



Digital Cameras for Microscopy



HAMAMATSU

Fast frame rate and high sensitivity

EM-CCD (Electron multiplication CCD) cameras

High dynamic range

ImagEM

Enhanced

Ideal format for short exposures, fast frame rate and high dynamic range

- Back-thinned 512 × 512 frame transfer CCD with maximum QE over 90 %
 - 16 μm pixels with large full well capacity
 - Optimized EM-CCD readout and stabilized dual mode cooling
-
- Short exposure and fast frame rate
 - Large dynamic range in both NORMAL-CCD and EM-CCD readout modes
 - Highly stabilized gain and minimal dark noise



High resolution

ImagEM-1K

Back-thinned format for high QE and high resolution

- Back-thinned 1024 × 1024 frame transfer CCD with maximum QE over 90 %
 - 13 μm pixels and 11 MHz readout
 - Optimized EM-CCD readout and stabilized dual mode cooling
-
- Short exposure and high resolution
 - Well matched to high NA objectives and fast readout
 - Highly stabilized gain and minimal dark noise



C9100-02

Front illuminated format for fast speed and high resolution imaging

- High EM gain factor (2000 times)
 - 1000 × 1000 × 8 μm pixel format and 30 frames/s readout
 - -50 °C air cooling stabilized up to 40 °C ambient temperature
-
- Great low signal detection
 - High spatial resolution well matched to high NA objectives
 - Consistent data regardless of ambient temperature



