How-To Geek

Multi-Layer SSDs: What Are SLC, MLC, TLC, QLC, and PLC?

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Solid-state drives improve the performance of aging computers and turn newer PCs into speed machines. But, when you shop for one, you're bombarded with terms, like SLC, SATA III, NVMe, and M.2. What does it all mean? Let's take a look!

It's All About the Cells

Current SSDs use NAND flash storage, the building blocks of which is the memory cell. These are the base units onto which data is written in an SSD. Each memory cell accepts a certain amount of bits, which are registered on the storage device as 1 or 0.

Single-Level Cell (SLC) SSDs

The most basic type of SSD is the single-level cell (SLC) SSD. SLCs accept one bit per memory cell. That's not a lot, but it has some advantages. First, SLCs are the fastest type of SSD. They're also more durable and less error-prone, so they're considered more reliable than other SSDs.

SLCs are popular in enterprise environments where data loss is less tolerable, and durability is key. SLCs tend to be more expensive, and they aren't typically available for consumers. For example, I found a 128 GB enterprise SLC SSD on Amazon that cost the same as a 1 TB, consumer-level SSD with TLC NAND.

If you do see a consumer SLC SSD, it probably has a different type of NAND and an SLC cache to improve performance.

Multi-Level Cell (MLC) SSDs

Intel's S3520 Series MLC SSD. Intel

The "multi-" in multi-level cell (MLC) SSDs isn't particularly accurate. They only store two bits per cell, which isn't very "multi-," but, sometimes, technology naming schemes aren't always forward-looking.

MLCs are a bit slower than SLCs because it takes more time to write two bits onto a cell than just one. They also take a hit in durability and reliability because data is written to the NAND flash more often than with an SLC.

Nevertheless, MLCs are solid SSDs. Their capacities aren't as high as other SSD types, but you can find a 1 TB MLC SSD out there.

Triple-Layer Cell (TLC) SSDs

As its name implies, TLC SSDs write three bits to each cell. At this writing, TLCs are the most common type of SSD.

They pack more capacity than SLC and MLC drives into a smaller package, but sacrifice relative speed, reliability, and durability. That

doesn't mean TLC drives are bad. In fact, they're probably your best bet right now—especially if you're hunting for a deal.

Don't let the notion of less durability get you down; TLC SSDs usually last for several years.

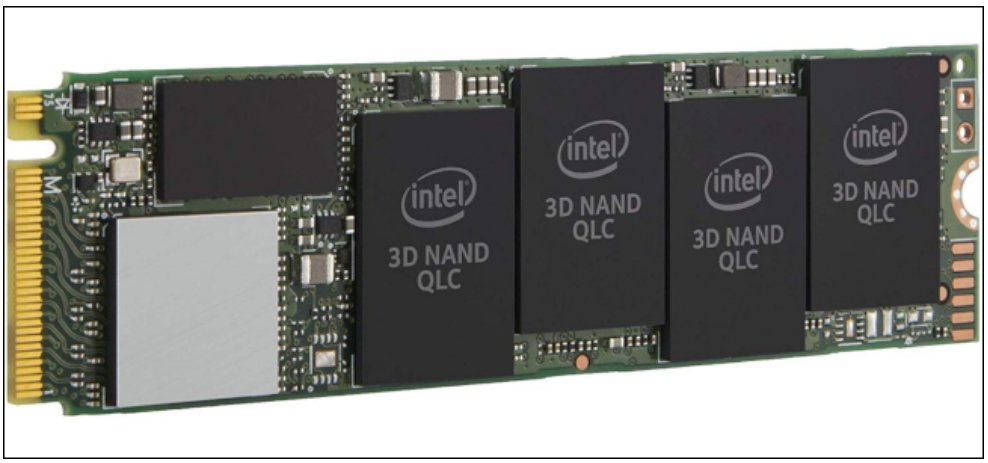
Terabytes Written (TBWs)

Typically, SSD durability is expressed as TBW (terabytes written). This is the number of terabytes that can be written to the drive before it fails.

The 500 GB model of the Samsung 860 Evo (a popular SSD from a few years ago) has a TBW rating of 600; the 1 TB model is 1,200 TBW. That's a whole lot of data, so a drive like this should serve you for many years.

TBWs are also "safe level" estimates; SSDs commonly exceed these limits. To be on the safe side, though, make sure you back up to minimize data loss—especially with older drives.

Quad-Level Cell (QLC) SSDs



Intel's 660p was an early consumer QLC SSD released in 2018. Intel

Quad-level cell (QLC) drives can write four bits per cell. Are you sensing a pattern at this point?

QLC NAND can pack a whole lot more data than other types, but, right now, QLC drives take a big hit on drive performance. This is especially true when the cache runs out during large file transfers (40 GB or higher). This might be a short-term problem, as manufacturers try to optimize QLCs.

