

Designing battery-powered applications with USB-C PD

Make the most of EZ-PD™ PMG1-B1, a high-voltage MCU for USB-PD with an integrated buck-boost battery charge controller

Abstract

Infineon's EZ-PD™ PMG1 family of high-voltage microcontrollers (MCUs) with USB-C Power Delivery (PD) provides an integrated solution for building embedded systems that supply/consume power to/from the high-voltage USB-C port and additionally need an MCU to implement the required product features.

This whitepaper targets embedded firmware engineers and system designers interested in adopting USB-C into their embedded applications, such as smart speakers, IoT hubs, home appliances, internet gateways, power, and garden tools. The purpose is to learn how to develop integrated solutions using EZ-PD™ PMG1-B1, the industry's first high-voltage microcontroller with an integrated buck-boost battery charge controller.

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1 Introduction

USB Type-C ports have become the connector of choice for consumer electronics and will soon be the default connector for embedded applications [1]. This whitepaper targets embedded firmware engineers and system designers interested in including USB-C ports in their embedded applications. It is part of a whitepaper series [2], [3] that provides system-level solutions for the evolving USB-C ecosystem based on [EZ-PD™ PMG1 high-voltage microcontrollers \(MCUs\)](#).

As the world transitions to USB-C-based DC power sources, more and more applications are expected to adopt USB-C ports for sourcing or sinking power. Infineon's EZ-PD™ PMG1 is a family of high voltage microcontrollers (MCU) for USB-C Power Delivery (PD) with 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 and easy-to-use solution while reducing bill of materials (BOM) cost through their high integration.

Figure 1 shows Infineon's portfolio of EZ-PD™ PMG1 MCUs and their features, flash size, RAM and GPIO. System designers can choose the MCU based on the features and flash size requirements of their end application. The product datasheets for these devices are available on the EZ-PD™ PMG1 web page.

