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COMPLIANCE SUMMARY REPORT

Applicant Name:
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Test Site/Location:
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Element, Morgan Hill, CA, USA
Element, Suwon
Document Serial No.:
1M2408260067-26.A3L

FCC ID:	**A3LSMS938U**
APPLICANT:	**SAMSUNG ELECTRONICS CO., LTD**

Report Type: Compliance Summary
DUT Type: Portable Handset
Model: SM-S938U
Additional Model(s): SM-S938U1

ilac-MRA

A2LA ACCREDITED
CERT #2041.01

FCC ID: A3LSMS938U	COMPLIANCE SUMMARY REPORT	Approved by: Technical Manager
Document S/N: 1M2408260067-26.A3L	DUT Type: Portable Handset	Page 1 of 10

REV 1.1
04/11/2022

TABLE OF CONTENTS

FCC ID: A3LSMS938U	COMPLIANCE SUMMARY REPORT	Approved by: Technical Manager
Document S/N: 1M2408260067-26.A3L	**DUT Type:** Portable Handset	Page 2 of 10

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 Gen2 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, WLAN, and Bluetooth operations. Additionally, this device supports NTN/UWB and NFC non Smart Tx Radio 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, WLAN, and Bluetooth, 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, WLAN, and Bluetooth, and *input.power.limit* for 5G mmW NR. The SAR and PD measurement in Part 1 is under static transmission condition.

The exposure from the simultaneous transmission of WWAN and WLAN/BT is evaluated in Part 2 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.

FCC ID: A3LSMS938U	COMPLIANCE SUMMARY REPORT	Approved by: Technical Manager
Document S/N: 1M2408260067-26.A3L	DUT Type: Portable Handset	Page 3 of 10

REV 1.1
04/11/2022

1.2   Nomenclature

Applicable Technologies	Term	Description
2G/3G/4G/5G Sub6/WLAN/BT	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/WLAN/BT	$regulatory\ body$	Regulatory body that the algorithm is designed to comply. Algorithm's time averaging window is dependent on either FCC or ICNIRP requirements.

1.3   Bibliography

Report Type	Report Serial Number
RF Exposure Part 1 Test Report	1M2408260067-23.A3L
PD Part 1 Test Report	1M2408260067-25.A3L
RF Exposure Part 0 Test Report	1M2408260067-31.A3L
PD Part 0 Test Report	
RF Exposure Part 2 Test Report	1M2408260067-24.A3L

FCC ID: A3LSMS938U	COMPLIANCE SUMMARY REPORT	Approved by: Technical Manager
Document S/N: 1M2408260067-26.A3L	DUT Type: Portable Handset	Page 4 of 10

REV 1.1
04/11/2022

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.

FCC ID: A3LSMS938U	COMPLIANCE SUMMARY REPORT	Approved by: Technical Manager
Document S/N: 1M2408260067-26.A3L	DUT Type: Portable Handset	Page 5 of 10

REV 1.1
04/11/2022

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.
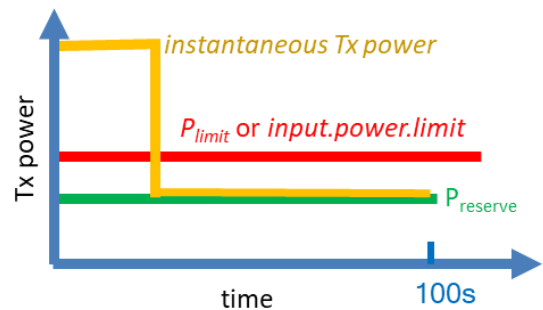
FCC ID: A3LSMS938U	COMPLIANCE SUMMARY REPORT	Approved by: Technical Manager
Document S/N: 1M2408260067-26.A3L	**DUT Type:** Portable Handset	Page 6 of 10

REV 1.1
04/11/2022
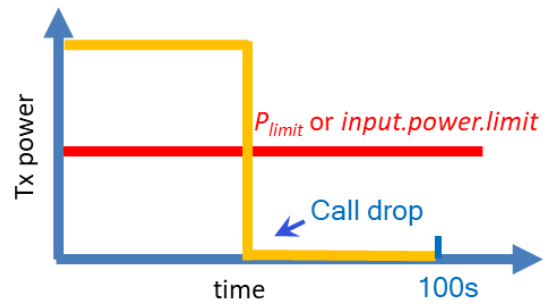
Figure 2-1
Transmit at high power when needed and permitted

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

FCC ID: A3LSMS938U	COMPLIANCE SUMMARY REPORT	Approved by: Technical Manager
Document S/N: 1M2408260067-26.A3L	DUT Type: Portable Handset	Page 7 of 10

REV 1.1
04/11/2022

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_target*. *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.
input.power.limit in *dBm* $f \geq 6$ GHz	Maximum time-averaged power at the input of antenna element port at which each antenna configuration/beam meets *PD_design_target.*

FCC ID: A3LSMS938U	COMPLIANCE SUMMARY REPORT	Approved by: Technical Manager
Document S/N: 1M2408260067-26.A3L	DUT Type: Portable Handset	Page 8 of 10

