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COMPLIANCE SUMMARY REPORT

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FCC ID:	**A3LSMH204V**
APPLICANT:	**SAMSUNG ELECTRONICS CO., LTD**

Report Type:	Compliance Summary
DUT Type:	Customer Premise Equipment (CPE)
Model:	SM-H204V

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1 STRATEGY FOR COMPLIANCE DEMONSTRATION

1.1 RF Exposure Evaluation Strategy

The FCC RF exposure limits are defined based on time-averaged RF exposure. Therefore, to demonstrate the compliance, the maximum time-averaged exposure needs to be below the corresponding limits.
Since Qualcomm CPE is under FCC “mobile” device category. The power density assessment is performed at 20 cm separation distance based on FCC 47 CFR 2.1091, and point PD should be applied throughout this RF exposure assessment package as the PD exposure for each radio is evaluated using Friis transmission equation regardless of operating frequency range (i.e., $f > 6$ GHz or $f < 6$ GHz).
Demonstrating compliance of Qualcomm CPE with Qualcomm Smart Transmit feature is completed in three parts:

Part 0. RF Exposure Compliance Test Report Part 0: PD Characterization

Part 0 report determines device design related total uncertainty for each radio supported, and then derive the *PD_design_target*. The resulted *PD_design_target* is less than FCC regulatory PD limit after accounting for device design related uncertainty.The PD Characterization determines the *input.power.limit* corresponding to PD design target for each radio configuration and RF exposure usage scenario. The *input.power.limit* represents the maximum time-averaged power level for the corresponding radio/antenna configuration. The determined input power limits will be loaded and stored in a wireless device via the Embedded File System (EFS), and then used as inputs for Smart Transmit to operate. For f < 6 GHz radios, using Friis transmission equation to calculate the *input.power.limit*, denoted as *Plimit* for f < 6 GHz radios, per technology/band/antenna/exposure scenario for a given antenna gain. For mmW NR, demonstrate the compliance via the validated simulation approach. Using the validated simulation approach to obtain the simulated array gain (antenna array gain + power amplifier array gain) for each beam supported, then derive input power limit for each beam, denoted as *input.power.limit* for mmW NR, using Friis transmission equation. The simulation is validated and the resulted *input.power.limit* corresponds to mmW NR PD design target which is less than FCC PD limit, thus, all the supported beams are in compliance with FCC PD limit.

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

The purpose of Part 1 test is to demonstrate that the EUT meets FCC PD limits when transmitting in static transmission scenario at maximum allowable time-averaged power levels (i.e., *Plimit* for sub-6 radio, and *input.power.limit* for mmW NR), or maximum RF tune-up power levels if they are lower than maximum allowable time-averaged power levels. For f < 6 GHz radios, measure conducted power at each supported antenna port for all the radio configurations required in the existing FCC KDB procedures, determine PD characterization using Friis transmission equation based on measured conducted power and antenna gain. For mmW NR, the compliance demonstration is done in the Part 0 report. In Part 1 report, PD measurement on a few of selected beams is performed for further verification.
NOTE: Note if the device supports radio(s) that is not controlled by Smart Transmit, the RF exposure assessment for simultaneous transmission containing non-Smart Transmit supported radio(s) is also conducted in Part 1 report.

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

The purpose of Part 2 report is to demonstrate the EUT complies with FCC RF exposure requirement under Tx varying transmission scenarios, thereby validity of Qualcomm Smart Transmit feature for FCC equipment authorization.

1.2 Nomenclature

Applicable Technologies	Term	Description
4G/5G Sub6	P_{Limit}	Power level that corresponds to the exposure design target (*SAR(or PD)_design_target)* after accounting for all device design related uncertainties
	P_{Max}	Maximum tune up output power
	$T_{SAR\ (or\ PD)}$	Defined time averaging window for $f < 6$ GHz
	SAR(or PD)_design_target	Target SAR (or PD) level resulting in maximum time-averaged exposure optimized from total uncertainty
	SAR (or PD) 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
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
MPE Report for Frequencies < 6 GHz (Part 1)	1M2004140062-01.A3L
MPE Report for Frequencies > 6 GHz (Part 1)	1M2004140062-18.A3L
RF Exposure Part 0 Test Report	1M2004140062-20.A3L
RF Exposure Part 2 Test Report	80-W5691-12

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.

