Camera External Trigger Instructions

TUCSEN

Catalog

1. Trigger Connector I/O Definition

1.1 Dhyan Series

Dhyana series cameras (except Dhyana 401D) have 4 hardware interfaces for external triggering, and its definition as shown in Tab 1-1, includes a trigger input, three output indicator.

Tab 1-1 I/O Function and Definition of the Interface

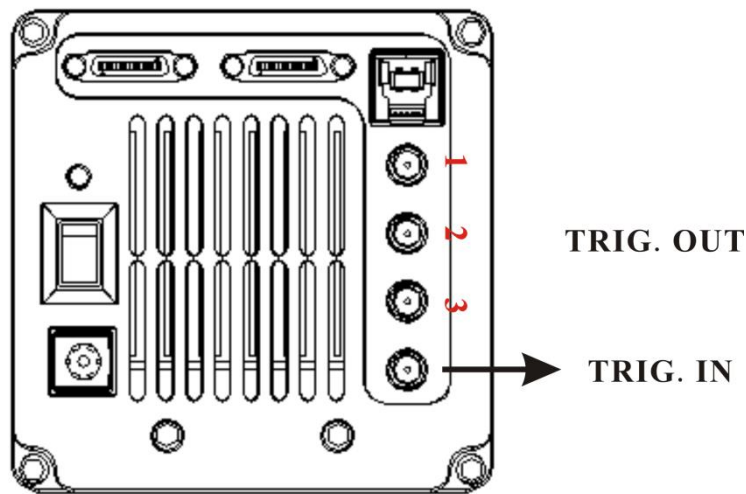| TRIG. IN	External trigger signal input
TRIG. OUT1	Image readout signal
TRIG. OUT2	Global exposure signal
TRIG. OUT3	Exposure start signal

Figure 1-1 Camera interface location map of Dhyana

1.2 FL-20BW/Dhyana 401D

FL-20BW/Dhyana 401D have 6 hardware interfaces for external triggering, and its definition as shown in Tab 1-2;

Tab 1-2 External Trigger Hardware Interface Definition

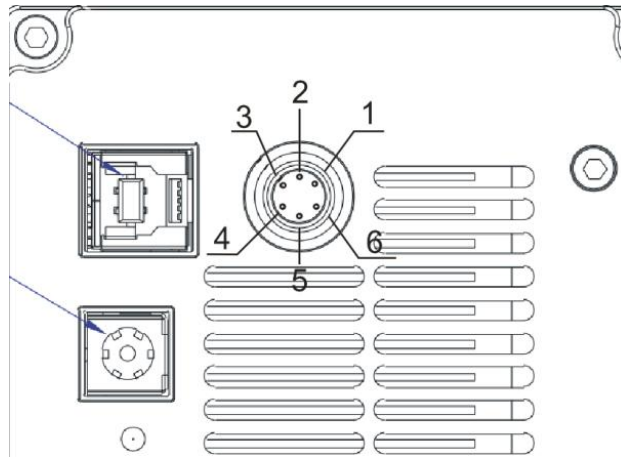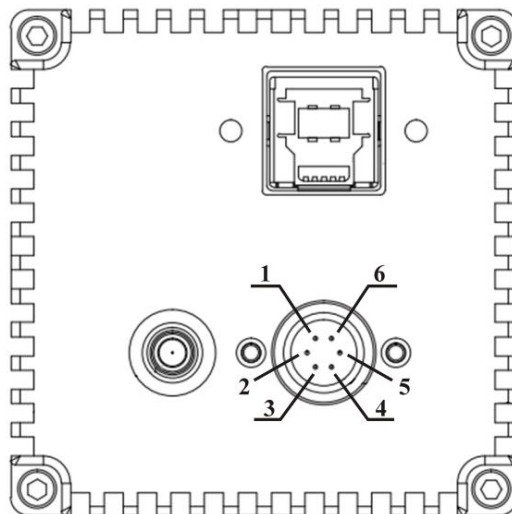| Pins for Connector	Pins Definition
1	TRI_IN (Standard mode)
2	TRI_GND TRI
3	NC
4	TRI_OUT0 (Exposure Start Signals)
5	TRI_OUT1 (Readout End Signals)
6	NC

Figure 1-2 Camera interface location map of FL-20BW

Figure 1-3 Camera interface location map of Dhyana 401D

2. The Timing Diagram of External Trigger and Signal Output Circuit

Dhyana series cameras (except Dhyana 401D) trigger input and output circuits are shown as below in Figure 2-1 and Figure 2-2.

