

Lt Camera Series™

Camera User's Manual

USB3 Vision – Monochrome & Color Area Scan



USB™
VISION

November 1, 2021

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 **TELEDYNE LUMENERA**
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Teledyne Lumenera, a business unit of Teledyne Digital Imaging Inc., is headquartered in Ottawa, Canada, and is a leading developer and manufacturer of high-performance digital cameras and custom imaging solutions. Teledyne Lumenera imaging solutions provide a unique combination of speed, resolution and sensitivity to meet the most demanding digital imaging requirements, and are deployed worldwide in a wide range of industrial and scientific applications.

Teledyne Imaging is an international high performance semiconductor and Electronics Company that designs, develops, manufactures, and markets digital imaging products and solutions, in addition to providing wafer foundry services.

Teledyne Digital Imaging offers the widest range of machine vision components in the world. From industry-leading image sensors through powerful and sophisticated cameras, frame grabbers, vision processors and software to easy-to-use vision appliances and custom vision modules.

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1 Series Overview

1.1 Description

Teledyne Lumenera USB3 Vision compliant cameras provide a quick and easy means of capturing high quality images on any USB 3.0 equipped desktop, laptop, or embedded computer. Because they are USB-based, there is no need for a frame grabber. Instead, a single cable provides full command control and data transfer at speeds of up to 380 MB/s (Lt series).

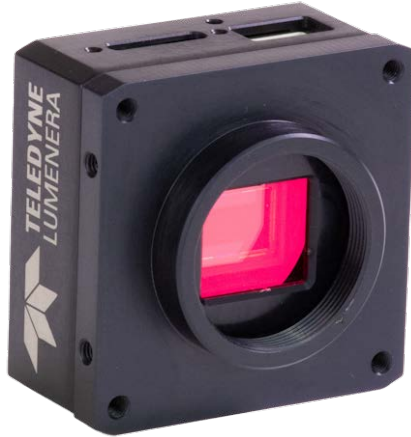
Lt-Ux0x-xxxxx and **Lt-Ux1x-xxxxx** USB 3 cameras are powered via the USB 3 computer port and may optionally be powered through the external interface header. **Lt-Ux2x-xxxxx** USB 3 cameras (XL) must be powered through the external interface header. The external interface header also provides access for hardware input and output signals.

Some of the Lt Series feature highlights include:

- Compliant with third-party USB3 Vision application development software
- Color or monochrome Sony IMX series electronic global shutter CMOS sensors
- High-Speed USB 3.1 Gen 1 interface for fastest image delivery and simplified connectivity
- 128 MB / 256 MB (XL models) low-latency RAM frame buffer
- Transfer Burst Mode supported
- Region of Interest (ROI) option to provide higher frame rates
- Selectable 8 or 12-bit pixel data
- Multiple data rates supported, each optimized for lowest noise performance
- Compact, robust form factor
- Locking industrial micro USB (power / data) and General Purpose I/O connectors for control of peripherals and lighting synchronization
- P-Iris connector for support of precise iris lens control (available with **LT-Ux0x-xxxxx** series camera models)
- The **Lt-Ux0x-xxxxx** series with 4 GPI/O, the options are: 1 optically isolated output, 1 optically isolated input, and 2 configurable I/O ports controls for synchronization (trigger and strobe) of multiple cameras, peripherals, and lighting
- The **Lt-Ux1x-xxxxx** series which uses a smaller case, has a reduced I/O signal set on a locking 9-pin connector
- The **Lt-Ux2x-xxxxx** series boasts up to 31 MP, is designed to support operating temperatures between 0°C–50°C and is suited for outdoor applications such as traffic monitoring.
- FCC Class B, CE Certified

1.2 Model Part Numbers

This manual covers the monochrome and color models of USB3 Vision cameras summarized in the tables below. Specific camera model specifications follow this section.



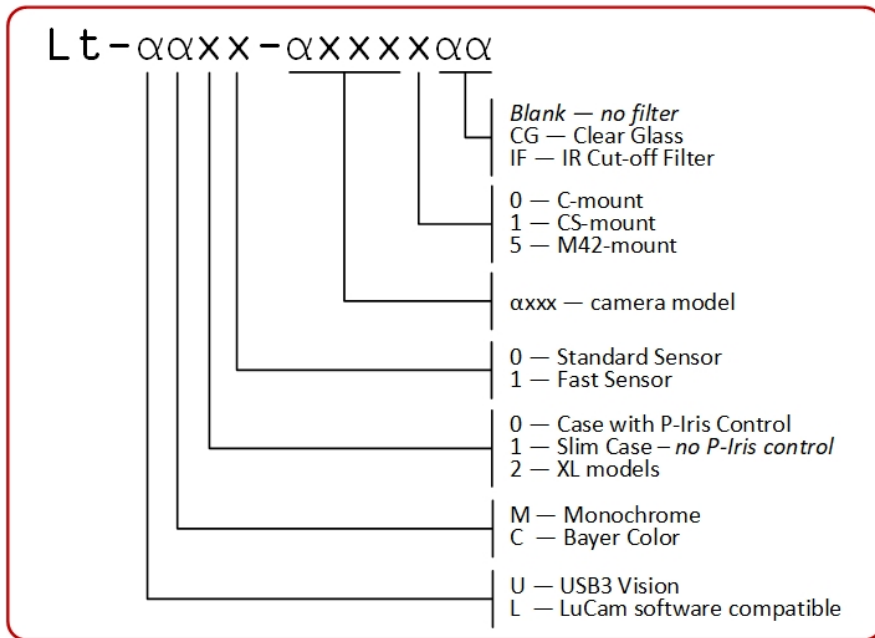
Compact models (P/N: LT-xx1x-xxxxx)



Medium size models with P-Iris (P/N: LT-xx0x-xxxxx)



XL models (P/N: LT-Ux2x-xxxxx)



Part number description

1.2.1 Monochrome Cameras

All models use Global Shutter sensors unless designated with ***RS** for Rolling Shutter.

Lt Model Full Resolution	Sensor & Size	Lens Mount case version	Lens Image Circle	Lt Part Number	Notes
Lt-M1610 1608 X 1104	Sony 1.7M (IMX432)	C-mount	1.1"	LT-UM11-M1610	
Lt-M1630 1632 x 1248	Sony 2.0M (IMX430)	C-mount	1/1.7"	LT-UM11-M1630	
Lt-M1950 1932 x 1216	Sony 2.3M (IMX392)	C-mount	1/2.3"	LT-UM10-M1950	
		CS-mount		LT-UM10-M1951	
Lt-M1980 1944 x 1472	Sony 2.9M (IMX429)	C-mount	2/3"	LT-UM11-M1980	
Lt-M2020 2064 x 1544	Sony 3.2M (IMX265)	C-mount	1/1.8"	LT-UM11-M2020	
		CS-mount		LT-UM11-M2021	
Lt-M2050 2064 x 1544	Sony 3.2M (IMX252)	C-mount w/P-Iris	1/1.8"	LT-UM00-M2050	
				LT-UM00-M2050CG	With Clear Glass
Lt-M2420 2464 x 2056	Sony 5.1M (IMX264)	C-mount	2/3"	LT-UM11-M2420	
		CS-mount		LT-UM11-M2421	
Lt-M2450 2464 x 2056	Sony 5.1M (IMX250)	C-mount w/P-Iris	2/3"	LT-UM00-M2450	
				LT-UM00-M2450CG	With Clear Glass
Lt-M3200 3216 x 2208	Sony 7.1M (IMX428)	C-mount	1.1"	LT-UM11-M3200	
Lt-M3840 3840 x 2160	Sony 8.3M (IMX334) *RS	C-mount	1/1.8"	LT-UM10-M3840	
		CS-mount		LT-UM10-M3841	
Lt-M4030 4112 x 2176	Sony 8.9M (IMX267)	C-mount	1"	LT-UM11-M4030	
Lt-M4060 4112 x 2176	Sony 8.9M (IMX255)	C-mount w/P-Iris	1"	LT-UM00-M4060	
				LT-UM00-M4060CG	With Clear Glass
Lt-M4020 4112 x 3008	Sony 12.4M (IMX304)	C-mount	1.1"	LT-UM11-M4020	
Lt-M4040 4112 x 3008	Sony 12.4M (IMX253)	C-mount w/P-Iris	1.1"	LT-UM00-M4040	
				LT-UM00-M4040CG	With Clear Glass
Lt-M5470 5472 x 3084	Sony 16.9M (IMX387)	M42-mount	4/3"	LT-UM20-M5475	
Lt-M4430 4432 x 4436	Sony 19.7M (IMX367)	M42-mount	4/3"	LT-UM20-M4435	

Lt Model Full Resolution	Sensor & Size	Lens Mount case version	Lens Image Circle	Lt Part Number	Notes
<u>Lt-M5500</u> 5472 x 3648	Sony 20.0M (IMX183) *RS	C-mount	1"	LT-UM10-M5500	
<u>Lt-M6480</u> 6480 x 4860	Sony 31.5M (IMX342)	M42-mount	APS-C	LT-UM20-M6485	


1.2.2 Color Cameras

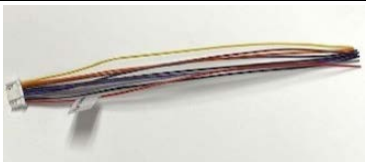
All models use Global Shutter sensors unless designated with ***RS** for Rolling Shutter.



Lt Model Full Resolution	Sensor & Size	Lens Mount case version	Lens Image Circle	Part Number	Notes
<u>Lt-C1610</u> 1608 X 1104	Sony 1.7M (IMX432)	C-mount	1.1"	LT-UC11-C1610IF	with IR Cut-off Filter
<u>Lt-C1630</u> 1632 x 1248	Sony 2.0M (IMX430)	C-mount	1/1.7"	LT-UC11-C1630IF	with IR Cut-off Filter
<u>Lt-C1900</u> 1944 x 1096	Sony 2.1M (IMX327) *RS	C-mount	1/2.8"	LT-UC10-C1900IF	with IR Cut-off Filter
		CS-mount		LT-UC10-C1901IF	with IR Cut-off Filter
<u>Lt-C1950</u> 1932 x 1216	Sony 2.3M (IMX392)	C-mount	1/2.3"	LT-UC10-C1950IF	with IR Cut-off Filter
		CS-mount		LT-UC10-C1951IF	with IR Cut-off Filter
<u>Lt-C1980</u> 1944 x 1472	Sony 2.9M (IMX429)	C-mount	2/3"	LT-UC11-C1980IF	with IR Cut-off Filter
<u>Lt-C2020</u> 2064 x 1544	Sony 3.2M (IMX265)	C-mount	1/1.8"	LT-UC11-C2020IF	with IR Cut-off Filter
		CS-mount		LT-UC11-C2021IF	with IR Cut-off Filter
<u>Lt-C2050</u> 2064 x 1544	Sony 3.2M (IMX252)	C-mount w/P-Iris	1/1.8"	LT-UC00-C2050	
				LT-UC00-C2050IF	with IR Cut-off Filter
<u>Lt-C2420</u> 2464 x 2056	Sony 5.1M (IMX264)	C-mount	2/3"	LT-UC11-C2420IF	with IR Cut-off Filter
		CS-mount		LT-UC11-C2421IF	with IR Cut-off Filter
<u>Lt-C2450</u> 2464 x 2056	Sony 5.1M (IMX250)	C-mount w/P-Iris	2/3"	LT-UC00-C2450	
				LT-UC00-C2450IF	with IR Cut-off Filter
<u>Lt-C3200</u> 3216 x 2208	Sony 7.1M (IMX428)	C-mount	1.1"	LT-UC11-C3200IF	with IR Cut-off Filter
<u>Lt-C3840</u> 3840 x 2160	Sony 8.3M (IMX334) *RS	C-mount	1/1.8"	LT-UC10-C3840IF	with IR Cut-off Filter
		CS-mount		LT-UC10-C3841IF	with IR Cut-off Filter
<u>Lt-C4030</u> 4112 x 2176	Sony 8.9M (IMX267)	C-mount	1"	LT-UC11-C4030IF	with IR Cut-off Filter
<u>Lt-C4060</u> 4112 x 2176	Sony 8.9M (IMX255)	C-mount w/P-Iris	1"	LT-UC00-C4060	
				LT-UC00-C4060IF	with IR Cut-off Filter
<u>Lt-C4020</u> 4112 x 3008	Sony 12.4M (IMX304)	C-mount	1.1"	LT-UC11-C4020IF	with IR Cut-off Filter
<u>Lt-C4040</u> 4112 x 3008	Sony 12.4M (IMX253)	C-mount w/P-Iris	1.1"	LT-UC00-C4040	
				LT-UC00-C4040IF	with IR Cut-off Filter
<u>Lt-C5470</u> 5472 x 3084	Sony 16.9M (IMX387)	M42-mount	4/3"	LT-UC20-C5475	



Lt Model Full Resolution	Sensor & Size	Lens Mount case version	Lens Image Circle	Part Number	Notes
<u>Lt-C4430</u> 4432 x 4436	Sony 19.7M (IMX367)	M42-mount	4/3"	LT-UC20-C4435	
<u>Lt-C5500</u> 5472 x 3648	Sony 20.0M (IMX183) *RS	C-mount	1"	LT-UC10-C5500IF	with IR Cut-off Filter
<u>Lt-C6480</u> 6480 x 4860	Sony 31.5M (IMX342)	M42-mount	APS-C	LT-UC20-C6485	

1.2.3 Optional Accessories

Accessories & Cables for all camera series	Part Number	
USB 3.1 Cable A-Male to Micro-B male Locking (3m / 9.75ft)	La303ML	

Accessories & Cables for camera series LT-Ux1x-xxxxxx	Part Number	
GPIO Sync cable, 9-Pin with I/O lead (power & lead cable)	La4000PAFL	




Accessories & Cables for camera series LT-Ux0x-xxxxxx	Part Number	
Locking 5V DC international power supply with GPIO cable (power & blunt lead cable)	La2000PIOK	
Hirose 8-Pin GPIO with I/O blunt lead	La2000PAFL	

Accessories & Cables for camera series LT-Ux2x-xxxxx	Part Number	
Generic 12 volt power supply for aux. connector (Samtec 10-Pin) – 4 meter length	G3-APWS-S10S04M	
IR Cut-off Filter M42 mount camera filter designed by Midopt to thread directly into our M42-mount camera between lens and sensor.	G3-AM42-SP644IF	

Accessories & Cables for camera series LT-Ux2x-xxxxx	Part Number	
Heatsink 51mm x 28mm x 15mm (screws included)	G3-AHSK-51X28	
Lens adapter M42 x 1mm to F-mount (Nikon)	G2-AM42-MOUNT4	
Cable (2M): Camera Auxiliary Samtec ISDF-05-D connector to breakout Euroblock connector	G3-AIOC-BRKOUT2M	
Cable (2M): Camera Auxiliary Samtec ISDF-05-D connector to flying Lead (open-ended) from pin 1 to 10	G5-AIOC-BLUNT2M	
Mounting Bracket Assembly Including Hole for the Third Mounting position (¼-20 Mounting Adapter) 35 mm of length 1/4 inch screw mount	G3-AMNT-BRA02	

See section [Ruggedized Cable Accessories](#) cabling options available directly from our preferred cable sources.

1.3 Software Requirements

	Windows OS & USB3 Vision Series Lt-Uxxx-xxxxx models are pre-set to be compatible with the Teledyne Sapera LT software SDK (USB3 Vision compliant) or with a third-party USB3 Vision compliant SDK.
	Windows OS & Lumenera LuCam API Series Lt-Lxxx-xxxxx models are pre-set to be compatible with the Lumenera LuCam software API. Series Lt-Ux2x-xxxxx models are compatible with the Lumenera LuCam software API versions 6.9 and up. LuCam is not USB3 Vision compliant.
	Linux OS & Lumenera LuCam API Series Lt-Lxxx-xxxxx and Lt-Ux2x-xxxxx models are compatible with the Linux software API. USB3 Vision and LuCam can be used with the Linux API. See Lumenera LuCam API for Linux OS .

Note for Lt-Ux2x-xxxxx Series Cameras: Lt-Ux2x-xxxxx series cameras may be used with either USB3 Vision SDK (Sapera LT/third-party) or LuCam SDK according to the driver that is used. See [Using the U3V Device Manager Tool](#) for details on selecting from drivers.

1.3.1 Firmware Files for all Lt Models

The latest firmware files for all Lt Models are available on the Teledyne Lumenera Lt Series support web site (subject to change):

<https://www.lumenera.com/support/industrial-usb-ethernet/drivers-downloads/usb3-camera-firmware-updater.html>

1.3.1.1 Firmware Update using Sapera LT

When using Sapera LT, update the camera firmware using CamExpert (see [File Access via the CamExpert Tool \(Quick Camera Firmware Upgrade\)](#)). The Camera firmware can easily be upgraded within your own application via the API. The camera has a failsafe scheme which prevents unrecoverable camera errors even in the case of a power interruption.

1.3.1.2 Firmware Update using Lumenera API

When using Lumenera API, use the Lumenera Updater tool. See [Using LtUpdater](#) for details.

1.3.1.3 Switching Camera Modes

The camera can be switched between LuCam mode and USB3 Vision mode as required by the user. See [Switching a Teledyne Lumenera camera from LuCam mode to USB3 Vision mode](#) and [Switching a Teledyne Lumenera camera from USB3 Vision mode to LuCam mode](#) for details on the procedure.

2 Series Specifications

2.1 Common Specifications

Camera Controls	
Synchronization Modes	Free running, External triggered, Software Triggered
Exposure Control	Internal – Programmable via the camera API External – based on Trigger Width
Exposure Mode	Programmable with time increments that are camera model specific Minimum (in μ s) is model specific Pulse controlled via Trigger pulse width
Inputs/Outputs (Lt-Ux0x-xxxxx series)	4 GPI/O options: 1 optically isolated output, 1 optically isolated input, and 2 configurable I/O ports controls for synchronization (trigger and strobe) of multiple cameras, peripherals, and lighting
Inputs/Outputs (Lt-Ux1x-xxxxx series)	2 GPI/O bi-directional terminals 1 optically isolated input 1 optically isolated output 3.3 Vdc output source (maximum 150 mA)
Inputs/Outputs (Lt-Ux2x-xxxxx series)	2 GP inputs 3 GP outputs
Features	
Flash memory	Non-volatile flash memory implemented
Image Buffer	128 MB (Lt-Ux0x-xxxxx and Lt-Ux1x-xxxxx series) 256 MB (Lt-Ux2x-xxxxx series)
Gain	Manual and automatic control – Analog and Digital (sensor specific)
Auto-Exposure	Yes, with user set target luminance level
Color model output	Color cameras support BayerBG8 and BayerBG16 output modes
LUT	Programmable LUT (Look-up-table)
Timestamp	Timer to Timestamp images and events
Back Focal Distance	
Back Focal Distance	17.52 mm (C-mount) 12.52 mm (CS-mount) 12 mm (M42-mount)
Mechanical Interface	
Data Interface	USB 3.1, micro-b locking connector
I/O Interface	Locking Hirose MXR-8R-8SA(71) (Lt-Ux0x-xxxxx series) Locking 9-pin JST NSHR-09V-S for the (Lt-Ux1x-xxxxx series) Locking 10-pin Samtec TFM-105-02-L-D-WT (Lt-Ux2x-xxxxx series)
Camera Dimensions (W x H x L) see Mechanical Specifications	44 x 44 x 61 mm (Lt-Ux0x-xxxxx series) 45 x 45 x 28 to 36 mm (model dependent for Lt-Ux1x-xxxxx series) 59 x 59 x 44 mm (Lt-Ux20-xxxxx series)
Mass	~ 140 g (approximate value for Lt-Ux0x-xxxxx series) ~ 88 g (approximate value for Lt-Ux1x-xxxxx series) ~ 263 g (approximate value for Lt-Ux20-xxxxx series)

Electrical Interface	
Input Voltage	5 V via power over USB or via external interface connector (Lt-Ux1x-xxxxx, Lt-Ux0x-xxxxx series) 10 to 28 V via external interface connector only (Lt-Ux2x-xxxxx series)
Power Dissipation (typical)	~ 4 W (Lt-Ux0x-xxxxxx series) ~ 2.3 to 3.6 W (Lt-Ux1x-xxxxxx series) ~ 8 W (Lt-Ux20-xxxxx series)
Environmental Conditions	
Operating Temperature (at camera front plate)	All Models: 0°C to +50°C <i>Any metallic camera mounting provides heat sinking, which consequently reduces the internal temperature.</i>
Operating Relative Humidity	5% to 90% non-condensing
Storage	-30°C to +70°C
Conformity	FCC Class B & CE Certified, RoHS & WEEE Compliant
Shock / Vibration	EC60721-4-7 Class 7M2 & IEC60068-2-27
Sinusoidal & Random Vibration	IEC60721-4-7 Class 7M2 & IEC60721-4-2 Class 2M2 IEC60068-2-6 & IEC60068-2-64
Case Protection Rating	IP50 (Optical Path) (Lt-Ux0x-xxxxx series) IP40 (Optical Path) (Lt-Ux1x-xxxxx series) IP40 for the Lt-Ux2x-xxxxx series

2.2 Sensor Cosmetic Specifications

After Factory Calibration and/or Corrections are applied (dependent on sensor)

Blemish Specifications	Maximum Number of Defects	Blemish Description
Hot/Dead Pixel defects	Typical 0.0025% Max 0.005%	Any pixel that deviates by $\pm 20\%$ from the average of neighboring pixels at 50% saturation including pixel stuck at 0 and maximum saturated value.
Spot defects	None	Grouping of more than 8 pixel defects within a sub-area of 3x3 pixels, to a maximum spot size of 7x7 pixels.
Clusters defects	None	Grouping of more than 5 single pixel defects in a 3x3 kernel.
Column defects	None	Vertical grouping of more than 10 contiguous pixel defects along a single column.
Row defects	None	Horizontal grouping of more than 10 contiguous pixel defects along a single row.

Cleanliness Test conditions

- Nominal light = illumination at 60% of saturation
- Camera temperature $\leq 55^\circ\text{C}$
- At exposures lower than 0.1 seconds
- At gain = 1

Defective Pixel Correction Test conditions

- Gray: illumination at 60% of saturation, gain = 1
- Black: gain = 15
- Camera temperature = $50^\circ\text{C} - 55^\circ\text{C}$

Sony Sensor Limitation

- Max pixel saturated values: Max Pixel format bit depth – 4095 (12-bit)

2.3 Dynamic Range & Signal to Noise Ratio Measurement Conditions

Specifications calculated according to EMVA-1288 standard, using white LED light.

Dynamic Range Test Conditions

- Exposure 100 μ s for 0% Full Light Level
- Lt-x1610 exposure 6 ms, gain 1, variable light source from dark to saturation
- Lt-x1630 exposure 40 ms, gain 1, variable light source from dark to saturation
- Lt-x1900 exposure 17 ms, gain 1, variable light source from dark to saturation
- Lt-x1950 exposure 60 ms, gain 1, variable light source from dark to saturation
- Lt-x1980 exposure 75 ms, gain 1, variable light source from dark to saturation
- Lt-x2020 exposure 16 ms, gain 1, variable light source from dark to saturation
- Lt-x2050 exposure 45 ms, gain 1, variable light source from dark to saturation
- Lt-x2420 exposure 28 ms, gain 1, variable light source from dark to saturation
- Lt-x2450 exposure 33 ms, gain 1, variable light source from dark to saturation
- Lt-x3200 exposure 38 ms, gain 1, variable light source from dark to saturation
- Lt-x3840 exposure 43 ms, gain 1, variable light source from dark to saturation
- Lt-x4030 exposure 150 ms, gain 1, variable light source from dark to saturation
- Lt-x4060 exposure 50 ms, gain 1, variable light source from dark to saturation
- Lt-x4020 exposure 150 ms, gain 1, variable light source from dark to saturation
- Lt-x4040 exposure 32 ms, gain 1, variable light source from dark to saturation
- Lt-x5500 exposure 10 ms gain 1, variable light source from dark to saturation
- Lt-x5470 exposure 3.5 ms, gain 1, variable light source from dark to saturation
- Lt-x4430 exposure 3.5 ms, gain 1, variable light source from dark to saturation
- Lt-x6480 exposure 3.5 ms, gain 1, variable light source from dark to saturation

SNR Test Conditions

- Exposure 2000 μ s
- 80% saturation

2.4 Mean Time between Failure (MTBF)

Teledyne Lumenera MTBF calculations use the Parts Count / Parts Stress method. Calculated assembly FIT values are rounded up with margin to provide adequate headroom and the final quoted MTBF is then rounded down to the nearest year.

In practice, MILSTD217F is used to model passive and simple active parts, such as diodes and transistors, because manufacturer data is unreliable. When MILSTD217F models are used to represent more than one physical part, worst case parameters are used. Manufacturer's data is used to model more complicated active parts, such as buffers and FPGAs, because the internal structures are not known, and the manufacturer data is more likely to be valid. When manufacturer data is used, it is modified to meet specific use conditions using the Arrhenius equation and the result is set to a 90% confidence level using the Chi-Squared Distribution Method. Again, when

more than one of the same part exist on an assembly, worst case parameters are used. Manufacturer data is either obtained from the manufacturer’s website or provided directly from the manufacturer.

The calculated MTBF only considers electronic components. It does not include mechanical parts unless specified.

MTBF assumptions

- Fixed Ground Environment Readily Accessible for Maintenance
- Manufactured to Specification
- Proper Operating Conditions/Environment During Life Cycle

It is important to note that the MTBF result provided here is subject to change due to design changes or as new reliability/test data becomes available.

Calculation Results

Lt Series Product MTBF Results (Lt-Ux0x-xxxxx, Lt-Ux1x-xxxxx)	
FIT Value	9500
MTBF Years	12.02

3 Model Specifications

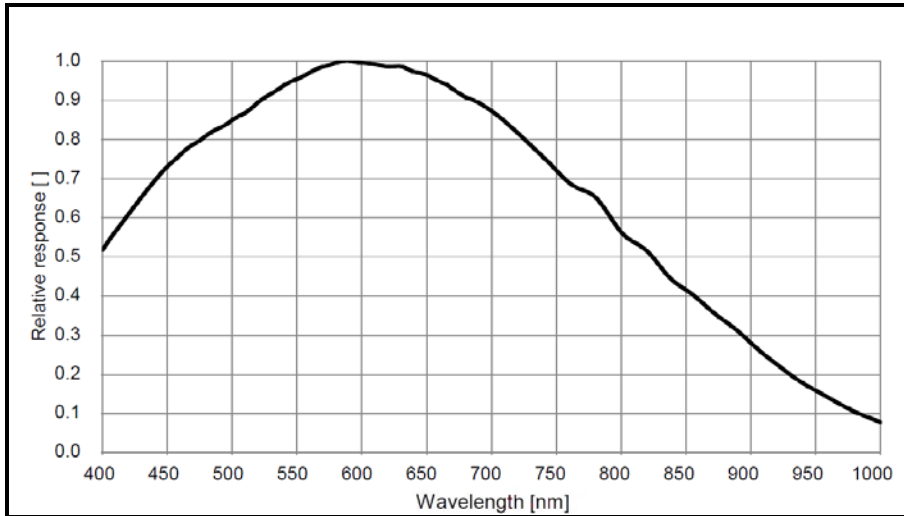
3.1 Specifications Lt-M1610 / Lt-C1610

Supported Features	Lt-M1610 / Lt-C1610	
Resolution	1608 x 1104	
Sensor	Sony IMX432 (1.7 MP)	
Pixel Size	9.00 μm x 9.00 μm	
Optical Format	1.1"	
Shutter type	Full frame electronic global shutter function	
Full Well charge	100.4 ke (max)	
Pixel Data Formats	Monochrome 8-bit or 12-bit	Bayer 8-bit or 12-bit
Max. Internal Frame Rate Full resolution	96.3 fps (8-bit, 12-bit)	
Maximum Sustained Frame Rate Output	96.3 fps (8-bit)	
Exposure Time Range	5 μs – 4295 s (triggered) 14 μs – 9.2 s (continuous)	
Trigger to Exposure Minimum Delay	1 μs	
Actual Exposure Time Minimum	5.00 μs (triggered) 13.81 μs (continuous) (Exposure time increment steps = Horizontal Line Time)	
Min. Time from End of Exposure to Start of Next Exposure	105.7 μs	
Horizontal Line Time	8.81 μs	
Readout Time	10.36 ms (Horizontal Line Time) x (lines in frame + 72) — in μs	
Auto-Exposure	Yes, with Auto-Brightness Target	
Black offset control	Yes (in DN)	
Gain Control	Yes (256 max)	
Color Enhancement Support	Monochrome Model — No	Color Model — Yes (Brightness, Contrast, Gamma)
Defective Pixel Replacement	Yes	
Image Correction	No	
Image Flip Support	Yes – On Sensor, Vertical and Horizontal	
Binning Support	No	
Multi-ROI Support	No	
Decimation Support	Yes – 1/2x, vertical and horizontal	
On-Board Image Memory	Yes (128 MB)	
Output Dynamic Range (dB)	72.7 dB	
SNR	50.0 dB	

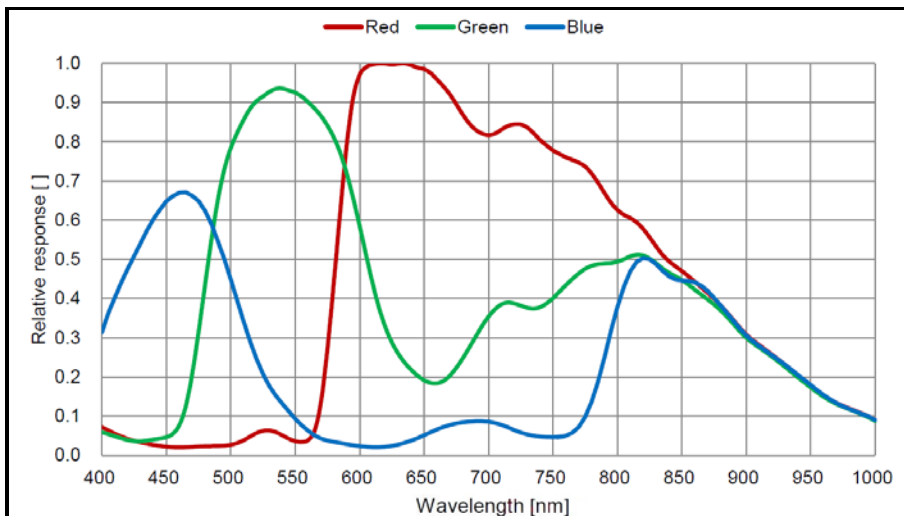
3.1.1 Spectral Response Curves Lt-M1610 / Lt-C1610

Response curves from sensor datasheet.

Monochrome (Lt-M1610)



Color (Lt-C1610)



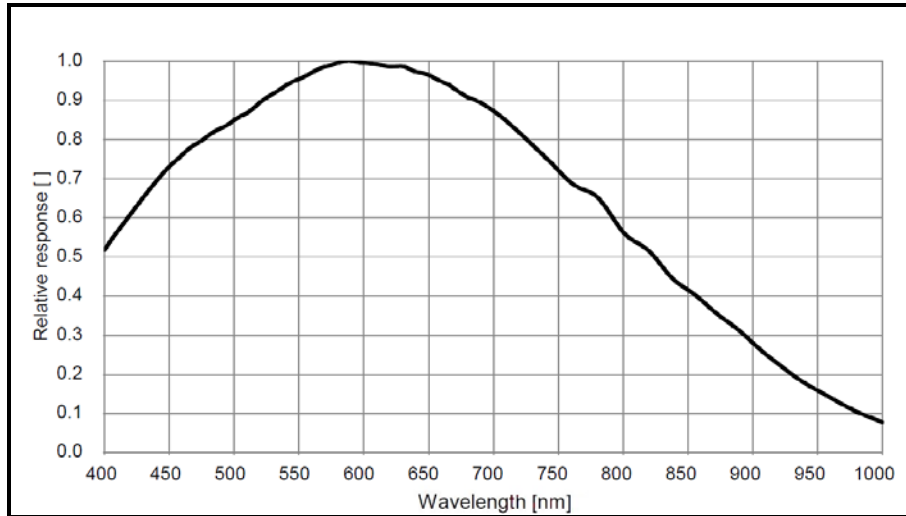
3.2 Specifications Lt-M1630 / Lt-C1630

Supported Features	Lt-M1630 / Lt-C1630	
Resolution	1632 x 1248	
Sensor	Sony IMX430 (2.0 MP)	
Pixel Size	4.50 μm x 4.50 μm	
Optical Format	1/1.7"	
Shutter type	Full frame electronic global shutter function	
Full Well charge	25.1 ke (max)	
Pixel Data Formats	Monochrome 8-bit or 12-bit	Bayer 8-bit or 12-bit
Max. Internal Frame Rate Full resolution	85.7 fps (8-bit, 12-bit)	
Maximum Sustained Frame Rate Output	85.7 fps (8-bit)	
Exposure Time Range	5 μs – 4295 s (triggered) 14 μs – 151.8 s (continuous)	
Trigger to Exposure Minimum Delay	1 μs	
Actual Exposure Time Minimum	5.00 μs (triggered) 14.05 μs (continuous) (Exposure time increment steps = Horizontal Line Time)	
Min. Time from End of Exposure to Start of Next Exposure	54.3 μs	
Horizontal Line Time	9.05 μs	
Readout Time	11.64 ms (Horizontal Line Time) x (lines in frame + 38) — in μs	
Auto-Exposure	Yes, with Auto-Brightness Target	
Black offset control	Yes (in DN)	
Gain Control	Yes (256 max)	
Color Enhancement Support	Monochrome Model – No	Color Model – Yes (Brightness, Contrast, Gamma)
Defective Pixel Replacement	Yes	
Image Correction	No	
Image Flip Support	Yes – On Sensor, Vertical and Horizontal	
Binning Support	Yes, on sensor, monochrome model	
Multi-ROI Support	No	
Decimation Support	Yes, 1/2x Vertical and Horizontal	
On-Board Image Memory	Yes (128 MB)	
Output Dynamic Range (dB)	72.7 dB	
SNR	44.0 dB	

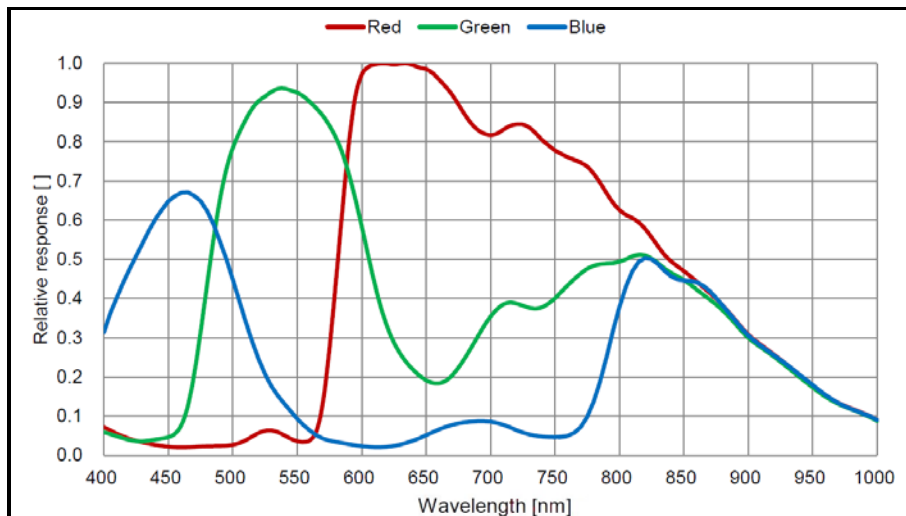
3.2.1 Spectral Response Curves Lt-M1630 / Lt-C1630

Response curves from sensor datasheet.

Monochrome (Lt-M1630)



Color (Lt-C1630)



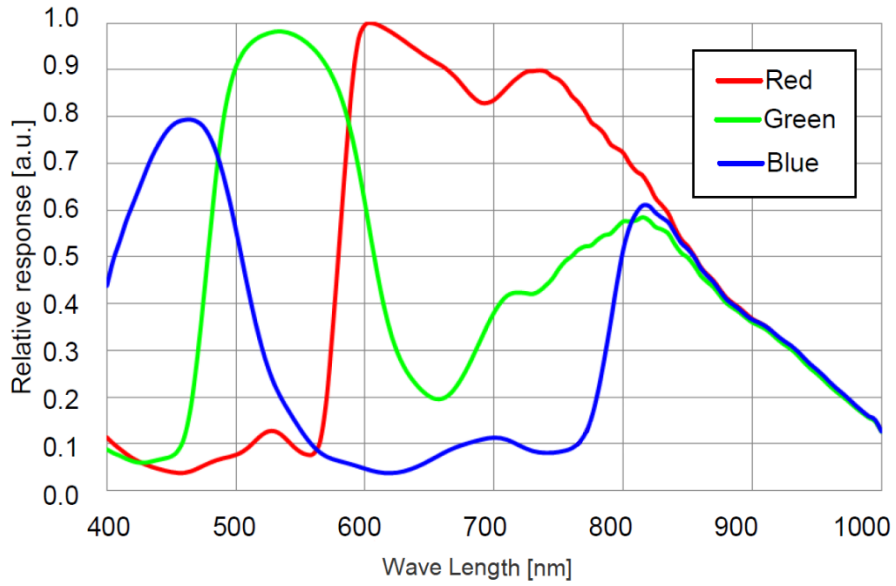
3.3 Specifications Lt-C1900

Supported Features	C1900
Resolution	1944 x 1096
Sensor	Sony IMX327 (2.1 MP)
Pixel Size	2.9 μm x 2.9 μm
Optical Format	1/2.8"
Shutter Type (see Guide to Using a Rolling Shutter Camera)	Electronic Rolling Shutter function (ERS) (continuous) Global Reset Release (GRR) function (single exposure)
Full Well charge	11.2 ke (max)
Pixel Data Formats	Bayer 8-Bit or 12-Bit
Max. Internal Frame Rate Full resolution	60 fps (8-bit, 12-bit)
Maximum Sustained Frame Rate Output	60 fps (8-bit)
Exposure Time Range	149 μs – 1 s (triggered) 15 μs – 1 s (continuous)
Trigger to Exposure Minimum Delay	1 μs
Actual Exposure Time Minimum	148.15 μs (triggered) 14.81 μs (continuous) (Exposure time increment steps = Horizontal Line Time)
Minimum Time from End of Exposure to Start of Next Exposure	118.5 μs
Horizontal Line Time	29.63 μs (triggered) 14.81 μs (continuous)
Readout Time	32.47 ms (triggered) 16.23 ms (continuous) (Horizontal Line Time) x (lines in frame) — in μs
Auto-Exposure	Yes, with Auto-Brightness Target (continuous only)
Black Offset control	Yes (in DN)
Gain Control	In-sensor gain (3715x digital max)
Color Enhancement Support	Yes – (Brightness, Contrast, Gamma)
Defective Pixel Replacement	Yes
Image Correction	No
Image Flip Support	Yes, in-sensor, both vertical and horizontal
Binning Support	No
Multi-ROI Support	No
Decimation Support	No
On-board image memory	Yes (128 MB)
Output Dynamic Range	72.7 dB
SNR	40.5 dB

3.3.1 Spectral Response Curves Lt-C1900

Response curves from sensor datasheet.

Color (Lt-C1900)



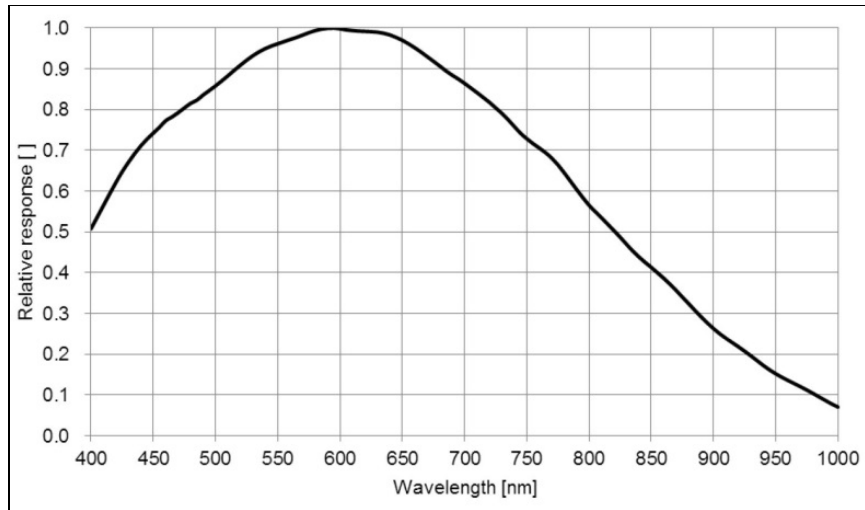
3.4 Specifications Lt-M1950 / Lt-C1950

Supported Features	Lt-M1950 / Lt-C1950	
Resolution	1932 x 1216	
Sensor	Sony IMX392 (2.3 MP)	
Pixel Size	3.45 μm x 3.45 μm	
Optical Format	1/2.3"	
Shutter type	Full frame electronic global shutter function	
Full Well charge	10.5 ke (max)	
Pixel Data Formats	Monochrome 8-bit or 12-bit	Bayer 8-bit or 12-bit
Max. Internal Frame Rate Full resolution	162 fps (8-bit) / 81 fps (12-bit)	
Maximum Sustained Frame Rate Output	162 fps (8-bit)	
Exposure Time Range	14 μs – 4295 s (triggered) 25 μs – 11.1 s (continuous)	
Trigger to Exposure Minimum Delay	1 μs	
Actual Exposure Time Minimum	13.73 μs (Exposure time increment steps = Horizontal Line Time)	
Min. Time from End of Exposure to Start of Next Exposure	31.7 μs	
Horizontal Line Time	3.96 μs	
Readout Time	4.91 ms (Horizontal Line Time) x (lines in frame + 23) — in μs	
Auto-Exposure	Yes, with Auto-Brightness Target	
Black offset control	Yes (in DN)	
Gain Control	Yes (max 256)	
Color Enhancement Support	No – Monochrome Models	Yes – Color Models (Brightness, Contrast, Gamma)
Defective Pixel Replacement	Yes	
Image Correction	No	
Image Flip Support	Yes, In-Sensor, Vertical and Horizontal	
Binning Support	Yes, on sensor, monochrome model	
Multi-ROI Support	No	
Decimation Support	Yes, 1/2x vertical and horizontal	
On-Board Image Memory	128 MB	
Output Dynamic Range (dB)	73.4 dB	
SNR	40.2 dB	

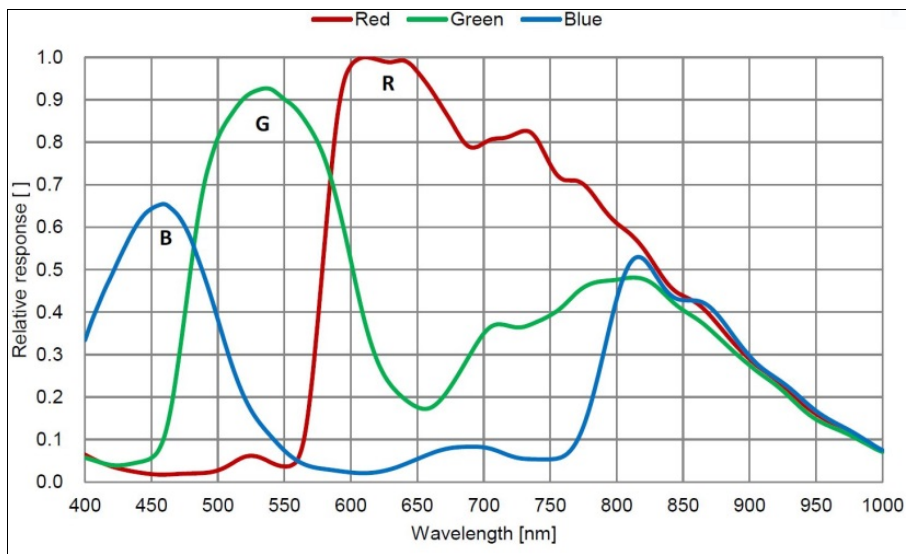
3.4.1 Spectral Response Curves Lt-M1950 / Lt-C1950

Response curves from sensor datasheet.

