

XtremeSense™ TMR Coreless, Differential, and Contactless Current Sensor with Programmable Gain

FEATURES AND BENEFITS

- User-programmable field range:
 - 6 to 24 mT
- Preset magnetic field ranges:
 - 0 to 6 mT
 - ± 6 mT
- Linear analog output voltage
- Common mode field rejection: -50 dB
- 1 MHz bandwidth
- Response time: <300 ns
- Reference voltage output for unipolar/bipolar field measurements
- Supply voltage: 4.75 to 5.50 V
- Low noise performance
- Filter pin to reduce noise on output
- Package options:
 - 8-lead SOIC
 - 8-lead TSSOP

APPLICATIONS

- Solar/power inverters
- Battery management systems
- Industrial equipment
- PFC systems
- Power utility meters
- Power conditioner
- DC/DC converters/power supplies

DESCRIPTION

The CT452 is a high-bandwidth and low-noise integrated zero-loss contactless current sensor that uses Allegro patented XtremeSense TMR technology to enable high-accuracy current measurements for many consumer, enterprise, and industrial applications. It supports two field ranges where the CT452 senses and translates the magnetic field into a linear analog output voltage. It achieves a total error output of less than $\pm 1.0\%$ over voltage and temperature.

This coreless current sensor is not only small in size and simple to design, but it also provides effective common mode field rejection of more than -50 dB. This enables the CT452 to have greater than 90% immunity to stray magnetic fields, thus having almost no impact on the accuracy of the current measurement.

The device has less than 300 ns output response time while the current consumption is about 6.0 mA. The CT452 is equipped with a filter function to reduce the noise on the output pin.

The CT452 is assembled in an 8-lead SOIC package and a low-profile, industry-standard 8-lead TSSOP package that are both green and RoHS compliant.

PACKAGES:



FUNCTIONAL BLOCK DIAGRAMS

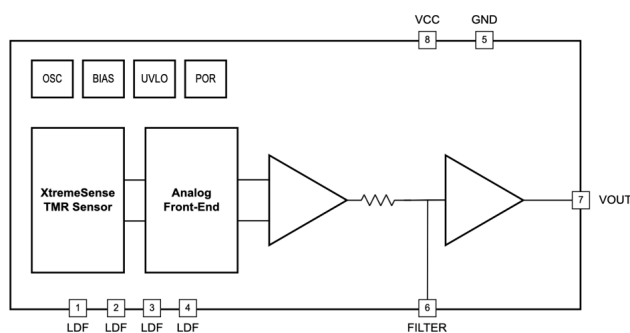


Figure 1: CT452 Functional Block Diagram for SOIC-8

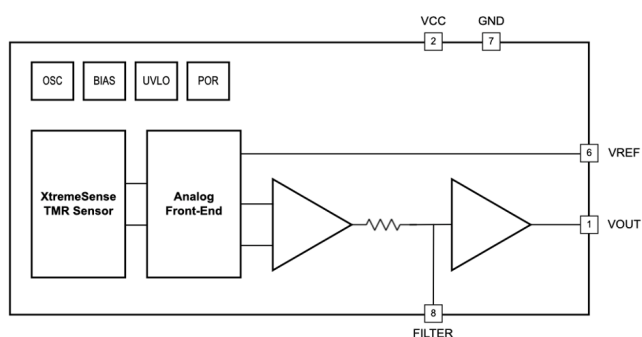


Figure 2: CT452 Functional Block Diagram for TSSOP-8

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SELECTION GUIDE

| Part Number | Automotive Grade | Range (mT) | Operating Temperature Range (°C) | Package | Packing |
|---------------------------------|------------------|------------|----------------------------------|---|---------------|
| BIPOLAR SENSITIVITY | | | | | |
| CT452-H06MRSN08 | – | ±6 | –40 to 125 | 8-lead SOIC 4.89 mm × 6.00 mm × 1.62 mm | Tape and Reel |
| CT452-H06MRTS08 | – | ±6 | –40 to 125 | 8-lead TSSOP 3.00 mm × 6.40 mm × 1.10 mm | Tape and Reel |
| UNIPOLAR SENSITIVITY | | | | | |
| CT452-H06DRSN08 | – | 6 | –40 to 125 | 8-lead SOIC 4.89 mm × 6.00 mm × 1.62 mm | Tape and Reel |
| CT452-H06DRTS08 | – | 6 | –40 to 125 | 8-lead TSSOP 3.00 mm × 6.40 mm × 1.10 mm | Tape and Reel |
| PROGRAMMABLE SENSITIVITY | | | | | |
| CT452-H00MRSN08 | – | ±6 to ±24 | –40 to 125 | 8-lead SOIC 4.89 mm × 6.00 mm × 1.62 mm | Tape and Reel |
| CT452-H00DRSN08 | – | 6 to 24 | | | |
| CT452-H00MRTS08 | – | ±6 to ±24 | –40 to 125 | 8-lead TSSOP 3.00 mm × 6.40 mm × 1.10 mm | Tape and Reel |
| CT452-H00DRTS08 | – | 6 to 24 | | | |

EVALUATION BOARD SELECTION GUIDE

| Part Number | Magnetic Field Range (mT) | Current Carrying Conductor | Operating Temperature Range (°C) | Package |
|---------------|---------------------------|----------------------------|----------------------------------|--|
| CTD452-BB-06U | 0 to 6 | Busbar | −40 to 125 | 8-lead SOIC 4.89 mm × 6.00 mm × 1.62 mm |
| CTD452-BB-06B | ±6 | | | |
| CTD452-PT-06U | 0 to 6 | PCB Trace | | |
| CTD452-PT-06B | ±6 | | | |

ABSOLUTE MAXIMUM RATINGS [1]

| Characteristic | Symbol | Notes | Rating | Unit |
|--|-----------|--|----------------------------|------|
| Supply Voltage Strength | V_{CC} | | –0.3 to 6.0 | V |
| Analog Input/Output Pins Maximum Voltage | $V_{I/O}$ | | –0.3 to $V_{CC} + 0.3$ [2] | V |
| Electrostatic Discharge Protection Level | ESD | Human Body Model (HBM) per JESD22-A114 | ± 2.0 (min) | kV |
| | | Charged Device Model (CDM) per JESD22-C101 | ± 0.5 (min) | kV |
| Junction Temperature | T_J | | –40 to 150 | °C |
| Storage Temperature | T_{STG} | | –65 to 155 | °C |
| Lead Soldering Temperature | T_L | 10 seconds | 260 | °C |

[1] Stresses exceeding the absolute maximum ratings may damage the CT452 and may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.

[2] The lower of $V_{CC} + 0.3$ V or 6.0 V.

RECOMMENDED OPERATING CONDITIONS [1]

| Characteristic | Symbol | Notes | Min. | Typ. | Max. | Unit |
|-------------------------------|-----------|-------|------|------|-----------|------|
| Supply Voltage Range | V_{CC} | | 4.75 | 5.00 | 5.50 | V |
| Output Voltage Range | V_{OUT} | | 0 | – | V_{CC} | V |
| Output Current | I_{OUT} | | – | – | ± 1.0 | mA |
| Operating Ambient Temperature | T_A | | –40 | 25 | 125 | °C |

[1] The Recommended Operating Conditions table defines the conditions for actual operation of the CT452. Recommended operating conditions are specified to ensure optimal performance to the specifications. Allegro does not recommend exceeding them or designing to absolute maximum ratings.

APPLICATION DIAGRAMS

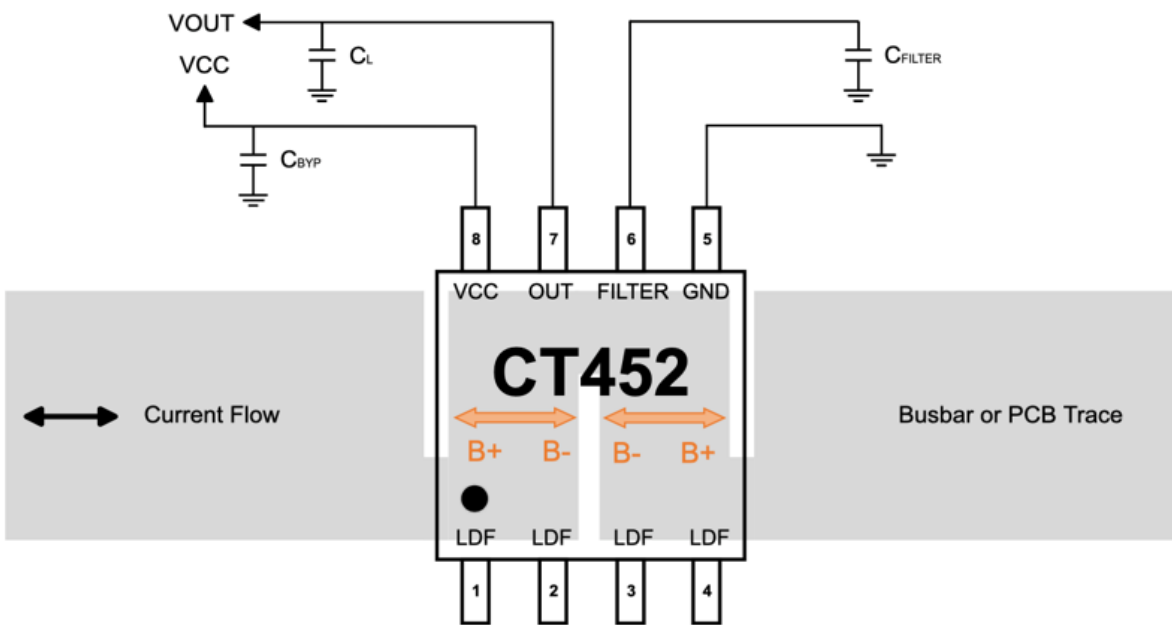


Figure 3: CT452 Application Diagram for SOIC-8

Table 1: Recommended External Components

| Component | Description | Vendor and Part Number | Min. | Typ. | Max. | Unit |
|---------------------|----------------------------|--------------------------|------|-----------|------|---------|
| C _{BYP} | 1.0 μ F, X5R or better | Murata GRM155C81A105KA12 | – | 1.0 | – | μ F |
| C _{FILTER} | Various, X5R or better | Murata | – | Figure 16 | – | pF |

