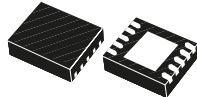


## Electronic fuse for 12 V line



TSOT23-8L



DFN10 (3x3 mm)

Maturity status link

[STEF12S](#)

### Features

- 15 V typical output overvoltage clamp
- Absolute maximum voltage of 25 V
- Adjustable current limit
- Thermal protection
- Input undervoltage lockout
- Low inrush current during startup
- Integrated 40 mΩ Power FET
- En/fault pin
- Adjustable slew rate for output voltage
- Gate control pin for reverse current blocking FET (DFN10 package)
- TSOT23-8L and DFN10 (3x3 mm) packages
- Latch (STEF12S) or autoretry (STEF12SA) versions
- UL2367 Recognized - File N. E468771
- IEC 62368-1 CB certified

### Applications

- Hard Disk and SSD drives
- Hard disk array
- Hot-swap board
- Hot-plug protection

### Description

The **STEF12S** is an integrated electronic fuse optimized to monitor the 12 V DC power lines.

When connected in series to the main power rail, it is able to precisely detect and react to overcurrent and overvoltage conditions.

When an overload condition occurs, the device limits the output current to a safe value defined by the user. If the anomalous overload condition persists, the device goes into an open state, disconnecting the load from the power supply.

In case of overvoltage on the input, the device regulates the output to a preset safe value.

Undervoltage lockout prevents the load from malfunction, keeping the device off if the rail voltage is too low.

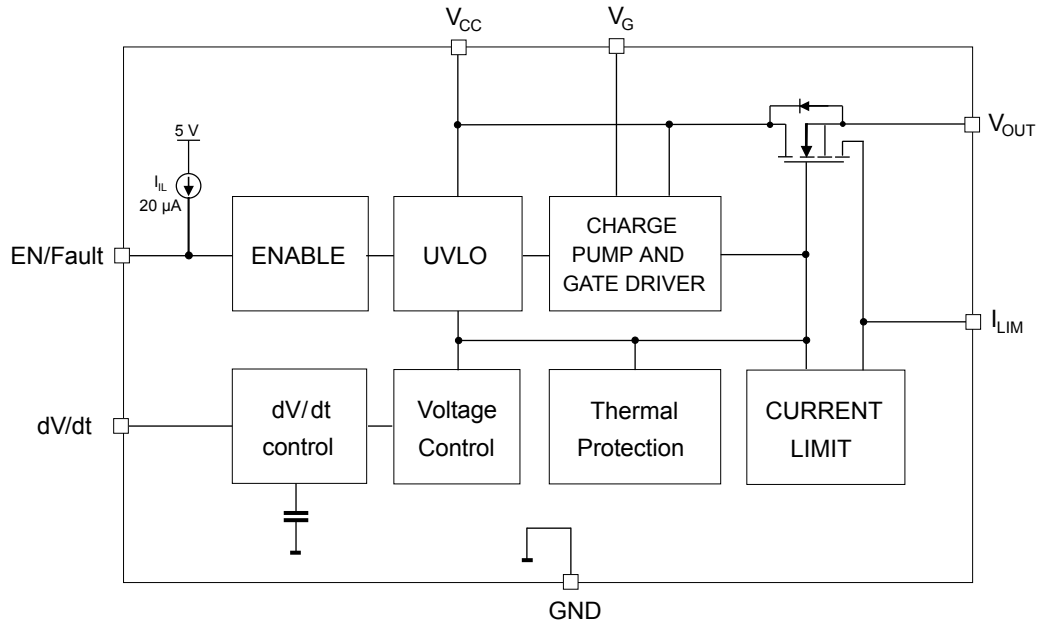
The **STEF12S** features the adjustable turn-on slew-rate, which is useful to keep the in-rush current under control during startup and hot-swap operations.

On the DFN10 package a dedicated pin provides a gate control for an external optional N-channel Power FET, used to implement the reverse current blocking in case of input voltage loss.

The **STEF05S** is a companion chip for the 5 V rails, useful to implement a complete power rail control in data-storage applications.

# 1 Diagram

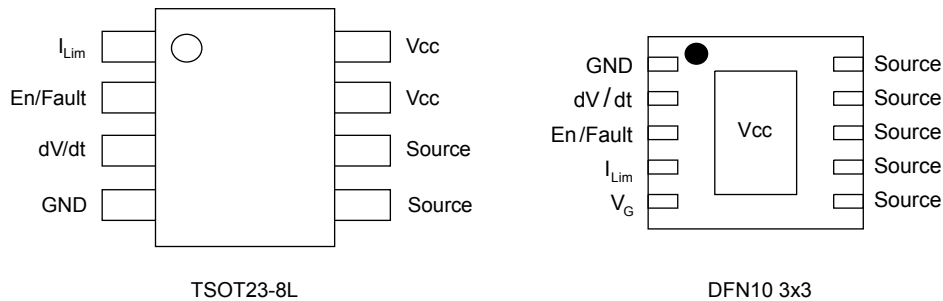
Figure 1. Block diagram



Note: Gate driver pin V<sub>G</sub> is available on DFN10 version only.

## 2 Pin configuration

**Figure 2. Pin connection (top view)**



**Table 1. Pin description**

Pin #		Symbol	Function
TSOT23-8L	DFN10		
1	4	I <sub>Lim</sub> <sup>(1)</sup>	An R <sub>Lim</sub> resistor between this pin and the Source pin sets the overload and short-circuit current limit levels.
2	3	En/Fault	The En/Fault pin is a tri-state, bi-directional interface. During the normal operation, the pin must be left floating, or it can be used to disable the output of the device by pulling it to ground using an open drain or open collector device. If a thermal fault occurs, the voltage on this pin goes into an intermediate state to signal a monitor circuit that the device is in thermal shutdown. It can be connected to another device of this family to cause a simultaneous shutdown during thermal events.
3	2	dV/dt	The internal dV/dt circuit controls the slew rate of the output voltage at turn-on. The internal capacitor allows a ramp-up time of around 0.85 ms. An external capacitor can be added to this pin to increase the ramp time. If an additional capacitor is not required, this pin should be left open.
4	1	GND	Ground connection.
5-6	6-10	Source/V <sub>OUT</sub>	Connected to the source of the internal power MOSFET and to the output terminal of the fuse.
-	5	V <sub>G</sub>	Gate driver output for the optional external reverse-blocking power MOS. Leave floating if not used.
7-8	Exposed pad	V <sub>CC</sub>	Positive input voltage of the eFuse.

1. Important: missing or shorted R<sub>Lim</sub> causes current limit circuit malfunction and may lead to device damage.

### 3 Typical application

Figure 3. Typical application circuit

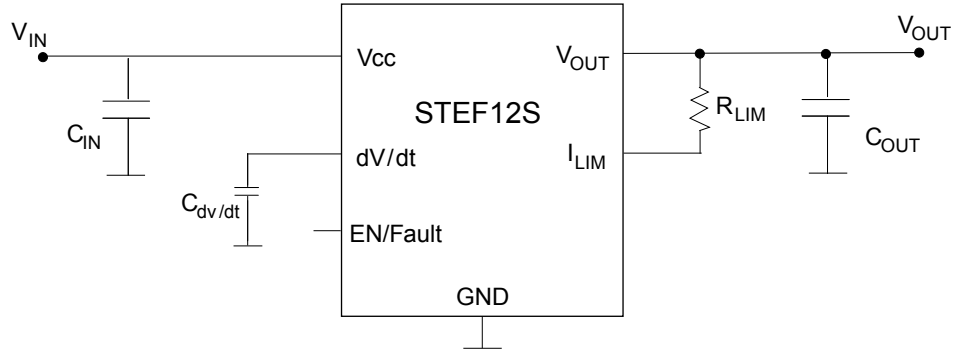
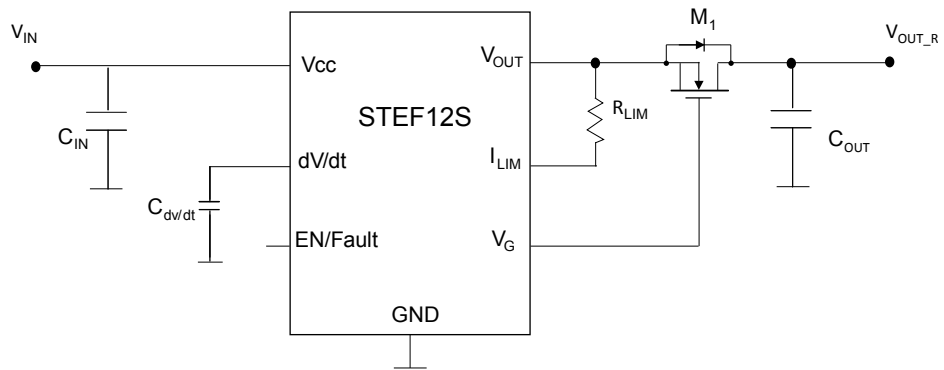


Figure 4. Application with external reverse current blocking MOSFET



## 4 Maximum ratings

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value	Unit
$V_{CC}$	Positive power supply voltage	-0.3 to 25	V
$V_{OUT/source}^{(1)}$	Output voltage	-0.3 to $V_{CC} + 0.3$	V
$V_G$	Gate driver pin voltage	-0.3 to $V_{OUT} + 5$	V
$I_{Lim}$	Current limit resistor pin voltage	-0.3 to 25	V
En/Fault	En/Fault pin voltage	-0.3 to 7	V
dV/dt	dV/dt pin voltage	-0.3 to 7	V
$T_{J-OP}$	Operating junction temperature range <sup>(2)</sup>	-40 to 125	°C
$T_{STG}$	Storage temperature range	-65 to 150	°C
$T_{LEAD}$	Lead temperature (soldering) 10 s	260	°C
HBM	ESD protection - human body model	2	kV
CDM	ESD protection - charged device model (TSOT23-8L package)	500	V
	ESD protection - charged device model (DFN10-3x3 package)	500	V

1. Fast  $V_{in}$  voltage dip due to input power removal may cause high reverse current flow through the internal body diode, that may damage the device. To avoid this, it is recommended to use the external reverse current blocking Mosfet.
2. The thermal limit is set above the maximum thermal ratings. It is not recommended to operate the device at temperatures greater than the maximum ratings for extended periods of time.

**Note:** Absolute maximum ratings are those values beyond which damage to the device may occur. Functional operation under these conditions is not implied. All values are referred to GND.

