AtlasScientific™
Environmental Robotics

V 2.0

Revised 5/18/18

EZO-RGB™

Embedded Color Sensor

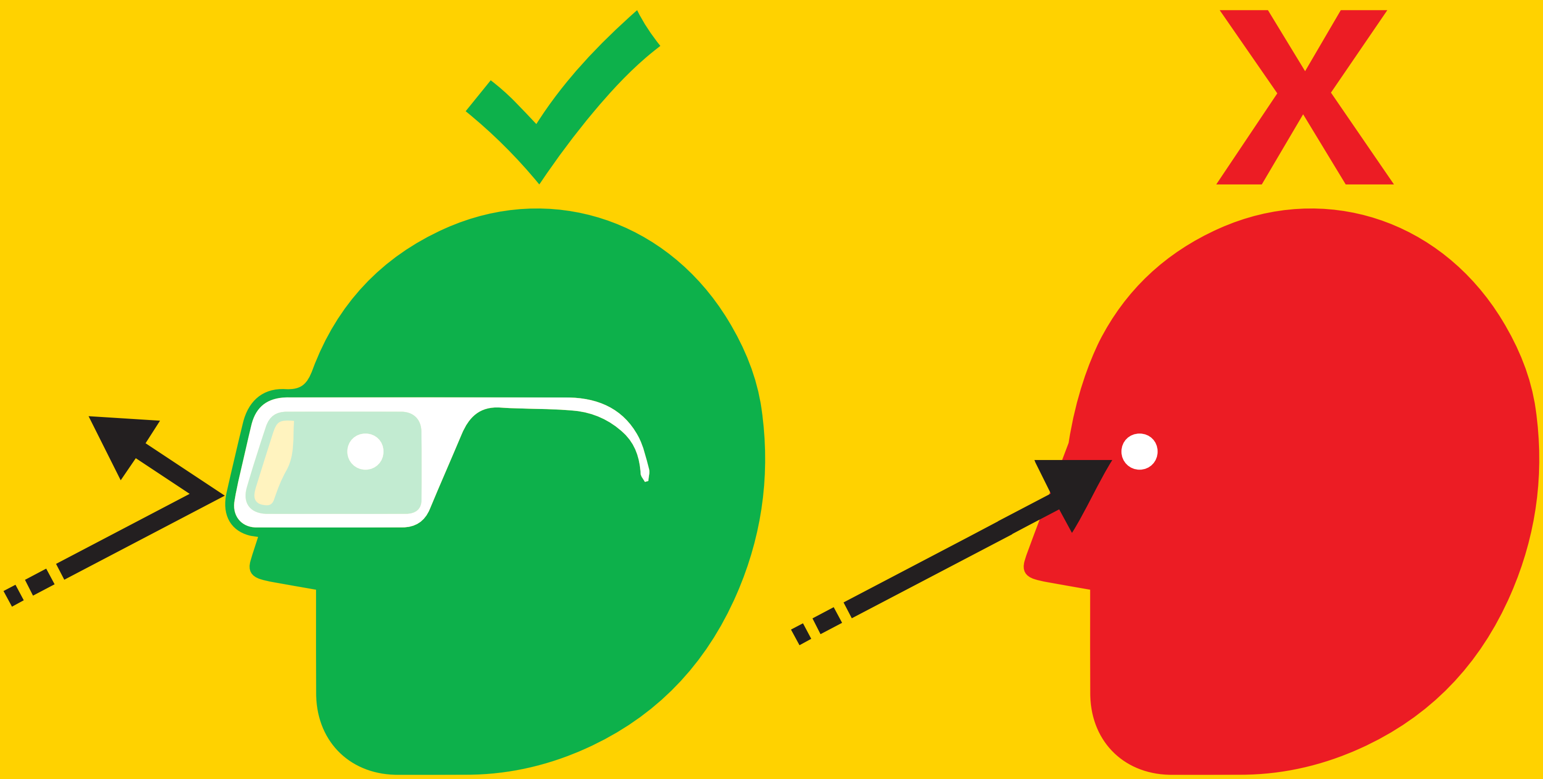
Reads	**RGB (24-bit)** **CIE (xyY)** **LUX (0 – 65535)** **Proximity (2 – 36cm)**
Features	**programmable color matching** **proximity triggering** **onboard LEDs**
Response time	**400ms**
Sensing area	**15° half angle**
Cable length	**1 meter**
Water proof/dust proof	**Yes**
Data protocol	**UART**
Data format	**ASCII**
Operating voltage	**3.3V – 5V**

Written by Jordan Press
Designed by Noah Press

This is an evolving document, check back for updates.

Caution

At full power the onboard LEDs are *VERY* bright.
Do not look directly at the light without eye protection!



Minimum brightness = **~400 Lux**
Maximum brightness = **~*40,000* Lux at 5V (*36,000* Lux at 3.3V)**

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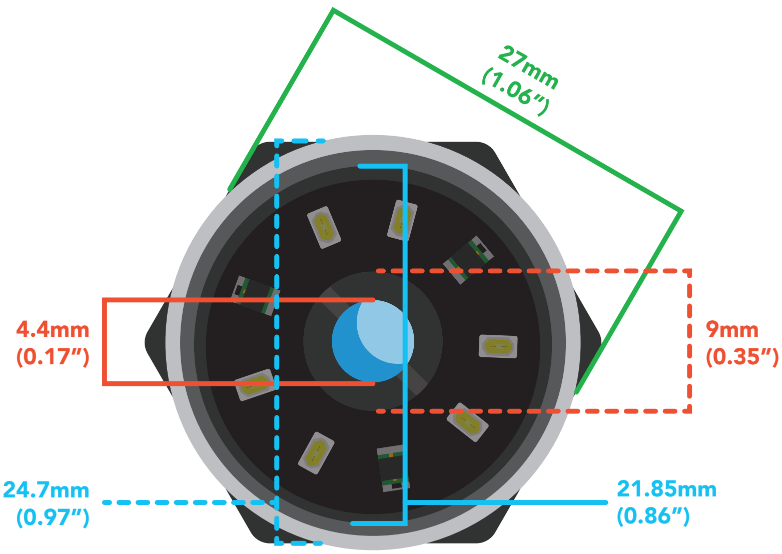
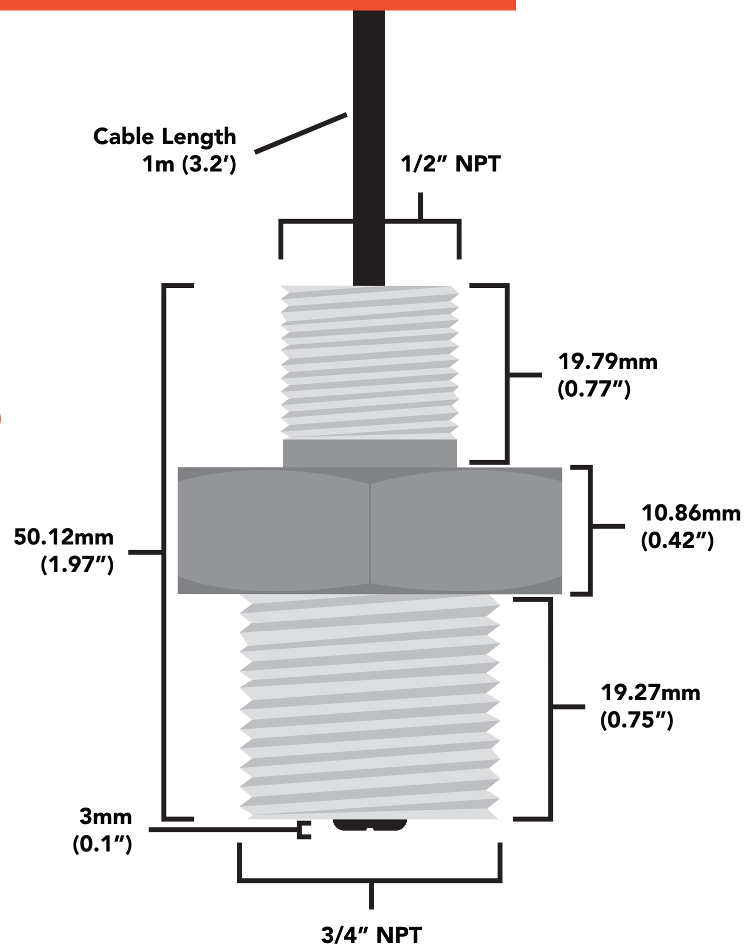
UART

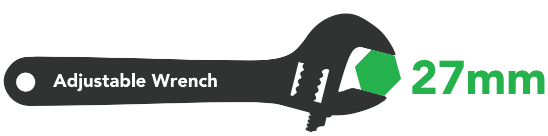
Physical properties

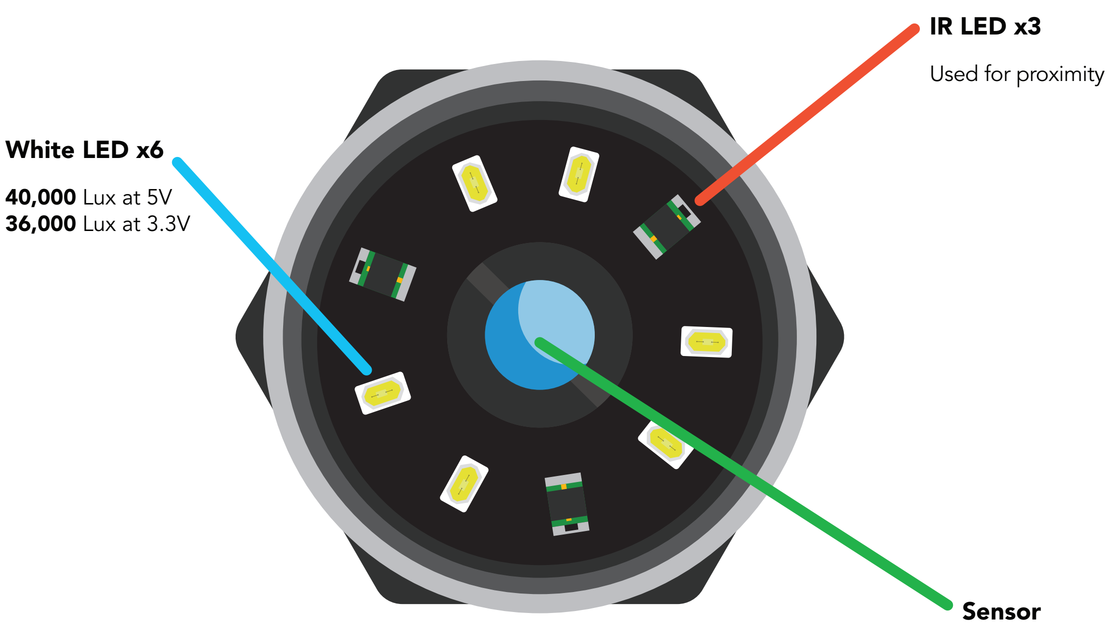
The EZO-RGB™ can be *fully submerged* in fresh water or salt water, up to the female connector *indefinitely*. However, it cannot be submerged in organic solvents, doing so will permanently damage the lens.





Weight 145g





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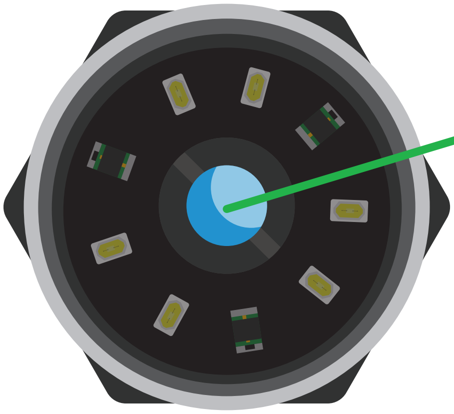
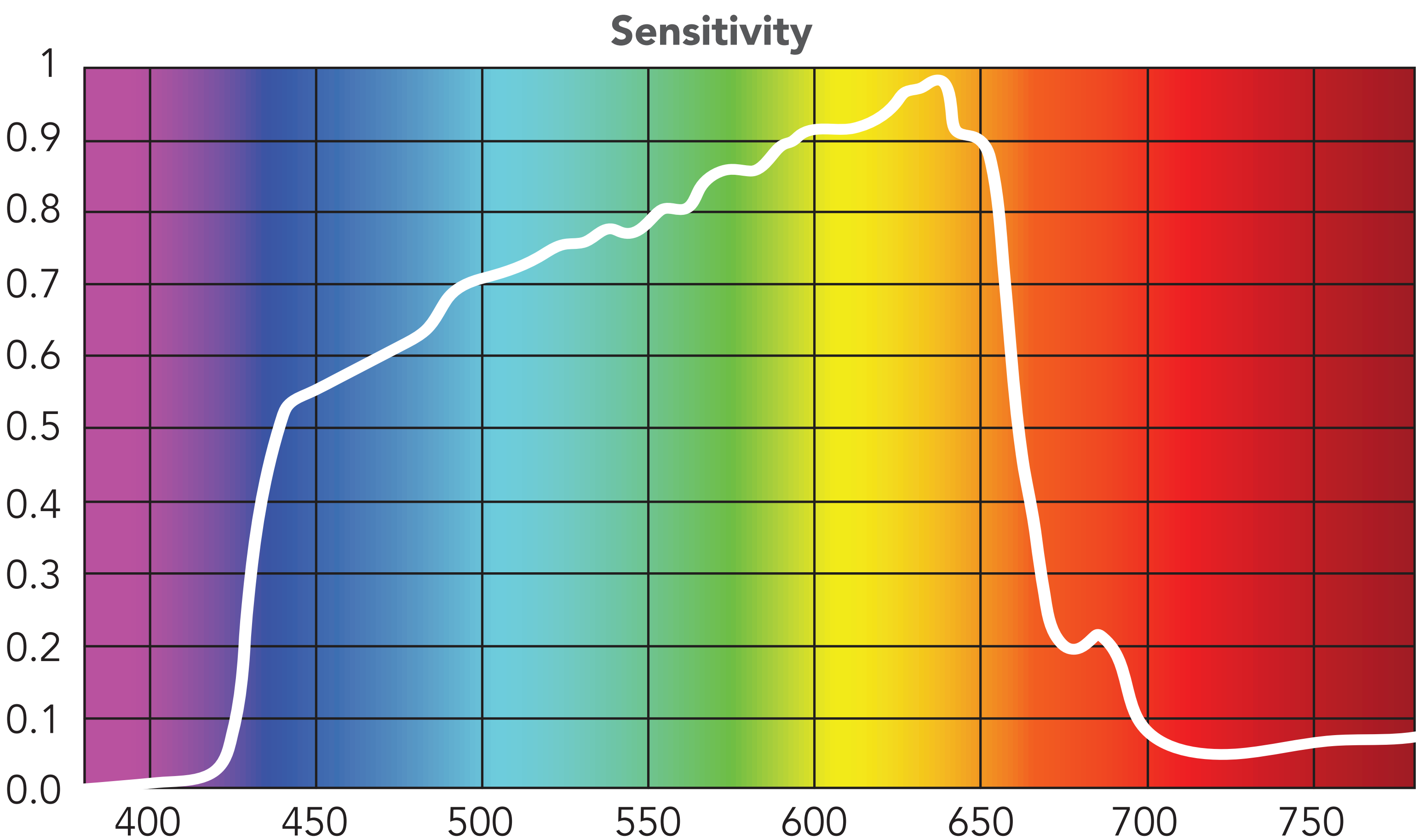
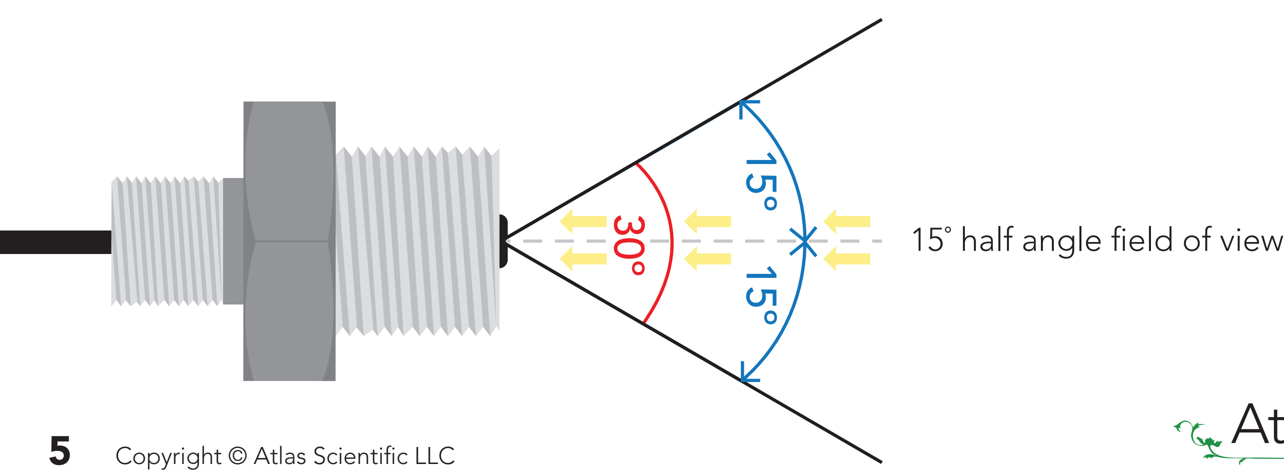
Sensor properties



