APPLICATION NOTE

AN-P12

CHEETAH CAMERA SERIES

CANON EF EOS LENS CONTROL

Abstract: This application note describes how to control a Canon EF EOS lens in the Imperx Cheetah cameras.

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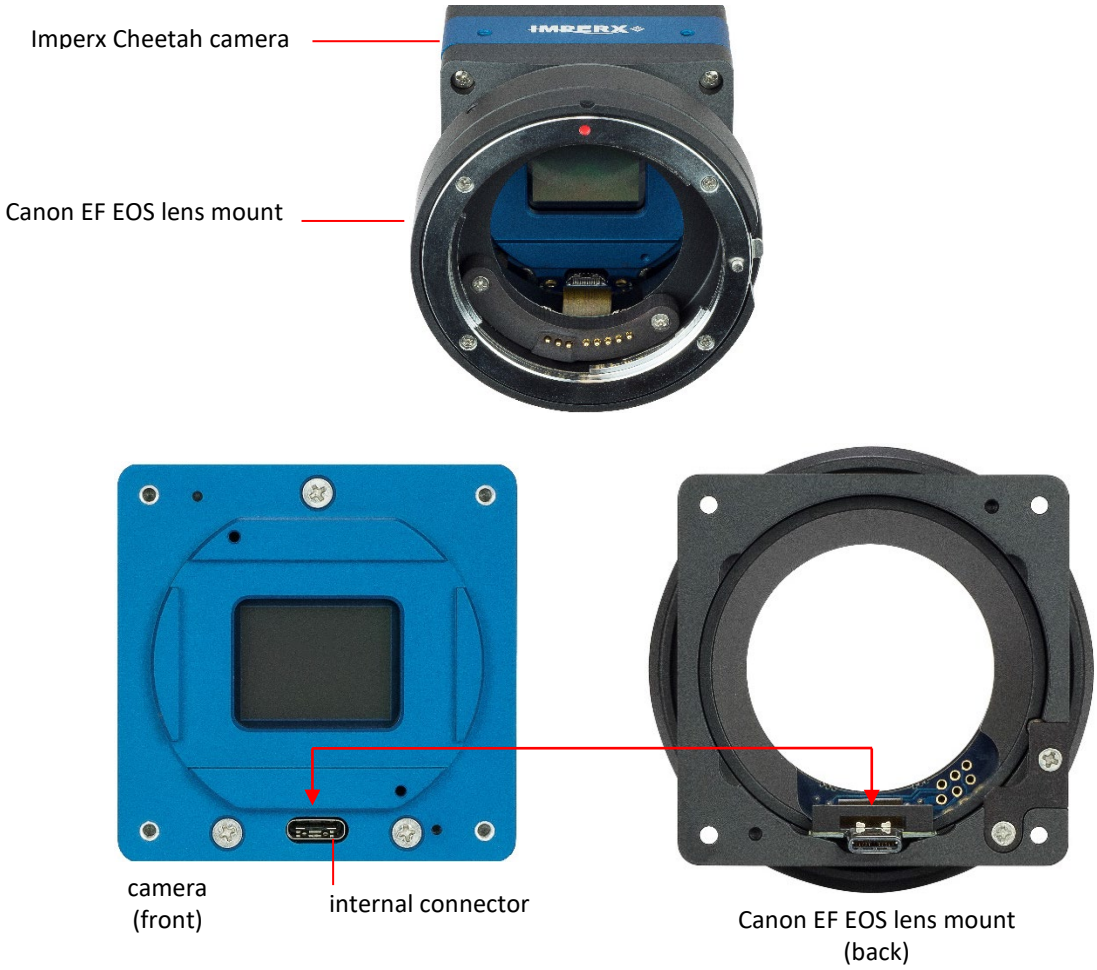
Introduction

A Canon EF EOS mount from Imperx features an internal connector that eliminates the need for a special power supply and external cable between the camera and the Canon EF EOS mount improving reliability and reducing system complexity. The camera's graphical user interface allows users to adjust the iris and focus and the camera SDK allows user to easily integrate lens control into their applications.

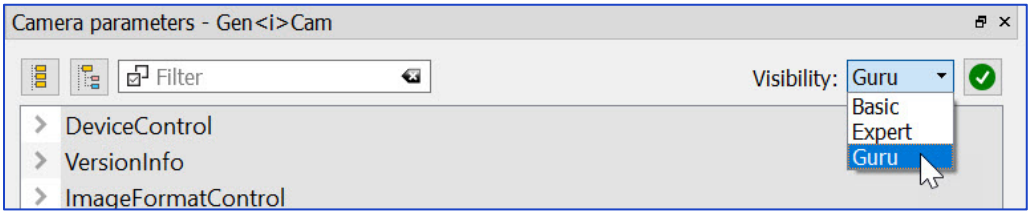


Imperx Cheetah cameras provide communication and power to the Canon EF EOS mount through an internal connector. The following Cheetah cameras support the Canon EF EOS mount:

Camera model	Interface
POE-C4410, POE-C5410, POE-C6410 POE-C4410-T, POE-C5410-T, POE-C6410-T	GigE Vision® with Power over Ethernet
CLF-C4420, CLF-C5420, CLF-C6420 CLF-C4420-T, CLF-C5420-T, CLF-C6420-T	Camera Link®
CXP-C4440, CXP-C5440, CXP-C6440, CXP-C9440	CoaXPress
SFP-C4440, SFP-C5440, SFP-C6440	10 GigE Vision® with SFP+ transceiver

Adjusting a Canon EF EOS Lens on POE, CXP, and SFP Cameras

Make sure that the switch on your Canon EF EOS lens is set to Auto (AF), and Visibility is set to Guru on the software GUI screen:



The camera initializes the lens upon power cycling. When the **Lens Controller Status** parameter InitLens status changes to "Done", the initialization was successfully completed, and the lens adjustments can begin. If the initialization failed, then issue the **InitLens** command on Controller Setting screen and recheck **Lens Controller Status** parameter.

