

# Time and Frequency Synchronizations in Broadcast Video

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## Introduction

Synchronization has always been important in broadcast video. Even analog TVs relied on synchronization pulses embedded into analog video signal to synchronize horizontal and vertical deflection of Cathode Ray Tube (CRT) electronic beam. The transition to digital broadcast video introduced need for bit rate synchronization while horizontal and vertical synchronization pulses, used in analog video, were replaced with code word sequences.

In this document we will present different equipment used in broadcast studios and explain why synchronization is crucial for their operation.

## Broadcast TV Studio

Any large televised events such as NFL games are simultaneously recorded with number of video cameras. These cameras need to be mutually synchronized to allow for seamless transition between them. Broadcast studios have all equipment synchronized to the same clock to avoid need for interpolation between lost frames which reduces quality of video material. Block diagram of a typical broadcast studio is shown in Figure 1.

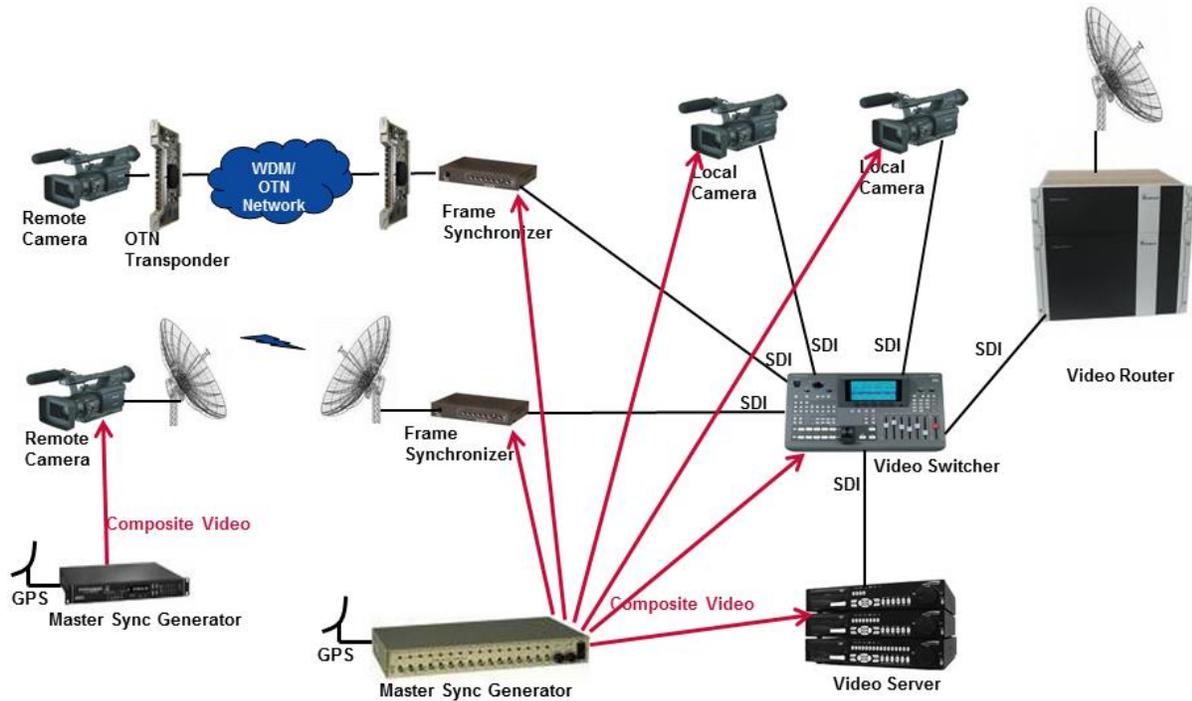


Figure 1 Broadcast Studio

## Master Sync Generator

Master Sync Generator is very accurate clock source whose signal is distributed to all equipment in a broadcast studio. Master Sync Generator gets its accurate clock by synchronizing to one of its input references (typically GPS signal, another Master Sync Generator or recovered Master Sync Clock from another studio), cleans the selected reference from phase noise with a Digital Phase Locked Loop (DPLL), synthesizes and embeds required clock frequencies into a standard video signal used for synchronization, and distributes it to all equipment in the studio via BNC cables. Master Sync Generator should have following features:

- Ability to synchronize to different input frequencies – Master Sync Generator should be able to synchronize to 1Hz signal from GPS receivers and to any clock or frame rate used in video applications.
- Seamless Reference Switching – If the reference Master Sync Generator is locked to fails, the Master Sync Generator will lock to another available reference without phase disturbances at its output.

