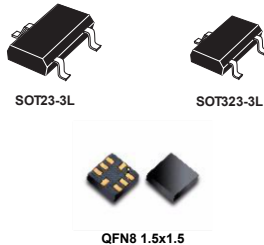


Micropower high precision series voltage reference



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 μ A (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.

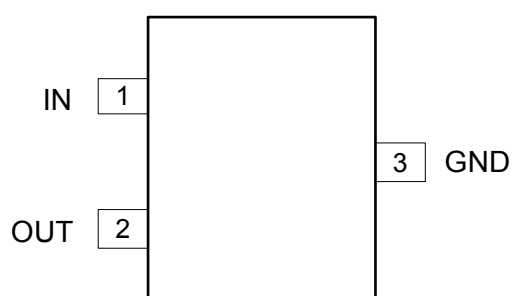
Available in QFN8, SOT23-3L and SOT323-3L surface mount packages, the TS33 can be designed in applications where space saving is a critical issue.

Maternity status link

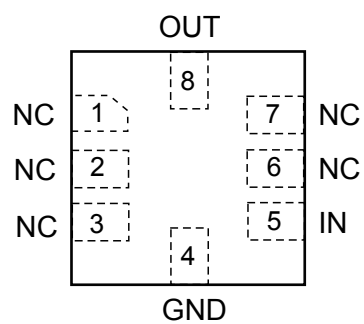
TS33

1 Pin configuration

Figure 1. Pin configuration (top view)



SOT23-3L/SOT323-3L



QFN8

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
P_d	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. P_d has been calculated with $T_{amb} = 25\text{ °C}$ and $T_{jmax} = 150\text{ °C}$

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

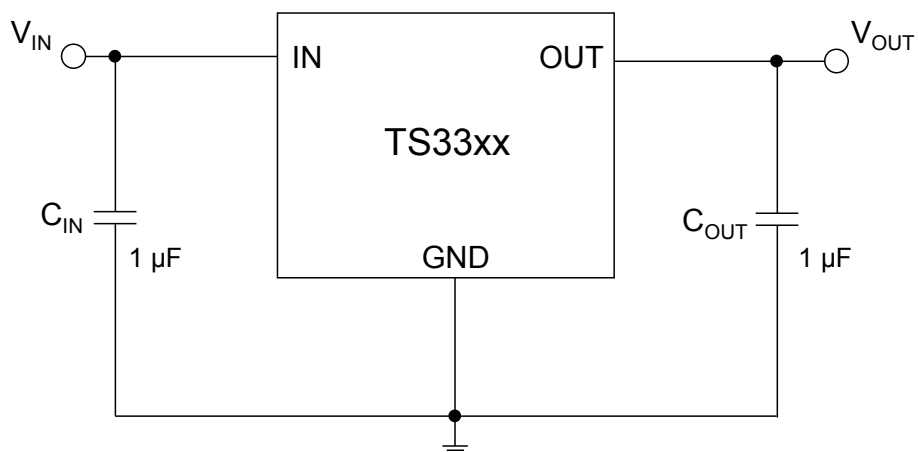
Symbol	Parameter	QFN8	SOT23-3L	SOT323-3L	Unit
R_{thJA}	Thermal resistance junction-ambient	159	246	242	°C/W
R_{thJC}	Thermal resistance junction-case	103	171	103	°C/W

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

3 Typical application

Figure 2. Typical application circuit



4 Electrical characteristics

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

Table 4. Electrical characteristics for TS3312

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

Table 5. Electrical characteristics for TS3320

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

Table 6. Electrical characteristics for TS3325

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

Table 7. Electrical characteristics for TS3330

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

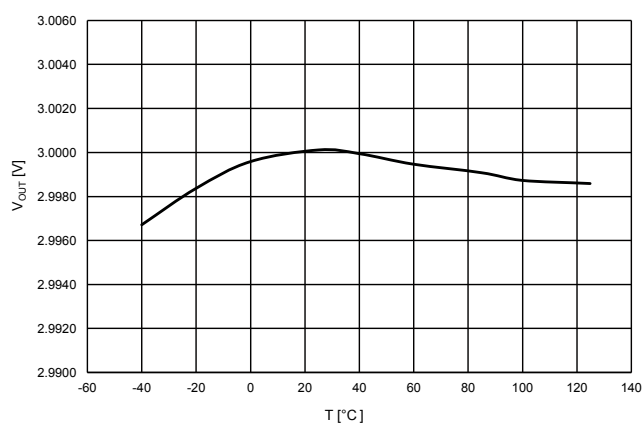
Table 8. Electrical characteristics for TS3333

