# COMPLIANCE SUMMARY REPORT

**Applicant Name:**

LG Electronics U.S.A., Inc.
111 Sylvan Avenue, North Building
Englewood Cliffs, NJ 07632
United States

**Test Site/Location:**
PCTEST Lab, Columbia, MD, USA
**Document Serial No.:**
1M2004230076-18.ZNF

| | |
|---|---|
| **FCC ID:** | **ZNFG900VM** |
| **APPLICANT:** | **LG ELECTRONICS U.S.A., INC.** |

**Report Type:** Compliance Summary
**DUT Type:** Portable Handset
**Model:** LM-G900VM
**Additional Model(s):** LMG900VM, G900VM, LM-G900QM6, LMG900QM6, G900QM6, LM-G902V, LMG902V, G902V

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# 1 STRATEGY FOR COMPLIANCE DEMONSTRATION

## 1.1 RF Exposure Evaluation Strategy

The FCC RF exposure limits defined based on time-averaged RF exposure. The device under test (DUT) uses the Qualcomm Smart Transmit feature to control and manage transmitting power in real time and to ensure at all times the time-averaged RF exposure is in compliance with the FCC requirement for 2G/3G/4G/5G NR operations. Additionally, this device supports WLAN/BT/NFC//WMC technologies but the output power of these modems is not controlled by the smart transmit algorithm.

Demonstrating compliance of DUT enabled with Qualcomm Smart Transmit feature is completed in three parts:

0. **RF Exposure Compliance Test Report Part 0: SAR Characterization and PD Characterization**

   The SAR and PD Characterization, denoted as SAR Char and PD Char, determines the power limit that meets FCC exposure requirement after accounting for device design related uncertainties for each supported radio configuration and RF exposure usage scenario. The determined power limits will be loaded and stored in the EUT via the Embedded File System (EFS), and then used as inputs for Smart Transmit to operate.

   For 2G/3G/4G/5G Sub6, SAR Char is derived from SAR test measurements and conducted power measurements to determine $P_{Limit}$ for each technology/band. For 5G mmW NR, PD Char is derived using simulation in combination with measurement as validation to determine the *input.power.limit* for each radio/antenna configuration (each beam). The $P_{Limit}$ and *input.power.limit* represents the maximum time-averaged power level for the corresponding radio/antenna configuration.

1. **RF Exposure Compliance Test Report Part 1: Test in Static Transmission Condition**

   Part 1 demonstrates that DUT meets FCC SAR and PD limits when transmitting at pre-determined maximum time-averaged power level: $P_{Limit}$ for 2G/3G/4G/5G Sub6 NR and *input.power.limit* for 5G mmW NR. The SAR and PD measurement in Part 1 is under static transmission condition.

   The compliance for WLAN/BT radio is demonstrated at a fixed power level (fixed = maximum RF tune-up level or power-back off level).

   The exposure from the simultaneous transmission of WWAN and WLAN/BT is evaluated in Part 1 report.

2. **RF Exposure Compliance Test Report Part 2: Test in Dynamic Transmission Condition**

   Part 2 demonstrates compliance in Tx varying transmission conditions and validates Qualcomm Smart Transmit algorithm. The test results reported in Part 2 demonstrates that DUT complies with FCC RF exposure requirement under Tx varying transmission scenarios, thereby validity of Qualcomm Smart Transmit algorithm.

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## 1.2    Nomenclature

| Applicable Technologies | Term | Description |
|---|---|---|
| 2G/3G/4G/5G Sub6 | $P_{Limit}$ | Power level that corresponds to the exposure design target (*SAR_design_target)* after accounting for all device design related uncertainties |
| | $P_{Max}$ | Maximum tune up output power |
| | $T_{SAR}$ | Defined time averaging window for $f$ < 6 GHz |
| | *SAR_design_target* | Target SAR level resulting in maximum time-averaged exposure optimized from total uncertainty |
| | *SAR Char* | Table containing *Plimit* for all technologies |
| 5G mmW NR | *input.power.limit* | Power level at antenna element for each beam corresponding to the exposure design target (*PD_design_target*) |
| | $T_{PD}$ | Defined time averaging window for $f$ > 6 GHz |
| | *PD_design_target* | Target PD level resulting in maximum time-averaged exposure optimized from total uncertainty |
| | *PD Char* | Table containing *input.power.limit* for all beams |
| 2G/3G/4G/5G Sub6/5G mmW NR | *regulatory body* | Regulatory body that the algorithm is designed to comply. Algorithm's time averaging window is dependent on either FCC or ICNIRP requirements. |
| | *reserve_power_margin* | Margin below $P_{Limit}$ reserved for future transmission |
| | $P_{reserve}$ | Minimum transmit power with a designated margin below $P_{Limit}$ |

