# DIO8650E

# Single Stage Fly-back & PFC Controller With Primary Side Control For LED Lighting

## Features

- Primary side control eliminates the opto-coupler
- Valley turn-on of the primary MOSFET to achieve lower switching losses
- Power factor >0.95 @230VAC
- THD < 10% @230VAC
- Reliable short LED and Open LED protection
- Quick start up:<500ms
- Low start up current:15μA typical
- Package: SOT23-6, SOIC-8

## Applications

- LED Lighting

## Descriptions

The DIO8650E is a single stage Fly-back and PFC controller targeting at LED lighting applications.

The DIO8650E is a primary side controller without applying any secondary feedback circuit for low cost, and drives the Fly-back converter in the quasi-resonant mode to achieve higher efficiency.

The DIO8650E keeps the Fly-back converter in constant on time operation to achieve high power factor.

This chip adopts special design to achieve quick start up and reliable protection for safety requirement.

## Block Diagram

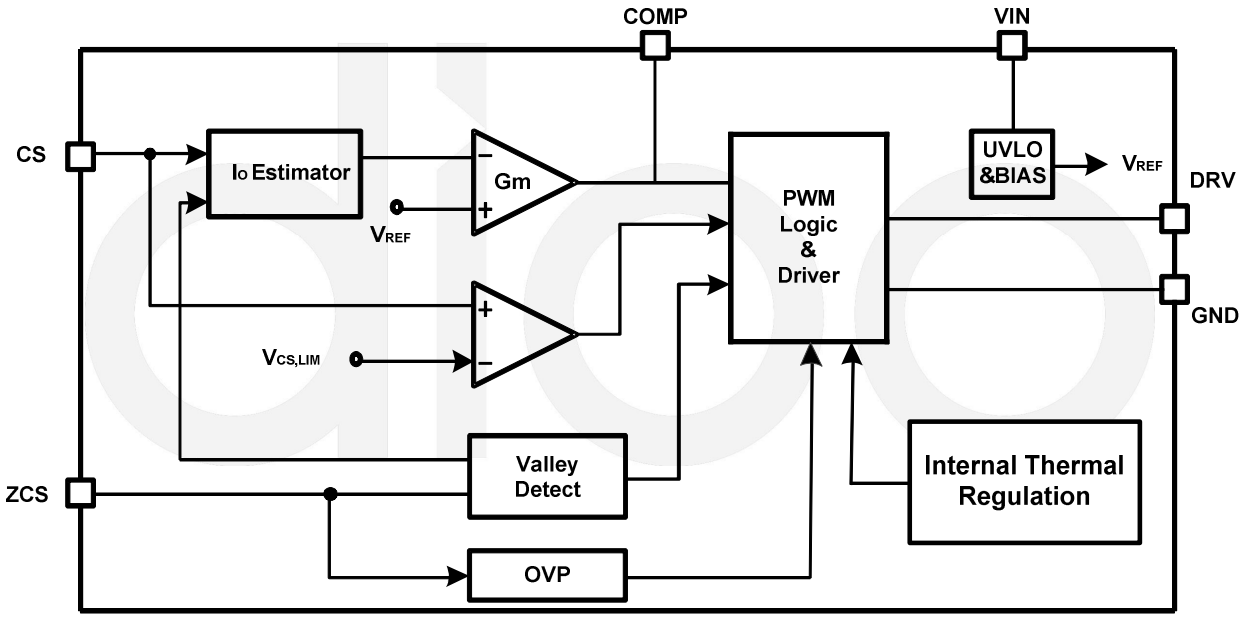



Figure1 Block Diagram

## Ordering Information

| Order Part Number | Top Marking | | $T_A$ | Package | |
|---|---|---|---|---|---|
| DIO8650ECST6 | YW6E | Green | -40 to +125°C | SOT23-6 | Tape & Reel, 3000 |
| DIO8650ECS8 | DIO8650E | Green | -40 to +125°C | SOIC-8 | Tape & Reel, 2500 |

