USB-C chargers & adapters

The semiconductor offering for high-performing, highly reliable and cost effective charging solutions

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Introduction

Over the last few years, the number of rechargeable battery-powered portable devices has increased substantially. The lack of unification and standardization in the charger and adapter equipment domain led to a situation that each device required its own bulky charger and cable, inconvenient for end-users.

To solve this, the USB-C power delivery (USB-PD) technology, standard for fast-charging and data transfer, gained significant importance. With the primary ambition of simplifying the end-user experience, USB-C PD chargers promise a compact-sized charging solution with higher power, making charging faster and more efficient. However, this convenience comes at the cost of higher engineering efforts.

From the technology point-of-view, the unification headway poses many new challenges to the engineers while laying the foundations of a highly competitive environment.

The latest technology and market trends in chargers and adapters are pushing the envelope of form-factor, charging power, battery capacity, and charging time. These needs are translated into more stringent performance requirements, i.e. a significant increase in power density and efficiency. Engineering teams must fulfill these requirements and at the same time, provide a comprehensive, customer-friendly, and high-quality solution at competitive cost. Ideally, all of these ahead of the competition to harvest the market by gaining more significant market share through a shorter time-to-market.

This selection guide will help designers to find the right-fit system solution that enables high-density USB-C charging designs at competitive cost.

Why Infineon

Ease-of-use and complexity reduction

- **Ready-to-use reference designs**
  A lineup of reference designs for different power ranges and form factor levels reduce design efforts and cost and shorten time to market.
- **Complexity reduction**
  A comprehensive offering of power and protocol controllers, high and low voltage switches and TVS diodes allow customers to source all components from one supplier.

High-efficiency designs

- **High efficiency and power density designs**
  Infineon's solutions based on secondary side controlled QR, Zero Voltage Switching (ZVS) control and hybrid flyback control enable smallest form factor designs.
- **High-efficiency switches**
  Power switches with low $R_{DS(on)}$ and low parasitic capacitances help to improve the system efficiency.
- **High-performance packaging**
  The Kelvin-source engaged ThinPAK and PQFN packages minimize power losses, reduce the PCB space, and improve thermal dissipation capabilities.

Differentiation

- **Programmable USB-C Power Delivery port controllers**
  Infineon's USB-C Power Delivery port controllers integrate either PFET or NFET gate driver for V_{BUS} and are compatible with the latest USB-C Power Delivery standard. Full programmability allow highest flexibility and shortest time to market and support custom protocol additions, legacy protocols and protocol updates.
- **Configurability and upgradeability**
  Infineon's power controllers XDP™ and EZ-PD™ PAG1 offer the flexibility to fix an existing issue or upgrade the firmware via flash or OTP during development, shortening time to market.

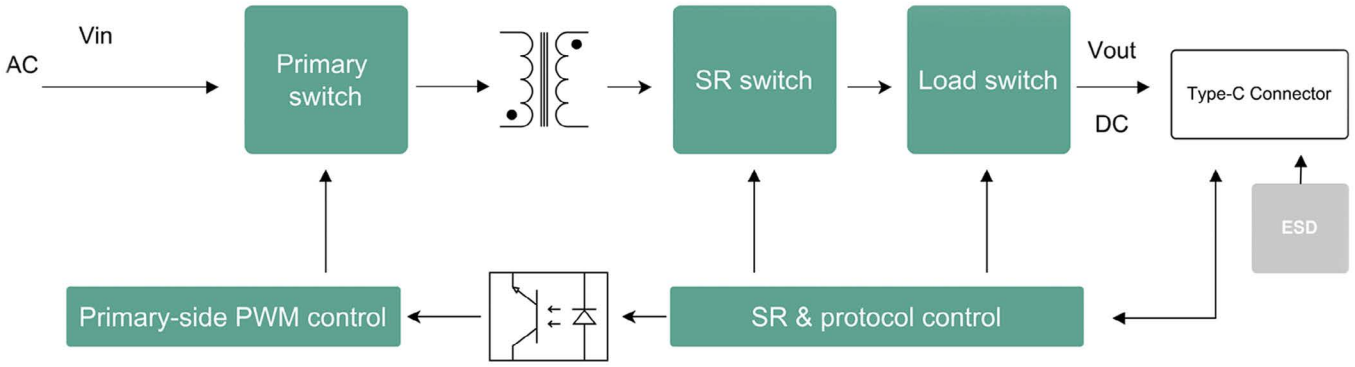
Secured supply chain

- **Capacity and security of supply**
  Infineon has the largest installed in-house power semiconductor capacity with 12" wafer production for discretes to ensure maximum security of supply.
- **Flexibility**
  Infineon offers dedicated supply chain programs to secure capacity and enable flexibility to demand fluctuations.

One-stop-shop - multiple solutions

Application block diagram

Primary side		Secondary side	
HV switch	**Portfolio**	**LV/MV switch**	**Portfolio**
› **Primary switch**	› 600 V/700 V/800 V CoolMOS™ P7 › 600 V CoolMOS™ PFD7 › 600 V/650 V CoolMOS™ C7	› **SR FET**	› OptiMOS™ PD 60 V, 80 V, 100 V, 120 V, 150 V › CoolGaN™ 100 V e-mode HEMT*
	› CoolGaN™ 600 V e-mode HEMT › CoolGaN™ IPS 600 V* (single HEMT + driver) › CoolGaN™ IPS 600 V (half-bridge + driver)	› **Load switch**	› OptiMOS™ PD 25 V, 30 V



Solution offering	PWM controller	SR controller	PD controller
› **20 W – 65 W** QR flyback topology	› EZ-PD™ PAG1P	› EZ-PD™ PAG1S (programmable)	
› **High density 45 W – 65 W** ZVS flyback topology	› XDP™ digital power XDPS21081	› 3rd party	› EZ-PD™ series CCG3PA (programmable)
› **Ultrahigh density 65 W** Hybrid flyback topology	› XDP™ digital power XDPS2201	› 3rd party	› EZ-PD™ series CCG3PA (programmable)
› **45 W/65 W GaN** QR flyback topology	› EZ-PD™ PAG1P	› EZ-PD™ PAG1S (programmable)	
› **Ultrahigh density >65 W *** Hybrid flyback topology	› 3rd party PFC + XDP™ digital power XDPS2210*	› 3rd party	› EZ-PD™ series, CCG3PA (programmable)
› **65 W dual Type-C port***	› EZ-PD™ PAG1P	› EZ-PD™ PAG1S + CCG7D (programmable)	

*coming soon

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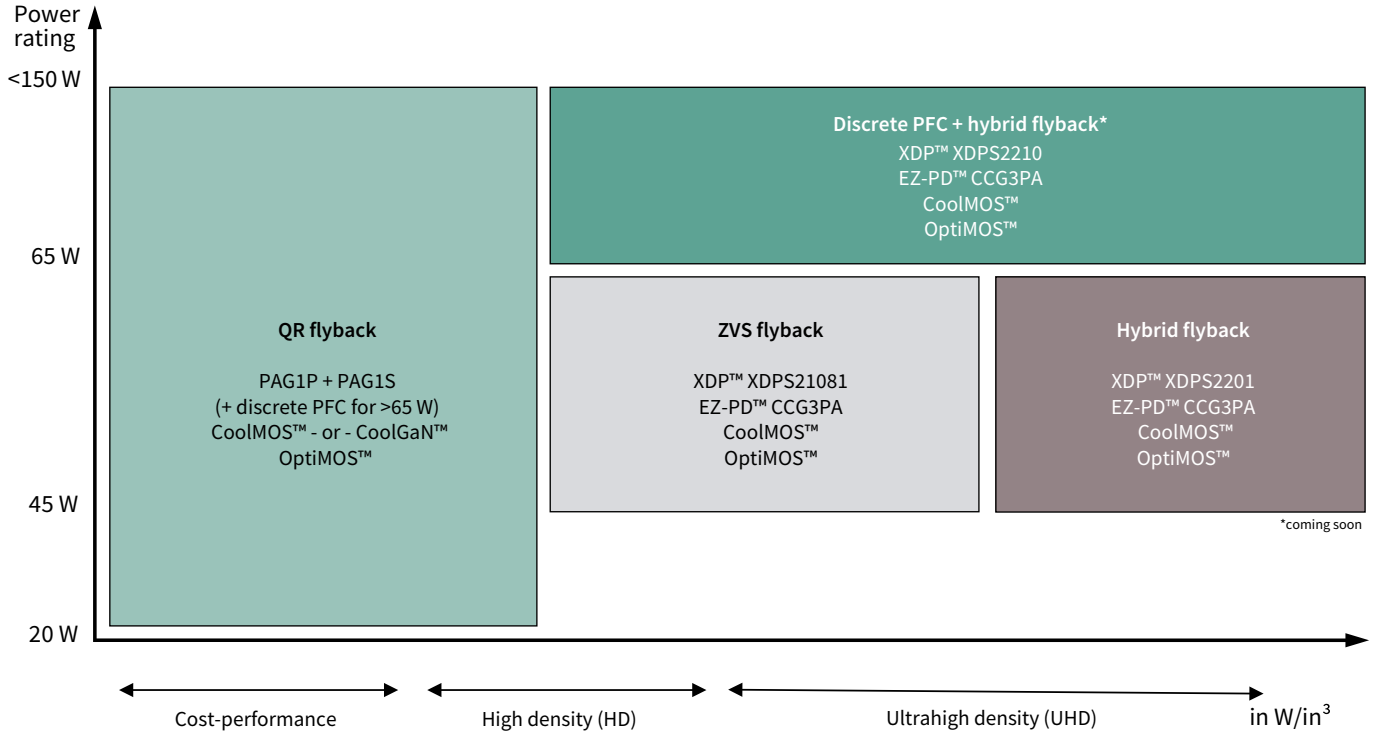
Perfect-fit solutions for prototyping

Shorten your time to market and reduce the development costs. Infineon's offer of reference designs provides the right environment for fast and easy prototyping. With available simulations, technical documentation, and global system support, Infineon is your reliable partner in every step of your USB-C charger design project.



Reference and demo design overview for USB-C chargers & adapters

Infineon offers a lineup of USB-C charger & adapter reference and demo designs based on quasi-resonant (QR), ZVS and hybrid flyback operation, for different power levels and power density requirements. The USB-C power delivery controllers offer full programmability and easy custom specific adoption. All reference designs are built on Infineon's leading switch technologies, ranging from silicon (CoolMOS™ superjunction MOSFETs, OptiMOS™ power MOSFETs) to gallium nitride (CoolGaN™ discretes and integrated solutions).

On the following pages, the related controller ICs and the complete switch portfolio for USB-C chargers and adapters is listed.

