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Content Level	BASIC		INTERMEDIATE		ADVANCED	✓	Confidentiality	Public	✓	Private	

Hardware Compatibility	Product Line	IoT Modules	Series	EM9291	EM9291P
				EM9293	EM9293P

Software Compatibility	All	Document Type	App Note	✓	Tech Note	

1 Introduction

This document is provided to Sierra Wireless distributors and clients. To request a new application/technical note, contact your regional Sierra Wireless Product Marketing Manager.

2 Scope

This document describes Qualcomm (QTI) Smart Transmit (ST), the ST certification workflow, and how to use the ST feature and associated tools to comply with SAR regulations.

Note: In this document, EM92 refers to EM92 series modules (EM9291, EM9291P, EM9293, EM9293P).

Important: *Instructions in this document are specifically for EM92 modules. To use ST with EM91 modules, refer to [4] EM919x/EM7690 Smart Transmit (Doc# 2174291).*

3 ST Overview

EM92 series modules introduce QTI's advanced ST feature for regulatory compliance, which replaces the legacy SAR backoff feature used in earlier Sierra Wireless modules.[1]

Important: *Integrators intending to use the Smart Transmit feature on the module may be required to obtain separate certifications (e.g., FCC, ISED, etc.) for either the module itself or the host platform in which the module is embedded.*

Note: If transitioning from a SAR backoff-oriented process to ST, refer to [3] Transition Guide — SAR Backoff to Smart Transmit (Doc# 2174315) for a suggested transition path.

1. Legacy SAR backoff via non-volatile memory items (and related AT commands, e.g., !SARBACKOFF) is no longer supported.

3.1 ST Exposure Methods

ST supports two exposure methods for managing a wireless device's target output power (P_{limit}), which is the output power requirement for SAR regulatory compliance:

- Time-averaged exposure — ST controls the wireless device's Tx power for all supported RAT/band combinations by dynamically adjusting instantaneous Tx power to achieve a target average power over a period of time (i.e., the "averaging window").

  Note that:
  - Average output power never exceeds the P_{limit}.
  - Instantaneous output power can exceed the P_{limit} and the wireless device's SAR design target (regulatory average SAR power limit), but the wireless device will cap the output power at its maximum transmit power limit (MTPL). (See the Figure 1 Time-Averaged Exposure example for details.)

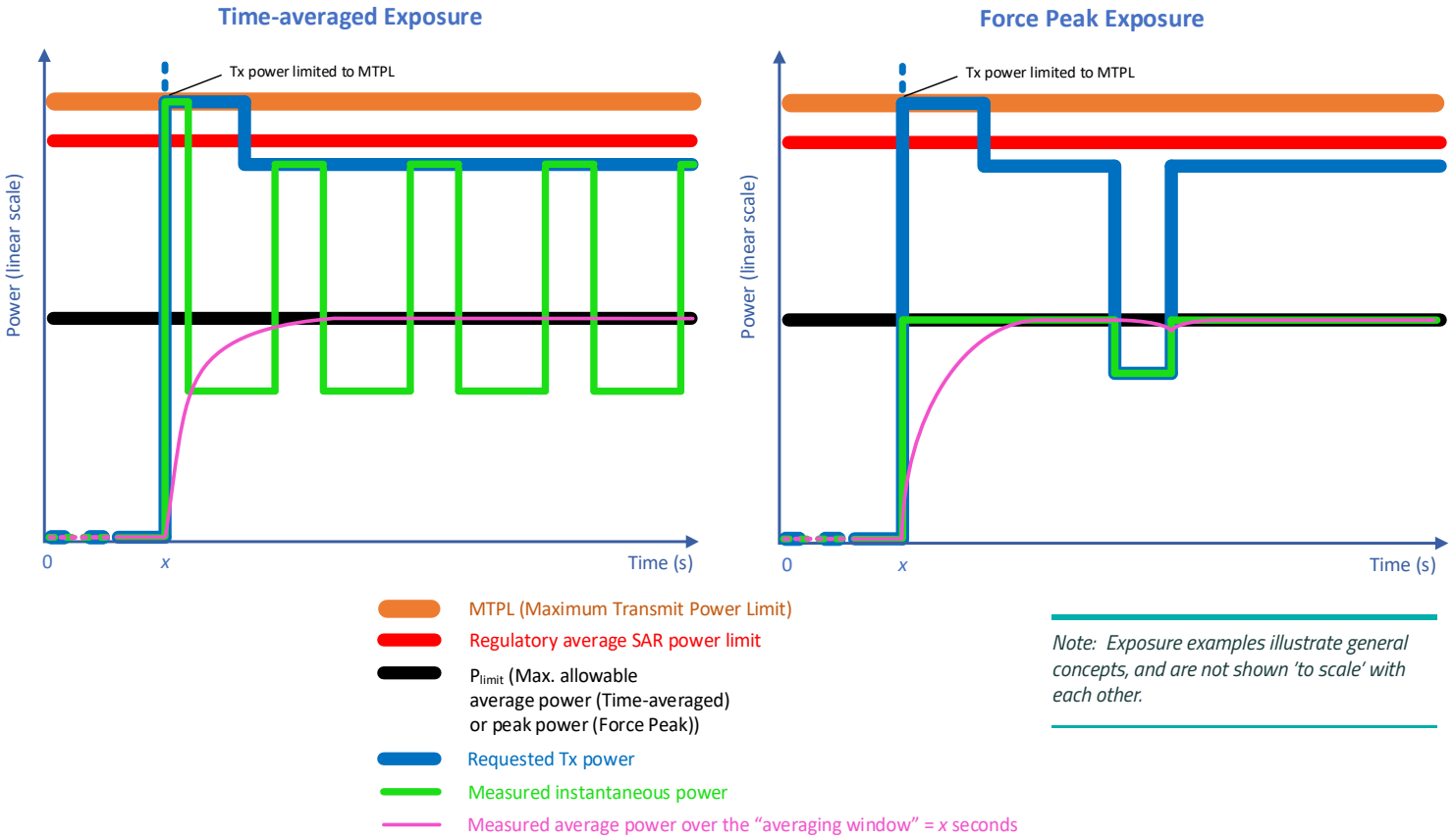
  Time-averaging allows the wireless device to maintain SAR regulatory compliance, while also achieving good user experience and network performance.
- Force Peak exposure — Instantaneous output power never exceeds the P_{limit} (see the Figure 1 Force Peak Exposure example).

  Note: Force Peak is the ST exposure method automatically used for any band that has not been configured to use a specific exposure method (see 5.4.2 mcc_list Tab for configuration details).

Important: *In the cases of ULCA or ENDC transmission where the Force Peak exposure method is used and where both Tx antennas belong to the same antenna group, measured instantaneous power may show power droops that resemble time-averaging behavior. This is expected behavior due to the application of the reserved power margin that is configured in the ST feature. For details, see 5.4.5 Reserve Margins tab.*

The ST exposure method, time-averaging window and SAR regulatory limit used for any given RAT/band combination are region-dependent and carrier-dependent.

Figure 1 displays the difference between the exposure methods. (For additional ST details, refer to *[5] Qualcomm Smart Transmit Feature for MPSS.DE.3.x (80-36245-8 Rev.AJ)*.)



Note: Exposure examples illustrate general concepts, and are not shown 'to scale' with each other.

Figure 1: ST Exposure Methods (Idealized) Comparison — Time-averaged vs. Force Peak

3.2 ST Customization by Region and Mobile Country Code (MCC)

To configure a wireless device to use ST, Sierra Wireless provides a radio transmitter SAR (rtsar) configuration template file that the OEM must populate with P_{limit} values for all of the device's exposure conditions, and with the regional MCCs that use those limits:

- rtsar_sub6.xlsx — For use in all regions, including those subject to FCC regulation and those in other (non-FCC) regions in the rest of the world (ROW).

Migration Note: ST for EM91 uses two template files — one for FCC and one for ROW.

After the OEM populates the ST rtsar configuration template file, Sierra Wireless converts it to an EFS file packaged in a single .cwe file. The OEM must load the .cwe package onto the module as a normal firmware download (e.g., using FDT, Sierra Wireless' module firmware download tool). ST settings automatically take effect on the next restart if ST initialization is successful.

For details, see 5.2 Evaluate SAR Exposure Scenarios, Assign DSIs, Specify SAR_design_target Values (Task#3) and 5.4 Populate ST rtsar Configuration File (Task #6).

4 ST Certification Workflow

The ST certification process involves the OEM, third-party labs (with SAR measurement and ST testing capabilities), and Sierra Wireless. (Note — Sierra Wireless does not recommend any specific third party labs.)

Figure 2 and Table 1 outline the ST certification procedure and brief descriptions of the actions taken for each task by the OEM, third-party lab or Sierra Wireless, and detailed descriptions of the OEM's tasks are included in 5 OEM Actions in the ST Certification Workflow.

Note: Figure 2 illustrates the ST certification workflow, and Table 1 adds additional context.

