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TS33

Datasheet

Micropower high precision series voltage reference



Features

- Fixed 1.25 V,1.8 V, 2.048 V, 2.5 V, 3.0 V, 3.3 V 4.096 V, 5.0 V output voltage
- Ultra low operating current: 3.9 µA (typ.) at 25 °C
- High initial accuracy: +/-0.15 %
- Stable when used with capacitive loads
- Extended temperature range: -40 to +125 °C
- 30 ppm/°C maximum temperature coefficient
- Available in QFN8 1.5x1.5, SOT23-3L and SOT323-3L packages.

Applications

- Portable equipment
- Data acquisition systems
- Instrumentation
- Medical equipment
- Test equipment

Description

The TS33 family of low power series voltage references is capable of providing stable and precise output voltages with an initial accuracy of 0.15% over an extended temperature range (-40 to +125 °C).

The ultra low operating current is a key advantage for power-restricted designs. In addition, the TS33 is very stable over the entire operating temperature range, making it suitable for high-precision applications.

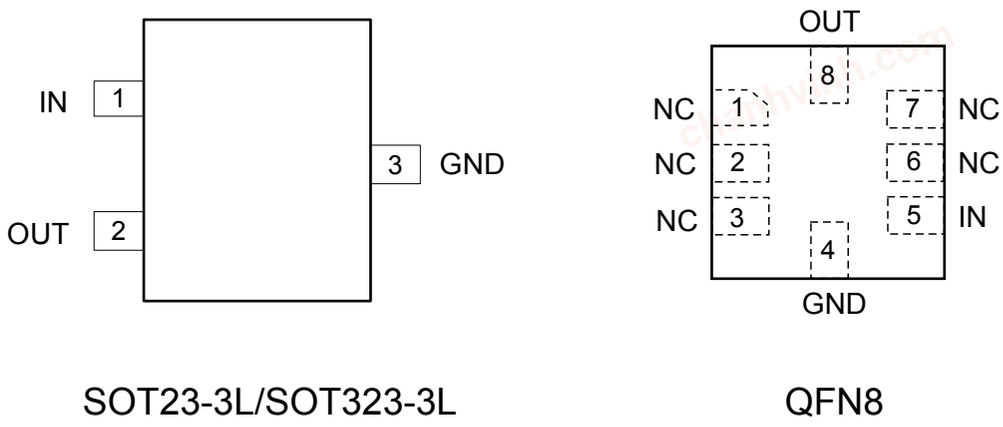
Available in QFN8, SOT23-3L and SOT323-3L surface mount packages, the TS33 can be designed in applications where space saving is a critical issue.

Maturity status link
TS33

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1 Pin configuration

Figure 1. **Pin configuration (top view)**



SOT23-3L/SOT323-3L QFN8

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2 Maximum ratings

Table 1. Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_{IN}	Maximum input voltage	-0.3 to 7	V
V_{OUT}	Maximum voltage on the output pin	-0.3 to V_{IN} +0.3	V
I_{OUT}	Output short-circuit current (sinking/sourcing)	Internally limited	mA
Pd	Power dissipation (1)	700	mW
T_{stg}	Storage temperature	-65 to +150	°C
ESD	Human body model (HBM)	4	kV
	Charged device model	1000	V
T_{lead}	Lead temperature (soldering) 10 s	260	°C
T_j	Max junction temperature	+150	°C

1. *Pd has been calculated with T_{amb} = 25 °C and T_{jmax} = 150 °C*

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

Table 2. Thermal data

Symbol	Parameter	QFN8	SOT23-3L	SOT323-3L	Unit
R_{thJA}	Thermal resistance junction-ambient	159	246	242	°C/W
R_{thJC}	Thermal resistance junction-case	103	171	103	°C/W

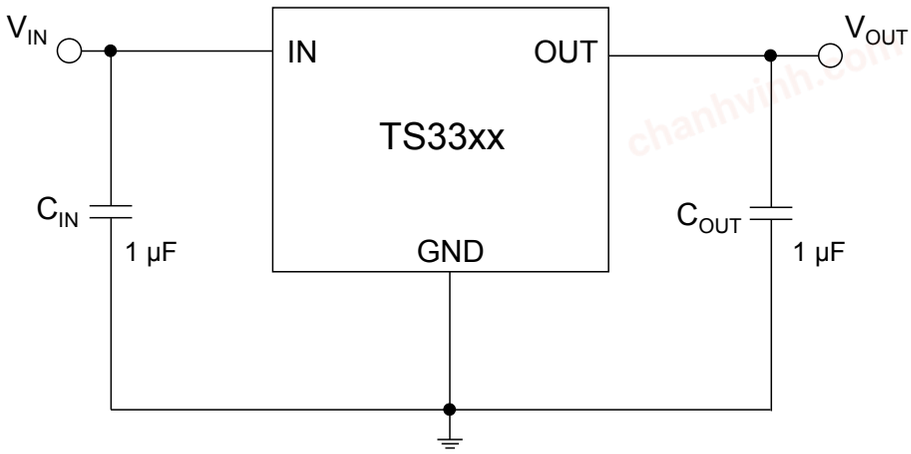
Table 3. Recommended operating conditions

Symbol	Parameter	Value	Unit
V_{IN}	Operating input voltage range	1.8 to 5.5	V
I_{OUT}	Maximum operating current	± 5	mA
T_{oper}	Operating free air temperature range	-40 to +125	°C

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3 Typical application

Figure 2. **Typical application circuit**



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4 Electrical characteristics

V_{IN} = 5 V, I_{LOAD} = 0 mA, T_{amb} = 25 °C (unless otherwise specified).

