# EG06xK&Ex120K&EM060K Series

# Software Thermal Management Guide

**LTE-A Module Series**

Version: 1.0

Date: 2023-03-28

Status: Released

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**Quectel Wireless Solutions Co., Ltd.**
Building 5, Shanghai Business Park Phase III (Area B), No.1016 Tianlin Road, Minhang District, Shanghai 200233, China
Tel: +86 21 5108 6236
Email: info@quectel.com

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# About the Document

## Revision History

| Version | Date | Author | Description |
|---|---|---|---|
| - | 2021-07-01 | Zilean CHEN | Creation of the document |
| 1.0 | 2023-03-28 | Aydan DING | Released |

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# 1 Introduction

This document outlines the use and AT commands related to the software thermal management mechanism on Quectel LTE-A EG060K series, EG065K series, EG120K series, EM120K-GL and EM060K series modules. When the temperature reaches a specific threshold, any one of the thermal management mechanism shall be adopted to cool down the module.

## 1.1. Applicable Modules

**Table 1: Applicable Modules**

| Module Family | Module |
|---|---|
| EG06xK | EG060K Series |
| | EG065K Series |
| Ex120K | EG120K Series |
| | EM120K-GL |
| - | EM060K Series |

# 2 AT Command Description

## 2.1. AT Command Introduction

### 2.1.1. Definitions

- **<CR>** Carriage return character.
- **<LF>** Line feed character.
- **<...>** Parameter name. Angle brackets do not appear on the command line.
- **[...]** Optional parameter of a command or an optional part of TA information response. Square brackets do not appear on the command line. When an optional parameter is not given in a command, the new value equals to its previous value or the default settings, unless otherwise specified.
- **Underline** Default setting of a parameter.

### 2.1.2. AT Command Syntax

All command lines must start with **AT** or **at** and end with **<CR>**. Information responses and result codes always start and end with a carriage return character and a line feed character: **<CR><LF><response><CR><LF>**. In tables presenting commands and responses throughout this document, only the commands and responses are presented, and **<CR>** and **<LF>** are deliberately omitted.

**Table 2: Types of AT Commands**

| Command Type | Syntax | Description |
|---|---|---|
| Test Command | **AT+<cmd>=?** | Test the existence of the corresponding command and return information about the type, value, or range of its parameter. |
| Read Command | **AT+<cmd>?** | Check the current parameter value of the corresponding command. |
| Write Command | **AT+<cmd>=<p1>[,<p2>[,<p3>[...]]]** | Set user-definable parameter value. |
| Execution Command | **AT+<cmd>** | Return a specific information parameter or perform a specific action. |

## 2.2. Declaration of AT Command Examples

The AT command examples in this document are provided to help you learn about the use of the AT commands introduced herein. The examples, however, should not be taken as Quectel's recommendations or suggestions about how to design a program flow or what status to set the module into. Sometimes multiple examples may be provided for one AT command. However, this does not mean that there is a correlation among these examples, or that they should be executed in a given sequence.

## 2.3. AT+QTEMP Query Module Temperature

This command queries module's specific temperature.

| AT+QTEMP Query Module Temperature | |
|---|---|
| Test Command<br>**AT+QTEMP=?** | Response<br>**OK** |
| Write Command<br>**AT+QTEMP** | Response<br>**+QTEMP:<sensor>,<temp>**<br>**…**<br><br>**OK** |
| Maximum Response Time | 300 ms |
| Characteristics | / |

### Parameter

| | | |
|---|---|---|
| **<sensor>** | String type. The sensor types. | |
| | "aoss-0-usr" | Always-on subsystem unit |
| | "q6-usr" | DSP processor |
| | "ipa-usr" | IP accelerator unit |
| | "cpuss-usr" | ARM processor |
| | "mdm-usr", | Modem processor core |
| | "xo-therm-usr", | XO |
| | "case-therm-usr" | BB chipset |
| | "pa-therm1-usr" | Power amplifier 1 |
| | "pa-therm2-usr" | Power amplifier 2 |
| **<temp>** | Integer type. The temperature. Unit: ºC. | |

**NOTE**

There is no sensor "pa-therm2-usr" on EG065K series module.

