ABSTRACT

Modern day electronic devices, such as cell phones and MP3 players, can usually be powered with either an adapter or USB source through a single input connector using a mini USB cable. For a simple charger, without separate power paths for the system and the battery, the system (including the device transceiver) is powered directly from the battery. If the battery is deeply discharged, it has to be charged (at the low 100-mA USB current limit) to the minimum cell voltage at which time the device transceiver is able to communicate with the USB host to increase the current limit for the USB port. However, waiting for the battery to charge sufficiently to enable communication and thus enable a higher charge rate is only necessary if the device was indeed powered from a USB port and not an adapter.

To distinguish between the two input sources, the bq24050/2/5 features automatic AC/USB detection. This feature provides for the use of a single input connector which allows an adapter to charge the discharged cell to a useable voltage sooner than with the default 100-mA USB setting. This application report discusses the details of this time-saving feature.

1 bq24050/2/5 Detection Features

The bq24050/2/5 has AC/USB detection on power up so that the charger can decide to remain at the default, safe 100-mA level, for a USB or unknown source, or to go to the programmed fast-charge current if an adapter is detected. This detection routine is run on every power up of the charger. The charger’s D+/D– connection is then disconnected, prior to any device transceiver-to-USB host communication, to avoid any interference on the USB bus. This advance detection of an adapter allows a discharged cell to charge faster with full system access sooner, while avoiding overloading a USB source. Once the device transceiver communicates with the personal computer’s (PC) USB host, the ISET2 pin can be used to set the negotiated 100-/500-mA input current limit level.

2 Mechanism

The bq24050/2/5 charger uses the D+/D– lines to determine the power source type by measuring the voltage levels on each line. Knowing the configuration of the adapter and USB D+/D– lines and their voltages indicates what source is present. The charger detection routine defines two classifications of sources: adapter or nonadapter. Detecting an adapter allows charging at the programmed fast-charge level, whereas detecting a USB source or unknown source only allows charging at 100 mA for safety reasons. The key to an accurate source detection is knowing that the adapter has its D+ and D– lines tied together with less than 200 Ω of resistance, whereas the USB port has each line (D+/D–) pulled to ground through a 15-kΩ resistor as shown in Figure 1(a) and (b).
As soon as power is applied, the bq24050/2/5 biases its D+ line to 0.6 V with a 200-µA current source and its D− line to ground with a 100-µA current sink. See Figure 2.

Once powered up, the device transceiver detects the input power and then pulls either the D+ or D− line high, through a 1.5-kΩ resistor to ~3 V, indicating that a full-speed or low-speed device is present, respectively. This is the first signal to the PC’s USB host that a transceiver is on line and wants to communicate. The PC’s USB host has to wait at least 100 ms to begin communication. The bq24050/2/5’s detection routine always completes before this wait time ends, allowing it to disconnect from the USB bus before communication begins.

If the transceiver is dead due to a discharged battery (or if no transceiver is present), the bq24050/2/5 automatically runs the detection routine after receiving a trigger, assuming the input connections are secure (any contact bounce has dampened out), and determines the source type.
After the input power has been applied, three actions trigger the adapter detection routine to start:

- **D+** pulled up to ~3 V (full-speed USB device)
- **D–** pulled up to ~0.6 V (D+/D– lines shorted) or ~3 V (low-speed USB device)
- No line pulled up above ~0.6 V and the 500-ms timer expires (transceiver not powered or transceiver absent or D+/D– lines floating).

The detection routine begins when it measures the D+ and D– voltages to determine if the D+ and D– inputs are shorted (have approximately the same voltage) and are pulled up to at least ~0.6 V. If this is the case, then an adapter source is detected. For any other measurements, the input source is assumed to be a USB source and defaults to the 100-mA input current limit level. Floating D+/D– lines default to the 100-mA current limit, as the D– line does not go above 0.6 V due to the current sink on that pin pulling it to ground.

This detection routine takes about 60 ms to complete. Once completed, it latches the input current limit to the programmed ISET value if an adapter source was detected and to the 100 mA level if a nonadapter source was detected. The IC’s connection to the D+/D– line is then disconnected before the PC’s USB host starts communication.

After the bq24050/2/5 has disconnected from the USB bus, the device’s host can change the input current limit setting by changing the state of the ISET2 pin, thus unlatching the detection setting. Once toggled, the ISET2 pin has three states: HI: 500-mA input current limit; Floating (~1 V): 100-mA input current limit; LOW: Input current limit programmed by the ISET pin.

The bq24050/2/5 gives the added flexibility of allowing a device without a transceiver to charge at a fixed, safe, 100-mA level. Without this feature, a USB source cannot be safely used, unless the charge current was always programmed to a low level.

**Figure 3 through Figure 6** are examples of typical power-up D+/D– routines with different configurations. **Figure 6** shows the D+ line pulled up indicating a full-speed transceiver is on line wanting to communicate with the host followed by a delay of ~130 ms before the host starts its communication.

![Graph showing D+/D– Detection for Adapter Hot Plug](image-url)
No signal detected on D+ or D−. After 500ms, the detection routine is forced to run.

**Figure 4. D+/D− Detection for Unknown Source Hot Plug**

(Device transceiver is "dead") After 500 ms, the detection routine is forced to run.

**Figure 5. D+/D− Detection for USB Hot Plug no Pullup**
3 Conclusion

The bq24050/2/5’s D+/D– detection routine is a useful feature for devices with a discharged battery or with a dead or missing device transceiver. This allows the battery to fast charge immediately, if an adapter is detected, allowing full use of the device sooner. The bq24050/2/5 avoids interference on the USB bus by running its detection routine and then disconnecting from the D+/D– inputs prior to the USB host starting its communication with the device transceiver. A simple mobile design that normally only has an adapter source can be sold as a USB-friendly charging device allowing the bq24050/2/5 to detect the USB source and charge at the 100-mA level without ever communicating with the host. The same assumption is made as with any dead battery charging: that no issues occur if 100 mA are pulled from the USB source prior to communication. Bear in mind that this is an industry assumption and not a certainty.
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