Imaging Diagnostics
Total vision solutions

TN0019 – CAMELOT, IDM-500 –EXPOSURE TIME AND FRAME RATE

1. Factors in Exposure Settings and Frame Rate

There are several parameters used to determine and control the **Exposure Time** and **Frame Rate** in the Camelot and IDM-500 cameras. The concepts behind these factors are described in the sections below.

1.1 Sensor's pixel clock

The pixel clock (PIXCLK) represents the time needed to sample 1 pixel from the sensor.
Some camera models, such as the WVGA and 1.3Mp, have a fixed pixel clock frequency.
Some models, such as the 5Mp and 10Mp versions enable control over the pixel clock.

1.2 Image Acquisition Mode

1.2.1 Electronic Rolling Shutter

In ERS mode, a picture is taken by scanning the rows of the sensor twice:

On the first scan, each row is released from reset, starting the exposure.

On the second scan, the row is sampled, processed, and returned to the reset state.

The exposure for any row is therefore the time between the first and second scans. Each row is exposed for the same duration, but at a slightly different point in time.

1.2.2 Global Reset Release

In GRR mode, all rows start exposure at the same time.
The second scan occurs as in ERS, so the exposure time for each row is different, since the sampling and processing is done sequentially, row by row. This means that each row sampled is exposed for more time than the previous one.
Note: GRR mode is applicable in snapshot mode only, and for selected models.

1.2.3 Global shutter

The WVGA model includes a global shutter sensor, thus all rows are exposed at the same time and duration.

1.3 Frame Max Resolution

The camera's maximum resolution is determined by the number of active pixels in the image sensor, and varies between the different models.

1.4 Region of Interest, ROI

In all camera models, part of the image can be selected, and only this part is sampled and sent.

1.5 Sub sampling

All cameras support sub sampling modes, where only half, quarter or eighth of the current ROI image is captured.

There are several modes of sub sampling:

Skipping – only the "sub sampled" pixels are exposed and sent.

Binning/Summing – All pixels are exposed, and by summing and/or averaging neighboring pixels, a single pixel value is sent.

1.6 Horizontal and Vertical Blanking

After each row and after each frame there is a "blank" area. Each sensor has a minimum, set amount of "blank area" between rows (horizontal blanking) and between frames (vertical blanking).

Horizontal blanking is added to each line, thus contributing to the exposure time.

Vertical blanking occurs after the exposure, and influences only the frame rate.

1.7 Shutter Width

The nominal exposure time is the effective shutter time in ERS mode, and is called Shutter Width.
A low Shutter Width setting means a lower exposure time and a darker picture.

1.8 Exposure Times and Frame Rate

Exposure time is a function of all camera parameters, as explained above.

The Camelot API enables querying the current exposure time, or setting the shutter width to achieve specific exposure time, based on current settings of pixel clock, ROI, sub sampling mode, and blanking.

Total exposure time, is a function of row exposure time, multiplied by the number of rows.

Maximum frame rate is determined by the sensor readout time, and the camera bandwidth.

EXAMPLE

Using a 5Mp sensor, streaming full frame resolution, 96MHz, the sensor readout is ~70ms = 14FPS.

NOTE

When using USB2.0 high speed, the maximum bandwidth enables only ~8FPS.

When the total exposure time settings exceeds the maximum sensor readout time, the frame time will be determined by the exposure time.

EXAMPLE

Using a 5Mp sensor streaming full frame, 96MHz, if we set exposure time for 100ms, then the sensor frame rate will be 10 FPS.

The vertical blanking can add delays between frames, and lower the frame rate.

EXAMPLE

Since the USB 2.0 bandwidth is limited to 8 FPS (full resolution) in 5Mp USB cameras, there is no reason for the sensor to output 10 FPS. By adding vertical blanking, FPS can be lowered without changing the exposure time. This will free up the DSP's CPU to perform other tasks, such as image processing.

2. Camelot API Functions for Setting Exposure Time

In addition to the functions that control a frame's size (`SET_SUBSAMPLING`, `GET_SUBSAMPLING`, `SET_FOV`, `GET_FOV`), the following functions can be used to set and query the frames' exposure time and rate.

2.1 SET_PLL_RATE

This function is only available for the 5Mp sensors, and sets the sensor pixel clock.
The pixel clock can be set to any even value from 16MHz to 96MHz.
Lower pixel clock enable longer exposure times, and less overload on the CPU, while higher pixel rate enables shorter exposure time and higher FPS.

NOTE

If Pixel clock rate is changed, exposure time and frame rate will be affected, and will have to be set again.

2.2 SET_EXPOSURE_TIME, GET_EXPOSURE_TIME

These functions either set or query the current exposure time.
Times are in microseconds (sec x 10^{-6}).

2.3 ADJUST_FLICKER

This function calculates and sets the nearest shutter width value that will cause the exposure time to be a multiple of 10ms or 8.333ms for 50Hz or 60Hz lighting.

2.4 SET_FRAME_RATE

This function manipulates the vertical blanking if a lower frame rate than the maximum is required.

NOTE

This function is for the sensor frame rate. Actual frame rate to the PC is influenced by the USB / Ethernet bandwidth.

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