**Table 3. Thermal data**

Symbol	Parameter	DFN10-3x3	TSOT23-8L	Unit
$R_{thJA}$	Thermal resistance junction-ambient <sup>(1)</sup>	53	140	°C/W
$R_{thJC}$	Thermal resistance junction-case	21	35	°C/W

1. Based on JESD51-7, 4-layer PCB.

**Table 4. Recommended operating condition**

Symbol	Parameter	Value	Unit
$V_{CC}$	Operating power supply voltage	10 to 13.8	V
$I_D$	Maximum continuous current $T_A = 25^\circ\text{C}$ <sup>(1)</sup>	3.5	A
$C_{IN}$	Suggested input capacitor	1	μF
$C_{OUT}$	Minimum output capacitor	1	μF
$R_{Lim}$	Current limit resistor range	15.4 to 300	Ω

1. The maximum allowable power dissipation is a function of the maximum junction temperature  $T_{J-OP}=125^\circ\text{C}$ , the junction-to-ambient thermal resistance  $R_{thJA}$ , and the ambient temperature  $T_A$  and can be estimated by:  $P_{D(MAX)} = (125^\circ\text{C} - T_A) / R_{thJA}$ . Exceeding the maximum allowable power dissipation produces overheating that may cause thermal shutdown.

## 5 Electrical characteristics

$V_{CC} = 12\text{ V}$ ,  $V_{En/Fault} = 5\text{ V}$ ,  $C_I = 10\text{ }\mu\text{F}$ ,  $C_O = 10\text{ }\mu\text{F}$ ,  $T_J = 25\text{ }^\circ\text{C}$  (unless otherwise specified).

**Table 5. Electrical characteristics**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
<b>Under/Oversvoltage protection</b>						
$V_{Clamp}$	Average output clamping voltage	$V_{CC} = 17\text{ V}$	13.8	15	16.2	V
$V_{UVLO}$	Undervoltage lockout	Turn-on, voltage rising	7.7	8.5	9.3	V
$V_{Hyst}$	UVLO hysteresis			0.8		V
<b>Power MOSFET</b>						
$t_{dly}$	Delay time	Enabling of chip to soft start beginning (10 % of $V_{OUT}$ ), No $C_{dv/dt}$		250		$\mu\text{s}$
$R_{DSon}$	On-resistance <sup>(1)</sup>	$T_J = 25\text{ }^\circ\text{C}$		40	50	m $\Omega$
		$T_J = 85\text{ }^\circ\text{C}$ <sup>(2)</sup>		48		
$V_{OFF}$	Off-state output voltage	$V_{CC} = 18\text{ V}$ , $V_{GS} = 0$ , $R_L = \text{infinite}$		1	10	mV
<b>Current Limit</b>						
$I_{Short}$	Short-circuit current limit	$R_{Lim} = 22\text{ }\Omega$ , STEF12SGR		2.8		A
$I_{Lim}$	Overload current limit	$R_{Lim} = 22\text{ }\Omega$ , STEF12SGR		5.5		A
$I_{Short}$	Short-circuit current limit	$R_{Lim} = 22\text{ }\Omega$ , STEF12SPUR		2.4		A
$I_{Lim}$	Overload current limit	$R_{Lim} = 22\text{ }\Omega$ , STEF12SPUR		4.6		A
$I_{Short}$	Short-circuit current limit	$R_{Lim} = 39\text{ }\Omega$ , STEF12SGR		1.9		A
$I_{Lim}$	Overload current limit	$R_{Lim} = 39\text{ }\Omega$ , STEF12SGR		3.8		A
<b>dv/dt circuit</b>						
dv/dt	Output voltage ramp time	From 10% to 90% of $V_{OUT}$ , no $C_{dv/dt}$		0.85		ms
<b>En/Fault</b>						
$V_{IL}$	Low level input voltage	Output disabled			1.8	V
$V_{I(INT)}$	Intermediate level input voltage	Thermal fault, output disabled	1.2	1.3	1.45	V
$V_{IH}$	High level input voltage	Output enabled	2.5			V
$V_{I(MAX)}$	High state maximum voltage			4.9		V
$I_{IL}$	Low level input current (sink)	$V_{En/Fault} = 0\text{ V}$		-20	-50	$\mu\text{A}$
$I_I$	High level leakage current for external switch	$V_{En/Fault} = 5\text{ V}$			1	$\mu\text{A}$
	Maximum fan-out for fault signal	Total numbers of chips that can be connected to this pin for simultaneous shutdown			3	Units
<b>Current consumption</b>						
$I_{Bias}$	Bias current	Device operational		0.37		mA
		Thermal shutdown <sup>(2)</sup>		0.16		
		Off mode, $V_{En/Fault} = 0\text{ V}$		0.12		
<b>External MOSFET gate driver (DFN10 package only)</b>						
$I_G$	Sourcing current	Device On		30		$\mu\text{A}$

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_P$	Pull-down current	$V_{En/fault} = 0\text{ V}$		8		mA
$V_G$	Gate driver voltage	$V_G - V_{OUT}$		5		V
<b>Thermal protection</b>						
$T_{SHDN}$	Thermal shutdown			165		°C
	Hysteresis			20		

1. Pulsed test.
2. Guaranteed by design and correlation but not tested in production.

## 6 Application information

### 6.1 Turn-on and soft startup feature

When the input voltage is applied, the En/Fault pin goes up to the high state and the internal control circuitry is enabled.

After an initial delay time of typically 250  $\mu$ s, the output voltage is ramped up with a slope defined by the internal dv/dt circuitry. If no additional capacitor is connected to dV/dt pin, the ramp-up time ( $V_{OUT}$  from 10% to 90%) is around 0.85 ms.

Connecting a capacitor between the  $C_{dv/dt}$  pin and GND allows the modification of the output voltage ramp-up time. Given the desired time interval  $\Delta t$  during which the output voltage goes from zero to its maximum value, the capacitance to be added on the  $C_{dv/dt}$  pin can be calculated using the following theoretical formula.

$$\Delta t [ms] = 0.85 + C_{dv/dt} [pF] \times 0.021$$

Figure 5. Delay time and  $V_{OUT}$  ramp-up time

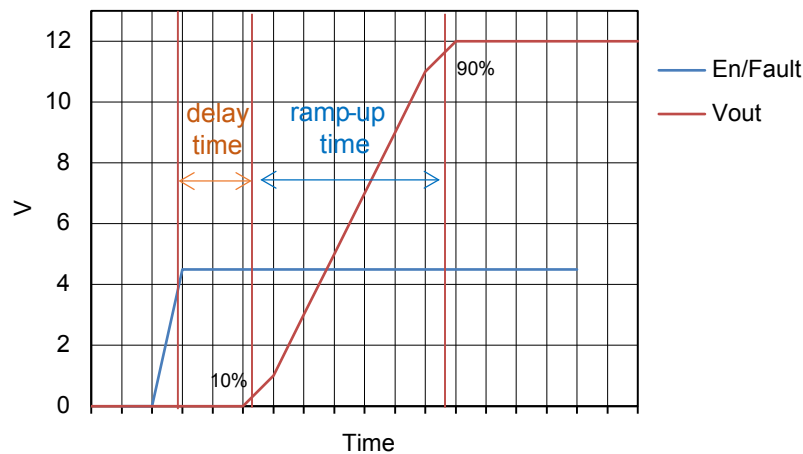


Table 6. Rise time vs.  $C_{dv/dt}$

$C_{dv/dt}$ (pF)	0	22	33	47	100	180	270	470	1000
Rise time (ms)	0.85	1.3	1.56	1.9	3	4.7	6.6	11	22

### 6.2 Maximum load at startup

Depending on supply voltage and load, it is possible that during startup the power dissipation is such that the maximum power protection is triggered and the output is shut down before the startup is complete. The EN/Fault signal is set according to Section 6.7. En/Fault pin behavior during thermal protection events.

In case of strong capacitive loads, the total start-up time may be longer than the programmed start-up time, since it is dependent also on the limitation current, the output load and the output capacitance value. In such a situation, the foldback current limit could activate, so that the startup is longer or interrupted by the intervention of thermal protection. To avoid this occurrence, a longer start-up time should be set by the appropriate selection of the  $C_{dv/dt}$  capacitor.

### 6.3 Normal operating conditions

The STEF12S eFuse behaves like a mechanical fuse, supplying the circuitry on its output with the same voltage shown on its input, with a small voltage fall due to the internal N-channel MOSFET  $R_{DS(on)}$ .



## 6.4 Output voltage clamp

This internal protection circuit clamps the output voltage to a maximum safe value, typically 15 V, if the input voltage exceeds the  $V_{CLAMP}$  threshold. In this condition, the device regulates the output voltage, therefore the power dissipation increases. Thermal shutdown can occur if the overvoltage persists.

## 6.5 Current limiting

During the operation, if the load current reaches the  $I_{LIM}$  threshold, an overload is detected. The current limiting circuit reduces the conductivity of the power MOSFET, in order to clamp the output current at the  $I_{SHORT}$  value. The overload threshold and current limit can be customized by the limiting resistor  $R_{Lim}$  [Figure 3](#).

As shown in [Section 1 Diagram](#), the device uses an internal N-channel sense FET with a fixed ratio, to monitor the output current and limit it at the level set by the user.

To achieve the requested current limitation, the  $R_{Lim}$  value can be selected by using the following table, together with the graph in [Figure 12](#) and [Figure 13](#). Higher resistor values can be used, but due to the current limit trend shown in the before mentioned graphs, the minimum values of  $I_{LIM}$  and  $I_{SHORT}$  are asymptotically limited.

**Table 7.  $I_{LIM} / I_{SHORT}$  vs.  $R_{Lim}$  STEF12SGR**

$R_{Lim}$ ( $\Omega$ )	15.4	22	24.9	30	39	49.9	100	200	300
$I_{LIM}$ (A)	8	5.5	5.1	4.4	3.8	3.2	2.4	1.7	1.5
$I_{SHORT}$ (A)	5.1	2.8	2.6	2.3	1.9	1.5	0.8	0.4	0.3

**Table 8.  $I_{LIM} / I_{SHORT}$  vs.  $R_{Lim}$  STEF12SPUR**

$R_{Lim}$ ( $\Omega$ )	15.4	22	24.9	30	39	49.9	100	200	300
$I_{LIM}$ (A)	5.9	4.6	4.4	3.8	3.2	2.8	2	1.5	1.3
$I_{SHORT}$ (A)	3.2	2.4	2.2	1.9	1.7	1.5	0.8	0.4	0.3

*Note:* Missing or shorted  $R_{Lim}$  causes current limit circuit malfunction and may lead to the device damage.

## 6.6 Thermal shutdown

If the device temperature exceeds the thermal shutdown threshold ( $T_{SHDN}$ ), typically 165 °C, the power MOSFET is turned off and the load disconnected.

On the STEF12S latch version, the EN/Fault pin of the device is automatically set to an intermediate voltage (typically 1.3 V), in order to signal the overtemperature event to the system controller.

The device can be reset from this condition either by cycling the supply voltage or by pulling down the EN pin below the  $V_{ij}$  threshold and then releasing it.

On the autoretry version (STEF12SA), the EN/Fault pin is set to a low logic level and the autoretry circuit attempts to restart the device with soft-start once the die temperature is reduced to 145 °C typ. (165 °C minus the hysteresis value, 20 °C typ.).