Power rating [W]	20	33	65	45	65	65	65
Topology	QR flyback	QR flyback	QR flyback	QR flyback	QR flyback	ZVS flyback	Hybrid flyback
Primary/secondary control	Secondary	Secondary	Secondary	Secondary	Secondary	Primary	Primary
PWM IC	PAG1P	PAG1P	PAG1P	PAG1P	PAG1P	XDPS21081	XDPS2201
SR IC	PAG1S	PAG1S	PAG1S	PAG1S	PAG1S	3rd party	3rd party
USB-PD IC						CCG3PA	CCG3PA
High-voltage PWM switch	CoolMOS™	CoolMOS™	CoolMOS™	CoolGaN™	CoolGaN™	CoolMOS™	CoolMOS™
Medium-voltage SR switch	OptiMOS™	OptiMOS™	OptiMOS™	OptiMOS™	OptiMOS™	OptiMOS™	OptiMOS™
V_{BUS} switch (Load switch)	OptiMOS™	OptiMOS™	OptiMOS™	OptiMOS™	OptiMOS™	OptiMOS™	OptiMOS™
Number of output ports (C=Type -C)	1C	1C	1C	1C	1C	1C	1C
Uncased size in mm x mm x mm	55 x 36 x 21	60 x 35 x 20	52 x 42 x 22	39 x 35.4 x 30.2	52 x 42 x 22	60 x 28 x 25	37 x 43 x 19
Uncased power density (W/in^3)	7.8	12.9	22.16	17.71	22.16	25.4	31
Full-load efficiency @ 264 V V_{IN} (in %)	87.35%	89.86%	90.78%	90.51%	91.82%	92.51%	93.7%
Full-load efficiency @ 100 V V_{IN} (in %)	88.32%	89.28%	88.62%	91.25%	90.40%	90.74%	91.9%
CoC Tier 2 & DoE Level VI compliance	✓	✓	✓	✓	✓	✓	✓
Standby Power (mW) – 230 V_{AC}	<25	<25	<50	<30	<50	<65	<60
Feedback loop	Pulse trf	Pulse trf	Pulse trf	Pulse trf	Pulse trf	Opto cplr	Opto cplr
Programmable USB-PD protocol functionality	✓	✓	✓	✓	✓	✓	✓
USB-PD PPS feature	✓	✓	✓	✓	✓	-	✓
Sales name	CY-SD1125	CY-SD1121A	CY-SD1126	CY-SD1124A	CY-SD1126A	REF_XD-PS21081_65W1	DEMO_XD-PS2201_65W1

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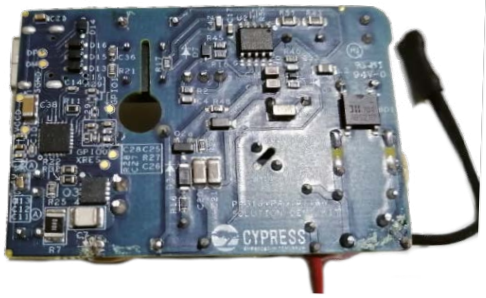
20 W USB-PD/PPS reference design withEZ-PD™ PAG1S+P

This is a 20 W USB-PD Type-C PPS charger demo board that uses Infineon's PAG1S and PAG1P controllers along with Infineon's high- and low-voltage MOSFETs. The solution meets the global efficiency standards including DoE Level VI/ CoC Tier 2 and offers a low standby power of <30 mW

Featured products	
Primary PWM controller	CYPAP111A3-10SXQ
Primary MOSFETs	IPS70R900P7S
Secondary SR MOSFET	BSZ097N10NS5
Load switch	BSZ0902NS
USB-PD IC	CYPAS111A1-10SXQ
Transformer	RM7
Bulk capacitor	42 uF

Technical specification	
Input voltage	90 V_{AC} ~ 265 V_{AC}
Input frequency	47-63 Hz
Output voltage	Variable V_{OUT} by PD protocol: Fixed PDOs : 5 V/3 A, 9 V/2 A, 9 V/2.22 A PPS: 3.3–5.9 V/3 A, 3.3 – 11 V/1.81 A
Output power	18/20 W
Efficiency	EC COCV5 Tier2 and DOELV6 (Peak efficiency of 89.27%)
Standby power (no load)	<30 mW
Board dimensions	55 x 36 x 21 mm^3 (L x W x H)



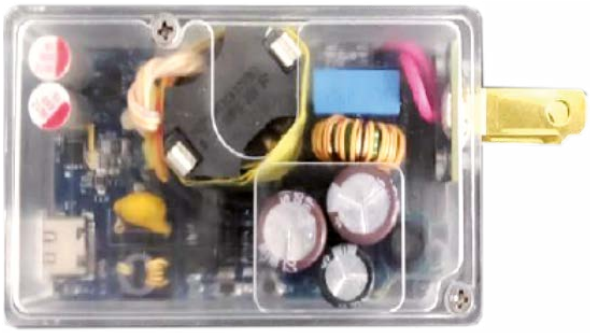
Order code: CY-SD 1125

33 W USB-PD/PPS reference design with EZ-PD™ PAG1S+P

This 33 W USB-PD type C PPS charger demo board comes along with the PAG1S and PAG1P controllers combined with Infineon 's high- and low-voltage MOSFETs. The solution meets the global efficiency standards including DoE Level VI/ CoC Tier 2 and is targeted for USB PD (including PPS), QC power adapters.

Featured products	
Primary PWM controller	CYPAP111A3-10SXQ
Primary MOSFETs	IPA70R600P7S
Secondary SR MOSFET	BSZ097N10NS5
Load switch	BSZ0902NS
USB-PD+SR IC	CYPAS111A1-24LQXQ
Transformer	RM8
Bulk capacitor	59 uF

Technical specification	
Input voltage	90 V_{AC} ~ 265 V_{AC}
Input frequency	47-63 Hz
Output voltage	Variable V_{OUT} by PD protocol: Fixed: 5 V/3 A, 9 V/3 A PPS: 3.3 – 11 V/3 A
Output power	33 W
Efficiency	EC COCV5 Tier2 and DOELV6 (Peak efficiency of 91.22 %)
Standby power (no load)	<30 mW
Board dimensions	60 x 35 x 20 mm^3 (L x W x H)



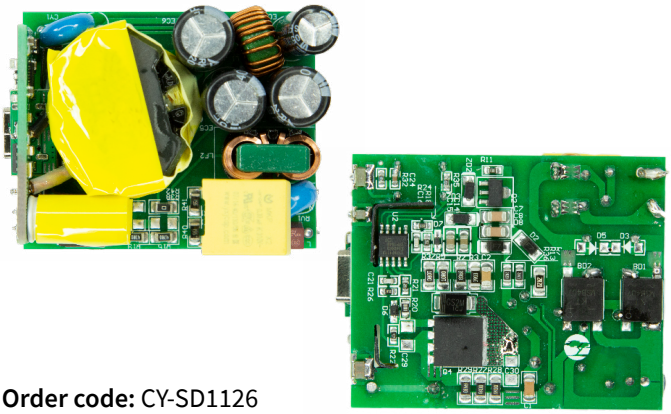
Order code: CY-SD1121A

65 W USB-PD/PPS reference design with EZ-PD™ PAG1S+P

Featured products	
Primary PWM controller	CYPAP111A3-10SXQ
Primary MOSFET	IPL60R185C7
Secondary SR MOSFET	BSC098N10NS5
V_{BUS} MOSFET	BSZ0902NS
PD+SR IC	CYPAS111A1-24LQXQ
Bulk capacitor	103 uF

Technical specification	
Input voltage	90 V_{AC} ~ 265 V_{AC}
Input frequency	47-63 Hz
Output voltage/current	Variable V_{OUT} by PD protocol as: Fixed PDOs: 20 V/3.25 A, 15 V/3 A, 12 V/3 A, 9 V/3 A, 5 V/3 A PPS PDOs : 3.3 – 21 V / 3 A
Output power	65 W
Efficiency	EC COCV5 Tier2 and DOELV6 (peak efficiency of 91.77%)
Input standby power	62 mW @ no load 265 V_{AC}
Power density (uncased)	22.16 W/in^3
Board dimensions	52 x 42 x 22 mm^3 (L x W x H)

The 65 W USB-PD Type-C PPS charger reference design features Infineon's EZ-PD™ PAG1S and PAG1P controllers along with Infineon's high-voltage CoolMOS™ superjunction MOSFET. The solution meets the global efficiency standards including DoE Level VI/ CoC Tier 2 and passes the conducted emission as per EN 55032 B standard.



Order code: CY-SD1126

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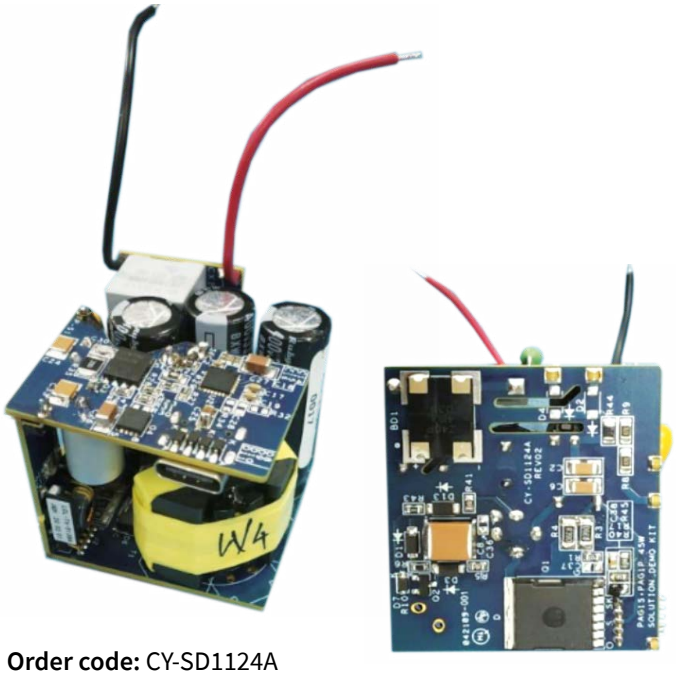
45 W USB-PD/PPS reference design with EZ-PD™ PAG1S+P and CoolGaN™

This 45 W USB-PD type-C PPS reference design features Infineon's PAG1S and PAG1P controllers together with the CoolGaN™ 600 V e-mode HEMT. The solution meets the global efficiency standards including DoE Level VI/ CoC Tier 2 and offers a standby power as low as <30 mW.

Featured products	
Primary PWM controller	CYPAP111A3-10SXQ
Primary MOSFET	IGT60R070D1
Secondary SR MOSFET	BSC160N15NS5
V_{BUS} MOSFET	BSZ0902NS
PD+SR IC	CYPAS111A1-24LQXQ
Transformer	RM8
Bulk capacitor	94 uF

Technical specification	
Input voltage	90 V_{AC} ~ 265 V_{AC}
Input frequency	47-63 Hz
Output voltage/current	Fixed PDOs: 20 V/2.25 A, 15 V/3 A, 9 V/3 A, 5 V/3 A PPS PDOs: 3.3 – 21 V / 2.25 A
Output power	45 W
Efficiency	EC COCV5 Tier2 and DOELV6 (Peak efficiency of 91.85%)
Standby power	<30 mW
Power density (uncased)	17.71 W/in^3
Board dimensions	39 x 35.4 x 30.2 mm^3 (L x W x H)



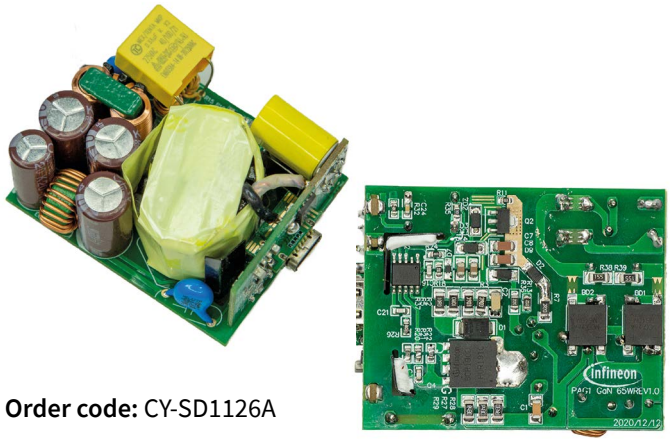
Order code: CY-SD1124A

65 W USB-PD/PPS reference design with EZ-PD™ PAG1S+P and CoolGaN™

Featured products	
Primary PWM controller	CYPAP111A3-10SXQ
Primary MOSFET	IGLD60R190D1S 190 mΩ 8X8
Secondary SR MOSFET	BSC0805LS 100 V 7 mΩ
V_{BUS} MOSFET	BSZ0909LS 30 V 3 mΩ
PD+SR IC	CYPAS111A1-24LQXQ
Transformer	RM10
Bulk capacitor	121 uF

Technical specification	
Input voltage	90 V_{AC} ~ 265 V_{AC}
Input frequency	47-63 Hz
Output voltage/current	Variable V_{OUT} by PD protocol as: Fixed PDOs: 20 V/3.25 A, 15 V/3 A, 12 V/3 A, 9 V/3 A, 5 V/3 A PPS PDOs : 3.3 – 21 V / 3 A
Output power	65 W
Efficiency	EC COCV5 Tier2 and DOELV6 (peak efficiency of 92.25%)
Input standby power	<50 mW @ no load 230 V_{AC}
Power density (uncased)	22.16 W/in^3
Board dimensions	52 x 42 x 22 mm^3 (L x W x H)

The 65 W USB-PD Type-C PPS charger reference design features Infineon's EZ-PD™ PAG1S and PAG1P controllers along with Infineon's high voltage CoolGaN™ 600 V e-mode HEMT. The solution meets the global efficiency standards including DoE Level VI/ CoC Tier 2 and passes the conducted emission as per EN 55032 B standard.



