CT110

XtremeSense™ High-Linearity, High-Resolution TMR Current Sensor with $\overline{\text{FLAG}}$ Output in Miniature Form Factor

FEATURES AND BENEFITS

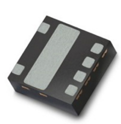
- Current range: ±5.0 A, ±10.0 A, ±15.0 A
- Resolution: 5 mA
- Total output error: <±0.5% (Typical)
- 2 kV isolation per IEC 62368-1
- Sampling frequency: 200 kHz
- Supply current: ~1.2 mA
- $\overline{\text{FLAG}}$ pin to detect 90% and 10% of full current range
  - Active low digital output (push-pull)
- Supply voltage: 2.7 to 5.5 V
- Operating temperature ranges:
  - Industrial: –40°C to 85°C
  - Extended Industrial: –40°C to 125°C
- Package: 6-lead DFN, 3.00 mm × 3.00 mm × 0.95 mm

APPLICATIONS

- Shunt resistor plus isolation amplifier replacement
- Smart plugs/IoT devices
- LED lighting products
- Power tools
- Appliances
- Drones
- Battery charger systems
- PCs and servers

PACKAGE:

Not to scale



6-lead DFN

DESCRIPTION

The CT110 is a high-linearity and high-resolution contact current sensor with isolation that is designed with its patented state-of-the-art XtremeSense™ TMR technology for high performance. The device measures the current flowing through the DFN package via its integrated current-carrying conductor (CCC) and converts it to an analog ratiometric output voltage that represents the current. The CT110 achieves superior performance with a typical total output error of less than ±0.5% and is capable of sensing current as low as 5 mA, providing unmatched resolution. The device supports a wide operating voltage range of 2.7 to 5.5 V which allows it to be used in a variety of applications.

The CT110 is an ideal solution to replace a shunt resistor plus isolation amplifier. At the same time, the CT110 simplifies design, PCB layout, and saves PCB area. The device is capable of supporting up to 15.0 A of AC and DC current.

The CT110 has a sampling frequency of 200 kHz but only has minimal current consumption of 1.0 mA to bias it since the measured current does not go through the device. Additionally, the CT110 integrates a $\overline{\text{FLAG}}$ output that is active low and will indicate when the field is above 90% and below 10% the full field range.

The CT110 is available in a low-profile and small form factor 3.00 mm × 3.00 mm × 0.95 mm, 6-lead DFN package.

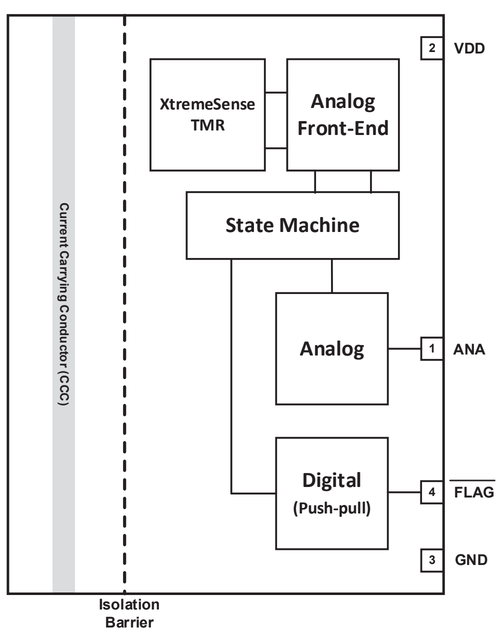


Figure 1: CT110 with Analog and $\overline{\text{FLAG}}$ Outputs in DFN-6 Package Block Diagram

SELECTION GUIDE

Part Number	Current Range (IP_{MAX}) (A)	Sensitivity (mV/A) V_{DD} = 5 V	Sensitivity (mV/A) V_{DD} = 3.3 V	Total Error (%FS)	Operating Temperature Range (°C)
CT110FDC-ID6	±5.0	412.5	272.25	±3.0	–40 to 85
CT110FDC-HD6					–40 to 125
CT110FDV-ID6				±5.0	–40 to 85
CT110FDV-HD6					–40 to 125
CT110PDC-ID6	±10.0	200	132	±3.0	–40 to 85
CT110PDC-HD6					–40 to 125
CT110PDV-ID6				±5.0	–40 to 85
CT110PDV-HD6					–40 to 125
CT110RDC-ID6	±15.0	132.5	87.45	±3.0	–40 to 85
CT110RDC-HD6					–40 to 125
CT110RDV-ID6				±5.0	–40 to 85
CT110RDV-HD6					–40 to 125

EVALUATION BOARD ORDERING INFORMATION

Part Number	Current Range (A)	Total Error (%FS)	Operating Temperature Range (°C)
EVB111-5.0A	±5.0	±3.0	–40 to 125
EVB111-10A	±10.0		
EVB111-15A	±15.0		

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PINOUT DIAGRAMS AND TERMINAL LIST

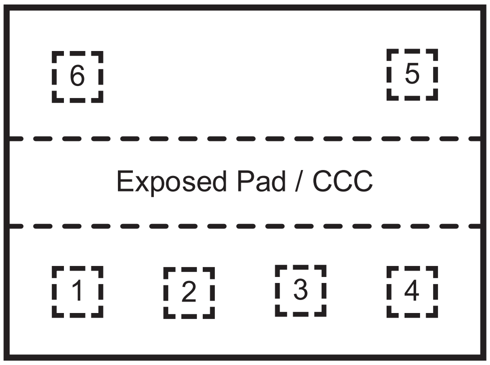

Figure 4: 6-Lead DFN Package, Top View (Through Package)

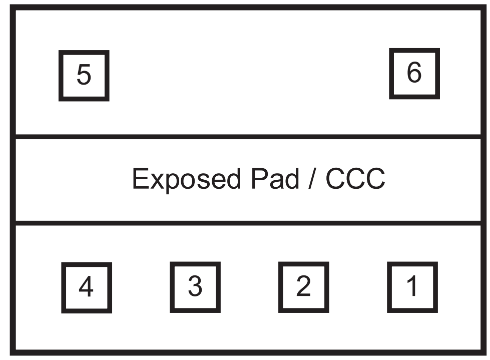

Figure 5: 6-Lead DFN Package, Bottom-up View

Terminal List Table

Number	Name	Function
1	ANA	Analog output voltage that represents the measured current.
2	VDD	Supply Voltage
3	GND	Ground
4	$\overline{\text{FLAG}}$	Outputs an active LOW flag signal to indicate when the current is above 90% or below 10% of the full current range. It is a push-pull output.
5	N/C	No Connect
6	N/C	No Connect

