

Fully Integrated, Hall Effect-Based Linear Current Sensor with High Voltage Isolation and a Low-Resistance Current Conductor

Features and Benefits

- Monolithic Hall IC for high reliability
- Single +5 V supply
- 3 kV_{RMS} isolation voltage between terminals 4/5 and pins 1/2/3 for up to 1 minute
- 18 kHz bandwidth
- Automotive temperature range
- End-of-line factory-trimmed for gain and offset
- Ultra-low power loss: 100 $\mu\Omega$ internal conductor resistance
- Ratiometric output from supply voltage
- Extremely stable output offset voltage
- Small package size, with easy mounting capability
- Output proportional to DC currents

Package: 5 pin module (leadform PFF)



Description

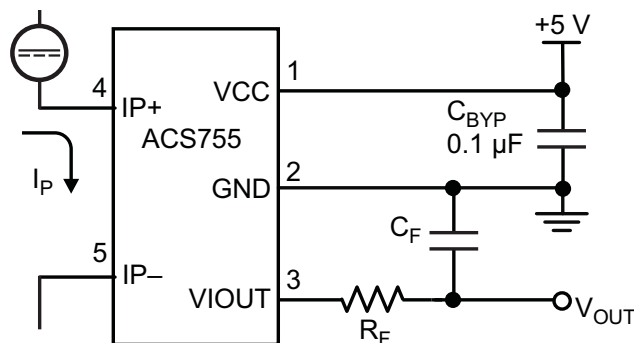
The Allegro ACS755 family of current sensors provides economical and precise solutions for DC current sensing in industrial, automotive, commercial, and communications systems. The device package allows for easy implementation by the customer. Typical applications include motor control, load detection and management, power supplies, and overcurrent fault protection.

The device consists of a precision, low-offset linear Hall sensor circuit with a copper conduction path located near 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. 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 BiCMOS Hall IC, which is programmed for accuracy at the factory.

The output of the device will be valid when a current flows through the primary copper conduction path from terminal 4 to terminal 5, which is the path used for current sensing. The internal resistance of this conductive path is 100 $\mu\Omega$ typical, providing low power loss.

Continued on the next page...

Typical Application



Application 1. The ACS755 outputs an analog signal, V_{OUT} , that varies linearly with the unidirectional DC primary sensed current, I_P , within the range specified. C_F is recommended for noise management, with values that depend on the application.

Description (continued)

The thickness of the copper conductor allows survival of the device at up to 5× overcurrent conditions. The terminals of the conductive path are electrically isolated from the sensor leads (pins 1 through 3). This allows the ACS755 family of sensors to be used in applications requiring electrical isolation without the use of opto-isolators or

other costly isolation techniques.

The device is fully calibrated prior to shipment from the factory. The ACS75x family is lead (Pb) free. All leads are plated with 100% matte tin, and there is no Pb inside the package. The heavy gauge leadframe is made of oxygen-free copper.

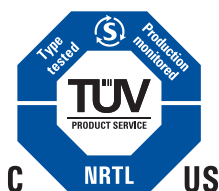
Selection Guide

| Part Number | T _{OP} (°C) | Primary Sensed Current, I _P (A) | Sensitivity Sens (Typ.) (mV/A) | Bandwidth (kHz) | Package | | Packing ¹ |
|-------------------|-------------------------|--|--------------------------------------|--------------------|-----------|-------------|-------------------------|
| | | | | | Terminals | Signal Pins | |
| ACS755LCB-050-PFF | −40 to 150 | 50 | 60 | 18 | Formed | Formed | 170 pieces per bulk bag |
| ACS755SCB-050-PFF | −20 to 85 | 50 | 60 | 18 | Formed | Formed | |

¹ Contact Allegro for additional packing options.

