

XtremeSense™ TMR Current Sensor with High dV/dt Immunity, 5 kV Isolation, and Common-Mode Field Rejection

FEATURES AND BENEFITS

- Integrated contact current sensing for low to medium current ranges:
 - 0 to 20 A □ ± 30 A □ 0 to 65 A
 - ± 20 A □ 0 to 50 A □ ± 65 A
 - 0 to 30 A □ ± 50 A □ 0 to 70 A
- Optimized for high dV/dt applications
- Integrated current carrying conductor (CCC)
- Linear analog output voltage
- Total error output $\leq \pm 1.0\%$ FS, -40°C to 125°C
- 1 MHz bandwidth
- Response time: ~ 300 ns
- UL/IEC 62368-1 and UL1577 certification
 - Rated isolation voltage: 5 kV_{RMS}
 - Working voltage for basic isolation: $1100\text{ V}_{\text{RMS}}$
 - Working voltage for reinforced isolation: $550\text{ V}_{\text{RMS}}$
- Low noise: 9 to $15\text{ mA}_{\text{RMS}}$ @ $f_{\text{BW}} = 100\text{ kHz}$
- Immunity to common mode fields: -54 dB
- Supply voltage: 4.75 to 5.50 V
- AEC-Q100 grade 1

DESCRIPTION

The CT432 is a high bandwidth and ultra-low noise integrated contact current sensor that uses Allegro patented XtremeSense™ TMR technology to enable high accuracy current measurements for many industrial, consumer, and automotive applications. The device supports multiple current ranges where the integrated current carrying conductor (CCC) will handle up to 70 A of current and generates a current measurement as a linear analog output voltage. The device achieves a total output error of less than $\pm 1.0\%$ full-scale (FS) over voltage and the full temperature range.

The device has a ~ 300 ns output response time while the current consumption is $\sim 6.0\text{ mA}$ and is immune to common mode fields. The CT432 is optimized for high dV/dt applications which minimizes capacitive coupling to V_{OUT} , allowing the CT432 to be used in switching applications.

The CT432 is offered in an industry-standard 16-lead SOIC wide package that is green and RoHS compliant.

APPLICATIONS

- Power inverters
- UPS, SMPS, and telecom power supplies
- Motor control
- Overcurrent fault protection

PACKAGE:



TÜV Certificate No.:
R 72226133 0001



UL Certificate No.:
UL-CA-2201235-0

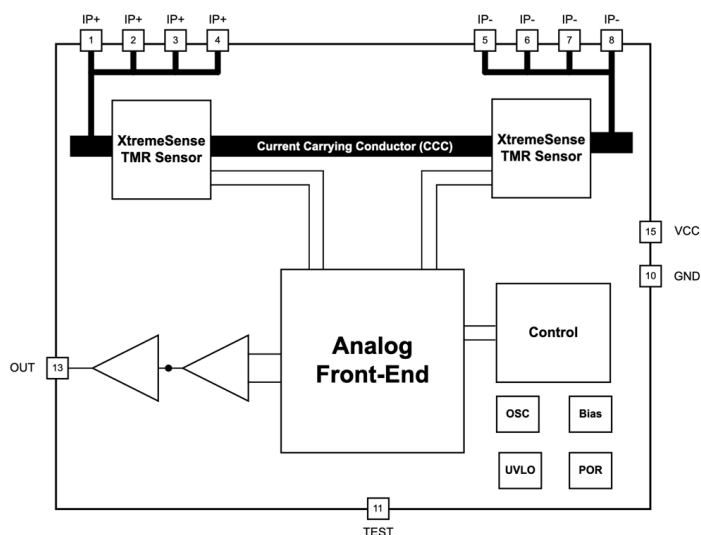


Figure 1: CT432 Functional Block Diagram for 16-lead SOICW Package

SELECTION GUIDE

Part Number	Current Range (I _{PMAX}) (A)	Sensitivity (mV/A)	Operating Temperature Range (°C)	Package	Packing
CT432-HSWF20MR	±20	100	−40 to 125	16-lead SOICW 10.21 mm × 10.31 mm × 2.54 mm	Tape and Reel
CT432-HSWF30MR	±30	66.7			
CT432-HSWF50MR	±50	40			
CT432-HSWF65MR	±65	30.8			
CT432-HSWF20DR	20	200			
CT432-HSWF30DR	30	133.3			
CT432-HSWF50DR	50	80			
CT432-HSWF65DR	65	61.5			
CT432-HSWF70DR	70	57.1			
AEC-Q100 GRADE 1					
CT432-ASWF20MR	±20	100	Grade 1 −40 to 125	16-lead SOICW 10.21 mm × 10.31 mm × 2.54 mm	Tape and Reel
CT432-ASWF30MR	±30	66.7			
CT432-ASWF50MR	±50	40			
CT432-ASWF65MR	±65	30.8			
CT432-ASWF20DR	20	200			
CT432-ASWF30DR	30	133.3			
CT432-ASWF50DR	50	80			
CT432-ASWF65DR	65	61.5			

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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
Current Carrying Conductor Maximum Current	$I_{CCC(MAX)}$	$T_A = 25^{\circ}C$	70	A
Dielectric Surge Strength Test Voltage	V_{SURGE}	IEC 61000-4-5: Tested ± 5 Pulses at 2/60 seconds, 1.2 μs (rise) and 50 μs (width)	6.0 (min)	kV
Surge Strength Test Current	I_{SURGE}	Tested ± 5 Pulses at 3/60 seconds, 8.0 μs (rise) and 20 μs (width)	3.0 (min)	kA
Electrostatic Discharge Protection Level	ESD	Human Body Model (HBM) per JESD22-A114	± 2.0	kV
		Charged Device Model (CDM) per JESD22-C101	± 0.5	kV
Junction Temperature	T_J		–40 to 150	$^{\circ}C$
Storage Temperature	T_{STG}		–65 to 155	$^{\circ}C$
Lead Soldering Temperature	T_L	10 seconds	260	$^{\circ}C$

^[1] Stresses exceeding the absolute maximum ratings may damage the CT432 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	Industrial	–40	25	85	$^{\circ}C$
		Extended Industrial	–40	25	125	$^{\circ}C$
		Automotive	–40	25	125	$^{\circ}C$

^[1] The Recommended Operating Conditions table defines the conditions for actual operation of the CT432. 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 RATINGS

Characteristic	Symbol	Notes	Rating	Unit
Impulse Withstand Voltage	V _{IMPULSE}	Tested ±5 pulses at 2/minute in compliance to IEC 61000-4-5 1.2 µs (rise) / 50 µs (width)	8000	V _{PK}
Dielectric Withstand Voltage	V _{ISO}	Agency rated for 60 seconds per UL 62368-1:2014 (edition 2) and per UL 1577 ^[1]	5000	V _{RMS}
Working Voltage for Basic Isolation	V _{WVBI}	Maximum approved working voltage for basic insulation according to UL 62368-1:2014 (edition 2)	1556	V _{PK}
			1100	V _{RMS}
Working Voltage for Reinforced Isolation	V _{WBRI}	Maximum approved working voltage for reinforced insulation according to UL 62368-1:2014 (edition 2)	778	V _{PK}
			550	V _{RMS}
Creepage Distance	D _{CR}	Minimum distance along package body from IP leads to signal leads.	7.8	mm
Clearance Distance	D _{CL}	Minimum distance through air from IP leads to signal leads	7.8	mm
Distance Through Isolation	DTI	Minimum internal distance through isolation	110	µm
Comparative Tracking Index	CTI	Material Group II	400 to 599	V

^[1] 100% Production-tested for 1 second in accordance with UL 62368-1 (edition 2) and UL 1577.

CMTI RATING ^[1]

Characteristic	Symbol	Test Conditions	Rating	Unit
Common Mode Transient Immunity	CMTI	The failure criterion is that output peak is greater than 100 mV, and duration is longer than 1 µs.	100	kV/µs

^[1] Common Mode Transient Immunity defines how the sensor output changes under a high dV/dt event.

