Where Innovation and Lighting Begin

LLM MANUAL

Rev. 2020/06/09

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1 PRODUCT OVERVIEW

The programmable LED Light Manager (LLM) addresses the lighting control needs of multi-light machine vision solutions, including photometric 3D, multispectral and other multi-light systems.

Additional information about the LED Light Manager (LLM) can be found at: **smartvisionlights.com/products/llm**.

2 CERTIFICATIONS & WARNINGS

CERTIFICATIONS

The programmable LED Light Manager (LLM) is in compliance with the standards set for health, safety, and environmental protection standards for products sold within the European Economic Area set by the EC directives.

The programmable LED Light Manager (LLM) is in compliance with the standards set for the restriction of the use of hazardous substances in electrical and electronic equipment set by the Restriction of Hazardous Substances Directive (RoHS).

WARNINGS

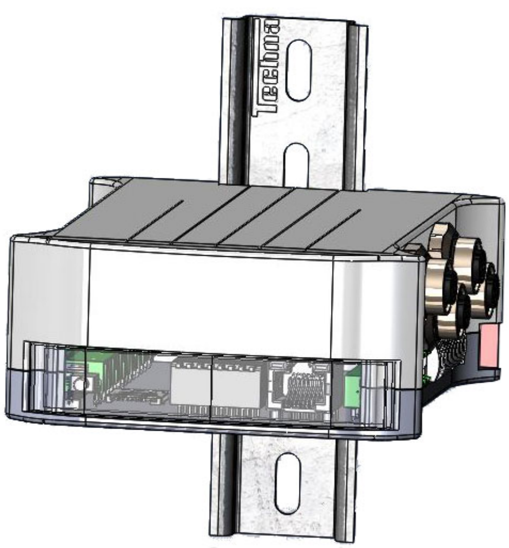
The user must ensure that the potential difference between any combination of applied signals does not exceed the supply voltage.

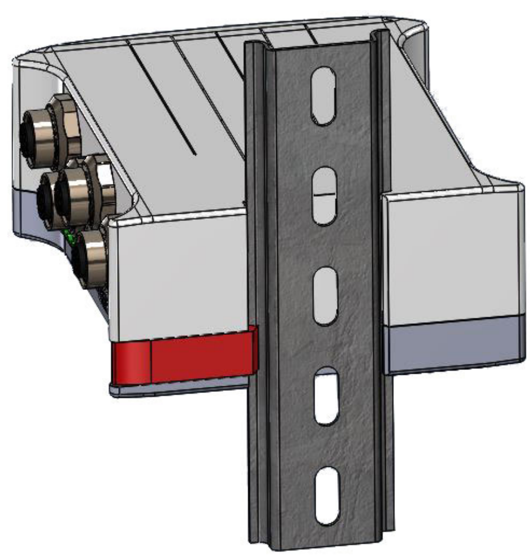
The LED Light Manager (LLM) must not be used in an application where its failure could cause a danger to personal health or damage to other equipment.

If in doubt, contact Smart Vision Lights for more details and instruction.

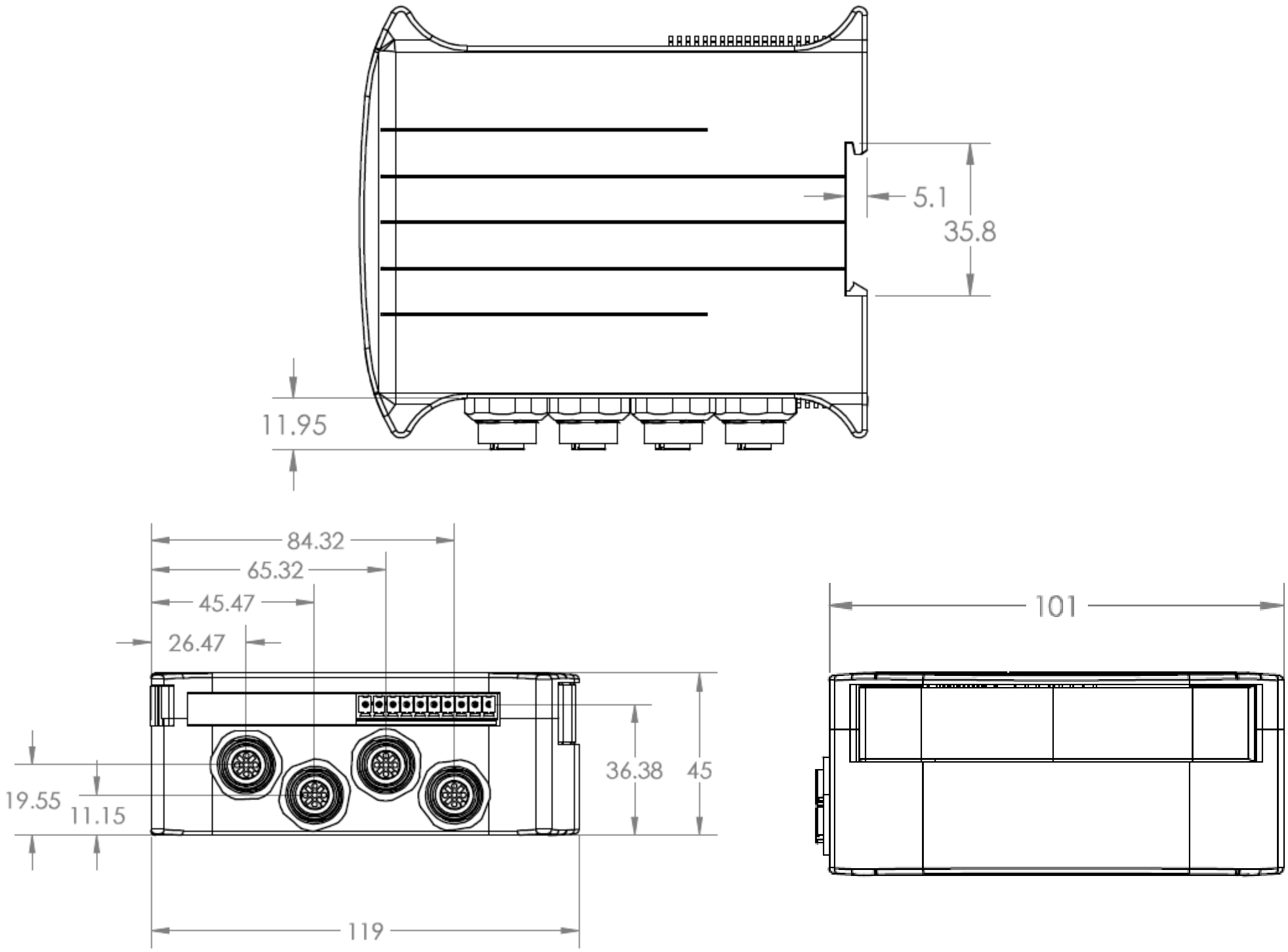
3 MECHANICAL

The LLM is designed to mount to standard 35mm DIN rail.





