



*Evan Sawyer* Feb 17, 2017

Other Parts Discussed in Post: [ADS8900B](#)



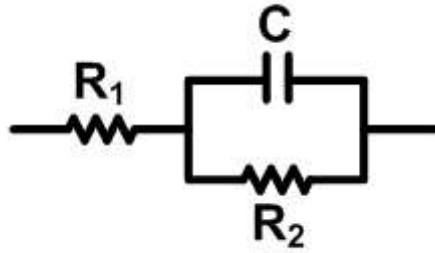
As battery-powered systems become more common, quickly identifying a failing battery so that it can be replaced is becoming increasingly important. From an individual battery powering a mobile phone to a bank of batteries used to store renewable energy, a faulty battery can lead to system downtime. At the heart of battery analyzers, which determine the health of a battery, [converter \(ADC\)](#).

In this post, I will explore how key specifications of these ADCs, including [performance in a battery analyzer](#), let's look at Randles' model of a lead-acid battery, shown in Figure 1.

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**Figure 1: Randles' model of a lead-acid battery**

In Figure 1,  $R_1$  is the active electrolyte resistance,  $R_2$  is the charge transfer resistance and  $C$  is the double layer capacity. Together, they create a simplified equivalent circuit of a lead-acid battery. By measuring all three components and comparing them to the expected/known values, it is possible to generate an approximation of the battery's "health," which includes its cold cranking amps (CCA), state of charge and capacity.

While there are a range of battery test methods, such as a discharge/charge cycle, DC load and AC testing, electrochemical impedance spectroscopy (EIS) is considered to be the most accurate by leading battery health researchers. EIS is preferred over other methods because of its capability to quickly measure CCA, SOC and battery capacity. The process involves drawing a range of small, low-frequency signals from the battery and measuring the corresponding current across a shunt resistor as well as the DC voltage of the battery. These measurements can determine  $R_1$ ,  $R_2$  and  $C$ , which in turn are compared with expected values to determine a battery's health.

Depending on the health of the battery as well as the type of battery being tested, the measured current and voltage can range from very small to quite large. As such, the ADC chosen to convert the measurements must be capable of accurately measuring small changes to the input signal, across a wide range of inputs.

In many cases, a successive approximation register (SAR) ADC is the preferred converter due to its dynamic range, speed, resolution and low latency. A high-resolution SAR ADC can precisely measure low-speed signals (DC to several megahertz), which can then be oversampled and digitally filtered by a host processor (e.g. FPGA) to increase system accuracy. Alternatives include delta-sigma ADCs (which are not as well-suited for measuring a range of input frequencies) and pipeline ADCs (which offer higher speed at the cost of resolution). Additionally, the low latency of a SAR ADC allows it to take a measurement without sacrificing measurement accuracy.

In the case of a battery analyzer, it can be difficult to measure current (ranging from several amps to high amps) or voltage (ranging from several volts to tens of volts) over a wide dynamic range. To do so, a high-resolution SAR ADC with a wide dynamic range (input range) and at least several

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- hundred kilo samples per second (kSPS) takes multiple measurements of each input signal, which the host processor then digitally filters to improve measurement accuracy. Figure 2 shows a simplified diagram of a battery tester system.

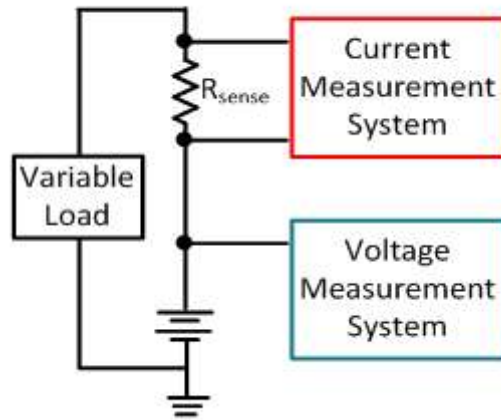


Figure 2: Diagram of a battery analyzer measuring current and voltage

In Figure 2, the load is varied to draw a range of AC currents from the battery, resulting in an AC voltage across a small, high-accuracy sense resistor. A high-precision data-acquisition system designed for minimal signal distortion typically amplifies and then measures the voltage created across the resistor. In the case of measuring the DC voltage of the battery, this input is often scaled down by an amplifier to enable an ADC to measure a wide range of voltages. In both cases, the ADC chosen to digitize the signal must have high-enough resolution to enable it to detect small changes to the input signal.

