



# TL431 family

## Adjustable precision shunt regulators

Rev. 6 — 9 January 2019

Product data sheet

## 1. Product profile

### 1.1. General description

Three-terminal shunt regulator family with an output voltage range between  $V_{ref} = 2.495\text{ V}$  and  $36\text{ V}$ , to be set by two external resistors.

Table 1. Product overview

| Reference voltage tolerance ( $V_{ref}$ ) | Temperature range ( $T_{amb}$ ) |                 |                  | Pinning configuration (see Table 5) |
|-------------------------------------------|---------------------------------|-----------------|------------------|-------------------------------------|
|                                           | 0 °C to 70 °C                   | -40 °C to 85 °C | -40 °C to 125 °C |                                     |
| 2.0 %                                     | TL431CDBZR                      | TL431IDBZR      | TL431QDBZR       | normal pinning                      |
|                                           |                                 |                 | TL431FDT         | normal pinning                      |
|                                           |                                 |                 | TL431MFDT        | mirrored pinning                    |
| 1.0 %                                     | TL431ACDBZR                     | TL431AIDBZR     | TL431AQDBZR      | normal pinning                      |
|                                           |                                 |                 | TL431AFDT        | normal pinning                      |
|                                           |                                 |                 | TL431AMFDT       | mirrored pinning                    |
| 0.5 %                                     | TL431BCDBZR                     | TL431BIDBZR     | TL431BQDBZR      | normal pinning                      |
|                                           |                                 |                 | TL431BFDT        | normal pinning                      |
|                                           |                                 |                 | TL431BMFDT       | mirrored pinning                    |

### 1.2. Features and benefits

- Programmable output voltage up to  $36\text{ V}$
- Three different reference voltage tolerances:
  - Standard grade: 2 %
  - A-Grade: 1 %
  - B-Grade: 0.5 %
- Typical temperature drift:  $9\text{ mV}$  (in a range of  $0\text{ °C}$  up to  $70\text{ °C}$ )
- Low output noise
- Typical output impedance:  $0.2\ \Omega$
- Sink current capability:  $1\text{ mA}$  to  $100\text{ mA}$
- AEC-Q100 qualified (grade 1)

1.3. Applications

- Shunt regulator
- Precision current limiter
- Precision constant current sink
- Isolated feedback loop for Switch Mode Power Supply (SMPS)

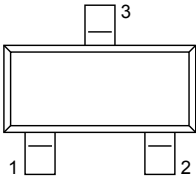
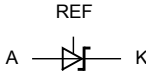
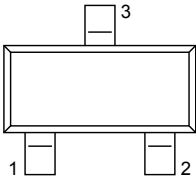
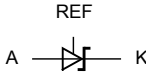
1.4. Quick reference data

Table 2. Quick reference data

| Symbol    | Parameter                | Conditions                                                                        | Min       | Typ  | Max  | Unit |
|-----------|--------------------------|-----------------------------------------------------------------------------------|-----------|------|------|------|
| $V_{KA}$  | cathode-anode voltage    |                                                                                   | $V_{ref}$ | -    | 36   | V    |
| $I_K$     | cathode current          |                                                                                   | 1         | -    | 100  | mA   |
| $V_{ref}$ | reference voltage        | $V_{KA} = V_{ref}; I_K = 10\text{ mA};$<br>$T_{amb} = 25\text{ }^{\circ}\text{C}$ |           |      |      |      |
|           | • Standard-Grade (2.0 %) |                                                                                   | 2440      | 2495 | 2550 | mV   |
|           | • A-Grade (1.0 %)        |                                                                                   | 2470      | 2495 | 2520 | mV   |
|           | • B-Grade (0.5 %)        |                                                                                   | 2483      | 2495 | 2507 | mV   |

2. Pinning information

Table 3. Pinning

| Pin                                                   | Symbol | Description | Simplified outline                                                                    | Graphic symbol                                                                                            |
|-------------------------------------------------------|--------|-------------|---------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|
| SOT23; normal pinning: All types without MFD T ending |        |             |                                                                                       |                                                                                                           |
| 1                                                     | K      | cathode     |  | <br><i>006aab355</i> |
| 2                                                     | REF    | reference   |                                                                                       |                                                                                                           |
| 3                                                     | A      | anode       |                                                                                       |                                                                                                           |
| SOT23; mirrored pinning: All types with MFD T ending  |        |             |                                                                                       |                                                                                                           |
| 1                                                     | REF    | reference   |  | <br><i>006aab355</i> |
| 2                                                     | K      | cathode     |                                                                                       |                                                                                                           |
| 3                                                     | A      | anode       |                                                                                       |                                                                                                           |

### 3. Ordering information

Table 4. Ordering information

| Type number | Package  |                                          |         |
|-------------|----------|------------------------------------------|---------|
|             | Name     | Description                              | Version |
| TL431CDBZR  | TO-236AB | plastic surface-mounted package; 3 leads | SOT23   |
| TL431IDBZR  |          |                                          |         |
| TL431QDBZR  |          |                                          |         |
| TL431FDT    |          |                                          |         |
| TL431MFDT   |          |                                          |         |
| TL431ACDBZR |          |                                          |         |
| TL431AIDBZR |          |                                          |         |
| TL431AQDBZR |          |                                          |         |
| TL431AFDT   |          |                                          |         |
| TL431AMFDT  |          |                                          |         |
| TL431BCDBZR |          |                                          |         |
| TL431BIDBZR |          |                                          |         |
| TL431BQDBZR |          |                                          |         |
| TL431BFDT   |          |                                          |         |
| TL431BMFDT  |          |                                          |         |

### 4. Marking

Table 5. Marking codes

| Type number | Marking code [1] | Type number | Marking code [1] |
|-------------|------------------|-------------|------------------|
| TL431CDBZR  | CA%              | TL431AFDT   | AS%              |
| TL431IDBZR  | CB%              | TL431AMFDT  | AV%              |
| TL431QDBZR  | CC%              | TL431BCDBZR | CG%              |
| TL431FDT    | AR%              | TL431BIDBZR | CH%              |
| TL431MFDT   | AU%              | TL431BQDBZR | CJ%              |
| TL431ACDBZR | CD%              | TL431BFDT   | AT%              |
| TL431AIDBZR | CE%              | TL431BMFDT  | AW%              |
| TL431AQDBZR | CF%              | -           | -                |

[1] % = placeholder for manufacturing site code.

## 5. Functional diagram

The TL431 family comprises a range of 3-terminal adjustable shunt regulators, with specified thermal stability over applicable automotive and commercial temperature ranges. The output voltage can be set to any value between  $V_{\text{ref}}$  (approximately 2.5 V) and 36 V with two external resistors (see Figure 8). These devices have a typical output impedance of 0.2  $\Omega$ . Active output circuitry provides a very sharp turn-on characteristic, making these devices excellent replacements for Zener diodes in many applications like on-board regulation, adjustable power supplies and switching power supplies.

