High Accuracy Hall-Effect-Based Current Sensor with 265 μΩ Integrated Conductor
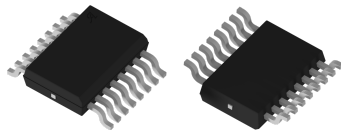
FEATURES AND BENEFITS

- AEC-Q100 automotive qualified
- Differential Hall sensing rejects common-mode fields
- UL60950-1 (ed. 2) and UL 62368 (ed. 1) certification
  - □ Withstand Voltage = 5 kV$_{RMS}$
  - □ Basic Isolation Working Voltage = 1140 V$_{RMS}$ and 1600 V$_{DC}$
  - □ Reinforced Isolation Working Voltage = 757 V$_{RMS}$ and 813 V$_{DC}$
- Filter pin allows user to filter output for improved resolution (noise) at lower bandwidth
- 265 μΩ primary conductor resistance for low power loss and high continuous current withstand capability
- Custom SOIC16W-like package with 2.5× thicker leads for reduced resistance and slightly oversized body to achieve > 8.2 mm of creepage/clearance
- 3.3 or 5 V single supply operation
- Output voltage proportional to AC or DC current
- Factory-trimmed sensitivity and quiescent output voltage for improved accuracy
- Chopper stabilization results in extremely stable quiescent output voltage
- Nearly zero magnetic hysteresis
- Ratiometric output from supply voltage

PACKAGE: 16-pin SOICW (suffix MC)

Not to scale

TÜV America
Certificate Number:
U8V 16 03 54214 040
CB 16 03 54214 039
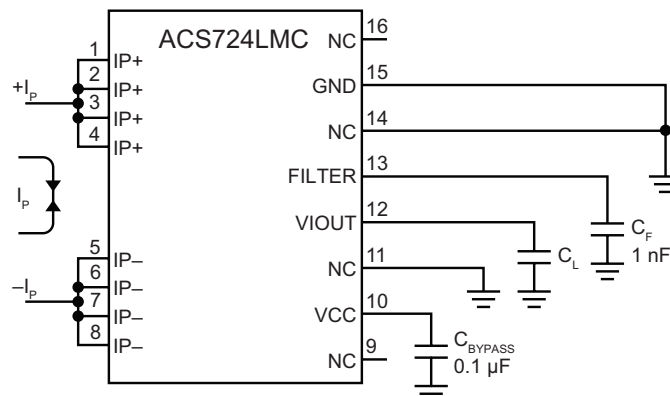
CB Certificate Number:
US-35763-UL
US-35764-UL

DESCRIPTION

The Allegro™ ACS724/5LMC current sensor IC is an economical and precise solution for AC or DC current sensing in industrial, and communication systems. The small package is ideal for space-constrained applications while also saving costs due to reduced board area. Typical applications include solar inverters, DC/DC, electric vehicles on-board chargers, motor control, load detection and management, switched-mode power supplies, and overcurrent fault protection.

The device consists of a precise, low-offset, linear Hall sensor 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 which is sensed by the integrated Hall IC and converted into a proportional voltage. The current is sensed differentially in order to reject common-mode fields, improving accuracy in magnetically noisy environments. The inherent device accuracy is optimized through the close proximity of the magnetic field to the Hall transducer. A precise, proportional voltage is provided by the low-offset, chopper-stabilized BiCMOS Hall IC, which includes Allegro's patented digital temperature compensation, resulting in extremely accurate performance over temperature. The output of the device has a positive slope when an increasing current flows through the primary copper conduction path (from pins 1 through 4, to pins 5 through 8), which is the path used for current sensing. The internal resistance of this conductive path is 265 μΩ typical, providing low power loss.

The terminals of the conductive path are electrically isolated from the sensor leads (pins 9 through 16). This allows the ACS724/5LMC current sensor IC to be used in high-side current sense applications without the use of high-side differential amplifiers or other costly isolation techniques.

Continued on the next page…

Typical Application

The ACS724/5LMC outputs an analog signal, V$_{IOUT}$, that changes proportionally with the bidirectional AC or DC primary sensed current, I$_P$, within the specified measurement range.

The FILTER pin can be used to decrease the bandwidth in order to optimize the noise performance.

DESCRIPTION (continued)

The ACS724/5LMC is provided in a custom SOIC16-like surface mount package. The pin pitch is the same as a standard SOIC16 but the lead-frame is 2.5 times as thick to reduce the resistance. The package body is also sized to achieve greater than 8.2 mm of creepage/clearance. The leadframe is plated with 100% matte tin, which is compatible with standard lead (Pb) free printed circuit board assembly processes. Internally, the device is Pb-free. The device is fully calibrated prior to shipment from the factory.

SELECTION GUIDE

Part Number	I_{PR} (A)	Sens(Typ) (mV/A)	Nominal V_{CC} (V)	T_A (°C)	Packing [1]
ACS724LMCTR-20AB-T	±20	100	5	–40 to 150	Tape and Reel, 1000 pieces per reel
ACS724LMCTR-30AB-T	±30	66	5		
ACS724LMCTR-65AB-T	±65	30.75	5		
ACS725LMCTR-20AB-T	±20	66	3.3		

[1] Contact Allegro for additional packing options.

SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS

Characteristic	Symbol	Notes	Rating	Units
Supply Voltage	V_{CC}		6	V
Reverse Supply Voltage	V_{RCC}		–0.1	V
Output Voltage	V_{IOUT}, V_{FILTER}	VIOUT and FILTER pins	V_{CC} + 0.5	V
Reverse Output Voltage	V_{RIOUT}, $V_{RFILTER}$	VIOUT and FILTER pins	–0.1	V
Operating Ambient Temperature	T_A	Range L	–40 to 150	°C
Junction Temperature	T_J(max)		165	°C
Storage Temperature	T_{stg}		–65 to 165	°C

