Harmonic Filtering & EDR for 8TR8217 / 8TR8218 / 8TR8219 IoT FEM

Application Notes

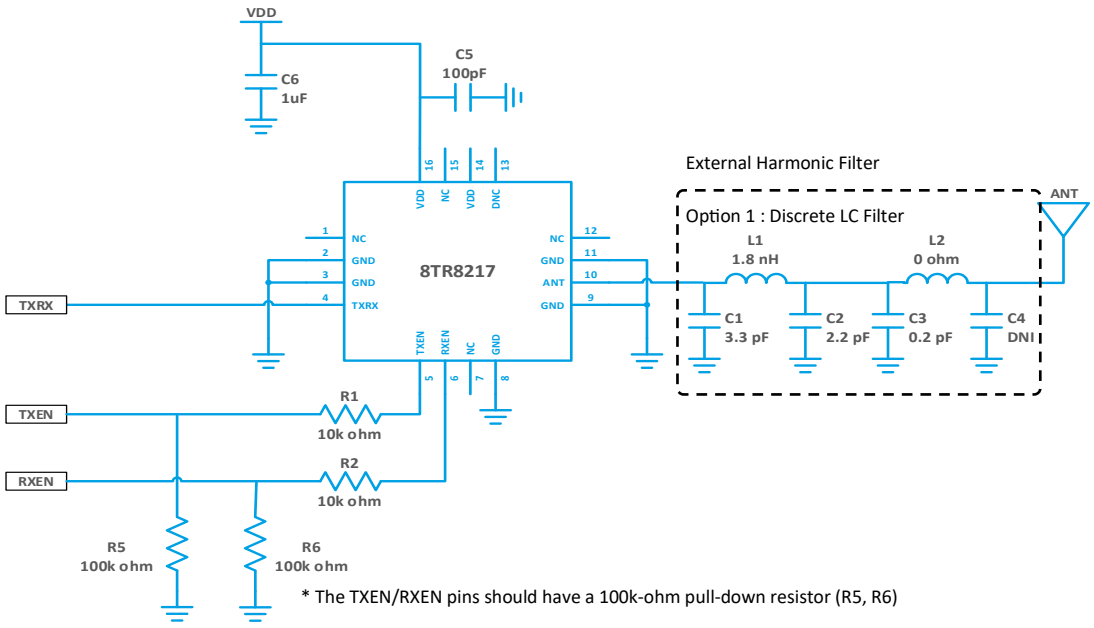
This application note describes the schematic, values and test results for the application of filters to remove harmonic products.

For more detailed product specifications of the 8TR8217 / 8TR8218 / 8TR8219, please check the datasheet.

Introduction

- Part Name: 8TR8217 / 8TR8218 / 8TR8219
- Test Board: BeRex 8TR8217 / 8TR8218 / 8TR8219 EVB
- Test Frequency: 2440MHz unless otherwise noted.
- Test VDD: +3.3V Test Vctrl: +1.6V
- Excluding RF Connector and PCB Loss
- Performance is sensitive to PCB parasitics.
  Therefore, custom PCB layout should emulate the Evaluation Board PCB layout attached to this design as closely as possible.

Application Schematic - Option 1: Discrete LC Filter



Option 1 : Discrete LC Filter
All inductors and capacitors must be populated and located as close as possible to ANT pin. Use ceramic multi-layer inductors for effective filtering.
Depending on layout, all inductor and capacitor values may require minor value tweaks for optimum impedance matching.

Figure 1. 8TR8217 Application Schematic - Option 1

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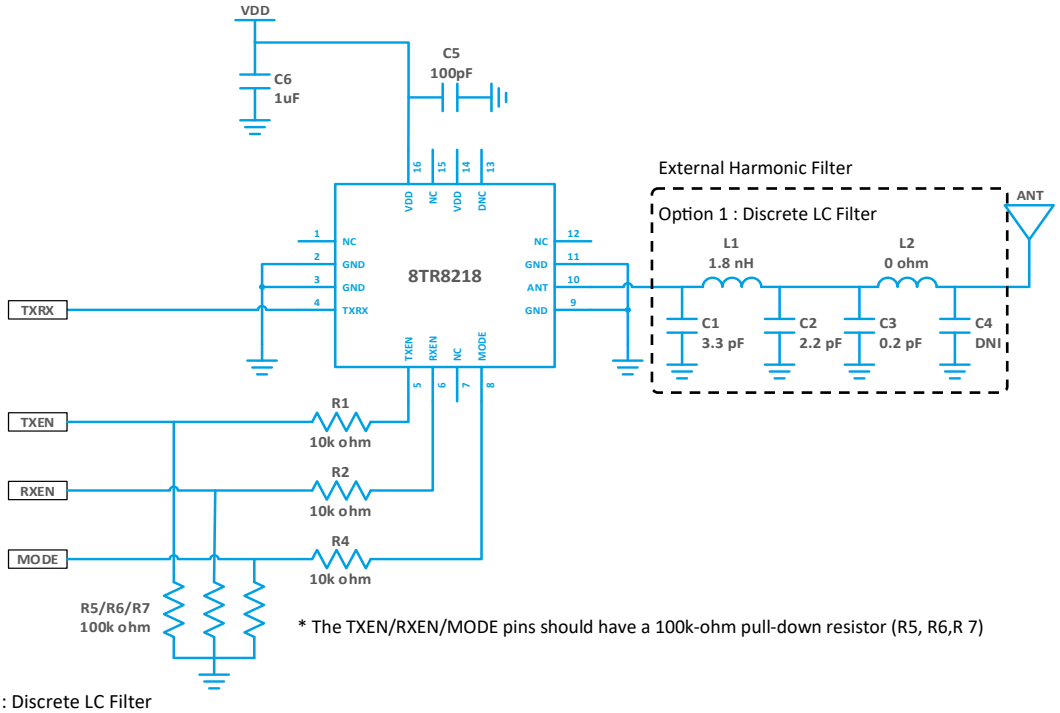
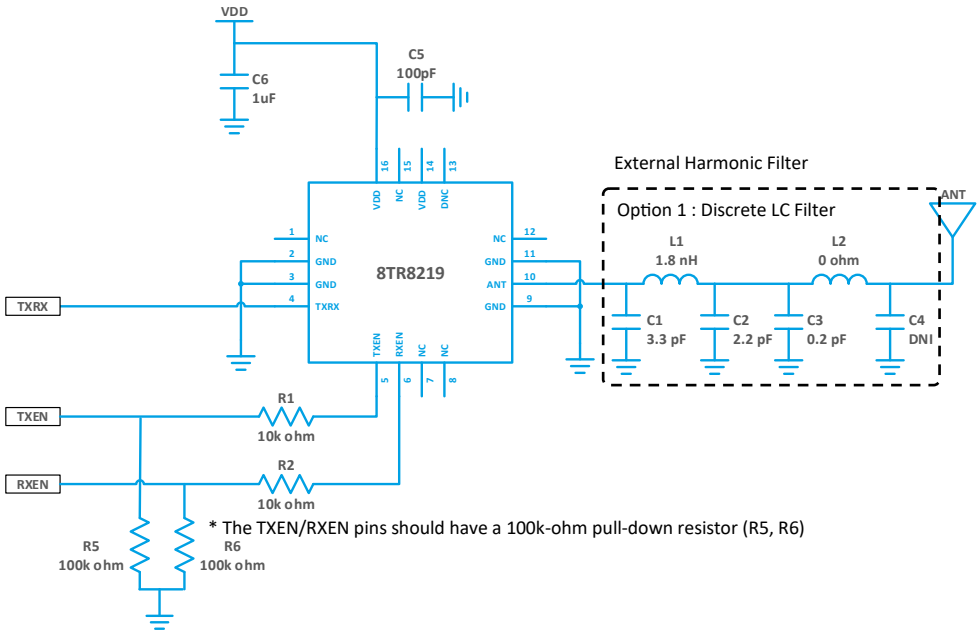


Option 1 : Discrete LC Filter
All inductors and capacitors must be populated and located as close as possible to ANT pin. Use ceramic multi-layer inductors for effective filtering.
Depending on layout, all inductor and capacitor values may require minor value tweaks for optimum impedance matching.

Figure 2. 8TR8218 Application Schematic - Option 1



Option 1 : Discrete LC Filter
All inductors and capacitors must be populated and located as close as possible to ANT pin. Use ceramic multi-layer inductors for effective filtering.
Depending on layout, all inductor and capacitor values may require minor value tweaks for optimum impedance matching.