Dimensions are in mm.



Mounting	DIN Rail The LLM should be mounted as to prevent entry of particles and moisture.
Dimensions	H = 120 mm (4.7") | L = 107 mm (4.2") | W = 45 mm (1.8")
Ambient Temperature	-18ºC–40ºC (0ºF-104ºF)
Ambient Humidity	0%–95% non-condensing
Weight	233g
Compliances	CE, RoHS
Terminal Blocks	Two position terminal block (Power Connector) Eight position terminal block (Input Connectors) Ten position terminal block (Output Connectors)
M12 Connectors	Four 5-pin M12 connectors provide power, strobing, and analog voltage

4 ELECTRICAL

4.1 POWER

Electrical Input	24VDC +/- 5%
Electrical Input Connector	2 position screw terminal block – 14 AWG max wire size
Operating Current (No Load)	70 mA
Number of Input Channels	8 (including 1 input channel with interrupt capability)
Input Connector	8 position screw terminal block – 14 AWG max wire size
Max Input Channel Voltage	Not to exceed electrical input voltage
On / Off Trigger Input	PNP mode: +4VDC or greater to activate (max 26VDC) NPN mode: GND (<1VDC) to activate
Input Channel Current	PNP line: 4 mA @ 4VDC | 10 mA @ 12VDC | 20 mA @ 24VDC NPN line: 15 mA @ Ground (0VDC)
Output Channels	4 channels for lights plus 2 additional outputs, such as a camera trigger
Output Connectors	4 5-pin M12 connectors 10 position screw terminal block – 14 AWG max wire size (configurable for NPN or PNP)
Output Current Per Channel (M12 Connector)	Maximum Continuous Operation: 2.8 A average Maximum Total Average Current: 8 A (polyfuse protected)
Trigger Output Current (Per Channel)	PNP (sourcing): 65 mA NPN (sinking): 65 mA
Analog Output (Per Channel)	Voltage: 1–10VDC, continuous mode intensity control Current: 0.5 mA max (with fault protection)
Slave Mode	Selectable and configurable with DIP switches
Indicator Lights	Power on = green light Ethernet = 2 indicator lights
Protection Circuitry	Polyfuse protection
Programming Connector	Ethernet port
SD Card	microSD card
Reset Button	Hold down for 3 seconds
Mounting	DIN rail
Dimensions	H = 120 mm (4.7"), L = 107 mm (4.2"), W = 45 mm (1.8")
Ambient Temperature	-18º–40º C (0º–104º F)
Ambient Humidity	0%–95% non-condensing
Weight	~233g
Compliances	CE, RoHS
Terminal Blocks (Included with LLM)	2 position terminal block plug 8 position terminal block plug 10 position terminal block plug

4.2 INPUTS

Eight input terminals can be configured for all NPN or all PNP signals.

4.3 OUTPUTS

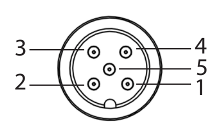
Using 5-pin M12 Connector

Lights can be connected using a standard 5-pin M12 connector. Up to *four lights can be connected to a single LLM.

*Using daisy-chainable and direct connect lights is possible as long as you do not exceed the 5-pin M12 connector max value (See Product Specifications for value).

NOTE:

Smart Vision Lights recommends referencing the digital sheet for each individual light for wiring configuration to determine exact wiring option and pin 5 function/signal.



5-pin M12 Connector
(Female)

5-pin M12 Connectors (Female) Pin Layout

Pin	Function	Signal
1	Power Out	+24VDC
2	NPN	Sinking Signal
3	GND	Ground
4	PNP	Sourcing Signal
5	*Varies by Light**	*Varies by Light**

*See Note

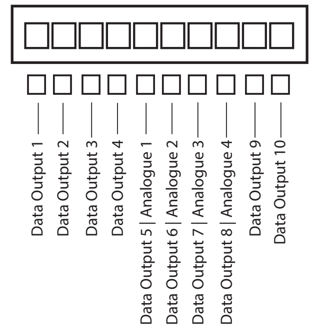
Using Output Terminal Blocks

If using a light with an external driver or a non-Smart Vision Lights' light with an internal driver, use digital output (1–4) to trigger PNP input.

Analog output is used when managing intensity control.

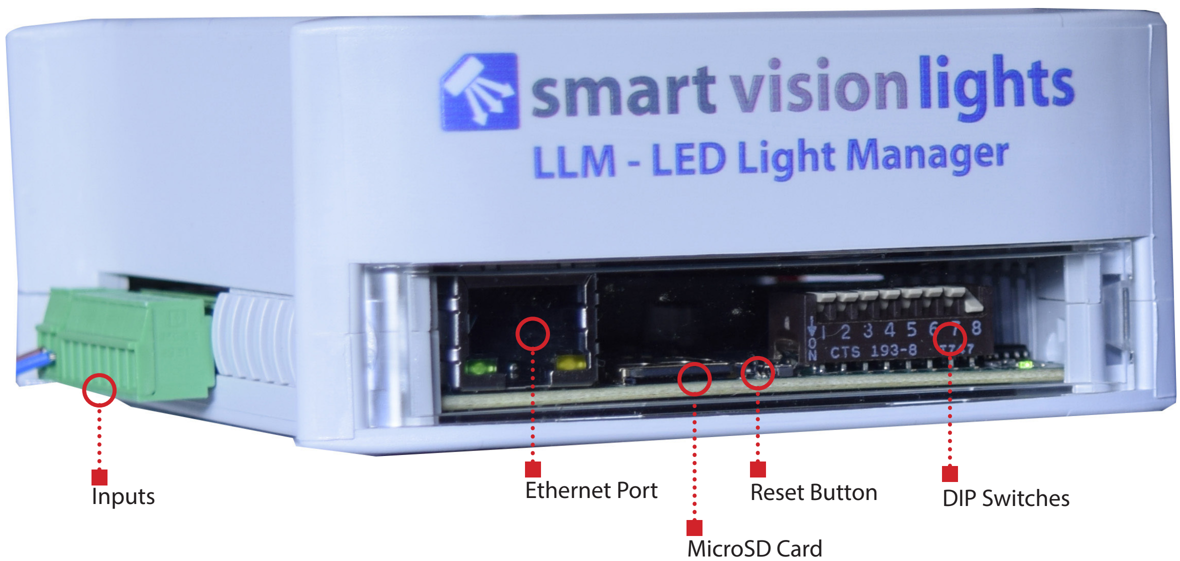
Digital output (9) can be used for controlling additional output devices, such as a Camera Trigger.

