USB power delivery solutions

December 2019

Agenda

1. Charger/adapter market overview and trends
2. Infineon’s USB-PD offering
3. 45 W reference design
4. Success cases
5. Support materials
6. Summary

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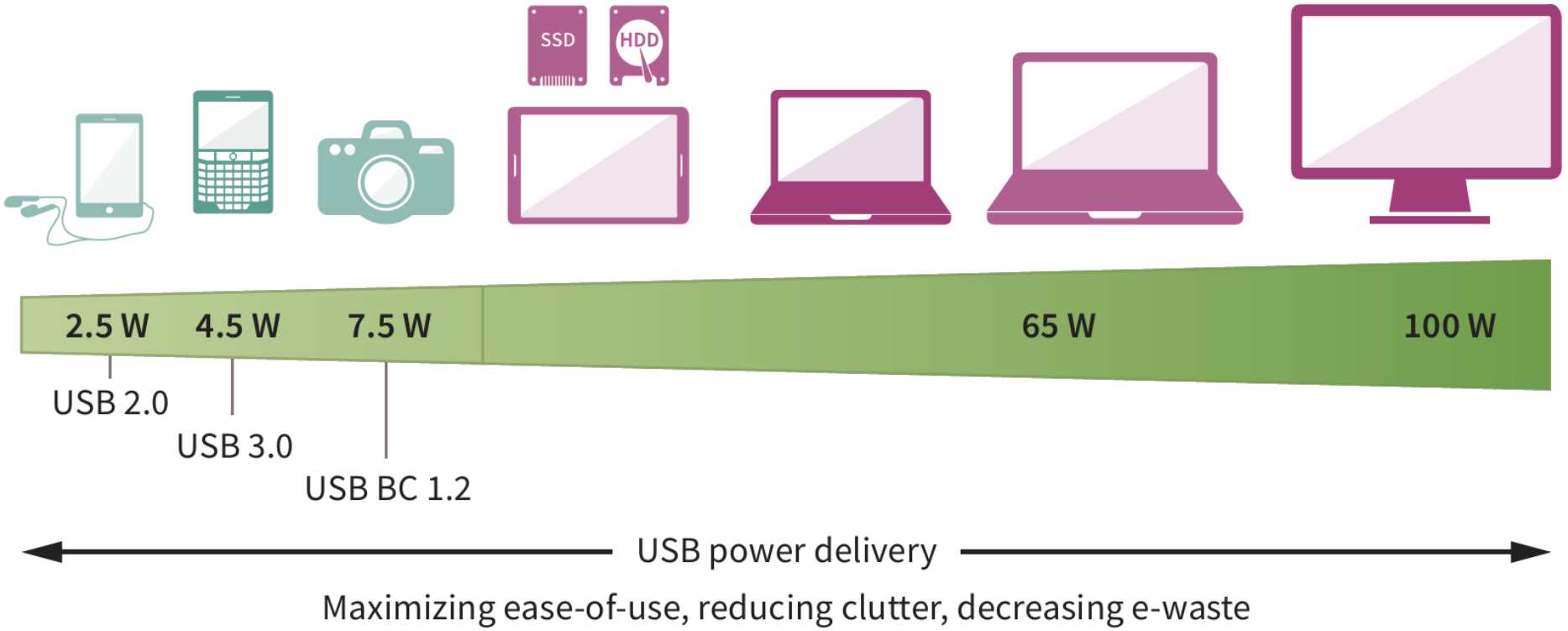
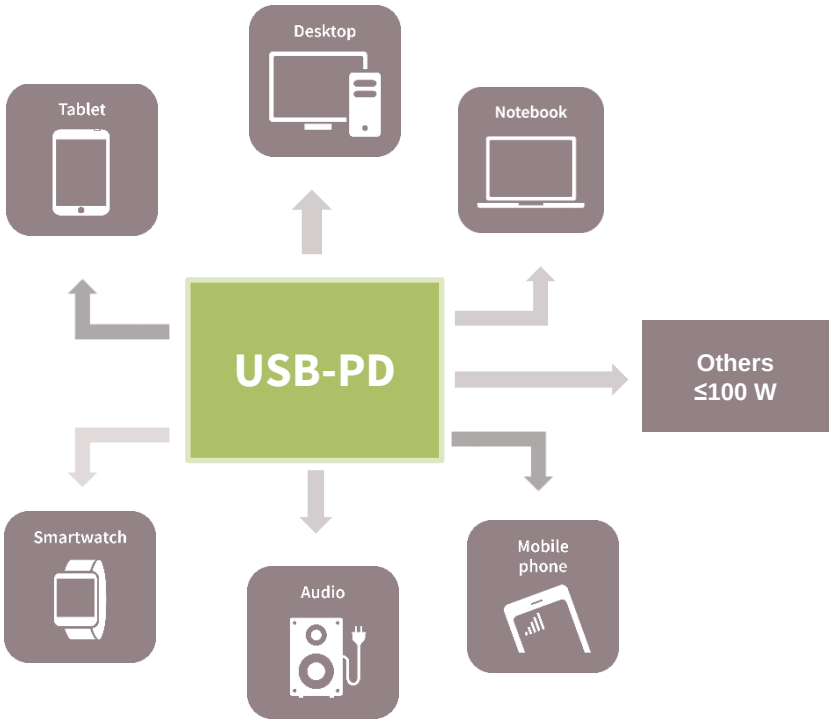
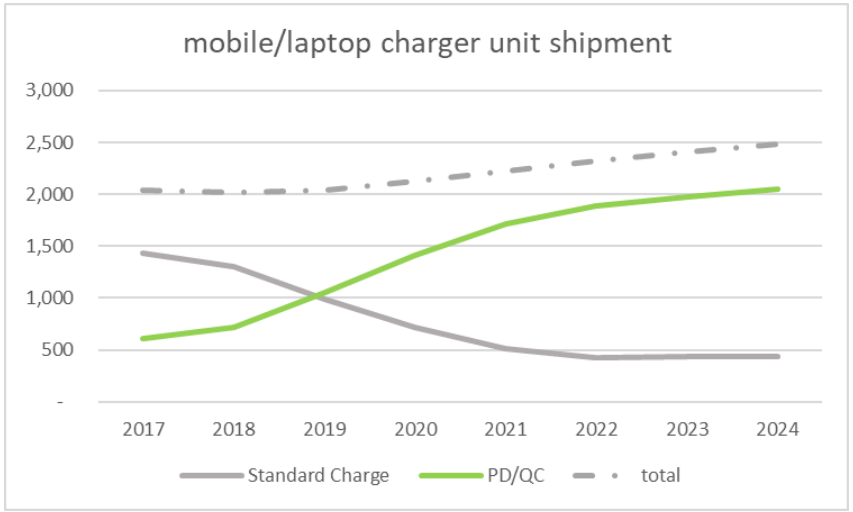
Power management optimization across multiple peripherals