CT110 DIRECTION OF CURRENT FLOW DIAGRAMS

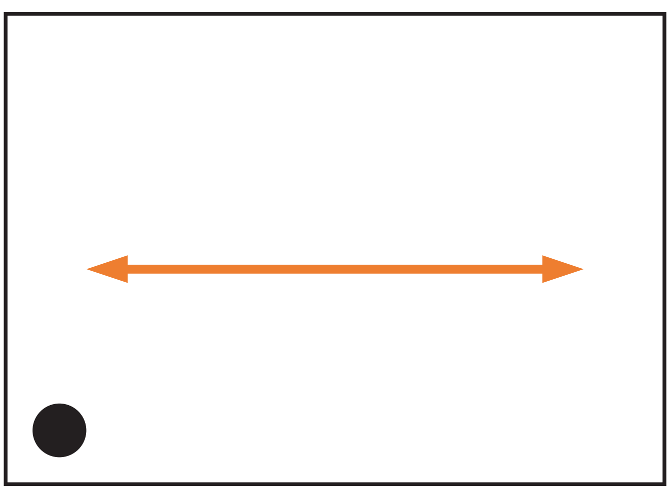

Figure 2: CT110, Direction of Bipolar Current Flow

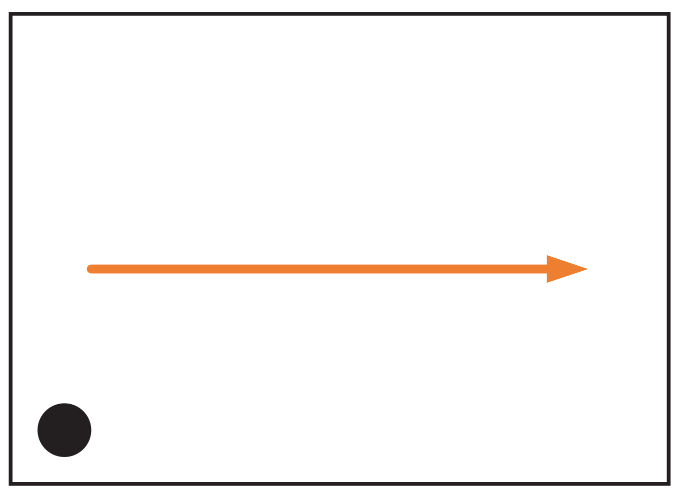

Figure 3: CT110, Recommended Direction for Unipolar Current Flow

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ABSOLUTE MAXIMUM RATINGS [1]

Characteristic	Symbol	Notes	Rating	Unit
Supply Voltage Strength	V_{DD}		–0.3 to 6.0	V
Push-Pull Output (Active LOW)	$V_{FLAG\#\_PP}$		–0.3 to V_{DD} + 0.3 [2]	V
Input/Output Pins Maximum Voltage	$V_{I/O}$		–0.3 to V_{DD} + 0.3 [2]	V
Electrostatic Discharge Protection Level	ESD	Human Body Model (HBM) per JESD22-A114	±2.0 (min)	kV
Junction Temperature	T_J		–40 to 150	°C
Storage Temperature	T_{STG}		–65 to 150	°C
Lead Soldering Temperature	T_L	10 seconds	260	°C

[1] Stresses exceeding the absolute maximum ratings may damage the CT110 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_{DD} + 0.3 V or 6.0 V.

RECOMMENDED OPERATING CONDITIONS [1]

Characteristic	Symbol	Notes	Min.	Typ.	Max.	Unit
Supply Voltage Range	V_{DD}		2.7	5.0	5.5	V
Output Voltage Range	V_{OUT}		0	–	V_{DD}	V
Output Current	I_{OUT}		–	–	±10.0	μA
Operating Ambient Temperature	T_A	Industrial	–40	25	85	°C
		Extended Industrial	–40	25	125	°C

[1] The Recommended Operating Conditions table defines the conditions for actual operation of the CT110. Recommended operating conditions are specified to ensure optimal performance to the specifications. Allegro does not recommend exceeding them or designing to absolute maximum ratings.

ISOLATION RATING

Characteristic	Symbol	Notes	Rating	Unit
Dielectric Strength Test (Rated Isolation) Voltage	V_{ISO}	Tested for 60 seconds per IEC 60950-1:2005 +Am1:2009 + Am2:2013 and UL1577	20 (typ.)	kV_{RMS}

THERMAL CHARACTERISTICS

Characteristic	Symbol	Test Conditions	Value	Unit
Junction-to-Ambient Thermal Resistance	$R_{\theta JA}$	Junction-to-ambient thermal resistance is a function of application and board layout and is determined in accordance to JEDEC standard JESD51 for a four (4) layer 2s2p FR-4 printed circuit board (PCB) with 2 oz. of copper (Cu). Special attention must be paid not to exceed junction temperature $T_{J(MAX)}$ at a given ambient temperature T_A.	162 (typ.) 187 (max)	°C/W

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ELECTRICAL CHARACTERISTICS: Valid for V_{DD} = 2.7 to 5.5 V, C_{BYP} = 1.0 µF and T_A = –40°C to 125°C, typical values are V_{DD} = 5.0 V and T_A = 25°C, unless otherwise specified

Characteristics	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
Average Supply Current	$I_{DD(AVG)}$	t ≥ 10 seconds	–	1.2	2.5	mA
Sampling Frequency	f_S		150	200	250	kHz
Idle Mode Time	t_{IDLE}	f_S = 200 kHz	4.0	5.0	6.7	µs
Resistance of CCC in DFN Package [1]	R_{CCC_DFN}		–	0.9	–	mΩ
ANALOG OUTPUT (ANA)						
Maximum Drive Capability	$I_{DRV(MAX)}$	ΔV_{OUT} ≤ 150 mV, V_{DD} ≥ 3.3 V	–10	–	10	µA
Analog Output Voltage Range	V_{ANA}		0.05 × V_{DD}	–	0.95 × V_{DD}	V
Voltage Output Quiescent	V_{OQ}		48.5	50.0	51.5	% V_{DD}
Rise Time [1]	t_{RISE}	$I_{CCC} = I_{CCC(MAX)}$, $t_{VANA\_90\%} - t_{VANA\_10\%}$	–	15.5	–	µs
Propagation Delay [1]	t_{DELAY}	$I_{CCC} = I_{CCC(MAX)}$, $t_{ICCC} - t_{VANA}$ @ 20% of output value	–	4.6	–	µs
Response Time [1]	t_{RESP}	$I_{CCC} = I_{CCC(MAX)}$, $t_{ICCC} - t_{VANA}$ @ 90% of output value	–	20.0	–	µs
Input Referred Noise Density [1]	e_{ND}	f_{BW} = 10 Hz	–	250	–	$\mu A_{RMS} / \sqrt{Hz}$
Output Capacitive Load	C_L		–	–	10	pF
$\overline{\text{FLAG}}$ PUSH-PULL OUTPUT ($\overline{\text{FLAG}}$)						
$\overline{\text{FLAG}}$ Voltage Low	$V_{FLAG\#\_OL}$	AC and DC current	–	0.9 × V_{DD}	–	V
		AC current	–	0.1 × V_{DD}	–	V
$\overline{\text{FLAG}}$ Voltage High	$V_{FLAG\#\_OH}$	AC and DC current	–	0.86 × V_{DD}	–	V
		AC current	–	0.14 × V_{DD}	–	V
$\overline{\text{FLAG}}$ Current	$I_{FLAG\#}$		–	±2	–	mA
TIMINGS						
Power-On Time [1]	t_{ON}	V_{DD} ≥ 2.7 V	–	50	75	µs
Active Mode Time	t_{ACTIVE}		–	2.5	–	µs
PROTECTION						
Undervoltage Lockout	V_{UVLO}	Rising V_{DD}	–	2.3	2.5	V
		Falling V_{DD}	2.0	2.2	–	V
UVLO Hysteresis	V_{UV_HYS}		–	100	–	mV

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

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TYPICAL TIMING AND ELECTRICAL CHARACTERISTICS

V_{DD} = 5.0 V, T_A = 25°C, and C_{BYP} = 1.0 µF (unless otherwise specified)

