



DIGITAL PRECISE TIMING:
SYNCHRONISED LIGHTING
FOR FASTER MACHINE VISION

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Sponsored
by:



This is evotron



- Our subject: Digital lighting for Machine Vision - patented **lumiSENS®** technology
- Our location: Suhl / Germany
- Our served industries: Machine Vision
Measuring technology
Automation for manufacturing industries
- Our business units:

evotron
products



LED Lighting &
LED lighting controller

evotron
design



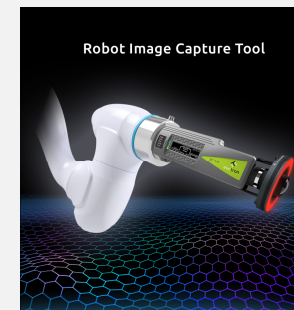
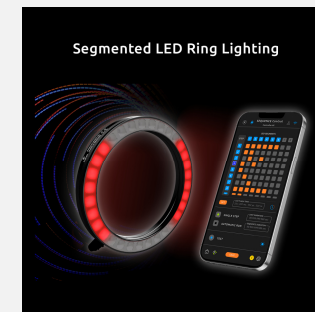
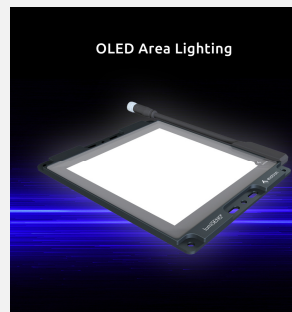
LED Lighting according to
customer requirements

evotron
academy



Marketing, training and
consulting platform

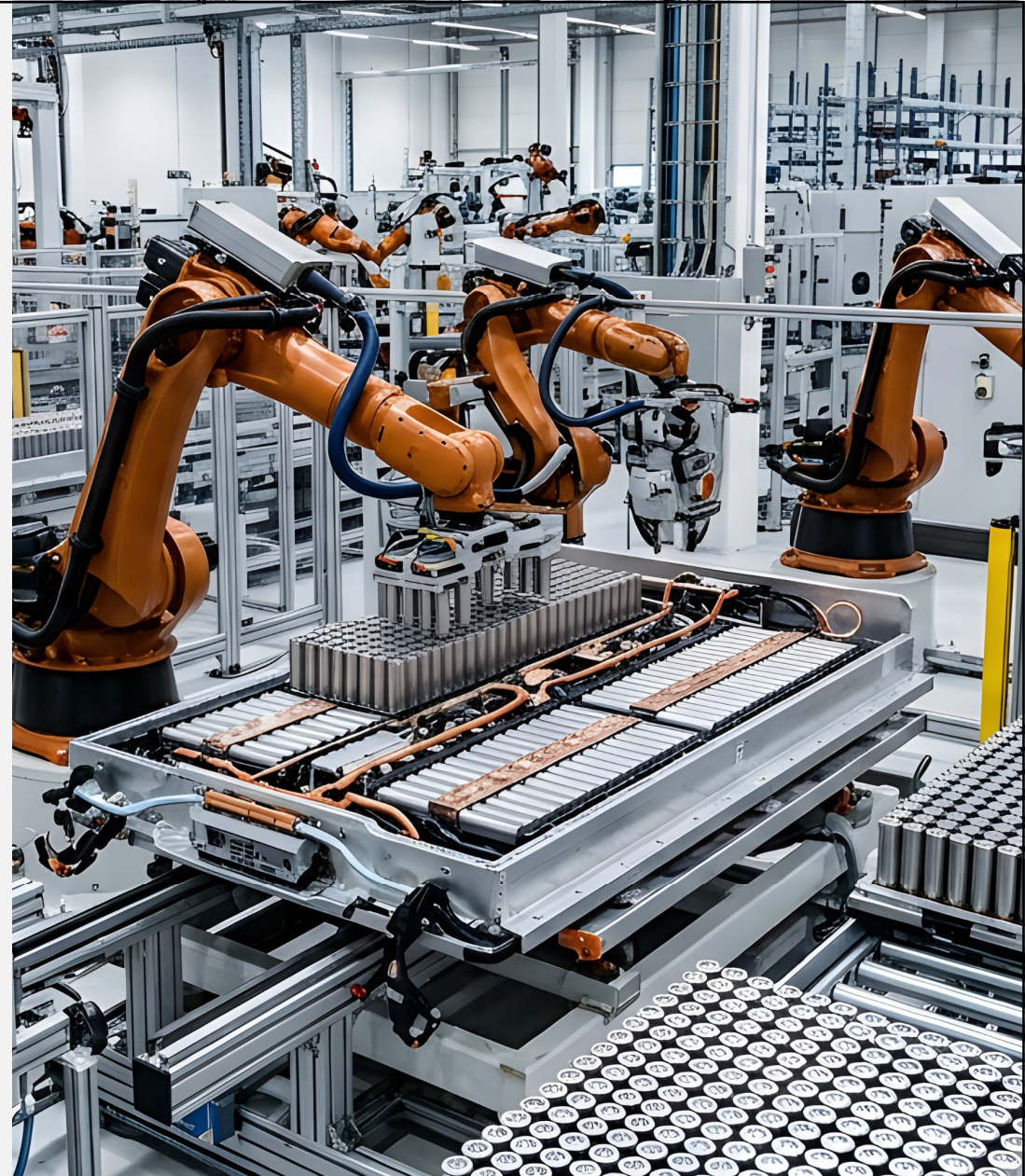
This is evotron lumiSENS® lighting products for Machine Vision



Driving trends to machine vision

- Robotics and Machine Vision go hand in hand
- 24/7 operation is the norm
- Human corrective interventions are becoming increasingly rare
- 'Dark fab' without human intervention is on the rise
- Machine builders expect vision components to be suitable for series production
- Complexity of machine vision is understood by an ever-decreasing number of experts

**All these trends
require more precise and faster lighting.**



Increasing requirements on machines

- Shorter cycle times
- More dynamic transport and handling
- More complex production and manufacturing systems
- More precise measurement and testing technology
- Situational adjustment of parameters by recipe management
- Greater availability is required (>95%)

