iXon^{EM}+ 860 (back-illuminated)

ANDOR™ TECHNOLOGY

low-light imaging

Features & benefits

EMCCD Technology
Ultimate in Sensitivity from EMCCD gain – even single photon signals are amplified above the noise floor. Full QE of CCD chip is harnessed (no intensifier).

TE cooling to -100°C
Critical for elimination of darkcurrent detection limit.

RealGain™
Absolute EMCCD gain selectable directly from a linear and quantitative scale.

515 full frames/sec
Ideal for highly dynamic, low light experiments.

iCam
Unique innovation that empowers the EMCCD to operate with market-leading acquisition efficiency through live cell microscopy software.

> 90% QE back-illuminated sensor Maximum possible photon collection efficiency.

Variable readout rates up to 10 MHz
Quantitative accuracy at all speeds and slower readout rate for enhanced 16-bit dynamic range.

UltraVac™♦1
Critical for sustained vacuum integrity and to maintain unequalled cooling and QE performance, year after year.

High dynamic range and 16-bit digitization available
Extended sensor dynamic range (readout speed dependent) and matched digitization for quantization of dim and bright signals.

Minimal Clock-Induced Charge
Unique pixel clocking parameters, yielding minimized spurious noise floor.

Cropped sensor mode
Specialised acquisition mode for continuous imaging with fast temporal resolution

Enhanced Baseline Clamp
Essential for quantitative accuracy of dynamic measurements.

Built-in C-mount compatible shutter (optional)
Easy means to record control dark images – excellent for optimization of experimental set-up.

"Lightning speed and ultra-sensitivity"

Andor's iXon^{EM}+ 860 back-illuminated EMCCD is designed for very rapid imaging of low light events, combining > 500 frames/sec with single photon detection capability and > 90% Quantum Efficiency. UltraVac™ vacuum technology provides absolute protection of the back-illuminated sensor, ensuring performance longevity.

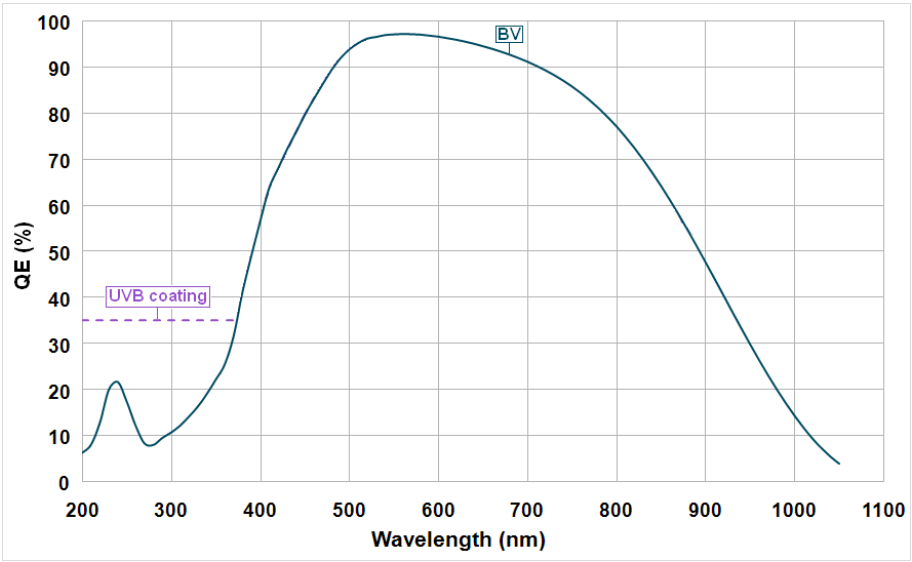
Thermoelectric cooling down to -100°C minimizes EM-amplified darkcurrent, whereas industry fastest vertical shift speeds minimizes both clock induced charge noise and vertical smear during frame transfer. The absolute EM gain multiplication can be varied linearly from unity up to a thousand times directly via RealGain™, a true quantitative EM gain scale.

Sub-millisecond biology is readily accessible through use of sub-array selection and pixel binning. The speed and sensitivity of the iXon^{EM}+ 860 also renders it ideal for adaptive optics.