Figure 2-1 Trigger Input Circuit

Figure 2-2 Trigger Output Circuit

The external trigger input and output circuit diagram of the FL-20BW/Dhyana 401D camera is shown in Figure 2-3, their external trigger circuits are optocoupler isolated circuits that require an external pull-up resistor to use the trigger function. Voltage

3.3V, resistance 1k Ω. The trigger signal supports either square wave or sine wave signals.
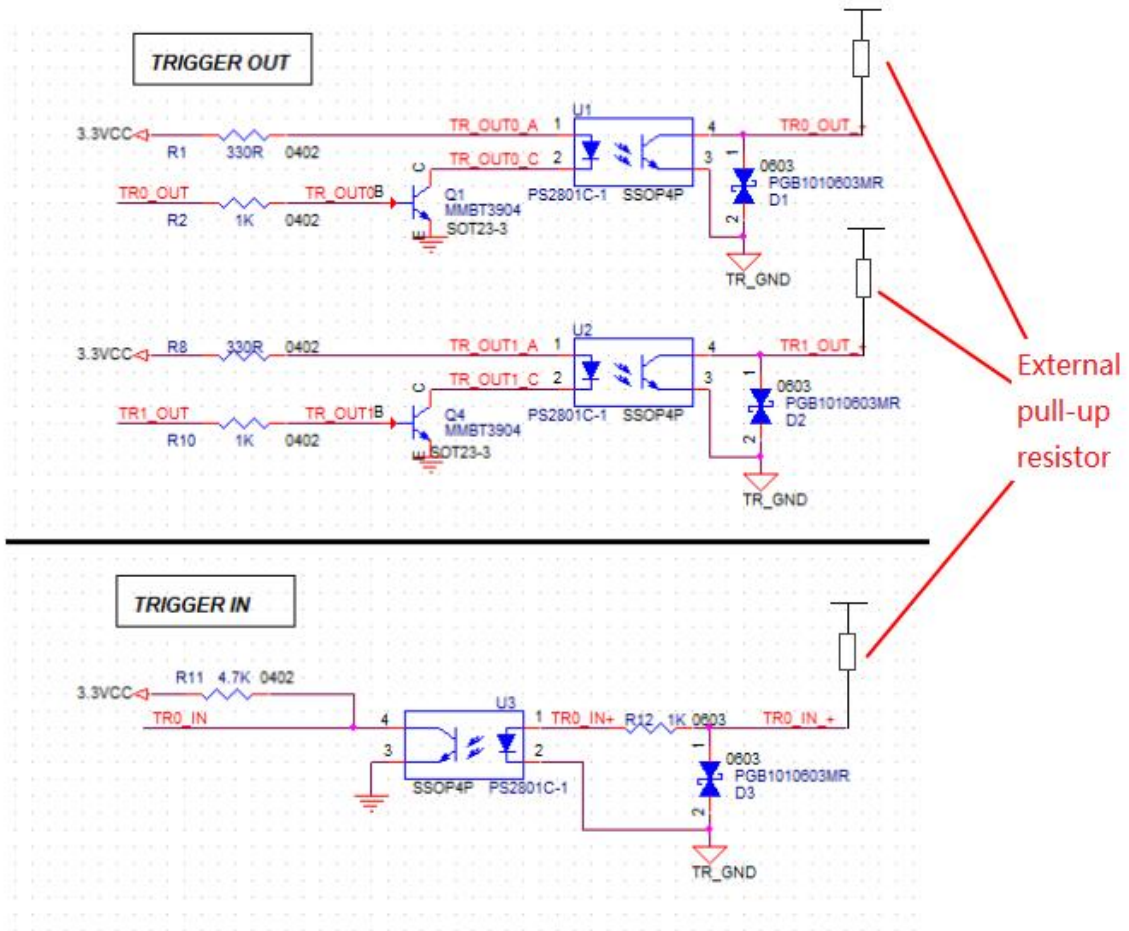

Figure 2-3 FL-20BW/Dhyana 401D Trigger Input&Output Circuit

The relationship between external trigger input pulse, indicator output signal and exposure timing diagram is shown in Figure 2-4 (Using rising edge level, standard trigger mode as an example).
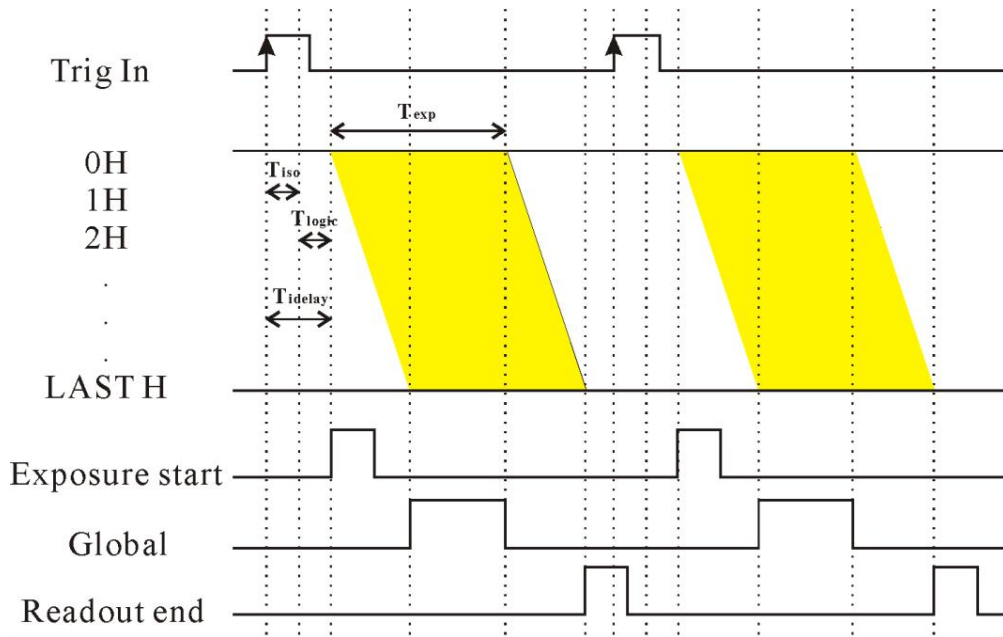
Figure 2-4 The Timing Diagram of Trigger Input&Output

