

APPENDIX E: MULTI-TX AND ANTENNA SAR CONSIDERATIONS

E.1 Introduction

The following procedures adopted from FCC KDB Publication 447498 D04v01 are applicable to devices with built-in unlicensed transmitters such as 802.11 and Bluetooth devices which may simultaneously transmit with the licensed transmitter.

E.2 Simultaneous Transmission Procedures

This device contains transmitters that may operate simultaneously. Therefore, simultaneous transmission analysis is required. Per FCC KDB Publication 447498 D01v06 and IEEE 1528-2013 Section 6.3.4.1.2, simultaneous transmission SAR test exclusion may be applied when the sum of the 1g SAR for all the simultaneous transmitting antennas in a specific physical test configuration is ≤ 1.6 W/kg. The different test positions in an exposure condition may be considered collectively to determine SAR test exclusion according to the sum of 1g or 10g SAR.

In 5G + LTE + WLAN + BT simultaneous transmission, WWAN transmission is managed and controlled by MediaTek TAS (TA-SAR/TA-PD) feature.

Since WLAN/BT does not employ time-averaging, 1g SAR measurements for WLAN/BT need to be conducted at their corresponding rated power following current FCC test procedures to determine reported SAR values.

MediaTek TAS (TA-SAR/TA-PD) current implementation assumes hotspots from 5G NR and UMTS/LTE are collocated. Therefore, for a total of 100% exposure margin, if UMTS/LTE uses x , then the exposure margin left for 5G NR is capped to y . Thus, the compliance equation for 5G + UMTS/LTE + WLAN + BT is

$$\begin{aligned}x * A + y * B + m &\leq 1 \\x + y &= g \leq 1 \\g + m &\leq 1\end{aligned}$$

Where, A is normalized reported time-averaged SAR exposure ratio from UMTS/LTE, and $A \leq 1.0$; B is normalized reported time-averaged exposure ratio from 5G NR, and $B \leq 1.0$. Let m = normalized reported time-averaged SAR exposure ratio from WLAN + BT, then for compliance

$$\begin{aligned}x * A + y * B + m &\leq 1 \quad (1) \\x * A + y * B &\leq x * \max(A, B) + (g - x) * \max(A, B) \leq \max(A, B) \\x * A + (g - x) * B + m &\leq \max(A, B) + m \leq 1.0 \quad (2)\end{aligned}$$

If $A + m \leq 1.0$ and $B + m \leq 1.0$ can be proven, then “ $x * A + y * B + m \leq 1.0$ ”. Therefore, simultaneous transmission analysis for 5G NR + LTE + WLAN + BT can be performed in two steps.

Step 1: Prove total exposure ratio (TER) of UMTS/LTE + WLAN + BT < 1

Step 2: Prove total exposure ratio (TER) of 5G NR + WLAN + BT < 1

Else, if $A + m > 1.0$ and/or $B + m > 1.0$, then the following need to hold true for compliance:

- i. A and m need to be checked if decoupled based on SPLSR criteria
- ii. $y * B + m \leq 1.0$ (or B and m need to be checked if decoupled based on SPLSR, and
- iii. $x * A + y * B \leq 1.0$

Note iii is covered in Part 2 report; I, and ii are covered in the Part 1 report. Above analysis is also apply to LTE/NR inter band uplink, LTE(NR)1 + LTE(NR)2 + WLAN + BT simultaneous transmission, so inter-band uplink

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CA no need to do additional simultaneously analysis again. Only required comply with total exposure ratio (TER) of LTE/NR + WLAN + BT < 1. Above analysis is also apply to NR band UL MIMO, NR(SISO1) + NR(SISO2) + WLAN + BT simultaneous transmission, So UL MIMO no need to do additional simultaneously analysis again. Only required comply with total exposure ratio (TER) of NR + WLAN + BT < 1.

Based on Mediatek's guidance and documentation, the TA-SAR Gen2 algorithm ensures compliance with time-averaged RF exposure limits and operates independently of the SAR source, including LTE and NR FR1 combinations. Scenario 4.9 in Part 2 testing confirms the algorithm's control during transitions between radio 1 only, radio 1 + radio 2, and radio 2 only.

Antennas are grouped by SAR-to-Peak Location Separation Ratio (SPLSR), and SAR values within the same group are summed to assess Total Exposure Ratio (TER) compliance. The algorithm applies SPLSR grouping to maintain consistent exposure control across all active radios.

These evaluations sufficiently cover simultaneous transmission cases, including AG0 + AG1 + WLAN/BT; thus, no additional evaluation under Part 1 is required.

