Advantages of Using Nanopower, Zero Drift Amplifiers for Battery Voltage and Current Monitoring in Portable Applications

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Lithium Ion batteries have become the chemistry of choice for portable applications such as laptops, cell phones, and cameras. As devices get smaller and lighter, with increased features by the generation, the device battery becomes a critical component of the system. The battery not only determines how long the device can be used before a recharge is needed, it also influences the size, cost, and weight of the device. In addition, these devices need to be efficient while also providing or receiving safe and reliable fast charging. As an example, fast charging in mobile phones provides charge to the battery in the shortest amount of time while still maintaining device performance and battery health. There are many custom methods for providing fast charging to a battery, but each of these requires being able to accurately monitor the voltage and current in and out of the battery.

A typical charging stage of a mobile phone consists of the charger, battery, battery monitoring stage, and MCU as shown in Figure 1. The voltage and current sensing takes place in the battery monitoring stage. The goal of this stage is to accurately monitor the current and voltage of the battery while using the least amount of power possible.

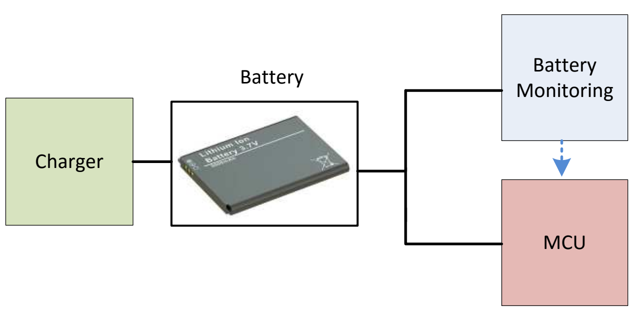

Figure 1. Mobile Phone Charging Stage

Current monitoring is typically done by placing an op-amp across a low resistance shunt resistor that is in series with the battery. In order to ensure the correct current measurement while maximizing the battery life, the op amp needs to be both precise and low power. One suitable op amp for this application is the LPV821. The LPV821 is the industry's first zero-drift nanopower amplifier, with quiescent current of only 650nA. The ultra-low current consumption of the LPV821 ensures the battery life is extended for as long as possible. The zero-drift, self-calibrating architecture of the LPV821 also makes it an excellent choice for this application. The LPV821 has an offset voltage of ±10 µV, enabling a very low shunt resistor value to be used while minimizing introduced error. Ohm's Law tells us the power dissipated across the resistor is proportional to the resistance value and current flowing through it. With a smaller resistance value, less power will be dissipated across the resistor. This, combined with the LPV821's nanopower consumption, means less power will be drained from the battery itself during the current measurement.

An example of this current measurement is shown in Figure 2. The LPV821 is used to measure the voltage of the shunt resistor through a single ended configuration. In this configuration, the trace resistance to ground in series with the shunt resistor becomes an important factor in introducing error to the measurement.

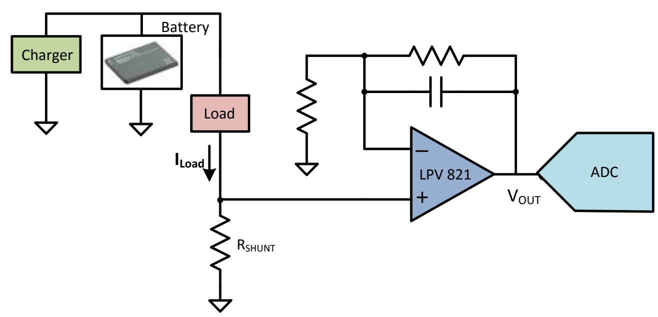

Figure 2. Single Ended Input Configuration

The LPV821 can also be used as a differential amplifier to perform current measurement. The example circuit is shown in Figure 3. This configuration eliminates the inaccuracy due to the trace resistance discussed in the single ended configuration. However, the CMRR of the op amp becomes important in this configuration and must be high, as it is in the LPV821, in order to obtain accurate measurements.

