Timing and Synchronization in a Standard Definition Hybrid Video Facility

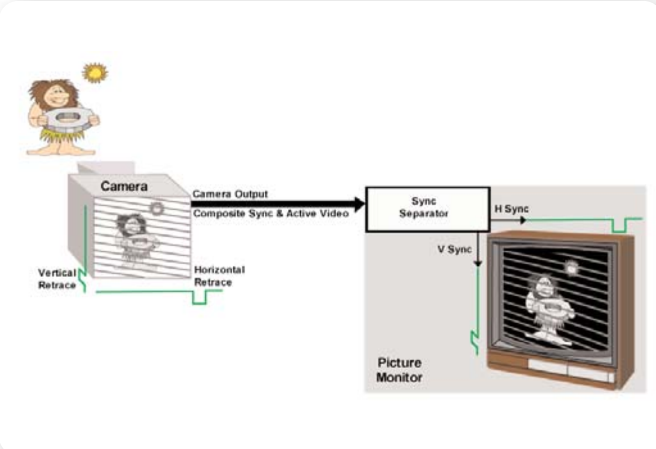
Introduction

Synchronization is one of the most fundamental and critical procedures in a video facility. Every device in a system must be synchronized in order to successfully create, transmit, and recover video pictures and audio information. The complexities of an analog and digital multi-standard, multi-format environment require flexibility to achieve and maintain synchronization in facilities that operate in a mix of formats.

Meeting the Challenges of Operating in Mixed Environments

Synchronization is one of the most fundamental and critical procedures in a video facility. Every device in a system (cameras, VTR's, editors, switchers, etc.) must be synchronized. Adjusting system timing to achieve and maintain synchronization has become even more important and challenging in facilities that operate in multiple formats. Signals from a master sync pulse generator (SPG) are used to synchronize all of the equipment in a system – resulting in a state known as generator locked, or genlocked, for short. In a typical studio or post-production plant, the SPG must provide a variety of timing and synchronization signals to address the needs of multi-format, multi-standard equipment in what is now referred to as a hybrid facility. This application note consists of two parts. The first part describes the basic timing properties of analog and digital systems. The second part describes the use of the versatile Tektronix SPG600 and SPG300, sync pulse generators to meet the many timing and synchronization challenges hybrid facilities. The SPG600/300 is a multi-format sync pulse generator platform that can be configured with a variety of options to serve the needs of analog and Standard Definition (SD)-Serial Digital Interface within hybrid facilities.

Tektronix
Enabling Innovation



▶ **Figure 1.** *Simplified Synchronizing process for analog video.*

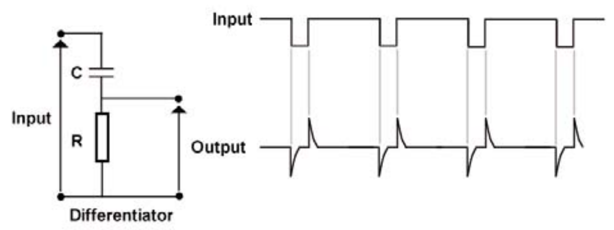
Basic Timing Properties of Analog and Digital Systems

Understanding Analog Timing

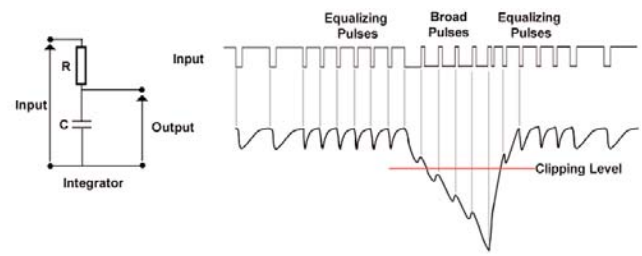
For accurate reproduction of a video image, the television receiver must be synchronized to the studio camera in order to scan the same part of the picture at the same time (Figure 1). Separate sync pulses are used for horizontal (line) and vertical (field) control of the electron beams that create the picture.

NOTE: The term "beams" is used throughout this note in reference to the three electron beams (Red, Green and Blue) as used in typical CRT-based color video monitors, even though monochrome monitors use only one electron beam and newer display types (LCD, Plasma, etc) do not use electron beams in the traditional sense.

The beams are scanned from left to right to create horizontal lines. At the end of each line, the beams must return to the left side of the picture – a process called **horizontal retrace**. The horizontal sync pulse coordinates the horizontal retrace. Lines are scanned from top to bottom of the screen to create an active picture. Standard analog systems **interlace** odd and even lines to create a full picture **frame** (two alternating fields). When the end of a field is reached at the bottom of the picture, the beams return to the top for the start of the next field – an interval known as **vertical retrace**. The vertical sync pulse signals the start of the vertical retrace. Because the vertical retrace takes more time than the horizontal retrace, a longer vertical synchronizing interval is required. The vertical sync pulses are wider than horizontal sync pulses to facilitate easy recognition by the electronic circuitry involved. During each horizontal and vertical retrace, the electron beams are turned off and nothing is written to the screen – a period referred to as the horizontal or vertical **blanking interval**.



▶ **Figure 2.** *Simple differentiating circuit to extract line sync pulses.*



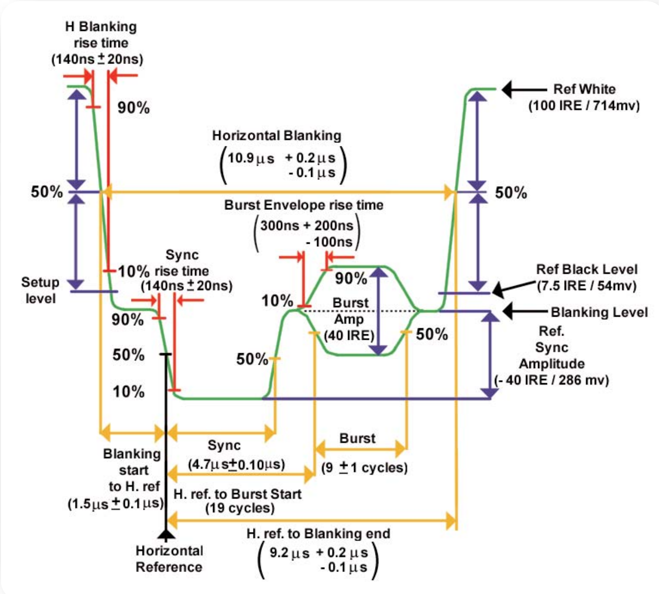
▶ **Figure 3.** *Simple integrating circuit to extract vertical sync pulses.*

The analog video delivery system combines the horizontal and vertical sync pulses into a single **composite sync signal** in a way that allows for easy extraction and separation at the receiver. When analog television signals were first developed, the circuit designs needed to be basic because of the limited technology available at the time. As a result, the sync separator that is used to extract the horizontal drive signal in the receiver is a simple differentiating circuit. The differentiator circuit produces sharp spiked pulses at both edges of each horizontal (line) sync pulse, as shown in Figure 2. The synchronizing circuit then uses the leading negative spike to ensure a lock to the negative pulse and ignores the positive spikes. To prevent drift of the horizontal drive circuit, the line sync pulses occur during the entire field interval. Longer pulse widths, known as **broad pulses**, distinguish the vertical sync from the horizontal sync pulses in a composite signal. Equalizing pulses are inserted before and after the broad pulses, which produce a similar pulse pattern for odd and even fields. A simple integrating circuit is used to extract the vertical pulses, as shown in Figure 3.

