Keysight Technologies
Testing Battery Chargers with the U2722A USB Modular Source Measure Unit

Application Note
Introduction

Today’s consumers are incredibly comfortable using technology. As a result, we find an increase demand for digital consumer electronic (CE) products in the market today. The personal and mobile device market is undergoing a rapid change as the distinction blurs among mobile phones, personal entertainment devices, and ultra-mobile PCs.

As more digital content becomes available, consumers demand new and improved ways to access this content via wired and wireless technologies. And, in an increasingly portable world, consumers are demanding ways in which to take their digital content with them, wherever they go, whenever they go. Portable CE device designers are being challenged to design products that are able to integrate various features, and yet still remain light in weight, compact, and low in price.

This presents many tough challenges in portable CE devices circuitry design, one of which is power management. This application note describes how the Keysight Technologies, Inc. U2722A USB modular source measure unit (SMU) can act as a battery emulator to help you discover more about your portable CE devices’ chargers, particularly for devices with low current consumptions such as Bluetooth® headsets.
Types of Rechargeable Batteries

There are many types of rechargeable batteries, namely nickel metal-hydride (Ni-MH), nickel cadmium (Ni-Cd), nickel lithium ion (Li-Ion), TMF lead acid, lithium polymer, and super hipower li-manganese. Ni-MH, Ni-Cd, and Li-Ion are commonly found in Bluetooth headsets’ battery due to their excellent overcharge endurance, high capacity, and no memory effects.

Charging Characteristics

Battery charging is a process of restoring the energy of a battery by using an external source. The charge of voltage is affected by current, ambient temperature, and time. Slow charging (also known as trickle charging) and fast charging are two common ways of charging a battery. Slow charging is usually defined as charging of current that can be applied to the battery indefinitely without damaging the battery. This is the main advantage of slow charging since it can not damage the battery regardless of how long it is charged. Most Ni-Cd and Ni-MH batteries are charged at a rate of 0.1 C (1/10 of the battery’s capacity rate). At this rate, a typical recharge time would be approximately 12 hours, which is the main disadvantage of slow charging.

On the other hand, at a charge rate of 1.2 C, fast charging an Ni-Cd or Ni-MH battery would only require approximately one hour. Short recharging time is the main advantage of recharging a battery in fast-charging mode. However, the downside of fast charging is that it must be done in a well-controlled battery temperature, usually between 10 °C to 40 °C.

The U2722A is suited for use to test battery chargers as a battery emulator. It is a three-channel SMU that is capable of four-quadrant operations. Each channel can source and sink up to 20 V and 120 mA. The channels can be connected in series or parallel to achieve ±60 V/±120 mA or ±20 V/±360 mA respectively.

The U2722A has a 16-bit resolution, with 0.1% basic accuracy. It is provided in a USB modular form factor with USBTMC 488.2 standard; allowing it to be easily set up and operated without the need for a computer with GPIB interface. Thus, it provides a low-cost solution with high measurement sensitivity and accuracy. For more details on the specifications of the U2722A SMU, refer to the Keysight USB Modular Products Data Sheet, 5989-9923EN.
Charging Profile

A 2/5 AAA-size rechargeable battery, for example, has a nominal capacity of 105 mA-h and operates at 3.7 V. When charging a battery of this type, the charger would first detect the voltage of the battery inserted into the charger. The charger would not start charging if the detected voltage is below a predefined value, for example 0.3 V. This would indicate that the circuit is shorted or that a faulty battery has been inserted.

If the battery voltage of 0.3 V and or more is detected, the charger will charge at a rate of 0.1 C. A 105 mA-h battery in this case, would require the charger to source a constant current of about 10 mA. The charger will continue to operate in this mode until the battery voltage increases to 2.5 V. At this voltage point, the charger will switch to constant voltage mode and start to operate at 4.2 V to charge at 1 C rate until the battery hits 4.2 V. Once the battery is fully charged, the charger will degrade the amount of current sourced and finally stop charging. Figure 2 below depicts a typical battery-charging profile.

![Battery-charging curve profile](image-url)
Testing Battery Charges with the U2722A

The U2722A can be programmed to a number of stages to match a typical battery-charging profile.

<table>
<thead>
<tr>
<th>Stages</th>
<th>Description</th>
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<tbody>
<tr>
<td>1</td>
<td>The U2722A is set to constant voltage mode to drive 0.3 V or lower with an input protection current set to 10 mA. This simulates a short-circuited condition. The charger should not charge at this stage.</td>
</tr>
<tr>
<td>2</td>
<td>The U2722A is set to constant voltage mode to drive between 0.3 V to 2.5 V with an input protection current set to 120 mA. This simulates the 0.1 C charging rate region. The charger should start charging at approximately 10 mA. Figure 4 shows a screen capture of the Keysight Measurement Manager (KMM) software when the U2722A is set to this stage.</td>
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<tr>
<td>3</td>
<td>The U2722A is set to constant voltage mode to drive between 2.5 V and 4.0 V with an input protection current set to 120 mA. This simulates the 1 C charging rate region. The charger should charge at approximately 105 mA. Figure 5 shows a screen capture of the KMM software when the U2722A is set to this stage.</td>
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<tr>
<td>4</td>
<td>The U2722A is set to constant current mode to sink 50 mA with an input protection voltage set to 4.3 V. The charger should source a 50 mA.</td>
</tr>
<tr>
<td>5</td>
<td>The U2722A is set to constant current mode to sink 20 mA with an input protection voltage set to 4.3 V. The charger should source a 20 mA.</td>
</tr>
<tr>
<td>6</td>
<td>The U2722A is set to constant voltage mode to drive a 4.2 V with an input protection current at 10 mA. The charger should stop charging.</td>
</tr>
</tbody>
</table>

Figure 3. The U2722A set up to test battery charges
Figure 4. Screen capture of U2722A when Channel 1 is 'charged' at 0.1 C rate

Figure 5. Screen capture of U2722A when Channel 1 is 'charged' at 1 C rate
Another example that utilizes the U2722A to test battery chargers is when a constant charging rate is applied throughout the whole charging process. Figure 6 depicts the charging profile of a typical 2/5 AAA size battery with 3.7 V and has a capacity of 105 mAh. In this charging profile, the U2722A is set to a constant current mode by sourcing 84 mA, which is 0.8 C rate for a 105 mAh battery. The input protection voltage could be programmed to sweep from 2.4 V to 4.2 V. The charger should output a constant 84 mA before the U2722A hits 4.2 V.

Figure 6. Example of a typical charging profile on a 2/5 AAA size battery

Summary

This application note shows the capabilities and benefits of utilizing the Keysight U2722A USB modular source measure unit to test battery chargers. The circuitry of a battery charger is as important as any circuitry part of any electronic devices. Extra care must be taken to understand the charging profile in order not to shorten the rechargeable battery's lifespan.

Related Literature

- USB Modular Products Data Sheet, literature number 5989-9923EN.