FCC 47 CFR § 2.1093
IEEE Std 1528-2013

RF EXPOSURE SUMMARY REPORT

FOR

WCDMA/LTE/5G NR Laptop + BT/BLE, DTS/UNII a/b/g/n/ac/ax

MODEL NUMBER: NP545XLA, NP545XLA-KA1TT, NP545XLA-KA1VZ

FCC ID: A3LNP545XLA

REPORT NUMBER: 4789893923-S1V1

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Testing Laboratory

TL-637

Revision History

Rev.	Date	Revisions	Revised By
V1	6/14/2021	Initial Issue	--

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1. Attestation of Test Results

Applicant Name	SAMSUNG ELECTRONICS CO.,LTD.		
FCC ID	A3LNP545XLA		
Model Number	NP545XLA, NP545XLA-KA1TT, NP545XLA-KA1VZ		
Applicable Standards	FCC 47 CFR § 2.1093 IEEE Std 1528-2013 IEC TR 63170-2018 Published RF exposure KDB procedures		
Exposure Category	SAR Limits (W/Kg) Peak spatial-average (1g of tissue)	Power Density Limits (mW/cm^2) 4cm^2 psPD	TER limits (Total Exposure Ratio)
General population / Uncontrolled exposure	1.6	1.0	1.0
RF Exposure Conditions	The Highest Reported RF Exposure Level		
Standalone - 1g (W/kg)	1.25		
Standalone – 4cm^2 psPD (mW/cm^2)	0.75		
Simultaneous Tx – 1g (W/kg)	1.56		
Simultaneous Tx TER (Total Exposure Ratio)	0.98		
Test Results	Pass		

UL Korea, Ltd. tested the above equipment in accordance with the requirements set forth in the above standards. All indications of Pass/Fail in this report are opinions expressed by UL Korea, Ltd. based on interpretations and/or observations of test results. Measurement Uncertainties were not taken into account and are published for informational purposes only. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

Note: The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. This document may not be altered or revised in any way unless done so by UL Korea, Ltd. and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL Korea, Ltd. will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by IAS, any agency of the Federal Government, or any agency of any government.

This test report contains SAR measurements to support a Permissive Change application that only affect specific exposure conditions for the GSM 1900 cellular operations. The tables in sections 1 and 1.1 below, and data used for the simultaneous analysis in section 13, for the operating bands and modes not detailed in this report have been taken directly from the test report submitted to support the original filing for device certification.

Approved & Released By:	Prepared By:
	
Justin Park Operations Leader UL Korea, Ltd. Suwon Laboratory	Sunghoon Kim Engineer UL Korea, Ltd. Suwon Laboratory

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2. Strategy for Compliance Demonstration

2.1. 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 3G/4G/5G NR operations. Additionally, this device supports WLAN/BT 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, denote as SAR Char and PD Char, determines the power limit that meets FCC exposure requirement after accounting for device 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 Embeded File System (EFS), and then used as inputs for Smart Transmit to operate.

For 3G/4G/5G Sub6 NR, SAR Char is deriverd 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 Conditiuon

Part 1 demonstrate that DUT meets FCC SAR and PD limits when transmitting at pre-determined maximum time-averaged power level: P_{limit} for 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 Conditiuon

Part 2 demonstrates compliance in Tx varying transmission conditons 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 scenatios, thereby validity of Qualcomm Smart Transmit algorith,.

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2.2. Nomenclature

Supported Technologies	Term	Description
2G/3G/4G/5G Sub6 NR	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 P_{limit} 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 NR & 5G mmW NR	*regulatory body*	Regulatory body that the algorithm is designed to comply. Algorithm's time averaging window is dependent on either FCC ot 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}

2.3. Report Compositions

Report Type	Report name
RF Exposure Summary	4789893923 -S1 FCC Report_RF exposure Summary
SAR Report_Part.0	4789893923 -S1 FCC Report SAR_Part 0
SAR Report_Part.1	4789893923 -S1 FCC Report SAR_Part 1
Power Density Report_Part.0	4789893923-S2 FCC Report PD_Part 0
Power Density Report_Part.1	4789893923-S2 FCC Report PD_Part 1
Power Density Simulation Report	Power Density Simulation Report (Part_0)_ A3LNP545XLA
RF exposure Report_Part.2	4789893923-S1 FCC Report RF exposure_Part 2

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3. Time Averaging Algorithm

3.1. 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 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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3.2. 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.

