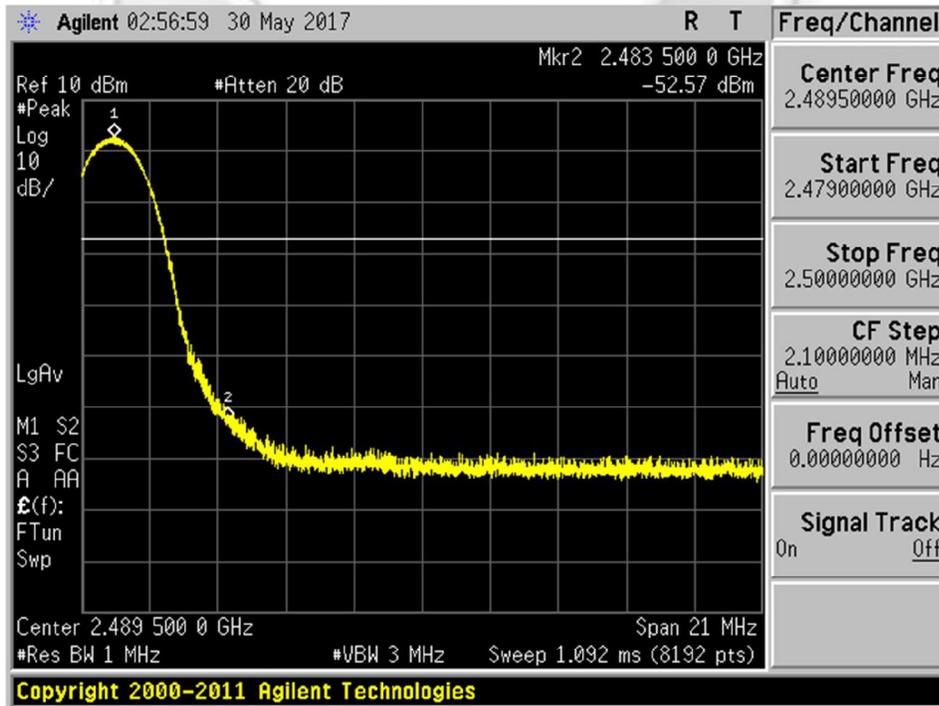


BAND EDGE COMPLIANCE (CONDUCTED) TEST

Band Edge Compliance (Conducted) Plots – Frequency Hopping Off (8DPSK)



Plot 55 – Lower Band Edge at 2.4000GHz



Plot 56 – Upper Band Edge at 2.4835GHz

BAND EDGE COMPLIANCE (RADIATED) TEST

47 CFR FCC Part 15.247(d) Band Edge Compliance (Radiated) Limits

The EUT shows compliance to the requirements of this section, which states in any 100kHz bandwidth outside the frequency band in which the spread spectrum intentional radiator (EUT) is operating, the radio frequency power that is produced by the EUT shall be at least 20dB below that in the 100kHz bandwidth within the band that contains the highest level of the desired power. In addition, radiated emissions which fall in the restricted bands shall comply to the radiated emission limits specified in 15.209.

47 CFR FCC Part 15.247(d) Band Edge Compliance (Radiated) Test Instrumentation

Instrument	Model	S/No	Cal Due Date
R&S Test Receiver – ESI1	ESI40	100010	11 Oct 2017
Schaffner Bilog Antenna –(30MHz-2GHz) BL4	CBL6112B	2593	18 Jan 2018
Com-Power Preamplifier (1MHz-1GHz)	PAM-103	441056	22 Jul 2017
TDK-RF Horn Antenna	HRN-0118	130256	18 Oct 2017
R&S Preamplifier (1GHz -18GHz)	SCU18	102191	10 Mar 2018
Agilent Preamplifier(1GHz-26.5GHz) (PA18)	8449D	3008A02305	12 Oct 2017
ETS Horn Antenna(18GHz-40GHz) (Ref)	3116	0004-2474	18 Oct 2017

47 CFR FCC Part 15.247(d) Band Edge Compliance (Radiated) Test Setup

1. The EUT and supporting equipment were set up as shown in the setup photo.
2. The power supply for the EUT was connected to a filtered mains.
3. The resolution bandwidth (RBW) and the video bandwidth (VBW) of the spectrum analyser were respectively set to 100kHz and 300kHz to show compliance of spurious at band edges are at least 20dB below the carriers. For restricted band spurious at band edges, peak and average measurement plots were taken using the following setting:
 - a. Peak Plot:
RBW = 1MHz, VBW = 3RBW
 - b. Average Plot
RBW = 1MHz, VBW = 10Hz
4. All other supporting equipment were powered separately from another filtered mains.

47 CFR FCC Part 15.247(d) Band Edge Compliance (Radiated) Test Method

1. The EUT was switched on and allowed to warm up to its normal operating condition. The EUT was then configured to operate in the test mode with frequency hopping sequence on.
2. The frequency span of the spectrum analyser was set to wide enough to capture the lower band edge of the transmission band, 2.400GHz and any spurious emissions at the band edge.
3. The spectrum analyser was set to max hold to capture any spurious emissions within the span. The signal capturing was continuous until no further spurious emissions were detected.
4. The steps 2 to 3 were repeated with the frequency span of the spectrum analyser was set to wide enough to capture the upper band edge frequency of the transmission band, 2.4835GHz and the any spurious emissions at the band-edge.



