Data Sheet

ACHL-7345xT

Fully Integrated, Automotive Hall-Effect Based Linear Current Sensor

Overview

The Broadcom® ACHL-7345xT is a fully integrated Hall-effect based isolated linear current sensor device that is designed for AC or DC current sensing in automotive applications. The ACHL-7345xT 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 mΩ 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

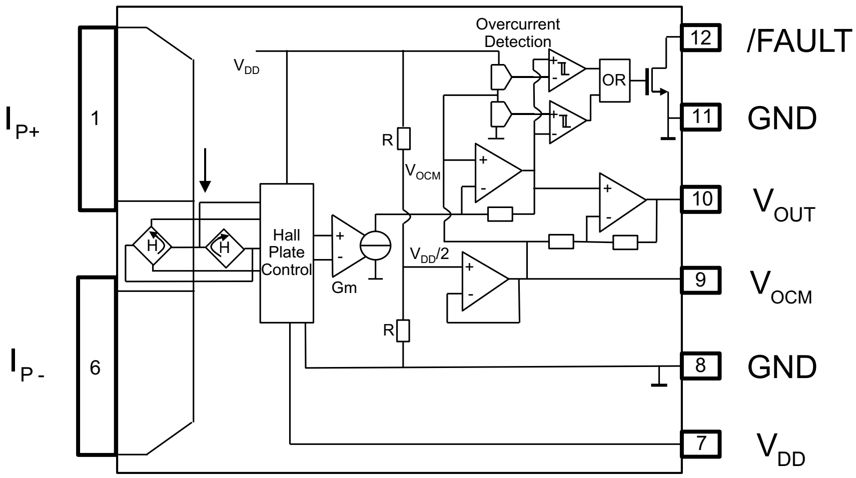
- Wide operating temperature: –40°C to +125°C
- Qualified to AEC-Q100 Grade 1 test guidelines
- Internal conductor resistance: 0.7 mΩ typical
- Output voltage proportional to AC or DC currents
- Current sensing range: ±50A
- Ratiometric output from supply voltage
- Single supply operation: 5.0V
- Bandwidth: 600 kHz typical
- Overcurrent fault feedback: 0.8 µs typical
- Total output error: ±1% typical
- Common mode transient immunity: >25 kV/µs
- Small footprint, low-profile SSO-12 package
- Worldwide safety approval: IEC/EN62368-1, UL/cUL1577
  - Isolation voltage: 4.24 kVrms, 1 minute

Applications

- Automotive motor inverter current sensing
- Automotive motor phase current sensing
- Automotive AC/DC and DC/DC converter current sensing
- General-purpose current sensing and monitoring

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 designed to be used in military or aerospace applications or environments.

Functional Diagram

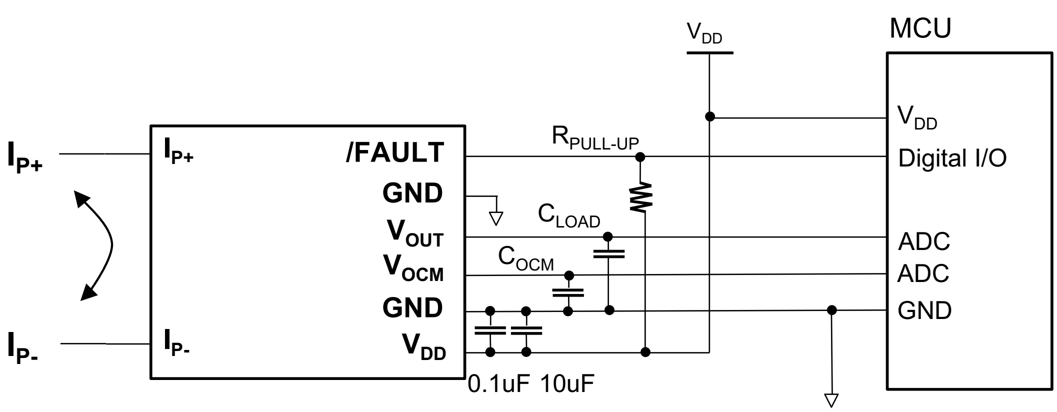


Pin Descriptions

Pin	Pin Name	Description	Pin	Pin Name	Description
1	I_{P+}	Positive terminal for input current	9	V_{OCM}	Output common mode voltage, $V_{DD}/2$. If the V_{OCM} pin is unused, leave the pin floating.
6	I_{P-}	Negative terminal for input current	10	V_{OUT}	Output voltage.
7	V_{DD}	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_{DD} even when the /FAULT pin is unused.

Typical Application Circuit

A typical application circuit of the ACHL-7345xT consists of 10 μF and 0.1 μF bypass capacitors between V_{DD} and GND, a fault pull-up resistor ($R_{PULL-UP}$) between /FAULT and V_{DD}, an output common mode voltage capacitor (C_{OCM}) between V_{OCM} and GND, and a load capacitor (C_{LOAD}) between V_{OUT} and GND. The recommended range of value for the $R_{PULL-UP}$, C_{OCM}, and C_{LOAD} can be found in the Recommended Operating Conditions table. The supply voltage (4.5V to 5.5V) is applied to V_{DD}. The input current is applied between pins 1 and 6, and its corresponding output voltage is measured directly from V_{OUT}. 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-7345ET	-000E	Stretched SO-12	X		X	80 per tube
	-500E		X	X	X	1000 per reel
ACHL-7345HT	-500E		X	X	X	1000 per reel
ACHL-7345FT[a]	-500E		X	X	X	1000 per reel
ACHL-7345CT[a]	-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.