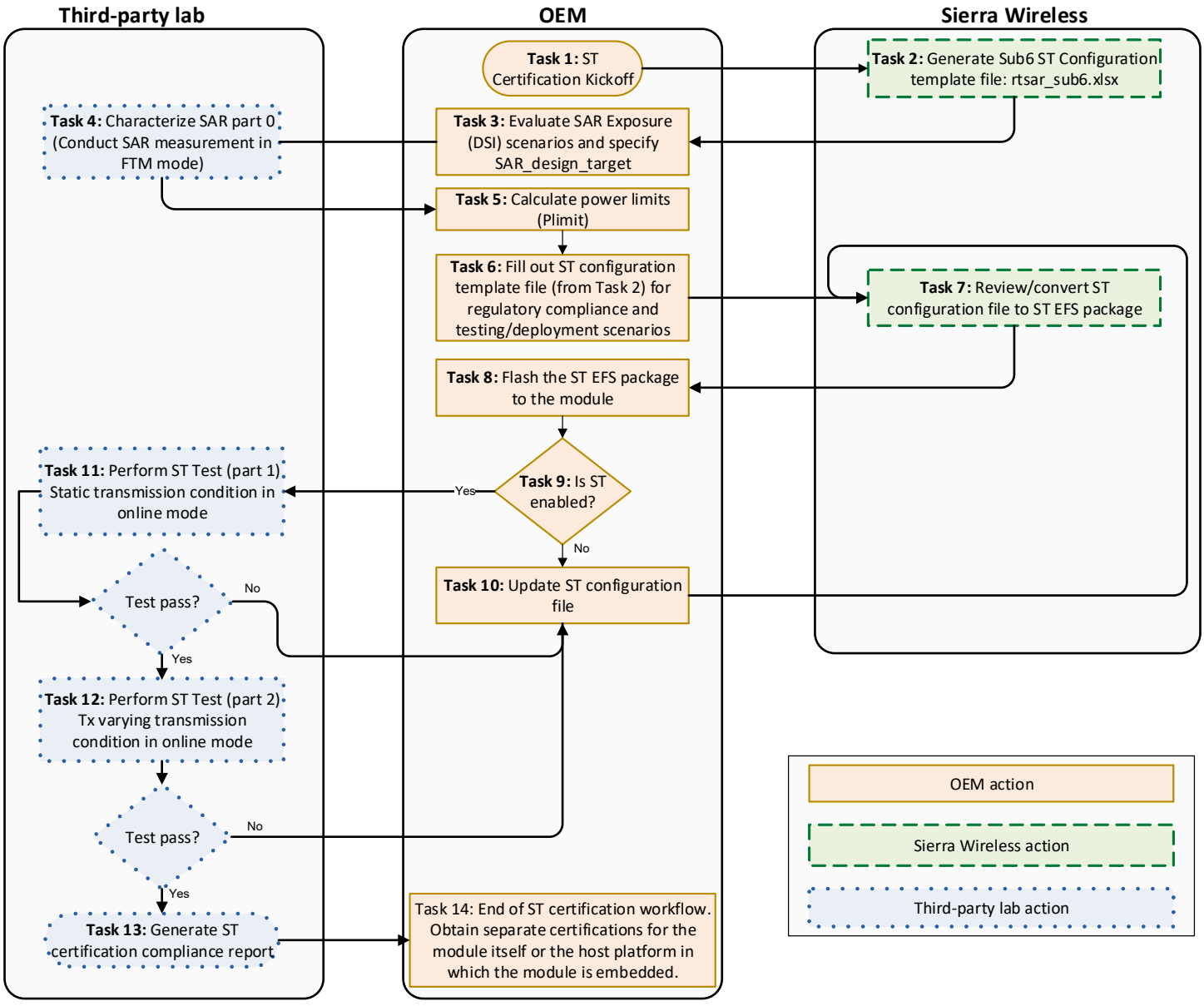


Figure 2: ST Certification Workflow for EM92 modules

Table 1: ST Certification Workflow Actions — Inputs and Outputs

Task	Action	Responsible Party	Input	Action / Output
#1	ST certification kickoff (Section 5.1)	OEM	—	OEM requests an ST rtsar configuration template file from Sierra Wireless and provides the following information: ▪ Firmware version that will be used for ST certification ▪ OEM's Project ID
#2	Generate an ST rtsar configuration template file	Sierra Wireless	#1 output	Sierra Wireless produces and sends the ST rtsar configuration template file (rtsar_sub6.xlsx) to the OEM.
#3	Evaluate SAR exposure scenarios, assign DSI values, and specify SAR_design_target values (Section 5.2)	OEM	#2 output	OEM determines their SAR exposure scenarios, assigns DSI index values to the scenarios, calculates SAR_design_target values, and provides the details to the lab.
#4	Characterize SAR part 0 — Conduct SAR measurement in FTM mode	Third-party Lab	#3 output (DSI scenarios)	Lab measures max power and SAR values for every antenna / RAT / band / DSI combination, and provides a report to the OEM.
#5	Calculate power limit (Section 5.3)	OEM	#4 output	OEM calculates power limit values for every antenna / RAT / band / DSI combination.
#6	Fill out the ST rtsar configuration template file (Section 5.4)	OEM	#5 output	OEM completes the ST rtsar configuration template file with required details for regulatory compliance testing, and for development testing and commercial field deployments. OEM returns the completed ST rtsar configuration file to Sierra Wireless.
#7	Verify and convert the OEM's completed ST rtsar configuration file to a signed ST EFS package	Sierra Wireless	#6 output or #10 output	Sierra Wireless uses the OEM's completed ST rtsar configuration file to prepare an EFS package (.cwe file), then sends it to the OEM. *Note: The package is used for (a) FCC and ROW regulatory compliance, and (b) FCC and ROW testing / deployment.*
#8	Flash the ST EFS package to the module (Section 5.5)	OEM	#7 output	OEM installs the ST EFS package on the module.
#9	Verify that ST is enabled (Section 5.6)	OEM	#8 output	OEM verifies that ST is enabled: ▪ If enabled, continue to Task #11. ▪ If not enabled, go to Task #10.
#10	Review the submitted ST rtsar configuration file for valid MCCs, DSIs, and P_{limit} values. Update the ST rtsar configuration file accordingly. (Section 5.7)	OEM	#9 test failure or #11 test failure or #12 test failure	OEM corrects the ST rtsar configuration file and resends it to Sierra Wireless with the same name that was used in Task #6.
#11	Flash the ST EFS package to the module. Perform testing for regulatory compliance — ST Test (part 1) in static transmission condition in online mode.	Third-party Lab	#9 output	Lab performs static transmission testing using a test SIM with MCC=1, which forces the device to operate in Force Peak exposure mode. ▪ If the test passes, continue to Task #12. ▪ If the test fails, go back to Task #10.

Table 1: ST Certification Workflow Actions — Inputs and Outputs (Continued)

Task	Action	Responsible Party	Input	Action / Output
#12	Perform testing for field use — ST Test (part 2) in Tx varying transmission condition in online mode	Third-party Lab	#11 test passes	Lab performs varying transmission testing using a SIM with a 'real' MCC (i.e., MCC != 1) that is configured in the template file to use time-averaging. ▪ If the test passes, continue to Task #13. ▪ If the test fails, go back to Task #10.
#13	Generate an ST certification compliance report	Third-party Lab	#12 test passes	Lab produces an ST certification compliance report and sends to the OEM.
#14	End of ST certification workflow	OEM	#13 report received	The module now is configured to use ST. **Important:** Integrators intending to use the Smart Transmit feature on the module may be required to obtain separate certifications (e.g., FCC, ISED, etc.) for either the module itself or the host platform in which the module is embedded.

4.1 Materials List

Table 2 describes the materials that OEMs require to engage in ST certification.

Table 2: Materials List

Tool or Test Equipment	Owner / Brand	Required for Task #	Remark
Callbox	CMW500, Anritsu MT8000A, or equivalent	#9 — Verify that ST is enabled	Populate template file with MCC 001.

5 OEM Actions in the ST Certification Workflow

This section describes actions the OEM must take for OEM-specific tasks in the ST certification workflow (Section 4).

Note — Actions performed by Sierra Wireless or third-party labs are summarized in Table 1.

5.1 ST Certification Kickoff (Task #1)

Important — ST Usage with Release 8+ Firmware

EM92 firmware Release 8 adds LTE B106 support for B106-enabled module SKUs (i.e., modules that have been factory-calibrated for B106).

To update a wireless device that is currently running ST v19 to Release 8+:

- B106 SKU: Sierra Wireless strongly recommends installing an ST v20 package before updating to Release 8+. If ST v19 is used on Release 8+, the module will crash if it enters B106 coverage.

  To obtain an ST v20 package, use the ST certification workflow below to get the latest ST rtsar configuration template (v20) and set the B106 limits (other band limits may not require changes compared to the ST v19 package).
- non-B106 SKU: The wireless device can update to Release 8+ without re-certifying.

New ST certifications (for any SKU) should use the v20 ST rtsar configuration template. When an ST v20 package is installed, two ST files are stored — a v20 file that is automatically used for Release 8+, and a v19 file that is automatically used for Release 6 and older.

To begin the ST certification workflow for a wireless device, the OEM must:

1. Determine where the wireless device will be used (deployed):
   - Regions subject to FCC regulation (i.e., U.S.A.) — FCC ST certification is required for FCC SAR compliance.
   - Rest of World — ROW ST certification is required for ICNIRP SAR compliance.
2. Contact your Sierra Wireless customer support representative to request an ST rtsar configuration template file for the wireless device.

   Be prepared to:

   a. If you have more than one project, indicate a project ID (0–255) to assign to the template file. If a project ID is not supplied, Sierra Wireless will assign one.

   b. Indicate the firmware version that will be used for ST certification.

   Important: *The firmware version is required to ensure the package that Sierra Wireless provides after you send a completed ST rtsar configuration file back is built using firmware that matches the EM92 module's firmware.*

   c. Indicate the deployment regions you identified in step 1.

   Based on the information you provide, Sierra Wireless performs Task #2 and provides the ST rtsar configuration template file (rtsar_sub6.xlsx) to the OEM.

5.2 Evaluate SAR Exposure Scenarios, Assign DSIs, Specify SAR_design_target Values (Task#3)

The OEM's wireless device must be SAR-characterized for all supported bands and Tx antenna paths. SAR characterization is evaluated at each surface of the wireless device for each SAR exposure scenario ("DSI scenario") — for example, "Head" scenarios (the device is near the head) and "Non_Head" scenarios (the device is not near the head — e.g., body, hotspot, extremity, etc.).[1]

To prepare for SAR characterization, the OEM must:

1. As described in 5.2.1 Define DSI Scenarios, identify all exposure scenarios that apply to the wireless device, assign unique Device State Index (DSI) values to each scenario, and calculate the worst-case RF exposure values for each scenario — 1gSAR for FCC, and 10gSAR for ROW.

   (Note — The OEM will populate the ST rtsar configuration template file with these DSI values and related details.)
2. Calculate SAR design target values for both regulatory regions (FCC, ROW) — see 5.2.2 Specify FCC / ROW SAR Design Target Values.
3. Provide the exposure scenario details and the SAR design target values ($SAR_{design\_target\_FCC}$, $SAR_{design\_target\_ROW}$) to the lab — the lab performs Task #4 and provides a SAR characterization report to the OEM.

5.2.1 Define DSI Scenarios

1. Identify all SAR exposure scenarios that apply to the wireless device and assign unique DSI values to each scenario:
   - If the device does not support any sensors or other SAR detection mechanisms, use DSI value 0 (as a Head scenario) to indicate there is only one exposure scenario (and that scenario is not distinguished). (Note: The default ST rtsar configuration comes with DSI 0 defined.)
   - Otherwise, assign unique DSI values from 0 (default) to 40 (maximum) to each exposure scenario — Note that only one Head SAR exposure scenario is needed.

