

APPLICATION NOTE

AN-L02

May 26, 2005

LYNX CAMERA SERIES

TRIGGERING MODES AND OPTIONS

Abstract: This application note describes the various triggering modes supported by the Lynx series of cameras and the procedure for programming them.

1. INTRODUCTION

In the normal mode of operation, the camera is free running. Using the external trigger mode allows the camera to be synchronized to an external timing pulse. When the camera is programmed to operate in trigger mode, the camera switches from free running operation to an idle mode and waits for an external pulse.

There are two input options available for external triggering:

- Hardware triggering
- Software triggering

Each triggering option supports three sub-modes:

- Standard triggering mode.
- Fast synchronized triggering (rapid capture) mode.
- Double exposure triggering mode.

1.1. HARDWARE TRIGGERING

In this mode, the camera uses the trigger signal coming from the black BNC connector located on the camera power cable. The hardware trigger input is optically isolated from the rest of the camera hardware - Figure 1. The input signals “+ TRIGGER IN” (BNC signal) and “- TRIGGER IN” (BNC shield) are used to connect to an external trigger source. On the edge of the external pulse which creates a positive voltage difference between “+ TRIGGER IN” and “- TRIGGER IN”, a trigger signal is sent to the camera. The voltage difference between the trigger inputs “+ TRIGGER IN” and “- TRIGGER IN” must be positive between 3.3 and 5.0 volts. The maximum trigger current **MUST NOT** exceed 25 mA.

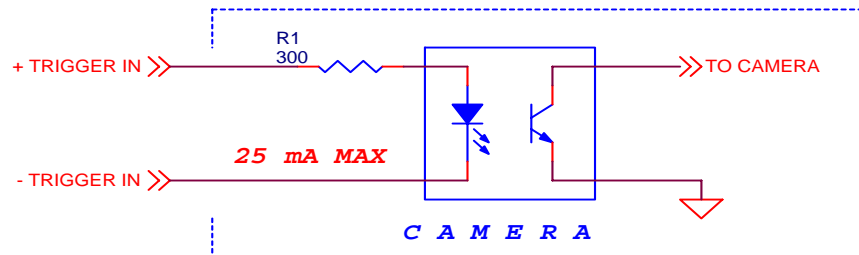


Figure 1 - Hardware Trigger Electrical Connection

The actual trigger pulse duration does not affect the integration time. The minimum duration of the trigger pulse is 100 microseconds. There are no restrictions for the maximum pulse duration, but it is recommended that the trigger pulse is kept as short as possible, especially if a series of pulses are used.

1.2. SOFTWARE TRIGGERING

In this mode, the camera uses the trigger signal coming from the frame grabber via the Camera Link cable's CC1 signal (camera control signal 1). The trigger signal is active HIGH.

2. STANDARD TRIGGERING MODE

When the standard triggering mode is enabled, the camera idles and waits for a trigger signal. Upon receiving the external trigger signal, the camera clears the horizontal and vertical registers, sends one 5 microsecond shutter pulse to clear the pixels and then starts integration – Figure 2. Thus, there is a fixed delay of 5 usec (because of the shutter pulse duration) between the rising edge of the trigger pulse and the beginning of the integration. Along with the shutter pulse, the camera sends one strobe pulse (200 microseconds duration) for synchronization with an external strobe. This pulse is always present in the external trigger mode.

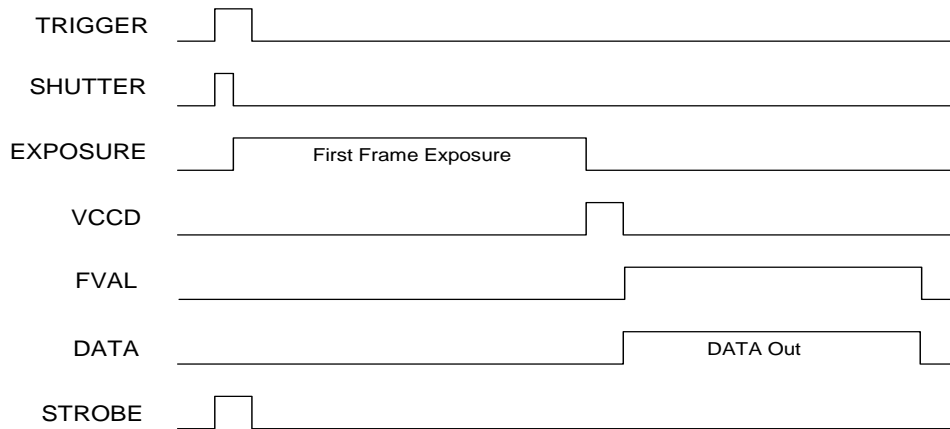


Figure 2 - Standard Triggering Timing

2.1. HARDWARE TRIGGER

Using LynxConfigurator (refer to Figure 3):

1 - To enable the standard mode using hardware trigger:

- 1a - select the 'Trigger' tab
- 1b - in the 'Trigger' box - select 'External'
- 1c - in the 'Mode' box - select 'Standard'

2 - To set the number of frames to be captured after the trigger:

Set the 'Captured Frames after Trigger' slider from 1 to 250 individual frames, or to be free-running.

