LED Drivers for High Power LEDs

# ILD2035

350 mA Step Down LED Driver

## Data Sheet

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Industrial and Multimarket

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| Revision History | |
|---|---|
| **Page or Item** | **Subjects (major changes since previous revision)** |
| **Revision 1.0, 2011-08-17** | |
| All | Initial release of data sheet |
| | |

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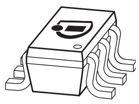
**350 mA Step Down LED Driver with Internal Switch**
**ILD2035**

# 1 Features

- Input voltage range 8 V to 22 V
- Internal switch for up to 400 mA average LED current
- Up to 92 % efficiency
- Over current protection
- Temperature protection mechanism
- Inherent open-circuit LED protection
- Soft-start capability
- Low shut down current
- Typical 3 % output current accuracy
- Minimum external components required
- Small package: SC74


SC74-3D

RoHS

**Applications**

- LED replacement lamps, e.g. MR16 halogen replacement
- Downlights
- Architectural lighting

| Product Name | Package | Pin Configuration | | | | | | Marking |
|---|---|---|---|---|---|---|---|---|
| ILD2035 | SC74-6-4 | 1 = $V_S$ | 2 = GND | 3 = EN | 4 = $V_{switch}$ | 5 = GND | 6 = $V_{sense}$ | 25 |

# 2 Product Brief

The ILD2035 is a hysteretic step down LED driver IC for general lighting applications, which is capable to drive high power LEDs with average currents up to 400 mA.

The IC incorporates an input voltage range from 8 to 22 V and an internal power switch. The output current level can be adjusted with an external sense resistor.

Depending on the value of the switching inductor the switching frequency and the voltage ripple can be set.

The precise internal bandgap stabilizes the circuit and provides stable current conditions over temperature range.

To ensure a long lifetime of the LED system, the ILD2035 incorporates an overcurrent protection.

In addition, the integrated thermal protection will actively control the output current to protect the LEDs and the IC against thermal stress and hence ensure longer LED lifetimes.

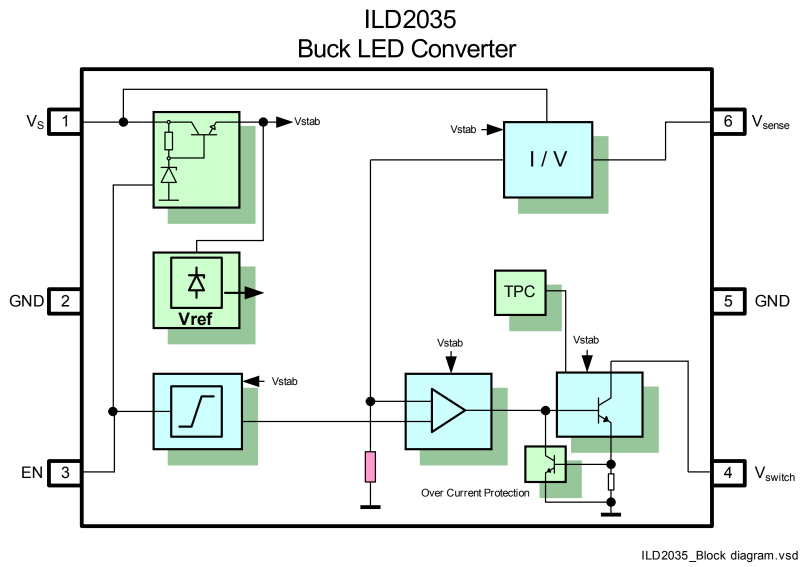



**Figure 1 Block Diagram**

## Pin Definition

**Table 1 Pin Definition and Function**

| Pin No. | Name | Pin Type | Buffer Type | Function |
|---|---|---|---|---|
| 1 | $V_s$ | Input | – | Supply voltage |
| 2 | GND | GND | – | IC ground |
| 3 | EN | Input | – | Chip enable signal |
| 4 | $V_{switch}$ | Output | – | Power switch output |
| 5 | GND | GND | – | IC ground |
| 6 | $V_{sense}$ | Input | – | LED current sense input |

# 3 Maximum Ratings

**Table 2 Maximum Ratings**

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Supply voltage | $V_S$ | – | – | 24 | V | – |
| Peak output current | $I_{Switch}$ | – | – | 550 | mA | Hysteretic peak current |
| Total power dissipation, $T_s \leq 85°C$ | $P_{tot}$ | – | – | 1000 | mW | – |
| Junction temperature | $T_J$ | – | – | 150 | °C | – |
| Solder temperature of GND pins | $T_{SGND}$ | – | – | 125 | °C | – |
| Storage temperature range | $T_{STG}$ | -65 | – | 150 | °C | – |
| ESD capability at all pins | $V_{ESD\ HBM}$ | – | – | 4 | kV | HBM acc. to JESD22-A114 |

***Attention:** **Stresses above the max. values listed here may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. Maximum ratings are absolute ratings; exceeding only one of these values may cause irreversible damage to the integrated circuit.***

# 4 Thermal Characteristics

**Table 3 Maximum Thermal Resistance**

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Junction - soldering point[1)] | $R_{thJS}$ | – | – | 65 | K/W | – |

1) For calculation of $R_{thJA}$ please refer to application note AN077 (Thermal Resistance Calculation)

