



OptoLed Lite

Instruction Manual

www.cairn-research.co.uk

Free Phone: **08453301267** (UK only)

Tel: +44 (0) 1795590140

Fax: +44 (0) 1795594510

Important Information

Please Read Before Installing and Operating Your OptoLED Lite

For maximum reliability and safety we recommend using the equipment within certain guidelines. If in any doubt, then please feel free to contact our technical support department (e-mail tech@cairnresearch.co.uk).

The following points should be considered when using the OptoLED for the first time:

1. The OptoLED is capable of producing very intense illumination. The LED heads should **NEVER** be viewed directly. If testing the LEDs then **ALWAYS** shine them at a white surface and view the resultant reflection or fluorescence. This is especially important with **ULTRAVIOLET LEDs** which will not appear bright to the human eye, but can cause permanent damage if not used with care.
2. Our standard LED heads have built in protection to avoid damage, however if in any doubt then please check with Cairn as to the rated power of the supplied heads, and use accordingly.
3. The OptoLED is typically supplied in conjunction with our modular microscope coupling system. Please refer to the separate documentation regarding your particular configuration.
4. The OptoLED system supports a vast range of different LEDs and LED arrays. Different sized LEDs require different condenser lenses. We always try to optimise the condensers for the LEDs ordered, but if you require help with optimisation then please ask.

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1 Introduction

The Cairn OptoLED Lite is capable of driving an LED over a wide range of currents. The standard operating current range, which is set either by a front panel control or by an external control voltage, is 0-2 amps (A). This current is limited by components in the interchangeable LED heads, above which the current driver will temporarily shut down in order to protect the LED from damage. However, since LEDs can be transiently overdriven above their continuous current limit (which is usually determined by thermal considerations), the protection circuitry also allows a higher transient current limit to be set. By incorporating the protection-setting components in each LED head, they can be tailored to match the maximum safe levels for that type of LED.

In addition, digital inputs are provided to switch the LED on and off with rise and fall times of just a few microseconds (for faster requirements you will need the full OptoLED). The operation of the unit will now be described, first with reference to the front and rear panel facilities, and then with reference to the further facilities available internally on the circuit boards.

Some more general notes on LED operation will follow after that. Finally, for users who wish to try out alternative LEDs, the necessary information for constructing or modifying LED heads is given in the Appendix.

2 Installation Guide

Depending on the required configuration the LED head may have been pre-installed in a microscope coupling (described in a separate manual), or it may be a discrete unit. Either way we would recommend connecting the LED to the controller box using the DIN plugs provided and pointing the LED (or output of coupling) at a piece of white paper (**NEVER VIEW THE LEDS DIRECTLY**). Next connect the power supply to the mains, and read the following description of the controls before verifying operation.

The front and rear panel controls are described in detail below, but if the user bears in mind that the LED has independent controls to set whether it is on or off and to set the intensity, and that either of these can be applied from the front panel or externally (e.g. from a PC) then operation is quite intuitive.

'OFF / EXT/ON' switch

This switch allows the LED to be permanently 'ON', permanently 'OFF' or digitally controlled 'EXT'. The digital signal is applied via the TTL (5V) 'EXT' socket on the rear panel and allows the LED to be switched between on and off very rapidly. When the switch is in the on or off position, this digital signal is overridden.

'CURRENT' Control

This control sets the LED drive current when the 'INT/EXT' switch on the front panel is in the 'INT'ernal position (otherwise control is via an external voltage). The current can be set between 0 and 5A, but the protection circuit in the LED head will usually limit maximum current.

'LED ON' Indicator

This indicator is illuminated whenever the corresponding LED is on. If it is lit and there is no light at the LED head then it is probably because the intensity level is set to zero on the front panel or the applied intensity voltage is 0V (if using the device under external intensity control). Since its status is affected by the digital control signals, this indicator may appear to be illuminated more or less brightly if the applied signals are changing too rapidly to be followed by eye.

'OVERLOAD' Indicator

If either the steady or the transient power through the LED exceed values preset by components within the LED head, this indicator will illuminate for about 1 sec, during which time the drive current will be switched off to protect the LED. Resetting is automatic, but the overload condition will keep re triggering for as long as the power remains above these values.