Table 4. Electrical characteristics for TS3312

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
V_{IN}	Minimum input voltage	I_{LOAD} = 0 mA T_{amb} = 25 °C	1.8			V
V_{OUT}	Output voltage	V_{IN} = 5 V		1.25		V
	Initial accuracy	I_{LOAD} = 0 mA T_{amb} = 25 °C	-0.15		0.15	%
$\Delta V_{OUT}/\Delta T$	Average temperature coefficient	-40 °C < T_{amb} < +85 °C		9	30	ppm/°C
		-40 °C < T_{amb} < +125 °C		8	30	
$\Delta V_{OUT}/\Delta V_{IN}$	Line regulation	V_{IN} = 1.8 V to 5.5 V	-50	6	+50	ppm/V
		0 °C < T_{amb} < 70 °C		6		
		-40 °C < T_{amb} < +85 °C		8		
		-40 °C < T_{amb} < +125 °C		30		
$\Delta V_{OUT}/\Delta I_{LOAD}$	Load regulation	V_{IN} = 1.8 V	-50	6	+50	ppm/mA
		I_{LOAD} = ±5 mA 0 °C < T_{amb} < 70 °C		10		
		-40 °C < T_{amb} < +85 °C		20		
		-40 °C < T_{amb} < +125 °C		20		
I_{SC}	Short-circuit current sourcing/ sinking			35		mA
I_Q	Quiescent current			3.9	7	µA
		-40 °C < T_{amb} < +85 °C		4.4	7.5	
		-40 °C < T_{amb} < +125 °C		4.8	10	
C_{OUT}	Capacitive load		0.1		10	µF
T_{ON}	Turn-on settling time	to 0.1 %, C_{OUT} = 1 µF		2		ms
e_n	Noise floor	f = 0.1 Hz to 10 Hz		27		μV_{P-P}

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Table 5. Electrical characteristics for TS3320

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{OUT}	Output voltage	V_{IN} = 5 V		2.048		V
	Initial accuracy	I_{LOAD} = 0 mA T_{amb} = 25 °C	-0.15		0.15	%
$\Delta V_{OUT}/\Delta T$	Average temperaturecoefficient	-40 °C < T_{amb} <+ 85 °C		9	30	ppm/°C
		-40°C < T_{amb}<+ 125 °C		8	30	
$\Delta V_{OUT}/\Delta V_{IN}$	Line regulation	V_{IN} = 2.7 V to 5.5 V	-50	6	+50	ppm/V
		0 °C < T_{amb} < 70 °C		6		
		- 40 °C < T_{amb} <+ 85 °C		8		
		- 40 °C < T_{amb} <+ 125 °C		30		
$\Delta V_{OUT}/\Delta I_{LOAD}$	Load regulation	V_{IN} = 2.7 V	-50	6	+50	ppm/mA
		I_{LOAD} = ±5 mA 0 °C < T_{amb} < 70 °C		10		
		-40 °C < T_{amb}<+85 °C		20		
		-40 °C < T_{amb} <+ 125 °C		20		
V_{DROP}	Minimum dropout voltage	I_{LOAD} = ±5 mA		100	160	mV
		0 °C < T_{amb} < 70 °C		70		
		-40 °C < T_{amb} <+ 85 °C		75		
		-40 °C < T_{amb}<+ 125 °C		80		
		I_{LOAD} = ± 2 mA -40 °C < T_{amb}<+ 85 °C			80	
I_{SC}	Short-circuit current sourcing/ sinking			35		mA
I_Q	Quiescent current			3.9	7	µA
		-40°C < T_{amb} < +85 °C		4.4	7.5	
		-40°C < T_{amb} < +125 °C		4.8	10	
C_{OUT}	Capacitive load		0.1		10	µF
T_{ON}	Turn-on settling time	to 0.1 %, C_{OUT} = 1 µF		2		ms
e_n	Noise floor	f = 0.1 Hz to 10 Hz		47		μV_{P-P}

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Table 6. Electrical characteristics for TS3325

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{OUT}	Output voltage	V_{IN} = 5 V		2.5		V
	Initial accuracy	I_{LOAD} = 0 mA T_{amb} = 25 °C	-0.15		0.15	%
$\Delta V_{OUT}/\Delta T$	Average temperaturecoefficient	-40 °C < T_{amb} <+ 85 °C		9	30	ppm/°C
		-40°C < T_{amb}<+ 125 °C		8	30	
$\Delta V_{OUT}/\Delta V_{IN}$	Line regulation	V_{IN} = 2.7 V to 5.5 V	-50	6	+50	ppm/V
		0 °C < T_{amb} < 70 °C		6		
		- 40 °C < T_{amb} <+ 85 °C		8		
		- 40 °C < T_{amb} <+ 125 °C		30		
$\Delta V_{OUT}/\Delta I_{LOAD}$	Load regulation	V_{IN} = 2.7 V	-50	6	+50	ppm/mA
		I_{LOAD} = ±5 mA 0 °C < T_{amb} < 70 °C		10		
		-40 °C < T_{amb}<+85 °C		20		
		-40 °C < T_{amb} <+ 125 °C		20		
V_{DROP}	Minimum dropout voltage	I_{LOAD} = ±5 mA		50	100	mV
		0 °C < T_{amb} < 70 °C		70		
		-40 °C < T_{amb} <+ 85 °C		75		
		-40 °C < T_{amb}<+ 125 °C		80		
		I_{LOAD} = ± 2 mA -40 °C < T_{amb}<+ 85 °C			70	
I_{SC}	Short-circuit current sourcing/ sinking			35		mA
I_Q	Quiescent current			3.9	7	µA
		-40°C < T_{amb} < +85 °C		4.4	7.5	
		-40°C < T_{amb} < +125 °C		4.8	10	
C_{OUT}	Capacitive load		0.1		10	µF
T_{ON}	Turn-on settling time	to 0.1 %, C_{OUT} = 1 µF		2		ms
e_n	Noise floor	f = 0.1 Hz to 10 Hz		57		μV_{P-P}

