# TSC200

Datasheet

## High voltage, current sense amplifier with open drain comparator and ref

MiniSO8

SO8

| Maturity status link |
| --- |
| TSC200 |

## Features

- Wide common mode voltage: -16 to 80 V
- 2.7 to 18 V supply voltage
- Amplification gain: 20 V/V
- 0.6 V internal reference
- Internal open-drain comparator
- Latching capability on comparator
- High accuracy: 3.5 % max. error overtemperature
- Bandwidth: 1 MHz
- Quiescent current: 1.8 mA maximum
- SO8 and MiniSO8 package

## Applications

- High-side current sensing
- Low-side current sensing
- Overcurrent protection
- Telecom equipment
- Test and measurement equipment
- Industrial process control

## Description

The TSC200 is a high-side current sense amplifier which delivers an analog voltage output. It can sense current via a shunt resistor over a wide range of common mode voltages, from -16 to +80 V, whatever the supply voltage is. It is available with an amplification gain of 20 V/V.

The TSC200 integrates an open-drain comparator with output latch function and an internal 0.6 V voltage reference connected to its input. External resistor divider can then set the switching threshold.

This device fully operates over the broad supply voltage range of 2.7 to 18 V and over the industrial temperature range of -40 to +125 °C.

# 1 Block diagram and pin description

Figure 1. **Block diagram**

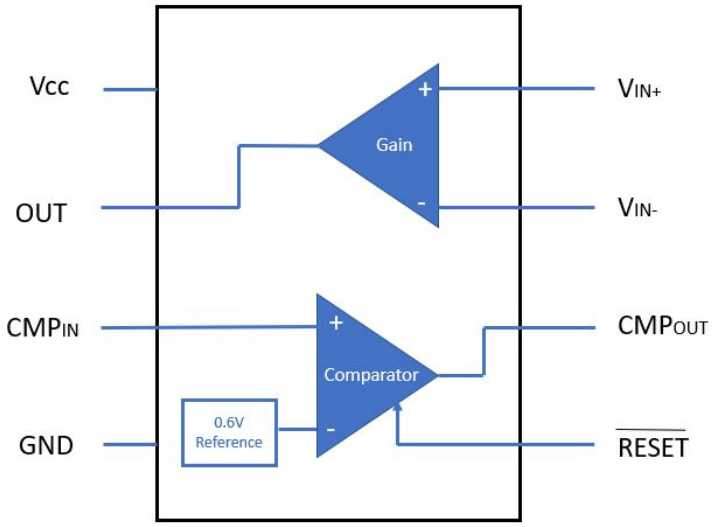



Figure 2. **Pin connections (top view)**

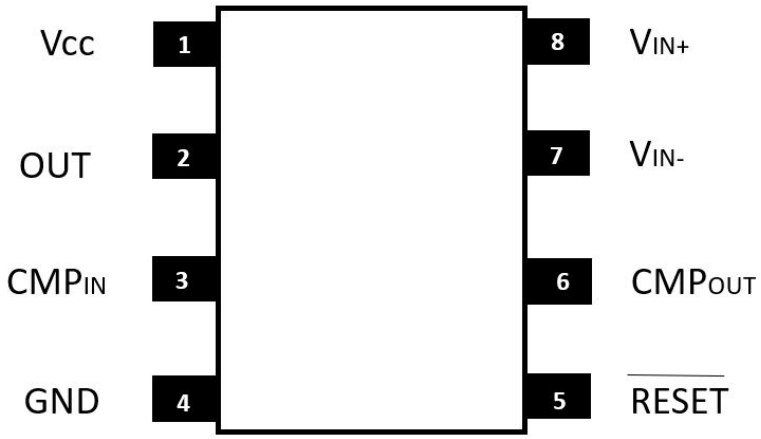



Table 1. **Pin description**

| Pin | Pin name | Description |
|---|---|---|
| 1 | $V_{CC}$ | Supply voltage |
| 2 | OUT | Current sense amplifier, output |
| 3 | $CMP_{IN}$ | Comparator input |
| 4 | GND | Ground |
| 5 | RESET | Comparator reset pin, active low |
| 6 | $CMP_{OUT}$ | Comparator output |
| 7 | $V_{IN-}$ | Current sense amplifier, negative input |
| 8 | $V_{IN+}$ | Current sense amplifier, positive input |

# 2 Absolute maximum ratings and operating conditions

**Table 2. Absolute maximum ratings**

| Symbol | Parameter | | Value | Unit |
|---|---|---|---|---|
| $V_{CC}$ | Supply voltage | | -0.3 to 18.3 | V |
| $V_{IN}$ +, $V_{IN-}$ | Differential voltage ($V_{IN+}$) – ($V_{IN-}$) | | 25% $V_{CC}$ (1) | |
| | Common mode voltage on input pins | | -18 to +82 | |
| $CMP_{IN}$, RESET | Voltage present on pins $V_{IN+}$, $V_{IN-}$, $CMP_{IN}$, RESET | | Gnd -0.3 to Vcc +0.3 | V |
| OUT | Analog output | | Gnd -0.3 to Vcc +0.3 | |
| $CMP_{OUT}$ | Voltage present on pin $CMP_{OUT}$ | | Gnd -0.3 to 18.3 | |
| $I_{IN}$ | Input current on $V_{IN+}$, $V_{IN-}$ | | 5 | mA |
| $T_J$ | Junction temperature | | 150 | °C |
| $T_{STG}$ | Storage temperature | | -65 to 150 | °C |
| ESD | Human Body Model (HBM) | | 4000 | V |
| | Charged Device Model (CDM) | | 1000 | |
| $R_{THJA}$ | Thermal resistance junction to ambient | SO8 | 125 | °C/W |
| | | MiniSO8 | 190 | |

1. *For $V_{CC}$ ≥ 12 V, Vdiff must not exceed 3 V.*

**Table 3. Operating conditions**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_{CC}$ | Supply voltage | 2.7 to 18 | V |
| $V_{ICM}$ | Common mode voltage on input pins | -16 to +80 | V |
| T | Operating free-air temperature range | -40 to 125 | °C |

# 3 Electrical characteristics

**Table 4. Electrical characteristics of the Current sense amplifier at $V_{CC}$ = 12 V, $V_{ICM}$ = 12 V, $V_{Sense}$ = 100 mV, $R_L$ = 10 kΩ to GND, $R_{pull-up}$ = 5.1 kΩ connected from $CMP_{OUT}$ to $V_{CC}$, $CMP_{IN}$ = GND, T = 25 °C (unless otherwise specified)**

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| **Input** | | | | | | |
| $V_{Sense}$ | Full scale sense input voltage | | | 0.15 | $\frac{V_{CC}-0.25}{Gain}$ | V |
| $V_{ICM}$ | Common mode input range | Tmin < T < Tmax | -16 | | 80 | V |
| CMR | Common mode rejection | $V_{IN}$+ = -16 to 80 V, | 80 | 110 | | dB |
| | | $V_{IN}$+ = 12 to 80 V, Tmin < T < Tmax | 100 | 120 | | |
| Vos | Offset voltage, RTI (1) (2) | T = 25 °C | -2.5 | ±0.1 | +2.5 | mV |
| | | 25 °C < T < Tmax | -3 | | +3 | |
| | | Tmin < T < 25 °C | -3.5 | | +3.5 | |
| \|ΔVos/ΔT\| | Offset drift (RTI) vs. temperature | Tmin < T < Tmax | | 0.5 | | µV/°C |
| SVR | Supply voltage rejection, RTI | $V_{OUT}$ = 2 V, $V_{IN}$+ = 18 V, $V_{CC}$ = 2.7 to 18 V, Tmin < T < Tmax | | 3 | 100 | µV/V |
| $I_{IB}$ | Input bias current, $V_{IN-}$ pin | Tmin < T < Tmax | | ±0.5 | ±16 | µA |
| **Output ($V_{Sense}$ ≥ 20 mV)** | | | | | | |
| G | Gain | TSC200 | | 20 | | V/V |
| $E_G$ | Gain error | $V_{Sense}$ = 20 to 100 mV | | ±0.05 | ±1 | % |
| | | Tmin < T < Tmax | | | ±2 | |
| $TE_G$ | Total output error (3) | $V_{Sense}$ = 120 mV, $V_{CC}$ = 16 V | | ±0.1 | ±2.2 | % |
| | | Tmin < T < Tmax | | | ±3.5 | |
| NLE | Non linearity error | $V_{Sense}$ = 20 to 100 mV | | ±0.002 | | % |
| $R_O$ | Output impedance | | | 1.5 | | Ω |
| $C_{Load}$ | Maximum capacitive load | No sustained oscillation | | 10 | | nF |
| **Output ($V_{Sense}$ < 20 mV)** | | | | | | |
| Output | TSC200 | -16 ≤ $V_{ICM}$ < 0 V | | 300 | | mV |
| | | 0 ≤ $V_{ICM}$ ≤ Vcc, $V_{CC}$ = 5 V | | | 400 | |
| | | Vcc < $V_{ICM}$ ≤ 80 V | | 300 | | |
| **Voltage output** | | | | | | |
| $V_{OH}$ | Output swing to the positive rail | $V_{IN-}$ = 11 V, $V_{IN}$+ = 12 V, Tmin < T < Tmax | | $V_{CC}$ - 0.15 | $V_{CC}$ - 0.25 | mV |
| $V_{OL}$ | Output swing to GND | $V_{IN-}$ = 0 V, $V_{IN}$+ = -50 mV, Tmin < T < Tmax | | 4 | 50 | mV |

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| **Dynamic performances** | | | | | | |
| BW | $C_{Load}$ = 5 pF | TSC200 | | 1 | | MHz |
| SR | Slew rate | | | 7 | | V/µs |
| Ts | Settling time | $V_{Sense}$ = 10 to 100 mVpp<br>Up to 1 % final value,<br>$C_{Load}$ = 5 pF | | 2 | | µs |
| **Noise, RTI** | | | | | | |
| $E_N$ | Voltage noise density | f = 100 kHz | | 55 | | nV/√Hz |
| **Power supply** | | | | | | |
| $I_{CC}$ | Current consumption | $V_{OUT}$ = 2 V | | 0.84 | 1.8 | mA |
| | | $V_{Sense}$ = 0 mV,<br>Tmin < T < Tmax | | | 1.85 | |
| C_POR | Comparator POR threshold [4] | | | 1.5 | | V |

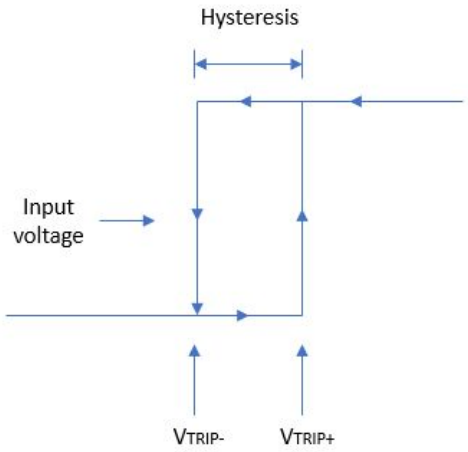
1. *RTI stands for "Related to input".*
2. *Offset is extrapolated from measurements of the output at $V_{Sense}$ of 20 mV and 100 mV.*
3. *Total output error considers effects of gain error and $V_{OS}$ inaccuracy.*
4. *The TSC200 is designed to power up with the comparator in a defined reset state as long as RESET is open or grounded. The comparator is in reset as long as the power supply is below the voltage shown here. The comparator assumes a state based on the comparator input above this supply voltage. If RESET is high at power-up, the comparator output comes up high and requires a reset to assume a low state, if appropriate.*

**Table 5. Electrical characteristics of the Comparator at $V_{CC}$ = 12 V, $V_{ICM}$ = 12 V, $V_{Sense}$ = 100 mV, $R_L$ = 10 kΩ to GND, $R_{pull-up}$ = 5.1 kΩ connected from $CMP_{OUT}$ to $V_{CC}$, T = 25 °C (unless otherwise specified)**

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| **Input** | | | | | | |
| $V_{TH}$ | Threshold | T = 25 °C | 590 | 608 | 620 | mV |
| | | Tmin < T < Tmax | 586 | | 625 | |
| Hyst | Hysteresis (1) | Tmin < T < Tmax | | -9 | | |
| $I_{IB}$ | Input bias current, $CMP_{IN}$ pin (2) | T = 25 °C | | 0.005 | 10 | nA |
| | | Tmin < T < Tmax | | | 15 | |
| $V_{IN}$ | Input voltage range, $CMP_{IN}$ pin | | 0 | | $V_{CC}$ -1.5 | V |
| **Output (open-drain)** | | | | | | |
| Av | Large signal differential voltage gain | $CMP_{OUT}$ from 1 to 4 V<br>$R_L$ ≥ 15 kΩ connected to 5 V | | 200 | | V/mV |
| $I_{OH}$ | High level leakage current (3) (4) | $V_{ID}$ = 0.4 V, $V_{OH}$ = $V_{CC}$ | | 0.0001 | 1 | µA |
| $V_{OL}$ | Low level output voltage (3) | $V_{ID}$ = -0.6 V, $I_{OL}$ = 2.35 mA | | 140 | 300 | mV |
| **Response time** | | | | | | |
| $T_P$ | Response time (5) | $R_L$ to 5 V, $C_{Load}$ = 15 pF,<br>100 mV input step with 5 mV overdrive | | 0.3 | | µs |
| **$\overline{RESET}$** | | | | | | |
| $V_T$ | $\overline{Reset}$ threshold (6) | | | 1.1 | | V |
| $R_I$ | Input impedance | | | 2 | | MΩ |
| $T_{DW}$ | Minimum $\overline{Reset}$ pulse width | | | 0.1 | | µs |
| $T_D$ | Propagation delay | | | 0.1 | | µs |

1. *See Figure 3 for details, Hysteresis=$V_{TRIP}$- - $V_{TRIP}$+.*
2. *Specified by design.*
3. *$V_{ID}$ is the differential voltage present at the comparator inputs.*
4. *Open-drain output can be pulled up to 2.7~18 V range, regardless of $V_{CC}$.*
5. *The comparator response time specified is the time interval between the input step and the instant when the output crosses 1.4 V.*
6. *The RESET input has an internal 2 MΩ (typical) pull-down. In case RESET pin is left open, the output shows a LOW state, with transparent comparator operation.*

**Figure 3. Typical comparator hysteresis**



# 4 Typical performance characteristics

T = 25 °C, $V_{CC}$ = 12 V, $V_{IN+}$ = 12 V and $V_{Sense}$ = 100 mV (unless otherwise specified).

**Figure 4. Gain vs. frequency ($C_L$ = 1000 pF)**

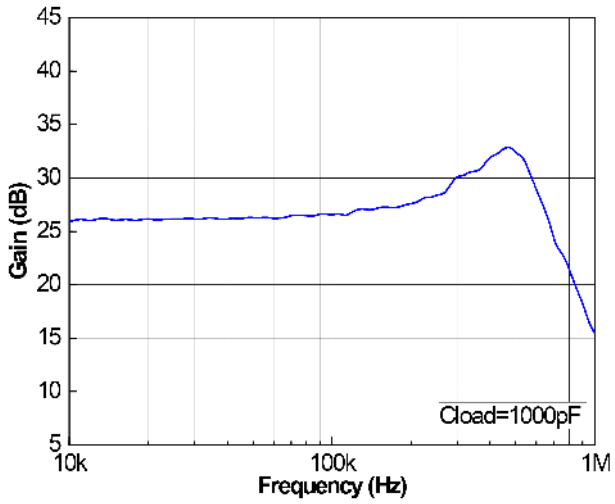



**Figure 5. Gain vs. frequency ($C_L$ = 100 pF)**

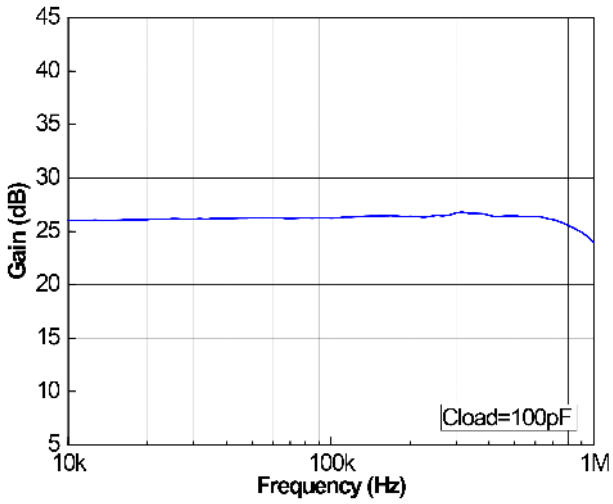



**Figure 6. Gain plot**

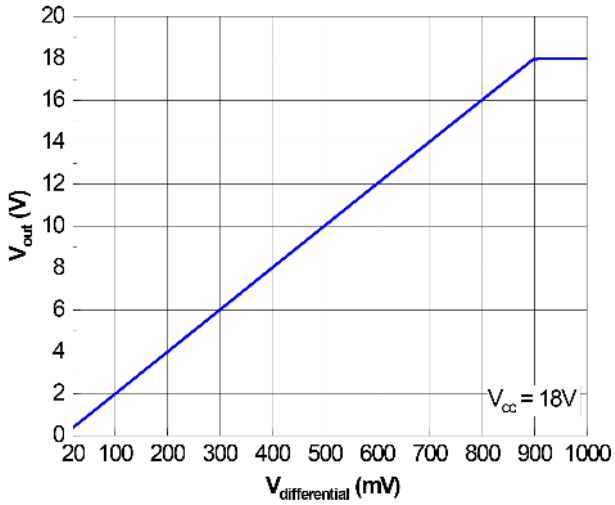



**Figure 7. CMRR and PSRR vs. frequency**

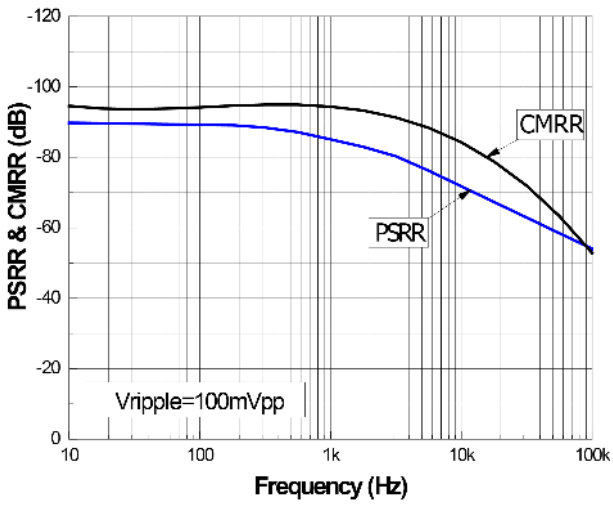


Figure 8. Output error vs. $V_{sense}$

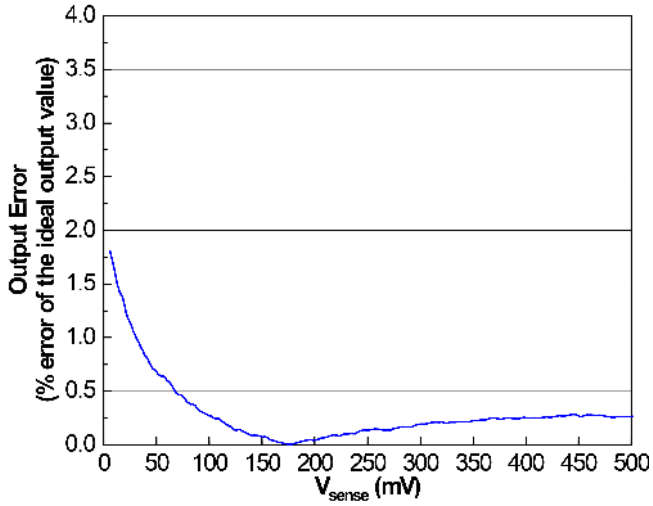



Figure 9. Output error vs. common mode voltage

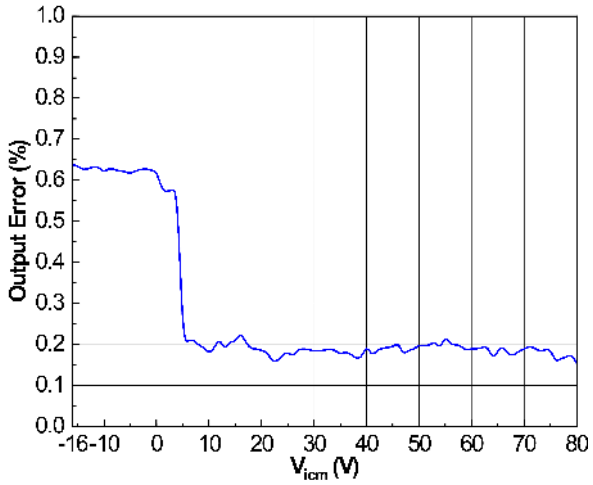



Figure 10. Output current vs. output voltage at $V_{CC}$ = 2.7 V

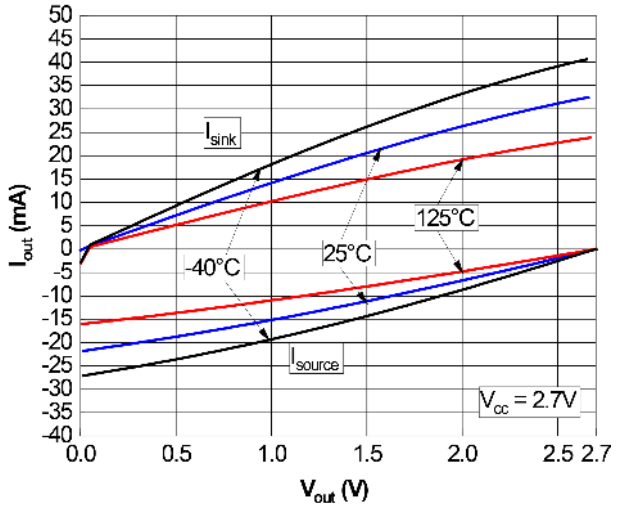



Figure 11. Output current vs. output voltage at $V_{CC}$ = 12 V

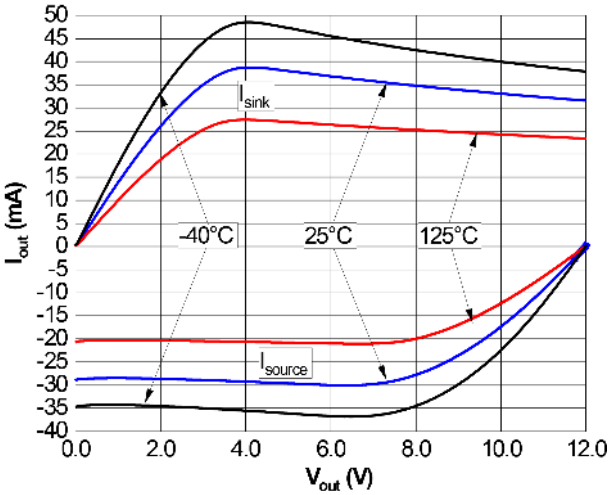



Figure 12. Quiescent current vs. output voltage

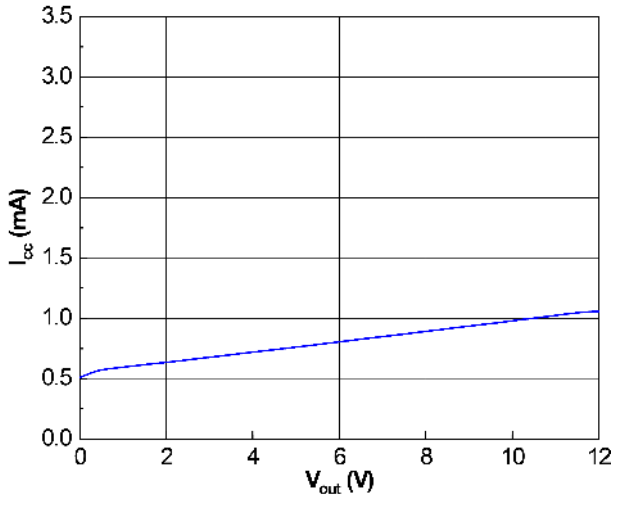



Figure 13. Quiescent current vs. common mode voltage

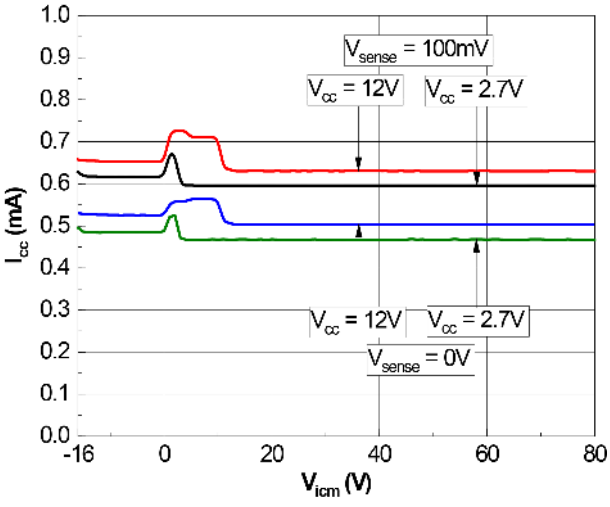


Figure 14. Output short-circuit current vs. supply voltage

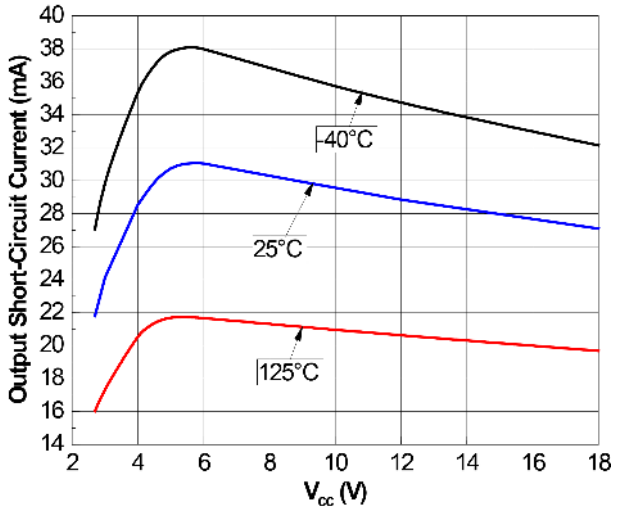



Figure 15. Step response for 20 to 30 mV $V_{sense}$

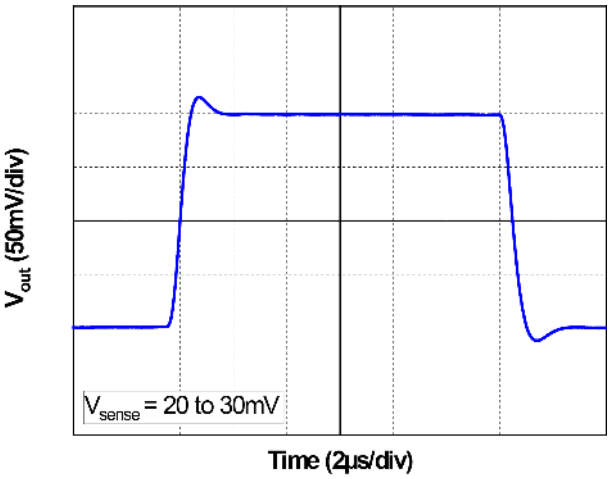



Figure 16. Step response for 20 to 110 mV $V_{sense}$

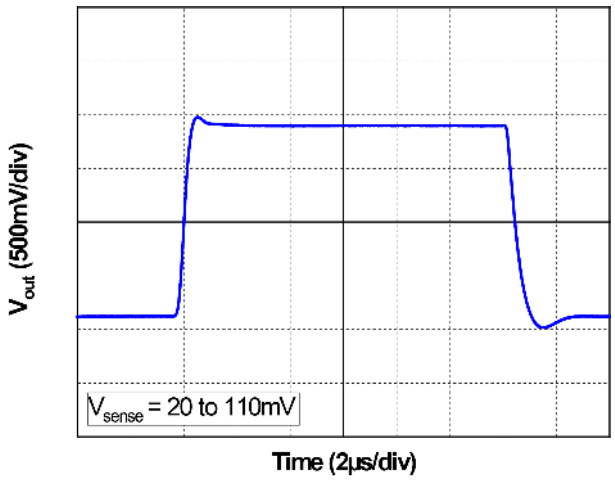



Figure 17. Step response for 90 to 100 mV $V_{sense}$

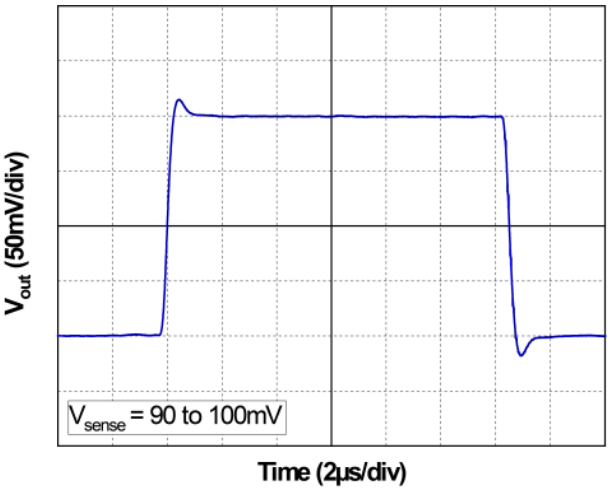



Figure 18. Comparator $V_{OL}$ vs. $I_{SINK}$

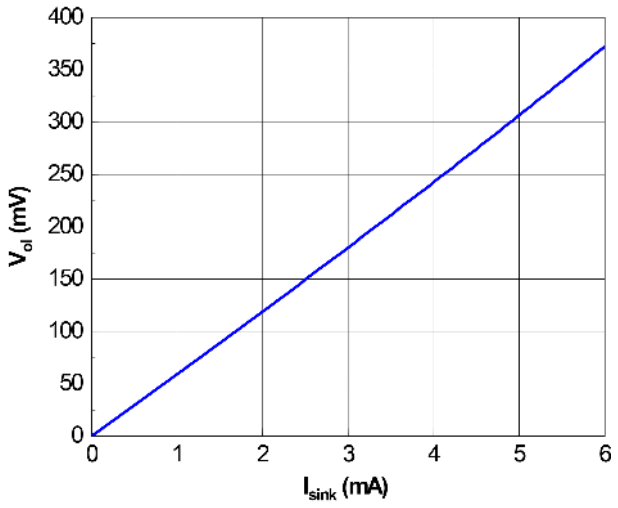



Figure 19. Comparator trip points vs. $V_{CC}$

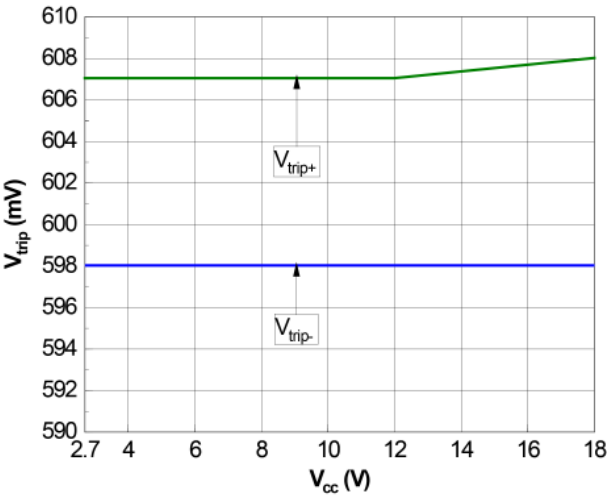


Figure 20. Comparator trip points vs. temperature

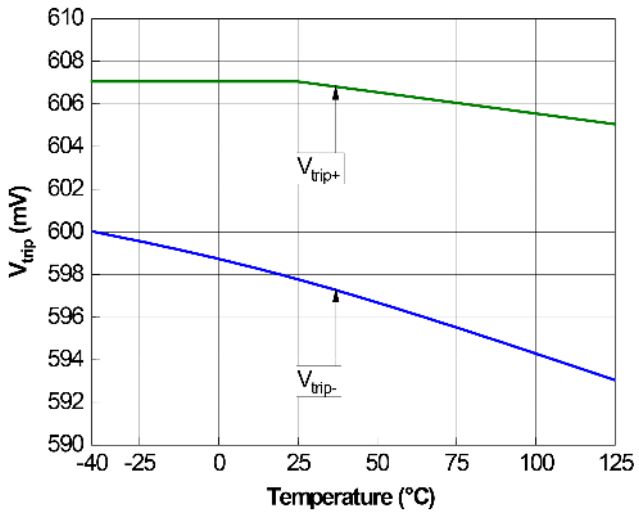



Figure 21. Comparator reset voltage vs. $V_{CC}$

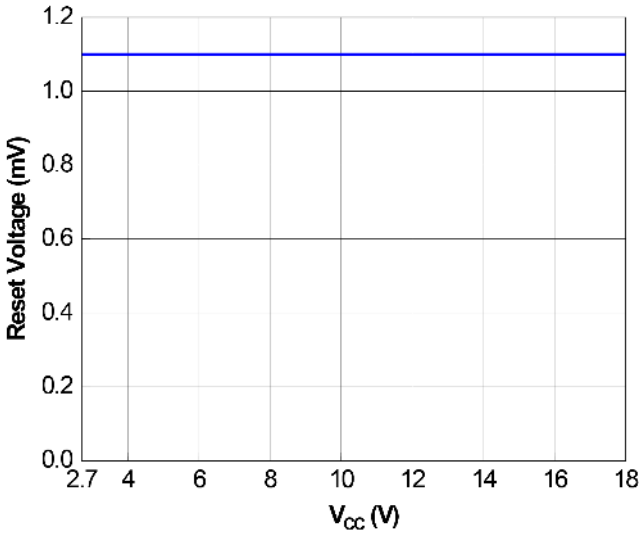



Figure 22. Comparator propagation delay vs. overdrive voltage

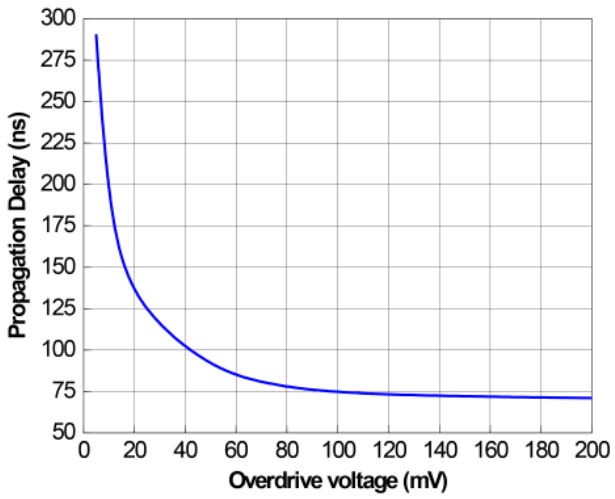



Figure 23. Comparator propagation delay vs. temperature

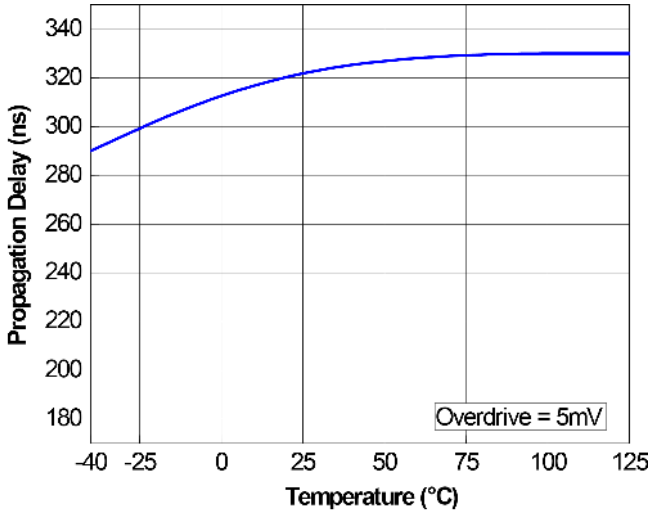
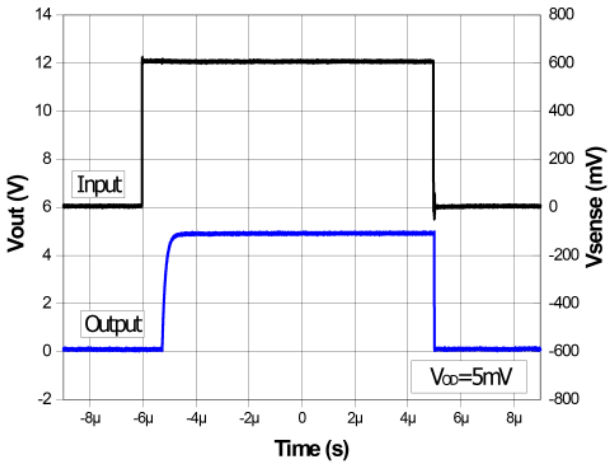



Figure 24. Comparator propagation delay



# 5 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.

## 5.1 SO8 package information

**Figure 25. SO8 package outline**

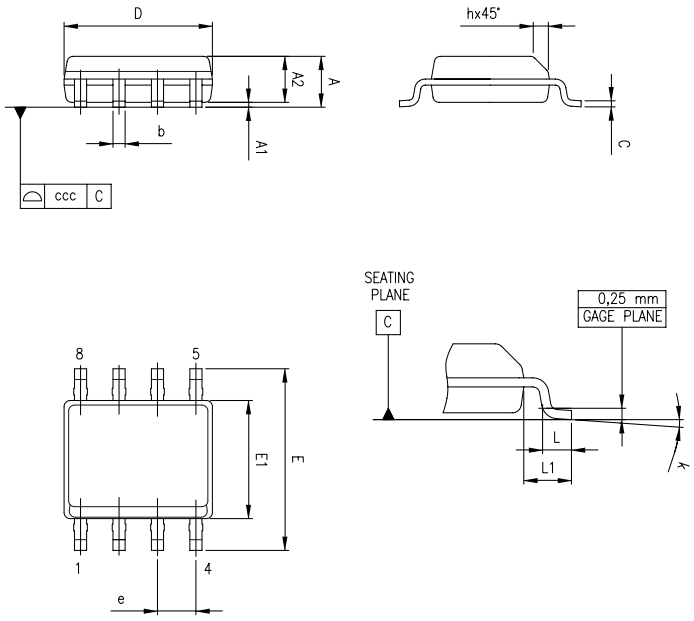



**Table 6. SO8 package mechanical data**

| Ref. | Dimensions | | | | | |
|---|---|---|---|---|---|---|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | | | 1.75 | | | 0.069 |
| A1 | 0.10 | | 0.25 | 0.04 | | 0.010 |
| A2 | 1.25 | | | 0.049 | | |
| b | 0.28 | 0.40 | 0.48 | 0.011 | 0.016 | 0.019 |
| c | 0.17 | | 0.23 | 0.007 | | 0.010 |
| D | 4.80 | 4.90 | 5.00 | 0.189 | 0.193 | 0.197 |
| E | 5.80 | 6.00 | 6.20 | 0.228 | 0.236 | 0.244 |
| E1 | 3.80 | 3.90 | 4.00 | 0.150 | 0.154 | 0.157 |
| e | | 1.27 | | | 0.050 | |
| h | 0.25 | | 0.50 | 0.010 | | 0.020 |
| L | 0.40 | 0.635 | 1.27 | 0.016 | | 0.050 |
| L1 | | 1.04 | | | 0.040 | |
| k | 1° | | 8° | 1° | | 8° |
| ccc | | | 0.10 | | | 0.004 |

## 5.2 MiniSO8 package information

Figure 26. **MiniSO8 package outline**

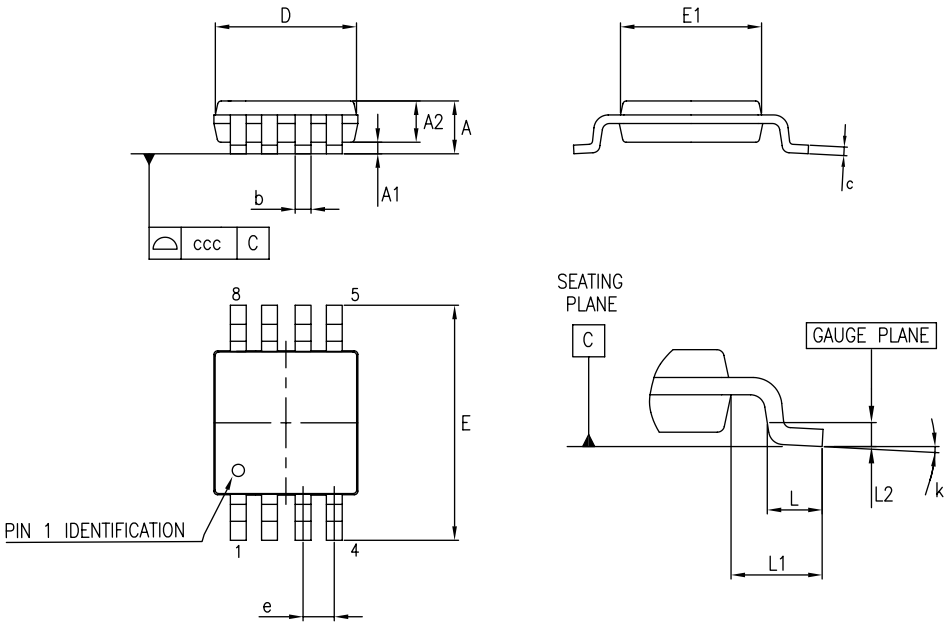



Table 7. **MiniSO8 mechanical data**

| Dim. | Millimeters | | | Inches | | |
|---|---|---|---|---|---|---|
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | | | 1.1 | | | 0.043 |
| A1 | 0 | | 0.15 | 0 | | 0.006 |
| A2 | 0.75 | 0.85 | 0.95 | 0.03 | 0.033 | 0.037 |
| b | 0.22 | | 0.4 | 0.009 | | 0.016 |
| c | 0.08 | | 0.23 | 0.003 | | 0.009 |
| D | 2.8 | 3 | 3.2 | 0.11 | 0.118 | 0.126 |
| E | 4.65 | 4.9 | 5.15 | 0.183 | 0.193 | 0.203 |
| E1 | 2.8 | 3 | 3.1 | 0.11 | 0.118 | 0.122 |
| e | | 0.65 | | | 0.026 | |
| L | 0.4 | 0.6 | 0.8 | 0.016 | 0.024 | 0.031 |
| L1 | | 0.95 | | | 0.037 | |
| L2 | | 0.25 | | | 0.01 | |
| k | 0° | | 8° | 0° | | 8° |
| ccc | | | 0.1 | | | 0.004 |

# 6 Ordering information

Table 8. **Ordering information**

| Order code | Gain (V/V) | Package | Packing | Marking |
|---|---|---|---|---|
| TSC200IDT | 20 | SO8 | Tape and reel | TSC200I |
| TSC200IST | 20 | MiniSO8 | | O123 |

## Revision history

Table 9. **Document revision history**

| Date | Version | Changes |
|---|---|---|
| 24-Jan-2022 | 1 | First release. |

# Contents

# List of tables

# List of figures