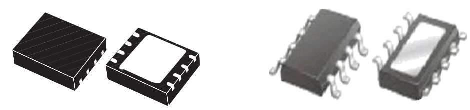
STCS1

1.5A Max constant current LED driver

Features

- Up to 40V input voltage
- Less than 0.5V voltage overhead
- Up to 1.5A output current
- PWM Dimming pin
- Shutdown pin
- Led disconnection diagnostic
- Slope control with external cap



DFN8 (3x3mm) **Power SO-8**

Applications

- Led constant current supplying for varying input voltages
- Low voltage lighting
- Small appliances 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 5V, 12V or 24V giving benefits in terms of precision, integration and reliability.

The current is set with external resistor up to 1.5A with a ±10% precision; a dedicated pin allows implementing PWM dimming. An external capacitor allows setting the slope for the current rise from tens of microseconds to tens of milliseconds allowing reduction of EMI.

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

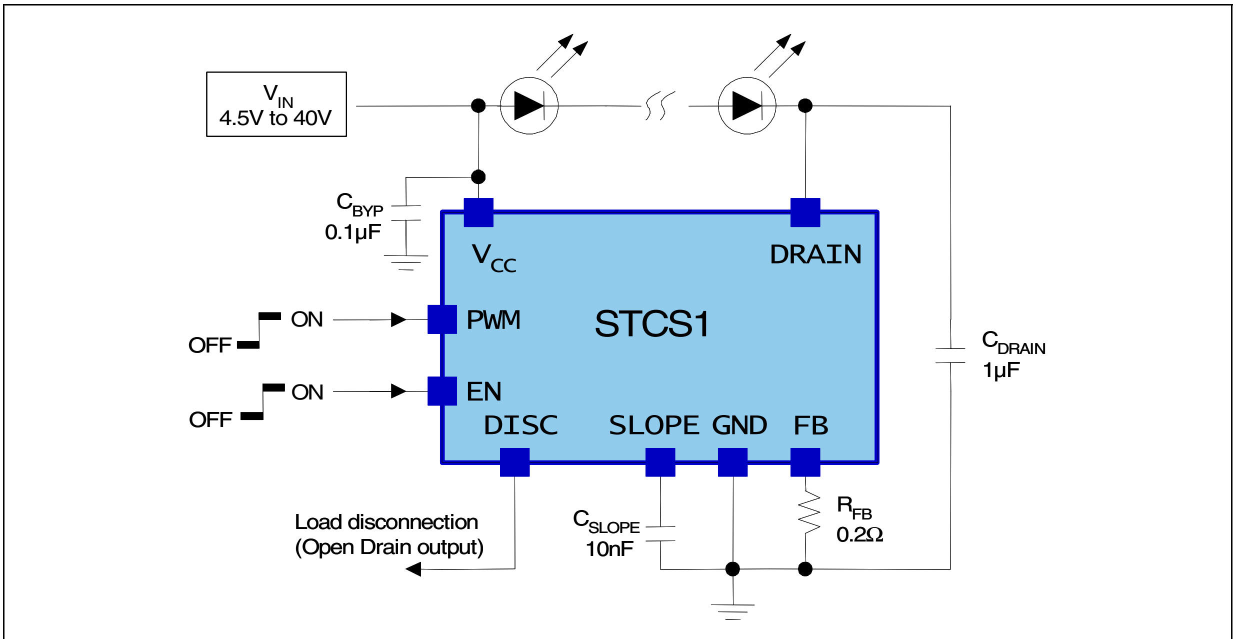
Order codes

Part number	Package	Packaging
STCS1PUR	DFN8 (3mm x 3mm)	3000 parts per reel
STCS1PHR	Power SO-8	2500 parts per reel

Contents

1 Application diagram

Figure 1. Typical application diagram for 0.5A LED current



2 Pin configuration

Figure 2. Pin connections (top view)

