Appendix I: Time-Averaged SAR(TAS) Verification

1. Introduction

The DUT supports time-averaged SAR (TAS) technology for the WLAN transmitters. This TAS implementation support 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.

This resulting “utilization ratio” for particular WLAN transmitter can then be added to the utilization ratio for all other WLAN transmitters in the device over the same time period to derive the total WLAN system utilization ratio. Consistent with FCC/ISED guidance on compliance with time averaging exposure limits, the TAS implementation uses the total WLAN utilization ratio over a nominal 60 second time window to manage the transmitter power level and ensure that the DUT does not exceed the average power levels documented in the SAR report. 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

To validate the proper functioning of the time-average algorithm of this device, the following test scenarios were performed. These scenarios define the operation of the algorithm in all operational states:

1. Change in Antenna
2. Change in Band/Channel
3. Change in Device State

Predefined transmit profiles for each test scenario were created in test automation software to control the operation of the DUT while synchronized operation 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 was never exceeded. Internally reported power values were captured via DUT firmware while conducted power was measured directly from the DUT antenna ports. These are referred to as Reported and Measured, respectively, in the test plots. The DUT WLAN chipset applies a 1.5 dB uncertainty budget to all power control functions.

Test scenarios were agreed upon with the ISED via email inquiry. Power mode B was used for all tests. Test scenarios 1 and 2 use ‘Cell off’ power values. Test scenario 3 uses ‘Cell off’ and ‘Cell on’ power values.

2.4 GHz parameters used during testing

Channel/ Mode	Cellular status	Power			
		Ant 3		Ant 4	
		P_{lim}	P_{opt}	P_{lim}	P_{opt}
Ch 6 802.11b	Cell off (dBm)	21.00	24.00	20.75	23.75
	Cell off (mW)	125.89	251.19	118.85	237.14
	Cell on (dBm)	18.00	21.00	17.75	20.75
	Cell on (mW)	63.10	125.89	59.57	118.85

5 GHz parameters used during testing

Channel/ Mode	Cellular status	Power			
		Ant 5		Ant 6	
		P_{lim}	P_{opt}	P_{lim}	P_{opt}
Ch 155 802.11ac	Cell off (dBm)	17.50	20.50	17.00	20.00
	Cell off (mW)	56.23	112.20	50.12	100.00
	Cell on (dBm)	13.75	16.75	13.00	16.00
	Cell on (mW)	23.71	47.32	19.95	39.81

Note, WLAN radios were configured to operate at 100% duty cycle.

2. Verification Test Results

2.1. Scenario 1: Change in Antenna Test Case

The evaluation in Figures 1, 2 and 3 shows switching between antennas on the 2.4GHz band at *Time*=120s. The test automation is controlling the WLAN radios to operate at 100% duty cycle. Figure 1 shows that the utilization ratio never exceeds 100% and Figure 2 shows that the average transmit power never exceeds the average P_{lim}. Figure 3 shows the measured instantaneous power during the test.

