Introduction

The EMxxLX family is the latest generation of MRAM devices based on Everspin's STT (Spin-Transfer Torque) technology. It is a high-performance, multiple I/O, xSPI compatible MRAM device featuring a low pin count SPI bus interface with supported frequencies up to 200 Mhz.

Several system variables impact certain Industrial STT-MRAM characteristics. Specifically, temperature and data payload size impact Data Retention and Device endurance respectively. This application note will focus on the effects of Temperature on Data Retention.

The information provided in this application note is specific to the Industrial STT-MRAM manufactured on the 28nm process node. Future generations of Industrial STT-MRAM will be manufactured on different process nodes with different data retention and endurance characteristics.

Contents

Data Retention versus Temperature

The EMxxLX industrial grade MRAM has a data retention specification of a minimum 10 years at 85°C ambient temperature. EMxxLX Extended temperature MRAM has a minimum data retention specification of 10 years at 105°C ambient temperature.

Data retention time is temperature dependent as shown in Figure 1. Data retention versus temperature is best represented in graphical format, as this allows customers the flexibility to extrapolate and determine operating temperature impact on system design. This graph is generated by using higher temperatures to accelerate the time-to-failure and extrapolates to predict the time at lower temperatures.

Another key characteristic of STT-MRAM is data retention does not degrade with write cycles over the life of the product. Other non-volatile memories, such as NOR Flash show significant degradation in data retention time with program/erase cycles. EMxxLX does not have this degradation, making predicting data retention of the EMxxLX product more straightforward and reliable.

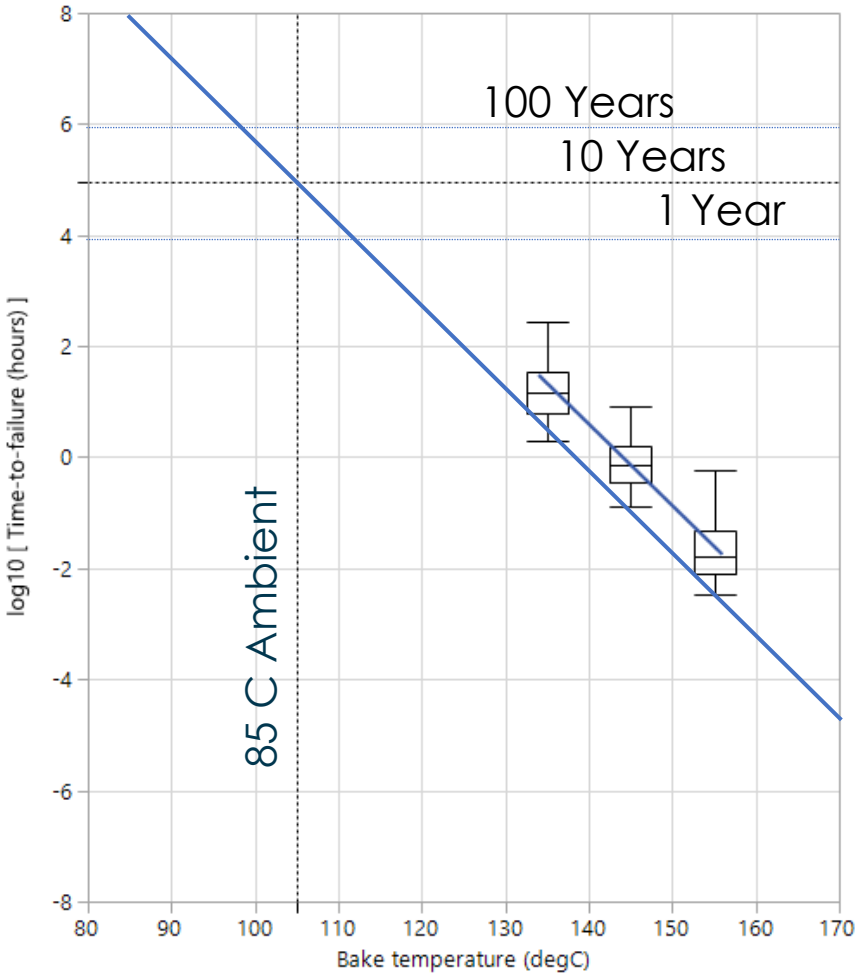

FIGURE 1 DATA RETENTION VERSUS TEMPERATURE

Notes to Fig. 1:

- Bake temperature is intended to reflect junction temperature. A bake temperature of 105°C approximates an ambient temperature of 85°C.

- The data points on the graph represent mean times with device variation.
- Time is shown in hours on a $\log_{10}$ scale.

Extending Data Retention Time

If the system or application requires defined data retention over the life of the product, implications of temperature must be considered.

If higher temperature device operation is a requirement, data scrubbing techniques can be implemented to keep data valid for extended periods of time. A characteristic of the EMxxLX family is data retention start time is considered from the last read or write to a given memory address. With this last read or write in mind, a system procedure to perform periodic reads to all memory locations allows data integrity retention. The timing or period of data scrubbing should be shorter than data retention time for any given temperature.