Note: For example, the hypothetical wireless device described in this procedure (e.g., Figure 3, Worst Case 1gSAR Determination Based on SAR Scenario Detection Scheme, on page 10) has three defined exposure scenarios (one Head and two Non-Head.

1. SAR characterization reference materials: *[8] SAR Evaluation Procedures for Portable Devices With Wireless Router Capabilities (941225 D06 Hot Spot SAR v02r01), [7] RF Exposure Compliance with Smart Transmit (Sub-6) (80-PM669-8 Rev.A) section 3 Part 0: SAR Characterization*

2. Determine the worst-case RF exposure values for each DSI (1gSAR values for FCC, 10gSAR values for ROW).

   The example shown in Figure 3 represents a wireless device with three exposure scenarios — one Head, and two Non_Head. (Note: Examples shown in this document (unless otherwise indicated) refer to 1gSAR values (FCC).)

Number of scenarios distinguished[a]	Worst-case 1gSAR
All scenarios distinguished — The wireless device has proximity sensors or other SAR scenario detection mechanisms for each exposure scenario.	Worst-case 1gSAR for each DSI (individual exposure scenario) is that DSI's SAR value: • Worst-case 1gSAR[DSI_{Head}] = SAR_{Head} • Worst-case 1gSAR[$DSI_{Non\_Head\_1}$] = $SAR_{Non\_Head\_1}$ • Worst-case 1gSAR[$DSI_{Non\_Head\_2}$] = $SAR_{Non\_Head\_2}$
No scenarios distinguished — The wireless device has no proximity sensors or other SAR scenario detection mechanisms.	All DSIs (individual exposure scenarios) use the same worst-case 1gSAR — the maximum of the 1gSAR values for all exposure scenarios: • Worst-case 1gSAR = max {SAR_{head}, $SAR_{Non\_Head\_1}$, $SAR_{Non\_Head\_2}$}
Some (not all) scenarios distinguished — The wireless device has proximity sensors or other SAR scenario detection mechanisms for some (but not all) exposure scenarios.	Worst-case 1gSAR for each DSI (individual exposure scenario) depends on whether the DSI is distinguished or not distinguished: • DSI is Distinguished = Yes — Worst-case 1gSAR is the DSI's SAR. • DSI is not Distinguished = No — Worst-case 1gSAR is the maximum of the 1gSAR values for all non-distinguished exposure scenarios.

a. 'Distinguished' scenarios are specific exposure scenarios that can be identified by the wireless device using proximity sensors or other SAR scenario detection mechanisms.

ST works with a single exposure scenario (DSI) at any time, using the power limit value (P_{limit}) recorded for the DSI / RAT / Band / Antenna combination, which is derived from the worst-case 1gSAR value associated with the current DSI (see 5.3 Calculate Power Limits (Task #5)).

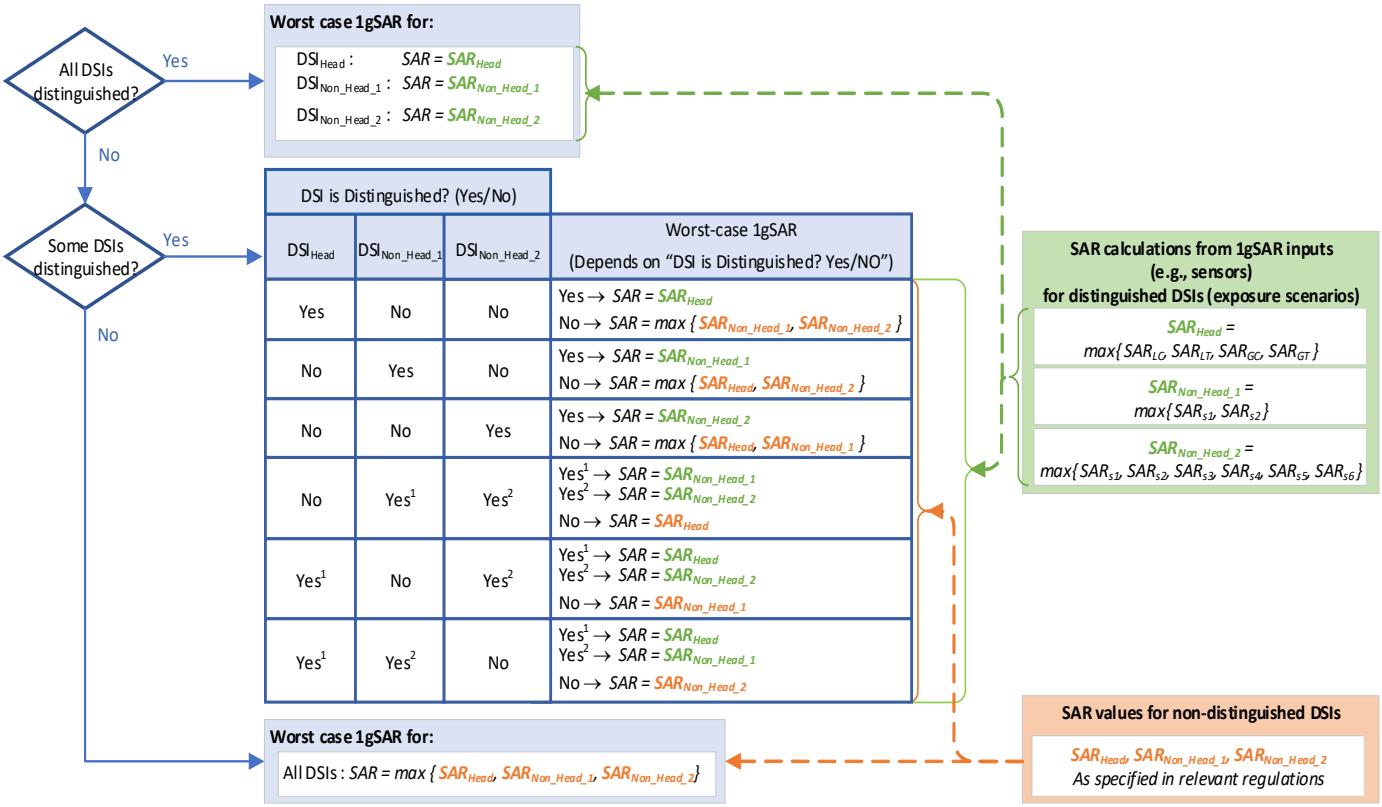


Figure 3: Worst Case 1gSAR Determination Based on SAR Scenario Detection Scheme

5.2.2 Specify FCC / ROW SAR Design Target Values

To enable the lab to perform SAR characterization, SAR design target values must be calculated for both regulatory regions — FCC (1gSAR limit) and ROW (10gSAR limit).

To calculate SAR design target values:

1. Use *(e.1)* to calculate the wireless device's total uncertainty from the EM92 module uncertainty and the wireless device's base uncertainty:

$$Uncertainty_{total} = Uncertainty_{device} + Uncertainty_{module} \quad (e.1)$$

where:

- $Uncertainty_{module} = 1.5\,\text{dB}$ (EM92 module uncertainty)
- $Uncertainty_{device} = (\text{TBD by OEM})\ \text{dB}$ (Base device uncertainty due to TxAGC uncertainties and device variance)

2. Use *(e.2)* as described in the following substeps to calculate SAR_{design_target} values for FCC and ROW from region-specific SAR regulatory limits and the device's total uncertainty:

$$SAR_{design\_target\_<Region>} < SAR_{regulatory\_limit\_<Region>} \times 10^{\frac{-Uncertainty_{total}}{10}} \quad (e.2)$$

where:

- $SAR_{regulatory\_limit\_FCC} = 1.6$ W/kg per 1g (FCC / ISED regulatory limit)
- $SAR_{regulatory\_limit\_ROW} = 2$ W/kg per 10g (ROW regulatory limit)

For example:

a. Calculate the FCC SAR design target value, assuming $Uncertainty_{total}$ = 1.5 dB, and round down to 1 decimal place:

$$SAR_{design\_target\_FCC} < SAR_{regulatory\_limit\_FCC} \times 10^{\frac{-Uncertainty_{total}}{10}}$$

$$SAR_{design\_target\_FCC} < 1.6 \times 10^{\frac{-1.5}{10}}$$

$$SAR_{design\_target\_FCC} < 1.1\,\text{W/kg per 1g} \quad \text{(rounded down from 1.133)}$$

b. Calculate the ROW SAR design target value, assuming $Uncertainty_{total}$ = 1.5 dB, and round down to 1 decimal place:

$$SAR_{design\_target\_ROW} < SAR_{regulatory\_limit\_ROW} \times 10^{\frac{-Uncertainty_{total}}{10}}$$

$$SAR_{design\_target\_ROW} < 2 \times 10^{\frac{-1.5}{10}}$$

$$SAR_{design\_target\_ROW} < 1.4\,\text{W/kg per 10g} \quad \text{(rounded down from 1.416)}$$

c. If the wireless device supports additional concurrent WLAN technologies that are not supported by ST (e.g., Bluetooth, Wi-Fi), reduce the calculated $SAR_{design\_target\_FCC}$ and $SAR_{design\_target\_ROW}$ values to account for the additional RF exposure.

$$SAR_{design\_target\_FCC} = SAR_{design\_Target\_FCC} - additionalRFexposure$$

$$SAR_{design\_target\_ROW} = SAR_{design\_Target\_ROW} - additionalRFexposure$$

3. If FCC and/or ROW certification is required for the wireless device, use *(e.3)* to calculate region-specific SAR design target extremity value(s) from the corresponding region-specific SAR regulatory limit for extremities and the device's total uncertainty:

$$SAR_{design\_target\_extremity\_<region>} = \frac{SAR_{design\_target\_<region>}}{SAR_{regulatory\_limit\_<region>}} \times SAR_{regulatory\_limit\_extremity\_<region>} \qquad (e.3)$$

where:

- $SAR_{regulatory\_limit\_extremity\_FCC}$ = 4 W/kg per 10g (FCC/ISED regulatory limit (extremity))
- $SAR_{regulatory\_limit\_extremity\_ROW}$ = 4 W/kg per 10g (ROW regulatory limit (extremity))

For example, using the $SAR_{design\_target\_FCC}$ and $SAR_{design\_target\_ROW}$ values calculated in step 2:

a. Calculate $SAR_{design\_target\_extremity\_FCC}$:

$$SAR_{design\_target\_extremity\_FCC} = \frac{SAR_{design\_target\_FCC}}{SAR_{regulatory\_limit\_FCC}} \times SAR_{regulatory\_limit\_extremity\_FCC}$$

$$SAR_{design\_target\_extremity\_FCC} = \frac{1.1}{1.6} \times 4$$

$$SAR_{design\_target\_extremity\_FCC} = 2.75\ \text{W/kg per 10g}$$

b. Calculate $SAR_{design\_target\_extremity\_ROW}$:

$$SAR_{design\_target\_extremity\_ROW} = \frac{SAR_{design\_target\_ROW}}{SAR_{regulatory\_limit\_ROW}} \times SAR_{regulatory\_limit\_extremity\_ROW}$$

$$SAR_{design\_target\_extremity\_ROW} = \frac{1.4}{2.0} \times 4$$

$$SAR_{design\_target\_extremity\_ROW} = 2.8\ \text{W/kg per 10g}$$

5.3 Calculate Power Limits (Task #5)

The SAR characterization report provided by the third-party lab (Task #4) should include measured power and measured SAR values for each DSI, at the maximum Tx power limit (MTPL) for each band/antenna path/device position/channel combination.