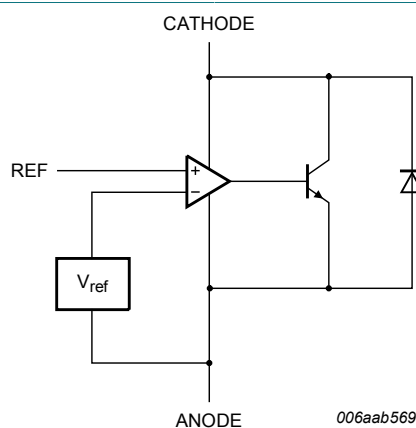


Fig. 1. Functional diagram

6. Limiting values

Table 6. Limiting values  
In accordance with the Absolute Maximum Rating System (IEC 60134).

| Symbol           | Parameter                | Conditions               | Min   | Max  | Unit |
|------------------|--------------------------|--------------------------|-------|------|------|
| V <sub>KA</sub>  | cathode-anode voltage    |                          | -     | 37   | V    |
| I <sub>K</sub>   | cathode current          |                          | -100  | 150  | mA   |
| I <sub>ref</sub> | reference current        |                          | -0.05 | 10   | mA   |
| P <sub>tot</sub> | total power dissipation  | T <sub>amb</sub> ≤ 25 °C | [1] - | 350  | mW   |
|                  |                          |                          | [2] - | 580  | mW   |
|                  |                          |                          | [3] - | 950  | mW   |
| T <sub>j</sub>   | junction temperature     |                          | -     | 150  | °C   |
| T <sub>amb</sub> | ambient temperature      |                          |       |      |      |
|                  | TL431XCDBZR              |                          | 0     | +70  | °C   |
|                  | TL431XIDBZR              |                          | -40   | +85  | °C   |
|                  | TL431XQDBZR<br>TL431XFDT |                          | -40   | +125 | °C   |
| T <sub>stg</sub> | storage temperature      |                          | -65   | +150 | °C   |

- [1] Device mounted on an FR4 Printed-Circuit Board (PCB), single-sided copper, tin-plated and standard footprint.  
[2] Device mounted on an FR4 PCB, single-sided copper, tin-plated, mounting pad for anode 1 cm<sup>2</sup>.  
[3] Device mounted on a ceramic PCB, Al<sub>2</sub>O<sub>3</sub>, standard footprint.

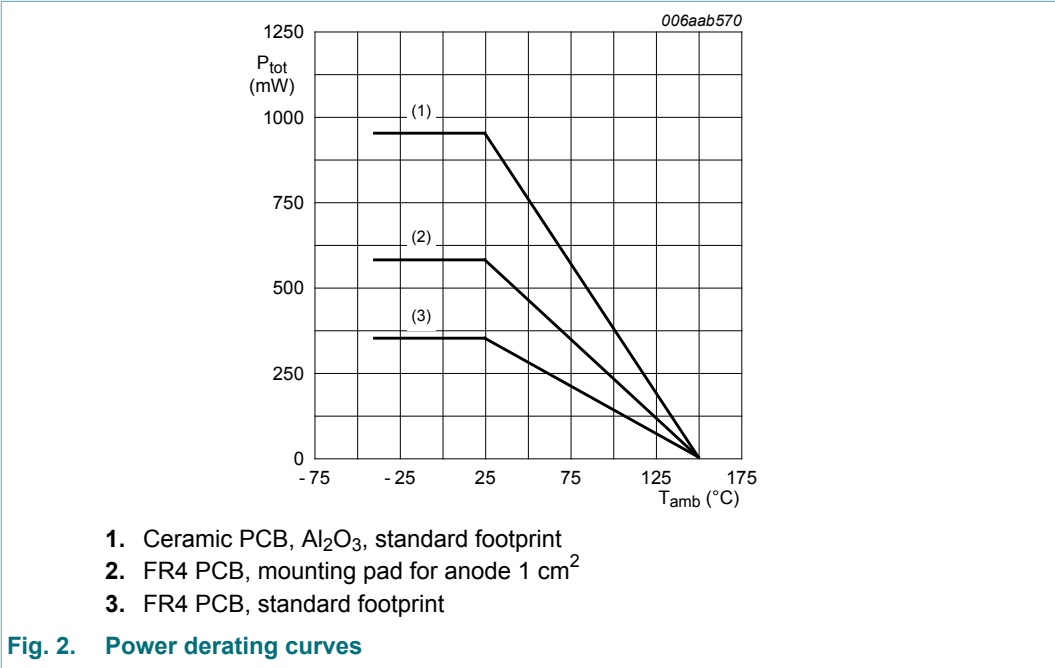


Table 7. ESD maximum ratings  
T<sub>amb</sub> = 25 °C unless otherwise specified.

| Symbol           | Parameter                       | Conditions                     | Min | Max | Unit |
|------------------|---------------------------------|--------------------------------|-----|-----|------|
| V <sub>ESD</sub> | electrostatic discharge voltage | MIL-STD-883 (human body model) | -   | 4   | kV   |

## 7. Recommended operating conditions

Table 8. Operating conditions

| Symbol   | Parameter             | Conditions |  | Min       | Max | Unit |
|----------|-----------------------|------------|--|-----------|-----|------|
| $V_{KA}$ | cathode-anode voltage |            |  | $V_{ref}$ | 36  | V    |
| $I_K$    | cathode current       |            |  | 1         | 100 | mA   |

## 8. Thermal characteristics

Table 9. Thermal characteristics

| Symbol         | Parameter                                        | Conditions  |     | Min | Typ | Max | Unit |
|----------------|--------------------------------------------------|-------------|-----|-----|-----|-----|------|
| $R_{th(j-a)}$  | thermal resistance from junction to ambient      | in free air | [1] | -   | -   | 360 | K/W  |
|                |                                                  |             | [2] | -   | -   | 216 | K/W  |
|                |                                                  |             | [3] | -   | -   | 132 | K/W  |
| $R_{th(j-sp)}$ | thermal resistance from junction to solder point |             | [4] | -   | -   | 50  | K/W  |

[1] Device mounted on an FR4 PCB, single-sided copper, tin-plated and standard footprint.

[2] Device mounted on an FR4 PCB, single-sided copper, tin-plated, mounting pad for anode 1 cm<sup>2</sup>.

[3] Device mounted on a ceramic PCB, Al<sub>2</sub>O<sub>3</sub>, standard footprint.

[4] Soldering point of anode.

## 9. Characteristics

**Table 10. Characteristics**

$T_{amb} = 25\text{ °C}$  unless otherwise specified.