**Example**

```
AT+QTEMP
+QTEMP: "aoss-0-usr",33

+QTEMP: "q6-usr",34

+QTEMP: "ipa-usr",34

+QTEMP: "cpuss-usr",34

+QTEMP: "mdm-usr",34

+QTEMP: "xo-therm-usr",32

+QTEMP: "case-therm-usr",32

+QTEMP: "pa-therm1-usr",31

+QTEMP: "pa-therm2-usr",32

OK
```

## 2.4. AT+QCFG="thermal/modem" Set PA Thermal Management Mechanism

This command queries or configures the temperature threshold for restricting UL data rate and PA power.

| AT+QCFG="thermal/modem" | Set PA Thermal Management Mechanism |
|---|---|
| Write Command<br>**AT+QCFG="thermal/modem"[,<level>,<trig>,<clr>]** | Response<br>If the optional parameters are omitted, query the current setting:<br>**+QCFG: "thermal/modem",1,<trig>,<clr>**<br>**+QCFG: "thermal/modem",2,<trig>,<clr>**<br><br>**OK** |

| | |
|---|---|
| | If the optional parameters are specified, set the thermal management level:<br>**OK**<br><br>If there is any error:<br>**ERROR** |
| Maximum Response Time | 300 ms |
| Characteristics | This command takes effect after the module is rebooted.<br>The configurations are saved automatically. |

## Parameter

| | |
|---|---|
| **<level>** | Integer type. Thermal management level. Each level corresponds to a set of **<trig>** and **<clr>**.<br>1 Level 1, limiting the UL data rate (see ***Chapter 3.1.1***)<br>2 Level 2, restricting the PA power based on Level 1 (see ***Chapter 3.1.2***) |
| **<trig>** | Integer type. Triggering temperature threshold. When the module temperature reaches **<trig>**, the corresponding thermal management mechanism (**<level>**) will be triggered. Recommended temperature range: 0–115000. Unit: 0.001 ºC.<br>When **<level>**=1, **<trig>** is the temperature threshold to trigger the UL data rate limit.<br>Default value: 100000.<br>When **<level>**=2, **<trig>** is the temperature threshold to trigger the PA power restriction. Default value: 105000. |
| **<clr>** | Integer type. Terminating temperature threshold. If the temperature drops to **<clr>**, the corresponding thermal management mechanism (**<level>**) will be terminated. Unit: 0.001 ºC.<br>When **<level>**=1, **<clr>** is the temperature threshold to terminate the UL data rate limit. Default: 95000.<br>When **<level>**=2, **<clr>** is the temperature threshold to terminate the PA power restriction. Default: 100000. |

## Example

```
AT+QCFG="thermal/modem"                    //Query the current temperature thresholds.
+QCFG: "thermal/modem",1,100000,95000

+QCFG: "thermal/modem",2,105000,100000

OK
```

## 2.5. AT+QCFG="thermal/mdm" Set MDM Thermal Management Mechanism

This command queries or configures the temperature threshold for restricting DL data rate and entering Limited-Service Mode.

| AT+QCFG="thermal/mdm" Set MDM Thermal Management Mechanism | |
|---|---|
| Write Command<br>**AT+QCFG="thermal/mdm"[,<level>,<trig>,<clr>]** | Response<br>If the optional parameters are omitted, query the current setting:<br>**+QCFG: "thermal/mdm",1,<trig>,<clr>**<br>**+QCFG: "thermal/mdm",2,<trig>,<clr>**<br><br>**OK**<br><br>If the optional parameters are specified, set the thermal management level:<br>**OK**<br><br>If there is any error:<br>**ERROR** |
| Maximum Response Time | 300 ms |
| Characteristics | The command takes effect after the module is rebooted.<br>The configurations are saved automatically. |

