

## 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.

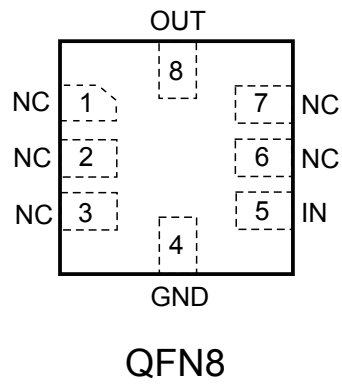
Available in QFN8 surface mount packages, the TS33 can be designed in applications where space saving is a critical issue.

Maturity status link

TS33

# 1 Pin configuration

Figure 2. 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**

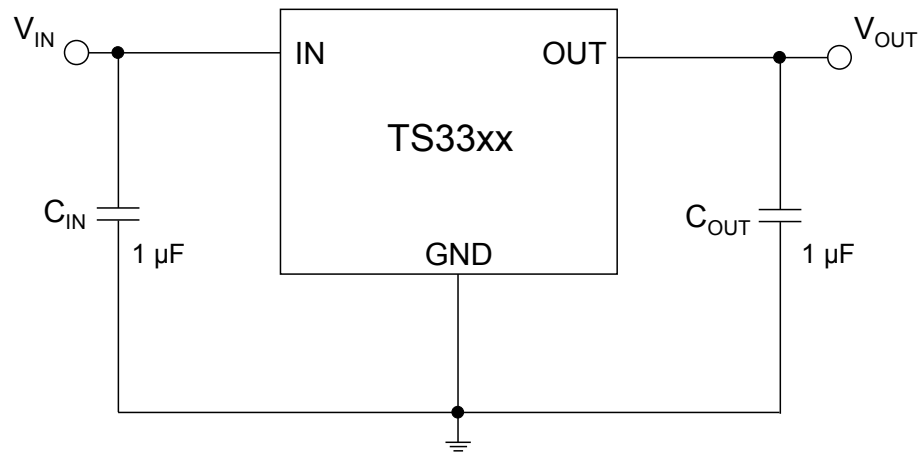
| Symbol     | Parameter                           | Value | Unit |
|------------|-------------------------------------|-------|------|
| $R_{thJA}$ | Thermal resistance junction-ambient | 159   | °C/W |
| $R_{thJC}$ | Thermal resistance junction-case    | 103   | °C/W |

**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 3. 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                      | $I_{LOAD} = 0\text{ mA}$<br>$T_{amb} = 25\text{ °C}$                   | 1.8   |      |      | V                   |
| $V_{OUT}$                        | Output voltage                             | $V_{IN} = 5\text{ V}$  |       | 1.25 |      | V                   |
|                                  | Initial accuracy                           | $I_{LOAD} = 0\text{ mA}$<br>$T_{amb} = 25\text{ °C}$                   | -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              |
|                                  |  | $I_{LOAD} = \pm 5\text{ mA}$<br>$0\text{ °C} < T_{amb} < 70\text{ °C}$ |       | 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/<br>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 TS3330**

| Symbol                           | Parameter                              | Test conditions   | Min.  | Typ. | Max. | Unit                |
|----------------------------------|--|---|-------|------|------|---------------------|
| $V_{OUT}$                        | Output voltage                         | $V_{IN} = 5\text{ V}$   |       | 3.0  |      | V                   |
|                                  | Initial accuracy                       | $I_{LOAD} = 0\text{ mA}$<br>$T_{amb} = 25\text{ °C}$  | -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              |
|                                  |  | $I_{LOAD} = \pm 5\text{ mA}$<br>$0\text{ °C} < T_{amb} < 70\text{ °C}$                            |       | 10   |      |                     |
|                                  |  | $-40\text{ °C} < T_{amb} < +85\text{ °C}$   |       | 20   |      |                     |
|                                  |  | $-40\text{ °C} < T_{amb} < +125\text{ °C}$  |       | 20   |      |                     |
| $V_{DROP}$                       | Minimum dropout voltage                | $V_{IN} = 3.2\text{ V}$<br>$I_{LOAD} = \pm 5\text{ mA}$<br>$0\text{ °C} < T_{amb} < 70\text{ °C}$ |       | 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   |      |                     |
|                                  |  | $I_{LOAD} = \pm 2\text{ mA}$<br>$-40\text{ °C} < T_{amb} < +85\text{ °C}$                         |       |      | 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   |      | $\mu\text{V}_{P-P}$ |

