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Content Level	BASIC	INTERMEDIATE	ADVANCED	✓	Confidentiality	Public	✓	Private
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Hardware Compatibility	Product Line	IoT Modules	Series	EM7590	
				EM7595	

Software Compatibility	ALL	Document Type	App Note	✓	Tech Note
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## 1 Version

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## 2 Introduction

This document is provided to Sierra Wireless distributors and clients to aid more rapid development of embedded applications using the Sierra Wireless portfolio of cellular solutions. To request a new application/technical note, contact your regional Sierra Wireless Product Marketing Manager.

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*Note: In this document:*  
 • EM759X refers to EM7590 and EM7595.

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## 3 Glossary

Term	Definition
CA	Carrier Aggregation (For details, see <a href="https://www.3gpp.org/technologies/keywords-acronyms/101-carrier-aggregation-explained">https://www.3gpp.org/technologies/keywords-acronyms/101-carrier-aggregation-explained</a> .)
CC	Component Carrier
DL	Downlink
LPM	Low Power Mode
MCC	Mobile Country Code
PA	Power Amplifier
PCC	Primary Component Carrier
SCC	Secondary Component Carrier
UL	Uplink

## 4 Overview

For safety and performance reasons, heat generated by embedded modules should be dissipated in the host device using a combination of passive (heatsink) and active cooling strategies.



If these strategies are insufficient, the EM759X module automatically attempts to reduce its operational temperature via a series of thermal mitigation techniques. These mitigation techniques are enabled as the operational temperature reaches specific thresholds for each technique.

This document describes these thermal mitigation techniques.

## 5 Host Device Conditions Affecting Thermal Mitigation

### 5.1 Heatsink/Active Cooling

Sierra Wireless recommends heat-sinking the module, and maximizing airflow over/around the module (e.g., by using existing fans in the host device). For additional details, refer to [1] *EM759X Series Product Technical Specification*.

## 6 Thermal Mitigation Details

### 6.1 Thermal Thresholds

Table 1 describes the thermal thresholds at which the EM759X module's operating state changes, including:

- “Enter” thresholds—Thresholds at which the module enables thermal mitigation actions as it attempts to reduce its operational temperature
- “Exit” thresholds—Thresholds at which thermal mitigations are disabled as the operational temperature decreases.

To ensure the module is protected:

- The module enters the next highest operating state when the temperature reported by either sensor (CPU or PA) increases to its “Enter” threshold.
- The module returns to the next lowest operating state when the temperature reported by both sensors (CPU and PA) decreases to its “Exit” threshold.

The module's temperature is affected by:

- Module's ambient air temperature—This should be kept as close as possible to the host platform's ambient temperature. If the module is in a small space, make sure the space is ventilated and the device is on a heatsink. Otherwise, the module's ambient air temperature could increase to tens of degrees higher than the platform's ambient air temperature.
- Heatsink effectiveness at spreading heat to avoid hot spots on the module.
- Data throughput rates
- UL and DL Carrier aggregation
- Transmit output power

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**Important:** *If a heatsink is not used to spread the heat from the module, hot spots may cause thermal mitigation to occur at lower reported board temperatures.*

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**Table 1: EM759X Operating State Thermal Thresholds<sup>a</sup> (with heatsink)**

Operating State	Thresholds (°C)			
	Enter when <u>either</u> sensor temperature rise to threshold or higher		Exit when <u>both</u> sensor temperatures drop to threshold or lower	
	CPU sensor	PA sensor	CPU sensor	PA sensor
High temperature shutdown (LPM)	107	110	75	70
Emergency service (Fourth thermal mitigation action)	105	107	89	90
UL Power Throttling (Third thermal mitigation action)	98	97	94	93
DL Data Throttling (Second thermal mitigation action)	95	95	91	91
UL Data Throttling (First thermal mitigation action)	93	92	89	88
Low temperature shutdown (LPM)	-40	-40	-29	-29

a. State change thresholds are based on default value. If values are modified using the !PCTEMPLIMITS AT command, entry/exit thresholds will vary from stated values.

**Table 2: EM759X Operation Classes**

Class	Temperature range (°C)
Class B (non-3GPP-compliant) operation	>70
Class A (3GPP-compliant) operation	-30 to 70
Class B (non-3GPP-compliant) operation	-40 to <-30

## 6.2 Current Temperature

The module's thermal sensors can be read using the AT commands !PCTEMP? (reports the CPU sensor temperature) and !PATEMP? (reports the highest temperature of the module's two PA sensors).