NOTE:
If lights are using a separate power source, number of lights per channel are limited only by digital output (1–4) or analog output (1–4). See Output Current per channel for digital output values or Analog Output per channel for analog output values in Product Specifications.



5 USER INTERFACE & COMMUNICATING WITH LLM

5.1 USER INTERFACE



Ethernet Port	RJ45, 10/100 Base-T Used to communicate via TCP/IP
DIP Switches (8 switches)	Used for selecting options, features, and configurations. The switch settings are read at power up.
MicroSD Card	Used to store the web page, data files, and IP address.
Reset Button	Application Specific.
Input Terminals	Eight input terminals can be configured for NPN or PNP signals. These can be used for strobbing, triggering, or handshaking with cameras and PLCs.

5.2 COMMUNICATING WITH THE LLM

Communicating With the LLM

- Open web browser and enter IP address (default IP address: 192.168.0.200)
- The web page will be displayed (the data fields will be initially empty)
- The following message will be displayed “Data loaded! Click OK to display data”
- Click OK, the data on the SD card will be displayed
- Once the data is displayed, make desired updates
- Review your updates
- Click on Save to save the updated data
- The following message will be displayed “Data saved” , Click OK

NOTE:

The LLM default IP address is set to: **192.168.0.200.**

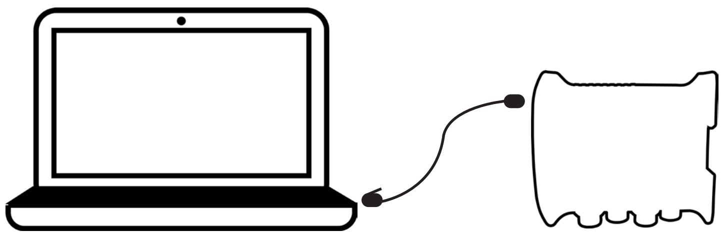
NOTE:

Time input range for both Trigger Delay* and Pulse Duration is: **0-65500µs or 0-65500ms.**

**There is built-in 10ms delay. See Managing Input Events section for more information.*

If your network is not set up to use 192.168.0.xxx, you will need to connect a computer to the LLM using a standard Ethernet cable (such as a Cat5e cable). Set your computer's IP address manually to 192.168.0.150. Set the subnet to 255.255.255.0. You will now be able to communicate with the LLM via your web browser.

Note: Make sure you set your computer back to the network settings prior to making the above changes to ensure your computer works properly on your network.



Managing Multiple LLM on the Same Network

The IP address for the LLM is static. The IP address is not dynamic and cannot be set via DCHP.
By setting each LLM IP address differently will allow multiple LLM to be on the same network.

The default IP address is: 192.168.0.200. To change the IP address, remove the SD card from the LLM and locate the ip.txt file. Open this file and change the IP address. Save the file. Place the SD card back into the LLM and restart the unit.

NOTE:
The IP address for the LLM is static. The IP address is not dynamic and cannot be set via DCHP.

6 TYPICAL CONFIGURATION AND USE CASES

6.1 USE CASE 1

The LLM can drive up to four separate lights of virtually any type or up to four individual zones or channels within an integrated photometric or multispectral ring light solution. Each program can contain up to six sequences with up to four lights set to continuous on, off, or any intensity level in between, and even OverDrive™ strobe mode.

Master Mode (Default Mode)

Master mode allows you to use the full function of the LLM. This mode allows you to control up to six sequences and zones using the built-in web browser based interface. **DIP switch 1 needs to be set to master mode.**

Slave Mode

Slave mode allows you to bypass the controls set using the web page interface. When the LLM is set to slave mode, the output signal follows the input signal and allows for the output signal to be set to the same or opposite polarity as the input signal.
DIP switch 1 needs to be set to slave mode.

The LLM uses the following convention for setting up the input triggering.

NPN triggering: The triggering device provides a sinking signal that is at ground potential (typically less than 1VDC)
PNP triggering: The triggering device provides a sourcing signal that is between 4VDC and 24VDC

