# Application of LED for Auto Focus in Digital Still Cameras

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## White Paper


### Abstract

Photography is definitely one of the most important inventions in history. It allowed us to capture moments and preserve them for years to come.

In these last few years, camera technology has improved dramatically, from analog to digital; from 352x288 pixels CIF to 640x480 pixels VGA to Mega-pixels resolution. Auto focus function from ultrasonic to infrared and from infrared to LEDs. Besides that, the sizes of the Digital Still Camera (DSC) have also become smaller and smaller.

Through continuous improvement, auto focus (AF) function has become critical for photo taking. The built-in AF LEDs will help focus the image further as well as make the quality of the image better. The use of AF using LED had been largely adopted by the camera industry.

This paper will describe how to use Avago LEDs for AF application in a Digital Still Camera.

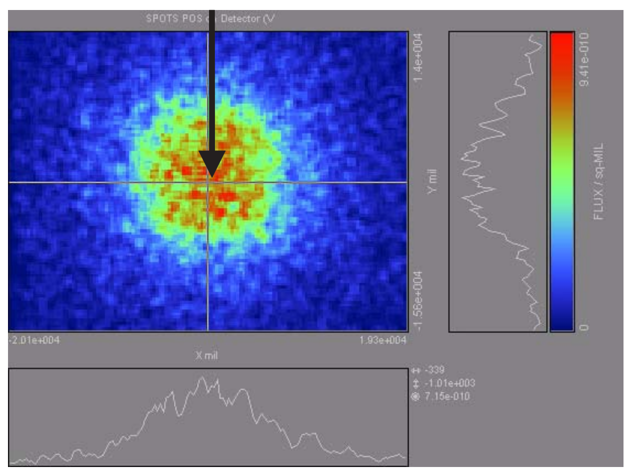


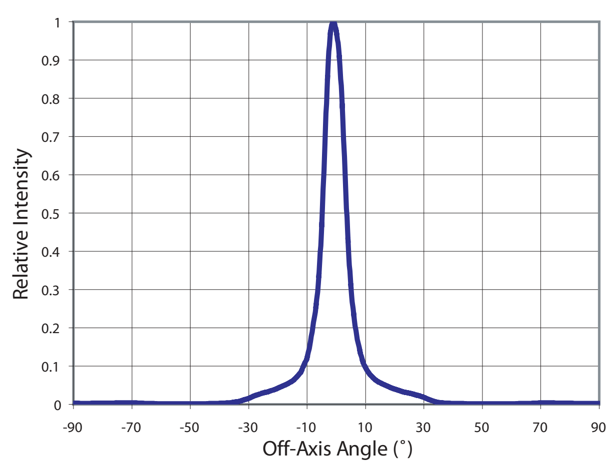
### How AF LED works in Digital Camera

Most of the DSC today use contrast detection methods for the Auto focus function. In low light condition, it requires the use of AF assist LED. Avago AF LEDs ASMT-FJ10, with a high intensity of typically 22cd and with narrow beam of 8° viewing angle, fulfills this need.

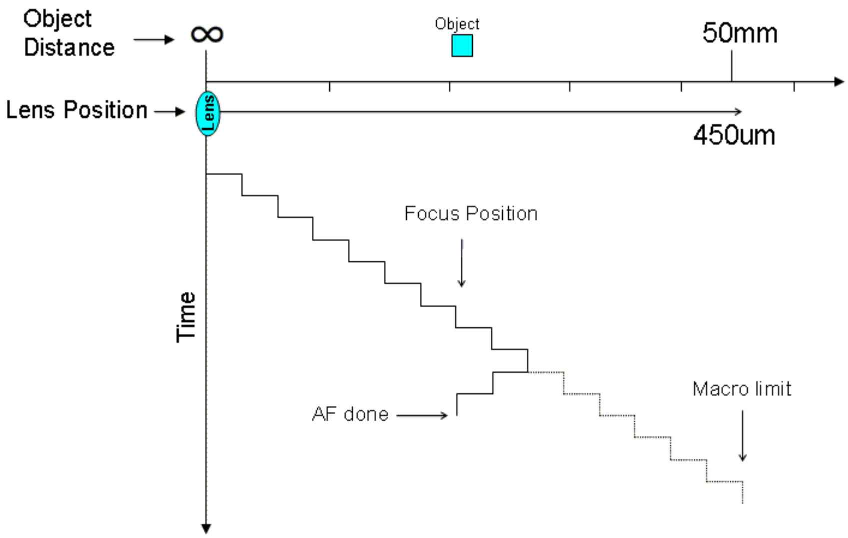
In this method, the lens position will sweep from "infinite focus position" to "macro focus limit position" within a short time until it finds the best focal point. The contrast of each frame is computed; the highest contrast will be the focal point, and finally the lens will fix the FOCAL position. Diagram 1 below shows the Auto focus mechanisms of a TYPICAL digital camera.

