

TRiCATT

Time-Resolved Intensified Camera Attachment

The TRiCATT is a compact lens-coupled image intensifier for scientific and industrial applications that require 1) low-light level imaging, 2) ultra-short exposures through fast gating, and/or 3) frequency-domain imaging using lock-in detection. The TRiCATT features an 18 or 25 mm image intensifier with a highly efficient relay lens that can be matched to any CCD or CMOS camera, resulting in a flexible solution that can easily be integrated in an existing imaging system.

The TRiCATT (Time Resolved intensified Camera Attachment) is the best choice for ultra-fast imaging in the time domain and/or frequency domain.

With a wide range of Gen II and Gen III image intensifiers, the TRiCATT offers high sensitivity down to single photon level and the optimal spectral bandwidth for your application. Different models covering a range in spectral sensitivity, phosphor, spatial resolution, gain, linearity, minimum gate width and gating frequency are available.

For time-domain imaging the intensifier is equipped with a fast gate unit (TRiCATT G40n/G2n) that enables the intensifier to operate as an electro-optical shutter. The gate unit can be operated up to repetition rates of up to 2.5 MHz in burst.



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A series of different intensifier control units provide functionality ranging from analog gain control to full digital control including an internal trigger generator and programmable gate trains.

For frequency-domain imaging the TRiCATT M supports gain modulation of 120 MHz (standard) and higher (external signal generator). Modulation is provided by a single-chip digital synthesizer to ensure an extremely low phase noise.

KEY FEATURES

High resolution image intensifiers

Gen II and Gen III image intensifiers offering the world's highest resolution and sensitivity in the UV, visible or near infrared

Small gate widths

Gate width down to less than 3 ns (FWHM) with minimal jitter

High gate repetition rates

Up to 300 kHz/2.5 MHz burst

Compact design

For an easy fit to your imaging or spectroscopy setup

Overexposure protection

User-definable current limitation and optional shutter

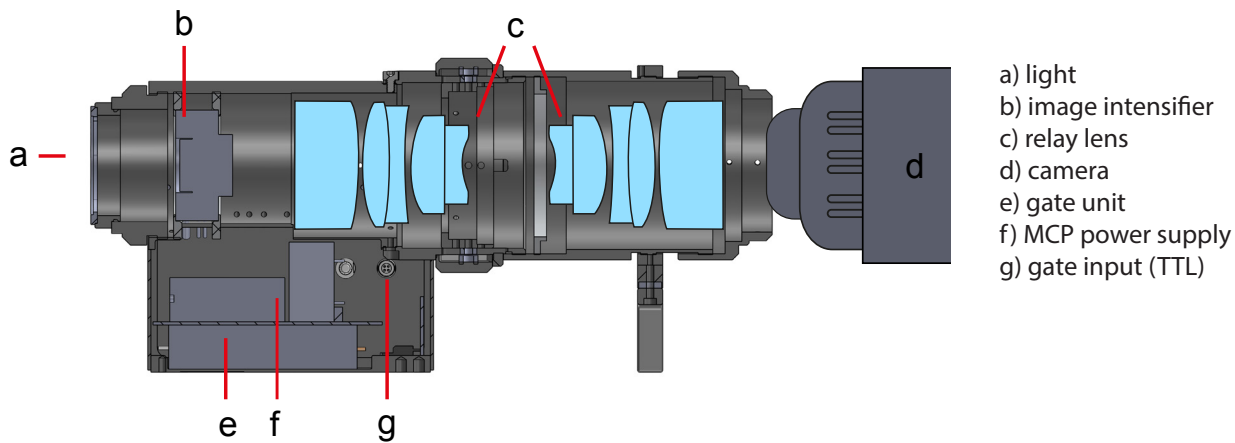
Easy coupling

Flexible and efficient lens coupling to any CCD and CMOS camera (up to 500 fps)

APPLICATIONS

- Time-resolved imaging and spectroscopy
- Particle Image Velocimetry (PIV)
- Laser Induced Fluorescence (LIF)
- Time-gated luminescence
- Fluorescence Lifetime-Imaging Microscopy (FLIM)
- Förster Resonance Energy Transfer (FRET)
- Oxygen imaging
- Viscosity imaging
- Single-molecule imaging
- Bio- and Chemiluminescence Imaging
- Solar PV and LED characterization
- Combustion
- Time-gated Raman
- Plasma physics
- X-ray Imaging

Image Intensifier Layout



- a) light
- b) image intensifier
- c) relay lens
- d) camera
- e) gate unit
- f) MCP power supply
- g) gate input (TTL)

When the TRiCATT is mounted to a lens or microscope, the incoming light (a) is focused onto the entrance window of the image intensifier (b). The image intensifier converts the optical image to electrons at the photocathode, amplifies this electron image at the micro-channel plate (MCP), and re-converts the electrons into photons at the anode screen. At the output of the intensifier, a relay objective is mounted with a magnification that matches the intensifier to the high-speed camera sensor.

