Fram technology moves under the hood

Grade one qualification introduced new problems for non-volatile memories because high temperature is a key accelerant of data loss. **Mike Alwais** explains that ferroelectric ram has overcome this by proving itself in a +125˚C environment

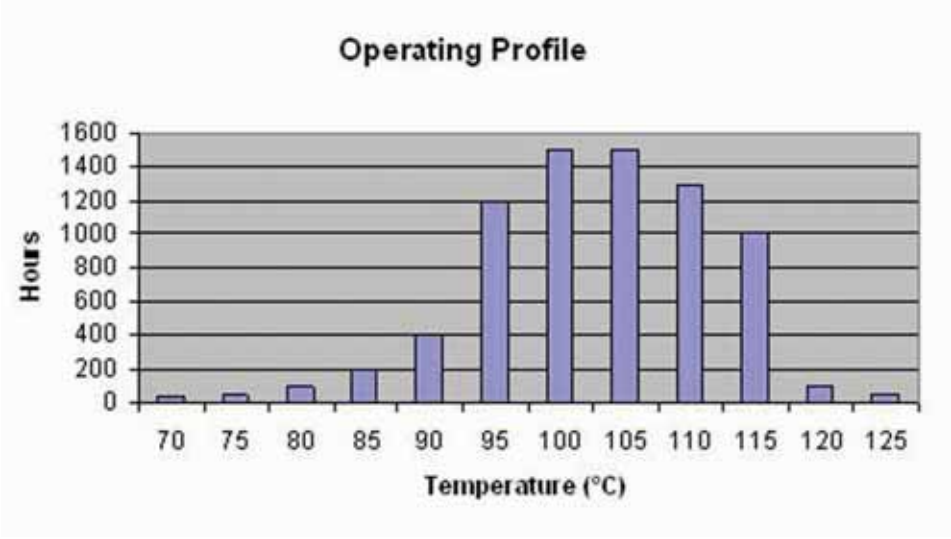

Fig. 1: Typical grade one operating profile

The automotive market is well known for adopting new technologies slowly and methodically. As a technology matures, it often finds use first 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 technology is to be used in high temperature automotive applications.

Ferroelectric random access memory (fram) technology has been moving along this track. As the most mature in a class of next generation non-volatile memories, fram is beginning to aid the automotive design community through its fast write-speed and high endurance characteristics. The most recent development is a technological milestone with successful AEC-Q100-qualification of a -40 to +125ßC degree (grade one) fram product. Fram technology has never been available in this temperature range before. This allows it to be widely adopted across core automotive platforms.

Qualifying components to grade one demonstrates operation at +125ßC, 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 one qualification is demanding for any component, but introduces additional problems for a non-volatile memory. Beyond operation, a non-volatile memory must exhibit data retention over the system lifetime. This is problematic because high temperature is a key accelerant of data loss and the +125ßC operating environment raises the bar.

For high temperature automotive applications, the operating temperature profile has two parts. When the vehicle is operating, the temperature is dictated by the heat generators including the engine, transmission and brakes. This temperature is much higher than typical industrial or commercial applications. However, the total time at elevated temperature is a small percentage of the total lifetime of a car.

The second part is non-operating time. Most of the hours on a vehicle are non-operating, but they still must be accounted for in the data retention lifetime. In this situation, the range of temperatures is dictated by outdoor ambient temperature so the average temperature is much lower than during operation.

For fram technology to reach 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 an overall vehicle life.

The high temperature portion of the lifetime is based on a target of 250,000km driving without major maintenance. Assuming an average speed of 56km/hr, this leads to an operating time of just over 4400 hours. During this time, there is an elevated operating temperature profile. It ranges from the ambient temperature when the car starts to +125ßC. In some applications there are excursions above this, but the time at temperature is critical and the excursions are insignificant. A model of a typical profile is shown in Fig. 1.

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 hours below 105ßC and 3900 hours at or above 105ßC.

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There are a number of fram configurations specified for the grade one (-40 to 125˚C) operating range

The average temperature of this profile is about 103ßC. To accommodate this profile, the fram data retention specification was set to 5000 hours between 70 and 105ßC, and 4500 hours between 105 and 125ßC.

The second portion for the lifetime is the non-operating time. This is assumed to be roughly 14 years or 125,000 hours. The non-operating time occurs at a much lower temperature. The profile in Fig. 2 is a typical temperature lifetime with an average of 38ßC.

From a data retention point of view, the impact of 125,000 hours at an average of 38ßC is a minimal burden compared with the high temperature requirement. Note that the non-operating profile is skewed towards a very warm climate. For purposes of data retention, this is the most severe assumption.

The existence of qualified +125ßC frams offer automotive system designers new choices for data collection and storage. Fram offers the fastest write speed of any automotive qualified non-volatile memory, nearly unlimited write endurance and low operating power consumption.

Significant interest already exists in high temperature applications including engine monitoring, steering, transmission and tyre pressure monitoring. ■

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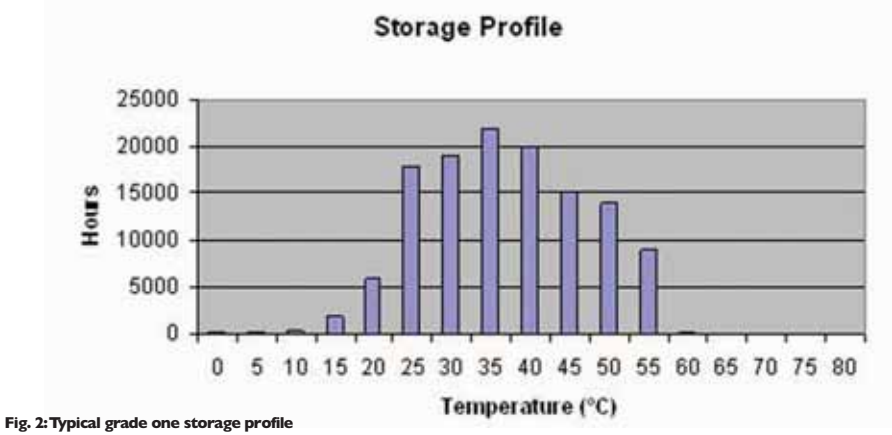

Fig. 2: Typical grade one storage profile

16kbit, 5V, serial peripheral interface fram specified for automotive temperatures