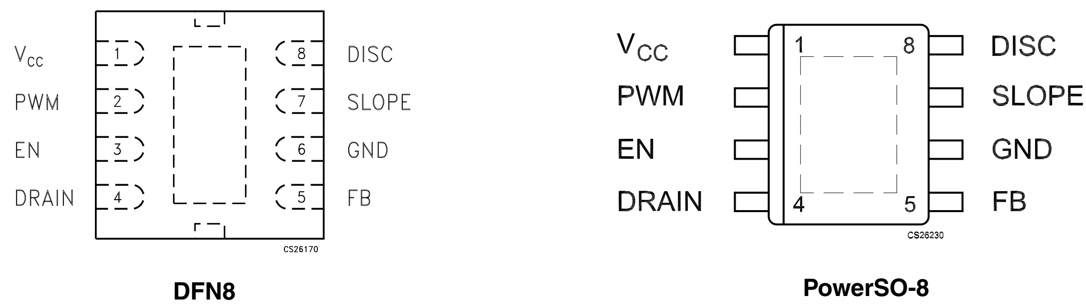


Table 1. Pin description

PIn N°	Symbol	Note
1	V_{CC}	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	SLOPE	Capacitor for slope control
8	DISC	Load disconnection flag (open drain)
	Exp-pad	Internally connected to ground.

3 Maximum ratings

Table 2. 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
SLOPE, FB	Configuration pins	-0.3 to + 3.3	V
ESD	Human body model (all pins)	±2	kV
Power Dissipation	DFN8 3x3mmT_A=25°C (1)	2.3	W
	PowerSO-8 T_A=25°C (2)	1.9	
T_J	Junction temperature	-40 to 150	°C
T_{STG}	Storage temperature range	-55 to 150	°C

1. See *Figure 16.* for details of max power dissipation for ambient temperaures higher than 25°C.
2. See *Figure 17.* for details of max power dissipation for ambient temperaures 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 3. Thermal data

Symbol	Parameter	DFN8	Power SO-8	Unit
R_{thJC}	Thermal Resistance Junction-Case	3	10	°C/W
R_{thJA}	Thermal Resistance Junction-Ambient	37.6 (1)	45 (2)	°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 4. Electrical characteristics
(V_{CC} = 12V; I_O = 100mA; T_A = -40°C to 85°C; V_{DRAIN} = 1V; C_{DRAIN} = 1µF; C_{BYP} = 100nF typical values are at T_A = 25 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} = 0.2Ω		500		mA
	Regulation (percentage with respect to V_{CC}=12V)	V_{CC} = 4.5 to 40V, I_O = 100mA; V_{DRAIN} = 1V	-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	µA
		Shutdown Mode; V_{CC} = 5 to 40V			1	
V_{DROP}	Dropout voltage (V_{DRAIN} to GND)	I_O = 100mA		0.12	0.16	V
		I_O = 1.5A		0.58	0.9	
$LEAK_{DRAIN}$	Drain leakage current	Shutdown; V_{DRAIN} = 40V			10	µA
T_R/T_F	Rise/Fall Time of the current on PWM transition	C_{SLOPE} = 10 nF		800		µs
T_D	Delay on PWM signal (see fig.1)	V_{PWM} rising, V_{CC} = 12V C_{SLOPE} = floating,		3		µs
		V_{PWM} falling, V_{CC} = 12V C_{SLOPE} = floating		1.2		
DISC	Low level voltage	I_{SINK} = 5mA		0.2	0.5	V
	Leakage current	V_{DISC} = 5V			1	µA
	Load disconnection threshold (V_{DRAIN}-GND)	DISC Turn-ON		75		mV
		DISC Turn-OFF		110		
Thermal Protection	Shutdown Temperature			155		°C
	Hysteresis			25		
Logic Inputs (PWM and EN)						
V_L	Input Low Level				0.4	V
V_H	Input High Level		1.2			V
	EN, PWM Leakage Current	V_{EN} = 5V; V_{PWM} = 5V			2	µA
	EN Input Leakage Current	V_{EN} = 40V			50	
	PWM Input Leakage Current	V_{PWM} = 40V			100	

Note: All devices 100% production tested at T_A = 25°C. Limits over the operating temperature range are guaranteed by design.

