AirPrime EM75xx

Technical Note—Thermal Mitigation

SIERRA WIRELESS®

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Rev 2

Important Notice

Due to the nature of wireless communications, transmission and reception of data can never be guaranteed. Data may be delayed, corrupted (i.e., have errors) or be totally lost. Although significant delays or losses of data are rare when wireless devices such as the Sierra Wireless modem are used in a normal manner with a well-constructed network, the Sierra Wireless modem should not be used in situations where failure to transmit or receive data could result in damage of any kind to the user or any other party, including but not limited to personal injury, death, or loss of property. Sierra Wireless accepts no responsibility for damages of any kind resulting from delays or errors in data transmitted or received using the Sierra Wireless modem, or for failure of the Sierra Wireless modem to transmit or receive such data.

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Do not operate the Sierra Wireless modem in areas where blasting is in progress, where explosive atmospheres may be present, near medical equipment, near life support equipment, or any equipment which may be susceptible to any form of radio interference. In such areas, the Sierra Wireless modem **MUST BE POWERED OFF**. The Sierra Wireless modem can transmit signals that could interfere with this equipment.

Do not operate the Sierra Wireless modem in any aircraft, whether the aircraft is on the ground or in flight. In aircraft, the Sierra Wireless modem **MUST BE POWERED OFF**. When operating, the Sierra Wireless modem can transmit signals that could interfere with various onboard systems.

Note: Some airlines may permit the use of cellular phones while the aircraft is on the ground and the door is open. Sierra Wireless modems may be used at this time.

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Revision History

Revision number	Release date	Changes
1	July 2018	Created
2	January 2020	Added SIM Type topic

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Thermal Mitigation Methods

Overview

For safety and performance reasons, heat generated by embedded modules (such as the Sierra Wireless AirPrime EM75xx) should be dissipated in the host device using a combination of passive (heatsink) and active cooling strategies.

If these strategies are insufficient, the EM75xx 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.

Host Device Conditions Affecting Thermal Mitigation

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). Refer to the module's Product Technical Specification (available at source.sierrawireless.com) document for additional details.

Note: The majority of the heat generated by the EM75xx module is channeled to its bottom face on the large copper ground pad shown below.

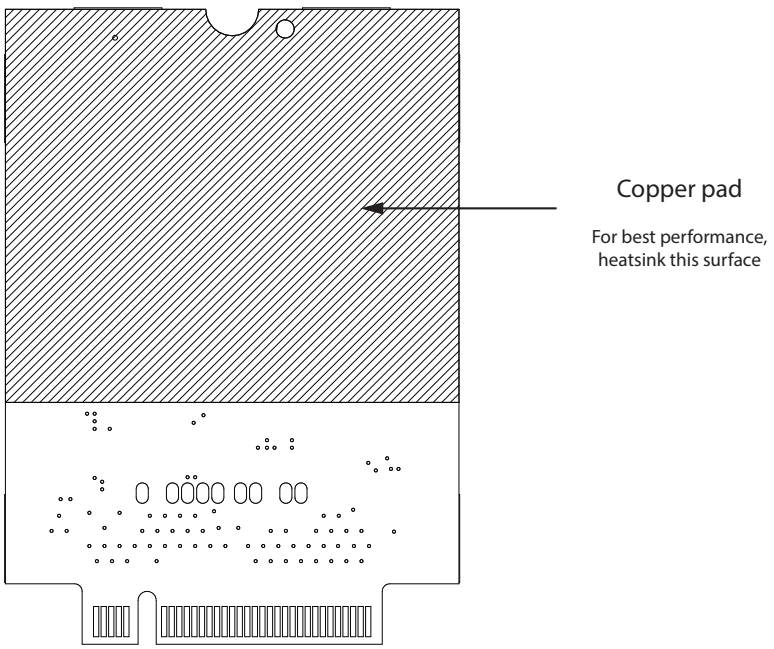

Figure 1: Recommended Heatsink Location

SIM Type

The EM75xx module's automatic thermal mitigation behavior techniques do not take effect when using a test SIM (a SIM that has an MCC in the range 001–012).

A commercial SIM (a SIM with an MCC > 012) must be used with the module to allow the automatic thermal mitigation techniques to take effect.

Thermal Mitigation Details

Thermal Thresholds

Table 1 describes the thermal thresholds at which the EM75xx module's operating state changes, including the thresholds at which the module enables thermal mitigation actions as it attempts to reduce its operational temperature.