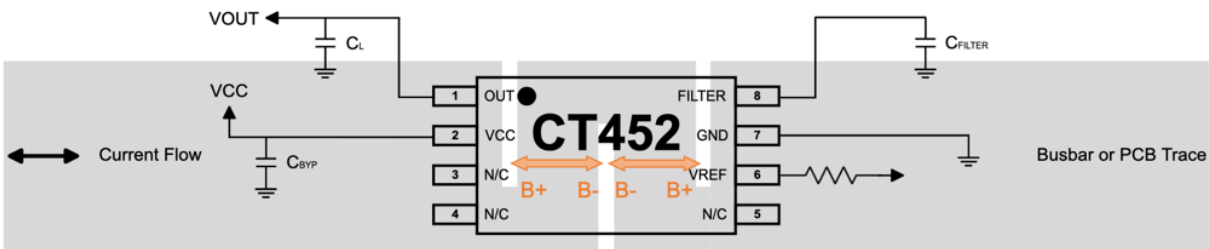


Figure 4: CT452 Application Diagram for TSSOP-8

Table 2: Recommended External Components

| Component | Description | Vendor and Part Number | Min. | Typ. | Max. | Unit |
|---------------------|----------------------------|--------------------------|------|-----------|------|------------|
| C _{BYP} | 1.0 μ F, X5R or better | Murata GRM155C81A105KA12 | – | 1.0 | – | μ F |
| C _{FILTER} | Various, X5R or better | Murata | – | Figure 16 | – | pF |
| R _{VREF} | 10 k Ω resistor | Various | – | 10 | – | k Ω |

PINOUT DIAGRAMS AND TERMINAL LISTS

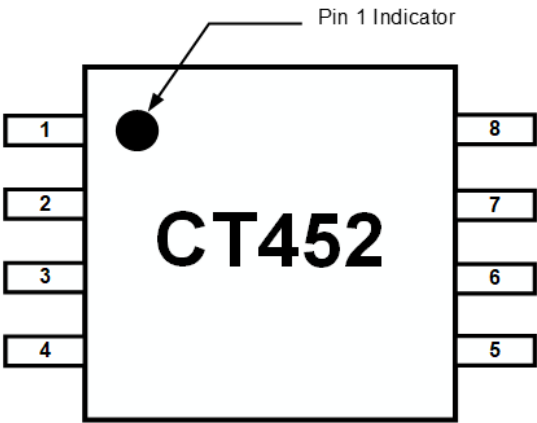


Figure 5: CT452 Pinout Diagram for 8-lead SOIC
Package (Top-Down View)

Terminal List

| Number | Name | Function |
|------------|--------|---|
| 1, 2, 3, 4 | LDF | Lead frame Pin – A single (1) LDF pin should be connected to GND. The other three (3) LDF pins should be left unconnected to avoid ground loops through the lead frame. |
| 5 | GND | Ground. |
| 6 | FILTER | Filter pin to improve noise performance by connecting an external capacitor to set the cutoff frequency. No connect if the FILTER pin is not used. |
| 7 | OUT | Analog output voltage that represents the measured current/field. |
| 8 | VCC | Supply voltage. |

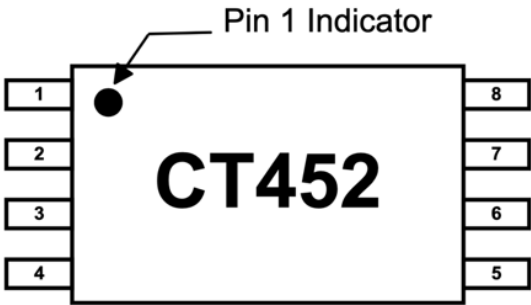


Figure 6: CT452 Pinout Diagram for 8-lead TSSOP
Package (Top-Down View)

Terminal List

| Number | Name | Function |
|---------|--------|---|
| 1 | OUT | Analog output voltage that represents the measured current/field. |
| 2 | VCC | Supply voltage. |
| 3, 4, 5 | NC | No connect (do not use). |
| 6 | VREF | Reference voltage output. If not used, then do not connect. |
| 7 | GND | Ground. |
| 8 | FILTER | Filter pin to improve noise performance by connecting an external capacitor to set the cutoff frequency. No connect if the FILTER pin is not used. |

ELECTRICAL CHARACTERISTICS: Valid for $V_{CC} = 4.75$ to 5.50 V, $C_{BYP} = 1.0$ μ F, and $T_A = -40^\circ\text{C}$ to 125°C , typical values are $V_{CC} = 5.00$ V and $T_A = 25^\circ\text{C}$, unless otherwise specified

| Characteristics | Symbol | Test Conditions | Min. | Typ. | Max. | Unit |
|--|----------------|--|-----------------|-----------------|------|------------|
| POWER SUPPLIES | | | | | | |
| Supply Current | I_{CC} | $f_{BW} = 1$ MHz, no load, $B_{OP} = 0$ mT | – | 6.0 | 9.0 | mA |
| OUT Maximum Drive Capability | I_{OUT} | OUT covers 10% to 90% of V_{CC} span | –1.0 | – | +1.0 | mA |
| OUT Capacitive Load | C_{L_OUT} | | – | – | 100 | pF |
| OUT Resistive Load | R_{L_OUT} | | – | 100 | – | k Ω |
| Internal Filter Resistance [1] | R_{FILTER} | | – | 15 | – | k Ω |
| Power Supply Rejection Ratio [1] | PSRR | | – | 35 | – | dB |
| Sensitivity Power Supply Rejection Ratio [1] | SPSRR | | – | 35 | – | dB |
| Offset Power Supply Rejection Ratio [1] | OPSRR | | – | 40 | – | dB |
| Common Mode Field Rejection Ratio [1] | CMFRR | | – | –50 | – | dB |
| ANALOG OUTPUT (OUT) | | | | | | |
| OUT Voltage Linear Range | V_{OUT} | $V_{SIG_AC} = \pm 2.00$ V, $V_{SIG_DC} = +4.00$ V | 0.50 | – | 4.50 | V |
| Output High Saturation Voltage | V_{OUT_SAT} | $T_A = 25^\circ\text{C}$ | $V_{CC} - 0.30$ | $V_{CC} - 0.25$ | – | V |
| REFERENCE VOLTAGE (VREF) FOR TSSOP-8 ONLY | | | | | | |
| Reference Voltage | V_{REF} | Unipolar variant | – | 0.50 | – | V |
| | | Bipolar variant | – | 2.50 | – | V |
| VREF Maximum Drive Capability | I_{VREF} | | –50 | – | 50 | μ A |
| VREF Capacitive Load | C_{L_VREF} | | – | – | 10 | pF |
| VREF Resistive Load | R_{L_VREF} | | – | 10 | – | k Ω |
| TIMINGS | | | | | | |
| Power-On Time | t_{ON} | $V_{CC} \geq 4.0$ V | – | 100 | 200 | μ s |
| Rise Time [1] | t_{RISE} | $B_{OP} = B_{OP(MAX)}$, $T_A = 25^\circ\text{C}$, $C_L = 100$ pF | – | 200 | – | ns |
| Response Time [1] | $t_{RESPONSE}$ | $B_{OP} = B_{OP(MAX)}$, $T_A = 25^\circ\text{C}$, $C_L = 100$ pF | – | 300 | – | ns |
| Propagation Delay [1] | t_{DELAY} | $B_{OP} = B_{OP(MAX)}$, $T_A = 25^\circ\text{C}$, $C_L = 100$ pF | – | 250 | – | ns |
| PROTECTION | | | | | | |
| Undervoltage Lockout | V_{UVLO} | Rising V_{CC} | – | 2.50 | – | V |
| | | Falling V_{CC} | – | 2.45 | – | V |
| UVLO Hysteresis | V_{UV_HYS} | | – | 50 | – | mV |

[1] Guaranteed by design and characterization; not tested in production.

