RutDevKit-PSoC62 USB Power Delivery Sink with CYPD3177

Gintaras Drukteinis,
RUTRONIK Electronics Worldwide, Kaunas, Lithuania

***Abstract* — The USB PD protocol is supposed to be used together with USB Type-C connectors which already are dominating today's handheld rechargeable devices. The multi-purpose power supplies with USB Type-C cable are quite common either. Some of the devices must keep simplistic design and need a highly integrated solution to adopt USB PD technology. Indeed, the CYPD3177 is a complete stand-alone solution that is used on the RutDevKit-PSoC62 development platform and described in this application note.**

***Index Terms* — Microcontroller (MCU), Universal Serial Bus Power Delivery (USB PD), Barrel Connector Replacement (BCR), Power Data Object (PDO).**

I. Introduction

The RutDevKit-PSoC62 development platform has versatile power management with various power sources, hence the developer can choose what suits the best for the actual application. One of the power sources is a USB Type-C connector with a USB PD controller which complies with the USB PD specifications and enables to load of the system up to 100W of power ($20V_{max}$, $5A_{max}$).

II. Hardware

The USB PD system on the RutDevKit-PSoC62 consists of the CYPD3177-24LQXQ controller, the MOSFET switches SSM6J507NU, IRFHS9351TRPBF, the current limiter TCK22946G and a microcontroller CY8C6245AZI-S3D72 which is interfaced with CYPD3177-24LQXQ via I^2C.

The USB PD controller CYPD3177-24LQXQ is also presented as EZ-PD™ Barrel Connector Replacement (BCR) by Infineon. This BCR controller has integrated a 30V-tolerant regulator and overvoltage protection to prevent the overvoltage from reaching the load. Normally, the power source should never supply more than 20V and 5A using EZ-PD BCR. In case more than 20V, high energy overvoltage spikes occur, the DFL20A-7 TVS diode should absorb them safely. Additionally, the BCR controller has protection against the short circuit between VBUS and CC lines what is useful if the Type-C connector gets damaged or plugged with a faulty cable. Despite the fact it is a stand-alone device adapted to work only using external resistor dividers that sets up the maximum, minimum voltages, and maximum current delivered to the load, it can be reconfigured using the I^2C interface.

The latest technology Toshiba's MOSFETs SSM6J507NU has been used as main power switches. The Drain-Source resistance must be less than 20mΩ while fully opened by the controller since the Gate-Source voltage is approximate -19V. The Gate-Source voltage of the MOSFET should never be more than -25V or breakdown of the isolation layer may occur, hence the Zener diode BZT52C20T is used here to keep the voltage below the critical level, but also not to interface the switching process.

The safe power enabling IRFHS9351TRPBF dual MOSFET is used here to use less space on the board. Besides the current is limited to the 400mA by the current limiter TCK22946G. The current limiting is done to prevent laptop or PC USB ports from going to the fault condition if more than 500mA is consumed. This is the maximum allowed current for the normal USB port.

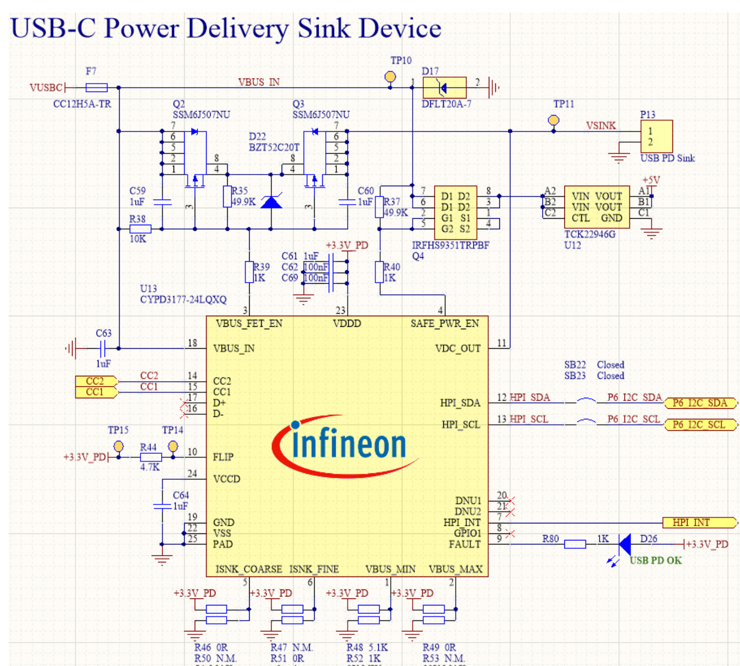

Fig. 1 The Infineon USB PD on the RutDevKit-PSoC development board.

