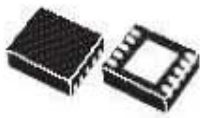
STEF4S

Electronic fuse for 3.3 V and 5 V lines

Datasheet - production data



DFN 3x3 - 10L

Features

- Power MOSFET on-resistance (typ.): 40 mΩ
- Enable function
- Output clamp voltage (typ.): 5.7 V in 5 V mode, and 3.8 V in 3.3 V mode
- Undervoltage lockout
- Short-circuit limit
- Overload foldback current limit
- Controlled soft-start
- Thermal auto-retry
- Internal sensing FET
- Operative temp. range: - 40 °C to 85 °C
- Available in DFN 3x3 10L package

Description

The STEF4S is an integrated electronic fuse optimized for monitoring the output current and the input voltage. It can be connected in series to 3.3 V or 5 V rails, protecting the electronic circuitry on its output from overcurrent and overvoltage. The operating mode (5 V or 3.3 V) can be selected by a dedicated pin. The STEF4S has a controlled turn-on time, adjustable by an external capacitor. When an overload condition occurs the device 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, the E-fuse limits the output current to a safe value.

In case of overvoltage on the input, the device clamps the output voltage to a predefined value and protects the load.

If the anomalous fault condition pe rsists, the internal thermal protection circuit shuts down the device and then automatically attempts to re-supply the load until the fault condition is removed.

Unlike mechanical fuses, which must be physically replaced after a single event, the E-fuse does not degrade in its performance after short-circuit/thermal protection interventions.

Applications

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

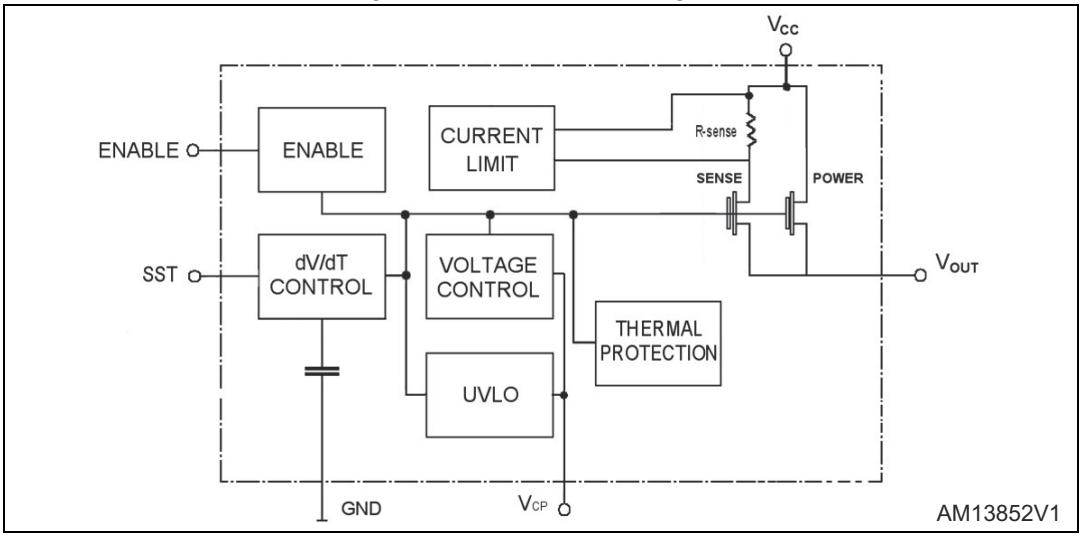
Table 1. Device summary

Order code	Package	Packing
STEF4SPUR	DFN 3x3 10L	Tape and reel

Contents

1 Block diagram

Figure 1. Device block diagram



2 Pin configuration

Figure 2. Pin configuration (top view)

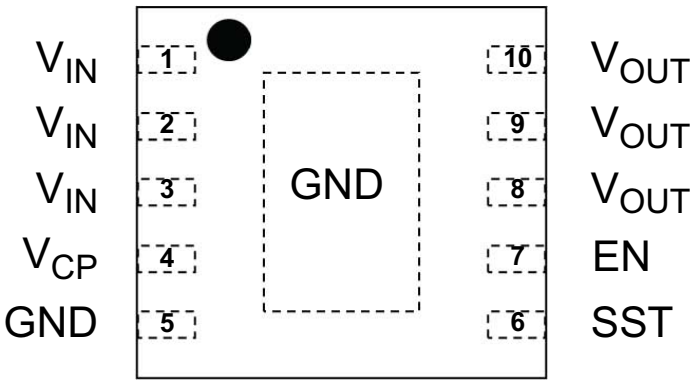


Table 2. Pin description

Pin n°	Symbol	Note
1, 2, 3	V_{IN}	Input supply voltage pin
4	V_{CP}	Voltage clamping and UVLO selection pin (high state 5 V, low state 3.3 V)
5	GND	Ground pin (can be left floating if TAB is connected to GND)
6	SST	Soft-start time selection pin. A capacitor can be connected between this pin and GND to increase the startup time
7	EN	Enable pin (active high)
8,9,10	V_{OUT}	Output voltage pin
EXP	GND	Exposed pad is internally connected to GND

3 Maximum ratings

Table 3. Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_{IN}	Positive power supply voltage	-0.3 to 15	V
V_{OUT}	Output voltage	-0.3 to 7	V
V_{CP}	UVLO and voltage clamp selection pin	-0.3 to V_{IN}	V
EN	Enable pin	-0.3 to V_{IN}	V
SST	Soft-start time selection pin	-0.3 to 4.6	V
T_J	Max. junction temperature(1)	-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 rating. It is not recommended the device to operate 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 4. Thermal data

Symbol	Parameter	Value	Unit
R_{thJA}	Thermal resistance junction-ambient	40	°C/W
R_{thJC}	Thermal resistance junction-case	2.5	°C/W

4 Electrical characteristics

Unless otherwise specified, typical values are referred to V_{IN}= 5 V for V_{CP} = V_{IN} and V_{IN} = 3.3 V for V_{CP} = GND, T = 25 ºC, min. and max. values are referred to T= - 40 ºC to 85 ºC.