Monochrome (Lt-M1950)



Color (Lt-C1950)



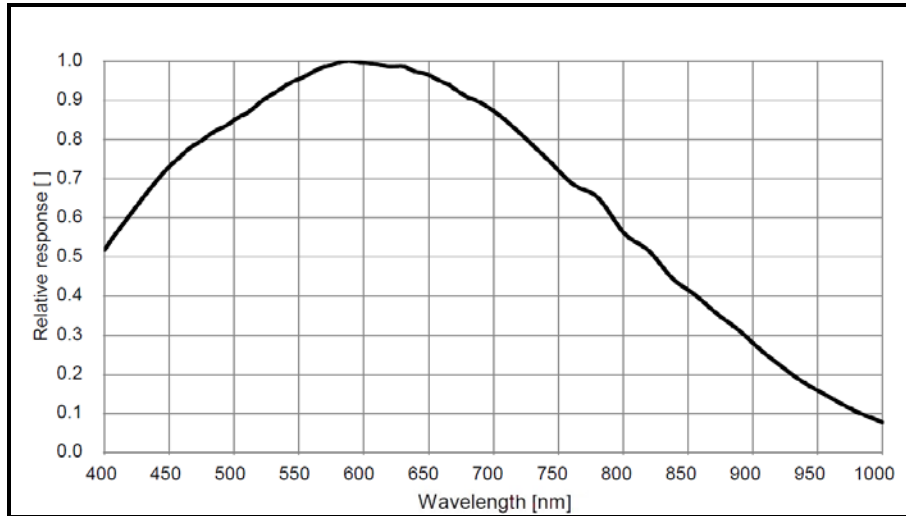
3.5 Specifications Lt-M1980 / Lt-C1980

Supported Features	Lt-M1980 / Lt-C1980	
Resolution	1944 x 1472	
Sensor	Sony IMX429 (2.9 MP)	
Pixel Size	4.50 μm x 4.50 μm	
Optical Format	2/3"	
Shutter type	Full frame electronic global shutter function	
Full Well charge	24.9 ke	
Pixel Data Formats	Monochrome 8-bit or 12-bit	Bayer 8-bit or 12-bit
Max. Internal Frame Rate Full resolution	62.8 fps (8-bit, 12-bit)	
Maximum Sustained Frame Rate Output	62.8 fps (8-bit)	
Exposure Time Range	5 μs – 4295 s (triggered) 16 μs – 177.1 s (continuous)	
Trigger to Exposure Minimum Delay	1 μs	
Actual Exposure Time Minimum	5.00 μs (triggered) 15.56 μs (continuous) (Exposure time increment steps = Horizontal Line Time)	
Min. Time from End of Exposure to Start of Next Exposure	42.2 μs	
Horizontal Line Time	10.56 μs	
Readout Time	15.92 ms (Horizontal Line Time) x (lines in frame + 36) — in μs	
Auto-Exposure	Yes, with Auto-Brightness Target	
Black offset control	Yes (in DN)	
Gain Control	Yes (256 max)	
Color Enhancement Support	Monochrome Model — No	Color Model — Yes (Brightness, Contrast, Gamma)
Defective Pixel Replacement	Yes	
Image Correction	No	
Image Flip Support	Yes, on sensor, vertical and horizontal	
Binning Support	Yes, on sensor, monochrome model	
Multi-ROI Support	No	
Decimation Support	Yes, 1/2x, vertical and horizontal	
On-Board Image Memory	128 MB	
Output Dynamic Range (dB)	72.0 dB	
SNR	43.9 dB	

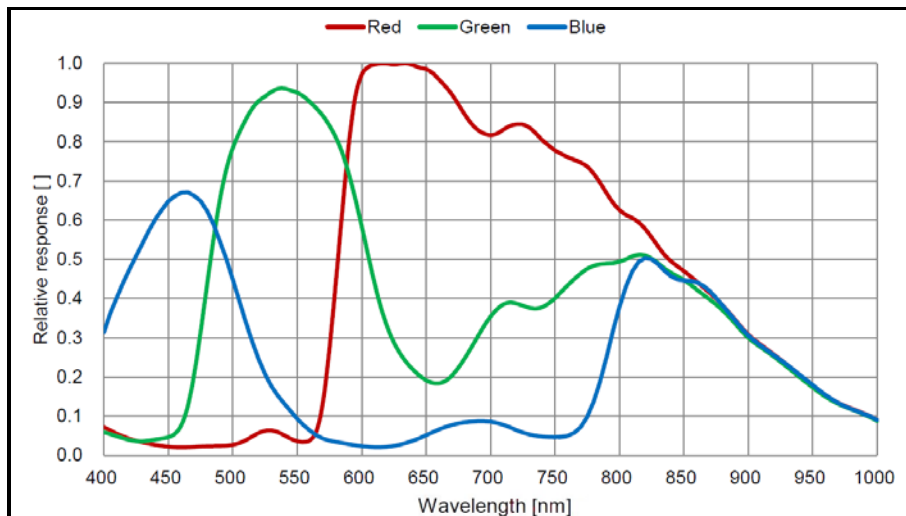
3.5.1 Spectral Response Curves Lt-M1980 / Lt-C1980

Response curves from sensor datasheet.

Monochrome (Lt-M1980)



Color (Lt-C1980)



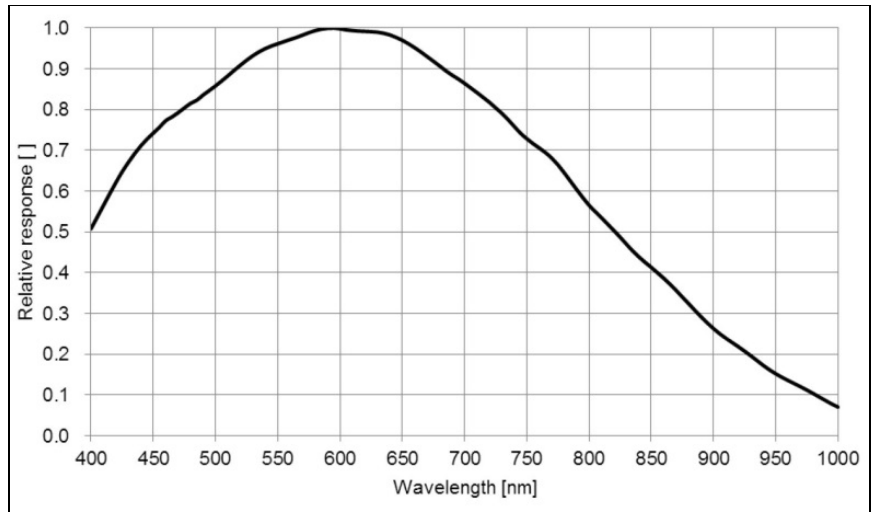
3.6 Specifications Lt-M2020 / Lt-C2020

Supported Features	M2020	C2020
Resolution	2064 x 1544	
Sensor	Sony IMX265 (3.2 MP)	
Pixel Size	3.45 μm x 3.45 μm	
Optical Format	1/1.8"	
Shutter type	Full frame electronic global shutter function	
Full Well charge	10.9 ke (max)	
Pixel Data Formats	Mono 8-bit & 12-bit	Bayer 8-Bit & 12-Bit
Max. Internal Frame Rate Full resolution	55 fps (8-bit, 12-bit)	
Maximum Sustained Frame Rate Output	55 fps (8-bit)	
Exposure Time Range	14 μs – 4295 s (triggered) 14 μs – 11.9 s (continuous)	
Trigger to Exposure Minimum delay	1 μs (Exposure time increment steps = Horizontal Line Time)	
Actual Exposure Time Minimum	13.73 μs	
Min. Time from End of Exposure to Start of Next Exposure (second frame)	91.2 μs	
Horizontal Line Time	11.40 μs	
Readout Time	17.80 ms (Horizontal Line Time) x (lines in frame + 17) — in μs	
Auto-Exposure	Yes, with Auto-Brightness Target	
Black offset control	Yes (in DN)	
Gain Control	In-sensor Gain (max 256)	
Color Enhancement Support	No – Monochrome Models	Yes – Color Models (Brightness, Contrast, Gamma)
Defective Pixel Replacement	Yes	
Image Correction	No	
Image Flip Support	Yes, In-Sensor, Vertical and Horizontal	
Binning Support	On selected monochrome model only, on FPGA	
Multi-ROI Support	No	
Decimation Support	Yes, 1/2x vertical and horizontal	
On-Board Image Memory	128 MB	
Output Dynamic Range (dB)	73.8 dB	
SNR	41.1 dB	

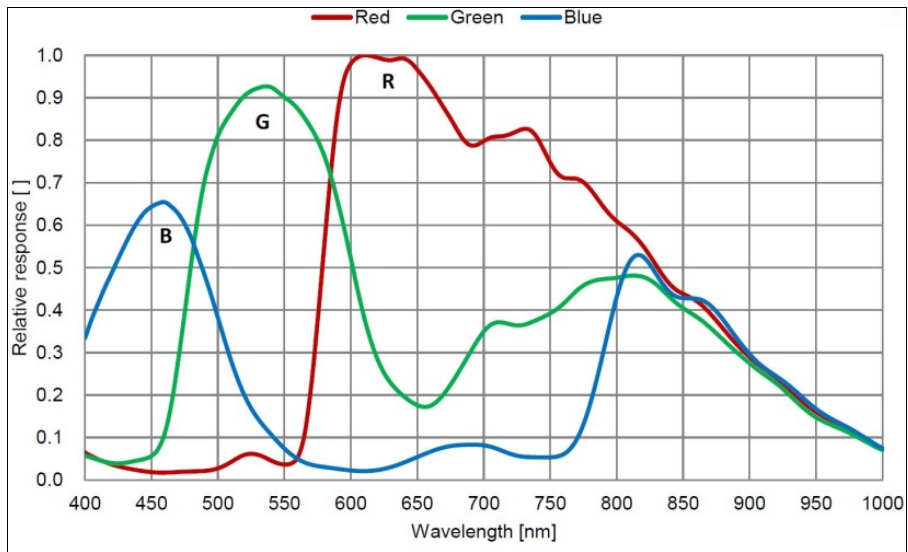
3.6.1 Spectral Response Curves Lt-M2020 / Lt-C2020

Response curves from sensor datasheet.

Monochrome (Lt-M2020)



Color (Lt-C2020)



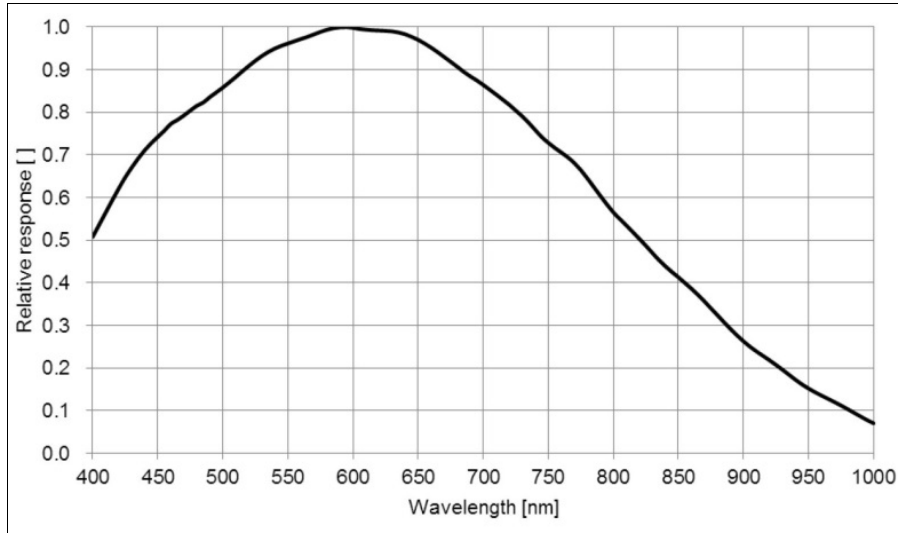
3.7 Specifications Lt-M2050 / Lt-C2050

Supported Features	Lt-M2050 / Lt-C2050	
Resolution	2064 x 1544	
Sensor	Sony IMX252 (3.2 MP)	
Pixel Size	3.45 μm x 3.45 μm	
Optical Format	1/1.8"	
Shutter type	Full frame electronic global shutter function	
Full Well charge	10.7 ke (max)	
Pixel Data Formats	Monochrome 8-bit or 12-bit	Bayer 8-bit or 12-bit
Max. Internal Frame Rate (Full resolution)	151 fps (8-bit) 83 fps (12-bit)	
Maximum Sustained Frame Rate Output	120 fps (8-bit)	
Exposure Time Range	14 μs – 4295 s (triggered) 14 μs – 8.2 s (continuous)	
Trigger to Exposure Minimum delay	1 μs	
Actual Exposure Time Minimum	13.73 μs (Exposure time increment steps = Horizontal Line Time)	
Min. Time from End of Exposure to Start of Next Exposure	41.7 μs	
Horizontal Line Time	4.17 μs	
Readout Time	6.60 ms (Horizontal Line Time) x (lines in frame + 38) — in μs	
Auto-Exposure	Yes, with Auto-Brightness Target	
Black offset control	Yes (in DN)	
Gain Control	Yes (max 256)	
Color Enhancement Support	No – Monochrome Models	Yes – Color Models (Brightness, Contrast, Gamma)
Defective Pixel Replacement	Yes	
Image Correction	No	
Image Flip	Yes, Horizontal and Vertical	
Binning Support	Yes, on sensor, monochrome model	
Multi-ROI Support	No	
Decimation Support	Yes, 1/2x vertical and horizontal	
On-Board Image Memory	128 MB	
Output Dynamic Range (dB)	73.0 dB	
SNR	40.3 dB	

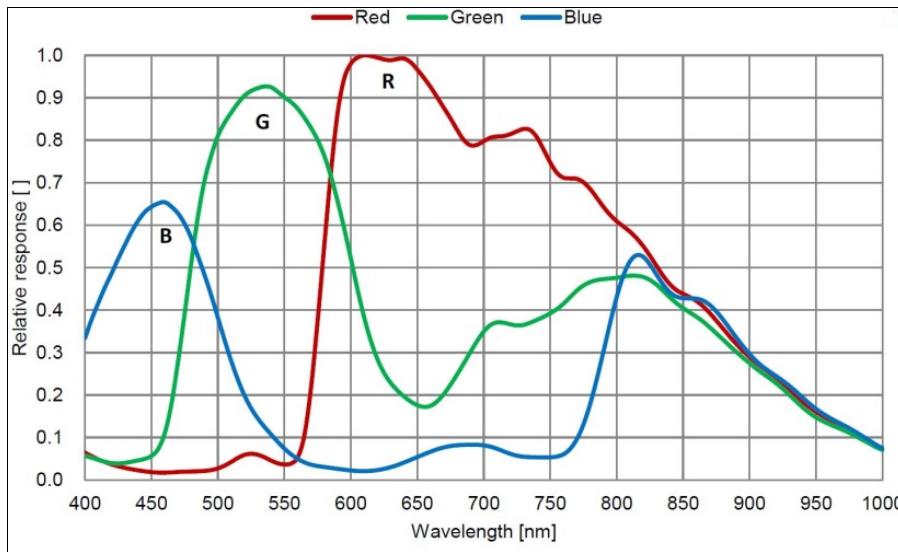
3.7.1 Spectral Response Curves Lt-M2050 / Lt-C2050

Response curves from sensor datasheet.

Monochrome (Lt-M2050)



Color (Lt-C2050)



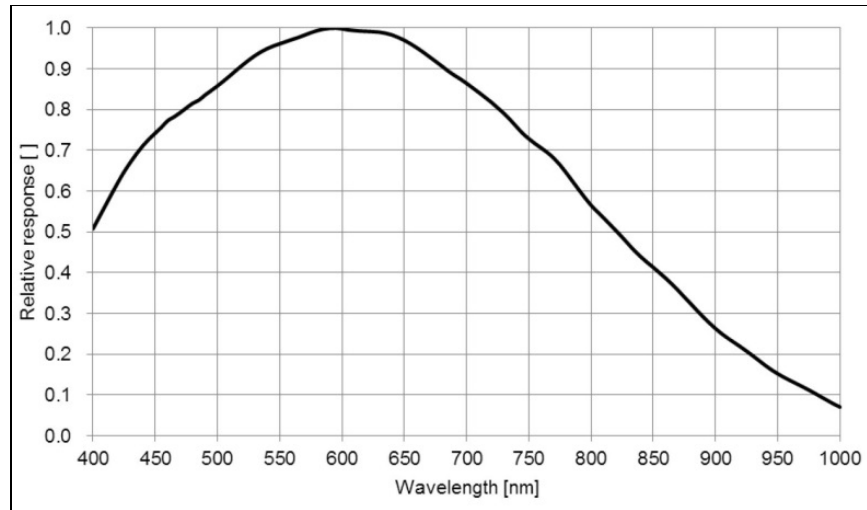
3.8 Specifications Lt-M2420 / Lt-C2420

Supported Features	Lt-M2420 / Lt-C2420	
Resolution	2464 x 2056	
Sensor	Sony IMX264 (5.1 MP)	
Pixel Size	3.45 μm x 3.45 μm	
Optical Format	2/3"	
Shutter type	Full frame electronic global shutter function	
Full Well charge	10.4 ke (max)	
Pixel Data Formats	Monochrome 8-bit or 12-bit	Bayer 8-bit or 12-bit
Max. Internal Frame Rate Full resolution	35 fps (8-bit, 12-bit)	
Maximum Sustained Frame Rate Output	35 fps (8-bit)	
Exposure Time Range	14 μs – 4295 s (triggered) 14 μs – 14.1 s (continuous)	
Trigger to Exposure Minimum delay	1 μs	
Actual Exposure Time Minimum	13.73 μs (Exposure time increment steps = Horizontal Line Time)	
Min. Time from End of Exposure to Start of Next Exposure	107.3 μs	
Horizontal Line Time	13.40 μs	
Readout Time	27.78 ms (Horizontal Line Time) x (lines in frame + 17) — in μs	
Auto-Exposure	Yes, with Auto-Brightness Target	
Black offset control	Yes (in DN)	
Gain Control	In-sensor Gain (max 256)	
Color Enhancement Support	No – Monochrome Models	Yes – Color Models (Brightness, Contrast, Gamma)
Defective Pixel Replacement	Yes	
Image Correction	No	
Image Flip Support	Yes, in sensor, Vertical and Horizontal	
Binning Support	No	
Multi-ROI Support	No	
Decimation Support	Yes, 1/2x vertical and horizontal	
On-Board Image Memory	128 MB	
Output Dynamic Range (dB)	73.0 dB	
SNR	40.2 dB	

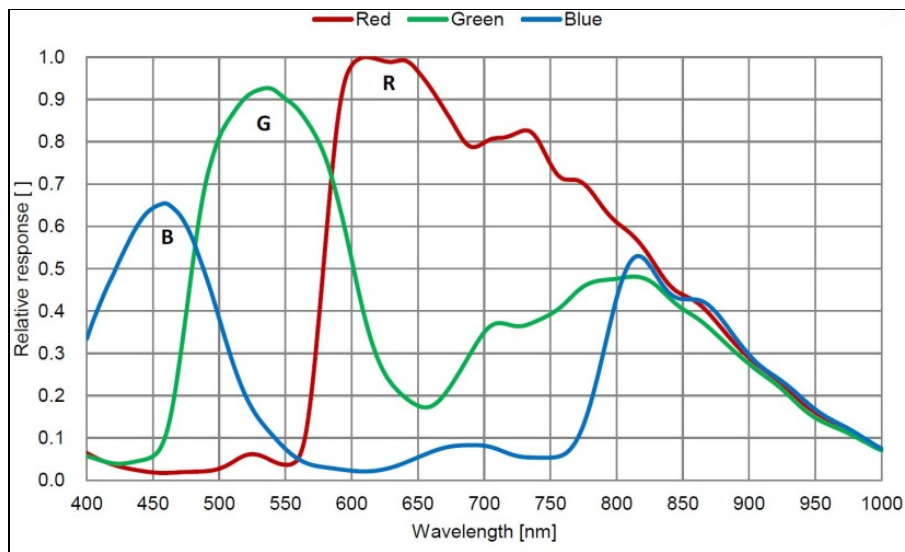
3.8.1 Spectral Response Curves Lt-M2420 / Lt-C2420

Response curves from sensor datasheet.

Monochrome (Lt-M2420)



Color (Lt-C2420)



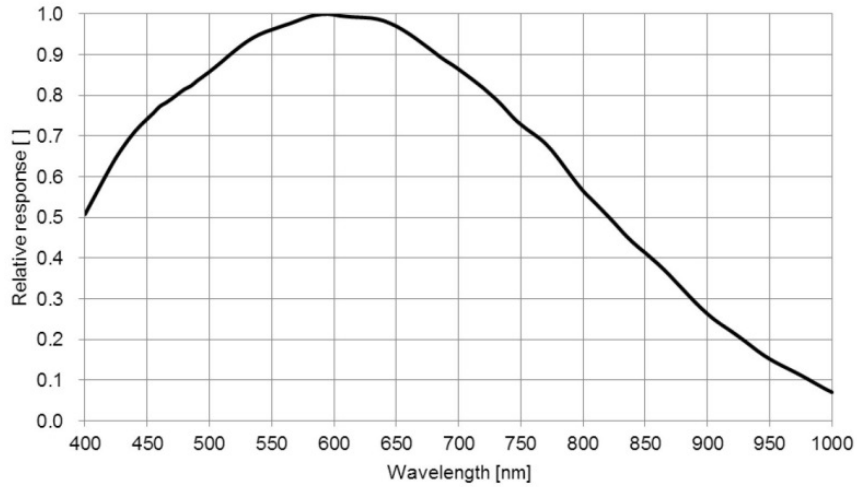
3.9 Specifications Lt-M2450 / Lt-C2450

Supported Features	Lt-M2450 / Lt-C2450	
Resolution	2464 x 2056	
Sensor	Sony IMX250 (5.1 MP)	
Pixel Size	3.45 μm x 3.45 μm	
Optical Format	2/3"	
Shutter type	Full frame electronic global shutter function	
Full Well charge	10.8 ke (max)	
Pixel Data Formats	Monochrome 8-bit or 12-bit	Bayer 8-bit or 12-bit
Max. Internal Frame Rate Full resolution	99 fps (8-bit) 53 fps (12-bit)	
Maximum Sustained Frame Rate Output	75 fps (8-bit)	
Exposure Time Range	14 μs – 4295 s (triggered) 14 μs – 9.6 s (continuous)	
Trigger to Exposure Minimum delay	1 μs	
Actual Exposure Time Minimum	13.73 μs (Exposure time increment steps = Horizontal Line Time)	
Min. Time from End of Exposure to Start of Next Exposure	48.5 μs	
Horizontal Line Time	4.85 μs	
Readout Time	10.16 ms (Horizontal Line Time) x (lines in frame + 38) — in μs	
Auto-Exposure	Yes, with Auto-Brightness Target	
Black offset control	Yes (in DN)	
Gain Control	Yes (max 256)	
Color Enhancement Support	No – Monochrome Models	Yes – Color Models (Brightness, Contrast, Gamma)
Defective Pixel Replacement	Yes	
Image Correction	No	
Image Flip Support	Yes, in sensor, Vertical and Horizontal	
Binning Support	Yes, on sensor, monochrome model	
Multi-ROI Support	No	
Decimation Support	Yes, 1/2x vertical and horizontal	
On-Board Image Memory	128 MB	
Output Dynamic Range (dB)	73.0 dB	
SNR	40.3 dB	

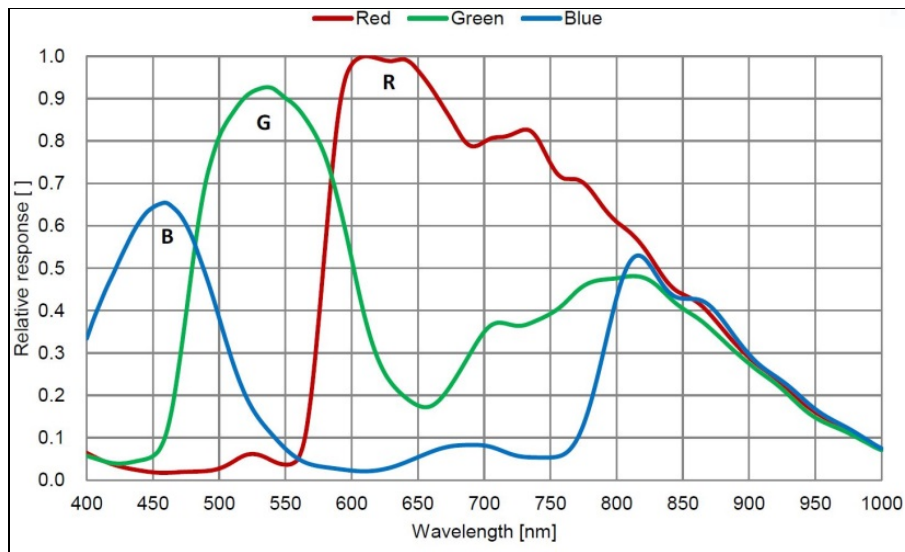
3.9.1 Spectral Response Curves Lt-M2450 / Lt-C2450

Response curves from sensor datasheet.

Monochrome (Lt-M2450)



Color (Lt-C2450)



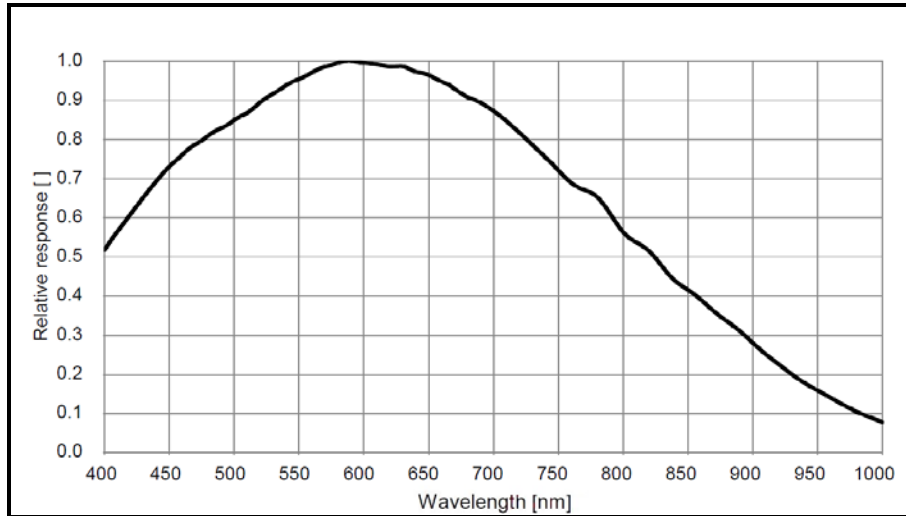
3.10 Specifications Lt-M3200 / Lt-C3200

Supported Features	Lt-M3200 / Lt-C3200	
Resolution	3216 x 2208	
Sensor	Sony IMX428 (7.1 MP)	
Pixel Size	4.50 μm x 4.50 μm	
Optical Format	1.1"	
Shutter type	Full frame electronic global shutter function	
Full Well charge	25.2 ke (max)	
Pixel Data Formats	Monochrome 8-bit or 12-bit	Bayer 8-bit or 12-bit
Max. Internal Frame Rate Full resolution	50 fps (8-bit, 12-bit)	
Maximum Sustained Frame Rate Output	50 fps (8-bit)	
Exposure Time Range	5 μs – 4295 s (triggered) 14 μs – 9.2 s (continuous)	
Trigger to Exposure Minimum Delay	1 μs	
Actual Exposure Time Minimum	5.00 μs (triggered) 13.81 μs (continuous) (Exposure time increment steps = Horizontal Line Time)	
Min. Time from End of Exposure to Start of Next Exposure	105.7 μs	
Horizontal Line Time	8.81 μs	
Readout Time	19.87 ms (Horizontal Line Time) x (lines in frame + 51) — in μs	
Auto-Exposure	Yes, with Auto-Brightness Target	
Black offset control	Yes (in DN)	
Gain Control	Yes (256 max)	
Color Enhancement Support	Monochrome Model – No	Color Model – Yes (Brightness, Contrast, Gamma)
Defective Pixel Replacement	Yes	
Image Correction	No	
Image Flip Support	Yes, on sensor, vertical and horizontal	
Binning Support	Yes, on sensor, monochrome model	
Multi-ROI Support	No	
Decimation Support	Yes, 1/2x vertical and horizontal	
On-Board Image Memory	128 MB	
Output Dynamic Range (dB)	72.4 dB	
SNR	44.0 dB	

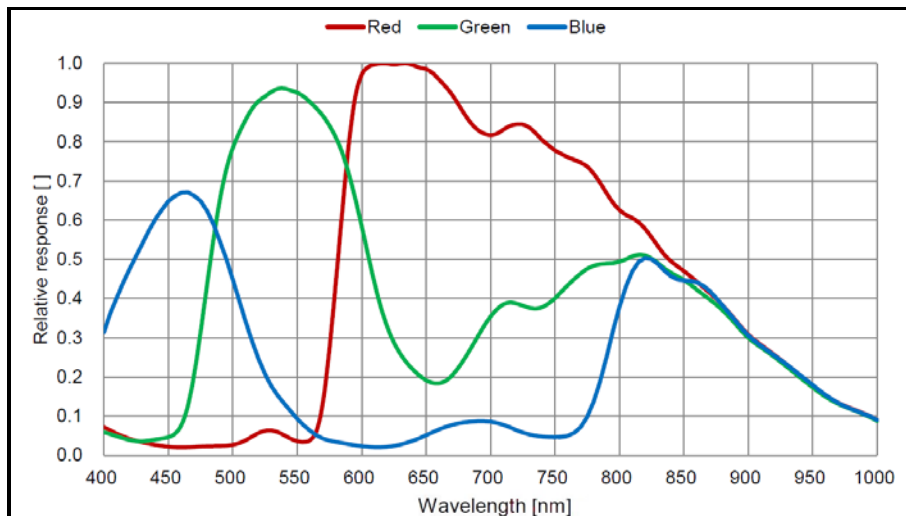
3.10.1 Spectral Response Curves Lt-M3200 / Lt-C3200

Response curves from sensor datasheet.

Monochrome (Lt-M3200)



Color (Lt-C3200)



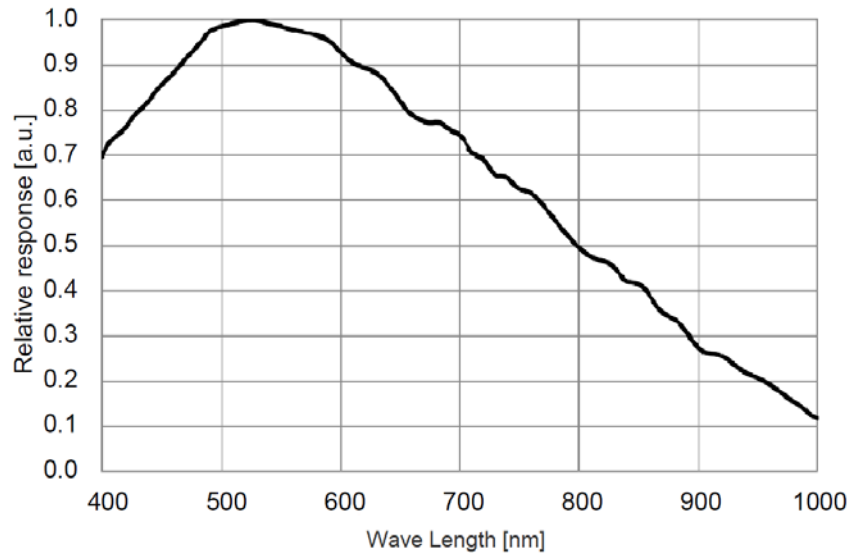
3.11 Specifications Lt-M3840 / Lt-C3840

Supported Features	Lt-M3840 / Lt-C3840	
Resolution	3840 x 2160	
Sensor	Sony IMX334 (8.3 MP)	
Pixel Size	2 μm x 2 μm	
Optical Format	1/1.8"	
Shutter type (see Guide to Using a Rolling Shutter Camera)	Electronic Rolling Shutter function (ERS) (continuous) Global Reset Release (GRR) function (single exposure)	
Full Well charge	7.0 ke (max)	
Pixel Data Formats	Monochrome 8-bit or 12-bit	Bayer 8-bit or 12-bit
Max. Internal Frame Rate Full resolution	44 fps (8-bit, 12-bit)	
Maximum Sustained Frame Rate Output	44 fps (8-bit)	
Exposure Time Range	104 μs – 1 s (triggered) 13 μs – 1 s (continuous)	
Trigger to Exposure Minimum delay	1 μs	
Actual Exposure Time Minimum	103.70 μs (triggered) 12.21 μs (continuous) (Exposure time increment steps = Horizontal Line Time)	
Min. Time from End of Exposure to Start of Next Exposure	29.6 μs	
Horizontal Line Time	14.81 μs (triggered) 9.91 μs (continuous)	
Readout Time	32.00 ms (triggered) 21.41 ms (continuous) (Horizontal Line Time) x (lines in frame) — in μs	
Auto-Exposure	Yes, with Auto-Brightness Target (continuous only)	
Black offset control	Yes (in DN)	
Gain Control	Yes (max 3317)	
Color Enhancement Support	No – Monochrome Models	Yes – Color Models (Brightness, Contrast, Gamma)
Defective Pixel Replacement	Yes	
Image Correction	No	
Image Flip Support	Yes in sensor, Vertical and Horizontal	
Binning Support	Yes, color model	
Multi-ROI Support	No	
Decimation Support	No	
On-Board Image Memory	Yes (128 MB)	
Output Dynamic Range (dB)	70.8 dB	
SNR	38.5 dB	

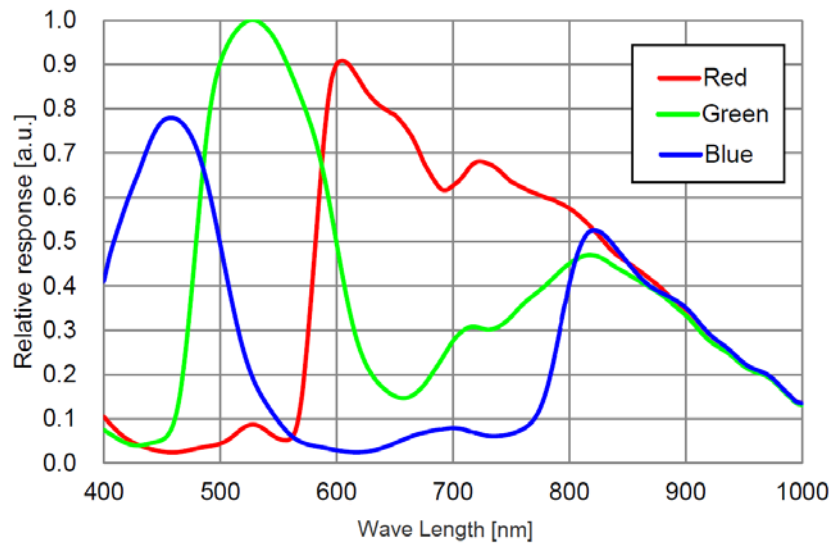
3.11.1 Spectral Response Curves Lt-M3840 / Lt-C3840

Response curves from sensor datasheet.

Monochrome (Lt-M3840)



Color (Lt-C3840)



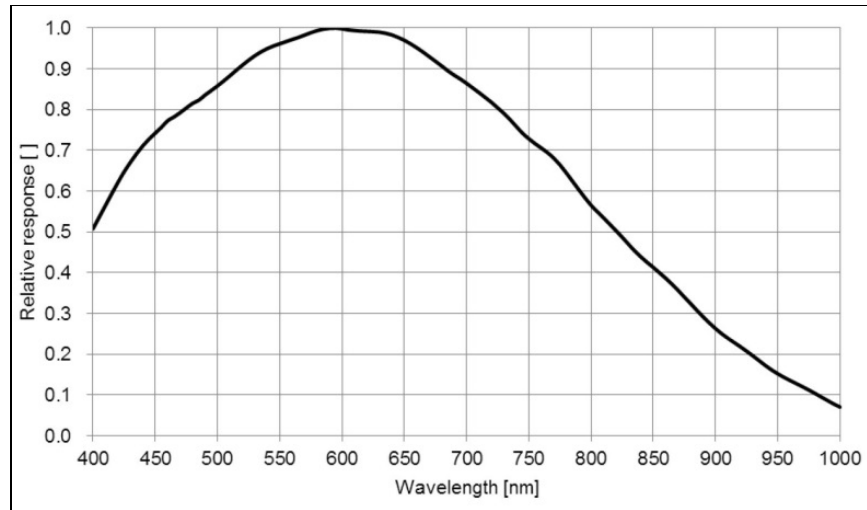
3.12 Specifications Lt-M4030 / Lt-C4030

Supported Features	Lt-M4030 / Lt-C4030	
Resolution	4112 x 2176	
Sensor	Sony IMX267 (8.9 MP)	
Pixel Size	3.45 μm x 3.45 μm	
Optical Format	1"	
Shutter type	Full frame electronic global shutter function	
Full Well charge	10.6 ke (max)	
Pixel Data Formats	Monochrome 8-bit or 12-bit	Bayer 8-bit or 12-bit
Max. Internal Frame Rate Full resolution	31 fps (8-bit) 21 fps (12-bit)	
Maximum Sustained Frame Rate Output	31 fps (8-bit)	
Exposure Time Range	14 μs – 4295 s (triggered) 14 μs – 22.8 s (continuous)	
Trigger to Exposure Minimum delay	1 μs	
Actual Exposure Time Minimum	14.26 μs (Exposure time increment steps = Horizontal Line Time)	
Min. Time from End of Exposure to Start of Next Exposure	115.5 μs	
Horizontal Line Time	14.40 μs	
Readout Time	31.61 ms (Horizontal Line Time) x (lines in frame + 19) — in μs	
Auto-Exposure	Yes, with Auto-Brightness Target	
Black offset control	Yes (in DN)	
Gain Control	Yes (max 256)	
Color Enhancement Support	No – Monochrome Models	Yes – Color Models (Brightness, Contrast, Gamma)
Defective Pixel Replacement	Yes	
Image Correction	No	
Image Flip Support	Yes in sensor, Vertical and Horizontal	
Binning Support	No	
Multi-ROI Support	No	
Decimation Support	Yes, 1/2x vertical and horizontal	
On-Board Image Memory	128 MB	
Output Dynamic Range (dB)	73.3 dB	
SNR	40.1 dB	

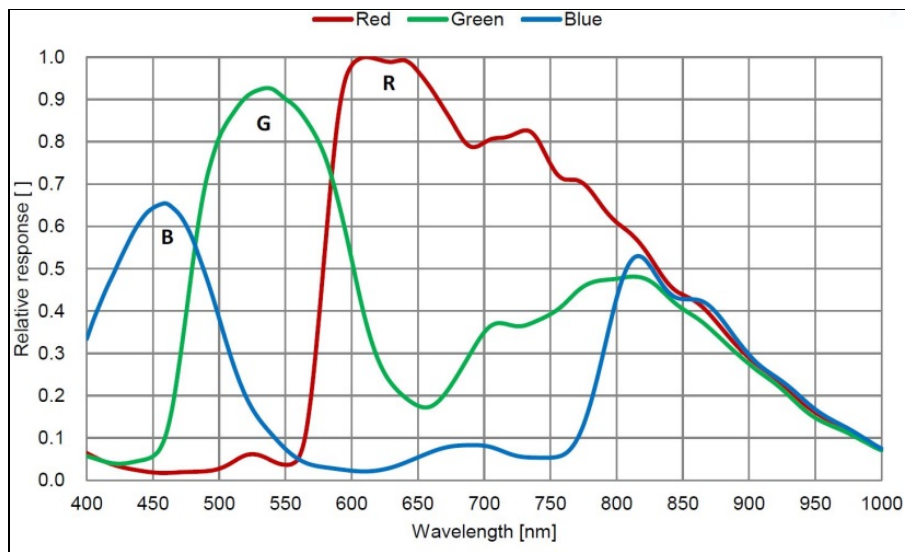
3.12.1 Spectral Response Curves Lt-M4030 / Lt-C4030

Response curves from sensor datasheet.