### Parameter

| | |
|---|---|
| **<level>** | Integer type. MDM thermal management level. Each thermal management level corresponds to a group of **<trig>** and **<clr>**.<br>1 Level 1. Limiting DL data rate (see ***Chapter 3.2.1***)<br>2 Level 3. Entering Limited-Service Mode. In Limited-Service Mode, data calls are not allowed. The UE only allows emergency voice calls (see ***Chapter 3.2.2***) |
| **<trig>** | Integer type. Triggering temperature threshold. When the temperature reaches **<trig>**, the corresponding thermal management mechanism (**<level>**) will be triggered. Range:0–120000. Unit: 0.001 ºC.<br>When **<level>**=1, **<trig>** is the temperature threshold of Level 1. Default value: 100000.<br>When **<level>**=2, **<trig>** is the temperature threshold for entering Limited-Service Mode. Default value: 115000. |
| **<clr>** | Integer type. Terminating temperature threshold. When the temperature drops to **<clr>**, the corresponding thermal management mechanism (**<level>**) will be terminated. Range: 0–120000. Unit: 0.001 ºC.<br>When **<level>**=1, **<clr>** is the temperature threshold of terminating Level 1.<br>Default value: 95000. |

| | |
|---|---|
| | When **<level>**=2, **<clr>** is the temperature threshold to exit the Limited-Service Mode. Default value: 110000. |

## Example

```
AT+QCFG="thermal/mdm",2,105000,98000     //Cool down the module by Limited-Service Mode at Level 3. If the temperature reaches 105 ºC, the network connection is disconnected, and only emergency voice calls are allowed. When the temperature drops to 98 ºC, the data throughput restores and the module exits from Level 3.
OK
AT+QCFG="thermal/mdm"                    //Query the current thermal management level of MDM.
+QCFG: "thermal/mdm",1,100000,97000

+QCFG: "thermal/mdm",2,105000,98000

OK
```

# 3 Thermal Management Mechanism

**Table 3: Thermal Management Mechanism**

| Mechanism | Level / Sensor | Level 1 | Level 2 | Level 3 |
|---|---|---|---|---|
| **PA** | pa-therm1-usr | UL throttling | Restrict PA power (MTPL) | - |
| **MDM** | mdm-usr | DL throttling | - | Limited service |

## 3.1. PA Thermal Management Mechanism

### 3.1.1. Limiting UL Data Rate

The workload of components such as CPU and PA can be reduced for cooling by limiting data rate. However, the thermal management is not effective in case of no data or low data rate.

By executing **AT+QCFG="thermal/modem",1,<trig>,<clr>**, the module limits the UL data rate at different target rates based on the configured temperature thresholds within a certain period. Target rates levels of uplink data rate limit are listed below:

**Table 4: Target Rates Levels of UL Data Rate Limit**

| Target Rate Level | Maximum Uplink Data Rate | Remark |
|---|---|---|
| target_rate[0] | 150 Mbps | Detection cycle: 13 seconds<br>Numbers of target rates: 13<br>Default rate: target_rate[8] |
| target_rate[1] | 100 Mbps | |
| target_rate[2] | 75 Mbps | |
| target_rate[3] | 50 Mbps | |
| target_rate[4] | 40 Mbps | |
| target_rate[5] | 25 Mbps | |

| | |
|---|---|
| target_rate[6] | 10 Mbps |
| target_rate[7] | 5 Mbps |
| target_rate[8] | 1 Mbps |
| target_rate[9] | 1 Mbps |
| target_rate[10] | 1 Mbps |
| target_rate[11] | 1 Mbps |
| target_rate[12] | 1 Mbps |

**NOTE**

1. The UL target data rate levels in the above table are the default values automatically configured by the module to enable the software thermal management mechanism. In the test procedure, they are different for different modules, and are affected by the module's own state, heat dissipation, and surrounding environment.
2. When performing the test on CMW500, the software thermal management mechanism can be triggered only if a SIM card with a non-PLMN of 001-01 is used.

