AN14886

MCX E31x Estimated Power-on Hours

Rev. 1.0 — 25 November 2025 Application note

Document information

Information	Content
Keywords	AN14886, MCX E31x, Power-on Hours (PoH), 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 E31x (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 how to interpret the different device qualification levels in terms of:

- Target operating voltage
- Maximum supported junction temperature (T_j)
- 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. 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. It 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_{jMax}, see *5V robust Arm®Cortex®-M7 core 32-bit MCU, up to 4 MB Flash, 512 KB SRAM, EdgeLock® Secure Enclave, Advanced Profile* (document MCXEP172M160FB0). 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_{jmax}. For more details on the limit, see the *5V robust Arm®Cortex®-M7 core 32-bit MCU, up to 4 MB Flash, 512 KB SRAM, EdgeLock® Secure Enclave, Advanced Profile* (document MCXEP172M160FB0)

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.

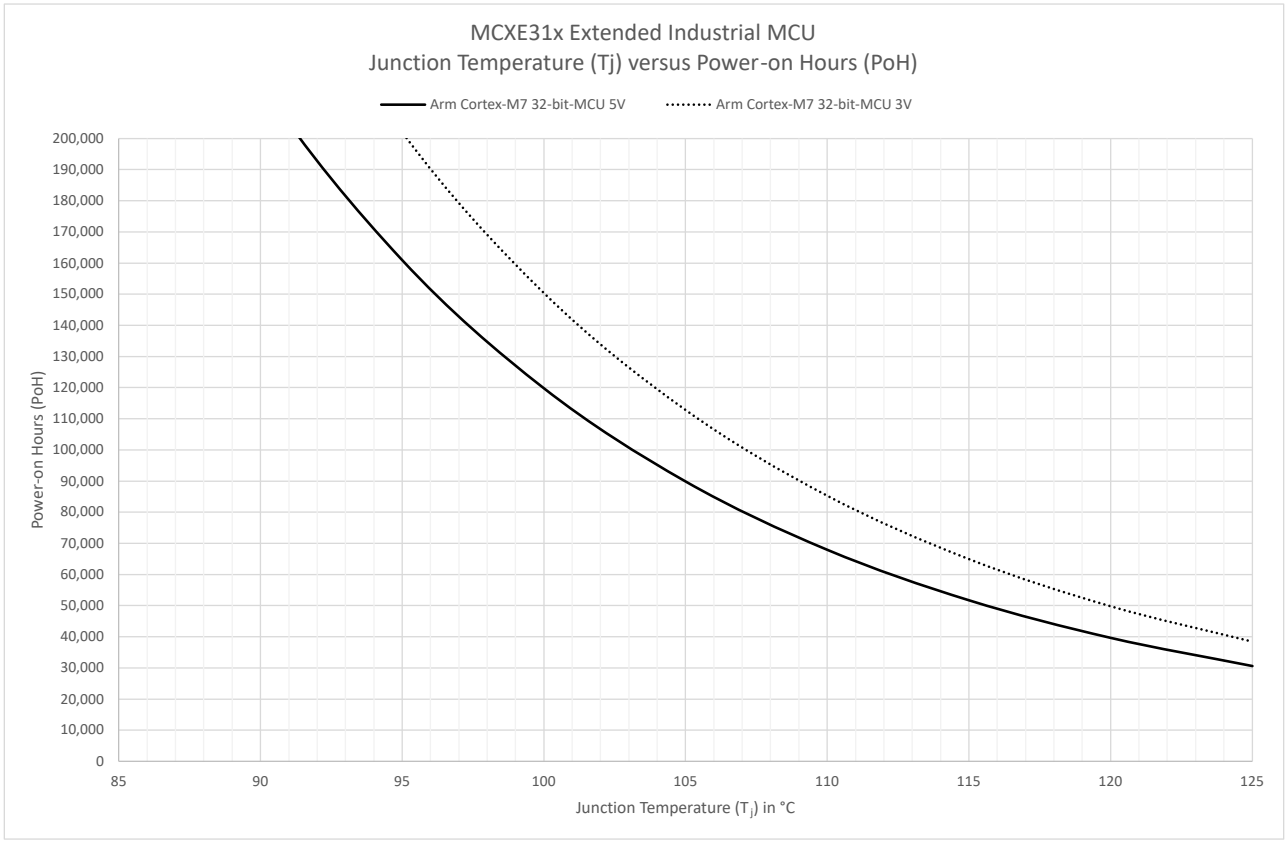

Figure 1. MCX E31x industrial PoH estimates

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 Figure 1.