ELECTRICAL CHARACTERISTICS

$V_{CC} = 5.00 \text{ V}$, $T_A = 25^\circ\text{C}$, and $C_{BYP} = 1.0 \mu\text{F}$ (unless otherwise specified)

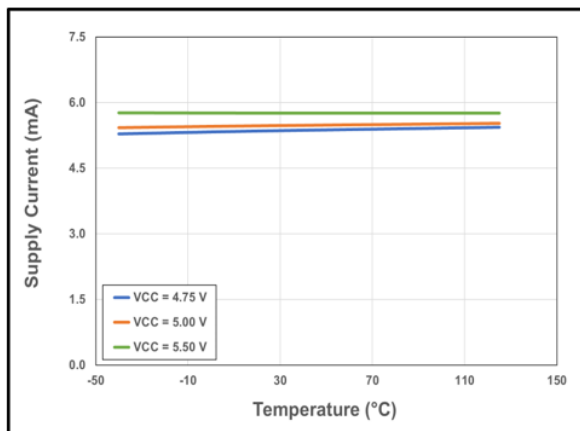


Figure 7: CT452 Supply Current vs. Temperature vs. Supply Voltage

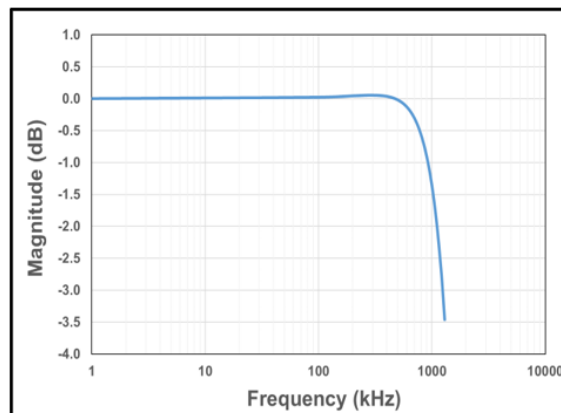


Figure 8: CT452 Bandwidth with $C_{FILTER} = 1.0 \text{ pF}$

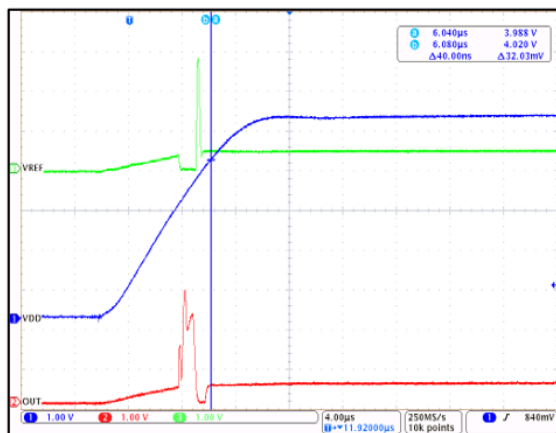


Figure 9: CT452 Startup Waveforms for $V_{OQ} = 0.50 \text{ V}$ (Unipolar Sensor Variant)

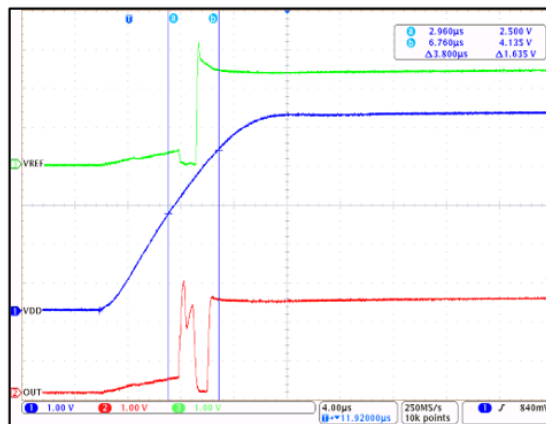


Figure 10: CT452 Startup Waveforms for $V_{OQ} = 2.50 \text{ V}$ (Bipolar Sensor Variant)

CT452-x06DR: 0 to 6 mT – ELECTRICAL CHARACTERISTICS: Valid for $V_{CC} = 4.75$ to 5.50 V, $C_{BYP} = 1.0$ μ F, and $T_A = -40^\circ\text{C}$ to 125°C , typical values are $V_{CC} = 5.00$ V and $T_A = 25^\circ\text{C}$, unless otherwise specified

| Characteristics | Symbol | Test Conditions | Min. | Typ. | Max. | Unit |
|-----------------------------------|------------------------|---|-------|-------|-------|-------------------|
| Magnetic Field Range | B _{RNG} | | 0 | – | 6 | mT |
| Voltage Output Quiescent | V _{OQ} | T _A = 25°C, B _{OP} = 0 mT | 0.495 | 0.500 | 0.505 | V |
| Sensitivity | S | B _{RNG(MIN)} < B _{OP} < B _{RNG(MAX)} | – | 666.7 | – | mV/mT |
| Bandwidth [1] | f _{BW} | Small Signal = –3 dB | – | 1.0 | – | MHz |
| Noise [1] | e _N | T _A = 25°C, f _{BW} = 100 kHz | – | 1.63 | – | mV _{RMS} |
| | | | – | 2.45 | – | μT _{RMS} |
| OUT ACCURACY PERFORMANCE | | | | | | |
| Non-Linearity Error | E _{LIN} | | – | ±0.2 | – | % FS |
| Sensitivity Error | E _{SENS} | | – | ±0.3 | – | % FS |
| Offset Voltage | V _{OFFSET} | B _{OP} = 0 mT | – | ±0.3 | – | % FS |
| LIFETIME DRIFT | | | | | | |
| Total Output Error Lifetime Drift | E _{TOT_DRIFT} | | – | ±1.0 | – | % FS |

[1] Guaranteed by design and characterization; not tested in production.

ELECTRICAL CHARACTERISTICS FOR CT452-x06DR

$V_{CC} = 5.0$ V, $T_A = 25^\circ\text{C}$, and $C_{BYP} = 1.0$ μ F (unless otherwise specified)

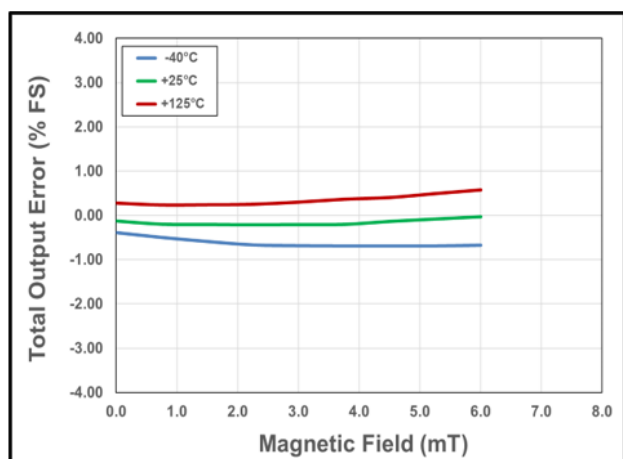


Figure 11: Total Output Error vs. B Field vs. Temperature

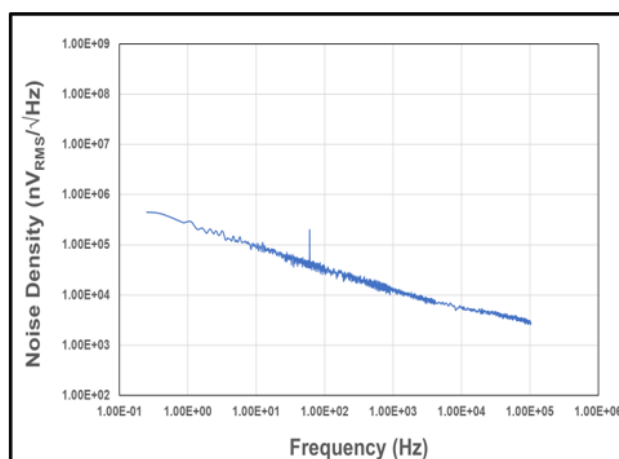


Figure 12: Noise Density vs. Frequency

CT452-x06MR: ±6 mT – ELECTRICAL CHARACTERISTICS: Valid for $V_{CC} = 4.75$ to 5.50 V, $C_{BYP} = 1.0$ μ F, and $T_A = -40^\circ\text{C}$ to 125°C , typical values are $V_{CC} = 5.00$ V and $T_A = 25^\circ\text{C}$, unless otherwise specified

| Characteristics | Symbol | Test Conditions | Min. | Typ. | Max. | Unit |
|-----------------------------------|------------------------|---|-------|-------|-------|-------------------|
| Magnetic Field Range | B _{RNG} | | −6 | − | 6 | mT |
| Voltage Output Quiescent | V _{OQ} | T _A = 25°C, B _{OP} = 0 mT | 2.490 | 2.500 | 2.510 | V |
| Sensitivity | S | B _{RNG(MIN)} < B _{OP} < B _{RNG(MAX)} | − | 333.3 | − | mV/mT |
| Bandwidth [1] | f _{BW} | Small Signal = −3 dB | − | 1.0 | − | MHz |
| Noise [1] | e _N | T _A = 25°C, f _{BW} = 100 kHz | − | 0.92 | − | mV _{RMS} |
| | | | − | 2.77 | − | μT _{RMS} |
| OUT ACCURACY PERFORMANCE | | | | | | |
| Non-Linearity Error | E _{LIN} | | − | ±0.1 | − | % FS |
| Sensitivity Error | E _{SENS} | | − | ±0.3 | − | % FS |
| Offset Voltage | V _{OFFSET} | B _{OP} = 0 mT | − | ±0.2 | − | % FS |
| LIFETIME DRIFT | | | | | | |
| Total Output Error Lifetime Drift | E _{TOT_DRIFT} | | − | ±1.0 | − | % FS |

[1] Guaranteed by design and characterization; not tested in production.

