Guidelines for estimating STM32H7 MCUs lifetime

Introduction

This application note presents lifetime usage estimates for STM32H7 devices.

These estimates must not be considered as the actual lifetime limit or as a product guarantee for any individual device from the supplier. Applicable sales and warranty terms and conditions remain in effect.

The data in this document is provided for convenience. However, it does not represent all potential failure mechanisms and may not accurately reflect behavior across all mission profiles or applications. High temperature operating life (HTOL) stress is used for product lifetime assessment trials. The Arrhenius equation is used to determine the device aging acceleration factor.

Table 1. **Applicable products**

Type	Product lines
Microcontrollers	STM32H742, STM32H743/753, STM32H745/755, STM32H747/757, STM32H750 value line STM32H723/733, STM32H725/735, STM32H730 value line STM32H7R3/7S3, STM32H7R7/7S7

1 General information

This document presents the STM32H7 series lifetime usage estimation. These estimates are qualified depending on frequencies, voltage, and junction temperature.

The frequencies and applied voltages are provided in the device datasheets.

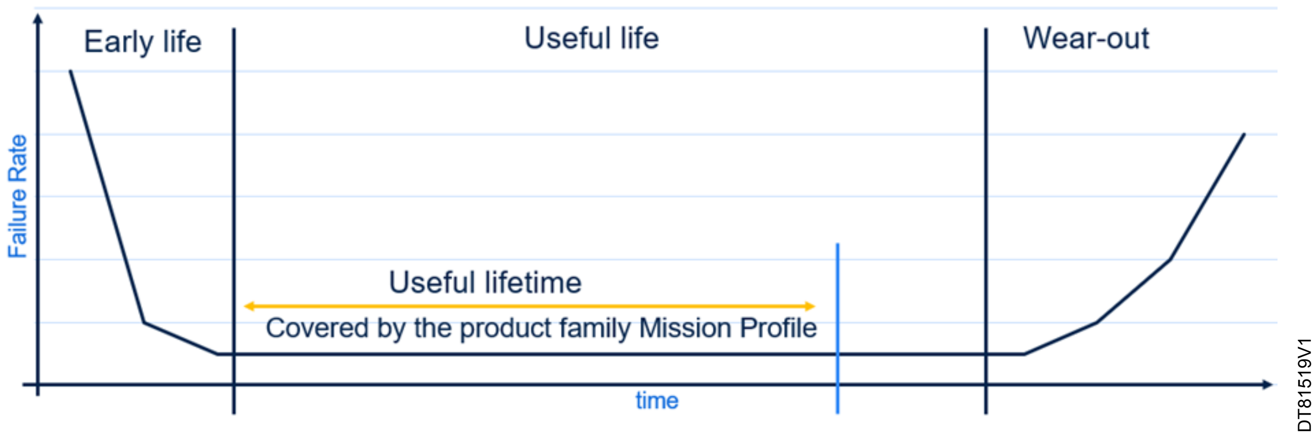
The STM32H7 series microcontrollers are Arm®-based devices.

Note: Arm is a registered trademark of Arm Limited (or its subsidiaries) in the US and/or elsewhere.

2 Reliability analysis using the bathtub curve model

The bathtub curve model is a widely used reliability concept that describes the failure rate of a device over its lifetime, divided into three distinct phases: Early life, Useful life, and Wear-out. This model is visually represented by a curve resembling the shape of a bathtub, where the vertical axis represents the failure rate and the horizontal axis represents time.

Figure 1. Bathtub curve concept



- Early Life (infant mortality)
  Characterized by a higher initial failure rate, which decreases rapidly (expressed in ppm). Usually attributed to manufacturing defects.
- Useful life
  Characterized by a relatively constant and low failure rate, which remains stable over the useful lifetime of the device.
- Wear-out
  Characterized by an increasing failure rate, but normally it should occur much later than the target useful life. The intrinsic wear-out mechanisms begin to dominate, and the failure rate increases exponentially.
- Device useful lifetime
  The useful lifetime of a device is the period covered by the product family mission profile, which is demonstrated on silicon.

Table 2. Lifetime phases and failure characteristics

Phase	Failure rate behavior	Causes
Early life	High, then decreasing	Early defects, usually manufacturing
Useful life	Low, constant	Random failures, intrinsic
End of useful life	Increasing	Aging, wear

3 Product mission profile

The product mission profile (MP) defines the various lifetimes available to the device under a given set of conditions. These conditions include the target core voltage (V_{CORE}) and main supply voltage (V_{DD}), the target junction temperature (T_J) of the device, and the operation ratio under which the device operates. For improved reliability and extended lifetime, it is recommended to select a target T_J margin below T_{Jmax}.

