



FG132 Series Temperature Control Application Guide

V1.1

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Applicable Model

No.	Applicable Model	Description
1	FG132 series	SDX35 platform

Change History

V1.1 (2024-07-26)	Modified Summary Section Description.
V1.0 (2024-06-24)	Initial version.

1 Overview

In order to ensure that the equipment can work normally under high temperature working conditions, different strategies are adopted to reduce the heat of the equipment for different temperatures, and corresponding temperature protection mechanisms are introduced.

The temperature protection architecture of FG132 series modules is shown in the following figure, and the main functions are completed in the Modem core.

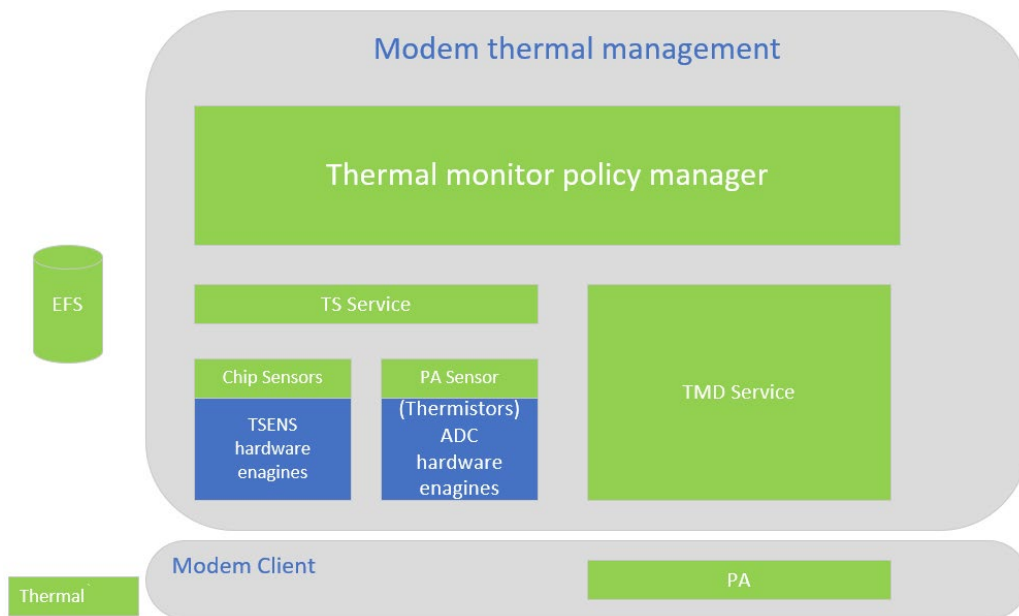


Figure 1. Basic framework

The following table describes each component related to Thermal in Figure 1.

Table 1. Description of components related to Thermal

Component	Description
Thermal monitor policy manager	Reads the config.ini user temperature control configuration in EFS, monitors the PA Sensor and Chip Sensors temperatures, and initiates TMD behaviors according to the user-configured temperature control policy.
TS Service	Acts on PA Sensors and Chip Sensors to collect temperature.
TMD Service	Acts on the Modem Client to initiate specific temperature control measures.
PA	Implements PA corresponding TMD.
Chip Sensors	A collection of chip internal sensors.
PA Sensor	The thermistor is converted into temperature by ADC, which intuitively reflects the PA temperature.

The distribution of Chip Sensors is shown in the following figure. There are 6 Sensors inside the chip, among which Sensor 4 and Sensor 6 temperatures are involved in the hardware shutdown strategy triggering.

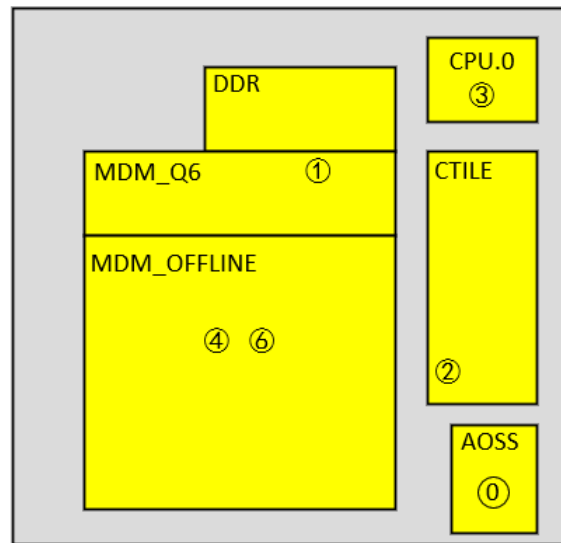


Figure 2. Chip Sensors

PA Sensor: The thermistor is converted into temperature by ADC, which intuitively reflects the PA temperature. The PA Temperature is involved in PA TMD strategy triggering.