Specifications

		High dynamic range	High resolution		
Model name		ImagEM Enhanced	ImagEM-1K	C9100-02	
Type number		C9100-13	C9100-14	C9100-02	
Camera head type		Hermetic vacuum-sealed air/water-cooled head ①	Hermetic vacuum-sealed air/water-cooled head ①	Hermetic vacuum-sealed air-cooled head ①	
Window		Anti-reflection (AR) coatings on both sides, single window	Anti-reflection (AR) coatings on both sides, single window	Single window	
AR mask		Yes	No ②	–	
Imaging device		Electron multiplication back-thinned frame transfer CCD	Electron multiplication back-thinned frame transfer CCD	Electron multiplication frame transfer CCD	
Effective number of pixels		512 (H) × 512 (V)	1024 (H) × 1024 (V)	1000 (H) × 1000 (V)	
Cell size (square format)		16 μm (H) × 16 μm (V)	13 μm (H) × 13 μm (V)	8 μm (H) × 8 μm (V)	
Effective area		8.19 mm (H) × 8.19 mm (V)	13.3 mm (H) × 13.3 mm (V)	8.0 mm (H) × 8.0 mm (V)	
Pixel clock rate	EM-CCD readout	11 MHz, 2.75 MHz, 0.69 MHz	11 MHz, 2.75 MHz, 0.69 MHz	35 MHz/pixel	
	NORMAL CCD readout	2.75 MHz, 0.69 MHz	2.75 MHz, 0.69 MHz	–	
EM (electron multiplication) gain (typ.) ③		1x or 4x to 1200x	1x or 10x to 1200x	6x to 2000x	
Ultra low light detection		Photon Imaging mode (1, 2, 3)	Photon Imaging mode (1, 2, 3)	–	
Fastest readout speed (with binning, sub-array)		31.9 frames/s to 405 frames/s	9.5 frames/s to 231 frames/s	30.1 frames/s to 520.8 frames/s	
		417 frames/s (Binning option)	242 frames/s (Binning option)		
Readout noise (r.m.s.) (typ.)	EM-CCD readout	EM gain 4x (C9100-13)	25 electrons (at 11 MHz)	10 electrons (at 11 MHz)	10 electrons (at 35 MHz)
		6x (C9100-02)	20 electrons (at 2.75 MHz)	8 electrons (at 2.75 MHz)	–
		10x (C9100-14)	8 electrons (at 0.69 MHz)	3 electrons (at 0.69 MHz)	–
	NORMAL CCD readout	EM gain 1200x (C9100-13)	1 electron max. (at 11 MHz)	1 electron max. (at 11 MHz)	1 electron max. (at 35 MHz)
		2000x (C9100-02)	1 electron max. (at 2.75 MHz)	1 electron max. (at 2.75 MHz)	–
		1200x (C9100-14)	1 electron max. (at 0.69 MHz)	1 electron max. (at 0.69 MHz)	–
		17 electrons (at 2.75 MHz)	19 electrons (at 2.75 MHz)	–	
		8 electrons (at 0.69 MHz)	10 electrons (at 0.69 MHz)	–	
Full well capacity (typ.) ④		370 000 electrons (Max. 800 000 electrons)	400 000 electrons (Max. 730 000 electrons)	70 000 electrons	
Analog gain		1/2 times to 5 times	1/2 times to 5 times	–	
Cooling method / temperature ⑤	Forced-air cooled	-65 °C stabilized (0 °C to +30 °C)	-55 °C stabilized (0 °C to +30 °C)	-50 °C stabilized (0 °C to +40 °C)	
		-75 °C (Room temperature: Stable at +20 °C)	-65 °C (Room temperature: Stable at +20 °C)	–	
	Water cooled ⑥	-80 °C stabilized (Water temperature: +20 °C)	-70 °C stabilized (Water temperature: +20 °C)	–	
		-90 °C (Water temperature: lower than +10 °C)	-80 °C (Water temperature: lower than +10 °C)	–	
Temperature stability (typ.)	Forced-air cooled	±0.03 °C (Room temperature: Stable at +20 °C) (-65 °C stabilized)	±0.05 °C (Room temperature: Stable at +20 °C) (-55 °C stabilized)	–	
	Water cooled	±0.01 °C (Water temperature: +20 °C [Operated with circulating water cooler]) (-80 °C stabilized)	±0.01 °C (Water temperature: +20 °C [Operated with circulating water cooler]) (-70 °C stabilized)	–	
Dark current ⑦ (typ.)	Forced-air cooled	0.01 electrons/pixel/s (-65 °C)	0.01 electrons/pixel/s (-55 °C)	–	
	Water cooled	0.001 electrons/pixel/s (-80 °C)	0.001 electrons/pixel/s (-70 °C)	–	
Exposure time ⑧	Internal sync mode	30.5 ms to 2 h	103.3 ms to 2 h	100 μs to 10 s	
	External trigger mode	10 μs to 2 h	10 μs to 2 h	100 μs to 10 s	
A/D converter		16 bit	16 bit	14 bit	
Output signal / External control		Camera Link			
Sub-array		Every 16 lines (horizontal, vertical) size, position can be set			
Binning		2 × 2, 4 × 4 (8 × 8, 16 × 16) ⑨	2 × 2, 4 × 4 (8 × 8, 16 × 16) ⑨	2 × 2, 4 × 4, 8 × 8, 16 × 16	
External trigger mode ⑩		Edge trigger, Level trigger, Start trigger, Synchronous readout trigger	Edge trigger, Level trigger, Start trigger, Synchronous readout trigger	Edge trigger, Level trigger, Synchronous readout trigger	
Trigger output ⑩		Exposure timing output, Programmable timing output (Delay and pulse length are variable)	Exposure timing output, Programmable timing output (Delay and pulse length are variable)	Integ start out	
Image processing features (real-time)		Background subtraction, Shading correction, Recursive filter, Frame averaging, Spot noise reducer ⑪	Background subtraction, Shading correction, Recursive filter, Frame averaging, Spot noise reducer ⑪	–	
EM gain protection		EM warning mode, EM protection mode	EM warning mode, EM protection mode	–	
EM gain readjustment		Available	Available	–	
Lens mount		C-mount			
Power requirements		AC 100 V to 240 V, 50 Hz / 60 Hz	AC 100 V to 240 V, 50 Hz / 60 Hz	DC + 12 V	
Power consumption		Approx. 140 V-A	Approx. 140 V-A	Approx. 60 V-A	
Ambient storage temperature		-10 °C to +50 °C			
Ambient operating temperature		0 °C to +40 °C			
Performance guaranteed temperature		0 °C to +30 °C	0 °C to +30 °C	0 °C to +40 °C	
Ambient operating / storage humidity		70 % max. (with no condensation)			

① The hermetic sealed head maintains a high degree of vacuum (10⁻⁸ Torr) without re-evacuation.