Order code: CY-SD1126A

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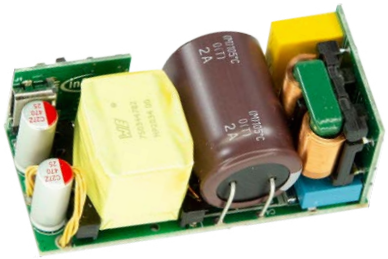
65 W USB-PD reference design with XDPS21081/CCG3PA

Featured products	
Primary PWM controller	XDPS21081
Primary MOSFET	IPL60R185C7
Secondary SR MOSFET	BSC0802LS
ZVS MOSFET	BSL606SN
PD IC	CYPD3174
Output switch	BSZ0910LS
S/R IC	3rd party

Technical specification	
Input voltage	90 V_{AC} ~ 265 V_{AC}
Input frequency	47~64 Hz
Output voltage/current	Variable V_{out} by PD protocol as: 20V/3.25A, 5V/3A, 9V/3A, 12V/3A, 15V/3A
Output power	65 W
Efficiency	EC COCV5 Tier2 and DOELV6
Input standby power	<70 mW @ no load
Board dimensions	60 x 28 x 25 mm^3 (L x W x H)
Power density (uncased)	25.4 W/in^3

This is a 65 W USB-PD Type-C charger reference design in a small form factor. The reference design has been developed to demonstrate the performance by meeting various regulatory limits as well as allowing for small form factor designs. It features Infineon's digital ZVS flyback controller XDPS21081, 600 V CoolMOS™ C7 Superjunction MOSFET, OptiMOS™ PD synchronous rectification MOSFET, CCG3PA USB-C Power Delivery port controller, 30 V OptiMOS™ MOSFET which serves as a safety switch and small-signal MOSFET.



Order code: REFXDPS2108165W1TOBO1

65 W USB-PD/PPS demo design with XDPS2201/CCG3PA

Featured products	
Primary PWM controller	XDPS2201
Primary MOSFETs	IPD60R180C7, IPP60R180C7
Secondary SR MOSFET	BSC093N15NS5
Load switch	BSZ086P03NS3
USB-PD IC	CYPD3174-24
Transformer	RM8
Bulk capacitor	100 uF

Technical specification	
Input voltage	90 V_{AC} ~ 265 V_{AC}
Input frequency	50/64 Hz
Output voltage/current	Variable V_{out} by PD protocol: 5 V, 9 V, 12 V, 15 V, 20 V & PPS: 5-20 V
Output power	65 W
Efficiency	@100 V_{AC} full power: 93.8%
Input standby power	<0.1 W
Board dimensions	37 x 43 x 19 mm^3 (L x W x H)
Power density (uncased)	31 W/in^3

This is a 65 W USB-PD Type-C PPS charger demo board that uses Infineon XDPS2201 together with two CoolMOS™ superjunction MOSFETs in a half-bridge configuration. It demonstrates high power density and high efficiency with both fixed and PPS output in an ultra-compact form factor supporting up to 65 W.
It features Infineon's digital hybrid flyback controller XDPS2201, dual 600 V CoolMOS™ C7 superjunction MOSFET, OptiMOS™ PD synchronous-rectification MOSFET, CCG3PA USB-C Power Delivery port controller and OptiMOS™ MOSFET which serves as a safety switch.

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Order code: DEMOXDPS220165W1TOBO1

QR flyback chipset EZ-PD™ PAG1S+P

EZ-PD™ PAG1P

The PAG1P is a primary start-up controller for AC/DC applications. It is designed to work with PAG1S in a secondary-side controlled AC/DC flyback converter topology where the voltage and current regulation is performed by PAG1S, and PAG1P provides the start-up function, drives the primary FET, and responds to the fault condition. The PAG1P also supports X-cap discharge-mode for better efficiency.

Key features

- Works across universal AC main input 85 V_{AC} to 265 V_{AC}
- Synchronizes to PWM from the secondary side using a pulse edge transformer
- Integrated low-side gate driver to drive primary side FET
- Integrated high-voltage start-up and shunt regulator
- Supports X-cap discharge mode for enhanced efficiency
- Integrated line UV, OCP, and secondary OVP
- Fixed auto-restart timer for fault recovery
- Programmable soft-start configurable with an external capacitor

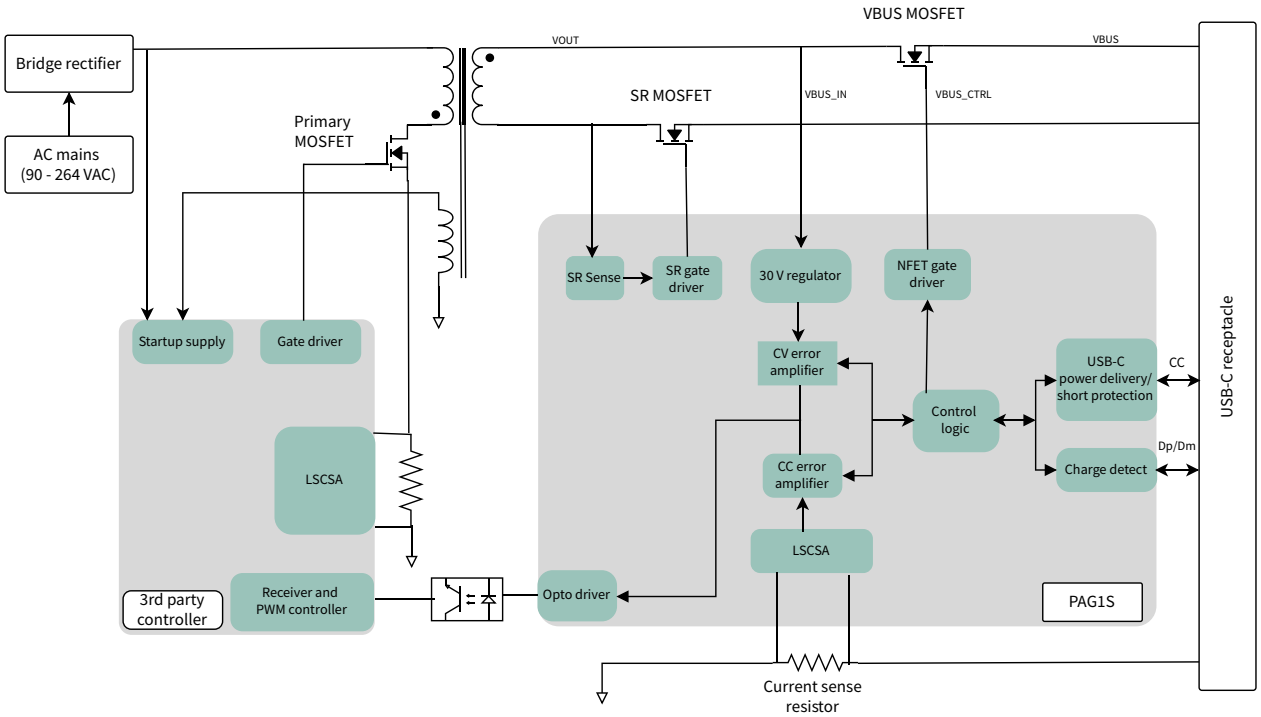
EZ-PD™ PAG1S

The PAG1S is a single-chip, secondary-side controller that integrates the synchronous rectification driver, PD controller, and a wide range of protection circuits. The controller is designed to support a traditional primary controlled flyback architecture, as well as a more efficient secondary controlled flyback architecture with a simple primary start-up up controller. The PAG1S helps design world-class, high-performance power adapters at lower BOM costs.

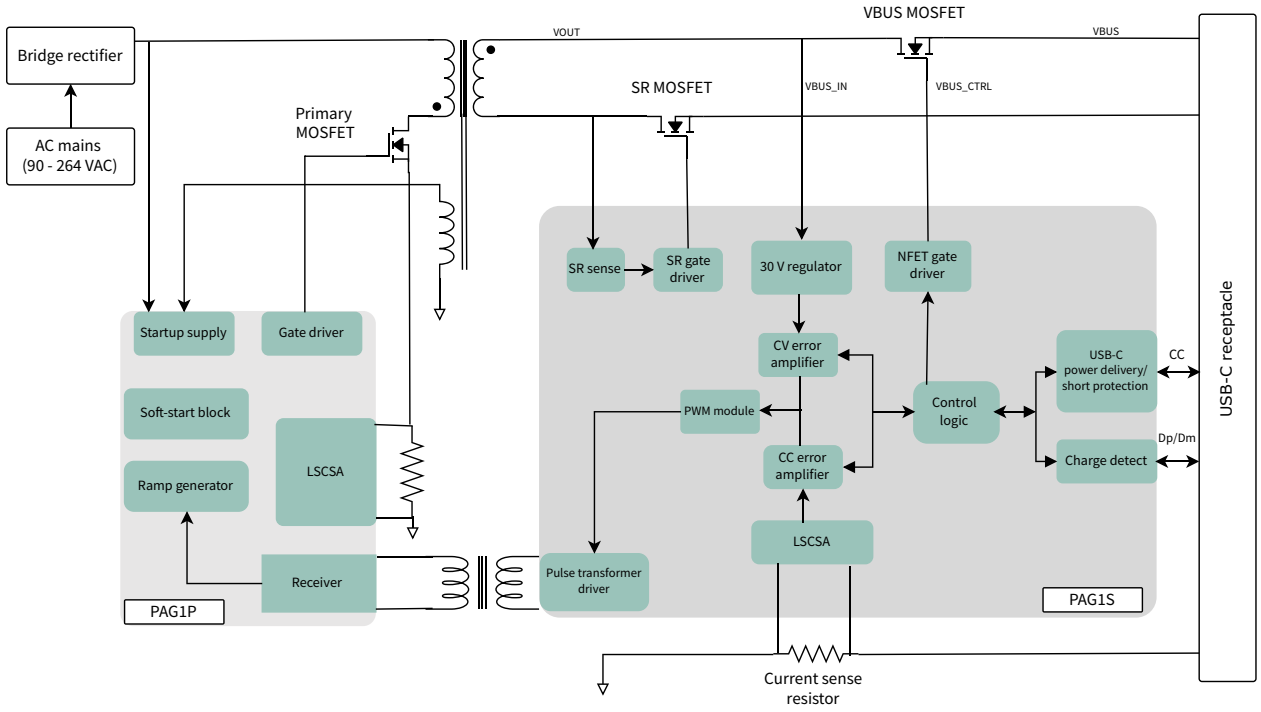
Key features

- Works with both primary-side and secondary-side controlled flyback designs
- Integrates secondary-side regulation, synchronous rectifier (SR), and charging port controller
- Supports quasi-resonant (QR) or critical conduction mode (CrCM), valley switching, discontinuous conduction mode (DCM), and burst mode for light load operations
- Switching frequency range of 20 kHz to 150 kHz
- Higher efficiency across the line and load levels with independent CC/CV loop control
- Supports USB PD 3.0 with PPS (USB-IF certified, TID:1475), QC4+
- Supports legacy charging protocols: BC v1.2, AFC, and Apple charging
- Integrates low side current sense amplifier and V_{BUS} NFET gate drivers
- Available in a 24 QFN (4x4) package