- The device operating T_{Jmax} is specified in its product datasheet.
- The operating device at its T_{Jmax} for an extended time reduces device lifetime.
- Effective device thermal regulation must always be ensured that T_J does not exceed what is specified in the product datasheet.

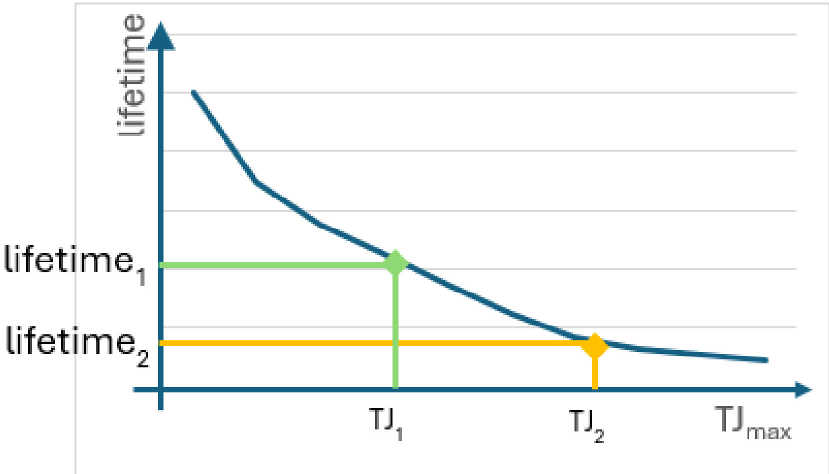
It is important to note that the device useful lifetime data provided in relation to the product mission profiles in this document are intended solely for intrinsic product lifetime estimation.

4 Lifetime curves

The lifetime curve example shown below represents the minimum product lifetime at T_{Jmax}, which is assessed by the HTOL reliability trial. Any T_J operating point that is lower than the T_{Jmax} operating point is intrinsically covered by this assessment trial. At each T_{Jx}, there is a corresponding estimated lifetime.

For example, if $T_{Jmax} > T_{J2} > T_{J1}$, then lifetime ($T_{Jmax}$) < lifetime ($T_{J2}$) < lifetime ($T_{J1}$)

Figure 2. Lifetime curve example

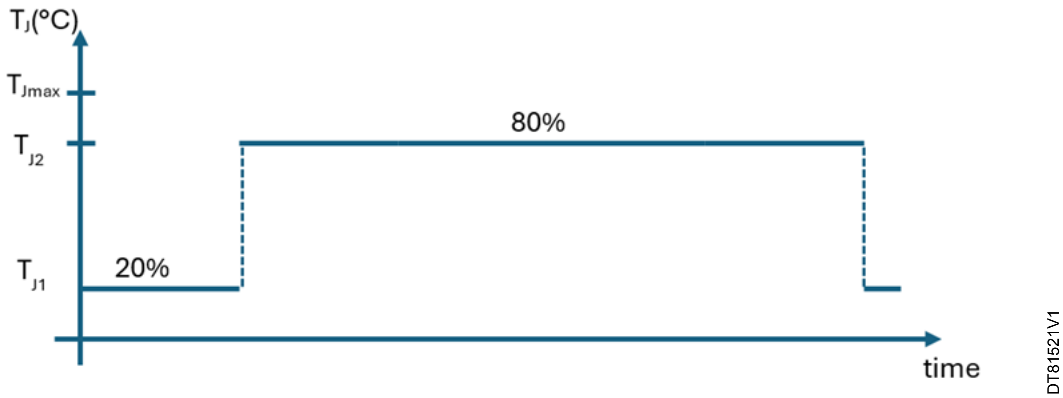


5 Multiple operation ratios with multiple T_J

When the T_J of the product does not stay constant during its operation, the target useful lifetime can be calculated using a weighting method based on the operation ratio percentage of the lifetime corresponding to its T_J which can be obtained directly from the estimated lifetime curve. As products age faster at higher T_J, the combined estimated lifetime is not just a simple average of multiple estimated lifetimes but a value from weighting on operation ratio percentage.

$$Lifetime(combined) = \sum^{n}(Weighting(Lifetime_n))$$

Figure 3. **Multiple duty cycles and multiple T_J**



The target useful estimated lifetime for a multitemperature use case is calculated with a computation formula with multiple temperatures profile:

Weighting method: Lifetime = (x% at T_{J1}°C) + (y% at T_{J2}°C)

x is the operation ratio at T_{J1}

y is the operation ratio at T_{J2}

x + y =100%

The target useful estimated lifetime = (x% T_{J1} + y% T_{J2})

An example of combined (multiple duty cycles and multiple T_J) lifetime estimation is calculated in the next section.