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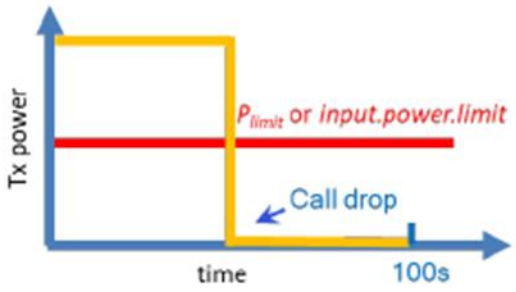
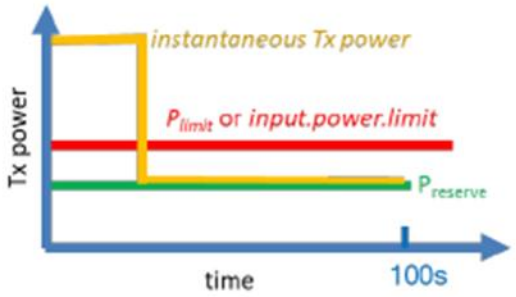


(a)

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

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3.3. 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.*

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4. DUT Description

Wireless technologies	Frequency bands	Operating mode	Duty Cycle used for SAR testing
W-CDMA (UMTS)	Band II Band IV Band V	UMTS Rel. 99 (Voice & Data) HSDPA (Category 14) HSUPA (Category 6) HSPA+ (DL only)	100%
LTE	FDD Band 2 FDD Band 4 FDD Band 5 FDD Band 7 FDD Band 12 FDD Band 13 FDD Band 14 FDD Band 29 (Rx only) FDD Band 46 (Rx only) FDD Band 66	QPSK 16QAM 64QAM 256QAM Rel. 15 Carrier Aggregation (2 Uplink and 7 Downlinks)	100% (FDD)
	FDD Band 5 (2CC) FDD Band 66 (2CC)		
	Does this device support SV-LTE (1xRTT-LTE)? ☐ Yes ☒ No		
5G NR (Sub 6)	NR Band n2 NR Band n5 NR Band n66 NR Band n77 NR Band n78	DFT-s-ODFM: ■ π/2 BPSK, QPSK, 16QAM, 64QAM, 256QAM CP-ODFM: ■QPSK, 16QAM, 64QAM, 256QAM	100%
5G NR (mmW)	NR Band n261 NR Band n260	DFT-s-ODFM: ■ QPSK, 16QAM, 64QAM CP-ODFM: ■ QPSK, 16QAM, 64QAM	100%
Wi-Fi	2.4 GHz	802.11b 802.11g 802.11n (HT20) 802.11ax (HE20)	SISO mode : 99.4% (802.11b) MIMO mode : 96.4% (802.11g)
	5 GHz	802.11a 802.11n (HT20), 802.11n (HT40) 802.11ac (VHT20), 802.11ac (VHT40), 802.11ac (VHT80) 802.11ax (HE20), 802.11ax (HE40), 802.11ax (HE80),	SISO mode: 96.6% (802.11a) 95.8% (802.11ac VHT80) MIMO mode: 96.7% (802.11a) 92.1% (802.11ac VHT80)
	Does this device support bands 5.60 ~ 5.65 GHz? ☒ Yes ☐ No		
	Does this device support Band gap channel(s)? ☒ Yes ☐ No		
Bluetooth	2.4 GHz	Version 5.0 LE	76.7% (DH5)

Notes:

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

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5. RF Exposure Compliance Summary

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

	RF exposure Evalaution	Power Level	FCC Limit	Highest RF exposure Level	Reference Report
SAR (W/kg)	Standalone 1g	P_{Limit}	1.6	1.25	FCC Report SAR_Part.1
	Simultaneous Tx-1g	P_{Limit}	1.6	1.56	
psPD (mW/cm^2)	$4cm^2$ psPD	*input.power.limit*	1.0	0.75	FCC Report PD_Part.1
TER	Total Exposure Ratio	P_{Limit} & *input.power.limit*	1.0	0.98	FCC Report SAR_Part.1

Notes:

For TER, SAR and PD are spatially separated, so the TER applied the ratio of Simultaneous SAR(1.56 W/kg / 1.60 W/kg).

END OF REPORT

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