

Quick Start Guide

8783-T TRIGGER KIT FOR GUIDESTAR II

The 8783-T Trigger Kit is used with the GuideStar II Beam Stabilization System to provide synchronization between exposure of the cameras and the arrival of optical pulses. Triggering is needed for pulsed lasers operating at less than ~500 Hz, and is essential for repetition rates significantly lower than this. For installation of 8783-T software and system setup not related to triggering, see Model 8783 documentation. The 8783-T software replaces the standard 8783 software.

STEP 1 - System Setup for Triggered Operation

Synchronization between cameras and optical pulses is accomplished with controller-to-camera USB cables which have a BNC break-out cable to accept a trigger signal from the laser, by enabling triggered operation in the 8783-T software, and by an optional hardware trigger delay. Details are shown in Figures 1 and 2.

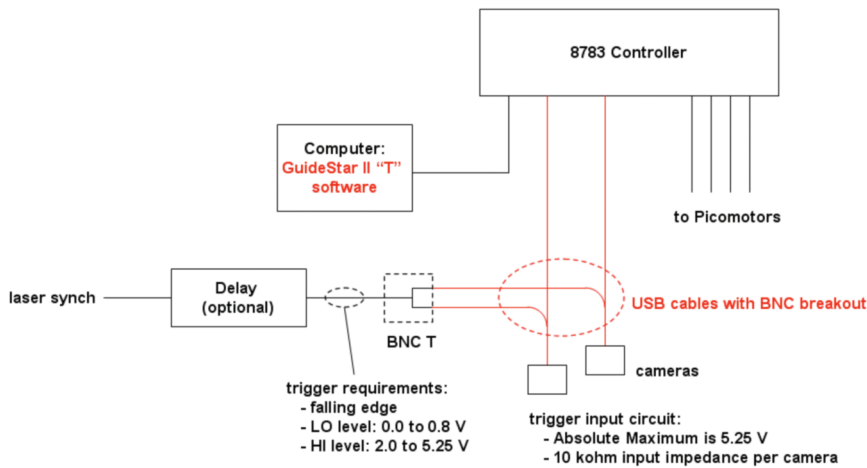


Figure 1. Typical set up for triggered operation. The optional hardware delay is discussed in the Camera Setup section. The delay and BNC T are user supplied. Software and breakout cables are supplied in the Trigger Kit.

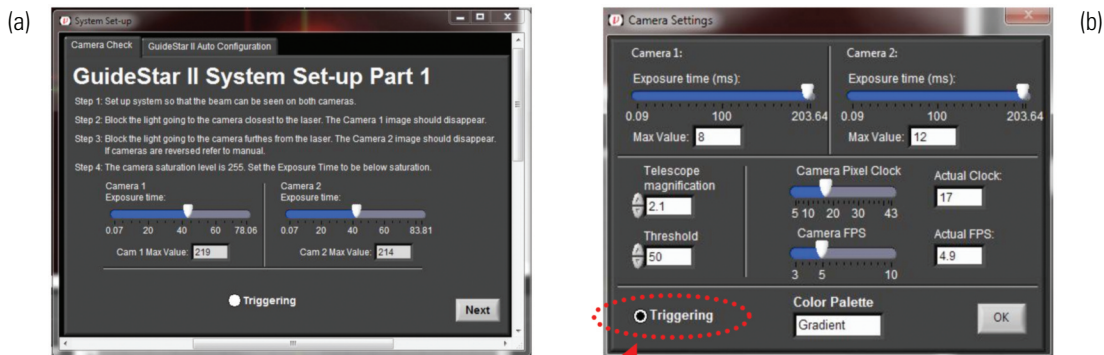


Figure 2. (a) Skip the System Set-up at initial software installation. (b) Instead, click Camera Settings, enable triggered operation, and set up the cameras and optical attenuation as needed. Then start Set-up.

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Begin by setting up the hardware as shown in Figure 1 and installing the software according to the GuideStar II Quick Start Guide. When the software is first installed, the first of two System Set-up Windows (shown in Figure 2a) will launch. For triggered operation, it is best to skip the System Set-up at this point and configure the cameras first. To skip the Set-up, click Next in the first Set-up window and then click Finished in the second Set-up window without performing any of the Set-up steps. Choose to not save any data. Then, after reading this guide and deciding on settings for the cameras, click Camera Settings on the main Guide Star II tab, click the button (Figure 2b) to enable triggered operation, and then configure the cameras as desired. It may also be necessary to change optical attenuation while configuring the cameras. Once cameras are operating satisfactorily, then start System Set-up from the main Guide Star II tab and proceed as instructed.