For users who, **at their own risk** of course(!), wish to experiment with the overload parameters, and/or wish to make their own custom LED heads, the

necessary information for how to do this is given in the Appendix.

'POWER ON' Indicator

This indicator is illuminated when the power is turned on both at the main socket as well as the power on switch located on the rear panel.

'INT/EXT' Switch

This switch controls whether the current applied to the LED is set from the front panel dial or referenced to an external voltage applied to the rear panel.

'TTL INPUT'

This is a logic-level (i.e. 0V or +5V) input, which determines whether the LED is on or off when in the 'EXT' mode. This input is at a logic low level by default if it isn't connected to a suitable drive signal.

'EXT LEVEL'

This is an external analogue input for the LED drive level where the input range is 0 to +5V. Each change in 1V corresponds to a change in 1A.

'ROTARY DIN' Socket

This is an 8-pin locking DIN socket for connection to the LED head. In case you would like to make up your own custom LED heads, the connections are described in the Appendix.

'POWER' Switch

This switch needs to be turned on for the machine to operate

3 Technical summary

LED technology is continuing to develop rapidly. The first LEDs operated mainly in the red or infra-red, and were relatively weak. However, they are now available with wavelengths across the visible spectrum, even extending into ultraviolet. Intensities have also increased by literally orders of magnitude, now rivalling incandescent lamps, and in many cases competing with arc lamps. The continual intensity improvements have caused some manufacturers to run short of superlatives for their newer devices, which therefore have to be called "superhyperultrabright" or some similar nonsense.

Of course, the major incentive for the development of brighter devices has been their potential use as illumination sources, rather than just as indicators. LED light sources have developed at a very fast rate over recent years and Cairn have now developed their own range of LED light sources for microscopy / macroscopy.

The general characteristics of LEDs are as follows. Since they are a type of diode, they have the basic characteristics of such devices, i.e. they only pass current in one direction, and the current rises very rapidly once the voltage in that direction exceeds a certain threshold. Ordinary silicon diodes have a threshold voltage of about 0.65V, but LEDs have significantly higher thresholds, e.g. around 1.2V for a standard red indicator LED. Devices designed for shorter wavelengths tend to have higher thresholds, of maybe around 2V or so, and in spite of the fairly steep diode characteristic they may drop as much as 3 or 4V when driven at full power. These figures are all for a single LED; please note that some "LEDs" may actually consist of several devices in series,

in which case their operating voltages will be correspondingly higher. In all cases the light output from an LED is approximately proportional to the current, so this is the parameter that one needs to control for optical as well as electrical reasons.

In order to drive an LED safely and reliably, a current source rather than a voltage source is required. For low-power operation a voltage source can be converted into a reasonable approximation of a current source by applying a voltage significantly in excess of the device's threshold voltage in series with an appropriate resistance. This is fine for indicator LEDs, where the current is low and unlikely to be varied, but is far less suited for power applications. In this case the only way to vary the power with reasonable efficiency is to vary the series resistance, and this really isn't feasible to do directly. Instead, a constant-current power supply with a variable current output is far more suitable, so this is what we are using here.

However, just as a constant-voltage power supply has a maximum output current, so does a constant-current power supply have a maximum output

voltage, and for general cost and efficiency reasons it is important to match the current or voltage limits to match what is reasonably to be expected. The OptoLED Lite controller therefore normally has a maximum output voltage of about 5V. We chose this value because it can comfortably drive one LED head. As to current ranges, indicator LEDs typically have maximum current ratings of a few tens of mill amps at most, whereas those used for illumination may require up to several amps. The standard drive current range for our supply is 0-5A. Although LEDs may become somewhat less efficient at higher currents, their maximum output is ultimately limited not by optical saturation but by thermal dissipation. Therefore, it is perfectly permissible for an LED to be driven transiently at a higher current than the safe steady-state limit. The extent to which this can be done, i.e. how much higher a current can be applied for how long, will depend on the characteristics of that particular type of LED, but information about this may be available in the device's data sheet. Otherwise, as a rough guide, we're talking about times of up to perhaps a few tens of milliseconds. In any case, most LEDs are relatively cheap, and they can be destroyed without damaging the power supply, then trial and error may be a perfectly acceptable way of exploring their safe operating limits.

