Data Sheet

ACHS-7124/7125

Fully Integrated, Hall Effect-Based Linear Current Sensor IC with 3 kV_{RMS} Isolation and Low-Resistance Current Conductor

Description

The Broadcom® ACHS-7124/7125 product series is a fully integrated Hall Effect-based isolated linear current sensor device family designed for AC or DC current sensing in industrial, commercial, and communications systems. Each of the ACHS-7124/7125 consists of a precise, low-offset, linear Hall circuit with a copper conduction path located near the surface of the die. Applied current flowing through this copper conduction path generates a magnetic field that the Hall IC converts into a proportional voltage. Device accuracy is optimized through the close proximity of the magnetic signal to the Hall transducer.

A precise, proportional voltage is provided by the low-offset, chopper-stabilized CMOS Hall IC, which is programmed for accuracy after packaging. The output of the device has a positive slope (>$V_{OUT(Q)}$) when an increasing current flows through the primary 4 oz copper conduction path (from pins 1 and 2, to pins 3 and 4), which is the path used for current sampling.

The internal resistance of this conductive path is 0.7 mΩ typical, providing low power loss. The terminals of the conductive path are electrically isolated from the signal leads (pins 5 through 8). This performance is delivered in a compact, surface mountable, SO-8 package that meets worldwide regulatory safety standards.

Part Number	Current Range	Sensitivity
ACHS-7124	±40A	50 mV/A
ACHS-7125	±50A[a]	40 mV/A

a. Due to the SO-8 package power dissipation limitations, the input RMS or DC current of 50A product needs to be derated above 85°C ambient at –25.2 mW/°C on 4 oz copper PCB.

Features

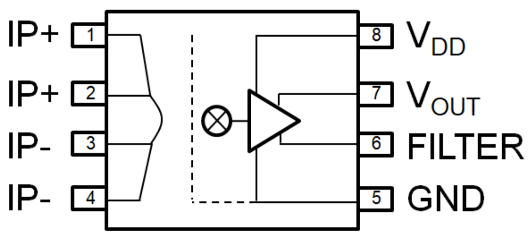
- Wide operating temperature: –40ºC to +110ºC
- Internal conductor resistance: 0.7 mΩ typ.
- Sensing current range ±40A and ±50A (see the table footnote[a] under the part number table to the left)
- Output sensitivity: 40mV/A to 50 mV/A
- Output voltage proportional to AC or DC currents
- Ratiometric output from supply voltage
- Single supply operation: 5.0V
- Low-noise analog signal path
- Device bandwidth is set using the new FILTER pin: 80-kHz typ. Bandwidth with 1-nF filter capacitor
- Factory-trimmed for accuracy
- Extremely stable output offset voltage
- Near zero magnetic hysteresis
- Typical total output error of ±1.5%
- >25 kV/µs common-mode Transient Immunity
- Small footprint, low-profile SO-8 package
- Worldwide safety approvals: UL; CSA; Isolation Voltage: 3 kVrms, 1 minute

Applications

- Low-power inverter current sensing
- Motor phase and rail current sensing
- Solar inverters
- Chargers and converters
- Switching power supplies

CAUTION! Take normal static precautions in handling and assembly of this component to prevent damage, degradation, or both, which may be induced by ESD. The components featured in this data sheet are not to be used in military or aerospace applications or environments. The component is not AEC-Q100 qualified and not recommended for automotive applications.

Functional Diagram



NOTE: The connection of 1-µF bypass capacitor between pins 8 and 5 is recommended.

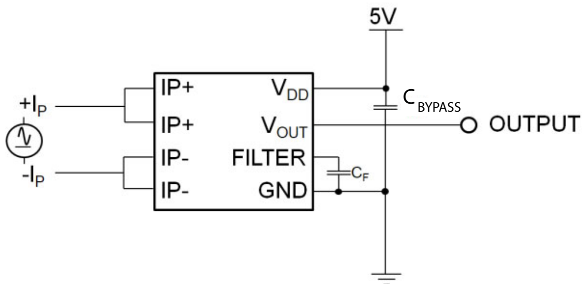
Pin Description

Pin	Pin Name	Description
1	I_{P+}	Terminals for current being sampled; fused internally
2	I_{P+}	
3	I_{P-}	Terminals for current being sampled; fused internally
4	I_{P-}	

Pin	Pin Name	Description
8	V_{DD}	Supply voltage relative to GND
7	V_{OUT}	Output voltage
6	FILTER	Filter pin to set bandwidth
5	GND	Output side ground

Typical Application Circuit

A typical application circuit for the ACHS-7124/7125 product series consists of a bypass capacitor and a filter capacitor as additional external components. On the input side, pins 1 and 2 are shorted together, and pins 3 and 4 shorted together. The output voltage is directly measured from the V_{OUT} pin.