PINOUT DIAGRAM AND TERMINAL LIST

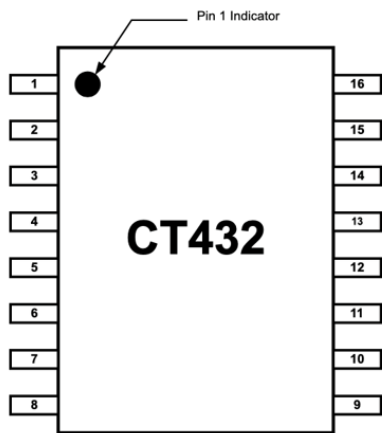


Figure 2: CT432 Pinout Diagram for 16-lead SOICW Package (Top-Down View)

Terminal List

Number	Name	Function
1, 2, 3, 4	IP+	Terminal for primary conductor (positive).
5, 6, 7, 8	IP-	Terminal for primary conductor (negative).
9	NC	No connect.
10	GND	Ground.
11	TEST	Pin used for factory calibration. Connect to Ground.
12	NC	No connect.
13	OUT	Analog output voltage that represents the measured current.
14	NC	No connect.
15	VCC	Supply voltage.
16	NC	No connect.

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, I _P = 0 A	–	6.0	9.0	mA
OUT Maximum Drive Capability ^[1]	I _{OUT}	OUT covers 10% to 90% of V _{CC} span	–1.0	–	+1.0	mA
OUT Capacitive Load ^[1]	C _{L_OUT}		–	–	100	pF
OUT Resistive Load ^[1]	R _{L_OUT}		–	100	–	kΩ
Primary Conductor Resistance ^[1]	R _{IP}		–	1	–	mΩ
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
ANALOG OUTPUT (OUT)						
OUT Voltage Linear Range, Typical	V _{OUT}	V _{SIG_AC} = ±2.00 V, V _{SIG_DC} = +4.00 V	0.50	–	4.50	V
Output High Saturation Voltage	V _{OUT_SAT}	V _{OUT} , T _A = 25°C	V _{CC} – 0.30	V _{CC} – 0.25	–	V
Common Mode Field Rejection Ratio ^[1]	CMFRR		–	–54	–	dB
			–	0.5	–	mA/G
TIMINGS						
Power-On Time ^[1]	t _{ON}	V _{CC} ≥ 2.50 V	–	100	200	μs
Rise Time ^[1]	t _{RISE}	I _P = I _{RANGE(MAX)} , T _A = 25°C, C _L = 100 pF	–	200	–	ns
Response Time ^[1]	t _{RESPONSE}	I _P = I _{RANGE(MAX)} , T _A = 25°C, C _L = 100 pF	–	300	–	ns
Propagation Delay ^[1]	t _{DELAY}	I _P = I _{RANGE(MAX)} , T _A = 25°C, C _L = 100 pF	–	250	–	ns
PROTECTION						
Undervoltage Lockout	V _{UVLO}	Rising V _{DD}	–	2.50	–	V
		Falling V _{DD}	–	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 $C_{BYP} = 1.0\text{ }\mu\text{F}$ (unless otherwise specified)

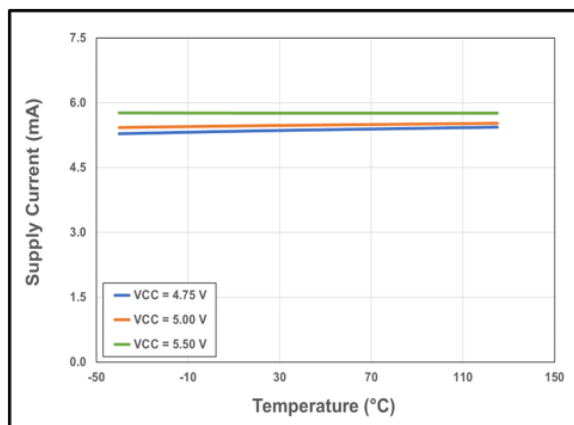


Figure 3: CT432 Supply Current vs. Temperature vs. Supply Voltage

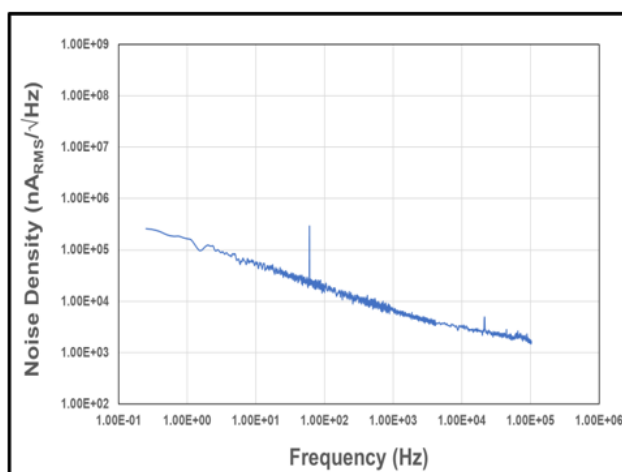


Figure 4: Noise Density vs. Frequency

ELECTRICAL CHARACTERISTICS (continued)

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

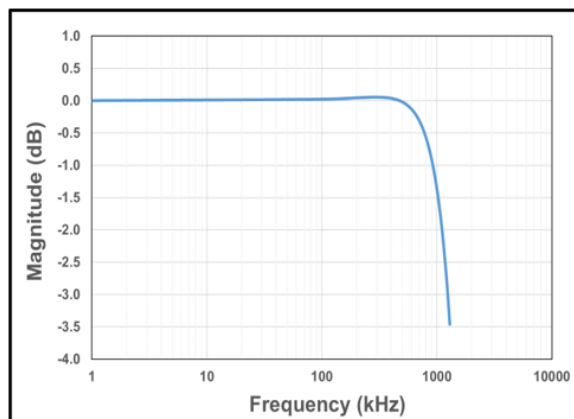


Figure 5: CT432 Bandwidth

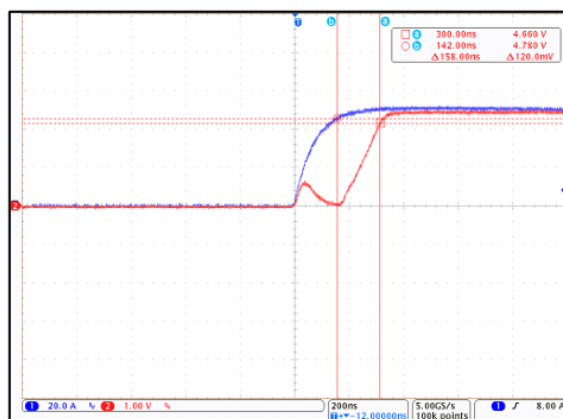


Figure 6: CT432 Response Time; $I_P = 50 \text{ A}_{PK}$ and $C_L = 100 \text{ pF}$ (Blue = I_{CCC} , Red = V_{OUT})

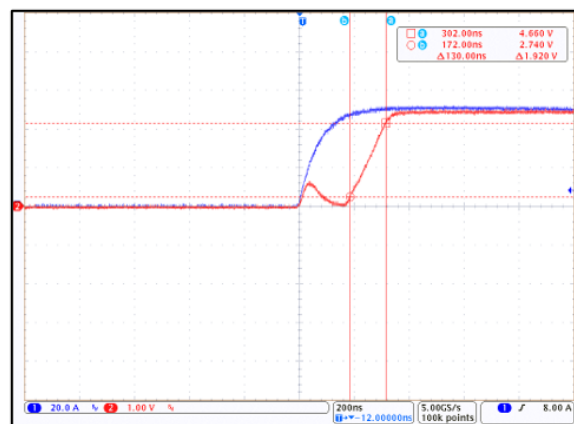


Figure 7: CT432 Rise Time; $I_P = 50 \text{ A}_{PK}$ and $C_L = 100 \text{ pF}$ (Blue = I_{CCC} , Red = V_{OUT})

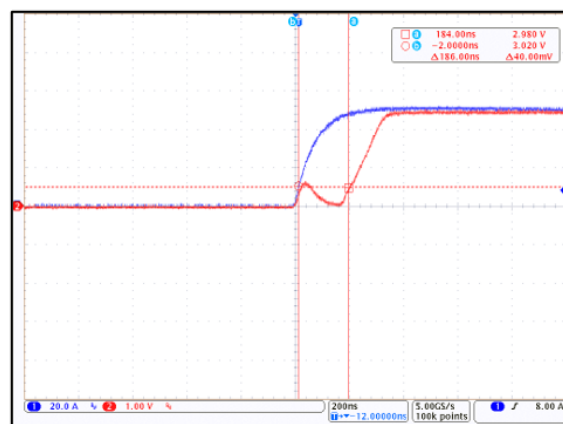


Figure 8: CT432 Propagation Delay; $I_P = 50 \text{ A}_{PK}$ and $C_L = 100 \text{ pF}$ (Blue = I_{CCC} , Red = V_{OUT})

