APPENDIX J: WIFI TIME-AVERAGED SAR VERIFICATION

1.1 WIFI Time-Averaged SAR Verification Summary

This device supports the manufacturer's time-averaged SAR (TAS) mechanism for WLAN operations. The output power is controlled in real-time so that the power averaged over any 30 second window does not exceed the level tested for SAR in this report. The time-averaged SAR algorithm tracks the energy contribution relative to the available energy budget for each transmitter, defined as the "utilization ratio." Once the utilization ratios for each of the individual WLAN transmitters are calculated, they are summed to derive the overall WLAN system power utilization ratio. This metric is used by the WLAN chipset to manage power levels over time and ensure that SAR limits are never exceeded.

Per FCC Guidance, the following test scenarios were defined to validate the TAS mechanism. The specific scenarios are constructed to validate the operation of the algorithm in all operational states, including transitions between states/antennas:

- Change in channel/band
- Change in antenna (includes connection drop scenario)
- Change in device state, e.g., Cell on/off WIFI power change

Predefined transmit profiles for each test scenario are provided by the manufacturer's test automation software to control the operation of the DUT while synchronized operational data was recorded from internal firmware and external power monitors. The data was plotted over time relative to the utilization limit to demonstrate that the maximum time-averaged power is never exceeded. "Reported" values were output and captured directly from DUT firmware, while "Measured" results were obtained from external power metering. The uncertainty budget applied to the WLAN power control functions for this device is 1.5 dB. In all test cases, WLAN radios were configured to operate at 100% duty cycle.

The DUT supports time-averaged SAR (TAS) technology for the WLAN transmitters. This TAS implementation supports per-packet tracking enhancement that accounts for per packet power variation. The actual output power is measured from the TSSI ADC reading and is reported in the form of Tx duration weighted for Pmax. Power levels in different bands with different operating states and power limits are not directly comparable so the TAS algorithm instead tracks the ratio of energy contribution relative to the available energy budget for each transmitter.

WWAN and RLAN energy budgets are fixed to maintain compliance considering simultaneous operation. The independent budgets ensure that differences in averaging windows do not impact the overall compliance of the device.

Table 1
WIFI Time-Averaged SAR Verification Summary

Mode	Antenna	Channel	Plim (dBm)	Plim (mW)
802.11b, 22 MHz Bandwidth	3a	6	12.50	17.8
802.11b, 22 MHz Bandwidth (Reduced)	3a	6	6.50	4.5
802.11b, 22 MHz Bandwidth	1a	6	12.00	15.8
802.11a, 20 MHz Bandwidth	3c	149	13.50	22.4
802.11a, 20 MHz Bandwidth	3a	149	9.50	8.9
802.11a, 20 MHz Bandwidth	3c	85	12.75	18.8
802.11a, 20 MHz Bandwidth	3a	85	8.00	6.3

Plim is the maximum time-averaged output power evaluated for SAR compliance

1.2 Verification Summary

Scenario 1: Change in Antenna

For this test, the effect on the time-averaging algorithm from a change in the active transmit antenna was evaluated. Figures J-1 and J-2 show a switch of 2.4 GHz transmissions from Antenna 3a to Antenna 1a at Time = 120 s, while Figures J-3 and J-4 show a comparable transition for Antenna 3c to Antenna 3a 5 GHz transmissions. Figures J-5 and J-6 show a switch of 6 GHz transmissions from Antenna 3c to Antenna 3a at Time = 120 s. In all cases the test automation is controlling the WLAN radios to operate at 100% duty cycle. The utilization ratio never exceeds 100% and the average transmit power never exceeds the Plim of each respective antenna.

