USB battery charging revision and the role of adapter emulators

USB-powered portable equipment needs a smart method for determining the appropriate amount of power to draw for both normal operation and charging, advises Mohamed Ismail, Maxim Integrated.

Most USB ports allow 100mA regardless of enumeration and continued activity; some ports even offer 500mA irrespective of the required power negotiation. Some portable devices require more than 100mA and make a faulty assumption that 500mA will always be available from a USB port.

BC1.2 introduction

Battery charging was not an original feature of USB. By establishing a method of communicating the power capabilities of a USB port, many of these issues are remedied with BC1.2. Batteries below the weak battery threshold are allowed to charge with a current higher than the 2.5mA suspend current, regardless of the port type. Once the battery reaches a nominal level, the device is mandated to enumerate within a certain timeframe.

BC1.2 outlines three types of USB port. A charging port is one that delivers currents higher than 500mA. A downstream port signals data as per USB 2.0. The BC1.2 specification also establishes how each port should appear to the end device, and the protocol to identify what type of port is implemented. The USB BC1.2 port types are SDP, DCP, and CDP (see Figure 1).

A standard downstream port (SDP) features

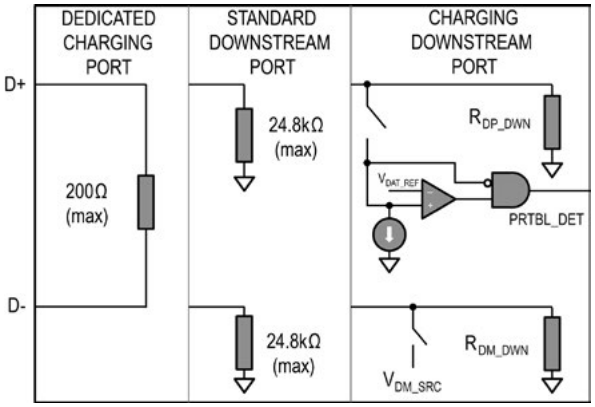

Figure 1: Port types outlined in the USB BC 1.

15kΩ pulldown resistors on both the D+ and D- lines. Current limits are 2.5mA when suspended, 100mA when connected, and 500mA when connected and configured for higher power. The second category is dedicated charging port (DCP). This port does not support any data transfer, but supplies charge currents beyond 1.5A. It features a short between the D+ and D- lines.

The third version is charging downstream port (CDP) which allows for both high-current charging and data transfer fully compliant with USB 2.0. It features the 15kΩ pulldown resistors necessary for the D+ and D- communication, and also has internal circuitry that is switched in during the charger detection phase. This internal circuitry allows the portable device to distinguish a CDP from other port types.

D+ and D- are shorted together and the lines are left floating with respect to ground. All a portable device needs to do to identify a DCP is drive either D+ or D- with a signal and observe the other line for the same signal.

A USB charger adapter emulator enables

a dedicated charger to appear as either a BC1.2 DCP or other proprietary charger. To integrate into a wall charger, USB charger adapter emulators must have a small profile and a low external component count. For example, the MAX14630/MAX14632 charger adapter emulators can be configured to automatically detect a USB BC1.2-compliant device, Apple 1.0A device, Apple 2.1A device, or Samsung Galaxy Tablet 2A device. Each of these USB adapter emulators requires only one bypass capacitor and comes in a 2.9x1.6mm package. The circuit (Figure 2) is a quick implementation of a single dedicated charger system that is compatible with Apple 1A and USB BC1.2-compliant devices.
The adapter emulator connects a resistive divider to the data lines by default, but can automatically detect a USB BC1.2 device and short D+ and D- together as per the BC1.2 specification. Used in conjunction with an AC/DC 5V power supply, a variety of portable devices can be charged using an adapter emulator to communicate current limits.

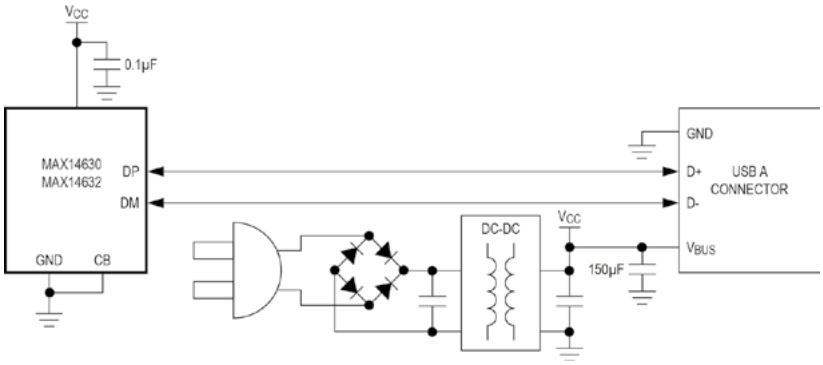

Figure 2: A DCP example for auto-detection of USB BC1.2/Apple 1A devices, featuring the MAX14630/MAX14632 USB charger adapter emulators.