Design example using PAG1S - primary-controlled flyback solution



Design example using PAG1P+S – secondary-controlled flyback solution



Key benefits

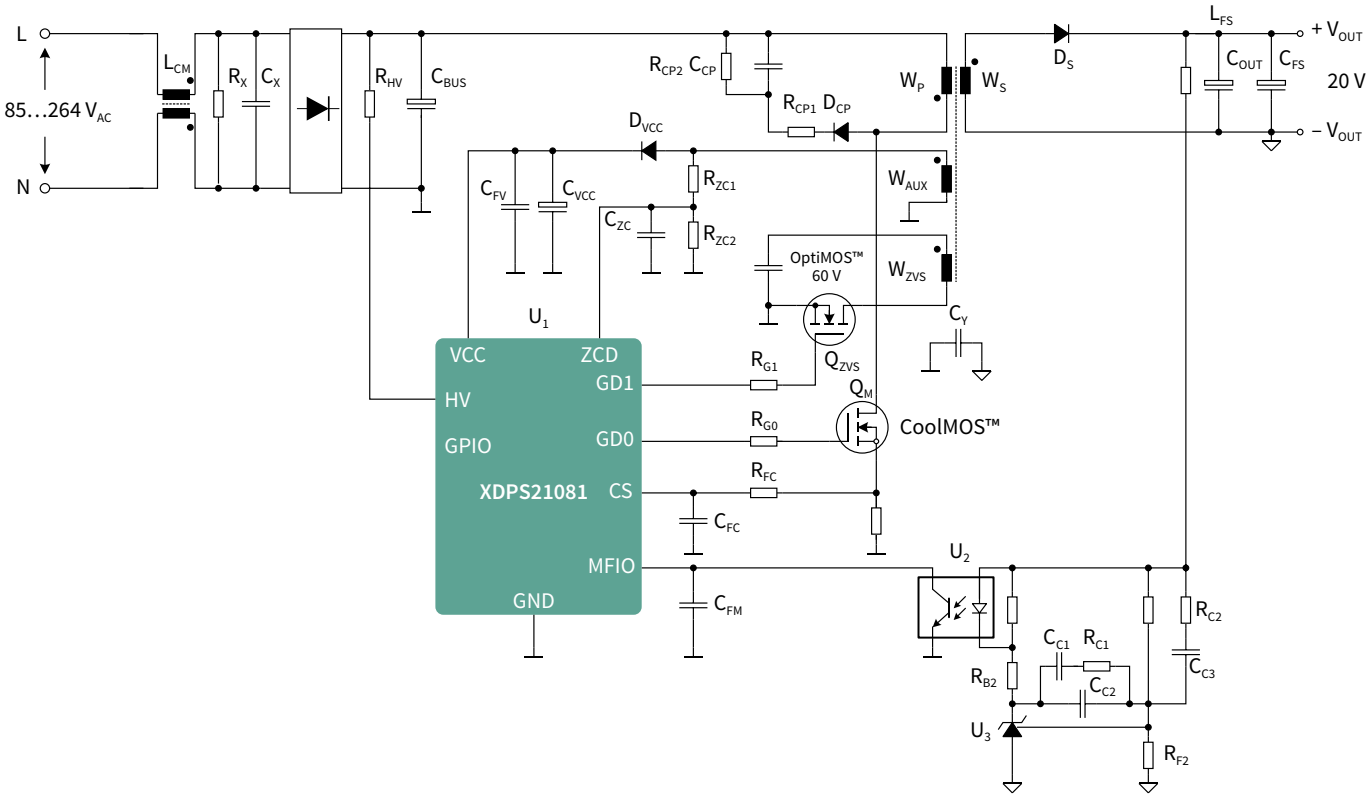
› PAG1 is a highly integrated 2 chip power adapter solution. It integrates SR+PD controller, all necessary protection circuitry, and FET drivers to drive the primary, SR, and load FETs

› The PAG1 solution is built with ARM® Cortex™-M0 and offers the flexibility to program the device as per the customer needs, configure the parameters across multiple platforms as well as upgrade the firmware on the field.

Digital ZVS flyback PWM controller XDP™ XDPS21081

The XDP™ digital power XDPS21081 is a digital flyback controller with ZVS (Zero Voltage Switching) on the primary side to achieve high efficiency with simplified circuitry and economical switches. By driving an external low voltage switch to induce a negative current to discharge the main high voltage MOSFET, switching losses can be reduced further than the traditional valley switching type of switching scheme. To achieve high efficiency with synchronous rectification, the multi-mode digital forced quasi-resonant (FQR) flyback controller ensures DCM (discontinued conduction mode) operation for a safe and robust operation.

Typical application schematic



Key features	Key benefits
› Zero voltage switching › Frequency law optimization › Active burst mode operation with multi-entry/exit threshold Integrated dual MOSFET gate driver › Easy ZVS implementation with an external 60 V MOSFET › CrCM operation with valley detection	› Reduce switching loss and achieve high efficiency › Optimize efficiency across various line/load condition › Optimize light and no-load efficiency › Save BOM count and cost with no messy external driver › Easy to drive, low cost ,and widely available off the shelf 60 V MOSFET › Fail-safe mechanism to limit output power in the event of PD controller failure

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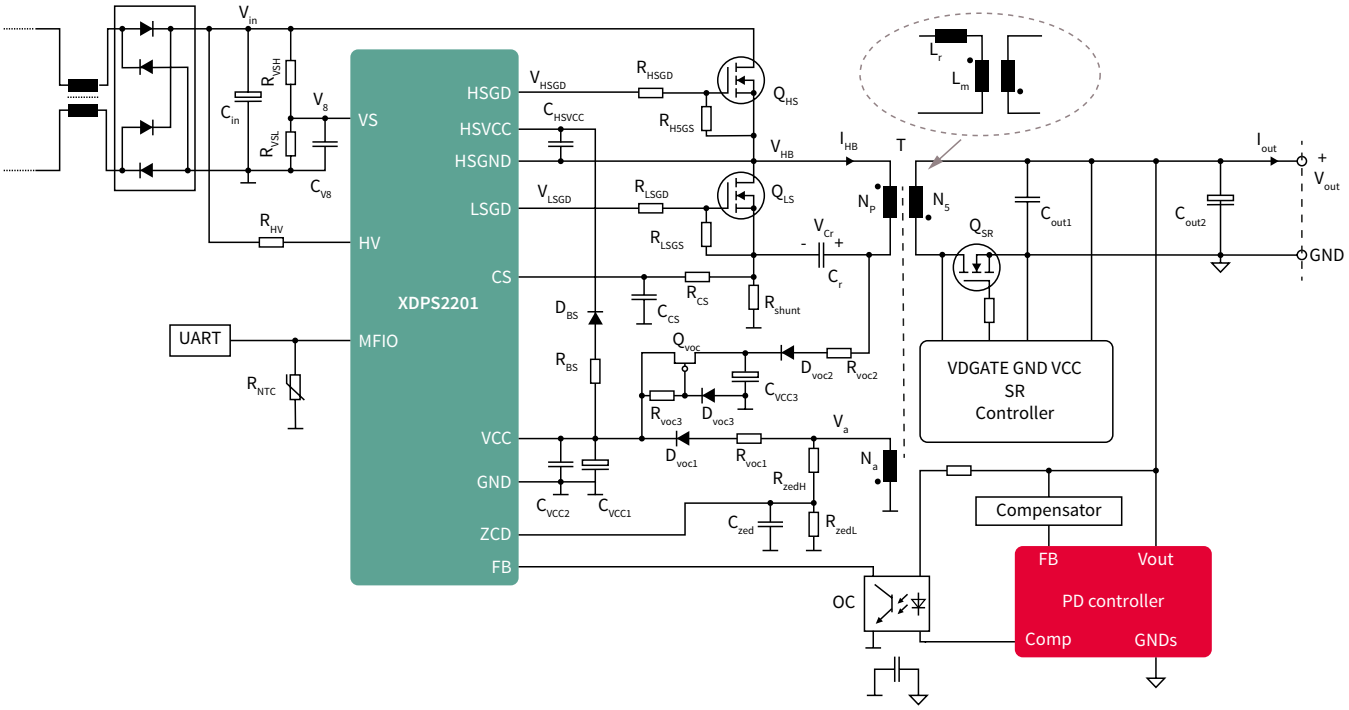
Digital hybrid flyback PWM controller XDP™ XDPS2201

The XDP™ digital power XDPS2201 is a digital multi-mode hybrid flyback controller that combines the simplicity of a traditional flyback topology with the performance of a resonant converter. By utilizing two high-voltage MOSFETs, such as CoolMOS™, the controller can drive both high and low-side MOSFETs in an asymmetric half-bridge flyback topology. Both zero voltage and current switching are achieved through means of regulating the polarity of the magnetizing current to increase efficiency. In addition, transformer leakage energy is recycled and thereby further increases efficiency.

Typical application schematic



Key features

- Zero voltage and current switching across all line, and load conditions
- Multi-mode operation (active burst mode, DCM, ZV-RCS and CRM
- Integrated high-side driver and 600 V start-up cell
- Single auxiliary transformer winding and resonant cap to supply power to IC
- Comprehensive suite of protection feature sets
- Digital platform with configurable parameters

Key benefits

- Reduce switching loss and achieve high efficiency
- Optimize efficiency across various line/load condition
- Save BOM count and cost
- Simplified transformer design to support wide output voltage range
- Robust and safe design
- Optimize and/or scale system performance and behavior to the requirement

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USB Type-C Power Delivery controller EZ-PD™ CCG3PA

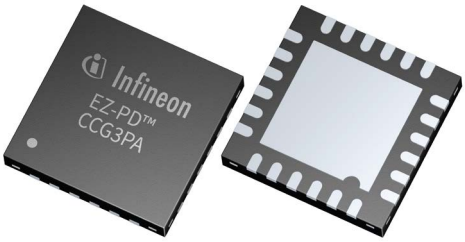
The EZ-PD™ CCG3PA is a single-chip USB Type-C power delivery (PD) controller and ideal for applications such as power adapters, mobile chargers, power banks and car chargers. It integrates USB-C transceiver along with the termination resistors, an integrated feedback control circuitry for voltage (V_{BUS} regulation), a 30V-tolerant regulator, V_{BUS} to CC short protection, a high-voltage PFET gate driver and system level ESD protection. The CCG3PA is a fully programmable solution, that supports Power Delivery 3.0 Programmable Power Supply and Quick Charge 4.0 standards.

