FEATURES

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SYNC-TO-TRIGGER

INTRODUCTION:

The sync to trigger function allows temporally consistent and replicable start of acquisition frames (exposures) in relation to the trigger signal actuation. The user can be sure, in a series of multiple tests; that 'Frame 1' of each Cine file occurs at the same time after a trigger; and therefore, frames numbers of each Cine file can be viewed with assurance that the image is comparable.

To best understand this feature it is worth reviewing how the frame synchronization (f-sync) clock pulse is used in Phantom cameras.

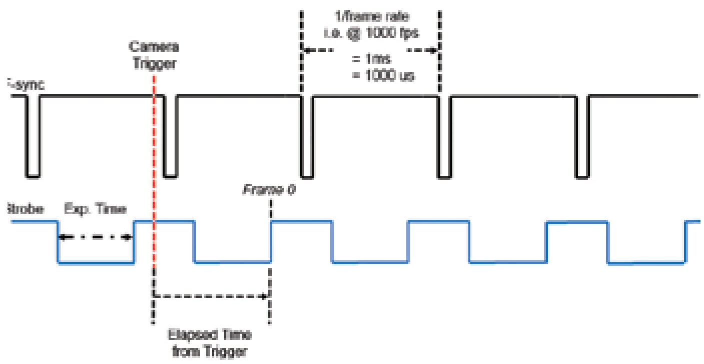

Figure 1: Internal Time

FRAME SYNCHRONIZATION TIMING METHODS

A 'frame synchronization' (f-sync) clock pulse is used to instruct the camera when a frame / image needs to be recorded into the camera's memory buffer. This clock pulse signal is known as an f-sync (Frame Synchronization). It is the only camera I/O (input / output) signal that can accept or transmit to / from a camera.

The source of the f-sync varies based on how the camera(s) are to be utilized, (standalone or multi-camera network). As of this writing, there are five f-sync clock source used to drive the camera's framing clock, including: Internal, External, Lock to IRIG, Sync to Video, and Sync to Trigger.

INTERNAL TIMED

The camera's internal frame rate generator (crystal oscillator) outputs a 4µs negative pulse on f-sync to initiate acquisition of image frames. 3-4µs after a negative edge is detected at f-sync, integration starts (Strobe[1] low). Typically, a new exposure cannot start until 3-7µs (camera dependent) after the previous one has ended.

If an f-sync pulse is detected before an exposure can start, it is latched and a new frame will start at the earliest possible opportunity. Additionally, an exposure cannot end until the previous frame was completely read out from the sensor. If such a case occurs, the integration period is extended until the readout has completed, overriding the exposure time setting.

This type of clock source is commonly used in standalone camera applications.

EXTERNAL TIMED

External frame clock pulses provide an externally supplied frame sync clock pulse to drive the camera's sample rate. The external input signal must be a TTL (Transistor-to-Transistor Logic) pulse, with a frequency up to the maximum sample rate.

The f-sync (input) clock pulse can be supplied by a master camera's internal oscillator, or an external clock source to generate a TTL pulse.

[1] Strobe is a pulse generated by the camera synchronous with the sample (frame) rate, which remains low for duration of the exposure. It is an isolated open collector output, with 1k pull-up. When asserted (low) the camera integrates (shutter is open).

