

## 1.5 A max constant current LED driver

### Features

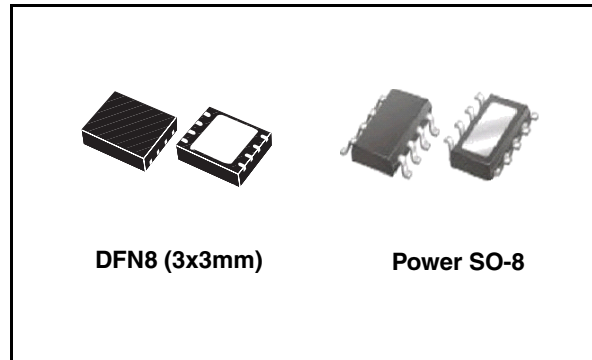
- Up to 40 V input voltage
- Less than 0.5 V voltage overhead
- Up to 1.5 A output current
- PWM dimming pin
- Shutdown pin
- LED disconnection diagnostic

### Applications

- Supplying LEDs with constant current for varying input voltages
- Low voltage lighting
- Small appliance LED lighting
- Car LED lights

### Description

The STCS1 is a BiCMOS constant current source designed to provide a precise constant current starting from a varying input voltage source. The main target is to replace discrete components solution for driving LEDs in low voltage applications such as 5 V, 12 V or 24 V giving benefits in terms of precision, integration and reliability.



The current is set with external resistor up to 1.5 A with a  $\pm 10\%$  precision; a dedicated pin allows implementing PWM dimming.

An open-drain pin output provides information on load disconnection condition.

**Table 1. Device summary**

| Order code | Package          | Packaging           |
|------------|------------------|---------------------|
| STCS1PUR   | DFN8 (3mm x 3mm) | 3000 parts per reel |
| STCS1PHR   | Power SO-8       | 2500 parts per reel |

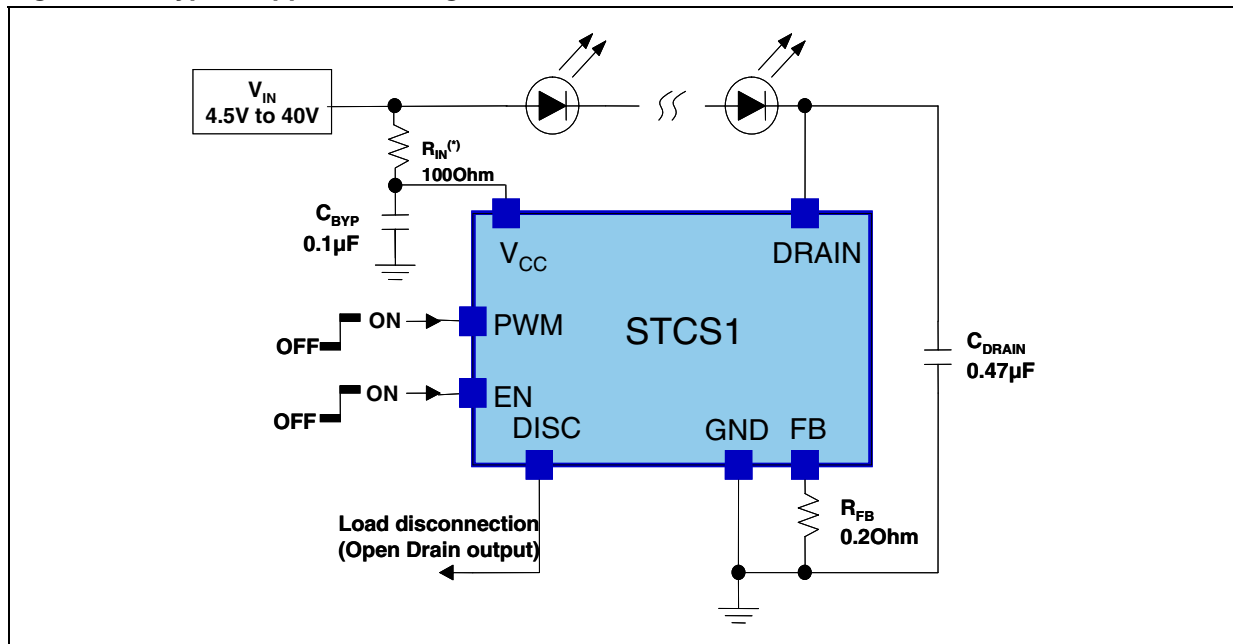
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# 1 Application diagram

Figure 1. Typical application diagram for 0.5 A LED current



(\*) The  $R_{IN}$  resistor must be inserted when  $dV_{CC}/dt$  is higher than  $10 \text{ V}/\mu\text{s}$

## 2 Pin configuration

Figure 2. Pin connections (top view)

