(Image for illustrative purposes only)

User manual

Lightning 12F

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Foreword / disclaimer

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Please provide feedback

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However, not all applications are the same and not all users have the same requirements. In order to make sure that the needs of as many as possible customers are served it is important to keep in touch with them. So if you can spare a minute please tell us what you do and do not like about our product. This way you will help us to keep on improving our solutions for your machine vision challenges.

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Thanks in advance.

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1 About Lightning 12F

Lightning 12F is a versatile power supply designed to pulse-drive LED-lamps at currents up to 12A and voltages up to 45V

The current pulses are supplied from an internal charge buffer, which is recharged at a lower current.
Because of his the Lightning 12F can supply pulse currents up to 12A, while drawing no more than 2A supply current.

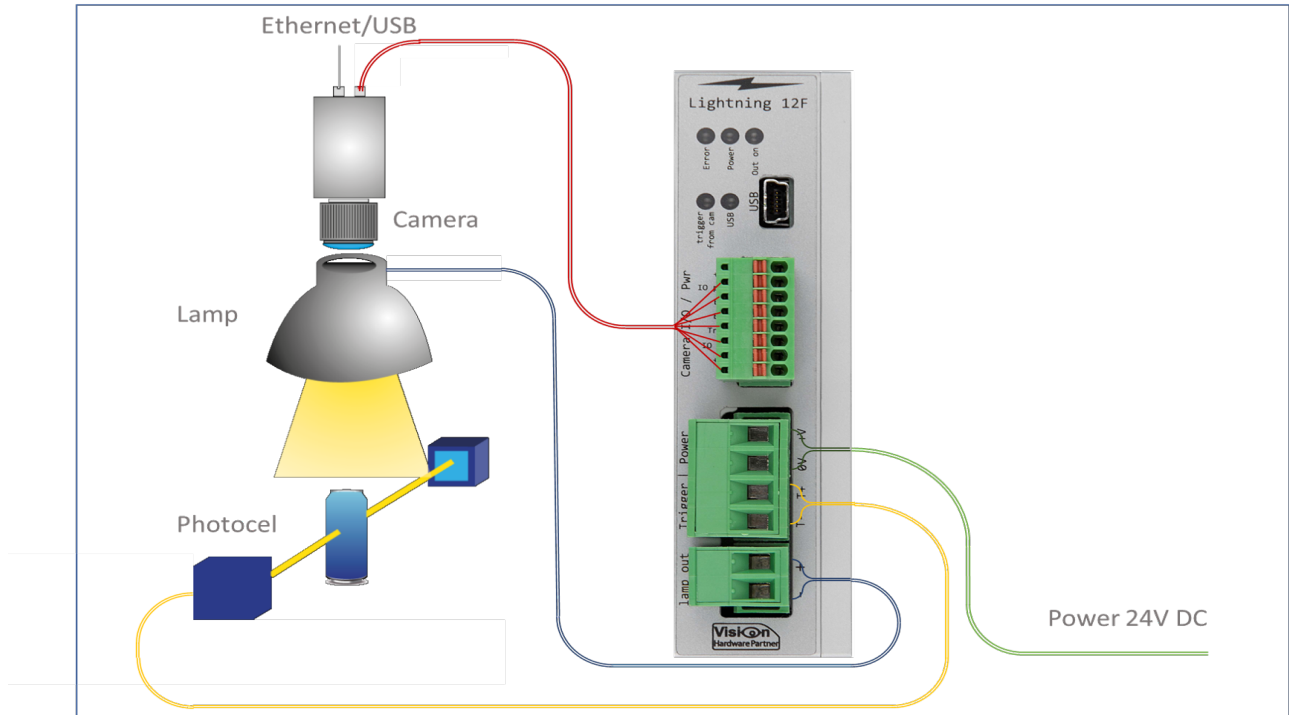Lightning 12F also supports a power / trigger interface to a camera.

Figure 1: the setup with the Lightning 12F
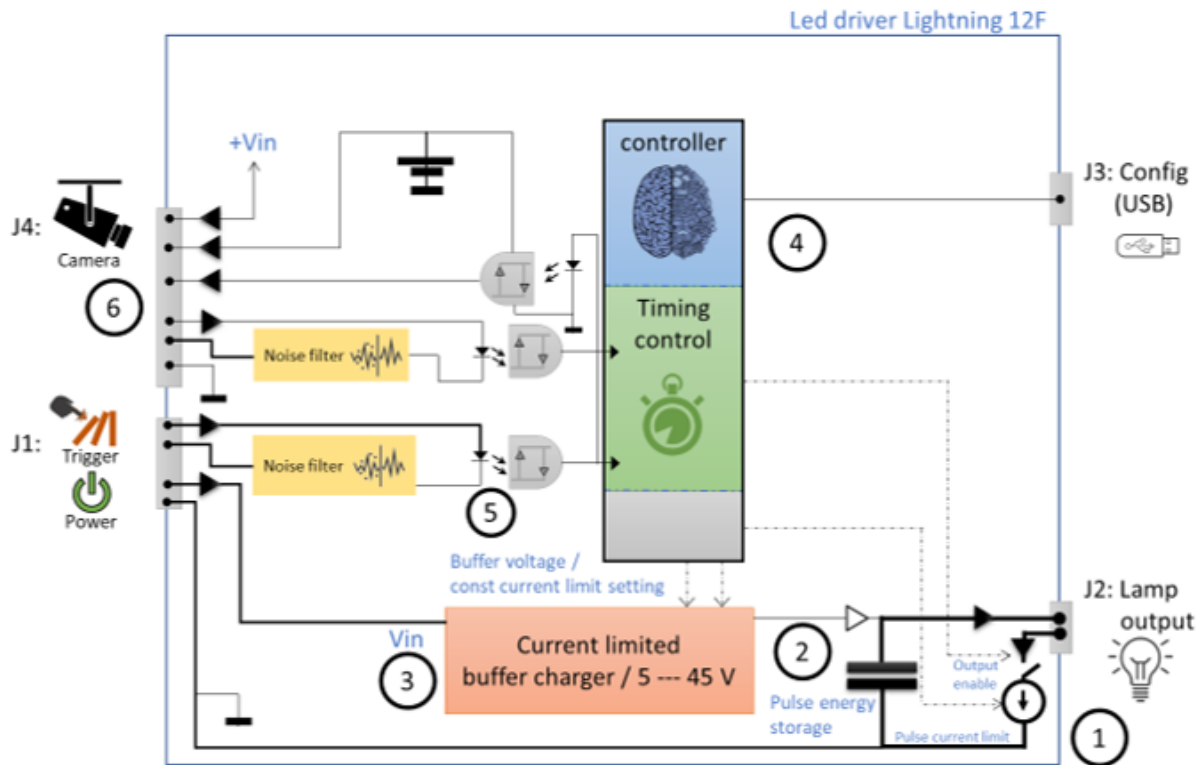
1.1 Functional overview