BAND EDGE COMPLIANCE (RADIATED) TEST

47 CFR FCC Part 15.247(d) Band Edge Compliance (Radiated) Results

Test Input Power	3.7Vdc	Temperature	24°C
Attached Plots	57 – 71	Relative Humidity	60%
		Atmospheric Pressure	1030mbar
		Tested By	Chang Wai Kit

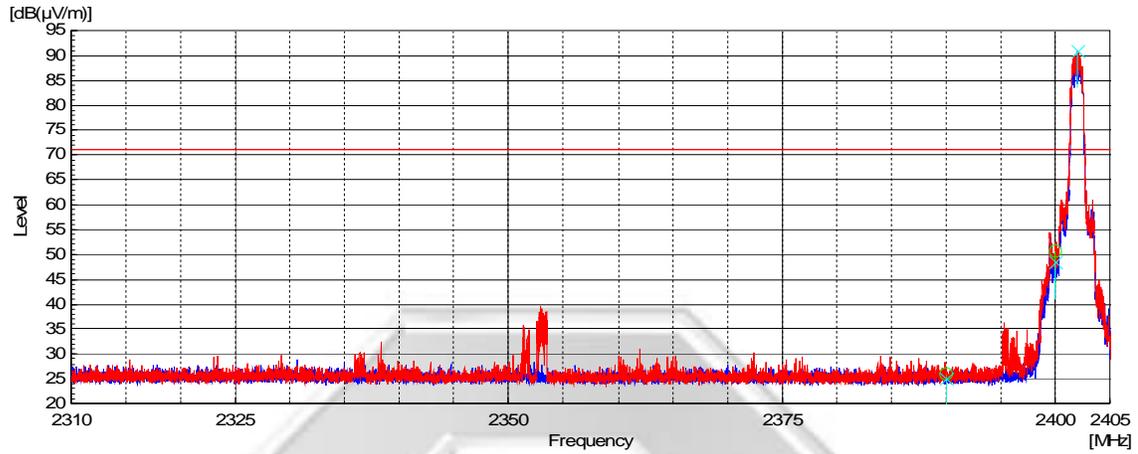
No significant signal was found and they were below the specified limit.



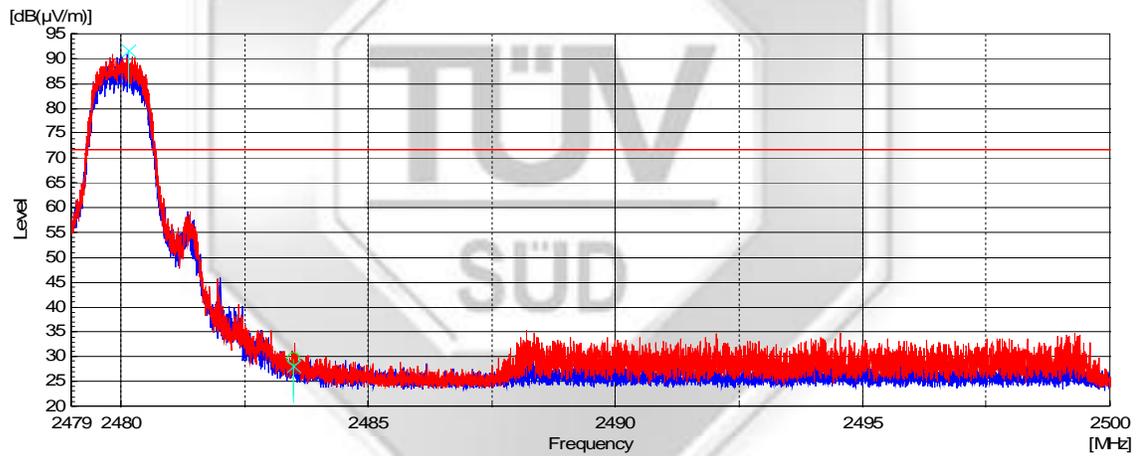


BAND EDGE COMPLIANCE (RADIATED) TEST

Band Edge Compliance (Radiated) Plots (20dB Delta from Carrier at Band Edge) – 8DPSK (Worst)