Important: Power class 3 is the default for all LTE and 5G NR bands. Subject to the conditions in Table 3, EM92 modules may support HPUE PC2 (power class 2) on LTE bands (B41/B42/B43) and 5G NR bands (n41/n77/n78/n79), and HPUE PC1.5 (power class 1.5) on the 5G NR PC2 bands.

Table 3: HPUE Required Operating Conditions

Operating conditions required to support HPUE (PC2 / PC1.5)	HPUE ('Y' required for all applicable conditions)		
	LTE PC2	5G NR PC2	5G NR PC1.5
ST rtsar configuration template file's Config tab has power_class value = 2	Y	Y	Y
LTE TDD UL/DL frame configuration 1–5 is in use	Y	n/a	n/a
Inter-band ULCA is not activated (HPUE band intra-contiguous ULCA is allowed)	Y	n/a	n/a
ULCA and ENDC are not activated	n/a	n/a	Y
MTPL in SIB1 is > +23 dBm	Y	Y	Y
Note: Typical MTPL values for HPUE bands[a]	+25 dBm	+26 dBm	+29 dBm (combined PC2 MTPL values of two antenna ports: 26 dBm + 26 dBm) **Important:** ST rtsar configuration template file Plimits are antenna port-specific. For PC1.5 support, configure the Plimits for each antenna port for PC1.5 exposure or EIRP requirement.
Note: For band-specific MTPL values, refer to the Conducted Maximum Tx (Transmit) Power Tolerances table in [1] EM92XX Product Technical Specification (Doc# 41114313).			
Two antenna ports, single layer Tx, FPM 1[b], non-coherent TPMI[b] = 2	n/a	n/a	Y

a. Typical MTPL values for non-HPUE bands are +23 dBm (LTE) and +24 dBm (5G NR).
b. FPTM 1 (Full Power Mode 1); TPMI (Transmit Precoding Matrix Indicator)

The OEM must use the lab report's measured power and measured SAR values to calculate power limit (P_{limit}) values for each DSI/band/antenna path combination at each device position and channel (low, middle, high).

To calculate the P_{limit} values for a specific DSI/band/antenna path combination:

1. Use *(e.4)* to calculate the P_{limit} values for each position/channel combination (see 5.3.1 Power Limit Calculation Example):

$$P_{limit} = MeasuredPower + 10 \times \log_{10}\left(\frac{SAR_{design\_target\_<region>}}{Measured\ SAR}\right) \quad (e.4)$$

where:

- $MeasuredPower$ — Refer to the lab report.
- $MeasuredSAR$ — Refer to the lab report.
- $SAR_{design\_target\_<region>}$ — Worst-case 1gSAR for the DSI as determined in 5.2.1 Define DSI Scenarios.

2. After calculating the P_{limit} values, enter the minimum P_{limit} value as the Tx power at Design Target for the DSI / band / antenna path combination in the ST rtsar configuration template file.

Migration Note: EM92 calculations are recorded in the ST rtsar configuration template file in dBm units; EM91 calculations are recorded in dBm10 units.

3. Go back to step 1 and repeat this procedure for the next DSI / band / antenna path combination.

5.3.1 Power Limit Calculation Example

Table 4 presents an excerpt of a lab report prepared for an example UE (User Equipment) device that has been FCC SAR-characterized for two positions — front and back.

The OEM uses *(e.4)* to calculate P_{limit} values for both positions for DSI 3 + LTE Band 5 at low, middle, and high channels.

For example, the first P_{limit} (DSI=3, LTE B5, Ant0, Position=Front, Channel=20450) in this example is 20.8 dBm (rounded down to 1 decimal place), calculated as follows:

$$P_{limit} = MeasuredPower + 10 \times \log_{10}\left(\frac{SAR_{design\_target\_FCC}}{Measured\ SAR}\right)$$

$$P_{limit} = 23.75 + 10 \times \log_{10}\left(\frac{1.1}{2.13}\right)$$

$$P_{limit} = 20.8\ \text{dB}$$

Table 4: Example — P_{limit} Calculation using Lab-provided SAR Characterization Report

DSI	Mode	RB / RB Offset	Ant#	Position	Channel	Freq (MHz)	Measured Power (dBm)	Measured SAR (W/kg)	$SAR_{design\_target\_FCC}$ (W/kg)	P_{limit} (dBm)[a] (Power level scaled at $SAR_{design\_target\_FCC}$)
									1 g	1 g
3	LTE Band 5 (10 MHz) QPSK	1/0	0	Front	20450	829	23.75	2.13	1.1	20.8
				Back				2.68		19.8
				Front	20525	836.5	23.73	2.93		19.4
				Back				3.70		18.4
				Front	20600	844	23.75	2.77		19.7
				Back				3.50		18.7
				Tx power at Design Target for LTE Band 5 for Ant#0 = min(P_{limit} for each combination above) →						**18.4**

a. P_{limit} values rounded down to 1 decimal place

5.4 Populate ST rtsar Configuration File (Task #6)

The OEM must populate the ST rtsar configuration template file that was received from Sierra Wireless, then send it back to Sierra Wireless to convert into an ST EFS package:

1. Populate the rtsar template file:
   a. Review the Config tab (section 5.4.1) and update if necessary.
   b. Populate the mcc_list Tab (section 5.4.2).
   c. Populate the FCC_FR1_Limits and ICNIRP_FR1_Limits tabs (section 5.4.3).
   d. Optionally, review the Sub6 Antenna Groups tab (section 5.4.4).
   e. Optionally, review the Reserve Margins tab (section 5.4.5).
2. Send the completed file to Sierra Wireless.
3. Sierra Wireless performs Task #7 and will contact the OEM to collect information needed to produce an ST EFS package. (Note — Only one package is needed for regulatory compliance and for testing/field deployment.

   Use the following commands and save their responses to provide to Sierra when requested:

```
ATI
<response>
OK

AT!SKU?
<response>
OK

AT!RFCID?
<response>
OK

AT!SECBOOTCFG?
<response>
OK
```

4. When the ST EFS package is ready, Sierra Wireless provides it to the OEM.

5.4.1 Config tab

This tab contains template file identification information and general configuration settings.

Important: *Only the oem_id can be modified by the OEM, as part of Update ST rtsar Configuration Template File (Task #10) on page 25. Do not change any other values.)*

	A	B
1	**Global Config**	
2	version	20
3	oem_id	1811939328
4	power_class	2
5	voice_call_exp_mode	Time-Averaged
6	volte_data_throttling_control	ON
7	vonr_data_throttling_control	ON
8	wlan_bt_control	OFF

← oem_id is the only setting that should be user-modified, only as part of Update ST rtsar Configuration Template File (Task #10) on page 25. Specifically, only the Project configuration file version portion of the oem_id (see Table 5) should be modified, if needed.

Do not change any other parts of the oem_ID, or any other values in this tab.

Note: Example ST rtsar configuration template (v20), subject to change.

Figure 4: Config Tab Parameters (ST v20 sample template, for example only)

The oem_id is a 4-byte decimal integer that combines several components to uniquely identify the ST package — a unique customer ID, an OEM-provided project ID, project configuration file version and (for ST v20) the firmware stack version.

v19 format

Byte 3	Byte 2	Byte 1	Byte 0
Customer ID	Project ID	Configuration file version (MSB, LSB)	

v20 format

Byte 3	Byte 2	Byte 1	Byte 0
Customer ID	Project ID	Stack version	Configuration File version

Figure 5: oem_id Format

Table 5: oem_id Format example

	ST v19	ST v20	Notes
Example oem_id	1813118997 (0x6c120015)	1813119253 (0x6c120115)	The oem_id is provided by Sierra Wireless in the initial ST rtsar configuration template for a new project.
Customer ID	Byte 3: 0x6c (108)	Byte 3: 0x6c (108)	Assigned by Sierra Wireless (Value range: 0–255) **Do not change this value.**
Project ID	Byte 2: 0x12 (18)	Byte 2: 0x12 (18)	Assigned by Sierra Wireless based on OEM input when requesting an ST rtsar configuration template for a new project (Value range: 0–255) **Do not change this value.**
Firmware stack Version (v20 only)	n/a	Byte 1: 0x01 (1)	Assigned by Sierra Wireless depending on the module's factory configuration. Values: 0x00: LE1.3; 0x01: LE1.3.1 (Note: ST support for B106 is only available on B106 SKUs with ST v20 installed. **Do not change this value.**
Project configuration file version	Bytes 1–0: 0x0015(21)	Byte 0: 0x15 (21)	Updated by OEM during Update ST rtsar Configuration Template File (Task #10) on page 25 (Value range: v19 (0–65535), v20: (0–255)).

To update the project configuration file version portion of the oem_id in the Config tab, as part of Update ST rtsar Configuration Template File (Task #10) on page 25:

1. Convert the oem_id from decimal format to hexadecimal.
   e.g., using the v20 example from Table 5:
   oem_id = 1813119253
   (hex) oem_id = 0x6c120115
2. The project configuration file version is byte0 (v20) or bytes1–0 (v19). e.g., "15" in the v20 example.
   Add 1 to the version (e.g., 0x15 + 0x01 = 0x16).

Important: ***Do not*** *change any other values in the oem_id.*

3. Convert the hexadecimal format oem_id back to decimal format and enter it in the oem_id field.
   e.g., using the v20 example from Table 5:
   (hex) oem_id = 0x6c120116
   oem_id = 1813119254
4. **Do not change** any other values in the Config tab, unless instructed to do so by Sierra Wireless.