5 Timing

Figure 3. PWM and output current timing

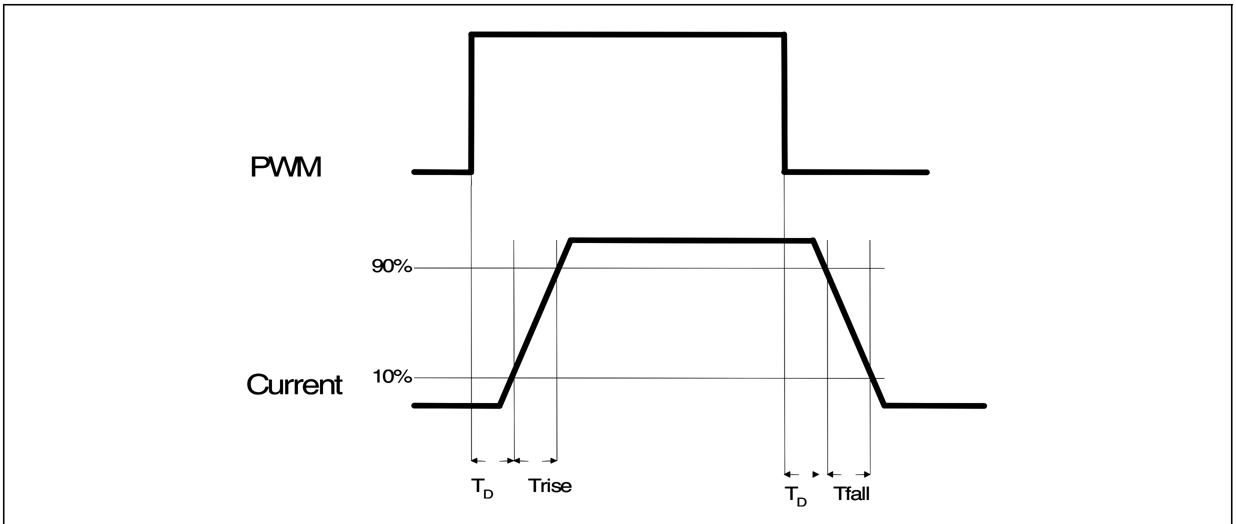
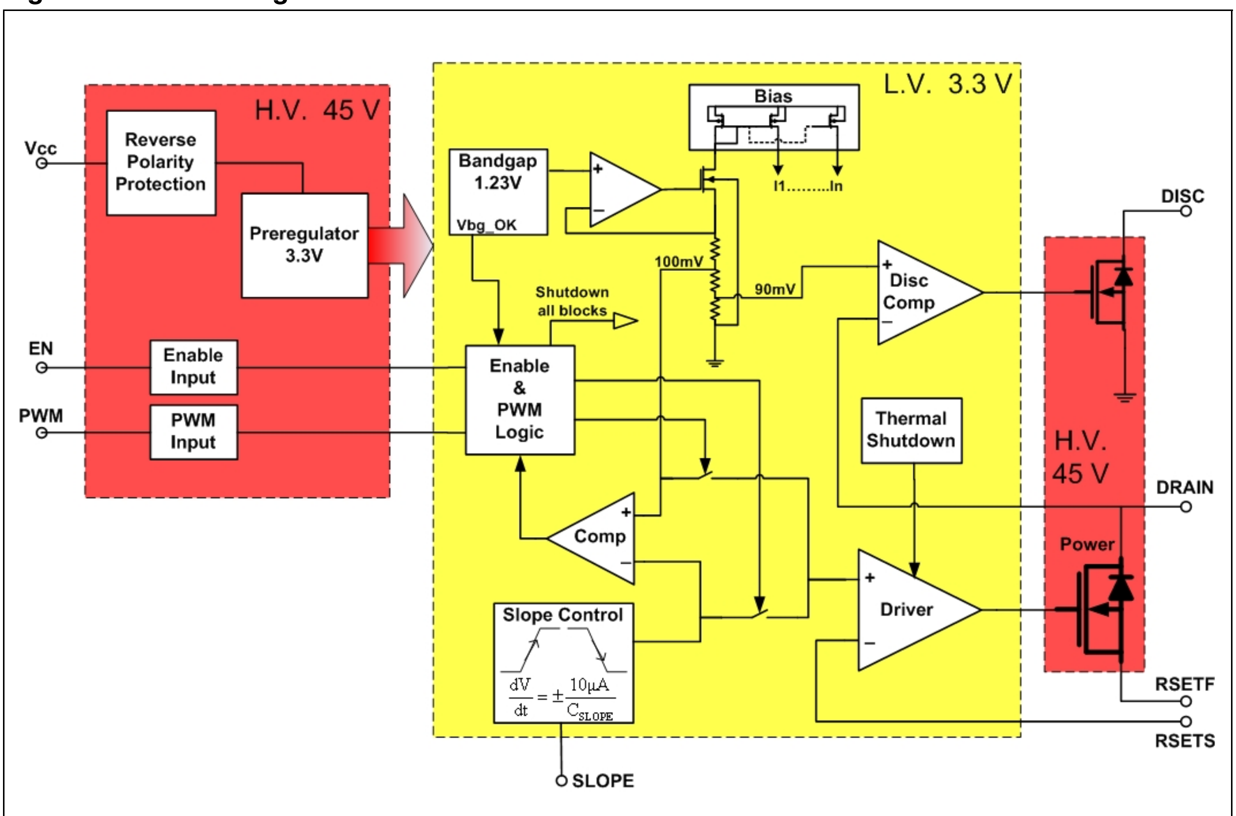