ELECTRICAL CHARACTERISTICS FOR CT452-x06MR

$V_{CC} = 5.0$ V, $T_A = 25^\circ\text{C}$, and $C_{BYP} = 1.0$ μ F (unless otherwise specified)

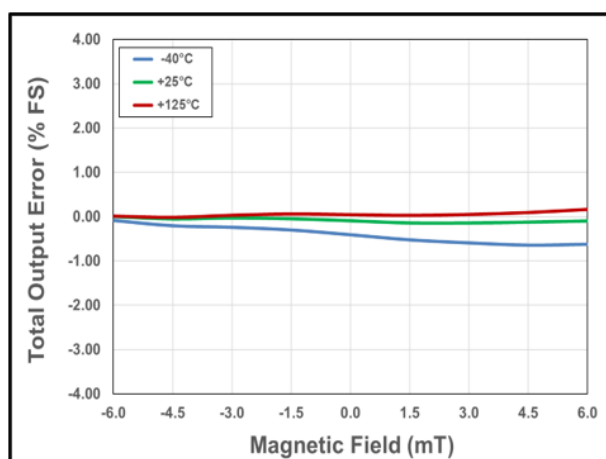


Figure 13: Total Output Error vs. B Field vs. Temperature

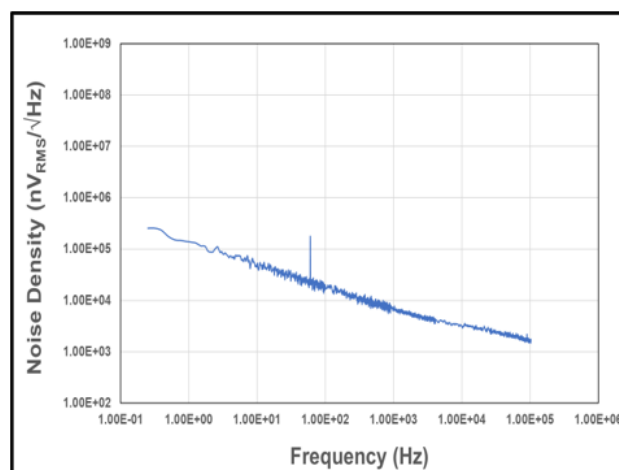


Figure 14: Noise Density vs. Frequency

CT452-x00MR: Programmable Gain – ELECTRICAL CHARACTERISTICS: Valid for $V_{CC} = 4.75$ to 5.50 V, $C_{BYP} = 1.0$ μ F, and $T_A = -40^\circ\text{C}$ to 125°C , typical values are $V_{CC} = 5.00$ V and $T_A = 25^\circ\text{C}$, unless otherwise specified

| Characteristics | Symbol | Test Conditions | Min. | Typ. | Max. | Unit |
|-----------------------------------|------------------|--|----------|-----------|----------|-------|
| Programmable Magnetic Field Range | B_{PRNG} | | ± 6 | – | ± 8 | mT |
| | | | ± 12 | – | ± 24 | mT |
| Voltage Output Quiescent | V_{OQ} | $T_A = 25^\circ\text{C}$, $B_{OP} = 0$ mT | 2.490 | 2.500 | 2.510 | V |
| Maximum Programmable Sensitivity | S_{PMAX} | $B_{RNG(MIN)} < B_{OP} < B_{RNG(MAX)}$ | – | 333.3 | – | mV/mT |
| Minimum Programmable Sensitivity | S_{PMIN} | $B_{RNG(MIN)} < B_{OP} < B_{RNG(MAX)}$ | – | 83.4 | – | mV/mT |
| Bandwidth ^[1] | f_{BW} | Small Signal = –3 dB | – | 1.0 | – | MHz |
| OUT ACCURACY PERFORMANCE | | | | | | |
| Non-Linearity Error | E_{LIN} | | – | ± 0.2 | – | % FS |
| Sensitivity Error | E_{SENS} | | – | ± 0.3 | – | % FS |
| Offset Voltage | V_{OFFSET} | $B_{OP} = 0$ mT | – | ± 0.2 | – | % FS |
| LIFETIME DRIFT | | | | | | |
| Total Output Error Lifetime Drift | E_{TOT_DRIFT} | | – | ± 1.0 | – | % FS |

^[1] Guaranteed by design and characterization; not tested in production.

Calibration Description

The CT452-x00MR is factory-trimmed for sensitivity and offset temperature drift. The sensor provides the ability to adjust gain to allow for all the mechanical tolerances during manufacturing. Gain calibration is recommended to be performed at room temperature (25°C) using the Allegro CTC4000 Calibration Box.

CT452-x00DR: Programmable Gain – ELECTRICAL CHARACTERISTICS: Valid for $V_{CC} = 4.75$ to 5.50 V, $C_{BYP} = 1.0$ μ F, and $T_A = -40^\circ\text{C}$ to 125°C , typical values are $V_{CC} = 5.00$ V and $T_A = 25^\circ\text{C}$, unless otherwise specified

| Characteristics | Symbol | Test Conditions | Min. | Typ. | Max. | Unit |
|-----------------------------------|------------------|--|-------|-----------|-------|-------|
| Programmable Magnetic Field Range | B_{PRNG} | | 6 | – | 8 | mT |
| | | | 12 | – | 24 | mT |
| Voltage Output Quiescent | V_{OQ} | $T_A = 25^\circ\text{C}$, $B_{OP} = 0$ mT | 0.495 | 0.500 | 0.505 | V |
| Maximum Programmable Sensitivity | S_{PMAX} | $B_{RNG(MIN)} < B_{OP} < B_{RNG(MAX)}$ | – | 666.7 | – | mV/mT |
| Minimum Programmable Sensitivity | S_{PMIN} | $B_{RNG(MIN)} < B_{OP} < B_{RNG(MAX)}$ | – | 166.7 | – | mV/mT |
| Bandwidth ^[1] | f_{BW} | Small Signal = –3 dB | – | 1.0 | – | MHz |
| OUT ACCURACY PERFORMANCE | | | | | | |
| Non-Linearity Error | E_{LIN} | | – | ± 0.3 | – | % FS |
| Sensitivity Error | E_{SENS} | | – | ± 0.3 | – | % FS |
| Offset Voltage | V_{OFFSET} | $B_{OP} = 0$ mT | – | ± 0.3 | – | % FS |
| LIFETIME DRIFT | | | | | | |
| Total Output Error Lifetime Drift | E_{TOT_DRIFT} | | – | ± 1.0 | – | % FS |

^[1] Guaranteed by design and characterization; not tested in production.

Calibration Description

The CT452-x00DR is factory-trimmed for sensitivity and offset temperature drift. The sensor provides the ability to adjust gain to allow for all the mechanical tolerances during manufacturing. Gain calibration is recommended to be performed at room temperature (25°C) using the Allegro CTC4000 Calibration Box.

FUNCTIONAL DESCRIPTION

Overview

The CT452 is a very high accuracy coreless and contactless current sensor that can sense magnetic fields from 6 to 24 mT. The device has high sensitivity and a wide dynamic range with excellent accuracy (low total output error) across temperature. This current sensor supports two field ranges as standard and can also be user-programmable:

- 0 to 6 mT
- ± 6 mT

The CT452 is also available in a user-programmable variant which enables end-of-line calibration of gain. While the sensor is pre-programmed to adjust sensitivity and offset temperature drift, the ability to adjust gain relaxes mechanical tolerances during sensor mounting.

When current is flowing through a busbar above or below the CT452, the XtremeSense TMR sensor inside the chip senses the field which in turn generates a differential voltage signals that then goes through the Analog Front-End (AFE) to output a current measurement as low as $\pm 1.0\%$ full-scale total output error (E_{OUT}).

The chip is designed to enable a fast response time of 300 ns for the current measurement from the OUT pin as the bandwidth for the CT452 is 1.0 MHz. Even with a high bandwidth, the chip consumes a minimal amount of power.

Linear Output Current Measurement

The CT452 provides a continuous linear analog output voltage which represents the current measurement. The output voltage range of OUT is from 0.50 to 4.50 V with a V_{OQ} of 0.50 V and 2.50 V for unidirectional and bidirectional currents, respectively. Figure 15 illustrates the output voltage range of the OUT pin as a function of the measured current.

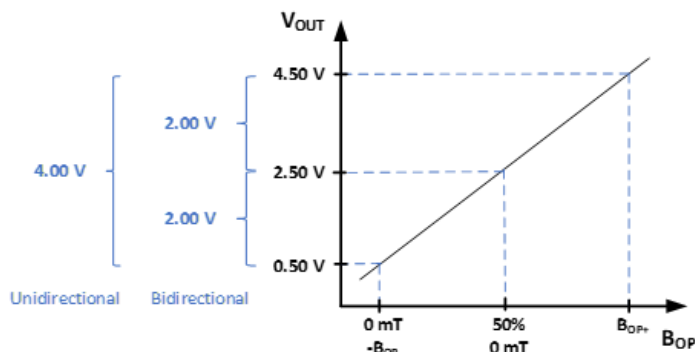


Figure 15: Linear Output Voltage Range (OUT) vs. Measured Magnetic Field (B_{OP})

Voltage Reference Function (VREF)

The CT452 in TSSOP-8 package has a reference voltage (VREF) pin that may be used as an output voltage reference for AC or DC field/current measurements. The VREF pin should be connected to a buffer circuit.

If VREF is not used, then it should be left unconnected.

Filter Function (FILTER)

The CT452 has a pin for the FILTER function which will enable it to improve the noise performance by changing the cutoff frequency. The bandwidth of the CT452 is 1.0 MHz; however, adding a capacitor to the FILTER pin—which will be in-series with an internal resistance of approximately 15 k Ω —will set the cutoff frequency to reduce noise. Figure 16 shows the capacitor values required to achieve different cutoff frequencies.

Experimentally measured bandwidth does not necessarily match the calculated bandwidth value obtained by using the equation $f_{BW} = 1/2\pi RC$ because of the parasitic capacitances due to PCB manufacturing and layout. This is further impacted by the small, picofarad level C_{FILTER} recommendations.