Figure 3. 8TR8219 Application Schematic - Option 1

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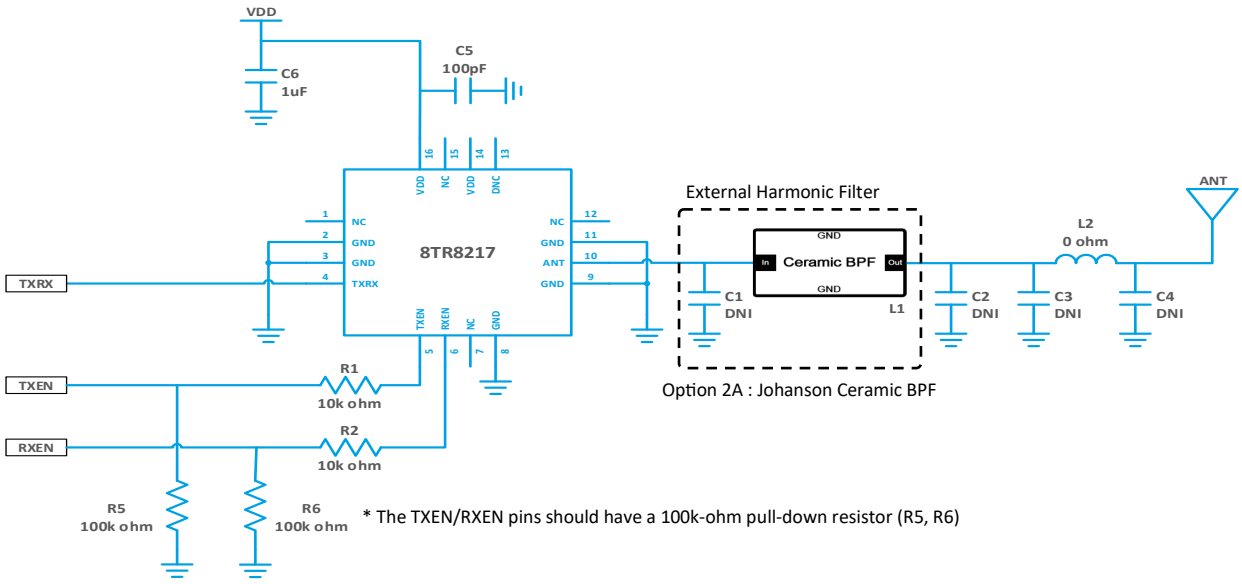
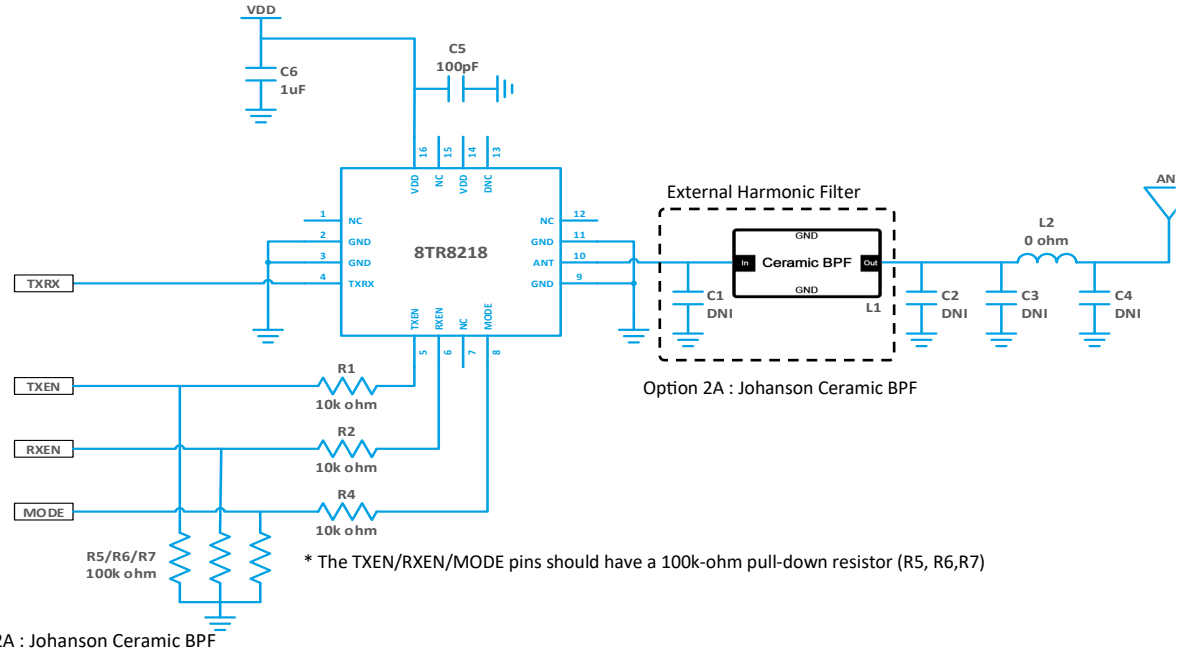
Application Schematic - Option 2A: Johanson Ceramic BPF



Option 2A : Johanson Ceramic BPF
L1 represents the option to replace the discrete pi filters by a ceramic low pass filter solution as follows:
Populate L1. (Johanson 2450BP15B100)
Populate L2 with 0 Ohm resistor (=jumpers). Do not populate C1, C2, C3 and C4.

Figure 4. 8TR8217 Application Schematic - Option 2A



Option 2A : Johanson Ceramic BPF
L1 represents the option to replace the discrete pi filters by a ceramic low pass filter solution as follows:
Populate L1. (Johanson 2450BP15B100)
Populate L2 with 0 Ohm resistor (=jumpers). Do not populate C1, C2, C3 and C4.

Figure 5. 8TR8218 Application Schematic - Option 2B

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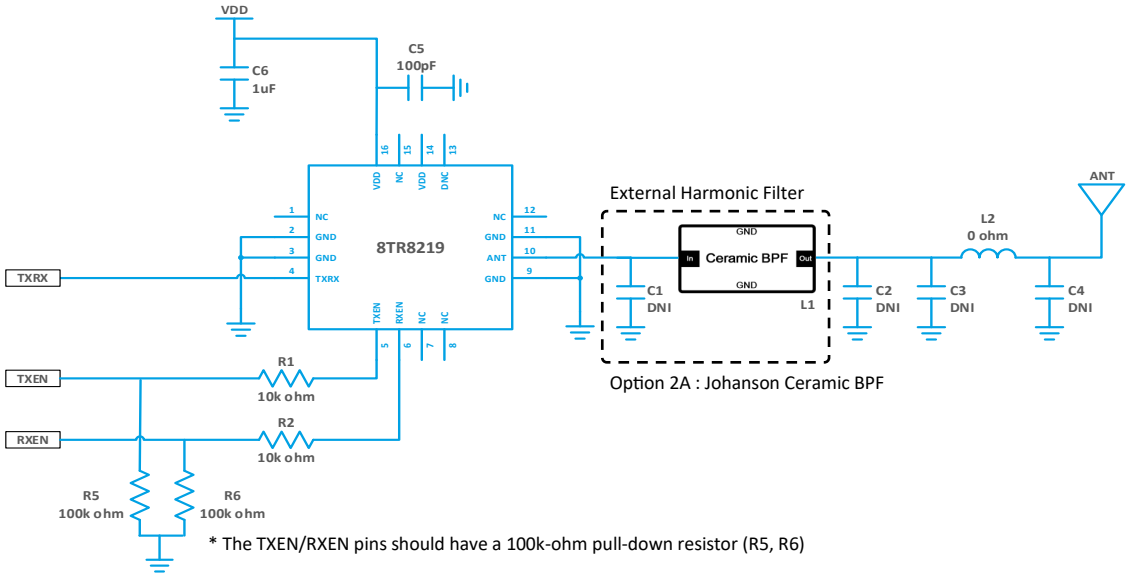
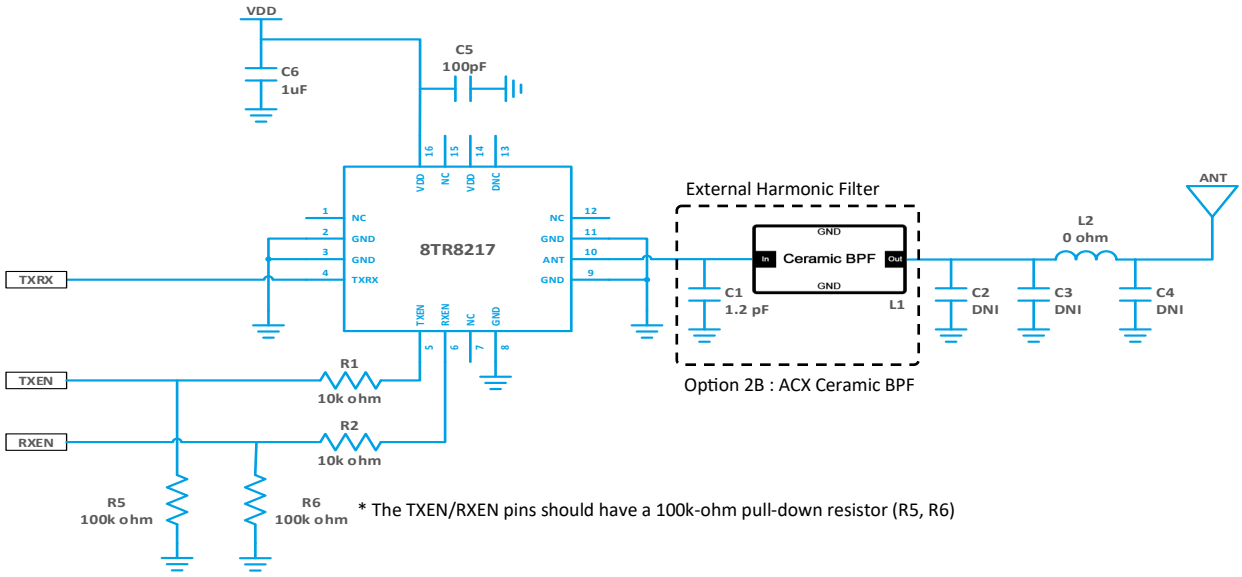


Option 2A : Johanson Ceramic BPF
L1 represents the option to replace the discrete pi filters by a ceramic low pass filter solution as follows:
Populate L1. (Johanson 2450BP15B100)
Populate L2 with 0 Ohm resistor (=jumpers). Do not populate C1, C2, C3 and C4.

Figure 6. 8TR8219 Application Schematic - Option 2A

Application Schematic - Option 2B: ACX Ceramic BPF



Option 2B : ACX Ceramic BPF
L1 represents the option to replace the discrete pi filters by a ceramic low pass filter solution as follows:
Populate L1. (ACX BF2012-F2R4DAA)
Populate L2 with 0 Ohm resistor (=jumpers). Do not populate C2, C3 and C4.
Populate C1 with 1.2pF capacitor.