Figure 4. Block diagram



6 Typical performance characteristics

Figure 5. I_{DRAIN} vs V_{CC}, T_A = 25°C

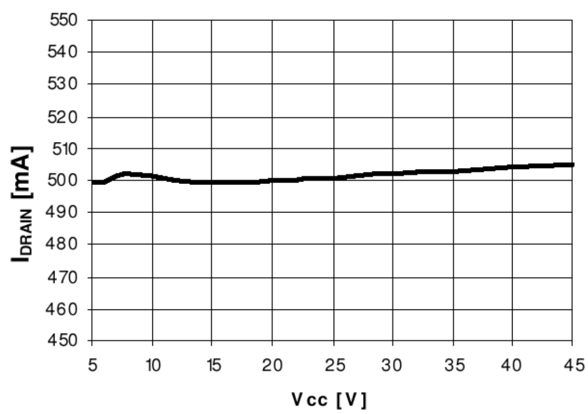


Figure 6. I_{DRAIN} vs R_{SET}

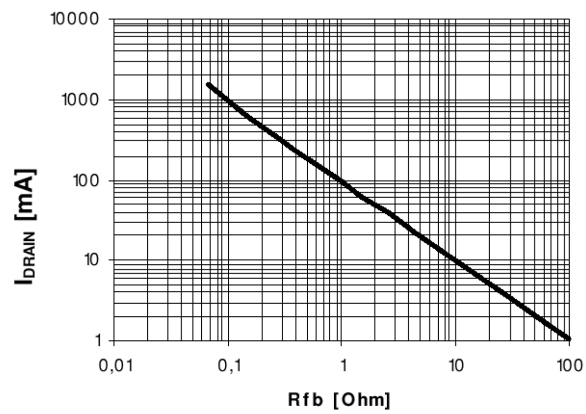


Figure 7. I_{DRAIN} vs Temperature

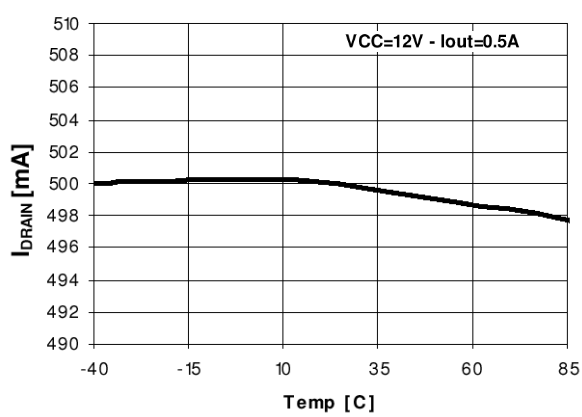


Figure 8. V_{DROP} (including V_{FB}) vs temperature

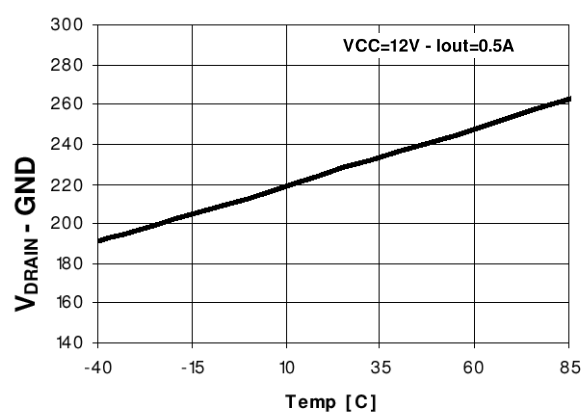


Figure 9. I_{CC} vs Temperature

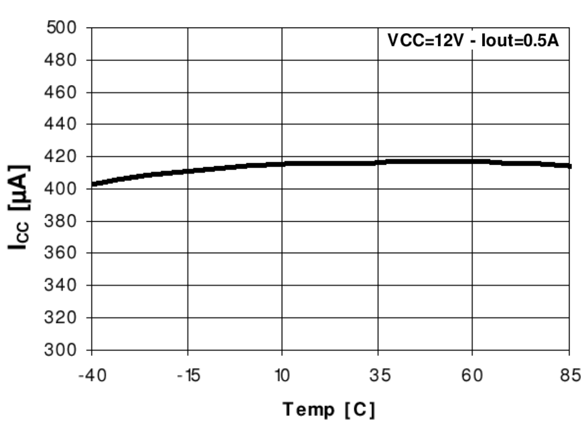


Figure 10. I_{CC} vs V_{CC}

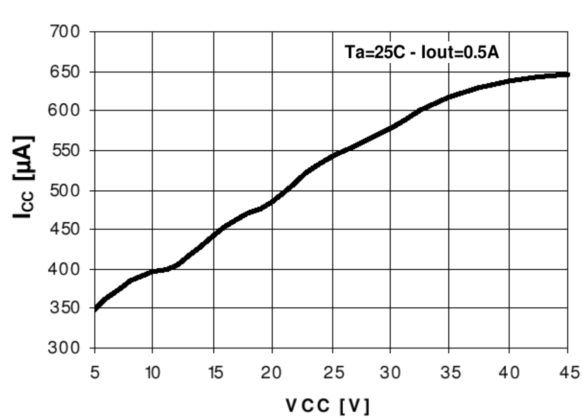


Figure 11. T_{rise}/T_{fall} vs C_{SLOPE}

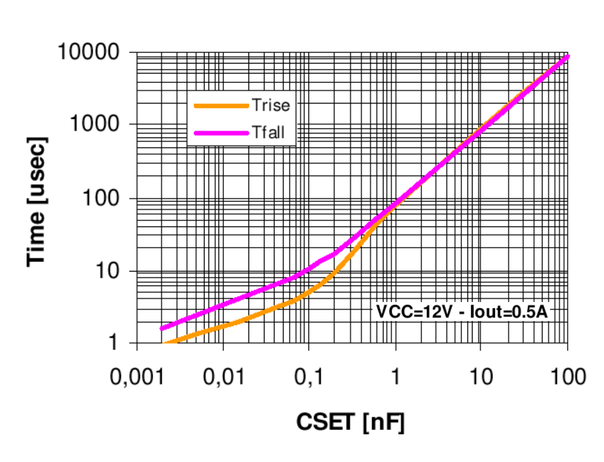


Figure 12. Turn-on time

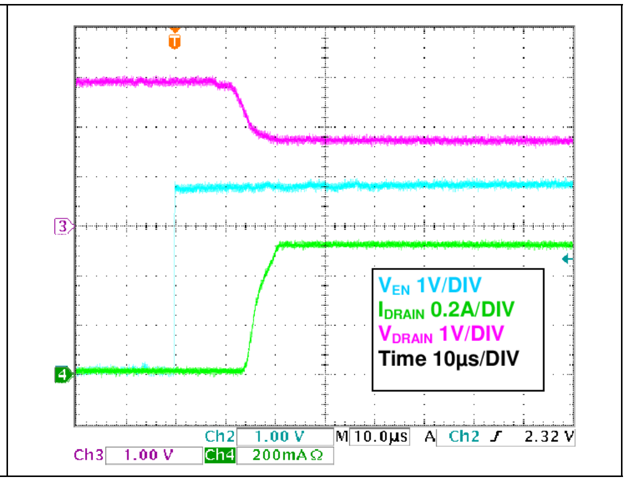


Figure 13. Dimming operation: Rise

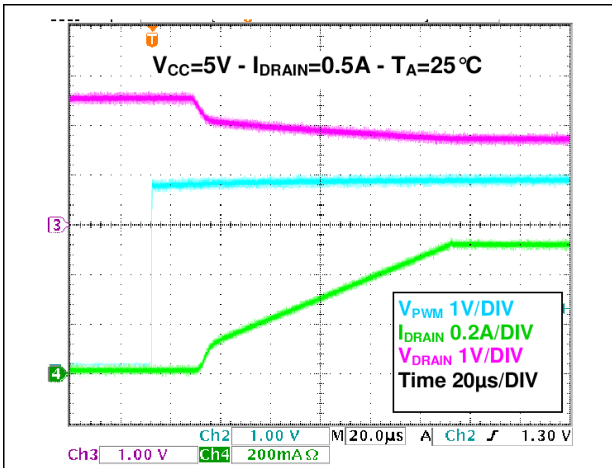
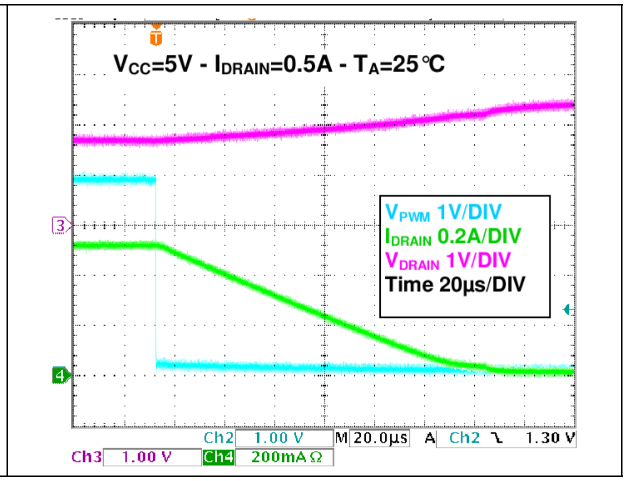


Figure 14. Dimming operation: Fall



7 Detalid 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 5V, 12V or 24V 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 100mV, then a low resistor value can be chosen reducing power dissipation. A value between 1mA and 1.5A can be set according to the resistor value, the resulting output current has a tolerance of ±10%.

