Application Note

Configuration Guide for Single-Cell Chargers With Integrated USB Type-C and Liquid Detection

Garrett Kreger *Battery Charging Products*

Abstract

This application note outlines the new USB Type-C® related features integrated on the BQ25630 and BQ25640 5A single-cell switching battery chargers with narrow voltage DC (NVDC) power path management. The document showcases USB Type-C detection in sink (SNK) only, source (SRC) only, and dual role port (DRP) modes, as well as liquid detection and corrosion mitigation functions. These features are fully integrated and require no additional components to simplify designs and save board space on battery powered systems. The document also provides hardware setup and test procedure suggestions for simulating a liquid when first testing the liquid detection functionality.

Table of Contents

1 Introduction 2
2 USB Type-C Adapter Detection Routine Overview 3
3 Liquid Detection Routine Overview 8
4 Liquid Detection Suggested Setup 11
5 Summary 13
6 References 14

Trademarks

USB Type-C® is a registered trademark of USB Implementers Forum.
All trademarks are the property of their respective owners.

Copyright © 2026 Texas Instruments Incorporated

1 Introduction

The USB Type-C connector has become the industry standard for charging electronic devices as this enables the transmission of both power and data on a single cable. The USB Type-C connector is a reversible connector and is defined to function across a large power range with a standard USB-C port able to source up to 15W and a USB Power Delivery (PD) port able to source up to 240W with the introduction of the extended power range in USB PD 3.1 specification. TI has integrated channel configuration pin functions (for example, CC1 and CC2) into battery chargers to support direct connection to the USB Type-C receptacle. The direct connection allows the charger IC to determine cable detection, cable orientation, current carrying capability, and if there is liquid present independent of additional components or a system host. Liquid detection functionality is uniquely relevant for the USB Type-C connector because pins are spaced closer together than prior USB connector types and when in SRC/DRP mode the port is advertising a current high enough to cause corrosion if pins are shorted by liquid.

Copyright © 2026 Texas Instruments Incorporated

2 USB Type-C Adapter Detection Routine Overview

The BQ25630 and BQ25640 battery chargers integrate CC1 and CC2 pin functions intended to directly connect to the USB Type-C receptacle. Figure 2-1 shows the CC Logic handshake between source (SRC) or downward facing port (DFP), such as a wall adapter, and the power sink (SNK) or upward facing port (UFP). A SRC is expected to present a pullup resistor (Rp) to the CC line and a SNK is expected to present a pulldown resistor (Rd) to the CC line.

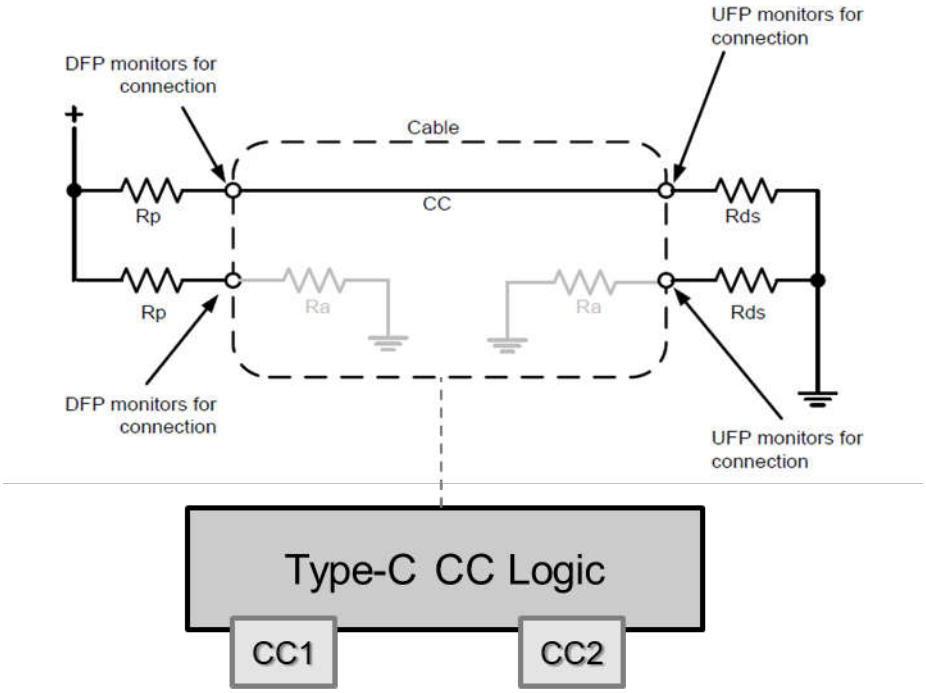


Figure 2-1. Type-C Logic Pullup and Pulldown Diagram

By default, the register configuration for the BQ25630/BQ25640 presents as an UFP with 5.1kΩ to GND on both CC1 and CC2 pins. This allows the charger IC to handshake with a USB SRC or DRP and begin charging even for a dead battery scenario. In Figure 2-2 captured using the BQ25630EVM, a 5V 3A rated USB Type-C input is connected, and the handshake occurs on the CC1 line. If the same USB-C cable is connected with the reverse orientation, the handshake occurs on the CC2 line instead. The handshake between SRC and SNK occurs on only one CC line and the other remains pulled low by the charger IC. Only after the successful handshake between Rp and Rd on either CC line, will the 5V from USB source turn on. Once input voltage is applied the charger IC Input Current Limit (IINDPM) is automatically updated to the 3A current rating advertised by the USB source, and subsequently constant current mode charge starts.