Table 5. STEF4S electrical characteristics

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{IN}	Operating input voltage				10	V
Under/overvoltage protection, 3.3 V mode						
V_{Clamp}	Output clamping voltage	V_{IN} = 10 V, V_{CP} = GND	3.6	3.8	4.0	V
V_{UVLO}	Under voltage lockout	V_{CP} = GND, Turn-on, voltage going up	2.2	2.3	2.4	V
V_{Hyst}	UVLO hysteresis	V_{CP} = GND	50	90	130	mV
Under/overvoltage protection, 5 V mode						
V_{Clamp}	Output clamping voltage	V_{IN} = 10 V, V_{CP} = V_{IN}	5.4	5.7	6.0	V
V_{UVLO}	Under voltage lockout	V_{CP} = V_{IN}, Turn-on, voltage going up	3.4	3.6	3.8	V
V_{Hyst}	UVLO hysteresis	V_{CP} = V_{IN}	60	105	150	mV
Power MOSFET						
$R_{DS(on)}$	ON-resistance $R_{DS(on)} = (V_{IN}-V_{OUT})/I_{OUT}$			40		mΩ
		T_j = 85 °C(1)			70	
Current limit						
I_{OL}	Protection trip current			5		A
I_{Lim}	Overload current limit		5	7	9	A
I_{Short}	Short-circuit current limit	V_{OUT} = 0 V		3		A
Soft-start circuit						
T_{ss}	Output voltage ramp time	From V_{IN}= V_{UVLO} to V_{OUT} = 90 %, no C_{SS}		0.6		ms
		From V_{IN} = V_{UVLO} to V_{OUT} = 90 %, C_{SS} = 100 nF	16	23	30	
Enable pin thresholds						
V_{EN-L}	Enable pin switch-off voltage	Output disabled			0.4	V
V_{EN-H}	Enable pin switch-on voltage	Output enabled	2			V
V_{CP} pin thresholds						
V_{CP-L}	3.3 V mode selection threshold	3.3 V mode enabled			0.4	V
V_{CP-H}	5 V mode selection threshold	5 V mode enabled	2			V

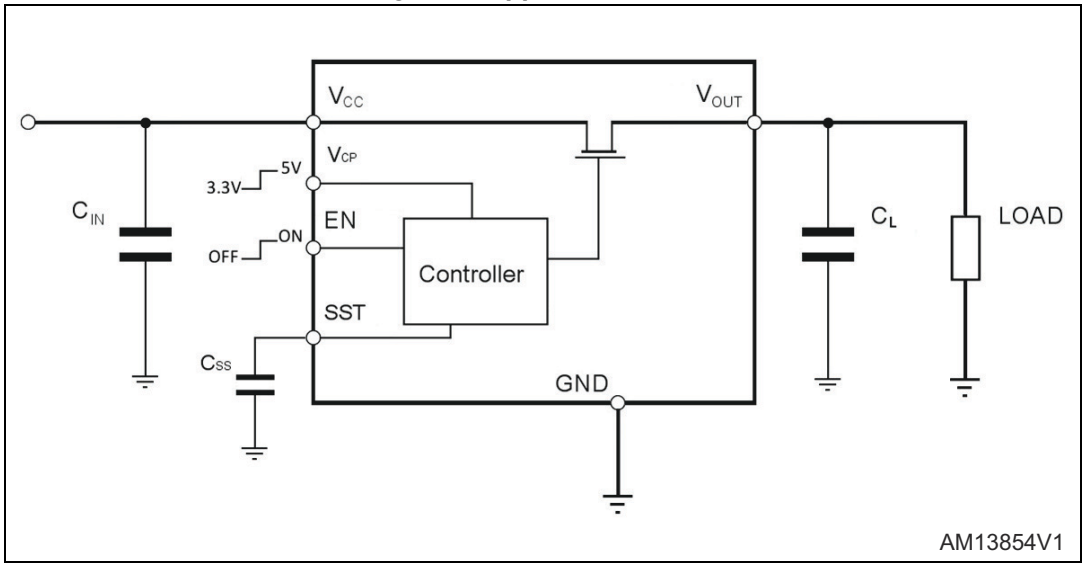
Table 5. STEF4S electrical characteristics

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
Total device						
I_{Bias}	Bias current	ON state, $V_{EN} = V_{IN} = 5$ V		50	65	µA
		OFF state, $V_{EN} = GND$, $V_{IN} = 5$ V		15		
V_{min}	Minimum operating voltage	Device is in OFF state ($V_{OUT} = 0$)	2			V
Thermal latch						
TSD	Shutdown temperature			140		°C
	Hysteresis			20		

1. Guaranteed by design, not tested in production.

5 Typical characteristics

Figure 3. Application circuit



5.1 Operating modes

5.1.1 Turn-on

When the input voltage is applied and the EN pin is high, the output voltage is supplied with a slope defined by the internal dv/dt circuitry. If no additional capacitor is connected to C_{SS} pin, the total time from the enable signal going high and the output voltage reaching the nominal value is around 0.6 ms.

5.1.2 Normal operating condition

The STEF4S E-fuse behaves like a mechanical fuse, buffering the circuitry on its output with the same voltage shown at its input, apart from a small voltage fall due to the MOSFET $R_{DS(on)}$.

5.1.3 Output voltage clamp

The internal voltage clamp circuit clamps the output voltage to the V_{Clamp} values reported in *Table 5* if the input voltage exceeds the typical thresholds of 3.8 V in the 3.3 V mode and 5.7 V in the 5 V mode.

5.1.4 Current limiting

When an overload event occurs, the current limiting circuit reduces the conductivity of the power MOSFET, in order to clamp the input current at the pre-programmed value. The current limit circuit has a foldback characteristic to reduce the power dissipation over the power MOSFET in short-circuit condition.

5.1.5 Thermal shutdown and auto-retry function

If the device temperature exceeds the thermal shutdown threshold, typically 140 °C, the thermal shutdown circuitry turns the power MOSFET off and disconnects the load. Once the die temperature has decreased about 20 °C the device automatically attempts to apply again the power to the load (auto-retry). This cycle persists until the fault condition is removed.

5.2 Startup time and C_{SS} calculation

Connecting a capacitor between the C_{SS} pin and GND allows the modification of the output voltage startup time.The startup time (T_{ss}) is defined as the time interval between the device UVLO threshold, which has been overcome, and V_{OUT} , which has reached 90% of the nominal value as shown in ***Figure 4***.