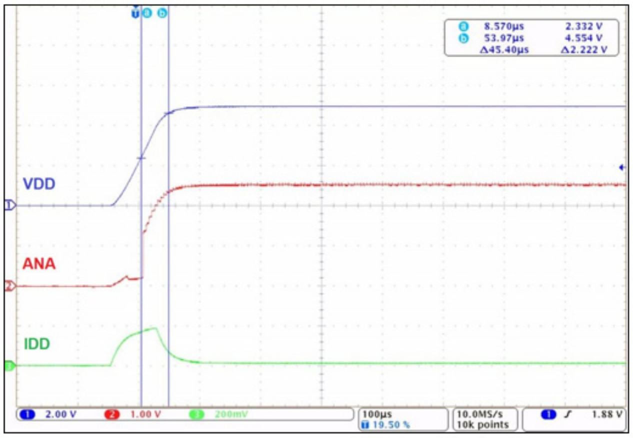

Figure 6: Power-On Time for CT110

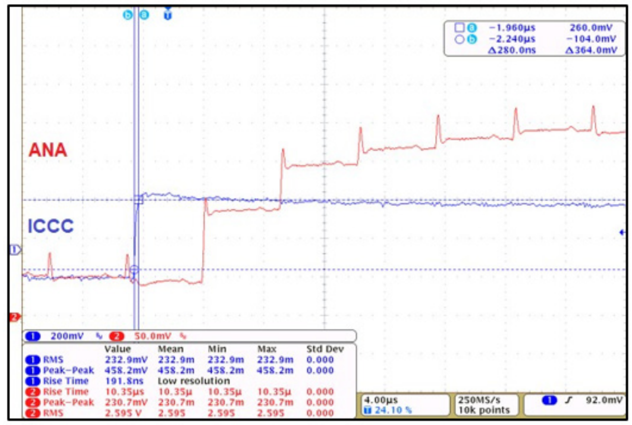

Figure 7: Rise Time for CT110

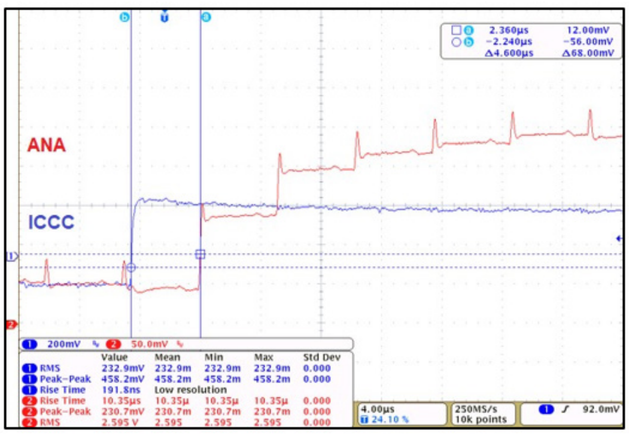

Figure 8: Propagation Delay Time for CT110

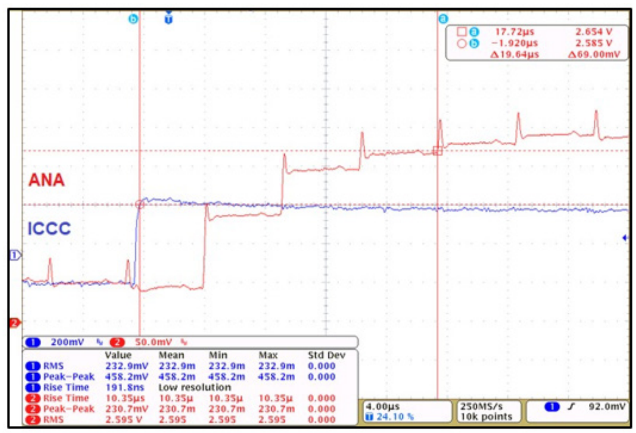

Figure 9: Response Time for CT110

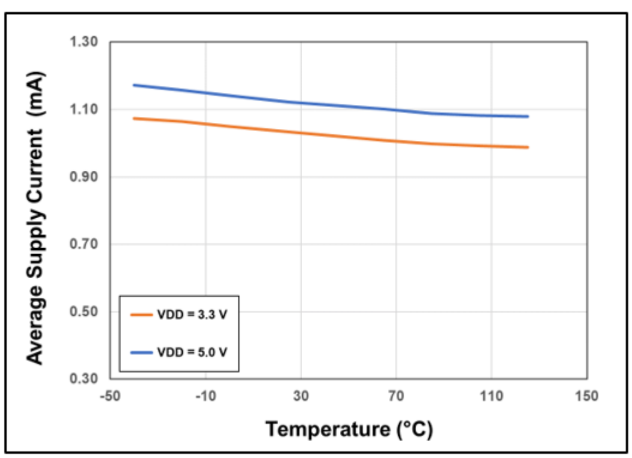

Figure 10: CT110 Average Supply Current vs. Temperature vs. Supply Voltage

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CT110FDx (±5.0 A) ELECTRICAL CHARACTERISTICS: Valid for V_{DD} = 2.7 to 5.5 V, C_{BYP} = 1.0 µF and T_A = –40°C to 125°C, typical values are V_{DD} = 5.0 V and T_A = 25°C, unless otherwise specified

Characteristics	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
ANALOG OUTPUT						
Gain	G	V_{DD} = 5.0 V, T_A = 25°C	392.5	412.5	432.5	mV/A
		V_{DD} = 3.3 V, T_A = 25°C	259.0	272.25	285.45	mV/A
Current Sensing Range [1]	I_{CCC}		–5	–	+5	A_{DC}
RESOLUTION						
Resolution	RES	I_{CCC} = ±5 A	–	5	–	mA
TOTAL OUTPUT ERROR PERFORMANCE						
Total Output Error for CT110FDC	E_{TOT_FDC}	T_A = 0°C to 125°C	–	±0.5	±1.5	% FS
		T_A = –40°C to 125°C	–	±0.5	±3.0	% FS
Total Output Error for CT110FDV	E_{TOT_FDV}	T_A = 0°C to 125°C	–	±0.5	±1.5	% FS
		T_A = –40°C to 125°C	–	±0.5	±5.0	% FS
TOTAL OUTPUT ERROR COMPONENTS						
Non-Linearity Error	e_{LIN}	I_{CCC} = 5 A	–	±0.15	–	% FS
Temperature Coefficient of Sensitivity for CT110FDC [1]	TCS_{FDC}	T_A = 0°C to 125°C	–	–70	–	ppm/°C
		T_A = –40°C to 125°C	–	–150	–250	ppm/°C
Temperature Coefficient of Sensitivity for CT110FDV [1]	TCS_{FDV}	T_A = 0°C to 125°C	–	–100	–	ppm/°C
		T_A = –40°C to 125°C	–	–200	-400	ppm/°C
Temperature Coefficient of Offset Voltage [1]	TCO	T_A = –40°C to 125°C, V_{DD} = 5.0 V	–	100	–	ppm/°C
NOISE						
Input Referred Noise [1]	e_N	f_{BW} = 1 Hz to 30 kHz, V_{DD} = 5.0 V	–	10	–	mA_{RMS}

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

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TYPICAL ELECTRICAL CHARACTERISTICS FOR CT110FDx

V_{DD} = 5.0 V, T_A = 25°C, and C_{BYP} = 1.0 µF (unless otherwise specified)