Copyright © 2026 Texas Instruments Incorporated

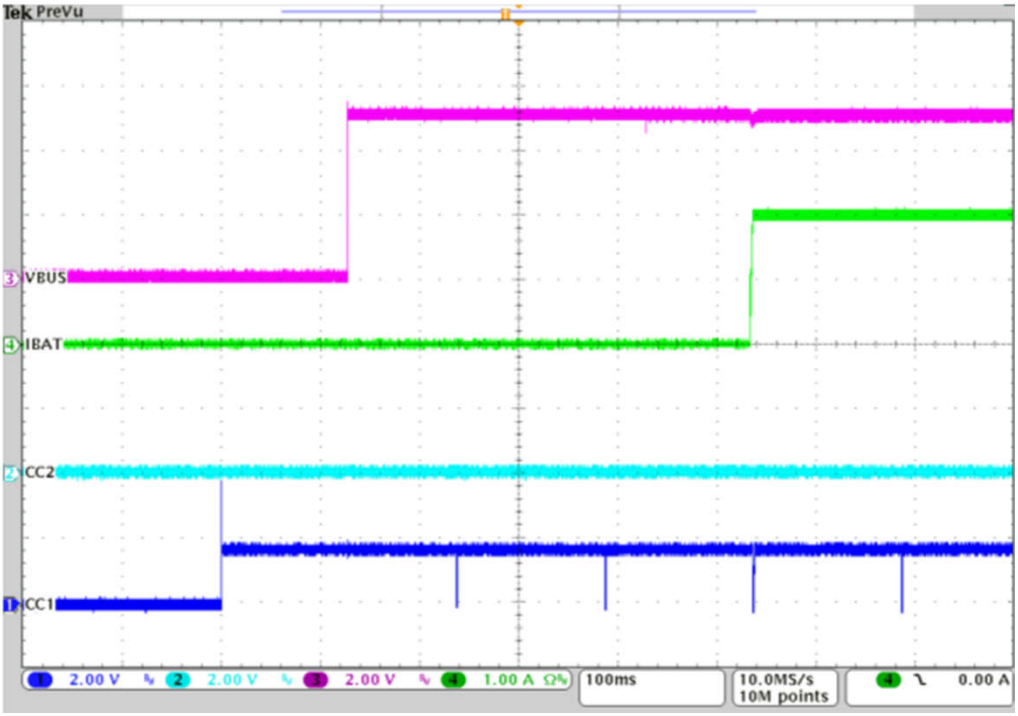


Figure 2-2. Plug-In in SNK Mode

In addition to SNK mode functionality the BQ25630 and BQ25640 can be configured by an I2C host controller to either a DRP or a DFP (SRC mode) via the CC_MODE register bits in REG0x44. An example application that makes sense for a battery powered system to be configured as a SRC in certain instances is a power bank. With the battery charged above a certain capacity the host can configure the device to present as a SRC to maintain that the device always negotiate as a DFP.

In SRC mode configuration the BQ25630/BQ25640 device internally pulls up both CC1 and CC2 lines continuously to present Rp. The Rp value is configurable via I2C so the system can advertise as a 3A, 1.5A, or 500mA/900mA SRC. The relevant register to adjust SRC mode maximum output current is RP_VALUE bits in REG0x44. Figure 2-3 illustrates a handshake between the charger IC in SRC mode attaching to a SNK only device. After the successful handshake on CC1 line the charger IC turns on the converter in OTG boost mode and the battery discharges to source 5V to VBUS.