Figure 2: Simplified functional diagram

Pulsing principle

Pulse mode is designed for situations where the used lamp current during the pulse is higher than its rated continuous current. This gives extra brightness during camera exposure, but it also introduces the risk of overheating the lamp, resulting in damage.

Therefore the average power to the lamp has to be maintained within the ratings.

In order to achieve this in pulse mode the lamp on-time is limited to a programmable value. After each lamp pulse the controller will force the lamp to be off for a set time. This time is referred to as the "cooldown time". Not only the lamps safety relies on this cooldown time. It is also used to recharge the energy buffer to the set level, and to let the pulse current limiter cool down.

The current pulses to the LED-lamp are supplied from a buffer. The buffer can deliver more output current than it will draw from the power supply. The buffer will recharge also during the "LED off-time". So during pulse the buffer is drained at a faster rate than it is recharged. The buffer voltage will therefore drop a certain amount. The LED driver will compensate for this drop as long as there is enough voltage in the buffer left to maintain the lamp at the set current.

The pulse current limiter (see Figure 2: Functional overview) regulates the lamp current to a set limit during the flash. The pulse current limiter is a fast linear regulator that converts the voltage difference between the buffer voltage and the required lamp voltage into heat. The greater the voltage difference between the buffer and the LED's required voltage, the more heat the pulse current limiter dissipates. The user must keep track of the heat dissipation.

⚠️ The drivers average dissipation must remain within operating limits. The user must make the calculations to make sure of this. As a rule of thumb: at pulse frequencies < 20 Hz combined with currents <5A, the maximum buffer voltage is still safe. **When in doubt: calculate to make sure!**

1. Pulse current limiter:
The pulse current limiter (shown at the lower right corner of figure 2) regulates the lamp current to a set limit during the the flash. The pulse current limiter is a fast linear regulator which converts the voltage difference between the buffer voltage and the required lamp voltage to heat.

2. Pulse energy storage:
The lamp is powered from a local energy buffer. This buffer allows for pulse currents up to 12.5A to be supplied to the lamp while drawing a considerably lower current from the supply power.

3. Buffer charger / voltage booster:
The buffer charger is used to recharge the energy storage at a controlled rate. It is also able to generate voltages up to 45V

4. Controller:
The controller is used to control the lamp output switch (including timing) and to set the operating values to the internal components.
The controller is designed to function fully autonomously. The USB port can be used to configure the device before it is used. It is not intended to be an "always on" connection.

5. Enable input:
The digital enable input works at all signal levels from LVTTL to 24V. It requires at least 5mA to detect an "on-level". In continuous mode the enable input works as a direct switch input. If the enable is set to on, the lamp is also set to on.
In pulse mode there are multiple options.

6. Camera connector:
Generic camera connector compatible to most cameras. Cameras generally have a multi wire I/O cable. This usually connects the cameras strobe/exposure output and image trigger input. Also, it can be powered through this cable. The LED driver can supply +12V or its own power (nominally 24V) to the camera.

1.2   Camera interface connector

Most cameras are equipped with two main interface connectors.
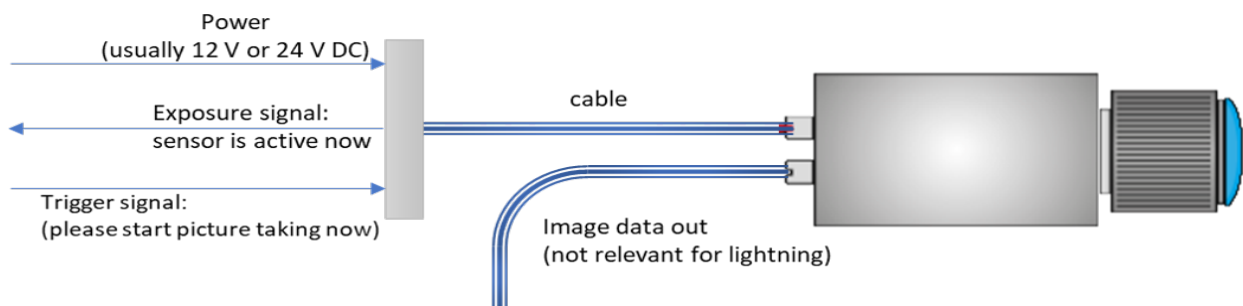
1. Data cable to send images to the computer
2. Power/IO cable. This cable supplies power and trigger signals to the camera and receives exposure signals from the camera.

Synchronization works as follows:

Trigger

An external trigger signal starts the image acquisition on the camera. The image acquisition is thus synchronized with the light pulse.

A typical use case is an external signal that indicates that the object that has to be photographed, is in the correct position. For example, the moment the product interrupts the beam of a light barrier, or a signal from a PLC telling that a container is in position.