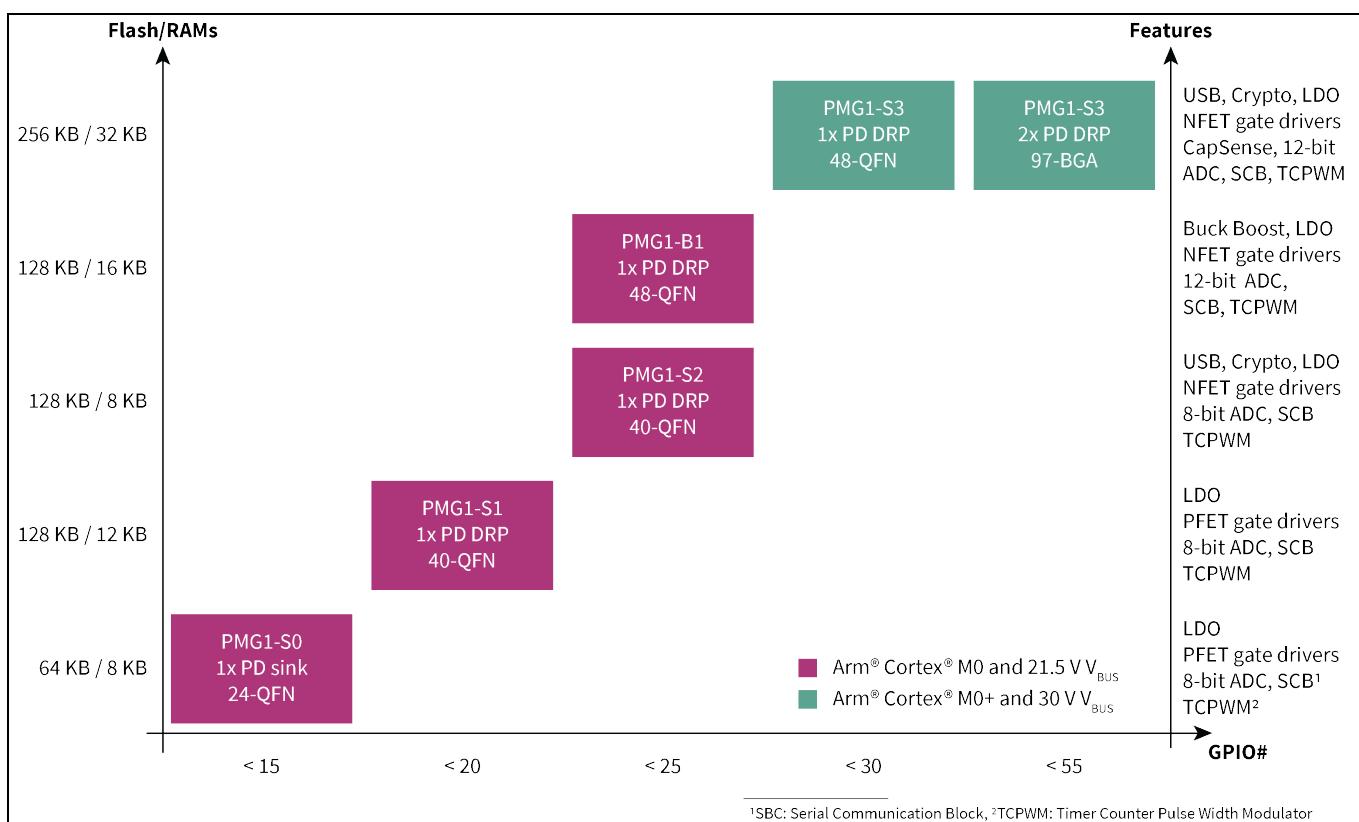


Figure 1 EZ-PD™ PMG1 MCU product portfolio

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In the following whitepaper, we discuss how EZ-PD™ PMG1-B1 MCU can help design battery-powered products that can be charged through a high-voltage USB PD port while needing a microcontroller with the capability to implement system functions. EZ-PD™ PMG1-B1 MCU supports USB-PD 3.1 specification with power levels up to 100 W (20 V, 5 A) on the USB-C port and charging of 3-5 cell batteries (5 V to 21.5 V), providing an integrated system solution for battery-powered applications.

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2 Powering portable electronics using Infineon's EZ-PD™ PMG1-B1 microcontroller

USB Type-C has become the port of choice for powering Portable electronics worldwide. USB-C without Power Delivery (PD) can support up to 5 V at 3 A (15 W), while USB-C Power Delivery (PD) with standard power range (SPR) allows the ecosystem to support several power levels up to a maximum of 20 V at 5 A (100 W). USB-C PD with extended power range (EPR) allows the system to support several power levels up to 48 V and 5 A (240 W). This increase in power level enables many industrial, communications, and consumer applications to adopt USB-C as the charging port of choice, replacing the different barrel connectors in the market.

Portable electronic systems powered by USB-C PD use a USB-PD controller and a buck-boost battery charging controller to charge the battery and power other electronics. EZ-PD™ PMG1-B1, shown in Figure 2, is the industry's first high-voltage microcontroller with an integrated buck-boost battery charge controller.

EZ-PD™ PMG1-B1 is a highly integrated USB Type-C Power Delivery (PD) MCU with integrated buck-boost battery charge controllers. It complies with the latest USB Type-C and PD 3.1 specifications. EZ-PD™ PMG1-B1 has on-chip 32-bit Arm® Cortex®-M0 processor, 128-KB flash, 16-KB RAM, and 32-KB ROM with integrated gate drivers for VBUS NFET on the consumer path for sink application. EZ-PD™ PMG1-B1 also includes hardware-controlled protection features on the VBUS. EZ-PD™ PMG1-B1 supports a wide input voltage range (4 V to 24 V with 40 V tolerance) and programmable switching frequency (150 to 600 kHz), enabling 3-5 cell battery charging in an integrated USB-C PD MCU solution.