THERMAL CHARACTERISTICS

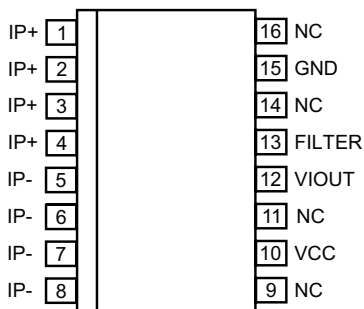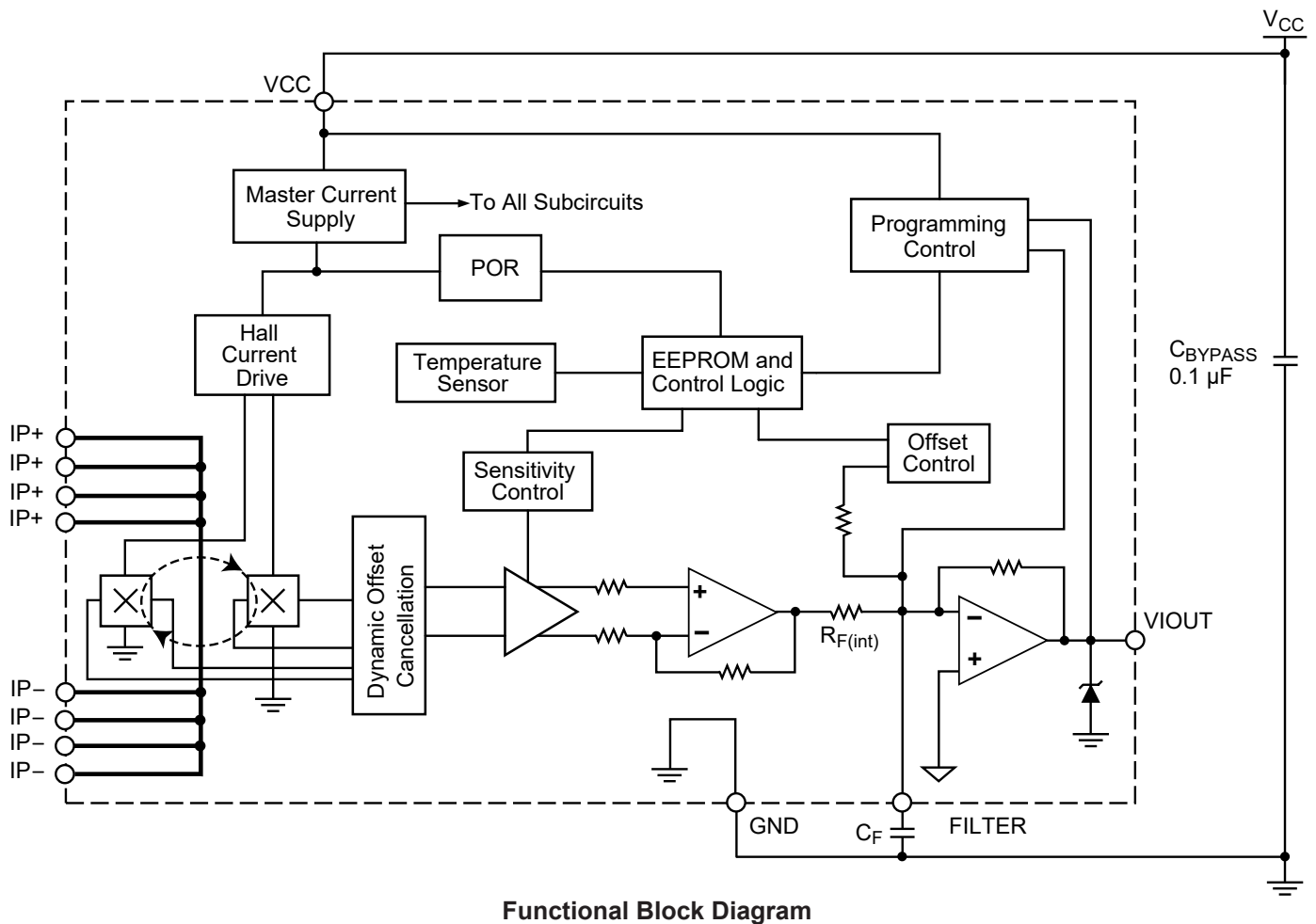| Characteristic	Symbol	Notes	Value	Unit
Package Thermal Resistance (Junction to Ambient)	$R_{\theta JA}$	Mounted on the standard MC current sensor evaluation board (ACSEVB-MC16)	19	°C/W
Package Thermal Metric (Junction to Top)	Ψ_{JT}		2.4	°C/W
Package Thermal Resistance (Junction to Case)	$R_{\theta JC}$	Simulated per the methods in JESD51-1	15	°C/W
Package Thermal Resistance (Junction to Board)	$R_{\theta JB}$	Simulated per the methods in JESD51-8	7.3	°C/W

ISOLATION AND PACKAGE CHARACTERISTICS

Characteristic	Symbol	Notes	Rating	Unit
Withstand Voltage [1][2]	V_{ISO}	Agency rated for 60 seconds per UL 62368-1 (edition 3)	5000	V_{RMS}
Working Voltage for Basic Isolation [2]	V_{WVBI}	Maximum approved working voltage for basic (single) isolation according to UL 62368-1 (edition 3)	1618	V_{PK} or V_{DC}
			1144	V_{RMS}
Working Voltage for Reinforced Isolation [2]	V_{WVRI}	Maximum approved working voltage for reinforced isolation according to UL 62368-1 (edition 3)	809	V_{PK} or V_{DC}
			572	V_{RMS}
Surge Voltage	V_{SURGE}	1.2 / 50 µs waveform, tested in dielectric fluid to determine intrinsic surge immunity of isolation barrier	13000	V_{PK}
Impulse Voltage	$V_{IMPULSE}$	1.2 / 50 µs waveform, tested in air	7071	V_{PK}
Clearance	D_{CL}	Minimum distance through air from IP leads to signal leads	8.7	mm
Creepage	D_{CR}	Minimum distance along package body from IP leads to signal leads	8.7	mm
Distance Through Insulation	DTI	Minimum internal distance through insulation	110	µm
Comparative Track Index	CTI	Material Group II	400 to 599	V

[1] Production-tested in accordance with UL 62368-1 (edition 3).
[2] Certification pending.