**illuminate on the center of the object to allow Auto Focus function**





## Auto focus mechanism of a digital camera




## Electrical Design Consideration for AF LED

Driving AF LED is as simple as driving a discrete LED. LED is a current driven component and, therefore it is highly recommended that it should be used with a constant current source in order to achieve a consistent optical performance. But, the Li-Ion battery in the digital camera is a voltage source and fluctuates according to the energy storage in it (usually fluctuates between 2.8V to 4.2V). This will cause the optical performance (brightness) of the LED to become unpredictable. Hence, direct source from the camera battery to the LED is not recommended.

Integrating the buck/boost converter in between the battery and LED is a suggested solution for this. Figure 1 clearly shows the methodology behind how an AF LED can be configured.

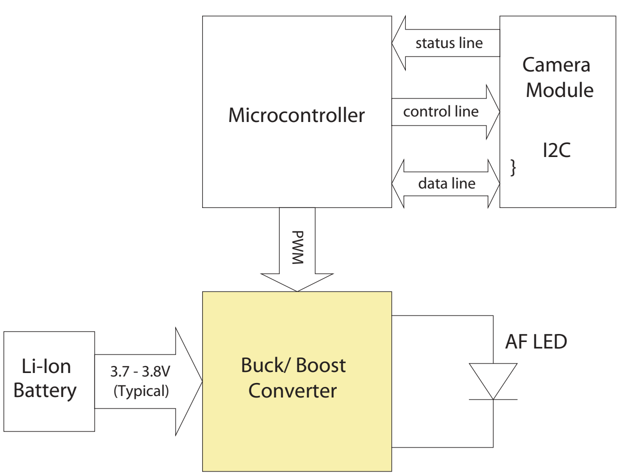



**Figure 1. General Camera System Diagram**

Figure 2 is an example of a buck/boost converter showing an AF LED drive circuit by using REG710. REG710 is a switched capacitor voltage converter that produces a regulated, low-ripple output voltage from an unregulated input voltage. A wide-input supply voltage of 1.8V to 5.5V makes the REG710 ideal for a variety of battery sources, such as single cell Li-Ion, or two and three cell nickel- or alkaline-based batteries. The input voltage may vary above and below the output voltage and the output will remain constant. It works equally well for step-up or step-down applications without the need for an inductor, providing low EMI DC/DC conversion. The high switching frequency allows the use of small surface-mount capacitors, saving board space and reducing cost. The REG710 is thermally protected and current limited, protecting the load and the regulator during fault conditions. Typical ground pin current (quiescent current) is 65μA with no load, and less than 1μA in shutdown mode. This REG710 is available in a thin TSOT23-6 package or small SOT23-6 package.