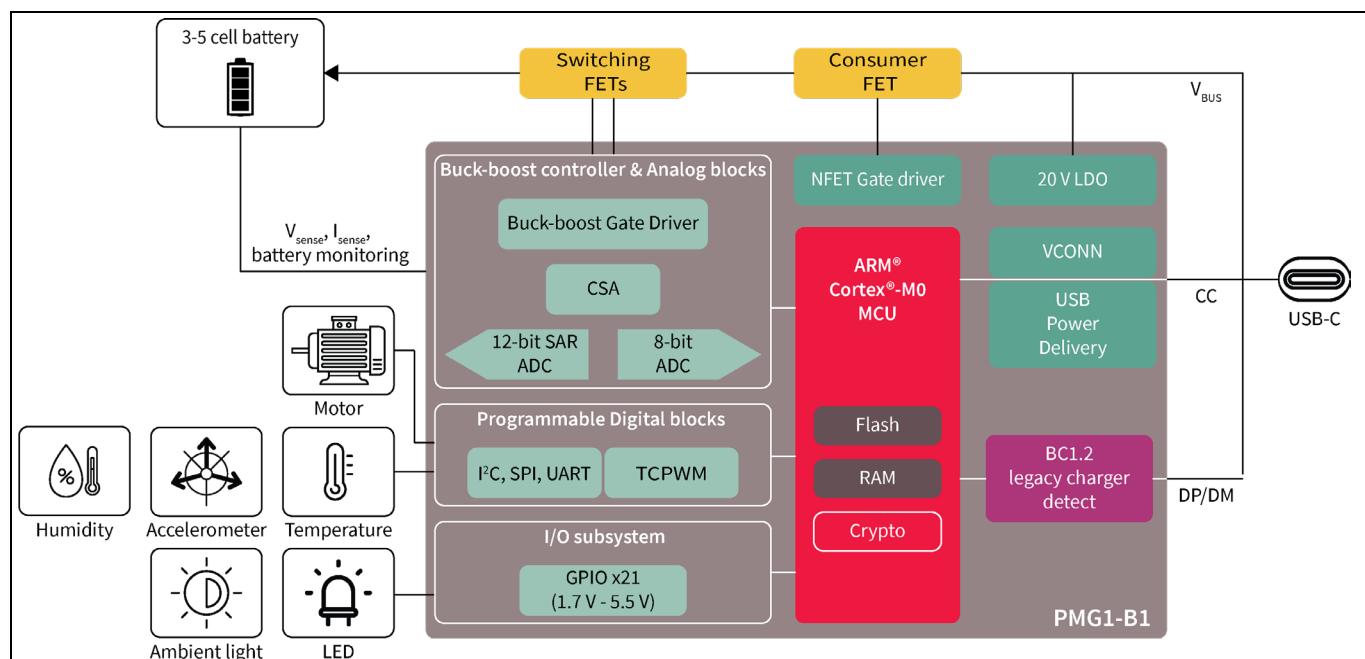


Figure 2 EZ-PD™ PMG1-B1 as a system MCU and buck-boost battery charge controller for 3-5 cell battery-powered applications

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2.1 EZ-PD™ PMG1-B1 for 3 to 5-cell battery-powered portable electronics

Figure 3 shows a block diagram of a portable electronic device, such as a Bluetooth speaker powered through a USB-C port. In this application, EZ-PD™ PMG1-B1 acts as a USB-C PD Sink enabling the charging of the battery in the system. EZ-PD™ PMG1-B1 negotiates USB-C PD power up to 100 W (20 V, 5 A) with the connected power adapter powered by an [EZ-PD™ PAG1](#) power adapter.

The integrated buck-boost battery charge controller enables voltage conversion to charge the battery in the system. EZ-PD™ PMG1-B1 devices can be configured to operate in buck-boost mode, buck-only mode, or boost-only mode. While buck-boost mode requires four external switching FETs, buck-only and boost-only modes need only two FETs.

Imagine a portable electronic device with a 3-cell battery that can benefit from USB-C PD charging at 12 V, 3 A. USB-C PD Power adapters from 15 W to 140 W are currently available in the market. If a 15 W (5V, 3A) power adapter is used to power the device, EZ-PD™ PMG1-B1 acts like a boost converter to charge the battery at a higher voltage and current. If the power adapter is able to provide 15 V or 20 V, then EZ-PD™ PMG1-B1 will act like a buck converter to charge the system.