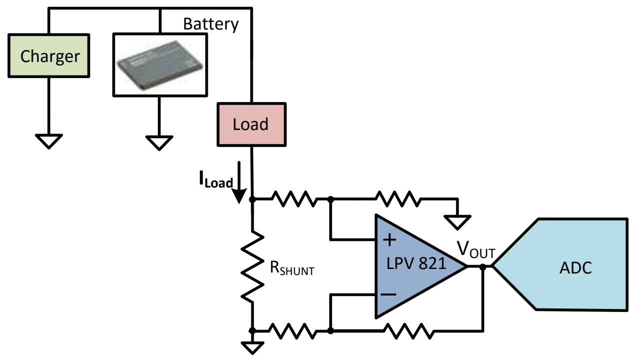

Figure 3. Differential Amplifier Configuration

There are also applications where there is the need to measure both charge and discharge currents. This method is known as bidirectional current sensing and an example circuit of this is shown in Figure 4. When a mobile phone is plugged in to the charging adapter, the adapter supplies power to the mobile phone and charges the battery. In this scenario the battery charging current is monitored to ensure the battery does not overheat and the power drawn from the charging adapter does not exceed limits. This is especially critical during fast charging when the temperature of the device can rise more than normal operation. When the battery is powering the system, the discharge current from the battery is monitored for the purpose of active power management to extend battery life. Based on these measurements actions can be taken to reduce power consumption and improve efficiency of the overall system. Two LPV821s can be used to perform bidirectional current sensing. The low power consumption of the LPV821 ensures the least amount of power is used during this measurement and more power is conserved for other features of the phone.

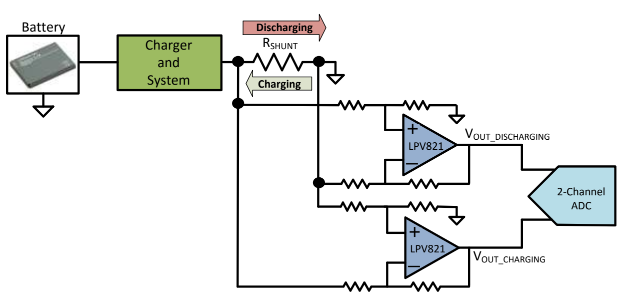

Figure 4. Bidirectional Current Sensing

The battery voltage, along with the current sensing methods described above, also needs to be measured for custom fast charging methods. The battery voltage is monitored in order to determine the stage of the charging profile. The LPV821 is an excellent fit for this application due to its low input offset and allows for accurate battery voltage monitoring. Along with that, the ultra-low power consumption of the LPV821 ensures the least amount of battery drain for this measurement. The measurement can be made by using the LPV821 as a voltage buffer to measure the voltage of the battery over a voltage divider as seen in Figure 5.

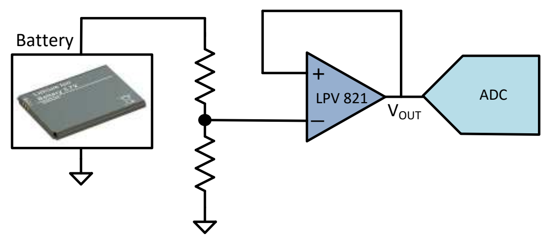

Figure 5. Battery Voltage Monitoring

In order to implement a custom fast charging solution, accurate measurements of charge/discharge currents and cell voltage are necessary. The nanopower, zero-drift LPV821 can be used to make these measurements accurately and does so in a power efficient manner, thus extending battery life.

Table 1. Alternative Device Recommendations

Device	Quiescent Current (Typ.)	GBW	Offset Voltage (Max)
LPV521	350nA	6.2 kHz	1mV
LPV812	425nA	8 kHz	300uV
OPA369	700nA	12 kHz	750uV
OPA333	17uA	350 kHz	10uV

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