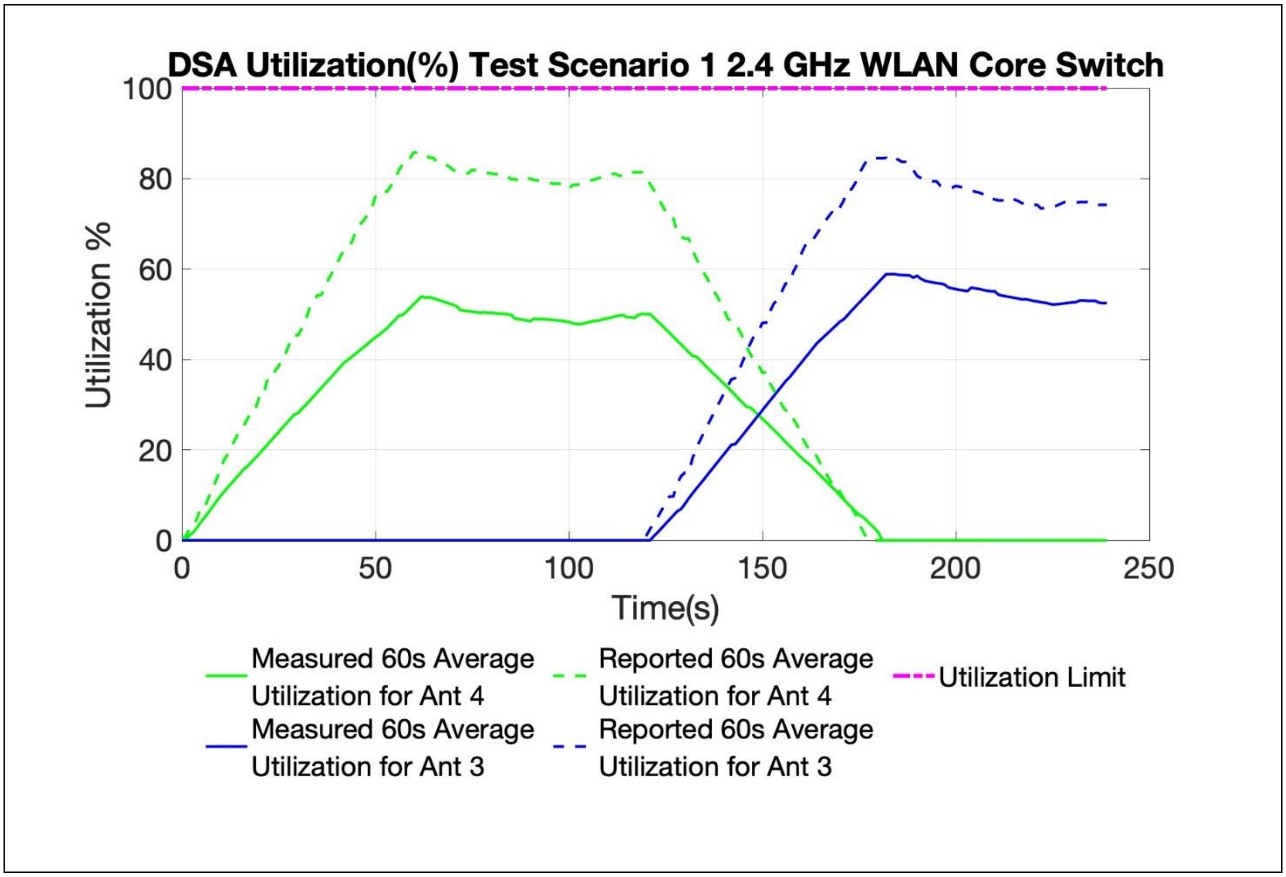

Figure 1
60 Second Aggregated SAR Utilization vs Time, 2.4GHz

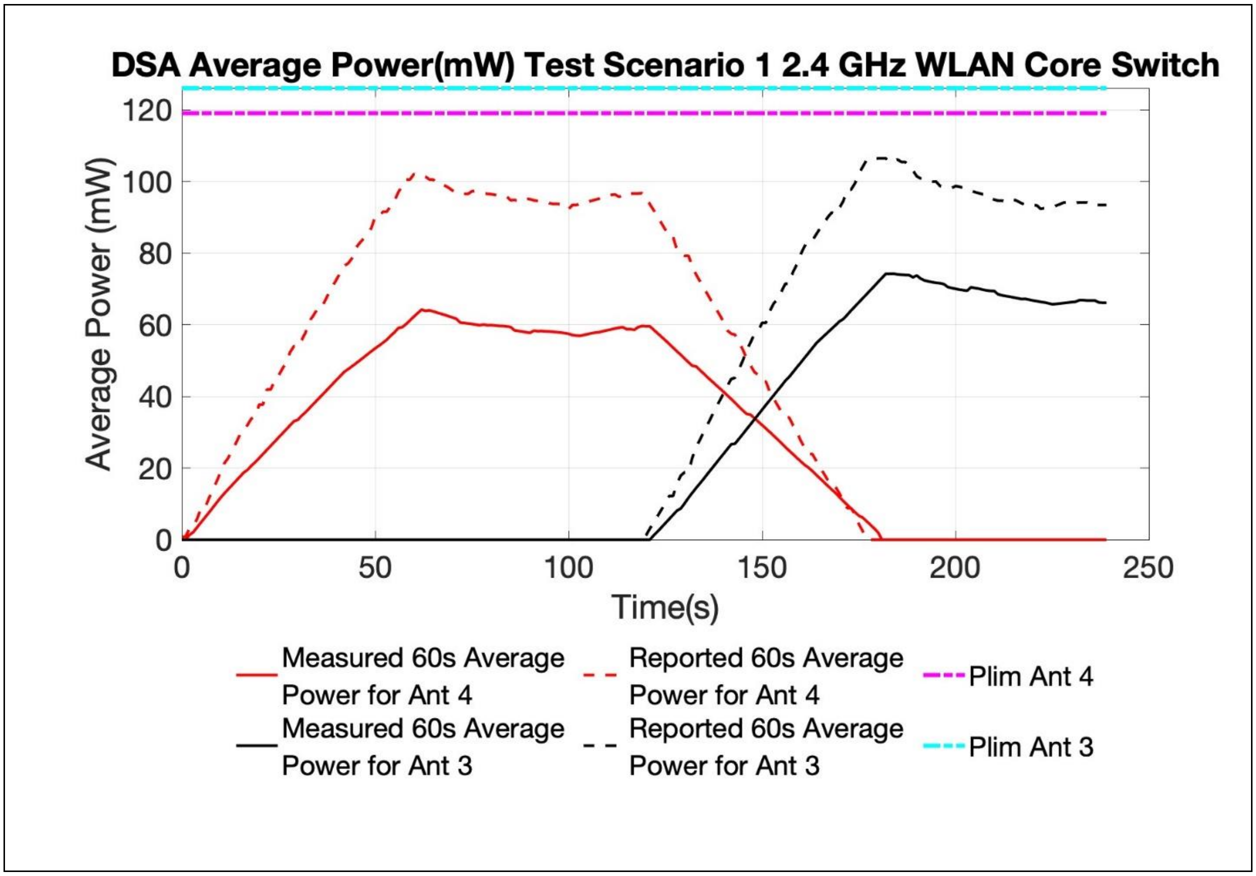

Figure 2
60 Second Average Power vs Time, 2.4GHz

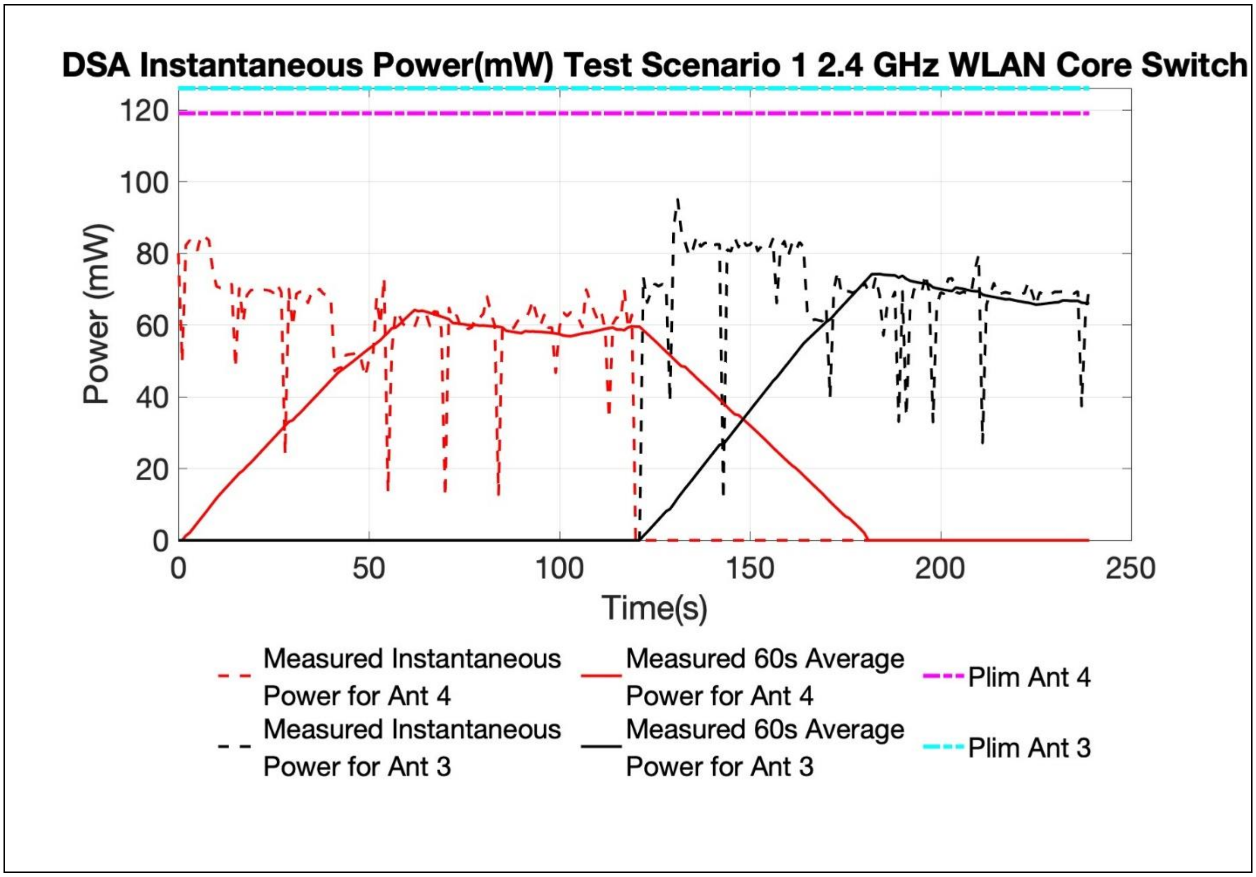

Figure 3
60 Second Average Power vs Time and Instantaneous Power, 2.4GHz

The evaluation in Figures 4, 5 and 6 shows switching between antennas on the 5GHz band at *Time*=120s. The test automation is controlling the WLAN radios to operate at 100% duty cycle. Figure 4 shows that the utilization ratio never exceeds 100% and Figure 5 shows that the average transmit power never exceeds the average P_{lim}. Figure 6 shows the measured instantaneous power during the test..

