EZ-PD™ PAG2S-2P 65 W high-frequency QR-ZVS low profile adapter solution user guide

REF_65W_HFZVS_LP_PAG2

About this document

Scope and purpose

This document provides instructions and a quick start guide for the EZ-PD™ PAG2S-2P controller-based Type-C adapter solution (REF_65W_HFZVS_LP_PAG2).

Intended audience

This document is intended for solution developers working with the EZ-PD™ PAG2S-2P high-frequency quasi-resonant zero voltage switching flyback (QR-ZVS) low profile adapter.

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Safety precautions

Note: *Please note the following warnings regarding the hazards associated with development systems.*

Table 1 Safety precautions

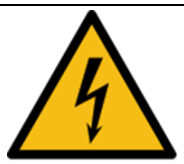	**Warning:** *The DC link potential of this board is up to 1000 VDC. When measuring voltage waveforms by oscilloscope, high voltage differential probes must be used. Failure to do so may result in personal injury or death.*
	**Warning**: *The evaluation or reference board contains DC bus capacitors which take time to discharge after removal of the main supply. Before working on the drive system, wait five minutes for capacitors to discharge to safe voltage levels. Failure to do so may result in personal injury or death. Darkened display LEDs are not an indication that capacitors have discharged to safe voltage levels.*
	**Warning:** *The evaluation or reference board is connected to the grid input during testing. Hence, high-voltage differential probes must be used when measuring voltage waveforms by oscilloscope. Failure to do so may result in personal injury or death. Darkened display LEDs are not an indication that capacitors have discharged to safe voltage levels.*
	**Warning:** *Remove or disconnect power from the drive before you disconnect or reconnect wires, or perform maintenance work. Wait five minutes after removing power to discharge the bus capacitors. Do not attempt to service the drive until the bus capacitors have discharged to zero. Failure to do so may result in personal injury or death.*
	**Caution:** *The heat sink and device surfaces of the evaluation or reference board may become hot during testing. Hence, necessary precautions are required while handling the board. Failure to comply may cause injury.*
	**Caution:** *Only personnel familiar with the drive, power electronics and associated machinery should plan, install, commission and subsequently service the system. Failure to comply may result in personal injury and/or equipment damage.*
	**Caution:** *The evaluation or reference board contains parts and assemblies sensitive to electrostatic discharge (ESD). Electrostatic control precautions are required when installing, testing, servicing or repairing the assembly. Component damage may result if ESD control procedures are not followed. If you are not familiar with electrostatic control procedures, refer to the applicable ESD protection handbooks and guidelines.*
	**Caution:** *A drive that is incorrectly applied or installed can lead to component damage or reduction in product lifetime. Wiring or application errors such as undersizing the motor, supplying an incorrect or inadequate AC supply, or excessive ambient temperatures may result in system malfunction.*
	**Caution:** *The evaluation or reference board is shipped with packing materials that need to be removed prior to installation. Failure to remove all packing materials that are unnecessary for system installation may result in overheating or abnormal operating conditions.*

Table of contents

1 Introduction

EZ-PD™ PAG2P CYPAP212A1-14SXI (Power Adapter Generation 2 Primary) is Infineon's second-generation integrated primary-side start-up controller for AC/DC applications targeting the mobile power adapter segment. PAG2P interfaces with the AC mains rectified output on the primary side and receives the necessary PWM signal from the secondary side to provide a regulated output voltage. PAG2P is designed to complement a secondary controlled AC/DC flyback converter topology. In this topology, voltage and current regulation are performed by the secondary controller (PAG2S). PAG2P is responsible for providing the start-up function, driving the primary-side FET as well as responding to fault conditions.

EZ-PD™ PAG2S CYPAS211A1-32LQXQ is an integrated secondary-side PWM controller and USB Power Delivery (USB PD) controller. PAG2S integrates a secondary side synchronous rectifier (SR), pulse-width modulator (PWM), and zero voltage switching (ZVS) control. PAG2S is targeted towards USB-C power adapters; it fits well into high-efficiency AC-DC flyback designs with USB PD and other standard charging protocols. PAG2S also supports USB PD Extended Power Range (EPR) mode.

