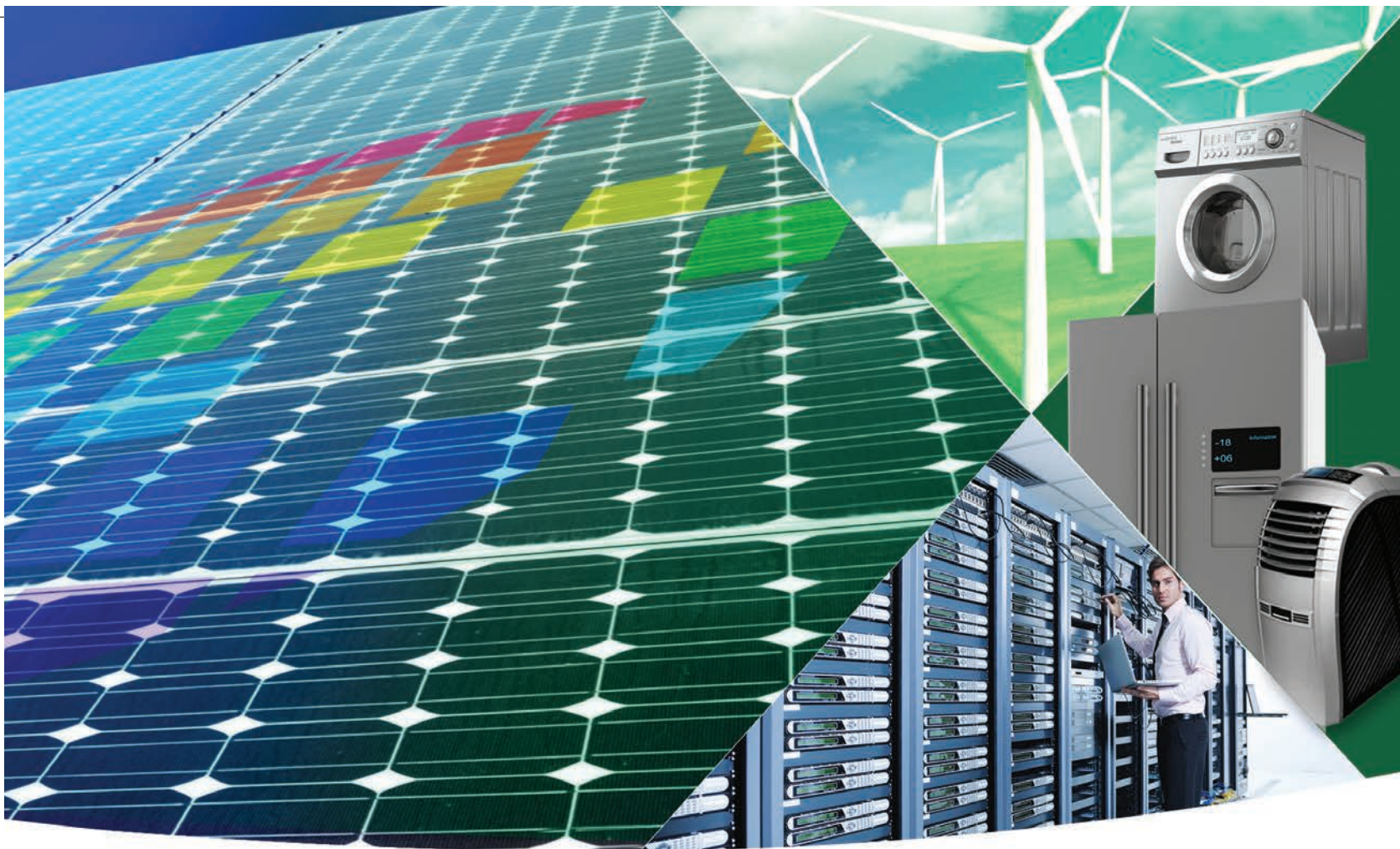




# Innovative Current Sensor ICs

For Industrial, Consumer and Computer Applications (IC&C)



# Innovative Current Sensor ICs

**Allegro MicroSystems, LLC** has developed a line of fully integrated Hall-effect current sensor ICs and Hall-effect linear ICs that provide highly accurate, low noise output voltage signals that are proportional to an applied AC or DC current. These current sensor ICs are in high volume production in a wide variety of industrial, consumer, and computer applications, including motor controllers, inverters, compressors, handheld radios, and server power supplies.