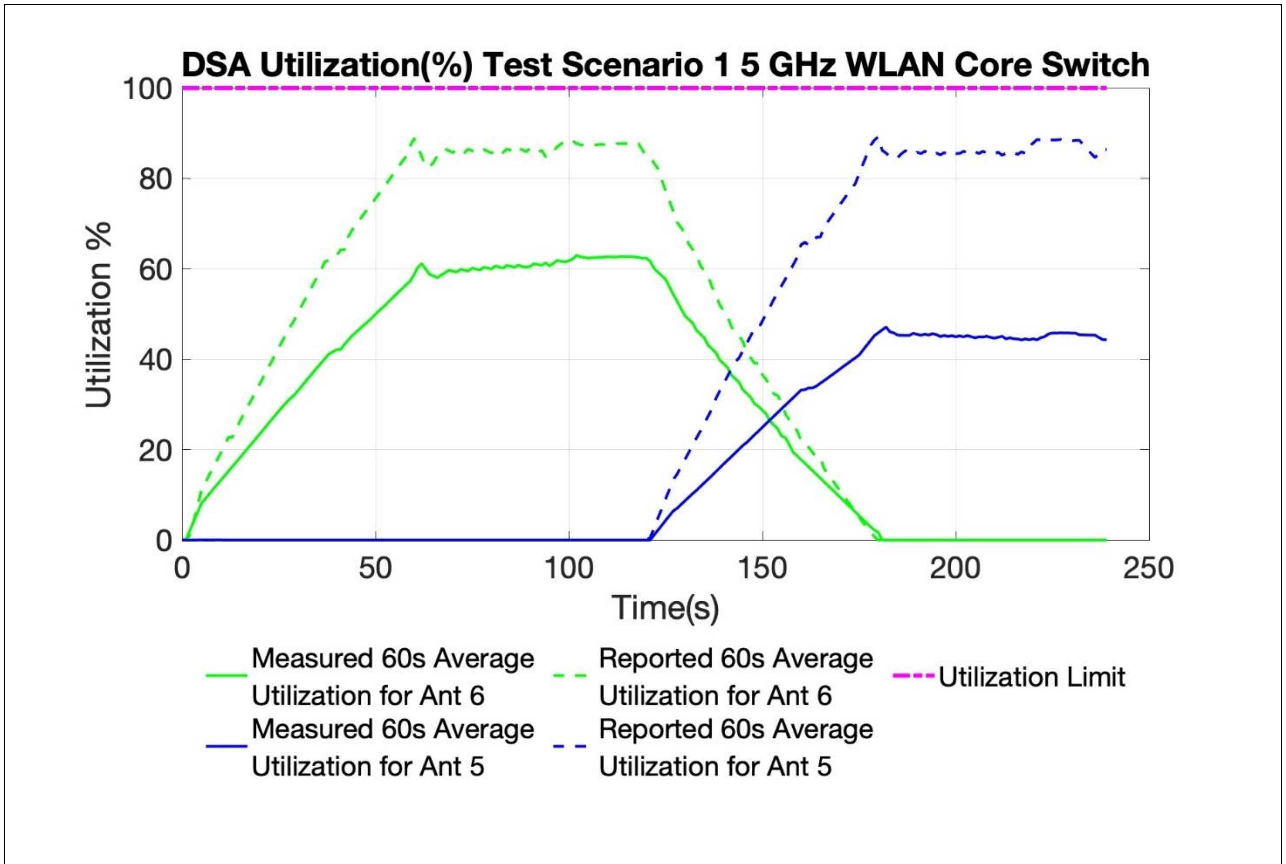

Figure 4
60 Second Aggregated SAR Utilization vs Time, 5GHz

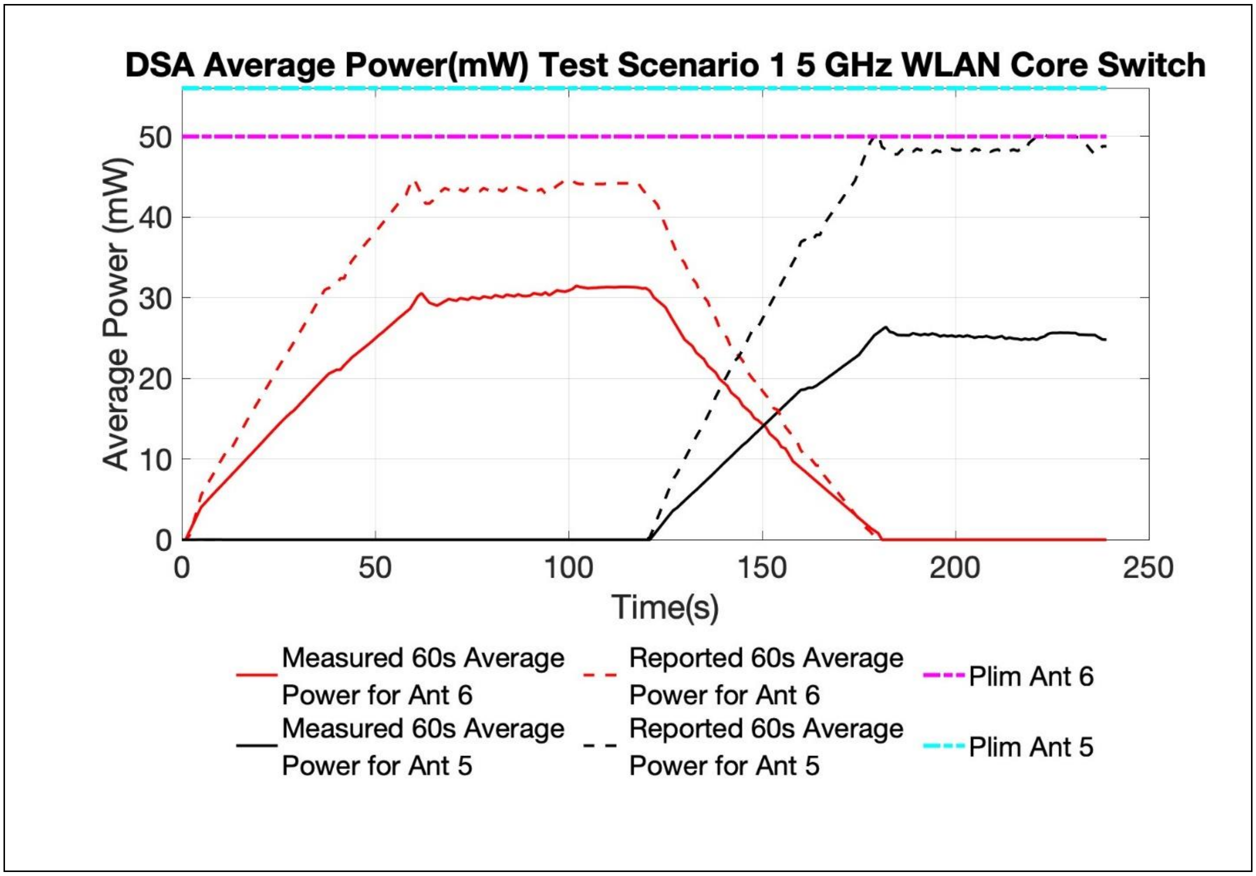

Figure 5
60 Second Average Power vs Time, 5GHz

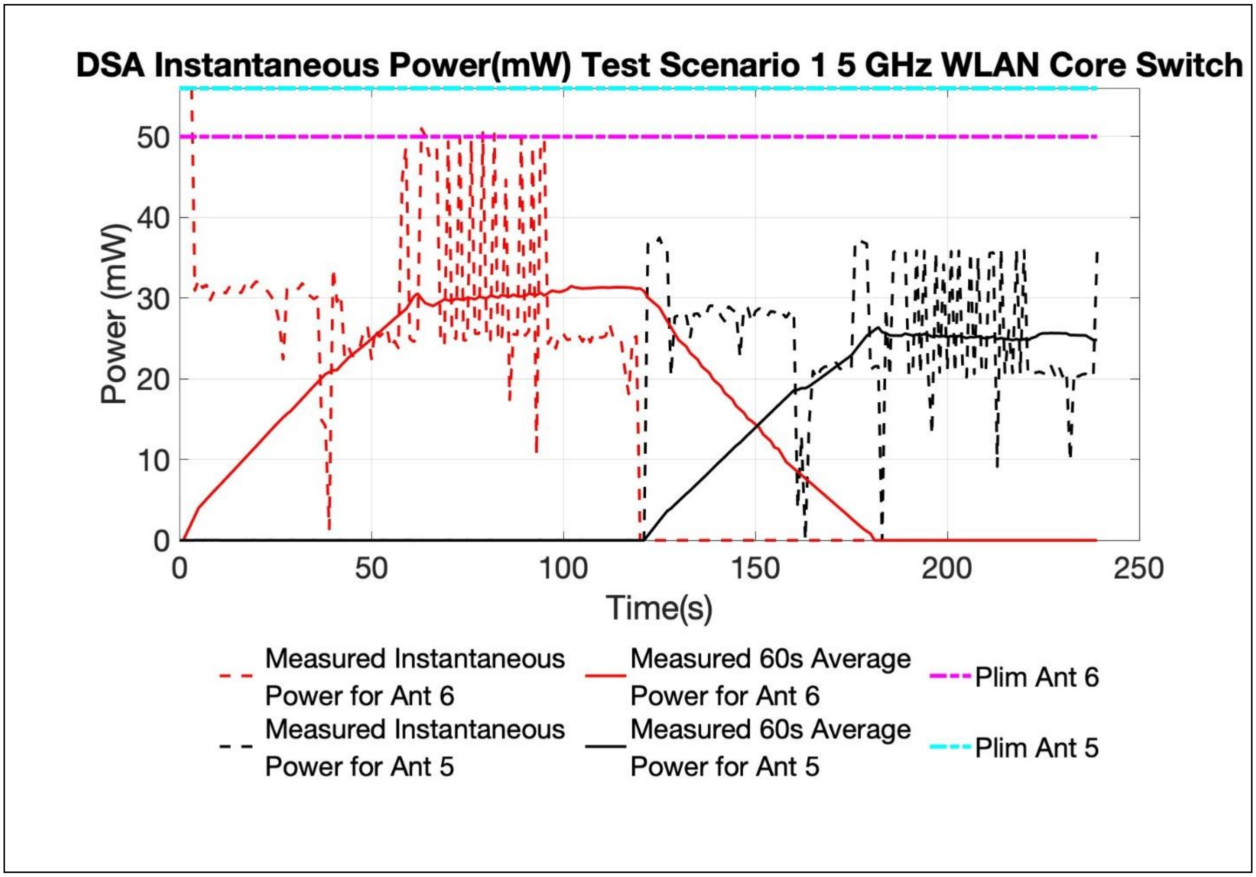

Figure 6
60 Second Average Power vs Time and Instantaneous Power, 5GHz

2.2. Scenario 2: Change in Channel/Band Test Case

The evaluation in Figures 7, 8 and 9 shows switching between 2.4GHz and 5GHz bands at *Time*=120s. The test automation is controlling the WLAN radios to operate at 100% duty cycle. Figure 7 shows that the utilization ratio never exceeds 100% and Figure 8 shows that the average transmit power never exceeds the average P_{lim}. Figure 9 shows the measured instantaneous power during the test..