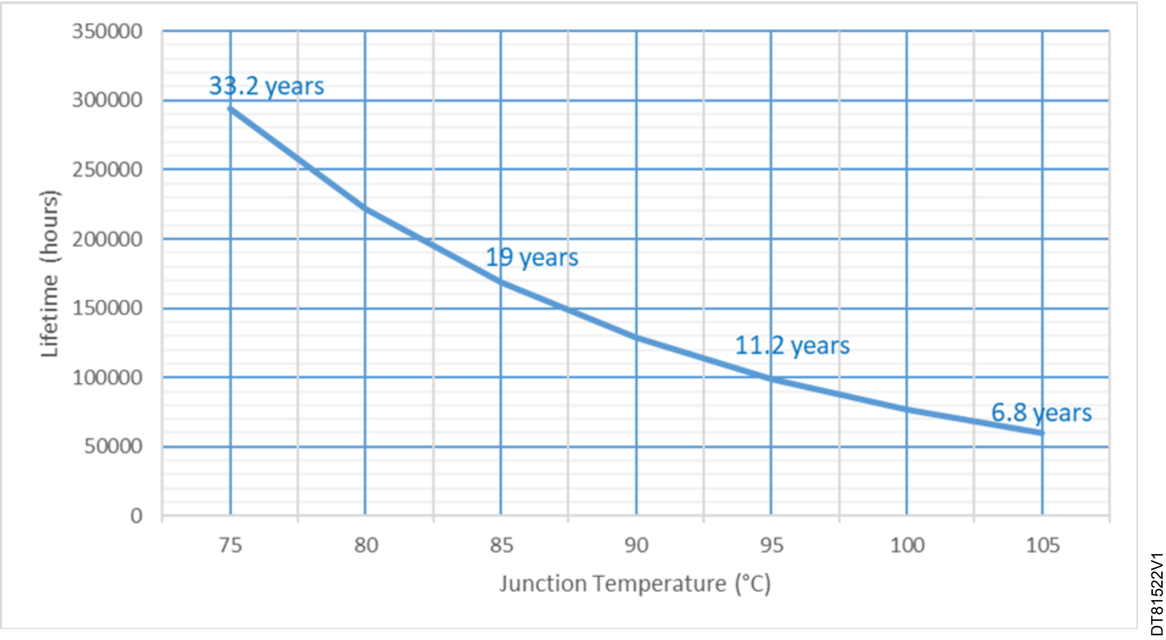
6 STM32H7R/7S lifetime usage estimation

This section presents data and tables representing the lifetime usage estimation for STM32H7R/7S devices for typical use conditions.

Table 3. STM32H7R/7S lifetime usage estimation for typical use conditions

Mission profile	Lifetime (Years)	Voltage scaling	Frequency (MHz)	Duty cycle (%)	V_{DD} nominal (V)	V_{CORE} nominal (V)	Junction temperature (T_J) (°C)
GP1	6.8	High	600	35	3.3	1.35	105
GP2	2.4	High	600	100	3.3	1.35	105
GP3	10.6	Low	400	35	3.3	1.20	135
GP4	3.7	Low	400	100	3.3	1.20	135