Absolute Maximum Ratings

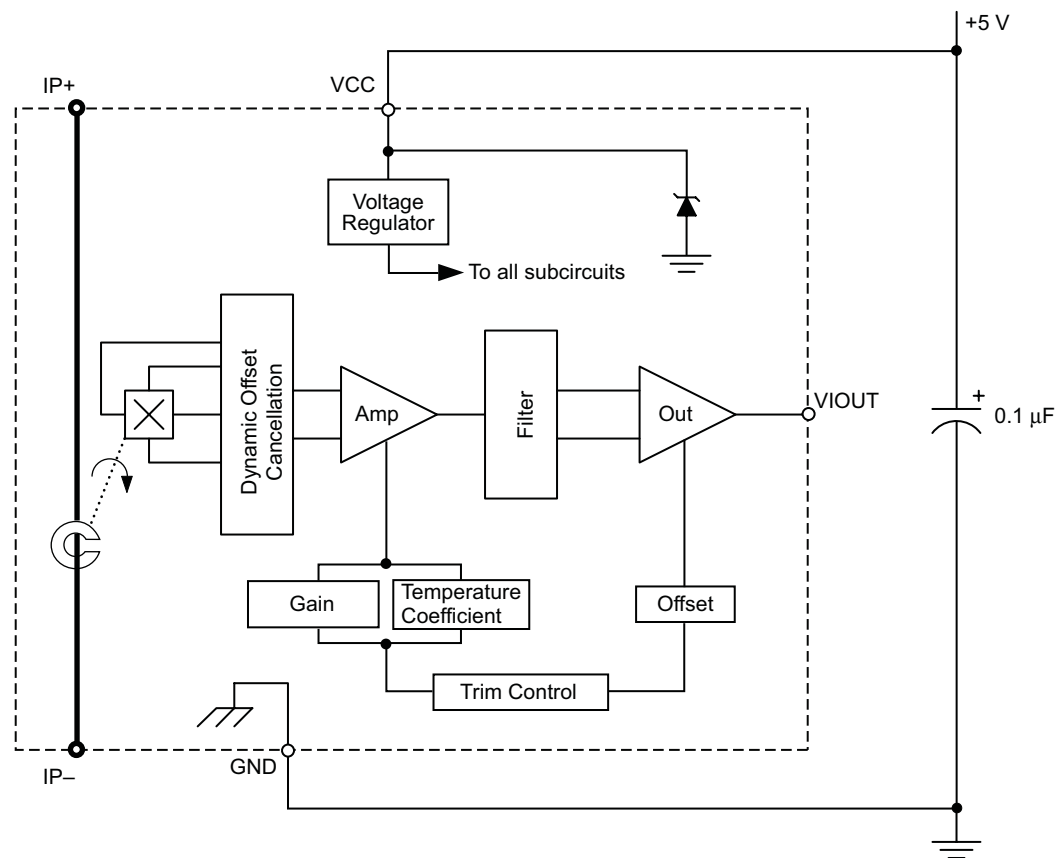
| Characteristic | Symbol | Notes | Rating | Units |
|---------------------------------------|--------------------------|---------|--------------------------------------|-------|
| Supply Voltage | V _{CC} | | 16 | V |
| Reverse Supply Voltage | V _{RCC} | | −16 | V |
| Output Voltage | V _{IOUT} | | 16 | V |
| Reverse Output Voltage | V _{RIOUT} | | −0.1 | V |
| Maximum Basic Isolation Voltage | V _{ISO} | | 353 VAC, 500 VDC, or V _{pk} | V |
| Maximum Rated Input Current | I _{IN} | | 200 | A |
| Output Current Source | I _{OUT(SOURCE)} | | 3 | mA |
| Output Current Sink | I _{OUT(SINK)} | | 10 | mA |
| Nominal Operating Ambient Temperature | T _A | Range L | −40 to 150 | °C |
| | | Range S | −20 to 85 | °C |
| Maximum Junction | T _{J(max)} | | 165 | °C |
| Storage Temperature | T _{stg} | | −65 to 170 | °C |



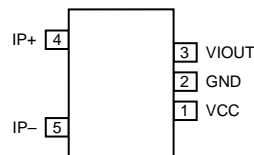
| | |
|---|---|
| TÜV America Certificate Number: U8V 04 11 54214 001 | Fire and Electric Shock EN60950-1:2001 |
|---|---|



Functional Block Diagram



Pin-out Diagram



Terminal List Table

| Number | Name | Description |
|--------|-------|-----------------------------------|
| 1 | VCC | Device power supply pin |
| 2 | GND | Signal ground pin |
| 3 | VIOUT | Analog output signal pin |
| 4 | IP+ | Terminal for current being sensed |
| 5 | IP- | Terminal for current being sensed |