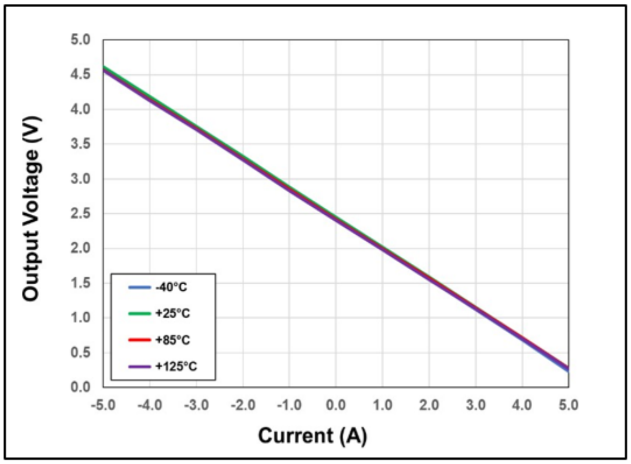

Figure 11: CT110FDx Output Voltage vs. Current vs. Temperature

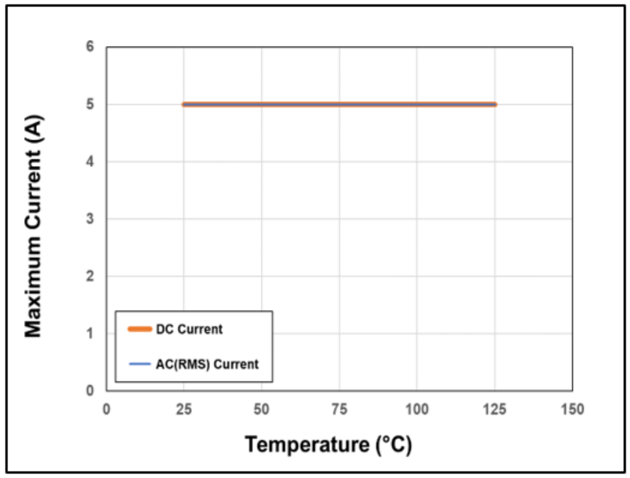

Figure 12: CT110FDx Maximum Current Derating Curve

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CT110PDx (±10.0 A) ELECTRICAL CHARACTERISTICS: Valid for V_{DD} = 2.7 to 5.5 V, C_{BYP} = 1.0 µF and T_A = –40°C to 125°C, typical values are V_{DD} = 5.0 V and T_A = 25°C, unless otherwise specified

Characteristics	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
ANALOG OUTPUT						
Gain	G	V_{DD} = 5.0 V, T_A = 25°C	190	200	210	mV/A
		V_{DD} = 3.3 V, T_A = 25°C	125.4	132	138.6	mV/A
Current Sensing Range [1]	I_{CCC}		–10	–	+10	A_{DC}
RESOLUTION						
Resolution	RES	I_{CCC} = ±10 A	–	5.0	–	mA
TOTAL OUTPUT ERROR PERFORMANCE						
Total Output Error for CT110PDC	E_{TOT_PDC}	T_A = 0°C to 125°C	–	±0.5	±1.5	% FS
		T_A = –40°C to 125°C	–	±0.5	±3.0	% FS
Total Output Error for CT110PDV	E_{TOT_PDV}	T_A = 0°C to 125°C	–	±0.5	±1.5	% FS
		T_A = –40°C to 125°C	–	±0.5	±5.0	% FS
TOTAL OUTPUT ERROR COMPONENTS						
Non-Linearity Error	e_{LIN}	I_{CCC} = 10 A	–	±0.15	–	% FS
Temperature Coefficient of Sensitivity for CT110FDC [1]	TCS_{FDC}	T_A = 0°C to 125°C	–	–70	–	ppm/°C
		T_A = –40°C to 125°C	–	–150	–250	ppm/°C
Temperature Coefficient of Sensitivity for CT110FDV [1]	TCS_{FDV}	T_A = 0°C to 125°C	–	–100	–	ppm/°C
		T_A = –40°C to 125°C	–	–200	-400	ppm/°C
Temperature Coefficient of Offset Voltage [1]	TCO	T_A = –40°C to 125°C, V_{DD} = 5.0 V	–	100	–	ppm/°C
NOISE						
Input Referred Noise [1]	e_N	f_{BW} = 1 Hz to 30 kHz, V_{DD} = 5.0 V	–	8	–	mA_{RMS}

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

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TYPICAL ELECTRICAL CHARACTERISTICS FOR CT110PDx

V_{DD} = 5.0 V, T_A = 25°C, and C_{BYP} = 1.0 µF (unless otherwise specified)

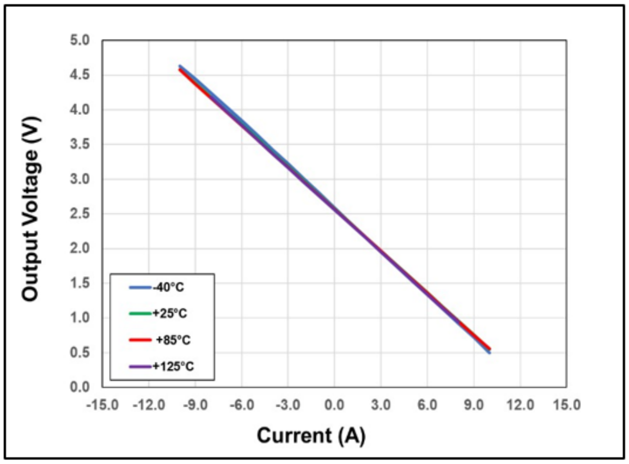

Figure 13: CT110PDx Output Voltage vs. Current vs. Temperature

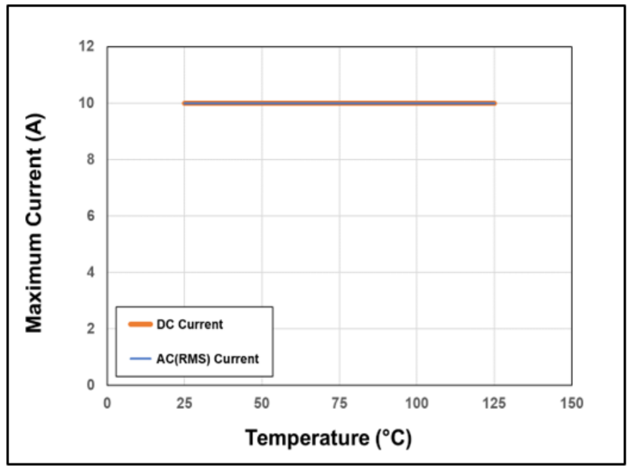

Figure 14: CT110PDx Maximum Current Derating Curve

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CT110RDx (±15.0 A) ELECTRICAL CHARACTERISTICS: Valid for V_{DD} = 2.7 to 5.5 V, C_{BYP} = 1.0 µF and T_A = –40°C to 125°C, typical values are V_{DD} = 5.0 V and T_A = 25°C, unless otherwise specified