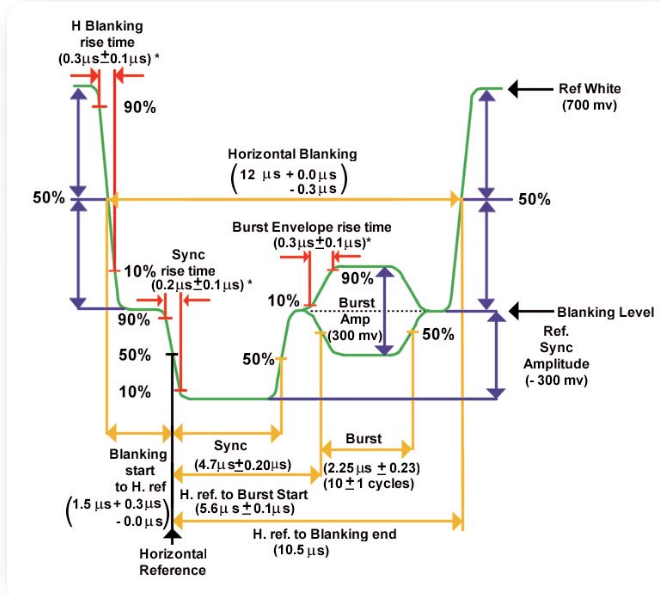
Analog Timing Parameters

In analog video timing, three basic parameters need to be synchronized in order to establish a reference and ensure picture quality:

- Horizontal sync for line timing
- Vertical sync for field timing
- Subcarrier for color synchronization



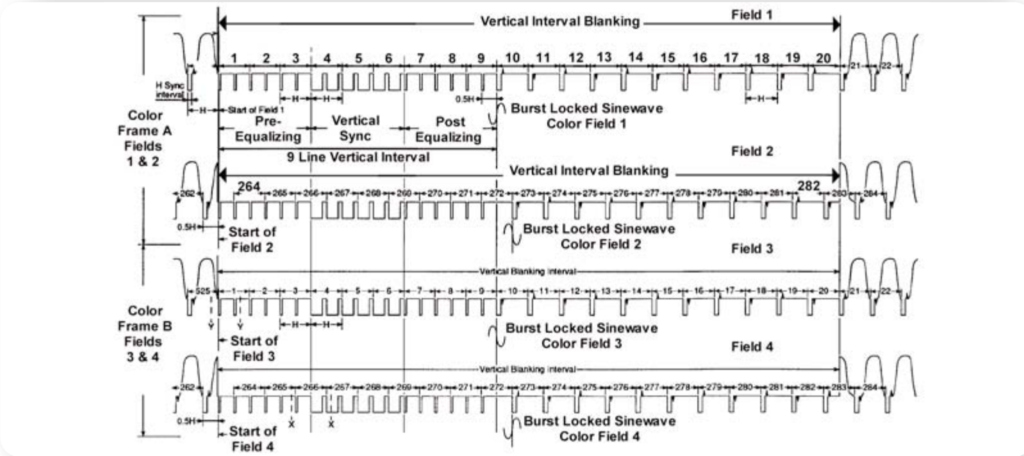
▶ **Figure 4.** *NTSC horizontal blanking interval (from SMPTE 170M).*



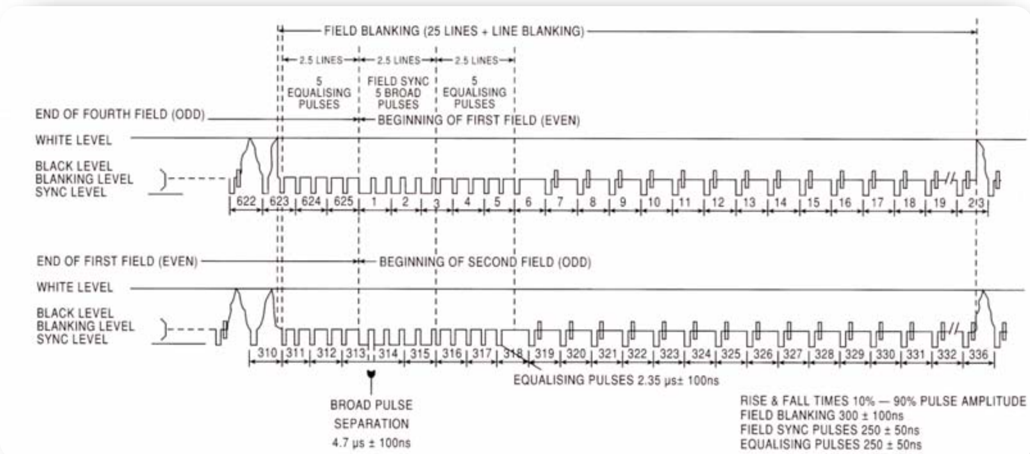
▶ **Figure 5.** *PAL horizontal blanking interval (from ITU-R.BT.470-6). Note that PAL-I systems use rise/fall times of (0.25 µs + 0.05 µs).*

Horizontal sync for line timing:

The **horizontal blanking interval** occurs once per line of video information and is composed of a horizontal sync, front porch, and back porch. The horizontal front porch defines a time for the video to settle to zero and prevents the video signal from interfering with sync extraction. The horizontal blanking interval allows enough time for the beams to return to the left side of the display (flyback) and settle before the start of the video signal. During the flyback period the beams are blanked to prevent the scan lines from appearing on the display. Figures 4 and 5 illustrate the relative timing of NTSC and PAL horizontal-blanking intervals. The color burst can also be seen on the back porch of each horizontal interval. The front porch interval is nominally considered to be the period noted as Blanking Start to H Ref. The Back Porch interval is nominally considered to be the period noted as H Ref to Blanking End minus the Sync Width.



▶ **Figure 6.** *NTSC vertical blanking interval.*



▶ **Figure 7.** *PAL vertical blanking interval.*

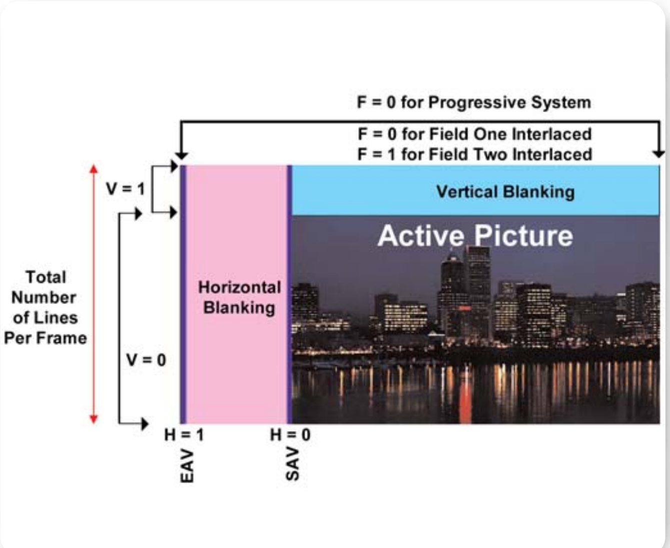
Vertical sync for field timing:

Vertical sync is extracted from the equalizing pulses and broad pulses during the vertical timing interval. The vertical interval allows the identification of the odd and even fields in an interlace system, and the longer vertical blanking time allows the picture tube electron beams to return to the top of the screen. The **vertical blanking interval** signals the end of an active picture and the start of the next picture, as shown in Figure 6 for NTSC and Figure 7 for PAL.