7.2 Enable

When the enable pin is low the device completely off thus reducing current consumption to less than 1µA. 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 50kHz. The maximum dimming frequency is limited by the minimum rise/fall time of the current (obtained with $C_{SLOPE} = 0$) which is around 4µs each. Above 50kHz 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 two important features: short delay time and controlled slope for the current.

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 µs, this is important to implement synchronization among several light LED sources.

The rise and fall slope of the current is controlled by the C_{SLOPE} capacitor. The rise and fall time are linear dependent from the C_{SLOPE} capacitor value (see graph in typical characteristics). A controlled rise time has two main benefits: reducing EMI noise and avoid current spike at turn on.

When C_{SLOPE} is left floating, the internal switch is turned on at maximum speed, in this condition an overshoot can be present on the LED current before the system goes into regulation.

Diagnostic

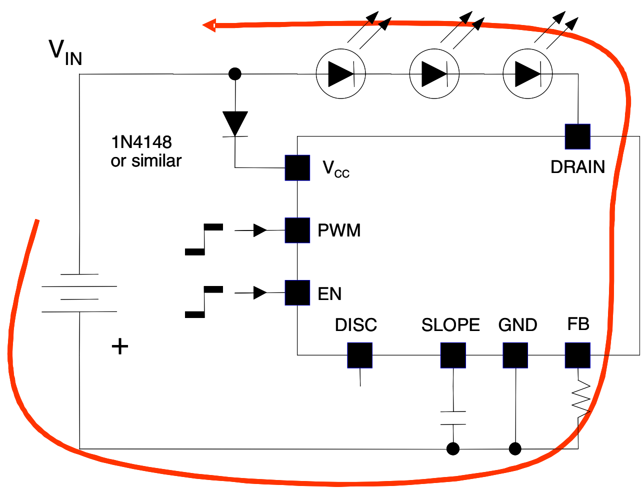
When STCS1 is in on mode (EN is high), the device is able to detect disconnection or fail of the LED string monitoring V_{DRAIN} pin. If V_{DRAIN} is lower than 75mV the DISC pin is pulled low regardless the PWM pin status. This information can be used by the system to inform that some problem happens 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 450μA 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 15. Reverse polarity condition



8.2 Thermal considerations

The STCS1 is able to control a LED current up to 1.5A and able to sustain a voltage on the drain pin up to 40V. 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: 12V;
- 3 white LEDs with an typical VF=3.6V;
- LEDs current: 500mA;

– Package: DFN8 3x3;
– $T_A = 50°C$;

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

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

The junction temperature will be:

$T_J = 37.6 \times 0.556 + 50 = 70.9°C$

For a correct operation of the chip, the junction temperature must not exceed 110°C.