ELECTRICAL CHARACTERISTICS, over operating ambient temperature range unless otherwise stated

| Characteristic | Symbol | Test Conditions | Min. | Typ. | Max. | Units |
|------------------------------|---------------|--|------|------|------|-------------|
| Primary Sensed Current | I_P | | 0 | – | 50 | A |
| Supply Voltage | V_{CC} | | 4.5 | 5.0 | 5.5 | V |
| Supply Current | I_{CC} | $V_{CC} = 5.0$ V, output open | 6.5 | 8 | 10 | mA |
| Output Resistance | R_{OUT} | $I_{OUT} = 1.2$ mA | – | 1 | 2 | Ω |
| Output Capacitance Load | C_{LOAD} | VOUT to GND | – | – | 10 | nF |
| Output Resistive Load | R_{LOAD} | VOUT to GND | 4.7 | – | – | k Ω |
| Primary Conductor Resistance | $R_{PRIMARY}$ | $I_P = +100$ A; $T_A = 25^\circ\text{C}$ | – | 100 | – | $\mu\Omega$ |
| Isolation Voltage | V_{ISO} | Pins 1-3 and 4-5; 60 Hz, 1 minute | 3.0 | – | – | kV |

PERFORMANCE CHARACTERISTICS, -20°C to $+85^\circ\text{C}$, $V_{CC} = 5$ V unless otherwise specified

| | | | | | | |
|--|----------------|--|-----|-----------|------------|---------------|
| Propagation time | t_{PROP} | $I_P = +50$ A, $T_A = 25^\circ\text{C}$ | – | 4 | – | μs |
| Response time | $t_{RESPONSE}$ | $I_P = +50$ A, $T_A = 25^\circ\text{C}$ | – | 20 | – | μs |
| Rise time | t_r | $I_P = +50$ A, $T_A = 25^\circ\text{C}$ | – | 20 | – | μs |
| Frequency Bandwidth | f | –3 dB, $T_A = 25^\circ\text{C}$ | – | 18 | – | kHz |
| Sensitivity | Sens | Over full range of I_P , $T_A = 25^\circ\text{C}$ | – | 60 | – | mV/A |
| | | Over full range of I_P | 53 | – | 65 | mV/A |
| Noise | V_{NOISE} | Peak-to-peak, $T_A = 25^\circ\text{C}$, no external filter | – | 85 | – | mV |
| Linearity | E_{LIN} | Over full range of I_P | – | – | ± 2.8 | % |
| Zero Current Output Voltage | $V_{OUT(Q)}$ | $I = 0$ A, $T_A = 25^\circ\text{C}$ | – | 0.6 | – | V |
| Electrical Offset Voltage (Magnetic error not included) | V_{OE} | $I = 0$ A, $T_A = 25^\circ\text{C}$ | –15 | – | 15 | mV |
| | | $I = 0$ A | –25 | – | 25 | mV |
| Magnetic Offset Error | I_{ERROM} | $I = 0$ A, after excursion of 100 A | – | ± 0.1 | ± 0.30 | A |
| Total Output Error (Including all offsets) | E_{TOT} | Over full range of I_P , $T_A = 25^\circ\text{C}$ | – | ± 1.0 | – | % |
| | | Over full range of I_P | – | – | ± 10.0 | % |

PERFORMANCE CHARACTERISTICS, -40°C to $+150^\circ\text{C}$, $V_{CC} = 5$ V unless otherwise specified

| | | | | | | |
|--|----------------|--|-----|-----------|------------|---------------|
| Propagation time | t_{PROP} | $I_P = +50$ A, $T_A = 25^\circ\text{C}$ | – | 4 | – | μs |
| Response time | $t_{RESPONSE}$ | $I_P = +50$ A, $T_A = 25^\circ\text{C}$ | – | 20 | – | μs |
| Rise time | t_r | $I_P = +50$ A, $T_A = 25^\circ\text{C}$ | – | 20 | – | μs |
| Frequency Bandwidth | f | –3 dB, $T_A = 25^\circ\text{C}$ | – | 18 | – | kHz |
| Sensitivity | Sens | Over full range of I_P , $T_A = 25^\circ\text{C}$ | – | 60 | – | mV/A |
| | | Over full range of I_P | 53 | – | 65 | mV/A |
| Noise | V_{NOISE} | Peak-to-peak, $T_A = 25^\circ\text{C}$, no external filter | – | 85 | – | mV |
| Linearity | E_{LIN} | Over full range of I_P | – | – | ± 2.8 | % |
| Zero Current Output Voltage | $V_{OUT(Q)}$ | $I = 0$ A, $T_A = 25^\circ\text{C}$ | – | 0.6 | – | V |
| Electrical Offset Voltage (Magnetic error not included) | V_{OE} | $I = 0$ A, $T_A = 25^\circ\text{C}$ | –15 | – | 15 | mV |
| | | $I = 0$ A | –50 | – | 50 | mV |
| Magnetic Offset Error | I_{ERROM} | $I = 0$ A, after excursion of 100 A | – | ± 0.1 | ± 0.30 | A |
| Total Output Error (Including all offsets) | E_{TOT} | Over full range of I_P , $T_A = 25^\circ\text{C}$ | – | ± 1.0 | – | % |
| | | Over full range of I_P | – | – | ± 11.0 | % |

