Whitepaper
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End-to-end USB-C PD solutions for embedded applications

A complete and easy-to-use design portfolio to build robust, efficient, and cost-effective system solutions

Abstract

EZ-PD™ PMG1, a family of High Voltage Microcontrollers (MCUs) with USB-C Power Delivery (PD), supports embedded firmware engineers and system designers to adopt USB-C into applications such as smart speakers, IoT hubs, home appliances, internet gateways, power and garden tools.

This article is intended for embedded firmware engineers and system designers interested in including USB-C in their embedded applications. Infineon provides end-to-end solutions for integrating USB-C into embedded applications using Infineon's EZ-PD™ PAG1 (Power Adapter Gen 1) USB-C AC/DC Adapters and EZ-PD™ PMG1 (Power Delivery Microcontroller Gen1) MCUs.

by

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1 Introduction

USB-C ports have become the connector of choice for consumer electronics — and soon will be the default connector. Government regulators hope to standardize power connectors in order to ensure interoperability and reduce e-waste, case in point the European Union which plans to make USB-C ports standard for all mobile devices beginning 2024. According to the EU directive, “USB-C will become the standard port for all smartphones, tablets, cameras, headphones, portable speakers and handheld videogame consoles.”

This whitepaper is intended for embedded firmware engineers and system designers interested in including USB-C ports into their embedded applications. This whitepaper is the first of a series that provides system-level solutions for the evolving USB-C ecosystem based on EZ-PD™ PMG1 High Voltage Microcontrollers.

As the world transitions to USB-C-based DC power sources, more and more applications are expected to need a USB-C-based DC power source and sink. This whitepaper discusses how Infineon’s EZ-PD™ PAG1 and PMG1 families provide end-to-end solutions for DC power source and sink.

Infineon’s EZ-PD™ PAG1 (Power Adapter Gen 1) USB-C Power Adapter Solution is built using PAG1S and PAG1P (PAG1 Solution). PAG1 is offered as a two-chip solution with a primary start-up controller (PAG1P) and a single-chip secondary-side controller (PAG1S) that integrates a synchronous rectification driver, PD controller, 30-V-tolerant regulator, high-voltage NFET gate drivers, OVP, SCP, and OCP protection. EZ-PD™ PAG1 solutions-based reference designs are available for power adapters from 20 W to 65 W.

Infineon’s EZ-PD™ PMG1 is a family of Microcontrollers (MCU) that includes Integrated Arm® Cortex® M0/M0+ CPUs with up to 256 KB Flash, up to 32 KB RAM, a USB full-speed device, and programmable analog and digital peripherals to interface with various sensors and perform system functions. EZ-PD™ PMG1 also integrates high-voltage circuits up to 28 V, such as regulators, FET gate drivers, and fault protection for overvoltage and overcurrent, to enable a robust, easy-to-use solution while reducing BOM cost through integration.

2 End-to-end solution using EZ-PD™ PAG1 and EZ-PD™ PMG1 for DC power up to 65 W

This section provides an overview of an end-to-end USB-C-PD-based embedded system built using Infineon's EZ-PD™ PAG1 power adapter solution (Figure 1) and EZ-PD™ PMG1 MCU (Figure 2) for source and sink of power of up to 65 W.