USB-PD single-cable solution offers faster charging, data transfer and ease-of-use





Source: Infineon market model

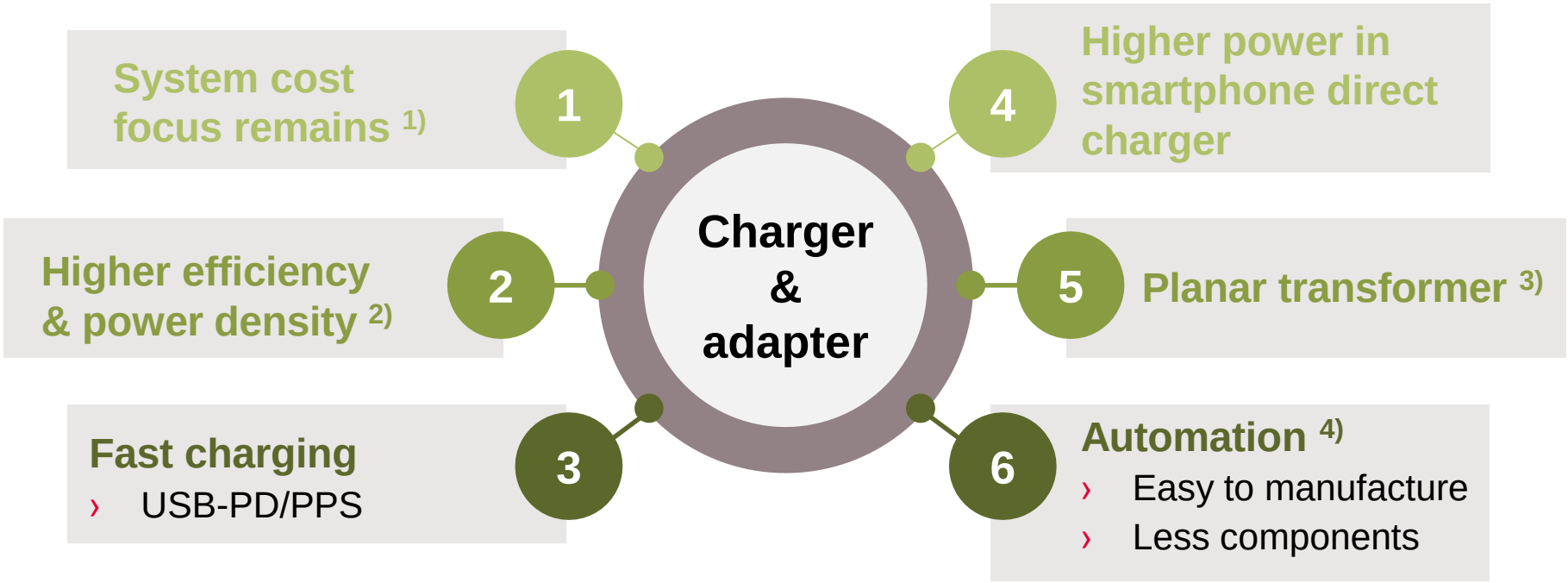
› **USB power delivery (USB-PD):**

- provides a smaller, thinner and more robust alternative to existing USB interconnect
- evolved from a data interface capable of supplying limited power (up to 100W) to a primary provider of power with a data interface

