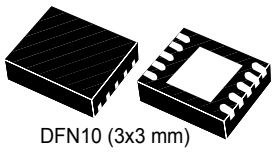
STEF12E

Datasheet

Electronic fuse for 12 V line



DFN10 (3x3 mm)

Maturity status link
STEF12E

Device summary	
Order code	STEF12EPUR
Package	DFN10 (3x3 mm)
Packing	Tape and reel

Features

- Continuous current typ. 3.6 A
- N-channel on-resistance typ. 45 mΩ
- Enable/fault functions
- Output clamp voltage typ. 15 V
- Undervoltage lockout
- Short-circuit limit
- Overload current limit
- Controlled output voltage ramp
- Thermal latch typ. 165 °C
- Uses tiny capacitors
- Operating junction temp. -40 °C to 125 °C
- Available in DFN10 (3x3 mm) package
- UL2367 Recognized - File N. E468771

Applications

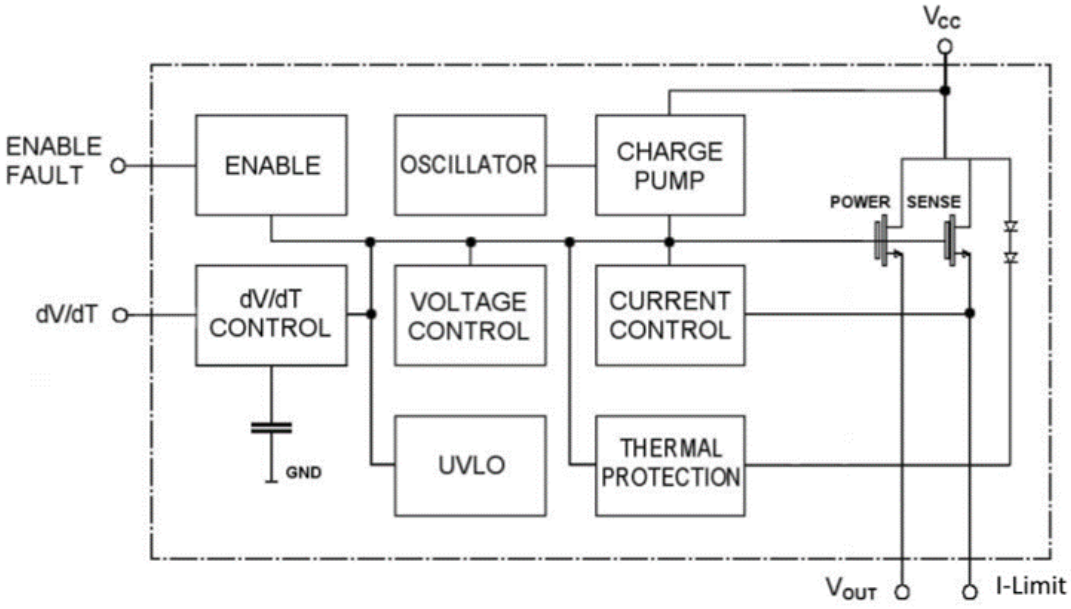
- Hard disk drives
- Solid state drives (SSD)
- Hard disk and SSD arrays
- Set-top boxes
- DVD and Blu-ray disc drivers

Description

The STEF12E is an integrated electronic fuse optimized for monitoring output current and input voltage. Connected in series to a 12 V rail, it is capable of protecting the electronic circuitry on its output from overcurrent and overvoltage. The device has a controlled delay and turn-on time. When an overload condition occurs, the STEF12E limits the output current to a predefined safe value. If the anomalous overload condition persists it goes into an open state, disconnecting the load from the power supply. If a continuous short-circuit is present on the board, when power is re-applied the E-fuse initially limits the output current to a safe value and then again goes into an open state. The device is equipped with a thermal protection circuit. The intervention of the thermal protection is signalled to the board monitoring circuits through a signal on the Fault pin. Unlike the mechanical fuses, which must be physically replaced after a single event, the Efuse does not degrade in its performance after short-circuit/thermal protection interventions and it is reset either by recycling the supply voltage or using the Enable pin. The companion chip for the 5 V power rails is also available with part number STEF05.