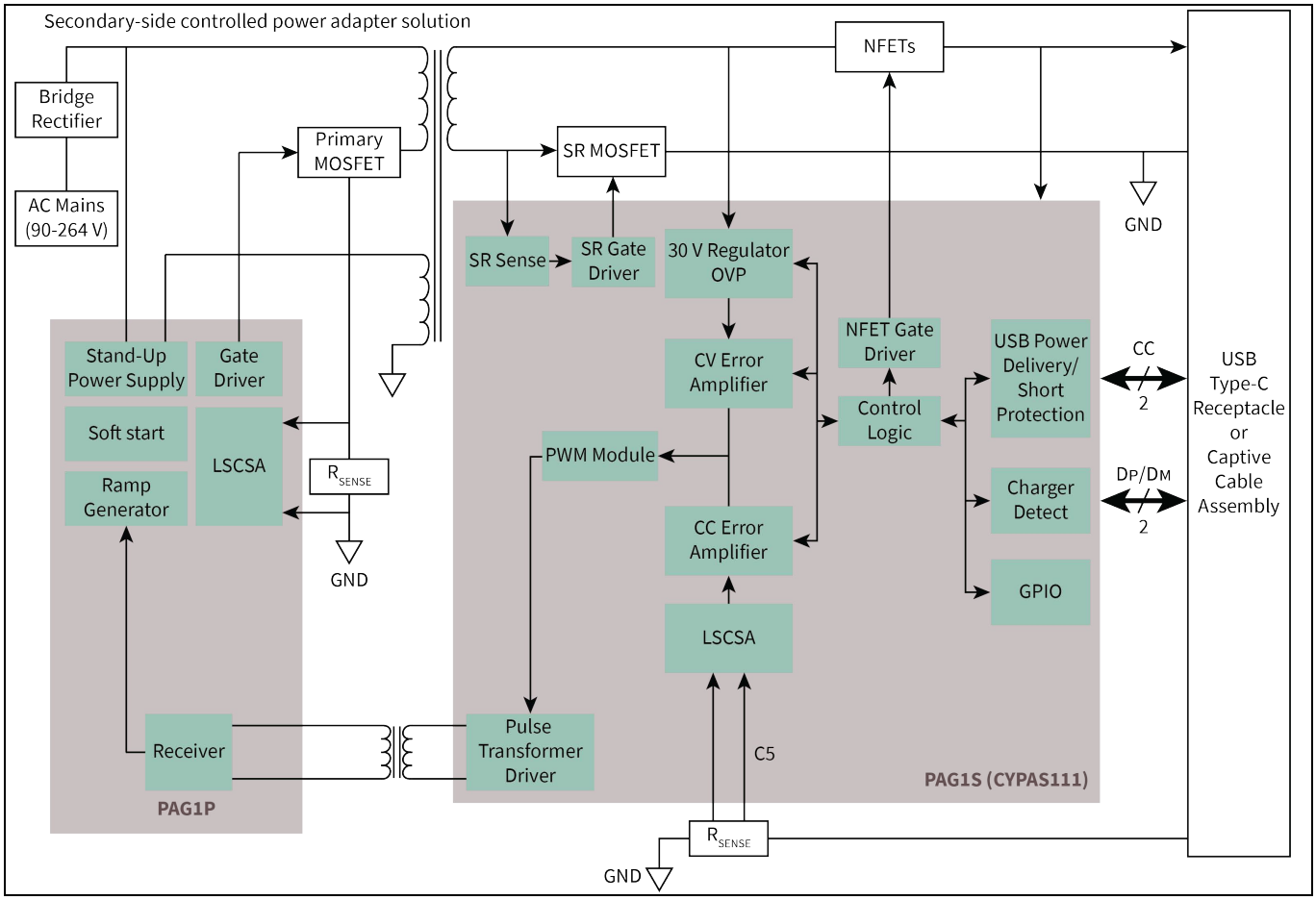

Figure 1 Infineon's end to end USB-C Power Delivery Solution – EZ-PD™ PAG1 AC/DC solution

