



# Power Reduction Evaluation Study for Multi-transmitter and Tablet Devices

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**QUALCOMM Incorporated  
5775 Morehouse Drive  
San Diego, CA 92121-1714  
U.S.A.**

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# Regulatory Certification Introduction

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- Regulatory Certification is required for WWAN devices prior to marketing in the respective market
  
- Typical Regulatory Requirements
  - Misc. Transmitter/Receiver measurements (e.g. max power, emissions, ACPR, freq stability)
  - Hearing Aid Compatibility (“HAC”)
  - RF Safety (Specific Absorption Rate “SAR”)
    - FCC SAR limit: 1.6 mW/g in 1 gram volume
    - ICNIRP (common in the rest of world) SAR limit: 2mW/g in a 10 gram volume
    - Head, body, hand SAR testing configurations dependent on the device and user model
  
- Specific Absorption Rate (“SAR”) testing is required for any device used <20cm from user
  - Includes handsets, smartphones, small form factor notebooks, etc.
  - Device must be compliant with all transmitters active

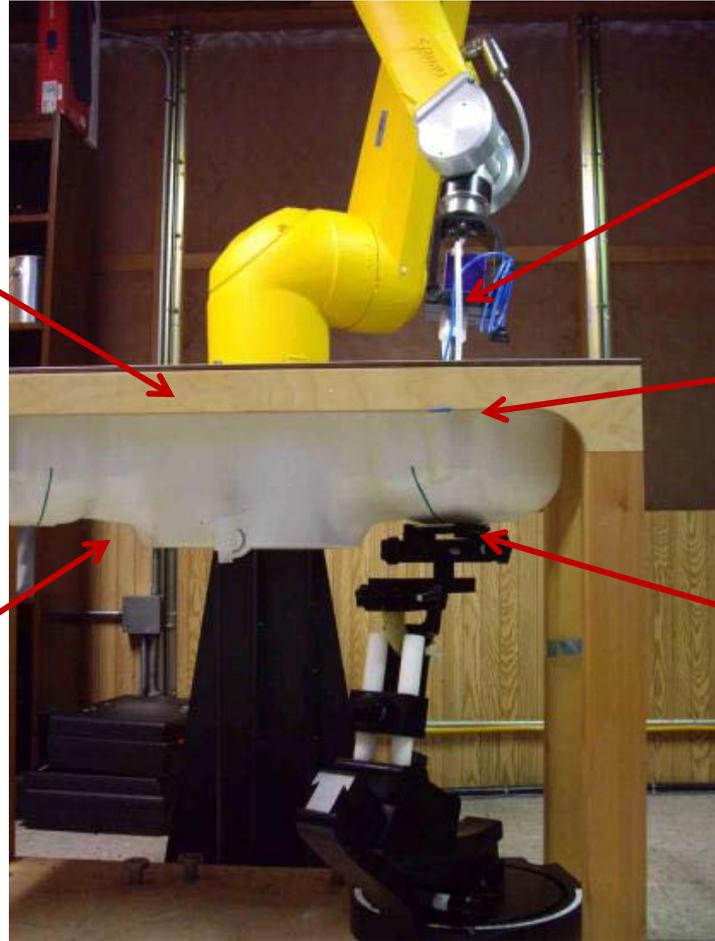
# SAR Test Requirements

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- Specific Absorption Rate (SAR) testing is completed with device positioned next to human body phantom to measure energy transmitted into the body
  - Head SAR tested against test head in defined test positions
  - Body SAR default test position is “flush” to test phantom – Compliance challenging
    - Phones tested with “belt clip” to provide separation distance for “body worn” SAR compliance
    - Tablets/eReaders, etc tested flush or with small separation distance
  - SAR results related to the proximity of the device/antenna to the test phantom
- SAR compliance challenging for devices supporting simultaneous transmission and/or devices that must be tested flush to the SAR test phantom (e.g. tablet)
- Depending on the antenna locations, transmit power and type of device, simultaneous transmission is evaluated by:
  - Direct summation of worst case individual SAR results for each transmitter (conservative result)
  - SAR measurement post-processing to combine individual SAR results