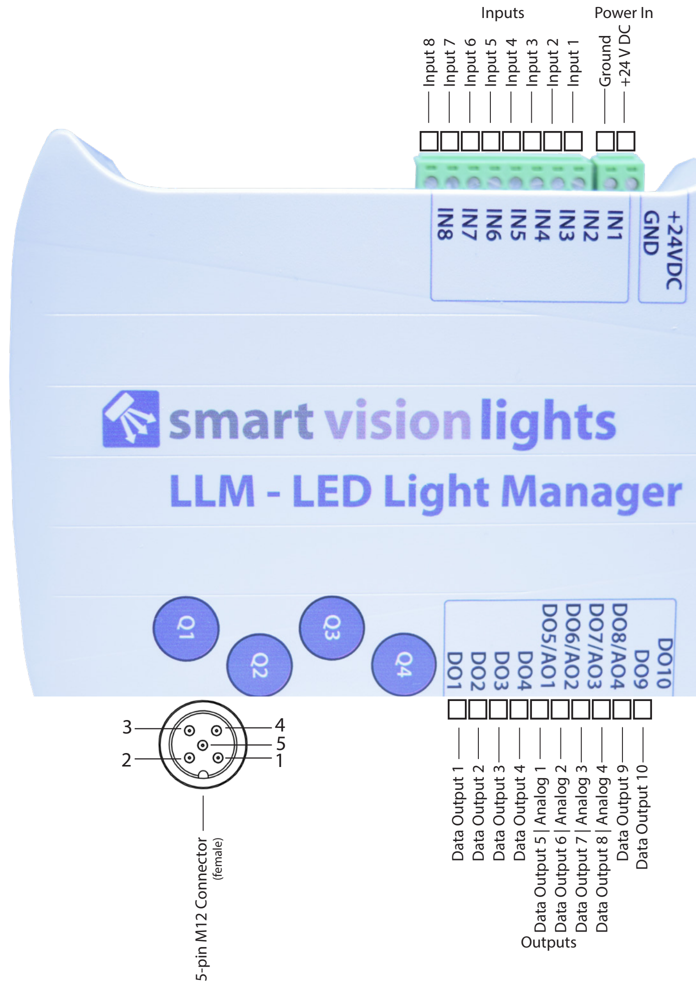
Master Mode

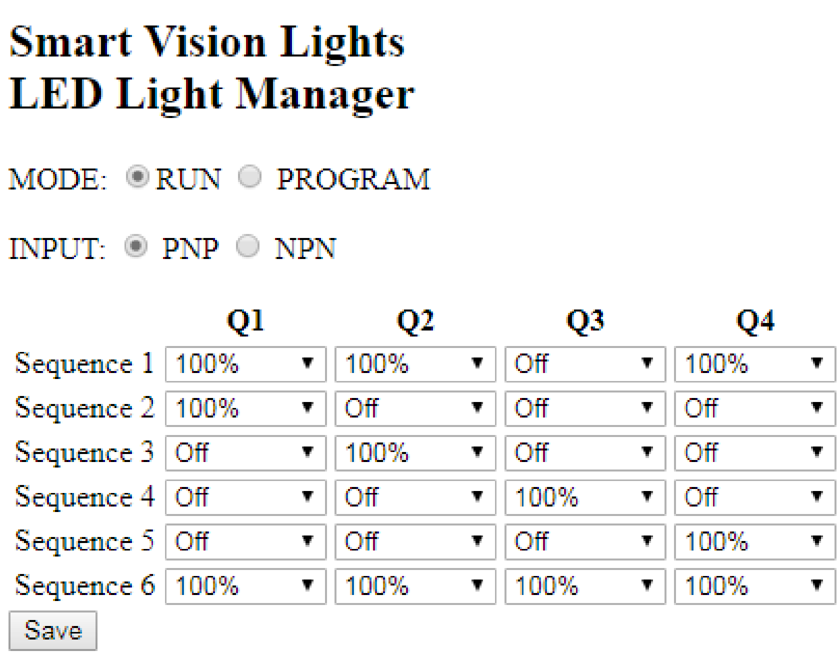
When connecting a camera to the LLM:

Action	Pin
Sequence Start	Input 6
Exposure Complete	Input 7
Camera Trigger	Data Output 9

Slave Mode

Data outputs 1–8 are slaves to the data input. They can be set to be the same or opposite polarity as the input signal.





Smart Vision Lights
LED Light Manager

MODE: RUN PROGRAM

INPUT: PNP NPN

	Q1	Q2	Q3	Q4
Sequence 1	100%	100%	Off	100%
Sequence 2	100%	Off	Off	Off
Sequence 3	Off	100%	Off	Off
Sequence 4	Off	Off	100%	Off
Sequence 5	Off	Off	Off	100%
Sequence 6	100%	100%	100%	100%

Save

The DIP switches located on the front of the LLM are used to configure the LLM for master or slave mode as follows:

Master Mode (DIP switch 1)

DIP switch 1 set the LLM to master mode. Master mode uses the settings configured during your last programming session.

Set Trigger Delay (DIP switch 6 - Active in Master mode)
Set camera trigger delay to 50 µs.

Restart Sequence Event (DIP switch 7 - active in Master mode)
Restart sequence event with each sequence start signal. *(See Restart Sequence Event for more information)*

Test Mode (DIP switch 8 - active in Master mode)
Allows you to select if you want to run the LLM in test mode. Available on version 1.7 or greater. *(See Test Mode for more information)*

Slave Mode (DIP switch 1)

When DIP switch 1 is set to slave mode, DIP switches 2 and 3 become active. Setting DIP switch 1 to slave mode bypasses the program created when accessing the web page interface. The output signal follows the input signal and allows the output signal to be set to the same or opposite polarity as the input signal. *Slave mode can only use terminal block (input/output).*

Input Signal PNP/NPN (DIP switch 2 - active in Slave mode)
Allows you to select your input signal as either PNP (sourcing) or NPN (sinking).

Output Signal PNP/NPN (DIP switch 3 - active in Slave mode)
Allows you to select your output signal as either PNP (sourcing) or NPN (sinking).

← ON

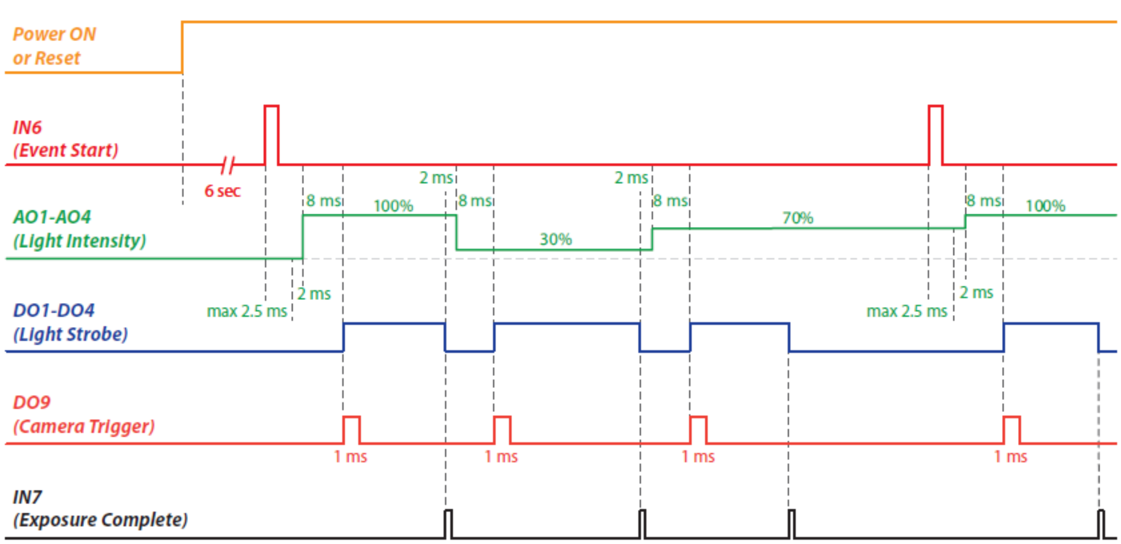
1	Slave		Master
2	Input NPN		Input PNP
3	Output NPN		Output PNP
4	Not Used		Not Used
5	Not Used		Not Used
6	Trigger Delay On		Trigger Delay Off
7	Restart Sequence On		Restart Sequence Off
8	Test Mode On		Test Mode Off

Example: Toggling DIP switch 1 in the opposite direction of the number (1) will set the LLM into Master mode.

NOTE:

In order to use the setting you program using the web page interface, you need to have **DIP switch 1 set to master**.