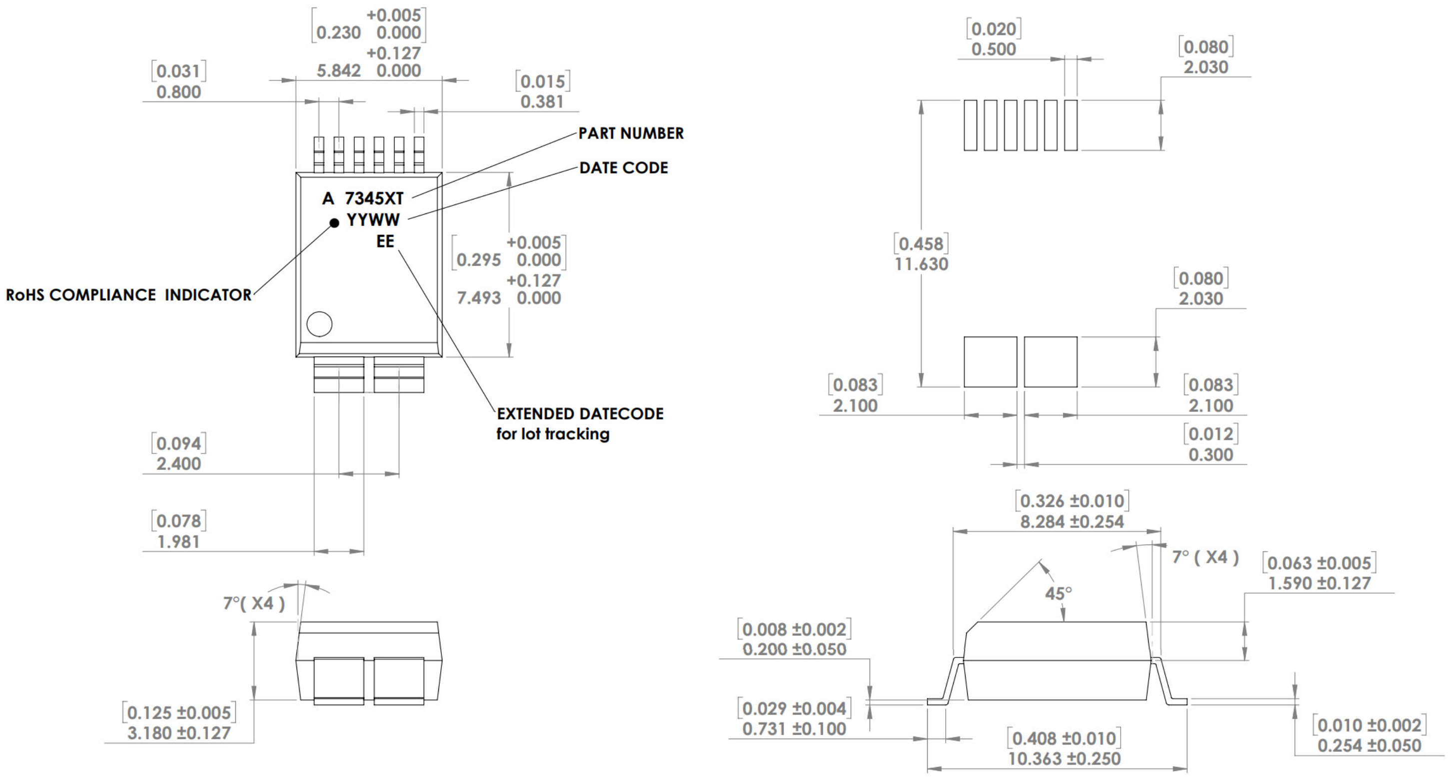
Example: Use ACHL-7345ET-500E to order the product with a SSO-12 surface-mount package in tape-and-reel packaging with UL1577 approval and RoHS compliant.

Overcurrent Trip Level Selection

Part Number	/FAULT Trip Level
ACHL-7345CT	70% of $|I_{PMAX}|$
ACHL-7345ET	100% of $|I_{PMAX}|$
ACHL-7345FT	120% of $|I_{PMAX}|$
ACHL-7345HT	150% of $|I_{PMAX}|$

Example: ACHL-7345ET is a product option with an input current range of ±50A and an overcurrent trip level of 100%. The fault signal will toggle from high to low when the input current ≤ –50A or the input current ≥ 50A.

ACHL-7345xT SSO-12 Package



NOTE:

- Dimensions 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-7345xT 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	Test 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°C
Output Current Sink	$I_{OUT(SINK)}$	—	20	mA	T_A = 25°C
Output Common Mode Current Source	$I_{OCM(SOURCE)}$	–10	—	mA	T_A = 25°C
Output Common Mode Current Sink	$I_{OCM(SINK)}$	—	10	mA	T_A = 25°C
/Fault Current Sink	$I_{/FAULT(SINK)}$	—	10	mA	T_A = 25°C
Overcurrent Transient Tolerance	$I_{P(TRANS)}$	—	200	A	1 pulse, 10 ms; T_A = 25°C
Input Power Dissipation	P_{IN}	—	1800	mW	T_A = 25°C
Output Power Dissipation	P_{OUT}	—	140	mW	T_A = 25°C
ESD – Human Body Model	ESD_{HBM}	2000	—	V	
ESD – Charged Device Model	ESD_{CDM}	750	—	V	

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	—	kΩ
/Fault Pull-up Resistor	$R_{PULL\text{-}UP}$	1	20	kΩ
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°C to 125°C. All typical values are based on T_A = +25°C, V_{DD} = 5.0V, C_{LOAD} = 0.47 nF.

Parameter	Symbol	Min.	Typ.	Max.	Unit	Test Condition	Fig.	Note
Supply Current	I_{DD}	—	19	25	mA	Output open	6	
Primary Conductance Resistance	$R_{PRIMARY}$	—	0.7	—	mΩ	—		
Output Internal Resistance	R_{OUT}	—	5	—	Ω	—		
Output Common Mode Internal Resistance	R_{OCM}	—	200	—	Ω	—		
Power-on Time	t_{PO}	—	21	200	µs	T_A = +25°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	—	µs	C_{LOAD} = 0.47 nF, input step with 0.3-µs rise time, 2V step on output (from V_{OCM} to V_{OCM} + 2V)	12	a
Output Response Time	$t_{RESPONSE}$	—	1	—	µs		7	a
Propagation Delay Time	t_{PD}	—	0.5	1.2	µs		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	—	µs	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	$R_{PULL\text{-}UP}$ = 1 kΩ		a

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

a. See Definitions of Electrical Characteristics and Application Information.

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

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 μs.

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 + 4σ from qualification test results. E_{TOT}, t_{ini}, is the Total Output Error test result from the initial test at T_A = 25°C.

h. Typical Lifetime Drift specifications are based on the population mean + 4σ from the worst-case AECQ-100 stress test qualification result.

Package Characteristics

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

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

b. This is a two-terminal measurement: pins 1 through 6 are shorted together, and pins 7 through 12 are shorted together.

c. 100% tested in production at 5200 V_{RMS} for 1 second.

d. See Definitions of Electrical Characteristics and Application Information.