Typical market requirements

1. **Moving fast** in product development to follow market trends
2. Close **technical support** to original design manufacturers
3. **Price competitiveness and flexibility** to meet dynamic consumer market
4. **Flexible delivery** in response to consumer expectations
5. Continuous investment on controller **roadmap**

Charger & adapter application trends



Remarks:

1) Higher IC cost for innovative solutions accepted, if overall system cost can be saved by e.g. reducing complexity, size, enabling specific transformer usage, production cost, etc.
2) Higher efficiency enabling smaller form factor, hence increasing power density
   Selected topology and discretes in combination with optimized transformer design play a major role
3) Form factor, cost, consistent performance, high volume production, etc.
4) Automated assembly of boards & magnetics. Less external components, SMD package, planar transformers, etc.

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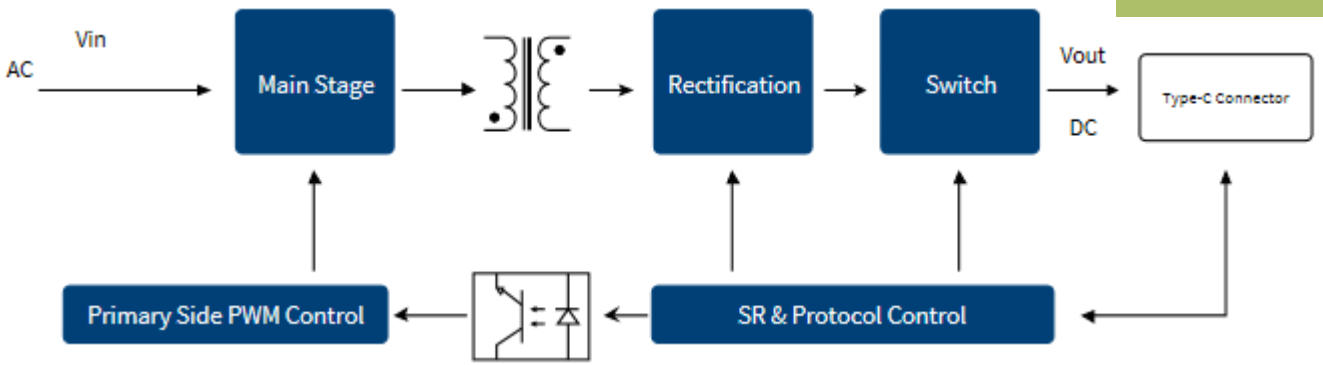
Proven one-stop-shop solution for high density adapters

Primary side	
HV switch	Infineon‘s product offering
› CoolMOS™	› 700 V CoolMOS™ P7 › 600 V CoolMOS™ PFD7

Secondary side	
SR switch	Infineon‘s product offering
› OptiMOS™ PD	› 30 V logic level › 60 V logic level › 80 V logic level › 100 V logic level › 120 V/150 V



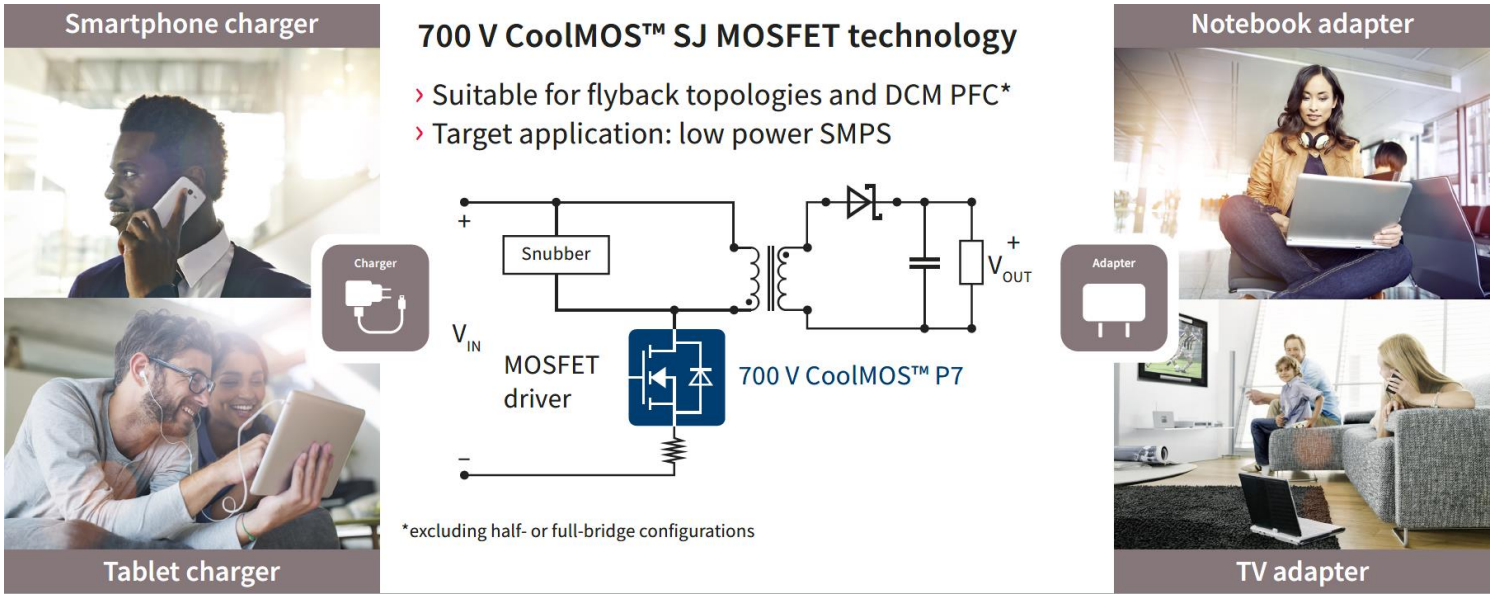
Controller type	Infineon‘s product offering
› Digital FFR flyback	› XDPS210x
› Hybrid flyback	› XDPS220x*
› ZVS flyback	› UCA11aG*

