

## 300 mA, 28 V low-dropout voltage regulator, with 5 $\mu$ A quiescent current



SOT23-5L

### Features

- Wide input voltage range : 2.5 V to 28 V
- Ultra-low quiescent current: typ. 5  $\mu$ A at no-load, 10  $\mu$ A max. across full temperature range
- Output voltage accuracy:  $\pm$  2%
- Output current up to 300 mA
- Fixed output voltage versions, starting from 1.2 V with 100 mV step
- Stable with low ESR capacitors (0.47  $\mu$ F min.)
- Thermal shutdown protection
- Current limit protection
- -40 °C to +125 °C operating temperature range

### Applications

- Post regulation
- Electronic meters
- Smoke detectors / alarms
- Portable equipment
- Industrial applications

### Description

#### Maturity status link

ST732

The ST732 is 300 mA LDO regulator, designed to be used in several medium voltage applications.

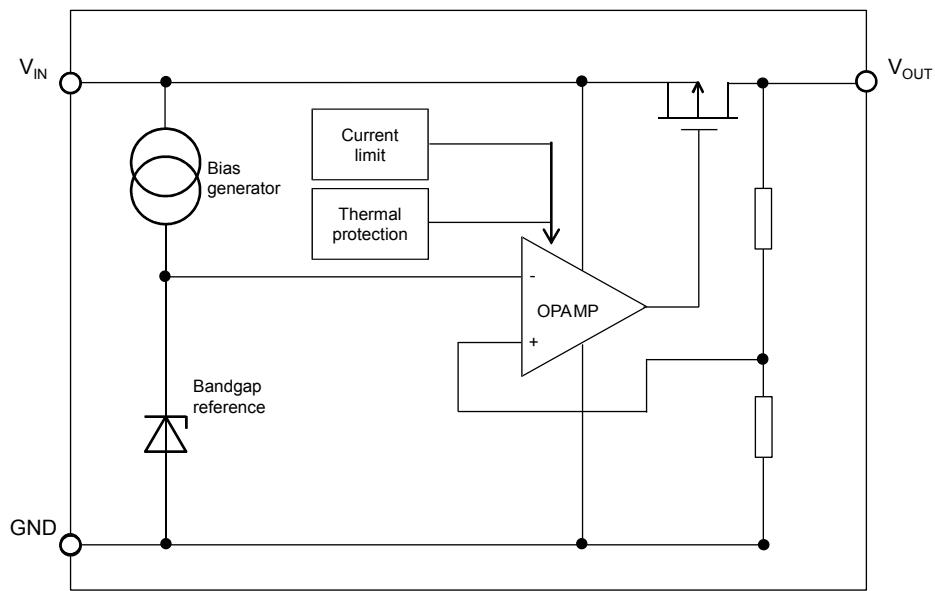
Ultra-low quiescent current of 5  $\mu$ A makes it suitable for applications permanently connected to power supply/battery.

This feature is also useful when electronic modules remain permanently turned on.

The ST732 embeds protection functions, such as: current limit, short-circuit and thermal shutdown. The extended input voltage range, very low drop voltage and low quiescent current features make it suitable also for low power after-market automotive and consumer applications.

## 1 Schematic diagram

Figure 1. Block diagram



## 2 Pin configuration

Figure 2. Pin connection (top view)

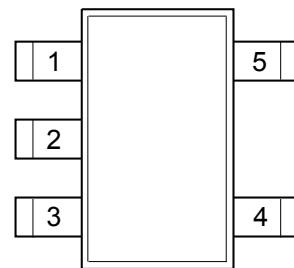
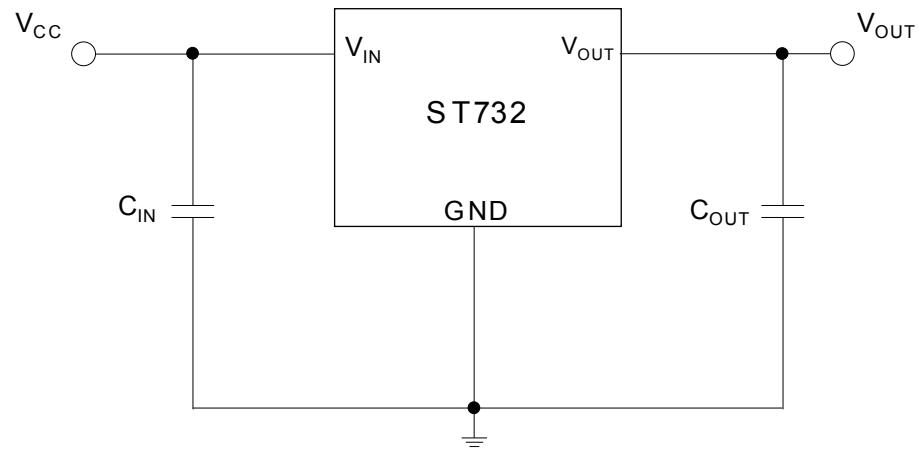