LLM Timing



Event Configuration:

- PNP Input
- 3 Sequence Event (maximum of 6 sequences)
- Timing for 1 light (maximum of 4 Lights)

***not to scale**

6.2 USE CASE 2

This application allows the user to control the 4 channels of SVL lights, giving the ability to strobe four lights independently and adjust the Delay, Pulse Duration, and Brightness separately for each input. The LLM uses 4 independent input lines (Inputs 1 – 4) and each can trigger any output channel (light) based on the user configuration. Each of the 4 input lines have the capability to trigger 1 to 4 of the output channels simultaneously. The intensity of each light can be set independently. The intensity levels can be set in increments of 1% from 10% to 100%, (or OverDrive™ for Multi-Drive lights). Any of the output channels can be selected to be off.

The LLM uses the following convention for setting up the input triggering.

PNP triggering: The triggering device provides a sourcing signal that is between 4VDC and 24VDC
NPN triggering: The triggering device provides a sinking signal that is at ground potential (typically less than 1VDC)

	Input 1		Input 2		Input 3		Input 4	
Light 1	100% ▼		100% ▼		100% ▼		100% ▼	
Light 2	100% ▼		100% ▼		100% ▼		100% ▼	
Light 3	100% ▼		100% ▼		100% ▼		100% ▼	
Light 4	100% ▼		100% ▼		100% ▼		100% ▼	
Trigger Delay	10000	us ▼	20555	us ▼	35500	us ▼	100	ms ▼
Pulse Duration	100	ms ▼	1000	ms ▼	25500	us ▼	3000	ms ▼

Save

The DIP switches located on the front of the LLM used to configure input events are as follows:

DIP Switch 2 **Input Signal PNP/NPN**

Allows you to select the input polarity as either PNP or NPN.

NOTE:

When a DIP switch is toggled, a reset or power cycling of the LLM is required.

← ON

1	Not Used		Not Used
2	Input NPN		Input PNP
3	Not Used		Not Used
4	Not Used		Not Used
5	Not Used		Not Used
6	Not Used		Not Used
7	Not Used		Not Used
8	Not Used		Not Used

Example: Toggling DIP Switch 2 in the opposite direction of the number (1) will set the LLM into Input NPN.

There is a 10ms Trigger Delay for each input event. For example: for a 30ms Trigger Delay, set the program value to be 20ms.

When the light intensity is changed from one input event to the next, there will be a minimum 10ms delay. This delay is required to give the lights enough time to adjust to the new intensity value.

Trigger Delay and Pulse Duration must be set using whole number values only - no decimals or commas are allowed. For fractional millisecond values, enter the value using whole number microseconds. For example, a 1.5ms Pulse Duration should be entered at 1500µs.

The maximum delay or strobe time is 65500ms (65.5 seconds).

The Camera Trigger value must be less than the total of the Trigger Delay and Pulse Duration values, or the input event will trigger again.

Camera Trigger < Trigger Delay + Pulse Duration

Minimum pulse width for Camera Trigger is 175µs.

7 COMMAND STRUCTURE & API

A carriage return is required at the end of each command.

NAME	TYPE	ACCESS	COMMENT
LineSelector	String (S)	R	Select the Line. (Line1 corresponds to Input 1, Line2 to Input 2, ect…).
LightBrightness[LightController]	Integer	RW	Set the brightness/intensity for a light. This change is applied to the Line (Input) previously selected (LineSelector), or Input 1 as a default. Accepted Values: 0 = OverDrive™ strobe mode, 101 = off, 10-100 = 10%-100%.
TimerDelay[Timer]	Integer	RW	Set the Timer Delay (Trigger Delay) in microseconds for each Line. Max value is 65500.
TimerDelayMs[Timer]	Integer	RW	Set the Timer Delay (Trigger Delay) in milliseconds for each Line. Max value is 65500.
TimerDuration[Timer]	Integer	RW	Set the Timer Duration (Pulse Duration) in microseconds for each Line. Max value is 65500.
TimerDurationMs[Timer]	Integer	RW	Set the Timer Duration (Pulse Duration) in milliseconds for each Line. Max value is 65500.

EXAMPLES

To set Light 3 on Input 2 to have an intensity value of 80%.

```
LineSelector=Line2
LightBrightness[LightController3]=80
```

To set the timing values for Input 3 to have a Timer Delay (Trigger Delay) of 100 ms and a Timer Duration (Pulse Duration) of 500 µs.
(There is a built-in 10 ms trigger delay for each input event automatically added.)

```
TimerDelayMs[Timer3]=90
TimerDuration[Timer3]=500
```

FULL CODE EXAMPLE

When setting all values for the LLM, the following code can be used. Depending on the terminal software

```
LineSelector=Line1
LightBrightness[LightController1]=100
LightBrightness[LightController2]=100
LightBrightness[LightController3]=101
LightBrightness[LightController4]=0
LineSelector=Line2
LightBrightness[LightController1]=95
LightBrightness[LightController2]=100
LightBrightness[LightController3]=65
LightBrightness[LightController4]=100
LineSelector=Line3
LightBrightness[LightController1]=101
LightBrightness[LightController2]=23
LightBrightness[LightController3]=100
LightBrightness[LightController4]=100
LineSelector=Line4
LightBrightness[LightController1]=100
LightBrightness[LightController2]=100
LightBrightness[LightController3]=0
LightBrightness[LightController4]=0
TimerDelay[Timer1]=10000
TimerDelay[Timer2]=20555
TimerDelay[Timer3]=35500
TimerDelayMs[Timer4]=100
TimerDurationMs[Timer1]=100
TimerDurationMs[Timer2]=1000
TimerDuration[Timer3]=25500
TimerDurationMs[Timer4]=3000
```

NOTES

- The timer delay (Trigger Delay) can be set to either a microsecond or millisecond value, but not both.
- The Timer Duration (Pulse Duration) can be set to either a microsecond or millisecond value, but not both.
- Light intensity setup:
  - 10-100 sets intensity to 10%-100%
  - 0 sets the Multi-Drive™ lights to OverDrive™ strobe mode
  - 101 will set the light to be off
- LineSelector corresponds to Input (Line1 corresponds to Input 1); there are four Inputs.
- LightController corresponds to a light with an internal driver. A total of four lights (or light strings) can be connected to the LLM.
- There is a built-in 10ms trigger delay for each input event. Example: if you want to have a 30ms Trigger Delay, set the program value to be 20ms. A carriage return is required at the end of each command.