Taking **AT+QCFG="thermal/modem",1,100000,95000** (triggering temperature threshold is 100 ºC and terminating temperature threshold is 95 ºC) as an example, the thermal management mechanism is as follows.

1. The temperature obtained by "pa-therm1-usr" reaches 100 ºC (triggering temperature threshold).
2. The module will enter Level 1 and limit the UL data rate to 1 Mbps (Default rate: *target_rate[8]*).
3. After 3 seconds, if the temperature drops below 95 °C (terminating temperature threshold), the UL data rate limit will be terminated. If the temperature remains above 95 °C, data rate will remain at 1 Mbps (the target rate level rises to *target_rate[9]*).
4. The temperature is detected every 3 seconds. If the temperature is still higher than 95 °C, the target rate level increases until it reaches *target_rate[12]*. After the temperature of the module drops below 95 °C, the data rate returns to 150 Mbps (*target_rate[0]*) step by step.

### 3.1.2. Limiting PA Power

Restricting the PA power is a good way to lighten PA workload. However, the PA power in field test is configured by the network. If the network signal is relatively good, the PA power is generally not high, and thus the thermal management is not effective by limiting the PA power. When the PA power is restricted and lower than that of the configured network, the network may not be able to receive the signal sent by the module or decode the signals, resulting in a decrease in the data throughput performance.

By executing **AT+QCFG="thermal/modem",2,<trig>,<clr>**, the module limits the PA power at different target rates based on the configured temperature thresholds within a certain period. PA power backoff information are listed below:

**Table 5: PA Power Backoff Information**

| Parameter Type | Parameter Name | Value | Remark |
|---|---|---|---|
| Reference power backoff | P_backoff | 5 dBm | The power backoff sequence: 5 dBm, 10 dBm, 13 dBm, 13 dBm, 13 dBm, 13 dBm... |
| Maximum power backoff | Max_backoff | 13 dBm | |
| Duration of normal power | T_up | 50 ms | Taking a normal PA power of 21 dBm as an example, the backoff powers are in the following order: 16 dBm, 11 dBm, 8 dBm, 8 dBm, 8 dBm... |
| Duration of power backoff | T_down | 50 ms | |
| Detection cycle | Step_timer | 15 s | |