Figure 7. 8TR8217 Application Schematic - Option 2B

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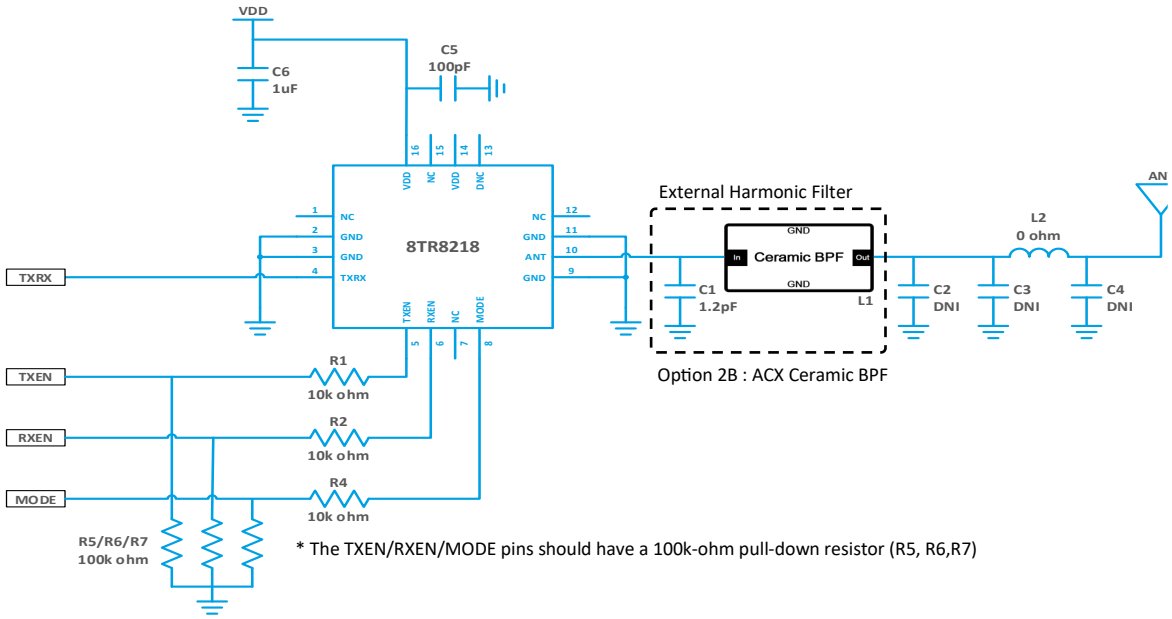
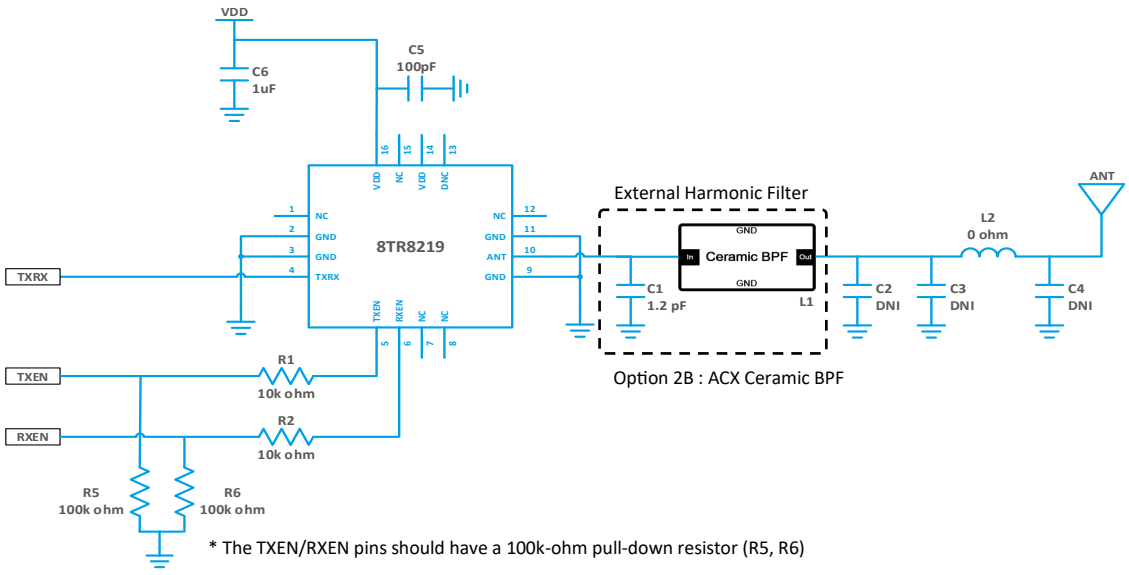


Option 2B : ACX Ceramic BPF
L1 represents the option to replace the discrete pi filters by a ceramic low pass filter solution as follows:
Populate L1. (ACX BF2012-F2R4DAA)
Populate L2 with 0 Ohm resistor (=jumpers). Do not populate C2, C3 and C4.
Populate C1 with 1.2pF capacitor.

Figure 8. 8TR8218 Application Schematic - Option 2A



Option 2B : ACX Ceramic BPF
L1 represents the option to replace the discrete pi filters by a ceramic low pass filter solution as follows:
Populate L1. (ACX BF2012-F2R4DAA)
Populate L2 with 0 Ohm resistor (=jumpers). Do not populate C2, C3 and C4.
Populate C1 with 1.2pF capacitor.

Figure 9. 8TR8219 Application Schematic - Option 2B

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Application Key Parts Value

Table 1. 8TR8217 / 8TR8218 / 8TR8219 Application Key Parts Value for Filter

Case	L1	C1	C2	C3	L2	C4
Without Filter	0ohm	DNI	DNI	DNI	0ohm	DNI
Option 1	1.8nH	3.3pF	2.2pF	0.2pF	0ohm	DNI
Option 2A	2450BP15B100 (Johanson)	DNI	DNI	DNI	0ohm	DNI
Option 2B	BF2012-F2R4DAA (ACX)	1.2pF	DNI	DNI	0ohm	DNI

Application Board Layout

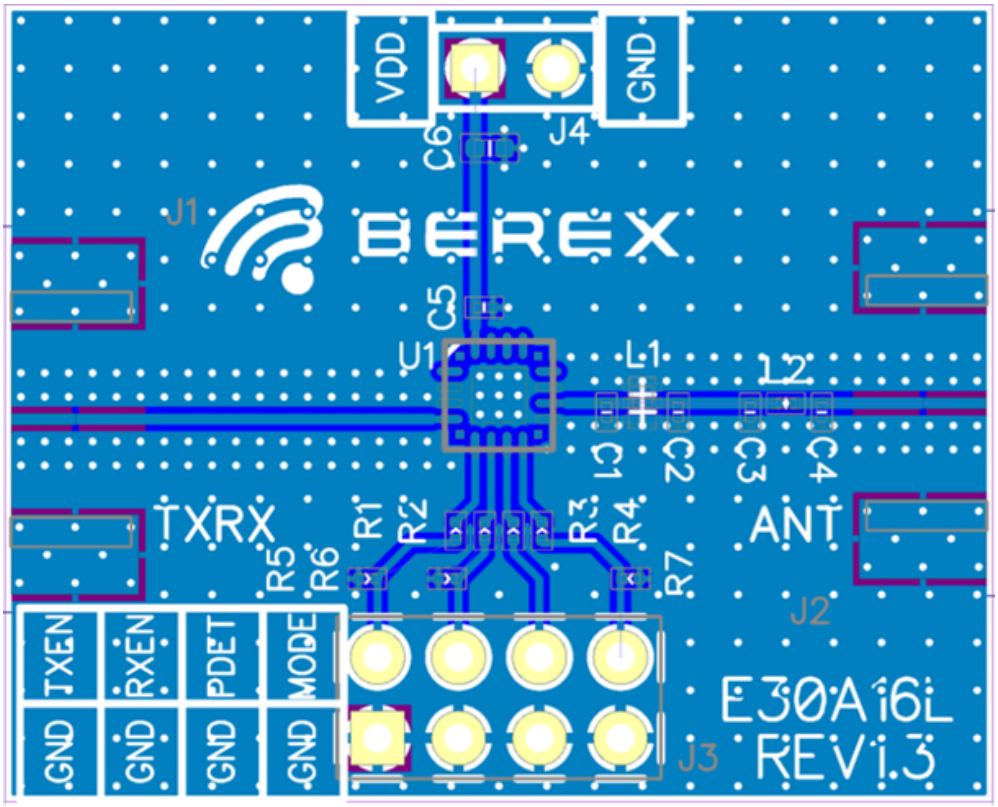

Figure 10. 8TR8217 / 8TR8218 / 8TR8219 Evaluation Board PCB Layout

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Typical Transmit Measurement Data

Table 2. 8TR8217 Transmit Measurement Data

Parameter	Units	Without Filter	Option 1	Option 2A	Option 2B	Remarks
Saturated Output Power	dBm	23.2	23.1	20.8	21.8	
Large-Signal Gain	dB	24.2	23.1	22.8	21.8	@Psat
Current Consumption	mA	152.8	202.2	132.2	183.5	@Psat
Second Harmonic	dBm/MHz	-2.0	-36.1	-51.8	-59.3	@Psat
Third Harmonic	dBm/MHz	-13.3	-56.1	-59.4	-62.5	@Psat
4th~10th Harmonic	dBm/MHz	-18.8	-47.4	-48.2	-42.2	@Psat
Input Return Loss	dB	15.0	12.3	14.3	12.9	2.4~2.485GHz
Output Return Loss	dB	13.2	8.3	16.5	9.7	2.4~2.485GHz

