

# FAN5611/FAN5612/FAN5613/FAN5614

## Low-Dropout LED Drivers for White, Blue, or any Color LED

### Features

- LED drivers for parallel-connected LEDs (2 to 4)
- Ultra-low voltage drop (< 300mV) to support direct Li-ion applications
- No EMI, no switching noise
- No external components needed for current matching
- Both analog and PWM brightness control
- FAN5611, FAN5613 feature up to 160mA bias current (up to 40mA for each LED)
- FAN5612 features up to 120mA bias current (up to 40mA for each LED)
- FAN5614 features up to 160mA bias current (up to 80mA for each LED)
- Enable/Shutdown control (FAN5612, FAN5613, FAN5614)
- Shutdown current < 1µA
- Small footprint SC-70 and MLP

### Applications

- Cell Phones
- PDA, DSC, MP3 Players
- Handheld Computers
- LCD Display Modules
- Keyboard Backlight
- LED Displays

### Description

The FAN5611/12/13/14 low-dropout product family is designed to drive two to four parallel LEDs, providing matched current source bias for all color LEDs. The LED current is set by an external resistor,  $R_{SET}$ . The FAN5611/13 supports four parallel LEDs with up to 160mA bias current (up to 40mA per output). The FAN5612 supports three LEDs with up to 120mA bias current (40mA per output). The FAN5614 drives two high-current LEDs (80mA per output). Pin I1 should always be connected to an LED to provide a matched current for any additional LEDs.

The FAN5612/13 and 14 are selected using an ENABLE pin. When the chip is not selected (ENABLE pin is LOW), the supply current drops to less than 1µA.

The FAN5611, FAN5612, and FAN5614 are available in an SC-70 package. The FAN5611 and FAN5613 are available in MLP packages.

### Ordering Information

Product Number	Package Type	Order Code
FAN5611	6-Lead SC-70 / 2x2mm 6-Lead MLP	FAN5611S7X / FAN5611MPX
FAN5612	6-Lead SC-70	FAN5612S7X
FAN5613	2x2mm 8-Lead MLP	FAN5613MPX
FAN5614	6-Lead SC-70	FAN5614S7X

Table 1. Ordering Information

## Typical Applications

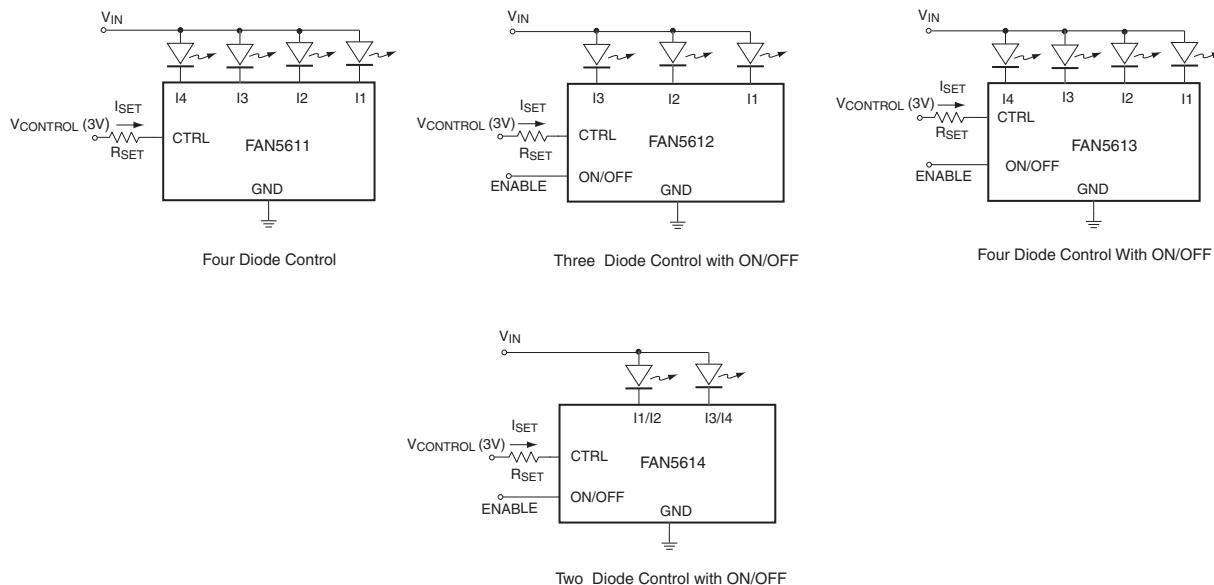
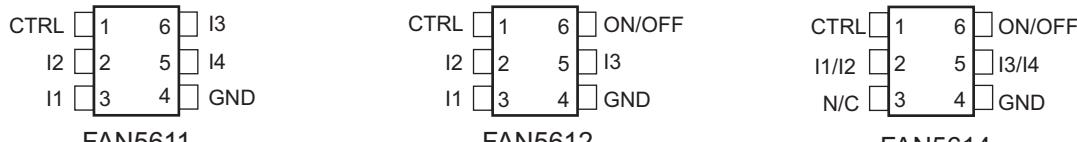