8 APPLICATION EXAMPLES

8.1 INTERFACING WITH 4ZMD FOR MULTI-ZONE LIGHTING

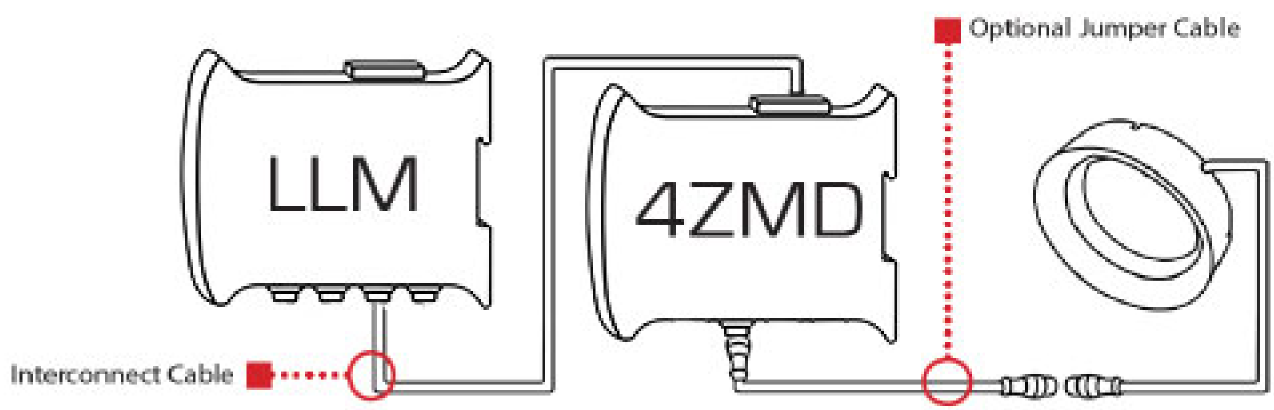
Using Input Terminal Block

The Input terminal block is used to interface the LLM with the 4ZMD by using an interconnect cable provided by Smart Vision Lights (Part Number: IC-400).

LLM Output Channels	4ZMD Input Channels
DO1	PNP IN1
DO2	PNP IN2
DO3	PNP IN3
DO4	PNP IN4
DO5/AO1	Analog 1
DO6/AO2	Analog 2
DO7/AO3	Analog 3
DO8/AO4	Analog 4

Managing Zones

The LLM provides a simple way to control and sequence a 4ZMD Multi-Zone driver whereby individual lighting zones, or individual lights, can be arranged in an arbitrary lighting sequence with both timing and light intensity settings. This includes the ability to operate in OverDrive™ stobe mode.



Zone control

Smart Vision Lights offers lights with four built-in, independently controllable LED zones. With the 4ZMD Multi-Zone driver, each zone can be set to continuous on, off, or any intensity level in between and OverDrive™ mode. Intensity levels can be set by programming the LLM to control the zones or by using the intensity limit controls on the front of the 4ZMD.

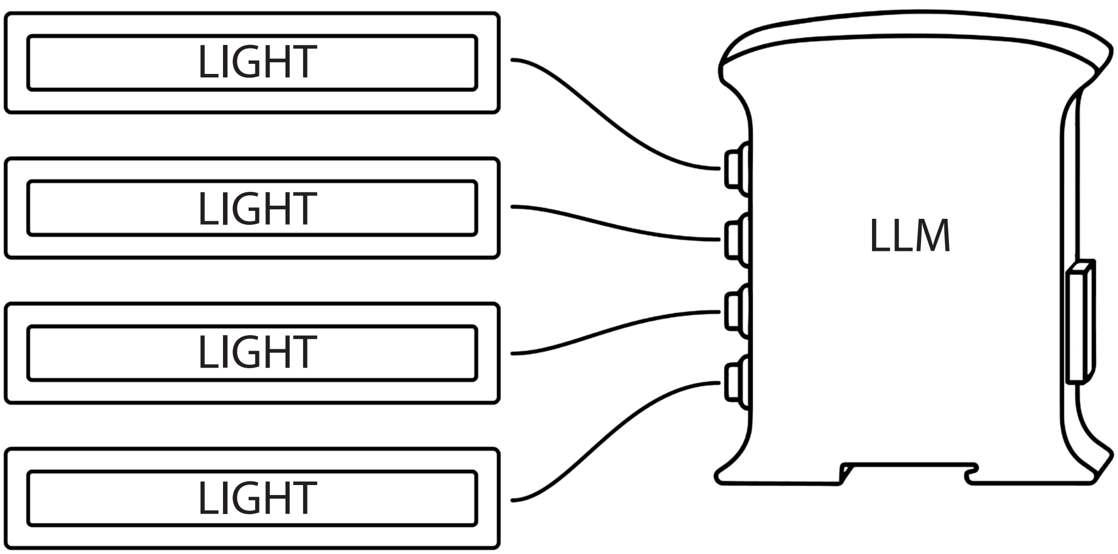
These four-zone lights enable any combination of the zones to be turned on at the same time, including adjacent and opposing zones.

8.2 CONNECTING THE LLM TO STANDARD SMART VISION LIGHTS PRODUCTS

SVL's lights with internal drivers can be connected directly to the LLM using the four M12 connectors.

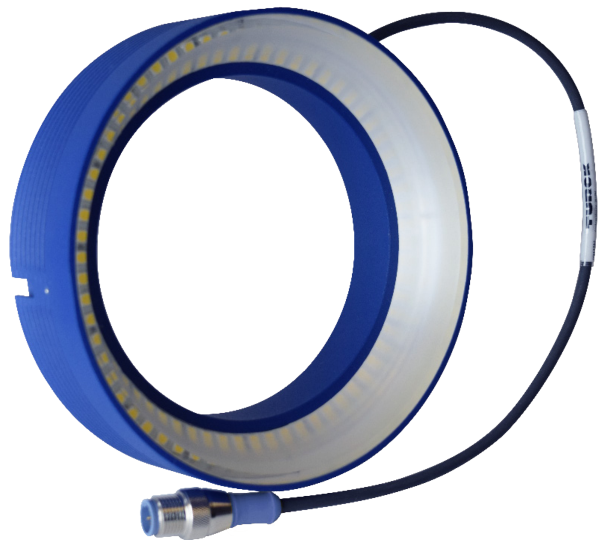
Below is an example diagram with four linear lights connected to the LLM.

The LLM provides the power, strobe signals, and analog voltage (intensity) to control the lights based on the setup via the local web page.