The below ***Table 6*** shows the typical startup time obtained with the industry-standard values of C_{SS}.

Table 6. Startup time vs. C_{ss} capacitor value

Parameter	Value			
C_{ss} [nF]	None	10	47	100
T_{ss} [ms]	0.6	2.3	10.8	23

The capacitance to be added to C_{SS} pin can be also estimated by using the following theoretical formula:

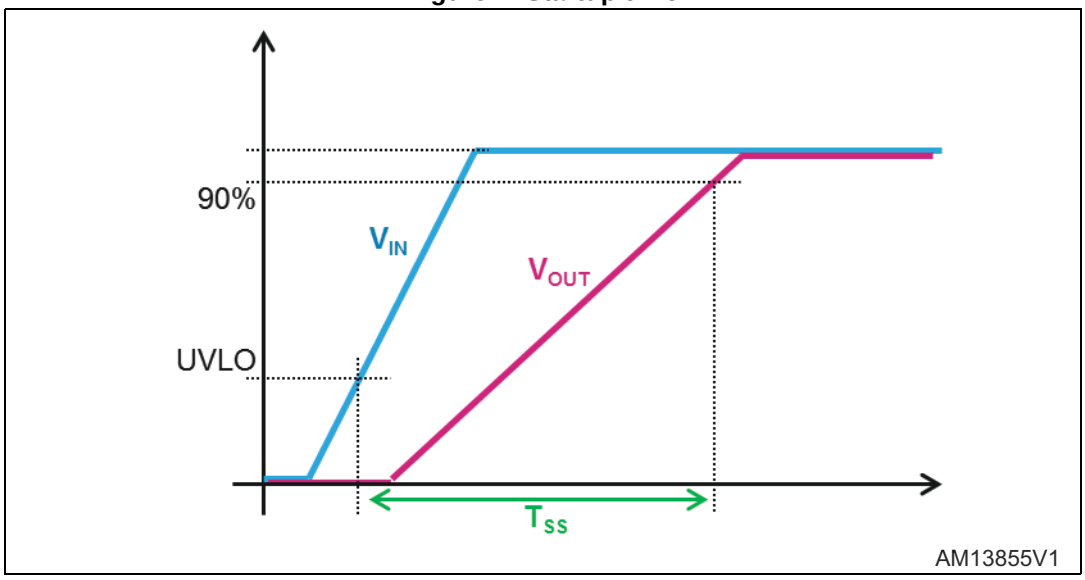
Equation 1

$$C_{SS} = 4.35 \times 10^{-6} \times Tss$$

The above value is not valid if C_{SS} is not connected. C_{SS} is expressed in Farad and the time in seconds.

A ceramic low leakage capacitor is suggested for this purpose. The formula is meant as a theoretical support to choose the C_{SS} capacitor and it does not take into account the capacitor tolerance, temperature and process variations.

Figure 4. Startup time



5.3 UVLO and voltage clamp selection

The device can be used either on the 3.3 V or on the 5 V lines. The operating mode can be selected through the V_{CP} pin.

If this pin is set at high level (V_{CP} > 2 V) the operating mode is 5 V. In this mode the UVLO threshold is 3.6 V typical, the clamping voltage is set to 5.7 V.

If the V_{CP} pin is pulled to low level (V_{CP} < 0.4 V), the operating mode is 3.3 V. In this mode the UVLO threshold is 2.3 V typical, the clamping voltage is set to 3.8 V.

5.4 Enable pin

The EN pin is used to turn on/off the device. The device is disabled when the EN pin voltage is lower than 0.4 V, enabled if the EN pin voltage is higher than 2 V.

6 Typical performance characteristics

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

Figure 5. $R_{DS(on)}$ vs temperature (3.3 V)

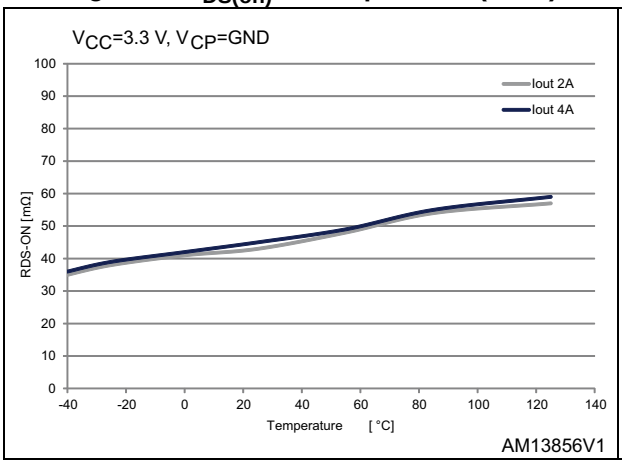


Figure 6. $R_{DS(on)}$ vs temperature (5 V)

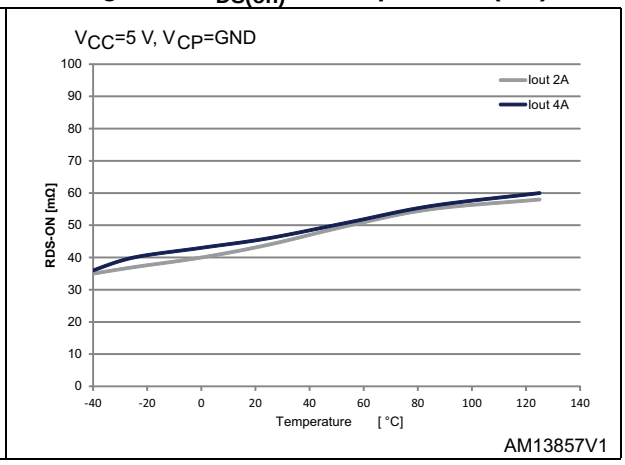


Figure 7. Clamping voltage vs temperature (3.3 V)