Sensor

The sensor detects colored light in the red, green and blue spectrum. It is least sensitive to blue light and most sensitive to red light.





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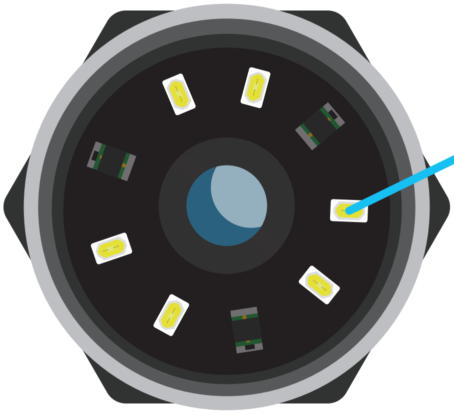
LED properties

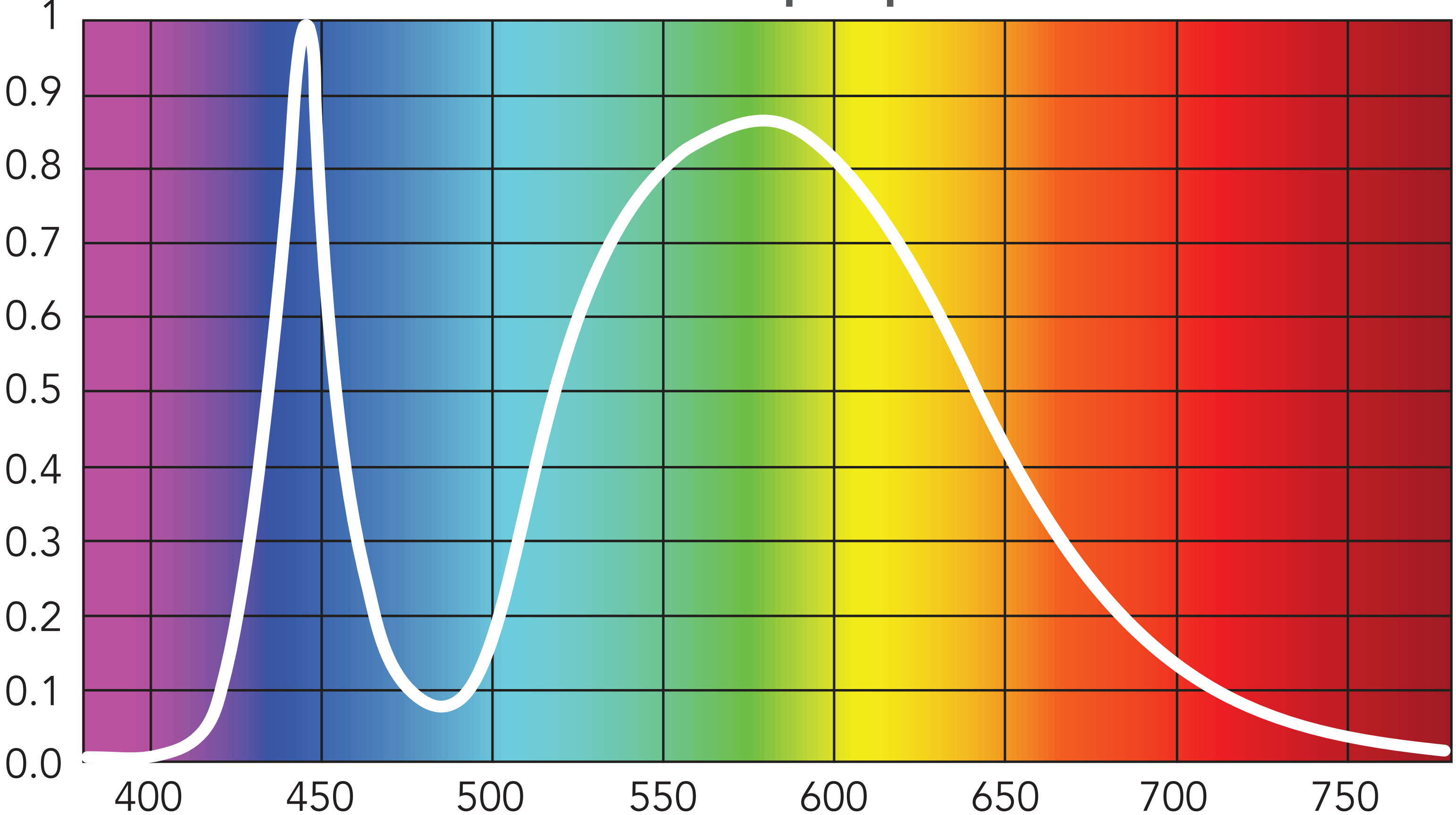


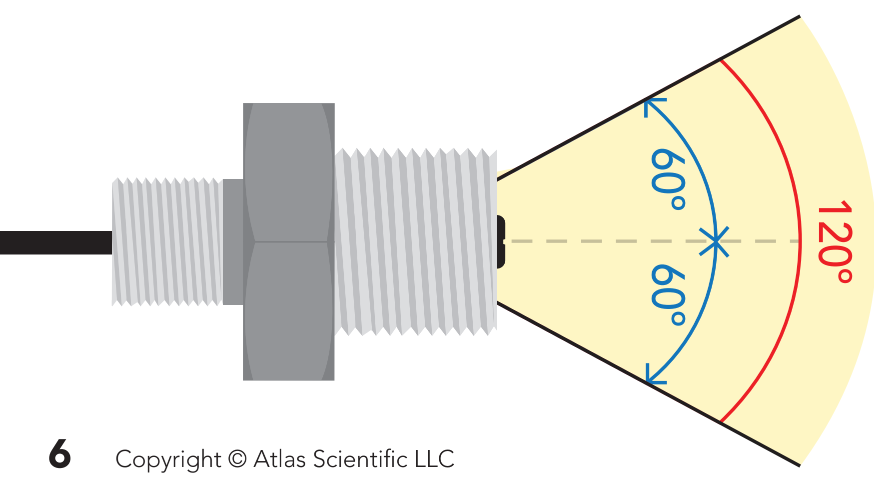
White LED x6

The spectrum output by the six onboard LEDs is strongest in the blue spectrum and weakest in the red spectrum. This is the opposite of the color sensors sensitivity giving it the best possible color sensing performance.

LED brightness
Minimum ~400 Lux
Maximum ~40,000 Lux

Onboard LEDs output spectrum





120˚ angle of illumination

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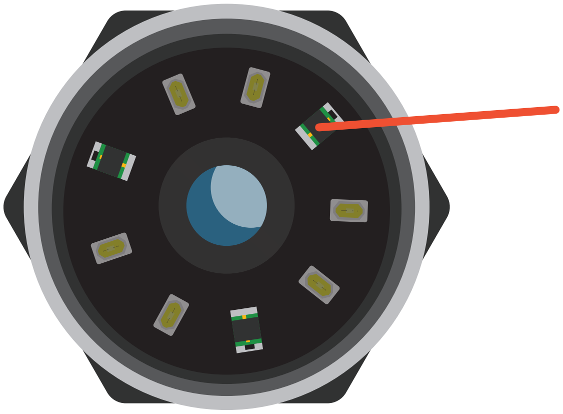
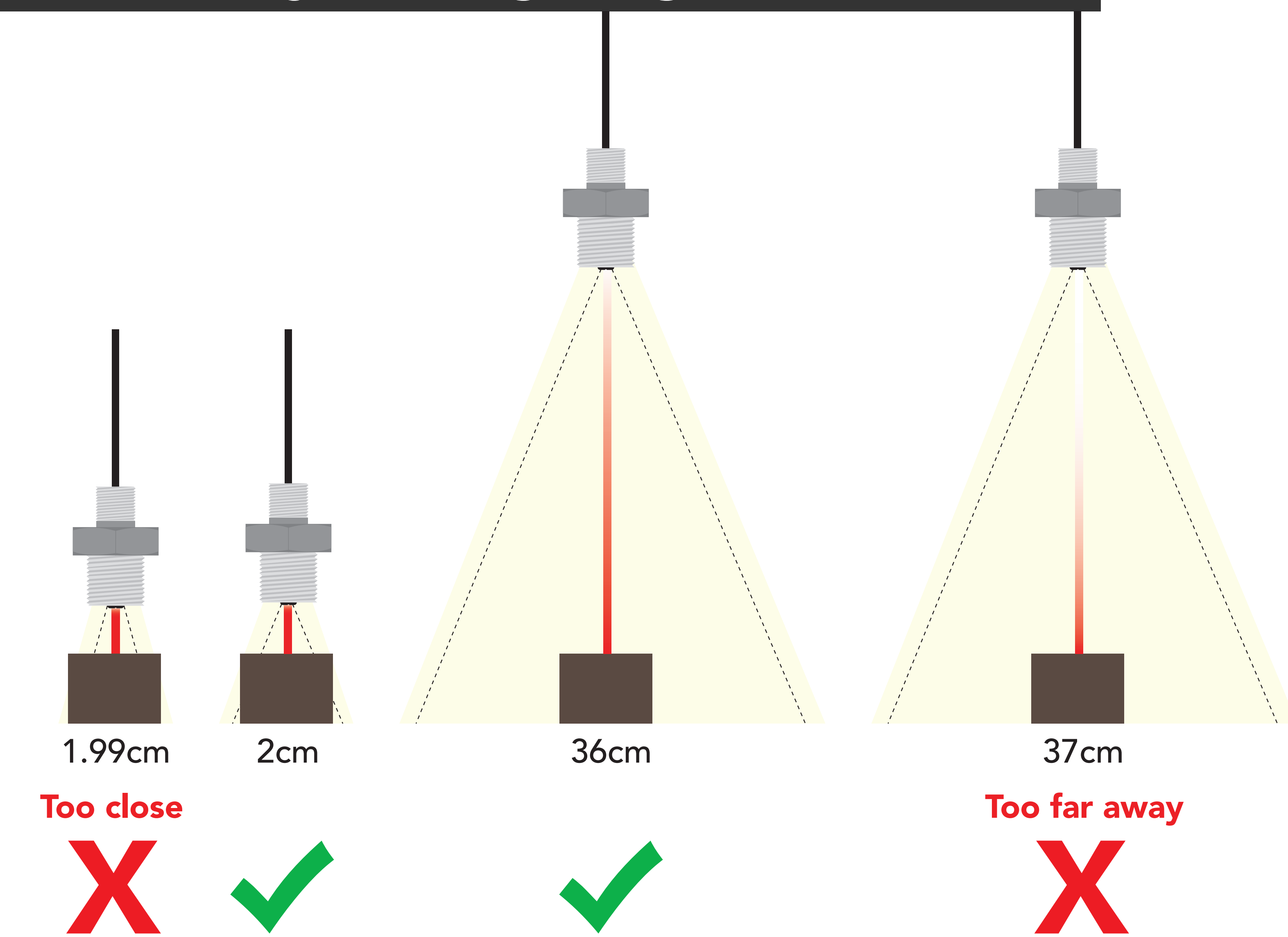
IR LED properties



IR LED x3
Wavelength = 850nm

The three IR LEDs use reflected infrared radiation to detect proximity.

