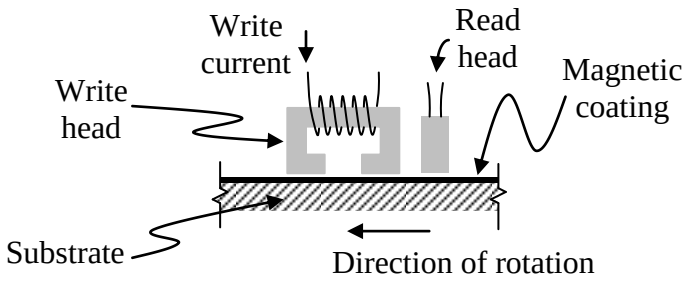
Hard Drive Characteristics

The read/write head of a hard drive only detects ***changes*** in the magnetic polarity of the material passing beneath it, not the direction of the polarity.

Writes are performed by sending current either one way or the other through the write head coil.

Reads are performed through a separate read head

- Partially shielded magneto resistive (MR) sensor
- Electrical resistance depends on direction of magnetic field – Passing current through it results in different voltage levels for different resistances
- MR head has higher frequency operation allowing better storage density and speed

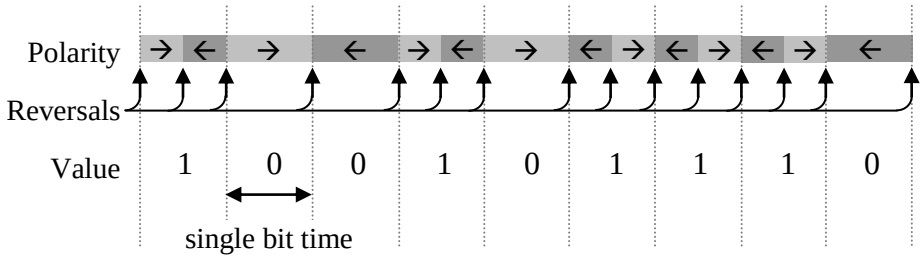


Data Encoding: It might seem natural to use the two directions of magnetic polarization to represent 1's and 0's. This is not the case for two reasons.

- The controllers only detect changes in magnetic direction, not the direction of the field itself.
- Large blocks of data that are all 1's or all 0's would be difficult to read because eventually the controller might lose track of where one bit ended and the next began.

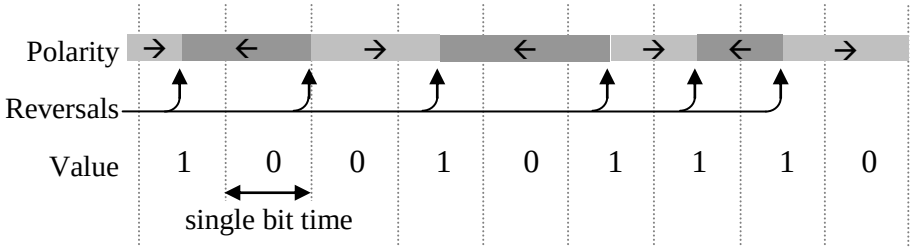
Frequency Modulation (FM)

- a magnetic field change at the beginning of every "bit time"
- a magnetic field change in the middle of a bit time for a logic 1



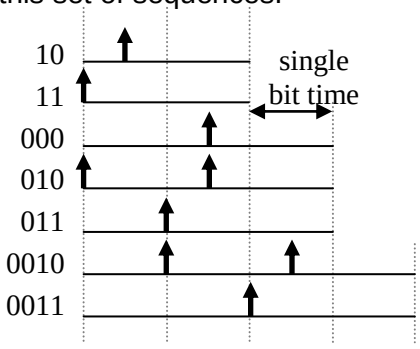
Modified FM (MFM)

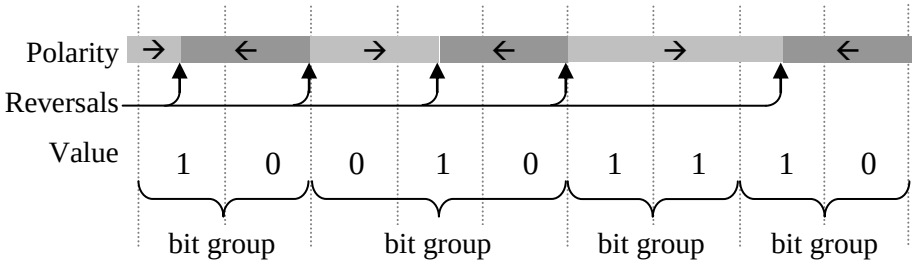
- a magnetic field change between two or more zeros
- a magnetic field change in the middle of a bit time for a logic 1



Run Length Limited (RLL)

Any pattern of ones and zeros can be represented using a combination of this set of sequences.