Figure 1. Typical Applications for FAN5611, FAN5612, FAN5613, FAN5614

## Pin Assignments



6-LEAD SC-70

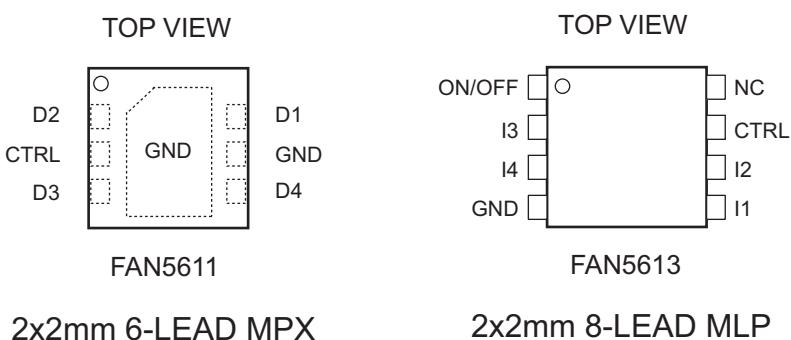


Figure 2. Pin Assignments for FAN5611, FAN5612, FAN5613, FAN5614

## Pin Descriptions

Pin #	Name				Description
	FAN5611	FAN5612	FAN5613	FAN5614	
1	CTRL	CTRL		CTRL	Sets LED Current (see Operational Descripton)
			ON/OFF		Chip ON/OFF/Disable
2	I2	I2			Connect to Cathode of LED
			I3		Connect to Cathode of LED
				I1/I2	
3	I1	I1			Connect to Cathode of LED
			I4		Connect to Cathode of LED
				N/C	No Connection
4	GND	GND	GND	GND	Ground
5	I4				Connect to Cathode of LED
		I3			Connect to Cathode of LED
			I1		Connect to Cathode of LED
				I3/I4	Connect to Cathode of LED
6	I3				Connect to Cathode of LED
		ON/OFF		ON/OFF	Chip ON/OFF/Disable
			I2		Connect to Cathode of LED
7			CTRL		Sets LED Current (see Operational Descripton)
8			NC		No Connection

**Table 2. Pin Descriptions**

**Notes:**

1. The DAP of FAN 5611MPX can be tied to the GND pin or left floating. For better power dissipation, tie to GND.

## Absolute Maximum Ratings

The “Absolute Maximum Ratings” are those values beyond which the safety of the device cannot be guaranteed. The device should not be operated at these limits. The parametric values defined in the Electrical Characteristics tables are not guaranteed at the absolute maximum ratings. The “Recommended Operating Conditions” table defines the conditions for actual device operation.

Parameter	Min.	Max.	Unit
$V_{I1}$ , $V_{I2}$ , $V_{I3}$ , $V_{I4}$ and ENABLE Voltage to GND	-0.3	6.0	V
CTRL Voltage to GND	-0.3	3.0	
Power Dissipated by package at $T_A = 85^\circ\text{C}$	6-Lead SC70	190	mW
	6, 8-Lead MLP	700	
$I_1, I_2, I_3, I_4$ Steady State Current	FAN5611/12/13	40	mA
$I_1/I_2, I_3/I_4$ Steady State Current	FAN5614	80	
Lead Temperature (Soldering 10 seconds)		300	$^\circ\text{C}$
Junction Temperature		150	$^\circ\text{C}$
Storage Temperature	-55	150	$^\circ\text{C}$
Electrostatic Discharge Protection (ESD) Level <sup>(1)</sup>	HBM	4	kV
	CDM	1	

Table 3. Absolute Maximum Ratings

## Recommended Operating Conditions

Parameter	Min.	Typ.	Max.	Unit
LED Cathode Voltage	FAN5611, FAN5612, FAN5613	0.3	0.5	1.0
	FAN5614	0.15		
Ambient Temperature	-40	25	85	$^\circ\text{C}$

Table 4. Recommended Operating Conditions

### Notes:

2. Using Mil Std. 883E, method 3015.7 (Human Body Model) and EIA/JESD22C101-A (Charge Device Model).

**DC Electrical Characteristics** $V_{IN} = 3.3V$  to  $5.5V$ ,  $ENABLE = V_{IN}$ ,  $T_A = 25^\circ C$  unless otherwise noted.

Parameter	Conditions	Min.	Typ.	Max.	Units
Current Gain	FAN5611/12/13 $I_{SET} = 100\mu A$ $V_{SAT} = 300mV$	140	200	260	
	FAN5614 $I_{SET} = 100\mu A$ $V_{SAT} = 150mV$				
LED Current (Per Diode)	FAN5611/12/13 $V_{SAT} = 300mV$ $I_{SET} = 100\mu A$		20		mA
	FAN5614 $V_{SAT} = 150mV$ $I_{SET} = 100\mu A$				
LED to LED Current Matching	FAN5611/12/13 $V_{SAT} = 300mV$ $I_{SET} = 100\mu A$ $T_A = -40^\circ C$ to $85^\circ C$	-3		3	%
	FAN5614 $V_{SAT} = 150mV$ $I_{SET} = 100\mu A$ $T_A = -40^\circ C$ to $85^\circ C$				
Peak Efficiency	$V_{IN} = 3V$		90		%
Current in OFF Mode ( $I_{SET}$ and $I_I$ )	$V_{EN} = 0V$			1	$\mu A$
Minimum ENABLE "ON Voltage" <sup>(2)</sup> (FAN5612, FAN5613, FAN5614)	$I_{SET} = 150\mu A$			2.8	V
Maximum ENABLE "OFF Voltage" <sup>(2)</sup> (FAN5612, FAN5613 FAN5614)		0.5			V