For time-resolved imaging, a gate unit (e) is used together with the image intensifier to yield an electro-optical shutter. The gate unit either generates a high voltage pulse signal or follows an external TTL pulse. The pulse width is variable and follows a TTL input pulse over the range from less than 3 ns to DC at a repetition rate up to 300 kHz.

IMAGE INTENSIFIER SPECIFICATION

	TRiCATT 18				TRiCATT 25			
Image intensifier	Proximity-focused Gen II or Gen III (filmless)							
Input window	S20: Quartz. S25, GaAs, GaAsP: Borosilicate glass							
Input diameter	18 mm				25 mm			
Input window thickness	5.5 mm				6.0 mm			
Effective area	Gen II: \varnothing 17.5 mm, Gen III: 13.5x10 mm				Gen II: \varnothing 24.5 mm, Gen III: 16x16 mm			
Sensitivity and spectral range	TRiCATT G: see graph on p. 5 (top-left)							
Min. gate width (FWHM)	TRiCATT G 40n: 40 ns TRiCATT G 2n: < 3 ns with Gen II, 5 ns with Gen III							
Max. repetition frequency	TRiCATT G 40n: 100 kHz TRiCATT G 2n: 300 kHz, 2.5 MHz in burst mode							
Photocathode	S20	S25	GaAs	GaAsP	S20	S25	GaAs	GaAsP
Luminous gain (max)* [lm/m ² /lx]	14800	30000	40000	22000			33000	22000
Equivalent Background Input	0.006	0.008	2×10^{-11}	3×10^{-12}			2×10^{-11}	3×10^{-23}
	e/px/s	e/px/s	lm/cm ²	lm/cm ²			lm/cm ²	lm/cm ²
Typical output resolution (lp/mm)								
1:1 lens coupling	60		63		57		57	
2:1 lens coupling	120		126		114		114	
3:1 lens coupling	180		189		171		171	
Lens coupling/output flange	1:1 C-mount 2:1 C-mount 1:1; 2:1; 3:1 F-mount on request				1:1 F-Mount 2:1 F-mount 3:1 F-mount			
Phosphor	P43 (P20, P46 on request)							
Spatial resolution bare intensifier	Gen II: up to 69 lp/mm, Gen III: up to 64 lp/mm							

* gain and EBI are specified for image intensifiers with P43 phosphor screen

Gating

The TRiCATT G can be used as an ultra-fast electro-optical shutter by gating the image intensifier. This eliminates motion blur and reduces the effective exposure time, thereby significantly widening the camera dynamic range. To prevent loss of intras-cene dynamic range when using a shorter gate the user can set a higher MCP gain. The pulse width and frequency are user defined: any pulse width from DC down to a few nanoseconds can be applied.

The table below summarizes the range of different intensifier control units available with the TRiCATT G. The gain-control models act as a power supply for the image intensifier, gate pulse trains are supplied externally. The gate-control model has its own pulse generator, giving the user direct control of the gate width and gate delay. The gate-generator models have an enhanced version of the pulse generator with lower jitter. These models allow the image intensifier to be synchronized to the exposure time of the camera by supplying a trigger signal. All models allow the gate frequency to be set by an external TTL signal.

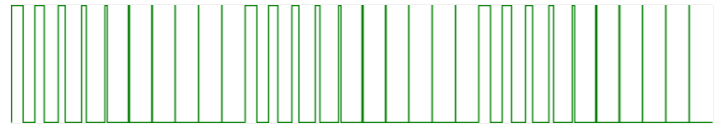
Microsoft Windows control software is provided with all control-unit models, except the manual model. The software provides full user control of the pulse width and delay, gating mode, and intensifier gain. The control unit is connected to the computer via USB (RS-232 is optional). For integration in third party software a full command set is available.