There are two time delays when the level signal through the optocoupler circuit:

1) Delay T_{iso}: When the external trigger level signal arrives, there will be a delay T_{iso} when the hardware circuit first passes (the nanosecond level delay, which is determined by the hardware delay).

2) Delay T_{logic}: a logic delay after T_{iso} when the trigger signal enters camera and becomes a level signal. The value range is 0-1 minimum exposure unit T_{line}. (Minimum exposure unit is the exposure time for one line of the sensor).

That is to say, the logic delay time range is 0-21µs for Dhyana 95. In short, the overall delay (T_{idelay}) from trigger signal input to first line exposure starting is a sum of T_{iso} and T_{logic}.

Note:

The timing diagrams below ignore signal delays.

The definitions of these one input signal interface and three output signal interfaces are shown as below:

TRIG. IN: The camera receives the trigger signal.

TRIG.OUT1: When choosing readout signal, OUT1 will output the indicator level signal starts from last line readout ending.

TRIG.OUT2: When choosing global signal, OUT2 will output the indicator level signal from last line exposure beginning to first line exposure ending.

TRIG.OUT3: When choosing exposure signal, OUT3 will output the indicator level signal from first line starts exposure.

These three indicator signal outputs are always on by default. The camera outputs a level signal to a third party device as its input signal. Three signals can be output to different devices simultaneously.
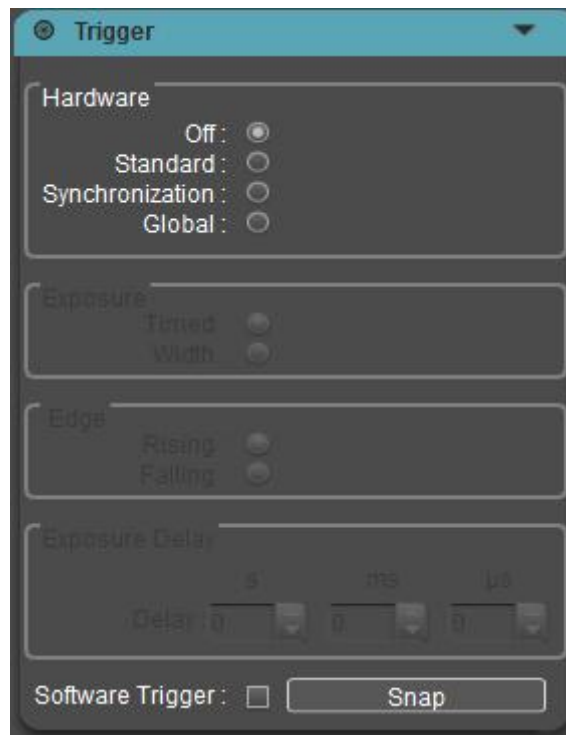
3. Instruction for External Trigger Mode

Figure 3-1 The Interface of Trigger Setting

3.1 Introduction

Image output modes are divided into two modes: Frame mode and Stream mode.

Stream mode

Also called free mode, the image output is continuously like stream, the mode supports hardware trigger capture.

Frame mode

Frame mode also called the external trigger mode. The mode outputs images based on the count of frame by receiving the trigger signals, including hardware trigger(Standard, Synchronization and Global mode) and software trigger.

The hardware trigger mode (Hardware) includes three modes: Standard, Synchronization, and Global. The FL-20BW and Dhyana 401D only support Standard hardware trigger mode.

3.2 API

The external trigger API introduced please see TUCAM API development guide.

3.3 External Trigger Functions

3.3.1 Off

External trigger mode turn off, the camera worked under stream mode. In this mode, the exposure time is set by the software manually or auto exposure, frame frequency is set to continuous imaging.

3.3.2 Standard Mode

There are two types of standard trigger modes: Level Trigger Mode and Edge Trigger Mode.