Definitions of Accuracy Characteristics

Sensitivity (Sens). The change in sensor output in response to a 1 A change through the primary conductor. The sensitivity is the product of the magnetic circuit sensitivity (G/A) 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.

Noise (V_{NOISE}). The product of the linear IC amplifier gain (mV/G) and the noise floor for the Allegro Hall effect linear IC (≈ 1 G). The noise floor is derived from the thermal and shot noise observed in Hall elements. Dividing the noise (mV) by the sensitivity (mV/A) provides the smallest current that the device is able to resolve.

Linearity (E_{LIN}). The degree to which the voltage output from the sensor varies in direct proportion to the primary current through its full-scale amplitude. Nonlinearity in the output can be attributed to the saturation of the flux concentrator approaching the full-scale current. The following equation is used to derive the linearity:

$$100 \left[1 - \frac{V_{\text{IOUT}_{-3/4 \text{ full-scale IP}}} - V_{\text{IOUT(Q)}}}{3 (V_{\text{IOUT}_{-1/4 \text{ full-scale IP}}} - V_{\text{IOUT(Q)}})} \right]$$

where

$V_{\text{IOUT}_{-1/4 \text{ full-scale IP}}}$ (V) is the output voltage when the sensed current approximates $0.25 \times I_{\text{P(max)}}$, and

$V_{\text{IOUT}_{-3/4 \text{ full-scale IP}}}$ (V) is the output voltage when the sensed current approximates $0.75 \times I_{\text{P(max)}}$.

Quiescent output voltage ($V_{\text{IOUT(Q)}}$). The output of the sensor when the primary current is zero. For a unipolar supply voltage,

it nominally remains at 0.6. Variation in $V_{\text{IOUT(Q)}}$ can be attributed to the resolution of the Allegro linear IC quiescent voltage trim and thermal drift.

Electrical offset voltage (V_{OE}). The deviation of the device output from its ideal quiescent value due to nonmagnetic causes.

Magnetic offset error (I_{ERROM}). The magnetic offset is due to the residual magnetism (remnant field) of the core material. The magnetic offset error is highest when the magnetic circuit has been saturated, usually when the device has been subjected to a full-scale or high-current overload condition. The magnetic offset is largely dependent on the material used as a flux concentrator. The larger magnetic offsets are observed at the lower operating temperatures.

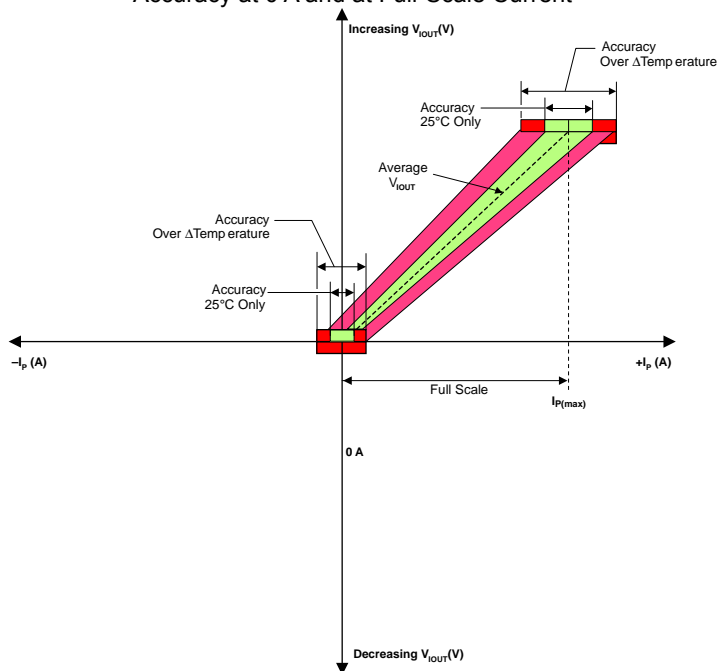
Accuracy (E_{TOT}). The accuracy represents the maximum deviation of the actual output from its ideal value. This is also known as the total output error. The accuracy is illustrated graphically in the output voltage versus current chart on the following page.