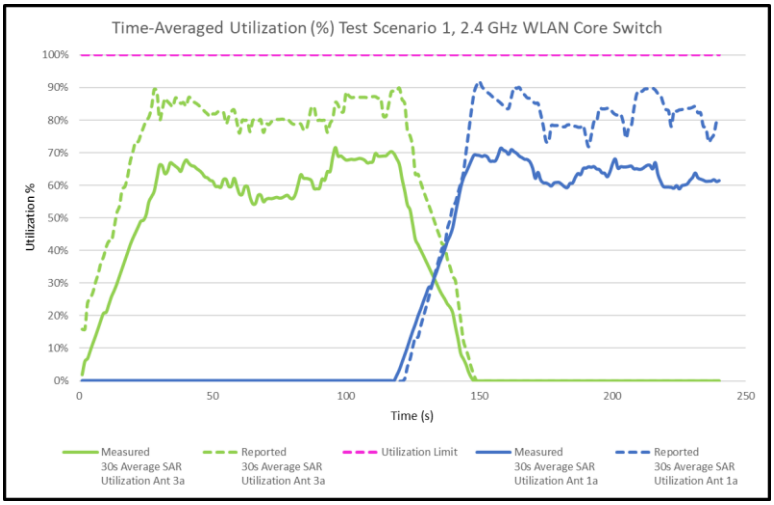

Figure J-1
30s Average SAR Utilization vs. Time, 2.4 GHz

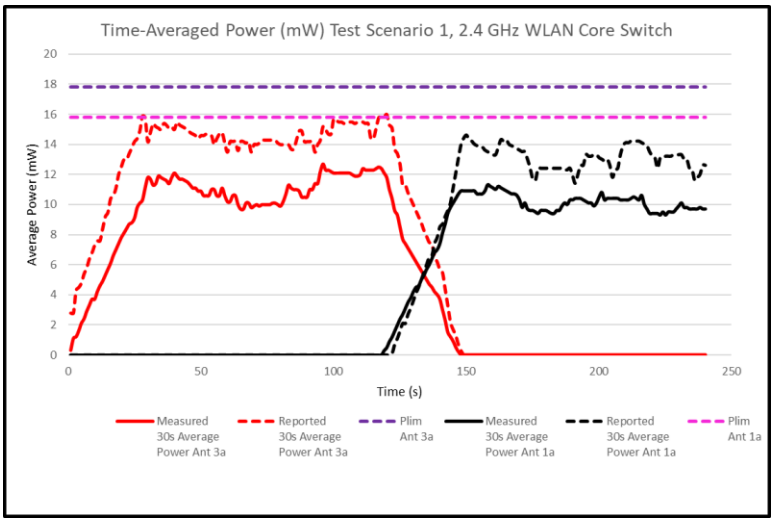

Figure J-2
30s Average Power vs. Time, 2.4 GHz

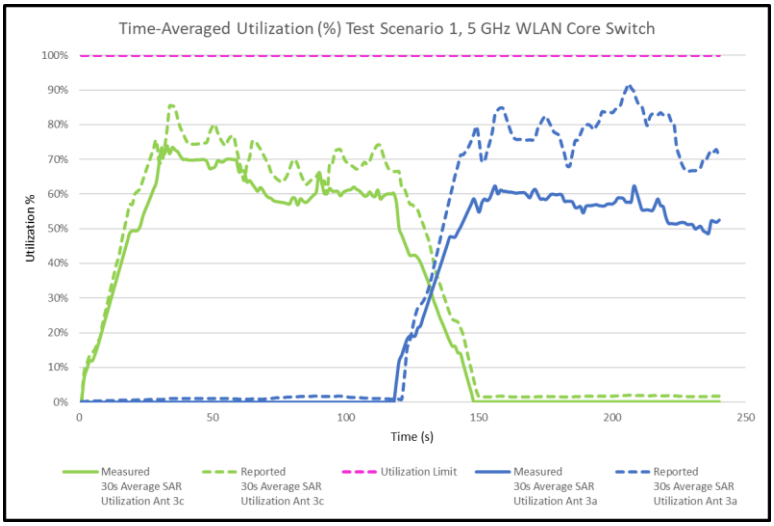

Figure J-3
30s Average SAR Utilization vs. Time, 5 GHz

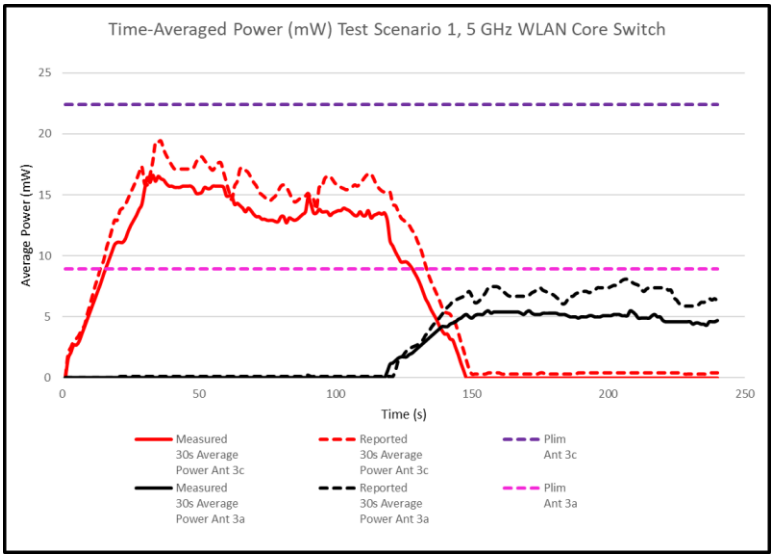

Figure J-4
30s Average Power vs. Time, 5 GHz

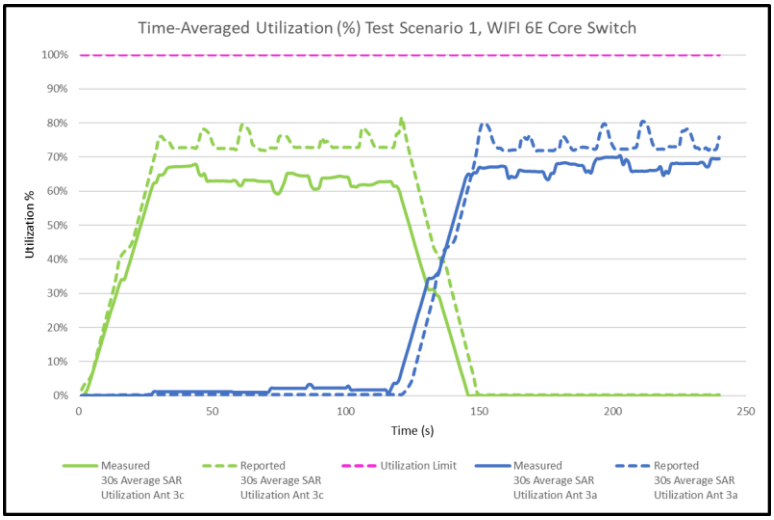

Figure J-5
30s Average SAR Utilization vs. Time, 6 GHz

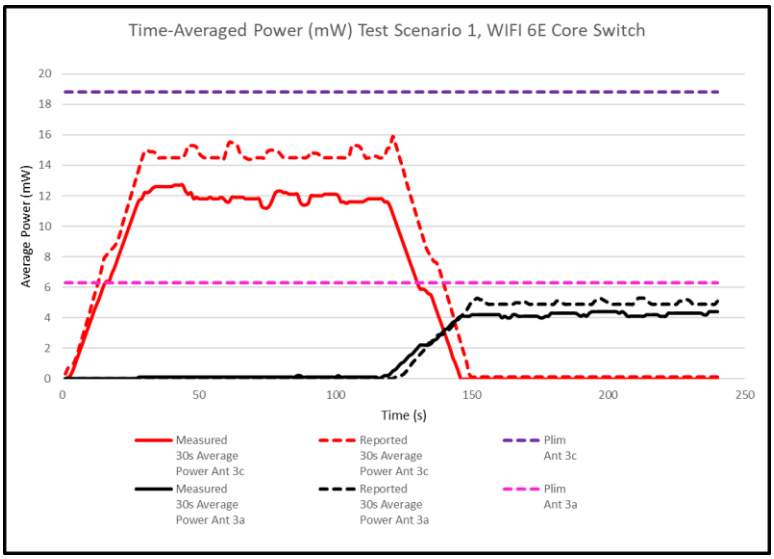

Figure J-6
30s Average Power vs. Time, 6 GHz

Scenario 2: Change in Channel/Band Test Case

This test demonstrates the efficacy of the time-averaged SAR algorithm while switching between 2.4 GHz and 5 GHz WLAN bands. In addition, it shows that the algorithm tracks time-averaged power and system utilization when the active transmitter is disabled and then reconnects.

The 2.4 GHz Antenna 3a transmitter is active at 100% duty cycle until Time = 120 s. When 2.4 GHz transmissions cease, the 5 GHz Antenna 3c transmitter is activated and begins to negotiate a new connection. The connection is established and the increase in average transmit power and utilization can clearly be seen. In this case the utilization ratio never exceeds 100% and the average transmit power never exceeds the Plim of each respective antenna.