Key features

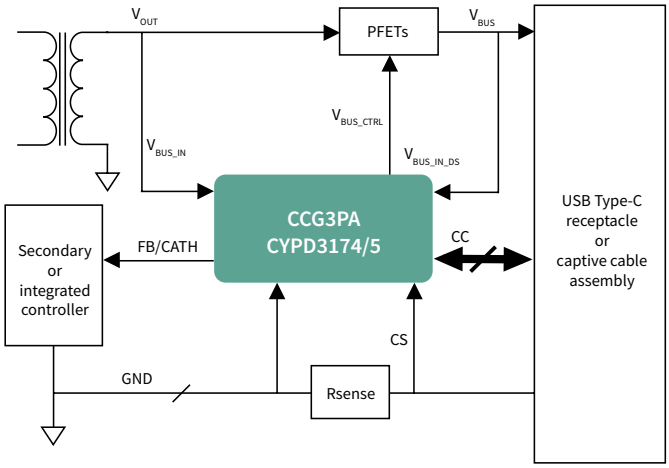
- Supports one USB type-C port and one type-A port
- Supports USB Power Delivery 3.0 PPS
- Supports the legacy protocols including Qualcomm QC 4.0, Apple charging 2.4 A, AFC, BC 1.2 at no additional BOM cost
- Programmable USB-C controller offering the flexibility to implement custom features and upgrade the firmware on the field
- Integrates voltage regulation and current sense amplifier
- Integrates 30 V-tolerant regulator
- On-chip OVP, OCP, UVP, SCP and V_{BUS} to CC short protection
- Integrates a PFET V_{BUS} gate driver
- Integrated system level ESD on V_{BUS}, CC and DP/DM
- Available in 24-pin QFN and 16-pin SOIC packages

Key benefits

- Integrates 30 V-tolerant regulator, including V_{BUS} PFET gate drivers, OVP and OCP circuitry
- Integrates voltage regulation and low-side current sense to support PD3.0 PPS and QC4.0
- Supports PWM/I2C/GPIO interface to control V_{BUS}
- Integrates V_{BUS} to CC short protection and ESD protection



Application schematic



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USB Type-C Power delivery controller EZ-PD™ CCG3PA-NFET

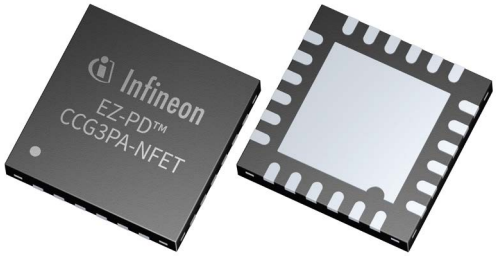
EZ-PD™ CCG3PA-NFET is a highly-integrated USB type-C PD protocol controller that complies with the latest USB type-C and PD standards and is designed for power adapters. It offers significant BOM advantage by integrating all type-C port termination resistors, 24 V-tolerant regulator, a high voltage V_{BUS} NFET gate driver, V_{BUS} to CC short protection, and an integrated feedback circuitry for voltage (V_{BUS}) regulation.

Key features

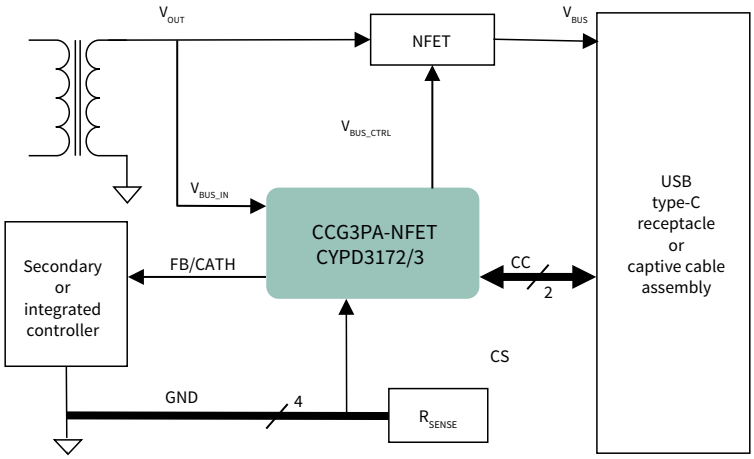
- Supports one USB Type-C port
- Supports USB Power Delivery 3.0 PPS
- Supports the legacy protocols including Qualcomm QC 4.0, Apple charging 2.4A, AFC, BC 1.2 at no additional BOM cost
- Independent CC-CV loop
- Integrates V_{BUS} NFET gate driver
- Programmable USB-C controller offering the flexibility to implement custom features and upgrade the firmware on the field
- On-chip OVP, OCP, UVP, SCP and V_{BUS} to CC Short protection
- Available in 24-pin QFN

Key benefits

- Provides type-C solution with power delivery 3.0 (PD 3.0) with programmable power supply support and quick charge 4.0 (QC 4.0)
- Includes an Arm® Cortex®-M0 and certified USB-PD stack
- Integrates voltage regulation, 24-V-tolerant regulator, V_{BUS}-to-CC short protection and high-voltage NFET gate driver
- Supports field upgrades with free, fully-compliant firmware



Application schematic



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CoolMOS™ high-voltage superjunction MOSFETs

Manufacturers of slimmer and lighter chargers require cost-effective MOSFETs in small packages that feature good electromagnetic interference (EMI) and excellent thermal performance, enabling high efficiency and low standby power. Infineon offers a wide range of high-voltage superjunction MOSFETs. For example, the CoolMOS™ P7 family, which combines high efficiency and optimized cost with ease of use.

600 V CoolMOS™ P7

- Most balanced technology of all CoolMOS™ families
- Integrated Zener diode
- Highest efficiency
- Excellent ease of use and commutation ruggedness
- Competitive price

700 V/800 V CoolMOS™ P7

- Price competitiveness compared to similar competitor technologies
- Supports increased switching frequency to reduce magnetics
- Integrated Zener diode
- Best fit for target applications in terms of
  - Thermals and efficiency
  - Ease of use level

600 V CoolMOS™ PDF7

- Minimizing switching and hysteresis losses
- BOM cost reduction and easy manufacturing
- Robustness and reliability
  - Integrated Zener Diode
  - Up to 2 kV ESD protection

600 V/650 V CoolMOS™ C7

- High switching performance enabling highest efficiency
- Ease of use level high
- Optimized devices for highest efficiency switched-mode power supplies

Soft-switching techniques enable devices to operate in ZVS, which means that the MOSFET is turned on only after its drain-source voltage reaches 0 V (or a value close to 0 V). This strategy eliminates the turn-on loss of the device, which is typically the major contributor to the overall switching loss. Unfortunately, all high-voltage SJ MOSFETs suffer from another type of loss due to their "non-lossless" behavior of the output capacitance. This means that when the MOSFET output capacitance (C_{oss}) is charged and subsequently discharged, some energy will be lost. Therefore, even when operating under ZVS conditions, all the energy stored in the output capacitance (E_{oss}) will not be recovered. This phenomenon is related to the hysteretic behavior of the C_{oss}, as shown below, which can be observed performing a C_{oss} charge/discharge cycle with a large signal measurement. This is why these losses are commonly known as Coss hysteresis losses ($E_{oss,hys}$). CoolMOS™ C7 series well reduce switching loss and hysteresis losses to maximize efficiency.

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600 V CoolMOS™ P7 SJ MOSFETs

The 600 V CoolMOS™ P7 SJ MOSFET family is a general purpose series, targeting a broad variety of applications, amongst them chargers & adapters. It is Infineon's most well-balanced CoolMOS™ technology in terms of combining ease of use and excellent efficiency performance. Compared to its predecessors, it offers higher efficiency and improved power density due to the significantly reduced gate charge (Q_G) and switching losses (E_{OSS}) levels, as well as optimized on-state resistance ($R_{DS(on)}$). The carefully selected integrated gate resistors enable very low ringing tendency and, thanks to its outstanding robustness of body diode against hard commutation, it is suitable for hard as well as soft switching topologies, such as LLC. In addition, an excellent ESD capability helps to improve the quality in manufacturing. The 600 V CoolMOS™ P7 family offers a wide range of on-resistance ($R_{DS(on)}$)/package combinations, including THD, as well as SMD devices, at an $R_{DS(on)}$ granularity from 24 to 600 mΩ and comes along with the most competitive price/performance ratio of all 600 V CoolMOS™ offerings.

Key features

- Suitable for hard and soft switching (PFC and LLC) due to an outstanding commutation ruggedness
- Optimized balance between efficiency and ease of use
- Significant reduction of switching and conduction losses leading to low MOSFET temperature
- Excellent ESD robustness >2 kV (HBM) for all products
- Better $R_{DS(on)}$/package products compared to competition
- Large portfolio with granular $R_{DS(on)}$ selection qualified for a variety of industrial and consumer applications

Key benefits

- Ease of use and fast design-in through low ringing tendency and usage across PFC and PWM stages
- Improved efficiency and simplified thermal management due to low switching and conduction losses
- Higher manufacturing quality due to >2 kV ESD protection
- Increased power density solutions enabled by using products with smaller footprint
- Suitable for a wide variety of applications and power ranges

600 V CoolMOS™ P7: recommended products for chargers & adapters

$R_{DS(on)}$ [mΩ]	DPAK	ThinPAK 8x8	TO-220 FullPAK	TO-220 FP narrow lead	SOT-223
600	IPD60R600P7S		IPA60R600P7S	IPAN60R600P7S	IPN60R600P7S
360/365	IPD60R360P7S	IPL60R365P7	IPA60R360P7S	IPAN60R360P7S	IPN60R360P7S
280/285	IPD60R280P7S	IPL60R285P7	IPA60R280P7S	IPAN60R280P7S	
180/185	IPD60R180P7S	IPL60R185P7	IPA60R180P7S	IPAN60R180P7S	
120/125		IPL60R125P7			
105		IPL60R105P7			

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700 V CoolMOS™ P7 SJ MOSFETs

The 700 V CoolMOS™ P7 family has been developed to serve today's and, especially, tomorrow's trends in flyback topologies. The family products address the low power SMPS market, mainly focusing on mobile phone chargers and notebook adapters. 700 V CoolMOS™ P7 achieves outstanding efficiency gains of up to 4 percent and a decrease in device temperature of up to 16 K compared to the competition. In contrast with the previous 650 V CoolMOS™ C6 technology, 700 V CoolMOS™ P7 offers 2.4 percent gain in efficiency and 12 K lower device temperature, measured at a flyback-based charger application, operated at 140 kHz switching speed.
Keeping the ease of use in mind, Infineon has developed the technology with a low threshold voltage ($V_{GS(th)}$) of 3 V and a very narrow tolerance of ±0.5 V. This makes the CoolMOS™ P7 easy to design-in and enables the usage of lower gate source voltage, which facilitates its driving and leads to lower idle losses. To increase the ESD ruggedness up to HBM class 2 level, 700 V CoolMOS™ P7 has an integrated Zener diode. This helps to support increased assembly yield, leads to reduction of production related failures and, finally, manufacturing cost savings on customer side.

Key features

- Highly performant technology
- Low switching losses (E_{oss})
- Highly efficient
- Excellent thermal behavior
- Allowing high speed switching
- Integrated protection Zener diode
- Optimized $V_{GS(th)}$ of 3 V with very narrow tolerance of the ± 0.5 V
- Finely graduated portfolio

Key benefits

- Cost-competitive technology
- Further efficiency gain at higher switching speed
- Supporting less magnetic size with lower BOM costs
- High ESD ruggedness up to HBM class 2 level
- Easy to drive and design-in
- Enabler for smaller form factors and high power density designs
- Excellent choice in selecting the best fitting product

700 V CoolMOS™ P7: recommended products for chargers & adapters

$R_{DS(on)}$ [mΩ]	TO-220 FP narrow lead 	TO-252 DPAK 	SOT-223 
2000			IPN70R2K0P7S
1400		IPD70R1K4P7S	IPN70R1K4P7S
1200			IPN70R1K2P7S
900	IPAN70R900P7S	IPD70R900P7S	IPN70R900P7S
750	IPAN70R750P7S		IPN70R750P7S
600	IPAN70R600P7S	IPD70R600P7S	IPN70R600P7S
450	IPAN70R450P7S		IPN70R450P7S
360	IPAN70R360P7S	IPD70R360P7S	IPN70R360P7S

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800 V CoolMOS™ P7 SJ MOSFETs

With the 800 V CoolMOS™ P7 series, Infineon sets a benchmark in 800 V superjunction technologies and combines best-in-class performance with the remarkable ease of use. This product family is a perfect fit for flyback-based consumer and industrial SMPS applications. In addition, it is also suitable for PFC stages within consumer, as well as solar applications, fully covering the market needs in terms of its price/performance ratio.

The technology offers fully optimized key parameters to deliver best-in-class efficiency as well as thermal performance. As demonstrated on an 80 W LED driver, bought on the market, the >45 percent reduction in switching losses (E_{oss}) and output capacitance (C_{oss}) as well as the significant improvement in input capacitance (C_{iss}) and gate charge (Q_G), compared to competitor technologies, lead to 0.5 percent higher efficiency at light load which helps to reduce standby power in the end application. At full load, the observed improvement is up to 0.3 percent higher efficiency and 6°C lower device temperature.