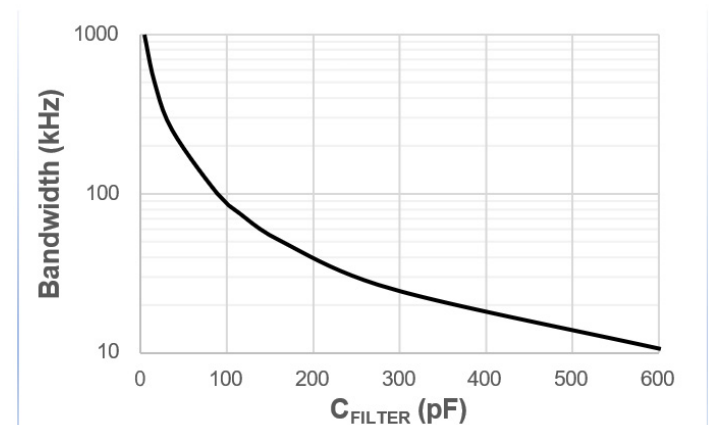


Figure 16: Bandwidth vs. C_{FILTER}

Total Output Error

The Total Output Error (E_{OUT}) is the maximum deviation of the sensor output from the ideal sensor transfer curve over the full temperature range relative to the sensor full scale.

The Total Output Error is measured by performing a full-scale primary current (IP) sweep and measuring V_{OUT} at multiple points.

$$E_{OUT} = 100 * \frac{\max(V_{OUT_{IDEAL}}(I) - V_{OUT}(I))}{F.S.}$$

The Ideal Transfer Curve is calculated based on datasheet parameters as described below.

$$V_{OUT_{IDEAL}}(I_P) = V_{OQ} + S * I_P$$

E_{OUT} incorporates all sources of error and is a function of the sensed current (I_P) from the current sensor.

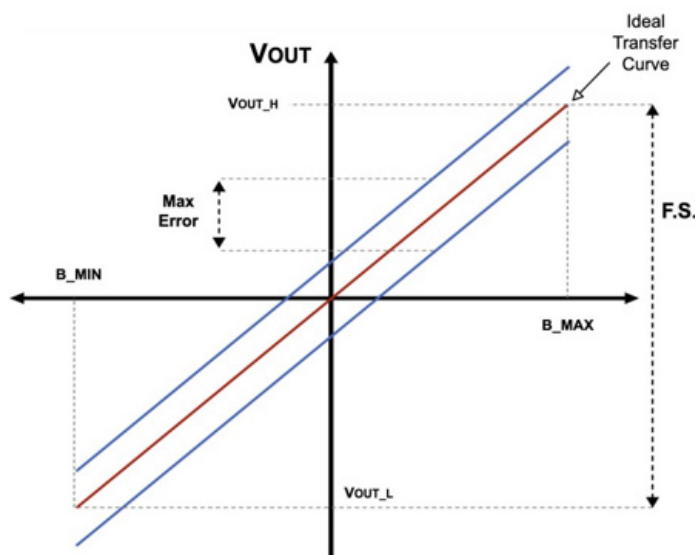


Figure 17: Total Output Error (E_{OUT}) vs. Field (B_{OP})

The CT452 achieves, after gain calibration, a total output error (E_{OUT}) that is less than $\pm 1.0\%$ of Full-Scale (FS) over supply voltage and temperature. It is designed with innovative and proprietary TMR sensors and circuit blocks to provide very accurate magnetic field measurements regardless of the operating conditions.

Common Mode Field Rejection (CMFR) Mode

The CT452 has a built-in CMFR mode that combines the design ease of contactless current sensing with excellent common mode field rejection. This is achieved by placing notches in the current-carrying busbar or PCB trace to generate a differential magnetic field in the vicinity of the CT452 sensor. The current sensor uses two full-bridge XtremeSense TMR sensors to achieve differential magnetic sensing capability, which allows the CT452 to greatly attenuate external magnetic fields and only capture the magnetic field generated by the current flowing in the busbar. Using this technique achieves better than -50 dB of CMFR without com-

promising the accuracy or the signal-to-noise ratio (SNR) of the CT452.

Figure 18 and Figure 19 shows an example of a 2-layer printed circuit board (PCB) where the CT452 is placed on the top layer of the PCB and the bottom layer is designed to generate differential magnetic fields as the current flows through this trace. The snake-like shape of the PCB trace produces the differential magnetic fields that almost completely eliminates the effects of stray magnetic fields to the CT452. This ensures that the CT452 outputs an accurate output voltage/current measurement to the host system.

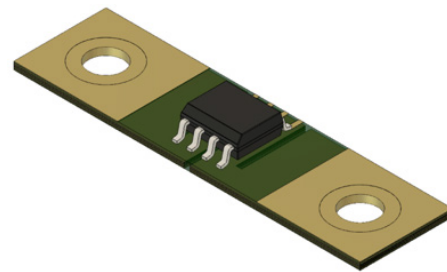


Figure 18: 3D View of CT452 and PCB Trace Design



Figure 19: PCB Trace Design to Generate Differential Magnetic Field for CT452 to Measure

An exploded view of the differential magnetic field generated by the PCB trace is illustrated in Figure 20. It demonstrates the IP+ current generating a clockwise field and goes around the bend or corner of the trace and coming out is IP- with a counter-clockwise field.

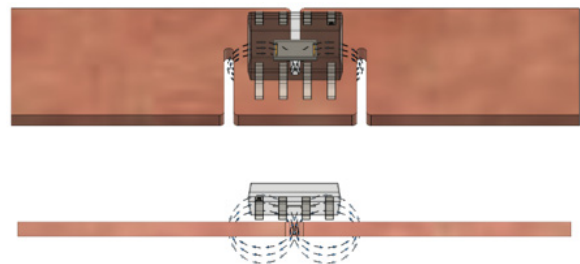


Figure 20: Differential Magnetic Fields Generated Current Through the Busbar (or PCB Trace) and Measured by the CT452

This concept is not restricted to PCB layers and can be extended to busbars carrying current in the hundreds to thousands of amperes. Figure 21 shows a graphic of the CT452 placed over a busbar that generates differential magnetic fields when 300 A or greater steady-state current through it which will also give CMFR ratio of -50 dB or greater than 90% immunity.

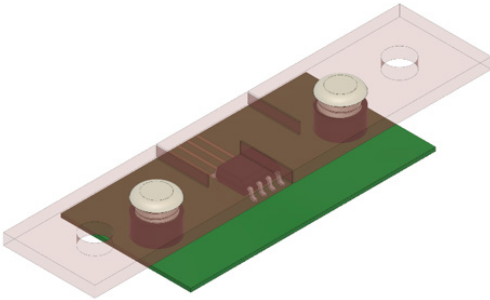


Figure 21: CT452 for Contactless Current Sensing Using Busbar

For more information on how to design the PCB trace and busbar to achieve this CMFR performance, see application note AN134, Fuse Time vs. Current for the CT43x Contact Current Sensors.

Sensitivity Error

The sensitivity error (E_{SENS}) is the sensitivity temperature drift error for unipolar or DC current. It is calculated using the equation below:

$$E_{SENS} = 100 \times \left(\frac{S_{MEASURED}}{S} - 1 \right)$$

For bipolar or AC current, the E_{SENS} is calculated by dividing the equation by 2.

Power-On Time (t_{ON})

Power-On Time (t_{ON}) of 100 μ s is the amount of time required by CT452 to start up, fully power the chip, and becoming fully operational from the moment the supply voltage is greater than the UVLO voltage. This time includes the ramp-up time and the settling time (within 10% of steady-state voltage under an applied magnetic field) after the power supply has reached the minimum V_{CC} .

Response Time ($t_{RESPONSE}$)

Response Time ($t_{RESPONSE}$) of 300 ns for the CT452 is the time interval between the following terms:

1. When the primary current signal reaches 90% of its final value,
2. When the chip reaches 90% of its output corresponding to the applied current.

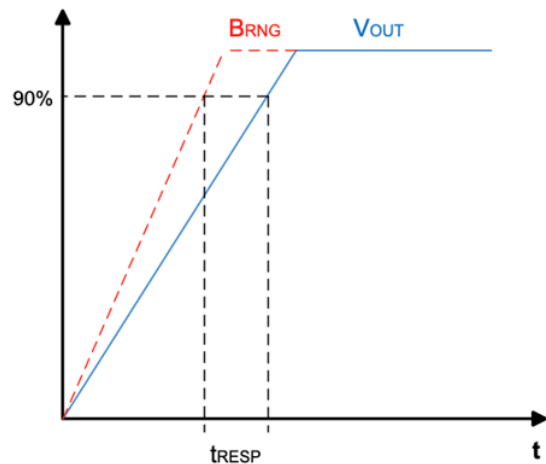


Figure 22: CT452 Response Time Curve

Rise Time (t_{RISE})

Rise Time (t_{RISE}) is the time interval of when it reaches 10% and 90% of the full-scale output voltage. The t_{RISE} of the CT452 is 200 ns.

Propagation Delay (t_{DELAY})

Propagation Delay (t_{DELAY}) is the time difference between these two events:

1. When the primary current reaches 20% of its final value
2. When the chip reaches 20% of its output corresponding to the applied current.

The CT452 has a propagation delay of 250 ns.

