FAN5610

LED Driver for White, Blue or any Color LED

Features

- LED Driver for 4 Parallel-connected LEDs
- Low Voltage Drop (<350mV) to Support Direct Li-ion Applications with Low V_F LEDs
- Independent Control Loop for Each LED
- Regulated, Matched Constant Current in LEDs
- No External Components
- No EMI, No Switching Noise
- Built-in DAC for Digital and PWM Brightness Control
- Up to 91% Maximum Efficiency
- Up to 84mA (21mA/LED) Bias Current
- 2.7V to 5.5V Input Voltage Range
- I_{CC} < 1µA in Shutdown Mode
- 3mmX3mm MLP-8 Package

Applications

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

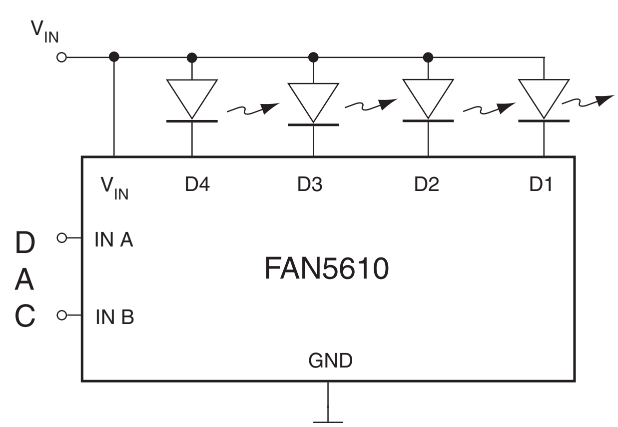
Description

The FAN5610 generates matched current source drives for a maximum of four LEDs. Since each LED current source has its own self-regulating loop, precise current matching is maintained even if there is a substantial forward voltage spread among the LEDs. LED pre-selection therefore is not required. In order to minimize voltage drop, and maximize efficiency, the value of the internal current sense resistors connected in series with the LEDs is very low (10Ω). This is an important consideration for direct DC-driven white LEDs in battery-powered systems.

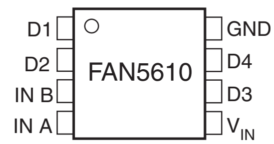
The LEDs current can be set to 0mA (OFF Mode), 7mA, 14mA, 21mA with a built-in two-bit digital-to-analog converter. Customized current settings can also be used. When the control bits are set to zero, the internal circuitry is disabled and the quiescent current drops below 1µA.

Both digital input lines (A, B) can be pulse width modulated. Using PWM, any value of average LED current can be obtained within the 1 to 20 mA range. The FAN5610 is available in an 8-lead 3X3 MLP package.

Typical Application



Pin Assignment



3x3mm 8-LEAD MLP PACKAGE

Pin Descriptions

Pin Name	Pin Function Description
D1	Cathode of Diode No.1
D2	Cathode of Diode No. 2
IN B	DAC Input B, Active High
IN A	DAC Input A, Active High
V_{IN}	Input Voltage
D3	Cathode of Diode No. 3
D4	Cathode of Diode No. 4
GND	Ground

Absolute Maximum Ratings

Parameter		Min.	Max.	Unit
V_{IN}, IN A/IN B Voltage to GND		-0.3	6.0	V
Lead Soldering Temperature (10 seconds)			300	°C
Operating Junction Temperature Range			150	°C
Storage Temperature		-55	150	°C
Electrostatic Discharge Protection Level (Note1)	HBM	4		kV
	CDM	2		

Recommended Operating Conditions

Parameter	Min.	Typ.	Max.	Unit
Input Voltage Range, V_{IN} (Note2)	2.7		5.5	V
Operating Ambient Temperature Range	-40	25	85	°C