Functional Block Diagram

Pinout Diagram

Terminal List Table

Number	Name	Description
1, 2, 3, 4	IP+	Terminals for current being sensed; fused internally
5, 6, 7, 8	IP-	Terminals for current being sensed; fused internally
9, 16	NC	No internal connection; recommended to be left unconnected in order to maintain high creepage
10	VCC	Device power supply terminal
11, 14	NC	No internal connection; recommened to connect to GND for the best ESD performance
12	VIOUT	Analog output signal
13	FILTER	Terminal for external capacitor that sets bandwidth
15	GND	Signal ground terminal

COMMON ELECTRICAL CHARACTERISTICS [1]: Valid through the full range of T_A = –40°C to 150°C and V_{CC} = V_{CC}(typ), unless otherwise specified

Characteristic	Symbol	Test Conditions		Min.	Typ.	Max.	Units
Supply Voltage	V_{CC}	ACS724		4.5	5	5	V
		ACS725		3	3.3	3.6	V
Supply Current	I_{CC}			–	12	14	mA
Output Capacitive Load	C_L	VIOUT to GND		–	–	10	nF
Output Resistive Load	R_L	VIOUT to GND		4.7	–	–	kΩ
Primary Conductor Resistance	R_{IP}	T_A = 25°C		–	265	–	µΩ
Internal Filter Resistance [2]	$R_{R(INT)}$			–	1.7	–	kΩ
Common Mode Field Rejection Ratio	CMFRR	Uniform External Magnetic Field		–	2.21	–	mA/G
Primary Hall Coupling Factor	G1	T_A = 25°C		–	3.5	–	G/A
Secondary Hall Coupling Factor	G2	T_A = 25°C		–	–0.5	–	G/A
Differential Coupling Factor	G1-G2	T_A = 25°C		–	4	–	G/A
Rise Time	t_r	I_P = I_P(max), T_A = 25°C, C_L = 1 nF		–	3	–	µs
Propagation Delay	t_{pd}	I_P = I_P(max), T_A = 25°C, C_L = 1 nF		–	2	–	µs
Response Time	$t_{RESPONSE}$	I_P = I_P(max), T_A = 25°C, C_L = 1 nF		–	4	–	µs
Internal Bandwidth	BW	small signal –3 dB, CL = 1nF		–	120	–	kHz
Noise Density	I_{ND}	Input-referenced noise density; T_A = 25°C, C_L = 1 nF	V_{CC} = 5 V	–	400	–	$µA_{RMS}/\sqrt{Hz}$
			V_{CC} = 3.3 V	–	550	–	$µA_{RMS}/\sqrt{Hz}$
Noise	I_N	Input-referenced noise; C_F = 4.7 nF, C_L = 1 nF, BW = 18 kHz, T_A = 25°C	V_{CC} = 5 V	–	70	–	mA_{RMS}
			V_{CC} = 3.3 V	–	80	–	mA_{RMS}
Nonlinearity	E_{LIN}	Through full range of I_P	V_{CC} = 5 V	–1	–	1	%
			V_{CC} = 3.3 V	–1.5	–	1.5	%
Saturation Voltage [3]	V_{OH}	R_L = 4.7 kΩ, T_A = 25°C	V_{CC} = 5 V	V_{CC} – 0.5	–	–	V
			V_{CC} = 3.3 V	V_{CC} – 0.3	–	–	V
	V_{OL}	R_L = 4.7 kΩ, T_A = 25°C	V_{CC} = 5 V	–	–	0.5	V
			V_{CC} = 3.3 V	–	–	0.3	V
Power-On Time	t_{PO}	Output reaches 90% of steady-state level, T_A = 25°C, I_P = I_{PR}(max) applied		–	80	–	µs
Shorted Output to Ground Current	$I_{SC(GND)}$	T_A = 25°C		–	3	–	mA
Shorted Output to V_{CC} Current	$I_{SC(VCC)}$	T_A = 25°C		–	45	–	mA

[1] Device may be operated at higher primary current levels, I_P, ambient temperatures, T_A, and internal leadframe temperatures, provided the Maximum Junction Temperature, T_J(max), is not exceeded.

ACS724LMCTR-20AB PERFORMANCE CHARACTERISTICS: T_A = –40°C to 150°C, V_{CC} = 5 V, unless otherwise specified

Characteristic	Symbol	Test Conditions	Min.	Typ. [1]	Max.	Units
NOMINAL PERFORMANCE						
Current Sensing Range	I_{PR}		–20	–	20	A
Sensitivity	Sens		–	$100 \times V_{CC} / 5$	–	mV/A
Zero Current Output Voltage	$V_{IOUT(Q)}$	Bidirectional; I_P = 0 A	–	$V_{CC} \times 0.5$	–	V
ACCURACY PERFORMANCE						
Total Output Error [2]	E_{TOT}	$I_P = I_{PR(max)}$, T_A = 25°C to 150°C	–2.5	±1.3	2.5	%
		$I_P = I_{PR(max)}$, T_A = –40°C to 25°C	–2.5	±1.5	2.5	%
TOTAL OUTPUT ERROR COMPONENTS [3]						
Sensitivity Error	E_{SENS}	$I_P = I_{PR(max)}$, T_A = 25°C to 150°C	–2	±1.2	2	%
		$I_P = I_{PR(max)}$, T_A = –40°C to 25°C	–2	±1.4	2	%
Offset Voltage [4]	V_{OE}	I_P = 0 A, T_A = 25°C to 150°C	–15	±8.8	15	mV
		I_P = 0 A, T_A = –40°C to 25°C	–15	±8.8	15	mV
LIFETIME DRIFT CHARACTERISTICS [5]						
Total Output Error Including Lifetime Drift [6]	$E_{TOT(DRIFT)}$	$I_P = I_{PR(max)}$, T_A = 25°C to 150°C	–3	±1.6	3	%
		$I_P = I_{PR(max)}$, T_A = –40°C to 25°C	–4.1	±1.5	4.1	%
Sensitivity Error Including Lifetime Drift [7]	$E_{SENS(DRIFT)}$	$I_P = I_{PR(max)}$, T_A = 25°C to 150°C	–2.7	±1.2	2.7	%
		$I_P = I_{PR(max)}$, T_A = –40°C to 25°C	–4.1	±1.4	4.1	%

[1] Typical values with ± are 3 sigma values, except for lifetime drift characteristics. The typical lifetime drift characteristics are the average values, including drift, from the worst case stress, observed during qualification.
[2] Percentage of I_P, with $I_P = I_{PR(max)}$, output filtered.
[3] A single part will not have both the maximum/minimum sensitivity error and maximum/minimum offset voltage, as that would violate the maximum/minimum total output error specification.
[4] All devices remained within the limits during the qualification for 25°C to 150°C and 25°C to –40°C, and the worst observed drift was 9 mV and 5 mV respectively.
[5] Pending qualification completion.
[6] All devices remained within the limits during the qualification for 25°C to 150°C and 25°C to –40°C, and the worst observed drift was 2% and 2% respectively.
[7] All devices remained within the limits during the qualification for 25°C to 150°C and 25°C to –40°C, and the worst observed drift was 2.1% and 1.5% respectively.