## 6.7 En/Fault pin

The EN/Fault pin has the dual function of controlling the output of the device and providing information about the device status to the application.

A simplified diagram of this circuit is depicted in Figure 6

When it is used as a standard Enable pin, it can be connected to an external open drain or open-collector device. In this case, when it is pulled to a low logic level, it turns the output of the eFuse off.

High and low logic levels are defined as  $V_{IH}$  and  $V_{IL}$  in Table 5.

If this pin is left floating, since it has an internal pull-up circuitry, the eFuse is turned on.

Pull-up current is  $20\ \mu\text{A}$  clamped to  $5\ \text{V}$  ( $V_{I(MAX)}$ ).

On the STEF12S (latch version), in case of thermal fault, the pin is pulled to an intermediate state ( $V_{I(INT)}$ ) as shown in Figure 7. This signal can be provided to a monitor circuit, informing it that a thermal shutdown has occurred, or it can be directly connected to the EN/Fault pins of other eFuse devices on the same application in order to achieve a simultaneous enable/disable feature.

When a thermal fault occurs, the device can be reset either by cycling the supply voltage or by pulling down the Enable pin below the  $V_{il}$  threshold and then releasing it.

On the STEF12SA autoretry version, once the thermal shutdown is triggered, the EN/Fault pin of the device is set to low state. It goes back to high level once the autoretry occurs.

Figure 6. En/Fault driver circuit

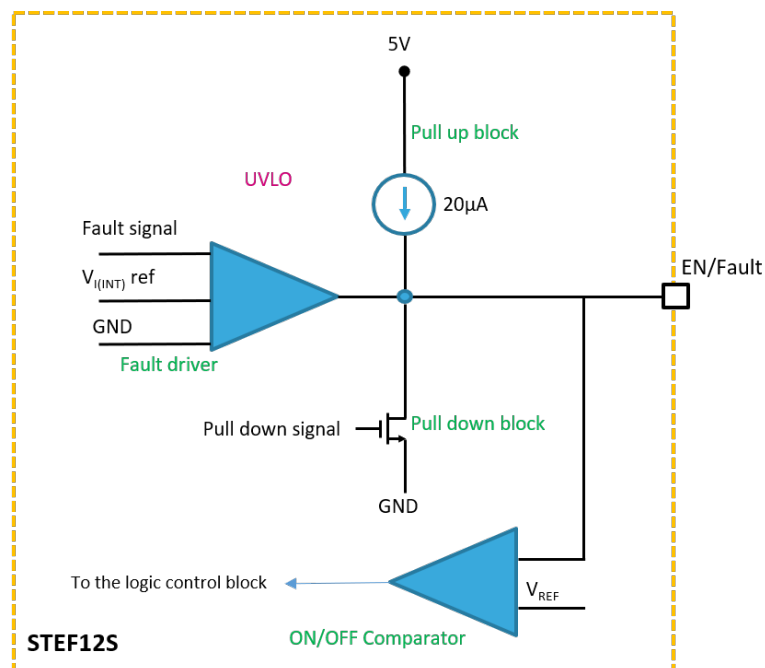
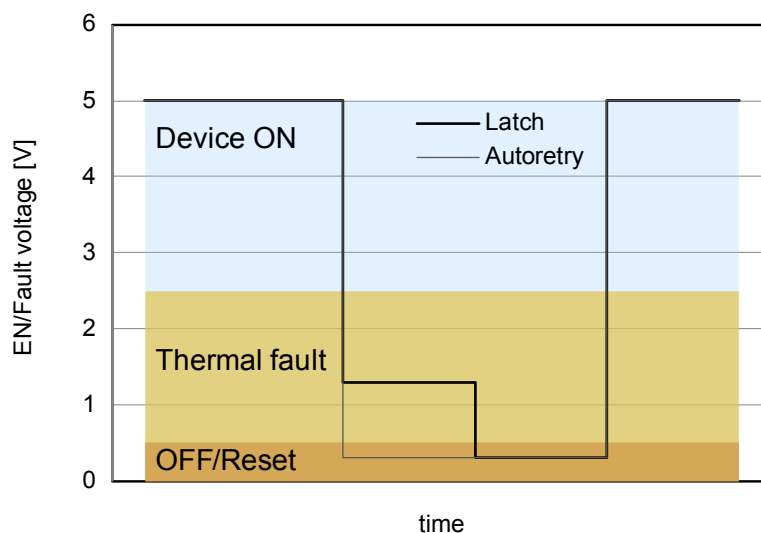


Figure 7. En/Fault pin status



## 6.8 Reverse blocking function

Many applications require reverse current blocking, to allow the completion of pending system activities (such as writing the data on SSD or parking the head in HDD) in case of power loss or during brownout.

The STEF12SPUR provides a dedicated gate drive signal on the  $V_G$  pin which can be used to control an external blocking MOSFET for reverse-current protection (RCP). See Figure 4.

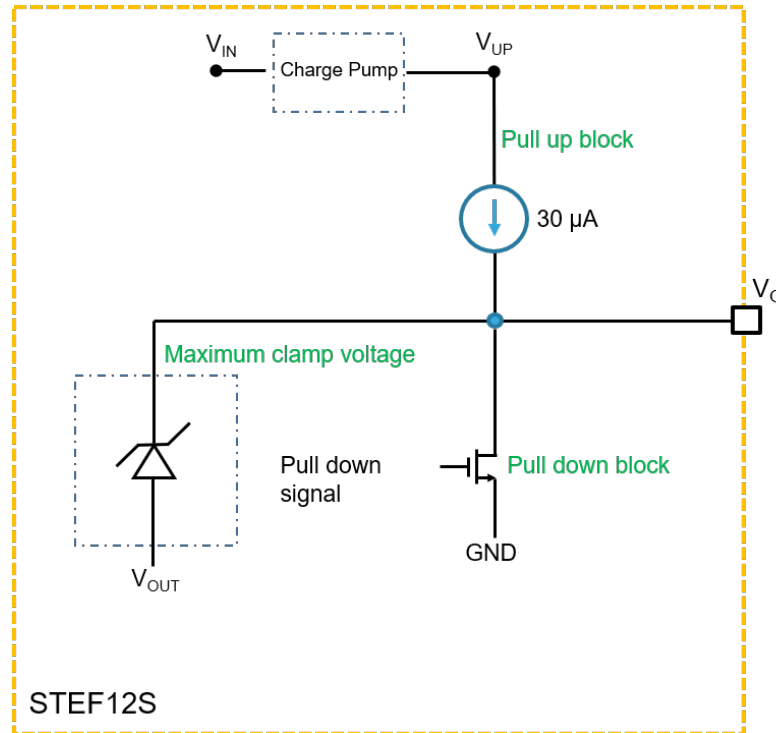
When the internal control circuitry is enabled to perform output start-up ramp, the  $V_{gate}$  pin is pulled up by the External FET charging current ( $I_G$ ) to the charge pump voltage, referred to the  $V_{in}$  voltage, in order to guarantee the activation of external FET. See Figure 8

If the input voltage reaches  $V_{clamp}$  threshold the  $V_{gate}$  voltage is also clamped to a safe value of  $V_{out} + 5.5 V$ .

Reverse current protection is activated if  $V_{IN}$  falls below the undervoltage lockout (UVLO), the enable (EN) voltage falls below the low-level threshold, or a fault event occurs.

For example, as  $V_{CC}$  drops during input power removal, the device turn off internal FET and it sinks current from the gate of the external FET to quickly turn it off, therefore blocking any current flow from the load to the input side.

By appropriate selection of  $C_{OUT}$  the required load current can be guaranteed to complete the power-down sequence.

**Figure 8. External gate driver circuit (only on DFN10 version)**


## 6.9 Application suggestions and PCB layout guidelines

Input and output capacitors are mandatory to guarantee the device control loop stability and reduce the transient effects of stray inductances, which may be present on the input and output power paths. In fact, when the STEF12S interrupts the current flow, input inductance generates a positive voltage spike on the input, and output inductance generates a negative voltage spike on the output.

To reduce the effects of such transients, a  $C_{IN}$  capacitor of at least 1  $\mu\text{F}$  (including voltage and temperature derating) is recommended between the input pin and GND, and located as close as possible to the device.

For the same reason, a  $C_{OUT}$  capacitor of at least 1  $\mu\text{F}$  (including voltage and temperature derating) must be connected to the output port.

When the device is powered by a power line made up of very long wires, the input inductance is higher than few  $\mu\text{H}$ , so the input capacitor should be increased in order to guarantee the proper operation of the device.

It is suggested to provide for additional protections and methods to address these transients, such as:

- Minimizing inductance of the input and output tracks
- TVS diodes on the input to absorb inductive spikes, see [Figure 9](#)
- Schottky diode on the output to absorb negative spikes, see [Figure 9](#). The negative AMR of  $V_{OUT}$  pin is -0.3 V (see [Table 2.](#)), nevertheless, negative transient up to -0.6 V with a maximum duration of 50  $\mu\text{s}$  are tolerated by the device. Schottky diode must be selected to satisfy the above requirements.
- Combination of ceramic and electrolytic capacitors on the input and output.

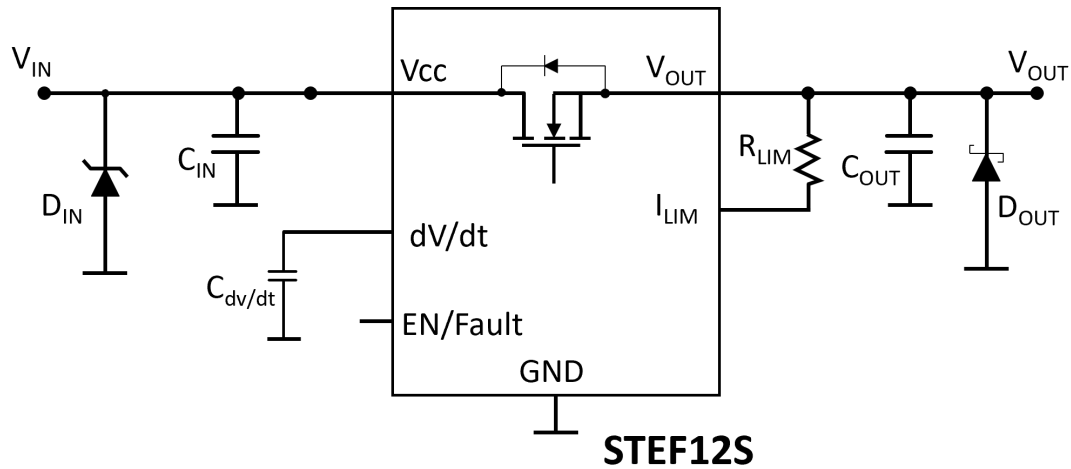
Fast input voltage dips due to input power removal may cause high reverse current flow through the internal body diode, that may lead to malfunction or damage the device.

In general, any application condition that may lead to an output voltage higher than input voltage, as per [Table 2](#). Absolute maximum ratings, should be avoided.