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

5 Typical performance characteristics

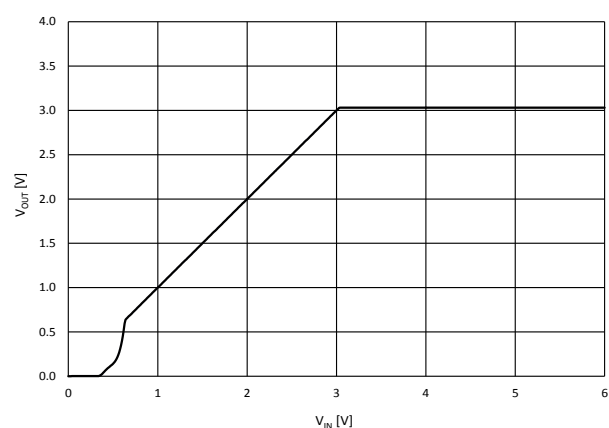
The following plots are referred to the typical application circuit and, unless otherwise noted, at $T_A = 25\text{ }^{\circ}\text{C}$, $V_{OUT} = 3.0\text{ V}$.

Figure 3. Output voltage vs. temperature



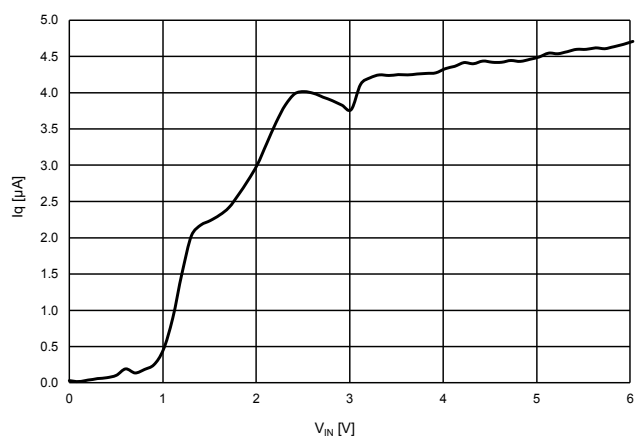
GAMG251120160930MT

Figure 4. Output voltage vs. input voltage



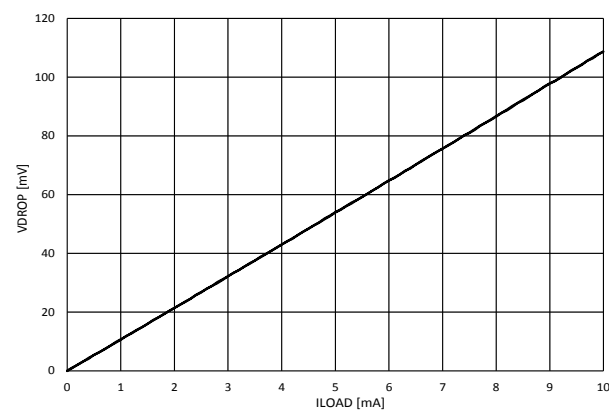
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Figure 5. Quiescent current vs. input voltage

