

## 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  $\mu\text{A}$  (typ.) at 25 °C
- High initial accuracy:  $\pm 0.15\%$
- 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.

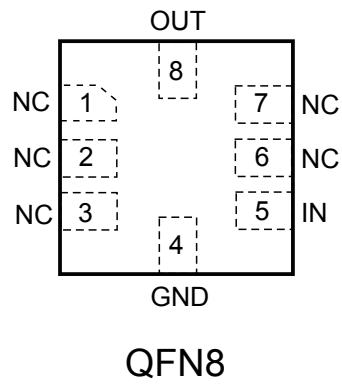
Available in QFN8 surface mount packages, the TS33 can be designed in applications where space saving is a critical issue.

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**

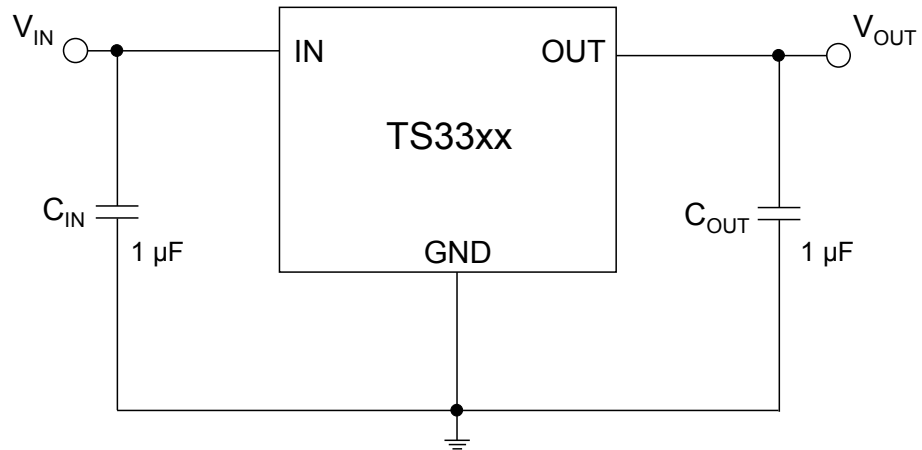
Symbol	Parameter	Value	Unit
$R_{thJA}$	Thermal resistance junction-ambient	159	°C/W
$R_{thJC}$	Thermal resistance junction-case	103	°C/W

**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**

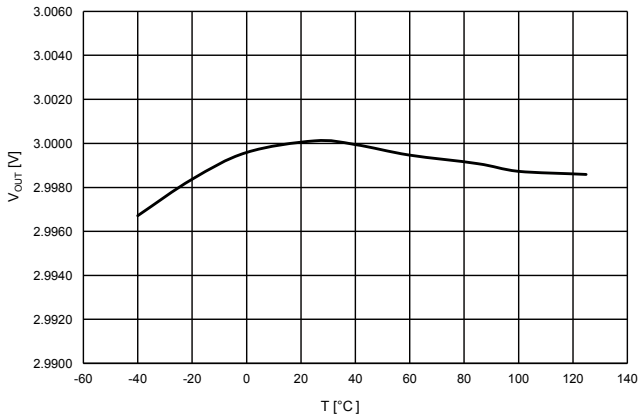
Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{OUT}$	Output voltage	$V_{IN} = 5\text{ V}$		3.3		V
	Initial accuracy	$I_{LOAD} = 0\text{ mA}$ $T_{amb} = 25\text{ °C}$	-0.15		0.15	%
$\Delta V_{OUT}/\Delta T$	Average temperature coefficient	$-40\text{ °C} < T_{amb} < +85\text{ °C}$		9	30	ppm/°C
		$-40\text{ °C} < T_{amb} < +125\text{ °C}$		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

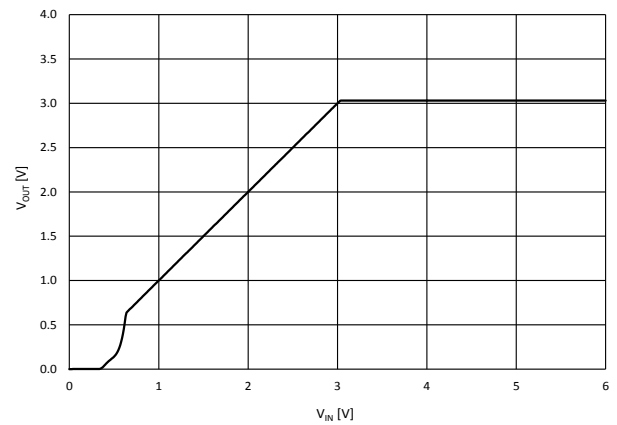
The following plots are referred to the typical application circuit and, unless otherwise noted, at  $T_A = 25\text{ }^\circ\text{C}$ ,  $V_{OUT} = 3.0\text{ V}$ .