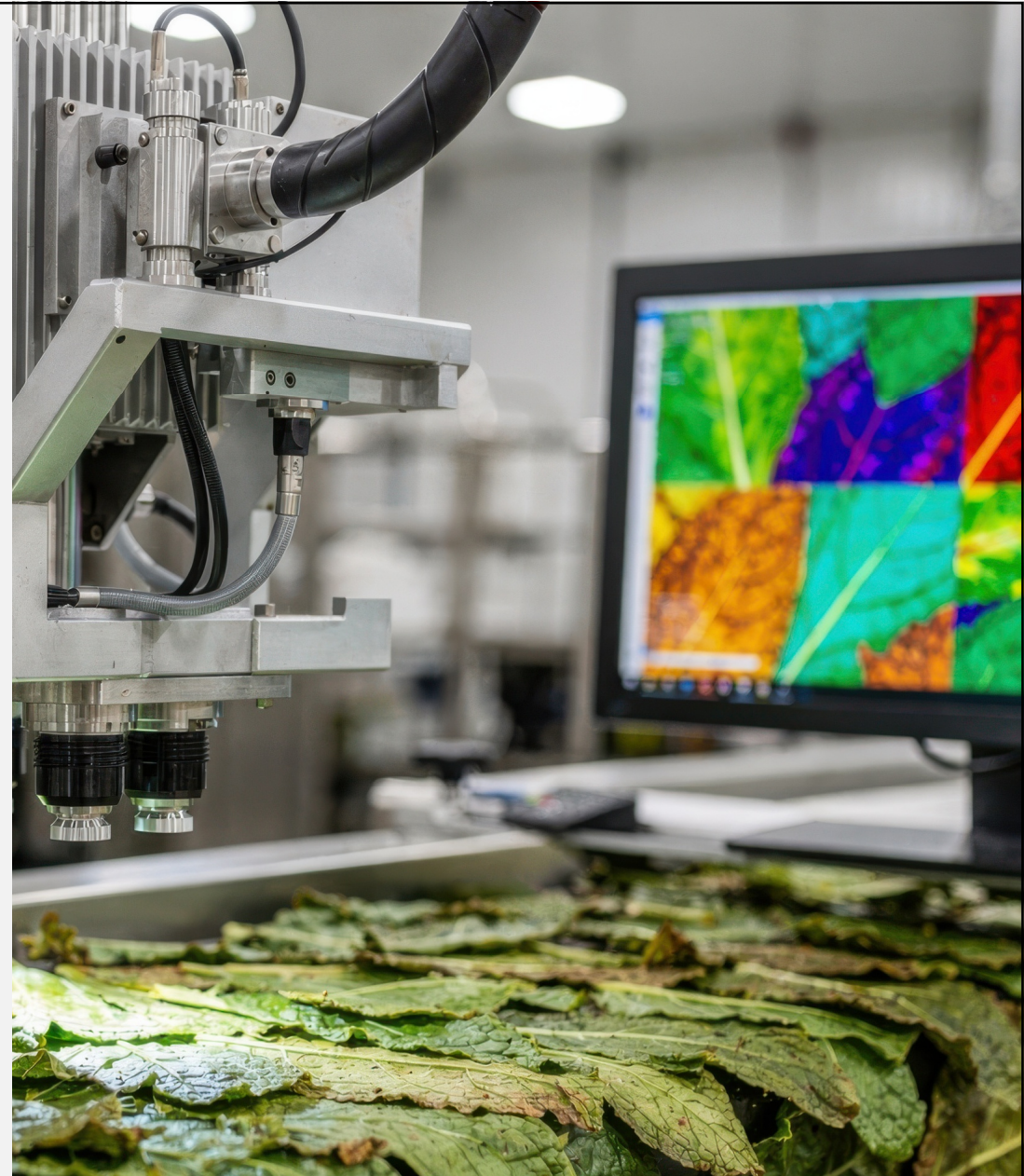
All these requirements need more precise and faster lighting.



Improving performance of all vision components

- Increasing geometric resolution of image sensors
- Higher brightness dynamics of image sensors
- Faster data interfaces
- Increasing optical resolution of optics
- Increasing spectral resolution
- Software is detecting ever smaller defects
- AI enables the detection of defects with higher complexity
- But where are lighting improvements?

All this improving performance requires more precise and faster lighting.



Performance data of lighting are almost stagnating



Power of LED light sources



Precise and stable lighting parameters (**brightness**, pulse duration, trigger, timing, jitter)



Repeatable settings (brightness, pulse duration, synchronisation, timing)



Management of drift, ageing and lifetime



Interfaces for automation



Confident handling during set-up, operation and maintenance/servicing



Providing operating and process data



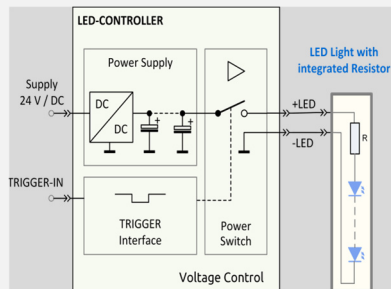
Generation of identical components (lighting clones for series machine production)



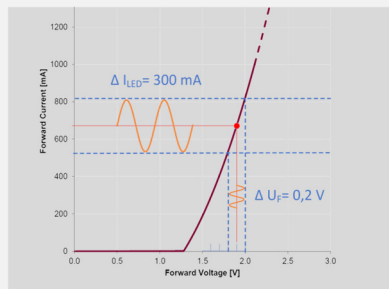
Digital data sheets for components and 'digital twin'

A whole lot has to change!

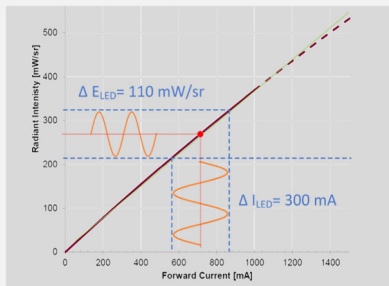
Ensure constant light intensity – the status quo



- Most common LED controllers work with voltage control
-  Simple construction
-  Low efficiency
-  Not suited for stable brightness



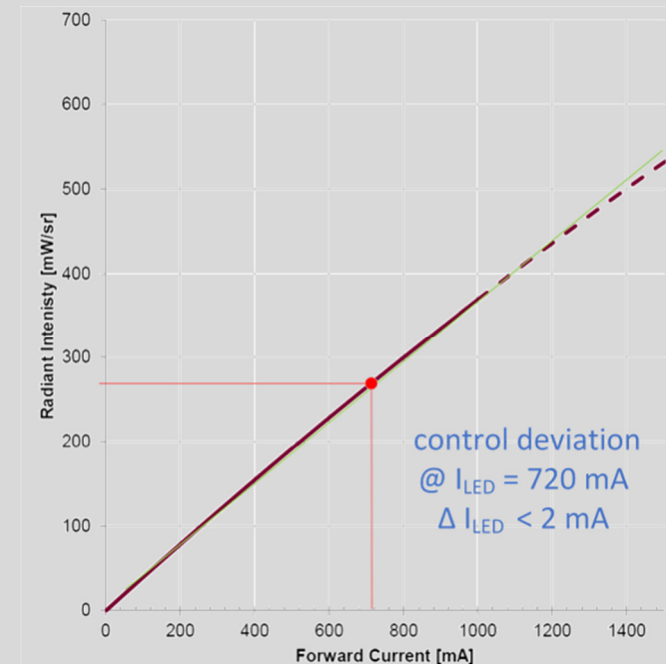
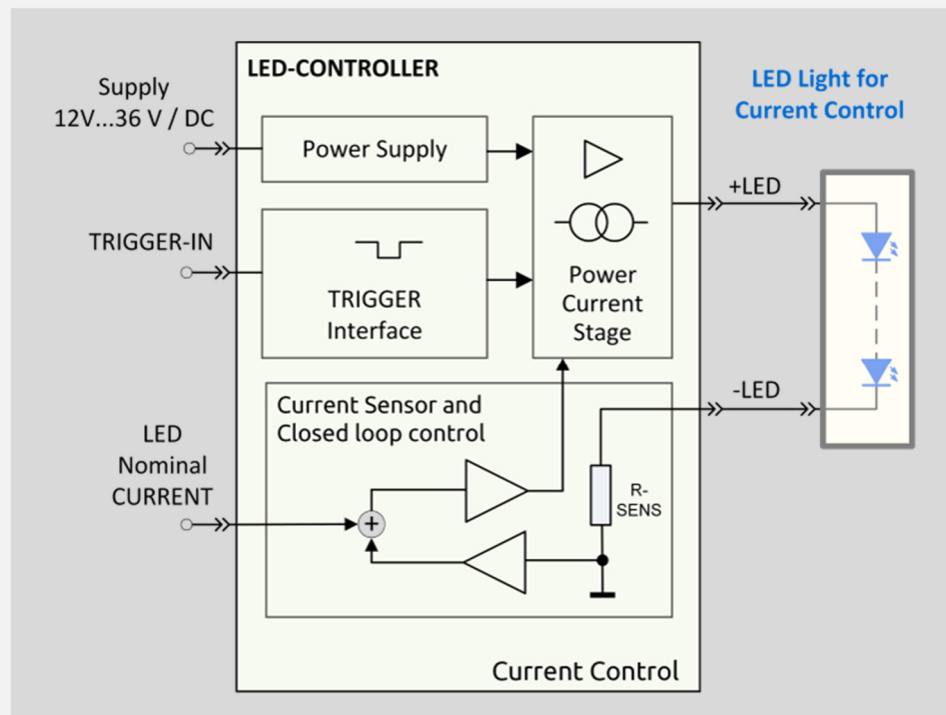
- Why? – The steep U-I characteristic curve
- Small voltage variations cause large current variations