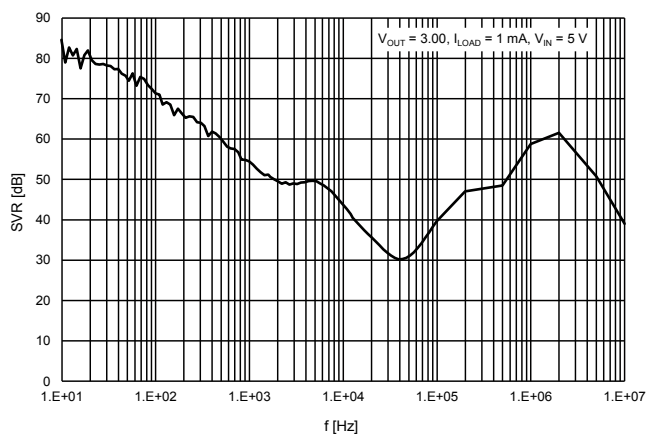


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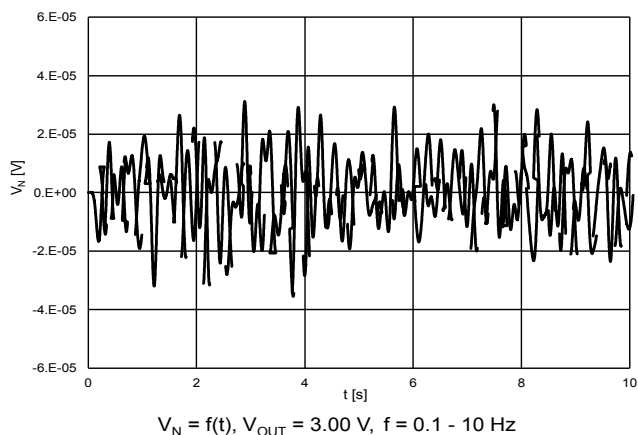
Figure 6. Dropout voltage vs. load current



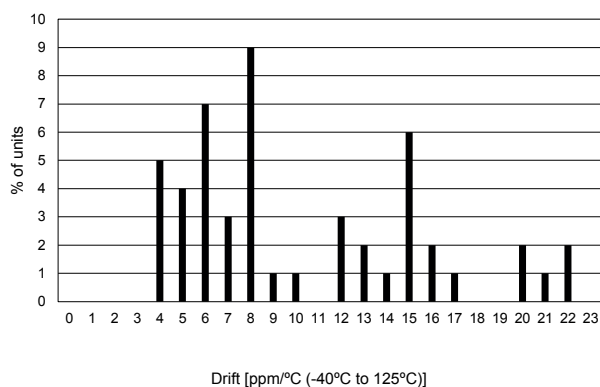
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Figure 7. SVR vs. frequency


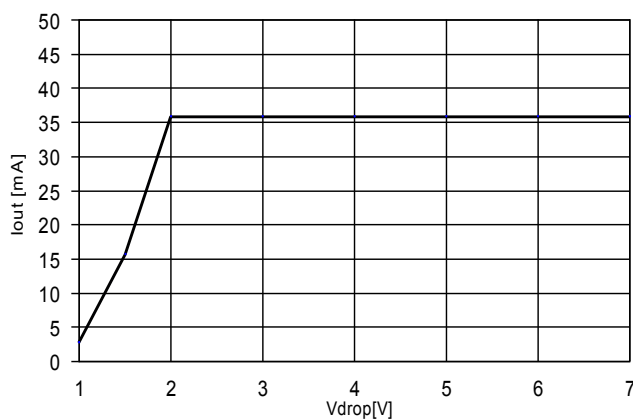
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Figure 8. Low frequency noise


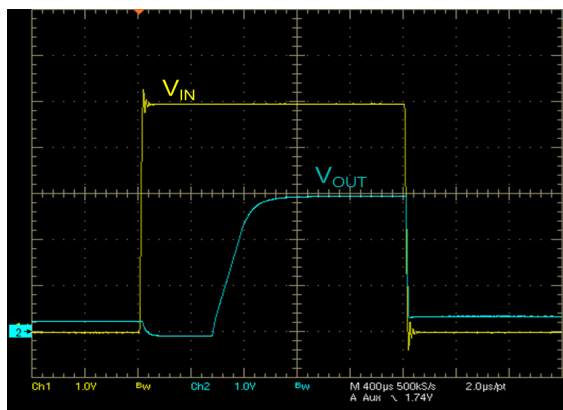
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Figure 9. Temperature drift


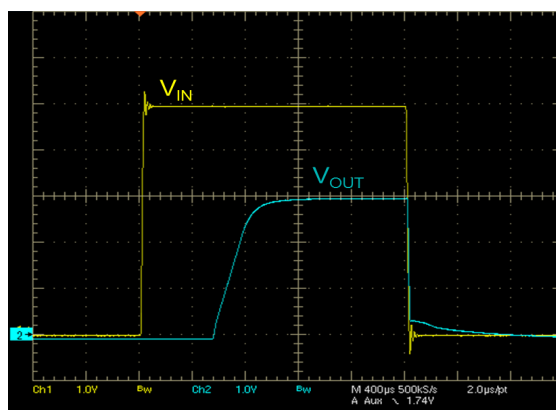
GAMG251120160936MT

Figure 10. Short-circuit current vs. dropout voltage

 $T = 25\text{ }^{\circ}\text{C}$, $C_{in} = 1\text{ }\mu\text{F}$, $C_{out} = 1\text{ }\mu\text{F}$

