



MM8108 Thermal Protection Mechanism Application Note 56

Working principle of thermal protection mechanism and its impact on throughput



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1 Introduction

The MM8108 SoC features an on-chip Power Amplifier (PA) capable of delivering up to 26 dBm average power. At such high output levels, the heat generated can raise the chip's temperature well above ambient. When the ambient temperature is already high, the measured temperature may exceed the chip's maximum rated operating temperature. Operating beyond this limit can cause the device to enter an unstable state, potentially resulting in permanent hardware failure or link disconnection. To prevent this, Morse Micro has built continuous thermal monitoring and a Thermal Protection Mechanism (TPM) into the firmware to keep the device operating reliably. This document explains how this thermal protection mechanism works.

2 Thermal Protection Mechanism (TPM)

To determine safe operating thresholds, MM8108-based modules undergo thermal characterization in a controlled temperature chamber. During these tests, the module transmits continuously at maximum average power. At the same time, temperature readings are logged every second, tracking how the chip's temperature rises toward a stable state or, if pushed too far, toward failure. This data is used to define two key thresholds:

- the thermal protection activation temperature (T_{p_on}), the point at which the protection mechanism activates to keep the chip within safe limits, and
- the recovery temperature (T_{p_off}), the point at which transmission is allowed to resume.

T_{p_off} is usually 5 °C lower than T_{p_on} . An on-chip sensor provides a direct reading of the chip's temperature (T_{chip}), which can be read in real time via the ``morsectrl stats`` command.

Before each transmission, the firmware checks the current chip temperature (T_{chip}) against T_{p_on} . If T_{chip} is at or above T_{p_on} , the firmware suspends transmission; it remains suspended until the chip cools to T_{p_off} , at which point transmission resumes.

Because the protection mechanism reacts dynamically to temperature, users may see variable, unpredictable throughput whenever it is engaged. In hotter ambient conditions, the chip reaches T_{p_on} more quickly, so transmissions are suspended more often and overall data rates drop accordingly. In effect, the mechanism adapts the transmit duty cycle in real time to keep the chip's temperature in check. In extreme heat, sustained operation can prevent the chip from ever cooling back to T_{p_off} , leading to prolonged transmission gaps or total link disconnection.

3 Operational Impact

This section and the table below explain the state of the Thermal Protection Mechanism (TPM) as it heats towards the key threshold temperatures.

State	Chip Temperature (T_{chip})	TPM Status	Transmission
1	$T_{chip} < T_{p_on}$	Off	Normal
2	$T_{p_off} \leq T_{chip} \leq T_{p_on}$ (TPM not yet triggered)	Off	Normal
3	$T_{chip} \geq T_{p_on}$	On	Suspended
4	$T_{p_off} \leq T_{chip} \leq T_{p_on}$ (TPM triggered)	On	Suspended
5	$T_{chip} \leq T_{p_off}$	Off	Normal

Table 1: Thermal Protection Mechanism (TPM) states

States 2 and 4 differ in whether the TPM has been triggered and establish the hysteresis loop that the TPM relies on. For example, in a simple case of temperature rising and then falling, state 2 occurs as the temperature rises, while state 4 occurs as the temperature falls.

- State 1: (T_{chip} is much lower than T_{p_on})
 - The chip temperature is well below T_{p_on} (e.g., $\sim 20^\circ\text{C}$ in this example), so transmission continues as normal.
- State 2: (T_{chip} is between T_{p_off} and T_{p_on} , rising toward T_{p_on})
 - The chip temperature has risen but is still below T_{p_on} , so the protection mechanism has not triggered and transmission continues as normal.
- State 3: (T_{chip} is at or above T_{p_on})
 - The chip temperature has reached T_{p_on} , so the protection mechanism triggers and suspends transmission. With transmission stopped, the chip should begin to cool.
- State 4: (T_{chip} is between T_{p_off} and T_{p_on} , falling toward T_{p_off})
 - The chip continues cooling but has not yet reached T_{p_off} , so transmission remains suspended.
- State 5: (T_{chip} is at or below T_{p_off})
 - The chip has now cooled to T_{p_off} , so the protection mechanism switches off and transmission resumes. As transmission resumes, the chip temperature rises again, repeating the cycle.