# SAR System Example

SAR Test Phantom



SAR measurement probe

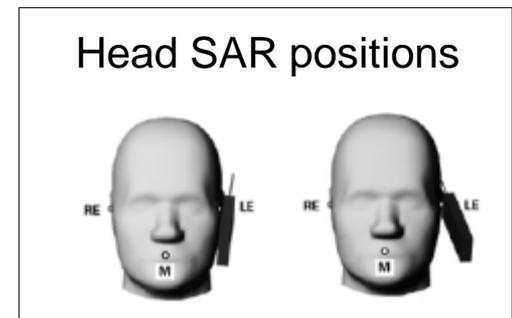
Phantom is filled with material that simulates dielectric properties of the human body

Handset mounted in standardized position for head SAR

Notebook/Tablet is mounted here:

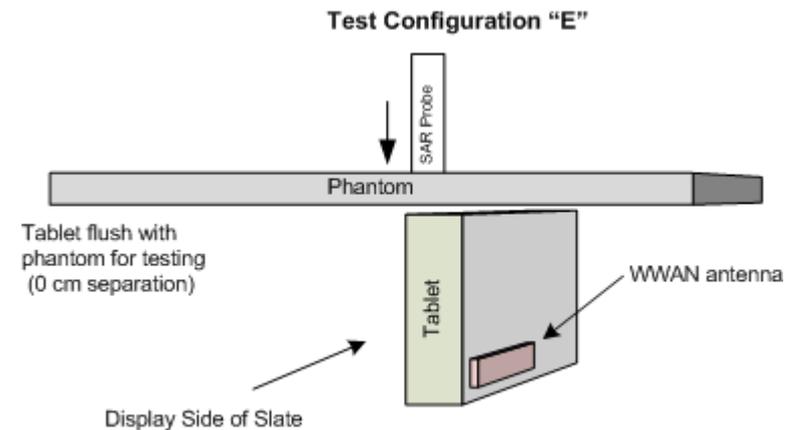
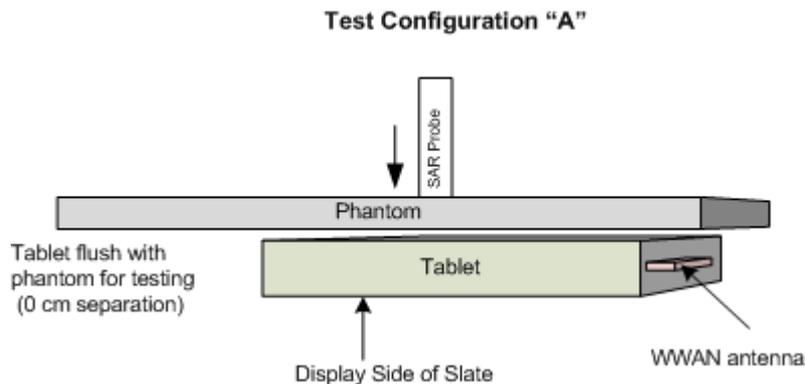
# Introduction to SAR Measurements

- SAR measurement is made by measuring electric field strength radiating from phones next to a human phantom filled with liquid simulating brain/body composition
  - Different dielectric properties for tissue simulants used to test different frequencies for both head and body
- SAR measurements made in two main configurations
  - Head SAR – Simulating held to hear applications
  - Body SAR – Simulating body worn applications
- SAR measurements procedures standardized around the world
  - Based on IEEE/IEC test procedures
  - FCC often leads the world with introduction of unique procedures
- Two SAR Limits Used around the world
  - FCC, Canada have a common SAR limit =  $1.6\text{mW/g}$  in 1gram volume
  - Rest of world =  $2\text{mW/g}$  in 10 gram volume
    - Slightly relaxed from FCC limit



# Notebook/Tablet SAR Position Examples

- Notebook/Slate tested with base and edges flush against phantom
  - Separation from phantom is only possible if user accessory provide or the FCC agrees to a specific separation distance



**Note:** Antenna is far from phantom so SAR may be compliant

# FCC RF Safety Simultaneous Exposure Test Requirements

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- FCC released procedures in 2008 for multi-band simultaneous transmission SAR evaluation
  - Procedures specifically released for WWAN + WLAN + BT
    - Same procedures should be applicable to WWAN + WWAN
  - Each transmitter completes an individual SAR test at max power
  