Accuracy is divided into four areas:

- **0 A at 25°C.** Accuracy of sensing zero current flow at 25°C, without the effects of temperature.
- **0 A over Δ temperature.** Accuracy of sensing zero current flow including temperature effects.
- **Full-scale current at 25°C.** Accuracy of sensing the full-scale current at 25°C, without the effects of temperature.
- **Full-scale current over Δ temperature.** Accuracy of sensing full-scale current flow including temperature effects.

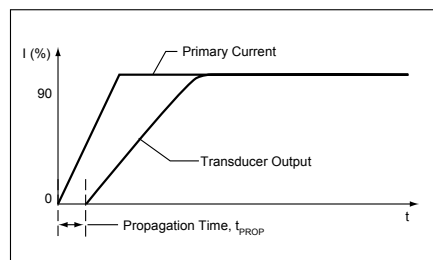
Output Voltage versus Sensed Current

Accuracy at 0 A and at Full-Scale Current

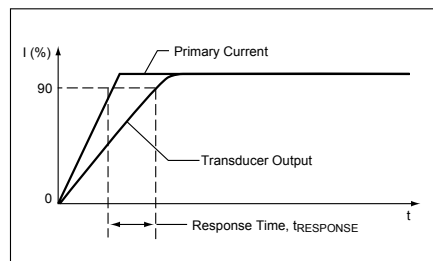


Definitions of Dynamic Response Characteristics

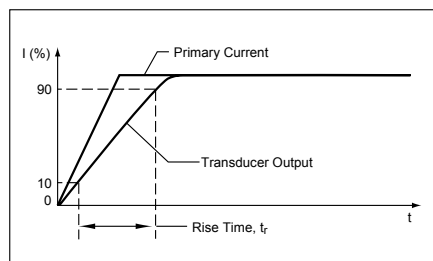
Propagation delay (t_{PROP}). The time required for the sensor output to reflect a change in the primary current signal. Propagation delay is attributed to inductive loading within the linear IC package, as well as in the inductive loop formed by the primary conductor geometry. Propagation delay can be considered as a fixed time offset and may be compensated.

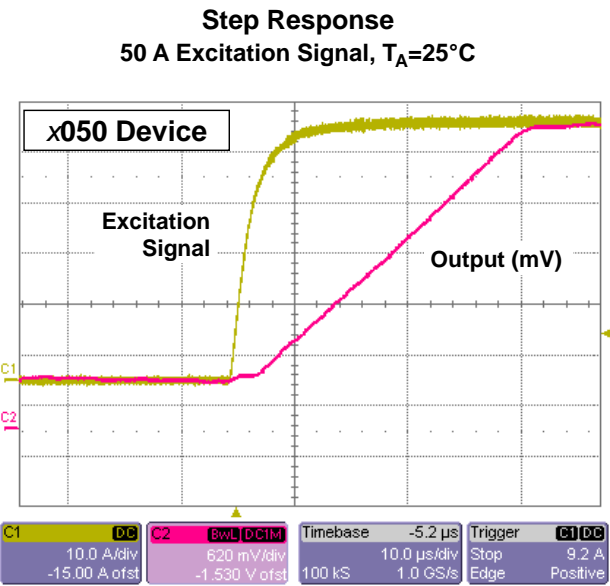


Response time ($t_{RESPONSE}$). The time interval between a) when the primary current signal reaches 90% of its final value, and b) when the sensor reaches 90% of its output corresponding to the applied current.

