Appendix A
Time Code

In the 1960s, electronic editing became a viable technology for video and audio production. However, the selective recording of program material from one transport to another presented problems. How could two or more tape transports be synchronized to insure frame accurate edits? How could specific points be identified to make dubs, to insert sound effects, or to mark the beginning of a particular sequence? Was the tape in motion and if so, what was its speed?

The answers were provided by the Society of Motion Pictures and Television Engineers (SMPTE) by the specification and approval of a time code format, now industry recognized as "SMPTE" time code.

SMPTE time code is an electronic signal which is recorded on the program tape, typically on a unused audio channel (longitudinal time code, or LTC). The signal is digital in nature, resembling a string of square waves, called "bits", which are encoded with binary "1"s and "0"s.

Because time code was originally developed for the video industry, many of the specifications relate to video technology. For example, time code is specified to have exactly 80 "bits" per video frame. In the U.S., our system of television was originally developed with a rate of 30 frames per second, therefore time code is generated at 2400 bits per second. In European countries that produce video at 25 frames per second, the time code rate calculates to 2000 bits per second.

Each 80 bits of data, numbered from bit "0" to bit "79", is called a time code "word".

In a video application, the time code word must be generated so that bit "0" starts at the beginning of each video frame and bit "79" stops exactly at the end of the frame. In an audio application the relationship between the start of the time code word and the recorded material is arbitrary and not important.

There are various types of information encoded within the 80-bit time code word, the most important being the address data. The time code address is the number used by editing and synchronizing systems to locate a particular point on the tape. The address is an eight digit number in a 24 hour time format of HOURS:MINUTES:SECONDS:FRAMES. Valid time code numbers range between 00:00:00:00 and 23:59:59:29, and occupy 26 of the 80 bits.

Also recorded into the time code word are "USER-BITS". User-Bits occupy 32 bits of data and are available for any end-user application. Typically, user-bits define static data, for example, the date of the recording, reel number, scene number, or any numeric label.

The remaining bits make up the "sync word", which defines the end of the time code word and the direction of the code in playback; and status bits which flag different modes of operation.

The most important mode and the one which causes the most confusion is "DROP-FRAME".

Drop-frame is a mode of operation which compensates for the difference in frame rates between black and white video and color video. Because of technical difficulties in transmitting the color signal on broadcast channels, the frame rate had to be adjusted from 30 frames per second to approximately 29.97 frames per second. In broadcast applications where time code was used as the station clock, the clock would run slow because of the reduced frame rate. The solution to the problem was Drop-Frame.

Drop-Frame compensates for the slower rate by jumping the frame count ahead at periodic intervals, just as you would adjust a slow running clock by pushing the hands forward. The Drop-Frame mode causes the frame count to "drop" the numbers "00" and "01" on the minute so that the count progresses from frame :28 to :29 to frame :02, i.e., pushed ahead by two frames. Because dropping 2 frames every minute would over-compensate the error, the "dropped frames" are added back in on the tenth minute, i.e., not dropped. Pushing the count ahead in this manner effectively causes the time code to increment at the same rate as a clock.

The Drop-Frame mode is much more important to the broadcaster than the post-production facility, so many studios choose the "Non-Drop" mode. The decision to use one mode or the other is up to the user. What is important is to select a mode and use it consistently; that is, not mix Drop-Frame and Non-Drop Frame modes because doing so can cause problems for some editing systems.

FRAME RATE

As mentioned above, there are different time code rates for different video systems. Choosing the correct rate is the single **most important** parameter when generating time code for either audio or video use.

When generating time code for video editing applications, the time code rate must be the same standard as the video. In the U.S. and other countries that use 60Hz power, that rate is typically 29.97 frames per second. In countries that use 50Hz power, the rate is 25 frames per second.

To insure the correct rate and phasing (where the time code word starts in relation to the video frame), the time code generator MUST be fed a sync reference signal. This signal may be: either the video signal which is to be recorded with time code; or an external reference in the form of composite video, composite sync, color bars or black-burst. When an external reference is used, it must be fed to the video recorder as well as to the time code generator.

For audio applications, where time code is used as the basis for transport synchronization, the correct frame rate is equally as important. SYNCHRONIZERS CAN NOT OPERATE PROPERLY USING TIME CODES WITH DIFFERENT RATES.

To maintain the correct speed, each synchronizer in a system controlling a transport must have time code of the same rate from both the master and <u>all</u> slave transports. The time code addresses can be different, and even the Drop-Frame modes can be different (using Adams-Smith products), but the frame rate must be the same.

The choice of an audio time code rate is determined by the final use of the program material.

If the audio material will ever be used in relation to video, then the audio time code should be recorded at the corresponding video rate. In the U.S., the time code generator would be set to 29.97 frames per second.

If the audio material is for an audio program only, then the choice of frame rate is arbitrary. The only requirement is all of the material must have the same rate time code. In practice, you should use a rate similar to the established norm, i.e., 29.97 or 30.00 frames per second in the U.S., or 25.00 frames per second where appropriate.

RECORDING TIME CODE

Time code is recorded in the same manner as any audio signal with one exception: **the record level is very critical.**

Because time code is in the form of a square wave, the signal becomes very distorted during the record-play process. Time code readers are designed to ignore most of these amplitude problems, but an excessive record level can introduce distortions which will cause decoding errors.

The shape of the time code signal also induces crosstalk problems which are aggrevated by a high record level.

The solution is to record time code at the lowest possible level which provides error-free decoding. Due to variations in types of transports, the best method of choosing a proper level is by trial and error, however experience has shown that the following values will give good performance.

1" vtr's = -5vu to -10vu
3/4" & 1/2" vcr's = -3vu to -5vu
audio recorders = -5vu to -10vu

To prevent crosstalk from entering adjacent pre-amp stages prior to the level controls, the time code signal from the generator should be less than 1 volt peak-to-peak.

Some recorders use special time code channels called "Address-Track" (video) or "Center-Channel Time Code" (audio) which eliminate the need for using an audio channel for the code. These tracks are optimized for time code recording and playback and do not require setting of the input or output signal levels. In these cases follow the directions of the manufacturer.

READING TIME CODE

Playing back time code is as simple as routing the recorder "audio out" with the time code signal, to the input of a reader or synchronizer. If there is an output level control, it should be set to match the input signal, i.e., a -3vu signal in should be -3vu out.

Problems with reading time code relate primarily to the recovery of the signal at other than "play" speed. The shape of the time code waveform was specified so that standard audio amplifiers having a frequency response of 50hz to 15khz could be used to record and reproduce the signal. If the tape speed is increased, even to only twice play speed, the standard audio amplifier will not accurately reproduce the signal due to high frequency bandwidth limiting.

Transports which reproduce time code at speeds greater than play require special amplifiers. At 50 times play speed the time code signal extends close to 1.0Mhz

At speeds slower than play, the greatest problem is waveform distortion. Time code readers can usually decode the signal accurately down to 1/5th play speed (Adams-Smith time code readers can usually decode the signal accurately down to 1/20th play speed).

Most audio transports are designed to lift the tape off the heads when in high speed shuttle. When this occurs, the time code signal as well as any audio channels are muted.

To compensate for defective or missing code at other than play speed, synchronizers automatically count control track or tach pulses to maintain the address reference.

Sections 4 and 5 of this manual describe in detail the correct procedures for recording, decoding and synchronizing using the ZETA-THREE.