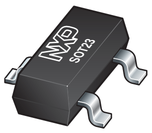



# TL431 family

## Adjustable precision shunt regulator

Rev. 5 — 01 September 2015 Product data sheet

# 1. Product profile

## 1.1 General description

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

- The TL431xDBZR types feature an enhanced stability area with a very low load capacity requirement.
- The TL431xFDT types offer an enhanced stability area and a higher ElectroMagnetic Interference (EMI) ruggedness, for example, for Switch Mode Power Supply (SMPS) applications.
- The TL431xSDT types are designed for standard requirements and linear applications.

**Table 1. Product overview**

| Reference voltage tolerance ($V_{ref}$) | Temperature range ($T_{amb}$) | | | Pinning configuration (see Table 3) |
|---|---|---|---|---|
| | 0 °C to 70 °C | –40 °C to 85 °C | –40 °C to 125 °C | |
| 2 % | TL431CDBZR | TL431IDBZR | TL431QDBZR | normal pinning |
| | | | TL431FDT | normal pinning |
| | | | TL431MFDT | mirrored pinning |
| | | | TL431SDT | normal pinning |
| | | | TL431MSDT | mirrored pinning |
| 1 % | TL431ACDBZR | TL431AIDBZR | TL431AQDBZR | normal pinning |
| | | | TL431AFDT | normal pinning |
| | | | TL431AMFDT | mirrored pinning |
| | | | TL431ASDT | normal pinning |
| | | | TL431AMSDT | mirrored pinning |
| 0.5 % | TL431BCDBZR | TL431BIDBZR | TL431BQDBZR | normal pinning |
| | | | TL431BFDT | normal pinning |
| | | | TL431BMFDT | mirrored pinning |
| | | | TL431BSDT | normal pinning |
| | | | TL431BMSDT | mirrored pinning |

## 1.2 Features and benefits

- Programmable output voltage up to 36 V
- Three different reference voltage tolerances:
  - Standard grade: 2 %
  - A-Grade: 1 %
  - B-Grade: 0.5 %
- Typical temperature drift: 6 mV (in a range of 0 °C up to 70 °C)
- Low output noise
- Typical output impedance: 0.2 Ω
- Sink current capability: 1 mA to 100 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)

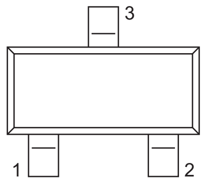
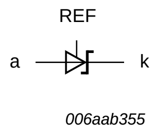
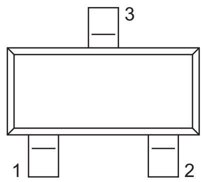
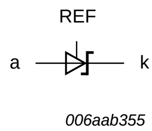
## 1.4 Quick reference data

**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 mA; $T_{amb}$ = 25 °C | | | | |
| | Standard-Grade (2 %) | | 2440 | 2495 | 2550 | mV |
| | A-Grade (1 %) | | 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 |
|---|---|---|---|---|
| **Normal pinning: All types without MFDT and MSDT ending** | | | | |
| 1 | k | cathode |  |  |
| 2 | REF | reference | | |
| 3 | a | anode | | |
| **Mirrored pinning: All types with MFDT and MSDT ending** | | | | |
| 1 | REF | reference |  |  |
| 2 | k | cathode | | |
| 3 | a | anode | | |

## 3. Ordering information

Table 4. Ordering information

| Type number | Package | | |
|---|---|---|---|
| | Name | Description | Version |
| TL431CDBZR | - | plastic surface-mounted package; 3 leads | SOT23 |
| TL431IDBZR | | | |
| TL431QDBZR | | | |
| TL431FDT | | | |
| TL431MFDT | | | |
| TL431SDT | | | |
| TL431MSDT | | | |
| TL431ACDBZR | | | |
| TL431AIDBZR | | | |
| TL431AQDBZR | | | |
| TL431AFDT | | | |
| TL431AMFDT | | | |
| TL431ASDT | | | |
| TL431AMSDT | | | |
| TL431BCDBZR | | | |
| TL431BIDBZR | | | |
| TL431BQDBZR | | | |
| TL431BFDT | | | |
| TL431BMFDT | | | |
| TL431BSDT | | | |
| TL431BMSDT | | | |

## 4. Marking

**Table 5. Marking codes**

| Type number | Marking code[1] | Type number | Marking code[1] |
|---|---|---|---|
| TL431CDBZR | CA* | TL431ASDT | RL* |
| TL431IDBZR | CB* | TL431AMSDT | LQ* |
| TL431QDBZR | CC* | TL431BCDBZR | CG* |
| TL431FDT | AR* | TL431BIDBZR | CH* |
| TL431MFDT | AU* | TL431BQDBZR | CJ* |
| TL431SDT | RM* | TL431BFDT | AT* |
| TL431MSDT | LR* | TL431BMFDT | AW* |
| TL431ACDBZR | CD* | TL431BSDT | MA* |
| TL431AIDBZR | CE* | TL431BMSDT | MB* |
| TL431AQDBZR | CF* | - | - |
| TL431AFDT | AS* | - | - |
| TL431AMFDT | AV* | - | - |

[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 may be set to any value between $V_{ref}$ (approximately 2.5 V) and 36 V with two external resistors (see Figure 8). These devices have a typical output impedance of 0.2 Ω. 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.

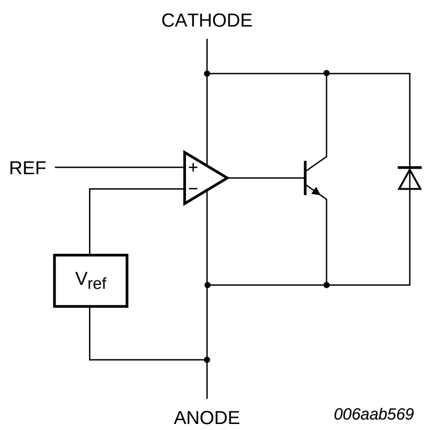



**Fig 1. Functional diagram**

## 6. Limiting values

**Table 6. Limiting values**

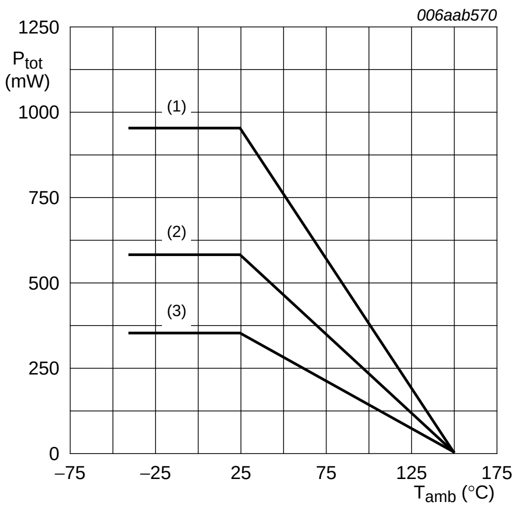
*In accordance with the Absolute Maximum Rating System (IEC 60134).*

| Symbol | Parameter | Conditions | | Min | Max | Unit |
|---|---|---|---|---|---|---|
| $V_{KA}$ | cathode-anode voltage | | | - | 37 | V |
| $I_K$ | cathode current | | | –100 | 150 | mA |
| $I_{ref}$ | reference current | | | –0.05 | 10 | mA |
| $P_{tot}$ | total power dissipation | $T_{amb} \leq 25$ °C | [1] | - | 350 | mW |
| | | | [2] | - | 580 | mW |
| | | | [3] | - | 950 | mW |
| $T_j$ | junction temperature | | | - | 150 | °C |
| $T_{amb}$ | ambient temperature | | | | | |
| | TL431XCDBZR | | | 0 | +70 | °C |
| | TL431XIDBZR | | | –40 | +85 | °C |
| | TL431XQDBZR<br>TL431XFDT<br>TL431XSDT | | | –40 | +125 | °C |
| $T_{stg}$ | 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 $cm^2$.