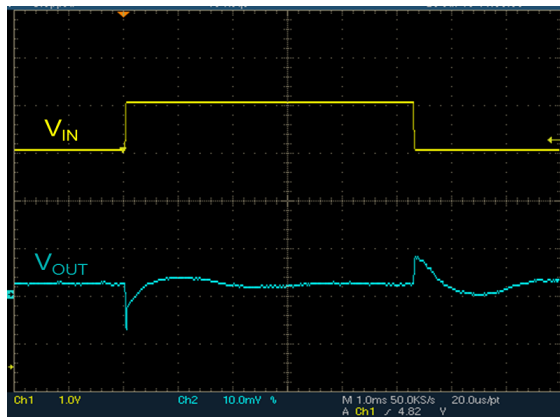
GAMG251120160937MT

Figure 11. Startup transient (no load)

 V_{IN} from 0 to 5V, $V_{OUT}=3\text{V}$, $I_{OUT}=0\text{mA}$, $C_{IN}=C_{OUT}=1\text{ }\mu\text{F}$

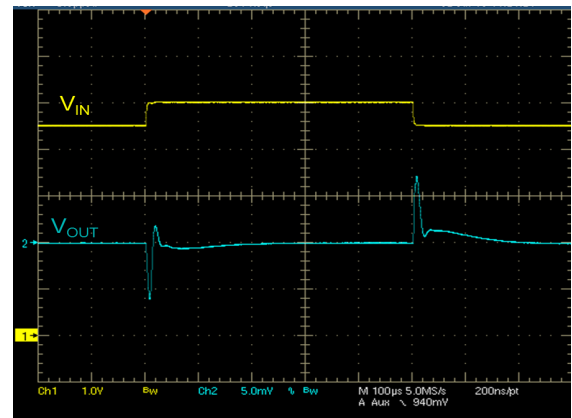
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Figure 12. Startup transient ($I_{OUT} = 5\text{ mA}$)

 V_{IN} from 0 to 5V, $V_{OUT}=3\text{V}$, $I_{OUT}=5\text{mA}$, $C_{IN}=C_{OUT}=1\text{ }\mu\text{F}$

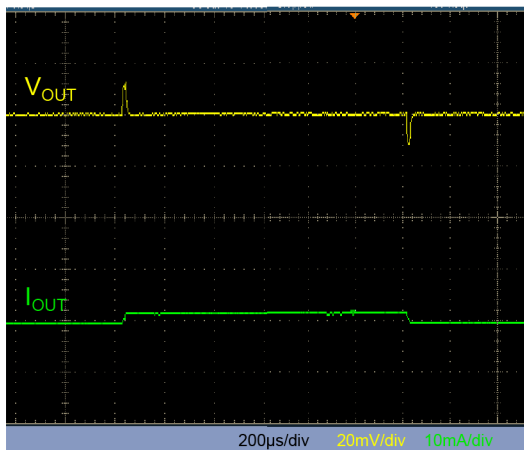
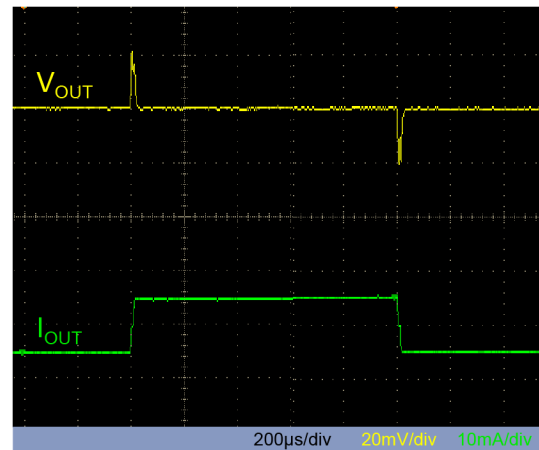
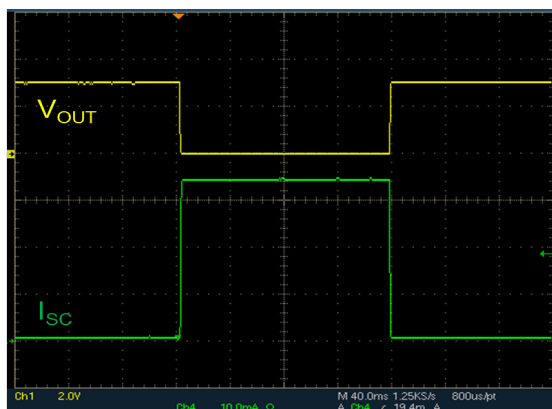
GAMG251120160939MT

