## General Description

The iML8684 is a Three Terminal Current Controller (TTCC) for regulating the current flowing through an LED string.

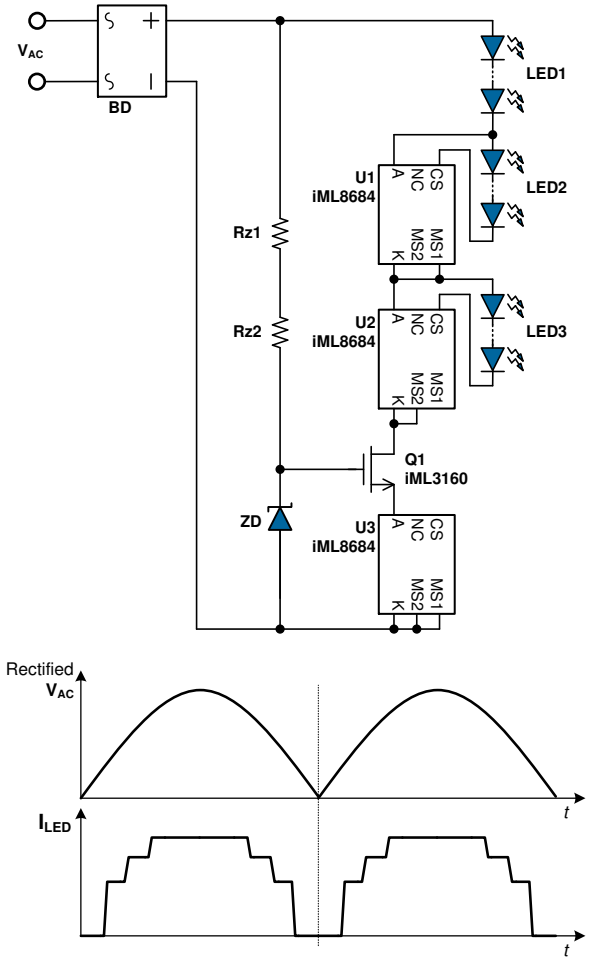
The application of the iML8684 is configured in parallel with an LED string. The iML8684 can work as voltage controlled current source, current regulator, or cut-off. It is suitable for the applications adopting periodical AC voltage source.

The PCB layout is also very flexible to meet various shape requirements. It is especially suitable for replacing incandescent light bulb and linear type fluorescent lamp.

## Features

- **System**
  - All solid state components.
  - No electrolytic capacitor required.
  - Compact size to minimize mechanical cost.
  - Driver-on-board and chip-on-board available which minimize process flow and assembly cost.
  - High PF and Low THD performance.
  - High efficiency achieved.
  - Flexible PCB layout style.
  - Wide range of LED forward voltage selection.
  - Distributed heat to several chips.
  - TRIAC dimmable.
- **Chip**
  - 88V input sustaining voltage.
  - <3V dropout voltage for up to 150mA regulating current.

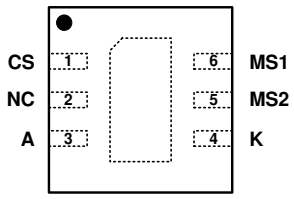
## Typical Application Circuit



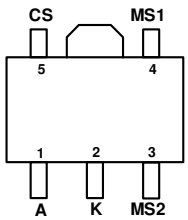

## Applications

- AC LED lighting engine.
- LED light bulb.
- LED light tube.
- LED down-light and ceiling light
- LED flat panel light

## Pin Diagram (Top View)




DFN- 2mmx2mm-6L




SOT-89- 5L

## Ordering Information

Package Type: DFN– 2mm x 2mm – 6L (Halogen Free)

| Part Number | Tape and Reel | 1st Line Marking | Regulating Current (mA) (Mode 0, MS1 and MS2 connected to pin K) |
|---|---|---|---|
| **iML8684NL-C1** | **iML8684NL-C1-TR** | i84C1 | 40 |
| **iML8684NL-C2** | **iML8684NL-C2-TR** | i84C2 | 66 |
| **iML8684NL-C3** | **iML8684NL-C3-TR** | i84C3 | 52 |
| **iML8684NL-D1** | **iML8684NL-D1-TR** | i84D1 | 80 |
| **iML8684NL-D2** | **iML8684NL-D2-TR** | i84D2 | 130 |
| **iML8684NL-D3** | **iML8684NL-D3-TR** | i84D3 | 104 |
| **iML8684NL-ADJ** | **iML8684NL-ADJ-TR** | i84AD | Determined by external resistor only |