Focus Control

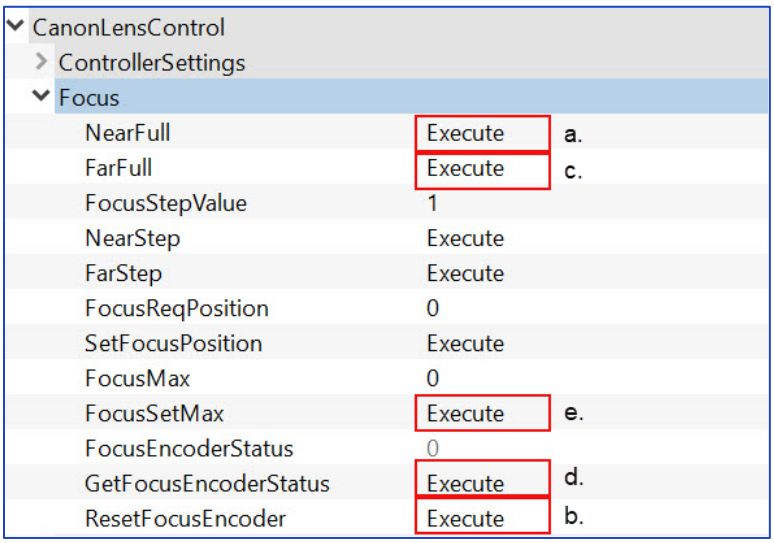
1. Upon power up, the focus encoder within the lens is reset to unknown values and the camera must 'learn' the range of the Canon lens's Focus Encoder. To calibrate and initialize the camera software, issue the following sequence of commands:
   a. Issue the *Canon Focus Near-Full* command.

   b. Issue the *Reset Focus Encoder* command.

   c. Issue the *Canon Focus Far-Full* command.

   d. Issue the *Get Focus Encoder Status* command.

   e. Issue the *Focus Set Max* command. The *Focus Max* parameter will be automatically set to the maximum value.



2. To set focus to a particular value, set *FocusReqPosition* to the desired value.

3. Issue the *SetFocusPosition* command.
   FocusEncoderStatus will change indicating the new focus position.

   The Focus Encoder is a Hall effect sensor and is not perfectly precise, so focus positions as provided by the *FocusEncoderStatus* feature can vary even if the requested focus position (using *FocusReqPosition*) is the same value. This variability also makes it impossible to power cycle the camera and then move the lens to a previous focus position using the *FocusReqPosition* feature. Additionally, positional errors tends to reduce focus accuracy after a number of focus movements. While restoring a previous focus position after power cycling using the *FocusReqPosition* feature is not possible, if the lens is focused and not moved, power cycling will not disturb this setting and the lens will retain focus even after repeated power cycling.

   Canon *FocusEncoderStatus* is a signed value (2's complement). Negative values can result if the Focus Encoder position is set beyond the Near Full position. For example, a value of 65352 means negative 184 or 184 steps past the Near Full Position.

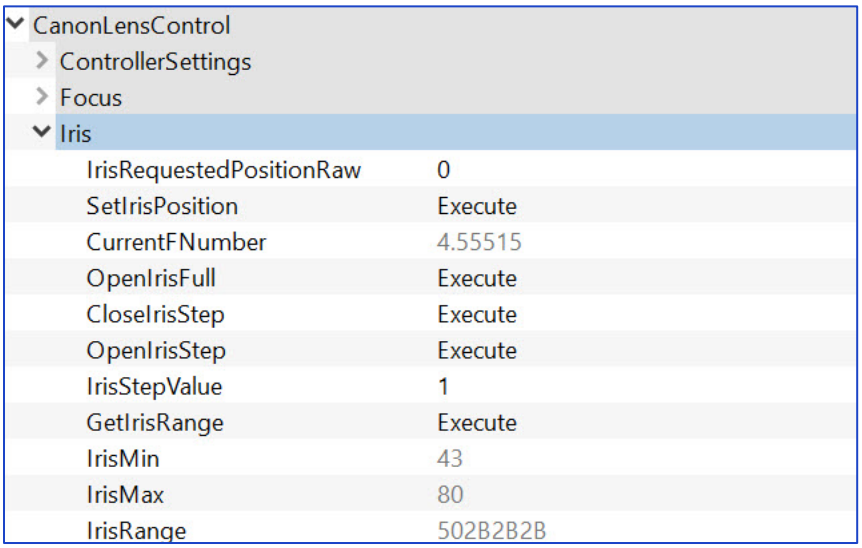
Iris Control

A Canon EF EOS lens provides an iris range in raw units, and the camera reads out this iris range from a Canon lens upon issuing the *GetIrisRange* command. Each time the iris is changed, the camera calculates and returns the *CurrentFNumber* using the following formula:

CurrentFNumber = Sqrt (2)^[(Raw unit/8) - 1]

For example, if Raw unit = 32, then CurrentFNumber = 2.83.