Proximity sensing range ~2cm – 36cm



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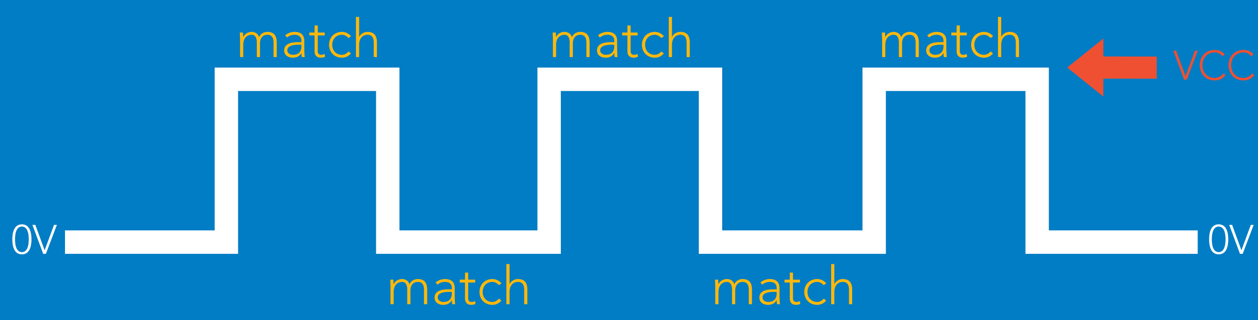
Pin out

Data and power cable pinout

- **White – RX**
- **Green – TX**
- **Black – GND**
- **Red – VCC**
- **Blue – INT**

The interrupt pin will change its state when a color match has been detected.



If unused leave **INT** floating. Do not connect **INT** to **VCC** or **GND**.

See page **29** to enable automatic color matching.

Power consumption

	LED	MAX	SLEEP
5V	ON 100%	175 mA	0.40 mA
	OFF	13.5 mA	
3.3V	ON 100%	138 mA	0.18 mA
	OFF	12.5 mA	

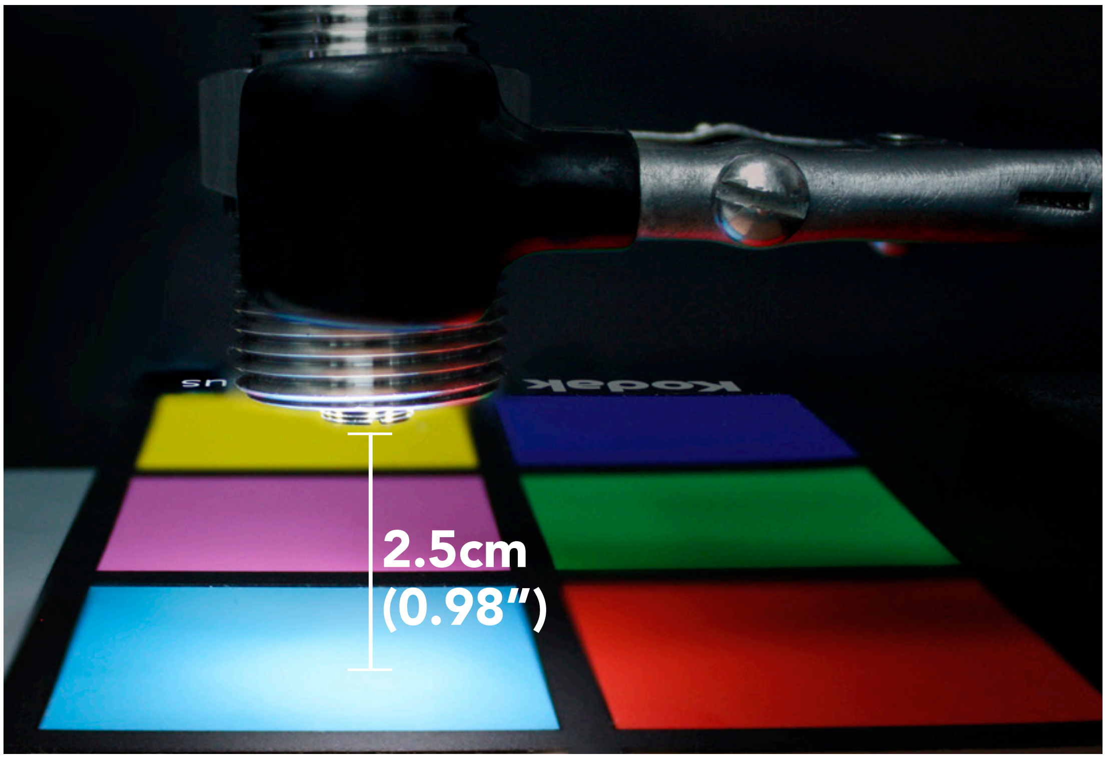
Absolute max ratings

Parameter	MIN	TYP	MAX
Storage temperature	-65 °C		125 °C
Operational temperature	-40 °C	25 °C	85 °C
VCC	3.3V	3.3V	5.5V
Pressure			1379kPa (200 PSI)

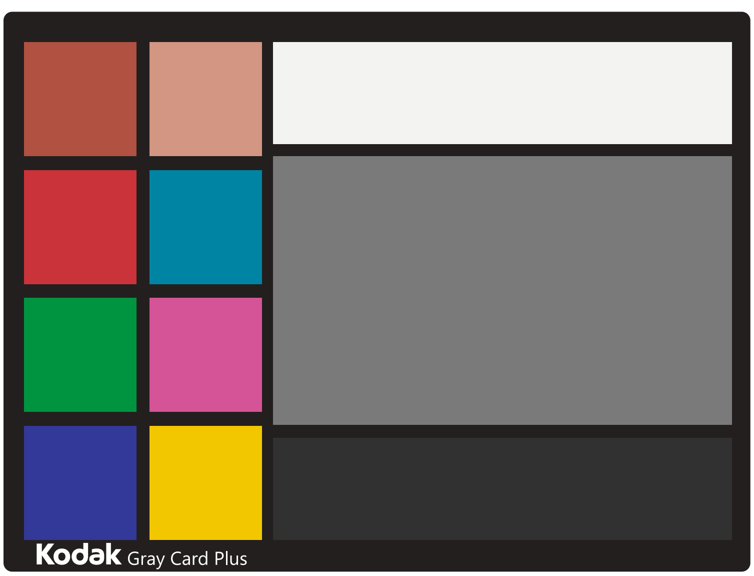
Performance testing

Color Sample	Kodak™ Gray Card Plus
Distance	2.5cm
On-board LEDs	100% power
VCC	5V

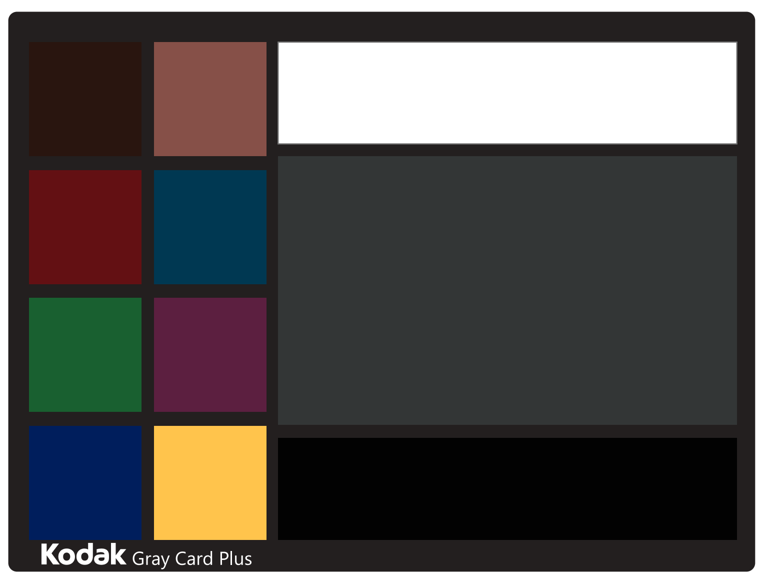
The color readings were displayed using the free software on the Atlas Scientific™ website located ***HERE***.



Kodak™ Gray Card Plus

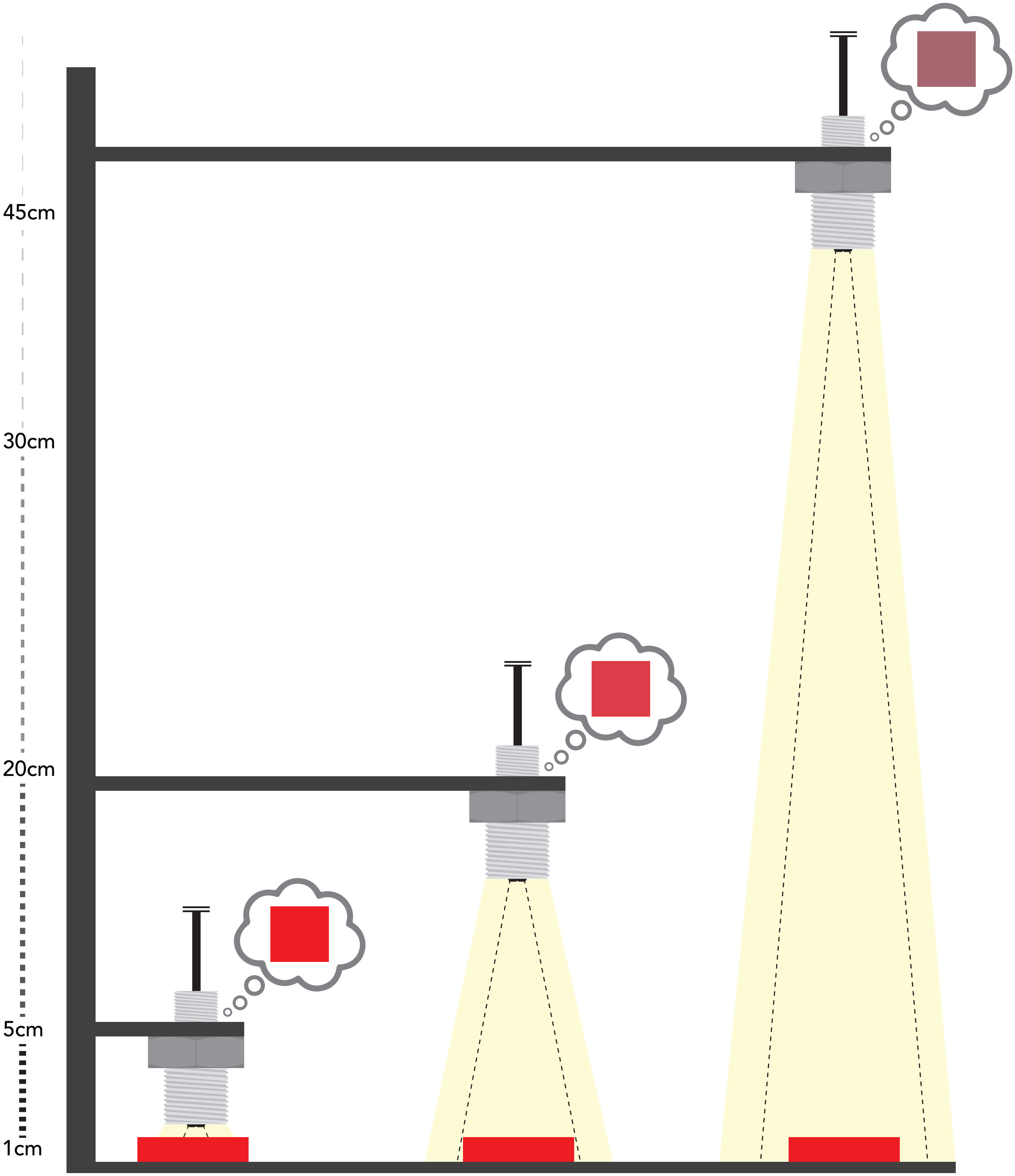


Color output from the EZO-RGB™



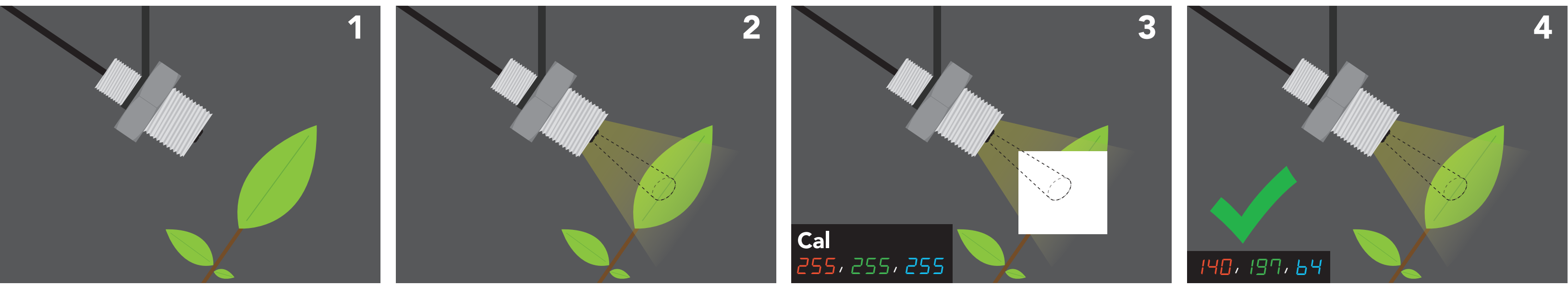
Sensitivity

As the EZO-RGB™ color sensor is placed further away from the target object, its ability to detect color is diminished. At distances greater than ***45cm*** most colors become varying shades of gray.