1 Device block diagram

Figure 1. **Block diagram**



2 Pin configuration

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

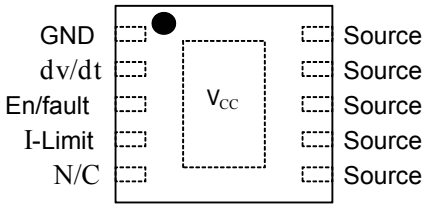


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Table 1. **Pin description**

Pin n°	Symbol	Note
1	GND	Ground pin.
2	dv/dt	The internal dv/dt circuit controls the slew rate of the output voltage on turn-on. The internal capacitor allows a ramp-up time of around 1 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.
3	En/fault	The Enable/Fault pin is a tri-state, bi-directional interface. During 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.
4	I-Limit	A resistor between this pin and the Source pin sets the overload and short-circuit current limit levels.
5	N/C	Not connected.
6 to 10	V_{OUT}/Source	Connected to the source of the internal power MOSFET and to the output terminal of the fuse.
11	V_{CC}	Exposed pad. Positive input voltage must be connected to V_{CC}.

3 Maximum ratings

Table 2. Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_{CC}	Positive power supply voltage (steady-state)	-0.3 to 18	V
	Positive power supply voltage (max. 100 ms)	-0.3 to 25	
V_{OUT}/source	(max. 100 ms)	-0.3 to Vcc+0.3	V
I-Limit	(max. 100 ms)	-0.3 to 25	V
En/fault		-0.3 to 7	V
dv/dt		-0.3 to 7	V
T_{op}	Operating junction temperature range	-40 to 125	°C
T_{STG}	Storage temperature range	-65 to 150	°C
T_{LEAD}	Lead temperature (soldering) 10 s	260	°C

1. *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.

Table 3. Thermal data

Symbol	Parameter	Value	Unit
R_{thJA}	Thermal resistance junction-ambient	52.7	°C/W
R_{thJC}	Thermal resistance junction-case	17.4	°C/W

1. *The value refers to the package mounted on a 4 layer JEDEC standard test board with 4 thermal vias connecting the thermal land to the first buried plane.*

Table 4. ESD performance

Symbol	Parameter	Test condition	Value	Unit
ESD	ESD protection	HBM	2	kV
		MM	200	V
		CDM	500	V

4 Electrical characteristics

V_{CC} = 12 V, V_{EN} = 3.3 V, C_I = 10 µF, C_O = 47 µF, T_J = 25 °C (unless otherwise specified).

Table 5. Electrical characteristics for STEF12E

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
Under/overvoltage protection						
V_{Clamp}	Output clamping voltage	V_{CC} = 18 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			0.80		V
Power MOSFET						
t_{dly}	Delay time	Enabling of chip to I_D = 100 mA with a 1 A resistive load		350		µs
R_{DSon}	On-resistance (1)		35	45	55	mΩ
		- 40 °C < T_J < 125 °C (2)			70	
V_{OFF}	Off-state output voltage	V_{CC} = 18 V, V_{GS} = 0, R_L = infinite		40	100	mV
I_D	Continuous current	0.5 in^2 pad, T_A = 25 °C (2)		3.6		A
		Minimum copper, T_A = 80 °C		1.7		
Current limit						
I_{Short}	Short-circuit current limit	R_{Limit} = 22 Ω	3.3	4.4	5.5	A
I_{Lim}	Overload current limit	R_{Limit} = 22 Ω		4.4		A
dv/dt circuit						
dv/dt	Output voltage ramp time	Enable to V_{OUT} = 11.7 V, No $C_{dv/dt}$	0.5	0.9	2.6	ms
Enable/fault						
V_{IL}	Low level input voltage	Output disabled	0.35	0.58	0.81	V
$V_{I(INT)}$	Intermediate level input voltage	Thermal fault, output disabled	0.82	1.4	1.95	V
V_{IH}	High level input voltage	Output enabled	1.96	2.64	3.3	V
$V_{I(MAX)}$	High state maximum voltage		3.4	4.3	5.4	V
I_{IL}	Low level input current (sink)	V_{Enable} = 0 V		-10	-30	µA
I_I	High level leakage current for external switch	V_{Enable} = 3.3 V			1	µA
	Maximum fan-out for fault signal	Total numbers of chips that can be connected to this pin for simultaneous shutdown			3	Units
Total device						
I_{Bias}	Bias current	Device operational		1.5	2	mA
		Thermal shutdown		1		
V_{min}	Minimum operating voltage				7.6	V
Thermal latch						
TSD	Shutdown temperature	(1)		165		°C

1. *Pulse test: pulse width = 300 µs, duty cycle = 2%.*
2. *Guaranteed by design, but not tested in production.*