- FCC released draft procedures in Oct 2010 for LTE
  - Procedures also address simultaneous transmitter measurements and power reduction to achieve SAR compliance
  - KDB 941225: <https://apps.fcc.gov/oetcf/kdb/forms/FTSSearchResultPage.cfm?switch=P&id=26930>

# Methods to Achieve Device SAR Compliance

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- Typical SAR Hardware compliance techniques used by Device manufactures
  - Modify antenna design and device mechanical structure
  - Physical design to increase antenna to user separation distance
  - Reduce Transmit Power
    - (SAR results reduce linearly with average transmit power)
  - Use of user accessory to increase antenna to user separation distance
- Device cannot always achieve compliance using hardware SAR reduction techniques
- Power reduction can utilized to achieve SAR compliance
  - Power can be reduced during simultaneous transmission
  - Power can be reduced for a device based on device input (e.g. proximity sensor)

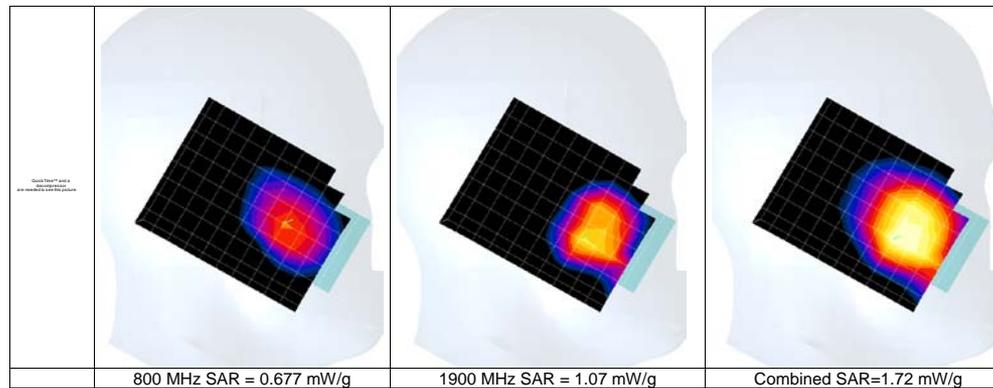
# Power Reduction Used for Tablet SAR compliance

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- Tablets using power reduction to achieve SAR compliance
- Proximity detector triggers power reduction for WWAN transmitter
- Different devices implement various power reduction values
  - Values range from 3-6dB
- SAR reports available for review on the FCC website
  - <https://apps.fcc.gov/oetcf/eas/reports/GenericSearch.cfm>

# Simultaneous Transmitter SAR Considerations

- SAR measurement post-processing typically results in lower combined SAR vs. individual SAR result summation
  - Measurement “Hot spots” may not align for different frequency bands (example below shows hotspot variation)
  - Single antenna for multiple transmitters results in higher combined SAR vs. a dual antenna solution



- SAR results are determined by the same design characteristics as single transmitter device:
  - Phone design (PCB design, device size, ground structure, trace routing , etc)
  - Antenna design / placement
  - Transmit Power Reduction
    - SAR results are proportional to average transmit power

# Commercial Device SAR Compliance Study and Summary

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- Study completed of existing WWAN devices to estimate conservative power reduction requirements to achieve SAR compliance if the device was converted to dual transmitter design with a single antenna
  - Study is approximate only has the hardware would require changes to implement a simultaneous transmit device and the measured SAR results would thus change for the actual devices
- FCC ID's used to query SAR test reports from FCC database
  - Extracted highest CDMA SAR results from FCC database
  - "Head" SAR only (e.g. no body worn SAR results)
  - Documented 850+1900, 850+850 MHz, 1900+1900 SAR Compliance
    - SAR is technology neutral so analysis is applicable to any technology
- Multiband 850 + 1900MHz SAR results (Multiband)
  - 13 of 20 phones fail
    - Indicates HW change or power reduction required
- SAR Data scaled to 23 dBm for both 850 and 1900 MHz
  - 5 of 20 phones fail
  - 2 phones fail by > 0.5 dB
    - Indicates significant HW change or power reduction required to pass FCC for failing devices
    - Many devices may require modifications for margin to SAR limit
- Multiple TX reduction scenarios where one or both transmitters reduced to achieve 1dB of margin to SAR limit