② AR mask is not placed because the proportion of CCD area to the window is large; therefore, reflection is quite small.

③ Even with maximum electron multiplication gain, the dark signal is kept at a low level during low light imaging.

④ Linearity is not assured when full well capacity is over 370 000 electrons (C9100-13) or 400 000 electrons (C9100-14), because of CCD performance.

⑤ The cooling temperature may not reach this temperature. It depends on the operation condition.

⑥ Water flow rate is 1.2 liter/min.

⑦ Typical thermal charge value (not guaranteed).

⑧ Image smearing may appear when the exposure time is short.

⑨ 8 × 8 and 16 × 16 binning are available by special order. Please consult with our sales office.

⑩ CMOS 3.3 V with reversible polarity.

⑪ Recursive filter, frame averaging, and spot noise reducer cannot be used simultaneously.

Low noise and multipurpose Integrating cameras

High speed, low noise and high sensitivity

ORCA-Flash2.8

Featuring the scientific CMOS image sensor

- 2.8 million pixel scientific CMOS with maximum QE 70 %
 - Very low readout noise (3 electrons r.m.s.)
 - 45 frames/s readout (up to 1273 frames/s by sub-array readout)
 - High dynamic range (4500:1)
-
- High resolution and short exposure times combined
 - Low noise and fast readout time simultaneously
 - High image quality (no fixed pattern noise)
 - Wider field of view than CCD (2/3 inch, 1.3 million pixels)



High speed and high sensitivity

ORCA-R²

Maximum versatility

- 1.37 million pixel interline CCD with maximum QE over 70 %
 - 14 MHz and 28 MHz readout modes included
 - 12 bit and 16 bit digitizers are included and software selectable
 - Air and water cooling capabilities are standard
-
- High resolution and short exposure times combined
 - Choice of very low noise or very fast readout to suit applications
 - Choice of bit depth to suit data and precision needs
 - Long exposures with very low dark current and no vibration



ORCA-03G, ORCA-05G

Affordable price and low noise

- 1.37 million pixel interline CCD with maximum QE over 70 %
 - Compact head with single cable and no controller
 - Wide spectral range from 400 nm to NIR region
 - 14.7 MHz readout at 12 bits
-
- High resolution and short exposure times combined
 - Fits into any laboratory space or setup
 - Good for both bright fluorescence and NIR-DIC
 - ORCA-03G model includes peltier cooling for extended exposures



High speed

C9300-221

High frame rate and high IR sensitivity

- High speed progressive scan VGA interline CCD
 - Single or dual tap readout modes are software selectable
 - 33 μ s shutter capability
 - High NIR sensitivity
-
- Good spatial resolution even at 694 frames/s
 - Full frame readout of 82 frames/s or 150.2 frames/s
 - Stop-action imaging of fast-moving specimens
 - Good choice for moving fluorescence and NIR-DIC specimens



Dual wavelength imaging

ORCA-D²

A one-of-a-kind solution for dual wavelength imaging

- 1.37 million pixel interline CCD ($\times 2$ chips) with maximum QE over 70 %
 - 11.2 frames/s readout (up to 33.5 frames/s by 4×4 binning)
 - Selectable wavelengths (changing optical blocks)
 - Auto-correction of focus and alignment
-
- Simultaneous capture of wide-field dual wavelength images
 - Dual focal plane imaging microscopy
 - During image capture, the camera automatically corrects focus, alignment and color shifting to produce high-quality images



Color

ORCA-3CCD

Simultaneous but independent exposures on R, G and B channels

- Total 4.13 million pixels on 3 progressive scan interline CCD chips
 - 36 bit color resolution
 - Cooled R, G and B CCDs with independent exposure settings
-
- High spatial resolution images of multicolor specimens in brightfield and fluorescence
 - Great color fidelity with superb backgrounds
 - Tremendous dynamic range of separate fluorophores



