

## ACHL-7345xU

### Fully Integrated Hall-Effect Based Linear Current Sensor

#### Overview

The Broadcom® ACHL-7345xU is a fully integrated Hall-effect based isolated linear current sensor device that is designed for AC or DC current sensing in industrial applications. The ACHL-7345xU 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 ( $>V_{OCM}$ ) when an increasing current flows through the primary copper conduction path (from pin 1 to pin 6), which is the path used for current sampling.

The internal resistance of this conductive path is 0.7 m $\Omega$  typical, providing low power loss. The terminals of the conductive path are electrically isolated from the signal leads (pins 7 through 12). This performance is delivered in a compact, auto-insert, SSO-12 package that meets worldwide regulatory safety standards.

#### Features

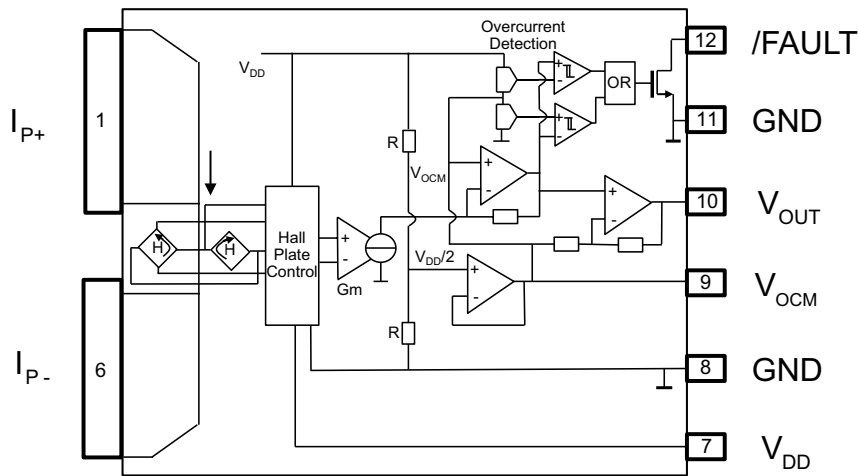
- Wide operating temperature:  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$
- Internal conductor resistance: 0.7 m $\Omega$  typical
- Output voltage proportional to AC or DC currents
- Current sensing range:  $\pm 50\text{A}$
- Ratiometric output from supply voltage
- Single supply operation: 5.0V
- Bandwidth: 600 kHz typical
- Overcurrent fault feedback: 0.8  $\mu\text{s}$  typical
- Total output error:  $\pm 1\%$  typical
- Common mode transient immunity:  $>25\text{ kV}/\mu\text{s}$
- Small footprint, low-profile SSO-12 package
- Worldwide safety approval: IEC/EN62368-1, UL/cUL1577
  - Isolation voltage: 4.24 kVrms, 1 minute

#### Applications

- Current sensing in AC and servo motor drives
- Current sensing for industrial robots
- Low-power inverter current sensing
- Motor phase and rail current sensing
- Output phase current sensing in photovoltaic inverters

**CAUTION!** Take normal static precautions in handling and assembly of this component to prevent damage and degradation that might be induced by electrostatic discharge (ESD). The components featured in this data sheet are not recommended to be used in military or aerospace applications or environments. The components are not AEC-Q100 qualified and not recommended for automotive applications.

Functional Diagram

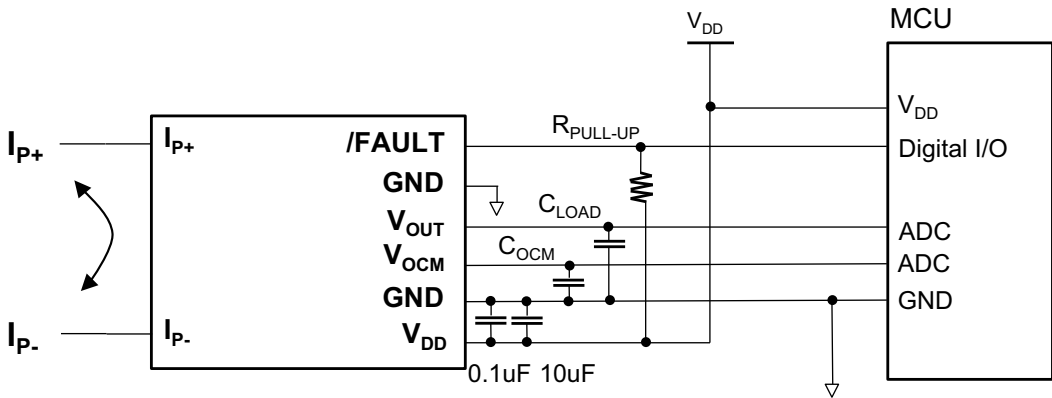


Pin Descriptions

Pin	Pin Name	Description	Pin	Pin Name	Description
1	I <sub>P+</sub>	Positive terminal for input current	9	V <sub>OCM</sub>	Output common mode voltage, V <sub>DD</sub> /2. If the V <sub>OCM</sub> pin is unused, leave the pin floating.
6	I <sub>P-</sub>	Negative terminal for input current	10	V <sub>OUT</sub>	Output voltage.
7	V <sub>DD</sub>	Supply voltage relative to GND	11	GND	Ground (Connected to pin 8 internally).
8	GND	Ground	12	/FAULT	Overcurrent fault feedback pin, active low. Connect a pull-up resistor between /FAULT to V <sub>DD</sub> even when the /FAULT pin is unused.

Typical Application Circuit

A typical application circuit of the ACHL-7345xU consists of 10  $\mu$ F and 0.1  $\mu$ F bypass capacitors between V<sub>DD</sub> and GND, a fault pull-up resistor (R<sub>PULL-UP</sub>) between /FAULT and V<sub>DD</sub>, an output common mode voltage capacitor (C<sub>OCM</sub>) between V<sub>OCM</sub> and GND, and a load capacitor (C<sub>LOAD</sub>) between V<sub>OUT</sub> and GND. The recommended range of value for the R<sub>PULL-UP</sub>, C<sub>OCM</sub>, and C<sub>LOAD</sub> can be found in the [Recommended Operating Conditions](#) table. The supply voltage (4.5V to 5.5V) is applied to V<sub>DD</sub>. The input current is applied between pins 1 and 6, and its corresponding output voltage is measured directly from V<sub>OUT</sub>. See the [Application Information](#) section for all features of the device.



## Ordering Information

Specify the part number followed by the option number.

Part Number	Option (RoHS Compliant)	Package	Surface Mount	Tape and Reel	UL 1577 Approval	Quantity
ACHL-7345EU	-000E	Stretched SO-12	X		X	80 per tube
	-500E		X	X	X	1000 per reel
ACHL-7345HU	-500E		X	X	X	1000 per reel
ACHL-7345FU <sup>a</sup>	-500E		X	X	X	1000 per reel
ACHL-7345CU <sup>a</sup>	-500E		X	X	X	1000 per reel

a. Contact your Broadcom sales representative or authorized distributor for information.

To form an order entry, choose a part number from the Part Number column and combine it with the desired option from the Option column.

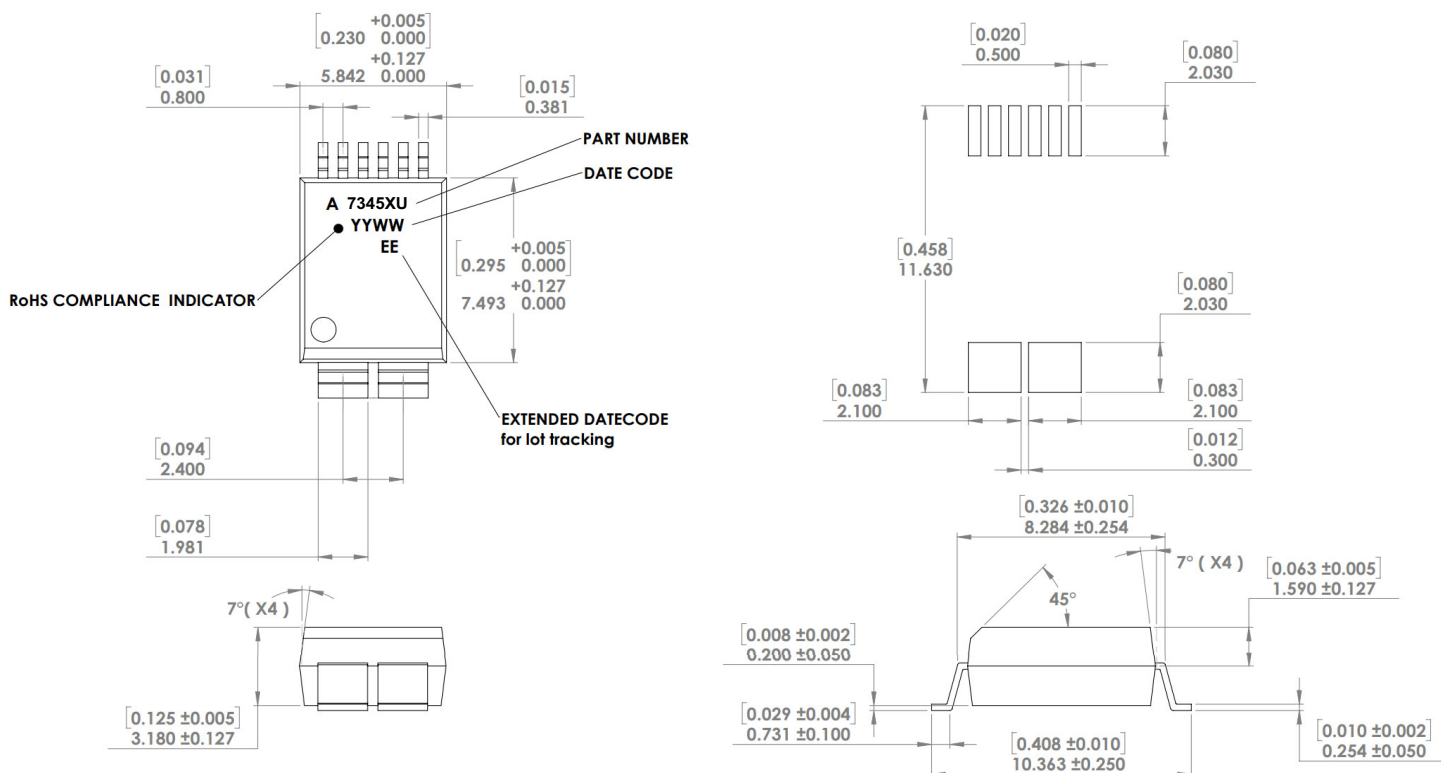
**Example:** Use ACHL-7345EU-500E to order the product with a SSO-12 surface-mount package in tape-and-reel packaging with UL1577 approval and RoHS compliance.