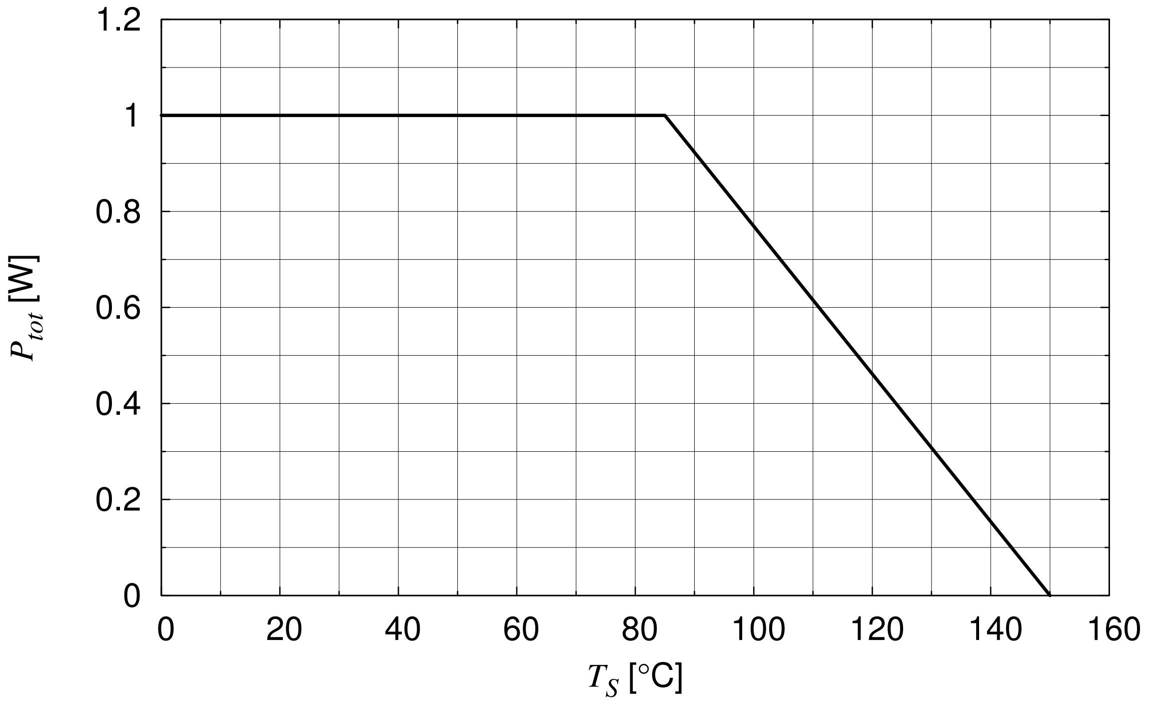



**Figure 2 Total Power Dissipation**

**Equation (1)** is gives an estimation for the power dissipation of ILD2035.

$$P_{tot} = 1.1V \cdot I_{LED} \cdot duty\ cycle + f_{Switch} \cdot 1\mu W \cdot {}^{I_{LED}}\!/_{350\ mA} \tag{1}$$

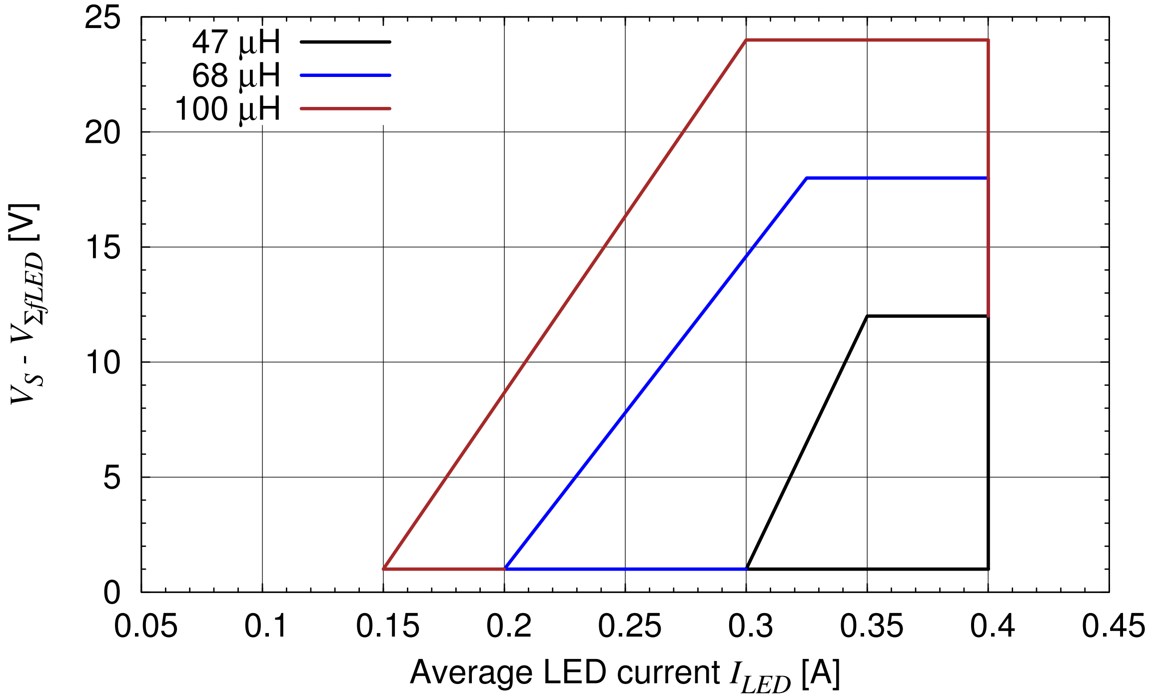



**Figure 3 Safe Operating Area**

**Figure 2** shows the safe operating area for the respective inductance values. The safe operating area consists of the minimum and maximum allowed average LED current and the resulting voltage overhead. The voltage overhead $V_{overhead}$ is the difference between the supply voltage $V_S$ and the sum of the LED forward voltages $V_{\Sigma fLED}$.

**Example calculation**

3 LEDs in series, $V_{fLED}$= 3V, $I_{LED}$ = 350 mA, $V_S$ = 12 V

$V_{overhead}$ = $V_S$ - $V_{\Sigma fLED}$ = 12 V - 9 V = 3 V

→ any of the above coil values can be used

Outside the safe operating area the switching frequency, hysteretic peak current and associated power dissipation $P_{tot}$ of ILD2035 will increase beyond the maximum ratings.

# 5 Electrical Characteristics

## 5.1 DC Characteristics

All parameters at $T_A$ = 25 °C, unless otherwise specified.

$V_S$ = 12 V, 3 LEDs, $R_{sense}$ = 303 mΩ ($I_{LED}$ = 375 mA), L = 100 µH, $V_{EN}$ = 12 V, $V_{fLED}$ = 3 V

**Table 4 DC Characteristics**

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Supply voltage | $V_S$ | 8 | – | 22 | V | |
| Overall current consumption open load | $I_{S\ open\ load}$ | – | 2.4 | – | mA | $V_S$ = 12 V<br>$I_{LED}$ = 0 mA |
| Overall standby current consumption | $I_{S\ standby}$ | – | – | 1 | µA | $V_{EN}$ = 0 V; $V_S$= 12 V |
| Current of Sense input | $I_{sense}$ | – | 20 | – | µA | at any LED current |
| Enable voltage for standby mode | $V_{EN,Off}$ | -0.3 | – | 0.4 | V | |
| Enable voltage for power on | $V_{EN,On}$ | 2.5 | 3 | 22 | V | full LED current |
| Min. power on puls duration | $t_{EN,On}$ | 10 | – | – | µs | |
| Input current of enable pin | $I_{EN}$ | – | 310 | – | µA | $V_{EN}$ =12 V |
| Over temperature protection | $T_{S,\ TSD}$ | – | 113 | – | °C | $T_S$ for 10 % $I_{LED}$ reduction, defined by $T_J$ |

## 5.2 Switching Characteristics

All parameters at $T_A$ = 25 °C, unless otherwise specified.

