

Current Sensing Applications in Wireless Infrastructure Equipment

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In this article, a fresh look is taken into the major electronic end equipment for cellular [wireless infrastructure](#) (WI) from the perspective of current sensing (CS). Several types of CS applications in such equipment are reviewed.

Current Sensing in Power Supply Block

As shown in [Figure 1](#), the power supply for the WI equipment comes from the utility grid, solar energy, or sometimes a combination of the two. The power supply is often backed up with battery storage for uninterrupted service during a power outage, especially in remote areas where solely depending on grid electricity is not an option due to limitations from physical accessibility or economic feasibility.

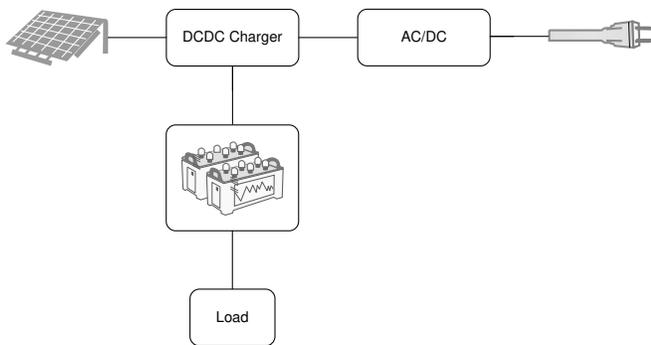


Figure 1. WI Power Supply Block Diagram

The power supply block can be either integrated into the WI end equipment, or it can be stand-alone. Regardless of the implementation, a common requirement is an intelligent power management system to charge batteries and ensure seamless transitions between power sources. Current and voltage sensing is an indispensable function in such power management systems.

Current sensing can be implemented either on the high side or on the low side. Dedicated high-voltage, shunt-based, Current Sense Amplifiers (CSA) such as the [INA240](#) might be needed for fault to ground prevention. Magnetic current sensors such as the [TMCS1100](#) family devices are another great choice for high-voltage applications due to their inherent galvanic isolation.

Current Sensing at Point Of Load

The typical WI electronic system is powered from a DC bus, such as 12 V to 48 V. Lower supply rails are derived from the bus voltage.

These lower voltage rails are called point of load (POL) supplies, stemming from the fact that they satisfy a set of specific requirements and are normally located in the vicinity of the loads they serve. Depending on how critical or informative the measurements are, sometimes it is desirable to monitor the current or voltage in one or more of these POL supplies. The main requirements for the CSA in this situation may include (among others) accuracy, speed, dynamic range, and power dissipation by the associated shunt resistor.

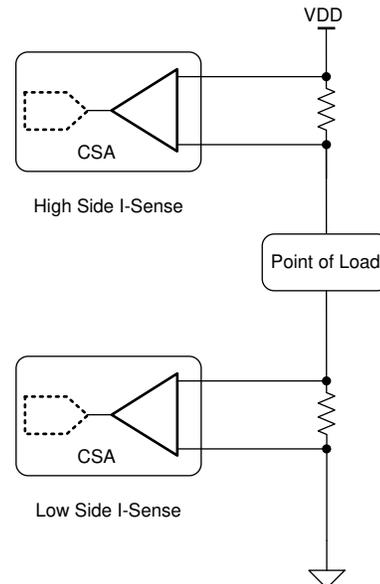


Figure 2. Point of Load Current Sensing Options

As shown in [Figure 2](#), current can be sensed at either side of the load, with analog or digital CSA, and through either external or integrated shunt resistor.

CSA comes with a matched resistor gain network that provides value in terms of cost, board space, and performance. Most CSAs feature fixed-gain, ranging from 10 to 1000. Some CSAs offer configurable gain. For example, the [INA225](#) has configurable gain through two digital control pins, while other CSAs have a gain that is configurable through an external resistor, such as [INA139](#).

System integration is further improved when a CSA is chosen that comes with integrated analog to digital conversion (ADC) and a shunt resistor.

The key considerations in selecting a CSA and associated shunt resistor for POL measurement starts with common-mode voltage, current range, accuracy, and speed. In addition, if overcurrent protection (OCP) is required, a CSA with an integrated fast-action comparator is often an ideal choice, where system parameters such as offset and propagation delay are specified. Compared with discrete components, such a CSA helps remove uncertainties and therefore simplifies the design.

To monitor multiple POLs, a multi-channel CSA like the [INA4180](#) might make sense, as it offers four channels of analog output. When a microcontroller or FPGA is present in the equipment, an ADC channel is normally available, as well as a digital bus such as I²C. In this situation, either an analog or digital output CSA may be implemented as a POL monitor. A multi-channel digital monitor such as the [INA3221](#) is another option that frees up controller ADC channels while taking advantage of an existing I²C bus. This device offers a number of warning and alert signals for fast action in case of a fault, as well as current, voltage, or power information of three independent channels.

Current Sensing in Power Amplifiers

The bias current in power amplifiers (PA) is adjusted to suit the need of an end application, modulation scheme, and operation class. A typical PA with current sensing is shown in [Figure 3](#).

The PA is often constructed with silicon LDMOS or GaN technology. Current sensing is important in PA applications, both from the standpoint of the PA operation and from the standpoint of overall energy efficiency management. Under the same bias voltage, the PA bias current differs due to device variation. Further, the bias current changes with temperature. Consequently, in order for the PA controller to accurately control the bias current, both the current and temperature information must be available. The bias current information is necessary in improving system efficiency, where around 50% of total system power is consumed by the PA itself.

Integrated power amplifier monitor and control systems, such as the [AMC7836](#), can simplify PA circuit design. As mentioned, due to natural device variation, knowing gate voltage alone is sometimes not sufficient in order to achieve accurate bias current control. When current sensing is required in the control loop, a separate high-voltage CSA, such as the [INA290](#), can be used.

Power amplifier monitor and control systems such as the [AMC7834](#) are another option with integrated current sensing capability. Such a solution offers the possibility of further reducing board space.

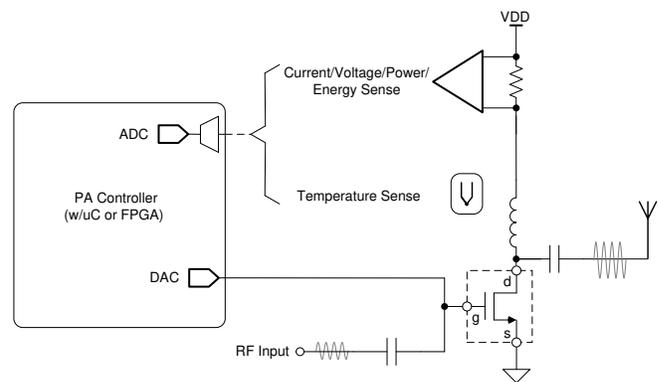


Figure 3. PA Biasing and Current Sensing

Alternate Device Recommendations

TI offers a complete line of CSA and magnetic sensors that serve well in WI end equipment, from high-voltage supply current and PA current sensing to general purpose POL current monitoring. The high-voltage [INA202](#) also comes with integrated comparator and reference output to facilitate the OCP requirement. For applications where superior accuracy is required, the [INA190](#) family of devices are good choices with nA input bias current. These devices are essential in situations where the sensed current is very small. Some of these devices come with Enable pins for further power reduction; some are offered in a WCSP package for board space optimization. For applications with lower common mode voltage requirements, the [INA180](#) offers excellent speed and overall performance value. The [INA301](#) family of devices features integrated fast comparators and high-speed amplifiers. Both outputs are available that suit the need of OCP.

Table 1. Alternate Device Recommendations

Device	Characteristics
INA202	Common mode range -16 V to 80 V; Comparator
INA180	Low I _Q ; High bandwidth
INA190	Low I _Q ; Low I _B ; Enable pin
INA301	High bandwidth amplifier; Fast comparator

Table 2. Related TI Tech Notes

SLPA013	Hybrid Battery Charger With Load Control for Telecom Equipment
SBOA165	Precision current measurements on high-voltage power supply rails
SLYA024	Common Uses for Multi-channel Current Monitoring

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