

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 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 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.

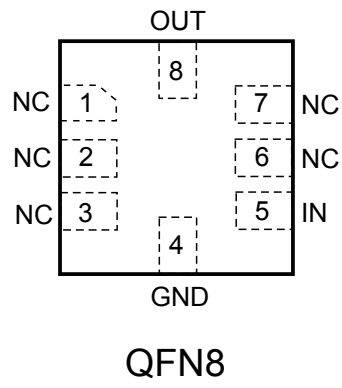
Available in QFN8 surface mount packages, the TS33 can be designed in applications where space saving is a critical issue.

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 ⁽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

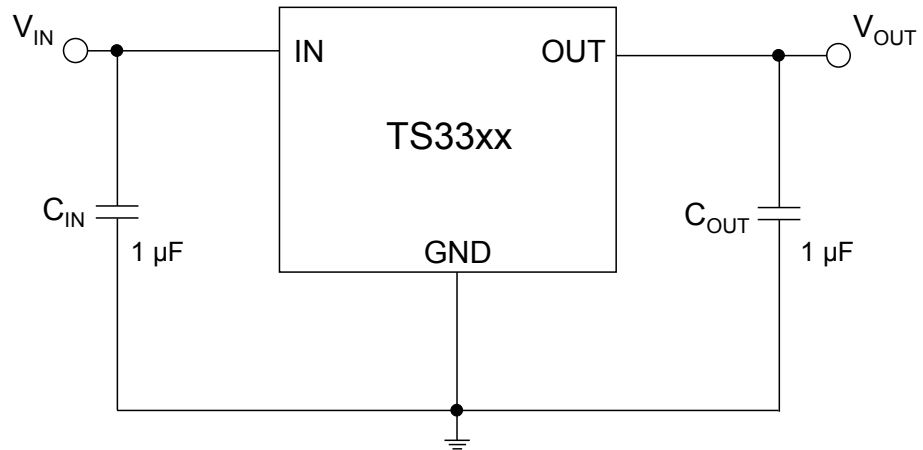
| Symbol | Parameter | Value | Unit |
|------------|-------------------------------------|-------|------|
| R_{thJA} | Thermal resistance junction-ambient | 159 | °C/W |
| R_{thJC} | Thermal resistance junction-case | 103 | °C/W |

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 | $I_{LOAD} = 0\text{ mA}$ $T_{amb} = 25\text{ °C}$ | 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 | $f = 0.1\text{ Hz to } 10\text{ Hz}$ | | 35 | | μV_{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 | $I_{LOAD} = 0\text{ mA}$ $T_{amb} = 25\text{ °C}$ | -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 | 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} |

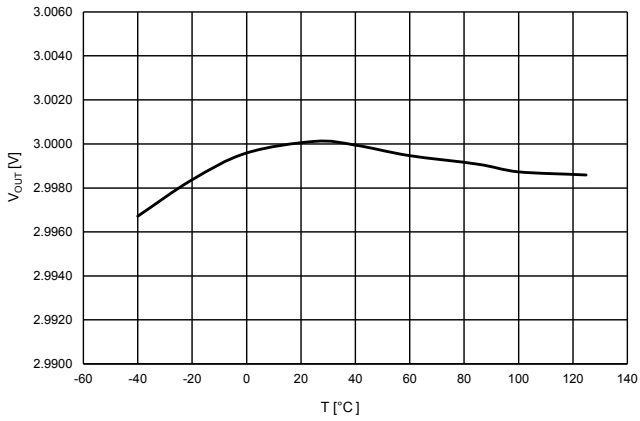
Table 6. Electrical characteristics for TS3333

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|----------------------------------|--|---|-------|------|------|---------------------|
| V_{OUT} | Output voltage | $V_{IN} = 5\text{ V}$ | | 3.3 | | V |
| | Initial accuracy | $I_{LOAD} = 0\text{ mA}$ $T_{amb} = 25\text{ °C}$ | -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 | |
| 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