CT432-xSWF20DR: 0 to 20 A – PERFORMANCE 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 , unless otherwise specified

Characteristics	Symbol	Test Conditions	Min.	Typ. ^[1]	Max.	Unit
Current Range	I _{RANGE}		0	–	20	
Voltage Output Quiescent	V _{OQ}	T _A = 25°C, I _P = 0 A	0.495	0.500	0.505	V
Sensitivity	S	I _{RANGE(MIN)} < I _P < I _{RANGE(MAX)}	–	200	–	mV/A
Bandwidth ^[1]	f _{BW}	Small Signal = –3 dB	–	1.0	–	MHz
Noise ^[1]	e _N	T _A = 25°C, f _{BW} = 100 kHz	–	9.0	–	mA _{RMS}
OUT ACCURACY PERFORMANCE						
Total Output Error	E _{TOT}	I _P sweep from I _{P(MIN)} to I _{P(MAX)}	–	–	±1.0	% FS
Linearity Error	E _{LIN}	I _P = I _{P(MAX)} , T _A = –40°C to 125°C	–	±0.2	–	% FS
Sensitivity Error	E _{SENS}	I _P = I _{P(MAX)} , T _A = 25°C	–	±0.2	–	%
		I _P = I _{P(MAX)} , T _A = 125°C	–	±1.4	–	%
		I _P = I _{P(MAX)} , T _A = –40°C	–	±1.1	–	%
Offset Voltage Error	V _{OE}	I _P = 0 A, T _A = 25°C	–	±6	–	mV
		I _P = 0 A, T _A = 125°C	–	±41	–	mV
		I _P = 0 A, T _A = –40°C	–	±27	–	mV
LIFETIME DRIFT						
Total Error Including Lifetime Drift	E _{TOT(DRIFT)}	I _P = I _{P(MAX)} , T _A = –40°C to 125°C	–	±1.8	–	% FS
Sensitivity Error Including Lifetime Drift	E _{SENS(DRIFT)}	I _P = I _{P(MAX)} , T _A = –40°C to 125°C	–	±1.7	–	%
Offset Voltage Error Including Lifetime Drift	V _{OE(DRIFT)}	I _P = 0 A, T _A = –40°C to 125°C	–	±49	–	mV

^[1] Typical values are the mean ± 3 sigma of production distributions. These are formatted as mean ± 3 sigma.

^[2] Lifetime drift characteristics are based on a statistical combination of production distributions and worst case distribution of parametric drift of individuals observed during AEC-Q100 qualification.

CT432-xSWF20MR: ±20 A – PERFORMANCE 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 , unless otherwise specified

Characteristics	Symbol	Test Conditions	Min.	Typ. ^[1]	Max.	Unit
Current Range	I _{RANGE}		−20	−	20	A
Voltage Output Quiescent	V _{OQ}	T _A = 25°C, I _P = 0 A	2.495	2.500	2.505	V
Sensitivity	S	I _{RANGE(MIN)} < I _P < I _{RANGE(MAX)}	−	100	−	mV/A
Bandwidth [1]	f _{BW}	Small Signal = −3 dB	−	1.0	−	MHz
Noise [1]	e _N	T _A = 25°C, f _{BW} = 100 kHz	−	10.0	−	mA _{RMS}
OUT ACCURACY PERFORMANCE						
Total Output Error	E _{TOT}	I _P sweep from I _{P(MIN)} to I _{P(MAX)}	−	−	±1.0	% FS
Linearity Error	E _{LIN}	I _P = I _{P(MAX)} , T _A = −40°C to 125°C	−	±0.1	−	% FS
Sensitivity Error	E _{SENS}	I _P = I _{P(MAX)} , T _A = 25°C	−	±0.2	−	%
		I _P = I _{P(MAX)} , T _A = 125°C	−	±1.2	−	%
		I _P = I _{P(MAX)} , T _A = −40°C	−	±1.3	−	%
Offset Voltage Error	V _{OE}	I _P = 0 A, T _A = 25°C	−	±4	−	mV
		I _P = 0 A, T _A = 125°C	−	±30	−	mV
		I _P = 0 A, T _A = −40°C	−	±35	−	mV
LIFETIME DRIFT						
Total Error Including Lifetime Drift	E _{TOT(DRIFT)}	I _P = I _{P(MAX)} , T _A = −40°C to 125°C	−	±1.7	−	% FS
Sensitivity Error Including Lifetime Drift	E _{SENS(DRIFT)}	I _P = I _{P(MAX)} , T _A = −40°C to 125°C	−	±1.8	−	%
Offset Voltage Error Including Lifetime Drift	V _{OE(DRIFT)}	I _P = 0 A, T _A = −40°C to 125°C	−	±42	−	mV

^[1] Typical values are the mean ±3 sigma of production distributions. These are formatted as mean ±3 sigma.

^[2] Lifetime drift characteristics are based on a statistical combination of production distributions and worst case distribution of parametric drift of individuals observed during AEC-Q100 qualification.

CT432-xSWF30DR: 0 to 30 A – PERFORMANCE 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 , unless otherwise specified

Characteristics	Symbol	Test Conditions	Min.	Typ. ^[1]	Max.	Unit
Current Range	I _{RANGE}		0	–	30	A
Voltage Output Quiescent	V _{OQ}	T _A = 25°C, I _P = 0 A	0.495	0.500	0.505	V
Sensitivity	S	I _{RANGE(MIN)} < I _P < I _{RANGE(MAX)}	–	133.3	–	mV/A
Bandwidth [1]	f _{BW}	Small Signal = –3 dB	–	1.0	–	MHz
Noise [1]	e _N	T _A = 25°C, f _{BW} = 100 kHz	–	10.0	–	mA _{RMS}
OUT ACCURACY PERFORMANCE						
Total Output Error	E _{TOT}	I _P sweep from I _{P(MIN)} to I _{P(MAX)}	–	–	±1.0	% FS
Linearity Error	E _{LIN}	I _P = I _{P(MAX)} , T _A = –40°C to 125°C	–	±0.2	–	% FS
Sensitivity Error	E _{SENS}	I _P = I _{P(MAX)} , T _A = 25°C	–	±0.1	–	%
		I _P = I _{P(MAX)} , T _A = 125°C	–	±1.4	–	%
		I _P = I _{P(MAX)} , T _A = –40°C	–	±1.0	–	%
Offset Voltage Error	V _{OE}	I _P = 0 A, T _A = 25°C	–	±4	–	mV
		I _P = 0 A, T _A = 125°C	–	±30	–	mV
		I _P = 0 A, T _A = –40°C	–	±23	–	mV
LIFETIME DRIFT						
Total Error Including Lifetime Drift	E _{TOT(DRIFT)}	I _P = I _{P(MAX)} , T _A = –40°C to 125°C	–	±1.8	–	% FS
Sensitivity Error Including Lifetime Drift	E _{SENS(DRIFT)}	I _P = I _{P(MAX)} , T _A = –40°C to 125°C	–	±1.7	–	%
Offset Voltage Error Including Lifetime Drift	V _{OE(DRIFT)}	I _P = 0 A, T _A = –40°C to 125°C	–	±39	–	mV

^[1] Typical values are the mean ± 3 sigma of production distributions. These are formatted as mean ± 3 sigma.

^[2] Lifetime drift characteristics are based on a statistical combination of production distributions and worst case distribution of parametric drift of individuals observed during AEC-Q100 qualification.