- But LED intensity is proportional to the current!
- **Varying intensity makes image processing unreliable.**

Ensure constant light intensity

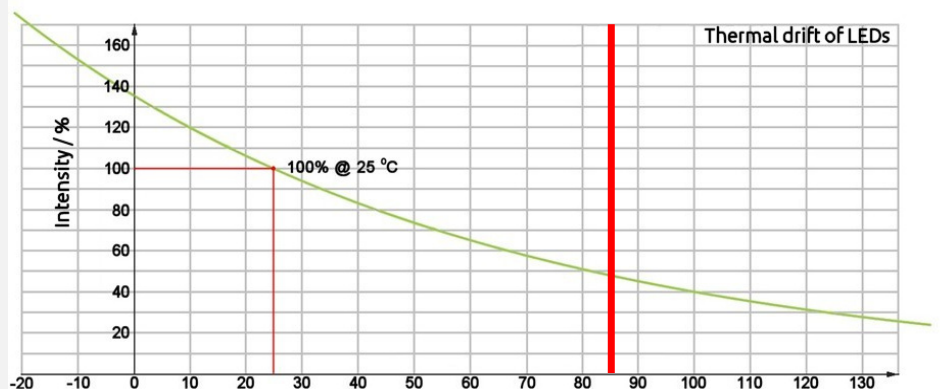
- 
 Precise light needs LED controller with constant current source
- works only with digital current control
- requires sensor technology for U, I, T, intensity



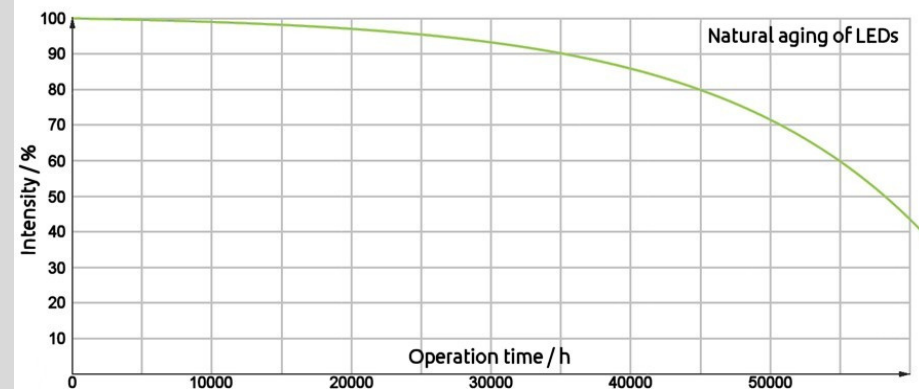
Ensure constant light intensity - opponents

- Thermal drift: decreasing intensity due to heat → **maximal temperature of LED chip: 85°C**
- Aging: decreasing intensity due to materials fatigue → temperatures above 85°C speed this up
- Drift and aging are working against stable intensity
- Intensity calibration and compensation is required