Monochrome (Lt-M4030)



Color (Lt-C4030)



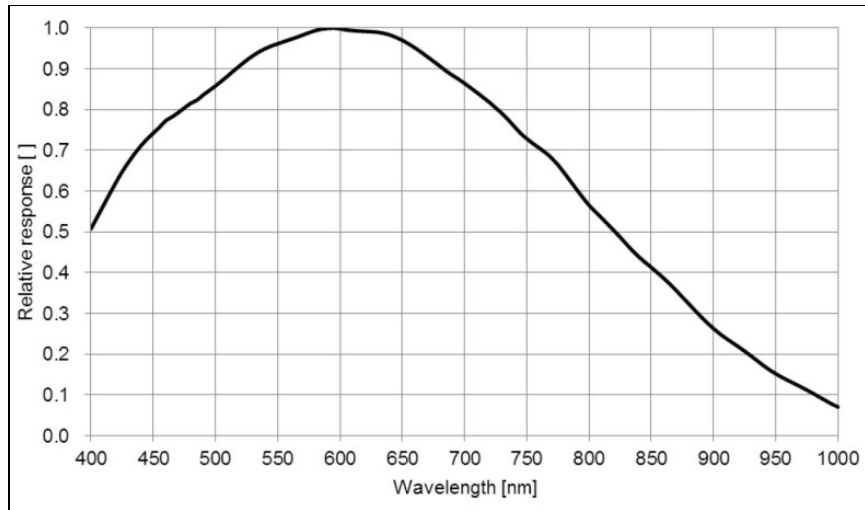
3.13 Specifications Lt-M4060 / Lt-C4060

Supported Features	Lt-M4060 / Lt-C4060	
Resolution	4112 x 2176	
Sensor	Sony IMX255 (8.9 MP)	
Pixel Size	3.45 μm x 3.45 μm	
Sensor Size	16.1 mm diagonal	
Optical Format	1"	
Shutter type	Full frame electronic global shutter function	
Full Well charge	10.5 ke (max)	
Pixel Data Formats	Monochrome 8-bit or 12-bit	Bayer 8-bit or 12-bit
Max. Internal Frame Rate Full resolution	57 fps (8-bit) 30 fps (12-bit)	
Maximum Sustained Frame Rate Output	42 fps (8-bit)	
Exposure Time Range	14 μs – 4295 s (triggered) 14 μs – 15.5 s (continuous)	
Trigger to Exposure Minimum delay	1 μs	
Actual Exposure Time Minimum	14.26 μs (Exposure time increment steps = Horizontal Line Time)	
Min. Time from End of Exposure to Start of Next Exposure	156 μs	
Horizontal Line Time	7.80 μs	
Readout Time	17.39 ms (Horizontal Line Time) x (lines in frame + 54) — in μs	
Auto-Exposure	Yes, with Auto-Brightness Target	
Black offset control	Yes (in DN)	
Gain Control	Yes (max 256)	
Color Enhancement Support	No – Monochrome Models	Yes – Color Models (Brightness, Contrast, Gamma)
Defective Pixel Replacement	Yes	
Image Correction	No	
Image Flip Support	Yes in sensor, Vertical and Horizontal	
Binning Support	Yes, on sensor, monochrome model	
Multi-ROI Support	No	
Decimation Support	Yes, 1/2x vertical and horizontal	
On-Board Image Memory	128 MB	
Output Dynamic Range (dB)	73.0 dB	
SNR	40.3 dB	

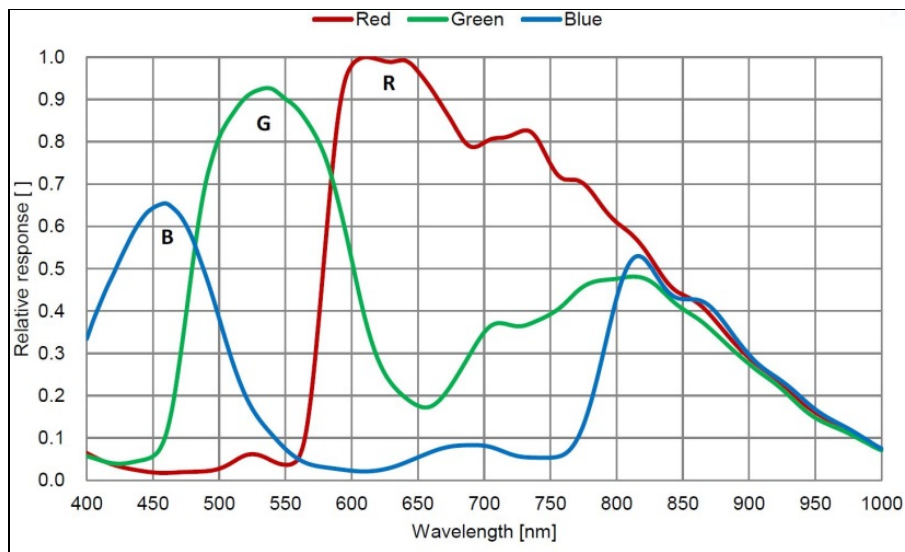
3.13.1 Spectral Response Curves Lt-M4060 / Lt-C4060

Response curves from sensor datasheet.

Monochrome (Lt-M4060)



Color (Lt-C4060)



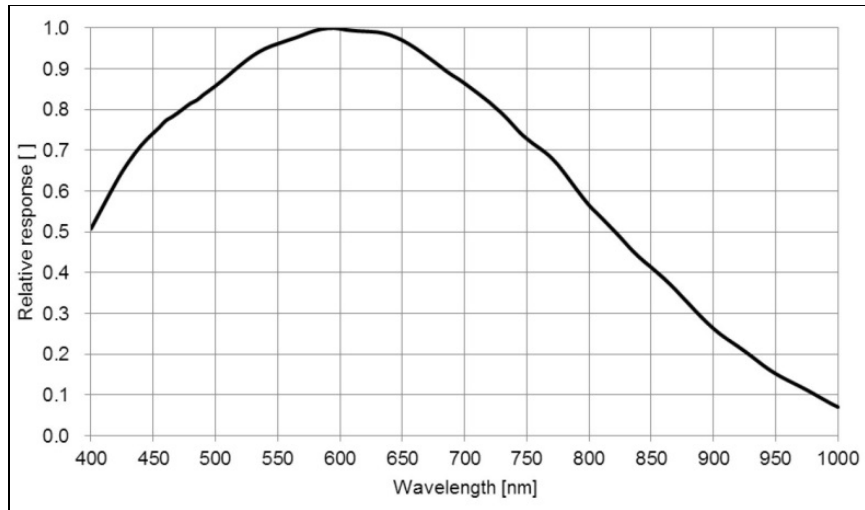
3.14 Specifications Lt-M4020 / Lt-C4020

Supported Features	Lt-M4020 / Lt-C4020	
Resolution	4112 x 3008	
Sensor	Sony IMX304 (12.4 MP)	
Pixel Size	3.45 μm x 3.45 μm	
Optical Format	1.1"	
Shutter type	Full frame electronic global shutter function	
Full Well charge	10.6 ke (max)	
Pixel Data Formats	Monochrome 8-bit or 12-bit	Bayer 8-bit or 12-bit
Max. Internal Frame Rate Full resolution	22 fps (8-bit) 15 fps (12-bit)	
Maximum Sustained Frame Rate Output	22 fps (8-bit)	
Exposure Time Range	14 μs – 4295 s (triggered) 14 μs – 22.8 s (continuous)	
Trigger to Exposure Minimum delay	1 μs	
Actual Exposure Time Minimum	14.26 μs (Exposure time increment steps = Horizontal Line Time)	
Min. Time from End of Exposure to Start of Next Exposure	115.5 μs	
Horizontal Line Time	14.40 μs	
Readout Time	43.59 ms (Horizontal Line Time) x (lines in frame + 19) — in μs	
Auto-Exposure	Yes, with Auto-Brightness Target	
Black offset control	Yes (in DN)	
Gain Control	Yes (max 256)	
Color Enhancement Support	No – Monochrome Models	Yes – Color Models (Brightness, Contrast, Gamma)
Defective Pixel Replacement	Yes	
Image Correction	No	
Image Flip Support	Yes in sensor, Vertical and Horizontal	
Binning Support	No	
Multi-ROI Support	No	
Decimation Support	Yes, 1/2x vertical and horizontal	
On-Board Image Memory	Yes (128 MB)	
Output Dynamic Range (dB)	73.0 dB	
SNR	40.1 dB	

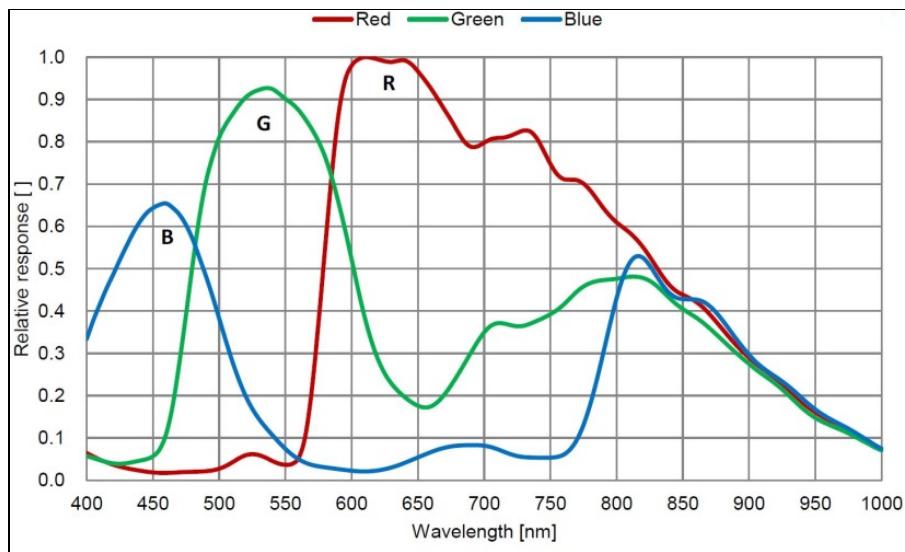
3.14.1 Spectral Response Curves Lt-M4020 / Lt-C4020

Response curves from sensor datasheet.

Monochrome (Lt-M4020)



Color (Lt-C4020)



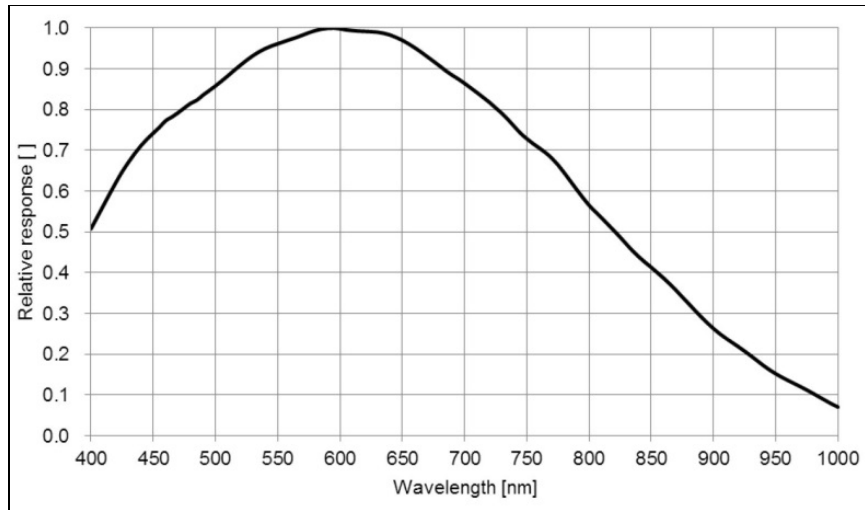
3.15 Specifications Lt-M4040 / Lt-C4040

Supported Features	Lt-M4040 / Lt-C4040	
Resolution	4112 x 3008	
Sensor	Sony IMX253 (12.4 MP)	
Pixel Size	3.45 μm x 3.45 μm	
Optical Format	1.1"	
Shutter type	Full frame electronic global shutter function	
Full Well charge	10.5 ke (max)	
Pixel Data Formats	Monochrome 8-bit or 12-bit	8-bit or 12-bit
Max. Internal Frame Rate Full resolution	42 fps (8-bit) 22 fps (12-bit)	
Maximum Sustained Frame Rate Output	30 fps (8-bit)	
Exposure Time Range	14 μs – 4295 s (triggered) 14 μs – 15.5 s (continuous)	
Trigger to Exposure Minimum delay	1 μs	
Actual Exposure Time Minimum	14.26 μs (Exposure time increment steps = Horizontal Line Time)	
Min. Time from End of Exposure to Start of Next Exposure	156 μs	
Horizontal Line Time	7.80 μs	
Readout Time	23.88 ms (Horizontal Line Time) x (lines in frame + 54) — in μs	
Auto-Exposure	Yes, with Auto-Brightness Target	
Black offset control	Yes (in DN)	
Gain Control	Yes (max 256)	
Color Enhancement Support	No – Monochrome Models	Yes – Color Models (Brightness, Contrast, Gamma)
Defective Pixel Replacement	Yes	
Image Correction	No	
Image Flip Support	Yes, on sensor, Vertical and Horizontal	
Binning Support	Yes, on sensor, monochrome model	
Multi-ROI Support	No	
Decimation Support	Yes, 1/2x vertical and horizontal	
On-Board Image Memory	128 MB	
Output Dynamic Range (dB)	73.0 dB	
SNR	40.4 dB	

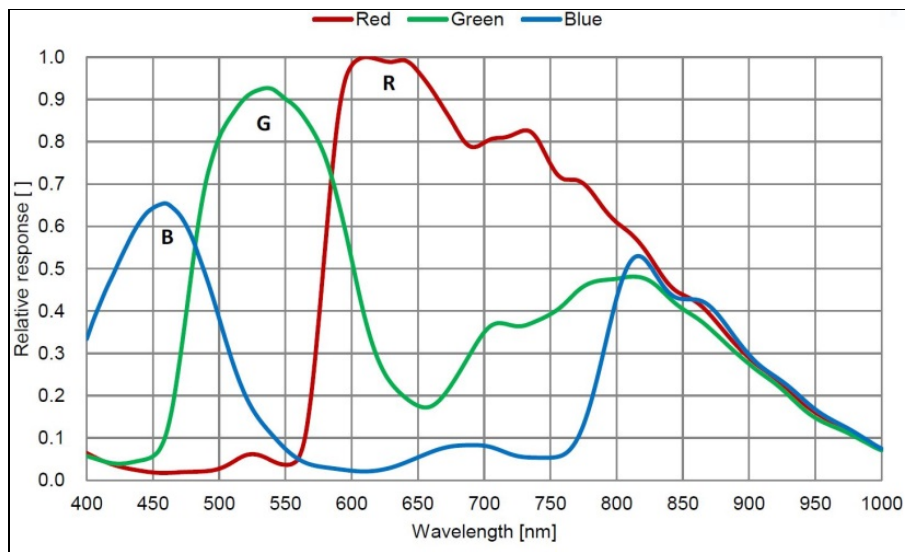
3.15.1 Spectral Response Curves Lt-M4040 / Lt-C4040

Response curves from sensor datasheet.

Monochrome (Lt-M4040)



Color (Lt-C4040)



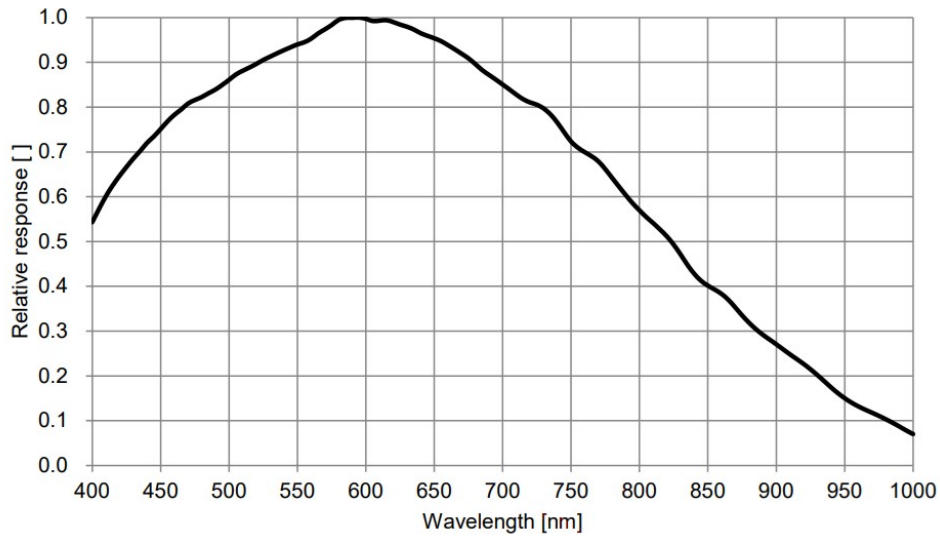
3.16 Specifications Lt-M5470 / Lt-C5470

Supported Features	Lt-M5470 / Lt-C5470	
Resolution	5472 x 3084	
Sensor	Sony IMX387 (16.9 MP)	
Pixel Size	3.45 μm x 3.45 μm	
Optical Format	4/3"	
Shutter type	Full frame electronic global shutter function	
Full Well charge	10.5 ke (max)	
Pixel Data Formats	Monochrome 8-bit or 12-bit	Bayer 8-bit or 12-bit
Max. Internal Frame Rate Full resolution	32 fps (8-bit) 22 fps (12-bit)	
Maximum Sustained Frame Rate Output	27 fps (8-bit) 18 fps (12-bit)	
Exposure Time Range	30 μs – 12.15 s	
Trigger to Exposure Minimum Delay	8 μs	
Actual Exposure Time Minimum	30.06 μs (Exposure time increment steps = Horizontal Line Time)	
Min. Time from End of Exposure to Start of Next Exposure	TBD	
Horizontal Line Time	9.86 μs (8-bit), 14.55 μs (12-bit)	
Readout Time	31.00 ms (Horizontal Line Time) x (lines in frame + 60) — in μs (8-bit continuous) (Horizontal Line Time) x (lines in frame + 48) — in μs (12-bit continuous)	
Auto-Exposure	Yes, with Auto-Brightness Target	
Black offset control	Yes (in DN)	
Gain Control	Yes (max 256)	
Color Enhancement Support	Monochrome – No	Color – No
Defective Pixel Replacement	No	
Image Correction	No	
Image Flip Support	Yes, on sensor, vertical and horizontal	
Binning Support	Yes, on sensor, monochrome model	
Multi-ROI Support	Yes	
Decimation Support	Yes, 1/2x vertical and horizontal	
On-Board Image Memory	256 MB	
Output Dynamic Range (dB)	69.1 dB	
SNR	40.2 dB	

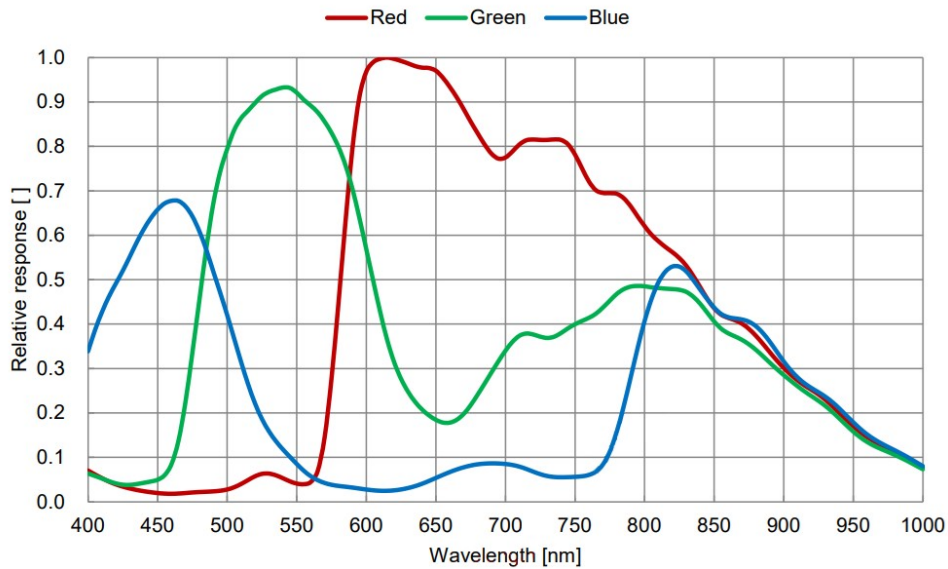
3.16.1 Spectral Response Curves Lt-M5470 / Lt-C5470

Response curves from sensor datasheet.

Monochrome (Lt-M5470)



Color (Lt-C5470)



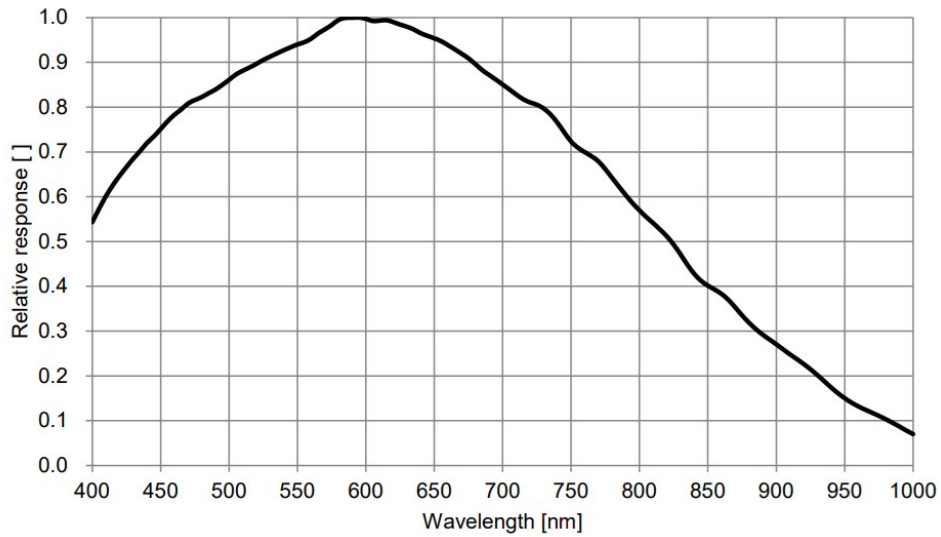
3.17 Specifications Lt-M4430 / Lt-C4430

Supported Features	Lt-M4430 / Lt-C4430	
Resolution	4432 x 4436	
Sensor	Sony IMX367 (19.7 MP)	
Pixel Size	3.45 μm x 3.45 μm	
Optical Format	4/3"	
Shutter type	Full frame electronic global shutter function	
Full Well charge	10.5 ke (max)	
Pixel Data Formats	Monochrome 8-bit or 12-bit	Bayer 8-bit or 12-bit
Max. Internal Frame Rate Full resolution	27 fps (8-bit) 19 fps (12-bit)	
Maximum Sustained Frame Rate Output	19 fps (8-bit) 13 fps (12-bit)	
Exposure Time Range	30 μs – 12.15 s	
Trigger to Exposure Minimum Delay	8 μs	
Actual Exposure Time Minimum	30.06 μs (Exposure time increment steps = Horizontal Line Time)	
Min. Time from End of Exposure to Start of Next Exposure	TBD	
Horizontal Line Time	8.08 μs (8-bit), 11.88 μs (12-bit)	
Readout Time	36.41 ms (Horizontal Line Time) x (lines in frame + 70) — in μs (8-bit continuous) (Horizontal Line Time) x (lines in frame + 54) — in μs (12-bit continuous)	
Auto-Exposure	Yes, with Auto-Brightness Target	
Black offset control	Yes (in DN)	
Gain Control	Yes (max 256)	
Color Enhancement Support	Monochrome – No	Color – No
Defective Pixel Replacement	No	
Image Correction	No	
Image Flip Support	Yes, on sensor, vertical and horizontal	
Binning Support	Yes, on sensor, monochrome model	
Multi-ROI Support	Yes	
Decimation Support	Yes, 1/2x, vertical and horizontal	
On-Board Image Memory	256 MB	
Output Dynamic Range (dB)	69.1 dB	
SNR	40.2 dB	

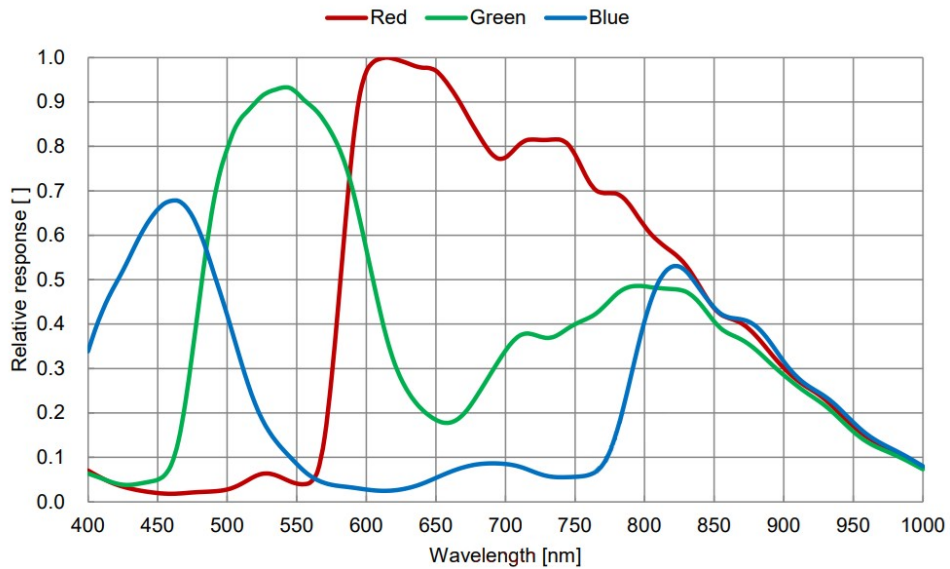
3.17.1 Spectral Response Curves Lt-M4430 / Lt-C4430

Response curves from sensor datasheet.

Monochrome (Lt-M4430)



Color (Lt-C4430)



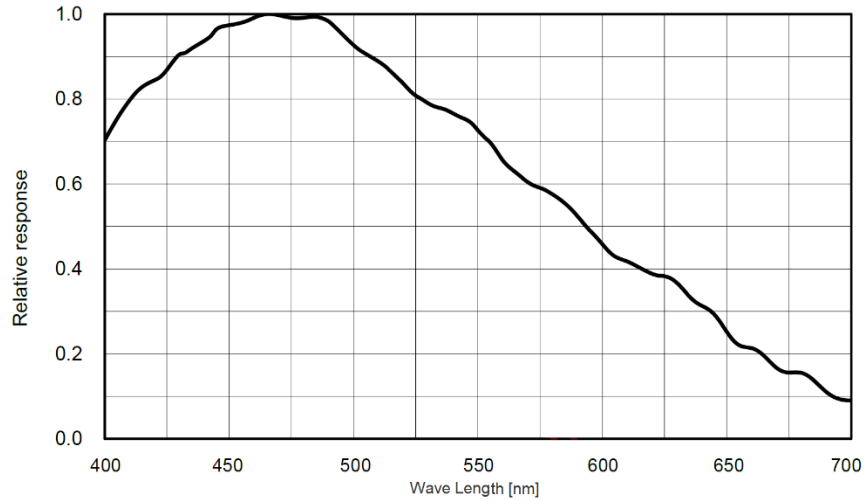
3.18 Specifications Lt-M5500 / Lt-C5500

Supported Features	Lt-M5500 / Lt-C5500	
Resolution	5472 x 3648	
Sensor	Sony IMX183 (20.0 MP)	
Pixel Size	2.40 μm x 2.40 μm	
Optical Format	1"	
Shutter type	Electronic Rolling Shutter function (ERS) (continuous) Global Reset Release (GRR) function (single exposure)	
Full Well charge	14.6 ke	
Pixel Data Formats	Monochrome 8-bit or 12-bit	Bayer 8-bit or 12-bit
Max. Internal Frame Rate Full resolution	20 fps (8-bit, 12-bit)	
Maximum Sustained Frame Rate Output	20 fps (8-bit)	
Exposure Time Range	1773 μs – 10 s (triggered) 57 μs – 1 s (continuous)	
Trigger to Exposure Minimum Delay	1 μs	
Actual Exposure Time Minimum	1772.44 μs (triggered) 57.44 μs (continuous) (Exposure time increment steps = Horizontal Line Time)	
Min. Time from End of Exposure to Start of Next Exposure	13.6 μs	
Horizontal Line Time	13.61 μs	
Readout Time	49.65 ms (Horizontal Line Time) x (lines in frame) — in μs	
Auto-Exposure	Yes, with Auto-Brightness Target	
Black offset control	Yes (in DN)	
Gain Control	Yes (max 180)	
Color Enhancement Support	Monochrome – No	Color – Yes (Brightness, Contrast, Gamma)
Defective Pixel Replacement	Yes	
Image Correction	No	
Image Flip Support	Yes, on sensor, vertical and horizontal	
Binning Support	Yes, on sensor, continuous	
Multi-ROI Support	No	
Decimation Support	No	
On-Board Image Memory	128 MB	
Output Dynamic Range (dB)	71.7 dB	
SNR	41.7 dB	

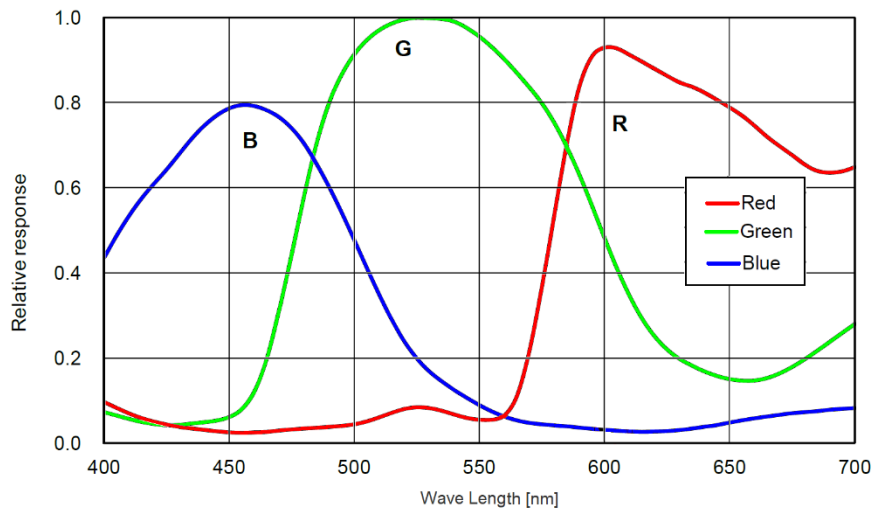
3.18.1 Spectral Response Curves Lt-M5500 / Lt-C5500

Response curves from sensor datasheet.

Monochrome (Lt-M5500)



Color (Lt-C5500)



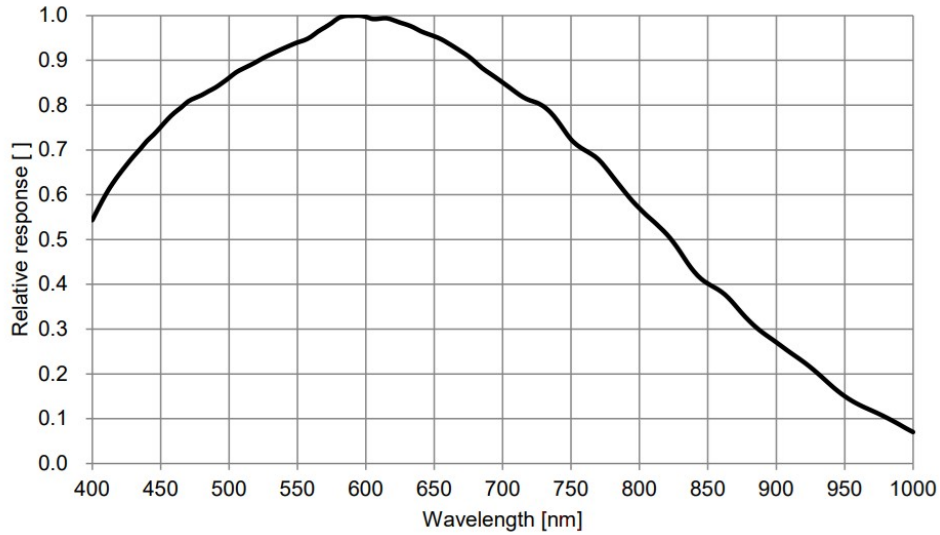
3.19 Specifications Lt-M6480 / Lt-C6480

Supported Features	Lt-M6480 / Lt-C6480	
Resolution	6480 x 4860	
Sensor	Sony IMX342 (31.5 MP)	
Pixel Size	3.45 μm x 3.45 μm	
Optical Format	APS-C	
Shutter type	Full frame electronic global shutter function	
Full Well charge	10.5 ke (max)	
Pixel Data Formats	Monochrome 8-bit or 12-bit	Bayer 8-bit or 12-bit
Max. Internal Frame Rate Full resolution	18 fps (8-bit) 12 fps (12-bit)	
Maximum Sustained Frame Rate Output	14 fps (8-bit) 10 fps (12-bit)	
Exposure Time Range	30 μs – 12.15 s	
Trigger to Exposure Minimum Delay	8 μs	
Actual Exposure Time Minimum	30.06 μs (Exposure time increment steps = Horizontal Line Time)	
Min. Time from End of Exposure to Start of Next Exposure	TBD	
Horizontal Line Time	11.58 μs (8-bit), 17.13 μs (12-bit)	
Readout Time	56.92 ms (Horizontal Line Time) x (lines in frame + 54) — in μs (8-bit continuous) (Horizontal Line Time) x (lines in frame + 44) — in μs (12-bit continuous)	
Auto-Exposure	Yes, with Auto-Brightness Target	
Black offset control	Yes (in DN)	
Gain Control	256 (max)	
Color Enhancement Support	Monochrome – No	Color – No
Defective Pixel Replacement	No	
Image Correction	No	
Image Flip Support	Yes, on sensor, vertical and horizontal	
Binning Support	Yes, on sensor, monochrome model	
Multi-ROI Support	Yes	
Decimation Support	Yes, 1/2x vertical and horizontal	
On-Board Image Memory	256 MB	
Output Dynamic Range (dB)	69.1 dB	
SNR	40.2 dB	

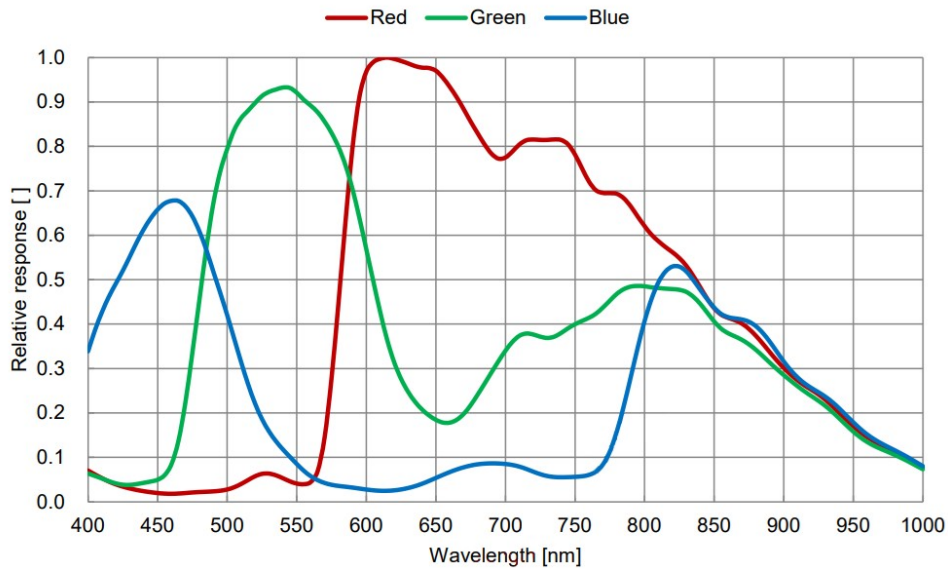
3.19.1 Spectral Response Curves Lt-M6480 / Lt-C6480

Response curves from sensor datasheet.

Monochrome (Lt-M6480)



Color (Lt-C6480)



3.20 Guide to Using a Rolling Shutter Camera

A few Lt Series cameras implement Sony rolling shutter sensors to achieve a high pixel density – low cost solution for a number of imaging implementations. These sensors have different usage characteristics and thus provide different application solutions compared to the Lt Series global shutter models. The following points highlight those differences:

Simpler Sensor Design Attributes

- Rolling shutter cameras have a simpler design with smaller pixels, allowing higher resolutions for a given sensor physical area. As an example, mobile phones use rolling shutter sensors.
- Depending on the imaging requirements, the higher density pixel array may require a higher quality lens. Lens specifications define the resolution and contrast/modulation attributes that must be considered. This commonly used gauge is the Modulation Transfer Function (MTF), which is extensively covered by lens suppliers to qualify their products. Consider reading <https://www.edmundoptics.com/resources/application-notes/optics/introduction-to-modulation-transfer-function/> as an initial start to understanding MTF.
- A rolling shutter sensor exposes, samples, and reads out sequentially, as part of the design criteria to achieve a higher pixel density via simplified circuitry.
- Rolling shutter sensors generate less heat, which translates to a lower noise level.
- Global shutter CMOS sensors require more complicated circuit architecture, thus limiting the pixel density for a given physical size.

Rolling Shutter Trade-offs

When selecting a rolling shutter camera, the user needs to understand that the camera is not suitable for all machine vision applications. Limitation examples are:

- A rolling shutter camera is unsuitable for applications like barcode scanning, machine vision, or automated inspection systems, which require the imaging of rapidly moving objects.
- Moving objects are subject to temporal distortions best described as positional errors (shifts) from the top of an object to its bottom, due to how individual lines are exposed (detailed below).
- Rolling shutter cameras using global reset release mode (GRR) are not suitable for moving objects in well-lit environments.
- Degree of distortions change as exposure time is increased or decreased.
- Use of a strobe flash with a controlled duration, in a dark imaging environment, is required to eliminate positional distortions.
- Many examples of visual distortions due to rolling shutter sensors can be found on Internet, mostly for cell phones and consumer cameras, for instance <https://www.youtube.com/watch?v=dNVtMmLIInoE> *Rolling Shutter Explained (Why Do Cameras Do This?)*.

The guidelines that follow will permit the successful usage of rolling shutter cameras in machine vision applications.

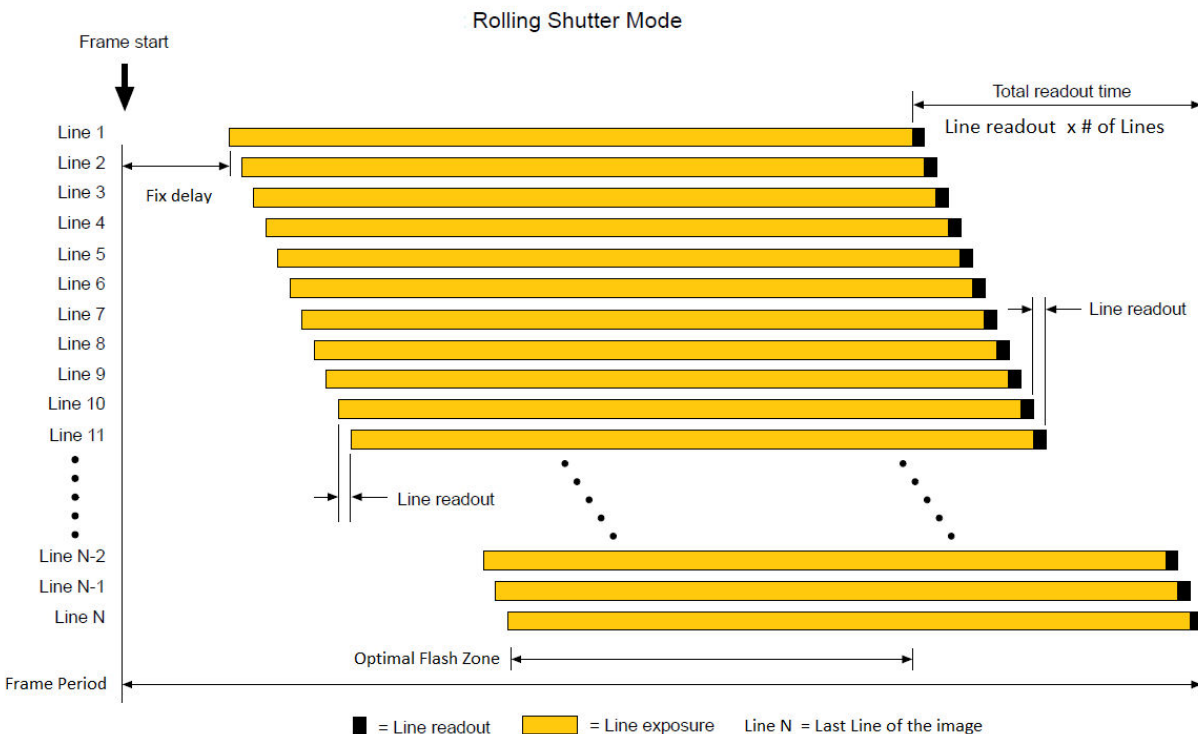
Guide to ERS or GRR Exposure Modes

The following two subsections provide overviews and constraints on using either the typical *Electronic Rolling Shutter (ERS) Exposures* or *Global Reset Release (GRR) Exposures* modes.