Characteristics	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
ANALOG OUTPUT						
Gain	G	V_{DD} = 5.0 V, T_A = 25°C	122.5	132.5	142.5	mV/A
		V_{DD} = 3.3 V, T_A = 25°C	80.85	87.45	94.0	mV/A
Current Sensing Range [1]	I_{CCC}		–10	–	+10	A_{DC}
RESOLUTION						
Resolution	RES	I_{CCC} = ±15 A_{PK}	–	5	–	mA
TOTAL OUTPUT ERROR PERFORMANCE						
Total Output Error for CT110RDC	E_{TOT_RMC}	T_A = 0°C to 125°C	–	±0.5	±1.5	% FS
		T_A = –40°C to 125°C	–	±0.5	±3.0	% FS
Total Output Error for CT110RDV	E_{TOT_RMV}	T_A = 0°C to 125°C	–	±0.5	±1.5	% FS
		T_A = –40°C to 125°C	–	±0.5	±5.0	% FS
TOTAL OUTPUT ERROR COMPONENTS						
Temperature Coefficient of Sensitivity for CT110FDC [1]	TCS_{FDC}	T_A = 0°C to 125°C	–	–70	–	ppm/°C
		T_A = –40°C to 125°C	–	–150	–250	ppm/°C
Temperature Coefficient of Sensitivity for CT110FDV [1]	TCS_{FDV}	T_A = 0°C to 125°C	–	–100	–	ppm/°C
		T_A = –40°C to 125°C	–	–200	-400	ppm/°C
Temperature Coefficient of Offset Voltage [1]	TCO	T_A = –40°C to 125°C, V_{DD} = 5.0 V	–	100	–	ppm/°C
NOISE						
Input Referred Noise [1]	e_N	f_{BW} = 1 Hz to 30 kHz, V_{DD} = 5.0 V	–	8	–	mA_{RMS}

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

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TYPICAL ELECTRICAL CHARACTERISTICS FOR CT110RDx

V_{DD} = 5.0 V, T_A = 25°C, and C_{BYP} = 1.0 µF (unless otherwise specified)

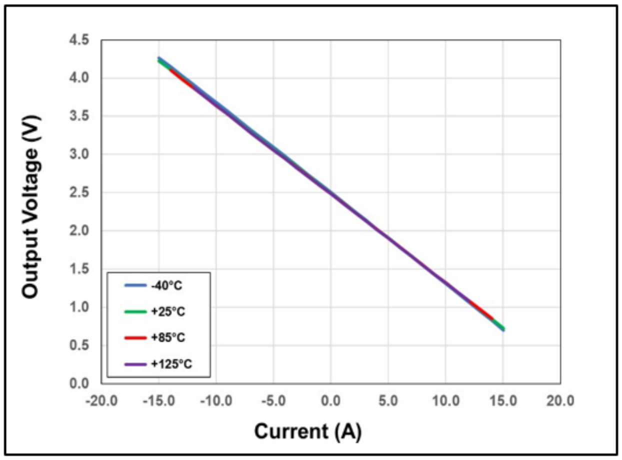

Figure 15: CT110RDx Output Voltage vs. Current vs. Temperature

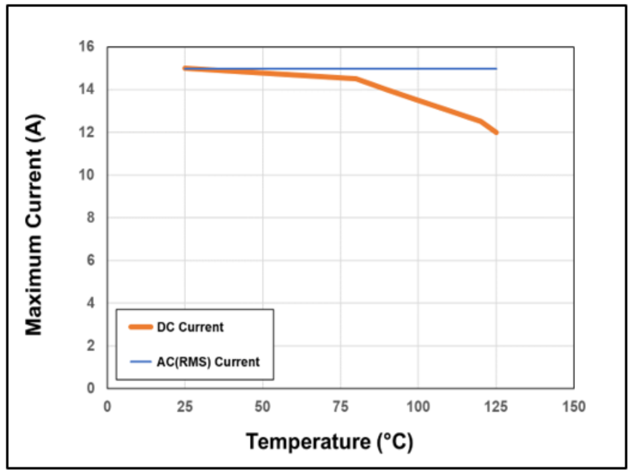

Figure 16: CT110RDx Maximum Current Derating Curve

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FUNCTIONAL DESCRIPTION

Overview

The CT110 is a high resolution and low noise contact current sensor with isolation and a $\overline{FLAG}$ output that operates from 2.7 to 5.5 V assembled in a custom DFN package. The chip measures the magnetic field of the current through the package and converts it to an analog signal that is equivalent to the current flowing through the printed circuit board (PCB) trace. The $\overline{FLAG}$ output indicates whether there is an overcurrent condition seen by CT110 during operation and will alert the host system.

Analog Output Measurement

The CT110 provides a continuous (sample and hold) linear analog output voltage which represents the measured magnetic field of the current. The output voltage range of ANA is 5.0% of V_{DD} to 95.0% of V_{DD} which represents the current from the typical low-end values (–5.0 A to –15.0 A_{PK}) to the maximum current values (+5.0 A to +15.0 A_{PK}) respectively. The output sample frequency is 200 kHz. A resistor-capacitor (R-C) filter may be implemented on the ANA pin to further lower the noise. Figure 17 illustrates the output voltage range of the ANA pin as a function of the measured current for ±5.0 A.

Current Detection Flag

The Current Detection circuitry detects when the current measured through the current carrying conductor is above 90% or below 10% of the full current range. As a result, it translates to greater than 90% of V_{DD} and 10% of V_{DD} on the ANA pin. This will generate a flag signal via the $\overline{FLAG}$ pin to the host system microcontroller as an active LOW signal. Once V_{ANA} falls below 86% or rises above 14% of V_{DD}, then the $\overline{FLAG}$ signal will go HIGH.

Rise Time (t_{RISE})

The CT110 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 CT110 is 15.5 µs.

Propagation Delay (t_{DELAY})

The propagation delay, t_{DELAY}, is the time measured between I_{CCC} reaching 20% of its final value and the CT110 attaining 20% of its full-scale output voltage. Its propagation delay is 4.6 µs.

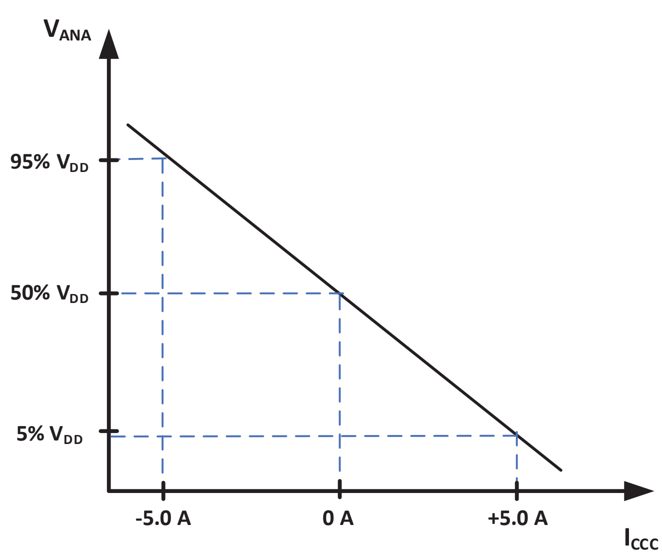

Figure 17: Linear Output Voltage Range vs. Measured Current for G = –88.2 mV/V/A and current range of ±5.0 A.

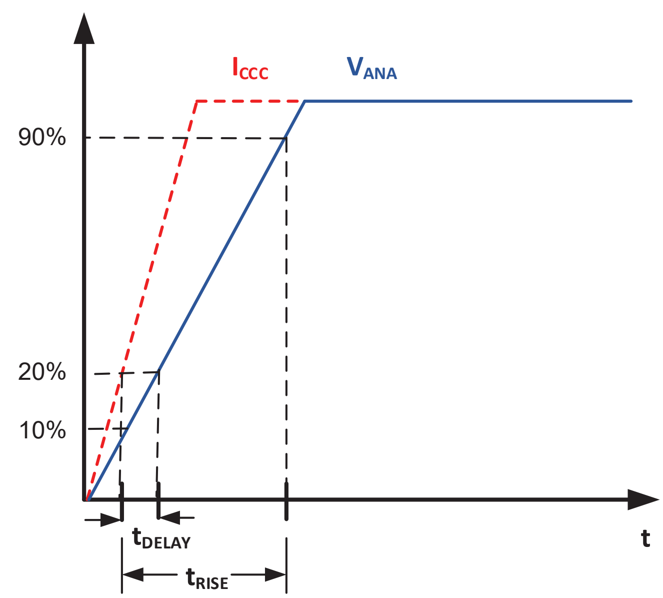

Figure 18: CT110 Propagation Delay and Rise Time Curve

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Response Time (t_{RESP})

The response time, t_{RESP}, is the difference in time from when I_{CCC} reaches 90% of its final value and V_{ANA} attains 90% of its final value. The CT110 response time is typically 20.0 µs.