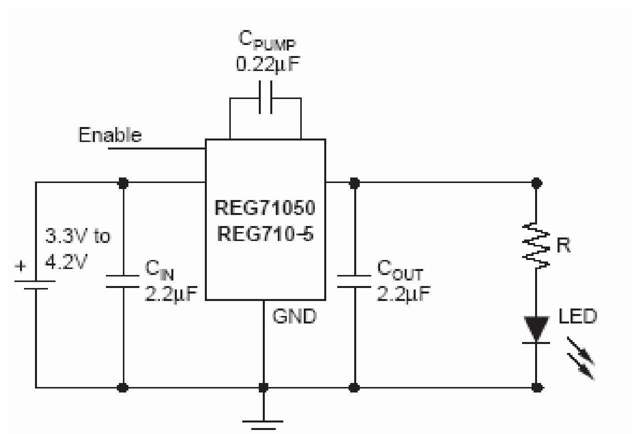



**Figure 2. Buck/ Boost Converter Design**

**REG710 Electrical Characteristic**

**Table 1. REG710 Electrical Characteristic**

| Parameter | Conditions | REG710NA | | | UNITS |
|---|---|---|---|---|---|
| | | MIN | TYP | MAX | |
| INPUT VOLTAGE | See conditions under Output Voltage with a | | | | |
| Tested Startup | resistive load not lower than typical $V_{OUT}/I_{OUT}$ | | | | |
| REG71055 | | 3.0 | | 5.5 | V |
| REG710-5 | | 2.7 | | 5.5 | V |
| All Other Models | | 1.8 | | 5.5 | V |
| OUTPUT VOLTAGE | | | | | |
| REG71055 | $I_{OUT} \leq$ 10mA, 3.0V $\leq V_{IN} \leq$ 5.5V | 5.2 | 5.5 | 5.8 | V |
| | $I_{OUT} \leq$ 30mA, 3.25V $\leq V_{IN} \leq$ 5.5V | 5.2 | 5.5 | 5.8 | V |
| REG710-5, REG71050 | $I_{OUT} \leq$ 10mA, 2.7V $\leq V_{IN} \leq$ 5.5V | 4.7 | 5.0 | 5.3 | V |
| | $I_{OUT} \leq$ 30mA, 3.0V $\leq V_{IN} \leq$ 5.5V | 4.7 | 5.0 | 5.3 | V |
| | $I_{OUT} \leq$ 60mA, 3.3V $\leq V_{IN} \leq$ 4.2V | 4.6 | 5.0 | 5.4 | V |
| REG710-3.3 | $I_{OUT} \leq$ 10mA, 1.8V $\leq V_{IN} \leq$ 5.5V | 3.10 | 3.3 | 3.50 | V |
| | $I_{OUT} \leq$ 30mA, 2.2V $\leq V_{IN} \leq$ 5.5V | 3.10 | 3.3 | 3.50 | V |
| REG710-3 | $I_{OUT} \leq$ 10mA, 1.8V $\leq V_{IN} \leq$ 5.5V | 2.82 | 3.0 | 3.18 | V |
| | $I_{OUT} \leq$ 30mA, 2.2V $\leq V_{IN} \leq$ 5.5V | 2.82 | 3.0 | 3.18 | V |
| REG710-2.7 | $I_{OUT} \leq$ 10mA, 1.8V $\leq V_{IN} \leq$ 5.5V | 2.54 | 2.7 | 2.86 | V |
| | $I_{OUT} \leq$ 30mA, 2.0V $\leq V_{IN} \leq$ 5.5V | 2.54 | 2.7 | 2.86 | V |
| REG710-2.5 | $I_{OUT} \leq$ 10mA, 1.8V $\leq V_{IN} \leq$ 5.5V | 2.35 | 2.5 | 2.65 | V |
| | $I_{OUT} \leq$ 30mA, 2.0V $\leq V_{IN} \leq$ 5.5V | 2.35 | 2.5 | 2.65 | V |

Based on the table above, REG710-5 and REG71050 are the most suitable for the Avago ASMT-FJ10-ADH00 AF LED which can be driven up to 60mA.