Charging downstream ports adds to the complexity of supporting USB 2.0 data rates and the capability of handling up to 1.5A of charge current. To distinguish itself from a dedicated charger, a CDP has internal circuitry outlined in BC1.2 that enables it to drive the D- line to a specific voltage when it senses a portable device driving D+ during the port-detection phase. This internal circuitry must only be switched on during port detection,

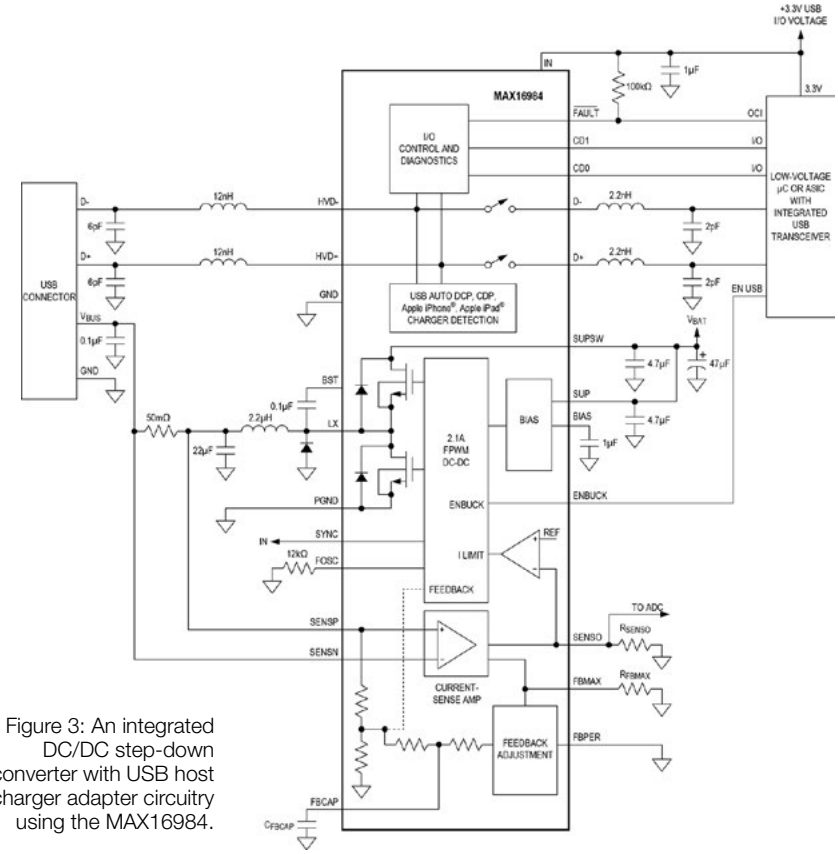

Figure 3: An integrated DC/DC step-down converter with USB host charger adapter circuitry using the MAX16984.

and must only contribute a specified amount of parasitic capacitance on the bus when switched off.

After the port-detection phase, a CDP compliant with BC1.2 disconnects the internal circuitry to allow normal USB data transfer.

Digital noise

According to USB 2.0, a ground current of 100mA through a USB cable can result in a 25mV difference between host ground and device ground. Since currents can be up to 1.5A, both a CDP and a portable device that are compliant with BC1.2 must be able to resolve data with a maximum ground offset of 375mV from device to host.

A USB host adapter emulator combines high-speed USB analogue switches to handle full USB 2.0 traffic at 480Mbit/s and USB charger adapter emulator circuitry. In addition to DCP and proprietary charger profiles, host adapter emulators can be configured for SDP and CDP pass-through modes, as outlined in BC1.2. In CDP pass-through mode, the devices emulate CDP functionality when a device is first attached. To support normal USB 2.0 traffic they hand over control of the D+ and D- lines to the USB host transceiver after the charger detection phase.

When a computer is connected to its power supply, it can enable a high-current USB charging port by configuring its host adapter emulator as a CDP. When running from a laptop's battery power, the computer can switch the adapter emulator to a standard USB port configuration to limit the current draw to 500mA maximum.

Improper switching from one state to another can cause a fault in downstream USB devices. MAX14640–MAXA14644 issue a bus reset to ensure that downstream devices are aware of any change in the host. They also feature an automatic current-limit switch-control output that resets portable devices whenever the host transceiver reconfigures the adapter emulator through I^2C or goes into standby.

After home and near a computer, the most common place to charge a USB device is in an automobile. Variations of battery voltage with temperature, may be as low as 9V or as high as 28V; temporary surges may be up to 40V. Some USB ports, such as car chargers and navigation systems, require both an automotive-qualified USB charger/host adapter emulator and a DC/DC converter to create the 5V necessary for USB power.

The MAX16984 is designed for 4.5 to 28V inputs, with protection from load-dump transients up to 42V. Its USB BC1.2-compliant circuitry supports Hi-Speed (480Mbit/s) USB data, and can emulate Apple 1A/2.1A chargers.

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