| Symbol                                                                          | Parameter                                                             | Conditions                                                                          | Min  | Typ  | Max  | Unit          |
|---------------------------------------------------------------------------------|-----------------------------------------------------------------------|-------------------------------------------------------------------------------------|------|------|------|---------------|
| Standard-Grade (2.0 %): TL431CDBZR; TL431IDBZR; TL431QDBZR; TL431FDT; TL431MFDT |                                                                       |                                                                                     |      |      |      |               |
| $V_{ref}$                                                                       | reference voltage                                                     | $V_{KA} = V_{ref}$ ; $I_K = 10\text{ mA}$                                           | 2440 | 2495 | 2550 | mV            |
| $\Delta V_{ref}$                                                                | reference voltage variation                                           | $V_{KA} = V_{ref}$ ; $I_K = 10\text{ mA}$                                           |      |      |      |               |
|                                                                                 | TL431CDBZR                                                            | $T_{amb} = 0\text{ °C to }70\text{ °C}$                                             | -    | 9    | 16   | mV            |
|                                                                                 | TL431IDBZR                                                            | $T_{amb} = -40\text{ °C to }85\text{ °C}$                                           | -    | 17   | 34   | mV            |
|                                                                                 | TL431QDBZR                                                            | $T_{amb} = -40\text{ °C to }125\text{ °C}$                                          |      |      |      |               |
|                                                                                 | TL431FDT                                                              |                                                                                     |      |      |      |               |
|                                                                                 | TL431MFDT                                                             |                                                                                     |      |      |      |               |
| $\Delta V_{ref}/\Delta V_{KA}$                                                  | reference voltage variation to cathode -anode voltage variation ratio | $I_K = 10\text{ mA}$                                                                |      |      |      |               |
|                                                                                 |                                                                       | $\Delta V_{KA} = 10\text{ V to }V_{ref}$                                            | -    | -1.4 | -2.7 | mV/V          |
|                                                                                 |                                                                       | $\Delta V_{KA} = 36\text{ V to }10\text{ V}$                                        | -    | -1   | -2   | mV/V          |
| $I_{ref}$                                                                       | reference current                                                     | $I_K = 10\text{ mA}$ ;<br>$R1 = 10\text{ k}\Omega$ ; $R2 = \text{open}$             | -    | 2    | 4    | $\mu\text{A}$ |
| $\Delta I_{ref}$                                                                | reference current variation                                           | $I_K = 10\text{ mA}$ ; $R1 = 10\text{ k}\Omega$ ; $R2 = \text{open}$                |      |      |      |               |
|                                                                                 | TL431CDBZR                                                            | $T_{amb} = 0\text{ °C to }70\text{ °C}$                                             | -    | 0.4  | 1.2  | $\mu\text{A}$ |
|                                                                                 | TL431IDBZR                                                            | $T_{amb} = -40\text{ °C to }85\text{ °C}$                                           | -    | 0.8  | 2.5  | $\mu\text{A}$ |
|                                                                                 | TL431QDBZR                                                            | $T_{amb} = -40\text{ °C to }125\text{ °C}$                                          |      |      |      |               |
|                                                                                 | TL431FDT                                                              |                                                                                     |      |      |      |               |
|                                                                                 | TL431MFDT                                                             |                                                                                     |      |      |      |               |
| $I_{K(min)}$                                                                    | minimum cathode current                                               | $V_{KA} = V_{ref}$                                                                  | -    | 0.4  | 1    | mA            |
| $I_{off}$                                                                       | off-state current                                                     | $V_{KA} = 36\text{ V}$ ; $V_{ref} = 0$                                              | -    | 0.1  | 1    | $\mu\text{A}$ |
| $Z_{KA}$                                                                        | dynamic cathode-anode impedance                                       | $I_K = 0.1\text{ mA to }100\text{ mA}$ ;<br>$V_{KA} = V_{ref}$ ; $f < 1\text{ kHz}$ | -    | 0.20 | 0.5  | $\Omega$      |
| A-Grade (1 %): TL431ACDBZR; TL431AIDBZR; TL431AQDBZR; TL431AFDT; TL431AMFDT     |                                                                       |                                                                                     |      |      |      |               |
| $V_{ref}$                                                                       | reference voltage                                                     | $V_{KA} = V_{ref}$ ; $I_K = 10\text{ mA}$                                           | 2470 | 2495 | 2520 | mV            |
| $\Delta V_{ref}$                                                                | reference voltage variation                                           | $V_{KA} = V_{ref}$ ; $I_K = 10\text{ mA}$                                           |      |      |      |               |
|                                                                                 | TL431ACDBZR                                                           | $T_{amb} = 0\text{ °C to }70\text{ °C}$                                             | -    | 9    | 16   | mV            |
|                                                                                 | TL431AIDBZR                                                           | $T_{amb} = -40\text{ °C to }85\text{ °C}$                                           | -    | 17   | 34   | mV            |
|                                                                                 | TL431AQDBZR                                                           | $T_{amb} = -40\text{ °C to }125\text{ °C}$                                          |      |      |      |               |
|                                                                                 | TL431AFDT                                                             |                                                                                     |      |      |      |               |
|                                                                                 | TL431AMFDT                                                            |                                                                                     |      |      |      |               |
| $\Delta V_{ref}/\Delta V_{KA}$                                                  | reference voltage variation to cathode-anode voltage variation ratio  | $I_K = 10\text{ mA}$                                                                |      |      |      |               |
|                                                                                 |                                                                       | $\Delta V_{KA} = 10\text{ V to }V_{ref}$                                            | -    | -1.4 | -2.7 | mV/V          |
|                                                                                 |                                                                       | $\Delta V_{KA} = 36\text{ V to }10\text{ V}$                                        | -    | -1.0 | -2.0 | mV            |
| $I_{ref}$                                                                       | reference current                                                     | $I_K = 10\text{ mA}$ ;<br>$R1 = 10\text{ k}\Omega$ ; $R2 = \text{open}$             | -    | 2.0  | 4.0  | $\mu\text{A}$ |