3.20.1 Overview of Electronic Rolling Shutter (ERS) Exposures

Referring to the following graphic:

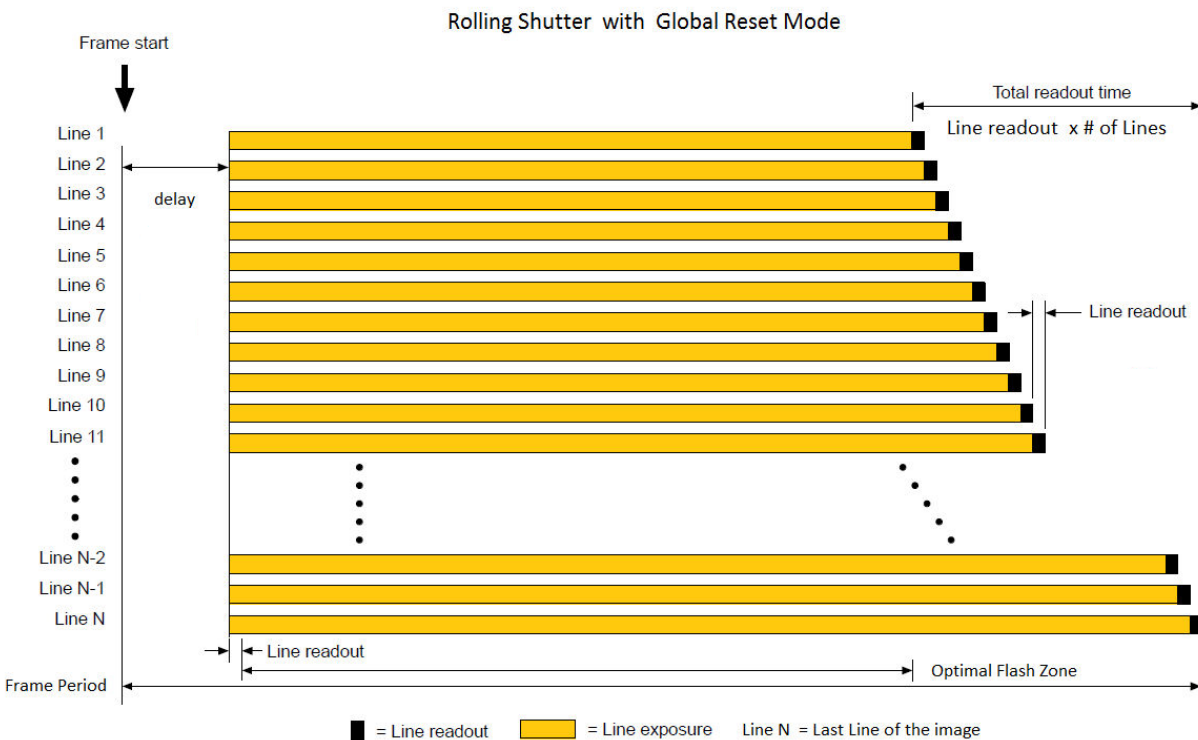
- Each sensor line is exposed for the programmed time integration period.
- Exposures start with Line 1. The sensor design uses a shared line readout circuit. Due to this simplified circuitry, only a single line of pixel data can be readout at any given time. Therefore, the line 2 exposure (integration period) is delayed by the required readout time of line 1.
- This delayed line exposure is repeated from the sensor's first line to its last sensor line.
- This sequence allows the common readout circuit to read the data from each row. This results in an exposure start time delay between the first to last row – thus the name rolling shutter.
- To avoid motion artifacts the user needs to freeze motion using flash lighting of suitable length in a dark environment. The flash is triggered at the start of the last line's exposure and stops at the end of the first line's exposure. The flash must maintain a constant light output during this period.
 - To control the flash device, use the Lt output signal with these feature selections: `outputLineSource=PulseOnStartofExposure`, `outputLinePulseDelay=flashZoneDelay` (delay to the start of the last line exposure), `outputLinePulseDuration=flashZoneDuration` (optimal flash zone time as shown in the graphic below).
 - The two new features mentioned, `flashZoneDelay` and `flashZoneDuration`, automatically provide the optimal flash zone time values no matter the exposure duration and any vertical cropping/offset settings. The user is free to use any delay or duration as required. See **Strobe and Flash Zone (Lt-3840, Lt-5500)** for settings.
- The dark environment illumination ensures minimal exposure (and thus minimal motion artifacts) during the sensor lines integration time occurring before and after the flash period.



3.20.2 Overview of Global Reset Release (GRR) Exposures

Referring to the following graphic:

- All sensor lines start integrating at the same time, therefore GRR mode is also known as Global Start Mode.
- The first sensor line (Line 1) only is exposed for the programmed time integration period.
- The sensor design uses a shared line readout circuit. Therefore again, only a single line of pixel data can be readout at any given time.
- With each sensor line starting exposure integration at once, each following line's exposure is increased by the readout time required by the previous row.
- In a well-lit environment with static objects, there is a visible exposure increase from the top sensor row to the bottom sensor row.
- With moving objects in a well-lit environment, there is motion blurring from top to bottom.
- Therefore, as described previously, flash lighting in a dark environment is used to freeze motion. The flash period matches the integration period for line 1. The increasing exposures for the other sensor lines will not be visible without any other illumination source.



4 Connecting the Camera

4.1 USB Vision Overview

Ratified in 2013, the USB Vision standard is a popular interface for industrial cameras connected to computer systems. Teledyne Lumenera USB 3 cameras comply with the standard as defined by the USB3 Vision Technical Committee of the Automated Imaging Association (www.visiononline.org).

The AIA USB3 Vision implementation uses the programming interface (API) previously defined by the GenICam™ standard for access and control features in compliant imaging products, which simplifies applications design and integration (device discovery, device control, event handling, data streaming, etc.) for camera and system manufacturers.

For viability in real world machine vision environments, the standard also specifies locking USB 3 compliant connectors such as the USB 3.0 Standard-B and USB 3.0 Powered-B connector.

See **Switching a Lumenera camera from LuCam mode to USB3 Vision mode** to use cameras with the Sopera LT development environment.

4.2 Connecting Power

Lt-Ux0x-xxxxx and **Lt-Ux1x-xxxxx** USB 3 cameras may be powered directly by the USB 3 computer port. This method provides a cabling solution for testing or for imaging installations where camera acquisitions are only software controlled and require no external I/O.

Lt-Ux2x-xxxxx XL series cameras must be powered through the external interface header. The external interface header also provides access for hardware input and output signals.

See section **I/O Connector Pinout Details** for the I/O connector and power supply specifications.

When the camera receives power, the status LED will indicate that the camera has initialized and is ready:

- **Lt-Ux0x-xxxxx** and **Lt-Ux1x-xxxxx**: steady green
- **Lt-Ux2x-xxxxx**: steady blue

4.2.1 Connectors

Depending on model, the camera has two or three connectors:

- **USB 3** – USB 3 connection to a computer
 - **Lt-Ux0x-xxxxx** and **Lt-Ux1x-xxxxx**: data and power
 - **Lt-Ux2x-xxxxx**: data only
- **External Interface Header** – Used for external signal connections and for camera power
 - **Lt-Ux0x-xxxxx** and **Lt-Ux1x-xxxxx**: optional power
 - **Lt-Ux2x-xxxxx**: required power

- **Iris Control (LT-Ux0x-xxxxx Series only)** – Standard 4 pin iris control for lenses with a motorized iris.

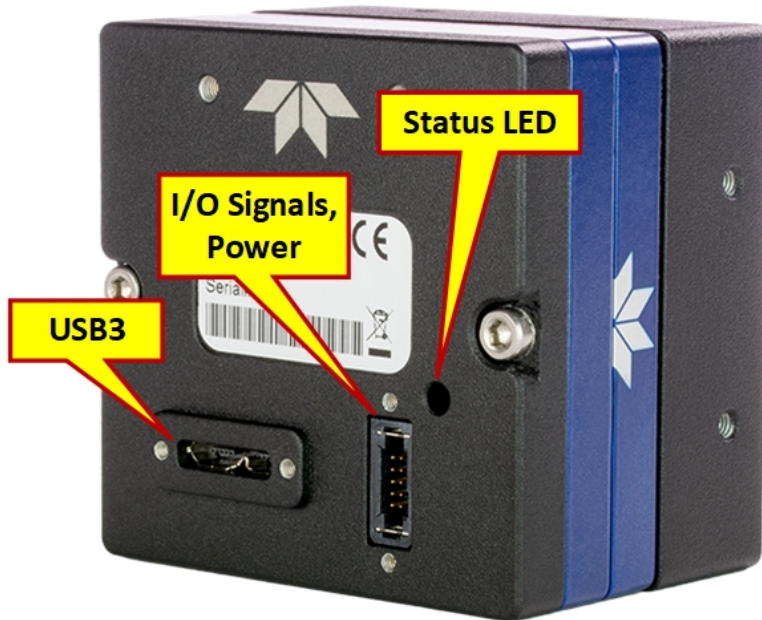
The following figures of the camera back side shows connector and LED locations. See **Mechanical Specifications** for details on the connectors and camera mounting dimensions.



Teledyne Lumenera LT-Ux0x-xxxxx Series



Teledyne Lumenera LT-Ux1x-xxxxx Series




Teledyne Lumenera LT-Ux2x-xxxxx Series

4.2.2 LED Status Indicator

The Lt Series has one multicolor LED located on the back panel, to provide a simple visible indication of camera state, as described below.

Lt-Ux0x-xxxxx, Lt-Ux1x-xxxxx	Lt-Ux2x-xxxxx	Description
LED is off	LED is off	No power to the camera
	Flashing red	Initialization sequence
Steady orange		Device driver failed to load
Flashing orange few times per second	Steady red	Firmware failed to load
Flashing orange once per 2 seconds	Steady red	FPGA failed to load
Steady green	Steady blue	Camera ready / operational
Dimmer green	Flashing green	Camera is streaming or fast frames mode is enabled
Dimmer green (snapshot)	Flashing green	LED will be dimmer green for duration of exposure/LED will flash on frame acquisition
Flashing orange/green		(case 1) Camera is connected to USB 2.0 ports and does not have external power connected (case 2) USB 3 port is not supplying enough camera power
	Steady red and flashing blue	Fatal Error. If the camera does not reboot itself contact Technical Support

4.3 Preventing Operational Faults due to ESD

	<p>Camera installations which do not protect against ESD (electrostatic discharge) may exhibit operational faults. Problems such as random camera resets and random loss of connections may all be solved by proper ESD management.</p> <p>The camera, when used with USB 3 power or a simple power supply, is not properly connected to earth ground and therefore is susceptible to ESD caused problems.</p>
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Teledyne Lumenera has performed ESD testing on cameras using an 8 kilovolt ESD generator without any indication of operational faults. The two following methods, either individually or together will prevent ESD problems.

- Method 1: Use a shielded/grounded power supply that connects to the ground pin of the I/O connector. The camera body is now properly connected to earth ground and can withstand ESD of 8 kilovolts.
- Method 2: Mount the camera on a metallic platform with a good connection to earth ground.

5 Feature Reference

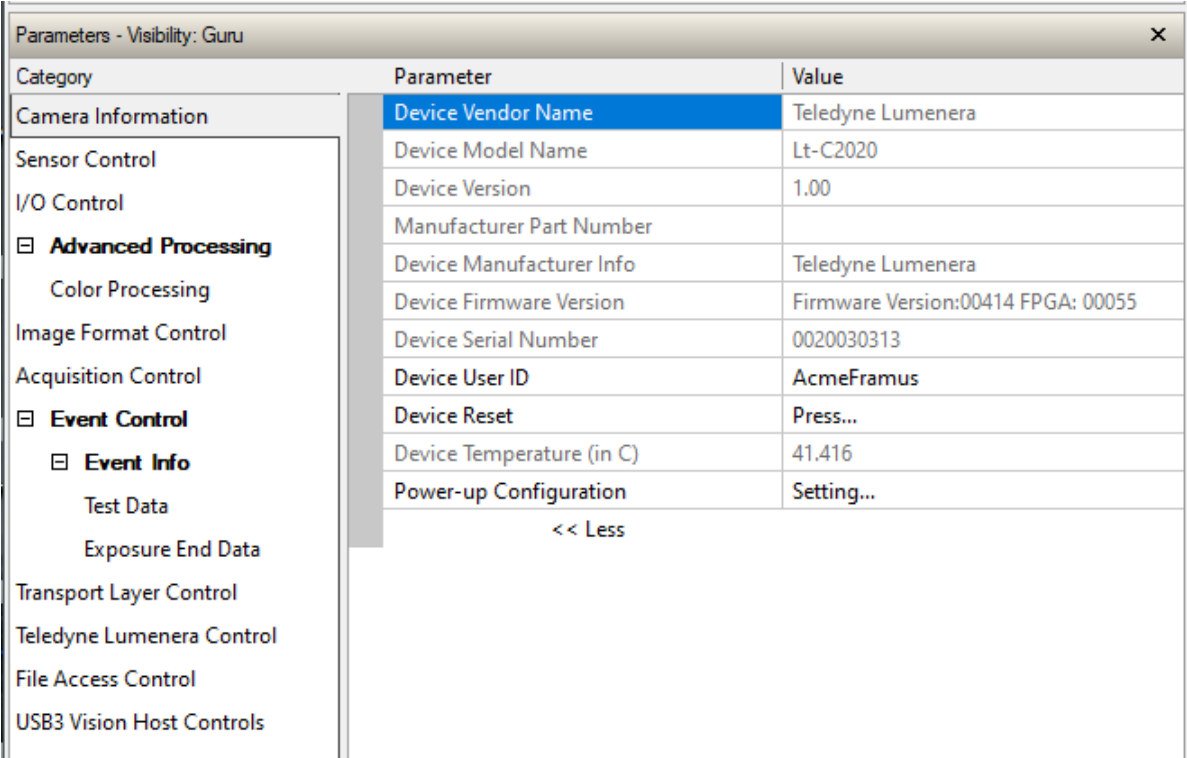
5.1 Lt Series Features

The Teledyne Lumenera Lt Camera series feature set is presented in functional categories as grouped by the camera's XML file. The USB3 GenICam control tool presents these features for the user to read or modify as required to explore the camera operation in the user's imaging setup.

5.2 Camera Information Category

Camera information is retrieved via a controlling application. USB3 Vision applications retrieve this information to identify the camera along with its characteristics. Parameters such as camera model, firmware version, etc. are read to uniquely identify the connected device. These features are typically read-only.

Features listed in the description table but tagged as *Invisible* are usually for third-party software usage—not typically needed by end-user applications.



The screenshot shows a software window titled "Parameters - Visibility: Guru" with a close button (X) in the top right corner. The window is divided into two main sections: a left-hand navigation pane and a right-hand data table.

The left-hand navigation pane lists several categories, each with a small square icon to its left:

- Camera Information
- Sensor Control
- I/O Control
- Advanced Processing**
 - Color Processing
- Image Format Control
- Acquisition Control
- Event Control**
 - Event Info**
 - Test Data
 - Exposure End Data
- Transport Layer Control
- Teledyne Lumenera Control
- File Access Control
- USB3 Vision Host Controls

The right-hand data table has three columns: "Category", "Parameter", and "Value". The "Camera Information" category is selected, and the "Device Vendor Name" parameter is highlighted in blue. The table contains the following data:

Category	Parameter	Value
Camera Information	Device Vendor Name	Teledyne Lumenera
	Device Model Name	Lt-C2020
	Device Version	1.00
	Manufacturer Part Number	
	Device Manufacturer Info	Teledyne Lumenera
	Device Firmware Version	Firmware Version:00414 FPGA: 00055
	Device Serial Number	0020030313
	Device User ID	AcmeFramus
	Device Reset	Press...
	Device Temperature (in C)	41.416
	Power-up Configuration	Setting...

At the bottom of the table, there is a button labeled "<< Less".

5.2.1 Camera Information Feature Descriptions

The following table describes the features and values found in the category, as well as the device version and visibility level (beginner, expert, guru, invisible). The device version represents a camera software functional level (different from the firmware revision number) and may differ for each camera sensor. A major device version release is shown in green. The last column also indicates whether the feature is a member of the DALSA Features Naming Convention (DFNC) or the GenICam Standard Features Naming Convention (SFNC, tag not shown).

Display Name	Feature & Values	Description	Device Version & View
Device Vendor Name	DeviceVendorName	Name of the manufacturer of the device.	1.00 Beginner
Device Model Name	DeviceModelName	Model of the device.	1.00 Beginner
Device Version	DeviceVersion	Version of the device.	1.00 Beginner
Manufacturer Part Number	deviceManufacturerPartNumber	Displays the device manufacturer part number.	1.00 DFNC Beginner
Manufacturer Info	DeviceManufacturerInfo	Manufacturer information about the device.	1.00 Beginner
Device Firmware Version	DeviceFirmwareVersion	Version of the firmware in the device.	1.00 Expert
Device Serial Number	DeviceSerialNumber	Device's serial number. This string is a unique identifier of the device.	1.00 Beginner
Device User ID	DeviceUserID	User-programmable device identifier.	1.00 Beginner
Device Reset	DeviceReset	Resets the device to its power up state. After reset, the device must be rediscovered.	1.00 Beginner
Device Temperature	DeviceTemperature	Device's sensor temperature in degrees Celsius (C).	1.00 Expert
Device Gen CP Version Major	DeviceGenCPVersionMajor	Major version of the GenCP specification.	1.00 Invisible
Device Gen CP Version Minor	DeviceGenCPVersionMinor	Minor version of the GenCP specification.	1.00 Invisible
Device Manifest XML Major Version	DeviceManifestXMLMajorVersion	Indicates the major version number of the GenICam XML.	1.00 Invisible
Device Manifest XML Minor Version	DeviceManifestXMLMinorVersion	Indicates the minor version number of the GenICam XML.	1.00 Invisible
Device Manifest XML Sub Minor Version	DeviceManifestXMLSubMinorVersion	Indicates the subminor version number of the GenICam XML.	1.00 Invisible

5.3 Sensor Control Category

The sensor control group has parameters such as frame rate, exposure time, exposure mode, gain, etc. Parameters shown on screen in gray are read-only, either because they are always read-only or due to other feature settings.

Features listed in the description table that are tagged as *Invisible* are usually for third-party software usage—not typically needed by end-user applications. Note that features shown may change with different camera models implementing different sensors, image resolutions and color versions.

Category	Parameter	Value
Camera Information	Sensor Shutter Mode	Global
Sensor Control	Auto-Brightness Target	152
I/O Control	Acquisition Frame Rate Control Mode	Maximum Speed
<input checked="" type="checkbox"/> Advanced Processing	Acquisition Frame Rate (in Hz)	55.555557
Color Processing	Exposure Time (in us)	9995.0
Image Format Control	Exposure Auto	Off
Acquisition Control	Auto-Exposure Time Max Value (in us)	100000.0
<input checked="" type="checkbox"/> Event Control	Exposure Mode	Timed
<input checked="" type="checkbox"/> Event Info	Exposure Alignment	Synchronous
Test Data	Gain Selector	All
Exposure End Data	Gain	1.0
Transport Layer Control	Gain Auto	Off
Teledyne Lumenera Control	Auto-Gain Max Value	256.0
File Access Control	Auto-Gain Min Value	1.0
USB3 Vision Host Controls	Black Level Selector	Analog
	Black Level (in DN)	5.0
	Black Level Auto	Continuous
	<< Less	

5.3.1 Sensor Control Feature Descriptions

The following table describes the features and values found in the category, as well as the device version and visibility level (beginner, expert, guru, invisible). The device version represents a camera software functional level (different from the firmware revision number) and may differ for each camera sensor. A major device version release is shown in green. The last column also indicates whether the feature is a member of the DALSA Features Naming Convention (DFNC) or the GenICam Standard Features Naming Convention (SFNC, tag not shown).

Display Name	Feature & Values	Description	Device Version & View
Sensor Shutter Mode	SensorShutterMode	States or selects the supported shutter mode of the device.	1.00 Beginner
<i>Global</i>	<i>Global</i>	<i>The shutter exposes all pixels at the same time.</i>	
<i>Global Reset</i>	<i>GlobalReset</i>	<i>The shutter opens at the same time for all pixels but ends in a line sequential manner.</i>	
<i>Rolling</i>	<i>Rolling</i>	<i>The shutter opens and closes sequentially for groups (typically lines) of pixels.</i>	
Auto-Brightness Target	autoBrightnessTarget	Sets the target image grayscale value in DN, for the auto-brightness algorithm. Features that use auto-brightness include ExposureAuto and GainAuto.	1.00 DFNC Expert
Acquisition Frame Rate Control Mode	acquisitionFrameRateControlMode	Set the frame control method used in free running mode.	1.00 DFNC Guru
<i>Programmable</i>	<i>Programmable</i>	<i>The camera frame rate is controlled by the AcquisitionFrameRate feature.</i>	
<i>MaximumSpeed</i>	<i>MaximumSpeed</i>	<i>The camera operates at its maximum frame rate using the current exposure (time and delay) configuration.</i>	
Acquisition Frame Rate	AcquisitionFrameRate	Controls the acquisition rate (in Hertz) at which the frames are captured.	1.00 Beginner
Exposure Time	ExposureTime	Sets the Exposure time. This controls the duration where the photosensitive cells are exposed to light.	1.00 Beginner
Exposure Auto	ExposureAuto	Sets the automatic exposure mode. The exact algorithm used to implement this control is device-specific.	1.00 Beginner
<i>Off</i>	<i>off</i>	<i>Exposure duration is user controlled using ExposureTime.</i>	
<i>Continuous</i>	<i>Continuous</i>	<i>Exposure duration is constantly adapted by the device to maximize the dynamic range.</i>	
Auto-Exposure Time Max Value	exposureAutoMaxValue	Sets the maximum exposure time value allowed by the user in microseconds for the Auto-Exposure function.	1.00 DFNC Expert
Exposure Mode	ExposureMode	Sets the operation mode for the camera exposure (or electronic shutter).	1.00 Beginner
<i>Timed</i>	<i>Timed</i>	<i>The exposure duration time is set using the Exposure Time feature and the exposure starts with a FrameStart event.</i>	
Exposure Alignment	exposureAlignment	Exposure Alignment specifies how the exposure is executed in relationship to the sensor capabilities and current frame trigger.	1.00 DFNC Expert
<i>Synchronous</i>	<i>Synchronous</i>	<i>Exposure is synchronous to the internal timing of the sensor. The readout is concurrent to the exposure for the fastest possible frame rate. When a valid trigger is received and the ExposureTime is shorter than the readout period, the ExposureStart event is latched in the previous frame's readout. That is; the ExposureStartEvent is delayed and is initiated when the actual exposure starts such that the exposure ends and readout begins as soon as the previous readout has completed.</i>	
<i>Reset</i>	<i>Reset</i>	<i>Sensor timing is reset to initiate exposure when a valid trigger is received. Readout is sequential to exposure, reducing the maximum achievable frame rates. That is, a trigger received during exposure or readout is ignored since data would be lost by performing a reset.</i>	
Gain Selector	GainSelector	Selects which gain is controlled when adjusting gain features.	1.00 Beginner
<i>All</i>	<i>All</i>	<i>Gain will be applied to all channels or taps.</i>	

Display Name	Feature & Values	Description	Device Version & View
High Gain Conversion Mode	HighGainConversionMode	Sets the high gain conversion mode.	1.01 DFNC Guru (model dependent)
<i>Off</i>	<i>Off</i>	High gain conversion mode is disabled.	
<i>Active</i>	<i>Active</i>	High gain conversion mode is enabled.	
Gain	Gain	Controls the selected gain as an amplification factor.	1.00 Beginner
Gain Auto	GainAuto	Sets the automatic gain control (AGC) mode. The exact algorithm used to implement AGC is device-specific.	1.00 Beginner
<i>Off</i>	<i>Off</i>	<i>Gain is User controlled using Gain.</i>	
<i>Continuous</i>	<i>Continuous</i>	<i>Gain is constantly adjusted by the device.</i>	
Auto-Gain Max Value	gainAutoMaxValue	Sets the maximum gain multiplier value for the automatic gain algorithm. The automatic gain function is an amplification factor applied to the video signal to obtain the auto-brightness target value.	1.00 DFNC Guru
Auto-Gain Min Value	gainAutoMinValue	Sets the minimum gain multiplier value for the automatic gain algorithm. The automatic gain function is an amplification factor applied to the video signal to obtain the auto-brightness target value.	1.00 DFNC Guru
Black Level Selector	BlackLevelSelector	Selects which Black Level to adjust using the Black Level features.	1.00 Expert
<i>Analog</i>	<i>AnalogAll</i>	<i>Sensor Dark Offset</i>	
Black Level	BlackLevel	Controls the black level as an absolute physical value. This represents a DC offset applied to the video signal, in DN (digital number) units. The Black Level Selector feature specifies the channel to adjust.	1.00 Expert
Black Level Auto	BlackLevelAuto	Sets the automatic black level control mode.	1.00 Expert
<i>Off</i>	<i>Off</i>	<i>Black Level is User controlled using Black Level.</i>	
<i>Continuous</i>	<i>Continuous</i>	<i>Black level is programmed automatically from other settings.</i>	

5.3.2 High gain conversion mode

High gain conversion mode is used to improve image quality in low light environments.

When high gain conversion is enabled (**High Gain Conversion Mode** = *Active*), read noise is minimized, which yields a lower absolute sensitivity threshold better suited for detecting weak signals with short exposures. This mode is therefore ideal when light levels are low.

In normal to very bright lighting conditions, the saturation capacity of the sensor pixels should be maximized to provide the highest dynamic range. In this case, the high gain conversion mode should be disabled (**High Gain Conversion Mode** = *Off*).

5.4 I/O Control Category

The I/O control has features used to configure external trigger and line inputs plus strobe output configuration. Parameters in gray are read-only, either always or due to another parameter being disabled. Parameters in black are user set or programmable via an imaging application.

Features listed in the description table but tagged as *Invisible* are usually for third-party software usage—not typically needed by end-user applications. Note that cameras are available in a number of models implementing different sensors which may support different features within this category.

Category	Parameter	Value
Camera Information	Trigger Selector	Single Frame Trigger(Start)
Sensor Control	Trigger Mode	Off
I/O Control	Trigger Software	Press...
<input type="checkbox"/> Advanced Processing Color Processing Image Format Control Acquisition Control	Trigger Source	Software
<input type="checkbox"/> Event Control <input type="checkbox"/> Event Info Test Data Exposure End Data	Trigger Activation	Rising Edge
Transport Layer Control	Trigger Delay (in us)	0.0
Teledyne Lumenera Control	Trigger Frames Count	1
File Access Control	Strobe Mode	Off
USB3 Vision Host Controls	Strobe Delay (in us)	0
	Strobe Duration (in us)	41
	Strobe Source	Line 1
	Line Selector	Line 0
	Line Name	GPI1 Opto
	Line Mode	Input
	Line Inverter	Not Enabled
	Line Status	False
	Output Line Source	Not Enabled
	Output Line Value	Not Enabled
	Line Status All	0x0000000000000000C

<< Less

5.4.1 I/O Control Feature Descriptions

The following table describes the features and values found in the category, as well as the device version and visibility level (beginner, expert, guru, invisible). The device version represents a camera software functional level (different from the firmware revision number) and may differ for each camera sensor. A major device version release is shown in green. The last column also indicates whether the feature is a member of the DALSA Features Naming Convention (DFNC) or the GenICam Standard Features Naming Convention (SFNC, tag not shown).

Display Name	Feature & Values	Description	Device Version & View
Trigger Selector	TriggerSelector	Selects which type of trigger to configure with the various Trigger features.	1.00 Beginner
Single Frame Trigger(Start)	FrameStart	Selects a trigger starting the capture of a single frame. Frame size is determined by image format feature "Height".	
MultiFrame Trigger(Start)	FrameBurstStart	Selects a trigger to capture multiple frames. The number of frames is specified by the triggerFrameCount feature.	
Trigger Mode	TriggerMode	Controls if the selected trigger is active.	1.00 Beginner
Off	Off	Disables the selected trigger.	
On	On	Enable the selected trigger.	
Trigger Software	TriggerSoftware	Generates an internal trigger. TriggerSource must be set to Software.	1.00 Beginner
Trigger Source	TriggerSource	Specifies the internal signal or physical input Line to use as the trigger source. The selected trigger must have its TriggerMode set to On.	1.00 Beginner
Software	Software	Specifies that the trigger source will be generated by software using the TriggerSoftware command.	
Line0	Line0	Specifies which physical line (or pin) and associated I/O control block to use as external source for the trigger signal.	
Line2	Line2	Specifies which physical line (or pin) and associated I/O control block to use as external source for the trigger signal.	
Line3	Line3	Specifies which physical line (or pin) and associated I/O control block to use as external source for the trigger signal.	
Trigger Activation	TriggerActivation	Specifies the activation mode of the trigger.	1.00 Beginner
Rising Edge	RisingEdge	Specifies that the trigger is considered valid on the rising edge of the source signal.	
Falling Edge	FallingEdge	Specifies that the trigger is considered valid on the falling edge of the source signal.	
Trigger Delay	TriggerDelay	Specifies the delay in microseconds to apply after receiving the trigger and before activating the triggerEvent.	1.00 Beginner
Trigger Frames Count	triggerFrameCount	Sets the maximum number of frames to acquire when a valid trigger is received. This feature is available when Trigger Selector = MultiFrame Trigger(Start).	1.00 Beginner
Strobe Mode	StrobeMode	Enables/disables the strobes in snapshot mode.	1.00 Beginner
Off	Off	Strobe Is Off	
On Trigger	OnTrigger	Strobe fires on the trigger.	
Strobe Delay	StrobeDelay	Trigger to strobe delay	1.00 Beginner
Strobe Duration	StrobeDuration	Strobe length	1.00 Beginner
Strobe Source	StrobeSource	Output physical line (pin) used to generate the strobe signal.	1.00 Guru
Line 1	Line1	Line 1	
Line 2	Line2	Line 2	
Line 3	Line3	Line 3	
Line Selector	LineSelector	Selects the physical line (or pin) of the external device connector to configure.	1.00 Beginner

Display Name	Feature & Values	Description	Device Version & View
<i>Line 0</i>	<i>Line0</i>	<i>Index of the physical line and associated I/O control block to use.</i>	
<i>Line 1</i>	<i>Line1</i>	<i>Index of the physical line and associated I/O control block to use.</i>	
<i>Line 2</i>	<i>Line2</i>	<i>Index of the physical line and associated I/O control block to use.</i>	
<i>Line 3</i>	<i>Line3</i>	<i>Index of the physical line and associated I/O control block to use.</i>	
<i>Line 4</i>	<i>Line4</i>	<i>Index of the physical line and associated I/O control block to use.</i>	
line Name	lineName	Description of the physical Pin associated with the logical line.	1.00 DFNC Beginner
<i>GPI1 Opto</i>	<i>Gpi1Opto</i>	<i>Associated with the logical line GPI1 Opto</i>	
<i>GPO1 Opto</i>	<i>Gpo1Opto</i>	<i>Associated with the logical line GPO1 Opto</i>	
<i>GPIO2</i>	<i>Gpio2</i>	<i>Associated with the logical line GPIO2</i>	
<i>GPIO3</i>	<i>Gpio3</i>	<i>Associated with the logical line GPIO3</i>	
<i>VCC3.3</i>	<i>VCC3.3</i>	<i>Associated with the logical line VCC3.3</i>	
Line Mode	LineMode	Reports if the physical Line is an Input or Output signal.	1.00 Expert
<i>Input</i>	<i>Input</i>	<i>The line is an input line.</i>	
<i>Output</i>	<i>Output</i>	<i>The line is an output line.</i>	
Line Inverter	LineInverter	Control to invert the polarity of the selected input or output line signal.	1.00 Beginner
Line Status	LineStatus	Returns the current status of the selected input or output line.	1.00 Expert
Output Line Source	outputLineSource	Selects which internal signal or event driven pulse or software control state to output on the selected output line.	1.00 DFNC Beginner
<i>Software Controlled</i>	<i>SoftwareControlled</i>	<i>The OutputLineValue feature changes the state of the output.</i>	
<i>Strobe on Trigger</i>	<i>Strobe</i>	<i>Generate a pulse on the Trigger event.</i>	
<i>Pulse on: Start of Exposure</i>	<i>PulseOnStartofExposure</i>	<i>Generate a pulse on the ExposureStart event. This option is typically used to trigger a strobe light.</i>	
<i>Pulse on: Start of Readout</i>	<i>PulseOnStartofReadout</i>	<i>Generate a pulse on the ReadoutStart event.</i>	
<i>Exposure Active</i>	<i>ExposureActive</i>	<i>Generate a signal that is active when the Exposure is active.</i>	
<i>Ready For Trigger</i>	<i>ReadyForTrigger</i>	<i>Generate a signal that is active when the camera is ready for a frame trigger.</i>	
Output Line Pulse Delay	outputLinePulseDelay	Sets the delay (in μ s) before the output line pulse signal. Applicable for the OutputLineSource feature.	1.00 Beginner DFNC
Output Line Pulse Duration	outputLinePulseDuration	Sets the width (duration) of the output line pulse in microseconds.	1.00 Beginner DFNC
Output Line Value	outputLineValue	Sets the output state of the selected Line if the outputLineSoftwareLatchControl = OFF. OutputLineSource must be SoftwareControlled. If the outputLineSoftwareLatchControl = Latch, the state of the pin will change with the outputLineSoftwareCmd command.	1.00 Beginner
<i>Active</i>	<i>Active</i>	<i>Sets the Output circuit to close</i>	
<i>Inactive</i>	<i>Inactive</i>	<i>Sets the Output circuit to open</i>	

Display Name	Feature & Values	Description	Device Version & View
Flash Zone Delay	flashZoneDelay	Returns the recommended output pulse delay, corresponding to the delay of the last line exposure start of a rolling shutter sensor, when the Output Line Source = <i>Pulse on Start of Exposure</i> . (RO)	1.01 Guru DFNC Lt-M/C3840, Lt-M/C5500 models
Flash Zone Duration	flashZoneDuration	Returns the recommended output pulse duration for controlling a flash device for the optimal flash zone time. (RO)	1.01 Guru DFNC Lt-M/C3840, Lt-M/C5500 models
Line Status All	LineStatusAll	Returns the current status of all available line signals, at time of polling, in a single bit field. The order is Line1, Line2, ...	1.00 Expert
Line Pinout	linePinAssociation	Enumeration of the physical line (or pin) on the I/O device connector.	1.00 Invisible
<i>Pin6-7=Opto Input</i>	<i>GpiOptoPin6and7</i>	<i>Pin 6 is the negative opto input and Pin 7 is the positive opto input on the I/O connector.</i>	
<i>Pin2-3=Opto Output</i>	<i>GpoOptoPin2and3</i>	<i>Pin 2 is the positive opto output and Pin 3 is the negative opto output on the I/O connector.</i>	
<i>Pin4=Signal - Pin8=Gnd - Pin1=Pwr</i>	<i>Pin4Signal_Pin8Gnd_Pin1Pwr</i>	<i>Pin 4 is the Signal, Pin 8 is the ground and Pin 1 is the common output Power on the I/O connector.</i>	
<i>Pin5=Signal - Pin8=Gnd - Pin1=Pwr</i>	<i>Pin5Signal_Pin8Gnd_Pin1Pwr</i>	<i>Pin 5 is the Signal, Pin 8 is the ground and Pin 1 is the common output Power on the I/O connector.</i>	
<i>Pin9-7=Opto Input</i>	<i>GpiOptoPin9and7</i>	<i>Pin 9 is the positive opto input and Pin 7 is the negative opto input on the I/O connector.</i>	
<i>Pin8-7=Opto Output</i>	<i>GpoOptoPin8and7</i>	<i>Pin 8 is the positive opto output and Pin 7 is the negative opto output on the I/O connector.</i>	
<i>Pin4=Signal - Pin2,6=Gnd - Pin1=Pwr</i>	<i>Pin4Signal_Pin2or6Gnd_Pin1Pwr</i>	<i>Pin 4 is the Signal, Pin 2 and 6 are the ground and Pin 1 is the common output Power on the I/O connector.</i>	
<i>Pin5=Signal - Pin2,6=Gnd - Pin1=Pwr</i>	<i>Pin5Signal_Pin2or6Gnd_Pin1Pwr</i>	<i>Pin 5 is the Signal, Pin 2 and 6 are the ground and Pin 1 is the common output Power on the I/O connector.</i>	
<i>Pin3=3.3V</i>	<i>Pin3Power</i>	<i>Pin 3 is the 3.3V optional output Power on the I/O connector.</i>	

5.4.1.1 Input and Output Line Details

The general purpose I/O line signals are on the GPIO connector located on the back or edge (dependent of model series) of the cameras. See section **Connectors** for details on connector pinout and I/O signal specifications.

5.4.1.2 Strobe and Flash Zone (Lt-3840, Lt-5500)

In the case of rolling shutter cameras, to help with settings when using a strobe light, the camera provides optimal values for the **Output Line Pulse Delay** and **Output Line Pulse Duration** features, which are found, respectively, in the **Flash Zone Delay** and **Flash Zone Duration** read-only features.

IT IS UP TO THE USER TO INPUT THOSE VALUES.

Note that these optimal values depend on camera settings, so that modifying the settings may induce changes to the flash zone values. Again, it is up to the user to re-enter the **Output Line Pulse Delay** and **Output Line Pulse Duration** values when necessary.

See section **Overview of Electronic Rolling Shutter (ERS) Exposures** for details.

To Use Strobe and Flash Zone in Video/Free Running Mode (Electronic Rolling Shutter)

1. Set **Line Selector** to *Line 3* (only option for video).
2. Set **Line Mode** to *Output*.
3. Set **Output Line Source** to *Pulse on: Start of Exposure*.
4. Set **Output Line Pulse Delay** to the value found in **Flash Zone Delay**.
5. Set **Output Line Pulse Duration** to the value found in **Flash Zone Duration**.

To Use Strobe and Flash Zone in Still/Triggered Single Frame Mode (Global Reset Release Shutter)

1. Set **Trigger Mode** to *On* to set the camera to still/single frame.
2. Set **Line Selector** to *Line 1, 2, or 3*.
3. Set **Line Mode** to *Output*.
4. Set **Output Line Source** to *Pulse on: Start of Exposure*.
5. Set **Output Line Pulse Delay** to the value found in **Flash Zone Delay**.
6. Set **Output Line Pulse Duration** to the value found in **Flash Zone Duration**.

5.5 Advanced Processing Category

This feature group includes controls for acquisition processing of color, gamma, LUT, etc. Parameters in gray are read-only, either always or due to other feature settings. Parameters in black are user set.

Features listed in the description table that are tagged as *Invisible* are usually for third-party software usage—not typically needed by end-user applications.

Parameters - Visibility: Guru		
Category	Parameter	Value
Camera Information	Gamma Correction	1.0
Sensor Control	Contrast Correction	1.0
I/O Control	Brightness Correction	0.0
<input checked="" type="checkbox"/> Advanced Processing	LUT Mode	Off
Color Processing	LUT Index	0
Image Format Control	LUT Value	
Acquisition Control	LUT Value All	
<input checked="" type="checkbox"/> Event Control	<< Less	
Transport Layer Control		
Teledyne Lumenera Control		
File Access Control		
USB3 Vision Host Controls		

Parameters - Visibility: Guru		
Category	Parameter	Value
Camera Information	Balance White Auto	Off
Sensor Control	Balance Ratio Selector	Red
I/O Control	Balance Ratio	1.25
<input checked="" type="checkbox"/> Advanced Processing	<< Less	
Color Processing		
Image Format Control		
Acquisition Control		
<input checked="" type="checkbox"/> Event Control		
Transport Layer Control		
Teledyne Lumenera Control		
File Access Control		
USB3 Vision Host Controls		

5.5.1 Advanced Processing Feature Descriptions

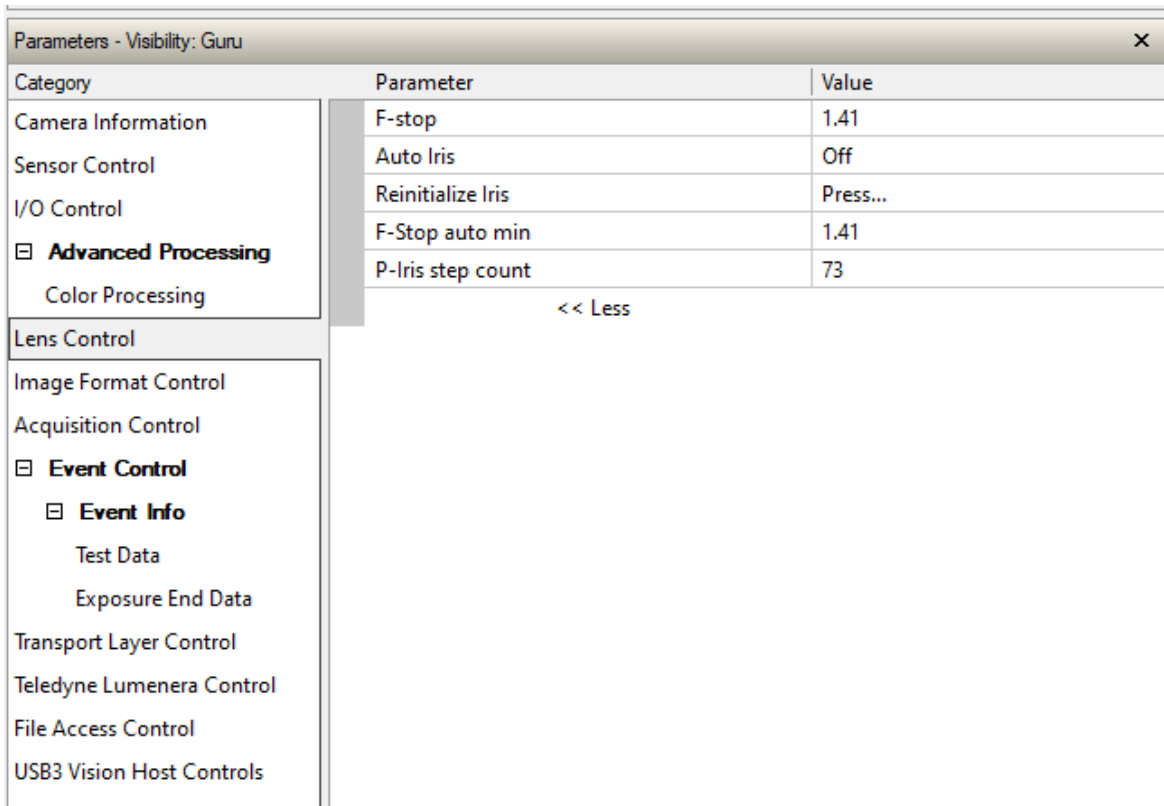
The following table describes the features and values found in the category, as well as the device version and visibility level (beginner, expert, guru, invisible). The device version represents a camera software functional level (different from the firmware revision number) and may differ for each camera sensor. A major device version release is shown in green. The last column also indicates whether the feature is a member of the DALSA Features Naming Convention (DFNC) or the GenICam Standard Features Naming Convention (SFNC, tag not shown).