Typical Performance Plots

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

Figure 1: Sensitivity vs Temperature

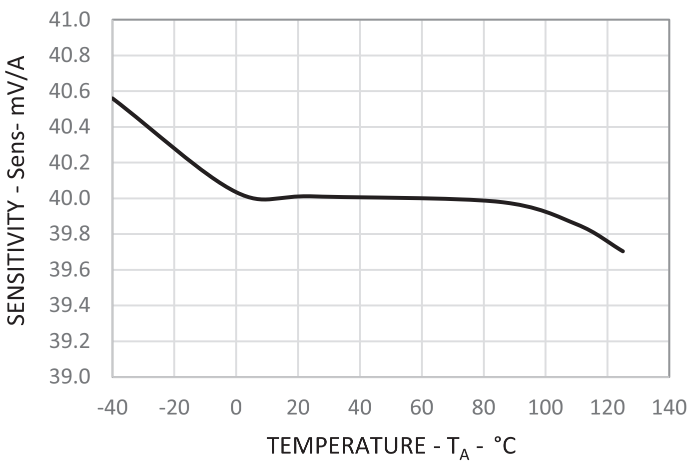


Figure 2: Sensitivity Error vs Temperature

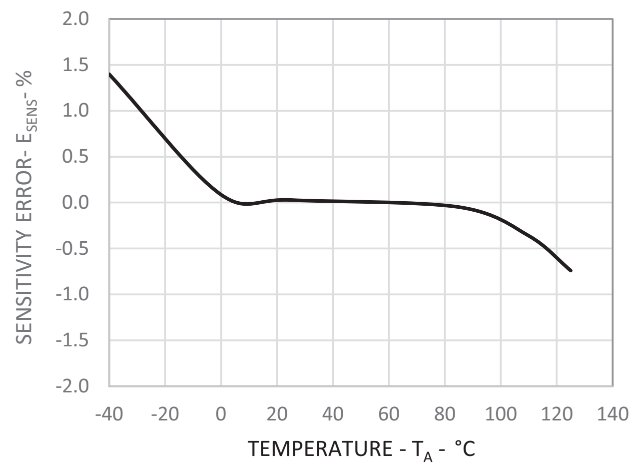


Figure 3: Offset Voltage vs Temperature

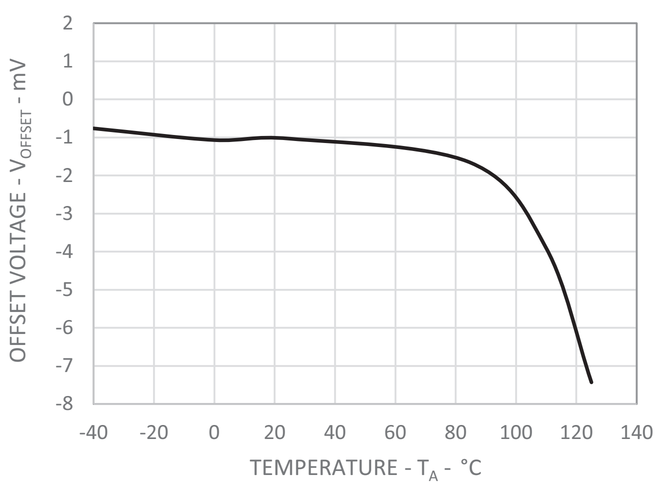


Figure 4: Total Output Error vs Temperature

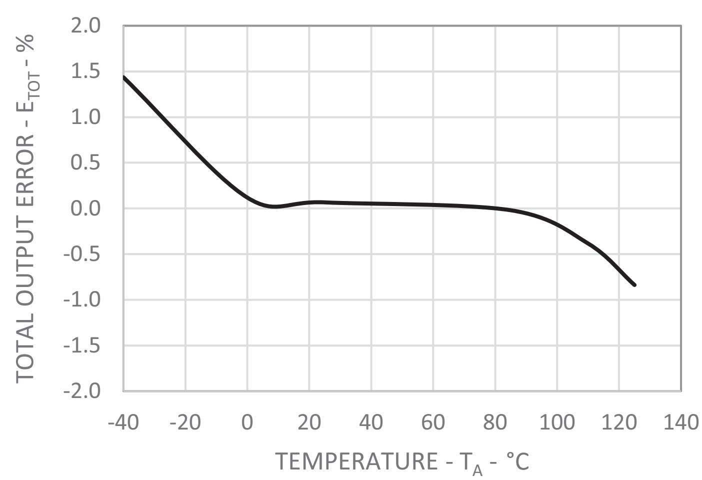


Figure 5: Nonlinearity vs Temperature

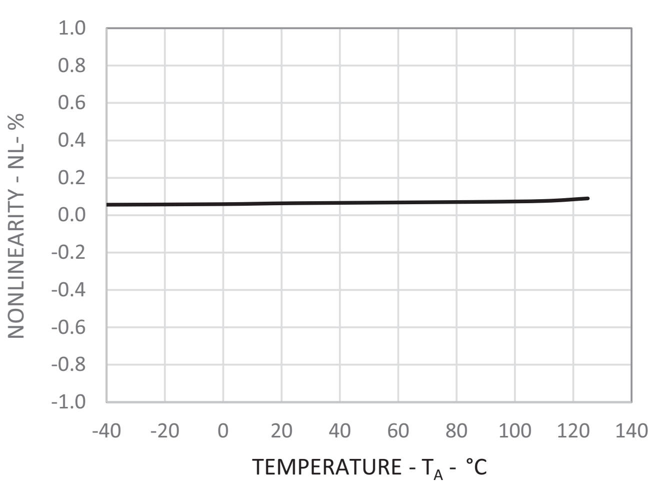


Figure 6: Supply Current vs Supply Voltage

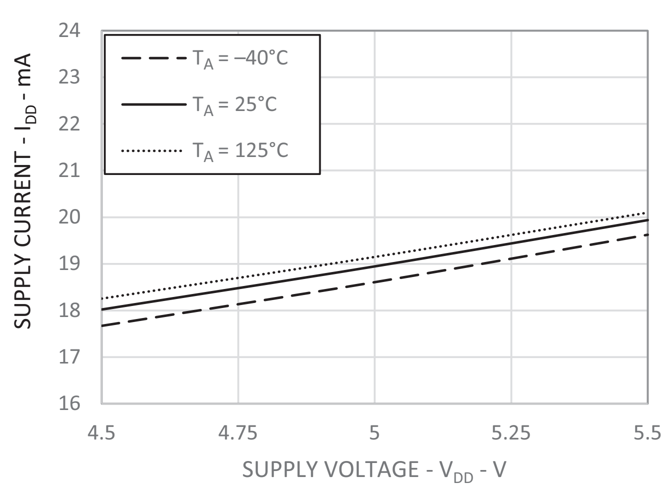


Figure 7: Output Response Time vs Temperature

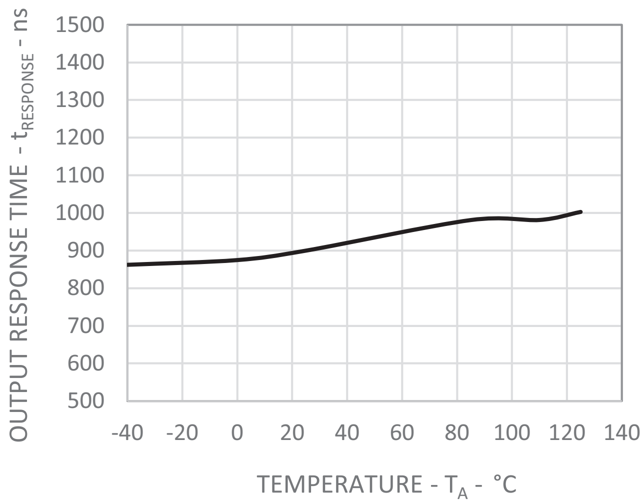


Figure 8: Propagation Delay Time vs Temperature

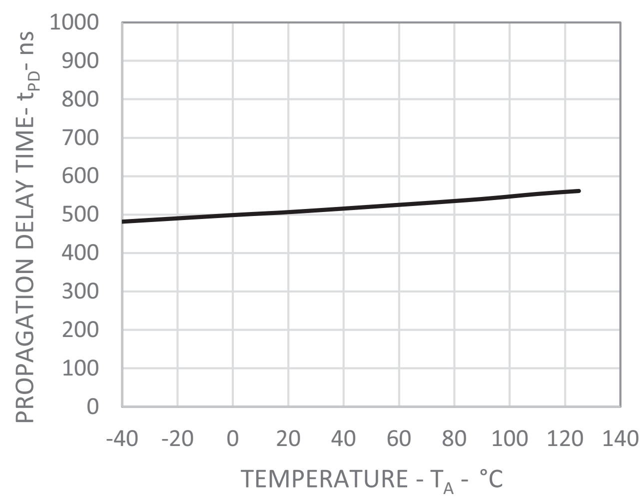


Figure 9: Fault Response Time vs Temperature

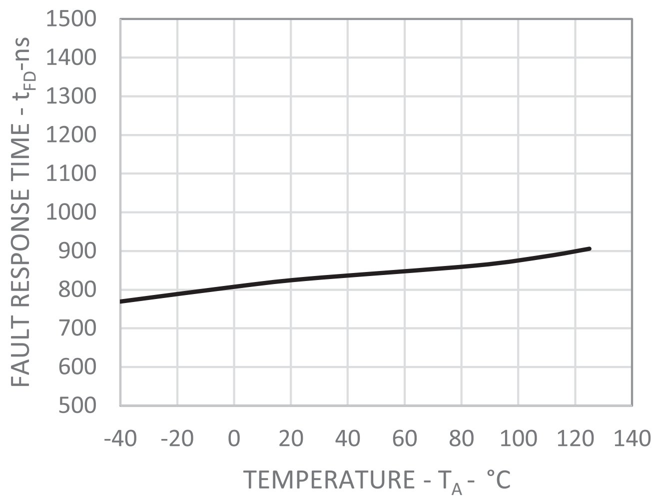


Figure 10: Fault Release Time vs Temperature

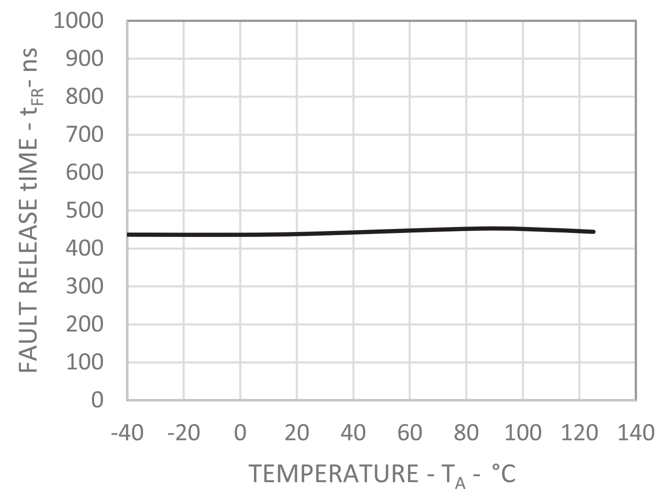