CT432-xSWF30MR: ±30 A – PERFORMANCE 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 , unless otherwise specified

Characteristics	Symbol	Test Conditions	Min.	Typ. ^[1]	Max.	Unit
Current Range	I _{RANGE}		−30	−	30	A
Voltage Output Quiescent	V _{OQ}	T _A = 25°C, I _P = 0 A	2.495	2.500	2.505	V
Sensitivity	S	I _{RANGE(MIN)} < I _P < I _{RANGE(MAX)}	−	66.7	−	mV/A
Bandwidth [1]	f _{BW}	Small Signal = −3 dB	−	1.0	−	MHz
Noise [1]	e _N	T _A = 25°C, f _{BW} = 100 kHz	−	11.5	−	mA _{RMS}
OUT ACCURACY PERFORMANCE						
Total Output Error	E _{TOT}	I _P sweep from I _{P(MIN)} to I _{P(MAX)}	−	−	±1.0	% FS
Linearity Error	E _{LIN}	I _P = I _{P(MAX)} , T _A = −40°C to 125°C	−	±0.1	−	% FS
Sensitivity Error	E _{SENS}	I _P = I _{P(MAX)} , T _A = 25°C	−	±0.2	−	%
		I _P = I _{P(MAX)} , T _A = 125°C	−	±1.5	−	%
		I _P = I _{P(MAX)} , T _A = −40°C	−	±1.2	−	%
Offset Voltage Error	V _{OE}	I _P = 0 A, T _A = 25°C	−	±2	−	mV
		I _P = 0 A, T _A = 125°C	−	±23	−	mV
		I _P = 0 A, T _A = −40°C	−	±34	−	mV
LIFETIME DRIFT						
Total Error Including Lifetime Drift	E _{TOT(DRIFT)}	I _P = I _{P(MAX)} , T _A = −40°C to 125°C	−	±1.7	−	% FS
Sensitivity Error Including Lifetime Drift	E _{SENS(DRIFT)}	I _P = I _{P(MAX)} , T _A = −40°C to 125°C	−	±1.8	−	%
Offset Voltage Error Including Lifetime Drift	V _{OE(DRIFT)}	I _P = 0 A, T _A = −40°C to 125°C	−	±42	−	mV

^[1] Typical values are the mean ±3 sigma of production distributions. These are formatted as mean ±3 sigma.

^[2] Lifetime drift characteristics are based on a statistical combination of production distributions and worst case distribution of parametric drift of individuals observed during AEC-Q100 qualification.

CT432-xSWF50DR: 0 to 50 A – PERFORMANCE 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 , unless otherwise specified

Characteristics	Symbol	Test Conditions	Min.	Typ. ^[1]	Max.	Unit
Current Range	I _{RANGE}		0	–	50	A
Voltage Output Quiescent	V _{OQ}	T _A = 25°C, I _P = 0 A	0.495	0.500	0.505	V
Sensitivity	S	I _{RANGE(MIN)} < I _P < I _{RANGE(MAX)}	–	80	–	mV/A
Bandwidth ^[1]	f _{BW}	Small Signal = –3 dB	–	1.0	–	MHz
Noise ^[1]	e _N	T _A = 25°C, f _{BW} = 100 kHz	–	10.0	–	mA _{RMS}
OUT ACCURACY PERFORMANCE						
Total Output Error	E _{TOT}	I _P sweep from I _{P(MIN)} to I _{P(MAX)}	–	–	±1.5	% FS
Linearity Error	E _{LIN}	I _P = I _{P(MAX)} , T _A = –40°C to 125°C	–	±0.2	–	% FS
Sensitivity Error	E _{SENS}	I _P = I _{P(MAX)} , T _A = 25°C	–	±0.1	–	%
		I _P = I _{P(MAX)} , T _A = 125°C	–	±1.7	–	%
		I _P = I _{P(MAX)} , T _A = –40°C	–	±1.2	–	%
Offset Voltage Error	V _{OE}	I _P = 0 A, T _A = 25°C	–	±3	–	mV
		I _P = 0 A, T _A = 125°C	–	±18	–	mV
		I _P = 0 A, T _A = –40°C	–	±18	–	mV
LIFETIME DRIFT						
Total Error Including Lifetime Drift	E _{TOT(DRIFT)}	I _P = I _{P(MAX)} , T _A = –40°C to 125°C	–	±2.3	–	% FS
Sensitivity Error Including Lifetime Drift	E _{SENS(DRIFT)}	I _P = I _{P(MAX)} , T _A = –40°C to 125°C	–	±1.9	–	%
Offset Voltage Error Including Lifetime Drift	V _{OE(DRIFT)}	I _P = 0 A, T _A = –40°C to 125°C	–	±29	–	mV

^[1] Typical values are the mean ± 3 sigma of production distributions. These are formatted as mean ± 3 sigma.

^[2] Lifetime drift characteristics are based on a statistical combination of production distributions and worst case distribution of parametric drift of individuals observed during AEC-Q100 qualification.

CT432-xSWF50MR: ±50 A – PERFORMANCE 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 , unless otherwise specified

Characteristics	Symbol	Test Conditions	Min.	Typ. ^[1]	Max.	Unit
Current Range	I _{RANGE}		−50	−	50	A
Voltage Output Quiescent	V _{OQ}	T _A = 25°C, I _P = 0 A	2.495	2.500	2.505	V
Sensitivity	S	I _{RANGE(MIN)} < I _P < I _{RANGE(MAX)}	−	40	−	mV/A
Bandwidth [1]	f _{BW}	Small Signal = −3 dB	−	1.0	−	MHz
Noise [1]	e _N	T _A = 25°C, f _{BW} = 100 kHz	−	14.0	−	mA _{RMS}
OUT ACCURACY PERFORMANCE						
Total Output Error	E _{TOT}	I _P sweep from I _{P(MIN)} to I _{P(MAX)}	−	−	±1.0	% FS
Linearity Error	E _{LIN}	I _P = I _{P(MAX)} , T _A = −40°C to 125°C	−	±0.1	−	% FS
Sensitivity Error	E _{SENS}	I _P = I _{P(MAX)} , T _A = 25°C	−	±0.1	−	%
		I _P = I _{P(MAX)} , T _A = 125°C	−	±1.4	−	%
		I _P = I _{P(MAX)} , T _A = −40°C	−	±1.0	−	%
Offset Voltage Error	V _{OE}	I _P = 0 A, T _A = 25°C	−	±1	−	mV
		I _P = 0 A, T _A = 125°C	−	±23	−	mV
		I _P = 0 A, T _A = −40°C	−	±25	−	mV
LIFETIME DRIFT						
Total Error Including Lifetime Drift	E _{TOT(DRIFT)}	I _P = I _{P(MAX)} , T _A = −40°C to 125°C	−	±1.6	−	% FS
Sensitivity Error Including Lifetime Drift	E _{SENS(DRIFT)}	I _P = I _{P(MAX)} , T _A = −40°C to 125°C	−	±1.6	−	%
Offset Voltage Error Including Lifetime Drift	V _{OE(DRIFT)}	I _P = 0 A, T _A = −40°C to 125°C	−	±33	−	mV

^[1] Typical values are the mean ± 3 sigma of production distributions. These are formatted as mean ± 3 sigma.

^[2] Lifetime drift characteristics are based on a statistical combination of production distributions and worst case distribution of parametric drift of individuals observed during AEC-Q100 qualification.

CT432-xSWF65DR: 0 to 65 A – PERFORMANCE 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 , unless otherwise specified

Characteristics	Symbol	Test Conditions	Min.	Typ. ^[1]	Max.	Unit
Current Range	I _{RANGE}		0	–	65	A
Voltage Output Quiescent	V _{OQ}	T _A = 25°C, I _P = 0 A	0.495	0.500	0.505	V
Sensitivity	S	I _{RANGE(MIN)} < I _P < I _{RANGE(MAX)}	–	61.5	–	mV/A
Bandwidth ^[1]	f _{BW}	Small Signal = –3 dB	–	1.0	–	MHz
Noise ^[1]	e _N	T _A = 25°C, f _{BW} = 100 kHz	–	10.0	–	mA _{RMS}
OUT ACCURACY PERFORMANCE						
Total Output Error	E _{TOT}	I _P sweep from I _{P(MIN)} to I _{P(MAX)}	–	–	±1.5	% FS
Linearity Error	E _{LIN}	I _P = I _{P(MAX)} , T _A = –40°C to 125°C	–	±0.2	–	% FS
Sensitivity Error	E _{SENS}	I _P = I _{P(MAX)} , T _A = 25°C	–	±0.2	–	%
		I _P = I _{P(MAX)} , T _A = 125°C	–	±1.7	–	%
		I _P = I _{P(MAX)} , T _A = –40°C	–	±1.3	–	%
Offset Voltage Error	V _{OE}	I _P = 0 A, T _A = 25°C	–	±2	–	mV
		I _P = 0 A, T _A = 125°C	–	±16	–	mV
		I _P = 0 A, T _A = –40°C	–	±16	–	mV
LIFETIME DRIFT						
Total Error Including Lifetime Drift	E _{TOT(DRIFT)}	I _P = I _{P(MAX)} , T _A = –40°C to 125°C	–	±2.4	–	% FS
Sensitivity Error Including Lifetime Drift	E _{SENS(DRIFT)}	I _P = I _{P(MAX)} , T _A = –40°C to 125°C	–	±1.9	–	%
Offset Voltage Error Including Lifetime Drift	V _{OE(DRIFT)}	I _P = 0 A, T _A = –40°C to 125°C	–	±27	–	mV

^[1] Typical values are the mean ± 3 sigma of production distributions. These are formatted as mean ± 3 sigma.