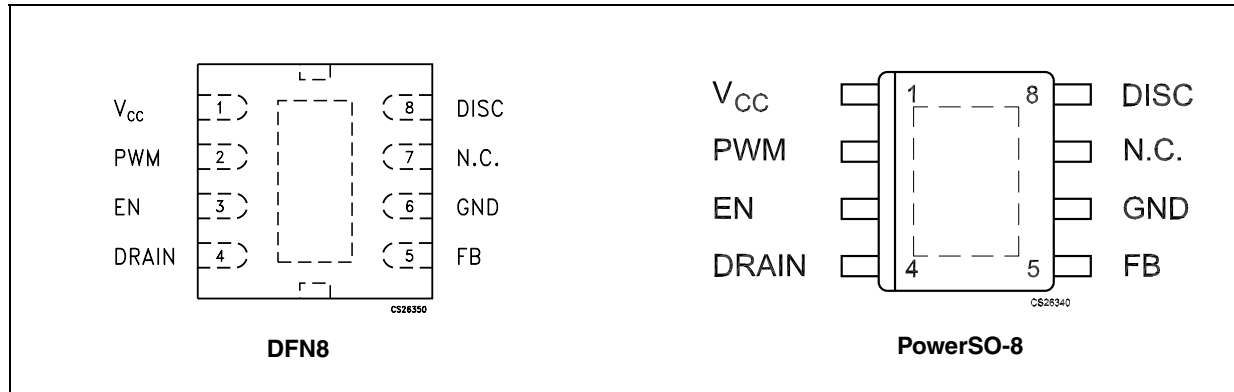


Table 2. Pin description

| Pin N° | Symbol          | Note   |
|--------|-----------------|--|
| 1      | V <sub>CC</sub> | Supply voltage   |
| 2      | PWM             | PWM dimming input  |
| 3      | EN              | Shutdown pin   |
| 4      | DRAIN           | Internal N-MOSFET drain  |
| 5      | FB              | External resistor connection for current set (N-MOSFET source) |
| 6      | GND             | Ground   |
| 7      | N.C.            | Not connected  |
| 8      | DISC            | Load disconnection flag (open drain)                           |
|        | Exp-pad         | Internally connected to ground.                                |

### 3 Maximum ratings

**Table 3. Absolute maximum ratings**

| Symbol        | Parameter                   | Value                    | Unit |
|---------------|-----------------------------|--------------------------|------|
| $V_{CC}$      | DC supply voltage           | -0.3 to +45              | V    |
| $V_D$         | Drain voltage               | -0.3 to +45              |      |
| PWM, EN, DISC | Logic pins                  | -0.3 to + $V_{CC} + 0.3$ | V    |
| FB            | Configuration pins          | -0.3 to + 3.3            | V    |
| ESD           | Human body model (all pins) | ±2                       | kV   |
| $T_J^{(1)}$   | Junction temperature        | -40 to 150               | °C   |
| $T_{STG}$     | Storage temperature range   | -55 to 150               | °C   |

1.  $T_J$  is calculated from the ambient temperature  $T_A$  and the power dissipation  $P_D$  according the following formula:  
 $T_J = T_A + (P_D \times R_{thJA})$ . See [Figure 12](#). and [Figure 13](#). for details of max power dissipation for ambient temperatures higher than 25°C.

*Note: Absolute Maximum Ratings are those values beyond which damage to the device may occur. Functional operation under these conditions is not implied.*

**Table 4. Thermal data**

| Symbol     | Parameter                           | DFN8                | Power SO-8        | Unit |
|------------|-------------------------------------|---------------------|-------------------|------|
| $R_{thJC}$ | Thermal resistance junction-case    | 10                  | 12                | °C/W |
| $R_{thJA}$ | Thermal resistance junction-ambient | 37.6 <sup>(1)</sup> | 45 <sup>(2)</sup> | °C/W |

1. This value is referred to four-layer PCB, JEDEC standard test board.
2. With two sides, two planes PCB following EIA/JEDEC JESD51-7 standard.

## 4 Electrical characteristics

**Table 5. Electrical characteristics**

( $V_{CC} = 12\text{ V}$ ;  $I_O = 100\text{ mA}$ ;  $T_A = -40^\circ\text{C}$  to  $85^\circ\text{C}$ ;  $V_{DRAIN} = 1\text{ V}$ ;  $C_{DRAIN} = 1\text{ }\mu\text{F}$ ;  $C_{BYP} = 100\text{ nF}$  typical values are at  $T_A = 25^\circ\text{C}$ , unless otherwise specified)