In level trigger mode, controlling the start and end of the exposure by inputting the rising or falling level of the external trigger signal. The duration of the exposure is determined by the duration of the level. The level trigger mode has a Trigger ready output, which is commonly used to photograph stationary or slow-moving objects.
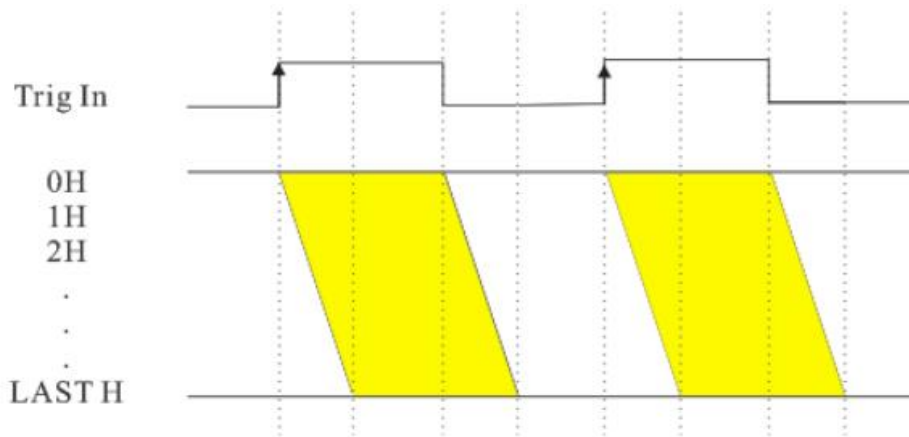

Figure 3-2 Standard Mode (Exposure: Width / Edge:Rising)

In the edge trigger mode, the exposure time is set directly on the software interface. Please note that the time (pulse width + pulse interval) of each pulse cycle of the trigger signal must be longer than or equal to the total time used for image output of each frame (ie, the reciprocal of the frame rate, including the delay time, exposure time, and readout time) to ensure that a frame of image is complete.
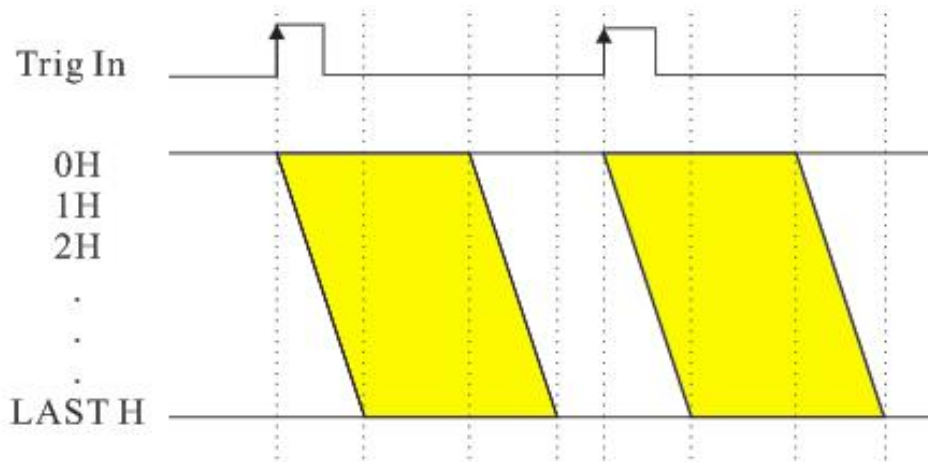
Figure 3-3 Standard Mode (Exposure: Timed / Edge:Rising)

When the Standard mode is selected, the camera starts exposure after receiving the level signal, and the number of frames is determined by the exposure time, pulse period, and number of pulses.

Standard Mode Configuration
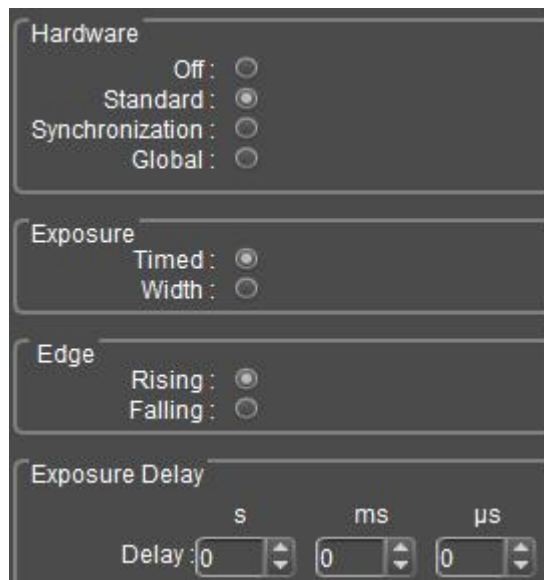

Figure 3-4

1) Exposure:

Timed: The exposure time is determined by software setting (Edge Trigger Mode).

Trigger Width: The exposure time is determined by the width of the input level signal (Level Trigger Mode).

2) Edge

   Rising Edge: Exposure starts when the camera receives rising edge signal.