The enhanced pulse generator of the gate-generator models has 4 independent programmable pulse outputs (one of which is used for gating) that provide precise timed TTL pulses with pulse widths down to less than 3 ns (FWHM).

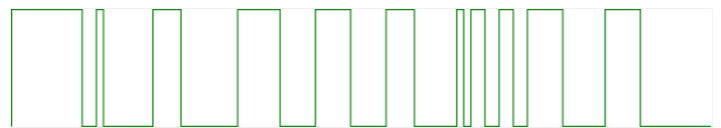
The intensifier gate generator is optionally available with programmable gate patterns. A frame storage facility allows storing many different delay/width-settings and the creation of scenarios of freely definable gate sequences.



Example 1: alternating gate width



Example 2: repeated linear reducing gate width



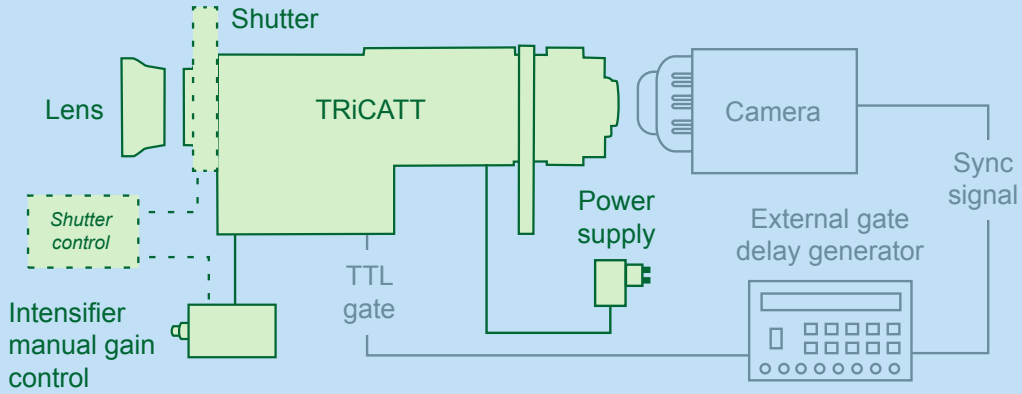
Example 3: complex gate pattern

For the TRiCATT M model described in the next section, the intensifier modulation signal at frequencies below 100 kHz is produced using the gate unit and timing pulse generator. In that case the pulse generator also provides the synchronisation signal for a modulated light source or acousto-optic modulator.