Power-On Time (t_{ON})

The Power-On Time (t_{ON}) of 50 µs is the amount of time required by the CT110 to start up, power-on, and acquire the first sample. The chip is fully powered up and operational from the moment the supply voltage passes the rising UVLO point (2.3 V). This time includes ramp-up time and settling time (within 10% of steady-state voltage when current is flowing through the package) after the power supply has reached the minimum V_{DD}.

Undervoltage Lockout (UVLO)

The Undervoltage Lockout protection circuitry of the CT110 is activated when the supply voltage (V_{DD}) falls below 2.1 V. The CT110 remains in a low quiescent state and the ANA output is not valid until V_{DD} rises above the UVLO threshold (2.3 V).

High Resolution and Low Noise

For DC current, the resolution is 5 mA while the input referred noise is 8 mA_{RMS} (up to 10 mA_{RMS}); however, there is no contradiction in the CT110 capability to sense this level of current because the 5 mA was measured with a digital multimeter (DMM) with limited bandwidth, whereas the noise is over a wider bandwidth (up to 30 kHz).

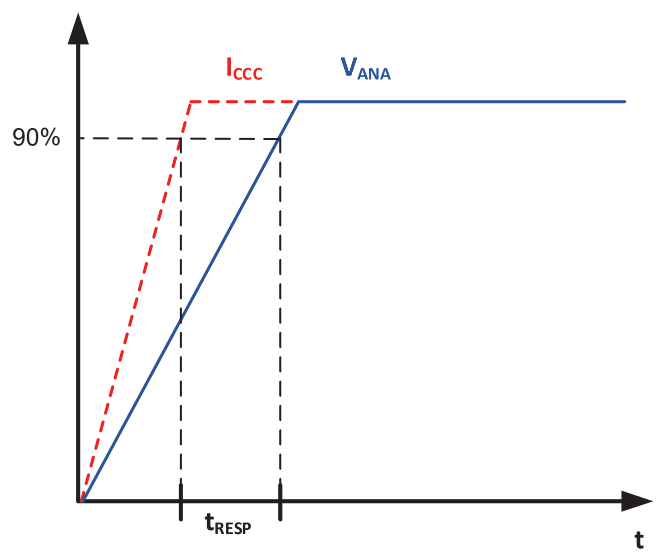

Figure 19: Linear Output Voltage Range vs. Measured Current for G = –88.2 mV/V/A and current range of ±5.0 A.

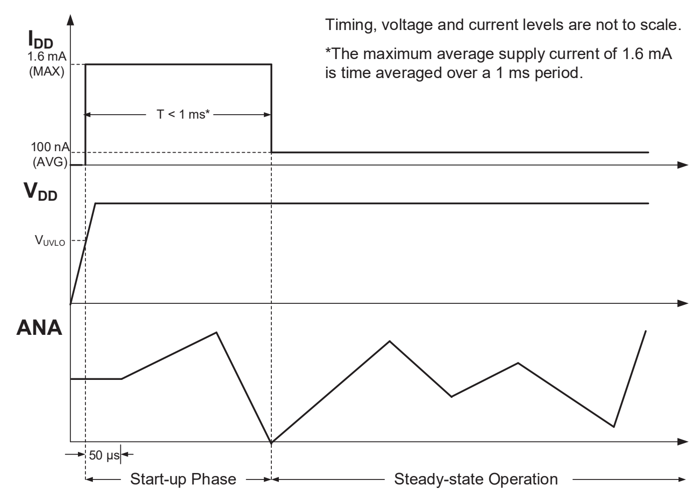

Figure 20: CT110 Propagation Delay and Rise Time Curve

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CALIBRATION GUIDE

Introduction

All current sensors, no matter how expensive they are, or what materials they use, or even if they were factory-calibrated, are susceptible to deviations from their Ideal Transfer Line.

To extract the absolute best performance from any current sensing system, calibration is required.

Ideal Transfer Line

Ideally, the sensor output follows a straight line, has a fixed slope, and crosses a fix offset point. This allows the user to apply a straightforward linear equation to extract the physical value being measured. In the case of a current sensor:

$$Current = \frac{Voltage - b}{a}$$

where a is the slope and b is the offset of the ideal curve. In a perfect sensor, both a and b coefficients can be simply looked up on the datasheet.

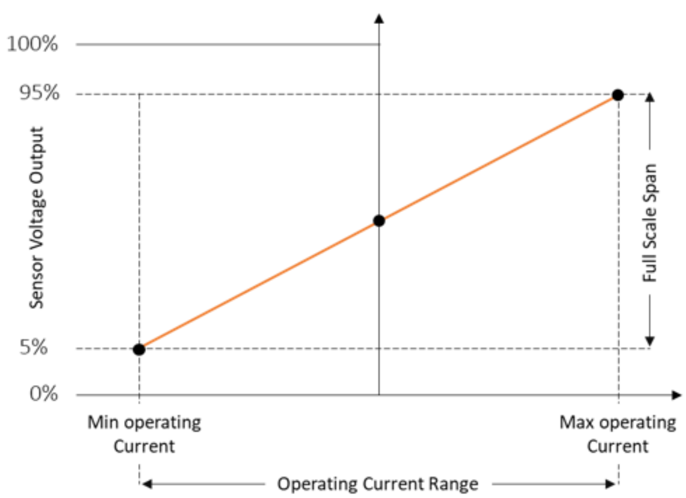

Figure 21: Ideal Transfer Line

Any deviations from this Ideal Line are considered sensor errors—more specifically, Accuracy Errors as they related in the case of Allegro sensors to Gain and Offset errors.

Offset Error

Based on the Ideal Transfer Line, when no current is applied, the voltage output of the sensor should be equal to 50% of V_{DD}.

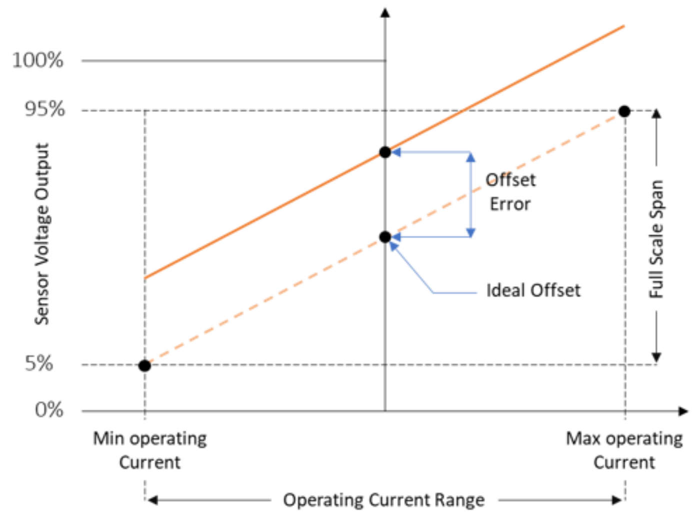

Figure 22: Exaggerated Offset Error

Gain Error

The Ideal Transfer Line shows a line that reaches 95% of V_{DD} at the maximum operating current and 5% of V_{DD} at the minimum.