Plot 57 – Lower Band Edge at 2.4000GHz

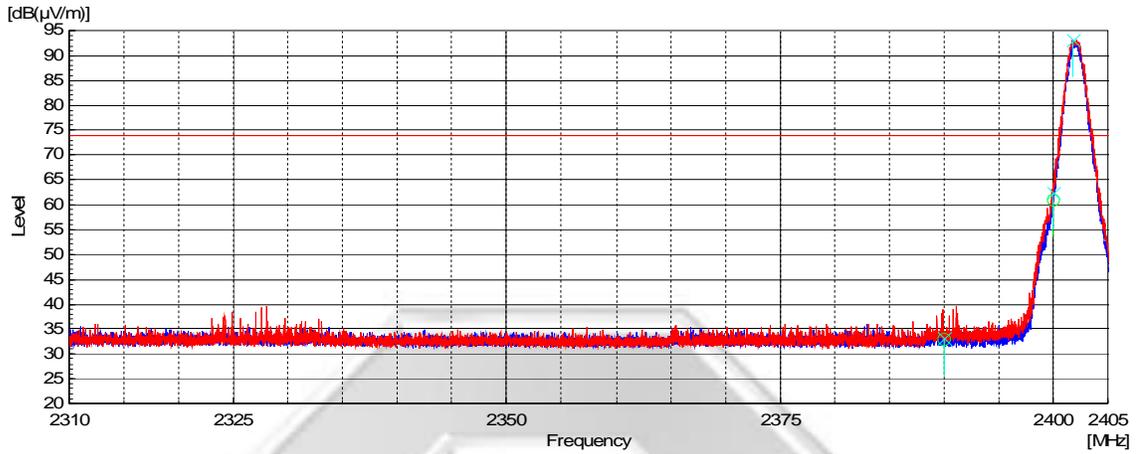


Plot 58 – Upper Band Edge at 2.4835GHz

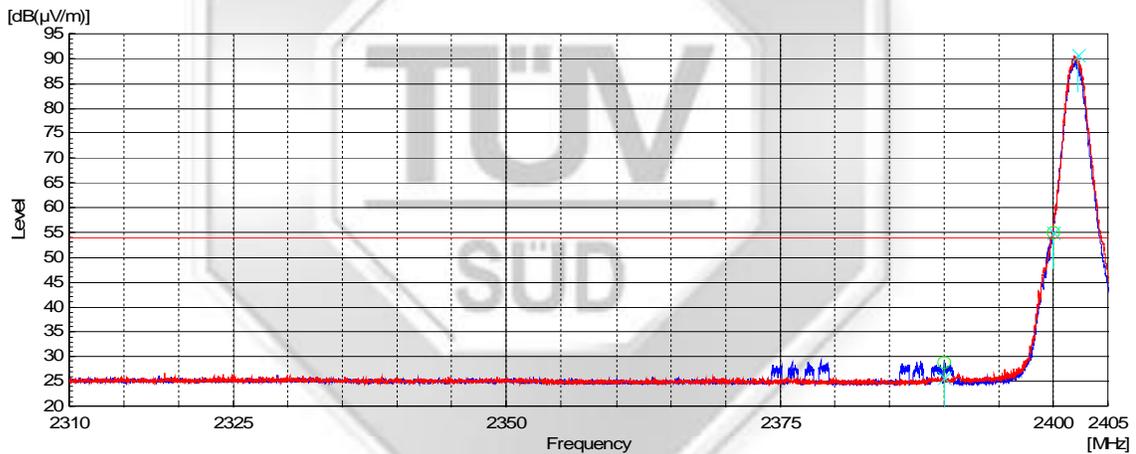


BAND EDGE COMPLIANCE (RADIATED) TEST

Band Edge Compliance (Radiated) Plots (Restricted Band) – 8DPSK (Worst)