## Overcurrent Trip Level Selection

Part Number	/FAULT Trip Level
ACHL-7345CU	70% of $ I_{P_{MAX}} $
ACHL-7345EU	100% of $ I_{P_{MAX}} $
ACHL-7345FU	120% of $ I_{P_{MAX}} $
ACHL-7345HU	150% of $ I_{P_{MAX}} $

**Example:** The ACHL-7345EU is a product option with an input current range of  $\pm 50A$  and an overcurrent trip level of 100%. The fault signal will toggle from high to low when the input current is  $\leq -50A$  or the input current is  $\geq 50A$ .

## ACHL-7345xU SSO-12 Package



### NOTE:

- Dimensions are in millimeters (inches).
- Lead coplanarity = 0.100 mm (0.004 inches).
- Mold flash on each side = 0.127 mm (0.005 inches).
- Contact your PCB manufacturer for solder mask tolerances between and around the signal pads.

## 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 ACHL-7345xU is approved by the following organizations.

UL/cUL
UL/cUL 1577, component recognition program up to $V_{ISO} = 4240 V_{RMS}$ IEC/EN 62368-1, maximum withstand voltage ( $V_{ISO}$ ) = $4240 V_{RMS}$

## Insulation and Safety Related Specifications

Parameter	Symbol	Value	Unit	Conditions
Minimum External Air Gap (External Clearance)	L(101)	8.3	mm	Measured from input terminals to output terminals, shortest distance through air.
Minimum External Tracking (External Creepage)	L(102)	8.5	mm	Measured from input terminals to output terminals, shortest distance path along body.
Minimum Internal Plastic Gap (Internal Clearance)	—	0.05	mm	The shortest straight line distance through insulation between conductor to conductor.
Tracking Resistance (Comparative Tracking Index)	CTI	>600	V	DIN IEC 112/VDE 0303 Part 1.
Isolation Group	I			Material Group (DIN VDE 0110).

## Absolute Maximum Ratings

Parameter	Symbol	Min.	Max.	Unit	Conditions
Storage Temperature	$T_S$	-55	150	°C	
Ambient Operating Temperature	$T_A$	-40	125	°C	
Junction Temperature	$T_{J(max)}$	—	150	°C	
Primary Conductor Lead Temperature	$T_{L(MAX)}$	—	150	°C	
Supply Voltage	$V_{DD}$	-0.5	6.0	V	
Output Voltage	$V_{OUT}$	-0.5	$V_{DD} + 0.5$	V	
Output Common Mode Voltage	$V_{OCM}$	-0.5	$V_{DD} + 0.5$	V	
/Fault Voltage	$V_{/FAULT}$	-0.5	$V_{DD} + 0.5$	V	
Output Current Source	$I_{OUT(SOURCE)}$	-20	—	mA	$T_A = 25^\circ\text{C}$
Output Current Sink	$I_{OUT(SINK)}$	—	20	mA	$T_A = 25^\circ\text{C}$
Output Common Mode Current Source	$I_{OCM(SOURCE)}$	-10	—	mA	$T_A = 25^\circ\text{C}$
Output Common Mode Current Sink	$I_{OCM(SINK)}$	—	10	mA	$T_A = 25^\circ\text{C}$
/Fault Current Sink	$I_{/FAULT(SINK)}$	—	10	mA	$T_A = 25^\circ\text{C}$
Overcurrent Transient Tolerance	$I_{P(TRANS)}$	—	200	A	1 pulse, 10 ms; $T_A = 25^\circ\text{C}$
Input Power Dissipation	$P_{IN}$	—	1800	mW	$T_A = 25^\circ\text{C}$
Output Power Dissipation	$P_{OUT}$	—	140	mW	$T_A = 25^\circ\text{C}$

## Recommended Operating Conditions

Parameter	Symbol	Min.	Max.	Unit
Ambient Operating Temperature	$T_A$	-40	125	°C
Supply Voltage	$V_{DD}$	4.5	5.5	V
Output Resistive Load	$R_{LOAD}$	10	—	k $\Omega$
/Fault Pull-up Resistor	$R_{PULL-UP}$	1	20	k $\Omega$
Output Capacitance Load	$C_{LOAD}$	—	0.47	nF
Output Common Mode Capacitive Load	$C_{OCM}$	1	100	nF
Input Current Range	$I_{PR}$	-50	50	A

## Electrical Specifications

Unless otherwise stated, all minimum/maximum specifications are over  $V_{DD} = 4.5V$  to  $5.5V$ ,  $T_A = -40^{\circ}C$  to  $125^{\circ}C$ . All typical values are based on  $T_A = +25^{\circ}C$ ,  $V_{DD} = 5.0V$ ,  $C_{LOAD} = 0.47$  nF.

Parameter	Symbol	Min.	Typ.	Max.	Unit	Conditions	Fig.	Note
Supply Current	$I_{DD}$	—	19	25	mA	Output open	6	
Primary Conductance Resistance	$R_{PRIMARY}$	—	0.7	—	m $\Omega$	—		
Output Internal Resistance	$R_{OUT}$	—	5	—	$\Omega$	—		
Output Common Mode Internal Resistance	$R_{OCM}$	—	200	—	$\Omega$	—		
Power-on Time	$t_{PO}$	—	21	200	$\mu s$	$T_A = +25^{\circ}C$ , measured from 90% of $V_{DD}$ to 90% of $V_{OUT}$		a
Bandwidth	BW	—	600	—	kHz	-3 dB, $C_{LOAD} = 0.47$ nF	13	
Rise Time	$t_r$	—	1	—	$\mu s$	$C_{LOAD} = 0.47$ nF, input step with 0.3- $\mu s$ rise time, 2V step on output (from $V_{OCM}$ to $V_{OCM} + 2V$ )	12	a
Output Response Time	$t_{RESPONSE}$	—	1	—	$\mu s$		7	a
Propagation Delay Time	$t_{PD}$	—	0.5	1.2	$\mu s$		8	a
Output High Saturation Voltage	$V_{OH(SAT)}$	$V_{DD} - 0.25$	—	—	V	$I_{OUT} = 5$ mA		
Output Low Saturation Voltage	$V_{OL(SAT)}$	—	—	0.25	V	$I_{OUT} = -5$ mA		
Output Source Current	$I_{OUT(SOURCE)}$	—	—	-10	mA	$V_{DD} = 5V$ , $V_{OUT}$ shorted to GND		
Output Sink Current	$I_{OUT(SINK)}$	10	—	—	mA	$V_{DD} = V_{OUT} = 5V$		
Output Common Mode Source Current	$I_{OCM(SOURCE)}$	—	—	-5	mA	$V_{DD} = 5V$ , $V_{OCM}$ shorted to GND		
Output Common Mode Sink Current	$I_{OCM(SINK)}$	5	—	—	mA	$V_{DD} = 5V$ , $V_{OCM} = 4V$		
Fault Power-on Time	$t_{PO(/FAULT)}$	—	54	—	$\mu s$	Measured from 90% of $V_{DD}$ to 90% of $V_{/FAULT}$		a
Fault Logic Low Output Voltage	$V_{/FAULT\_L}$	—	0.03	0.25	V	$R_{PULL-UP} = 1$ k $\Omega$		a