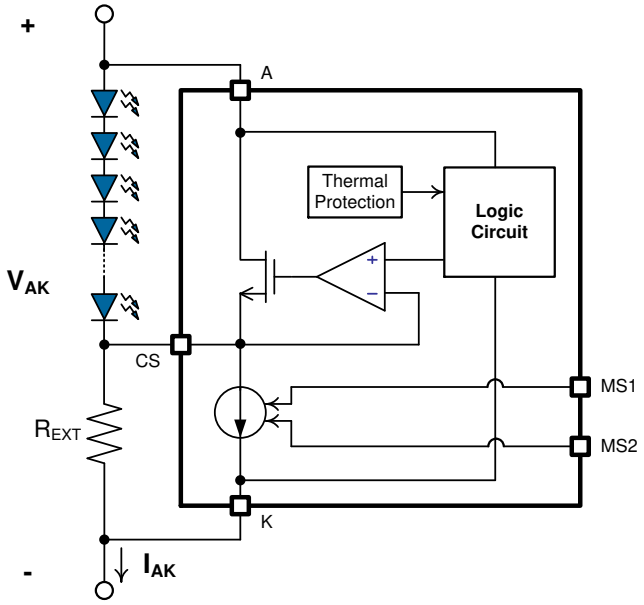
Package Type: SOT–89 – 5L (Halogen Free)

| Part Number | Tape and Reel | 1st Line Marking | Regulating Current (mA) (Mode 0, MS1 and MS2 connected to pin K) |
|---|---|---|---|
| **iML8684BP-C1** | **iML8684BP-C1-TR** | i8684C1 | 40 |
| **iML8684BP-C2** | **iML8684BP-C2-TR** | i8684C2 | 66 |
| **iML8684BP-C3** | **iML8684BP-C3-TR** | i8684C3 | 52 |
| **iML8684BP-D1** | **iML8684BP-D1-TR** | i8684D1 | 80 |
| **iML8684BP-D2** | **iML8684BP-D2-TR** | i8684D2 | 130 |
| **iML8684BP-D3** | **iML8684BP-D3-TR** | i8684D3 | 104 |
| **iML8684BP-ADJ** | **iML8684BP-ADJ-TR** | i8684AD | Determined by external resistor only |

Dice

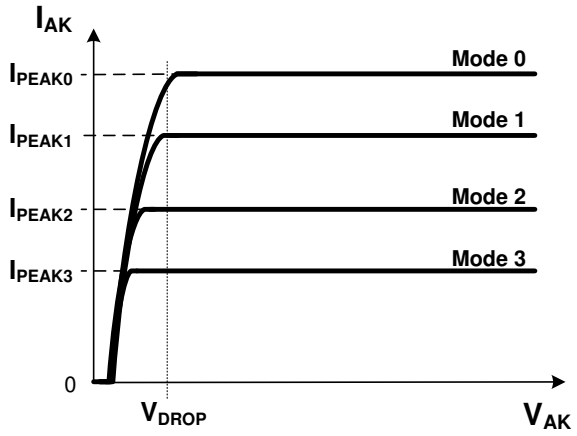
| Part Number | Regulating Current (mA) (Mode 0, MS1 and MS2 connected to pin K) |
|---|---|
| **iML8684BZ-C1** | 40 |
| **iML8684BZ-C2** | 66 |
| **iML8684BZ-C3** | 52 |
| **iML8684BZ-D1** | 80 |
| **iML8684BZ-D2** | 130 |
| **iML8684BZ-D3** | 104 |
| **iML8684BZ-ADJ** | Determined by external resistor only |