Plot 59 – Peak Plot at Lower Band Edge at 2.4000GHz

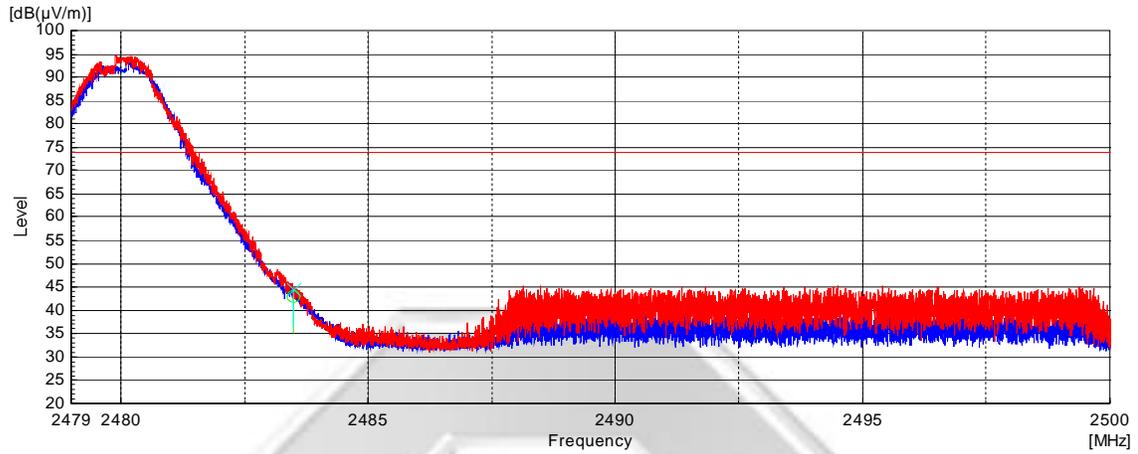


Plot 60 – Average Plot at Lower Band Edge at 2.4000GHz

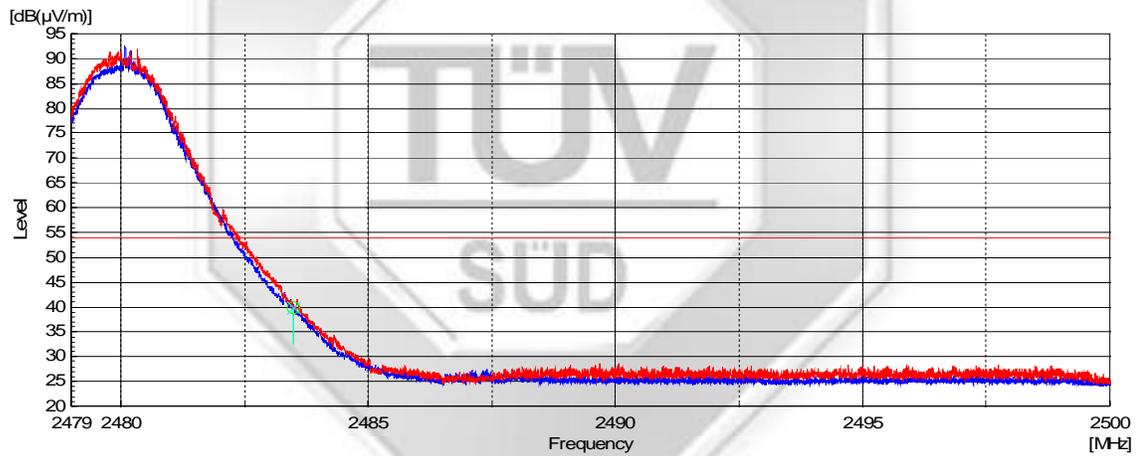


BAND EDGE COMPLIANCE (RADIATED) TEST

Band Edge Compliance (Radiated) Plots (Restricted Band) – 8DPSK (Worst)



Plot 61 – Peak Plot at Upper Band Edge at 2.4835GHz



Plot 62 – Average Plot at Upper Band Edge at 2.4835GHz



PEAK POWER SPECTRAL DENSITY TEST

47 CFR FCC Part 15.247(e) Peak Power Spectral Density Limits

The EUT shows compliance to the requirements of this section, which states the peak power spectral density conducted from the intentional radiator (EUT) to the antenna shall not be greater than 8dBm (6.3mW) in any 3kHz band during any time interval of continuous transmission.

47 CFR FCC Part 15.247(e) Peak Power Spectral Density Test Instrumentation

Instrument	Model	S/No	Cal Due Date
Agilent Spectrum Analyzer	E4440A	MY45304764	04 Jan 2018

47 CFR FCC Part 15.247(e) Peak Power Spectral Density Test Setup

1. The EUT and supporting equipment were set up as shown in the setup photo.
2. The power supply for the EUT was connected to a filtered mains.
3. The RF antenna connector was connected to the spectrum via a low-loss coaxial cable.
4. The resolution bandwidth (RBW) and the video bandwidth (VBW) of the spectrum analyser were respectively set to 3kHz and 10kHz.
5. All other supporting equipment were powered separately from another filtered mains.

47 CFR FCC Part 15.247(e) Peak Power Spectral Density Test Method

1. The EUT was switched on and allowed to warm up to its normal operating condition. The EUT was then configured to operate in the test mode, non-hopping with transmitting frequency at Channel 0 (2.402GHz) (*lower ch*).
2. The sweep time of the spectrum analyser was set to the value of the ratio of the frequency span divided by the RBW.
3. The peak power density of the transmitting frequency was detected and recorded.
4. The step 3 was repeated with the transmitting frequency was set to Channel 39 (2.441GHz) (*mid ch*) and Channel 78 (2.480GHz) (*upper ch*) respectively.



PEAK POWER SPECTRAL DENSITY TEST

47 CFR FCC Part 15.247(e) Peak Power Spectral Density Results

Test Input Power	3.7Vdc	Temperature	24°C
Attached Plots	63 – 65	Relative Humidity	60%
Modulation	GFSK	Atmospheric Pressure	1030mbar
		Tested By	Liau Lee Yin

Channel	Channel Frequency (GHz)	Peak Power Spectral Density (mW)	Limit (mW)
0 (lower ch)	2.402	0.0724	6.3
39 (mid ch)	2.441	0.0792	6.3
78 (upper ch)	2.480	0.0044	6.3

Test Input Power	3.7Vdc	Temperature	24°C
Attached Plots	66 – 68	Relative Humidity	60%
Modulation	($\pi/4$) DQPSK	Atmospheric Pressure	1030mbar
		Tested By	Liau Lee Yin

Channel	Channel Frequency (GHz)	Peak Power Spectral Density (mW)	Limit (mW)
0 (lower ch)	2.402	0.0815	6.3
39 (mid ch)	2.441	0.0921	6.3
78 (upper ch)	2.480	0.0609	6.3