DC Electrical Characteristics

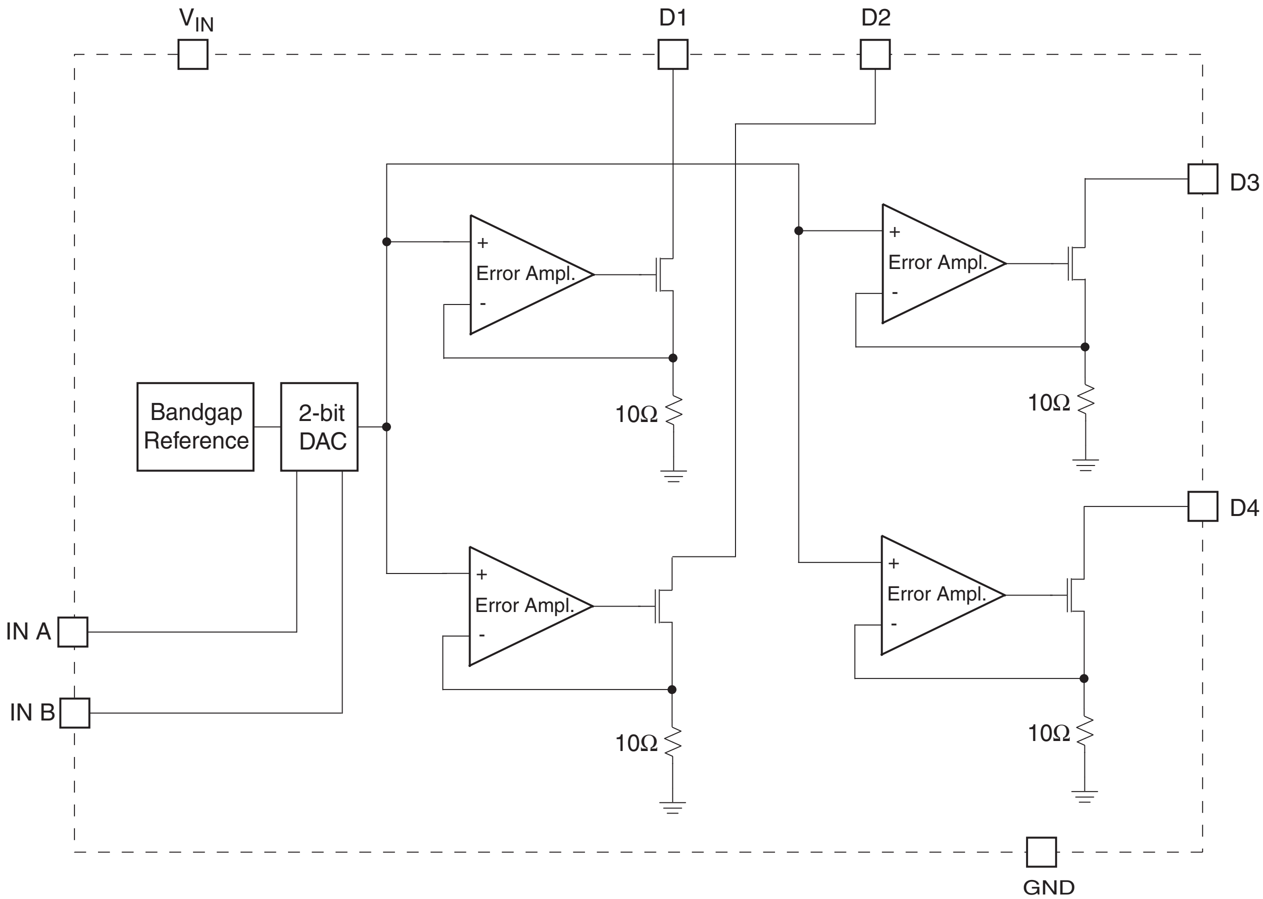
(V_{IN} =3.3V to 5.5V, T_A = 25 °C, unless otherwise noted. **Boldface** values indicate specifications over the ambient operating temperature range.)

Parameter	Conditions	Min.	Typ.	Max.	Units
Supply Current, OFF Mode	IN A = 0 IN B = 0		<1	**2**	µA
Output Current Accuracy	V_D > 0.3V IN A = 1, IN B = 1	**14.8**	21	**26**	mA
LED to LED Current Matching	V_{IN} = 3.6V IN A = 1, IN B = 1	**-7.5**		**7.5**	%
DAC Input Voltage Threshold	LOW	**0**		**$0.3 \times V_{IN}$**	V
	HIGH	**$0.6 \times V_{IN}$**		**V_{IN}**	
Peak Efficiency	LED V_F =3V at 20mA		91		%

Notes:

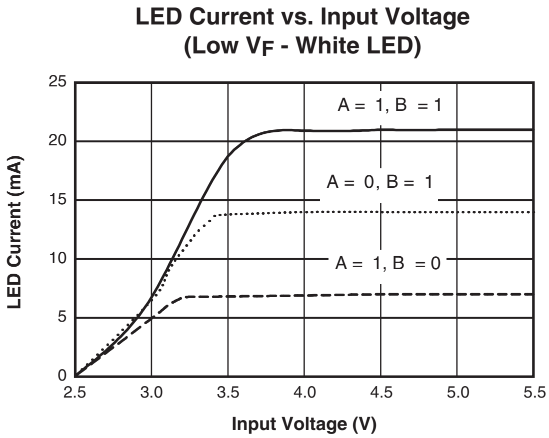
1. Using Mil Std. 883E, method 3015.7(Human Body Model) and EIA/JESD22C101-A (Charge Device Model).
2. The minimum operating voltage depends on the LED's operating voltage, as shown in the "Application Information" section.