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Table 7. Electrical characteristics for TS3330

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{OUT}	Output voltage	V_{IN} = 5 V		3.0		V
	Initial accuracy	I_{LOAD} = 0 mA T_{amb} = 25 °C	-0.15		0.15	%
$\Delta V_{OUT}/\Delta T$	Average temperature coefficient	-40 °C < T_{amb} < +85 °C		9	30	ppm/°C
		-40 °C < T_{amb} < +125 °C		8	30	
$\Delta V_{OUT}/\Delta V_{IN}$	Line regulation	V_{IN} = 3.2 V to 5.5 V	-50	6	+50	ppm/V
		0 °C < T_{amb} < 70 °C		6		
		-40 °C < T_{amb} < +85 °C		8		
		-40 °C < T_{amb} < +125 °C		30		
$\Delta V_{OUT}/\Delta I_{LOAD}$	Load regulation	V_{IN} = 3.2 V	-50	6	+50	ppm/mA
		I_{LOAD} = ±5 mA 0 °C < T_{amb} < 70 °C		10		
		-40 °C < T_{amb} < +85 °C		20		
		-40 °C < T_{amb} < +125 °C		20		
V_{DROP}	Minimum dropout voltage	I_{LOAD} = ±5 mA		50	100	mV
		0 °C < T_{amb} < 70 °C		70		
		-40 °C < T_{amb} < +85 °C		75		
		-40 °C < T_{amb} < +125 °C		80		
		I_{LOAD} = ±2 mA -40 °C < T_{amb} < +85 °C			70	
I_{SC}	Short-circuit current sourcing/ sinking			35		mA
I_Q	Quiescent current			3.9	7	µA
		-40 °C < T_{amb} < +85 °C		4.4	7.5	
		-40 °C < T_{amb} < +125 °C		4.8	10	
C_{OUT}	Capacitive load		0.1		10	µF
T_{ON}	Turn-on settling time	to 0.1 %, C_{OUT} = 1 µF		2		ms
e_n	Noise floor	f = 0.1 Hz to 10 Hz		67		μV_{P-P}

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Table 8. Electrical characteristics for TS3333

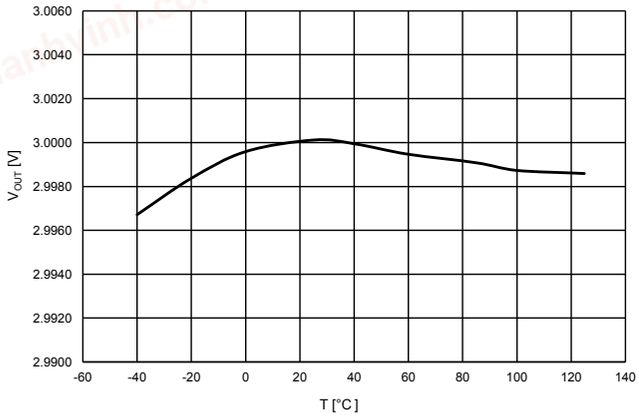
Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{OUT}	Output voltage	V_{IN} = 5 V		3.3		V
	Initial accuracy	I_{LOAD} = 0 mA T_{amb} = 25 °C	-0.15		0.15	%
$\Delta V_{OUT}/\Delta T$	Average temperature coefficient	-40 °C < T_{amb} < +85 °C		9	30	ppm/°C
		-40 °C < T_{amb} < +125 °C		8	30	
$\Delta V_{OUT}/\Delta V_{IN}$	Line regulation	V_{IN} = 3.5 V to 5.5 V	-50	6	+50	ppm/V
		0 °C < T_{amb} < 70 °C		6		
		-40 °C < T_{amb} < +85 °C		8		
		-40 °C < T_{amb} < +125 °C		30		
$\Delta V_{OUT}/\Delta I_{LOAD}$	Load regulation	V_{IN} = 3.5 V	-50	6	+50	ppm/mA
		I_{LOAD} = ±5 mA 0 °C < T_{amb} < 70 °C		10		
		-40 °C < T_{amb} < +85 °C		20		
		-40 °C < T_{amb} < +125 °C		20		
V_{DROP}	Minimum dropout voltage	I_{LOAD} = ±5 mA		50	100	mV
		0 °C < T_{amb} < 70 °C		70		
		-40 °C < T_{amb} < +85 °C		75		
		-40 °C < T_{amb} < +125 °C		80		
		I_{LOAD} = ±2 mA -40 °C < T_{amb} < +85 °C			70	
I_{SC}	Short-circuit current sourcing/ sinking			35		mA
I_Q	Quiescent current			3.9	7	µA
		-40 °C < T_{amb} < +85 °C		4.4	7.5	
		-40 °C < T_{amb} < +125 °C		4.8	10	
C_{OUT}	Capacitive load		0.1		10	µF
T_{ON}	Turn-on settling time	to 0.1 %, C_{OUT} = 1 µF		2		ms
e_n	Noise floor	f = 0.1 Hz to 10 Hz		73		μV_{P-P}

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5 Typical performance characteristics

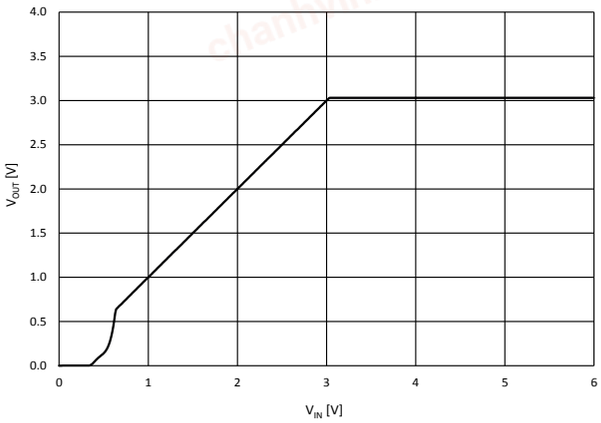
The following plots are referred to the typical application circuit and, unless otherwise noted, at T_A = 25 °C, V_{OUT} = 3.0 V.

