Technical Application Note TAN2008002

High Dynamic Range Modes Available in Firefly MV
Revised March 3, 2010

1.1. Subject

Technical Application Note (TAN2008002): High Dynamic Range Modes Available in Firefly MV

1.2. Applicable Product(s)

- ***Firefly MV***

1.3. Application Note Description

The purpose of this Technical Application Note is to describe the various High Dynamic Range (HDR) modes available in the Firefly MV.

1.4. Additional Resources

MT9V022: 1/3 inch Wide-VGA Digital Image Sensor data sheet
This document makes multiple references to this data sheet. The data sheet is available upon request from Micron. Point Grey Research is unable to directly distribute any Micron documentation not already on our web site.

1.5. Overview

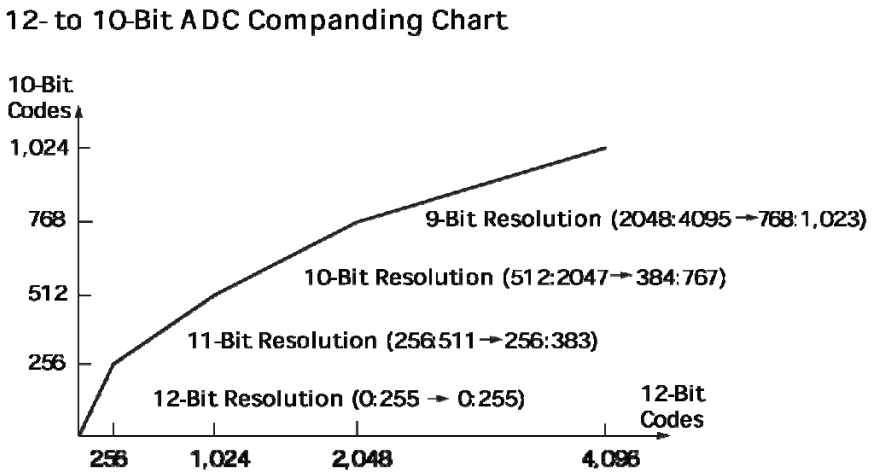
There are 2 main methods of enabling HDR mode in a Firefly MV camera:

- 12- to 10-Bit Companding
- Manual HDR control

The first method is fully automatic once enabled, while the second method enables varying amounts of manual control. The second method also requires writing directly to the registers on the sensor.

1.6. 12- to 10-Bit Companding

This mode can be enabled in the Firefly MV by setting the Gamma register on the Firefly MV to 1. This companding scheme results in reduced quantization noise at low light levels due to the higher ADC resolution. Consequently, the resolution is lower at higher light levels. The following chart details the conversion between 12-bit and 10-bit codes.



1.6.1. Example

The following command shows how to enable 12- to 10-Bit Companding. It assumes that the camera has been initialized and that a valid camera context is present.

```
flycaptureSetCameraPropertyEx( context, FLYCAPTURE_GAMMA, false, true, false, 1,
0);
```

1.7. Manual HDR Control

1.7.1. Writing to Sensor Registers

There is no PGR API to write to the registers on the sensor directly. However, the Firefly MV is capable of passing register read and writes to the sensor. Follow the steps below to write to the sensor's registers:

1. Write the address of the sensor register to camera register `0x1A00`.
2. To get the value stored within the sensor register, read camera register `0x1A04`. Write to the same camera register to write a value to the sensor register.

1.7.2. Enabling Manual HDR Mode

To enable HDR mode, bit 6 of sensor register `0x0F` (Pixel Operation Mode) must be set to 1. The corresponding voltage and shutter width sensor registers must be set correctly in order for this mode to operate correctly.

1.7.3. Voltage Settings

'The step voltage on the sensor is set according to each phase of integration. The step voltage is set to V1 for integration time t1. It is then set to V2 for t2, and then on to V3 for t3, finishing at V4 at the end of integration.