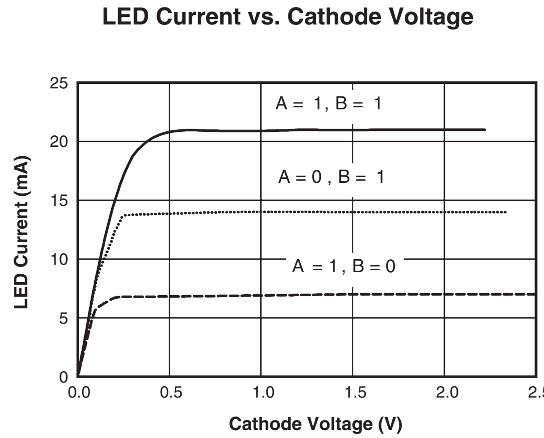
Block Diagram

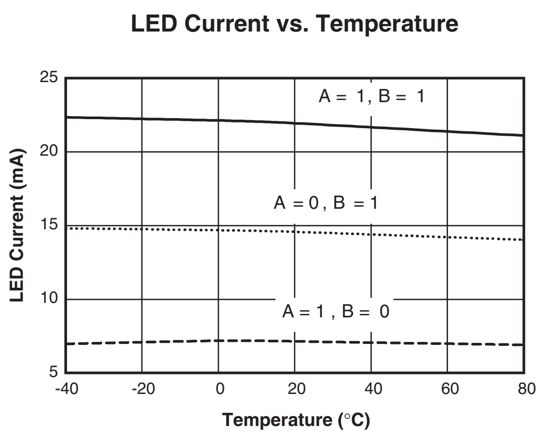


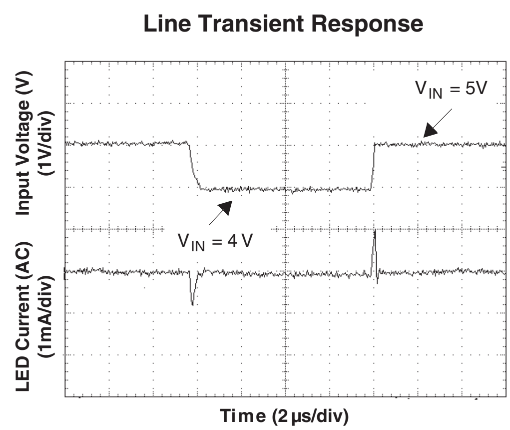
Typical Performance Characteristics

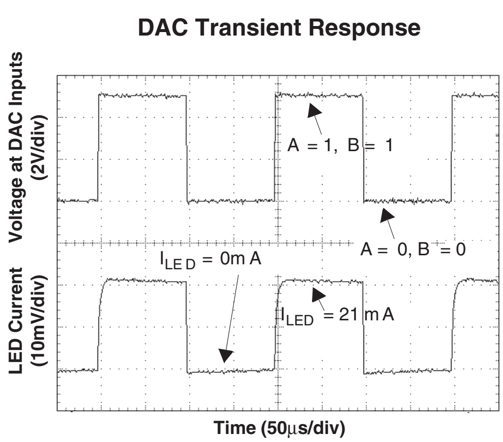
Unless otherwise specified, T_A = 25 °C, using Fairchild QTLP670IW Super Bright LED.











Digital LED Brightness Control

1. Digital Control

A digital to analog converter selects the following modes of operation: OFF, 7mA, 14mA, 21mA per diode. In addition, by turning the "IN B" pin ON and OFF , the current can be modulated between 8 to 20mA to achieve any $I_{average}$ value.