Display Name	Feature & Values	Description	Device Version & View
Gamma Correction	gammaCorrection	Sets the gamma correction factor. The gamma correction is applied as an inverse exponent to the original pixel value.	1.00 DFNC Expert
Contrast Correction	contrastCorrection	Sets the contrast correction factor.	1.00 DFNC Expert
Brightness Correction	brightnessCorrection	Sets the brightness correction as a percentage.	1.00 DFNC Expert
LUT Mode	lutMode	Sets the enable state of the LUT module (Lookup Table).	1.00 DFNC Expert
<i>Off</i>	<i>Off</i>	<i>Disables the LUT.</i>	
<i>Active</i>	<i>Active</i>	<i>Enables the LUT.</i>	
LUT Index	LUTIndex	Selects the index (offset) of the coefficient to access in the selected LUT.	1.00 Guru
LUT Value	LUTValue	Returns the value at specified LUT index entry of the LUT selected by the LUT Selector feature.	1.00 Guru
LUT Value All	LUTValueAll	Accesses all the LUT coefficients in a single access without using individual LUT indices. This feature accesses the LUT values in the currently active LUT table set by the LUT Current Active Set feature.	1.00 Guru
Balance White Auto	BalanceWhiteAuto	Controls the mode for automatic white balancing between the color channels. The white balancing ratios are automatically adjusted.	1.00 Expert
<i>Off</i>	<i>Off</i>	<i>White balancing is user controlled using BalanceRatioSelector and BalanceRatio.</i>	
<i>Continuous</i>	<i>Continuous</i>	<i>White balancing is constantly adjusted by the device.</i>	
Balance Ratio Selector	BalanceRatioSelector	Selects which color gain is controlled with the BalanceRatio feature.	1.00 Expert
<i>Red</i>	<i>Red</i>	<i>RED gain is controlled by Balance Ratio.</i>	
<i>Green</i>	<i>Green</i>	<i>GREEN gain is controlled by Balance Ratio.</i>	
<i>Blue</i>	<i>Blue</i>	<i>BLUE gain is controlled by Balance Ratio.</i>	
Balance Ratio	BalanceRatio	Sets the digital gain of the selected color component (BalanceRatioSelector).	1.00 Expert

5.6 Lens Control (for LT-Ux0x-xxxxx series)

The LT-Ux0x-xxxxx Series lens control has parameters used to configure features controlling motorized iris lens. Parameters in gray are read-only, either always or due to another parameter being disabled. Parameters in black are user programmable via an imaging application.

Features listed in the description table but tagged as *Invisible* are usually for third-party software usage—not typically needed by end-user applications.



5.6.1 Lens Control Feature Descriptions

The following table describes the features and values found in the category, as well as the device version and visibility level (beginner, expert, guru, invisible). The device version represents a camera software functional level (different from the firmware revision number) and may differ for each camera sensor. A major device version release is shown in green. The last column also indicates whether the feature is a member of the DALSA Features Naming Convention (DFNC) or the GenICam Standard Features Naming Convention (SFNC, tag not shown).

Display Name	Feature & Values	Description	Device Version & View
F-stop	iris	F-number setting. The larger the number the smaller the aperture.	1.00 DFNC Expert

Display Name	Feature & Values	Description	Device Version & View
Auto Iris	irisAuto	Iris automatic mode	1.00 DFNC Beginner
	<i>Off</i>	<i>Off</i>	
	<i>Continuous</i>	<i>Continuous</i>	
Reinitialize Iris	irisInit	Initializes the iris	1.00 DFNC Beginner
F-Stop auto min	irisAutoMin	The user set limit to the lowest iris F-Stop number (i.e. the maximum iris aperture opening – <i>maximum exposure</i>) when Auto Iris is enabled. The maximum iris F-Stop number (<i>minimum aperture</i>) is lens dependent.	1.00 DFNC Expert
P-Iris step count	irisStepsCount	Number of positions in the P-Iris stepping motor. Users must consult their lens's manual and set it correctly before accessing their lens.	1.00 DFNC Guru

5.6.2 F-stops vs. Exposure Overview

The Lt Series Lens F-stop control allows adjusting the lens iris with small incremental steps. It is important to remember that full stop increases will half the incoming illumination and requires doubling the exposure time to compensate.

The common aperture scale is as follows:

f/1.4	(large opening of aperture – a lot of light)
f/2.0	(half as much light as f/1.4)
f/2.8	(half as much light as f/2.0)
f/4.0	(half again)
f/5.6	(half again)
f/8.0	(half again)
f/11.0	(half again)
f/16.0	(half again)
f/22.0	(half again)
f/32.0	(very small aperture, lets in little light)

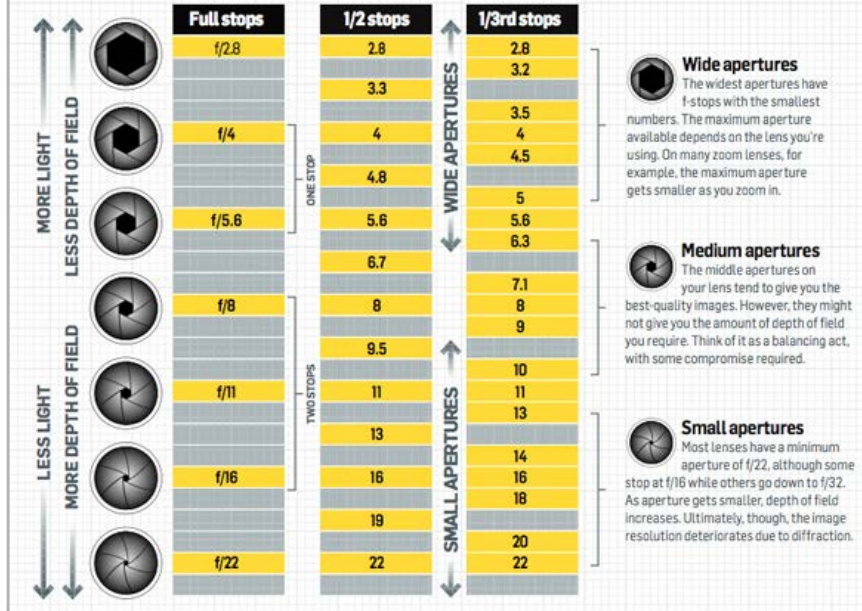
For users unfamiliar with lens iris controls (F-stops), the following photography site has a good explanation of this subject and along with a handy table of standard F-stop values.

Digital Camera World's web site

<https://www.digitalcameraworld.com/tutorials/cheat-sheet-how-to-understand-f-stops>

MAKING SENSE OF F-STOPS

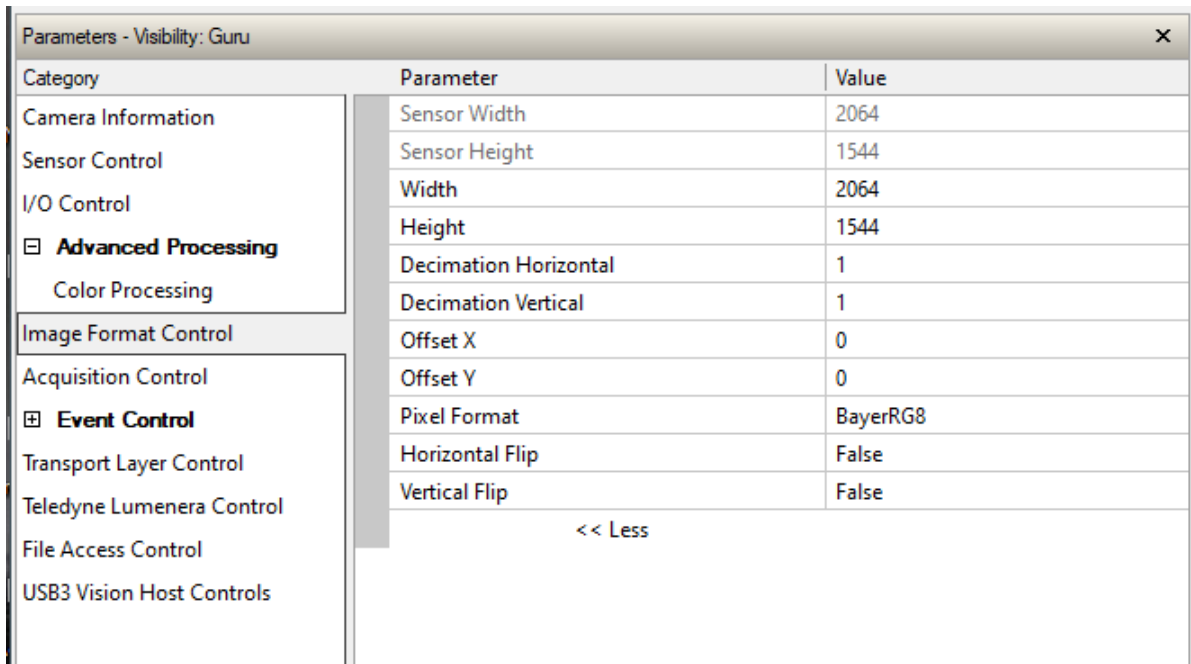
Your at-a-glance guide to aperture scales and what the numbers mean



5.7 Image Format Control Category

The LT Series Image Format control has parameters used to configure camera pixel format, image cropping, decimation and others. Parameters in gray are read-only, either always or due to another parameter being disabled. Parameters in black are user set.

Features listed in the description table but tagged as *Invisible* are usually for third-party software usage—not typically needed by end-user applications. Note that Teledyne Lumenera cameras are available in a number of models implementing different sensors and image resolutions which may not support the full feature set defined in this category.



5.7.1 Image Format Control Feature Description

The following table describes the features and values found in the category, as well as the device version and visibility level (beginner, expert, guru, invisible). The device version represents a camera software functional level (different from the firmware revision number) and may differ for each camera sensor. A major device version release is shown in green. The last column also indicates whether the feature is a member of the DALSA Features Naming Convention (DFNC) or the GenICam Standard Features Naming Convention (SFNC, tag not shown).

Display Name	Feature & Values	Description	Device Version & View
Sensor Width	SensorWidth	Effective width of the sensor in pixels.	1.00 Expert
Sensor Height	SensorHeight	Effective height of the sensor in pixels.	1.00 Expert

Display Name	Feature & Values	Description	Device Version & View
<u>Width</u>	Width	Width of the Image provided by the device (in pixels).	1.00 Beginner
<u>Height</u>	Height	Height of the Image provided by the device (in lines).	1.00 Beginner
Binning Horizontal	BinningHorizontal	Number of horizontal pixels to combine together. This reduces the horizontal resolution of the image.	1.00 Beginner
Binning Vertical	BinningVertical	Number of vertical pixels to combine together. This reduces the vertical resolution of the image.	1.00 Beginner
Decimation Horizontal	DecimationHorizontal	Horizontal sub-sampling of the image. This reduces the horizontal resolution (width) of the image by the specified horizontal decimation factor.	1.00 Beginner
Decimation Vertical	DecimationVertical	Vertical sub-sampling of the image. This reduces the vertical resolution (height) of the image by the specified vertical decimation factor.	1.00 Beginner
Offset X	OffsetX	Horizontal offset from the origin to the region of interest (in pixels).	1.00 Beginner
Offset Y	OffsetY	Vertical offset from the origin to the region of interest (in pixels).	1.00 Beginner
Pixel Format	PixelFormat	Format of the pixels provided by the device. It represents all the information provided by PixelSize, PixelColorFilter combined in a single feature.	1.00 Beginner
<i>Mono8</i>	<i>Mono8</i>	<i>Monochrome 8-Bit</i>	
<i>Mono16</i>	<i>Mono16</i>	<i>Monochrome 16-Bit (12-bit image only in a 16-bit buffer)</i>	
<i>BayerGR8</i>	<i>BayerGR8</i>	<i>Bayer Green-Red 8-bit</i>	
<i>BayerGR16</i>	<i>BayerGR16</i>	<i>Bayer Green-Red 16-bit (12-bit image only in a 16-bit buffer)</i>	
<i>BayerGB8</i>	<i>BayerGB8</i>	<i>Bayer Green-Blue 8-bit</i>	
<i>BayerGB16</i>	<i>BayerGB16</i>	<i>Bayer Green-Blue 16-bit (12-bit image only in a 16-bit buffer)</i>	
<i>BayerBG8</i>	<i>BayerBG8</i>	<i>Bayer Blue-Green 8-bit</i>	
<i>BayerBG16</i>	<i>BayerBG16</i>	<i>Bayer Blue-Green 16-bit (12-bit image only in a 16-bit buffer)</i>	
<i>BayerRG8</i>	<i>BayerRG8</i>	<i>Bayer Red-Green 8-bit</i>	
<i>BayerRG16</i>	<i>BayerRG16</i>	<i>Bayer Red-Green 16-bit (12-bit image only in a 16-bit buffer)</i>	
<u>Horizontal Flip</u>	ReverseX	Horizontal image flip function.	
<u>Vertical Flip</u>	ReverseY	Vertical image flip function.	1.00 Expert
Width Max	WidthMax	Maximum width of the image (in pixels). The dimension is calculated after horizontal binning, decimation or any other function changing the horizontal dimension of the image.	1.00 Invisible
Height Max	HeightMax	Maximum height of the image (in pixels). This dimension is calculated after vertical binning, decimation or any other function changing the vertical dimension of the image.	1.00 Invisible

Display Name	Feature & Values	Description	Device Version & View
Pixel Color Filter	PixelColorFilter	Indicates the type of color filter applied to the image.	1.00 Invisible
<i>None</i>	<i>None</i>	<i>No color filter.</i>	
<i>BayerRG</i>	<i>BayerRG</i>	<i>Bayer Red Green filter.</i>	
<i>BayerGB</i>	<i>BayerGB</i>	<i>Bayer Green Blue filter.</i>	
<i>BayerGR</i>	<i>BayerGR</i>	<i>Bayer Green Red filter.</i>	
<i>BayerBG</i>	<i>BayerBG</i>	<i>Bayer Blue Green filter.</i>	

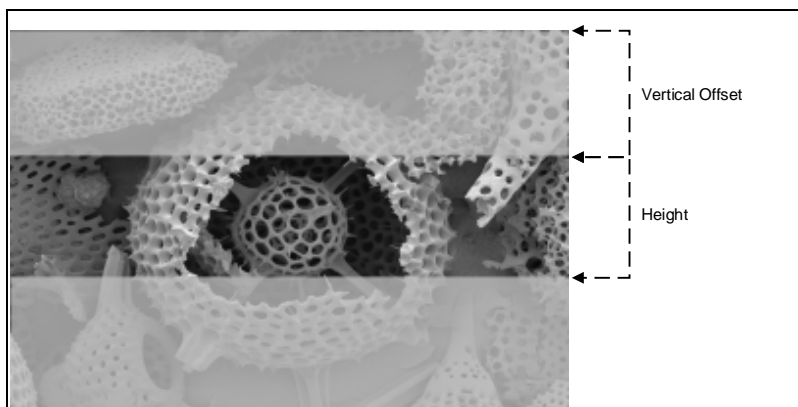
5.7.2 Width and Height Features for Partial Scan Control

Width and Height controls, along with their respective offset settings, allow the camera to grab a region of interest (ROI) within the full image frame. Besides eliminating post acquisition image cropping done by software in the host computer, a windowed ROI grab reduces the transfer bandwidth required since less pixels are transmitted.

5.7.2.1 Vertical Cropping (Partial Scan)

The Height and Vertical Offset features, used for vertical cropping, reduce the number of video lines grabbed for a frame. By not scanning the full height of the sensor, the maximum possible acquisition frame rate is proportionately increased, up to the Lt Camera maximum.

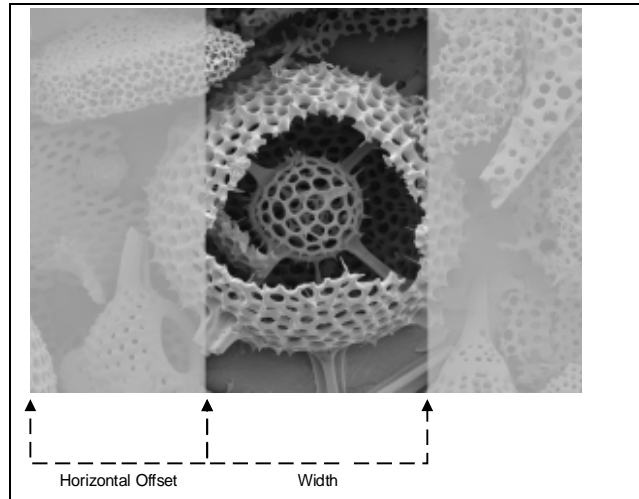
The following figure is an example of a partial scan acquisition using both Height and Vertical Offset controls. The Vertical Offset feature defines at what line number from the sensor origin to acquire the image. The Height feature defines the number of lines to acquire (to a maximum of the remaining frame height). Note that only the partial scan image (ROI) is transmitted to the host computer.



Note: In general, using short exposures at high frame rates will exceed the maximum bandwidth transfer speed, when the camera buffer memory is filled. The tables below (for different models) describe frame rate maximums written to internal memory that can be sustained during continuous acquisition. Increase the exposure time, decrease the frame rate, or acquire a limited number of frames, so as to not exceed the transfer bandwidth.

5.7.2.2 *Horizontal Cropping (Partial Scan)*

Lt Series cameras support cropping the acquisition horizontally by grabbing fewer pixels on each horizontal line. Horizontal offset defines the start of the acquired video line while horizontal width defines the number of pixels per line.



5.7.3 **Horizontal and Vertical Flip**

The Image Flip features activate image acquisition with horizontal and/or vertical inversion.

- Support of one or both functions is camera model specific since it is a function of sensor data readout, not post sensor processing.
- When image flip is supported directly at the sensor, activation of the flip function does not reduce the maximum frame rate possible from that model.
- The horizontal and/or vertical image flip functions acquire images as expected.

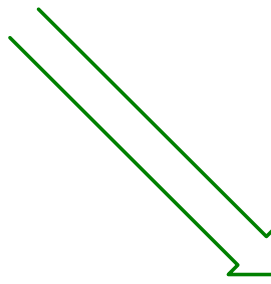
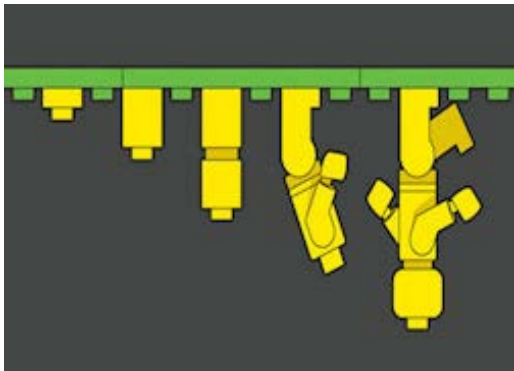
Acquisition Flip Features



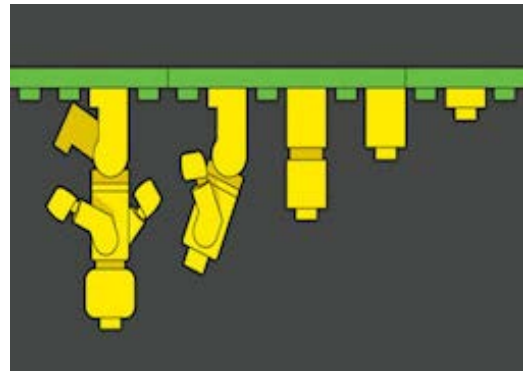
Horizontal Flip (Mirror)



Vertical Flip



Both Horizontal & Vertical Flip



5.8 Acquisition Control Category

This feature group includes controls for acquisition management. Parameters in gray are read-only, either always or due to other feature settings. Parameters in black are user set.

Features listed in the description table that are tagged as *Invisible* are usually for third-party software usage—not typically needed by end-user applications.

Category	Parameter	Value
Camera Information	Acquisition Mode	Not Enabled
Sensor Control	Acquisition Frame Count	Not Enabled
I/O Control	Burst Count	1
<input checked="" type="checkbox"/> Advanced Processing	Acquisition Start	Not Enabled
Color Processing	Acquisition Stop	Not Enabled
Lens Control	Acquisition Abort Cmd	Not Enabled
Image Format Control	<< Less	
Acquisition Control		
<input checked="" type="checkbox"/> Event Control		
<input checked="" type="checkbox"/> Event Info		
Test Data		
Exposure End Data		
Transport Layer Control		
Teledyne Lumenera Control		
File Access Control		
USB3 Vision Host Controls		

5.8.1 Acquisition Control Feature Descriptions

The following table describes the features and values found in the category, as well as the device version and visibility level (beginner, expert, guru, invisible). The device version represents a camera software functional level (different from the firmware revision number) and may differ for each camera sensor. A major device version release is shown in green. The last column also indicates whether the feature is a member of the DALSA Features Naming Convention (DFNC) or the GenICam Standard Features Naming Convention (SFNC, tag not shown).

Display Name	Feature & Values	Description	Device Version & View
Acquisition Mode	AcquisitionMode	Sets the acquisition mode of the device. It defines mainly the number of frames to capture during an acquisition and the way the acquisition stops.	1.00 Beginner

Display Name	Feature & Values	Description	Device Version & View
<i>Continuous</i>	<i>Continuous</i>	<i>Frames are captured continuously until stopped with the AcquisitionStop command.</i>	
<i>Single Frame</i>	<i>SingleFrame</i>	<i>One frame is captured for each AcquisitionStart Command. An AcquisitionStop occurs at the end of the Active Frame.</i>	
<i>Multi-Frame</i>	<i>MultiFrame</i>	<i>A sequence of frames is captured for each AcquisitionStart Command. The number of frames is specified by AcquisitionFrameCount feature. An AcquisitionStop occurs at the end of the Active Frame(s).</i>	
Acquisition Frame Count	AcquisitionFrameCount	Number of frames to be acquired in MultiFrame acquisition mode.	1.00 Beginner
Burst Count	AcquisitionBurstFrameCount	Number of consecutive snapshots to acquire on cameras that support fast multiple snapshots.	1.00 Guru
Acquisition Start	AcquisitionStart	Starts the Acquisition of the device. The number of frames captured is specified by AcquisitionMode.	1.00 Beginner
Acquisition Stop	AcquisitionStop	Stops the Acquisition of the device at the end of the current Frame.	1.00 Beginner
Acquisition Abort CMD	AcquisitionAbort	Aborts the acquisition immediately. This will end the capture without completing the current frame or aborts waiting on a trigger. If no acquisition is in progress, the command is ignored.	1.00 Beginner
Device Registers Streaming Start	DeviceRegistersStreamingStart	Announces the start of registers streaming without immediate checking for consistency.	1.00 Invisible
Device Registers Streaming End	DeviceRegistersStreamingEnd	Announces end of registers streaming and performs validation for registers consistency before activating them.	1.00 Invisible
Registers Check	DeviceRegistersCheck	Performs an explicit register set validation for consistency.	1.00 Invisible
Registers Valid	DeviceRegistersValid	States if the current register set is valid and consistent.	1.00 Invisible

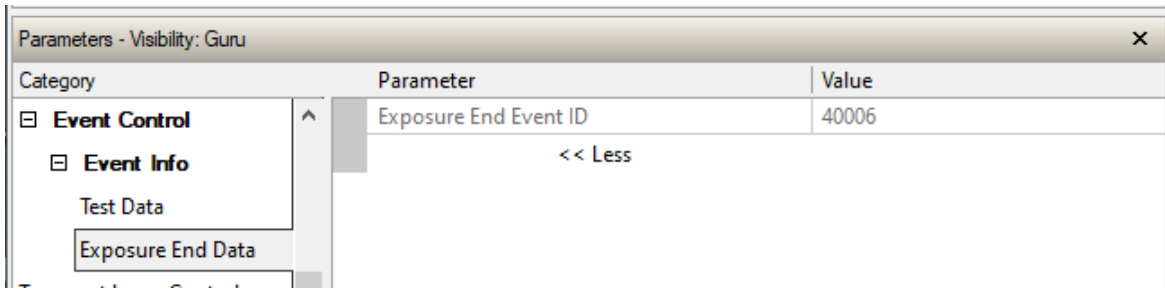
5.9 Event Control Category

This feature group includes controls for event management. Parameters in gray are read-only, either always or due to other feature settings. Parameters in black are user set.

Features listed in the description table that are tagged as *Invisible* are usually for third-party software usage—not typically needed by end-user applications.

Category	Parameter	Value
Camera Information	Timestamp Latch Value (in ns)	0
Sensor Control	Timestamp Latch	Press...
I/O Control	Timestamp Increment	320
Advanced Processing	Event Selector	End of Exposure
Color Processing	Event Notification	Off
Lens Control	<< Less	
Image Format Control		
Acquisition Control		
Event Control		
Event Info		
Test Data		
Exposure End Data		
Transport Layer Control		
Teledyne Lumenera Control		
File Access Control		
USB3 Vision Host Controls		

Category	Parameter	Value
Event Control	Test Event ID	20479
Event Info	<< Less	
Test Data		
Exposure End Data		



5.9.1 Event Control Feature Descriptions

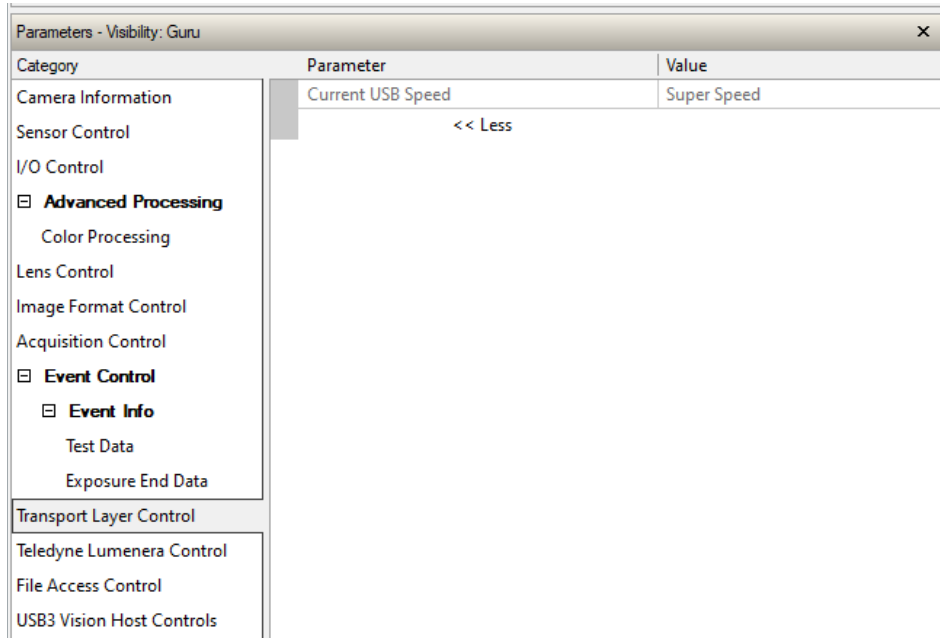
The following table describes the features and values found in the category, as well as the device version and visibility level (beginner, expert, guru, invisible). The device version represents a camera software functional level (different from the firmware revision number) and may differ for each camera sensor. A major device version release is shown in green. The last column also indicates whether the feature is a member of the DALSA Features Naming Convention (DFNC) or the GenICam Standard Features Naming Convention (SFNC, tag not shown).

Display Name	Feature & Values	Description	Device Version & View
Timestamp Latch Value	TimestampLatchValue	Returns the latched value of the timestamp.	1.00 Expert
Timestamp Latch	TimestampLatch	Latches the current Timestamp in the TimestampValue feature.	1.00 Expert
Timestamp Increment	timestampIncrement	Timestamp Increment	1.00 DFNC Expert
Event Selector	EventSelector	Select the Event to enable/disable with the EventNotification feature.	1.00 Expert
<i>End of Exposure</i>	<i>ExposureEnd</i>	<i>Event sent on control channel on end of exposure.</i>	
Event Notification	EventNotification	Enable Events for the event type selected by the EventSelector feature.	1.00 Expert
<i>Off</i>	<i>Off</i>	<i>The selected event is disabled.</i>	
<i>On</i>	<i>On</i>	<i>The selected event will generate a software event.</i>	
Test Event ID	EventTest	Represents the event ID to identify the EventTest software Event.	1.00 Guru
Test Data	EventTestData	Data of the U3V test event	1.00 Guru
Test Event Timestamp	EventTestTimestamp	Timestamp of the Test event.	1.00 Guru
Exposure End Event ID	EventExposureEnd	Represents the event ID to identify the EventExposureEnd software Event.	1.00 Guru
Exposure End Data	EventExposureEndData	Data of the exposure end event	1.00 Guru
Exposure End Event Timestamp	EventExposureEndTimestamp	Timestamp of the EventExposureEnd event.	1.00 Guru

5.10 Transport Layer Control Category

The Transport Layer control, as shown by a camera software tool, has parameters used to configure features related to USB3 Vision specification. Parameters in gray are read-only, either always or due to another parameter being disabled. Parameters in black are user set or programmable via an imaging application.

Features listed in the description table but tagged as *Invisible* are usually for third-party software usage—not typically needed by end-user applications.



5.10.1 Transport Layer Feature Descriptions

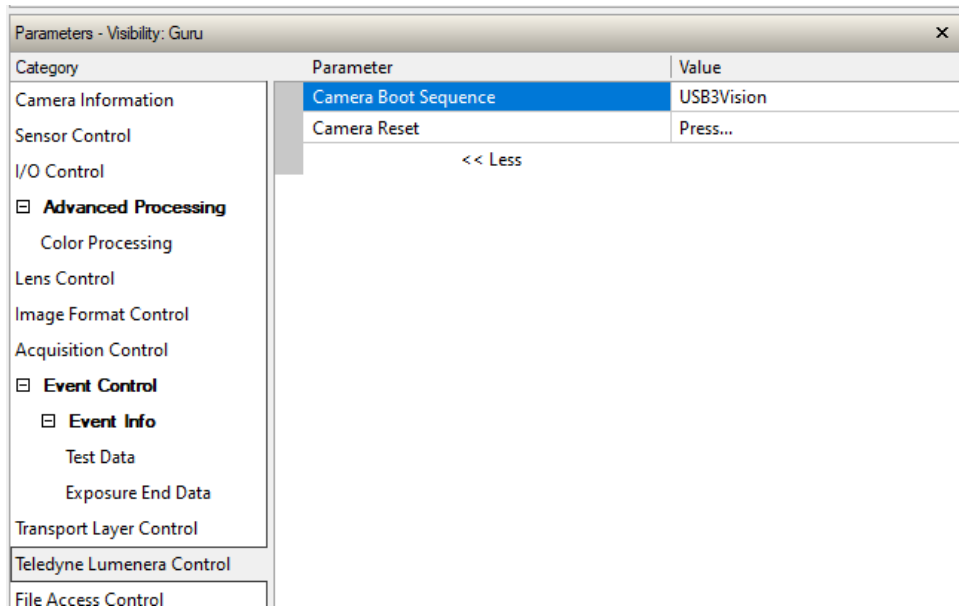
The following table describes the features and values found in the category, as well as the device version and visibility level (beginner, expert, guru, invisible). The device version represents a camera software functional level (different from the firmware revision number) and may differ for each camera sensor. A major device version release is shown in green. The last column also indicates whether the feature is a member of the DALSA Features Naming Convention (DFNC) or the GenICam Standard Features Naming Convention (SFNC, tag not shown).

Display Name	Feature & Values	Description	Device Version & View
Current USB Speed	u3VCurrentSpeed	Current Speed of the USB link.	1.00 Beginner
<i>Low Speed</i>	<i>LowSpeed</i>		
<i>Full Speed</i>	<i>FullSpeed</i>		
<i>High Speed</i>	<i>HighSpeed</i>		
<i>Super Speed</i>	<i>SuperSpeed</i>		
	PayloadSize	Provides the number of bytes transferred for each image or chunk on the stream channel.	1.00 Invisible

5.11 Teledyne Lumenera Control Category

Features listed in the description table but tagged as *Invisible* are usually for third-party software usage—not typically needed by end-user applications.

Warning: Setting the **cameraBootSequence** feature to *Lucam* and resetting the camera will disable access to the camera via USB3 Vision. The LuCam mode protocol is required for use of the Lumenera LuCam API – not Sopera LT API. The **cameraBootSequence** feature only applies to the Lt-Ux0x-xxxxx and Lt-Ux1x-xxxxx series cameras. See **Switching a Lumenera camera from LuCam mode to USB3 Vision mode** and **Switching a Lumenera camera from USB3 Vision mode to LuCam mode** for information and methods required to switch a camera mode.



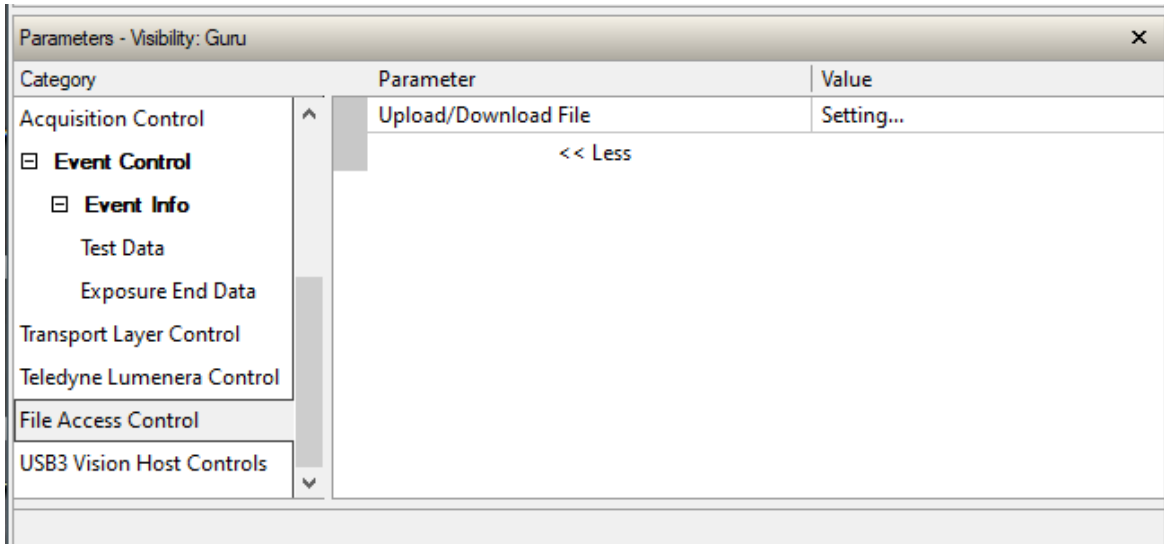
5.11.1 Teledyne Lumenera Control Feature Descriptions

The following table describes the features and values found in the category, as well as the device version and visibility level (beginner, expert, guru, invisible). The device version represents a camera software functional level (different from the firmware revision number) and may differ for each camera sensor. A major device version release is shown in green. The last column also indicates whether the feature is a member of the DALSA Features Naming Convention (DFNC) or the GenICam Standard Features Naming Convention (SFNC, tag not shown).

Display Name	Feature & Values	Description	Device Version & View
Camera Boot Sequence	cameraBootSequence	Boot camera as USB3 Vision or LuCam.	Guru
<i>Lucam</i>	<i>Lucam</i>	<i>Lucam protocol (applicable when using the Teledyne Lucam API software)</i>	
<i>USB3Vision</i>	<i>USB3Vision</i>	<i>USB3Vision protocol (compatible with Genicam and USB3 Vision software API)</i>	
Camera Reset	CameraReset	Resets the camera features to its power-on default state but does not do a hardware camera reset.	Beginner

5.12 File Access Control Category

File Access control in CamExpert allows the user to quickly upload or download camera firmware and other data.



5.12.1 File Access Control Feature Descriptions

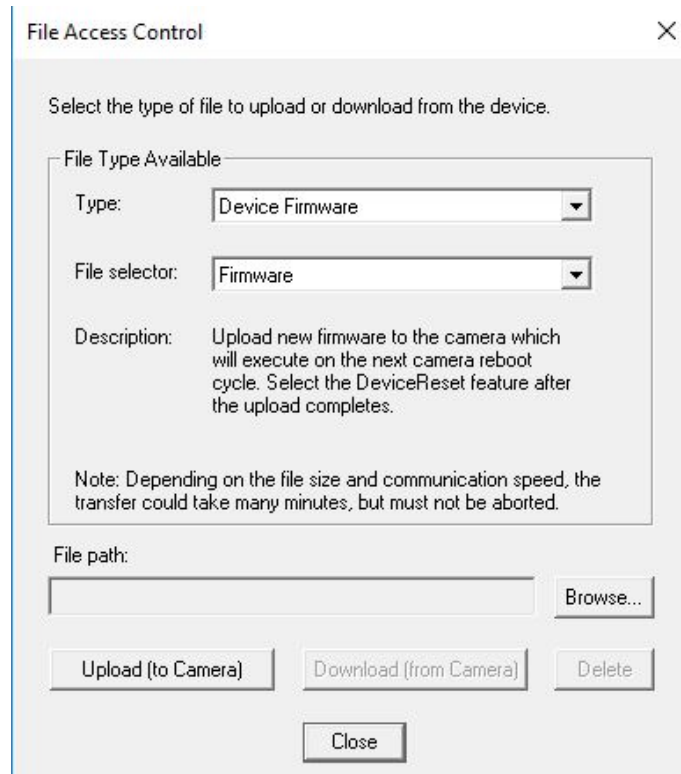
The following table describes the features and values found in the category, as well as the device version and visibility level (beginner, expert, guru, invisible). The device version represents a camera software functional level (different from the firmware revision number) and may differ for each camera sensor. A major device version release is shown in green. The last column also indicates whether the feature is a member of the DALSA Features Naming Convention (DFNC) or the GenICam Standard Features Naming Convention (SFNC, tag not shown).

Display Name	Feature & Values	Description	Device Version & View
File Selector	FileSelector	Selects the file to access. The file types which are accessible are device-dependent.	1.00 Guru
<i>Firmware</i>	<i>Firmware1</i>	<i>Upload new firmware to the camera, which will execute on the next camera reboot cycle. Select the DeviceReset feature after the upload completes.</i>	
<i>Image</i>	<i>Image</i>	<i>Sample image taken with this unit.</i>	
File Operation Selector	FileOperationSelector	Selects the target operation for the selected file in the device. This operation is executed when the File Operation Execute feature is called.	1.00 Guru
<i>Open</i>	<i>Open</i>	<i>Select the Open operation - executed by FileOperationExecute.</i>	
<i>Close</i>	<i>Close</i>	<i>Select the Close operation - executed by FileOperationExecute</i>	
<i>Read</i>	<i>Read</i>	<i>Select the Read operation - executed by FileOperationExecute.</i>	
<i>Write</i>	<i>Write</i>	<i>Select the Write operation - executed by FileOperationExecute.</i>	

Display Name	Feature & Values	Description	Device Version & View
<i>Delete</i>	<i>Delete</i>	<i>Select the Delete operation - executed by FileOperationExecute.</i>	
File Operation Execute	FileOperationExecute	Executes the operation selected by File Operation Selector on the selected file.	1.00 Guru
File Open Mode	FileOpenMode	Selects the access mode used to open a file on the device.	1.00 Guru
<i>Read</i>	<i>Read</i>	<i>Select read-only open mode</i>	
<i>Write</i>	<i>Write</i>	<i>Select write-only open mode</i>	
File Access Offset	FileAccessOffset	Controls the mapping offset between the device file storage and the file access buffer.	1.00 Guru
File Access Length	FileAccessLength	Controls the mapping length between the device file storage and the file access buffer.	1.00 Guru
File Access Buffer	FileAccessBuffer	Defines the intermediate access buffer that allows the exchange of data between the device file storage and the application.	1.00 Guru
File Operation Status	FileOperationStatus	Displays the file operation execution status.	1.00 Guru
<i>Success</i>	<i>Success</i>	<i>The last file operation has completed successfully.</i>	
<i>Failure</i>	<i>Failure</i>	<i>The last file operation has completed unsuccessfully for an unknown reason.</i>	
<i>File Unavailable</i>	<i>FileUnavailable</i>	<i>The last file operation has completed unsuccessfully because the file is currently unavailable.</i>	
<i>File Invalid</i>	<i>FileInvalid</i>	<i>The last file operation has completed unsuccessfully because the selected file is not present in this camera model.</i>	
File Operation Result	FileOperationResult	Displays the file operation result. For Read or Write operations, the number of successfully read/written bytes is returned.	1.00 Guru
File Size	FileSize	Represents the size of the selected file in bytes.	1.00 Guru

5.12.2 File Access via the CamExpert Tool (Quick Camera Firmware Upgrade)

- In the **File Access Control** category, click **Setting** to open the File Access Control dialog.