| Symbol                           | Parameter  | Test conditions   | Min. | Typ. | Max. | Unit             |
|----------------------------------|--|---|------|------|------|------------------|
| $V_{CC}$                         | Supply voltage range   |   | 4.5  |      | 40   | V                |
|                                  | Output current range   |   | 1    |      | 1500 | mA               |
| $I_O$                            | Output current   | $R_{FB} = 0.2\text{ }\Omega$  |      | 500  |      | mA               |
|                                  | Regulation (percentage with respect to $V_{CC}=12\text{V}$ ) | $V_{CC} = 4.5$ to $40\text{ V}$ ,<br>$I_O = 100\text{ mA}$ ; $V_{DRAIN} = 1\text{ V}$ | -1   |      | +1   | %                |
| $V_{FB}$                         | Feedback voltage   | All the current range   | 90   | 100  | 110  | mV               |
| $I_{CC}$                         | Quiescent current (measured on $V_{CC}$ pin)                 | On Mode   |      | 450  | 650  | $\mu\text{A}$    |
|                                  |  | Shutdown Mode;<br>$V_{CC} = 5$ to $40\text{ V}$                                       |      |      | 1    |                  |
| $V_{DROP}$                       | Dropout voltage ( $V_{DRAIN}$ to GND)                        | $I_O = 100\text{ mA}$   |      | 0.12 | 0.16 | V                |
|                                  |  | $I_O = 1.5\text{ A}$  |      | 0.58 | 0.9  |                  |
| $LEAK_{DRAIN}$                   | Drain leakage current  | Shutdown; $V_{DRAIN} = 40\text{ V}$   |      |      | 10   | $\mu\text{A}$    |
| $T_D$                            | Delay on PWM signal (see <a href="#">Figure 3.</a> )         | $V_{PWM}$ rising, $V_{CC} = 12\text{ V}$  |      | 3    |      | $\mu\text{s}$    |
|                                  |  | $V_{PWM}$ falling, $V_{CC} = 12\text{ V}$   |      | 1.2  |      |                  |
| DISC                             | Low level voltage  | $I_{SINK} = 5\text{ mA}$  |      | 0.2  | 0.5  | V                |
|                                  | Leakage current  | $V_{DISC} = 5\text{ V}$   |      |      | 1    | $\mu\text{A}$    |
|                                  | Load disconnection threshold ( $V_{DRAIN}$ -GND)             | DISC Turn-ON  |      |      | 75   | mV               |
|                                  |  | DISC Turn-OFF   |      |      | 110  |                  |
| Thermal Protection               | Shutdown temperature   |   |      | 155  |      | $^\circ\text{C}$ |
|                                  | Hysteresis   |   |      | 25   |      |                  |
| <b>Logic Inputs (PWM and EN)</b> |  |   |      |      |      |                  |
| $V_L$                            | Input low level  |   |      |      | 0.4  | V                |
| $V_H$                            | Input high level   |   | 1.2  |      |      | V                |
|                                  | EN, PWM leakage current                                      | $V_{EN} = 5\text{ V}$ ; $V_{PWM} = 5\text{ V}$  |      |      | 2    | $\mu\text{A}$    |
|                                  | EN input leakage current                                     | $V_{EN} = 40\text{ V}$  |      |      | 50   |                  |
|                                  | PWM input leakage current                                    | $V_{PWM} = 40\text{ V}$   |      |      | 100  |                  |

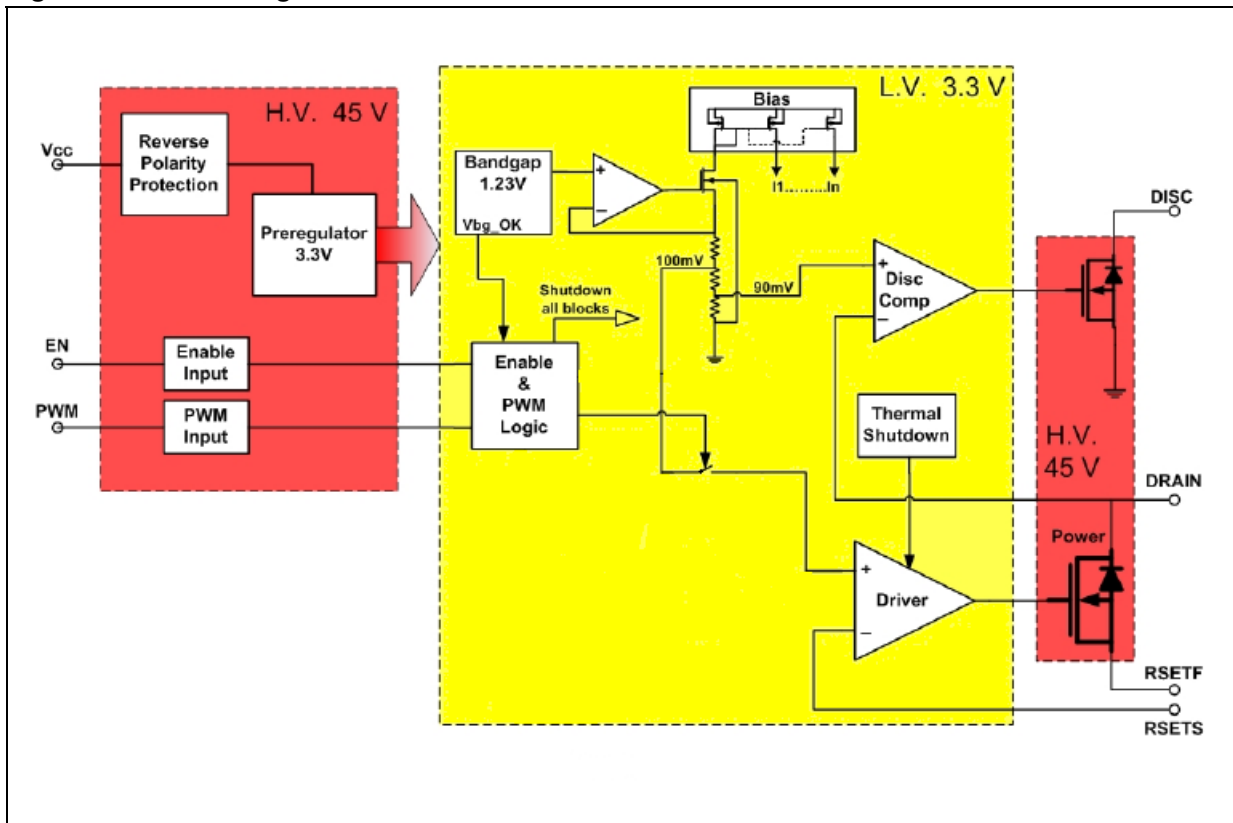
*Note:* All devices 100% production tested at  $T_A = 25^\circ\text{C}$ . Limits over the operating temperature range are guaranteed by design.