ACS724LMCTR-30AB PERFORMANCE CHARACTERISTICS: T_A = –40°C to 150°C, V_{CC} = 5 V, unless otherwise specified

Characteristic	Symbol	Test Conditions	Min.	Typ. [1]	Max.	Units
NOMINAL PERFORMANCE						
Current Sensing Range	I_{PR}		–30	–	30	A
Sensitivity	Sens		–	$66 \times V_{CC} / 5$	–	mV/A
Zero Current Output Voltage	$V_{IOUT(Q)}$	Bidirectional; I_P = 0 A	–	$V_{CC} \times 0.5$	–	V
ACCURACY PERFORMANCE						
Total Output Error [2]	E_{TOT}	$I_P = I_{PR(max)}$, T_A = 25°C to 150°C	–2.5	±1.3	2.5	%
		$I_P = I_{PR(max)}$, T_A = –40°C to 25°C	–2.5	±1.5	2.5	%
TOTAL OUTPUT ERROR COMPONENTS [3]						
Sensitivity Error	E_{SENS}	$I_P = I_{PR(max)}$, T_A = 25°C to 150°C	–2	±1.2	2	%
		$I_P = I_{PR(max)}$, T_A = –40°C to 25°C	–2	±1.4	2	%
Offset Voltage [4]	V_{OE}	I_P = 0 A, T_A = 25°C to 150°C	–15	±8.8	15	mV
		I_P = 0 A, T_A = –40°C to 25°C	–15	±8.8	15	mV
LIFETIME DRIFT CHARACTERISTICS [5]						
Total Output Error Including Lifetime Drift [6]	$E_{TOT(DRIFT)}$	$I_P = I_{PR(max)}$, T_A = 25°C to 150°C	–3	±1.6	3	%
		$I_P = I_{PR(max)}$, T_A = –40°C to 25°C	–4.1	±1.5	4.1	%
Sensitivity Error Including Lifetime Drift [7]	$E_{SENS(DRIFT)}$	$I_P = I_{PR(max)}$, T_A = 25°C to 150°C	–2.7	±1.2	2.7	%
		$I_P = I_{PR(max)}$, T_A = –40°C to 25°C	–4.1	±1.4	4.1	%

[1] Typical values with ± are 3 sigma values, except for lifetime drift characteristics. The typical lifetime drift characteristics are the average values, including drift, from the worst case stress, observed during qualification.
[2] Percentage of I_P, with $I_P = I_{PR(max)}$, output filtered.
[3] A single part will not have both the maximum/minimum sensitivity error and maximum/minimum offset voltage, as that would violate the maximum/minimum total output error specification.
[4] All devices remained within the limits during the qualification for 25°C to 150°C and 25°C to –40°C, and the worst observed drift was 9 mV and 5 mV respectively.
[5] Pending qualification completion.
[6] All devices remained within the limits during the qualification for 25°C to 150°C and 25°C to –40°C, and the worst observed drift was 2% and 2% respectively.
[7] All devices remained within the limits during the qualification for 25°C to 150°C and 25°C to –40°C, and the worst observed drift was 2.1% and 1.5% respectively.

ACS724LMCTR-65AB PERFORMANCE CHARACTERISTICS: T_A = –40°C to 150°C, V_{CC} = 5 V, unless otherwise specified

Characteristic	Symbol	Test Conditions	Min.	Typ. [1]	Max.	Units
NOMINAL PERFORMANCE						
Current Sensing Range	I_{PR}		–65	–	65	A
Sensitivity	Sens		–	30.75 × V_{CC} / 5	–	mV/A
Zero Current Output Voltage	$V_{IOUT(Q)}$	Bidirectional; I_P = 0 A	–	V_{CC} × 0.5	–	V
ACCURACY PERFORMANCE						
Total Output Error [2]	E_{TOT}	I_P = $I_{PR(max)}$, T_A = 25°C to 150°C	–2.5	±1.3	2.5	%
		I_P = $I_{PR(max)}$, T_A = –40°C to 25°C	–2.5	±1.5	2.5	%
TOTAL OUTPUT ERROR COMPONENTS [3]						
Sensitivity Error	E_{SENS}	I_P = $I_{PR(max)}$, T_A = 25°C to 150°C	–2	±1.2	2	%
		I_P = $I_{PR(max)}$, T_A = –40°C to 25°C	–2	±1.4	2	%
Offset Voltage [4]	V_{OE}	I_P = 0 A, T_A = 25°C to 150°C	–15	±8.8	15	mV
		I_P = 0 A, T_A = –40°C to 25°C	–15	±8.8	15	mV
LIFETIME DRIFT CHARACTERISTICS [5]						
Total Output Error Including Lifetime Drift [6]	$E_{TOT(DRIFT)}$	I_P = $I_{PR(max)}$, T_A = 25°C to 150°C	–3	±1.6	3	%
		I_P = $I_{PR(max)}$, T_A = –40°C to 25°C	–4.1	±1.5	4.1	%
Sensitivity Error Including Lifetime Drift [7]	$E_{SENS(DRIFT)}$	I_P = $I_{PR(max)}$, T_A = 25°C to 150°C	–2.7	±1.2	2.7	%
		I_P = $I_{PR(max)}$, T_A = –40°C to 25°C	–4.1	±1.4	4.1	%

[1] Typical values with ± are 3 sigma values, except for lifetime drift characteristics. The typical lifetime drift characteristics are the average values, including drift, from the worst case stress, observed during qualification.
[2] Percentage of I_P, with I_P = $I_{PR(max)}$, output filtered.
[3] A single part will not have both the maximum/minimum sensitivity error and maximum/minimum offset voltage, as that would violate the maximum/minimum total output error specification.
[4] All devices remained within the limits during the qualification for 25°C to 150°C and 25°C to –40°C, and the worst observed drift was 9 mV and 5 mV respectively.
[5] Pending qualification completion.
[6] All devices remained within the limits during the qualification for 25°C to 150°C and 25°C to –40°C, and the worst observed drift was 2% and 2% respectively.
[7] All devices remained within the limits during the qualification for 25°C to 150°C and 25°C to –40°C, and the worst observed drift was 2.1% and 1.5% respectively.