Allegro's proprietary fully integrated Hall-effect current sensor ICs employ advanced IC and packaging techniques for sensing current from 5 A to 200 A. For currents up to 1000 A and beyond, an Allegro current sensor linear IC can be used with a magnetic concentrator to create a current sensing module. Allegro current sensor ICs allow design engineers to use Hall-effect-based current sensor ICs in new applications where increased energy efficiency or new operating features are required.

**Wherever current sensing is needed, an Allegro sensor IC can provide a solution.**

## Current Sensor Packaging Technology Overview

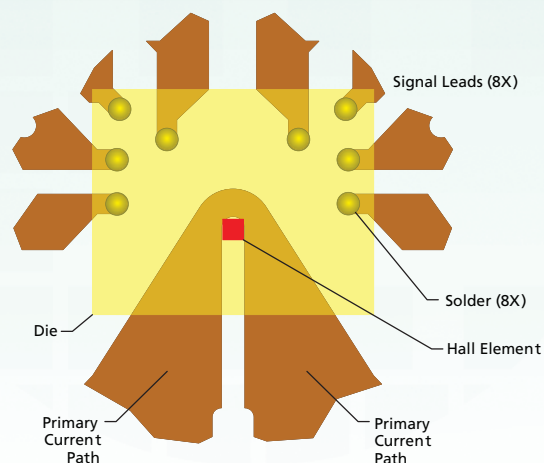
**Allegro has a long history of packaging innovation for current sensor IC solutions.**

For measuring less than 50 A currents, Allegro employs its patented flip chip current sensor assembly technology for its integrated current sensor ICs. This packaging technique provides several major benefits to any circuit designer: increased sensitivity, high galvanic isolation, low primary resistance, and enables the use of standard, surface mount packages. By flipping the die inside the package, the Hall-effect sensor IC is placed as close as possible to the current conductor, thereby increasing the magnetic field that it sees. Second, the IC is electrically isolated from the primary conductor, providing galvanic isolation up to 3600 VRMS for 60 seconds. This enables high side current monitoring without the need for additional components to provide the isolation barrier necessary to interface the current measurement circuit with other low voltage circuits. Third, the primary conductor design is independent of the IC itself, so that its shape can be optimized for low resistance,  $\leq 1 \text{ m}\Omega$ , reducing power losses in the system. Finally, these parts are all manufactured in surface mount packages with JEDEC standard foot prints, simplifying assembly for high volume applications.

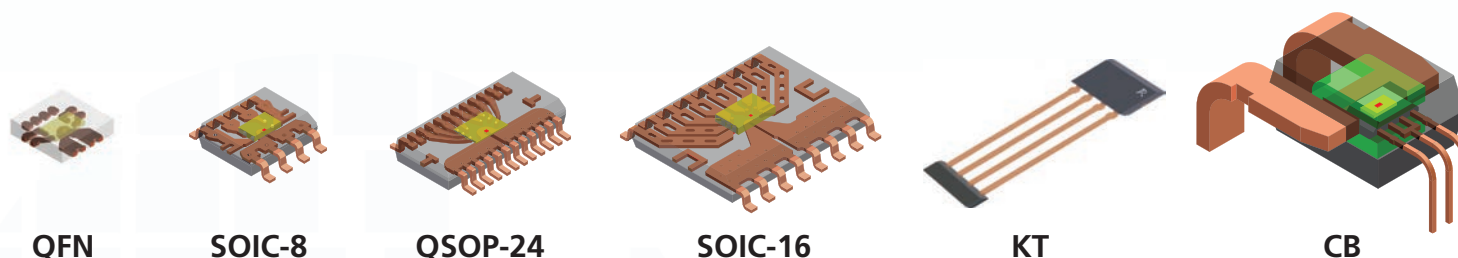
For 50 A to 200 A current ranges, Allegro has created its proprietary CB package. The CB package integrates a copper primary conductor and a linear Hall-effect current sensor IC in a single thru-hole package. This provides an extremely robust solution that can handle up to 200 A continuously and pulses up to 1200 A.