^[2] Lifetime drift characteristics are based on a statistical combination of production distributions and worst case distribution of parametric drift of individuals observed during AEC-Q100 qualification.

CT432-xSWF65MR: ±65 A – PERFORMANCE 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 , unless otherwise specified

Characteristics	Symbol	Test Conditions	Min.	Typ. ^[1]	Max.	Unit
Current Range	I _{RANGE}		−65	−	65	A
Voltage Output Quiescent	V _{OQ}	T _A = 25°C, I _P = 0 A	2.495	2.500	2.505	V
Sensitivity	S	I _{RANGE(MIN)} < I _P < I _{RANGE(MAX)}	−	30.8	−	mV/A
Bandwidth [1]	f _{BW}	Small Signal = −3 dB	−	1.0	−	MHz
Noise [1]	e _N	T _A = 25°C, f _{BW} = 100 kHz	−	13.5	−	mA _{RMS}
OUT ACCURACY PERFORMANCE						
Total Output Error	E _{TOT}	I _P sweep from I _{P(MIN)} to I _{P(MAX)}	−	−	±1.0	% FS
Linearity Error	E _{LIN}	I _P = I _{P(MAX)} , T _A = −40°C to 125°C	−	±0.1	−	% FS
Sensitivity Error	E _{SENS}	I _P = I _{P(MAX)} , T _A = 25°C	−	±0.2	−	%
		I _P = I _{P(MAX)} , T _A = 125°C	−	±1.6	−	%
		I _P = I _{P(MAX)} , T _A = −40°C	−	±1.3	−	%
Offset Voltage Error	V _{OE}	I _P = 0 A, T _A = 25°C	−	±1	−	mV
		I _P = 0 A, T _A = 125°C	−	±20	−	mV
		I _P = 0 A, T _A = −40°C	−	±31	−	mV
LIFETIME DRIFT						
Total Error Including Lifetime Drift	E _{TOT(DRIFT)}	I _P = I _{P(MAX)} , T _A = −40°C to 125°C	−	±1.7	−	% FS
Sensitivity Error Including Lifetime Drift	E _{SENS(DRIFT)}	I _P = I _{P(MAX)} , T _A = −40°C to 125°C	−	±1.9	−	%
Offset Voltage Error Including Lifetime Drift	V _{OE(DRIFT)}	I _P = 0 A, T _A = −40°C to 125°C	−	±39	−	mV

^[1] Typical values are the mean ± 3 sigma of production distributions. These are formatted as mean ± 3 sigma.

^[2] Lifetime drift characteristics are based on a statistical combination of production distributions and worst case distribution of parametric drift of individuals observed during AEC-Q100 qualification.

CT432-xSWF70DR: 0 to 70 A – PERFORMANCE 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 , unless otherwise specified

Characteristics	Symbol	Test Conditions	Min.	Typ. ^[1]	Max.	Unit
Current Range	I _{RANGE}		−70	−	70	
Voltage Output Quiescent	V _{OQ}	T _A = 25°C, I _P = 0 A	0.495	0.500	0.505	V
Sensitivity	S	I _{RANGE(MIN)} < I _P < I _{RANGE(MAX)}	−	57.1	−	mV/A
Bandwidth ^[1]	f _{BW}	Small Signal = −3 dB	−	1.0	−	MHz
Noise ^[1]	e _N	T _A = 25°C, f _{BW} = 100 kHz	−	10.0	−	mA _{RMS}
OUT ACCURACY PERFORMANCE						
Total Output Error	E _{TOT}	I _P sweep from I _{P(MIN)} to I _{P(MAX)}	−	−	±1.5	% FS
Linearity Error	E _{LIN}	I _P = I _{P(MAX)} , T _A = −40°C to 125°C	−	±0.2	−	% FS
Sensitivity Error	E _{SENS}	I _P = I _{P(MAX)} , T _A = 25°C	−	±0.2	−	%
		I _P = I _{P(MAX)} , T _A = 125°C	−	±1.7	−	%
		I _P = I _{P(MAX)} , T _A = −40°C	−	±1.3	−	%
Offset Voltage Error	V _{OE}	I _P = 0 A, T _A = 25°C	−	±2	−	mV
		I _P = 0 A, T _A = 125°C	−	±16	−	mV
		I _P = 0 A, T _A = −40°C	−	±16	−	mV
LIFETIME DRIFT						
Total Error Including Lifetime Drift	E _{TOT(DRIFT)}	I _P = I _{P(MAX)} , T _A = −40°C to 125°C	−	±2.2	−	% FS
Sensitivity Error Including Lifetime Drift	E _{SENS(DRIFT)}	I _P = I _{P(MAX)} , T _A = −40°C to 125°C	−	±1.9	−	%
Offset Voltage Error Including Lifetime Drift	V _{OE(DRIFT)}	I _P = 0 A, T _A = −40°C to 125°C	−	±27	−	mV

^[1] Typical values are the mean ± 3 sigma of production distributions. These are formatted as mean ± 3 sigma.

^[2] Lifetime drift characteristics are based on a statistical combination of production distributions and worst case distribution of parametric drift of individuals observed during AEC-Q100 qualification.

FUNCTIONAL DESCRIPTION

Overview

The CT432 is a high accuracy contact current sensor with an integrated current-carrying conductor that handles up to 65 A. It has high sensitivity and a wide dynamic range with excellent accuracy (low total output error) across temperature. This current sensor supports nine current ranges:

- 0 to 20 A
- ±30 A
- 0 to 65 A
- ±20 A
- 0 to 50 A
- ±65 A
- 0 to 30 A
- ±50 A
- 0 to 70 A

When current is flowing through the current-carrying conductor, the XtremeSense TMR sensors inside the chip senses the field which in turn generates differential voltage signals that then goes through the Analog Front-End (AFE) to output a current measurement with less than ±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 CT432 is 1.0 MHz. Even with a high bandwidth, the chip consumes a minimal amount of power.

Linear Output Current Measurement

The CT432 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 9 illustrates the output voltage range of the OUT pin as a function of the measured current.

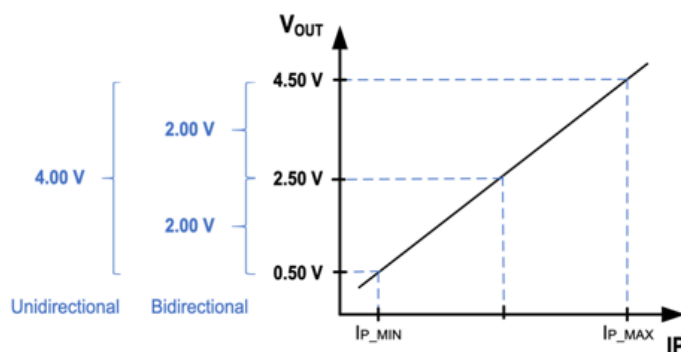


Figure 9: Linear Output Voltage Range (OUT) vs. Measured Current (IP)

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.

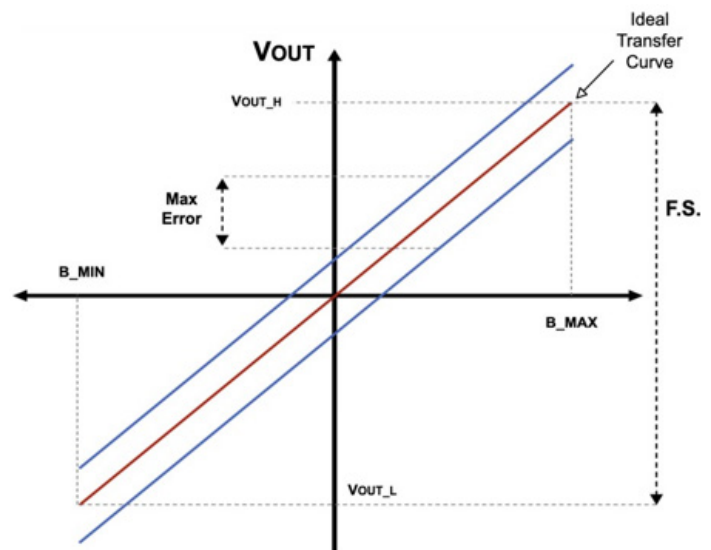


Figure 10: Total Output Error (E_{OUT}) vs. Sensed Current (I_P)

The CT432 achieves a total output error (E_{OUT}) that is less than ±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 current measurements regardless of the operating conditions.

