

Inside a New Architecture for USB Type-C Applications

Introduction

The USB-C interface is revolutionizing the way we charge our electronics devices. Its USB Type-C connector cable slides right in to your smartphone or ultrabook no matter what orientation you use. Physically, the Type-C connector is both bidirectional (either end of the cable can be inserted into either device) and non-polarized (connector can go in either right side up or upside down). The connecting systems electrically figure out polarity as part of the negotiation process. In addition to data transfer, USB-C also supports bidirectional power flow at a much higher level. With a default 5V voltage, the USB-C port is capable of negotiating with a plugged-in device to raise the port voltage up to 20V, or another mutually agreed on voltage, and at an agreed to current level. The USB-C port's maximum power delivery is 100W (20V at 5A), which is more than adequate to charge a laptop. With such appeal, it is easy to understand why electronic device makers are flocking to USB-C for their next generation products.

With the increasing use of USB power delivery (PD) and USB Type-C, the computer industry has significantly raised the performance requirement for the voltage regulator. Compared to conventional USB Type-A and USB Type-B fixed voltages, USB Type-C is a bidirectional port featuring a variable input and 5V to 20V output voltage range. Its adjustable output voltage allows notebooks and other mobile devices to use USB Type-C to replace the conventional AC/DC power adapter and USB Type-A and B terminals. Considering these advantages, some customers are designing in dual or multiple USB Type-C ports into their systems.

However, the current system architecture for dual or multiple USB Type-C ports is complicated and cannot meet many customer requirements. This white paper proposes a new system architecture using Renesas' ISL95338 buck-boost voltage regulator and ISL95521A combo battery charger. We will discuss how this architecture simplifies design and fully supports all USB-C functions. We'll also describe how it can be applied to the adapter side to implement a programmable power supply (PPS), which outputs an adjustable voltage to match the USB-C variable input voltage.

A New Architecture for USB Type-C

Figure 1 shows a new USB Type-C architecture that consists of the ISL95338 bidirectional buck-boost (BB) voltage regulator and ISL95521A combo battery charger or ISL9238 BB battery charger. It allows a system to charge its battery through USB Type-C ports, and it supports the fast charge function when two PD chargers are plugged into USB-C_1 and USB-C_2. This new architecture also supports full USB 3.1 On-The-Go (OTG) for both ports without additional complex port-control logic circuits or ICs.

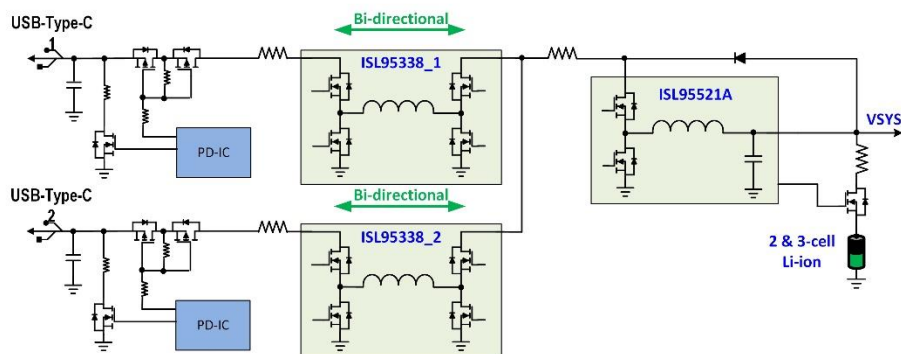


Figure 1. Renesas battery charger architecture—dual USB Type-C ports with 2x BB regulator + buck charger

Comparing Figure 1 and Figure 2, it's easy to see that the current battery charger architecture requires more devices and complicated external circuitry to implement the same functions and performance level as Renesas' battery charger architecture. Obviously, with the current battery charger system, every individual charger path requires a USB-PD controller to control two ASGATE and perform the charge function, which increases the design's system cost. To implement 5V buck OTG, the OTG gate also needs a PD controller. Note that the current buck converter can only output a single fixed voltage. Figure 2 shows that if the 5V buck is adapted, designers can only output a fixed 5V, which doesn't match the adjustable 5V up to 20V OTG output voltage required by many USB Type-C applications.

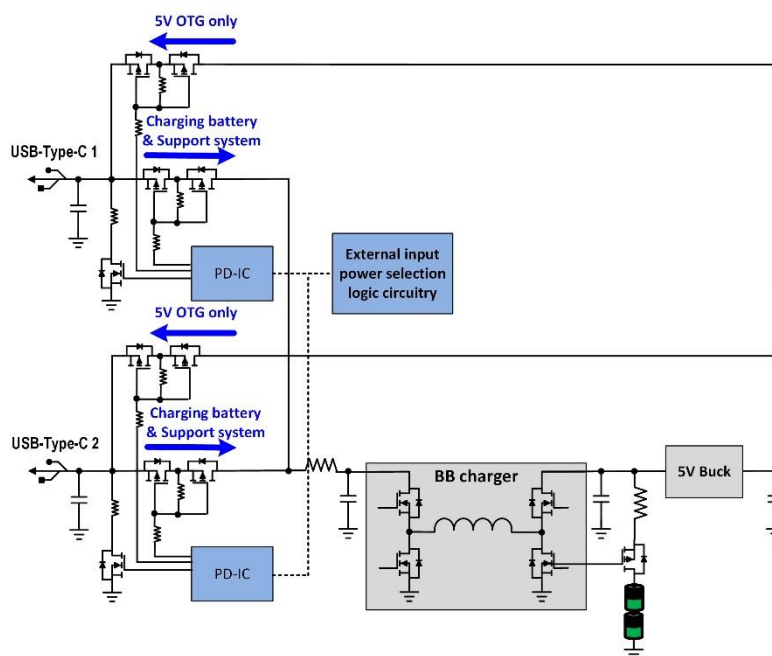


Figure 2. Current battery charger architecture—single BB charger + complicated external logic