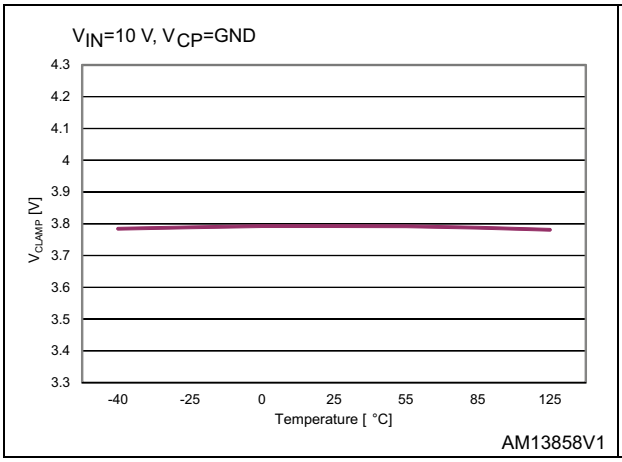


Figure 8. Clamping voltage vs temperature (5 V)

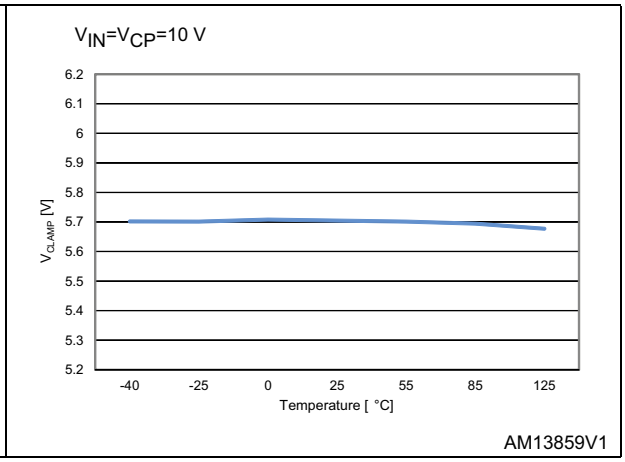


Figure 9. UVLO threshold vs temperature (3.3 V)

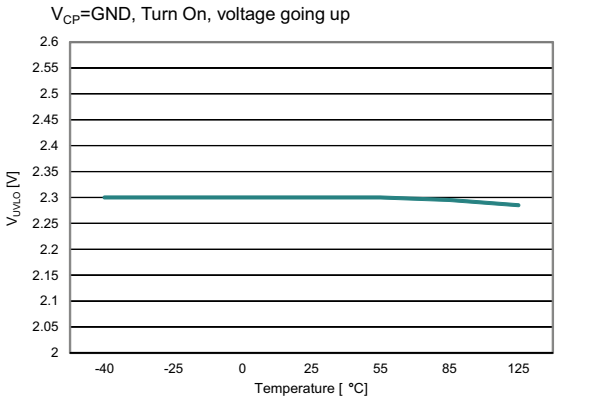


Figure 10. UVLO threshold vs temperature (5 V)

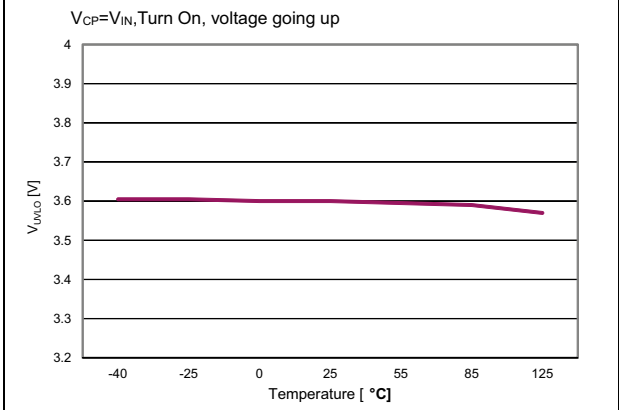


Figure 11. Bias current vs temperature (3.3 V)

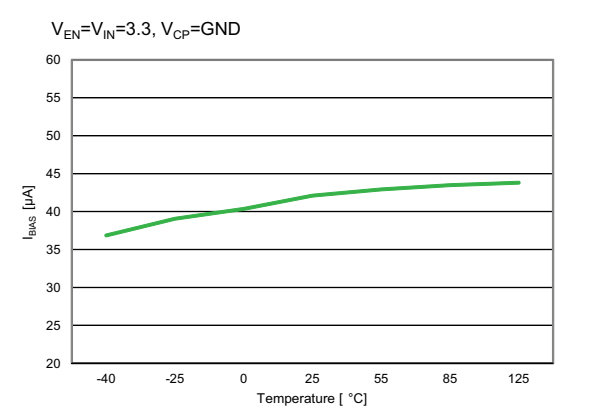


Figure 12. Bias current vs temperature (5 V)

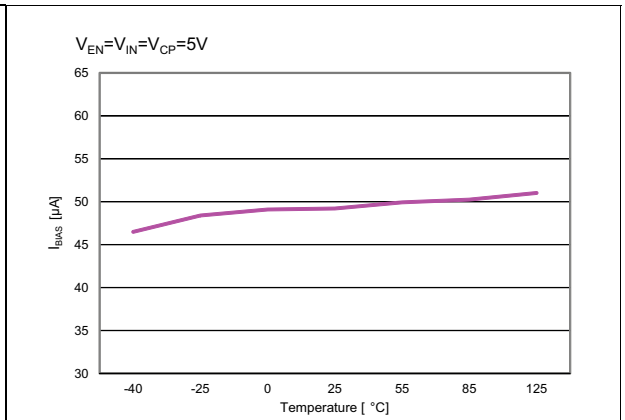


Figure 13. Shutdown current vs temperature (3.3 V)

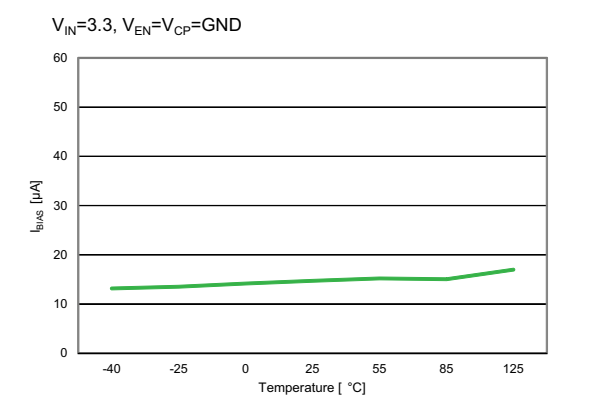


Figure 14. Shutdown current vs temperature (5 V)