A system timer which incorporates time and date stamps can help system designers implement scrubbing algorithms to meet system data retention requirements.

Extending Data Retention at 115C Ambient

To assist system designers and developers in achieving robust data retention, an example of extending data retention beyond 105C ambient operating temperature and governing retention formula is included below.

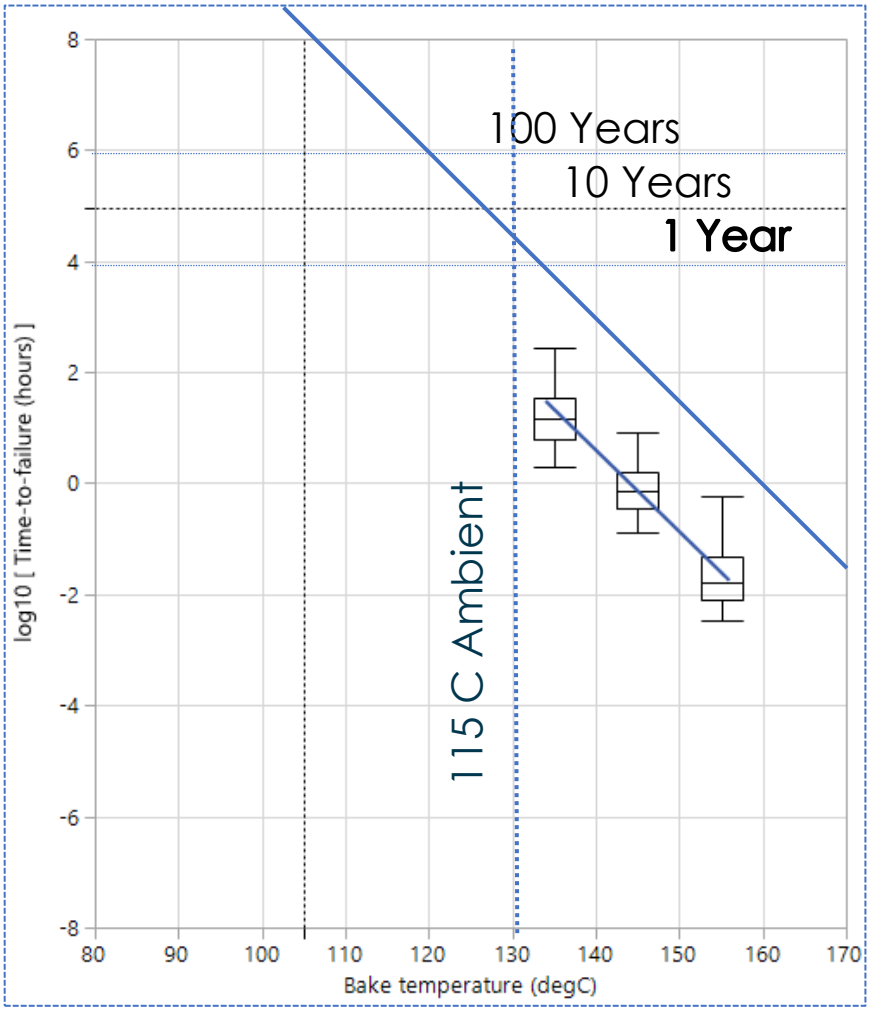

FIGURE 2 DATA RETENTION VS 115C AMBIENT EXTENDED TEMP DEVICE

The Governing formula for calculating time to fail is described below:

log10(TTF(hrs)) = 22.693 – 0.1467 * T_J (degC)

1) Tj = Junction Temperature
2) Tj = Ta + Delta
3) Delta = Joule Heating variable base upon device package and mode of operation.
    a. Delta for BGA 24 EMxxLX based on device characterization = 16
    b. Delts for DFN 8 EMxxLX based on device characterization = 2

Using the defined variable above and plugging into TTF equation yields the following result.

Log10(TTF(hr)) = 22.693 – 0.1467*131 = 3.475

TTF(hr) = 10^(3.4755) ~ 2,985 hrs

2,985 hrs/(24hrs/day) ~ 124 Days.

Conclusion

The EMxxLX has excellent data retention and is specified at a minimum of 10 years at ambient temperature of 85°C for Industrial rated devices and 10 years at 105C for Extended temperature devices. Unlike other non-volatile memory types there is no degradation in data retention time over the cycling life of the product.

Data retention of EMxxLX is temperature dependent. For example, when the ambient temperature is 70°C data retention will be > 100 years. Conversely, operating at higher temperatures causes data retention degradation. A data scrubbing implementation can mitigate this effect with very little overhead or impact to performance if more than 10 years at 115°C is required.

Revision History

Revision	Date	Description of change
1.0	Sept 24, 2022	Initial release
1.1	Feb 14, 2024	Added EMxxLX Extended temperature. Changed BGA24 Delta heating from 20 to 16. Updated DR governing equation for Extended Temperature devices. Added DFN8 Delta heating = 2

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