Table 3. 8TR8218 Transmit Measurement Data

Parameter	Units	Without Filter	Option 1	Option 2A	Option 2B	Remarks
Saturated Output Power	dBm	22.8	23.1	21.6	22.1	
Large-Signal Gain	dB	23.8	23.1	22.6	22.1	@Psat
Current Consumption	mA	151.7	203.7	152.8	192.0	@Psat
Second Harmonic	dBm/MHz	-4.6	-41.7	-64.5	-52.4	@Psat
Third Harmonic	dBm/MHz	-12.1	-50.8	-61.9	-57.8	@Psat
4th~10th Harmonic	dBm/MHz	-17.6	-46.4	-48.9	-42.1	@Psat
Input Return Loss	dB	15.7	14.4	15.5	15.3	2.4~2.485GHz
Output Return Loss	dB	13.7	8.2	17.2	9.9	2.4~2.485GHz

Table 4. 8TR8219 Transmit Measurement Data

Parameter	Units	Without Filter	Option 1	Option 2A	Option 2B	Remarks
Saturated Output Power	dBm	23.0	23.0	21.8	21.8	
Large-Signal Gain	dB	24.0	23.0	22.8	21.8	@Psat
Current Consumption	mA	160.0	200.0	155.7	178.3	@Psat
Second Harmonic	dBm/MHz	-2.7	-37.2	-50.3	-58.6	@Psat
Third Harmonic	dBm/MHz	-13.4	-54.1	-58.3	-61.9	@Psat
4th~10th Harmonic	dBm/MHz	-16.3	-47	-48.9	-42.1	@Psat
Input Return Loss	dB	15.0	12.2	14.3	12.9	2.4~2.485GHz
Output Return Loss	dB	10.0	8.3	16.5	9.7	2.4~2.485GHz

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Typical Receive Measurement Data

Table 5. 8TR8217 Receive Measurement Data

Parameter	Units	Without Filter	Option 1	Option 2A	Option 2B	Remarks
Small-Signal Gain	dB	19.3	18.8	17.9	17.1	2.4~2.485GHz
Noise figure	dB	1.6	2.7	3.4	3.7	2.4~2.485GHz
Input Return Loss	dB	8.6	13.0	8.2	8.5	2.4~2.485GHz
Output Return Loss	dB	12.9	11.1	10.4	13.0	2.4~2.485GHz

Table 6. 8TR8218 Receive Measurement Data

Parameter	Units	Without Filter	Option 1	Option 2A	Option 2B	Remarks
Small-Signal Gain	dB	19.0	18.6	17.9	16.9	2.4~2.485GHz
Noise figure	dB	1.6	2.9	3.3	3.8	2.4~2.485GHz
Input Return Loss	dB	8.4	13.7	11.0	9.7	2.4~2.485GHz
Output Return Loss	dB	12.0	10.2	11.9	11.7	2.4~2.485GHz

Table 7. 8TR8219 Receive Measurement Data

Parameter	Units	Without Filter	Option 1	Option 2A	Option 2B	Remarks
Small-Signal Gain	dB	16.5	16	14.8	14	2.4~2.485GHz
Noise figure	dB	1.9	2.97	3.92	3.86	2.4~2.485GHz
Input Return Loss	dB	7.0	9.3	9.4	7.5	2.4~2.485GHz
Output Return Loss	dB	10.0	8.7	11.5	9.7	2.4~2.485GHz

Typical Transmit EDR Measurement Data

Table 8. 8TR8217 / 8218 / 8219 EDR Spectral Mask

Parameter	Units	2402MHz	2441MHz	2480MHz	Remarks
8TR8217	dBm	11.3	13.1	11.6	EDR, 8-DPSK with 3-DH5 packets Data rate: 3Mbps Spectral Mask compliant
8TR8218	dBm	12.0	11.9	10.9	
8TR8219	dBm	11.3	12.6	11.5	

- VDD = 3.3V, TXEN = High, RXEN = Low or High, $T_{Ambient}$ = 25°C
- Without Harmonic Filter
- Excluding PCB and Connector Loss

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Typical Transmit Harmonics Characteristics - 8TR8217

(VDD = 3.3V, TXEN = High, RXEN = Low or High, $T_{Ambient}$ = 25°C, F = 2440 MHz, Excluding PCB and Connector Loss, Unless Otherwise Noted)

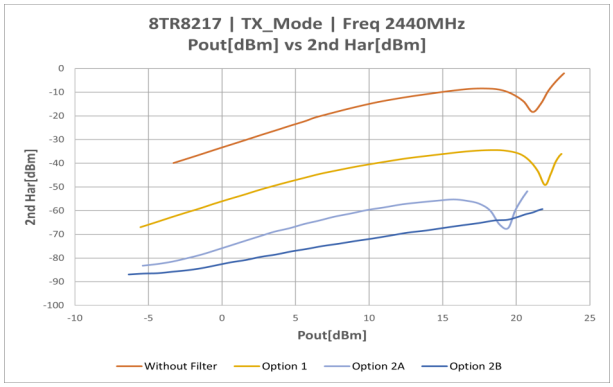

Figure 11. TX Pout vs 2nd Harmonic

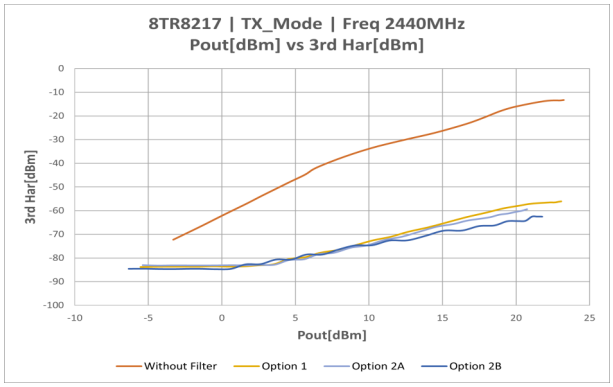

Figure 12. TX Pout vs 3rd Harmonic

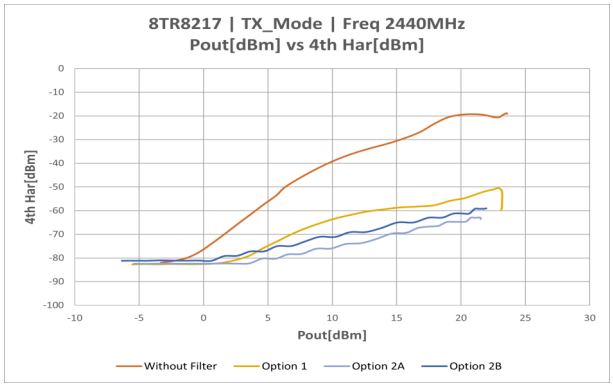

Figure 13. TX Pout vs 4th Harmonic

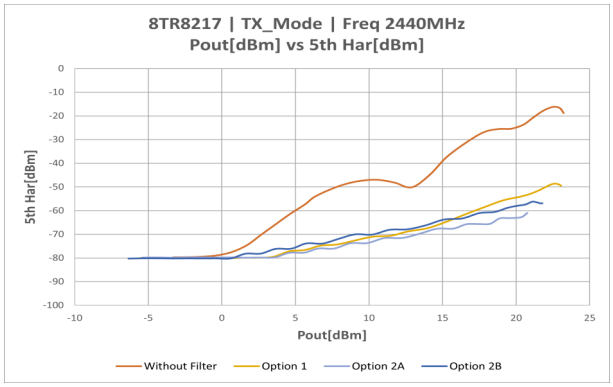

Figure 14. TX Pout vs 5th Harmonic

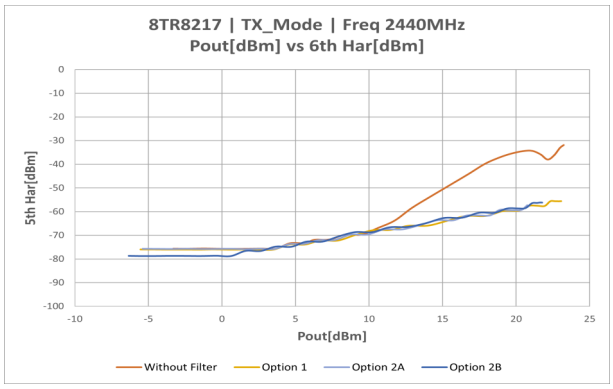

Figure 15. TX Pout vs 6th Harmonic

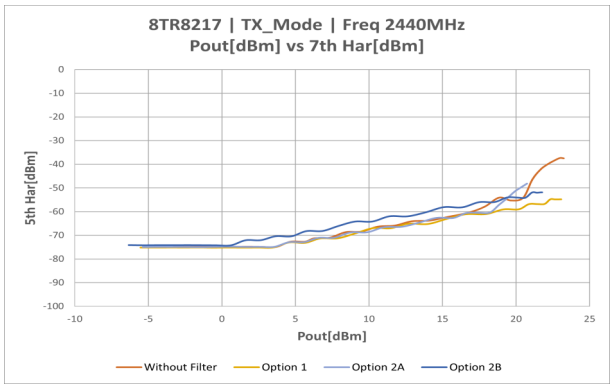

Figure 16. TX Pout vs 7th Harmonic

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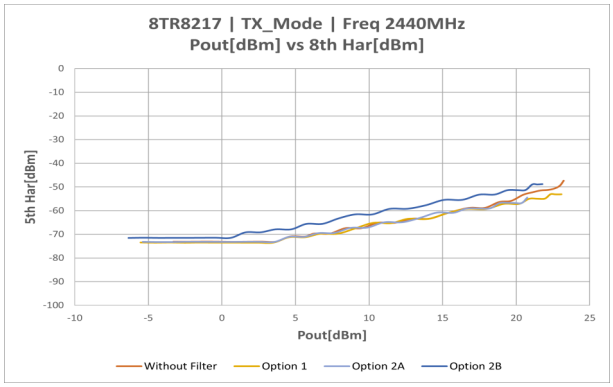