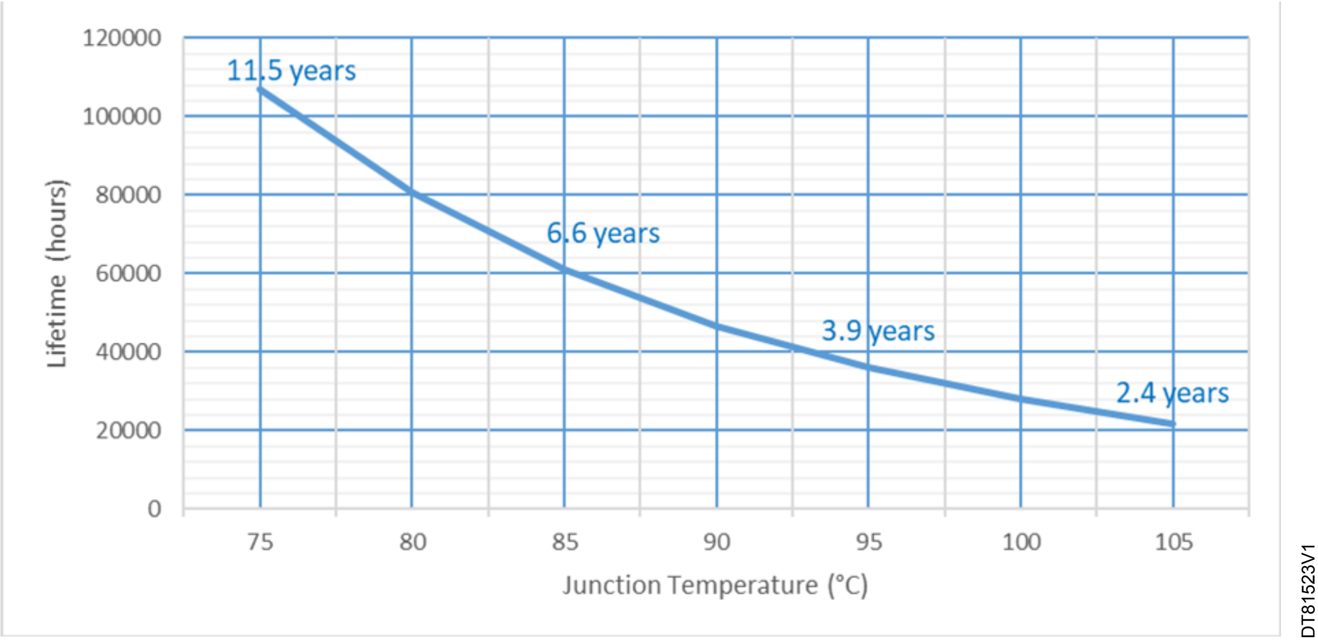
Figure 4. Lifetime estimation GP1



According to Figure 4, when V_{DD} = 3.3 V, V_{CORE} = 1.35 V and duty cycle 35%. Some examples are illustrated such as:

- Tj = 105°C the lifetime estimation is 6.8 years
- Tj = 95°C the lifetime estimation is 11.2 years