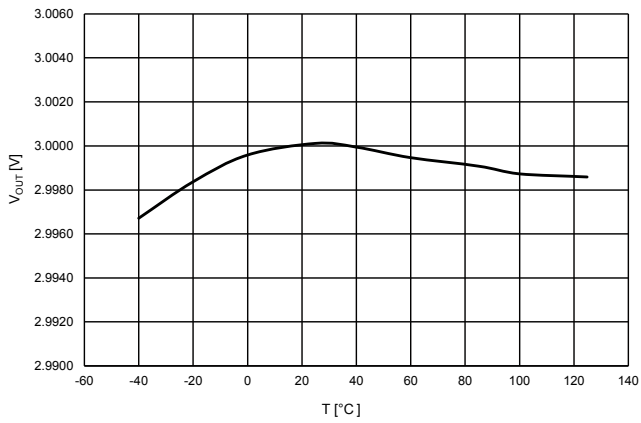
**Table 6. Electrical characteristics for TS3333**

| Symbol                           | Parameter                              | Test conditions   | Min.  | Typ. | Max. | Unit                |
|----------------------------------|--|---|-------|------|------|---------------------|
| $V_{OUT}$                        | Output voltage                         | $V_{IN} = 5\text{ V}$   |       | 3.3  |      | V                   |
|                                  | Initial accuracy                       | $I_{LOAD} = 0\text{ mA}$<br>$T_{amb} = 25\text{ °C}$  | -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              |
|                                  |  | $I_{LOAD} = \pm 5\text{ mA}$<br>$0\text{ °C} < T_{amb} < 70\text{ °C}$                            |       | 10   |      |                     |
|                                  |  | $-40\text{ °C} < T_{amb} < +85\text{ °C}$   |       | 20   |      |                     |
|                                  |  | $-40\text{ °C} < T_{amb} < +125\text{ °C}$  |       | 20   |      |                     |
| $V_{DROP}$                       | Minimum dropout voltage                | $V_{IN} = 3.5\text{ V}$<br>$I_{LOAD} = \pm 5\text{ mA}$<br>$0\text{ °C} < T_{amb} < 70\text{ °C}$ |       | 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   |      |                     |
|                                  |  | $I_{LOAD} = \pm 2\text{ mA}$<br>$-40\text{ °C} < T_{amb} < +85\text{ °C}$                         |       |      | 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                            | $f = 0.1\text{ Hz to } 10\text{ Hz}$  |       | 73   |      | $\mu\text{V}_{P-P}$ |

## 5 Typical performance characteristics

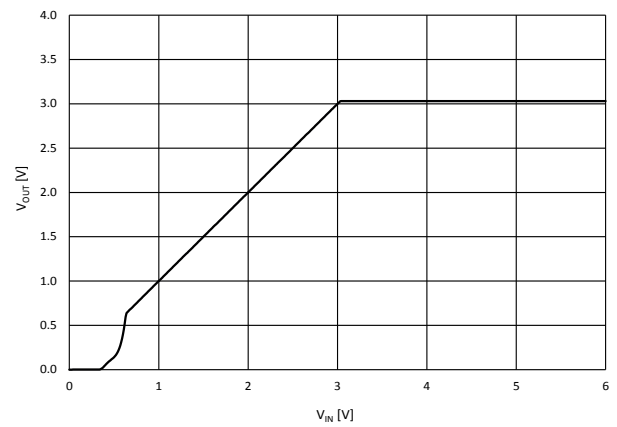
The following plots are referred to the typical application circuit and, unless otherwise noted, at  $T_A = 25\text{ }^\circ\text{C}$ ,  $V_{OUT} = 3.0\text{ V}$ .

**Figure 4. Output voltage vs. temperature**



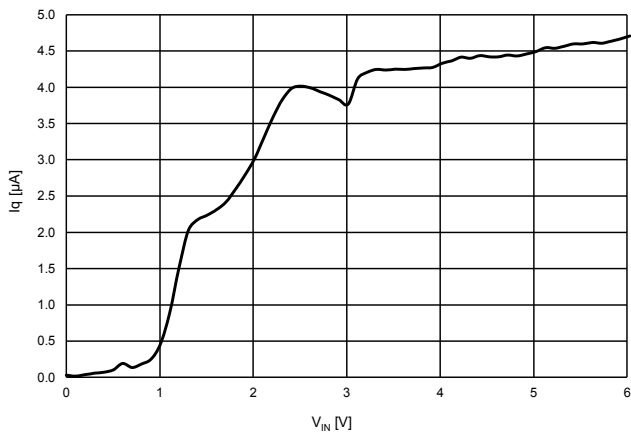
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**Figure 5. Output voltage vs. input voltage**



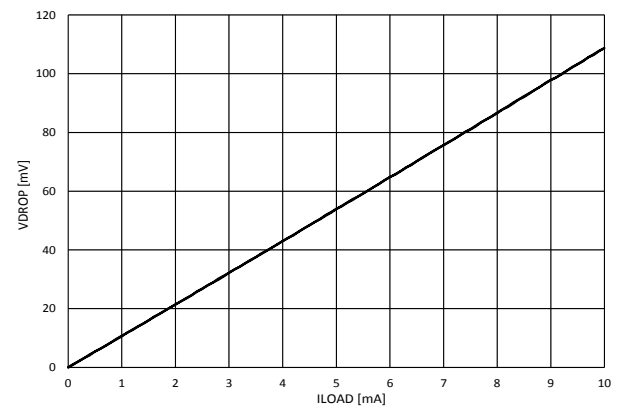
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**Figure 6. Quiescent current vs. input voltage**



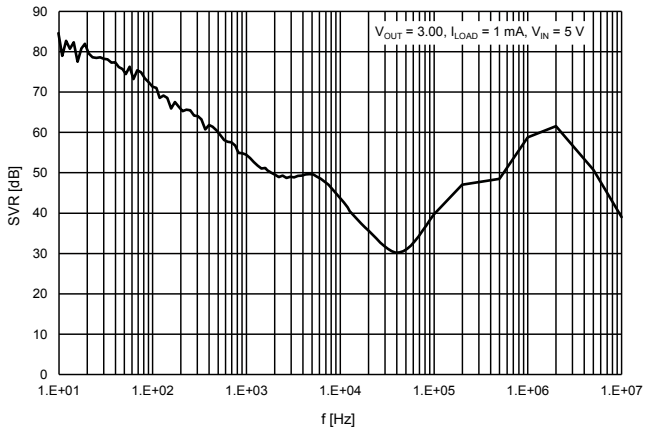
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**Figure 7. Dropout voltage vs. load current**

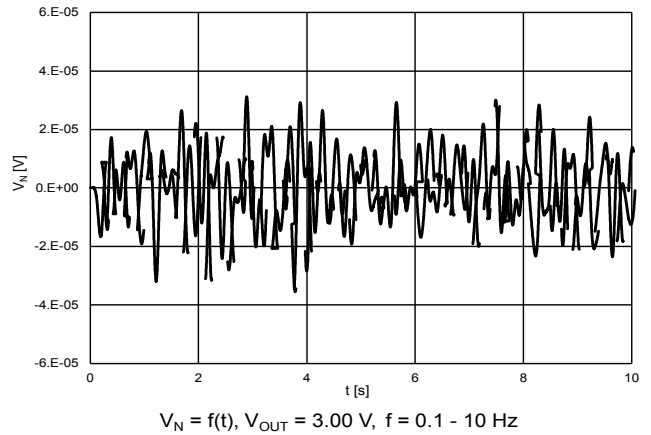


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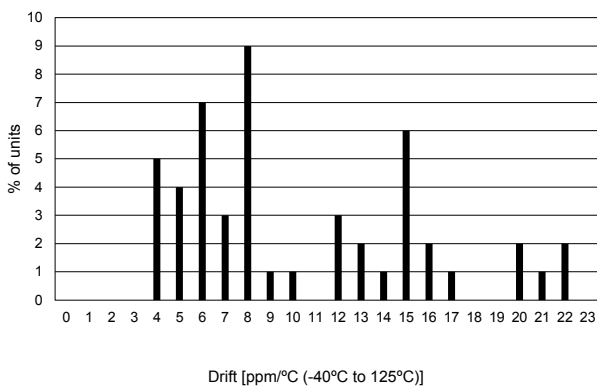