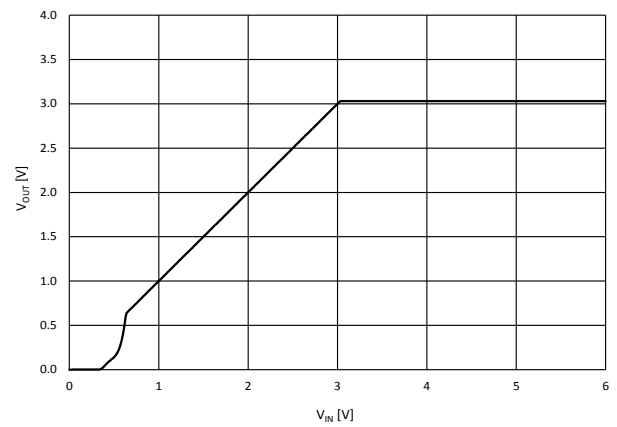
The following plots are referred to the typical application circuit and, unless otherwise noted, at $T_A = 25\text{ }^\circ\text{C}$, $V_{OUT} = 3.0\text{ V}$.

Figure 4. Output voltage vs. temperature



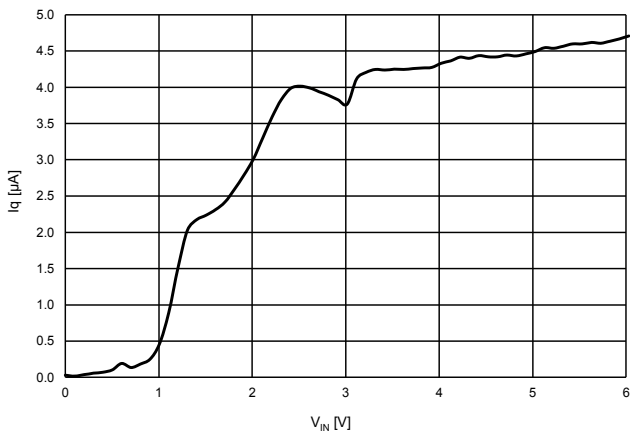
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Figure 5. Output voltage vs. input voltage



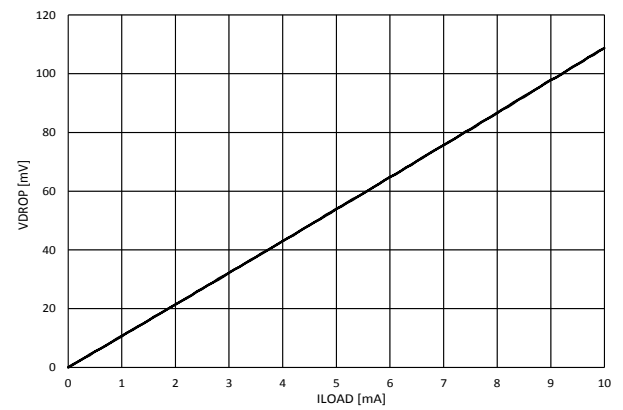
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Figure 6. Quiescent current vs. input voltage