Table 1. Pin description

Pin	Symbol	Function
1	GND	Ground
2	$V_{IN}$	Input voltage
3	$V_{OUT}$	Regulated output voltage
4, 5	NC	Not internally connected

### 3 Typical application

Figure 3. Typical application circuit



## 4 Maximum ratings

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value	Unit
$V_{IN}$	DC input voltage	-0.3 to 30	V
$V_{OUT}$	DC output voltage	-0.3 to 14	V
$I_{OUT}$	Output current	Internally limited	mA
$P_D$	Power dissipation	Internally limited	mW
$T_{ST}$	Storage temperature range	-65 to 150	°C
$T_{OP}$	Operating temperature range	-40 to 125	°C

**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	Value	Unit
$R_{thJA}$	Thermal resistance junction-ambient	190	°C/W
$R_{thJC}$	Thermal resistance junction-case	75	°C/W

**Note:**  $R_{thJA}$  based on 4-layer (2S2P) JEDEC test board constructed based on JESD 51-7 specification.

**Table 4. Electro static discharge**

Symbol	Parameter	Value	Unit
HBM	Human body model	±2	kV
CDM	Charged device model	±500	V

## 5 Electrical characteristics

$T_A = T_J = -40$  °C to  $+125$  °C, typical values refer to  $T_A = +25$  °C,  $V_{IN} = V_{OUT} + 1$  V,  $I_{OUT} = 10$  mA,  $C_{IN} = 0.1$  µF,  $C_{OUT} = 0.47$  µF, unless otherwise specified (see note).

Table 5. Electrical characteristics

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{IN}$	Operating input voltage		2.5		28	V
$V_{OUT}$	Output voltage accuracy	$T_J = 25$ °C	-1		+1	%
		$-40$ °C $< T_J < +125$ °C	-3		+3	%
$\Delta V_{OUT}$	Static line regulation	$V_{IN} = V_{OUT(NOM)} + 1$ V to 28 V		0.01	0.05	%/V
$\Delta V_{OUT}$	Static load regulation	$I_{OUT} = 1$ mA to 300 mA <sup>(1)</sup>		0.0001		%/mA
$V_{DROP}$	Dropout voltage	$I_{OUT} = 100$ mA, $V_{IN} = V_{OUT(NOM)} - 0.1$ V		200	350	mV
		$I_{OUT} = 300$ mA, $V_{IN} = V_{OUT(NOM)} - 0.1$ V		600	1200	mV
$I_Q$	Quiescent current	$I_{OUT} = 0$ mA		5	10	µA
		$I_{OUT} = 300$ mA		120	200	
$e_N$	Output noise voltage <sup>(2)</sup>	$f = 10$ Hz to 100 kHz, $I_{OUT} = 10$ mA $C_{OUT} = 1$ µF		70		µVRMS/ $V_{OUT}$
SVR	Supply voltage rejection <sup>(2)</sup>	$V_{IN} = V_{OUT(NOM)} + 1$ V $\pm V_{RIPPLE}$ $V_{RIPPLE} = 0.5$ V, $f = 120$ Hz, $V_{OUT(NOM)} = 5$ V		75		dB
		$V_{IN} = V_{OUT(NOM)} + 1$ V $\pm V_{RIPPLE}$ $V_{RIPPLE} = 0.5$ V, $f = 1$ kHz, $V_{OUT(NOM)} = 5$ V		75		
		$V_{IN} = V_{OUT(NOM)} + 1$ V $\pm V_{RIPPLE}$ $V_{RIPPLE} = 0.5$ V, $f = 10$ kHz, $V_{OUT(NOM)} = 5$ V		42		
		$V_{IN} = V_{OUT(NOM)} + 1$ V $\pm V_{RIPPLE}$ $V_{RIPPLE} = 0.5$ V, $f = 100$ Hz, $V_{OUT(NOM)} = 5$ V		35		
$I_{SC}$	Short-circuit current <sup>(3)</sup>	$R_L = 0$		450		mA
$T_{SHDN}$	Thermal shutdown <sup>(2)</sup>			160		°C
	Hysteresis <sup>(2)</sup>			20		

1. The device is able to properly regulate the output voltage with no load.
2. Guaranteed by design, not tested in production.
3. The current limit is a function of  $(V_{IN} - V_{OUT})$  differential during operation. Maximum available current is limited. Refer to Section 6.3 Protection features for more information.