Parameter	Symbol	Min.	Typ.	Max.	Unit	Conditions	Fig.	Note
Fault Logic High Output Current	$I_{/FAULT\_H}$	—	—	5	$\mu A$	$V_{/FAULT} = 5V$		a
Fault Response Time	$t_{FD}$	—	0.8	—	$\mu s$	$R_{PULL-UP} = 1\text{ k}\Omega$ , tested at input current step from 0 to 125% of $I_{P_{MAX}}$ . Tested at $/FAULT$ trip level of 100% of $I_{P_{MAX}}$ .	9	a
Fault Release Time	$t_{FR}$	—	0.5	1	$\mu s$	$R_{PULL-UP} = 1\text{ k}\Omega$	10	a
Offset Power Supply Rejection Ratio	OPSRR	—	64	—	dB	$\Delta V_{DD} = 5.5V - 4.5V = 1V$		a, b
Common Mode Transient Immunity	CMTI	25	—	—	kV/ $\mu s$	$T_A = 25^\circ C$ , $V_{CM} = 1000V$		a, c
Optimized Accuracy Range	$I_{PR}$	–50	—	50	A	—		d
Sensitivity	Sens	—	40	—	mV/A	$-50A \leq I_P \leq 50A$	1	a
Sensitivity Error	$E_{Sens}$	–2	—	2	%	$V_{DD} = 5V, T_A = 25^\circ C$	2	a
		–4.5	—	4.5	%	$V_{DD} = 5V, T_A = -40^\circ C \text{ to } 125^\circ C$	2	
Output Common Mode Voltage	$V_{OCM}$	—	$V_{DD}/2$	—	V	—		a
Output Common Mode Voltage Offset	$V_{OCM(OFFSET)}$	–5	0.1	5	mV	$V_{DD} = 5V, T_A = 25^\circ C$		
		–10	0.1	10	mV	$V_{DD} = 5V, T_A = -40^\circ C \text{ to } 125^\circ C$		
Offset Voltage ( $V_{OUT} - V_{OCM}$ )	$V_{OFFSET}$	–15	$\pm 1$	15	mV	$V_{DD} = 5V, T_A = 25^\circ C$	3	a
		–35	$\pm 1$	20	mV	$V_{DD} = 5V, T_A = -40^\circ C \text{ to } 125^\circ C$		a
Nonlinearity	NL	—	0.1	0.5	%	$V_{DD} = 5V$	5	a, e
Total Output Error	$E_{TOT}$	–4.5	$\pm 1$	4.5	%	$V_{DD} = 5V$	4	a, f, g
Input Reference Noise	$I_{N(RMS)}$	—	199	—	$mA_{RMS}$	$BW = 500\text{ kHz}$		
Noise Density	$I_{ND}$	—	281	—	$\mu A/Hz^{1/2}$	—		
Fault Input Current Hysteresis	$I_{HYSTERESIS}$	—	$0.1 \times  I_{P_{MAX}} $	—	A	Tested at overcurrent trip level of 100% of $I_{P_{MAX}}$ .		a
Fault Trip Level Error	$E_{/FAULT}$	—	$\pm 2$	—	%	Tested at overcurrent trip level of 100% of $I_{P_{MAX}}$ .		a
Sensitivity Error Lifetime Drift	$E_{SENS\_DRIFT}$	—	$\pm 2.5$	—	%	—		
Total Output Error Lifetime Drift	$E_{TOT\_DRIFT}$	—	$\pm 2.5$	—	%	—		

a. See [Definitions of Electrical Characteristics](#) and [Application Information](#).

b. The Offset Power Supply Rejection Ratio is calculated using  $OPSRR = 20\log(\Delta V_{DD}/\Delta V_{OFFSET})$ .

c. The Common Mode Transient Immunity is tested by applying a fast rising/falling voltage pulse across input pins (pins 1 and 6) and GND (pins 8 and 11). The output glitch observed is less than 0.2V from the average output voltage for less than 1  $\mu s$ .

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

e. 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.

f. The total output error in percentage is the sum of the Sensitivity Error, Nonlinearity, and Offset Voltage Error.

g. The Typical Total Output Error ( $E_{TOT}$ ),  $t_{ini}$ , is based on population the mean +  $4\sigma$  from qualification test results.  $E_{TOT}$ ,  $t_{ini}$ , is the Total Output Error test result from the initial test at  $T_A = 25^\circ C$ .

## Package Characteristics

Parameter	Symbol	Min.	Typ.	Max.	Unit	Conditions	Note
Input-Output Momentary Withstand Voltage	$V_{ISO}$	4240	—	—	$V_{RMS}$	$RH < 50\%$ , $t = 1 \text{ min.}$ , $T_A = 25^\circ\text{C}$	a,b,c
Resistance (Input-Output)	$R_{I-O}$	—	$10^{14}$	—	$\Omega$	$V_{I-O} = 500 \text{ V}_{DC}$	b
Capacitance (Input-Output)	$C_{I-O}$	—	1.6	—	pF	$f = 1 \text{ MHz}$	b
Junction-to-Ambient Thermal Resistance (Due to Primary Conductor)	$\theta_{21}$	—	26.7	—	$^\circ\text{C/W}$	Based on Broadcom evaluation board	d
Junction-to-Ambient Thermal Resistance (Due to IC)	$\theta_{22}$	—	4.1	—	$^\circ\text{C/W}$	Based on Broadcom evaluation board	d

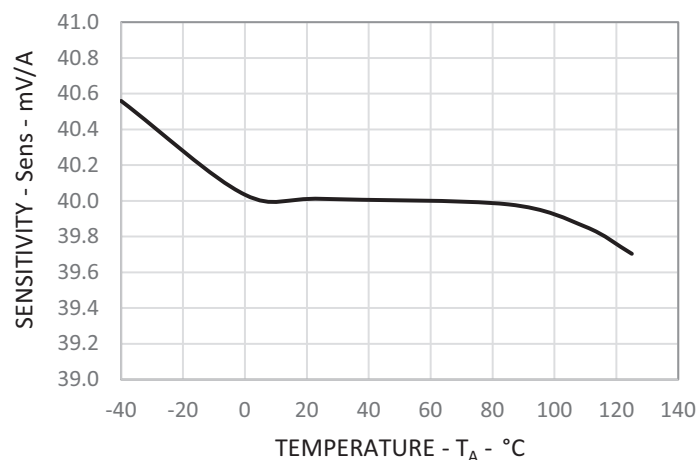
- The Input-Output Momentary Withstand Voltage is a dielectric voltage rating that should not be interpreted as an input-output continuous voltage rating.
- This is a two-terminal measurement: pins 1 through 6 are shorted together, and pins 7 through 12 are shorted together.
- 100% tested in production at  $5200 \text{ V}_{RMS}$  for 1 second.
- See [Definitions of Electrical Characteristics](#) and [Application Information](#).



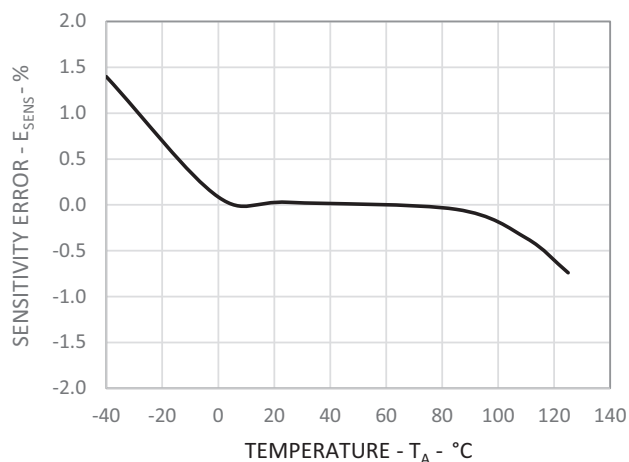
## Typical Performance Plots

All typical plots are based on  $T_A = 25^\circ\text{C}$ ,  $V_{DD} = 5.0\text{V}$ ,  $C_{LOAD} = 0.47\text{ nF}$ , unless otherwise stated.

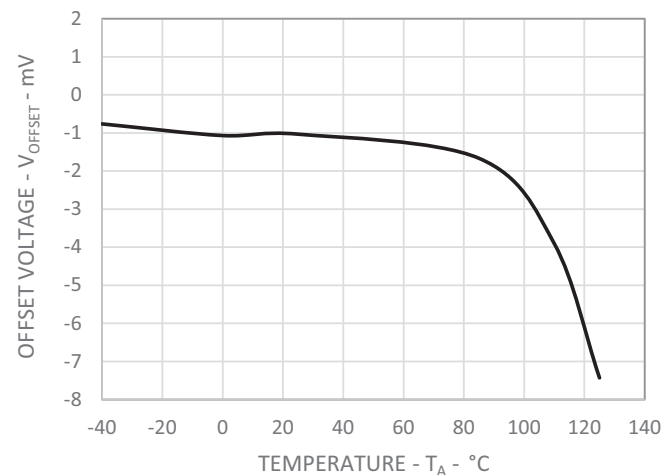
**Figure 1: Sensitivity vs Temperature**



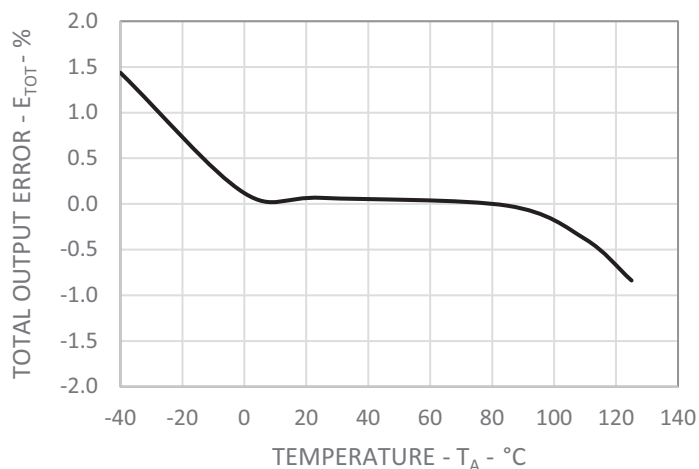
**Figure 2: Sensitivity Error vs Temperature**



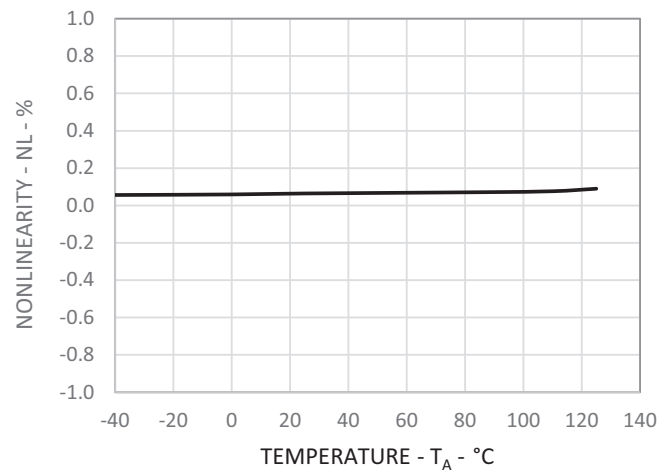
**Figure 3: Offset Voltage vs Temperature**



