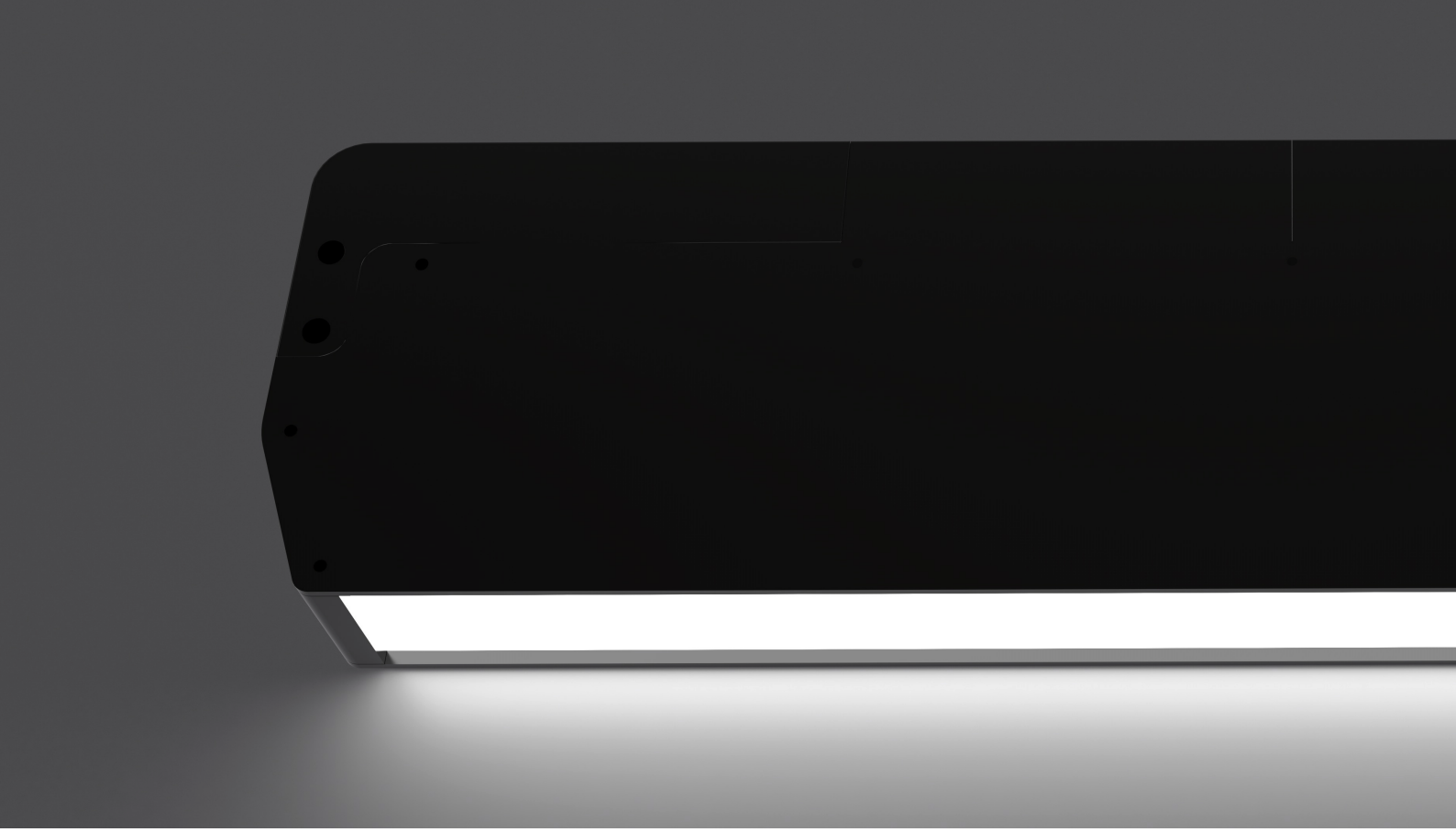
data sheet

High-illuminance Linear LED Lights with Programmable Segments

Rev. 2.03



Product highlights

LiLi Series are high-illuminance modular linear LED lights well-suited for industrial high-speed cameras used in machine vision applications. The LiLi Series is designed with focus on key features:

- Available device lengths are configurable from 200 to 800 mm in 100 mm steps (other lengths upon request)
- Narrow beam of illumination focused by lenses
- High lumen output (up to 2800 lumens per 100 mm segment)
- High light temperature (6200K) is suitable for machine vision applications
- Flicker-free design for high-speed cameras
- In-built overheat protection
- RS-485 communication interface with Modbus protocol
- .NET Standard library for communication available
- GUI Application for easy setup

