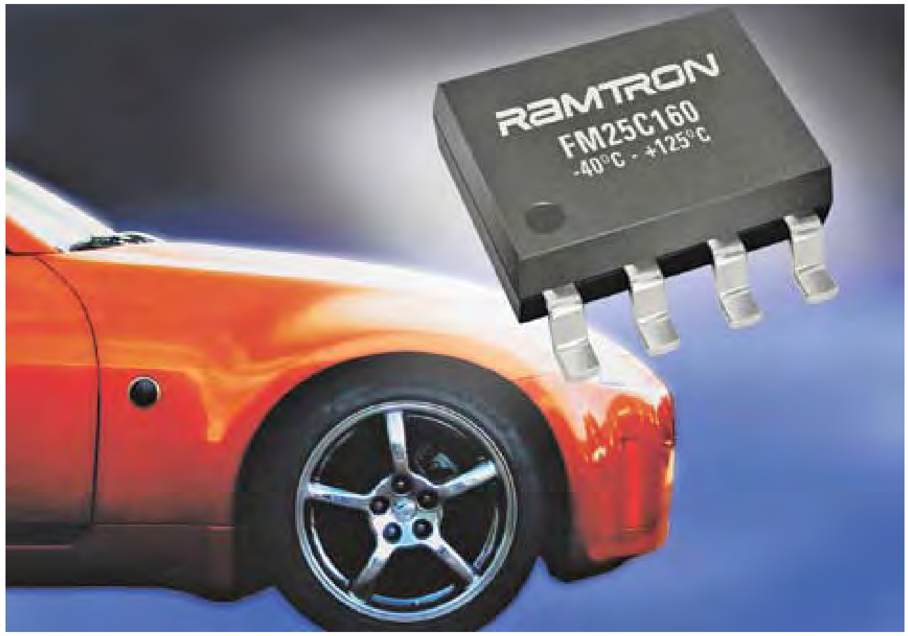
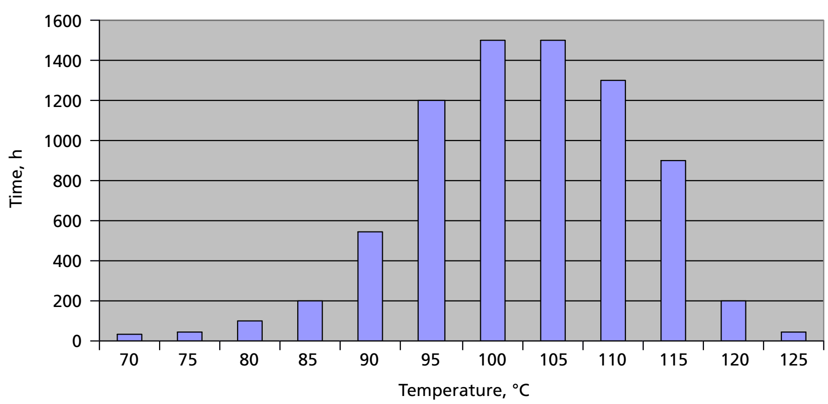
FRAM moves under hood

The automotive market is well known for adopting new technologies slowly and methodically. As a technology matures, it often finds first use in entertainment and navigation systems. Eventually, it may move into in-cab applications. These are core automotive applications that are not subject to temperature extremes beyond other industrial electronics. The final step in a maturing automotive technology is to be used in high-temperature applications.

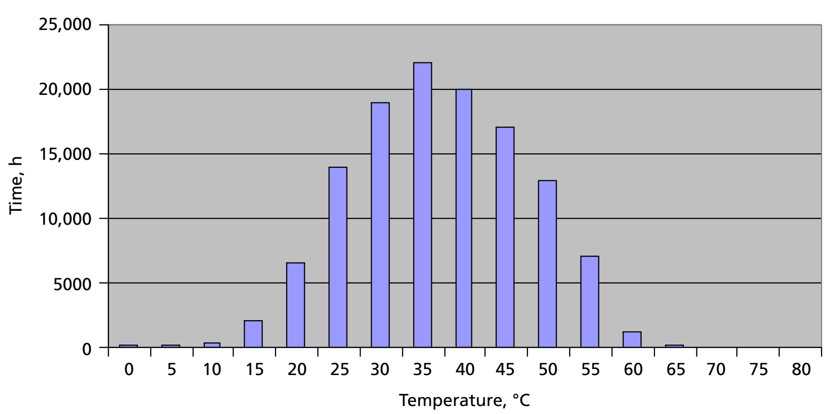
FRAM (ferroelectric random access memory) technology has been moving along this track. As the most mature in a class of next-generation nonvolatile memories, FRAM is beginning to aid the automotive design community through its fast write speed and high-endurance characteristics. The most recent development—successful AEC-Q100 qualification of a -40 to +125°C (-40 to +257°F), or grade 1, FRAM product—is a technological mile-