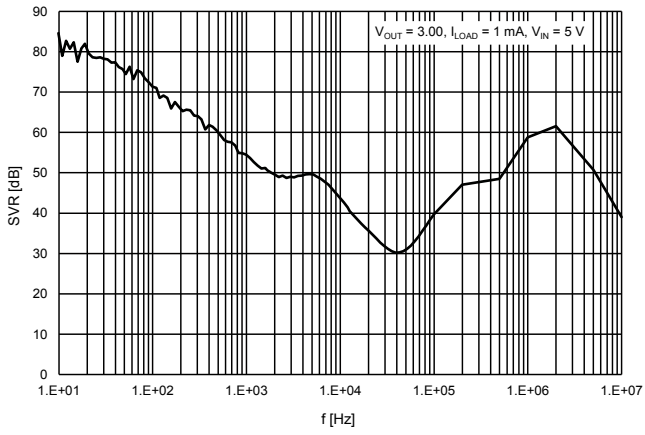


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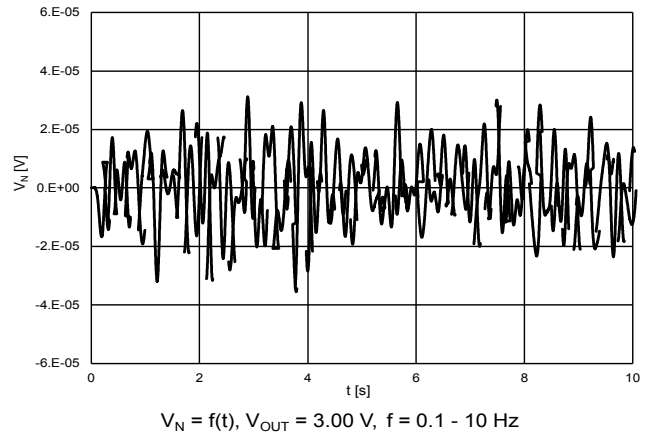
Figure 7. Dropout voltage vs. load current



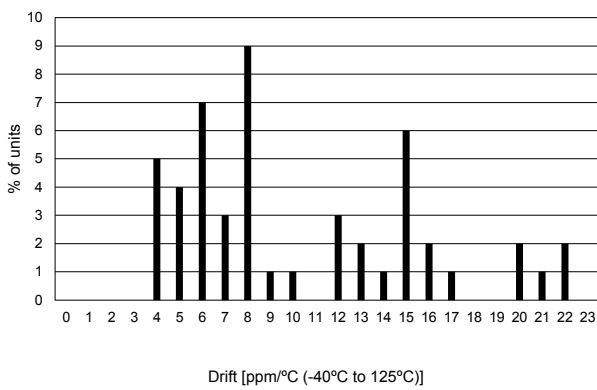
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Figure 8. SVR vs. frequency


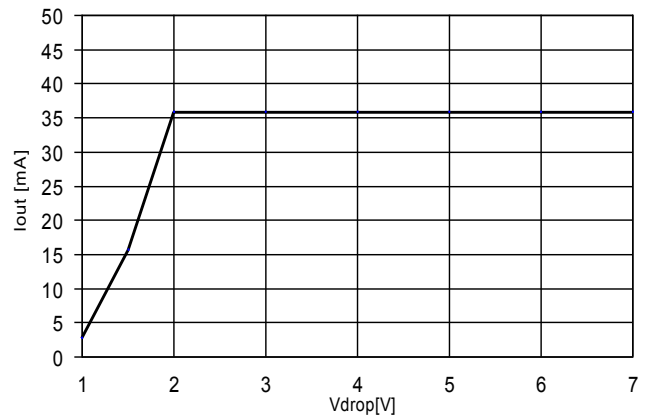
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Figure 9. Low frequency noise


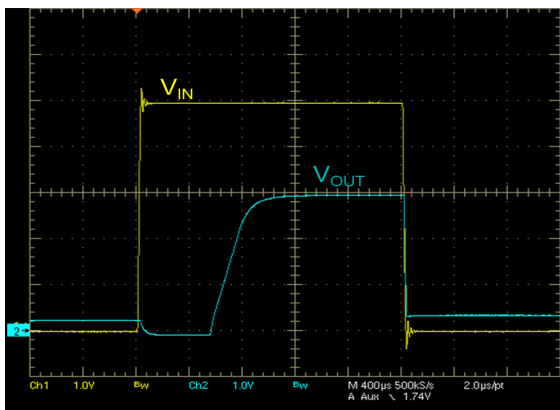
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Figure 10. Temperature drift