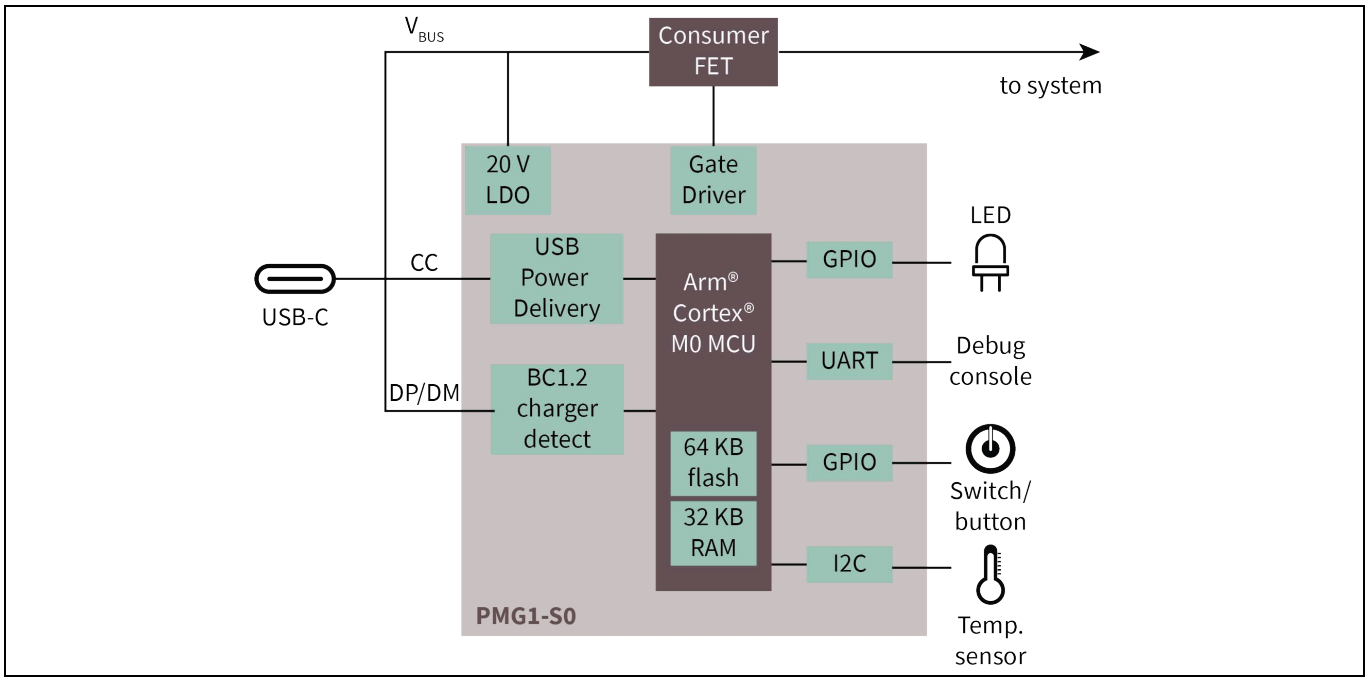

Figure 2 Infineon's end to end USB-C Power Delivery Solution – EZ-PD™ PMG1 MCUs

Infineon's EZ-PD™ PAG1 USB-C Power Adapter Solution is built using PAG1S and PAG1P. PAG1 based reference designs are available for power adapters from 18 W to 65 W. Table 1 and Table 2 show the list of USB-C PD Charger reference designs based on PAG1.

Table 1 EZ-PD™ PAG1 reference designs from 18 W to 65 W AC/DC USB-C Power Adapters

Parameter	18 W (QR, DCM)	20 W (QR, DCM)	33 W (QR, DCM)	33 W (Diodes)
Dimension	55x36x21	55x36x21	60x35x20	60x25x40 w/enclosure
Primary FET	IPS70R900P7S	IPS70R900P7S	IPA70R600P7S	IPA70R600P7S
Power density [W/in^3]	7.8 (20 W)	7.8 (20 W)	12.9	12.9
Open Frame				
Standby power [mW] @ 230 VAC	25	25	25	53
COC Power	Pass	Pass	Pass	Pass
Peak efficiency [%]	89.27	89.27	91.22	91.01
Protection	OVP, UVP, OCP, SCP, OTP	OVP, UVP, OCP, SCP, OTP	OVP, UVP, OCP, SCP, OTP	OVP, UVP, OCP, SCP, OTP
CE/RE passing	CE/RE	CE/RE	CE	CE
Release date	Available	Available	Available	Available
Notes	IEC62638+EMC	CE	CE	AP3302A
Test Report (links)	18 W Test Report	20 W Test Report	33 W Test Report	33 W Test Report

Table 2 EZ-PD™ PAG1 reference designs from 18 W to 65 W AC/DC USB-C Power Adapters

