

# E2-A High-Speed Strobe

## User Manual

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### Description

#### Working Principle

The E2-A is an LED-based photographic strobe which can produce strobes lasting from 500 nanoseconds to 4 microseconds. In order to create sufficient exposure (total light) in such a short amount of time, 12 high-powered CREE COB LED’s are used. The LED’s were selected for maximum brightness given their cost. The LED’s are driven at currents many times higher than their rated current, resulting in significantly higher light output than rated by the manufacturer.

## Advantages

Typical xenon flashtube-based strobes ('Speedlight' flashes) are designed for typical photographic applications such as sports, portrait, or macro photography. When attempting to image high-speed subjects (such as a bullet), the duration of the light is far too long to 'freeze' the subject. The E2-A is a 'high-speed' strobe designed to produce extremely short bursts of light which results in much sharper images with less motion blur.

In addition to the prolonged flash duration, the ramp-up and ramp-down characteristics of the flashtube are not ideal. The image is exposed in a non-uniform manner, resulting in difficulty identifying the leading and trailing edges of the subject. The E2-A's LED's ramp up and down rapidly (about 200 nanoseconds) which prevents the faded edges.

Finally, the E2-A's response time to a trigger input is orders of magnitude faster than a standard photographic flash. This simplifies the trigger timing for imaging high-speed objects at a particular position.

## Disadvantages

Because the exposure duration is incredibly short, the resulting image exposure is less than that produced by a typical flashtube strobe (even at its lowest power). Compensation for the reduced exposure can include adjustment of camera settings (aperture and ISO), changing the lighting setup (moving the flash closer to the subject), and using a reflector to focus the flash's output.

The LED current has been carefully selected by destructively testing numerous LED's. Multiple factors can result in LED failure including maximum current draw, strobe duration, and turn-on and turn-off current rates and profiles. While the E2-A has a design factor which provides a significant margin of safety, the use of LED's so far above their rated current can always pose the danger of damage to the LED's. Early failures are identified during the quality control protocol which involves several thousand strobes. If damage has not yet occurred, the LED's are expected to last at least one hundred-thousand strobes.

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## Caution

The strobe contains capacitors which are charged to a dangerous voltage.

- Do not disassemble the strobe
- If disassembly is absolutely necessary, remove the batteries prior to doing so
- Keep the strobe dry

The strobe is equipped with a small amount of input protection on the trigger circuit.

- It is recommended not to apply a voltage to the trigger input. A switch or transistor can be used to transmit a trigger signal. When using an Arduino or other development board to trigger the flash, simply toggle the GPIO pin from tri-state (INPUT) to sinking (OUTPUT LOW) to transmit the trigger signal.
  - If applying a voltage is necessary, then do not apply a reverse voltage to the trigger input. The 3.5mm connector tip **MUST** be positive relative to the base. Do not apply more than 5V to the trigger.
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## User Interface

The strobe is equipped with a simple user interface consisting of a display, encoder (dial), and audio element.

The display is always on unless the unit is turned off or is in a **FULLY ARMED** state, at which point it turns off to prevent unintended image exposure. After a strobe, the display will stay on for one second or until the trigger signal is released, whichever is longer.

The encoder can be turned to adjust a setting. It can also be depressed to change menu screens. A short-press of the encoder will cycle to the next menu screen, and a long-hold will cycle between the **READY TO ARM** and **FULLY ARMED** states (described below).

The battery voltage is displayed on the bottom of the screen. The LED anode voltage is also displayed when the strobe is charged. A flashing battery voltage indicates that the battery voltage is too low for operation.

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## Strobe Settings

### Settings Screens

The E2-A has five menu screens. Following is a summary of the menu screens, the allowable values, and how to navigate between screens.

Menu Screen	Values	Short Button Press	Long Button Press	Trigger Input
Strobe Duration	0.5, 1.0, 2.0, 4.0 us	Multi-Strobe Screen	READY TO ARM	-
Multi-Strobe	1x - 6x	Strobe Rate Screen		
Strobe Rate	250 us – 2,000 us	Initial Delay Screen		
Initial Delay	0 – 9,999 ms	Strobe Duration Screen		
READY TO ARM	-		FULLY ARMED	FULLY ARMED

*Table 1: Menu Screens*

Following are summaries of the settings and how operation is affected.

- **Strobe Duration** – The total illumination time of each individual strobe. Note that a shorter strobe duration will result in less motion blur and lower exposure. Each strobe duration setting produces one stop more or less light than the next (0.5 us produces one stop less light than 1.0 us, etc.)
- **Multi-Strobe** – The number of consecutive strobes per trigger. Default is a single strobe. If a single strobe is selected, then the Strobe Rate screen is not available.
- **Strobe Rate** – The time between the start of one strobe to the start of the next strobe. IE., if a 4.0 us strobe duration is set with 250 us between strobes, the second strobe will start 246 us after the first ends.
- **Initial Delay** – The time delay (in milliseconds) between the trigger signal and the first strobe.

## Multi-Strobe Limitations

The strobe was designed to overdrive the LED's significantly in order to achieve the exposure level in an extremely short period of time. Single strobes do not damage the LED as the duration of the strobe is too short to generate damaging levels of heat. Multi-strobes can also be performed without damaging the LED, but limitations have been installed to prevent excessive strobing which can eventually lead to LED damage.