Subcarrier for color synchronization:

For the detection of color in the picture, a subcarrier burst is added to the back porch in the horizontal interval and is used for subcarrier timing. Proper color synchronization of transmitted and received signals relies on their subcarrier bursts being in phase and locked to the horizontal sync time with a specific "zero time" reference point. The color burst frequency is 3.579545 MHz for NTSC and 4.43361875 MHz for PAL. These frequencies were chosen to increase the separation of color and luma signals and to prevent interference with monochrome television signals. Figure 6 shows the alternating fields, and the four-field NTSC color frame sequence. The color subcarrier comes back into the same relationship with the vertical sync after four fields in NTSC. The PAL sync and subcarrier take eight fields to return to the original relationship because of the horizontal sync to subcarrier relationship.

The phase relationship between the PAL and NTSC vertical sync patterns is important when one source of a video signal joins or is suddenly replaced by another source, as when the video is edited, switched or combined by special effects equipment. The critical process of identifying the correct field and color subcarrier phase is referred to as **Subcarrier-to-Horizontal Phase** (SCH phase). (Refer to SCH Phase application note 20W-5613-2 NTSC and 20W-5614-1 PAL.)



▶ **Figure 8.** *Spatial layout of the digital frame with V, F, and H-bit values.*

Bit Number	9 (MSB)	8	7	6	5	4	3	2	1	0 (LSB)
Function	Fixed (1)	F	V	H	P3	P2	P1	P0	Fixed (0)	Fixed (0)

- Bit 9 – (Fixed bit) fixed at 1
- Bit 8 – (F-bit) always 0 in a progressive scan system; 0 for field one and 1 for field two of an interlaced system
- Bit 7 – (V-bit) 1 during vertical blanking interval; 0 during active video lines
- Bit 6 – (H-bit) 1 indicates the EAV sequence; 0 indicates the SAV sequence
- Bits 5, 4, 3, 2 – (Protection bits) provide a limited error correction of the data in the F, V, and H bits
- Bits 1, 0 – (Fixed bits) set to zero to have identical word value in 10 or 8 bit systems

▶ **Table 2.** *Format of EAV/SAV "XYZ" Word*

Genlock reference for analog video:

The **black burst** signal is often used to genlock equipment. It is a composite signal that contains horizontal and vertical syncs and a small packet of NTSC or PAL color subcarrier (color burst). The term black burst arises from the fact that the active picture portion of the signal is at black level (0 mV for PAL, 7.5 IRE (black) for NTSC (America) and 0 IRE for NTSC no-setup (Japan)). The black burst signal is used for system timing, the synchronizing signals are derived from the black burst signal and used for genlock within equipment. The color burst is used to obtain the color framing reference and provide synchronization of the color subcarrier. In some cases, a **Continuous Wave** (CW) signal is used to genlock a sync pulse generator (SPG). The CW signal is a clock signal of sinusoidal shape, usually selectable in frequency at 1, 5 or 10 MHz, depending on the device. This sine wave signal has no positional information of H and V because it is only a clock. Therefore, the timing output of the SPG cannot be guaranteed if the CW signal is removed from the SPG and then re-applied.

Understanding Timing for Digital Video and Audio Signals

There are no analog sync signals in digital video. Synchronization in the digital environment is achieved by the use of specific codeword sequences that represent the **Start of Active Video** (SAV) and the **End of Active Video** (EAV). Each codeword is composed of values starting with a data packet of $3FF_h$ followed by the words 000_h, 000_h,and then a value of XYZ_h that contains information on the field (F), vertical blanking (V), and horizontal (H), as shown in Table 2. This data is used to synchronize the timing in the digital video signal. Figure 8 shows how the F, V and H bits are used in the video signal. The vertical count begins at line 1, field 1 of the video signal.

Digital systems include audio equipment in the facility, as well. Most professional digital audio systems use a 48 kHz sample rate, conforming to the AES/EBU standards. It is important to ensure that digital audio equipment is synchronized to eliminate clock rate drift that would cause clicks in the audio because of misalignment of the data between devices. Therefore, a digital audio reference should be applied to all digital audio equipment. This reference is usually an AES/EBU signal or, in some cases, a 48-kHz word clock.

▶ **Figure 9.** *SPG600 and SPG300 Sync Pulse generators front and rear panels.*

Timing and Synchronization Solutions

Configuring the SPG600 and SPG300 for Analog and Digital Environments

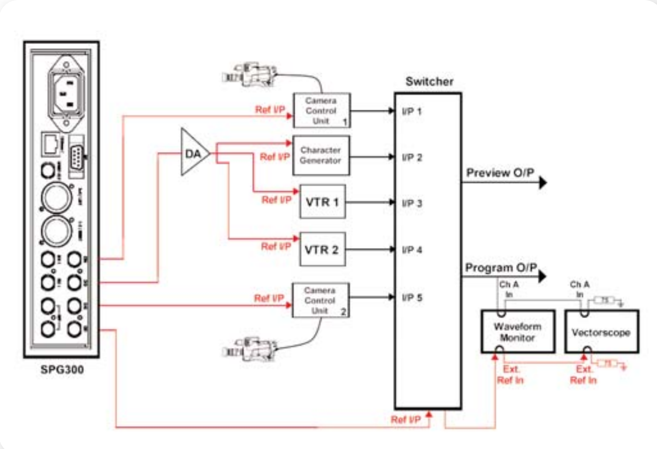
The Tektronix SPG300 sync pulse generator is a half rack 1RU (rack unit) designed for simple edit suite locations and remote truck applications where limited space is a concern. The wide variety of outputs, as shown in Figure 9, allows flexibility in configuring the unit to meet the needs of a hybrid facility. The SPG300 offers four analog independently time-able analog black burst outputs. The SPG300 four analog outputs can be configured as a test signal output. The user can select from one to all four of the outputs to be the test signal output. Two SD-SDI outputs are also available as one black and one test signal output, each independently time-able. Two channels of analog audio or four channels of digital AES/EBU audio are switchable to the two XLR balanced outputs; a separate word clock output is also available for synchronization of audio systems.

The Tektronix SPG600 is a full rack 1RU instrument. It is ideal as a master sync pulse generator for larger installations where a large number of outputs and configurations are required in a hybrid facility. The SPG600 offers the same functionality as the SPG300 with the addition of 8 channels (4 outputs) of unbalanced AES/EBU digital audio. Additional options can add four more analog outputs for blacks or test signal or another option can add two additional SD-SDI digital outputs, one black and one test signal. Each unit can be controlled remotely via an Ethernet port or ground closure connection.

