Samsung Portable handset

(FCC ID: A3LSMN976V) RF Exposure Compliance Summary Report

Revision A

July 11, 2019

1 Strategy for Compliance Demonstration

The FCC RF exposure limits, i.e., SAR limit and Power Density (PD) limit, 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.

The equipment under test (EUT) is Samsung portable handset (FCC ID: A3LSMN976V), it contains:

1. Qualcomm® SM8150 modem supporting WWAN 2G/3G/4G technologies
2. Qualcomm® SDX50 modem supporting WWAN 5G mmW NR 28GHz and 39GHz bands.
3. WLAN/BT

Both of Qualcomm® SM8150 and SDX50 modems are enabled with Qualcomm® Smart Transmit feature. This feature performs time averaging algorithm in real time to control and manage transmitting power and ensure the time-averaged RF exposure in compliance with FCC requirements all the time. The following section provides the overview of Qualcomm® Smart Transmit.

The WLAN/BT is not enabled with Smart Transmit.

Demonstrating compliance of EUT 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 WWAN radios supported by Samsung portable handset (FCC ID: A3LSMN976V), SAR Char is determined based on SAR test results documented listed below, and 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 input power limit represents the maximum time-averaged power level for the corresponding radio/antenna configuration.

- See Document S/N 1M1905130071-20-R2.A3L: A3LSMN976V Part 0 SAR and PD Char

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

Part 1 test is to demonstrate that EUT meets FCC SAR and PD limits when transmitting at pre-determined maximum time-averaged power level for WWAN radios (i.e., 2G/3G/4G/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.

- See Document S/N 1M1905130071-01-R2.A3L: A3LSMN976V Part 1 SAR Evaluation Report
- See Document S/N 1M1905130071-21-R2.A3L: A3LSMN976V Part 1 Near-Field PD Report

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

   In Part 2 test, the compliance is assessed in Tx varying transmission condition to validate the Qualcomm® Smart Transmit algorithm. The test results reported in Part 2 demonstrates that EUT complies with FCC RF exposure requirement under Tx varying transmission scenarios, thereby validity of Qualcomm Smart Transmit algorithm for FCC equipment authorization of Samsung portable handset (FCC ID: A3LSMN976V).

   - See Document S/N 80-W5681-2 Rev. F: Samsung portable handset (FCC ID: A3LSMN976V) RF Exposure Compliance Test Report, Part 2: Test Under Dynamic Transmission Condition

2 Overview of Qualcomm® Smart Transmit

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 (in turn, time-averaged RF exposure) in compliance with FCC limits.

- If time-averaged transmit power approaches the P_{limit}, then the modem needs to limit instantaneous transmit power to ensure the time-averaged transmit power does not exceed the P_{limit} or *input.power.limit* in any T_{SAR} and T_{PD} time windows (i.e., the time-averaged RF exposure complies with the FCC RF exposure limit in any T_{SAR} or T_{PD} time window).

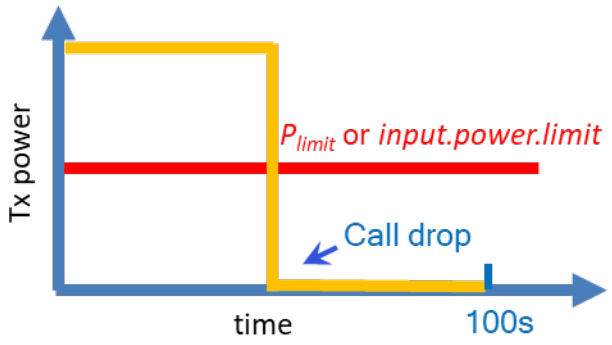
- The wireless device can instantaneously transmit at high transmit powers and exceed the P_{limit} or *input.power.limit* level for a short duration before limiting the power to maintain the time-averaged transmit power under P_{limit} or *input.power.limit*.
- If the wireless device transmits at high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

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

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:

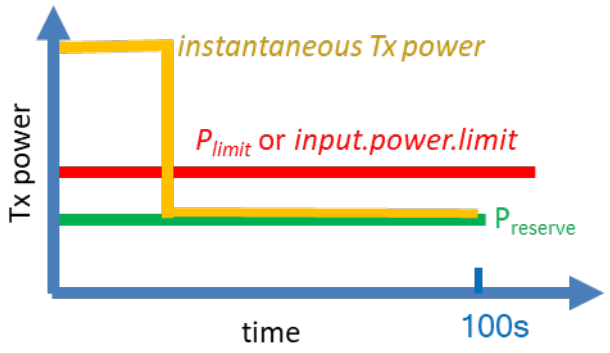
$$mmW\_time.avg.Tx\ power = \frac{1}{T_{PD}} \int_{t-T_{PD}}^{t} mmW\_Tx\ power(t)\, dt \leq input.power.limit$$

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 3-1 Transmit at high power when needed and permitted



(b)

Figure 3-2 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, i.e.,

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

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

- Regulatory body

  The *regulatory body* entry should be filled out with either "0" or "1" to correspond to the FCC or ICNIRP requirement, so that Smart Transmit algorithm can select the appropriate averaging time windows. For FCC, Smart Transmit uses 100 seconds averaging window for transmit frequencies f<3GHz, 60 seconds for 3GHz < f < 6GHz, and 4 seconds for 24GHz < f < 42GHz.