E.3 Exposure Ratios

Exposure ratio (ER) for different transmitters is calculated as following:

$$ER_{SAR,n} = \frac{SAR_n}{SAR_{limit}}$$

Where:

- SAR_n is the SAR value for the n -th transmitter/test frequency
- SAR_{limit} is the basic restriction limit that is applicable to the n -th transmitter/test frequency

Compliance with the SAR-PD-UWB based RF exposure limits is achieved if $TER_{SAR} \leq 1$. When $TER_{SAR} > 1$, SPLSR is additionally evaluated per below equation:

$$SPLSR = \frac{(ER_j + ER_k)^{1.5}}{R}$$

Where:

- ER_j and ER_k are exposure ratio of transmitter j and k
- R is the distance between transmitter j and k

When SPLSR is ≤ 0.02 for 1g exposure conditions or SPLSR is ≤ 0.013 for 10g exposure conditions simultaneous SAR evaluation is not required.

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E.4 Tablet GSM/UMTS/LTE Simultaneous Analysis

Table E-1
GSM/UMTS/LTE Highest ER

AG0 Ratio to Limit					AG1 Ratio to Limit			
Body	Configuration	M1 ECI=0	M1 ECI = 2/3	Max	Body	Configuration	S3 ECI=0/1/2/3/4/5	Max
	Back	0.324	0.397	0.397		Back	0.403	0.403
	Top	0.446	0.466	0.466		Top	0.001	0.001
	Bottom	0.074	-	0.074		Bottom	0.291	0.291
	Right	0.168	0.251	0.251		Right	0.013	0.013
	Left	0.389	-	0.389		Left	0.023	0.023

Table E-2
Simultaneous Transmission Scenarios for WLAN/BT

[illegible]

Values with * were tested at a higher, more conservative power level

Configurations labeled as “Worst Case” represent the maximum values between grip sensor inactive and active

Table E-3
GSM/UMTS/LTE Simultaneous Sums

Body	Configuration	AG0 Ratio to Limit	AG1 Ratio to Limit	WLAN/BT Worst-case Combination Ratio to Limit	AG0 + WLAN/BT Ratio to Limit	AG1 + WLAN/BT Ratio to Limit
	Back	0.397	0.403	0.590	0.987	0.993
	Top	0.466	0.001	0.386	0.852	0.387
	Bottom	0.074	0.291	0.123	0.197	0.414
	Right	0.251	0.013	0.638	0.889	0.651
	Left	0.389	0.023	0.607	0.996	0.630
	Average	0.266	0.104	0.351	0.655	0.501

Notes:

1. For all combinations where the TER sum of AG0/AG1 + WLAN + BT is not greater than 1, there's no further analysis required for compliance demonstration.

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E.5 Tablet NR Simultaneous Analysis

Table E-4
NR Highest ER

AGO Ratio to Limit							AG1 Ratio to Limit								
Body	Configuration	M1 ECI = 0	M4 ECI = 0	M1 ECI = 2/3	M4 ECI = 3	Max	Body	Configuration	S1 ECI = 0	S4 ECI = 0	S1 ECI = 5	S2 ECI = 0/1/2/3/4/5	S3 ECI = 0/1/2/3/4/5	S4 ECI = 4	Max
	Back	0.303	0.012	0.403	0.086	0.403		Back	0.029	0.081	0.021	0.454	0.384	0.429	0.454
	Top	0.558	0.004	0.604	0.049	0.604		Top	0.000	0.050	-	0.000	0.000	-	0.050
	Bottom	0.058	0.001	-	-	0.058		Bottom	0.034	0.042	0.126	0.624	0.184	0.126	0.624
	Right	0.143	0.049	0.218	0.401	0.401		Right	0.000	0.437	-	0.105	0.006	0.561	0.561
	Left	0.422	0.000	-	-	0.422		Left	0.006	0.015	0.218	0.001	0.141	-	0.218

Table E-5
Simultaneous Transmission Scenarios for WLAN/BT

[illegible]

Values with * were tested at a higher, more conservative power level

Table E-6
NR Simultaneous Sums

Body	Configuration	AG0 Ratio to Limit	AG1 Ratio to Limit	WLAN/BT Worst-case Combination Ratio to Limit	AG0 + WLAN/BT Ratio to Limit	AG1 + WLAN/BT Ratio to Limit
	Back	0.403	0.454	0.539	0.942	0.993
	Top	0.604	0.050	0.386	0.990	0.436
	Bottom	0.058	0.624	0.123	0.181	0.747
	Right	0.401	0.561	0.556	0.957	See Tables Below
	Left	0.422	0.218	0.559	0.981	0.777

[illegible]

Bolded values represent the highest sums for their respective edges.