Thermal drift: Intensity vs. temperature

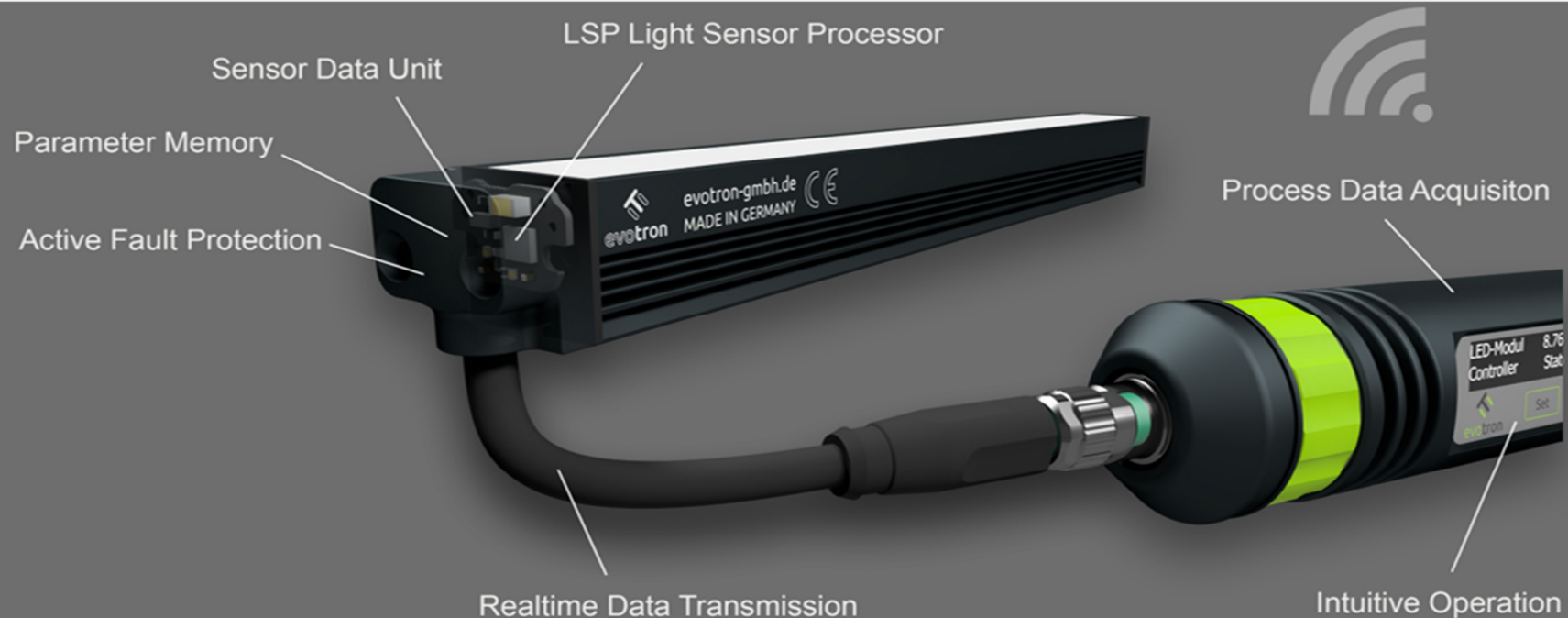


Aging: Intensity vs. operation time



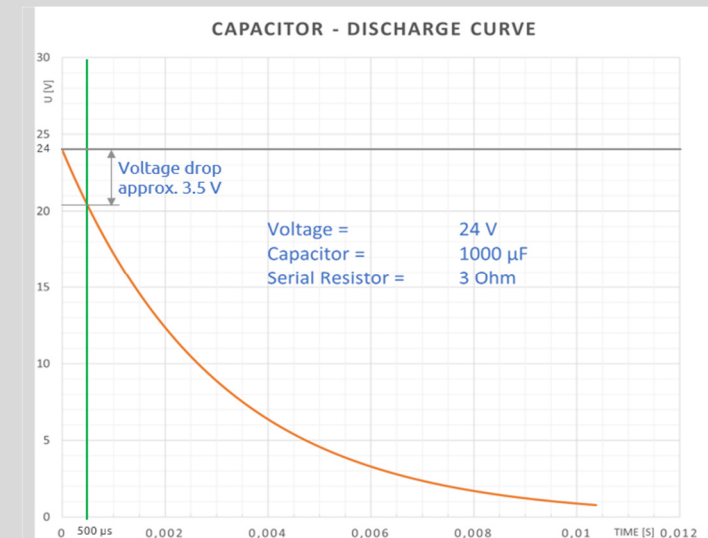
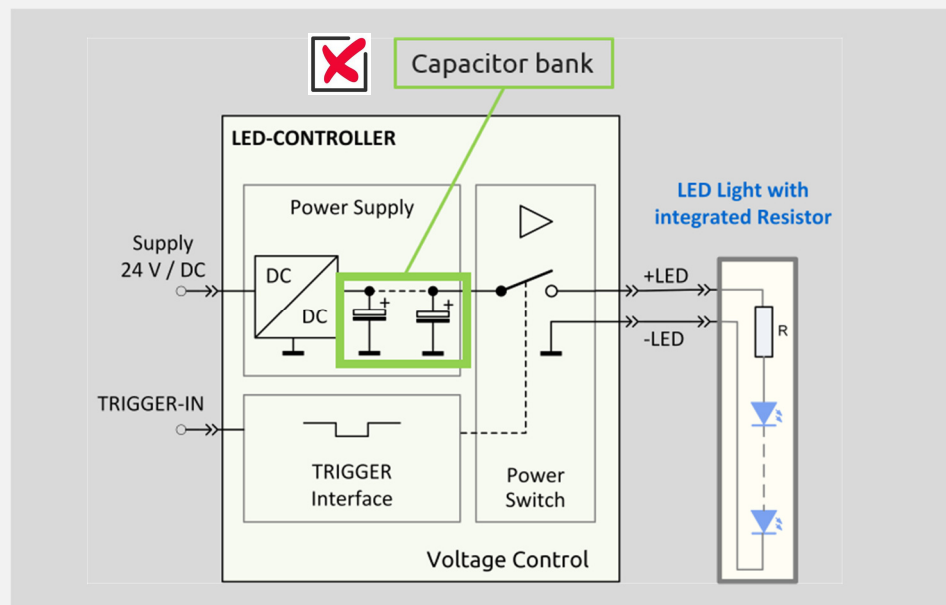
Ensure constant light intensity - the lumiSENS® technology solution

- LSP measures state of the LEDs: U, I, T, intensity
- LED lighting and LED controller create a digital unit that communicates with each other
- FPGA inside the LED controller provides fast current control
- Lighting is being calibrated



Ensure constant light pulse-intensity – impossible with capacitor discharge

- Capacitor discharge and voltage control → no guarantee for constant LED pulse current / intensity
- Why? The amount of energy in capacitors varies on pulse length and charging time
- ☒ Constant current source with fast control is required



Ensure constant pulse-intensity lumiSENS® technology solution

Short light pulses with precise synchronisation of:

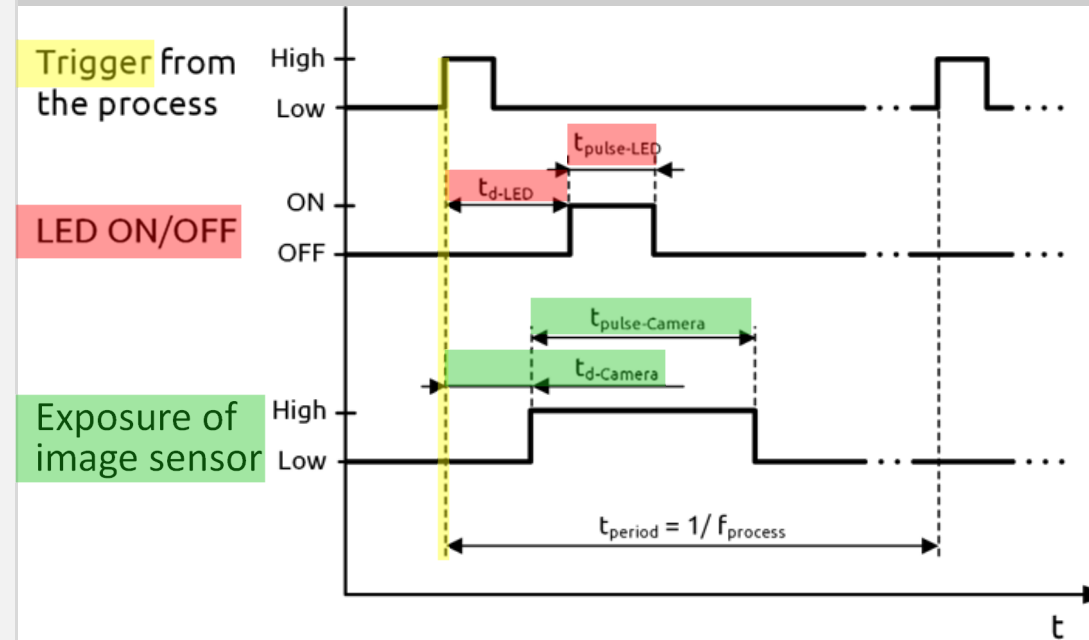
Trigger - **Lighting** - **Camera**

Operation modes: - camera triggers lighting
- lighting triggers camera

Conditions for handling of high-speed processes:

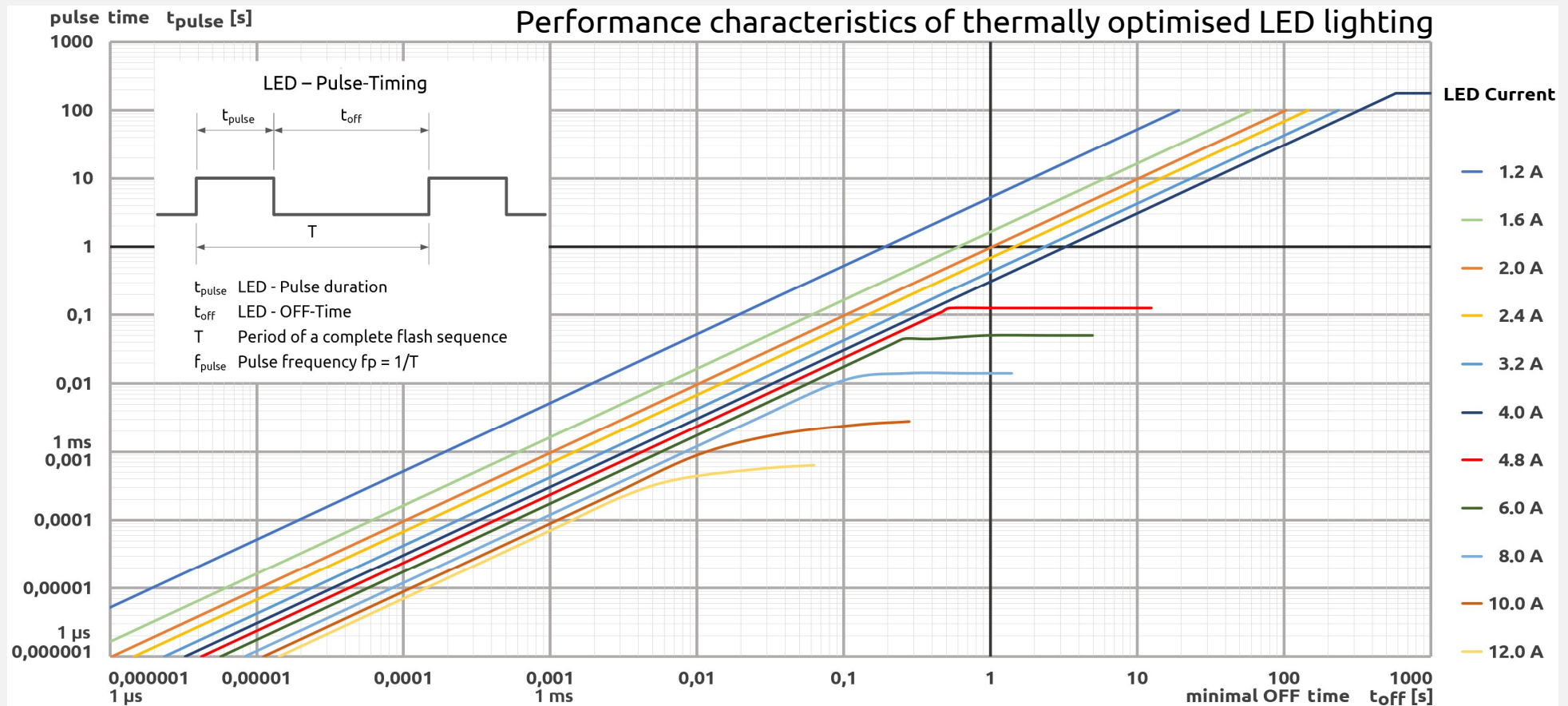
- Highly intensive light
- Short and constant pulse width
- Fast repeatable pulses
- Stable timing with low jitter
- Adjustable timing