The step voltages for each phase of integration can be set by setting sensor registers `0x31`, `0x32`, `0x33` and `0x34` for V1, V2, V3 and V4 voltages respectively. The formula used to calculate the step voltage is as follows:


```
V_Step = (bits 4:0) * 62.5mV + 0.5625V
```

The range and defaults for each voltage setting are as follows:

Voltage	Range (V)	Default (V)	Default (Hex)
V1	0.5625 – 2.5	2.375	1D
V2	0.5625 – 2.5	2.0625	18
V3	0.5625 – 2.5	1.875	15
V4	0.5625 – 2.5	0.8125	4

1.7.4. Automatic Knee Point Timing

Auto adjustments of the exposure knee points can be enabled by setting bit 8 of the sensor register 0x0A (Shutter Width Control) to HIGH (1). If the Auto Adjust Enabler value is set to HIGH, then the knee points are calculated automatically using the following formula:

$$^{t}1 = {}^{t}INT - {}^{t}2 - {}^{t}3$$
$$^{t}2 = {}^{t}INT - (½)^{T2\_Ratio}$$
$$^{t}3 = {}^{t}INT - (½)^{T3\_Ratio}$$

The T2 (bits 3:0) and T3 ratios (bits 7:4) specified in the Shutter Width Control register will be used in the calculations. The default values are 1/16 of ^{t}INT for ^{t}2 (i.e. T2_Ratio = 4) and 1/64 of ^{t}INT for ^{t}3 (i.e. T3_Ratio = 6).

1.7.5. Manual Knee Point Timing

If the Auto Adjust Enabler value is set to LOW, then the knee points are calculated using the following formula:

$$^{t}1 = \text{Reg0x08, bits 14:0}$$
$$^{t}2 = (\text{Reg0x09, bits 14:0}) - (\text{Reg0x08, bits 14:0})$$
$$^{t}3 = {}^{t}INT - {}^{t}1 - {}^{t}2$$

In this case, sensor registers 0x08 and 0x09 (Shutter Width 1 and Shutter Width 2 respectively) need to be set.to a value between 1 and 480. The relation between shutter widths is as follows:

$$t^{1} = \text{Shutter Width 1}$$
$$t^{2} = \text{Shutter Width 2} - \text{Shutter Width 1}$$
$$t^{3} = \text{Total integration} - \text{Shutter Width 2}$$

1.7.6. Examples

The following example shows how to enable manual HDR control with automatic knee point timing It assumes that the camera has been initialized and that a valid camera context is present.

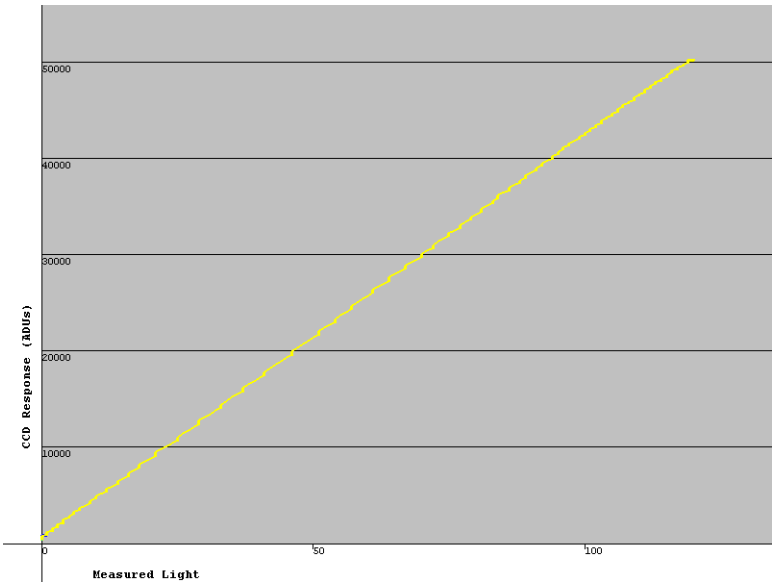
```
// Create a variable to hold the register values
unsigned long ulValue = 0;

// Set 0x0F (Pixel Operation Mode) to be the sensor register to be written to
flycaptureSetCameraRegister( context, 0x1A00, 0x0F );

// Flip bit 6 of the register to 1 to enable HDR mode
flycaptureGetCameraRegister( context, 0x1A04, &ulValue );
ulValue |= 0x00000040;
```

```
flycaptureSetCameraRegister( context, 0x1A04, ulValue );

// Set 0x0A (Shutter Width Control) to be the sensor register to be written to
flycaptureSetCameraRegister( context, 0x1A00, 0x0A );

// Flip bit 8 of the register to 1 to enable automatic knee point timing
ulValue = 0;
flycaptureGetCameraRegister( context, 0x1A04, &ulValue );
ulValue |= 0x00000100;
flycaptureSetCameraRegister( context, 0x1A04, ulValue );
```