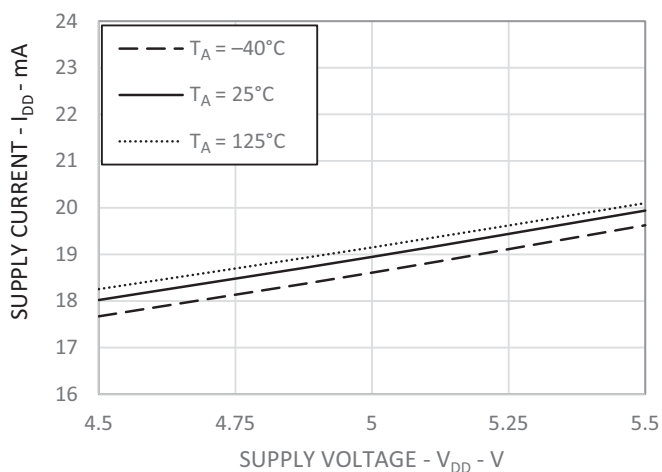
**Figure 4: Total Output Error vs Temperature**



**Figure 5: Nonlinearity vs Temperature**



**Figure 6: Supply Current vs Supply Voltage**



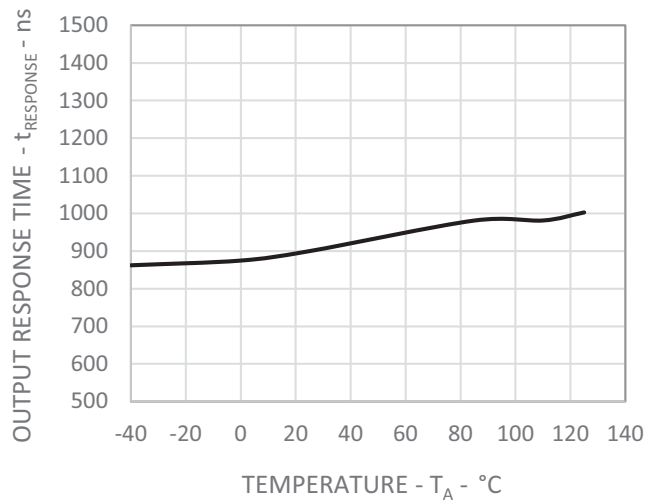
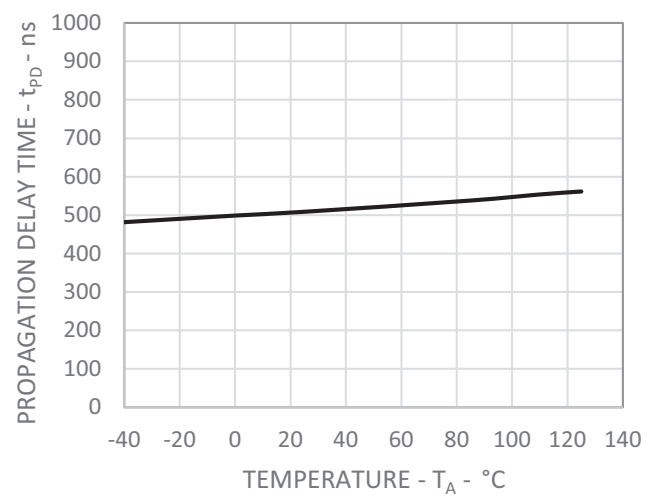
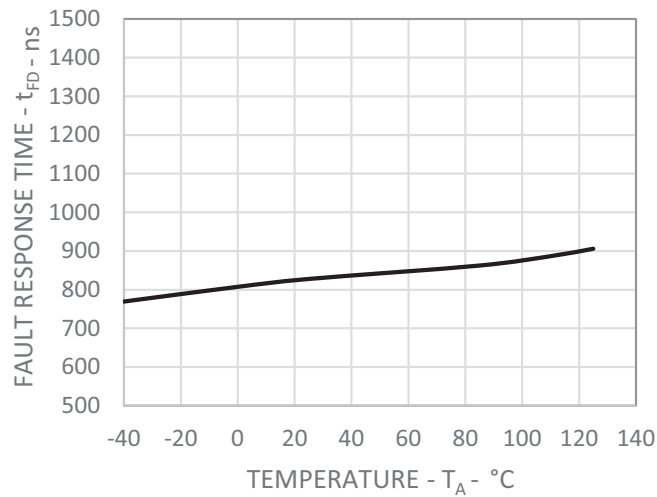
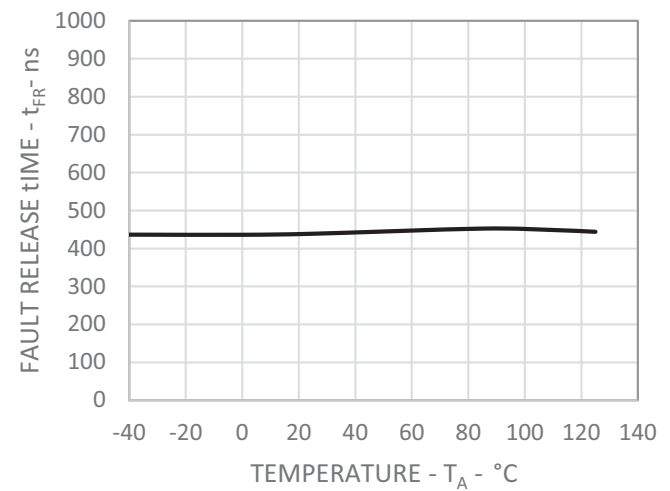
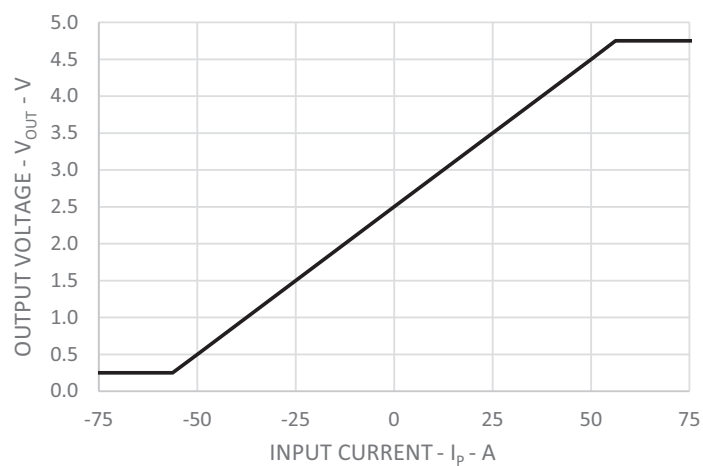
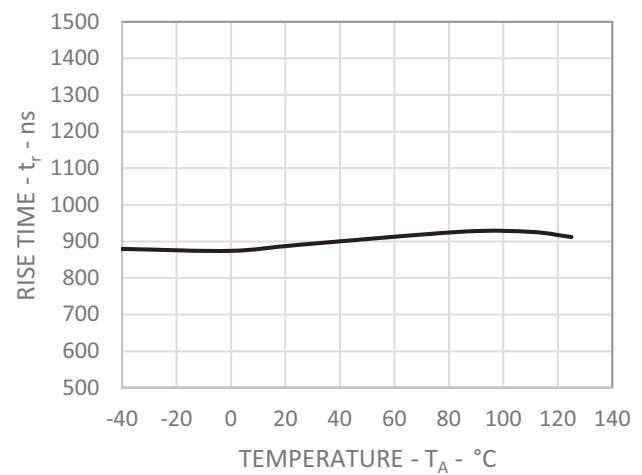
**Figure 7: Output Response Time vs Temperature****Figure 8: Propagation Delay Time vs Temperature****Figure 9: Fault Response Time vs Temperature****Figure 10: Fault Release Time vs Temperature****Figure 11: Output Voltage vs Input Current****Figure 12: Rise Time vs Temperature**