5 Typical application

Figure 3. Application circuit

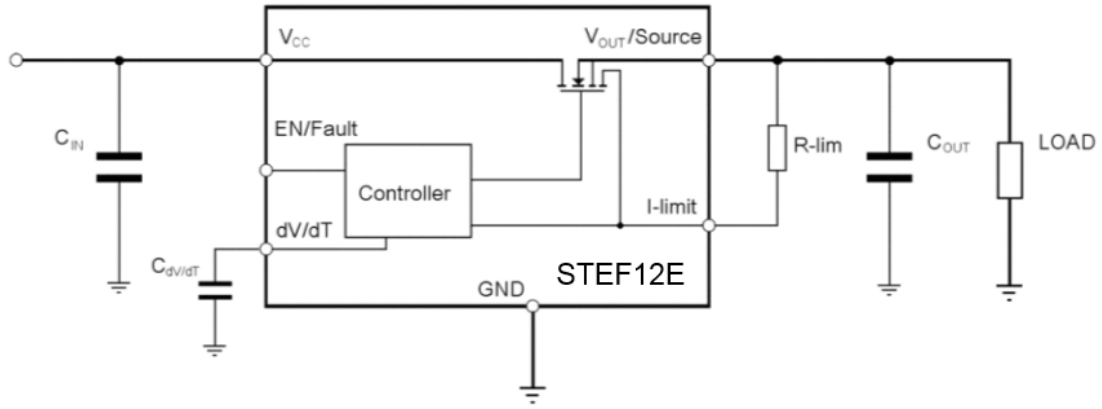
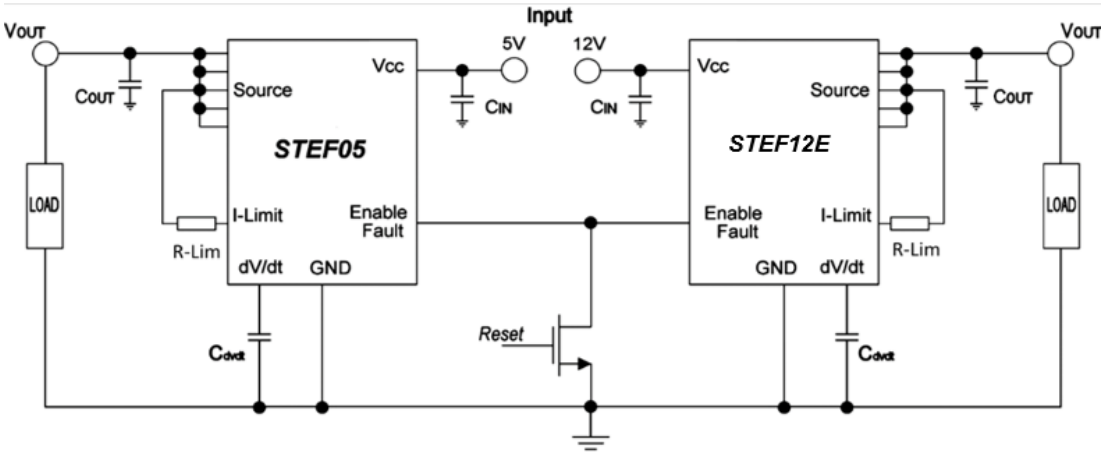


Figure 4. Typical HDD application circuit



6 Operating modes

6.1 Turn-on

When the input voltage is applied, the enable/fault pin goes up to the high state, enabling the internal control circuitry.

After an initial delay time of typically 350 µs, the output voltage is supplied with a slope defined by the internal dv/dt circuitry. If no additional capacitor is connected to dv/dt pin, the total time, from the enable signal going high to the output voltage reaching the nominal value, is around 1 ms (refer to Figure 5. Delay time and V_{OUT} ramp-up time).

6.2 Normal operating conditions

The STEF12E E-Fuse behaves like a mechanical fuse, buffering the circuitry on its output with the same voltage shown on its input, with a small voltage fall due to the N-channel MOSFET $R_{DS(on)}$.

6.3 Output voltage clamp

This internal protection circuit clamps the output voltage to a maximum safe value, typically 15 V, if the input voltage exceeds this threshold.

6.4 Current limiting

When an overload event occurs, the current limiting circuit reduces the conductivity of the power MOSFET, in order to clamp the output current at the value selected externally by the limiting resistor R_{Limit} (see Figure 3. Application circuit).