1.8. Sample Results

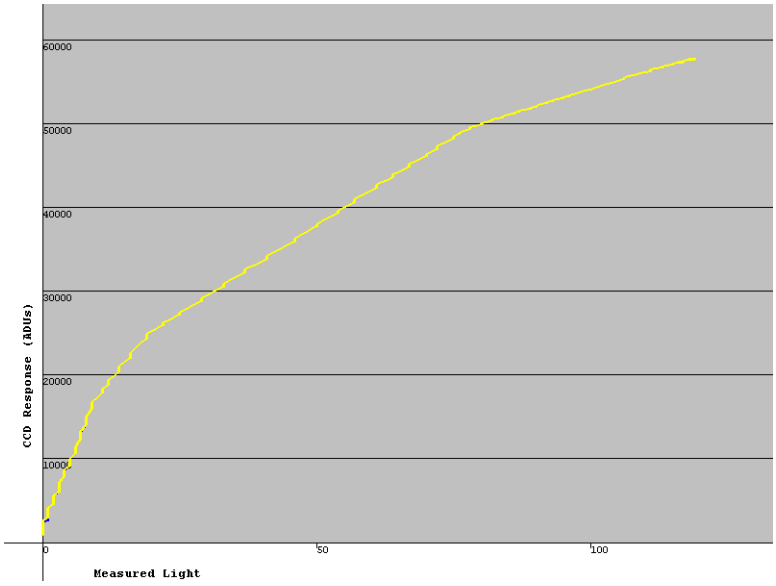
1.8.1. Baseline

The following graph shows the response when the camera is neither in Companding or HDR mode.



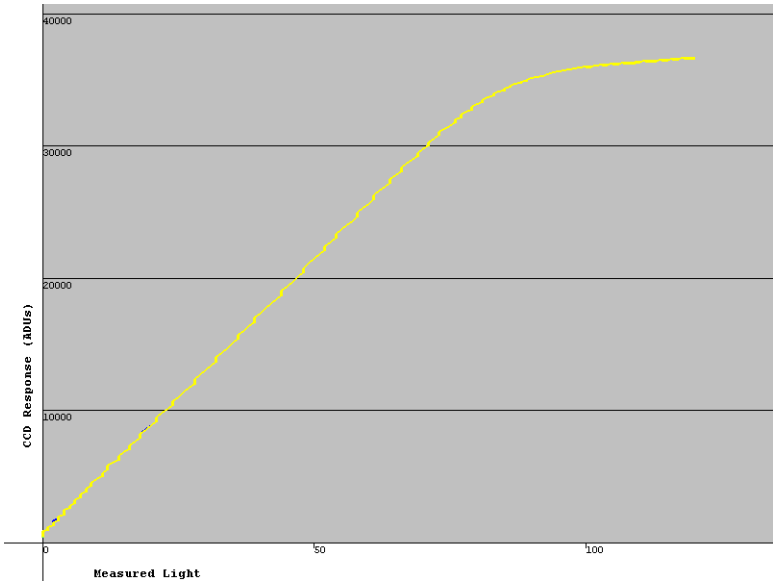
1.8.2. 12- To 10-Bit Companding

The following graph shows the response when the camera is in 12- To 10-Bit Companding mode.



1.8.3. Manual HDR Mode (Automatic Knee Point)

The following graph shows the response when the camera is in manual HDR mode with automatic knee point timing. Note that the graph will vary depending on the voltage levels and shutter ratios chosen.



1.9. Additional Downloads and Support

Access more Technical Application Notes on the web at www.ptgrey.com/support/downloads.

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Knowledge Base

Our on-line knowledge base at www.ptgrey.com/support/kb/ contains answers to some of the most common support questions. It is constantly updated, expanded, and refined to ensure that our customers have access to the latest information.

Product Downloads

Customers with a Customer Login Account can access the latest software and firmware for their cameras from our downloads site at www.ptgrey.com/support/downloads. We encourage our customers to keep their software and firmware up-to-date by downloading and installing the latest versions.

Contacting Technical Support

Before contacting Technical Support, have you:

1. *Read the product documentation and user manual?*
2. *Searched the Knowledge Base?*
3. *Downloaded and installed the latest version of software and/or firmware?*

If you have done all the above and still can't find an answer to your question, contact our Technical Support team at www.ptgrey.com/support/contact/.