Figure 1 shows the application diagram for a power adapter implementing a secondary side controlled synchronous flyback converter topology. PAG2S modulates the pulse width of the primary MOSFET in voltage control mode. PAG2S engages the internal error amplifier (EA) and a programmable ramp generator to determine the pulse width of PWM. The PWM signal is transferred from the secondary to the primary side through a pulse-edge transformer. In this topology, PAG2S integrates three key features: Secondary-side PWM control, charging protocol control, and fault protection. This approach of integrating the ZVS on the secondary side has the following advantage over the traditional primary-side control:

- Programmable high side ON time to reach true ZVS operation to achieve optimized efficiency

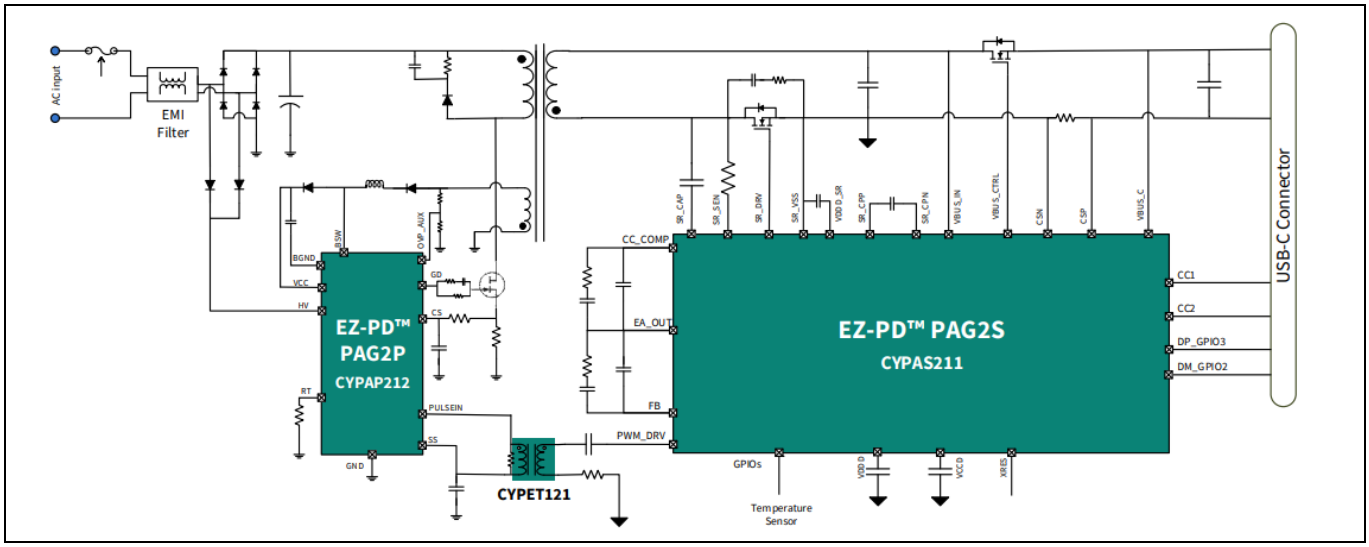

Figure 1 High-level block diagram of EZ-PD™ PAG2S-2P REF_65W_HFZVS_LP_PAG2 solution

Table 2 Critical components bill of materials (BOM)

Designator	Description	Part number	Manufacturer
U2	PAG2P primary side startup controller	CYPAP212A1-14SXQ	Infineon Technologies
U3	PAG2S USB PD power adapter secondary side controller	CYPAS211A1-32LQXQ	Infineon Technologies
Q1	OptiMOS™ N-channel 30 V 19 A	BSZ0902NS	Infineon Technologies
Q4	OptiMOS™ 6 N-channel 120 V 3.04 mΩ	ISC030N12NM6	Infineon Technologies
Q3	700 V 150 mΩ E-mode GaN transistor	GS-065-009-6S-L	Infineon Technologies
T1	118 µH ATQ23.2 power transformer	EF-247004	Better Magnetics Corp
T2	Pulse-edge transformer	ALTWR-C33TF	Infineon Technologies
C2	Capacitor ALUM 120 µF 400 V 12.5 x 42 Radial	MHT400V120UF87EC0448	KNSCHA
C9, C8	Aluminum organic polymer capacitors 560 µF 25 V (6.3 x 10)	NPX 560 µF 25 V 6.3 x 10	Sh-ymin