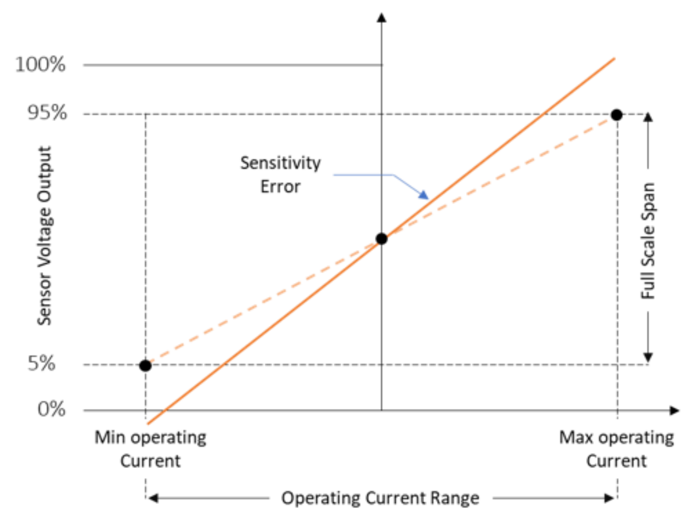

Figure 23: Exaggerated Gain Error

Calibration

Different methods can be applied for offset and/or gain correction. The complexity of these methods lead to different calibration results. The higher the complexity the better the error correction.

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Simple Offset Correction

Offset calibration is achieved simply by storing the voltage output of the sensor at zero flowing current.

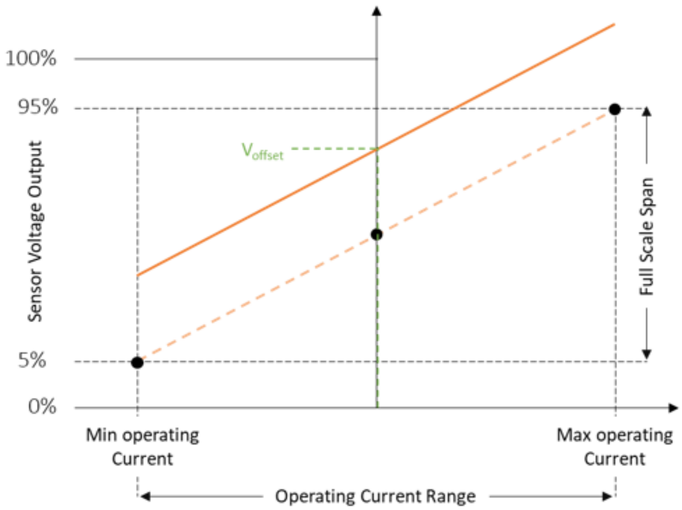

Figure 24: Simple Offset Calibration

This stored value V_{OFFSET} becomes the coefficient b in the linear transfer function:

$$Current = \frac{Voltage - b}{a}$$

Simple Gain Correction

Basic Gain calibration can be achieved by applying a known current value (A_1) and measuring the sensor output voltage value (V_1).

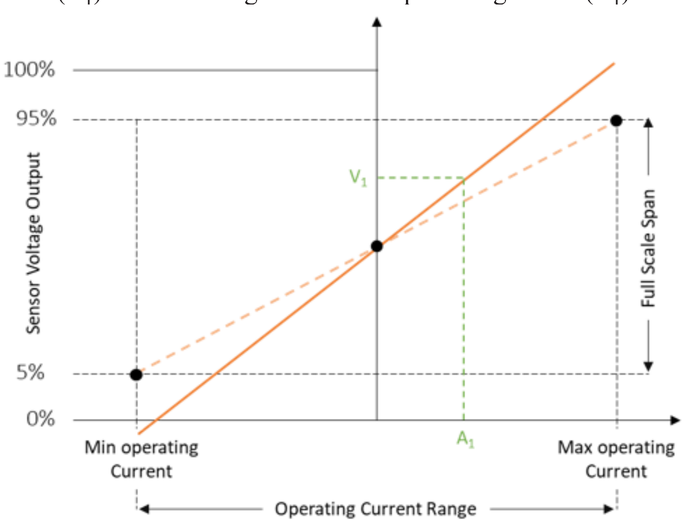

Figure 25: Simple Gain Calibration

The following equation is used to calculate the slope coefficient a:

$$a = \frac{V_1 - V_{OFFSET}}{A_1}$$

Recommended Offset and Gain Correction

For bidirectional current applications, the steps below are recommended for users trying to perform the best error correction of gain and offset.

1. Apply a known current value (A_1) and measure voltage output (V_1)
2. Apply a second current value (A_2) and measure the voltage output (V_2)
3. Calculate the slope using the following equation

It is recommended that the applied currents A_1 and A_2 are the absolute maximum and minimum operating current the sensor will see during its normal operations.

Also, A1 = –A2 for bidirectional current sensing.

$$a = \frac{V_1 - V_2}{A_1 - A_2} \qquad b = \frac{V_1 + V_2}{2}$$

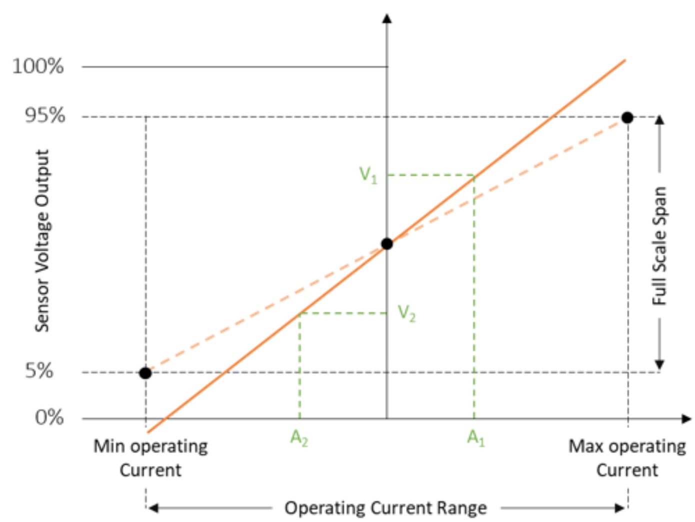

Figure 26: Gain Calibration

Both calculated coefficients a and b are then used to calculate the current:

$$Current = \frac{Voltage - b}{a}$$

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APPLICATIONS INFORMATION

The CT110 is able to replace a shunt resistor plus isolation amplifier circuit to measure the current in various applications. It has an embedded exposed pad that can support up to +10 A_{DC} or ±15.0 A_{PK} of current flow through the package. Figure 27 illustrates the CT110 where the PCB trace is connected to the current-carrying conductor (CCC) to allow the current flow through it. The current that flows through the exposed pad generates a magnetic field and is sensed by the XtremeSense TMR sensor in the CT110 and converts it into a ratiometric linear analog output voltage that is representative of the measured current. The C110 has at least 2 kV of isolation to protect low voltage circuits from high voltage circuits. The CT110 only needs a 1.0 µF bypass capacitor. A resistor-capacitor filter on the ANA pin is recommended to minimize the output noise as shown in Figure 27. Refer to Table 2 for recommended cutoff frequencies.