   Falling Edge: Exposure starts when the camera receives falling edge signal.

3) Exposure Delay

   Set the delay time after receiving a trigger signal. The range is between 0-10s.

Note

1) If the time of each pulse cycle of the trigger signal is shorter than the time used for image output, the next pulse is shielded before the frame is fully output, resulting in less frames than the number of pulses. In a pulse process, the time of image reading is equal to the exposure time of one line of image multiplied by the total number of lines, and the line-by-line reading is started from the end of the first line of exposure.

2) Normal conditions, the time interval between each frame is the interval of each pulse period. The time from the receipt of the trigger signal to the output of an image is between [the total time taken for each frame readout] and [the time of each pulse period].

Example

1) The maximum frame rate of the Dhyana 95 camera is 24fps at full resolution, and the time per frame is 1000/24≈42ms. If the pulse period is set to 10ms and the number of pulses is 10, the second, third and fourth pulses will be shielded because the first frame is exposed, then output the first image. The fifth pulse starts the second image exposure, the sixth, seventh and eighth pulses will be shielded, and then outputs the second image.

2) Dhyana 401D, the time (pulse width + pulse interval) of each pulse cycle of the trigger signal must be longer than or equal to the total time used for image output of each frame (ie, the reciprocal of the frame rate, including the delay time, exposure time, and readout time) to ensure that a frame of image is completed.

3) The main difference between the external trigger of the FL-20BW and the Dhyana 401D is that a minimum trigger period is: [readout time + exposure time], while Dhyana 401D is the minimum period of exposure time and readout time whichever is greater. The maximum frame rate of FL 20BW under full resolution is 8fps, and the frame readout time is about 1000ms/8=125ms. Assuming the exposure time is 50ms and the rising edge triggers, the period of the trigger signal must be greater than or equal to [exposure time + readout time], that is [T1+T2≥readout time + exposure time = 50ms+125ms].

Assuming it is pulse width trigger and the rising edge is valid, the high level of the trigger signal is the exposure time, and the low level must be greater than or equal to the frame readout time of 125ms
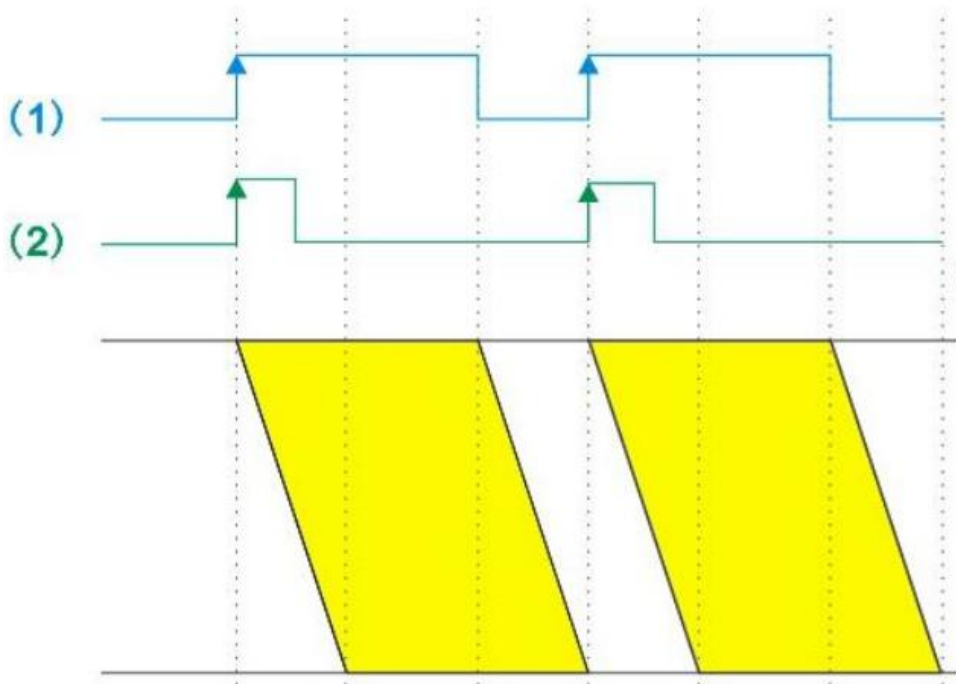

Figure 3-5 The trigger Timing Diagram of FL-20BW

(1) Exposure select Width: [High level = exposure time] and [Low level≥Frame time].

(2) Exposure select Timed: [High level+Low level≥Exposure time+Frame time].

3.3.3 Synchronization Mode

This mode is not supported on the FL-20BWDhyana 401D.

