

## Micropower high precision series voltage reference



QFN8 1.5x1.5

### 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  $\mu$ 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 package

### 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.

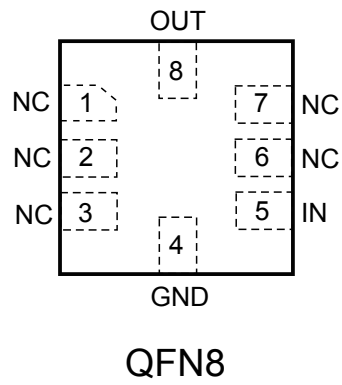
Available in QFN8 surface mount packages, the TS33 can be designed in applications where space saving is a critical issue.

Maturity status link

TS33

## 1 Pin configuration

Figure 1. Pin configuration (top view)



GAMG190120171500MT

## 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 <sup>(1)</sup>	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**

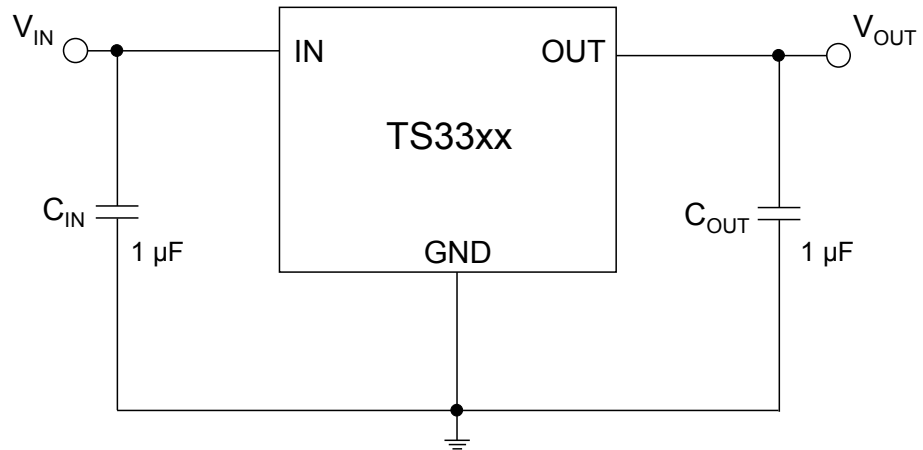
Symbol	Parameter	Value	Unit
$R_{thJA}$	Thermal resistance junction-ambient	159	°C/W
$R_{thJC}$	Thermal resistance junction-case	103	°C/W

**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	$\mu\text{A}$
		$-40\text{ °C} < T_{amb} < +85\text{ °C}$		4.4	7.5	
		$-40\text{ °C} < T_{amb} < +125\text{ °C}$		4.8	10	
$C_{OUT}$	Capacitive load		0.1		10	$\mu\text{F}$
$T_{ON}$	Turn-on settling time	to 0.1 %, $C_{OUT} = 1\text{ }\mu\text{F}$		2		ms
$e_n$	Noise floor	$f = 0.1\text{ Hz to }10\text{ Hz}$		35		$\mu\text{V}_{P-P}$

**Table 5. 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	$V_{IN} = 2.7\text{ V}$ $I_{LOAD} = \pm 5\text{ mA}$ $0\text{ °C} < T_{amb} < 70\text{ °C}$		50	100	mV
		$-40\text{ °C} < T_{amb} < +85\text{ °C}$		70		
		$-40\text{ °C} < T_{amb} < +125\text{ °C}$		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	$\mu\text{A}$
		$-40\text{ °C} < T_{amb} < +85\text{ °C}$		4.4	7.5	
		$-40\text{ °C} < T_{amb} < +125\text{ °C}$		4.8	10	
$C_{OUT}$	Capacitive load		0.1		10	$\mu\text{F}$
$T_{ON}$	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		$\mu\text{V}_{P-P}$