The complete assembly is calibrated at the factory, eliminating the need for the customer to program the part. These parts are UL recognized and provide superior galvanic isolation, with a dielectric withstand voltage of 4800 VRMS for 60 s, basic isolation of 700 VRMS and a reinforced isolation rating of 450 VRMS. Lastly, the ultra low resistance (typical =  $100 \mu\Omega$ ) helps minimize power losses in high current applications.

Allegro also offers Hall-effect current sensor ICs in SIP packages for integration with a magnetic concentrator to create custom current sensing assemblies. Allegro has recently developed an ultra-thin 1 mm thick KT package to enable magnetic concentrators with very small air gaps and therefore very high gain.



**Figure 1: Flip chip current sensor IC assembly - Top view**



**Figure 2: Current sensor IC package options**



## Digital Temperature Compensation Overview

Allegro's patented digital temperature compensation circuitry greatly improves both sensitivity and quiescent voltage output (QVO) error performance over a wide operating temperature range. The sensitivity and QVO of each part is measured at final test at both room temperature and hot (85°C ~ 150°C depending on the part), and the necessary compensation coefficients required to insure a flat response over the full operating temperature range are stored in EEPROM memory for both sensitivity and QVO. Allegro achieves  $\pm 1\%$  typical total error performance from 25°C ~ 150°C with the use of this new technology. And by performing this calibration at final test, Allegro removes the need to do any temperature calibration of the parts once they are mounted on your PCB, making it easier to design into any application.

It is important to note that the temperature compensation is done in parallel with the analog signal path, so there is no reduction in the overall system bandwidth as a result of this new temperature compensation circuitry. When compared to previous generations of products, this circuitry results in much more accurate and stable output signal performance without

compromising the response time of the output signal.

See the plots below for typical sensitivity, QVO and total error performance for the ACS723LLCTR-20AB-T product, one of the most recent current sensor ICs from Allegro that incorporates this new digital temperature compensation technology.

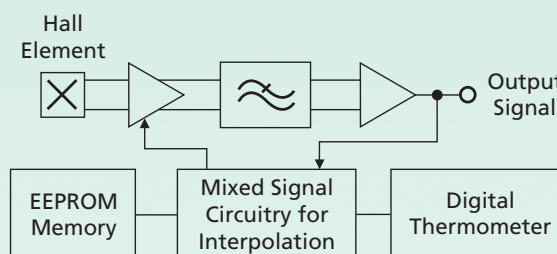
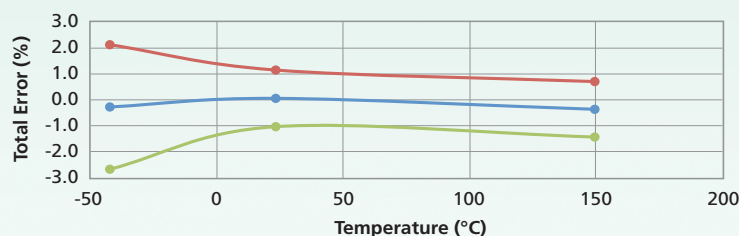
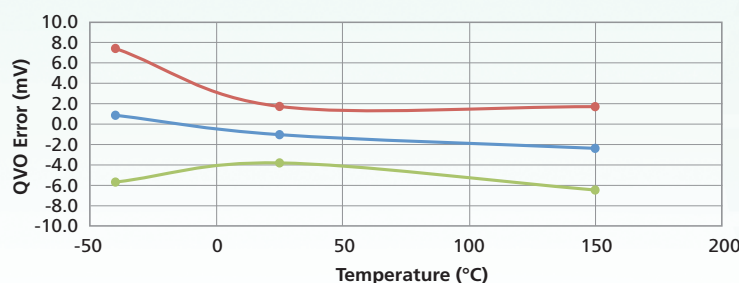


Figure 3: Typical signal chain for current sensor IC with digital temperature compensation