Figure 17. TX Pout vs 8th Harmonic

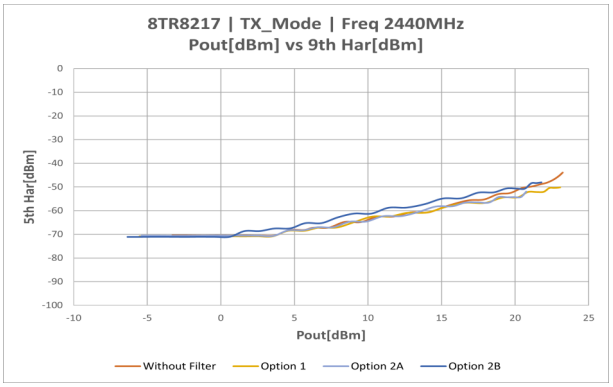

Figure 18. TX Pout vs 9th Harmonic

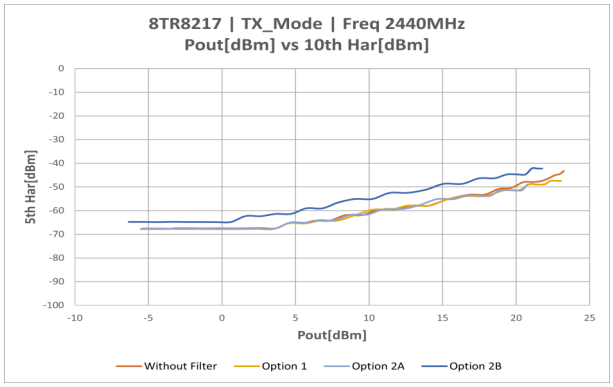

Figure 19. TX Pout vs 10th Harmonic

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Typical Transmit Harmonics Characteristics - 8TR8218

(VDD = 3.3V, TXEN = High, RXEN = Low or High, $T_{Ambient}$ = 25°C, F = 2440 MHz, Excluding PCB and Connector Loss, Unless Otherwise Noted)

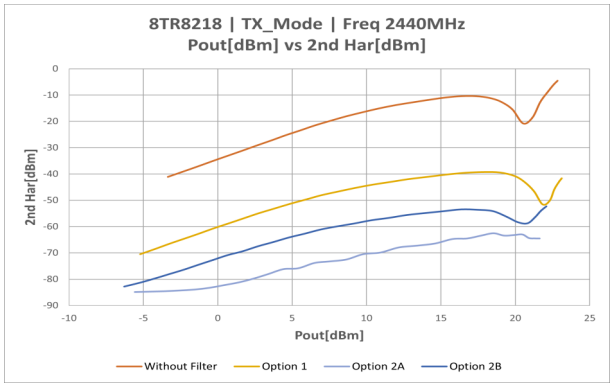

Figure 20. TX Pout vs 2nd Harmonic

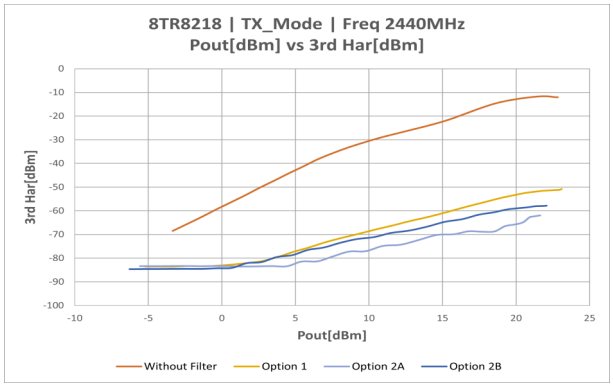

Figure 21. TX Pout vs 3rd Harmonic

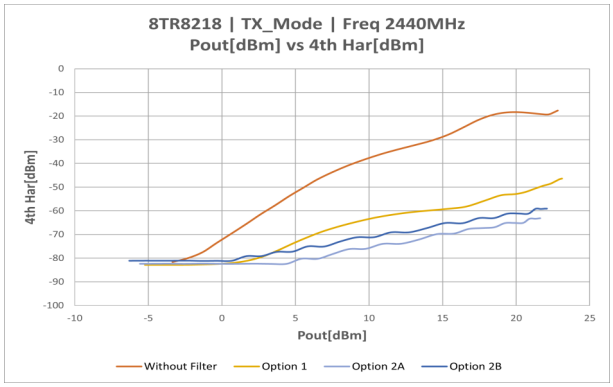

Figure 22. TX Pout vs 4th Harmonic

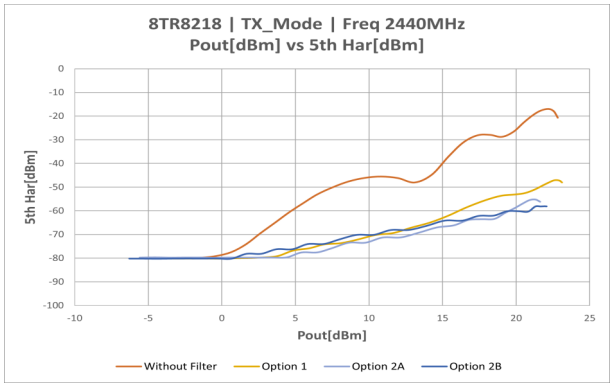

Figure 23. TX Pout vs 5th Harmonic

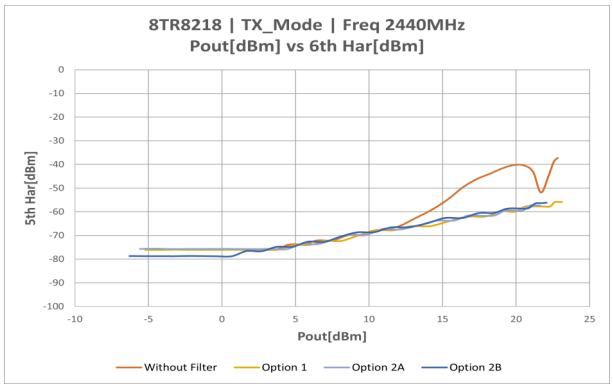

Figure 24. TX Pout vs 6th Harmonic

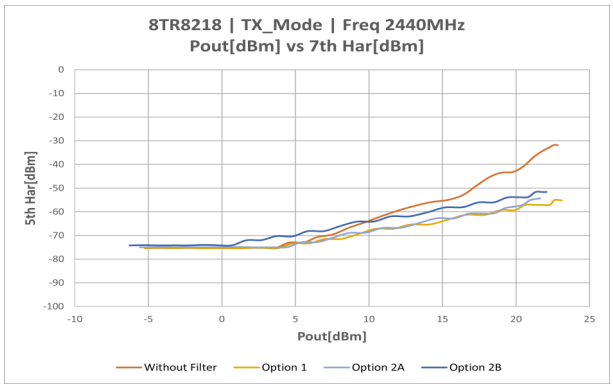

Figure 25. TX Pout vs 7th Harmonic

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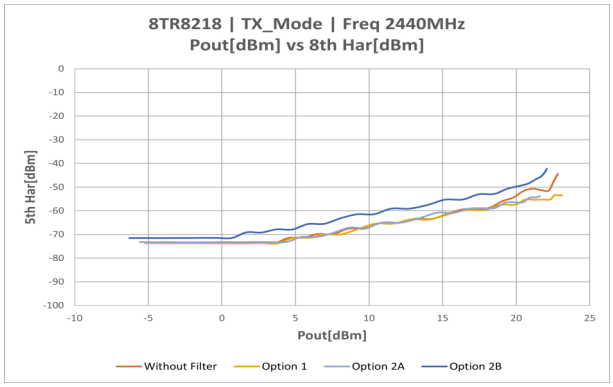

Figure 26. TX Pout vs 8th Harmonic

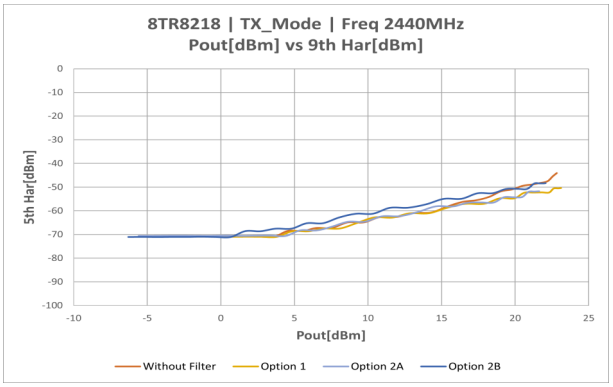

Figure 27. TX Pout vs 9th Harmonic

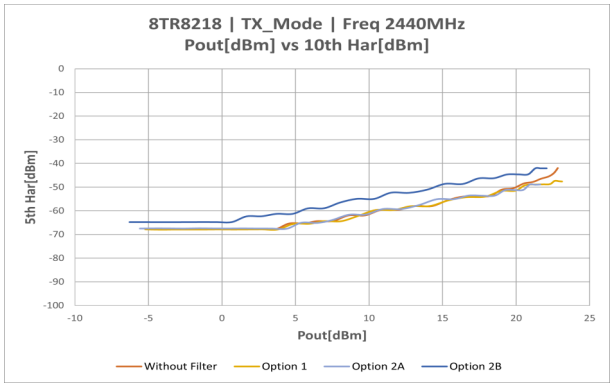

Figure 28. TX Pout vs 10th Harmonic

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Typical Transmit Harmonics Characteristics - 8TR8219