Chipset

Controller type	Infineon‘s product offering
› SR controller › Protocol controller	› UCA12aG* › UCA13aG*

*coming soon

700 V CoolMOS™ P7 tailored for low power SMPS market for flyback topologies

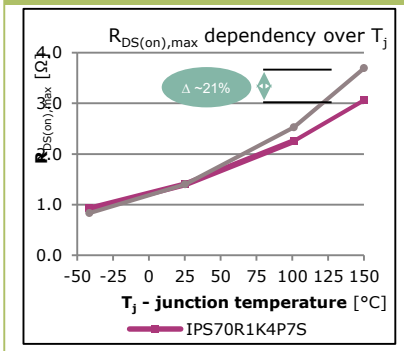


Corner stones of 700 V P7 Superjunction MOSFET technology:

- **Cost competitiveness** compared to similar competitor technologies
- Supporting **increased switching frequency** in order to reduce magnetics
- **Right fit** for **target applications** in terms of
  - Standard grade to optimize the cost
  - Same performance as other CoolMOS™ series, e.g. thermals and efficiency performance
  - Small features tolerance
  - 12’ production allowing for higher output

Technological highlights of CoolMOS™ P7

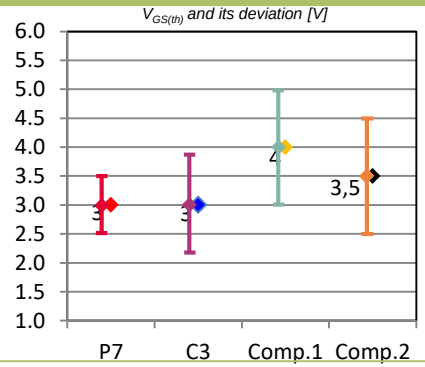
Best-in-class $R_{DS(on)}$ dependency over T_j



CoolMOS™ P7

- lower $R_{DS(on)}$ increase with increasing junction temp.
- Reduced conduction losses, especially at low input voltage

Best-in-class $V_{GS(th)}$ and lowest $V_{GS(th)}$ tolerance



Customer benefits

Easy to drive

- Avoiding MOSFET linear mode operation
- Allowing lower driving voltage
- Reducing idle loss

Easy to design in

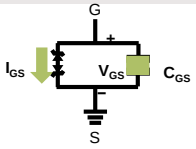
- Increased design freedom due to tighter tolerance

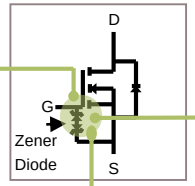
Integrated Zener diode ESD protection

ESD protection mechanism

During ESD event:

- V_{GS} is clamped by Zener diode
- I_{GS} flows through Zener diode
- Thus protect gate oxide