6.5 Thermal shutdown

If the device temperature exceeds the thermal latch threshold, typically 165 °C, the thermal shutdown circuitry turns the power MOSFET off, thus disconnecting the load. The EN/fault pin of the device is automatically set to an intermediate voltage, in order to signal the overtemperature event. In this condition the E-Fuse can be reset either by cycling the supply voltage or by pulling down the EN pin below the V_{IL} threshold and then releasing it.

6.6 R-Lim calculation

As shown in Figure 3. Application circuit, the device uses an internal N-channel SenseFET 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 estimated by using the following theoretical formula, together with the graph in Figure 13. Current limit vs. R_{Limit} .

$$R_{Lim} = \frac{95}{IShort} \quad (1)$$

6.7 $C_{dv/dt}$ calculation

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 Δt, during which the output voltage goes from zero to its maximum value, the capacitance to be added to the $C_{dv/dt}$ pin can be calculated using the following theoretical formula:

$$C_{dv/dt} = 3.92 \times 10^{-8} \Delta t - 35.3 \times 10^{-12} \quad (2)$$

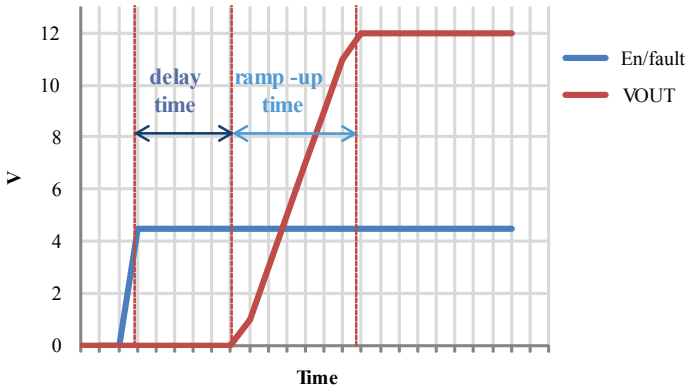
Where $C_{dv/dt}$ is expressed in farads and the time in seconds.

The addition of an external $C_{dv/dt}$ also influences the initial delay time, defined as the time between the enable signal going high and the start of the V_{OUT} slope (Figure 5. Delay time and V_{OUT} ramp-up time).

The contribution of the external capacitor to this time interval can be estimated by using the following theoretical formula:

$$delay\ time\ [s] = 35 \times 10^{-5} + 71 \times 10^{5} \times C_{dv/dt}\ [F] \quad (3)$$

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



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6.8 En/fault pin

The En/fault pin has the dual function to control the output of the device and, at the same time, provide the application with information about the device status.

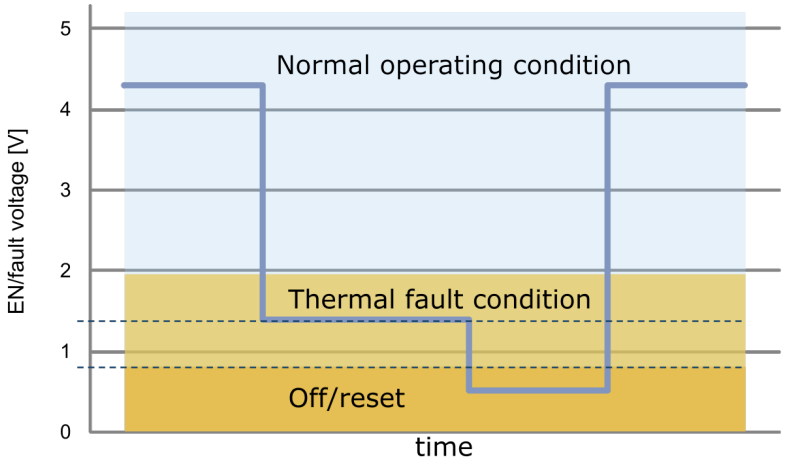
When it is used as a standard enable pin, it should be connected to an external open-drain or open-collector device. In this case, when it is pulled to low logic level, it turns the output of the E-Fuse off.

If this pin is left floating, since it has an internal pull-up circuitry, the output of the E-Fuse is kept on, in normal operating conditions.

In case of thermal fault, the pin is pulled to an intermediate state (Figure 6. En/fault pin status). 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 Enable/fault pin of the other STEFxx 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.