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

Figure 16. Maximum power dissipation vs T_A for DFN8 3x3mm

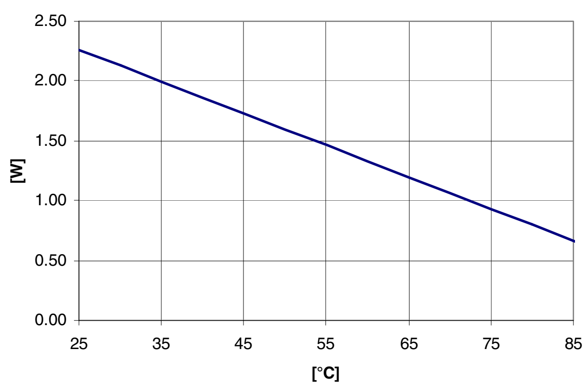
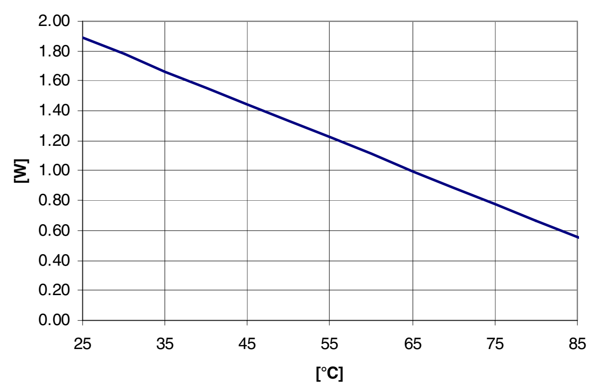


Figure 17. Maximum power dissipation vs T_A for PowerSO-8

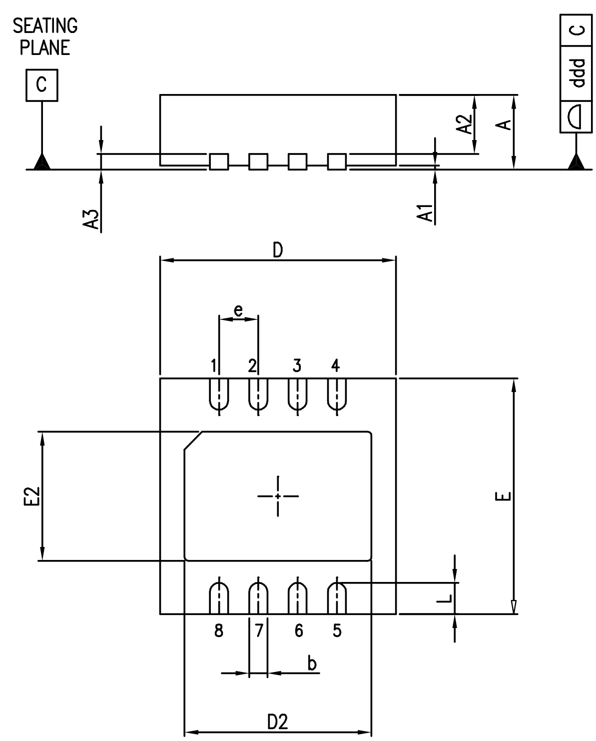


9 Package mechanical data

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.