**Figure 8. SVR vs. frequency**


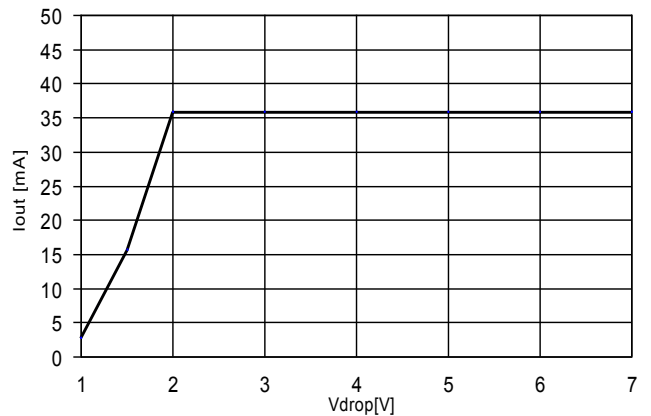
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**Figure 9. Low frequency noise**


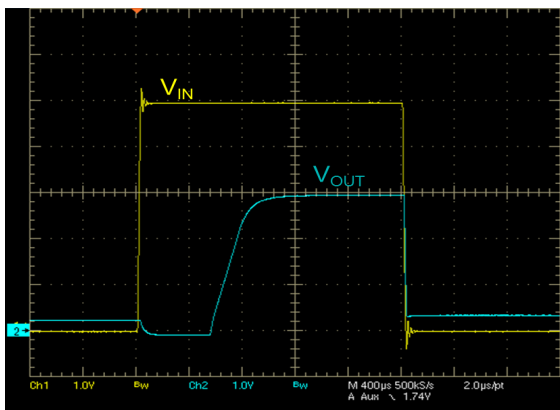
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**Figure 10. Temperature drift**


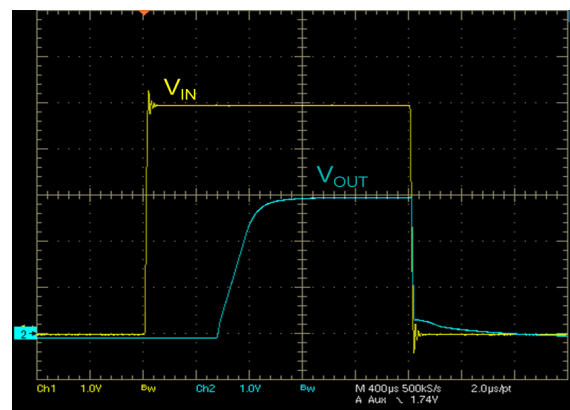
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**Figure 11. Short-circuit current vs. dropout voltage**