## Block Diagram

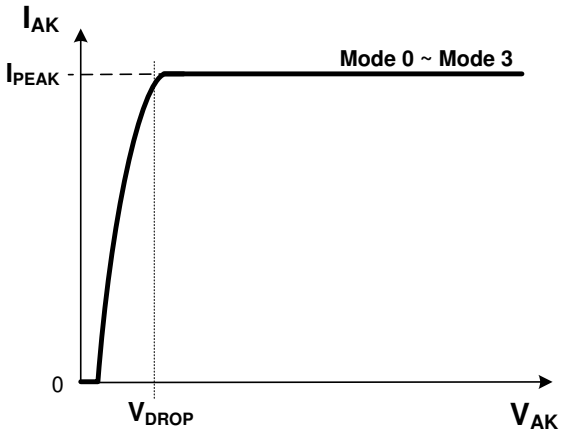



## I-V Curve

**Cx / Dx Options**




**ADJ Options**



## Pin Descriptions

| Pin Name | Pin Number | | Pin Function |
|---|---|---|---|
| | DFN | SOT-89 | |
| CS | 1 | 5 | Current sense pin. Connected to negative end of LED string. |
| A | 3 | 1 | Regulating current input pin. Connected to positive end of LED string. |
| K | 4 | 2 | Regulating current output pin. |
| MS2 | 5 | 3 | Mode selection pin 2. Floating or connecting to pin K only. |
| MS1 | 6 | 4 | Mode selection pin 1. Floating or connecting to pin K only. |
| NC | 2 | - | No Connection |
| Exposed Thermal Pad | | | Exposed thermal pad of the chip. Use this pin to enhance the power dissipation ability. The thermal conductivity will be improved if a copper foil on PCB is soldered with the thermal pad. It is recommended to connect the thermal pad to pin K. |

## Absolute Maximum Ratings

***Caution***: Values beyond absolute ratings can cause the device to be prematurely damaged.
Absolute maximum ratings are stress ratings only and functional device operation is not guaranteed.

| | | |
|---|---|---|
| Sustaining Voltage | A to K | -0.3V ~ 88V |
| | CS, MS1, MS2 to K | -0.3V ~ 1V |
| Regulating Current | | 150mA |
| Maximum Operating Junction Temperature, $T_J$ | | 165°C |
| Operating Temperature, $T_{opr}$ | | -40°C to 110°C |
| Storage Temperature Range | | -55°C to 150°C |
| Lead Temperature (Soldering, 10 seconds) | | 260°C |

**Note:**

1). All voltages are with respect to Ground. Currents are positive into, negative out of the specified terminal.
2). All parameters having Min/Max specifications are guaranteed. Typical values are for reference purpose only.
3). Unless otherwise noted, all tests are pulsed tests at the specified temperature, therefore: $T_J = T_C = T_A$.

## Recommended Operating Conditions

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Regulating Current (with Adequate Heat Sinking) *Note | $I_{AK}$ | | | 130 | mA |
| Input Voltage*Note | $V_{AK}$ | 3 | | 80 | V |
| Maximum Junction Temperature | $T_J$ | | | 150 | °C |
| Operating Free-Air Temperature Range | $T_A$ | -30 | | 100 | °C |

Note: Due to thermal dissipation consideration, the maximum LED Vf in parallel should decrease with the regulating current.

## Electrical Characteristics

Unless otherwise noted, typical values are @ $T_A$ = 25°C.

| Parameter | Symbol | Test Conditions | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| Peak Regulating Current *Note 1,2 | $I_{PEAK0}$ | $V_{AK}$=5V, Mode 0 (MS1/ MS2 connected to K) | Option C1 | 38.4 | 40 | 41.6 | mA |
| | | | Option C2 | 63.4 | 66 | 68.6 | |
| | | | Option C3 | 49.9 | 52 | 54.1 | |
| | | | Option D1 | 76.8 | 80 | 83.2 | |
| | | | Option D2 | 124.8 | 130 | 135.2 | |
| | | | Option D3 | 99.8 | 104 | 108.2 | |
| Current Ratio of Mode Selection *Note 1 | $I_{PEAK0}/I_{PEAK0}$ | Option C1/C2/C3/D1/D2/D3, Mode 0, $V_{AK}$=5V (MS1/ MS2 connected to K) | | | 100 | | % |
| | $I_{PEAK1}/I_{PEAK0}$ | Option C1/C2/C3/D1/D2/D3, Mode 1, $V_{AK}$=5V (MS1 open, MS2 connected to K) | | 75 | 80 | 85 | |
| | $I_{PEAK2}/I_{PEAK0}$ | Option C1/C2/C3/D1/D2/D3, Mode 2, $V_{AK}$=5V (MS2 open, MS1 connected to K) | | 50 | 55 | 60 | |
| | $I_{PEAK3}/I_{PEAK0}$ | Option C1/C2/C3/D1/D2/D3, Mode 3, $V_{AK}$=5V (MS1/ MS2 open) | | 32 | 35 | 38 | |
| Regulating Current Line Regulation *Note 3 | $\Delta I_{LR}/I_{PEAKx}$ (x=0~3) | Option C1/C2/C3/D1/D2/D3, Mode 1~3, $V_{AK}$=5V and 40V | | | ±1 | ±2 | % |
| | | Option C1/C2/C3/D1/D2/D3, Mode 0, $V_{AK}$=5V and 40V | | -4 | -8 | -15 | |
| CS Pin Voltage | $V_{CS}$ | Option ADJ, Mode 0, $V_{AK}$=5V, with 1KΩ external resistor between CS and K | | 0.26 | 0.27 | 0.28 | V |
| CS Pin Voltage Line Regulation *Note 4 | $\Delta V_{LR}/V_{CS}$ | Option ADJ, Mode 1~3, $V_{AK}$=5V and 40V with 1KΩ external resistor between CS and K | | | ±1 | ±2 | % |
| | | Option ADJ, Mode 0, $V_{AK}$=5V and 40V with 1KΩ external resistor between CS and K | | -4 | -8 | -15 | % |
| Dropout Voltage *Note 5 | $V_{DROP}$ | Mode 0 (MS1/ MS2 connected to K) | | | 2.8 | 3.8 | V |
| Thermal Protection Trip Temperature *Note 6 | $T_{TP}$ | When $T_J$ is higher than $T_{TP}$, the peak regulating current decreases to $I_{TP}$ linearly. | | 120 | 130 | | °C |
| Thermal Protection Mode Regulating Current | $I_{TP}/I_{PEAKx}$ (x=0~3) | $T_J$ = 175°C | | | 50 | | % |