5.4.2 mcc_list Tab

This tab lists the preferred exposure methods (Time-averaged or Force Peak) and related fields for groups (MCC Lists) of carrier (network) MCCs.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	MCC List	Exposure Mode	Averaging Windows	SAR Limit	PD Limit	Smart Tx Gen	Multi Tx Factor	Hand applicability when device held next to head	Note: Please list out the M				
2	Default MCC	Peak	FCC_timewindow	FCC_FR1_Limits	FCC_FR2_Limits	GEN1	1.0	No					
3	MCC List 1	Time-Averaged	FCC_timewindow	FCC_FR1_Limits	FCC_FR2_Limits	GEN2_SUB6	1.0	No	310	311	312	313	31
4	MCC List 2	Peak	FCC_timewindow	FCC_FR1_Limits	FCC_FR2_Limits	GEN2_SUB6	1.0	No	1				
5	MCC List 3	Time-Averaged	ICNIRP1998_timewindow	FCC_FR1_Limits	FCC_FR2_Limits	GEN2_SUB6	1.0	No	302				
6	MCC List 4	Peak	ICNIRP1998_timewindow	ICNIRP_FR1_Limits	FCC_FR2_Limits	GEN2_SUB6	1.0	No	202	204	206	208	21

Note: Example ST rtsar configuration template (v20), subject to change.

Figure 6: mcc_list Tab Parameters (ST v20 sample template, for example only)

The tab includes a default set of MCC Lists with typical configurations for specific countries, as detailed in Table 6.

Important: *Do not delete the Default MCC List.*

Table 6: Default ST rtsar configuration template "MCC List" Countries

MCC List	ST v19	ST v20
Default MCC	Used automatically for any MCC that is not specifically linked to one of the "MCC List #" entries	
MCC List 1	USA	USA
MCC List 2	Test MCC, for use by labs in Part 1 testing	Test MCC, for use by labs in Part 1 testing
MCC List 3	Germany	Canada
MCC List 4	India	Various European countries, Russia, etc.
MCC List 5	Canada	n/a

Migration Note: In EM91 ST, the Canadian MCC was required to be in the ROW template and used FCC limits. In EM92 ST, the corresponding default MCC List for Canada is MCC List 5 (ST v19) or MCC List 3 (ST v20).

Important:

- Any MCC can appear in only one MCC List row — If the MCC is duplicated in more than one MCC List, ST will not work.
- If an MCC is not specified in any MCC List rows, the Default MCC list configuration is used.
- If a country has more than one MCC and the MCCs are assigned to different MCC Lists, each of the lists must have the same "Smart Tx Gen" value. For example, Indian MCCs (404, 405, 406) are included in MCC List 4. If MCC 405 is moved to a new list (e.g., "MCC List 6"), the new list must also use Smart Tx Gen = GEN2_SUB6.)
- Modify only the values described in the procedure below. If any other values are modified, ST will not work correctly with the design.

To update the MCC Lists (e.g., add or update carrier MCCs in existing or new MCC Lists):

1. For the first carrier MCC to add or modify, determine which MCC List it should be in:
   - Existing or new MCC List — Used to group MCCs that use the same settings.
   - Default MCC — Used to group MCCs that will use the default setting behavior (i.e., apply FCC P_{limit} values for each RAT / band / antenna combination using the Force Peak Exposure method).

   Note: MCCs that are not included in any "MCC List #" automatically use the Default MCC.
2. If the MCC should use the default MCC configuration, make sure the MCC is not included in any "MCC List #" row, then go back to step 1 to process the next carrier MCC.

   Otherwise, continue to the next step.
3. Optionally, if the MCC's required configuration is used by an existing MCC List, add the carrier's MCC to the MCC List in the next available cell starting at column 'I', and then go back to step 1 to process the next carrier MCC.

   Otherwise, continue to the next step.
4. In the next empty row, add a new MCC List with the configuration required for the carrier MCC:
   a. In the MCC List field, enter "MCC List *n*" (e.g., "MCC List 6", "MCC List 7", etc.)
   b. In the Exposure Mode field, select the mode the carrier MCC supports:
      - "Time-Averaged"
      - "Peak" (i.e., Force Peak)

      Note: The Time-Averaged exposure mode can be overridden for specific RAT / band / antenna combinations by the "force peak" parameter in the FCC_FR1_Limits or ICNIRP_FR1_Limits tab (section 5.4.3).

      Important: *In the cases of ULCA or ENDC transmission where the Force Peak exposure method is used and where both Tx antennas belong to the same antenna group, measured instantaneous power may show power droops that resemble time-averaging behavior. This is expected behavior due to the application of the reserved power margin that is configured in the ST feature. For details, see 5.4.5 Reserve Margins tab.*

   c. In the Averaging Windows field, select the appropriate averaging window method:
      - "FCC_timewindow"
      - "ICNIRP1998_timewindow"
   d. In the SAR Limit field, select the limits type used by the carrier:
      - "FCC_FR1_Limits" — Uses the SAR limits from the FCC_FR1_Limits tab.
      - "ICNIRP1998_FR1_Limits" — Uses the SAR limits from the ICNIRP_FR1_Limits tab.
   e. In the PD Limit field, select "FCC_FR2_Limits".
   f. In the Smart Tx Gen field, select "GEN2_SUB6". (Only the Default MCC list uses "GEN1".)
   g. In the Multi Tx Factor field, enter 1.0 unless instructed otherwise by Sierra Wireless. (This value controls how power is split when there is more than one transmitter. "1.0" splits the power evenly.)
   h. In the Hand applicability when device held next to head field, select "No".
   i. Add the carrier's MCC in the next available cell starting at column 'I', and then go back to step 1 to process the next carrier MCC. When all carrier MCCs have been processed, continue to the next step.
5. Go back to step 1 to process the next carrier MCC.
6. **Important:** After all MCC's have been processed, review each MCC List and make sure that none of the MCCs are duplicated in another MCC List:
   - If an MCC appears in more than one MCC List, remove all duplicates. (ST will not work if any MCC appears in two or more MCC Lists.)
   - Reminder: If an MCC is not in any of the MCC Lists, the Default MCC list configuration is used for ST.

5.4.3 FCC_FR1_Limits and ICNIRP_FR1_Limits tabs

These tabs list all RATs/Bands supported by the customer design, and includes DSI details for each supported RAT/Band/Antenna combination. Separate tabs are used for FCC limits and ICNIRP limits.

	A	B	C	D	E	F	G	H	I	J	K
1		DSI	0			1			2		
2		category	Head			Non_Head			Non_Head		
3	Tech_Band	Antenna	force peak	2G/3G/4G/ 5G FR1 backoff for Wifi/BT (dB)	Tx power at Design Target (dBm)	force peak	2G/3G/4G/ 5G FR1 backoff for Wifi/BT (dB)	Tx power at Design Target (dBm)	force peak	2G/3G/4G/ 5G FR1 backoff for Wifi/BT (dB)	Tx power at Design Target (dBm)
4	LTE_B1	0			24.5			24.5			24.5
5	LTE_B12	0			24.5			24.5			24.5
6	LTE_B13	0			24.5			24.5			24.5
7	LTE_B14	0			24.5			24.5			24.5
8	LTE_B17	0			24.5			24.5			24.5
9	LTE_B18	0			24.5			24.5			24.5
10	LTE_B19	0			24.5			24.5			24.5
11	LTE_B2	0			24.5			24.5			24.5
12	LTE_B20	0	x		24.5	x		24.5	x		24.5
13	LTE_B25	0			24.5			24.5			24.5
14	LTE_B25	1			24.5			24.5			24.5
15	LTE_B25	2			24.5			24.5			24.5
16	LTE_B25	3			24.5			24.5			24.5
17	LTE_B26	0			24.5			24.5			24.5
18	LTE_B28	0	x		24.5	x		24.5	x		24.5
19	LTE_B3	0			24.5			24.5			24.5
20	LTE_B30	0	x		15	x		15	x		15

Note: Example ST rtsar configuration template (v19), subject to change.

Figure 7: FCC_FR1_Limits/ICNIRP_FR1_Limits Tabs Parameters (ST v19 sample template, for example only)

Notes:

- The default ST rtsar configuration template file has one DSI defined (DSI 0). The example shown in Figure 7 corresponds to the example from 5.2.1 Define DSI Scenarios, where DSI 0 (yellow) represents the DSI_{Head} scenario, and DSI 1 (green) and DSI 2 represent different DSI_{Non_Head} scenarios.)

  The default DSI 0 definition has Tx power at Design Target values with no backoff for all bands — power class 3 bands are set to 24.5 dBm and HPUE-capable (power class 2) bands are set to 26.5 dBm
- Bands that support the Sounding Reference Signal (SRS) feature are listed with all four antennas (ANT0–ANT3). For example, see LTE_B25 in Figure 7.

  (For a list of SRS-supporting bands, refer to *[1] EM92XX Product Technical Specification (Doc# 4111431 3)* section "Sounding Reference Signal".)

  During lab testing of SRS bands:
  - Part 0 testing (determining P_{limit} values) — All four antennas are included.
  - Part 1 testing (static mode P_{limit} verification) — A continuous wave (CW) is used to test all four antennas in Force Peak mode.
  - Part 2 testing (time-average verification) — Testing should be done without the SRS dedicated antenna(s) due to low average Tx power. (i.e., SRS transmission in signaling mode is not long enough to be included in any time-averaged regulatory testing.)

Important: *SRS Tx power depends on the serving (PUSCH) antenna(s) for SRS antenna switching and does not change when SRS switches antennas. This behavior is by design to ensure all SRS paths have equal power. For details, see 7.1 UL MIMO/SRS Tx Power lower than expected on some antennas.*

Important:

- Do not delete any rows (otherwise the deleted RAT/Band/Antenna path combinations will not work).

  If a band must be added or removed, submit a request to Sierra Wireless for review and to generate a new ST rtsar configuration template.

  Note that after passing certification, any changes made to band/antenna path combinations, Tx power at Design target (P_{limit}) values or force peak values void the certification, and new certification will be required.
- Modify only the values described in the procedure below. If any other values are modified, ST will not work correctly with the design.
- The same DSIs must be defined in both the FCC_FR1_Limits and ICNIRP_FR1_Limits tabs (i.e., in the example shown, both Limits tabs require DSI 0 (Head), DSI 1 (Non_Head), and DSI 2 (Non_Head).