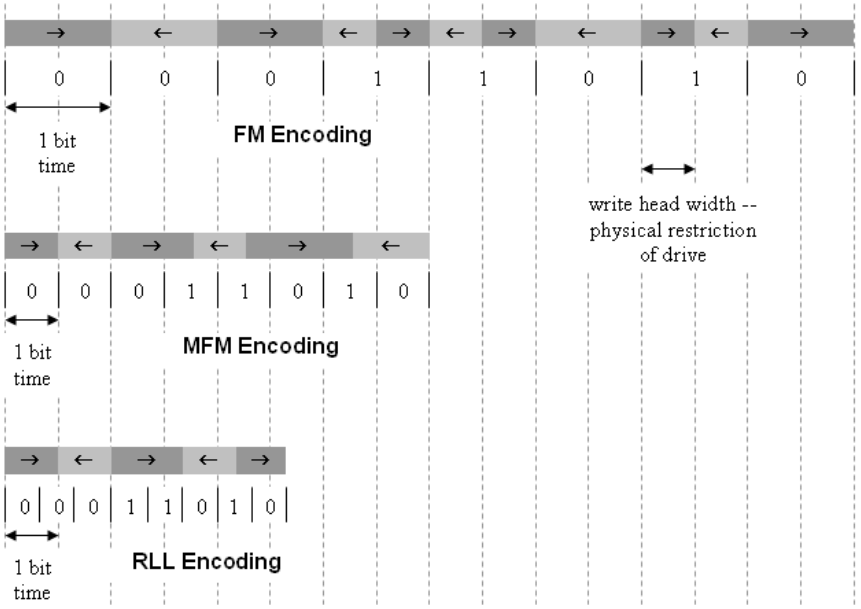




Goals of encoding:

- to ensure enough polarity changes to maintain bit synchronization;
- to ensure enough bit sequences are defined so that any sequence of ones and zeros can be handled; and
- to allow for the highest number of bits to be represented with the fewest number of polarity changes

SIDE-BY-SIDE COMPARISON OF ENCODING METHODS



LATEST ENCODING TECHNOLOGIES

- Improved encoding methods have been introduced since the development of RLL
- Use digital signal processing and other methods to realize better data densities.
- These methods include Partial Response, Maximum Likelihood (PRML) and Extended PRML (EPRML) encoding.

HOW LONG WILL I HAVE TO WAIT FOR MY DATA?

Queuing time: waiting for I/O device to be useable

- Waiting for device – The device may be busy serving another request.
- Waiting for channel – If device shares I/O channel with other devices, the channel may be busy.
- Sleep mode – Energy saving feature may turn off disk forcing O/S to wait for spin-up.

Seek time: the time it takes for the head to move to the correct position

- Find correct track by moving head (moveable head)
- Some details cannot be pinned down and are random
  - Ramping functions for any mechanical movement
  - Distance between current track and desired track
  - Shorter distances and lighter components have reduced seek time
- Typical seek times:
  - Typical seek times for a hard drive are between 4 and 8 ms.
  - CDROMS are slower because of heavier heads.
  - Solid state drives (1 head per track) have little or no seek time – they simply switch heads.

Rotational Latency: the time it takes for the data to rotate to a position beneath the head

- Floppies – 3600 RPM
- Hard Drives – up to 15,000 RMP
- Average rotational delay is 1/2 time for full rotation: ½ × 60 sec/min ÷ rotational speed in RPM
- Maximum rotational delay is 1 full rotation
- Example: For a 7200 RPM disk, average rotational delay = ½ × 60 sec/min 7200 rot/min = 4.2 ms

Transfer time: the time it takes to send the data from the hard drive to the requesting device

$$\text{Transfer time } (T) = b/(rN)$$

- b = number of bytes to transfer
- N = number of bytes on a track (i.e., bytes per full revolution)
- r = rotation speed in RPS (i.e., tracks per second)

Total access time = queuing + seek + rotational + transfer