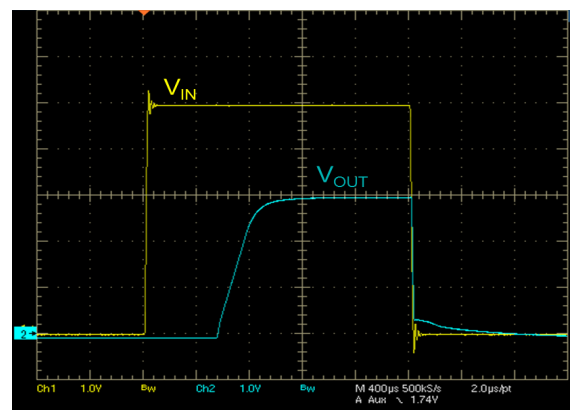
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Figure 11. Short-circuit current vs. dropout voltage

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

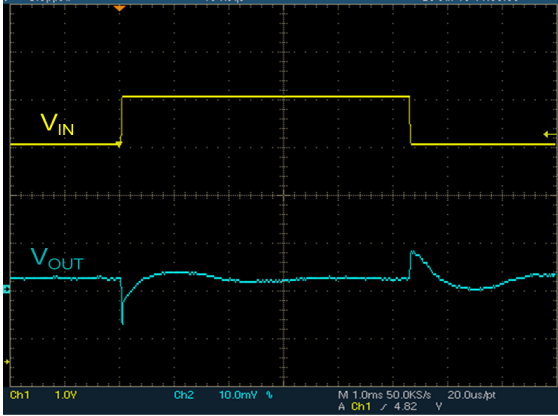
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Figure 12. Startup transient (no load)

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

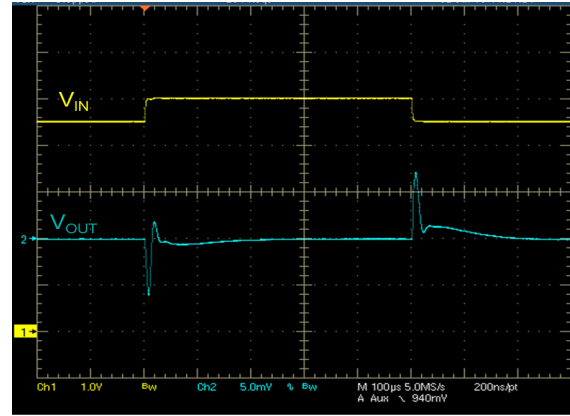
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Figure 13. Startup transient (I_{OUT} = 5 mA)

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

GAMG251120160939MT

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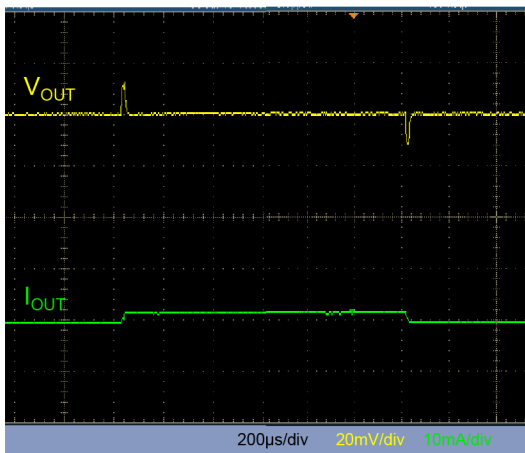
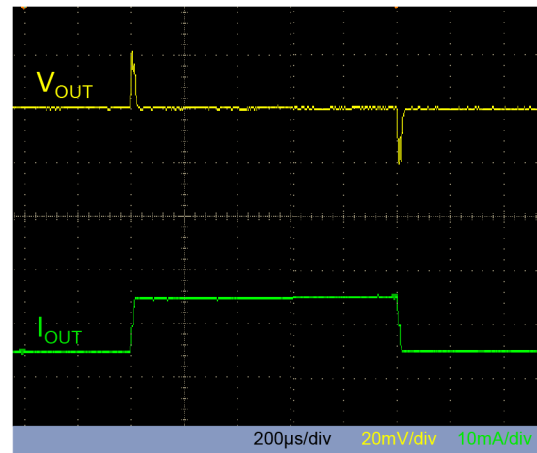
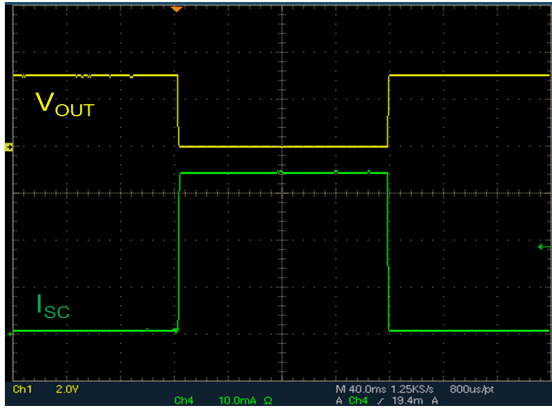
Figure 16. Load transient ($I_{OUT} = \pm 1\text{ mA}$)