Copyright © 2026 Texas Instruments Incorporated

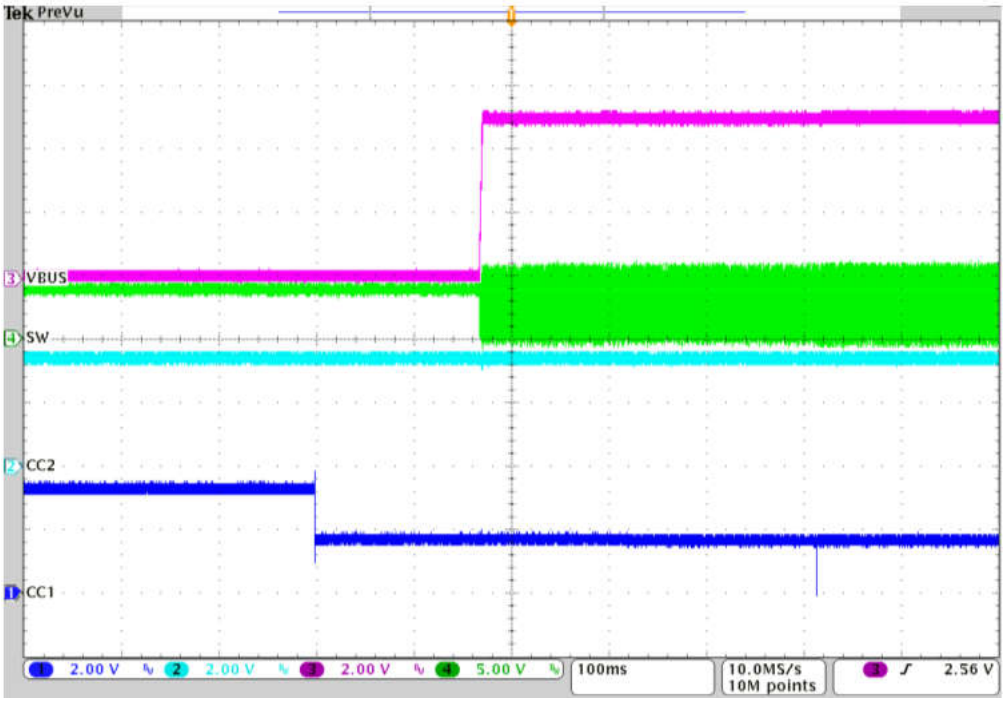


Figure 2-3. Plug-in in SRC Mode

The third possible configuration for USB detection is dual role port. As a DRP, the charger IC continually toggles between sink and source status on both CC lines and can negotiate to either SNK mode or SRC mode depending on what is connected to the other end of the USB Type-C cable. For example, as a DRP the device sinks power when connected to a SRC only device (for example, a wall outlet) and source power if connected to a SNK only device (for example, small handheld electronic device). Figure 2-4 and Figure 2-5 below are examples of BQ25630 configured as a DRP negotiating to both a SNK and SRC. On the left side of each waveform both CC lines toggle between presenting Rp pullup (SRC mode) and Rd pulldown (SNK mode). In both instances the handshake at cable plug in occurs on the CC1 line. Once the USB cable is connected and the handshake is complete, the CC lines no longer toggle between SRC and SNK until the cable is removed from the USB receptacle.