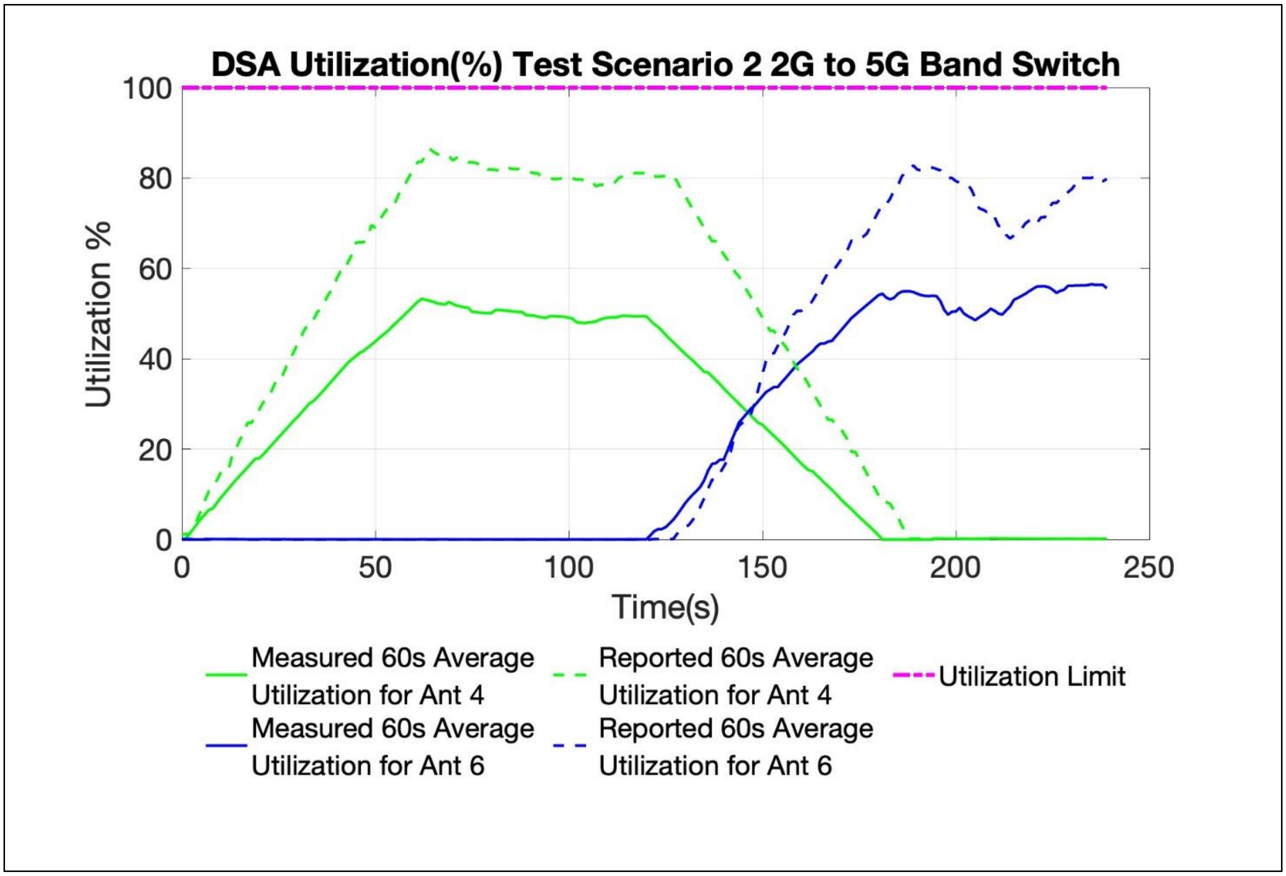

Figure 7
60 Second Aggregated SAR Utilization vs Time during Band Switch

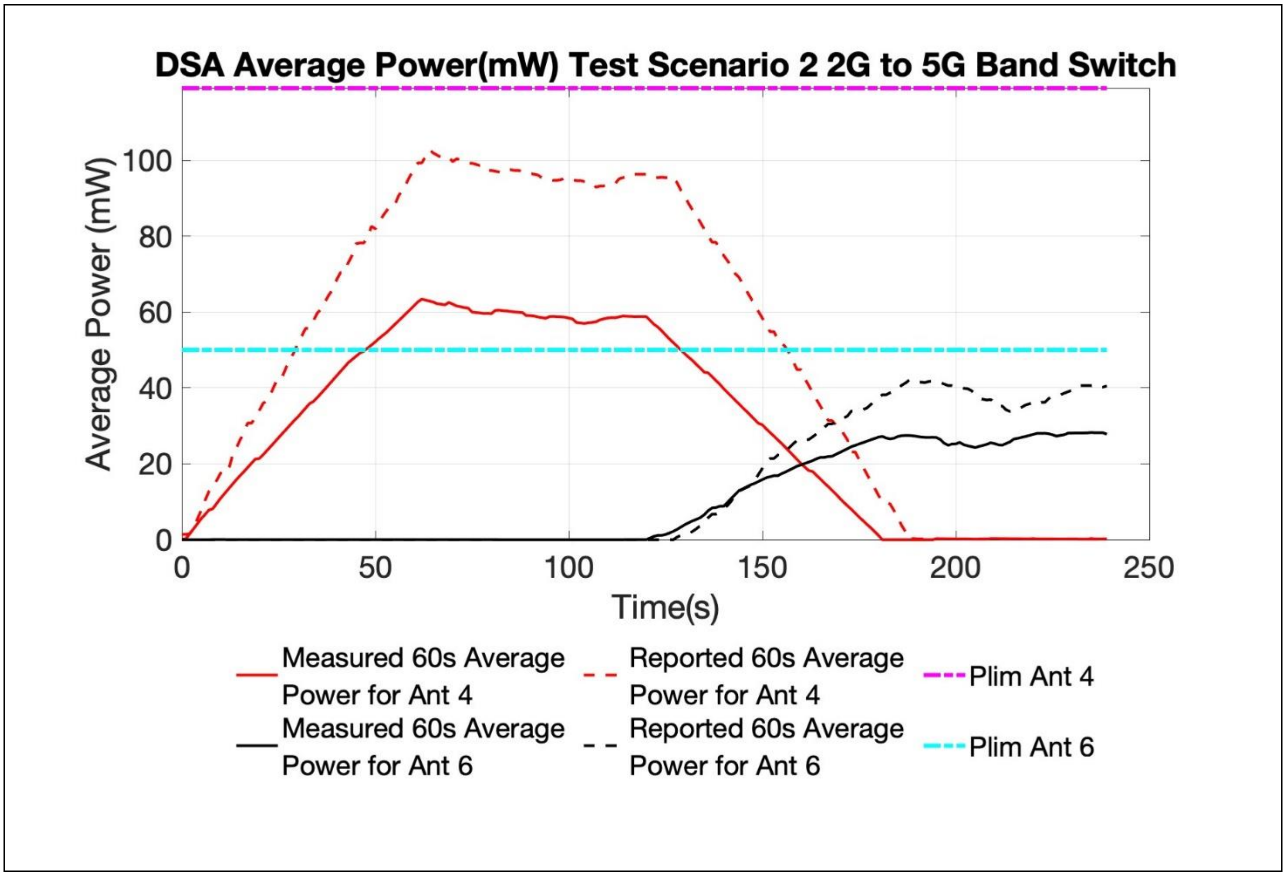

Figure 8
60 Second Average Power vs Time during Band Switch

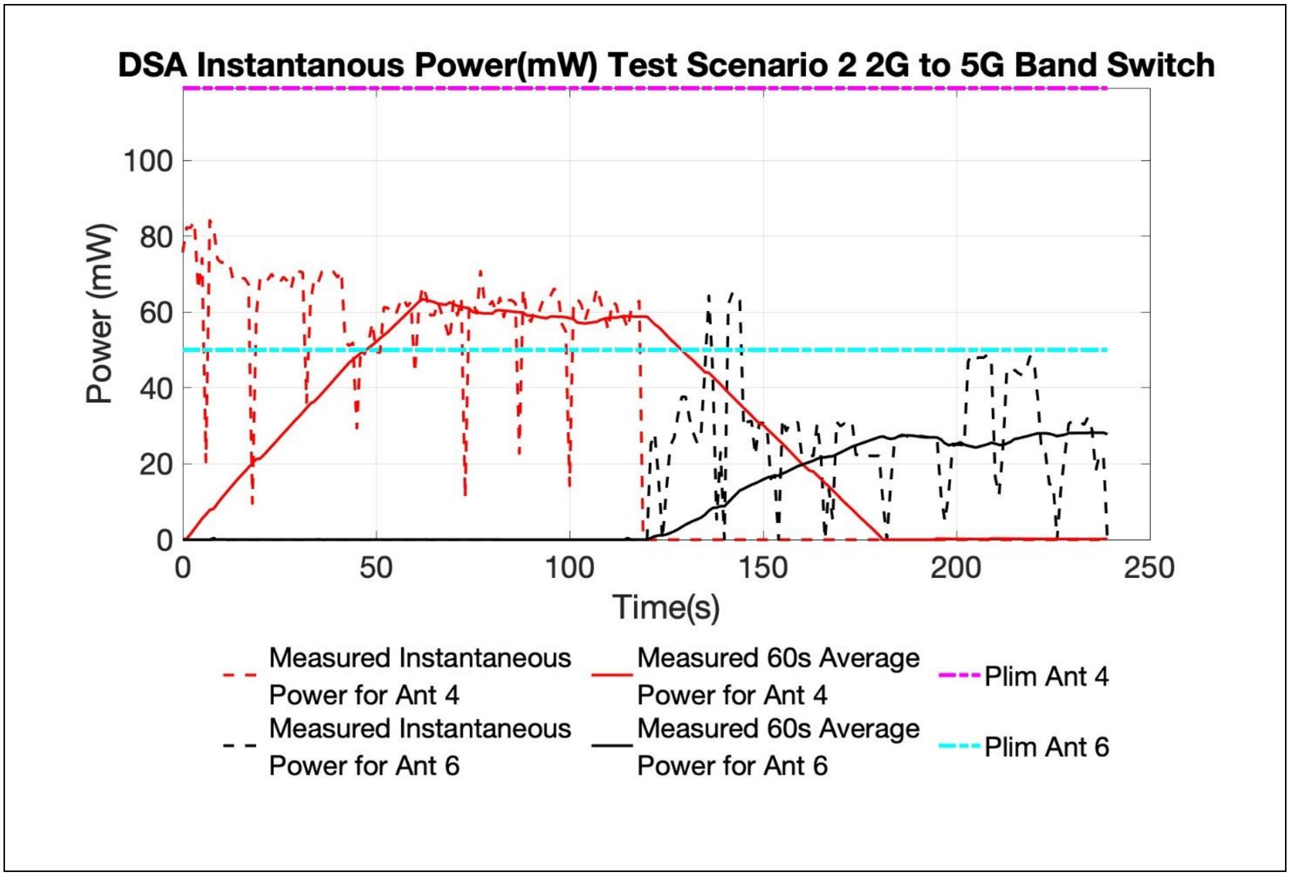

Figure 9
60 Second Average Power vs Time during Band Switch and Instantaneous Power