Camera overview

Active Pixels	128 x 128
Pixel Size (W x H; µm)	24 x 24
Image Area (mm)	3.1 x 3.1
Active Area Pixel Well Depth (e^-)	
Typical	160000
Maximum	220000
Gain Register pixel well depth (e^-, typical)	800,000♦2
Max Readout Rate (MHz)	10
Frame Rates (frames per sec)	500 up to several thousands
Read Noise (e^-)	< 1 to 48 @ 10 MHz

Quantum efficiency♦3



Peak Quantum Efficiency (%)	
CCD Type	**Typical**
BV @ 575 nm	92.5

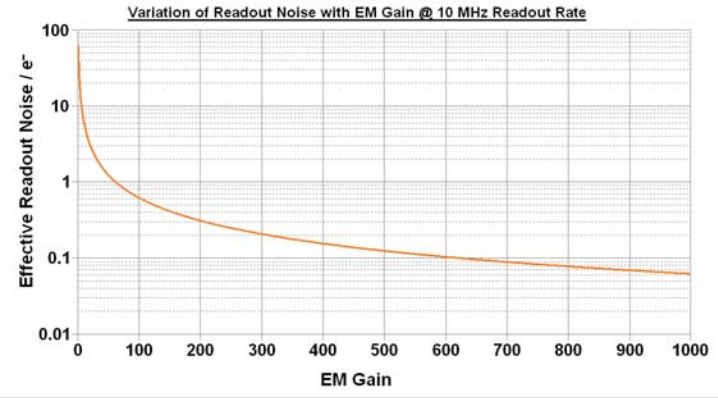
Technical specifications

System characteristics

Pixel Readout Rate (MHz)	
Electron Multiplying Amplifier	10, 5, 3, 1
Conventional Amplifier	3 & 1
Digitization	True 14-bit @ 10, 5, 3 & 1 MHz readout rate (16 bit available @ 1 MHz)
Vertical Clock Speed (µs)	0.0875 to 0.45 (variable)
Linear Absolute Electron Multiplier Gain	1 - 1000 times (software controlled)
Linearity (%, maximum)♦4	1
Triggering	Internal, External, External Start
Camera window type	Single window with double-sided AR coating (standard for BV model)

System Readout Noise (e^-)♦5

	Typical	With Electron Multiplication
10 MHz through EMCCD amplifier	48	<1
5 MHz through EMCCD amplifier	40	<1
3 MHz through EMCCD amplifier	28	<1
1MHz (16-bit) through EMCCD amplifier	18	<1



Minimum sensor temperatures (typical)

Air cooled (ambient air at 20ºC)	-85ºC
Water cooled using Re-circulator (ambient air @ 20ºC)	-90ºC
Water cooled using Chiller (@ 10ºC, 0.75 l / min)	-100ºC

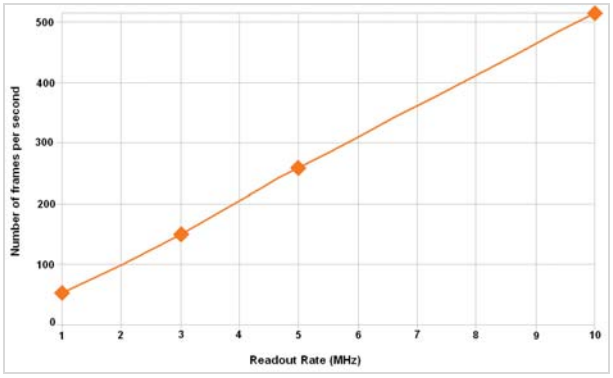
Dark Current & Background Events

Dark Current @ -85°C (e^-/pix/sec)♦6	0.002
EMCCD-Amplified Background Events♦7 (events/pix @ 1000 x gain and -85°C)	0.02

Blemish specification

As defined by the sensor manufacturer e2V.
Can be accessed in the CCD60 back-illuminated sensor datasheet, downloadable from this web page: **http://www.e2v.com/module/page-357/l3-vision-datasheets-and-technical-notes.cfm**

Full frame rate♦8



Max frames per second♦9

	Array size			
Binning	128 x 128 (Full Frame)	64 x 64	32 x 32	128H x 50V
1 x 1	515	943	1613	1163
1 x 2	943	1613	2500	1923
2 x 2	943	1613	2500	1923
1 x 4	1613	2500	3571	2941
4 x 4	1613	2500	3571	2941

Computer requirements

To handle data transfer rates of 10 MHz readout over extended kinetic series, a powerful computer is recommended, e.g.:

- 3 GHz Pentium (or better)
- 1GB RAM
- 10,000 rpm SATA hard drive preferred for extended kinetic series
- PCI-compatible computer. PCI slot must have bus master capability.
- Available auxiliary internal power connector
- 32 MB free hard disc space

Operating & storage conditions

Operating Temperature	0ºC to 30ºC ambient
Relative Humidity	< 70% (non-condensing)
Storage Temperature	-25ºC to 55ºC