**Table 5. DC Electrical Characteristics****Notes:**

3. ENABLE "ON" is  $V_{EN}$  where  $I_{I1} > 20mA$  @  $V_{I1} = 0.3V$ , while ENABLE "OFF" is  $V_{EN}$  where  $I_{I1} < 1\mu A$  @  $V_{I1} > 0.3V$ .

## Typical Performance Characteristics

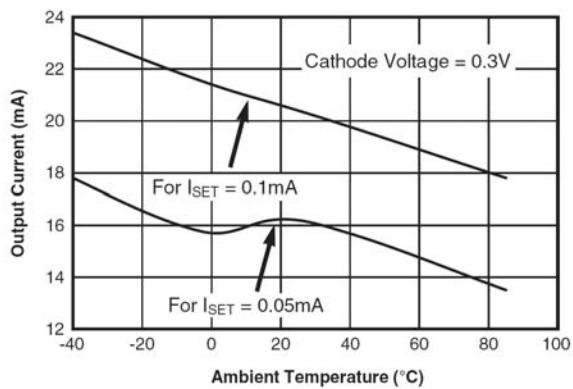


Figure 3. FAN5611/12/13  
Output Current vs. Temperature

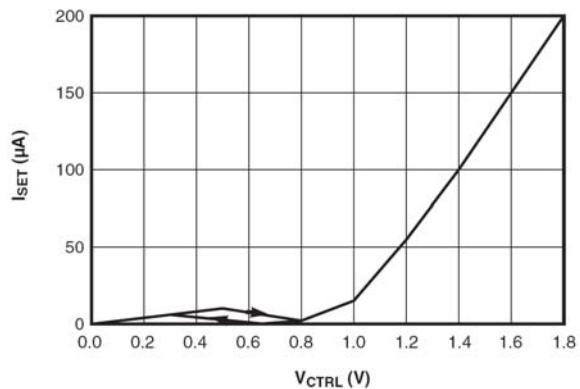


Figure 4. I\_SET vs. V\_CTRL

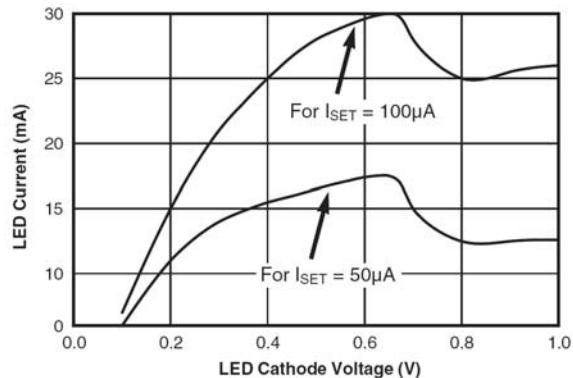


Figure 5. FAN5611/12/13  
LED Current vs. LED Cathode Voltage

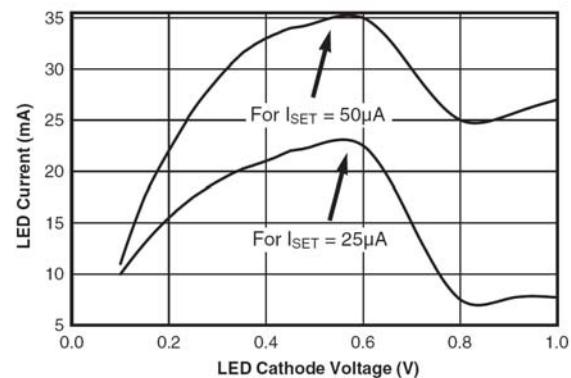


Figure 6. FAN5614  
LED Current vs. LED Cathode Voltage

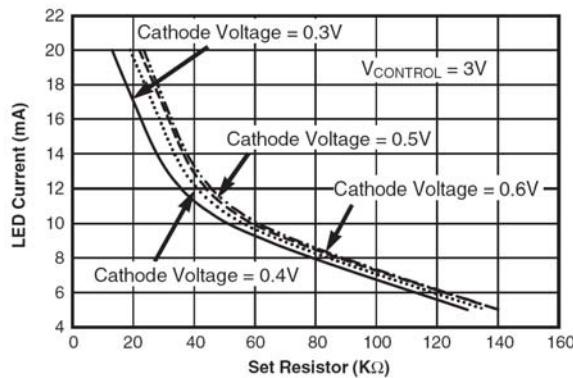


Figure 7. FAN5611/12/13  
LED Current vs. Set Resistor

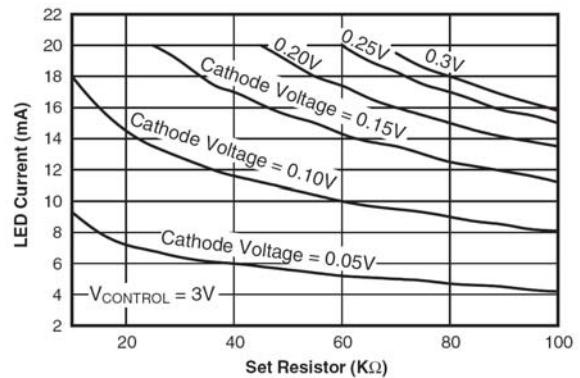
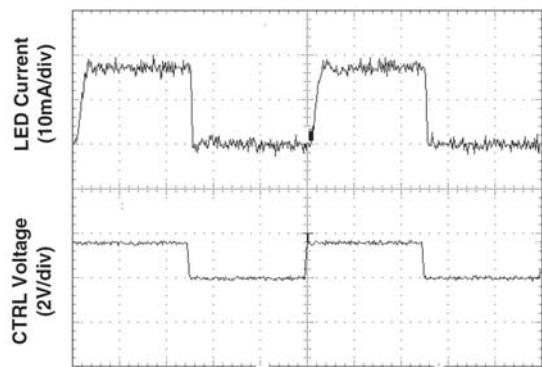
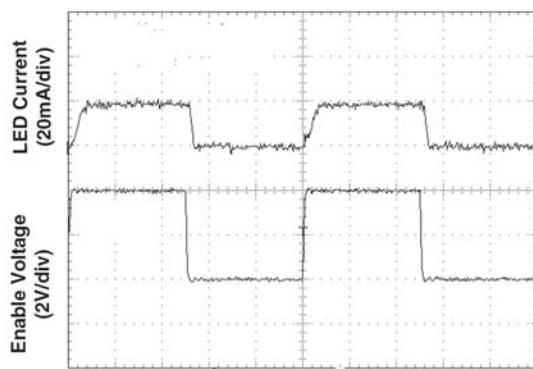


Figure 8. FAN5614 LED Current vs. Set Resistor

## Typical Performance Characteristics (Continued)



**Figure 9. FAN5611/12/13/14**  
Control Voltage Transient Response



**Figure 10. FAN5612/13/14**  
Enable Voltage Transient Response

## Application Information

### Operational Description

The regulated current through each LED is a multiplication of the  $I_{SET}$  current. The  $I_{SET}$  value is determined by the  $R_{SET}$  value. The  $I_{SET}$  value can be calculated as:

$$I_{SET} = I_{LED} / \text{Current Gain}$$

Reference Figure 4, the  $I_{SET}$  vs.  $V_{CTRL}$  graph, to estimate  $V_{CTRL}$ . The value of  $R_{SET}$  is calculated according to the formula:

$$R_{SET} = (V_{CONTROL} - V_{CTRL}) / I_{SET}$$

For example, with  $V_{CONTROL} = 3V$ , a 10mA current limit through the LED results in  $I_{SET} = 50\mu A$ . That translates to an approximate value of 1.2V for  $V_{CTRL}$ , shown in Figure 4. The resulting  $R_{SET}$  value that maintains 10mA regulation is  $36k\Omega$ .

The LED intensity can be adjusted by varying the duty cycle of a square wave applied to the enable pin. Frequency greater than 100Hz is best to avoid a "flickering" effect. The maximum operation frequency is 10MHz.

### Efficiency Considerations

The FAN561X driver's low-dropout architecture can significantly improve the efficiency compared to using simple ballast resistors. The system efficiency, defined as the ratio between the LEDs' power and the input supplied power, can be calculated as:

$$\text{Efficiency} = (V_{IN} - V_{CATHODE}) / V_{IN}$$

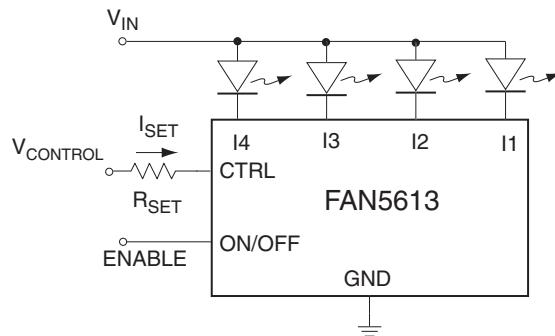
The lower the  $V_{CATHODE}$ , the higher the system efficiency. Efficiency can be further improved by using a higher  $V_{IN}$  with more LEDs, as shown in Example 3.

### Application Notes

The ultra-low voltage drop across the FAN561X series of LED drivers allows the devices to drive white, blue, and other color LEDs in a wide range of input voltages. The driver can be used in many applications. Although only the FAN5613 is shown in all three examples, any of the FAN561X-series LED drivers can be used in the applications presented, due to their similar operation.