Durability is also a concern, though. The budget-level Crucial P1 QLC NVMe drive only has a 100 TBW rating on the 500 GB model, and only 200 TBW on the 1 TB. That's quite a drop from the TLC, but it's still good enough for home use.

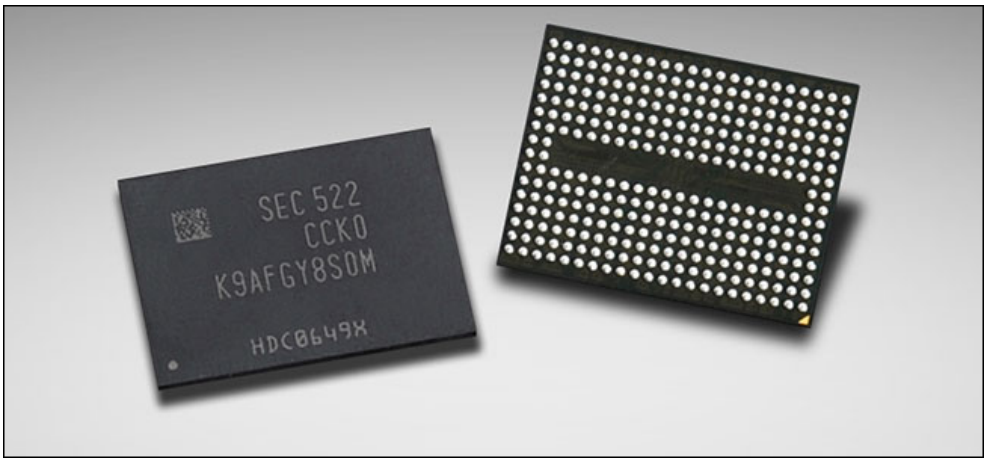
Penta-Level Cell (PLC) SSDs

PLC SSDs, which can write 5 bits per cell, don't exist yet for consumers, but they're on the way. Toshiba mentioned PLC drives in late August 2019, and Intel the following month. PLC drives should be able to pack even more capacity into SSDs. However, they'll have the same problems as TLCs and QLCs when it comes to durability and performance.

We advise you wait until reviews come out before you purchase an early PLC SSD. Also, check out the TBW ratings to see how long they'll last, and how the TBW breaks down in real-world terms.

For example, the QLC drive we mentioned above has a lower TBW rating, but it works out to about 54 GB written per day over five years. No one writes that much data at home, so you could expect that drive to last a long time, despite its lower TBW rating.

Other SSD Terms



An early example of Samsung's 3D NAND flash. Samsung

Those are the basic types of NAND flash, but here are a few more terms it might help you to know:

- **3D NAND:** At one point, NAND manufacturers tried to put NAND memory cells closer together on a flat surface to make drives smaller and increase capacity. This worked up to a point, but flash memory

starts to lose its reliability when the cells are too close together. To get around this, they stacked the memory cells on top of each other to increase capacity. This is commonly called 3D NAND, or sometimes, vertical NAND.

- **Wear leveling technology:** SSD memory cells start degrading as soon as they're used. To help keep drives in good shape for longer, manufacturers include wear technology, which tries to write data to memory cells as equally as possible. Instead of writing a certain block in one section of the drive all the time, it distributes data evenly, so all cells are filled at relatively the same rate.
- **Cache:** Every SSD has a cache in which data is briefly stored before it's written to the drive. These caches are critical for boosting SSD performance. They're typically comprised of SLC or MLC NAND. When the cache is full, performance tends to drop significantly—this is especially true for some TLC and most QLC drives.
- **SATA III:** This is the most common hard drive and SSD interface available for PCs. In this context, "interface" just means how a drive connects to the motherboard. SATA III has a maximum throughput of 600 megabytes per second.
- **NVMe:** This interface connects an SSD to the motherboard. NVMe travels over PCIe for blazing-fast speeds. Current NVMe consumer drives are about three times faster than SATA III.
- **M.2:** This is the form factor (physical size, shape, and design) of NVMe drives. They're often called "gumstick" drives because they're tiny and rectangular. They fit into special slots on most modern motherboards.

That wraps up our quick primer on NAND flash in modern solid-state drives. Now, you're well-equipped to go forth and choose the best drive for your needs.

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Ian Paul is a freelance writer with over a decade of experiencing writing about tech. In addition to writing for How-To Geek, he regularly contributes to PCWorld as a critic, feature writer, reporter, deal hunter, and columnist. His work has also appeared online at The Washington Post, ABC News, MSNBC, Reuters, Macworld, Yahoo Tech, Tech.co, TechHive, The Huffington Post, and

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