Figure 13: Gain vs Frequency

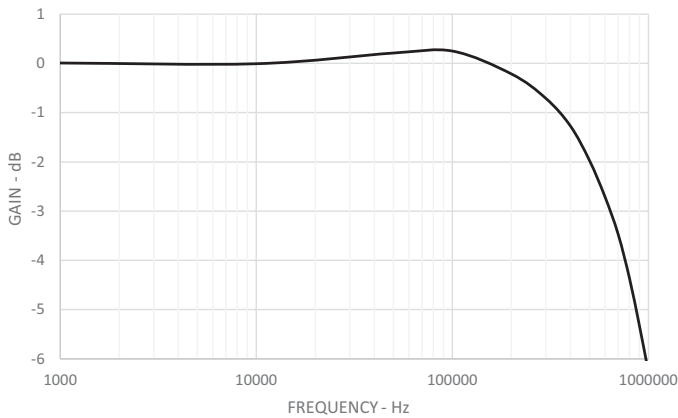


Figure 14: Phase vs Frequency

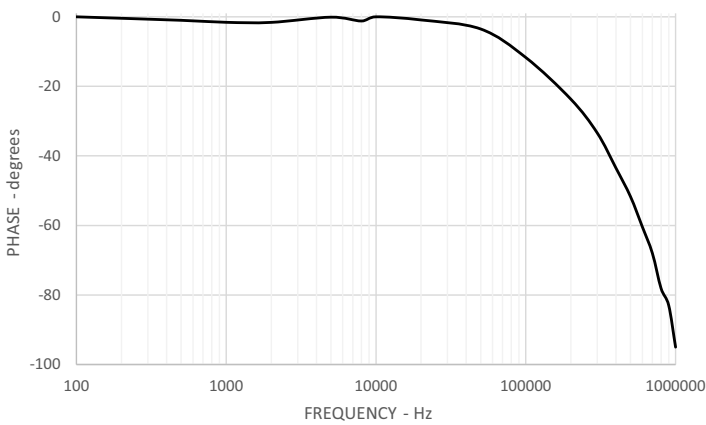


Figure 15: Thermal Derating (Input Power) Using a 2-oz. Broadcom Board

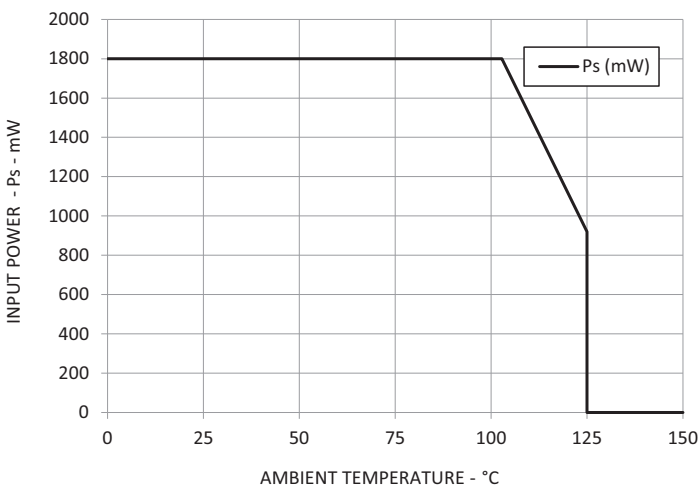
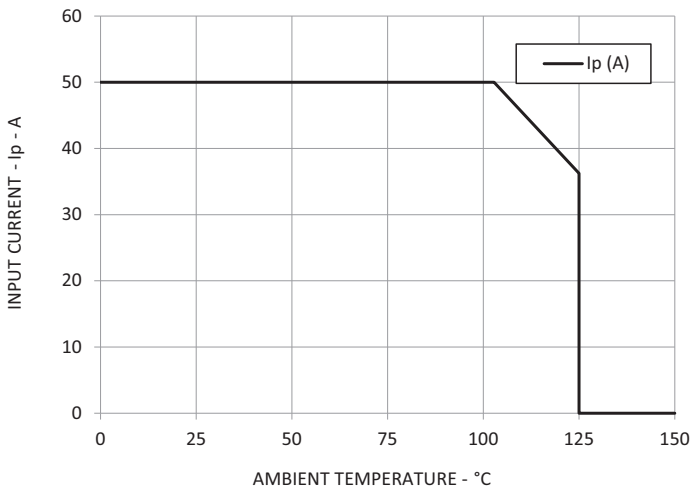


Figure 16: Thermal Derating (Input Current) Using a 2-oz. Broadcom Board



## Definitions of Electrical Characteristics

The ACHL-7345xU 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 the magnetic field, the output voltage is half of the supply voltage. It can detect both DC and AC current.

## Ratiometric Output

The output voltage of the ACHL-7345xU 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, when the  $V_{DD}$  is increased by +10% from 5V to 5.5V, the output common mode voltage will change from 2.5V to 2.75V and the sensitivity will also change 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, which 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 6.

## Offset Voltage

The offset voltage ( $V_{OFFSET}$ ) is the difference between the output voltage and ideal output voltage when the input current is zero. The offset voltage is calculated using the difference between the output voltage and output common mode voltage:

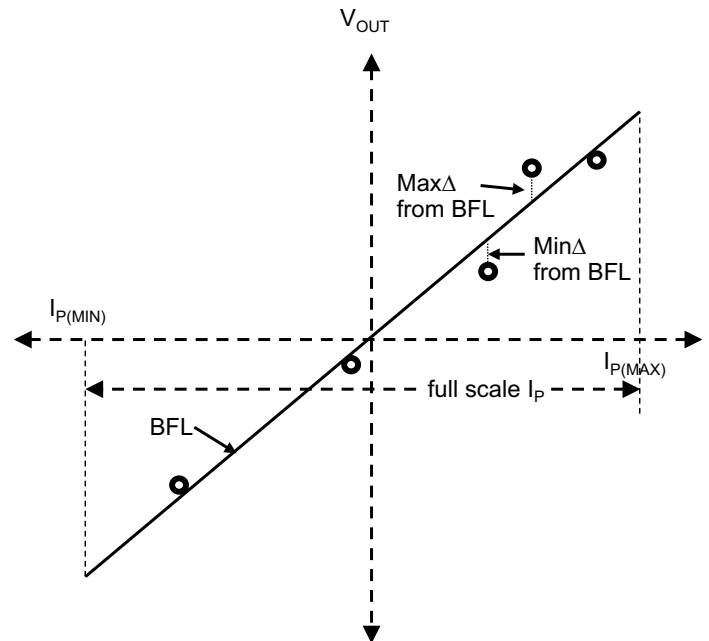
$$V_{OFFSET} = V_{OUT} - V_{OCM}$$

## 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 the full-scale input current ( $I_P$ ).

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

Figure 17: Nonlinearity Scale



## Total Output Error

Total output error is the difference between the actual measured voltage and the ideal output voltage. It is the sum of all sources of error such as sensitivity error, offset voltage error, and nonlinearity. The total output error in percentage is expressed in this equation:

$$E_{TOT}(\%) = E_{Sens} + 100 \times V_{OFFSET} / (\text{Sens} \times \text{Full-Scale } I_P) + NL$$

## Offset Power Supply Rejection Ratio

OPSR is the rate of change in the offset voltage relative to the change in supply voltage expressed in dB.

$OPSR = 20\log_{10} (\Delta V_{DD} / \Delta V_{OFFSET})$ , which means that a value of 64 dB corresponds to a 0.315 mV change in the  $V_{OFFSET}$  for a 500 mV change in  $V_{DD}$ .

## Timing Parameters

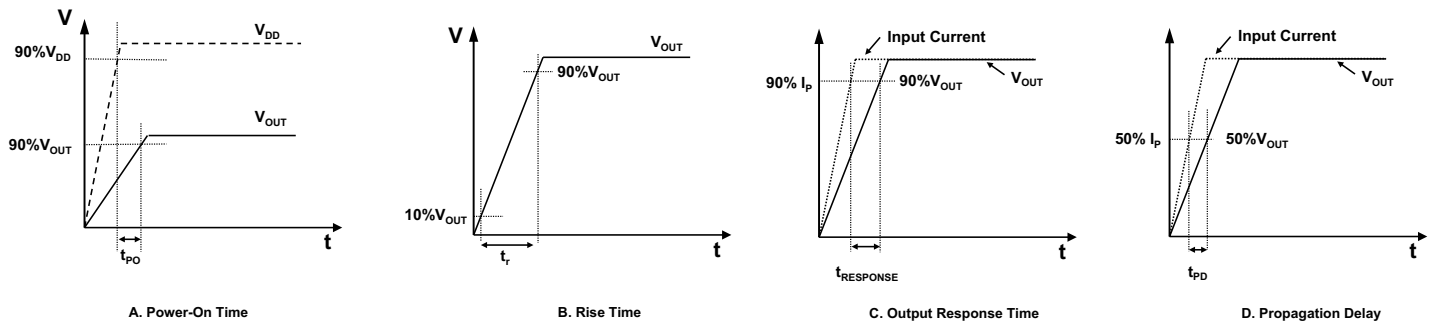
Power-on time is the time required for the internal circuitry of the device to be ready during the ramping of the supply voltage. Power-on time is defined as the finite time.

Rise time is the time taken by the output signal to rise from 10% to 90% of its full-scale value. It is required for the output voltage to settle after the supply voltage reached its recommended operating voltage.

Output response time is the time interval between 90% of the input current and 90% of the output voltage.

Propagation delay time is the time interval between 50% of the input current and 50% of the output voltage.

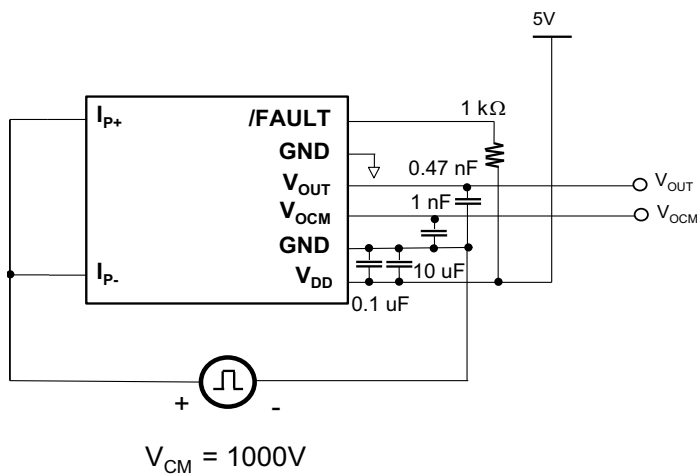
**Figure 18: Timing Parameters**



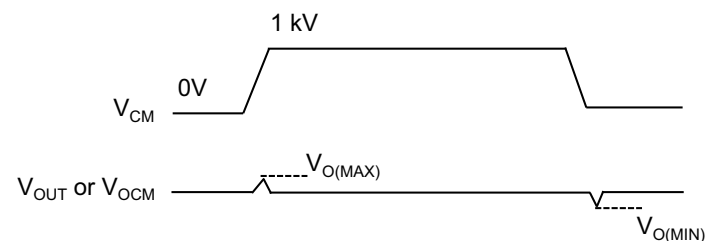
## Common Mode Transient Immunity

Ideally, the Hall-effect sensor is immune to common mode interference and would have complete isolation between the input side and output side. But the physical proximity between the input leadframe and output leadframe creates a small capacitance known as  $C_{I-O}$ . The effect of common mode interference can be seen in Figure 20. When a high voltage with fast transient (large  $dv/dt$ ) is applied between input side and output side, an output glitch appears on the measured output voltage.