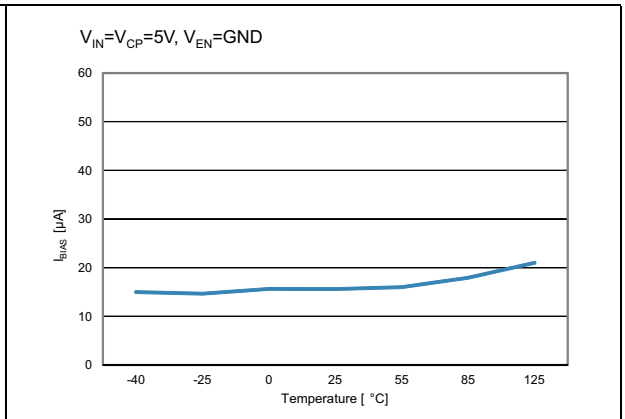


Figure 15. Trip point, overload and short-circuit current (3.3 V)

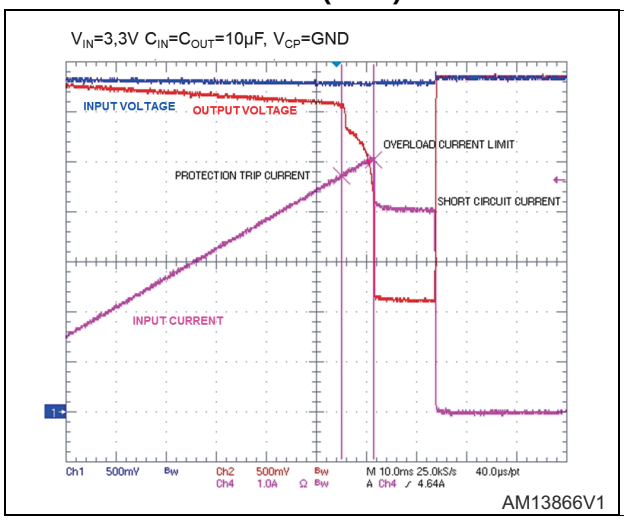


Figure 16. Trip point, overload and short-circuit current (5 V)

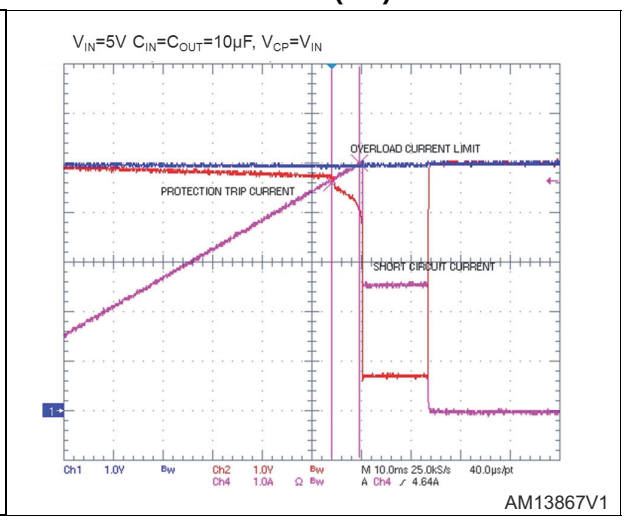


Figure 17. Startup into short-circuit (3.3 V)

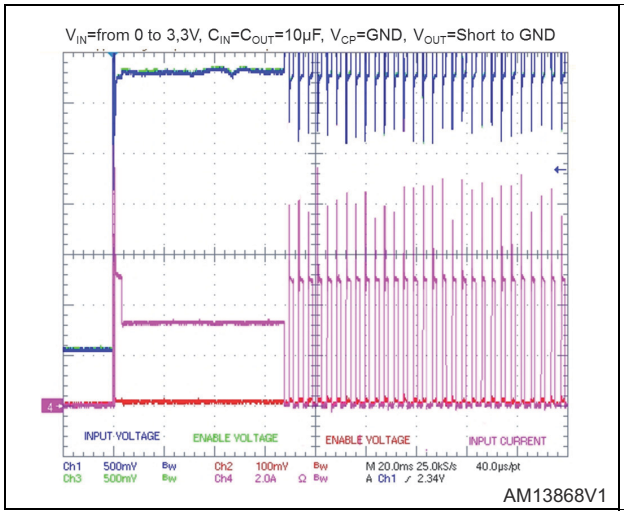


Figure 18. Startup into short-circuit (5 V)

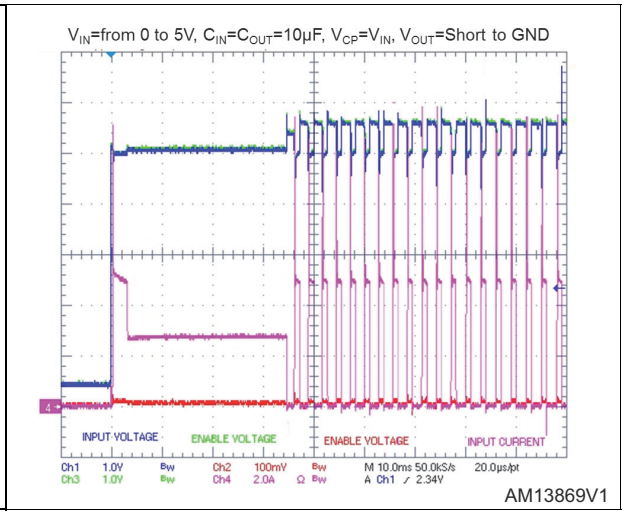


Figure 19. Soft-start behavior (3.3 V)