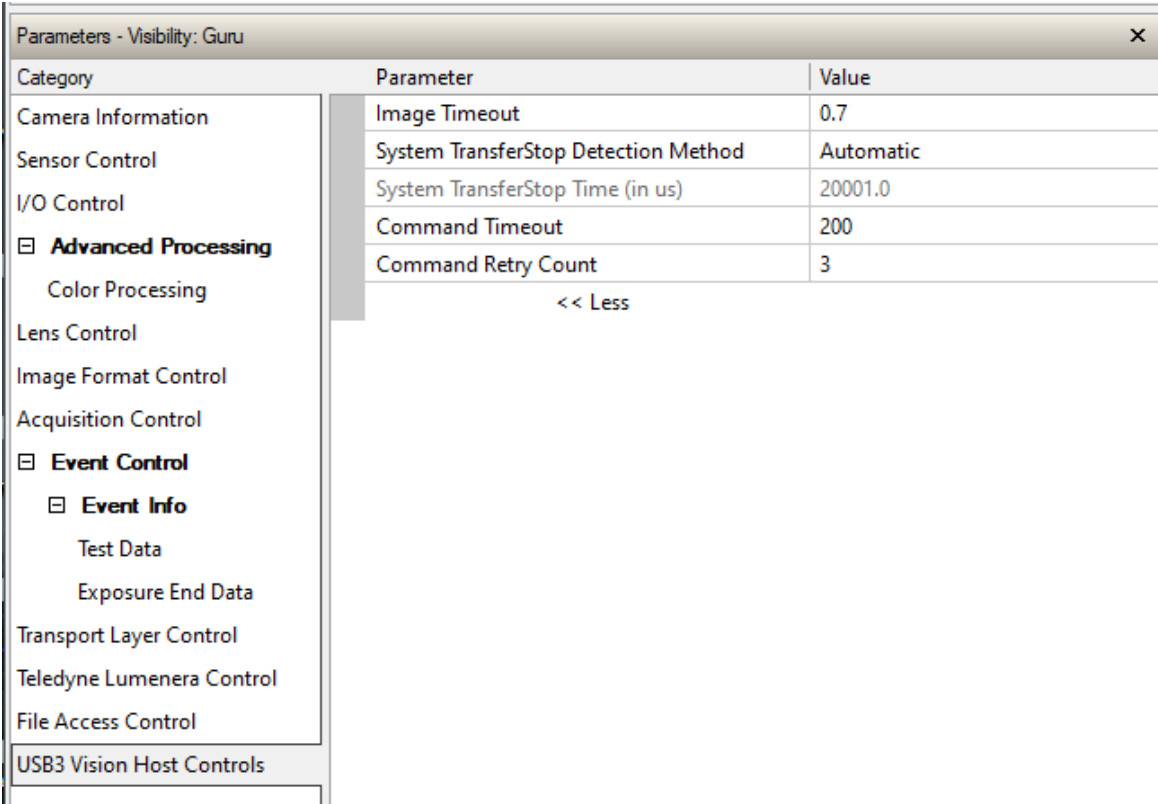


- From the **Type** list, choose the type of file to upload to the camera.
- From the **File selector** list, choose *Firmware*.
- Click **Browse** to open Windows Explorer.
- Select the .cbf firmware file to upload.
- Click **Upload (to Camera)** to execute the file transfer to the camera.

5.13 USB3 Vision Host Controls

The USB3 Vision Host Controls group parameters are used to configure the host computer system features used for camera communication management. None of the parameters are stored in the camera.

The features allow optimizing the configuration for maximum bandwidth.



The screenshot shows a software window titled "Parameters - Visibility: Guru" with a close button (X) in the top right corner. The window is divided into two main sections: a left-hand navigation pane and a right-hand main display area.

The left-hand navigation pane lists various parameter categories, including:

- Camera Information
- Sensor Control
- I/O Control
- Advanced Processing**
 - Color Processing
- Lens Control
- Image Format Control
- Acquisition Control
- Event Control**
 - Event Info**
 - Test Data
 - Exposure End Data
- Transport Layer Control
- Teledyne Lumenera Control
- File Access Control
- USB3 Vision Host Controls** (highlighted)

The right-hand main display area shows a table with three columns: "Category", "Parameter", and "Value". The table contains the following data:



Category	Parameter	Value
Camera Information	Image Timeout	0.7
Sensor Control	System TransferStop Detection Method	Automatic
I/O Control	System TransferStop Time (in us)	20001.0
<input checked="" type="checkbox"/> Advanced Processing	Command Timeout	200
<input checked="" type="checkbox"/> Advanced Processing	Command Retry Count	3

Below the table, there is a button labeled "<< Less".


6 Technical Specifications

6.1 Identification and Mechanical Notes

Identification Label

Teledyne Lumenera LT cameras have an identification label applied to the bottom side, with the following information:	
	<p>Model Part Number Serial number Barcode FCC and CE logo Made in Canada</p>
	

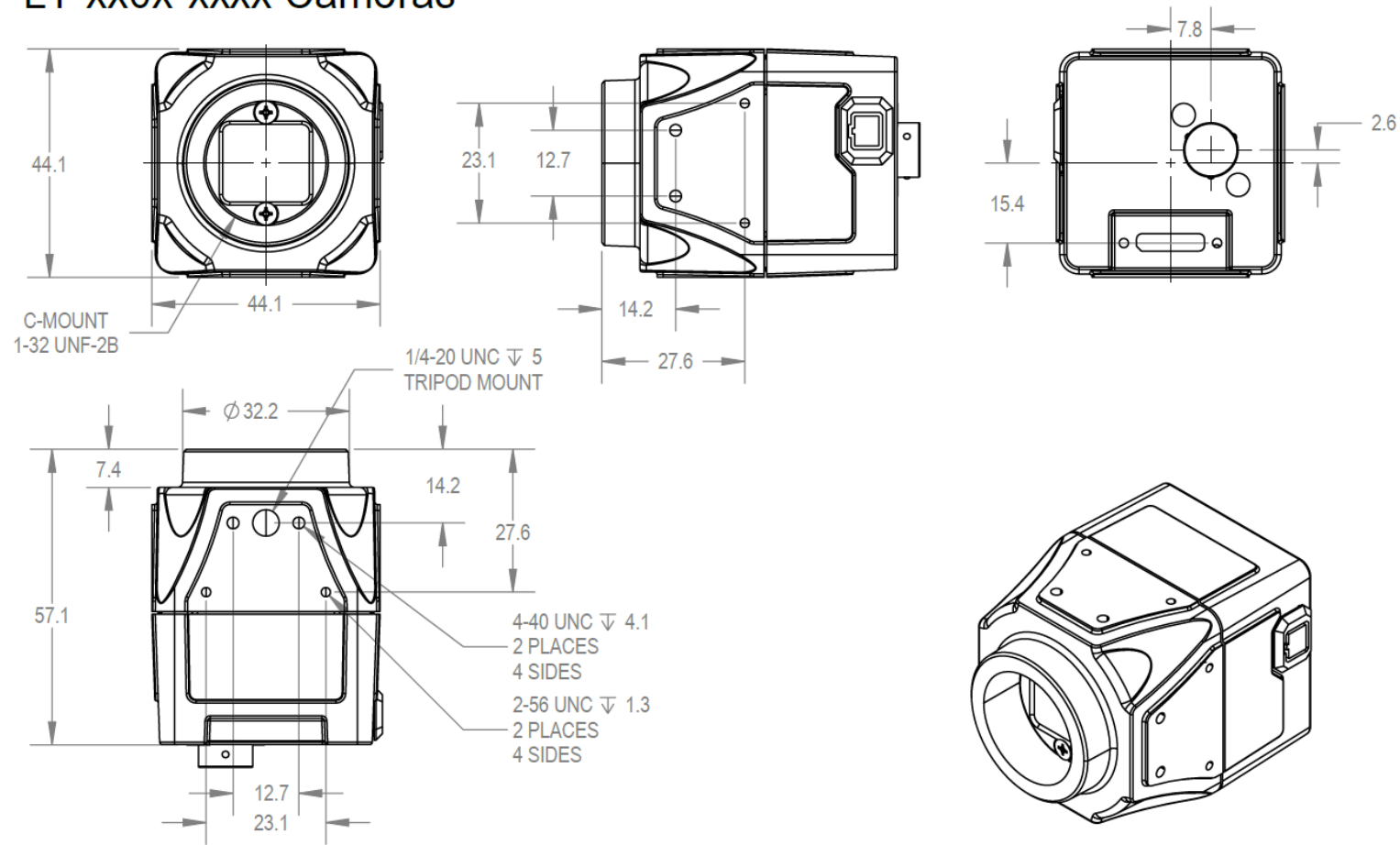
Additional Mechanical Notes

	<p>Lt camera series supports a screw lock USB 3 cable as described in Ruggedized Cable Accessories Ruggedized Cable Accessories. For information on lens requirements see Choosing a Lens with the Correct Image Circle. Each camera side has mounting holes providing good grounding capabilities. Overall height or width tolerance is $\pm 0.05\text{mm}$.</p>
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6.2 Mechanical Specifications

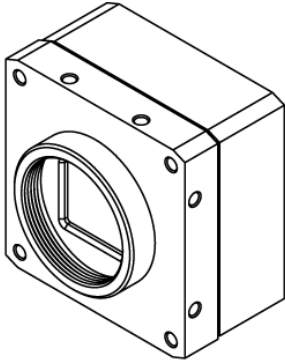
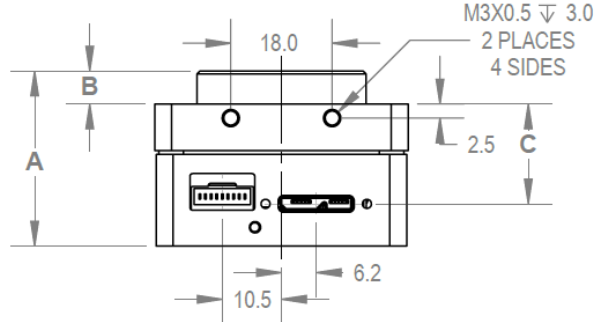
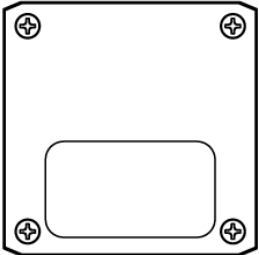
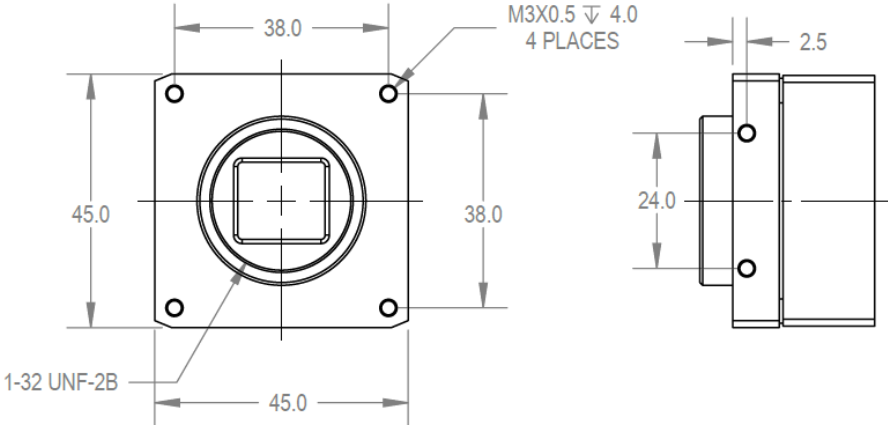
6.2.1 Models Lt-Ux0x-xxxxx

LT-xx0x-xxxx Cameras



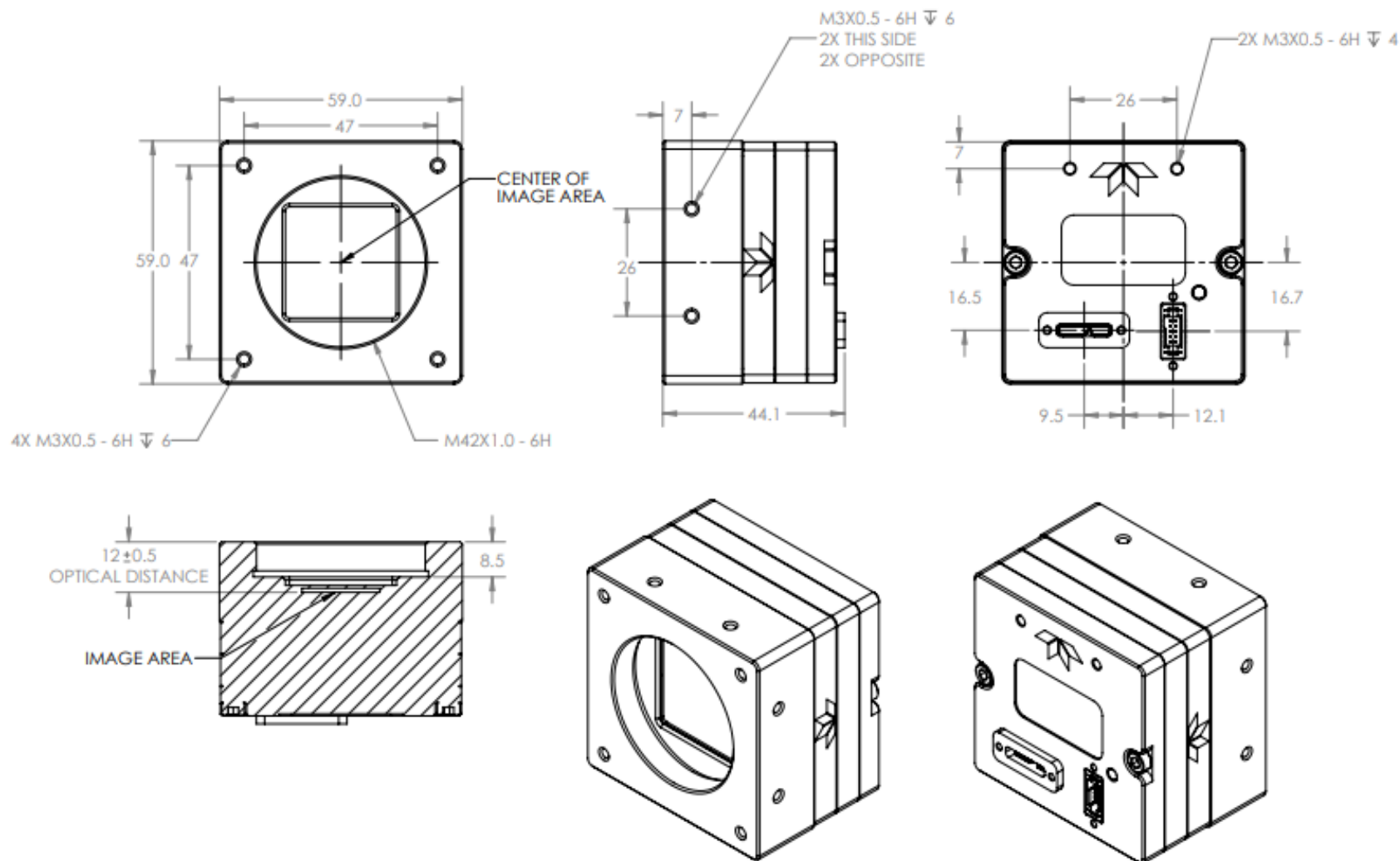
6.2.2 Models Lt-Ux1x-xxxxx

LT-xx1x-xxxx Cameras



MODELS	MOUNT	DIMENSION		
		A	B	C
Lt-1610 Lt-1630 Lt-1950 Lt-1980 Lt-2020 Lt-2420 Lt-3200 Lt-4020 Lt-4030 Lt-5500	C-	36.1	10.8	17.7
Lt-1951 Lt-2021 Lt-2421 Lt-4021 Lt-4031	CS-	31.1	5.8	17.7
Lt-1900 Lt-3840	C-	32.8	10.8	14.5
Lt-1901 Lt-3841	CS-	27.8	5.8	14.5

6.2.3 Models Lt-Ux20-xxxxx



6.3 Temperature Management

Lt Series cameras are designed to optimally transfer internal component heat to the outer metallic body. If the camera is free standing (i.e. not mounted) it will be very warm to the touch.

Basic heat management is achieved by mounting the camera onto a metal structure via its mounting screw holes. Heat dissipation is improved by using thermal paste between the camera body (not the front plate) and the metal structure.

6.4 Sensor Alignment Specification

The following figure specifies sensor alignment for the Lt Series where all specifications define the absolute maximum tolerance allowed for production cameras. Dimensions X, Y, Z are in microns and referenced to the mechanical body or the optical focal plane (for the Z-axis dimension). Theta specifies the sensor rotation relative to the sensor's center and mechanical body.

		Lt-Ux0x-xxxxx Lt-Ux1x-xxxxx	Lt-Ux2x-xxxxx	
X variance	0 mm nominal	+/- 0.97 mm	+/-0.50 mm	<p>Sensor Alignment Reference</p> <p>(+/-) Y variance</p> <p>(+/-) theta variance</p> <p>Z variance not shown</p> <p>(+/-) X variance</p>
Y variance	0 mm nominal	+/- 0.97 mm	+/-0.50 mm	
Z lens mount to sensor	nominal per lens mount	+ .21 mm to -.42 mm	+/-0.42 mm	
Theta variance		+/- 2 degree	+/- 2 degree	

6.5 Connectors

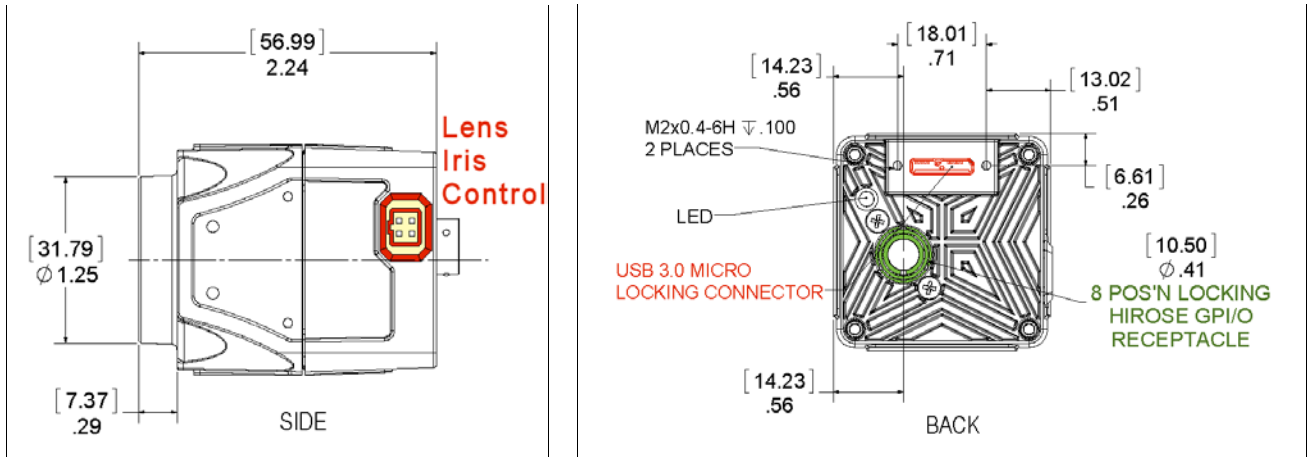
6.5.1 Connector Locations for Lt-Ux0x-xxxxx

The camera has three connectors: data, I/O signals and alternate power, and iris control. Descriptions and specifications are provided below.

- USB 3:** The standard USB 3 connection to a computer provides the control and data transfer interface while also typically supplying the camera 5 Volt power. The camera is designed for a USB 3.0 Type Micro B with screw lock cable assembly. See [USB3 Long Distance Active Cables](#) for a suggested cable type.

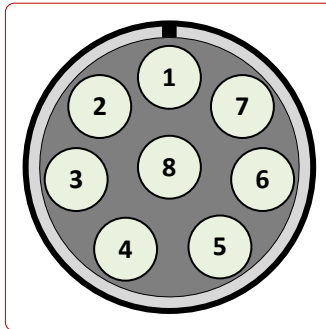
- **I/O signals and alternative power:** Used for external signal connections and for camera power if the USB 3 connection cannot supply the camera.
- **Iris control:** Standard 4 pin P-Iris control for lenses with a motorized iris.

6.5.1.1 Side and Face View



LT-Ux0x-xxxxx connector locations highlighted

6.5.1.2 I/O Connector Pinout Details (LT-Ux0x-xxxxx)



I/O connector MXR-8PIN pin numbers as viewed by user

Digi-Key Part Number HR1824-ND connector can be used as a mating connector.

Pin Number	Function	Description
1	V-External	External power input terminal (5-24V +/- 7.5%, 2A)
2	GPO1+	Optically isolated output - positive terminal
3	GPO1-	Optically isolated output - negative terminal
4	GPIO2	Bi-directional general purpose I/O #2 terminal
5	GPIO3	Bi-directional general purpose I/O #3 terminal
6	GPI1-	Optically isolated input - negative terminal
7	GPI1+	Optically isolated input - positive terminal
8	GND	External power ground reference terminal

6.5.1.3 Optional I/O Connector Packages (LT-Ux0x-xxxxx)

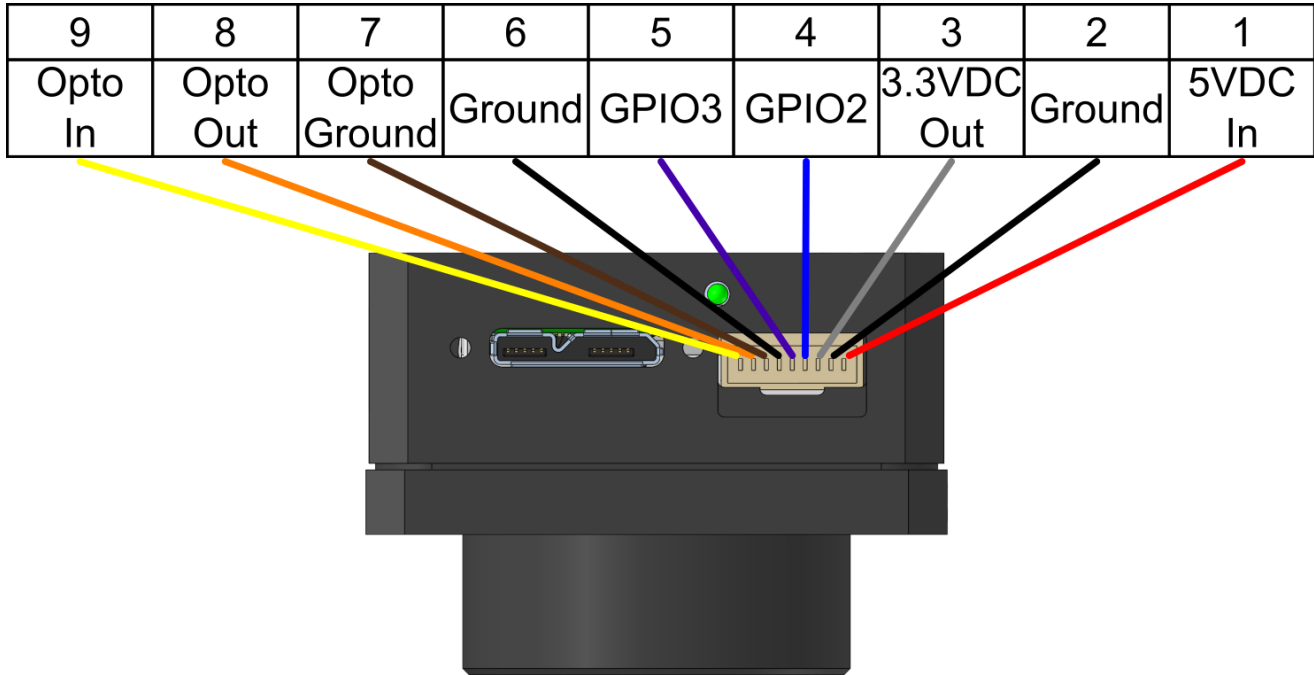
Two optional connector packages are available from Teledyne Lumenera:

- La2000PK — provides a 5 V power adapter and the Digi-Key Part HR1824-ND connector for external power usage.
- La2000PIOK — which combines a 5 V power adapter and the Hirose connector with blunt end wire assembly for easy access to the GPIO signal lines. The following figure lists the wiring color mapping.

Pin #	Function	Wire color	Description
1	V-External	RED	External power input terminal (+5Vdc)
2	GPO1+	GREEN	Optically isolated output positive terminal
3	GPO1-	ORANGE	Optically isolated output negative terminal
4	GPIO2	BLUE	Bi-directional general purpose I/O
5	GPIO3	BROWN	Bi-directional general purpose I/O
6	GPI1-	YELLOW	Optically isolated input negative terminal
7	GPI1+	GREY	Optically isolated input positive terminal
8	GND	BLACK	External power ground reference terminal

La2000PIOK optional connector and wire color information

6.5.2 Connector Locations for Lt-Ux1x-xxxxx



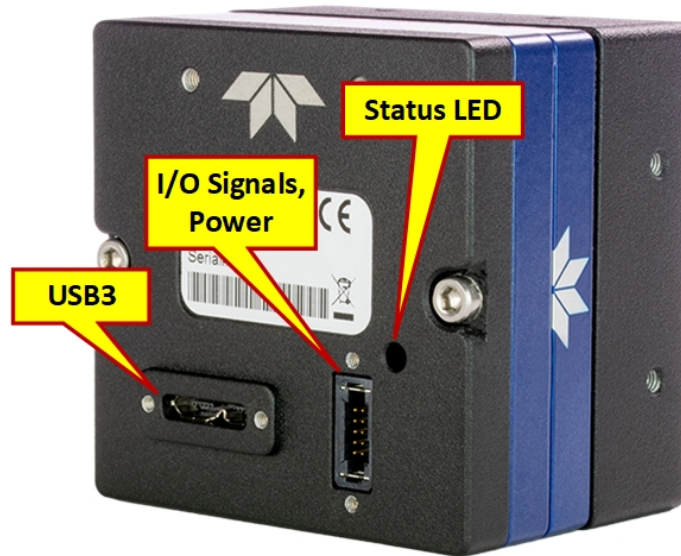
I/O Connector Pin Numbers as Viewed by User

6.5.2.1 I/O Connector Pinout Details (LT-Ux1x-xxxxx)

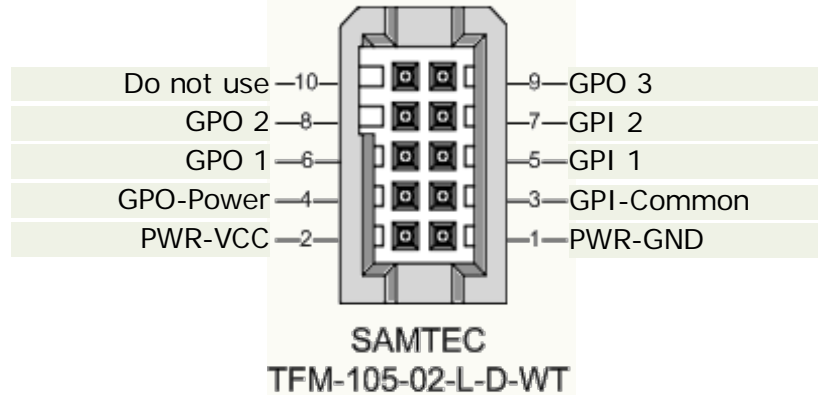
Mating connector JST NSHR-09V-S is available at Digi-Key (ref: 455-2785-ND)

Pin Number	Function	Description
1	V-External	External power input terminal (5V +/- 7.5%, 2A) Takes priority over USB 3 power
2	GND	External power ground reference terminal
3	3.3 Vdc output	Output supplying a maximum of 150 mA
4	GPIO2	Bi-directional general purpose I/O #2 terminal
5	GPIO3	Bi-directional general purpose I/O #3 terminal
6	GND	External power ground reference terminal
7	Opto GND	External ground reference for Opto signal
8	Opto Output	Optically isolated output
9	Opto Input	Optically isolated input

6.5.3 Connector Locations for Lt-Ux2x-xxxxx



6.5.3.1 Connector Pinout Details (LT-Ux2x-xxxx)



I/O connector for LT-Ux2x-xxxxx models

Pin Number	Lt-Ux2x series	Direction	Definition
1	PWR-GND	—	Camera Power – Ground
2	PWR-VCC	—	Camera Power – DC +10 to +28 Volts
3	GPI-Common	—	General Input Common Ground
4	GPO-Power	—	General Output Common Power
5	GPI 1	In	General External Input 1
6	GPO 1	Out	General External Output 1
7	GPI 2	In	General External Input 2

8	GPO 2	Out	General External Output 2
9	GPO 3	Out	General External Output 3
10	-	-	Do not use.

6.5.3.2 Optional I/O Connector Packages (LT-Ux2x-xxxxx)

For users wishing to build their own custom I/O cabling, the following product information is provided to expedite your cable solutions. Samtec web information for the discrete connector and a cable assembly with retention clips follows the table.

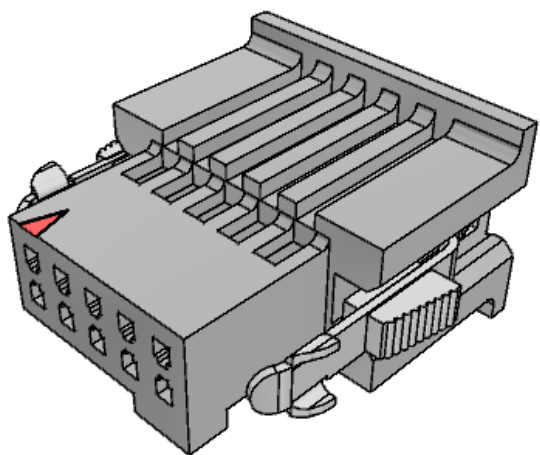
MFG	Part #	Description	Data Sheet
Samtec	ISDF-05-D ISDF-05-D-M (see image below)	Discrete Connector (see example below)	https://www.samtec.com/products/isdf
Samtec	SFSD-05-[WG]-G-[AL]-DR-[E2O] WG : Wire Gauge AL : Assembled Length E2O : End 2 Option	Discrete Cable Assembly (see example below)	https://www.samtec.com/products/sfsd
ISDF-05-D-M Connector Availability On-Line			
North America (specific country can be selected)		http://www.newark.com/samtec/isdf-05-d-m/connector-housing-receptacle-10/dp/06R6184	
Europe (specific country can be selected)		http://uk.farnell.com/samtec/isdf-05-d-m/receptacle-1-27mm-crimp-10way/dp/2308547?ost=ISDF-05-D-M	
Asia-Pacific (specific country can be selected)		http://sg.element14.com/samtec/isdf-05-d-m/receptacle-1-27mm-crimp-10way/dp/2308547?ost=ISDF-05-D-M	
Important: Samtec ISDF-05-D-S is not compatible with the Lt-Ux2x-xxxxx			

Samtec ISDF-05-D-M mating connector for customer-built cables with retention clips .050 Tiger Eye™ Discrete Wire Socket Housing

ISDF-05-D-M

Description	Value
Series	ISDF
No. of Positions	-05
Row	-D - Double Row
End Options	-M - Metal Retention L
Part Number	ISDF-05-D-M

3D Preview
2D View
Download
Help



**Samtec connector-cable assembly SFSD-05-28-H-03.00-SR with retention clips
.050 Tiger Eye™ Double Row Discrete Wire Cable Assembly, Socket**

Description	Value
Series	SFSD
No. of Positions	-05
Wire Gauge	-28 AWG
Wire Color Code	All Black Wire
Plating Options	-H - 30µ" Heavy Gold
Assembly Length	3.00 INCH
End Option	-SR - Single Ended wit
Notch Option	Not Available
Part Number	SFSD-05-28-H-03.00-SR
Cable Type Option	PVC Cable

6.5.4 Bi-directional I/O DC Specifications

Lt-Ux0x-xxxxx and Lt-Ux1x-xxxxx only

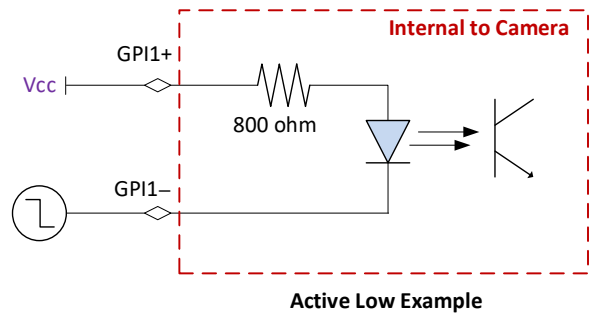
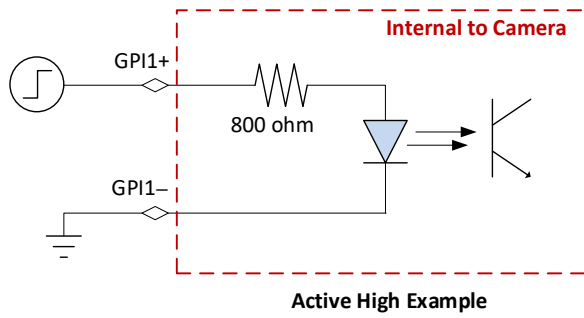
GPO Operating Characteristics (GPIO2 & GPIO3 as outputs)		
LOW value: 0.0 to 0.6 V	HIGH value: 2.65 to 3.3 V	Typical output current: 24 mA
GPI Operating Characteristics (GPIO2 & GPIO3 as inputs)		
LOW input voltages: 0.0 to 0.8 V	HIGH input voltages: 2.0 to 5.0 V	

6.5.5 Optically-Isolated Input Specifications

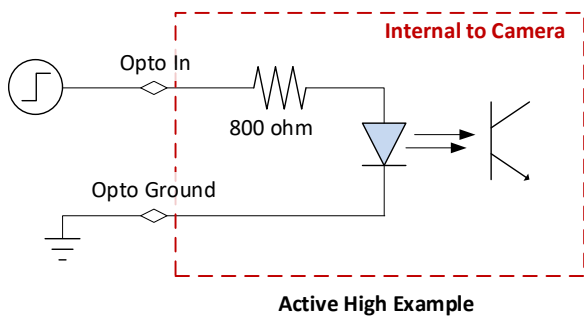
The optically-isolated input pins are designed to operate from 3.3 V to 24 V at a typical current of 20 mA (maximum 50 mA, minimum 5 mA @ 3.3 V). Greater input voltages are supported with use of an external voltage dropping resistor. The opto-isolated internal current limiting resistor is 800 Ω.

- **Lt-Ux0x-xxxxx / Lt-Ux1x-xxxxx** – The external signal is applied to the GPI1+/Opto In input and the GPI1–/Opto Ground is connected to ground. When the external signal goes positive relative to ground and current flows through the input pins, the camera receives an active high trigger signal.
- **Lt-Ux0x-xxxxx models only** – The external signal is applied to the (–) input and the (+) is connected to a positive voltage (Vcc). When the external signal goes negative relative to Vcc and current flows through the GPI input pins, the camera receives an active high trigger signal.
- **Lt-Ux1x-xxxxx** models only allow for active high configuration.

LT-Ux0x-xxxx models



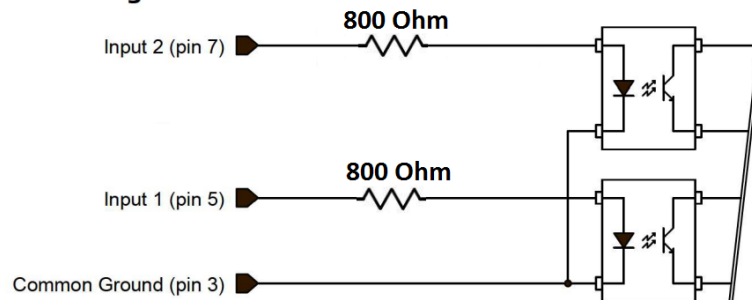
LT-Ux1x-xxxx models



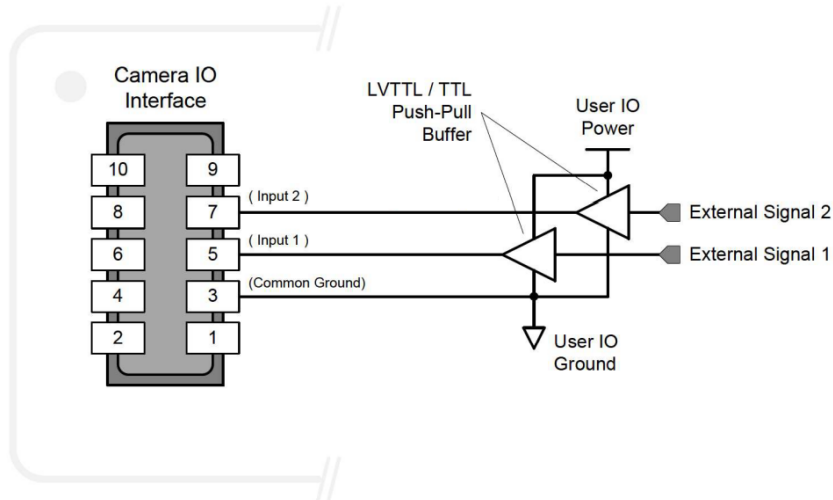
Lt-Ux2x-xxxxx models

Input Signals Electrical Specifications

External Inputs Block Diagram

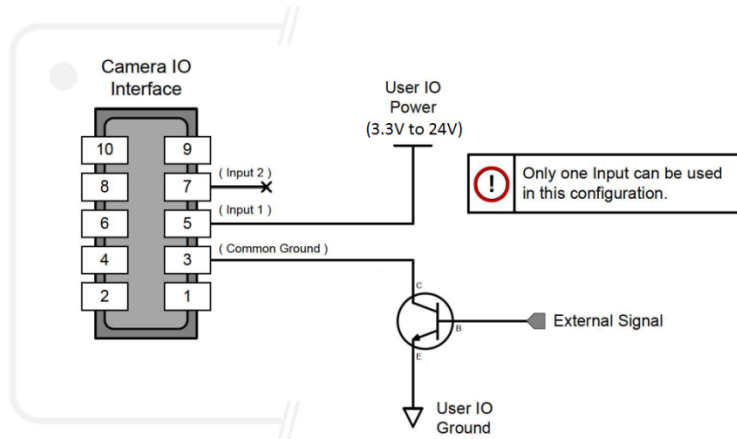


External Inputs: Using TTL/LVTTL Drivers

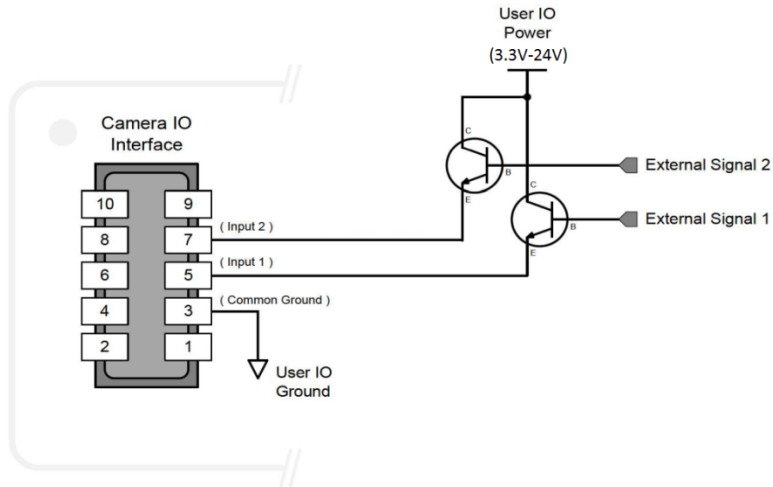


External Inputs: Using Common Emitter NPN Driver

- Warning: Only one External Signal can be used (input 1 or input 2).

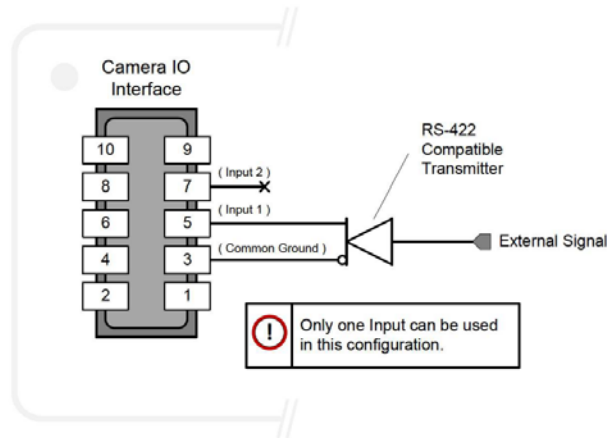


External Inputs: Using Common Collector NPN Drivers



External Inputs: Using a Balanced Driver

- Warning: Only one External Signal can be used (input 1 or input 2).