EXTENSIVE CONFIGURATION

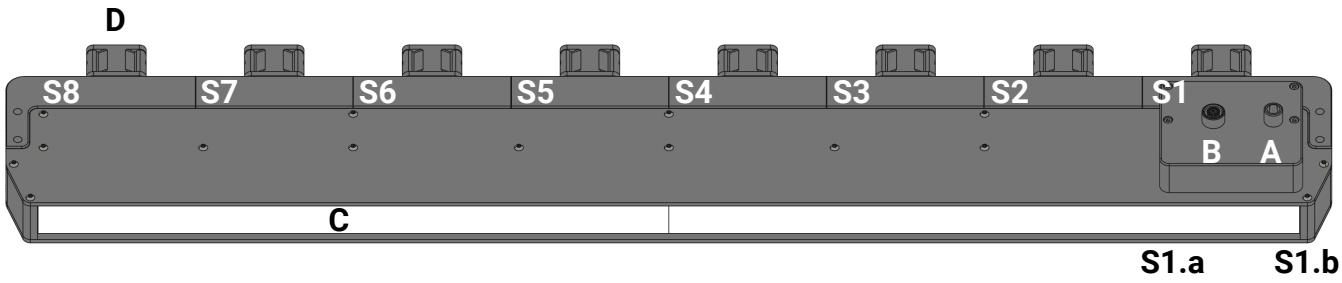
- Available intensity control provides illuminance adjustability for each 50 mm increment
- Temporary/persistent configuration storage
- Light can be triggered by binary input (HW trigger) or by writing into Modbus register over RS-485 communication interface (SW trigger)
- Hardware trigger input logic levels

ADVANCED DIAGNOSTICS

- Multi-point temperature monitoring
- Output light intensity monitoring
- Fan speed monitoring
- LED current and voltage monitoring

Device description

The modular design allows to offer LiLi Series devices in different lenghts from 200 mm up to 800 mm. The 800 mm Linear Light is shown in Figure 1 and parts description is sumarrized in Table 1. The LEDs are controlled by LED drivers with different power. There are low-power and full-power Linear Light versions available. All variants of power and length are shown in the following sections. Other variants are available upon request.



Marking	Light part
A	Power connector
B	Communication connector
C	Focusing lens
D	Cooling fans
S#	Light segment no. #
S#.a	Segment side 1
S#.b	Segment side 2

Table 1: Device parts marking and description

OPTICAL AND ELECTRICAL CHARACTERISTICS

The maximum input powers and maximum luminous outputs are listed in Table 2.

Length of light beam [mm]	Max .input power (24LP) [W]	Max. input power (24FP) [W]	Max. luminous output (24LP) [lm]	Max. luminous output (24FP) [lm]	Approx. weight [kg]
200	53	93	2 600	5 600	1.6
300	79.5	139.5	3 900	8 500	2.2
400	106	186	5 100	11 300	2.8
500	132.5	232.5	6 400	14 100	3.4
600	159	279	7 700	16 900	4.0
700	185.5	325.5	9 000	19 800	4.6
800	212	372	10 300	22 600	5.2

Table 2: Optical and electrical characteristics

ABSOLUTE MAXIMUM RATINGS

Please note that operation out of the limits defined in Table 3 may cause permanent damage to the device.

	Min.	Max.
Operating voltage	Vcc[4] – 10%	Vcc[4] + 10%
Operating temperature[1]	5 °C	45 °C
Trigger input[2] voltage	0 V	Vcc[3]
Trigger input[2] Active current	10 mA	20 mA
Output[3] pins voltage	0 V	Vcc[3]
Output[3] Active current		24 mA

Table 3: Operating conditions

[1]Linear light shall be used in indoor environment in stable temperature with non- condensing humidity.
[2]Input is designed as a current-loop, see Trigger input section for details.
[3]Output is designed to be used as a current-loop source, see Output signal section for details.
[4]See operating voltage of used product in Figure 2.

PRODUCT NUMBER KEY

This datasheet is valid for the whole LiLi Series. The relevant product number markings are expanded in Figure 2.

LILI XXXX - YYYY - ZZ

Device family LiLi

Length	
0200	200 mm
0300	300 mm
0400	400 mm
0500	500 mm
0600	600 mm
0700	700 mm
0800	800 mm

LED color	
W6	white, 6200K

Configuration variant	
24LP	24 V operating voltage, 350 mA LED driver
24FP	24 V operating voltage, 1000 mA LED driver

Figure 2: Product number key

MOUNTING OF THE DEVICE

The device dimensions can be found in Figure 3. All the given dimensions are in millimeters, where L stands for the chosen length of the Linear Light. There is a heatsink with active fan cooling on the back of the Linear Light. Keep free space behind the Linear Light for the cooling to work properly.