Setting Exposure Time In most situations, the optional hardware delay in Figure 1 may be omitted such that the laser synch connects directly to the cameras (note trigger signal requirements given in Figure 1). In this case, in order to obtain uniform illumination of the camera sensor, the exposure times must be set precisely to the interval between pulses or a multiple (N) thereof. Exposure times in the range of 50 to 200 ms are typical. Details of operation without the delay are discussed below under **Operating Mode 1**. For pulse intervals > 1 s or where ambient light is a problem, the approach discussed in **Operating Mode 2** (with the delay) should be used.

Optical Attenuation When using the cameras with single or few pulse-per-frame operation (low N), the ability to control exposure via the camera exposure time is lost or limited. For this reason higher-resolution optical attenuation may be needed to achieve a good signal level.

STEP 2 – Details of Camera Setup and Timing

This section provides reference information on camera setup and timing. Use the Summary and Example Settings section when choosing settings. It is assumed throughout this guide that the optical pulse and the trigger signal from the laser occur simultaneously.

The cameras operate such that each line of the sensor array is exposed slightly later than the preceding line. Figure 3 shows the timing details with a trigger.

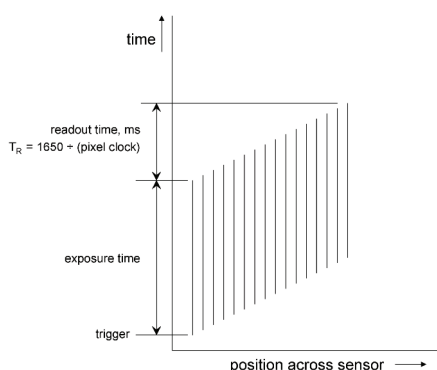


Figure 3. Details of camera timing with trigger. The trigger initiates exposure of the first line of pixels, and exposure of each successive line is delayed slightly. This leads to a total delay between exposure of the first and last lines defined as T_R . The minimum time required between triggers is the sum of T_R and the exposure time. The vertical lines in the diagram indicate the exposure periods for lines across the sensor (the actual number of lines is ~ 1000).

There are two modes of operation which will lead to successful triggering. Operating Mode 1 omits the optional hardware delay and is suitable for most situations. Operating Mode 2, which uses the delay, is useful for lasers with very low repetition rates and/or where ambient light is a problem. See the discussion under Ambient Light below to determine if ambient light will be a problem.

2.1 – Operating Mode 1 – Without the optional delay

For uniform exposure across the sensor, exposure time is set to a multiple N of the pulse interval. Three example scenarios are shown in Figure 5—the first two show $N=1$, and the last shows $N=2$. N may be chosen to help set the proper exposure level, and in certain situations a larger N may offer some advantage (see Pulse interval shorter than T_R below).

The maximum exposure time possible is ~980 ms, achieved with Pixel Clock = 5 and FPS = 1. Thus, Operating Mode 1 is possible down to ~1 Hz.

Ambient Light To determine if ambient light will be a problem in Operating Mode 1, set exposure time to the desired level, block the beam (but not the ambient light), and then read the ambient light level from the Max Value display below the exposure time slider bar. If this value is sufficiently small compared to the signal level of the beam then Operating Mode 2 is not needed. Whether the ambient light level is low enough must be determined for a given application and setup. Given the full-scale level is 255, a beam signal level will typically be ~200, so ambient light below ~10 may be acceptable.

Pulse interval shorter than T_R When the pulse interval is shorter than T_R , not all regions of the sensor will detect the same pulse(s). This could lead to noise in the detected beam position if the pulse-to-pulse energy fluctuation is significant and the beam lies partly in one region and partly in another. For this reason, if possible, it is best to choose a Pixel Clock high enough to make the pulse interval longer than T_R . If not possible, it is better to position the beams entirely within a single region. Note also that it may be useful to adjust Pixel Clock (and hence T_R), which will move the borders, or “seams”, between the regions. If the beam can’t be positioned entirely within a single region, then operating at higher values of N will reduce this source of noise. Because the first pulse on one side of a seam pairs with the last ($N+1^{\text{st}}$) pulse on the other side of the seam to achieve uniform exposure, the contribution of these two pulses to the overall signal will be diminished as N increases.

To minimize the width of the seams, exposure time for each camera should be set precisely to N times the pulse interval. Under this condition, the entire sensor will be illuminated by N pulses. The limited resolution in setting exposure time may result in seams where one or a few lines receive either one pulse too many or one too few, producing a bright or a dark band. (See Figure 4) Such visible seams may be used to one’s advantage as they indicate the regions which are illuminated by the same pulse or group of pulses.