Figure 3. Output voltage vs. temperature



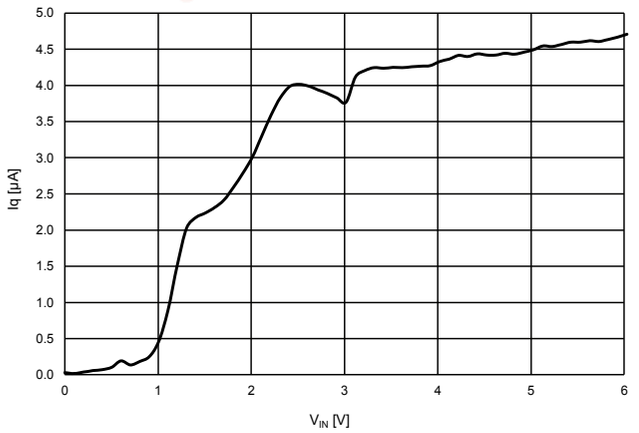
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Figure 4. Output voltage vs. input voltage



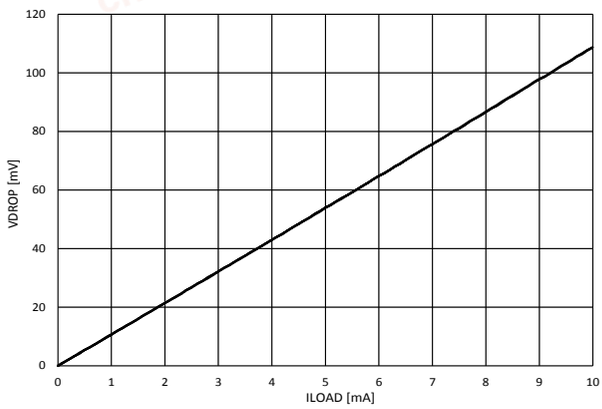
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Figure 5. Quiescent current vs. input voltage



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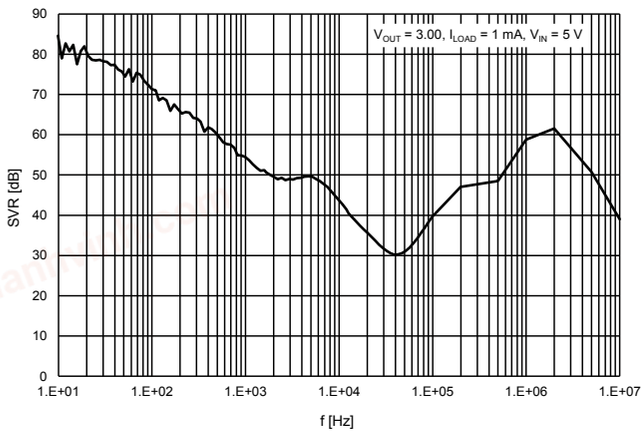
Figure 6. Dropout voltage vs. load current



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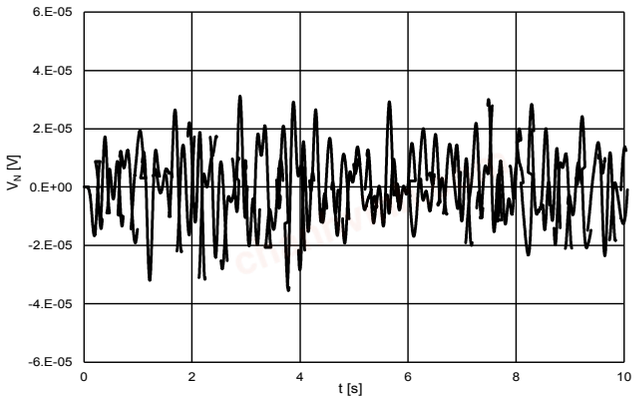
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Figure 7. SVR vs. frequency



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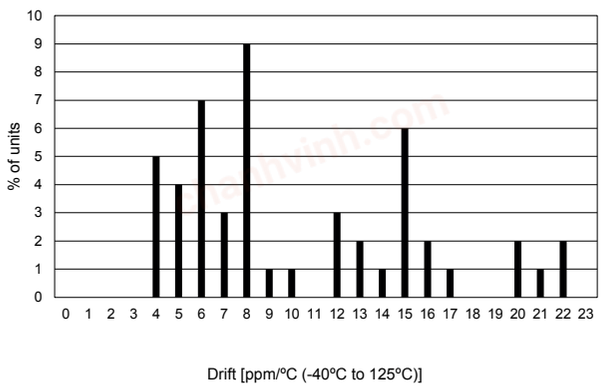
Figure 8. Low frequency noise