Note: Values in full temperature range are guaranteed by design and/or characterization tested at  $T_A = \sim T_J$ . Low duty-cycle pulse techniques are used.

## 6 Application information

### 6.1 External capacitors

The ST732 voltage regulator requires external capacitors to ensure the control loop stability. These capacitors must be selected to meet the requirements of minimum capacitance and equivalent series resistance defined in the following chapters. Input and output capacitors should be located as close as possible to the relevant pins.

#### Input capacitor

An input capacitor, whose minimum value is 0.1  $\mu$ F, must be placed as close as possible to the input in of the device and returned to a clean analog ground. A good quality, low-ESR ceramic capacitor is suggested. It helps to ensure stability of the control loop, reduces the effects of inductive sources and improves ripple rejection. Values, which are higher than 0.1  $\mu$ F, are suggested in case of fast load transients in the application. There is no maximum limit to the output capacitance.

#### Output capacitor

The ST732 requires a capacitor connected on its output, to keep the control loop stable and reduce the risk of ringing and oscillations. The control loop is designed to be stable with any good quality ceramic capacitor (such as X5R/X7R types) with a minimum value of 0.47  $\mu$ F and equivalent series resistance in the [5 – 500 m $\Omega$ ] range.

It is important to highlight that the output capacitor must maintain its capacitance and ESR in the stable region over the full operating temperature, load and input voltage ranges, to assure stability. Therefore, capacitance and ESR variations must be taken into account in the design phase to ensure the device works in the expected stability region.

There is no maximum limit to the output capacitance, provided that the above conditions are satisfied.

### 6.2 Power dissipation

A proper PCB design is recommended, to ensure that the device internal junction temperature is kept below 125 °C, in all operating conditions. The thermal energy, generated by the device, flows from the die surface to the PCB copper area through the package leads. The PCB copper area acts as a heat sink. The footprint copper pads should be as wider as possible to spread and dissipate heat to the surrounding environment. Thermal micro-vias to the inner or backside copper layers improve the overall thermal performance of the device.

The power dissipation of the LDO depends on the input voltage, output voltage and output current, and is given by:

$$P_D = (V_{IN} - V_{OUT}) I_{OUT} \quad (1)$$

The junction temperature of the device is:

$$T_{J\_MAX} = T_A + R_{thJA} \times P_D \quad (2)$$

where:  $T_{J\_MAX}$  is the maximum junction of the die, 125 °C;  $T_A$  is the ambient temperature;  $R_{thJA}$  is the thermal resistance junction-to-ambient.

With the above equation it is possible to calculate the allowable maximum power dissipation, therefore the maximum load current for a certain voltage drop. Appropriate de-rating of the operating condition can be applied accordingly.

### 6.3 Protection features

#### Current limit

Due to the wide input voltage range, high power dissipation could occur in case of damaged/shorted load. For this reason the ST732 embeds an SOA protection-current limit circuit, which acts in case of overload or short-circuit on the output, clamping the load current to a safe value.

The current limit value on purpose depends on the voltage drop ( $V_{IN} - V_{OUT}$ ), so that the maximum dissipated power is always kept under control.

The non-constant current limit characteristic shown in [Figure 15. Current limit vs. temperature](#) should be taken into account to calculate the maximum load current the device can supply for a certain dropout voltage.

Normal operation is restored if the overload disappears, but prolonged operation in current limit may lead to high power dissipation inside the LDO and subsequently to thermal shutdown.

### Thermal protection

An internal thermal feedback loop disables the output voltage if the die temperature reaches approximately 160 °C. This feature protects the device from excessive temperature that could lead to permanent damage to the LDO.

Once the thermal protection is triggered and the device is shut down, normal operation is automatically recovered if the die temperature falls below 140 °C (thermal protection hysteresis of 20 °C typically).