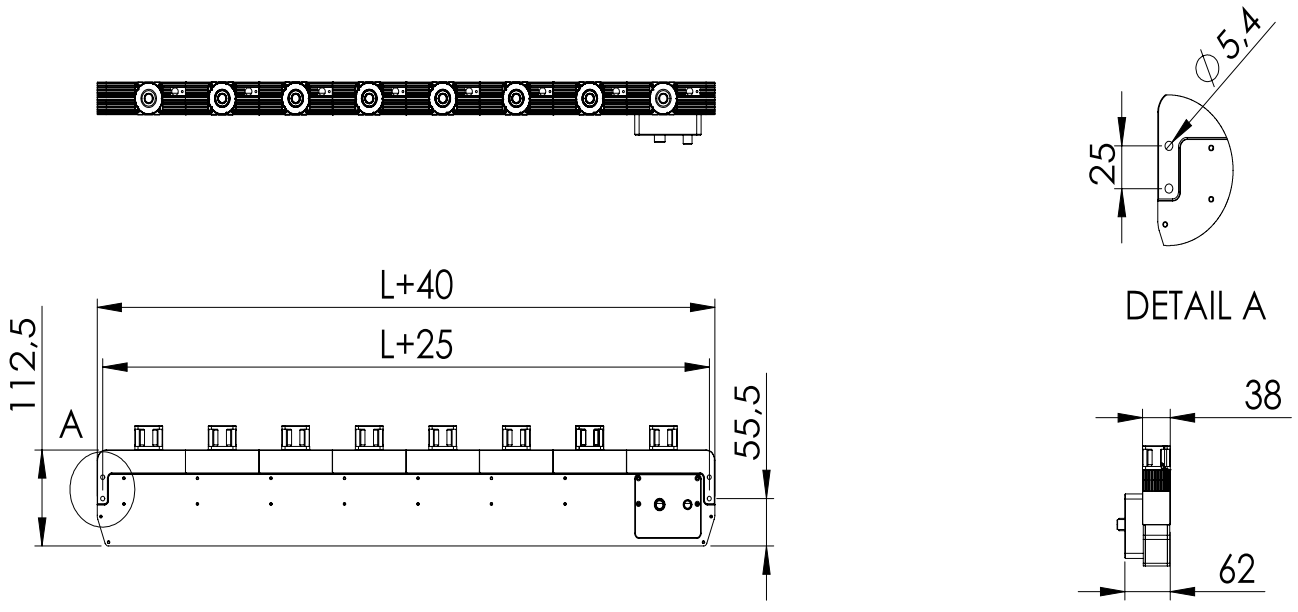


Figure 3: Mechanical dimensions

BEAM SHAPE

The illumination pattern is a light beam of width depending on the working distance. See Table 4 for specific values. Relative spatial intensity distribution can be found in Figure 4.

Working distance	0.5 m	1 m	1.5 m	2 m
Width of beam	15.9 mm	30.0 mm	37.6 mm	47.6 mm

Table 4: Width of projected beam depending on distance

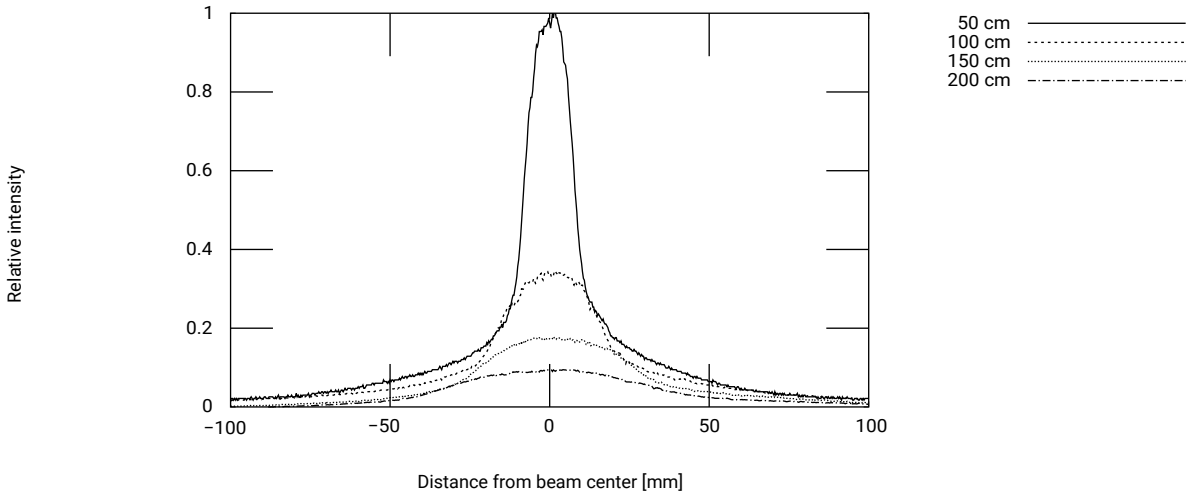


Figure 4: Relative intensity depending on working distance

COMPLIANCE WITH NORMS AND REGULATIONS

The Linear Light is certified as an industrial light regarding norms and regulations listed in Table 5.