3 - To set the exposure time for the first frame after trigger:

Set the 'First Frame Exp – Standard' slider from 10 usec to 655 msec in 10 usec increments.

4 - To set the exposure time for frame #2 and beyond (if Captured Frames is not set to 1):

- 4a - Select the exposure tab
- 4b - Enable the 'Shutter Time'
- 4c - Set the 'Shutter Time' slider to the desired integration time

Note that if the shutter is disabled, then the resultant exposure time will be determined by the free-running camera timing (i.e. 1/frame rate).

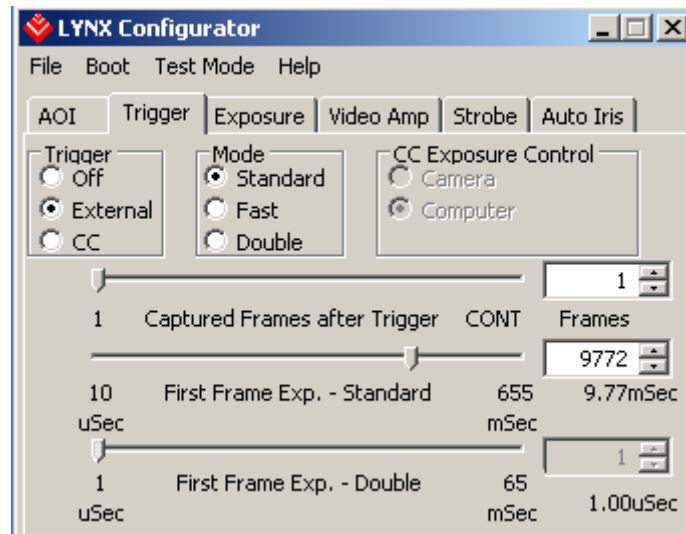


Figure 3 - Hardware trigger standard mode using LynxConfigurator

Using a terminal (refer to Figure 4):

- 1 - To enable the standard mode using hardware trigger:
Enter '**str et s**' command (Set Trigger to External and Standard).
- 2 - To set the number of frames to be captured after the trigger:
Enter '**std 1**' command (Set Trigger Duration to 1 frame).
- 3 - To set the exposure time for the first frame after trigger:
Enter '**spe 9772**' command (Set Pre Exposure to 9772 us).

Note that since the increment is 10 us, the last digit is rounded and in this example the actual exposure will be 9770 us.

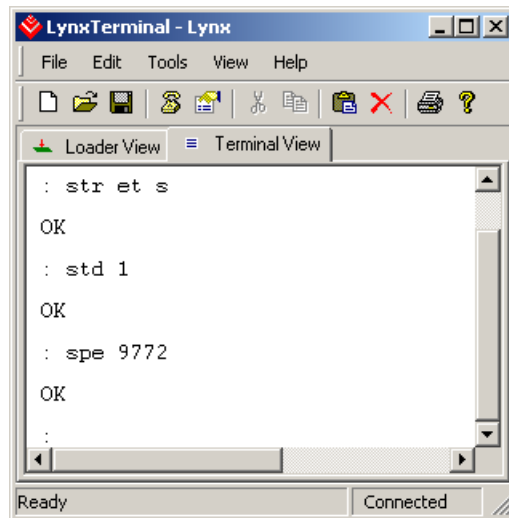


Figure 4 - Hardware trigger standard mode using a terminal

2.2. SOFTWARE TRIGGER

The standard mode, using software trigger, behaves identically to the hardware mode with one exception: there are two ways to determine the exposure time for the first frame:

1. The integration (exposure) time for the first frame is determined by the value programmed in the 'Pre Exposure – Standard' register. This register is programmed from 10 usec to 655 msec in 10 usec increments. This is called 'Camera' timed.
2. The integration (exposure) time for the first frame is determined by the duration of the actual CC1 trigger pulse width. This is called 'Computer' timed.

Using LynxConfigurator (refer to Figures 5 and 6):

1 - To enable the standard mode using software trigger:

- 1a - select the 'Trigger' tab
- 1b - in the 'Trigger' box - select 'CC'
- 1c - in the 'Mode' box - select 'Standard'

2 - To set the number of frames to be captured after the trigger:

Set the 'Captured Frames after Trigger' slider from 1 to 250 individual frames, or to be free-running.

3 - To set the exposure time for the first frame after trigger using 'Camera' timing:

- 3a - in the 'CC Exposure Control' box - select 'Camera'.

3b - set the 'First Frame Exp – Standard' slider from 10 usec to 655 msec in 10 usec increments.

or

To set the exposure time for the first frame after trigger using 'Computer' timing:

3c - in the 'CC Exposure Control' box - select 'Computer'.