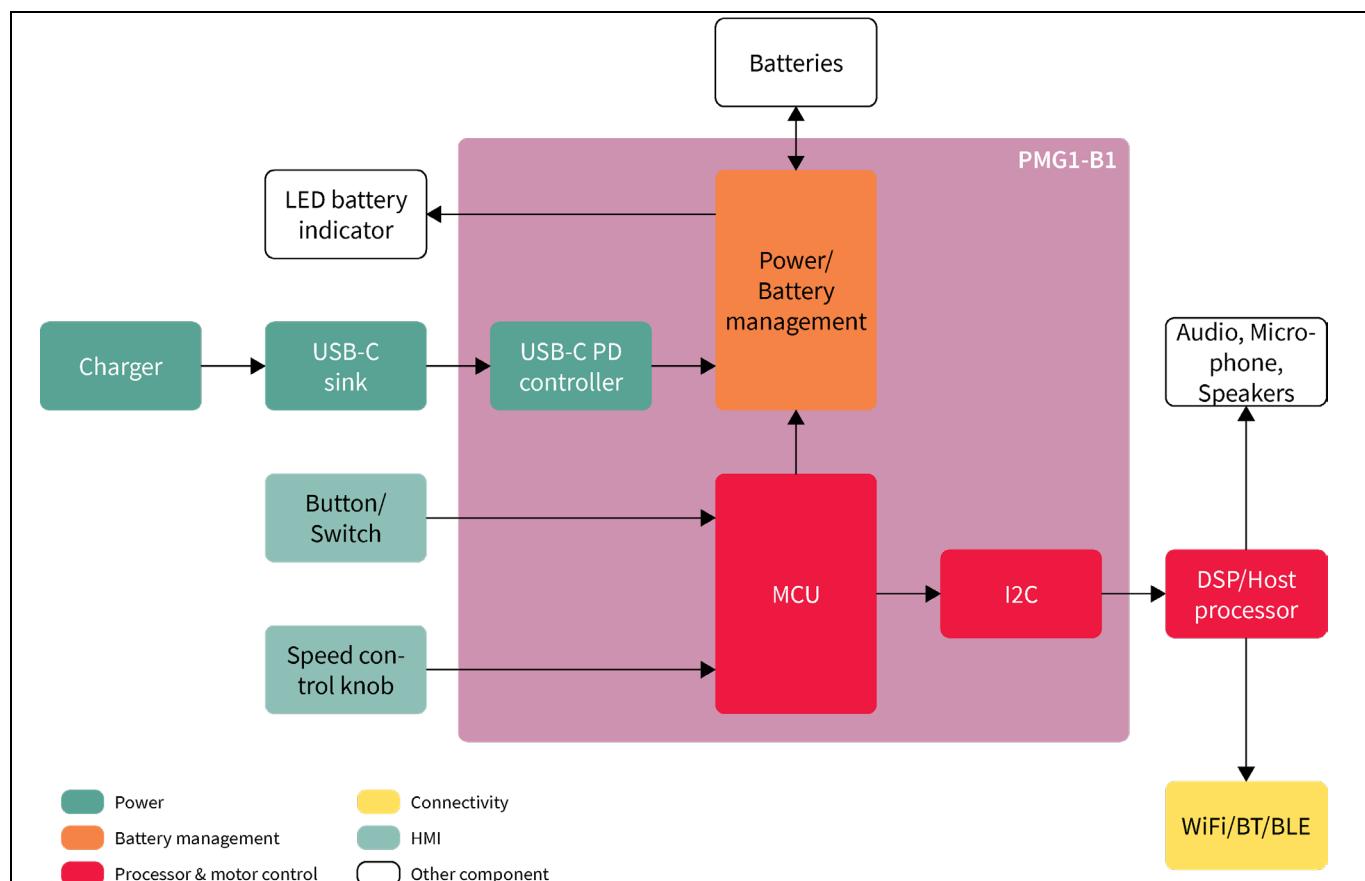


Figure 3 EZ-PD™ PMG1-B1 as a system MCU and buck-boost battery charge controller for portable speaker applications

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The buck-boost subsystem in EZ-PD™ PMG1-B1 devices can be configured to operate in buck-boost mode, buck-only mode, or boost-only mode. While buck-boost mode requires four external switching FETs, buck-only and boost-only modes require only two FETs.

EZ-PD™ PMG1-B1 also measures the battery temperature using an external NTC thermistor. EZ-PD™ PMG1-B1 throttles the buck-boost output power based on battery voltage and temperature and shuts off the power under critical conditions. EZ-PD™ PMG1-B1 supports constant current and constant voltage charging of the battery. When no load is connected to the USB Type-C port, EZ-PD™ PMG1-B1 remains in standby mode without switching on the buck-boost controller.

2.2 EZ-PD™ PMG1-B1 for battery-powered brushed DC motor control applications

Portable electronics applications like portable blenders, mixers, toys, and electric shavers can benefit from the system integration offered by EZ-PD™ PMG1-B1. Figure 4 shows a system where EZ-PD™ PMG1-B1 acts as a USB-C PD MCU to sink up to 100 W through the USB-C port while utilizing the buck-boost battery charge controller for charging the battery of the portable blender. The PWMs in EZ-PD™ PMG1-B1 are used to control the power FET to drive the brushed dc motor in the blender. The PWMs and 12-bit ADC in EZ-PD™ PMG1-B1 can be used to support [brushed](#) and [brushless DC motor control](#) applications. EZ-PD™ PMG1-B1 integrates the above functions in a single-chip solution leading to a reduced BOM.