(VDD = 3.3V, TXEN = High, RXEN = Low or High, $T_{Ambient}$ = 25°C, F = 2440 MHz, Excluding PCB and Connector Loss, Unless Otherwise Noted)

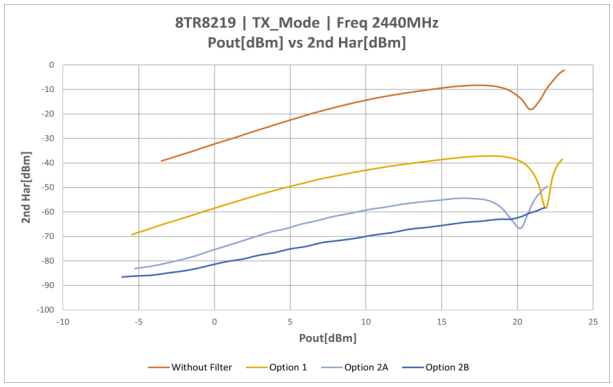

Figure 29. TX Pout vs 2nd Harmonic

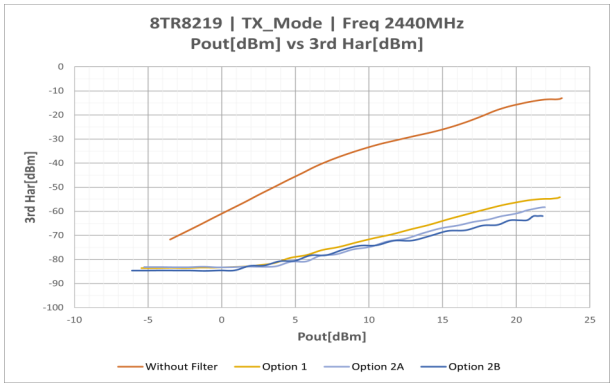

Figure 30. TX Pout vs 3rd Harmonic

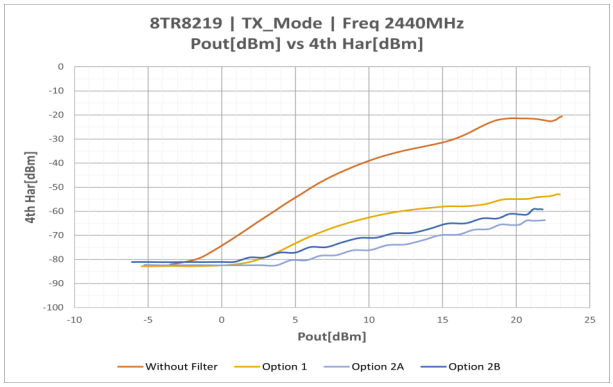

Figure 31. TX Pout vs 4th Harmonic

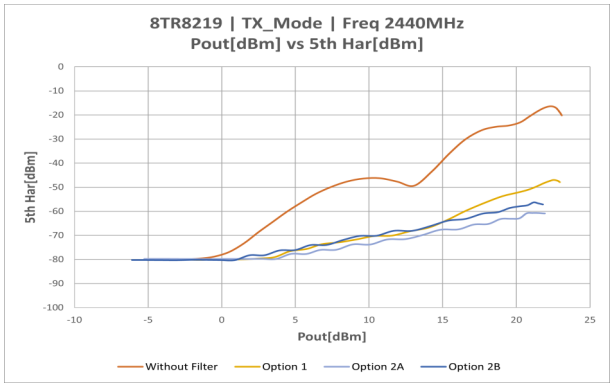

Figure 32. TX Pout vs 5th Harmonic

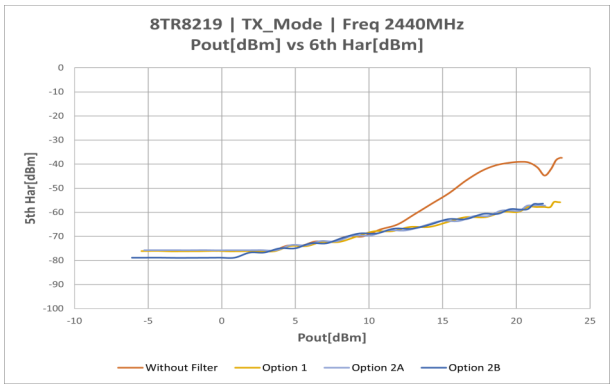

Figure 33. TX Pout vs 6th Harmonic

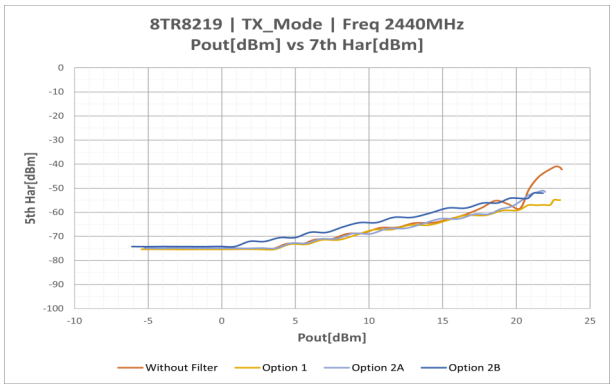

Figure 34. TX Pout vs 7th Harmonic

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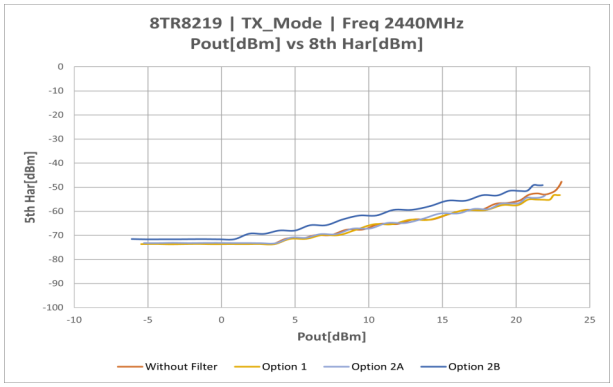

Figure 35. TX Pout vs 8th Harmonic

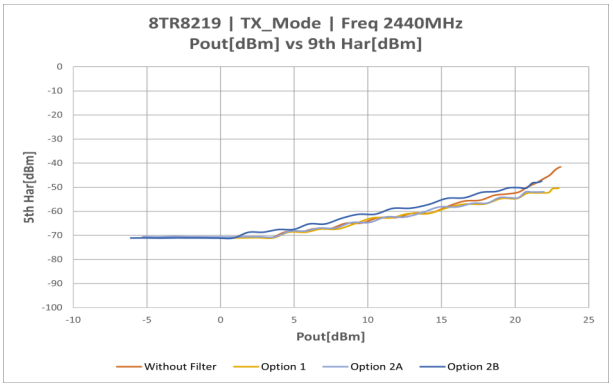

Figure 36. TX Pout vs 9th Harmonic

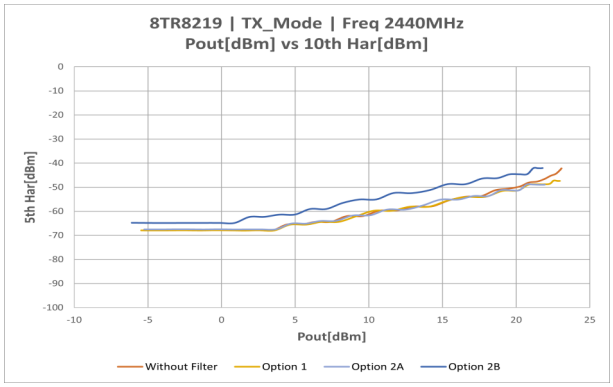

Figure 37. TX Pout vs 10th Harmonic

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Typical Transmit EDR Characteristics - 8TR8217

- VDD = 3.3V, TXEN = High, RXEN = Low or High, $T_{Ambient}$ = 25°C, Without Harmonic Filter, Excluding PCB and Connector Loss)
- Channel Frequency: 2402MHz/2441MHz/2480MHz (Ch0/Ch39/Ch78)
- EDR, 8-DPSK with 3-DH5 packets (Data rate: 3Mbps)