4 - To set the exposure time for frame #2 and beyond (if Captured Frames is not set to 1):

4a - Select the exposure tab

4b - Enable the 'Shutter Time'

4c - Set the 'Shutter Time' slider to the desired integration time

Note that if the shutter is disabled, then the resultant exposure time will be determined by the free-running camera timing (i.e. 1/frame rate).

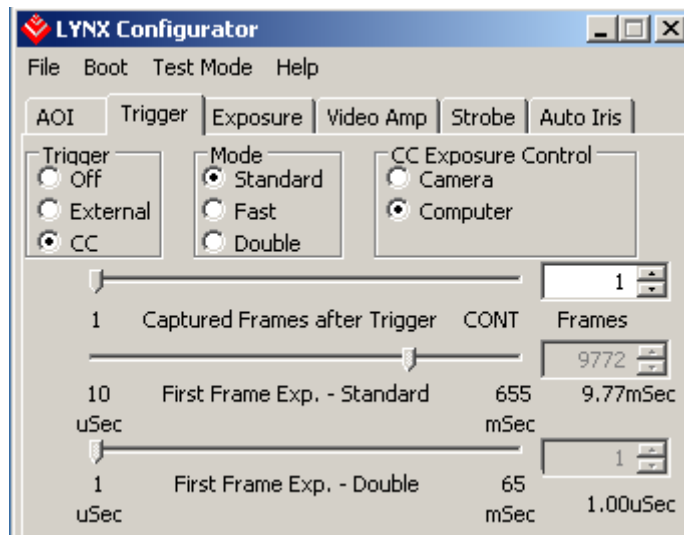


Figure 5 - Software trigger standard mode w/computer control using LynxConfigurator

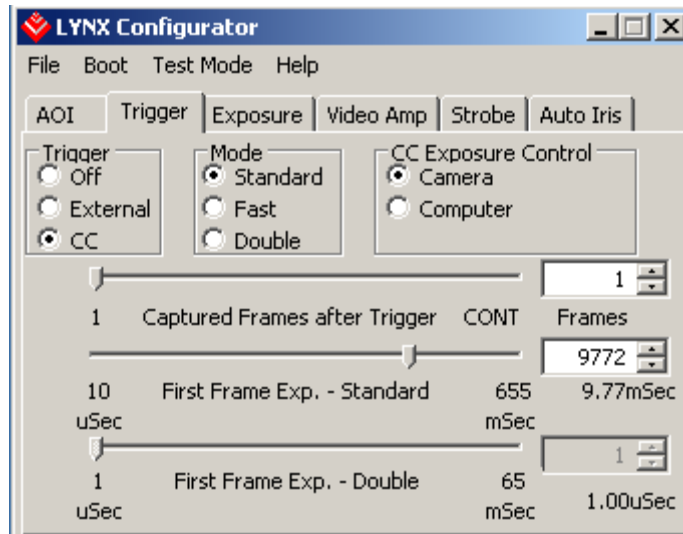


Figure 6 - Software trigger standard mode w/camera control using LynxConfigurator

Using a terminal (refer to Figures 7 and 8):

1 - To enable the standard mode using software trigger:

Enter '**str cc s**' command (Set Trigger to CC and Standard).

2 - To set the number of frames to be captured after the trigger:

Enter '**std 1**' command (Set Trigger Duration to 1 frame).

3 - To set the exposure time for the first frame after trigger using 'Camera' control:

3a - enter '**sci off**' command (Set CC Integration to Off).

3b - enter '**spe 9772**' command (Set Pre Exposure to 9772 us).

Note that since the increment is 10 us, the last digit is rounded and in this example the actual exposure will be 9770 us.

or

To set the exposure time for the first frame after trigger using 'Computer' control:

3c – enter '**sci on**' command (Set CC Integration to On).