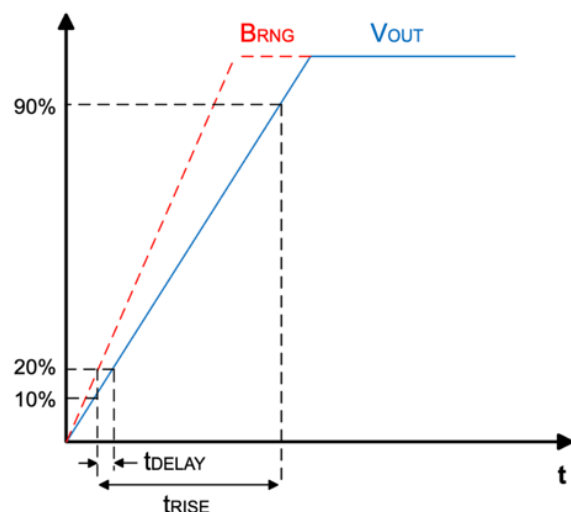


Figure 23: CT452 Propagation Delay and Rise Time Curve

Undervoltage Lockout (UVLO)

The Undervoltage Lockout protection circuitry of the CT452 is activated when the supply voltage (V_{CC}) falls below 2.45 V. The CT452 remains in a low quiescent state until V_{CC} rises above the UVLO threshold (2.50 V). In this condition where V_{CC} is less than 2.45 V and UVLO is triggered, the output from the CT452 is not valid. Once V_{CC} rises above 4.0 V, then the UVLO is cleared.

Recommended PCB Trace Design

The CT452 requires a different PCB trace or busbar design than the standard current trace or busbar to enable common mode field rejection. Figure 24 and Figure 25 show the shape and design of a PCB trace or busbar.

Other considerations in the PCB layout include the thickness of the trace and the amount of copper to support the current. Also placing the PCB trace on the bottom layer of the board will increase the isolation voltage. The greater distance between the CT452 and the current trace will result in a higher isolation voltage.

For more information on how to design the current-carrying busbar or PCB trace, see AN135 application note, CT452/3 Busbar Design.

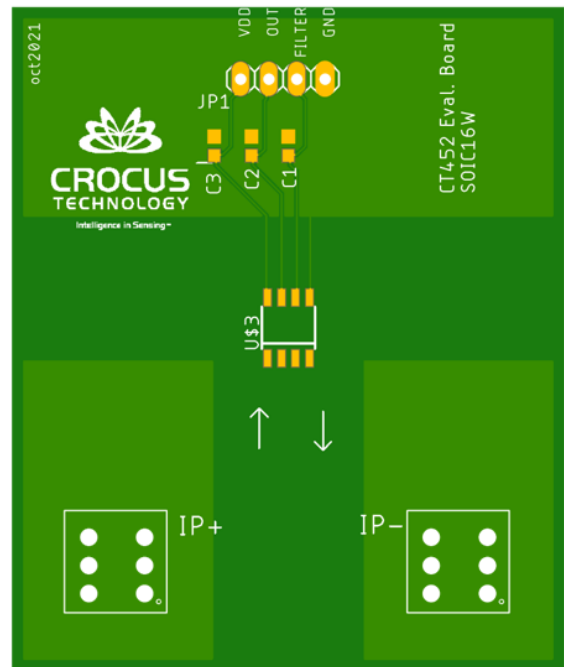


Figure 24: Recommended PCB Layout (Top Layer) for CT452

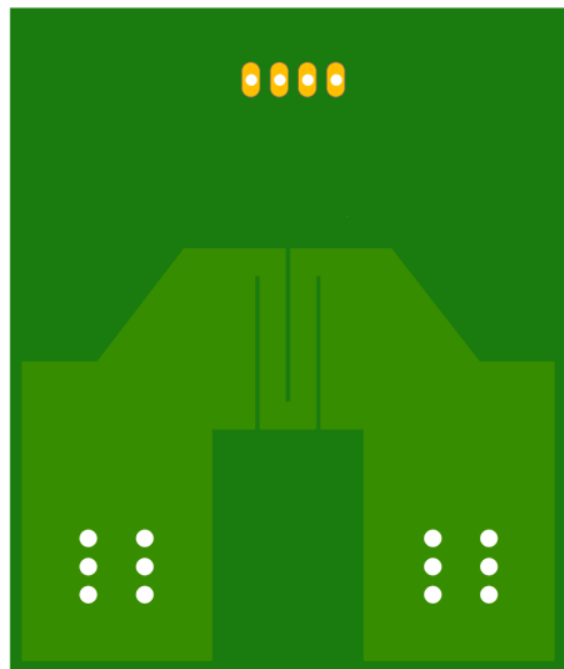


Figure 25: Recommended PCB Layout (Bottom Layer) for CT452

XtremeSense TMR Current Sensor Location

The XtremeSense TMR current sensor location of the CT452 is shown below. All dimensions in the figures are nominal.

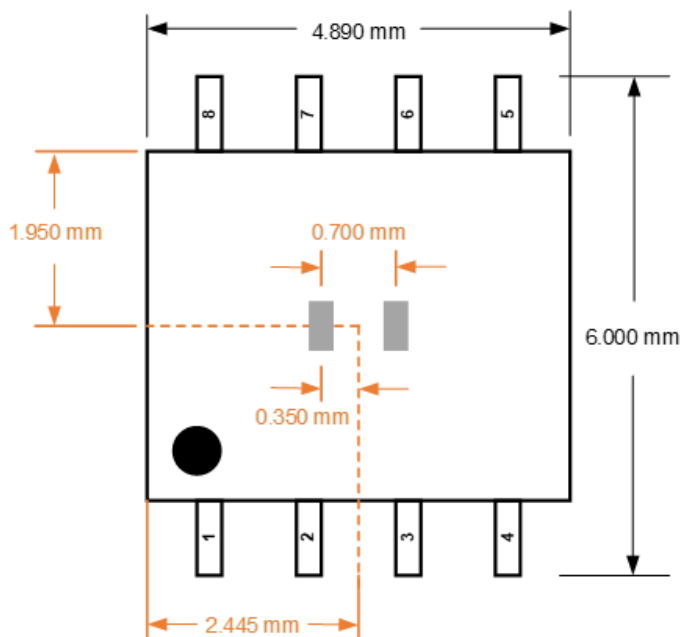


Figure 26: XtremeSense TMR Current Sensor Location in x-y Plane for CT452 in SOIC-8 Package

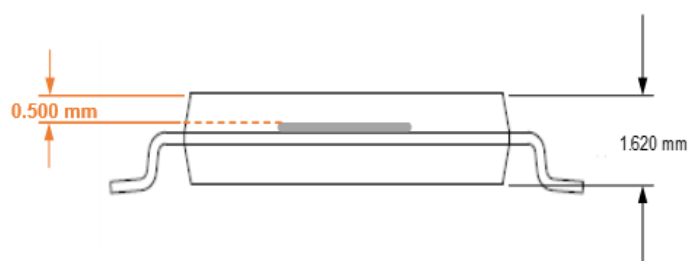


Figure 27: XtremeSense TMR Current Sensor Location in z Dimension for CT452 in SOIC-8 Package

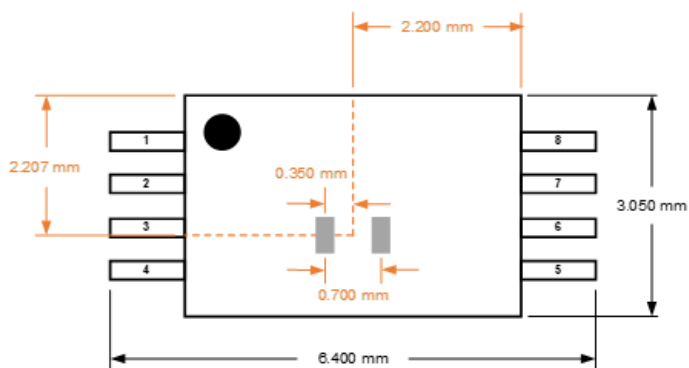


Figure 28: XtremeSense TMR Current Sensor Location in x-y Plane for CT452 in TSSOP-8 Package

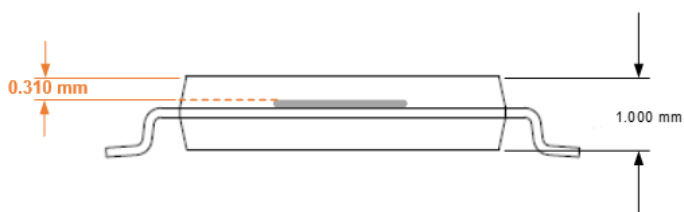


Figure 29: XtremeSense TMR Current Sensor Location in z Dimension for CT452 in TSSOP-8 Package