Figure 6. **En/fault pin status**



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7 Typical performance characteristics

The following plots are referred to the typical application circuit and, unless otherwise noted, at T_A = 25 °C.

Figure 7. Clamping voltage vs. temperature

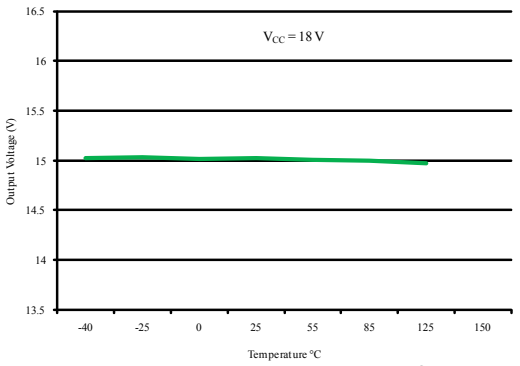

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Figure 8. UVLO voltage vs. temperature

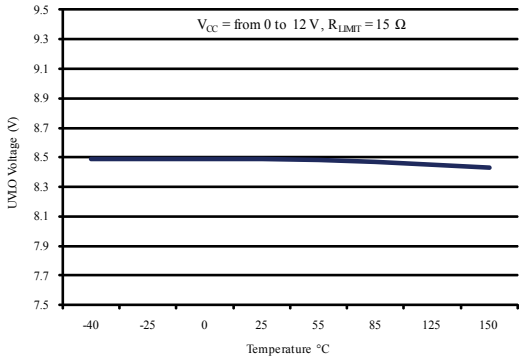

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Figure 9. UVLO hysteresis vs. temperature

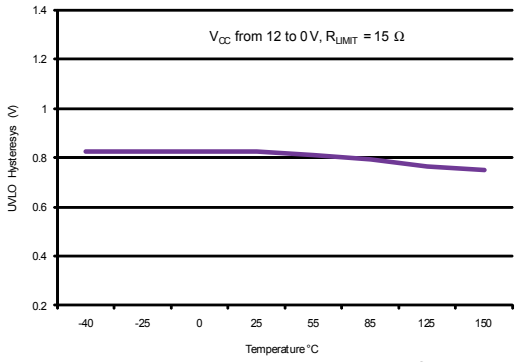

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Figure 10. Off-state voltage vs. temperature

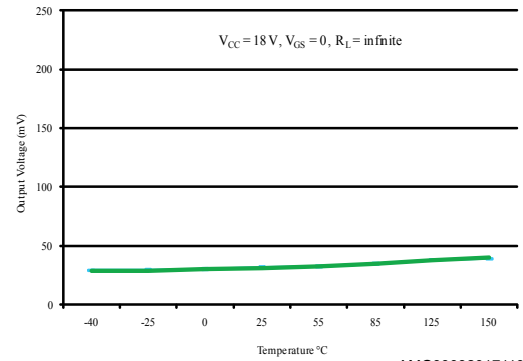

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Figure 11. Bias current (device operational)

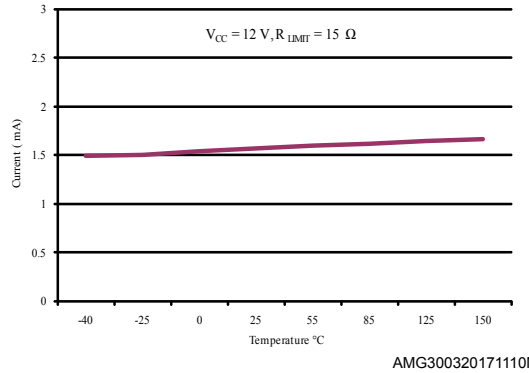

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Figure 12. ON-resistance vs. temperature

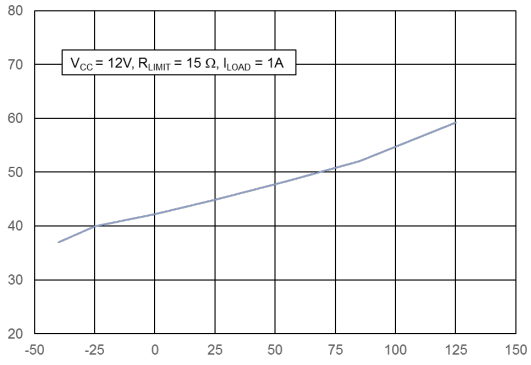

Figure 13. Current limit vs. R_{Limit}

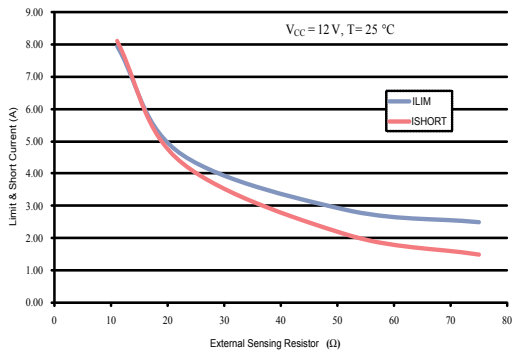

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Figure 14. Thermal latch delay vs. power