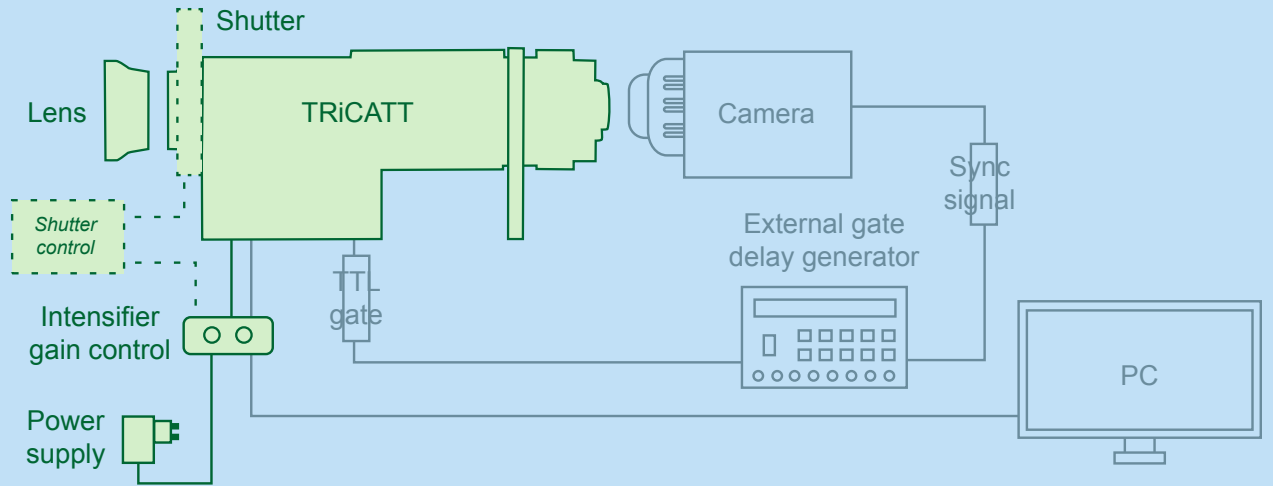
CONTROL UNITS AND GATING PROPERTIES

Control Unit Model	No control unit	Intensifier gain control	Intensifier gate control	Intensifier gate generator
Gain control	Manual	✓	✓	✓
Gate control	External TTL	External TTL	✓	✓
Anode current limiter	x	✓	✓	✓
Internal trigger generator	x	x	✓	✓
Programmable gate pattern	x	x	3 presets	Optional
Shutter control	x	Optional	Optional	✓
Additional TTL outputs	x	x	2	3
Gating properties				
Width range			10 ns – 10 s	< 3 ns – 10 s
Resulting min pulse width (increments)			10 ns (10 ns)	< 3 ns (10 ps)
Pulse repetition rate			< 10 MHz	< 16 MHz
Delay jitter (width)			< 250 ps RMS	< 35 ps (< 35 ps)
Insertion delay			20 ns	20 ns
Trigger input			✓	Programmable trigger level, divider and bursts (m out of n triggers)