Figure 13. Line transient (no load)

 $V_{IN} = 5V$, $V_{OUT} = 3V$, $I_{OUT} = 0mA$, $C_{OUT} = 1\mu F$, $\Delta V_{IN} = 500mV$

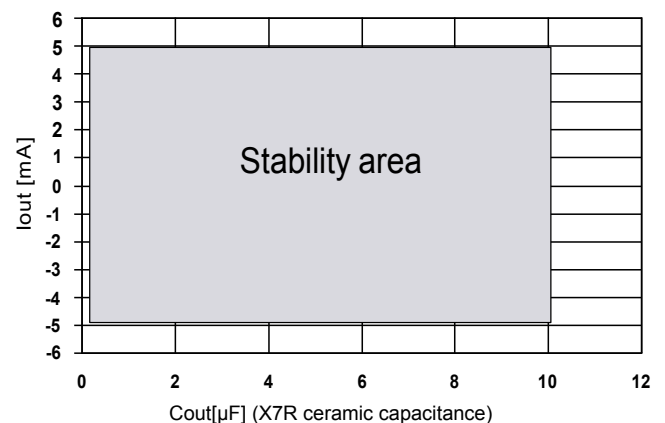
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Figure 14. Line transient ($I_{OUT} = 1mA$)

 $V_{IN} = 5V$, $V_{OUT} = 3V$, $I_{OUT} = 1mA$, $C_{OUT} = 1\mu F$, $\Delta V_{IN} = 500mV$

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Figure 15. Load transient ($I_{OUT} = \pm 1mA$)

 $V_{OUT} = 3V$, $I_{OUT} = \pm 1mA$, $C_{IN} = C_{OUT} = 1\mu F$
Figure 16. Load transient ($I_{OUT} = \pm 5mA$)

 $V_{OUT} = 3V$, $I_{OUT} = \pm 5mA$, $C_{IN} = C_{OUT} = 1\mu F$
Figure 17. Short-circuit response

 $V_{IN} = 5V$, $T = 25^\circ C$, $C_{IN} = 1\mu F$, $C_{OUT} = 1\mu F$

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Figure 18. Stability plan


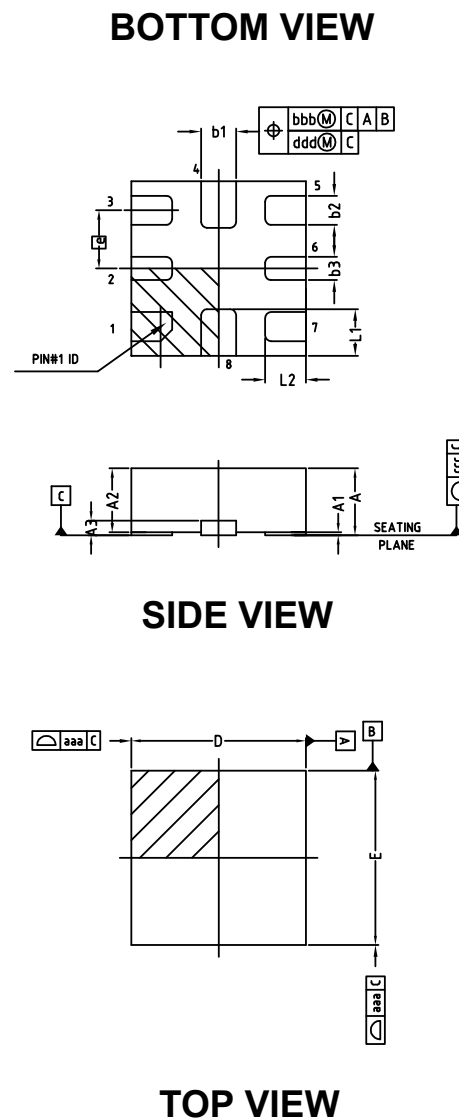
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6 Package information