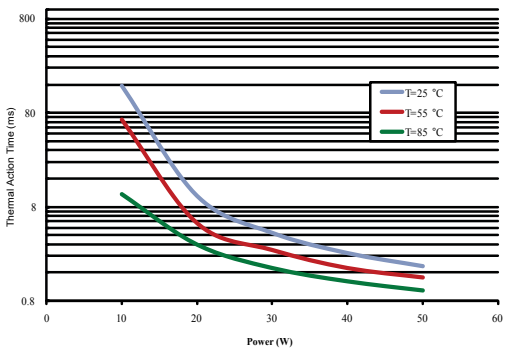

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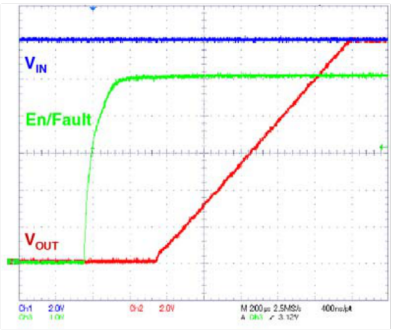
Figure 15. V_{OUT} ramp-up vs. enable



V_{CC} = 12 V, C_{IN} = 10 µF, C_{OUT} = 10 µF, R_{LIMIT} = 22 Ω, N_o $C_{dv/dt}$, T = 25 °C

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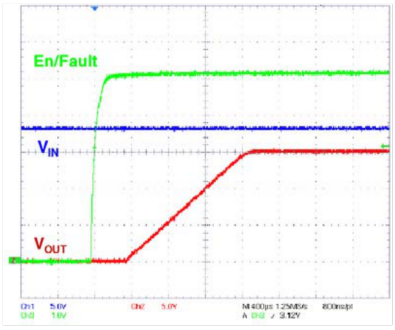
Figure 16. V_{OUT} clamping



V_{CC} = 18 V, C_{IN} = 10 µF, R_{LIMIT} = 22 Ω, No $C_{dv/dt}$,T = 25 °C

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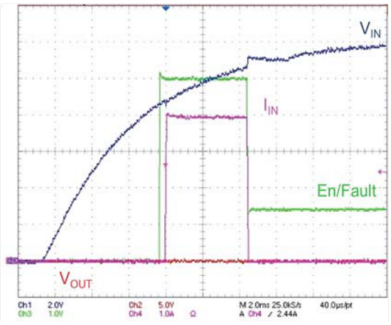
Figure 17. Line transient



V_{CC} = 12 V, R_{LIMIT} = 22 Ω, V_{OUT} = connected to GND

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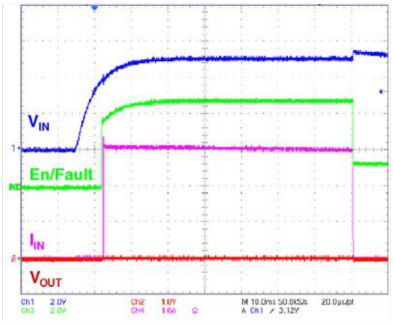
Figure 18. Startup into output short-circuit



V_{CC} = 12 V, R_{LIMIT} = 22 Ω, V_{OUT} = connected to GND

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Figure 19. Thermal latch from 2 A load to short-circuit

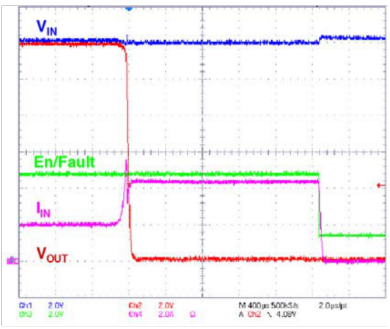

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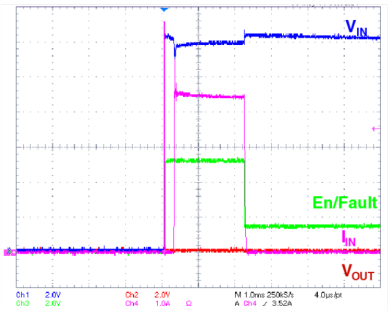
Figure 20. Startup into output short-circuit (fast rise)



V_{CC} = 12 V, R_{LIMIT} = 22 Ω, V_{OUT} = connected to GND

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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. ECOPACK is an ST trademark.