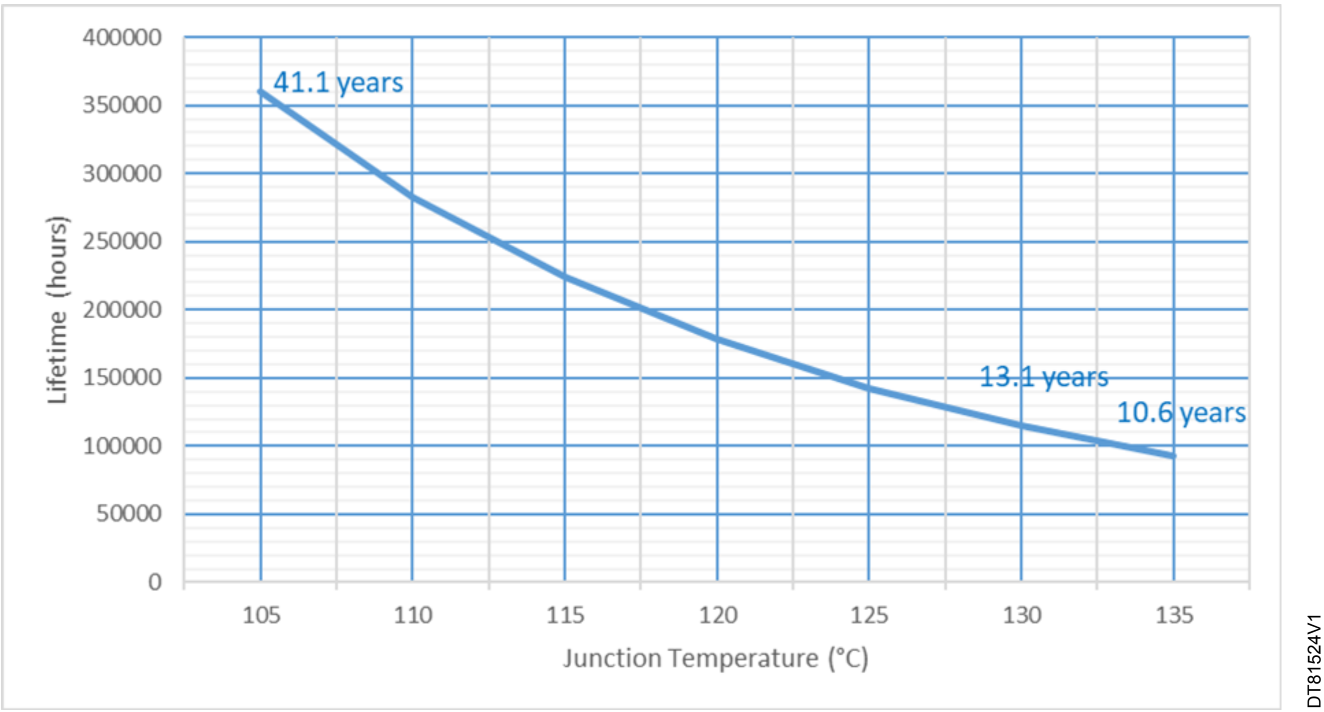
Figure 5. **Lifetime estimation GP2**



According to , when V_{DD} = 3.3 V, V_{CORE} = 1.35 V and duty cycle 100%. Some examples are illustrated such as:

- Tj = 105°C the lifetime estimation is 2.4 years
- Tj = 95°C the lifetime estimation is 3.9 years

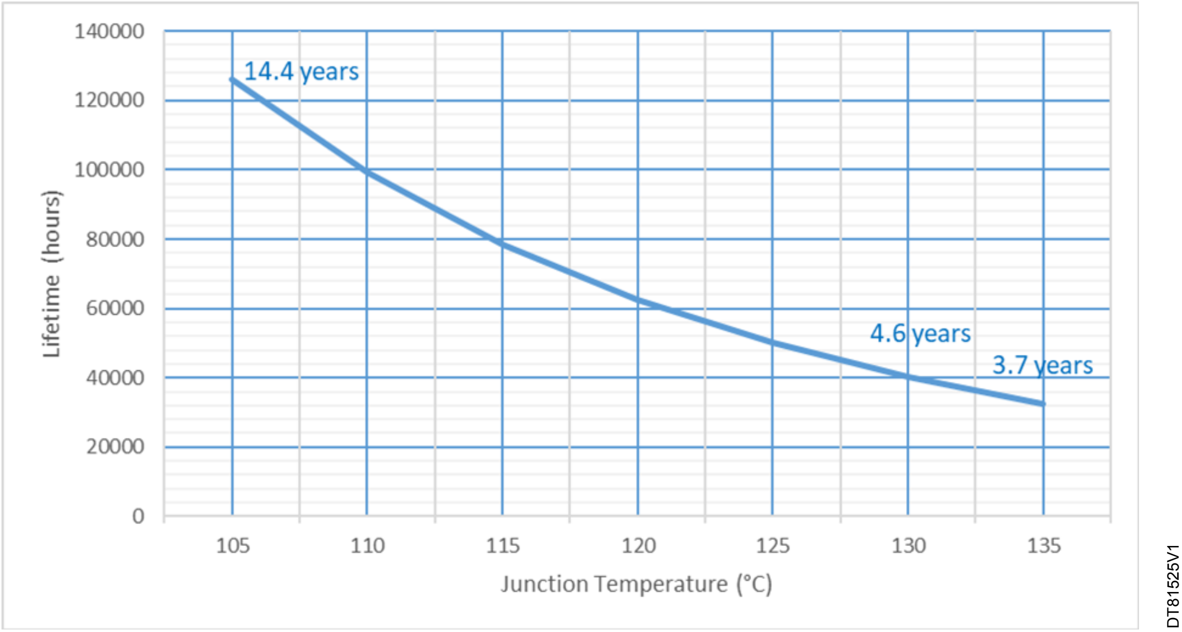
Figure 6. **Lifetime estimation GP3**



According to , when V_{DD} = 3.3 V, V_{CORE} = 1.20 V and duty cycle 35%. Some examples are illustrated such as:

- Tj = 135°C the lifetime estimation is 10.6 years
- Tj = 105°C the lifetime estimation is 41.1 years

Figure 7. Lifetime estimation GP4



According to , when V_{DD} = 3.3 V, V_{CORE} = 1.20 V and duty cycle 100%. Some examples are illustrated such as:

- Tj = 135°C the lifetime estimation is 3.7 years
- Tj = 105°C the lifetime estimation is 14.4 years

7 STM32H7 lifetime usage estimation

Note: This section does not apply to STM32H7R/7S devices. Refer to previous section for the corresponding data.

