Trevor de Clercq
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Chapter 5 Abstract

The title of this chapter is "Digital recording and transmission principles," and in this chapter, John Watkinson addresses some of the basic problems encountered in storing and sending digital data along with solutions developed to overcome these problems. Perhaps out of sheer convenience, many methods of recording and transmission were borrowed or developed out of the analog means already in place.

The fundamental transmission hurdle to digital audio, oddly enough, exists in the analog domain. Although binary information is transmitted in discrete pulses of ones and zeros, this information is communicated between devices in the form of analog pulses. For example, an electric cable of high impedance is generally know to significantly attenuate high frequencies with cable lengths over 25 feet. While analog signals are directly affected by high frequency loss, digital information is only affected by cable impedance once the rate (or frequency) of information in the digital signal exceeds an upper limit set by the cable impedance. Digital transfer over consumer quality cables, therefore, can be rate limited by excessive cable length. Obviously, whereas high frequency loss due to cable limitations only slightly affects analog information, digital data becomes corrupted and thus uninterpretable at exceedingly high transmission rates.

Four types of digital data storage mediums are described in this chapter, magnetic recording, azimuth recording, optical recording, and magneto-optical recording. Magnetic recording is borrowed directly from the analog domain. A digital record head generates flux due to the absence or existence of current flowing through the coil in its circuit. This changing magnetic field (flux) affects the magnetic tape which is passing next to it and thus realigns particles in the direction of the head for positive flux values. Tracks are recorded on the tape perpendicularly to the heads and parallel to the direction of tape. Many digital recorders, such as DASH (stationary head), DCC, and RDAT employ this magnetic based storage process.

Azimuth recording is similar to magnetic recording except that two magnetic heads are positioned at an angle to the direction to tape movement and also at an angle (20 degrees) to each other. The effect of these offset heads reduces the amount of crosstalk between the various tracks and thus allows for a denser placement of the tracks on tape. Often, the term guard-band-less recording is used synonymously with azimuth recording since the guard bands which are needed in regular magnetic recorders to reduce crosstalk are no longer needed. The azimuth method is one of the hallmarks of RDAT recording.

Optical discs, such as the CD, try a very different approach than magnetic recording. Instead of relying of the closeness of a changing magnetic field, optical recorders rely on focusing light from a distance and therefore do away with the need for physical contact between the pickup and the medium. Wear and tear on mechanisms, therefore, ceases to be a concern with optical systems. Digital data is encoded optically through bumps in the surface of the recording medium. The diffraction of focused light versus the reflection of light represent the on and off states. To protect the optical disc from scratches which would also diffract light and therefore cause burst errors, optical discs are covered in a thick layer of plastic through which the laser beam of light passes by dust particles and other surface imperfections and becomes focused within the thickness of the coating.

The final storage medium discussed by Watkinson is that of MiniDisc: magnetic-optical discs. By this method, the medium is initially magnetized in one direction only. Underneath the medium sits a coil which emits a steady magnetic field in the opposite direction. Particles on the surface only become affected by the coil's opposite polarity once they are heated to their "Curie temperature." This heating effect is produced by a finely focused laser. To erase with this method, the coil's polarity has to be reversed and the heating laser continuously operated as it passes along the track.

As practice shows with digital mediums, it is necessary to free them of any DC artifacts. Direct current (DC) is represented for any specified period by a stream of ones since during this time, the recorder is in a continuously "on" state. DC is a danger to recordings, as is my understanding, because it emits a magnetic field of its own. The right-hand rule in physics tell us that electrical impulse in one direction will emit a magnetic field (and vice versa). This magnetic field produced by the recorded information, since the channels of digital information are spaced so closely, will re-magnetize and thus affect nearby tracks. The end result is a corruption of the stored data and a loss of sound quality. To combat the existence of DC in digital recording, codes have been developed through which to represent certain strings of ones by inserting extra zeros and thus disrupting the steady flow of current. Obviously, since consistent ones are broken up, it is therefore necessary to increase the amount of bits per recorded sample.

Many such codes exist, all depending on the basic density of the digital information which is to be recorded. Usually, the codes are referred to by the number of bits being encoded followed by the number of bits used to do the encoding itself. Thus, in a 2/3 code, two bits are encoded by a three bit code. Similarly, 4/6 code uses six bits to encode a four bit piece of information. A particularly relevant code in my research is the 8/10 code used in RDAT. The main impetus for developing this code was the extremely close spaced tracks used in azimuth recording. Not only DC has to be excluded, but low frequencies as well (low frequencies are particularly susceptible to crosstalk) must be attenuated. Therefore, the code has to be lengthened to accommodate the addition of various combinations that would combat this cross-magnetic field effect and preserve the integrity of the recorded information.