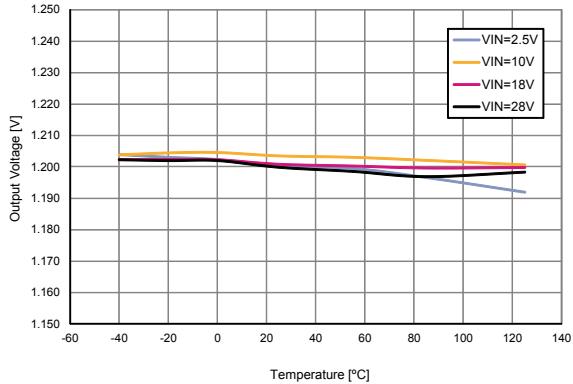
Continuous operation above the maximum ratings may lead to permanent damage to the device.

In case of operations with strongly inductive loads, undershoots on the output may happen. If those negative spikes overcome the absolute maximum ratings of the device, permanent damage may occur. A Schottky diode connected in parallel to the output port reduces the risk of damages in such operating cases.

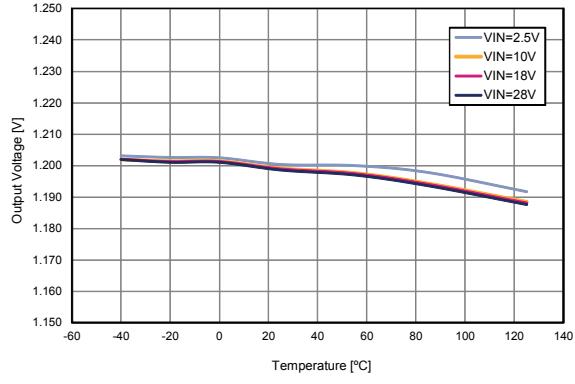
## 7 Typical performance characteristics

$C_{IN} = C_{OUT} = 1 \mu F$ ,  $V_{IN} = 2.5 V$ ,  $V_{OUT} = 1.2 V$ ,  $T_J = 25 ^\circ C$ , unless otherwise specified.

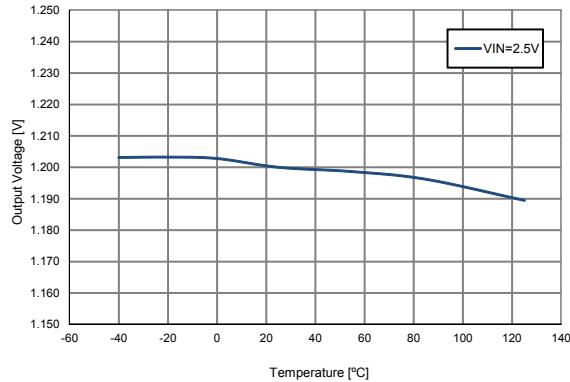
**Figure 4. Output voltage vs. temperature ( $I_{OUT} = 0 \text{ mA}$ )**



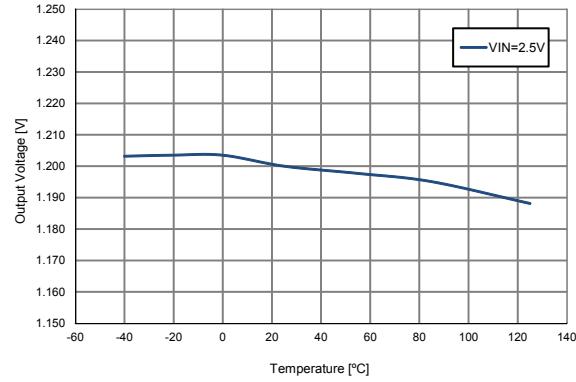
**Figure 5. Output voltage vs. temperature ( $I_{OUT} = 10 \text{ mA}$ )**