**Table 6. 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	$V_{IN} = 3.2\text{ V}$ $I_{LOAD} = \pm 5\text{ mA}$ $0\text{ °C} < T_{amb} < 70\text{ °C}$		50	100	mV
		$-40\text{ °C} < T_{amb} < +85\text{ °C}$		70		
		$-40\text{ °C} < T_{amb} < +125\text{ °C}$		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	$\mu\text{A}$
		$-40\text{ °C} < T_{amb} < +85\text{ °C}$		4.4	7.5	
		$-40\text{ °C} < T_{amb} < +125\text{ °C}$		4.8	10	
$C_{OUT}$	Capacitive load		0.1		10	$\mu\text{F}$
$T_{ON}$	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		$\mu\text{V}_{P-P}$

**Table 7. Electrical characteristics for TS3333**

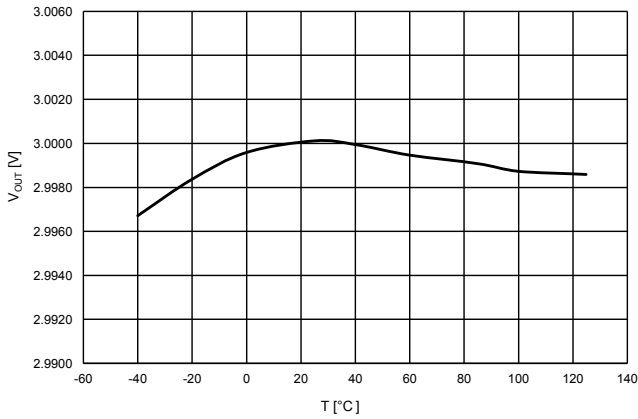
Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{OUT}$	Output voltage	$V_{IN} = 5\text{ V}$		3.3		V
	Initial accuracy	$I_{LOAD} = 0\text{ mA}$ $T_{amb} = 25\text{ °C}$	-0.15		0.15	%
$\Delta V_{OUT}/\Delta T$	Average temperature coefficient	$-40\text{ °C} < T_{amb} < +85\text{ °C}$		9	30	ppm/°C
		$-40\text{ °C} < T_{amb} < +125\text{ °C}$		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	$V_{IN} = 3.5\text{ V}$ $I_{LOAD} = \pm 5\text{ mA}$ $0\text{ °C} < T_{amb} < 70\text{ °C}$		50	100	mV
		$-40\text{ °C} < T_{amb} < +85\text{ °C}$		70		
		$-40\text{ °C} < T_{amb} < +125\text{ °C}$		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	
		$-40\text{ °C} < T_{amb} < +85\text{ °C}$				
$I_{SC}$	Short-circuit current sourcing/sinking			35		mA
$I_Q$	Quiescent current			3.9	7	$\mu\text{A}$
		$-40\text{ °C} < T_{amb} < +85\text{ °C}$		4.4	7.5	
		$-40\text{ °C} < T_{amb} < +125\text{ °C}$		4.8	10	
$C_{OUT}$	Capacitive load		0.1		10	$\mu\text{F}$
$T_{ON}$	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		$\mu\text{V}_{P-P}$



## 5 Typical performance characteristics

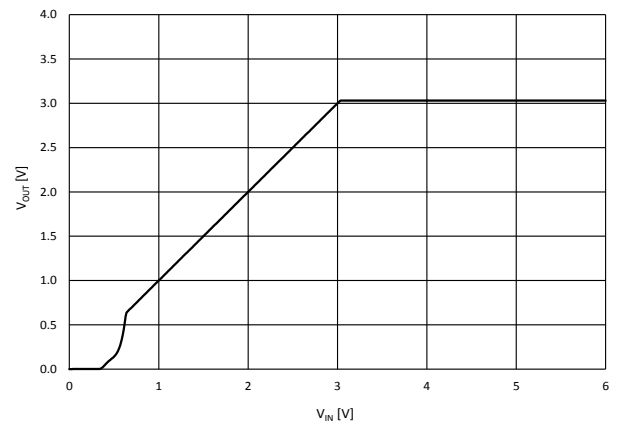
The following plots are referred to the typical application circuit and, unless otherwise noted, at  $T_A = 25\text{ }^\circ\text{C}$ ,  $V_{OUT} = 3.0\text{ V}$ .