ACS725LMCTR-20AB PERFORMANCE CHARACTERISTICS: T_A = –40°C to 150°C, V_{CC} = 3.3 V, unless otherwise specified

Characteristic	Symbol	Test Conditions	Min.	Typ. [1]	Max.	Units
NOMINAL PERFORMANCE						
Current Sensing Range	I_{PR}		–20	–	20	A
Sensitivity	Sens		–	$66 \times V_{CC} / 3.3$	–	mV/A
Zero Current Output Voltage	$V_{IOUT(Q)}$	Bidirectional; I_P = 0 A	–	$V_{CC} \times 0.5$	–	V
ACCURACY PERFORMANCE						
Total Output Error [2]	E_{TOT}	$I_P = I_{PR(max)}$, T_A = 25°C to 150°C	–2.5	±1.3	2.5	%
		$I_P = I_{PR(max)}$, T_A = –40°C to 25°C	–2.5	±1.5	2.5	%
TOTAL OUTPUT ERROR COMPONENTS [3]						
Sensitivity Error	E_{SENS}	$I_P = I_{PR(max)}$, T_A = 25°C to 150°C	–2	±1.2	2	%
		$I_P = I_{PR(max)}$, T_A = –40°C to 25°C	–2	±1.4	2	%
Offset Voltage [4]	V_{OE}	I_P = 0 A, T_A = 25°C to 150°C	–15	±8.8	15	mV
		I_P = 0 A, T_A = –40°C to 25°C	–15	±8.8	15	mV
LIFETIME DRIFT CHARACTERISTICS [5]						
Total Output Error Including Lifetime Drift [6]	$E_{TOT(DRIFT)}$	$I_P = I_{PR(max)}$, T_A = 25°C to 150°C	–3	±1.3	3	%
		$I_P = I_{PR(max)}$, T_A = –40°C to 25°C	–4	±1.5	4	%
Sensitivity Error Including Lifetime Drift [7]	$E_{SENS(DRIFT)}$	$I_P = I_{PR(max)}$, T_A = 25°C to 150°C	–2.7	±1.25	2.7	%
		$I_P = I_{PR(max)}$, T_A = –40°C to 25°C	–3.8	±1.4	3.8	%

[1] Typical values with ± are 3 sigma values, except for lifetime drift characteristics. The typical lifetime drift characteristics are the average values, including drift, from the worst case stress, observed during qualification.
[2] Percentage of I_P, with $I_P = I_{PR(max)}$, output filtered.
[3] A single part will not have both the maximum/minimum sensitivity error and maximum/minimum offset voltage, as that would violate the maximum/minimum total output error specification.
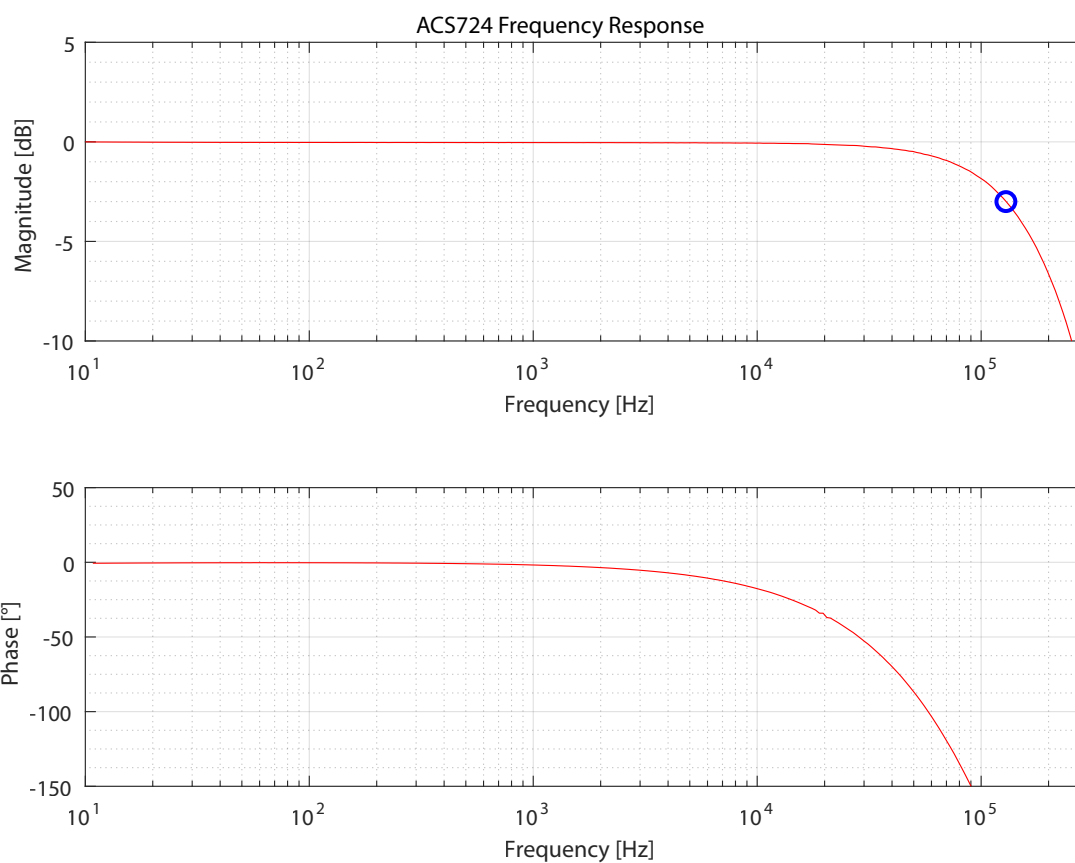[4] All devices remained within the limits during the qualification for 25°C to 150°C and 25°C to –40°C, and the worst observed drift was 13 mV and 8 mV respectively.
[5] Pending qualification completion.
[6] All devices remained within the limits during the qualification for 25°C to 150°C and 25°C to –40°C, and the worst observed drift was 2.5% and 2% respectively.
[7] All devices remained within the limits during the qualification for 25°C to 150°C and 25°C to –40°C, and the worst observed drift was 2.5% and 1.8% respectively.

CHARACTERISTIC PERFORMANCE
ACS724 TYPICAL FREQUENCY RESPONSE

ACS724 Frequency Response

DEFINITIONS OF ACCURACY CHARACTERISTICS

Sensitivity (Sens)

The change in sensor IC output in response to a 1 A change through the primary conductor. The sensitivity is the product of the magnetic coupling factor (G/A) (1 G = 0.1 mT) and the linear IC amplifier gain (mV/G). The linear IC amplifier gain is programmed at the factory to optimize the sensitivity (mV/A) for the full-scale current of the device.

Nonlinearity (E$_{LIN}$)

The nonlinearity is a measure of how linear the output of the sensor IC is over the full current measurement range. The nonlinearity is calculated as:

$$E_{LIN} = \left\{ 1 - \left[\frac{V_{IOUT}(I_{PR(max)}) - V_{IOUT(Q)}}{2 \times V_{IOUT}(I_{PR(max)/2}) - V_{IOUT(Q)}} \right] \right\} \times 100 \ (\%)$$

where $V_{IOUT}(I_{PR(max)})$ is the output of the sensor IC with the maximum measurement current flowing through it and $V_{IOUT}(I_{PR(max)}/2)$ is the output of the sensor IC with half of the maximum measurement current flowing through it.