Ordering Information

Part Number	Current Range	Option (RoHS) Compliant	Package	Surface Mount	Tape and Reel	UL 3kV_{RMS} 1 min. Rating	Quantity
ACHS-7124	±40A	-000E	SO-8	X		X	100 per tube
		-500E		X	X	X	1500 per reel
ACHS-7125	±50A	-000E		X		X	100 per tube
		-500E		X	X	X	1500 per reel

To order, choose a part number from the part number column and combine with the desired option from the option column to form an order entry.

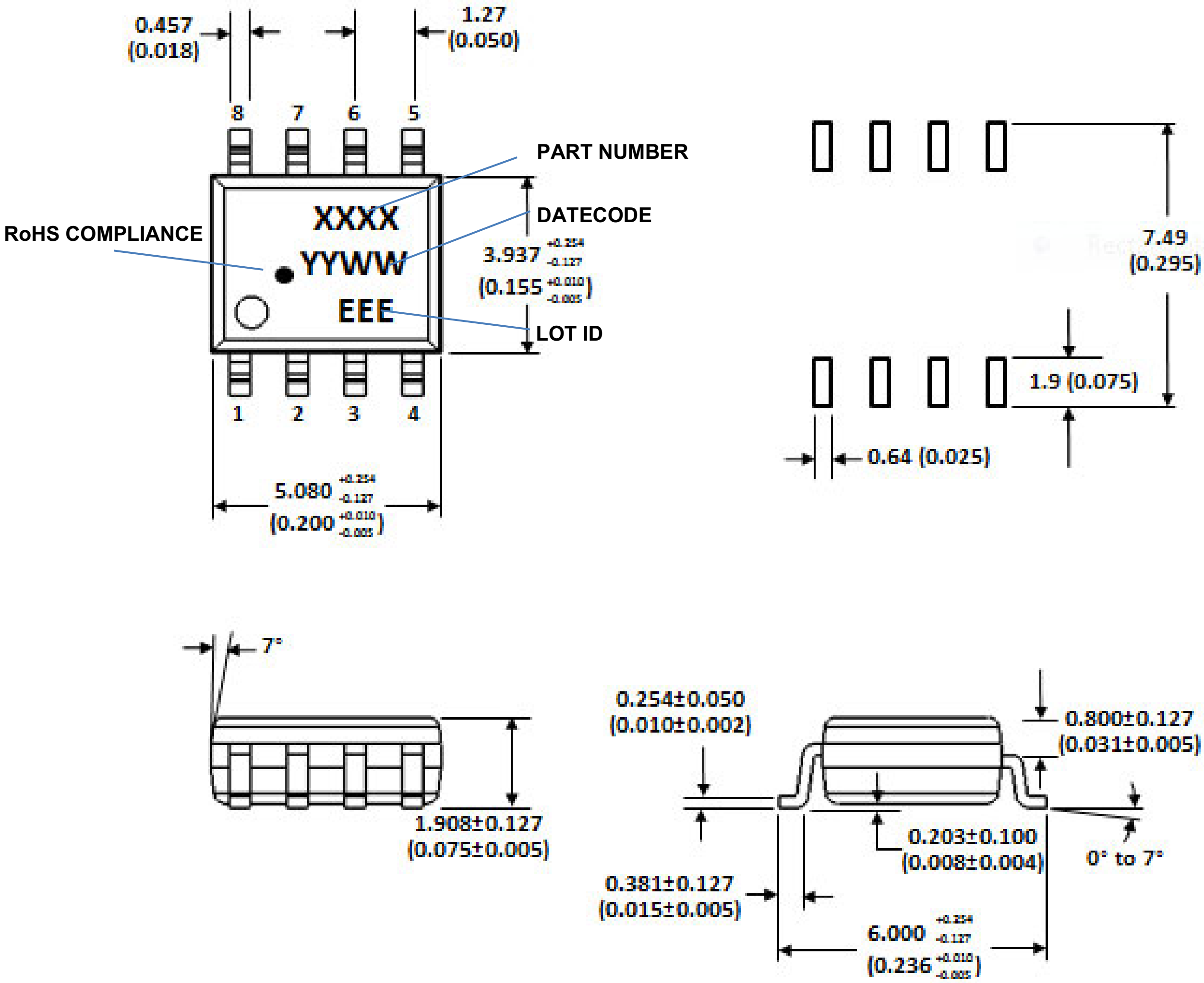
Example 1:

ACHS-7124-500E to order product of ±40A, Surface Mount package in Tape and Reel packaging and RoHS compliance. Contact your Broadcom sales representative or authorized distributor for information.

Option data sheets are available. Contact your Broadcom sales representative or authorized distributor for information.

Package Outline Drawing

ACHS-7124/7125 SO-8 Package



Dimensions in millimeters (in.).

NOTE:

Lead co-planarity = 0.100 mm (0.004 in.) maximum

Floating lead protrusion = 0.254 mm (0.010 in.) maximum

Mold flash on each side = 0.127 mm (0.005 in.) maximum

Recommended Pb-Free IR Profile

Recommended reflow condition as per JEDEC Standard, J-STD-020 (latest revision). Non-halide flux should be used.