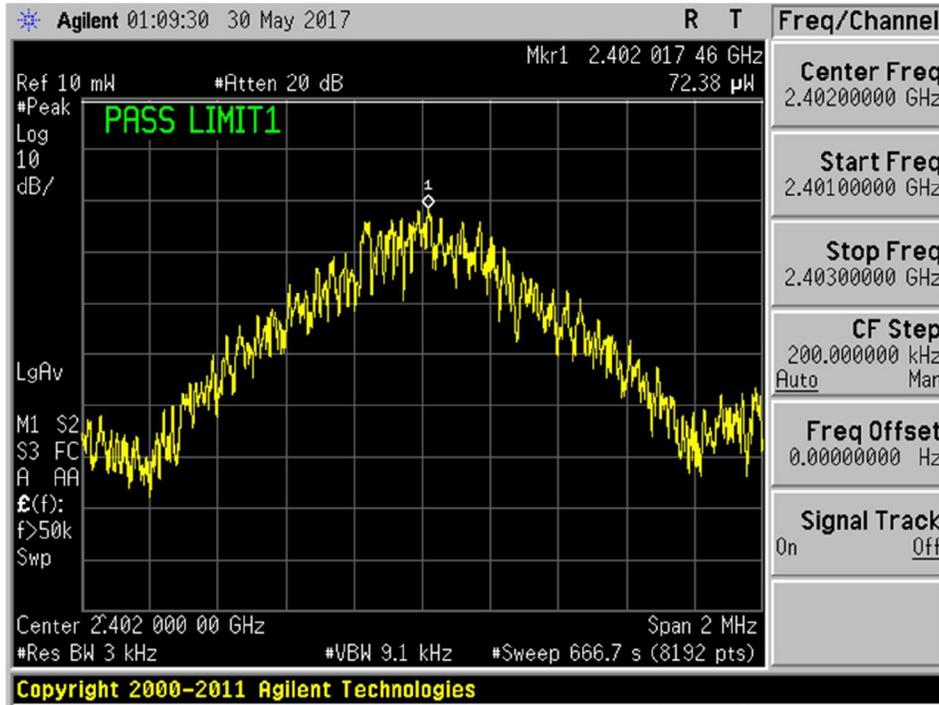
Test Input Power	3.7Vdc	Temperature	24°C
Attached Plots	69 – 71	Relative Humidity	60%
Modulation	8DPSK	Atmospheric Pressure	1030mbar
		Tested By	Liau Lee Yin

Channel	Channel Frequency (GHz)	Peak Power Spectral Density (mW)	Limit (mW)
0 (lower ch)	2.402	0.0848	6.3
39 (mid ch)	2.441	0.0975	6.3
78 (upper ch)	2.480	0.0650	6.3

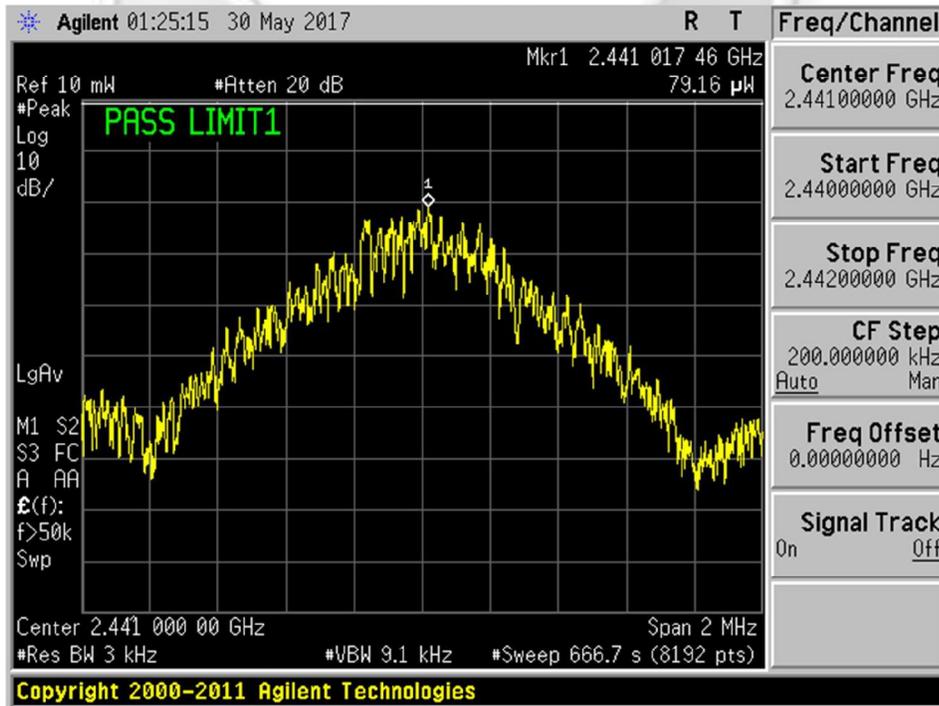


PEAK POWER SPECTRAL DENSITY TEST

Peak Power Spectral Density Plots – GFSK



Plot 63 – Channel 0 (lower ch)