 T = 25 °C, C<sub>IN</sub> = 1 μF, C<sub>OUT</sub> = 1 μF

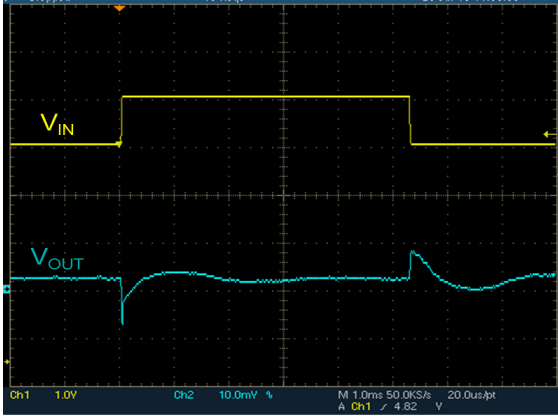
GAMG251120160937MT

**Figure 12. 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

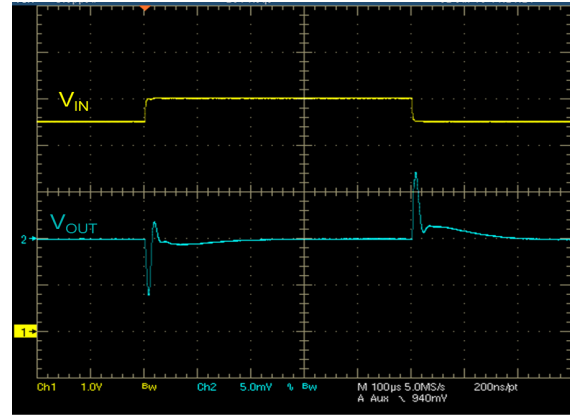
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**Figure 13. Startup transient (I<sub>OUT</sub> = 5 mA)**

 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 14. 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 15. 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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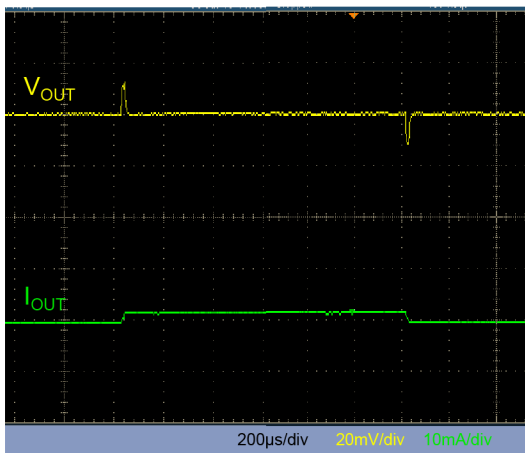
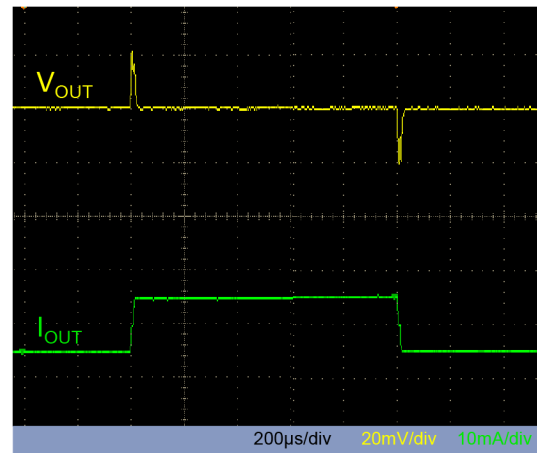
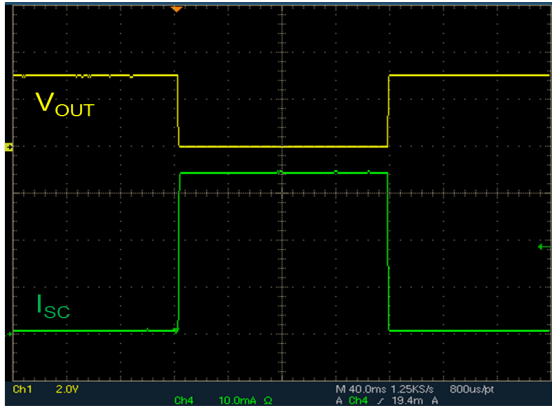
**Figure 16. Load transient ( $I_{OUT} = \pm 1\text{ mA}$ )**

 $V_{OUT} = 3V, I_{OUT} = \pm 1mA, C_{IN} = C_{OUT} = 1\mu F$ 
**Figure 17. Load transient ( $I_{OUT} = \pm 5\text{ mA}$ )**