PHOTOMETRIC STEREO IMAGING

Photometric stereo imaging is a technique used to resolve surface shape and orientation by capturing multiple images of an object illuminated by a sequence of lights at varying illumination angles. This technique, achieved with multi-zone lighting, can be useful when surface features are obscured by textures or other complex variations in surface reflectance. In a typical photometric stereo setup, a stationary camera captures multiple images of a stationary object, with each image resulting from different illumination angles provided by the carious lighting zone locations. These images are then processed together to produce a resultant image that shows relative surface shape variations as pixel intensity variations.



The applications on the next two pages use the following setup:

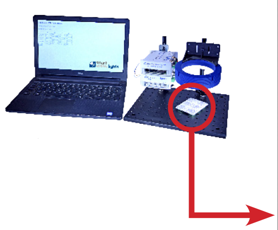
LIGHT: RM140-4Z

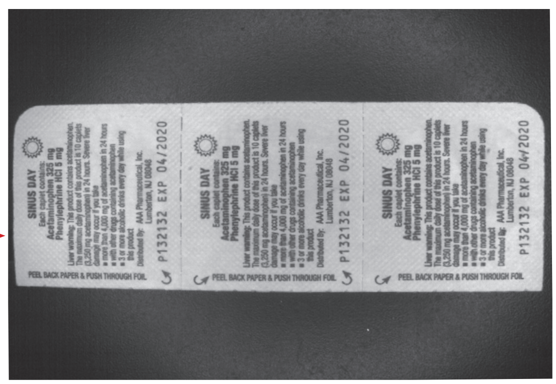
DRIVER: 4ZMD

SOFTWARE: Open-source image processing with Fiji

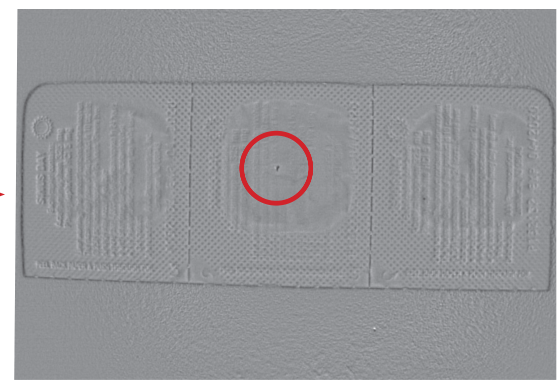
APPLICATION: PILL PACK WITH PUNCTURE

Photometric stereo detects a pinhole, otherwise obscured by print and lighting, on a pill pack.



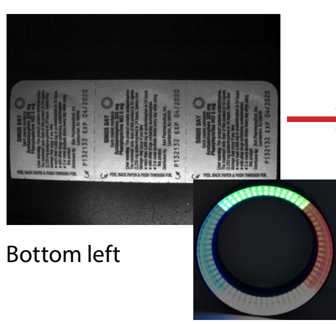


Original image (average of all four images)

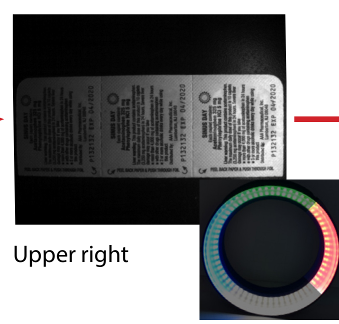


Photometric stereo image. The pinhole is easily distinguished from the print. Note that because the print has a sheen to it, the algorithm does not completely eliminate the print.

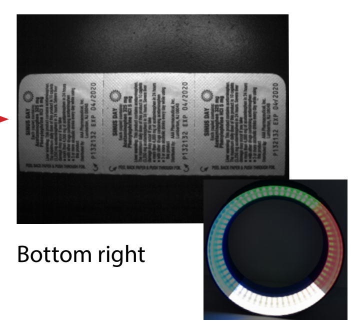
Upper left



Bottom left



Upper right

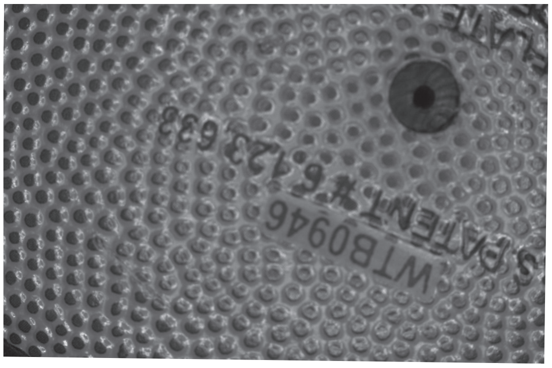


Bottom right

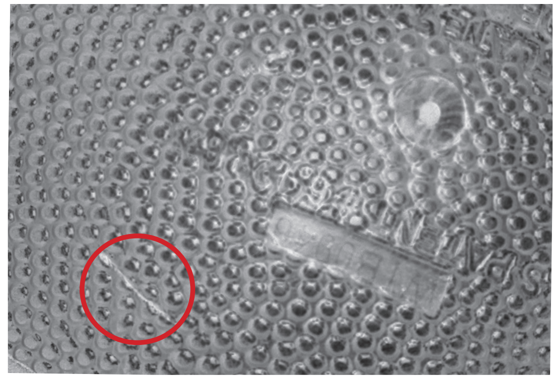
APPLICATION: COMPLEX SURFACE TEXTURE WITH SCRATCH

The overall surface of a basketball has high curvature and many small features that can hide defects.

Photometric stereo reveals a scratch on the bottom right side of the ball.

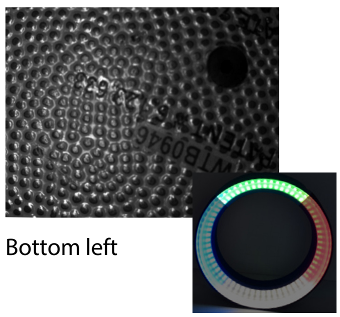


Original image (average of all four images)

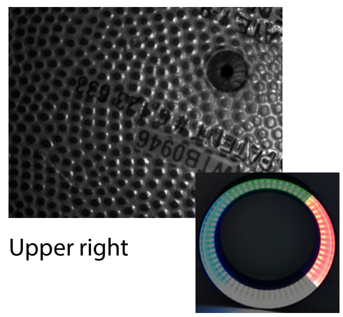


Photometric stereo image. Notice scratch in bottom right corner. Print on ball disappears. Only embossed surface features will appear in the resulting image.