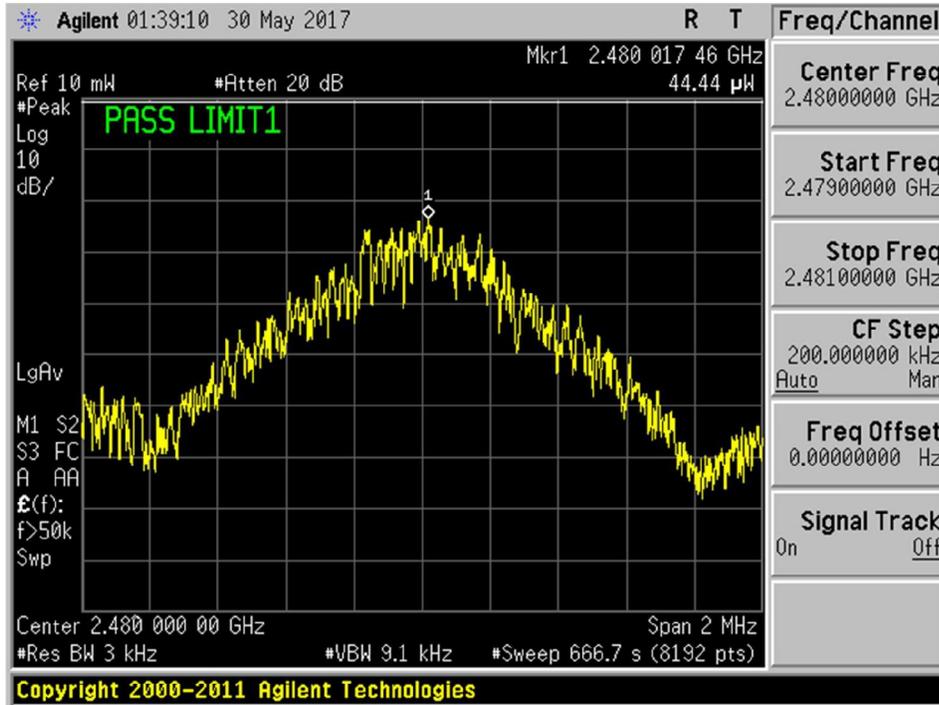


Plot 64 – Channel 39 (mid ch)



PEAK POWER SPECTRAL DENSITY TEST

Peak Power Spectral Density Plots – GFSK



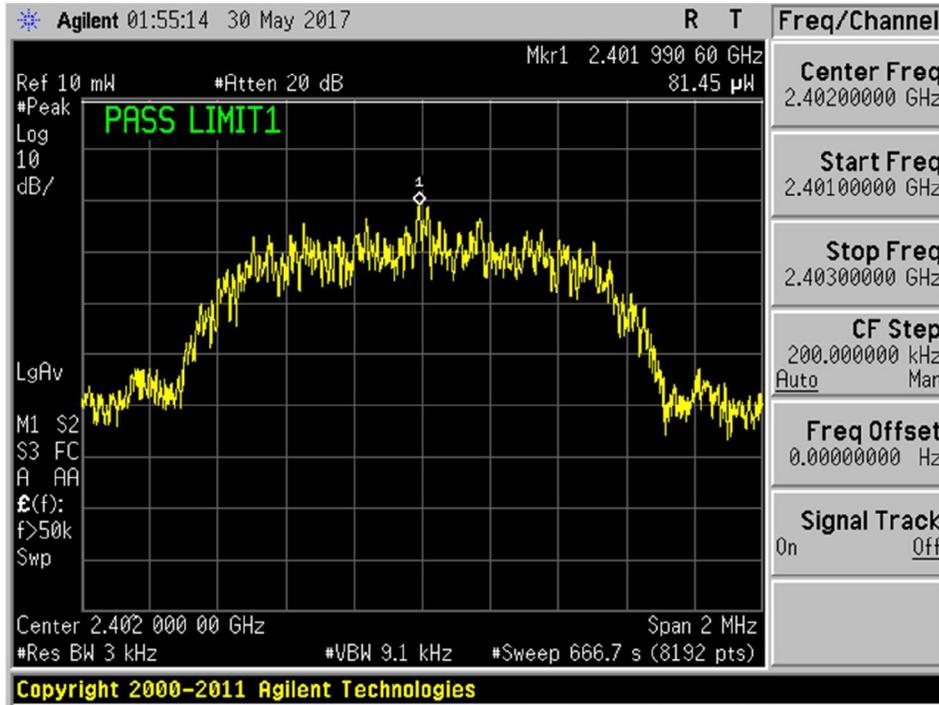
Plot 65 – Channel 78 (upper ch)



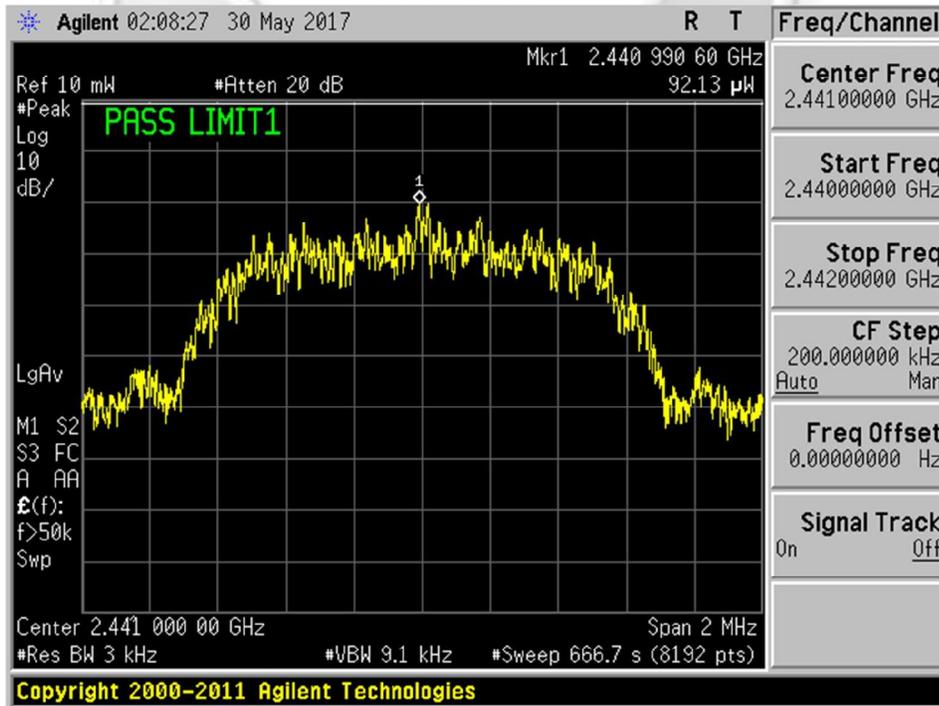


PEAK POWER SPECTRAL DENSITY TEST

Peak Power Spectral Density Plots – ($\pi/4$) DQPSK



Plot 66– Channel 0 (lower ch)