Speciality high QE, low noise

ORCA II-BT-512G

Huge dynamic range and great sensitivity

- Back thinned 512×512 pixel full frame CCD with maximum QE over 90 %
 - Large full well capacity
 - Very low dark current (0.032 electrons/pixel/s) with stabilized -75°C cooling
-
- Very efficient light collection of dim signals
 - Dynamic range of 32 875:1
 - Suitable for fluorescence and luminescence



ORCA II-BT-1024G

High resolution, large dynamic range and great sensitivity

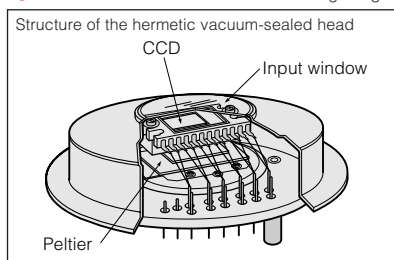
- Back thinned 1024×1024 pixel full frame CCD with maximum QE over 90 %
 - Wide spectral sensitivity from 200 nm to 1000 nm
 - Very low dark current (0.0012 electrons/pixel/s) with stabilized -75°C cooling
-
- High resolution and fast exposure times for microscopy
 - Broad range of applications including UV imaging
 - Suitable for high resolution fluorescence and luminescence



Specifications

		High speed / sensitivity, low noise	High speed and high sensitivity			
Model name		ORCA-Flash2.8	ORCA-R2	ORCA-03G	ORCA-05G	
Type number		C11440-10C	C10600-10B	C8484-03G02	C8484-05G02	
Camera head type		Passive air-cooled head	Hermetic vacuum-sealed air/water-cooled head ^①	Hermetic vacuum-sealed air-cooled head ^①	Passive air-cooled head	
Mechanical shutter		-	-	-	-	
Imaging device		FL-280 scientific CMOS	ER-150 progressive scan interline CCD			
Effective number of pixels		1920 (H) x 1440 (V)	1344 (H) x 1024 (V)			
Cell size (square format)		3.63 μm (H) x 3.63 μm (V)	6.45 μm (H) x 6.45 μm (V)			
Effective area		6.97 mm (H) x 5.23 mm (V)	8.67 mm (H) x 6.60 mm (V)			
Pixel clock rate	High speed readout	-	28.0 MHz/pixel	14.7 MHz/pixel		
	High precision readout	-	14.0 MHz/pixel	-		
Frame rate	High speed readout	1 x 1	45.4 frames/s	16.2 frames/s	8.9 frames/s	
		binning	2 x 2	-	28.4 frames/s	16.3 frames/s
			4 x 4	-	45.7 frames/s	27.8 frames/s
			8 x 8	-	64.3 frames/s	43.0 frames/s
	High precision readout	1 x 1	-	8.5 frames/s	-	
		binning	2 x 2	-	15.6 frames/s	-
4 x 4	-		26.7 frames/s	-		
8 x 8	-		40.6 frames/s	-		
Readout noise (r.m.s.) typ.	High speed readout	3 electrons (gain 8x)	10 electrons	6 to 8 electrons	10 electrons	
	High precision readout	-	6 electrons	-	-	
Full well capacity typ.	1 x 1	18 000 electrons	18 000 electrons	15 000 electrons		
	binning	-	36 000 electrons (at High dynamic range mode)	-		
Dynamic range typ. ^②	High speed readout	4500:1 (gain 1x)	-	2142:1	1500:1	
	High precision readout	1 x 1	-	-	-	
		binning	-	3000:1	-	-
Cooling method		Peltier cooling, passive air cooled	Forced air/water peltier cooling, with hermetic sealing	Forced air peltier cooling, with hermetic sealing	-	
Cooling temperature (at +20 °C ambient temperature)		+5 °C (ambient temperature:+20 °C)	-40 °C (absolute value) (Water cooled)	-10 °C (absolute value)	-	
Dark current		-	0.0005 electrons/pixel/s	0.1 electrons/pixel/s	-	
A/D converter	High speed readout	12 bit	12 bit or 16 bit	12 bit		
	High precision readout	-	12 bit or 16 bit	-		
Interface / Output signal (digital output)		Camera Link Base Configuration	IEEE1394b-2002	IEEE1394-1995 / Non-compressed data (Mono 16)		
Exposure time		20 μs to 10 s (at internal trigger / external trigger)	10 μs to 4200 s	10 μs to 10 s	10 μs to 1 s	
External control		Camera Link	IIDC 1394-Based Digital Camera Specification Ver.1.31 **	IIDC 1394-Based Digital Camera Specification Ver.1.30 **		
Sub-array		Yes				
External trigger		Yes				
Contrast enhancement	High speed readout	Analog gain (8 times max.)	Analog gain (10 times max.) and offset function	High gain / Low gain	High gain / Low gain	
	High precision readout	-	Analog gain (10 times max.) and offset function	-	-	
Lens mount		C-mount				
Line voltage		AC 100 V to 240 V, 50 Hz / 60 Hz		DC +12 V	DC +8 V to DC +30 V	
Power consumption		approx. 45 V·A	approx. 60 V·A	approx. 24 V·A	approx. 8 V·A	
Ambient storage temperature		-10 °C to +50 °C				
Ambient operating temperature		0 °C to +40 °C				
Ambient operating / storage humidity		70 % max. (no condensation)				