SYNC-TO-TRIGGER

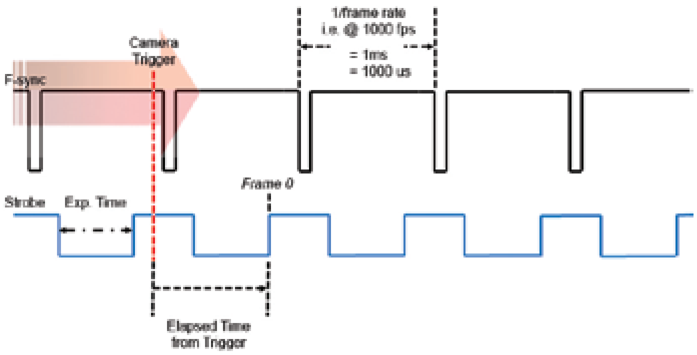

Figure 2: External Time via an external clock device

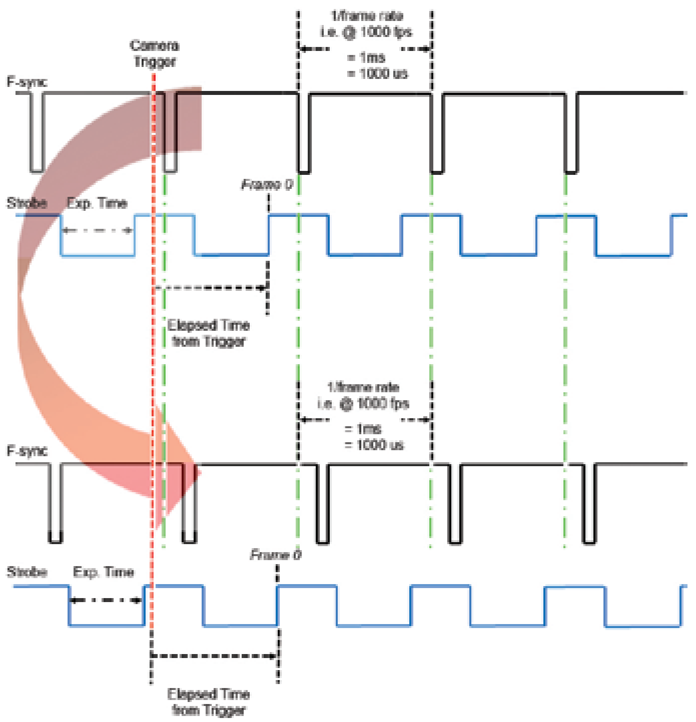

Figure 3: External Time via the master camera internal oscillator

The illustrations (above) show two options of providing an f-sync clock to a second camera. Figure 2 depicts the f-sync clock being provided by an external clock generator while Figure 3 shows the f-sync clock being generated from an internal oscillator of a master camera to a secondary (slave) camera. Notice when cameras are slaved off a master camera, there can be a short often negligible delay between the f-sync clocks; if a delay is evident this delay is adjustable to align the exposure acquisitions from both cameras.

This type of clock source is commonly used to synchronize multiple (slave) cameras to a master camera's internal clock, or synchronize several (slave) cameras, typically located within close proximity of one another, to an external clock source.

LOCK TO IRIG

Inter-Range Instrumentation Group (IRIG) time codes are standard formats for transferring timing information. A cameras' clock can be locked to an IRIG-B signal, by either the internal (IRIG-B equivalent) oscillator or externally supplied via an IRIG-B receiver.

An IRIG-B time code signal, utilizes pulse width coding provided by a range of devices, to supply a camera with a frame clock (in multiple of 100fps). It is typically distributed as a DC level shift (DCLS), pulse-width coded signal ("unmodulated IRIG-B") or as an amplitude- modulated signal based on a sine-wave carrier at a frequency of 1kHz ("modulated IRIG-B"). Modified Manchester modulation is also specified in the standard but is less common.

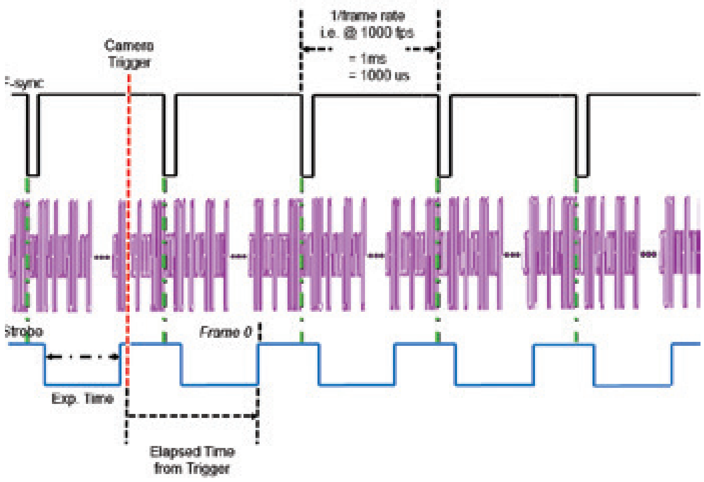

Figure 4: Lock to IRIG

The signal itself has a pulse rate of 100 pulses-per-second with an index count of 10 milliseconds over its one-second time frame.