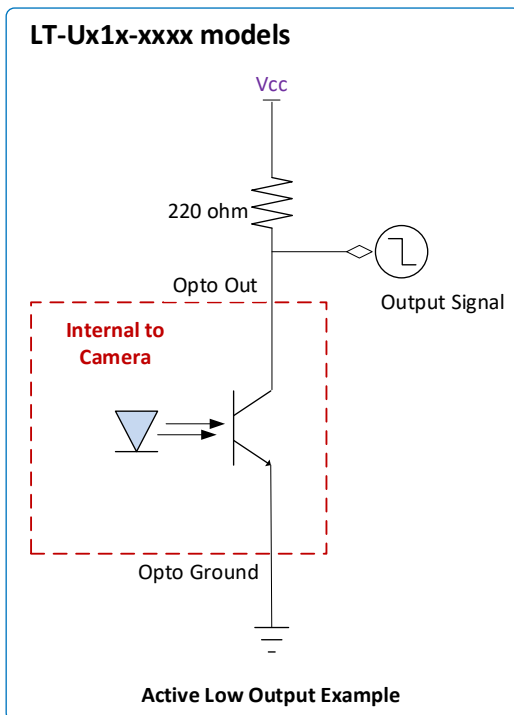
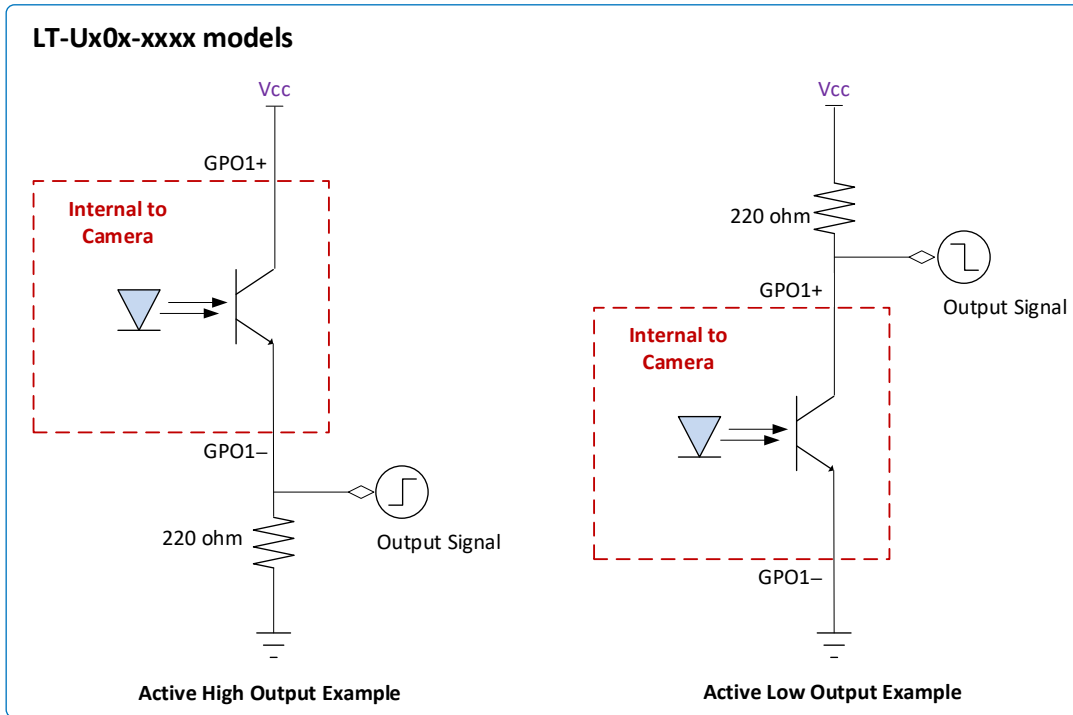
6.5.6 Optically-Isolated Output Specifications

The optically-isolated output requires an external resistor and biasing current. The current flow through the signal output transistor should nominally be 20 mA and must not exceed 50 mA.

- **Lt-Ux0x-xxxxx / Lt-Ux1x-xxxxx** – As shown in the following simplified circuit diagrams, two methods for connecting the output to an external circuit are used dependent on choosing an

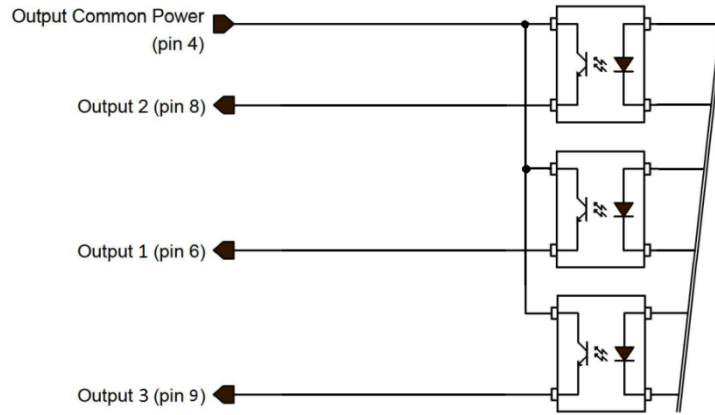
active high or low signal. The two examples use a 5 V bias supply (output referenced to 5 V) and a 220 Ω series resistor.

- When using a 12 V bias supply (for Vcc) a 560 Ω resistor is suggested.
- For either active high or low configurations, the output signal swings between Vcc and ground.
- **Lt-Ux1x-xxxx** models only allow for active low configuration.

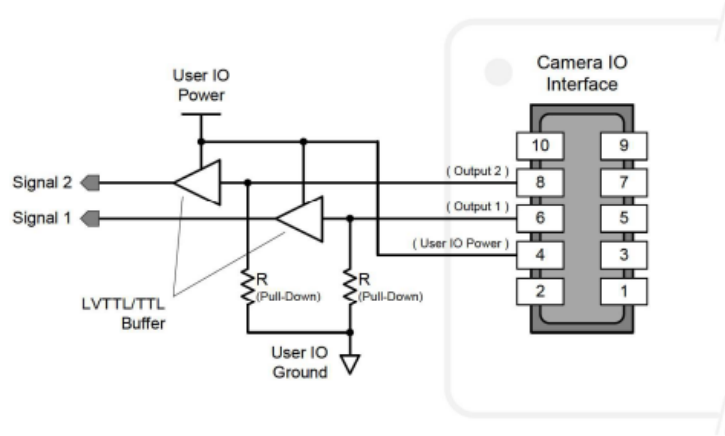


Output Signals Electrical Specifications

External Outputs Block Diagram

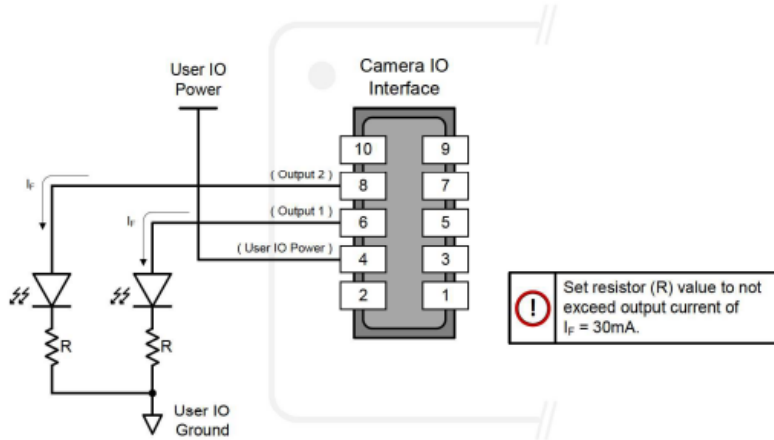


External Outputs: Using External TTL/LVTTL Drivers



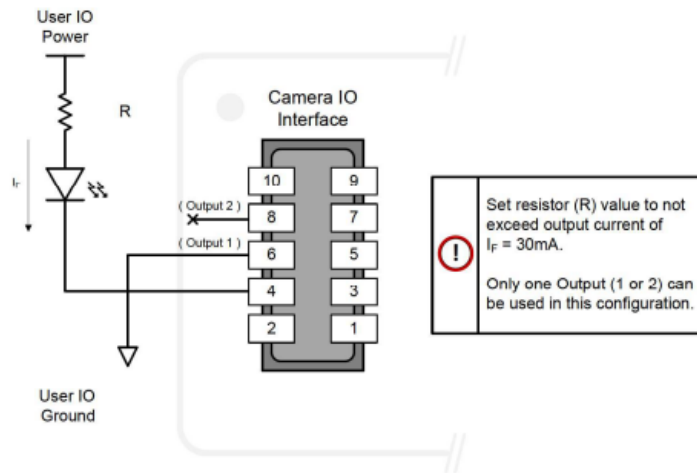
External Outputs: Using External LED Indicators

- Two external LEDs can be connected in the Common Cathode configuration.



Lt-Ux2x-xxxxx models

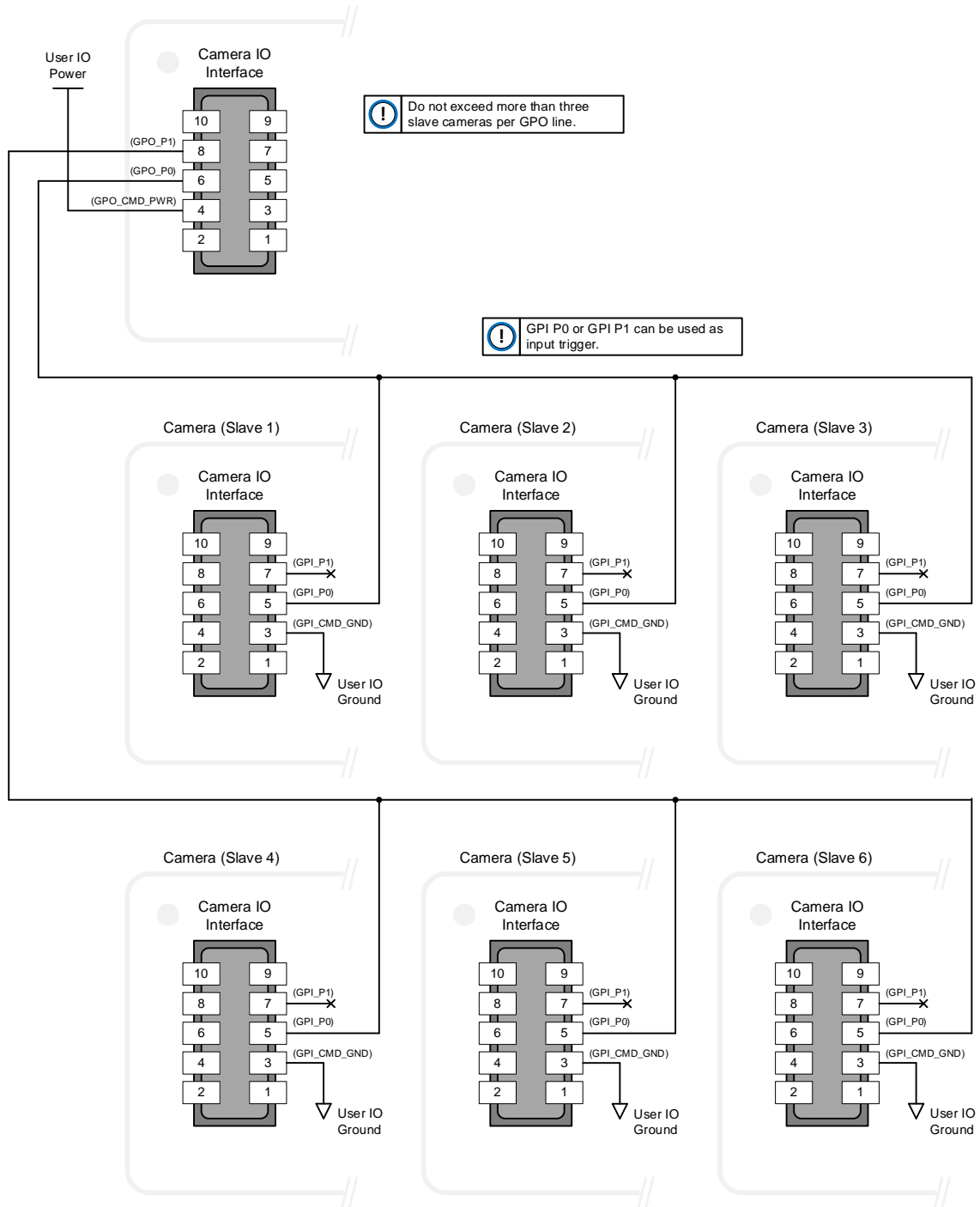
- Alternatively one external LED can be connected in the Common Anode configuration.



Lt-Ux2x-xxxxx models

Using camera outputs to drive other camera inputs

- A synchronization method where one camera signals other cameras.
- Note: One camera output can drive a maximum of three inputs, as illustrated below.



6.6 Computer Requirements for Lt Cameras

- A USB 3.0 equipped desktop, laptop or embedded computer will have the 5 volt power supply required by the Lt Series cameras.
- The computer requires the Windows 10 or Linux operating system.
- Teledyne DALSA Sopera LT development package or LuCam SDK.
- Alternatively refer to your USB3 Vision compliant SDK for computer requirements.

6.7 EC & FCC Declarations of Conformity

Certificate 1 of 3



EC Declaration of Conformity

Products: Lt-C2050, Lt-M2050, Lt-C2450, Lt-M2450, Lt-C4060, Lt-M4060, Lt-C4040, Lt-M4040

Note: These cameras are identical to the camera model variants listed in the test reports.

Model Variants	Equivalent Listed Model Variants
Lt-C2050, Lt-M2050	Lt345RC, Lt345RM
Lt-C2450, Lt-M2450	Lt545RC, Lt545RM
Lt-C4060, Lt-M4060	Lt945RC, Lt945RM
Lt-C4040, Lt-M4040	Lt1245RC, Lt1245RM

Directives: 2014/30/EU (Electromagnetic Compatibility Directive)
2011/65/EU (Restriction of Hazardous Substances Directive)

Standards to which conformity is declared:

- EN55024: 2010
- EN55032: 2012
- EN61000-3-2:2014
- EN61000-3-3:2013
- EN50581: 2012

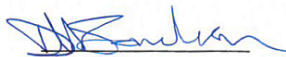
Manufacturer's Name and Address:

Teledyne Lumenera Corporation
7 Capella Court
Ottawa, Ontario
K2E 8A7
Canada

Type of Equipment: Digital Camera

This is to certify that the Teledyne Lumenera Cameras meet or exceed the standards for CE compliance per the Council Directives noted above. All equipment is assembled at Teledyne Lumenera Corporation.

Authorization Signature:

 3/18/2020
Doug Sanderson Date
VP Engineering



EC Declaration of Conformity

Products:

Lt-C1610, Lt-C1630, Lt-C1900, Lt-C1950, Lt-C1980, Lt-C2020, Lt-C2420, Lt-C3200, Lt-C3840, Lt-C4020, Lt-C4030, Lt-C5500, Lt-M1610, Lt-M1630, Lt-M1950, Lt-M1980, Lt-M2020, Lt-M2420, Lt-M3200, Lt-M3840, Lt-M4020, Lt-M4030, Lt-M5500

Directives: 2014/30/EU (Electromagnetic Compatibility Directive)
2011/65/EU (Restriction of Hazardous Substances Directive)

Standards to which conformity is declared:

EN 55032:2015/A11:2020 (Lt-C5500 and Lt-M5500 only)
EN 55032:2012/AC:2013
EN 55035:2017
EN 50581:2012

Manufacturer's Name and Address:

Teledyne Lumenera Corporation
7 Capella Court
Ottawa, Ontario
K2E 8A7
Canada

Type of Equipment: Digital Camera

This is to certify that the Teledyne Lumenera Cameras meet or exceed the standards for CE compliance per the Council Directives noted above. All equipment is assembled at Teledyne Lumenera Corporation.

Authorization Signature:

Doug Sanderson
VP Engineering

Jun 8, 2021

Date



EC Declaration of Conformity

Products:

Lt-C4430, Lt-C5470, Lt-C6480, Lt-M4430, Lt-M5470, Lt-M6480

Directives: 2014/30/EU (Electromagnetic Compatibility Directive)

2011/65/EU (Restriction of Hazardous Substances Directive)

Standards to which conformity is declared:

EN 55032:2015/A11:2020

EN 55035:2017/A11:2020

EN 50581:2012

Manufacturer's Name and Address:

Teledyne Lumenera Corporation
7 Capella Court
Ottawa, Ontario
K2E 8A7
Canada

Type of Equipment: Digital Camera

This is to certify that the Teledyne Lumenera Cameras meet or exceed the standards for CE compliance per the Council Directives noted above. All equipment is assembled at Teledyne Lumenera Corporation.

Authorization Signature:

Doug Sanderson
VP Engineering

Oct / 20 / 2021

Date

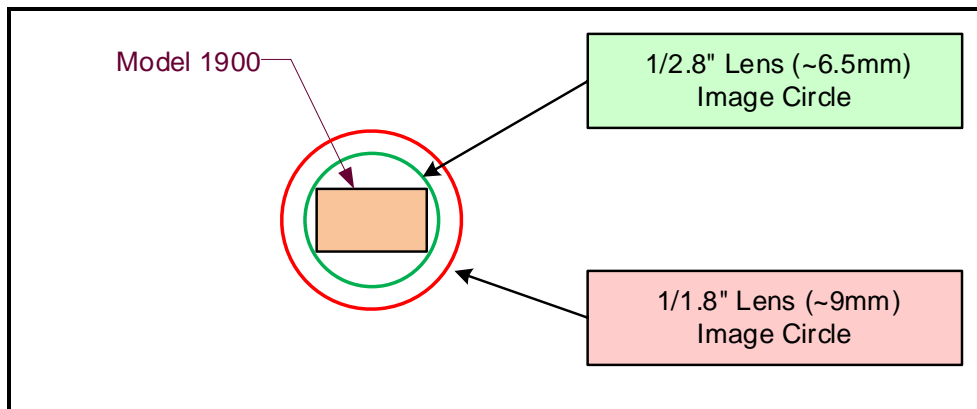
7 Additional Reference Information

7.1 Choosing a Lens with the Correct Image Circle

Each Lt Series model requires a lens with an image circle specification to fully illuminate the sensor. The following section graphically shows the minimum lens image circle for each model family along with alternative lens types. Brief information on other lens parameters to consider follows those sections.

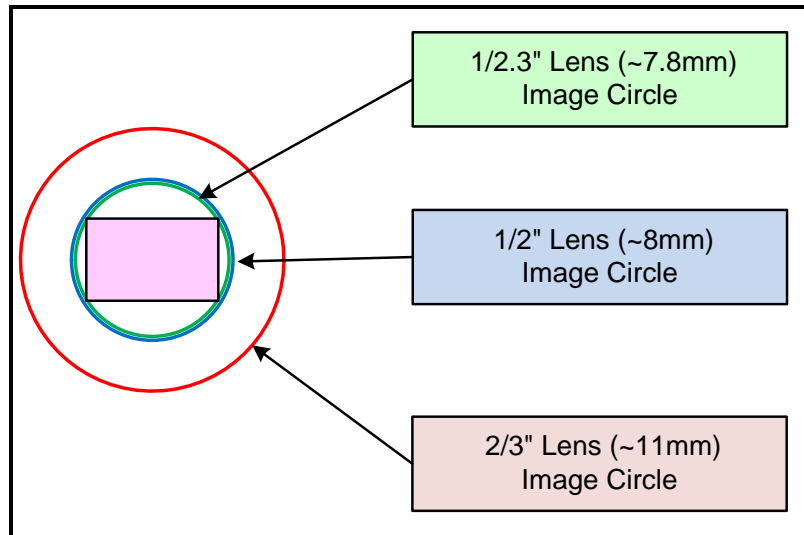
7.1.1 Lens Options for Lt-1900

- The following figure shows the lens image circles relative to this model, in color or monochrome versions.
- A 1/2.8" lens can be used with this model.



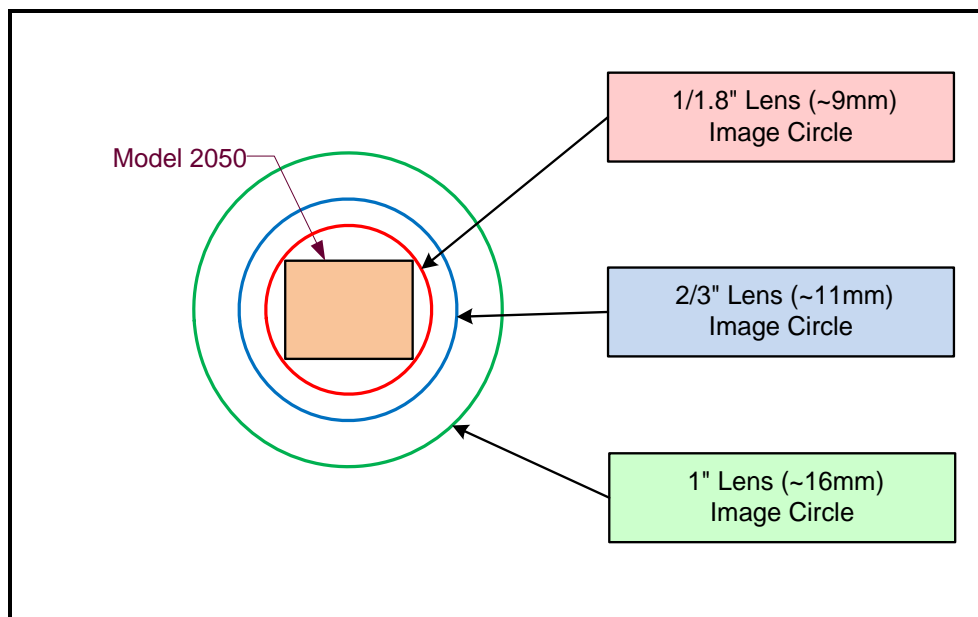
7.1.2 Lens Options for Lt-1950

- The following figure shows the lens image circles relative to this model, in color or monochrome versions.
- A 1/2.3" lens can be used with these models.



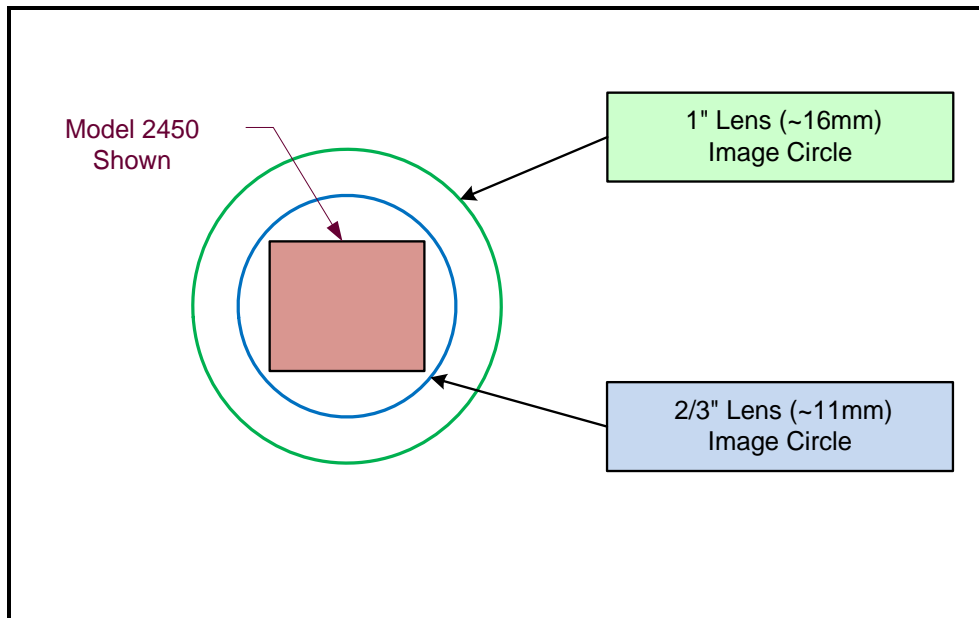
7.1.3 Lens Options for Lt-2020, Lt-2050, Lt-3840

- The following figure shows the lens image circles relative to these models, in color or monochrome versions.
- A 1/1.8" lens can be used with these models.



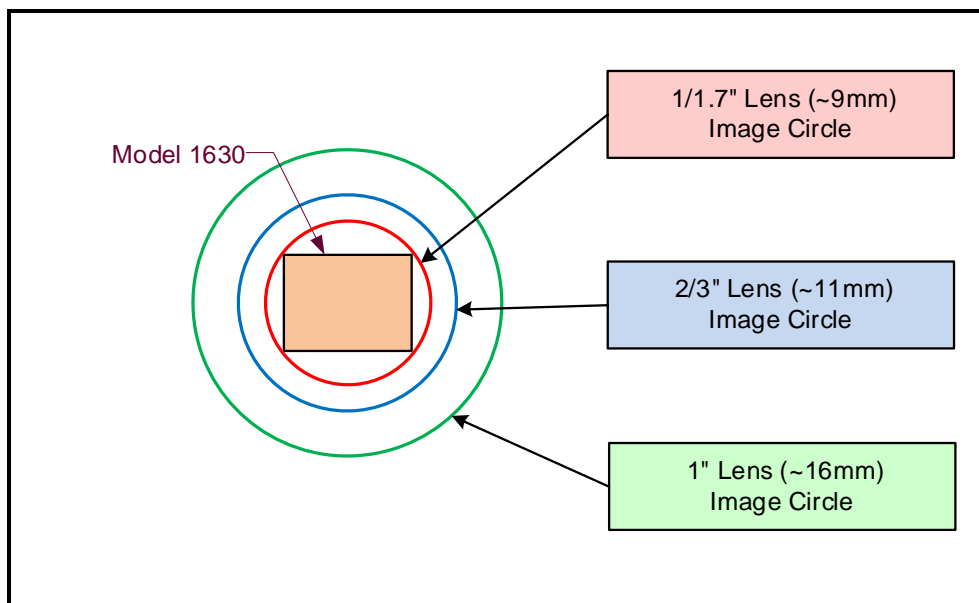
7.1.4 Lens Options for Lt-1980, Lt-2420, Lt-2450

- The following figure shows the lens image circles relative to these models, in color or monochrome versions.
- A typical 2/3" lens will fully illuminate these sensors.



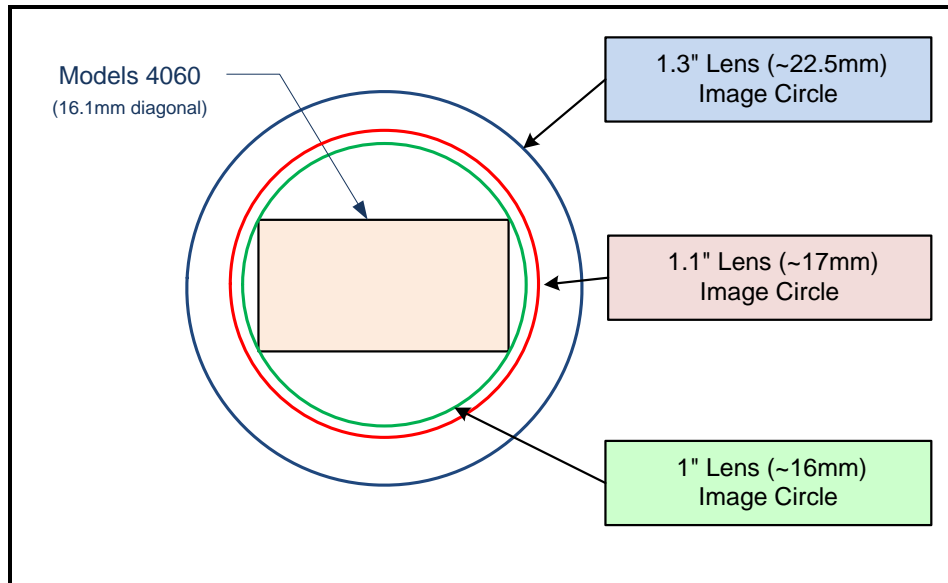
7.1.5 Lens Options for Lt-1630

- The following figure shows the lens image circles for this model, in color or monochrome versions.
- A 1/1.7" lens can be used with this model.



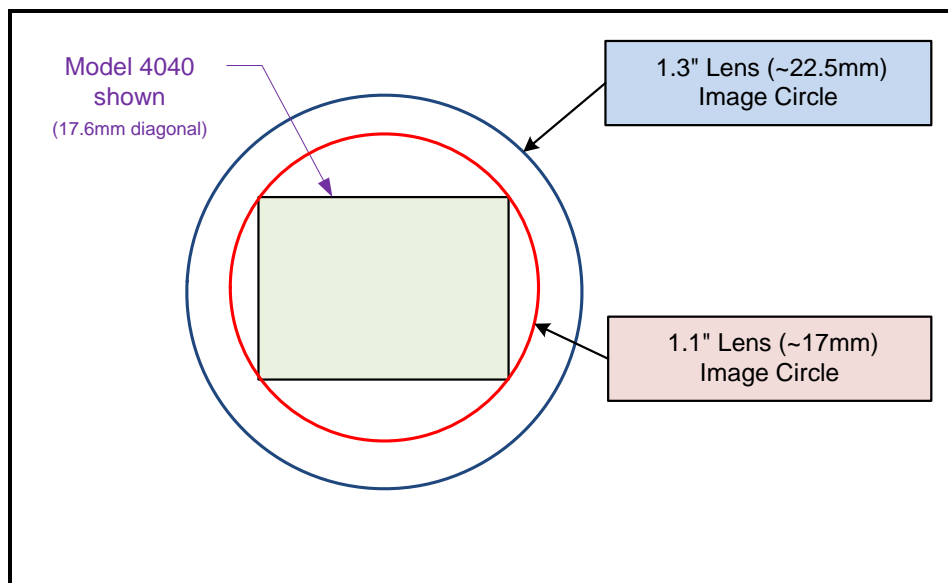
7.1.6 Lens Options for Lt-4030, Lt-4060, Lt-5500

- The following figure shows the lens image circles relative to these models, in color or monochrome versions.
- A typical 1" lens will just illuminate these sensors while larger image circle lens will avoid any corner shading.



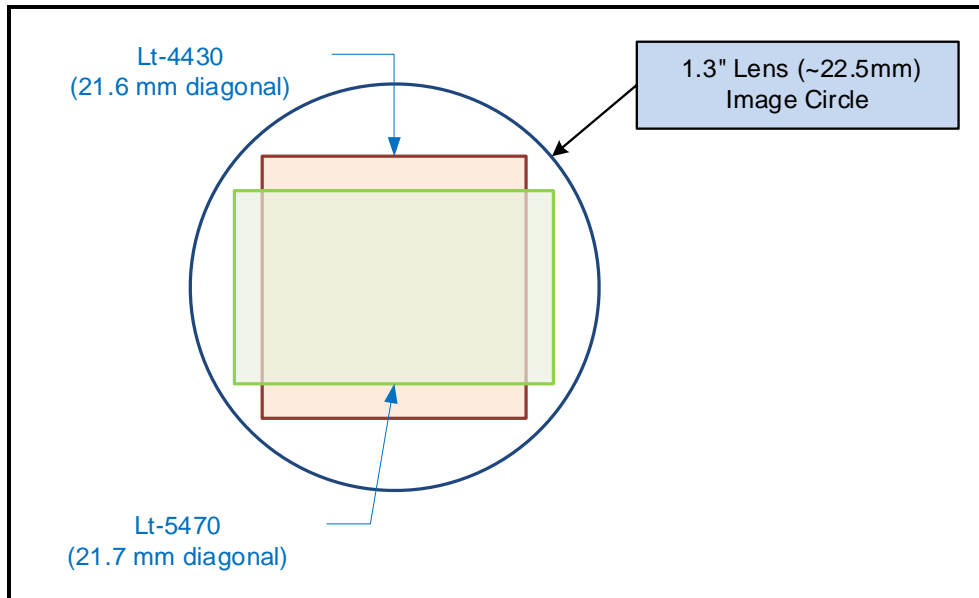
7.1.7 Lens Options for Lt-1610, Lt-3200, Lt-4020, Lt-4040

- The following figure shows the lens image circles relative to these models, in color or monochrome versions.
- A typical 1.1" lens will illuminate these sensors.



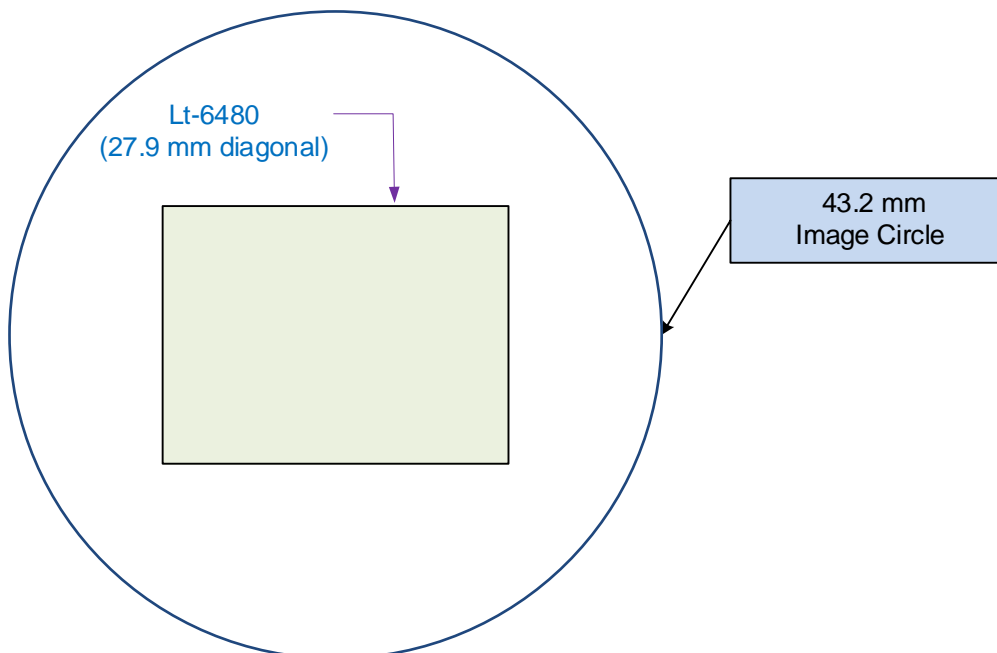
7.1.8 Lens Options for Lt-5470, Lt-4430

- The following figure shows the lens image circles relative to these models, in color or monochrome versions.
- A typical 4/3" lens will illuminate these sensors.



7.1.9 Lens Options for Lt-6480

- The following figure shows a 43.2 mm lens image circle relative to Lt-6480 sensors.



7.1.10 Additional Lens Parameters (application specific)

There are other lens parameters that are chosen to meet the needs of the vision application. These parameters are independent of the Lt Model (assuming that the Lens Mount and Lens Sensor Size parameters are correct, as previously covered in this section). A vision system integrator or lens specialist should be consulted when choosing lenses since there is a trade-off between the best lenses and cost. An abridged list of lens parameters follows – all of which need to be matched to the application.

- **Focal Length:** Defines the focus point of light from infinity. This parameter is related to the Lt Mount (C, CS, M42 mount). See [Back Focal Variance when using any Filter](#).
- **Field of View:** A lens is designed to image objects at some limited distance range, at some positive or negative magnification. This defines the field of view.
- **F-Number (aperture):** The lens aperture defines the amount of light that can pass. Lenses may have fixed or variable apertures. Additionally, the lens aperture affects Depth of Field which defines the distance range which is in focus when the lens is focus at some specific distance.
- **Image Resolution and Distortion:** A general definition of image quality. A lens with poor resolution seems to never be in focus when used to image fine details.
- **Aberrations (defect, chromatic, spherical):** Aberrations are specific types of lens faults affecting resolution and distortion. Lens surface defects or glass faults distort all light or specific colors. Aberrations are typically more visible when imaging fine details.
- **Spatial Distortions:** Describes non-linear lens distortions across the field of view. Such distortion limits the accuracy of measurements made with that lens.

7.2 Optical Considerations

This section provides an overview to illumination, light sources, filters, lens modeling and lens magnification. Each of these components contributes to the successful design of an imaging solution.

7.2.1 Illumination

The amount and wavelengths of light required to capture useful images depend on the application. Factors include the nature, speed and spectral characteristics of objects being imaged, exposure times, light source characteristics, environmental and acquisition system specifics, and more. The Teledyne DALSA Web site provides an introduction to this potentially complicated issue, along with many other application notes and guides on machine vision. Start with this Knowledge Center article: <http://www.teledynedalsa.com/en/learn/knowledge-center/machine-vision-101-an-introduction/>

It is often more important to consider exposure than illumination. The total amount of energy (which is related to the total number of photons reaching the sensor) is more important than the rate at which it arrives. For example, 5 $\mu\text{J}/\text{cm}^2$ can be achieved by exposing 5 mW/cm^2 for 1 ms just the same as exposing 5 W/cm^2 for 1 μs .

7.2.2 Light Sources

Keep these guidelines in mind when selecting and setting up light source:

- LED light sources are relatively inexpensive; provide a uniform field, and longer life span compared to other light sources. However, they also require a camera with excellent sensitivity.
- Halogen light sources generally provide very little blue relative to infrared light (IR).
- Fiber-optic light distribution systems generally transmit very little blue relative to IR.
- Some light sources age such that over their life span they produce less light. This aging may not be uniform—a light source may produce progressively less light in some areas of the spectrum but not others.

7.2.3 Monochrome Cameras with Anti-Reflection Filter

Lt-Ux0x-xxxxx and Lt-Ux1x-xxxxx series monochrome models are available with AR/AR coated glass filters, factory installed for optimized imaging solutions. See section **Monochrome Cameras** for ordering information.

7.2.3.1 AR/AR Filter Specification Highlights

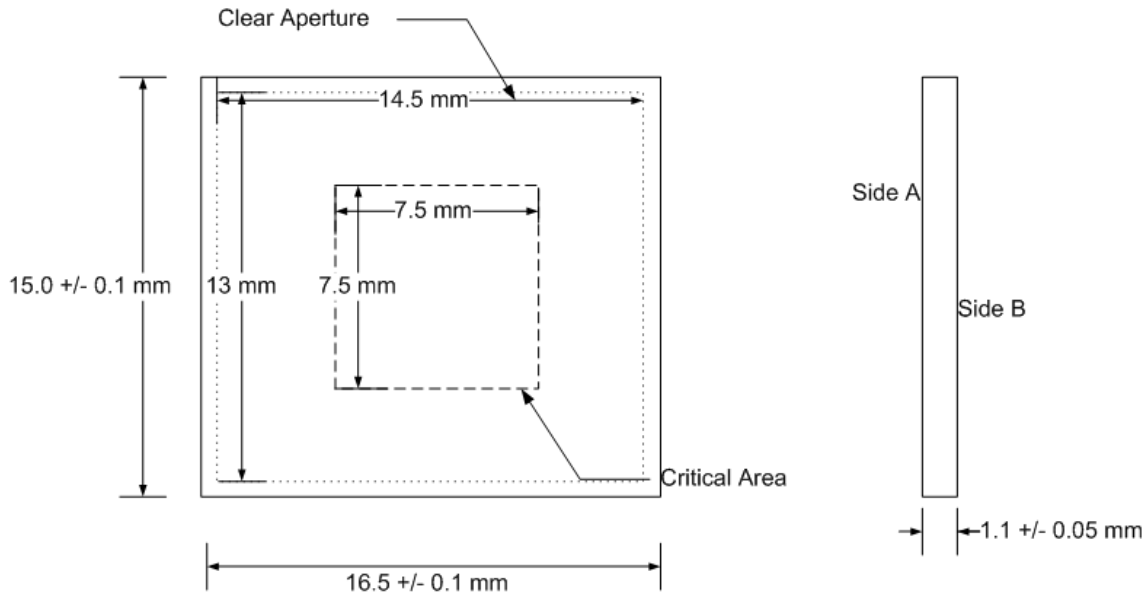
Spectral Performance

Parameter	Value	Unit	Comment
Reflectance 380nm – 399nm	< 4	%	Maximum
Reflectance 400nm – 700nm	< 2	%	Maximum
Reflectance 701nm - 1100nm	< 4	%	Maximum

Coating Uniformity

There will be less than ± 1 nm variation in the transmittance of any wavelength when measured across the clear aperture area of one filter

Dimensions



7.2.4 Color Camera with IR Cut-off Filter

Lt Series color cameras are responsive to near infrared (IR) wavelengths, meaning that they have a spectral response that extends into near IR wavelengths (as defined for each sensor model in the sensor specification descriptions). Images captured will have washed out color if the sensor response is not limited to the visible light band

To prevent infrared from distorting the color balance of visible light acquisitions, use a “hot mirror” or IR cut-off filter that transmits visible wavelengths but does not transmit near infrared wavelengths and above.

Lt Camera color models are available with NIR/AR coated glass filters, factory installed for optimized imaging solutions. See **Color Cameras** for ordering information.