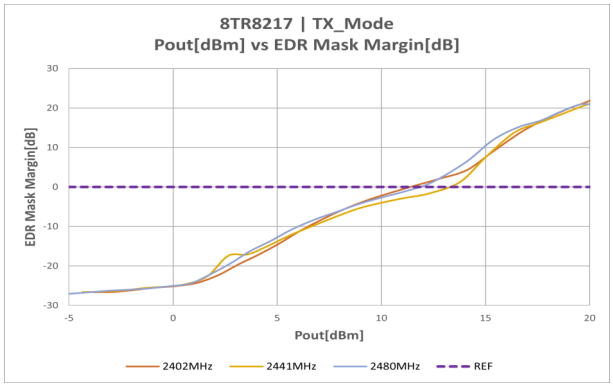

Figure 38. 8TR8217 Pout vs EDR Mask Margin

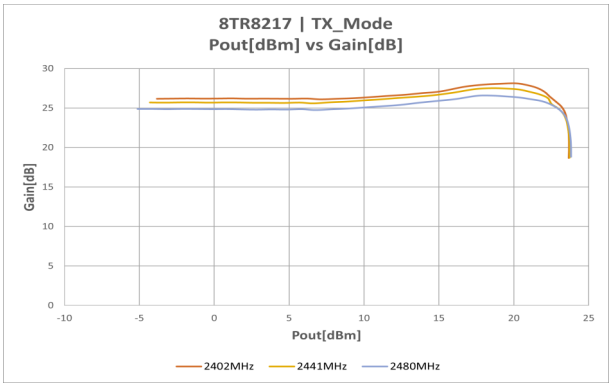

Figure 39. 8TR8217 Pout vs Gain

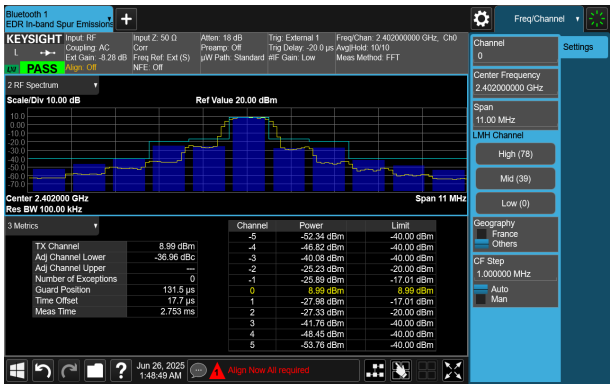

Figure 40. 8TR8217 Ch0 EDR In-band Spur Emission

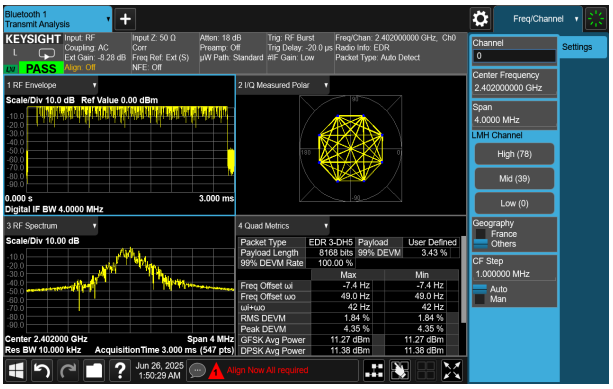

Figure 41. 8TR8217 Ch0 Transmit Analysis

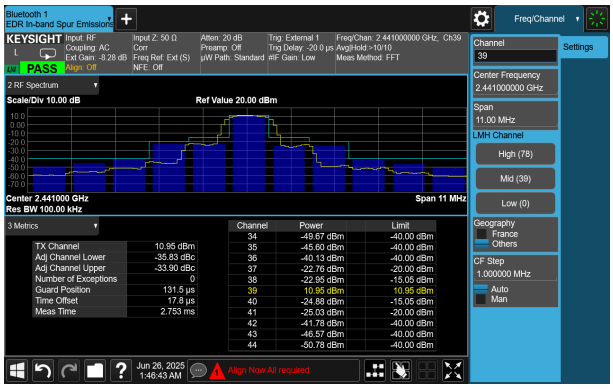

Figure 42. 8TR8217 Ch39 EDR In-band Spur Emission

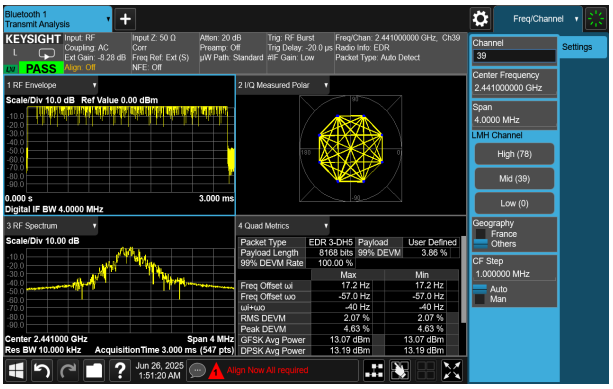

Figure 43. 8TR8217 Ch39 Transmit Analysis

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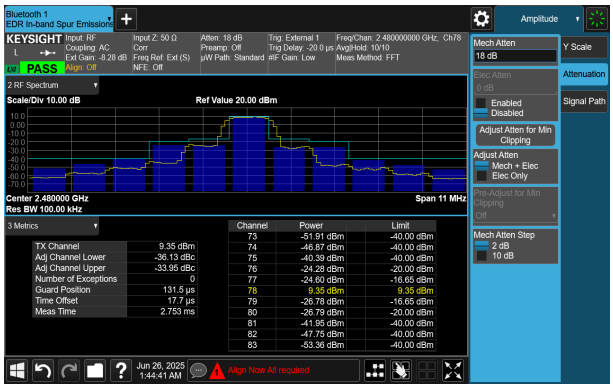

Figure 44. 8TR8217 Ch78 EDR In-band Spur Emission

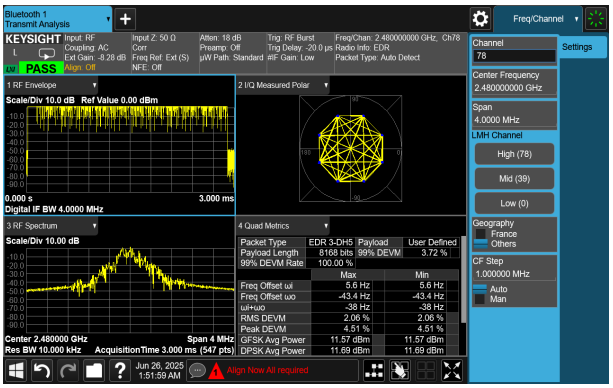

Figure 45. 8TR8217 Ch78 Transmit Analysis

Typical Transmit EDR Characteristics - 8TR8218

- VDD = 3.3V, TXEN = High, RXEN = Low or High, $T_{Ambient}$ = 25°C, Without Harmonic Filter, Excluding PCB and Connector Loss)
- Channel Frequency: 2402MHz/2441MHz/2480MHz (Ch0/Ch39/Ch78)
- EDR, 8-DPSK with 3-DH5 packets (Data rate: 3Mbps)

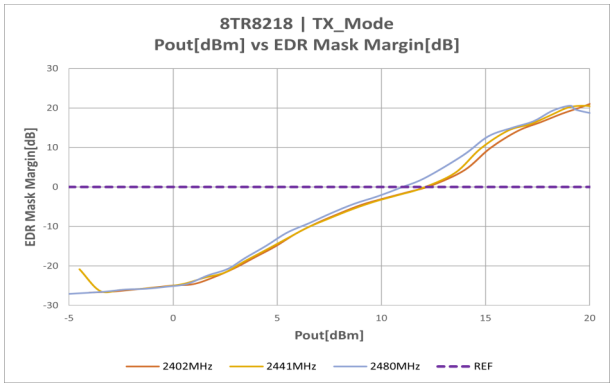

Figure 46. 8TR8218 Pout vs EDR Mask Margin

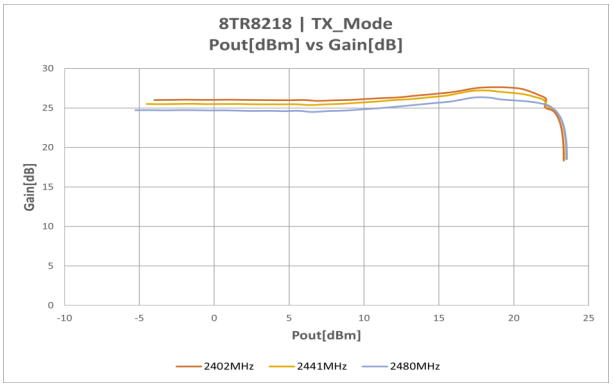

Figure 47. 8TR8218 Pout vs Gain

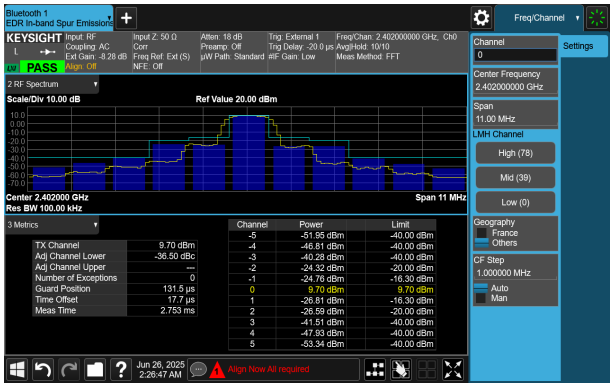

Figure 48. 8TR8218 Ch0 EDR In-band Spur Emission

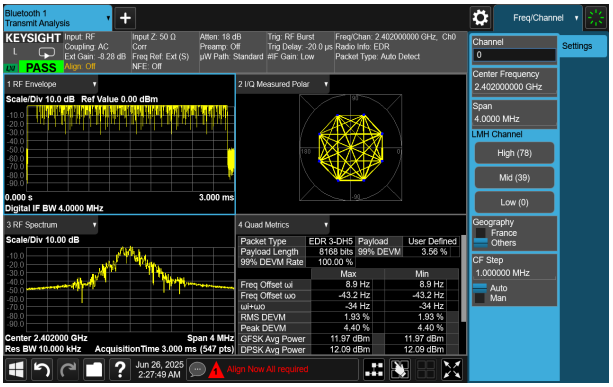

Figure 49. 8TR8218 Ch0 Transmit Analysis

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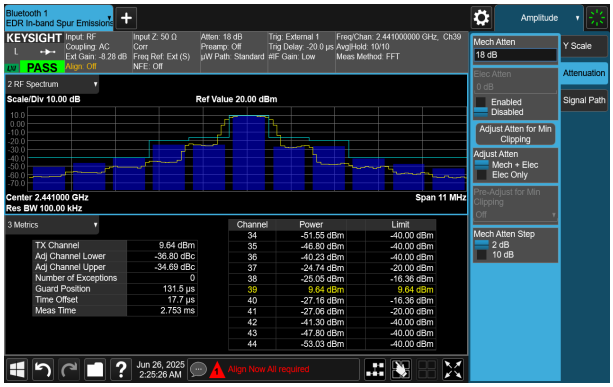