#### Example 1: Drive low $V_F$ white or blue LEDs directly from single cell Li-ion

When using white or blue low  $V_F$  LEDs, and utilizing the drivers low voltage drop, only 3.4V in  $V_{IN}$  is needed for the full 20mA LED current. At 3.1V, there is 5mA typical current available for the LEDs. The single cell Li-ion is utilized in applications like cell phones or digital still cameras. In most cases, the Li-ion battery voltage level only goes down to 3.0V voltage level, not down to the full discharge level (2.7V) before requesting the charger.



- $V_{DROP} < 0.3V$
- $V_F$  (at 20mA) < 3.1V (Low  $V_F$ )
- $V_{IN}$  (at 20mA) =  $V_{DROP} + V_F$  = 3.4V
- $V_{IN}$  (at 5mA Typical) ~ 3.1V

where  $V_{IN}$  = Single cell Li-ion voltage.

#### Key advantages:

- No boost circuit is needed for the LCD or keyboard backlight.
- Drivers are directly connected to a Li-ion battery.
- No EMI, no switching noise, no boost efficiency lost, no capacitor, and no inductor.

#### Example 2: Drive high $V_F$ white or blue LEDs from existing bus from 4.0V to 5.5V

High  $V_F$  white or blue LEDs have forward voltage drop in the range of 3.2V to 4.0V. Driving these LEDs with the maximum current of 20mA for maximum brightness, usually requires a boost circuit for a single cell Li-ion voltage range. In some cases, there is already a voltage bus in the system, which can be utilized. Due to the ultra-low voltage drop of the FAN561X series of LED drivers to drive high- $V_F$  white or blue LEDs, the  $V_{IN}$  needs to be only 300mV higher than the highest  $V_F$  in the circuit.

- $V_{DROP} < 0.3V$
- $V_F$  (at 20mA) < 3.3V to 4.0V (High  $V_F$ )
- $V_{IN}$  (at 20mA) =  $V_{DROP} + V_F$  = 3.6V to 4.3V
- $V_{IN}$  (at 5mA Typical) ~ 3.3V

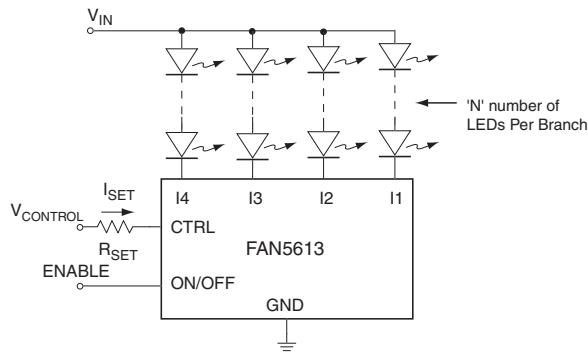
where  $V_{IN}$  = existing bus = 3.3V to 4.3V.

#### Key advantages:

- No boost circuit is needed for LCD or keyboard backlight.
- Driver utilizes the existing bus.
- Ultra-low voltage drop provides the full 20mA LED current at the lowest possible voltage level.

**Example 3: Drive white, blue, red, amber LEDs string**

Assuming a boost circuit or existing voltage bus, the FAN561X series of LED drivers can be used to drive a whole string of LEDs with flexible brightness control via analog and/or PWM.



- $V_{DROP} < 0.3V$
- $V_{IN\_MIN} = N \times V_F + V_{DROP}$
- $V_{IN\_MAX} = N \times V_F + 5.5V$

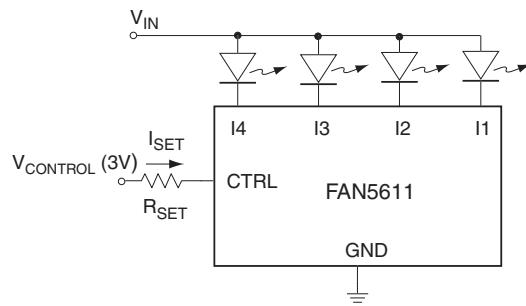
where  $V_{IN}$  = existing bus, boost voltage.

**Key advantage:**

- No need for current matching resistors and discrete transistor for brightness control.

**LED Brightness Control**

All of the FAN561X LED drivers feature analog and PWM controls to give designers flexible brightness control. These control methods can be applied to the circuit in two different ways to provide more flexibility than other solutions. To determine the value of  $R_{SET}$ , use the  $I_{SET}$  vs.  $V_{CTRL}$  graph in Figure 4.

**1. FAN5611****- Analog**

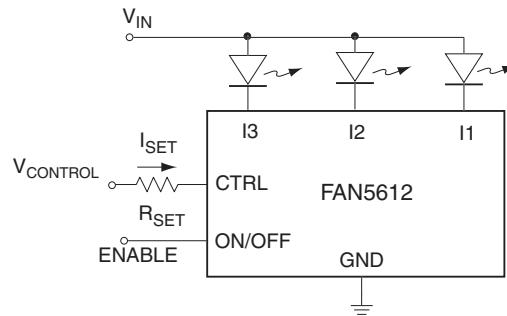
Set  $V_{CONTROL}$  and  $R_{SET}$  for LED current using:

$$I_{LED} = \frac{200 \times (V_{CONTROL} - V_{CTRL})}{R_{SET}}$$

**- PWM**

$$V_{CONTROL} = \text{PWM}$$

- Amplitude sets maximum LED current.
- Pulse width controls between 0 and maximum.

