The 8-Inch Floppy

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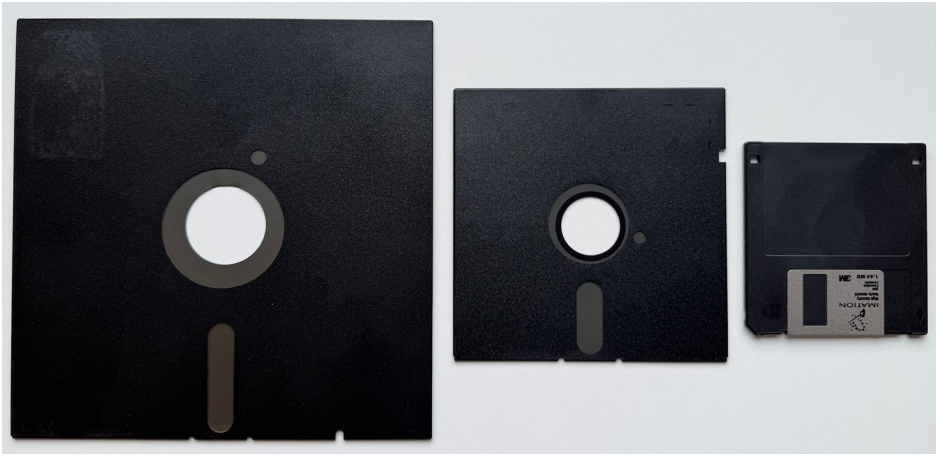
In the last HISTEC issue I wrote about half-inch 9-track magnetic tapes. In this article I will continue the historic storage theme and cover the 8-inch floppy diskette, a technology that helped start the microcomputer revolution. In the late 1960s IBM started "Project Minnow" to develop a cheap storage method for loading microcode and diagnostic programs into mainframe computers. IBM combined the concept of random access spinning disks with the low cost portability of magnetic tape to create the 8-inch (200mm) “Diskette”, also known as a “floppy disk”, with the equivalent storage capacity of 3000 punch-cards.

IBM 8-inch floppies



Size comparison between 8, 5.25 and 3.5 inch floppies

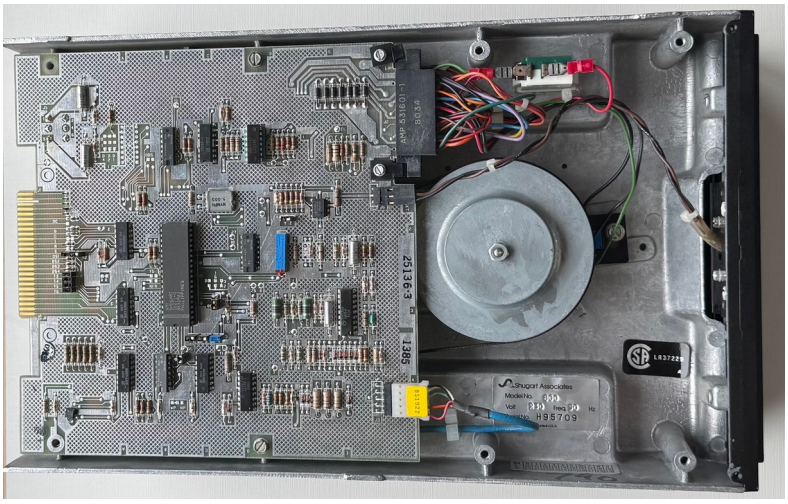
Commercial products were introduced by IBM in the early 1970s and the thin flexible 8-inch disks soon became an industry standard for small capacity data exchange. Mini-computers and large desk-side systems were shipped with 8-inch floppy drives (DEC RX01/02 for example). Micro-computers like RadioShack's TRS-80 Model II, the IBM 5120, and S-100 bus computers like the Altair 8800, used 8-inch floppy drives. The 8-inch floppy was also prominently shown with an IMSAI 8080 in the 1983 film WarGames.