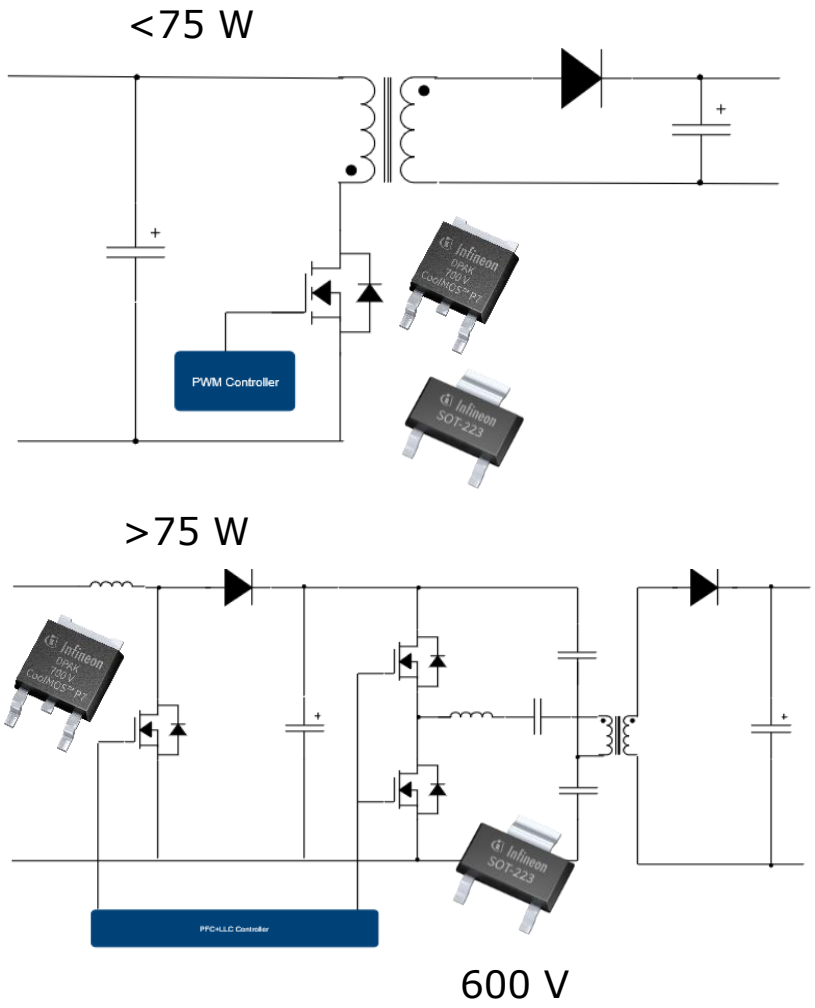
Customer benefits

- Better assembling yield thus less cost
- Less field failure rate
- Higher quality and better reputation

CoolMOS™ P7 ESD robustness

600 V	HBM	0.12-0.60 Ω: 2-4 kV	Class 2
	CDM	>1 kV	Class C3
700 V	HBM	0.75-2.00 Ω: 1–2 kV	Class 1C
		0.36-0.60 Ω: 2–4 kV	Class 2
	CDM	>1 kV	Class C3
800 V	HBM	2.00-4.50 Ω: 1–2 kV	Class 1C
		0.28-1.40 Ω: 2–4 kV	Class 2
	CDM	>1 kV	Class C3
950 V	HBM	2.00-3.70 Ω: 1-2 kV	Class 1C
		0.45-1.20 Ω: 2-4 kV	Class 2
	CDM	>1 kV	Class C3

Recommended SMD package for charger/adapter applications

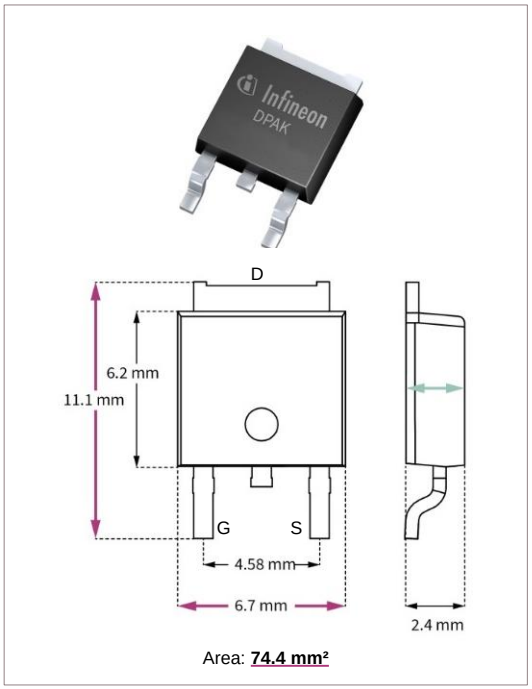


Value offer

- Optimized cost in SMD package, and higher reliability
- Cost saving in assembly, productivity increase with better yield
- Higher ruggedness for ESD protection since add Zener diode P7 component
- More flexible delivery support

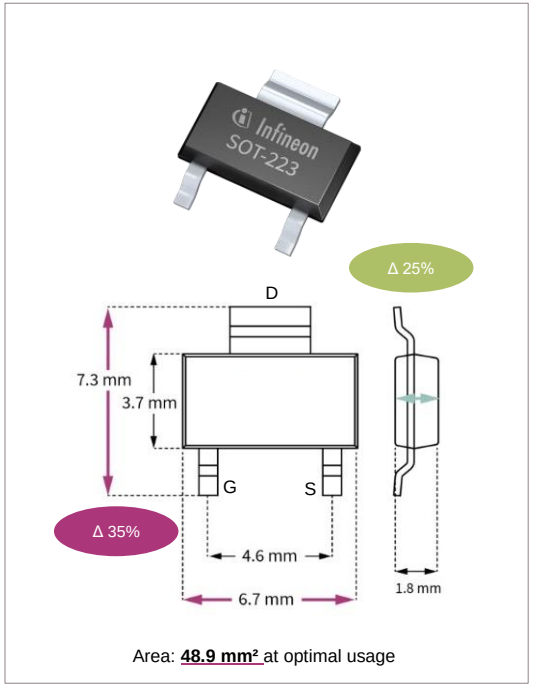
SOT-223 offers smaller footprint while being pin-to-pin compatible with DPAK

