

# Why digital

Although many textbooks provide good introductions to digital memory technology, I intend to make this chapter unique in presenting both past and present technologies to some degree of detail. While many of these memory designs are obsolete, their foundational principles are still quite interesting and educational, and may even find re-application in the memory technologies of the future.

The basic goal of digital memory is to provide a means to store and access binary data: sequences of 1's and 0's. The digital storage of information holds advantages over analog techniques much the same as digital communication of information holds advantages over analog communication. This is not to say that digital data storage is unequivocally superior to analog, but it does address some of the more common problems associated with analog techniques and thus finds immense popularity in both consumer and industrial applications. Digital data storage also complements digital computation technology well, and thus finds natural application in the world of computers.

The most evident advantage of digital data storage is the resistance to corruption. Suppose that we were going to store a piece of data regarding the magnitude of a voltage signal by means of magnetizing a small chunk of magnetic material. Since many magnetic materials retain their strength of magnetization very well over time, this would be a logical media candidate for long-term storage of this particular data (in fact, this is precisely how audio and video tape technology works: thin plastic tape is impregnated with particles of iron-oxide material, which can be magnetized or demagnetized via the application of a magnetic field from an electromagnet coil. The data is then retrieved from the tape by moving the magnetized tape past another coil of wire, the magnetized spots on the tape inducing voltage in that coil, reproducing the voltage waveform initially used to magnetize the tape).

If we represent an analog signal by the strength of magnetization on spots of the tape, the storage of data on the tape will be susceptible to the smallest degree of degradation of that magnetization. As the tape ages and the magnetization fades, the analog signal magnitude represented on the tape will appear to be less than what it was when we first recorded the data. Also, if any spurious magnetic fields happen to alter the magnetization on the tape, even if its only by a small amount,

that altering of field strength will be interpreted upon re-play as an altering (or corruption) of the signal that was recorded. Since analog signals have infinite resolution, the smallest degree of change will have an impact on the integrity of the data storage.

If we were to use that same tape and store the data in binary digital form, however, the strength of magnetization on the tape would fall into two discrete levels: "high" and "low," with no valid in-between states. As the tape aged or was exposed to spurious magnetic fields, those same locations on the tape would experience slight alteration of magnetic field strength, but unless the alterations were *extreme*, no data corruption would occur upon re-play of the tape. By reducing the resolution of the signal impressed upon the magnetic tape, we've gained significant immunity to the kind of degradation and "noise" typically plaguing stored analog data. On the other hand, our data resolution would be limited to the scanning rate and the number of bits output by the A/D converter which interpreted the original analog signal, so the reproduction wouldn't necessarily be "better" than with analog, merely more rugged. With the advanced technology of modern A/D's, though, the tradeoff is acceptable for most applications.

Also, by encoding different types of data into specific binary number schemes, digital storage allows us to archive a wide variety of information that is often difficult to encode in analog form. Text, for example, is represented quite easily with the binary ASCII code, seven bits for each character, including punctuation marks, spaces, and carriage returns. A wider range of text is encoded using the Unicode standard, in like manner. Any kind of numerical data can be represented using binary notation on digital media, and any kind of information that can be encoded in numerical form (which almost any kind can!) is storable, too. Techniques such as parity and checksum error detection can be employed to further guard against data corruption, in ways that analog does not lend itself to.

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