| Symbol                                                           | Parameter                                                            | Conditions                                                                                      | Min  | Typ  | Max  | Unit          |
|------------------------------------------------------------------|----------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|------|------|------|---------------|
| $\Delta I_{\text{ref}}$                                          | reference current variation                                          | $I_K = 10 \text{ mA}$ ; $R1 = 10 \text{ k}\Omega$ ; $R2 = \text{open}$                          |      |      |      |               |
|                                                                  | TL431ACDBZR                                                          | $T_{\text{amb}} = 0 \text{ }^\circ\text{C}$ to $70 \text{ }^\circ\text{C}$                      | -    | 0.4  | 1.2  | $\mu\text{A}$ |
|                                                                  | TL431AIDBZR                                                          | $T_{\text{amb}} = -40 \text{ }^\circ\text{C}$ to $85 \text{ }^\circ\text{C}$                    | -    | 0.8  | 2.5  | $\mu\text{A}$ |
|                                                                  | TL431AQDBZR                                                          | $T_{\text{amb}} = -40 \text{ }^\circ\text{C}$ to $125 \text{ }^\circ\text{C}$                   |      |      |      |               |
|                                                                  | TL431AFDT                                                            |                                                                                                 |      |      |      |               |
|                                                                  | TL431AMFDT                                                           |                                                                                                 |      |      |      |               |
| $I_{K(\text{min})}$                                              | minimum cathode current                                              | $V_{KA} = V_{\text{ref}}$                                                                       |      |      |      |               |
|                                                                  | TL431ACDBZR                                                          | $T_{\text{amb}} = 0 \text{ }^\circ\text{C}$ to $70 \text{ }^\circ\text{C}$                      | -    | 0.4  | 0.6  | $\text{mA}$   |
|                                                                  | TL431AIDBZR                                                          | $T_{\text{amb}} = -40 \text{ }^\circ\text{C}$ to $85 \text{ }^\circ\text{C}$                    |      |      |      |               |
|                                                                  | TL431AQDBZR                                                          | $T_{\text{amb}} = -40 \text{ }^\circ\text{C}$ to $125 \text{ }^\circ\text{C}$                   |      |      |      |               |
|                                                                  | TL431AFDT                                                            |                                                                                                 |      |      |      |               |
|                                                                  | TL431AMFDT                                                           |                                                                                                 |      |      |      |               |
| $I_{\text{off}}$                                                 | off-state current                                                    | $V_{KA} = 36 \text{ V}$ ; $V_{\text{ref}} = 0$                                                  | -    | 0.1  | 0.5  | $\mu\text{A}$ |
| $Z_{KA}$                                                         | dynamic cathode-anode impedance                                      | $I_K = 0.1 \text{ mA}$ to $100 \text{ mA}$ ;<br>$V_{KA} = V_{\text{ref}}$ ; $f < 1 \text{ kHz}$ | -    | 0.2  | 0.5  | $\Omega$      |
| B-Grade (0.5 %): TL431BCDBZR; TL431BIDBZR; TL431BFDT; TL431BMFDT |                                                                      |                                                                                                 |      |      |      |               |
| $V_{\text{ref}}$                                                 | reference voltage                                                    | $V_{KA} = V_{\text{ref}}$ ; $I_K = 10 \text{ mA}$                                               | 2483 | 2495 | 2507 | $\text{mV}$   |
| $\Delta V_{\text{ref}}$                                          | reference voltage variation                                          | $V_{KA} = V_{\text{ref}}$ ; $I_K = 10 \text{ mA}$                                               |      |      |      |               |
|                                                                  | TL431BCDBZR                                                          | $T_{\text{amb}} = 0 \text{ }^\circ\text{C}$ to $70 \text{ }^\circ\text{C}$                      | -    | 9    | 16   | $\text{mV}$   |
|                                                                  | TL431BIDBZR                                                          | $T_{\text{amb}} = -40 \text{ }^\circ\text{C}$ to $85 \text{ }^\circ\text{C}$                    | -    | 17   | 34   | $\text{mV}$   |
|                                                                  | TL431BQDBZR                                                          | $T_{\text{amb}} = -40 \text{ }^\circ\text{C}$ to $125 \text{ }^\circ\text{C}$                   |      |      |      |               |
|                                                                  | TL431BFDT                                                            |                                                                                                 |      |      |      |               |
|                                                                  | TL431BMFDT                                                           |                                                                                                 |      |      |      |               |
| $\Delta V_{\text{ref}}/\Delta V_{KA}$                            | reference voltage variation to cathode-anode voltage variation ratio | $I_K = 10 \text{ mA}$                                                                           |      |      |      |               |
|                                                                  |                                                                      | $\Delta V_{KA} = 10 \text{ V}$ to $V_{\text{ref}}$                                              | -    | -1.4 | -2.7 | $\text{mV/V}$ |
|                                                                  |                                                                      | $\Delta V_{KA} = 36 \text{ V}$ to $10 \text{ V}$                                                | -    | -1.0 | -2.0 | $\text{mV/V}$ |
| $I_{\text{ref}}$                                                 | reference current                                                    | $I_K = 10 \text{ mA}$ ;<br>$R1 = 10 \text{ k}\Omega$ ; $R2 = \text{open}$                       | -    | 2.0  | 4.0  | $\mu\text{A}$ |
| $\Delta I_{\text{ref}}$                                          | reference current variation                                          | $I_K = 10 \text{ mA}$ ; $R1 = 10 \text{ k}\Omega$ ; $R2 = \text{open}$                          |      |      |      |               |
|                                                                  | TL431BCDBZR                                                          | $T_{\text{amb}} = 0 \text{ }^\circ\text{C}$ to $70 \text{ }^\circ\text{C}$                      | -    | 0.4  | 1.2  | $\mu\text{A}$ |
|                                                                  | TL431BIDBZR                                                          | $T_{\text{amb}} = -40 \text{ }^\circ\text{C}$ to $85 \text{ }^\circ\text{C}$                    | -    | 0.8  | 2.5  | $\mu\text{A}$ |
|                                                                  | TL431BQDBZR                                                          | $T_{\text{amb}} = -40 \text{ }^\circ\text{C}$ to $125 \text{ }^\circ\text{C}$                   |      |      |      |               |
|                                                                  | TL431BFDT                                                            |                                                                                                 |      |      |      |               |
|                                                                  | TL431BMFDT                                                           |                                                                                                 |      |      |      |               |
| $I_{K(\text{min})}$                                              | minimum cathode current                                              | $V_{KA} = V_{\text{ref}}$                                                                       |      |      |      |               |
|                                                                  | TL431BCDBZR                                                          | $T_{\text{amb}} = 0 \text{ }^\circ\text{C}$ to $70 \text{ }^\circ\text{C}$                      | -    | 0.4  | 0.6  | $\text{mA}$   |
|                                                                  | TL431BIDBZR                                                          | $T_{\text{amb}} = -40 \text{ }^\circ\text{C}$ to $85 \text{ }^\circ\text{C}$                    |      |      |      |               |
|                                                                  | TL431BQDBZR                                                          | $T_{\text{amb}} = -40 \text{ }^\circ\text{C}$ to $125 \text{ }^\circ\text{C}$                   |      |      |      |               |
|                                                                  | TL431BFDT                                                            |                                                                                                 |      |      |      |               |
|                                                                  | TL431BMFDT                                                           |                                                                                                 |      |      |      |               |
| $I_{\text{off}}$                                                 | off-state current                                                    | $V_{KA} = 36 \text{ V}$ ; $V_{\text{ref}} = 0$                                                  | -    | 0.1  | 0.5  | $\mu\text{A}$ |
| $Z_{KA}$                                                         | dynamic cathode-anode impedance                                      | $I_K = 0.1 \text{ mA}$ to $100 \text{ mA}$ ;<br>$V_{KA} = V_{\text{ref}}$ ; $f < 1 \text{ kHz}$ | -    | 0.2  | 0.5  | $\Omega$      |

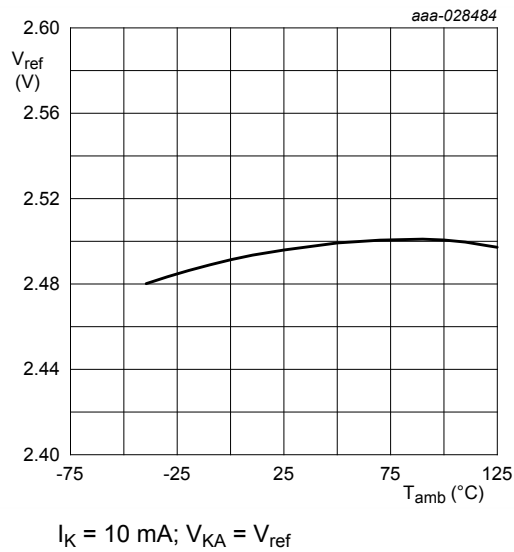


Fig. 3. Reference voltage as a function of ambient temperature; typical values

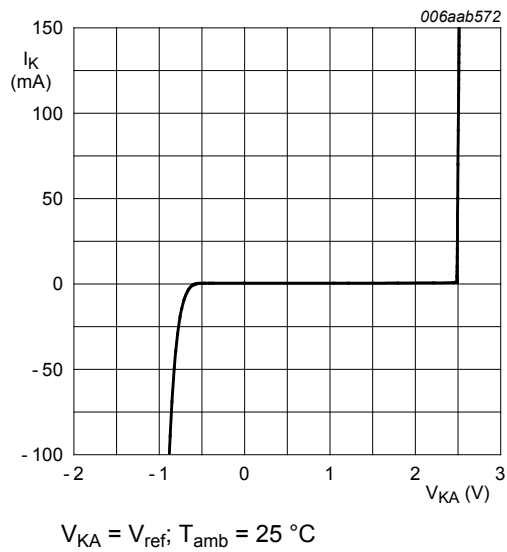
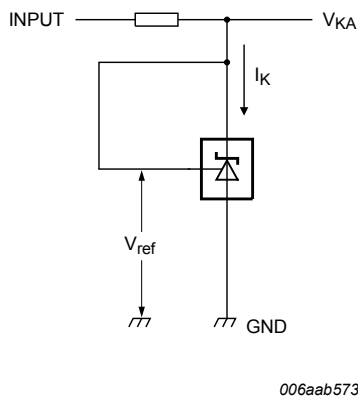


Fig. 4. Cathode current as a function of cathode-anode voltage; typical values



$I_K = 10\text{ mA}$ ;  $V_{KA} = V_{ref}$

Fig. 5. Test circuit to Figures 3 and 4

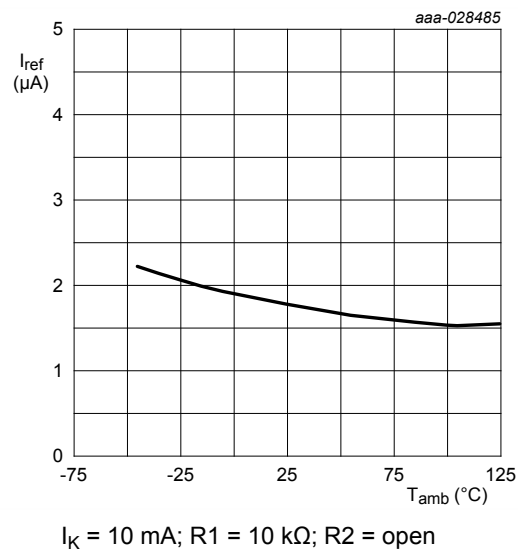


Fig. 6. Reference current as a function of ambient temperature; typical values

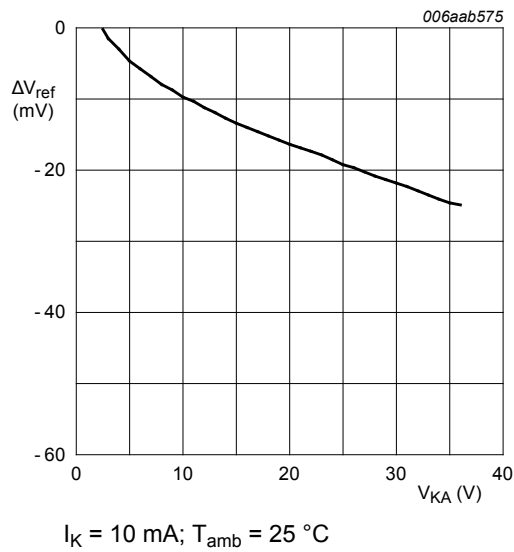
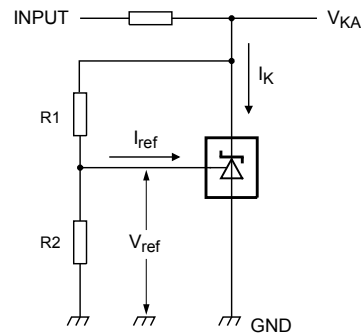


Fig. 7. Reference voltage variation as a function of cathode-anode voltage; typical values



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$$V_{KA} = V_{ref} \times \left(1 + \frac{R1}{R2}\right) + I_{ref} \times R1$$

Fig. 8. Test circuit to Figures 6 and 7

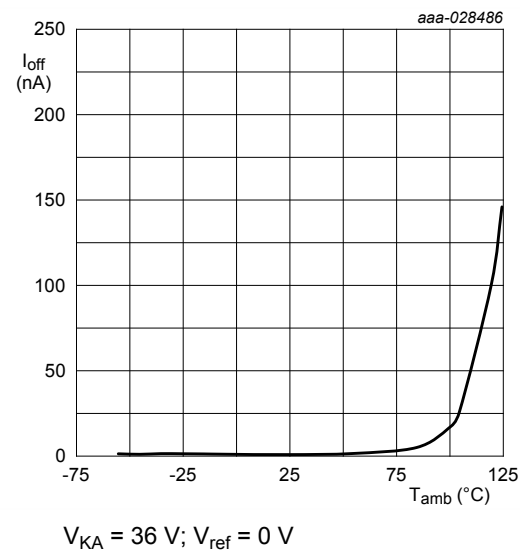
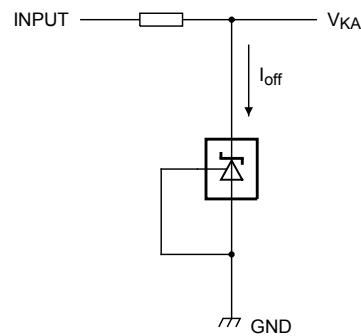


Fig. 9. Off-state current as a function of ambient temperature; typical values



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$$V_{KA} = 36\text{ V}; V_{ref} = 0\text{ V}$$

Fig. 10. Test circuit to Figure 9

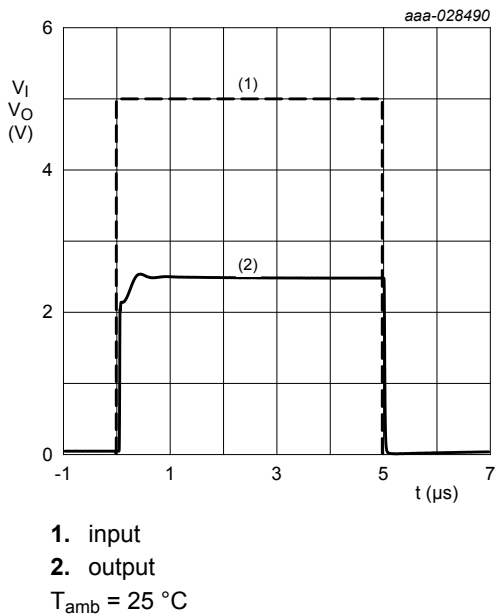


Fig. 11. Input voltage and output voltage as a function of time; typical values

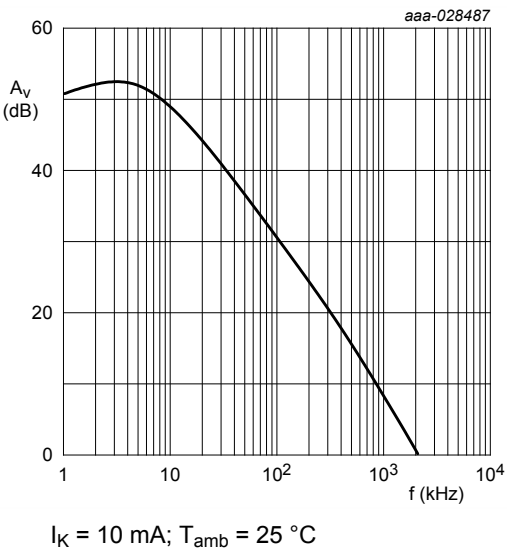


Fig. 13. Voltage amplification as a function of frequency; typical values

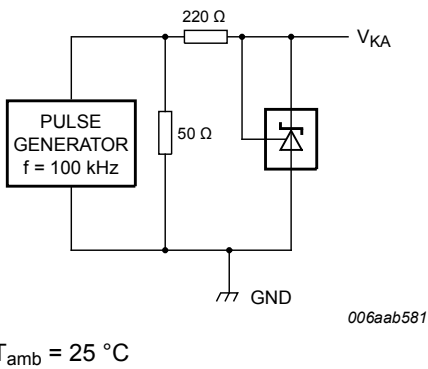


Fig. 12. Test circuit to Figure 11

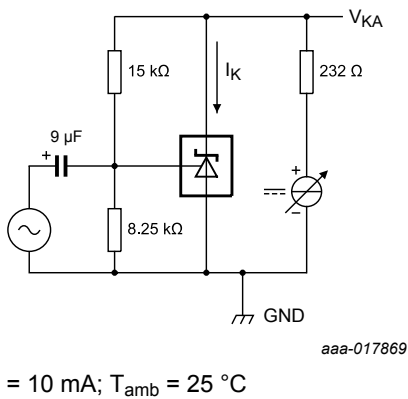


Fig. 14. Test circuit to Figure 13

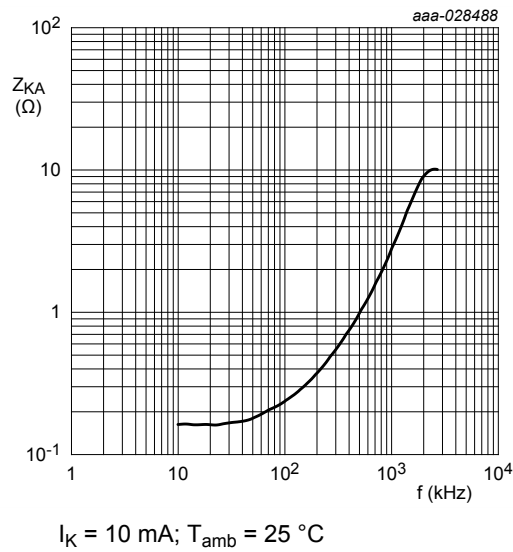
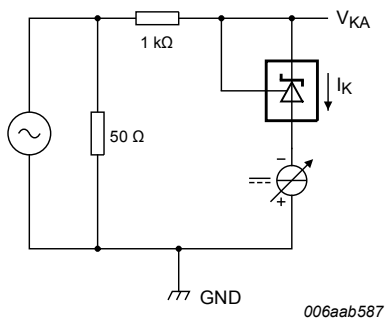


Fig. 15. Dynamic cathode-anode impedance as a function of frequency; typical values



$I_K = 10 \text{ mA}; T_{\text{amb}} = 25 \text{ }^{\circ}\text{C}$

Fig. 16. Test circuit to Figure 15

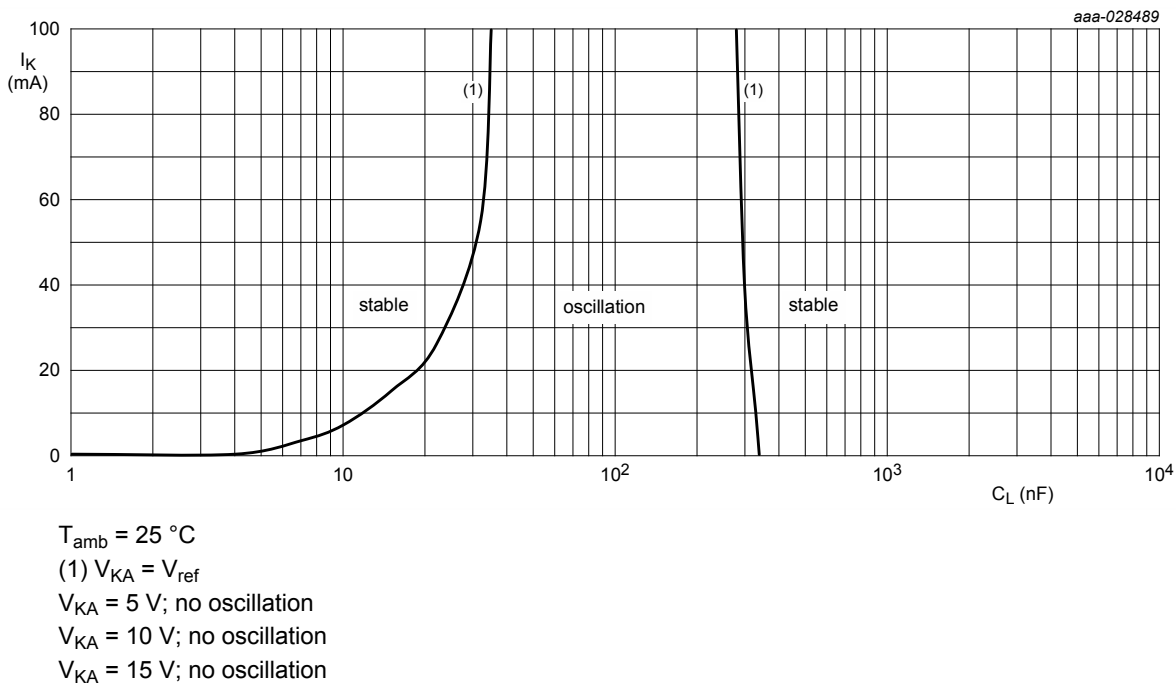
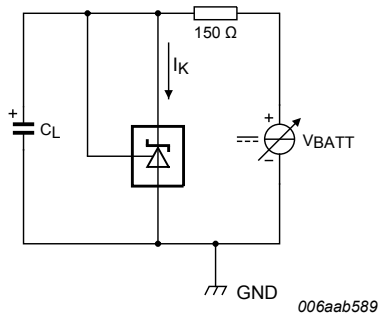
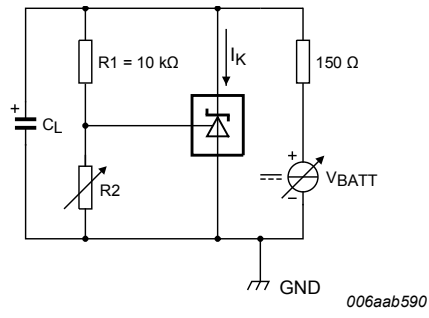


Fig. 17. Cathode current as a function of load capacitance, typical values



$V_{KA} = V_{\text{ref}}; T_{\text{amb}} = 25 \text{ }^{\circ}\text{C}$

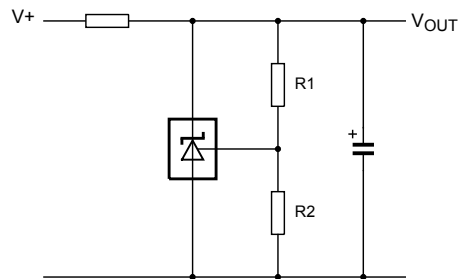
Fig. 18. Test circuit to Figure 17



$V_{KA} > 5 \text{ V}$ ; stable operation;  $T_{\text{amb}} = 25 \text{ }^{\circ}\text{C}$

Fig. 19. Test circuit to Figure 17

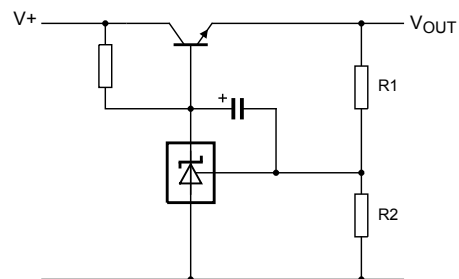
## 10. Application information



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$$V_{OUT} = \left(1 + \frac{R1}{R2}\right) \times V_{ref}$$

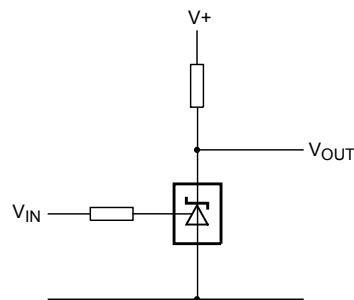
**Fig. 20. Shunt regulator**



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$$V_{OUT} = \left(1 + \frac{R1}{R2}\right) \times V_{ref} \quad V_{OUT(min)} = V_{ref} + V_{be}$$

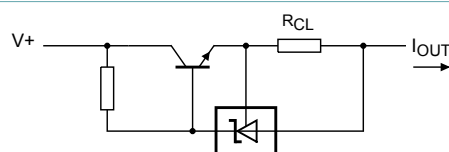
**Fig. 21. Series pass regulator**



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$$\begin{aligned} T_{th} &= V_{ref} \\ T_{IN} < V_{ref} &\Rightarrow V_{OUT} > 0 \\ T_{IN} > V_{ref} &\Rightarrow V_{OUT} \cong 2 \end{aligned}$$

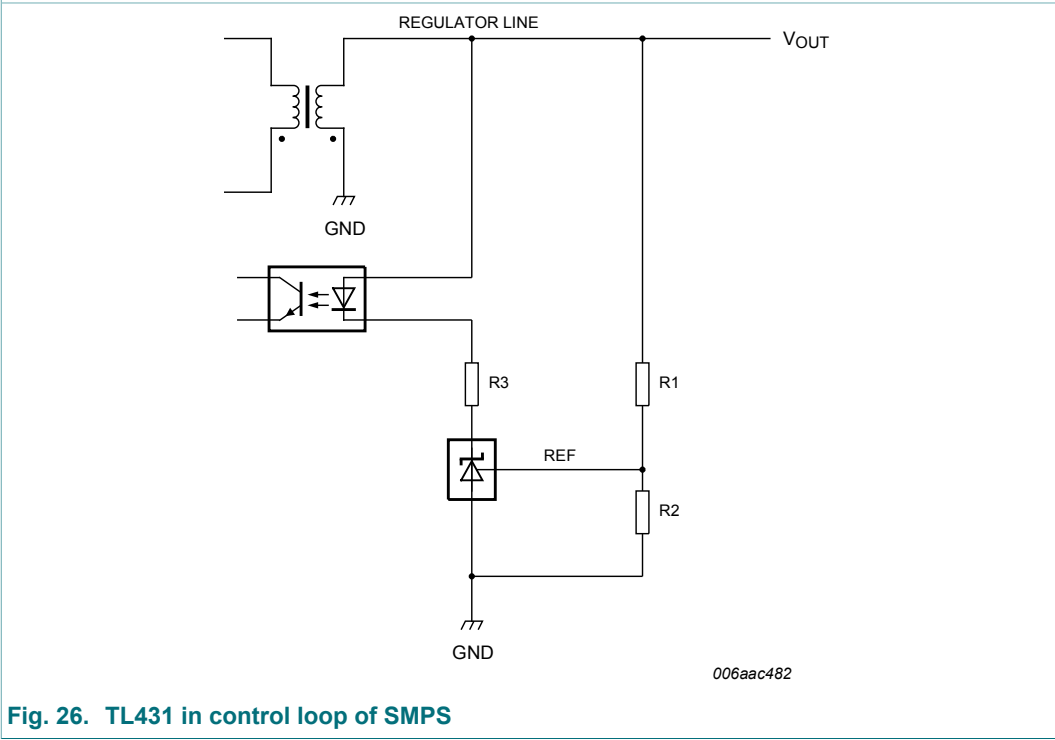
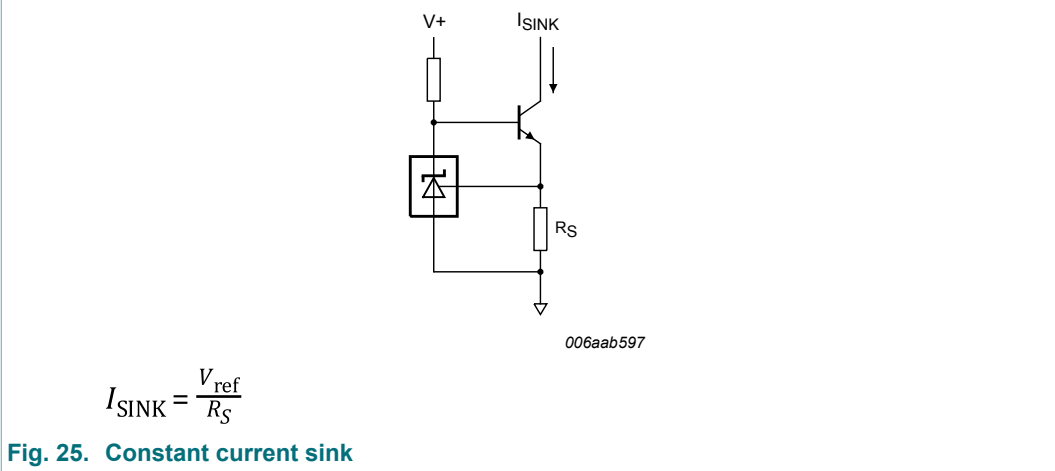
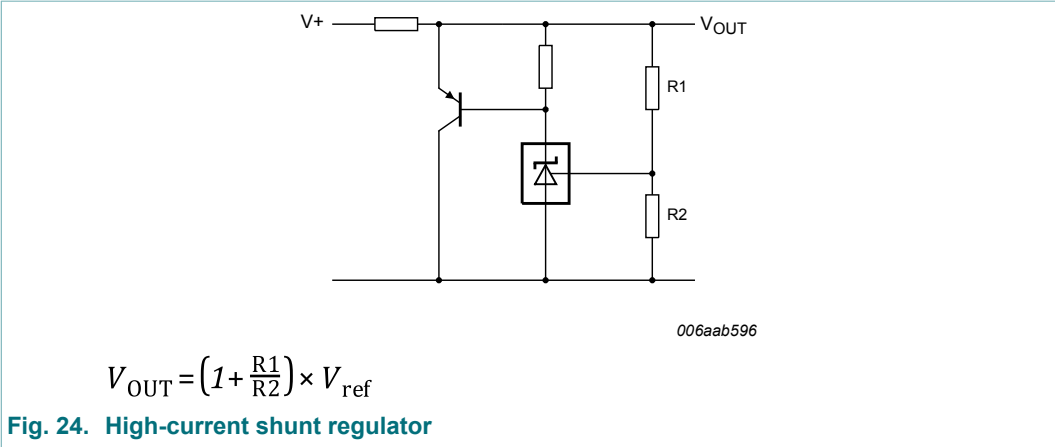
**Fig. 22. Single-supply comparator with temperature-compensated threshold**



006aab595

$$I_{OUT} = \frac{V_{ref}}{R_{CL}}$$

**Fig. 23. Constant current source**

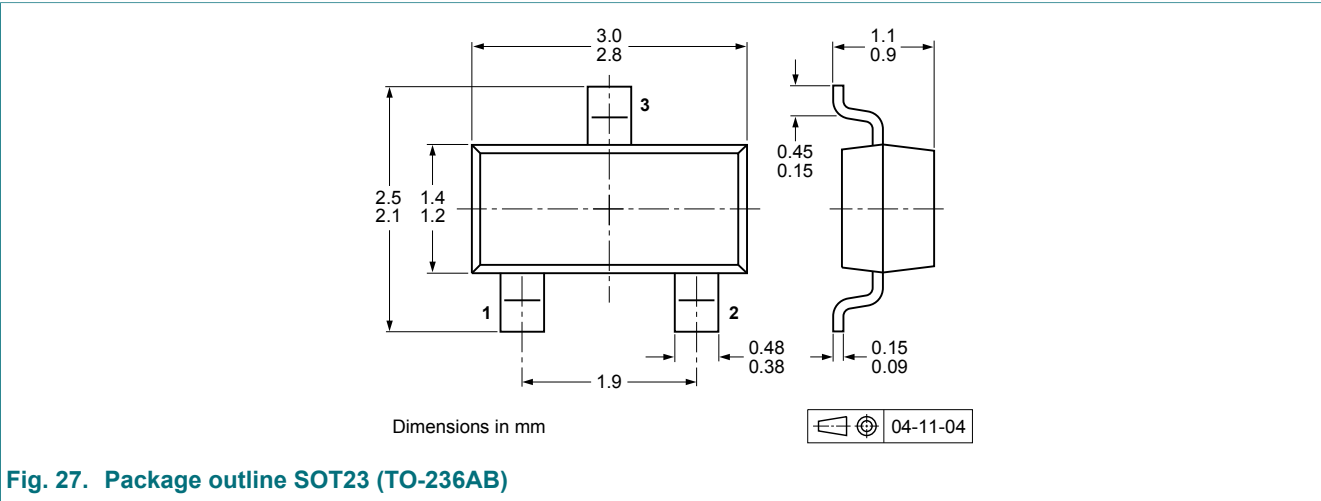


11. Test information

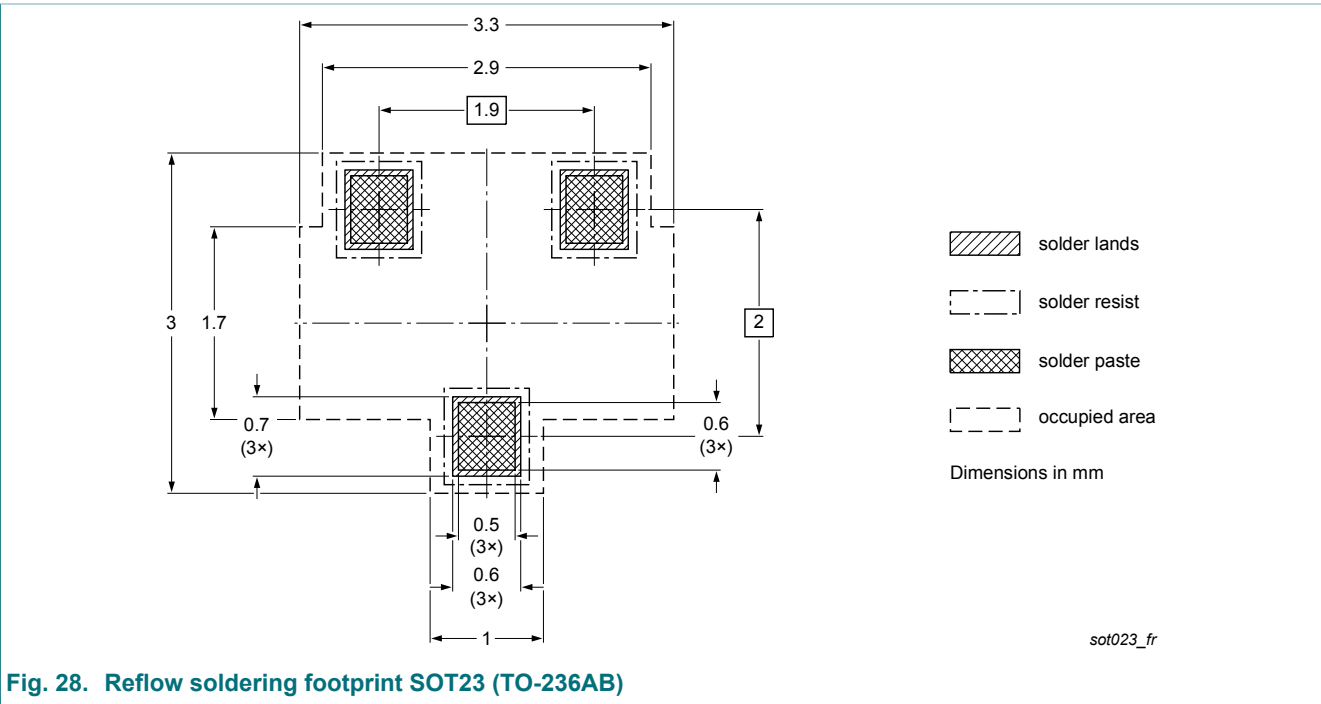
Quality information

This product has been qualified in accordance with the Automotive Electronics Council (AEC) standard Q100 - Failure mechanism based stress test qualification for integrated circuits, and is suitable for use in automotive applications.

12. Package outline



13. Soldering



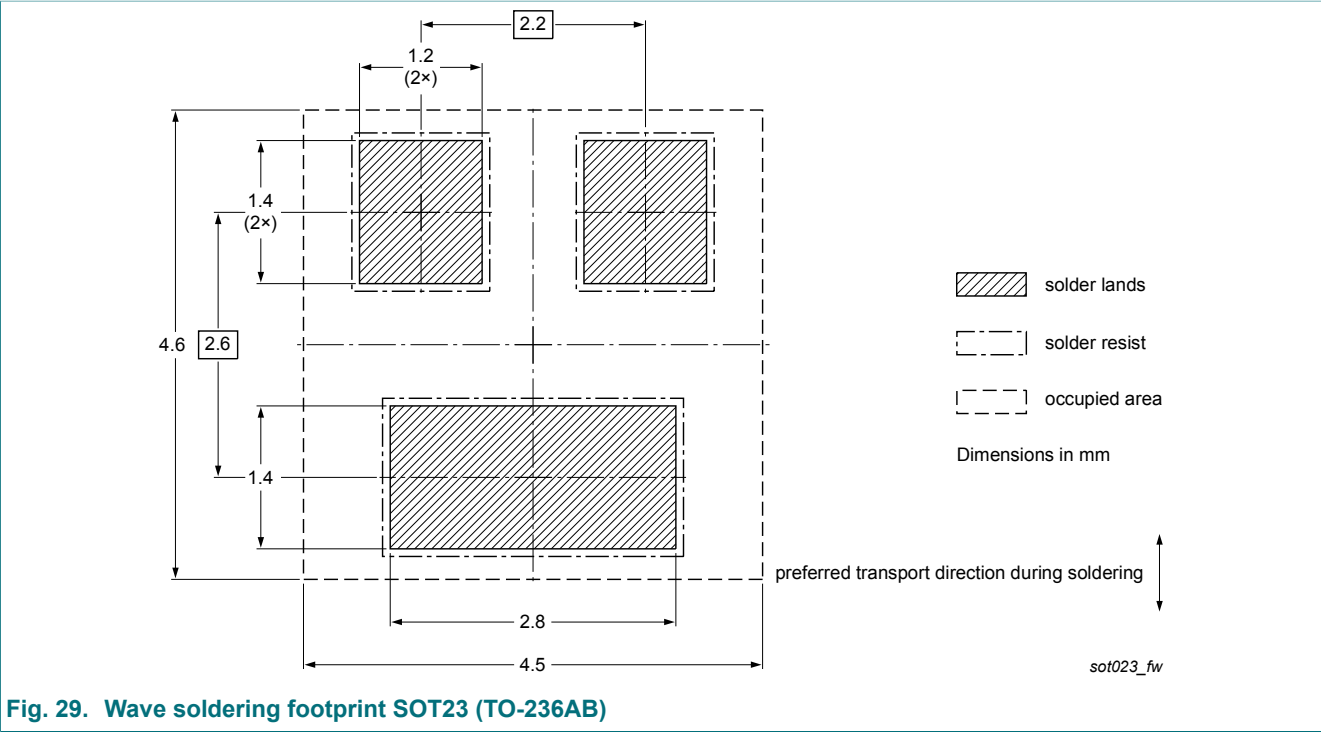


Fig. 29. Wave soldering footprint SOT23 (TO-236AB)

## 14. Revision history

Table 11. Revision history

| Document ID     | Release date                                                                                                                                                                                                                                                                                                                              | Data sheet status  | Change notice | Supersedes   |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|---------------|--------------|
| TL431_8_FAM v.6 | 20190109                                                                                                                                                                                                                                                                                                                                  | Product data sheet | -             | TL431FAM v.5 |
| Modifications   | <ul style="list-style-type: none"><li>• TL431SDT and TL431MSDT removed</li><li>• Figures of TL431XDBZR and TL431XFDT updated</li><li>• The format of this data sheet has been redesigned to comply with the identity guidelines of Nexperia.</li><li>• Legal texts have been adapted to the new company name where appropriate.</li></ul> |                    |               |              |
| TL431FAM v.5    | 20150901                                                                                                                                                                                                                                                                                                                                  | Product data sheet | -             | TL431FAM v.4 |
| TL431FAM v.4    | 20110630                                                                                                                                                                                                                                                                                                                                  | Product data sheet | -             | TL431FAM v.3 |
| TL431FAM v.3    | 20101105                                                                                                                                                                                                                                                                                                                                  | Product data sheet | -             | TL431FAM v.2 |
| TL431FAM v.2    | 20100120                                                                                                                                                                                                                                                                                                                                  | Product data sheet | -             | TL431FAM v.1 |
| TL431FAM v.1    | 20090806                                                                                                                                                                                                                                                                                                                                  | Product data sheet | -             | -            |

## 15. Legal information

### Data sheet status

| Document status<br>[1][2]      | Product status [3] | Definition                                                                            |
|--------------------------------|--------------------|---------------------------------------------------------------------------------------|
| Objective [short] data sheet   | Development        | This document contains data from the objective specification for product development. |
| Preliminary [short] data sheet | Qualification      | This document contains data from the preliminary specification.                       |
| Product [short] data sheet     | Production         | This document contains the product specification.                                     |

- [1] Please consult the most recently issued document before initiating or completing a design.
- [2] The term 'short data sheet' is explained in section "Definitions".
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