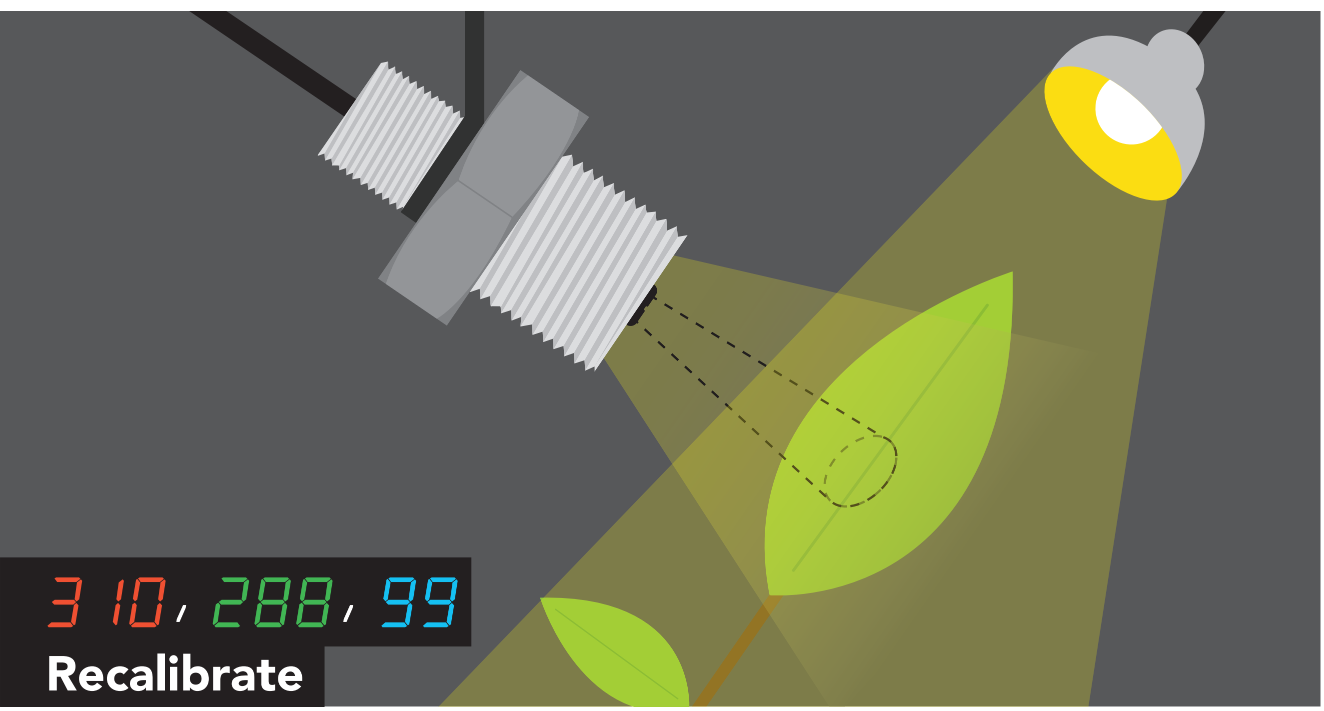


Calibration theory

The EZO-RGB™ color sensor is designed to be calibrated to a white object at the maximum brightness the object will be viewed under. In order to get the best results Atlas Scientific strongly recommends that the sensor is mounted into a fixed location. Holding the sensor in your hand during calibration will decrease performance.



1. Embed the EZO-RGB™ color sensor into its intended use location.
2. Set LED brightness to the desired level.
3. Place a white object in front of the target object and issue the calibration command "Cal".
4. A single color reading will be taken and the device will be fully calibrated.



The RGB output has a three comma separated value, ranging from 0–255. However, It is possible to get RGB readings where one, or all of the values are greater than 255. This is because brightness is encoded in a RGB reading, if the subject being viewed is brighter than the calibrated brightness, the RGB values can go above 255. If this happens, the EZO-RGB™ Embedded Color Sensor needs to be re-calibrated for the correct brightness.

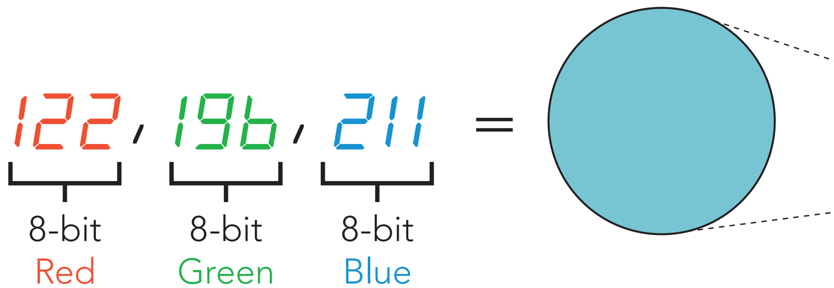
Data output

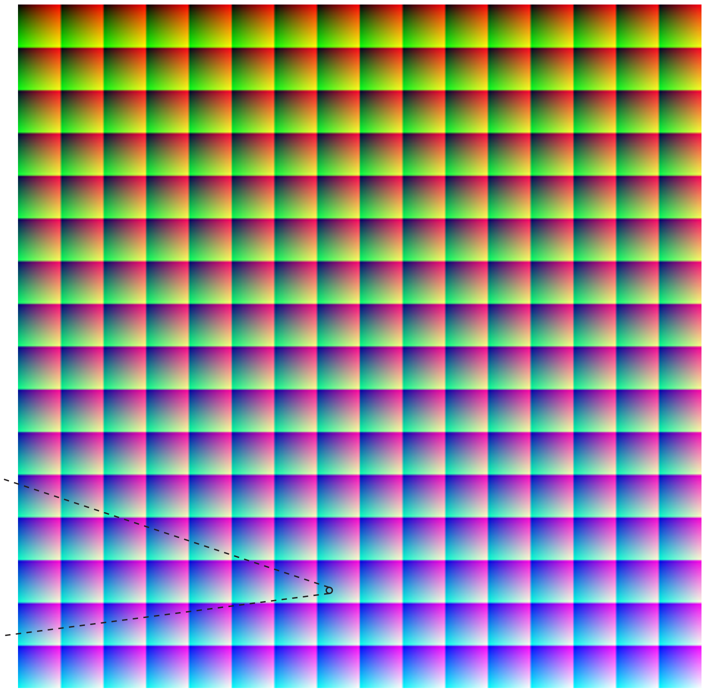
RGB 8-bit color graphics

Default output

8-bit Red
8-bit Green
8-bit Blue
} **24 bits in total**

Color pallet	16,777,216 colors *(24 Bit)*
Output frequency	1 reading every 400ms
Output format	CSV string 24 bits

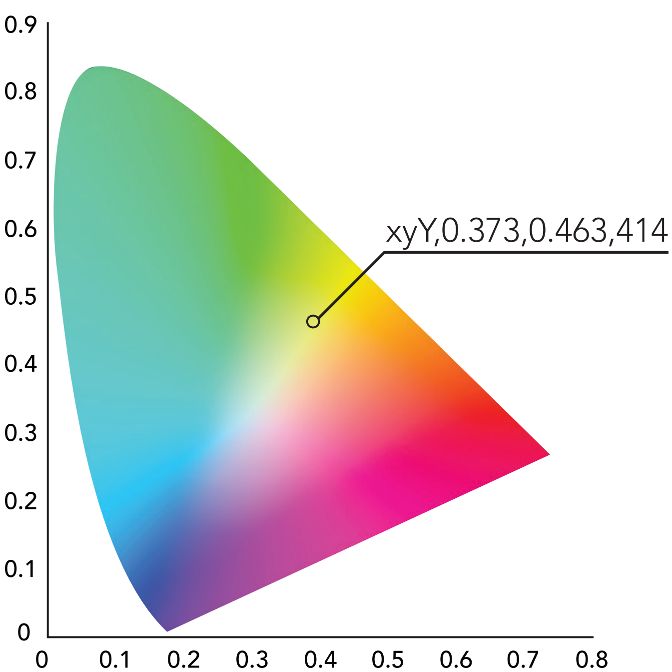




16,777,216 RGB colors

CIE 1931 color space

Human perception of color is not the same as a sensors perception of color. The CIE output is a representation of human color perception, while the RGB output is a representation of machine perception. While the two are close, they are not the same.



Identifier x y Y

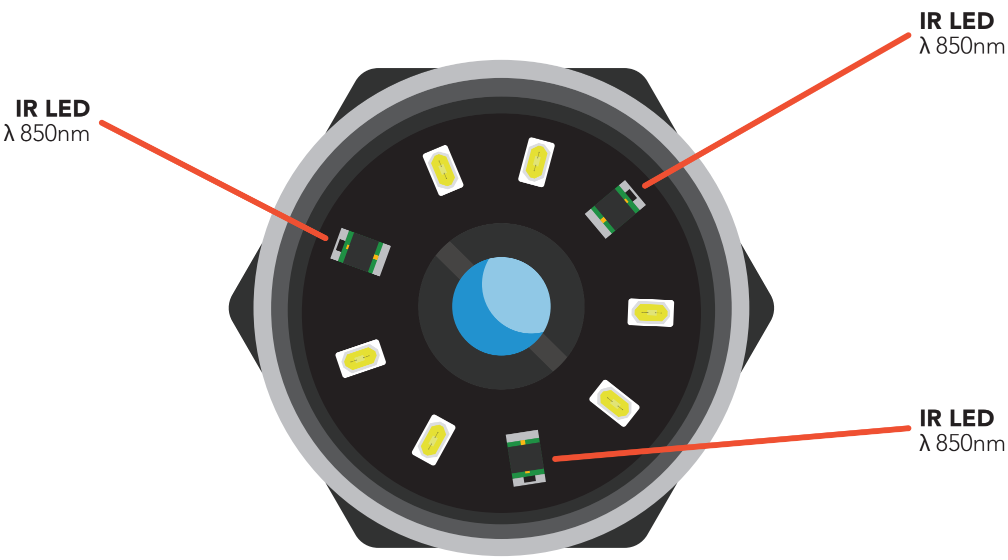
xyY,0.373,0.463,414

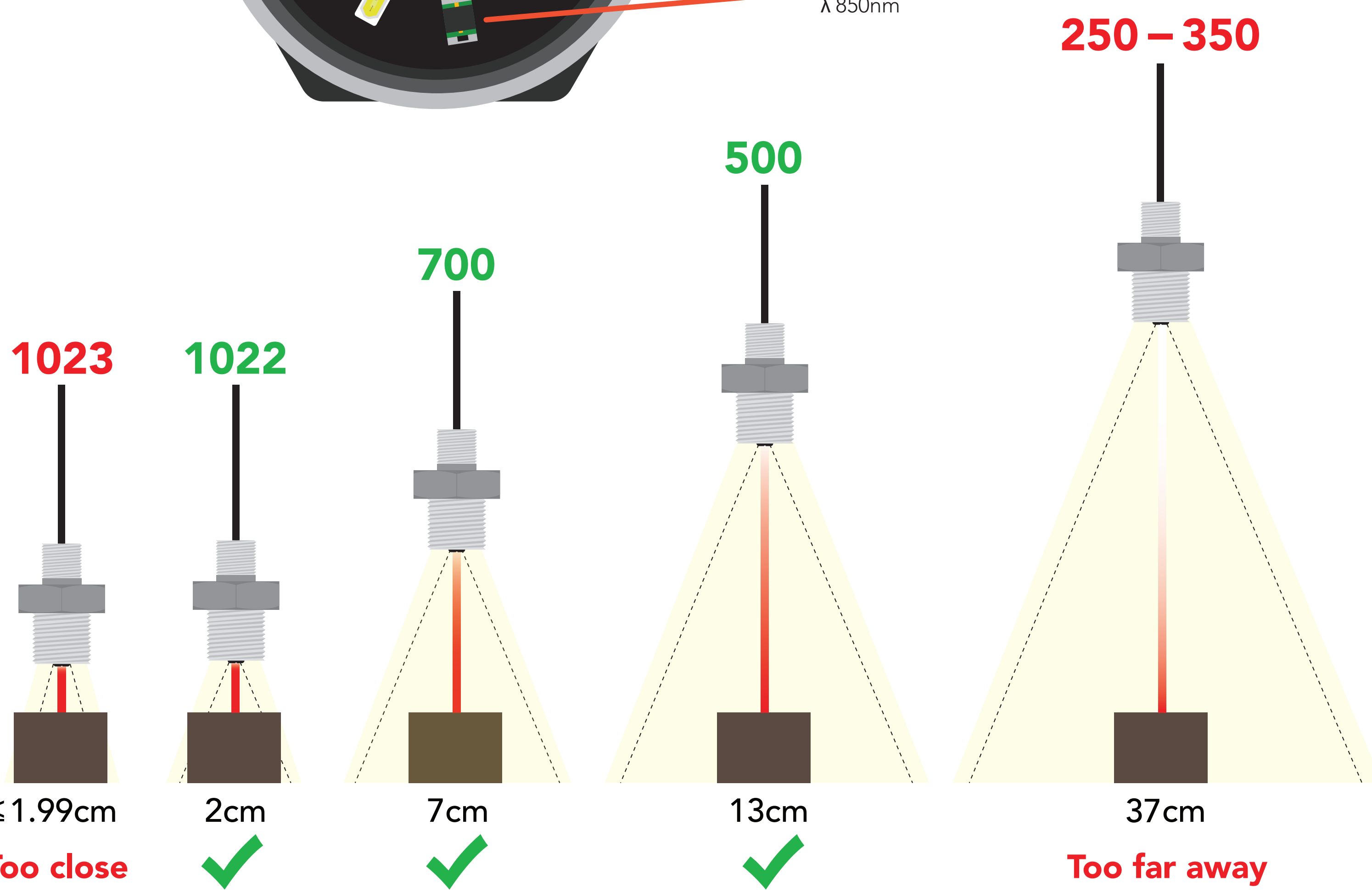
xy = coordinates
Y = luminance

Proximity sensing

The EZO-RGB™ uses three IR emitters to detect its proximity to another object. The intensity of the reflected IR light is used to determine if an object is in front of it. Because the IR reflectivity of materials is not uniform, the EZO-RGB™ proximity sensing capabilities should not be used as a precise distance measuring device.

The proximity output has a comma separated identifier **"P"** followed by a single integer value from ~250–1023. When the proximity sensor detects nothing the readings will be ~250–350.