Using XML features *IrisRequestedPositionRaw* and *SetIrisPosition* you can set an aperture to a required value. The aperture will be changed with *IrisStepValue* until it is greater than or equal to the target position in raw units. For best precision to return the iris to a previous F-number, Imperx recommends using an *IrisStepValue* of 1 or 2.



Canon Lens Control XML Parameters

Controller Settings

Parameter Name	Type	Value		Access	Description
InitLens	Command			WO	Initializes the Canon Lens. Always initialize lens after power-up.
StopLens	Command			WO	Removes power from the Iris drive. Run the *InitLens* command to resume the lens control.
LensControllerStatus	Enumeration	**String** InitLens_Failed InitLens_Done	**Num.** 0 1	RO	Shows status of Canon Lens initialization.
LensAF_MF	Enumeration	**String** AutoFocus ManualFocus	**Num.** 0 1	RO	Shows status of Auto/Manual focus switch located on the lens.
GetLensID	Command			WO	Requests value of Lens ID register.
LensID	Integer			RO	Returns Lens ID after *GetLensID* is issued.

Focus

Parameter Name	Type	Value	Access	Description
NearFull	Command		WO	Drives the focus to the fully Near position.
FarFull	Command		WO	Drives the focus to the fully Far position.
FocusStepValue	Integer	Min: 1 Max: 255	RW	Sets the focus step to be moved with *NearStep* and *FarStep* commands.
NearStep	Command		WO	Drives the focus to the Near direction by the amount defined in the *FocusStepValue* feature.
FarStep	Command		WO	Drives the focus to the Far direction by the amount defined in the FocusStepValue feature.
FocusReqPosition	Integer	Min: 0 Max: FocusMaxReg	RW	Sets the desired focus value to use with the *SetFocusPosition* command.
SetFocusPosition	Command		WO	Drives the focus to the absolute position defined in the FocusReqPosition feature.
FocusMax	Integer		RO	Returns maximum focus encoder value.
FocusSetMax	Command		WO	Sets the Focus Max Register with current *FocusMax* value.
FocusEncoderStatus	Integer		RO	Returns the current focus encoder value after the *GetFocusEncoderStatus* command is issued.

Parameter Name	Type	Value	Access	Description
GetFocusEncoderStatus	Command		WO	Requests the focus encoder position value.
ResetFocusEncoder	Command		WO	Resets the Focus encoder.

Iris

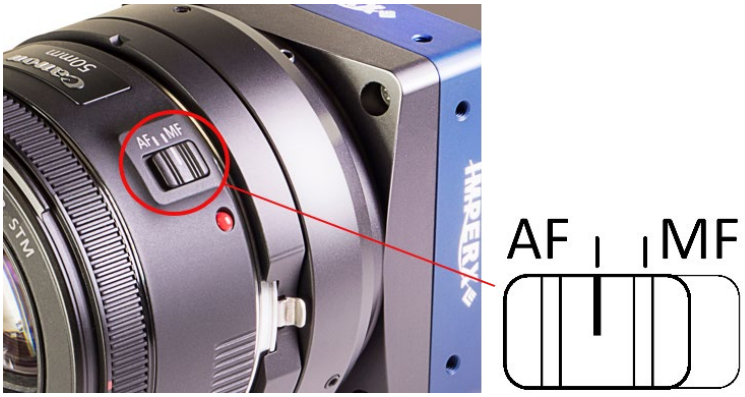
Parameter Name	Type	Value	Access	Description
IrisRequestedPositionRaw	Integer	Min: IrisMin2 Max: IrisMax	RW	Sets raw iris absolute position.
SetIrisPosition	Command		WO	Drives the iris to the absolute position value of *IrisRequestedPositionRaw*.
CurrentFNumber	Float		RO	Returns the current f-number value of the lens iris. Value of 0.0 signals an unknown iris position.
OpenIrisFull	Command		WO	Opens the iris to the fully opened position.
CloseIrisStep	Command		WO	Closes the iris by the amount defined in the *IrisStepValue* feature.
OpenIrisStep	Command		WO	Opens the iris by the amount defined in the *IrisStepValue* feature.
IrisStepValue	Integer	Min: 1 Max: 127	RW	Sets the iris step to be moved with *OpenStep* and *CloseStep* commands.
GetIrisRange	Command		WO	Sends the *GetIrisRange* command to the camera.
IrisMin	Integer		RO	Returns the minimum iris limit.
IrisMax	Integer		RO	Returns the maximum iris limit.
IrisRange	Integer		RO	Displays the Limit values of the iris, after the *GetIrisRange* command is issued.

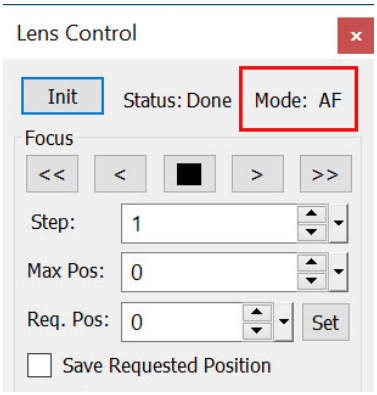
Adjusting a Canon EF EOS Lens on Camera Link (CLF) Cameras

Imperx intends on offering the ability to save EF Lens Focus and Iris positions to the User Space as a standard feature in all Cheetah cameras supporting EF mount lenses. It is important to note that any time the EF mount focus or iris is moved, there are small errors introduced and it is impossible to perfectly restore iris and focus positions due to errors introduced within the EF mount lens electro-mechanical systems.