$V_S$ = 12 V, 3 LEDs, $R_{sense}$ = 303 mΩ ($I_{LED}$ = 375 mA), L = 100 µH, $V_{EN}$ = 12 V, $V_{fLED}$ = 3 V

**Table 5 Switching Characteristics**

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Switching frequency | $f_{Switch}$ | – | 120 | – | kHz | |
| Maximum switching frequency | $f_{Switch\ max}$ | – | – | 500 | kHz | for any coil value |
| Mean current sense threshold voltage | $V_{sense}$ | – | 114 | – | mV | |
| Sense threshold hysteresis | $V_{sensehys}$ | – | ±7.5 | – | % | |
| Residual voltage at collector of power transistor | $V_{switch\ on}$ | – | 1.1 | – | V | output switch turned on |
| Output current accuracy | $I_{outacc}$ | – | ±3 | – | % | |

## 5.3 Digital Signals

All parameters at $T_A$ = 25 °C, unless otherwise specified.

**Table 6 Digital Control Parameter at Pin EN**

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Input voltage for power on | $V_{On}$ | 2.5 | 3 | 22 | V | full LED current |
| Input voltage for power off | $V_{Off}$ | -0.3 | – | 0.4 | V | |
| Min. power on puls duration | $t_{On}$ | 10 | – | | µs | |

# 6 Basic Application Information

This section covers the basic information required for calculating the parameters for a certain LED application. For detailed application information please visit our web site **http://www.infineon.com/led.appnotes**

## 6.1 Setting the average LED current

The average output current for the LEDs is set by the external sense resistor $R_{sense}$. To calculate the value of this resistor a first approximation can be calculated using **Equation (2)**.

$V_{sense}$ is dependent on the supply voltage $V_S$ and the number of LEDs in series.

$$R_{sense} = \frac{V_{sense}}{I_{LED}} \tag{2}$$

**Example calculation**

$V_S$ = 12 V, 100 µH, $V_{fLED}$ = 3 V, 3 LEDs in series

→ $V_{sense}$ = 114 mV

$I_{LED}$ = 375 mA

→ $R_{sense}$ = 303 mΩ

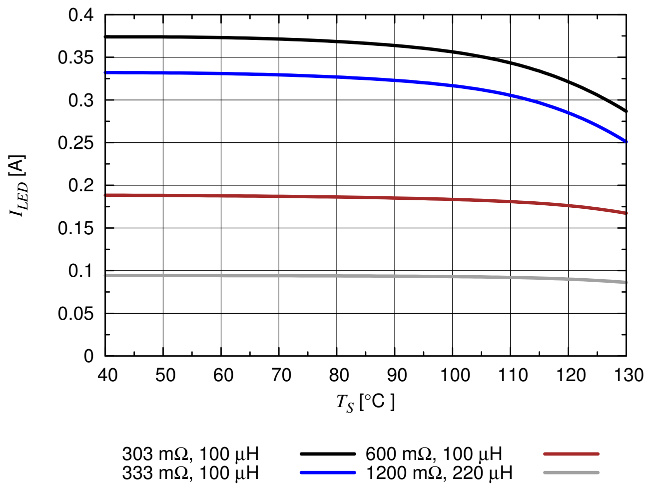
An easy way to achieve these resistor values is to connect standard resistors in parallel.

### 6.1.1 Temperature Protection Circuit

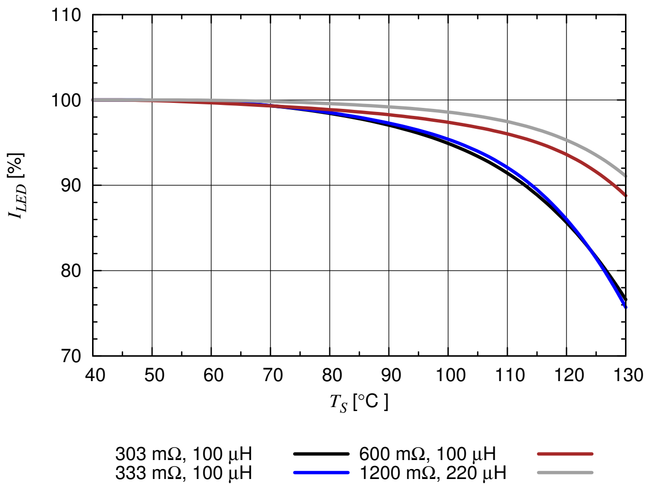
ILD2035 incorporates a temperature protection circuit referring to the junction temperature of the IC. The higher the junction temperature the lower the current of the LEDs. This feature helps to reduce the power dissipation of ILD2035 and the LEDs. Yet still the product specific maximum ratings for the junction temperature need to be observed to avoid a permanent damage of the devices.

ILD2035 has been characterized on ILD4035/4001 application board heated from the backside without additional air flow on the circuit board surface besides natural convection. The size and layout of the circuit board as well as the air flow around it influence the thermal resistance junction to ambient $R_{thJA}$ of ILD2035 and thus its junction temperature. Below figures show the LED current versus soldering point temperature $T_S$.