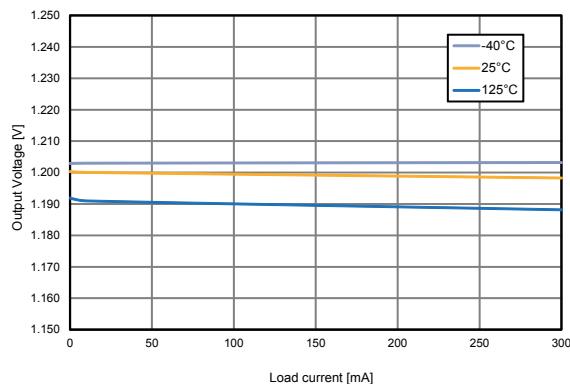
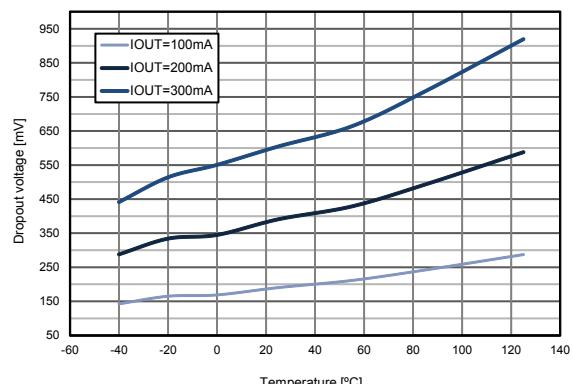
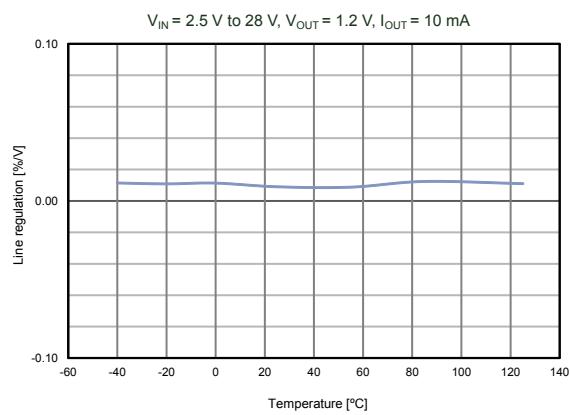
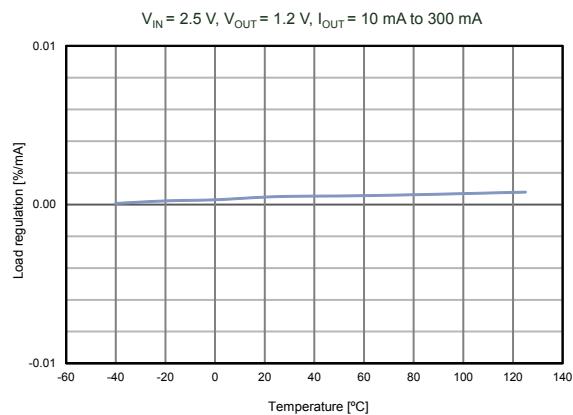
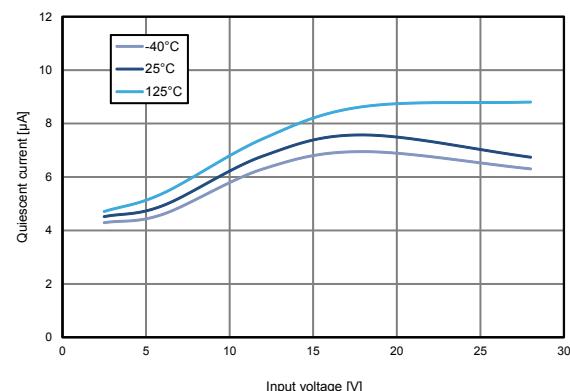
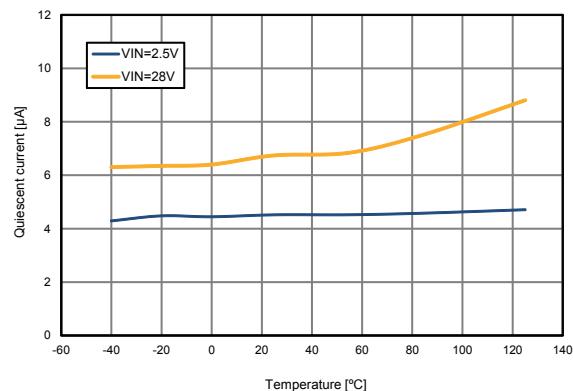