Parameter	45 W (QR, DCM)	65 W (QR, DCM)	45 W (QR, DCM)	65 W (QR, DCM)	65 W (Dual-port)
Dimension	43x37.5x30.2	52x42x22	39x835.4x30	52x42x22	51x51x29
Primary FET	TP65H070LSG	IPL60R185C7	IGT60R070D1AT	IGLD60R190D1	IPL60R185C7
Power density [W/in^3] Open Frame	15.15	22.16	28	22.16	14.13
Standby power [mW] @ 230 VAC	27	47	27	43	48
COC Power	Pass	Pass	Pass	Pass	DOE VI
Peak efficiency [%]	91.59	91.77	91.85	92.25	91.01
Protection	OVP, UVP, OCP, SCP, OTP	OVP, UVP, OCP, SCP, OTP	OVP, UVP, OCP, SCP, OTP	OVP, UVP, OCP, SCP, OTP	OVP, UVP, OCP, SCP, OTP
CE/RE passing	CE	CE	CE	CE	CE
Release date	Available	Available	Available	Available	Available
Notes	GaN+CE	CE	CE	CE	CE
Test Report (links)	45 W Test Report	65 W Test Report	45 W Test Report	65 W Test Report	65 W Test Report

The product datasheets and details on the above reference designs can be found on the EZ-PD™ PAG1 web page.

Figure 3 shows Infineon's portfolio of EZ-PD™ PMG1 MCUs and their features, flash size, RAM and GPIO. The product datasheets for these devices can be found on the EZ-PD™ PMG1 web page.

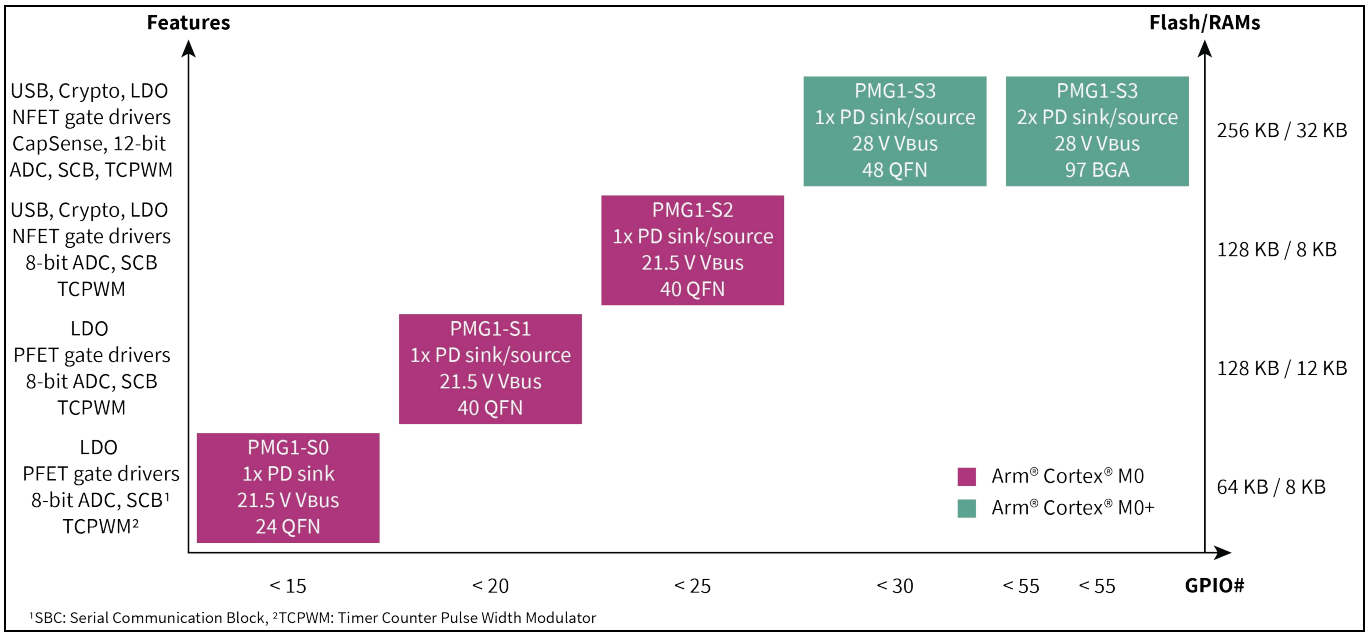

Figure 3 EZ-PD™ PMG1 MCU Product Portfolio

System designers can choose the MCU based on the features and flash size requirements of their end application.