Exposure

After a delay (propagation delay), the camera will activate its image sensor and start integrating. At that moment most cameras can give a digital signal to confirm this. This is called the exposure or strobe signal. The exposure signal of the camera is thus used as a trigger to start the lamp pulse.
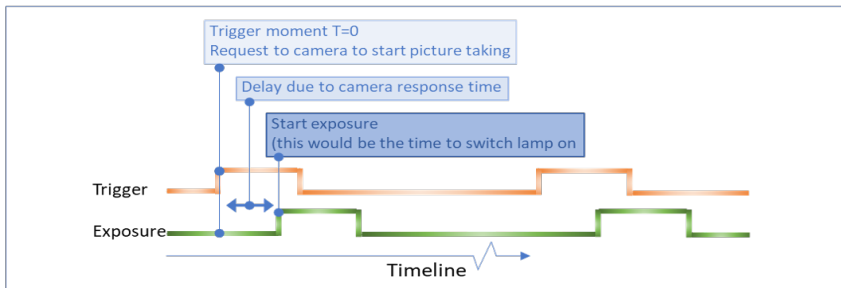
1.3 Trigger interface block schematics
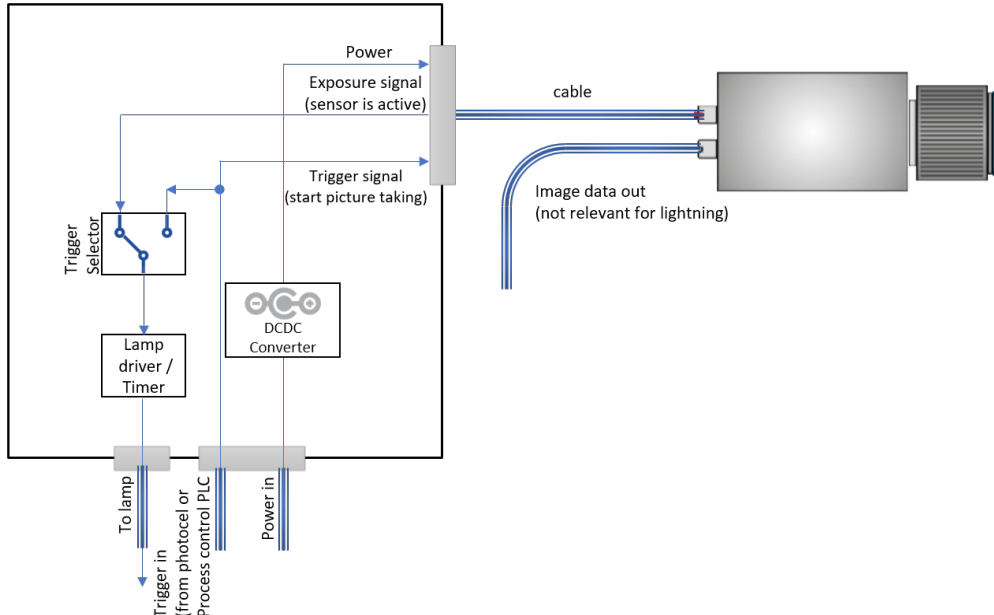
The block schematics describe how the LED-lamp driver handles the trigger interface and the camera I/O.

Power: The power supplying the LED lamp driver (usually 24V) comes in at "Power in" and is routed to the camera power, either through a **DCDC converter** to 12V or directly. The user makes this choice by choosing either the one or the other pin.

Trigger: The trigger signal offered by the photocell or PLC at **Trigger in** will also be routed to the camera's **trigger in**.

Exposure: The **exposure** signal of the camera is used by the LED lamp driver as a trigger for the flash.

Trigger selector: (in the lightning config software: **trigger from:....**) This selects if the lamp flash starts on a rising edge of the camera exposure signal, or from the **trigger/enable** input. See *Configuration tool* for more information.

It is recommended to trigger the lamp flash from the camera exposure signal. That way the illumination is also synchronized to the camera if there is no photocell or PLC trigger. For example if the camera is in free running mode. However in some cases (for example when the camera cannot give the exposure signal), the driver can be triggered directly through the trigger/enable input.
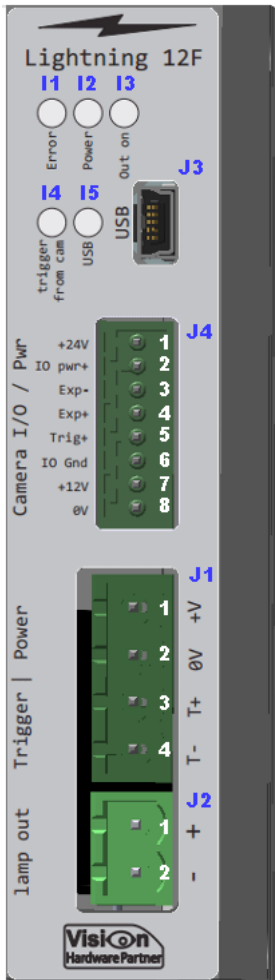
2 Getting started

Figure 6: Connectors and indicators

2.1 Connecting the device

2.1.1 Connector J1: Power | Trigger

This connector connects both the supply power and the trigger signal input.

Pin	Name	description
1	Power +	The power input features both reverse polarity and over voltage protection. However, activating one of these protections results in blowing a fuse. Replacing the fuse requires opening the housing.
2	Power 0V	
3	Trigger+	The trigger input has galvanic separation. Both terminals must be connected .
4	Trigger-	The input is compatible with 3.3V/5V TTL and 24V I/O standards. The signal threshold is approximately 2.8V at a current consumption of 5mA. This means that any voltage higher than 2.8V will generate a logic high, provided that the current is at least 5mA. At 24V the current draw will be no more than 11mA.

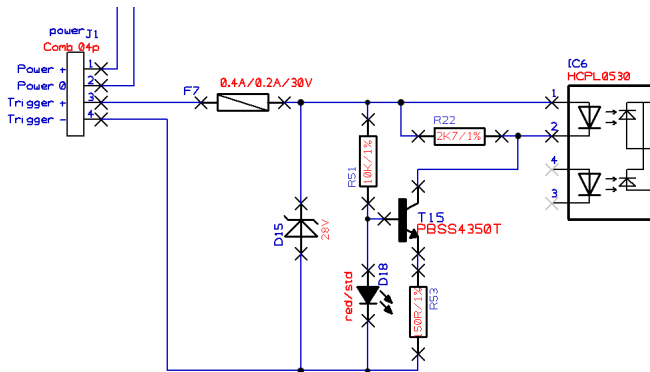*Figure 3: Trigger input circuit*

2.1.2 Connector J2: lamp output

⚠️ ***Do NOT connect the lamp to any other terminal! Connecting the lamp to 0V will bypass the current regulation and damage the lamp and possibly the driver***

Pin	Name	description
1	Lamp+	
2	Lamp-	

2.1.3 Connector J3: USB

Connector for configuring the device through USB.