- 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 $T_{j\text{-}eff}$.
- $T_{j\text{-}eff}$ 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 customer 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:

$$FR_{AV}=\left[t_1 \cdot e^{\frac{-E_A}{k \cdot T_1}} + t_2 \cdot e^{\frac{-E_A}{k \cdot T_2}} + \ldots + t_n \cdot e^{\frac{-E_A}{k \cdot T_n}} \right] \quad (1)$$

3. The effective temperature can then be calculated as:

$$T_{j\text{-}eff} = \frac{-E_A}{k \cdot \ln(FR_{AV})} \quad (2)$$

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

- E_A = Activation Energy. A typical value is 0.7 eV and is what is used to generate the charts in this document.
- k = Boltzmann constant. 8.62×10^{-5}
- T_n: The temperatures must be noted in Kelvin. The result for $T_{j\text{-}eff}$ is also n 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 $T_{j\text{-}avg}$ and $T_{j\text{-}eff}$. 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.

$$FR_{AV}=\left[0.5 \cdot e^{\frac{-0.7}{k \cdot 373.15}} + 0.5 \cdot e^{\frac{-0.7}{k \cdot 323.15}} \right] = 1.83 \times 10^{-10} \quad (3)$$

$$T_{j\text{-}eff} = \frac{-0.7}{k \cdot \ln(FR_{AV})} = 362.18\ K = 89.03°C \quad (4)$$

In this example, the $T_{j\text{-}eff}$, 89 °C, is higher than the average temperature of 75 °C, which shows 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. Trade-offs between the target operating voltage/frequency of the device and the operating junction temperature (T_j) of the device can greatly improve the PoH of the device.

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. To match the voltage specified in the datasheet, adjust the operating frequency lower.

The data and examples provided in this application 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
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
5V robust Arm®Cortex®-M7 core 32-bit MCU, up to 4 MB Flash, 512 KB SRAM, EdgeLock® Secure Enclave, Advanced Profile (document MCXEP172M160FB0)	MCXEP172M160FB0

7 Revision history

Table 3 summarizes the revisions to this document.

Table 3. Revision history

Document ID	Release date	Description
AN14886 v.1.0	25 November 2025	Initial public release

Legal information

Definitions

Draft — A draft status on a document indicates that the content is still under internal review and subject to formal approval, which may result in modifications or additions. NXP Semiconductors does not give any representations or warranties as to the accuracy or completeness of information included in a draft version of a document and shall have no liability for the consequences of use of such information.

Disclaimers

Limited warranty and liability — Information in this document is believed to be accurate and reliable. However, NXP Semiconductors does not give any representations or warranties, expressed or implied, as to the accuracy or completeness of such information and shall have no liability for the consequences of use of such information. NXP Semiconductors takes no responsibility for the content in this document if provided by an information source outside of NXP Semiconductors.

In no event shall NXP Semiconductors be liable for any indirect, incidental, punitive, special or consequential damages (including - without limitation - lost profits, lost savings, business interruption, costs related to the removal or replacement of any products or rework charges) whether or not such damages are based on tort (including negligence), warranty, breach of contract or any other legal theory.

Notwithstanding any damages that customer might incur for any reason whatsoever, NXP Semiconductors' aggregate and cumulative liability towards customer for the products described herein shall be limited in accordance with the Terms and conditions of commercial sale of NXP Semiconductors.

Right to make changes — NXP Semiconductors reserves the right to make changes to information published in this document, including without limitation specifications and product descriptions, at any time and without notice. This document supersedes and replaces all information supplied prior to the publication hereof.

Suitability for use — NXP Semiconductors products are not designed, authorized or warranted to be suitable for use in life support, life-critical or safety-critical systems or equipment, nor in applications where failure or malfunction of an NXP Semiconductors product can reasonably be expected to result in personal injury, death or severe property or environmental damage. NXP Semiconductors and its suppliers accept no liability for inclusion and/or use of NXP Semiconductors products in such equipment or applications and therefore such inclusion and/or use is at the customer's own risk.

Applications — Applications that are described herein for any of these products are for illustrative purposes only. NXP Semiconductors makes no representation or warranty that such applications will be suitable for the specified use without further testing or modification.