Zero Current Output Voltage (V$_{IOUT(Q)}$)

The output of the sensor when the primary current is zero. For a unipolar supply voltage, it nominally remains at $0.5 \times V_{CC}$ for a bidirectional device and $0.1 \times V_{CC}$ for a unidirectional device. For example, in the case of a bidirectional output device, $V_{CC} = 5.0$ V translates into $V_{IOUT(Q)} = 2.50$ V. Variation in $V_{IOUT(Q)}$ can be attributed to the resolution of the Allegro linear IC quiescent voltage trim and thermal drift.

Offset Voltage (V$_{OE}$)

The deviation of the device output from its ideal quiescent value of $0.5 \times V_{CC}$ (bidirectional) or $0.1 \times V_{CC}$ (unidirectional) due to nonmagnetic causes. To convert this voltage to amperes, divide by the device sensitivity, Sens.

Total Output Error (E$_{TOT}$)

The difference between the current measurement from the sensor IC and the actual current (I_P), relative to the actual current. This is equivalent to the difference between the ideal output voltage and the actual output voltage, divided by the ideal sensitivity, relative to the current flowing through the primary conduction path:

$$E_{TOT}(I_P) = \frac{V_{IOUT\_ideal}(I_P) - V_{IOUT}(I_P)}{Sens_{ideal}(I_P) \times I_P} \times 100 \ (\%)$$

The Total Output Error incorporates all sources of error and is a function of I_P. At relatively high currents, E_{TOT} will be mostly due to

sensitivity error, and at relatively low currents, E_{TOT} will be mostly due to Offset Voltage (V_{OE}). In fact, at $I_P = 0$, E_{TOT} approaches infinity due to the offset. This is illustrated in Figure 1 and Figure 2. Figure 1 shows a distribution of output voltages versus I_P at 25°C and across temperature. Figure 2 shows the corresponding E_{TOT} versus I_P.
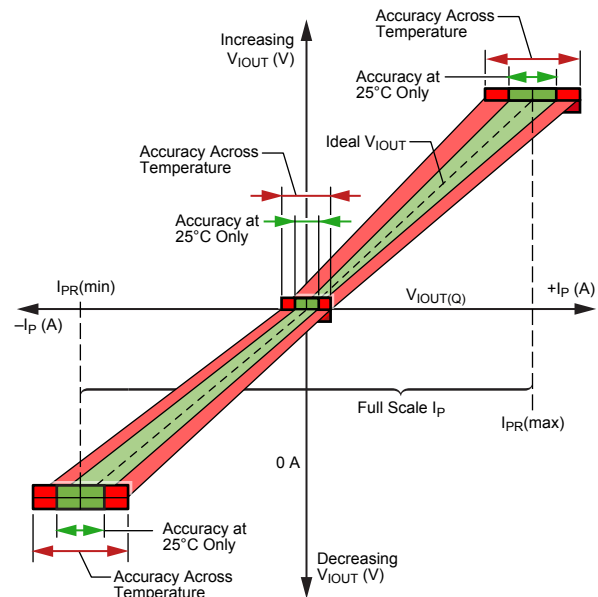

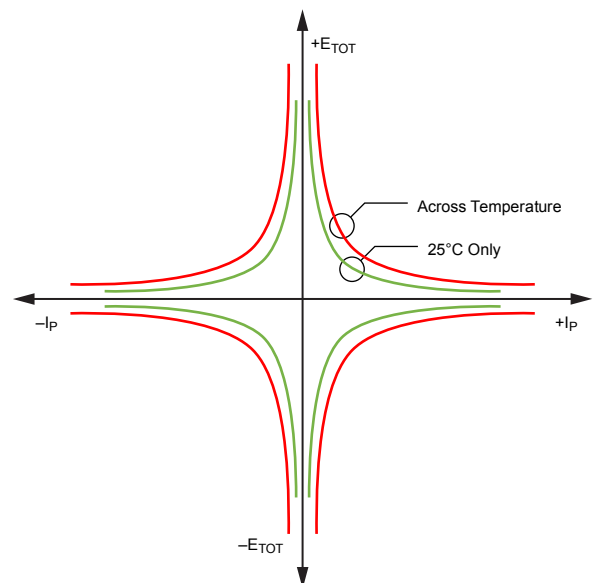**Figure 1: Output Voltage versus Sensed Current**

Figure 2: Total Output Error versus Sensed Current

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Estimating Total Error versus Sensed Current

The Performance Characteristics tables give distribution (± 3 sigma) values for Total Error at $I_{PR(max)}$; however, one often wants to know what error to expect at a particular current. This can be estimated by using the distribution data for the components of Total Error, Sensitivity Error, and Offset Voltage. The ± 3 sigma value for Total Error (E_{TOT}) as a function of the sensed current (I_P) is estimated as:

$$E_{TOT}(I_P) = \sqrt{E_{SENS}{}^2 + \left(\frac{100 \times V_{OE}}{Sens \times I_P}\right)^2}$$

Here, E_{SENS} and V_{OE} are the ± 3 sigma values for those error terms. If there is an average sensitivity error or average offset voltage, then the average Total Error is estimated as:

$$E_{TOT_{AVG}}(I_P) = E_{SENS_{AVG}} + \frac{100 \times V_{OE_{AVG}}}{Sens \times I_P}$$

The resulting total error will be a sum of E_{TOT} and E_{TOT_AVG}. Using these equations and the 3 sigma distributions for Sensitivity Error and Offset Voltage, the Total Error versus sensed current (I_P) is shown here for the ACS724/5LMCTR-20AB. As expected, as one goes towards zero current, the error in percent goes towards infinity due to division by zero.

DEFINITIONS OF DYNAMIC RESPONSE CHARACTERISTICS

Power-On Time (t$_{PO}$)

When the supply is ramped to its operating voltage, the device requires a finite time to power its internal components before responding to an input magnetic field.

Power-On Time (t$_{PO}$) is defined as the time it takes for the output voltage to settle within ±10% of its steady-state value under an applied magnetic field, after the power supply has reached its minimum specified operating voltage (V$_{CC}$(min)) as shown in the chart at right (refer to Figure 3).

Rise Time (t$_r$)

The time interval between: a) when the sensor IC reaches 10% of its full-scale value; and b) when it reaches 90% of its full-scale value (refer to Figure 4). The rise time to a step response is used to derive the bandwidth of the current sensor IC, in which $f(-3 \text{ dB}) = 0.35/t_r$. Both t$_r$ and t$_{RESPONSE}$ are detrimentally affected by eddy current losses observed in the conductive IC ground plane.