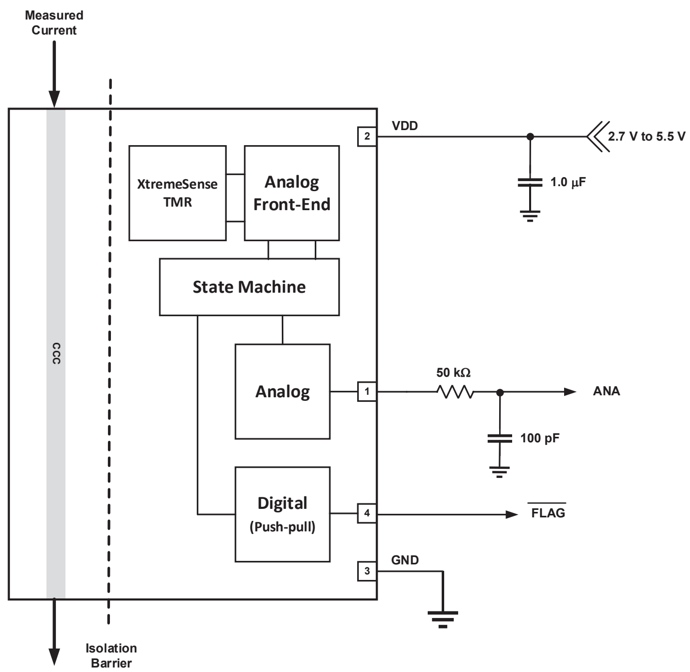

Figure 27: CT110 with Analog and FLAG Outputs Application Block Diagram

Table 1: Recommended External Components for CT110

Component	Description	Vendor and Part Number	Parameter	Min.	Typ.	Max.	Unit
C_{BYP}	1.0 µF, X5R or Better	Murata RM155C81A105KA12	C	–	1.0	–	µF
R_{FILTER}	50 kΩ, ±5%	Various	R	–	47	–	kΩ
C_{FILTER}	10 pF, X5R or Better	Various	C	–	10	–	pF

Table 2: Recommended Cut-off Frequencies for CT110 and its Resistor-Capacitor Values

Cut-off Frequency (kHz)	Resistor Value (kΩ)	Capacitor Value (pF)
1	105	1,500
10	105	150
30	50	100

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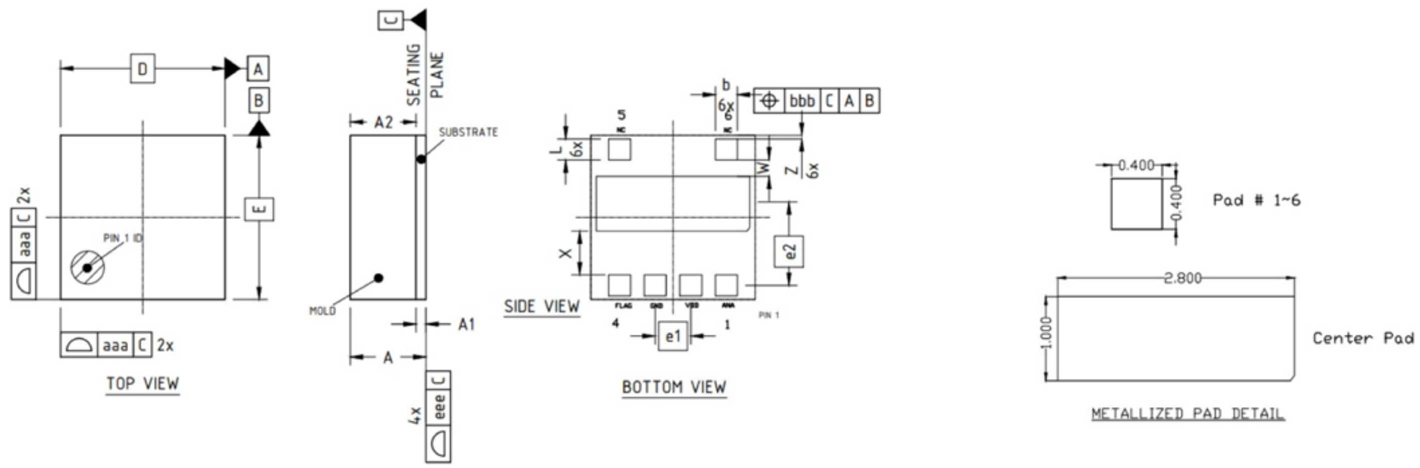
PACKAGE OUTLINE DRAWING



NOTES:

1. Dimension *e* represents the basic terminal pitch. It specifies the geometric position of the terminal axis.
2. Dimension *b* applies to the metalized terminal pads.
3. Dimension *A* includes package warpage.
4. Exposed metalized pads are Cu (Copper) pads with OSP surface.
5. All dimensions are in millimeters (mm).

Figure 28: DFN-6 Package Drawing and Dimensions

Table 3: CT110 DFN-6 Package Dimensions

Symbol	Dimensions in Millimeters (mm)		
	Min.	Typ.	Max.
A	0.880	0.950	1.020
A1	0.225	0.250	0.255
A2	0.650	0.700	0.750
b	0.375	0.400	0.425
D	3.00 BSC		
E	3.00 BSC		
L	0.375	0.400	0.425
X	0.775	0.800	0.825
W	0.275	0.300	0.325
Z	0.025	0.050	0.075
e1	0.65 BSC		
e2	1.50 BSC		
aaa	0.050		
bbb	0.050		
eee	0.050		

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PACKAGE INFORMATION

Table 4: CT110 Package Information

Part Number	Package Type	# of Leads	Package Quantity	Lead Finish	MSL Rating [2]	Operating Temperature [3]	Device Marking [4]
CT110FDC-ID6	DFN	6	3000	Sn	3	–40°C to 85°C	10FDC YYWWS
CT110FDC-HD6	DFN	6	3000	Sn	3	–40°C to 125°C	10FDC YYWWS
CT110FDV-ID6	DFN	6	3000	Sn	3	–40°C to 85°C	10FDV YYWWS
CT110FDV-HD6	DFN	6	3000	Sn	3	–40°C to 125°C	10FDV YYWWS
CT110PDC-ID6	DFN	6	3000	Sn	3	–40°C to 85°C	10PDC YYWWS
CT110PDC-HD6	DFN	6	3000	Sn	3	–40°C to 125°C	10PDC YYWWS
CT110PDV-ID6	DFN	6	3000	Sn	3	–40°C to 85°C	10PDV YYWWS
CT110PDV-HD6	DFN	6	3000	Sn	3	–40°C to 125°C	10PDV YYWWS
CT110RDC-ID6	DFN	6	3000	Sn	3	–40°C to 85°C	10RDC YYWWS
CT110RDC-HD6	DFN	6	3000	Sn	3	–40°C to 125°C	10RDC YYWWS
CT110RDV-ID6	DFN	6	3000	Sn	3	–40°C to 85°C	10RDV YYWWS
CT110RDV-HD6	DFN	6	3000	Sn	3	–40°C to 125°C	10RDV YYWWS

[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 ≤ 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 +150°C and storage temperature range of –65°C to 160°C.
[4] Device Marking for DFN is defined as 10xDy where x = current rating of CT110 and y = total output error; and YYWWZ = date code information where YY = year, WW = work week and Z = sequential number.

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Revision History

Number	Date	Description
3	November 2, 2023	Document rebranded and minor editorial updates

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