DPAK



Area: **74.4 mm²**

SOT-223



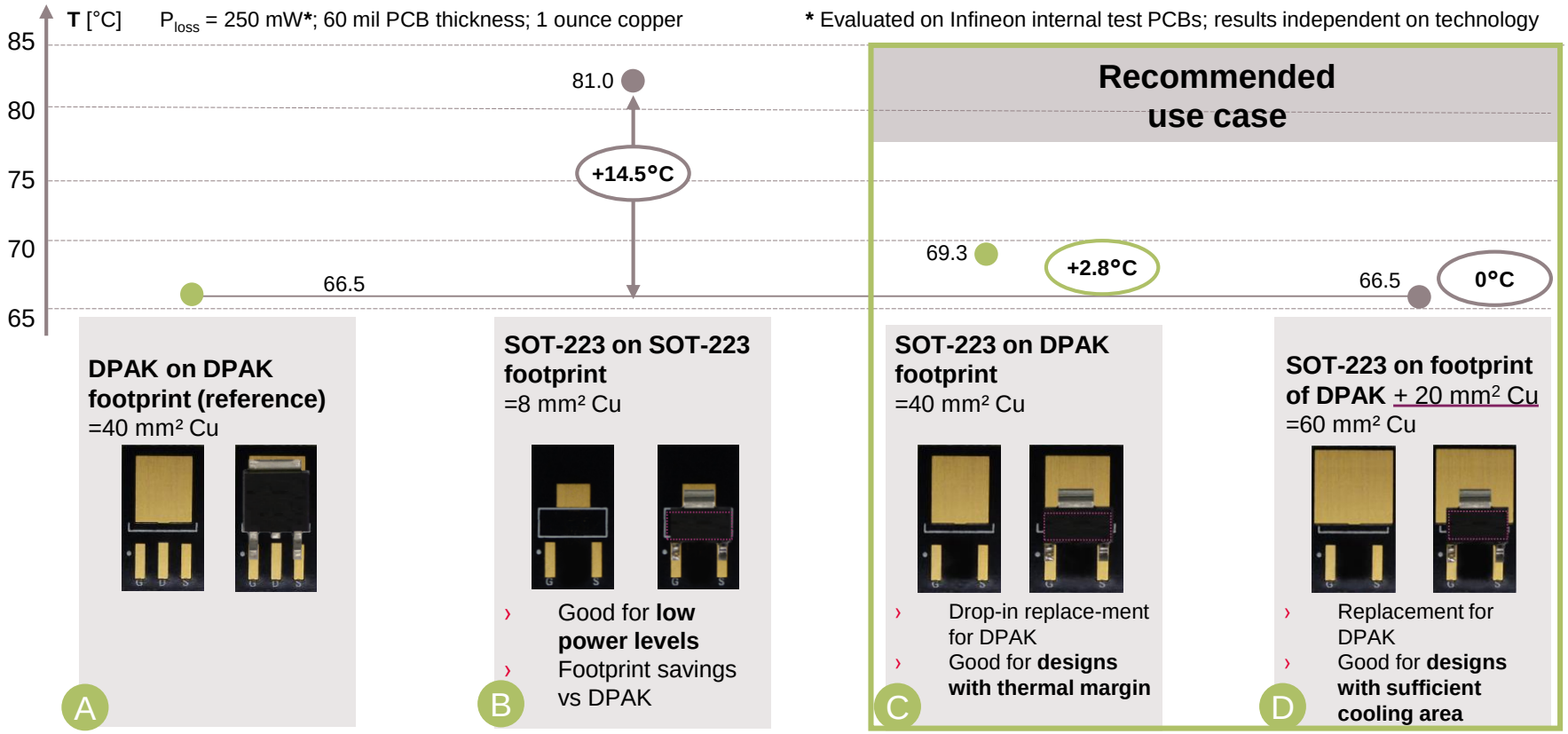
Area: **48.9 mm²** at optimal usage

Smaller form factor | reduced cost | higher efficiency

Value proposition

- Lower cost
- Smaller footprint while DPAK pin-to-pin compatible
- Enabling space savings in compact designs
- No major disadvantage in thermals

SOT-223 can achieve similar thermal performance



OptiMOS™ PD perfectly addresses the needs of charger & adapter designs

- OptiMOS™ PD **meets EU efficiency standards** even in a 3x3 package
- OptiMOS™ PD enables **high power density designs**

