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# Choosing the right solid-state storage device for industrial applications

Solid-state storage devices are slowly revolutionising the consumer storage market, with continuing advances in technology leading to lower priced and higher density drives. Solid state drives are now common place in laptop's and home computers.

Solid state storage devices have many advantages over the more traditional rotating media and it's not surprising to see why this revolution is extending to the industrial and military markets. The rising cost of military-grade solid-state drives, and the recognition that drives designed for the consumer market are not always capable of sustained performance over wide temperature ranges is creating the need for solid state drives optimized for harsh environments, which we will refer to as "the industrial market".


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## Why solid-state drives?

Solid-state drives have many advantages over the more traditional rotating media historically associated with mass storage, including the following:

- A wide variety of form-factors (including CompactFlash, microSD, 2.5" and 1.8" disk drive formats
- Good choice of drive capacity (256MB to 512GB)
- Faster data transfer
- Lower power consumption
- Lower weight
- Greater resistance to shock and vibration
- Wider operating temperature ranges
- Backwards compatibility, where applicable, with existing interface formats
- Supported by all common operating systems

All of these advantages play into the military and industrial environments, increasingly making solid-state storage the storage of choice. However, not all drives are equal, and to ensure that the storage is reliable and fit for purpose, the designer should carefully consider a few key factors to ensure success. Some factors relate to the underlying technology, whilst others relate more to the manufacturer and the manufacturing process that ensures that the devices will repeatedly perform to the data sheet specifications over the operational temperature range and lifetime of the final product.

## Flash technology considerations when selecting a drive for industrial applications

The vast majority of industrial solid-state storage is based on Flash memory technology, and the user needs to be aware of the fundamental differences of the two technologies predominant in industrial drives, SLC and MLC.

- **SLC Flash** – SLC stands for single-level cell and refers to the structure used to create the individual storage elements within the semiconductor Flash device. Typically SLC structures require more silicon real estate for any given capacity, making them more expensive. Crucially, however, this structure is very robust and is ideally suited for applications requiring a long life, measured in read/write cycles. Lifetime is typically 10 times that of an equivalent MLC device.
- **MLC Flash** – MLC stands for multi-level cell and is the structure most commonly found in consumer drives. The advantage of MLC is that for a given density the silicon real estate is smaller, leading to an associated reduction in price; however, there is a lifetime impact, measured in read/write cycles. Typically MLC products have one tenth of the lifetime of an equivalent density SLC product for the same read/write profile.
- **EM MLC Flash** – EM MLC Flash is an emerging technology which aims to offset some of the lifetime issues found with MLC. EM MLC or endurance managed multi-level cell products use specially selected MLC product along with advanced firmware algorithms, resulting in products with a substantial lifetime improvement over MLC with typically only a 2x cost penalty.

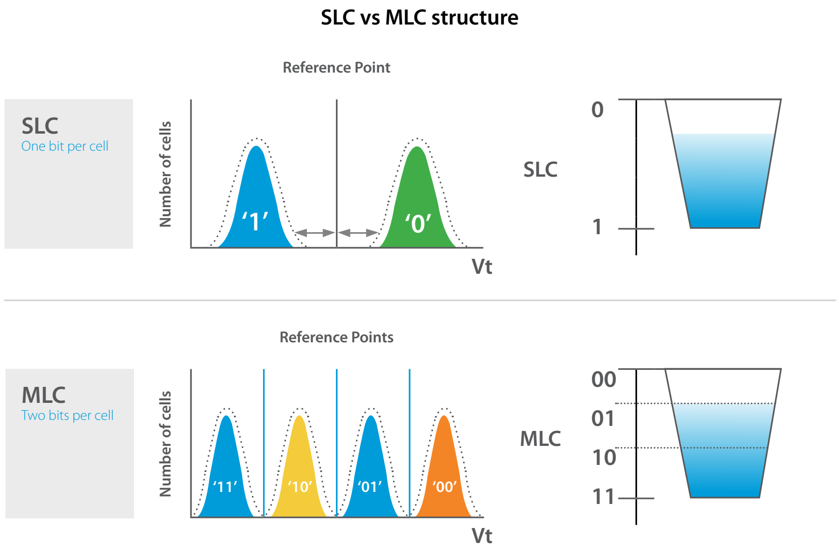
## Typical specifications for SLC and MLC Flash memory ICs

| | SLC | MLC |
|---|---|---|
| **Storage** | One bit per cell | Two bits per cell |
| **Typical cell program/erase cycles** | 100,000 | 3,000 to 10,000 |
| **Typical cell program/erase time** | Program: 300µs/page<br>Erase: 2ms/block | Program: 800µs/page<br>Erase: 2ms/block |
| **Cost-per-bit** | Higher | Lower |
| **Density** | Lower | Higher |
| **Power consumption** | Lower | Higher |

The decision as to whether an MLC memory solution is sufficient or an SLC solution is needed is not a simple one to make, because there are many factors that need to be considered. In principle, two profiles can be distinguished. The first is "extreme data retention" applications, in which data is primarily read and hardly ever written. The other is "high endurance" applications, which involve high numbers of write operations and are used for example in video surveillance cameras.

An example of an "extreme data retention" application is the car navigation system. Theoretically, map data is only written once to the storage device, and is thereafter only read. In this case it would seem that MLCs with their lower "write endurance" would be sufficient as write-endurance is not an issue. However, if the device is then exposed to high temperatures then data retention is a factor. High temperatures impair data retention times considerably. If a device is expected to retain data reliably at high temperatures for years, this can only be achieved with special data refresh methods, which the firmware executes using clever analysis techniques. These algorithms may not be deployed on lower cost consumer devices where the focus is on manufacturing a low cost product without the same focus on long-term data reliability.

## SLC vs MLC Flash memory structures

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## Life-time estimation tools

In choosing solid-state drives for industrial applications, lifetime estimation is a key factor, and as we have seen it is not necessarily a straight forward decision. Manufacturer's lifetime estimation tools therefore form a key part of the selection process. Typically manufacturers characterise their hard drives, building this into sophisticated models. The design engineer should then use these models to estimate the anticipated lifetime of the drive in a particular application.

For applications in critical systems, some vendors are also introducing drives with sophisticated lifetime management features, not found on commercial drives. When implemented, the drive is then able to report lifetime information to the host operating system, and inform of expected failure date, allowing proactive preventative maintenance to take place.

## Quality and traceability

With the underlying technology identified, it is then important to assess the manufacturer's capabilities, as this will give underlying confidence that products will comply with the manufacturer's datasheet specifications across the stated temperature range as well as from product to product. It is important to ensure that the manufacturers use controlled bills of materials (BoM) and manufacture in accordance with recognised quality standards. This is important as component changes can have an adverse effect on performance and can affect inter-operability, especially with embedded designs. It is also important that this control extends to the firmware installed in the drive.

## Customisation

Occasionally applications demand something that is not found with an off-the-shelf offering. For example, the storage device may be deployed in harsh and corrosive atmospheres, or specific firmware may be required to secure a partition on the drive. In these cases, Acal BFi can provide a customised solution, subject to minimum order quantities.

## Successful implementation

Whilst the decision to use a solid-state drive might seem obvious for industrial applications it should now be clear that there are additional factors to consider, that if not assessed could seriously impact system performance, and life-time in the field.

Acal BFi understand these trade-offs and can supply you with the support, engineering expertise and tools to make sure that you choose the right solid-state drive for your individual needs.

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