When this mode is selected, the camera receives a certain level signal and starts exposure. When the next level signal is received, the exposure is ended and starts to readout the image, at the same time the next exposure begins, and so on. Both the beginning exposure and the readout of the frame are fully synchronized with the external trigger signal. For this mode, the exposure time can only be determined by the trigger signal cycle time. When entering this mode for the first time, the image will not be generated if there is only single pulse and can be generated by the second time. If the signal is multi-pulse, the first trigger will be one frame less than the preset. The trigger will be equal to the preset number of frames at the second time. This mode is very useful for confocal microscopy imaging. For example, it can achieve the synchronous control of the camera's exposure time and the confocal rotation speed of the turntable to eliminate the effect of uneven light. The camera starts to take exposure shooting after receiving a certain level signal. When the next level signal is received, it ends the exposure, reads out and starts a new round of exposure. When clicking apply, it is equivalent to entering the mode for the first time, a level signal is required to start exposure shooting.
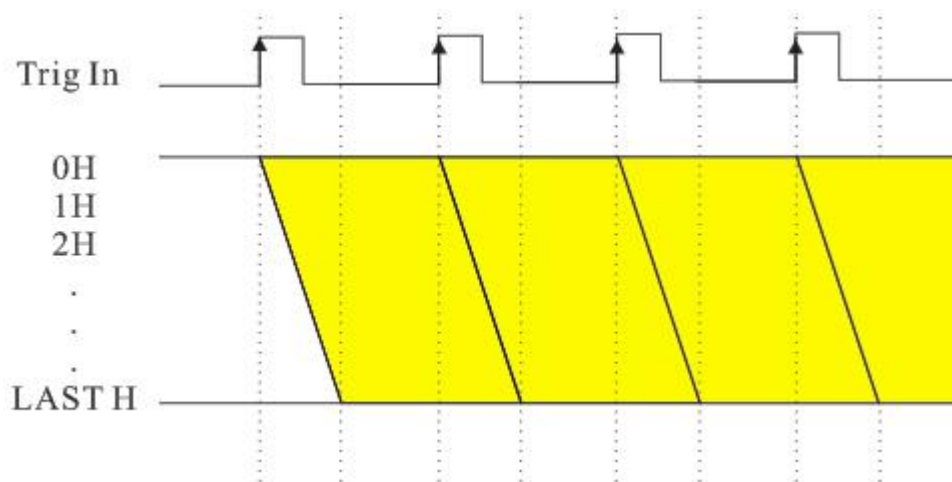

Figure 3-6 Synchronization Mode(Edge: Rising)

If the pulse width of the external pulse signal is T1 and the interval between the pulses is T2, so the exposure time of the image is equal to T1+T2. Taking the Dhyana 95 camera as an example, the frame rate is 24fps at full resolution, and the time per frame is about 42ms. So the pulse T1+T2 must be longer than or equal to 42ms, which ensures that each frame can have enough time for exposure and readout. If T1+T2 is less than 42ms, when the second pulse arrives, the first frame is not yet fully read, so the second pulse signal is invalid.

Configuration

Only one configuration in this mode: the exposure time is determined by inputting level signal width.
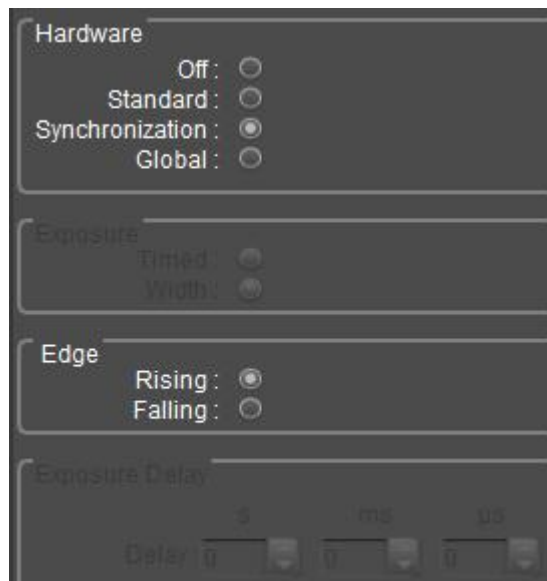

Figure 3-7

Edge: chose the type of trigger-response level edge.

Rising Edge: exposure starts when the camera receives the rising edge signal.

Falling Edge: exposure starts when the camera receives the falling edge signal.

Note: All modes are set to invalid for new trigger signal when the exposure is not over.

3.3.4 Global Mode

This mode is not supported on the FL-20BWDhyana 401D.