**2. FAN5612****- Analog**

Set  $V_{CONTROL}$  and  $R_{SET}$  for LED current using:

**- PWM - 1**

$$I_{LED} = \frac{200 \times (V_{CONTROL} - V_{CTRL})}{R_{SET}}$$

$$V_{CONTROL} = \text{PWM}$$

- Amplitude sets maximum LED current.
- Pulse width controls between 0 and maximum.

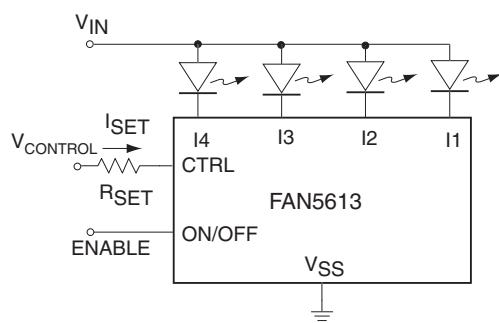
**- PWM - 2**

Set  $V_{CONTROL}$  and  $R_{SET}$  for maximum LED current using:

$$I_{LED} \sim 200 \times I_{SET}$$

$$\text{ON/OFF} = \text{PWM}$$

- Amplitude has no effect on current.
- Pulse width controls between 0 and maximum.

**3. FAN5613****- Analog**

Set  $V_{CONTROL}$  and  $R_{SET}$  for LED current using:

$$I_{LED} = \frac{200 \times (V_{CONTROL} - V_{CTRL})}{R_{SET}}$$

**- PWM - 1**

$$V_{CONTROL} = \text{PWM} \quad \text{[Pulse Width Modulation waveform diagram]}$$

- Amplitude sets maximum LED current.
- Pulse width controls between 0 and maximum.

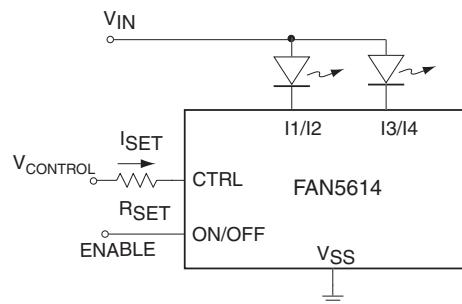
**- PWM - 2**

Set  $V_{CONTROL}$  and  $R_{SET}$  for maximum LED current using:

$$I_{LED} \sim 200 \times I_{SET}$$

$$\text{ON/OFF} = \text{PWM} \quad \text{[Pulse Width Modulation waveform diagram]}$$

- Amplitude has no effect on current.
- Pulse width controls between 0 and maximum.

**4. FAN5614****- Analog**

Set  $V_{CONTROL}$  and  $R_{SET}$  for LED current using:

$$I_{LED} = \frac{200 \times (V_{CONTROL} - V_{CTRL})}{R_{SET}}$$

**- PWM - 1**

$$V_{CONTROL} = \text{PWM} \quad \text{[Pulse Width Modulation waveform diagram]}$$

- Amplitude sets maximum LED current.
- Pulse width controls between 0 and maximum.

**- PWM - 2**

Set  $V_{CONTROL}$  and  $R_{SET}$  for maximum LED current using:

$$I_{LED} \sim 200 \times I_{SET}$$

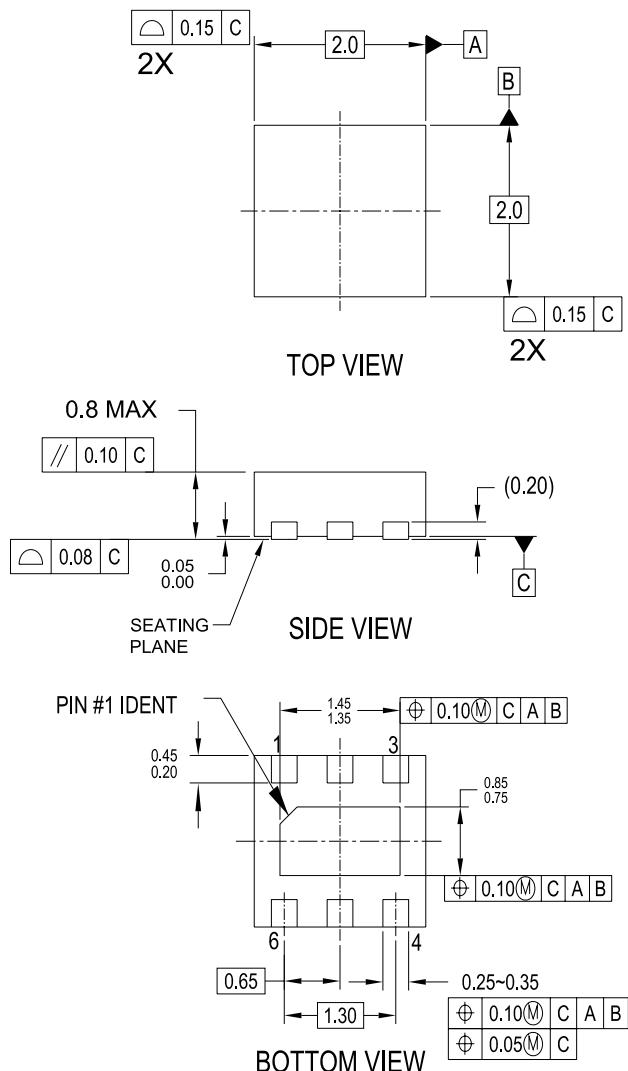
$$I_{LED} = \frac{200 \times (V_{CONTROL} - V_{CTRL})}{R_{SET}}$$

$$\text{ON/OFF} = \text{PWM} \quad \text{[Pulse Width Modulation waveform diagram]}$$

- Amplitude has no effect on current.
- Pulse width controls between 0 and maximum.