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

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

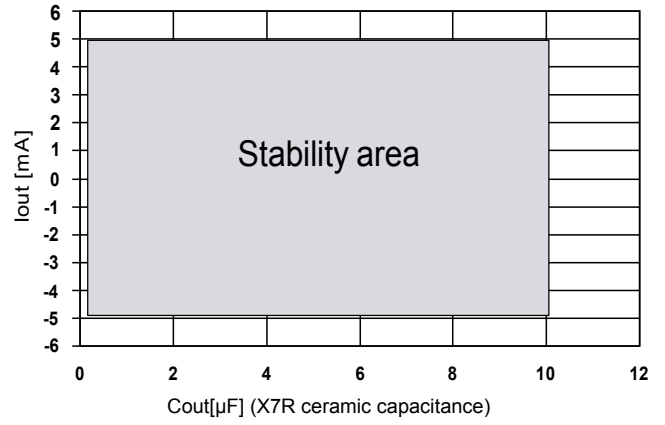
Figure 18. Short-circuit response



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

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Figure 19. Stability plan



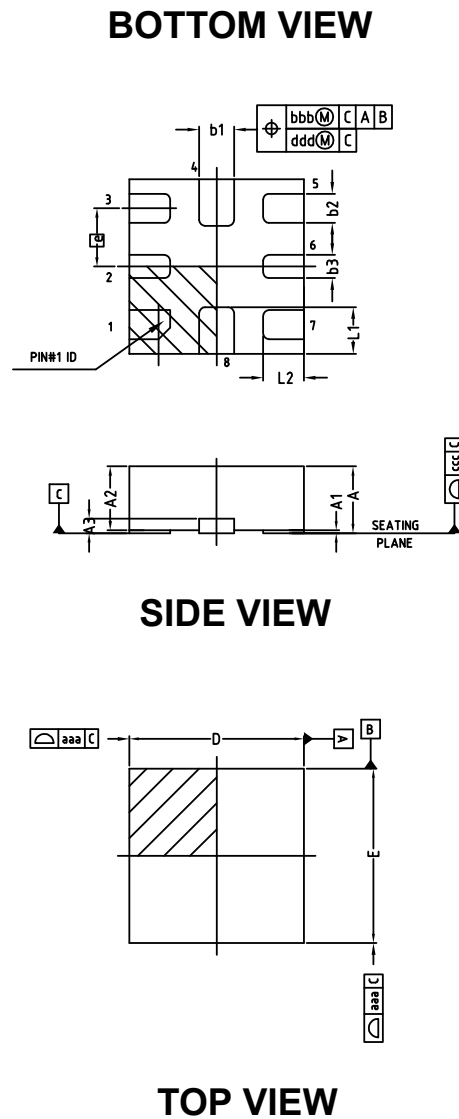
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6 Package information