Only possible with fast digital current control:



**20 ns step size for tuning t_{d-LED} and $t_{pulse-LED}$
with lumiSENS®**

Ensure constant light pulse-intensity – Pulse load diagram – current / intensity up to the limits



The benefits of the lumiSENS® technology

- High-precision flash control for high-speed vision, even with sectors and sequences
- Long-term stable lighting for 24/7 inspection
- Predictive maintenance and condition-based maintenance now possible for lighting
- Plug-and-play replication for production machines and roll-outs (lighting clones)
- Process data-based quality assurance and traceability
- Cost-optimized integration with one universal controller



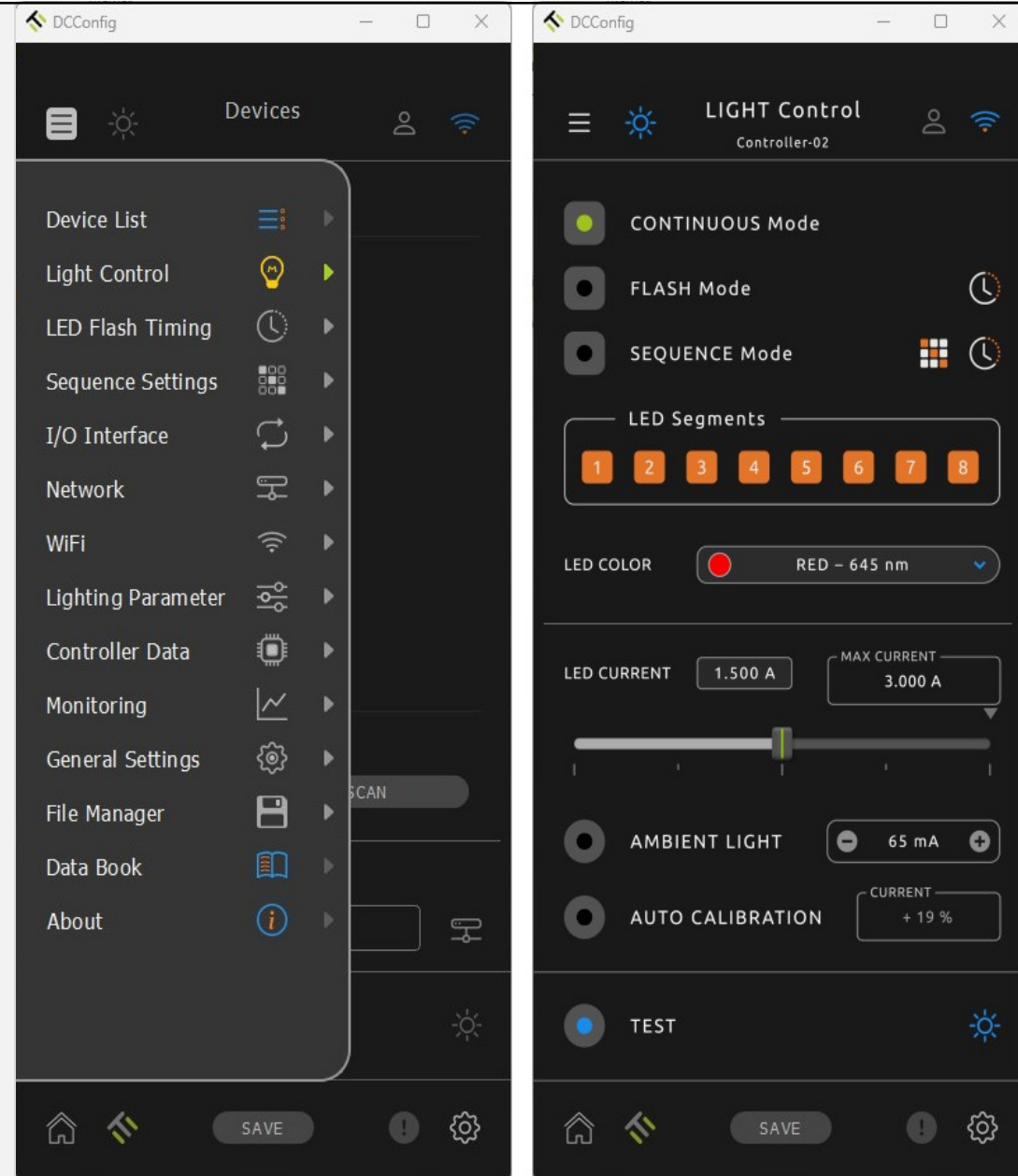
The UI for configuration Gateway to lumiSENS® technology

App-based parametrization via Wi-Fi or USB-C

Simple and intuitive management of:

- Lighting control
- Flash-Timing
- Sequence settings
- Synchronization
- all devices and network connections
- IO-Interfaces
- Monitoring
- Updating and Service