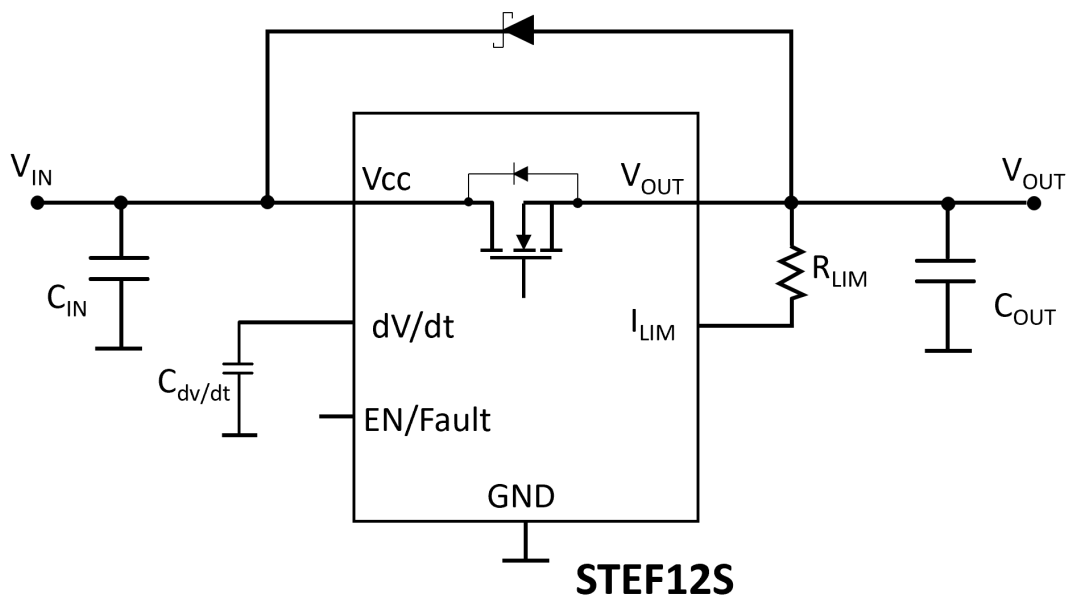
In those applications where this kind of condition exists, it is recommended to protect the device by adding external circuits as:

- Schottky diode connected in anti-parallel configuration with the eFuse power switch to drive any reverse current outside the eFuse's intrinsic body diode (see [Figure 10](#)).
- Reverse current blocking FET in series with the power path (on STEF12SPUR, it can be directly controlled via the eFuse VG pin, as shown in [Figure 4](#)).
- Diode in series to the power path .

**Figure 9. External protections against inductive voltage spikes**



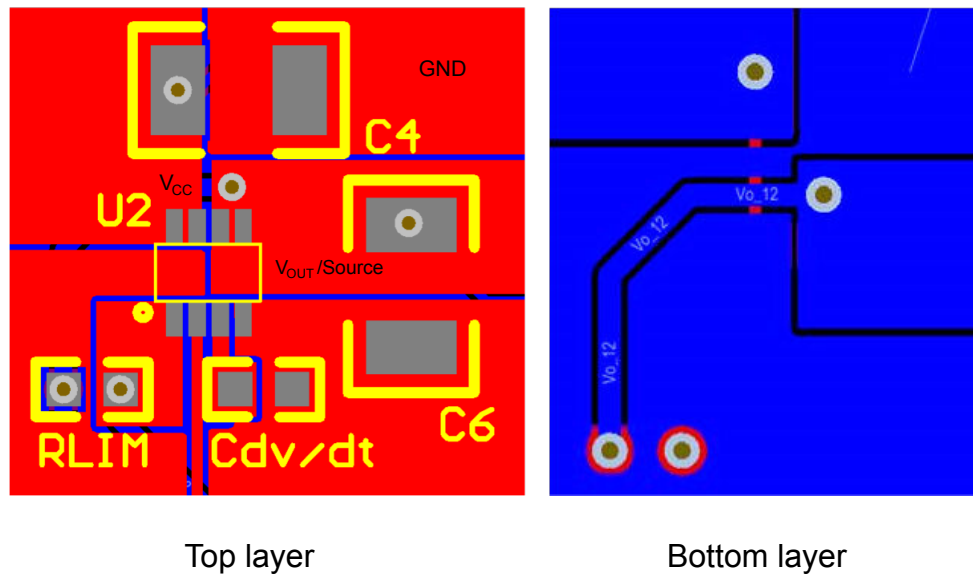
**Figure 10. External diode to address reverse current flow**



The PCB layout is critical for a stable and reliable operation. Refer to the typical PCB layout example shown in [Figure 11](#) and to the following guidelines:

- Defining the high current input and output copper traces as short as possible and adequately sized to sustain at least the overload current
- Placing the  $R_{LIM}$  resistor close to the  $I_{LIM}$  pin and connect the other terminal of the component to  $V_{OUT}$  with the shortest possible trace. In fact, parasitic effects on the  $R_{LIM}$  connection trace can affect the current limit accuracy.
- Placing the  $C_{dv/dt}$  capacitor close to the  $dV/dt$  pin and connect the other terminal to GND with the shortest possible trace. Use low-leakage components for  $C_{dv/dt}$ .
- The TSOT23-8L package dissipates the thermal power mainly through the leads, so providing large enough copper areas around the PCB soldering pads is recommended.

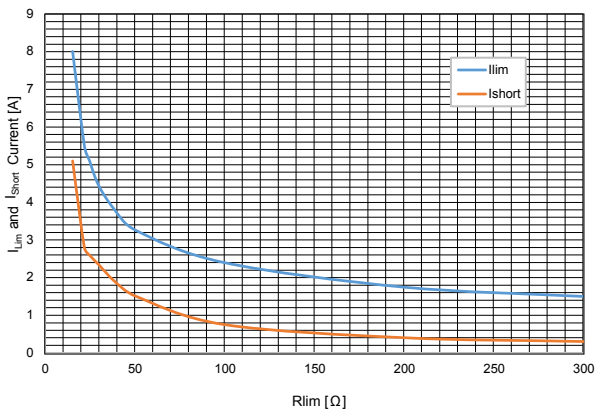
Figure 11. PCB layout example



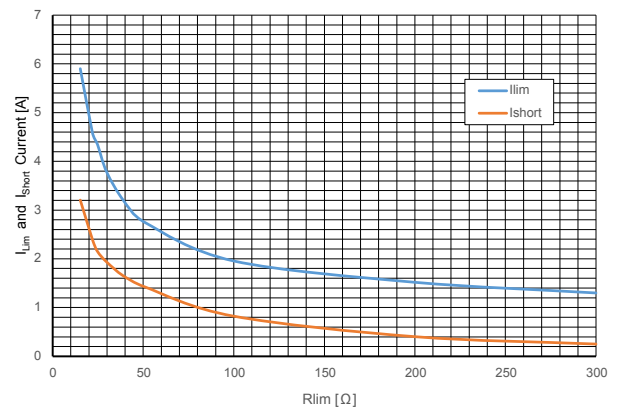
## 7 Typical characteristics

$V_{CC} = 12\text{ V}$ ,  $V_{En/Fault} = \text{floating}$ ,  $R_{Lim} = 22\ \Omega$ ,  $C_{OUT} = 10\ \mu\text{F}$ ,  $C_{dV/dt} = \text{floating}$ ,  $T_A = 25^\circ\text{C}$ , unless otherwise specified.

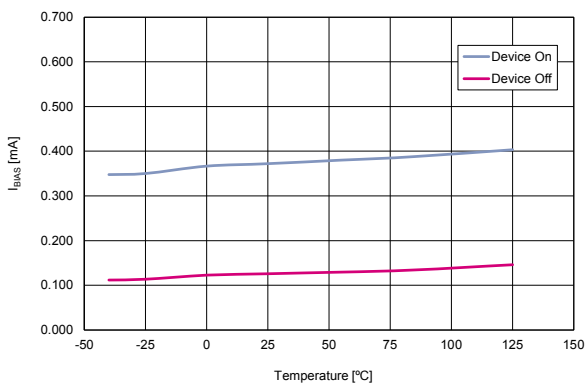
**Figure 12.  $I_{Lim}$  and  $I_{Short}$  vs.  $R_{Lim}$  - (STEF12SGR)**



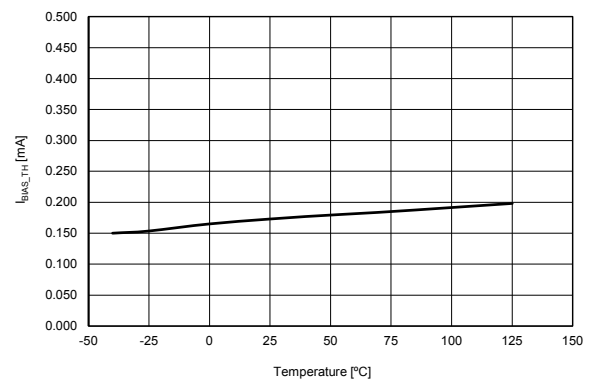
**Figure 13.  $I_{Lim}$  and  $I_{Short}$  vs.  $R_{Lim}$  - (STEF12SPUR)**



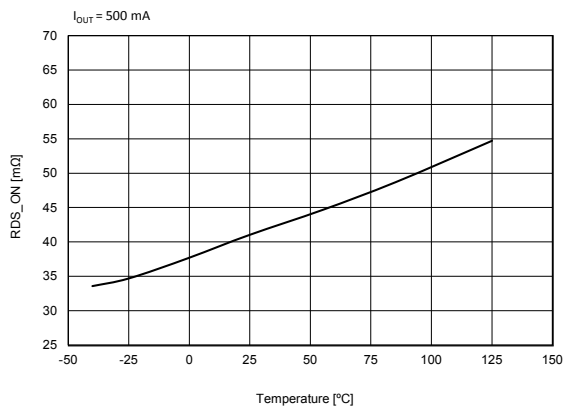
**Figure 14. Bias current vs. temperature**



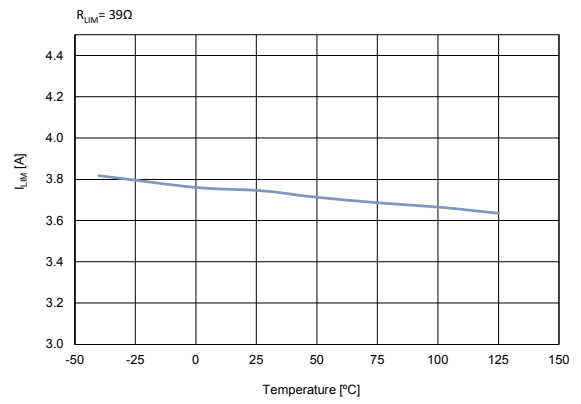
**Figure 15. Bias current vs. temperature (thermal shutdown)**