2 Description of Temperature Control Strategy

FG132 series modules only support LTE and NR network standards. Different network standards correspond to different TMDs. The temperature control strategies of LTE network standards are described in Table 2, and the temperature control strategies of NR network standards are described in Table 3.

Table 2. Temperature control strategies of LTE network standard

TMD	Temperature Control Strategy	Description
pa_lte_sdr0_dsc	UL Throttling	The purpose of the UL Throttling mitigation measures is to limit uplink rate transmission and reduce PA active time to reduce PA power consumption.
	MTPL	The purpose of MTPL (Maximum transmit power limit) mitigation measures is to limit the maximum transmit power of all channels to reduce PA power consumption, which has obvious effect on temperature control.
	Limited Service Mode	The purpose of the Limited Service Mode mitigation measures is not to allow data calls. If the terminal exits connected mode and enters idle mode, only emergency voice calls are allowed. It is usually used as an emergency mode.
HW	HW Shutdown	When the temperature of Sensor 4 or Sensor 6 exceeds 120 degrees, the hardware shuts down, and the hardware behavior is not controlled by the software.

Table 3. Temperature control strategies of NR network standard

TMD	Temperature Control Strategy	Description
pa_nr_sdr0_dsc	UL Throttling	The purpose of the UL Throttling mitigation measures is to limit uplink rate transmission and reduce PA active time to reduce PA power consumption.
	MTPL	The purpose of MTPL (Maximum transmit power limit) mitigation measures is to limit the maximum transmit power of all channels to reduce PA power consumption, which has obvious effect on temperature control.
	Limited Service Mode	The purpose of the Limited Service Mode mitigation measures is not to allow data calls. If the terminal exits connected mode and enters

		idle mode, only emergency voice calls are allowed. It is usually used as an emergency mode.
HW	HW Shutdown	When the temperature of Sensor 4 or Sensor 6 exceeds 120 degrees, the hardware shuts down, and the hardware behavior is not controlled by the software.

3 Temperature Control Configuration Analysis

The temperature control strategy of FG132 series modules is configured using the config.ini file, which is stored in the EFS /nv/item_files/therm_monitor/ directory. The following are the specific parameters of the temperature control configuration file of LTE and NR network standards of FG132 series modules.

[pa]				
thermal_zone	pa_lte_sdr0_dsc			
sampling	1000	1000	1000	1000
thresholds	95000	105000	115000	528000
thresholds_clr	-273000	90000	100000	110000
actions	mitigate	mitigate	mitigate	mitigate
action_info	0	9	12	255
[pa]				
thermal_zone	pa_nr_sdr0_dsc			
sampling	1000	1000	1000	1000
thresholds	95000	105000	115000	528000
thresholds_clr	-273000	90000	100000	110000
actions	mitigate	mitigate	mitigate	mitigate
action_info	0	9	12	255

The config.ini configuration parameters are parsed as shown in the following table.

Table 4. config.ini configuration parameters parsing

Parameter	Description
[pa]	PA Sensor is selected
thermal_zone	TMD (see Table 5 and Table 6)
sampling	Sampling period (in ms)
thresholds	Temperature control trigger thresholds
thresholds_clr	Clearing temperature control threshold
action_info	TMD execution level (see the State column in Table 5 and Table 6)

Details of pa_lte_sdr0_dsc are shown in the following table.

Table 5. pa_lte_sdr0_dsc

TMD = pa_lte_sdr0_dsc

State	UL Throttling	MTPL	Limited Service Mode
0	0%	--	--
1	10%	--	--
2	20%	--	--
3	30%	--	--
4	40%	--	--
5	50%	--	--
6	60%	--	--
7	70%	--	--
8	80%	--	--
9	90%	--	--
11	90%	3db	--
12	90%	6db	--
255		--	Yes

Details of pa_nr_sdr0_dsc are shown in the following table.