2 Specifications

Table 3 Test specifications

Parameter	Value
Input voltage and frequency	100 V to 240 V AC, 47 Hz to 63 Hz
Max output power	65 W [20 V, 3.25 A]
Output voltage	Fixed PDOs: 5.0 V/3.0 A, 9.0 V/3.0 A, 15.0 V/3.0 A, 20.0 V/3.25 A
Peak efficiency	>94%
Protections	1. Input overvoltage protection 2. Input undervoltage protection 3. V_{BUS_C} overvoltage protection (OVP) 4. V_{BUS_C} undervoltage protection (UVP) 5. Overcurrent protection (OCP) 6. Short-circuit protection (SCP) 7. Overtemperature protection (OTP) 8. V_{BUS_C} to CC short protection
Charging standards supported	1. USB-C PD v3.1 2. Apple Charging 2.4 A 3. Qualcomm QC 2.0, 3.0, 4.0, 5.0 4. Samsung AFC 5. USB BC 1.2
EMI/EMC	1. Conducted emissions, CISPR32 Class B, 4 dB margin at 115/220 V AC 2. ESD, IEC 61000-4-2, ±8 kV contact, ±15 kV air, Criteria A 3. Surge, IEC 61000-4-5, ±1 kV DM, Criteria B

3 Board overview

The USB PD adapter solution based on EZ-PD™ PAG2S-2P 65 W high frequency QR-ZVS low profile flyback (REF_65W_HFZVS_LP_PAG2) is shown in Figure 2. The solution board is designed to meet the specifications shown in Table 3.

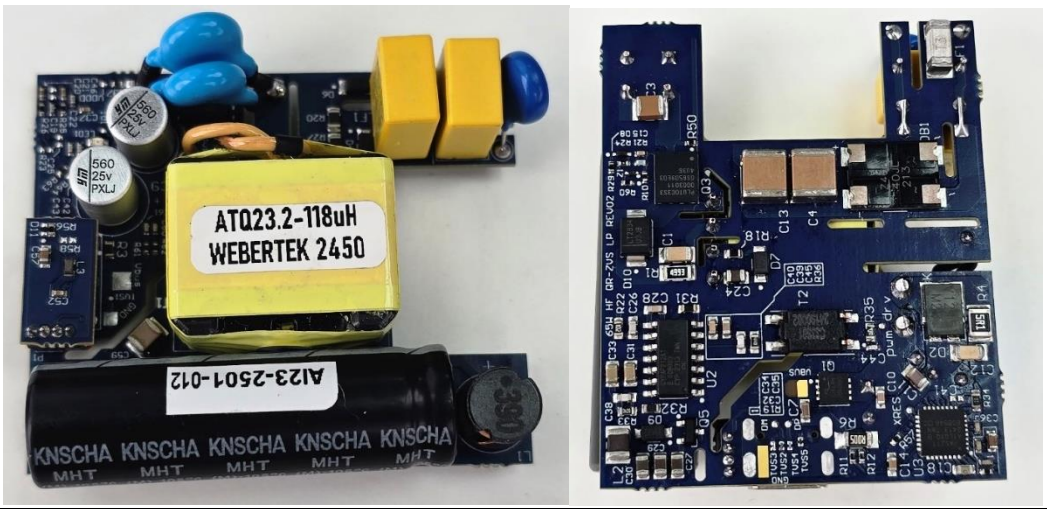

Figure 2 REF_65W_HPZVS_LP_PAG2 solution board

In this solution, EZ-PD™ PAG2x operates with an optimal frequency of 150 kHz and functions as a secondary side flyback and SR controller. The board dimensions are: 54.5 mm × 45.1 mm × 16.25 mm.

REF_65W_HFZVS_LP_PAG2

Board overview

Figure 3 shows the schematic of PAG2S-2P-based 65 W high frequency QR-ZVS low profile flyback adapter solution.