## Mechanical Dimensions

2x2mm 6-Lead MLP



### NOTES:

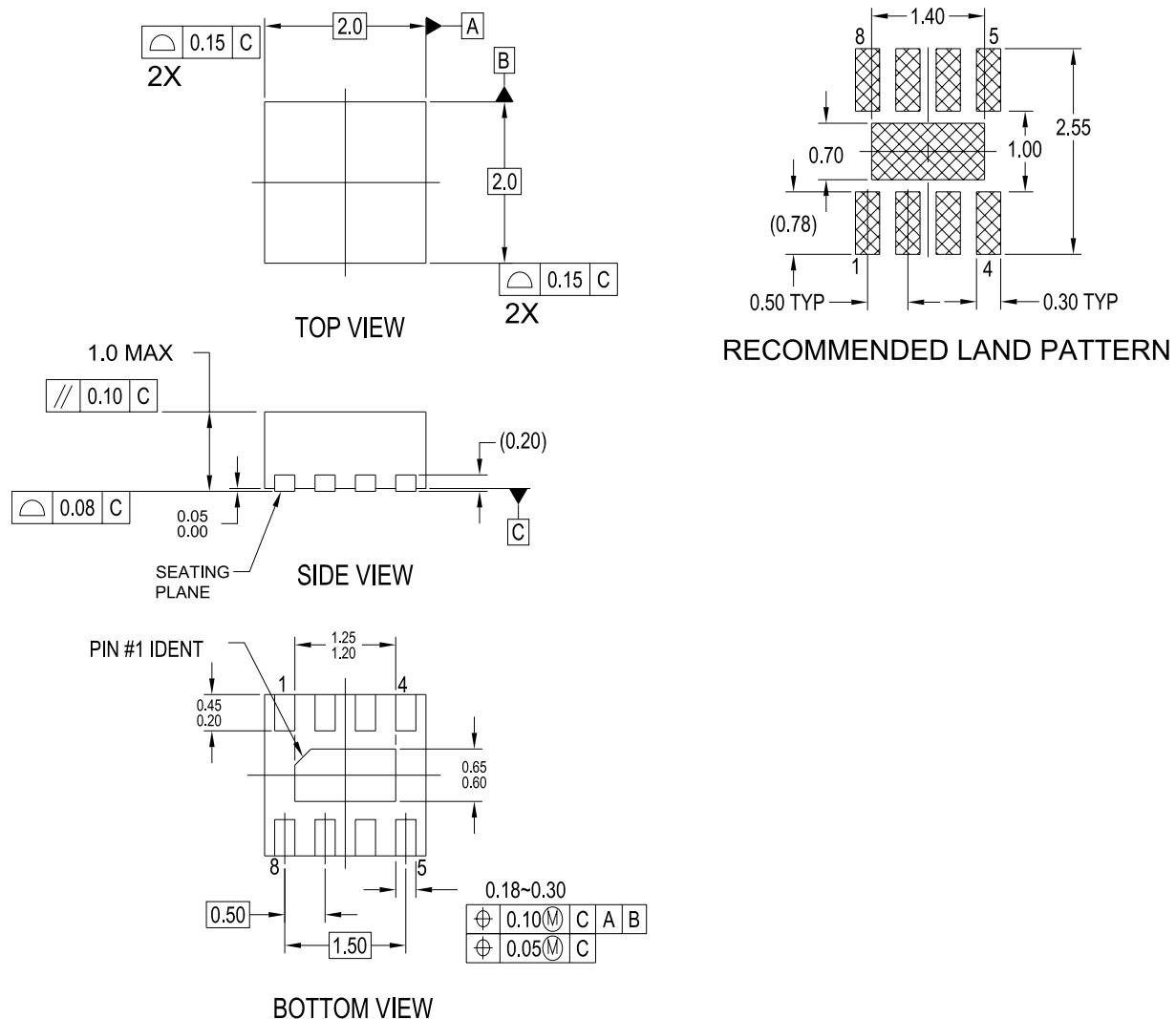
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- C. DIMENSIONS AND TOLERANCES PER