To populate the FCC_FR1_Limits and ICNIRP_FR1_Limits tabs:

1. Make sure each DSI scenario that was distinguished in 5.2.1 Define DSI Scenarios is included in both tabs as shown in Figure 7 (e.g., DSI 0 (Head), DSI 1 (Non_Head), DSI 2 (Non_Head)).

   If any DSIs must be added, then for each new DSI:

   a. Copy rows 1–2 from one DSI and paste them in the next available columns and assign a DSI number. (For example, if DSI 0, 1, and 2 are present and a new DSI has to be added, copy and paste DSI 2 rows 1–3 to the next columns.)

   b. In the DSI field, enter an available DSI value in the range 0–40.

   c. In the category field, select the SAR exposure category:
      - Head
      - Non_Head
      - Note — Do not use the third category (0mm_Extremity).

   Note: If no DSI scenarios were distinguished, make sure only one DSI is shown, with the DSI value set to 0.

2. For each RAT/antenna path/band/DSI combination:

   a. In the force peak field, enter the exposure method to use for the combination:
      - blank — The exposure mode will be selected for each network on which the wireless device operates, based on the mcc_list tab:
        - MCC is listed in an MCC List with Exposure Mode = "Time-Averaged" — Use the Time-averaged method.
        - MCC is listed in an MCC List with Exposure Mode = "Peak" — Use the Force Peak method.
        - MCC is not listed in any MCC List — Use the Default MCC list configuration.

        Note — The Force Peak exposure mode will be used for voice calls (e.g., WCDMA circuit switched calls).
      - x — Always use the Force Peak exposure mode for this combination. This overrides the Exposure Mode assigned in the mcc_list tab.

        See Figure 8 on page 21 for an example of how the exposure method is determined.

   Important: *In the cases of ULCA or ENDC transmission where the Force Peak exposure method is used and where both Tx antennas belong to the same antenna group, the measured instantaneous power may show power droops that resemble time-averaging behavior. This is expected behavior due to the application of the reserved power margin that is configured in the ST feature. For details, see 5.4.5 Reserve Margins tab.*

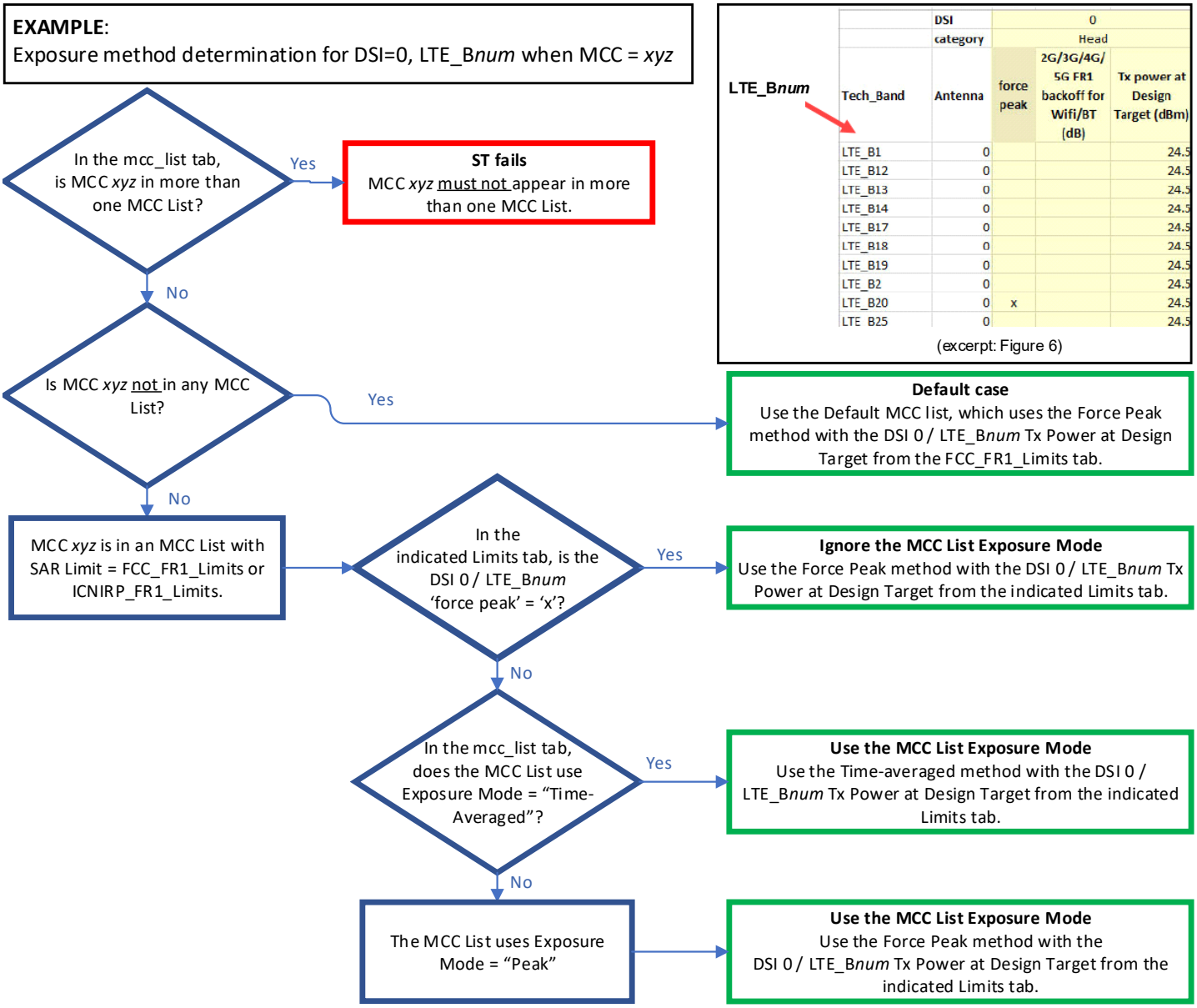
   b. Leave the 2G/3G/4G/5G FR1 backoff for Wifi/BT (dB) field blank.

c. In the Tx power at Design target (dBm) field:

- If the antenna port will be used as the secondary port for UL MIMO or SRS-2T4R operation, set the P_{limit} value to 3 dB lower than the primary port's P_{limit} value.
  (**Note:** This is necessary because for UL MIMO or SRS-2T4R operation, the module automatically caps both the primary and secondary serving antenna ports' maximum power at the lowest P_{limit} of the two ports. Therefore, for EIRP and SAR compliance, the P_{limit} of the secondary antenna port should be set 3 dB lower than the primary antenna port so that the aggregated power of both antenna ports does not exceed the design target.
  For example, for n41 UL MIMO, the primary Tx path is ANT2 and the secondary Tx path is ANT0. If the calculated P_{limit} for ANT2 in SISO operation is 20 dBm, the P_{limit} for ANT0 should be 17 dBm for UL MIMO operation.)

  or
- If the combination requires a SAR limit, enter the minimum P_{limit} value that was calculated for the combination in 5.3 Calculate Power Limits (Task #5),
  or
- If the combination does not need a power limit and can operate up to the maximum power (i.e., no power backoff), enter 24.5 for power class 3 bands, or 26.5 for HPUE-capable (power class 2) bands
  or
- If the combination requires power backoff to meet EIRP requirements (e.g., B48 combinations), enter an appropriate maximum value based on the antenna gain (e.g., 15 dBm) and set the force peak field to 'x'.

Migration Note: EM91 ST disabled power backoff when the Tx Power at Design Target value was entered as 24.5 dB.



LTE_B*num*

	DSI	0		
	category	Head		
Tech_Band	Antenna	force peak	2G/3G/4G/ 5G FR1 backoff for Wifi/BT (dB)	Tx power at Design Target (dBm)
LTE_B1	0			24.5
LTE_B12	0			24.5
LTE_B13	0			24.5
LTE_B14	0			24.5
LTE_B17	0			24.5
LTE_B18	0			24.5
LTE_B19	0			24.5
LTE_B2	0			24.5
LTE_B20	0	x		24.5
LTE_B25	0			24.5

(excerpt: Figure 6)

Figure 8: Exposure Method Determination Example

5.4.4 Sub6 Antenna Groups tab

Important: ***Do not make any changes*** *to the antenna groups tab unless instructed to do so by Sierra Wireless. If any Antenna Groups are modified or added, you must make sure that all antennas in each group are mutually-exclusive, as detailed in [6] RF Exposure Compliance Test Report for FCC Equipment Authorization of QRD (80-W2112-4 Rev. YD).*

This tab allows specific antennas to be configured into different groups for specific exposure scenarios in both Head DSI and non-Head DSI exposure categories.

The default template file assigns all four of the EM92 module's antennas (WWAN0–WWAN3) to Antenna Group 0.

	A	C	D	E	F	G	H	I	J	K
1										
2	**Head DSI AGs**	**Antenna**	**Antenna**	**Antenna**	**Antenna**	**Antenna**	**Antenna**	**Antenna**	**Antenna**	**Antenna**
3	Antenna Group 0	WWAN 0	WWAN 1	WWAN 2	WWAN 3					
4	Antenna Group 1									
5	Antenna Group 2									
6	Antenna Group 3									
7										
8	**nonHead DSI AGs**	**Antenna**	**Antenna**	**Antenna**	**Antenna**	**Antenna**	**Antenna**	**Antenna**	**Antenna**	**Antenna**
9	Antenna Group 0	WWAN 0	WWAN 1	WWAN 2	WWAN 3					
10	Antenna Group 1									
11	Antenna Group 2									
12	Antenna Group 3									

Note: Example ST rtsar configuration template (v19/v20), subject to change.

Figure 9: Reserve Sub6 Antenna Groups Tab Parameters (ST v19/v20 sample template, for example only)

5.4.5 Reserve Margins tab

Important: ***Do not make any changes*** *to the Reserve Margins tab, unless instructed to do so by Sierra Wireless.*

This tab contains settings (for Head DSI and nonHead DSI) that define minimum reserve power margins required for each antenna group. It also contains additional advanced settings that typically do not need to be modified.