Copyright © 2026 Texas Instruments Incorporated

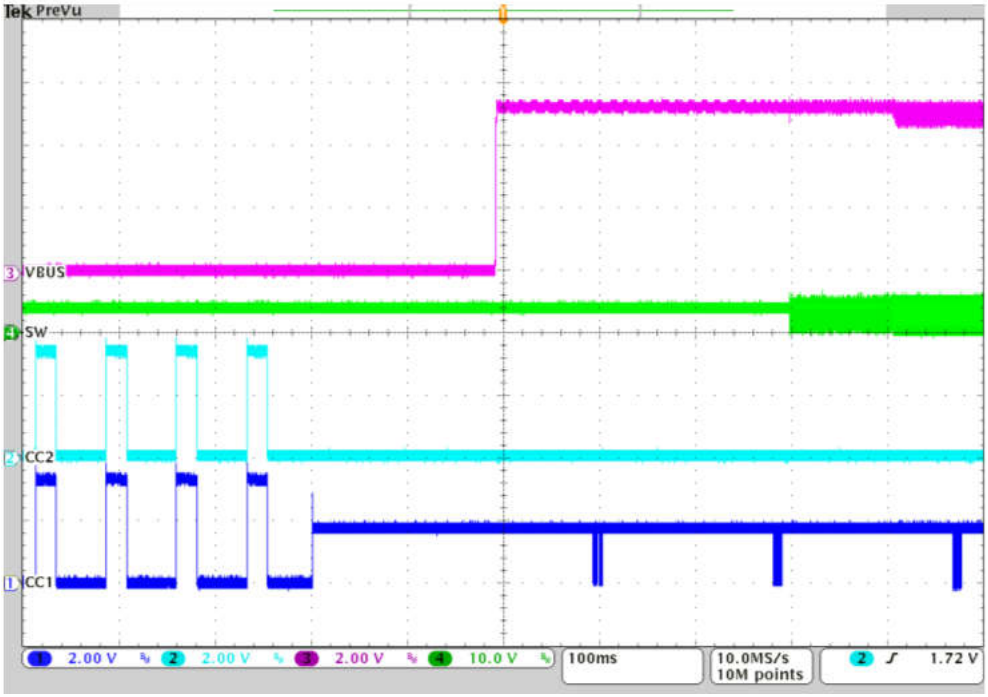


Figure 2-4. Plug-in in DRP Mode, Negotiates to a SNK

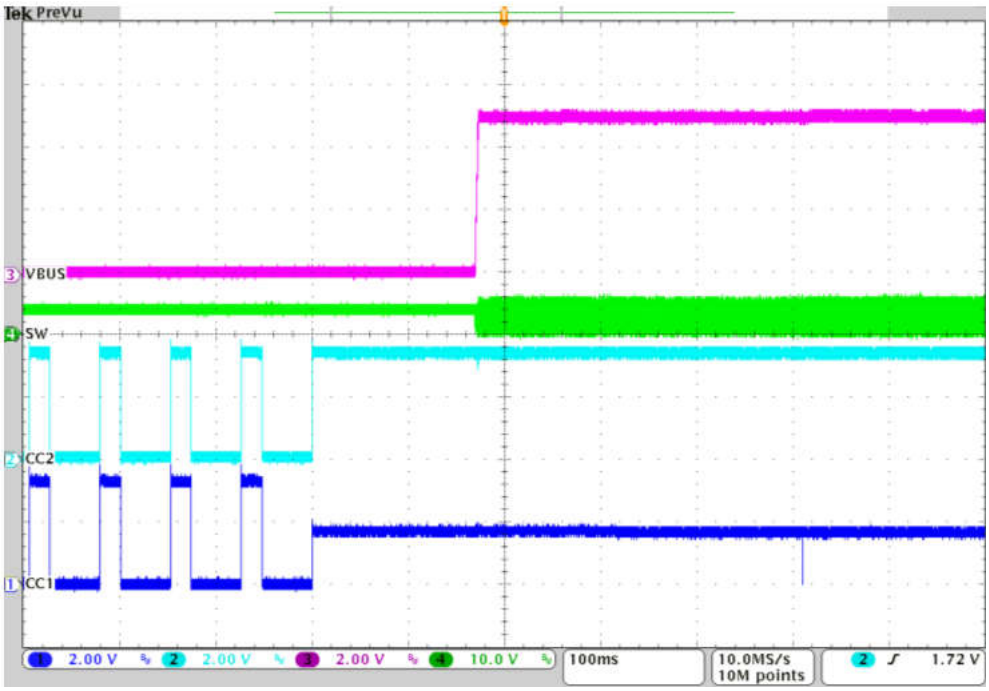


Figure 2-5. Plug-in in DRP Mode, Negotiates to a SRC

DRP mode has an additional level of configurability called DRP_PREF, also located in REG0x44. This register setting allows the I2C host to set the device as SNK preferred, SRC preferred, or no preference. Selecting a preferred role is relevant when a DRP device connects to another DRP device because in general the role each device assumes when two DRPs are connected is random. By setting SNK preferred or SRC preferred the device can attempt to re-negotiate after initial handshake to switch roles to the configured preference. For example, operating in 'Try.SNK' configuration allows the charger IC to negotiate to SNK mode if connected to another DRP configured for no preference or SRC preferred. Figure 2-6 showcases the charger IC reattempt to negotiate as a SNK when configured as a DRP, Try.SNK by presenting Rd on both CC1 and CC2 after initial

Copyright © 2026 Texas Instruments Incorporated

handshake as the SRC. The charger IC eventually completes the handshake as the SRC due to the other device in the negotiation being a SNK only type device and the battery discharges to power 5V rail at VBUS.

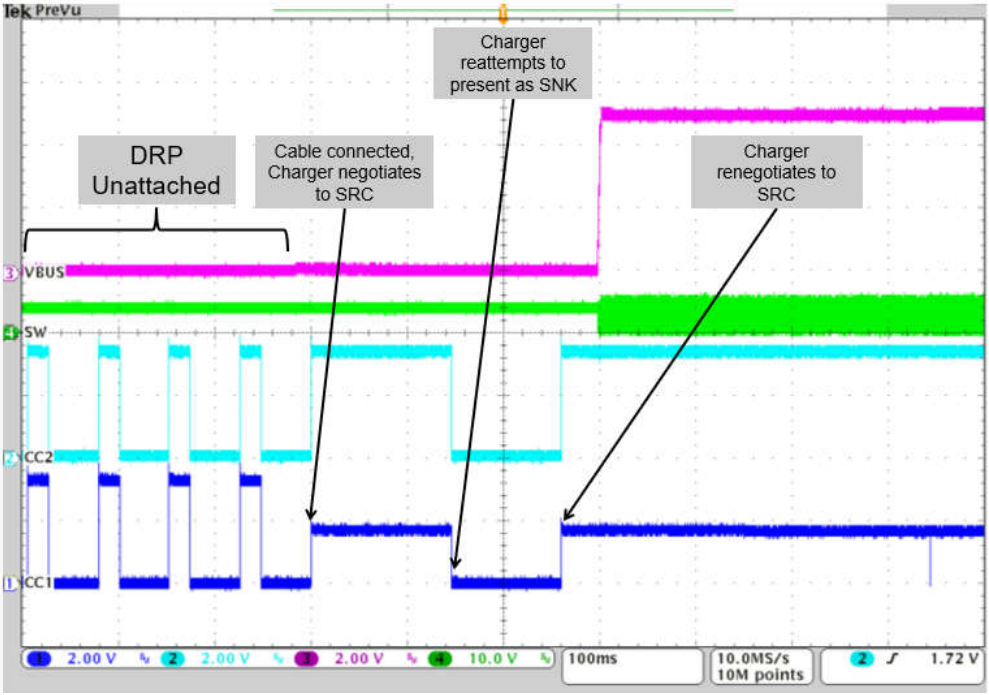


Figure 2-6. Plug-in in DRP Mode, Try.SNK Config, Negotiates to SRC

Copyright © 2026 Texas Instruments Incorporated

3 Liquid Detection Routine Overview

A USB Type-C receptacle can corrode when exposed to moisture/liquid as voltage differential across pins shorted by liquid oxidize the connector over time, causing permanent damage. The BQ25630 and BQ25640 contain a liquid detection routine compliant with USB Type-C Specification 2.3 to help with corrosion mitigation in the event of everyday liquid entering the USB Type-C connector. The liquid detection routine can be executed in SNK only, SRC only, or DRP configuration. When liquid is detected the charger IC prevents USB receptacle corrosion by preventing 5V source turn-on and pulling CC1/CC2 to GND instead of continuing to present Rp (in other words a high voltage) if in DRP or SRC only mode.

Through I2C configuration the charger IC can either perform a single liquid detection check every time FORCE_LQD_DET bit is set or automatically run the same liquid detection check periodically if AUTO_LQD_DET bit is set. The regular interval for the automatic liquid detection check is 500ms, but can be increased to every 10 seconds if preferred to conserve battery power. With default register configuration the liquid detection check is performed on CC1 and CC2 pins. Alternatively, the charger IC has the option to run the detection check on D+/D- lines instead. Figure 3-1 below shows expected behavior of a liquid detection check for a dry connector. When there is no cable connected the detection routine is run on CC1 then subsequently on CC2. If a standard USB Type-C to Type-C cable is connected the liquid detection check only runs on the free CC line.