Various external 8-inch floppy drives

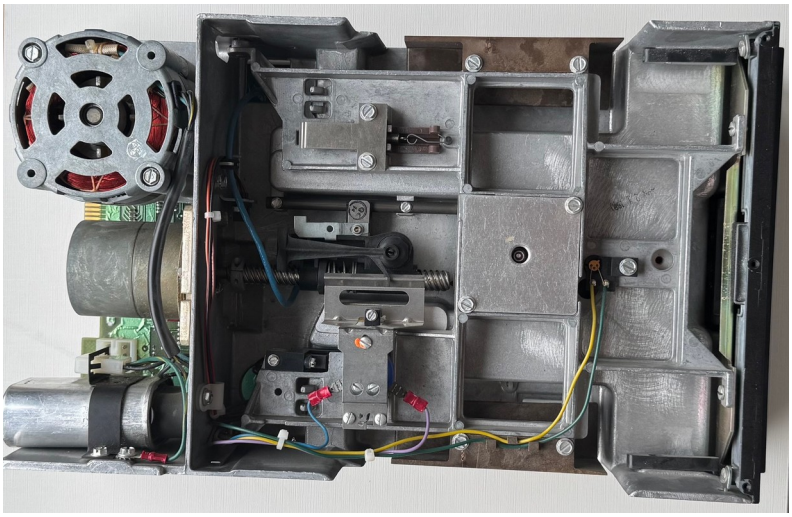
The ECMA (European Computer Manufacturers Association) published the following, freely available, standards for 8-inch floppies (officially named “flexible disk cartridges”) which are based on the American and International equivalent standards:

- ECMA-54 Data interchange on 200 mm flexible disk cartridges using two-frequency recording at 13262 ftprad on one side
- ECMA-59 Data interchange on 200 mm flexible disk cartridges using two-frequency recording at 13262 ftprad on both sides
- ECMA-69 Data interchange on 200 mm flexible disk cartridges using MFM recording at 13262 ftprad on both sides
- ECMA-58 Flexible Disk Cartridge Labeling and File Structure for Information Interchange

Popular 8-inch drives were often contained in a separate enclosure next to the computer system. A single internal drive weighed around 6kg with dimensions of roughly 12x22x36cm (newer drives came in half-height variants). The control circuitry was distributed between the on-drive electronics, additional electronics within the drive enclosure, and the controller card inside the computer (possibly connected with a 50pin ribbon cable). A drive motor would spin the disk, a stepper motor would move the head, and additional solenoids were sometimes used to engage the head loading and door mechanisms.



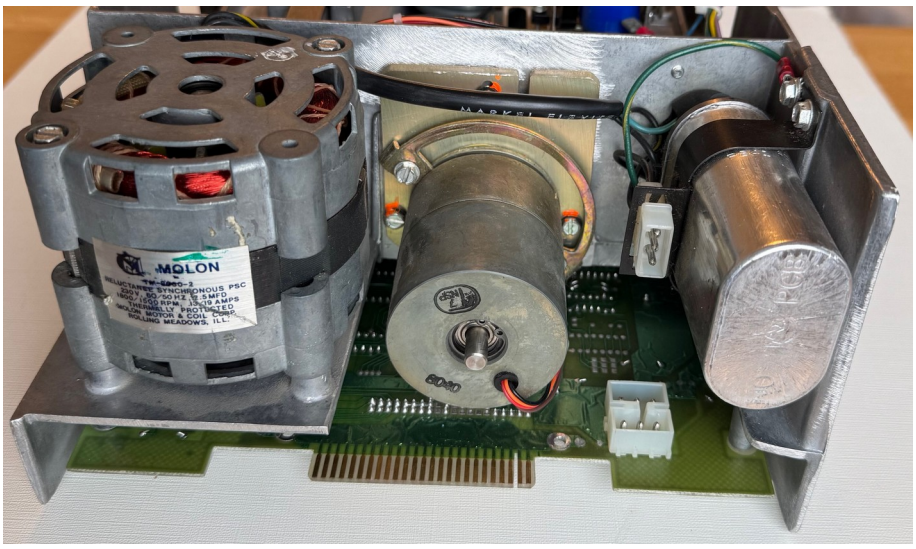
Shugart SA800 drive - bottom



Shugart SA800 drive - top

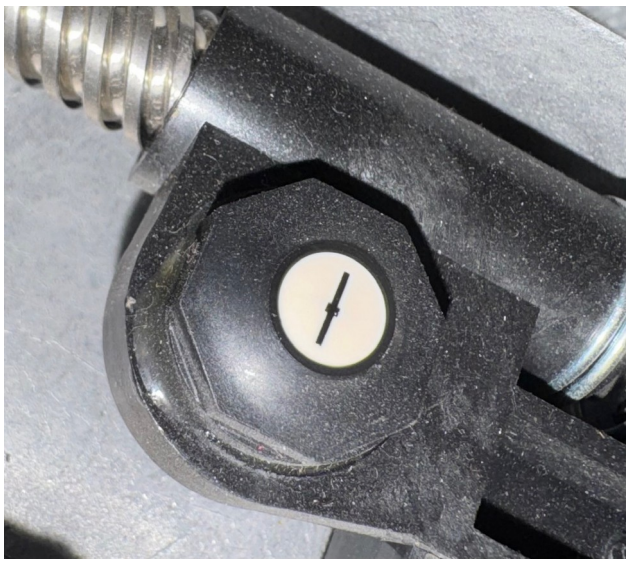
The power required for the drive was typically 115v/220v AC for the drive motor (like a small washing machine motor!), plus 24v and 5v DC for the stepper motor and drive electronics (TTL chips).