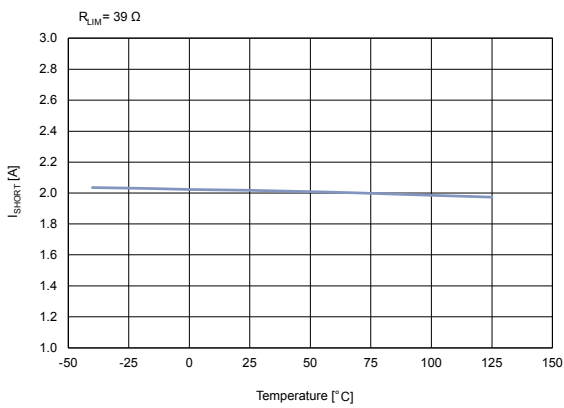
**Figure 16.  $R_{DS\_ON}$  vs. temperature**



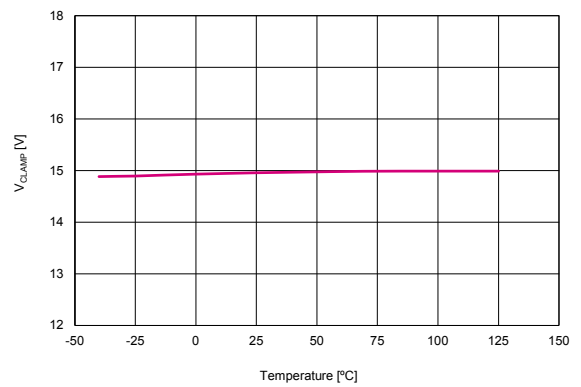
**Figure 17.  $I_{LIM}$  vs. temperature**



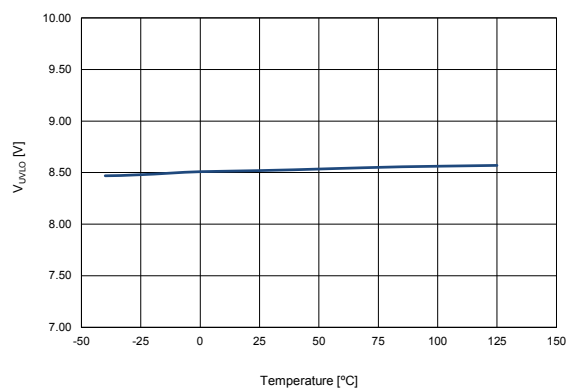
**Figure 18.  $I_{short}$  vs. temperature**



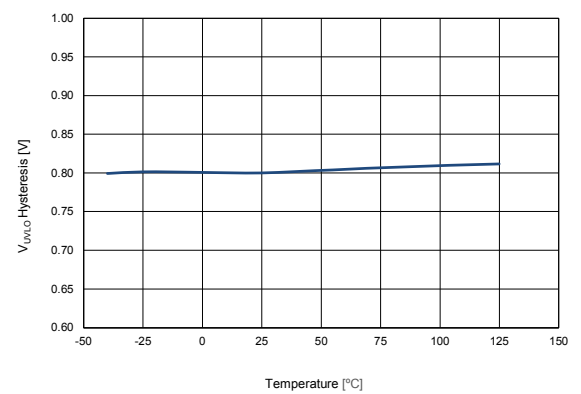
**Figure 19. Clamping voltage vs. temperature**



**Figure 20. UVLO vs. temperature**

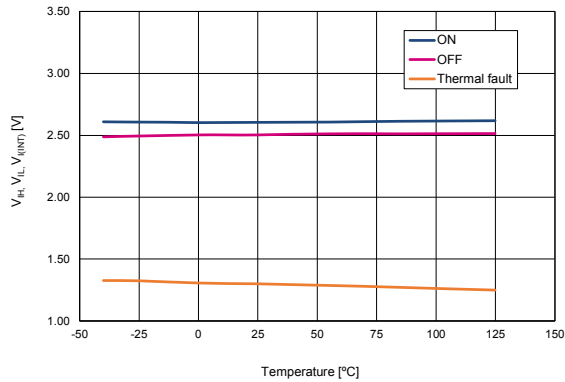


**Figure 21. UVLO hysteresis vs. temperature**

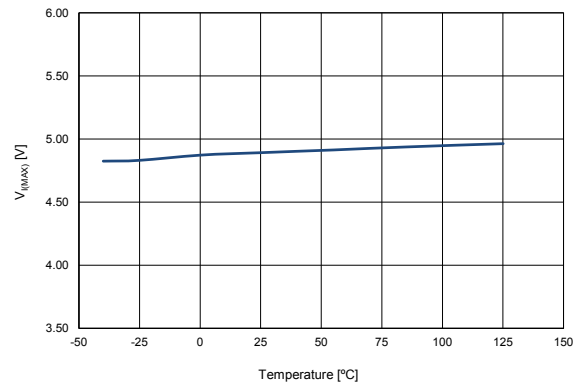




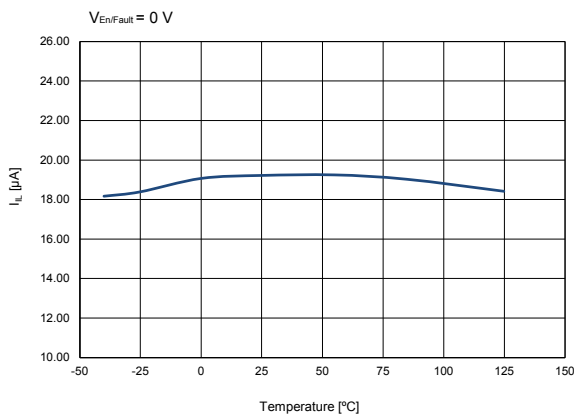
**Figure 22. En/Fault pin thresholds vs. temperature**



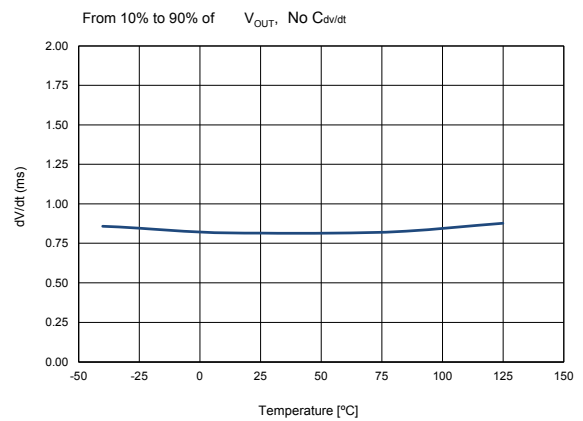
**Figure 23. En/Fault pull-up voltage vs. temperature**



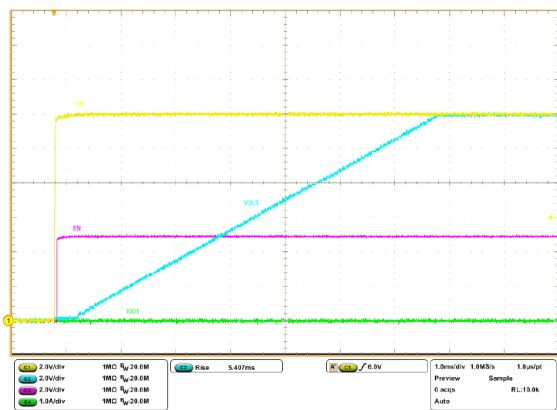
**Figure 24. En/Fault pin current vs. temperature (En/Fault to GND)**



**Figure 25. Soft-start time vs. temperature (no C<sub>dvdt</sub>)**

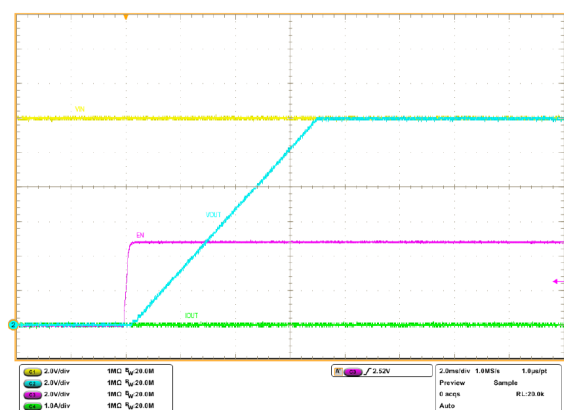


**Figure 26. Start-up via input voltage (no load)**



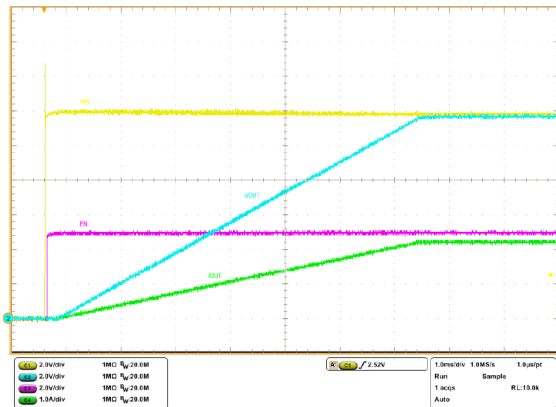
V<sub>IN</sub>=from 0V to 12V, I<sub>OUT</sub>= 0 mA, C<sub>dv/dt</sub>= 220 pF, C<sub>IN</sub>= 2.2 μF, C<sub>OUT</sub>= 10 μF, R<sub>LIM</sub>= 22Ω

**Figure 27. Start-up via En/Fault pin (no load)**



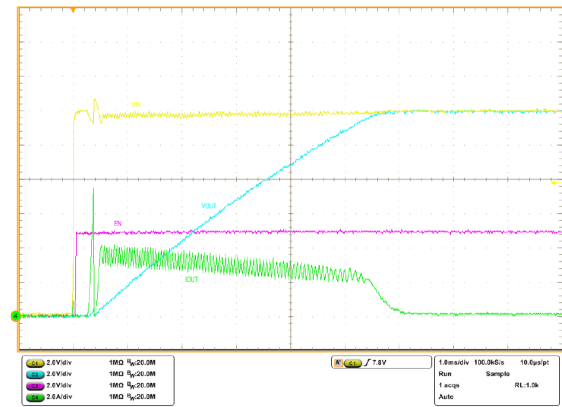
V<sub>En/Fault</sub>=from 0V to floating, I<sub>OUT</sub>= 0 mA, C<sub>dv/dt</sub>= 220 pF, C<sub>IN</sub>= 2.2 μF, C<sub>OUT</sub>= 10 μF, R<sub>LIM</sub>= 22Ω