## Pin Assignments

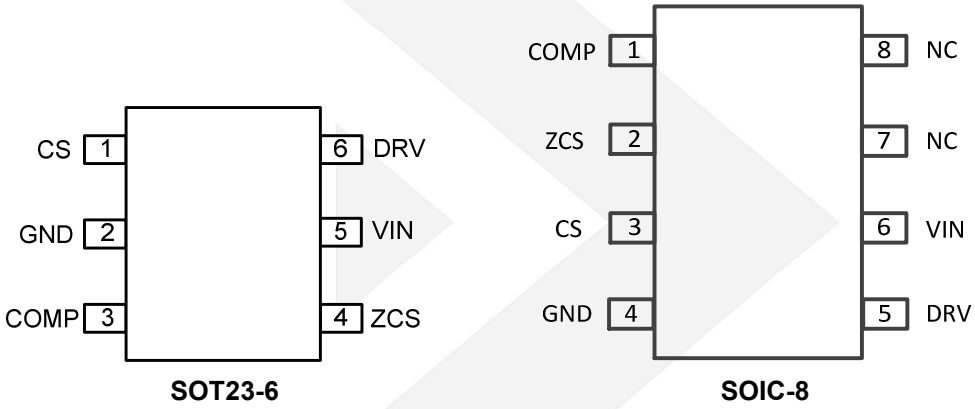



**Figure 2 Pin Assignment (Top View)**

## Pin Definitions

| Pin Name | Description |
|---|---|
| CS | Current sense pin. Connect this pin to the source of the primary switch. Connect the sense resistor across the source of the primary switch and the GND pin.<br>(current sense resister Resistor: $R_{CS} = k \times \frac{V_{ref} \times N_{ps}}{I_{out}}$, k=0.167)<br>Also this pin used to detect transformer and secondary is short or not. |
| GND | Ground pin |
| COMP | Loop compensation pin. Connect a RC network across this pin and ground to stabilize the control loop. |
| ZCS | Inductor current zero-crossing detection pin. This pin receives the auxiliary winding voltage by a resister divider and detects the inductor current zero crossing point. This pin also provides over voltage protection and line regulation modification function simultaneously. If the voltage on this pin is above $V_{ZCS,OVP}$, the IC would enter over voltage protection mode. Good line regulation can be achieved by adjusting the upper resistor of the divider |
| VIN | Power supply pin. This pin also provides output over voltage protection along with ZCS pin. |
| DRV | Gate driver pin. Connect this pin to the gate of primary MOSFET. |
| NC | Not Connect. |

## Absolute Maximum Ratings

Stresses beyond those listed under “Absolute Maximum Rating” may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other condition beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maxim rating conditions for extended periods may affect device reliability.

| Parameter | | Rating | Unit |
|---|---|---|---|
| VIN, DRV | | -0.3 to 33 | V |
| Supply Current $I_{VIN}$ | | 15 | mA |
| ZCS | | -0.3 to VIN+0.3 | V |
| CS, COMP | | -0.3 to 5 | V |
| Power Dissipation, $P_D$ @ $T_A$ = 25°C, SOT23-6 | | 0.6 | W |
| Package Thermal Resistance, SOT23-6 | $\Theta_{JA}$ | 170 | °C/W |
| | $\Theta_{JC}$ | 130 | |
| Power Dissipation, $P_D$ @ $T_A$ = 25°C, SOIC-8 | | 1.1 | W |
| Package Thermal Resistance, SOIC-8 | $\Theta_{JA}$ | 100 | °C/W |
| | $\Theta_{JC}$ | 50 | |
| Storage Temperature Range | | -65 to 150 | °C |
| Junction Temperature Range | | 150 | °C |
| Lead Temperature Range | | 260 | °C |
| ESD | HBM, JEDEC: JESD22-A114 | 2000 | V |
| | MM, JEDEC: JESD22-A115 | 200 | |

## Recommend Operating Conditions

The Recommended Operating Conditions table defines the conditions for actual device operation. Recommended Operating conditions are specified to ensure optimal performance to the datasheet specifications. DIOO does not Recommend exceeding them or designing to Absolute Maximum Ratings.