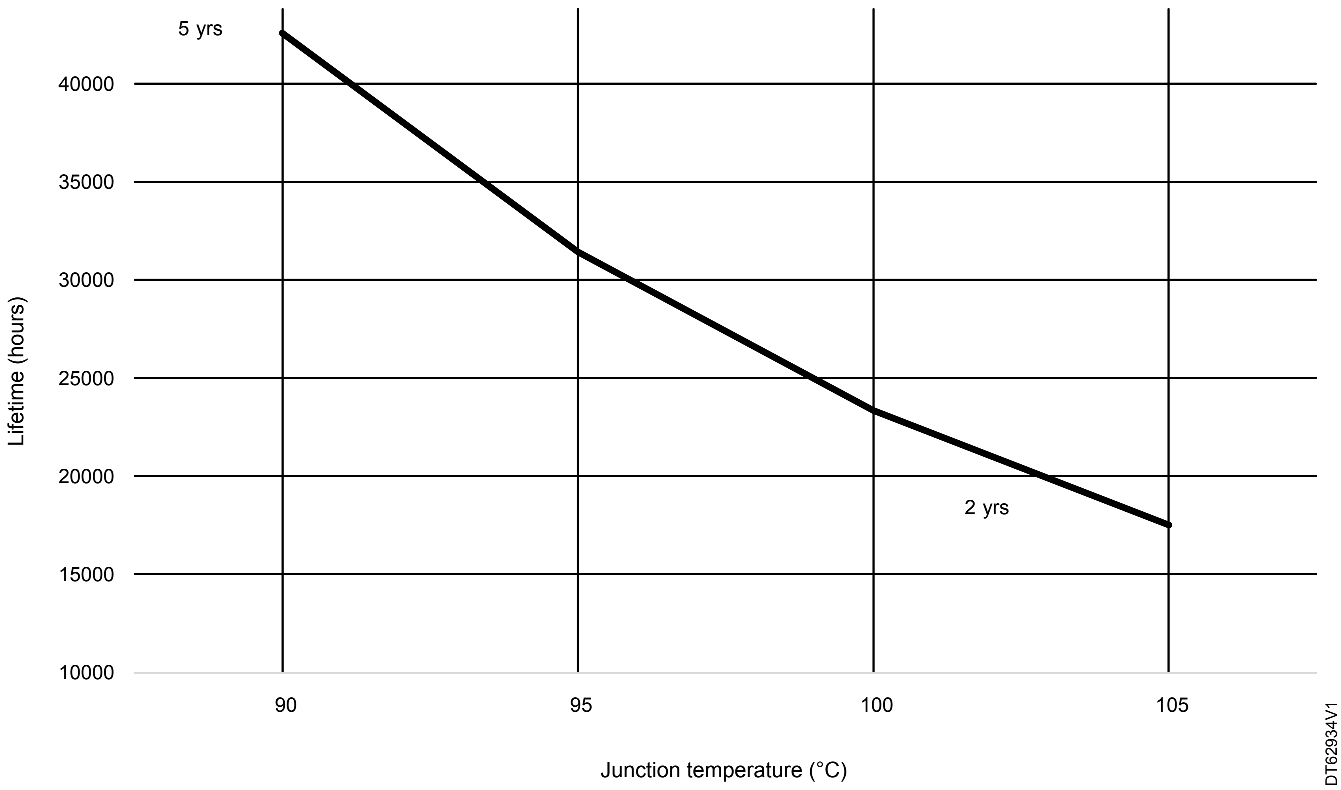
This section presents data and tables representing the lifetime usage estimation for STM32H7 devices for typical use conditions.

Table 4. STM32H7 lifetime usage estimation for typical use conditions

-	Lifetime (years)	Duty cycle (%)	V_{DD} nominal (V)	V_{CORE} nominal (V)	Junction temperature (T_J) (°C)
VOS0[1]	10	20	3.3	1.35	105
VOS1[2]	10	20	3.3	1.2	140[3]
VOS2 - VOS3	10	100	3.3	<1.10	140[3]

1. *Not applicable for STM32H757xxxxA.*
2. *Max CPU1 frequency of 480 MHz and max CPU2 frequency of 240 MHz is achievable with VOS1 only for STM32H757xxxxA.*
3. *The temperature of 140°C cannot be reached by all part numbers; it is exclusive to SMPS part numbers. Refer to the product datasheet for more details.*