**Figure 28. Start-up via input voltage (5 Ω load)**



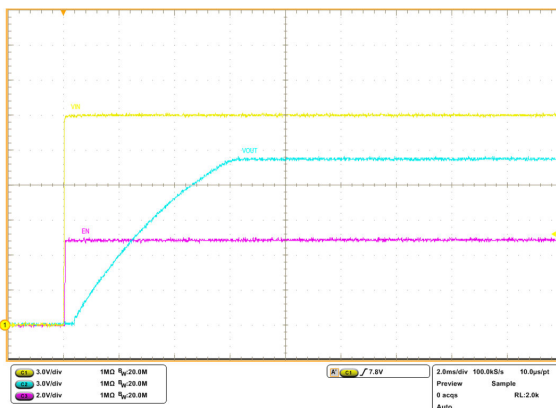
$V_{IN}$ =from 0V to 12V,  $R_{LOAD}$ = 5 Ω,  $C_{dV/dt}$ = 220 pF,  $C_{IN}$ = 2.2 μF,  $C_{OUT}$ = 10 μF,  $R_{LIM}$ = 22Ω

**Figure 29. Start-up via input voltage ( $C_{OUT}$  = 1500 μF)**



$V_{IN}$ =from 0V to 12V, No load,  $C_{dV/dt}$ = 220 pF,  $C_{IN}$ = 2.2 μF,  $C_{OUT}$ = 1500 μF,  $R_{LIM}$ = 22Ω

**Figure 30. Start-up into voltage clamp**



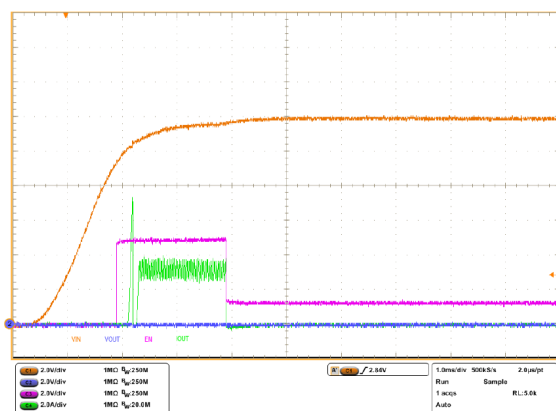
$V_{IN}$ =from 0V to 18V, No load,  $C_{dV/dt}$ = 220 pF,  $C_{IN}$ = 2.2 μF,  $C_{OUT}$ = 10 μF,  $R_{LIM}$ = 22Ω

**Figure 31. Voltage clamp during operation**



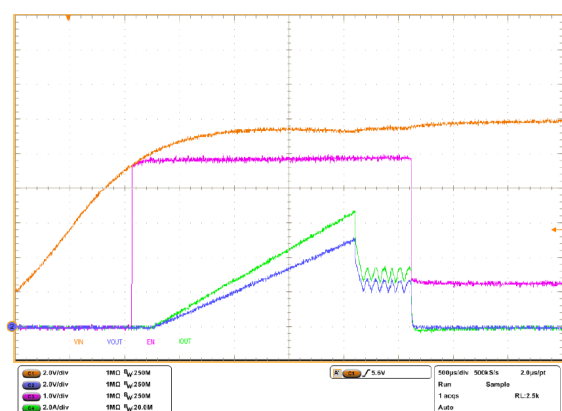
$V_{IN}$ =from 12V to 18V, No load,  $C_{dV/dt}$ = 220 pF,  $C_{IN}$ = 2.2 μF,  $C_{OUT}$ = 10 μF,  $R_{LIM}$ = 22Ω

**Figure 32. Start-up into output short-circuit**



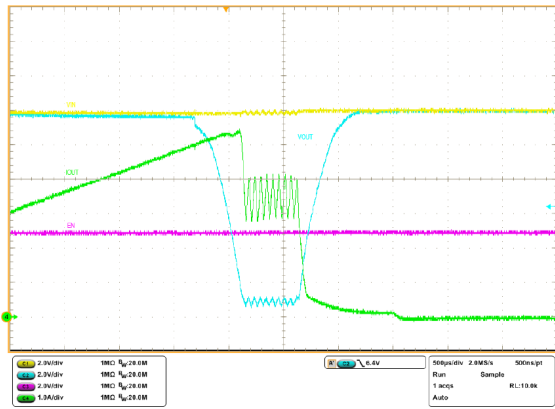
$V_{IN}$ = 12V,  $V_{OUT}$  shorted to GND,  $C_{dV/dt}$ = 220 pF,  $C_{IN}$ = 2.2 μF,  $C_{OUT}$ = 10 μF,  $R_{LIM}$ = 22Ω

**Figure 33. Start-up into overload**



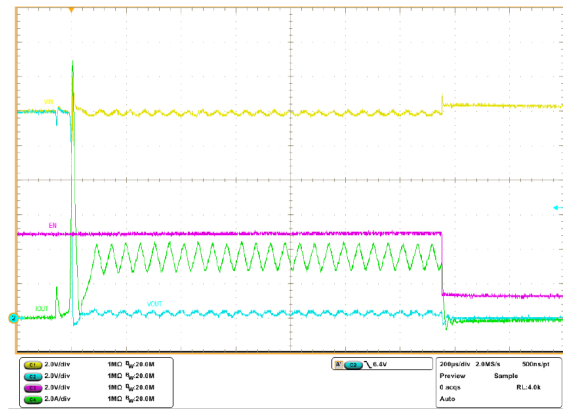
$V_{IN}$ = 12V,  $R_{LOAD}$ = 0.75 Ω,  $C_{dV/dt}$ = 220 pF,  $C_{IN}$ = 2.2 μF,  $C_{OUT}$ = 10 μF,  $R_{LIM}$ = 22Ω

Figure 34. Overcurrent protection during operation



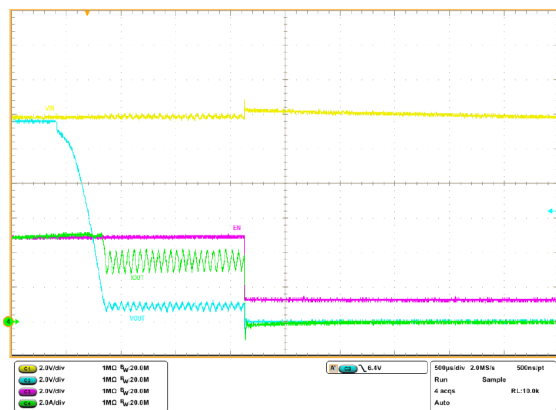
$V_{IN} = 12V$ ,  $I_{OUT}$  = from 0 to current limit,  $C_{dV/dt} = 220\text{ pF}$ ,  $C_{IN} = 2.2\text{ }\mu\text{F}$ ,  $C_{OUT} = 10\text{ }\mu\text{F}$ ,  $R_{LIM} = 22\Omega$

Figure 35. Output short-circuit during operation



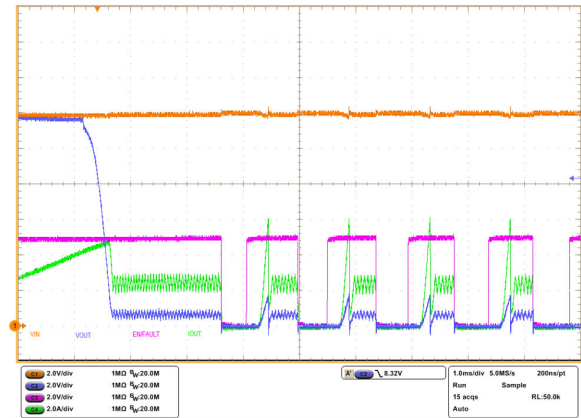
$V_{IN} = 12V$ ,  $V_{OUT}$  = from 12V to GND,  $C_{dV/dt} = 220\text{ pF}$ ,  $C_{IN} = 2.2\text{ }\mu\text{F}$ ,  $C_{OUT} = 10\text{ }\mu\text{F}$ ,  $R_{LIM} = 22\Omega$

Figure 36. Thermal shutdown (latched version)



$V_{IN} = 12V$ ,  $C_{dV/dt} = 220\text{ pF}$ ,  $C_{IN} = 2.2\text{ }\mu\text{F}$ ,  $C_{OUT} = 10\text{ }\mu\text{F}$ ,  $R_{LIM} = 22\Omega$

Figure 37. Thermal shutdown (auto-retry version)



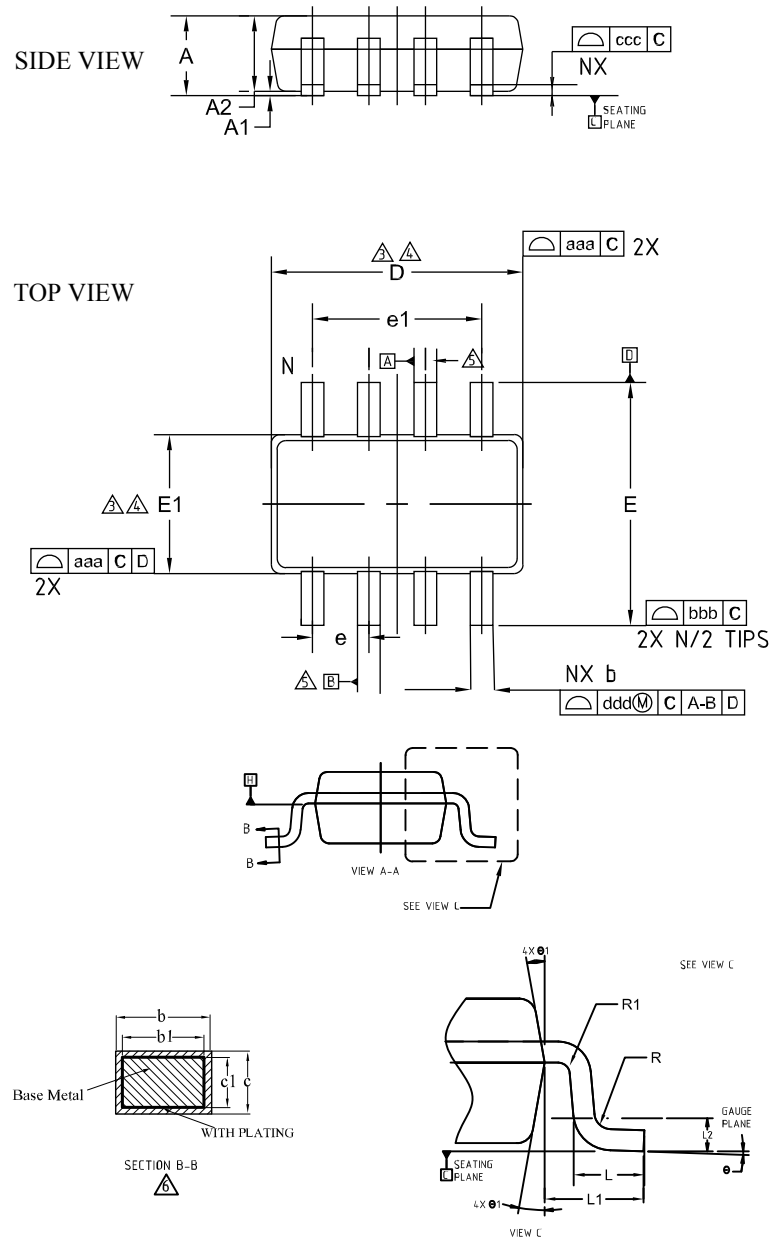
$V_{IN} = 12V$ ,  $C_{dV/dt} = 220\text{ pF}$ ,  $C_{IN} = 2.2\text{ }\mu\text{F}$ ,  $C_{OUT} = 10\text{ }\mu\text{F}$ ,  $R_{LIM} = 22\Omega$

## 8 Package information

In order to meet environmental requirements, ST offers these devices in different grades of **ECOPACK** packages, depending on their level of environmental compliance. ECOPACK specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK is an ST trademark.