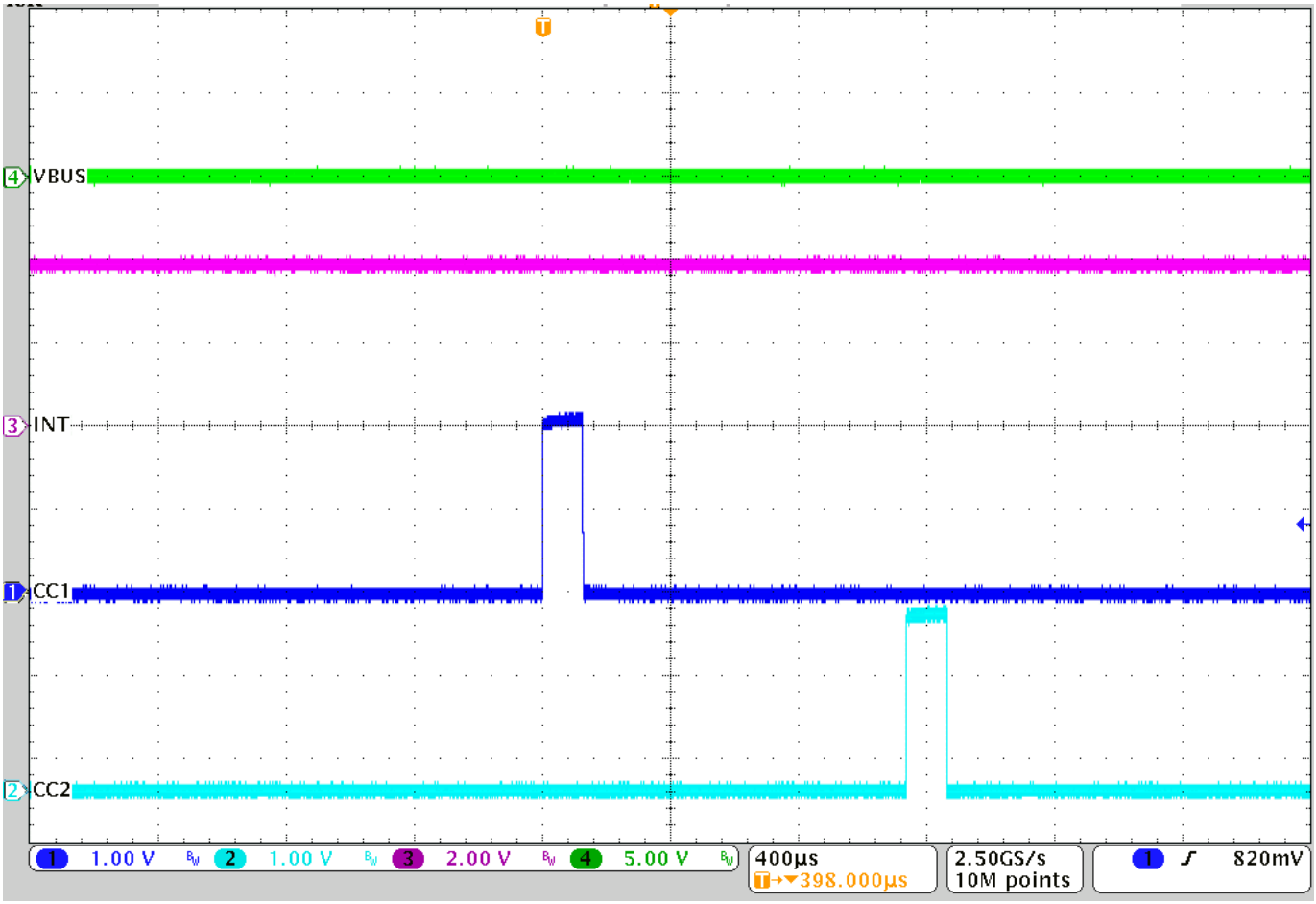


Figure 3-1. Liquid Detection Check With No Liquid Present

The liquid detection routine test method is performed by sourcing a small current pulse, ILQD, on the Type-C connector pins and measuring the voltage increase. Liquids are commonly modeled as resistive and capacitive to capture how they conduct electrical current. With this principle in mind the capacitive and resistive properties of the liquid affect the voltage rise when a current pulse is applied. For the charger IC liquid detection routine if

Copyright © 2026 Texas Instruments Incorporated

voltage on the CC pin does not reach the VLQD threshold (default set to 1.6V) within the detection test duration, TLQD, then a liquid is considered detected.

The charger IC allows for configuration flexibility to shorten or lengthen TLQD duration, increase or decrease ILQD current, and increase or decrease VLQD threshold via REG0x47. Shortening TLQD, decreasing ILQD, or increasing VLQD results in a harder criteria for the port to be considered dry. Lengthening TLQD, increasing ILQD, or decreasing VLQD has the opposite effect. TI recommends starting evaluation of the function with default register configuration and adjusting as needed to achieve end result of a dry port crossing VLQD threshold, while a port with moisture does not.

Figure 3-2 below illustrates the detection of tap water in the connector when a standard USB Type-C cable with liquid present is connected. Liquid is successfully detected as CC line voltage does not increase above VLQD threshold within the liquid check time window. There is subsequent voltage rise observed after the TLQD time window to verify it is not in fact an Ra connection on the CC line. If a liquid is detected the device transitions to the corrosion mitigation state, LQD_STAT register is updated accordingly, and an interrupt is generated to the host. In corrosion mitigation the CC1 and CC2 lines initially transition to HIZ state to signal a disconnect to a USB-C device already connected then are strongly pulled to GND so any new Type-C cable plug in does not result in VBUS turn on.