III. Firmware Example

No firmware development for the EZ-PD BCR is needed for typical applications. Nevertheless, some applications may require to change the PDOs at runtime of the system. Rutronik has developed a firmware example and a library that enables users to access and control the EZ-PD BCR via I²C. All the provided function prototypes are given below:

```
/*EZ-PD BCR Library Functions*/
uint32_t cypd3177_i2c_init(void);
uint32_t cypd3177_write(uint16_t reg, uint8_t* data, uint16_t
size);
uint32_t cypd3177_read(uint16_t reg, uint8_t* data, uint16_t
size);
_Bool cypd3177_online(void);
uint32_t cypd3177_id( uint8_t* data);
uint32_t cypd3177_bus_voltage_mv( uint16_t* voltage);
uint32_t cypd3177_int_read(cypd3177_int_t* status);
uint32_t cypd3177_typec_status_read(cypd3177_type_c_status_t*
status);
uint32_t cypd3177_pd_status_read(cypd3177_pd_status_t* status);
uint32_t cypd3177_change_pdo(uint32_t* pdo);
```

The purpose of the firmware example is to show how to establish the communication with the EZ-PD BCR, to read the most actual data such as VBUS voltage, USB Type-C connection status, and USB PD policy status. After the initialization and data read procedures are complete, the PDOs are changed to 5V 900mA and 9V 2000mA. By default, the hardware settings set the EZ-PD BCR to the 20V 5A in the RutDevKit-PSoC62 board. After the firmware completes the setup of the device the voltage should be 9V at the Sink output terminal if the correct power supply is used. The EZ-PD BCR can be configured to have up to 9 PDOs, although only 2 is configured in the example what is enough to be able to alter the Sink output voltage and current.

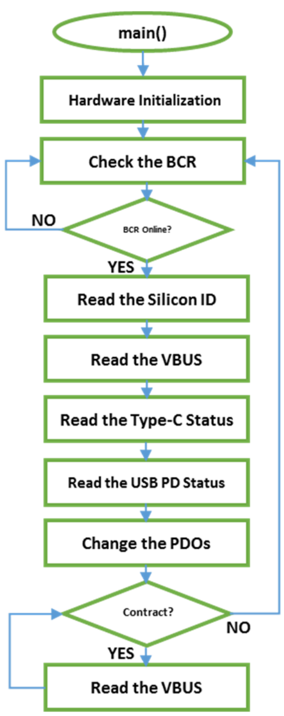

Fig. 2 The Infineon USB PD on the RutDevKit-PSoC development board.

The whole firmware workflow can be monitored via the Kitprog3 UART terminal. The debug information will be printed if the status changes or the fault event happens.

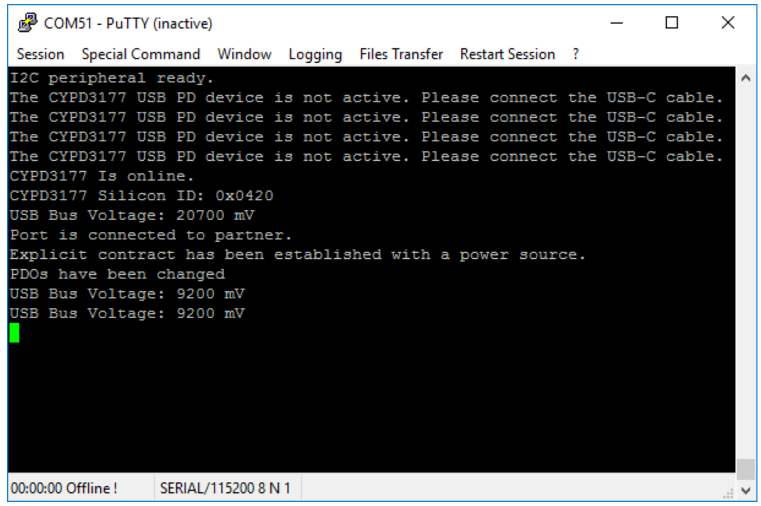

Fig. 3 The debug information of the firmware example. The exchange of the PDOs can be monitored.