8.1 DFN10 (3x3 mm) package information

Figure 21. DFN10 (3x3 mm) package outline

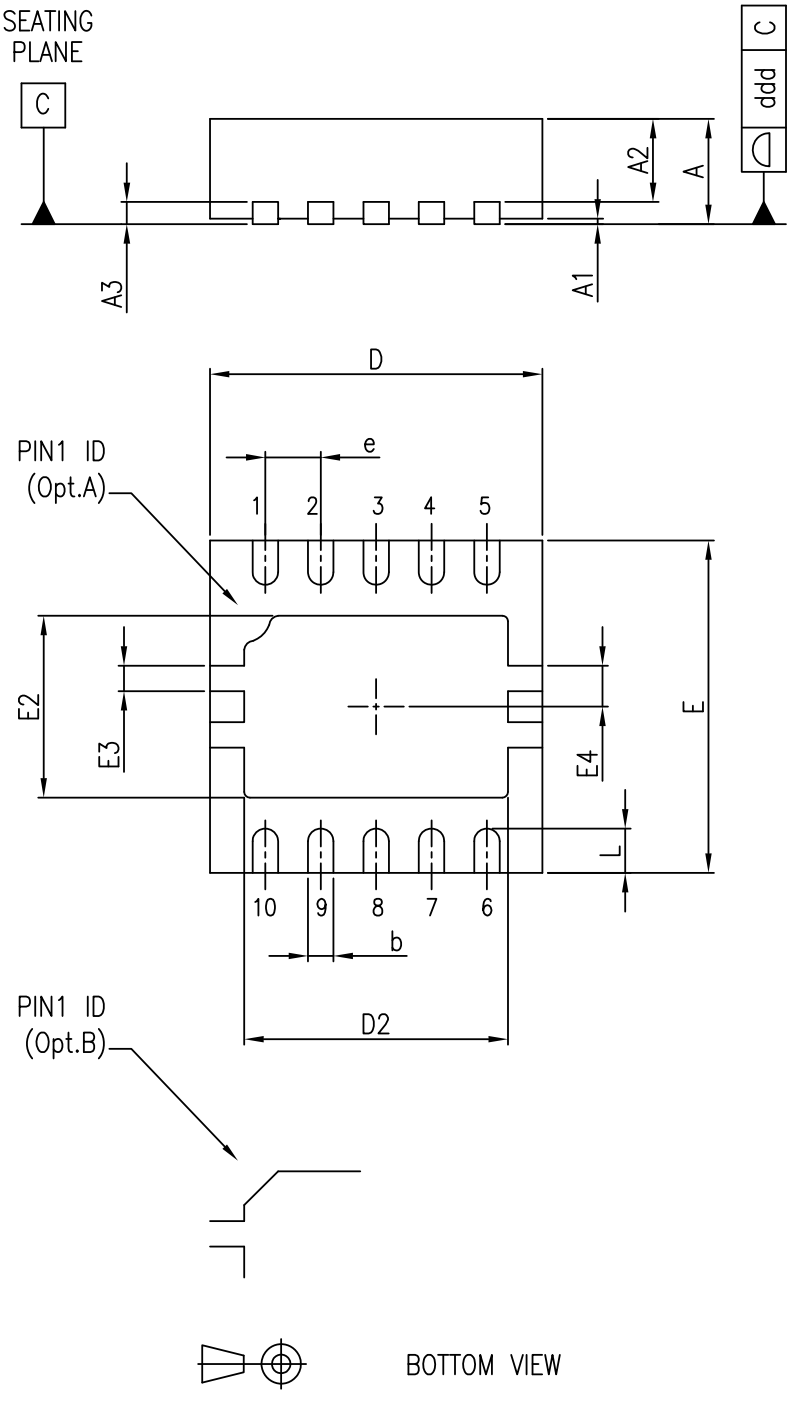
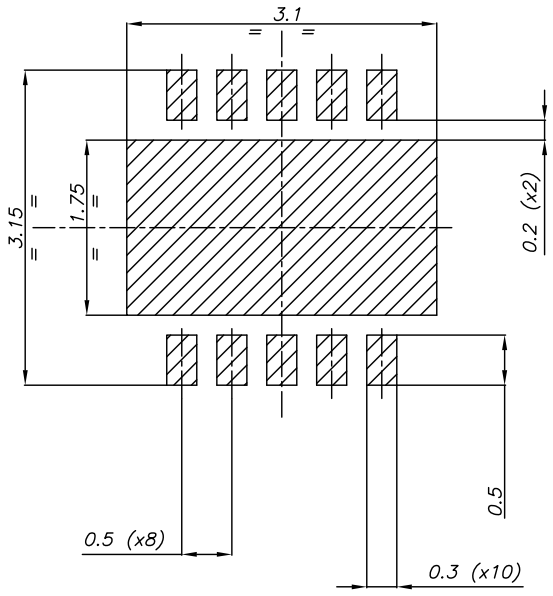