7.2.4.1 NIR/AR Filter Specification Highlights

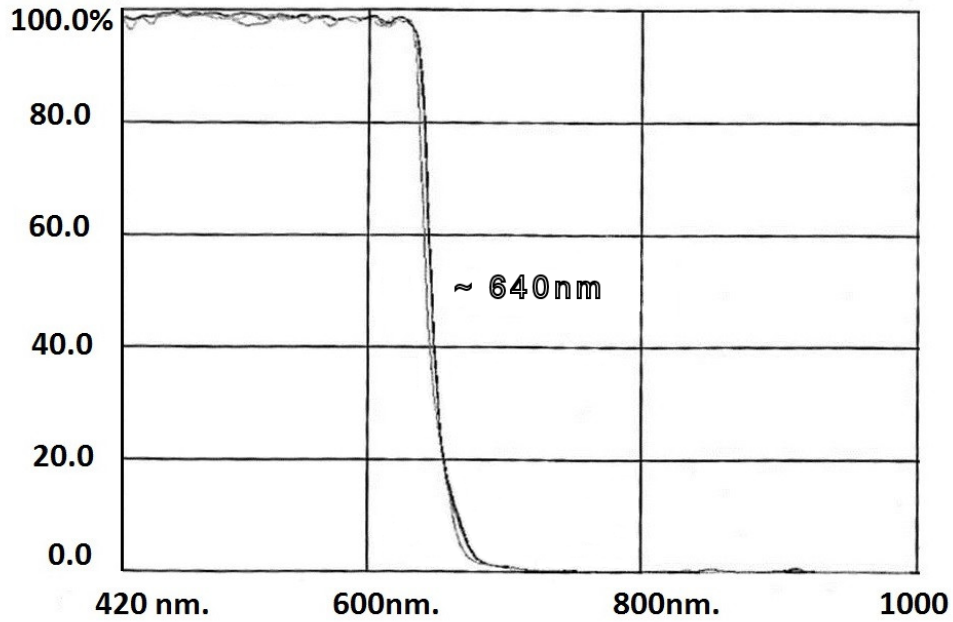
Spectral Performance

Parameter	Value	Unit	Comment
Transmittance 400nm – 620nm	≥ 91	%	Minimum
Transmittance 400nm – 620nm	≥ 96	%	Average
Cutoff wavelength T=50%	640	nm	± 5 nm
Transmittance 700nm – 1100nm	≤ 1	%	Average
Transmittance 700nm – 1100nm	≤ 2	%	Maximum

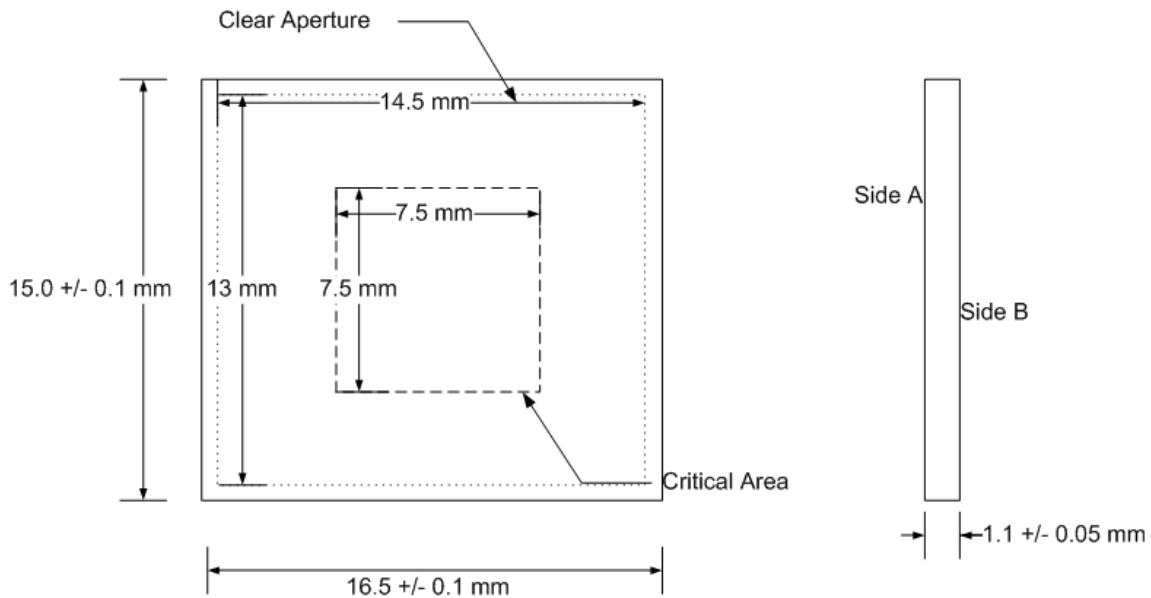
Coating Uniformity

There will be less than ± 1 nm variation in the upper cutoff wavelength (640 nm) when measured across the clear aperture area of one filter.

NIR Filter Response Graphic



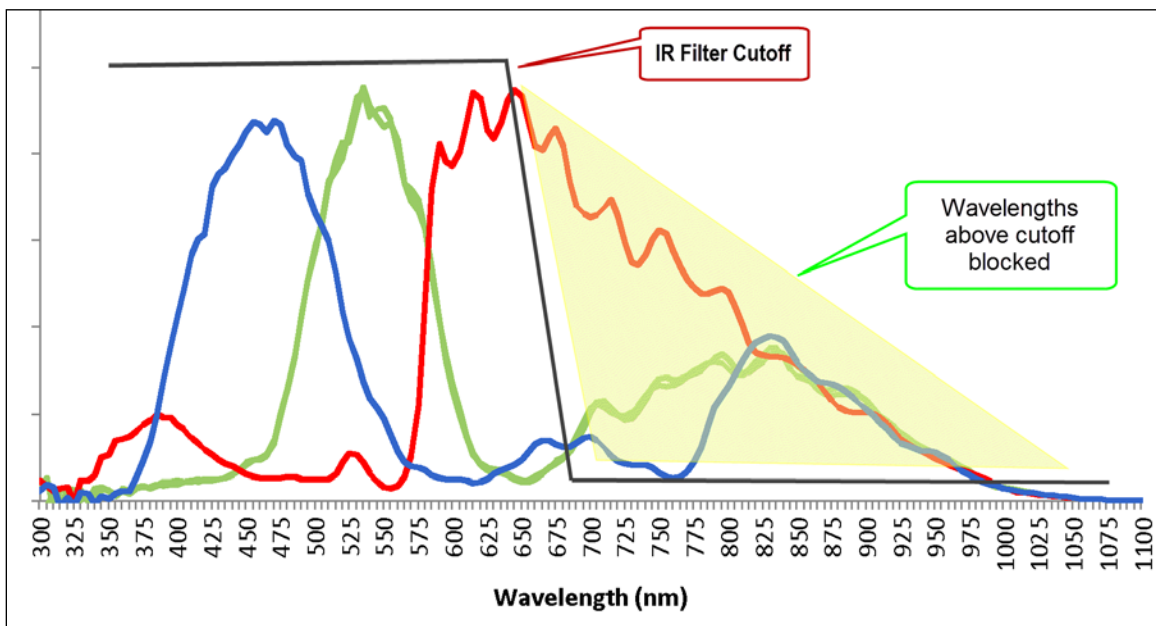
Dimensions



7.2.4.2 Guidelines for Choosing IR Cut-off Filters

The following graphic, using a color sensor response spectrum, shows the transmission response of typical filters designed for CMOS sensor cameras. When selecting an IR cut-off filter, choose a near

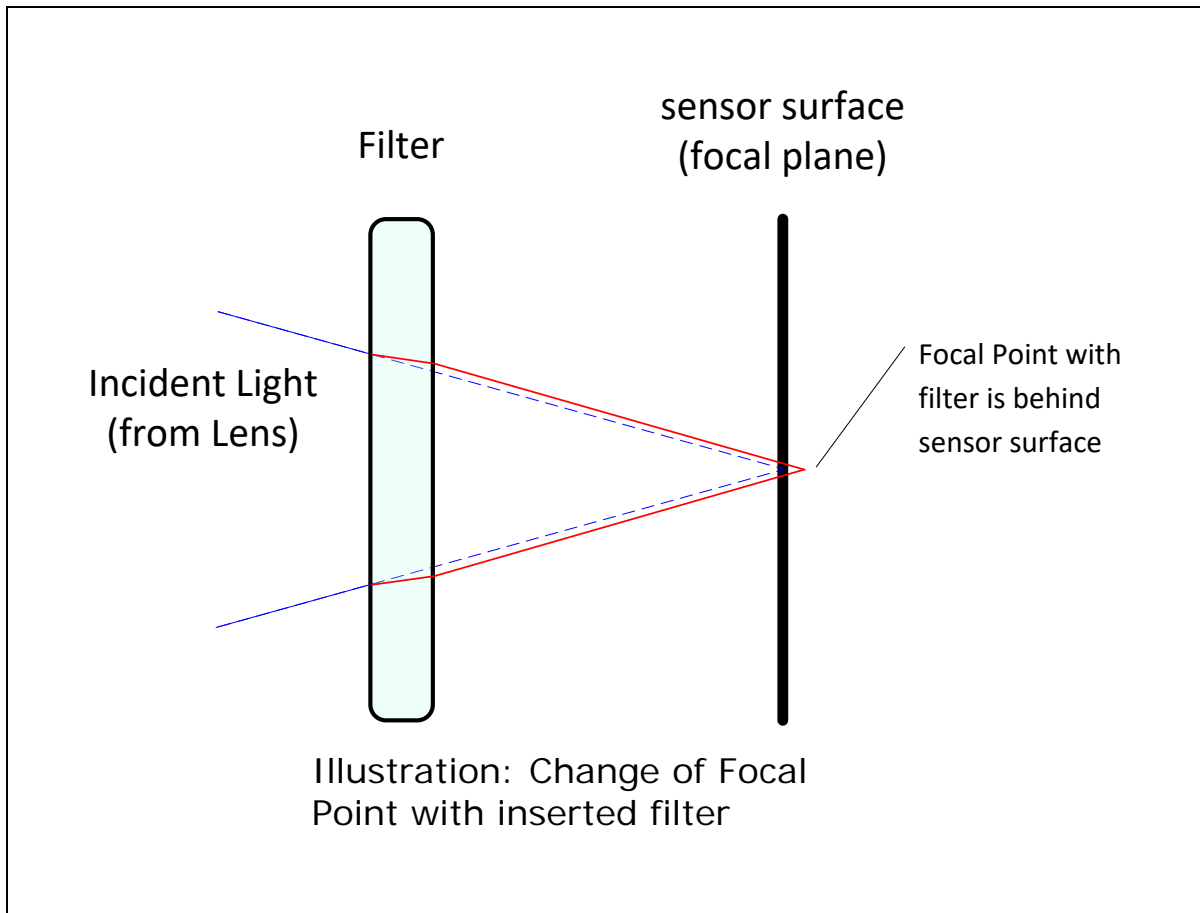
infrared blocking specification of ~650 nm. Filters that block at 700 nm or longer wavelengths, designed for CCD cameras, are not recommended for Lt color cameras.



7.2.4.3 Back Focal Variance when using any Filter

Inserting a filter between a lens and sensor changes the back focal point of the lens used. A variable focus lens simply needs to be adjusted, but in the case of a fixed focus lens, the changed focal point needs correction.

The following simplified illustration describes this but omits any discussion of the Optics, Physics and the math behind the refraction of light through glass filter media.



In this example when a glass filter is inserted between the lens and the camera sensor, the focal point is now about 1/3 of the filter thickness behind the sensor plane. Filters are typically specified as 1mm thick.

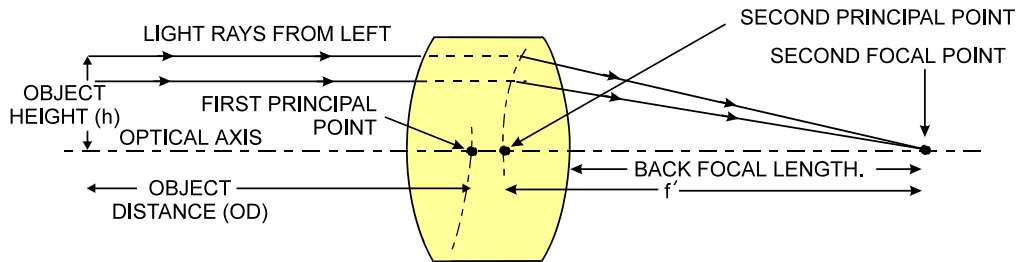
For Lt Series models normally shipped without filters, when a filter is installed a fixed focus lens requires a 1/3mm C-mount shim (spacer) added to move the lens focal point back to the sensor surface. Such shims are available from filter and lens suppliers. Alternatively use a variable focus lens and secure its focus ring after adjustment.

7.3 Lens Modeling

Any lens surrounded by air can be modeled for camera purposes using three primary points: the first and second principal points and the second focal point. The primary points for a lens should be available from the lens data sheet or from the lens manufacturer. Primed quantities denote characteristics of the image side of the lens. That is, h is the object height and h' is the image height.

The focal point is the point at which the image of an infinitely distant object is brought to focus. The effective focal length (f') is the distance from the second principal point to the second focal point. The back focal length (BFL) is the distance from the image side of the lens surface to the second focal point. The object distance (OD) is the distance from the first principal point to the object.

Primary Points in a Lens System



7.3.1 Magnification and Resolution

The magnification of a lens is the ratio of the image size to the object size:

$$m = \frac{h'}{h}$$

Where m is the magnification, h' is the image height (pixel size) and h is the object height (desired object resolution size).

By similar triangles, the magnification is alternatively given by:

$$m = \frac{f'}{OD}$$

These equations can be combined to give their most useful form:

$$\frac{h'}{h} = \frac{f'}{OD}$$

This is the governing equation for many object and image plane parameters.

Example: An acquisition system has a 512 x 512 element, 10 μm pixel pitch area scan camera, a lens with an effective focal length of 45 mm, and requires that 100 μm in the object space correspond to each pixel in the image sensor. Using the preceding equation, the object distance must be 450 mm (0.450 m).

$\frac{10\mu\text{m}}{100\mu\text{m}} = \frac{45\text{mm}}{OD}$	OD=450 mm
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7.4 Sensor Handling Instructions

This section reviews proper procedures for handling, cleaning, or storing the Lt camera. Specifically, the Lt sensor needs to be kept clean and away from static discharge to maintain design performance.

7.4.1 Electrostatic Discharge and the Sensor

Cameras sensors containing integrated electronics are susceptible to damage from electrostatic discharge (ESD).

Electrostatic charge introduced to the sensor window surface can induce charge buildup on the underside of the window that cannot be readily dissipated by the dry nitrogen gas in the sensor package cavity. With charge buildup, problems such as higher image lag or a highly non-uniform response may occur. The charge normally dissipates within 24 hours and the sensor returns to normal operation.



Important: Charge buildup will affect the camera's flat-field correction calibration. To avoid an erroneous calibration, ensure that you perform flat-field correction only after a charge buildup has dissipated over 24 hours.

7.4.2 Protecting Against Dust, Oil and Scratches

The sensor window is part of the optical path and should be handled like other optical components, with extreme care.

Dust can obscure pixels, producing dark patches on the sensor response. Dust is most visible when the illumination is collimated. The dark patches shift position as the angle of illumination changes. Dust is normally not visible when the sensor is positioned at the exit port of an integrating sphere, where the illumination is diffuse.

Dust can normally be removed by blowing the window surface using a compressed air blower, unless the dust particles are being held by an electrostatic charge, in which case either an ionized air blower or wet cleaning is necessary.

Oil is usually introduced during handling. Touching the surface of the window barehanded will leave oily residues. Using rubber finger cots and rubber gloves can prevent oil contamination. However, the friction between the rubber and the window may produce electrostatic charge that may damage the sensor.

Scratches can be caused by improper handling, cleaning or storage of the camera. When handling or storing the camera without a lens, always install the C-mount protective cap. Scratches diffract incident illumination. When exposed to uniform illumination, a sensor with a scratched window will normally have brighter pixels adjacent to darker pixels. The location of these pixels changes with the angle of illumination.

7.4.3 Cleaning the Sensor Window

Even with careful handling, the sensor window may need cleaning. The following steps describe various cleaning techniques to clean minor dust particles to accidental finger touches.

- Use compressed air to blow off loose particles. This step alone is usually sufficient to clean the sensor window. Avoid moving or shaking the compressed air container and use short bursts of air while moving the camera in the air stream. Agitating the container will cause condensation to form in the air stream. Long air bursts will chill the sensor window causing more condensation. Condensation, even when left to dry naturally, will deposit more particles on the sensor.
- When compressed air cannot clean the sensor, Teledyne Lumenera recommends using lint-free ESD-safe cloth wipers that do not contain particles that can scratch the window. The Anticon Gold 9"x 9" wiper made by Milliken is both ESD safe and suitable for class 100 environments. Another ESD acceptable wiper is the TX4025 from Texwipe.
- An alternative to ESD-safe cloth wipers is Transplex swabs that have desirable ESD properties. There are several varieties available from Texwipe. Do not use regular cotton swabs, since these can introduce static charge to the window surface.
- Wipe the window carefully and slowly when using these products.

7.5 Ruggedized Cable Accessories

Teledyne provides optional I/O cable assemblies for Lt series cameras. Users wishing to build their I/O cabling by starting from available cable packages should consider these popular assemblies described below. Contact Sales for pricing and delivery.

Users also may order cable assembly quantities directly from Alysium-Tech or Components Express. In such cases use the manufacturer's part number shown on the cable assembly engineering drawing.

7.5.1 Cable Manufactures Contact Information

<p>For Information contact: (see their web site for worldwide offices)</p>	<p>Components Express, Inc. (CEI) 10330 Argonne Woods Drive, Suite 100 Woodridge, IL 60517-4995 Phone: 630-257-0605 / 800.578.6695 (outside Illinois) Fax: 630-257-0603 http://www.componentsexpress.com/</p>
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<p>For Information contact: (see their web site for worldwide offices)</p>	<p>Alysium-Tech 101 Montgomery Street, Suite 2050 San Francisco, CA 94104 Phone: 415 248 7807 Fax: 415 248 7800 https://www.alysium.com/</p>
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7.5.2 Long Passive Cables and Optical Cables

Contact Alysium-Tech for information on these cabling choices.

7.5.3 USB3 Long Distance Active Cables

CEI's USB3 BitMaxx cables offer Plug & Play active cable solutions for USB Vision. Please visit the website for Components Express to review their cable options.

https://www.componentsexpress.com/Bit_MAXX-long-distance-usb3-cables

cei COMPONENTS EXPRESS, INC.
INDUSTRY LEADING PERFORMANCE

Machine Vision
Long distance USB3 Cables

5M
Standard USB3 Vision Cables
Maximum Length 5 Meters

10M
CEI BITMAXX
Extended Distance
USB3 Vision Cables
Super Speed USB 3.0
Available Lengths
10M, 15M, and 20M

15M

20M

8 Troubleshooting

8.1 Overview

This section provides information for troubleshooting camera installation problems. A few important items from the web site FAQ are repeated here, followed by troubleshooting flow charts enabling the user to pinpoint the problem type.

Teledyne Lumenera Troubleshooting FAQ on the web:

<https://www.lumenera.com/support/industrial-usb-ethernet/usb-faqs.html#Troubleshooting>

8.2 USB 3 Camera FAQ Items

My USB camera is not recognized by the system and not listed in Device Manager

If the camera does not show up in the Windows Device Manager, the cause could be one of the following:

- If the camera LED remains dark (off), verify that the USB 3 cable is not faulty. The camera is normally powered by the USB 3 port 5 volt power. Test the camera with another USB 3 cable.
- Test the camera by connecting it into another USB 3 port, or on another PC. When the camera is detected by host, an entry will appear in the Windows Device Manager – regardless of whether the device driver is loaded on the computer.

Windows Device Manager incorrectly lists the camera, or displays an exclamation mark beside the device

This describes the situation that occurs when the correct device drivers are not loaded to the camera by the operating system. It may occur if the camera is connected to the PC before the software and device drivers have been installed. Teledyne Lumenera camera device drivers are signed and compliant with Microsoft requirements, so device drivers should load automatically whenever the camera is connected to a PC where the device drivers are resident.

My image is darker in the corners

This issue known as vignetting happens when the lens image circle used is too small for the camera sensor. Make sure that you use the proper lens/optics for the camera. Your camera's datasheet will state the size of the sensor used so that you can properly match your lens/optics.

Also see **Choosing a Lens with the Correct Image Circle** for additional details.

Settings which have an impact on the camera frame rate

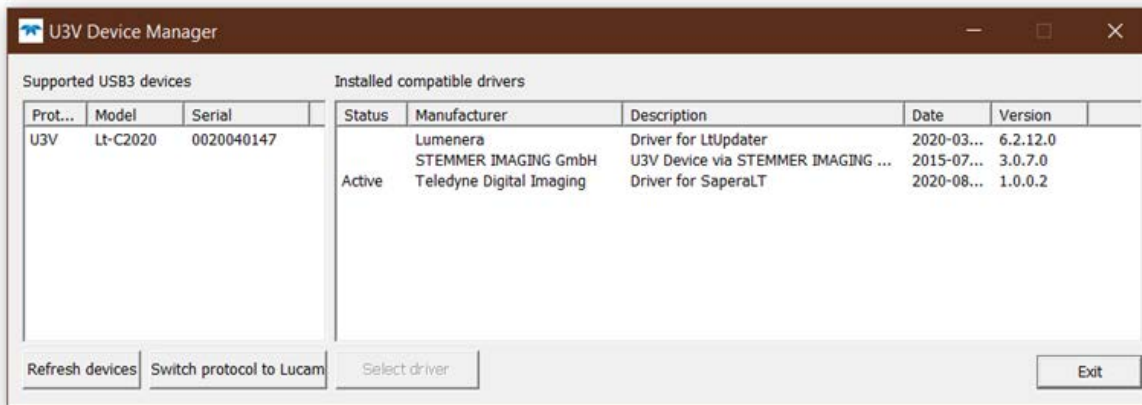
There are a few reasons why you cannot get the advertised frame rate.

- The selected exposure time can limit the frame rate. Make sure that the exposure time is $fps < 1/desired\ frame\ rate$.

- There are not enough computer resources to keep up with the current camera data rate. You will need to minimize the resource usage or operate the camera on a faster computer which easily handles the continuous video stream on the USB 3 port.

8.3 Using the U3V Device Manager Tool

The Teledyne Lumenera U3V Device Manager, included with Sopera LT since version 8.60, allows quick changes between multiple installed camera drivers. Select the connected camera. The mode may then be switched, and the driver may be selected from a list of installed drivers.





Alternatively, drivers may be selected with Windows Device Manager.

8.4 Switching a Teledyne Lumenera camera from LuCam mode to USB3 Vision mode

8.4.1 Using LtUpdater

- Go to the Teledyne Lumenera web site and register your name and password to login and access the download area. [www.lumenera.com]
- Go to */Home/Support/Industrial (USB & Ethernet)/Drivers & Downloads*
- Read the **Important Notes** and use Firefox or Chrome as recommended.
- Download the following three files:

1	LuCam Software and Software Development Kit	
2	USB 3.0 Camera Firmware and Updater	
3	Latest Firmware ZIP file for your camera model	NOTE: DO NOT uncompress the zip file

Important: DO NOT connect the camera to the USB 3 port before the two software installations that follow.

- Install the **LuCam Software and Software Development kit** first (file 1). This is required to run the LtUpdater tool.
- Install the **USB 3.0 Camera Firmware and Updater** tool (file 2).
- Connect the Teledyne Lumenera camera to a USB 3 port.
- Run the Teledyne Lumenera **LtUpdater.exe** tool from the desktop shortcut or from the typical path "*C:\Program Files\Teledyne Lumenera\LtUpdater\LtUpdater.exe*".
The LtUpdater tool window will show that there is a camera connected in LuCam Mode. If all fields are grayed out, then either the camera is not connected to the computer, is unpowered or is already in USB3 Vision mode.
- Click **Select Packages** and select the camera firmware zip file you have downloaded for your camera model. The LtUpdater tool will automatically show the components within the zip file that will update the camera.
- Click **Update** and wait for confirmation of each updated component. The camera has been programmed with the latest firmware version.

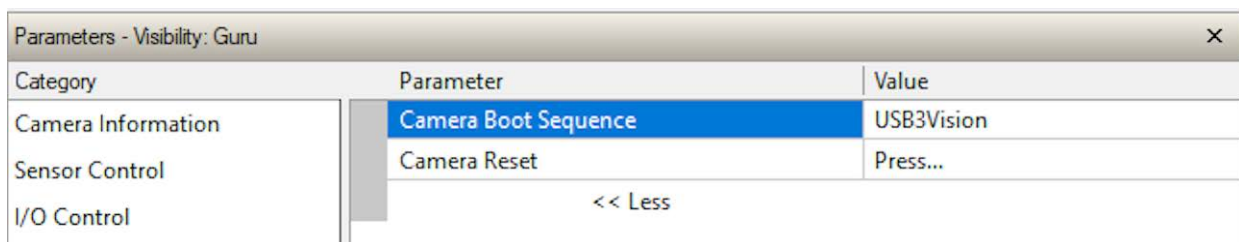
8.4.2 Using LtUpdater to Switch to USB3 Vision Mode

- From the LtUpdater tool Camera Mode field, switch the camera from LuCam mode to USB3 Vision mode.
- Close the LtUpdater tool.
- Cycle the camera power to reset the camera into USB3 Vision Mode.
- Start the Spera LT CamExpert application to work with the Teledyne Lumenera camera as a Spera device.

8.5 Switching a Teledyne Lumenera camera from USB3 Vision mode to LuCam mode

This procedure describes how to change mode with Spera Lt CamExpert. You can also change it with a USB3 Vision compliant third-party tool using the same features.

- Run CamExpert and select the **Teledyne Lumenera Control** category.



- Change the **Camera Boot Sequence** value from *USB3Vision* to *LuCam*.

- Click *Press...* next to **Camera Reset**.
- Cycle the camera power.

The camera is now in LuCam mode. Sapera LT CamExpert cannot access the camera.

To return the camera to USB3 Vision mode, follow the procedure from section **Switching a Teledyne Lumenera camera from LuCam mode to USB3 Vision mode**.

8.6 Lumenera LuCam API for Linux OS

The Linux LucamSDK provides a LucamAPI-compatible driver and example applications.

To install the driver and compile the sample applications

1. Download the LucamSDK software package and untar it.
2. Unplug any Lumenera devices from the system.
3. Change to the SDK directory:

```
cd lucam-sdk_<version>
```

4. Compile the driver and install it:

```
sudo make install ALL_DRVS=1
```

5. Compile the example applications:

```
make examples
```

6. Plug a supported Teledyne Lumenera camera into a USB 3.x port.
7. Confirm that the driver is functional, and communicate with the camera by running the 'helloCamera' example program:

```
./examples/helloCamera/helloCamera
```

8. You should see the following output:

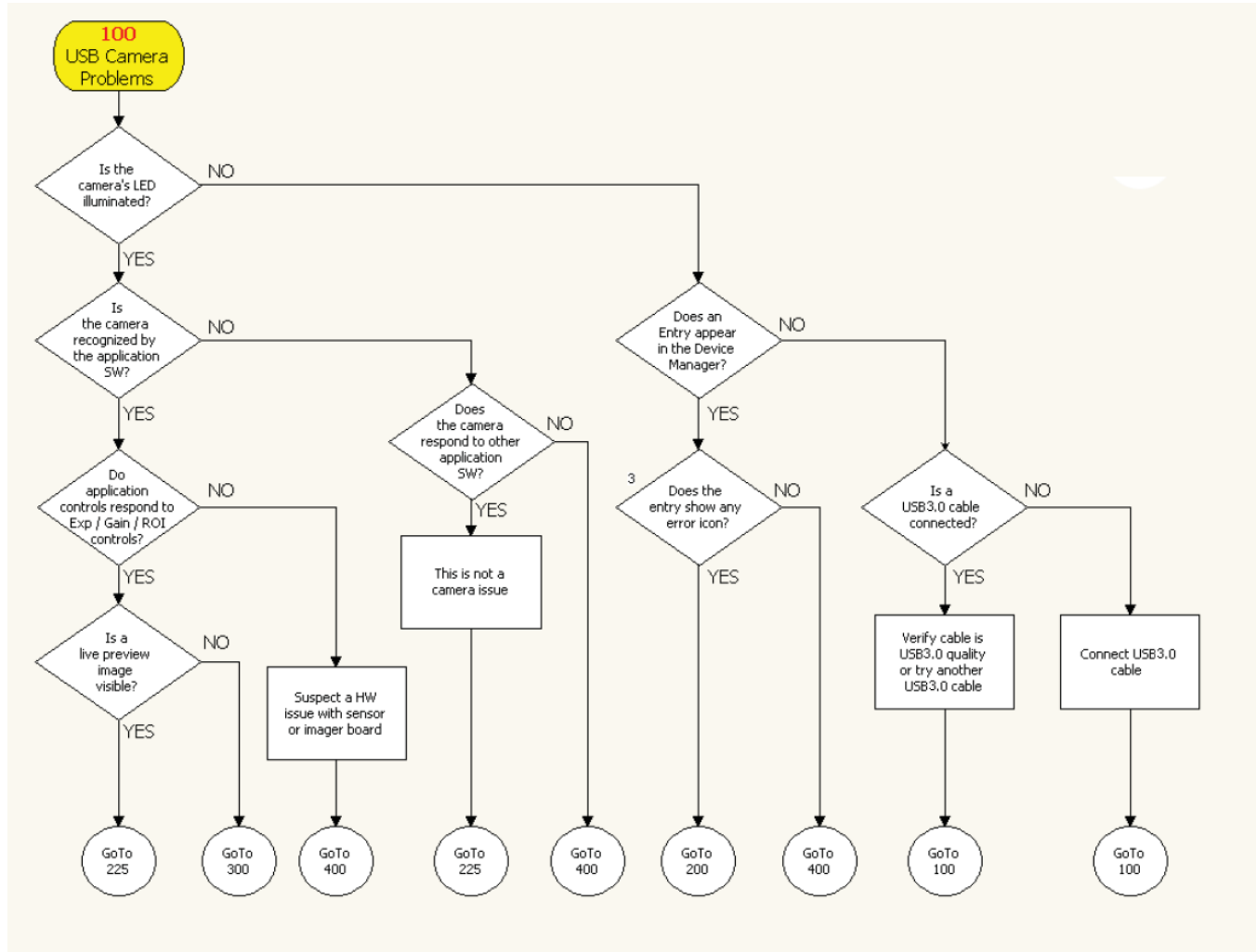
```
Hello camera!
```

In the `doc/` directory of the LinuxSDK, you will find the Lumenera USB Camera API Reference Manual if you need more information on using the API to communicate with the camera with your own applications.

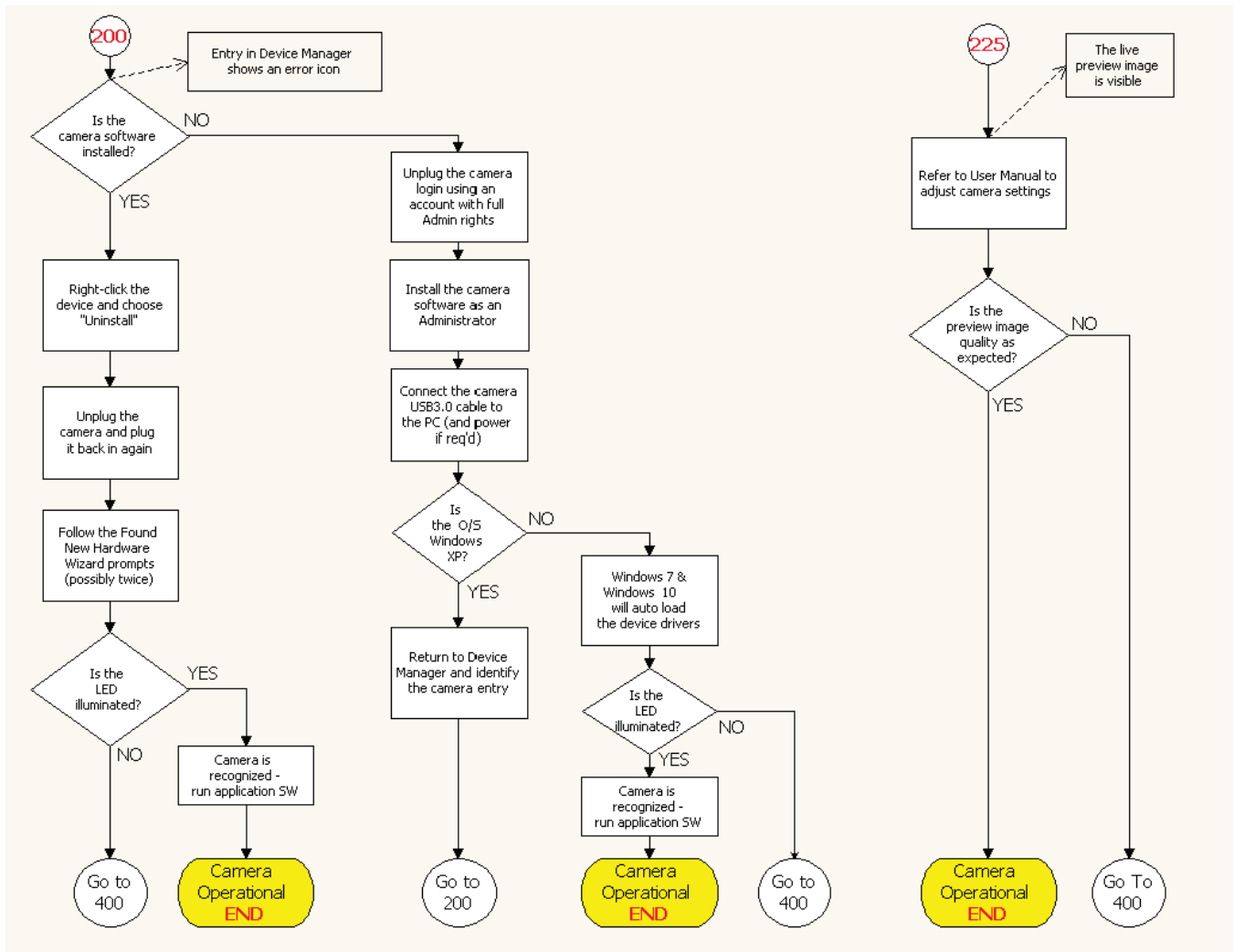
8.7 Troubleshooting Flow Charts

Use the following flowchart to help identify problem with a Teledyne Lumenera Lt camera.

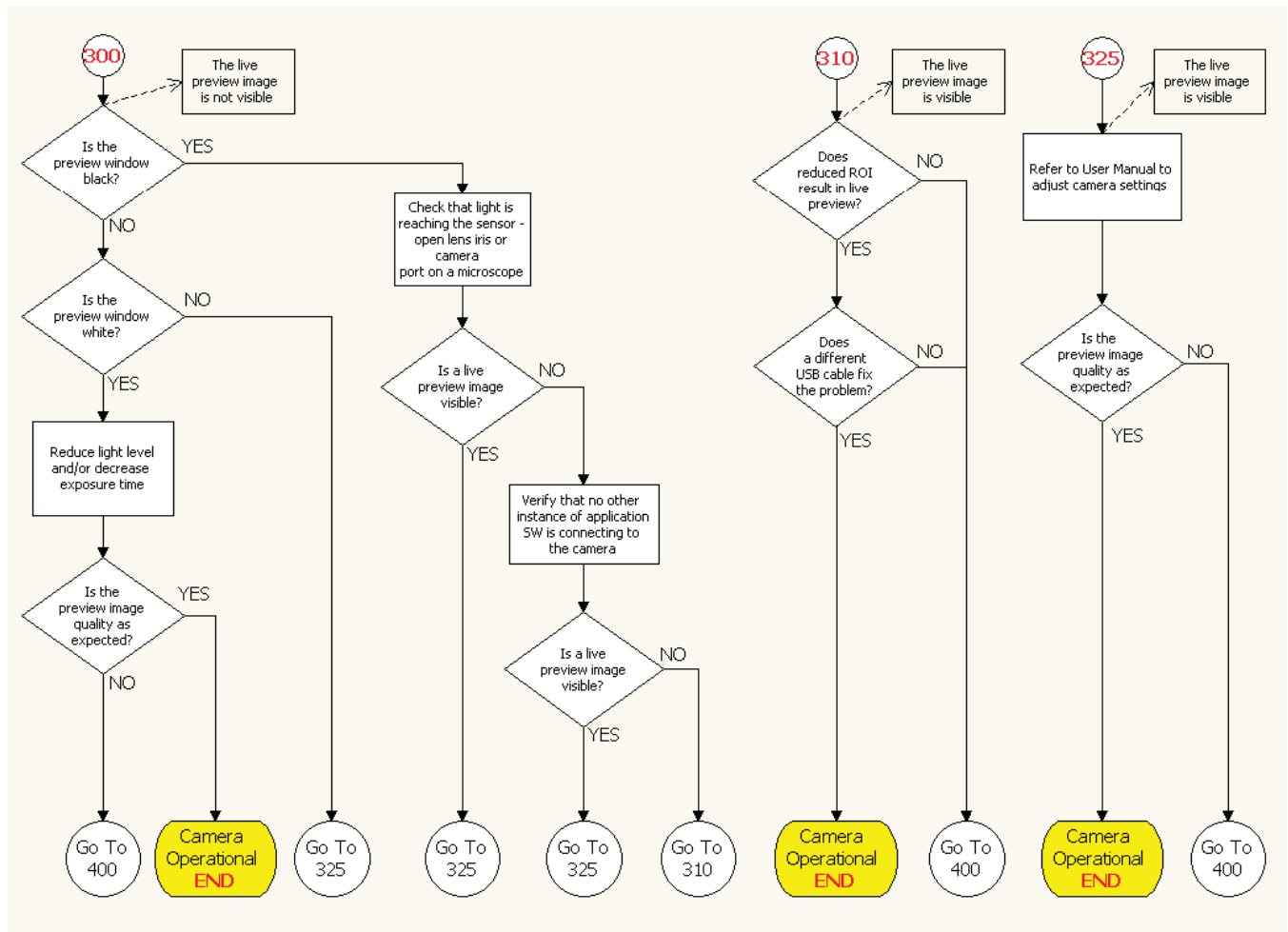
8.7.1 Chart 1



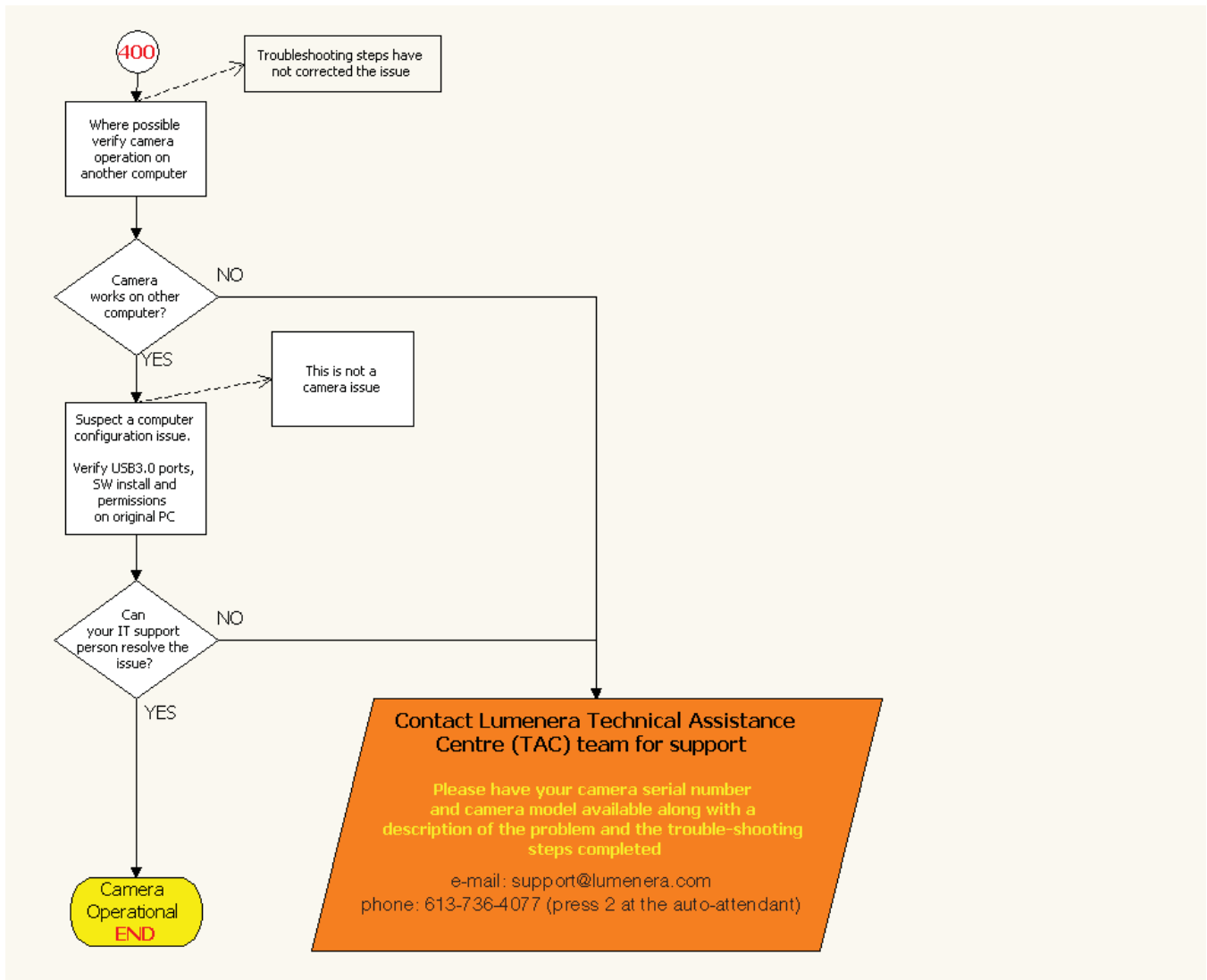
8.7.2 Chart 2



8.7.3 Chart 3



8.7.4 Chart 4



9 Revision History

Revision	Date	Major Change Description
001	April 9, 2020	Preliminary Internal Version
002	February 1, 2021	Support for USB3 Vision and Sapera LT
003	June 11, 2021	Addition of new models and related updates. Improvements targeting uniformity of specifications for the different models. A few corrections to model specifications.
004	November 1, 2021	Added Lt-Ux20-xxxxx series cameras

10 Contact Information

10.1 Sales Information

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10.2 Technical Support

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Technical support form via our web page:
Support requests for imaging product installations,
Support requests for imaging applications

<https://www.lumenera.com/support/about-technical-support.html>

Camera support information

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Product literature and driver updates