The reserve power margin equation is:

$$Reserve\_power\_margin = |10 \times \log_{10}(TOTAL\_MIN\_RES\_RATIO)| \quad (e.5)$$

For example, the EM92 reserve power margin (based on the values shown in Figure 10) is:

Reserve_power_margin = |(10 x $\log_{10}$(TOTAL_MIN_RES_RATIO))|
Reserve_power_margin = |10 x $\log_{10}$(0.5)|
Reserve_power_margin = 3 dB

	A	B	C	D	E
1	Head DSI	Minimum Reserve Margin			
2		Antenna Group 0	Antenna Group 1	Antenna Group 2	Antenna Group 3
3	TOTAL_MIN_RES_RATIO	0.5	0.5	0.5	0.5
4	WWAN_PRI_SPLIT_RATIO	1	1	1	1
5	WWAN_SEC_SPLIT_RATIO	1	1	1	1
6	WLAN_SPLIT_RATIO	1	1	1	1
7					
8	WLAN_MARGIN_IN_MODEM_APM	0.5	0.5	0.5	0.5
9					
10	BT Config				
11	BT_STANDALONE	0.9	0.9	0.9	0.9
12	BT_AND_1_RADIO_SAME_AG	0.3	0.3	0.3	0.3
13	BT_AND_2+_RADIO_SAME_AG	0.2	0.2	0.2	0.2

Note: Example ST rtsar configuration template (v19/v20), subject to change.

Figure 10: Reserve Margins Tab Parameters — Head DSI excerpt (ST v19/v20 sample template, for example only)

Migration Note: The EM92 template's Reserve Margins default TOTAL_MIN_RES_RATIO values (0.5) correspond to setting the EM91 template's Header tab reserve_power_margin_db_ 10 value to 30 (i.e., 3 dB).

Reserve_power_margin for Single Transmitter or Multiple Transmitters (different Antenna Groups)

When only a single transmitter is used, or multiple transmitters in different antenna groups are used, the module uses the Reserve_power_margin (see example below equation *(e.5)* on page 22) to define the reserved power limit ($P_{reserve}$) for any given band.

$P_{reserve}$ is the minimum transmit power that ST uses to avoid call drops/data disconnection while it keeps measured average power (for the time-averaged method) or instantaneous power (for the Force Peak method) from exceeding the P_{limit}.

(Note: If the requested Tx power < $P_{reserve}$, the requested Tx power is used.)

For example, if P_{limit}(LTE B12) = 24.5 dBm:

$P_{reserve}$(LTE B12) = P_{limit} (LTE B12) - Reserve_power_margin
= 24.5 - 3 dB
= 21.5 dBm

Reserve_power_margin for Multiple Transmitters (same Antenna Group)

In multiple Tx cases (i.e., ULCA, ENDC) where the transmitters are in the same antenna group, it is not always possible to hold both radios to their design target P_{limit} values (especially if both are requesting high power). The radios can reach the design target P_{limit} values as long as there is SAR headroom, and then will fall to their $P_{reserve}$ values.

Since the transmitters for the two bands are on the same antenna group, the module combines the Reserve_power_margin values for each component carrier (PCC and SCC) so that the aggregate measured average power (for time-averaged method) or instantaneous power (for Force Peak method) is kept from exceeding the P_{limit} and falls to the $P_{reserve}$ levels.

The equations for calculating the Reserve_power_margin values for PCC and SCC are:

Reserve_power_margin(PCC) = |(10 x $\log_{10}$(TOTAL_MIN_RES_RATIO * (WWAN_PRI_SPLIT_RATIO) / (WWAN_PRI_SPLIT_RATIO+WWAN_SEC_SPLIT_RATIO)))|

Reserve_power_margin(SCC) = |(10 x $\log_{10}$(TOTAL_MIN_RES_RATIO * (WWAN_SEC_SPLIT_RATIO) / (WWAN_PRI_SPLIT_RATIO+WWAN_SEC_SPLIT_RATIO)))|

Example:

Assumptions (for example purposes only):

- ULCA transmission on LTE bands B2 and B5
- P_{limit} values: LTE B2 = 24.5 dBm; LTE B5 = 20.0 dBm
- Reserve _power_margin values for single transmitter operation: LTE B2 = 3 dB; LTE B5 = 3 dB

For multiple transmitter operation, the Reserve_power_margin values for each band will be 6 dB (instead of the 3 dB for single transmitter operation:

Reserve_power_margin(PCC) = |(10 x $\log_{10}$(TOTAL_MIN_RES_RATIO * (WWAN_PRI_SPLIT_RATIO) / (WWAN_PRI_SPLIT_RATIO+WWAN_SEC_SPLIT_RATIO)))|
= |(10 x $\log_{10}$(0.5 * 1 / (1+1)))|
= 6 dB

Reserve_power_margin(SCC) = |(10 x $\log_{10}$(TOTAL_MIN_RES_RATIO * (WWAN_SEC_SPLIT_RATIO) / (WWAN_PRI_SPLIT_RATIO+WWAN_SEC_SPLIT_RATIO)))|
= |(10 x $\log_{10}$(0.5 * 1 / (1+1)))|
= 6 dB

$P_{reserve}$(LTE B2) = P_{limit} (LTE B2) - Reserve_power_margin(PCC)
= 24.5 - 6
= 18.5 dBm

$P_{reserve}$(LTE B5) = P_{limit} (LTE B5) - Reserve_power_margin(SCC)
= 20.0 - 6
= 14.0 dBm

Therefore, the $P_{reserve}$ values will be 18.5 dBm (LTE B2) and 14.0 dBm (LTE B5):

Reserve_power_margin(PCC) = |(10 x $\log_{10}$(TOTAL_MIN_RES_RATIO * (WWAN_PRI_SPLIT_RATIO) / (WWAN_PRI_SPLIT_RATIO+WWAN_SEC_SPLIT_RATIO)))|
= |(10 x $\log_{10}$(0.5 * 1 / (1+1)))|
= 6 dB

Reserve_power_margin(SCC) = |(10 x $\log_{10}$(TOTAL_MIN_RES_RATIO * (WWAN_SEC_SPLIT_RATIO) / (WWAN_PRI_SPLIT_RATIO+WWAN_SEC_SPLIT_RATIO)))|
= |(10 x $\log_{10}$(0.5 * 1 / (1+1)))|
= 6 dB

$P_{reserve}$(LTE B2) = P_{limit} (LTE B2) - Reserve_power_margin(PCC)
= 24.5 - 6
= 18.5 dBm

$P_{reserve}$(LTE B5) = P_{limit} (LTE B5) - Reserve_power_margin(SCC)
= 20.0 - 6
= 14.0 dBm

Important: *In the cases of ULCA or ENDC transmission where the Force Peak exposure method is used and where both Tx antennas belong to the same antenna group, the measured instantaneous power may show power droops that resemble time-averaging behavior. This is expected behavior due to the application of the reserved power margin that is configured in the ST feature.*

5.5 Flash ST Package to the Wireless Device (Task #8)

After Sierra Wireless verifies and converts the ST rtsar configuration file that was prepared in Task #6 and sends it back to the OEM as a .cwe package, the OEM must flash (install) the package to the wireless device's EM92 module.

To install a package:

1. Use the fdt2 tool:

```
$ fdt2 - rtsar_config.cwe
```

5.6 Verify ST is Enabled (Task #9)

After installing an ST EFS package to the EM92 module, confirm that ST is enabled:

1. Confirm the EFS package was properly flashed, and determine if the correct ST files have been used:
   a. Use the !STEFS command to display the names of the ST files that are currently installed, e.g., for an ST v20 package on firmware Release 8+:

```
AT!STEFS?
<st_file_1> <sha256_file_1>
<st_file_2> <sha256_file_2>
<st_file_3> <sha256_file_3>
OK

e.g.:

AT!STEFS?
rtsar_config    71C178A81FD1C72867916A5466A504B28749CA9F8567B09CC4062503EC6E3826
rtsar_config_priority    81FD1C72867916A546677FD4355C0A504B28749CA9F8567B09CC4062503EC6E3
rtsar_swi_v2    3D62756977FD4355C01E111C3762D2EC96328953912285E2F618F2647B541028
OK
```

Note: The rtsar_config_priority file appears only for ST v20 packages on Release 8+. ST v20 packages on Release 6 or older, and ST v19 packages on any release, will list only rtsar_config and rtsar_swi_v2.

b. If the command returned a "File missing" message, the package did not flash successfully — the submitted ST rtsar configuration file must be revised and resubmitted to Sierra Wireless to receive an updated package. Go to 5.7 Update ST rtsar Configuration Template File (Task #10).

Otherwise, continue to the next step.

c. Compare the sha256 checksums returned by !STEFS? to the checksums provided by Sierra Wireless with the ST EFS package. If the checksums do not match, re-attempt the download if possible. If the checksums still do not match, contact your Sierra Wireless customer service representative.

2. Confirm that ST successfully initialized — Use the !STSTATUS command:

```
AT!STSTATUS?
ST_FW_VERSION: <fw_ver>
ST_Config_version: <cfg_ver>
ST_OEM_ID: <oem_id_hex> (<oem_id_dec>)
ST_Current_MCC: <mcc>
ST_Exposure_mode: <exposure_mode>
ST_Sensing_mode: <sensing_mode>
OK
```

Note: If ST_Config_version=20 and the module is a B106 SKU, ST will work for B106. Otherwise, ST will not work for B106.

If the command returns output as shown above, ST has initialized successfully:

i. If the <fw_ver> and <cfg_ver> match, continue to step 3.

ii. Otherwise, contact your Sierra Wireless customer service representative to determine if a newer ST rtsar configuration template file is available and should be used.

Otherwise, if an error message is returned (e.g. "ST unknown status", "ST configuration not present", etc.), ST did not initialize. Go to 5.7 Update ST rtsar Configuration Template File (Task #10) to revise the submitted ST rtsar configuration file and resubmit it to Sierra Wireless to receive an updated package.

3. Manually test that ST is enabled:

a. Connect the wireless device to a callbox.

b. Initiate one data call from the callbox.

c. Set Tx power control to maximum power.

d. Set a valid DSI state (i.e. one that is listed in the ST rtsar configuration file) — see 6 How to Select the DSI (Exposure Scenario) for Sub-6 ST.

e. Observe the Tx power limit changing with DSI state.

During this test, ensure there is data transmission from the wireless device to the network after the data call has been established. The expected Tx power behavior depends on whether the force peak option for the band and antenna path under test is disabled or enabled:

- Disabled — Tx power is expected to increase and decrease around the expected Tx power at Design Target value.
- Enabled — Tx power should never exceed the Tx power at Design Target value.