**Figure 6. Output voltage vs. temperature ( $I_{OUT} = 150 \text{ mA}$ )**

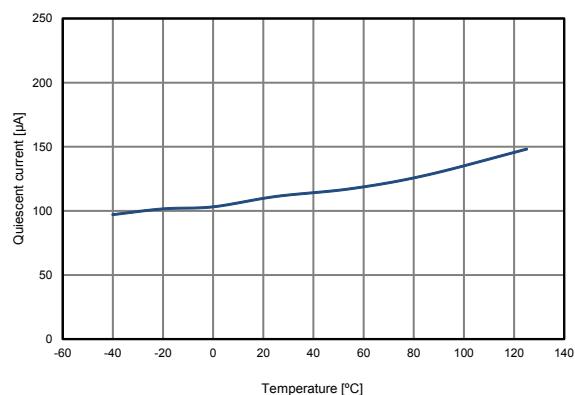


**Figure 7. Output voltage vs. temperature ( $I_{OUT} = 300 \text{ mA}$ )**

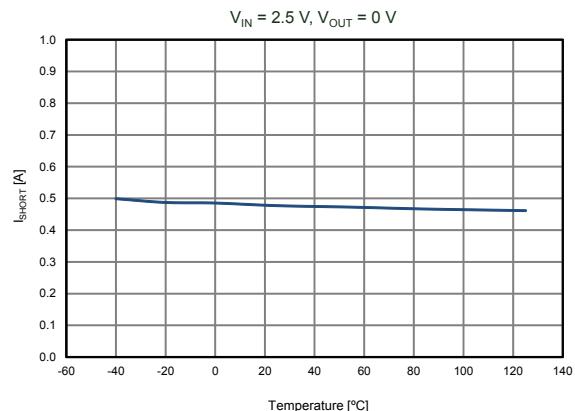


**Figure 8. Output voltage vs. load current**

**Figure 9. Dropout voltage vs. temperature**

**Figure 10. Line regulation vs. temperature**

**Figure 11. Load regulation vs. temperature**

**Figure 12. Quiescent current vs. input voltage (I<sub>OUT</sub> = 0 mA)**

**Figure 13. Quiescent current vs. temperature (I<sub>OUT</sub> = 0 mA)**


**Figure 14. Quiescent current vs. temperature ( $I_{OUT} = 300$  mA)**



**Figure 15. Current limit vs. temperature**



**Figure 16. Short-circuit current vs. dropout voltage**

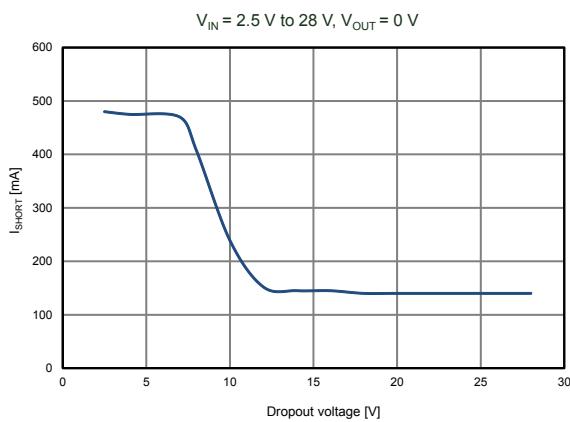
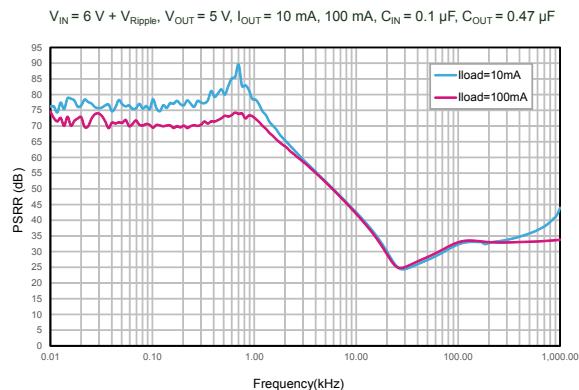
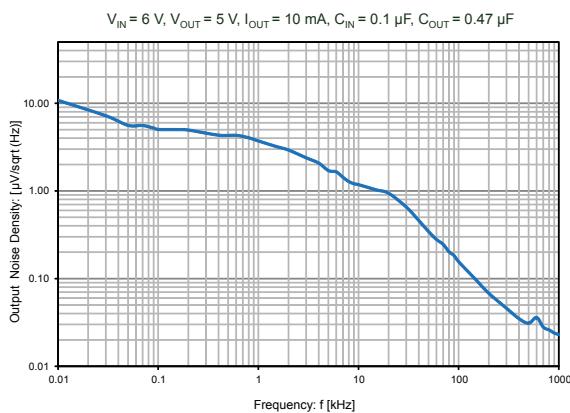