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:

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

Power-On Time (t_{ON})

Power-On Time (t_{ON}) of 100 μ s is the amount of time required by CT432 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 CT432 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.

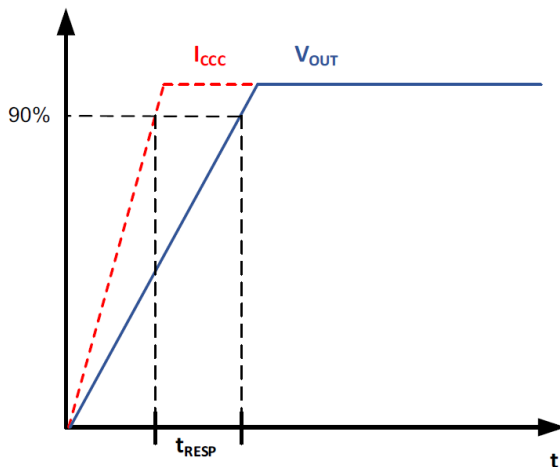


Figure 11: CT432 Response Time Curve

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 CT432 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 CT432 has a propagation delay of 250 ns.

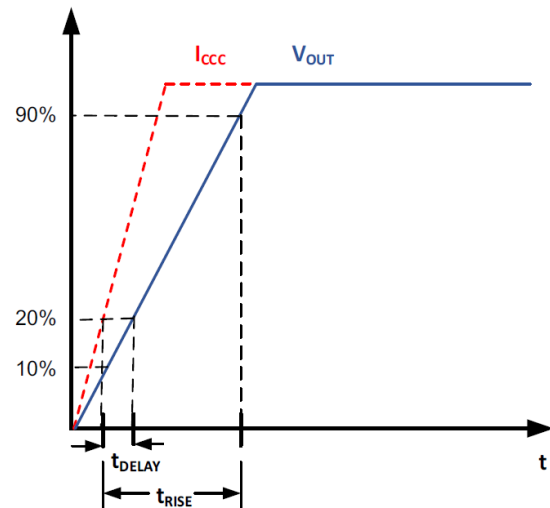


Figure 12: CT432 Propagation Delay and Rise Time Curve

Immunity to Common Mode Fields

The CT432 is housed in custom plastic package that uses a U-shaped leadframe to reduce the common mode fields generated by external stray magnetic fields. With the U-shaped leadframe, the stray fields cancel one another thus reducing electro-magnetic interference (EMI). The CT432 is able to achieve -54 dB of Common Mode Rejection Ratio (CMFRR). Also, good PCB layout of the CT432 will optimize performance and reduce EMI.

Creepage and Clearance

Two important terms as it relates to isolation provided by the package are: creepage and clearance. Creepage is defined as the shortest distance across the surface of the package from one side the leads to the other side of the leads. The definition for clearance is the shortest distance between the leads of opposite side through the air.

Undervoltage Lockout (UVLO)

The Undervoltage Lockout protection circuitry of the CT432 is activated when the supply voltage (V_{CC}) falls below 2.45 V. The CT432 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 CT432 is not valid. Once V_{CC} rises above 2.50 V then the UVLO is cleared.

Fuse Time vs. Current

Since the CT432 is a contact current sensor, it dissipates heat as current is conducted through its leadframe. The CT432 leadframe has 0.5 mΩ resistance (typ) which results in low power dissipation during normal operation.

However, when the current surges above the rated nominal values of the CT432 due to short circuit or transient current spikes for a specific duration of time, the leadframe will be permanently damaged.

Figure 14 illustrates the CT432 fuse time for 100 A, 200 A, and 300 A current levels. The CT432 tolerates 100 A for 32 seconds, while at 200 A and 300 A, the fuse times are 194 ms and 45 ms, respectively.

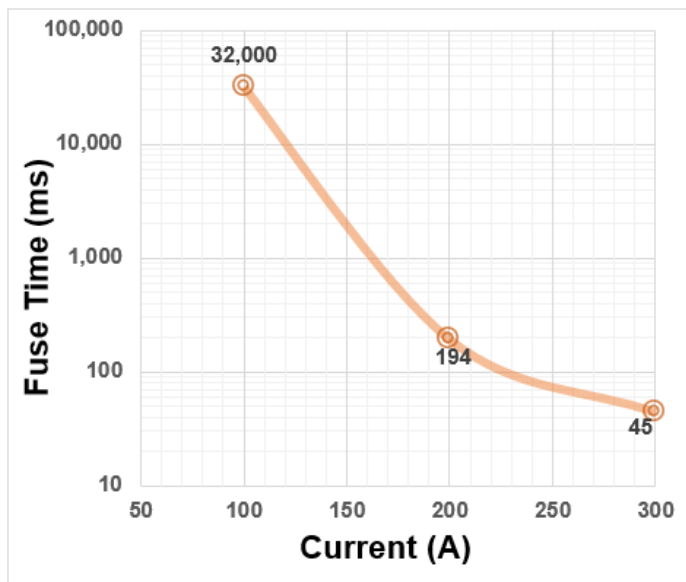


Figure 14: CT432 Fuse Time vs. Current

Thermal Rise vs. Primary Current

Self-heating due to the flow of current should be considered during the design of any current sensing system. The sensor, printed circuit board (PCB), and contacts to the PCB will generate heat as current moves through the system.

The thermal response is highly dependent on PCB layout, copper thickness, cooling techniques, and the profile of the injected current.

The current profile includes peak current, current on-time, and duty cycle. While the data presented in this section was collected with direct current (DC), these numbers may be used to approximate thermal response for both AC signals and current pulses.

The plot in Figure 15 shows the measured rise in steady-state die temperature of the current sensor versus continuous current at an ambient temperature, T_A , of 25 °C. The thermal offset curves may be directly applied to other values of T_A .