Example of calculation:

If required $I_{OUT}$ = 50mA

$V_{LED}$ = 2.3V @ 50mA

$V_{OUT} = I_{OUT} * R + V_{LED}$

5V = 50mA * R + 2.3V

R = 54Ω

If required $I_{OUT}$ = 20mA

$V_{LED}$ = 2V @ 20mA

$V_{OUT} = I_{OUT} * R + V_{LED}$

5V = 20mA * R + 2.0V

R = 150Ω

## Maximum driving condition

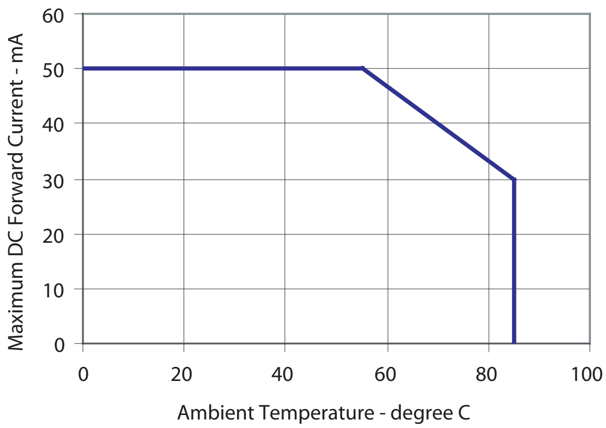



**Figure 3. Maximum forward current vs ambient temperature.**

Avago Technologies' AF LED can be driven up to 50mA under DC condition to illuminate 72.6lux at 1m distance. Figure 3 shows the relationship between the maximum forward current vs. ambient temperature. This AF LED start to derate after 55°C.

Figure 4 shows the achievable Luminace at various current and distance.

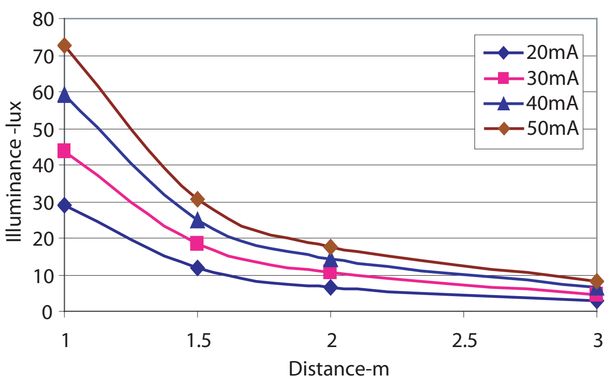



**Figure 4. Luminance vs. Distance**

### Table 2. Luminance performance data

| | Illuminance @ various distance (lux) | | | |
|---|---|---|---|---|
| **Current** | **1m** | **1.5m** | **2m** | **3m** |
| 20mA | 28.82 | 11.78 | 6.72 | 3 |
| 30mA | 43.72 | 18.3 | 10.5 | 4.5 |
| 40mA | 59.26 | 25.04 | 14.3 | 6.5 |
| 50mA | 72.6 | 30.74 | 17.7 | 8 |

Pictured below is an example where the object is being illuminated by Avago AF LED at 3m away with driving current of 50mA under 0 lux ambient condition.

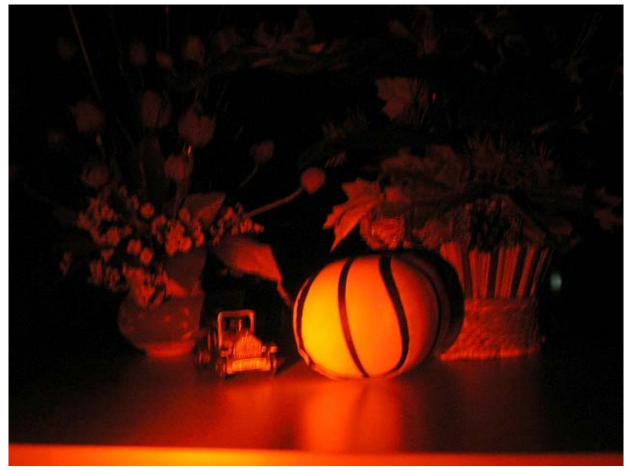


**Figure 5. Picture taken at 50mA 3m distance**

## Eye Safety

These orange Surface Mount AF Lamp are use for camera application. The LEDs have lenses, which focus the beam at about 10mm from the front of the lens, from where the beam diverges relatively slowly. If the LEDs were placed in a product, they would create a Class 1 LED to IEC/EN 60825-1 (2001) under all conditions of operation and single fault failure, as long as no collimating optics are added to the optical path. If a high aperture optic is added, the classification might not be valid.