Figure 8. Lifetime estimation VOS0



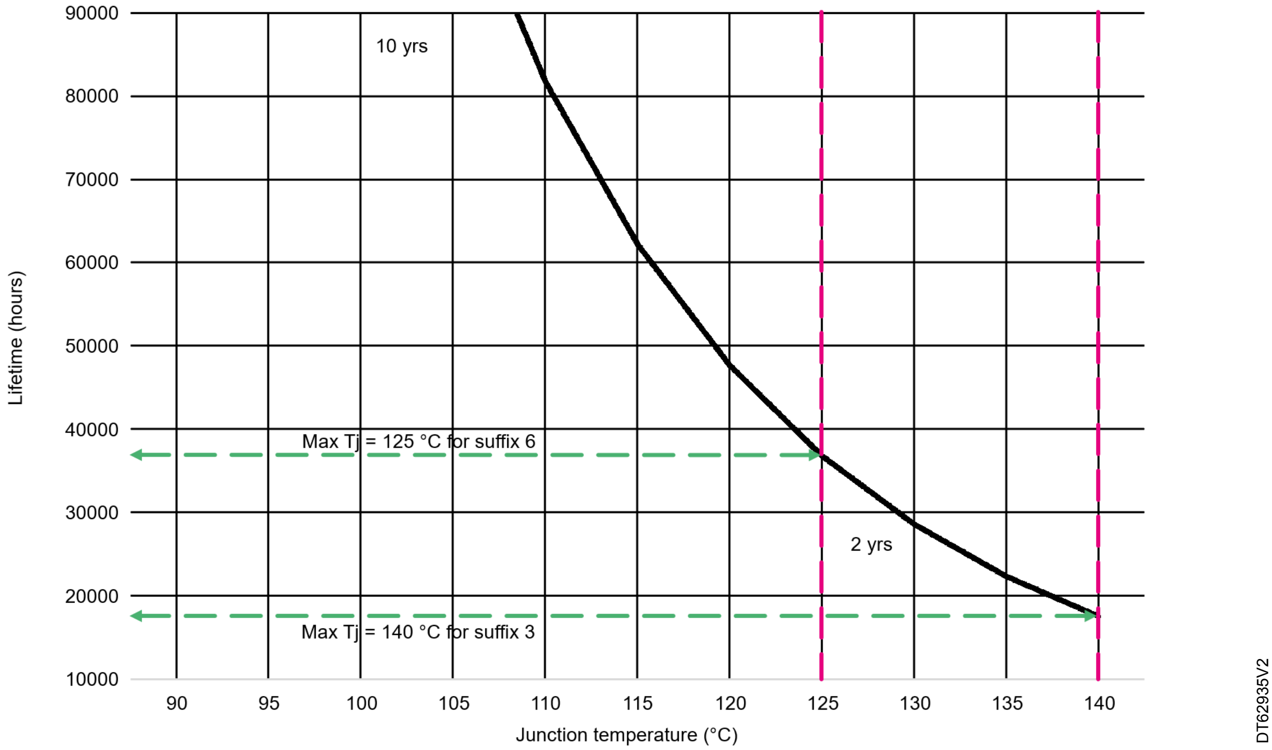
According to Figure 8, when VOS0, V_{DD} = 3.3 V, V_{CORE} = 1.35 V and duty cycle 100%. Some examples are illustrated such as:

- Tj = 105°C the lifetime estimation is 2 years
- Tj = 95°C the lifetime estimation is 3.5 years

In the same conditions and for a duty cycle of 20%, the lifetime estimation is as following:

- Tj = 105°C the lifetime estimation is 10 years
- Tj = 95°C the lifetime estimation is 17.5 years