Customers are responsible for the design and operation of their applications and products using NXP Semiconductors products, and NXP Semiconductors accepts no liability for any assistance with applications or customer product design. It is customer's sole responsibility to determine whether the NXP Semiconductors product is suitable and fit for the customer's applications and products planned, as well as for the planned application and use of customer's third party customer(s). Customers should provide appropriate design and operating safeguards to minimize the risks associated with their applications and products.

NXP Semiconductors does not accept any liability related to any default, damage, costs or problem which is based on any weakness or default in the customer's applications or products, or the application or use by customer's third party customer(s). Customer is responsible for doing all necessary testing for the customer's applications and products using NXP Semiconductors products in order to avoid a default of the applications and the products or of the application or use by customer's third party customer(s). NXP does not accept any liability in this respect.

Limiting values — Stress above one or more limiting values (as defined in the Absolute Maximum Ratings System of IEC 60134) will cause permanent damage to the device. Limiting values are stress ratings only and (proper) operation of the device at these or any other conditions above those given in the Recommended operating conditions section (if present) or the Characteristics sections of this document is not warranted. Constant or repeated exposure to limiting values will permanently and irreversibly affect the quality and reliability of the device.

Terms and conditions of commercial sale — NXP Semiconductors products are sold subject to the general terms and conditions of commercial sale, as published at https://www.nxp.com/profile/terms, unless otherwise agreed in a valid written individual agreement. In case an individual agreement is concluded only the terms and conditions of the respective agreement shall apply. NXP Semiconductors hereby expressly objects to applying the customer's general terms and conditions with regard to the purchase of NXP Semiconductors products by customer.

No offer to sell or license — Nothing in this document may be interpreted or construed as an offer to sell products that is open for acceptance or the grant, conveyance or implication of any license under any copyrights, patents or other industrial or intellectual property rights.

Quick reference data — The Quick reference data is an extract of the product data given in the Limiting values and Characteristics sections of this document, and as such is not complete, exhaustive or legally binding.

Export control — This document as well as the item(s) described herein may be subject to export control regulations. Export might require a prior authorization from competent authorities.

Suitability for use in non-automotive qualified products — Unless this document expressly states that this specific NXP Semiconductors product is automotive qualified, the product is not suitable for automotive use. It is neither qualified nor tested in accordance with automotive testing or application requirements. NXP Semiconductors accepts no liability for inclusion and/or use of non-automotive qualified products in automotive equipment or applications.

In the event that customer uses the product for design-in and use in automotive applications to automotive specifications and standards, customer (a) shall use the product without NXP Semiconductors' warranty of the product for such automotive applications, use and specifications, and (b) whenever customer uses the product for automotive applications beyond NXP Semiconductors' specifications such use shall be solely at customer's own risk, and (c) customer fully indemnifies NXP Semiconductors for any liability, damages or failed product claims resulting from customer design and use of the product for automotive applications beyond NXP Semiconductors' standard warranty and NXP Semiconductors' product specifications.

HTML publications — An HTML version, if available, of this document is provided as a courtesy. Definitive information is contained in the applicable document in PDF format. If there is a discrepancy between the HTML document and the PDF document, the PDF document has priority.

Translations — A non-English (translated) version of a document, including the legal information in that document, is for reference only. The English version shall prevail in case of any discrepancy between the translated and English versions.

Security — Customer understands that all NXP products may be subject to unidentified vulnerabilities or may support established security standards or specifications with known limitations. Customer is responsible for the design and operation of its applications and products throughout their lifecycles to reduce the effect of these vulnerabilities on customer's applications and products. Customer's responsibility also extends to other open and/or proprietary technologies supported by NXP products for use in customer's applications. NXP accepts no liability for any vulnerability. Customer should regularly check security updates from NXP and follow up appropriately.

Customer shall select products with security features that best meet rules, regulations, and standards of the intended application and make the ultimate design decisions regarding its products and is solely responsible for compliance with all legal, regulatory, and security related requirements concerning its products, regardless of any information or support that may be provided by NXP.

NXP has a Product Security Incident Response Team (PSIRT) (reachable at PSIRT@nxp.com) that manages the investigation, reporting, and solution release to security vulnerabilities of NXP products.

NXP B.V. — NXP B.V. is not an operating company and it does not distribute or sell products.

Trademarks

Notice: All referenced brands, product names, service names, and trademarks are the property of their respective owners.

NXP — wordmark and logo are trademarks of NXP B.V.

EdgeLock — is a trademark of NXP B.V.

Microsoft, Azure, and ThreadX — are trademarks of the Microsoft group of companies.

Contents