- *Tx_power_at_SAR_design_target* (P_{limit} in dBm) for Tx transmitting frequency < 6GHz

  The maximum time-averaged transmit power, in dBm, at which this radio configuration (i.e., band and technology) reaches the *SAR_design_targe*t. This *SAR_design_target* is pre-determined for the specific device and it shall be 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. The P_{limit} could vary with technology, band and DSI (device state index), therefore it has the unique value for each technology, band and DSI.

- *Reserve_power_margin* (dB)

  The margin, in dB, below the P_{limit} to reserve for future transmission with a minimum transmit power ($P_{reserve}$):

  $P_{reserve}$ (dBm) = P_{limit} (dBm) – *Reserve_power_margin* (dB)

When the *Reserve_power_margin* is set to zero dB, Smart Transmit effectively limits the upper bound of wireless device transmit power to P_{limit}, in other words, the wireless device transmits continuously at P_{limit}, and in this case, Smart Transmit dynamic control feature is not utilized.

- *input.power.limit (*dBm) for Tx transmitting frequency ≥ 6GHz

  The maximum time-averaged power at the input of antenna element port, in dBm, at which each antenna configuration (i.e., each beam) meets the *PD_design_target* that is less than the regulatory power density limit after accounting for all design related tolerances.

3 Product Description

DUT Type: Portable Handset

Model: SM-N976V

Additional Model(s): SM-N976XU

Band & Mode	Operating Modes	Tx Frequency
Cell. CDMA/EVDO	Voice/Data	824.70 - 848.31 MHz
PCS CDMA/EVDO	Voice/Data	1851.25 - 1908.75 MHz
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
LTE Band 12	Voice/Data	699.7 - 715.3 MHz
LTE Band 13	Voice/Data	779.5 - 784.5 MHz
LTE Band 26 (Cell)	Voice/Data	814.7 - 848.3 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 7	Voice/Data	2502.5 - 2567.5 MHz
LTE Band 48	Voice/Data	3552.5 - 3697.5 MHz
LTE Band 41	Voice/Data	2498.5 - 2687.5 MHz
LTE Band 38	Voice/Data	2572.5 - 2617.5 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
ANT+	Data	2402 - 2480 MHz
MST	Data	555 Hz - 8.33 kHz
NR Band n260	Data	37000 - 40000 MHz
NR Band n261	Data	27500 - 28350 MHz

NR Operations Information						
Form Factor	Portable Handset					
Channel Bandwidths per NR Band	NR Band n261: 50MHz, 100MHz					
Channel Bandwidths per NR Band	NR Band n260: 50MHz, 100MHz					
Channel Numbers and Frequencies	Low		Mid		High	
	Channel	Frequency (GHz)	Channel	Frequency (GHz)	Channel	Frequency (GHz)
NR Band n261: 50MHz BW	2071413	27.53484	2077891	27.92352	2084491	28.31952
NR Band n261: 100MHz BW	2071821	27.55932	2077891	27.92352	2084035	28.29216
NR Band n260: 50MHz BW	2229621	37.02732	2254147	38.49888	2278603	39.96624
NR Band n260: 100MHz BW	2230029	37.05180	2254147	38.49888	2278331	39.94992
Subcarrier Spacing (kHz)	120					
Total Number of Supported Uplink CCs (SISO)	UL: 4					
Total Number of Supported Uplink CCs (MIMO)	UL:2					
Modulations Supported in UL	CP-OFDM-QPSK, CP-OFDM-16QAM, CP-OFDM-64QAM					
LTE Anchor Bands	LTE Band 13/5/4/66/2					

4 Compliance Summary

Samsung portable handset (FCC ID: A3LSMN976V) complies with FCC RF exposure requirements.

Table 4-1 *Reported* RF exposure level

	FCC Limit	*Reported* RF Exposure level	Notes
Highest 1g SAR at P_{limit} (W/kg)	1.6	1.17	PCTEST Document S/N: 1M1905130071-01-R2.A3L
Highest 10g SAR at P_{limit} (W/kg)	4.0	3.14	PCTEST Document S/N: 1M1905130071-01-R2.A3L
Highest 4cm^2-avg PD at *input.power.limit* (mW/cm^2)	1.0	0.75	PCTEST Document S/N: 1M1905130071-21-R2.A3L
Highest normalized exposure ratio for simultaneous Tx	1.0	0.999	PCTEST Document S/N: 1M1905130071-21-R2.A3L