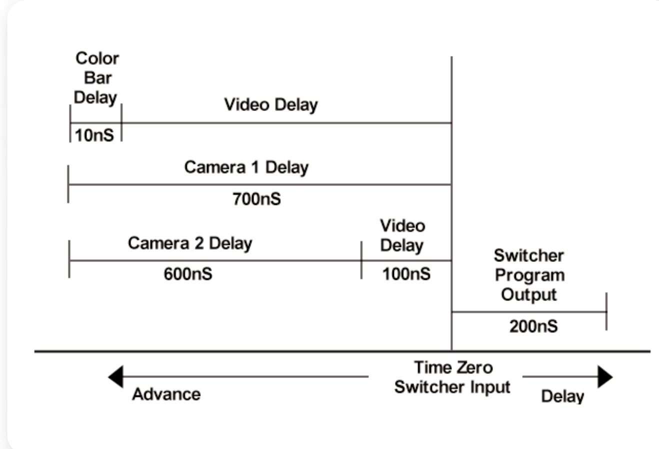
The SPG600/300 offers a unique Stay Genlock™ mode. This feature was first introduced in the TG700 AGL7 module and now is available within the SPG600/300. When the unit is configured to “Stay Current Frequency” mode in the genlock menu, any momentary loss of genlock input will cause minimal disturbance to the video outputs.

In most sync pulse generators, the internal reference frequency set during calibration is used when “Loss of Signal” happens. However, the TG700/AGL7, SPG600 and SPG300 can keep the last value of genlock frequency control with their unique digital genlock architecture. The last invalid control data may be discarded by the process so the unit can move into the “Stay Current Frequency” mode very smoothly. This means that there will be no shock or phase jump when the reference signal is interrupted and re-applied.

When the reference signal re-appears, the “Stay Current Frequency” mode operation keeps the timing relation with the reference signal as close as possible during the disruption. In most cases, the disturbance at re-lock is very small. The “Stay Current Frequency” mode cannot eliminate a disturbance if the reference signal has a vastly different timing and frequency from the current “stay” value when re-applied – a normal genlock shock is expected in this case.



▶ **Figure 10.** *Basic analog video system.*

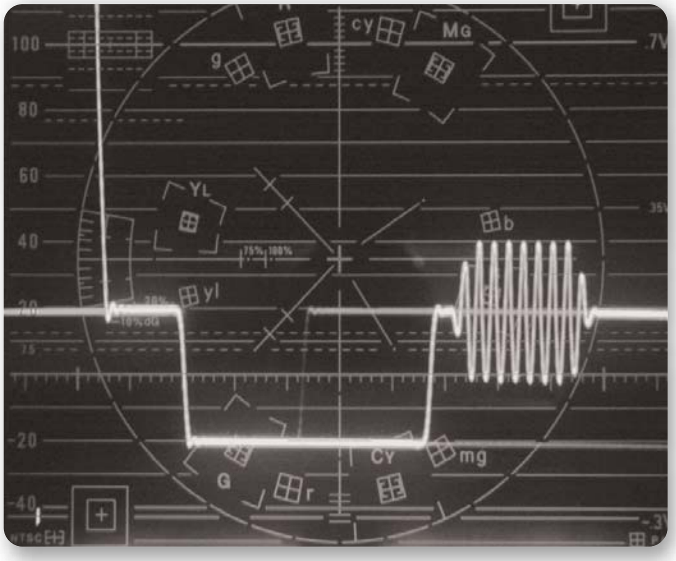


▶ **Figure 11.** *System timing through the studio.*

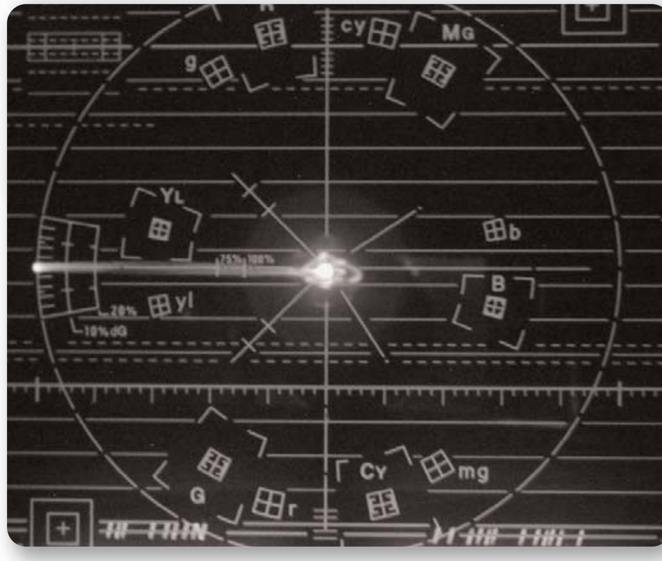
Measuring and Adjusting Analog System Timing

When various video sources are combined, their signals must be timed together or the picture will roll, jump, tear or have incorrect colors. A precision reference signal from an SPG, such as the SPG600/300, is applied appropriately to each device, each device achieves proper genlock, and the outputs of the various devices are now synchronized with the timing of the reference. Careful system design is necessary to ensure synchronization between all signals in the facility. In planning the system timing of a facility, the processing delays of the equipment and the propagation delays of the various lengths of cable needed to connect the equipment must be taken into account. Typically the propagation delay through one foot of cable is approximately 1.5 ns (1 meter equals approximately 5 ns) depending on the type of cable used – a significant factor in long lengths of cable. Figure 10 shows a typical basic analog video system. It is important to know the cable lengths, the processing delays of the equipment, and how timing adjustments can be made to correct for them. In this scenario, the video tape recorders (VTRs) have Time Base Correctors and allow output timing adjustment; the character generator allows output timing adjustments via software and the Camera Control Units require external delay adjustments in order to guarantee system timing.

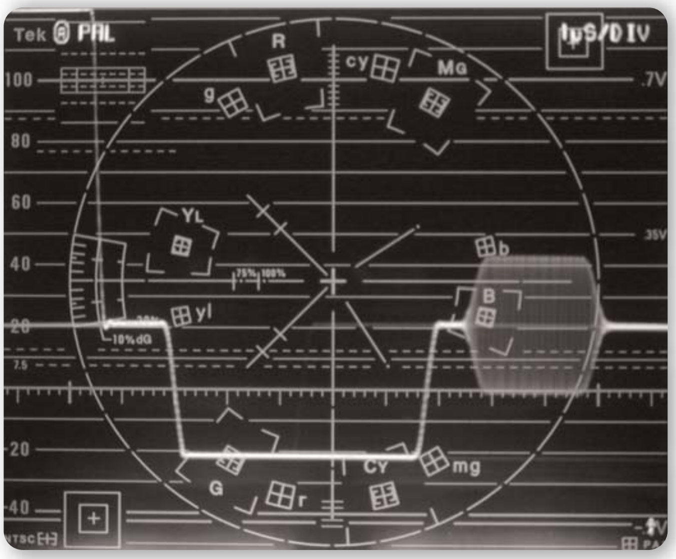
Figure 11 shows the calculated delays throughout the system. The first step is to document the timing of each piece of equipment in order to determine the longest delay through the system. The objective is to have every signal arrive at the switcher at the same time, defined as **Time Zero**, by introducing compensating delays. In this example, the combined processing delay and cable delay is greatest through the signal path for Camera 1, so it will be used as the basis for timing every other signal. Appropriate delays must be inserted into the other signal paths to match that delay and synchronize them at the input to the switcher. Delays are inserted by using the timing adjustments of the SPG600/300 for each black output. In this example, a separate black output is used for each camera control unit to adjust the delay appropriately. The character generator and VTRs each have built-in timing adjustments, so a **Distribution Amplifier** (DA) can be used to route the SPG600/300 reference signal to each of them. Note that using a DA in the system will also introduce a small processing delay. If the equipment is in close proximity, the reference signal can be looped through them. The internal adjustments of each piece of equipment can then be used to ensure synchronization to the switcher's input. Analog system timing adjustments are made with a waveform monitor and vectorscope connected to the switcher output, as shown in Figure 10. The external reference is selected on both the waveform monitor and vectorscope so that the units are synchronized to the black burst reference. Care should be taken to ensure that the measurements are made at the 50% levels, which is standard practice for analog signals; otherwise errors can occur in the measurement. Select the black reference signal to the output of the switcher, which will be the zero time reference to compare the other signals applied to the switcher's inputs.