**LED current versus $T_S$, $V_S$ = 12 V**




**LED current (relative) versus $T_S$, $V_S$ = 12 V**

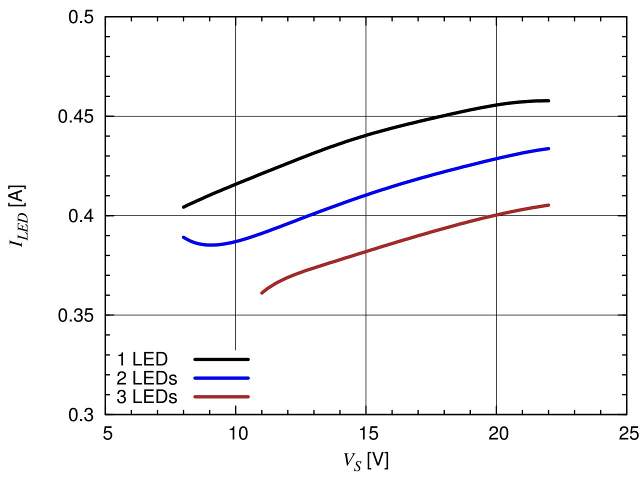



## 6.2 Switching Parameters

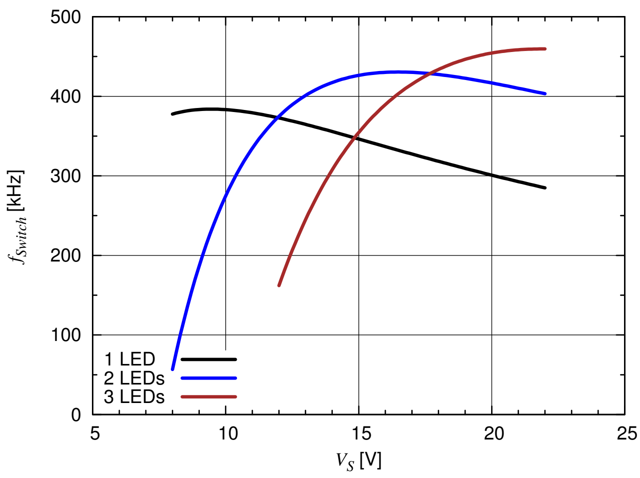
For all shown parameters ILD2035 has been measured at $T_A$ = 25 °C. Used LEDs have a typical $V_{fLED}$ of 3 V.

**$R_{sense}$ = 303 mΩ, L= 47 µH**

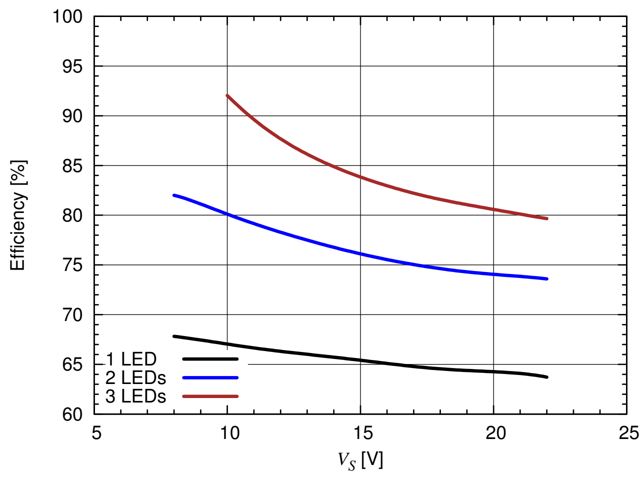
**$I_{LED}$ versus $V_S$ and Number of LEDs**



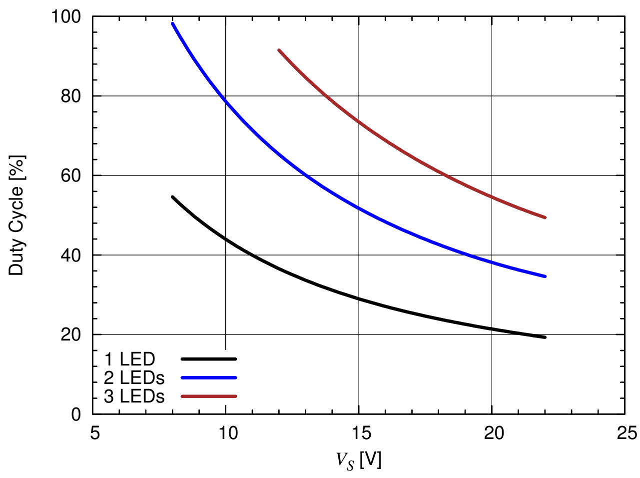

**$f_{Switch}$ versus $V_S$ and Number of LEDs**




**Efficiency versus $V_S$ and Number of LEDs**

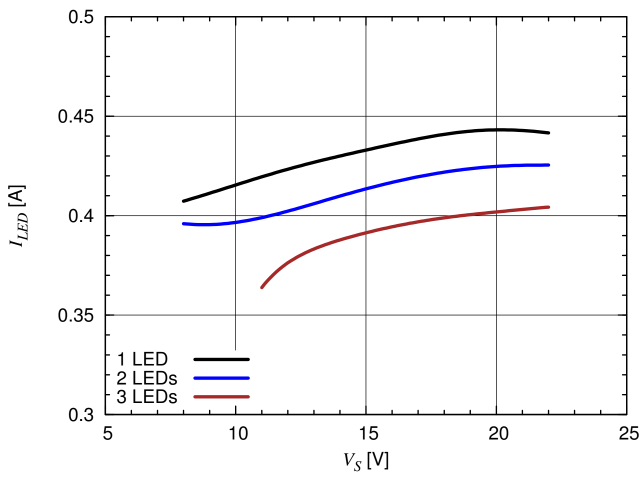



**Duty Cycle versus $V_S$ and Number of LEDs**

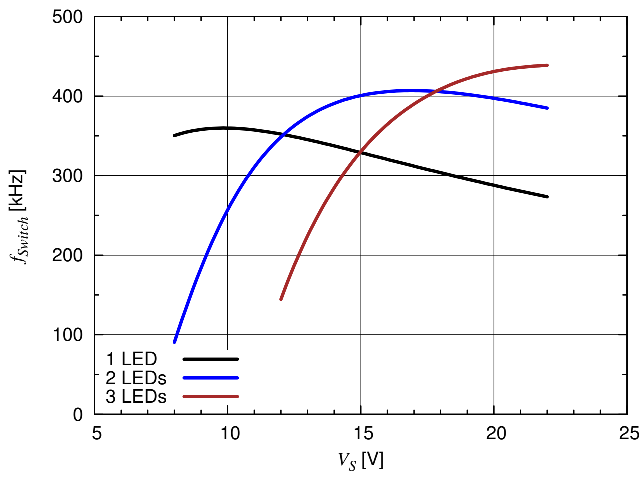


**$R_{sense}$ = 303 mΩ, L= 68 µH**

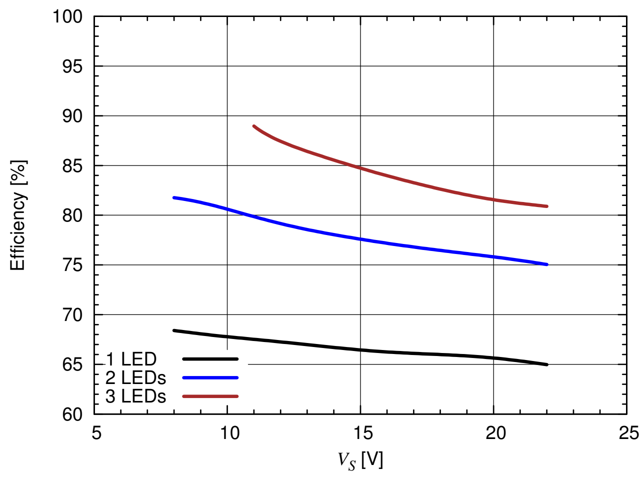
**$I_{LED}$ versus $V_S$ and Number of LEDs**



