AN14771

Estimated Power-on Hours for the MCX E24x

Rev. 1.0 — 9 October 2025 | Application note

Document information

Information	Content
Keywords	AN14771, MCX E24x, Power-on Hours (PoH), junction temperature (T_j), effective junction temperature ($T_{j\text{-}eff}$), $T_j$max, HTOL
Abstract	This document guides on how to interpret the different device qualification levels in terms of the target operating voltage, junction temperature (T_j) of the device, and relation of these qualification levels to the PoH of the device.

1 Introduction

This document describes the estimated product Power-on Hours (PoH) for the MCX E24x (device). It uses the criteria from the qualification process.

The product PoH described here are estimates and do not represent a guaranteed lifetime for a product.

This document guides on how to interpret the different device qualification levels in terms of the:

- Target operating voltage
- Junction temperature (T_j) of the device
- Relation of these qualification levels to the PoH of the device

The data presented in this document is provided for convenience. However, it does not represent all potential failing mechanisms and may not accurately represent behavior for all mission profiles or applications. For more details on NVM reliability as another potential failing mechanism, see *Robust 5V Arm Cortex M4F MCU with up to 2MB flash Data Sheet* (document MCXEP144M112F70). The data is based on a single activation energy and voltage acceleration parameter, using the Arrhenius equation for temperature acceleration and Power Law for voltage acceleration. The data is also based on the data collected during High-Temperature Operating Life (HTOL) to demonstrate how temperature could impact the PoH of the product.

2 Device qualification level and available PoH

Each supported qualification level (Industrial) defines several PoH available to the device under a given set of conditions, such as T_j:

- The device can operate at the $T_j$max, see *Robust 5V Arm Cortex M4F MCU with up to 2MB flash Data Sheet* (document MCXEP144M112F70). However, operating the device at this temperature for an extended time reduces its operating PoH.
- Ensure that the device is thermally managed and the T_j does not exceed the $T_j$max. For more details on the limit, see the *Robust 5V Arm Cortex M4F MCU with up to 2MB flash Data Sheet* (document MCXEP144M112F70).

Note: *The data provided in this document are estimates for the PoH using the qualification test data and experience with this product. These estimates must not be viewed as a limit on an individual device lifetime or be construed as a guarantee by NXP as to the actual lifetime of the device. Sales and warranty terms and conditions still apply.*

2.1 Industrial qualification

Figure 1 provides the number of PoH for the use conditions of the Industrial device. The PoH value assumes that the product is powered on and active for 100 % of the time (100 % duty cycle). The PoH can be read directly from the curves to determine the impact of the T_j at the listed conditions.