Regulatory Information

The ACHS-7124/7125 is approved by the following organizations:

UL/cUL
UL 1577, component recognition program up to V_{ISO} = 3000 V_{RMS}. Approved under CSA Component Acceptance Notice#5.

Insulation and Safety Related Specifications

Parameter	Symbol	Value	Units	Conditions
Minimum External Air Gap (External Clearance)	L(101)	4.0	mm	Measured from the input terminals to the output terminals, the shortest distance through air
Minimum External Tracking (External Creepage)	L(102)	4.0	mm	Measured from the input terminals to the output terminals, the shortest distance path along body
Minimum Internal Plastic Gap (Internal Clearance)	—	0.05	mm	Through the insulation distance, conductor to conductor, usually the direct distance between the primary input conductor and he detector IC
Tracking Resistance (Comparative Tracking Index)	CTI	>175	V	DIN IEC 112/VDE 0303 Part 1
Isolation Group	—	IIIa	—	Material Group (DIN VDE 0110, 1/89, Table 1)

Absolute Maximum Ratings

Parameter	Symbol	Min.	Max.	Units	Test Conditions
Storage Temperature	T_S	–55	+125	°C	
Ambient Operating Temperature	T_A	–40	+110	°C	
Junction Temperature	T_J	—	+150	°C	
Primary Conductor Lead Temperature	T_L	—	+150	°C	Pins 1, 2, 3, or 4
Supply Voltages	V_{DD}	–0.5	8.0	V	
Output Voltage	V_{OUT}	–0.5	V_{DD} + 0.5	V	
Output Current Source	$I_{OUT(source)}$	—	10	mA	T_A = 25°C
Output Current Sink	$I_{OUT(sink)}$	—	10	mA	T_A = 25°C
Overcurrent Transient Tolerance	I_P	—	100	A	1 pulse, 100 ms; T_A = 25°C
Input Power Dissipation[a]	P_{IN}	—	1750	mW	
Output Power Dissipation	P_{OUT}	—	90	mW	

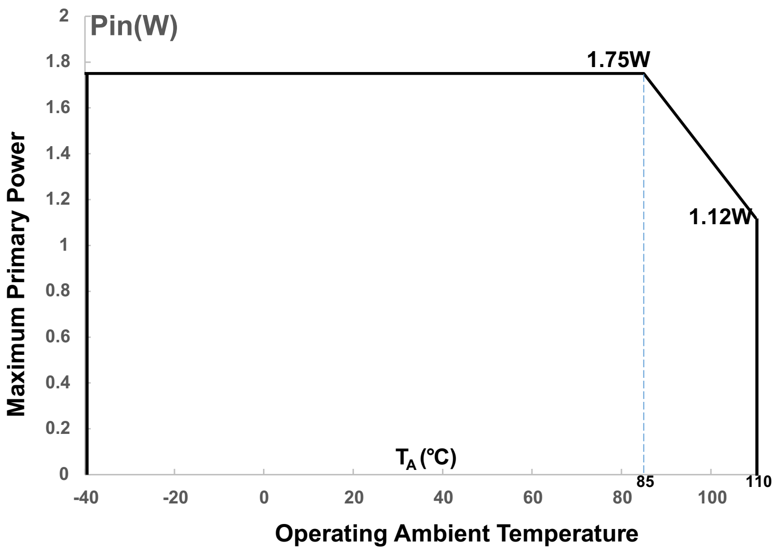
a. Absolute Maximum Input Power Dissipation is only valid if 4-oz copper PCB is used. This power is valid up to 85°C ambient temperature. For >85°C ambient, a derating factor of –25.2 mW/°C is needed.

Recommended Operating Conditions

Parameter		Symbol	Min.	Max.	Units
Ambient Operating Temperature		T_A	–40	110	°C
Supply Voltage		V_{DD}	4.5	5.5	V
Output Capacitance Load		C_{LOAD}	—	10	nF
Output Resistive Load		R_{LOAD}	4.7	—	kΩ
Input Peak Current Range	ACHS-7124	I_p	–40	40	A
	ACHS-7125[a]		–50	50	A

a. Due to the SO-8 package power dissipation limitations, the input peak current is valid up to 85°C ambient temperature only on 4-oz copper PCB. For >85°C ambient, derating is needed. For details, refer to Footnote *a* at Absolute Maximum Ratings. For Input Power Derating Curve, refer to the curve as shown in the following section.

Primary Power Derating Curve for ACHS-7125



NOTE: Mounted on Broadcom's Evaluation Board as shown in Figure 16 and Figure 17.

Common Electrical Specifications

Unless otherwise stated, all minimum/maximum specifications are over recommended operating conditions, C_F=1 nF. All typical values are based on T_A = 25°C, V_{DD} = 5.0V, C_F=1 nF.