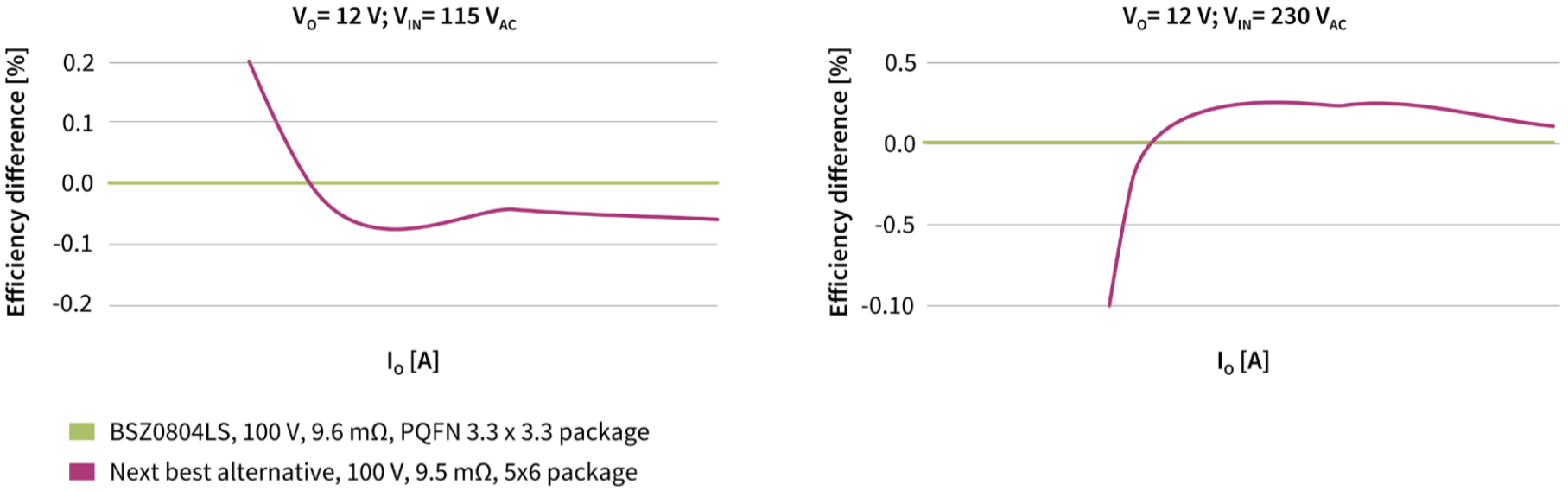
- Quick quote response
- Short lead times

- …with OptiMOS™ PD in **5x6 and 3x3 packages**

- OptiMOS™ PD achieves **lower temperature** in a 3x3 package compared to the next best alternative in 5x6

- OptiMOS™ provides **lower charges** for:
  - less switching losses
  - excellent price/performance ratio

OptiMOS™ PD 100 V logic level
SR Efficiency comparison



OptiMOS™ PD 100 V offers similar overshoot at a 3x smaller footprint than the next best 100 V alternative resulting in higher power density.

BSZ0804LS
V_{in} = 90 V_{AC} 60 Hz

Next best alternative 100 V, 9.5 mΩ in 5x6 package
V_{in} = 90 V_{AC} 60 Hz

OptiMOS™ PD – optimized for synchronous rectification in charger and adapter designs

Package	Voltage Class [V]	$R_{DS(on)}$ max. @V_{GS} = 10V [mΩ]	$R_{DS(on)}$ max. @V_{GS} = 4.5V [mΩ]	Part number	Status	Application
SuperSO8 	60	2.7	3.9	**BSC0702LS**	released	5V/5A 5V/6A
		6.5	9.4	**BSC0703LS***	released	5V/5A 18W QC3.0
		9.4	13.5	BSC0704LS*	released	18W QC2.0 18W QC3.0
	100	3.4	4.8	**BSC0802LS***	released	USB PD 3.0
		7.0	10.2	**BSC0805LS**	released	>35W PD< 65W PD
		9.8	14.0*	**BSC0804LS**	released	>35W PD< 65W PD
		14.6	20.8	BSC0803LS*	released	24W QC2.0
	120	8.2	11.0	**BSC0302LS***	in development	>35W PD< 65W PD
	150	9.3	10.5**	**BSC0402NS**	released	>35W PD< 65W PD
		11.0	11.5**	**BSC0403NS**	released	>35W PD< 65W PD
PQFN 3.3x3.3 	60	4.0	5.6	BSZ0702LS*	released	5V/4~5A 18W QC3.0
		6.5	9.4	BSZ0703LS	released	18W QC3.0
		9.9	14	BSZ0704LS*	released	18W QC2.0
	80	7.0	9.4	**BSZ0602LS***	released	18W QC3.0
	100	9.6	13.5	**BSZ0804LS***	released	>35W PD< 65W PD
		14.6	20.8	BSZ0803LS*	released	24W QC2.0