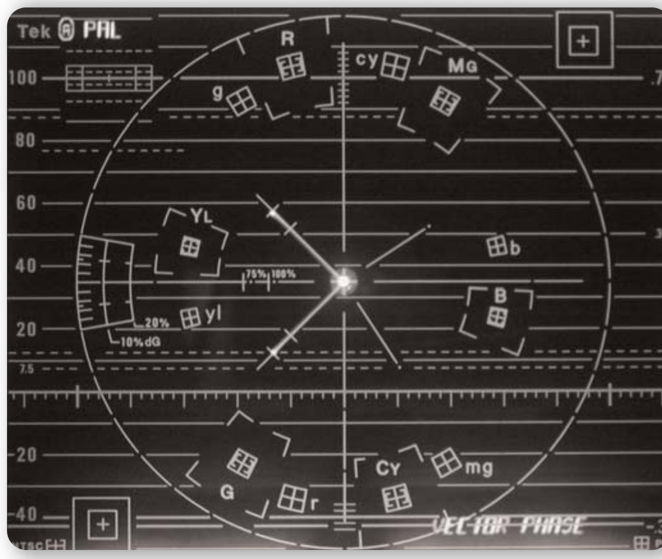
▶ **Figure 12a.** *NTSC waveform in H Mag with two lines selected.*



▶ **Figure 12b.** *Vector display in variable gain mode.*



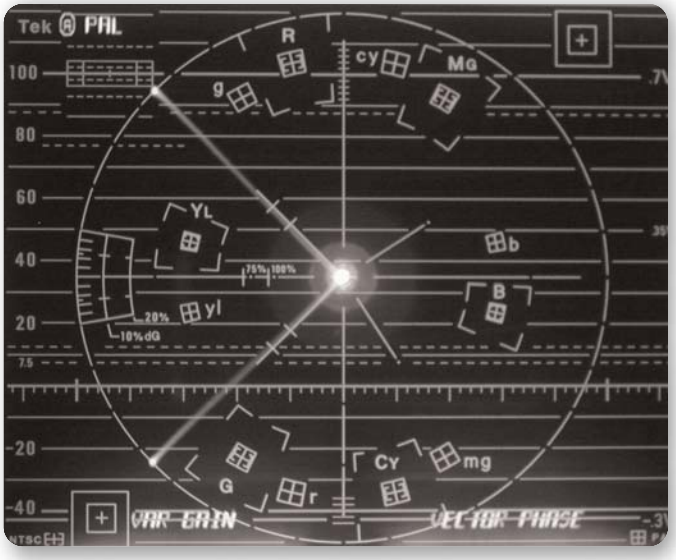
▶ **Figure 13a.** *PAL Waveform in H Mag with two lines selected.*



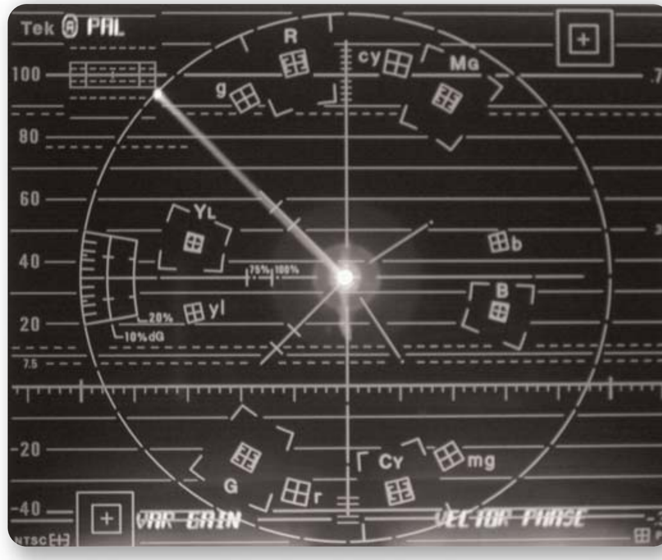
▶ **Figure 13b.** *Pal Vector Display.*

Start by ensuring that vertical timing is correct between the inputs. On the waveform monitor, select the A input and set-up the waveform display in a horizontal magnification *(H MAG) 2 field sweep* mode to show the vertical interval of the waveform. Position the waveform so that line 1, field 1 is placed at a major tick mark on the waveform monitor. All the other inputs to the switcher can then be compared with the zero black reference and adjusted vertically so that the signals are in the exact same position as the reference.

The next step is to adjust the horizontal timing of the signals. Select the black reference signal at the switcher's output and select an *H MAG one-line sweep* mode on the waveform display so that a horizontal sync pulse is displayed. Position the waveform so that the 50% point of the leading edge of sync is at one of the major tick marks. A similar procedure can be performed with the vectorscope to ensure color burst subcarrier phase. For NTSC, position the color burst to the 9 o'clock position and magnify (MAG) the display so that the burst amplitude lies on the outer edge of the compass rose, as shown in Figure 12. Set this up with the black reference and then adjust the phasing for all other inputs to the switcher. A similar approach is used in PAL systems, but the phase of the burst is switched on alternate lines and lies at +135° and +225°, as shown in Figure 13.



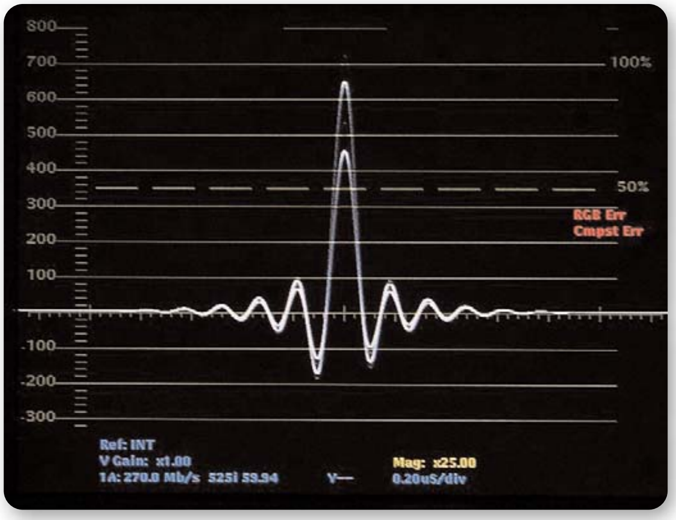
▶ **Figure 14.** *PAL Vectorscope MAG display.*



▶ **Figure 15.** *PAL Vectorscope MAG display with V axis switched.*

The PAL burst can be magnified as shown in Figure 14, so that it lies along the 135° axis to the outer edge of the compass rose. The *V axis switched* setting can be selected on the vectorscope to simplify the display, as shown in Figure 15. Sync and burst signals are now referenced to Time Zero and the various inputs to the switcher can be selected to ensure they are positioned at the appropriate places on the waveform monitor and vectorscope. If the vectorscope has the capability, S/CH phase should be measured between the reference signal and other inputs of the switcher. This is particularly important in the editing process to prevent disturbances when the signal is switched. Once this task is completed, you will be able to switch smoothly between video sources and make clean edits without picture roll, horizontal jumps or color flashes. Editing suites and studios have used **Component Analog Video** (CAV) to avoid composite artifacts and improve the management of signals. This is a simpler approach since the process requires the timing of the horizontal and vertical signals, but does not require the timing of the color subcarrier. However, the CAV system does require additional attention to appropriate inter-channel timing of the three video signals (Y', P'b, P'r) or (R', G', B') per distribution path.