Note 1: For ADJ option, the regulating current is determined by an external resistor, $R_{EXT}$, connected between the CS pin and the K pin. The mode selection function will not change the current ratio of option ADJ. To activate the line regulation function, the chip (U3) connected in series with the LED string should be set in Mode 0 (MS1 and MS2 connected to pin K). The regulating current will be:

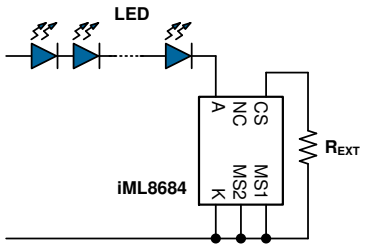
$$I_{PEAK}=0.27/R_{EXT}$$

And the maximum regulating current of second step (ex: U2 in Mode 1) should not exceed 80% of the top level (ex: U3 in Mode 0), otherwise the circuit operation might become abnormal when OTP function is activated. It is strongly recommended to set at 75%.

Note 2: The user can add an external resistor $R_{EXT}$ between the CS pin and the K pin of U3 (Mode 0, serial connected to the LED string) to increase the regulating current of option C1, C2, C3, D1, D2 and D3, as shown in below. For U1 ~ U2 (Mode 1 ~ Mode 3, parallel connected to the LED string), adding an external resistor $R_{EXT}$ between the CS pin and the K pin may cause abnormal operation and chip damage.

For option C1/ C2/ C3, the regulating current variation $\Delta I_{PEAK}/I_{PEAK} = 6.25/R_{EXT}$.

For option D1/ D2/ D3, the regulating current variation $\Delta I_{PEAK}/I_{PEAK} = 3.13/R_{EXT}$.




| | U3 (Mode 0) regulating current | |
|---|---|---|
| | Without external resistor | With 100Ω external resistor |
| Option C1 | 40 | 42.5 |
| Option C2 | 66 | 70.1 |
| Option C3 | 52 | 55.3 |
| Option D1 | 80 | 82.5 |
| Option D2 | 132 | 136.1 |
| Option D3 | 104 | 107.3 |

Note 3: The Regulating Current Line Regulation is defined as:

For Mode 1~3: $$\Delta I_{LR}/I_{PEAKx}=\frac{I_{AK(V_{AK}=40V)}-I_{AK(V_{AK}=5V)}}{I_{AK(V_{AK}=5V)}}, \quad x=1\sim3$$

For Mode 0: $$\Delta I_{LR}/I_{PEAK0}=\frac{I_{AK(V_{AK}=40V)}-I_{AK(V_{AK}=5V)}}{I_{AK(V_{AK}=5V)}}$$