Norm	Description	Test details
ČSN EN 61000-6-3	Mains Terminal Spurious Voltage	limits due to EN 55015, Table 2a
ČSN EN 61000-6-2	Radiated Field	limits due to EN 55015, Table 3b
ČSN EN 61000-4-2	ESD Immunity	contact ± 4kV, air ± 8 kV
ČSN EN 61000-4-3	Field Immunity	vertical, horizontal polarization, 1 kHz modulation, 80 MHz to 2.7 GHz, maximal severity 10 V/m (to 1 GHz)
ČSN EN 61000-4-4	Electrical Fast Transients /Bursts Immunity	+24V, GND wires ±2 kV, communication cable ± 1 kV
ČSN EN 61000-4-6	Immunity to Conducted Disturbances	severity level 10 V

Table 5: Norms compliance

The Linear Light with LED color W6 is an optical radiation Class 1 device according to EN62471:2009. The measured spectral intensity of the light can be found in Figure 5.

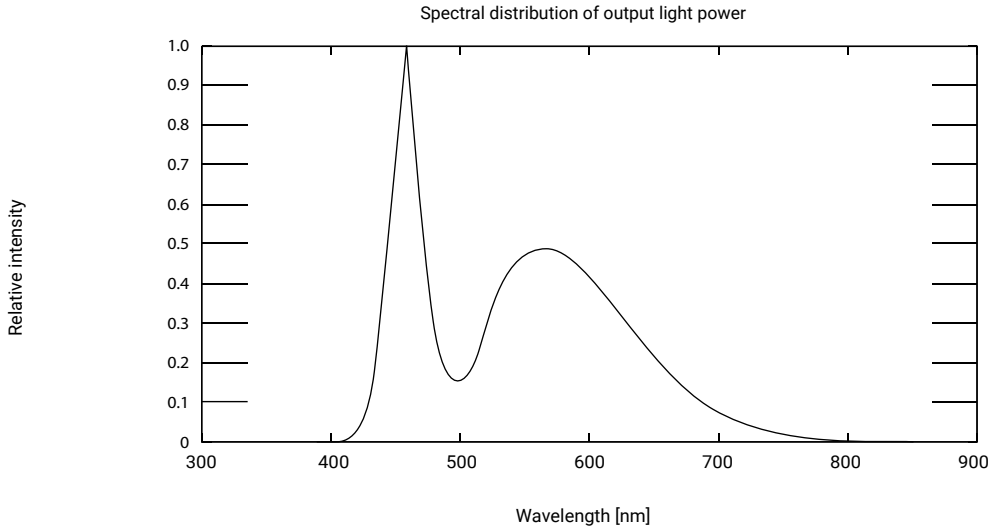


Figure 5: Measured spectral intensity

Device connection

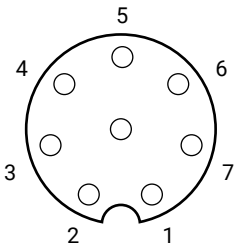
The Linear Light is designed as a smart device with extensive configuration and diagnostics options. Therefore it can be connected and fully controlled using RS-485 line with Modbus protocol. Binary trigger input and output signals are also provided for interfacing with binary I/O.

PINOUT AND CABLING

Note: D- is an inverting signal, D+ is non-inverting signal. Logic is transferred to TTL level UART by result of comparison D+ > D-.

The signal cable needs to be M12 8 pin A-coded socket, twisted-pair, shielded cable, for example Phoenix 1407404. Twisted pairs should be: 1-7, 2-3, 4-6, 5-8. The maximum allowed cable length is 30 m.

Signal connection



1 - D-
2 - OUT+
3 - OUT-
4 - GND
5 - TRIG+
6 - GND
7 - D+
8 - TRIG-

Figure 6: Communication connector pinout

The power supply cable should be L-coded M12 socket, shielded cable of minimum conductor cross section 5 x 2.5 mm^2, for currents of 16 A, for example Phoenix 1414773. The maximum allowed cable length is 30 m.