## 6.3 Thermal Mitigation

The EM759X employs the following thermal mitigations to reduce the heat generated on the uplink (UL) and downlink (DL) paths as the operational temperature reaches the thresholds in [Table 1](#):

- [UL Data Throttling](#)—Reduce uplink data rate
- [DL Data Throttling](#)—Reduce number of receive carriers
- [UL Power Throttling](#)—Reduce transmission output power
- [Emergency Service](#)—Limited service only



## 6.4 UL Data Throttling

UL data throttling is the first thermal mitigation method employed by the EM759X.

UL data throttling acts to reduce the uplink data rate. Throttling begins when the CPU or PA sensor temperature reaches the Enter threshold for UL Data Throttling, causing the module to step down the maximum throughput from 150 Mbps to 5 Mbps as shown in [Figure 1](#). To attempt to quickly mitigate the temperature, the first throttling step (50 Mbps) is the largest.

If the:

- CPU or PA temperature continues to increase to the next Enter threshold, the second thermal mitigation method ([DL Data Throttling](#)) occurs.
- CPU and PA temperatures both drop to their Exit thresholds, the module steps the maximum throughput back up from 5 Mbps to 150 Mbps.

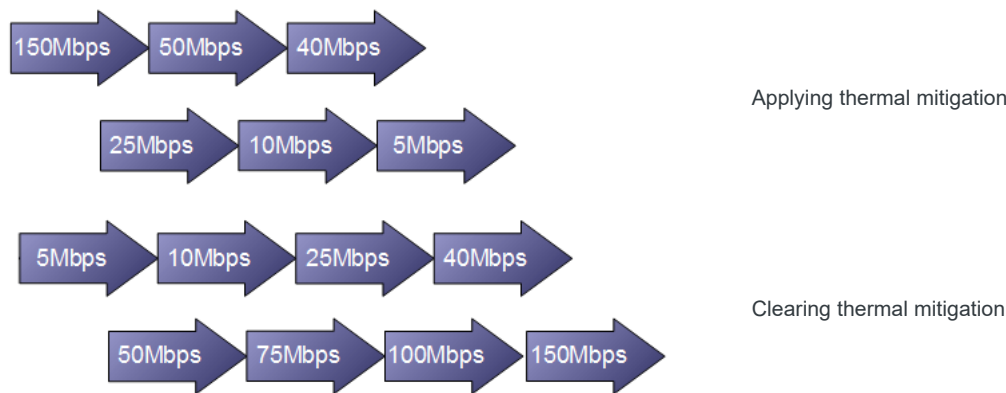


Figure 1: Thermal Mitigation Level 1—Uplink Data Throttling

## 6.5 DL Data Throttling

DL data throttling is the second thermal mitigation method employed by the EM759X, if uplink data throttling is not able to control the module's temperature.

The amount of heat generated by the downlink path is dependent on the number of receive carriers in operation:

- EM7590—Aggregates two receive carriers to support DL rates up to Cat 13 (400 Mbps, 2CA)
- EM7595—Aggregates three receive carriers to support DL rates up to Cat 12 (600 Mbps, 3CA)

The module's main processor is responsible for processing the data from these carriers. If the CPU or PA temperature is close to the Enter threshold for DL Data Throttling, DL data throttling mitigation is triggered to reduce the temperature:

- EM7590—Reduces from 3 CA (PCC + 2xSCC) → 2 CA (PCC+SCC) (i.e., the first SCC is dropped), and then reduces again from 2 CA (PCC+SCC) → 1 CA (PCC) (i.e., the second SCC is dropped).
- EM7595—Reduces from 2 CA (PCC+SCC) → 1 CA (PCC) (i.e., the SCC is dropped)

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Note: When a downlink (Rx) SCC is dropped, the corresponding uplink (Tx) is also dropped.

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If the:

- CPU or PA temperature continues to increase to the next Enter threshold, the third thermal mitigation method ([UL Power Throttling](#)) occurs.
- CPU and PA temperatures both drop to their Exit thresholds, the module increases operation back to normal — i.e., the SCC(s) are reactivated.