Compared to competition, the 800 V CoolMOS™ P7 technology allows to integrate much lower $R_{DS(on)}$ values into small packages, such as a DPAK. This finally enables high power density designs at highly competitive price levels.

Key features

- Best-in-class FOM $R_{DS(on)}$ * E_{OSS}; reduced Q_g, C_{iss} and C_{OSS}
- Best-in-class DPAK $R_{DS(on)}$ of 280 mΩ
- Best-in-class $V_{(GS)th}$ of 3 V and smallest $V_{(GS)th}$ variation of ± 0.5 V
- Integrated Zener diode ESD protection up to Class 2 (HBM)
- Best-in-class quality and reliability
- Fully optimized portfolio

Key benefits

- 0.1% to 0.6% efficiency gain and 2°C to 8°C lower MOSFET temperature as compared to CoolMOS™ C3
- Enabling higher power density designs, BOM savings and lower assembly cost
- Easy to drive and to design-in
- Better production yield by reducing ESD related failures
- Less production issues and reduced field returns
- Easy to select right parts for fine tuning of designs

800 V CoolMOS™ P7: recommended products for chargers & adapters

$R_{DS(on)}$ [mΩ]	TO-220 FullPAK 	TO-220 FullPAK narrow lead 	TO-252 DPAK 	SOT-223 
1400	IPA80R1K4P7		IPD80R1K4P7	IPN80R1K4P7
1200	IPA80R1K2P7		IPD80R1K2P7	IPN80R1K2P7
900	IPA80R900P7		IPD80R900P7	IPN80R900P7
750	IPA80R750P7		IPD80R750P7	IPN80R750P7
600	IPA80R600P7		IPD80R600P7	IPN80R600P7
450	IPA80R450P7	IPAN80R450P7	IPD80R450P7	
360	IPA80R360P7	IPAN80R360P7	IPD80R360P7	
280	IPA80R280P7	IPAN80R280P7	IPD80R280P7	

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600 V CoolMOS™ PFD7 SJ MOSFETs

The 600 V CoolMOS™ PFD7 MOSFET series sets a new benchmark in 600 V superjunction (SJ) technologies, shaped by Infineon's experience of more than 20 years in pioneering in superjunction technology innovation. The series combines best-in-class performance with state-of-the-art ease of use and features an integrated fast body diode ensuring a robust device and in turn reduced BOM for the customer. This product family offers up to 1.17 percent efficiency increase compared to the CoolMOS™ P7 technologies, which leads to a power density increase of 1.8 W/in^3.CoolMOS™ PFD7 pushes the SJ MOSFET technology to new limits leading to outstanding improvement of lower conduction and charge/discharge losses as well as a reduced turn-off and gate-driving losses.
A broad range of $R_{DS(on)}$ values in combination with a variety of packages helps in selecting the right part to optimize designs. Furthermore, an integrated ESD protection of up to 2 kV eliminates ESD-related yield loss. At the same time, especially our industry-leading SMD package offering contributes to bill-of-material and PCB space savings and simplifies manufacturing. This unique set of product features and their resulting benefits, position the CoolMOS™ PFD7 superjunction MOSFET family exceptionally well for ultrahigh density applications like chargers and adapters.

Key features

- Very low FOM $R_{DS(on)}$ x E_{OSS}
- Integrated robust fast body diode
- Ultra-low Q_{rr} and industry's fastest recovery time (T_{rr})
- Up to 2kV ESD protection (HBM class 2)
- Wide range of $R_{DS(on)}$ values and broad package portfolio
- Excellent commutation ruggedness
- Low EMI

Key benefits

- Minimized switching losses
- Power density improvement compared to latest CoolMOS™ charger technology
- Increased efficiency (especially at light-load operation) and improved thermal behavior compared to CoolMOS™ CE technology for home appliance motor drives
- BOM cost reduction and easy manufacturing
- Robustness and reliability
- Easy to select right parts for design fine-tuning

600 V CoolMOSTM PFD7: recommended products for chargers & adapters

$R_{DS(on)}$ [mΩ]	TO-220 FullPAK narrow lead	TO-252 DPAK	SOT-223	ThinPAK 5x6
2000		IPD60R2K0PFD7S	IPN60R2K0PFD7S	
1500		IPD60R1K5PFD7S	IPN60R1K5PFD7S	IPLK60R1K5PFD7
1000		IPD60R1K0PFD7S	IPN60R1K0PFD7S	IPLK60R1K0PFD7
600		IPD60R600PFD7S	IPN60R600PFD7S	IPLK60R600PFD7
360	IPAN60R360PFD7S	IPD60R360PFD7S	IPN60R360PFD7S	IPLK60R360PFD7
280	IPAN60R280PFD7S	IPD60R280PFD7S		
210	IPAN60R210PFD7S	IPD60R210PFD7S		
125	IPAN60R125PFD7S			

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600 V / 650 V CoolMOS™ C7 SJ MOSFETs

The 600 V and 650 V CoolMOS™ C7 Superjunction MOSFET series are designed to achieve record level efficiency performance – they offer substantial efficiency benefits over the whole load range in hard switching applications compared to previous series and competition. This is achieved by minimizing switching losses via ultralow levels of switching losses (E_{OSS}) (approximately 50 percent reduction compared to the CoolMOS™ CP), reduced gate charge (Q_G) and a careful balance of other relevant product key parameters. The low E_{oss} and Q_G also enable operation at higher switching frequency and related size reduction of the circuit magnetics.

Key features

- Reduced switching loss parameters such as Q_G and C_{OSS} enabling higher switching frequency
- 50 percent E_{OSS} reduction compared to older CoolMOS™ CP
- Suitable for hard switching topologies (650 V and 600 V)
- Suitable for high-end resonant (600 V only) topologies

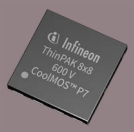
Key benefits

- Increased efficiency in hard switching topologies such as PFC and TTF
- Reduced size and cost of magnetic components by increased switching frequency (e.g. 65 – 130 kHz)
- Increased power density by smaller packages for the same $R_{DS(on)}$

600 V CoolMOS™ C7: recommended products for chargers & adapters

$R_{DS(on)}$ [mΩ]	TO-262 DPAK 	ThinPAK 8x8 	TO-220 FullPAK 
180/185	IPD60R180C7	IPL60R185C7	IPA60R180C7
120/125		IPL60R125C7	IPA60R120C7
99/104		IPL60R104C7	IPA60R099C7

650 V CoolMOS™ C7: recommended products for chargers & adapters

$R_{DS(on)}$ [mΩ]	TO-262 DPAK 	ThinPAK 8x8 	TO-220 FullPAK 
225/230	IPD65R225C7	IPL65R230C7	IPA65R225C7
190/195	IPD65R190C7	IPL65R195C7	IPA65R190C7
125/130		IPL65R130C7	IPA65R125C7
95/99		IPL65R099C7	IPA65R095C7

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CoolMOS™ SJ MOSFET packages for charger & adapter applications

In charger designs, the total loop inductance of the MOSFET (consisting of the gate-source and drain-source inductances) is important to prevent the MOSFET from turning on again and also to reduce EMI. Compared to the DPAK or the FullPAK THD packages, ThinPAK offers a reduction in gate-, drain- and source inductances. Compared with the DPAK package, the internal source inductance of the ThinPAK is also reduced, by 63 percent.

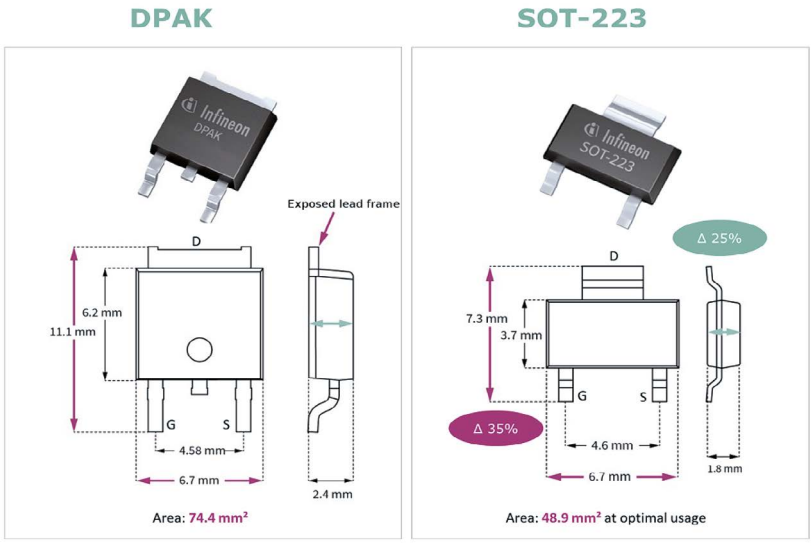
To reduce the ringing on the gate of the MOSFET, the total gate-source inductance ($L_{gate\_loop} = L_{source} + L_{gate}$) is important. When the LC resonant tank is formed by the gate capacitance (C_{iss}) and the total gate loop inductance ($L_{source\_ext.} + L_{gate\_loop}$) is excited by a square wave driving waveform, this can cause ringing on the gate of the MOSFET. By reducing the total L_{gate_loop}, the amount of ringing seen on the gate of the MOSFET can be reduced.

The cost-effective drop-in replacement for DPAK

SOT-223

The SOT-223 package without a middle pin is a cost-effective alternative to DPAK, addressing the need for cost reductions in price- sensitive applications. It offers a smaller footprint, while still being pin-to-pin compatible with DPAK, thus, allowing a drop-in replacement for DPAK and second sourcing. Moreover, SOT-223 achieves comparable thermal performance to DPAK and enables customers to achieve improved form factors or space savings in designs with low power dissipation.

The figure on the right side shows a comparison of the dimensions of the DPAK and SOT-223 packages, the leads of the SOT-223 package will fit directly on the DPAK footprint. This common footprint means that the SOT-223 can easily be used as a direct replacement in existing PCB designs. The SOT-223 comes with a size advantage because it has a 25 percent lower package height and 35 percent shorter package length than the DPAK package. The SOT-223 can achieve similar thermal dissipation performance if the copper area is increased, e.g. by at least 20 mm² to 40 mm², the operating temperature of the SOT-223 device will drop to the same level as the DPAK device.



		$R_{DS(on)}$ [mΩ]									
Voltage [V]	Series	0-59	60-89	90-149	150-199	200-299	300-400	401-600	601-899	900-1500	>1500
600 V	P7						360	600			
700 V	P7						360	450/600	700	900/1200/ 1400	2000
800 V	P7								650/750	900/1200/ 1400	2000/2400/ 3300/4500

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CoolMOS™ SJ MOSFET packages for charger & adapter applications

Solution for slim and small adapters and chargers

ThinPAK 5x6

ThinPAK 5x6 reduces the PCB area by 52 percent and height by 54 percent when compared to the DPAK package which is widely used in chargers and adapters. Also, ThinPAK 5x6 enables a reduced charger and adapter case hot spot temperature by increasing the space between the MOSFET and the charger and adapter case.