Power connection

1 - L1 (+24V)
2 - N2 (GND)
3 - N1 (GND)
4 - L2 (+24V)
5 - FE

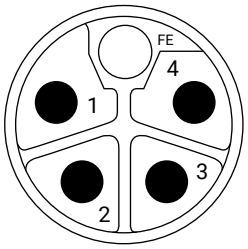


Figure 7: Power input connector pinout

TYPICAL WIRING

Typical device wiring connection can be found in Figure 8. Notice that the device should be used as a terminating device on RS-485 bus, as the terminating resistor is included in the device. It is recommended to use a fuse in +24 V power supply line for protection of inner electronics. During operation, all of the power supply wires must be used. When interfacing the input and output signals, “no-potential” connection is recommended.

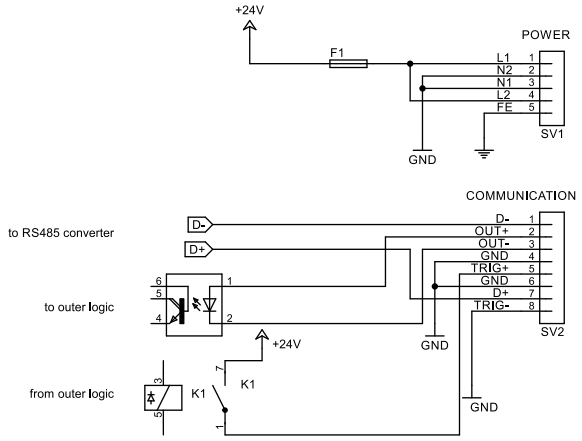


Figure 8: Typical device wiring connection

TRIGGER INPUT

The trigger input is designed as a current-loop input with nominal current of 20 mA. The equivalent input schematic can be seen in Figure 9. For recommended input connection, see Typical wiring chapter. Input is considered Active when current flows through the optocoupler. Otherwise, input is Idle.

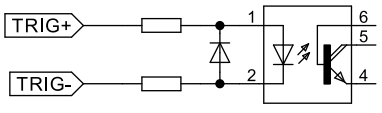


Figure 9: Equivalent input schematics

OUTPUT SIGNAL

The Linear Light logic output signal is designed to be used as a current-loop signal. Equivalent output schematic can be seen in Figure 10. Recommended output wiring schematic can be found in the Typical wiring section. Output is considered Active when Q1 is open (current can flow through Q1). Otherwise it is considered Idle.

Note: Output signal is reserved for future use. Current behavior is such that output signal is negating the value of trigger input.

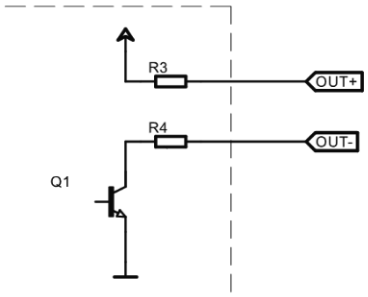


Figure 10: Equivalent output schematics

Luminous intensity

LUMINOUS INTENSITY SETTING

In each Segment (100 mm long), the Linear Light can control luminous intensity by switching LDU (Led Driver Unit) for each Segment side (50 mm long), see Figure 1. The LDUs output power is set by Modbus holding registers in the range 25 % – 100 %, see Modbus register dictionary section for more information.

LUMINOUS INTENSITY SENSING

In each Segment, the Linear Light senses luminous intensity by a LUX meter. Note that the LUX meter measures not only the luminous intensity induced by the LEDs, but also any ambient light incoming through the lens. The LUX value is stored to Modbus input register, see Modbus register dictionary section for more information.

Voltage and current sensing

In each Segment there are two LED chains on a LED strip – one on side A, the other on side B. For each of these LED chains, the Linear Light is capable of measuring voltage across the chain and current through it. Each chain is driven by a switching LDU (Led Driver Unit), which controls LED chain current. A diagram of LED drive chain can be found in Figure 11.

The measurements can not be done correctly with currents below approximately 65 mA. In this case, zero values will be returned for both voltage and current.

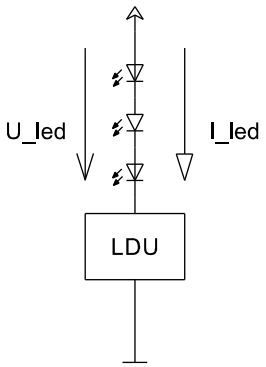


Figure 11: Current and voltage sensing

Cooling

FAN CONTROL

The Linear Light is equipped with powerful cooling fans on the back side. For cooling to work properly, keep free space behind the Linear Light. The modes of fan speed control can be found in Table 6. Furthermore, fans can be completely enabled or disabled using Fan Enable discrete input. See Modbus register dictionary section for more information.

Fan mode register value	Mode name	Description
0	Manual speed control	The speed is set by Fan set speed holding register.
1	Automatic speed control	The speed is determined automatically based on Body temperature. The relation of Fan speed vs Body Temperature can be found in Figure 12. The individual thresholds can be read from Linear Light input registers. See sectionTable 7: Modbus communication parameters Modbus register dictionary for more details.