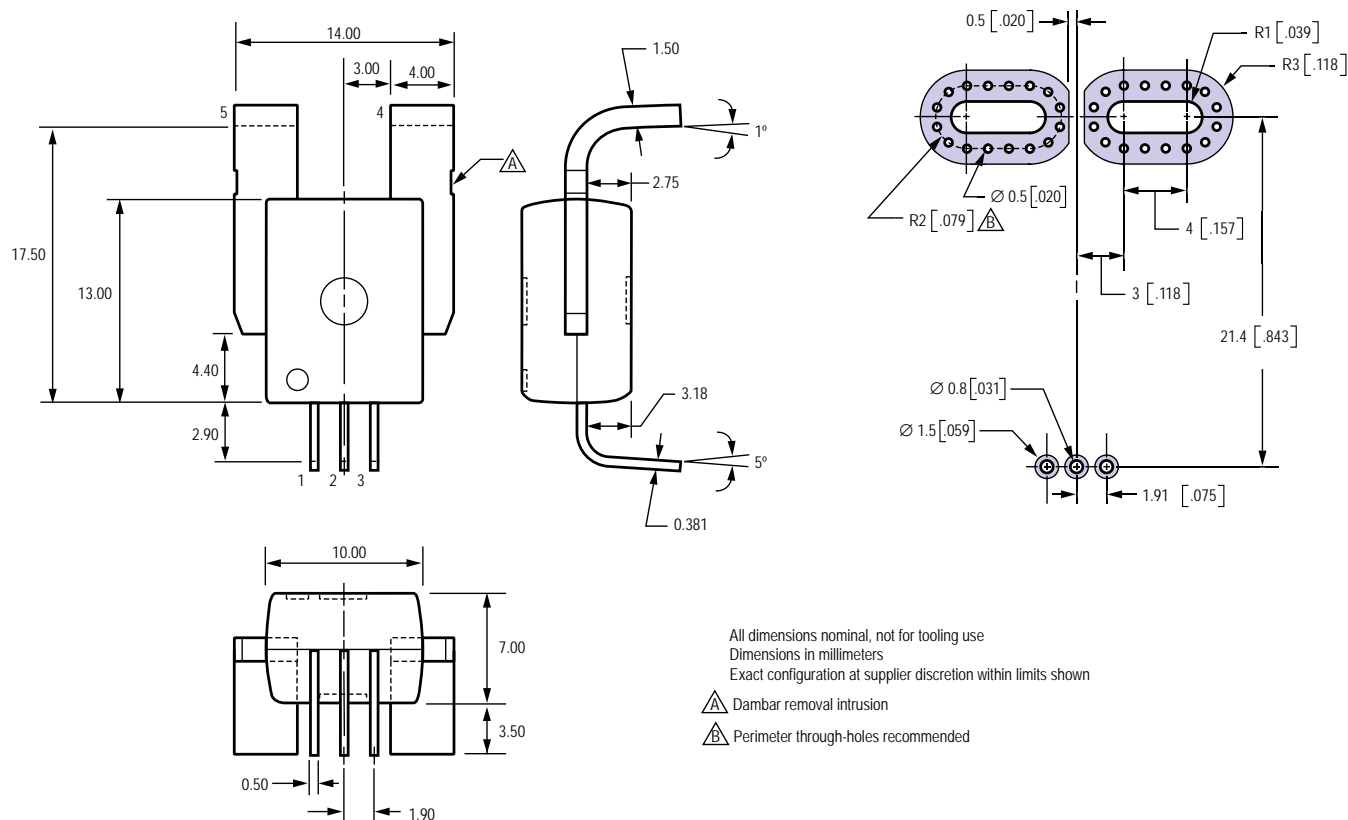


Rise time (t_r). The time interval between a) when the sensor reaches 10% of its full scale value, and b) when it reaches 90% of its full scale value. The rise time to a step response is used to derive the bandwidth of the current sensor, in which $f(-3 \text{ dB}) = 0.35/t_r$. Both t_r and $t_{RESPONSE}$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





Package CB, 5-pin module, leadform PFF



Package Branding

Two alternative patterns are used

Creepage distance, current terminals to sensor pins: 7.25 mm
Clearance distance, current terminals to sensor pins: 7.25 mm
Package mass: 4.63 g typical

| | | |
|---------------------------|-----|--|
| ACS755 RCBPPP YYWWA | ACS | Allegro Current Sensor |
| | 755 | Device family number |
| | R | Operating ambient temperature range code |
| | CB | Package type designator |
| | PPP | Primary sensed current |
| YYWWA | YY | Date code: Calendar year (last two digits) |
| | WW | Date code: Calendar week |
| | A | Date code: Shift code |

| | | |
|-----------------------------------|-------|--|
| ACS755 RCBPPP L...L YYWW | ACS | Allegro Current Sensor |
| | 755 | Device family number |
| | R | Operating ambient temperature range code |
| | CB | Package type designator |
| | PPP | Primary sensed current |
| YYWW | L...L | Lot code |
| | YY | Date code: Calendar year (last two digits) |
| | WW | Date code: Calendar week |

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