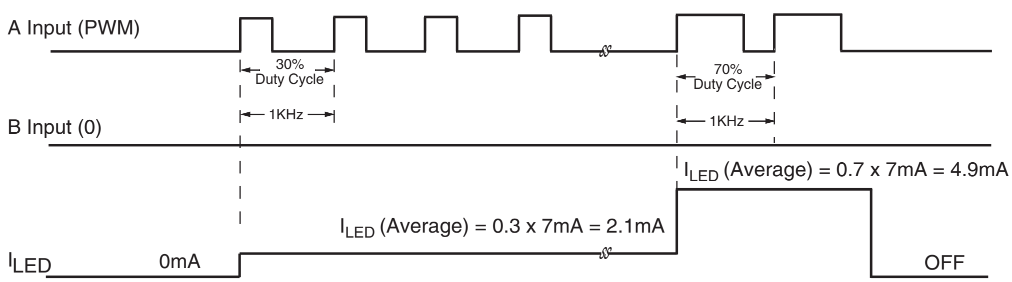
A	0	1	0	1
B	0	0	1	1
I_{LED}	OFF	7mA	14mA	21mA

2. Digital Control with PWM

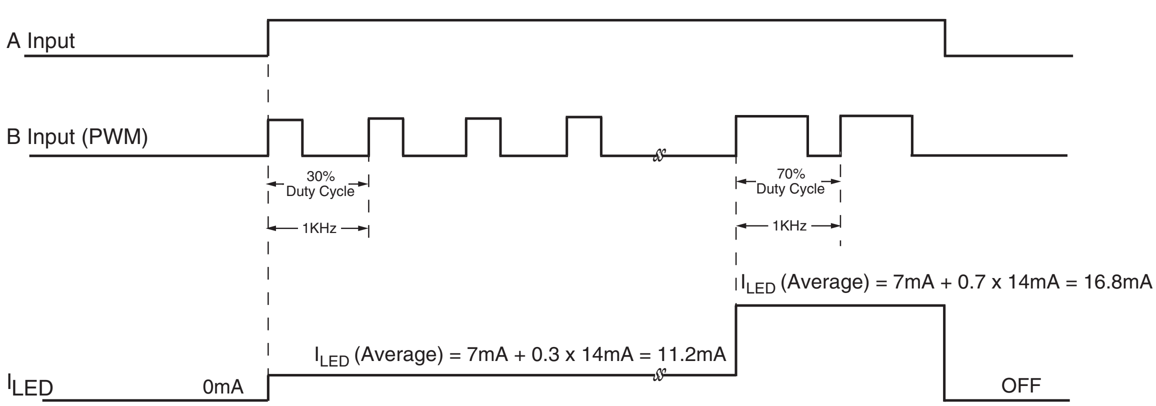
Any pin can be modulated by a variable duty cycle (δ) pulse train. Care should be taken not to use too low frequency, otherwise a flickering effect can be seen.The minimum range is between 100Hz to 5KHz. For a maximum range of LED current, both A&B can be modulated at the same time.

Digital Control with PWM

A is PWM and B is Low. I_{LED} (Average) = δ x 7mA where δ is Duty Cycle. (Note 3)



A is High and B is PWM. I_{LED} (Average) = 7mA + δ x 14mA where δ is Duty Cycle. (Note 4, 5)

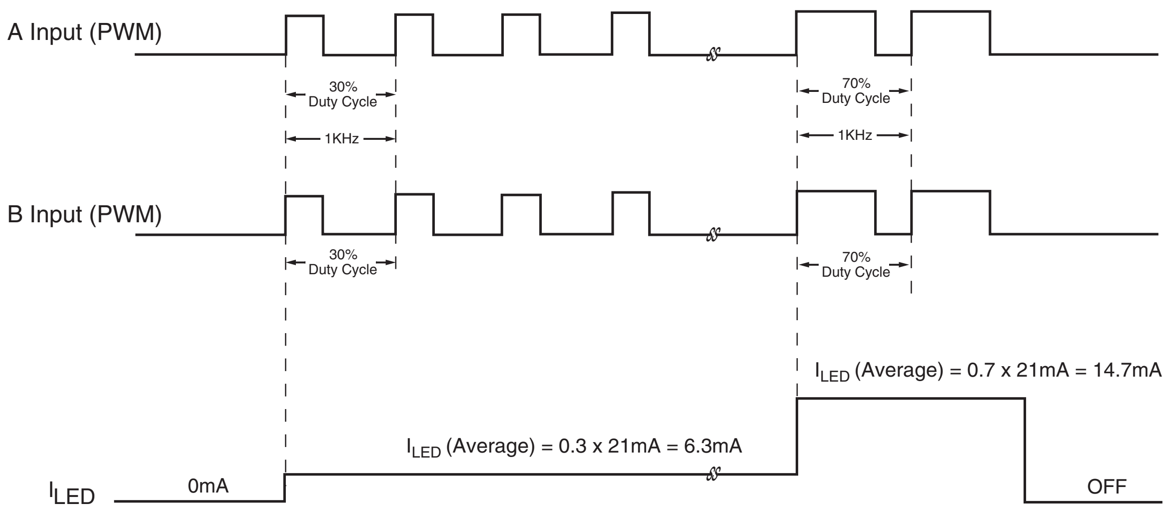


Notes:

3. Proportionally select the duty cycle to achieve a typical LED current between 1mA to 6mA.
4. If any one of inputs A or B is high continuously, the other input can be modulated at a maximum rate of 30kHz. If this is not the case, the maximum rate of modulation should be limited to 1kHz.
5. Proportionally select the duty cycle to achieve a typical LED current between 8mA to 20mA.

Digital Control with PWM (Continued)

A and B are PWM. I_{LED} (Average) = δ x 21mA where δ is Duty Cycle. (Note 6)



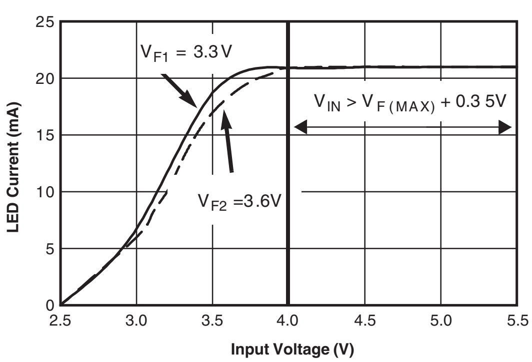
Note:

6. Proportionally select the duty cycle to achieve the desired value of typical LED current between 1mA to 20mA.

Application Information

As seen in the block diagram, the FAN5610 includes four independent current regulators able to maintain a programmable constant current through LEDs, regardless of their forward voltage. This is true over a wide range of input voltage starting from V_{F_max} + 0.35V, where V_{F_max} is the highest forward voltage among the LEDs driven by FAN5610. The independence of current (LED current changes less than 1%) with change in V_{IN} and V_F for $V_{IN} > V_{F\,(MAX)} + 0.35V$, is shown in graph below.

Current Regulation Performance



Program the LED's brightness by applying continuous voltage level or a PWM signal at the inputs of the built-in digital to analog converter (DAC). When a PWM signal is utilized to drive the DAC inputs, the current through LEDs is switched between two levels with the PWM signal frequency. Consequently, the average current changes with the duty cycle. The LED current waveform tracks the PWM signal, so the LED brightness depends upon the duty cycle.

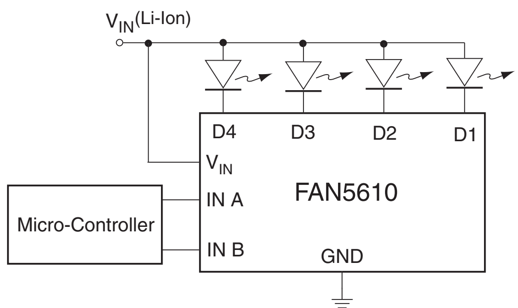
Four white LEDs the spectral composition is optimal at a current level specified by the manufacturer. The DAC inputs should be programmed to set the current required to achieve white LED spectrum and PWM used for dimming. To maintain the "purest" white, the current through LEDs should be switched between zero and specified current level (usually around 20mA) corresponding to the white light chromaticity coordinate.

Conversion errors are minimized and the best LED to LED matching is achieved over the entire range of average current settings, when PWM brightness control is used to modulate the LED current between zero and the maximum value (A=1, B=1).

Application Examples:

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 3.45V in V_{IN} is needed for the full 20mA LED current. Usually at 3.1V, there is still 5mA current available for the LEDs. The single cell Li-ion is utilized in most 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, and not down to the full discharge level (2.7V) before requesting the charger.



- V_{DROP} ~ 0.35V
- $V_{F\ (at\ 20mA)} < 3.1V$ (Low V_F)
- $V_{IN\ (at\ 20mA)} = V_{DROP} + V_F = 3.45V$
- $V_{IN\ (at\ 5mA\ Typical)}$ ~ 3.1V

Where V_{IN} = Single cell Li-ion Voltage

Key advantages:

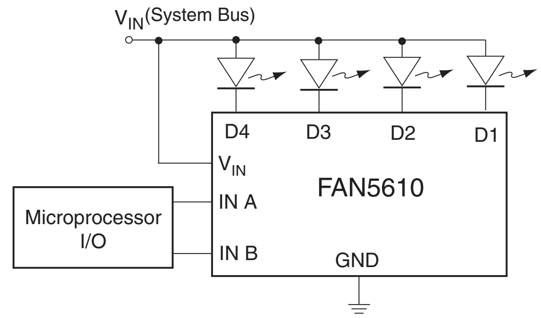
- No boost circuit needed for the LCD or keyboard backlight
- Drivers directly connected to a Li-ion battery
- No EMI, no switching noise, no boost efficiency lost, no capacitor, and no inductor.