### 8.1 TSOT23-8L package information

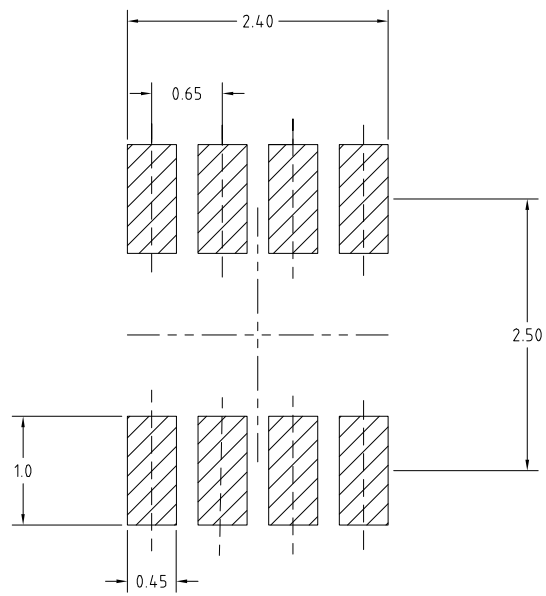
Figure 38. TSOT23-8L package outline



**Table 9. TSOT23-8L mechanical data**

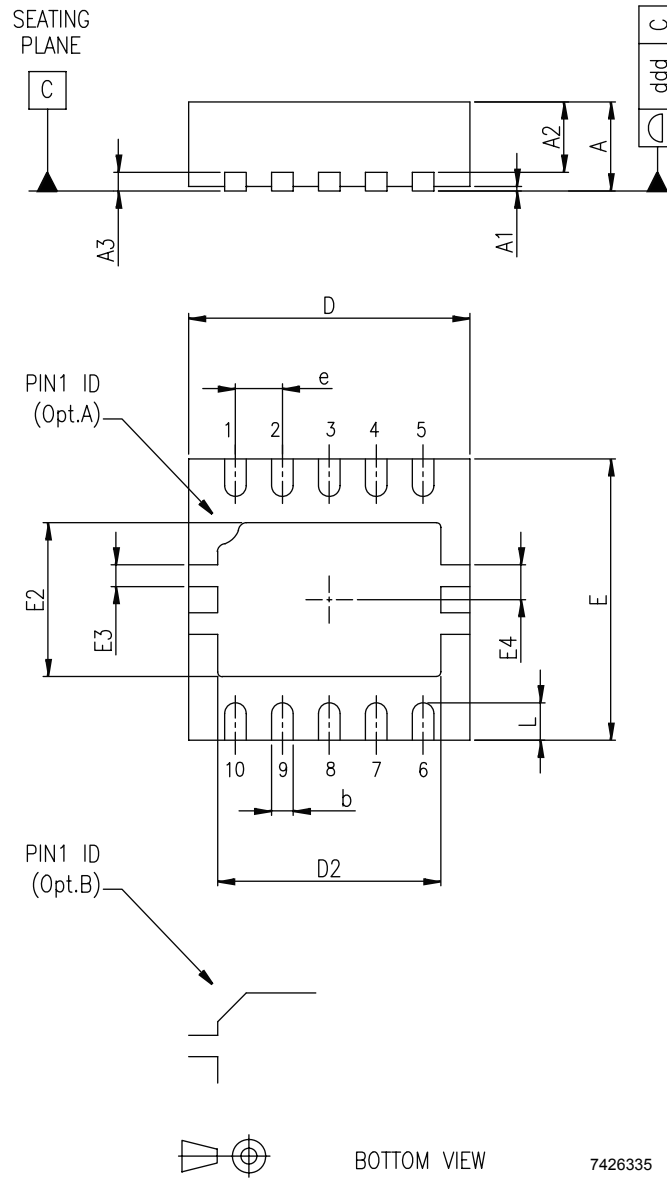
Dim.	mm		
	Min.	Typ.	Max.
A			1
A1	0.01	0.05	0.1
A2	0.84	0.87	0.9
b	0.22	-	0.36
b1	0.22	0.26	0.3
c	0.12	0.15	0.2
c1	0.08	0.13	0.16
D	-	2.90 BSC	-
E	-	2.80 BSC	-
E1	-	1.60 BSC	-
e	-	0.65 BSC	-
e1	-	1.95 BSC	-
L	0.3	0.4	0.5
L1	-	0.60 BSC	-
L2	-	0.25 BSC	-
R	0.1	-	-
R1	0.1	-	0.25
Θ	0	4°	8°
Θ1	4°	10°	12°
<b>Tolerance of form and position</b>			
aaa		0.15	
bbb		0.25	
ccc		0.1	
ddd		0.13	
N		8	
ND		4	

Figure 39. TSOT23-8L recommended footprint



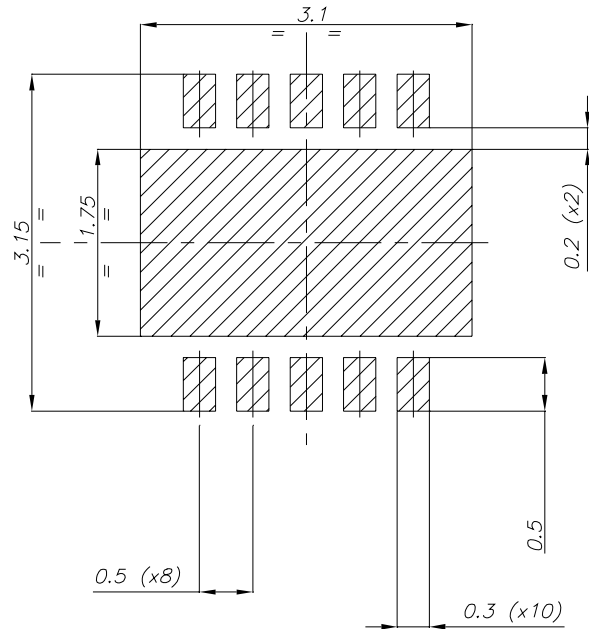
## 8.2 DFN10 (3 x 3 mm) package information

Figure 40. DFN10 (3 x 3 mm) package outline



**Table 10. DFN10 (3 x 3 mm) mechanical data**

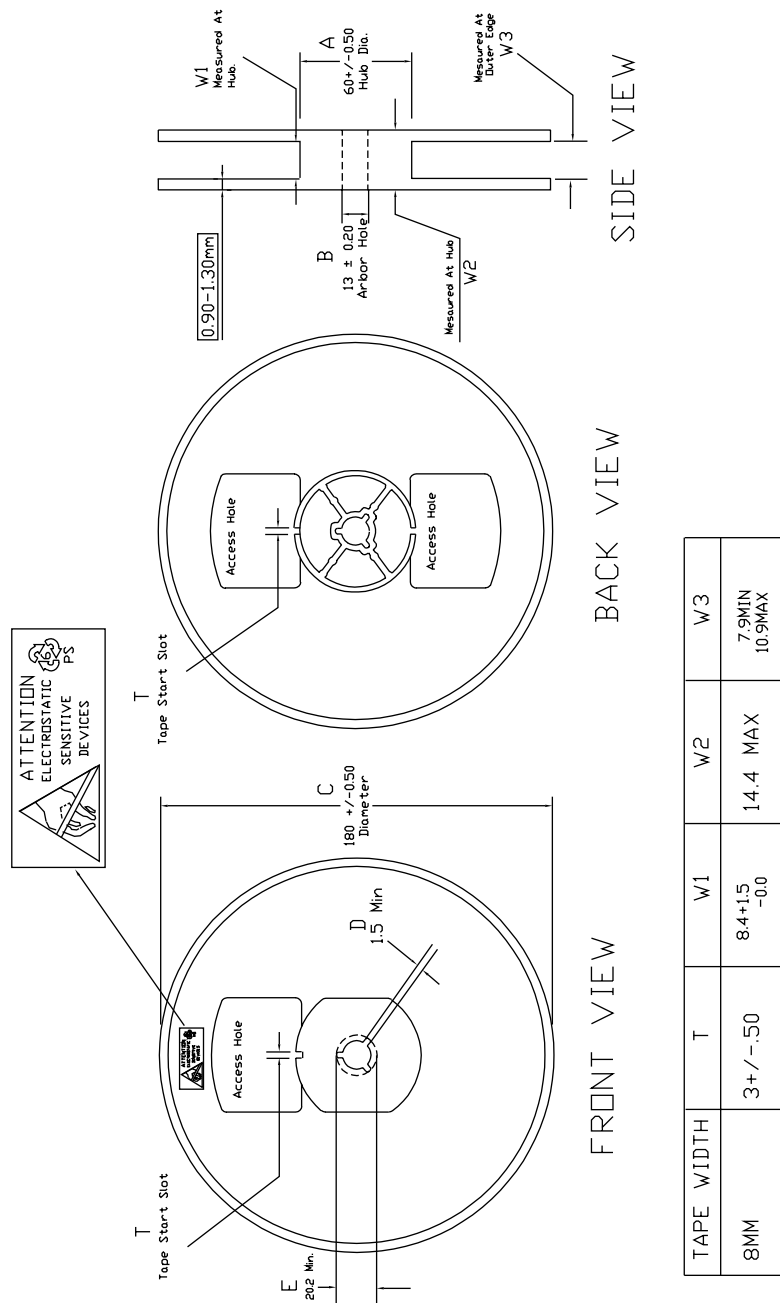
Dim.	mm		
	Min.	Typ.	Max.
A	0.80	0.90	1.00
A1		0.02	
A2		0.70	
A3		0.20	
b	0.18	0.23	0.30
D	2.85	3.00	3.15
D2	2.23	2.38	2.52
E	2.85	3.00	3.15
E2	1.49	1.64	1.75
E3	0.230		
E4	0.365		
e		0.50	
L	0.30	0.40	0.50
ddd			0.08