PACKAGE OUTLINE DRAWINGS

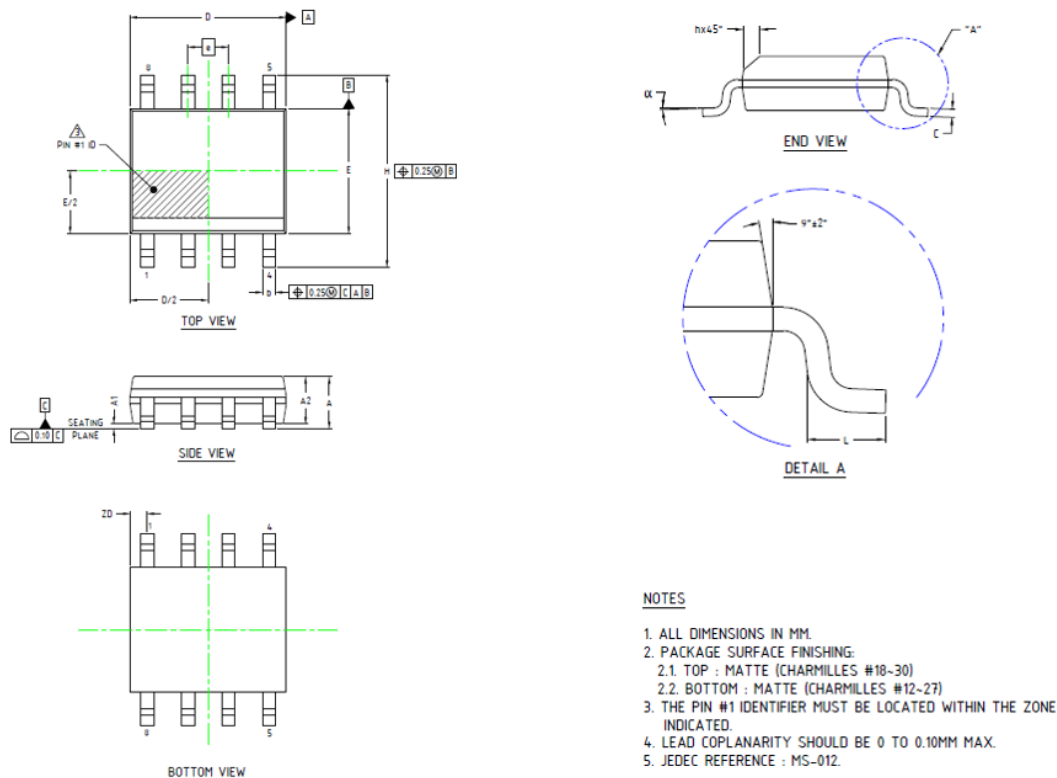


Figure 30: SOIC-8 Package Drawing and Dimensions

Table 3: CT452 SOIC-8 Package Dimensions

| Symbol | Dimensions in Millimeters (mm) | | |
|--------|--------------------------------|------|------|
| | Min. | Typ. | Max. |
| A1 | 0.10 | 0.18 | 0.25 |
| b | 0.36 | 0.41 | 0.46 |
| C | 0.19 | 0.22 | 0.25 |
| D | 4.80 | 4.89 | 4.98 |
| E | 3.81 | 3.90 | 3.99 |
| e | 1.27 BSC | | |
| H | 5.80 | 6.00 | 6.20 |
| h | 0.25 | 0.37 | 0.50 |
| L | 0.41 | — | 1.27 |
| A | 1.52 | 1.62 | 1.72 |
| α | 0° | — | 8° |
| ZD | 0.53 REF | | |
| A2 | 1.37 | 1.47 | 1.57 |

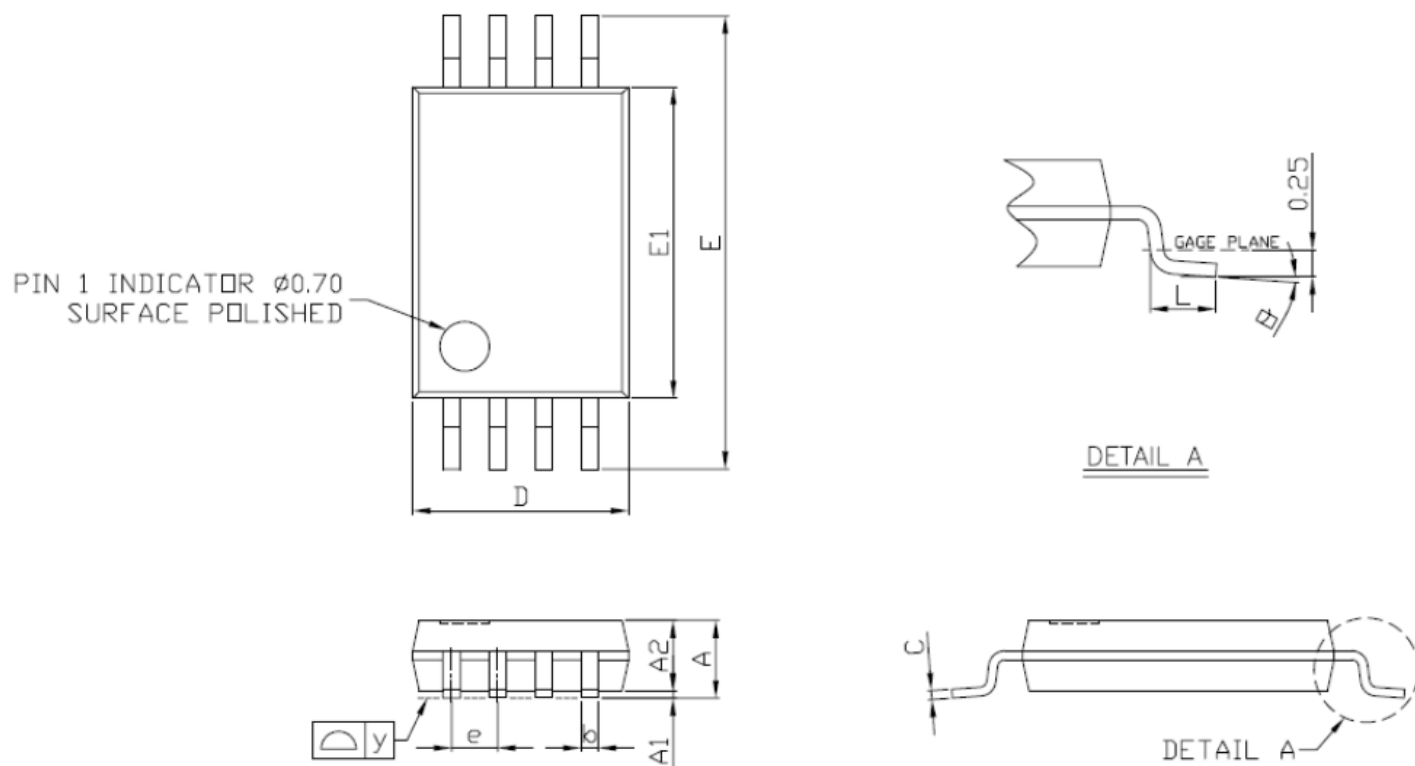


Figure 31: TSSOP-8 Package Drawing and Dimensions

Table 4: CT452 TSSOP-8 Package Dimensions

| Symbol | Dimensions in Millimeters (mm) | | |
|----------|--------------------------------|-------|-------|
| | Min. | Typ. | Max. |
| A | 1.05 | 1.10 | 1.20 |
| A1 | 0.05 | 0.10 | 0.15 |
| A2 | — | 1.00 | 1.05 |
| b | 0.25 | — | 0.30 |
| C | — | 0.127 | — |
| D | 2.90 | 3.05 | 3.10 |
| E | 6.20 | 6.40 | 6.60 |
| E1 | 4.30 | 4.40 | 4.50 |
| e | — | 0.65 | — |
| L | 0.50 | 0.60 | 0.70 |
| y | — | — | 0.076 |
| θ | 0° | 4° | 8° |