2.1.4 Connector J4: Camera interface V2

This connector can be used to connect to the power/interface cable of many types of cameras.

It will provide power to the camera as well as trigger/strobe signals.

Pin	Name	description
1	Power +24V	+24V for powering the camera. Most camera's will take either 12V or 24V power. **Check first which voltages are acceptable to the camera before connecting it.**
2	I/O power +	Connect to the cameras I/O pwr. If the camera has active low (NPN) outputs it might not have this connection. In that case it can be left open.
3	Exposure -	Optocoupler input for the camera exposure signal. This can be used for both cameras with active high and with active low output
4	Exposure +	
5	Trigger +	Trigger signal to the camera. The trigger signal received on J1 will be forwarded to this pin
6	I/O GND / Trigger -	Connect to the cameras I/O GND
7	Power +12V	+12V for powering the camera
8	Power 0V	0V for powering the camera

2.2 Indicators

Ind.	Name	description
I1	Error	Indicates an error. Possible errors are: • If the driver is out of regulation (lamp current too low) at the end of the pulse the indicator will light for one second. Most likely cause is the buffer voltage being too low, or lamp connection error. • If the indicator keeps lighting for longer than 1 second when no pulses are applied there is a system error. In that case please contact the supplier.
I2	Power	Indicates that power supply is present
I3	Out on	Indicates that the driver is currently busy (lamp on or in cool down)
I4	Trig from cam	Indicates that the device will (only) pulse on triggers received through the camera I/O connector. If the LED is off it the trigger input on J1 will be used.
I2	USB	Lights green when the USB cable is connected and drivers are loaded. Is orange when data is received through USB. Is red when there is a USB connection, but the LED driver is not powered.

3   Configuring Lightning 12F

3.1   connecting the device

Settings can be adjusted through a USB connection.

As the Lightning 12F is a stand alone unit which can function fully independently of the USB port the cable only needs to be connected during communication. The configuration port is a standard USB port which does not provide for extra ruggedness like galvanic separation or additional transient protection as recommended in an industrial environment. Therefore it is highly recommended to only connect the cable while applying the settings.
In case that the USB connection is used permanently, it is recommended to keep the cable as short as possible.

Configuration changes can be made using the Lightning Config software or directly through a virtual serial port. This manual will only cover the software tool. If you want to communicate to the driver directly from your own software then please contact Vision Hardware Partner for details.

3.2   Main settings

Main settings are: The lamp current, pulse duration / cooldown time and the buffer voltage.

The lamp current and the pulse duration depend on the lamps operating limits. Please contact the manufacturer for choosing the right settings for these items.

The most important point is that the average power sent to the lamp must not exceed the lamps ratings for continuous power. The period duration to calculate the average over must not exceed 10ms, or 2ms for very high pulse currents. Please contact Vision Hardware Partner for details.

3.3   Setting the buffer voltage

The buffer voltage must be set neither too low nor too high.

The LED lamp is always driven in current mode. That means that the lamp current is regulated. The voltage is a means to reach the right amount of current. Unlike the current, the voltage is not a stable factor.

If the lamp current and pulse duration are set correctly, the setting for buffer voltage will never lead to damage to the LEDs. However, there are other reasons for carefully considering the correct value for buffer voltage.

Let's take a closer look into the lamp current regulation principle

First the pulse buffer will be charged up to the set voltage. During the pulse (lamp flash) the buffer will drain and as a result the buffer voltage will drop. As long as the buffer voltage is high enough the driver can compensate for the loss of voltage and maintain the set current to the lamp.
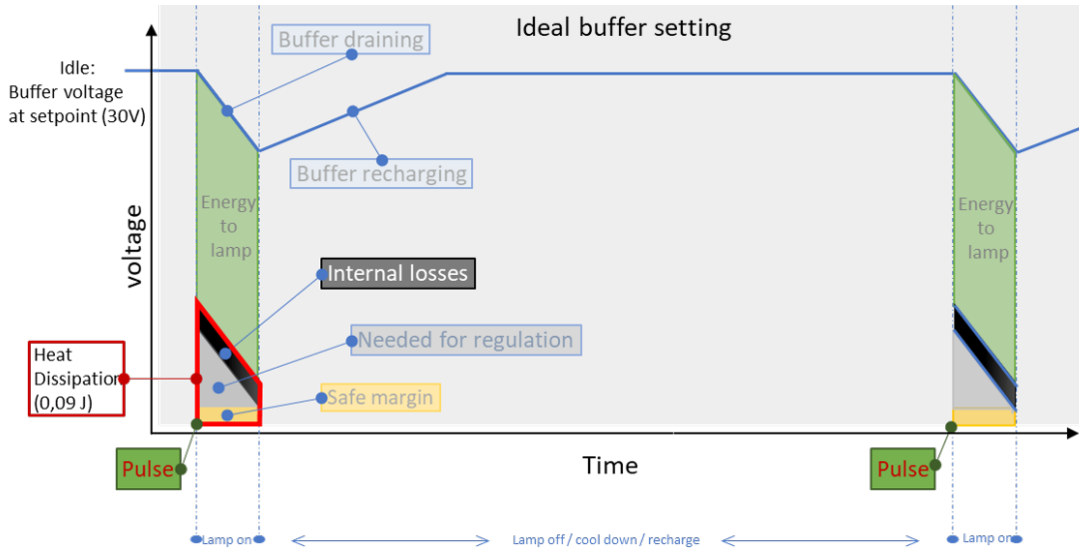
The heat dissipation mentioned here is an example, assuming a certain set of conditions

Higher buffer voltage means more stored energy, so the pulse can be sustained for longer. It also means higher dissipation (heat development) while pulsing. This in turn may overheat the device. To limit the dissipation the buffer voltage must be set to a safe value.

The basic formula is that the buffer voltage needs to be just high enough to supply the lamp voltage and compensate for the voltage drop and some small losses. It is not useful to set the voltage any higher. It will only contribute to more heat development.

The voltage needed for the lamp depends on the type of lamp, set current and its temperature. Contact the lamps manufacturer for the right values. Many lamp manufacturers are not familiar with pulse-driving. They might not be able to give the needed information. In that case Vision Hardware Partner might be able to help.