- Holdover Mode – If the reference, Master Sync Generator is locked to fails, the Master Sync Generator should go to holdover mode where it generates output clock whose frequency is very close to the frequency of the input reference before it failed.
- Long Term Stability – If none of references is available, the Master Sync Generator should fall back to local accurate oscillator such as Ovenized Crystal or Rubidium Oscillator.
- Reference Monitoring – Master Sync Generator should monitor quality of its input references and should be able to switch to an alternative reference or go into holdover mode if the reference it is locked to fails.
- Programmable loop bandwidth of its DPLL to be able to filter jitter and wander that builds up in clock distribution network.
- Ability to simultaneously generate synchronization signals with integer and non-integer frame rates
- Ability to generate black burst composite video signal and HD tri-level sync outputs.
- Ability to generate video test patterns in different formats (PAL, NTSC, SDI, HD-SDI) used for adjustment and debugging of video equipment.
- Adjustable delay and advancement of synchronization outputs in order to compensate for delay difference in distribution cables.

Block diagram of a Master Sync Generator is shown in Figure 2.

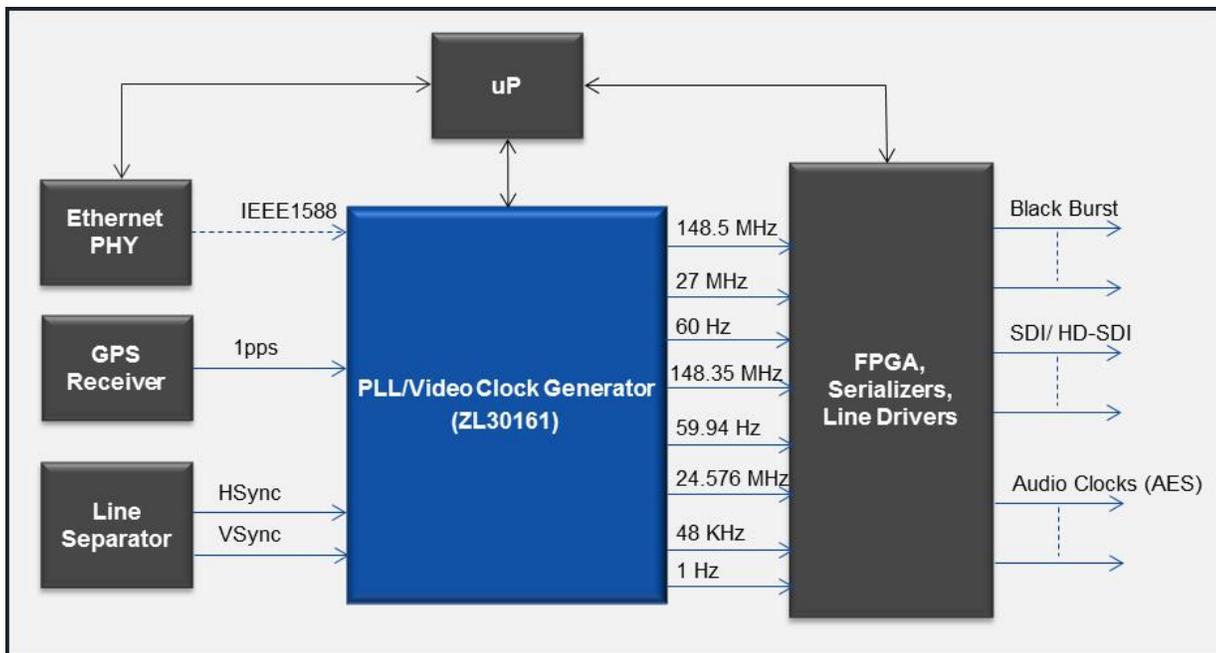


Figure 2 Master Sync Generator

In the future Master Sync Generators will need to support Precision Timing Protocol (PTP) commonly known as IEEE1588 which is delivered via Ethernet links. Although at the time of writing this article some Master Sync

Generators already support PTP, exact requirements for broadcast video applications are still in development by Video Standard body (SMPTE).

## Professional Video Camera

Block diagram of a Professional Video Camera is shown in Figure 3.