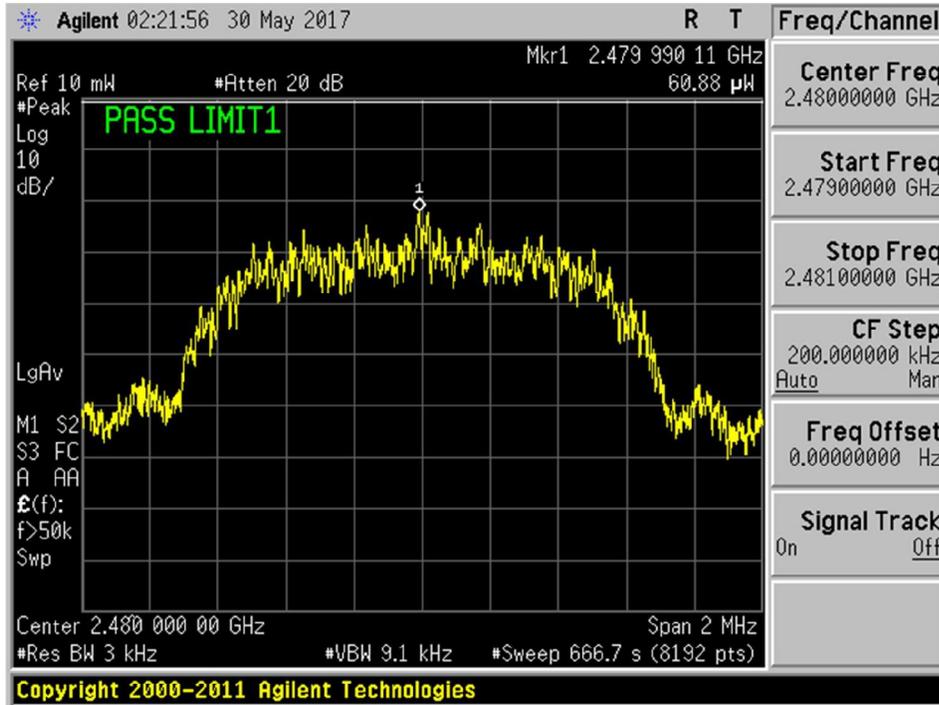


Plot 67 – Channel 39 (mid ch)



PEAK POWER SPECTRAL DENSITY TEST

Peak Power Spectral Density Plots – ($\pi/4$) DQPSK



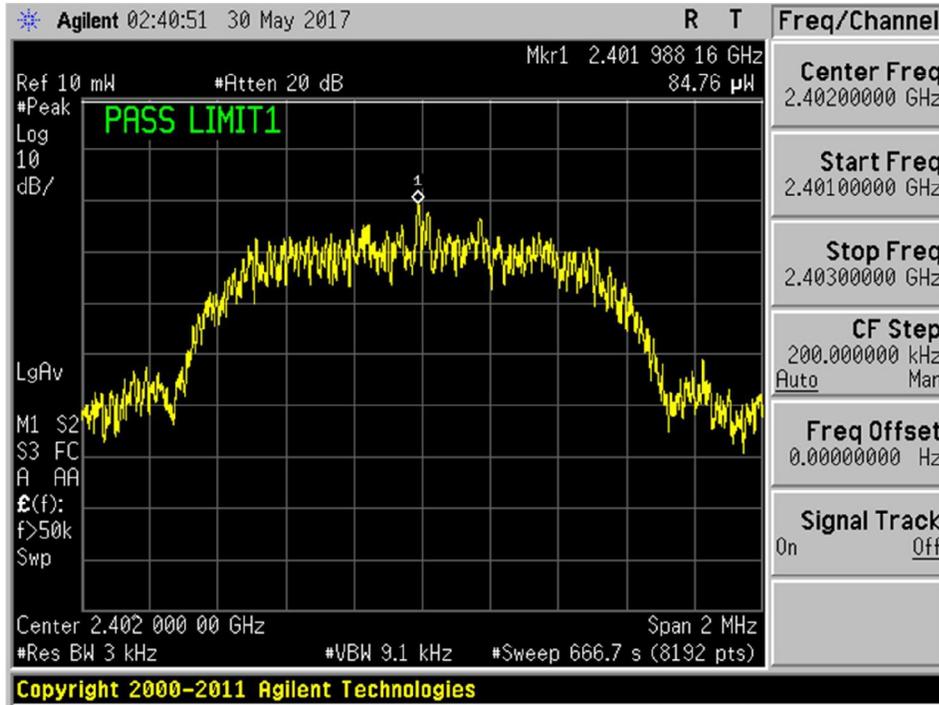
Plot 68 – Channel 78 (upper ch)