IV. Test Results

The power delivery system was tested under maximum load conditions using a 4Ω resistor with a nominal power of 100W. The wire-wound resistor was cooled in a water-filled reservoir during the tests to avoid any damage.

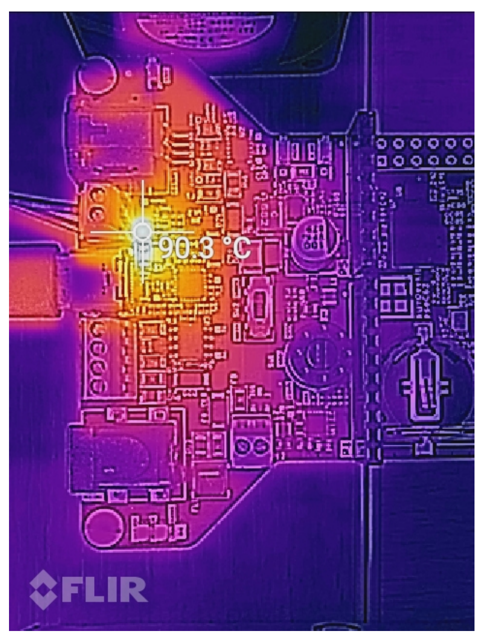

Fig. 4 USB PD Under test. 4,73A and 20,8V with active cooling.

The RutDevKit-PSoC62's temperature was monitored using a thermal imaging device. The voltage drop on the resistor was 20.8V and the current flow was 4.73A. The hottest parts on the board appeared to be MOSFETs. If no cooling was applied, the temperature rose to more than 120C° in two minutes and kept rising.

After applying the active cooling with airflow coming from the fan, the temperature has stabilized to 90C°. A DC brushless fan ADDA AD0412LB-C73GP powered from a 12V power supply was used to cool the board.

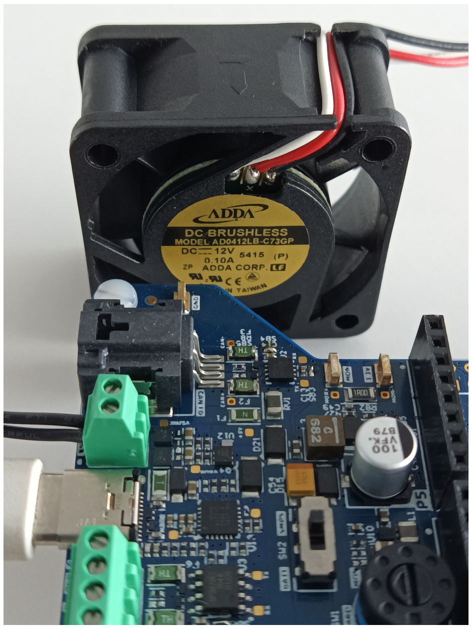

Fig. 5 Fan position for cooling the MOSFETs.

V. Summary

Although the new USB PD 3.1 specification is being presented to the world with up to 240W power delivery capability, the most of power supplies are needed below 100W now, hence the USB PD 3.0 compatible devices still going to be in production for a while.

The RutDevKit-PSoC62 can deliver 100W to the Sink output, though cooling is needed. If the maximum current is needed, the developers should consider larger copper areas around the MOSFETs or cooling. The more powerful MOSFETs in bigger packages also might be put into consideration, if only this will not increase the system price to the unacceptable level. For the systems that consume less than 3.5A, no additional action for cooling the MOSFETs needs to be taken.

The EZ-PD BCR stand-alone USB PD controller with the capability to be controlled over the I^2C proves to be versatile and easy to use on the RutDevKit-PSoC62 development platform designed by Rutronik.

References

[1] "PSoC 6 MCU: CY8C6xx5 Architecture Technical Reference Manual (TRM)" User Manual, by Infineon (July 2020).

[2] "PSoC 6 MCU: CY8C62X5 Datasheet" Datasheet, by Infineon (November 2020).

[3] "EZ-PD™ BCR Datasheet", by Infineon (August 2019).

[4] "EZ-PD™ BCR Host Processor Interface Specification", by Infineon (March 2019).

[5] "USB Power Delivery Specification" Website, by USB Organization.

Contact:

Gintaras Drukteinis
Technical Support Engineer
RUTRONIK Elektronische Bauelemente GmbH
Jonavos g. 30
44262 Kaunas
Lithuania
gdr@rutronik.com
www.rutronik.com