# Simulated Simultaneous SAR Compliance for Commercial Devices

- SAR data extracted from FCC certifications to generate approximation of device SAR compliance for multiple transmitters
  - SAR limit = 1.6 mW/g
- Highest values summed to determine multi-TX FCC SAR Compliance

Phone Example	850 MHz Measured TX (dBm)	850 Measured SAR (mW/g 1g)	1900 MHz Measured TX (dBm)	1900 Measured SAR (mW/g 1g)	FCC Simul-TX SAR Compliance 850+1900 MHz		
					850+1900 MHz	850+850 MHz	1900+1900 MHz
1	24.5	1.101	24.7	0.956	Fail	Fail	Fail
2	24.5	0.587	24.2	0.908	Pass	Pass	Fail
3	24	0.624	24	0.868	Pass	Pass	Fail
4	24.38	1.29	23.39	1.43	Fail	Fail	Fail
5	23.8	0.344	24	0.606	Pass	Pass	Pass
6	25.27	0.432	25.25	1.36	Fail	Pass	Fail
7	23.6	0.691	23.5	1.41	Fail	Pass	Fail
8	24.31	1.01	24.32	1.12	Fail	Fail	Fail
9	24.8	0.99	23.8	1.18	Fail	Fail	Fail
10	25	0.932	25.1	0.411	Pass	Fail	Pass
11	25.3	0.603	25.2	0.687	Pass	Pass	Pass
12	24.4	0.919	24.1	0.461	Pass	Fail	Pass
13	25	1.3	25.3	0.354	Fail	Fail	Pass
14	25	1.1	25.3	1.04	Fail	Fail	Fail
15	24.5	0.605	24.7	1.32	Fail	Pass	Fail
16	23.95	0.58	23.89	1.5	Fail	Pass	Fail
17	24.7	0.979	25	0.955	Fail	Fail	Fail
18	24.7	0.761	24.7	0.288	Pass	Pass	Pass
19	24.59	1.25	24.67	1.16	Fail	Fail	Fail
20	25	1.04	25.1	1.33	Fail	Fail	Fail

# Both 850/1900 TX Power Scaled to 23dBm

Device	850 Scaled Power (dBm)	1900 Scaled Power (dBm)	Scaled 850MHz SAR	Scaled 1900MHz SAR (mW/g 1g)	850+1900 Scaled SAR (mW/g 1g)	Margin (dB)	Pass Fail
1	23.0	23.0	0.779	0.646	1.426	0.5	Pass
2	23.0	23.0	0.416	0.689	1.104	1.6	Pass
3	23.0	23.0	0.496	0.689	1.185	1.3	Pass
4	23.0	23.0	0.939	1.307	2.246	-1.5	Fail
5	23.0	23.0	0.286	0.481	0.767	3.2	Pass
6	23.0	23.0	0.256	0.810	1.066	1.8	Pass
7	23.0	23.0	0.602	1.257	1.858	-0.7	Fail
8	23.0	23.0	0.747	0.826	1.573	0.1	Pass
9	23.0	23.0	0.654	0.981	1.636	-0.1	Fail
10	23.0	23.0	0.588	0.253	0.841	2.8	Pass
11	23.0	23.0	0.355	0.414	0.769	3.2	Pass
12	23.0	23.0	0.666	0.358	1.024	1.9	Pass
13	23.0	23.0	0.820	0.208	1.029	1.9	Pass
14	23.0	23.0	0.694	0.612	1.306	0.9	Pass
15	23.0	23.0	0.428	0.892	1.321	0.8	Pass
16	23.0	23.0	0.466	1.222	1.688	-0.2	Fail
17	23.0	23.0	0.662	0.603	1.264	1.0	Pass
18	23.0	23.0	0.514	0.195	0.709	3.5	Pass
19	23.0	23.0	0.867	0.790	1.656	-0.2	Fail
20	23.0	23.0	0.656	0.820	1.476	0.3	Pass