Propagation Delay (t$_{pd}$)

The propagation delay is measured as the time interval between: a) when the primary current signal reaches 20% of its final value, and b) when the device reaches 20% of its output corresponding to the applied current (refer to Figure 4).
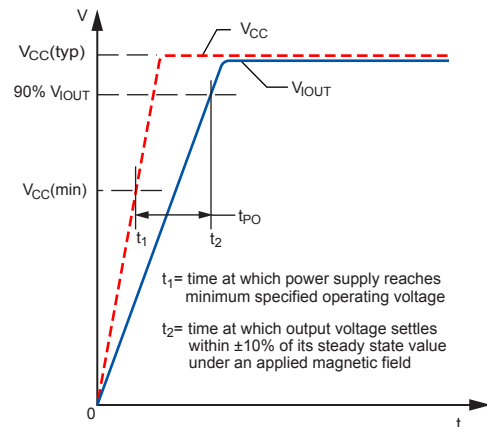
Response Time (t$_{RESPONSE}$)

The time interval between: a) when the primary current signal reaches 90% of its final value, and b) when the device reaches 90% of its output corresponding to the applied current (refer to Figure 5).
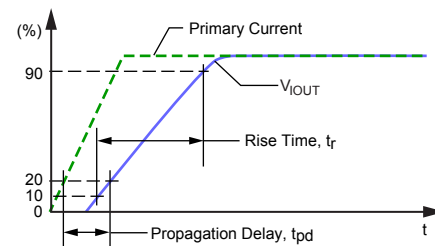

Figure 3: Power-On Time
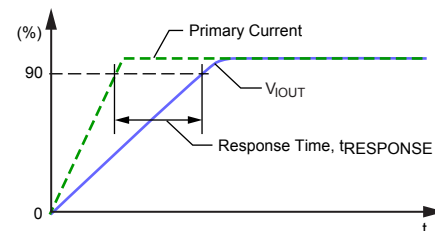

Figure 4: Rise Time and Propagation Delay

Figure 5: Response Time

APPLICATION INFORMATION

Thermal Rise vs. Primary Current

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

The thermal response is highly dependent on PCB layout, copper thickness, cooling techniques, and the profile of the injected current. The current profile includes peak current, current "on-time", and duty cycle. While the data presented in this section was collected with direct current (DC), these numbers may be used to approximate thermal response for both AC signals and current pulses.

The plot in Figure 6 shows the measured rise in steady-state die temperature of the ACS724/5MC versus continuous current at an ambient temperature, T_A, of 25 °C. The thermal offset curves may be directly applied to other values of T_A. Conversely, Figure 7 shows the maximum continuous current at a given T_A. Surges beyond the maximum current listed in Figure 7 are allowed given the maximum junction temperature, $T_{J(MAX)}$ (165°C), is not exceeded.
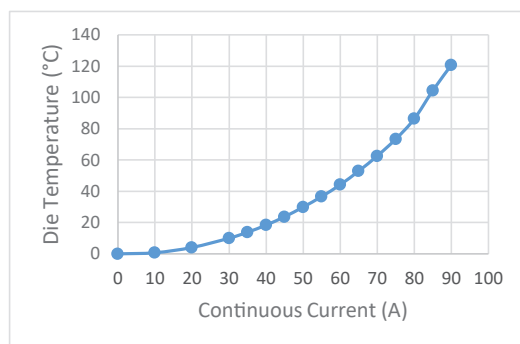

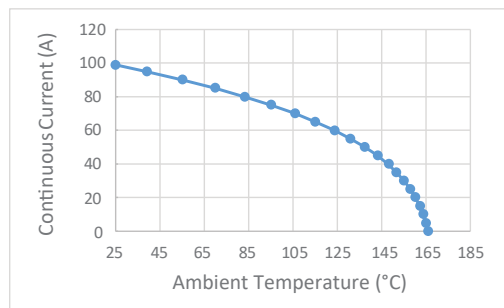**Figure 6: Self-heating in the MC package due to current flow**

Figure 7: Maximum continuous current at a given T_A

The thermal capacity of the ACS724/5LMC should be verified by the end user in the application's specific conditions. The maxi-

mum junction temperature, $T_{J(MAX)}$, should not be exceeded. Further information on this application testing is available in the "DC and Transient Current Capability" application note [1] on the Allegro website.

ASEK724/5 MC Evaluation Board Layout

Thermal data shown in Figure 6 and Figure 7 was collected using the ASEK724/5 MC Evaluation Board (TED-0002977). This board includes 1500 mm^2 of 2 oz. (0.1388 mm) copper connected to pins 1 through 4, and to pins 5 through 8, with thermal vias connecting the layers. Top and bottom layers of the PCB are shown below in Figure 8.
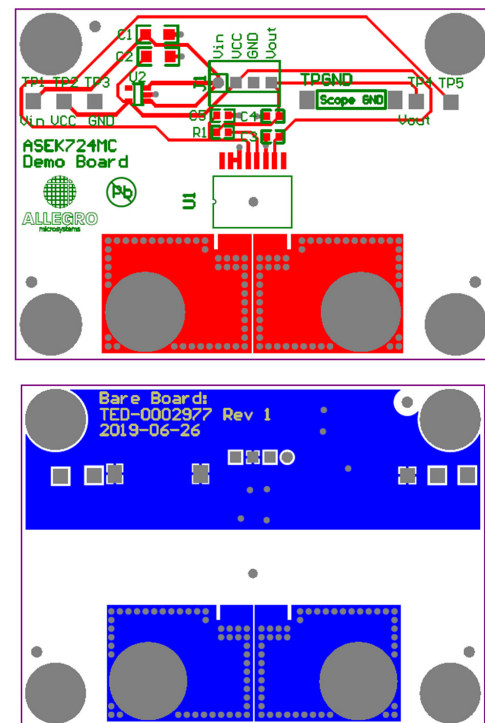

Figure 8: Top and bottom layers for ASEK724/5 MC evaluation board

Gerber files for the ASEK724/5 MC evaluation board are available for download from the Allegro website. See the technical documents section of the ACS724xMC device webpage [2].