ASME Y14.5M, 1994

MLP06KrevA

## Mechanical Dimensions

2x2mm 8-Lead MLP



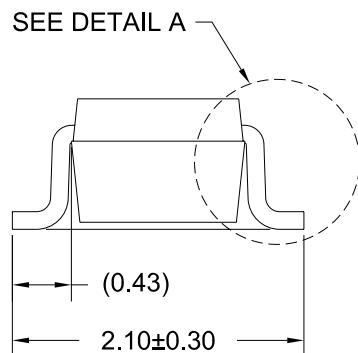
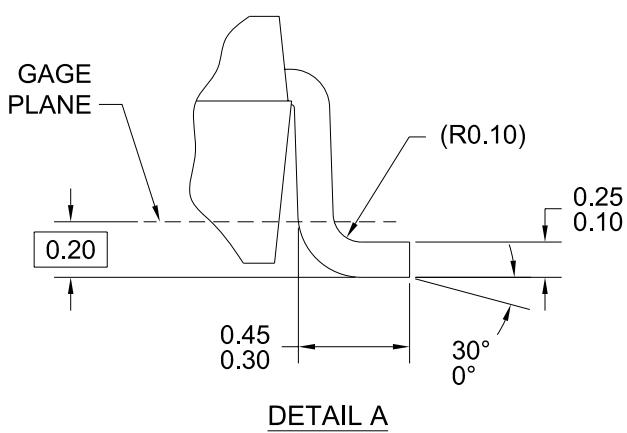
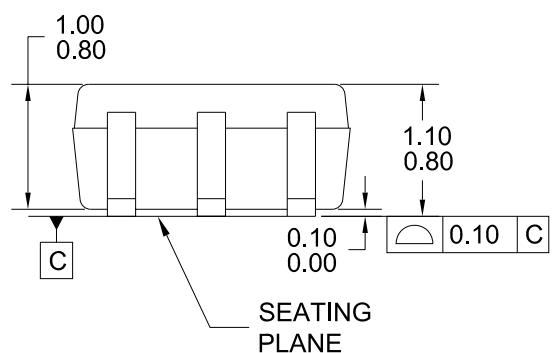
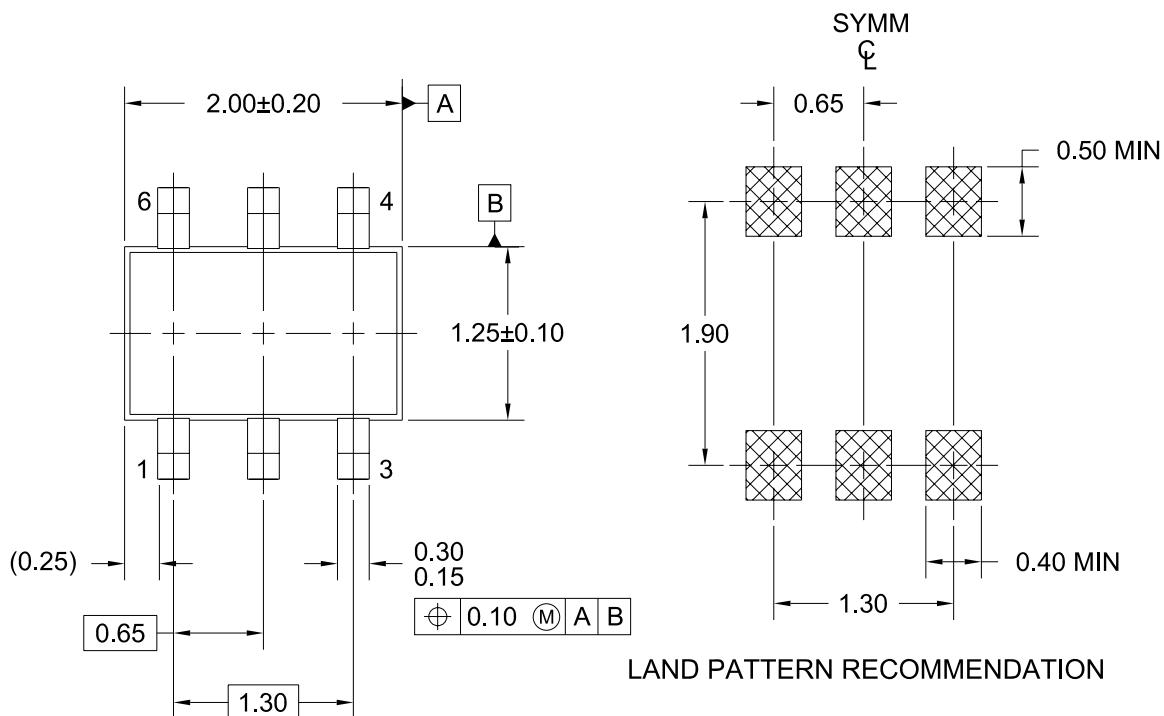
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MLP08CrevB

## Mechanical Dimensions

6-Lead SC-70 Package



NOTES: UNLESS OTHERWISE SPECIFIED

- A) THIS PACKAGE CONFORMS TO EIAJ SC-88A, 1996.
- B) ALL DIMENSIONS ARE IN MILLIMETERS.
- C) DIMENSIONS DO NOT INCLUDE BURRS OR MOLD FLASH.

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EcoSPARK™	IntelliMAX™	PowerEdge™	SuperSOT™-8	
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FASTr™	MicroPak™	QT Optoelectronics™	TinyPWM™	
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