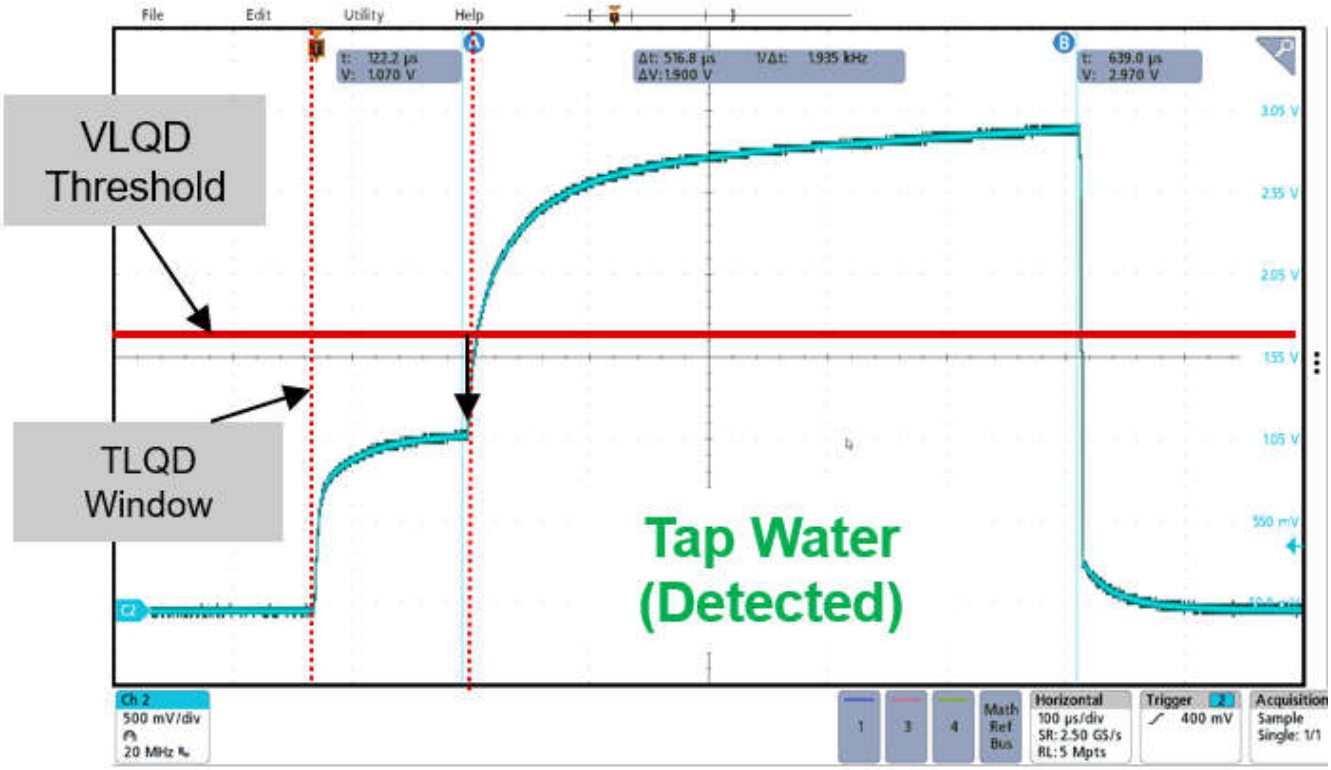


Figure 3-2. Successful Liquid Detection of Tap Water

After a liquid has been detected and the charger IC is in corrosion mitigation there are two options for monitoring when the receptacle returns to dry status. The first is automatic dry detection, configured by setting AUTO_DRY_DET bit to a 1b. With this setting the charger IC performs liquid detection checks at the same time interval as the automatic liquid detection. As long as liquid continues to be detected, the device remains in corrosion mitigation state. The alternate option, which helps conserve battery power, is to disable automatic dry detection and instead have the I2C host write FORCE_LQD_DET to check for a dry port at longer intervals. Note that a device in liquid detected status returns to no liquid detected (in other words dry) status if liquid detection function is disabled by setting EN_LQD_DET bit to a 0b. For further details on all register settings related to liquid detection function please refer to Liquid Control 0 (REG0x46) and Liquid Control 1 (REG0x47) tables in the register map section of the BQ25630 and BQ25640 datasheets.

Copyright © 2026 Texas Instruments Incorporated

Figure 3-3 demonstrates the full workflow from automatic liquid detection enabled, to liquid detected, to dry port detected using a simulated liquid for simplicity. Prior to instance (1) the charger IC is in SNK only mode with no cable connected so both CC1 and CC2 lines are low. At instance (1) automatic liquid detection is enabled via host command, then at instance (2) moisture is detected on the CC1 line. An interrupt is generated and CC2 is expectedly not also checked. Then between instance (2) and (3) the charger IC is in corrosion mitigation and periodically performing automatic dry detections. Liquid continues to be detected on CC1, hence no pulses are observed on CC2. The pulse voltage is larger with liquid detected to distinguish from an Ra connection. Finally, at instance (3) the port is detected as dry when both CC1 and CC2 lines pass the dry detection. An interrupt is again generated, and the charger IC returns to periodic automatic liquid detection checks.