^① The hermetic sealed head maintains a high degree of vacuum (10⁻⁸ Torr) without re-evacuation.



^② Calculated from the ratio of the full well capacity and average readout noise.

^③ The hermetic vacuum-sealed air-cooled head is available. Please consult your local sales representative.

* "ORCA-3CCD Digital Color Camera with front cable mount" for the C7780-10
 "ORCA-3CCD Digital Color Camera with rear cable mount" for the C7780-20

** Hamamatsu is a member of 1394 Trade Association



High speed	Dual wavelength imaging	Color	Speciality high QE, low noise	
C9300-221	ORCA-D2	ORCA-3CCD	ORCA II-BT-512G	ORCA II-BT-1024G
C9300-221	C11254-10B	C7780-10, C7780-20 *	C4742-98-26LWG2	C4742-98-26KWG2
Forced air-cooled head	Hermetic vacuum-sealed air-cooled head	Passive air-cooled head	Hermetic vacuum-sealed water-cooled head ①	
-	-	-	Built-in (Control: Open / Close / Auto)	
Progressive scan interline CCD	ER-150 progressive scan interline CCD		S7170 full-frame transfer CCD	CCD47-10 full-frame transfer CCD
640 (H) x 480 (V)	1280 (H) x 960 (V)	1344 (H) x 1024 (V)	512 (H) x 512 (V)	1024 (H) x 1024 (V)
7.4 μm (H) x 7.4 μm (V)	6.45 μm (H) x 6.45 μm (V)	6.45 μm (H) x 6.45 μm (V)	24 μm (H) x 24 μm (V)	13 μm (H) x 13 μm (V)
4.74 mm (H) x 3.55 mm (V)	8.67 mm (H) x 6.19 mm (V)	8.67 mm (H) x 6.60 mm (V)	12.29 mm (H) x 12.29 mm (V)	13.3 mm (H) x 13.3 mm (V)
30 MHz/pixel	20.0 MHz/pixel	16.0 MHz/pixel	2.5 MHz/pixel	5 MHz/pixel
-	-	-	156 kHz/pixel	312.5 kHz/pixel
150 frames/s	11.2 frames/s	9.1 frames/s	6.34 frames/s	3.05 frames/s
274 frames/s	18.8 frames/s	17.9 frames/s	9.84 frames/s	4.58 frames/s
461 frames/s	27.7 frames/s	31.5 frames/s	13.6 frames/s	6.12 frames/s
694 frames/s	33.5 frames/s	49.2 frames/s	16.8 frames/s	7.36 frames/s
82 frames/s	-	-	0.55 frames/s	0.28 frames/s
155 frames/s	-	-	1.07 frames/s	0.54 frames/s
280 frames/s	-	-	2.05 frames/s	1.01 frames/s
465 frames/s	-	-	3.75 frames/s	1.83 frames/s
-	8 electrons	13 electrons	-	-
20 electrons	-	-	7 electrons	6 electrons
20 000 electrons	18 000 electrons	18 000 electrons	230 000 electrons	80 000 electrons
-	36 000 electrons	-	-	-
1000:1	2250:1	1384:1	-	-
-	-	-	32 875:1	13 333:1
-	-	-	-	-
Forced air peltier cooling	Peltier cooling, forced air cooled	Peltier cooling, air radiation system	Water-cooling and peltier cooling, with hermetic sealing ③	
0 °C to +5 °C	-10 °C (ambient temperature: +20 °C)	0 °C (absolute value)	-75 °C (absolute value) ③	
2 electrons/pixel/s	0.1 electrons/pixel/s	0.5 electrons/pixel/s	0.032 electrons/pixel/s ③	0.0012 electrons/pixel/s ③
12 bit				
12 bit	-	-	16 bit	
Camera Link	IEEE1394b-2002	12 bit, 10 bit and 8 bit x3 channels parallel output	IEEE1394-1995 / Non-compressed data (Mono 16)	
33.1 μs to 10 s	117 μs to 60 s	128 μs to 10 s	20 ms to 7200 s	
Camera Link	IEEE1394-Based Digital Camera Specification Ver.1.32	RS-232C	IICD 1394-Based Digital Camera Specification Ver.1.30 **	
Yes				
Yes				
Analog gain (5 times max.)	-	-	1 to 6 times	
Analog gain (5 times max.)	-	-	1, 4, 16 times	1, 4, 18 times
C-mount	2/3 inch bayonet mount (flange back 48 mm)		C-mount	
AC 100 V to 240 V, 50 Hz / 60 Hz				
approx. 10 V-A	approx. 70 V-A	approx. 77 V-A	approx. 220 V-A	
-10 °C to +50 °C				
0 °C to +40 °C	+10 °C to +35 °C	-	0 °C to +40 °C	
70 % max. (no condensation)				