[1] http://www.allegromicro.com/en/Design-Center/Technical-Documents/Hall-Effect-Sensor-IC-Publications/DC-and-Transient-Current-Capability-Fuse-Characteristics.aspx

[2] https://www.allegromicro.com/en/products/sense/current-sensor-ics/zero-to-fifty-amp-integrated-conductor-sensor-ics/acs724ma
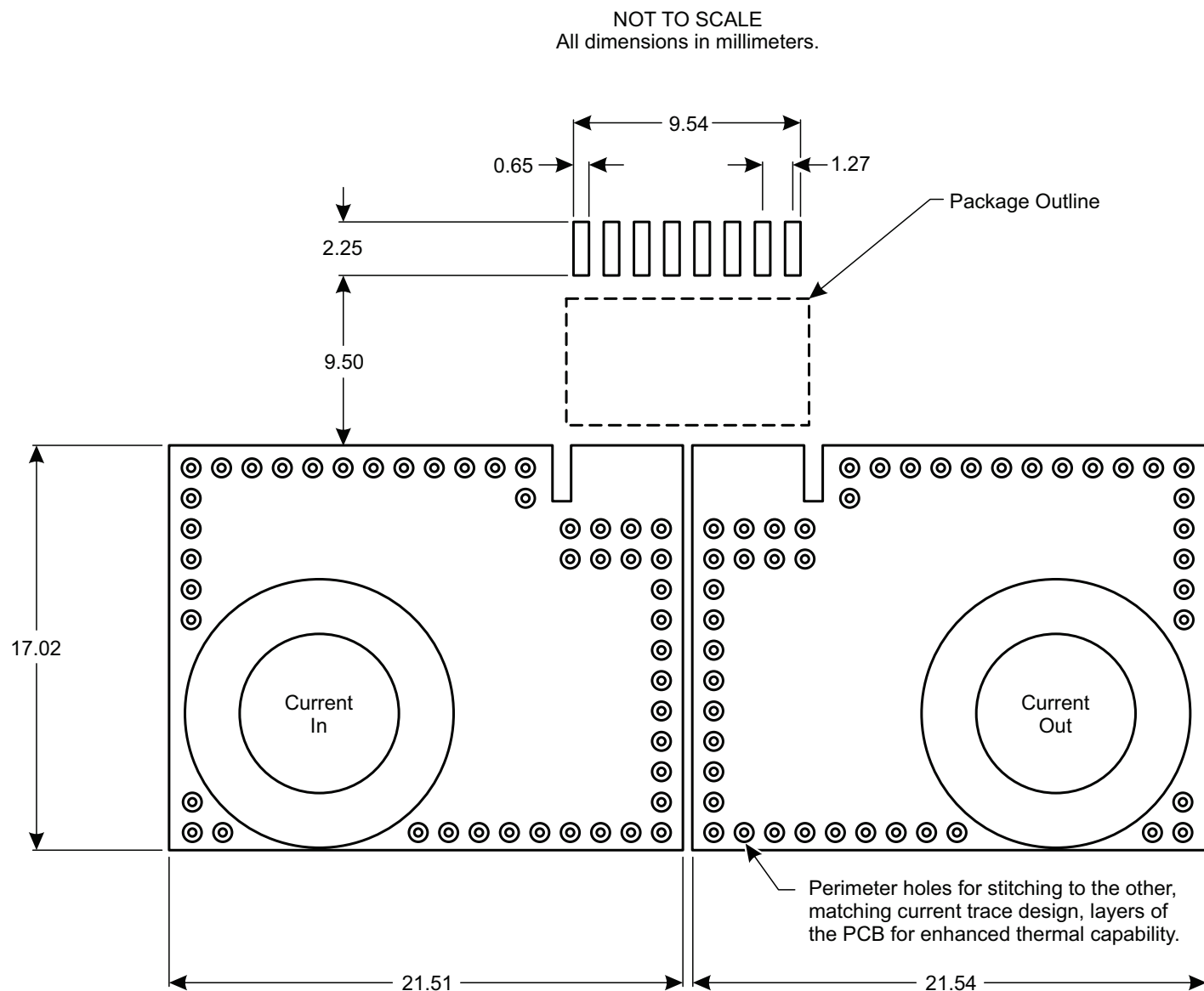
NOT TO SCALE
All dimensions in millimeters.

Figure 9: High-Isolation PCB Layout

PACKAGE OUTLINE DRAWING

For Reference Only; Not for Tooling Use
(reference DWG-0000714, Rev. 2)
Dimensions in millimeters
Dimensions exclusive of mold flash, gate burrs, and dambar protrusions
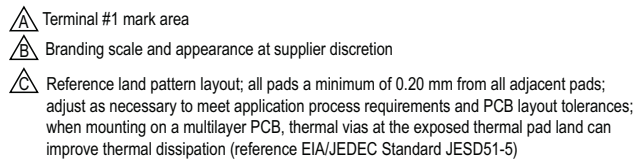Exact case and lead configuration at supplier discretion within limits shown

4° ±4°

0.538 ±0.06

9° ±3°
TYP (8×)

0.85

0.53

7.52 ±0.10

13.00 ±0.32

0.48 × 45°
TYP

R0.91

1.25

10°

R0.41

1.08 ±0.43

1.00

GAGE PLANE

SEATING PLANE

0.25

1.04

11.29 ±0.10

2.59 ±0.15

0.42 ±0.10

BASE PLANE

SEATING PLANE

1.27
TYP

0.53 ±0.10

0.800

1.27 TYP

3.360

XXXXXXXXXXXX
Lot Number

(0,0)

4.443

5.943

1

/B\ Standard Branding Reference View

Lines 1, 2 = 12 characters

Line 1: Part Number
Line 2: First 8 characters of
          Assembly Lot Number

/C\ PCB Layout Reference View

/A\ Terminal #1 mark area

/B\ Branding scale and appearance at supplier discretion

/C\ Reference land pattern layout; all pads a minimum of 0.20 mm from all adjacent pads;
     adjust as necessary to meet application process requirements and PCB layout tolerances;
     when mounting on a multilayer PCB, thermal vias at the exposed thermal pad land can
     improve thermal dissipation (reference EIA/JEDEC Standard JESD51-5)

Figure 10: Package MC, 16-Pin SOICW

Revision History

Number	Date	Description
–	February 6, 2020	Initial advance information release
1	March 13, 2020	AEC-Q100 qualification marked pending (page 1); removed ESD ratings and Current Surge Strength (page 3); updated performance characteristics (pages 6-9)
2	June 25, 2020	Updated certification status and added Reinforced Isolation Working Voltage spec (pages 1 and 3)
3	September 25, 2020	Updated CB certificate numbers (page 1)
4	February 5, 2021	Updated Functional Block Diagram (page 4)
5	January 11, 2022	Updated package drawing (page 16)
6	July 5, 2022	Updated AEC-Q100 qualification to qualified (page 1)
7	July 10, 2024	Updated TUV certification and Withstand Voltage feature (page 1); removed Pb symbol (page 2); added Thermal Resistance and Isolation Characteristics tables (page 3); removed Advanced status (all)

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www.allegromicro.com