For the above reason, some clients set the focus and iris positions and do not want the positions changed when loading new user spaces or they set the focus and only want the iris position to change when loading the user space or they set iris and only want the focus position to change when loading the user space. To accommodate all these different potential user requirements, a new feature is added to the camera which allows the user to 'enable saving Focus/Iris Positions' to the User Spaces. When this feature is disabled, the camera will not adjust the EF lens focus and iris when the User Space is loaded.

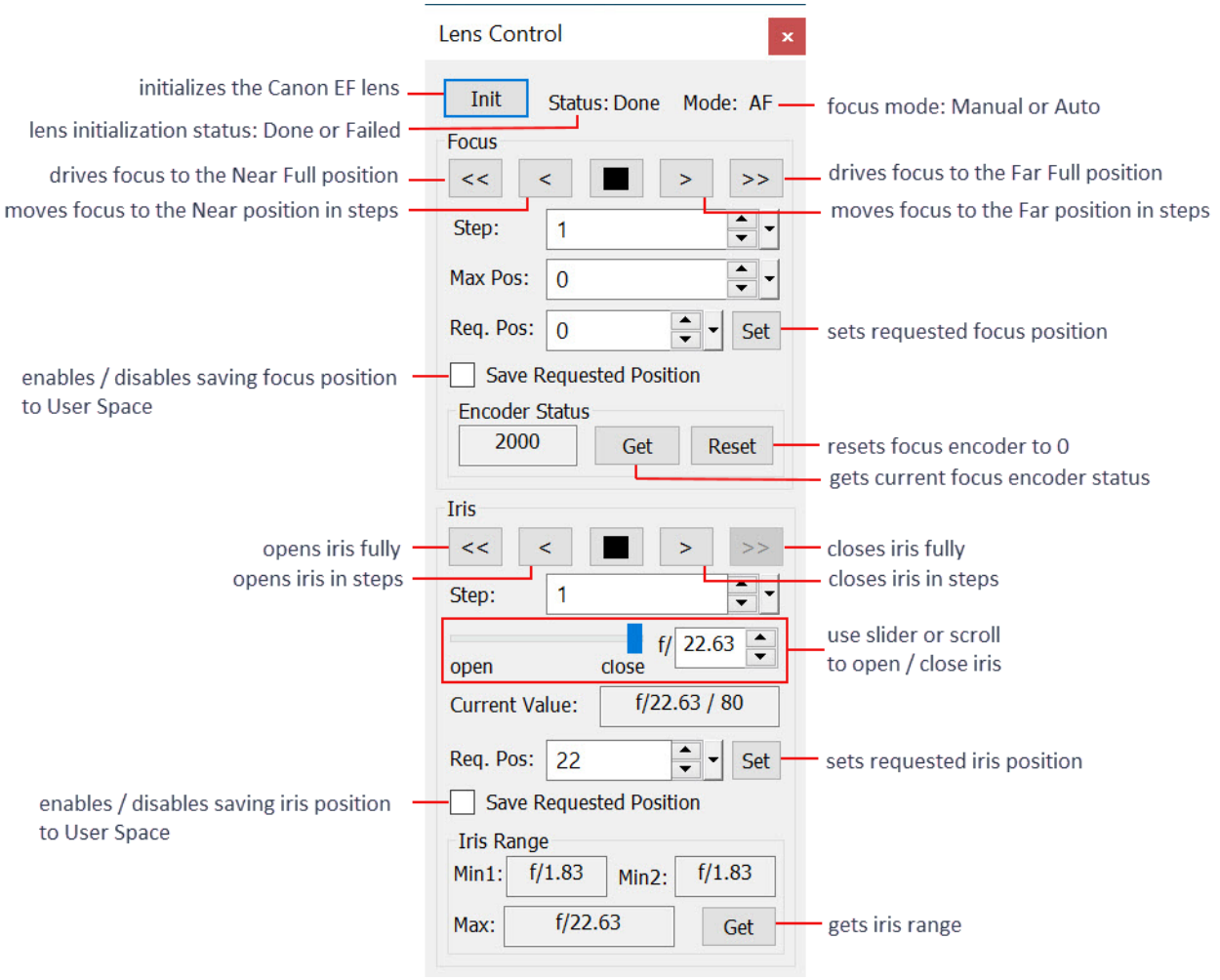
NOTE ⊛ Make sure that the lens's focus mode switch is set to Autofocus (AF) position on your Canon EF EOS lens. When the switch is set to AF, the Mode parameter is AF on the Lens Control panel. In this mode, you can control the lens using Lens Control panel. If the switch is set to Manual focus (MF) position, the Lens Control panel is disabled.





Lens Control Panel

You can control the lens iris and focus from the Lens Control panel of the CamConfig software. The panel also provides the current status of the lens control unit, encoder, iris, and iris range.



Settings	Descriptions
Init	Initializes the Canon EF lens.
Status	Indicates status of lens initialization, either Done or Failed.
Mode	Indicates mode of the lens focus, either Manual or Auto.
Focus	Controls for focusing the lens in real-time.
Step	Changes the focus position step granularity from fine (step 1) to coarse (step 255). Imperx recommends a step value of 4 for fine focus.
Max Pos	Sets maximum focus encoder value. To set the maximum focus position, enter the value in the **Max Pos** field and press **Enter**.
Req. Pos	Sets requested focus position. To set focus to a desired position, enter the value in **Req. Pos** field, press **Enter**, and click **Set**.
Save Requested Position	Enables/disables saving focus position to User Space

Settings	Descriptions
Encoder Status	Provides a relative measure of the lens focus position but does not provide sufficiently accurate location information to return the lens to a previous lens focus position after power cycling. Once the lens is focused, however, it will retain focus position even after repeated power cycling. • Click **Get** to display the current location of the lens position. • Click **Reset** to reset encoder to zero value.
Iris	Controls for opening/closing iris.
Req. Pos	Sets requested iris position in raw units. To set iris to a desired position, enter the value in **Req. Pos** field, press **Enter**, and click **Set**
Save Requested Position	Enables/disables saving iris position to User Space
Iris Range	Shows iris range and current iris value. Click **Get** to update current iris range values.