Table 6. **DFN10 (3x3 mm) mechanical data**

Dim.	mm		
	Min.	Typ.	Max.
A	0.80	0.90	1.00
A1		0.02	00.5
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	2.50
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 22. **DFN10 (3x3 mm) recommended footprint**



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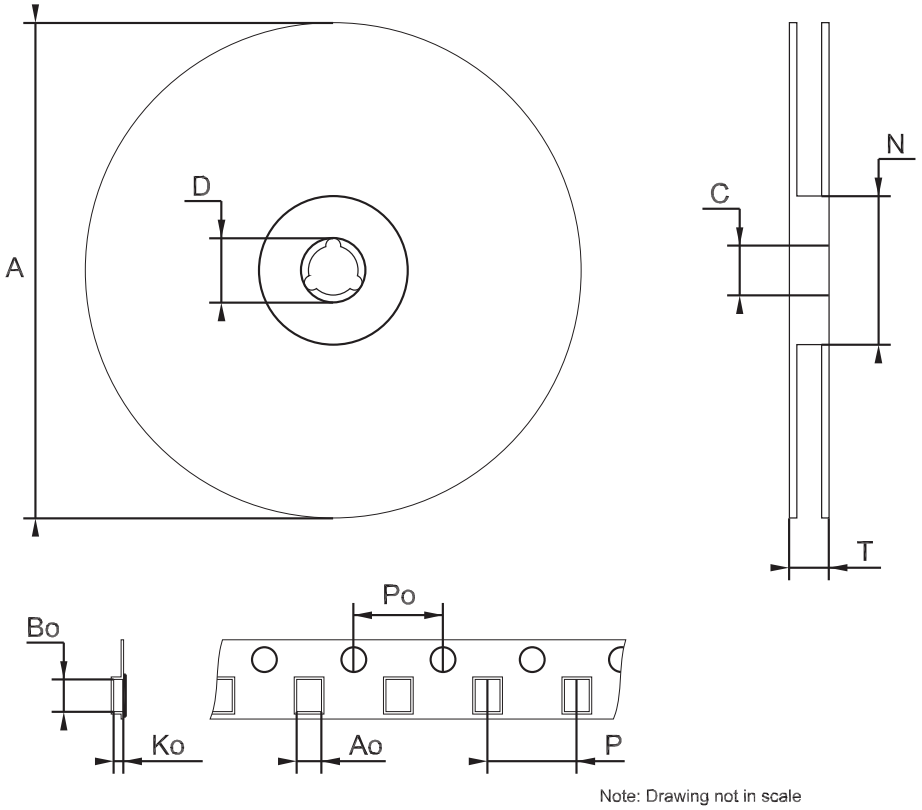
8.2 DFN10 (3 x 3 mm) package information

Figure 23. **DFN10 (3x3 mm) tape and reel outline**



Note: Drawing not in scale

Table 7. **DFN10 (3x3 mm) tape and reel mechanical data**

Dim.	mm		
	Min.	Typ.	Max.
A			330
C	12.8		13.2
D	20.2		
N	60		
T			18.4
Ao		3.3	
Bo		3.3	
Ko		1.1	
Po		4	
P		8	

Revision history

Table 8. **Document revision history**

Date	Revision	Changes
30-Oct-2018	1	Initial release.
27-Jul-2022	2	Added features on the cover page.

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