When this mode is selected, all pixels are pre-triggered before the camera triggers, and all pixels are exposed simultaneously when the camera receives an external trigger signal. This mode is often used in scenarios where the light source can be controlled.
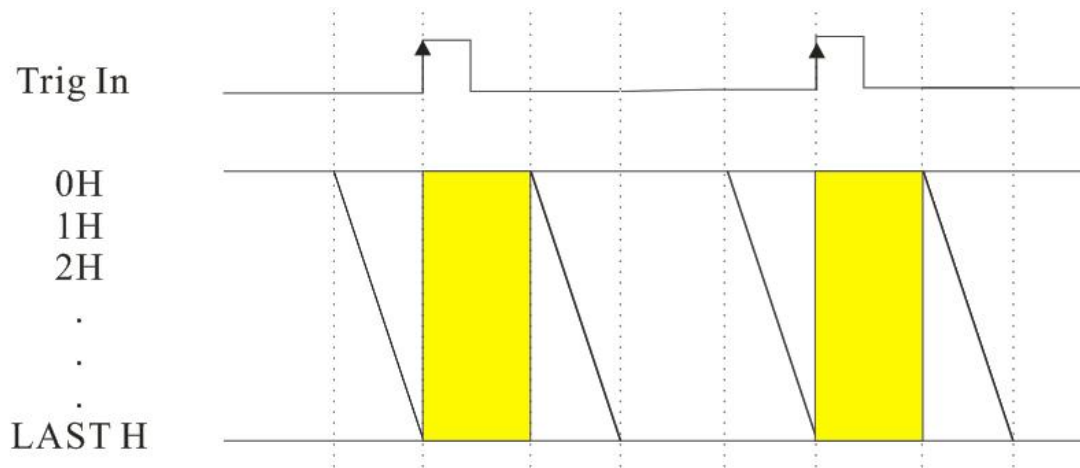
Figure 3-8 Global Mode (Exposure: Time / Edge:Rising)

Global exposure level trigger has four characteristics:

1) The camera is pre-exposed, but not scanned.

2) The light source triggers the camera to begin exposure, and the lighting phase must ensure that all lines are in the exposure phase.

3) Exposure time is determined by the level width, and the output data consists of 2 successive frames.

4) It is not a continuous shooting mode.

The global mode is characterized by a camera in the rolling mode, which achieves simultaneous exposure of all lines by pre-triggering and cooperation with an external light source. In the rolling mode, after one line is reset, the line starts to be exposed until readout, and one line period is required when a line is reset. In global mode, all lines can be exposed only after all lines are reset.

Configuration

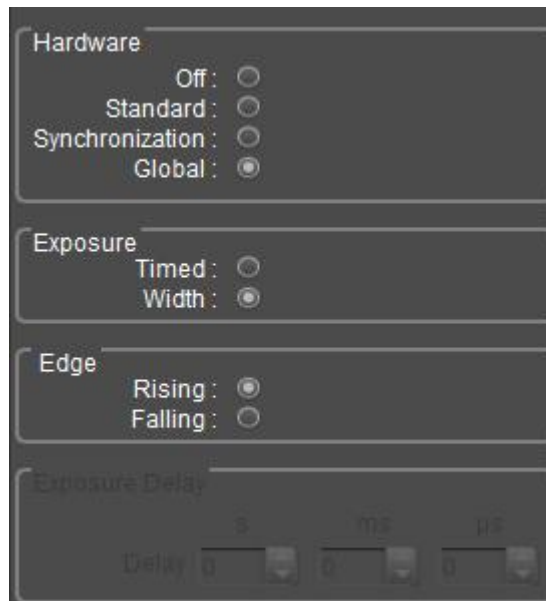Figure 3-9

1) Exposure time:

   Timed: The exposure time length is determined by software setting.

   Width: The exposure time length is determined by the width of inputting level.

2) Activation Edge

   Rising Edge: exposure starts when the camera receives rising edge signal.

   Falling Edge: exposure starts when the camera receives falling edge signal.

When Timed mode is selected, the exposure time of the image depends on the settings by the software interface. Assuming that the pulse width of the external pulse signal is T1 and the interval between the pulses is T2, the pulse T1+T2 must be longer than the exposure time set by the software interface plus the sum of the line periods of all the lines, ensuring that each frame can have sufficient time to reset, exposure and readout. If T1+T2 is smaller than the exposure time set by the software interface plus the sum of the line periods of all the lines, when the second pulse comes, the first frame image is not fully readout, so the second pulse signal is invalid.

When the Width mode is selected, assuming that the pulse width of the external pulse signal is T1 and the interval between the pulses is T2, so T2 must be longer than or equal to the sum of the line periods of all the lines.

Note:

Because the sensor does not support a global shutter, this mode is generally not recommended

- Dhyana 400D: T_{line}=13μs and the sum of the line periods of all lines is 2048×13μs=26.624ms;

- Dhyana 95: T_{line}=21μs and the sum of the line periods of all lines is 2048×21μs=43ms;

- Dhyana 400BSI: T_{line}=14μs and the sum of the line periods of all lines is 2048×14μs=28.672ms.

- Dhyana 400BSI V2: T_{line}=6.6μs and the sum of the line periods of all lines is 2048×6.6μs=13.517ms.

3.3.5 Software Trigger

Under software trigger mode, by clicking Snap, an image acquisition command will be sent to the camera. One image can be captured each time.

Note:

1) When switching between external trigger mode and real-time free mode, the user needs to click Apply to enable the new mode to come into effect.