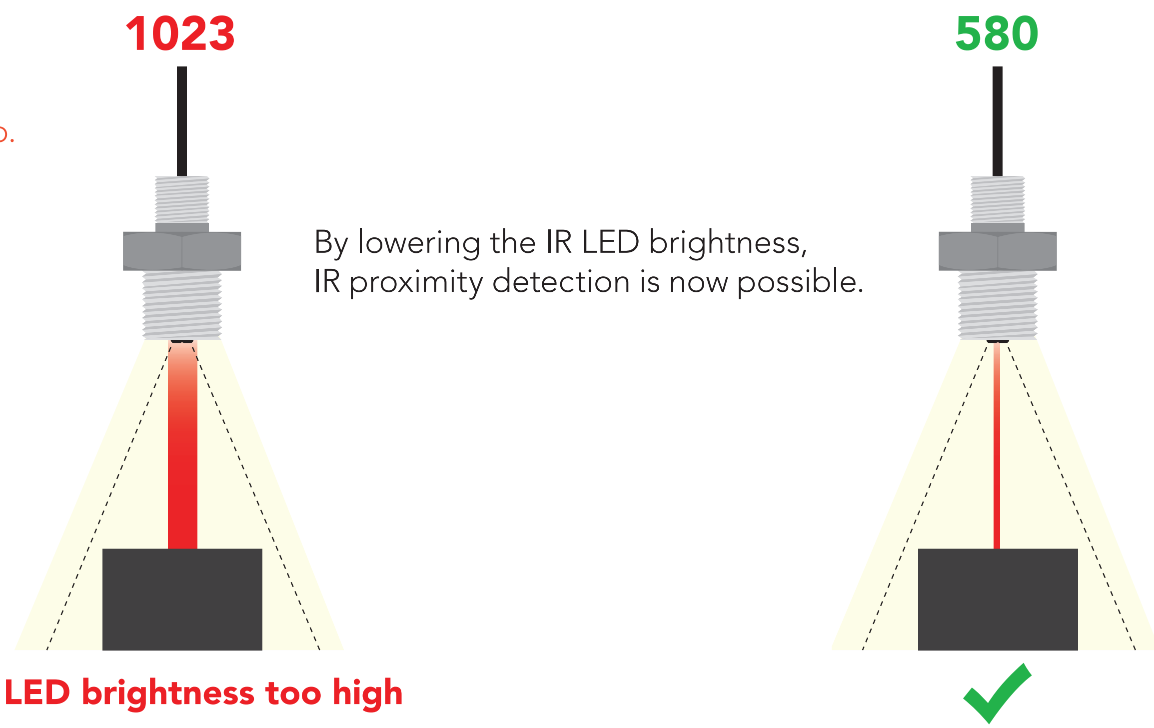




IR LED brightness control

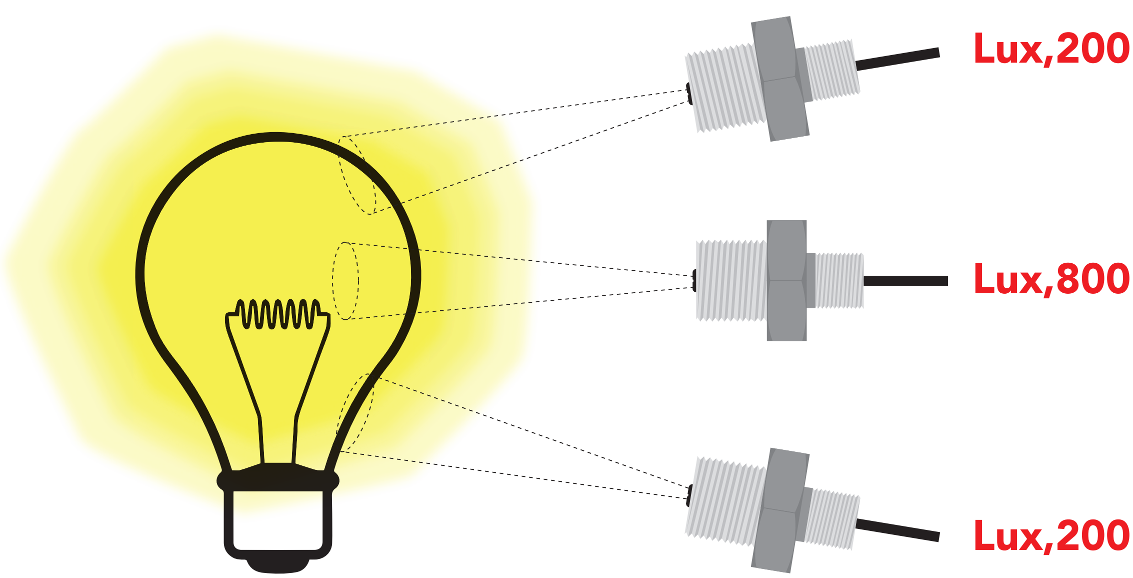
Controlling the IR LED brightness is necessary because, not all objects have the same IR reflectivity. Some objects can have an IR reflectivity that is too intense, therefor it is necessary to lower the brightness of the IR LEDs to achieve repeatable IR proximity detection.

High default
Medium
Low
See page **28** for more info.



Lux

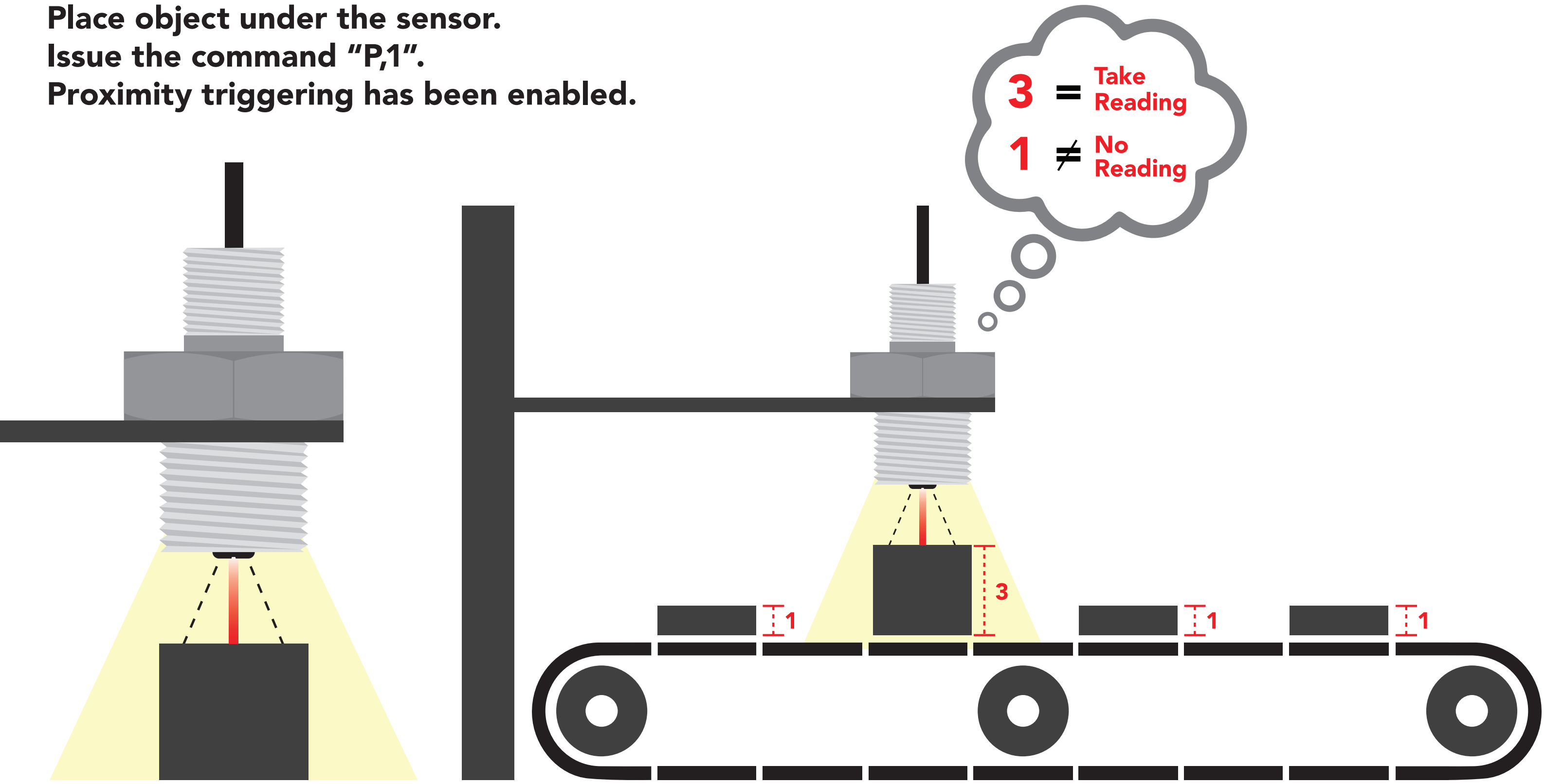
Lux is a measure of light intensity as perceived by the human eye. The lux output has a comma separated identifier **"Lux"** followed by a single integer value from 0 – 65535. Lux readings will be effected by the sensors position.



Proximity triggering

The EZO-RGB™ takes a color reading only when a set proximity is met or exceeded.

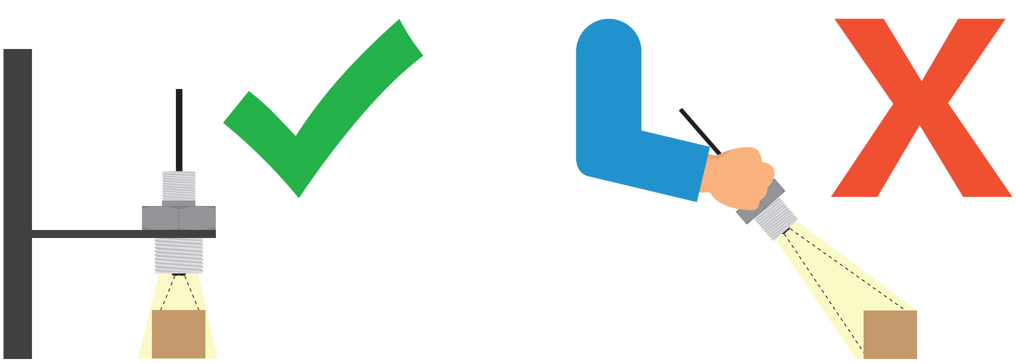
Place object under the sensor.
Issue the command "P,1".
Proximity triggering has been enabled.



Once proximity triggering has been enabled, no readings will be transmitted ***until*** an object of ***equal, or greater height*** has been detected under the EZO-RGB™.

Color readings that are taken when a proximity match has been detected will be appended with **"*P"**

In order for proximity triggering to work the EZO-RGB™ must be securely mounted and remain a fixed distance from its target.



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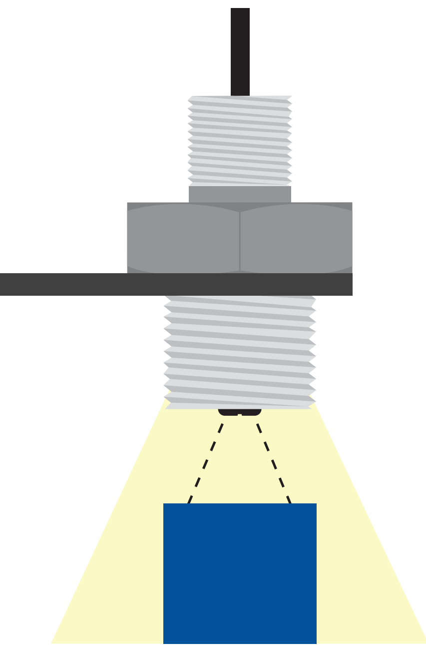
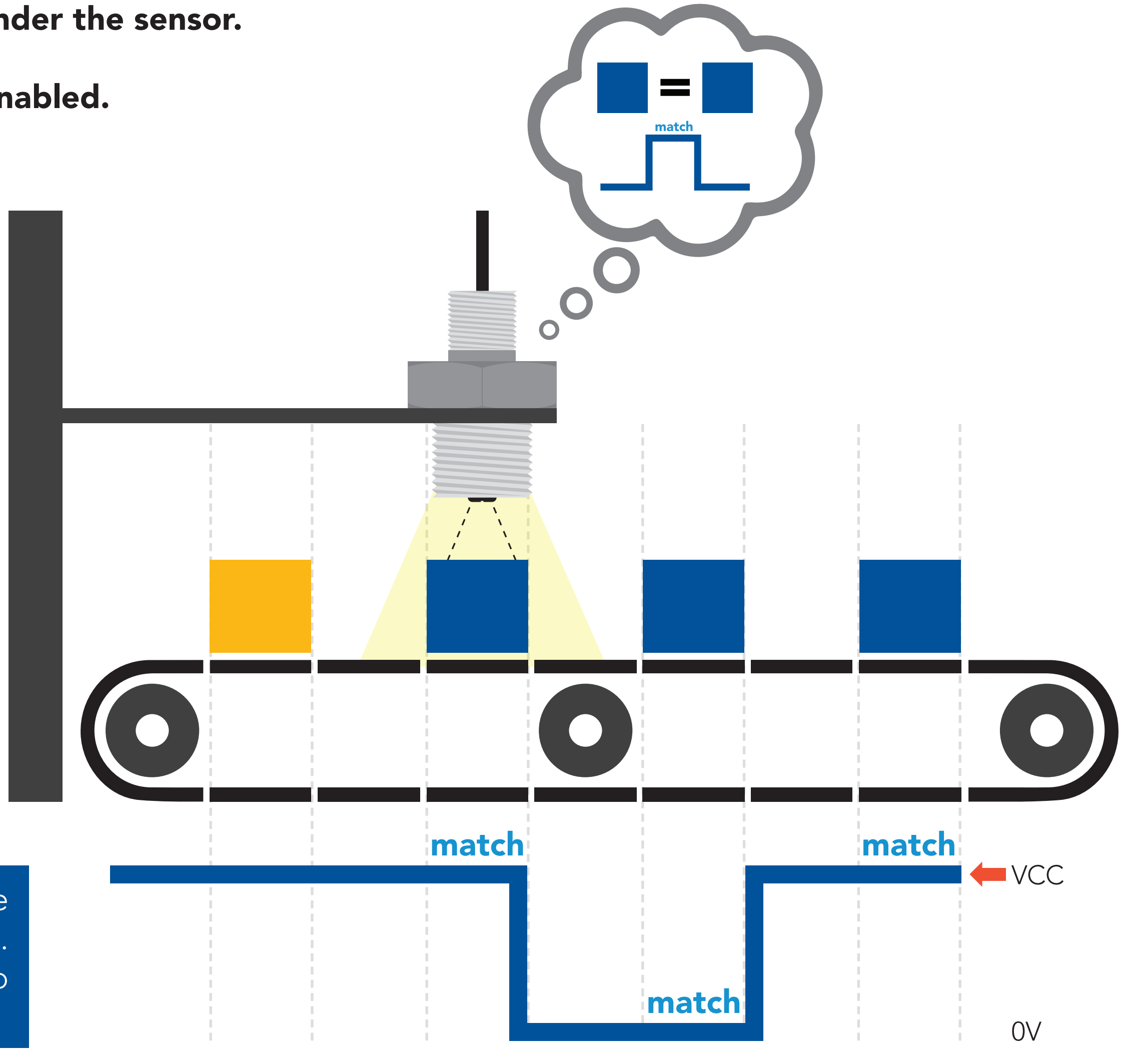
Color matching

The EZO-RGB™ can indicate when a preset color is detected.