The lamp can be damaged by an incorrect combination of current and pulse duration.

The driver can be damaged by setting the buffer voltage too high.

The lamp cannot be damaged by applying an incorrect setting for buffer voltage.

If the buffer voltage is set too low, the lamp current will not reach the set value. In that case the driver will be outside its working range.
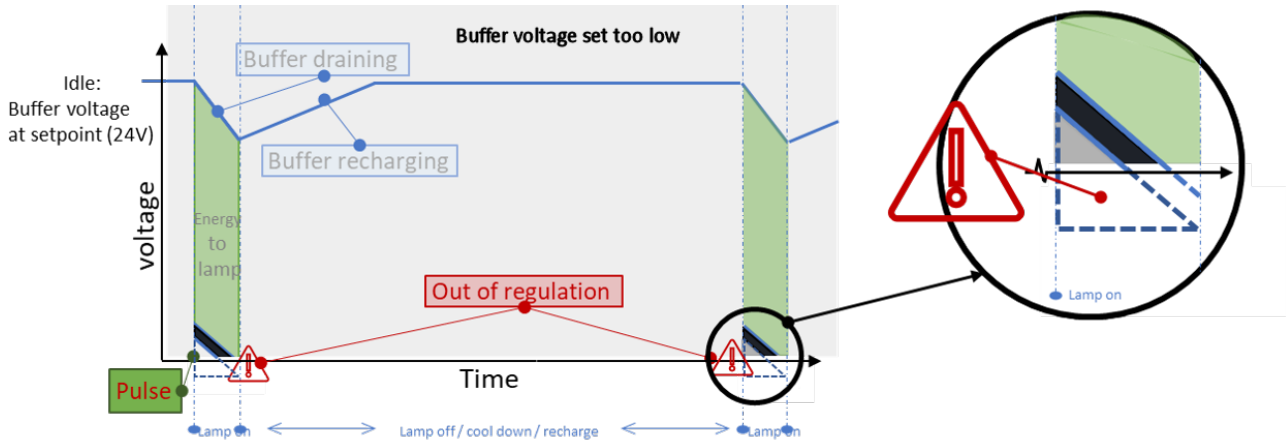
The driver needs a minimum voltage in order to be able to supply the set current to the lamp, and compensate for the voltage loss of the draining buffer. If the buffer voltage is set too low, the driver will not be able to maintain regulation. This will be indicated by the "error" LED, which will light for 1 second after each pulse.
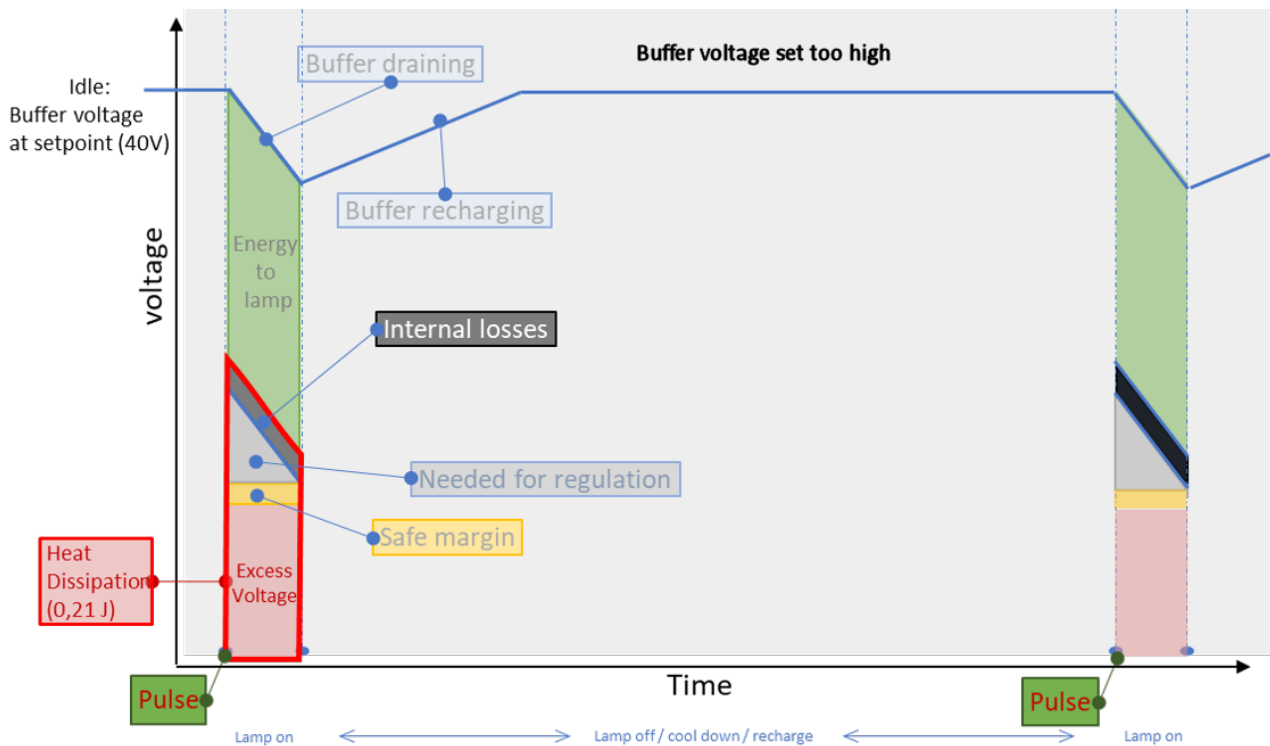
For the finding correct maximum for the buffer voltage it is important to take into account the driver power dissipation. For reliable operation over the whole temperature range it is recommended to limit the dissipation to a maximum of 3W.

Appendix A provides the necessary formulas for calculating the buffer voltage drop during pulsing and the pulse driver power dissipation.

Lightning 12F's firmware will also give an estimation of the voltage which will be available to the lamp at the end of the pulse. The method used for this is explained in appendix A.
Whenever the user changes a pulse setting, the unit will report the calculated available voltage. More about

this in 3.5.2.3

3.4 User types

The Lightning series are generic pulse current supplies which can be configured to drive a range of difference lamps with different driving properties. Not all lamps will be able to handle the amount of power that can be supplied by the driver. Therefore it is of great importance that the device is only configured by users with in-depth knowledge of the connected lamp's limits.