2.3. Scenario 3: Change in Device State Test Case

The evaluation in Figures 10, 11 and 12 shows switching between Cell off and Cell on in the 2.4GHz band at *Time*=120s. The test automation is controlling the WLAN radios to operate at 100% duty cycle. Figure 10 shows that the utilization ratio never exceeds 100% and Figure 11 shows that the average transmit power never exceeds the average P_{lim}. Figure 12 shows the measured instantaneous power during the test..

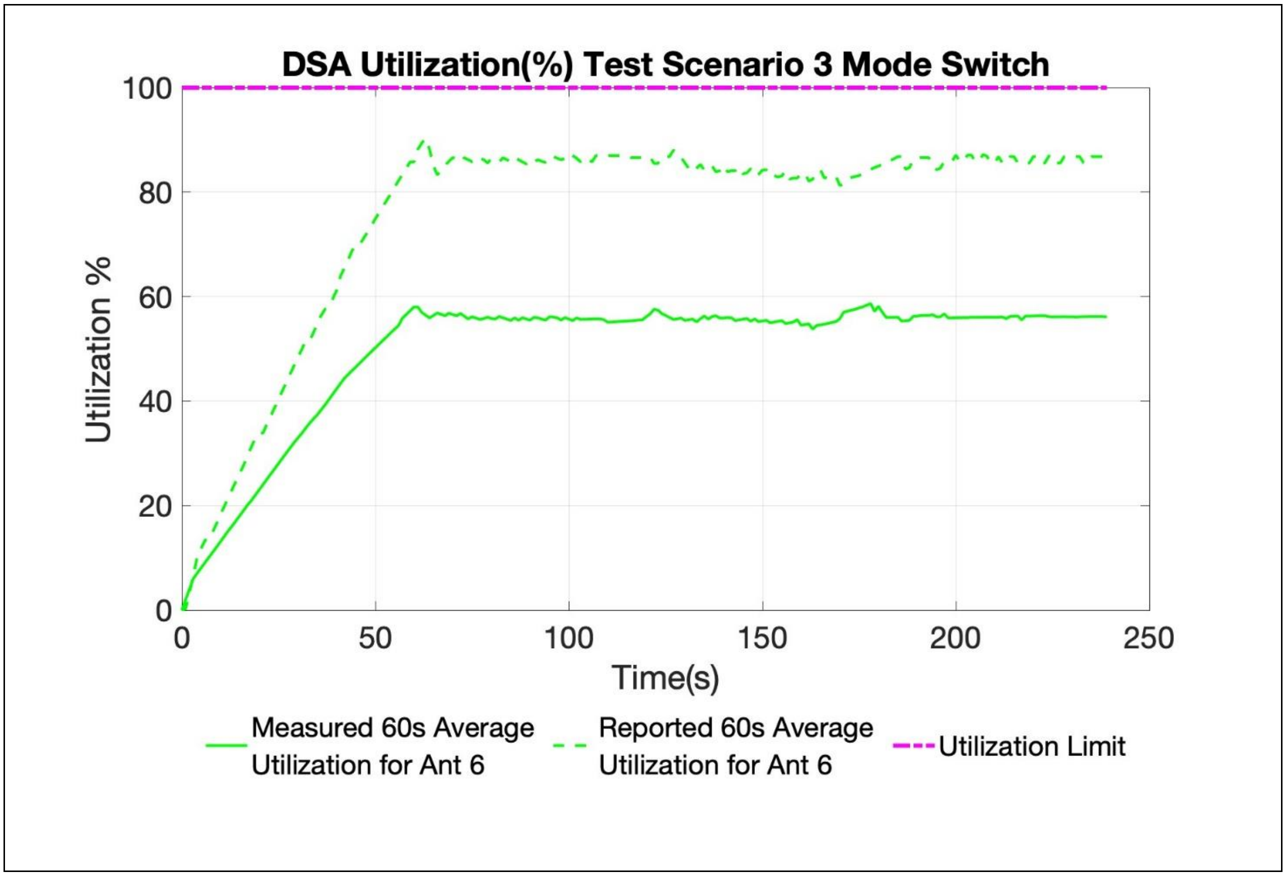

Figure 10
60 Second Aggregated SAR Utilization vs Time during Mode Switch

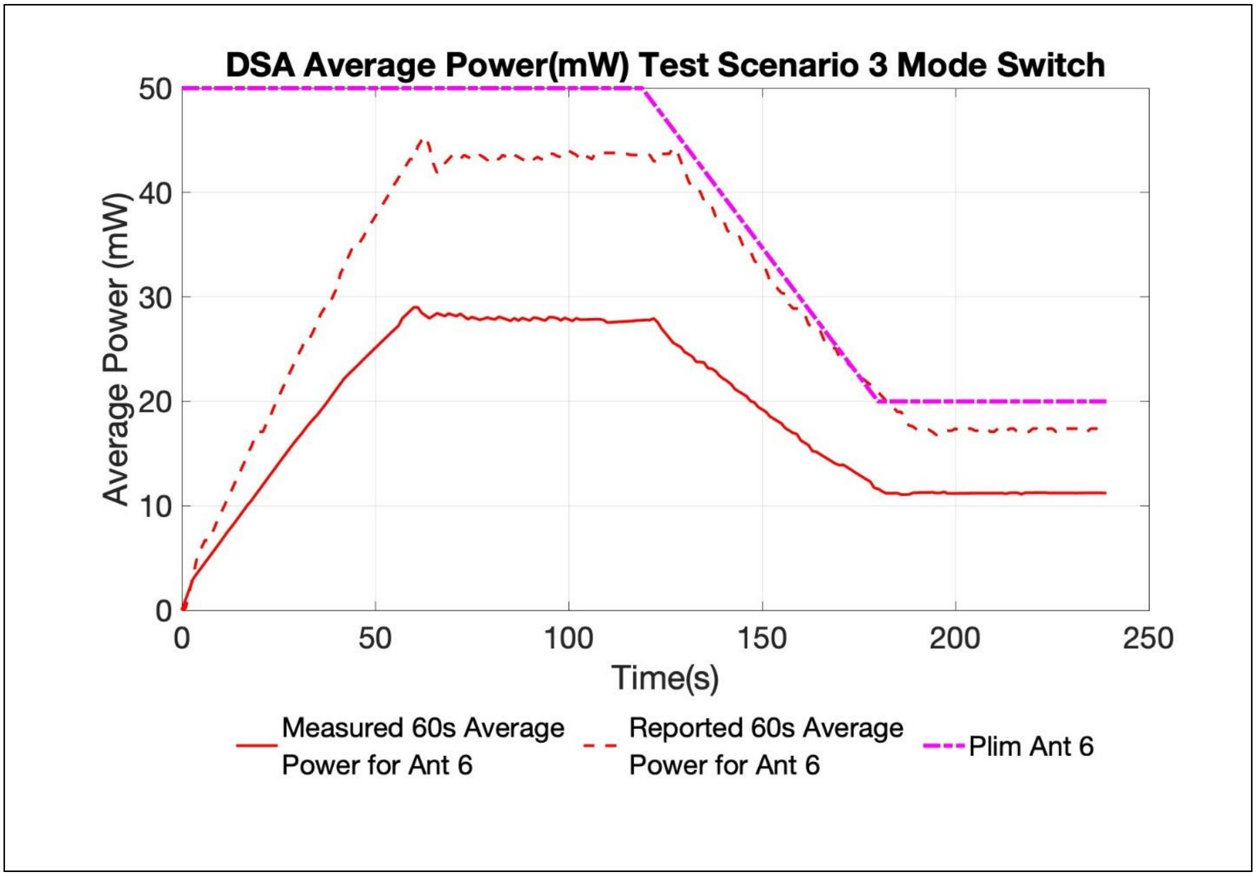

Figure 11
60 Second Average Power vs Time during Mode Switch

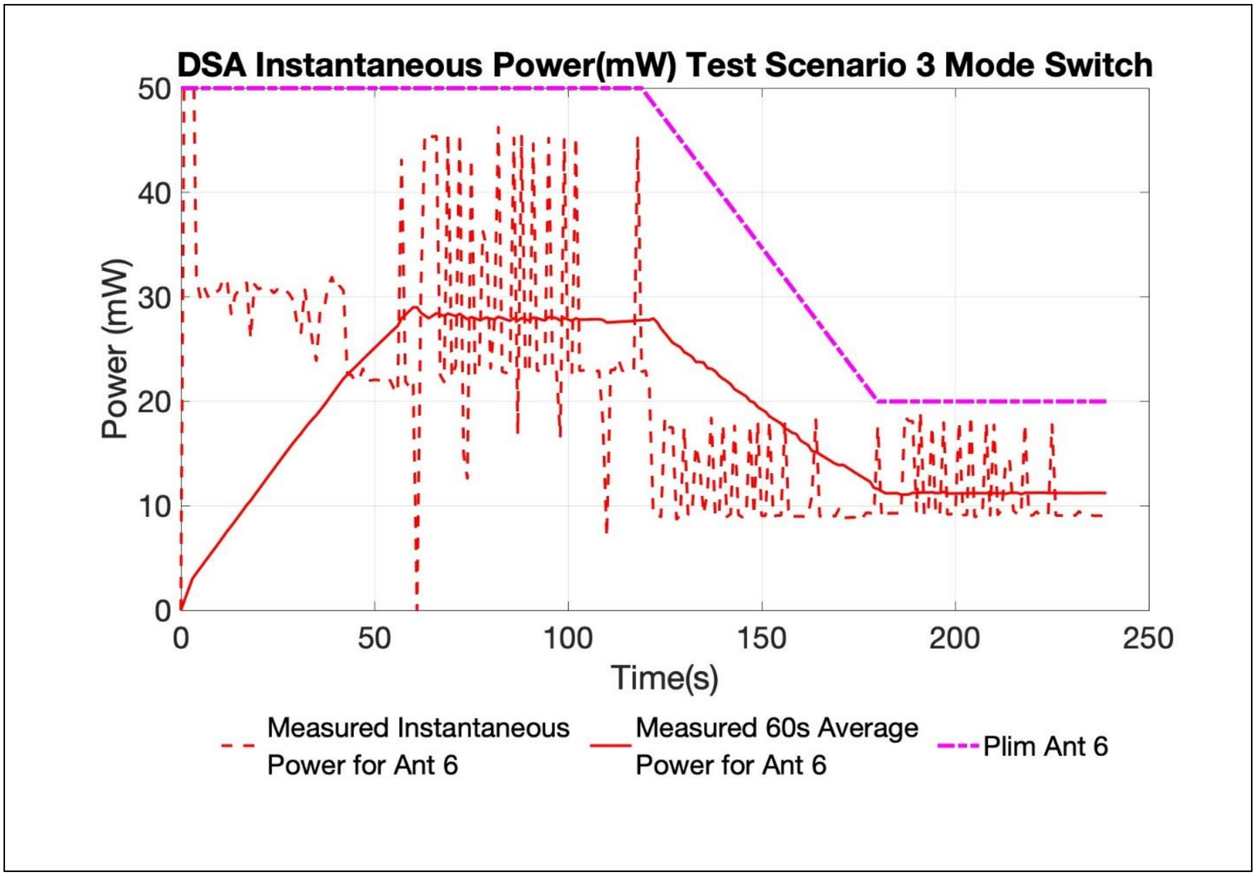

Figure 12
60 Second Average Power vs Time during Mode Switch and Instantaneous Power