Component Serial Digital Interface (SDI) offers a means to distribute the signal on a single cable and maintain video quality throughout the video facility. However, it brings other new challenges and techniques for timing in a hybrid facility.



▶ **Figure 16.** *XYZ pulse of Y channel with pass through selected on WFM700.*

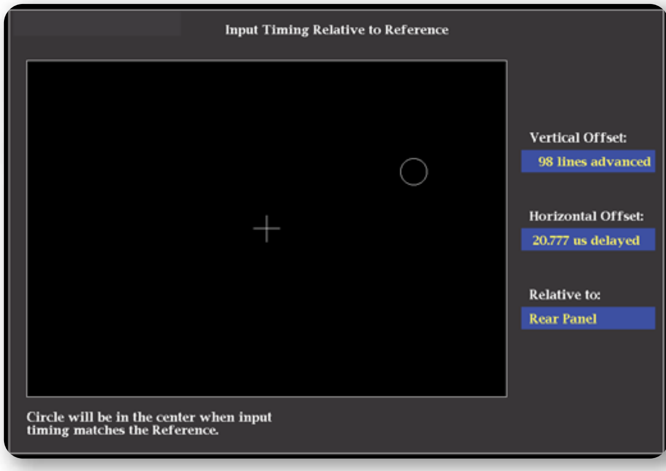
Measuring and Adjusting Digital System Timing

Digital equipment has some advantages over analog and is a little more forgiving when dealing with timing. A digital switcher usually has partial automatic timing of the inputs and it can compensate for timing errors, provided the signal is within a range of approximately 30 to 150 µs, depending on the equipment. However, care is still needed to ensure vertical timing because of the large processing delays in some digital equipment.

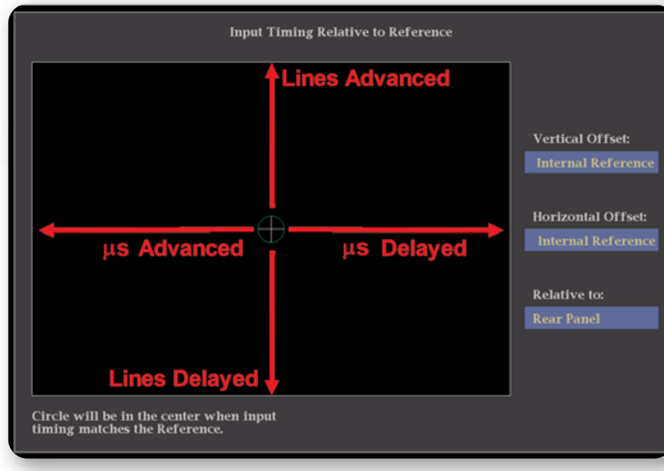
Analog black burst is still the predominant reference signal, although a SDI Black signal can be used on some digital equipment. Measuring the timing of two digital signals is a simple procedure using a digital waveform monitor such as the Tektronix WFM601, WVR600 series or the WFM700. The SDI signals are connected to Channel A and Channel B and the waveform monitor is externally referenced to the black burst or tri-level sync (as appropriate). Care must be taken to terminate all signals correctly. In the configuration menu of the waveform monitor, select *pass EAV* and *SAV* mode and the $3FF_h$, 000_h, 000_h, XYZ_h values will be displayed on the waveform monitor, as shown in Figure 16. The transition from $3FF_h$ to 000_h and 000_h to XYZ_h produces ringing on the display when passed through the appropriate SD filter. The SAV or EAV pulse can be used as a timing reference by positioning it on a major tick mark of the waveform display and comparing it to the other SDI signals – ensuring that they are positioned at the same mark. There are no vertical pulses in the digital domain – digital systems calculate their video position based on the values of F, V, and H. Therefore, a reference point must be defined in order to measure vertical timing. For simplicity, the first line of active video can be used as the reference, because the vertical blanking lines are normally blank.

To measure vertical timing, set *Line Select* and *Sweep* for two-line mode, select *Field 1* and line select at the setting that will display the last line in the vertical interval and the first line of active signal. This setting should be line 19 for 525 interlace, or 22 for 625 interlace. If necessary, adjust the vertical timing of the source until the display is correct. Next, select channel B and make sure the last vertical and first active lines are displayed. If necessary, adjust the vertical timing to align both vertical positions to the start of active video. Lastly, switch back to channel A and set *MAG* to ON, noting the amplitude of the SAV pulses. If the amplitudes of both pulses are identical, they are in the same field. If not, the two signals are in opposite fields and timing adjustments should be made to align the sources to the same starting point.

To measure horizontal timing, switch to channel A and set the waveform monitor to sweep one line. Use the horizontal position knob to set the SAV pulse to a major graticule tick mark, or use cursor mode and set a cursor on the SAV pulse. Compare the timing to the signal on channel B by selecting the channel and adjust the fine timing controls to match the timing position of channel A.