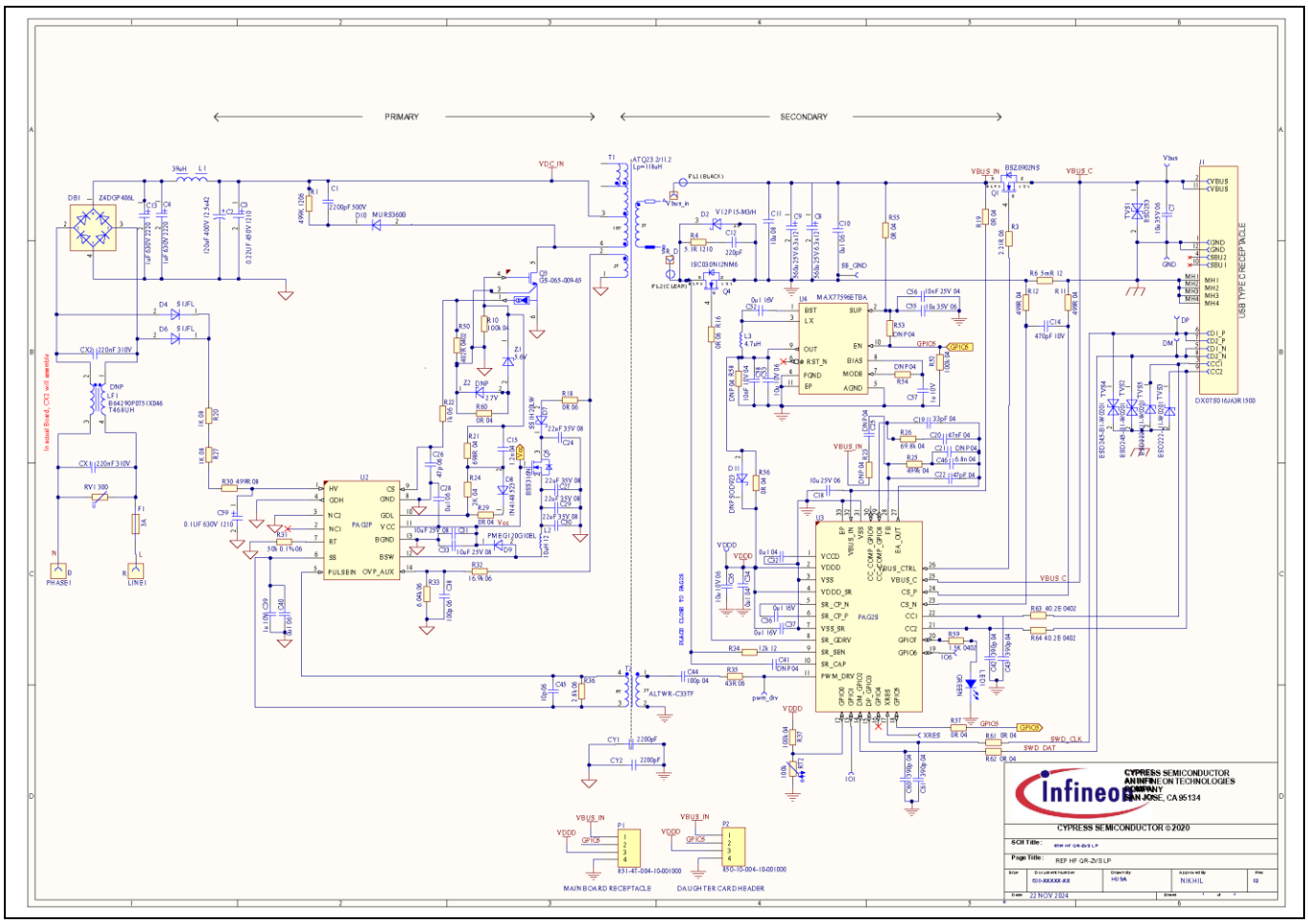

Figure 3 REF_65W_HFZVS_LP_PAG2 schematic

PAG2S uses MiniProg4 Program and Debug Kit (CY8CKIT-005-A), which is an all-in-one development programmer and debugger for PSOC™ 4, PSOC™ 5LP, and PSOC™ 6 MCU devices to program the EZ-PD™ controllers. The PAG2S-based board uses a PSOC™ MiniProg4 five-pin connection and a JTAG to Type-C connector board. In this way, one can simply program the PAG2S-2P-based 65 W QR-ZVS flyback low profile adapter board using a Type-C connector.

Figure 4 MiniProg4 Program and Debug Kit (CY8CKIT-005-A)

3.1 Programming interface and settings

The PSOC™ Programmer software is used as a programming interface to program the firmware (*.hex* file) in an PAG2S-based board. For programming, select the “PAG2S” platform and update the settings as shown in Figure 5.