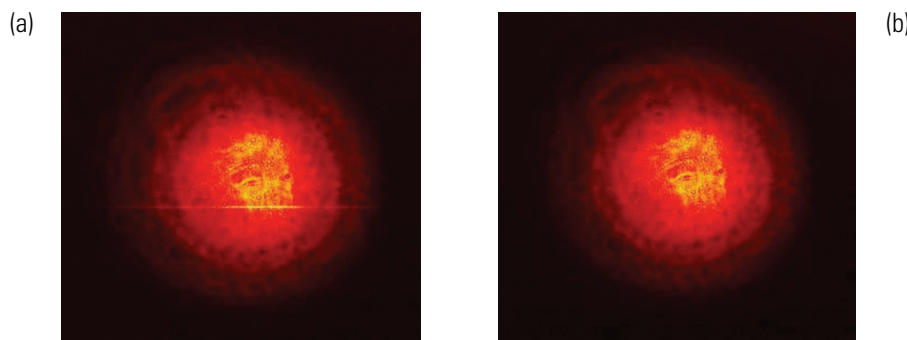


Figure 4 (a) A bright seam resulting from exposure time slightly longer than the pulse interval.

(b) The same beam with exposure time equal to pulse period.

Seams will not adversely affect beam stabilization since their locations will remain constant. In most situations a seam can be ignored, and for larger N seams may not even be visible to the eye.

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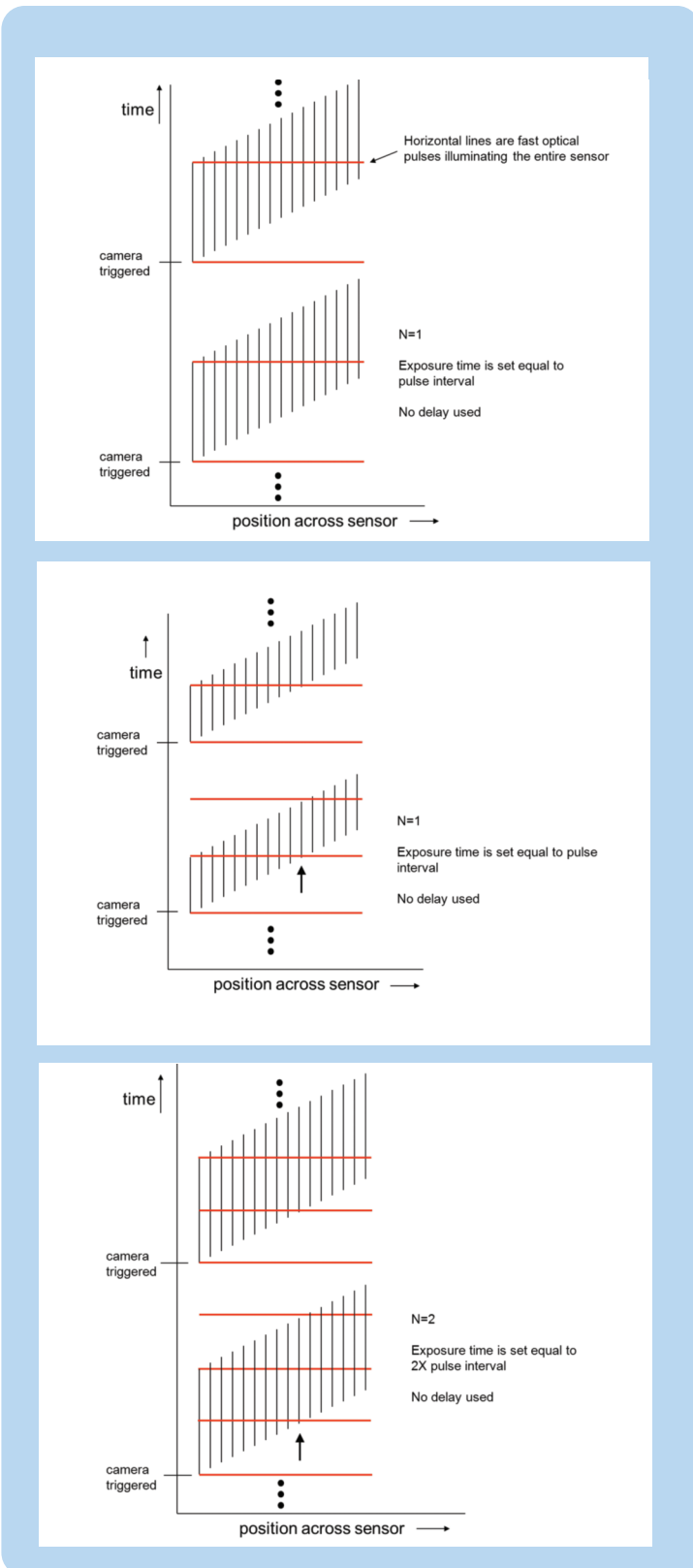


Figure 5.

Operating Mode 1: Timing scenarios without a delay in the trigger path. Cameras are only ready for a new trigger after exposure of the last line in the preceding exposure is complete. (a) $N=1$, with a pulse interval longer than T_R so the entire sensor detects the same pulse.