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Condition	Figure	Note
Supply Current	I_{DD}	—	13	15	mA	V_{DD} = 5V, output open	7, 8	
Primary Conductance Resistance	$R_{PRIMARY}$	—	0.7	—	mΩ			
Zero Current Output Voltage	$V_{OUT(Q)}$	—	V_{DD} / 2	—	V	Bidirectional, I_P = 0A	2	
Input Filter Resistance	$R_{F(INT)}$	—	1.6	—	kΩ			
Bandwidth	BW	—	80	—	kHz	–3 dB		
Rise Time	t_r	—	4	—	µs		10	
Power-on Time	t_{PO}	—	21	—	µs		9	
Common Mode Transient Immunity	CMTI	25	—	—	kV/µs	V_{CM} = 1000V		a

a. Common Mode Transient Immunity is tested by applying a fast rising/falling voltage pulse across Pin 4 and GND (pin 5). The output glitch observed is less than 0.2 V from the average output voltage for less than 1 µs.

Electrical Specifications

ACHS-7124

Unless otherwise stated, all minimum/maximum specifications are over recommended operating conditions, C_F=1 nF. All typical values are based on T_A = +25°C, V_{DD} = 5.0V, C_F = 1 nF.

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions	Figure	Note
Optimized Accuracy Range	I_P	–40	—	+40	A		4	a
Sensitivity	Sens	—	50	—	mV/A	–40A ≤ I_P ≤ 40A	1	b
Sensitivity Error	E_{SENS}	–3	—	+3	%	T_A = 25°C, V_{DD} = 5V	1	b
Sensitivity Slope	ΔSens	—	0.01	—	mV/A/°C	T_A = –40°C to 25°C	1	b
Sensitivity Slope	ΔSens	—	0.01	—	mV/A/°C	T_A = 25°C to 110°C	1	b
Zero Current Output Error	V_{OE}	–20	—	+20	mV	T_A = 25°C	2	b
Zero Current Output Error Slope	ΔV_{OE}	—	–0.01	—	mV/°C	T_A = –40°C to 25°C	2	b
Zero Current Output Error Slope	ΔV_{OE}	—	0.02	—	mV/°C	T_A = 25°C to 110°C	2	b
Output Noise	$V_{N(RMS)}$	—	2	—	mV	BW = 2 kHz	5	c
Nonlinearity	NL	—	0.1	—	%		3	d
Total Output Error	E_{TOT}	—	±1.5	—	%	T_A = 25°C	6	e
Sensitivity Error Lifetime Drift	E_{SENS_DRIFT}	—	±2	—	%			b
Total Output Error Lifetime Drift	E_{TOT_DRIFT}	—	±2	—	%			b

a. The device may be operated at higher primary current levels, I_P, provided that the Maximum Junction Temperature, $T_{J(MAX)}$ is not exceeded.

b. Refer to Definition of Electrical Characteristics of this data sheet.

c. Output Noise is the noise level of ACHS-7124/7125 expressed in root mean square (RMS) voltage.

d. Nonlinearity is defined as half of the peak-to-peak output deviation from the best-fit line, expressed as a percentage of the full-scale output voltage. Refer to Definition of Electrical Characteristics of this data sheet for the complete definition and formula.

e. Total Output Error in percentage is the difference between the measured output voltage at maximum input current (I_{PMAX}) and the ideal output voltage at I_{PMAX} divided by the ideal output voltage at I_{PMAX}. The Total Output Error's typical value is based on total output error measured at the point of product release.

ACHS-7125[1]

Unless otherwise stated, all minimum/maximum specifications are over recommended operating conditions, C_F=1 nF. All typical values are based on T_A = +25°C, V_{DD} = 5.0V, C_F = 1 nF.

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions	Figure	Note
Optimized Accuracy Range	I_P	–50	—	+50	A		4	a
Sensitivity	Sens	—	40	—	mV/A	–50A ≤ I_P ≤ +50A	1	b
Sensitivity Error	E_{SENS}	–3	—	+3	%	T_A = 25°C, V_{DD} = 5V	1	b
Sensitivity Slope	∆Sens	—	0.01	—	mV/A/°C	T_A = –40°C to 25°C	1	b
Sensitivity Slope	∆Sens	—	0	—	mV/A/°C	T_A = 25°C to 110°C	1	b
Zero Current Output Error	V_{OE}	–20	—	+20	mV	T_A = 25°C	2	b
Zero Current Output Error Slope	ΔV_{OE}	—	–0.01	—	mV/°C	T_A = –40°C to 25°C	2	b
Zero Current Output Error Slope	ΔV_{OE}	—	0.01	—	mV/°C	T_A = 25°C to 110°C	2	b
Output Noise	$V_{N(RMS)}$	—	1.7	—	mV	BW = 2 kHz	5	c
Nonlinearity	NL	—	0.08	—	%		3	d
Total Output Error	E_{TOT}	—	±1.5	—	%	T_A = 25°C	6	e
Sensitivity Error Lifetime Drift	E_{SENS_DRIFT}	—	±2	—	%		-	b
Total Output Error Lifetime Drift	E_{TOT_DRIFT}	—	±2	—	%		-	b

a. The device may be operated at higher primary current levels, I_P, provided that the Maximum Junction Temperature, $T_{J(MAX)}$ is not exceeded.