Grade 1 qualification introduced new challenges for nonvolatile memories because high temperature is a key accelerant of data loss. FRAM devices such as Ramtron's FM25C160 have overcome these challenges by being proven in a 125°C (257°F) operating environment.



In this typical grade 1 operating profile, the high-temperature portion of the lifetime is based on 250,000 km (155,000 mi) driving without major maintenance, assuming an average speed of 56 km/h (35 mph).



This typical grade 1 storage profile shows that the impact of 125,000 h at an average of 38°C (100°F) is minimal compared to the high-temperature requirement.

stone. FRAM technology has never been available in this temperature range, which allows it to be widely adopted across core automotive platforms.

Qualifying components to grade 1 demonstrates operation at 125°C (257°F) degrees even after a variety of qualification stresses. Component qualification uses stress to simulate the operating lifetime of a system. These stresses include high temperature, high voltage, low temperature, pressure, humidity, and rapid changes between extremes. Achieving this level of performance requires demonstration of consistent reliability across the full temperature range. Grade 1 qualification is demanding for any component, but introduces additional challenges for a nonvolatile memory. Beyond operation, a nonvolatile memory must exhibit data retention over the system lifetime. This is challenging because high temperature is a key accelerant of data loss, and the 125°C (257°F) operating environment raises the bar.

For high-temperature automotive applications, the operating temperature profile has two components. When the vehicle is operating, the temperature is dictated by heat generators including the engine, transmission, and brakes. This temperature is much higher than typical industrial or commercial applications, but the total amount of time at elevated temperatures is a small percentage of the total lifetime of a car. The second part is nonoperating time. Most of the hours on a vehicle are nonoperating, but they still must be accounted for in the data-retention lifetime. In this situation, the range of temperatures is dictated by outdoor ambients, so the average temperature is much lower than during operation.

For FRAM technology to qualify for under-the-hood applications, a data retention specification that considers the two-part profile needed to be developed. The first part is operating life; the second is what remains of overall vehicle life. The high-temperature portion of the lifetime is based on a target of 250,000 km (155,000 mi) driving without major maintenance. Assuming an average speed of 56 km/h (35 mph), this leads to an operating time of just over 4400 h. During this time, the elevated operating temperature profile ranges from ambient when the car starts to 125°C (257°F). In some applications, there are excursions above this, but the time at temperature is critical and the excursions are insignificant.

This model assumes 7400 operating hours rather than the expected 4400. Considering the reliability expectations of the automotive industry, this is a reasonable guard band. In this profile, there are roughly 3500 h below 105°C (221°F) and 3900 h at or above 105°C (221°F). The average temperature of this profile is about 103°C (217°F). To accommodate this profile, the FRAM data-retention specification was set to 5000 h between 70°C and 105°C (158 and 221°F), and 4500 h between 105°C and 125°C (221 and 257°F).

The second portion for the lifetime—the nonoperating time—is assumed to be roughly 14 years or 125,000 h and occurs at a much lower temperature, with an average of 38°C (100°F). From a data-retention point of view, the impact of this is minimal compared to the high-temperature requirement. The nonoperating profile is skewed toward a very warm climate; for purposes of data retention, this is the most severe assumption.

The introduction of a qualified 125°C (257°F) FRAM memory offers automotive system designers new choices for data collection and storage. FRAM offers the fastest write speed of any automotive-qualified nonvolatile memory, nearly unlimited write endurance, and low operating power consumption. Significant interest already exists in high-temperature applications such as engine monitoring, steering, transmissions, and tire-pressure monitoring.

Mike Alwais of **Ramtron** International wrote this article for *AEI.*

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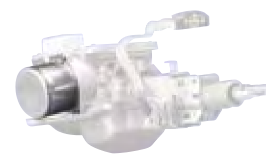

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