Once an IRIG signal is detected the signal will automatically over-ride the cameras' internal crystal-oscillator frame clock (equivalent to IRIG). However, if the IRIG time code is lost the camera oscillator will immediately provide the frame clock to the camera until the IRIG signal re-syncs with the camera.

This type of clock source is commonly used to synchronize multiple cameras, normally position at significant distances from one another, to a single clock source.

SYNC TO VIDEO

Sync to Video allows a camera to capture frames at a rate that is a multiple of the video frame rate, with a defined phase relationship with the video signal.

When this frame clocking technique is used the capture of frames is triggered by f-sync pulses generated by the video raster generator. The first f-sync pulse of a video frame is coincident with the start of vertical sync, and further pulses are spread through the frame at equal intervals in order to obtain the desired frame rate.

The camera will only accept frame rates that are a multiple of the video frame rate. If other values are requested, they will be rounded to the nearest multiple.

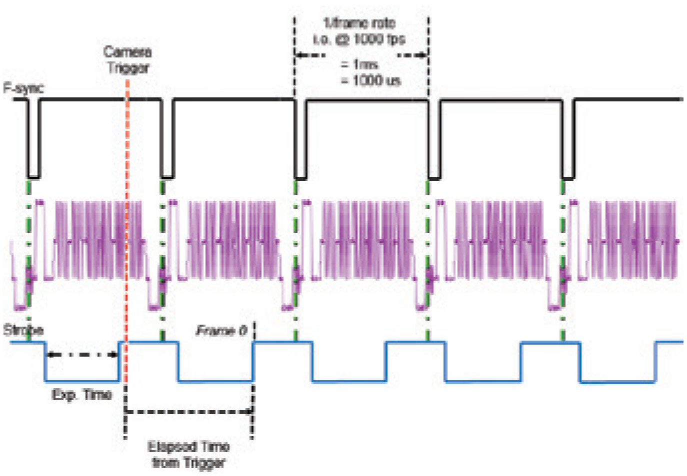

Figure 5: Sync to Video

For example, if the camera is set to 1080psf 23.98, and a frame rate of 100fps is requested, the camera will round the 100fps to 96 (the nearest multiple of 24). The true frame rate of the camera will be 95.904 fps, four times 23.976.

Using Sync to Video brings the following benefits: when both recording and play-back need to be synchronized (such as in stereoscopy applications), an FSYNC connection between cameras is no longer needed - 'Genlock' will suffice; the cameras can capture at the 'fractional' frame rates of 23.98, 29.97 and their multiples; the live output from the camera maintains a stable phase in relation to frame capture.

Not all cameras support the frame clocking technique.

SYNC TO TRIGGER

Sync to Trigger re-aligns the frame exposure start point (f-start) to fall as soon as possible after a trigger signal has been recognized.

The benefit of the feature is as follows; in many applications, a series of tests are performed, which require comparisons with each other (often several hundreds of tests). When these tests are performed the camera trigger can fall at a repetitively and accurate time within the event sequence. This is great as it presents a baseline from which to make comparisons.

In most situations, the f-start can then follow at any time within the next 1/frame rate cycle. The trigger has occurred at the expected moment, but the first frame after the trigger may not show the same moment in time (elapsed time from trigger) as the test before or after it.

Although cameras do their best to convince users that they can easily collect the data on when that frame occurred, and the time from trigger. In reality, if they need to look at the same moment in time (despite the temporal duration of that frame acquisition), they simply cannot do this using any of the previously mentioned frame clocking methods. It is actually a natural assumption that this would be the case. However, the trigger signal and f-sync are not related.

Now that I've tried to explain it, here is an example application, 'Small arm projectile testing'.

As a projectile (bullet) moves into the frame, the camera is triggered by an optical mechanism, at a certain duration, after it passes pixel 'x' (trigger position).

The user wants to see the bullets' trajectory, position, azimuth, etc. at exactly the same moment after the trigger between tests. Without Sync to Trigger, the end-user cannot reliably say that the bullet has moved by an x-amount, at n-microseconds after the trigger, as shown in Figure 6.