It is assumed that the Lightning LED drivers must also be able to be operated by persons without detailed knowledge of electronics and / or pulsing LEDs.
To make sure that the non-expert users will not damage the lamp or the device, settings are divided into two user groups: end users and expert users.

User type	Permissions
End users	change all parameters marked with "user: all"
Expert users	Change all parameters. This means experts must have proper knowledge and understanding of the ratings of the connected hardware. They can set the limits for voltage and currents in such a way that end users can safely control their set of parameters.

⚠️ None of the settings are password protected. It is the user's own responsibility to use the settings wisely. Do not make any changes without reading the manual on that particular item.

3.5 Configuration tool

The configuration tool is used to make settings for specific lamp types and contexts. These settings can then be written to the device. Also settings of a device can be read into the configuration tool.

Also in the configuration tool there is two types of settings.

- **End user settings**: These can be applied by anyone without damaging the lamp or driver

- **Expert settings**: These can potentially damage the lamp or driver when set incorrectly
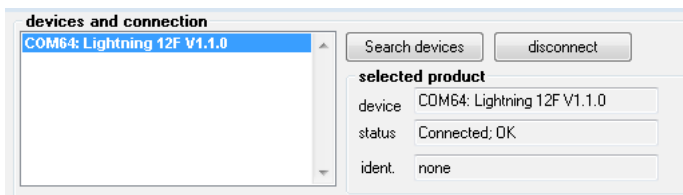
The expert will first set safe limits to the device, after which the end user can safely change settings in the end user section.
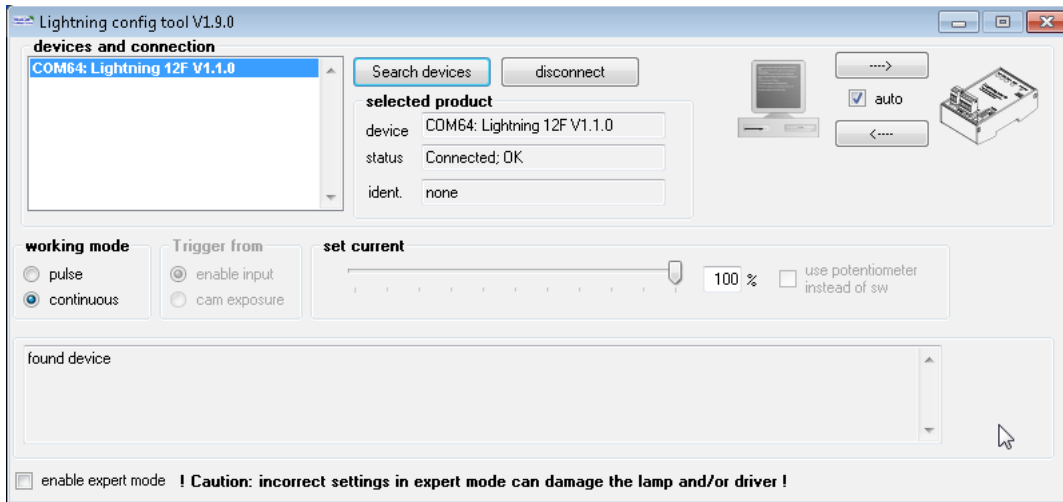
When opened the tool will start in the safe *end user* mode. This will only show the settings safe for end users.

3.5.1 Controls for all user types

3.5.1.1 Find and connect to devices

The devices and connection menu is used to select devices and connect to them.

The detected devices are listed in the box at the left. To connect to a device, highlight it by clicking on it in the list and then press the **connect/disconnect** button.

Detailed information about the device is shown below the text "**selected product**". This shows the device name, status and identity.

 On startup the application automatically scans for available devices and lists them in the box. This list is not automatically updated when a device is added or removed. The user can do this by clicking the "**search devices**" button.

3.5.1.2 Message pane
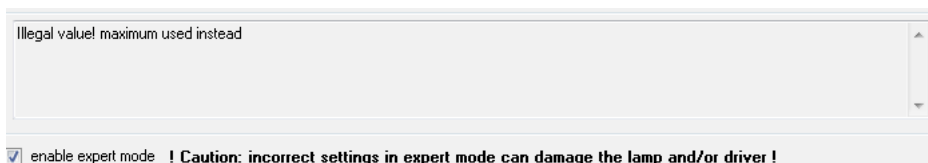
The message pane will show event notifications like: "found devices", "connected", "disconnected". If the user enters an illegal value he will also be notified through the message pane.

3.5.1.3 Synchronize settings

The settings in the device and on the screen are not necessarily the same. By default when connecting to a device the tool is synchronized to the device. All settings are read from the device and the screen is updated. If the "**auto**" checkbox is ticked (default behaviour) settings are synchronized from the screen to the device on the following events:

- When the enter key is pressed
- When the cursor leaves a field

If the "auto" checkbox is unticked settings are not automatically synchronized. The user can then manually synchronize by clicking arrow buttons.

- The button with the arrow pointing to the device icon synchronizes from the computer to the device
- The button with the arrow pointing to the computer icon synchronizes from the device to the computer

3.5.1.4 Working mode
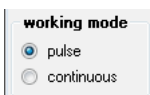
pulse: is intended for using the lamp in overdrive mode. The lamp is driven at a higher than nominal current for a limited time. The lamp is switched on on the rising edge of the trigger signal and goes off either when the on-time limit is exceeded or when the trigger input goes low, depending on the timing settings.

continuous: the lamp will light continuously as long as the input trigger (enable) signal is high. The lamp will be driven at a much lower current than in pulse mode.

Continuous mode can be used to have the lamp on during calibration of the lighting setup. Separate limits are used for setting the lamp current in pulse and continuous mode.

3.5.1.5 Trigger input select

See also sections 1.2 and 1.3 on the trigger interface.
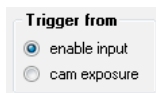
This selects on which input the lamp trigger is expected.

cam exposure: the device is triggered by a pulse signal from a camera. Camera trigger signal is connected to pin 3 and 4 on connector J3.

enable input: the device is triggered from an external source like a photocell. An external trigger signal is connected to pin 3 and 4 on connector J1.