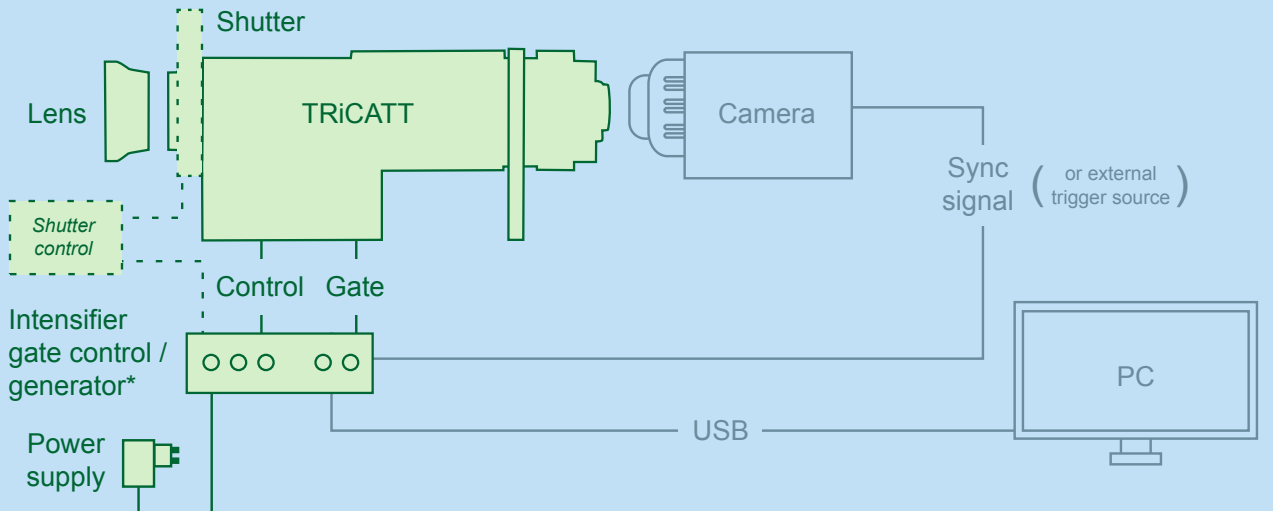
intensifier manual gain control



intensifier gain control

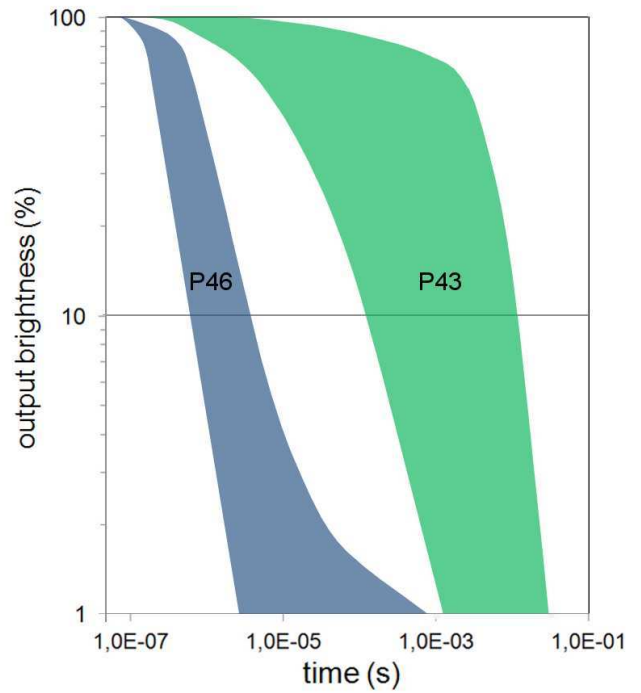
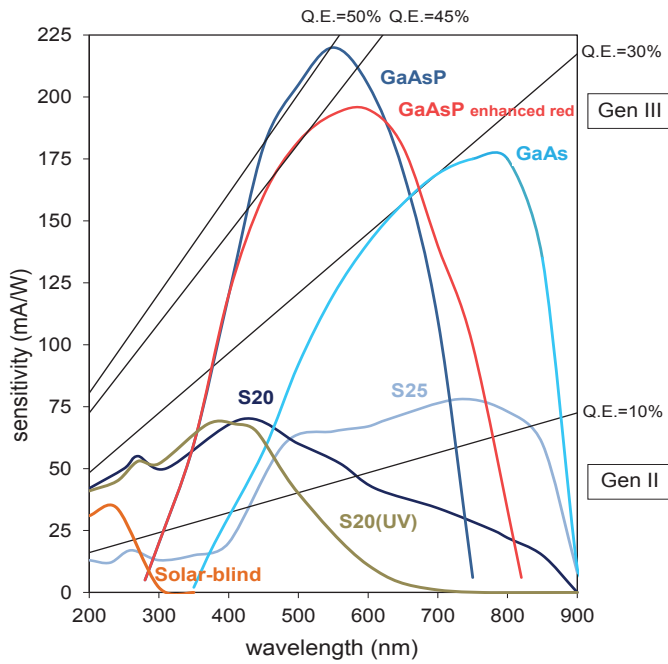


intensifier gate control



*The intensifier gate generator can also operate as master trigger source for camera, intensifier and other devices

Spectral response and phosphor decay time



Phosphor	Efficiency	Decay time to 10%	Decay time to 1%
P43 (standard)	20 photons/e-/kV	1.5 ms	3 ms
P46 (optional)	6 photons/e-/kV	500 ns	2000 ns

P20 and P24 available on request

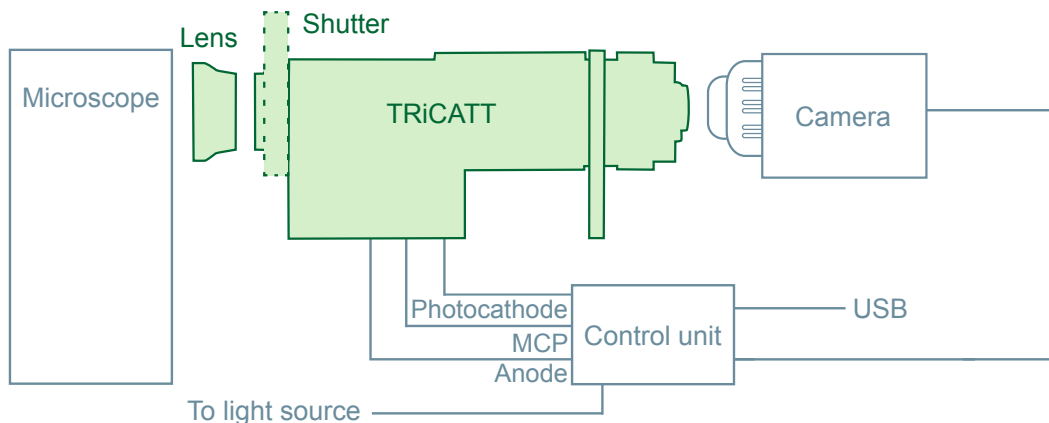
Modulation control unit

The TRiCATT M provides highly accurate frequency-domain imaging with high-resolution gain modulated Gen II and Gen III image intensifiers.

The TRiCATT M combines the image intensifier with a separate modulation control unit. The modulation control unit contains a single-chip dual channel DDS for generation and amplification of two RF modulation signals, one for the modulated light-source or acousto-optic modulator (AOM) and one for the image intensifier (100 kHz – 120 MHz standard). The control unit

further supplies the high-voltage for the image intensifier. A software SDK is provided for digital control of the gain, modulation and cathode bias voltages via an USB interface, emulating a standard RS-232 serial communications port.