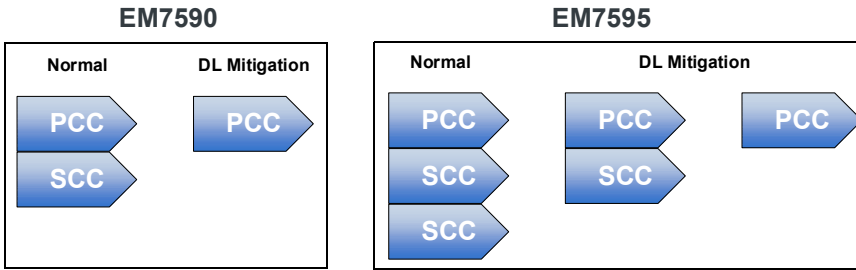


Figure 2: Thermal Mitigation Level 2—Downlink Thermal Mitigation

## 6.6 UL Power Throttling

UL power throttling is the third thermal mitigation method employed by the EM759X.

If downlink data throttling is not able to control the module's temperature, the module slowly reduces the transmit power from maximum power to 10 dBm, as shown in [Figure 3](#).

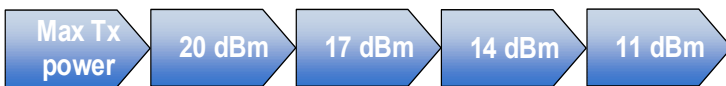


Figure 3: Thermal Mitigation Level 3—Uplink Thermal Mitigation via Power Throttling

Depending on RF coverage, this power throttling could reduce the signal strength the base station sees and, in fringe coverage areas, the base station might drop the call if coverage shrinks to the point where the link can no longer be kept up.

If the:

- CPU or PA temperature continues to increase to the next Enter threshold, the fourth thermal mitigation method ([Emergency Service](#)) occurs.
- CPU and PA temperatures both drop to their Exit thresholds, the module returns the transmit power to maximum power.

## 6.7 Emergency Service

Emergency Service is the fourth (and final) thermal mitigation method employed by the EM759X, if uplink power throttling is not able to control the module's temperature.

In Emergency Service state:

- Voice-capable module will drop the current call (if one is in progress). Only emergency calls will be allowed.
- Module remains attached to the network, providing limited service.
- If the overall temperature drops to the exit threshold, a voice-capable module can be used to make a call.

## 6.8 Current Thermal Mitigation Status

To display details of the module's current thermal mitigation status, use the AT command `!TMSTATUS` (see [\[2\] EM759X Series AT Commands Reference](#)).



## 7 Low Power Mode

If DL and UL thermal mitigation actions are insufficient and the module exceeds the high temperature shutdown thresholds (CPU—107°C; PA—110°C), it drops the current data session and enters low power mode (LPM—RF disabled, module operational). The module remains in this mode until the temperature drops to the exit threshold.

When the module leaves LPM, DL and UL thermal mitigations remain in effect until both the CPU and PA temperatures drop to their Exit levels (described in [Table 1](#)).

Note: This has always been the behavior for extreme temperature events.

## 8 Reference Documents

The following documents are available at [source.sierrawireless.com](http://source.sierrawireless.com):

Document	Document #	Description
[1] EM759X Series Product Technical Specification	41114425	Product details (RF, Power, Interfaces, Mechanical, etc.)
[2] EM759X Series AT Commands Reference	41114426	Supported standard and proprietary AT commands.

## 9 Support

For direct clients: contact your Sierra Wireless FAE

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## 10 Document History

Revision	Release Date	Changes
1	April 08, 2022	Creation
2	June 08, 2022	Updated 6.1 Thermal Thresholds (description, updated mitigation sequence) Updated Table 1, EM7590 Operating State Thermal Thresholds (with heatsink) (two sensors, all values) Updated Table 2, EM7590 Operation Classes (moved from Table 1, updated values) Updated 6.2 Current Temperature (added !PATEMP, updated temperature recommendation) Updated 6.4 UL Data Throttling (two sensors, updated Figure 1) Updated 6.5 DL Data Throttling (two sensors) Updated 6.6 UL Power Throttling (two sensors, updated Figure 3) Updated 7 Low Power Mode (two sensors)



Revision	Release Date	Changes
3	July 07, 2023	Updated Table 1, EM7590 Operating State Thermal Thresholds (with heatsink) (updated values) Updated Table 2, EM7590 Operation Classes Updated 6.2 Current Temperature (updated values) Updated 7 Low Power Mode (updated values)
4	August 16, 2023	Added EM7595 Updated <a href="#">Table 1, EM759X Operating State Thermal Thresholds (with heatsink)</a> (threshold values) Updated <a href="#">Table 2, EM759X Operation Classes</a> (clarified temperature ranges) Updated <a href="#">6.5 DL Data Throttling</a> Updated <a href="#">7 Low Power Mode</a> (references to threshold values)

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