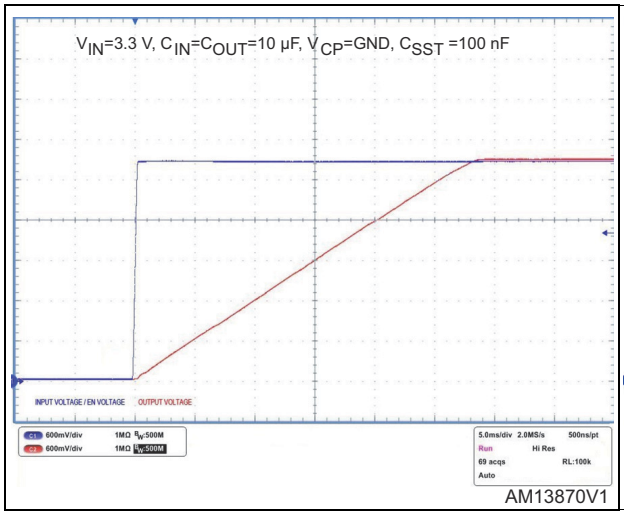
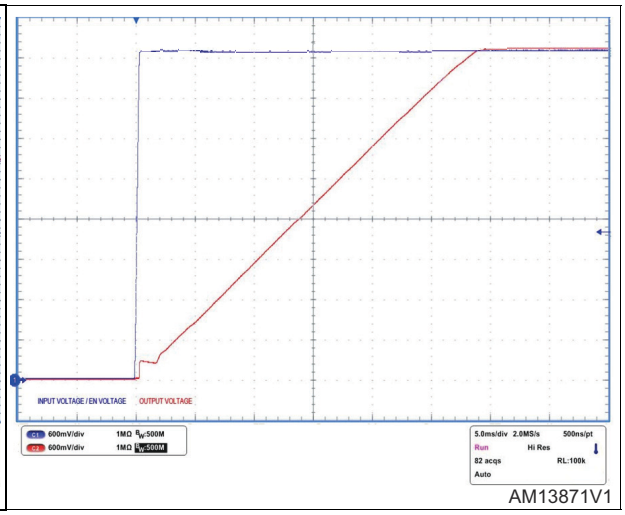


Figure 20. Soft-start behavior (5 V)



7 Package mechanical data

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.

Table 7. DFN6 (3 x 3 mm) mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A	0.70	0.75	0.80