**Figure 3. Output voltage vs. temperature**



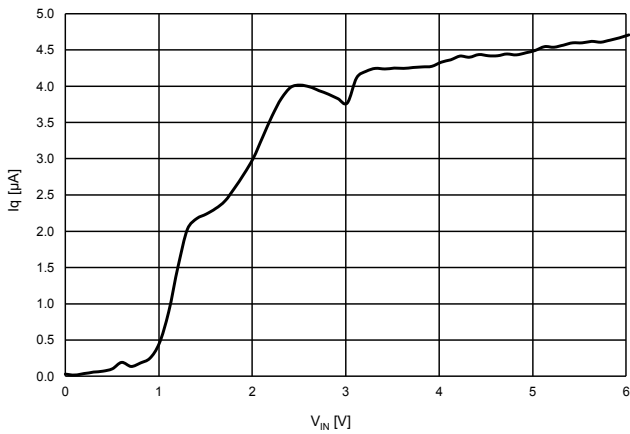
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**Figure 4. Output voltage vs. input voltage**



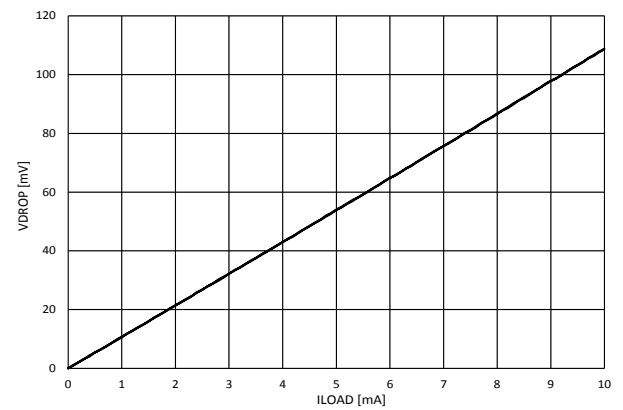
GAMG251120160931MT

**Figure 5. Quiescent current vs. input voltage**

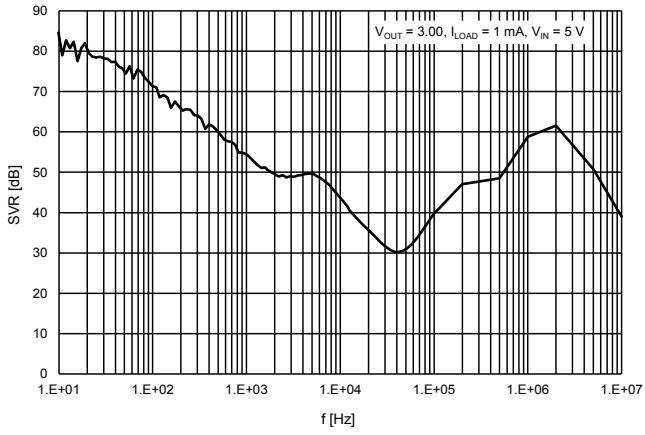


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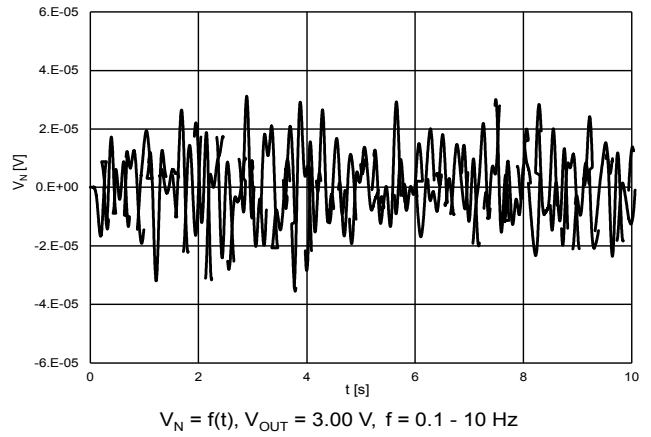
**Figure 6. Dropout voltage vs. load current**