Figure 11: Output Voltage vs Input Current

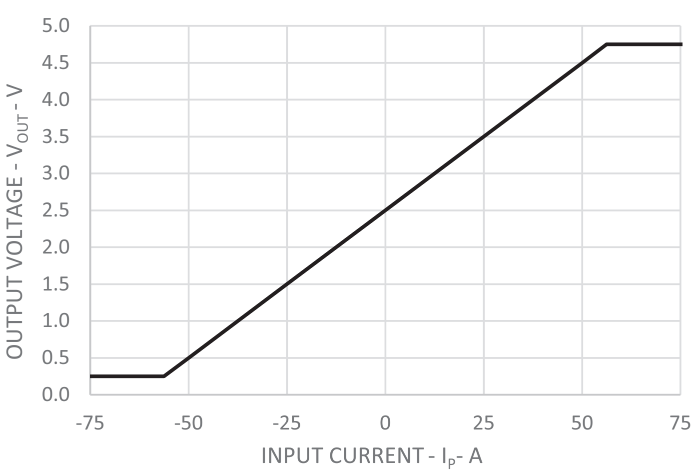


Figure 12: Rise Time vs Temperature

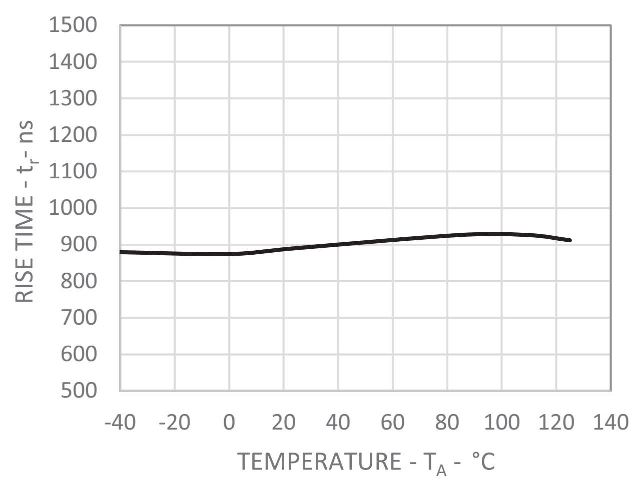


Figure 13: Gain vs Frequency

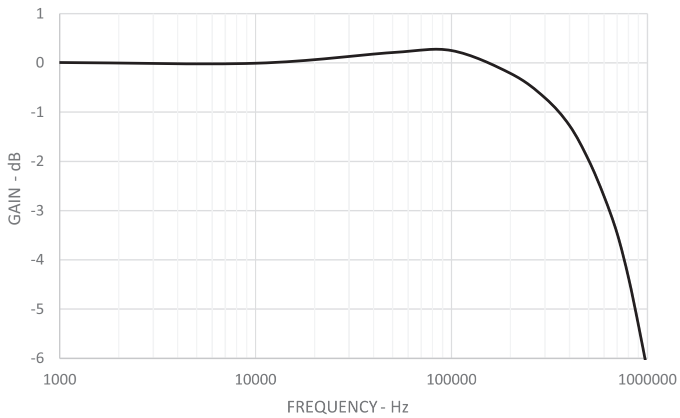


Figure 14: Phase vs Frequency

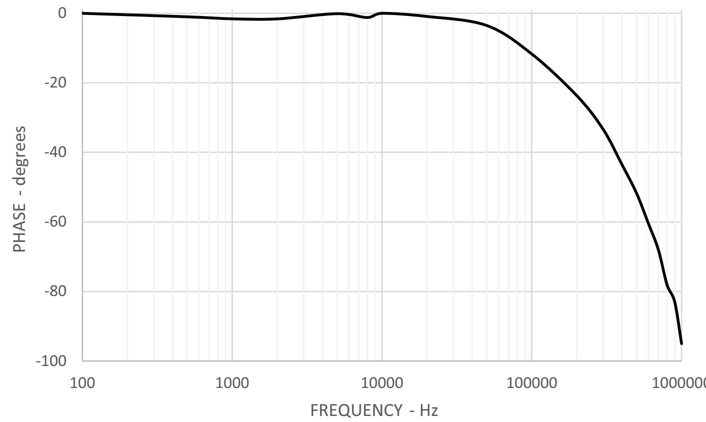


Figure 15: Thermal Derating (Input Power) Using a 2-oz. Broadcom Board

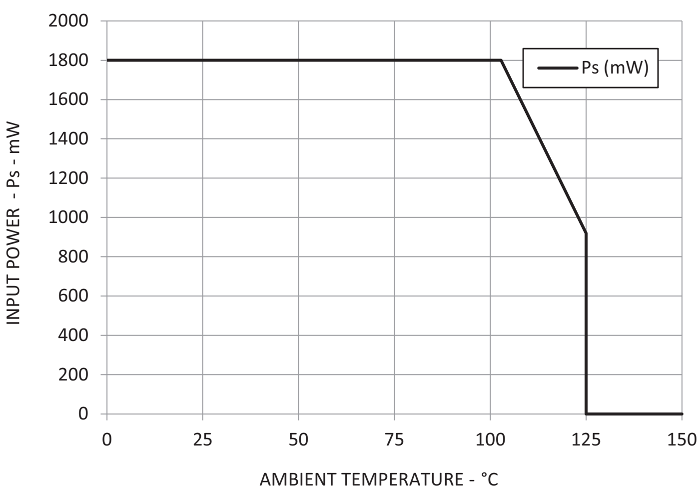
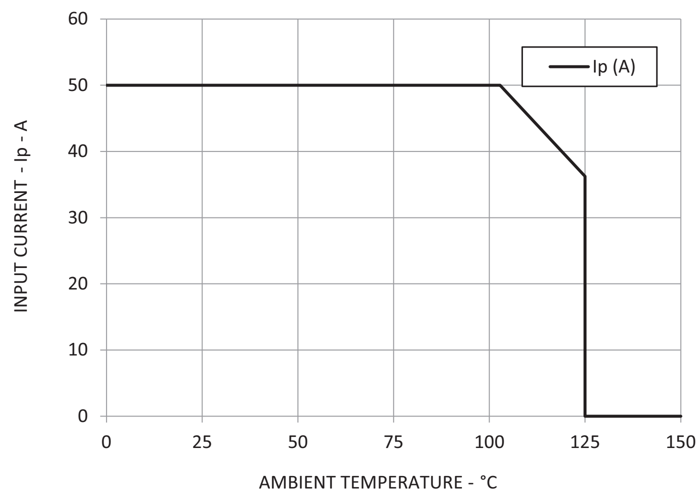


Figure 16: Thermal Derating (Input Current) Using a 2-oz. Broadcom Board



Definitions of Electrical Characteristics

The ACHL-7345xT 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-7345xT 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

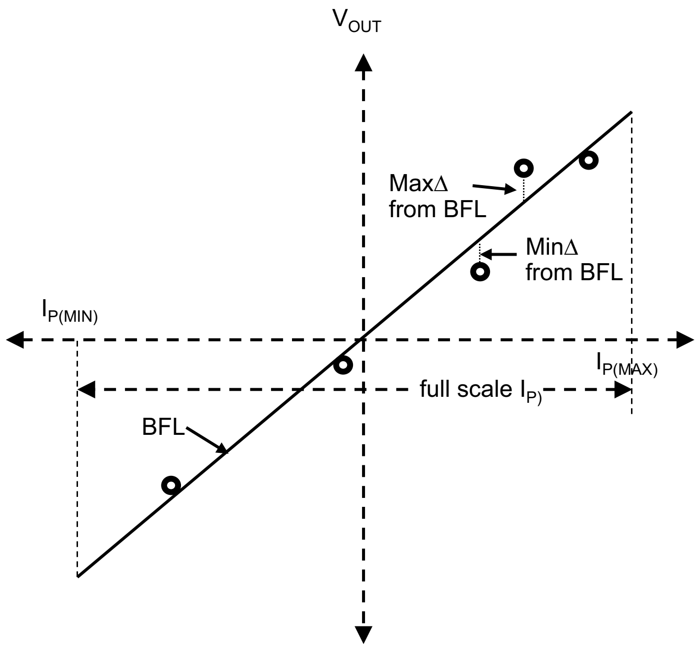
The offset voltage (V_{OFFSET}) is the difference between the output voltage and ideal output voltage when the input current is zero. The offset voltage is calculated using the difference between the output voltage and output common mode voltage: $V_{OFFSET} = V_{OUT} – V_{OCM}$.