A1	0.00	0.02	0.05
b	0.18	0.25	0.30
D		3.00	
E		3.00	
e		0.5	
D2	2.234	2.384	2.484
E2	1.496	1.646	1.746
K	0.20		
L	0.30	0.40	0.50
aaa		0.05	
bbb		0.10	
ccc		0.10	
ddd		0.05	
eee		0.08	

Figure 21. DFN6 (3 x 3 mm) drawings

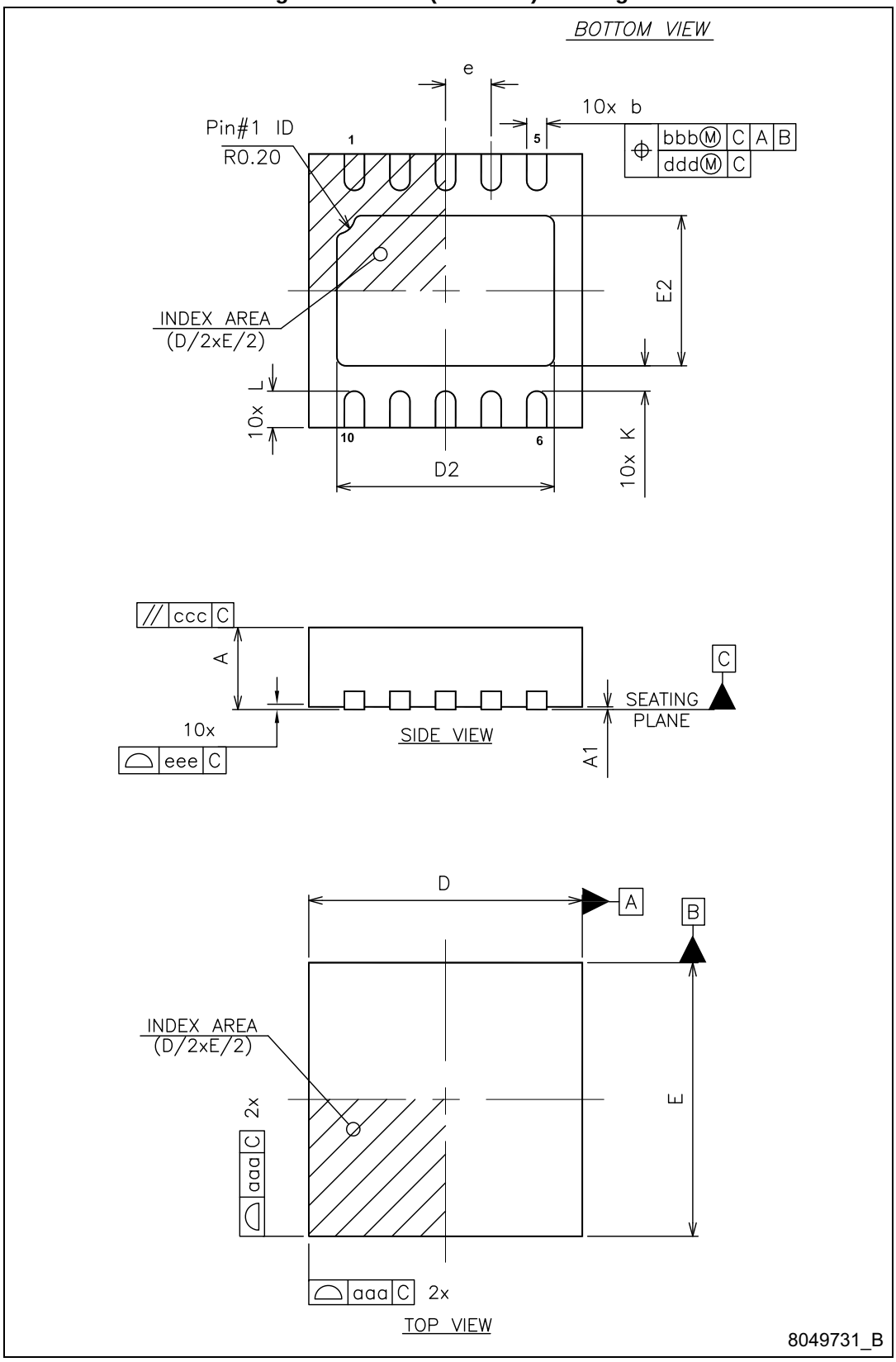
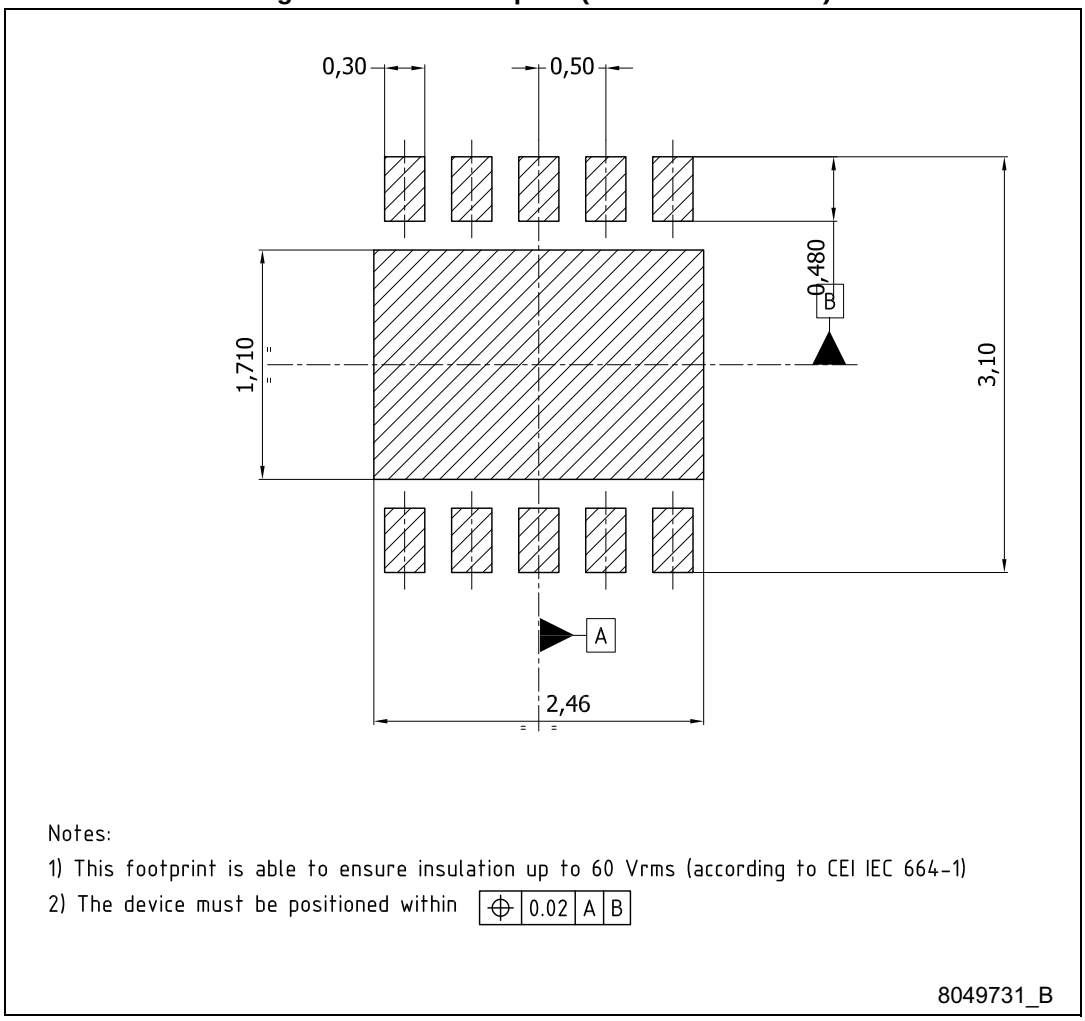


