

12 AC power-line conducted emissions

12.1 Definition

Line-to-ground radio-noise voltage that is conducted from all of the EUT current-carrying power input terminals that are directly (or indirectly via separate transformers or power supplies) connected to a public power network.

12.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Screen Room 2
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.2
EUT Channels:	2437 MHz
Deviations From Standard:	None
Measurement Detectors:	Quasi-Peak and Average

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 °C to +35 °C (as declared)
Humidity: 40 % RH	20 % RH to 75 % RH (as declared)
Supply: 110 Vac	110 V ac $\pm$ 10 % (as declared)

12.3 Test Limit

A radio apparatus that is designed to be connected to the public utility (AC) power line shall ensure that the radio frequency voltage, which is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz, shall not exceed the limits in Table 3.

Table 3 – AC Power Line Conducted Emission Limits

Frequency (MHz)	Conducted limit (dB μ V)	
	Quasi-Peak	Average**
0.15 to 0.5	66 to 56*	56 to 46*
0.5 to 5	56	46
5 to 30	60	50

*The level decreases linearly with the logarithm of the frequency.

**A linear average detector is required.

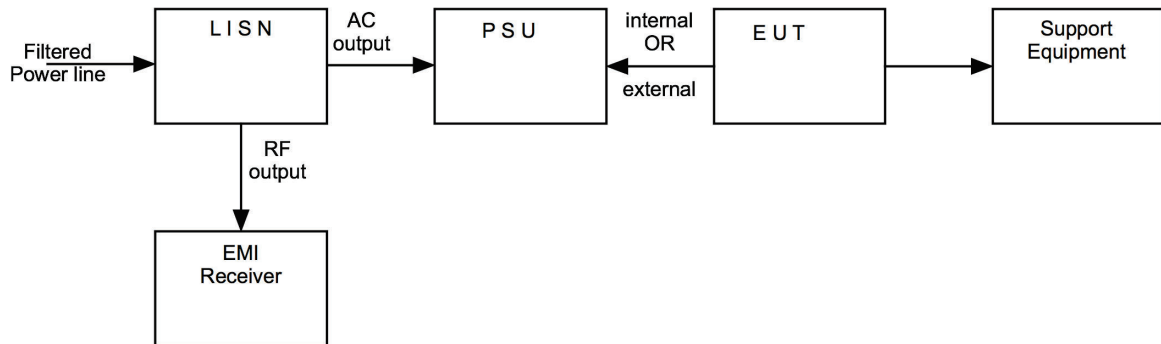
12.4 Test Method

With the EUT setup in a screened room, as per section 9 of this report and connected as per Figure ii, the power line emissions were measured on a spectrum analyzer / EMI receiver.

AC power line conducted emissions from the EUT are checked first by preview scans with peak and average detectors covering both live and neutral lines. A spectrum analyzer is used to determine if any periodic emissions are present.

Formal measurements using the correct detector(s) and bandwidth are made on frequencies identified from the preview scans. Final measurements were performed with EUT set at its maximum duty in transmit and receive modes.

Figure ii Test Setup



12.5 Test Set-up Photograph

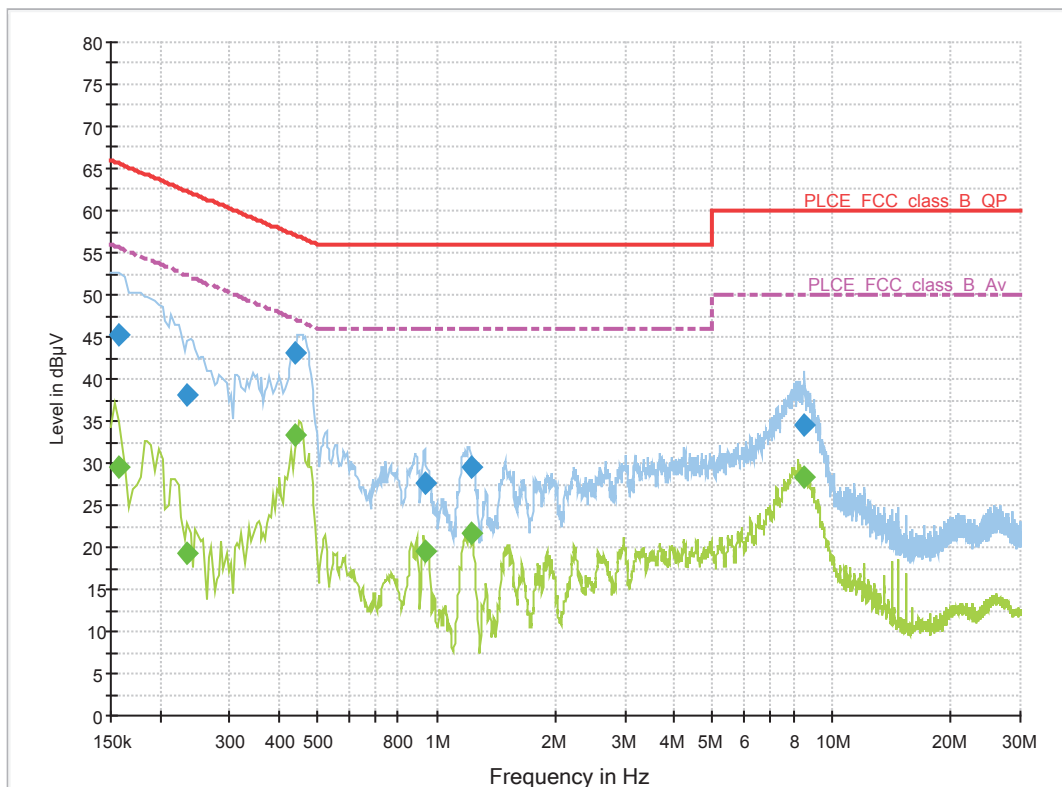


12.6 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
Measuring Receiver	R&S	ESHS10	RFG125	2021-01-22
LISN	R&S	ESH3-Z5	RFG732	2021-05-18
Pulse Limiter	R&S	ESH3-Z2	RFG680	2021-06-09

12.7 Test Results

AC power-line conducted emissions, Transmit mode						
Results measured using the average detector						
Reference Number	Frequency (MHz)	Conductor	Result (dBuV)	Specification Limit (dBuV)	Margin (dB)	Result Summary
1	0.158	L1	9.7	55.6	26.2	PASS
2	0.233	L1	9.8	52.3	33.1	PASS
3	0.441	L1	9.8	47.0	13.7	PASS
4	0.933	N	9.8	46.0	26.4	PASS
5	1.221	L1	9.9	46.0	24.4	PASS
6	8.517	L1	11.2	50.0	21.6	PASS
Results measured using the quasi-peak detector						
Reference Number	Frequency (MHz)	Conductor	Result (dBuV)	Specification Limit (dBuV)	Margin (dB)	Result Summary
1	0.158	L1	9.7	65.6	20.3	PASS
2	0.233	L1	9.8	62.3	24.3	PASS
3	0.441	L1	9.8	57.0	13.8	PASS
4	0.933	N	9.8	56.0	28.4	PASS
5	1.221	L1	9.9	56.0	26.4	PASS
6	8.517	L1	11.2	60.0	25.4	PASS



13 Occupied Bandwidth

13.1 Definition

The emission bandwidth (x dB) is defined as the frequency range between two points, one above and one below the carrier frequency, at which the spectral density of the emission is attenuated x dB below the maximum in-band spectral density of the modulated signal.

13.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Laboratory 1
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.8
EUT Frequencies Measured:	2412 MHz / 2437 MHz / 2462 MHz & 2422 MHz / 2437 MHz / 2452 MHz
EUT Channel Bandwidths:	20 MHz & 40 MHz
Deviations From Standard:	None
Measurement BW:	100 kHz
Spectrum Analyzer Video BW:	300 kHz
Measurement Span:	30 MHz (for 20 MHz channels), 60 MHz (for 40 MHz channels)
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 °C to +35 °C (as declared)
Humidity: 46 % RH	20 % RH to 75 % RH (as declared)
Supply: 5 Vdc	As declared

13.3 Test Limit

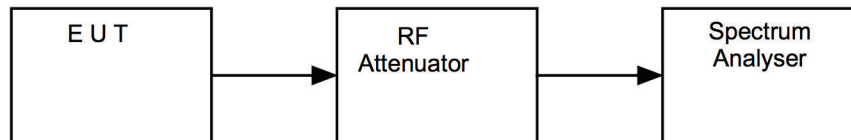
The minimum -6 dB bandwidth shall be at least 500 kHz.

13.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure iii, the bandwidth of the EUT was measured on a spectrum analyser.

The measurements were performed with EUT set at its maximum duty. All modulation schemes, data rates and power settings were used to observe the worst-case configuration in each bandwidth.

Figure iii Test Setup

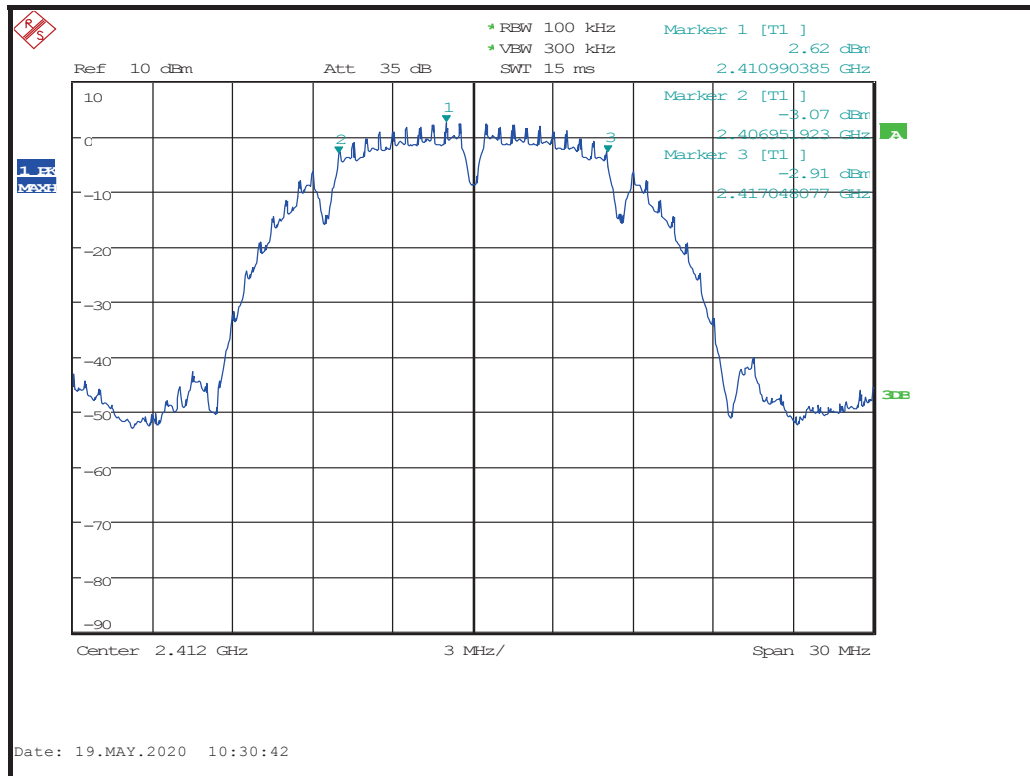


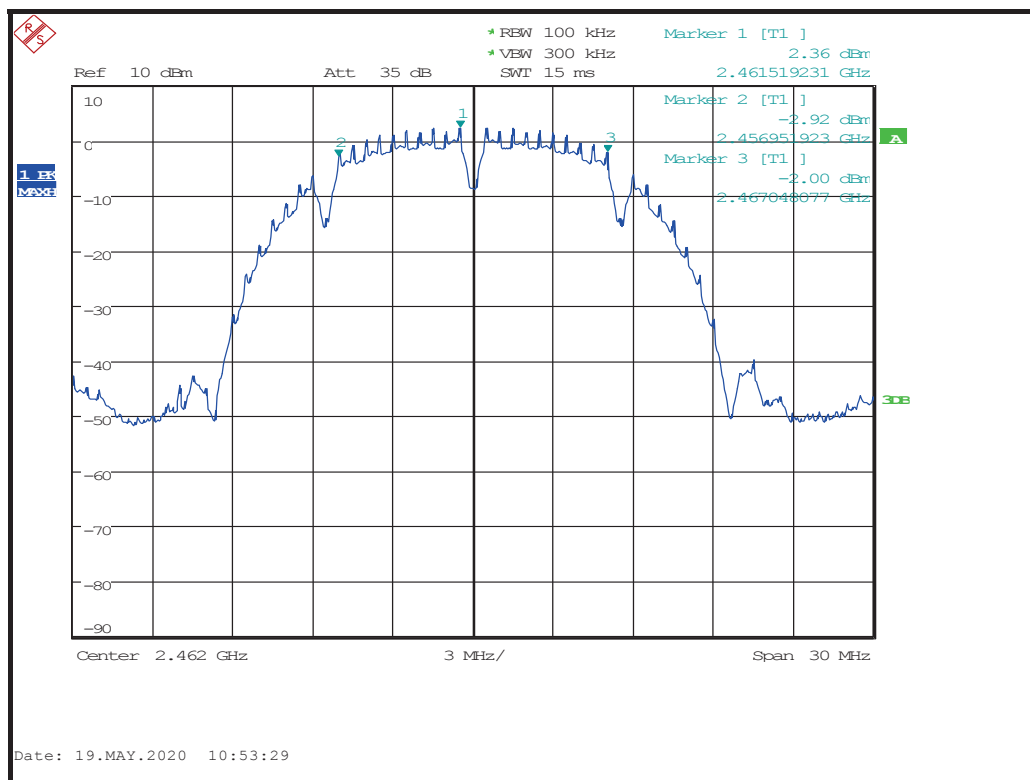
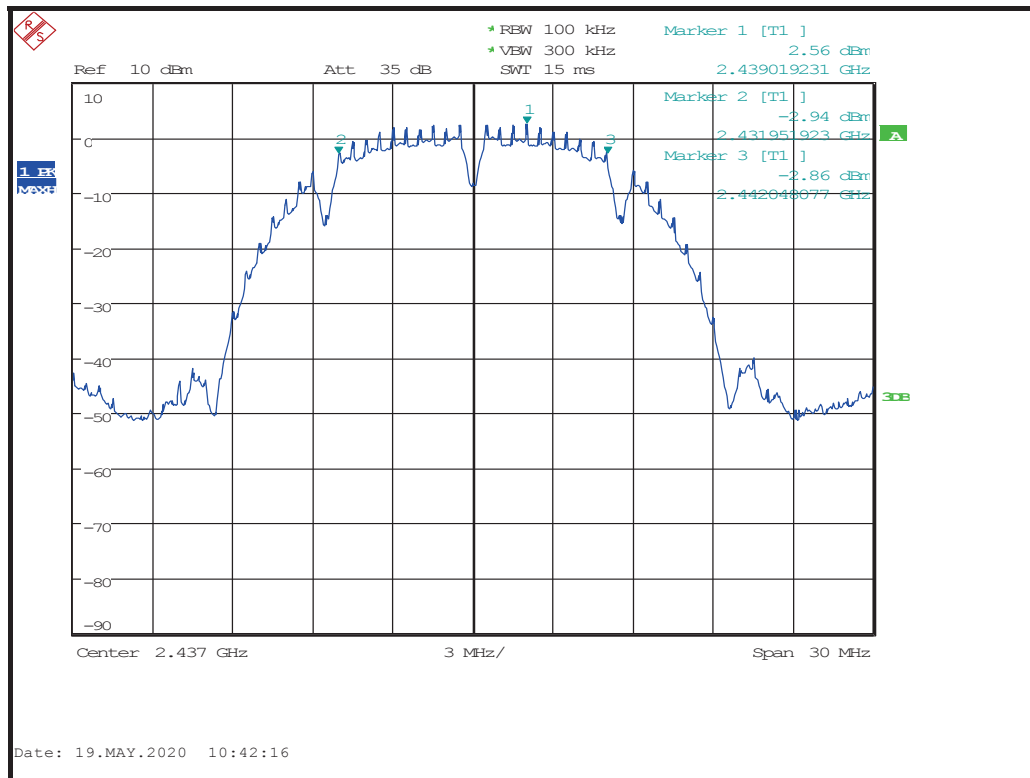
13.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU50	R&S	Spectrum Analyser	U544	2021-06-17
LT30-2	Farnell	Power Supply	RFG035	Cal with REF887
34405A	Agilent	Multimeter	REF887	2021-10-12

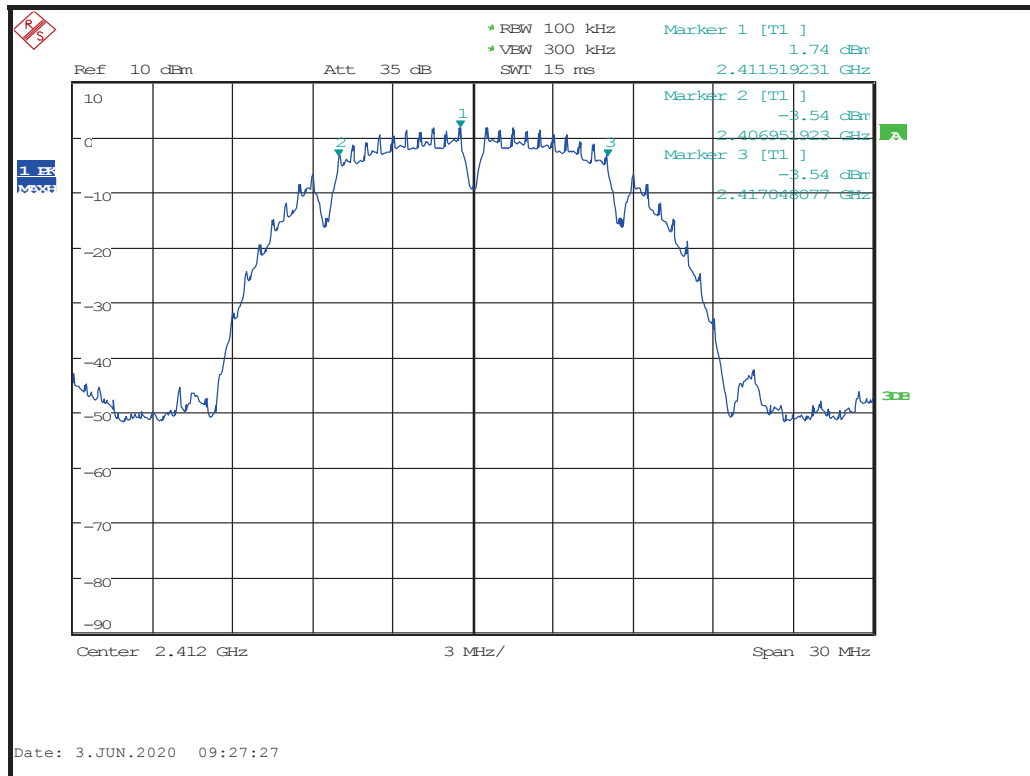
13.6 Test Results

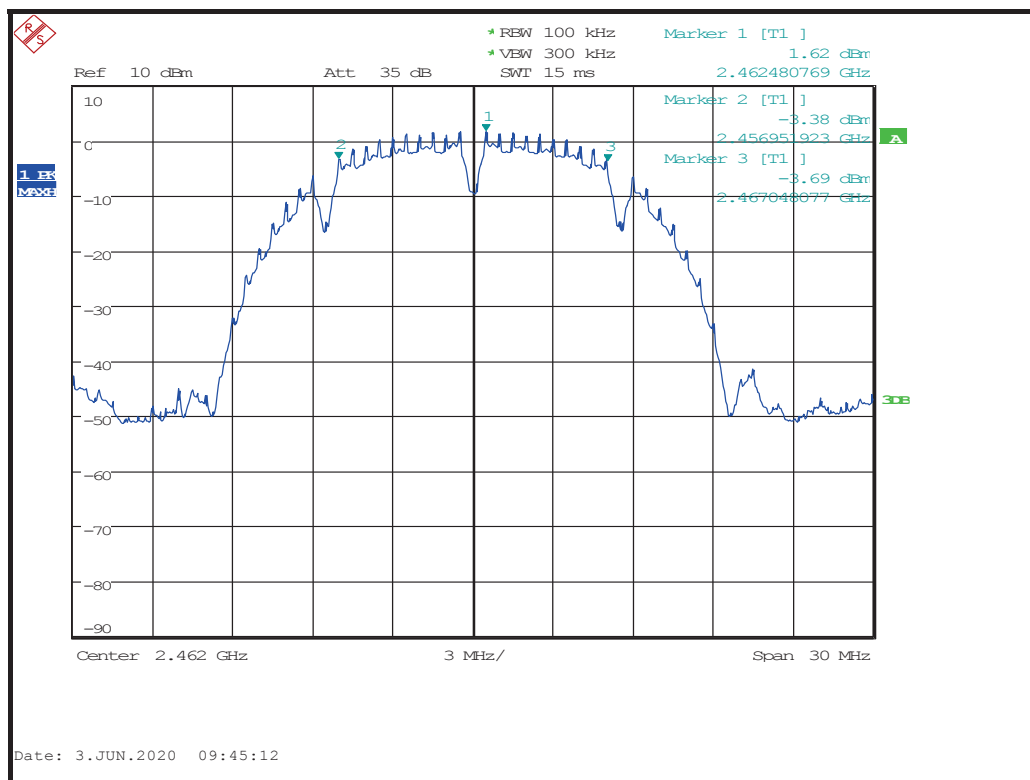
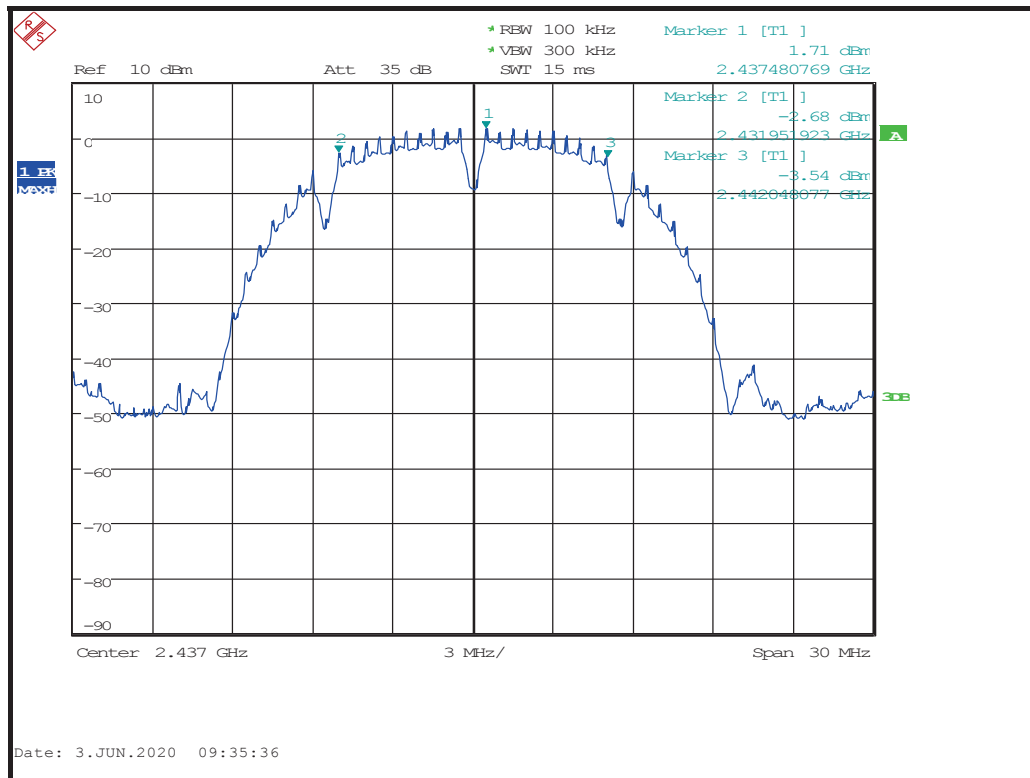
FCC 15.247. Modulation: 802.11b; Data rate: 1 Mbit/s; Main Antenna					
Channel Frequency (MHz)	Power Setting	F_L (MHz)	F_H (MHz)	6dB Bandwidth (kHz)	Result
2412	12	2406.951923	2417.948077	10996.154	PASS
2437	12	2431.951923	2442.048077	10096.154	PASS
2462	12	2456.951923	2467.048077	10096.154	PASS