## 1.3    Bibliography

| Report Type | Report Serial Number |
|---|---|
| SAR Evaluation Report (Part 1) | 1M2004230076-01-R1.ZNF |
| PD Evaluation Report (Part 1) | 1M2004230076-16-R1.ZNF |
| SAR Evaluation Report (Part 0) | Rev. F |
| PD Evaluation Report (Part 0) | Rev. A (Ver. 1.0) |
| RF Exposure Part 2 Test Report | 1M2004230076-17.ZNF |
| PD Simulation Report | Rev. A (Ver. 1.6) |

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## 2       TIME AVERAGING ALGORITHM

### 2.1      Algorithm Description

The FCC RF exposure limit is defined based on time-averaged RF exposure. When running in a wireless device, Qualcomm Smart Transmit algorithm enables more elegant power control mechanisms for RF exposure management. It ensures at all times the wireless device is in compliance with the FCC limit of RF exposure time-averaged over a defined time window, denoted as $T_{SAR}$ and $T_{PD}$ for specific absorption rate (SAR for transmit frequency < 6 GHz) and power density (PD for transmit frequency > 6 GHz) time windows, respectively.

The Smart Transmit algorithm not only ensures the wireless device complies with RF exposure requirement, but also improves the user experience and network performance.

For a given wireless device, RF exposure is proportional to the transmitting power.

- Once the SAR and PD of the wireless device is characterized at a transmit power level, RF exposure at a different power level for the characterized configurations can be scaled by the change in the corresponding power level.

- Therefore, for a characterized device, RF exposure compliance can be achieved through transmit power control and management.

The Smart Transmit algorithm embedded in Qualcomm modems reliably controls the transmit power of the wireless device in real time to maintain the time-averaged transmit power, in turn, time-averaged RF exposure, below the predefined time-averaged power limit for each characterized technology and band.

- This predefined time-averaged power limit is denoted as $P_{Limit}$ corresponding SAR limit (frequency < 6 GHz) and *input.power.limit* corresponding PD limit (frequency > 6 GHz) in this report.

- The wireless device continuously transmitting at $P_{Limit}$ level or *input.power.limit* level complies with the FCC RF exposure requirement.

In a simultaneous transmission scenario, the algorithm manages all active transmitters and make sure the total exposure ratio from each transmitter not exceeding to 1.

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## 2.2　Basic concept of the algorithm

The Smart Transmit algorithm controls and manages the instantaneous transmit power (Tx) to maintain the time-averaged Tx power and therefore, time-averaged RF exposure in compliance with FCC limits.

- If time-averaged transmit power approaches $P_{Limit}$ or *input.power.limit*, then the modem needs to limit instantaneous transmit power to ensure the time-averaged transmit power does not exceed $P_{Limit}$ or *input.power.limit* in any $T_{SAR}$ and $T_{PD}$ time windows since the time-averaged RF exposure is required to comply with the FCC RF exposure limit in any $T_{SAR}$ or $T_{PD}$ time window.

- The wireless device can instantaneously transmit at high transmit powers and exceed the $P_{Limit}$ or *input.power.limit* level for a short duration before limiting the power to maintain the time-averaged transmit power under $P_{Limit}$ or *input.power.limit*.

- If the wireless device transmits at high power for a long time, then the radio link needs to be dropped to be compliant with time-averaged Tx power requirement (see Figure 2-1).

- To avoid dropping the radio link, Smart Transmit algorithm starts the power limiting enforcement earlier in time to back off the Tx power to a reserve level (denoted as $P_{reserve}$), so the wireless device can maintain the radio link at a minimum reserve power level for as long as needed, and at the same time ensure the time-averaged Tx power over any defined time window is less than $P_{Limit}$ at all times (see Figure 2-2). At all times, Smart Transmit meets the below equation:

$$time.avg.Tx\ power = \frac{1}{T_{SAR}} \int_{t-T_{SAR}}^{t} inst.Tx\ power(t)\ dt \le P_{limit}$$
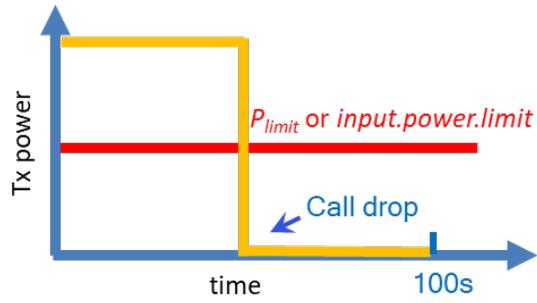
**Equation 2-1**

where, $time.avg.Tx\ power$ is the transmit power averaged between $t\text{-}T_{SAR}$ and $t$ time period; $T_{SAR}$ is the time window defined by FCC for time-averaging RF exposure for Tx frequency less than 6GHz (sub6); *inst. Tx power (t)* is the instantaneous transmit power at $t$ time instant; $P_{Limit}$ is the predefined time-averaged power limit. Similarly, Smart Transmit meets the below equation for mmW transmission:

$$mmW\_time.avg.Tx\ power = \frac{1}{T_{PD}} \int_{t-T_{PD}}^{t} mmW\_Tx\ power(t)\ dt \le input.power.limit$$

**Equation 2-2**

where, $mmW\_time.avg.Tx\ power$ is the mmW transmit power averaged between $t\text{-}T_{PD}$ and $t$ time period; $T_{PD}$ is the time window defined by FCC for time-averaging RF exposure for mmW bands; *mmW_Tx power (t)* is the instantaneous mmW transmit power at $t$ time instant; $input.power.limit$ is the predefined time-averaged power limit for the beam under test.

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**Figure 2-1**
**Transmit at high power when needed and permitted**
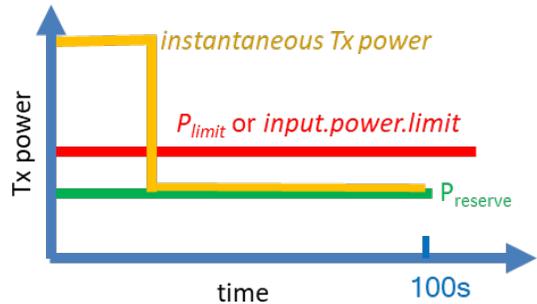


**Figure 2-2**
**Transmit with reserve power to support continuous transmission at a minimum power level ($P_{reserve}$)**

- In the case of simultaneous transmission, Smart Transmit manages all active transmitters and make sure the total exposure ratio is less than 1

$$\sum \frac{\frac{1}{T_{SAR}} \int_{t-T_{SAR}}^{t} SAR(t)\, dt}{FCC\ SAR\ limit} + \sum \frac{\frac{1}{T_{PD}} \int_{t-T_{psPD}}^{t} 4cm^2 psPD(t)\, dt}{FCC\ psPD\ limit} \leq 1$$

**Equation 2-3**

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## 2.3    Configurable Parameters

The following input parameters are required for functionality of Qualcomm Smart Transmit algorithm. These parameters cannot be accessed by the end user, because at the factory they are entered through the embedded file system (EFS) entries by the OEM

| Input Parameter | Description |
|---|---|
| *regulatory body* | • Inputs of "0" and "1" corresponding to FCC and ICNIRP requirements for the averaging time windows.<br>• For FCC, algorithm uses an averaging window of 100 seconds for $f < 3$ GHz, 60 seconds for 3 GHz $< f <$ 6 GHz, and 4 seconds for 24 GHz $< f <$ 42 GHz. |
| *Tx_power_at_SAR_design_target*<br>(P$_{Limit}$ *in dBm*)<br>*f* < 6 GHz | The maximum time-averaged transmit power, in dBm, corresponding to the *SAR_design_target*.<br><br>*SAR_design_target* is pre-determined for this DUT and it is less than regulatory SAR limit after accounting for all design related tolerances. The time-averaged SAR is assessed against this *SAR_design_target* in real time to determine the compliance.<br><br>$P_{Limit}$ could vary with technology, band and Device State Index (DSI) and therefore, it has the unique value for each technology, band and DSI. |
| *reserve_power_margin*<br>(P$_{reserve}$ *in dBm*) | The margin below $P_{Limit}$ reserved for future transmission with a minimum transmit power $P_{reserve}$<br><br>$$P_{reserve}\,(\text{dBm}) = P_{limit}\,(\text{dBm}) - Reserve\_power\_margin\,(\text{dB})$$<br><br>When the *Reserve_power_margin* is set to 0 dB, Smart Transmit effectively limits the upper bound of the transmit power to $P_{limit}$ and the DUT transmits continuously at $P_{limit}$ without utilizing Smart Transmit dynamic control feature. |
| *input.power.limit* in *dBm*<br>*f* ≥ 6 GHz | Maximum time-averaged power at the input of antenna element port at which each antenna configuration/beam meets *PD_design_target.* |