The accessible radiation was measured through a 7mm aperture at r = 44mm from focal point. The beam diverges enough for a Condition 1 test to be unnecessary.

The AEL for class 1 is given by:

$AEL = 7x10^{-4} C_6/T_2^{0.25} W$,

where $C_6 = 12.9$ and $T_2^{0.25} = 1.97$

$AEL = 4.58mW$.

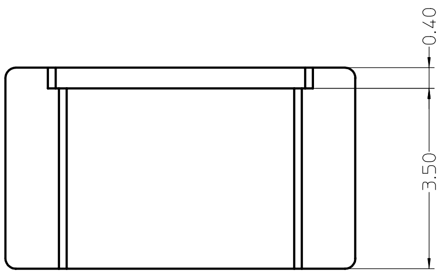
These AF LEDs gave out around 0.54mW at 20mA and 1.32mW at 50mA. Pass AEL class 1.

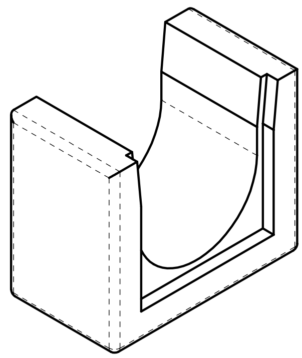
## Recommended Avago's AF LED Holder Design

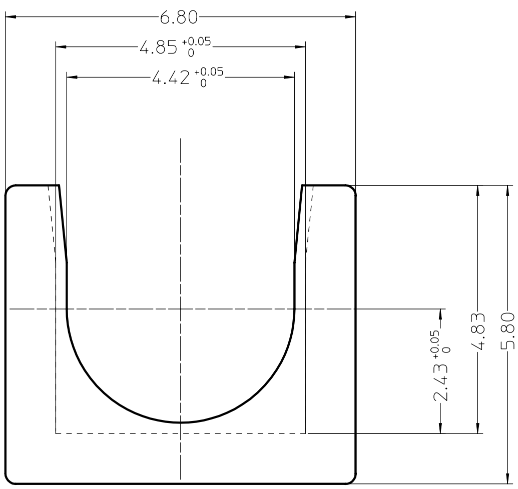
The LED holder design is very critical when positioning the LED to focus the image. If the LED is tilted, the sensor will detect wrong information and thus will affect the focal point accuracy.

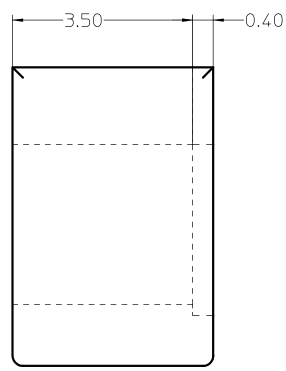
There will be 2 types of recommended holder designs to suit for Avago ASMT-FJ10 LED as shown below:

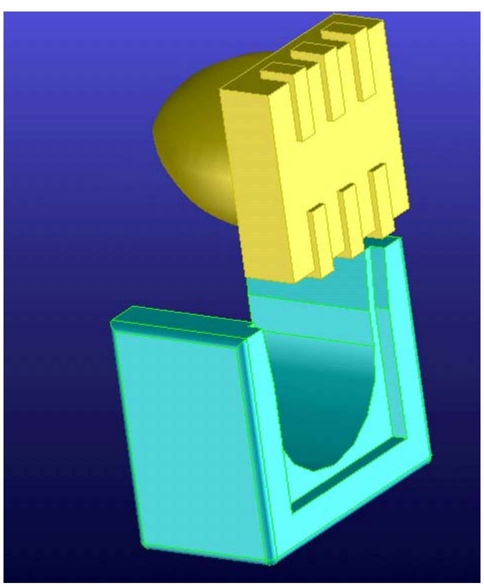
## Recommended "U" shape holder for Avago AF LED