2) After selecting external trigger mode, exposure mode, edge and delay, the user needs to click Apply.
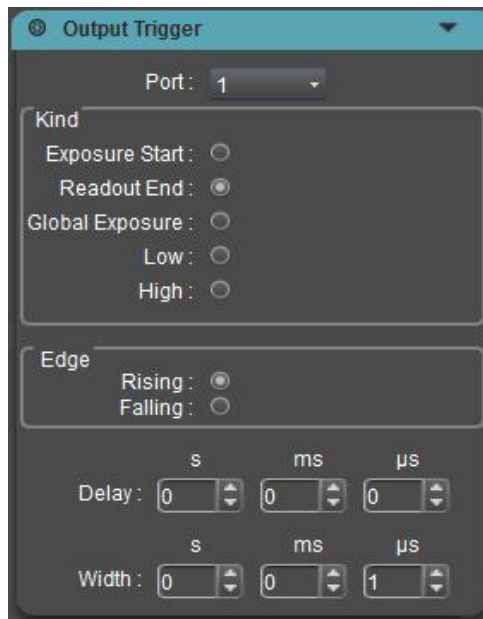
4. Output Trigger

Figure 4-1

Dhyana series cameras (except Dhyana 401D) have three trigger output ports TRIG.OUT1, TRIG.OUT2, and TRIG.OUT3, which correspond to Port1, Port2, and Port3 in the software interface.

FL-20BW/Dhyana 401D have two trigger output ports TRIG.OUT0 and TRIG.OUT1, which correspond to Port1 and Port2.

These output signals are on by default and are controlled by software. When the software is turned on, the signal will output. The camera outputs the level signal to a third-party device as its input signal. The three signals can work independently and can be output to different devices at the same time.
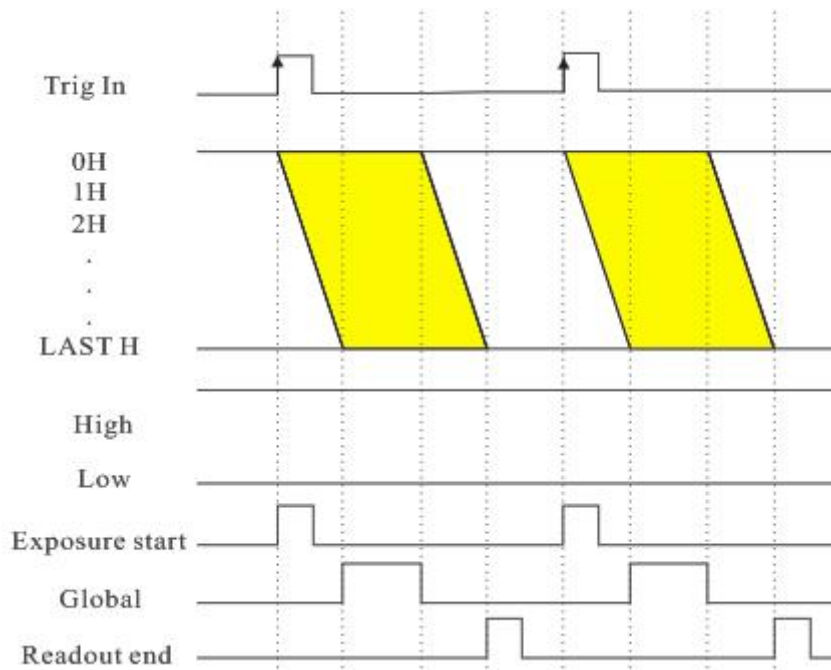
4.1 The Output Level Configuration

Figure 4-2 Diagram of Output Signal

High: Output high level signal all the time.

Low: Output low level signal all the time.

Exposure Start: The signal output by the Exposure Start will be the level signal from the first line starts to exposure and the width could be customized. Exposure Start is the default mode of Port 3.

Readout End: The signal output by the Readout End will be the level signal from the last line starts to readout and the width could be customized. Readout End is the default mode of Port 1.

Global: The signal output by the Global Exposure will be the level signal from the last line starts to be exposure to the end of the first line starts to readout (The exposure time need to greater than the frame time). Global Exposure is the default mode of Port 2.

4.2 Edge

Configuration of the Output Signal Polarity.

Rising: The rising edge of the trigger signal is valid.

Falling: The falling edge of the trigger signal is valid.

4.3 Delay

Delay time for configuring the output level signal and the default time is 0.

4.4 Width

Configure the level width of the pulse and the default width is 5ms.

Note:

1) When the Global Exposure signal output is selected, the pulse width configuration is invalid and its output according to the actual pulse width.

2) When High or Low signal output is selected, other configurations are invalid.

3) The Delay and Width signals in the streaming mode cannot be too long, otherwise the next frame signal will be lost;

4) The configuration precision of Delay and Width signals is up to us, the setting range of Delay is 0~10s, and the setting range of Width is 1us~10s;

5) When the camera enters the external trigger mode, the port can also output the same external trigger input signal. The delay time can be configured. However, the configuration of the pulse width is invalid, depending on the externally triggered input signal.