b. Refer to Definition of Electrical Characteristics in this data sheet.

c. Output Noise is the noise level of ACHS-7124/7125 expressed in root mean square (RMS) voltage.

d. Nonlinearity is defined as half of the peak-to-peak output deviation from the best-fit line, expressed as a percentage of the full-scale output voltage. Refer to Definition of Electrical Characteristics of this data sheet for the complete definition and formula.

e. Total output error in percentage is the difference between the measured output voltage at maximum input current (I_{PMAX}) and the ideal output voltage at I_{PMAX} divided by the ideal output voltage at I_{PMAX}. The Total Output Error's typical value is based on total output error measured at the point of product release.

1. Due to the SO-8 package power dissipation limitations, the input RMS or DC current of 50A product must be derated above 85°C ambient at –25.2 mW/°C on 4 oz copper PCB.

Package Characteristics

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Condition	Note
Input-Output Momentary Withstand Voltage	V_{ISO}	3000	—	—	V_{RMS}	RH < 50%, t = 1 min., T_A = 25°C	a, b, c
Resistance (Input-Output)	R_{I-O}	—	10^{14}	—	Ω	V_{I-O} = 500 V_{DC}	c
Capacitance (Input-Output)	C_{I-O}	—	1.2	—	pF	f = 1 MHz	c
Junction-to-Ambient Thermal Resistance (due to primary conductor)	$R_{\theta 12}$	—	35	—	°C/W	Based on the Broadcom evaluation board	d
Junction-to-Ambient Thermal Resistance (due to IC)	$R_{\theta 22}$	—	22	—	°C/W	Based on the Broadcom evaluation board	d

a. In accordance with UL 1577, each device is proof tested by applying an insulation test voltage ≤ 3600 V_{RMS} for 1 second.

b. The Input-Output Momentary Withstand Voltage is a dielectric voltage rating that should not be interpreted as an input-output continuous voltage rating.

c. This is a two-terminal measurement: pins 1 through 4 are shorted together and pins 5 through 8 are shorted together.

d. The Broadcom evaluation board has 600 mm^2 (total area including top and bottom copper minus the mounting holes) of 4-oz copper connected to pins 1 and 2 and pins 3 and 4. Refer to Thermal Consideration in this data sheet for additional information on thermal characterization.

Typical Performance Plots

All typical plots are based on T_A = 25°C, V_{DD} = 5V, C_F = 1 nF, unless otherwise stated.