These thresholds refer to the module's operational temperature, which 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

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

Table 1: EM75xx Operating State Thermal Thresholds[a] (with heatsink)

Operating state	Approx. Board Temperature (°C)	
	Threshold to enter state	Threshold to exit state
High temperature shutdown (LPM)	105	84
Emergency service (Fourth thermal mitigation action)	102	95
UL Power Throttling[b] (Third thermal mitigation action)	91	79
DL Data Throttling[b] (3CA→2CA→1CA) (Second thermal mitigation action)	90	80
UL Data Throttling (First thermal mitigation action)	86	74
Class B (non-3GPP-compliant) operation	>70 to 85[c]	

Table 1: EM75xx Operating State Thermal Thresholds[a] (with heatsink)

Operating state	Approx. Board Temperature (°C)	
	Threshold to enter state	Threshold to exit state
Class A (3GPP-compliant) operation	>-30 to 70	
Class B (non-3GPP-compliant) operation	>-45 to -30	
Low temperature shutdown (LPM)	-45	-29

a. State change thresholds are based on default values. If values are modified using !PCTEM-PLIMITS, entry/exit thresholds will vary from stated values.
b. Sequence for UL Power Throttling and DL Data Throttling may switch due to the small difference between trigger points.
c. A high temperature warning (QMI_DMS_SWI_EVENT_REPORT_IND) is issued when the temperatures reaches 85°C.

Current Temperature

The module's temperature can be read using the following methods, which return the overall board temperature:

- AT command—**!PCTEMP?** (See AirPrime EM75xx AT Command Reference (Document #41111748) for details.)
- SDK API call—**SLQSNasSwiModemStatus**

In general, the reported temperature should be kept below 80°C to ensure thermal mitigation actions are not initiated. As noted in Table 1, the first thermal mitigation action (UL Data Throttling) is not reversed until the temperature drops significantly.

Thermal Mitigation

The EM75xx 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

UL Data Throttling

UL data throttling is the first thermal mitigation method employed by the EM75xx.

UL data throttling acts to reduce the uplink data rate. Throttling begins when either of the module's PAs approaches the thermal threshold (see Table 1 on page 6), causing the module to step down the maximum throughput from 150 Mbps to 10 kbps as shown in Figure 2.

If the:

- PA temperature continues to increase, the second thermal mitigation method (DL Data Throttling) occurs.
- Board temperature drops to the exit threshold, the module steps the maximum throughput back up from 10 kbps to 150 Mbps.

Thermal mitigation steps

Clearing thermal mitigation

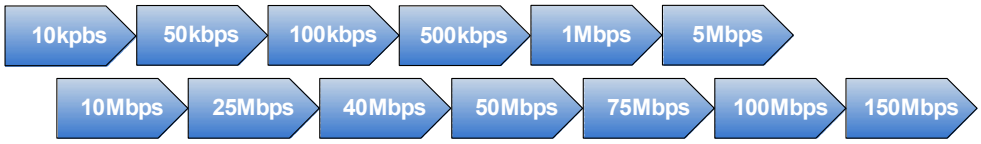

Figure 2: Uplink Thermal Mitigation Via Data Throttling

DL Data Throttling

DL data throttling is the second thermal mitigation method employed by the EM75xx, if uplink data throttling is not able to control the module's temperature.

Note: Sequence for UL Power Throttling and DL Data Throttling may switch due to the small difference between trigger points.

The amount of heat generated by the downlink path is dependent on the number of receive carriers in operation. The EM75xx 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 its overall temperature is close to the DL Data Throttling threshold in Table 1, the module reduces operation to 2CA and then, if necessary, to 1CA to reduce overall temperature.

Note: When operation reduces from 2 CA (PCC+SCC) to 1 CA (PCC), the secondary Tx is also dropped.

If the:

- PA temperature continues to increase, the third thermal mitigation method (UL Power Throttling) occurs.
- Overall temperature drops to the exit threshold, the module increases operation back to normal (3CA).

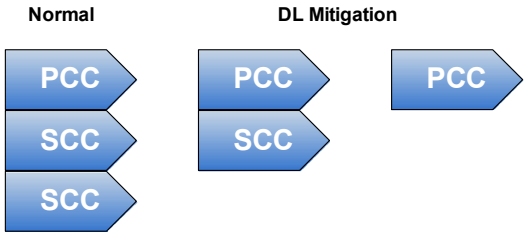

Figure 3: Downlink Thermal Mitigation

UL Power Throttling

UL power throttling is the third thermal mitigation method employed by the EM75xx.

Note: Sequence for DL Data Throttling and UL Power Throttling may switch due to the small difference between trigger points.

If uplink and downlink data throttling are 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 4.

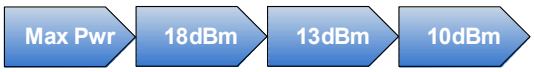

Figure 4: Uplink Thermal Mitigation via Power Throttling

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:

- PA temperature continues to increase, the fourth thermal mitigation method (Emergency Service) occurs.
- Overall temperature drops to the exit threshold, the module returns the transmit power to maximum power.

Emergency Service

Emergency Service is the fourth (and final) thermal mitigation method employed by the EM75xx, 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.

Current Thermal Mitigation Status

To display details of the module's current thermal mitigation status, use the **!TMSTATUS** command (see AirPrime EM75xx AT Command Reference (Document #41111748) for details).

Low Power Mode

If DL and UL thermal mitigation actions are insufficient and the module exceeds the high temperature shutdown threshold (105°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 mitigation remain in effect until the operating temperature decreases to the exit levels described in Table 1.

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