### ACS723LLCTR-20AB-T Total Error vs. Temperature



### ACS723LLCTR-20AB-T QVO Error vs. Temperature



### ACS723LLCTR-20AB-T Sensitivity Error vs. Temperature

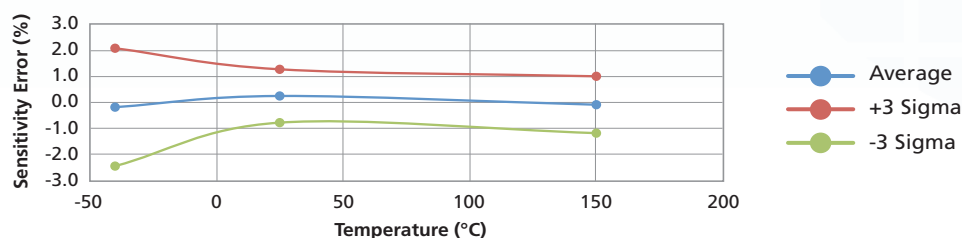


Figure 4: Typical performance characteristics for a current sensor IC with digital temperature compensation

# Innovative Current Sensor ICs



## Current Sensing in Motor Control Applications

Allegro's current sensor ICs can be used in several locations in a typical motor drive application due to their galvanic isolation and good  $dV/dt$  performance.

They can be used to measure the DC+ bus, position 1 in the diagram below, phase currents, shown in position 2, or on the low side, position 3.

Due to their high galvanic isolation, Allegro's current sensor ICs are well suited to measuring the phase currents in a motor directly. This simplifies the control (no need to recreate the phase currents from indirect measurements) and reduces the bandwidth requirements on the current sensor, leading to a lower noise solution. The low resistance primary conductor,  $\leq 1\text{m}\Omega$ , translates into low power losses. And the surface mount packages make assembly cheaper and more reliable.

Parts like the ACS710, ACS711, and ACS716 also include integrated fault outputs that can be used to detect short circuits or other over current conditions.

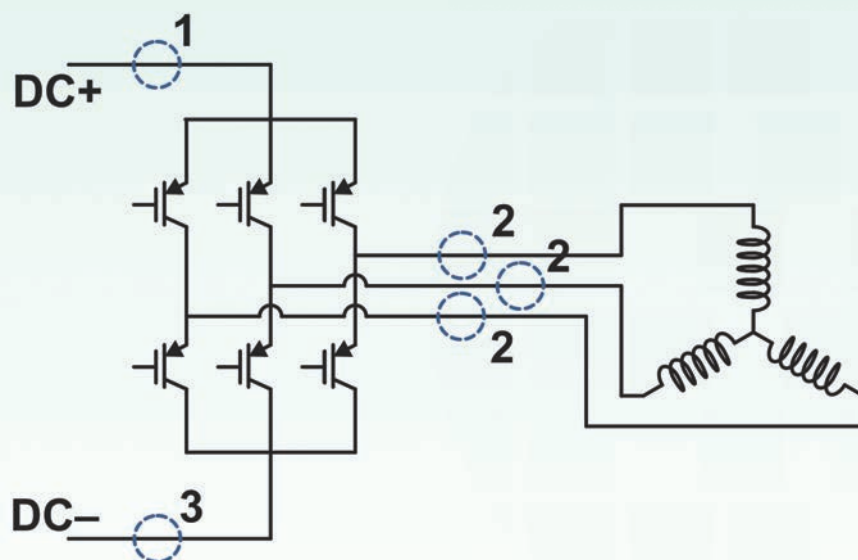


Figure 5: Typical current sensing locations in motor controller applications

### Available Features

- High bandwidth, low noise analog outputs – up to 120 kHz
- High galvanic isolation – up to 3 kV dielectric withstand strength
- Low resistance on the primary conductor –  $0.65\text{ m}\Omega \sim 1\text{ m}\Omega$
- Dedicated fault pin available on selected devices
- High  $dV/dt$  immunity due to integrated shield in flip chip devices

### Key Devices

- ACS710 – 5 V, 120 kHz current sensor IC w/ dedicated fault pin, 3 kV isolation
- ACS716 – 3.3 V, 120 kHz current sensor IC w/ dedicated fault pin, 3 kV isolation
- ACS722 – 3.3 V, 80 kHz current sensor IC w/ digital temperature compensation
- ACS723 – 5 V, 80 kHz current sensor IC w/ digital temperature compensation
- ACS726 – differential output current sensor IC w/ digital temperature compensation
- ACS711 – price competitive current sensor IC for low side sensing

## Current Sensing in Solar Microinverters

In any microinverter for use with solar panels, there are multiple stages where current sensing is needed for efficient control.