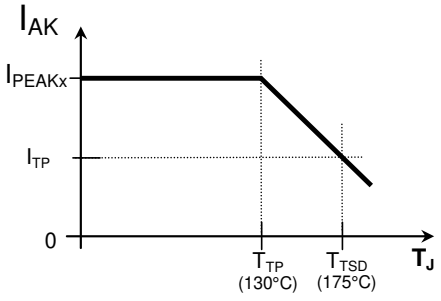
Note 4: The CS Pin Voltage Line Regulation is defined as:

For Mode 1~3: $$\Delta V_{LR}/V_{CS}=\frac{V_{CS(V_{AK}=40V)}-V_{CS(V_{AK}=5V)}}{V_{CS(V_{AK}=5V)}}$$

For Mode 0: $$\Delta V_{LR}/V_{CS}=\frac{V_{CS(V_{AK}=40V)}-V_{CS(V_{AK}=5V)}}{V_{CS(V_{AK}=5V)}}$$

Note 5: Dropout voltage = $V_{AK}$ @ 90% × ($I_{PEAK0}$ @ $V_{AK}$ = 5V)

Note 6: When $T_J > T_{TP}$, the peak regulating current decreases linearly to around 50% at 175°C.

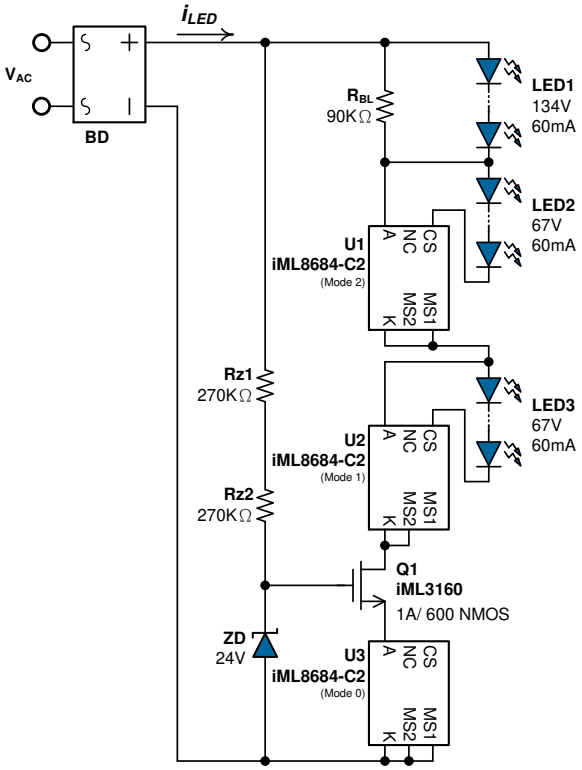


## Application Circuit

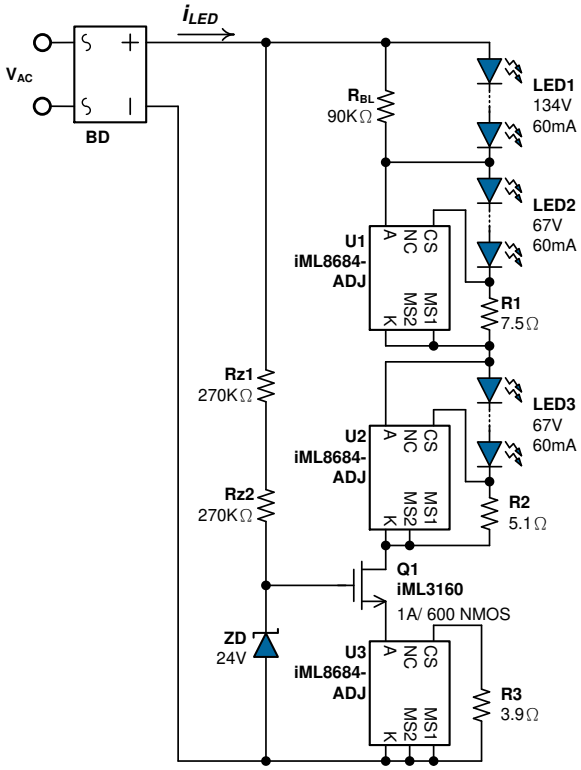
### (1) 220$V_{AC}$/ 10W LED Light Engine

- 3 steps, PF=0.98, THD=16%

- To pass 1KV surge test, Q1 can be changed to 800V NMOS.