TAPE AND REEL POCKET DRAWINGS AND DIMENSIONS

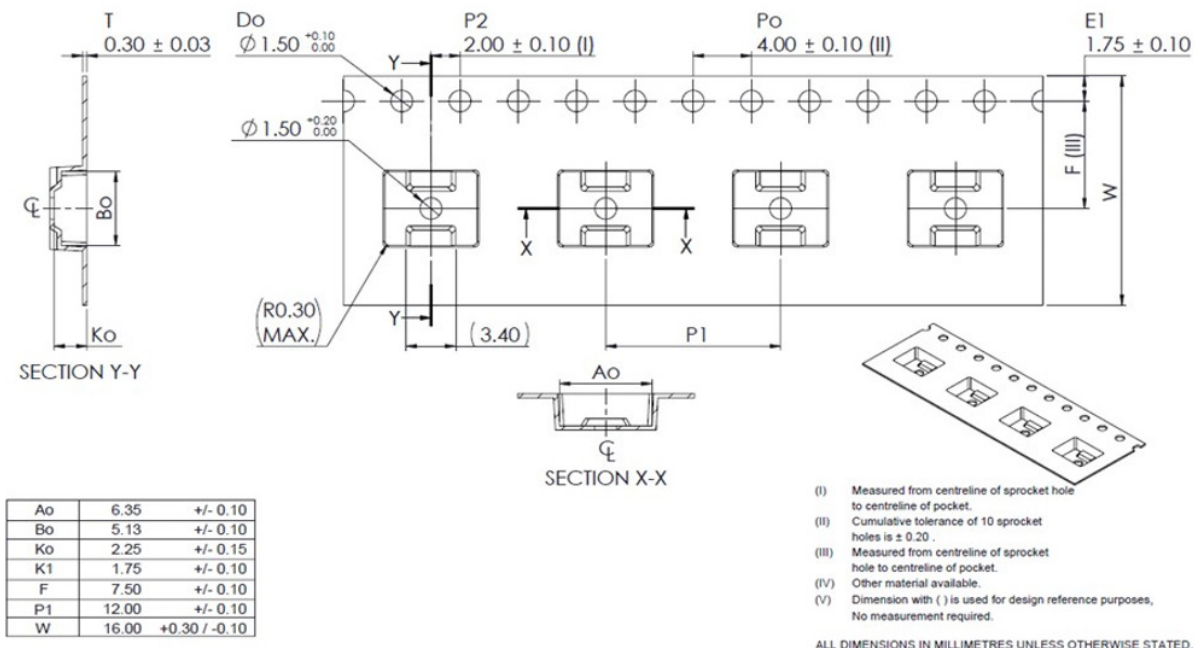


Figure 32: Tape and Pocket Drawing for SOIC-8 Package

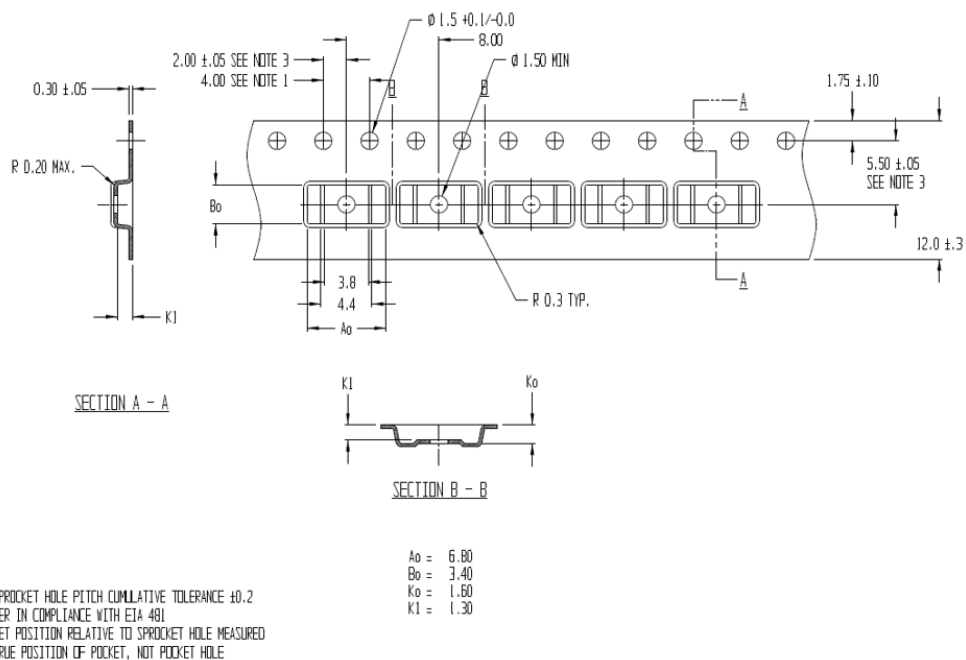


Figure 33: Tape and Pocket Drawing for TSSOP-8 Package

PACKAGE INFORMATION

Table 5: CT452 Package Information

| Part Number | Package Type | # of Leads | Package Quantity | Lead Finish | MSL Rating [2] | Operating Temperature (°C) [3] | Device Marking [4] |
|-----------------|--------------|------------|------------------|-------------|----------------|--------------------------------|-------------------------|
| CT452-H06MRTS08 | TSSOP | 8 | 3000 | Sn | 1 | –40 to 125 | CT452-06MR YYWWLL |
| CT452-H06MRSN08 | SOIC | 8 | 2000 | Sn | 3 | –40 to 125 | CT452 06MR YYWWLL |
| CT452-H06DRTS08 | TSSOP | 8 | 3000 | Sn | 1 | –40 to 125 | CT452-06DR YYWWLL |
| CT452-H06DRSN08 | SOIC | 8 | 2000 | Sn | 3 | –40 to 125 | CT452 06DR YYWWLL |
| CT452-H00MRTS08 | TSSOP | 8 | 3000 | Sn | 1 | –40 to 125 | CT452-00MR YYWWLL |
| CT452-H00DRTS08 | TSSOP | 8 | 3000 | Sn | 1 | –40 to 125 | CT452-00DR YYWWLL |
| CT452-H00MRSN08 | SOIC | 8 | 2000 | Sn | 3 | –40 to 125 | CT452 00MR YYWWLL |
| CT452-H00DRSN08 | SOIC | 8 | 2000 | Sn | 3 | –40 to 125 | CT452 00DR YYWWLL |

[1] RoHS is defined as semiconductor products that are compliant to the current EU RoHS requirements. It also will meet the requirement that RoHS substances do not exceed 0.1% by weight in homogeneous materials. Green is defined as the content of chlorine (Cl), bromine (Br), and antimony trioxide based flame retardants satisfy JS709B low halogen requirements of $\leq 1,000$ ppm.

[2] MSL Rating = Moisture Sensitivity Level Rating as defined by JEDEC standard classifications.

[3] Package will withstand ambient temperature range of –40°C to 125°C and storage temperature range of –65°C to 150°C.

[4] For the CT452, device marking for the SOIC-8 is defined as CT452 xxZR YYWWLL where the first 2 lines = part number, and third line is YY = year, WW = work week, and LL = lot code. Device marking for the TSSOP-8 is defined as CT450 xxZR YYWWLL where the first line = part number, and second line is YY = year, WW = work week, and LL = lot code.

DEVICE MARKINGS

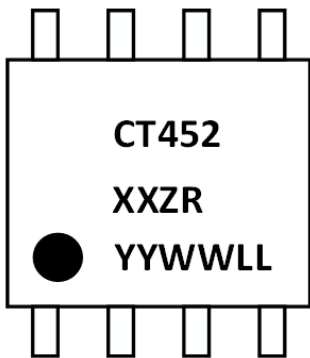


Figure 34: CT452 Device Marking
for 8-Lead SOIC Package

Table 6: CT452 Device Marking Definition for 8-lead SOIC Package

| Row No. | Code | Definition |
|---------|-------|----------------------|
| 3 | • | Pin 1 Indicator |
| 1 | CT452 | Allegro Part Number |
| 2 | XX | Maximum Field Rating |
| 2 | ZR | Polarity |
| 3 | YY | Calendar Year |
| 3 | WW | Work Week |
| 3 | LL | Lot Code |

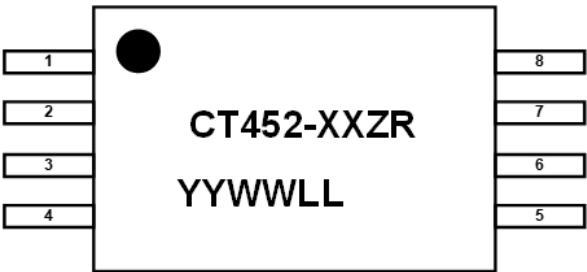
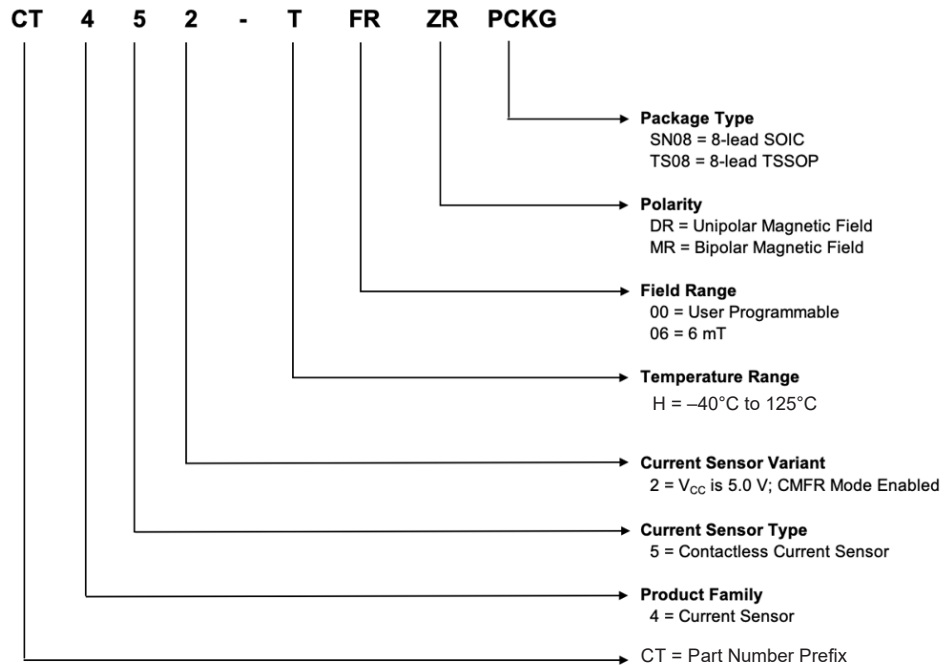


Figure 35: CT452 Device Marking
for 8-Lead TSSOP Package

Table 7: CT452 Device Marking Definition for 8-lead TSSOP Package

| Row No. | Code | Definition |
|---------|-------|-------------------------------|
| 1 | • | Pin 1 Indicator |
| 2 | CT452 | Allegro Part Number |
| 2 | XX | Maximum Magnetic Field Rating |
| 2 | ZR | Magnetic Field Range |
| 3 | YY | Calendar Year |
| 3 | WW | Work Week |
| 3 | LL | Lot Code |

PART ORDERING NUMBER LEGEND



Revision History

| Number | Date | Description |
|--------|-------------------|--|
| 1 | November 2, 2023 | Document rebranded and minor editorial updates |
| 2 | February 15, 2024 | Removed AEC-Q100 (pages 1, 2, 21-23), and updated Selection Guide (page 2) and MSL levels (page 21) |
| 3 | February 29, 2024 | Updated Offset Voltage (pages 9-12); removed Out Accuracy Performance and Lifetime Drift footnotes (pages 9-12); updated Sensitivity and removed Noise (pages 11-12); and updated branding information (pages 21-22) |

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