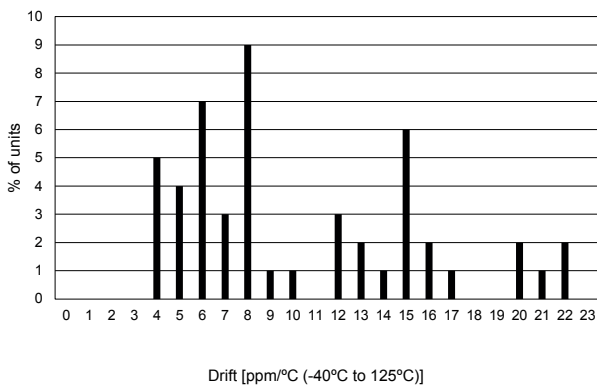
GAMG251120160933MT

**Figure 7. SVR vs. frequency**


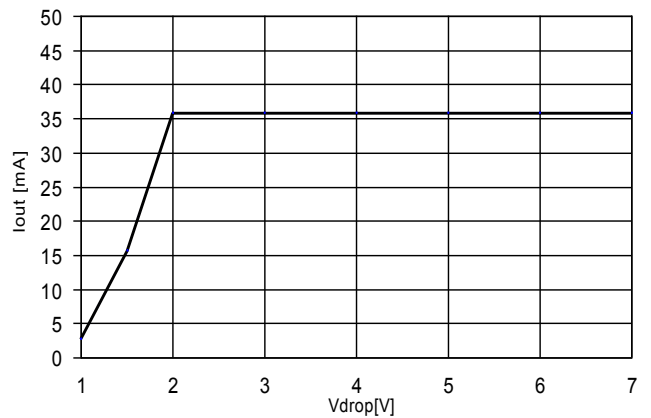
GAMG251120160934MT

**Figure 8. Low frequency noise**


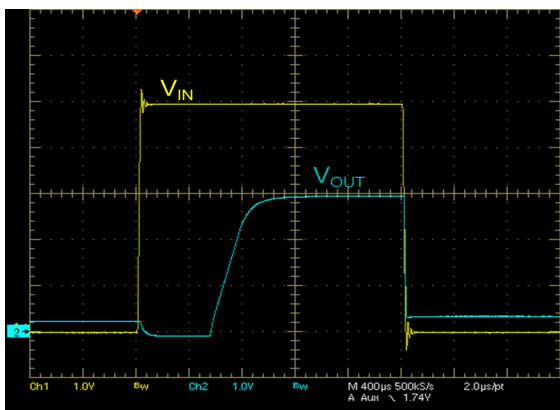
GAMG251120160935MT

**Figure 9. Temperature drift**


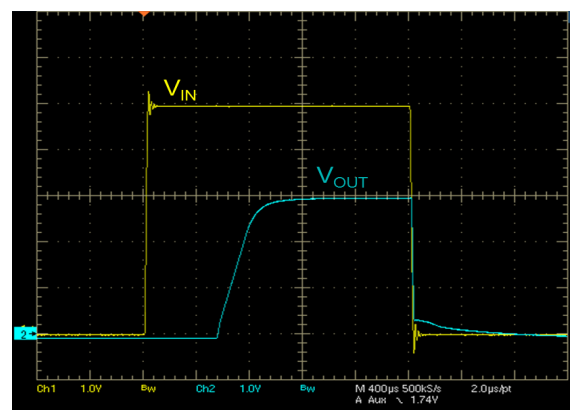
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**Figure 10. Short-circuit current vs. dropout voltage**