[3] Device mounted on a ceramic PCB, $Al_2O_3$, standard footprint.




(1) Ceramic PCB, $Al_2O_3$, standard footprint

(2) FR4 PCB, mounting pad for anode 1 $cm^2$

(3) FR4 PCB, standard footprint

**Fig 2. Power derating curves**

**Table 7. ESD maximum ratings**

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

| Symbol | Parameter | Conditions | | Min | Max | Unit |
|---|---|---|---|---|---|---|
| $V_{ESD}$ | 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 $cm^2$.

[3] Device mounted on a ceramic PCB, $Al_2O_3$, standard footprint.

[4] Soldering point of anode.

# 9. Characteristics

**Table 10. Characteristics**

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

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **Standard-Grade (2 %): TL431CDBZR; TL431IDBZR; TL431QDBZR; TL431FDT; TL431MFDT; TL431SDT; TL431MSDT** | | | | | | |
| $V_{ref}$ | reference voltage | $V_{KA} = V_{ref}$; $I_K$ = 10 mA | 2440 | 2495 | 2550 | mV |
| $\Delta V_{ref}$ | reference voltage variation | $V_{KA} = V_{ref}$; $I_K$ = 10 mA | | | | |
| | TL431CDBZR | $T_{amb}$ = 0 °C to 70 °C | - | 6 | 16 | mV |
| | TL431IDBZR | $T_{amb}$ = –40 °C to 85 °C | - | 14 | 34 | mV |
| | TL431QDBZR<br>TL431FDT<br>TL431MFDT<br>TL431SDT<br>TL431MSDT | $T_{amb}$ = –40 °C to 125 °C | | | | |
| $\Delta V_{ref}/\Delta V_{KA}$ | reference voltage variation to cathode-anode voltage variation ratio | $I_K$ = 10 mA | | | | |
| | | $\Delta V_{KA}$ = 10 V to $V_{ref}$ | - | –1.4 | –2.7 | mV/V |
| | | $\Delta V_{KA}$ = 36 V to 10 V | - | –1 | –2 | mV/V |
| $I_{ref}$ | reference current | $I_K$ = 10 mA;<br>R1 = 10 kΩ; R2 = open | - | 2 | 4 | μA |
| $\Delta I_{ref}$ | reference current variation | $I_K$ = 10 mA;<br>R1 = 10 kΩ; R2 = open | | | | |
| | TL431CDBZR | $T_{amb}$ = 0 °C to 70 °C | - | 0.4 | 1.2 | μA |
| | TL431IDBZR | $T_{amb}$ = –40 °C to 85 °C | - | 0.8 | 2.5 | μA |
| | TL431QDBZR<br>TL431FDT<br>TL431MFDT<br>TL431SDT<br>TL431MSDT | $T_{amb}$ = –40 °C to 125 °C | | | | |
| $I_{K(min)}$ | minimum cathode current | $V_{KA} = V_{ref}$ | - | 0.4 | 1 | mA |
| $I_{off}$ | off-state current | $V_{KA}$ = 36 V; $V_{ref}$ = 0 | - | 0.1 | 1 | μA |
| $Z_{KA}$ | dynamic cathode-anode impedance | $I_K$ = 1 mA to 100 mA;<br>$V_{KA} = V_{ref}$; f < 1 kHz | - | 0.2 | 0.5 | Ω |
| **A-Grade (1 %): TL431ACDBZR; TL431AIDBZR; TL431AQDBZR; TL431AFDT; TL431AMFDT; TL431ASDT; TL431AMSDT** | | | | | | |
| $V_{ref}$ | reference voltage | $V_{KA} = V_{ref}$; $I_K$ = 10 mA | 2470 | 2495 | 2520 | mV |
| $\Delta V_{ref}$ | reference voltage variation | $V_{KA} = V_{ref}$; $I_K$ = 10 mA | | | | |
| | TL431ACDBZR | $T_{amb}$ = 0 °C to 70 °C | - | 6 | 16 | mV |
| | TL431AIDBZR | $T_{amb}$ = –40 °C to 85 °C | - | 14 | 34 | mV |
| | TL431AQDBZR<br>TL431AFDT<br>TL431AMFDT<br>TL431ASDT<br>TL431AMSDT | $T_{amb}$ = –40 °C to 125 °C | | | | |
| $\Delta V_{ref}/\Delta V_{KA}$ | reference voltage variation to cathode-anode voltage variation ratio | $I_K$ = 10 mA | | | | |
| | | $\Delta V_{KA}$ = 10 V to $V_{ref}$ | - | –1.4 | –2.7 | mV/V |
| | | $\Delta V_{KA}$ = 36 V to 10 V | - | –1 | –2 | mV/V |

**Table 10. Characteristics** *...continued*

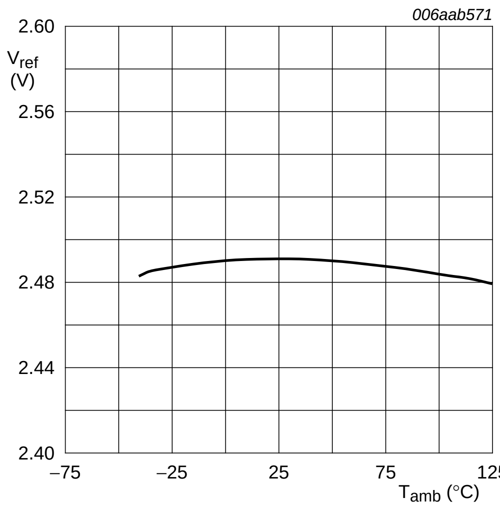
*$T_{amb}$ = 25 °C unless otherwise specified.*

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $I_{ref}$ | reference current | $I_K$ = 10 mA; R1 = 10 kΩ; R2 = open | - | 2 | 4 | μA |
| $\Delta I_{ref}$ | reference current variation | $I_K$ = 10 mA; R1 = 10 kΩ; R2 = open | | | | |
| | TL431ACDBZR | $T_{amb}$ = 0 °C to 70 °C | - | 0.4 | 1.2 | μA |
| | TL431AIDBZR | $T_{amb}$ = −40 °C to 85 °C | - | 0.8 | 2.5 | μA |
| | TL431AQDBZR TL431AFDT TL431AMFDT TL431ASDT TL431AMSDT | $T_{amb}$ = −40 °C to 125 °C | | | | |
| $I_{K(min)}$ | minimum cathode current | $V_{KA}$ = $V_{ref}$ | | | | |
| | TL431ACDBZR | $T_{amb}$ = 0 °C to 70 °C | - | 0.4 | 0.6 | mA |
| | TL431AIDBZR | $T_{amb}$ = −40 °C to 85 °C | | | | |
| | TL431AQDBZR TL431AFDT TL431AMFDT TL431ASDT TL431AMSDT | $T_{amb}$ = −40 °C to 125 °C | | | | |
| $I_{off}$ | off-state current | $V_{KA}$ = 36 V; $V_{ref}$ = 0 | - | 0.1 | 0.5 | μA |
| $Z_{KA}$ | dynamic cathode-anode impedance | $I_K$ = 1 mA to 100 mA; $V_{KA}$ = $V_{ref}$; f < 1 kHz | - | 0.2 | 0.5 | Ω |
| **B-Grade (0.5 %): TL431BCDBZR; TL431BIDBZR; TL431BQDBZR; TL431BFDT; TL431BMFDT; TL431BSDT; TL431BMSDT** | | | | | | |
| $V_{ref}$ | reference voltage | $V_{KA}$ = $V_{ref}$; $I_K$ = 10 mA | 2483 | 2495 | 2507 | mV |
| $\Delta V_{ref}$ | reference voltage variation | $V_{KA}$ = $V_{ref}$; $I_K$ = 10 mA | | | | |
| | TL431BCDBZR | $T_{amb}$ = 0 °C to 70 °C | - | 6 | 16 | mV |
| | TL431BIDBZR | $T_{amb}$ = −40 °C to 85 °C | - | 14 | 34 | mV |
| | TL431BQDBZR TL431BFDT TL431BMFDT TL431BSDT TL431BMSDT | $T_{amb}$ = −40 °C to 125 °C | | | | |
| $\Delta V_{ref}/\Delta V_{KA}$ | reference voltage variation to cathode-anode voltage variation ratio | $I_K$ = 10 mA | | | | |
| | | $\Delta V_{KA}$ = 10 V to $V_{ref}$ | - | −1.4 | −2.7 | mV/V |
| | | $\Delta V_{KA}$ = 36 V to 10 V | - | −1 | −2 | mV/V |
| $I_{ref}$ | reference current | $I_K$ = 10 mA; R1 = 10 kΩ; R2 = open | - | 2 | 4 | μA |

**Table 10. Characteristics** *...continued*

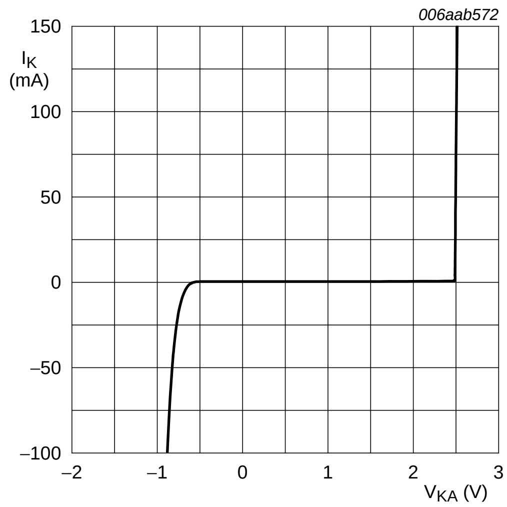
*$T_{amb}$ = 25 °C unless otherwise specified.*

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $\Delta I_{ref}$ | reference current variation | $I_K$ = 10 mA; R1 = 10 kΩ; R2 = open | | | | |
| | TL431BCDBZR | $T_{amb}$ = 0 °C to 70 °C | - | 0.4 | 1.2 | μA |
| | TL431BIDBZR | $T_{amb}$ = −40 °C to 85 °C | - | 0.8 | 2.5 | μA |
| | TL431BQDBZR<br>TL431BFDT<br>TL431BMFDT<br>TL431BSDT<br>TL431BMSDT | $T_{amb}$ = −40 °C to 125 °C | | | | |
| $I_{K(min)}$ | minimum cathode current | $V_{KA} = V_{ref}$ | | | | |
| | TL431BCDBZR | $T_{amb}$ = 0 °C to 70 °C | - | 0.4 | 0.6 | mA |
| | TL431BIDBZR | $T_{amb}$ = −40 °C to 85 °C | | | | |
| | TL431BQDBZR<br>TL431BFDT<br>TL431BMFDT<br>TL431BSDT<br>TL431BMSDT | $T_{amb}$ = −40 °C to 125 °C | | | | |
| $I_{off}$ | off-state current | $V_{KA}$ = 36 V; $V_{ref}$ = 0 | - | 0.1 | 0.5 | μA |
| $Z_{KA}$ | dynamic cathode-anode impedance | $I_K$ = 1 mA to 100 mA; $V_{KA} = V_{ref}$; f < 1 kHz | - | 0.2 | 0.5 | Ω |



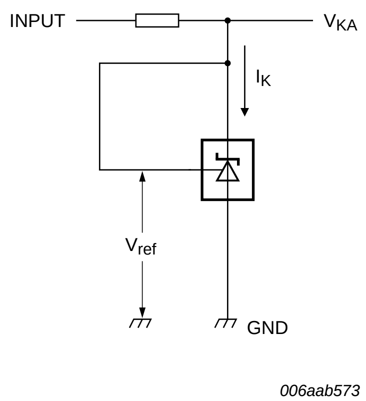

$I_K$ = 10 mA; $V_{KA}$ = $V_{ref}$

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



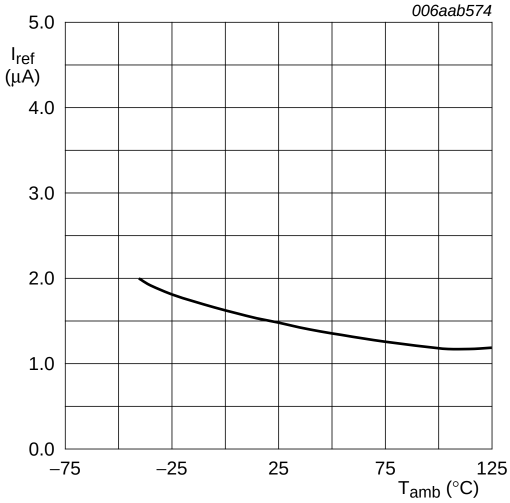

$V_{KA}$ = $V_{ref}$; $T_{amb}$ = 25 °C

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



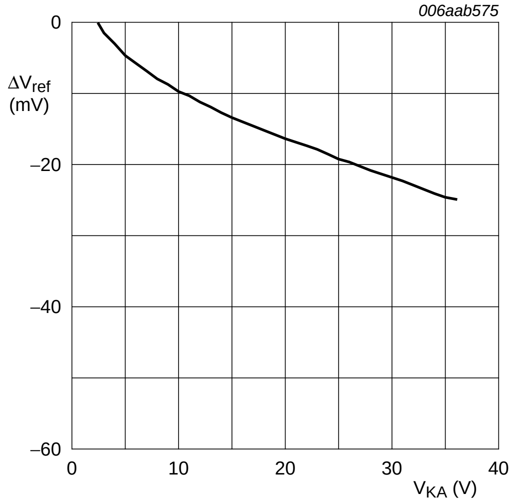

$I_K$ = 10 mA; $V_{KA}$ = $V_{ref}$

**Fig 5. Test circuit to Figure 3 and Figure 4**



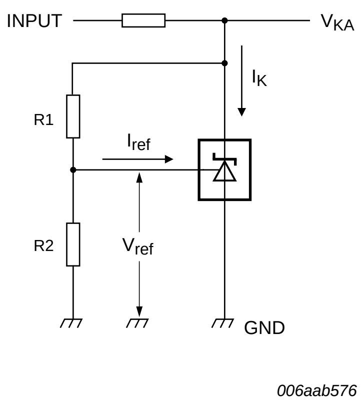

$I_K$ = 10 mA; R1 = 10 kΩ; R2 = open

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



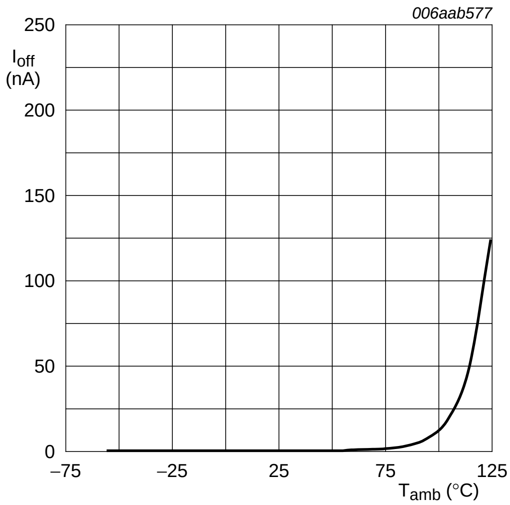

$I_K$ = 10 mA; $T_{amb}$ = 25 °C

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



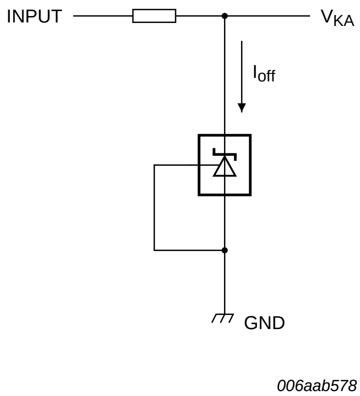

$$V_{KA} = V_{ref} \times \left(1 + \frac{R1}{R2}\right) + I_{ref} \times R1$$

**Fig 8. Test circuit to Figure 6 and Figure 7**



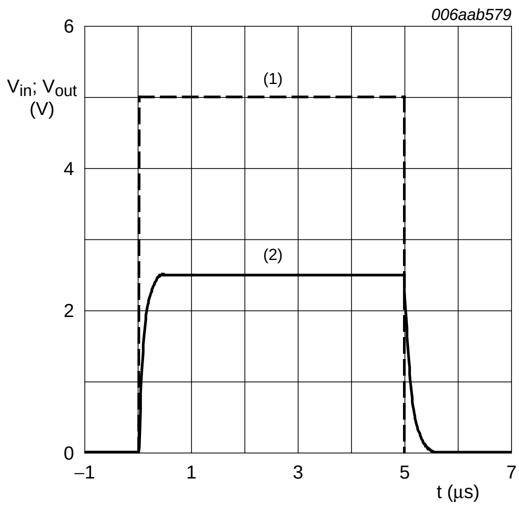

$V_{KA}$ = 36 V; $V_{ref}$ = 0 V

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




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

**Fig 10. Off-state current as a function of ambient temperature; test circuit**

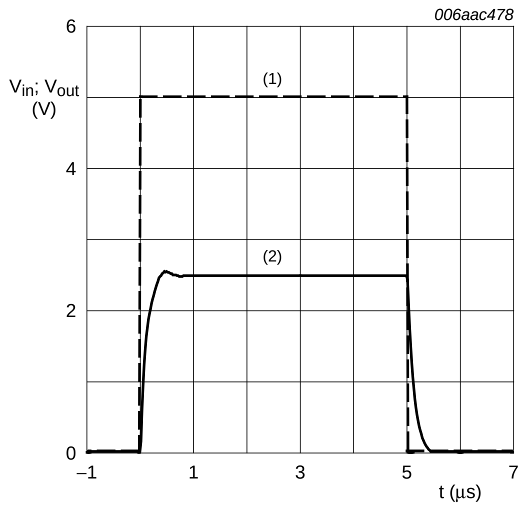



$T_{amb}$ = 25 °C

(1) Input

(2) Output

**Fig 11. All types except TL431XFDT and TL431XSDT: Input voltage and output voltage as a function of time; typical values**

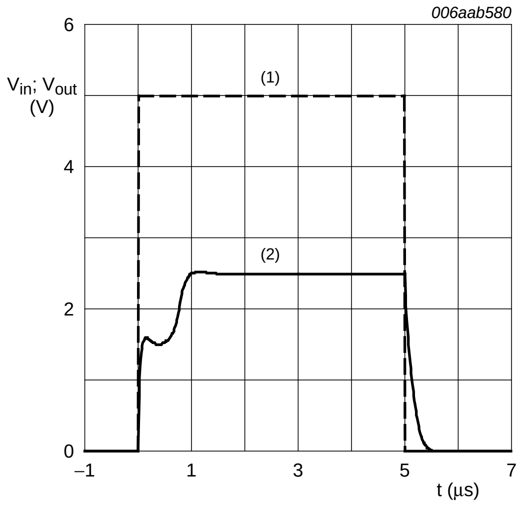



$T_{amb}$ = 25 °C

(1) Input

(2) Output

**Fig 12. TL431XFDT: Input voltage and output voltage as a function of time; typical values**

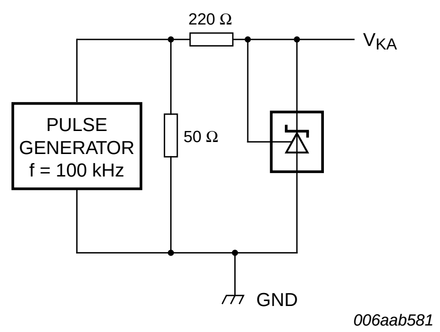



$T_{amb}$ = 25 °C

(1) Input

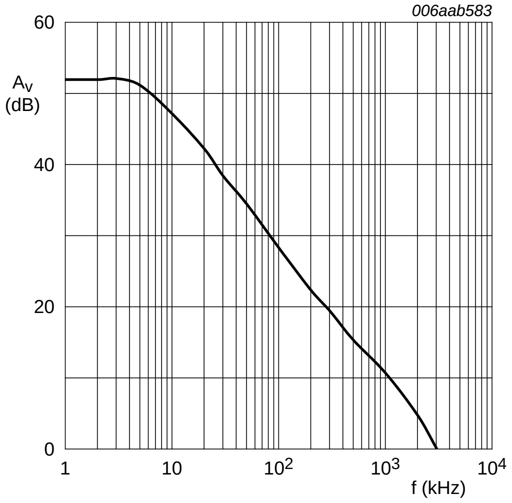
(2) Output

**Fig 13. TL431XSDT: Input voltage and output voltage as a function of time; typical values**



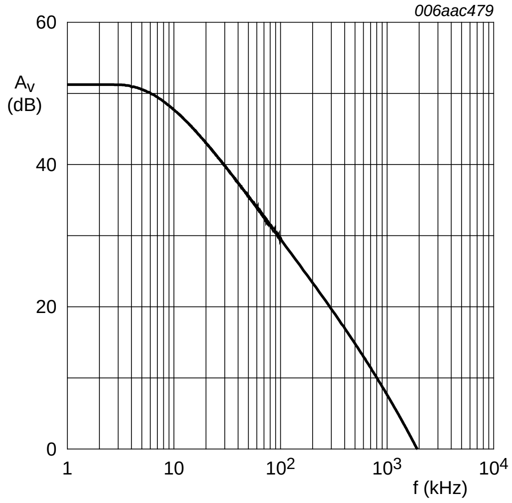

$T_{amb}$ = 25 °C

**Fig 14. Test circuit to Figure 11, Figure 12 and Figure 13**



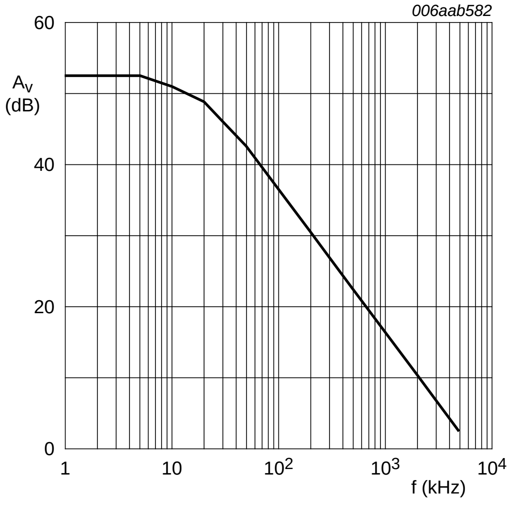

$I_K$ = 10 mA; $T_{amb}$ = 25 °C

**Fig 15. All types except TL431XFDT and TL431XSDT: Voltage amplification as a function of frequency; typical values**



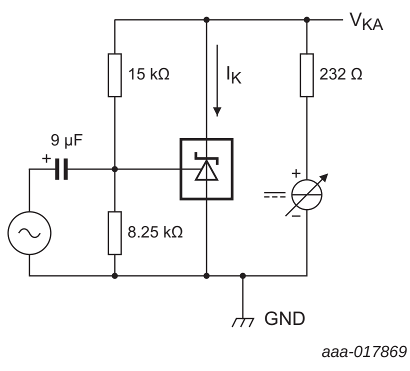

$I_K$ = 10 mA; $T_{amb}$ = 25 °C

**Fig 16. TL431XFDT: Voltage amplification as a function of frequency; typical values**



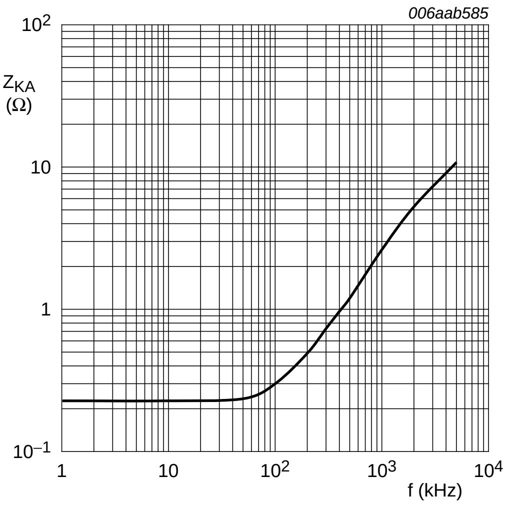

$I_K$ = 10 mA; $T_{amb}$ = 25 °C

**Fig 17. TL431XSDT: Voltage amplification as a function of frequency; typical values**



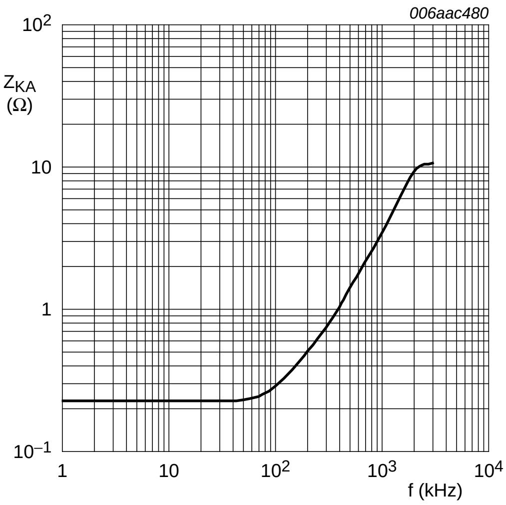

$I_K$ = 10 mA; $T_{amb}$ = 25 °C

**Fig 18. Test circuit to Figure 15, Figure 16 and Figure 17**



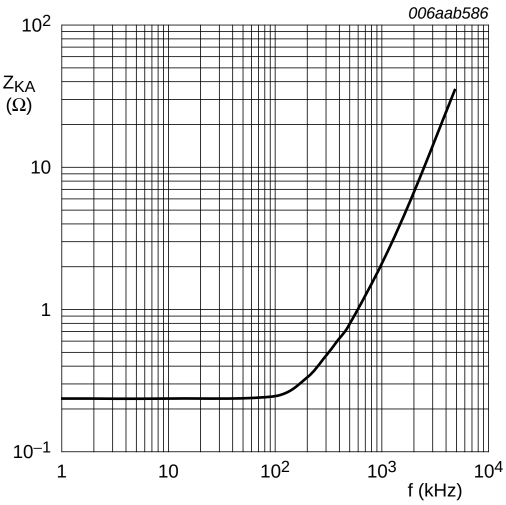

$I_K$ = 10 mA; $T_{amb}$ = 25 °C

**Fig 19. All types except TL431XFDT and TL431XSDT: Dynamic cathode-anode impedance as a function of frequency; typical values**