Table 6: Fan speed control modes

Note: Fans will remain off in Automatic speed control mode if fans are disabled in Fan Enable discrete input register.

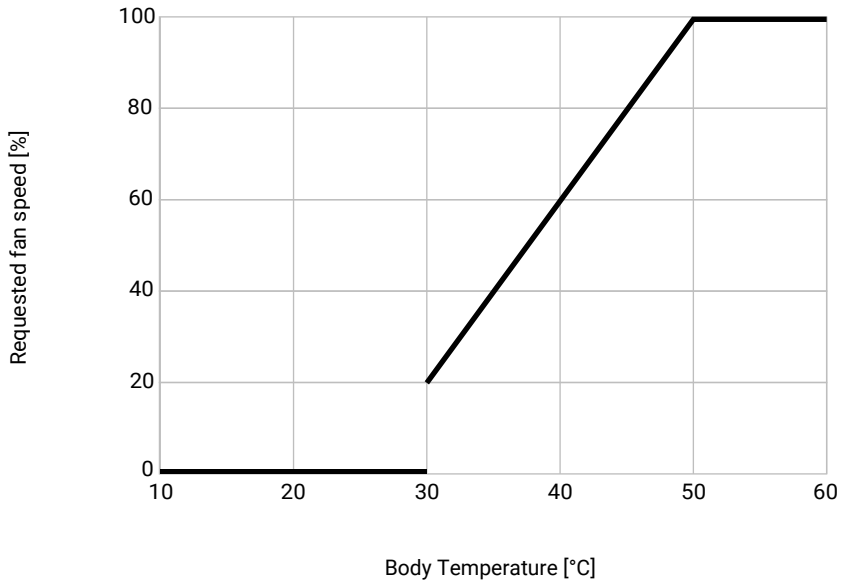


Figure 12: Fan auto control chart

OVERHEAT PROTECTION

In each Segment, the Linear Light measures the temperature of segment body and LED strip. If any of the measured temperatures exceeds the maximal threshold, overheat flag is set. When the overheat flag is set in a Segment, the Segment forces cooling procedure to start.

During cooling, all light intensities and light status bit of the Segment will be forced to 0 and the fans will run at 100 % speed.

The Linear Light returns to normal operation after the temperatures descend a couple of degrees below the temperature overheat thresholds. The individual overheat thresholds can be read from Linear Light input registers. See Modbus register dictionary section for more details.

Modbus

The Linear Light is developed according to the Modbus standard. It consists of N individual slave devices (where N is the number of segments of the light). The last segment has a terminating resistor included in the device.

MODBUS SLAVE DEVICE PARAMETERS

The Linear Light individual segments are each representing a single slave device of address 1 to N. The communication parameters are defined as shown in Table 7.

Note: Linear Light device can utilize broadcast messages (slave address – 0). When using broadcast messages, take into account that broadcast messages are by design unacknowledged and therefore unreliable.

Modbus type	RS-485 RTU
Serial line baud rate	38400
Serial line parity	Even
Serial line stop bits	1
Modbus device address	1..N (according to segment No.)
Inter-frame delay	1.75 ms

Table 7: Modbus communication parameters

MODBUS REGISTER DICTIONARY

In Table 8, there is a Modbus register dictionary description for Protocol Version 1.03.
Writing/reading coils/registers not specified in this document may result in unpredictable behavior. Writing value not specified in this document into coil or holding register may result in unpredictable behavior.

Register address	Register name	Type	Access	Description
1000	Light Status Bit	Discrete Input	r	When set, illumination is on.
1001	Hardware Trigger	Discrete Input	r	Reflects value of hardware trigger input (Active when set, Idle otherwise).
1002	Segment Overheat Flag	Discrete Input	r	Segment overheat flag is set to 1 when either body overheat flag or LED Overheat Flag is set.
1101	Body Overheat Flag	Discrete Input	r	Set to 1 when Body temperature exceeds Body temperature overheat threshold.
1201	LED Overheat Flag	Discrete Input	r	Set to 1 when LED temperature exceeds LED temperature overheat threshold.
2000	Software Trigger[1,3]	Coil	rw	When set to 1, software trigger is Active, it is Idle otherwise.
2001	Fan Enable[1]	Coil	rw	When set to 1, fan is running. Otherwise, fan is off.
3000	Protocol Version	Input Register	r	Number indicating version of modbus dictionary in the form HighByte.LowByte
3001	Software Version	Input Register	r	Number indicating version of SW in the form HighByte.LowByte
3002	Hardware Version	Input Register	r	Number indicating version of HW in the form HighByte.LowByte
3003	Linear Light Serial Number (High Word)	Input Register	r	Returns the Most Significant Word of serial number[2] of the Linear Light. Note that all of the segments of the Linear Light will be returning same value.
3004	Linear Light Serial Number (Low Word)	Input Register	r	Returns the Least Significant Word of serial number[2] of the Linear Light. Note that all of the segments of the Linear Light will be returning same value.
3005	Linear Light Product Number (High Word)	Input Register	r	Returns the Most Significant Word of product number of the device. Note that all of the segments of the Linear Light will be returning same value.