# 5 Timing

Figure 3. PWM and output current timing



Figure 4. Block diagram



# 6 Typical performance characteristics

Figure 5.  $I_{DRAIN}$  vs  $V_{CC}$ ,  $T_A = 25^\circ C$



Figure 6.  $I_{DRAIN}$  vs  $R_{SET}$

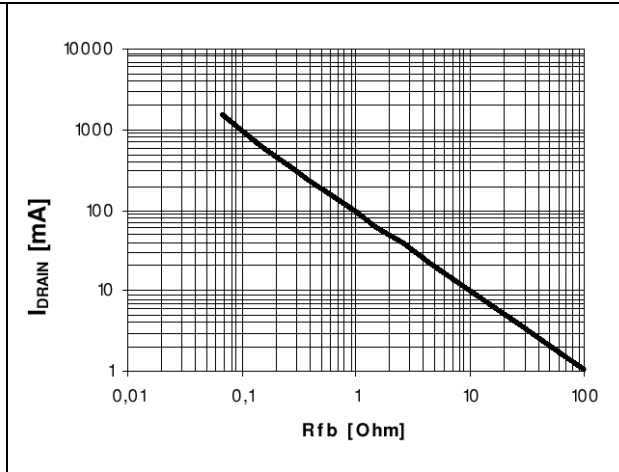


Figure 7.  $I_{DRAIN}$  vs Temperature



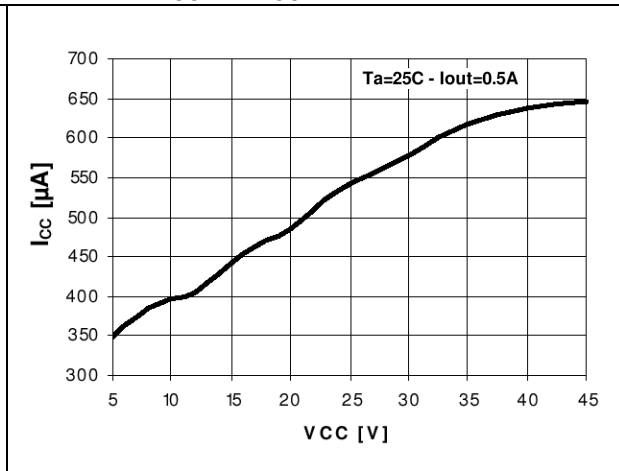
Figure 8.  $V_{DROP}$  (including  $V_{FB}$ ) vs temperature



Figure 9.  $I_{CC}$  vs Temperature



Figure 10.  $I_{CC}$  vs  $V_{CC}$





## 7 Detail description

The STCS1 is a BiCMOS constant current source designed to provide a precise constant current starting from a varying input voltage source. The main target is to replace discrete components solution for driving LEDs in low voltage applications such as 5 V, 12 V or 24 V giving benefits in terms of precision, integration and reliability.

### 7.1 Current setting

The current is set with an external sensing resistor connected to the FB pin. The feedback voltage is 100 mV, then a low resistor value can be chosen reducing power dissipation. A value between 1 mA and 1.5 A can be set according to the resistor value, the resulting output current has a tolerance of  $\pm 10\%$ .

### 7.2 Enable

When the enable pin is low the device completely off thus reducing current consumption to less than 1  $\mu$ A. When in shutdown mode, the internal main switch is off.

### 7.3 PWM dimming

The PWM input allows implementing PWM dimming on the LED current; when the PWM input is high the main switch will be on and vice versa. A typical frequency range for the input is from few Hertz to 50 kHz. The maximum dimming frequency is limited by the minimum rise/fall time of the current which is around 4  $\mu$ s each. Above 50 kHz the current waveforms starts assuming a triangular shape.

While the PWM input is switching, the overall circuitry remains on, this is needed in order to implement a short delay time TD (see [Figure 3](#)).

Since the PWM pin is controlling just the main switch, the overall circuitry is always on and it is able to control the delay time between the PWM input signal and the output current in the range of few  $\mu$ s, this is important to implement synchronization among several light LED sources.