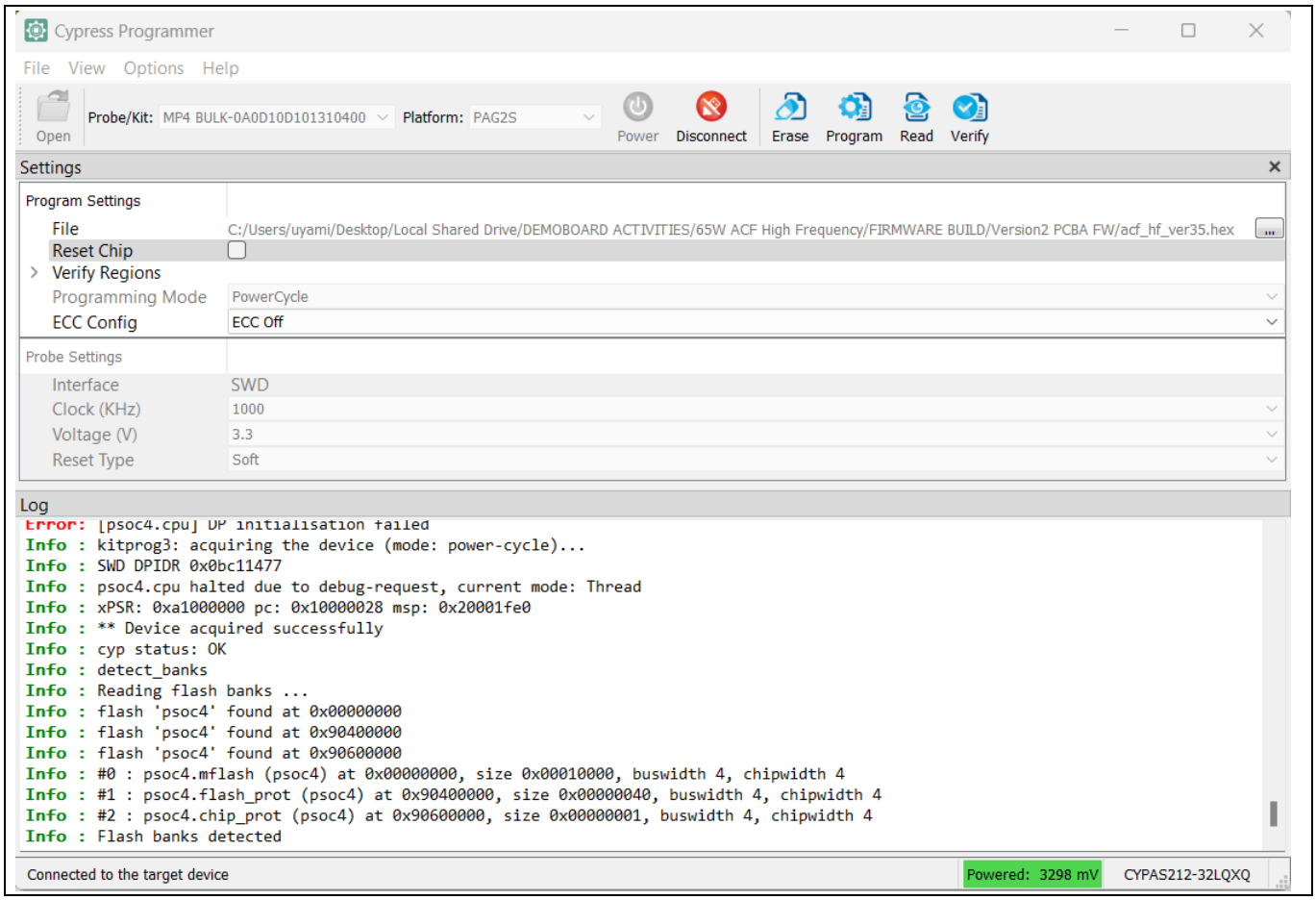

Figure 5 Programming interface to program the PAG2S board

4 Test setup

Figure 6 shows the test setup to measure the electrical data of the DUT. The following is the optimal setup to measure the efficiency:

- Input power using a power meter
- Output power using high-resolution output multimeters