Figure 1: Sensitivity vs. Temperature

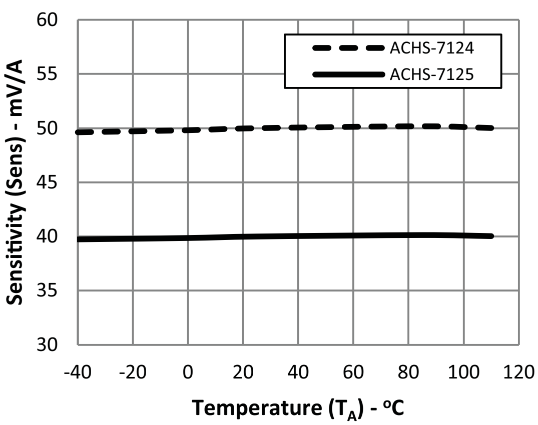


Figure 2: Zero Current Output Voltage vs. Temperature

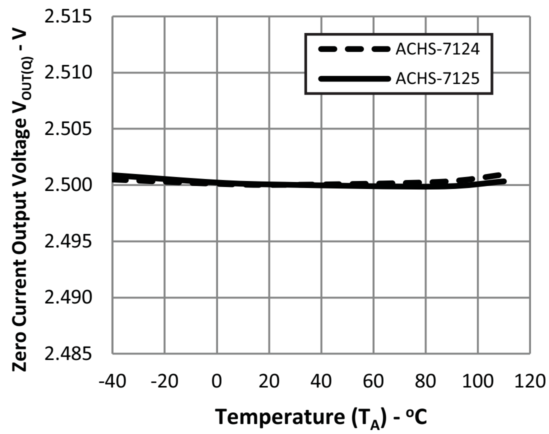


Figure 3: Nonlinearity vs. Temperature

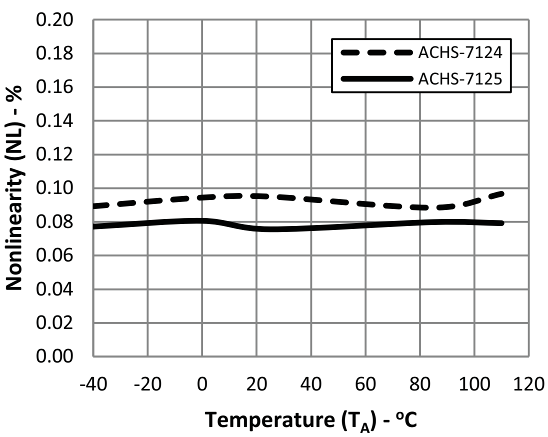


Figure 4: Output Voltage vs. Input Current

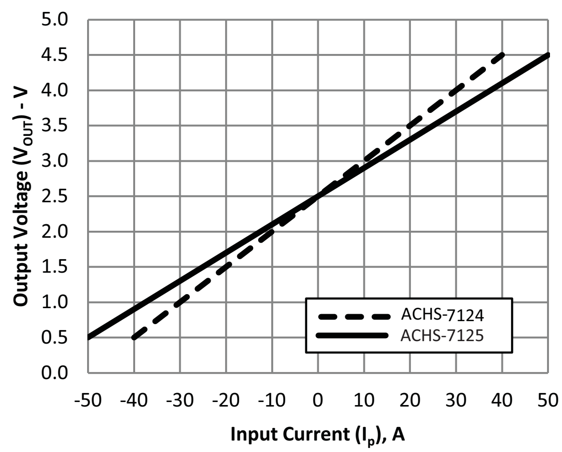


Figure 5: Output Noise vs. External Filter Capacitance

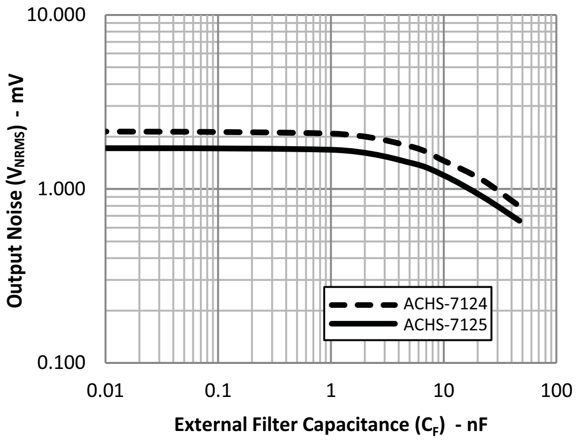


Figure 6: Total Output Error at $I_{P(MAX)}$ vs. Temperature

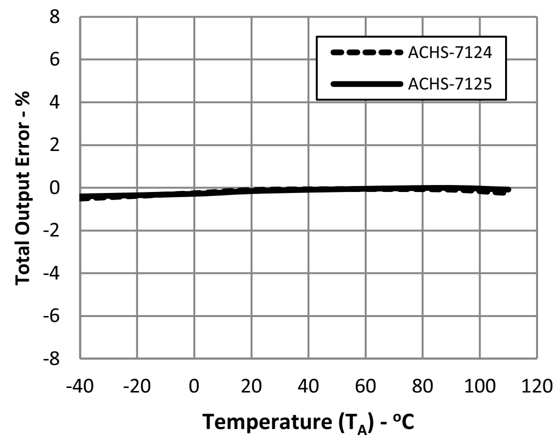


Figure 7: Mean Supply Current vs. Temperature

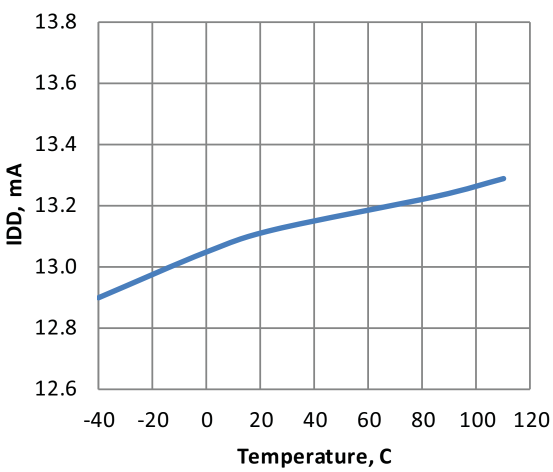


Figure 8: Supply Current vs. Supply Voltage

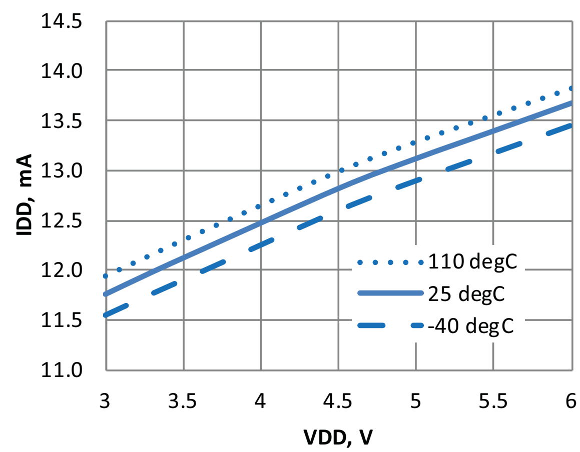


Figure 9: Power-on Time vs. External Filter

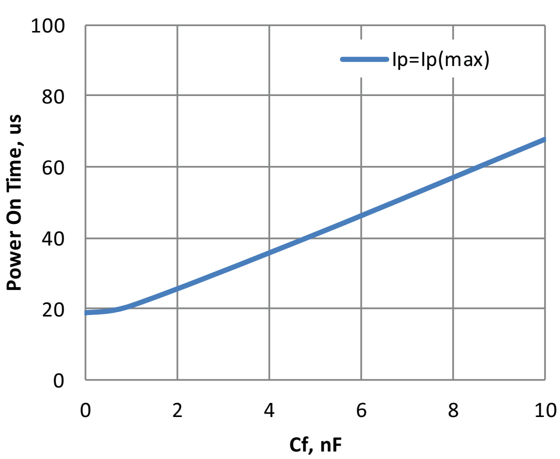
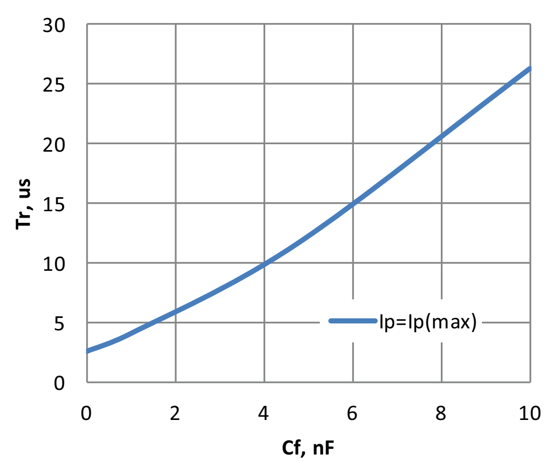


Figure 10: Rise Time vs. External Filter



Definition of Electrical Characteristics

The ACHS-7124/7125 product series is a Hall-Effect current sensor that outputs an analog voltage proportional to the magnetic field intensity caused by the current flowing through the input primary conductor. Without magnetic field the output voltage is half of the supply voltage. The sensor can detect both DC and AC current.

Ratiometric Output

The output voltage of the ACHS-7124/7125 series is ratiometric or proportional to the supply voltage. The sensitivity (Sens) of the device and the quiescent output voltage changes when there is a change in the supply voltage (V_{DD}). For example, for ACHS-7125 when the V_{DD} is increased by +10% from 5V to 5.5V, the quiescent output voltage will change from 2.5V to 2.75V and the sensitivity also changes from 40 mV/A to 44 mV/A.