Place object of any color under the sensor.
Issue command "M,1".
Color matching has been enabled.

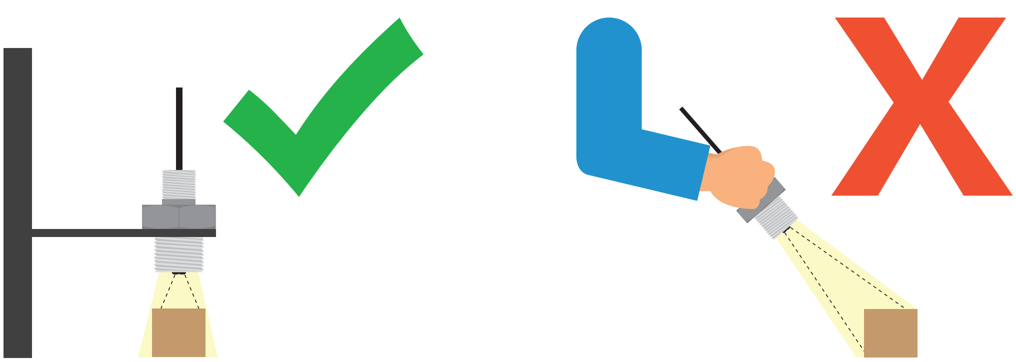




The interrupt pin can only be used to signal a color match. It cannot be programmed to signal any other condition.

When a color match has been detected the reading will be appended with **"*M"** and the interrupt pin with go high.

In order for color matching to work the EZO-RGB™ must be securely mounted and remain a fixed distance from its target.



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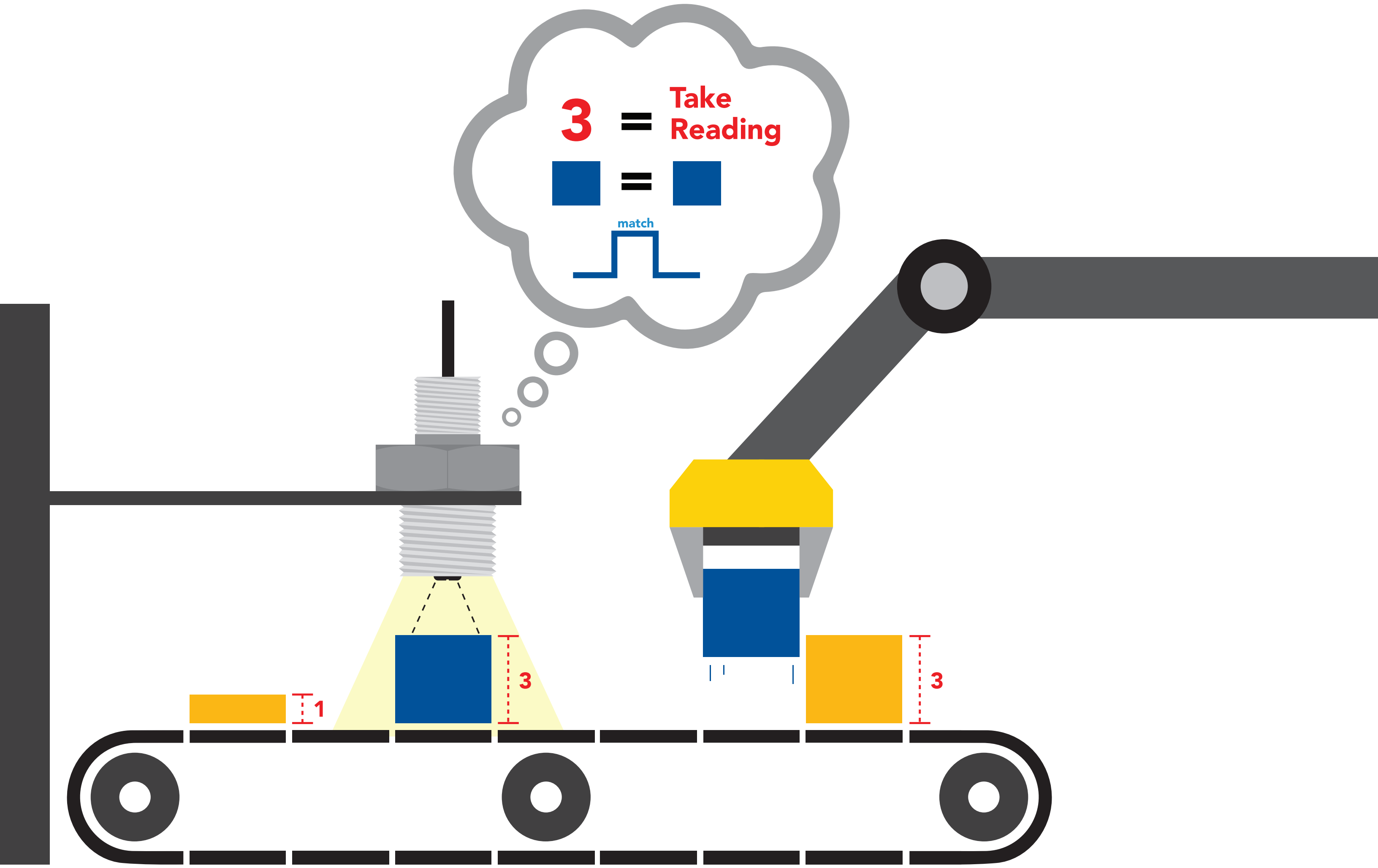
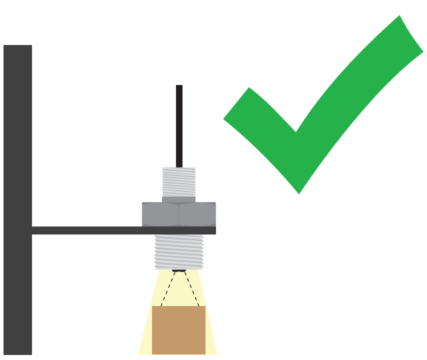
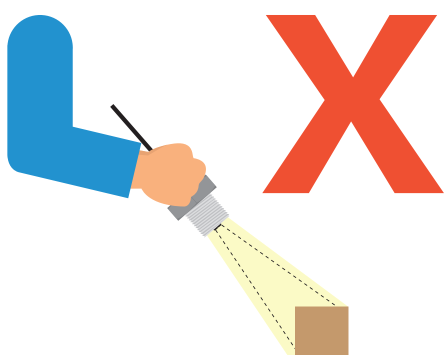
Proximity and color matching

Both proximity and color matching functions can be enabled simultaneously, permitting the engineer to quickly develop an object sorter with minimal coding.



In order for proximity triggering and color matching to work the EZO-RGB™ must be securely mounted and remain a fixed distance from its target.





✓ Available data protocol

UART

X Unavailable data protocols

I^2C

SPI

Analog

RS-485

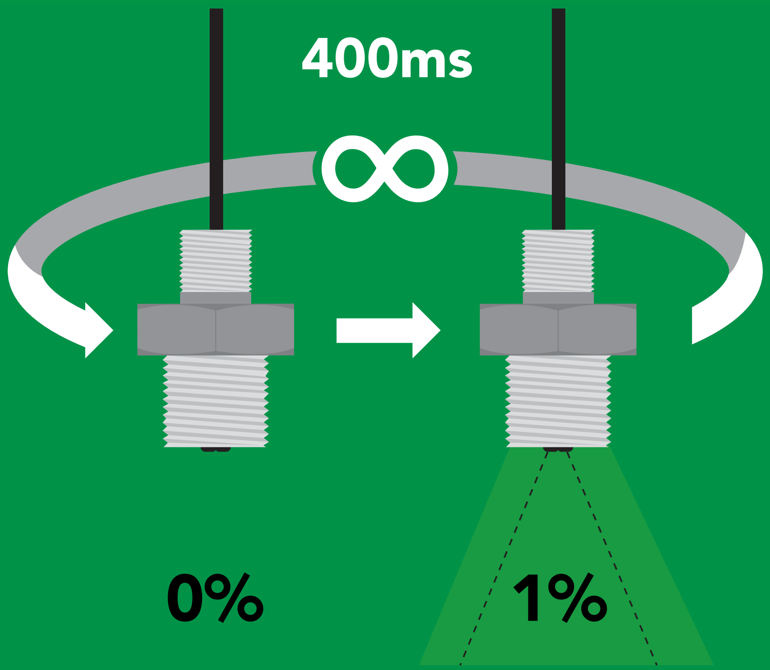
Mod Bus

4–20mA

Default state

UART mode

Baud	**9,600**
Readings	**continuous**
Speed	**400 milliseconds**
LED	**on, when taking reading**



Settings that are retained if power is cut

Baud rate
Calibration
Continuous mode
Device name
Enable/disable parameters
Enable/disable response codes
LED control

Settings that are *NOT* retained if power is cut

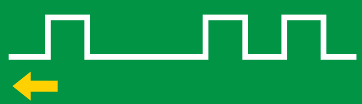
Sleep mode

UART mode

8 data bits	no parity
1 stop bit	no flow control

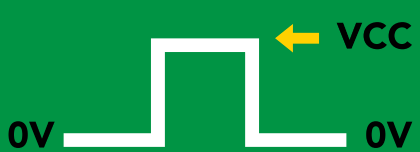
Baud
300
1,200
2,400
9,600 default
19,200
38,400
57,600
115,200

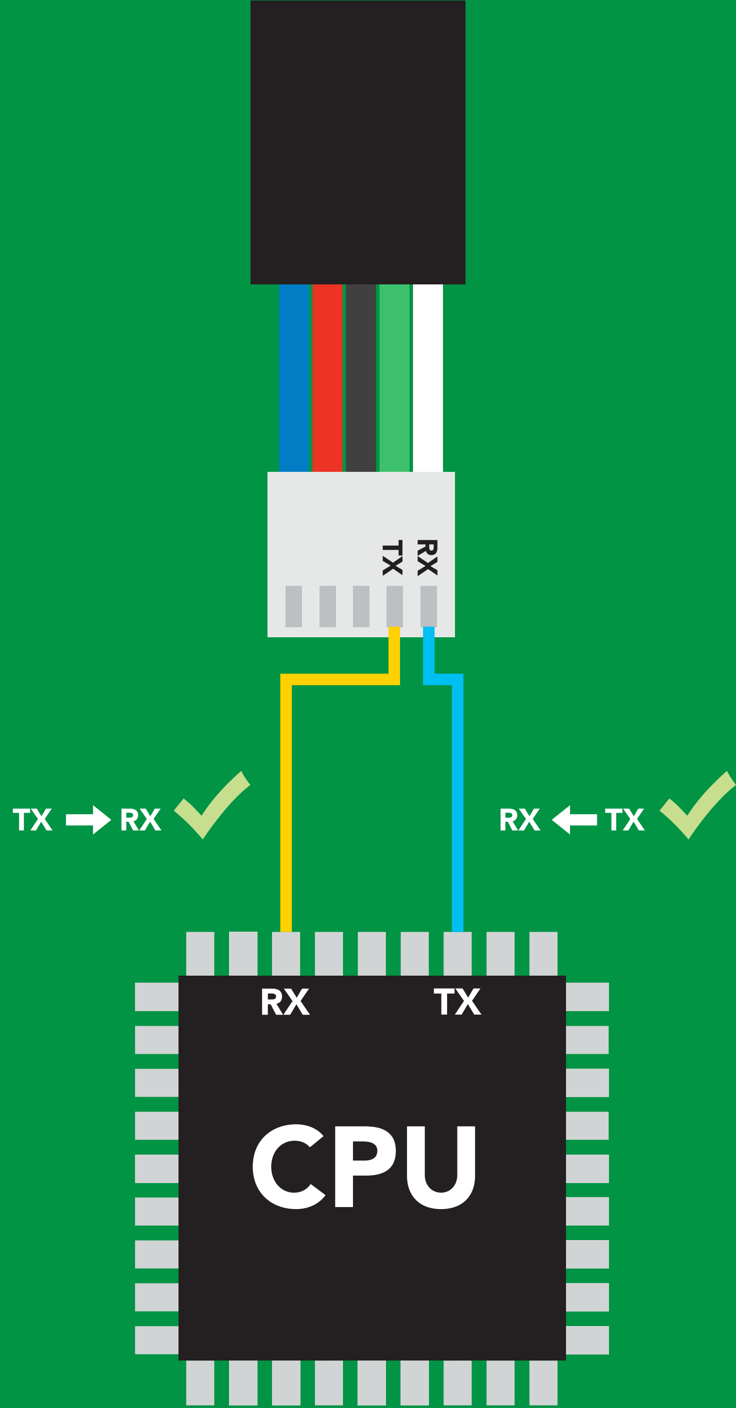
RX
Data in



TX
Data out

Vcc 3.3V – 5V





Data format

Units	RGB, LUX, CIE, and proximity	Data type	integer & floating point
Encoding	ASCII	Decimal places	3
Format	string	Smallest string	4 characters
Terminator	carriage return	Largest string	52 characters