| Parameter | Rating | Unit |
|---|---|---|
| Supply Voltage | 9.5 to 27 | V |
| Ambient Temperature Range | -40 to 125 | °C |

# Electrical Characteristics

$V_{IN}$ = 12V, $T_A$ = 25°C, unless otherwise specified.

| Symbol | Parameter | Test Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $V_{VIN,ON}$ | VIN turn-on threshold | | | 25.3 | | V |
| $V_{VIN,OFF}$ | VIN turn-off threshold | | | 8.5 | | V |
| $V_{VIN,OVP}$ | VIN OVP voltage | | | 30 | | V |
| $I_{ST}$ | Start up Current | $V_{VIN}$< $V_{IN,OFF}$ | | 15 | | μA |
| $I_{VIN\_OVP}$ | Shunt current in OVP mode | After $V_{VIN}$>$V_{VIN,OVP}$, then set VIN=15V | 1.6 | 2 | 2.5 | mA |
| $I_Q$ | Quiescent Current | No switching | | 0.26 | | mA |
| $I_{VIN}$ | Operation current | $C_L$=100pF,f=15kHz | | 0.36 | | mA |
| **Error Amplifier Section** | | | | | | |
| $V_{REF}$ | Internal reference voltage | | 0.294 | 0.3 | 0.306 | V |
| **ZCS pin Section** | | | | | | |
| $V_{ZCS,\ OVP}$ | ZCS pin OVP voltage threshold | | | 1.5 | | V |
| $V_{FAST\_ST}$ | Fast start up threshold | | | 0.55 | | V |
| **Current Sense Section(Source PIN of integrated MOSFET)** | | | | | | |
| $V_{CS.LMT}$ | Current limit reference voltage | | | 0.45 | | V |
| $K_2$ | CC Feed forward coefficient | | | 0.1 | | |
| $R_{K2}$ | CC Feed forward resistor $R_{K2}$ | | | 340 | | Ω |
| **PWM Section** | | | | | | |
| $T_{ON.MAX}$ | Max on time | COMP high clamp | | 15.7 | | μs |
| $T_{LEB}$ | Leading edge blanking time | | | 300 | | ns |
| $T_{OFF,MAX}$ | Max OFF time | | | 151 | | μs |
| $T_{LEB.ZCD}$ | ZCD Blanking Time | After turn off | | 2 | | μs |
| $f_{MAX}$ | Maximum switching frequency | | | 115 | | kHz |
| **Gate Driver** | | | | | | |
| $V_{GATE\_CLAMP}$ | Output Clamp Voltage | $V_{CC}$=20V | | 12 | | V |
| $T_{RISING}$ | rising time from 10% to 90% | $C_{LOAD}$=1nF | | 410 | | ns |
| $T_{FALLING}$ | falling time from 90% to 10% | $C_{LOAD}$=1nF | | 50 | | ns |
| **Thermal Section** | | | | | | |
| $T_{SD}$ | Thermal Shutdown Temperature | | | 150 | | °C |