Modulation frequencies below 100 kHz are supported by the optional gate unit and pulse generator. This also produces the synchronization signal for an external modulated light source or AOM.



MODULATION SPECIFICATION

TRiCATT M

Frequency range	100 kHz–120 MHz (standard) Up to at least 250 MHz with an external signal generator
Frequency adjustment resolution	1 kHz
Frequency deviation	100 ppm max.
Phase adjustment range	0–360° in 1° steps, phase deviation < 0.01°
Harmonics suppression	Better than 25 dB
High light level protection	Integrated intensifier protection, switches off all DC and AC power

Output 1. TRiCATT

AC signal level	Adjustable from –30 to 0 dBm
AC signal after amplification	50 Vpp max.

Output 2. Lightsource

Programmable options:

a) Multi-LED

AC signal level	Adjustable in 250 steps
DC current adjust	0–1000 mA, 12 bit

b) Modulated laser diode

AC signal level	0.00–1.00 V peak-peak
DC level adjust	0.00–1.00 V

c) AOM for CW laser

AC signal level	0.00–1.00 V peak-peak
Frequency	Half the frequency of output 2

Modulation input	Input for external modulation signal, 250mV (peak-peak), 50Ω
External trigger input	LVTTL (high frequency mode only), 50Ω
Trigger input	Available upon request
Monitor output	Output modulation signal monitor
Interface	USB 2.0

TRiCATT GM, as TRiCATT M plus:

Frequency range	0–100 kHz
Min. gate width (FWHM)	40 ns
Gate pulse width control	40 ns – 10 s, 10 ps resolution
Gate delay time control	0–10 s, 10 ps resolution
Dead time after trailing edge	100 ns
Pulse generator resolution ; jitter	10 ps ; < 35 ps
Insertion delay	45 ns
Trigger input	3.5 V – 5.0 V 50 Ω
Output A/B pulse width control	Fully programmable, 50 Ω source impedance
Output A/B delay control	Fully programmable, 50 Ω source impedance
Interface	USB 2.0

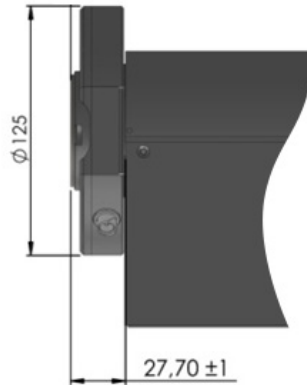
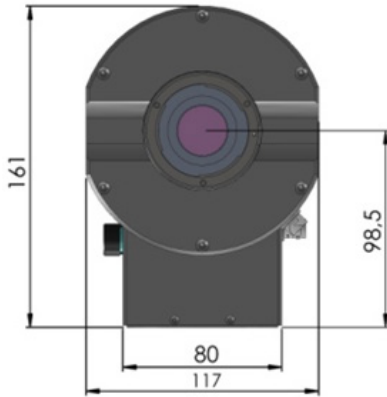
Mechanical shutter

The TRiCATT can be supplied with an optional mechanical shutter for preventing damage to the image intensifier by high intensity stray light or direct laser light. It is further recommended to close the shutter between measurements to increase the lifespan of the image intensifier.

The shutter is encased in an aluminum housing with a standard F-mount input that replaces the original F-mount adapter of the TRiCATT. The back focal distance of the F-mount input is

unchanged, so any F-mount objective can be used. The shutter comes with a power supply and a remote control. A timer can be used to automatically close the shutter after a predetermined time. The remote control has an ergonomic design and a large LCD screen.

The shutter can also be controlled by the Windows software of the TRiCATT or by an external TTL signal.



SHUTTER SPECIFICATION

Shutter	UNIBLITZ VS35
Repetition Rate	DC to 5 Hz (20 Hz burst of maximal 4 s, with 1 minute between bursts)
Transfer time on opening/closing	13 ms
Minimal open time	20 ms
Lens mount	F-mount
Shutter control via	- Hand-held remote control with push-button and timer - External TTL signal
Delay-timer specification	1 s to 99 hrs in 1 s increments
TTL input	0–5 V, minimal pulse width of 20 ms