 T = 25 °C, C<sub>in</sub> = 1 μF, C<sub>out</sub> = 1 μF

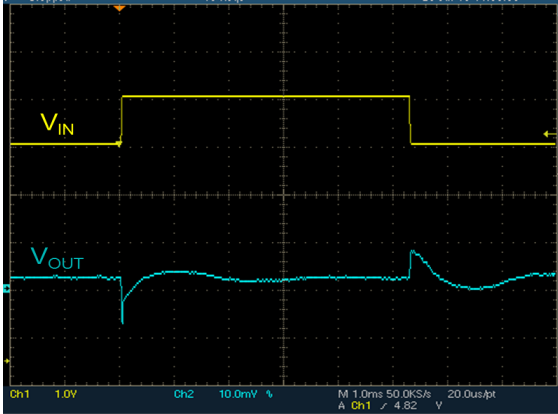
GAMG251120160937MT

**Figure 11. Startup transient (no load)**

 V<sub>IN</sub> from 0 to 5V, V<sub>OUT</sub>=3V, I<sub>OUT</sub>=0mA, C<sub>IN</sub>= C<sub>OUT</sub>= 1μF

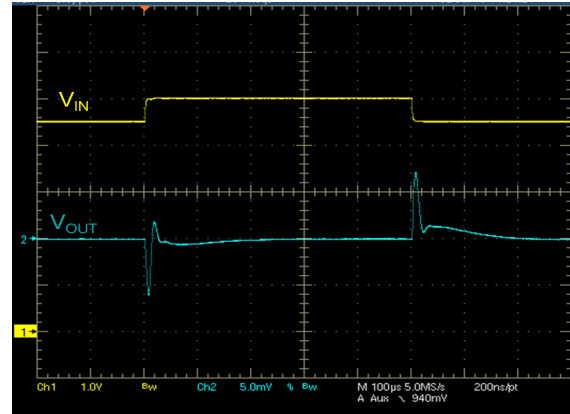
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**Figure 12. Startup transient (I<sub>OUT</sub> = 5 mA)**

 V<sub>IN</sub> from 0 to 5V, V<sub>OUT</sub>=3V, I<sub>OUT</sub>=5mA, C<sub>IN</sub>= C<sub>OUT</sub>= 1μF

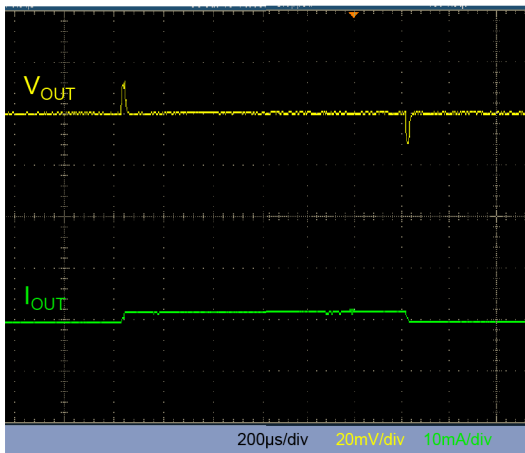
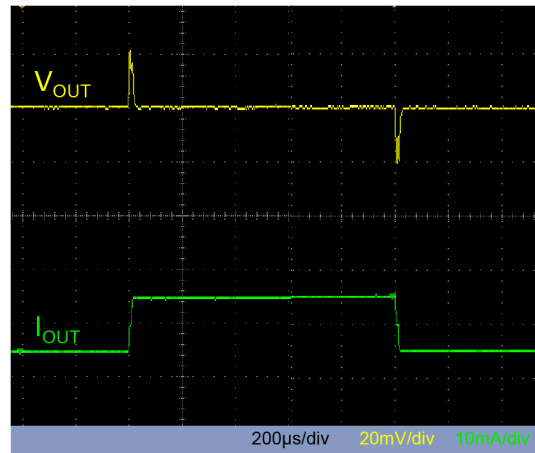
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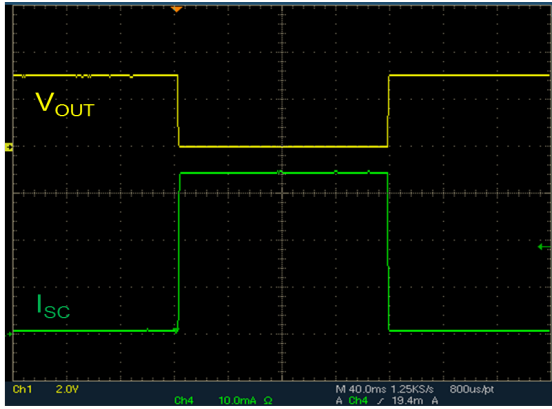
**Figure 13. Line transient (no load)**