The DC/DC converter stage requires current sensor ICs that can accurately sense the current flowing in the DC bus, withstand high  $dV/dt$  events, and provide the necessary functional isolation to survive operation at 400 Vdc or greater.

With increasing demands on the accuracy of reporting power fed back onto the grid, there are increased requirements on the measurement accuracy at the output of the inverter as well.

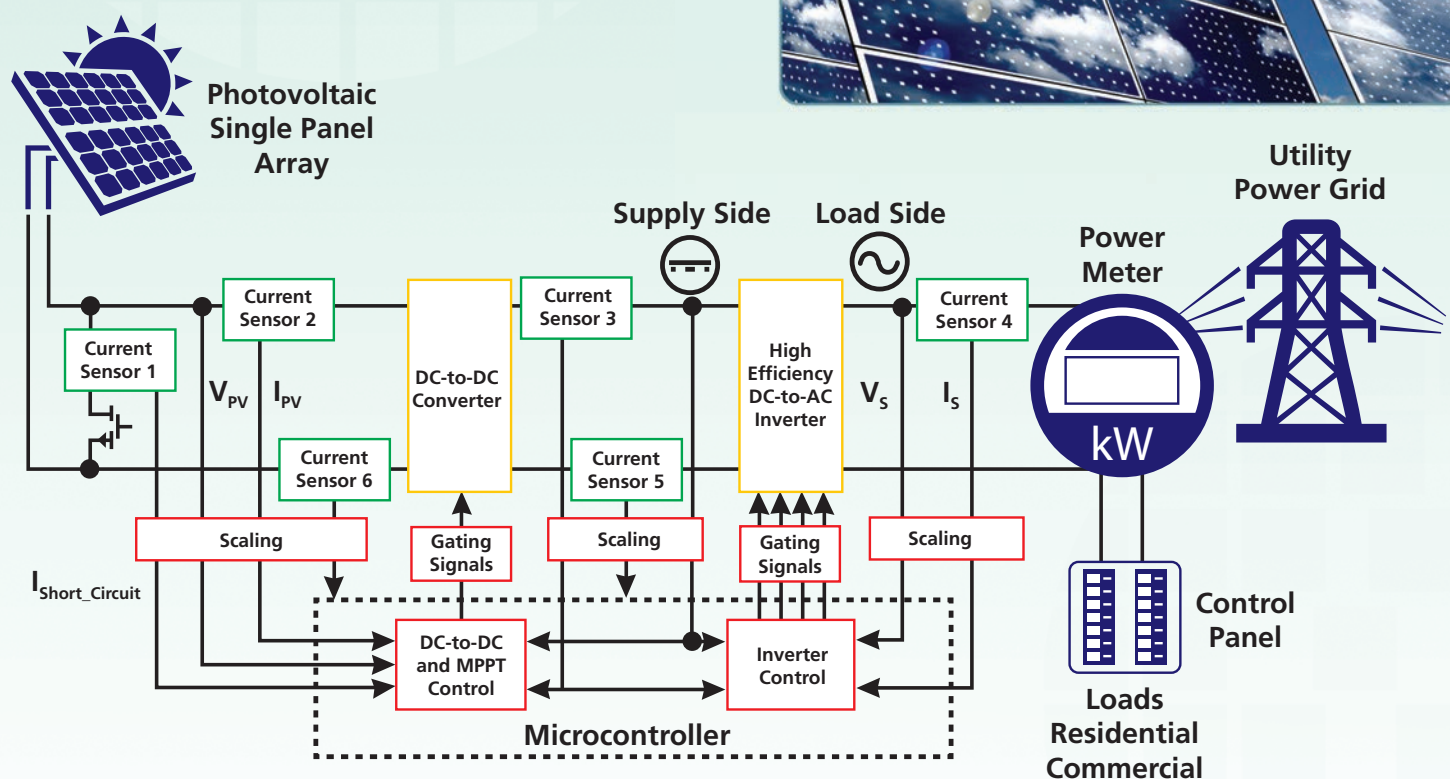


Figure 6: Typical current sensing locations in a solar inverter

### Available Features

- High bandwidth, low noise analog outputs – up to 120 kHz
- High galvanic isolation – up to 3 kV dielectric withstand strength
- Low resistance on the primary conductor – 0.65 mΩ ~ 1 mΩ
- Dedicated fault pin available on selected devices
- High  $dV/dt$  immunity due to integrated shield in flip chip devices