## Typical Application

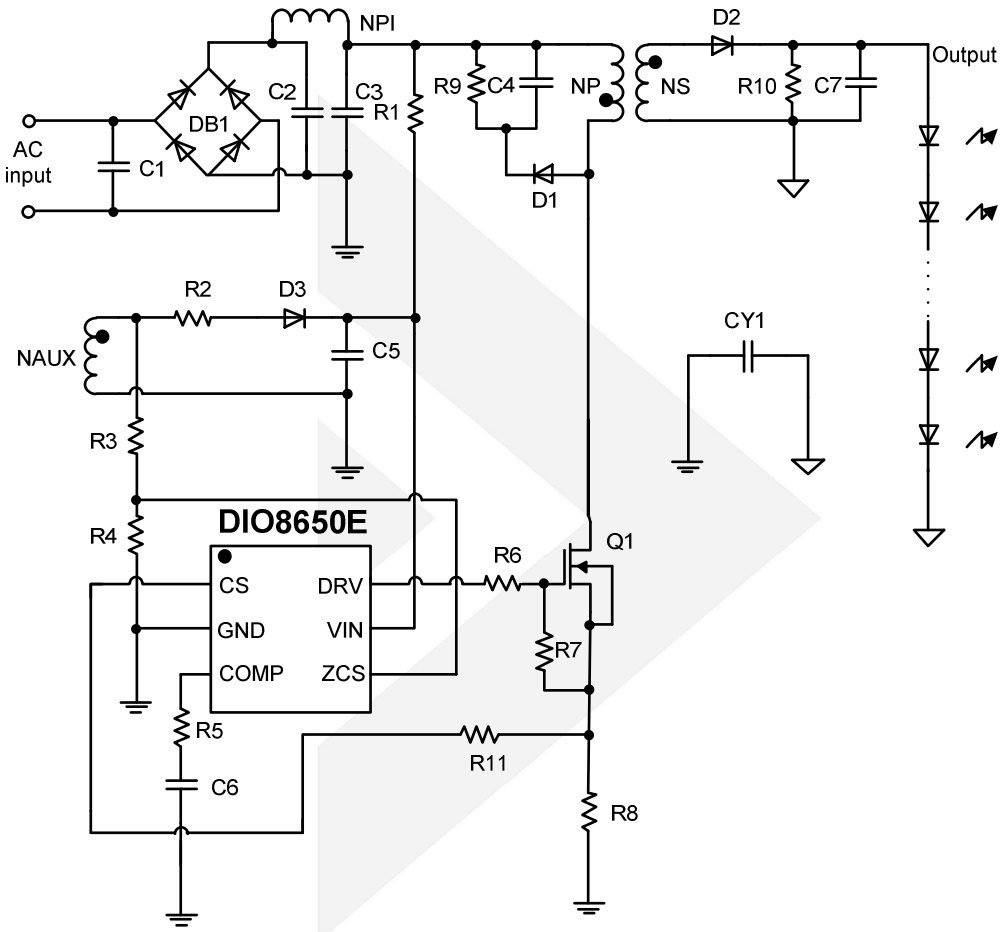



**Figure 3 Typical fly-back application**

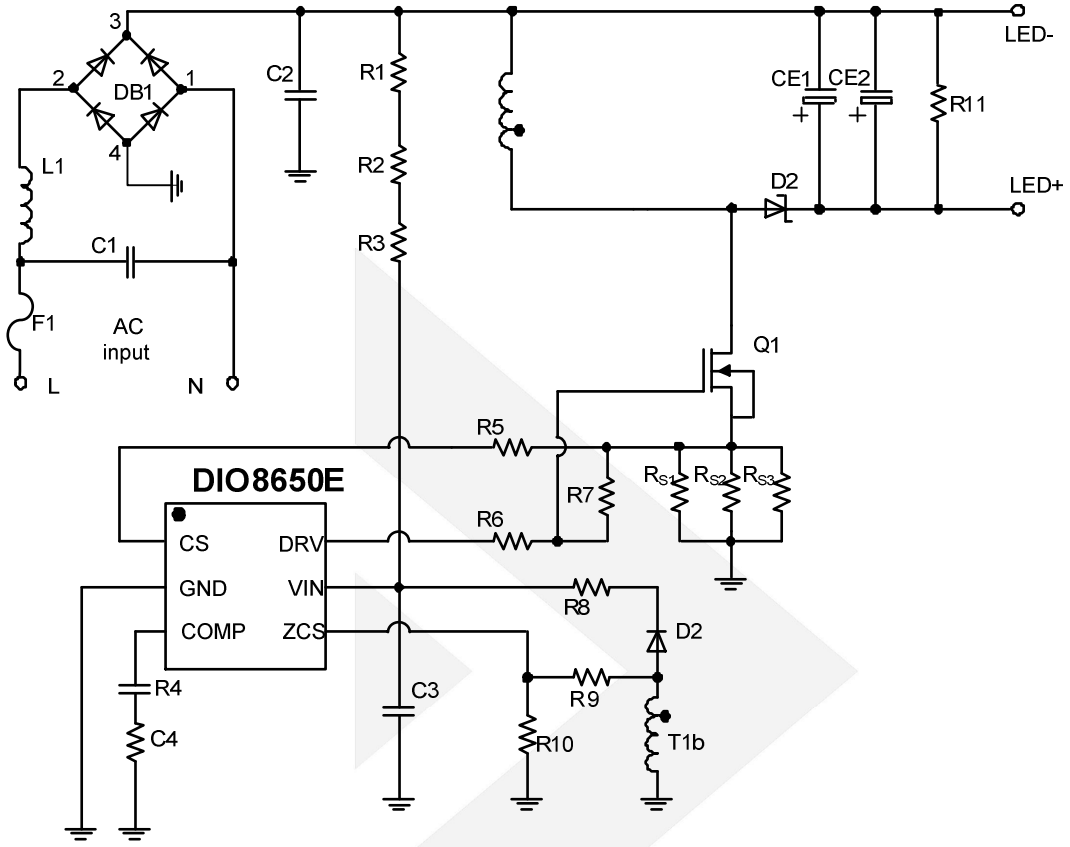



**Figure 4 Typical buck-boost application**

# Application Information

### Start up

After AC or DC supply is powered on, the capacitor $C_{VIN}$ across VIN and GND pin is charged up by BUS voltage through a start up resistor $R_{ST}$. Once $V_{VIN}$ rises up to $V_{VIN-ON}$, the internal blocks start to work and PWM output is enabled.

### Shut down

After AC supply or DC BUS is powered off, the energy stored in the BUS capacitor will be discharged. When the auxiliary winding of Fly-back transformer can't supply enough energy to VIN pin, $V_{VIN}$ will drop down. Once $V_{VIN}$ is below $V_{VIN-OFF}$, the IC will stop working and $V_{COMP}$ will be discharged to zero.

### Primary-side constant-current control

Primary side control is applied to eliminate secondary feedback circuit or opto-coupler, which reduces the circuit cost.