REV 1.1
04/11/2022

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 1750	Voice/Data	1712.4 - 1752.6 MHz
UMTS 1900	Voice/Data	1852.4 - 1907.6 MHz
LTE Band 71	Voice/Data	665.5 - 695.5 MHz
LTE Band 12	Voice/Data	699.7 - 715.3 MHz
LTE Band 13	Voice/Data	779.5 - 784.5 MHz
LTE Band 14	Voice/Data	790.5 - 795.5 MHz
LTE Band 26	Voice/Data	814.7 - 848.3 MHz
LTE Band 5	Voice/Data	824.7 - 848.3 MHz
LTE Band 66	Voice/Data	1710.7 - 1779.3 MHz
LTE Band 4	Voice/Data	1710.7 - 1754.3 MHz
LTE Band 25	Voice/Data	1850.7 - 1914.3 MHz
LTE Band 2	Voice/Data	1850.7 - 1909.3 MHz
LTE Band 30	Voice/Data	2307.5 - 2312.5 MHz
LTE Band 7	Voice/Data	2502.5 - 2567.5 MHz
LTE Band 41	Voice/Data	2498.5 - 2687.5 MHz
LTE Band 38	Voice/Data	2572.5 - 2617.5 MHz
LTE Band 48	Voice/Data	3552.5 - 3697.5 MHz
NR Band n71	Voice/Data	665.5 - 695.5 MHz
NR Band n12	Voice/Data	701.5 - 713.5 MHz
NR Band n14	Voice/Data	790.5 - 795.5 MHz
NR Band n26	Voice/Data	816.5 - 846.5 MHz
NR Band n5	Voice/Data	826.5 - 846.5 MHz
NR Band n70	Voice/Data	1697.5 - 1707.5 MHz
NR Band n66	Voice/Data	1712.5 - 1777.5 MHz
NR Band n25	Voice/Data	1852.5 - 1912.5 MHz
NR Band n2	Voice/Data	1852.5 - 1907.5 MHz
NR Band n30	Voice/Data	2307.5 - 2312.5 MHz
NR Band n7	Voice/Data	2502.5 - 2567.5 MHz
NR Band n41	Voice/Data	2501.01 - 2685 MHz
NR Band n38	Voice/Data	2575 - 2615 MHz
NR Band n48	Voice/Data	3555 - 3694.98 MHz
NR Band n78	Voice/Data	3455.01 - 3544.98 MHz; 3705 - 3795 MHz
NR Band n77	Voice/Data	3455.01 - 3544.98 MHz; 3705 - 3975 MHz
NTN Band 255	Data	1629 - 1658 MHz
NR Band n258	Data	24250 - 24450 MHz; 24750 - 25250 MHz
NR Band n260	Data	37000 - 40000 MHz
NR Band n261	Data	27500 - 28350 MHz
2.4 GHz WIFI	Voice/Data	2412 - 2462 MHz
5 GHz WIFI	Voice/Data	U-NII-1: 5180 - 5240 MHz U-NII-2A: 5260 - 5320 MHz U-NII-2C: 5500 - 5720 MHz U-NII-3: 5745 - 5825 MHz U-NII-4: 5845 - 5885 MHz
6 GHz WIFI	Voice/Data	U-NII-5: 5935 - 6415 MHz U-NII-6: 6435 - 6515 MHz U-NII-7: 6535 - 6875 MHz U-NII-8: 6895 - 7115 MHz
2.4 GHz Bluetooth	Data	2402 - 2480 MHz
NFC	Data	13.56 MHz
UWB	Data	6489.6 - 7987.2 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 2G/3G/4G/5G/WLAN/Bluetooth operations. Additionally, this device supports NFC/UWB/NTN technologies but the output power of these modems is not controlled by the smart transmit algorithm.

FCC ID: A3LSMS938U	COMPLIANCE SUMMARY REPORT	Approved by: Technical Manager
Document S/N: 1M2408260067-26.A3L	**DUT Type:** Portable Handset	Page 9 of 10

REV 1.1
04/11/2022

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	1.26	FCC SAR Evaluation Report (Part 1)
	Standalone 10g SAR	P_{limit}	4.0	2.80	
	Simultaneous Tx 1g SAR	P_{limit}	1.6	1.59	
	Simultaneous Tx 10g SAR	P_{limit}	4.0	1.87	
psPD (mW/cm²)	Standalone 4cm² psPD	*input.power.limit*	1.0	0.891	FCC PD Evaluation Report (Part 1)
	Simultaneous Tx 4cm² psPD	*input.power.limit*	1.0	0.895	FCC SAR Evaluation Report (Part 1)
TER	Total Exposure Ratio	P_{limit} for SAR, *input.power.limit* for psPD	1.0	0.996	FCC SAR Evaluation Report (Part 1)

FCC ID: A3LSMS938U	COMPLIANCE SUMMARY REPORT	Approved by: Technical Manager
Document S/N: 1M2408260067-26.A3L	DUT Type: Portable Handset	Page 10 of 10

REV 1.1
04/11/2022