**Figure 19: CMTI Test Setup**



**Figure 20: CMTI Test Waveform**



### Pass/Fail Criteria:

Output Glitch ( $V_{O(MAX)}$  or  $V_{O(MIN)}$ ) must be less than 0.2V from the average output voltage for less than 1  $\mu s$ .

# Application Information

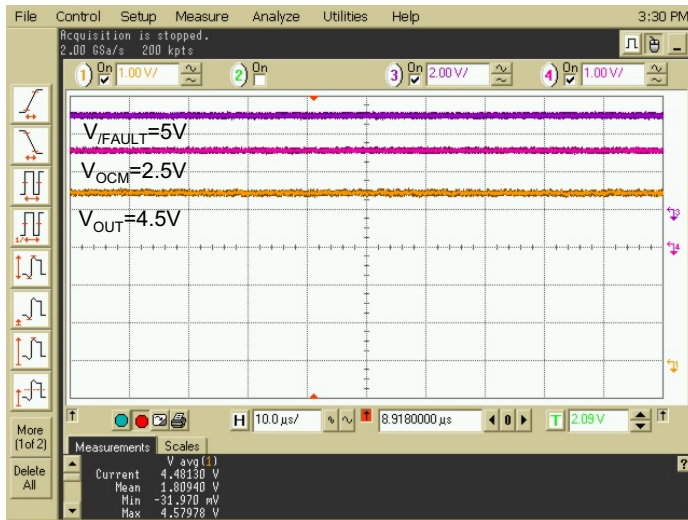
## Operation

The ACHL-7345xU can measure both DC and AC current. When an input current is applied,  $V_{OUT}$  will increase proportional to the input current. Output voltage is expressed by this equation:

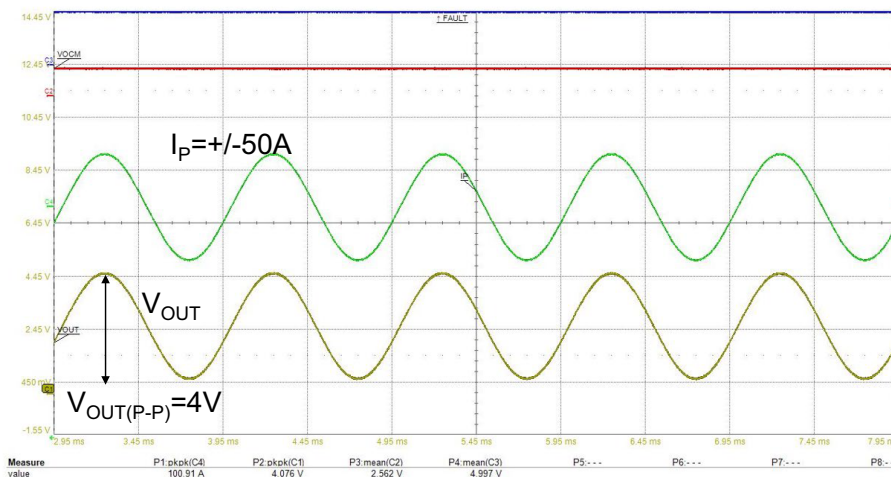
$$V_{OUT} = V_{DD}/2 + \text{Sens} \times I_P$$

For example, when  $V_{DD} = 5V$  and  $I_P = 50A$ ,  $V_{OUT} = 5V/2 + (40 \text{ mV/A} \times 50 \text{ A}) = 4.5V$ .

**Figure 21: DC Transfer Function with Input Current ( $I_P$ ) = 50A**



**Figure 22: Transfer Function with AC Input Current**

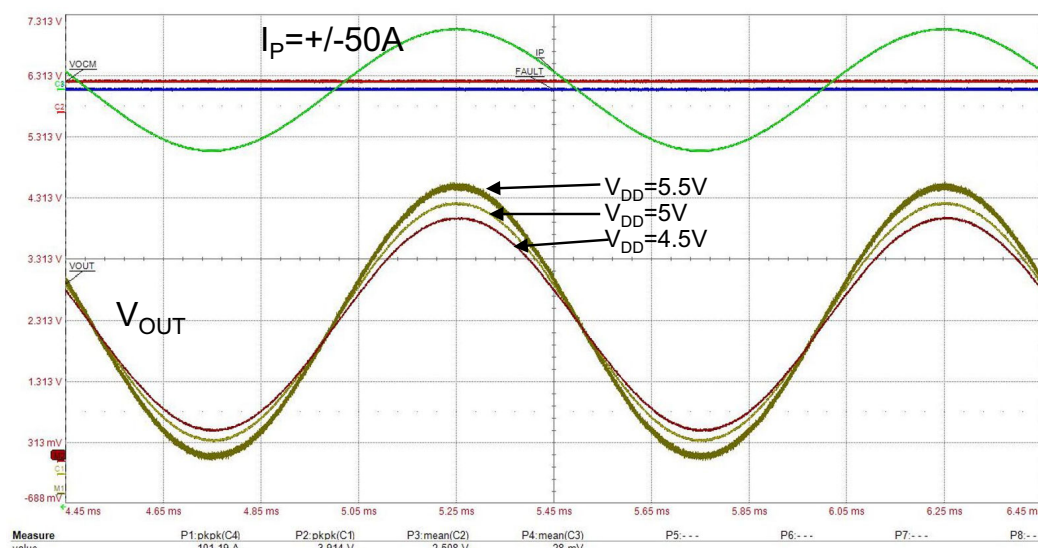


## Ratiometry

The ACHL-7345xU is a ratiometric sensor wherein the output voltages ( $V_{OCM}$  and  $V_{OUT}$ ) and sensitivity changes proportionally with the change of supply voltage. For example, when the  $V_{DD}$  is increased by +10% from 5V to 5.5V, the output voltages will change from 2.5V to 2.75V and the sensitivity (Sens) will also change from 40 mV/A to 44 mV/A. The following table shows the changes in output voltages when there is a change in supply voltage.

Input Current ( $I_P$ )	Output Voltage ( $V_{OUT}$ ) ( $V_{DD} = 5V$ )	Output Voltage ( $V_{OUT}$ ) ( $V_{DD} = 4.5V$ )	Output Voltage ( $V_{OUT}$ ) ( $V_{DD} = 5.5V$ )
50A	4.5V	4.05V	4.95V
-50A	0.5V	0.45V	0.55V

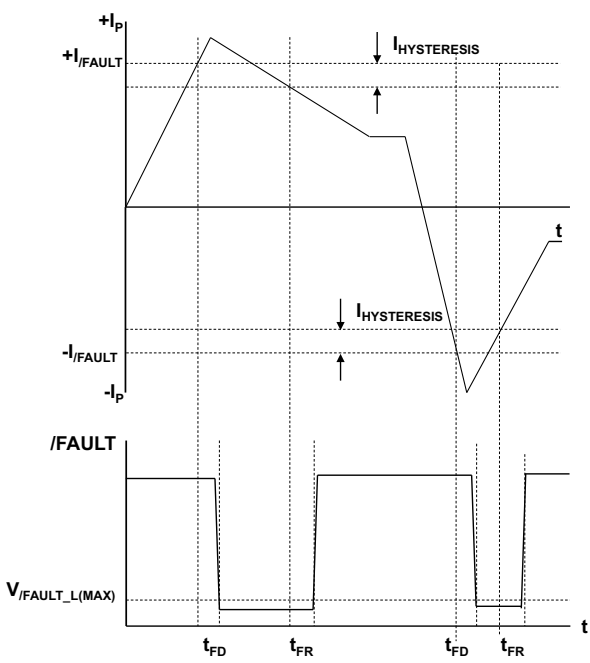
Figure 23: Output Voltage at  $V_{DD} = 4.5V$ , 5V, and 5.5V



## Overcurrent Fault Detection

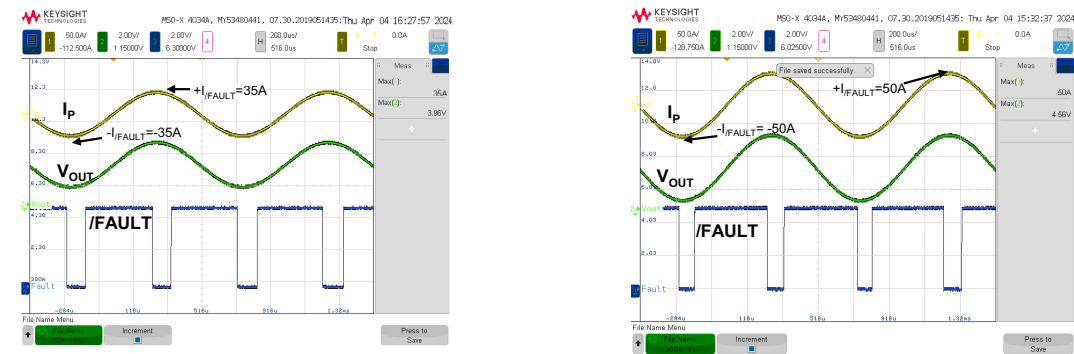
The ACHL-7345xU has an overcurrent fault detection that toggles the  $/FAULT$  signal from High to Low when the detected current exceeds the preset threshold  $+I_{/FAULT}$  or  $-I_{/FAULT}$ . The fault input current hysteresis ( $I_{HYSTERIS}$ ) is 10% of  $I_{PMAX}$ , which is 5A. The  $/FAULT$  signal goes back to High once the detected current goes below 5A of  $+I_{/FAULT}$  or above 5A of  $-I_{/FAULT}$  for negative current. For example, for ACHL-7345EU (fault trip level = 50A and -50A), the  $/FAULT$  signal will toggle from High to Low when the input signal is  $\geq 50A$ . When the input signal decreases to 45A, the  $/FAULT$  signal will toggle back from Low to High indicating the end of overcurrent. The fault detection accuracy is  $\pm 2\%$ .