4 Validation Testing Procedure

This section details how the Thermal Protection Mechanism can be tested in a lab to confirm that it works as intended.

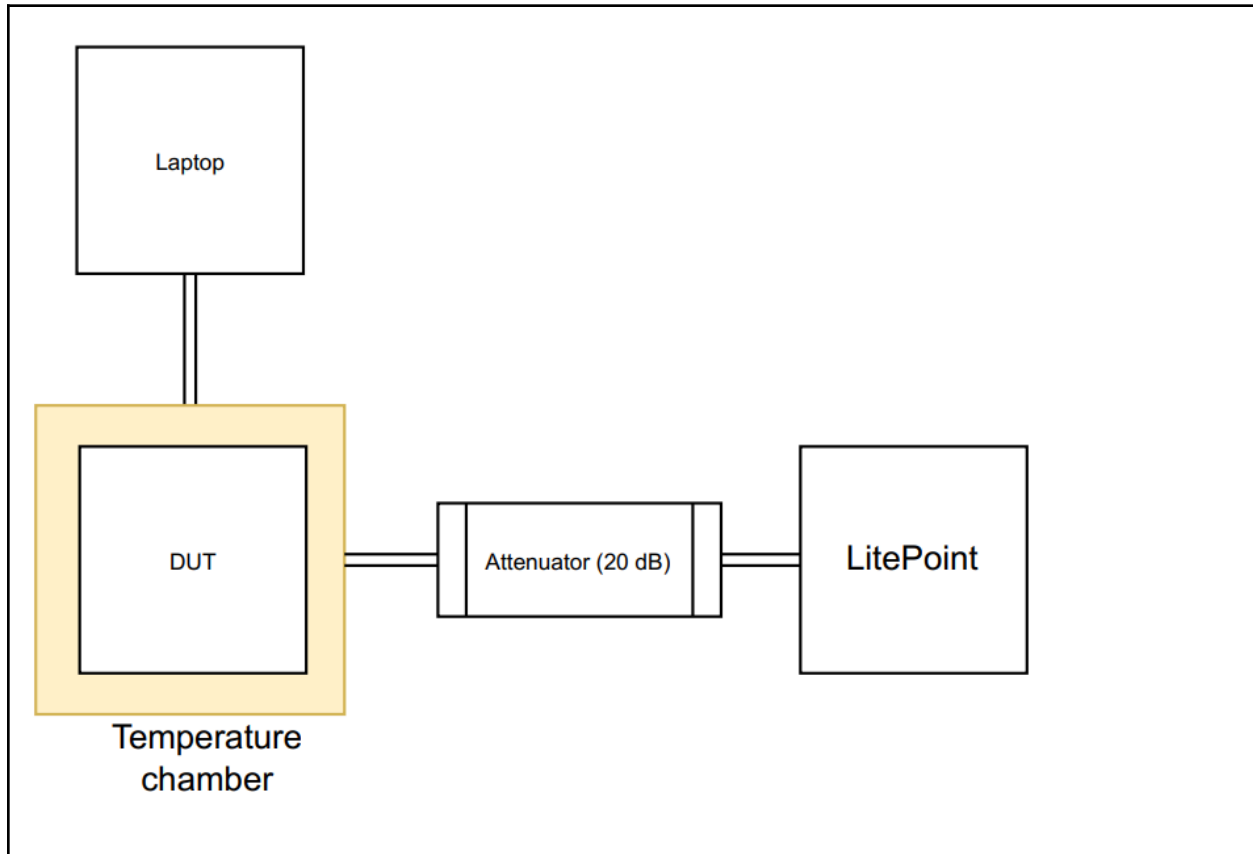


Figure 1: Measurement setup overview

To study the impact of the Thermal Protection Mechanism (TPM), an MM8108-based module is placed inside a temperature chamber. Figure 1 above shows the setup. The chamber is held at 55 °C while the module continuously transmits 1 MHz MCS 0 packets, and chip statistics are read every second.