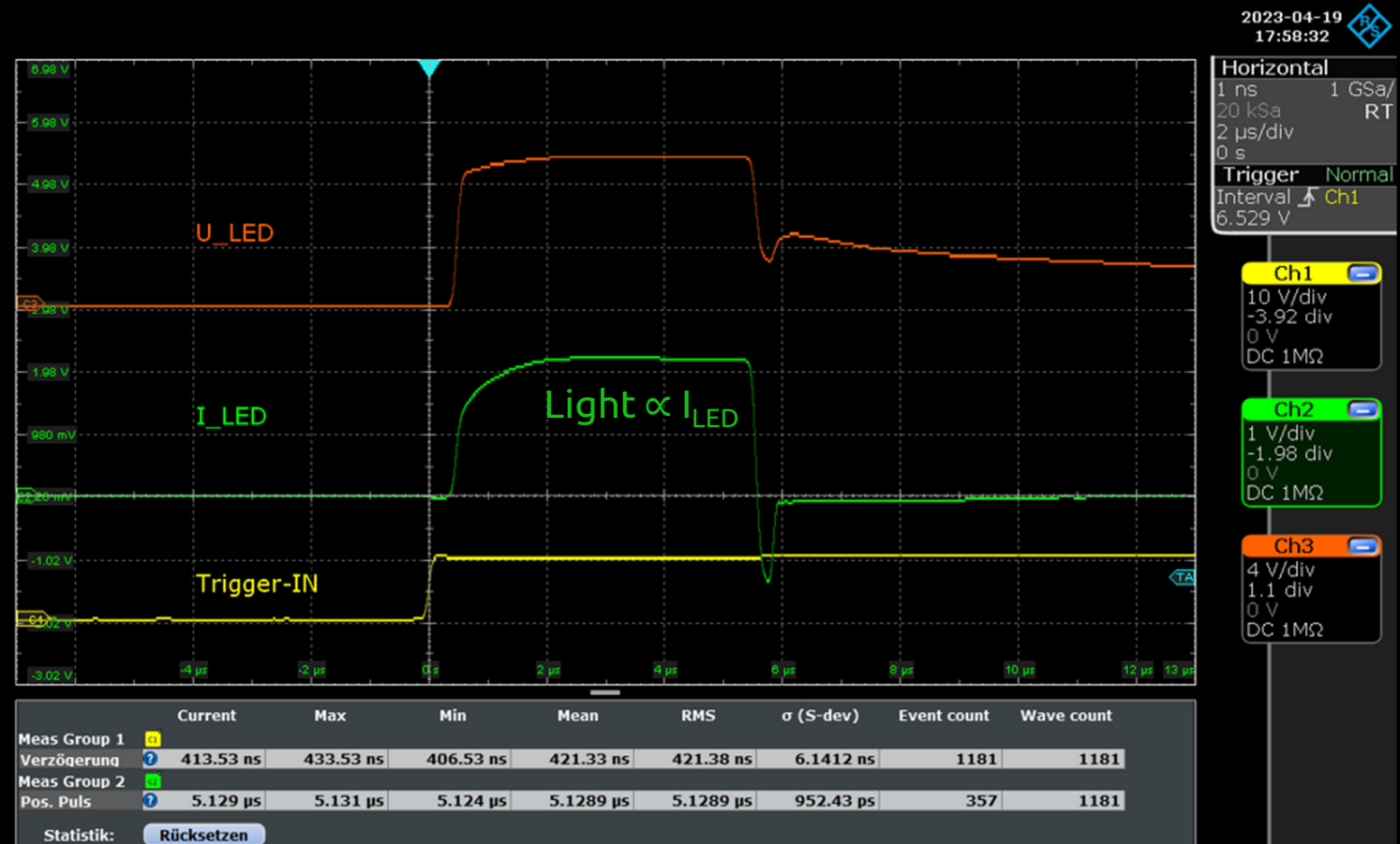
API is available.



lumiSENS® technology - generating precise light pulses



- LED current: 2 A
- Light output proportional to LED current
- Pulse width : 5 μ s
- Cable length : 200 mm
- Delay time $t_{\text{dLED-ON}}$: 420 ns
- Jitter : 5,13 ns



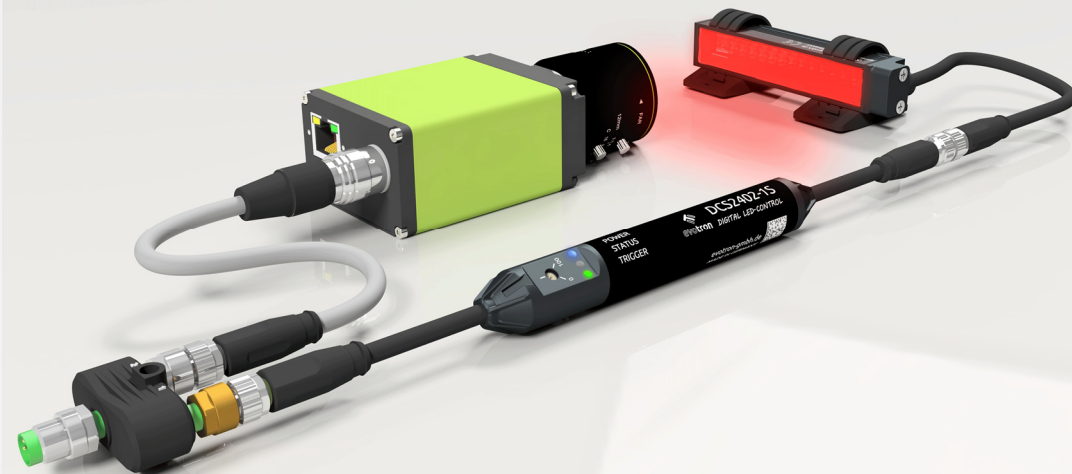
Time response evotron DCC2404-1WS , Time interval: 2 μ s

lumiSENS® application #1

Generating precise light pulses

- Light pulses with a length of $>1\ \mu\text{s}$
- Repeatability: 5 ns
- Intensity accuracy: 0,1%
- Consistent throughout entire lifetime of the lighting
- Two synchronisation modes available:
 - Camera triggers lighting
 - Lighting triggers camera
- Settings can be adjusted directly on the controller or via the app
- Highly cost-effective cabling solutions with M8 standard automation cables

$> 1\ \mu\text{s}$	light pulse width
$< 500\ \text{kHz}$	pulse frequency
0,1%	intensity accuracy
420 ns	delay trigger-light
$< 5\text{ns}$	jitter

