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Digital Audio Signal Timing in Video Systems

Introduction

All television systems engineers understand the importance of proper video signal timing. They know that in order to ensure glitch-free switching, all video sources must be driven by a common reference. In addition, to ensure proper operation of video production switchers, master control switchers, and other devices that combine 2 or more video signals, differential delays between sources must be kept to a minimum.

Unfortunately, not all video engineers are aware of the importance of proper digital audio signal timing. The concept of "timing" as applied to audio signals is foreign to them. However, many of the same rules that apply to video signal timing apply to digital audio signal timing. If those rules aren't followed, the result will be pops, clicks, and other undesirable audio artifacts.

This article will discuss basic digital audio system timing concepts and provide practical system design examples.

Video System Timing Fundamentals

In all television broadcast, production, or post production facilities, a master sync generator is used to provide a timing reference for all equipment in the facility. The most commonly used reference signal is analog color black, because nearly all professional video equipment – both analog and digital – is capable of locking to color black. Typically, color black is fanned out using analog video DA's and distributed throughout the plant.

In larger facilities, delay lines and/or slave sync generators may be used to provide independently adjustable timing references that are all locked to the facility's master reference. This is often done to allow all sources, including the outputs of studios, edit suites, and other equipment "islands" to be zero timed at the input of the house router.

A properly-designed timing chain will ensure that all video sources are locked to a common reference and synchronized with respect to one another.

Anatomy of a Digital Audio Signal

Digital audio is produced by sampling an analog audio signal and formatting the samples into a serial bit stream. By convention, in a video environment, digital audio is sampled at 48kHz. In order to maintain a

stable, predictable relationship between video and audio sample clocks, the 48kHz digital audio sample clock must be derived from the same master oscillator as the facility's video reference.

The digital audio bit stream is formatted per AES3, a standard published by the Audio Engineering Society. In addition to the audio samples contained in the bit stream, the AES3 signal also includes synchronizing information, status bits, user bits, and CRC (Cyclic Redundancy Check) data. Like a video signal, data is organized into frames, each of which contains 192 two-channel samples.

It is worth noting that, in 50 field per second television systems, there are exactly 5 AES3 frames per field of video. In 59.94 field per second television systems, there are 4.1708333 AES3 frames per field of video. Therefore, in 50 field/sec systems, at best, AES and video frame boundaries are in alignment only once every 5 video fields. In 59.94 field/second systems, AES and video frame alignment is totally arbitrary.

System Timing Concepts for Digital Audio

The first step in designing a well behaved digital audio system is to ensure that all sources are locked to a common reference. The reference may be color black, silent AES3, or Word Clock. In some instances, it may be necessary to utilize a mix of all three. However, in order to ensure satisfactory results, they must all be derived from the same master reference.

Here are 3 different categories of digital audio sources that might be used in a video facility:

1. Those that are video sources as well: DVTRs, servers, non-linear video editing systems, etc. These typically derive their digital audio clocks from the video signal input or video reference input.

2. Audio-only sources that have an AES3 or Word Clock reference input: A/D converters, tone/test signal generators, digital audio clip players, audio consoles, etc. These require an AES3 or Word Clock reference that is locked to the video reference.

3. Audio-only sources that do not have any reference input whatsoever: CD players, DAT recorders, MP3 players, etc. These are not capable of being externally referenced, and they may not even utilize or support a 48kHz sample rate.

Integrating the first category of sources into a video facility is a straightforward exercise. Connect the video reference, adjust the video timing, and you're done. Video and audio from the source will be synchronous with the plant reference and properly timed.

Integrating the second category of sources into a video facility requires the use of an AES3 or Word Clock reference. An AES3 reference is simply a silent AES3 signal. Word Clock is a 48kHz square wave. More about these digital audio reference signals in a moment.

Integrating the third category of sources into a video facility requires the use of a device called a Sample Rate Converter (SRC). As the name implies, a Sample Rate Converter is used to convert one audio sample rate to another. Most SRCs accept a wide range of input sample rates. The output sample rate is usually set to a fixed, standard rate like 48kHz. On most SRCs, the output sample rate may be locked to an external AES3 or Word Clock reference. Standalone SRCs are available from a variety of manufacturers.

Not all video sync generators have AES3 or Word Clock outputs. Fortunately, AES3 and Word Clock can both be derived easily and inexpensively from analog color black using a Graham-Patten VRG-1 Video Referenced AES/Word Clock Generator, available from the ISIS Group. The VRG-1 is a compact, self-contained module that accepts an analog color black input and provides a balanced AES3 output, an unbalanced AES3id output, and a Word Clock output.

The VRG-1 is a valuable addition to any video facility. In addition to providing reference signals for locking digital audio equipment to plant sync, the AES3 output can be used as a source of silent AES on the house router. More information may be found at: www.gpsys.com/products/VRG1.htm

Test Signals

It is customary to provide one or more video/audio test signals as sources on the house router – color bars and tone, for example. The plant sync generator and/or a dedicated test signal generator is typically used to provide the video test signal(s). Audio test signals are not always available from these devices, and when audio test signals are available, the selection of format, frequency, and level is often very limited.

The Graham-Patten DTG-1 Digital Test Generator is a compact, versatile audio test signal generator that provides the following switch-selectable test signals:

- Sine waves at 6 pre-programmed frequencies: 20Hz, 100Hz, 440Hz, 1kHz, 3kHz, and 10kHz
- 1kHz tone with left/right channel ID

- Phase ID
- Sine wave frequency/amplitude sweep/step
- White noise
- Pink noise
- Silence

Output level is adjustable from 0 to -60dBFS.

The DTG-1 has both AES3 (balanced) and AES3id (unbalanced) outputs, as well as an external reference input that accepts either word clock or AES3id.

Multiple DTG-1 modules, all locked to a common reference, may be used to provide a set of several different audio test signals simultaneously. For example: 440Hz tone, 1kHz tone with left/right channel ID, and sweep. More information may be found at: www.gpsys.com/products/DTG1.htm

Summary

Digital audio signal timing in a television facility is just as important as video signal timing. Improperly timed digital audio sources are likely to cause pops, clicks, and other undesirable artifacts.

There are only a few basic rules that need to be followed to avoid these problems:

- All sources should be locked to a common reference.
- If any sources require an AES3 or Word Clock reference, the AES3 or Word Clock reference must be locked to the master video reference.
- Any digital audio sources that cannot be externally referenced or that do not utilize a 48kHz sample rate should be processed by a Sample Rate Converter before they are used with other sources in the facility.

Don't forget to include a digital audio test signal generator in your system design. In addition to providing a means to check signal path continuity, it can prove invaluable in diagnosing other system problems.