Power requirements♦10

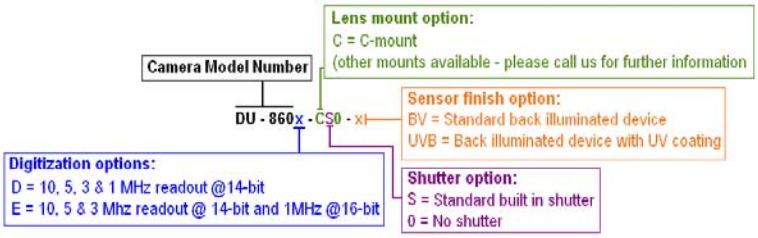
- 0.6A @ +12V
- 0.3A @ -12V
- 3.0A @ +5V

Need more information? Please contact us at:

International Office	US Office
Phone: +44 28 9023 7126	**Phone:** 800.296.1579
Fax: +44 28 9031 0792	**Fax:** 860.290.9566
Japanese Office	**Chinese Office**
Phone: +81 3 3511 0659	**Phone:** +86-10-5129-4977
Fax: +81 3 3511 0662	**Fax:** +86-10-6445-5401

Ordering information & notes

To order the camera you require, please use the following ordering system:



E.g. a **DU-860D-CSO-UVB** is a **back-illuminated iXon^{EM}+ 860** camera with **14-bit digitization** at 10, 5, 3 and 1 MHz readout speeds, **EMCCD** & **Conventional output amplifiers**, **standard shutter** and **UV-enhanced coating**.

The iXon^{EM}+ 860 requires the following controller card:

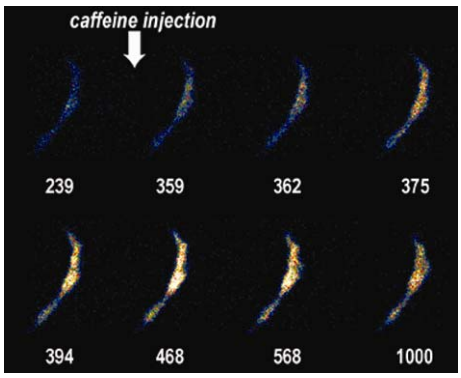
CCI-23	PCI controller card

The iXon^{EM}+ 860 also requires one of the following software options:

Andor Solis (i)	A ready-to-run Windows 2000 or XP-based package with rich functionality for data acquisition and processing.
Andor SDK	A DLL driver and software development kit that let you create your own applications for the Andor Camera. Available for Windows 2000 or XP and Linux.
Andor iQ	A comprehensive multi-dimensional imaging software package. Offers tight synchronization of EMCCD with a comprehensive range of microscopy hardware, along with comprehensive rendering and analysis functionality. Modular architecture for best price/performance package on the market.
Third party software compatibility	Drivers are available so that the iXon^{EM}+ range can be operated through a large variety of third party imaging packages.

The following accessories are available for use with the iXon^{EM}+ 860:

XW-RECR	Re-circulator for enhanced cooling performance
XW-CHIL-150	Chiller/re-circulator for maximum cooling performance
REMOTE CTRL KIT	Programmable remote control for controlling functions from anywhere around the optical set-up



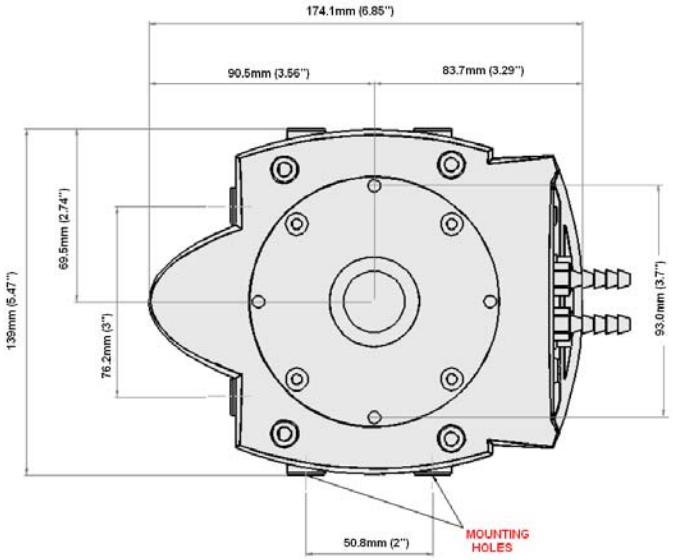
Selected frames from a kinetic series, showing Ca2+ flux change in smooth muscle cells recorded with Andor iXon^{EM}+ at 100 fps full frame.