Sensitivity

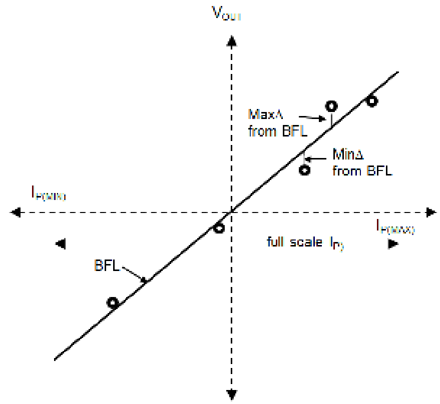
The output sensitivity (Sens) is the ratio of the output voltage (V_{OUT}) over the input current (I_P) flowing through the primary conductor. It is expressed in mV/A. When an applied current flows through the input primary conductor, it generates a magnetic field that the Hall IC converts into a voltage. The proportional voltage is provided by the Hall IC, which is programmed in the factory for accuracy after packaging. The output voltage has a positive slope when an increasing current flows through the pins 1 and 2 to pins 3 and 4. Sensitivity Error (E_{SENS}) is the difference between the measured Sensitivity and the Ideal Sensitivity expressed as a percentage (%).

Nonlinearity

Nonlinearity is defined as half of the peak-to-peak output deviation from the best-fit line (BFL), expressed as a percentage of the full-scale output voltage. The full-scale output voltage is the product of the sensitivity (Sens) and full scale input current (I_P).

$$NL\ (\%) = \frac{[(Max\Delta \text{ from BFL} - Min\Delta \text{ from BFL}) / 2]}{Sens \times \text{full scale } I_P} \times 100\%$$

Figure 11: Nonlinearity Calculation



Zero Current Output Voltage

This is the output voltage of ACHS-7124/7125 when the primary current is zero. Zero current output voltage is half of the supply voltage (V_{DD} / 2).

Zero Current Output Error

This the voltage difference between the measured output voltage and the ideal output voltage (V_{DD} / 2) when there is no input current to the device.