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



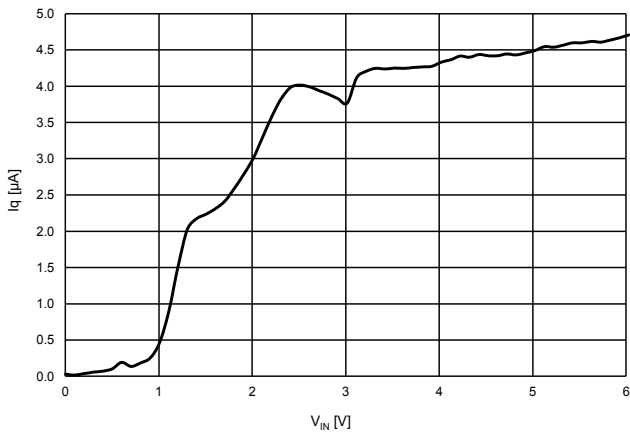
GAMG251120160930MT

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



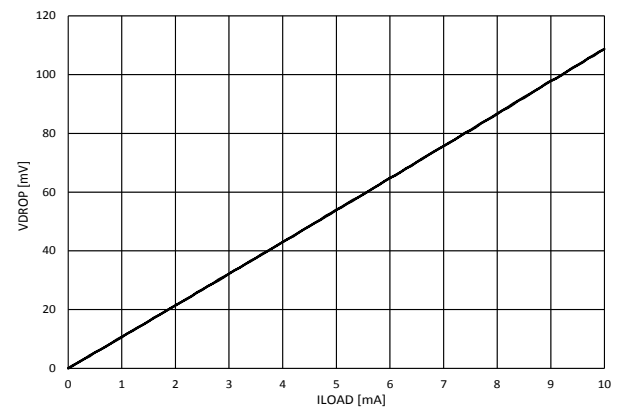
GAMG251120160931MT

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

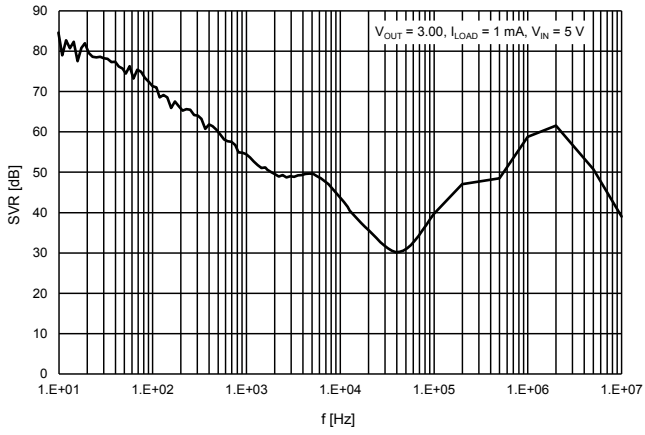


GAMG251120160932MT

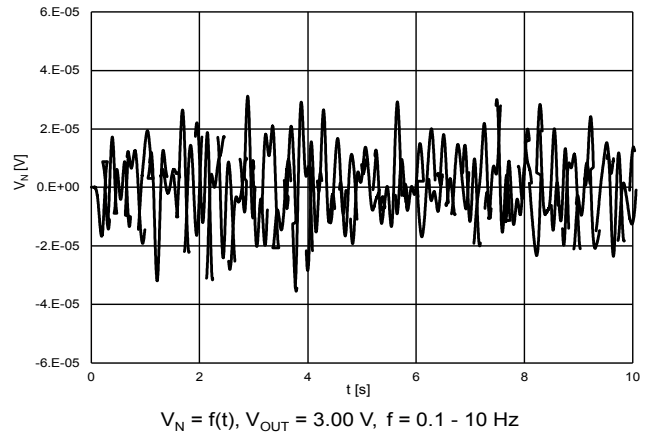
**Figure 6. Dropout voltage vs. load current**



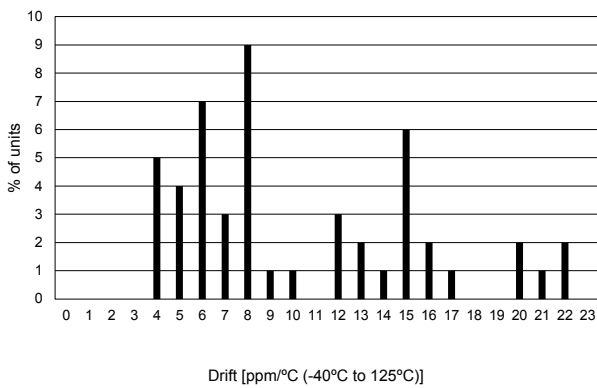
GAMG251120160933MT

**Figure 7. SVR vs. frequency**


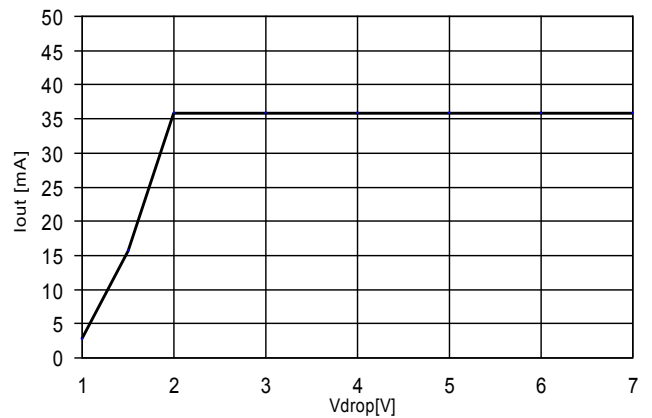
GAMG251120160934MT

**Figure 8. Low frequency noise**


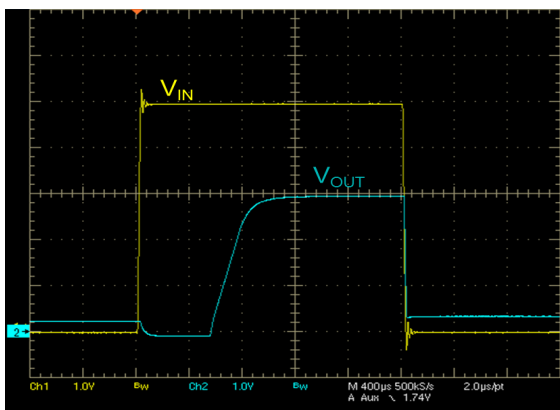
GAMG251120160935MT

**Figure 9. Temperature drift**


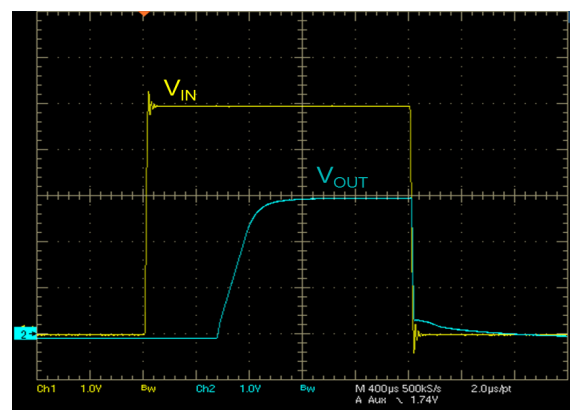
GAMG251120160936MT

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

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

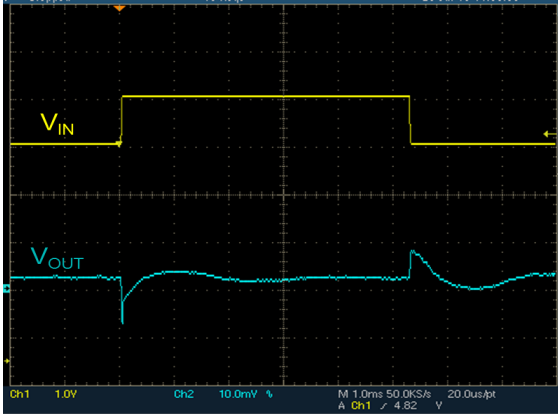
GAMG251120160937MT

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

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

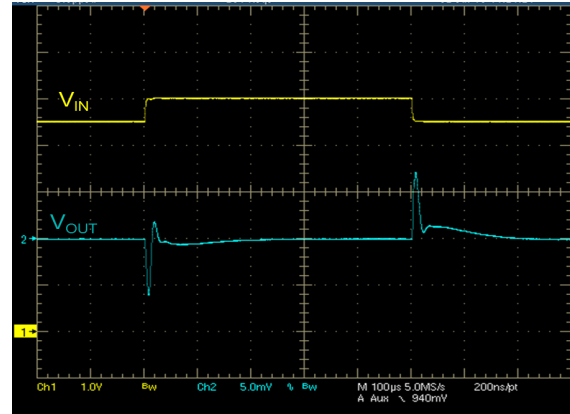
GAMG251120160938MT

**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

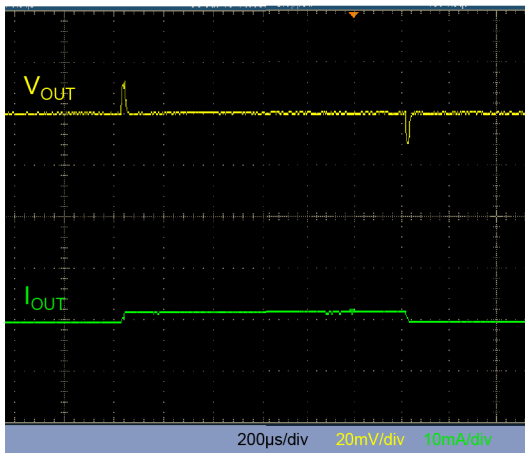
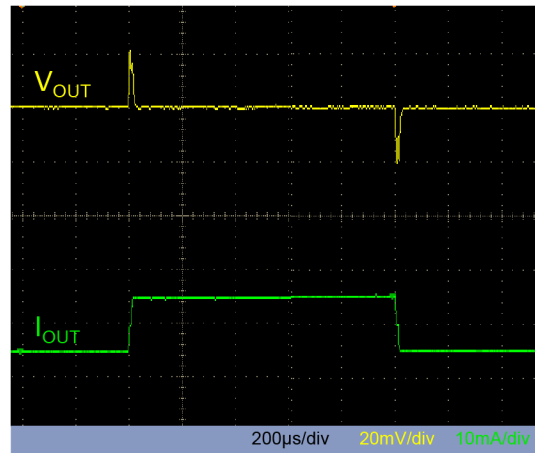
GAMG251120160939MT

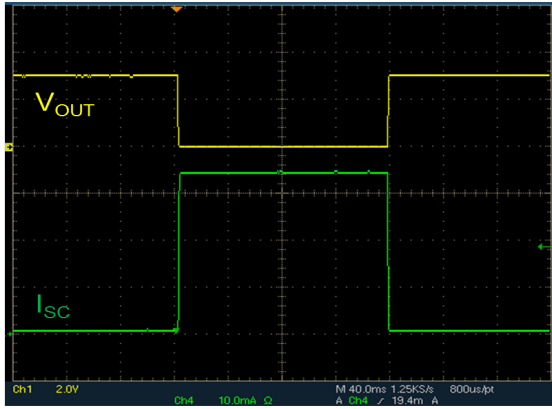
**Figure 13. Line transient (no load)**

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

GAMG251120160940MT

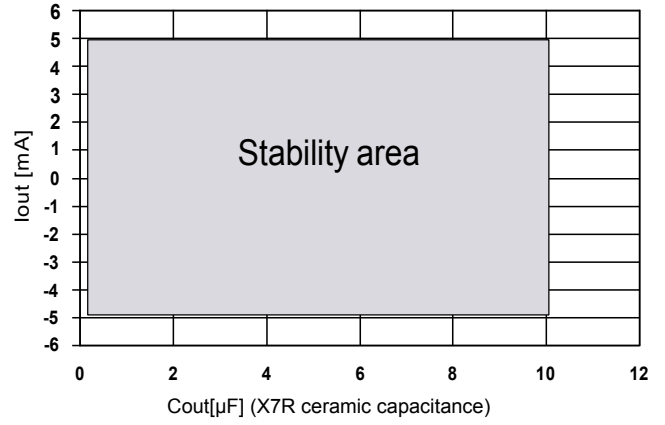
**Figure 14. Line transient ( $I_{OUT} = 1\text{ mA}$ )**