**Quasi-Resonant Operation**

QR mode operation provides low turn-on switching losses for Fly-back converter.

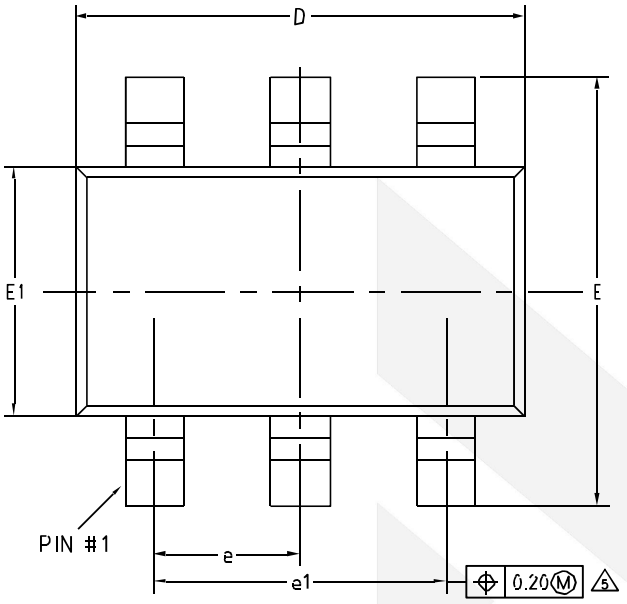
**Over Voltage Protection (OVP) & Open LED Protection (OLP)**

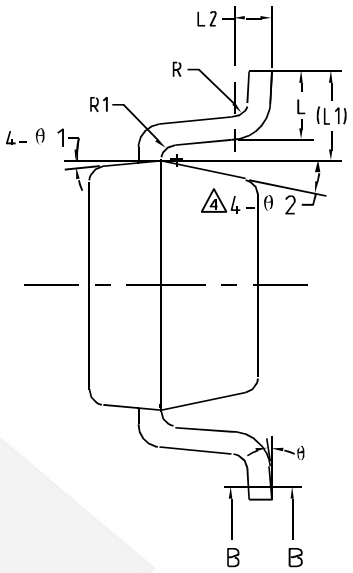
The output voltage is reflected by the auxiliary winding voltage of the Fly-back transformer, and both ZCS pin and VIN pin provide over voltage protection function. When the load is null or large transient happens, the output voltage will exceed the rated value. When $V_{VIN}$ exceeds $V_{VIN,OVP}$ or $V_{ZCS}$ exceeds $V_{ZCS,OVP}$, the over voltage protection is triggered and the IC will discharge $V_{VIN}$ by an internal current source $I_{VIN,OVP}$. Once $V_{VIN}$ is below $V_{VIN,OFF}$, the IC will shut down and be charged again by BUS voltage through start up resistor. If the overvoltage condition still exists, the system will operate in hiccup mode.