Figure 2 below plots the results: the blue curve shows the measured chip temperature, and the red curve shows the number of packets transmitted per second. From cold start (0 s), the chip temperature rises to around 88 °C after ~70 s. In this example, T_{p_on} is set to 90 °C and T_{p_off} to 85 °C. Once the chip temperature reaches T_{p_on} , the TPM triggers and cycles between suspending and resuming transmission as described above, causing the red curve to fluctuate for the rest of the run instead of holding steady. Note that although the protection mechanism activates instantaneously once the chip temperature reaches 90 °C, logging temperature only once per second means the plotted curve does not always capture the exact instant this threshold is crossed.

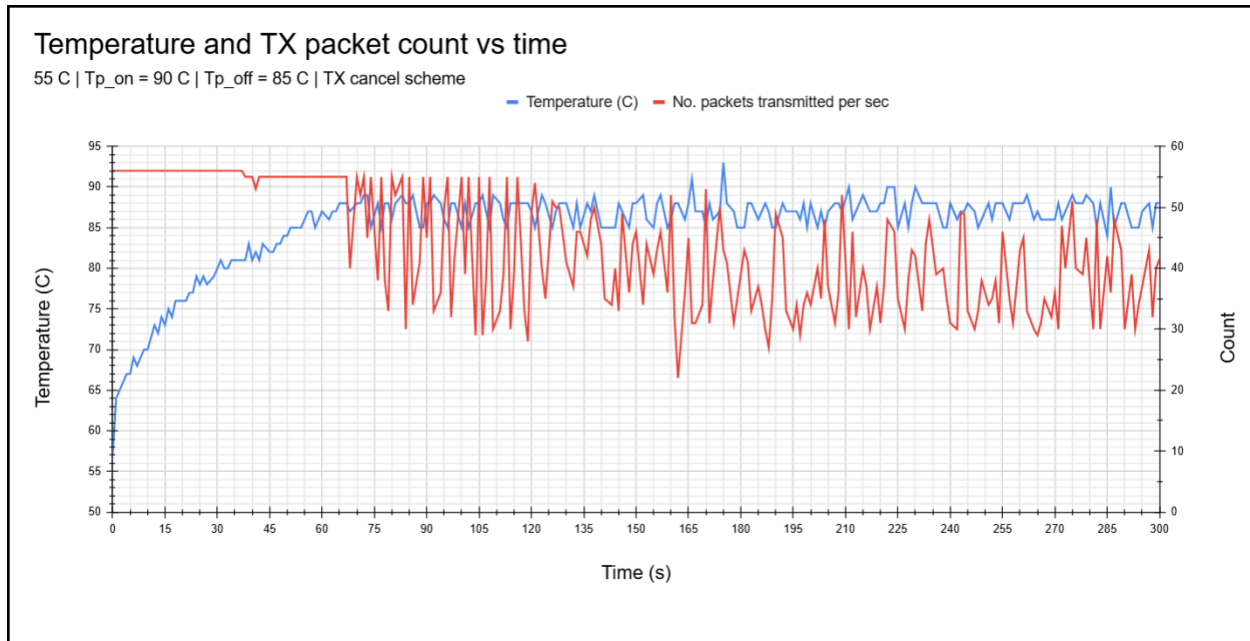


Figure 2: Chip temperature and transmitted packet count.

5 Conclusion and recommendations

A robust Thermal Protection Mechanism (TPM) is essential to preserve the SoC's operational lifespan and prevent it from entering an unstable state. As a result, users should expect time-varying throughput under extreme conditions, since the protection mechanism suspends transmission whenever the chip runs hot. In sustained high temperatures, this can also lead to prolonged transmission gaps or link disconnection.

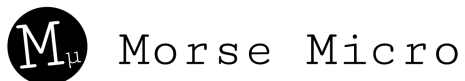
In firmware release 1.17.9, the activation threshold (Tp_on) is set to 90 °C and the recovery threshold (Tp_off) to 85 °C.

In firmware release 2.0.0 and later, the Tp_on threshold defaults to 125 °C and can be configured via BCF. Tp_off is hardcoded to Tp_on – 5 °C in firmware.

6 Revision History

Version Number	Release Date	Release Notes
1	31 Aug 2026	First release of thermal protection mechanism on MM8108
2	04 Sep 2026	Updated information related to BCF parameters and default thresholds.

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