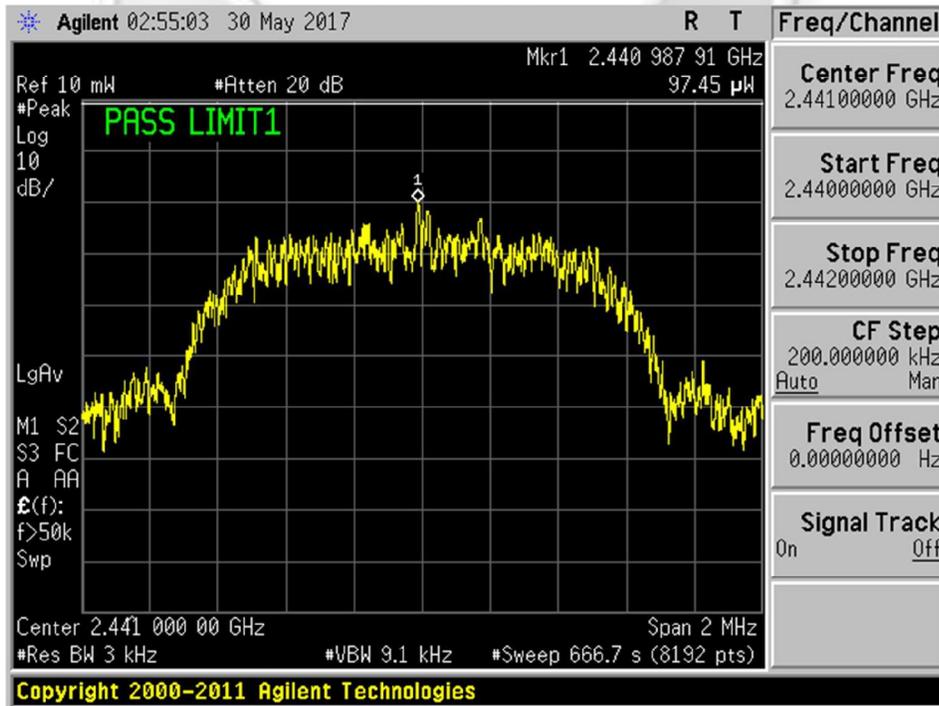


PEAK POWER SPECTRAL DENSITY TEST

Peak Power Spectral Density Plots – 8DPSK



Plot 69– Channel 0 (lower ch)

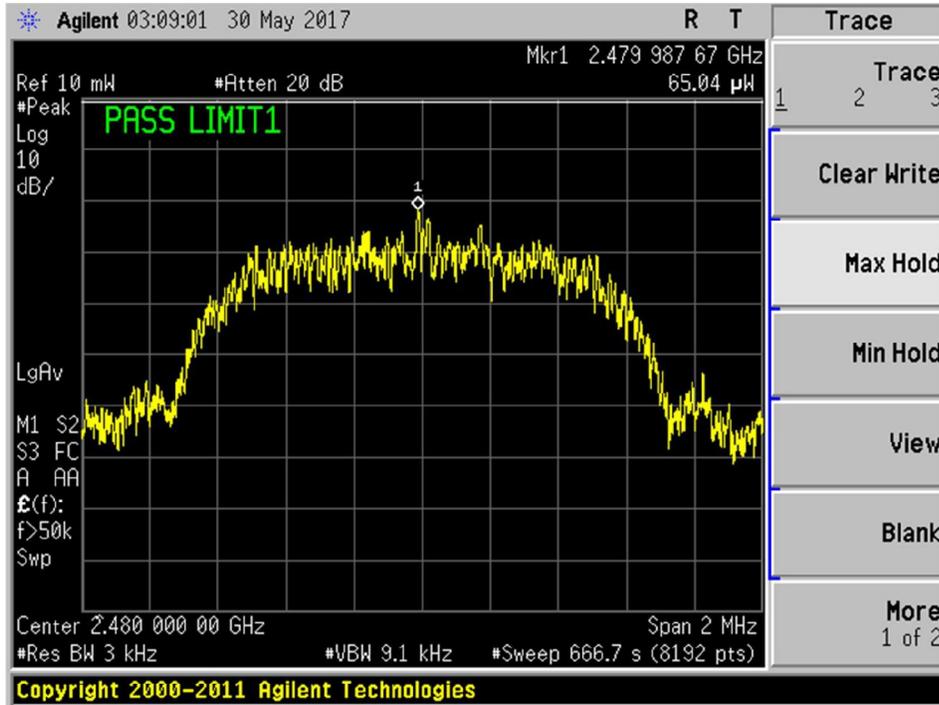


Plot 70 – Channel 39 (mid ch)



PEAK POWER SPECTRAL DENSITY TEST

Peak Power Spectral Density Plots – 8DPSK



Plot 71 – Channel 78 (upper ch)





RF EXPOSURE EVALUATION

47 CFR FCC Part 2.1093 RF Exposure Evaluation Results

The EUT is exempted for RF Exposure Evaluation requirement as it is below the SAR test exclusion thresholds as stated in FCC's KDB 447498 D01 General RF Exposure Guidance V06. See below the computation of the SAR test exclusion threshold:

$$\begin{aligned} \text{SAR Test Exclusion Threshold} &= [\text{Maximum RF Power of the EUT (mW)} / \text{Minimum test separation (mm)}] \times \\ &\quad \text{RF channel frequency (GHz)} \\ &= [1.0 / 5] \times 2.402 \\ &= 0.4804 \text{ (worst result)} \\ &\leq 3.0 \text{ (SAR exclusion threshold for 1-g head)} \end{aligned}$$





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