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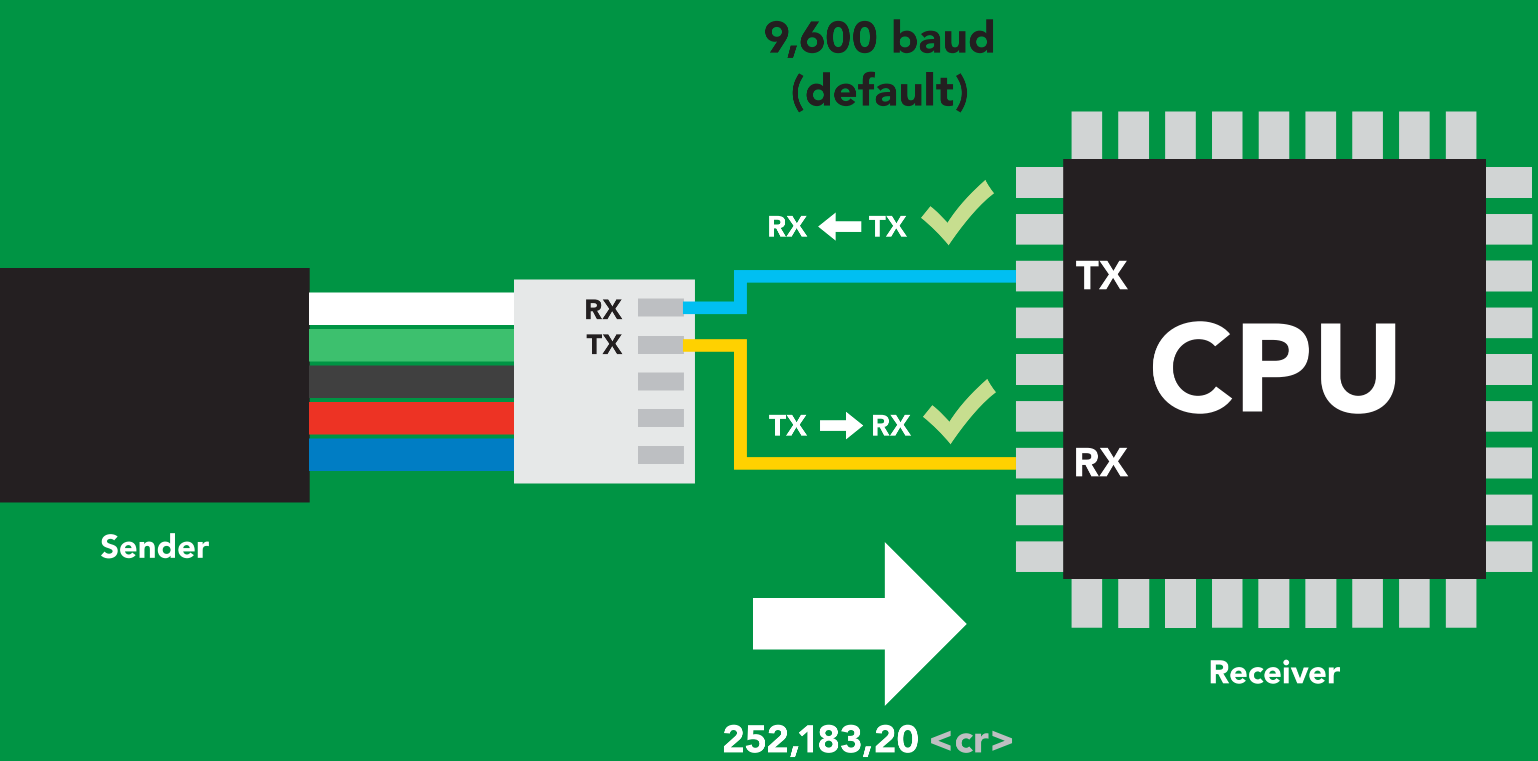
Receiving data from device



Advanced

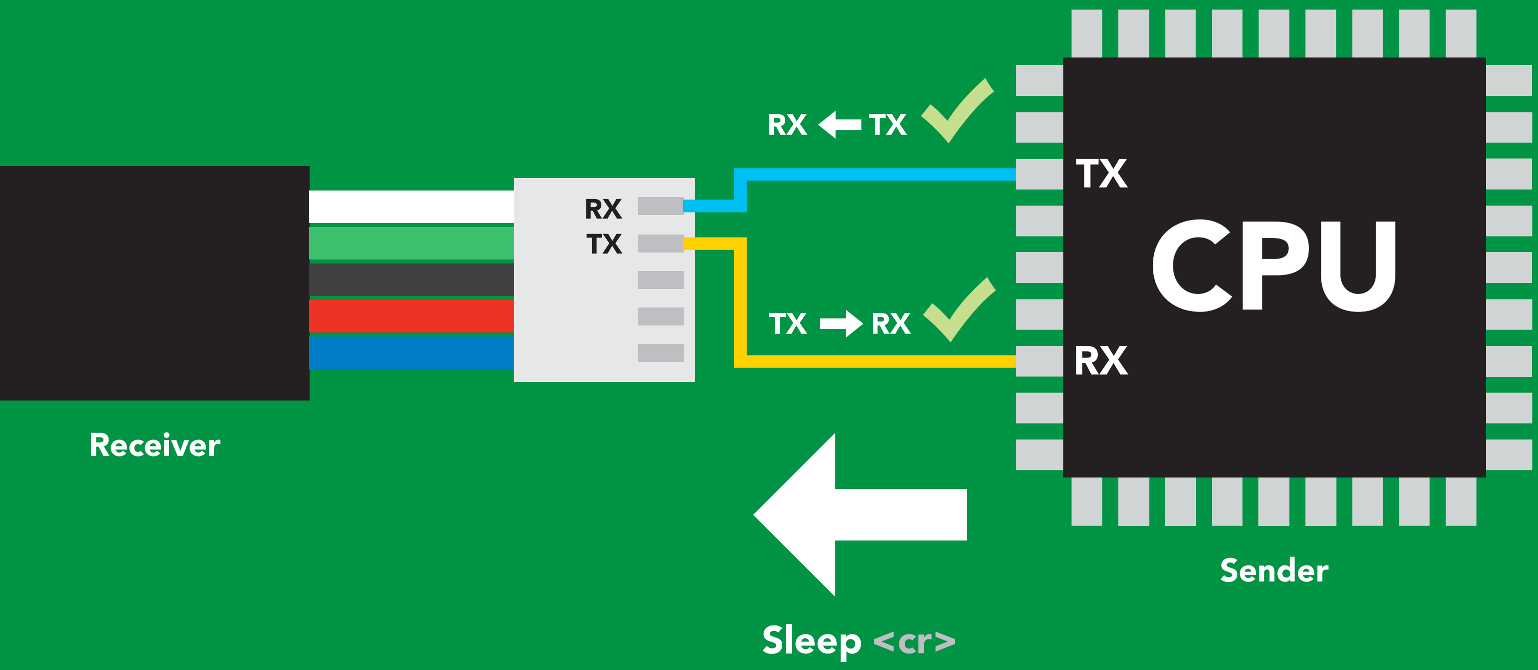
ASCII:	2	5	2	,	1	8	3	,	2	0	<cr>
Hex:	32	35	32	2C	31	38	33	2C	32	30	0D
Dec:	50	53	50	44	49	56	51	44	50	48	13

Sending commands to device

2 parts

Command (not case sensitive) — ASCII data string

Carriage return <cr> — Terminator



Advanced

ASCII:	S	l	e	e	p	<cr>
Hex:	53	6C	65	65	70	0D
Dec:	83	108	101	101	112	13

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UART mode
command quick reference

All commands are ASCII strings or single ASCII characters.

Command	Function		Default state
C	enable/disable continuous mode	pg. 21	enabled
Cal	performs calibration	pg. 30	n/a
Factory	enable factory reset	pg. 40	n/a
G	gamma correction	pg. 40	n/a
i	device information	pg. 34	n/a
L	enable/disable LED	pg. 20	enabled
M	automatic color matching	pg. 20	enabled
Name	set/show name of device	pg. 33	not set
O	enable/disable parameters	pg. 31	RGB
P	proximity triggering	pg. 27	n/a
R	returns a single reading	pg. 22	n/a
Serial	change baud rate	pg. 38	9,600
Sleep	enter sleep mode/low power	pg. 37	n/a
Status	Retrieve Status Information	pg. 22	n/a
*OK	enable/disable response codes	pg. 37	n/a

LED control

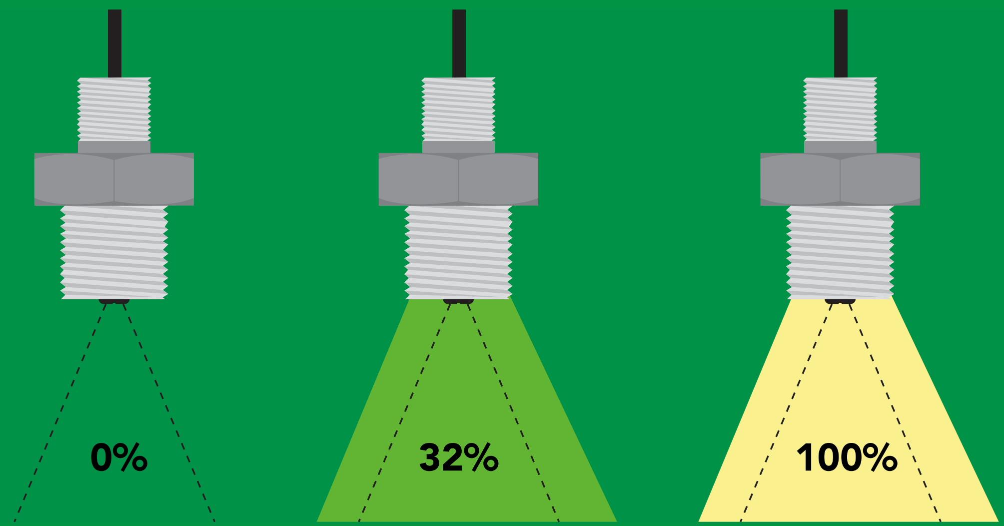
Command syntax

% represents the percentage of LED brightness. (any number from 0–100)

L,%	<cr>	set LED brightness
L,%,T	<cr>	set LED brightness/trigger LED only when a reading is taken *(power saving)*
L,?	<cr>	LED state on/off?

Example	Response	
L,32 <cr>	*OK <cr>	LED set to 32% brightness.
L,14,T <cr>	*OK <cr>	LED set to 14% brightness, and will only turn on when a reading is taken
L,? <cr>	?L, %, [T] <cr> *OK <cr>	

L,0 <cr>　　L,32 <cr>　　L,100 <cr>



Continuous mode

Command syntax

C,1 <cr> enable continuous readings once per 400ms **default**

C,0 <cr> disable continuous readings

C,? <cr> continuous reading mode on/off?

Example	Response
C,1 <cr>	*OK <cr> R,G,B (400ms) <cr> R,G,B (800ms) <cr> R,G,B (1200ms) <cr>
C,0 <cr>	*OK <cr>
C,? <cr>	?C,1 <cr> or ?C,0 <cr> *OK <cr>

Single reading mode

Command syntax

R <cr> **takes single reading**

Example	Response
R <cr>	R,G,B <cr> *OK <cr>

Calibration

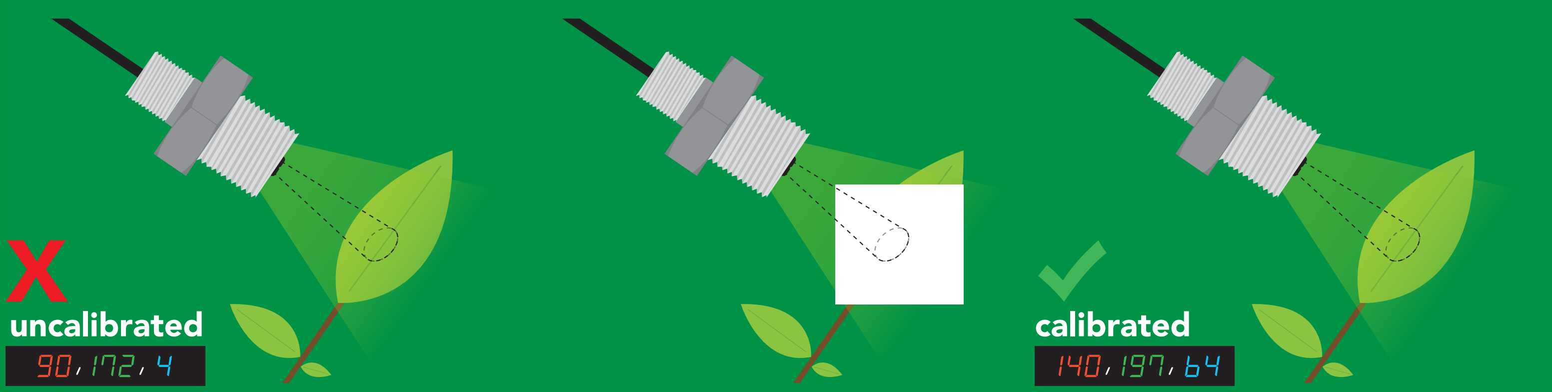
Command syntax

Cal <cr> **calibrates the EZO-RGB™**

1. place white object *(such as a piece of paper)* in front of target
2. Issue "cal" command

Example	Response
Cal <cr>	*OK <cr>

Cal <cr>



Proximity Detection

Command syntax

P,[1,0]	<cr>	enable / disable
P,n	<cr>	manually enable proximity detection at n distance where n = any number from 250 – 1023
P,[H, M, L]	<cr>	set IR LEDs brightness to high, medium or low
P,?	<cr>	proximity state on/off?

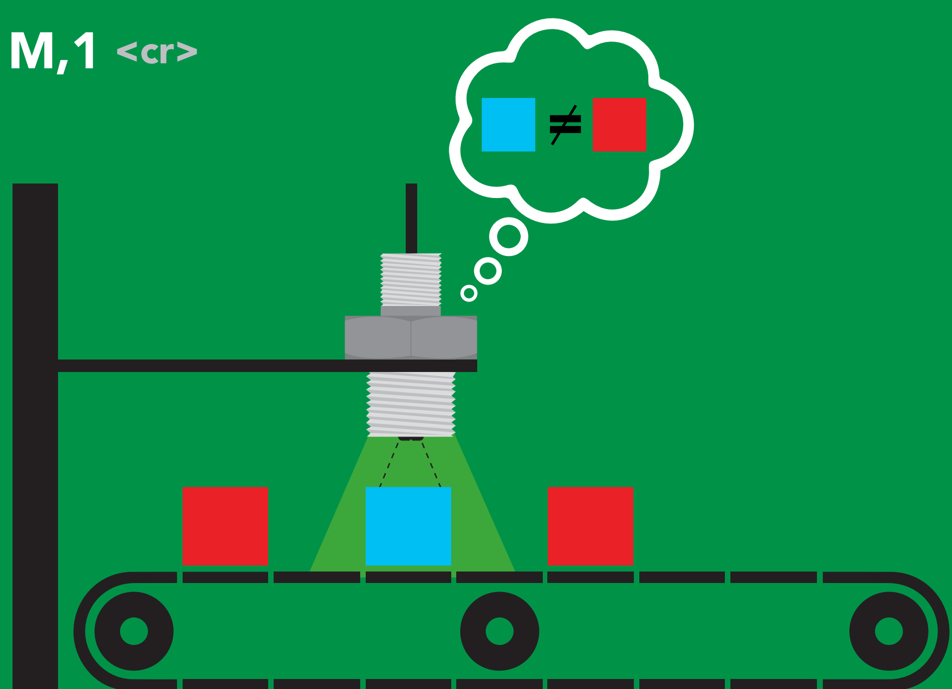
Example	Response
P,1 <cr>	*OK <cr>
P,800 <cr>	*OK <cr>
P,L <cr>	*OK <cr>
P,? <cr>	?P,0,L <cr>

Automatic color matching

Command syntax

M,1 <cr> enables automatic color matching
M,0 <cr> disables automatic color matching
M,? <cr> color matching on/off?