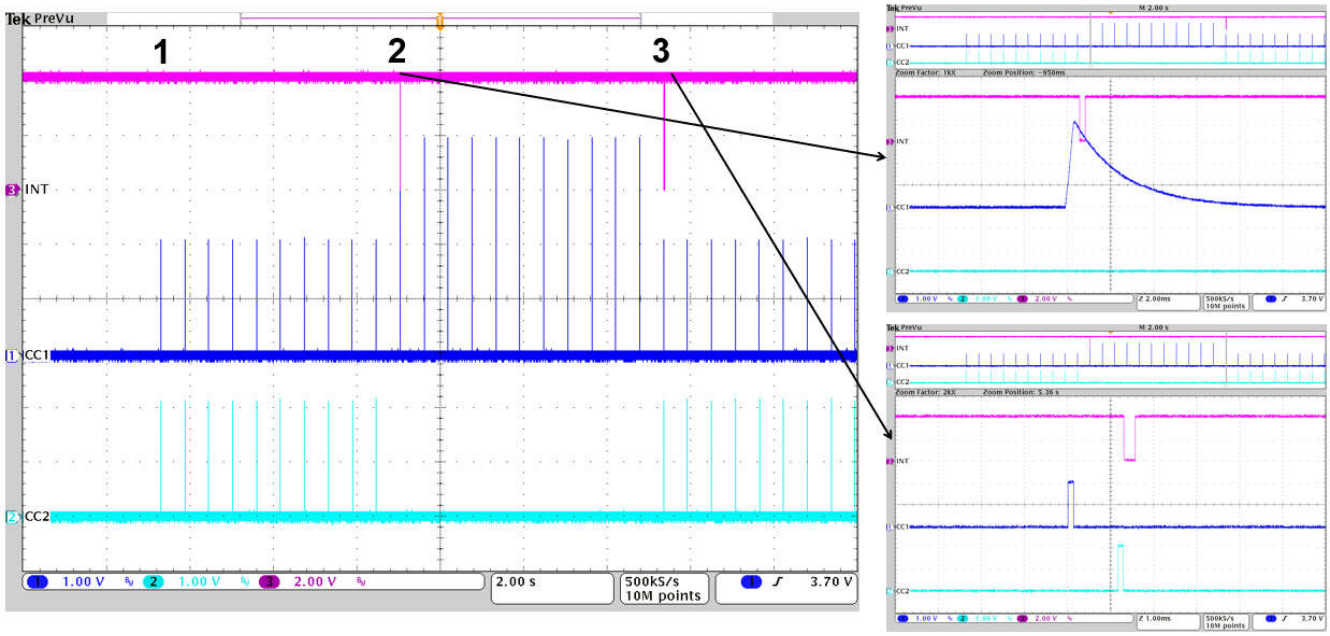


Figure 3-3. Automatic Liquid Detection Full Workflow

Copyright © 2026 Texas Instruments Incorporated

4 Liquid Detection Suggested Setup

The ensuing section provides recommended hardware setup and register configuration when first evaluating the liquid detection function of the BQ25630 and BQ25640. When first evaluating functionality with the BQ25630EVM, BQ25640EVM or a prototype board there may be a desire to avoid testing with real liquids in the USB Type-C port. For this scenario it is recommended to simulate a liquid with an RC network. To accurately simulate the electrical properties of a liquid or moisture in the USB Type-C port connect a resistor and capacitor in parallel from either CC pin to GND. If testing with the EVM board one can simply connect the parallel resistor and capacitor to the CC1 or CC2 test point. Table 4-1 lists approximate resistance and capacitance values to simulate a few common liquids.

Table 4-1. Recommended Values for Simulated Liquid

	Resistance	Capacitance
Filtered tap water	212kΩ	20nF
Coffee	106kΩ	50nF
Sweat	10kΩ	150nF

Some minor register configurations are also necessary to test the liquid detection function as it is not enabled by default. An I2C write to 'Liquid_Control_0' REG0x46 is necessary to enable liquid detection and then set either automatic liquid detection or force a single liquid detection check. Especially if using automatic liquid detection, it is recommended to first disable the watchdog timer to ensure EN_LQD_DET and AUTO_LQD_DET bits remain set to enabled state.

Sequence to start automatic liquid detection for either the BQ25630 or BQ25640:

1. Disable watchdog timer by writing REG0x16[1:0] to 00b
2. Enable liquid detection and turn on automatic detection by writing REG0x46[7:6] to 11b

If instead using force liquid detection to run a single liquid check one should first set EN_LQD_DET=1b (REG0x46[7]=1b) then set FORCE_LQD_DET=1b (REG0x46[3]=1b).