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 3.3V to 4.0V. To drive 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 low voltage drop of the FAN5610, V_{IN} needs to be only 350mV higher than the voltage V_F of LEDs connected to FAN5610.

- V_{DROP} ~ 0.35V
- $V_{F\ (at\ 20mA)} = 3.3V$ to 4.0V (High V_F)
- $V_{IN(at\ 20mA)} \geq V_{DROP} + V_F = 4.35V(max)$

Where V_{IN} = Existing bus = 5V

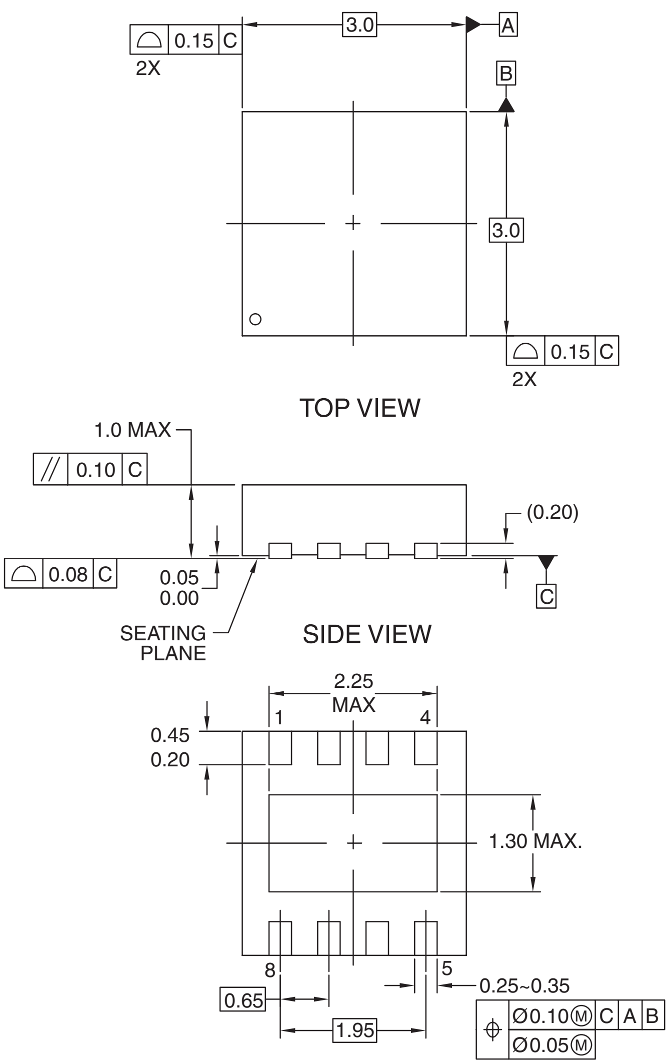


Key advantages:

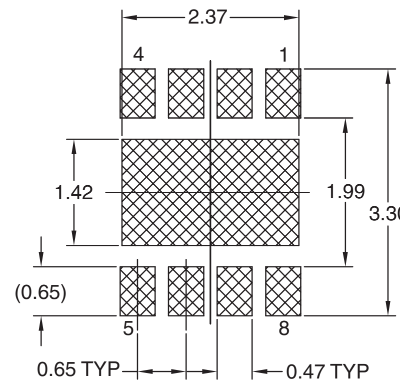
- No boost circuit needed for LCD or keyboard backlight
- Driver utilizes the existing bus
- Low voltage drop provides the full 20mA LED current at the lowest possible voltage level.

Mechanical Dimensions

3mmX3mm 8-Lead MLP Package



BOTTOM VIEW



RECOMMENDED LAND PATTERN

NOTES:

A. CONFORMS TO JEDEC REGISTRATION MO-229, VARIATION VEEC, DATED 11/2001

B. DIMENSIONS ARE IN MILLIMETERS.

C. DIMENSIONS AND TOLERANCES PER ASME Y14.5M, 1994

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