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:

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

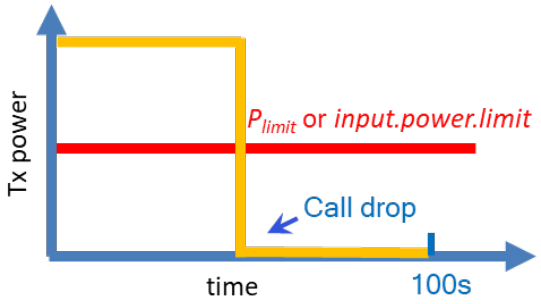
Equation 2-1

where, $time.avg.Tx\ power$ is the transmit power averaged between t-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:

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

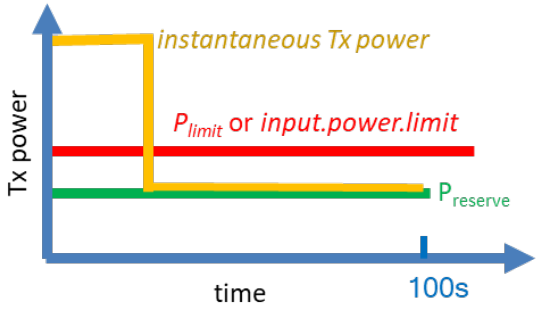
Equation 2-2

where, $mmW\_time.avg.Tx\ power$ is the mmW transmit power averaged between t-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.



(a)

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



(b)

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

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. • 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 (P_{Limit} *in dBm)* *f* < 6 GHz	The maximum time-averaged transmit power, in dBm, corresponding to the *SAR_design_targe*t. *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. 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 ($P_{reserve}$ *in dBm)*	The margin below P_{Limit} reserved for future transmission with a minimum transmit power $P_{reserve}$ $P_{reserve}\,(\mathrm{dBm}) = P_{limit}\,(\mathrm{dBm}) - Reserve\_power\_margin\,(\mathrm{dB})$ 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* *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
LTE Band 13	Data	779.5 - 784.5 MHz
LTE Band 5 (Cell)	Data	824.7 - 848.3 MHz
LTE Band 66 (AWS)	Data	1710.7 - 1779.3 MHz
LTE Band 4 (AWS)	Data	1710.7 - 1754.3 MHz
LTE Band 2 (PCS)	Data	1850.7 - 1909.3 MHz
LTE Band 48	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
2.4 GHz WLAN	Data	2412 - 2462 MHz
U-NII-1	Data	5180 - 5240 MHz
U-NII-2A	Data	5260 - 5320 MHz
U-NII-2C	Data	5500 - 5720 MHz
U-NII-3	Data	5745 - 5825 MHz
Bluetooth	Data	2402 - 2480 MHz
NR Band n260	Data	37000 - 40000 MHz
NR Band n261	Data	27500 - 28350 MHz

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 4G/5G operations. Additionally, this device supports WLAN/BT technologies, but the output power of these modems is not controlled by the smart transmit algorithm.

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
psPD (mW/cm²)	4cm² psPD for f < 6 GHz	P_{limit}	10*f/1.5 (f in GHz)	0.16	FCC MPE Report for Frequencies < 6 GHz (Part 1)
psPD (mW/cm²)	4cm² psPD for f > 6 GHz	*input.power.limit*	1.0	0.51	FCC MPE Report for Frequencies > 6 GHz (Part 1)
Simultaneous Tx	Normalized Exposure Ratio	P_{limit} for SAR, *input.power.limit* for psPD	1.0	0.92	FCC MPE Report for Frequencies < 6 GHz (Part 1)