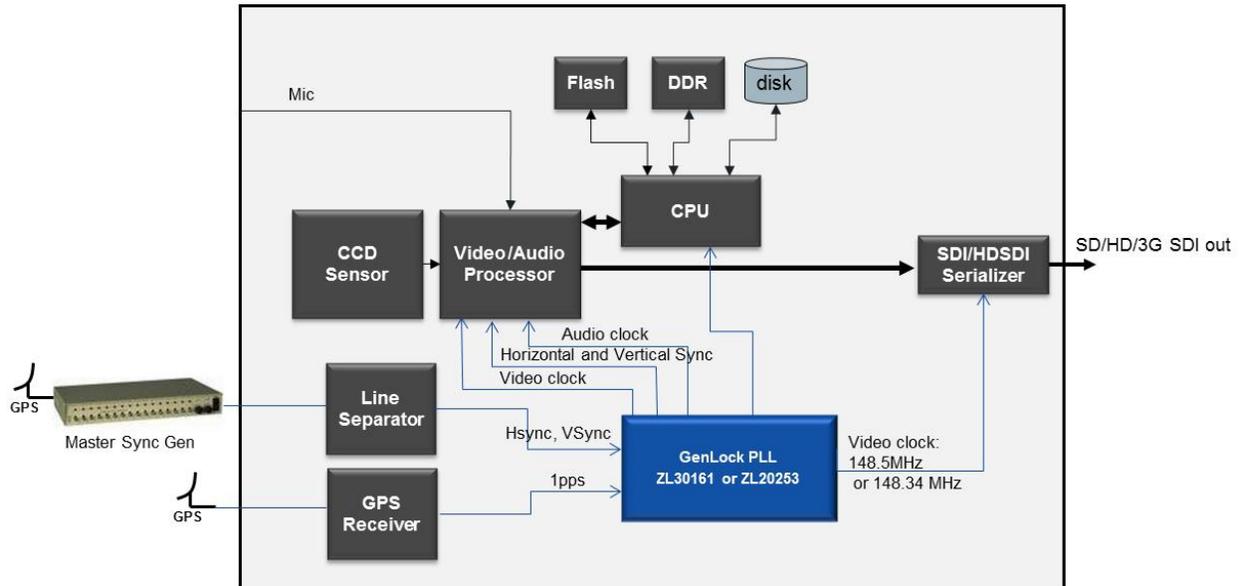


Figure 3 Professional Video Camera

Light reflected from recorded object passes through the lens and falls onto the camera's image sensor. The image sensor contains number of pixels arranged in x-y matrix and each of pixels generate electrical signal dependent on amount of light that falls on it. Video processor device scans horizontally and vertically through the sensor matrix and samples (digitizes) electrical signal of each pixel with an A/D converter. There are two different types of image sensors CCD (Charge Coupled Device) and CMOS (Complementary Metal-oxide Semiconductor) and their differences are beyond the scope of this article. It should be noted that image sensor, regardless of the type, can measure only light intensity and not the color –they are color blind. To obtain the color information, sensor is typically preceded by a (RGB) color filter so that each pixel measures light intensity for a particular color. Another alternative is to separate light that passes through the lens to red, green and blue components with an optical prism. In this case each light beam needs its own image sensor. This type of cameras is commonly called 3-CCD or 3CMOS camera depending on the type of image sensors. For simplicity Figure 3 shows only one sensor. .

Video processor combines RGB samples into one of uncompressed video formats (the most common is 4:2:2 YCbCr) and passes it to 10 bit parallel bus for SDI and 20 bit bus for HD-SDI Serializer.

To facilitate seamless switchover between cameras their video processor sampling clocks and sync pulses as well as SDI/HD-SDI clocks need to be synchronized via genlock to the other equipment in the studio. Video processor requires clock with very low jitter because any jitter present on the clock will affect signal to noise ration of A/D converter.

Audio signal from microphone(s) is digitized in audio processor. The audio sampling clock needs to be synchronized to the video clock because digital audio signal is further embedded with video signal into SDI/HD-SDI stream.

There are two types of professional video cameras: electronic news gathering (ENG) cameras which are just high-end camcorders and television studio cameras. Basic block diagram is quite similar except that television studio cameras do not have recording capability – same as in Figure 3 but without disk drive.

## Video Server

Video server can be viewed as data server equipped with SDI/HD-SDI interface cards. The purpose of video server is to store captured video signal for playback and later post processing. It is obvious that Video Server needs to be synchronized to the other equipment in the studio to prevent data loss. Block diagram of Video Server is shown in Figure 4. Block diagram shows beside black burst, server could also get synchronized via IEEE1588.