V_N = f(t), V_{OUT} = 3.00 V, f = 0.1 - 10 Hz

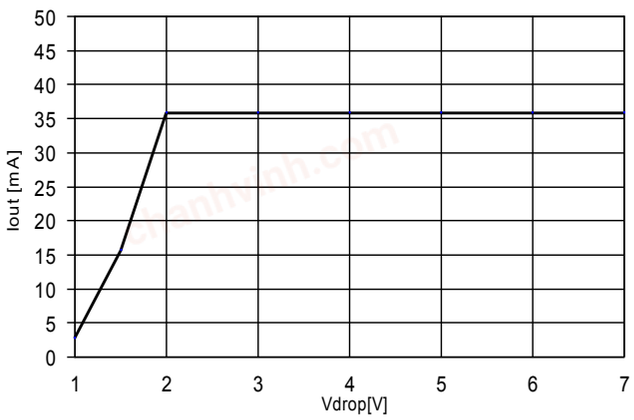
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Figure 9. Temperature drift



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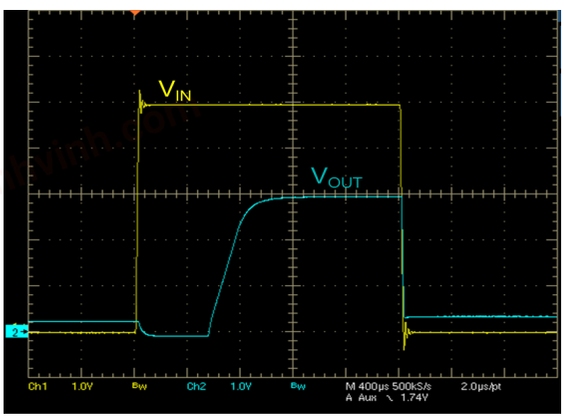
Figure 10. Short-circuit current vs. dropout voltage



T = 25 °C, Cin = 1 µF, Cout = 1 µF

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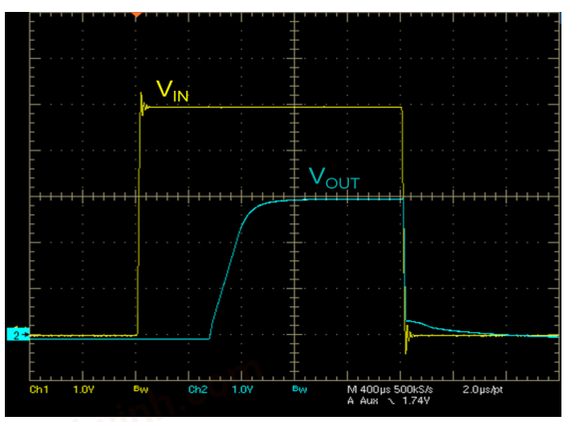
Figure 11. Startup transient (no load)



V_{IN} from 0 to 5V, V_{OUT}=3V, I_{OUT}=0mA, C_{IN}= C_{OUT}= 1µF

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Figure 12. Startup transient (I_{OUT} = 5 mA)

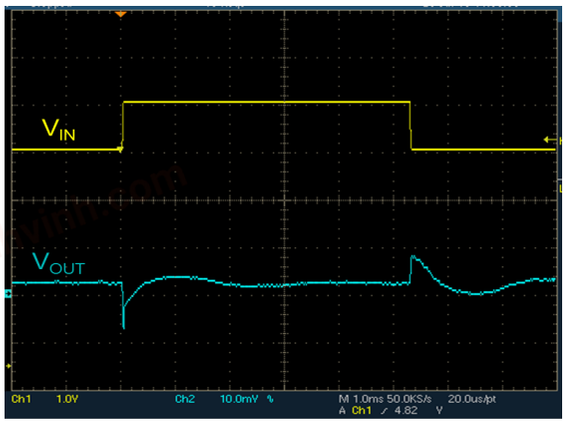


V_{IN} from 0 to 5V, V_{OUT}=3V, I_{OUT}=5mA, C_{IN}= C_{OUT}= 1µF

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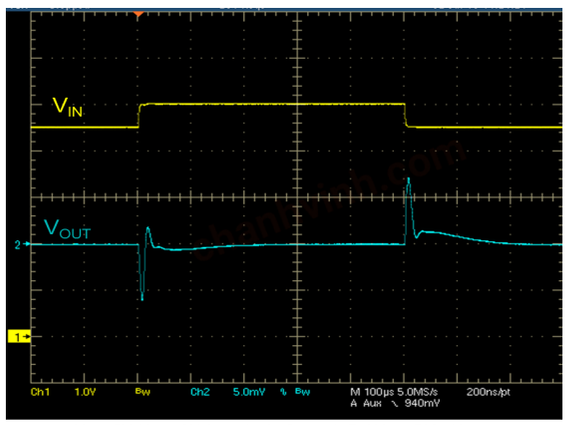
Figure 13. Line transient (no load)



V_{IN} = 5V, V_{OUT}=3V, I_{OUT}=0mA, C_{OUT}= 1µF, ΔV_{IN} = 500mV

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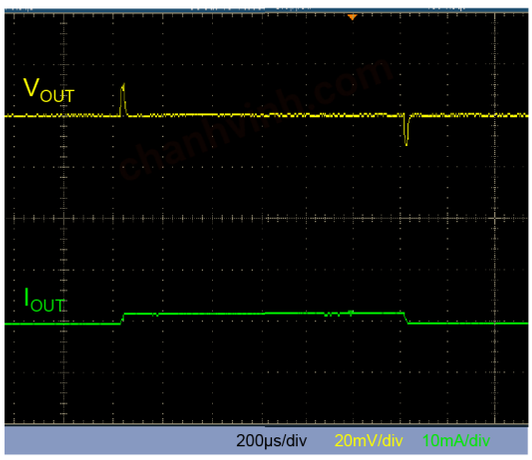
Figure 14. Line transient (I_{OUT} = 1 mA)