Using any combination of EZ-PD™ PAG1 reference designs listed in Table 1 or Table 2 and EZ-PD™ PMG1 microcontrollers (MCUs) that can natively handle USB-C PD with high levels of integration shown in Figure 2, the system designer can create an end-to-end, easy-to-use, readily available, low BOM solution powered by USB-C PD.

For example, consider a system similar to the one shown in Figure 2 that needs to draw 45 W of power over USB-C while performing basic housekeeping functions like reading a temperature sensor and toggling a few GPIOs. The designer will need a USB-C charger adapter solution that can provide 45 W while needing a USB-C PD sink solution with MCU functionality. In the example solution included in this whitepaper, a CY7110 EZ-PD™ PMG1-S0 prototyping kit is hooked up to an EZ-PD™ PAG1 reference design.

The USB PD block in the EZ-PD™ PMG1-S0 is used for USB Type-C source attach detection and negotiating a 45 W power delivery contract. EZ-PD™ PMG1-S0 has 14 general-purpose IOs that can be used for system functions. In the example solution, a GPIO is used to detect system enable/disable functions. It is connected to the user switch SW2 in the EZ-PD™ PMG1-S0 kit. The switch replicates the on/off switch functions in real-world applications.

The EZ-PD™ PMG1-S0 has two configurable serial communication blocks (SCB0 and SCB1) that can be configured as I2C, SPI, or UART. The SCBs are configured using a simple GUI configuration tool available in ModusToolbox™. In the current solution, SCB0 is configured as I2C running at 400 kHz. The I2C can be configured to run at 100 kHz, 400 kHz, or 1 MHz. The I2C interface communicates with DPS310, a temperature/pressure sensor from Infineon. System designers can integrate a multitude of sensors, based on their application through either I2C or SPI, with the EZ-PD™ PMG1. SCB1 is configured as UART and is used for printing debug messages and sensor data to the terminal.

All of this was accomplished using the ModusToolbox™. ModusToolbox™ is Infineon's firmware development environment with Windows, macOS, and Linux support. For more details, please refer to ModusToolbox™ online web page.

This EZ-PD™ PMG1-S0 example solution shown in Figure 2 is accompanied by a ModusToolbox™ project that includes firmware libraries, source code, and the necessary documentation to get system engineers started with the EZ-PD™ PMG1. The ModusToolbox™ IDE with the EZ-PD™ PMG1 SDK, prototyping kits, and quick start guides makes firmware development and debugging simple and easy, significantly reducing development time and time-to-market.

Refer to "Getting started with EZ-PD™ PMG1 MCU on ModusToolbox™ software" Application Note to see how it can be used to develop firmware applications for the EZ-PD™ PMG1. This example solution is supported on the EZ-PD™ PMG1-S0, PMG1-S1, PMG1-S2, and PMG1-S3 boards. Remember to use the appropriate EZ-PD™ PMG1 Board Support Package (BSP) in ModusToolbox™.

3 Summary

Infineon’s end-to-end USB-C solutions enable easy integration of USB-C PD ports into embedded applications by providing a market-proven USB-C PD stack, ensuring spec compliance and interoperability, so embedded firmware engineers and system designers can focus their efforts on developing applications using the ARM Cortex MCU on the EZ-PD™ PMG1.

The integration of ARM Cortex M0/M0+, up to 256 KB flash memory, 32 KB SRAM, USB full-speed device, programmable GPIOs, gate drivers, LDOs, protection circuits, and a USB-IF certified USB-C PD in EZ-PD™ PMG1 leads to a single chip solution with reduced overall Bill of Materials for customers.

The next whitepaper of this series discusses how EZ-PD™ PMG1-S1 can be used as a USB-C power delivery MCU for power sequencing and monitoring, brownout detection, and High-Speed USB communication.

References

[1] Github location for downloading the FW package: https://github.com/Infineon/mtb-example-pmg1-usbpd-sink-dps310-i2c-sensor/

[2] USB Power Delivery specification: https://usb.org/document-library/usb-power-delivery

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