Figure 50. 8TR8218 Ch39 EDR In-band Spur Emission

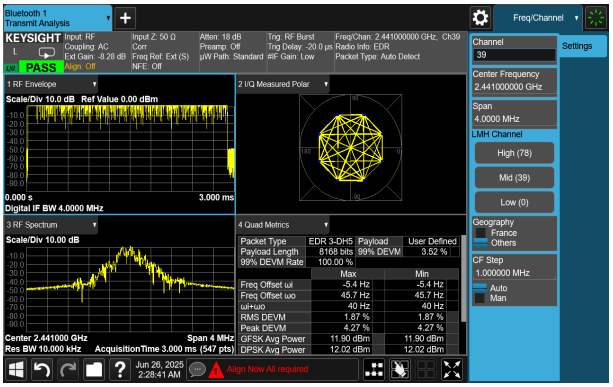

Figure 51. 8TR8218 Ch39 Transmit Analysis

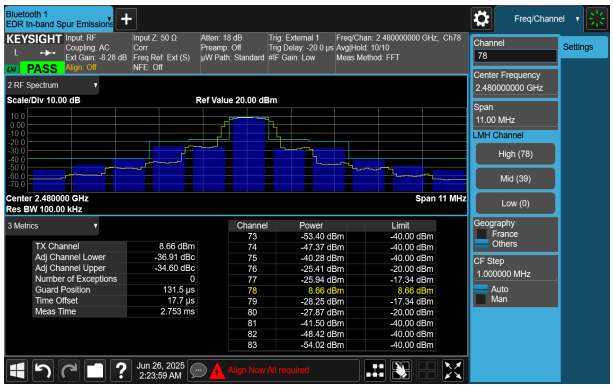

Figure 52. 8TR8218 Ch78 EDR In-band Spur Emission

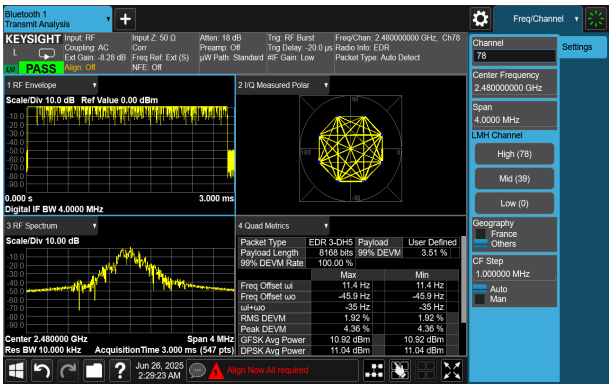

Figure 53. 8TR8218 Ch78 Transmit Analysis

Typical Transmit EDR Characteristics - 8TR8219

- VDD = 3.3V, TXEN = High, RXEN = Low or High, $T_{Ambient}$ = 25°C, Without Harmonic Filter, Excluding PCB and Connector Loss)
- Channel Frequency: 2402MHz/2441MHz/2480MHz (Ch0/Ch39/Ch78)
- EDR, 8-DPSK with 3-DH5 packets (Data rate: 3Mbps)

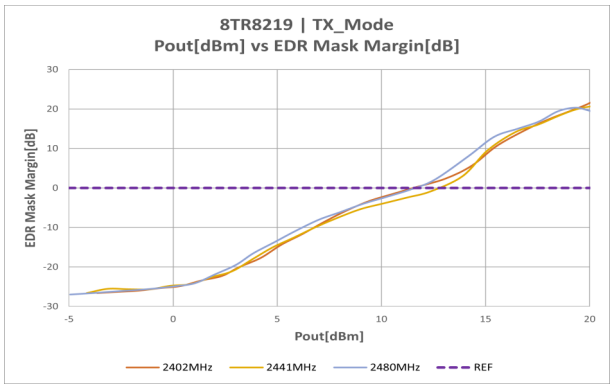

Figure 54. 8TR8219 Pout vs EDR Mask Margin

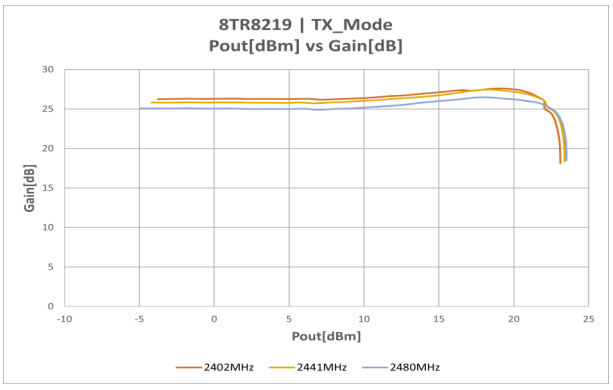

Figure 55. 8TR8219 Pout vs Gain

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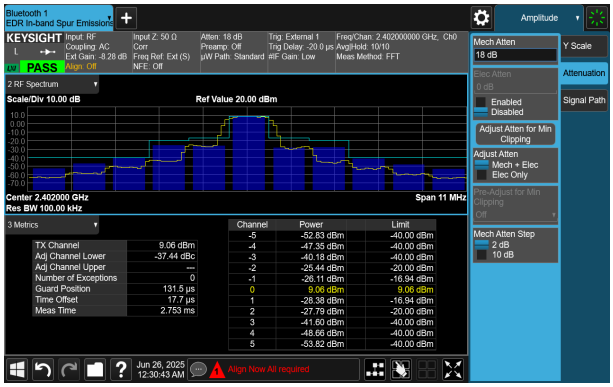

Figure 56. 8TR8219 Ch0 EDR In-band Spur Emission

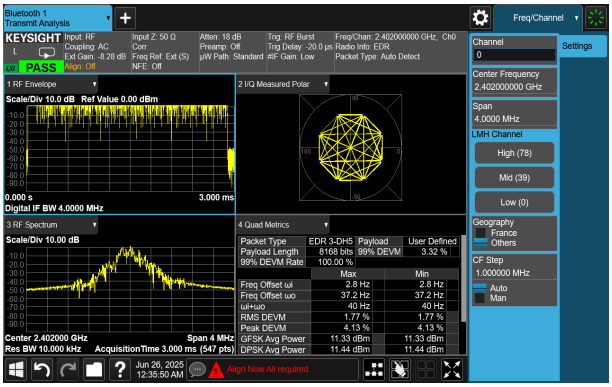

Figure 57. 8TR8219 Ch0 Transmit Analysis

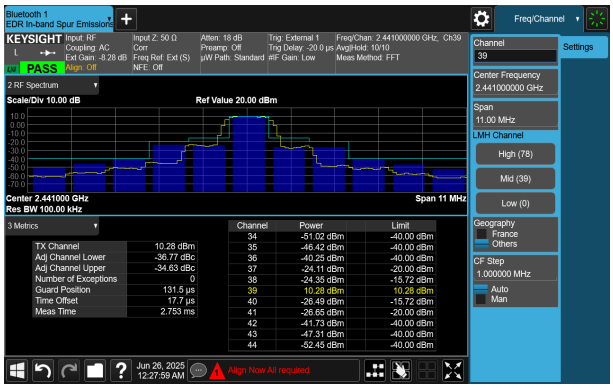

Figure 58. 8TR8219 Ch39 EDR In-band Spur Emission

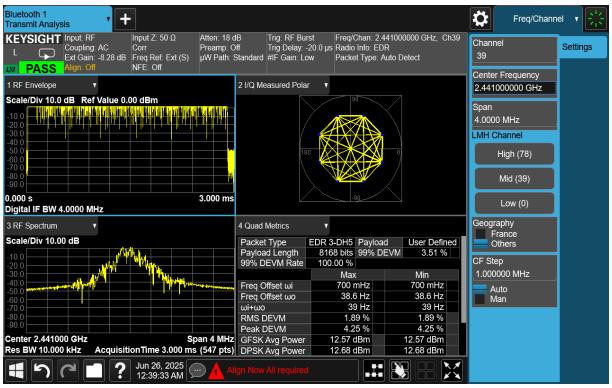

Figure 59. 8TR8219 Ch39 Transmit Analysis

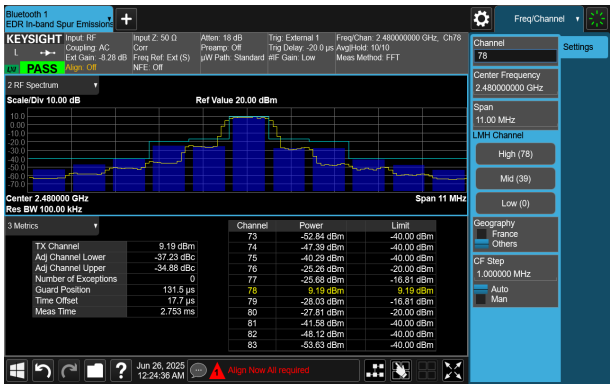

Figure 60. 8TR8219 Ch78 EDR In-band Spur Emission

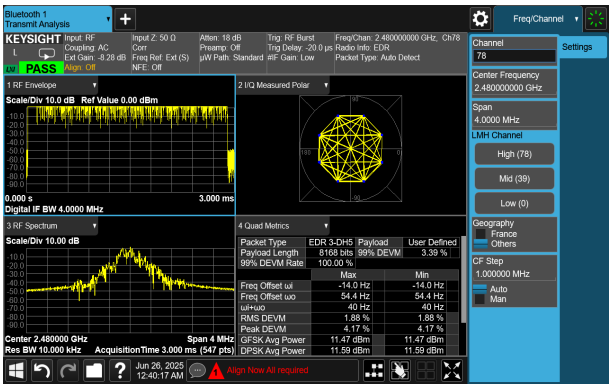

Figure 61. 8TR8219 Ch78 Transmit Analysis

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