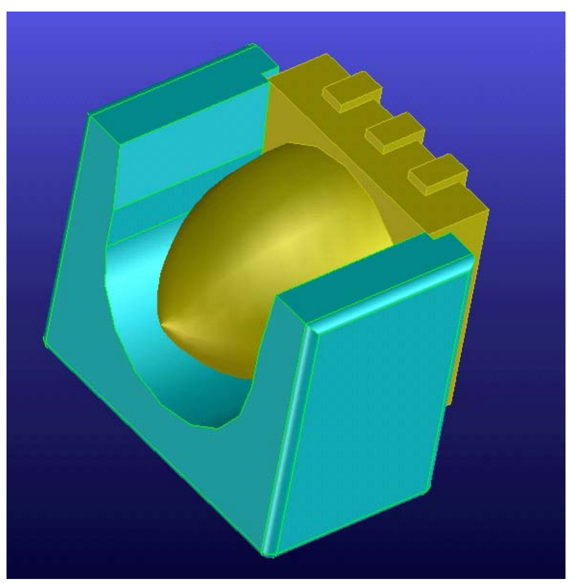


Figure 6 below shows how the AF LED should be place into the “U” Shape holder. The spring force should be applied at the bottom of the “U” shape; this is to prevent the AF LED from tilting. Figure 7 is the incorrect pushing direction of the AF LED, which will cause the AF LED to tilt downwards.

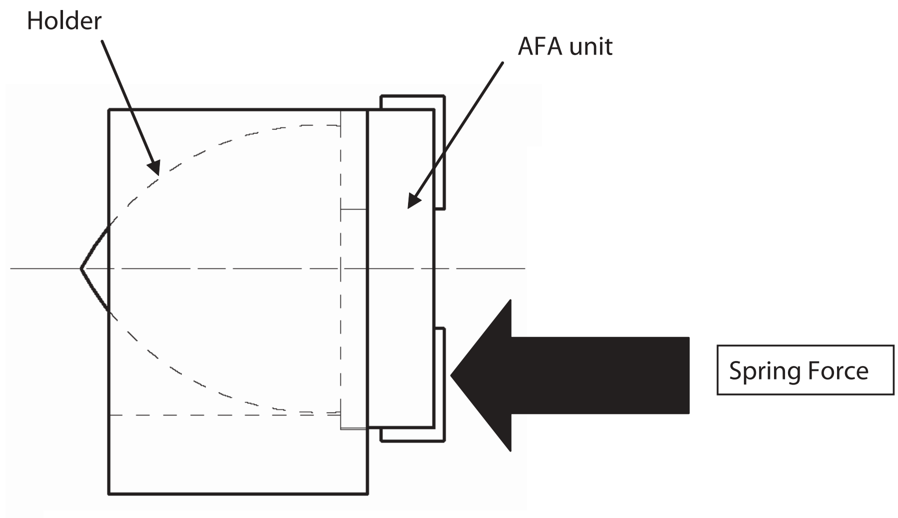
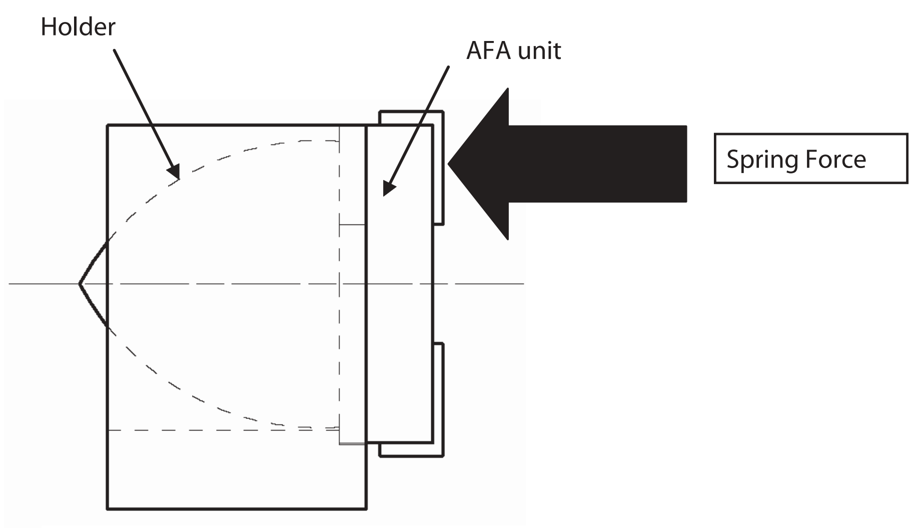