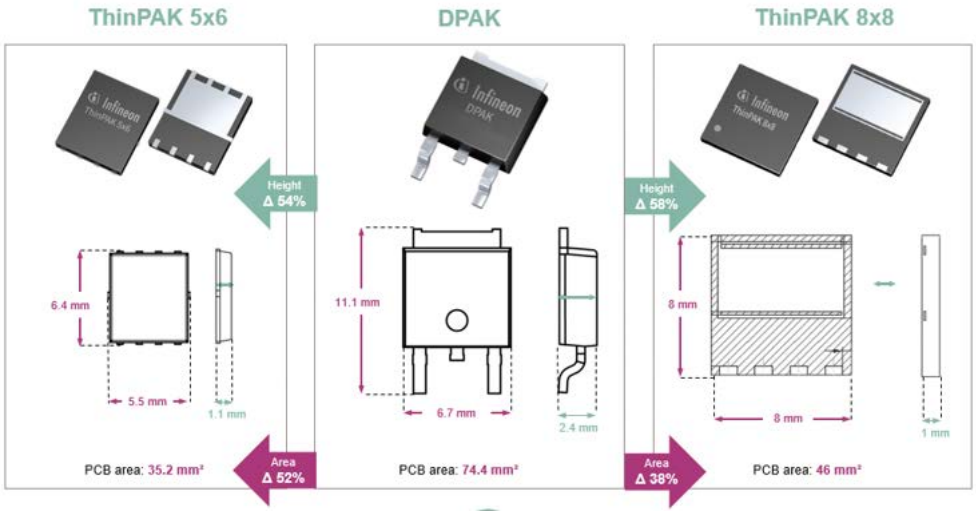
		$R_{DS(on)}$ [mΩ]									
Voltage [V]	Series	0-59	60-89	90-149	150-199	200-299	300-400	401-600	601-899	900-1500	>1500
600 V	PFD7						360	600		1000/1500	

Enabling significant space savings

ThinPAK 8x8

With a very small footprint of only 64 mm² (vs. 150 mm² for the D²PAK) and a very low profile with only 1 mm height (vs. 4.4 mm for the D²PAK) the ThinPAK 8x8 leadless SMD package for high voltage MOSFETs is a first choice to decrease system size in power-density driven designs. Low parasitic inductance and a separate 4-pin Kelvin source connection offer the best efficiency and ease of use. The package is RoHS compliant with halogen-free mold compound.

		$R_{DS(on)}$ [mΩ]									
Voltage [V]	Series	0-59	60-89	90-149	150-199	200-299	300-400	401-600	601-899	900-1500	>1500
600 V	P7		65/85	105/125	185	285	365				
	C7		65	104/125	185						
650 V	C7		70	99/130	195	230					



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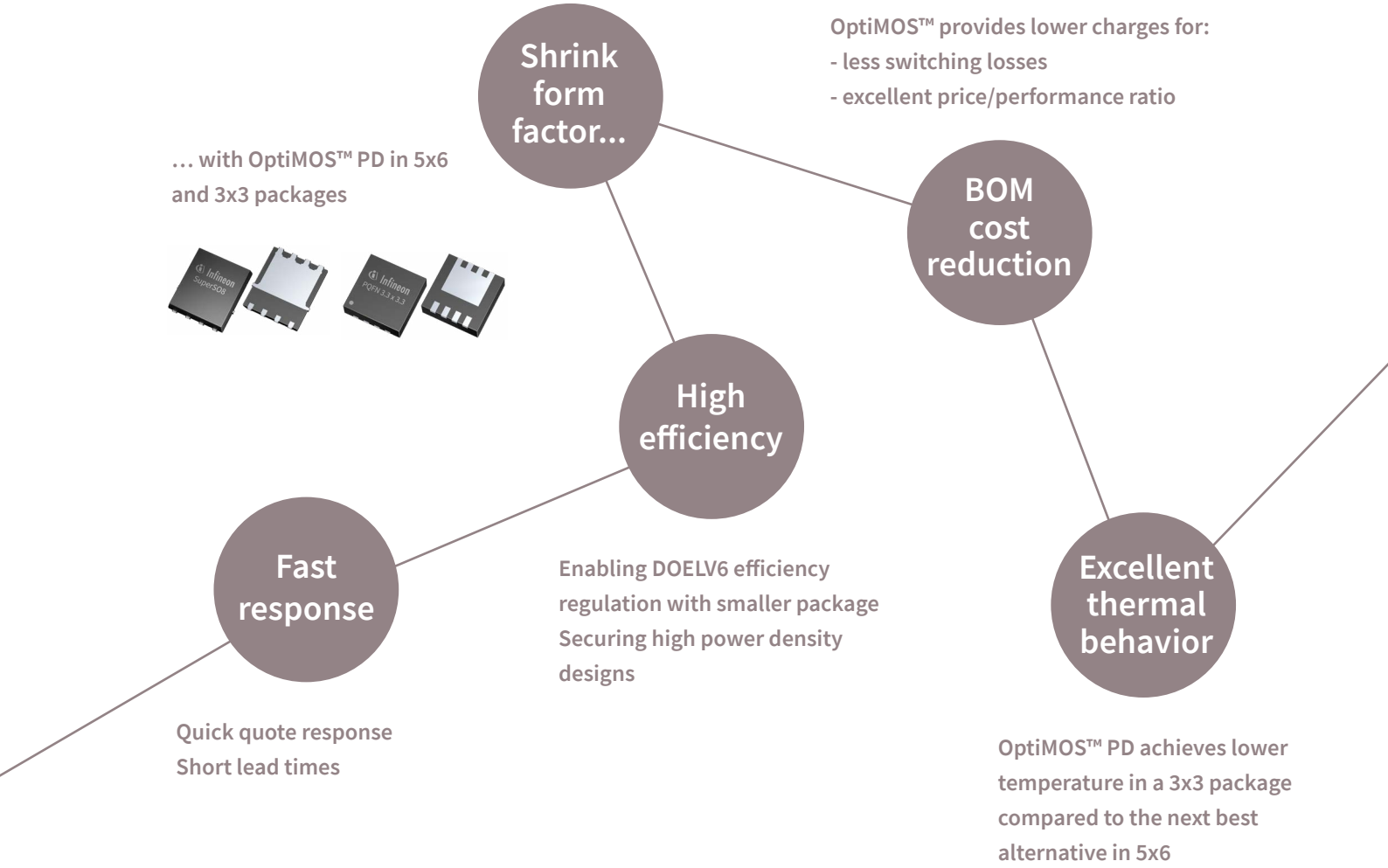
OptiMOS™ PD

The tailor-made portfolio for USB-PD synchronous rectification

Infineon's OptiMOS™ PD low-voltage MOSFET portfolio represents the best fit for USB power delivery and fast charger designs.
OptiMOS™ PD power MOSFETs in PQFN 3.3 mm x 3.3 mm and SuperSO8 packages are optimized for synchronous rectification in charger and adapter SMPS applications. The small package sizes translates into shrinking form factors.

Key features	Key benefits	Value proposition to designers	Value proposition to end customers
Logic Level availability: low threshold voltage	Parts fully driven from 4.5 V or directly from microcontroller → Less parts count	Designs with lower BOM cost	Less costly high quality products
Low on-state resistance ($R_{DS(on)}$) without increasing charges	Lower overall losses	Highest efficiency and power density designs	Compact, lightweight, environmentally friendly products
Low charges – gate, output and recovery	Lower switching losses	BOM cost reduction	Excellent price/performance ratio
Small standard packages (PQFN 3.3x3.3, SSO8)	Space saving packages	Designs with low form factor	More compact products



OptiMOS™ PD: selected highlight products for synch rect in chargers & adapters

	V_{DS}	$R_{DS(on)}$ max. @ V_{GS} = 10 V [mΩ]	Package	Power
ISC0702NLS	60 V	2.8 mΩ	PQFN 5x6	5V/5A;10V/5A
ISC0703NLS	60 V	6.9 mΩ	PQFN 5x6	5V/5A
ISZ0702NLS	60 V	4.5 mΩ	PQFN 3x3	5V/5A
BSZ0602LS	80 V	7.0 mΩ	PQFN 3x3	10V/5A
BSC0802LS	100 V	3.4 mΩ	PQFN 5x6	10V/5A; 100W PD
BSC0805LS	100 V	7.0 mΩ	PQFN 5x6	65W PD
BSC0804LS	100 V	9.6 mΩ	PQFN 5x6	45W/65W PD
BSZ0804LS	100 V	9.6 mΩ	PQFN 3x3	45W/65W PD
BSC0302NS	120 V	8.0 mΩ	PQFN 5x6	65W/100W PD
BSC0402LS	150 V	9.3 mΩ	PQFN 5x6	65W/100W PD

OptiMOS™ PD: selected highlight products serving as loading switch in chargers & adapters

	V_{DS}	$R_{DS(on)}$ max. @ V_{GS} = 10 V [mΩ]	Package	Power
BSZ0909LS	30 V	3.0 mΩ	PQFN 3x3	5V/5A; 10V/5A
BSZ0910LS	30 V	5.7 mΩ	PQFN 3x3	5V/5A; 10V/5A; USB-PD
BSZ0911LS	30 V	7.0 mΩ	PQFN 3x3	USB-PD

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Power MOSFET recommendation for ≤ 65 W

Primary side	V_{DS}	$R_{DS(on)}$	Package	Power
IPN70R1K4P7S	700 V	1.4 mΩ	SOT-223	18 W
IPN70R900P7S	700 V	0.9 mΩ	SOT-223	33 W
IPN70R600P7S	700 V	0.6 mΩ	SOT-223	45 W
IPAN70R600P7S	700 V	0.6 mΩ	TO-220F	45 W
IPL60R365P7	600 V	0.365 mΩ	ThinPAK 8x8	45/65 W
IPN70R360P7S	700 V	0.36 mΩ	SOT-223	65 W
IPD70R600P7S	700 V	0.6 mΩ	TO-252	65 W
IPAN70R360P7S	700 V	0.36 mΩ	TO-220F narrow lead	65 W
IPL60R185C7	600 V	0.185 mΩ	ThinPAK 8x8	65 W
IPL60R185P7	600 V	0.185 mΩ	ThinPAK 8x8	65 W

Synchronous rectification	V_{DS}	$R_{DS(on)}$	Package	Power
ISC0702NLS	60 V	2.8 mΩ	PQFN 5x6	5 V/5 A;10 V/5 A
ISC0703NLS	60 V	6.9 mΩ	PQFN 5x6	5 V/5 A
ISZ0702NLS	60 V	4.5 mΩ	PQFN 3x3	5 V/5 A
BSZ0602LS	80 V	7.0 mΩ	PQFN 3x3	10 V/5 A
BSC0802LS	100 V	3.4 mΩ	PQFN 5x6	10 V/5 A; 100 W PD
BSC0805LS	100 V	7.0 mΩ	PQFN 5x6	65 W PD
BSC0804LS	100 V	9.6 mΩ	PQFN 5x6	45 W/65 W PD
BSZ0804LS	100 V	9.6 mΩ	PQFN 3x3	45 W/65 W PD
BSC0302NS	120 V	8.0 mΩ	PQFN 5x6	65 W/100 W PD
BSC0402LS	150 V	9.3 mΩ	PQFN 5x6	65 W/100 W PD

Loading switch	V_{DS}	$R_{DS(on)}$	Package	Power
BSZ0909LS	30 V	3.0 mΩ	PQFN 3x3	5 V/5 A; 10 V/5 A
BSZ0910LS	30 V	5.7 mΩ	PQFN 3x3	5 V/5 A; 10 V/5 A; USB-PD
BSZ0911LS	30 V	7.0 mΩ	PQFN 3x3	USB-PD

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Power MOSFET recommendation for > 75 W

PFC	V_{DS}	$R_{DS(on)}$	Package	Topology
IPD60R180P7S	600 V	0.18 mΩ	TO-252	PFC
IPAN60R280P7S	600 V	0.28 mΩ	TO-220F	PFC
IPAN60R180P7S	600 V	0.18 mΩ	TO-220F	PFC
IPL60R185C7	600 V	0.185 mΩ	ThinPAK 8x8	PFC
IPL60R125C7	600 V	0.125 mΩ	ThinPAK 8x8	PFC