Table 6. pa_nr_sdr0_dsc

TMD = pa_nr_sdr0_dsc			
State	UL Throttling	MTPL	Limited Service Mode
0	0%	--	--
1	10%	--	--
2	20%	--	--
3	30%	--	--
4	40%	--	--
5	50%	--	--
6	60%	--	--
7	70%	--	--
8	80%	--	--
9	90%	--	--
11	90%	3db	--
12	90%	6db	--
255		--	Yes

Take LTE network standards as an example:

[pa] means that the Sensor selected for monitoring is PA Sensor. The PA temperature is sampled once per second.

- When the PA temperature exceeds 95°C, execute TMD (pa_lte_sdr0_dsc) action_info 9. As shown in Table 5, this action level is a maximum limit of 90% based on the uplink theoretical rate (75 Mbps). When the temperature is lower than 90°C, execute TMD (pa_lte_sdr0_dsc) action_info 0 (that is, limit is canceled).
- When the PA Sensor temperature is greater than 105°C, execute TMD (pa_lte_sdr0_dsc) action_info 12. As shown in Table 5, this action level is a maximum limit of 90% based on the uplink theoretical rate (75 Mbps) and a maximum limit of 6db based on the maximum transmit power (23 db). When the temperature is lower than 100°C, execute TMD (pa_lte_sdr0_dsc) action_info 9.
- When the PA Sensor temperature is greater than 115°C, execute TMD (pa_lte_sdr0_dsc) action_info 255. As shown in Table 5, this action level is Limited Service Mode, which represents that the network is dropped. Only when the TMD level falls back to 0 (the temperature is lower than 90°C) will it recover.

4 Summary

The temperature control of FG132 is summarized in the following table.

Table 7. FG132 temperature control summary

Network System	Temperature Trigger Threshold	Description
LTE	95°C	When the PA temperature exceeds 95°C, start the first level temperature control strategy. The maximum limit is 90% based on the theoretical uplink rate (75Mbps), and the limit is canceled when the PA temperature is lower than 90°C.
	105°C	When the PA temperature exceeds 105°C, start the second level temperature control strategy. The maximum limit is 90% based on the theoretical uplink rate (75Mbps) and 6db based on the maximum transmit power (23db), and the temperature control strategy is restored to the first level temperature control strategy when the PA temperature is lower than 100°C.
	115°C	When the PA temperature exceeds 115°C, start the third level temperature control strategy and execute the Limited Service Mode. Only when the PA temperature is lower than 90°C can this limit be canceled.
	120°C	If the temperature of Sensor 4 or Sensor 6 is higher than 120°C, start the fourth level temperature control strategy and shut down the hardware.
NR	95°C	When the PA temperature exceeds 95°C, start the first level temperature control strategy. The maximum limit is 90% based on the theoretical uplink rate (122Mbps), and the limit is canceled when the PA temperature is lower than 90°C.
	105°C	When the PA temperature exceeds 105°C, start the second level temperature control strategy. The maximum limit is 90% based on the theoretical uplink rate (122Mbps) and 6db based on the maximum transmit power (23db), and the temperature control strategy is restored to the first level temperature control strategy when the PA temperature is lower than 100°C.
	115°C	When the PA temperature exceeds 115°C, start the third level temperature control strategy and execute the Limited Service Mode. Only when the PA temperature is lower than 90°C can this limit be canceled.
	120°C	When the temperature of Sensor 4 or Sensor 6 is higher than 120°C, the hardware shuts down.



Under the instrument test, the temperature control strategy will only take effect for the instrument card whose IMSI begins with 46003, which can be queried through AT+CIMI.

Users can query the temperature of Chip Sensors, PA Sensor and other temperatures of PMU chips through AT+MTSM=8, **where Modem and PA temperature** participate in temperature control strategy triggering, as shown in the following table.

Table 8. MTSM=8

Parameter	Description	Module Internal sys Node
Main	PMIC DIE chip temperature	/sys/class/thermal/thermal_zone0/temp
DSP	Sensor 1 temperature in Chip Sensors	/sys/class/thermal/thermal_zone8/temp
IPA	Sensor 2 temperature in Chip Sensors	/sys/class/thermal/thermal_zone9/temp
CPU	Sensor 3 temperature in Chip Sensors	/sys/class/thermal/thermal_zone10/temp
Modem	Sensor 4 temperature in Chip Sensors (same temperature as Sensor 6)	Sensor 4:/sys/class/thermal/thermal_zone11/temp Sensor 6:/sys/class/thermal/thermal_zone12/temp
XO	XO crystal temperature	/sys/class/thermal/thermal_zone4/temp
PA	PA Sensor temperature	/sys/class/thermal/thermal_zone5/temp