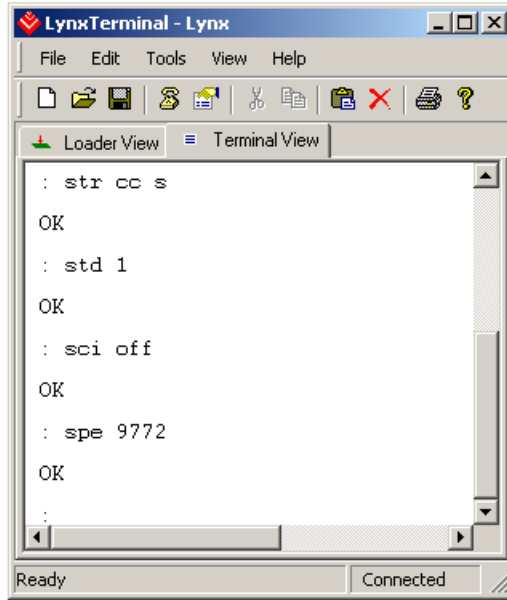


Figure 7 - Software trigger standard mode w/camera control using a terminal

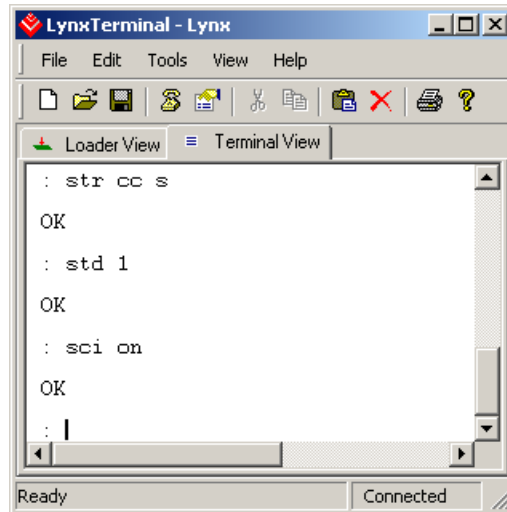


Figure 8 - Software trigger standard mode w/computer control using a terminal

CAUTION NOTE

1. If series of trigger pulses are used, make sure that the timing interval between them is greater than the sum of the frame readout time and the selected pre-exposure.

3. FAST SYNCHRONIZED TRIGGERING (RAPID CAPTURE) MODE

Fast synchronized triggering (a.k.a. rapid capture) provides the ability to run the camera in a slave mode, allowing several cameras to be synchronized with an external master trigger signal. This mode also enables the camera to run close to its original frame rate. If hardware or software option is enabled in rapid capture mode, the camera idles and waits for a trigger signal to come from the selected source (the external connector or CC1). Upon receiving the first trigger signal, the camera starts integration until the next trigger is received. Then the information is transferred to the registers and read out. During this time the next frame is exposed – Figure 9. In this mode the camera exposure cannot be controlled with the shutter.

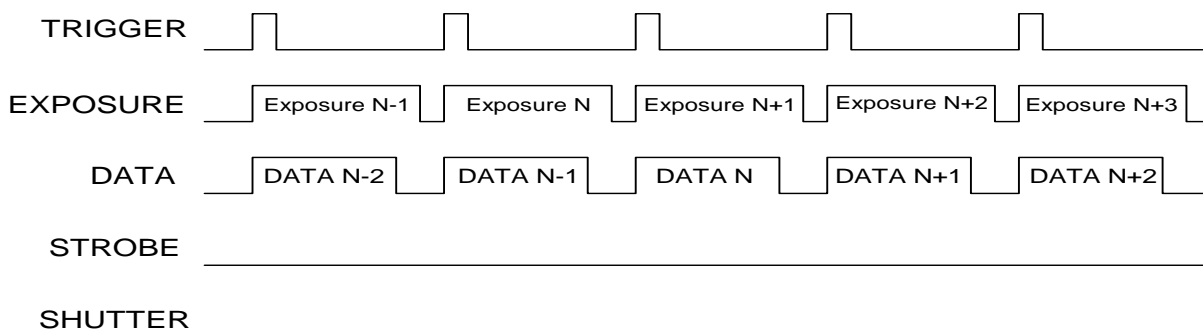


Figure 9 - Fast Synchronized Triggering - Rapid Capture

3.1. HARDWARE TRIGGER

Using LynxConfigurator (refer to Figure 10):

1 - To enable the standard mode using hardware trigger:

- 1a - select the ‘Trigger’ tab
- 1b - select ‘External’
- 1c - select ‘Fast’

2 - To set the number of frames to be captured after the trigger:

Note that in this mode, only one frame is generated per trigger signal.

3 - To set the exposure time:

Note that in this mode, the exposure time is controlled by the period of the trigger signal.

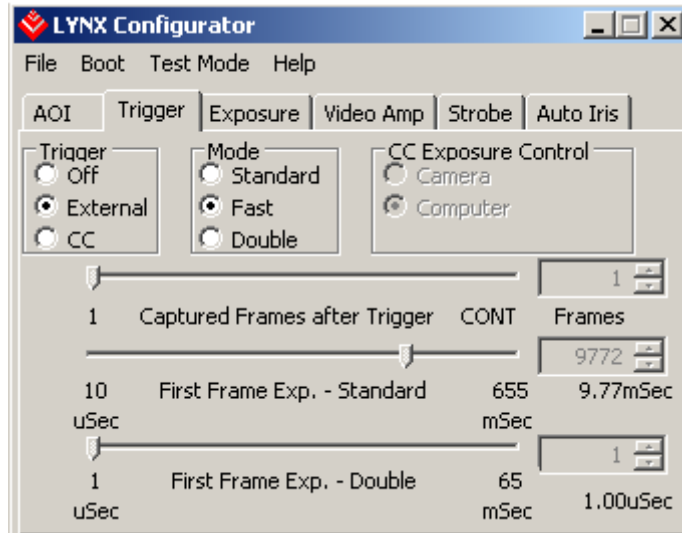


Figure 10 - Hardware trigger fast mode using LynxConfigurator

Using a terminal (refer to Figure 11):

1 - To enable the fast mode using hardware trigger:

Enter '**str et f**' command (Set Trigger to External and Fast).