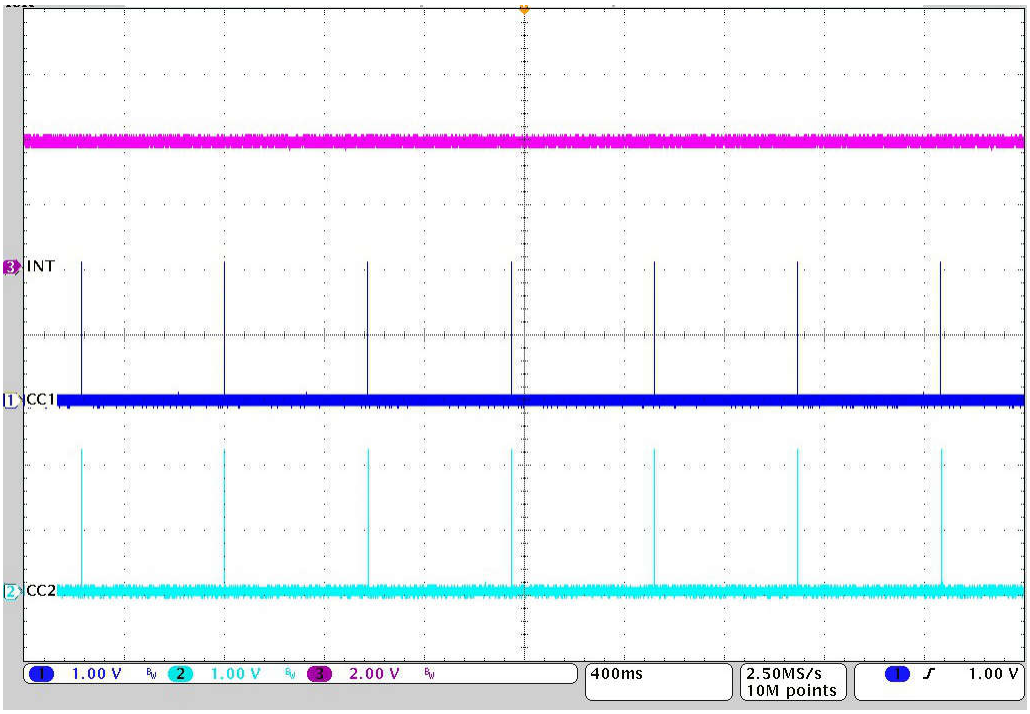


Figure 4-1. Expected Behavior With Automatic Liquid Detection Enabled

Copyright © 2026 Texas Instruments Incorporated

Figure 4-1 illustrates expected behavior on CC1 and CC2 lines with charger IC in SNK mode, automatic liquid detection enabled, and no liquid present. The device continues to check each CC line every 500msec indefinitely. Figure 4-2 shows the detection of a simulated liquid connected at CC1 line. In the example the components for the simulated liquid are R = 200kΩ & C = 15nF to approximately simulate filtered tap water. CC1 voltage does not rise above 1.6V VLQD threshold within the TLQD time window (set to default value), hence a liquid is considered detected. Upon successful detection an interrupt to system host is generated and liquid check does not run on CC2 line due to detection on CC1. LQD_STAT register bit is updated to a 1b, which indicates liquid detected status.

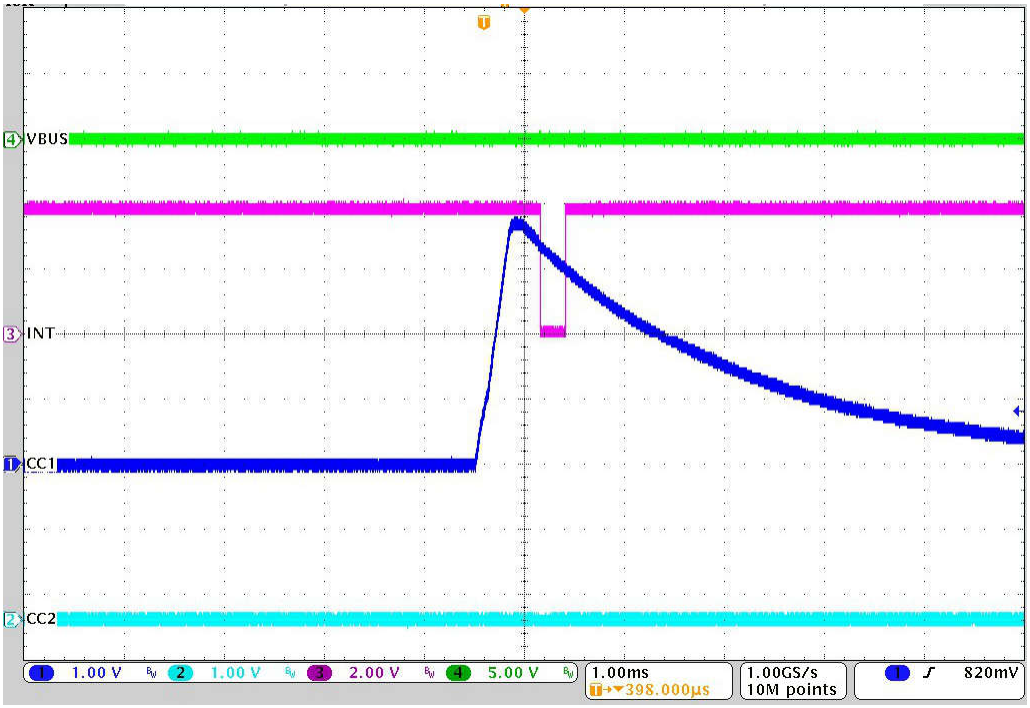


Figure 4-2. Simulated Liquid (R = 200kΩ & C = 15nF) Detected

Copyright © 2026 Texas Instruments Incorporated

5 Summary

This application note described new integrated USB Type-C detection and liquid detection functionalities available on the BQ25630 and BQ25640 single cell battery charger ICs. Integrated CC pins and ability to configure charger IC allows system to present as a SNK, SRC, or DRP without any additional components or discrete ICs. The device can negotiate to source power or sink power depending on configuration mode without host interaction. The liquid detection function available in all 3 USB Type-C roles helps to prevent corrosion of the USB receptacle in the scenario where moisture is present. Finally, the application note outlined a simple recommended method for testing the liquid detection function when first evaluating the charger IC for one's system.

Copyright © 2026 Texas Instruments Incorporated

6 References

1. Texas Instruments, *BQ25630 I2 C Controlled Single Cell 5A Buck Charger with USB-C Detection*, data sheet
2. Texas Instruments, *BQ25640 I2 C Controlled Single Cell 5A Buck Charger with USB-C Detection*, data sheet

Copyright © 2026 Texas Instruments Incorporated

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you fully indemnify TI and its representatives against any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale, TI’s General Quality Guidelines, or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products. Unless TI explicitly designates a product as custom or customer-specified, TI products are standard, catalog, general purpose devices.

TI objects to and rejects any additional or different terms you may propose.

Copyright © 2026, Texas Instruments Incorporated

Last updated 10/2025