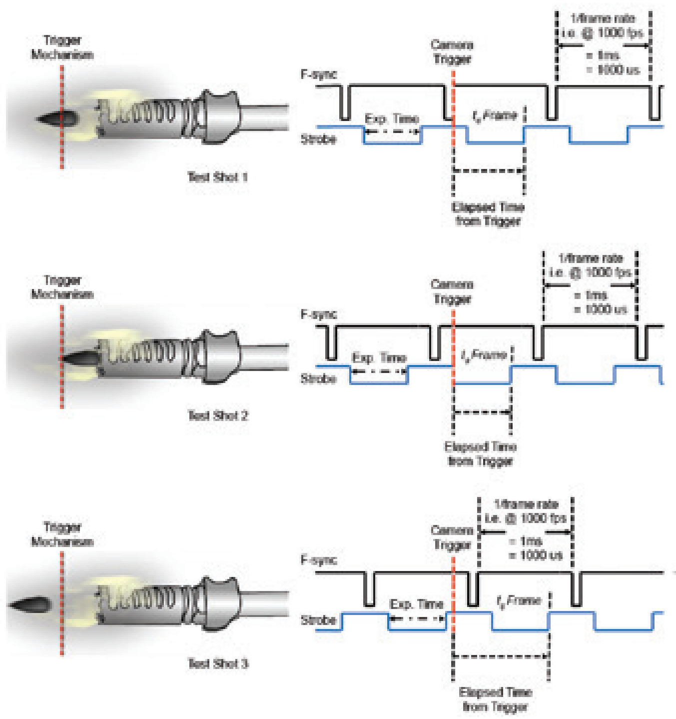

Figure 6: Repetitive test shots without 'Sync to Trigger'

This occurs because the camera detects the trigger signal, for each test shot, at a different moment in time with relationship to the frame synchronization (f-sync) pulse, thereby causing the 'elapsed time from trigger' to be different for each shot resulting in capturing the bullets in a different position for their t_0 (Frame 0) frames.

The 'Sync to Trigger' function timing allows f-start to fall at a repetitively accurate duration after the trigger, as shown in Figure 7.

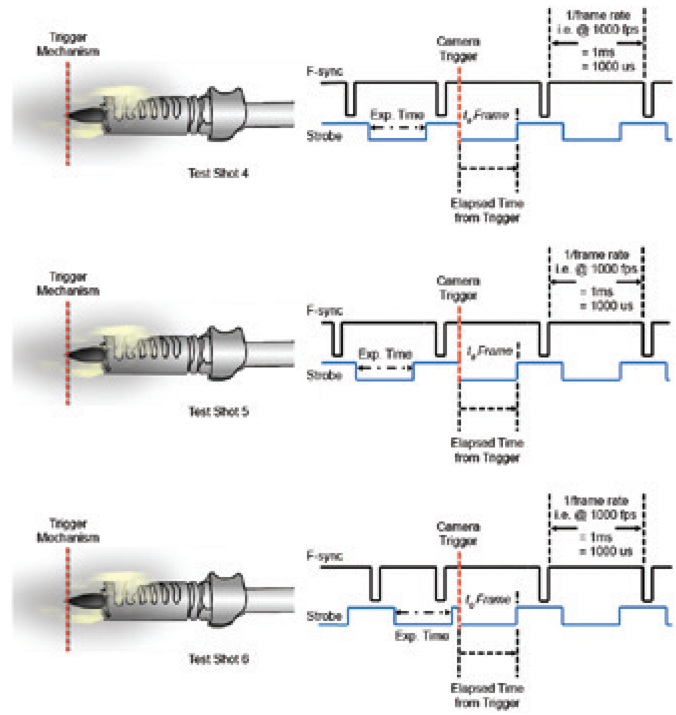

Figure 7: Repetitive test shots with 'Sync to Trigger'

If you look carefully you'll notice the moment trigger is detected a 'new' f-sync timer begins, forcing the next f-sync pulse to be exactly one interval (1/frame rate) later. This results in the exposure and elapsed time from trigger to be consistent for all repetitive shots.

Sync to Trigger is only suitable for applications where a slight exposure difference in some pre-trigger frames is acceptable.

Not all cameras support Sync to Trigger.

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