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

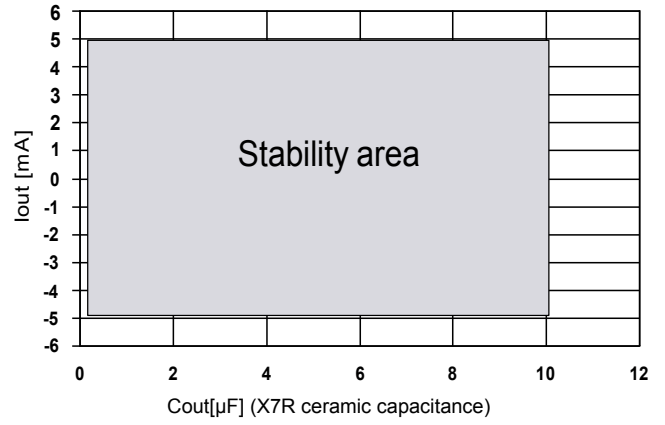
Figure 18. Short-circuit response



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

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Figure 19. Stability plan



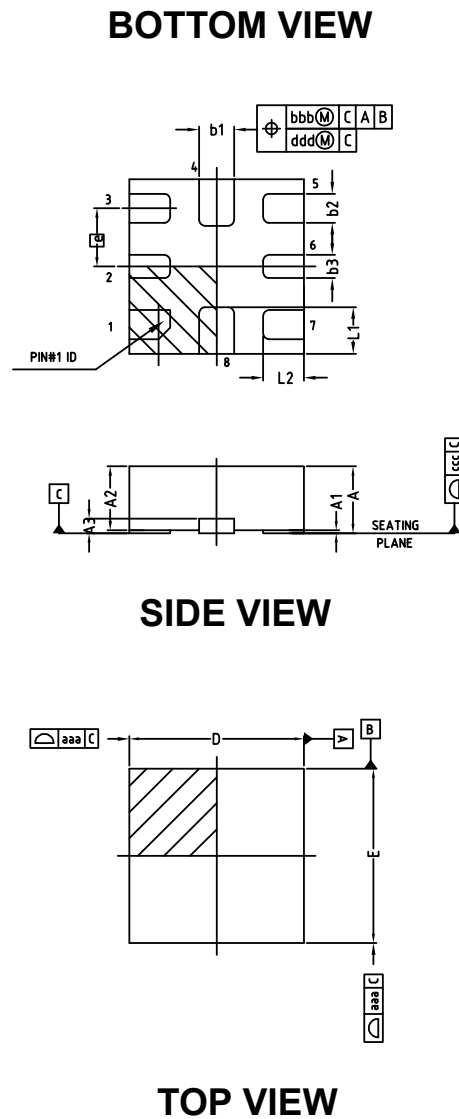
GAMG251120160945MT

## 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 20. QFN8 package outline



DM00182817\_A

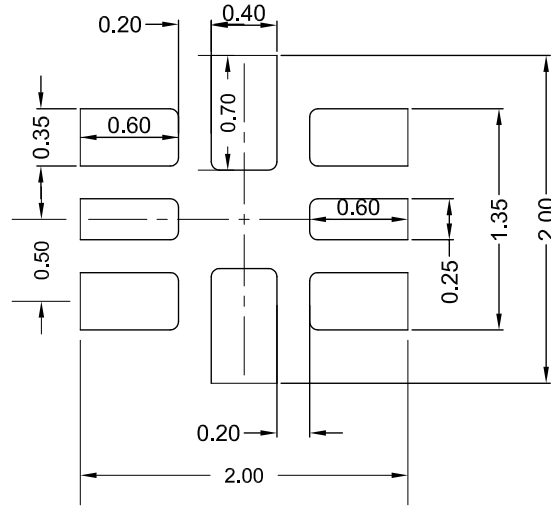
**Table 7. QFN8 mechanical data**

| 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 8. 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 21. QFN8 recommended footprint



DM00182817\_A

## 7 Ordering information

**Table 9. Order codes**

| Part number               | Output voltage (V) | Precision | Package | Temperature range |
|---------------------------|--------------------|-----------|---------|-------------------|
| TS3312AQPR                | 1.25               | ±0.15 %   | QFN8    | -40 to +125 °C    |
| TS3325AQPR <sup>(1)</sup> | 2.5                |           |         |                   |
| TS3330AQPR                | 3.0                |           |         |                   |
| TS3333AQPR                | 3.3                |           |         |                   |

1. *In development.*

## Revision history

**Table 10. Document revision history**

| Date        | Revision | Changes  |
|-------------|----------|--|
| 05-Sep-2017 | 1        | Initial release.   |
| 26-Sep-2018 | 2        | Added new order codes TS3325AQPR and TS3333AQPR in <a href="#">Table 9. Order codes.</a> |



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