Figure 9. Lifetime estimation VOS1



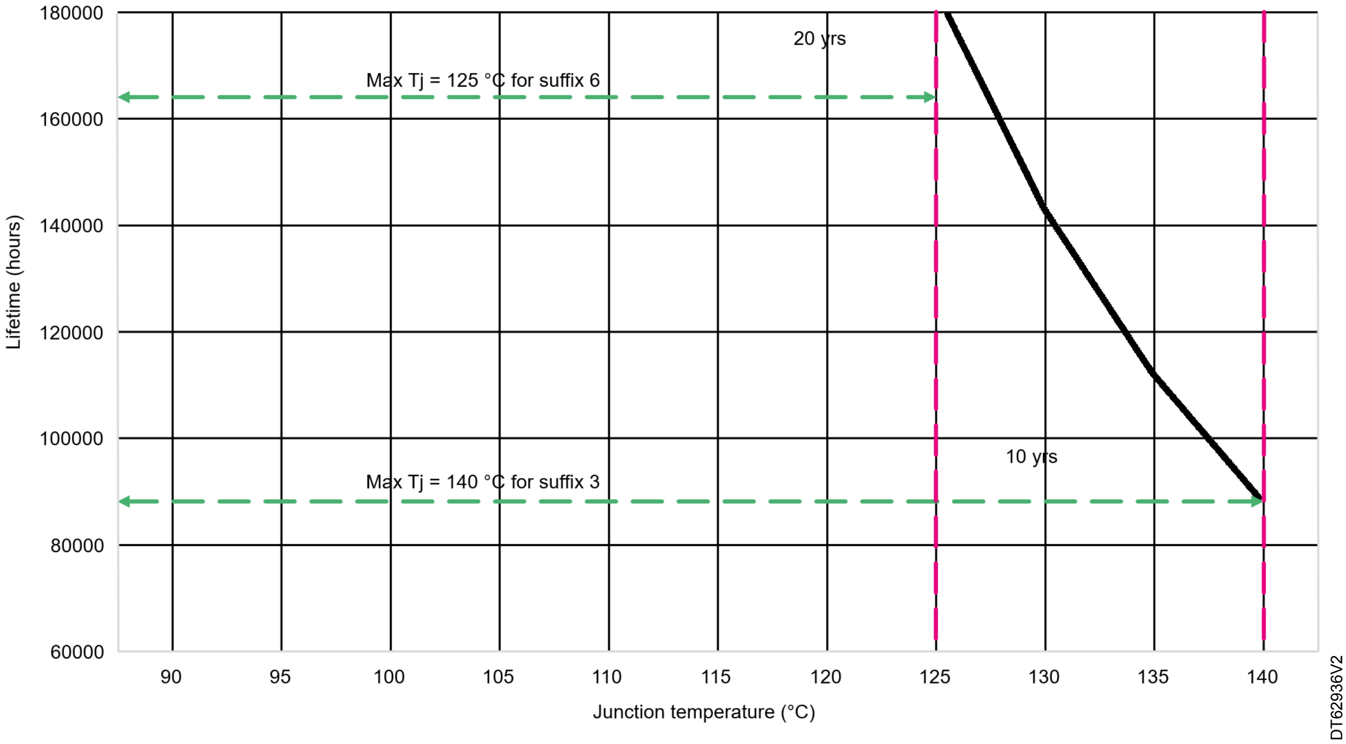
According to Figure 9, when VOS1, V_{DD} = 3.3 V, V_{CORE} = 1.2 V and duty cycle of 100%. Some examples are illustrated such as:

- Tj = 105°C the lifetime estimation is > 10 years
- Tj = 125°C the lifetime estimation is 4 years
- Tj = 140°C the lifetime estimation is 2 years

In the same conditions and for a duty cycle of 20%, the lifetime estimation is as following:

- Tj = 125°C the lifetime estimation is 20 years
- Tj = 140°C the lifetime estimation is 10 years

Figure 10. Lifetime estimation VOS2 and VOS3



According to Figure 10, when VOS2 or VOS3, VDD = 3.3 V, V_{CORE} < 1.10 V and duty cycle 100%. Some examples are illustrated such as:

- Tj = 125°C the lifetime estimation is > 20 years
- Tj = 130°C the lifetime estimation is 16 years
- Tj = 140°C the lifetime estimation is 10 years

Note: For more information about the suffix 3 or 6, refer to the product datasheet available on www.st.com.

8 Conclusion

The lifetime analysis shows that, for the specified voltage-scaling modes and mission profiles, the required intrinsic useful lifetime can be achieved. Lifetime is mainly driven by junction temperature, voltage-scaling mode, and operation ratio: lower T_J, reduced duty cycle, and lower VOS levels significantly extend lifetime. The curves and formulas provided allow designers to verify that their specific mission profile remains within the demonstrated intrinsic reliability capability of STM32 MCU devices.

Revision history

Table 5. **Document revision history**

Date	Version	Changes
19-Jun-2019	1	Initial release.
03-Jul-2020	2	Added STM32H723, STM32H733, STM32H725, STM32H735, and STM32H730 part numbers. Removed all the tables providing frequencies versus voltage scaling and temperature ranges for all product series.
18-Apr-2024	3	Updated: • Document title • Section 7: STM32H7 lifetime usage estimation
06-Jul-2026	4	Added: • Section 2: Reliability analysis using the bathtub curve model • Section 3: Product mission profile • Section 4: Lifetime curves Updated: • Section Introduction • Section 7: STM32H7 lifetime usage estimation

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