▶ **Figure 17.** *WVR600 Series timing display,*

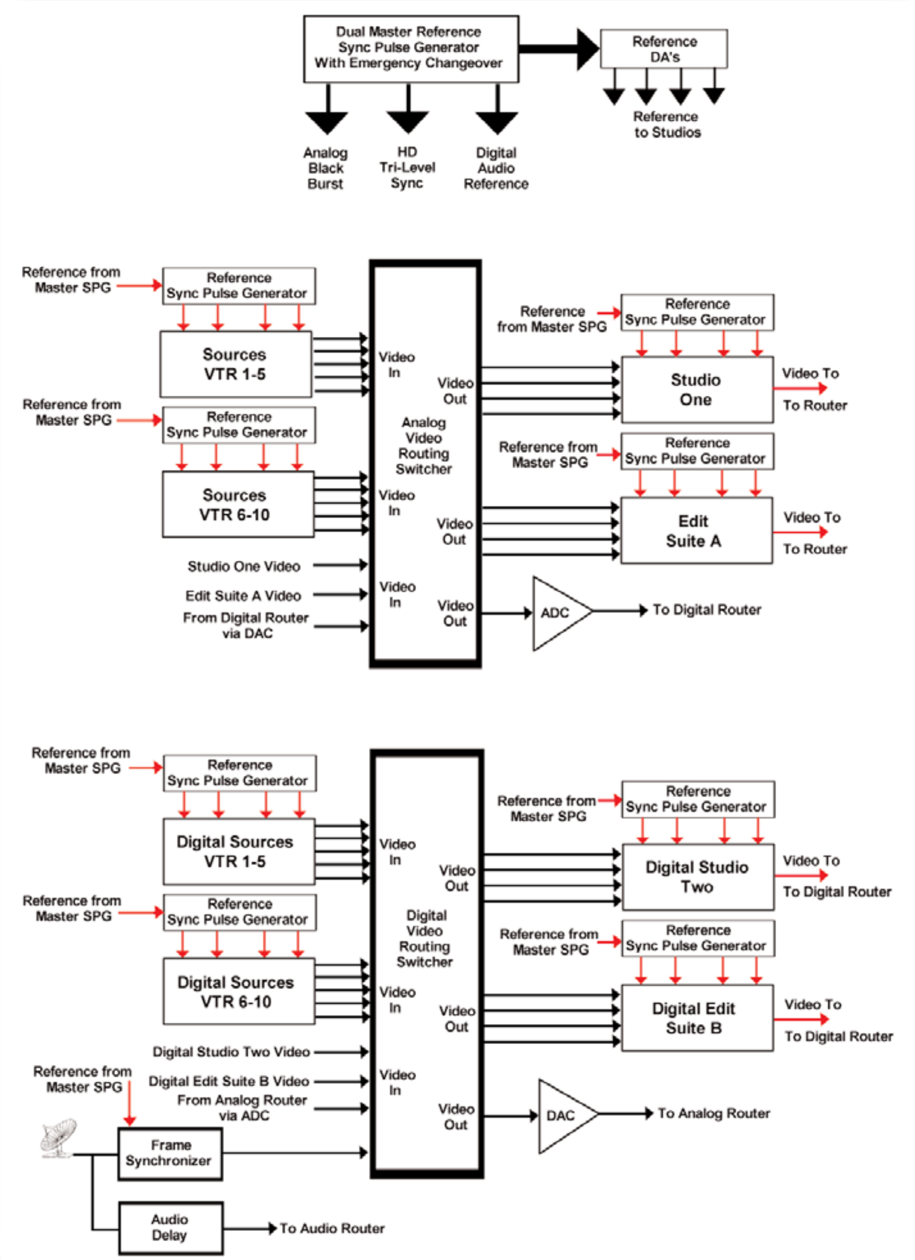


▶ **Figure 18.** *Interpretation of Timing Display,*

Tektronix has developed a simple proprietary method for timing of an analog and digital facility with the WVR Series of waveform rasterizers. The Timing display provides a simple graphical rectangle window, which shows the relative timing between the external reference and input signal. Measurement readouts in line and microseconds (µs) of the difference between the two signals are also provided as shown in Figure 17. The input signal can either be a SD-SDI or an analog composite signal. The input timing is compared to the analog black external reference input.

The rectangle display represents one frame for SD-SDI inputs, or a color frame for composite inputs. The crosshair at the center is zero offset and the circle represents the timing of the input signal. Line timing errors, advanced or delayed, are shown as vertical displacement of the circle, while timing errors (H timing) of less than a line are shown as horizontal displacement of the circle. See Figure 18. If the input is at the same time as the reference, the circle will be centered on the cross hair and it will change color to green.

The “Relative to” box indicates the chosen zero point reference for the timing display. The default is the selected reference at the rear panel. In this mode the offset is zero when the input and reference are at the same timing at the rear of panel of the instrument. The other choice is to use the Saved offset. In this mode, you can save the timing from one of the input signals and then display the timing relative to this “saved” offset. This is especially useful in timing the inputs to a router. By selecting one of the inputs to the router as the master relative reference and applying this signal to the input of the WVR Series along with the external reference signal being used by the router. Press and hold the MEAS button to display the timing configuration menu. Select the Saved Offset menu item and press the Select button on the front panel of the instrument this will now save the offset between the input signal and the external reference. In the timing configuration menu select the “Relative to:” selection and change the selection from Rear Panel to Saved Offset. The circle will now move to the center of the crosshair and change to a green color. Now, by routing each of the other router inputs to the WVR600 Series, the measurement will show the relative offset between the master relative reference and the other video inputs. Simply adjust the horizontal and vertical timing controls of each input signal until the circle and the crosshair are overlaid and the circle turns green. Fine timing adjustment can be done directly from the number readouts of the right hand side of the display. Once this process has been completed, each of the inputs to the router is timed relative to the master input signal. This intuitive display can save considerable effort in the timing of video systems.



▶ **Figure 19.** *Standard Definition hybrid facility.*

Timing Across a Standard Definition Hybrid Facility

The basic principles, which have been applied to the timing requirements for separate analog and digital systems, can be used across a multi-format facility. To guarantee the quality of the program, the timing changes between various formats should be minimized. Typically, format islands are created to keep signals in a single format while they are being processed in a specific production area. Timing and synchronization facilitates flexible use of the equipment between the format islands in the hybrid facility. Figure 19 illustrates the basic components of a typical multi-format hybrid facility. A dual master reference SPG is used in conjunction with an emergency change-over unit to ensure a precisely timed reference throughout the facility.

An appropriate analog or digital distribution amplifier (DA) distributes each of the reference output signals throughout the facility. There are two types of digital distribution amplifiers:

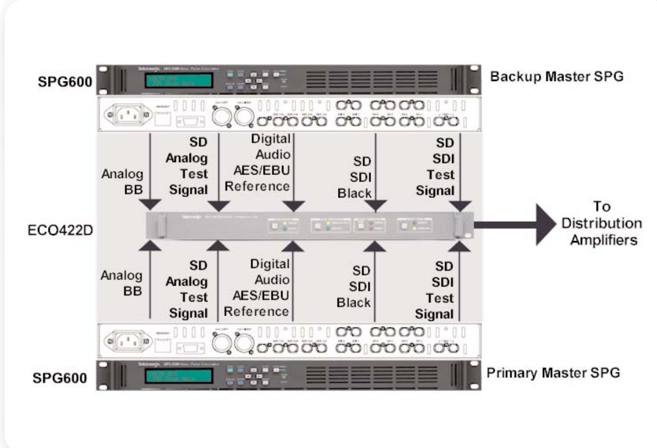
- Fan-out providing a loop-through input and multiple non-reclocked outputs

- Equalizing/Reclocking which has additional circuitry to recover and equalize a digital signal over a long cable run (>200 m). The signal is re-clocked to produce a completely regenerated digital signal and provide multiple outputs

The Master reference signals are distributed to individual areas, such as studios or editing suites, where these signals are connected to Slave SPGs. Slave SPGs are often used to produce independent reference time signals for each area. The use of the slave generator helps minimize the complexities of overall studio reference time and affords some measure of independent operation within a given work group. Although the majority of systems still use analog black burst references, as shown in Figure 19, some types of digital equipment now use a digital black reference signal. The SPG600/300 provides a digital black reference output for those pieces of equipment that support an SDI reference input. The advantages of an SDI reference are that it does not suffer from the typical analog distortions, such as hum or noise, which may affect the analog genlock circuits. Secondly the SDI reference contains a higher resolution clock frequency, as compared to the composite subcarrier frequency. However the SDI signal requires a serial decoder to obtain the F, V and H pulses in order to derive the sync signals for engineers and operators who are more familiar with an analog black burst signal and can more easily determine horizontal and vertical synchronization.