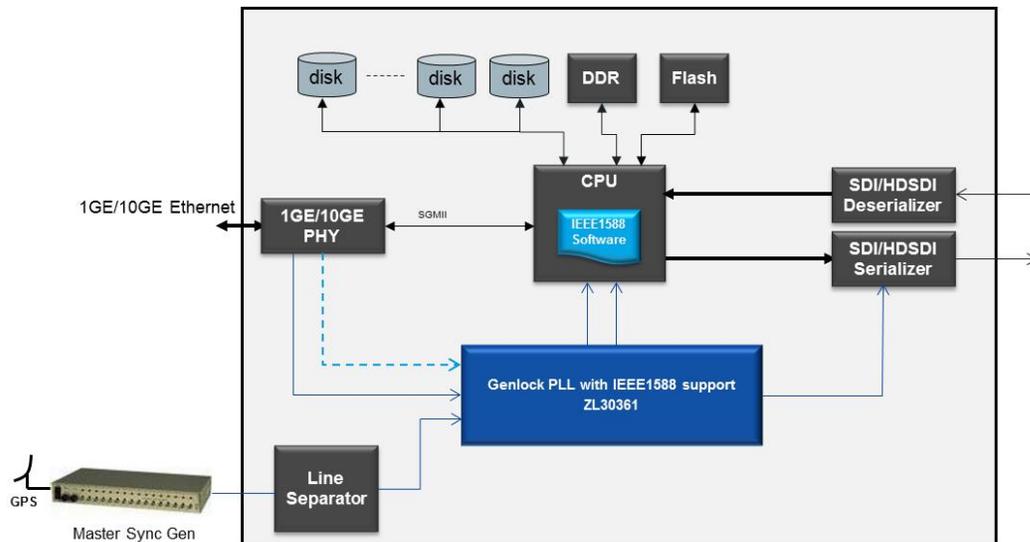


Figure 4 Video Server

## Video Switcher

Video switcher (also called Video Mixer) is used to select one out of several available video sources during live television (football game example mentioned previously). In the past it was used for video editing as well but nowadays video editing is mostly done on computer. Block diagram of Video Switcher is shown in Figure 5

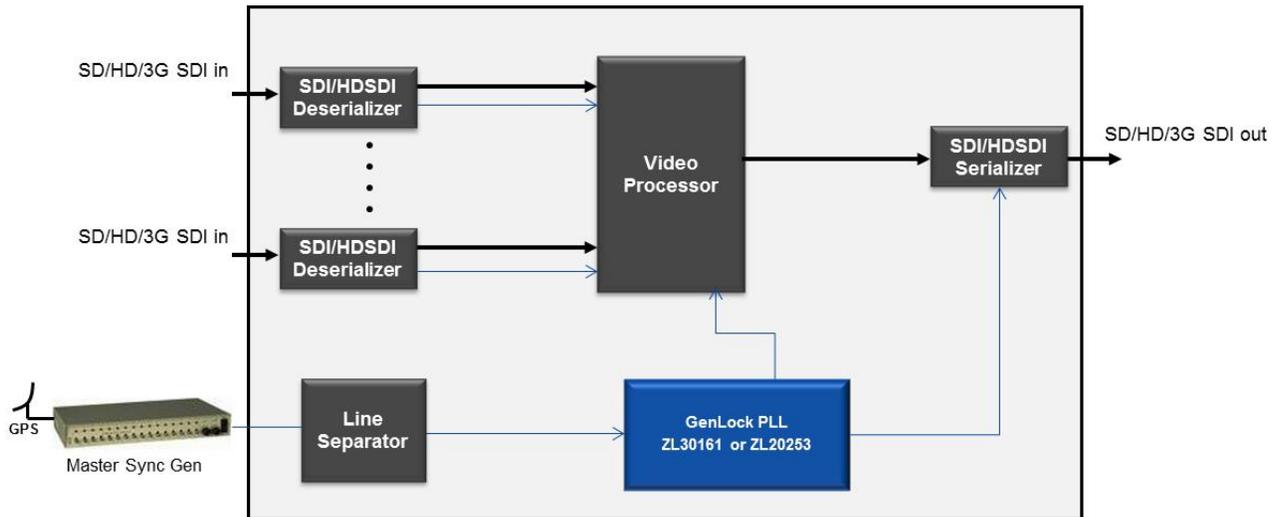


Figure 5 Video Switcher

## Conclusion

Synchronization is of very important in broadcast video application. In a broadcast studio all equipment is synchronized (Genlocked) to Master Sync Generator via black burst composite clocks signals.

This article has described importance of synchronization in broadcast video and how it is done in present video equipment. The article has also shown how synchronization can be done via Ethernet by using IEEE1588 protocol which is in process of been adapted by Video standard body ( SMPTE).