Advantages of an interline transfer CCD (ER-150 CCD)

New interline transfer CCDs, like the Hamamatsu ER-150 CCD (Fig. 1) used in the ORCA series of cameras, offer characteristics ideally suited to many scientific applications.

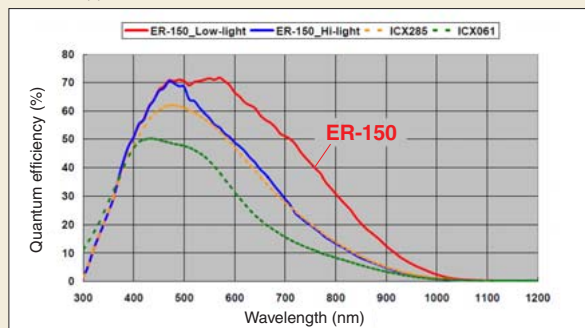


Fig. 1 QE of the ER-150 interline transfer CCD (See line in red.)



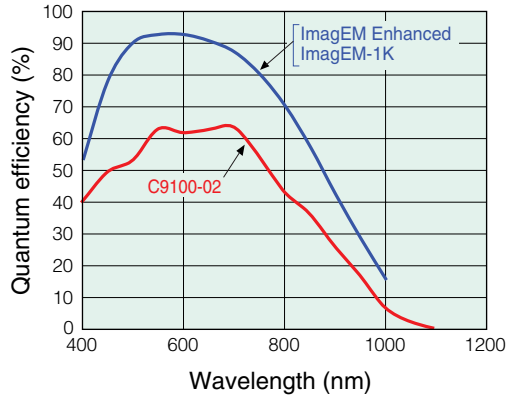
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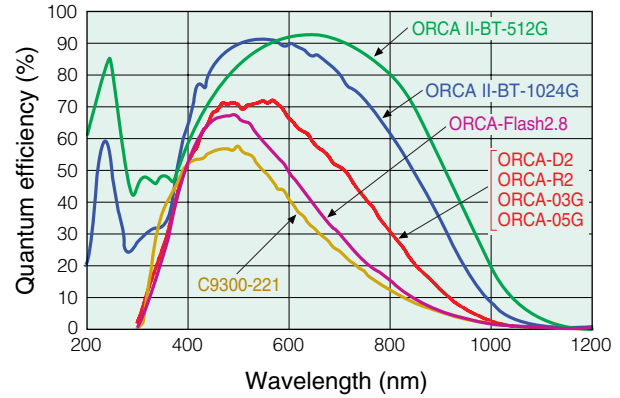
Spectral response characteristics

* These are typical, not guaranteed.