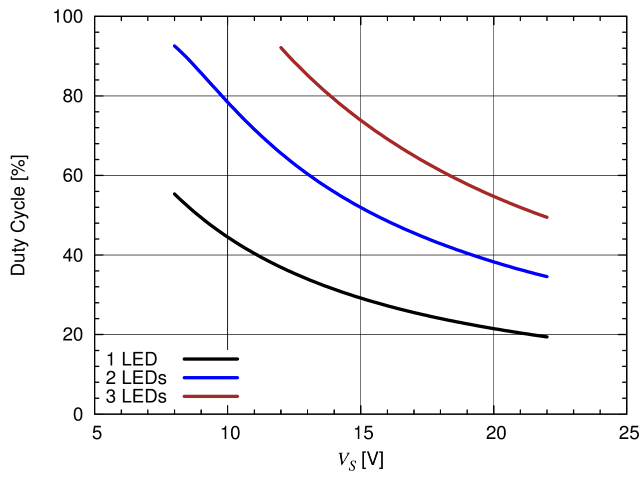

**$f_{Switch}$ versus $V_S$ and Number of LEDs**




**Efficiency versus $V_S$ and Number of LEDs**

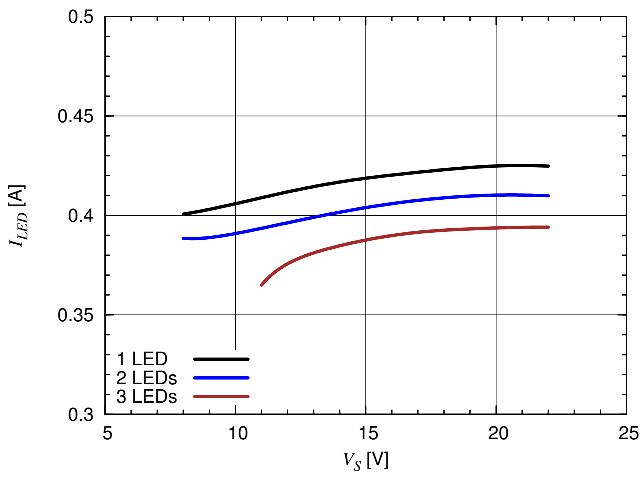



**Duty Cycle versus $V_S$ and Number of LEDs**

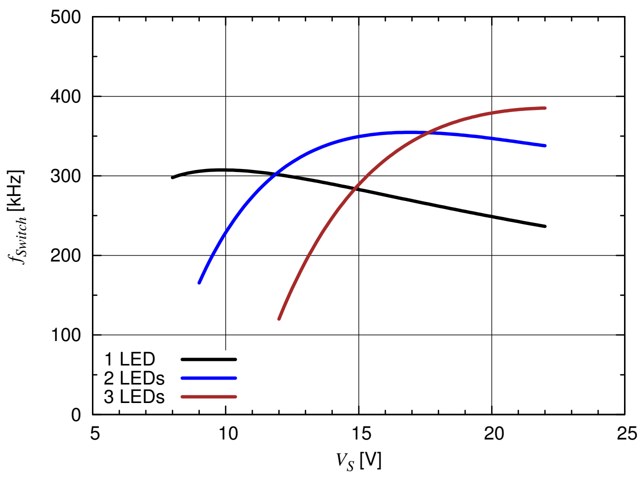


**$R_{sense}$ = 303 mΩ, L= 100 µH**

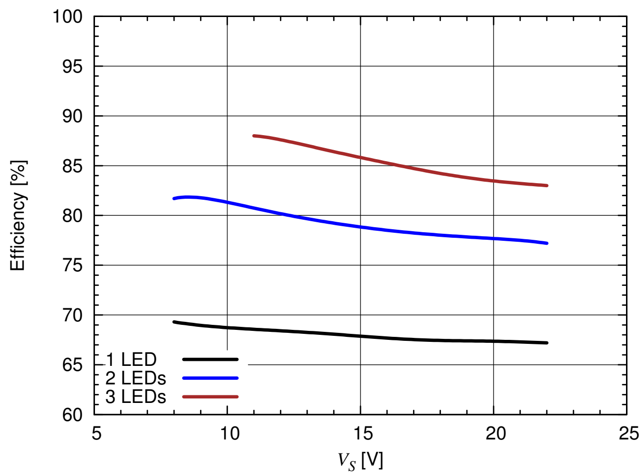
### $I_{LED}$ versus $V_S$ and Number of LEDs