Antenna Pair		Standalone Values		Standalone Sum	Peak Separation Distance (mm)	SPLS Ratio
		Exposure Ratio (ER)	Exposure Ratio (ER)			
Ant "a"	Ant "b"	a	b	a+b	D _{a-b}	(a+b) ^{1.5} /D _{a-b}
NR Band n77 Ant S4	2.4 GHz WLAN RSDB MIMO + 6 GHz WLAN RSDB MIMO	0.561	0.474	1.035	165.90	0.01
NR Band n77 Ant S4	2.4 GHz WLAN RSDB MIMO + 5 GHz WLAN RSDB MIMO	0.561	0.556	1.117	165.90	0.01
NR Band n77 Ant S4	2.4 GHz BT WIFI0 + 2.4 GHz WLAN WIFI 0 + 5 GHz WLAN RSDB MIMO	0.561	0.534	1.095	165.90	0.01
NR Band n77 Ant S4	2.4 GHz BT WIFI0 + 2.4 GHz WLAN WIFI 0 + 6 GHz WLAN RSDB MIMO	0.561	0.452	1.013	165.90	0.01

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Notes:

1. For all combinations where the TER sum of AG0/AG1 + WLAN + BT is not greater than 1, there's no further analysis required for compliance demonstration.
2. No evaluation was performed to determine the TER for these configurations as the SPLS ratio between the antenna pairs was not greater than 0.02 per FCC KDB 447498 D04v01. Please see the Highest Report ER and Hotspot Location Section for Y-axis peak locations

E.6 Laptop SAR Analysis

Table E-7
Licensed Band Highest ER

AG0 Ratio to Limit					AG1 Ratio to Limit					
Body	Configuration	M1	M4	Max	Body	Configuration	S1	S2	S3	Max
	Bottom	0.106	0.000	0.106		Bottom	0.012	0.000	0.141	0.002