The proposed Renesas architecture overcomes all of these disadvantages. Figure 1 shows that two ISL95338 are in parallel to interface two USB Type-C ports to the ISL95521A battery charger. The system architecture is simplified, saving significant costs for customers because several components are eliminated, including individual PD controllers, ASGATE and OTG GATE. Most importantly, using fewer components does not degrade performance. For example, if the battery needs to be charged, power is delivered directly from the USB-C input to the ISL95521A. In addition, having two ISL95338's in parallel provides even more options for customer applications.

For instance, two USB-C inputs with different power ratings can be applied for heavy charging the battery, which means the battery charge power is higher than the single USB-C input power. Figure 1 illustrates how this can be accomplished with one ISL95338 (set for USB-C high power rating) in the voltage loop to support a constant voltage (V_0) for ISL95521A input, while the other ISL95338 (set with a USB-C small power rating) is in the current loop to automatically deliver maximum power to ISL95521A. In other words, there is no need to add external circuitry or logic to determine the different power rating operation of the two paralleled ISL95338 BB voltage regulators.

The control loop inside the ISL95338 can be automatically selected based on different power ratings to make full use of the input source. For the OTG function, battery power can be delivered through a diode with the ISL95338 transferring it to the USB-C output. This eliminates the need for the 5V buck and OTG gate,

shown in Figure 2. Also, by using SMBus communication between the two ISL95338's, ISL95521A and PD controller, the OTG voltage can be adjusted instead of using a fixed value. Figure 3 shows a high power fast charging application where the new Renesas battery charging architecture can be extended to parallel four ISL95338's with one ISL95521A or ISL9238 battery charger. Each USB-C port can operate individually as a sink or source. This architecture can also combine the conventional adapter as a power source for the system, without increasing BOM cost.

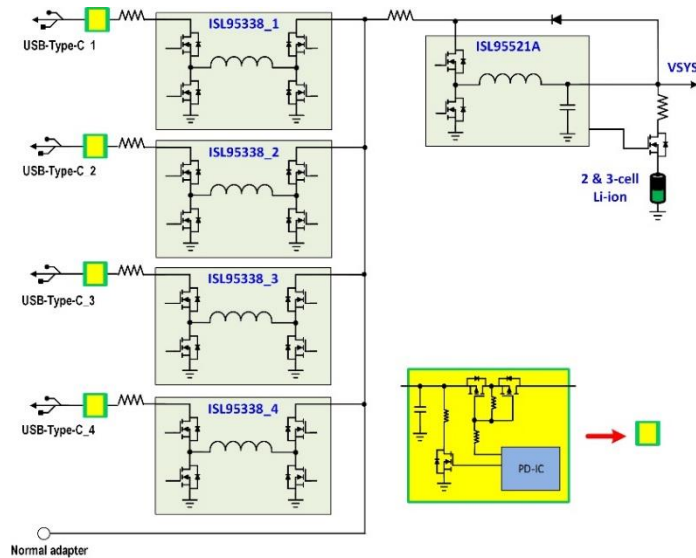


Figure 3. Renesas battery charger architecture for four USB Type-C ports—4x BB regulator + buck charger

Programmable Power Supply Solution

In conventional USB Type-A and USB Type-B applications, the input voltage is a fixed value, which brings new challenges to USB Type-C because USB-C can also accept variable input voltages. The solution is the programmable power supply (PPS) function, which allows the power supply's output voltage and current to be programmed and adjusted in 20mV/50mA steps to optimize the power path. As shown in Figure 4, the ISL95338 buck-boost voltage regulator works well with PPS because it outputs an adjustable, bidirectional voltage using SMBus communication from the USB-PD controller.

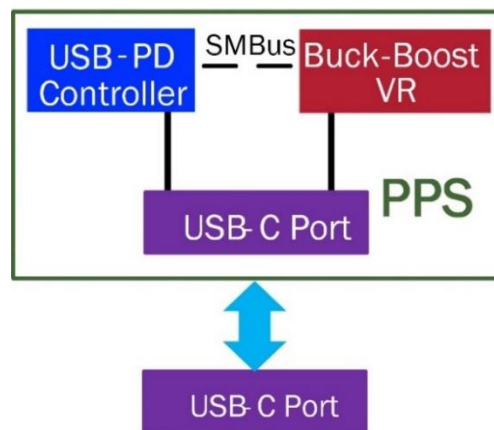


Figure 4. New Renesas PPS architecture

Conclusion

Applying the ISL95338 in a multiport USB Type-C battery charging system enables a new, easy to use charging architecture. Compared to today's currently available charging architecture, Renesas' new architecture can be implemented at much lower cost, and achieve higher performance, faster charging and longer battery life. Furthermore, all USB Type-C requirements are in full compliance, including the ability to address PPS, one of the key USB additions required for future applications.

Next Steps

- [Learn more about the ISL95338 bidirectional buck-boost regulator](#)
- [Download the ISL95338 datasheet](#)
- [Download the ISL95521A buck combo battery charger datasheet](#)
- [Download the ISL9238 buck-boost charger datasheet](#)
- [Download the R9A02G011 USB-PD controller datasheet](#)

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