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

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

OPSRR = $20\text{Log}_{10} (\Delta V_{DD}/\Delta V_{OFFSET})$, 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

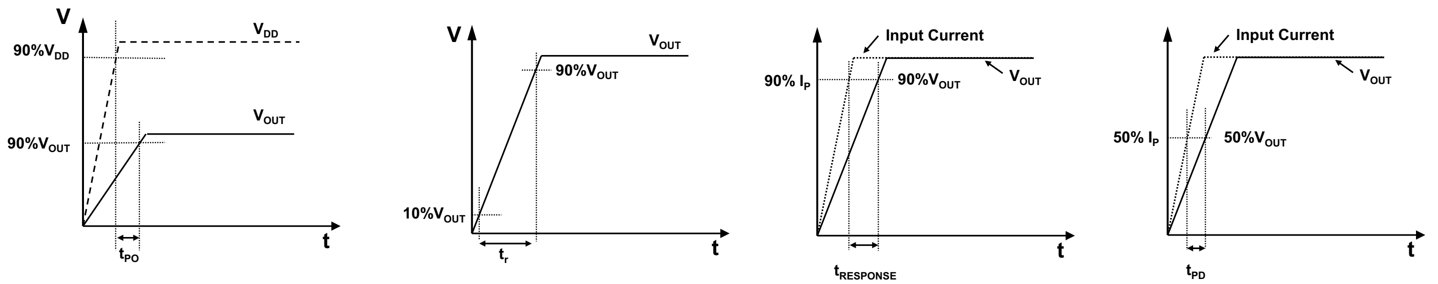
Power-on time is the time required for the internal circuitry of the device to be ready during the ramping of the supply voltage. Power-on time is defined as the finite time.

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



A. Power-On Time B. Rise Time C. Output Response Time D. Propagation Delay

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 $C_{I\text{-}O}$. 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

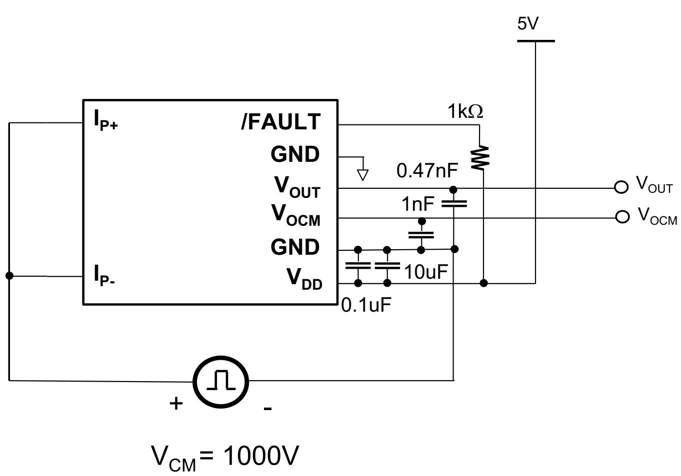
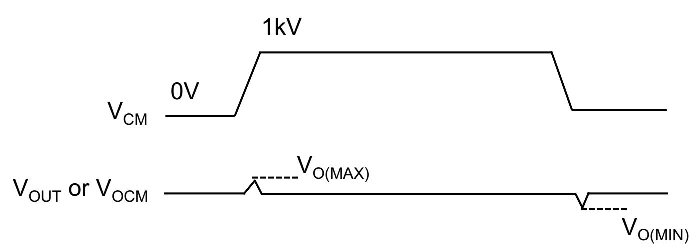


Figure 20: CMTI Test Waveform



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 µs.