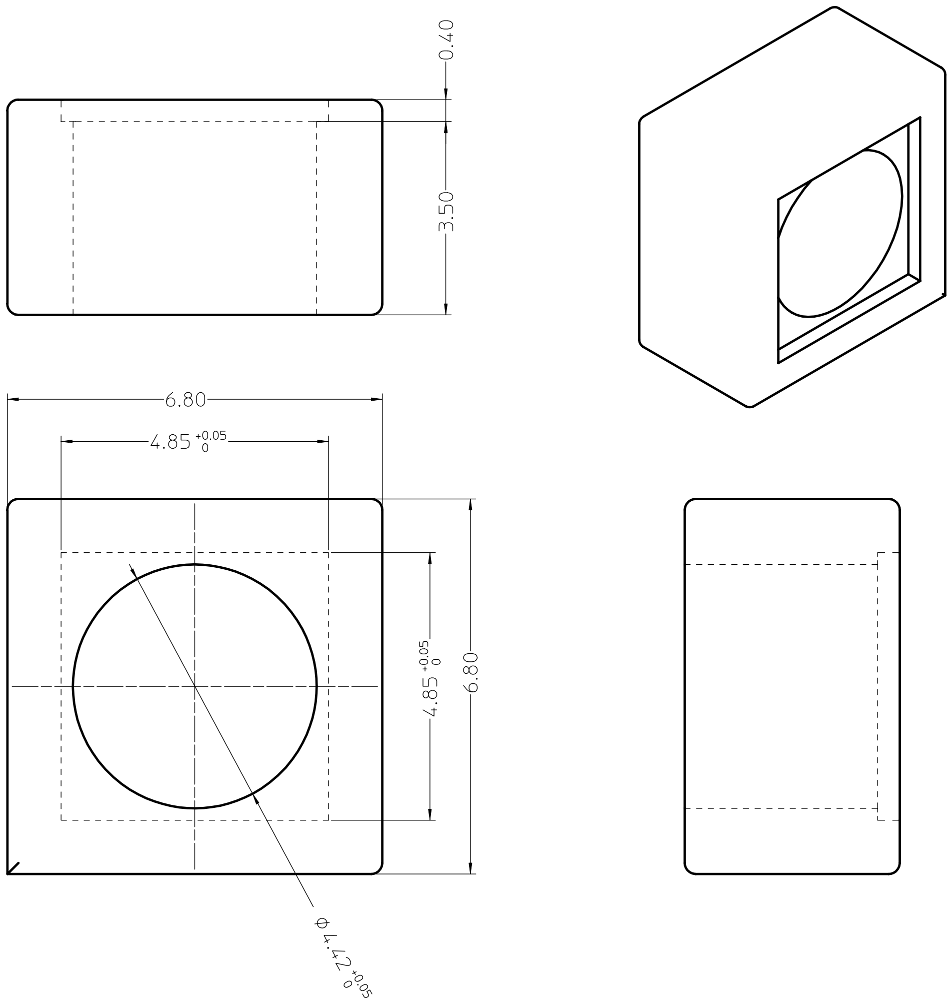

**Figure 6. Correct positioning of spring loaded pusher for AF LED**



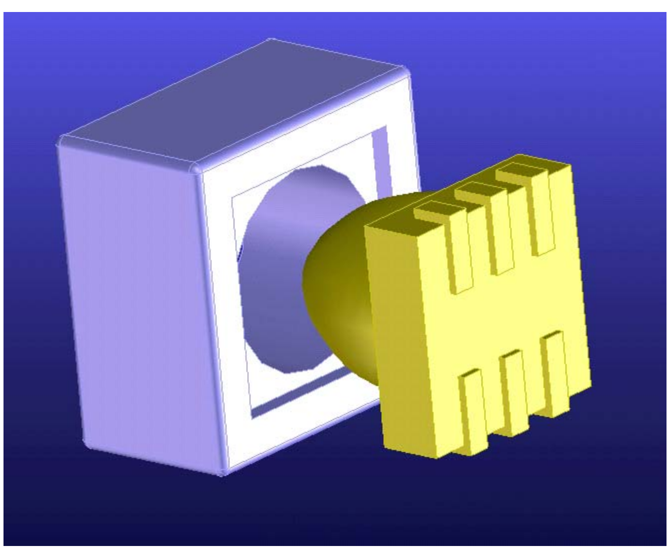

Note: Applying force at the top of assembly can cause tilting of the AF LED..

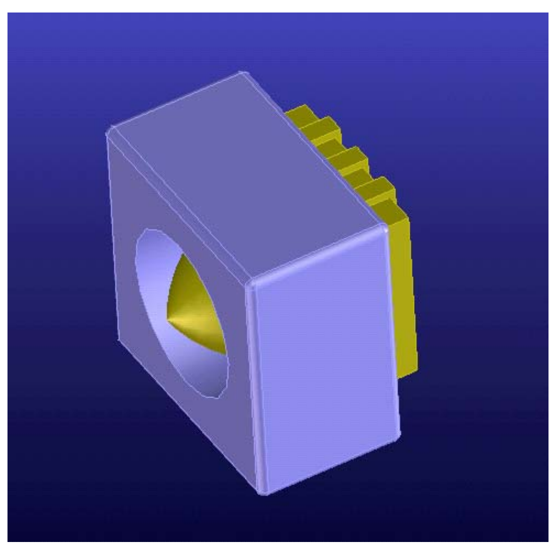
**Figure 7. Incorrect positioning of spring loaded pusher for AF LED**

## Recommended Enclose Shape Holder for Avago AF LED




Note: These dimensions are for reference only





## Automatic Placement Equipment Consideration

Avago recommends a 3.2mm inner diameter nozzle to pick up ASMT-Fx10 series SMT LED.

Refer to Table 3 for the pick-and-place evaluation done on the ASMT-Fx10 series LED. Proper machine set up and optimization needs to be done to minimize yield loss.

Refer to Application Note 1060, "Surface Mounting SMT LED Indicator Components", for further general information on surface mount LED lamps.

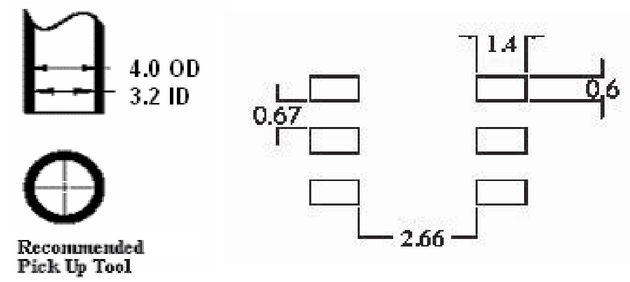


**Figure 8. Recommended pick up tool and Soldering land pattern**

**Table 3.**

| Machine Manufacturer | Machine Model | Speed (sec/component) | Nozzle Dimension (mm) | | Sample Size | Throw Percentage (%) |
|---|---|---|---|---|---|---|
| | | | Inner | Outer | | |
| JUKI | KE-760 | 2 | 3.2 | 4.0 | 3000 | 0.00% |

## Handling Precaution

When the bag is opened, parts are required to be mounted within 168 hours of factory conditions ≤ 30 °C/60%, and stored at <10% RH.

Devices are required to bake, before mounting if:

a. The humidity indicator card is > 10% when read at 23±5°C

b. The pack has been opened for more than 168 hours

Baking recommended condition: 60 ± 5°C for 20 hours.

Note:

1. Do not stack the units after reflow.
2. This part is Class 1 ESD sensitive. Observe appropriate precautions during handling and processing. Refer to Application Note AN-1142 for additional details.

For product information and a complete list of distributors, please go to our web site: **www.avagotech.com**

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AV01-0413EN - September 6, 2006

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