For (b), $N=1$, and for (c), $N=2$. For both (b) and (c) the pulse interval is shorter than T_R so different regions of the sensor detect different pulses. See the section Pulse interval shorter than T_R . Note that for an exposure time slightly longer than shown, the line marked with an arrow (a "seam") would detect an extra pulse and would thus appear twice as bright as the other lines in the image. Also note that while a trigger signal will accompany each optical pulse, the cameras will ignore signals which occur during an exposure

2.2 – Operating Mode 2 – With the optional delay

For low repetition rate lasers, Operating Mode 1 above will have long exposure times which could lead to problems with ambient light creating noise in the detected beam position. This problem can be remedied by using the optional hardware delay shown in Figure 1 and setting the delay as described in Figure 6. With this approach the exposure time is set to T_R which may be significantly shorter than the pulse interval so that noise from ambient light is reduced. Operating Mode 2 also allows operation at repetition rates below 1 Hz.

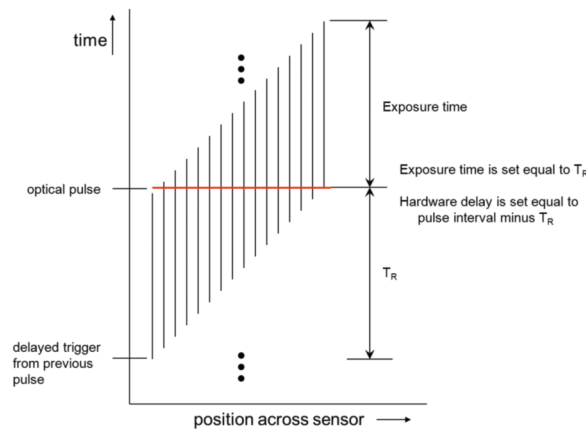


Figure 6. Operating Mode 2 (for very low repetition rates): this approach minimizes the exposure time but requires a hardware trigger delay. Minimizing the exposure time reduces noise from ambient light.

3 – Setting Pixel Clock and Exposure Time

In setting up the cameras both exposure time and Pixel Clock must be chosen and set.

Pixel Clock determines T_R which is given by $1650 \div \text{Pixel Clock}$. Thus, a Pixel Clock of 20 will yield $T_R = 82.5$ ms. Problem-free communication with the cameras may only be obtained over a limited range of Pixel Clock; at higher values (> 20–25) a “Pixel Clock Error” message may appear and Pixel Clock will need to be reduced.

Exposure time is set directly in the software with the range of possible values determined by the frame rate (FPS). Since the range of possible FPS values is in turn determined by Pixel Clock, it may be necessary to adjust both Pixel Clock and FPS to reach a desired exposure time with high precision.

For best resolution in setting exposure time, FPS should be set at or somewhat below the inverse of the desired exposure time. Typically, it is possible to set exposure time within $\sim 0.1\%$ of the target value. Changing FPS slightly may help to reach values closer to the target. If a beam lies on a seam, it is possible to look at the camera image and adjust exposure time to minimize the seam's width.

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4 – Summary and Example Settings

The below procedures can serve as guidelines in choosing settings. For repetition rates in the low-Hz range either Mode 1 or Mode 2 may be used. Table 1 shows example settings for lasers at various repetition rates along with resulting T_R and N values. These settings may be used as a guide for initial setup and should be adjusted if needed. Note that 11.6 FPS is the maximum frame rate at Pixel Clock = 20.

Procedure for Mode 1 (for repetition rates above a few Hz):

1. Exposure time – to achieve uniform illumination, set to precisely $N \times$ pulse interval, with N chosen to help set the proper exposure level of the cameras.
2. Pixel Clock – It is preferable that $T_R (=1650 / \text{Pixel Clock, in ms})$ be less than the pulse interval. If possible, choose a sufficiently large Pixel Clock to accomplish this. (see Pulse interval shorter than T_R above). A lower Pixel Clock may be necessary for longer exposure times to allow a sufficiently low FPS (which in turn allows longer exposure times).
3. FPS – set slightly below the inverse of the desired exposure time to allow high resolution when setting the exposure time.

Procedure for Mode 2 (for repetition rates below a few Hz):

1. Pixel Clock – set between 15 and 20. Higher values allow shorter exposure times.
2. Exposure time – set to $T_R (=1650 / \text{Pixel Clock, in ms})$
3. FPS - set slightly below the inverse of the desired exposure time
4. Hardware delay – set to the pulse interval minus T_R .

Laser Rate (Hz)	Operating Mode	Pixel Clock	FPS	HW delay	Exposure Time (ms)	T_R (ms)	N
500	1	20	11.6	--	50	82.5	25
100	1	20	11.6	---	50	82.5	5
10	1	20	9	--	100	82.5	1
1	1	5	1	--	980	330	1
1	2	20	11	917.5	82.5	82.5	--

Table 1 Example settings



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