The data and control interface on most 8-inch drives is a 50-pin Shugart edge connector on the drive circuit board. There were some proprietary interfaces used for internal and external peripherals, but most drive and computer manufacturers and adopted the Shugart standard.



Shugart SA800 - rear

Floppy drive and diskette technology evolved over time to expand the storage capacity. A floppy can be single-sided (SS) or double-sided (DS). Double-sided drives have two heads and store data on both top and bottom disk surfaces to double the capacity. The location of the index hole indicates if the floppy is SS or DS, the hole is closer to the center of the floppy on single-sided diskettes (the original IBM Minnow had the hole on the lower outer edge of the diskette). Double-sided drives have two optical sensors to detect the type of floppy. Diskettes are typically labeled with SS/DS and SD/DD to indicate intended use.



Drive head

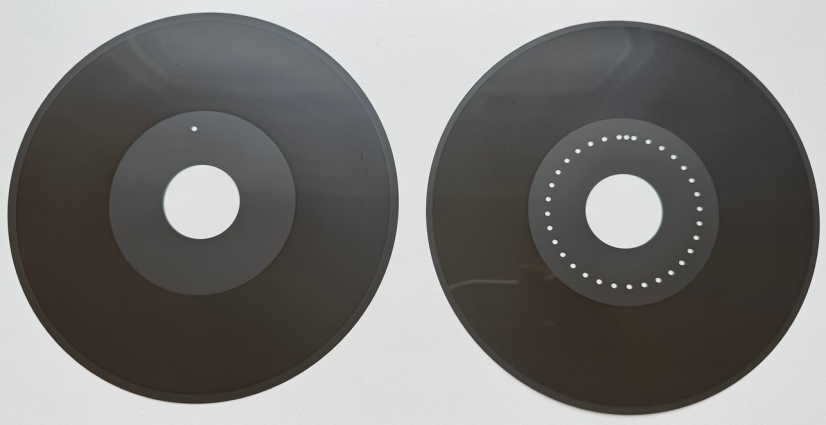
Index holes for double & single sided disks

Digital bits are encoded using magnetized domains on the surface of the disk. As a reading head passes over these magnetic flux transitions, electrical signals are produced. A writing head creates the magnetic flux transitions. Early drives used two-frequency encoding, or FM (Frequency Modulation), which is known as Single Density (SD or 1D). Newer drives used MFM (Modified FM) encoding which is known as Double Density (DD or 2D), effectively doubling the capacity again. The direction of diskette rotation is counterclockwise when facing the labeled side.

A track is a discrete concentric ring of encoded bits 0.3 mm wide, and the path which a drive head follows during a single rotation. There are 77 tracks on an 8-inch floppy. Each track is divided into multiple arcs called sectors. SD diskettes have 26 sectors with 128 bytes/sector. DD diskettes can have 26, 15, or 8 sectors, with 256, 512, or 1024 bytes/sector respectively.

There are some exceptions defined in the ECMA standards. Track 0 side 0 must be FM encoded with 26 sectors of 128 bytes/sector. This ensures that the oldest single density 8-inch drives can still read the label of newer double density (MFM) diskettes. On track 0 side 1, there must be 26 sectors of 256 bytes. And the last two cylinders should be reserved for replacing defective cylinders.

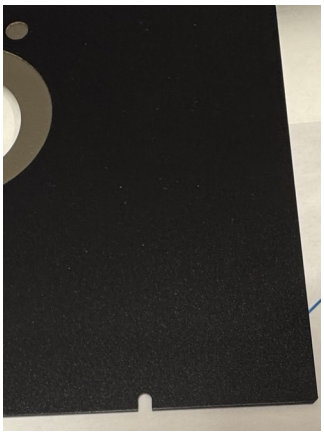
The drive uses optical sensors and an index hole to find the start of a track and for timing on a rotating floppy. Floppies can be hard or soft sectored. A hard sector floppy has a hole for every sector, a soft sector floppy has the sector information on the disk itself (written in the sector identifier field during formatting).