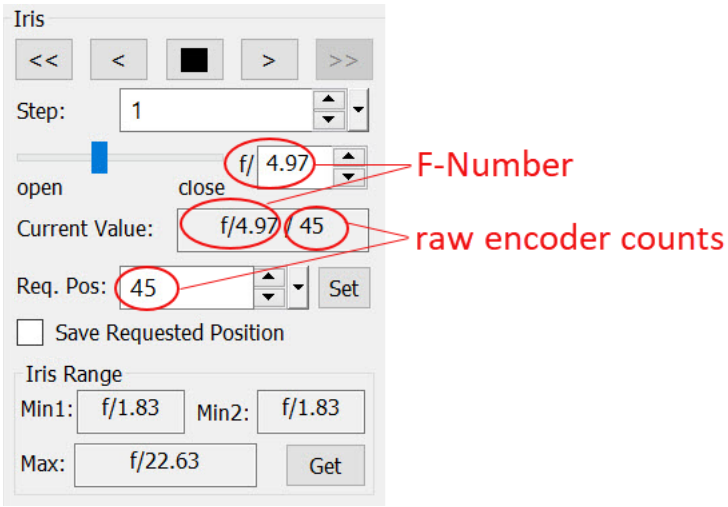
Iris Control

A Canon EF EOS lens provides an iris range in raw encoder counts, and the camera reads out this iris range from a Canon lens upon issuing the CANON Get Aperture Range command (0x6234). Each time the iris is changed, the camera calculates and returns the Current F-Number using the following formula:

Current F-Number = Sqrt (2)^[(Raw unit/8) - 1]

For example, if Raw unit = 45, then Current F-Number = 4.97.

The CamConfig GUI specifies the iris position in raw encoder counts using the F-number/Raw counts format:



Using registers CANON IRIS Saved Position (0x0400) and Set IRIS Position (0x620C) you can set the iris to a required value. The aperture will be changed with IRIS Step Value (0x6200) until it is greater than or equal to the target position in raw units. For best precision to return the iris to a previous F-number, Imperx recommends using an IRIS Step Value of 1 or 2.

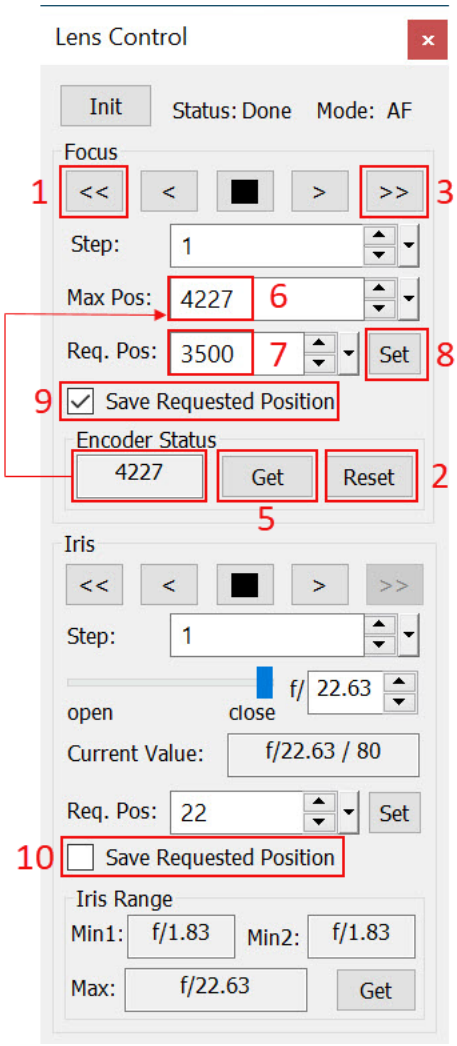
Saving and Restoring EF Lens Focus and Iris Positions from User Space

Use case 1. Save Focus Position and adjust when loading User Space, do not save Iris Position so Iris Position does not change when loading user space.

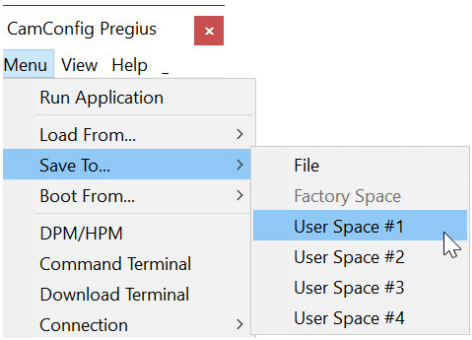
1. On the **Focus** pane, adjust the focus to **Near Full** position by clicking << button (address: 0x6224).
2. Click **Reset** (address: 0x6240).

>>

4. Repeat steps 1–3 three times.
5. Click **Get** (0x623C).
6. Copy **Encoder Status** value into the **Max Pos**. field (address: 0x0414) and press **Enter** .
7. Enter a desired focus value in the **Req. Pos**. field (address: 0x0410) and press **Enter**.
8. Click **Set** (address: 0x6244).
9. Check the **Save Requested Position** checkbox (set data bit 1 to 1 at 0x0404).
10. On the Iris pane, make sure that the checkbox is unchecked (set data bit 0 to 0 at 0x0404).