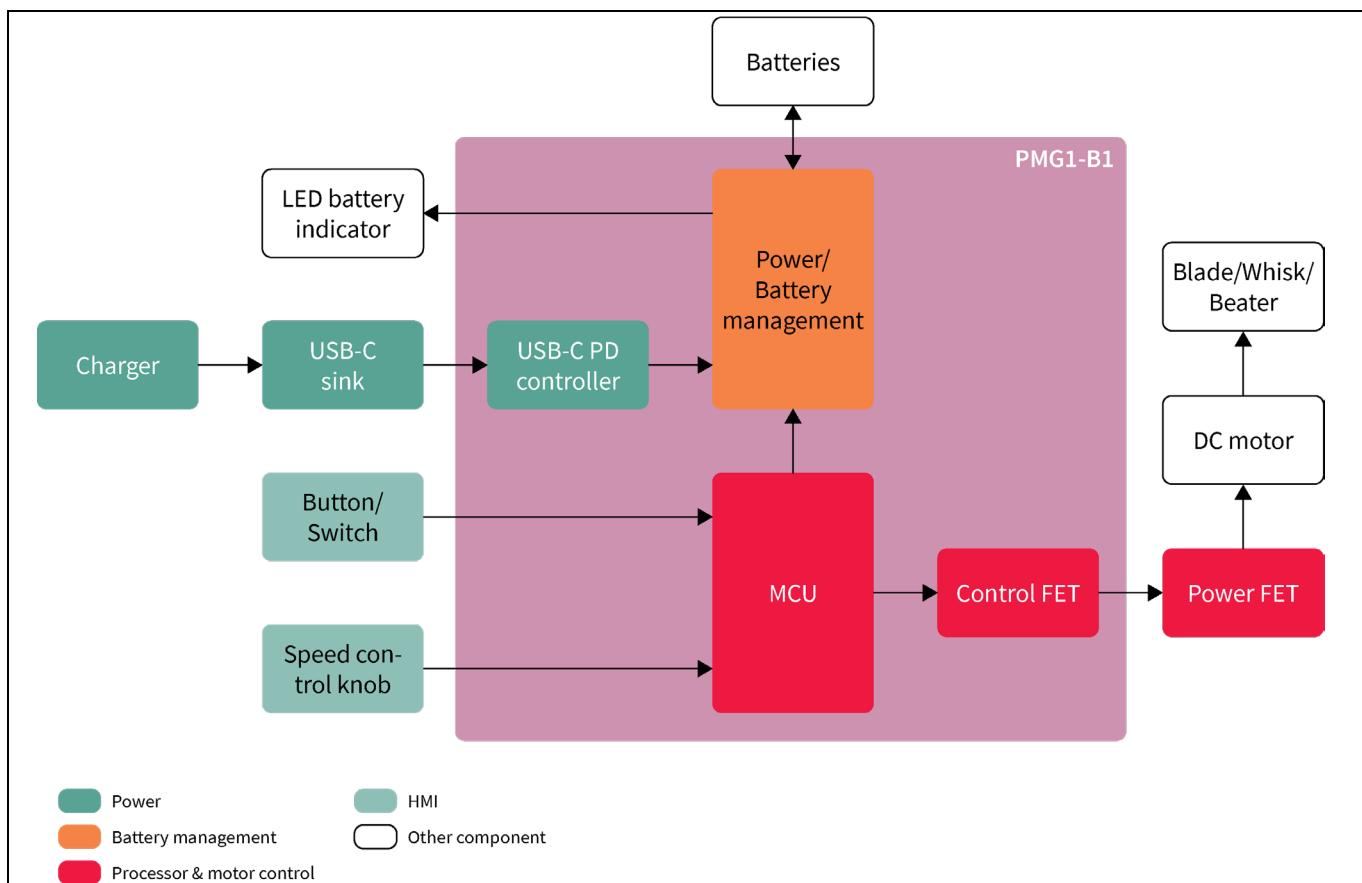


Figure 4 USB-C PD-powered portable kitchen appliance with a brushed DC motor

2.3 ModusToolbox™ development environment

The application development on EZ-PD™ PMG1 is accomplished using the [ModusToolbox™](#) and the EZ-PD™ PMG1 software development kit (SDK). ModusToolbox™ is Infineon's firmware development environment with Windows, macOS, and Linux support.

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. EZ-PD™ PMG1 SDK in ModusToolbox™ also hosts numerous code examples making it simple to develop new applications using the EZ-PD™ PMG1 MCUs.

Refer to the application note "Getting started with EZ-PD™ PMG1 MCU on ModusToolbox™ software" [4] 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](#) kits. PMG1-B1 kits will be available in Q1 2023. 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 and ensuring spec compliance and interoperability. Consequently, embedded firmware engineers and system designers can focus 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, Crypto Block for authentication, and a USB-IF certified USB-C PD in EZ-PD™ PMG1 leads to a single chip solution with a reduced overall bill of materials (BOM) and area for end-customers.

The next whitepaper of this series showcases how the EZ-PD™ PMG1 portfolio of MCUs can support different [motor control applications](#) that are powered by USB-C PD.

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