# 3    DUT DESCRIPTION

## 3.1    Device Overview

| Band & Mode | Operating Modes | Tx Frequency |
|---|---|---|
| GSM/GPRS/EDGE 850 | Voice/Data | 824.20 - 848.80 MHz |
| GSM/GPRS/EDGE 1900 | Voice/Data | 1850.20 - 1909.80 MHz |
| UMTS 850 | Voice/Data | 826.40 - 846.60 MHz |
| UMTS 1900 | Voice/Data | 1852.4 - 1907.6 MHz |
| Cell. CDMA/EVDO | Voice/Data | 824.70 - 848.31 MHz |
| PCS CDMA/EVDO | Voice/Data | 1851.25 - 1908.75 MHz |
| LTE Band 12 | Voice/Data | 699.7 - 715.3 MHz |
| LTE Band 13 | Voice/Data | 779.5 - 784.5 MHz |
| LTE Band 5 (Cell) | Voice/Data | 824.7 - 848.3 MHz |
| LTE Band 66 (AWS) | Voice/Data | 1710.7 - 1779.3 MHz |
| LTE Band 4 (AWS) | Voice/Data | 1710.7 - 1754.3 MHz |
| LTE Band 2 (PCS) | Voice/Data | 1850.7 - 1909.3 MHz |
| LTE Band 48 | Voice/Data | 3552.5 - 3697.5 MHz |
| NR Band n5 (Cell) | Data | 826.5 - 846.5 MHz |
| NR Band n66 (AWS) | Data | 1712.5 - 1777.5 MHz |
| NR Band n2 (PCS) | Data | 1852.5 - 1907.5 MHz |
| NR Band n260 | Data | 37000 - 40000 MHz |
| NR Band n261 | Data | 27500 - 28350 MHz |
| 2.4 GHz WLAN | Voice/Data | 2412 - 2462 MHz |
| U-NII-1 | Voice/Data | 5180 - 5240 MHz |
| U-NII-2A | Voice/Data | 5260 - 5320 MHz |
| U-NII-2C | Voice/Data | 5500 - 5720 MHz |
| U-NII-3 | Voice/Data | 5745 - 5825 MHz |
| Bluetooth | Data | 2402 - 2480 MHz |
| NFC | Data | 13.56 MHz |
| WMC | Data | 500 Hz - 4 KHz |

This device uses the Qualcomm Smart Transmit feature to control and manage transmitting power in real time and to ensure at all times the time-averaged RF exposure is in compliance with the FCC requirement for 2G/3G/4G/5G operations. Additionally, this device supports WLAN/BT/NFC/WMC technologies, but the output power of these modems is not controlled by the smart transmit algorithm.

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# 4     COMPLIANCE SUMMARY

## 4.1     RF Exposure Compliance Summary

All transmission scenarios that the DUT supports comply with FCC time-averaged RF exposure requirements, as shown in Table 4-1.

**Table 4-1**
**Reported RF Exposure Levels**

|  | RFx Evaluation | Power Level | FCC Limit | *Reported* RF Exposure Level | Test Report |
|---|---|---|---|---|---|
| **SAR (W/kg)** | Standalone 1g SAR | $P_{limit}$ | 1.6 | 1.19 | FCC SAR Evaluation Report (Part 1) |
|  | Standalone 10g SAR | $P_{limit}$ | 4.0 | 3.09 |  |
|  | Simultaneous Tx 1g SAR | $P_{limit}$ | 1.6 | 1.59 |  |
|  | Simultaneous Tx 10g SAR | $P_{limit}$ | 4.0 | 3.94 |  |
| **psPD (mW/cm$^2$)** | 4cm$^2$ psPD | *input.power.limit* | 1.0 | 0.75 | FCC PD Evaluation Report (Part 1) |
| **TER** | Total Exposure Ratio | $P_{limit}$ for SAR, *input.power.limit* for psPD | 1.0 | 0.975 | FCC PD Evaluation Report (Part 1) |

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