2 - To set the number of frames to be captured after the trigger:

Note that in this mode, only one frame is generated per trigger signal.

3 - To set the exposure time:

Note that in this mode, the exposure time is controlled by the period of the trigger signal.

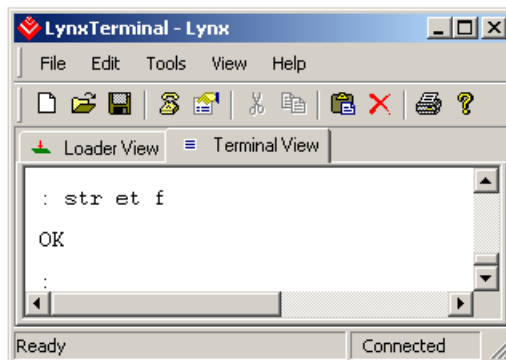


Figure 11 - Hardware trigger fast mode using a terminal

3.2. SOFTWARE TRIGGER

In this mode, the exposure is determined by the interval between the trigger pulses (trigger period) and therefore the computer/camera controls option has no effect.

Using LynxConfigurator (refer to Figure 12):

1 - To enable the fast mode using software trigger:

- 1a - select the 'Trigger' tab
- 1b - in the 'Trigger' box - select 'CC'
- 1c - in the 'Mode' box - select 'Fast'

2 - To set the number of frames to be captured after the trigger:

Note that in this mode, only one frame is generated per trigger signal.

3 - To set the exposure time:

Note that in this mode, the exposure time is controlled by the period of the trigger signal.

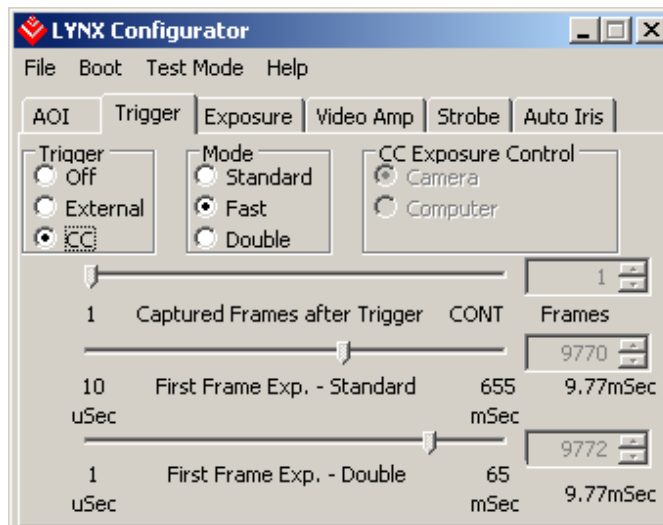


Figure 12 - Software trigger fast mode using LynxConfigurator

Using a terminal (refer to Figure 13):

1 - To enable the fast mode using software trigger:

Enter '**str cc f**' command (Set Trigger to CC and Fast).

2 - To set the number of frames to be captured after the trigger:

Note that in this mode, only one frame is generated per trigger signal.

3 - To set the exposure time:

Note that in this mode, the exposure time is controlled by the period of the trigger signal.

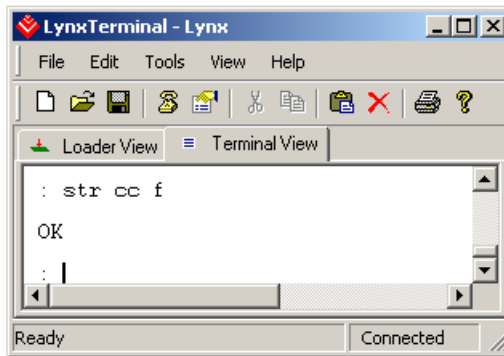


Figure 13 - Software trigger fast mode using a terminal

CAUTION NOTE

1. The time interval between the trigger pulses (trigger period) must be greater than the camera readout time.
2. If the interval between the trigger pulses is greater than 2 to 4 times the standard readout time, it is recommended that the standard triggering option be used in order to avoid over-exposure.
3. In fast mode there is no shutter or strobe pulse associated with each trigger.