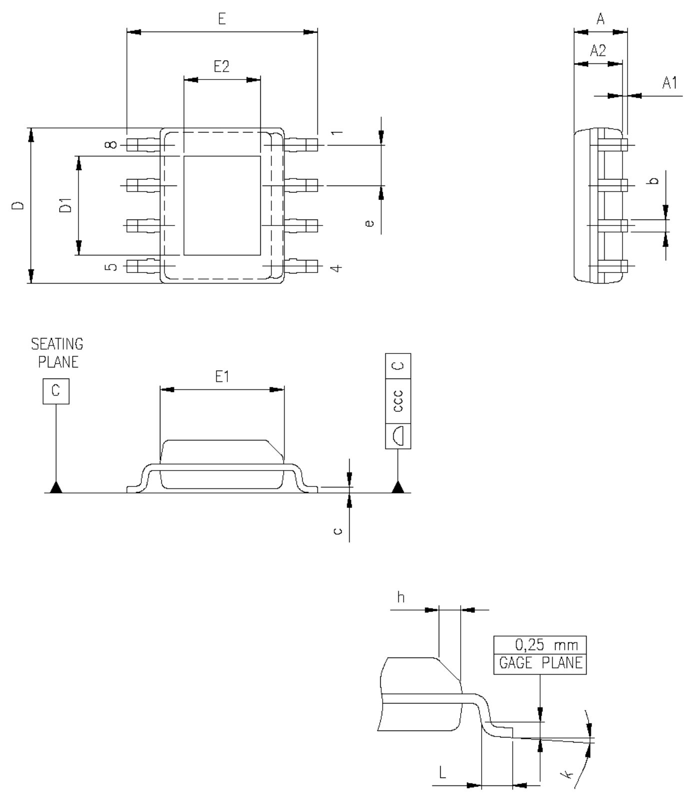
DFN8 (3x3) MECHANICAL DATA

DIM.	mm.			inch		
	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

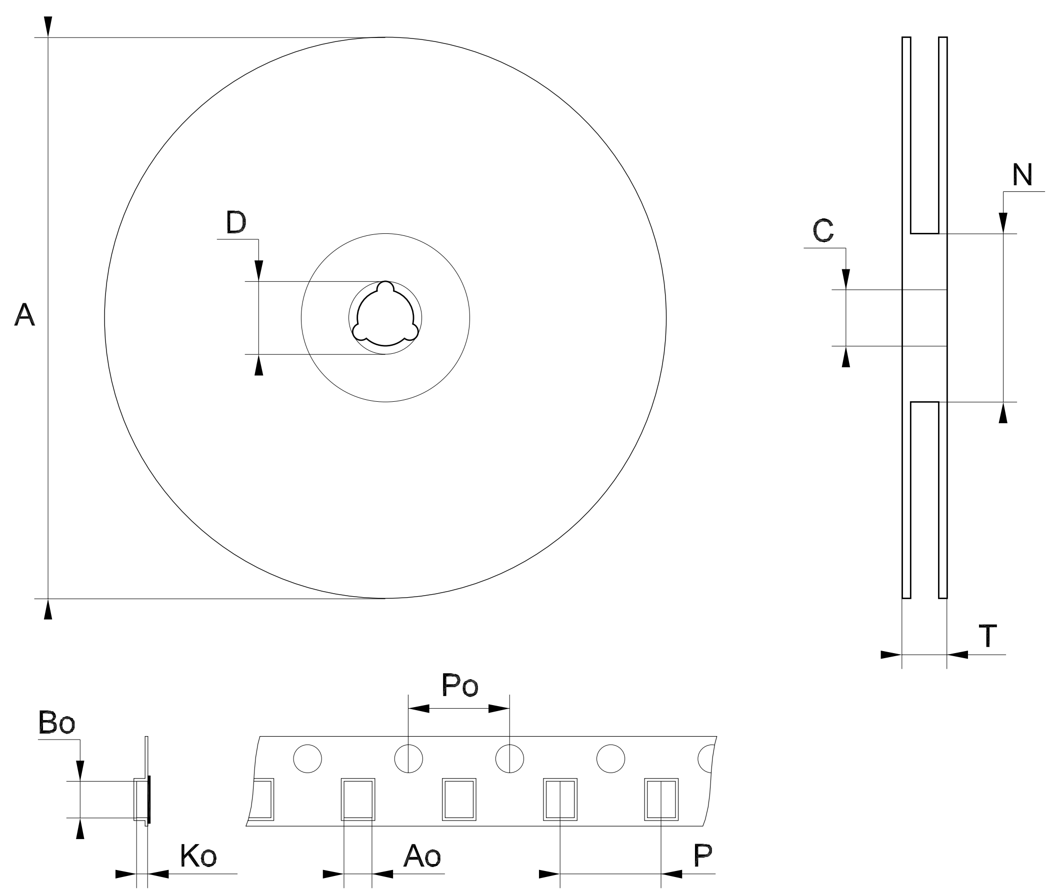
DIM.	mm.			inch.		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A			1.70			0.067
A1	0.00		0.15	0.00		0.006
A2	1.25			0.049		0.142
b	0.31		0.51	0.012		0.020
c	0.17		0.25	0.007		0.010
D	4.80	4.90	5.00	0.189	0193	0.197
D1	ACCORDING TO PAD SIZE			ACCORDING TO PAD SIZE		
E	5.80	6.00	6.20	0.228	0.236	0.244
E1	3.80	3.90	4.00	0.150	0.154	0.157
E2	ACCORDING TO PAD SIZE			ACCORDING TO PAD SIZE		
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			330			12.992
C	12.8		13.2	0.504		0.519
D	20.2			0.795		
N	60			2.362		
T			18.4			0.724
Ao		3.3			0.130	
Bo		3.3			0.130	
Ko		1.1			0.043	
Po		4			0.157	
P		8			0.315	



Note: Drawing not in scale

10 Revision history

Table 5. Revision history

Date	Revision	Changes
10-Apr-2007	1	Initial release.

Please Read Carefully: