

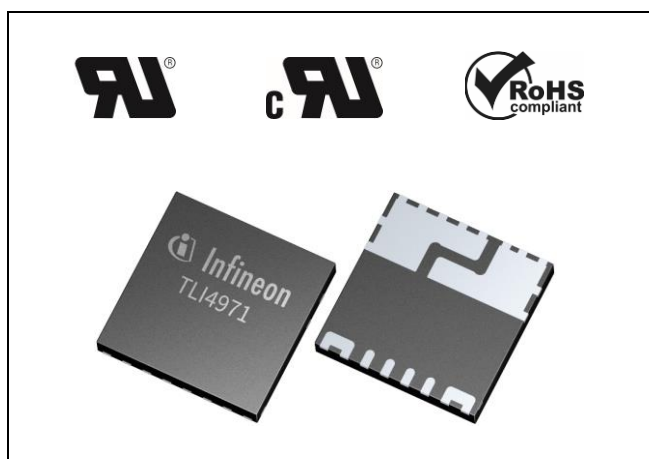


**THE DATASHEET OF  
TLI4971A120T5UE0001XUMA1**



## Features & Benefits

- Integrated current rail with typical  $220\mu\Omega$  insertion resistance enables ultra-low power loss
- Less than 1nH parasitic inductance of integrated current rail enables wide bandgap design
- Bandwidth of 240kHz enables wide range of applications
- 8x8mm form factor
- Very low sensitivity error over temperature
- Galvanic functional isolation up to 1150V
- $V_{ISO}$  3500V RMS agency type-tested for 60 seconds per UL1577
- Differential sensing principle
- Two independent ultrafast Over Current Detection outputs



Coreless current sensor in PG-TISON-8 package

## Description

TLI4971 is a high precision miniature coreless magnetic current sensor for AC and DC measurements with analog interface and two fast over-current detection outputs.

Infineon's well-established and robust monolithic Hall technology enables accurate and highly linear measurement of currents with a full scale up to  $\pm 120A$ . All negative effects (saturation, hysteresis) commonly known from open loop sensors using flux concentration techniques are avoided. The sensor is equipped with internal self-diagnostic feature.

Typical applications are electrical drives and general purpose inverters.

The differential measurement principle allows great stray field suppression for operation in harsh environments.

Two separate interface pins (OCD) provide a fast output signal in case a current exceeds a pre-set threshold.

The sensor is shipped as a fully calibrated product without requiring any customer end-of-line calibration.

All user-programmable parameters such as OCD thresholds, blanking times and output configuration modes are stored in an embedded EEPROM memory.

## Order Information

| Product Name           | Product Type  | Marking   | Ordering Code | Package    |
|------------------------|---|-----------|---------------|------------|
| TLI4971-A120T5-U-E0001 | 120A measurement range, UL certified device <sup>1)2)</sup> | H71I1A1UH | SP005272936   | PG-TISON-8 |
| TLI4971-A120T5-E0001   | 120A measurement range <sup>1)2)</sup>                      | H71I1A1_H | SP005344532   | PG-TISON-8 |
| TLI4971-A075T5-U-E0001 | 75A measurement range, UL certified device <sup>1)2)</sup>  | H71I3A1UH | SP005446655   | PG-TISON-8 |
| TLI4971-A075T5-E0001   | 75A measurement range <sup>1)2)</sup>                       | H71I3A1_H | SP005446653   | PG-TISON-8 |
| TLI4971-A050T5-U-E0001 | 50A measurement range, UL certified device <sup>1)2)</sup>  | H71I4A1UH | SP005446651   | PG-TISON-8 |
| TLI4971-A050T5-E0001   | 50A measurement range <sup>1)2)</sup>                       | H71I4A1_H | SP005446648   | PG-TISON-8 |
| TLI4971-A025T5-U-E0001 | 25A measurement range, UL certified device <sup>1)2)</sup>  | H71I6A1UH | SP005446646   | PG-TISON-8 |
| TLI4971-A025T5-E0001   | 25A measurement range <sup>1)2)</sup>                       | H71I6A1_H | SP005446644   | PG-TISON-8 |

1) Current sensor for industrial / consumer applications, qualified according to AEC Q100 grade 2

2) Semi-differential mode, non-ratiometric output sensitivity

## Pin Configuration

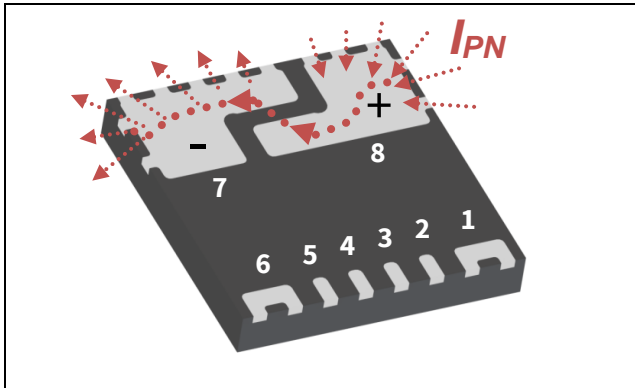


Figure 1 Pin layout PG-TISON-8-5

The current  $I_{PN}$  is measured as a positive value when it flows from pin 8 (+) to pin 7 (-) through the integrated current rail.

### Pin configuration

| Pin No. | Symbol | Function  |
|---------|--------|---|
| 1       | VDD    | Supply voltage                                      |
| 2       | GND    | Ground  |
| 3       | VREF   | Reference voltage input or output                   |
| 4       | AOUT   | Analog signal output                                |
| 5       | OCD1   | Over-current detection output 1 (open drain output) |
| 6       | OCD2   | Over-current detection output 2 (open drain output) |
| 7       | IP-    | Negative current terminal pin (current-out)         |
| 8       | IP+    | Positive current terminal pin (current-in)          |

## Target Applications

The TLI4971 is suitable for AC as well as DC current measurement applications:

- Electrical drives
- General purpose inverters
- PV inverters
- Chargers
- Current monitoring
- Overload and over-current detection

Due to its implemented magnetic interference suppression, it is extremely robust when exposed to external magnetic fields. The device is suitable for fast over-current detection with a configurable threshold level. This allows the control unit to switch off and protect the affected system from damage, independently from the main measurement path.

## General Description

The current flowing through the current rail on the primary side induces a magnetic field that is differentially measured by two Hall probes. The differential measurement principle of the magnetic field combined with the current rail design provides superior suppression of any ambient magnetic stray fields. A high performance amplifier combines the signal resulting from the differential field and the internal compensation information provided by the temperature and stress compensation unit. Finally the amplifier output signal is fed into a differential output amplifier which is able to drive the analog output of the sensor.

Depending on the selected programming option, the analog output signal can be provided either as:

- Single-ended
- Fully-differential
- Semi-differential

In single-ended mode, the pin VREF is used as a reference voltage input. The analog output signal is provided on pin AOUT. In fully-differential mode, both AOUT (positive polarity) and VREF (negative polarity) are used as signal outputs whereas VDD is used as reference voltage input. Compared to the single-ended mode, the fully-differential mode enables doubling of the output voltage swing.

In semi-differential mode a chip-internal reference voltage is used and provided on VREF (output). The current sensing information is provided in a single-ended way on AOUT.

For fast over-current detection, the raw analog signal provided by the Hall probes is fed into comparators with programmable switching thresholds.

A user-programmable deglitch filter is implemented to enable the suppression of fast switching transients. The open-drain outputs of the OCD pins are active “low” and they can be directly combined into a wired-AND configuration on board level to have a general over-current detection signal.

All user-programmable parameters such as OCD thresholds, deglitching filter settings and output configuration mode are stored in an embedded EEPROM memory.

Programming of the memory can be performed in the application through a Serial Inspection and Configuration Interface (SICI). The interface is described in detail in the programming guide which can be found on the Infineon website. Please contact your local Infineon sales office for further documentation.

## Standard Product Configuration

- The pre-configured full scale range is either set to  $\pm 120\text{A}$ ,  $\pm 75\text{A}$ ,  $\pm 50\text{A}$  or  $\pm 25\text{A}$  depending on the chosen product variant.
- The pre-configured output mode is set to semi-differential mode.
- The quiescent voltage is set to 1.65V.
- The OCD threshold of channel 1 is set to the factor 1.25 of the full scale range.
- The OCD threshold of channel 2 is set to the factor 0.82 of the full scale range.
- The pre-defined setting of the OCD deglitching filter time is set to 0 $\mu\text{s}$ .
- The sensor is pre-configured to work in the non-ratiometric mode.
- The sensitivity and the derived measurement range (full scale) can be reprogrammed by user according to the sensitivity ranges listed in Table 4.
- The sensor can be reprogrammed into single-ended operating mode or fully-differential mode by user without any recalibration of the device.
- The OCD thresholds and filter settings can be reprogrammed by the user according to the values listed in Table 6 and Table 7.
- For semi-differential uni-directional mode or ratiometric output sensitivity, please contact your local Infineon sales office.

## Block Diagram

The current flowing through the current rail on the primary side induces a magnetic field, which is measured by two Hall probes differentially. The differential measurement principle provides superior suppression of any ambient magnetic stray fields. A high performance amplifier combines the signal resulting from the differential field and the compensation information, provided by the temperature and stress compensation unit. Finally the amplifier output signal is fed into a differential output amplifier, which is able to drive the analog output of the sensor.

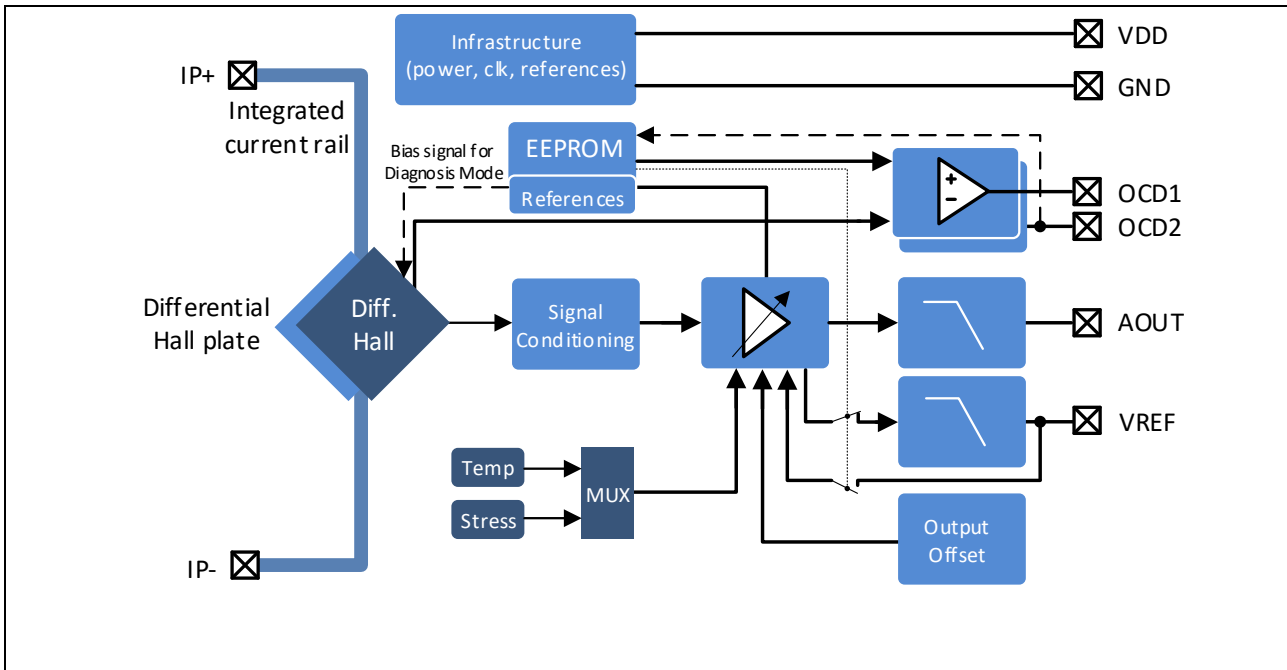


Figure 2 Block Diagram

## Absolute Maximum Ratings

Table 1 Absolute Maximum Ratings

General conditions (unless otherwise specified):  $V_{DD} = 3.3V$ ;  $T_S = -40^{\circ}C \dots +105^{\circ}C$

| Parameter                                      | Symbol         | Min  | Typ | Max            | Unit        | Note / Test Condition  |
|--|----------------|------|-----|----------------|-------------|--|
| Supply voltage                                 | $V_{DD}$       | -0.3 | 3.3 | 3.6            | V           |  |
| Primary nominal rated current LF <sup>1)</sup> | $I_{PNRLF}$    | -70  | -   | 70             | A           | Peak, frequency < 10Hz   |
| Primary nominal rated current HF <sup>1)</sup> | $I_{PNRHF}$    | -70  | -   | 70             | A           | RMS, frequency $\geq$ 10Hz   |
| Primary current                                | $I_{PNS}$      | -250 | -   | 250            | A           | Single peak for 10 $\mu$ s, 10 assertions per lifetime                         |
| Voltage on interface pins VREF, OCD1, AOUT     | $V_{IO}$       | -0.3 | -   | $V_{DD} + 0.3$ | V           |  |
| Voltage on Interface pin OCD2                  | $V_{IO\_OCD2}$ | -0.3 | -   | 21             | V           |  |
| ESD voltage <sup>2)</sup>                      | $V_{ESD\_HBM}$ | -2   | -   | 2              | kV          |  |
| ESD voltage <sup>3)</sup>                      | $V_{ESD\_SYS}$ | -16  | -   | 16             | kV          | In the application circuit   |
| Voltage slew-rate on current rail              | $\Delta V/dt$  | -    | -   | 10             | V/ns        | Full voltage range   |
| Maximum junction temperature                   | $T_{J\_max}$   | -    | -   | 130            | $^{\circ}C$ |  |
| Storage temperature                            | $T_{A\_STORE}$ | -40  | -   | 130            | $^{\circ}C$ |  |
| Life time                                      | $LT$           | 15   | -   | -              | Years       | Considering continuous operation with $T_S = 70^{\circ}C$ and $I = 30 A_{RMS}$ |

1) Tested with primary nominal rated current of 70A peak on Infineon reference PCB at Low Frequency (LF). Thermal equilibrium reached after 2 min.

2) Human Body Model (HBM), according to standard AEC-Q 100-002

3) According to standard IEC 61000-4-2 electrostatic discharge immunity test

Stress above the limit values listed here may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. Maximum ratings are absolute ratings. Exceeding only one of these values may cause irreversible damage to the integrated circuit.

## Product Characteristics

Table 2 Operating Ranges

General conditions (unless otherwise specified):  $V_{DD} = 3.3V$ ;  $T_S = -40^{\circ}C \dots +105^{\circ}C$

| Parameter                              | Symbol         | Min. | Typ. | Max. | Unit        | Note / Test Condition   |
|--|----------------|------|------|------|-------------|---|
| Supply voltage                         | $V_{DD}$       | 3.1  | 3.3  | 3.5  | V           |   |
| Ambient temperature at soldering point | $T_S$          | -40  | -    | 105  | $^{\circ}C$ | Measured at soldering point   |
| Capacitance on analog output pin       | $C_O$          | 4.7  | 6.8  | 8    | nF          | W/o decoupling resistor, including parasitic cap on the board                               |
| Capacitor on VDD                       | $C_{VDD}$      | -    | 220  | -    | nF          |   |
| Reference input voltage                | $V_{REF}$      | -    | 1.65 | -    | V           | Default value is semi-differential mode. Other values available by EEPROM: 1.2V, 1.5V, 1.8V |
| Reference input voltage variation      | $V_{REF\_var}$ | -10  | -    | 10   | %           |   |
| EEPROM programming voltage             | $V_{IO\_PRG}$  | 20.5 | -    | 21.0 | V           |   |

Table 3 Operating Parameters

General conditions (unless otherwise specified):  $V_{DD} = 3.3V$ ;  $T_S = -40^{\circ}C \dots +105^{\circ}C$

| Parameter                              | Symbol         | Min. | Typ. | Max.           | Unit        | Note / Test Condition   |
|--|----------------|------|------|----------------|-------------|---|
| Current consumption                    | $I_{DD}$       | -    | 18   | 25             | mA          | $I(AOUT) = 0mA$   |
| Primary path resistance                | $R_{PN}$       | -    | 220  | -              | $\mu\Omega$ | $25^{\circ}C$ , when soldered on PCB with $140\mu m$ copper thickness   |
| Power-on delay time                    | $t_{POR}$      | -    | 1.0  | 1.5            | ms          | From $V_{DD}$ rising above $V_{DD(min)}$ to full operation. 0A primary input current.                         |
| Voltage on interface pin OCD1          | $V_{IO\_OCD1}$ | -0.3 | -    | 3.5            | V           |   |
| Voltage on interface pin OCD2          | $V_{IO\_OCD2}$ | -0.3 | -    | 3.5            | V           | In functional mode  |
| Voltage on analog output AOUT          | $V_{AOUT}$     | -0.3 | -    | $V_{DD} + 0.3$ | V           |   |
| Undervoltage/overvoltage lockout delay | $t_{UVLOe}$    | 1    | 2.4  | 3              | $\mu s$     | Enabled to disabled   |
| Thermal resistance <sup>1)</sup>       | $R_{THJS}$     | -    | 0.25 | -              | K/W         | Current rail to soldering point, on Infineon reference PCB (see related application note AppNote TLI4971 PCB) |

1) Not subject to production test. Verified by design and characterization.

## Functional Output Description

The analog output signal depends on the selected output mode:

- Single-ended
- Fully-differential
- Semi-differential

### Single-Ended Output Mode

In single-ended mode VREF is used as an input pin to provide the analog reference voltage,  $V_{REF}$ . The voltage on AOUT,  $V_{AOUT}$ , is proportional to the measured current  $I_{PN}$  at the current rail:

$$V_{AOUT}(I_{PN}) = V_{OQ} + S \cdot I_{PN}$$

The quiescent voltage  $V_{OQ}$  is the value of  $V_{AOUT}$  when  $I_{PN}=0$ .  $V_{OQ}$  tracks the voltage on VREF

$$V_{OQ}(V_{REF}) = V_{REF}$$

The reference voltage can be set to different values which allow either bidirectional or unidirectional current sensing. The possible values of  $V_{REFNOM}$  are indicated in Table 2.

The sensitivity is by default non ratiometric to  $V_{REF}$ . If ratiometricity is activated the sensitivity becomes as follows:

$$S(V_{REF}) = S(V_{REFNOM}) \cdot \frac{V_{REF}}{V_{REFNOM}}$$

### Fully-Differential Output Mode

In fully-differential output mode, both VREF and AOUT are analog outputs to achieve double voltage swing: AOUT is the non-inverting output, while VREF is the inverting output:

$$\begin{aligned} V_{AOUT}(I_{PN}) &= V_{QAOUT} + S \cdot I_{PN} \\ V_{REF}(I_{PN}) &= V_{QREF} - S \cdot I_{PN} \end{aligned}$$

The quiescent voltage is derived from the supply pins VDD and GND and has the same value on both AOUT and VREF:

$$V_{QAOUT}(V_{DD}) = V_{QREF}(V_{DD}) = \frac{V_{DD}}{2}$$

The sensitivity in the fully-differential mode can be generally expressed as:

$$S(V_{DD})_{diff} = S(3.3V)_{diff} \cdot \frac{V_{DD}}{3.3V}$$

In this mode, the quiescent voltages and the sensitivity are both ratiometric with respect to  $V_{DD}$  if ratiometricity is enabled.

### Semi-Differential Output Mode

In semi-differential output mode, the sensor is using a chip-internal reference voltage to generate the quiescent voltage that is available on pin VREF (used as output).

The analog measurement result is available as single-ended output signal on AOUT. The dependence of sensitivity and output offset on reference voltage is the same as described in single-ended output mode.

The quiescent voltage is programmable at 3 different values,  $V_{OQbid\_1}$  and  $V_{OQbid\_2}$  for bidirectional current and  $V_{OQuni}$  for unidirectional current (see Table 4).

### Total error distribution

Figure 3 shows the total output error at 0h ( $E_{TOTt}$ ) and over lifetime ( $E_{TOTL}$ ) over the full scale range for sensitivity range S1 (10mV/A).

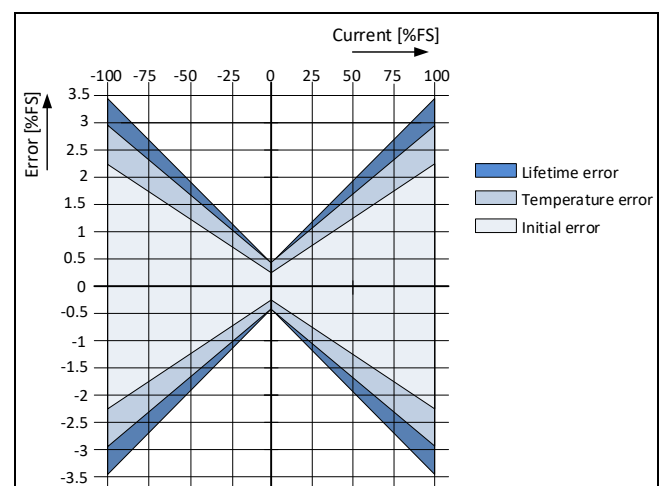


Figure 3 Distribution of max. total error in S1 range

Table 4 Analog Output Characteristics

General conditions (unless otherwise specified):  $V_{DD} = 3.3V$ ;  $T_S = -40^{\circ}C \dots +105^{\circ}C$

| Parameter   | Symbol            | Min | Typ          | Max | Unit              | Note / Test conditions  |
|---|-------------------|-----|--------------|-----|-------------------|---|
| Quiescent output voltage (bidirectional option 1) <sup>1)2)</sup> | $V_{OQbid\_1}$    | -   | $V_{DD}/2$   | -   | V                 | $I_{PN} = 0A$ ; fully-differential or semi-differential (bidirectional) modes, standard setting               |
| Quiescent output voltage (bidirectional option 2) <sup>2)</sup>   | $V_{OQbid\_2}$    | -   | 1.5          | -   | V                 | $I_{PN} = 0A$ ; semi-differential (bidirectional) mode; for this option the ratiometricity offset is disabled |
| Quiescent output voltage (unidirectional mode) <sup>2)</sup>      | $V_{OQuni}$       | -   | $V_{DD}/5.5$ | -   | V                 | $I_{PN} = 0A$ ; semi-differential (unidirectional) mode   |
| Sensitivity, range1 <sup>1)2)3)</sup>                             | S1                | -   | 10           | -   | mV/A              | $\pm 120A$ FS (Full Scale)  |
| Sensitivity, range2 <sup>2)3)</sup>                               | S2                | -   | 12           | -   | mV/A              | $\pm 100A$ FS   |
| Sensitivity, range3 <sup>2)3)</sup>                               | S3                | -   | 16           | -   | mV/A              | $\pm 75A$ FS  |
| Sensitivity, range4 <sup>2)3)</sup>                               | S4                | -   | 24           | -   | mV/A              | $\pm 50A$ FS  |
| Sensitivity, range5 <sup>2)3)</sup>                               | S5                | -   | 32           | -   | mV/A              | $\pm 37.5A$ FS  |
| Sensitivity, range6 <sup>2)3)</sup>                               | S6                | -   | 48           | -   | mV/A              | $\pm 25A$ FS  |
| Sensitivity ratiometry factor                                     | $K_S$             | -   | 1            | -   | -                 |   |
| Quiescent ratiometry factor                                       | $K_{OQ}$          | -   | 1            | -   | -                 |   |
| Analog output drive capability                                    | $I_O$             | -2  | -            | 2   | mA                | DC current  |
| Analog output saturation voltage                                  | $V_{SAT}$         | -   | 150          | 300 | mV                | $V_{DD} - V_{AOUT}$ ;<br>Output current = 2mA   |
| Transfer function cutoff frequency                                | $BW$              | 120 | 240          | -   | kHz               | -3dB criterion, $C_O = 6.8nF$   |
| Output phase delay <sup>4)</sup>                                  | $\varphi_{delay}$ | -   | -            | 48  | °                 | $f_{signal} = 120kHz$   |
| Output Noise density <sup>5)6)</sup>                              | $I_{NOISE}$       | -   | 350          | -   | $\mu A/\sqrt{Hz}$ | Referenced to Input current, typical value is at 25°C. Higher noise is present at higher temperatures.        |
| External Homogenous magnetic field suppression <sup>4)</sup>      | $B_{SR}$          | 34  | 40           | -   | dB                | Frequency up to 150kHz. Up to 20mT homogeneous field applied  |

1) Pre-configured setting, for other pre-configured versions please contact your local sales.

2) Can be programmed by the user (valid only for 120A version).

3) Values refer to semi-differential mode or single-ended mode, with  $V_{REF} = 1.65 V$ .

In fully-differential mode the sensitivity value is doubled.

4) Not subject to production test. Verified by design and characterization.

5) Typical value in fully-differential mode, sensitivity range S6

6)  $Noise\ Density = \frac{Output\ Noise\ [V_{RMS}]}{\sqrt{\frac{\pi}{2} * BW[Hz]}} * \frac{1}{Sensitivity\ [\frac{V}{A}]}$

**Table 4 Analog Output Characteristics (cont'd)**

General conditions (unless otherwise specified):  $V_{DD} = 3.3V$ ;  $T_S = -40^{\circ}C \dots +105^{\circ}C$

| Parameter  | Symbol        | Min   | Typ | Max  | Unit | Note / Test conditions   |
|--|---------------|-------|-----|------|------|--|
| Sensitivity error (all ranges)   | $E_{SENS}$    | -1.4  | -   | 1.4  | %    | $T_S = 25^{\circ}C, 0h, \pm 3\sigma$   |
| Sensitivity error (all ranges) over temperature                            | $E_{SENST}$   | -2.1  | -   | 2.1  | %    | $T_S = -40^{\circ}C \text{ to } 25^{\circ}C, 0h, \pm 3\sigma$                            |
|  |               | -1.5  | -   | 1.5  | %    | $T_S = 25^{\circ}C \text{ to } 105^{\circ}C, 0h, \pm 3\sigma$                            |
| Sensitivity error (all ranges) over temperature and lifetime <sup>4)</sup> | $E_{SENSL}$   | -3    | -   | 3    | %    |  |
| Output offset (all ranges)   | $E_{OFF}$     | -200  | -   | 200  | mA   | $T_S = 25^{\circ}C, 0h, \pm 3\sigma$   |
| Output offset (all ranges) over temperature                                | $E_{OFFT}$    | -200  | -   | 200  | mA   | $T_S = -40^{\circ}C \text{ to } 25^{\circ}C, 0h, \pm 3\sigma$                            |
|  |               | -250  | -   | 250  | mA   | $T_S = 25^{\circ}C \text{ to } 105^{\circ}C, 0h, \pm 3\sigma$                            |
| Output offset (all ranges) over temperature and lifetime <sup>4)</sup>     | $E_{OFF\_L}$  | -500  | -   | 500  | mA   |  |
| Total error (S1)   | $E_{TOT\_S1}$ | -1.6  | -   | 1.6  | %    | $T_S = 25^{\circ}C, 0h, \pm 3\sigma$ , includes linearity error                          |
| Total error (S1) over temperature  | $E_{TOT\_S1}$ | -2.3  | -   | 2.3  | %    | $T_S = -40^{\circ}C \text{ to } 25^{\circ}C, 0h, \pm 3\sigma$ , includes linearity error |
|  |               | -1.7  | -   | 1.7  | %    | $T_S = 25^{\circ}C \text{ to } 105^{\circ}C, 0h, \pm 3\sigma$ , includes linearity error |
| Total error (S6)   | $E_{TOT\_S6}$ | -1.7  | -   | 1.7  | %    | $T_S = 25^{\circ}C, 0h, \pm 3\sigma$ , includes linearity error                          |
| Total error (S6) over temperature  | $E_{TOT\_S6}$ | -2.3  | -   | 2.3  | %    | $T_S = -40^{\circ}C \text{ to } 25^{\circ}C, 0h, \pm 3\sigma$ , includes linearity error |
|  |               | -2.0  | -   | 2.0  | %    | $T_S = 25^{\circ}C \text{ to } 105^{\circ}C, 0h, \pm 3\sigma$ , includes linearity error |
| Total error over temperature and lifetime <sup>4)</sup>                    | $E_{TOTL}$    | -3.45 | -   | 3.45 | %    | Percentage of FS, sensitivity S1; includes sensitivity, offset and linearity error       |

4) Not subject to production test. Verified by design and characterization.

## Fast Over-Current Detection (OCD)

The Over-Current Detection (OCD) function allows fast detection of over-current events. The raw analog output of the Hall probes is fed directly into comparators with programmable switching thresholds. A user programmable deglitch filter is implemented to enable the suppression of fast switching transients. The two different open-drain OCD pins are active low and can be directly combined into a wired-AND configuration on board level to have a general over-current detection signal. TLI4971 supports two independent programmable OCD outputs, suited for different application needs.

The OCD pins are providing a very fast response, thanks to independence from the main signal path. They can be used as a trap functionality to quickly shut down the current source as well as for precise detection of soft overload conditions.

### OCD pins external connection

The OCD pins can be connected to a logic input pin of the microcontroller and/or the gate-driver to quickly react to over-current events. They are designed as open-drain outputs to easily setup a wired-AND configuration and allow monitoring of several current sensors outputs via only one microcontroller pin.

### OCD thresholds

The symmetric threshold level of the OCD outputs is adjustable and triggers an over-current event in case of a positive or negative over-current. The possible threshold levels are listed in Table 6 and Table 7. The instruction for the settings is documented in the TLI4971 programming guide.

### OCD outputs timing behavior

Both output pins feature a deglitch filter to avoid false triggers by noise spikes on the current rail. Deglitch filter settings can be programmed according to application needs. Available options are listed in Table 6 and Table 7.

Figure 4 shows the OCD output pin typical behavior during an over-current event.

Over-current Pulse 1: duration exceeds the over-current response time  $t_{D\_OCDx}$  + response time jitter  $\Delta t_{D\_OCDx}$  + deglitch filter time  $t_{deglitch}$ . The OCD output voltage is set low until the current value drops below the OCD threshold.

Over-current Pulse 2: duration does not exceed the over-current response time  $t_{D\_OCDx}$  and therefore no OCD event is generated.

Over-current Pulse 3: duration exceeds the response time  $t_{D\_OCDx}$  + response time jitter  $\Delta t_{D\_OCDx}$ , but does not exceed the glitch filter time  $t_{deglitch}$  and no OCD event is generated.

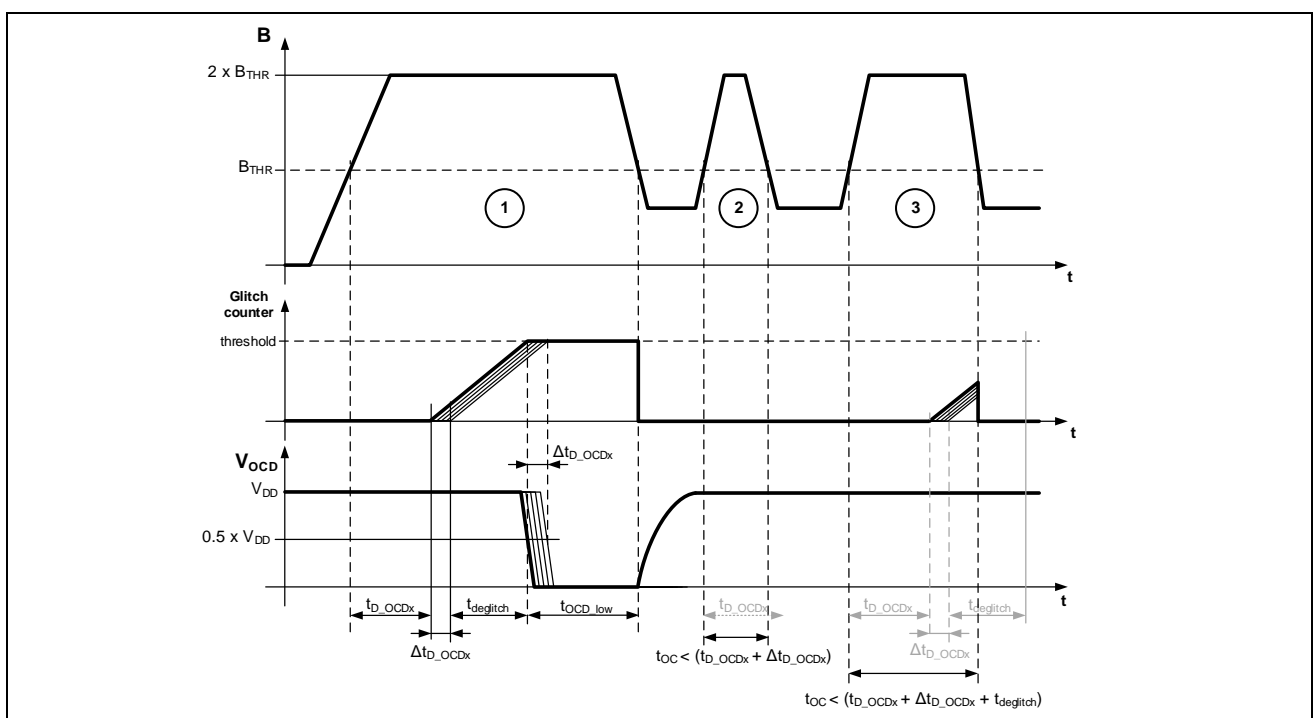


Figure 4 Fast over-current detection output timing

## Fast Over-Current Detection (OCD) Output Parameters

Table 5 Common OCD Parameters

General conditions (unless otherwise specified):  $V_{DD} = 3.3V$ ;  $T_S = -40^{\circ}C \dots +105^{\circ}C$ ,  $C_L = 1nF$ ,  $R_{PU} = 4.7k\Omega$

| Parameter                               | Symbol              | Min | Typ | Max  | Unit       | Note / Test Conditions  |
|---|---------------------|-----|-----|------|------------|---|
| Threshold level tolerance <sup>1)</sup> | $I_{THT}$           | -10 | -   | 10   | %          |   |
| Response time jitter <sup>1)</sup>      | $\Delta t_{D\_OCD}$ | -   | -   | 0.25 | $\mu s$    | At $3\sigma$ , $I_{rail} = 2 \times I_{THR.x}$ , input rise time $0.1\mu s$ |
| Deglintch filter basic time             | $t_{OCDgl}$         | 400 | 500 | 600  | ns         |   |
| Detection minimum time                  | $t_{OCD\_low}$      | 3   | -   | -    | $\mu s$    | Valid for both OCDs   |
| Load capacitance                        | $C_L$               | -   | -   | 1    | nF         |   |
| Open-drain current                      | $I_{OD\_ON}$        | -   | -   | 1    | mA         | DC current  |
| Pull-up resistor                        | $R_{PU}$            | 1   | 4.7 | 10   | k $\Omega$ | To $V_{DD}$   |

1) Not subject to production test. Verified by design and characterization.

Table 6 OCD1 Parameters

| Parameter                                  | Symbol           | Min | Typ  | Max | Unit             | Note / Test Conditions  |
|--|------------------|-----|------|-----|------------------|---|
| Threshold level - Level1 <sup>1)2)3)</sup> | $I_{THR1.1}$     | -   | 1.25 | -   | $\times I_{FSR}$ | Factor with respect to $I_{FS}$ ( $I_{FS}$ = current full scale according to programming i.e. 120A) |
| Threshold level - Level2 <sup>1)2)</sup>   | $I_{THR1.2}$     | -   | 1.39 | -   | $\times I_{FSR}$ | Factor with respect to $I_{FS}$   |
| Threshold level - Level3 <sup>1)2)</sup>   | $I_{THR1.3}$     | -   | 1.54 | -   | $\times I_{FSR}$ | Factor with respect to $I_{FS}$   |
| Threshold level - Level4 <sup>1)2)</sup>   | $I_{THR1.4}$     | -   | 1.68 | -   | $\times I_{FSR}$ | Factor with respect to $I_{FS}$   |
| Threshold level - Level5 <sup>1)2)</sup>   | $I_{THR1.5}$     | -   | 1.82 | -   | $\times I_{FSR}$ | Factor with respect to $I_{FS}$   |
| Threshold level - Level6 <sup>1)2)</sup>   | $I_{THR1.6}$     | -   | 1.96 | -   | $\times I_{FSR}$ | Factor with respect to $I_{FS}$   |
| Threshold level - Level7 <sup>1)2)</sup>   | $I_{THR1.7}$     | -   | 2.11 | -   | $\times I_{FSR}$ | Factor with respect to $I_{FS}$   |
| Threshold level - Level8 <sup>1)2)</sup>   | $I_{THR1.8}$     | -   | 2.25 | -   | $\times I_{FSR}$ | Factor with respect to $I_{FS}$   |
| Response time <sup>4)</sup>                | $t_{D\_OCD1}$    | -   | 0.7  | 1   | $\mu s$          | $I_{PN} = 2 \times I_{THR1.x}$  |
| Fall time <sup>5)</sup>                    | $t_{f\_OCD1}$    | -   | 100  | 150 | ns               |   |
| Deglintch filter setting <sup>2)6)</sup>   | $OCD1_{gl\_mul}$ | 0   | -    | 7   | -                | $t_{deglitch} = OCD1_{gl\_mul} \times t_{OCDgl}$<br>pre-configured setting = 0                      |

1) Symmetric threshold level for positive and negative currents.

2) Can be programmed by user.

3) Pre-configured threshold level

4) Time between primary current exceeding current threshold and falling edge of OCD1-pin at 50%.

5) Not subject to production test. Verified by design and characterization.

6) The specified deglitching timing is valid when input current step overtakes the threshold of at least 10%.

Table 7 OCD2 Parameters

| Parameter                                  | Symbol           | Min | Typ  | Max | Unit             | Note / Test Conditions   |
|--|------------------|-----|------|-----|------------------|--|
| Threshold level - level1 <sup>1)2)</sup>   | $I_{THR2.1}$     | -   | 0.5  | -   | $\times I_{FSR}$ | Factor with respect to $I_{FS}$<br>( $I_{FS}$ = current full scale according to programming i.e. 120A) |
| Threshold level - level2 <sup>1)2)</sup>   | $I_{THR2.2}$     | -   | 0.61 | -   | $\times I_{FSR}$ | Factor with respect to $I_{FS}$  |
| Threshold level - level3 <sup>1)2)</sup>   | $I_{THR2.3}$     | -   | 0.71 | -   | $\times I_{FSR}$ | Factor with respect to $I_{FS}$  |
| Threshold level - level4 <sup>1)2)3)</sup> | $I_{THR2.4}$     | -   | 0.82 | -   | $\times I_{FSR}$ | Factor with respect to $I_{FS}$  |
| Threshold level - level5 <sup>1)2)</sup>   | $I_{THR2.5}$     | -   | 0.93 | -   | $\times I_{FSR}$ | Factor with respect to $I_{FS}$  |
| Threshold level - level6 <sup>1)2)</sup>   | $I_{THR2.6}$     | -   | 1.04 | -   | $\times I_{FSR}$ | Factor with respect to $I_{FS}$  |
| Threshold level - level7 <sup>1)2)</sup>   | $I_{THR2.7}$     | -   | 1.14 | -   | $\times I_{FSR}$ | Factor with respect to $I_{FS}$  |
| Threshold level - level8 <sup>1)2)</sup>   | $I_{THR2.8}$     | -   | 1.25 | -   | $\times I_{FSR}$ | Factor with respect to $I_{FS}$  |
| Response time <sup>4)</sup>                | $t_{D\_OCD2}$    | -   | 0.7  | 1.2 | $\mu s$          | $I_{PN} = 2 \times I_{THR2.x}$   |
| Fall time <sup>5)</sup>                    | $t_{f\_OCD2}$    | -   | 200  | 300 | ns               |  |
| Deglintch filter setting <sup>2)6)</sup>   | $OCD2_{gl\_mul}$ | 0   | -    | 15  | -                | $t_{degitch} = OCD2_{gl\_mul} \times t_{OCDgl}$<br>pre-configured setting = 0                          |

1) Symmetric threshold level for positive and negative currents.

2) Can be programmed by user.

3) Pre-configured threshold level.

4) Time between primary current exceeding current threshold and falling edge of OCD2-pin at 50%.

5) Not subject to production test. Verified by design and characterization.

6) The specified deglitching timing is valid when input current step overtakes the threshold of at least 10%.

## Undervoltage / Overvoltage detection

TLI4971 is able to detect undervoltage or overvoltage condition of its own power supply ( $V_{DD}$ ). When an undervoltage ( $V_{DD} < U_{VLOH}$ ) or overvoltage ( $V_{DD} > O_{VLOH}$ ) condition is detected both OCD pins are pulled down in order to signal such a condition to the user.

The undervoltage detection on OCD pins is performed only if  $V_{DD} > V_{DD, OCD}$ .

Both OCD pins are pulled down at start up. When  $V_{DD}$  exceeds the undervoltage threshold  $U_{VLOH\_R}$  and the power on delay time  $t_{POR}$  has been reached, the sensor indicates the correct functionality and high accuracy by releasing the OCD pins.

Table 8 Undervoltage / Overvoltage parameters

General conditions (unless otherwise specified):  $V_{DD} = 3.3V$ ;  $T_S = -40^\circ C \dots +105^\circ C$

| Parameter                             | Symbol        | Min. | Typ. | Max. | Unit | Note / Test Condition   |
|---------------------------------------|---------------|------|------|------|------|---|
| Supply undervoltage lockout threshold | $U_{VLOH\_R}$ | -    | -    | 3    | V    | $V_{DD}$ at rising edge                                       |
| Supply undervoltage lockout threshold | $U_{VLOH\_F}$ | 2.5  | -    | -    | V    | $V_{DD}$ at falling edge                                      |
| Supply overvoltage lockout threshold  | $O_{VLOH}$    | 3.55 | -    | -    | V    | $V_{DD}$ at rising edge                                       |
| OCD undervoltage detection limit      | $V_{DD, OCD}$ | 1.8  | -    | -    | V    | For $V_{DD} < V_{DD, OCD}$ undervoltage may not be performed. |

## Isolation Characteristics

TLI4971 conforms functional isolation.

Table 9 Isolation Characteristics

| Parameter   | Symbol       | Min               | Typ | Max  | Unit       | Note / Test Conditions                                |
|---|--------------|-------------------|-----|------|------------|---|
| Maximum rated working voltage (sine wave) <sup>1)2)3)</sup>   | $V_{IOWM}$   | -                 | -   | 690  | V          | RMS, @ 4000m altitude                                 |
| Maximum rated working voltage (sine wave) <sup>1)2)3)</sup>   | $V_{IOWMP}$  | -                 | -   | 975  | V          | Peak, @ 4000m altitude                                |
| Maximum repetitive isolation voltage <sup>2)3)</sup>          | $V_{IORM}$   | -                 | -   | 1150 | V          | Max DC voltage, spike, @ 4000m altitude               |
| Apparent charge voltage capability (method B) <sup>2)3)</sup> | $V_{PDtest}$ | 1500              | -   | -    | V          | Partial discharge < 5pC peak @ 0m altitude            |
| Isolation test voltage <sup>3)4)</sup>                        | $V_{ISO}$    | 3500              | -   | -    | V          | RMS, 60s  |
| Isolation production test voltage                             | $V_{ISOP}$   | 3000              | -   | -    | V          | RMS, in production, 1.2s, UL certified version        |
|   | $V_{ISOP}$   | 2470              | -   | -    | V          | RMS, in production, 600ms, Non-UL certified version   |
| Isolation pulse test voltage <sup>3)</sup>                    | $V_{pulse}$  | 6500              | -   | -    | V          | Peak, rise time = 1.2 $\mu$ s, fall time = 50 $\mu$ s |
| Minimum external creepage distance                            | $CPG$        | 4                 | -   | -    | mm         |   |
| Minimum external clearance distance                           | $CLR$        | 4                 | -   | -    | mm         |   |
| Minimum comparative tracking index                            | $CTI$        | Material group II | -   | -    | -          |   |
| Isolation resistance <sup>3)</sup>                            | $R_{IO}$     | 10                | -   | -    | G $\Omega$ | $U_{IO} = 500V$ DC, 1min                              |

1) The given value is considered an example based on pollution degree 2.

2) After stress test according to qualification plan.

3) Not subject to production test. Verified by design and characterization.

4) Agency type tested for 60 seconds by UL according to UL 1577 standard.

### System integration

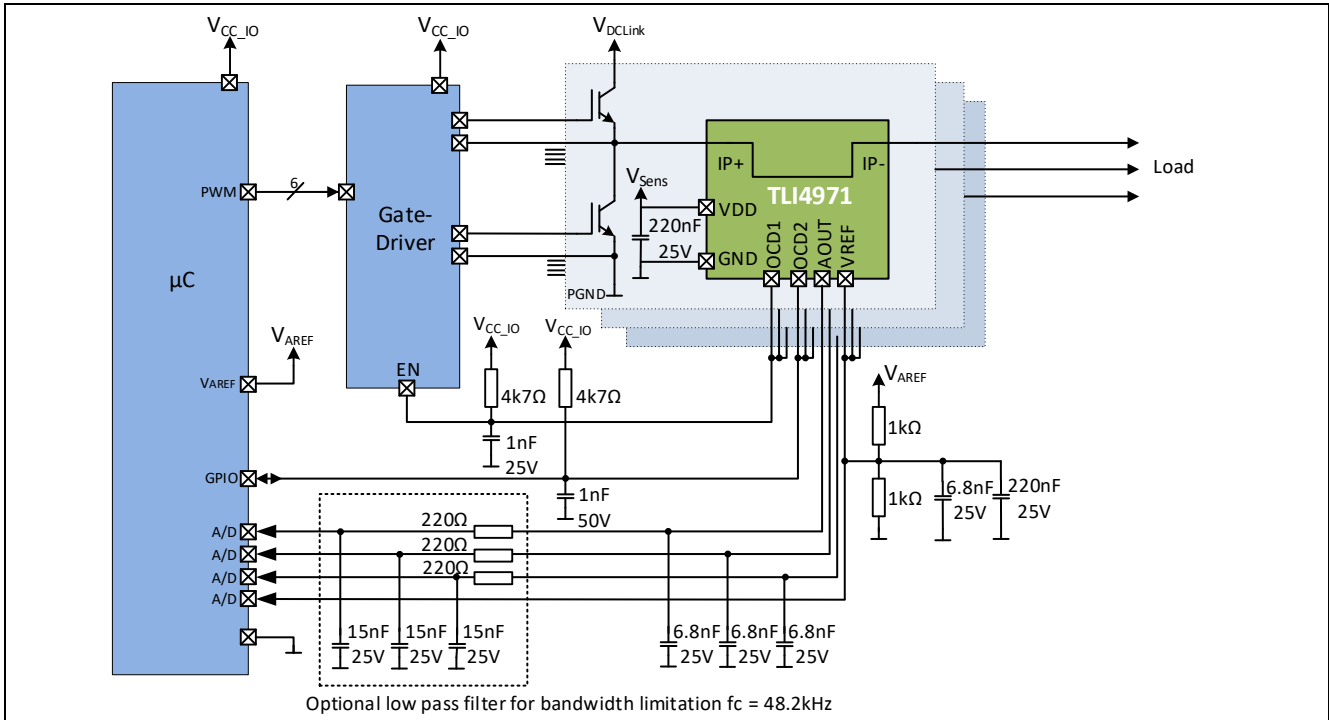


Figure 5 Application circuit for three phase system in single-ended configuration. In-circuit-programming not included.

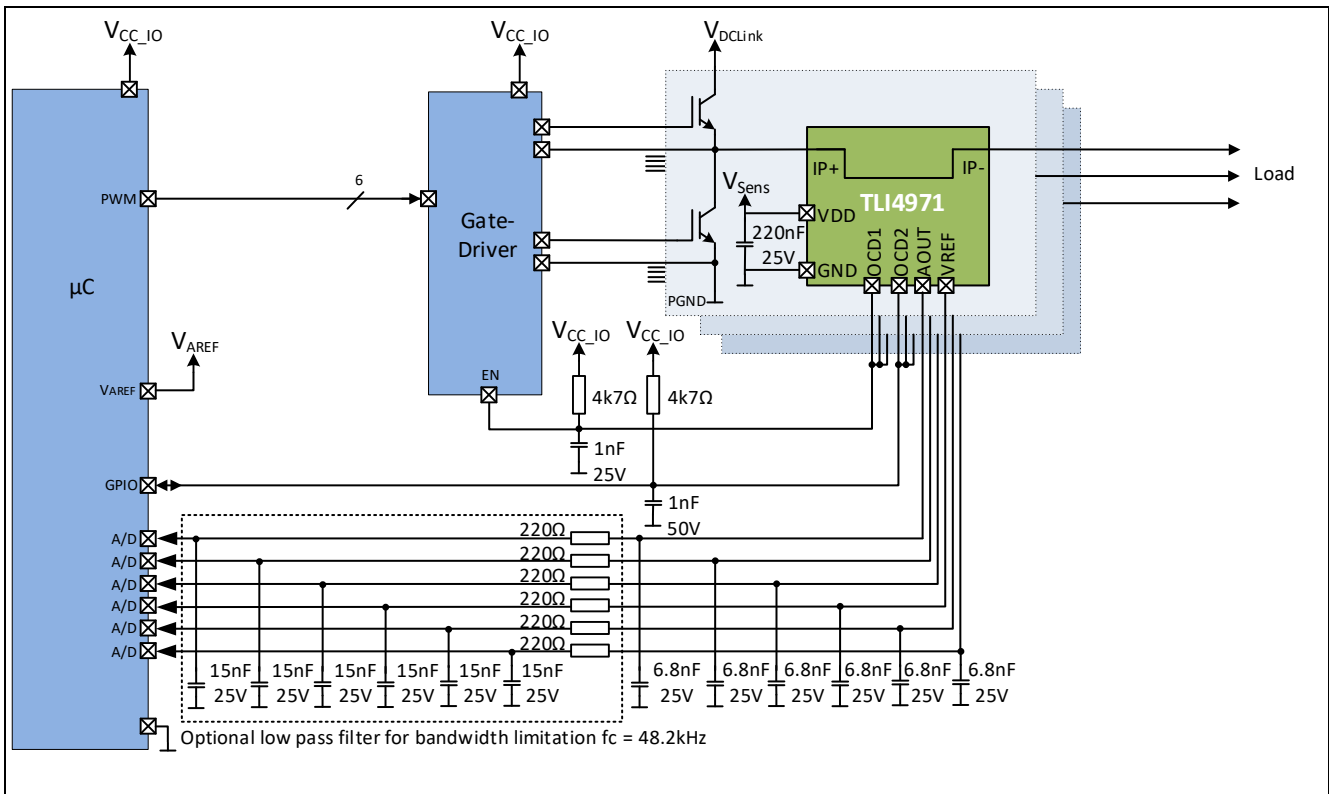


Figure 6 Application circuit for three phase system in differential configuration. In-circuit-programming not included.

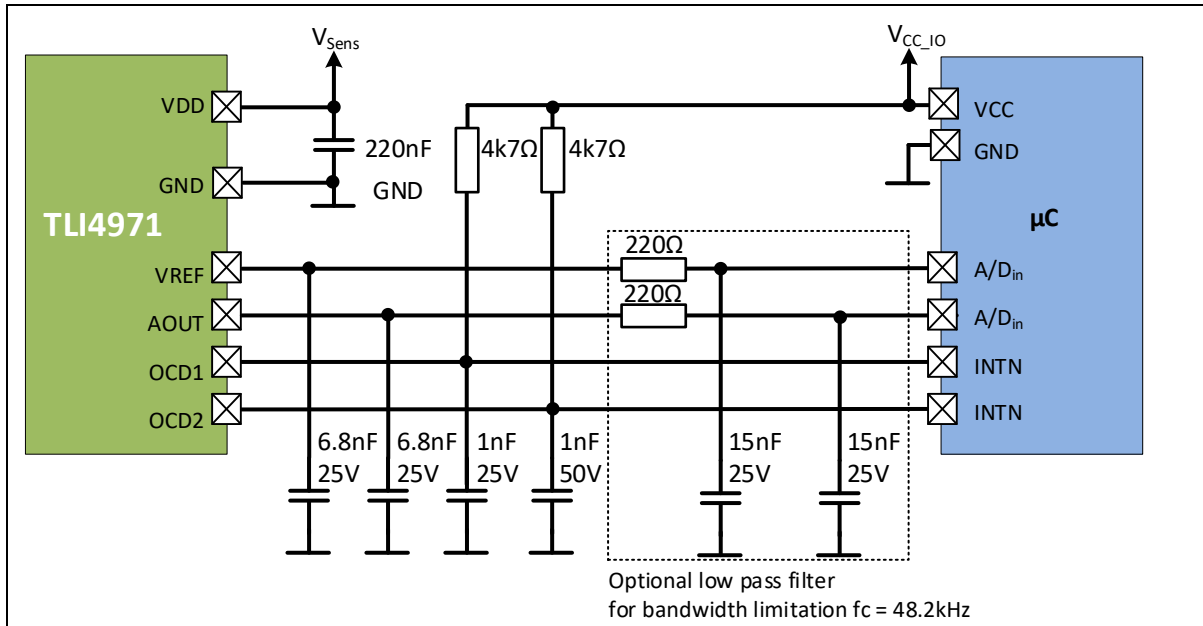


Figure 7 Application circuit with external components. In-circuit-programming not included.

For bandwidth limitation an external filter is recommended as shown in the above application circuits.

## Typical Performance Characteristics

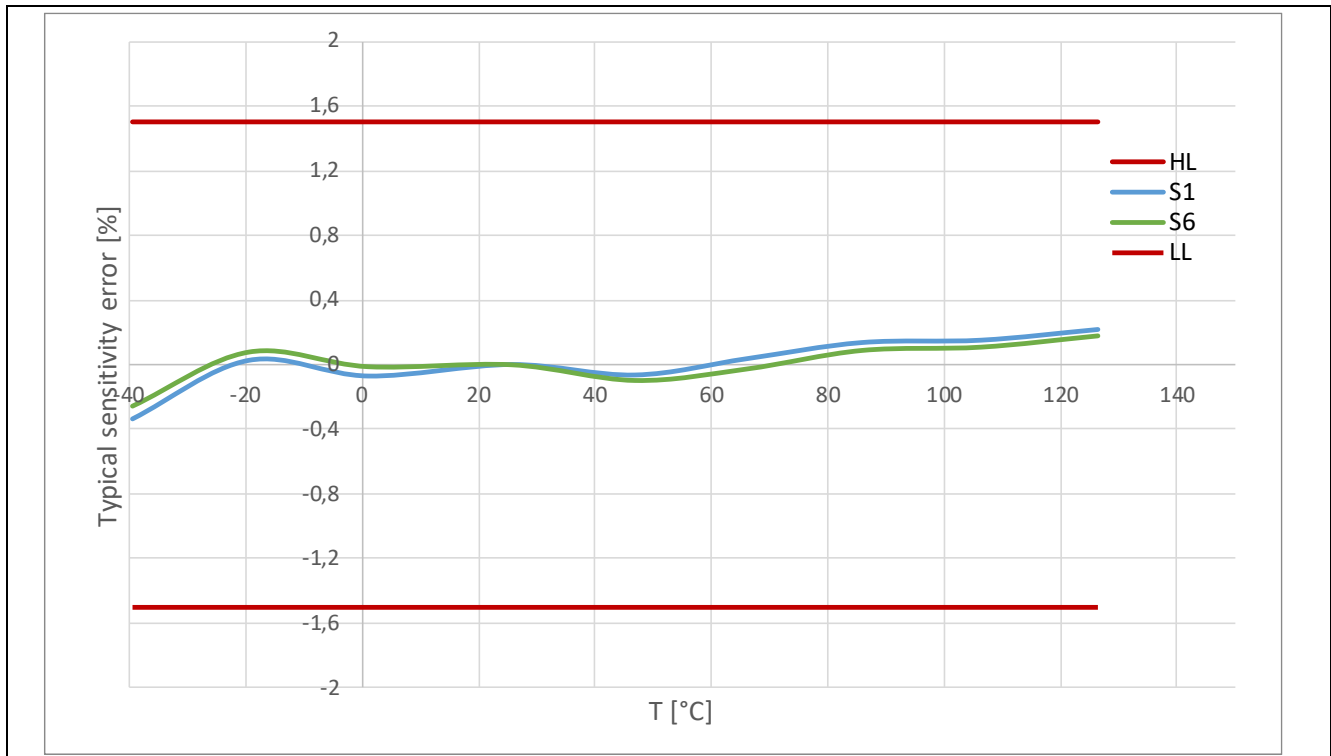


Figure 8 Typical error in sensitivity over temperature

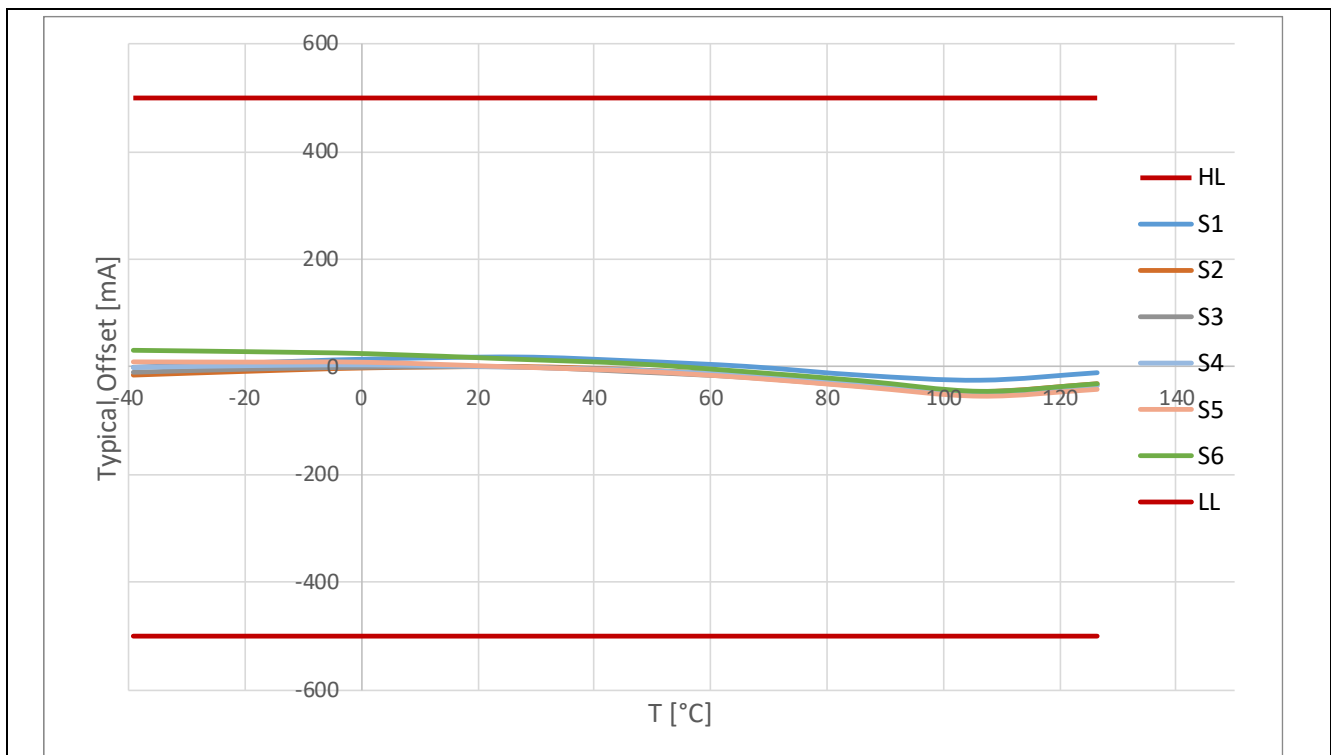


Figure 9 Typical offset drift over temperature

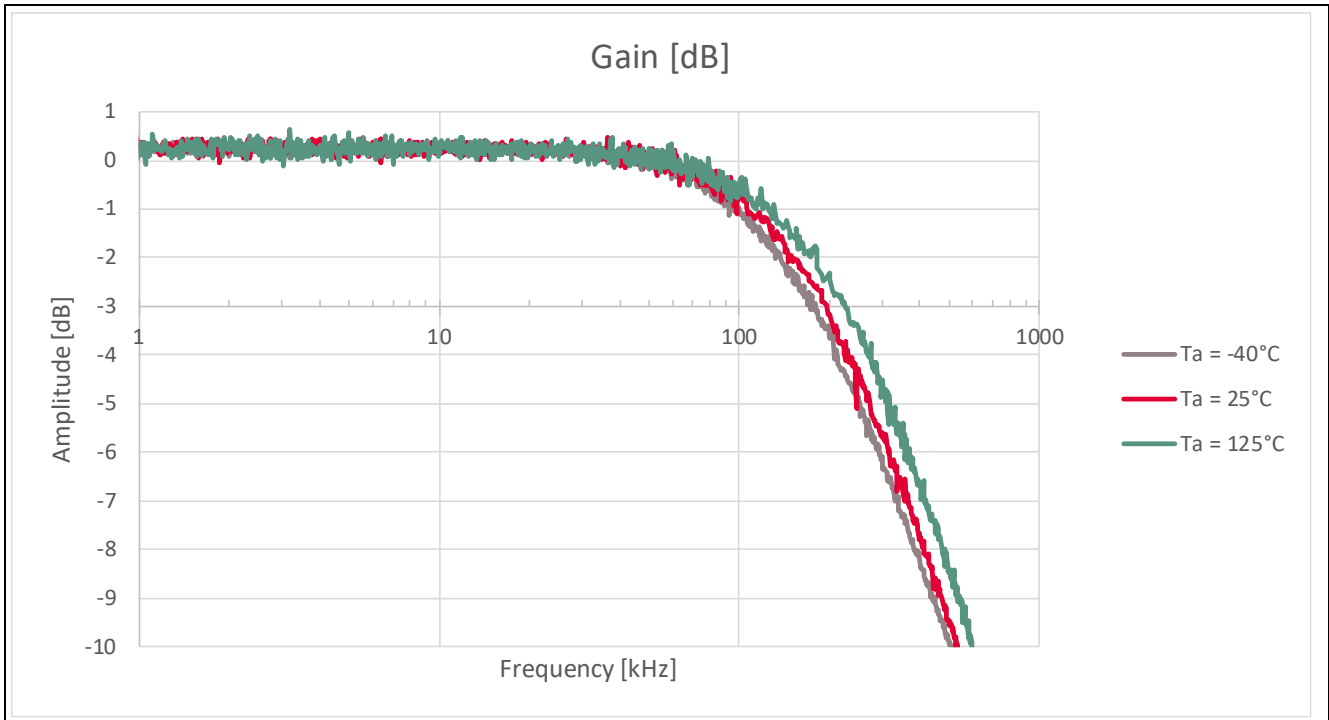


Figure 10 Typical amplitude over frequency

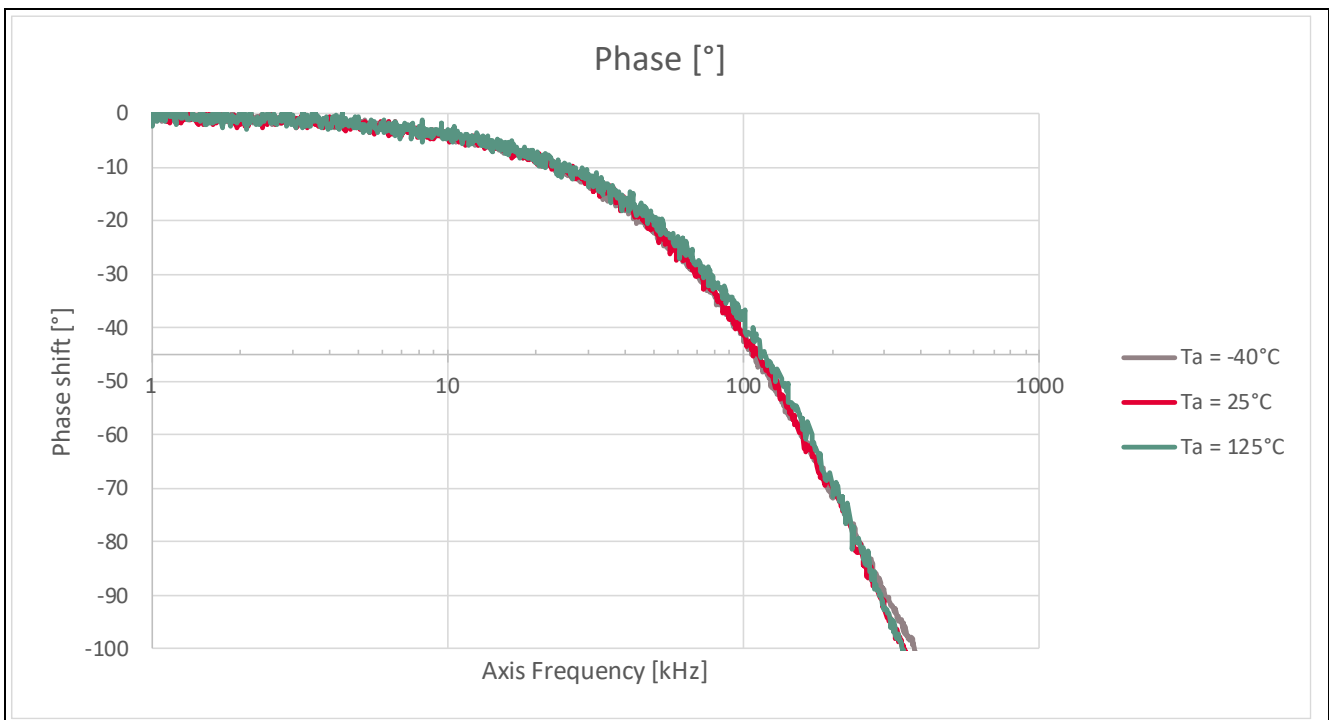


Figure 11 Typical phase-shift over frequency

## Package

The TLI4971 is packaged in a RoHS compliant, halogen-free leadless package (QFN-like).

### PG-TISON-8 Package Outline

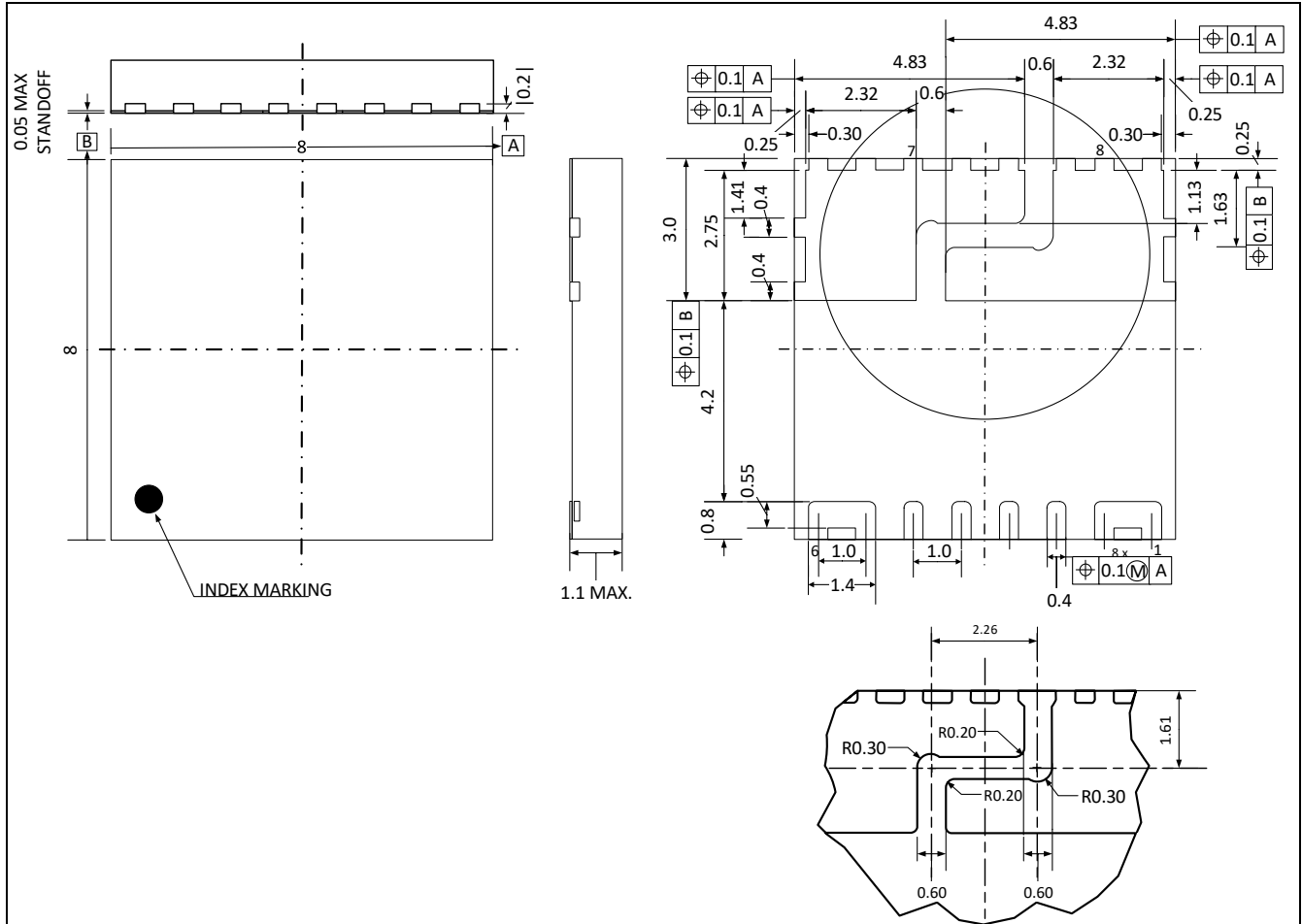


Figure 12 PG-TISON-8 package dimensions

## Revision History

### Major changes since the last revision

| Date       | Description of change  |
|------------|--|
| 10-02-2020 | Datasheet version 1.10   |
| 12-02-2021 | Editorial changes first page: shorten features, benefits and description                           |
|            | Add 6 new variants to order information  |
|            | Pre-configured OCD threshold levels changed: Page3, Table 6 and Table 7                            |
|            | Updated Table 9, isolation characteristics   |
|            | Updated application circuits   |
|            | Increase upper limit of EEPROM programming voltage from 20.7 to 21.0                               |
|            | Added chapter "typical performance characteristics"  |
|            | Datasheet version 1.20   |
| 01-12-2021 | Updated Table 3: Added typical value for the Power-on delay time                                   |
|            | Updated Table 4: Reprogramming limited to 120A – version only                                      |
|            | Updated Table 4: Added accuracy criterion $3\sigma$ to initial sensitivity, offset and total error |
|            | Updated Table 5: Enlarged the allowed range of pull-up resistor                                    |
|            | Separated Table 8 which was former part of Table 3: Overvoltage / Undervoltage parameters          |
|            | Updated Figure 8 and Figure 9: latest production data  |
|            | Adding Figure 10 and Figure 11: gain, phase-shift over frequency                                   |
|            | Datasheet version 1.30   |
|            |  |

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