A hybrid facility is typically going to have digital or analog islands to minimize the transitions between standards and formats and to ensure the quality of the program material. When signals need to be converted from analog to digital or digital to analog, an Analog-to-Digital Converter (ADC) or Digital-to-Analog Converter (DAC) provides signals to the digital and/or analog router to be distributed to the islands. These ADC and DAC devices do introduce some delay within the signal path but this is typically a minimal amount. The specifications of the device should be checked to see what the manufacturer defines as the throughput delay of the module.

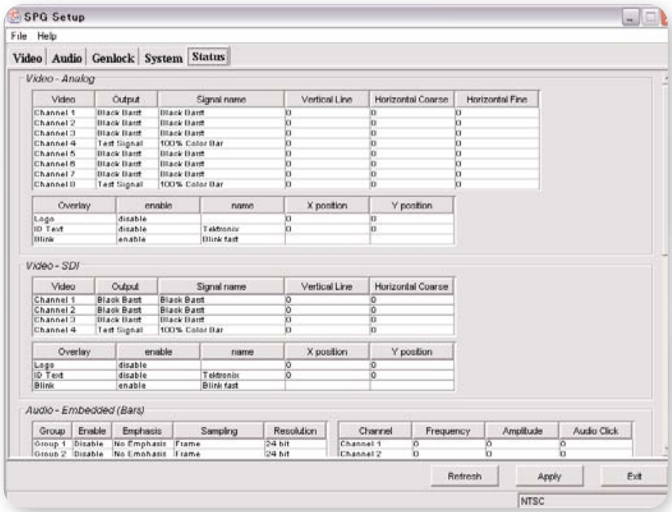
In some cases, Frame Synchronizers are used to synchronize external sources such as satellite feeds. They are also very useful for re-timing the signals coming from the various islands that might be operating as time-independent entities. A timing reference (black burst) is applied to the frame Synchronizer to facilitate the timing of these external sources into the facility. Video frame synchronizers can introduce several fields of processing delay in the video path. The audio associated with these external video signals must also be delayed by the same amount as the video. Appropriate audio delay must be added and the inserted audio delay may need to track with the video delay where a particular external input path's timing may vary from day to day or signal source to signal source. Audio delay, and occasionally audio advance control mechanisms, may also be needed to compensate for large video processing delays in other digital equipment, in order to avoid lip-sync problems.



▶ **Figure 20.** *Dual SPGs with emergency change-over unit.*

Redundant Synchronization

Synchronization throughout the facility is a critical operation for guaranteed, predictable and smooth system performance. Designing a facility with redundant synchronization provides a complete fault-tolerant, flexible, and robust system. Emergency Change-Over (ECO) units, such as the Tektronix ECO422D, are used to automatically switch from one sync source to another upon fault detection in any active source, which helps to alleviate loss of service in a facility. The SPG600/300 can be used in combination with a second SPG600/300 to provide the backup signal source in case of failure of one of the components in the timing system as shown in Figure 20. Both Primary and Backup Master SPGs should be genlocked to the same reference signal in order for the relative timings of both instruments to be coincident. The ECO422D is able to detect a loss of signal amplitude on any one of its eleven user configurable channels and automatically switch to the back-up SPG generator.



▶ **Figure 21.** *Status Display of java application for SPG600/300.*

The ECO422D can be configured to support any of the following formats: Analog Black Burst (PAL or NTSC), HD tri-level sync, AES/EBU digital audio, SD-SDI, or HD-SDI. Two User-Defined amplitude settings are also provided for selected custom needs.

An uninterruptible power supply (UPS) should also be incorporated into the system to alleviate further concern for loss of signals. The UPS prevents power surges or short term loss of power from disrupting the output configurations of the SPG and interfering with the timing settings.

After completing the timing set-up of the whole facility, it is important to save the settings of the Master and Slave SPGs. The SPG600/300 can be connected to a network via the Ethernet port on the back of the unit. A Java enabled web browser (for instance Internet Explorer greater than 5.0 and Java Realtime Environment JRE 1.4.1) is required to load the application. Simply enter the IP address into the address bar of the web browser and the Java application will be installed. Once the application is installed, it is possible to remotely control all the functions of the unit. The status view, as shown in Figure 21, gives an overview of the configuration of the instrument. After the unit is configured for the facility, the setup of the instrument can be saved as a *.CSV file to a PC. This file can then be loaded back into the unit at a later date, or can be used to clone the settings to another instrument. For instance, once the settings of the Primary Master SPG have been made, these settings can be saved and then loaded into the Backup Master SPG to make its configuration identical to the primary instrument.

Synchronizing Digital Audio

The Tektronix SPG600/300 Digital Audio outputs provide a range of AES/EBU audio tones and silence. A separate word clock output is also provided. The digital audio outputs can also be locked to the video reference for synchronization between audio and video equipment.

For 625/50 line systems, there is a direct relationship between the 25 Hz video and 48 kHz audio of 1920 samples per video frame. There are 192 frames in the AES/EBU digital audio structure that produce exactly ten audio interface frames per video frame. For NTSC, there are a non-integer number of samples per frame because of the frame rate of 29.97 Hz (30/1.001). It takes five NTSC frames to reach an integer number of audio samples (8008). The SPG600/300 is able to offset the timing relationship between the video and audio signals by +/-160 ms in 1 µs intervals.

Conclusion

Television timing, using black burst as the reference, has been a critical part of any analog video facility. The transition to digital has introduced the need to synchronize a wide variety of analog and digital formats, often simultaneously. In addition, audio conversion, which never required synchronization in analog formats, now requires the use of a digital audio reference signal to synchronize digital audio equipment. The flexibility of the SPG600 and SPG300 allows for simplification of system timing design. They support a wide range of video and audio outputs. The Tektronix family of analog and digital television signal generation equipment enables you to meet the many new challenges of operating conditions within traditional analog and new hybrid facilities.

Contact Tektronix:

ASEAN / Australasia / Pakistan (65) 6356 3900
Austria +43 2236 8092 262
Belgium +32 (2) 715 89 70
Brazil & South America 55 (11) 3741-8360
Canada 1 (800) 661-5625
Central Europe & Greece +43 2236 8092 301
Denmark +45 44 850 700
Finland +358 (9) 4783 400
France & North Africa +33 (0) 1 69 86 80 34
Germany +49 (221) 94 77 400
Hong Kong (852) 2585-6688
India (91) 80-22275577
Italy +39 (02) 25086 1
Japan 81 (3) 6714-3010
Mexico, Central America & Caribbean 52 (55) 56666-333
The Netherlands +31 (0) 23 569 5555
Norway +47 22 07 07 00
People's Republic of China 86 (10) 6235 1230
Poland +48 (0) 22 521 53 40
Republic of Korea 82 (2) 528-5299
Russia, CIS & The Baltics +358 (9) 4783 400
South Africa +27 11 254 8360
Spain (+34) 901 988 054
Sweden +46 8 477 6503/4
Taiwan 886 (2) 2722-9622
United Kingdom & Eire +44 (0) 1344 392400
USA 1 (800) 426-2200
USA (Export Sales) 1 (503) 627-1916
For other areas contact Tektronix, Inc. at: 1 (503) 627-7111
Last Update August 13, 2004

For Further Information
Tektronix maintains a comprehensive, constantly expanding collection of application notes, technical briefs and other resources to help engineers working on the cutting edge of technology. Please visit **www.tektronix.com**

09/04 EA/WOW 20W-14229-2

Enabling Innovation