Application Information

Operation

The ACHL-7345xT 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:

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

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

Figure 21: DC Transfer function with Input Current (I_P) = 50A

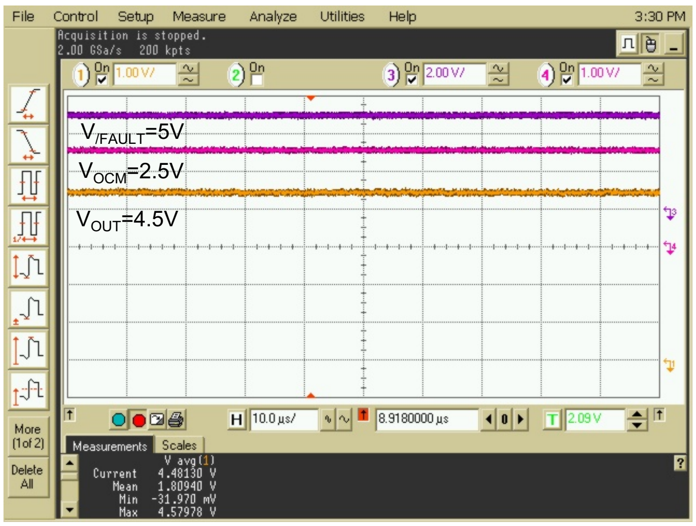
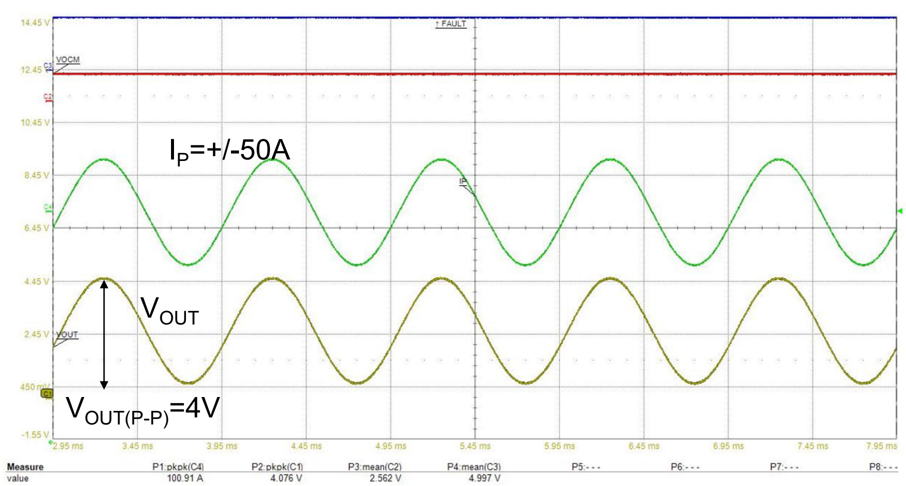


Figure 22: Transfer Function with AC Input Current

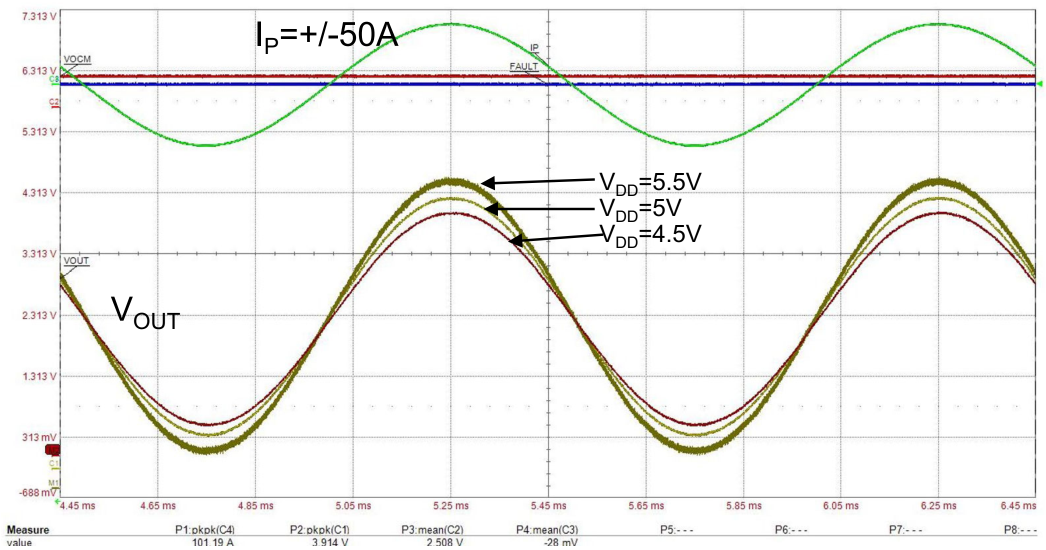


Ratiometry

ACHL-7345xT 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

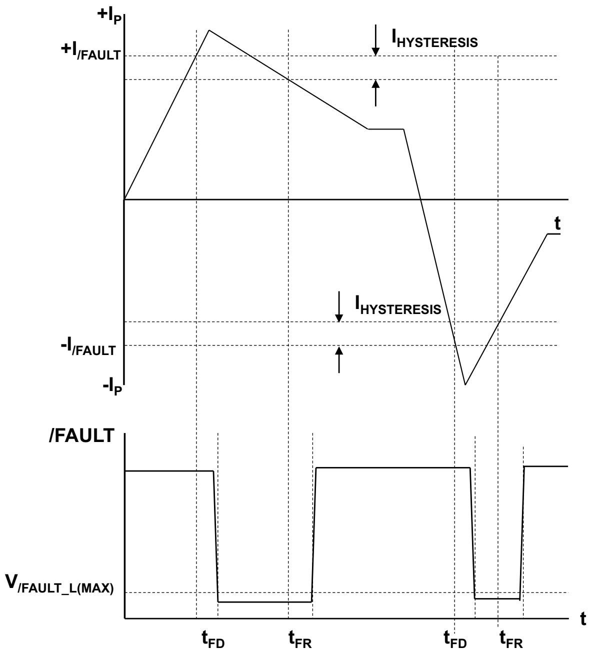
Figure 23: Output Voltage at V_{DD} = 4.5V, 5V, and 5.5V



Overcurrent Fault Detection

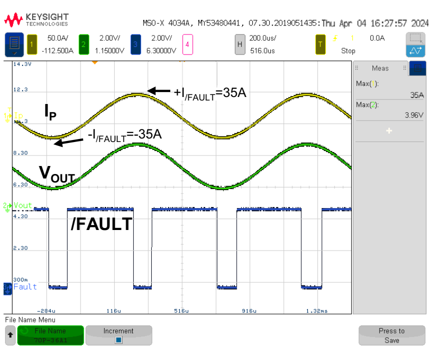
The ACHL-7345xT has an overcurrent fault detection that toggles the /FAULT signal from High to Low when the detected current exceeds the preset threshold $+I_{/FAULT}$ or $–I_{/FAULT-}$. The fault input current hysteresis ($I_{HYSTERIS}$) is 10% of I_{PMAX}, which is 5A. The /FAULT signal goes back to High once the detected current goes below 5A of $+I_{/FAULT}$ or above 5A of $–I_{/FAULT}$ for negative current. For example, for ACHL-7345ET (fault trip level = 50A and –50A), the /FAULT signal will toggle from High to Low when the input signal is ≥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 ±2%.