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



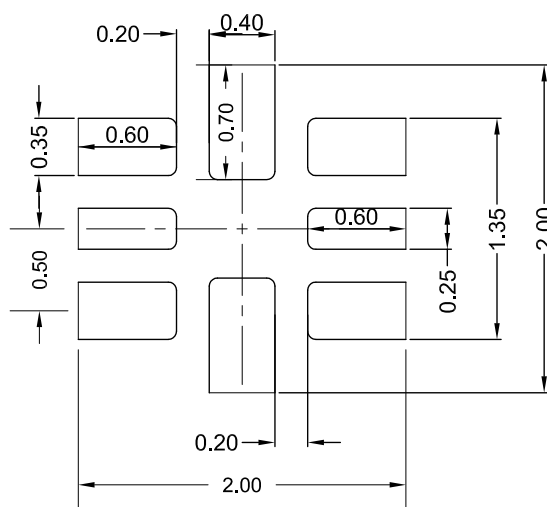
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Table 9. QFN8 mechanical data

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


DM00182817_A

6.2 SOT23-3L package information

Figure 21. SOT23-3L package outline

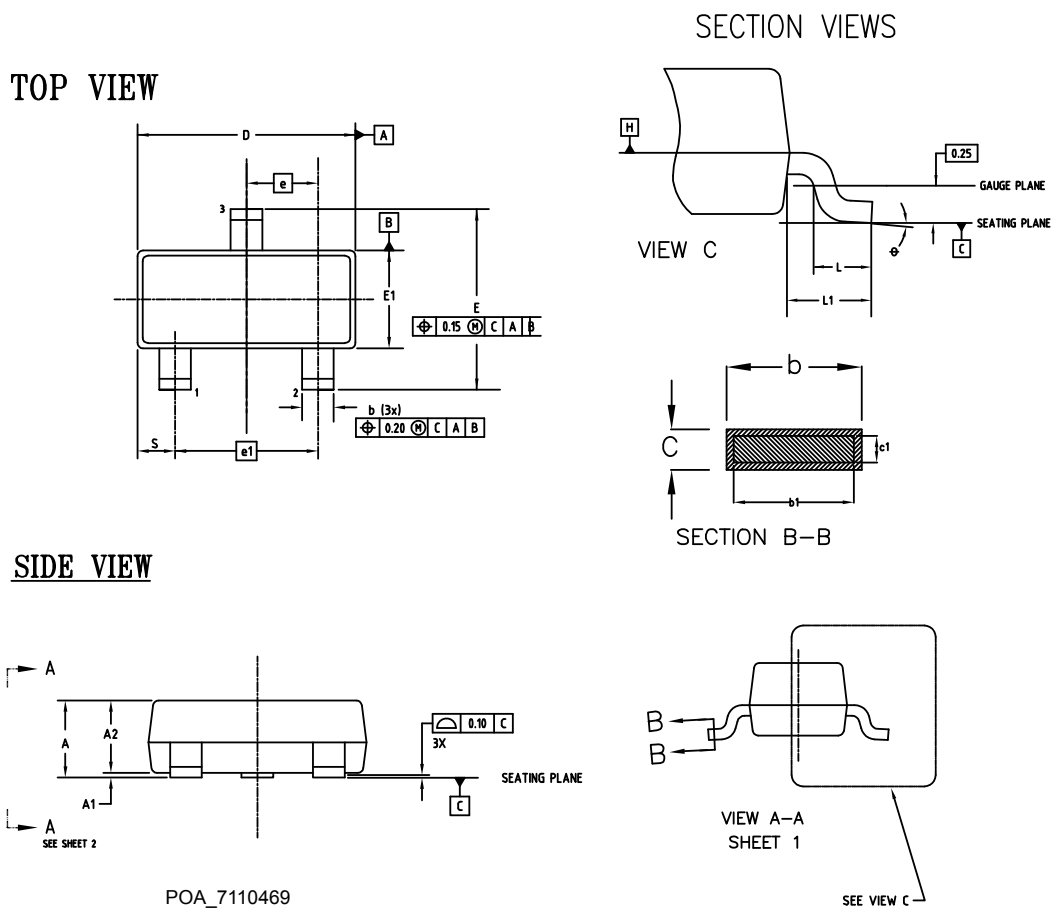
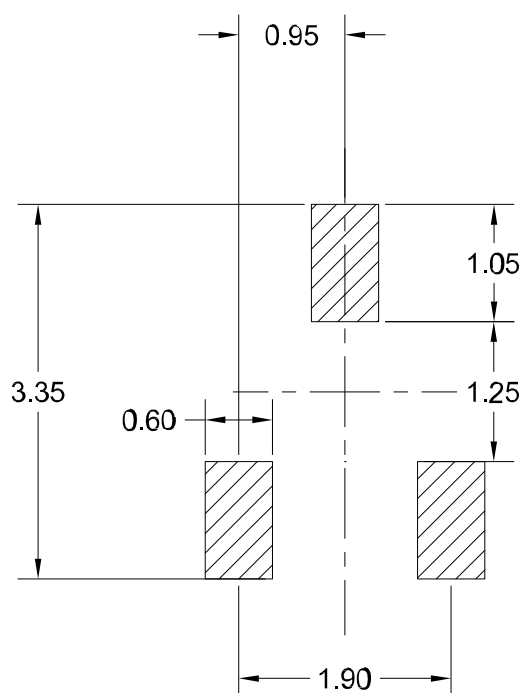