	#	%
Total Phones	20	
Fail with 850/1900 Scaled to 23 dBm	5	25%

# Power Reduction Scenarios

Device	Baseline 850 MHz Power (dBm)	Baseline 1900 MHz Power (dBm)	Baseline 850 MHz SAR	Baseline 1900 MHz SAR	Case 1: 850MHz Pwr fixed		Case 2: 1900 MHz Pwr fixed		Case 3: Dual 850 MHz TX- Both 850MHz Transmitters Reduced		Case 4: Dual 1900 MHz TX- Both 1900MHz Transmitters Reduced		Case 5: Dual 850 Mhz- One Transmitter Reduced		Case 6: Dual 1900 Mhz- One Transmitter Reduced	
					Required 1900 MHz Power Reduction (dB)	Reduced 1900 MHz Power	Required 850 MHz Power Reduction (dB)	Reduced 850 MHz Power	Required 850 MHz for both Transmitters (dB)	Reduced 850 MHz Power	Required 1900 MHz for both Transmitters (dB)	Reduced 1900 MHz Power	Required 850 MHz Reduction for one Transmitter (dB)	Reduced 850 MHz Power	Required 1900 MHz Reduction for one Transmitter (dB)	Reduced 1900 MHz Power
1	24.50	24.7	1.101	0.956	-7.5	17.2	-5.4	19.1	-2.4	22.1	-1.77	22.9	-8.1	16.4	-4.8	19.9
2	24.50	24.2	0.587	0.908	-1.2	23.0	-2.1	22.4	-3.0	21.5	-3.00	21.2	0.7	25.2	-4.0	20.2
3	24.00	24.0	0.624	0.868	-1.3	22.7	-1.9	22.1	0.0	24.0	-1.35	22.6	0.2	24.2	-3.3	20.7
4	24.38	23.4	1.29	1.43	**	**	**	**	-3.1	21.3	-3.52	19.9	**	**	**	**
5	23.80	24.0	0.344	0.606	0.0	24.0	0.0	23.8	0.0	23.8	0.00	24.0	4.3	28.1	0.0	24.0
6	25.27	25.3	0.432	1.36	-2.1	23.2	**	**	0.0	25.3	-3.30	21.9	2.9	28.2	**	**
7	23.60	23.5	0.691	1.41	-3.9	19.6	**	**	-0.4	23.2	-3.46	20.0	-0.8	22.8	**	**
8	24.31	24.3	1.01	1.12	-6.3	18.0	-8.3	16.1	-2.0	22.3	-2.46	21.9	-5.9	18.4	-8.7	15.6
9	24.80	23.8	0.99	1.18	-6.2	17.6	-10.4	14.4	-1.9	22.9	-2.69	21.1	-5.5	19.3	-11.1	12.7
10	25.00	25.1	0.932	0.411	-0.8	24.3	-0.3	24.7	-1.7	23.3	0.00	25.1	-4.4	20.6	0.0	25.1
11	25.30	25.2	0.603	0.687	-0.1	25.1	-0.1	25.2	0.0	25.3	-0.34	24.9	0.4	25.7	-0.7	24.5
12	24.40	24.1	0.919	0.461	-1.2	22.9	-0.5	23.9	-1.6	22.8	0.00	24.1	-4.2	20.2	0.0	24.1
13	25.00	25.3	1.3	0.354	**	**	-1.5	23.5	-3.1	21.9	0.00	25.3	**	**	0.0	25.3
14	25.00	25.3	1.1	1.04	-7.8	17.5	-6.8	18.2	-2.4	22.6	-2.14	23.2	-8.1	16.9	-6.5	18.8
15	24.50	24.7	0.605	1.32	-3.0	21.7	**	**	0.0	24.5	-3.17	21.5	0.4	24.9	**	**
16	23.95	23.9	0.58	1.5	-3.4	20.5	**	**	0.0	24.0	-3.73	20.2	0.8	24.7	**	**
17	24.70	25.0	0.979	0.955	-5.1	19.9	-4.9	19.8	-1.9	22.8	-1.77	23.2	-5.3	19.4	-4.8	20.2
18	24.70	24.7	0.761	0.288	0.0	24.7	0.0	24.7	-0.8	23.9	0.00	24.7	-1.7	23.0	0.0	24.7
19	24.59	24.7	1.25	1.16	-17.4	7.2	-10.5	14.1	-2.9	21.7	-2.61	22.1	-17.8	6.8	-10.2	14.5
20	25.00	25.1	1.04	1.33	-7.6	17.5	**	**	-2.1	22.9	-3.21	21.9	-6.5	18.5	**	**

\*\*=1dB of SAR margin not achievable due to baseline SAR



➤ Thank You