Example	Response
M,1 <cr>	*OK <cr>
M,0 <cr>	*OK <cr>
M,? <cr>	?M,1 <cr> or ?M,0 <cr> *OK <cr>



Gamma correction

Command syntax

Adjusting the gamma correction helps adjust the color seen by the sensor.

G,n <cr> **set gamma correction**

where n = a floating point number from 0.01 – 4.99

G,? <cr> **gamma correction value?**

The default gamma correction is 1.00 which represents no correction at all.
A gamma correction factor is a floating point number from 0.01 to 4.99.

Example	Response
G,1.99 <cr>	*OK <cr>
G,? <cr>	?G,1.99 <cr> *OK <cr>

Enable/disable parameters from output string

Command syntax

O, [parameter],[1,0]	<cr>	enable or disable output parameter
O,?	<cr>	enabled parameter?

Example	Response
O,RGB,1 / O,RGB,0 <cr>	*OK <cr> enable / disable RGB
O,PROX,1 / O,PROX,0 <cr>	*OK <cr> enable / disable proximity
O,LUX,1 / O,LUX,0 <cr>	*OK <cr> enable / disable lux
O,CIE,1 / O,CIE,0 <cr>	*OK <cr> enable / disable CIE
O,? <cr>	?,O,RGB,PROX,LUX,CIE <cr> if all enabled

Parameters

RGB	red, green, blue
PROX	proximity
LUX	illuminance
CIE	CIE 1931 color space

Followed by 1 or 0

1	enabled
0	disabled

* If you disable all possible data types your readings will display “no output”.

AtlasScientific Environmental Robotics

Naming device

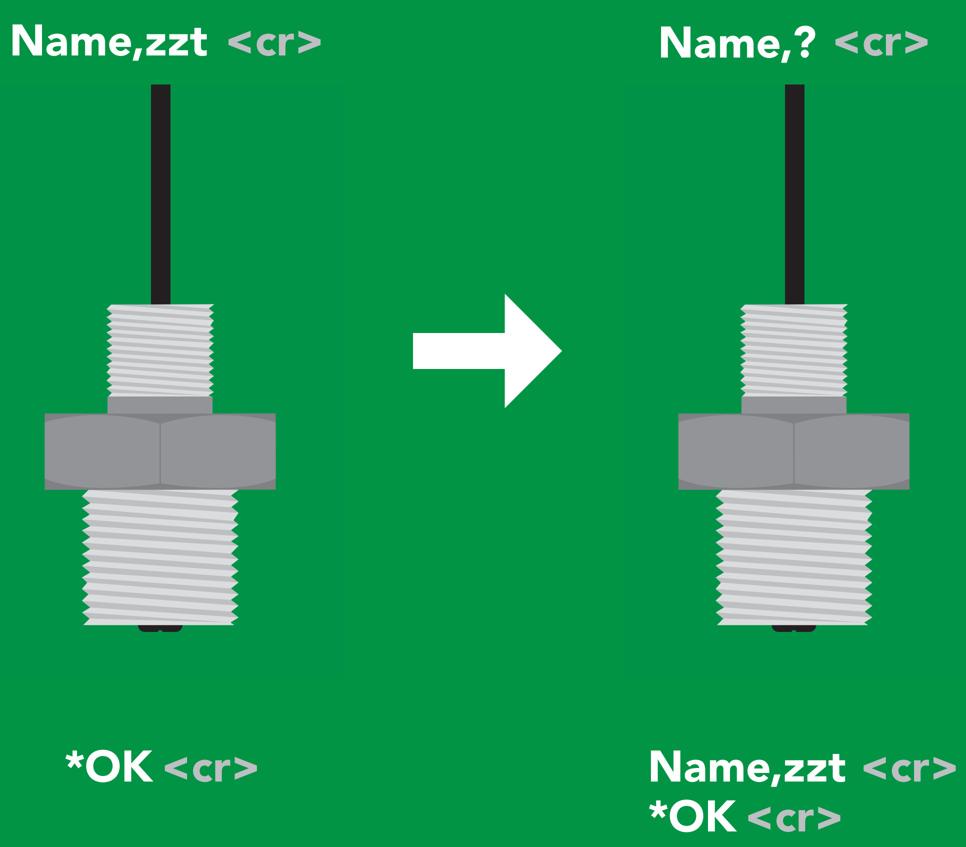
Command syntax

Name,n	<cr>	set name
Name,?	<cr>	show name

n = _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

Up to 16 ASCII characters

Example	Response
Name,zzt <cr>	*OK <cr>
Name,? <cr>	?Name,zzt <cr> *OK <cr>



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Device information

Command syntax

i <cr> **device information**

Example	Response
i <cr>	?i,RGB,1.3 <cr> *OK <cr>

Response breakdown

?i,	RGB,	1.3
	Device	Firmware

Response codes

Command syntax

*OK,1	<cr>	enable response	default
*OK,0	<cr>	disable response	
*OK,?	<cr>	response on/off?	

Example	Response
R <cr>	140,197,64 <cr> *OK <cr>
*OK,0 <cr>	no response, *OK disabled
R <cr>	140,197,64 <cr> *OK disabled
*OK,? <cr>	?*OK,1 <cr> or ?*OK,0 <cr>

Other response codes

*ER	unknown command
*OV	over volt (VCC>=5.5V)
*UV	under volt (VCC<=3.1V)
*RS	reset
*RE	boot up complete, ready
*SL	entering sleep mode
*WA	wake up

These response codes cannot be disabled

Reading device status

Command syntax

Status	<cr>	voltage at Vcc pin and reason for last restart

Example	Response
Status <cr>	**?Status,P,5.038** <cr> ***OK** <cr>

Response breakdown

?Status,	P,	5.038
	Reason for restart	Voltage at Vcc

Restart codes

P	powered off
S	software reset
B	brown out
W	watchdog
U	unknown

Sleep mode/low power

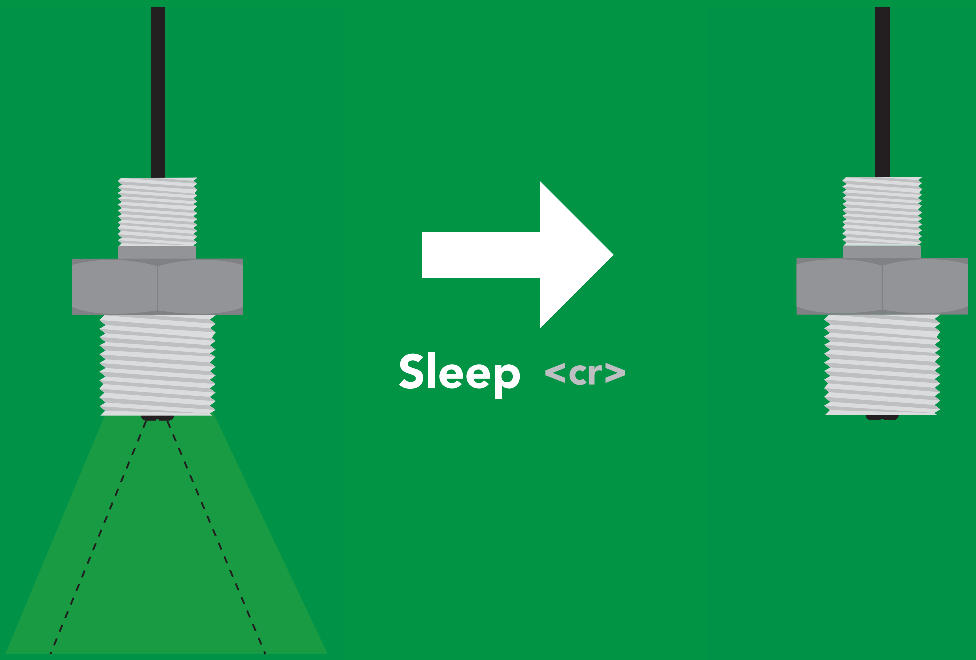
Command syntax

Send any character or command to awaken device.

Sleep <cr> enter sleep mode/low power

Example	Response
Sleep <cr>	*SL
Any command	*WA <cr> wakes up device

	MAX	SLEEP
5V	175 mA	0.40 mA
3.3V	138 mA	0.18 mA



Change baud rate

Command syntax

Serial,n <cr> **change baud rate**

Example	Response
Serial,38400 <cr>	*OK <cr>
Serial,? <cr>	?Serial,38400 <cr> *OK <cr>

n =
- 300
- 1200
- 2400
- 9600 default
- 19200
- 38400
- 57600
- 115200

Factory reset

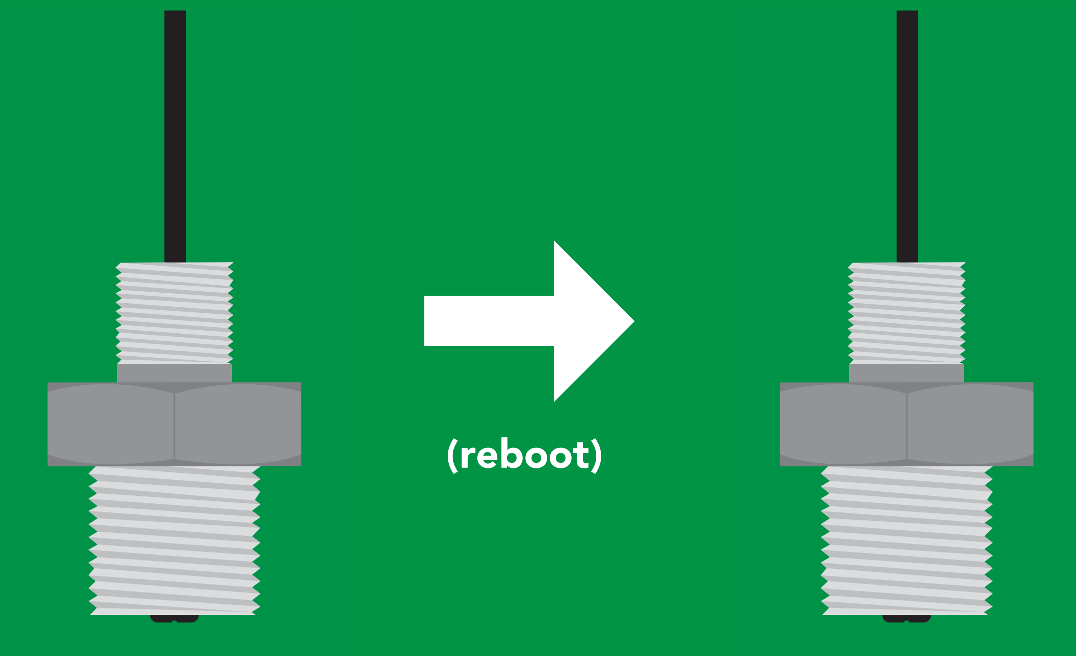
Command syntax

Clears calibration
Reset LED brightness to 1%
Reset output to RGB
"*OK" enabled

Factory <cr> enable factory reset

Example	Response
Factory <cr>	*OK <cr>

Factory <cr>



*OK <cr>

*RS <cr>
*RE <cr>

Baud rate will not change

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Datasheet change log

Datasheet V 2.0

Revised entire datasheet

Firmware updates

V1.10 – (November 7, 2015)

- Fixed sleep mode bug

V1.15 – (November 30, 2015)

- Fixed threshold bug

V1.16 – (February 2, 2016)

- Fixed glitch where excessive newline characters would be output for every line

v1.18 - (Sept 19, 2016)

- Updated manufacturing process

v1.2 - (June 29, 2017)

- I^2C command now returns error.

Warranty

Atlas Scientific™ Warranties the EZO-RGB™ Embedded Color Sensor to be free of defect during the debugging phase of device implementation, or 30 days after receiving the EZO-RGB™ Embedded Color Sensor (which ever comes first).

The debugging phase

The debugging phase as defined by Atlas Scientific™ is the time period when the EZO-RGB™ Embedded Color Sensor is connected into a bread board, or shield. If the EZO-RGB™ Embedded Color Sensor is being debugged in a bread board, the bread board must be devoid of other components. If the EZO-RGB™ Embedded Color Sensor is being connected to a microcontroller, the microcontroller must be running code that has been designed to drive the EZO-RGB™ Embedded Color Sensor exclusively and output the EZO-RGB™ Embedded Color Sensor data as a serial string.

It is important for the embedded systems engineer to keep in mind that the following activities will void the EZO-RGB™ Embedded Color Sensor warranty:

- **Soldering any part to the EZO-RGB™ Embedded Color Sensor.**
- **Running any code, that does not exclusively drive the EZO-RGB™ Embedded Color Sensor and output its data in a serial string.**
- **Embedding the EZO-RGB™ Embedded Color Sensor into a custom made device.**
- **Removing any potting compound.**

Reasoning behind this warranty

Because Atlas Scientific™ does not sell consumer electronics; once the device has been embedded into a custom made system, Atlas Scientific™ cannot possibly warranty the EZO-RGB™ Embedded Color Sensor, against the thousands of possible variables that may cause the EZO-RGB™ Embedded Color Sensor to no longer function properly.

Please keep this in mind:

1. **All Atlas Scientific™ devices have been designed to be embedded into a custom made system by you, the embedded systems engineer.**

2. **All Atlas Scientific™ devices have been designed to run indefinitely without failure in the field.**

3. **All Atlas Scientific™ devices can be soldered into place, however you do so at your own risk.**

Atlas Scientific™ is simply stating that once the device is being used in your application, Atlas Scientific™ can no longer take responsibility for the EZO-RGB™ Embedded Color Sensor continued operation. This is because that would be equivalent to Atlas Scientific™ taking responsibility over the correct operation of your entire device.