Figure 24: Fault Timing Diagram

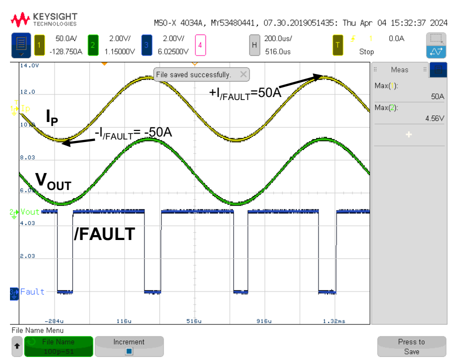


The following figures show an overcurrent event for different ACHL-7345xT options.

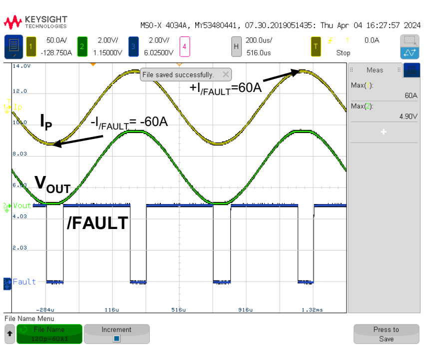
Figure 25: Overcurrent Event for ACHL-7345xT Options



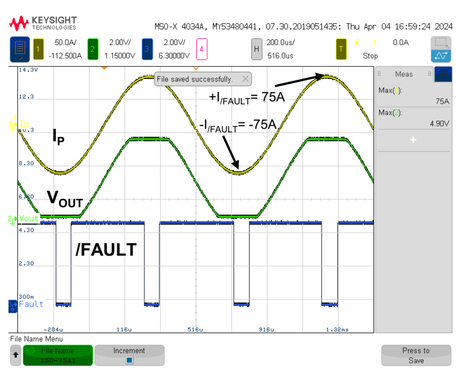
A. ACHL-7345CT (Fault Trip Level = 70% of $|I_{PMAX}|$)



B. ACHL-7345ET (Fault Trip Level = 100% of $|I_{PMAX}|$)



C. ACHL-7345FT (Fault Trip Level = 120% of $|I_{PMAX}|$)

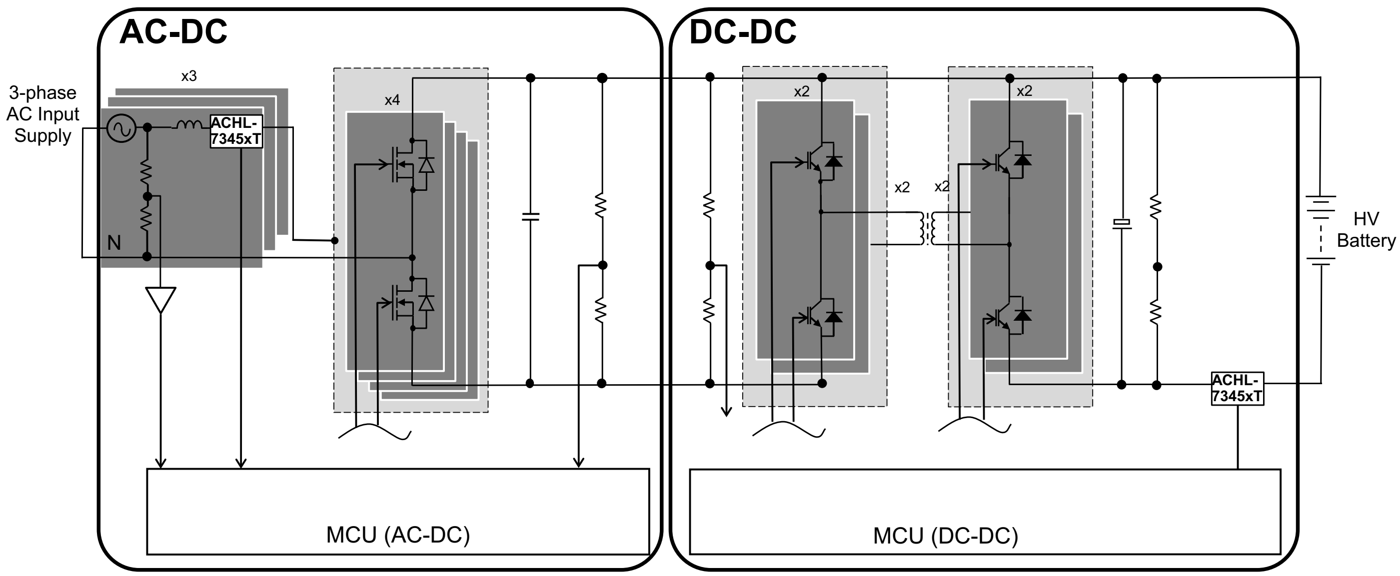


D. ACHL-7345HT (Fault Trip Level = 150% of $|I_{PMAX}|$)

Typical Application

The typical application of ACHL-7345xT 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-7345xT can be used in a ±50A 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 /FAULT pin. A precise reference voltage that represent $V_{DD}/2$ can be used as well if necessary through the V_{OCM} pin.

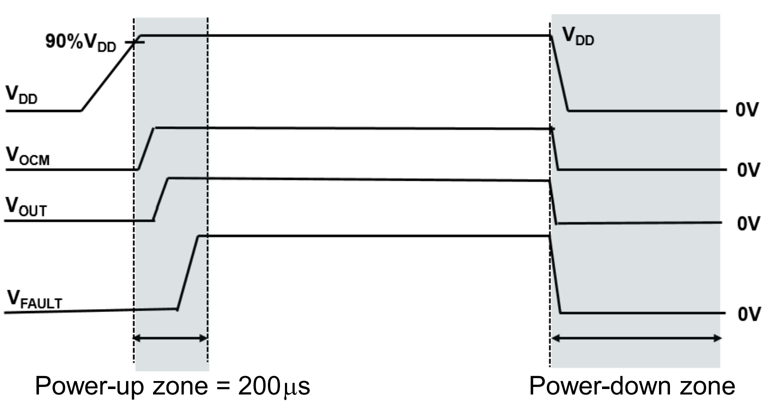
Figure 26: Onboard Charger Simplified Block Diagram



Initial Power-Up and Power-Down

During the initial power-up, it is recommended to read any measurement after 200 µs from 90% of V_{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_{OUT}, V_{OCM}, $V_{/FAULT}$) when V_{DD} starts to ramp down (power-down zone).