### 7.4 Diagnostic

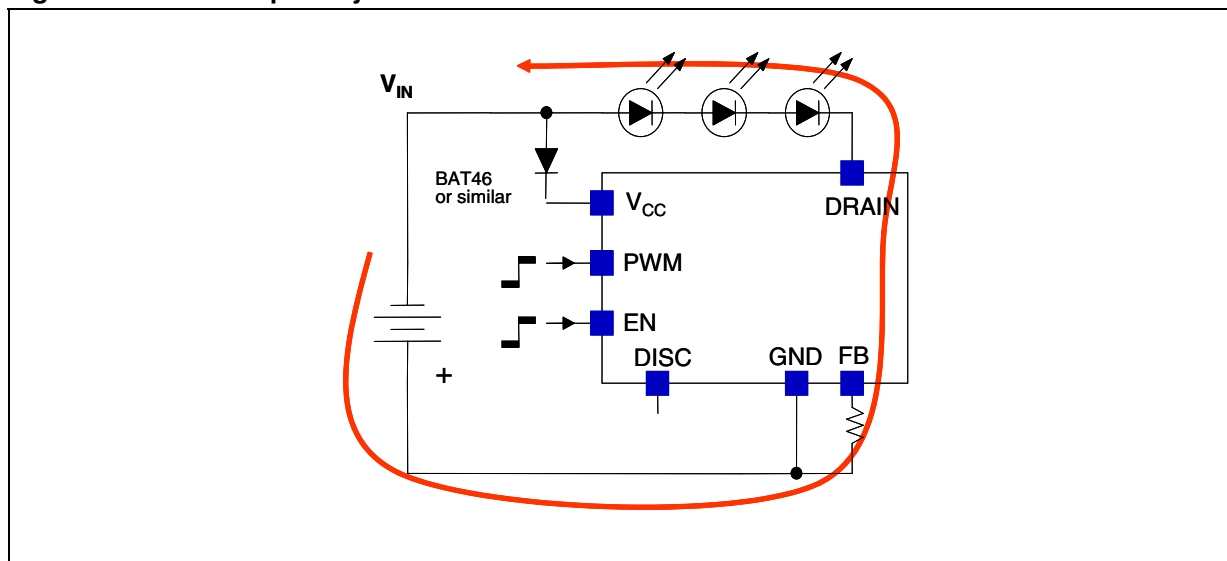
When STCS1 is in on mode (EN is high), the device is able to detect disconnection or fail of the LED string monitoring  $V_{DRAIN}$  pin. If  $V_{DRAIN}$  is lower than 75 mV the DISC pin is pulled low regardless the PWM pin status. This information can be used by the system to inform that some problem happens in the LEDs.

## 8 Application information

### 8.1 Reverse polarity protection

STCS1 must be protected from reverse connection of the supply voltage. Since the current sunk from  $V_{CC}$  pin is in the range of 450  $\mu\text{A}$  a small diode connected to  $V_{CC}$  is able to protect the chip. Care must be taken for the whole application circuit, especially for the LEDs, in fact, in case a negative voltage is applied between  $V_{IN}$  and GND, a negative voltage will be applied to the LED string that must have a total breakdown voltage higher than the negative applied voltage in order to avoid any damage.

Figure 11. Reverse polarity condition



### 8.2 Thermal considerations

The STCS1 is able to control a LED current up to 1.5 A and able to sustain a voltage on the drain pin up to 40 V. Those operating conditions are however limited by thermal constraints, the thermal resistances shown in the THERMAL DATA section are the typical ones, in particular  $R_{thJA}$  depends on the copper area and the number of layers of the printed circuit board under the pad. DFN8 and PowerSO-8 have an exposed die attach pad which enhances the thermal conductivity enabling high power application.

The power dissipation in the device can be calculated as follow:

$$P_D = (V_{DRAIN} - V_{FB}) \times I_{LED} + (V_{CC} \times I_{CC})$$

basing on this and on the thermal resistance and ambient temperature, the junction temperature can be calculated as:

$$T_J = R_{thJA} \times P_D + T_A$$

A typical application could be:

- Input Voltage: 12 V;
- 3 white LEDs with an typical  $V_F = 3.6$  V;
- LEDs current: 500mA;

- Package: DFN8 3x3 mm;
- $T_A = 50^\circ\text{C}$ ;

In this case  $V_{\text{DRAIN}} = 12 - 3 \times 3.6 = 1.2 \text{ V}$

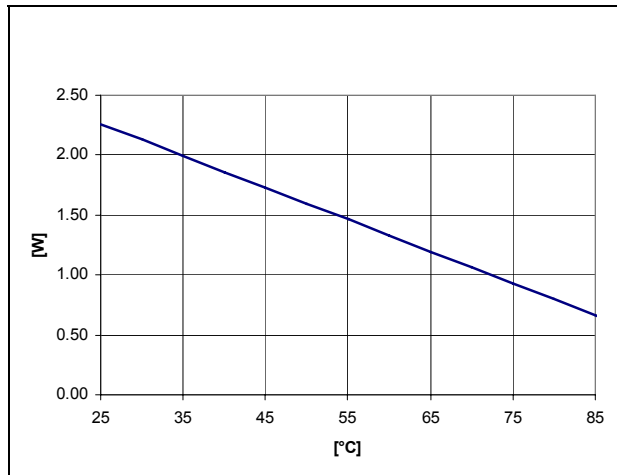
$$P_D = (1.2 - 0.1) \times 0.5 + 12 \times 0.5 \times 10^{-3} = 0.55 + 6 \times 10^{-3} = 556 \text{ mW}$$

The junction temperature will be:

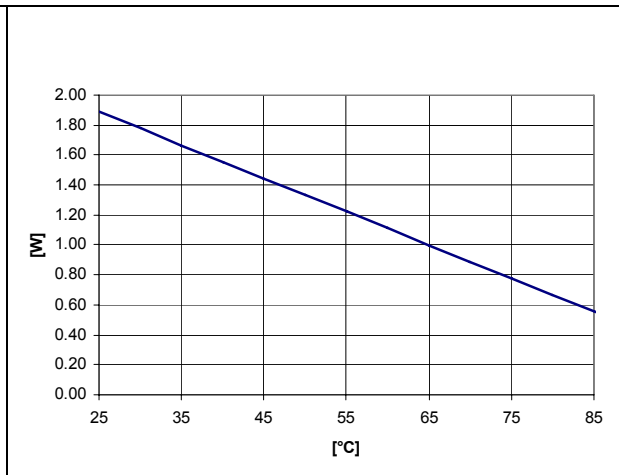
$$T_J = 37.6 \times 0.556 + 50 = 70.9^\circ\text{C}.$$

The following pictures show the maximum power dissipation according to the ambient temperature for both packages:

**Figure 12. Maximum power dissipation vs  $T_A$  for DFN8 3x3mm**



**Figure 13. Maximum power dissipation vs  $T_A$  for PowerSO-8**

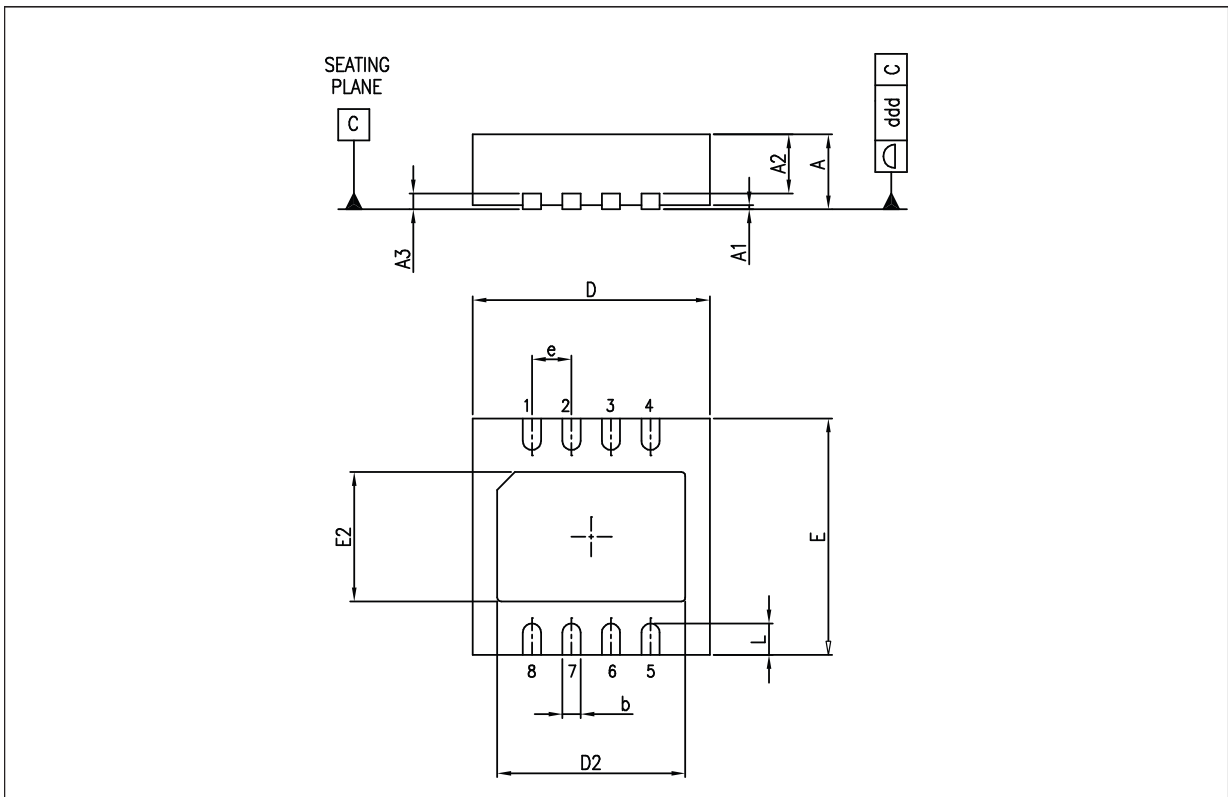


## 9 Package mechanical data

In order to meet environmental requirements, ST offers these devices in ECOPACK® packages. These packages have a Lead-free second level interconnect. The category of second Level Interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an ST trademark. ECOPACK specifications are available at: [www.st.com](http://www.st.com).