Figure 24: Fault Timing Diagram



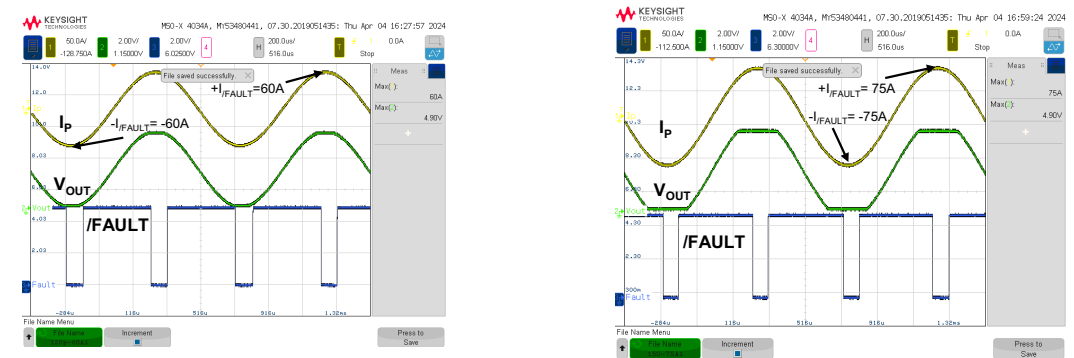
The following figures show an overcurrent event for different ACHL-7345xU options.

Figure 25: Overcurrent Event for ACHL-7345xU Options



A. ACHL-7345CU (Fault Trip Level = 70% of  $|I_{P_{MAX}}|$ )

B. ACHL-7345EU (Fault Trip Level = 100% of  $|I_{P_{MAX}}|$ )



C. ACHL-7345FU (Fault Trip Level = 120% of  $|I_{P_{MAX}}|$ )

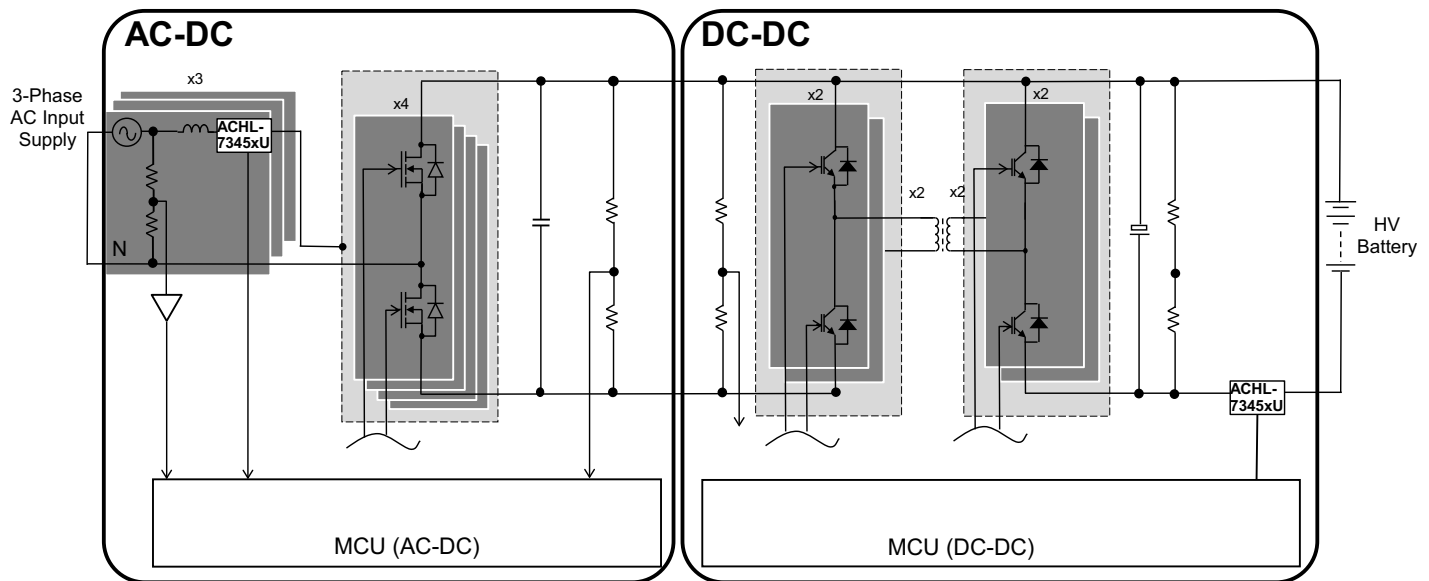
D. ACHL-7345HU (Fault Trip Level = 150% of  $|I_{P_{MAX}}|$ )



## Typical Application

The typical application of ACHL-7345xU is current sensing in onboard chargers where PFC and DC-DC circuits ensure that the electric vehicle complies with regulations. The Hall-effect current sensors are used to measure the AC or DC current flowing in the system by providing linear voltage output and overcurrent feedback to the microcontroller. In a three-phase input current sensing application, for example, the ACHL-7345xU can be used in a  $\pm 50\text{A}$  current range for each phase. The linear output voltage that is proportional to the sensed input current is read by the microcontroller while providing isolation between the high-voltage/high-current side and microcontroller. Overcurrent detection is implemented through the  $/\text{FAULT}$  pin. A precise reference voltage that represents  $V_{\text{DD}}/2$  can also be used if necessary through the  $V_{\text{OCM}}$  pin.

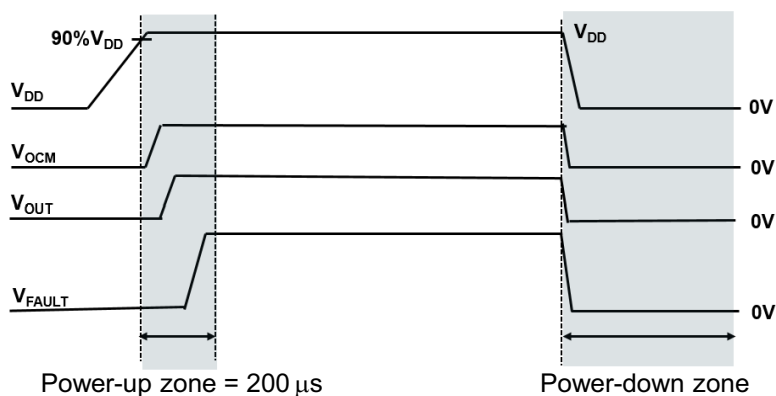
Figure 26: Onboard Charger Simplified Block Diagram



## Initial Power-Up and Power-Down

During the initial power-up, it is recommended to read any measurement after  $200\ \mu\text{s}$  from  $90\%$  of  $V_{\text{DD}}$  (power-up zone) in order for all internal circuitry to be ready. Consequently, during power-down, it is recommended not to read any measurement ( $V_{\text{OUT}}$ ,  $V_{\text{OCM}}$ ,  $V_{\text{FAULT}}$ ) when  $V_{\text{DD}}$  starts to ramp down (power-down zone).

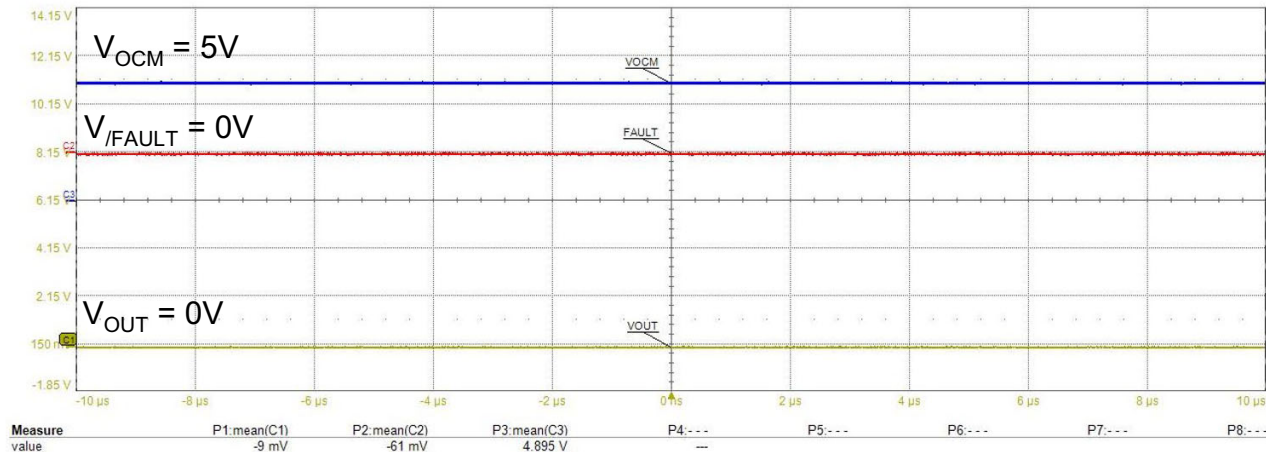
Figure 27: Power-Up Zone and Power-Down Zone



## Detection of Missing Pull-up Resistor ( $R_{PULL-UP}$ ) and Overcurrent Protection on /FAULT Pin

If the connection from the /FAULT to  $V_{DD}$  is open due to a missing pull-up resistor or open circuit, the  $V_{OCM}$  signal will toggle High and the  $V_{OUT}$  signal will toggle Low. The /FAULT pin also has a built-in current limiter circuit that protects the /FAULT pin from overcurrent in the event of a pull-up resistor short. This built-in circuit prevents internal circuit damage to the device due to overcurrent.