**Figure 41. DFN10 (3 x 3 mm) recommended footprint**


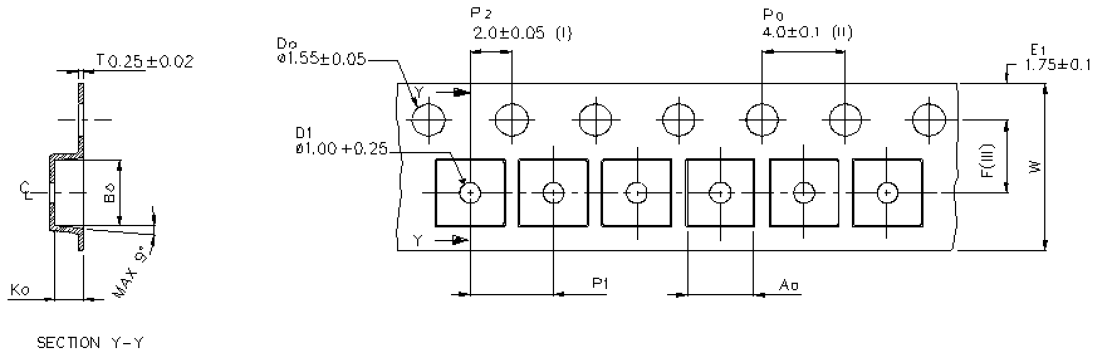


### 8.3 TSOT23-8L packing information

Figure 42. TSOT23-8L reel drawing outline



**Figure 43. TSOT23-8L carrier tape**

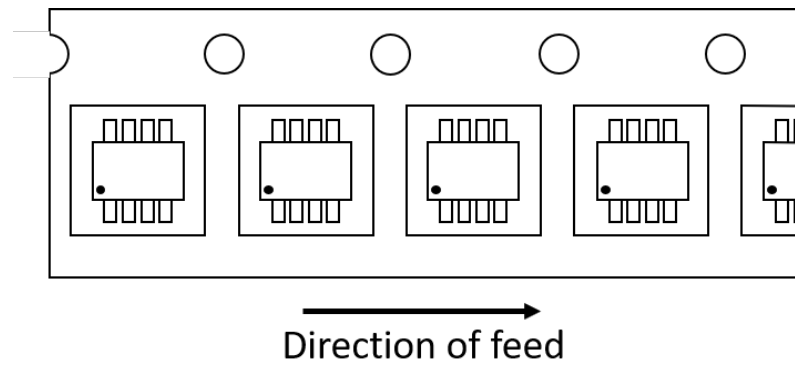


A <sub>φ</sub>	3.23 +/−0.10
B <sub>φ</sub>	3.17 +/−0.10
K <sub>φ</sub>	1.37 +/−0.10
F	3.50 +/−0.05
P <sub>1</sub>	4.00 +/−0.10
W	8.00 +0.3/−0.1

- (I) Measured from centreline of sprocket hole to centreline of pocket.
- (II) Cumulative tolerance of 10 sprocket holes is ± 0.20 .
- (III) Measured from centreline of sprocket hole to centreline of pocket.
- (IV) Other material available.
- (V) Typical SR of form tape Max. 10° QHM/SR

ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED.

**Figure 44. TSOT23-8L device orientation in tape**



## 8.4 DFN10 (3 x 3 mm) packing information

Figure 45. DFN10 (3 x 3 mm) reel drawing outline

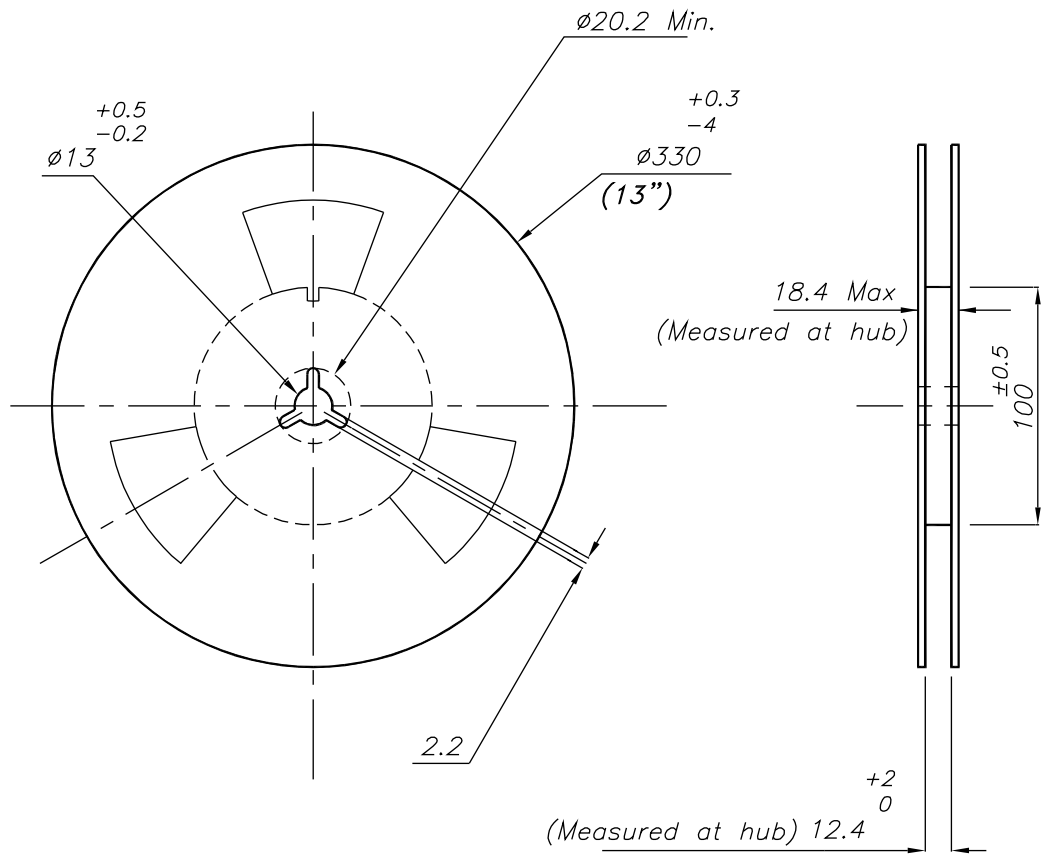


Figure 46. DFN10 (3 x 3 mm) carrier tape

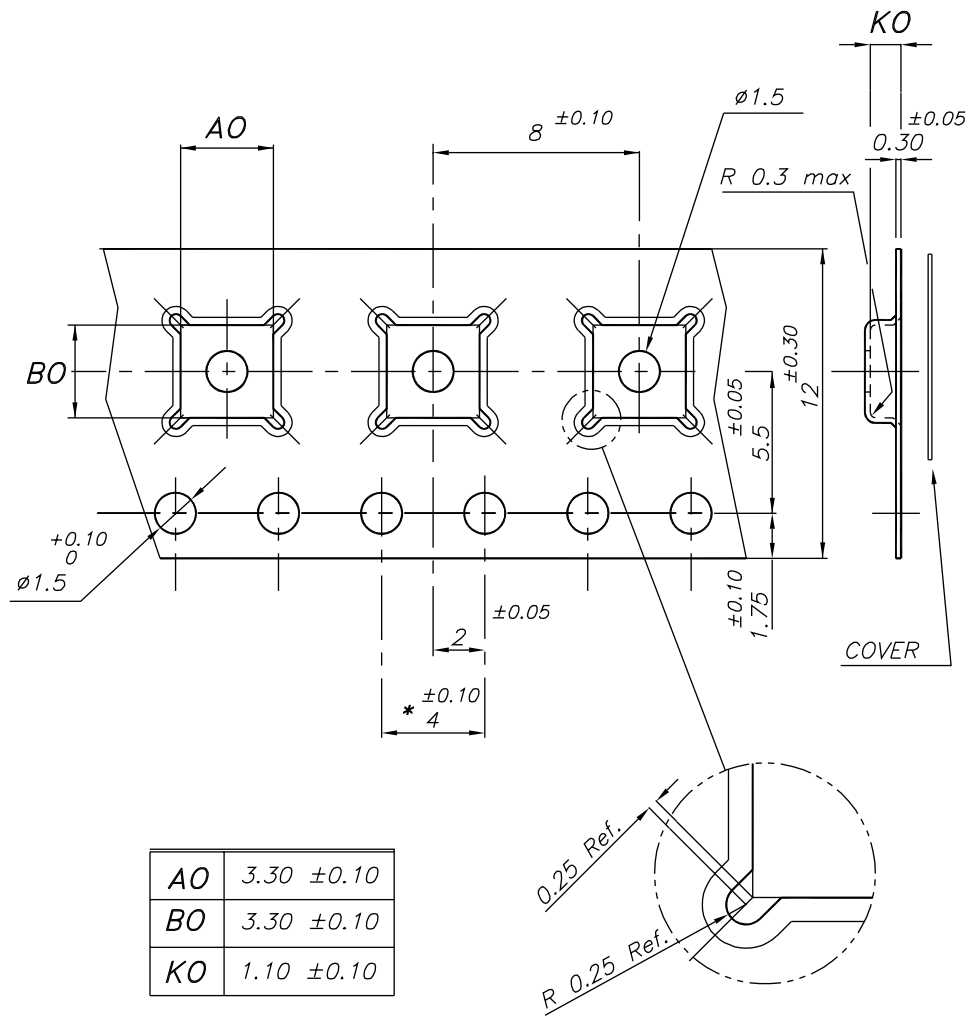
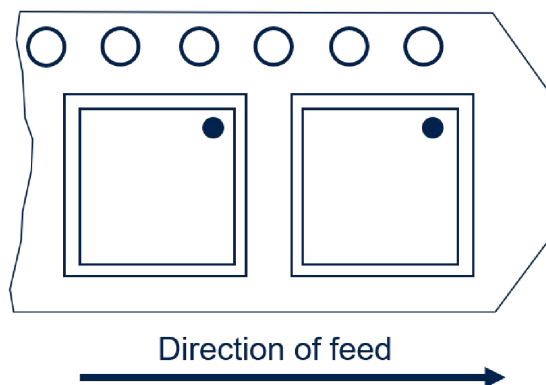


Figure 47. DFN10 (3 x 3 mm) device orientation in tape



## 9 Ordering information

**Table 11. Order codes**

Order code	Package	Packaging	Marking	Thermal protection
STEF12SGR	TSOT23-8	Tape and reel	12SL	Latch-off
STEF12SAGR			12HA	Autoretry
STEF12SPUR	DFN10-3x3		12SLP	Latch-off
STEF12SAPUR			12HA	Autoretry

## Revision history

**Table 12. Document revision history**

Date	Revision	Changes
17-Dec-2019	1	Initial release.
29-May-2020	2	Updated Figure 1, $V_{I(INT)}$ max. value in Table 5, Section 6.7 En/Fault pin, Section 6.9 Application suggestions and PCB layout guidelines and Figure 33. Added row $R_{Lim}$ parameter in Table 4 and new order code STEF12SAPUR in Table 11.
25-Aug-2020	3	Updated Table 11. Order codes.
23-Jun-2021	4	Added new section 8.3 TSOT23-8L packing information and Section 8.4 DFN10 (3 x 3 mm) packing information.
28-Feb-2022	5	Added DFN10-3x3 new column values in Table 3.
18-Dec-2023	6	Updated applications on the cover page. Added footnote in Table 2. Added Figure 9 and Figure 10

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