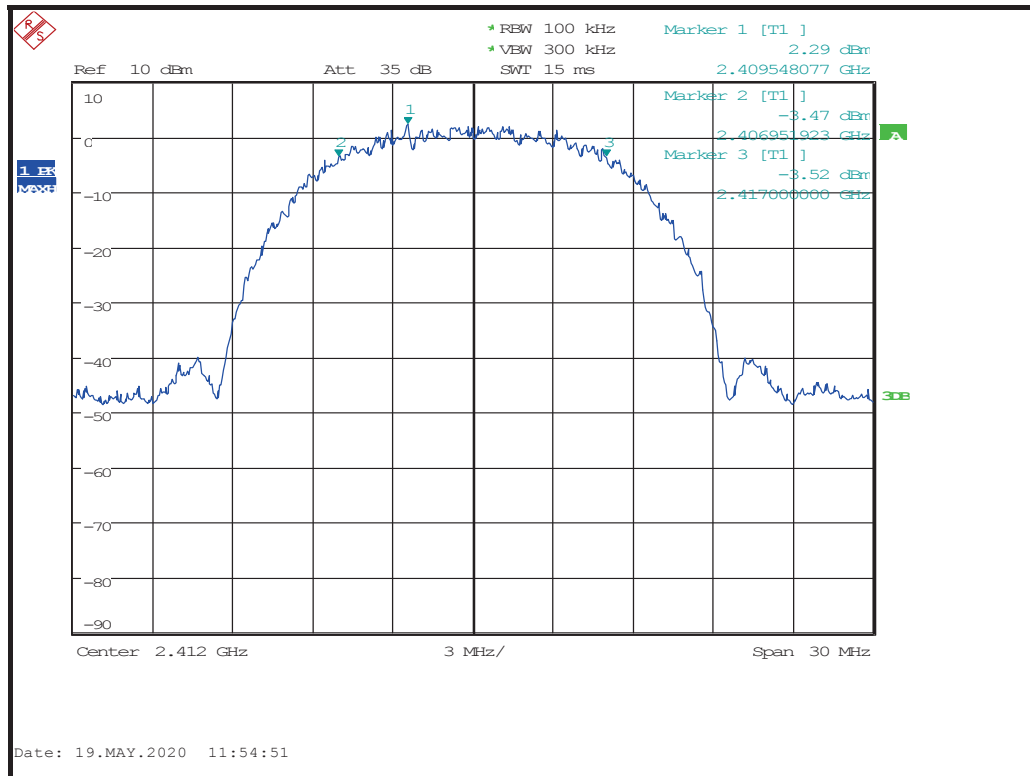


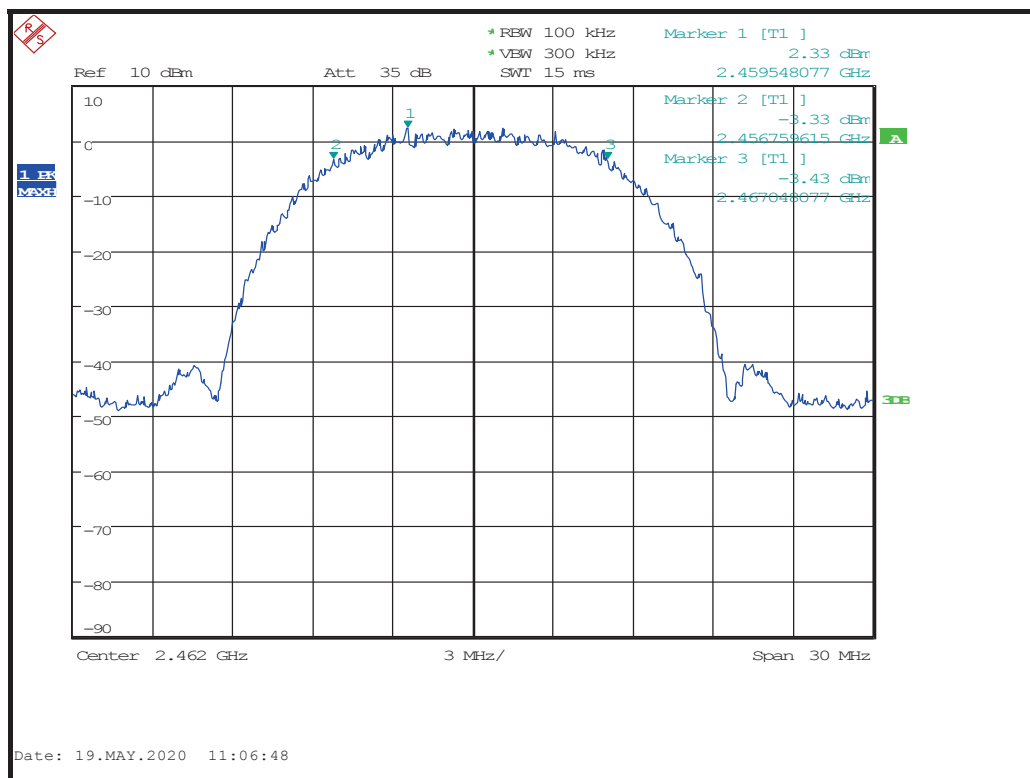
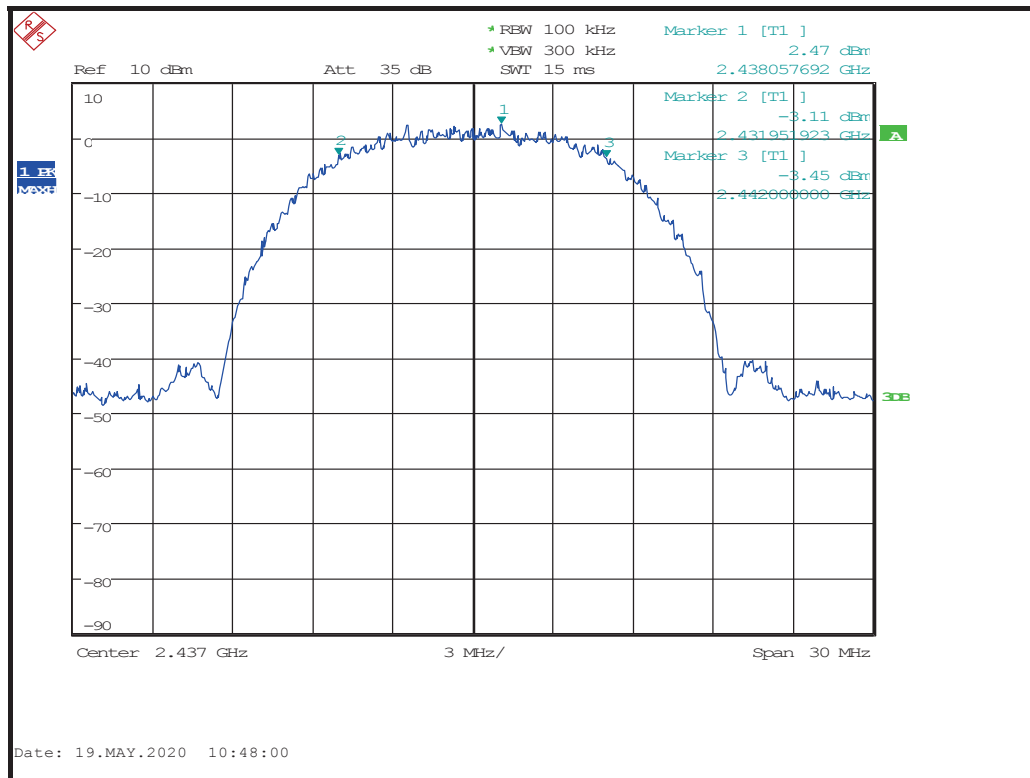
FCC 15.247. Modulation: 802.11b; Data rate: 1 Mbit/s; Aux Antenna					
Channel Frequency (MHz)	Power Setting	F_L (MHz)	F_H (MHz)	6dB Bandwidth (kHz)	Result
2412	12	2406.951923	2417.048077	10096.154	PASS
2437	12	2431.951923	2442.048077	10096.154	PASS
2462	12	2456.951923	2467.048077	10096.154	PASS



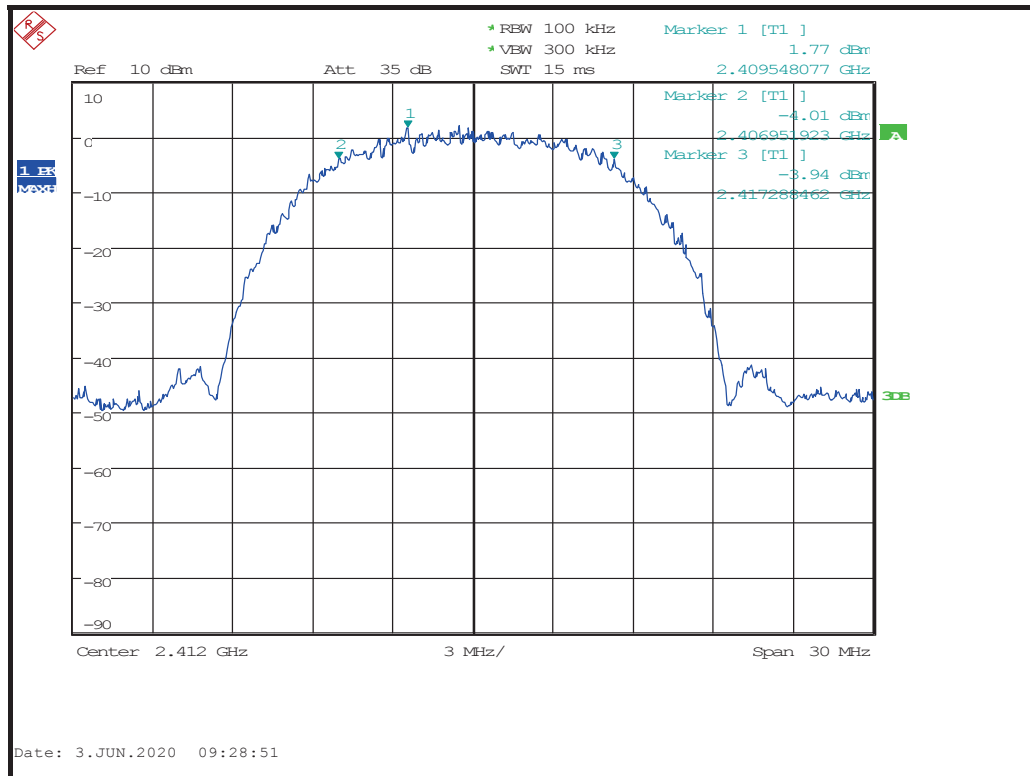


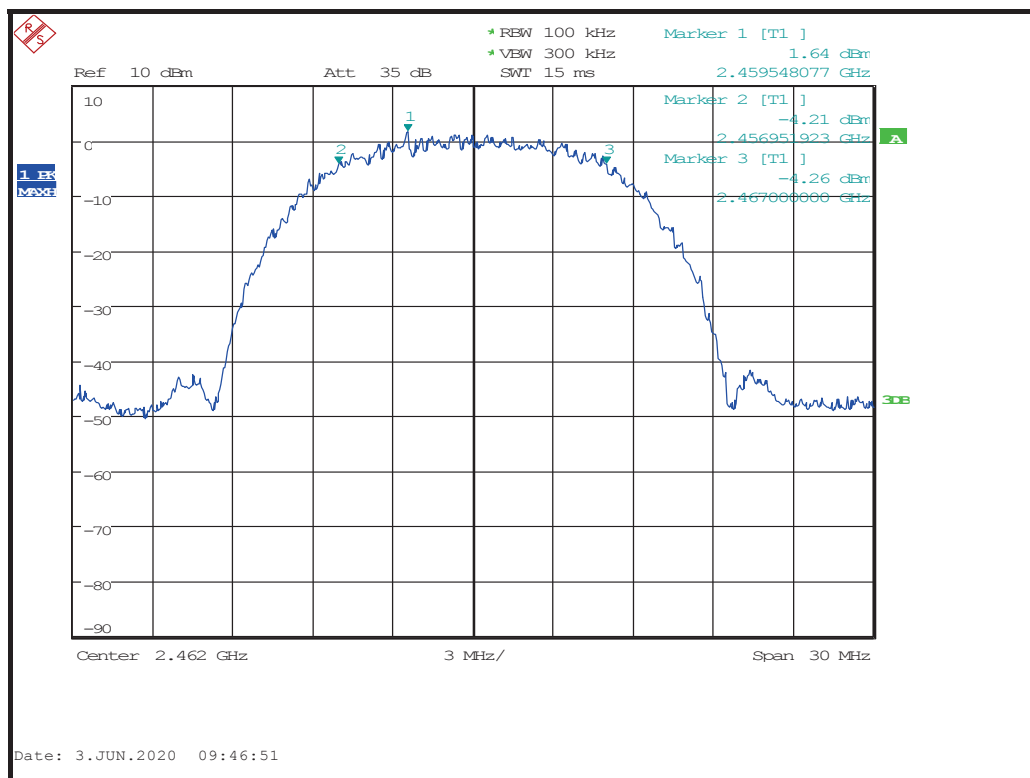
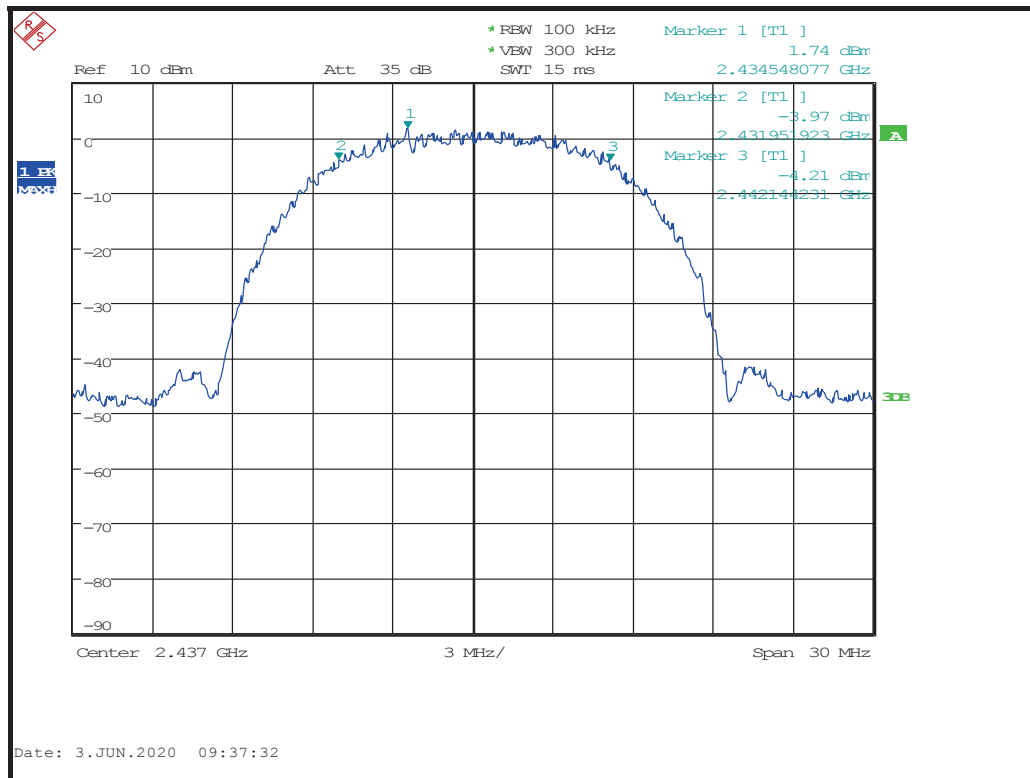
FCC 15.247. Modulation: 802.11b; Data rate: 11 Mbit/s; Main Antenna					
Channel Frequency (MHz)	Power Setting	F_L (MHz)	F_H (MHz)	6dB Bandwidth (kHz)	Result
2412	12	2406.951923	2417.000000	10048.077	PASS
2437	12	2431.951923	2442.000000	10048.077	PASS
2462	12	2456.759615	2467.048077	11188.462	PASS



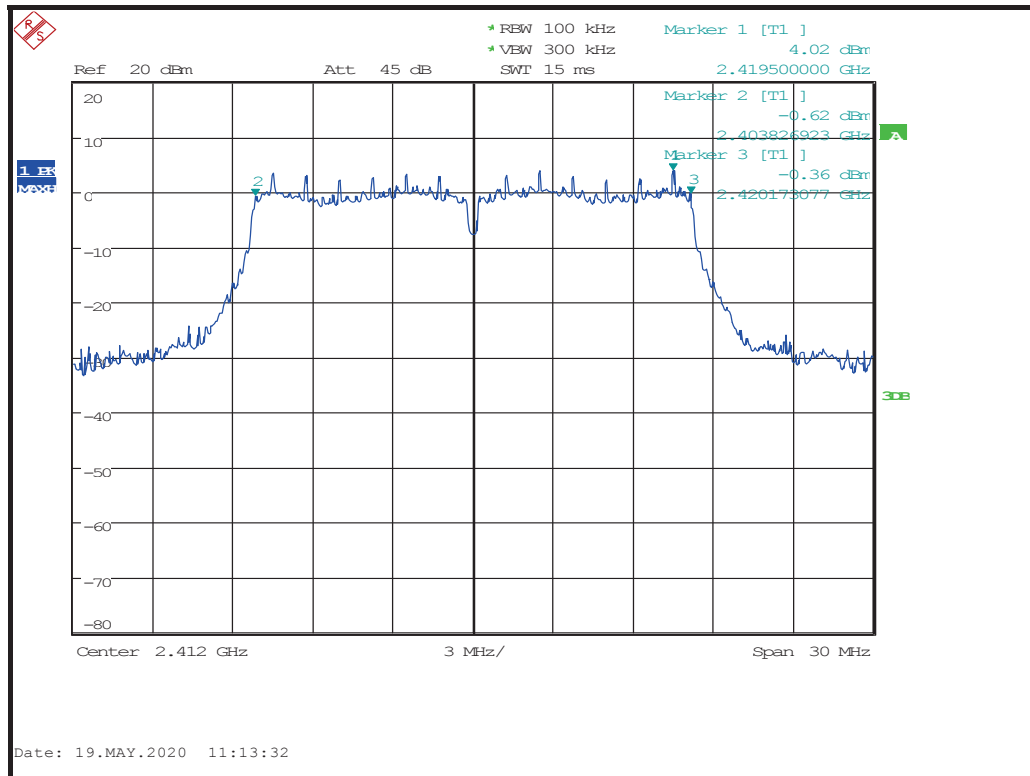


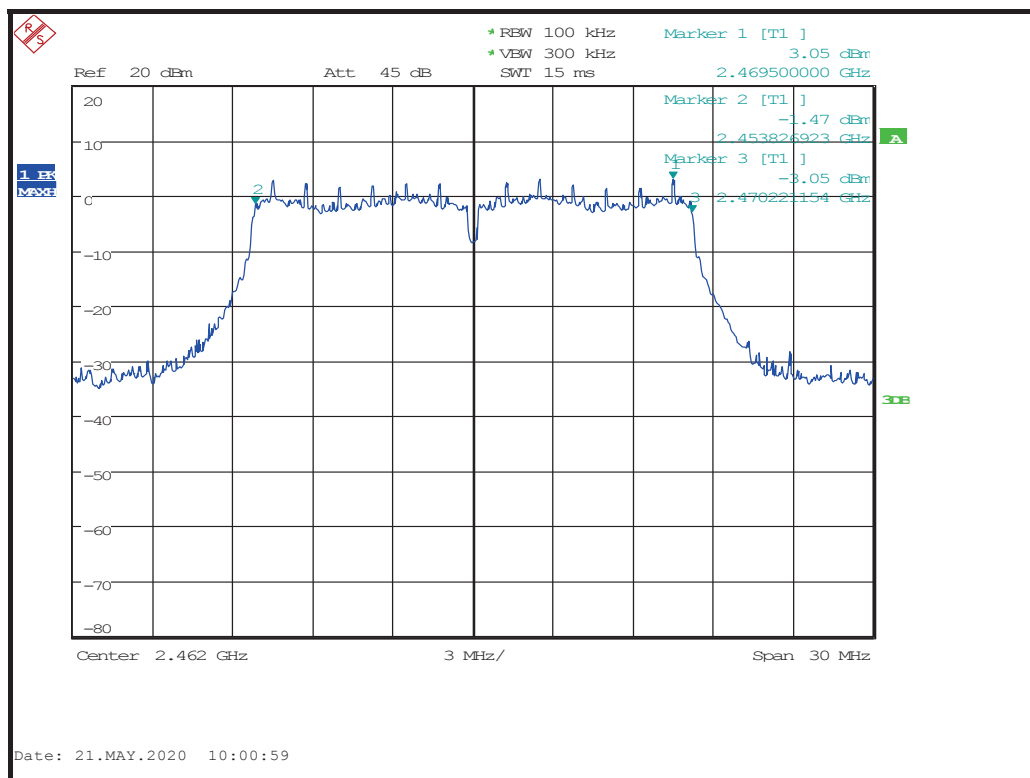
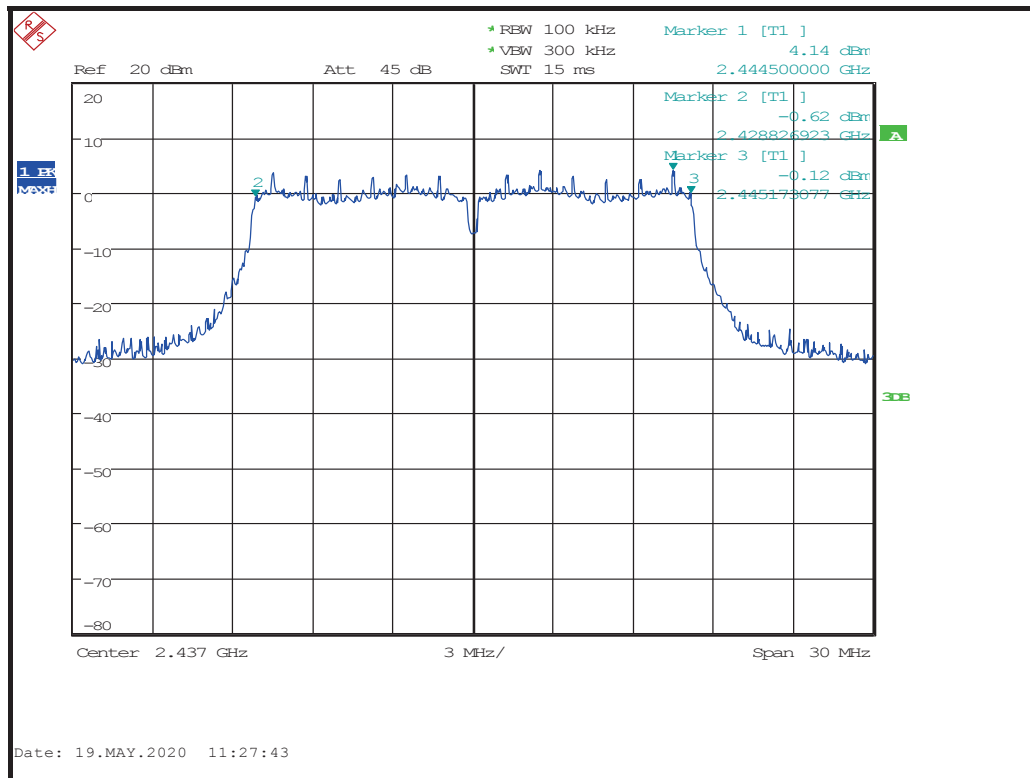
FCC 15.247. Modulation: 802.11b; Data rate: 11 Mbit/s; Aux Antenna					
Channel Frequency (MHz)	Power Setting	F_L (MHz)	F_H (MHz)	6dB Bandwidth (kHz)	Result
2412	12	2406.951923	2417.288462	10336.539	PASS
2437	12	2431.951923	2442.144231	10192.308	PASS
2462	12	2456.951923	2467.000000	10048.077	PASS



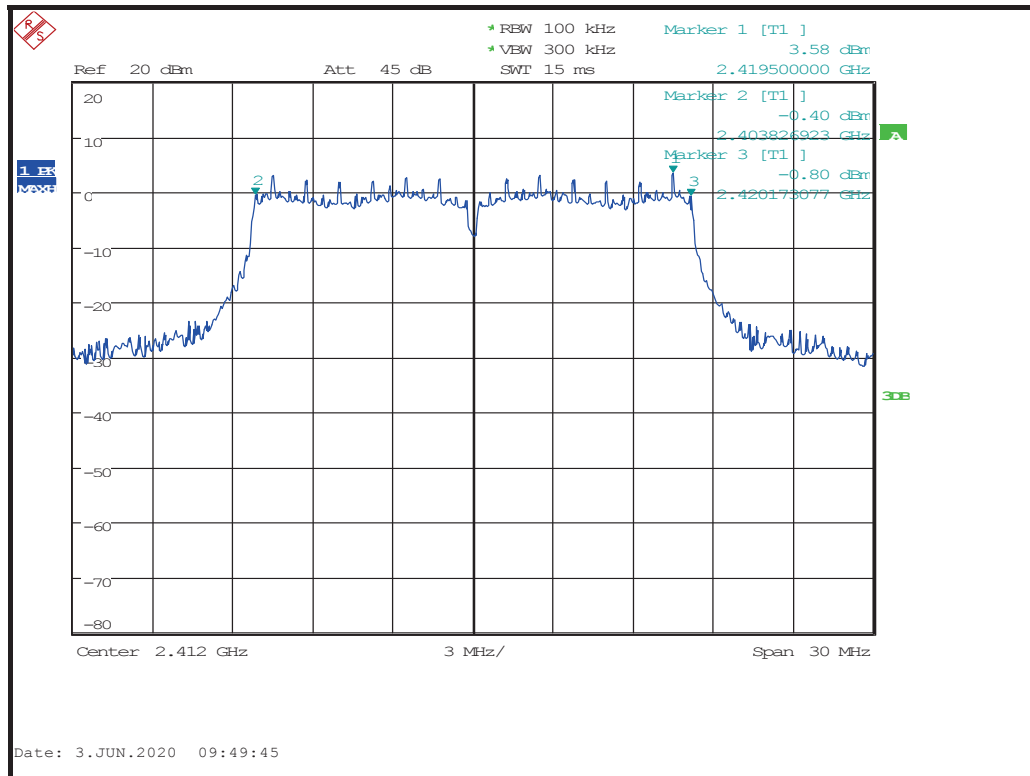


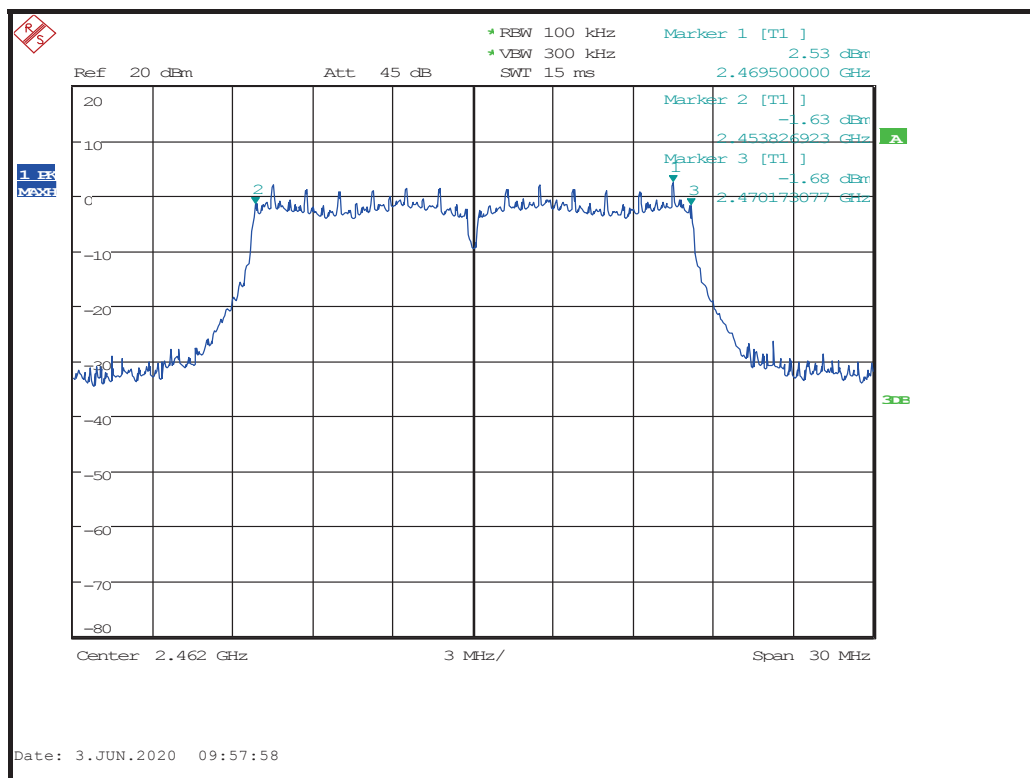
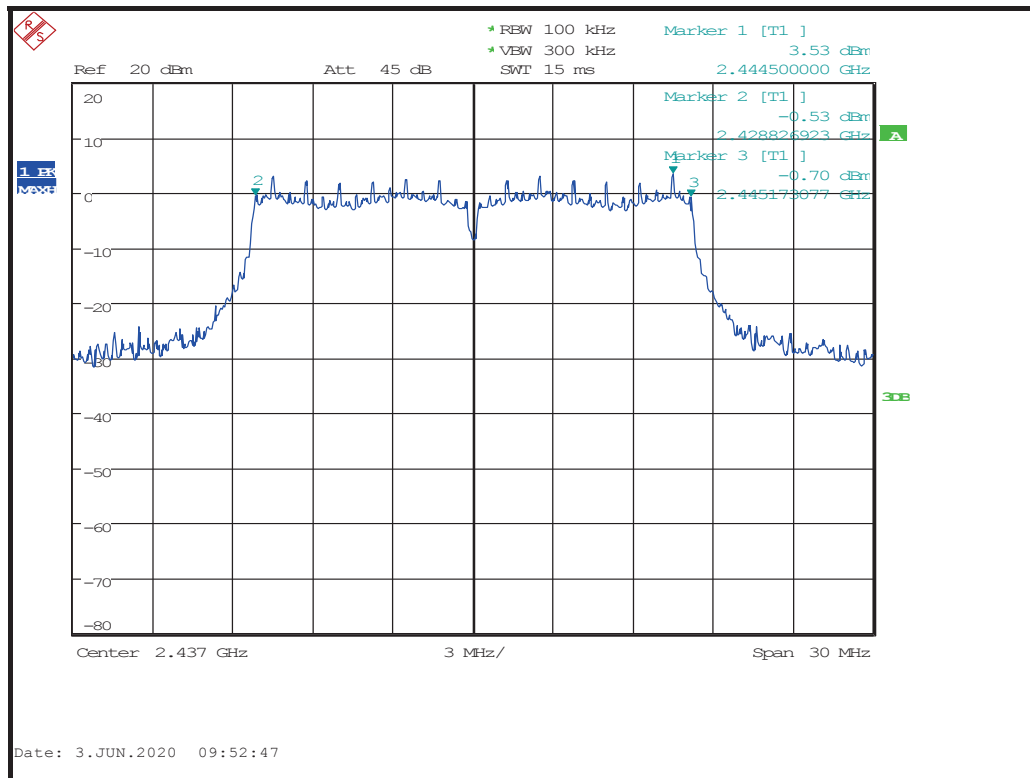
FCC 15.247. Modulation: 802.11g; Data rate: 6 Mbit/s; Main Antenna					
Channel Frequency (MHz)	Power Setting	F_L (MHz)	F_H (MHz)	6dB Bandwidth (kHz)	Result
2412	15	2403.826923	2420.173077	16346.154	PASS
2437	15	2428.823923	2445.173077	16349.154	PASS
2462	14	2453.826923	2470.221154	16394.231	PASS



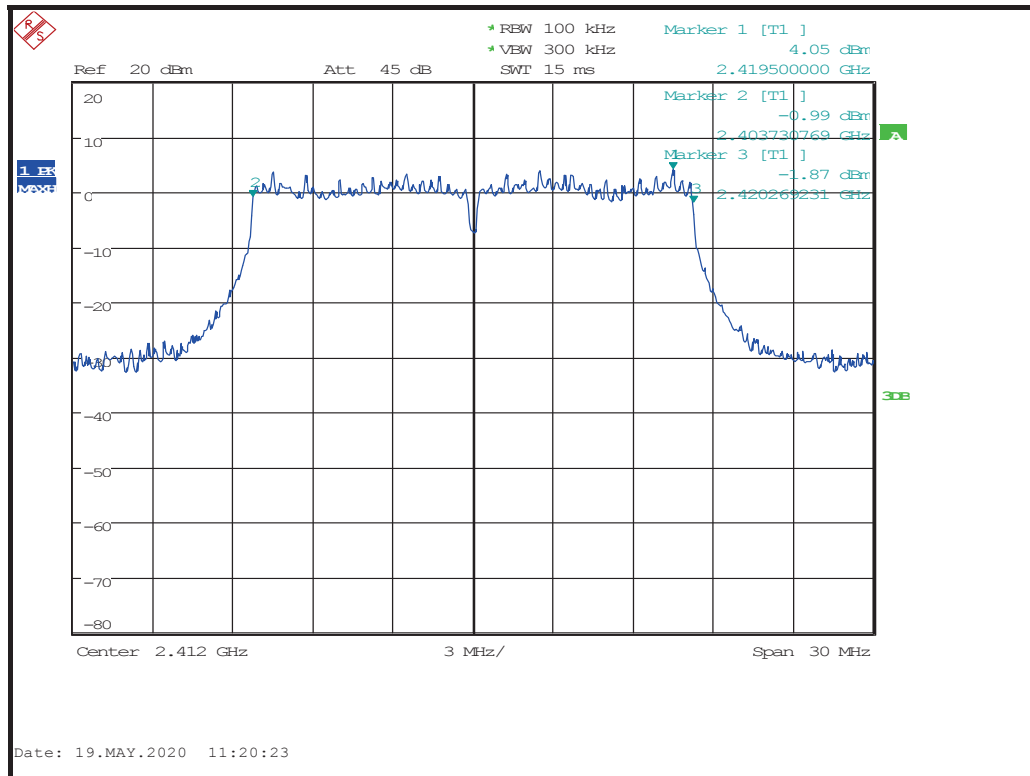


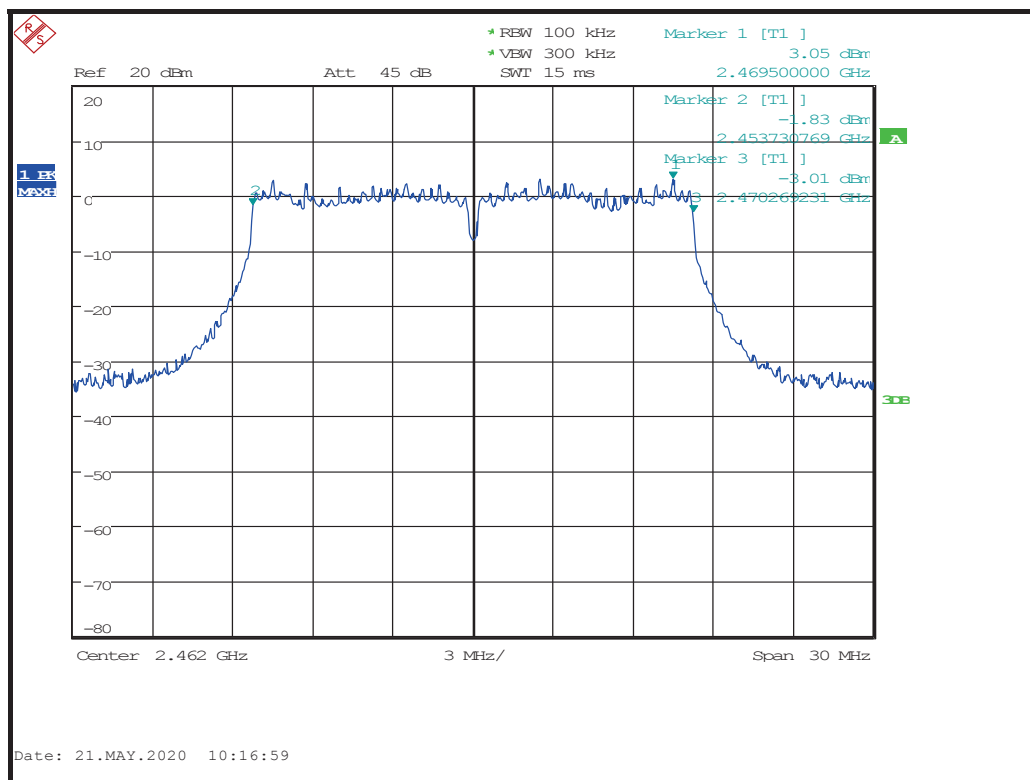
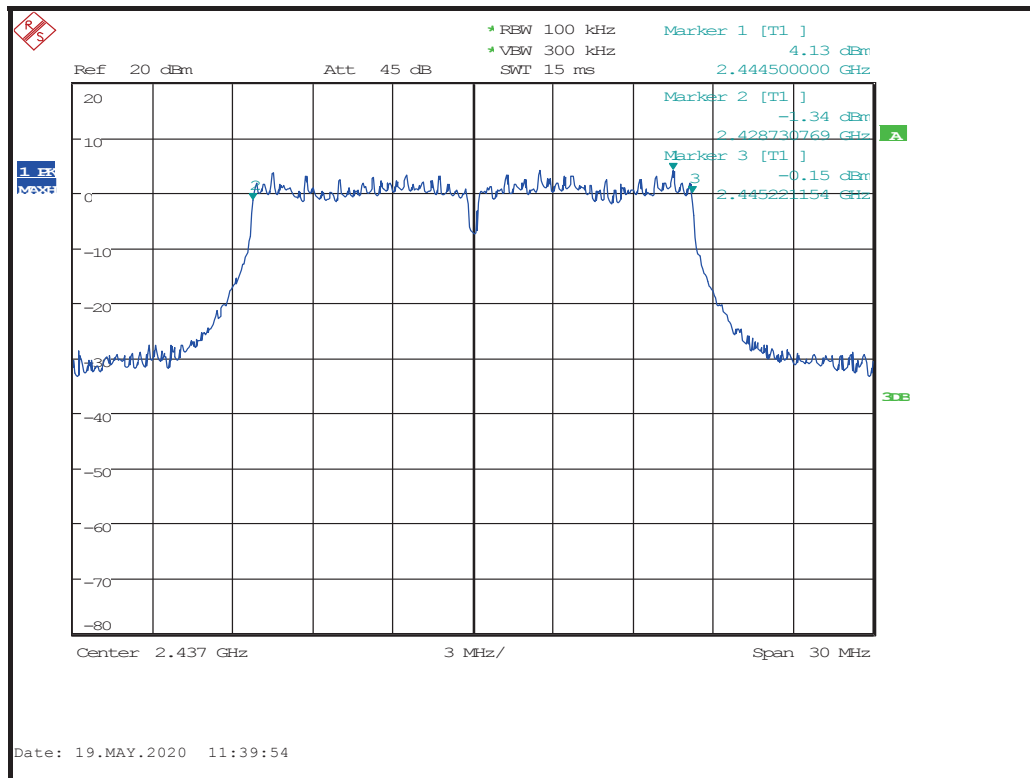
FCC 15.247. Modulation: 802.11g; Data rate: 6 Mbit/s; Aux Antenna					
Channel Frequency (MHz)	Power Setting	F_L (MHz)	F_H (MHz)	6dB Bandwidth (kHz)	Result
2412	15	2403.826923	2420.173077	16346.154	PASS
2437	15	2428.826923	2445.173077	16346.154	PASS
2462	14	2453.826923	2470.173077	16346.154	PASS



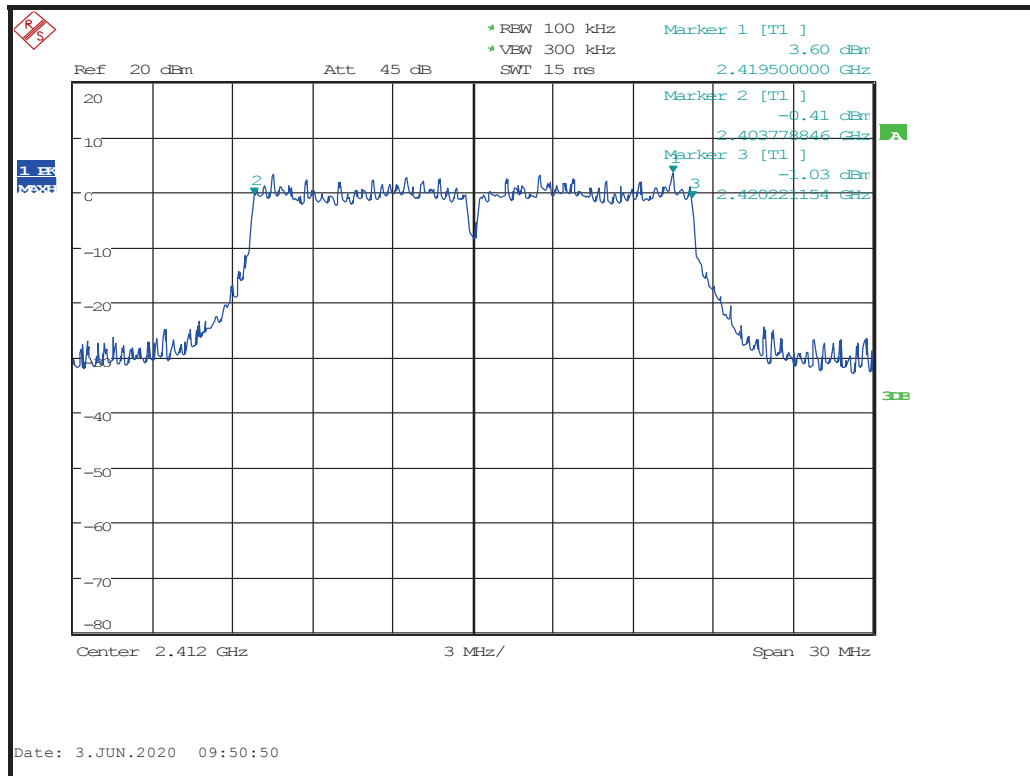


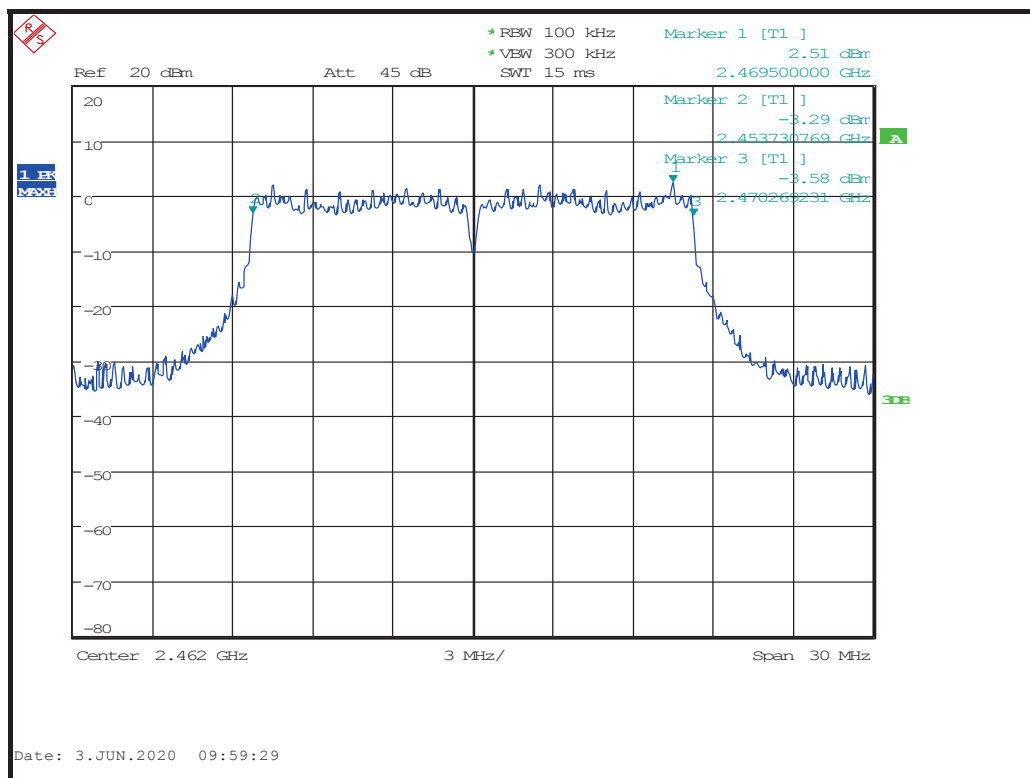
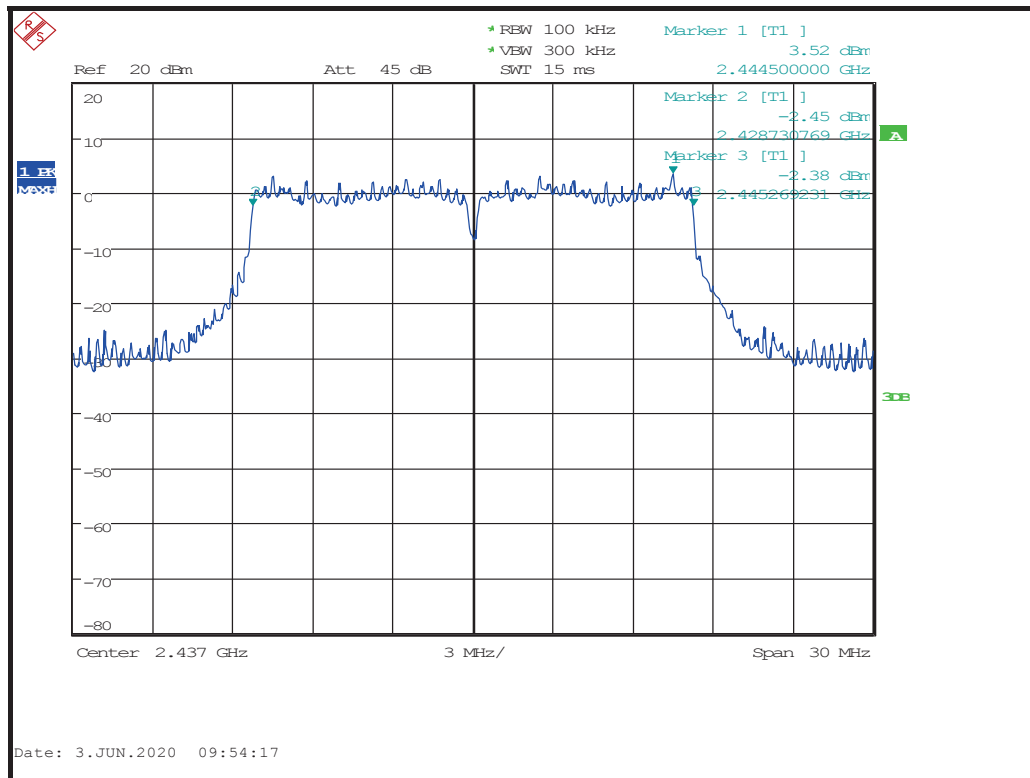
FCC 15.247. Modulation: 802.11g; Data rate: 54 Mbit/s; Main Antenna					
Channel Frequency (MHz)	Power Setting	F_L (MHz)	F_H (MHz)	6dB Bandwidth (kHz)	Result
2412	15	2403.730769	2420.269231	16538.462	PASS
2437	15	2428.730769	2445.221154	16490.385	PASS
2462	14	2453.730769	2470.269231	16538.462	PASS



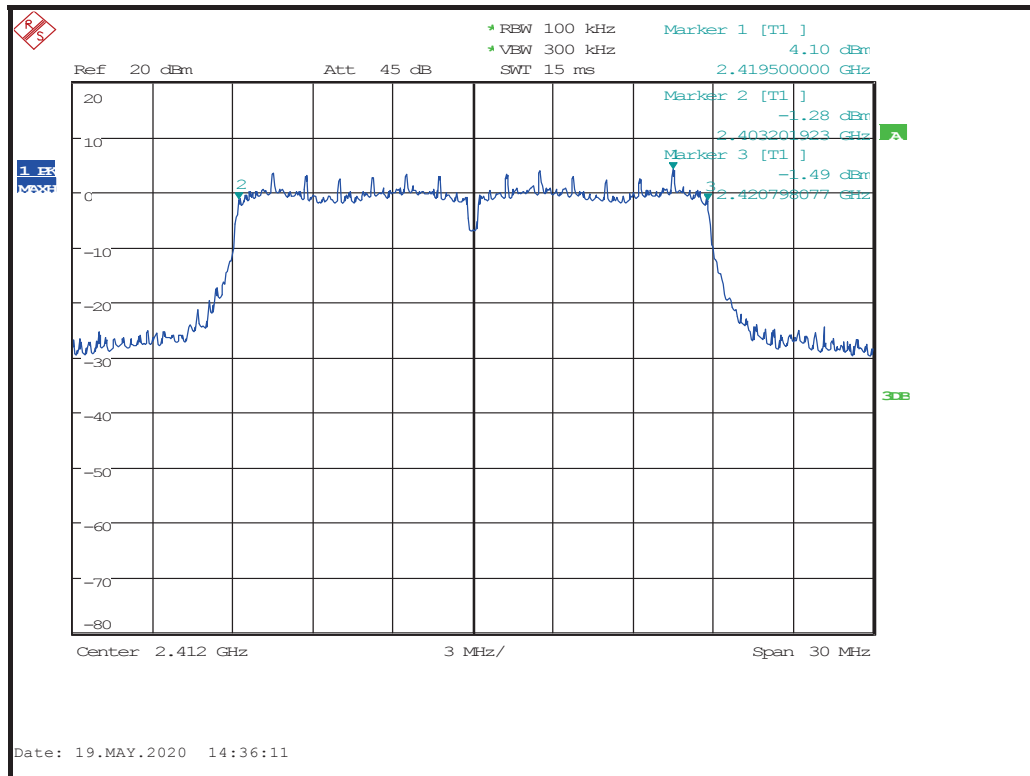


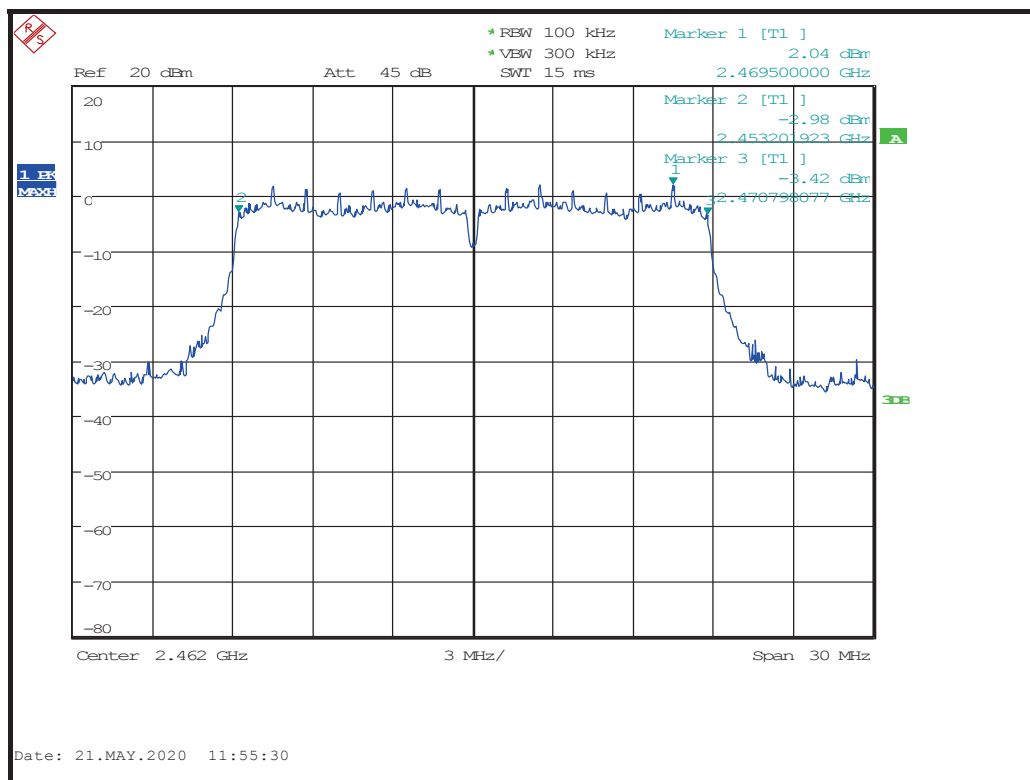
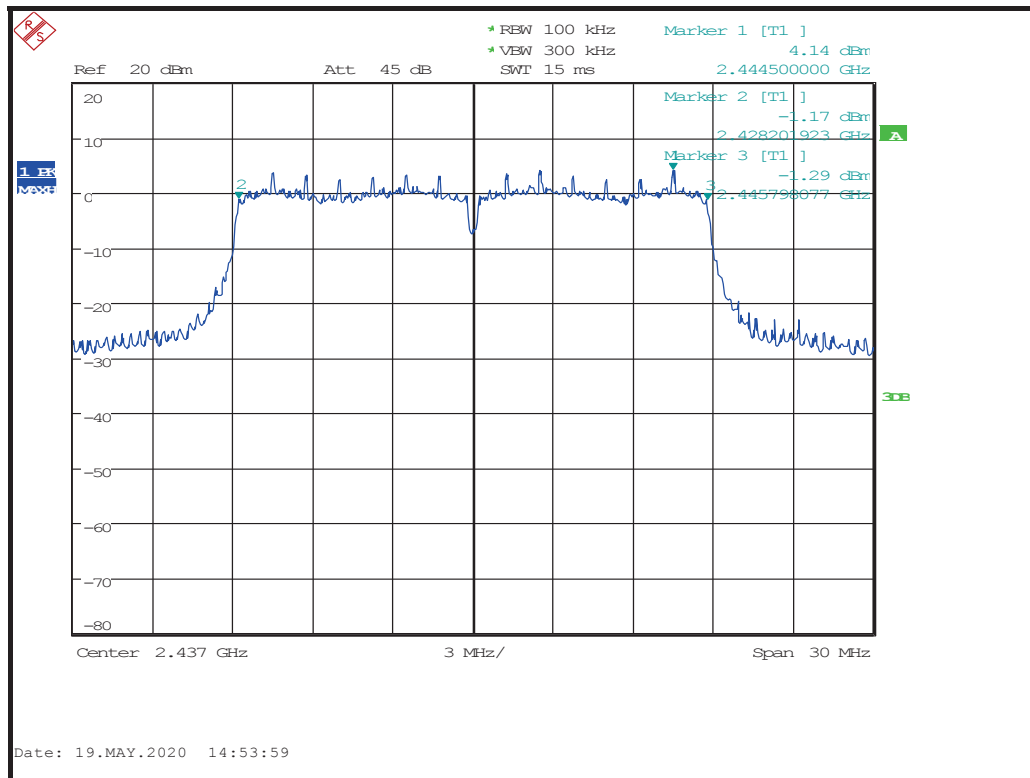
FCC 15.247. Modulation: 802.11g; Data rate: 54 Mbit/s; Aux Antenna					
Channel Frequency (MHz)	Power Setting	F_L (MHz)	F_H (MHz)	6dB Bandwidth (kHz)	Result
2412	15	2403.778846	2420.221154	16442.308	PASS
2437	15	2428.730769	2445.269231	16538.462	PASS
2462	14	2453.730769	2470.269231	16538.462	PASS



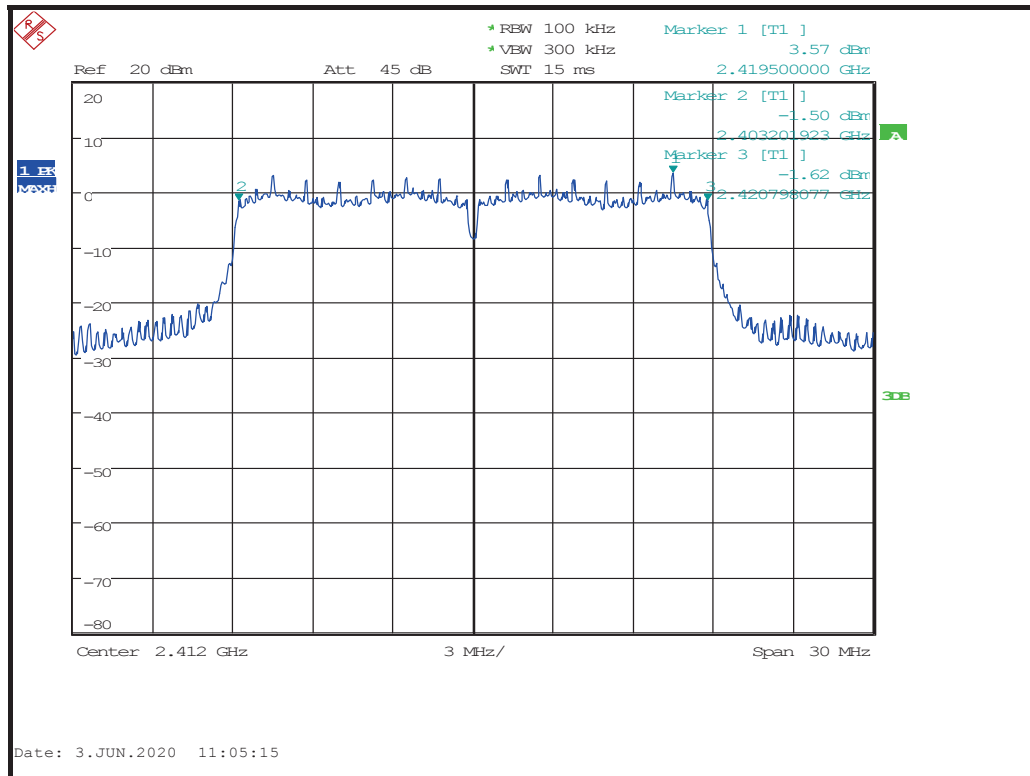


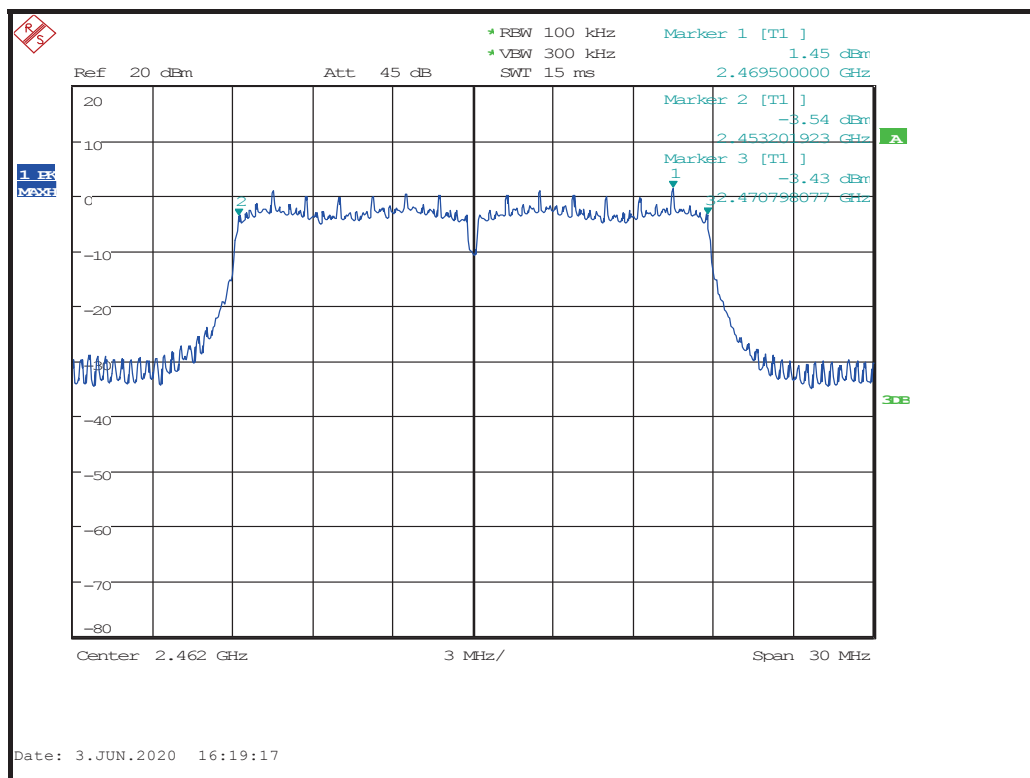
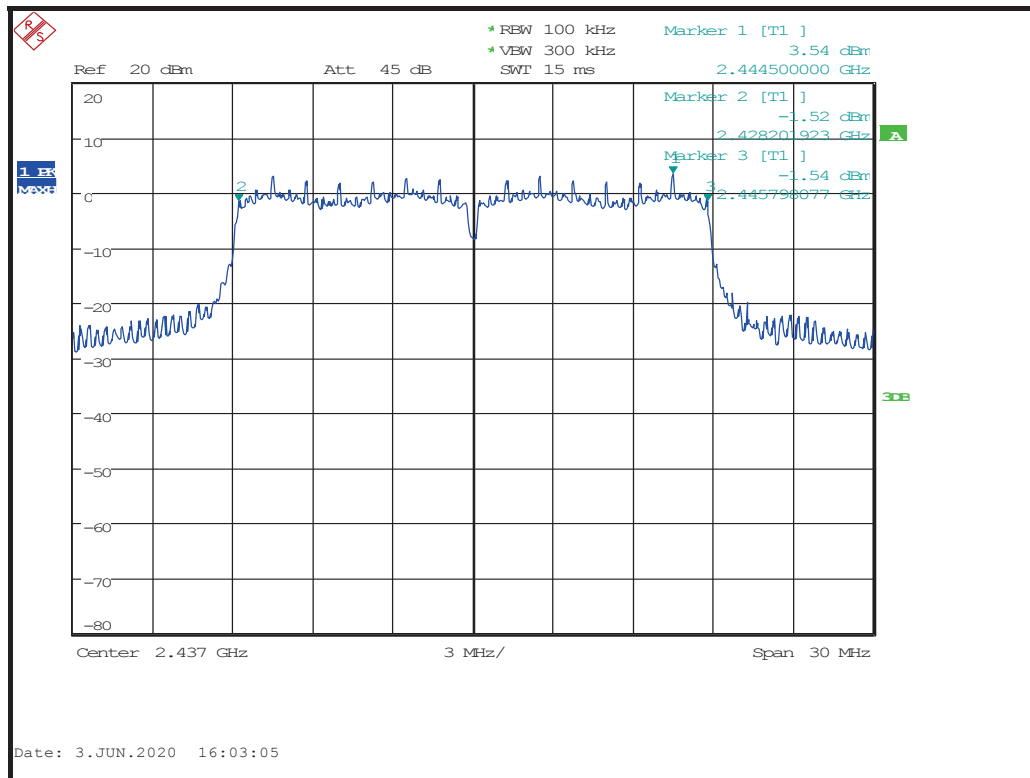
FCC 15.247. Modulation: 802.11n-20; Data rate: MCS0; Main Antenna					
Channel Frequency (MHz)	Power Setting	F_L (MHz)	F_H (MHz)	6dB Bandwidth (kHz)	Result
2412	15	2403.201923	2420.798077	17596.154	PASS
2437	15	2428.201923	2445.798077	17596.154	PASS
2462	13	2453.201923	2470.798077	17596.154	PASS



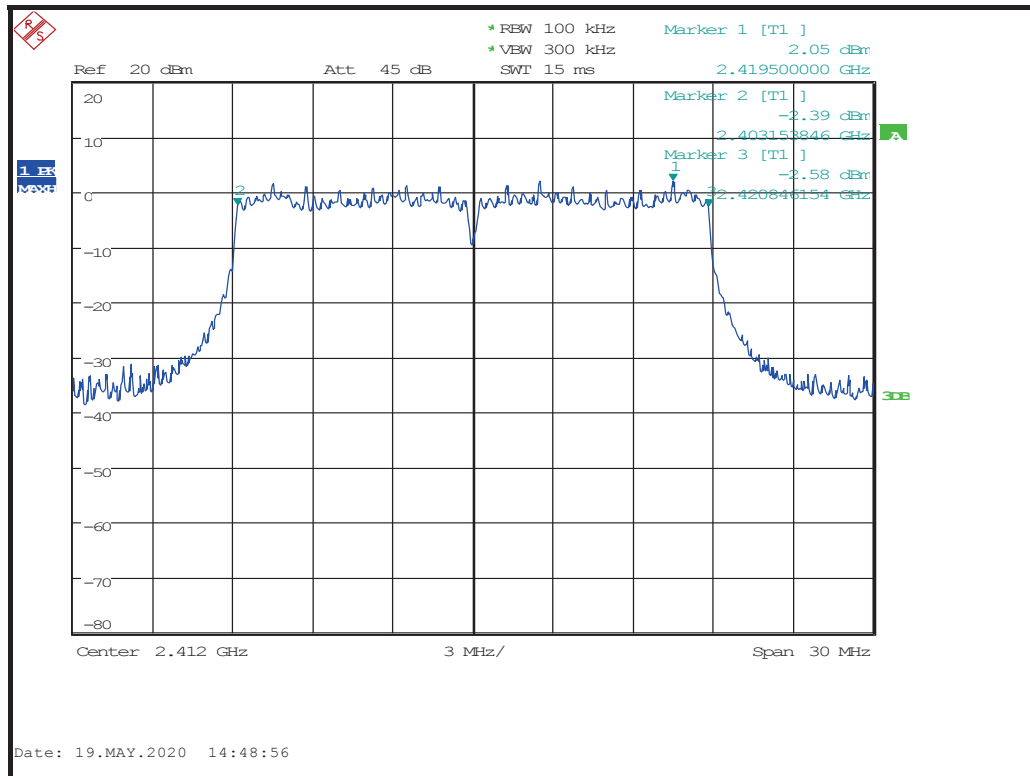


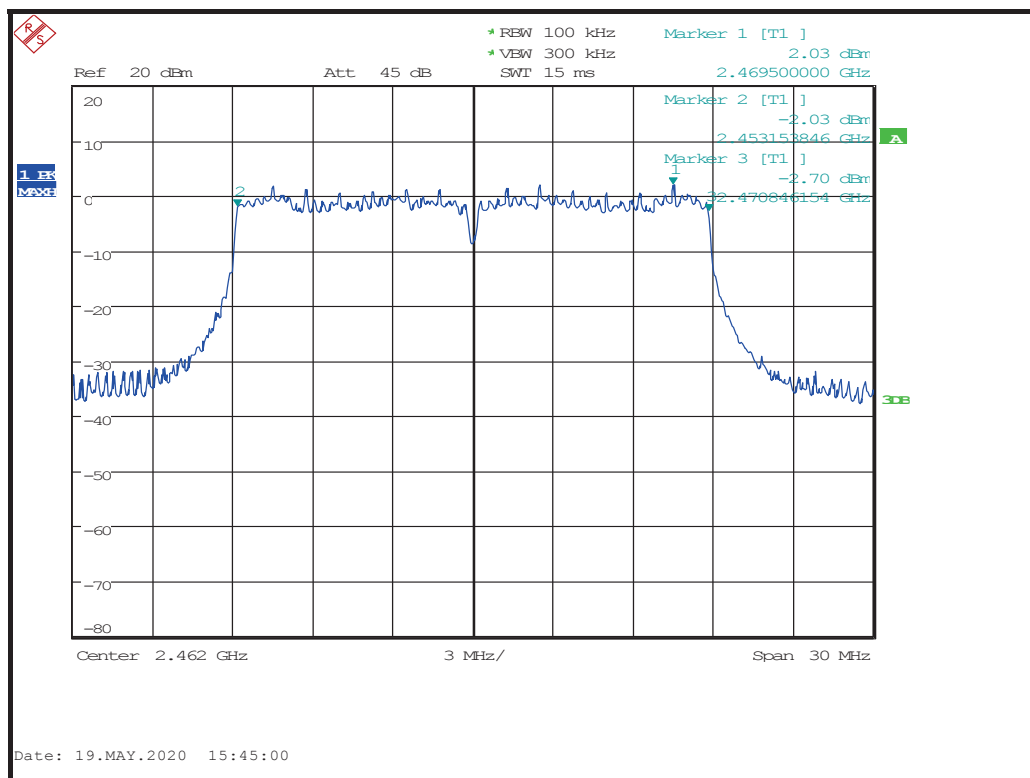
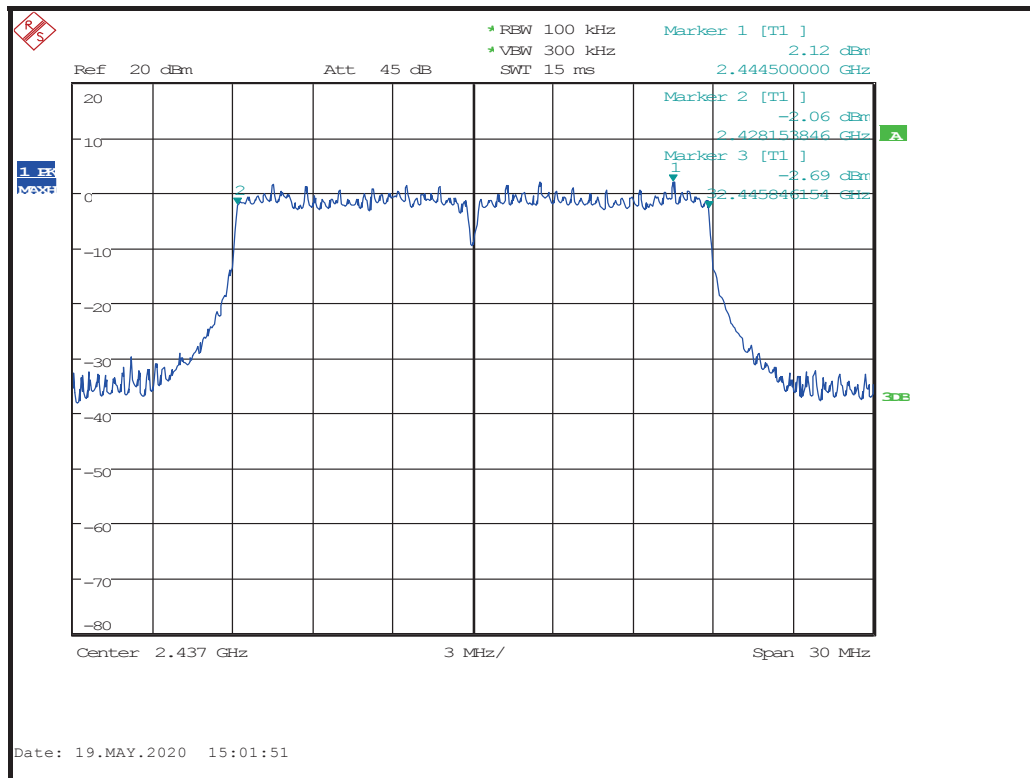
FCC 15.247. Modulation: 802.11n-20; Data rate: MCS0; Aux Antenna					
Channel Frequency (MHz)	Power Setting	F_L (MHz)	F_H (MHz)	6dB Bandwidth (kHz)	Result
2412	15	2403.201923	2420.798077	17596.154	PASS
2437	15	2428.201923	2445.798077	17596.154	PASS
2462	13	2453.201923	2470.798077	17596.154	PASS



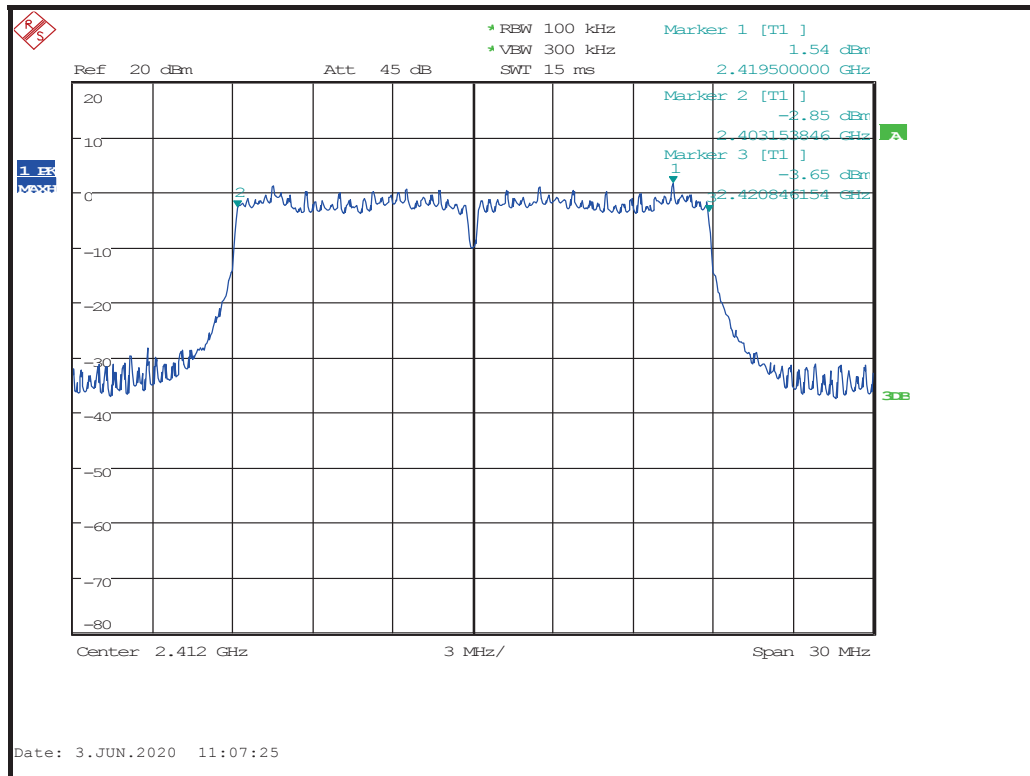


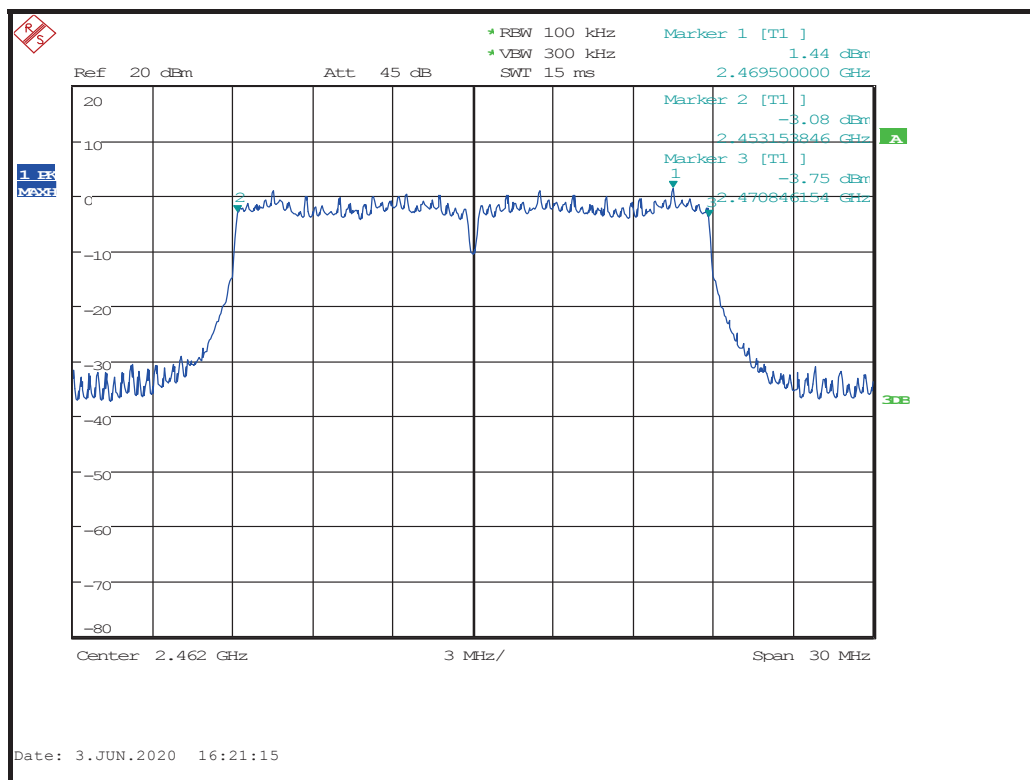
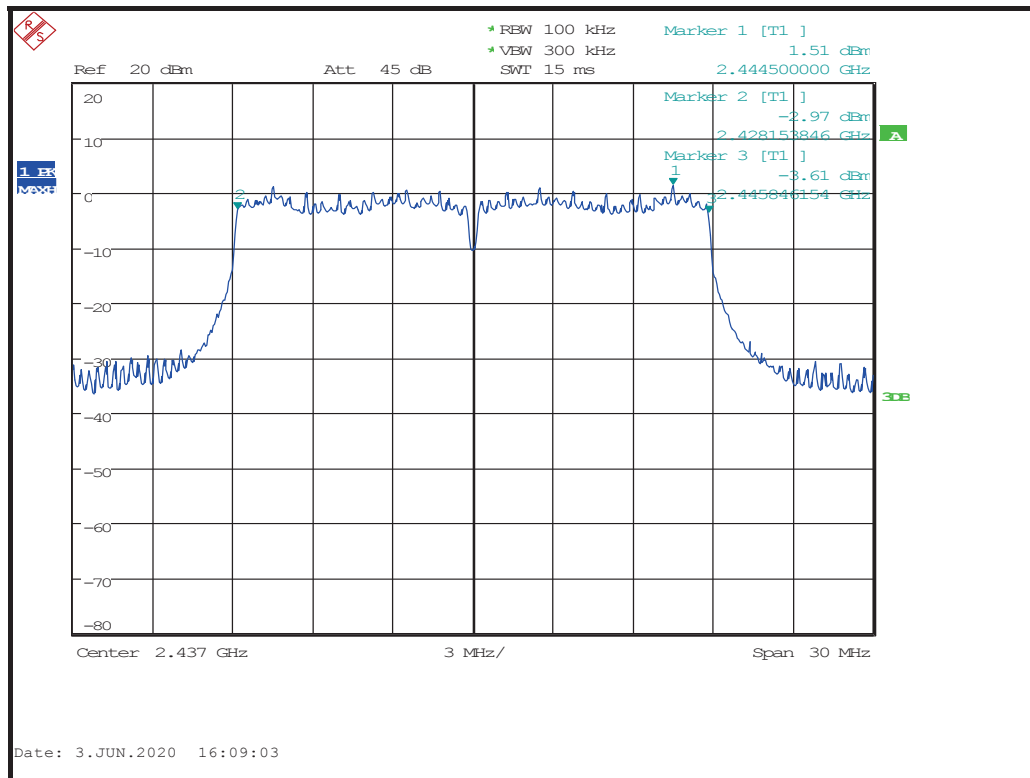
FCC 15.247. Modulation: 802.11n-20; Data rate: MCS7; Main Antenna					
Channel Frequency (MHz)	Power Setting	F_L (MHz)	F_H (MHz)	6dB Bandwidth (kHz)	Result
2412	13	2403.153846	2420.846154	17692.308	PASS
2437	13	2428.153846	2445.846154	17692.308	PASS
2462	13	2453.153846	2470.846154	17692.308	PASS



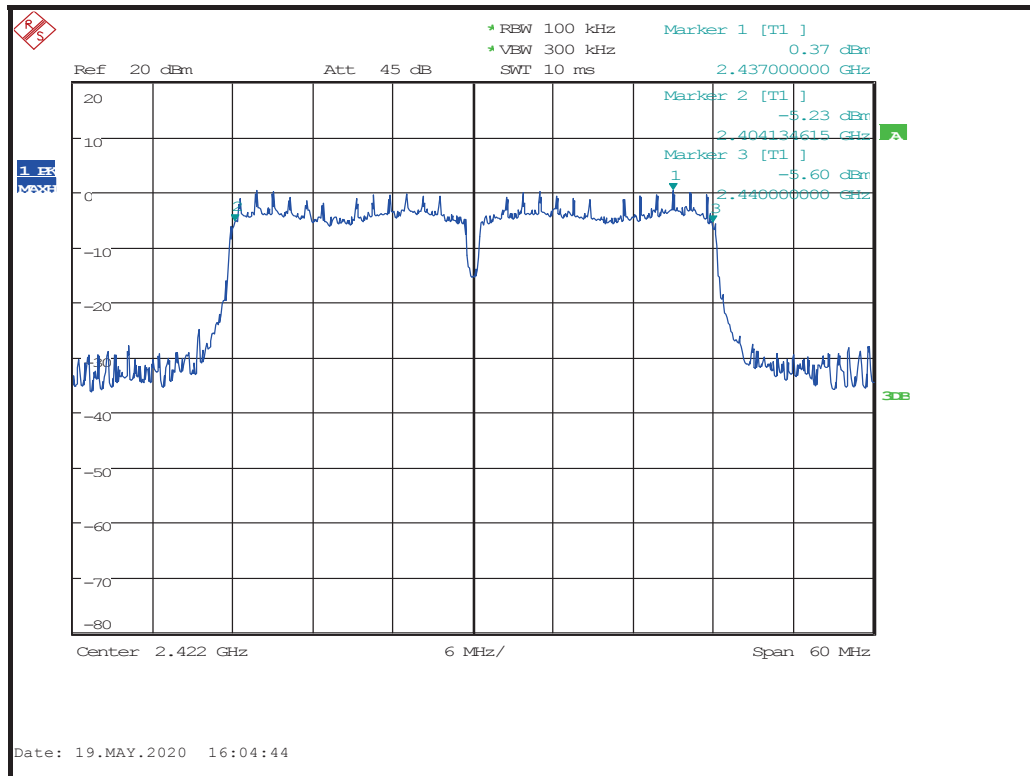


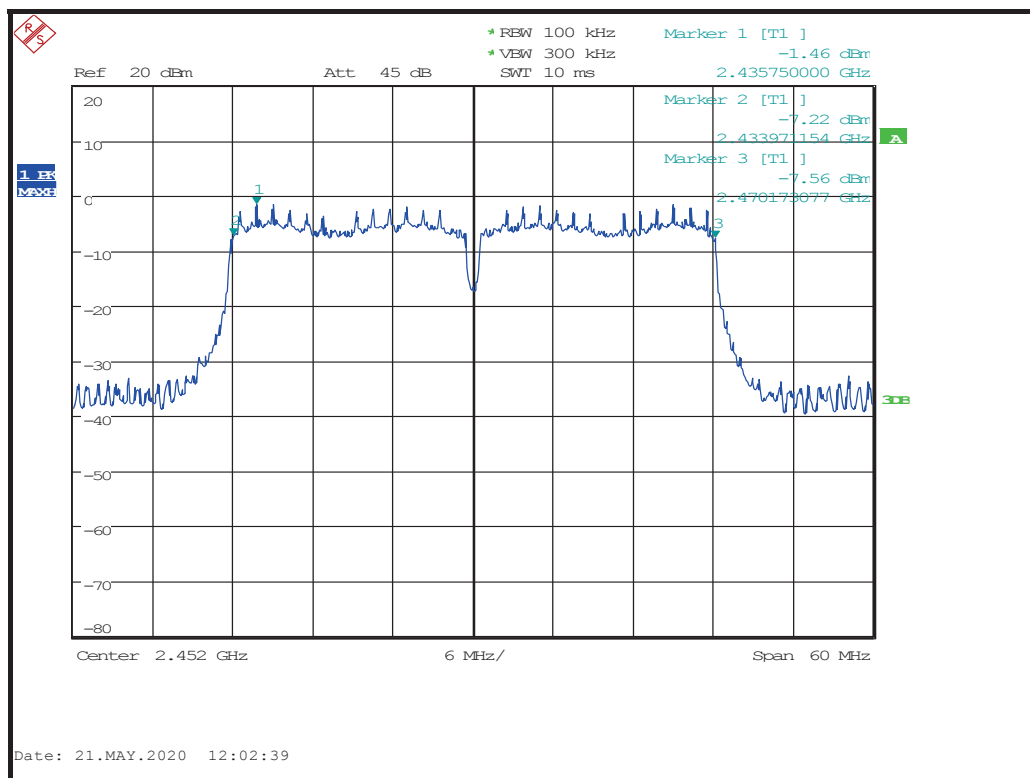
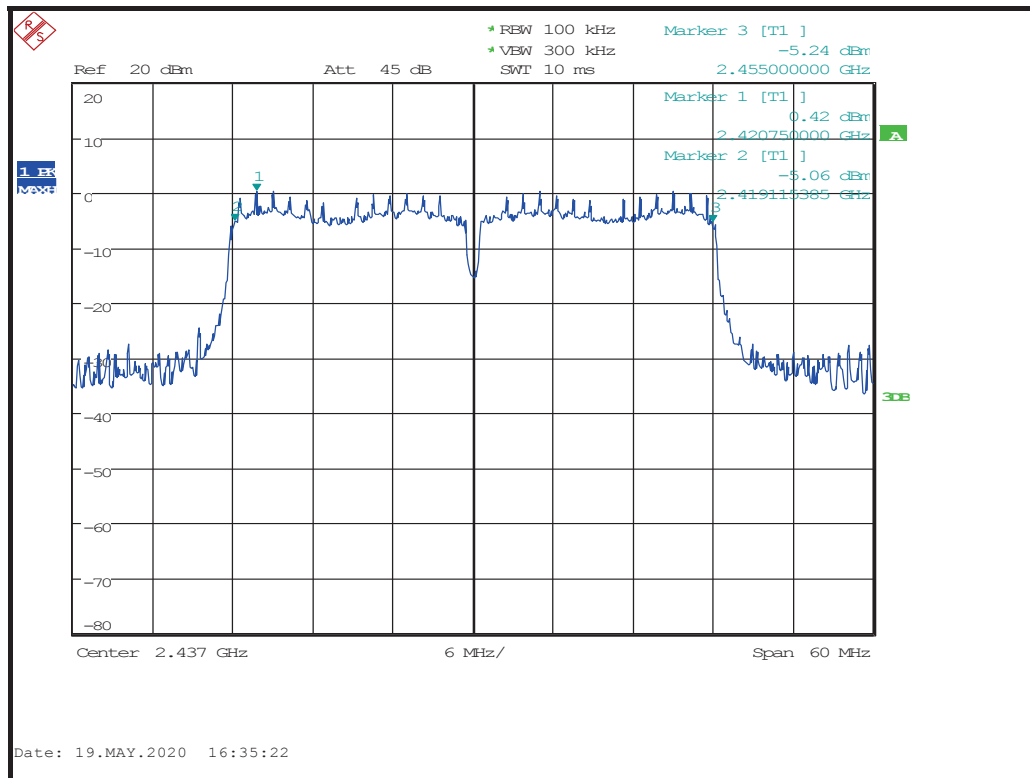
FCC 15.247. Modulation: 802.11n-20; Data rate: MCS7; Aux Antenna					
Channel Frequency (MHz)	Power Setting	F_L (MHz)	F_H (MHz)	6dB Bandwidth (kHz)	Result
2412	13	2403.153846	2420.846154	17692.308	PASS
2437	13	2428.153846	2445.846154	17692.308	PASS
2462	13	2453.153846	2470.846154	17692.308	PASS



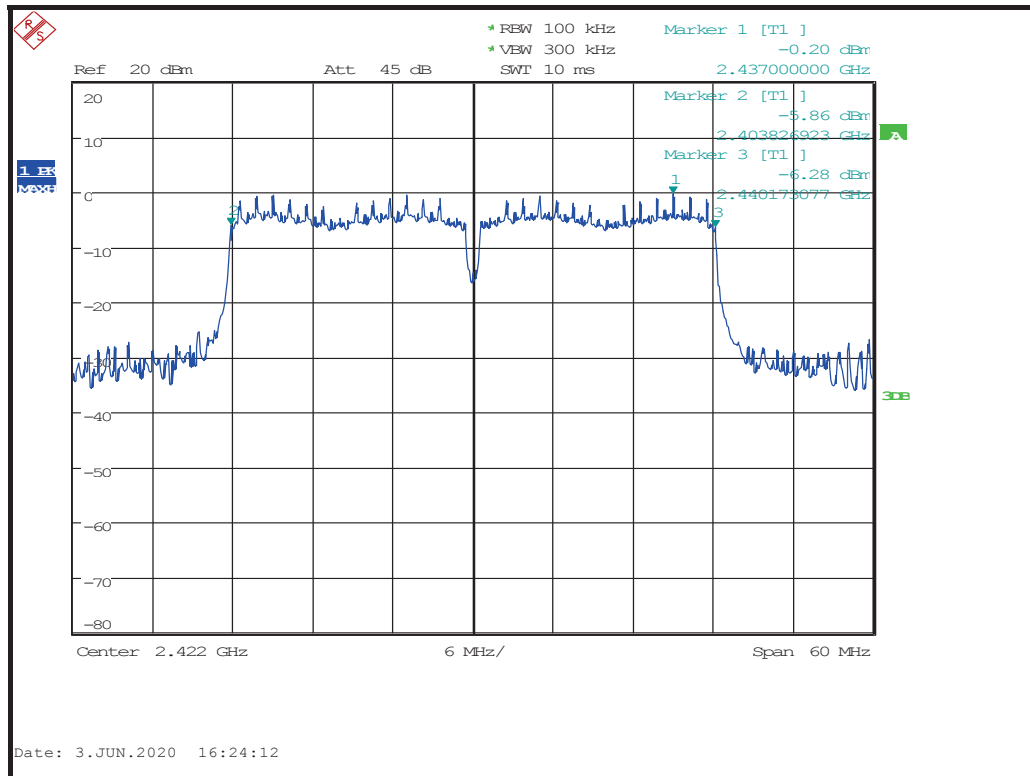


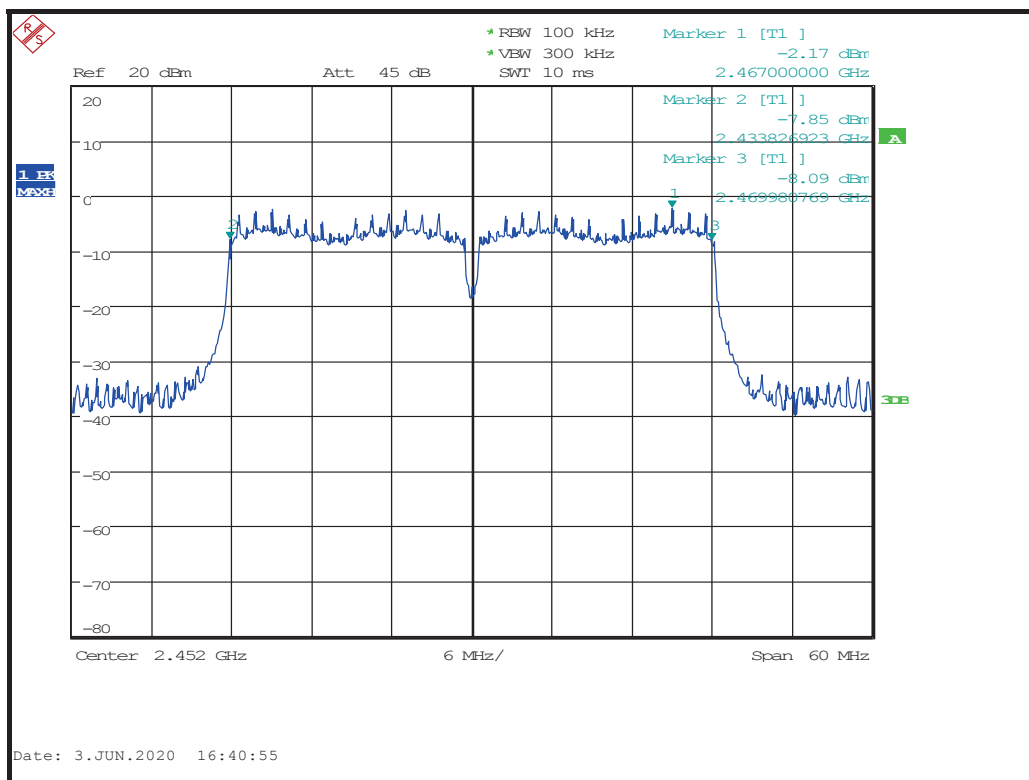
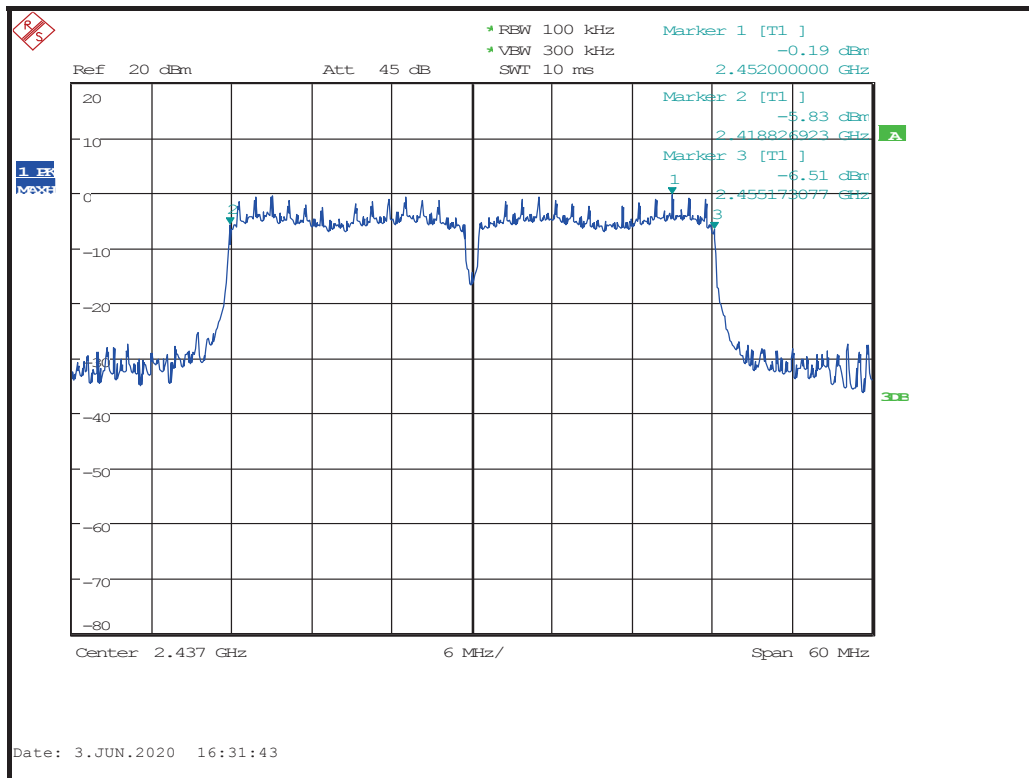
FCC 15.247. Modulation: 802.11n-40; Data rate: MCS0; Main Antenna					
Channel Frequency (MHz)	Power Setting	F_L (MHz)	F_H (MHz)	6dB Bandwidth (kHz)	Result
2422	14	2404.134612	2440.000000	35865.388	PASS
2437	14	2419.115385	2455.000000	35884.615	PASS
2452	12	2433.971154	2470.173077	36201.923	PASS



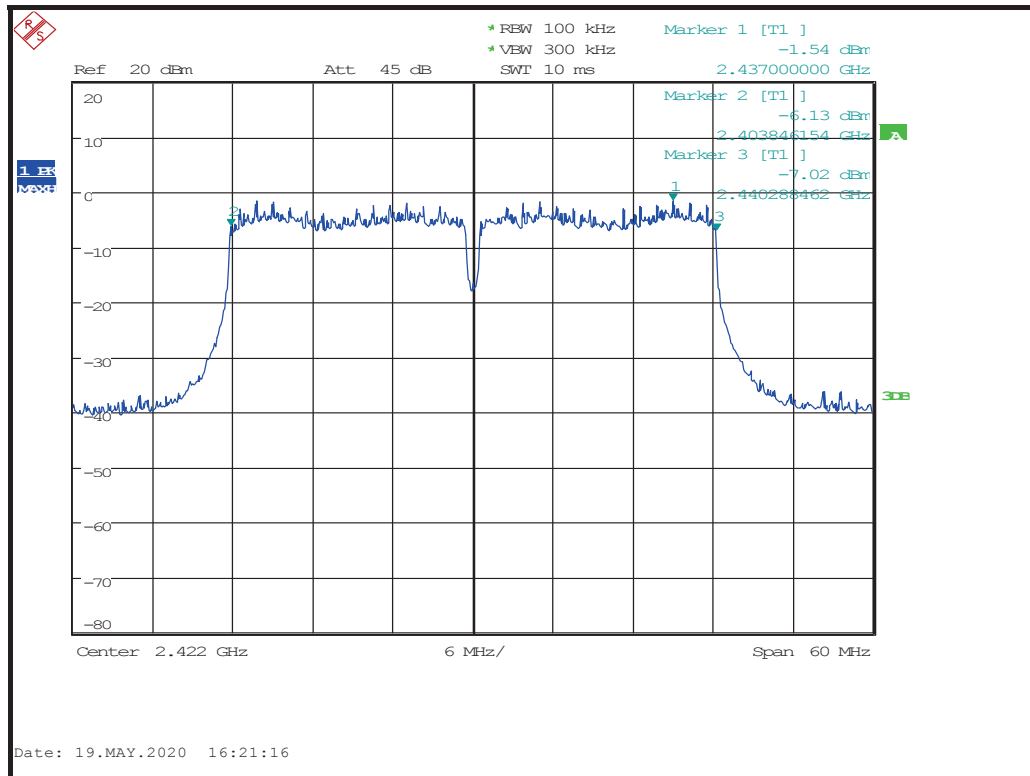


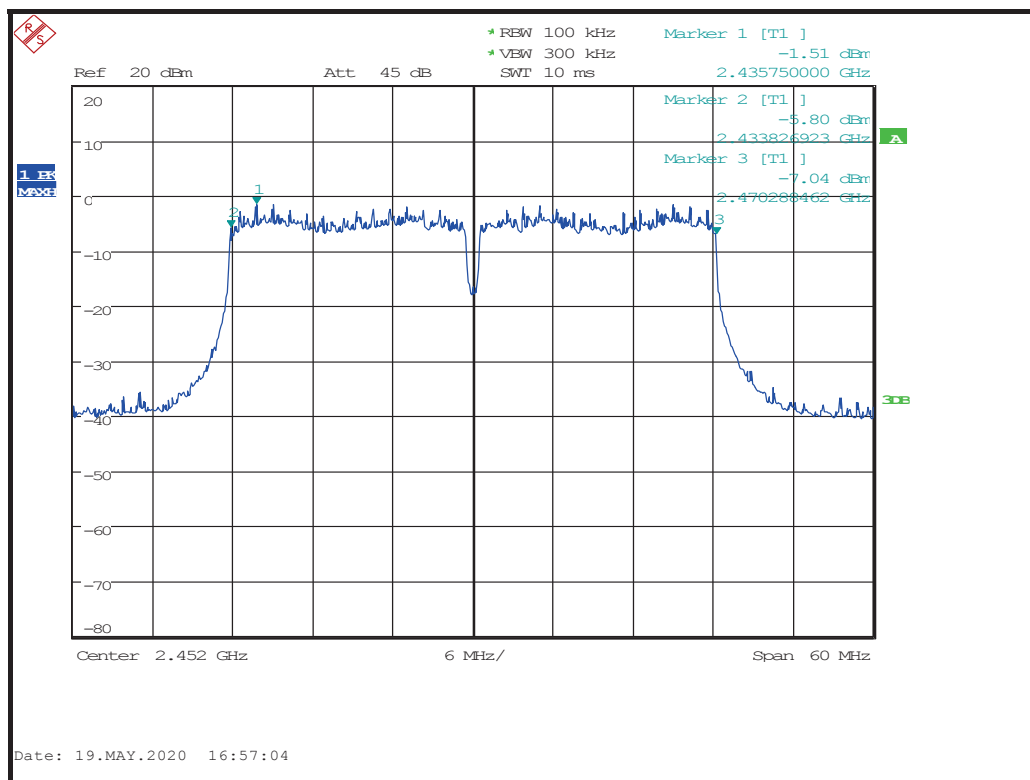
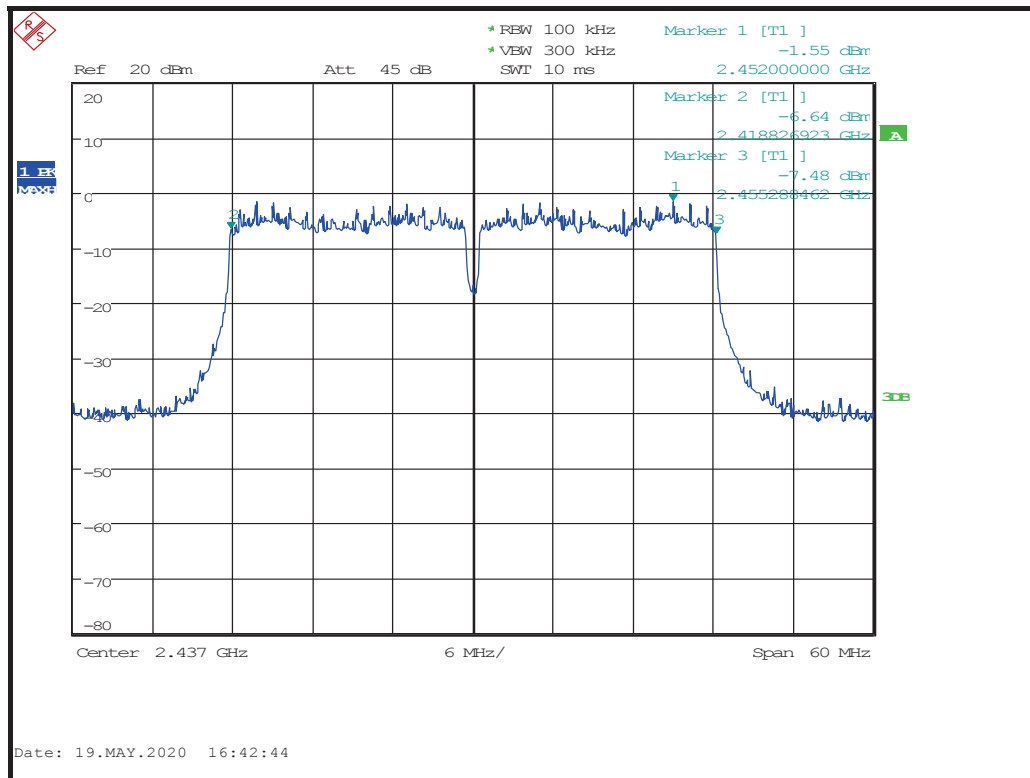
FCC 15.247. Modulation: 802.11n-40; Data rate: MCS0; Aux Antenna					
Channel Frequency (MHz)	Power Setting	F_L (MHz)	F_H (MHz)	6dB Bandwidth (kHz)	Result
2422	14	2403.826923	2440.173077	36346.154	PASS
2437	14	2418.826923	2455.173077	36346.154	PASS
2452	12	2433.826923	2469.980769	36153.846	PASS



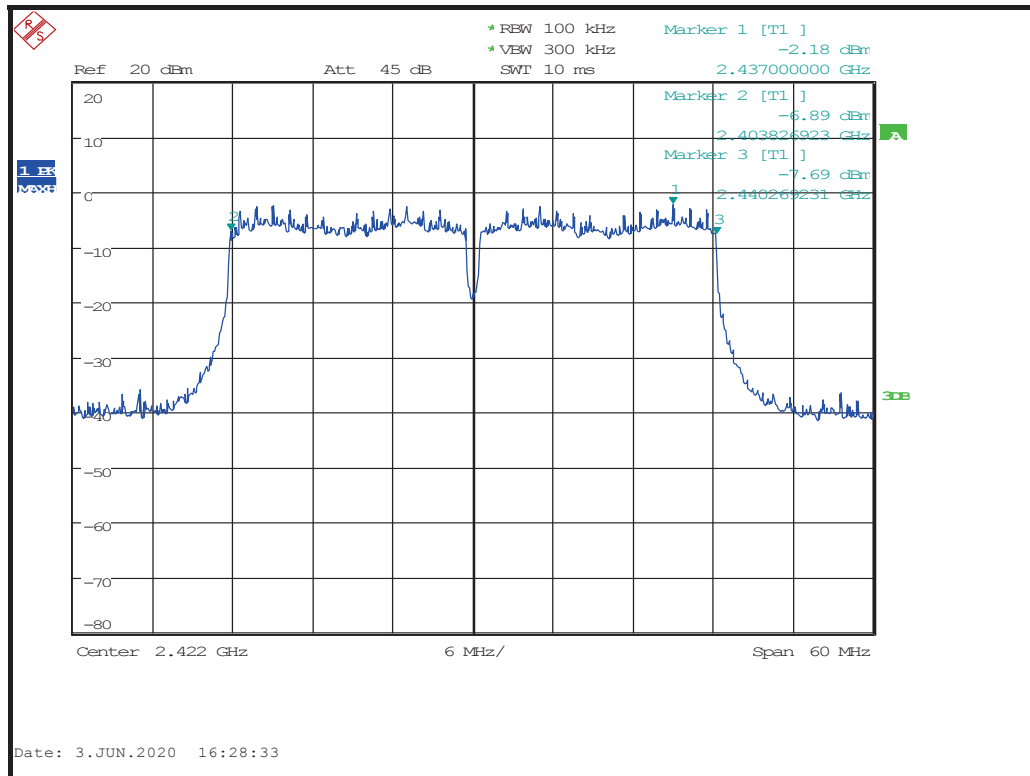


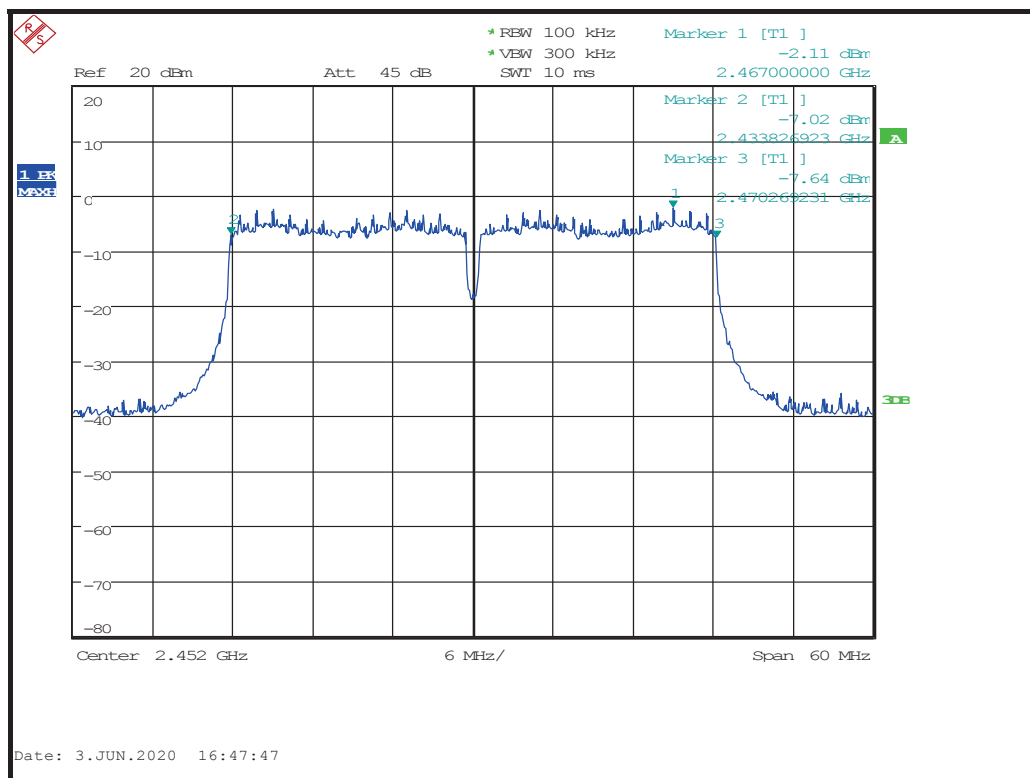
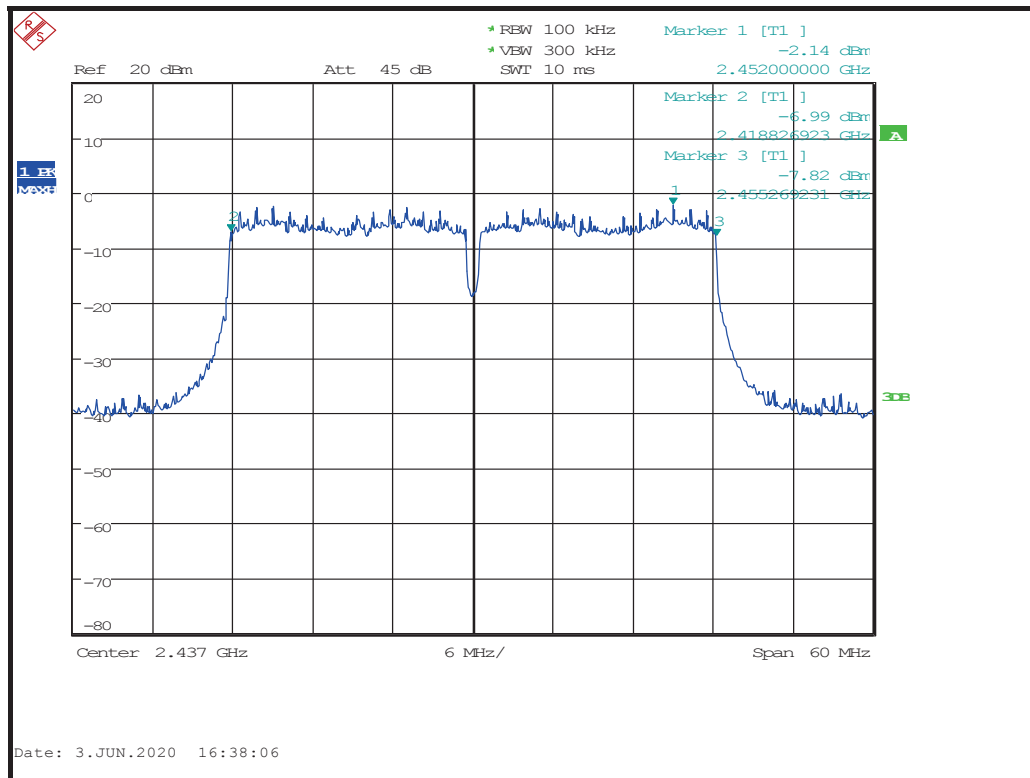
FCC 15.247. Modulation: 802.11n-40; Data rate: MCS7; Main Antenna					
Channel Frequency (MHz)	Power Setting	F_L (MHz)	F_H (MHz)	6dB Bandwidth (kHz)	Result
2422	12	2403.846154	2440.288462	36442.308	PASS
2437	12	2418.826923	2455.288462	36461.539	PASS
2452	12	2433.826923	2470.288462	36461.539	PASS





FCC 15.247. Modulation: 802.11n-40; Data rate: MCS7; Aux Antenna					
Channel Frequency (MHz)	Power Setting	F_L (MHz)	F_H (MHz)	6dB Bandwidth (kHz)	Result
2422	12	2403.826923	2440.269231	36442.308	PASS
2437	12	2418.826923	2455.269231	36442.308	PASS
2452	12	2433.826923	2470.269231	36442.308	PASS





14 Maximum conducted output power

14.1 Definition

The maximum peak conducted output power is defined as the maximum power level measured with a peak detector using a filter with width and shape of which is sufficient to accept the signal bandwidth.

The maximum conducted output power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level.

14.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Laboratory 1
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.9.2
EUT Frequencies Measured:	2412 MHz / 2437 MHz / 2462 MHz & 2422 MHz / 2437 MHz / 2452 MHz
EUT Occupied Bandwidths:	20 MHz & 40 MHz
EUT Duty Cycle:	> 98%
Deviations From Standard:	None
Measurement BW:	N/A (wideband power meter used)
Measurement Span:	N/A (wideband power meter used)
Measurement Points:	N/A (wideband power meter used)
Measurement Detector:	Peak
Voltage Extreme Environment Test Range:	DC power in place of battery (5 Vdc).

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 °C to +35 °C (as declared)
Humidity: 43 % RH	20 % RH to 75 % RH (as declared)

14.3 Test Limit

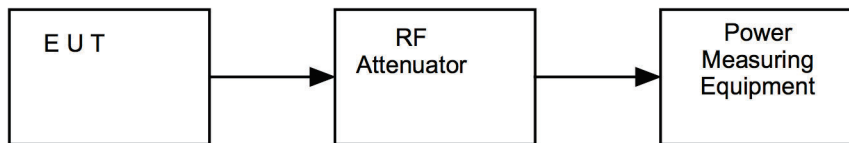
For systems employing digital modulation techniques operating in the bands 902 to 928 MHz, 2400 to 2483.5 MHz and 5725 to 5850 MHz, the maximum peak conducted output power shall not exceed 1 W.

14.4 Test Method

The EUT was setup as per section 9 of this report and, as per Figure iv, the analyser was used to measure each antenna output in turn, having taken account of all path losses. The resolution bandwidth of the spectrum analyser was set between 1 and 5 % of the EUT occupied bandwidth and the analyser band power function used to calculate the average power. The results were summed as in the tables below.

The measurements were performed with EUT set at its maximum duty. All modulation schemes, data rates and power settings were used to observe the worst case configuration in each bandwidth.

Figure iv Test Set-up



14.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
N1911A	Agilent	Power Meter	REF836	2022-09-08
LT30-2	Farnell	Power Supply	RFG035	Cal with REF887
34405A	Agilent	Multimeter	REF887	2021-10-12

14.6 Test Results

14.6.1 Test results for SISO modes

Note: When operating in SISO modes both RF chains on the EUT are active and transmitting the same data. This is for the purposes of Spatial Diversity and the data is non-correlated.

Channel: 2412 MHz; Modulation: 802.11b; Data rate: 1 Mbit/s; Power setting: 12			
Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
Main	14.7	0.7	34.7
Aux	14.5	0.7	33.1
Total:			67.8
Result:			PASS

Channel: 2437 MHz; Modulation: 802.11b; Data rate: 1 Mbit/s; Power setting: 12			
Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
Main	14.8	0.7	35.5
Aux	14.3	0.7	31.6
Total:			67.1
Result:			PASS

Channel: 2462 MHz; Modulation: 802.11b; Data rate: 1 Mbit/s; Power setting: 12			
Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
Main	14.8	0.7	35.5
Aux	14.1	0.7	30.2
Total:			65.7
Result:			PASS

Channel: 2412 MHz; Modulation: 802.11b; Data rate: 11 Mbit/s; Power setting: 12			
Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
Main	14.8	0.7	35.5
Aux	14.5	0.7	33.1
Total:			68.6
Result:			PASS

Channel: 2437 MHz; Modulation: 802.11b; Data rate: 11 Mbit/s; Power setting: 12			
Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
Main	14.8	0.7	35.5
Aux	14.3	0.7	31.6
Total:			67.1
Result:			PASS

Channel: 2462 MHz; Modulation: 802.11b; Data rate: 11 Mbit/s; Power setting: 12			
Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
Main	14.9	0.7	36.3
Aux	14.2	0.7	30.9
Total:			67.2
Result:			PASS

Channel: 2412 MHz; Modulation: 802.11g; Data rate: 6 Mbit/s; Power setting: 15			
Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
Main	22.0	0.7	186.2
Aux	21.3	0.7	158.5
Total:			344.7
Result:			PASS

Channel: 2437 MHz; Modulation: 802.11g; Data rate: 6 Mbit/s; Power setting: 15			
Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
Main	22.2	0.7	195.0
Aux	21.2	0.7	154.9
Total:			349.9
Result:			PASS

Channel: 2462 MHz; Modulation: 802.11g; Data rate: 6 Mbit/s; Power setting: 14			
Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
Main	22.3	0.7	199.5
Aux	21.1	0.7	151.4
Total:			350.9
Result:			PASS

Channel: 2412 MHz; Modulation: 802.11g; Data rate: 54 Mbit/s; Power setting: 15			
Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
Main	22.2	0.7	195.0
Aux	21.3	0.7	158.5
Total:			353.5
Result:			PASS

Channel: 2437 MHz; Modulation: 802.11g; Data rate: 54 Mbit/s; Power setting: 15			
Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
Main	22.3	0.7	199.5
Aux	21.2	0.7	154.9
Total:			354.4
Result:			PASS

Channel: 2462 MHz; Modulation: 802.11g; Data rate: 54 Mbit/s; Power setting: 14			
Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
Main	22.4	0.7	204.2
Aux	21.1	0.7	151.4
Total:			355.6
Result:			PASS

Channel: 2412 MHz; Modulation: 802.11n-20; Data rate: MCS0; Power setting: 15			
Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
Main	22.1	0.7	190.5
Aux	21.3	0.7	158.5
Total:			349.0
Result:			PASS

Channel: 2437 MHz; Modulation: 802.11n-20; Data rate: MCS0; Power setting: 15			
Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
Main	22.2	0.7	195.0
Aux	21.2	0.7	154.9
Total:			349.9
Result:			PASS

Channel: 2462 MHz; Modulation: 802.11n-20; Data rate: MCS0; Power setting: 13			
Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
Main	22.4	0.7	204.2
Aux	21.1	0.7	151.4
Total:			355.6
Result:			PASS

Channel: 2412 MHz; Modulation: 802.11n-20; Data rate: MCS7; Power setting: 13			
Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
Main	22.2	0.7	195.0
Aux	21.3	0.7	158.5
Total:			353.5
Result:			PASS

Channel: 2437 MHz; Modulation: 802.11n-20; Data rate: MCS7; Power setting: 13			
Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
Main	22.3	0.7	199.5
Aux	21.2	0.7	154.9
Total:			354.4
Result:			PASS

Channel: 2462 MHz; Modulation: 802.11n-20; Data rate: MCS7; Power setting: 13			
Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
Main	22.4	0.7	204.2
Aux	21.2	0.7	154.9
Total:			359.1
Result:			PASS

Channel: 2422 MHz; Modulation: 802.11n-40; Data rate: MCS0; Power setting: 14			
Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
Main	22.2	0.7	195.0
Aux	21.3	0.7	158.5
Total:			353.5
Result:			PASS

Channel: 2437 MHz; Modulation: 802.11n-40; Data rate: MCS0; Power setting: 14			
Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
Main	22.3	0.7	199.5
Aux	21.2	0.7	154.9
Total:			354.4
Result:			PASS

Channel: 2452 MHz; Modulation: 802.11n-40; Data rate: MCS0; Power setting: 12			
Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
Main	22.4	0.7	204.2
Aux	21.2	0.7	154.9
Total:			359.1
Result:			PASS

Channel: 2422 MHz; Modulation: 802.11n-40; Data rate: MCS7; Power setting: 12			
Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
Main	22.2	0.7	195.0
Aux	21.3	0.7	158.5
Total:			353.5
Result:			PASS

Channel: 2437 MHz; Modulation: 802.11n-40; Data rate: MCS7; Power setting: 12			
Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
Main	22.3	0.7	199.5
Aux	21.3	0.7	158.5
Total:			358.0
Result:			PASS

Channel: 2452 MHz; Modulation: 802.11n-40; Data rate: MCS7; Power setting: 12			
Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
Main	22.4	0.7	204.2
Aux	21.3	0.7	158.5
Total:			362.7
Result:			PASS

14.6.2 Test results for MIMO modes

Channel: 2412 MHz; Modulation: 802.11n-20; Data rate: MCS8; Power setting: 13			
Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
Main	22.3	0.7	199.5
Aux	21.3	0.7	158.5
Total:			358.0
Result:			PASS

Channel: 2437 MHz; Modulation: 802.11n-20; Data rate: MCS8; Power setting: 13			
Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
Main	22.3	0.7	199.5
Aux	21.3	0.7	158.5
Total:			358.0
Result:			PASS

Channel: 2462 MHz; Modulation: 802.11n-20; Data rate: MCS8; Power setting: 13			
Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
Main	22.3	0.7	199.5
Aux	21.1	0.7	151.4
Total:			350.9
Result:			PASS

Channel: 2412 MHz; Modulation: 802.11n-20; Data rate: MCS15; Power setting: 13			
Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
Main	22.2	0.7	195.0
Aux	21.4	0.7	162.2
Total:			357.2
Result:			PASS

Channel: 2437 MHz; Modulation: 802.11n-20; Data rate: MCS15; Power setting: 13			
Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
Main	22.3	0.7	199.5
Aux	21.2	0.7	154.9
Total:			354.4
Result:			PASS

Channel: 2462 MHz; Modulation: 802.11n-20; Data rate: MCS15; Power setting: 13			
Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
Main	22.3	0.7	199.5
Aux	21.1	0.7	151.4
Total:			350.9
Result:			PASS

Channel: 2422 MHz; Modulation: 802.11n-40; Data rate: MCS8; Power setting: 12			
Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
Main	22.2	0.7	195.0
Aux	21.4	0.7	162.2
Total:			357.2
Result:			PASS

Channel: 2437 MHz; Modulation: 802.11n-40; Data rate: MCS8; Power setting: 12			
Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
Main	22.3	0.7	199.5
Aux	21.3	0.7	158.5
Total:			358.0
Result:			PASS

Channel: 2452 MHz; Modulation: 802.11n-40; Data rate: MCS8; Power setting: 12			
Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
Main	22.2	0.7	195.0
Aux	21.2	0.7	154.9
Total:			349.9
Result:			PASS

Channel: 2422 MHz; Modulation: 802.11n-40; Data rate: MCS15; Power setting: 12			
Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
Main	22.3	0.7	199.5
Aux	21.4	0.7	162.2
Total:			361.7
Result:			PASS

Channel: 2437 MHz; Modulation: 802.11n-40; Data rate: MCS15; Power setting: 12			
Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
Main	22.3	0.7	199.5
Aux	21.3	0.7	158.5
Total:			358.0
Result:			PASS

Channel: 2452 MHz; Modulation: 802.11n-40; Data rate: MCS15; Power setting: 12			
Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
Main	22.3	0.7	199.5
Aux	21.3	0.7	158.5
Total:			358.0
Result:			PASS

15 Out-of-band and conducted spurious emissions

15.1 Definition

Out-of-band emission.

Emission on a frequency or frequencies immediately outside the necessary bandwidth that results from the modulation process but excluding spurious emissions.

Spurious emission.

Emission on a frequency or frequencies that are outside the necessary bandwidth and the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products, and frequency conversion products, but exclude out-of-band emissions.

15.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Laboratory 1
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.11
EUT Frequencies Measured:	2412 MHz / 2437 MHz / 2462 MHz & 2422 MHz / 2437 MHz / 2452 MHz
EUT Channel Bandwidths:	20 MHz & 40 MHz
Deviations From Standard:	None
Measurement BW:	100 kHz
Spectrum Analyzer Video BW:	300 kHz
Measurement Detector:	Peak
Measurement Range:	30 MHz to 26.5 GHz

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 °C to +35 °C (as declared)
Humidity: 43 % RH	20 % RH to 75 % RH (as declared)
Supply: 5 Vdc	As declared

15.3 Test Limit

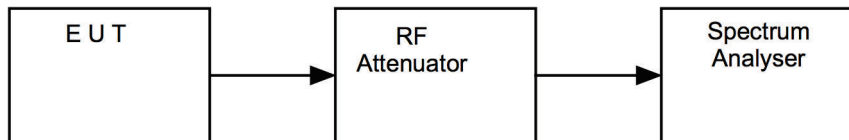
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in FCC 47CFR15.209(a) is not required.

15.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure v, the emissions from the EUT were measured on a spectrum analyser.

The measurements were performed with EUT set at its maximum duty. All modulation schemes, data rates and power settings were used to observe the worst case configuration in each bandwidth.

Figure v Test Setup



15.5 Test Equipment

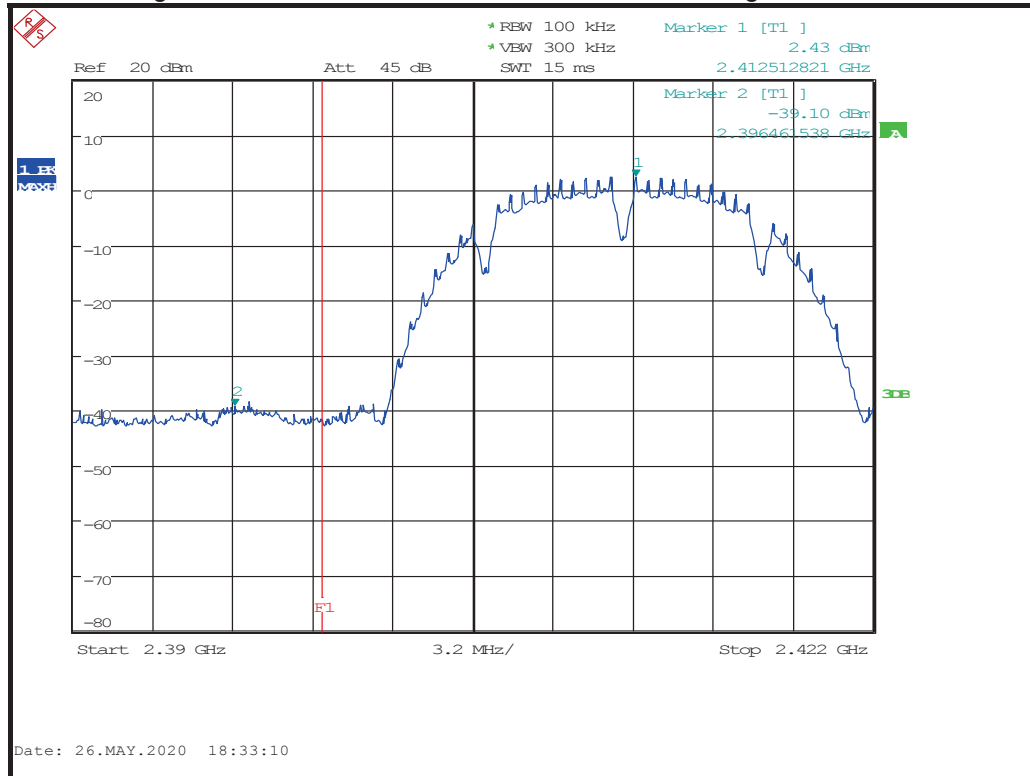
Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU50	R&S	Spectrum Analyser	U544	2021-06-17
LT30-2	Farnell	Power Supply	RFG035	Cal with REF887
34405A	Agilent	Multimeter	REF887	2021-10-12

15.6 Test Results

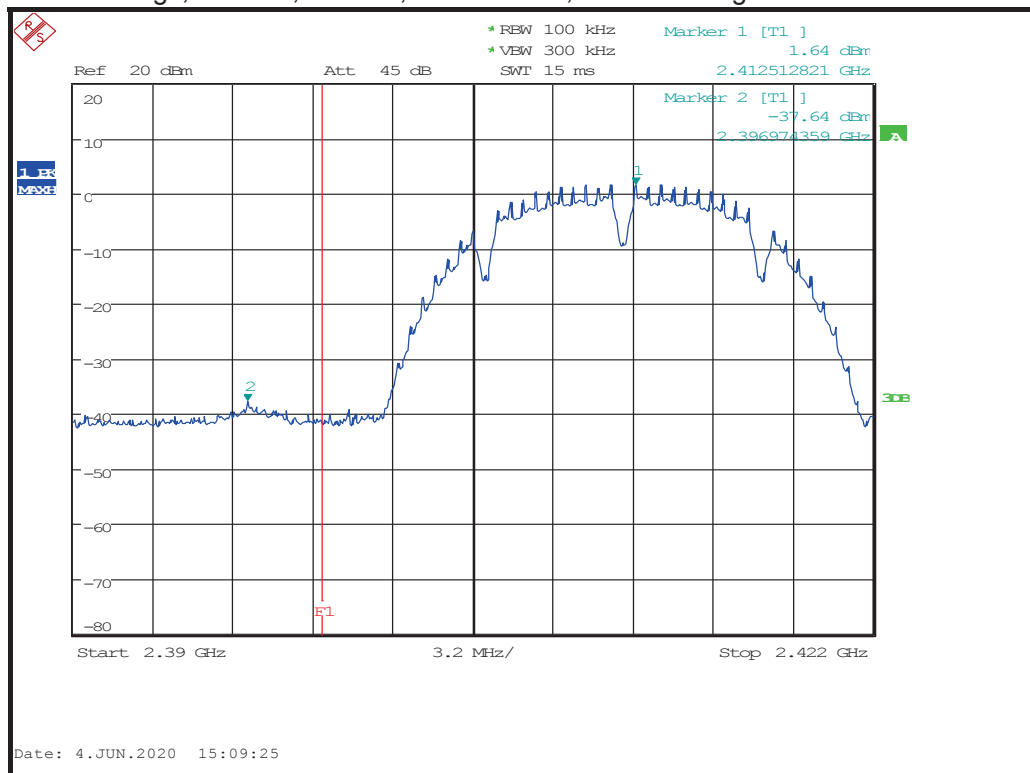
Compliance data for this test has been collected as part of the Radiated Spurious Emissions testing. In addition, Lower Band Edge measurements have been made using conducted test methods.

Worst Case Emission in Lower Non-Restricted Band (2390 MHz to 2400 MHz)						
Modulation	Data Rate	Main Antenna (dBc)	Aux Antenna (dBc)	Limit (dBc)	Margin (dB)	Result
802.11b	1 Mbit/s	41.5	39.3	20	19.3	PASS
802.11b	11 Mbit/s	40.9	40.3	20	20.3	PASS
802.11g	6 Mbit/s	31.6	28.8	20	8.8	PASS
802.11g	54 Mbit/s	32.0	28.9	20	8.9	PASS
802.11n-20	MCS0	30.0	24.2	20	4.2	PASS
802.11n-20	MCS7	33.7	30.9	20	10.9	PASS
802.11n-40	MCS0	27.4	27.0	20	7.0	PASS
802.11n-40	MCS7	35.0	33.4	20	13.4	PASS

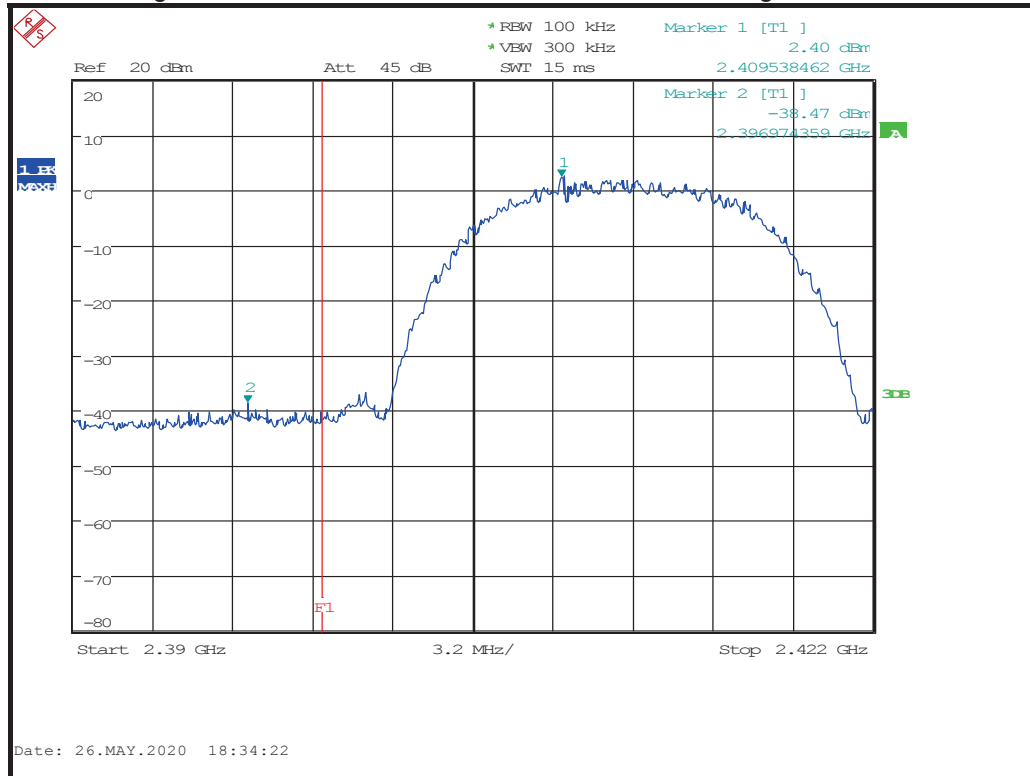
Lower Band Edge; 802.11b, 1 Mbit/s, Main Antenna, Power Setting 12



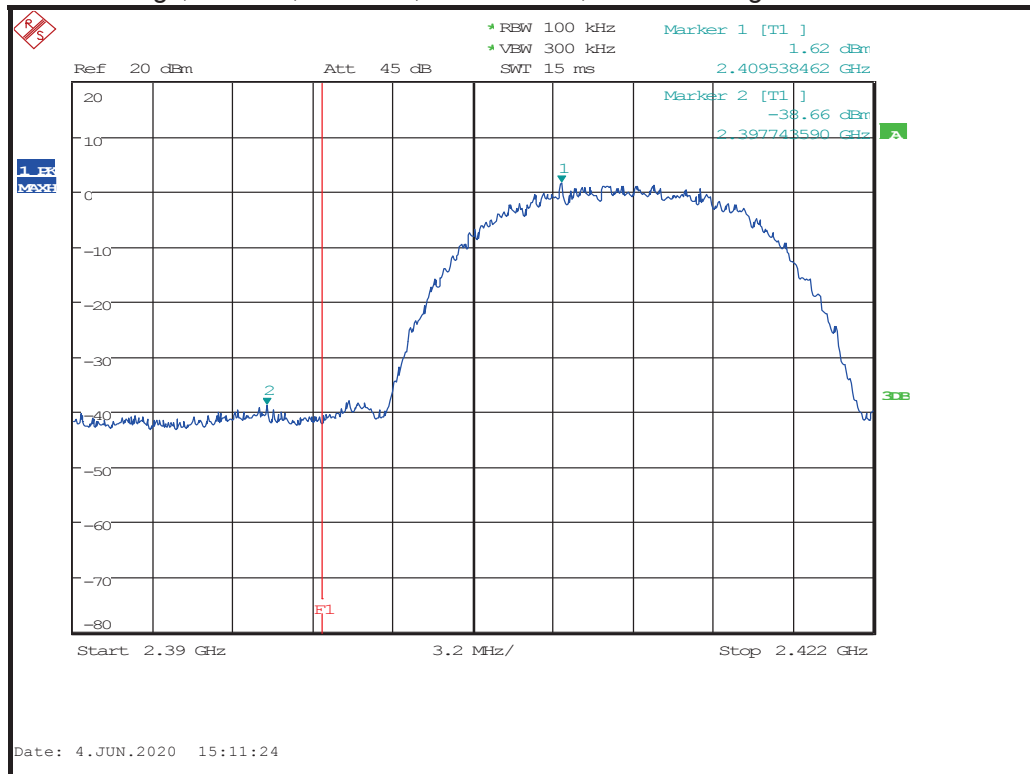
Lower Band Edge; 802.11b; 1 Mbit/s, Aux Antenna, Power Setting 12



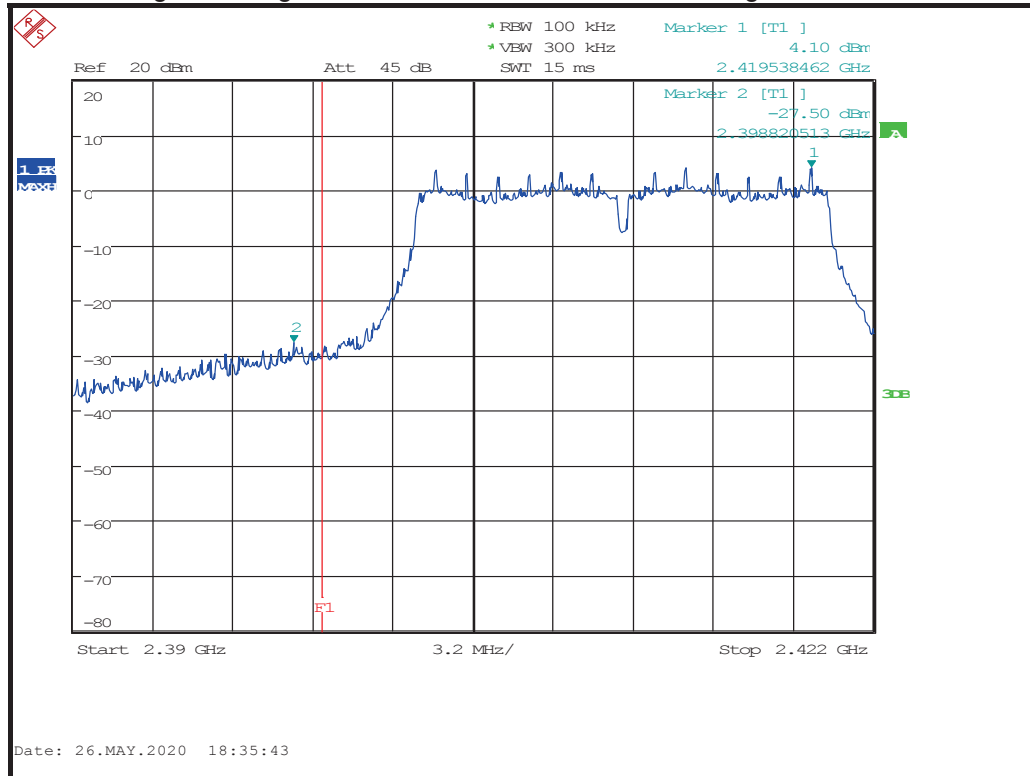
Lower Band Edge; 802.11b; 11 Mbit/s, Main Antenna, Power Setting 12



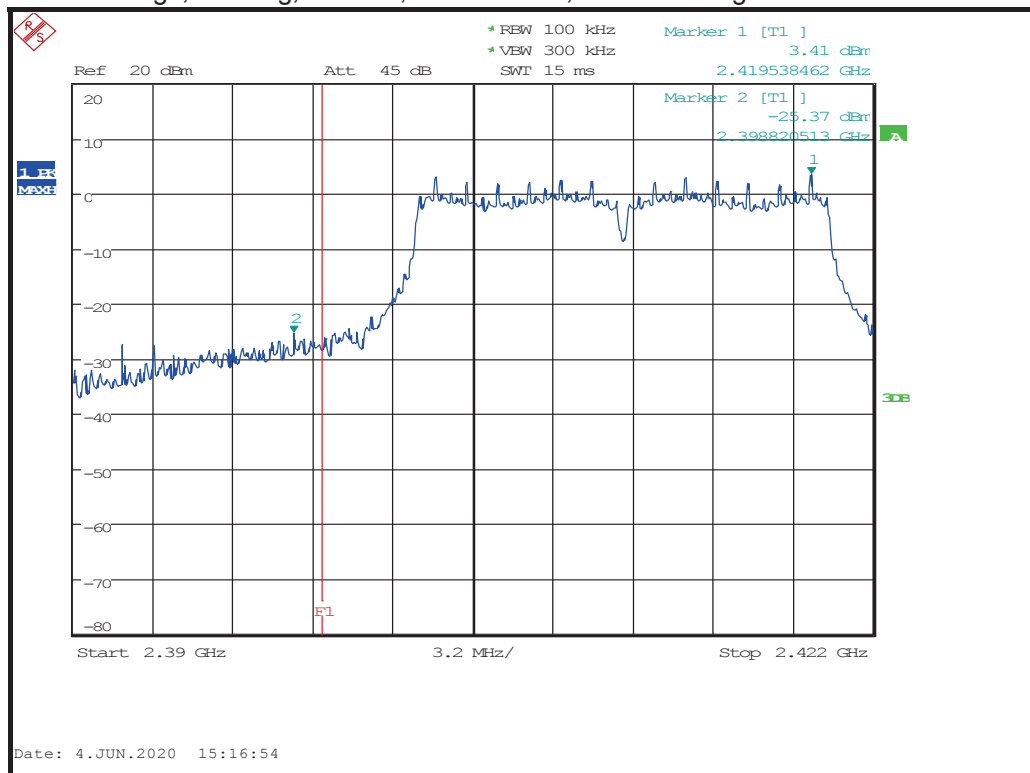
Lower Band Edge; 802.11b; 11 Mbit/s, Aux Antenna, Power Setting 12



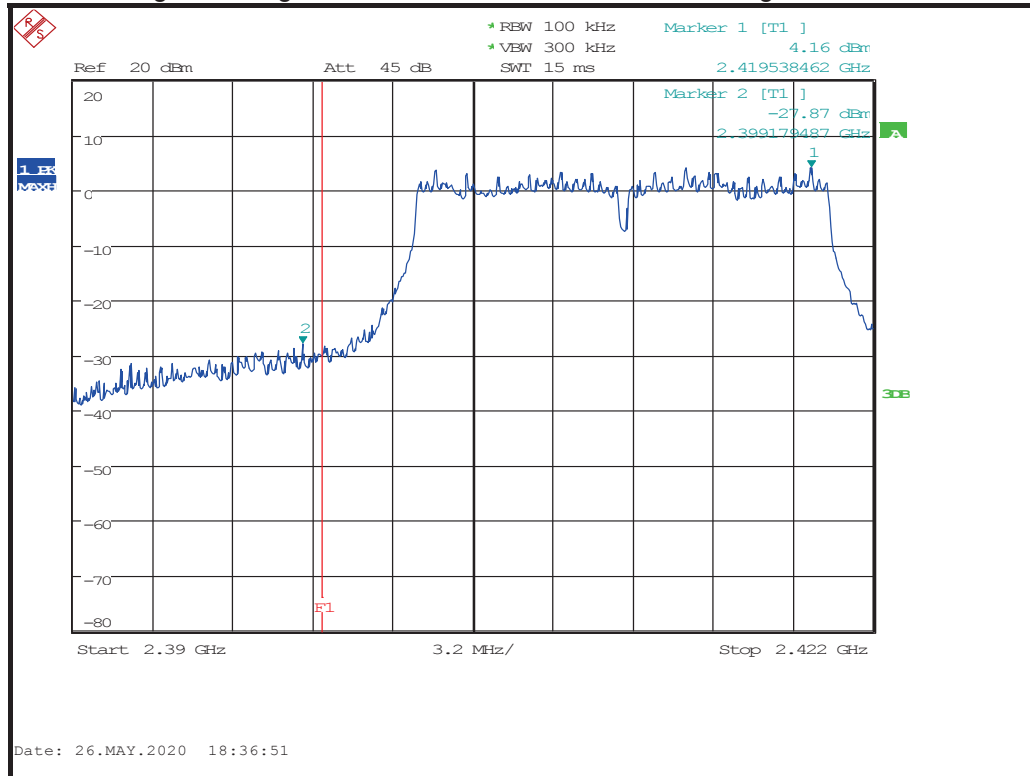
Lower Band Edge; 802.11g; 6 Mbit/s, Main Antenna, Power Setting 15



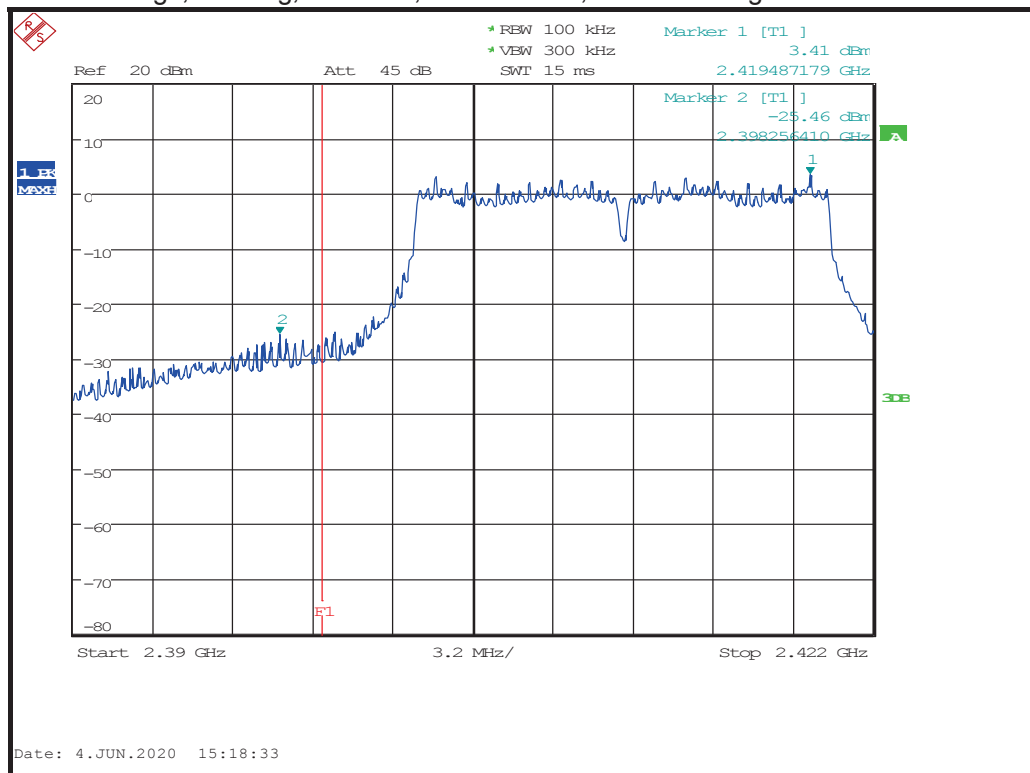
Lower Band Edge; 802.11g; 6 Mbit/s, Aux Antenna, Power Setting 15



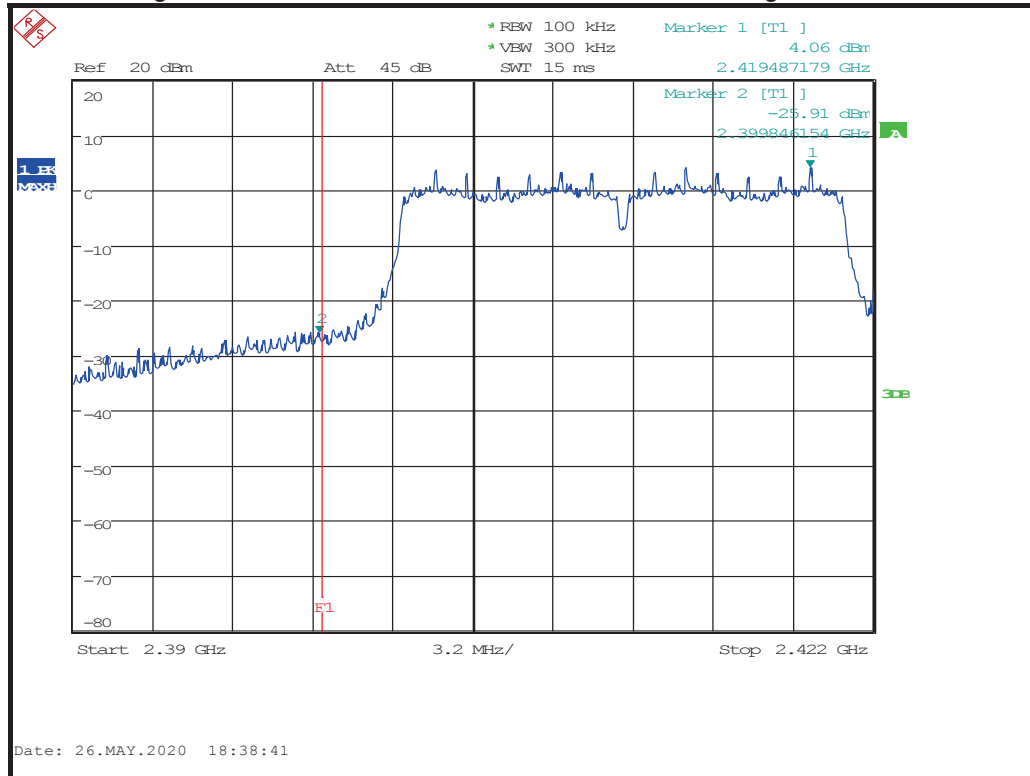
Lower Band Edge; 802.11g, 54 Mbit/s, Main Antenna, Power Setting 15



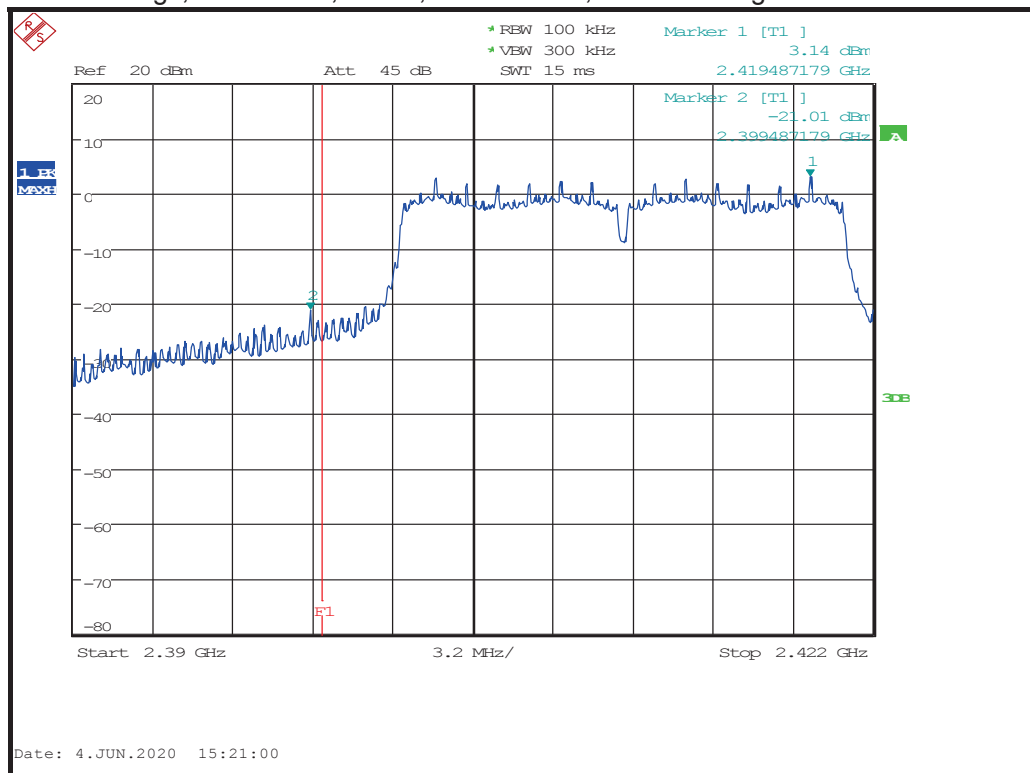
Lower Band Edge; 802.11g; 54 Mbit/s, Aux Antenna, Power Setting 15



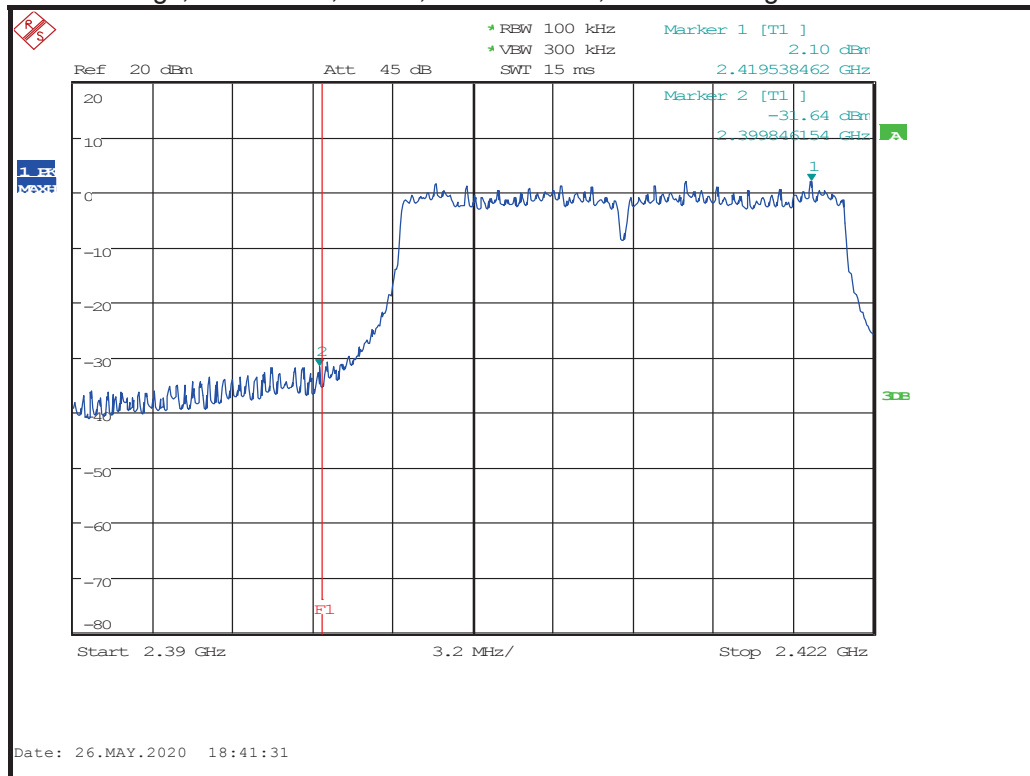
Lower Band Edge; 802.11n-20; MCS0, Main Antenna, Power Setting 15



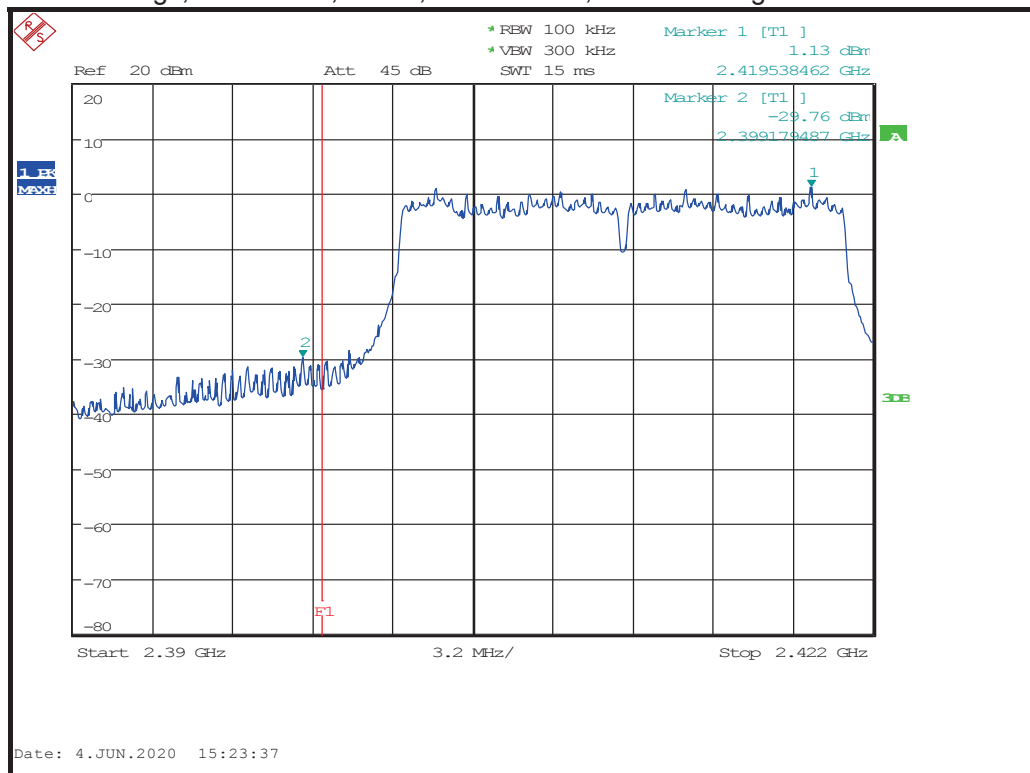
Lower Band Edge; 802.11n-20; MCS0, Aux Antenna, Power Setting 15



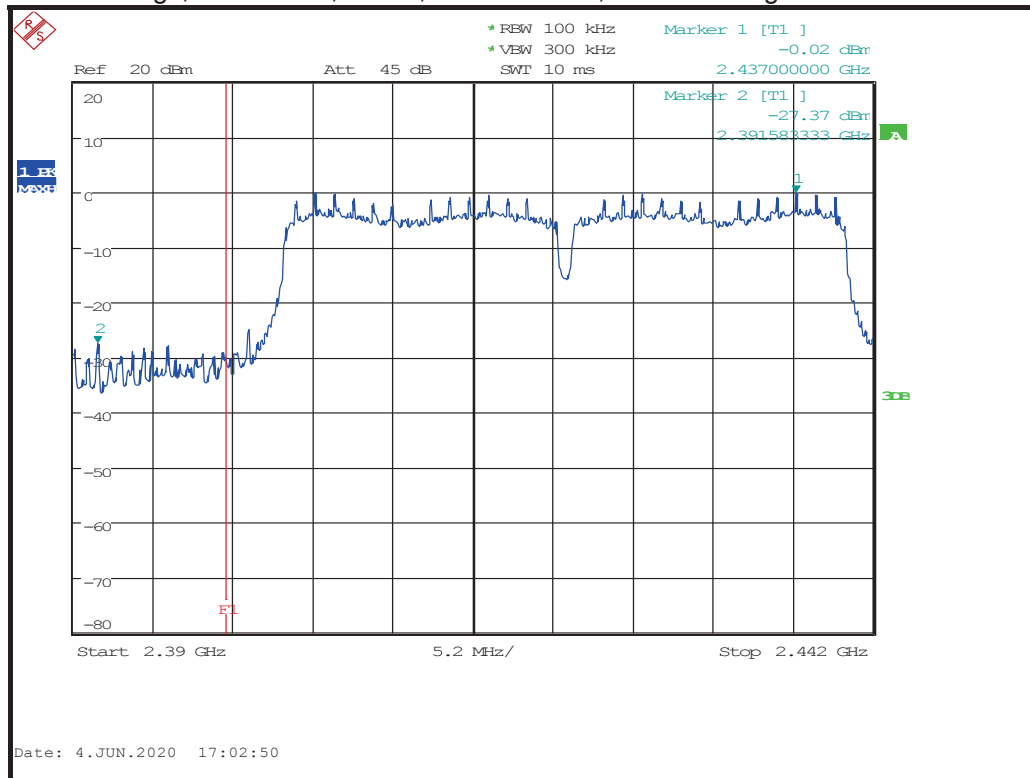
Lower Band Edge; 802.11n-20; MCS7, Main Antenna, Power Setting 13



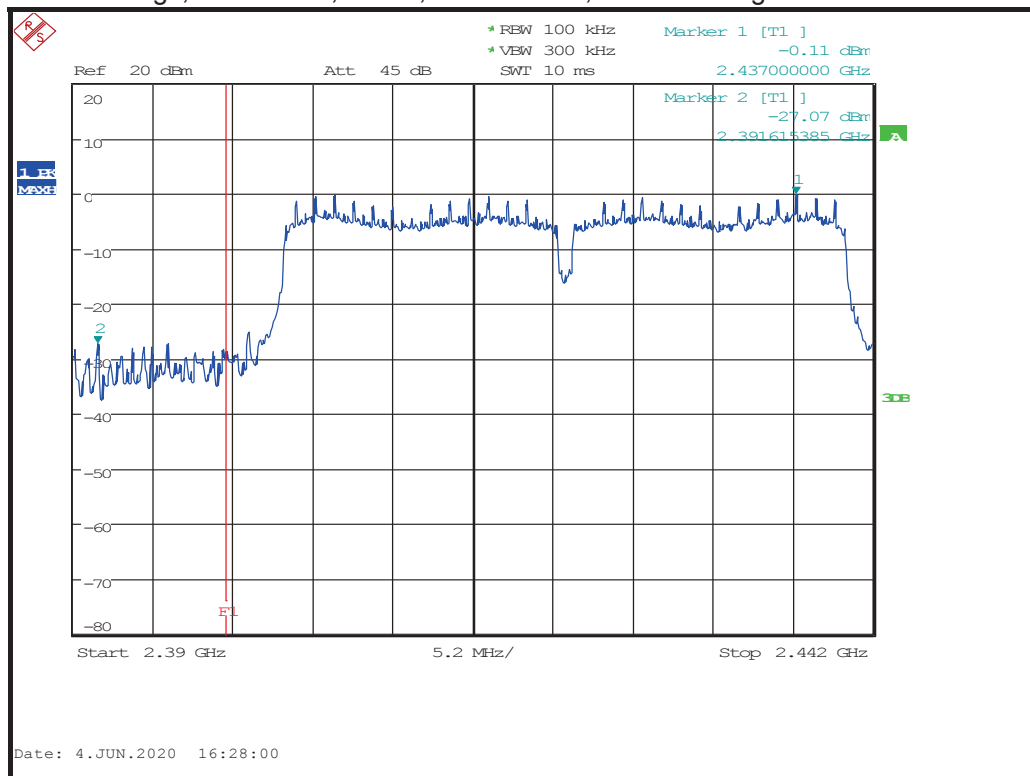
Lower Band Edge; 802.11n-20; MCS7, Aux Antenna, Power Setting 13



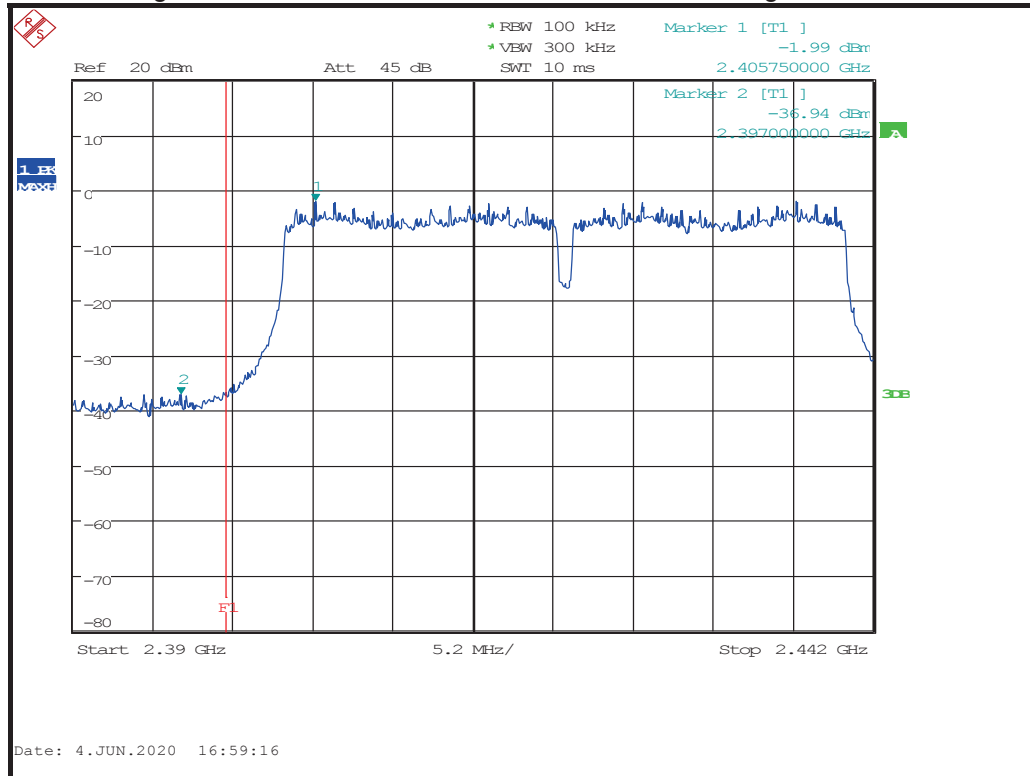
Lower Band Edge; 802.11n-40; MCS0, Main Antenna, Power Setting 14



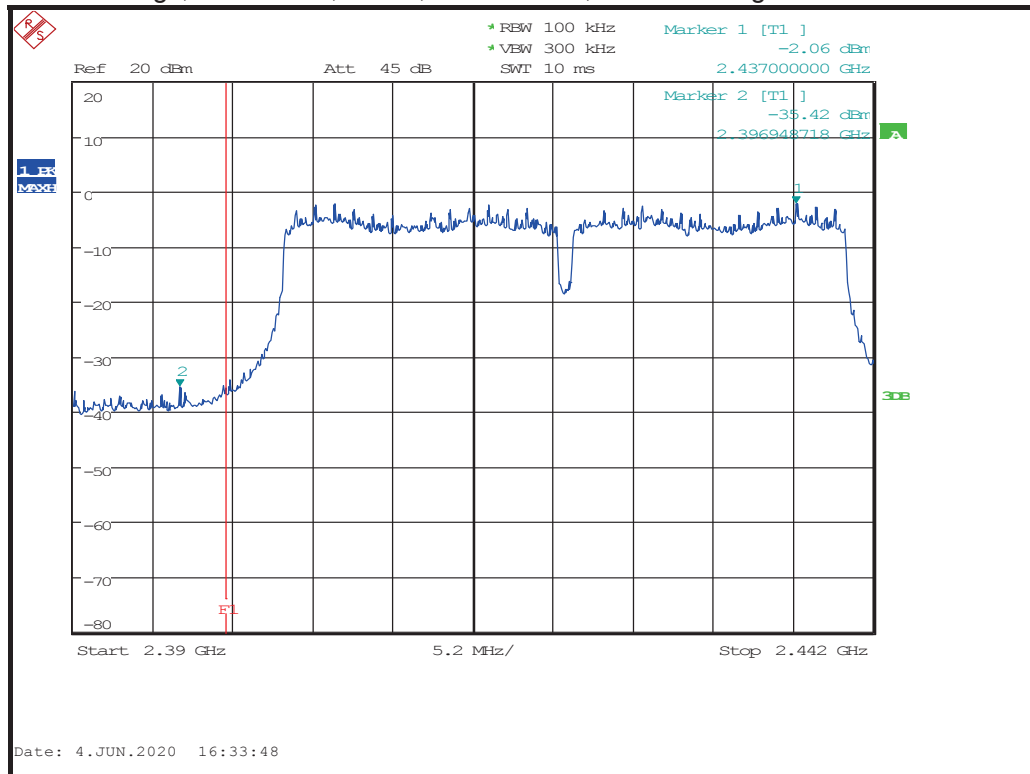
Lower Band Edge; 802.11n-40; MCS0, Aux Antenna, Power Setting 14



Lower Band Edge; 802.11n-40; MCS7, Main Antenna, Power Setting 12



Lower Band Edge; 802.11n-40; MCS7, Aux Antenna, Power Setting 12



16 Power spectral density

16.1 Definition

The power per unit bandwidth.

16.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Laboratory 1
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.10
EUT Frequencies Measured:	2412 MHz / 2437 MHz / 2462 MHz & 2422 MHz / 2437 MHz / 2452 MHz
EUT Channel Bandwidths:	20 MHz & 40 MHz
Deviations From Standard:	None
Measurement BW:	10 kHz
Spectrum Analyzer Video BW:	30 kHz
Measurement Span:	30 MHz (for 20 MHz channels), 60 MHz (for 40 MHz channels)
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 23 °C	+15 °C to +35 °C (as declared)
Humidity: 42 % RH	20 % RH to 75 % RH (as declared)
Supply: 5 Vdc	As declared

16.3 Test Limit

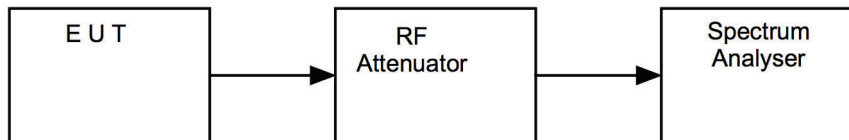
The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

16.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure vi, the peak emission of the EUT was measured on a spectrum analyser, with path losses taken into account.

The measurements were performed with EUT set at its maximum duty. All modulation schemes, data rates and power settings were used to observe the worst case configuration in each bandwidth.

Figure vi Test Setup



16.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU50	R&S	Spectrum Analyser	U544	2021-06-17
LT30-2	Farnell	Power Supply	RFG035	Cal with REF887
34405A	Agilent	Multimeter	REF887	2021-10-12

16.6 Test Results

Modulation: 802.11b; Data rate: 1 Mbit/s						
Channel Frequency (MHz)	Power Setting	Analyzer Level on Main port (dBm/3kHz)	Analyser Level on Aux port (dBm/3kHz)	Cable Loss (dB)	Combined PSD (dBm/3kHz)	Result
2412	12	-6.5	-6.5	0.7	-2.8	Pass
2437	12	-6.4	-6.6	0.7	-2.8	Pass
2462	12	-6.3	-6.7	0.7	-2.8	Pass

Modulation: 802.11b; Data rate: 11 Mbit/s						
Channel Frequency (MHz)	Power Setting	Analyzer Level on Main port (dBm/3kHz)	Analyser Level on Aux port (dBm/3kHz)	Cable Loss (dB)	Combined PSD (dBm/3kHz)	Result
2412	12	-0.2	1.2	0.7	4.3	Pass
2437	12	-1.3	0.7	0.7	3.5	Pass
2462	12	1.0	0.6	0.7	4.5	Pass

Modulation: 802.11g; Data rate: 6 Mbit/s						
Channel Frequency (MHz)	Power Setting	Analyzer Level on Main port (dBm/3kHz)	Analyser Level on Aux port (dBm/3kHz)	Cable Loss (dB)	Combined PSD (dBm/3kHz)	Result
2412	15	-3.9	-5.2	0.7	-0.8	Pass
2437	15	-5.0	-4.1	0.7	-0.8	Pass
2462	14	-5.4	-5.9	0.7	-1.9	Pass

Modulation: 802.11g; Data rate: 54 Mbit/s						
Channel Frequency (MHz)	Power Setting	Analyzer Level on Main port (dBm/3kHz)	Analyser Level on Aux port (dBm/3kHz)	Cable Loss (dB)	Combined PSD (dBm/3kHz)	Result
2412	15	-4.4	-4.6	0.7	-0.8	Pass
2437	15	-4.0	-3.9	0.7	-0.2	Pass
2462	14	-5.3	-5.0	0.7	-1.4	Pass

Modulation: 802.11n-20; Data rate: MCS0						
Channel Frequency (MHz)	Power Setting	Analyzer Level on Main port (dBm/3kHz)	Analyser Level on Aux port (dBm/3kHz)	Cable Loss (dB)	Combined PSD (dBm/3kHz)	Result
2412	15	-4.4	-4.3	0.7	-0.6	Pass
2437	15	-3.8	-3.7	0.7	0.0	Pass
2462	13	-5.5	-6.4	0.7	-2.2	Pass

Modulation: 802.11n-20; Data rate: MCS7						
Channel Frequency (MHz)	Power Setting	Analyzer Level on Main port (dBm/3kHz)	Analyser Level on Aux port (dBm/3kHz)	Cable Loss (dB)	Combined PSD (dBm/3kHz)	Result
2412	13	-6.3	-6.4	0.7	-2.6	Pass
2437	13	-5.8	-6.2	0.7	-2.3	Pass
2462	13	-5.8	-6.7	0.7	-2.5	Pass

Modulation: 802.11n-40; Data rate: MCS0						
Channel Frequency (MHz)	Power Setting	Analyzer Level on Main port (dBm/3kHz)	Analyser Level on Aux port (dBm/3kHz)	Cable Loss (dB)	Combined PSD (dBm/3kHz)	Result
2422	14	-8.3	-8.8	0.7	-4.8	Pass
2437	14	-8.5	-8.6	0.7	-4.8	Pass
2452	12	-10.1	-10.5	0.7	-6.6	Pass

Modulation: 802.11n-40; Data rate: MCS7						
Channel Frequency (MHz)	Power Setting	Analyzer Level on Main port (dBm/3kHz)	Analyser Level on Aux port (dBm/3kHz)	Cable Loss (dB)	Combined PSD (dBm/3kHz)	Result
2422	12	-10.6	-10.4	0.7	-6.8	Pass
2437	12	-10.4	-10.2	0.7	-6.6	Pass
2452	12	-9.9	-10.8	0.7	-6.6	Pass

Modulation: 802.11n-20; Data rate: MCS8						
Channel Frequency (MHz)	Power Setting	Analyzer Level on Main port (dBm/3kHz)	Analyser Level on Aux port (dBm/3kHz)	Cable Loss (dB)	Combined PSD (dBm/3kHz)	Result
2412	13	-5.8	-6.2	0.7	-2.3	Pass
2437	13	-5.6	-5.7	0.7	-1.9	Pass
2462	13	-5.0	-5.9	0.7	-1.7	Pass

Modulation: 802.11n-20; Data rate: MCS15						
Channel Frequency (MHz)	Power Setting	Analyzer Level on Main port (dBm/3kHz)	Analyser Level on Aux port (dBm/3kHz)	Cable Loss (dB)	Combined PSD (dBm/3kHz)	Result
2412	13	-6.2	-6.4	0.7	-2.6	Pass
2437	13	-6.0	-6.4	0.7	-2.5	Pass
2462	13	-6.0	-7.0	0.7	-2.8	Pass

Modulation: 802.11n-40; Data rate: MCS8						
Channel Frequency (MHz)	Power Setting	Analyzer Level on Main port (dBm/3kHz)	Analyser Level on Aux port (dBm/3kHz)	Cable Loss (dB)	Combined PSD (dBm/3kHz)	Result
2422	12	-10.2	-10.7	0.7	-6.7	Pass
2437	12	-10.4	-10.1	0.7	-6.5	Pass
2452	12	-10.3	-10.0	0.7	-6.4	Pass

Modulation: 802.11n-40; Data rate: MCS15						
Channel Frequency (MHz)	Power Setting	Analyzer Level on Main port (dBm/3kHz)	Analyser Level on Aux port (dBm/3kHz)	Cable Loss (dB)	Combined PSD (dBm/3kHz)	Result
2422	12	-11.0	-9.6	0.7	-6.5	Pass
2437	12	-10.9	-9.2	0.7	-6.3	Pass
2452	12	-10.8	-9.2	0.7	-6.2	Pass

17 Measurement Uncertainty

Radio Testing – General Uncertainty Schedule

All statements of uncertainty are expanded standard uncertainty using a coverage factor of 1.96 to give a 95 % confidence where no required test level exists.

Reference No.	Parameter	Description	Value	Unit
1	Adjacent Channel Power	Uncertainty in test result	1.86	dB
2	Carrier Power	Uncertainty in test result (Power Meter)	0.070	dB
		Uncertainty in test result (Spectrum Analyser)	3.11	
3	Effective Radiated Power	Uncertainty in test result	4.71	dB
4	Radiated Spurious Emissions	Uncertainty in test result 30 MHz to 1 GHz	4.75	dB
		1 GHz to 18 GHz	4.46	
5	Maximum Frequency Error	Uncertainty in test result (CMTA)	113.441	Hz

Reference No.	Parameter	Description	Value	Unit
6	Radiated Emissions, Field Strength, OATS 9 kHz – 110 GHz Electric Field	Uncertainty in test result (9 kHz – 30 MHz)	2.3	dB
		Uncertainty in test result (30 MHz – 1 GHz)	4.75	
		Uncertainty in test result (1 GHz – 18 GHz)	4.46	
		Uncertainty in test result (18 GHz – 26 GHz)	3.2	
		Uncertainty in test result (26 GHz – 40 GHz)	3.3	
		Uncertainty in test result (40 GHz – 50 GHz)	3.5	
		Uncertainty in test result (50 GHz – 75 GHz)	3.6	
		Uncertainty in test result (75 GHz – 110 GHz)	3.6	
7	Frequency Deviation	Uncertainty in test result	3.7	%
8	Magnetic Field Emissions	Uncertainty in test result	2.3	dB
9	Conducted Spurious	Uncertainty in test result Up to 26 GHz	0.921	dB
10	Channel Bandwidth	Uncertainty in test result	15.71	%
11	Spectrum Mask Measurements	Uncertainty in test result (frequency)	2.59	%
		Uncertainty in test result (amplitude)	1.32	dB
12	Adjacent Sub Band Selectivity	Uncertainty in test result	1.24	dB
13	Receiver Blocking – Listen Mode, Radiated	Uncertainty in test result	3.23	dB

Reference No.	Parameter	Description	Value	Unit
14	Receiver Blocking – Talk Mode, Radiated	Uncertainty in test result	3.36	dB
15	Receiver Blocking – Talk Mode, Conducted	Uncertainty in test result	1.24	dB
16	Receiver Threshold	Uncertainty in test result	3.42	dB
17	Transmission Time Measurement	Uncertainty in test result	4.40	%
18	AC Power Line conducted emissions	Uncertainty in test result	3.42	dB