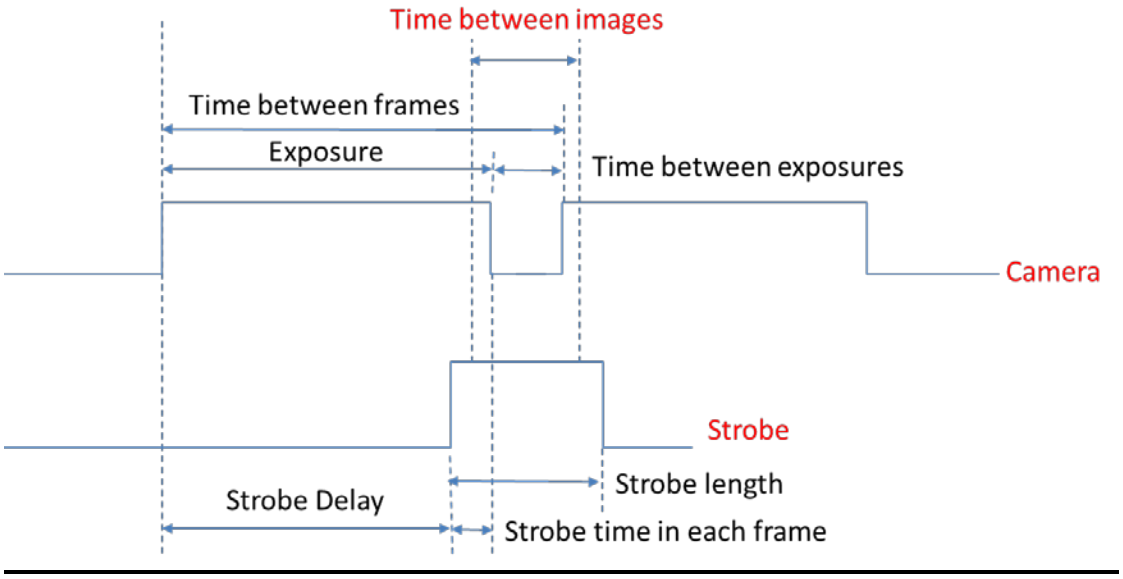
PIV CAMERA CONTROL

The ability of the CCD sensor to simultaneously readout an image while exposing the next image, allows a relatively short time between two images, given the camera's exposure time setting is equal to or greater than the sensor readout time. Sensor readout time can be approximated to 1/max camera frame rate. The minimum time between exposures value can be useful for particle image velocimetry (PIV) applications, where two images are taken in rapid succession to measure the speed of a moving object. Because the exposure time setting must be greater than or equal to the sensor readout time, which is equal to 1/(camera max frame rate), PIV users will need to use precisely timed strobe(s) in an otherwise dark operating environment:



To reach the highest frame rate of the PIV camera one needs to use a combination of gigabit router and a gigabit Ethernet card capable of jumbo frames. Conventionally, jumbo frames can carry up to 9000 bytes of payload. Using the highest frame rate is important in cyclic flows because there will be more data points in each cycle resulting in smoother graphs.

The Time Between Images are used in the PIV calculations. Time Between Images is selected based on the speed of the flow. For slow flows this value is smaller compared to faster flows.

For a given frames per second:

1) Time between frames = 1/Frames per second
2) Exposure = Time between frames – Time between images + Strobe time in each frame
3) Strobe duration = 2 x Strobe time in each frame + time between exposures
4) Strobe delay = Exposure - Strobe time in each frame + Strobe Delay Modification

In Flowex™ these values can be entered using the camera control. However, for convenience several options have been provided based on the flow speed. Once the option is selected the values will be automatically set and the user does not need to enter the values manually.

There are parameters that have been measured using an oscilloscope and must be incorporated into the calculations. The camera configuration parameters are preset in Flowex based on the speed of the flow, however, if the user wishes to vary the camera parameters to achieve different values of Time Between Images, the user needs to take account of the following measured values:

- The parameters given in this document have been measured for fixed Exposure and may vary for different Exposures:
  - For 67.308 fps: Exposure is 14,682 µs.
  - For 25.5 fps: Exposure is 39,041 µs.

- There is a time delay between LED/Laser and camera which needs to be taken into account. This is measured at the factory and depends on the camera frame rate. This time delay has to be compensated to achieve an equal brightness in each frame, and for accurate PIV measurements. The factory measured values are:
  - LED:
    - For 67.308 fps: Strobe Delay Modification is -67 µs.
    - For 25.5 fps: Strobe Delay Modification is -101 µs.
  - Laser:
    - For 67.308 fps: Strobe Delay Modification is -137 µs.
    - For 25.5 fps: Strobe Delay Modification is -146 µs.

- Time Between Exposures is measured at the factory:
  - For 67.308 fps: Time Between Exposures is [Calculated Value + 30 µs].
  - For 25.5 fps: Time Between Exposures is [Calculated Value - 20 µs].

Example

Here is an example of how one can calculate the parameters if required:

	Calculated	Measured
Frames per second	67.308	
Time between frames, µs	14857	
Strobe Delay Modification, µs	-137	
Time between exposures, µs	175	205
Strobe time in each frame, µs	111	
Strobe delay, µs	14445	
Strobe Duration, µs	375	426
Exposure, µs	14682	
Time between images, µs	316	

Summary Table of the dt for the Laser and LED

LASER	67.308 fps						25.5 fps						
	Fast Flow					Slow Flow	Fast Flow						Slow Flow
Strobe delay	14445	14220	13720	9720	7720	4720	38720	38570	38070	34070	29070	19070	9070
Strobe Duration	375	825	1825	9825	13825	19825	450	750	1750	9750	19750	39750	59750
Exposure	14682	14682	14682	14682	14682	14682	39041	39041	39041	39041	39041	39041	39041
Time between images	316	541	1041	5041	7041	10041	329	479	979	4979	9980	19980	29980

LED	67.308 fps						25.5 fps						
	Fast Flow					Slow Flow	Fast Flow						Slow Flow
Strobe delay	14515	14290	13790	12790	11790	10790	38840	38615	38115	36115	34115	32115	29115
Strobe Duration	375	825	1825	3825	5825	7825	375	825	1825	5825	9825	13825	19825
Exposure	14682	14682	14682	14682	14682	14682	39041	39041	39041	39041	39041	39041	39041
Time between images	368	594	1094	2094	3094	4094	343	569	1069	3069	5070	7070	10070