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GROUNDING TECHNIQUES FOR THE ACS37800, ALLEGRO'S POWER MONITORING IC: ENSURING PROPER DEVICE FUNCTIONALITY AND MEASUREMENT ACCURACY

Current Sensors System Engineering
Allegro MicroSystems

INTRODUCTION

The ACS37800 is a highly versatile and integrated power monitoring IC designed for accurate power measurement in both AC and DC applications. The device simplifies the process of adding power monitoring capabilities to systems by allowing the sensor to be powered from the same supply as the system's microcontroller unit (MCU), thereby eliminating the need for multiple power supplies.

The device features a copper conduction path for current sensing and uses Allegro's Hall-effect and galvanically isolated current sensing technology to achieve reinforced isolation ratings within a compact PCB footprint. This enables isolated current sensing without the need for expensive external components like Rogowski coils or oversized current transformers. User configuration is facilitated through on-chip EEPROM, allowing for accuracy improvements through customer calibration. The ACS37800 is offered in two different SOICW-16 packages, the MA and the MC.

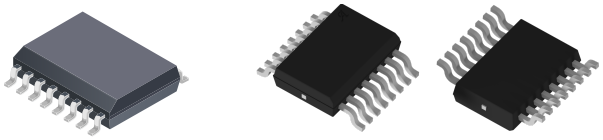

Figure 1: ACS37800 in the MA package (left) and the MC package (right)

This application note provides information on grounding techniques to ensure the proper functionality and measurement accuracy of the ACS37800. When sensing AC power, it is crucial to consider two separate grounds: device ground and the neutral/earth ground of the AC input. This application note explores the significance of these grounding techniques and offers guidance on proper grounding connections.

DEVICE GROUND

When sensing AC power, the ACS37800 has two separate grounds to keep in mind: device ground (GND) and neutral/earth ground with the MCU and any other devices connected to the MCU.

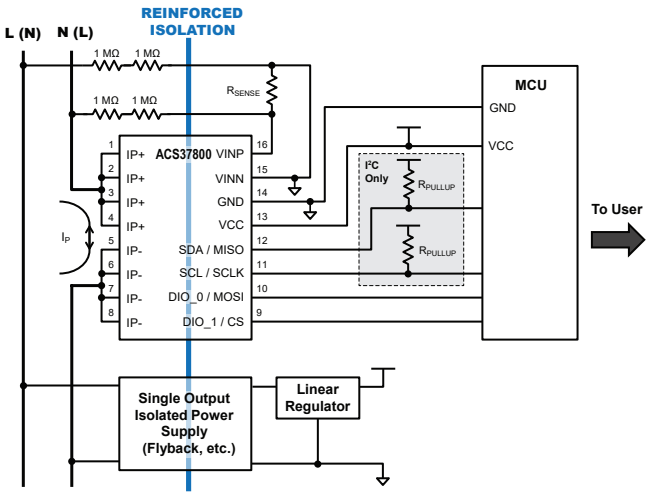

Figure 2: ACS37800 Typical Application Circuit Diagram

AC WIRING AND NEUTRAL/EARTH GROUND

AC outlets always have a live (also referred to as line or hot) and neutral connection and often a third ground connection. Current flows through live and neutral. Neutral is a reference while live is an AC voltage. An easy way to conceptualize this is that neutral is staying at a constant 0 V while live is a voltage sine wave at 120/220 V_{RMS} 50/60 Hz. The ground connection is for fault protection and provides a return path to earth ground in the event that live is shorted. In normal operation, the ground connection will carry no current. Neutral and earth ground are closely related and tied together at the electrical panel meaning there is a low-impedance connection from neutral to earth ground.

CONNECTION FROM DEVICE GROUND TO NEUTRAL/EARTH GROUND

Because of the low-impedance connection from neutral to earth ground, it simplifies the explanation to assume that neutral and earth ground are at equal voltage potential.

The ACS37800 has two recommended connections for voltage channel sensing: shorting the device ground to neutral or isolating the device ground from neutral with two 1 MΩ resistors (refer to Figure 3 and Figure 4). Regardless of the ground connection, VINP must be isolated from the live connection.