Soft sector and hard sector 8-inch diskettes

Some new 8-inch floppy diskettes have a “write-inhibit” notch on the bottom right side (with label facing you). A write enable label/tab (small stiff sticker) must be applied before first use. If you want to protect a disk from writing, the label can be removed. The exact location, width, and depth of the notch is defined, and self-punched notches can also be made.

Write enable labels

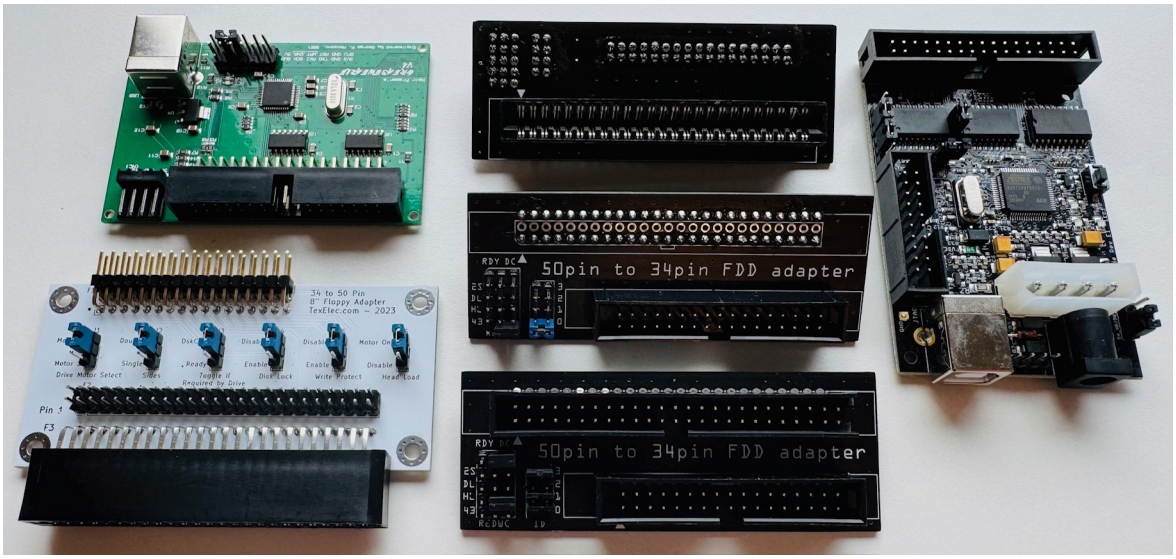


Write-inhibit notch

The disk capacity varies depending on multiple factors, such as encoding (FM or MFM), number of heads (single or double sided), ftprad (flux transitions per radian, 13262 for 8-inch floppies), tpi/tpmm (tracks per inch or mm), and other format specific reserved areas. The formatted capacity of common 8-inch floppies is:

- SS/SD 240-256kb
- SS/DD 480-512kb (not ECMA standard, popular with DEC RX02)
- DS/DD 1.0-1.2mb (with different sector sizes)

Extracting data from an 8-inch floppy can be a challenge. No standard USB adapter exists for 8-inch (or 5.25-inch) floppies because only 3.5-inch floppies are included in the USB Floppy Interface (UFI) Mass Storage Class specification.



Various devices and adapters for reading 8-inch floppies

You can use the original computer system, if available and functional, to extract data. There are ISA controller cards available that support 8-inch drives on PC ISA mainboards (texelec.com). A popular method for modern systems is to use a Greaseweazle, Kryoflux, or other USB-to-Shugart interface device. The advantage of using these modern devices is the ability to read and create an image of the magnetic flux on the disk surface. This is a high resolution analog image, not a digital copy, so it will be much larger than the expected diskette size. A normal-sized digital copy can be made from the flux image with a correctly specified format. The resulting digital image can be

mounted on a modern operating system or accessed with tools for extracting files from disk images (Linux mtools for example). Diskette images can also be written to floppy using these devices. There are many floppy image repositories with old software (including many games) found on the Internet which can be freely downloaded, written to diskette, and used on older computers.

References:

The original English version can be found here: https://digitalforensics.ch/enter/
ECMA standards https://ecma-international.org/?s=200+mm+flexible+disk+cartridges
Shugart interface https://bitsavers.org/pdf/shugart/SASI/
Greaseweazle https://decromancer.ca/greaseweazle/
Kryoflux https://www.kryoflux.com/
HxC Floppy Emulator https://hxc2001.com (the software is free/open source)
Flux Engine https://cowlark.com/fluxengine/index.html