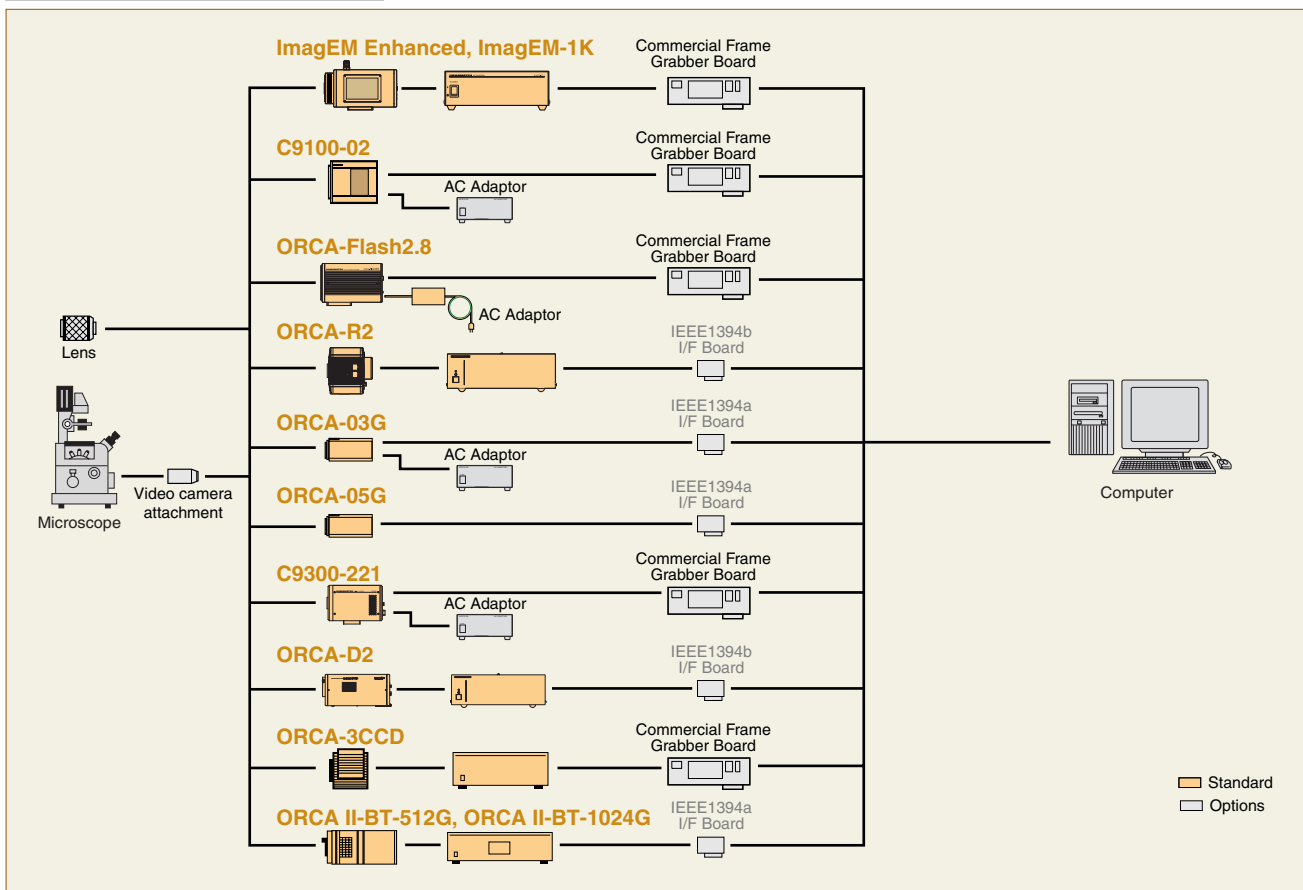
EM-CCD (Electron multiplication CCD) cameras



Integrating cameras



System configurations



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