In continuous mode the enable signal is always expected on connector J1

3.5.1.6 lamp current slider
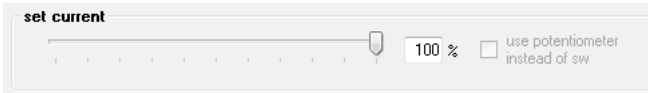
This slider is used to set the lamp current relative to the maximum values set in the expert settings.

In pulse mode this is a percentage of the set maximum pulse current. In continuous mode it is a percentage of the set continuous current.

3.5.2 Expert user controls

Expert user controls are made available by ticking the checkbox "**enable expert mode**". The form will then expand and show the expert settings.

Incorrect settings in the expert mode can damage the lamp and/or the driver

3.5.2.1 Limit settings

Here the user can set the limits for the lamp current and buffer voltage. If the lamp current slider (see 3.1.5.6) is set to 100% these values are the set current for the lamp.
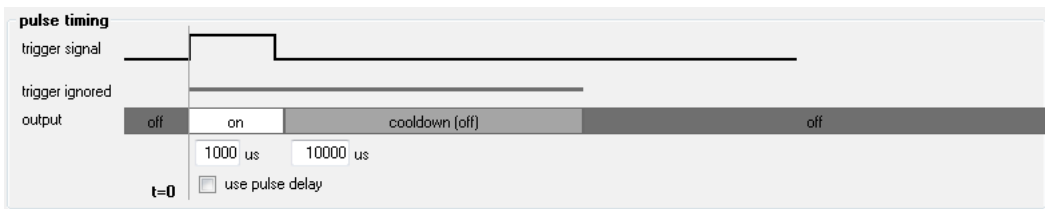
Max continuous current: This the current when the driver is in continuous mode

max pulse current: This the current when the driver is in pulse mode

Pulse buffer voltage: The pulse buffer will charge to this voltage.

Refer to the lamps operating limits and section 3.3 (setting the buffer voltage) for finding the correct values.

3.5.2.2 Timing control

The line at the top, marked with "**trigger signal**" shows the expected incoming trigger signal. The bar marked with **output** shows the possible lamp states and their logical order.

- The lamp starts in the idle (off) state. On the rising edge of the trigger signal the pulse cycle starts.

- The lamp is switched on

- when the lamp pulse (flash) is complete the lamp is switched of and the driver enters the cooldown state. During cooldown any incoming triggers are ignored, allowing the lamp and driver to cool down and the buffer to be recharged.
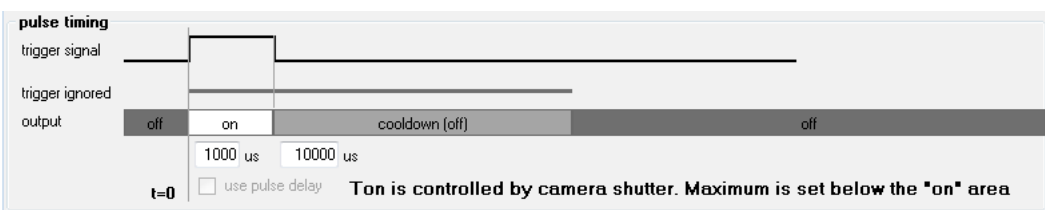
The drivers exact behaviour depends upon a number of choices. These are described below.

Timing can either be controlled entirely by the drivers timer or partly by the cameras exposure(strobe) signal. If the above selector is set to "**camera shutter signal**" the lamp will mirror the state of the exposure (trigger)

signal. So it goes on/off when the exposure signal does. This is shown in the graphical user interface by lines linking the lamp on and off moments to the exposure signal edges (shown above). Please note that the on-time is still limited to the set maximum. So regardless of the exposure signal the lamp is switched of when the maximum on-time is reached.

If the selector is set to the "**lightning mini timer**" the timing is entirely controlled by the drivers built in timer. In that case the lamp will remain on for just as long as the set on-time, regardless of the duration of the exposure (trigger) signal.
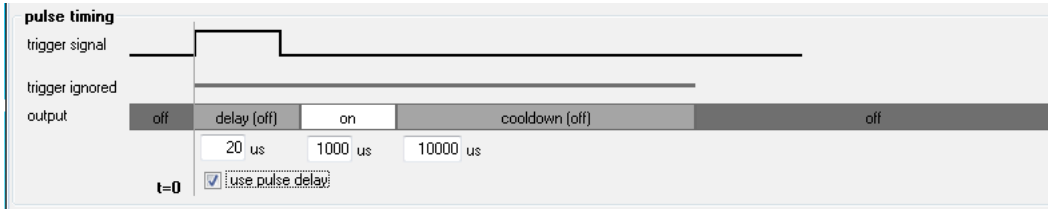
With the checkbox "**use pulse delay**" ticked switching on the lamp can be delayed. This delay is to compensate for the camera response time. This is mainly useful when both the LED driver and the camera are triggered from the same signal.

3.5.2.3   Resulting practical limitations
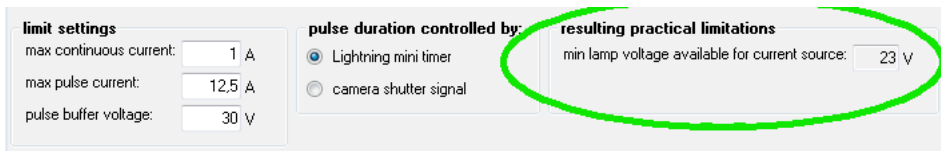
In this section the driver shows the estimated voltage available to the lamp at the end of the pulse at the set buffer voltage, current and duration. Please refer to 3.3 (setting the buffer voltage) for details.