V_{IN} = 5V, V_{OUT}=3V, I_{OUT}=1mA, C_{OUT}= 1µF, ΔV_{IN} = 500mV

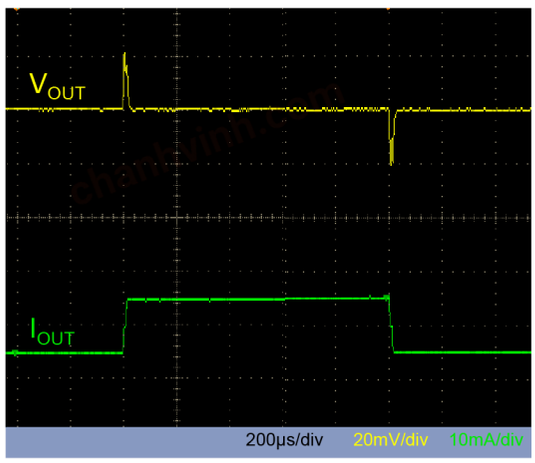
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Figure 15. Load transient (I_{OUT} = +/-1 mA)



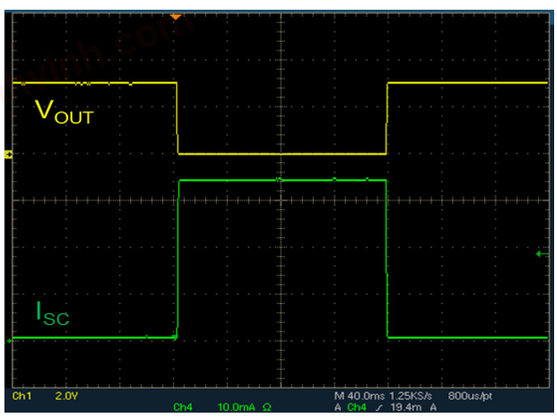
V_{OUT}=3V, I_{OUT}= ± 1mA, C_{IN}=C_{OUT}=1µF

Figure 16. Load transient (I_{OUT} = +/-5 mA)



V_{OUT}=3V, I_{OUT}= ± 5mA, C_{IN}=C_{OUT}=1µF

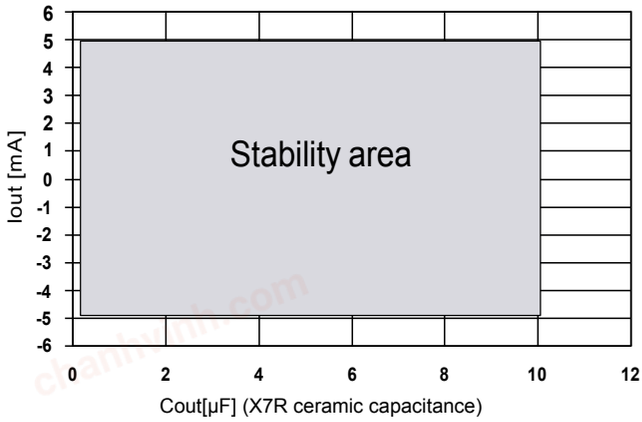
Figure 17. Short-circuit response



V_{IN}=5V, T=25°C, C_{IN}=1µF, C_{OUT}=1µF

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Figure 18. Stability plan



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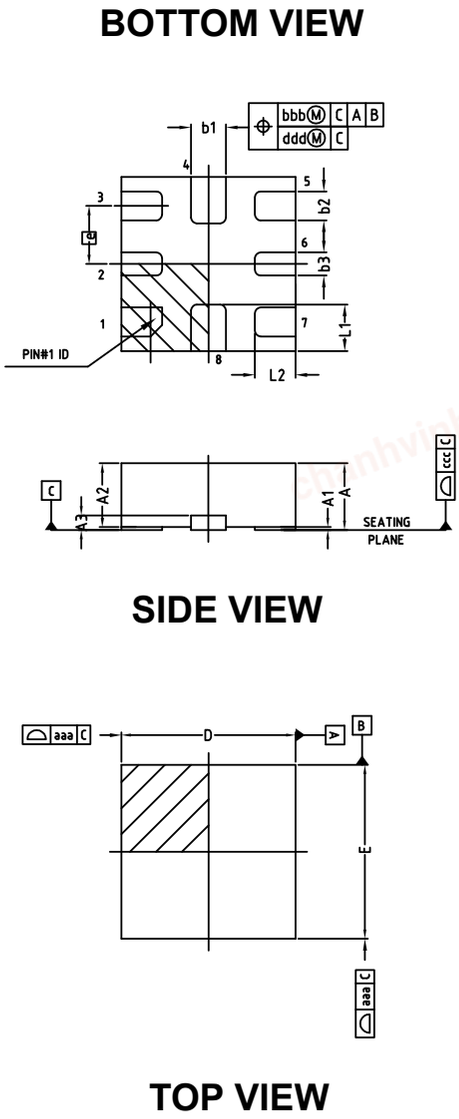
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6 Package information

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.