Register address	Register name	Type	Access	Description
3006	Linear Light Product Number (Low Word)	Input Register	r	Returns the Least Significant Word of product number of the device. Note that all of the segments of the Linear Light will be returning same value.
3101	Body Temperature	Input Register	r	Temperature of segment body in degrees Celsius
3102	Body Temperature Overheat Threshold	Input Register	r	Temperature threshold in degrees Celsius
3109	Fan Speed	Input Register	r	Current fan speed in rpm
3110	Requested Fan Speed	Input Register	r	Current fan set speed in %. The current fan speed depends on Fan Enable and Fan Mode. See Fan control section for more information.
3111	Min. Set Fan Speed	Input Register	r	Min. fan speed in Automatic speed control mode
3112	Max. Set Fan Speed	Input Register	r	Max. fan speed in Automatic speed control mode
3113	Low temp. threshold	Input Register	r	Low temperature threshold in Automatic speed control mode
3114	High temp. threshold	Input Register	r	High temperature threshold in Automatic speed control mode
3201	LED Temperature	Input Register	r	Temperature of LED Strip in degrees Celsius
3202	LED Temperature Overheat Threshold	Input Register	r	Temperature threshold in degrees Celsius
3208	LED Lux Meter Value	Input Register	r	Lux meter value in lux.
3213	Voltage LED a	Input Register	r	Forward voltage on LED chain of segment side 1 in millivolts

Register address	Register name	Type	Access	Description
3214	Current LED a	Input Register	r	Current through LED chain of segment side 1 in milliamperes
3223	Voltage LED b	Input Register	r	Forward voltage on LED chain of segment side 2 in millivolts
3224	Current LED b	Input Register	r	Current through LED chain of segment side 2 in milliamperes
4000	Input Setting[1]	Holding Register	rw	0: light will be set on when HW trigger is Active, off otherwise 1: light will be set on when HW trigger is Idle, off otherwise 2: light will be set on when SW trigger is Active, off otherwise 3 - 65535: reserved
4090	Config. Management	Holding Register	rw	Refer to Configuration management section
4109	Fan set speed[1]	Holding Register	rw	Requested Fan Speed in percent
4110	Fan mode[1]	Holding Register	rw	Refer to Fan control section
4215	Set intensity a[1]	Holding Register	rw	Intensity in percent for side 1 of a segment. The light intensity is regulated between 25 % and 100 %.
4225	Set intensity b[1]	Holding Register	rw	Intensity in percent for side 2 of a segment. The light intensity is regulated between 25 % and 100 %.

Table 8: Modbus register dictionary

[1]These coils/registers are persisted using user configuration. See Configuration management section for more details.
[2]The serial number marked on the device's sticker is coded as a hexadecimal number.
[3]Although it is possible to turn on the whole Linear Linght using a broadcast message, bear in mind that broadcasting is not a reliable communication in Modbus protocol.

Configuration management

The Linear Light can store and apply user configuration holding different parameters as noticed in the Modbus register dictionary section.
If a user configuration has been stored, it will be used to setup the Linear Light upon startup. Otherwise, the default configuration will be used.

You can manage user configuration by writing function commands into Configuration Management Modbus holding register, see Table 9.

Function code	Command name	Command description
0x5AFE	Store user configuration	User configuration is saved into FLASH memory.
0xDEFA	Load default configuration	Default configuration is set, user configuration is deleted from device FLASH memory.

Table 9: Configuration set function codes

After the command is finished, the segment sets command result value back into Modbus holding register, see Table 10. The response is cleared to 0x0000 after reading.

Response code	Response name	Response description
0x0000	Configuration OK	Command has been executed successfully.
0xE007	Unknown command error	Written command does not exist.
0xE500	User config save error	User configuration saving failed.
0xED00	Default config load error	Failed to load default configuration.

Table 10: Configuration set response codes

Note that configuration is saved into device FLASH memory. The maximum number of FLASH memory writes is limited to 10k write cycles. After exceeding the FLASH memory life, configuration management may stop working.

Control library

A control library for Linear Light control through .NET application is available.
Source code is publicly available at: https://github.com/DataVisionSRO/LinearLight2
Nuget packages are available through nuget.org.