### Key Devices

- ACS710 – 5 V, 120 kHz current sensor IC w/ dedicated fault pin, 3 kV isolation
- ACS716 – 3.3 V, 120 kHz current sensor IC w/ dedicated fault pin, 3 kV isolation
- ACS722 – 3.3 V, 80 kHz current sensor IC w/ digital temperature compensation
- ACS723 – 5 V, 80 kHz current sensor IC w/ digital temperature compensation
- ACS726 – differential output current sensor IC w/ digital temperature compensation



# Innovative Current Sensor ICs



## Available Features

- Space saving, surface mount packages – QFN and SOIC-8
- Integrated low resistance primary conductor for low power loss – 0.6 mΩ~1.2 mΩ
- 3.3 V or 5 V single supply operation
- Resistor-like transfer function for easy integration

## Key Devices

- ACS711 – 100 kHz current sensor IC in QFN or SOIC package
- ACS712 – 80 kHz current sensor IC in SOIC package

## Current Sensing in Power Amplifiers

Whether you are designing a base station or a handheld radio, being able to properly control the power amplifier in your radio is key to balancing power output vs. performance.

Drain bias current is a key parameter to monitor in many output stages, and Allegro offers several current sensor ICs that are well suited to this task.

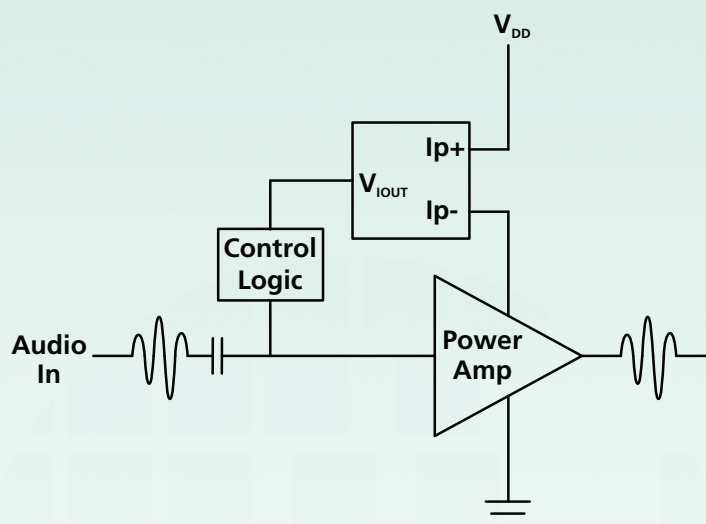


Figure 7: Typical current sensing location in a power amplifier

## Current Sensing in Servers

Allegro offers several current sensing solutions for use in server power management. The integrated current conductor in these ICs reduces I<sup>2</sup>R losses in the power path.

Some ICs include I<sup>2</sup>C communications interfaces and dedicated fault output pins for easy system integration.



## Available Features

- Low resistance primary conductor for low power losses – 0.1 mΩ ~ 0.5 mΩ
- Allegro's latest digital temperature compensation circuitry
- I<sup>2</sup>C interface for easy system integration
- Dedicated fault output for fast response to overcurrent events

## Key Devices

- ACS764 – 0.5 mΩ current sensor IC w/ I<sup>2</sup>C interface
- ACS770 – 0.1 mΩ current sensor IC for up to 200 A