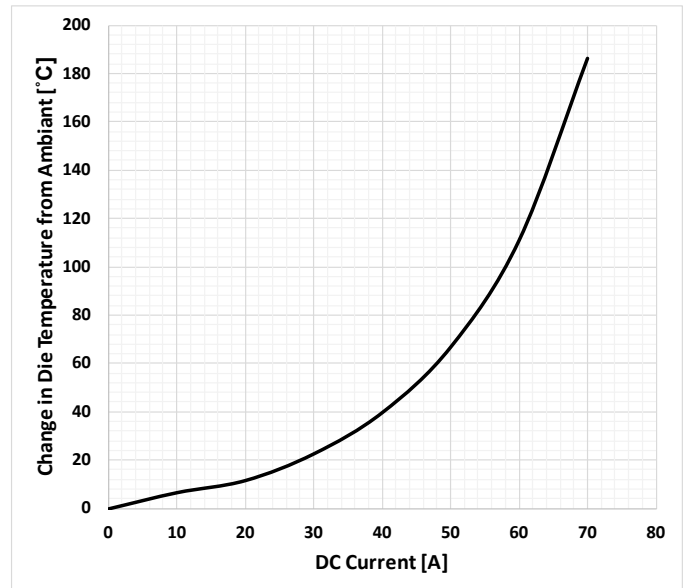


Figure 15: Self Heating in the LA Package Due to Current Flow

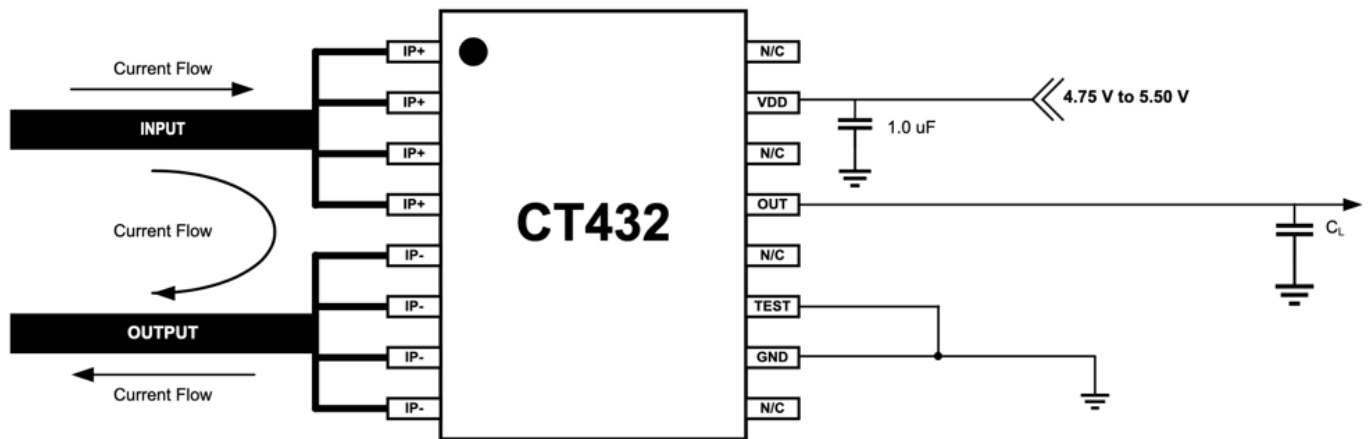


Figure 13: CT432 Application Block Diagram

Application

The CT432 is an integrated contact current sensor that can be used in many applications from measuring current in power supplies to motor control to overcurrent fault protection. It is a plug-and-play solution in that no calibration is required, and it can output to a microcontroller a simple linear analog output voltage which corresponds to a current measurement value. Figure 13 is an application diagram of how CT432 would be implemented in a system.

The device is designed to support an operating voltage range of 4.75 V to 5.50 V, but it is ideal to use a 5.0 V power supply where the output tolerance is less than $\pm 5\%$.

Overcurrent Detection

The TEST pin of the CT432 can be used as a $\overline{\text{FLT}}$ pin to detect when the primary measured current is higher than the sensor maximum range. This pin is an open drain output. It requires a pull-up resistor value of 100 k Ω to be connected from the pin to VCC and also a 1.0 nF capacitor to be connected from the pin to ground.

The $\overline{\text{FLT}}$ pin is not user-programmable and has fixed trigger value of $1.1 \times I_{\text{RANGE(MAX)}}$ or 110% the maximum linear sensing range of the CT432.

Not grounding the TEST pin will reduce the sensor immunity to high dV/dt events.

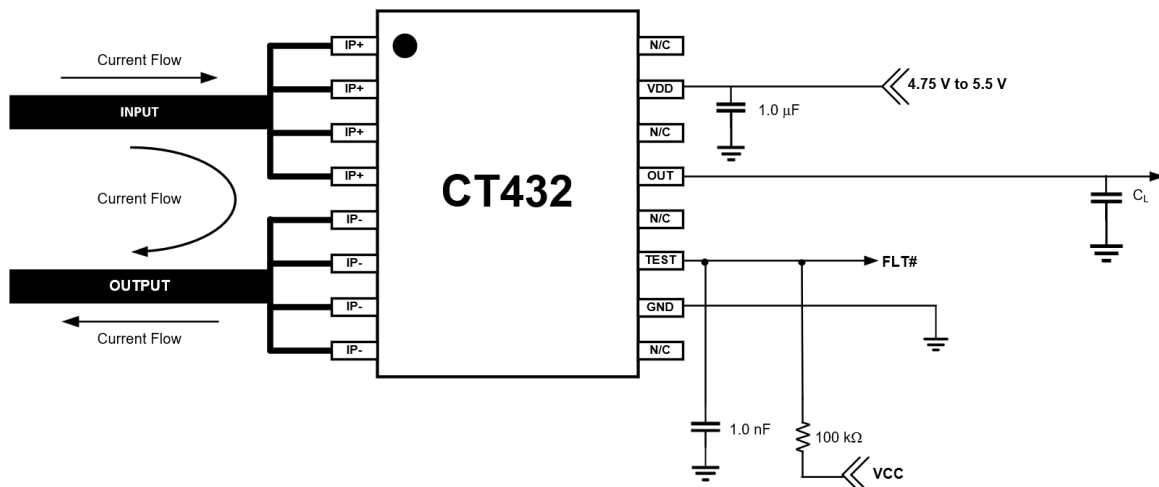
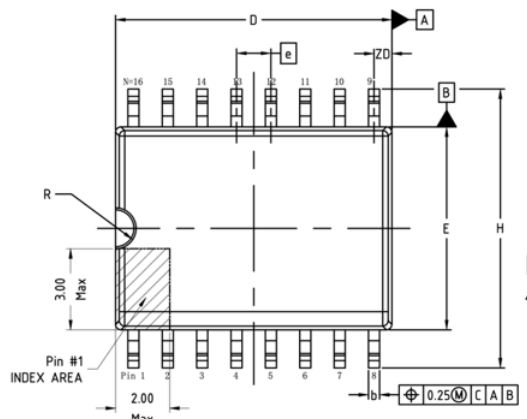


Figure 16: CT432 Application Block Diagram – With Overcurrent Detection

PACKAGE OUTLINE DRAWING



TOP VIEW

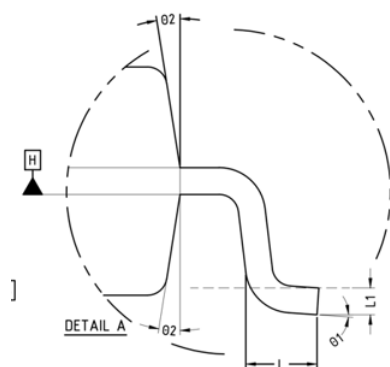
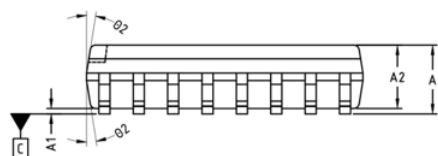
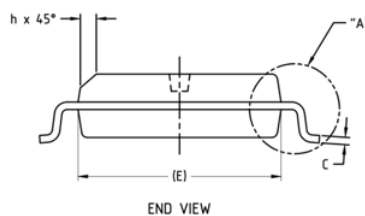


Table 1: CT432 SOICW-16 Package Dimensions

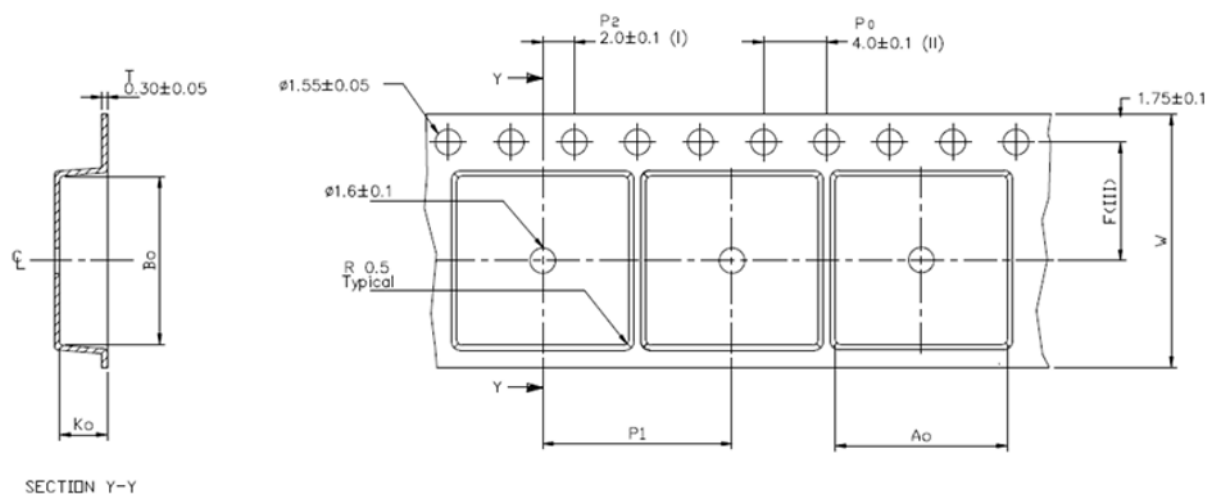
Symbol	Dimensions in Millimeters (mm)		
	Min.	Typ.	Max.
A	2.44	2.54	2.64
A1	0.10	0.20	0.30
A2	2.24	2.34	2.44
b	0.36	0.41	0.46
C	0.23	—	0.32
D	10.11	10.21	10.31
E	7.40	7.50	7.60
e	1.27 BSC		
H	10.11	10.31	10.51
h	0.31	0.51	0.71
L	0.51	0.76	1.01
L1	0.25 BSC		
R	0.76 REF		
θ1	0.25 BSC	0.25 BSC	0.25 BSC
θ2	0.76 REF	0.76 REF	0.76 REF
ZD	0.66 REF		
N	16		