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 QFN8 package information

Figure 20. QFN8 package outline



DM00182817_A

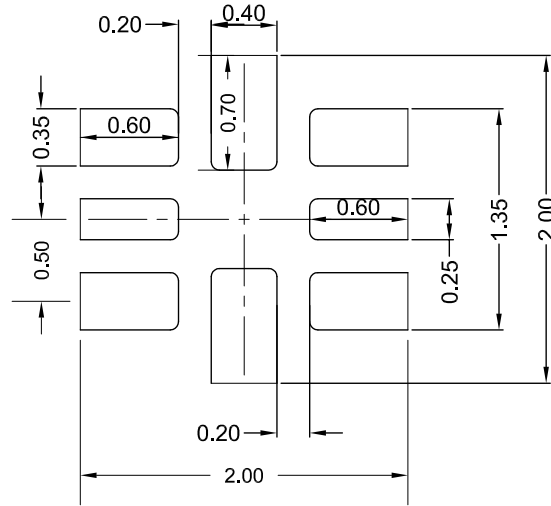
Table 7. QFN8 mechanical data

| 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 ⁽¹⁾ | 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 Table 9. Order codes. |

Contents

| | | |
|------------|--|-----------|
| 1 | Pin configuration | 2 |
| 2 | Maximum ratings | 3 |
| 3 | Typical application | 4 |
| 4 | Electrical characteristics | 5 |
| 5 | Typical performance characteristics | 8 |
| 6 | Package information | 12 |
| 6.1 | QFN-8 package information | 12 |
| 7 | Ordering information | 15 |
| | Revision history | 16 |
| | Contents | 17 |
| | List of tables | 18 |
| | List of figures | 19 |

List of tables

| | | |
|------------------|---|----|
| Table 1. | Absolute maximum ratings | 3 |
| Table 2. | Thermal data | 3 |
| Table 3. | Recommended operating conditions | 3 |
| Table 4. | Electrical characteristics for TS3312 | 5 |
| Table 5. | Electrical characteristics for TS3330 | 6 |
| Table 6. | Electrical characteristics for TS3333 | 7 |
| Table 7. | QFN8 mechanical data | 13 |
| Table 8. | QFN8 tolerance of form and position | 13 |
| Table 9. | Order codes | 15 |
| Table 10. | Document revision history | 16 |

List of figures

| | | |
|-------------------|--|----|
| Figure 2. | Pin configuration (top view) | 2 |
| Figure 3. | Typical application circuit | 4 |
| Figure 4. | Output voltage vs. temperature | 8 |
| Figure 5. | Output voltage vs. input voltage | 8 |
| Figure 6. | Quiescent current vs. input voltage | 8 |
| Figure 7. | Dropout voltage vs. load current | 8 |
| Figure 8. | SVR vs. frequency | 9 |
| Figure 9. | Low frequency noise | 9 |
| Figure 10. | Temperature drift. | 9 |
| Figure 11. | Short-circuit current vs. dropout voltage | 9 |
| Figure 12. | Startup transient (no load) | 9 |
| Figure 13. | Startup transient ($I_{OUT} = 5 \text{ mA}$) | 9 |
| Figure 14. | Line transient (no load) | 10 |
| Figure 15. | Line transient ($I_{OUT} = 1 \text{ mA}$) | 10 |
| Figure 16. | Load transient ($I_{OUT} = +/-1 \text{ mA}$) | 10 |
| Figure 17. | Load transient ($I_{OUT} = +/-5 \text{ mA}$) | 10 |
| Figure 18. | Short-circuit response | 11 |
| Figure 19. | Stability plan | 11 |
| Figure 20. | QFN8 package outline | 12 |
| Figure 21. | QFN8 recommended footprint. | 14 |

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