Appendix B
Synchronization

Synchronization is a process which forces two or more audio or video transports to run at a precise speed and position in relation to each other. The device used to perform these functions is a tape synchronizer. In common usage, "synchronization" is considered to be taking place while the synchronizer is in the act of achieving this precise relationship, or "synchronism". When synchronism has been achieved, the transports are said to be running in synchronism, in "sync", synchronized, "locked up", or in "lock".

Running multiple transports "in sync" permits time- and event-related material to be listened to and/or viewed simultaneously in their correct relationship.

For example, when preparing to build an audio track to complement an edited video tape, it is standard practice to first transfer the dialog audio from the video tape to a multi-track audio recorder. The transports carrying the picture and sound, respectively, can then be run in sync while additional dialog, sound effects or music is recorded on the multi-track recorder. This material might come from a tape played on an additional audio transport, which is itself synchronized to one of the other transports.

After the track-building procedure (sometimes called "audio editing") has been completed, the audio material on the multi-track recorder is usually mixed down to make a single or stereo audio track. This can be done with both the multi-track (which is now a "source" transport) and a smaller "record" audio transport synchronized to the same video play-back transport (carrying the same "work-print" of the previously edited video material) a process sometimes referred to as "mix-to-picture". Finally, if the transport carrying the completed audio mix is synchronized to the video transport carrying the video edit master, the mix can be recorded back onto the video tape's audio channels again, in what is often referred to as a "lay-back" session.

Another application of synchronization is to make larger transports out of smaller ones (increase the number of available tracks). For example, two 8-track recorders, when synchronized, perform exactly like a 16-track recorder; three synchronized 24-track recorders operate as a 72-track recorder. There is no limitation to the number of transports which can be made to operate in sync.

In order for a tape synchronizer to do its job it must be able to identify locations on both tapes with a high degree of precision. Longitudinal time code (LTC), a serial digital code containing signals which can be handled by audio amplifiers at play speed, is now used almost exclusively for this purpose. See Appendix A for an explanation of time code.

Synchronizers use two techniques for reading longitudinal time code from tape.

The first technique requires the use of a wide-speed-range LTC reader to read the code (Adams-Smith wide-speed-range LTC readers will recover LTC at all speeds from about 1/20 play speed to 100 times play speed). Additionally, the tape transport carrying the time-coded tape must be capable of reproducing the time code at those speeds. One-inch C-format VTR's and some VCRs contain wide-band address tracks and heads which can provide continuous code. Most VCRs do not have an address track, and may not even keep the tape against the audio heads when in FF and RW. These types of VCRs must be modified by the user to use this first technique. Almost all audio recorders (the exception being the new center-track time code track transports) must be modified by wide-banding the playback amplifier of the track on which time code is recorded. Additionally, the tape lifters must be defeated to allow the tape to remain against the heads while in Fast-Forward and Rewind.

The second technique used by synchronizers for reading time code requires only a play speed LTC reader. At other speeds, the time code is updated using tach pulses and direction signals from audio recorders, or control track and direction tally signals from VTRs. Since all recorders can reproduce LTC at playspeed, no recorder modifications are required, and the tape lifters of audio recorders can be allowed to operate normally. Since the second technique is less costly, and does not require recorder modification, it is almost always used in audio-for-video post-production even though tape cueing and parking may not be quite as accurate as when reading LTC at all speeds, because of tape slippage and tach errors.

Normally, it is only necessary to read LTC at all times (the first technique) when a tape contains discontinuous code, as it may if it is an original source tape. Time code discontinuities occur in source tapes if the time code generator is kept running continuously, perhaps to record time-of-day time code, instead of being stopped when recording stops and started again when recording starts again.

Before synchronizing can begin, the synchronizer must be told what positional relationship exists between the master and slave time code addresses. This relationship, called the "offset" is calculated by selecting a pair of corresponding addresses on the two tapes and subtracting the master address from the slave address.

For instance, assume a video transport has been designated as the master in a synchronizing system, and an audio transport has been designated as the slave (a lay-back configuration). If the time code address of a door slamming, as seen on video tape, is one hour and 20 minutes, and the corresponding sound of the door slam on audio tape is one hour, 20 minutes and 15 seconds, then the offset is 15 seconds, obtained by subtracting the master address from the slave address.

In post-production operations, the offset between the master video tape and the slave multi-track audio tape is often deliberately made zero for convenience This is accomplished by simultaneously copying the time code along with the audio program material from the video recorder to the multi-track audio recorder. In situations where the offset between the material on the video and multi-track recorder is not zero, then the offset value must be entered by the user into the synchronizer. Offsets may be known as a result of prior work and entered into the synchronizer, or captured from incoming master and slave time codes while the tapes are running in sync; or an individual sync point on each tape may be captured or entered, with the synchronizer automatically calculating the offset.

Using time-code from each transport as speed and position references, a synchronizer first achieves, and then maintains, a zero offset error.

There are three distinct routines in the synchronizing process. Assume that the tapes have been played, at least momentarily, and the synchronizer knows their locations and status (stopped). When the "synchronize" (or "chase") command is given, the first step begins. The synchronizer compares the MTC and STC addresses, computes the current offset, compares it to the desired offset, and determines the offset error. The synchronizer will then issue motion commands to the slave transport in order to cause the quickest reduction of the offset error. The transport will then be commanded to stop or "park"

When the master tape is put into Play, the second routine begins. In this routine the capstan of the slave transport is controlled by the synchronizer to make the slave tape move faster or slower than play speed, as necessary, to reduce the offset error to zero. Achieving lock from park usually takes no more than a very few seconds.

Once synchronism has been achieved, the synchronizer minutely speeds up or slows down the slave transport to maintain a zero offset error. The accuracy of synchronism must be on the order of microseconds, equivalent to 1/1000 of a TV frame and stable enough not to add any audible distortions.

Additional information on the process of synchronization is available throughout the ZETA-THREE manual.