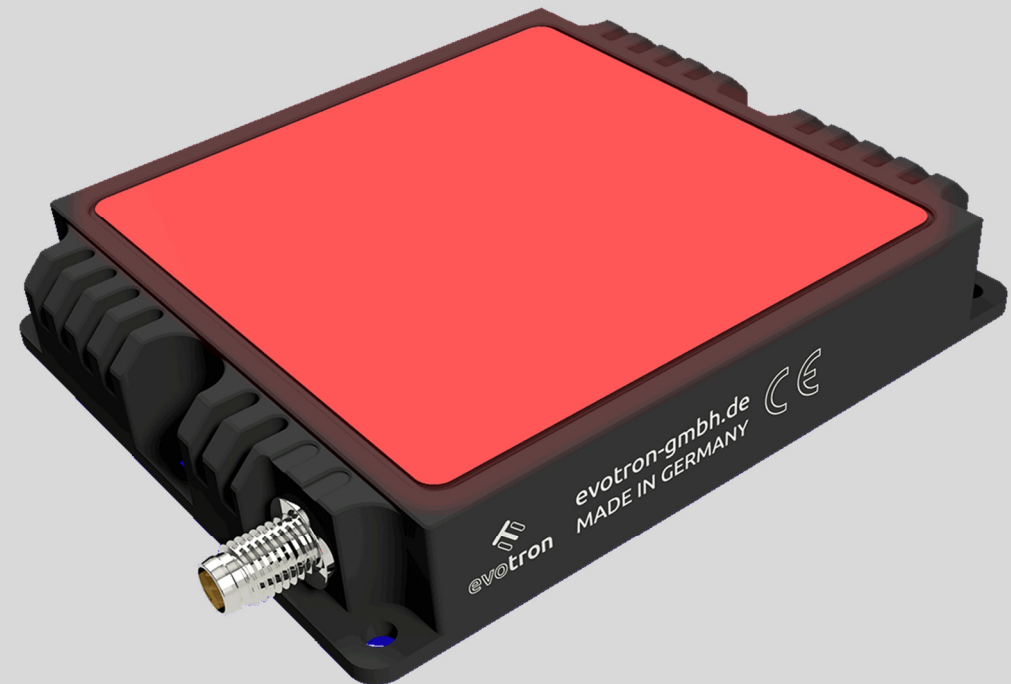


lumiSENS® application #2

Multi-channel colour control

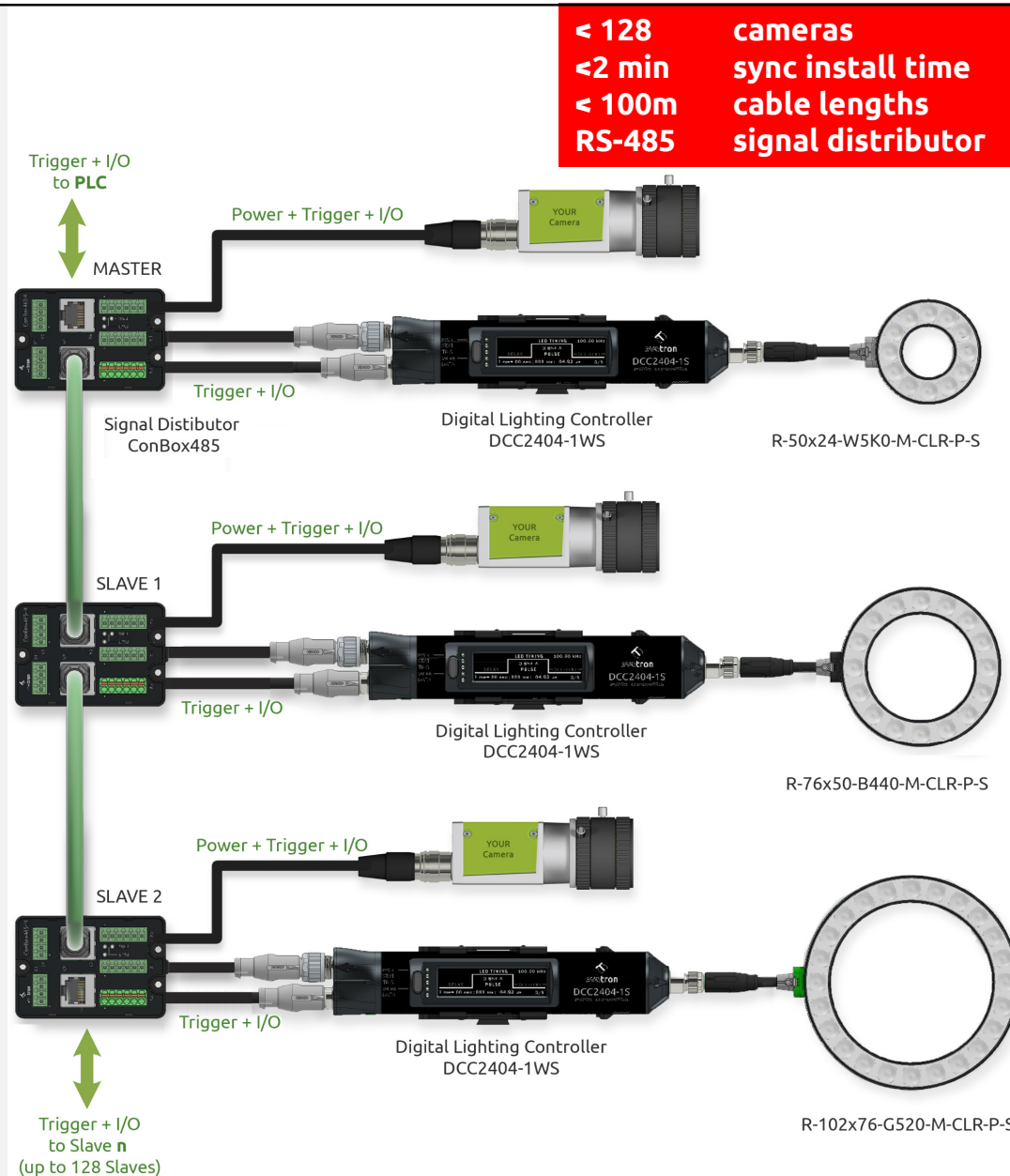
- Changing the lighting colour whilst the system is running
- Managing multi-channel coloured lighting **using only one controller and cable**
- Available for area lights and dome lights
- Multi- and hyperspectral observation of material and parts, surface inspection using only one lighting
- Colour change by API

> 1µs	light pulse width
< 500 kHz	pulse frequency
0,1%	intensity accuracy
420 ns	delay trigger-light
<5ns	jitter



lumiSENS® application #3 time synchronised triggering

- Up to 128 slave units
- Fast Signal distribution with RS-485
- Interference-free trigger signal
- Distribution over long distances (up to 100m)
- Two synchronisation modes available:
 - Camera triggers lighting
 - Lighting triggers camera
- Highly cost-effective cabling solutions with M8 standard automation cables
- Installation time (synchronisation) per camera: < 2 minutes



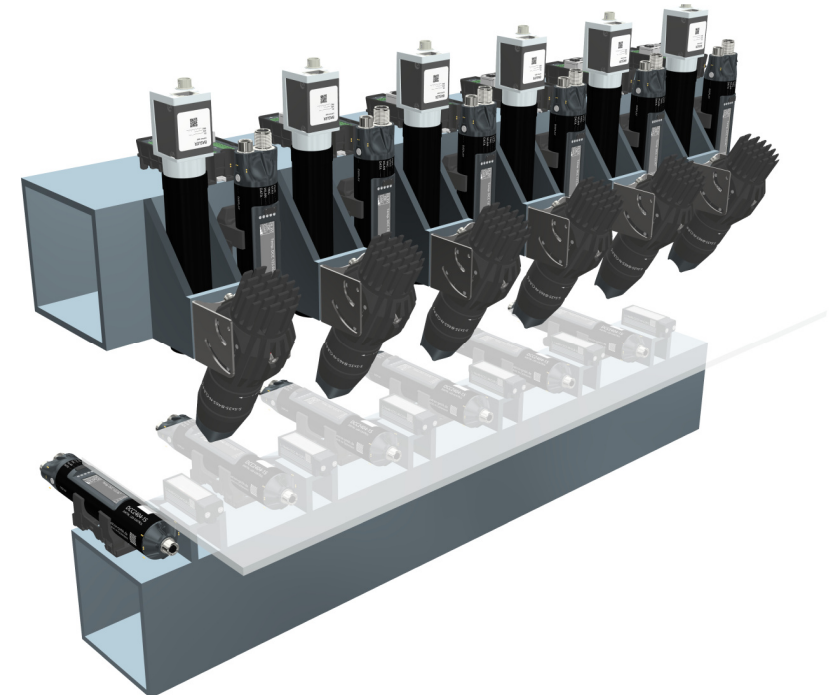
lumiSENS® application #3 time synchronised triggering

- Example:
Highspeed measurement of thin film solar panels
- Feed rate: 1,6 m/s
- Geometrical resolution: 1,6 μm / px
- Exposure time / pulse time: 1,4 μs
- Illuminance at the object: 1 million lux
- Synchronising of 12 cameras with top light alternative