END VIEW

Figure 17: SOICW-16 Package Drawing and Dimensions

TAPE AND REEL POCKET DRAWING AND DIMENSIONS



A ₀	10.90 +/− 0.1
B ₀	10.70 +/− 0.1
K ₀	3.00 +/− 0.1
F	7.50 +/− 0.1
P ₁	12.00 +/− 0.1
W	16.00 +/− 0.3

- (I) Measured from centreline of sprocket hole to centreline of pocket.
- (II) Cumulative tolerance of 10 sprocket holes is ± 0.20 .
- (III) Measured from centreline of sprocket hole to centreline of pocket.
- (IV) Other material available.
- (V) Typical SR of form tape Max 10⁸ OHM/SQ

ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED.

Figure 18: Tape and Pocket Drawing for SOICW-16 Package

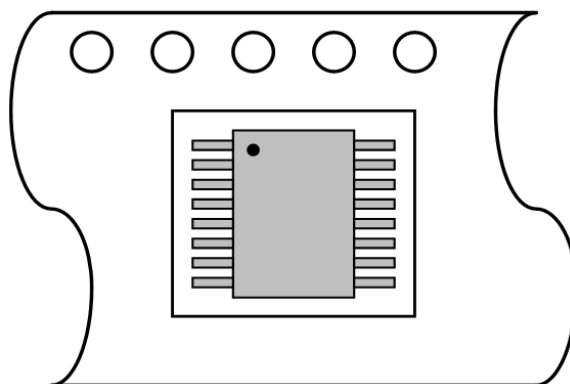


Figure 19: SOICW-16 Orientation in Tape Pocket

PACKAGE INFORMATION

Table 2: CT432 Package Information

Part Number	Package Type	# of Leads	Package Quantity	Lead Finish	MSL Rating [2]	Operating Temperature (°C) [3]	Device Marking [4]
CT432-HSWF20DR	SOICW	16	1000	Sn	3	–40 to 125	CT432 SWF20DR YYWWLL
CT432-ASWF20DR	SOICW	16	1000	Sn	3	–40 to 125	CT432A SWF20DR YYWWLL
CT432-HSWF20MR	SOICW	16	1000	Sn	3	–40 to 125	CT432 SWF20MR YYWWLL
CT432-ASWF20MR	SOICW	16	1000	Sn	3	–40 to 125	CT432A SWF20MR YYWWLL
CT432-HSWF30DR	SOICW	16	1000	Sn	3	–40 to 125	CT432 SWF30DR YYWWLL
CT432-ASWF30DR	SOICW	16	1000	Sn	3	–40 to 125	CT432A SWF30DR YYWWLL
CT432-HSWF30MR	SOICW	16	1000	Sn	3	–40 to 125	CT432 SWF30MR YYWWLL
CT432-ASWF30MR	SOICW	16	1000	Sn	3	–40 to 125	CT432A SWF30MR YYWWLL
CT432-HSWF50DR	SOICW	16	1000	Sn	3	–40 to 125	CT432 SWF50DR YYWWLL
CT432-ASWF50DR	SOICW	16	1000	Sn	3	–40 to 125	CT432A SWF50DR YYWWLL
CT432-HSWF50MR	SOICW	16	1000	Sn	3	–40 to 125	CT432 SWF50MR YYWWLL
CT432-ASWF50MR	SOICW	16	1000	Sn	3	–40 to 125	CT432A SWF50MR YYWWLL
CT432-HSWF65DR	SOICW	16	1000	Sn	3	–40 to 125	CT432 SWF65DR YYWWLL
CT432-ASWF65DR	SOICW	16	1000	Sn	3	–40 to 125	CT432A SWF65DR YYWWLL
CT432-HSWF65MR	SOICW	16	1000	Sn	3	–40 to 125	CT432 SWF65MR YYWWLL
CT432-ASWF65MR	SOICW	16	1000	Sn	3	–40 to 125	CT432A SWF65MR YYWWLL
CT432-HSWF70DR	SOICW	16	1000	Sn	3	–40 to 125	CT432A SWF70DR 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] Device Marking for CT432 is defined as CT432 SWFxxZR YYWWLL where the first 2 lines = part number, YY = year, WW = work week, and LL = lot code.

DEVICE MARKING

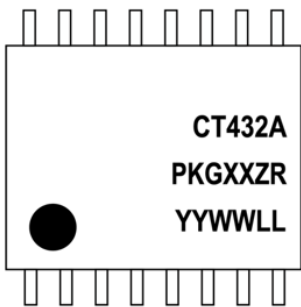
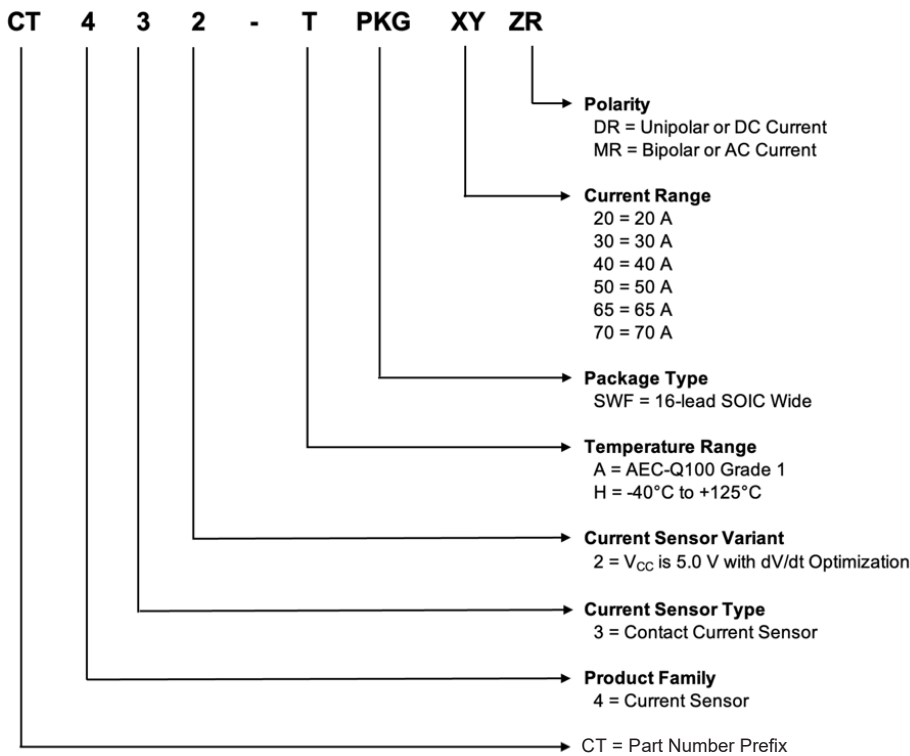


Figure 20: CT432 Device Marking for 16-lead Package

Table 3: CT432 Device Marking Definition for 16-lead SOICW Package

Row No.	Code	Definition
3	•	Pin 1 Indicator
1	CT432	Allegro Part Number
1	A	AEC-Q100 Qualified
2	PKG	Package Type
2	XX	Maximum Current Rating
2	ZR	Polarity
3	YY	Calendar Year
3	WW	Work Week
3	LL	Lot Code

PART ORDERING NUMBER LEGEND



Revision History

Number	Date	Description
2	November 2, 2023	Document rebranded and minor editorial updates
3	May 2, 2024	Updated Description and Features and Benefits (page 1); updated Table of Contents (page 2); removed Thermal Characteristics table (page 3); removed IEC 61000 reference (pages 1 and 3); updated Isolation Ratings table (page 4); updated Primary Conductor Resistance value (page 6); updated Total Output Error values (pages 13 and 15); updated Total Error Including Lifetime Drift value (page 17); added Thermal Rise vs. Primary Current section (page 20); removed performance graph pages.

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