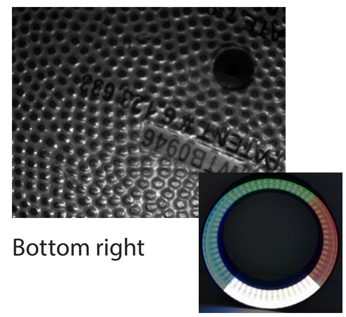
Upper left



Bottom left

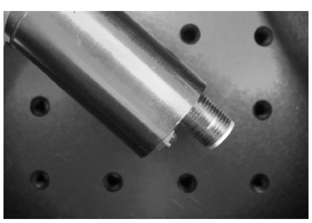


Upper right

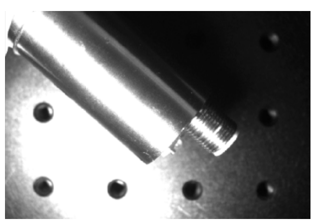


Bottom right

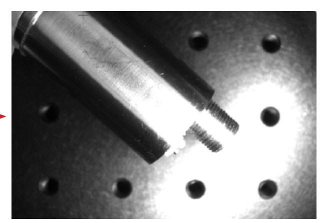
APPLICATION: STAINLESS STEEL CYLINDER



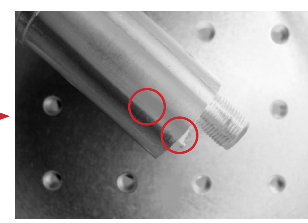
Original image
(average of all four images)



Bottom left



Bottom right



Photometric stereo image. Glare on part is significantly reduced to reveal scratches. The depth information of the background holes is also revealed.

MULTISPECTRAL IMAGING

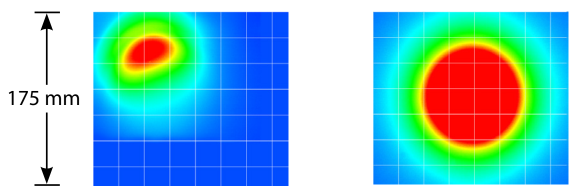
Multispectral imaging refers to a system capable of capturing between three and 10 wide spectral wavelength bands. By carefully analyzing image data within multiple spectral bands, machine vision systems can solve color applications that were beyond the capability of traditional RGB machine vision solutions. Where multispectral images must be precisely registered to one another, multiple image sensors can capture different wavelengths.

LIGHT: RM75-4Z

LIGHT PATTERNS

The RM75-4Z Mini Ring Light produces a uniform light pattern.

Working distance = 100 mm



One Zone — Four Zones

(Grid set to 25 mm x 25 mm)

Lighting Illumination for the RM75-4Z

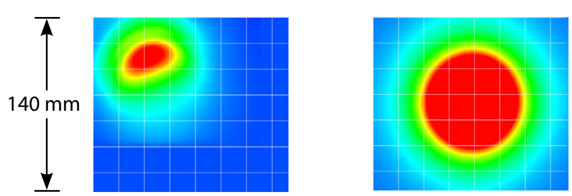
Continuous Operation Mode		
Typical Output Performance	Illuminance (Lux)	
	1 Zone	All Zones
Distance = 100 mm	55,000	200,000
Illumination measurement taken on white light, 4800 K		

OverDrive™ Strobe Mode		
Typical Output Performance	Illuminance (Lux)	
	1 Zone	All Zones
Distance = 100 mm	44,000	160,000
Illumination measurement taken on white light, 4800 K		

Smart Vision Lights recommends using the RM75-4Z at a working distance between 50 mm and 200 mm.

The RM140-4Z Mini Ring Light produces a uniform light pattern.

Working distance = 100 mm



One Zone — Four Zones

(Grid set to 20 mm x 20 mm)

Lighting Illumination for the RM140-4Z

Continuous Operation Mode		
Typical Output Performance	Illuminance (Lux)	
	1 Zone	All Zones
Distance = 100 mm	12,000	35,000
Illuminance measurement taken on white light, 4800 K		

OverDrive™ Strobe Mode		
Typical Output Performance	Illuminance (Lux)	
	1 Zone	All Zones
Distance = 100 mm	96,000	280,000
Illuminance measurement taken on white light, 4800 K		

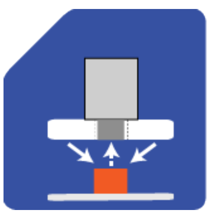
Smart Vision Lights recommends using the RM140-4Z at a working distance between 50 mm and 200 mm.

MULTISPECTRAL APPLICATION: €500 NOTE

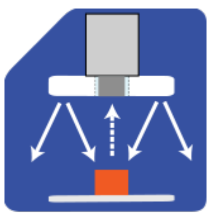
The first image shows a €500 banknote illuminated with standard white light. Modern banknotes use visible inks of differing colors as well as inks and embedded anti-counterfeiting features that are only revealed by nonvisible light, magnetic fields, and other security apparatuses. For example, fine details within the building are lost when the note is illuminated by red light.

As the illumination wavelength moves into the near and shortwave infrared, at 850 nm hidden watermarks, as well as the embedded magnetic strip inside the paper, are revealed. Also, half the building is apparently printed with infrared sensitive ink, while the other half is not. By moving to the longer wavelength of 1200 nm, the infrared light penetrates farther through the paper, revealing printed features on the opposite side of the note. As the wavelength shifts to even longer infrared light (1450 nm), even more features from the opposite side are revealed, making the paper substrate appear transparent. These different colors and features — visible and hidden — all form a complex anti-counterfeit security system that is revealed only through multispectral imaging.

RM75-4Z and RM140-4Z lights work best for:



Dark Field

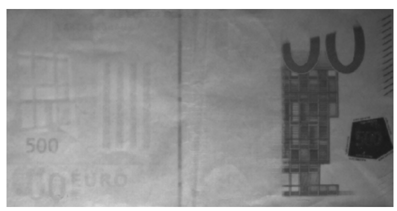


Radial

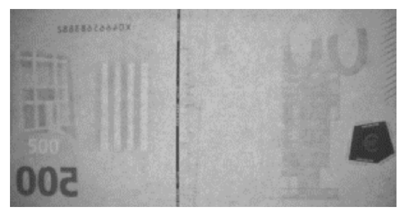
Original image (white light)

470 nm (blue): The stars on the right show up very well with the blue light.

530 nm (green): Many of the fine details seem to pop out here. Notice the details inside the stars. The stars on the right side seem to disappear.



850 nm: Watermarks and embedded strip show up. Hidden features start to appear. It looks as if the building were printed with different types of ink.



1450 nm backlight: Features from the other side of the bill start to show; the substrate material looks semitransparent.