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

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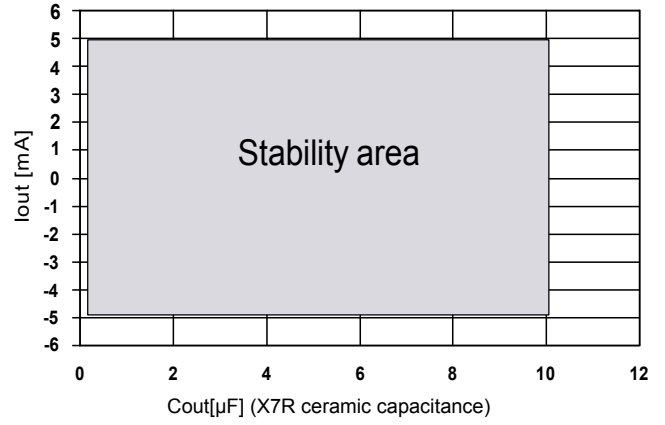
**Figure 14. Line transient ( $I_{OUT} = 1\text{ mA}$ )**

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

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

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

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

**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**


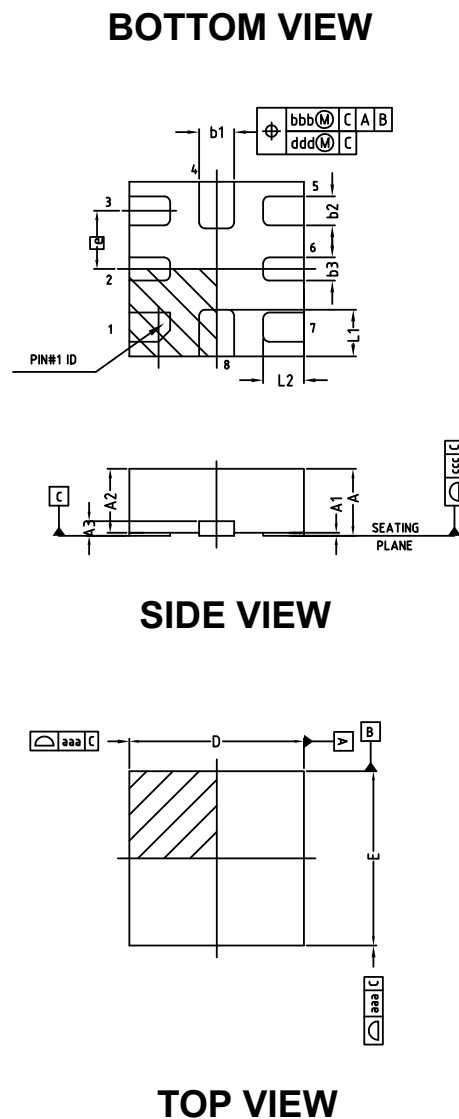
GAMG251120160945MT

## 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](http://www.st.com). ECOPACK is an ST trademark.

### 6.1 QFN8 package information

Figure 19. QFN8 package outline



DM00182817\_A

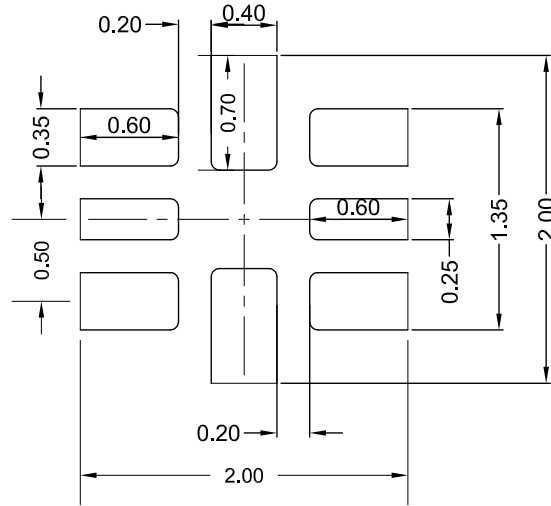
**Table 8. QFN8 mechanical data**

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 9. 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

## 7 Ordering information

**Table 10. Order codes**

Part number	Output voltage (V)	Precision	Package	Temperature range
TS3312AQPR	1.25	±0.15 %	QFN8	-40 to +125 °C
TS3325AQPR	2.5			
TS3330AQPR	3.0			
TS3333AQPR	3.3			



## Revision history

**Table 11. 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 <a href="#">Table 5. Electrical characteristics for TS3325</a> . Removed footnote in <a href="#">Table 10</a> .