**C2 Option**

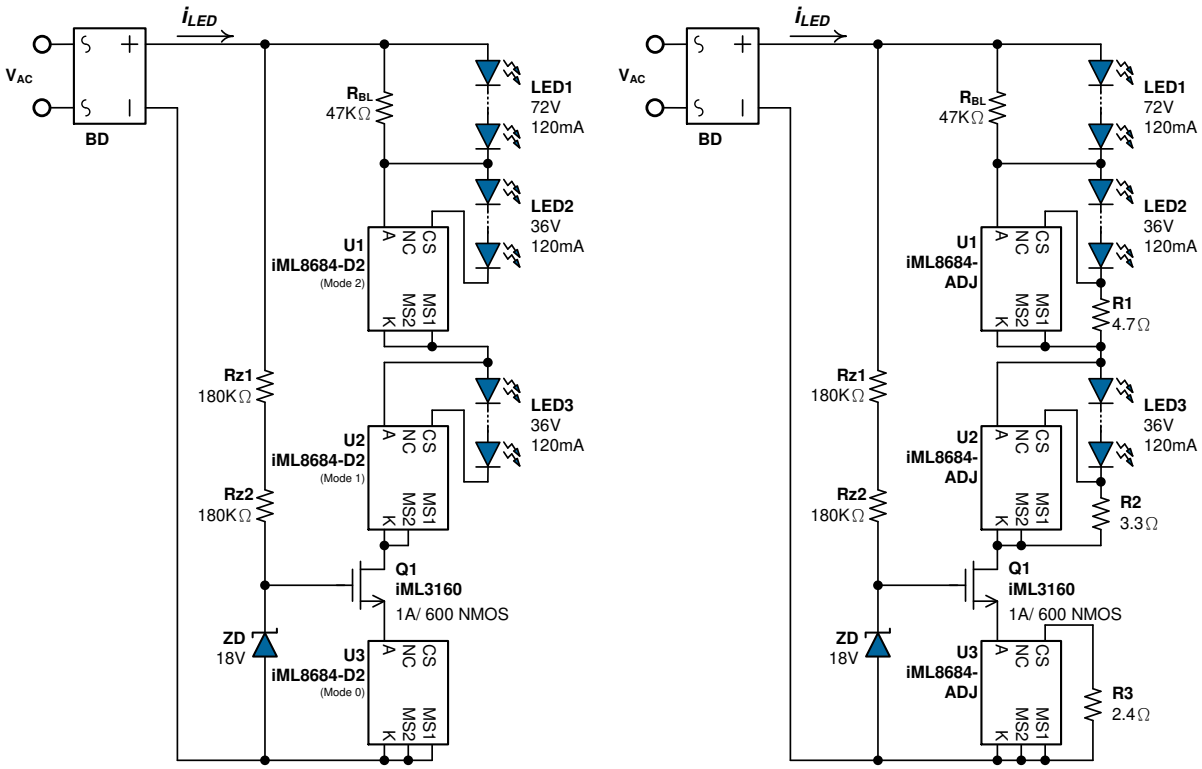



**ADJ Options**

## (2) 10W LED Light Engine

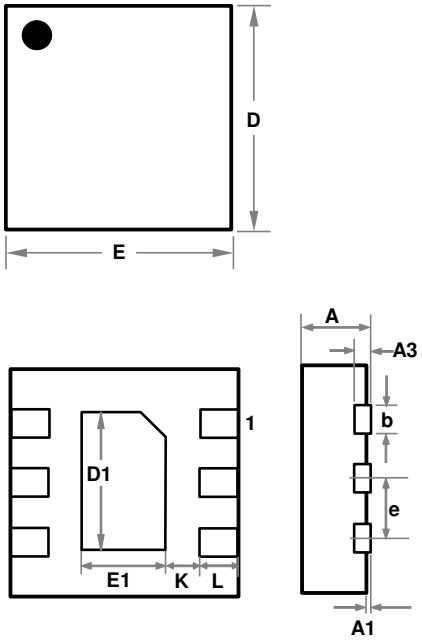
- 3 steps, PF=0.98, THD=16%

- To pass 1KV surge test, Q1 can be changed to 800V NMOS.