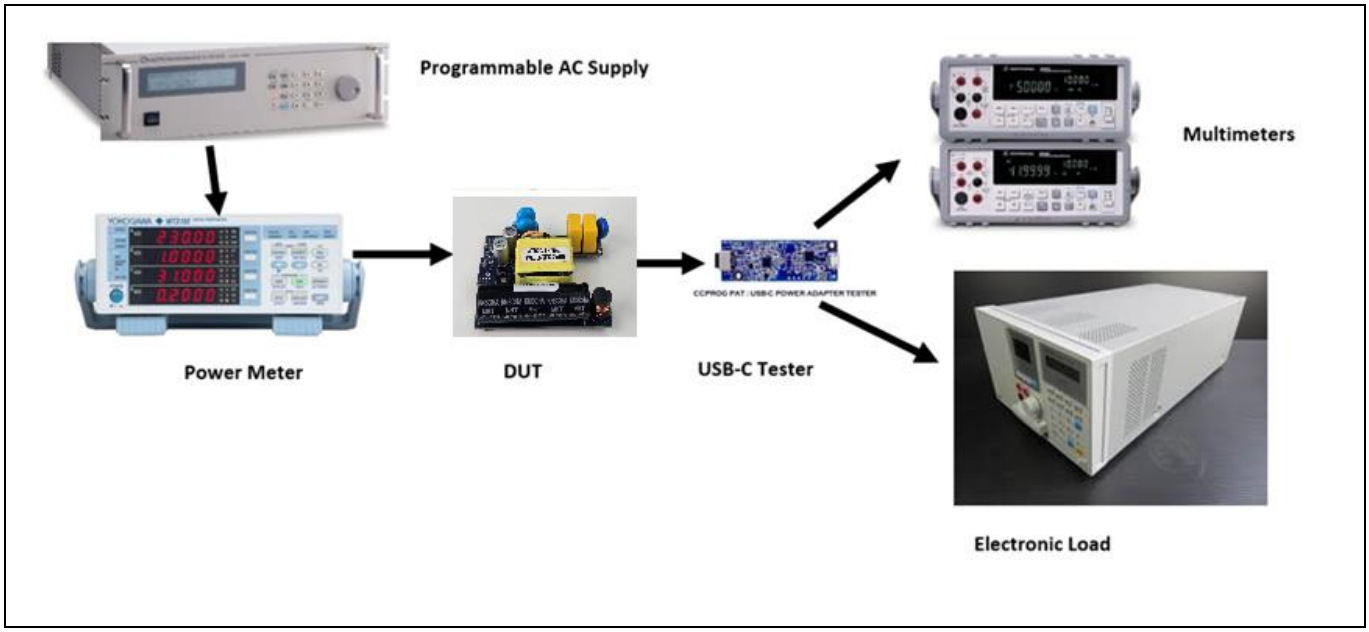

Figure 6 Test equipment connected to the standalone REF_65W_HFZVS_LP_PAG2 board

4.1 Test equipment

Table 4 shows the test equipment to measure performance parameters such as efficiency, ripple, regulation, and transient response.

Table 4 Test equipment details

Test setup	Description
Programmable AC source	Chroma 61501
AC power meter	Yokogawa WT310E
PAT tester	USBCEE PAT
Electronic load	Chroma 63113A
Multimeters	Keysight 34465A

4.2 Power adapter tester (PAT)

Connect the DUT to a USB-C PAT using a USB-C cable. After the connection is established, the PAT UI does a PDO discovery and displays the results.

The PAG2S-2P based 65 W QR-ZVS flyback low profile adapter solution is preconfigured with four PDOs:

- **Fixed PDOs**: 5.0 V/3.0 A; 9.0 V/3.0 A; 15.0 V/3.0 A; 20.0 V/3.25 A

Choose a suitable preconfigured PDO or configure a new one using the EZ-PD™ Configuration Utility. Tests in the following sections use preconfigured PDOs.

To know more about the PAT tester, see USBCEE.