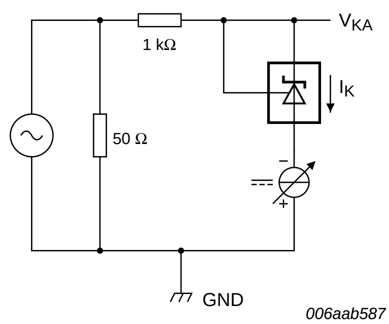

$I_K$ = 10 mA; $T_{amb}$ = 25 °C

**Fig 20. TL431XFDT: Dynamic cathode-anode impedance as a function of frequency; typical values**



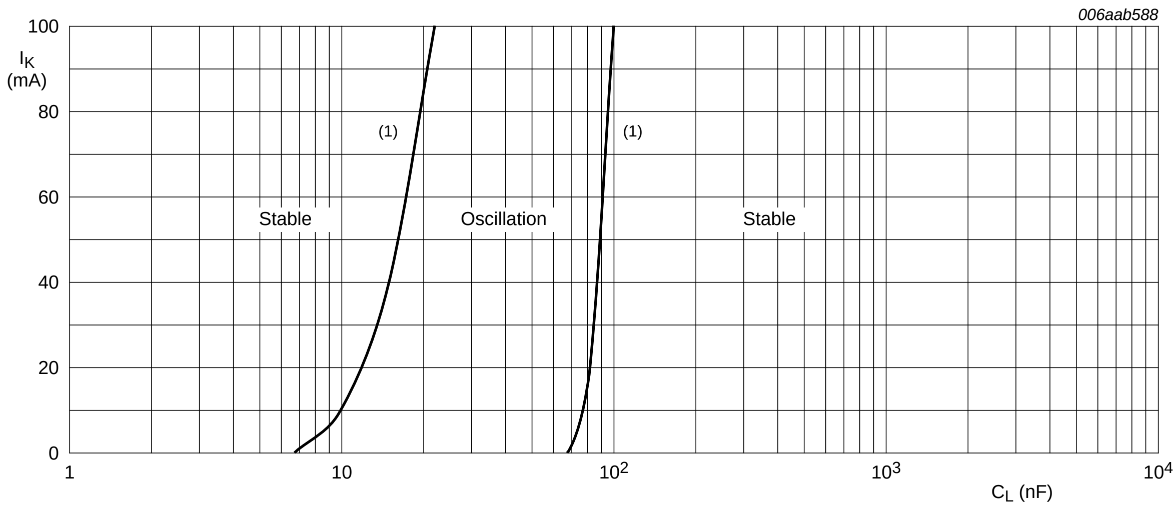

$I_K$ = 10 mA; $T_{amb}$ = 25 °C

**Fig 21. TL431XSDT: Dynamic cathode-anode impedance as a function of frequency; typical values**




$I_K$ = 10 mA; $T_{amb}$ = 25 °C

**Fig 22. Test circuit to Figure 19, Figure 20 and Figure 21**




$T_{amb}$ = 25 °C

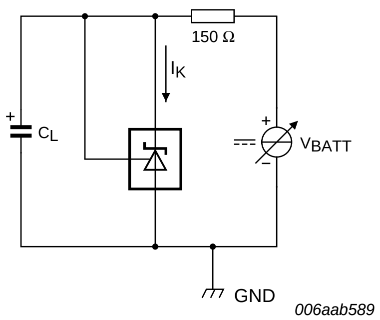
(1) $V_{KA} = V_{ref}$

$V_{KA}$ = 5 V: no oscillation

$V_{KA}$ = 10 V: no oscillation

$V_{KA}$ = 15 V: no oscillation

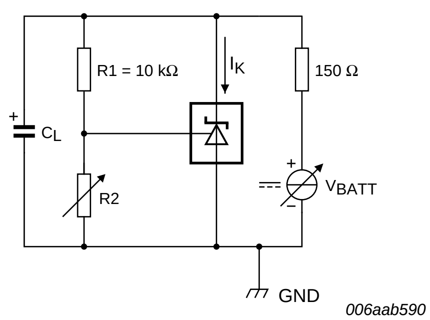
**Fig 23. All types except TL431XFDT and TL431XSDT: Cathode current as a function of load capacitance; typical values**




$V_{KA} = V_{ref}$

$T_{amb}$ = 25 °C

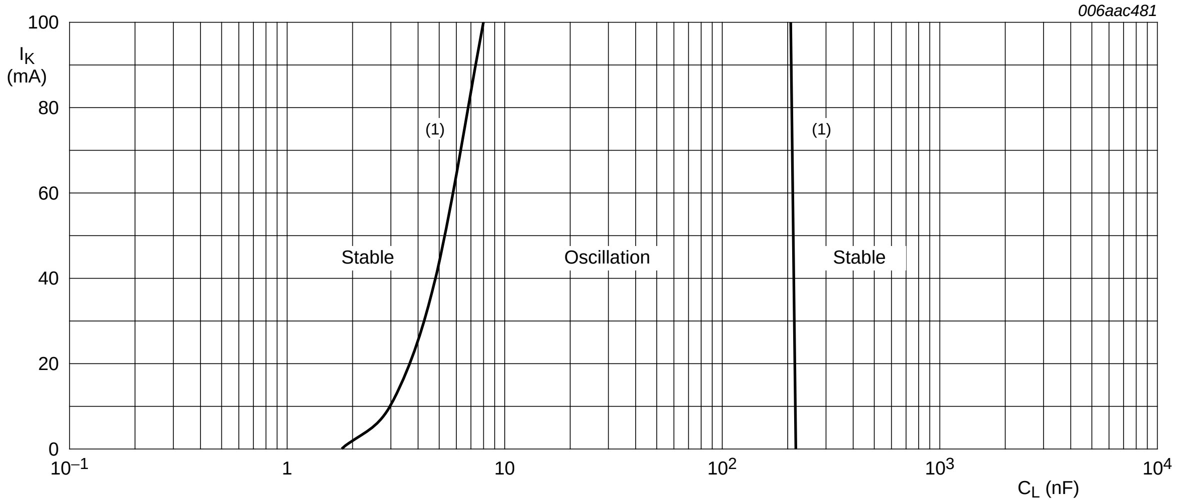
**Fig 24. Test circuit (1) to Figure 23**




$V_{KA}$ > 5 V: stable operation

$T_{amb}$ = 25 °C

**Fig 25. Test circuit (2) to Figure 23**




$T_{amb}$ = 25 °C

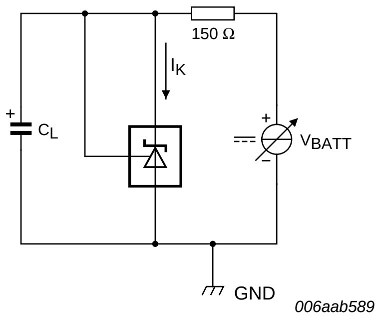
(1) $V_{KA} = V_{ref}$

$V_{KA}$ = 5 V: no oscillation

$V_{KA}$ = 10 V: no oscillation

$V_{KA}$ = 15 V: no oscillation

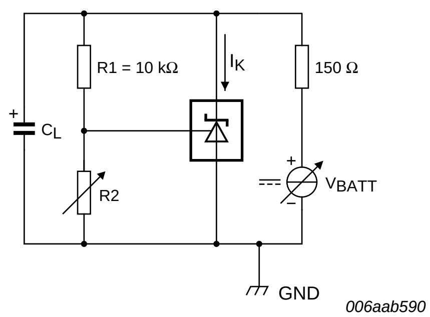
**Fig 26. TL431XFDT: Cathode current as a function of load capacitance; typical values**




$V_{KA} = V_{ref}$

$T_{amb}$ = 25 °C

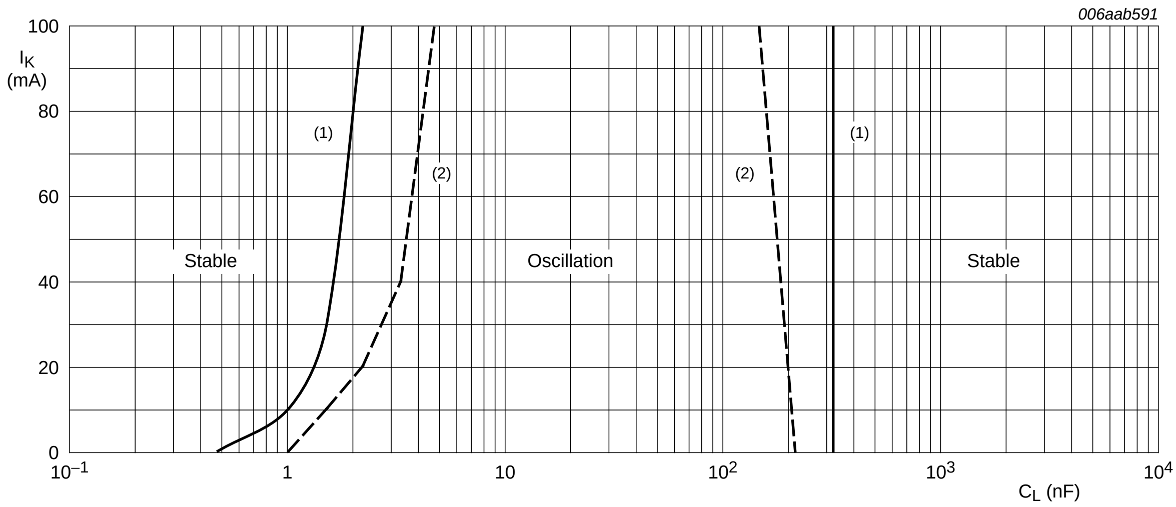
**Fig 27. Test circuit (1) to Figure 26**




$V_{KA}$ > 5 V: stable operation

$T_{amb}$ = 25 °C

**Fig 28. Test circuit (2) to Figure 26**




$T_{amb}$ = 25 °C

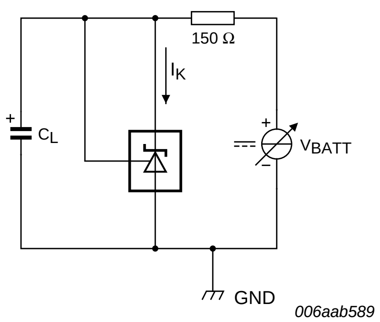
(1) $V_{KA} = V_{ref}$

(2) $V_{KA}$ = 5 V

$V_{KA}$ = 10 V: no oscillation

$V_{KA}$ = 15 V: no oscillation

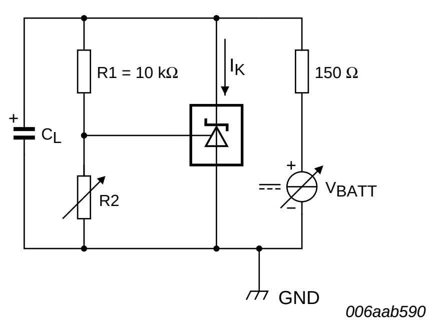
**Fig 29. TL431XSDT: Cathode current as a function of load capacitance; typical values**




$V_{KA} = V_{ref}$

$T_{amb}$ = 25 °C

**Fig 30. Test circuit (1) to Figure 29**



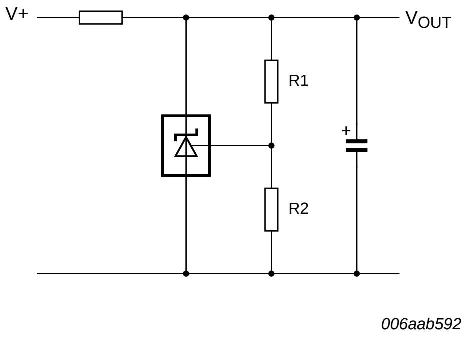

$V_{KA}$ = 5 V

$V_{KA}$ > 10 V: stable operation

$T_{amb}$ = 25 °C

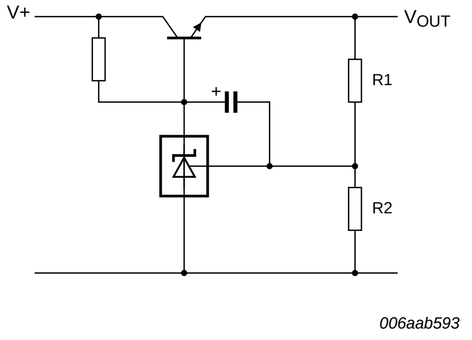
**Fig 31. Test circuit (2) to Figure 29**

# 10. Application information




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

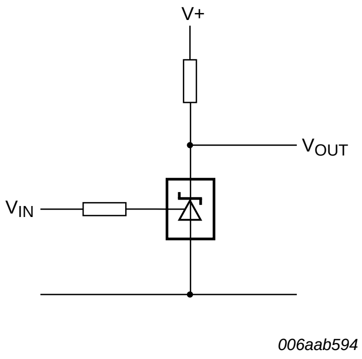
**Fig 32. Shunt regulator**




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

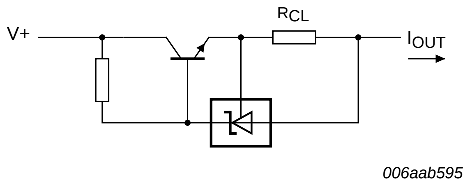
$$V_{OUT(min)} = V_{ref} + V_{be}$$

**Fig 33. Series pass regulator**



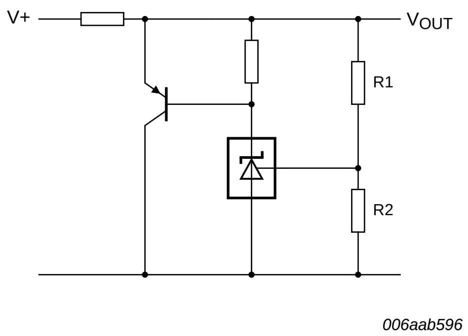

$$V_{th} = V_{ref}$$
$$V_{IN} < V_{ref} \Rightarrow V_{OUT} > 0$$
$$V_{IN} > V_{ref} \Rightarrow V_{OUT} \cong 2V$$

**Fig 34. Single-supply comparator with temperature-compensated threshold**



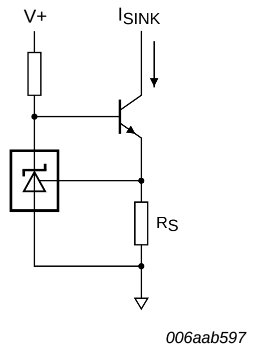

$$I_{OUT} = \frac{V_{ref}}{R_{CL}}$$

**Fig 35. Constant current source**




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

**Fig 36. High-current shunt regulator**




$$I_{SINK} = \frac{V_{ref}}{R_S}$$

**Fig 37. Constant current sink**

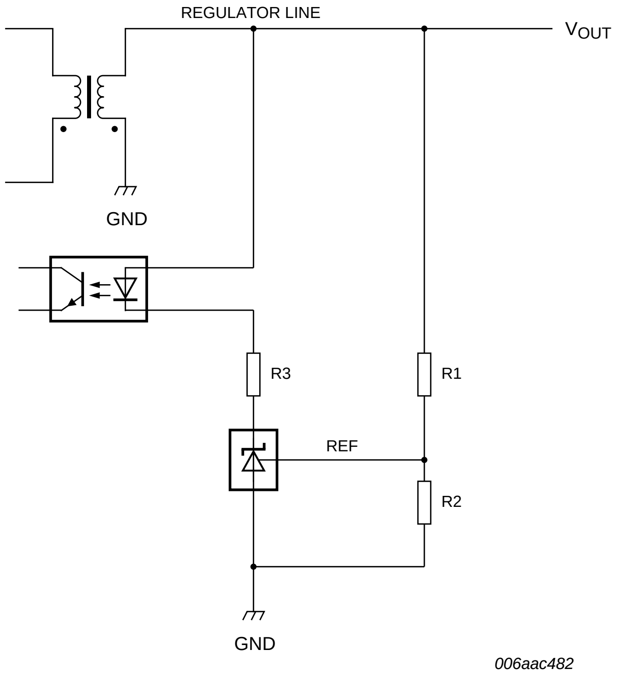



Fig 38. TL431 in control loop of SMPS

## 11. Test information

### 11.1 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

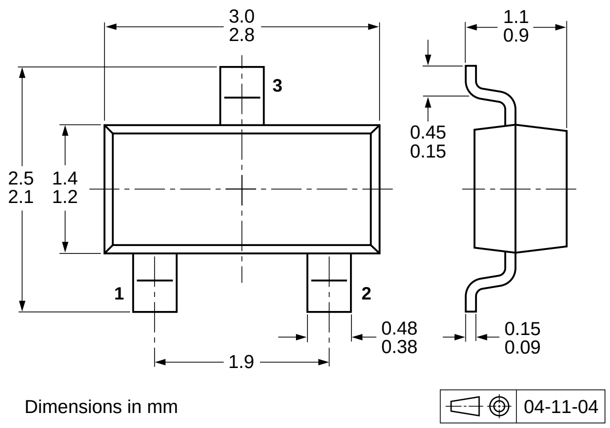



Fig 39. Package outline SOT23 (TO-236AB)

# 13. Soldering

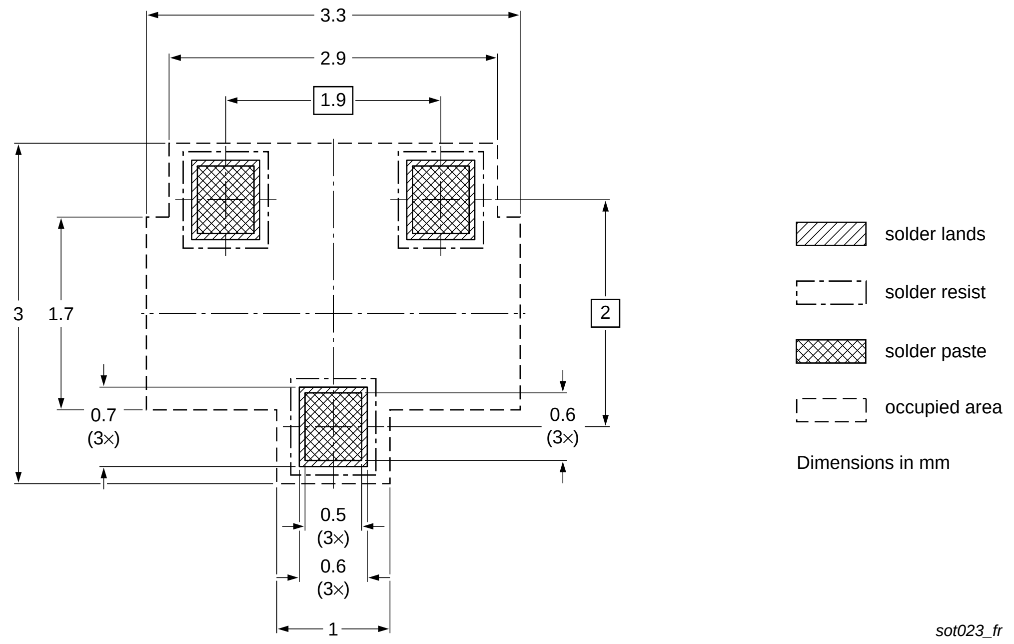



Fig 40. Reflow soldering footprint SOT23 (TO-236AB)

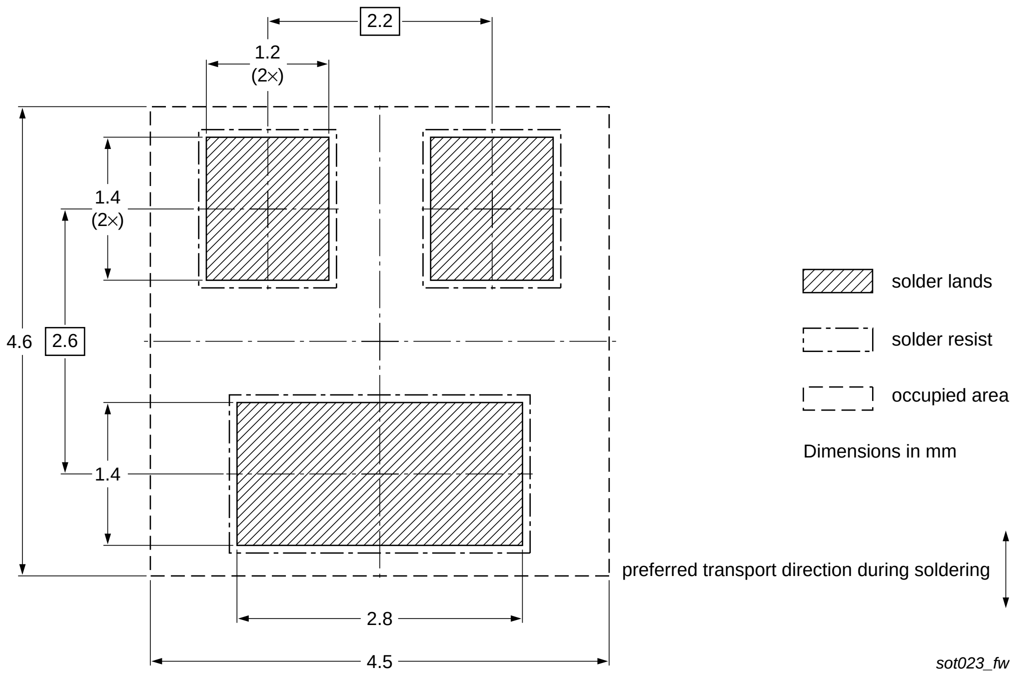



Fig 41. Wave soldering footprint SOT23 (TO-236AB)

## 14. Revision history

**Table 11. Revision history**

| Document ID | Release date | Data sheet status | Change notice | Supersedes |
|---|---|---|---|---|
| TL431_FAM v.5 | 20150901 | Product data sheet | - | TL431_FAM v.4 |
| Modifications: | • Figure 18: Capacitor value corrected | | | |
| TL431_FAM v.4 | 20110630 | Product data sheet | - | TL431_FAM v.3 |
| TL431_FAM v.3 | 20101105 | Product data sheet | - | TL431_FAM v.2 |
| TL431_FAM v.2 | 20100120 | Product data sheet | - | TL431_FAM v.1 |
| TL431_FAM v.1 | 20090806 | Product data sheet | - | - |

# 15. Legal information

## 15.1 Data sheet status

| Document status[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".

[3] The product status of device(s) described in this document may have changed since this document was published and may differ in case of multiple devices. The latest product status information is available on the Internet at URL http://www.nxp.com.

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## 17. Contents





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**Date of release: 01 September 2015**

**Document identifier: TL431 family**