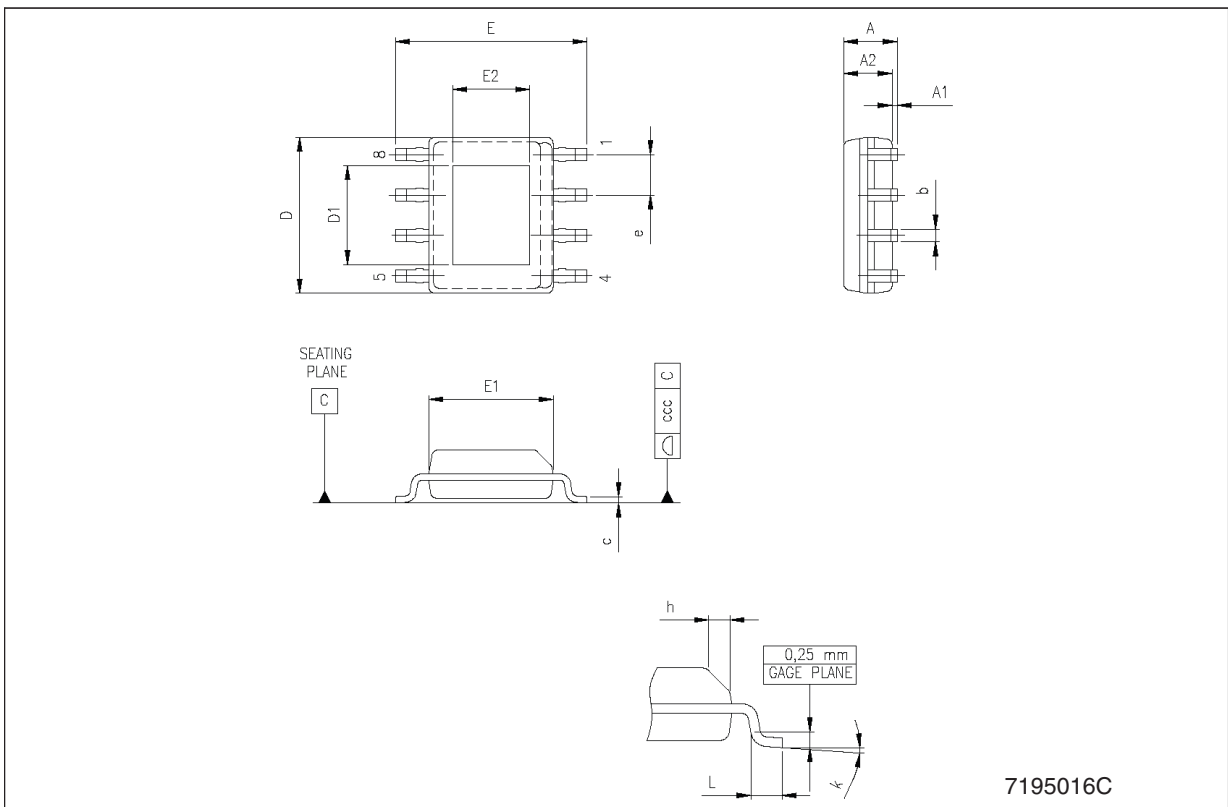
**DFN8 (3x3 mm) mechanical data**

| Dim. | mm.  |      |      | mils. |       |      |
|------|------|------|------|-------|-------|------|
|      | Min. | Typ. | Max. | Min.  | Typ.  | Max. |
| A    | 0.80 | 0.90 | 1.00 | 31.5  | 35.4  | 39.4 |
| A1   |      | 0.02 | 0.05 |       | 0.8   | 2.0  |
| A2   |      | 0.70 |      |       | 27.6  |      |
| A3   |      | 0.20 |      |       | 7.9   |      |
| b    | 0.18 | 0.23 | 0.30 | 7.1   | 9.1   | 11.8 |
| D    |      | 3.00 |      |       | 118.1 |      |
| D2   | 2.23 | 2.38 | 2.48 | 87.8  | 93.7  | 97.7 |
| E    |      | 3.00 |      |       | 118.1 |      |
| E2   | 1.49 | 1.64 | 1.74 | 58.7  | 64.6  | 68.5 |
| e    |      | 0.50 |      |       | 19.7  |      |
| L    | 0.30 | 0.40 | 0.50 | 11.8  | 15.7  | 19.7 |