## Package Information

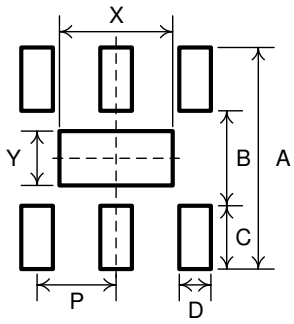
DFN– 2mmx2mm– 6L




| SYMBOLS | MIN. | NOM. | MAX. |
|---|---|---|---|
| A | 0.70 | 0.75 | 0.80 |
| A1 | 0.00 | 0.02 | 0.05 |
| A3 | - | 0.20 | - |
| b | 0.20 | 0.30 | 0.35 |
| D | - | 2.00 | - |
| D1 | - | 1.20 | - |
| E | - | 2.00 | - |
| E1 | - | 0.70 | - |
| e | - | 0.65 | - |
| K | 0.20 | - | - |
| L | - | 0.30 | - |

UNIT: MILLIMETERS

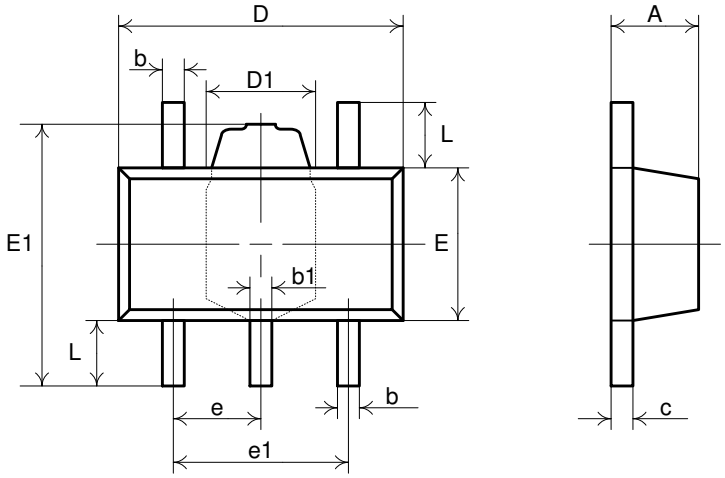
**Footprint Suggestion**




| SYMBOLS | Footprint Dimension |
|---|---|
| A | 2.80 |
| B | 1.20 |
| C | 0.80 |
| D | 0.35 |
| P | 0.65 |
| X | 1.40 |
| Y | 0.70 |

| | |
|---|---|
| $\theta_{JA}$ | 103 °C / W |

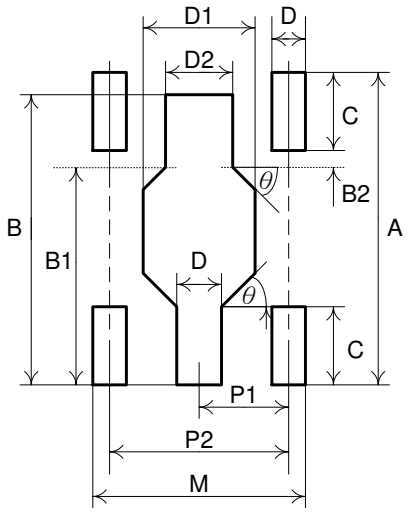
## SOT-89-5L




| SYMBOLS | MIN. | MAX. |
|---|---|---|
| A | 1.40 | 1.60 |
| b | 0.32 | 0.52 |
| b1 | 0.36 | 0.56 |
| c | 0.35 | 0.44 |
| D | 4.40 | 4.60 |
| D1 | 1.40 | 1.80 |
| E | 2.30 | 2.60 |
| E1 | 3.94 | 4.25 |
| e | 1.50 TYP | |
| e1 | 2.90 | 3.10 |
| L | 0.90 | 1.10 |

UNIT: MILLIMETERS

**Footprint Suggestion**




| SYMBOLS | Footprint Dimension |
|---|---|
| A | 5.20 |
| B | 4.80 |
| B1 | 3.60 |
| B2 | 0.25 |
| C | 1.35 |
| D | 0.70 |
| D1 | 1.90 |
| D2 | 1.30 |
| M | 3.70 |
| P1 | 1.50 |
| P2 | 3.00 |
| θ | 45° |

UNIT: MILLIMETERS

| | |
|---|---|
| $\theta_{JA}$ | 127.5 °C / W |

## Records of Revisions

| Rev. | Date | Page | Description |
|---|---|---|---|
| 1.0 | Nov. 13, 2014 | All | First release. |
| 1.1 | Dec. 19, 2014 | 3 | Update the Block Diagram and I-V Curve. |
| | | 6 | Update the Notes. |
| | | 7, 8 | Add the Application Circuits. |
| | | 11 | Add Records of Revision |
| | | All | Change the LOGO. |
| | | | |