Finally, a few notes about the most suitable types of LED. For general illumination purposes, the more powerful types are clearly to be preferred. However, for microscope illumination the situation is rather different, and in practice better results may be achieved from using a less powerful LED here. The reason for this is as follows. A high-magnification microscope needs to use the condenser (or objective in the case of epi-illumination) to focus the light onto a very small area. This requires the light going into the condenser or objective to be nearly parallel, which is only the case if it has come from (or behaves as if it has come from) a very compact source. Unless the output per unit source area is also higher, any increase in source size above about 1mm is unlikely to give brighter illumination, although it will make set-up less critical. The chip size and configuration in the device is easily observable, and a common configuration for the multi chip devices is to have four emitters in a square array. For more general illumination, LED arrays with many more devices are also available. The OptoLED Lite can drive any of these as long as their required voltage and current requirements are within the specifications given below.

4 Specifications

Mains input voltage 85-260V, 50-60Hz, CE compliant

Maximum output 20V

Maximum output current 5A

Response time to change in external analogue input <10usec

External analogue control voltage range 0 to+5V

Digital inputs TTL level (0V or +5V nominal)

Overload detection, parameters set by components in the LED heads
cut-out duration during overload, 1 sec nominal, auto reset

5 Appendix

The information given here is provided to allow users to construct their own LED heads if they wish to do so. Alternatively - and perhaps more conveniently - it will allow heads supplied by us to be customised to use other LEDs if required.

5.1 LED Head Connections

The LED head has an 8-way locking DIN connector. The pin numbering for these connectors can most politely be described as bizarre, having evolved from connectors with fewer and more widely spaced pins. Therefore the pin numbers are just given here for reference, as the following visual description is likely to be much more helpful. Looking into the back (cable side) of the plug, oriented with the locator slot at the bottom, you will see seven pins forming most of a circle, with an eighth one (which actually is pin 8!) near the centre. The connections are described in a sequence going clockwise from the pin to the left of the locator slot, and ending with the near-central one. Heads for the OptoLED Lite do not include a feedback photodiode so only the pins indicated in bold are used. The heads are interchangeable between the OptoLED and the OptoLED Lite, with the extra functionality only being active if the full OptoLED heads are used with a full OptoLED controller.

- Pin 6 Positive connection to the LED.
- Pin 1 Negative (ground) connection to the LED.
- Pin 4 “Array” signalling connection. If this pin is connected to a positive voltage source, i.e. the positive supply voltage for the photodiode amplifier on pin 7, the “array” indicator on the controller will be illuminated, and the power readings on the meter will be reduced by a factor of 10, to allow power levels of 20W or more to be displayed. Otherwise this pin should be left disconnected.
- Pin 2 Input connection for the overload protection network. The resistors and capacitor comprising this network should be connected between here and ground, i.e. pin 3.
- Pin 5 Signal output from the photodiode amplifier.
- Pin 3 Ground connection for the protection network and the photodiode amplifier.
- Pin 7 Positive supply (+12 to +24V, depending on the drive voltage requirements for the LED, which are selected automatically) for the photodiode amplifier.

Pin 8 Negative supply [-5V] for the photodiode amplifier. Note that the controller detects the presence of an LED head by the current drawn from here by the photodiode amplifier.

Therefore if no amplifier is fitted, a 10Kohm resistor should be connected from here to ground [pin 3] in order to provide a dummy load.

5.2 Overload protection

The overload protection is programmed by an RC network in the plug for the LED head. This network forms part of a voltage divider from the measured power signal. Normally the power signal is 100mV/W, except when an LED array is used (detected by another connection in the LED head plug), in which case the signal is 10mV/W to allow higher powers to be controlled.

In both cases the power signal is connected to one of two comparator inputs (the signal input) in the OptoLED via a 100K resistor. This comparator input also connects to the RC network in the plug via a 1K series resistor (the resistor slightly complicates the RC network calculations but is there to protect the comparator input), and the other end of the RC network is connected to ground. The other comparator input (the reference input) is connected to a 200mV internal reference input.