**PowerSO-8 mechanical data**

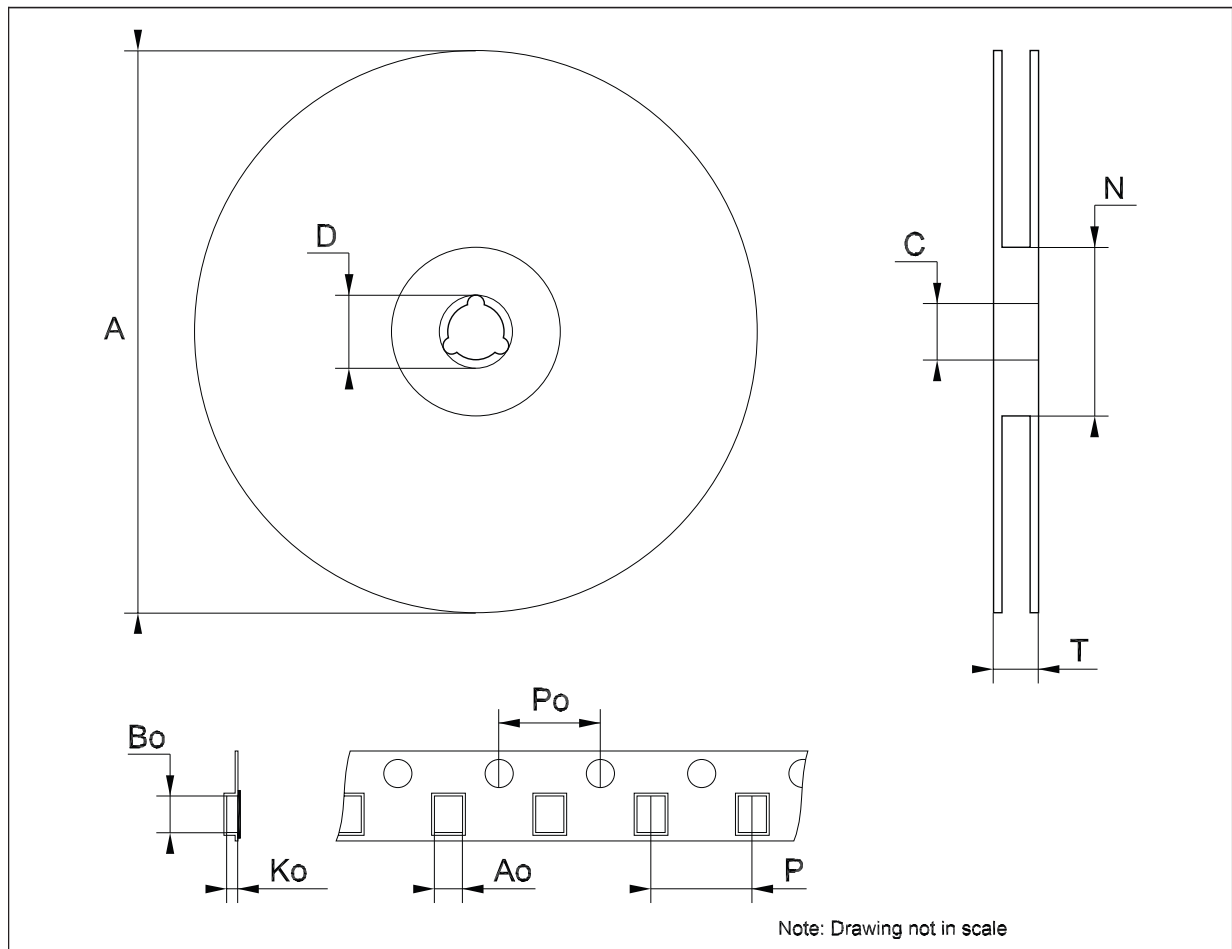
| Dim. | mm.  |      |      | inch. |       |       |
|------|------|------|------|-------|-------|-------|
|      | Min. | Typ. | Max. | Min.  | Typ.  | Max.  |
| A    |      |      | 1.70 |       |       | 0.067 |
| A1   | 0.00 |      | 0.15 | 0.00  |       | 0.006 |
| A2   | 1.25 |      |      | 0.049 |       | 0.142 |
| b    | 0.31 |      | 0.51 | 0.012 |       | 0.020 |
| c    | 0.17 |      | 0.25 | 0.007 |       | 0.010 |
| D    | 4.80 | 4.90 | 5.00 | 0.189 | 0.193 | 0.197 |
| D1   | 2.24 | 3.10 | 3.20 | 0.088 | 0.122 | 0.126 |
| E    | 5.80 | 6.00 | 6.20 | 0.228 | 0.236 | 0.244 |
| E1   | 3.80 | 3.90 | 4.00 | 0.150 | 0.154 | 0.157 |
| E2   | 1.55 | 2.41 | 2.51 | 0.061 | 0.095 | 0.099 |
| e    |      | 1.27 |      |       | 0.050 |       |
| h    | 0.25 |      | 0.50 | 0.010 |       | 0.020 |
| L    | 0.40 |      | 1.27 | 0.016 |       | 0.050 |
| k    | 0°   |      | 8°   | 0°    |       | 8°    |
| ccc  |      |      | 0.10 |       |       | 0.004 |



7195016C

**Tape & reel QFNxx/DFNxx (3x3) mechanical data**

| Dim. | mm.  |      |      | inch. |      |       |
|------|------|------|------|-------|------|-------|
|      | Min. | Typ. | Max. | Min.  | Typ. | Max.  |
| A    |      |      | 180  |       |      | 7.087 |
| C    | 12.8 |      | 13.2 | 0.504 |      | 0.519 |
| D    | 20.2 |      |      | 0.795 |      |       |
| N    | 60   |      |      | 2.362 |      |       |
| T    |      |      | 14.4 |       |      | 0.567 |
| Ao   |      | 3.3  |      | 0.130 |      |       |
| Bo   |      | 3.3  |      | 0.130 |      |       |
| Ko   |      | 1.1  |      | 0.043 |      |       |
| Po   |      | 4    |      | 0.157 |      |       |
| P    |      | 8    |      | 0.315 |      |       |



## 10 Revision history

**Table 6. Document revision history**

| Date        | Revision | Changes  |
|-------------|----------|--|
| 10-Apr-2007 | 1        | Initial release.   |
| 07-May-2007 | 2        | PowerSO-8 mechanical data has been updated and the $R_{thJC}$ for PowerSO-8 value on <a href="#">Table 4</a> . is changed. |
| 24-May-2007 | 3        | Change value $C_{BYP}$ 0.1 $\mu$ F ==> 1 $\mu$ F on <a href="#">Figure 1</a> . typical application.                        |
| 27-Sep-2007 | 4        | Add $R_{IN}$ on <a href="#">Figure 1</a> . application diagram.  |
| 02-Oct-2007 | 5        | <a href="#">Figure 1</a> . updated.  |



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