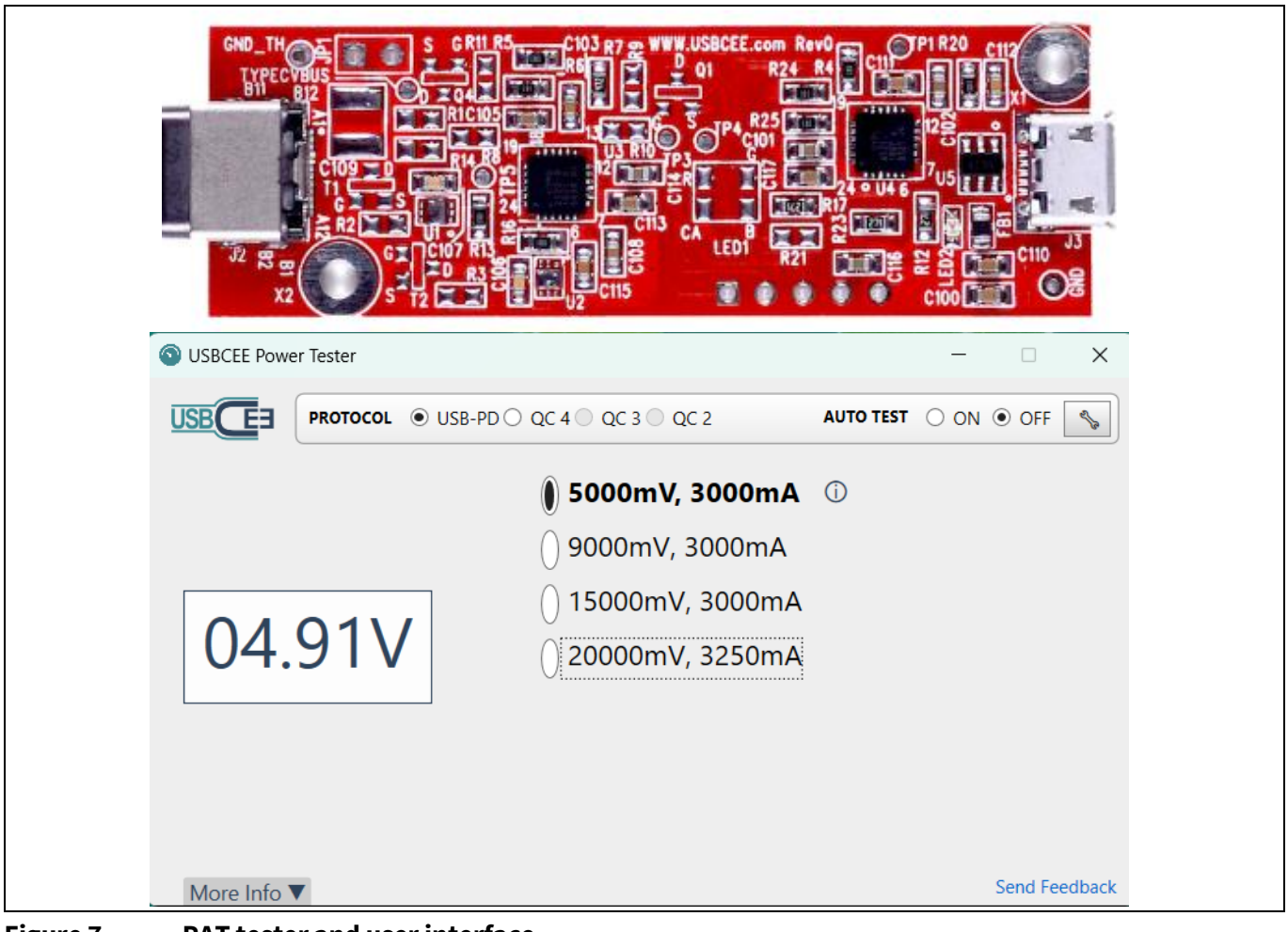

Figure 7 PAT tester and user interface

5 Quick steps for demo

1. Connect the 65 W solution board to a power meter AC terminal that is already connected to the programmable AC supply as shown in Figure 6
2. Connect a USB PD tester or a power adapter tester (PAT) to the port and ensure that the USB PD tester gets a successful Power Delivery contract as shown in Figure 7
3. Connect the electronic load at the PAT tester load terminal as shown in Figure 6
4. Select the desired voltage on the PAT UI and ramp up the load on the electronic load

References

[1] Infineon Technologies AG: *EZ-PD™ PAG2P primary-side startup controller (002-34772 Rev. *F)*; 2023-06-13; Available online

[2] Infineon Technologies AG: *EZ-PD™ PAG2S-QZ integrated USB PD and secondary-side QR-ZVS controller (002-37216 Rev. *C)*; 2023-12-20; Available online

Revision history

Document revision	Date	Description of changes
**	2025-03-18	Initial release

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Edition 2025-03-18

Published by

Infineon Technologies AG

81726 Munich, Germany

Do you have a question about this document?

Email: erratum@infineon.com

Document reference

002-41277 Rev. **

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