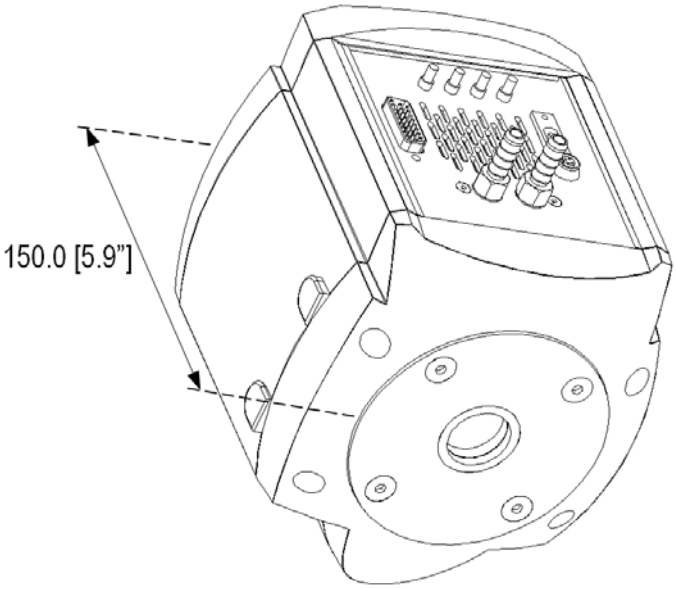
Specifications are subject to change without notice

♦1	Assembled in a state-of-the-art Class 10,000 cleanroom facility, Andor's UltraVac™ vacuum process combines a permanent hermatic vacuum seal (no o-rings), with a stringent protocol to minimize outgassing, including use of proprietary materials. Outgassing is the release of trapped gases that would otherwise prove highly problematic for high-vacuum systems.
♦2	The EM register on CCD60 sensors has a linear response up to 400,000 electrons maximum and a full well depth of ~800,000 electrons maximum.
♦3	Quantum efficiency of the CCD sensor as measured by the CCD Manufacturer.
♦4	Linearity is measured from a plot of Counts vs. Signal up to the saturation point of the system. Linearity is expressed as a percentage deviation from a straight line fit.
♦5	System Readout noise is for the entire system. It is a combination of CCD readout noise and A/D noise. Measurement is for Single Pixel readout with the CCD at a temperature of -85°C and minimum exposure time under dark conditions. Under Electron Multiplying conditions, the effective system readout noise is reduced to sub 1e$^-$ levels. Noise values will change with **p**re-**a**mplifier **g**ain (**PAG**) selection. Values quoted are measured with highest available PAG setting.
♦6	This value is obtained using the traditional method of measuring dark current, as for any CCD camera, i.e. taking a long integration time (with no EM gain applied) to get a darksignal that is well above the read noise. The dark current measurement is averaged over the CCD area excluding any regions of blemishes.
♦7	Using **E**lectron **M**ultiplication (**EM**) the iXon^{EM} + is capable of detecting single photons, therefore the true camera detection limit is set by the number of "dark" background events. These background events consist of both residual thermally generated electrons and **C**lock **I**nduced **C**harge (**CIC**) electrons (also referred to as **Spurious Charge**), each appearing as random single spikes that are well above the read noise floor. A thresholding scheme is employed to count these single electron events and is quoted as a probability of an event per pixel. Acquisition conditions are full resolution and max frame rate (10 MHz readout; frame-transfer mode; 0.3µs vertical clock speed; x 1000 EM gain; 30ms exposure; -85°C). It is important to realise that to get to this single photon detection regime there must be sufficient cooling, such that there is significantly less than 1 event per pixel.
♦8	The graph shows the full frame rates possible when reading out the sensor at 10, 5, 3 and 1 MHz pixel readout rates, and using 0.3µs vertical clock speed.
♦9	The max frames / second for iXon^{EM} + imaging CCDs is the maximum speed at which the device can acquire images in a standard system. Shown are the frame rates at 10 MHz digitization rates for a range of binning or array size combinations. All measurements are made with 0.3µs vertical clock speed. It also assumes internal trigger mode of operation
♦10	These power requirements are the maximum load that will be drawn from the computer for the camera head and controller card combined.

Dimensions

Weight: 3.4 kg [7.5 lb]





Notes:

1. **The clearance from the C-mount face plate to the shutter is 6mm. Please ensure that when fitting a lens, to a system with a built in shutter, that it does not extend into the housing by more than 5mm.**
2. **There are mounting holes (¼-20UNC) located on three sides of the camera. They are positioned centrally at a distance of 40mm from the front of the front face.**

Connections