4. DOUBLE EXPOSURE TRIGGERING MODE

Double exposure allows two events (two images) to be captured in rapid succession using a single trigger pulse. In this mode, the camera idles and waits for a trigger signal to come from the selected source (the external connector or CC1). Upon receiving the external trigger signal, the camera clears the horizontal and vertical registers, sends one 5 microseconds shutter pulse to clear the pixels, and starts integration. Thus, there is a fixed delay of 5 usec (because of the shutter pulse duration) between the rising edge of the trigger pulse and the beginning of the integration. Upon receiving the trigger signal the camera starts integration for the first frame, completes the integration, transfers the information to the vertical registers and then captures the second image. While capturing the second image the first one is being read out. After exposing the second image, the information is transferred to the vertical registers and read out – Figure 14. The second image exposure is equal to the corresponding camera readout time. Along with the shutter pulse, the camera sends one strobe pulse (200 microseconds duration) for synchronization with an external strobe. This pulse is always present in the external trigger mode.

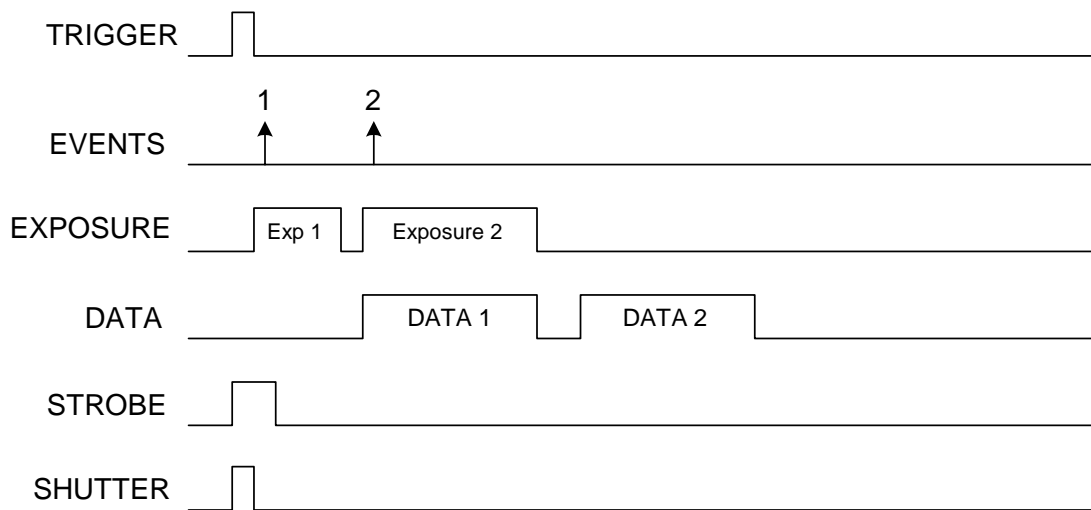


Figure 14 - Double Exposure Triggering

4.1. HARDWARE TRIGGER

Using LynxConfigurator (refer to Figure 15):

1 - To enable the standard mode using hardware trigger:

- 1a - select the 'Trigger' tab
- 1b - in the 'Trigger' box - select 'External'
- 1c - in the 'Mode' box - select 'Double'

2 - To set the number of frames to be captured after the trigger:

Note that in this mode, only two frames are generated per trigger signal. The ‘Captured Frames after Trigger’ slider has no effect.

3 - To set the exposure time for the first frame after trigger:

Set the ‘First Frame Exp – Double’ slider from 1 usec to 65 msec in 1 usec increments.

4 - To set the exposure time for the second frame:

Note that in this mode, the second frame’s exposure is controlled by the cameras free-running timing (i.e. readout time). The ‘Shutter Time’ slider has no effect.

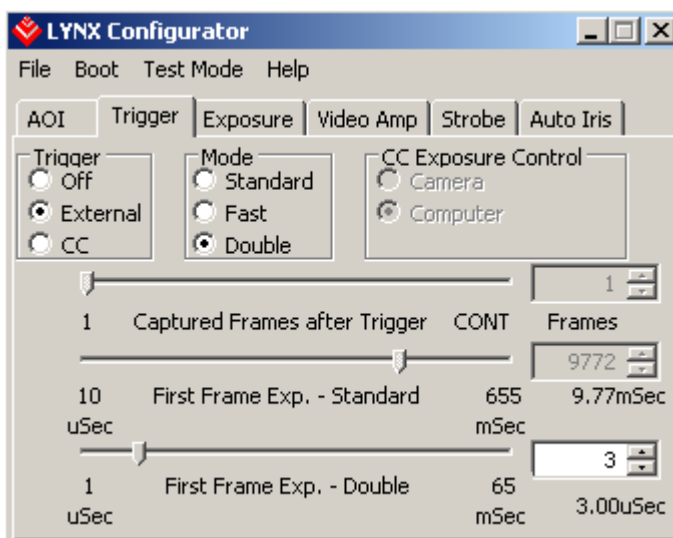


Figure 15 - Hardware trigger double mode using LynxConfigurator

Using a terminal (refer to Figure 16):

1 - To enable the double mode using hardware trigger:

Enter ‘**str et d**’ command (Set Trigger to External and Double).

2 - To set the number of frames to be captured after the trigger:

Note that in this mode, only two frames are generated per trigger signal. The ‘**std**’ command (Set Trigger Duration) has no effect.