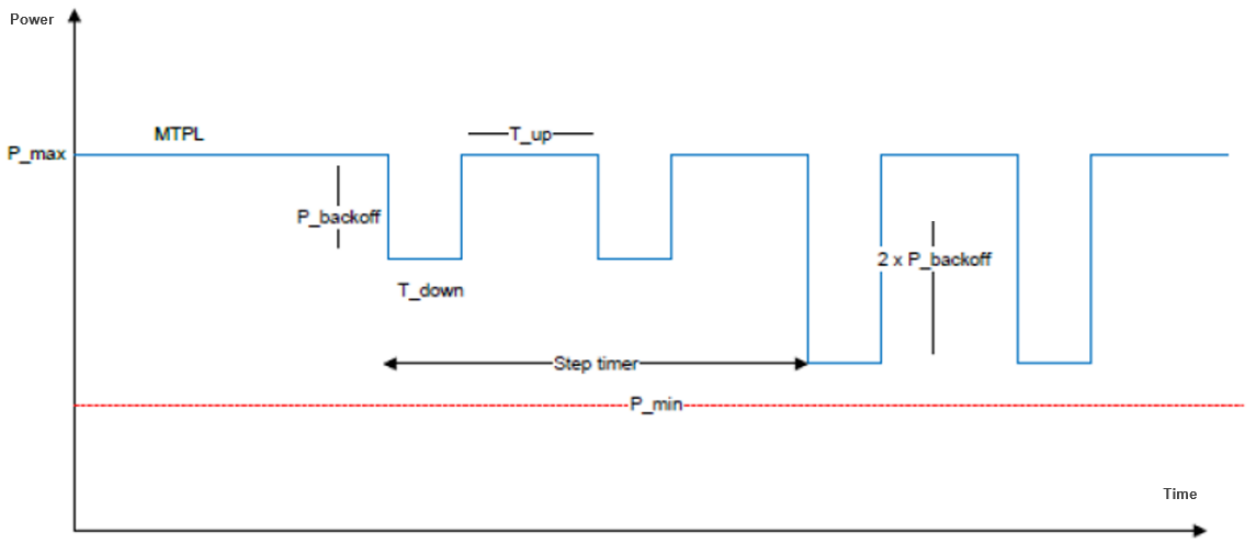


**Figure 1: Power Backoff Diagram**

Taking **AT+QCFG="thermal/modem",2,105000,100000** (triggering temperature threshold is 105 ºC and terminating temperature threshold is 100 ºC) and 21 dBm normal power as an example, the thermal management mechanism is as follows.

1. When the temperature obtained by "pa-therm1-usr" reaches 105 ºC (triggering temperature threshold).
2. The module enters Level 2 and automatically starts and maintains 5 dBm PA backoff (PA power drops to 16 dBm) for 50 ms (*T_up*). After 50 ms, it returns to 21 dBm for 50 ms (*T_down*), and then drops to

16 dBm for 50 ms and so on. 15 s is a power backoff cycle (*Step_timer*).

3. After 15 s, if the temperature drops below 100 °C (terminating temperature threshold), the power backoff will be terminated. If the temperature remains above 100 °C, power backoff value will increase to 10 dBm, and the PA power will alternate between 21 dBm and 11 dBm at 50 ms intervals.
4. Power backoff of 10 dBm lasts 15 s. if the temperature drops below 100 °C, the power backoff will be terminated. If the temperature remains above 100 °C, the power backoff value will increase to 13 dBm.
5. Power backoff of 13 dBm lasts 15 s. if the temperature drops below 100 °C, the power backoff will be terminated. If the temperature remains above 100 °C, the power backoff value will remain at 13 dBm until the temperature drops below 100 °C and the PA power limit is terminated.

**NOTE**

When the module enters Level 2, the thermal management mechanism of Level 1 takes effect at the same time, that is, executing reducing the UL data rate and the PA power at the same time.

## 3.2. MDM Thermal Management Mechanism

### 3.2.1. Limiting DL Data Rate

When the temperature obtained by "mdm-usr" is higher than 100 ºC, mechanism of limiting the DL data rate will be triggered. The module reduces SCC and lower the power on the RF transceiver and modem baseband to reduce the temperature. If the temperature drops below the terminating temperature 100 °C, the limitation will be stopped.

The thermal management mechanism is described as follows:

- The number of receiving antennas will fall back from 4RX to 2RX.
- The module reports CQI-0 ( indicating SCells are dropped) to the network.

**NOTE**

This mechanism is not triggered when the module configuration is 2RX.

### 3.2.2. Entering Limited-Service Mode

Once the temperature of "mdm-usr" reaches 115 ºC, the module is forced into a Limited-Service Mode to protect the hardware. When the temperature of "mdm-usr" drops below 105 ºC, the module exits Limited-Service Mode.

## 3.3. Module Rebooting

When the temperature of the module is over 120 ºC, it will automatically reboot to protect the hardware. Please note that neither the mechanism nor the triggered temperature can be configured manually.

# 4 Appendix References

**Table 6: Terms and Abbreviations**

| Abbreviation | Description |
|---|---|
| ARM | Advanced RISC Machine |
| BB | Baseband |
| CA | Carrier Aggregation |
| CC | Component Carrier |
| CPU | Central Processing Unit |
| DSP | Digital Signal Processor |
| IP | Internet Protocol |
| PA | Power Amplifier |
| RX | Receive |
| TA | Terminal Adapter |
| XO | Crystal Oscillator |