The following three tables describe the multi-strobe limitations. All three tables contain the same information but are presented differently.

<b>Strobe Duration</b>	<b>Strobe Rate</b>							
	<b>250 us</b>	<b>500 us</b>	<b>750 us</b>	<b>1,000 us</b>	<b>1,250 us</b>	<b>1,500 us</b>	<b>1,750 us</b>	<b>2,000 us</b>
<b>0.5 us</b>	6x							
<b>1.0 us</b>	4x			6x				
<b>2.0 us</b>	2x			4x				
<b>4.0 us</b>	1x			2x				

Table 2: Max Consecutive Strokes

# Consecutive Strobes	Strobe Rate							
	250 us	500 us	750 us	1,000 us	1,250 us	1,500 us	1,750 us	2,000 us
2x	2.0 us			4.0 us				
3x	1.0 us	2.0 us						
4x								
5x	0.5 us	1.0 us						
6x								

Table 3: Max Strobe Duration

<b>Strobe Duration</b>	<b># Consecutive Strokes</b>				
	<b>2x</b>	<b>3x</b>	<b>4x</b>	<b>5x</b>	<b>6x</b>
<b>0.5 us</b>	250 us				
<b>1.0 us</b>	250 us			1,000 us	
<b>2.0 us</b>	1,000 us			-	-
<b>4.0 us</b>	1,000 us	-	-	-	-

Table 4: Max Strobe Rate

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## Arming & Triggering

### Arming

The strobe will not fire unless it is in the **FULLY ARMED** state. In this state, the display is turned off and the strobe will wait until the strobe has fired or the unit has been turned off.

In order to enter the **FULLY ARMED** state, the strobe's button must be held until the display shows **READY TO ARM**. The strobe is not yet armed. A second long-hold of the button or a long-hold of the trigger signal will set the strobe in the **FULLY ARMED** state. A short button press in the **READY TO ARM** screen will return to the other settings screens.

When the unit is in the **READY TO ARM** or **FULLY ARMED** states, the capacitor charger turns on and rapidly recharges the capacitor anodes. When a settings menu is displayed, the capacitor charger is turned off.

### Triggering

Once the strobe has entered the **FULLY ARMED** state, it will execute a strobe immediately upon receiving a trigger signal. If an initial delay is set, the timer will begin immediately upon receiving a trigger signal. The only way to exit the **FULLY ARMED** state without firing the strobe is to turn it off.

The trigger port accepts a 3.5mm connector. The trigger behaves similar to a typical hotshoe-style camera flash: the 3.5mm plug base is grounded and the tip is held high by an internal pullup resistor.

- When the state of the trigger changes while the settings menu is displayed, the unit will sound a high- or low- frequency chirp to indicate the change.
- When the strobe is in the **READY TO ARM** state, holding the trigger will cause the unit to enter the **FULLY ARMED** state.
- Once in the **FULLY ARMED** state, the unit will trigger on a change in trigger state (low to high or high to low).

Note that the maximum triggering rate is approximately 1 trigger per second. This limitation is designed to prevent damage to the LED's by frequent strobing.

Also, note that the response time in Active-Low triggering is shorter than Active-High triggering. When possible, use a normally-open switch or change from Tri-State (INPUT) to Sinking (OUTPUT LOW) for fastest response time.

# System Settings

## Settings Menu

The system settings menu can be accessed by pressing and holding the encoder for five seconds when the strobe is turned on. Once in the system settings menu, turning the encoder will adjust the setting and pressing the encoder will cycle to the next setting adjustment. The settings will be saved by cycling through all settings and returning to the strobe menu screen.

The following settings can be adjusted:

- Encoder Reversal: reverses direction of encoder rotation
- Display Flip: rotates the display 180 degrees
- Sound: turns the sound on and off
- CalBattery2V, CalBattery6V, CalAnode: calibration factors for the battery and capacitor voltages. These calibration factors are usually set during the initial setup and are never adjusted afterward.

## Status

The Serial Number and Firmware Version are displayed in the system settings menu.

After cycling through all of the above system settings, pressing the encoder once more will display the total strobe count. Each strobe duration displays the actual number of strobes fired at that duration, so a 4x 1-microsecond strobe trigger will increment the 1-microsecond counter by 4. The TOTAL count only increments by one for each trigger, regardless of the number of strobes. The 4x 1-microsecond strobe trigger will increment the TOTAL count by 1.

## Specifications

Batteries:	4x AA (Alkaline OR Rechargeable)
Input Voltage:	2.5V – 6.0V
Illumination Duration:	0.5 – 4.0 microseconds
Illumination Rise/Fall:	200 nanoseconds
Trigger Delay:	1 microsecond (active-low) / 5 microsecond (active-high)
Size:	Appr. 180mm x 125mm x 45mm (W x H x D)
Mass:	Appr. 650 grams
Expected Life:	100,000 strobes

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## License

This manual and all other documentation of the E2-A are licensed under the [Creative Commons Attribution 4.0 International License](#).

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## Changelog

2020-06-12   VTG   Initial Commit, Firmware v1.0