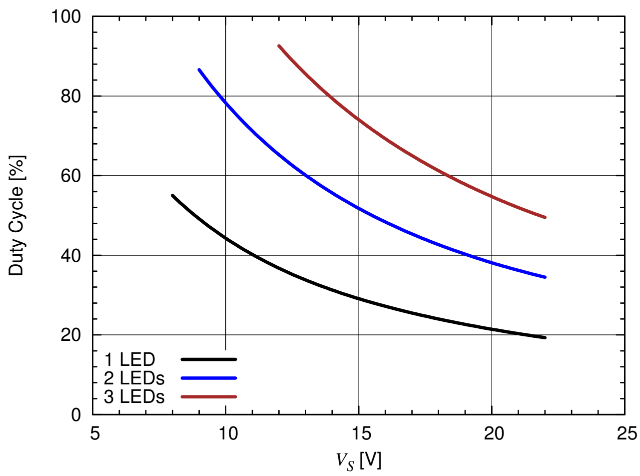

### $f_{Switch}$ versus $V_S$ and Number of LEDs




### Efficiency versus $V_S$ and Number of LEDs

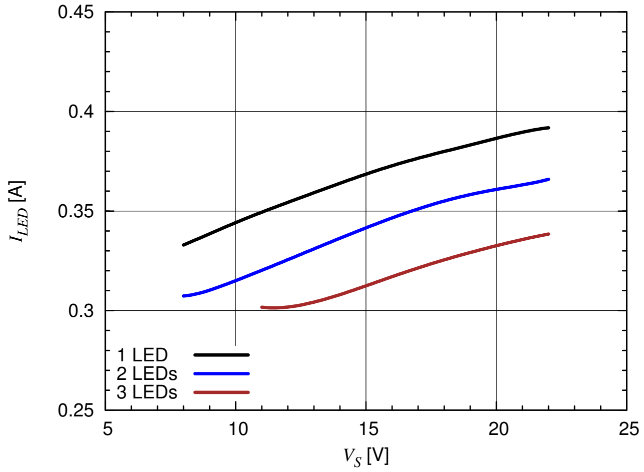



### Duty Cycle versus $V_S$ and Number of LEDs

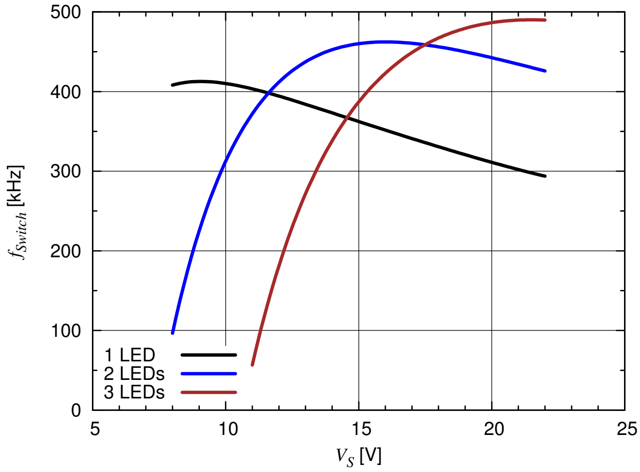


**$R_{sense}$ = 367 mΩ, L= 47 µH**

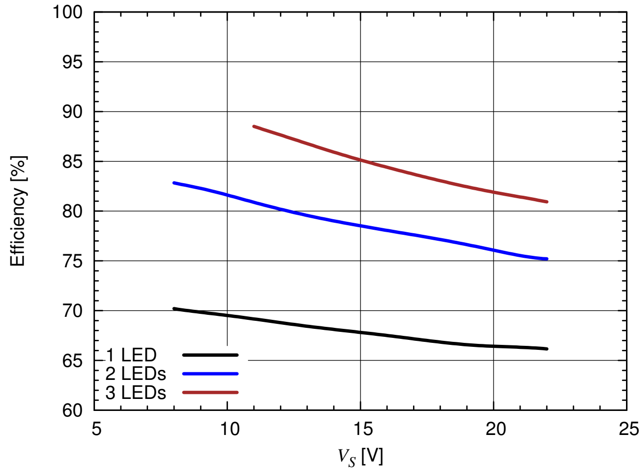
### $I_{LED}$ versus $V_S$ and Number of LEDs



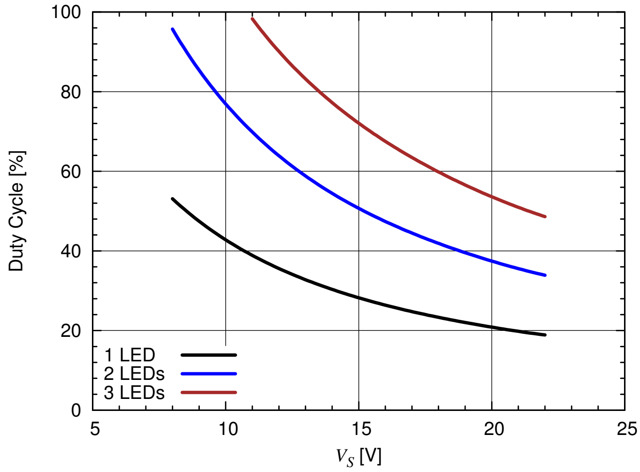

### $f_{Switch}$ versus $V_S$ and Number of LEDs




### Efficiency versus $V_S$ and Number of LEDs

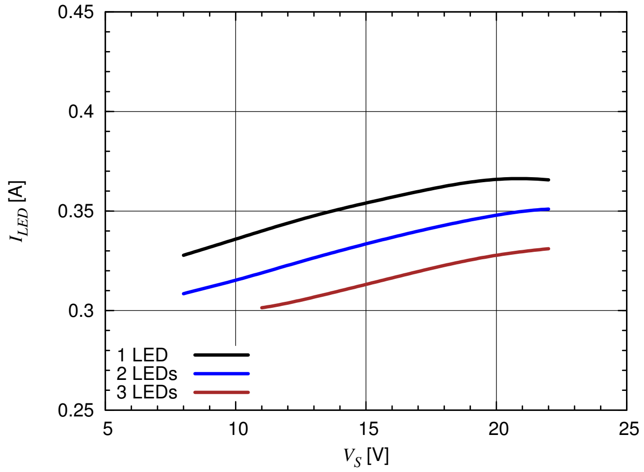



### Duty Cycle versus $V_S$ and Number of LEDs

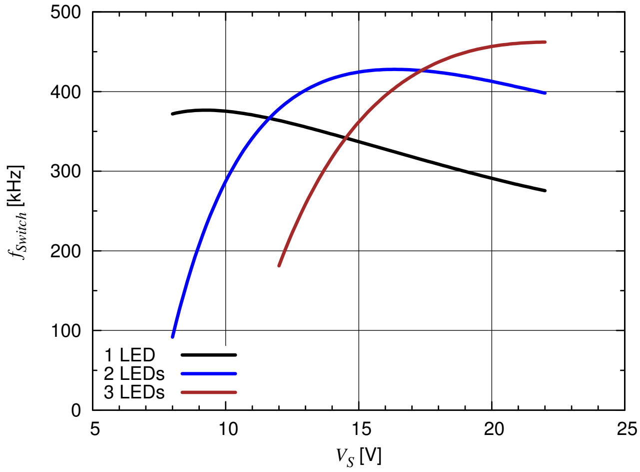


**$R_{sense}$ = 367 mΩ, L= 68 µH**

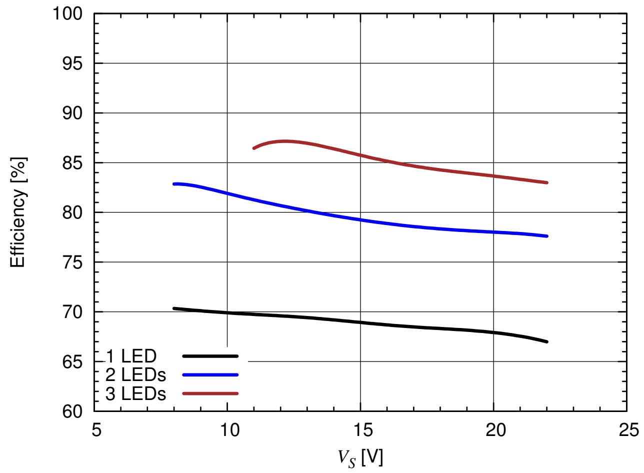
**$I_{LED}$ versus $V_S$ and Number of LEDs**