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

GAMG251120160941MT

**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**

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

GAMG251120160944MT

**Figure 18. Stability plan**


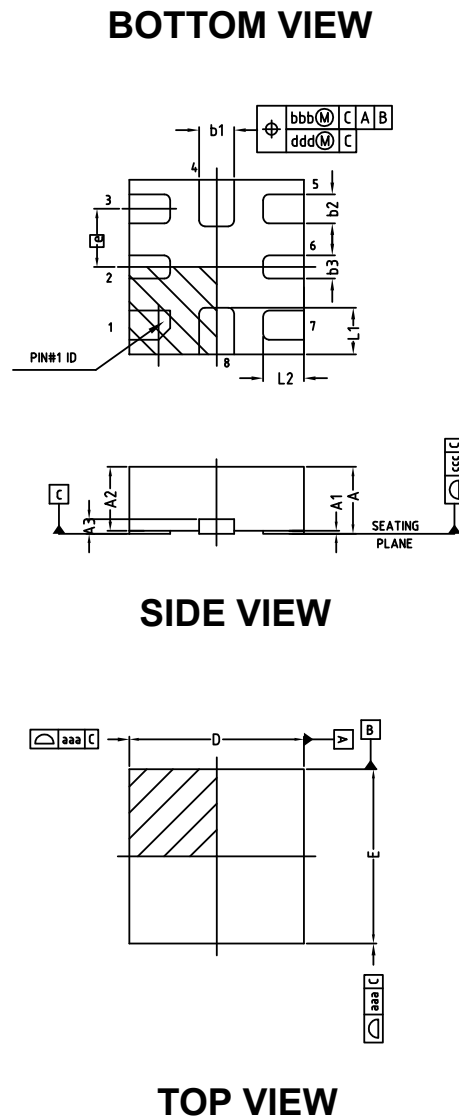
GAMG251120160945MT

## 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

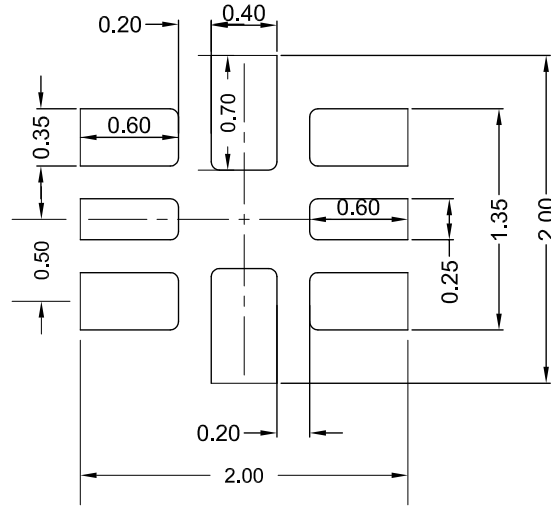
**Table 8. QFN8 mechanical data**

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

**IMPORTANT NOTICE – PLEASE READ CAREFULLY**

STMicroelectronics NV and its subsidiaries (“ST”) reserve the right to make changes, corrections, enhancements, modifications, and improvements to ST products and/or to this document at any time without notice. Purchasers should obtain the latest relevant information on ST products before placing orders. ST products are sold pursuant to ST’s terms and conditions of sale in place at the time of order acknowledgement.

Purchasers are solely responsible for the choice, selection, and use of ST products and ST assumes no liability for application assistance or the design of Purchasers’ products.

No license, express or implied, to any intellectual property right is granted by ST herein.

Resale of ST products with provisions different from the information set forth herein shall void any warranty granted by ST for such product.

ST and the ST logo are trademarks of ST. For additional information about ST trademarks, please refer to [www.st.com/trademarks](http://www.st.com/trademarks). All other product or service names are the property of their respective owners.

Information in this document supersedes and replaces information previously supplied in any prior versions of this document.

© 2020 STMicroelectronics – All rights reserved

# Mouser Electronics

Authorized Distributor

Click to View Pricing, Inventory, Delivery & Lifecycle Information:

[STMicroelectronics:](#)

[TS3330AQPR](#) [TS3312AQPR](#) [TS3333AQPR](#) [TS3325AQPR](#)