## 0 to 50 A Integrated Current Sensor ICs

| Part Number | Type                           | Measurement Range (A) | Isolation Voltage (V <sub>RMS</sub> ) | Supply Voltage | Bandwidth (kHz) | Temperature Ranges | Packages         | Features                                                                                                                                                  |
|-------------|--------------------------------|-----------------------|---------------------------------------|----------------|-----------------|--------------------|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| ACS709      | Bidirectional                  | ±12 to 75             | 2100                                  | 3.3 ~ 5        | 120             | L                  | QSOP-24          | High bandwidth, low noise current sensor IC in a thermally enhanced package                                                                               |
| ACS710      | Bidirectional                  | ±12 to 75             | 3000                                  | 3.3 ~ 5        | 120             | K                  | SOIC-16          | High bandwidth, low noise current sensor IC in a high isolation package with a customer programmable fault output                                         |
| ACS711      | Bidirectional                  | ±12.5 to 32           | <100 V <sub>DC</sub>                  | 3.3 ~ 5        | 100             | E, K               | QFN-12<br>SOIC-8 | Economic, high bandwidth current sensor IC offered in space saving QFN and SOIC-8 packages                                                                |
| ACS712      | Bidirectional                  | ±5 to 30              | 2100                                  | 5              | 80              | E                  | SOIC-8           | Low noise, shielded current sensor IC with fast response times                                                                                            |
| ACS713      | Unidirectional                 | 0~20, 0~30            | 2100                                  | 5              | 80              | E                  | SOIC-8           | Low noise, shielded current sensor IC with fast response times                                                                                            |
| ACS714      | Bidirectional                  | ±5 to 50              | 2100                                  | 5              | 80              | E, L               | SOIC-8           | Automotive-grade, low noise, shielded current sensor IC with fast response times                                                                          |
| ACS715      | Unidirectional                 | 0~20, 0~30            | 2100                                  | 5              | 80              | E, L               | SOIC-8           | Automotive-grade, low noise, shielded current sensor IC with fast response times                                                                          |
| ACS716      | Bidirectional                  | ±12 to 75             | 3000                                  | 3.3            | 120             | K                  | SOIC-16          | High bandwidth, low noise current sensor IC that operates off a single 3.3 V supply in a high isolation package                                           |
| ACS722      | Bidirectional & Unidirectional | ±5 to 40              | 2400                                  | 3.3            | 80              | L                  | SOIC-8           | Next generation temperature compensation circuitry in an improved SOIC-8 package with lower resistance and higher isolation                               |
| ACS723      | Bidirectional & Unidirectional | 0~10 to 0~40          | 2400                                  | 5              | 80              | L                  | SOIC-8           | Next generation temperature compensation circuitry in an improved SOIC-8 package with lower resistance and higher isolation                               |
| ACS726      | Bidirectional                  | ±20, ±40              | 2100                                  | 3.3            | 120             | L                  | QSOP-24          | Includes an on-chip back-end amplifier to scale the output to fully utilize the dynamic range of your ADC, no matter what the size of the input signal is |
| ACS764      | Unidirectional                 | 0~16, 0~32            | <100 V <sub>DC</sub>                  | 3.3            | 2               | X                  | QSOP-24          | Unidirectional current sensor IC with I <sup>2</sup> C interface and fault output                                                                         |