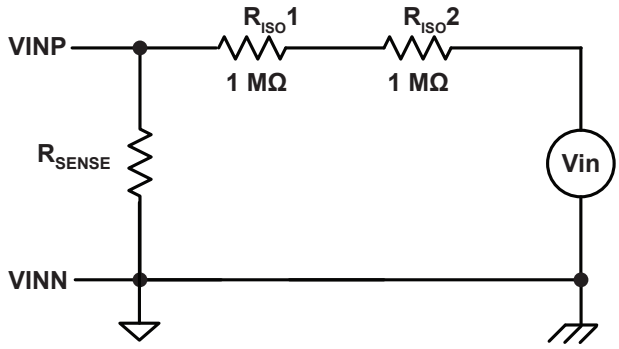

Figure 3: Voltage Channel Application Circuit; Device GND is Connected to Neutral

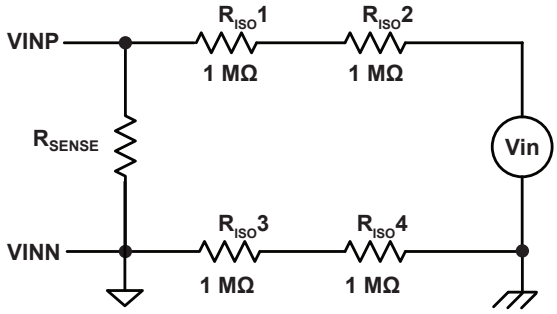

Figure 4: Voltage Channel Application; Device GND is Isolated from Neutral

Depending on isolation requirements, it may be necessary to have the device ground isolated from neutral. One common drive for this requirement is in the event of an outlet being wired in reverse (live and neutral swapped), which can happen when amateur or inexperienced electricians wire an outlet, the fully isolated setup will protect the device while the setup with neutral connected to device ground will destroy the device and may potentially endanger the user.

KEEPING DEVICE GROUND ISOLATED

Most users of the ACS37800 intend to fully isolate the device (the ACS37800 Allegro evaluation board has 1 MΩ isolation resistors populated; see Figure 5 of the ACS37800 evaluation board) but sometimes inadvertently short device ground to neutral. This does not damage the device or make it function improperly as it is still one of the recommended setups. It will however result in unexpected measurements if the isolation resistors unknowingly get shorted or if an alternative path to ground reduces the resistance from device ground to neutral.

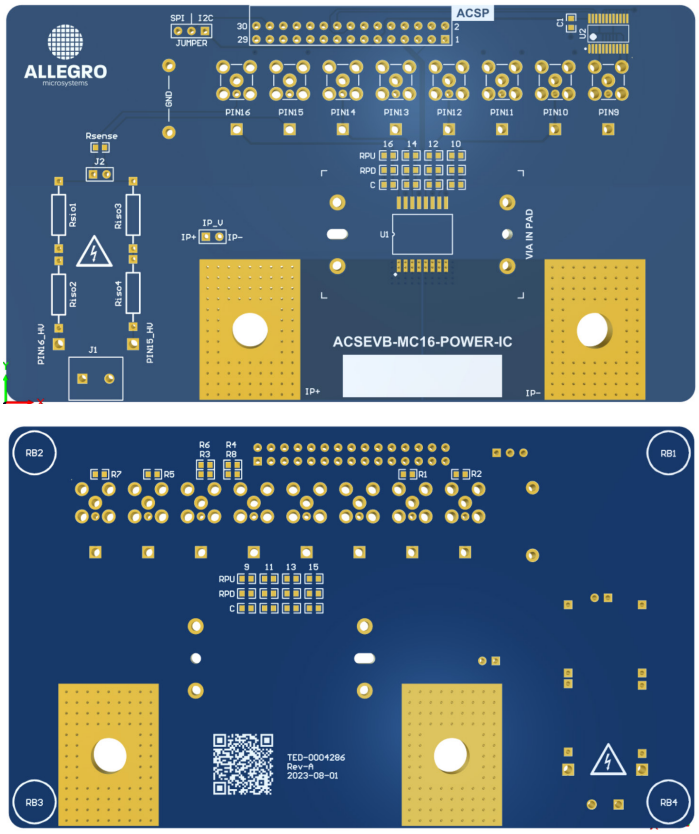

Figure 5: ACSEVB-MC16-POWER-IC/ACSEVB-MC16-POWER-IC

Common causes for unintentionally shorting or reducing resistance from the device ground to neutral include the following:

1. **Supplying the ACS37800 with a source that is also connected to the AC voltage being measured:** Say that a standard DC supply is hooked up to an outlet and the outlet next to it is routed for measurement to the ACS37800. If the two outlets are part of the same electrical panel (which is a very high probability), the device supply neutral is connected to earth ground at the panel which is also connected to the neutral of the outlet being sensed. This shorts out the isolation resistors.
2. **Using a laptop to read measurements from the ACS37800 that is plugged into a wall:** For the same reason that the above shorts the isolation resistors, a laptop can do the same when plugged into the wall.
3. **Using a laptop to read measurements from the ACS37800 that is not plugged into the wall but still has a faint path to ground:** Even if your laptop is not directly grounded through a cord to the outlet, a path to ground can still be created. The construction of most laptops creates a grounding plane on the case of

the laptop. Therefore, if the laptop is touching something that is also touching ground, such as a table or even a person, a secondary path to ground is created that reduces the resistance from device ground to neutral. The is especially common in labs where most lab benches are purposefully grounded for safety. This may sound trivial, but even a 20 MΩ path to ground can throw off device measurements.

AVOIDING INACCURATE MEASUREMENTS AS A RESULT OF IMPROPER GROUNDING

If the intention is to use the fully isolated schematic, it is imperative to also use a supply that is isolated from device and MCU ground. This may not be possible in some cases when using an evaluation board that must communicate with a laptop. When doing evaluation with a laptop displaying results, it is easiest to short R_{ISO3} and R_{ISO4} on the board and recalculate the desired R_{SENSE} by following the instructions:

To determine the value of R_{SENSE} required for a particular application using either of the recommended circuits, the following equation can be used:

$$R_{SENSE} = \frac{\Delta V_{INR(MAX)}}{V_{LINE(MAX)} - \Delta V_{INR(MAX)}} \times R_{ISO}$$

where $\Delta V_{INR(MAX)}$ = 250 mV, $V_{LINE(MAX)}$ is the maximum V_{LINE} voltage to be measured, and R_{ISO} is the sum of all the isolation resistors.

If using the overvoltage detection functionality of the ACS37800, this should be considered when determining the maximum V_{LINE} voltage to be measured. For example, in an application when the nominal V_{LINE} is equal to 120 V_{RMS} and a 50% overvoltage detection is required, $V_{LINE(MAX)}$ is:

$$120\ V_{RMS} \times \sqrt{2} \times 1.5 = 255\ V,$$

where the √2 is used to approximate the peak voltage assuming a sinusoidal input.

Additionally, the tolerance of all resistors should be considered when determining R_{SENSE}. The minimum tolerance of the isolation resistors should be used along with the maximum tolerance of R_{SENSE}.

If the R_{SENSE} is not sized appropriately, this can lead to the voltage input to the ACS37800 exceeding the maximum input range, which can cause the instantaneous voltage measurement to saturate. This can lead to errors in the RMS calculations.

CONCLUSION

In conclusion, establishing proper grounding techniques is vital for maintaining the functionality and measurement accuracy of the ACS37800. By understanding the role of device ground and the relationship between neutral and earth ground, users can make informed decisions regarding grounding connections. Whether shorting device ground to neutral or isolating device ground from neutral, these grounding techniques play a crucial role in protecting the device and ensuring accurate measurements. By following the recommendations outlined in this application note, users can optimize the performance and reliability of the ACS37800 in AC power sensing applications. For more specific information regarding the ACS37800, refer to the device datasheet located on the Allegro website.

Revision History

Number	Date	Description
–	August 20, 2024	Initial release

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