3 - To set the exposure time for the first frame after trigger:

Enter ‘**sde 9772**’ command (Set Double Exposure to 9772 us).

Note that the increment is 1 us and in this example the actual exposure will be 9772 us.

4 - To set the exposure time for the second frame:

Note that in this mode, the second frame's exposure is controlled by the camera's free-running timing (i.e. readout time). The 'sst' command (Set Shutter Time) has no effect.

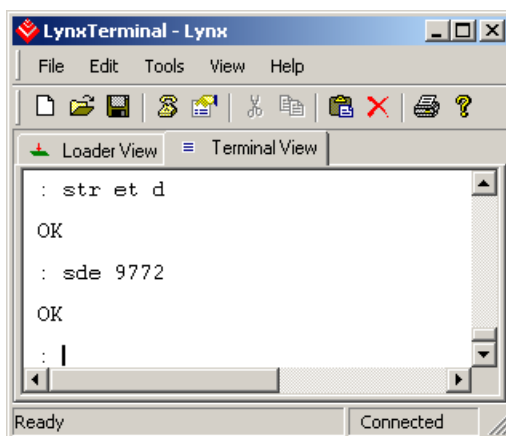


Figure 16 - Hardware trigger double mode using a terminal

4.2. SOFTWARE TRIGGER

The double mode, using software trigger, behaves identically to the hardware mode with one exception: there are two ways to determine the exposure time for the first frame:

1. The integration (exposure) time for the first frame is determined by the value programmed in the 'Pre Exposure – Double' register. This register is programmed from 1 usec to 65 msec in 1 usec increments. This is called 'Camera' timed.
2. The integration (exposure) time for the first frame is determined by the duration of the actual CC1 signal's pulse width. This is called 'Computer' timed.

Using LynxConfigurator (refer to Figures 17 and 18):

1 - To enable the double mode using software trigger:

- 1a - select the 'Trigger' tab
- 1b - in the 'Trigger' box - select 'CC'
- 1c - in the 'Mode' box - select 'Double'

2 - To set the number of frames to be captured after the trigger:

Note that in this mode, only two frames are generated per trigger signal. The ‘Captured Frames after Trigger’ slider has no effect.

3 - To set the exposure time for the first frame after trigger using ‘Camera’ timing:

3a - in the ‘CC Exposure Control’ box - select ‘Camera’.

3b - set the ‘First Frame Exp – Double’ slider from 1 usec to 65 msec in 1 usec increments.

or

To set the exposure time for the first frame after trigger using ‘Computer’ timing:

3c - in the ‘CC Exposure Control’ box - select ‘Computer’.

4 - To set the exposure time for the second frame:

Note that in this mode, the second frame’s exposure is controlled by the cameras free-running timing (i.e. readout time). The ‘Shutter Time’ slider has no effect.

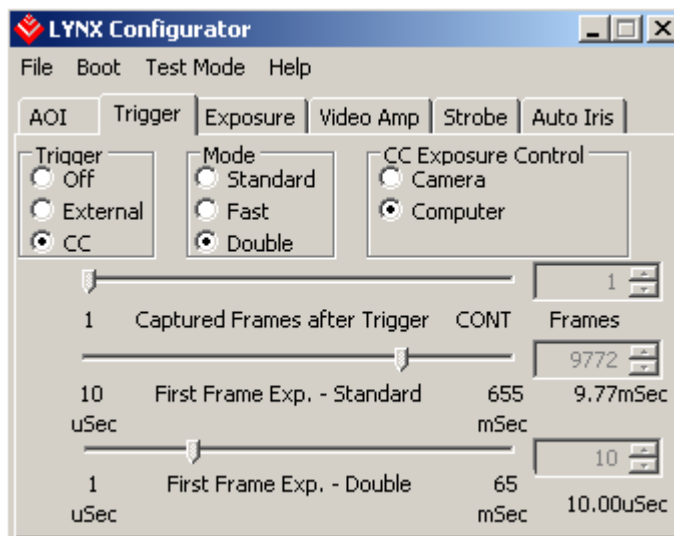


Figure 17 - Software trigger double mode w/computer control using LynxConfigurator

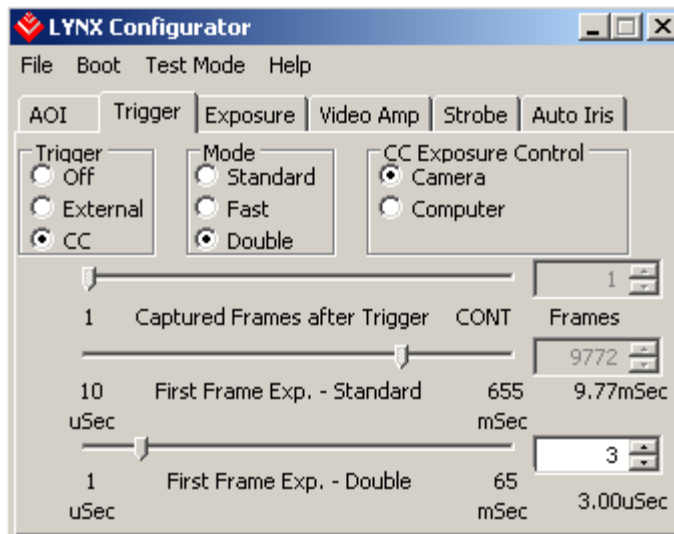


Figure 18 - Software trigger double mode w/camera control using LynxConfigurator

Using a terminal (refer to Figures 19 and 20):

1 - To enable the standard mode using software trigger:

Enter '**str cc d**' command (Set Trigger to CC and Double).