Table 11. SOT23-3L mechanical data

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


6.3 SOT323-3L package information

Figure 23. SOT323-3L package outline

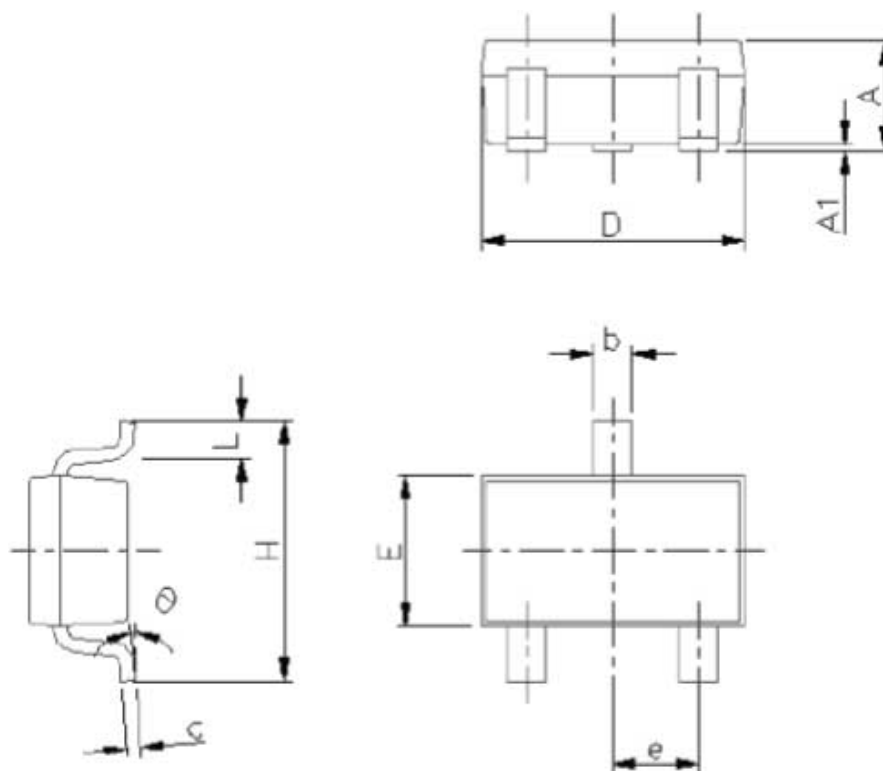
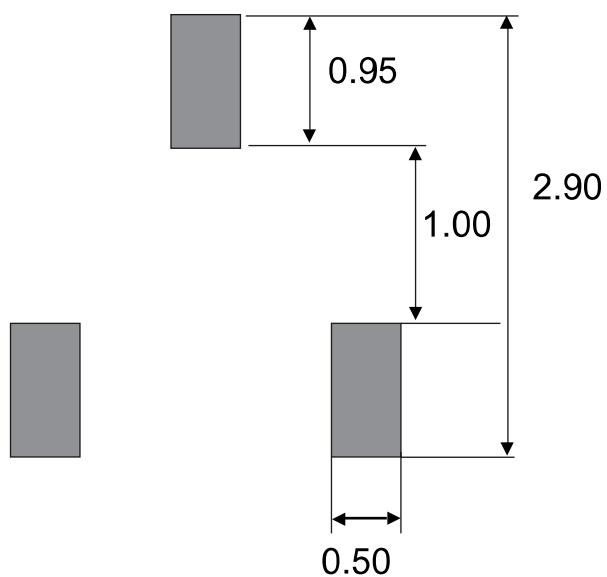


Table 12. SOT323-3L mechanical data

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

Figure 24. SOT323-3L recommended footprint



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			

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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