## Contents

<b>1</b>	<b>Pin configuration</b> .....	<b>2</b>
<b>2</b>	<b>Maximum ratings</b> .....	<b>3</b>
<b>3</b>	<b>Typical application</b> .....	<b>4</b>
<b>4</b>	<b>Electrical characteristics</b> .....	<b>5</b>
<b>5</b>	<b>Typical performance characteristics</b> .....	<b>9</b>
<b>6</b>	<b>Package information</b> .....	<b>13</b>
<b>6.1</b>	<b>QFN-8 package information</b> .....	<b>13</b>
<b>7</b>	<b>Ordering information</b> .....	<b>16</b>
	<b>Revision history</b> .....	<b>17</b>
	<b>Contents</b> .....	<b>18</b>
	<b>List of tables</b> .....	<b>19</b>
	<b>List of figures</b> .....	<b>20</b>

## List of tables

<b>Table 1.</b>	Absolute maximum ratings . . . . .	3
<b>Table 2.</b>	Thermal data . . . . .	3
<b>Table 3.</b>	Recommended operating conditions . . . . .	3
<b>Table 4.</b>	Electrical characteristics for TS3312 . . . . .	5
<b>Table 5.</b>	Electrical characteristics for TS3325 . . . . .	6
<b>Table 6.</b>	Electrical characteristics for TS3330 . . . . .	7
<b>Table 7.</b>	Electrical characteristics for TS3333 . . . . .	8
<b>Table 8.</b>	QFN8 mechanical data . . . . .	14
<b>Table 9.</b>	QFN8 tolerance of form and position . . . . .	14
<b>Table 10.</b>	Order codes . . . . .	16
<b>Table 11.</b>	Document revision history . . . . .	17

## List of figures

<b>Figure 1.</b>	Pin configuration (top view) . . . . .	2
<b>Figure 2.</b>	Typical application circuit . . . . .	4
<b>Figure 3.</b>	Output voltage vs. temperature . . . . .	9
<b>Figure 4.</b>	Output voltage vs. input voltage . . . . .	9
<b>Figure 5.</b>	Quiescent current vs. input voltage . . . . .	9
<b>Figure 6.</b>	Dropout voltage vs. load current . . . . .	9
<b>Figure 7.</b>	SVR vs. frequency . . . . .	10
<b>Figure 8.</b>	Low frequency noise . . . . .	10
<b>Figure 9.</b>	Temperature drift. . . . .	10
<b>Figure 10.</b>	Short-circuit current vs. dropout voltage . . . . .	10
<b>Figure 11.</b>	Startup transient (no load) . . . . .	10
<b>Figure 12.</b>	Startup transient ( $I_{OUT} = 5 \text{ mA}$ ) . . . . .	10
<b>Figure 13.</b>	Line transient (no load) . . . . .	11
<b>Figure 14.</b>	Line transient ( $I_{OUT} = 1 \text{ mA}$ ) . . . . .	11
<b>Figure 15.</b>	Load transient ( $I_{OUT} = +/-1 \text{ mA}$ ) . . . . .	11
<b>Figure 16.</b>	Load transient ( $I_{OUT} = +/-5 \text{ mA}$ ) . . . . .	11
<b>Figure 17.</b>	Short-circuit response . . . . .	12
<b>Figure 18.</b>	Stability plan . . . . .	12
<b>Figure 19.</b>	QFN8 package outline . . . . .	13
<b>Figure 20.</b>	QFN8 recommended footprint. . . . .	15

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