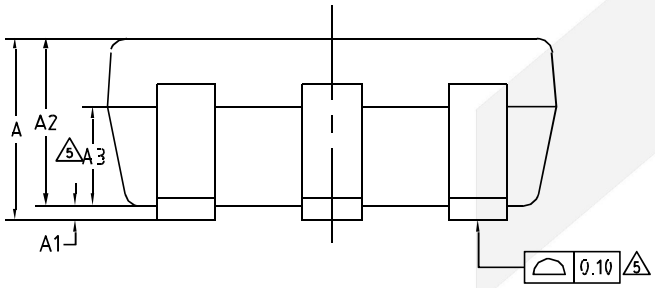
**Short Circuit Protection (SCP)**

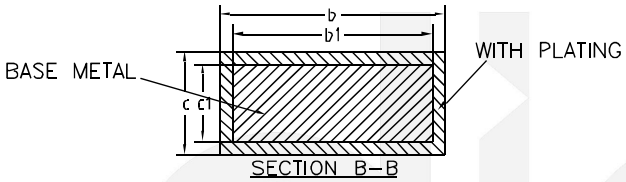
When the output is shorted to ground, the output voltage is clamped to zero. The voltage of the auxiliary winding is proportional to the output winding, so valley signal cannot be detected by ZCS. Without valley detection, MOSFET cannot be turned ON until maximum off time $t_{OFF,MAX}$ is matched. If MOSFET is turned ON by $t_{OFF,MAX}$ 64 times continuously, IC will be shut down and enter into hiccup mode. If the output voltage is not low enough to disable valley detection in short condition, $V_{VIN}$ will dropdown without auxiliary winding supply. Once $V_{VIN}$ is below $V_{VIN,OFF}$, the IC will shut down and be charged again by the BUS voltage through the start up resistor. If the short circuit condition still exists, the system will operate in hiccup mode.