Flyback or half-bridge	V_{DS}	$R_{DS(on)}$	Package	Topology
IPD60R360P7S	600 V	0.36 mΩ	TO-252	ACF, LLC
IPAN60R600P7S	600 V	0.60 mΩ	TO-220F	ACF, LLC
IPAN60R360P7S	600 V	0.36 mΩ	TO-220F	ACF, LLC
IPL60R365P7	600 V	0.365 mΩ	ThinPAK 8x8	ACF, LLC
IPLK60R360PFD7	600 V	0.36 mΩ	ThinPAK 5x6	ACF, LLC
IPAN70R360P7S	700 V	0.36 mΩ	TO-220F	Flyback
IPA65R225C7	650 V	0.225 mΩ	TO-220F	Flyback
IPL65R230C7	650 V	0.23 mΩ	ThinPAK 8x8	Flyback
IPL65R195C7	650 V	0.195 mΩ	ThinPAK 8x8	Flyback
IPD65R190C7	650 V	0.19 mΩ	TO-252	Flyback

Synchronous rectification	V_{DS}	$R_{DS(on)}$	Package
ISC0702NLS	60 V	2.8 mΩ	PQFN 5x6
ISC0703NLS	60 V	6.9 mΩ	PQFN 5x6
ISZ0702NLS	60 V	4.5 mΩ	PQFN 3x3
BSZ0602LS	80 V	7.0 mΩ	PQFN 3x3
BSC0802LS	100 V	3.4 mΩ	PQFN 5x6
BSC0805LS	100 V	7.0 mΩ	PQFN 5x6
BSC0302NS	120 V	8.0 mΩ	PQFN 5x6
BSC0402LS	150 V	9.3 mΩ	PQFN 5x6

Loading switch	V_{DS}	$R_{DS(on)}$	Package
BSZ0909LS	30 V	3.0 mΩ	PQFN 3x3
BSZ0910LS	30 V	5.7 mΩ	PQFN 3x3
BSZ0911LS	30 V	7.0 mΩ	PQFN 3x3

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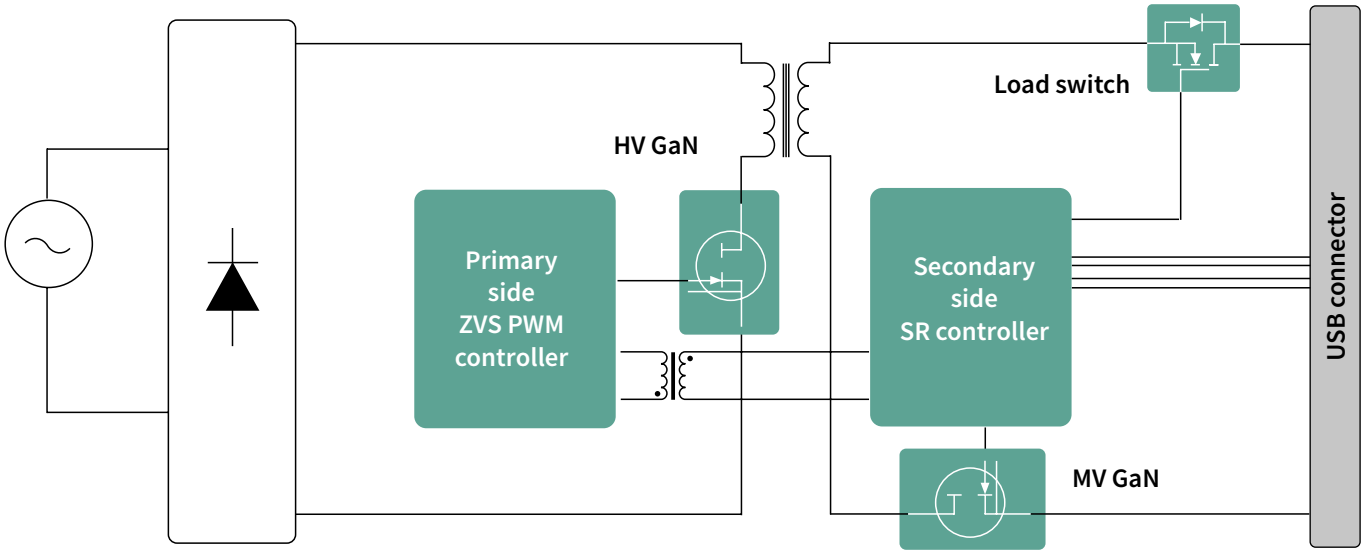
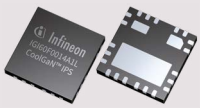
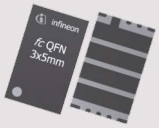
The full gallium nitride solution for USB-C chargers & adapters

Gallium nitride (GaN) offers fundamental advantages over silicon. In particular, the higher critical electrical field makes it very attractive for power semiconductor devices with outstanding specific dynamic on-state resistance and smaller capacitances compared to silicon MOSFETs, which makes GaN HEMTs great for high speed switching. Not only because of the resulting power savings and total system cost reduction, it also allows a higher operating frequency, improves the power density as well as the overall system efficiency.

Application schematic



Product		Part number	Package
	CoolGaN™ 600 V e-mode HEMT	IGLD60R190D1S	PG-LSON-8-1 (DFN 8x8)
	CoolGaN™ 600 V Integrated Power Stage (driver + single HEMT)	IGI60F0014A1L	PG-LIQFN-21-1 (QFN 8x8)
	CoolGaN™ 600 V Integrated Power Stage (driver + half bridge HEMT)	IGI60F1414A1L	PG-TIQFN-28-1 (QFN 8x8)
	CoolGaN™ 100 V e-mode HEMT*	IQC0800NLS	PG-VSON-6-3 (PQFN 3x5)

*coming soon

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CoolGaN™ Integrated Power Stage (IPS) 600 V half-bridge

Ease of use with integrated drivers for highest efficiency and power density

The IGI60F1414A1L combines a half-bridge power stage consisting of two 140 mΩ (typ. $R_{DS(on)}$) / 600 V enhancement-mode CoolGaN™ switches with dedicated gate drivers in a thermally enhanced 8 x 8 mm QFN-28 package. It is thus ideally suited to support the design of compact appliances in the low-to-medium power area.

Infineon's CoolGaN™ provides a very robust gate structure. When driven by a continuous gate current of a few mA in the "on" state, a minimum on-resistance $R_{DS(on)}$ is always guaranteed, independent of temperature and parameter variations. Due to the GaN-specific low threshold voltage and the fast switching transients, a negative gate drive voltage is required in certain applications to avoid spurious turn-on effects. This can be achieved by the well-known RC interface between driver and switch. A few external SMD resistors and capacitors would enable easy adaptation to different applications (low/medium power, hard/soft switching).

The driver utilizes an on-chip coreless transformer (CT) technology to achieve level-shifting to the high side. Besides, CT guarantees excellent robustness even for extremely fast switching transients above 150 V/ns.

CoolGaN™ IPS provides:

- Smaller form factor
- Lighter designs
- Higher efficiency

Key features	Key benefits
› Digital-in, power-out building block › Application configurable switching behavior › Highly accurate and stable timing › Thermally enhanced 8 x 8 mm QFN-28 package	› Easy to drive with 2x digital PWM Input › Configurability of gate path with low inductance loop on PCB › Allows short dead-time setting in order to maximize system efficiency › Small package for compact system designs

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Complete product offering for charger and adapter

Funktional block	Product category	Topology	Product	Benefits
Flyback converter	High-voltage MOSFETs and HEMTs	Flyback	600 V/700 V/800 V CoolMOS™ P7 SJ MOSFETs	› Fast switching speed for improved efficiency and thermals › Reduced gate charge for enhanced light-load efficiency › Optimized gate-to-source voltage (VGS) threshold for lower turn-off losses
			600 V/650 V CoolMOS™ C7	› High switching performance enabling highest efficiency › Ease of use level high › Optimized devices for highest efficiency switched-mode power supplies
		ACF, FMCI	600 V CoolMOS™ PFD7 SJ MOSFETs	› Robustness and reliability with integrated robust fast body diode and up to 2 kV ESD protection › Reduced gate charge for enhanced light-load efficiency › Lower hysteresis loss
		Flyback (ACF, FFR, etc.)	CoolGaN™ 600 V e-mode HEMTs	› Highest efficiency › Highest power density
	Control ICs	FFR flyback IC	XDPS21071	› DCM operation with digital force-frequency resonant › Ideal for USB-PD
		FFR flyback IC	XDPS21081	› Optimization of low line AC input with forced quasi-resonant › Suitable for high power density design
		Hybrid flyback IC	XDPS2201	› Asymmetrical half-bridge ZVS control to maximize efficiency › Supports a wide range of configurable parameters › Supports Ultra-high power density (20W/in3) design
		QR flyback	PAG1P/S	› Secondary-side-controlled flyback solution › 2 chip flyback solution with integrated SR+PD controller
	Gate driver IC	Active-clamp flyback (ACF)	IRS25752L	› High-side gate driver enables active clamp mode of operation › Cost-effective, 600 V, single-channel driver in SOT23 package
			IRS21271S	› High-side gate driver enables active clamp mode of operation › 600 V, single-channel driver with over-current protection (OCP)
PFC DC-DC	High-voltage MOSFETs, HEMTs, and diodes	DCM PFC	600 V CoolMOS™ P7 SJ MOSFETs	› Fast switching speed for improved efficiency › Reduced gate charge for enhanced light load efficiency › Optimized gate-to-source voltage (VGS) threshold for lower turn-off losses
		DCM/CCM PFC	CoolGaN™ 600 V e-mode HEMTs	› Highest efficiency contribution via less parasitic parameter › Space saving with SMD smaller package
	Boost diode	DCM/PFC	650 V Rapid 1 diodes	› Low conduction losses
		PFC/LLC Combo	IDP2308	› Digital multi-mode PFC and LLC combined controller with a floating high side driver and a startup cell › Comprehensive and configurable protection features › Wide set of configurable parameters
	High-voltage MOSFETs and HEMTs	HB LLC	600 V CoolMOS™ P7 SJ MOSFETs	› Fast switching speed for improved efficiency and thermals › Reduced gate charge for enhanced light load efficiency › Optimized gate-to-source voltage (VGS) threshold for lower turn-off losses
			CoolGaN™ 600 V integrated power stage (half-bridge)	› Highest efficiency and highest power density › Isolated gate driver integrated
	Gate driver IC	HB LLC	EiceDRIVER™ Compact: 1EDI60N12AF, 1ED3124MU12F	› Isolated gate driver, up to 14 A, 100 ns propagation delay
Synchronous rectification	Low-voltage MOSFETs	Synchronous rectification	OptiMOS™ PD 100-150 V	› Low conduction losses, reduced overshoot › Adapter-oriented synchronous rectification MOSFETs
	Control ICs	Synchronous rectification	IR1161LTRPBF	› High efficiency › Simple external circuitry
			PAG1S	› Integration of synchronous rectification and PD controller › Configurable protection, like OTP, OCP, OVP, UVP, short circuit, etc.
Protocol control	USB-C ICs	Protocol controller	PAG1S	› Supports USB PD2.0, PD 3.0 with PPS, QC4+, QC 4.0, QC 3.0,QC 2.0, Samsung AFC, Apple charging, and BC v1.2 charging protocols
		Protocol controller	EZ-PD™ CCG3PA-NFET	› Supports USB PD3.0 with Programmable Power Supply (PPS) › Independent constant current (CC) and constant voltage (CV) modes › Configurable OVP, OCP, and OTP › Integrates NFET gate driver to drive the load switch › 64KB Flash Memory
			EZ-PD™ CCG3PA	› Supports USB PD3.0 with PPS, QC4, Apple 2.4 A charging, AFC, BC1.2 etc. › Supports 1C and 1A port › 64 kB flash memory
		Multi-port controller	EZ-PD™ CCG7D multi-port controller	› Integrates 2 USB-C PD controllers + 2 DC-DC controllers in one single chip › Supports latest USB-C PD v3.0 with PPS, QC4+, QC4.0, Samsung AFC, Apple 2.4A, BCv1.2 › Configurable switching frequency of 150 kHZ- 600 kHZ › Arm® Cortex®-M0 with flash allows users to implement custom features

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We are the link between the real and the digital world.

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We innovate
We perform

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We make life easier, safer and greener.

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