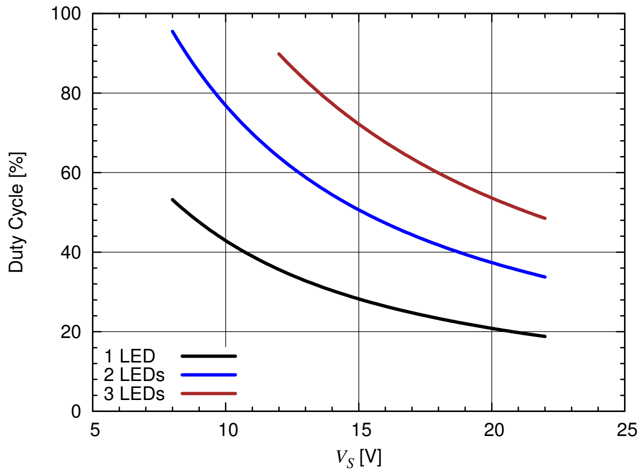

**$f_{Switch}$ versus $V_S$ and Number of LEDs**




**Efficiency versus $V_S$ and Number of LEDs**

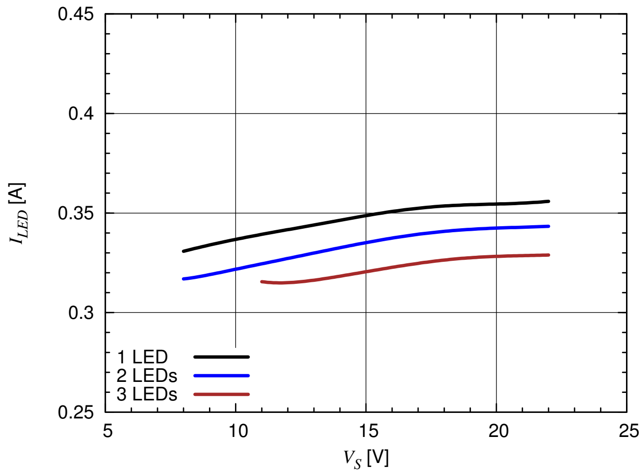



**Duty Cycle versus $V_S$ and Number of LEDs**

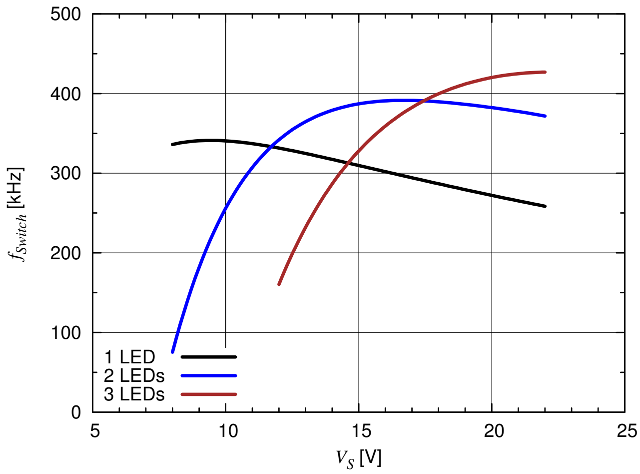


**$R_{sense}$ = 367 mΩ, L= 100 µH**

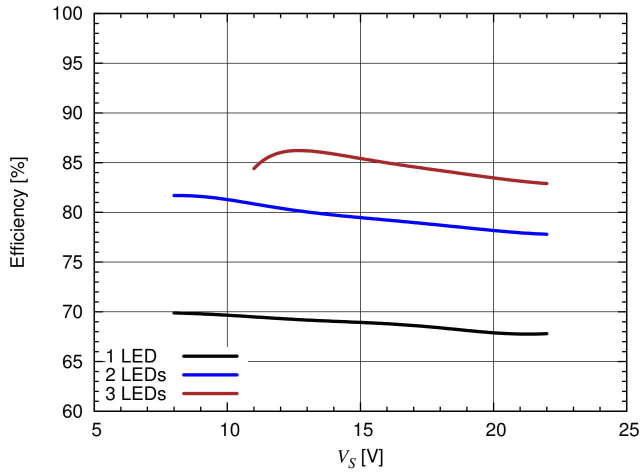
### $I_{LED}$ versus $V_S$ and Number of LEDs