# Physical Dimensions: SOT-23-6



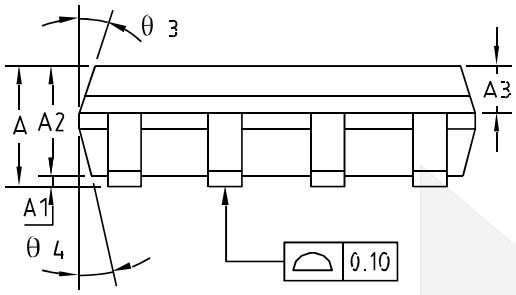



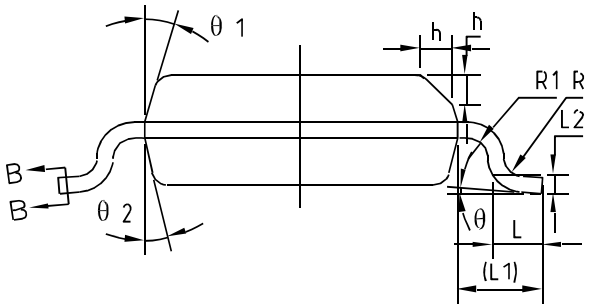



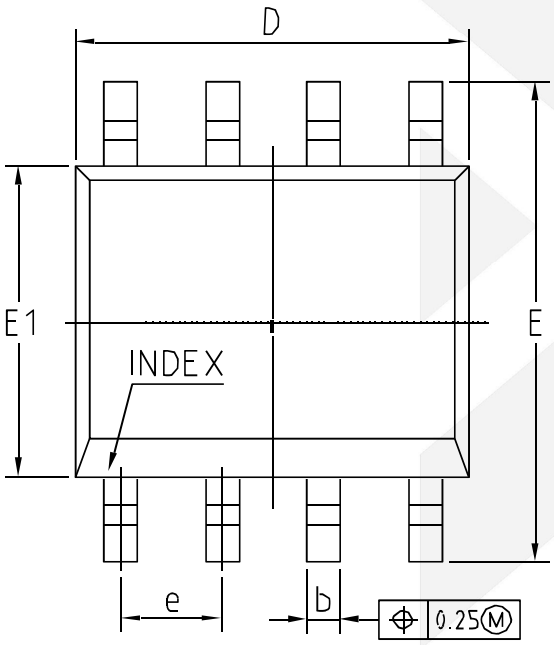




| COMMON DIMENSIONS (UNITS OF MEASURE=MILLIMETER) | | | |
|---|---|---|---|
| **Symbol** | **MIN** | **NOM** | **MAX** |
| A | - | - | 1.25 |
| A1 | 0 | - | 0.15 |
| A2 | 1.00 | 1.10 | 1.20 |
| A3 | 0.60 | 0.65 | 0.70 |
| b | 0.36 | - | 0.50 |
| b1 | 0.36 | 0.38 | 0.45 |
| c | 0.14 | - | 0.20 |
| c1 | 0.14 | 0.15 | 0.16 |
| D | 2.826 | 2.926 | 3.026 |
| E | 2.60 | 2.80 | 3.00 |
| E1 | 1.526 | 1.626 | 1.726 |
| e | 0.90 | 0.95 | 1.00 |
| e1 | 1.80 | 1.90 | 2.00 |
| L | 0.35 | 0.45 | 0.60 |
| L1 | 0.59REF | | |
| L2 | 0.25BSC | | |
| R | 0.10 | - | - |
| R1 | 0.10 | - | 0.25 |
| Θ | 0° | - | 8° |
| Θ1 | 3° | 5° | 7° |
| Θ2 | 6° | - | 14° |

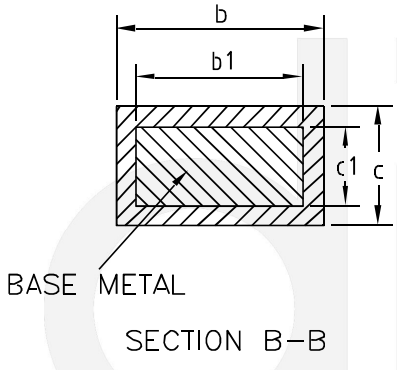
## Physical Dimensions: SOIC-8




| COMMON DIMENSIONS (UNITS OF MEASURE=MILLIMETER) | | | |
|---|---|---|---|
| **Symbol** | **MIN** | **NOM** | **MAX** |
| A | 1.35 | 1.55 | 1.75 |
| A1 | 0.10 | 0.15 | 0.25 |
| A2 | 1.25 | 1.40 | 1.65 |
| A3 | 0.50 | 0.60 | 0.70 |
| b | 0.38 | - | 0.51 |
| b1 | 0.37 | 0.42 | 0.47 |
| c | 0.17 | - | 0.25 |
| c1 | 0.17 | 0.20 | 0.23 |
| D | 4.80 | 4.90 | 5.00 |
| E | 5.80 | 6.00 | 6.20 |
| E1 | 3.80 | 3.90 | 4.00 |
| e | 1.27BSC | | |
| L | 0.45 | 0.60 | 0.80 |
| L1 | 1.04REF | | |
| L2 | 0.25BSC | | |
| R | 0.07 | - | - |
| R1 | 0.07 | - | - |
| h | 0.30 | 0.40 | 0.50 |
| Θ | 0° | - | 8° |
| Θ1 | 15° | 17° | 19° |
| Θ2 | 11° | 13° | 15° |
| Θ3 | 15° | 17° | 19° |
| Θ4 | 11° | 13° | 15° |



## CONTACT US

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