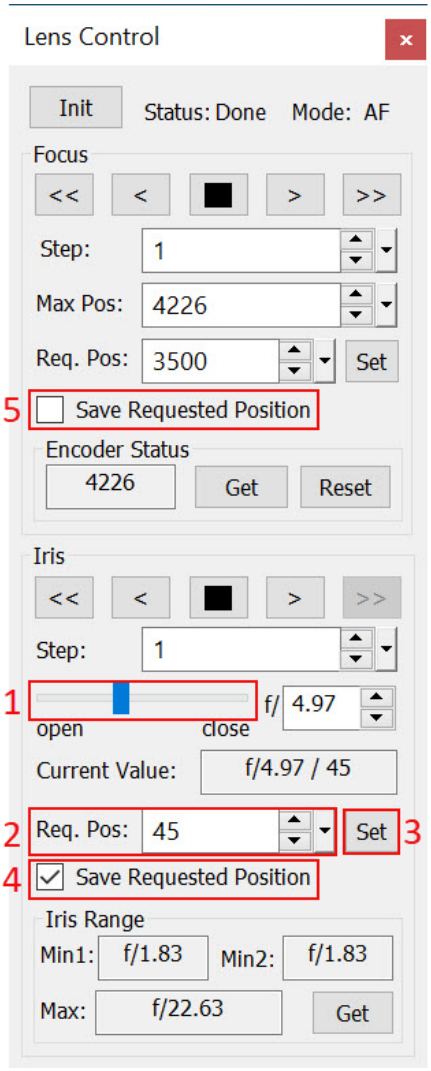


11. Click Menu → Save to…→ User Space #1.

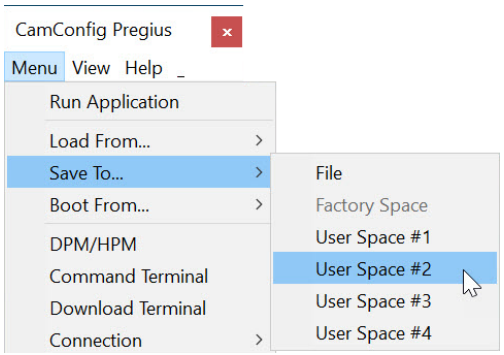


Use case 2. Do not save Focus Position so focus does not change when loading User Space, save Iris Position and adjust when loading user space.

1. On the **Iris** pane, adjust the iris position using slider.
2. Enter a desired iris position in the **Req. Pos**. field (address: 0x0400) and press **Enter**.
3. Click **Set** (address: 0x620C).
4. Check the **Save Requested Position** checkbox (set data bit 0 to 1 at 0x0404).
5. On the Focus pane, make sure that the checkbox **Save Requested Position** is unchecked (set data bit 1 to 0 at 0x0404).



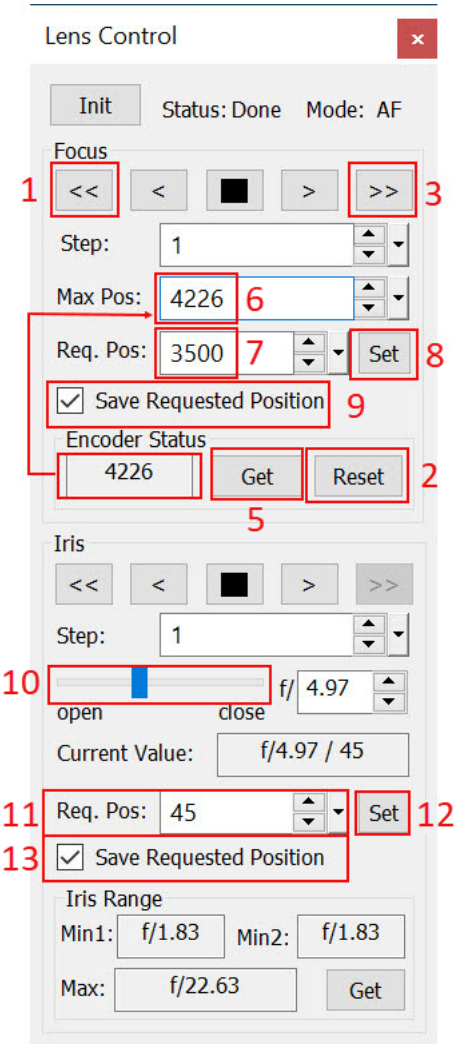
6. Click Menu → Save to…→ User Space #2.



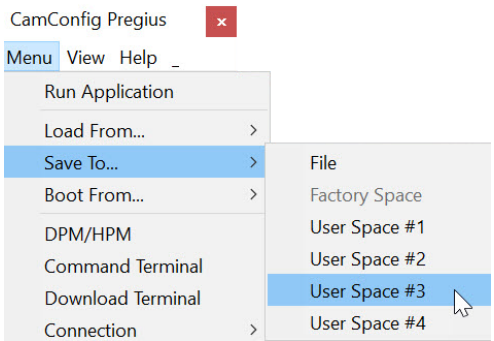
Use case 3. Save Focus Position and adjust when loading User Space, Save Iris Position and adjust when loading User Space

2. Click **Reset** (address:0x6240).

4. Repeat steps 1–3 three times.
5. Click **Get** (address: 0x623C).
6. Copy **Encoder Status** value into the **Max Pos**. field (address: 0x0414) and press **Enter**.
7. Enter a desired focus value in the **Req. Pos**. field (address: 0x0410) and press **Enter**.
8. Click **Set** (address: 0x6244).
9. Check the **Save Requested Position** checkbox (set data bit 1 to 1 at 0x0404).
10. On the **Iris** pane, adjust the iris position using slider.
11. Enter a desired iris position in the **Req. Pos**. field (address: 0x0400) and press **Enter**.
12. Click **Set** (address: 0x620C).
13. Check the **Save Requested Position** checkbox (set data bit 0 to 1 at 0x0404).