2 - To set the number of frames to be captured after the trigger:

Note that in this mode, only two frames are generated per trigger signal. The '**std**' command (Set Trigger Duration) has no effect.

3 - To set the exposure time for the first frame after trigger using 'Camera' control:

3a - enter '**sci off**' command (Set CC Integration to Off).

3b - enter '**sde 9772**' command (Set Double Exposure to 9772 us).

Note that the increment is 1 us and in this example the actual exposure will be 9772 us.

or

To set the exposure time for the first frame after trigger using 'Computer' control:

3c – enter '**sci on**' command (Set CC Integration to On).

4 - To set the exposure time for the second frame:

Note that in this mode, the second frame's exposure is controlled by the cameras

free-running timing (i.e. readout time). The ‘sst’ command (Set Shutter Time) has no effect.

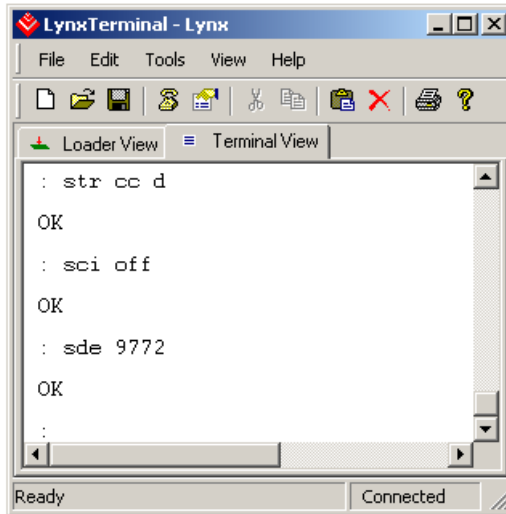


Figure 19 - Software trigger double mode w/camera control using a terminal

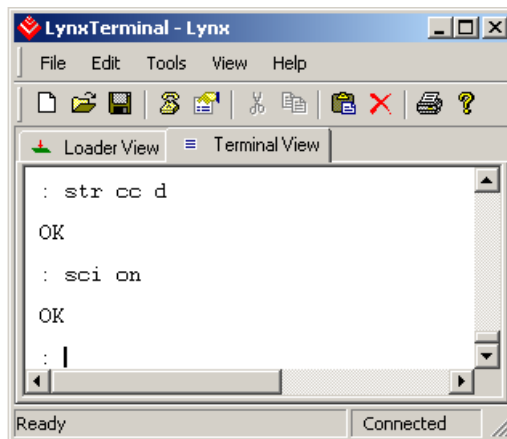


Figure 20 - Software trigger double mode w/computer control using a terminal

CAUTION NOTE

1. If series of trigger pulses are used, make sure that the timing interval between them is greater than the sum of the two standard frame readout times and the selected double trigger pre-exposure.
2. It is recommended that the minimum interval between the events is greater then the vertical transfer pulse duration:
 - 5 microseconds for VGA, 1M48, 2M30, 2M30H and 4M15.
 - 10 microseconds for 11M5.



5. EXAMPLES

EXAMPLE 1

Set the camera in external trigger, standard mode, to capture 10 frames after trigger, with 30 ms first frame exposure, and 10 ms the rest of the frames.

In LYNX Terminal window type:

```
sst 10000    - set shutter ( exposure ) time to 10 ms  
std 10      - set trigger duration ( # frames captured ) to 10  
spe 30000   - set first frame exposure to 30 ms  
str et s    - set trigger to external, standard mode
```

EXAMPLE 2

Set the camera in CC trigger, standard mode, to capture 1 frame after trigger, 2 ms first frame exposure, exposure controlled by the computer (computer will generate the 2 ms trigger pulse).

In LYNX Terminal window type:

```
sci on      - enable cc integration control mode  
std 1      - set trigger duration ( # frames captured ) to 1  
str cc s    - set trigger to cc, standard mode
```

EXAMPLE 3

Set the camera in CC trigger, double exposure mode, with 10 us first frame exposure, exposure controlled by the camera.

In LYNX Terminal window type:

```
sci off     - disable cc integration control mode  
sde 10     - set first frame exposure to 10 us  
str cc d   - set trigger to cc, double exposure mode
```

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