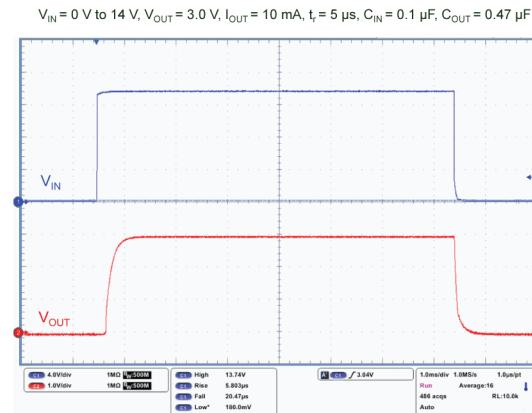
Figure 17. PSRR vs. frequency



**Figure 18. Output noise spectrum**

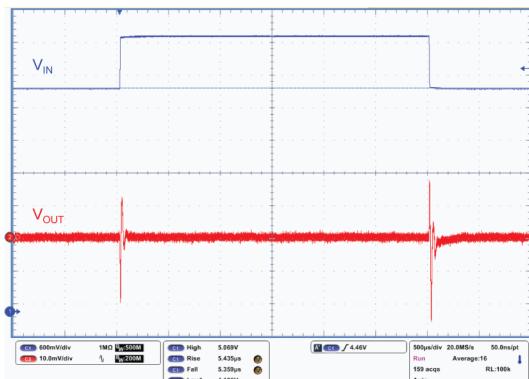


**Figure 19. Start-up transient**



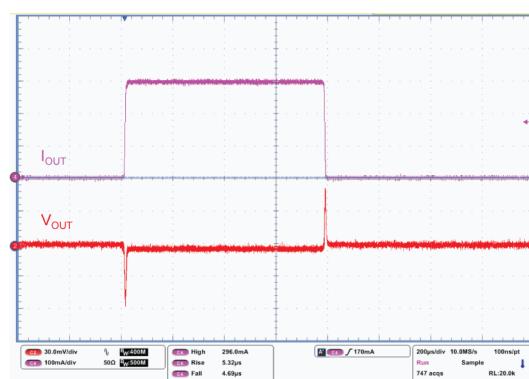
**Figure 20. Line transient**

$V_{IN} = 4 \text{ V to } 5 \text{ V}$ ,  $V_{OUT} = 3.0 \text{ V}$ ,  $I_{OUT} = 10 \text{ mA}$ ,  $t_r = t_f = 5 \text{ } \mu\text{s}$ ,  $C_{IN} = 0.1 \text{ } \mu\text{F}$ ,  $C_{OUT} = 0.47 \text{ } \mu\text{F}$



**Figure 21. Load transient**

$$V_{IN} = 2.5 \text{ V}, V_{OUT} = 1.2 \text{ V}, I_{OUT} = 10 \text{ mA to } 300 \text{ mA}, t_r = 5 \text{ } \mu\text{s}, C_{IN} = 0.1 \text{ } \mu\text{F}, C_{OUT} = 10 \text{ } \mu\text{F}$$



## 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 SOT23-5L package information

Figure 22. SOT23-5L package outline

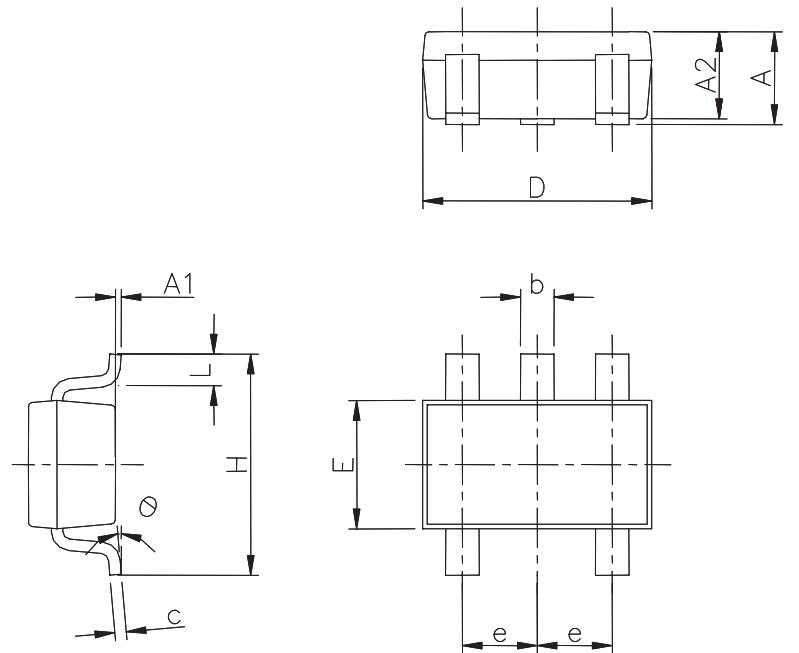
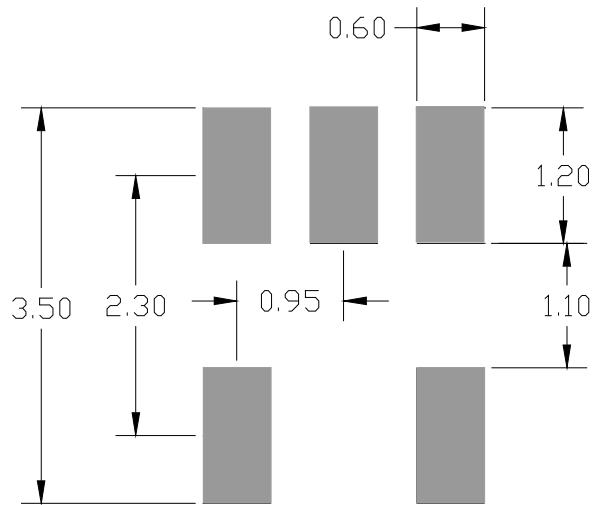