Figure 22. DFN6 footprint (dimensions in mm)



8 Packaging mechanical data

Table 8. DFN6 tape and reel mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A0	3.20	3.30	3.40
B0	3.20	3.30	3.40
K0	1	1.10	1.20

Figure 23. Tape for DFN6

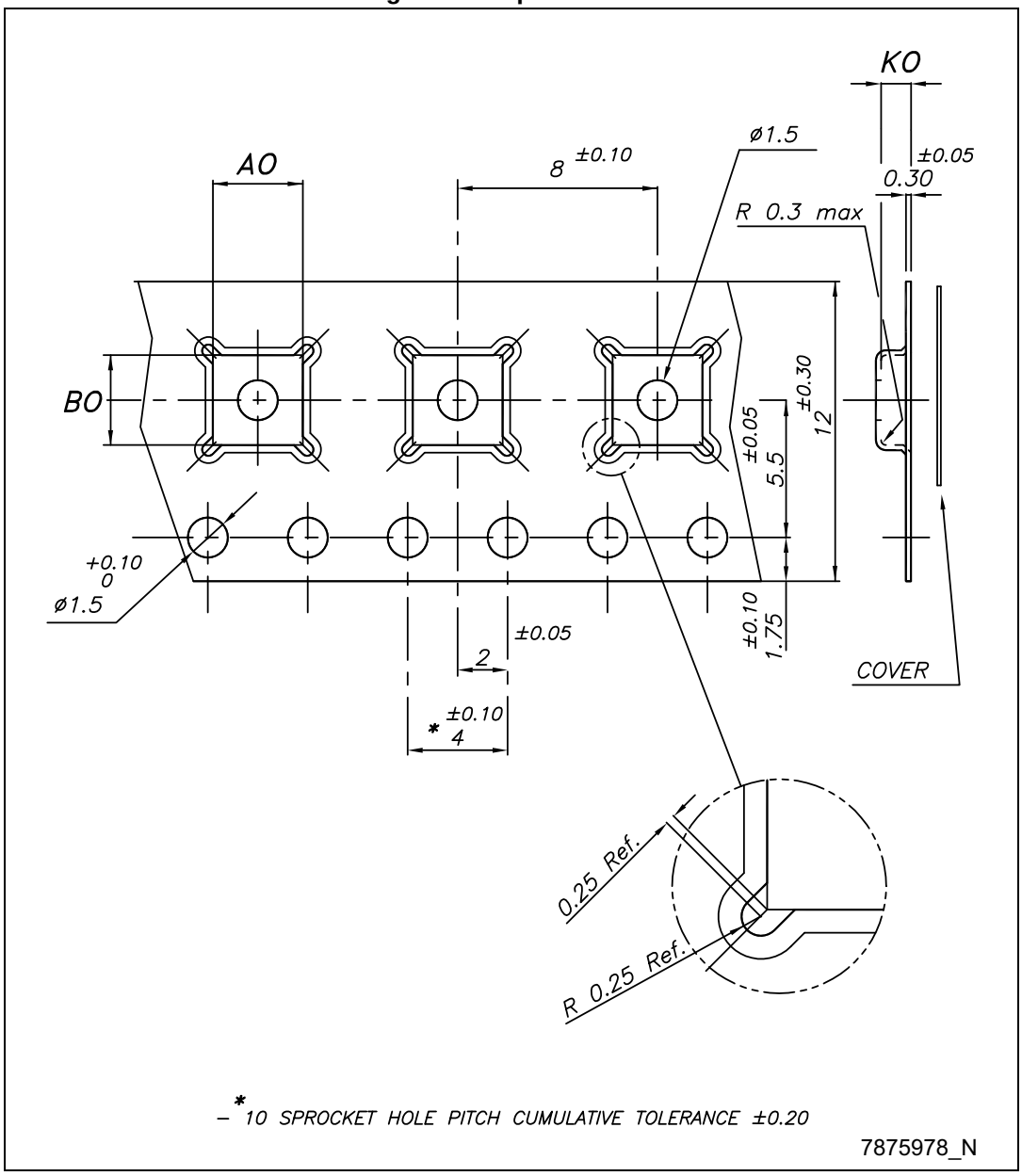


Figure 24. Reel for DFN6

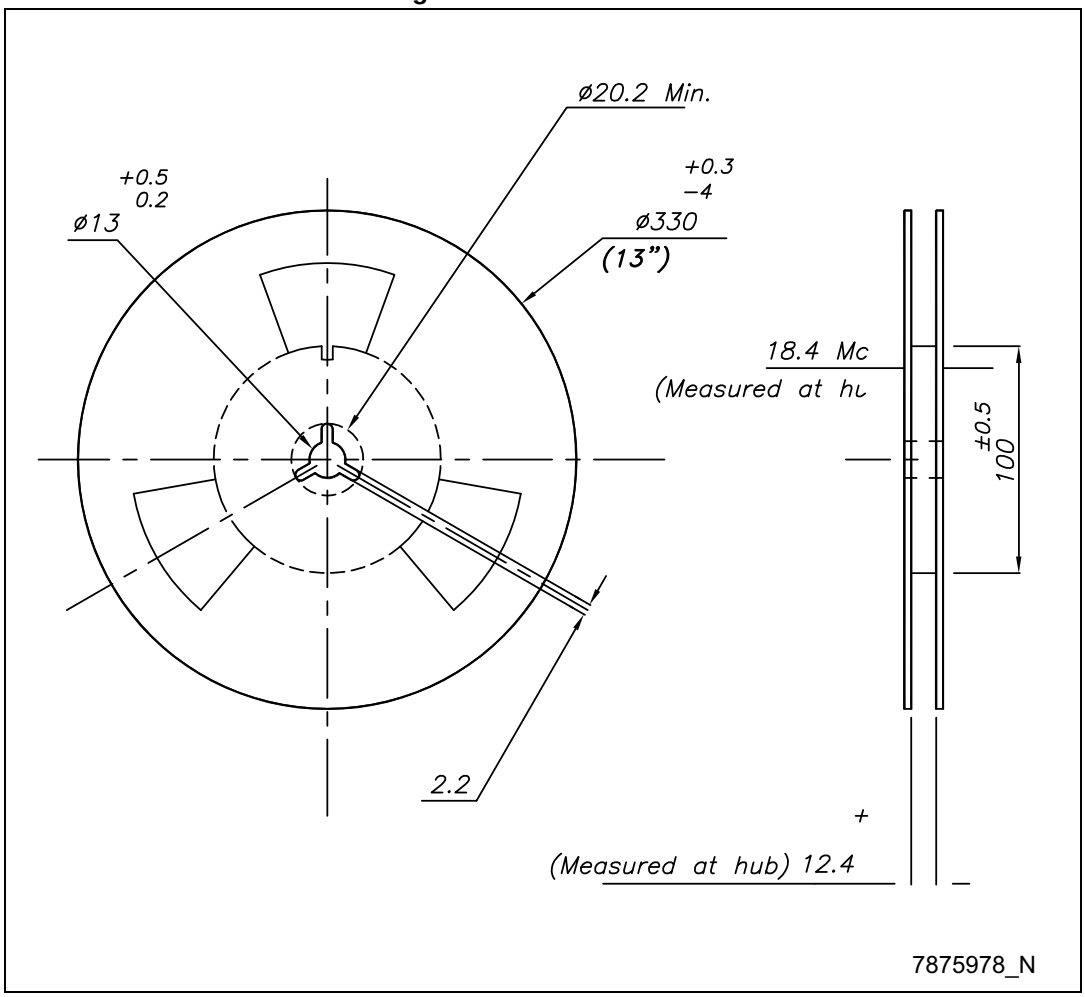
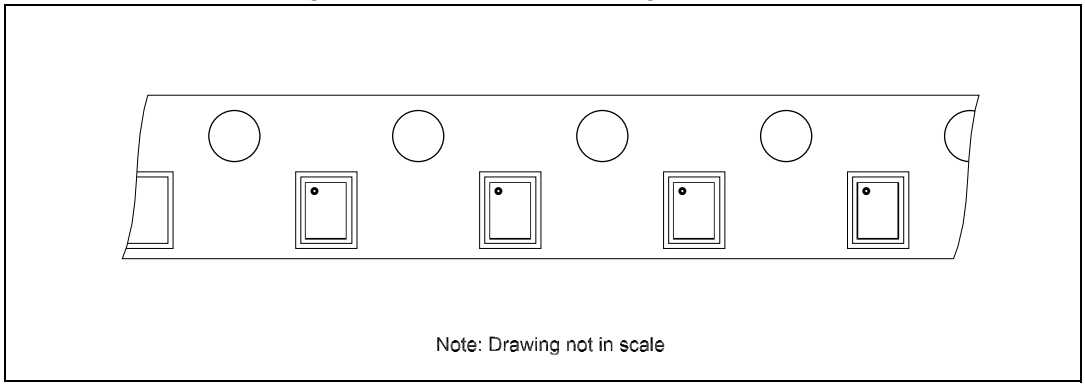


Figure 25. Schematic drawing orientation



9 Revision history

Table 9. Document revision history

Date	Revision	Changes
23-Oct-2013	1	Initial release.

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