6.1 QFN-8 package information

Figure 19. QFN8 package outline



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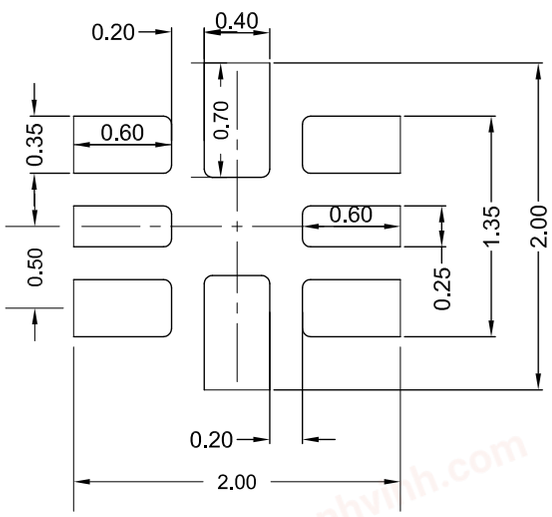
Table 9. **QFN8 mechanical data**

Dim.	mm			Note
	Min.	Typ.	Max.	
A	0.40	-	0.55	4
A1	0.00	-	0.05	12
A2	0.33	0.43	0.53	4
A3		-		4
b1	0.25	0.3	0.35	4.9
b2	0.20	0.25	0.30	
b3	0.15	0.20	0.25	
D	1.40	1.50	1.60	4
e		0.50		4
E	1.40	1.50	1.60	4
L1	0.30	0.40	0.50	4
L2	0.25	0.35	0.45	4
N		8		15

Table 10. **QFN8 tolerance of form and position**

Symbol	Tolerance of form and position
aaa	0.15
bbb	0.10
ccc	0.08
ddd	0.05
eee	0.10

Figure 20. **QFN8 recommended footprint**

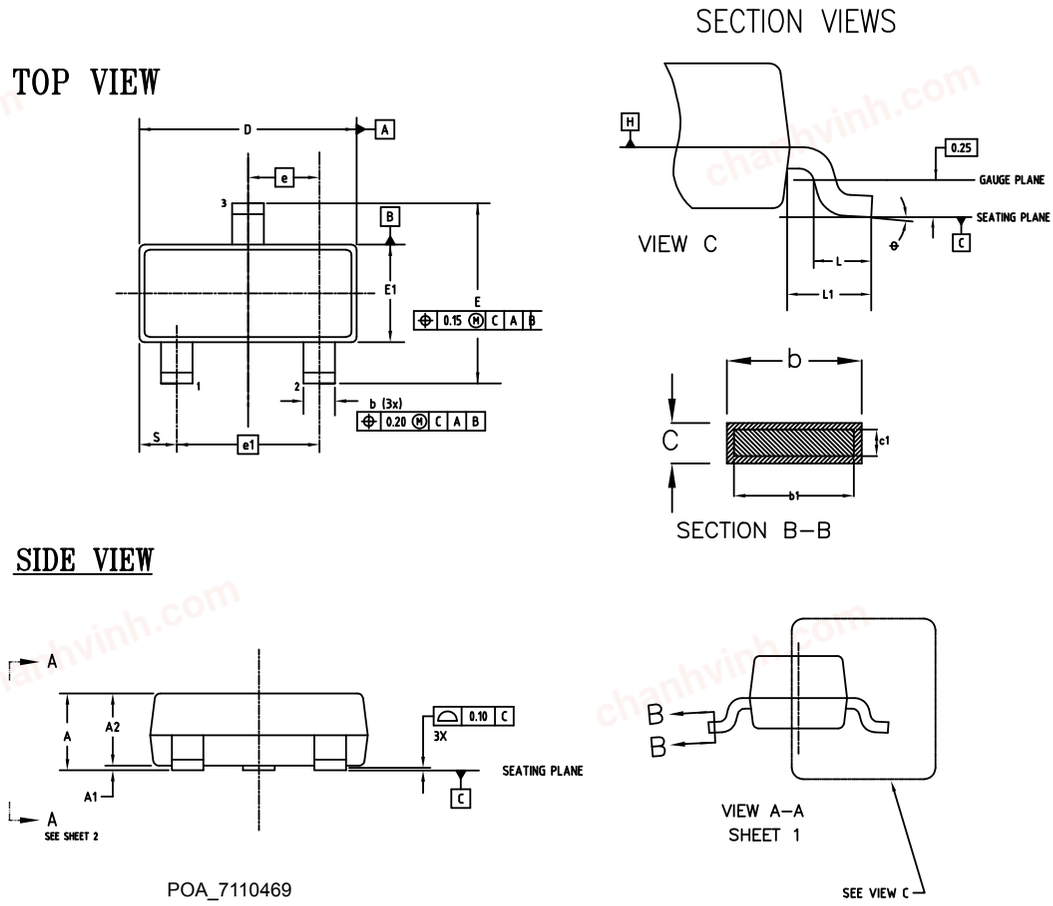


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6.2 SOT23-3L package information

Figure 21. **SOT23-3L package outline**

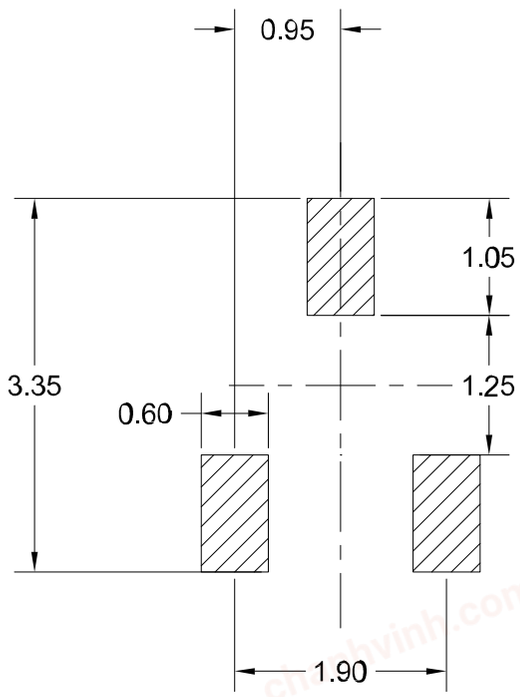


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Table 11. **SOT23-3L mechanical data**