Total Output Error

Total output error in percentage is the difference between the measured output voltage at maximum input current (I_{PMAX}) and the ideal output voltage at I_{PMAX} divided by the ideal output voltage at I_{PMAX}.

$$Error\ (\%) = \frac{\text{Measured } V_{OUT} @ I_{PMAX} - \text{Ideal } V_{OUT} @ I_{PMAX}}{\text{Ideal } V_{OUT} @ I_{PMAX}} \times 100\%$$

Power-on Time

This is the time required for the internal circuitry of the device to be ready during the ramping of the supply voltage. Power on time is defined as the finite time required for the output voltage to settle after the supply voltage reached its recommended operating voltage.

FILTER Pin

The ACHS-7124/7125 has a FILTER pin for improving the signal-to-noise ratio of the device. This eliminates the need for external RC filter to the V_{OUT} pin of the device that can cause attenuation of the output signal. A ceramic capacitor, C_F, can be connected between the FILTER pin to GND.

Application Information

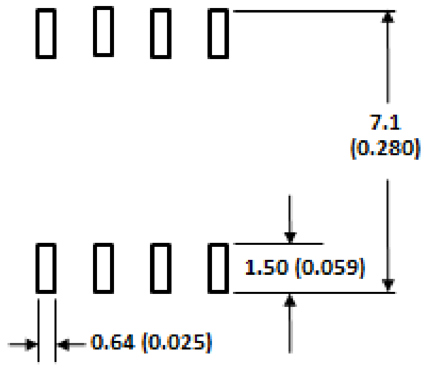
PCB Layout

The design of the printed circuit board (PCB) should follow good layout practices, such as keeping bypass capacitors close to the supply pin and use of ground and power planes. A bypass capacitor must be connected between pins 5 and 8 of the device. The layout of the PCB can also affect the common mode transient immunity of the device due to stray capacitive coupling between the input and output circuits. To obtain maximum common mode transient immunity performance, the layout of the PCB should minimize any stray coupling by maintaining the maximum possible distance between the input and output sides of the circuit and ensuring that any ground or power plane on the PCB does not pass directly below or extend much wider than the body of the device.

Land Pattern for 4-mm Board Creepage

For applications that require PCB creepage of 4-mm between input and output sides, the land pattern in Figure 12 can be used.

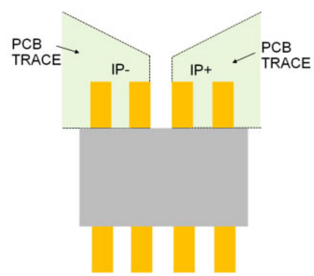
Figure 12: Land Pattern for 4-mm Creepage



Effect of PCB Layout on Sensitivity

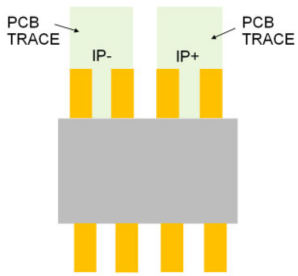
The trace layout on the input pins of ACHS-7124/7125 affects the sensitivity. It is recommended that the PCB trace connection to the input pins covers the pins fully as shown in Figure 13.

Figure 13: Recommended Trace Layout on the Input Pins



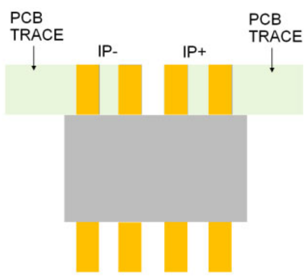
When the connection to the input pin only covers the vertical portion of the input pin, there is a sensitivity variation of about –0.6% versus recommended PCB trace layout as shown in Figure 14.

Figure 14: Vertical Portion Connection



When the connection to the input pin only covers the horizontal portion of the input pin, there is a sensitivity variation of about +1.2% versus recommended PCB trace layout as shown in Figure 15.

Figure 15: Horizontal Portion Connection



Thermal Consideration

The evaluation board used in the thermal characterization is shown in Figure 16. The inputs IP+ and IP- are each connected to input plane of 4 oz. copper with at least 600 mm^2 total area (including top and bottom planes, minus the screws mounting holes). The output side GND is connected to a ground plane of 4 oz. copper with 460 mm^2 total area (including top and bottom planes). The 4 oz. copper enables the board to conduct higher current and achieve good thermal distribution in a limited space.

Figure 16: Broadcom Evaluation Board – Top Layer

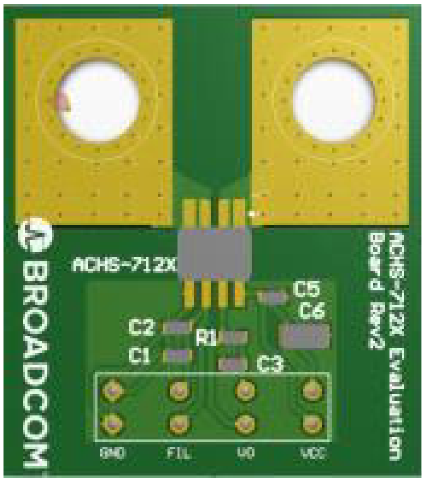


Figure 17: Broadcom Evaluation Board – Bottom Layer