5.7 Update ST rtsar Configuration Template File (Task #10)

If 5.6 Verify ST is Enabled (Task #9) indicated there was a problem (i.e, ST did not flash successfully or did not initialize successfully), the submitted ST rtsar configuration file (or a new template from Sierra Wireless, if provided) must be revised and resubmitted to Sierra Wireless to receive an updated package.

The most common errors that will prevent Sierra Wireless from building an ST EFS package and will require corrections to the template file are:

- An MCC is included in more than one MCC List in the “mcc_list” tab.
- No valid DSIs are populated (0–40)

To update the ST configuration file:

1. Review the file to identify and fix any errors / omissions (based on the requirements described in 5.4 Populate ST rtsar Configuration File (Task #6)).
2. Make sure to update the oem_id value in the Config tab — add 1 to the project configuration file version part of the oem_id as described in Config tab on page 14.
3. Resubmit the corrected configuration file to Sierra Wireless for verification and conversion.

5.8 End of Certification Workflow (Task #14)

When the OEM has received an ST certification compliance report from the third-party lab, the ST certification workflow process is complete and the module is now configured to use ST.

Important: *Integrators intending to use the Smart Transmit feature on the module may be required to obtain separate certifications (e.g., FCC, ISED, etc.) for either the module itself or the host platform in which the module is embedded.*

6 How to Select the DSI (Exposure Scenario) for Sub-6 ST

To select the DSI (i.e, to select the exposure scenario) to use for ST, use an appropriate method (AT commands, SDK API, GPIO) as described in this section.

6.1 Set DSI via AT Command

To set the DSI using AT commands:

1. Enable access to password-protected AT commands:

```
AT!ENTERCND=<password>      ← The password is factory-configured and can be changed using !SETCND.
OK                            If the password is not known, contact Sierra Wireless for assistance.
```

2. Disable the DPR GPIO function if it is enabled (note — DPR GPIO is disabled by default):

```
AT!CUSTOM="GPIOSARENABLE",0
OK

AT!RESET
```

3. Set the DSI to select a desired exposure scenario (note — this setting does not persist across power cycles):

```
AT!SARSTATE=<dsi_index>
OK
```

Refer to *[2] EM9 Series AT Command Reference (Doc# 41113480)* for AT command details.

6.2 Set DSI via SDK API

To set the DSI using an SDK API:

1. Disable the DPR GPIO function if it is enabled (note — DPR GPIO is disabled by default):

```
AT!CUSTOM="GPIOSARENABLE",0
OK

AT!RESET
```

2. Set the DSI to select a desired exposure scenario (note — this setting does not persist across power cycles) — Use the "pack_sar_SLQSSetRfSarState()" API.

6.3 Set DSI via GPIO

The DPR GPIO (pin 25) can be used to switch exposure scenarios between DSI 0 and DSI 1.

For example, consider a device with two distinguished exposure scenarios — DSI 0 (default configuration) and DSI 1 (a human body scenario — head, body, etc.):

- Because the default ST rtsar configuration template's DSI 0 configuration was used to build the ST package, the Tx power at Design Target values for all bands are set to max Tx power — (24.5 dBm for power class 3 bands, and 26.5 dBm for HPUE-capable (power class 2) bands).
- For this example, assume DSI 1 is configured with lower Tx power at Design Target values (i.e, SAR backoffs applied) for various bands.

In this case:

- The DPR GPIO can be used to switch from DSI 0 to DSI 1 (i.e., enabling SAR backoff) when the device's sensors (or other detection mechanisms) detect the human body scenario (DSI1).
- When the human body scenario is no longer detected, the DPR GPIO can be used to switch back to DSI 0 from DSI 1 (i.e., disabling SAR backoff).

To set the DSI with the DPR GPIO:

1. Enable access to password-protected AT commands:

```
AT!ENTERCND=<password>      ← The password is factory-configured and can be changed using !SETCND.
OK                            If the password is not known, contact Sierra Wireless for assistance.
```

2. Enable the DPR GPIO function if it is disabled:

```
AT!CUSTOM="GPIOSARENABLE",1
OK

AT!RESET
```

3. Set the DPR pin mode:

```
AT!SARINTGPIOMODE=<0 or 1>    ← Note: If using an EM9190 DEV KIT BOARD, use '0'. The dev kit does not
OK                              correctly detect the DPR pin state if the DPR logic is inverted using '1'.

AT!RESET
```

4. Pull DPR GPIO (pin 25) high or low to switch the DSI. The EM92 series module's firmware monitors DPR GPIO and adjusts the RF Tx power for the indicated DSI, as detailed in Table 7.

Note: Only change the DSI state away from default (DSI 0) if matching ST configuration files are loaded.

Table 7: Dynamic Power Selection of ST DSI

!SARINTGPIOMODE[a]	DPR Internal Pull	DPR Pin	ST State
0 (default)	Pull up	High[b]	DSI 0
		Low	DSI 1
1	Pull down	Low	DSI 0
		High	DSI 1

a. !SARINTGPIOMODE=1 inverts the DPR logic.
b. The host can implement an open collector drive for the DPR pin (if a 1.8V-compatible drive is not available).

7 Troubleshooting

7.1 UL MIMO / SRS Tx Power lower than expected on some antennas

This behavior is expected when the module operates in UL MIMO or SRS-2T4R. In these cases, the aggregated power of both antennas must not exceed the design target, to ensure EIRP and SAR compliance.

The module accomplishes this as follows:

- When the UL duty cycle is ≤ 50% (typical use case), the ST algorithm uses P_{lowest} (the lowest P_{limit} of the two antenna ports) as the maximum power for each antenna (see detailed description in 5.4.3 FCC_FR1_Limits and ICNIRP_FR1_Limits tabs — Step c on page 20).
- When the UL duty cycle is > 50% (atypical use case), the ST algorithm may set the maximum power for each antenna slightly lower than P_{lowest}.

7.2 Removing the ST EFS Package

If necessary, the ST EFS package can be removed from a module. Contact your Sierra Wireless customer support representative for assistance.

8 References

Sierra Wireless

[1] EM92XX Product Technical Specification (Doc# 41114313)

[2] EM9 Series AT Command Reference (Doc# 41113480)

[3] Transition Guide — SAR Backoff to Smart Transmit (Doc# 2174315)

[4] EM919x / EM7690 Smart Transmit (Doc# 2174291)

Qualcomm Technologies, Inc.

[5] Qualcomm Smart Transmit Feature for MPSS.DE.3.x (80-36245-8 Rev.AJ)

[6] RF Exposure Compliance Test Report for FCC Equipment Authorization of QRD (80-W2112-4 Rev. YD)

[7] RF Exposure Compliance with Smart Transmit (Sub-6) (80-PM669-8 Rev.A)

FCC

[8] SAR Evaluation Procedures for Portable Devices With Wireless Router Capabilities (941225 D06 Hot Spot SAR v02r01)

9 Glossary

Term	Definition
CP-OFDM	Cyclic Prefix OFDM
CW	Continuous Waveform
DRI	Device Range Index

Term	Definition
DSI	Device State Index (Value corresponding to a specific usage scenario)
EFS	Qualcomm Embedded Files System (Latest version — EFS2)
FCC	Federal Communications Commission (FCC ST certification is the American standard smart transmit certification)
FPM	Full Power Mode
FTM	Factory Test Mode
HPUE	High Power User Equipment
ICNIRP	International Commission on Non-Ionizing Radiation Protection
ISED	Innovation, Science, Economic Development Canada
MCC	Mobile Country Code
Module	Sierra Wireless EM92 series module
MTPL	Maximum Tx Power Limit — The module's maximum (non-configurable) Tx power. Tx power will be limited to this value if the requested Tx power is higher.
PD	Power Density (W/m^2)
Plimit	Power Limit — The maximum power, in dBm, at which a given radio configuration reaches the SAR design target. The SAR design target is predetermined for the specific device and will be less than the regulatory SAR limit after accounting for all design-related tolerances.
QTI	Qualcomm Technologies, Inc.
RAT	Radio Access Technology
RF	Radio Frequency
ROW	Rest of World (ROW ST certification is the European standard smart transmit certification)
SAR	Specific Absorption Rate (W/kg)
SIB1	System Information Block #1
ST	Smart Transmit
Sub-6	3G/4G/5G-Sub6 Technology
TPMI	Transmit Precoding Matrix Indicator
ULCA	Uplink Carrier Aggregation
Wireless device	Host platform (i.e., chassis in which a module is installed)

10 Support

For direct clients: contact your Sierra Wireless FAE

For distributor clients: contact your distributor FAE

For distributors: contact your Sierra Wireless FAE

11 Document History

Revision number	Release date	Changes
1	February 2024	Creation
2	September 2025	General update (formatting, layout, rephrasing for clarity, etc.) Added details for v20 (which adds B106 support) vs. v19 ST rtstar configuration templates where appropriate Added Important notes for integrators re: obtaining certifications for the module or host platform. Added Important notes and instructions regarding UL MIMO/2RS-2T4R operation (behavior, setting Tx power at Design target (dBm)), in sections 5.4.3 FCC_FR1_Limits and ICNIRP_FR1_Limits tabs and 7.1 UL MIMO/SRS Tx Power lower than expected on some antennas) Updated 3.1 ST Exposure Methods (exposure mode descriptions; Figure 1, ST Exposure Methods (Idealized) Comparison — Time-averaged vs. Force Peak Updated 4 ST Certification Workflow (added Task#14 — Figure 2, ST Certification Workflow for EM92 modules, Table 1, ST Certification Workflow Actions — Inputs and Outputs) and added 5.8 End of Certification Workflow (Task #14) Added Important note for B106 usage (5.1 ST Certification Kickoff (Task #1)) Updated 5.3 Calculate Power Limits (Task #5) (added detailed HPUE information and added Table 3, HPUE Required Operating Conditions) Updated 5.4.1 Config tab (overall update, updated oem_id format, added Table 5, oem_id Format example) Updated 5.4.2 mcc_list Tab (Updated description, added Table 6, Default ST rtsar configuration template "MCC List" Countries, rephrased/clarified procedure steps) Updated 5.4.3 FCC_FR1_Limits and ICNIRP_FR1_Limits tabs (rephrased/clarified procedure steps; updated step for setting Tx power at Design target (dBm) field for UL MIMO/SRS-2T4R operation) Updated 5.4.5 Reserve Margins tab (added details and examples for reserve power margin calculations) Updated Table 7, Dynamic Power Selection of ST DSI (ST State descriptions) Added 7 Troubleshooting

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