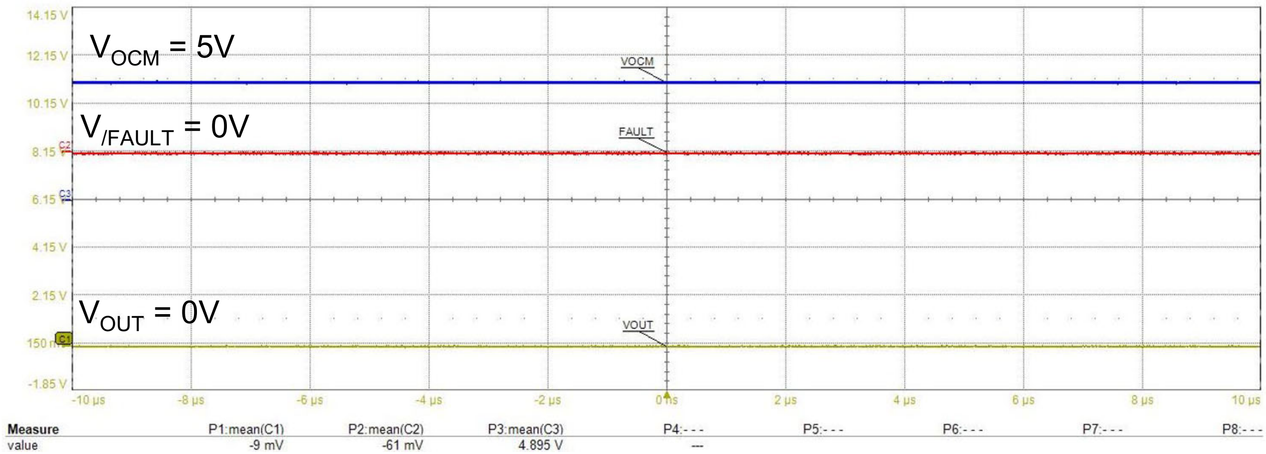
Figure 27: Power-Up Zone and Power-Down Zone



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

In the event that 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 will prevent internal circuit damage to the device due to overcurrent.

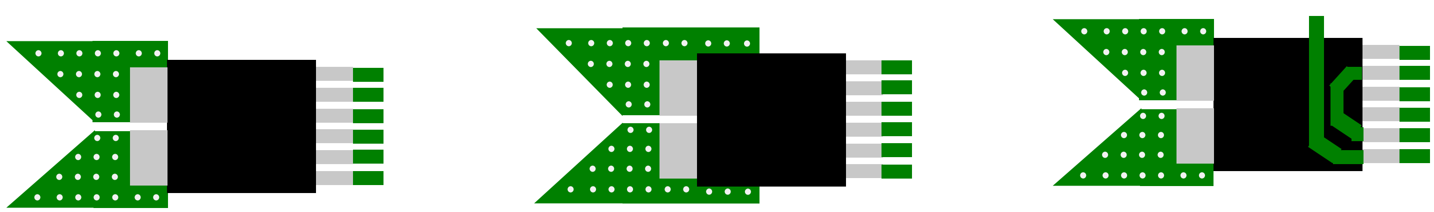
Figure 28: V_{OCM}, V_{FAULT}, and V_{OUT} DC Voltages When $R_{PULL-UP}$ Is Missing



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.

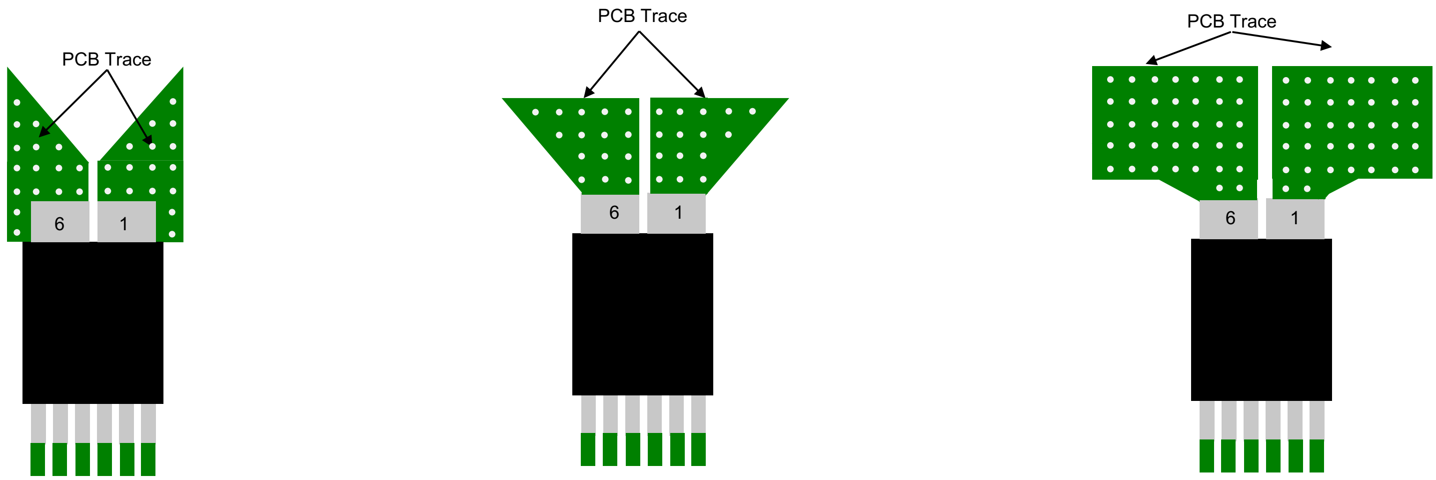
Figure 29: PCB Ground Plane Layout



A. Recommended Layout **B. Not Recommended** **C. Not Recommended**

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



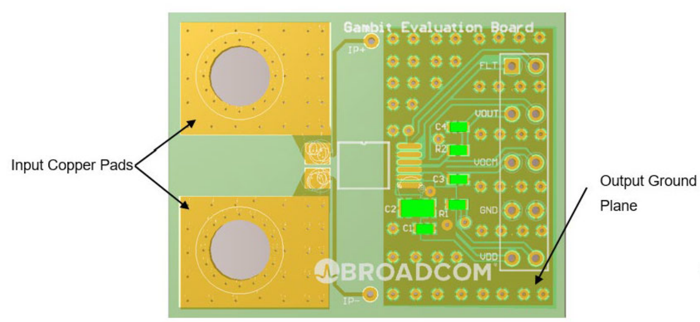
A. Recommended **B. Recommended** **C. Recommended**

Thermal Considerations

The evaluation board used in the thermal characterization is shown in Figure 31 and Figure 32. 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 input copper pad with at 305 mm^2 total area (including the top and bottom planes, minus the screw mounting holes). The output side GND is connected to a ground plane with 1056 mm^2 total area (including top and bottom planes). The V_{DD} pin is connected to copper pad area of 24 mm^2 (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 more 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 θ_{21} (thermal resistance due to heating of the input power) and θ_{22} (thermal resistance due to heating of the output power).

- θ_{21} = 26.7°C/W
- θ_{22} = 4.1°C/W

Junction temperature can be calculated using the 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 device junction temperatures will be calculated and it will be determined if derating is required for each operating conditions.

Example 1:

- Ambient temperature (T_A) = 85°C
- Input current = 50A
- Output supply voltage = 5.0V
- Output supply current = 19 mA

To determine the device junction temperature:

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

T_J = (26.7°C/W × (50A × 50A × 0.7 mΩ) + (4.1°C/W × 5.0V × 19 mA) + 85°C

T_J = 132.1°C

The calculated junction temperature is less than 150°C (maximum allowable junction temperature). Derating is not required.

Example 2:

- Ambient temperature (T_A) = 125^{o}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°C/W × (50A × 50A × 0.7 mΩ) + (4.1°C/W × 5.0V × 19 mA) + 125°C

T_J = 172.1°C

The calculated junction temperature is more than 150°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.