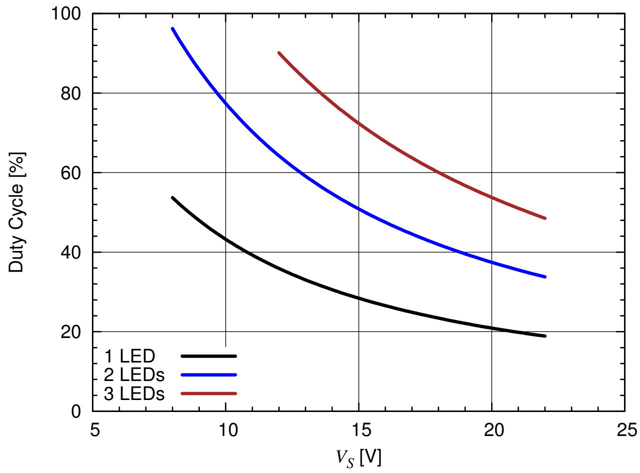

### $f_{Switch}$ versus $V_S$ and Number of LEDs




### Efficiency versus $V_S$ and Number of LEDs




### Duty Cycle versus $V_S$ and Number of LEDs



# 7 Application Circuit

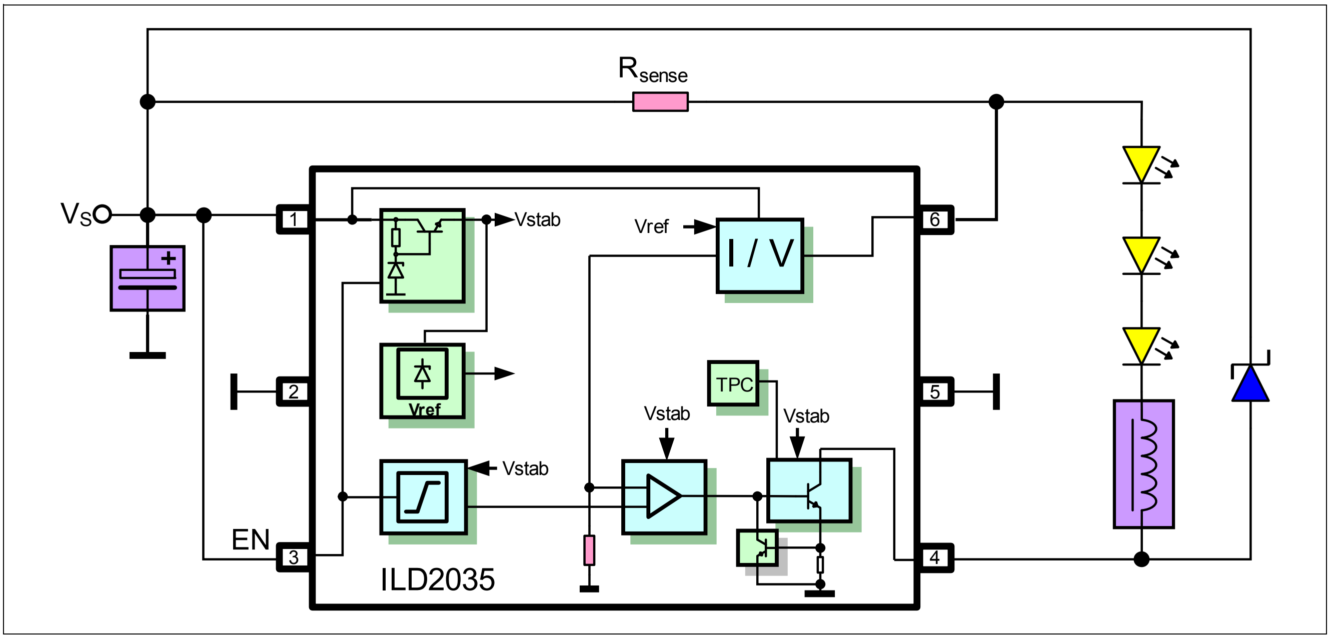



**Figure 4 Application Circuit**

## 7.1 Evaluation Board

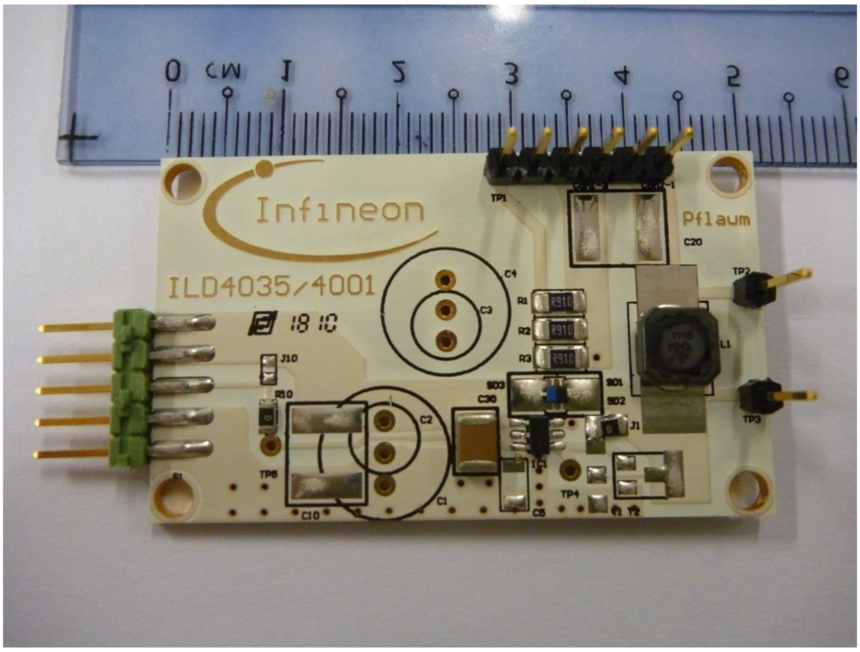



**Figure 5 ILD2035 on Evaluation Board**

# 8 Package Information

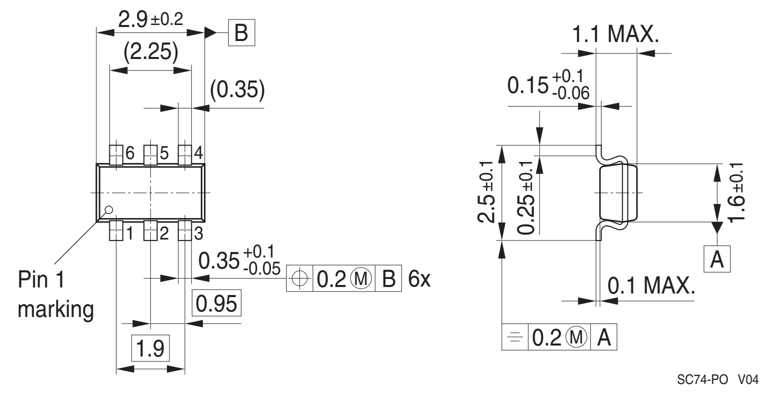



**Figure 6 Package Outline SC74**

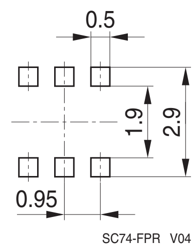



**Figure 7 Recommended PCB Footprint for Reflow Soldering**

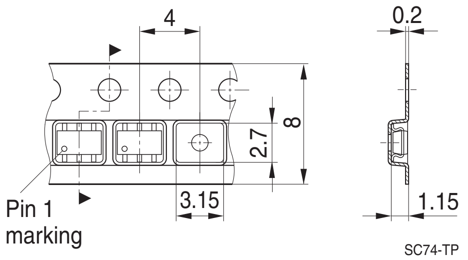



**Figure 8 Tape Loading**

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