Table 6. SOT23-5L package mechanical data

Dimension	mm		
	Min.	Typ.	Max.
A	0.90		1.45
A1	0		0.15
A2	0.90		1.30
b	0.30		0.50
c	0.09		0.20
D		2.95	
E		1.60	
e		0.95	
H		2.80	
L	0.30		0.60
$\theta$	0		10

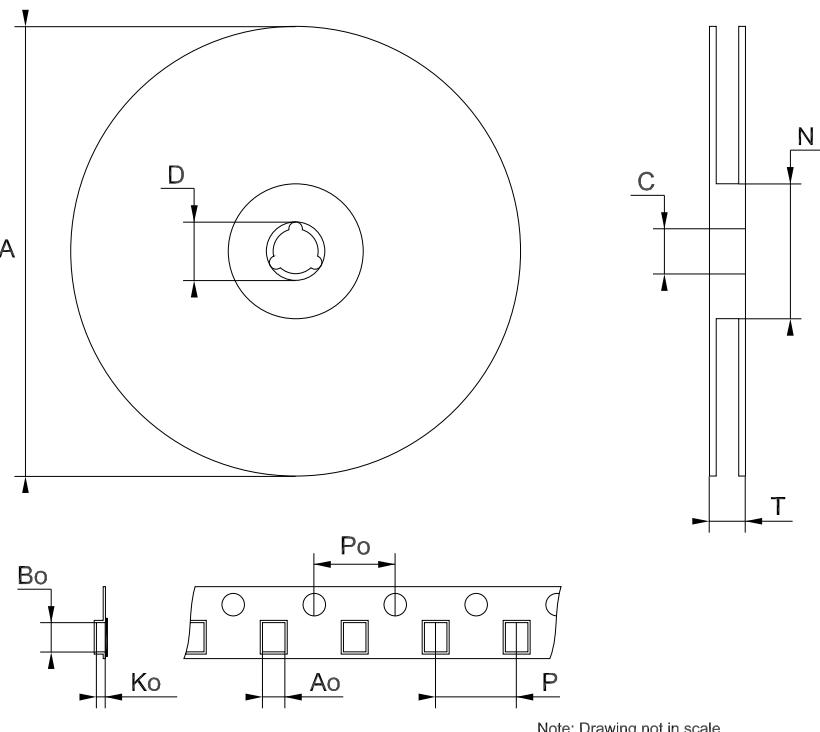
Figure 23. SOT23-5L recommended footprint



Note: Dimensions are in mm

## 8.2 Packing information

Figure 24. SOT23-5L tape and reel drawing



**Table 7. SOT23-5L tape and reel mechanical data**

Dimension	mm		
	Min.	Typ.	Max.
A			180
C	12.8	13.0	13.2
D	20.2		
N	60		
T			14.4
Ao		3.15	
Bo		3.2	
Ko		1.4	
Po	3.9	4.0	4.1
P	3.9	4.0	4.1
W	7.9	8	8.3

## 9 Ordering information

**Table 8. Order code**

Order code	Output voltage	Marking
ST732M28R	2.8 V	228
ST732M30R	3.0 V	230
ST732M33R	3.3 V	233
ST732M36R	3.6 V	236
ST732M50R	5.0 V	250

*Note:* Other voltage options available on request.

## Revision history

**Table 9. Document revision history**

Date	Revision	Changes
03-May-2018	1	Initial release.
16-Jun-2020	2	Updated Order code.
22-04-2021	3	Added new order code in Table 8

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