While there are many SAR ADCs that you can select to measure this voltage, the [ADS8900B](#) family shown in Table 1 offers several unique advantages, including high resolution, a fast sampling rate, and excellent AC and DC performance. These features are critical for measuring the wide dynamic-range signals encountered in battery health analysis while maintaining accuracy across the input range.

	ADS890xB	ADS891xB	ADS892xB
Resolution	20 bits	18 bits	16 bits
Speed	Up to 1MSPS	Up to 1MSPS	Up to 1MSPS
Input range	$\pm 5V$	$\pm 5V$	$\pm 5V$
Integral nonlinearity (typ)	$\pm 1.1LSB$	$\pm 0.5LSB$	$\pm 0.3LSB$
Signal-to-noise ratio (typ)	104.5dB	102.5dB	99.5dB
Total harmonic distortion (typ)	-125dB	-125dB	-125dB
Gain (typ)	$\pm 0.005\%FSR$	$\pm 0.005\%FS$	$\pm 0.005\%FS$
Offset (typ, $-40^{\circ}C$ to $125^{\circ}C$ )	$\pm 10.5LSB$	$\pm 3LSB$	$\pm 3LSB$
Package	4mm-by-4mm QFN	4mm-by-4mm QFN	4mm-by-4mm QFN

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## Table 1: ADS8900B family key specifications

These devices also feature an internal reference buffer that further increases system accuracy and reduces its size, which is especially important for portable battery analyzers. Figure 3 shows an external vs. internal reference buffer in a data-acquisition system.

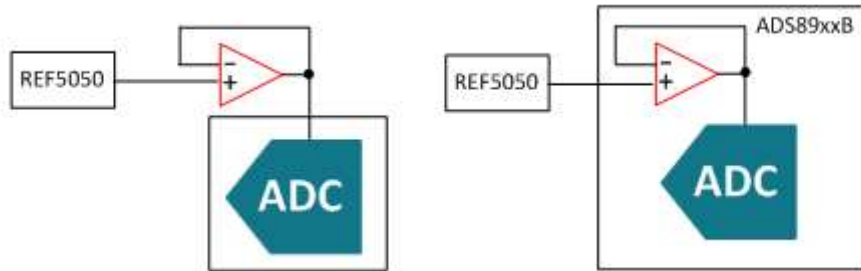


Figure 3: External vs. internal voltage reference buffer

The reference voltage circuit is critical in precision data-acquisition systems, as it provides a point of reference for the data converter to compare against an input signal. Any error in the reference voltage will result in inaccurate measurements of the input signal. During each conversion cycle, the ADC will draw considerable current from the reference due to the internal switched-capacitor architecture of the converter. A reference buffer minimizes the voltage droop created during conversion. In the case of the ADS8900B family, the internal reference buffer is optimized to drive the ADC's reference pin, maximizing AC and DC performance and resulting in a higher precision system than one using an external reference buffer.

I hope I've explained how the ADS8900B is enabling battery analyzers to more accurately measure battery health, although any system requiring precise measurement of a small and/or dynamic signal can realize the benefits that this device has to offer. Stay tuned for a future post, where I'll show how you can use a pair of discrete ADCs to simultaneously sample inputs and how new ADCs are reducing the headaches of digital design for high-speed, high-resolution data-acquisition systems. Be sure to sign in and subscribe to Precision Hub to get these posts delivered right to your inbox.

### Additional resources

- Explore TI's selection of [precision ADCs](#).
- Read more about designing with the [ADC8900B](#).
- Learn more about the TI Design, "[20-bit, 1-MSPS, 4-Ch Small Form Factor Measurement Applications Reference Design](#)."

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