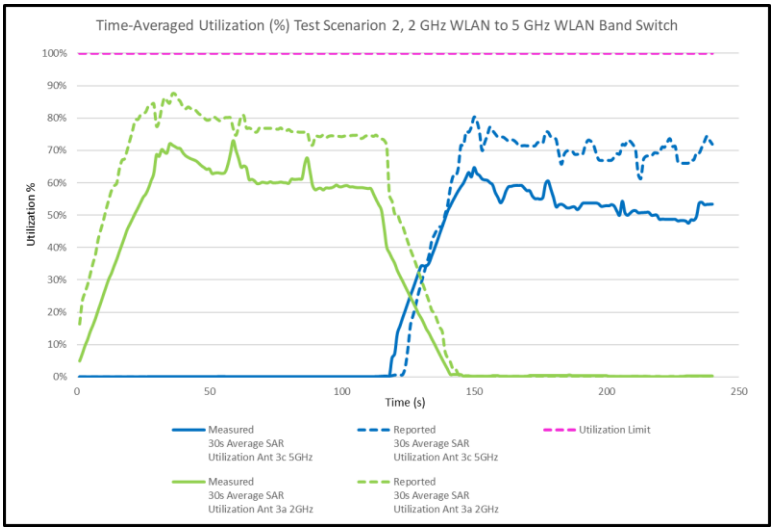

Figure J-7
30s Average Utilization vs. Time during Band Switch

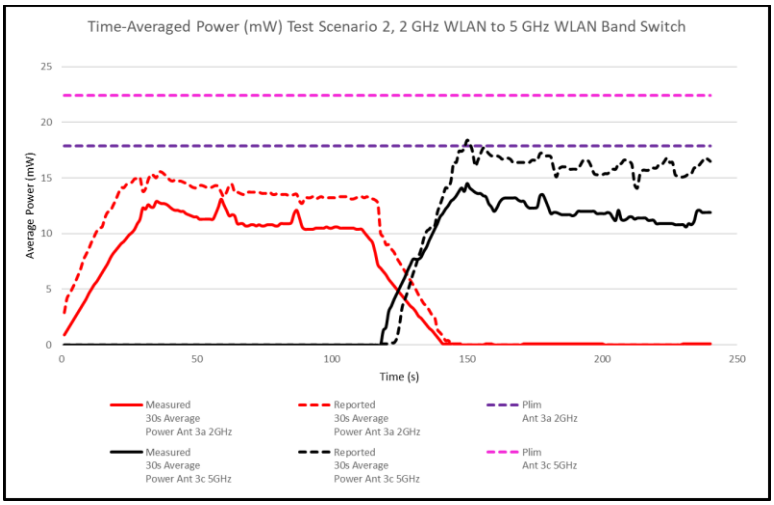

Figure J-8
30s Average Power vs. Time during Band Switch

Scenario 3: Change in Device State

This test demonstrates the efficacy of the time-averaged SAR algorithm when an external power control trigger is activated, transitioning between cell off and cell on at Time = 120 s.

The 2.4 GHz Ant 3a transmitter is active at 100% duty cycle until Time = 120 s. At this point a cellular connection occurs. The connection is established and the decrease in average transmit power and can clearly be seen, while utilization remains consistent. In this case the utilization ratio never exceeds 100% and the average transmit power never exceeds the Plim of the device state.

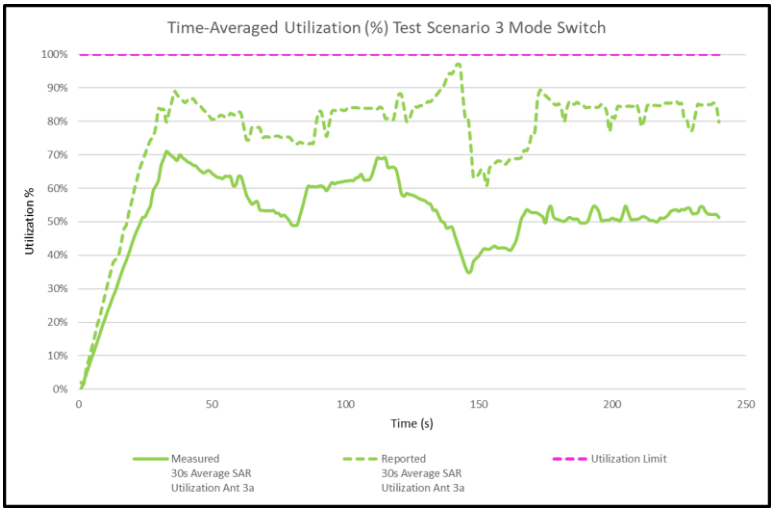

Figure J-9
30s Average Utilization vs. Time during Mode Switch

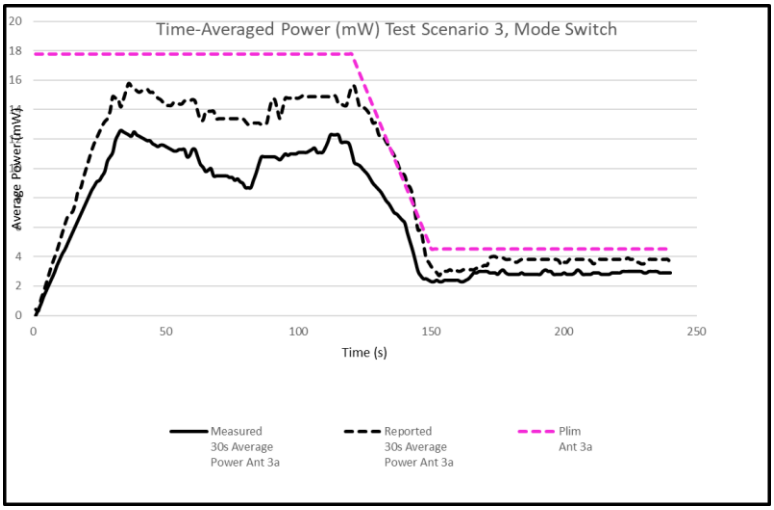

Figure J-10
30s Average Power vs. Time during Mode Switch