Overload is triggered as soon as the signal input at the comparator exceeds the reference input; this cuts the power for about 1 second. If the protection "network" is just a single resistor, overload will be triggered as soon as the power exceeds the value set by this resistor. In practice, however, LEDs can be transiently over driven, and this can be permitted by connecting a second resistor in parallel with the first, but with a capacitor in series with the second resistor. The peak (transient) power is set by the parallel value of the two resistors, and this declines to the steady-state value set by the first resistor, with a time constant that depends on the resistor and capacitor values.

The resistance value R in K ohms to set a given steady-state power level P in watts is given by

$$R = 20 / (0.1P - 0.2) - 1$$

Solving for P rather than for R we obtain

$$P = 2 + (200/R + 1)$$

These relations give a minimum power of 2W (or 20W for an array) when R is infinite.

Calculated values and nearest preferred resistor values for higher powers are as follows:

Power	Calculated	Preferred
3W	199K	200K
4W	99K	100K
5W	65.7K	68K
6W	49K	47K
7W	39K	39K
8W	32.3K	33K
9W	27.6K	27K
10W	24K	22K
12W	19K	18K
15W	14.4K	15K
17W	12.3K	12K
20W	10.1K	10K
25W	7.7K	7K5
30W	6.1K	6K2
40W	4.3K	4K3
50W	3.2K	3K3
100W	1.04K	1K

These resistor values correspond to tenfold higher power levels in array mode, which is signalled as described in the LED head connections section of this Appendix. Note that the highest power that can be metered is 20W (200W for an array, although that power can't be achieved in practice), but the overload circuitry can in theory measure power levels of up to 100W.

For many LEDs the maximum drive specification may be given as a current rather than a power. In such cases the voltage drop across the LED at its maximum rated current should be measured and then multiplied by the current to determine the equivalent power level. This voltage is likely to be in the 3-4V range for green and blue LEDs, possibly rather more for UV devices and rather less for red ones. The permissible transient power levels may well not be quoted, so may need to be determined by trial and error if you want to exploit this possibility. Transient levels of 2-4 times the steady-state level, with

a decay time constant of around 10-20msec or possibly a little longer, will probably be about as far as we can go.

For setting a higher transient power overload level, another resistor R_p , in series with a capacitor C is connected in parallel with the resistance R calculated as above. The steady-state overload level will be the same as before, and the transient level will be given by the value of the two resistances in parallel. The procedure is to choose the effective parallel resistance value, R_{eff} , of R and R_p to give the required transient level, and then to calculate R_p from the relation $R_p = 1 / [1/R_{eff} - 1/R]$.

The time constant with which the overload power level declines from its transient to its steady-state value is set by the capacitance C that is in series with the parallel resistor, in conjunction with an equivalent resistance R_e , to give a time constant of $R_e C$. The procedure for calculating C for a given time constant T is as follows. First calculate R_e , which is given by $R+1K$ in parallel with $100K$, in series with R_p , i.e. $R_e = 1 / \{1/(R+1K) + 1/100K\} + R_p$. Then calculate the required value of C from $C = T/R_e$.

These components are connected between pins 2 (signal) and 3 (ground) of the connector plug. The orientation is unimportant, but by convention it makes more sense to have the capacitor on the ground side.

A practical example may be helpful in order to give some idea of the typical size of C . Let us assume we want a transient power level of 10W, declining to a steady-state level of 5W with a 10msec time constant. From the table we select 68K for R to get 5W steady-state power, and then select R_p to give a resistance of 24K (for R and R_p in parallel) to get 10W transient power. This requires R_p to be 37K, for which the nearest preferred value of 39K will be close enough. We now calculate R_e as above to get a value of 79.8K, giving a required value of C of about 125nF, for which either 120nF, or 100nF in parallel with 22nF, would be close enough.

6 Technical Support

e-mail : tech@cairn-research.co.uk

Web : <http://www.cairn-research.co.uk/>

Address : Cairn Research Ltd
Graveney Road
Faversham
Kent
ME13 8UP

Telephone : +44 (0) 1795 590 140

Fax : +44 (0) 1795 594 510