Table E-8
Simultaneous Transmission Scenarios for WLAN/BT

Configuration	2.4 GHz WLAN Ant WiFi 0 Ratio to Limit	2.4 GHz WLAN Ant WiFi 0 at 11.5 dBm Ratio to Limit	2.4 GHz WLAN Ant WiFi 0 Worst Case Ratio to Limit	2.4 GHz WLAN Ant WiFi 1 Ratio to Limit	2.4 GHz WLAN MIMO Ratio to Limit	2.4 GHz WLAN MIMO at 14.5 dBm Ratio to Limit	2.4 GHz WLAN MIMO Worst Case Ratio to Limit	5 GHz WLAN Ant WiFi 0 Ratio to Limit	5 GHz WLAN Ant WiFi 0 at 7 dBm Ratio to Limit	5 GHz WLAN Ant WiFi 0 Worst Case Ratio to Limit	5 GHz WLAN MIMO Ratio to Limit	5 GHz WLAN MIMO at 10 dBm Ratio to Limit	5 GHz WLAN MIMO Worst Case Ratio to Limit	6 GHz WLAN Ant WiFi 0 Ratio to Limit	6 GHz WLAN Ant WiFi 0 at 6 dBm Ratio to Limit	6 GHz WLAN Ant WiFi 0 Worst Case Ratio to Limit	6 GHz WLAN Ant WiFi 1 Ratio to Limit	6 GHz WLAN MIMO Ratio to Limit	6 GHz WLAN MIMO at 9 dBm Ratio to Limit	6 GHz WLAN MIMO Worst Case Ratio to Limit	2.4 GHz Bluetooth Ant WiFi 0 Ratio to Limit	2.4 GHz Bluetooth Ant WiFi 0 at 9.5 dBm Ratio to Limit	2.4 GHz Bluetooth Ant WiFi 0 Worst Case Ratio to Limit	2.4 GHz Bluetooth Ant WiFi 1 Ratio to Limit	
	1a	1b	1c	2a	3a	3b	3d	4a	4b	4c	5a	6a	6b	6d	7a	7b	7c	8a	9a	9b	9c	10a	10b	10c	11a
Bottom	0.135	0.207	0.207	0.003	0.157	0.216	0.216	0.125	0.138	0.138	0.016	0.148	0.153	0.153	0.031	0.035	0.035	0.004	0.038	0.039	0.039	0.054	0.081	0.081	0.000
Configuration	2.4 GHz Bluetooth Ant WiFi 1 Ratio to Limit	2.4 GHz Bluetooth Ant WiFi 1 + 6 GHz WLAN MIMO Worst Case Ratio to Limit	2.4 GHz Bluetooth Ant WiFi 1 + 5 GHz WLAN MIMO Worst Case Ratio to Limit	2.4 GHz Bluetooth Ant WiFi 0 Worst Case Ratio to Limit	2.4 GHz Bluetooth Ant WiFi 0 Worst Case + 6 GHz WLAN MIMO Worst Case Ratio to Limit	2.4 GHz Bluetooth Ant WiFi 0 Worst Case + 5 GHz WLAN MIMO Worst Case Ratio to Limit	2.4 GHz WLAN MIMO Worst Case + 6 GHz WLAN MIMO Worst Case Ratio to Limit	2.4 GHz WLAN MIMO Worst Case + 5 GHz WLAN MIMO Worst Case Ratio to Limit	2.4 GHz WLAN MIMO Worst Case Ratio to Limit	6 GHz WLAN MIMO Worst Case Ratio to Limit	5 GHz WLAN MIMO Worst Case Ratio to Limit	2.4 GHz Bluetooth Ant WiFi 0 Worst Case + 2.4 GHz WLAN Ant WiFi 1 + 6 GHz WLAN MIMO Worst Case Ratio to Limit	2.4 GHz Bluetooth Ant WiFi 0 Worst Case + 2.4 GHz WLAN Ant WiFi 1 + 5 GHz WLAN MIMO Worst Case Ratio to Limit	2.4 GHz Bluetooth Ant WiFi 0 Worst Case + 2.4 GHz WLAN Ant WiFi 1 Ratio to Limit	2.4 GHz WLAN Ant WiFi 0 Worst Case Ratio to Limit	2.4 GHz WLAN Ant WiFi 0 Worst Case Ratio to Limit	5 GHz WLAN Ant WiFi 0 Worst Case Ratio to Limit	5 GHz WLAN Ant WiFi 1 Ratio to Limit	6 GHz WLAN Ant WiFi 0 Worst Case Ratio to Limit	6 GHz WLAN Ant WiFi 0 Worst Case Ratio to Limit	6 GHz WLAN Ant WiFi 1 Ratio to Limit	WLAN/BT Worst-case Combination Ratio to Limit			
	11a	11a+9c	11a+6d	10c	10c+9c	10c+6d	3d+9c	3d+6d	3d	9c	6d	10c+2a+7c	10c+2a+6d	10c+2a	1c	2a	4c	5a	7c	8a			0.369		
Bottom	0.000	0.039	0.153	0.081	0.120	0.234	0.255	0.369	0.216	0.039	0.153	0.119	0.237	0.084	0.207	0.003	0.138	0.016	0.035	0.004					

Configurations labeled as "Worst Case" represent the maximum values of grip sensor active and inactive.

Table E-9
Simultaneous Sums

Body	Configuration	AG0 Ratio to Limit	AG1 Ratio to Limit	WLAN/BT Worst-case Combination Ratio to Limit	AG0 + WLAN/BT Ratio to Limit	AG1 + WLAN/BT Ratio to Limit
	Bottom	0.106	0.141	0.369	0.475	0.510

Notes:

1. For all combinations where the TER sum of AG0/AG1 + WLAN/BT is not greater than 1, there's no further analysis required for compliance demonstration.

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E.7 Highest Exposure Ratio and Hotspot Locations

Table E-10
Tablet Right Edge Peak Coordinates

Mode/Band	y (mm)	SAR/SAR Limit (ER)
NR Band n77 Ant S4	54.10	0.561
2.4 GHz WLAN RSDB MIMO + 6 GHz WLAN RSDB MIMO	-111.80	0.474
2.4 GHz WLAN RSDB MIMO + 5 GHz WLAN RSDB MIMO	-111.80	0.556
2.4 GHz BT WIFI0 + 2.4 GHz WLAN WIFI 0 + 5 GHz WLAN RSDB MIMO	-111.80	0.534
2.4 GHz BT WIFI0 + 2.4 GHz WLAN WIFI 0 + 6 GHz WLAN RSDB MIMO	-111.80	0.452

E.8 Conclusion

The above numerical summed TER results and SPLSR are sufficient to show that simultaneous transmission cases will not exceed the SAR limit and therefore no further analysis is required per FCC KDB Publication 447498 D04v01 and IEEE 1528- 2013 Section 6.3.4.1.

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