Admin console

AdminConsole is a GUI setup tool which can be used for reading internal measurements and setting parameters of the Linear Light. You can find the application on our website www.datavision.software . A sample screenshot of this application can be seen in Figure 13 (basic setting) and Figure 14 (advanced setting).

Figure 13: Control application user interface – Basic setting

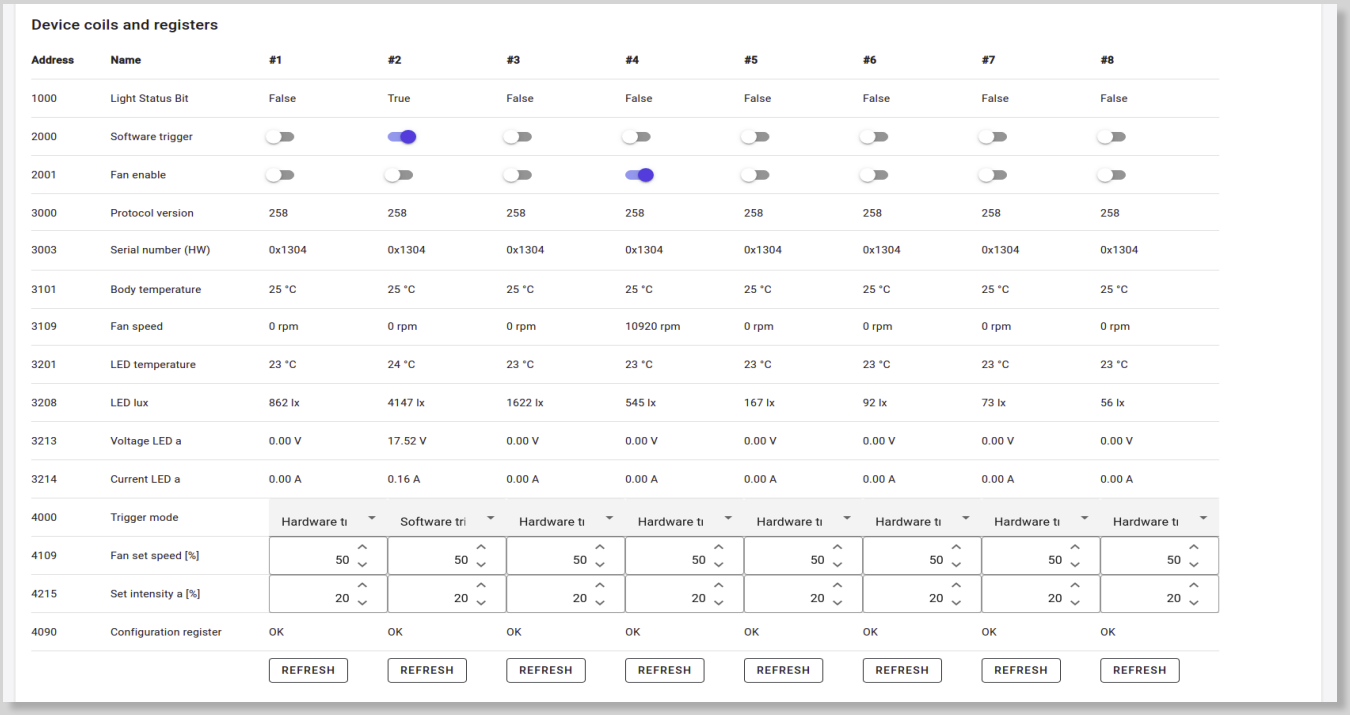


Figure 14: Control application user interface – Advanced setting

Disclaimer

Technical data has been fully checked, but accuracy of printed matter is not guaranteed. This document can be subject to change without prior notice.

Revisions

Revision	Date	Note
1.0	26.8.2019	First numbered revision. Revisions prior to this are replaced by this document.
1.01	30.8.2019	Update of protocol to v1.01. Added description of current and voltage measurements.
1.02	25.11.2019	Update of protocol to v1.02. Protocol change introduces configuration management.
1.03	24.1.2020	Fixed switched values in columns LP and FP in Table 2: Optical and electrical characteristics
1.04	14.4.2020	Update of protocol to v1.03. Added description of fan control function. Added operating temperature note. Added note on Broadcasting Software Trigger. Added AdminConsole and Control library sections.
2.00	30.6.2020	Reorganized chapters and style. Update delay between Modbus requests (inter-frame delay). Added notes, intensity is configurable for each 50 mm of length.
2.01	3.7.2020	Fixed a formatting error.
2.02	1.9.2020	Added information about Advanced settings environment.
2.03	18.2.2021	Added links to .NET library Fixed modbus input register numbers in Linear Light Product Number.

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