3.5.2.4   Save/load settings

The device settings can be saved and loaded. This enables the user to save a settings profile for a specific application and load it into new devices. Also the saved settings can be used for later reference.
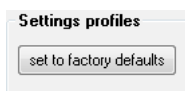

Click the ---> to save settings

Click the <--- to load settings

For both actions, a dialogue screen appears asking where to save the settings to or load the settings from.
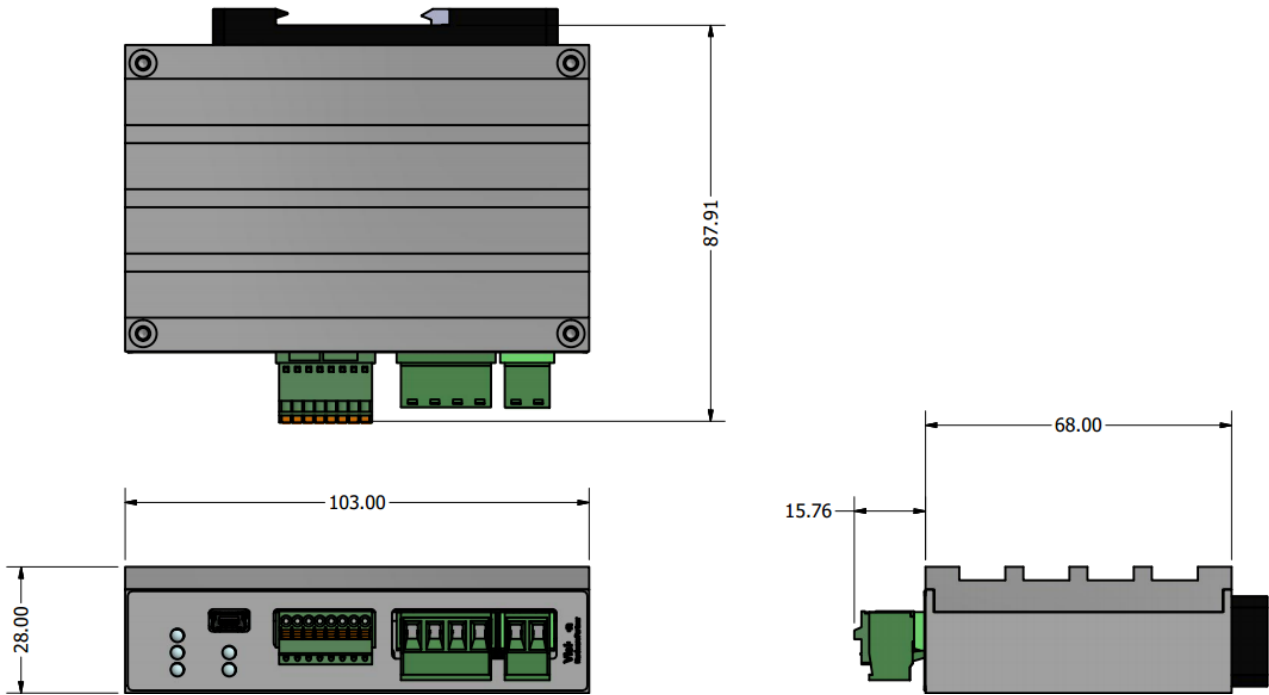
3.5.2.5   Restore defaults

Clicking this button resets the device to factory settings.

4 Specifications

4.1 Dimensions

4.2 Electrical characteristics

Item	min	typ	max	unit
Supply voltage	20	24	28	V
Operational current			2	A
Inrush current <= 20uS			65	A
Inrush current <= 100uS			20	A
Trigger, exposure input voltage	3.0		30	V
Enable signal high threshold	2.0	2.5	3.0	V
enable high input current	5	8	11	mA
Pulse driver dissipation (absolute max)			5	W
Pulse driver dissipation (recommended)		3		W

4.3 Timing

Item	min	typ	max	unit
Trigger to driver on*		3.5	4.0	µS
Trigger to output current stable*		5.5	6.0	µS

*set pulse current needs to be > 100mA

4.4 Range / resolution

Item	min	max	res	unit
Output voltage range	5	45	0.23	V
Pulse mode output current	0	12.5	0.005	A
Pre pulse delay	0	30000	1	µS
Pulse duration	10	10000	1	µS
Cooldown duration	100	30000	20	µS

4.5 Conditions

Item	min		max	unit
operating temperature	0		45	°C

Appendix A: calculations

Pulse driver dissipation

The driver dissipation is calculated with the following formula:

$P_d = (V_{out} - 0.2 * I_{set} - V_{lamp}) * I_{set} * T_{pulse} * F_{pulse}$

In which:
P_d is the dissipated power in Watts
V_{out} is the set buffer voltage in Volts (VOUT_MV /1000)
I_{set} is the output current set in Amperes (IOUT_MAX_PULSE_MA / 1000)
V_{lamp} is the estimated lamp voltage at the set current in Volts
T_{pulse} is the pulse duration set in Seconds (PULSE_DURATION_US / 1000000)
F_{pulse} is the maximum pulse frequency in Hz

Note that the values T_{pulse} and F_{pulse} have a large influence on the dissipated power.
The formula can be simplified in order to do a quick check if the dissipation is in a dangerous region:

$P_d = V_{out} * I_{set} * T_{pulse} * F_{pulse}$

This formula assumes lamp voltage = 0V. If P_d is ok according to this formula, ratings will never be exceeded.
If it is not you can still use the first formula to check if the more realistic model checks out ok.

Voltage drop due to buffer drain

As mentioned before, the high pulse current is achieved by using a power buffer. The buffer will drain during the pulse. Due to this the useful pulse duration and current are limited. The device will calculate the expected voltage drop when applying settings. and notify the user.

> **Note: this is an estimated voltage drop. It is recommend to make sure that the minimum pulse voltage is at least 2V higher than the required minimum lamp voltage.**
> **One of the reasons is that the lamp will need a higher voltage at lower temperatures.**

$V_{drop} = 0.12 * I_{set} + (I_{set} * T_{pulse}) / 2040$

In which:

V_{drop} is the voltage drop over a single pulse
I_{set} is the output current set in amperes (IOUT_MAX_PULSE_MA / 1000)
T_{pulse} is the pulse duration set in Microseconds PULSE_DURATION_US

In order to keep the output current regulated the output voltage must be set to a value which includes both the
buffer voltage drop and the lamp voltage. The formula for meeting this condition is:

$V_{out} >= V_{drop} + V_{lamp}$

V_{out} is the output voltage that needs to be set in order to remain within regSulation
V_{drop} is the voltage drop over a single pulse as calculated above
V_{lamp} is the estimated lamp voltage at the set current