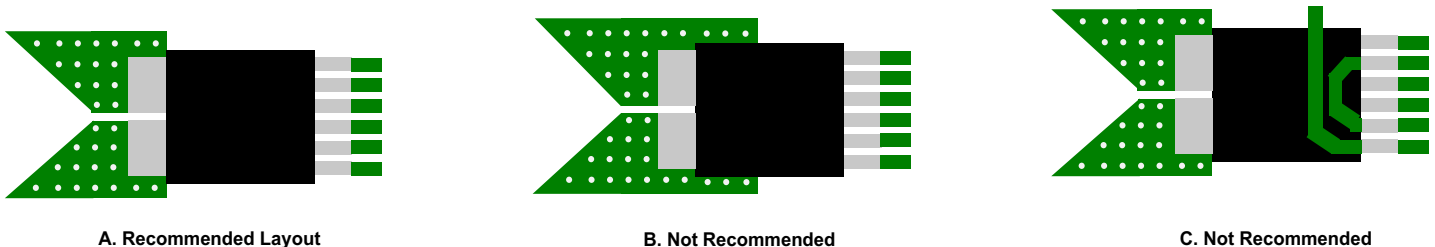
Figure 28:  $V_{OCM}$ ,  $V_{FAULT}$ , and  $V_{OUT}$  DC Voltages When  $R_{PULL-UP}$  Is Missing



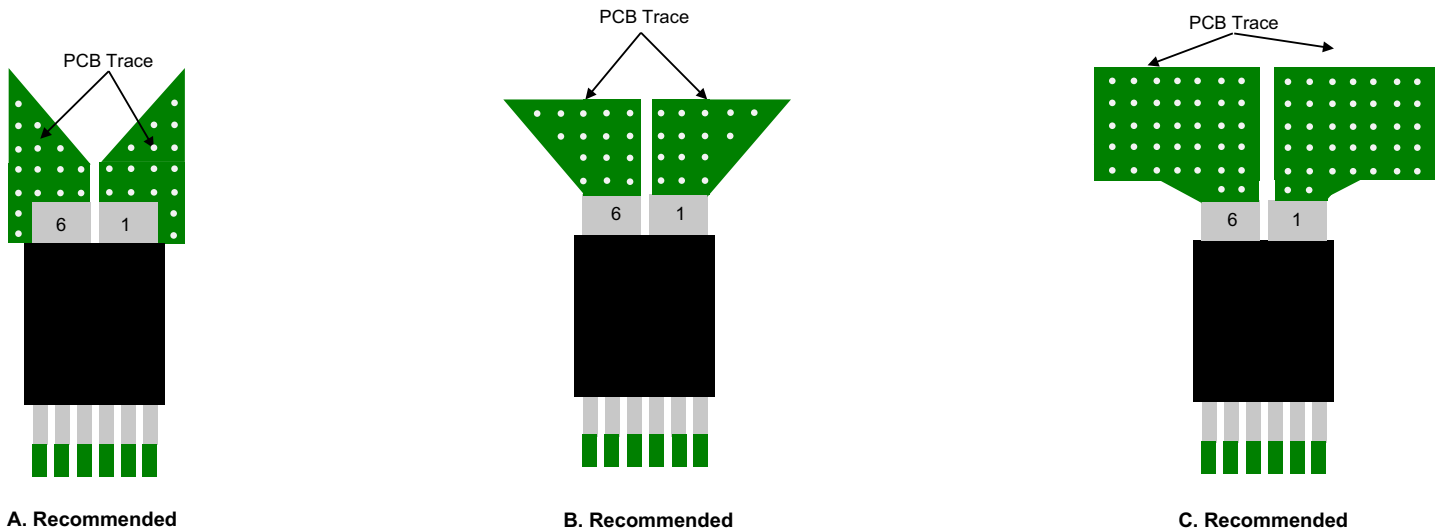
## PCB Layout and Thermal Consideration

The design of the printed circuit board should follow good layout practices, such as keeping bypass capacitors close to the supply pin and the use of ground and power planes. 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. Avoid routing the two ground pins (8 and 11) as shown in Figure 29c. It is recommended to connect these ground pins through the ground plane.

Figure 29: PCB Ground Plane Layout

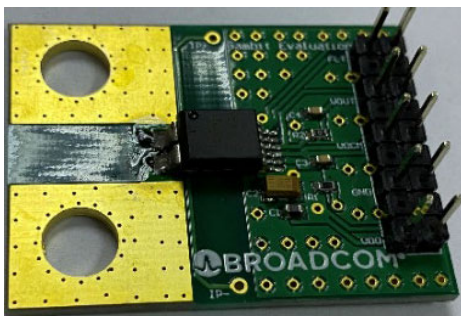
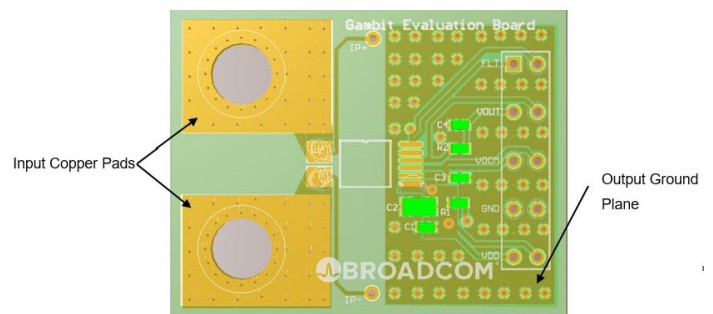


The trace layout on the input pins of the device has an effect on the sensitivity. It is recommended that the PCB trace connection to the input pins cover the pins fully as shown in Figure 30.

**Figure 30: Trace Connections Layout**

## Thermal Considerations

Figure 31 and Figure 32 show the evaluation board used in the thermal characterization. The board used an FR4 material with two layers of 2-oz/2-oz copper. The inputs  $I_{P+}$  and  $I_{P-}$  are each connected to the input copper pad with at 305-mm<sup>2</sup> total area (including the top and bottom planes, minus the screw mounting holes). The output side GND is connected to a ground plane with a 1056-mm<sup>2</sup> total area (including top and bottom planes). The  $V_{DD}$  pin is connected to the copper pad area of 24 mm<sup>2</sup> (bottom layer only). This design enables the board to conduct high current and achieve good thermal distribution in a limited space. For applications that operate at an ambient temperature greater than 102°C, it is recommended to use a 4-oz/4-oz copper board.

**Figure 31: Broadcom Evaluation Board****Figure 32: Layout of the Broadcom Evaluation Board**

## Thermal Calculations

The two thermal resistances of the device are  $\theta_{21}$  (thermal resistance due to heating of the input power) and  $\theta_{22}$  (thermal resistance due to heating of the output power).

- $\theta_{21} = 26.7^{\circ}\text{C/W}$
- $\theta_{22} = 4.1^{\circ}\text{C/W}$

The IC junction temperature can be calculated using the following equation:

$$T_J = \theta_{21} \times P_{IN} + \theta_{22} \times P_O + T_A$$

Where:

- $T_J$  = Junction temperature of the device
- $P_{IN}$  = Input power
- $P_O$  = Output power
- $T_A$  = Ambient operating temperature

In the following two examples, the IC junction temperature is calculated to determine if derating is required for each operating condition.

### Example 1:

- Ambient temperature ( $T_A$ ) =  $85^{\circ}\text{C}$
- Input current = 50A
- Output supply voltage = 5.0V
- Output supply current = 19 mA

To determine the IC junction temperature:

$$T_J = \theta_{21} \times P_{IN} + \theta_{22} \times P_O + T_A$$

$$T_J = (26.7^{\circ}\text{C/W} \times (50\text{A} \times 50\text{A} \times 0.7 \text{ m}\Omega) + (4.1^{\circ}\text{C/W} \times 5.0\text{V} \times 19 \text{ mA}) + 85^{\circ}\text{C}$$

$$T_J = 132.1^{\circ}\text{C}$$

The calculated junction temperature is less than  $150^{\circ}\text{C}$  (maximum allowable junction temperature). Derating is not required.

### Example 2:

- Ambient temperature ( $T_A$ ) =  $125^{\circ}\text{C}$
- Input current = 50A
- Output supply voltage = 5.0V
- Output supply current = 19 mA

To determine the IC junction temperature:

$$T_J = \theta_{21} \times P_{IN} + \theta_{22} \times P_O + T_A$$

$$T_J = (26.7^{\circ}\text{C/W} \times (50\text{A} \times 50\text{A} \times 0.7 \text{ m}\Omega) + (4.1^{\circ}\text{C/W} \times 5.0\text{V} \times 19 \text{ mA}) + 125^{\circ}\text{C}$$

$$T_J = 172.1^{\circ}\text{C}$$

The calculated junction temperature is more than  $150^{\circ}\text{C}$  (maximum allowable junction temperature). Derating is required at these operating conditions.

Derating can be achieved by either lowering the ambient operating temperature or reducing the input current in the device. The input current used in these calculations is continuous DC current. Use the RMS input current equivalent if the input current is not DC. See [Typical Performance Plots](#) for the derating curves for current and power derating.

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