14. Click Menu → Save to…→ User Space #3.



Canon Lens Control Registers for Camera Link (CLF) Cameras

Address	Register Name	Data	Type	Usage
0x0400	CANON IRIS Saved Position	Data (7:0) <hex value> Data (31:8) N/A	RW	Sets the requested iris position to use with Set IRIS Position command (0x620C).
0x0404	CANON Saved IRIS/FOCUS Active	Data (0) 0 – disable saving iris position to User Space 1 – enable saving iris position to User Space Data (1) 0 – disable saving focus position to User Space 1 – enable saving focus position to User Space Data (31:2) N/A	RW	Enables/disables saving EF lens focus and iris to User Space.
0x0410	CANON FOCUS Saved Position	Data (15:0) <hex value> Min: 0 Max: CANON Focus Max Position Increment: 1 Data (31:16) N/A	RW	Sets the desired focus value to use with Set FOCUS Position command (0x6244).
0x0414	CANON FOCUS Max Position	Data (15:0) <hex value> Data (31:16) N/A	RW	Sets maximum focus encoder value.
0x6200	IRIS Step Value	Data (7:0) <IRIS Step> Data (31:8) N/A	RW	Sets the iris step increment value.
0x6204	IRIS Close Step	CMD value 0x1	WO	Closes iris one step per command. The step value is set above 0x6200.
0x6208	IRIS Open Step	CMD value 0x1	WO	Opens iris one step per command. The step value is set above 0x6200.
0x620C	Set IRIS Position	CMD value 0x1	WO	Command drives the iris to the position value of CANON IRIS Saved Position (0x0400) using IRIS Step Value.
0x6210	IRIS Open Full	CMD value 0x1	WO	Command fully opens the iris.
0x6214	IRIS Stop	CMD value 0x1	WO	Command stops IRIS movement.
0x6218	FOCUS Step Value	Data (7:0) <FOCUS Step> Data (31:8) N/A	WR	Sets focus step increment value.
0x621C	FOCUS Close Step	CMD value 0x1	WO	Closes focus one step per command. The step value is set above 0x6218.

Address	Register Name	Data	Type	Usage
0x6220	FOCUS Open Step	CMD value 0x1	WO	Opens focus one step per command. The step value is set above 0x6218.
0x6224	FOCUS Near Full	CMD value 0x1	WO	Command sets focus to full near position.
0x6228	FOCUS Far Full	CMD value 0x1	WO	Command sets focus to full far position.
0x622C	FOCUS Stop	CMD value 0x1	WO	Command stops focus if/while its moving.
0x6230	CANON Lens Init	CMD value 0x1	WO	Command initializes CANON lens.
0x6234	CANON Get Aperture Range	CMD value 0x1	WO	Command gets CANON lens iris range.
0x623C	CANON Get FOCUS Encoder Value	CMD value 0x1	WO	Command gets CANON lens encoder value.
0x6240	CANON Reset FOCUS Encoder Value	CMD value 0x1	WO	Command that gets the CANON lens reset encoder value.
0x6244	Set FOCUS Position	CMD value 0x1	WO	Command drives the focus to the requested position defined in the CANON FOCUS Saved Position (0x0410).
0x6258	CANON IRIS State	Data (15:0) <Current Position> Data (15:8) <Min1> Data (23:16) <Min2> Data (31:24) <IRIS State>	RO	Holds iris state value.
0x625C	CANON FOCUS State	Data (15:0) <FOCUS State> Data (31:16) N/A	RO	Holds focus state value.
0x6260	CANON Lens Status	Data (0) 0x0 – iris is fully opened 0x1 – iris is fully closed Data (1) Electronic ring drive: 0x0 – off 0x1 – on Data (2) Focusing ring is Active (accelerating or decelerating): 0x0 – inactive 0x1 – active (FcsDrvIsMovingFlg) Data (3) N/A Data (4) Focus Drive ineffective: 0x0 – focusing ring can move 0x1 – drive stopped because focusing ring can't move (FcsDrvIneffectiveFlg) Data (5) Fast focus movement	RO	Returns lens status register value

Address	Register Name	Data		Type	Usage
			0x0 – a lens does not support fast focus movement 0x1 – a lens supports fast focus movement, and a focusing ring is active (Data (2) is 0x1)		
		Data (6)	N/A		
		Data (7)	Focus switch: 0x0 – auto focus 0x1 – manual focus		
		Data (31:8)	N/A		
0x6264	CANON Lens Controller Status	Data (1:0)	N/A	RO	Holds Lens Controller Status value.
		Data (2)	0x0 – auto focus 0x1 – manual focus		
		Data (3)	0x0 – lens initialization failed 0x1 – lens initialization done		
		Data (31:4)	N/A		

Canon Lens Control Features for POE, SFP, and CXP Cameras

The Canon Lens Controller is a part of the camera firmware which receives commands and controls the lens. The Canon EF Lens Controller supports motorized iris and focus, but not zoom.