Dim.	mm		
	Min.	Typ.	Max.
A	0.89		1.12
A1	0.013		0.10
A2	0.88	0.95	1.02
b	0.37		0.50
b1	0.37	0.40	0.45
c	0.085		0.18
c1	0.085		0.16
D	2.80		3.04
E	2.10		2.64
E1	1.20		1.40
e	0.95BSC		
e1	1.90 BSC		
*L	0.28	0.38	0.48
L1	0.55		
R	0.05		
R1	0.05		
q	0°		8°
s	0.45		0.60

Figure 22. **SOT23-3L recommended footprint**



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6.3 SOT323-3L package information

Figure 23. **SOT323-3L package outline**

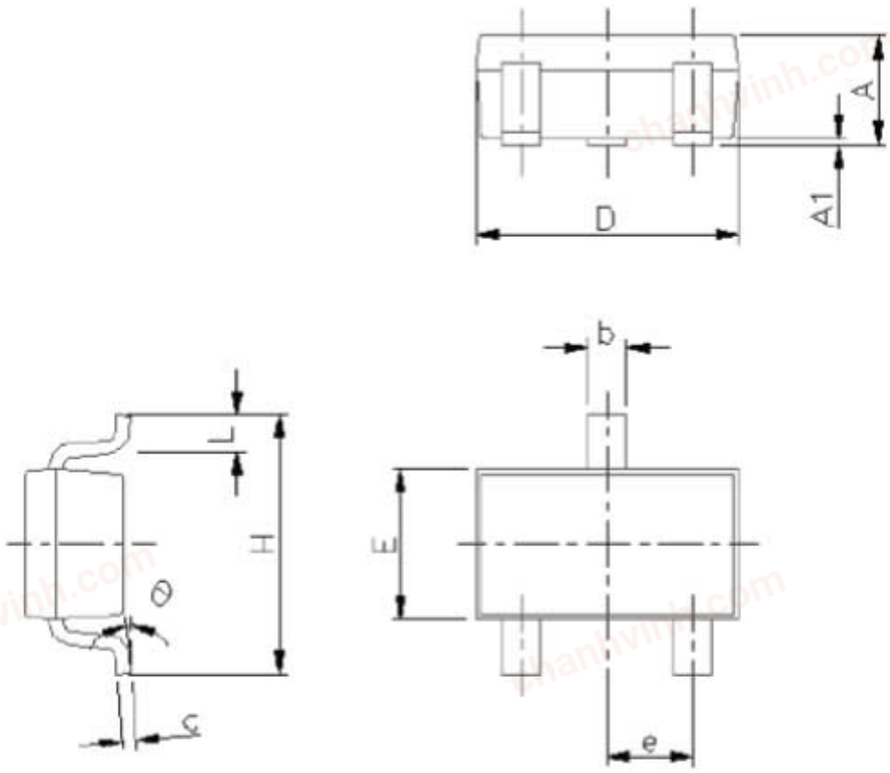
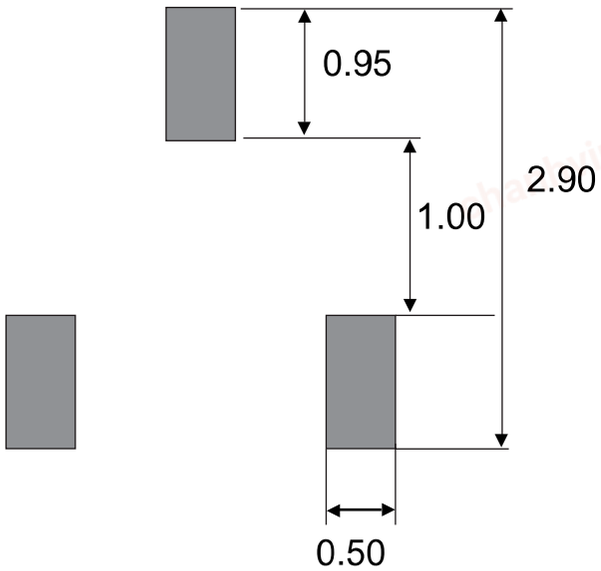


Table 12. **SOT323-3L mechanical data**

Dim.	mm		
	Min.	Typ.	Max.
A	0.80		1.10
A1	0.00		0.10
b	0.25		0.40
c	0.10		0.18
D	1.80		2.20
E	1.15		1.35
e	0.60	0.65	0.70
H	1.80		2.40
L	0.10		0.30

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Figure 24. **SOT323-3L recommended footprint**



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7 Ordering information

Table 13. **Order codes**

Part number	Output voltage (V)	Precision	Package	Temperature range
TS3312AQPR	1.25	±0.15 %	QFN8	-40 to +125 °C
TS3320AQPR	2.048			
TS3325AQPR	2.5			
TS3330AQPR	3.0			
TS3333AQPR	3.3			
TS3312ACR	1.25	±0.15 %	SOT323-3L	-40 to +125 °C
TS3320ACR	2.048			
TS3325ACR	2.5			
TS3330ACR	3			
TS3333ACR	3.3			
TS3312AMR	1.25	±0.15 %	SOT23-3L	-40 to +125 °C
TS3320AMR	2.048			
TS3325AMR	2.5			
TS3330AMR	3			
TS3333AMR	3.3			

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Revision history

Table 14. **Document revision history**

Date	Revision	Changes
05-Sep-2017	1	Initial release.
26-Sep-2018	2	Added new order codes TS3325AQPR and TS3333AQPR in Table 9. Order codes.
16-Mar-2020	3	Added Table 5. Electrical characteristics for TS3325. Removed footnote in Table 10.
04-Aug-2021	4	Added new packages SOT23-3L and SOT323-3L Section 6.2 , Section 6.3 , new Table 5 new order code in Section 7.
07-Dic-2021	5	Removed footnote Table 13. Order codes

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