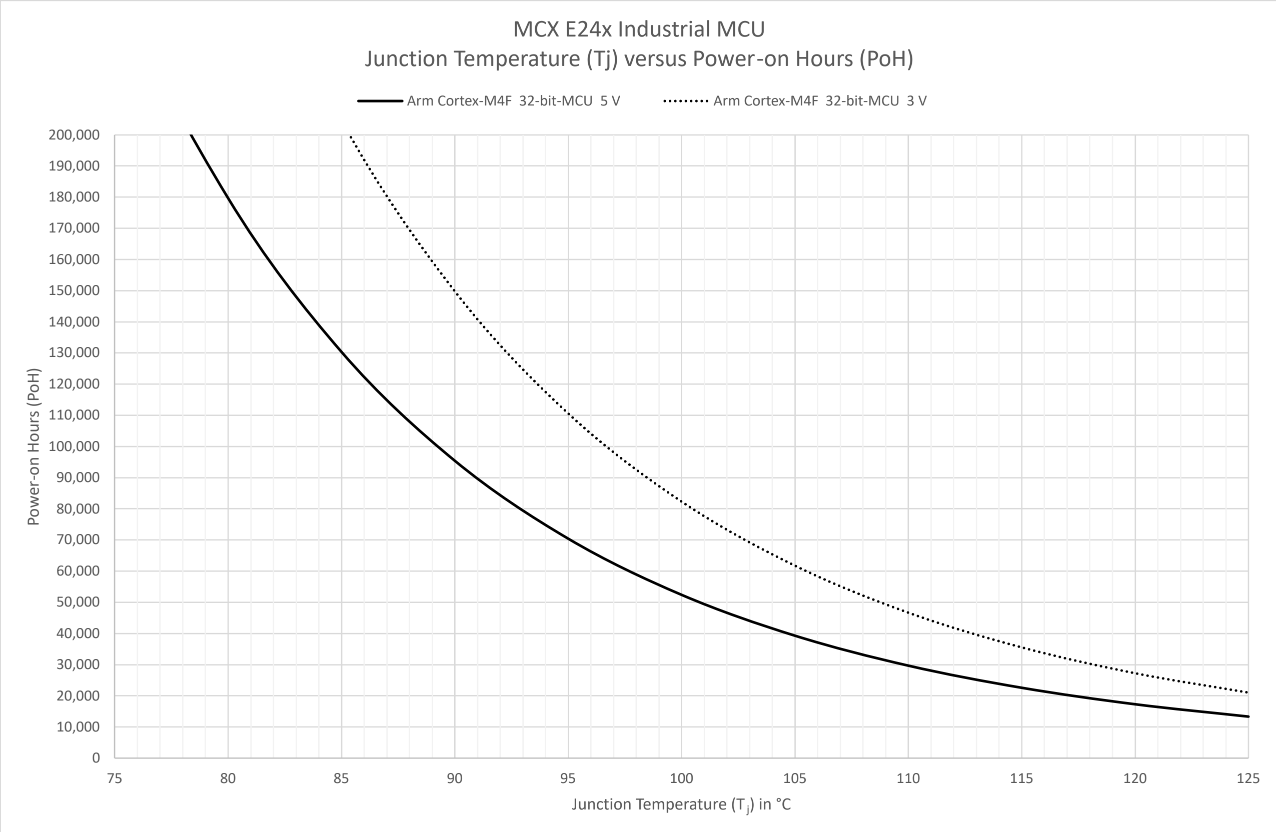

Figure 1. MCX E24x industrial PoH estimates

3 Effective junction temperature ($T_{j\text{-eff}}$)

The T_j of the device is the temperature of the transistors in the device. It is a different measurement than the case and the ambient temperature. Most applications do not have a constant T_j during operation.

The charts in this document show the relationship between the T_j and PoH. The percentage of on-time at different temperatures defines each mission profile. The $T_{j\text{-eff}}$ is the single T_j that represents the mission profile and can be used to extrapolate the PoH in the charts above.

- The $T_{j\text{-eff}}$ depends only on the temperatures during on-time duty cycles of a mission profile. Temperatures when the device is powered off do not affect $T_{j\text{-eff}}$.
- The $T_{j\text{-eff}}$ is not a simple average of temperatures as the on-time at higher temperatures consumes more operating life than on-time at lower temperatures.
- When the T_j is not constant during the user application, the $T_{j\text{-eff}}$ can be calculated using weighting with the Arrhenius factor.

3.1 Calculating $T_{j\text{-eff}}$

Assuming that the temperature dependence follows Arrhenius behavior, you can calculate the $T_{j\text{-eff}}$ using the following method:

1. Determine the percentage of time (t_n) that the application is powered on at a small set of discrete temperatures (T_n).
2. Calculate the average failure rate using the Arrhenius method:

$$FR_{AV} = \left[t_1 \times e^{\frac{-E_A}{kT_1}} + t_2 \times e^{\frac{-E_A}{kT_2}} + \dots + t_n \times e^{\frac{-E_A}{kT_n}} \right]$$

3. The effective temperature can then be calculated as:

$$T_{j\text{-eff}} = \frac{-E_A}{k \times \ln(FR_{AV})}$$

The following are the details related to the variables and constants used in the formulas:

E_A = Activation energy. A typical value is 0.7 eV and is used to generate the charts in this document.

k = Boltzmann constant. The value is 8.62 X 10^{-5}.

T_n = The temperatures and result for $T_{j\text{-eff}}$ must be noted in Kelvin.

t_n = The percentage of time at a given temperature must be noted in decimal. For instance, 50 % is 0.50.

The following is a simple example that shows the difference between Tj-avg and Tj-eff. The T_j of the device is at 100 °C for 50 % of the time, and 50 °C for the other 50 % of the time, when the device is powered on. It results in an average of 75 °C.

$$FR_{AV} = \left[0.5 \times e^{\frac{-0.7}{k \times 373.15}} + 0.5 \times e^{\frac{-0.7}{k \times 323.15}} \right] = 1.83 \times 10^{-10}$$

$$T_{j\text{-eff}} = \frac{-0.7}{k \times \ln(FR_{AV})} = 362.18\ K = 89.03\ °C$$

The 89 °C $T_{j\text{-eff}}$ is higher than the average temperature of 75 °C, showing that higher temperatures have a bigger impact on the life of the device.

4 Conclusion

Selecting the optimal operating performance point and thermal envelope is critical to meet the target application PoH.

Lowering the T_j in the application is the most effective means to increase the PoH of the device without affecting the performance of the device. To lower the T_j, increase the thermal dissipation capacity in the application. In cases where the thermal properties cannot be altered, a lower operating voltage can be used to increase the PoH of the device. Lowering the voltage can result in lower performance.

The data and examples provided in this document are for reference to support the customer in their application development.

5 Acronyms

Table 1 lists the acronyms used in this document.

Table 1. Acronyms

Acronym	Description
HTOL	High-Temperature Operating Life
MCU	Microcontroller Unit
NVM	Non-Volatile Memory
PoH	Power-on Hours

6 References

Table 2 lists the references used to supplement this document.

Table 2. Related documentation/resources

Document	Link/how to access
Robust 5V Arm Cortex M4F MCU with up to 2MB flash Data Sheet (document MCXEP144M112F70)	MCXEP144M112F70

7 Revision history

Table 3. Revision history

Document ID	Release date	Description
AN14771 v.1.0	9 October 2025	Initial public release

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