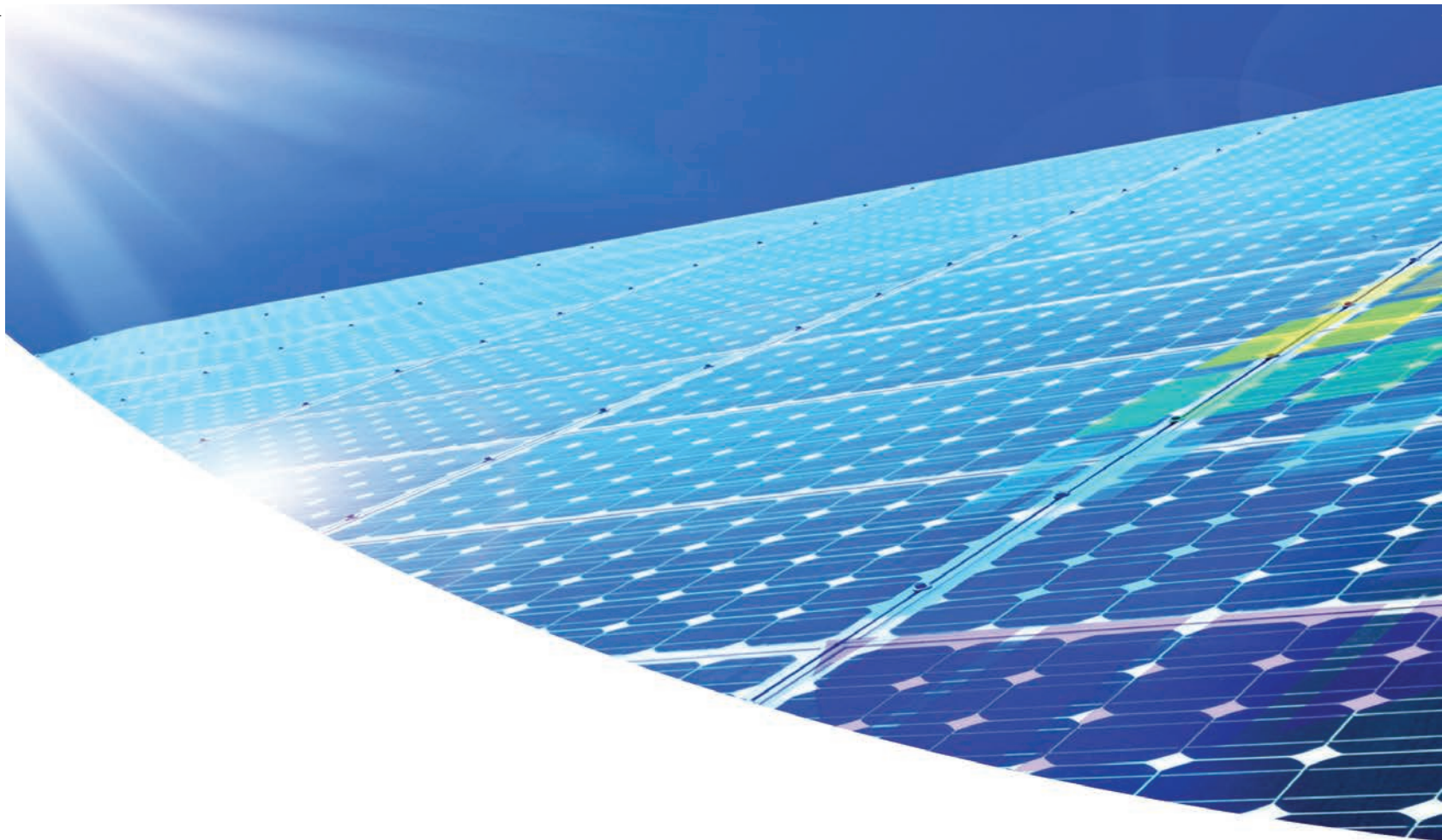
## 50 to 200 A Integrated Current Sensor ICs

| Part Number | Type                           | Measurement Range (A) | Isolation Voltage (V <sub>RMS</sub> ) | Supply Voltage | Bandwidth (kHz) | Temperature Ranges | Packages | Features                                                                                      |
|-------------|--------------------------------|-----------------------|---------------------------------------|----------------|-----------------|--------------------|----------|-----------------------------------------------------------------------------------------------|
| ACS758      | Bidirectional & Unidirectional | ±50 to 200            | 4800                                  | 5              | 120             | E, K & L           | CB       | Thermally enhanced, high bandwidth current sensor IC for monitoring currents from 50 to 200 A |
| ACS759      | Bidirectional & Unidirectional | ±50 to 200            | 4800                                  | 3.3            | 120             | E, K & L           | CB       | Thermally enhanced, high bandwidth current sensor IC for monitoring currents from 50 to 200 A |
| ACS770      | Bidirectional & Unidirectional | ±50 to 200            | 4800                                  | 5              | 120             | E, K & L           | CB       | Next generation temperature compensation for improved accuracy                                |

## SIP Package 0 to >1000 A Current Sensor ICs

| Part Number | Supply Voltage | Quiescent Output (V)    | Typical Sensitivity (mV/G)        | Output Bandwidth (kHz) | Temperature Ranges | Packages | Features                                                                 |
|-------------|----------------|-------------------------|-----------------------------------|------------------------|--------------------|----------|--------------------------------------------------------------------------|
| A1363       | 4.5 to 5.5     | Typ 50% V <sub>CC</sub> | 0.6~14, customer programmable     | 120                    | L                  | KT, LU   | Next generation temperature compensation, TC factory programmed to 0%/°C |
| A1366       | 4.5 to 5.5     | Typ 50% V <sub>CC</sub> | 1, 2, 5, & 10, factory programmed | 120                    | L                  | KT, LU   | Next generation temperature compensation, TC factory programmed to 0%/°C |

Temperature range codes: S = -20°C to 85°C, E = -40°C to 85°C, K = -40°C to 125°C, L = -40°C to 150°C, X = -20°C to 125°C



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