Controller Settings

Address	Feature Name	Data	Type	Usage
0x20006230	InitLens	CMD value 0x1	WO	Initializes the Canon Lens. Always initialize lens after power-up.
0x20006214	StopLens	CMD value 0x1	WO	Removes power from the Iris drive. Run the *InitLens* command to resume the lens control.
0x20006264	LensControllerStatus	Data (1:0) N/A Data (2) 0x0 – auto focus 0x1 – manual focus Data (3) 0x0 – init lens failed 0x1 – init lens done Data (31:4) N/A	RO	Shows status of Canon Lens initialization.
0x20006260	LensStatus	Data (0) 0x0 – iris is fully opened 0x1 – iris is fully closed Data (1) Electronic ring drive: 0x0 – off 0x1 – on Data (2) Focusing ring is Active (accelerating or decelerating): 0x0 – inactive 0x1 – active (FcsDrvIsMovingFlg) Data (3) N/A Data (4) Focus Drive ineffective: 0x0 – focusing ring can move 0x1 – drive stopped because focusing ring can't move (FcsDrvIneffectiveFlg) Data (5) Fast focus movement 0x0 – a lens does not support fast focus movement 0x1 – a lens supports fast focus movement, and a focusing ring is active (Data (2) is 0x1) Data (6) N/A Data (7) Focus switch: 0x0 – auto focus 0x1 – manual focus Data (31:8) N/A	RO	Returns Lens Status register value.

Address	Feature Name	Data	Type	Usage
0x20006250	GetLensID	CMD value 0x1	WO	Requests Lens ID register.
0x20006268	LensID	Data (15:0) <hex value> Data (31:16) N/A	RO	Returns Lens ID register value after *GetLensID* command is issued.

Focus

Address	Feature Name	Data	Type	Usage
0x20006224	FocusNearFull	CMD value 0x1	WO	Drives the focus to the fully Near position.
0x20006228	FocusFarFull	CMD value 0x1	WO	Drives the focus to the fully Far position.
0x20006218	FocusStepValue	Data (7:0) <hex value> Min: 0x1 – 1 Max: 0xFF – 255 Increment: 1 Data (31:8) N/A	RW	Sets the focus step to be moved with *NearStep* and *FarStep* commands.
0x20006220	FarStep	CMD value 0x1	WO	Drives the focus to the Far direction by the amount defined in the *FocusStepValue* register.
0x2000621C	NearStep	CMD value 0x1	WO	Drives the focus to the Near direction by the amount defined in the *FocusStepValue* feature.
0x2000622C	SetFocusMax	CMD value 0x1	WO	Sets the maximum focus encoder value by copying current encoder value.
0x20006240	ResetFocusEncoder	CMD value 0x1	WO	Resets the Focus encoder.
0x2000623C	GetFocusEncoderStatus	CMD value 0x1	WO	Requests the focus encoder position value.
0x2000625C	FocusEncoderStatus	Data (15:0) <hex value> Data (31:16) N/A	RO	Returns the current focus encoder value after the *GetFocusEncoderStatus* command is issued.
0x20006270	FocusReqPosition	Data (15:0) <hex value> Min: 0 Max: FocusMaxValue Increment: 1 Data (31:16) N/A	RW	Sets the desired focus position- use with *SetFocusPosition* command.
0x20006244	SetFocusPosition	CMD value 0x1	WO	Drives the focus to the absolute position defined in the *FocusReqPosition* feature.
0x20006274	FocusMaxValue	Data (15:0) <hex value> Data (31:16) N/A	RO	Returns maximum focus encoder value.

Iris

Address	Feature Name	Data	Type	Usage
0x2000626C	IrisRequestedPositionRaw	Data (7:0) <hex value> Min: Iris Min2 Max: Iris Max Increment: 1 Data (31:8) N/A	RW	Sets Canon Iris Requested Position Raw value.
0x2000620C	SetIrisPosition	CMD value 0x1	WO	Drives the iris to the absolute position value of *IrisRequestedPositionRaw* using IrisStepValue
0x20006210	OpenIrisFull	CMD value 0x1	WO	Opens the iris to the fully opened position.
0x20006204	CloseIrisStep	CMD value 0x1	WO	Closes the iris by the amount defined in the *IrisStepValue* feature.
0x20006208	OpenIrisStep	CMD value 0x1	WO	Opens the iris by the amount defined in the *IrisStepValue* feature.
0x20006200	IrisStepValue	Data (7:0) <hex value> Min: 0x1 – 1 Max: 0x7F – 127 Increment: 1 Data (31:8) N/A	RW	Sets the iris step to be moved with *OpenIrisStep* and *CloseIrisStep* commands.
0x20006234	GetIrisRange	CMD value 0x1	WO	Sends command to update the *IrisState* register.
0x20006258	IrisState	Data (7:0) <hex value> current position Data (15:8) <hex value> Iris Min 1 Data (23:16) <hex value> Iris Min2 Data (31:24) <hex value> Iris Max	RO	Returns current position, Min1, Min2, and Max Iris limits.

Appendix A: Programming Guide

Canon Lens Control Focus Init Subroutine

When a user controls the camera through a custom application using SDK, software must provide for delays in the lens response. The subroutine shown below polls *LensStatus* and *FocusEncoderStatus* registers and the Focus Drive is Moving Flag (FcsdrvisMovingflg) to accommodate lens response delays. This subroutine is used to learn focus range.

A Python code example file *CheetahPregiusGevConsole_Canon_LC_SAMPLE.py* is available upon request.