Synchronising of 6 cameras with top light and back light



1,4 μs	light pulse width
12	cameras / lighting
1,6 mm/px	geom. resolution
0,1%	intensity accuracy
1.000.000	lux



lumiSENS® application #4

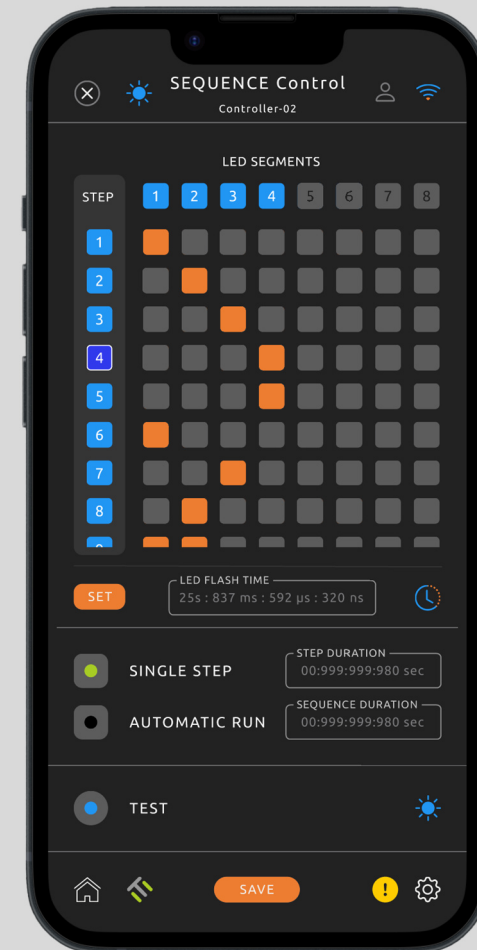
Fast control: sectors & sequences

- Fast Control of sectors and sequences
- Fully synchronised to image acquisition
- Only 1 single-channel controller and 1 M8 standard automation cable required
- Management of up to 8 light sectors, up to 16 sequence steps
- Frame rate up to 10.000 fps
- Graphical programming of sectors & sequences with UI
- Modes:
Single step **or** automatic operation / sync
- Available for ring lights and dome lights (multi-colour, segmented)



<5 min
Up to 8
Up to 16
Up to 10.000

configuration
sectors
sequences
fps



lumiSENS® application #4

Fast control: sectors & sequences

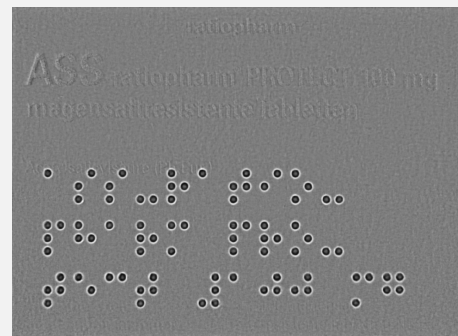
- Example:
Computational imaging / Photometric Stereo:

Making visible Braille code without influence
of surface colour and structures
- 1 Camera - 1 sector ring light - 1 LED controller

ambient light image



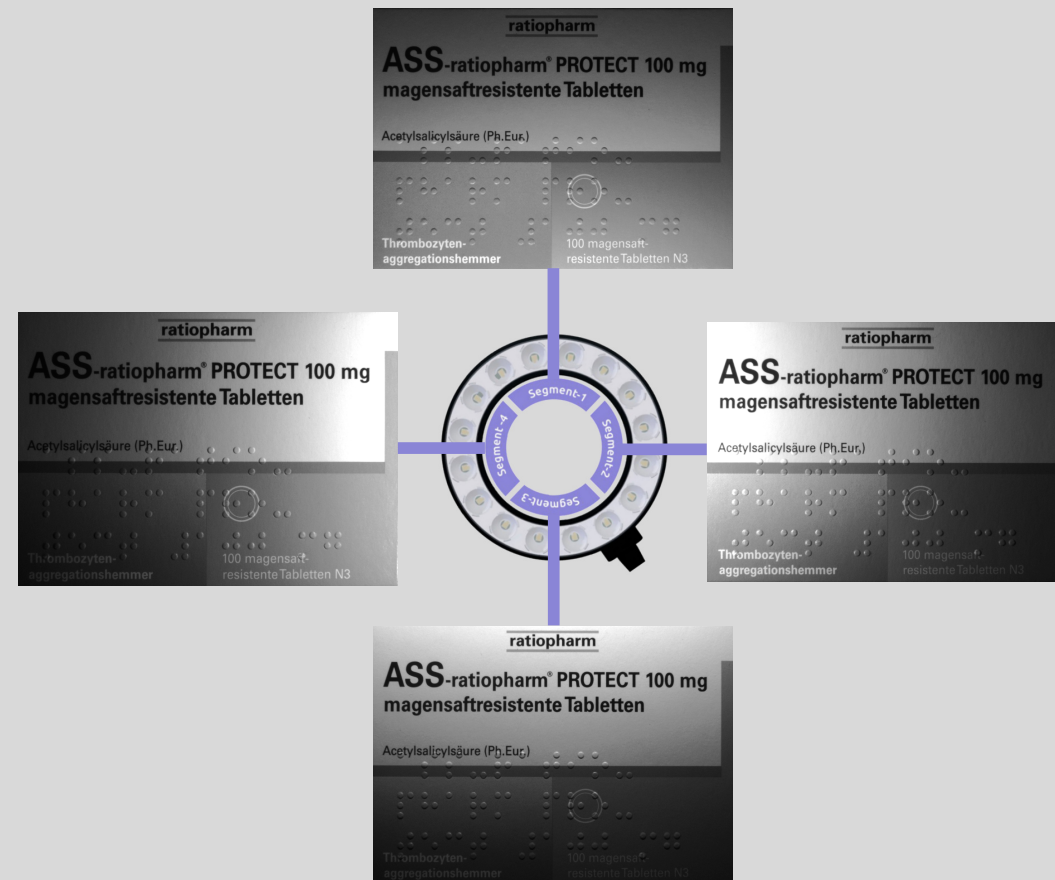
calculated inclination image



4 sectors – 4 images

<2 min
 4
 2000 Hz
 500 Hz
 80µs

configuration
 sectors
 sector frequency
 image acquisition
 exposure time



lumiSENS® application #5

Enhancing AI training data through precise lighting

Faster
Better
More
Increased

training
result quality
reliability
accuracy

- AI decisions are based on training data
- In Machine Vision those training data are images, made from light!

Consequences for AI Vision:

- Properties that are not made visible by light cannot be added at a later stage
- Changing lighting conditions generate same effect as varying product quality
- Lighting should not influence AI decisions → images must be of the highest possible quality
- Precise and constant lighting is conditions for AI training data images

Precise and constant lighting has same importance as better training data.

lumiSENS® application #6

The compact solution for robotics: RCAM

> 1µs	light pulse width
< 500 kHz	pulse frequency
0,1%	intensity accuracy
420 ns	delay trigger-light
<5ns	jitter



evotronCONTROL
Robot Image Capture Tool

- CMOS camera
- LED controller
- 4 segment light

evotron lumiSENS® Technology

Flexibility and high precision
Fast and easy installation
for all robots with standard ISO 9409-1 flange

Conclusion

- Precise and reproducible lighting - essential for reliable / fast Machine Vision
- Upgrading the lighting is only possible with current control and sensors
- High-speed needs stable and adjustable synchronisation through fast FPGA control algorithms
- Precision & repeatability - important for rule-based, **but equally** for AI-based vision solutions
- lumiSENS® technology helps to provides - increasing reliability and availability
 - faster set-up, service and maintenance
 - process data of lighting
 - a successful start in the field of digital lighting.

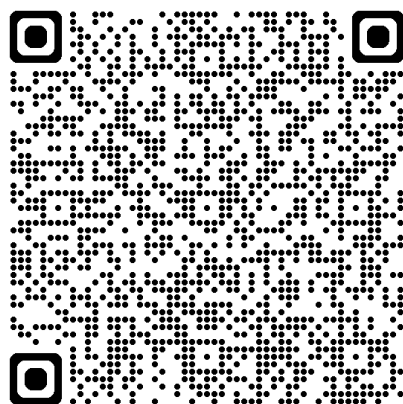
lumiSENS® is currently the only technology available on the market that makes Machine Vision lighting future-proof. It is continuously adapted to meet the steadily growing requirements and is being intensively further developed by evotron.

Thank you for your attention!

Meet evotron at VISION 2026:
Hall 10, Stand H26



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