*@V_{GS} = 6 V**@V_{GS} = 8 V

*coming soon

BiC performance for differentiated designs

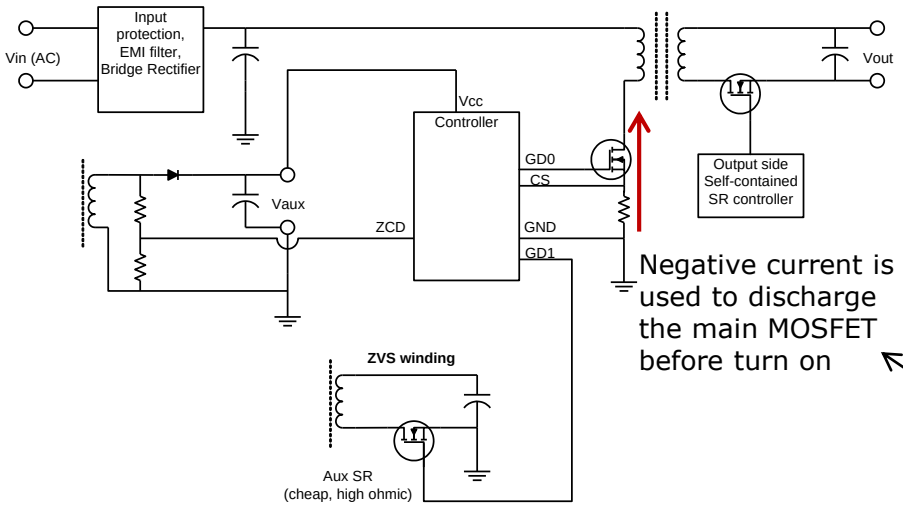
Best choice for a wide range of designs
Lead time optimized (<10 weeks LT)

OptiMOS™ PD
Value proposition

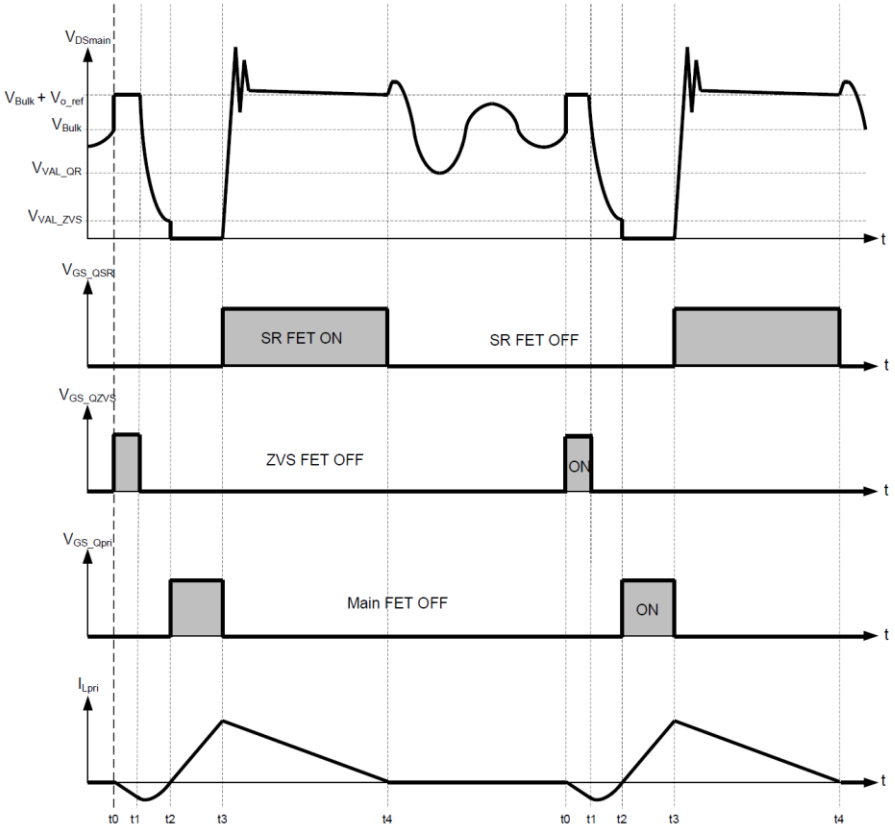
Key features	Key benefits	Value proposition to designers	Value proposition to end customers
Logic Level availability: low threshold voltage	Parts fully driven from 4.5 V or directly from microcontroller -> Less parts count	Designs with lower BOM cost	Less costly high quality products
Low on-state resistance ($R_{DS(on)}$) 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

XDPS™ digital FFR flyback controller
ZVS operating principle

Application block diagram



Operation waveform



- $ZVS_{ton} \sim \sqrt{L_p * C_{eqv}} * \frac{V_{bulk}+N_{pa}*V_{zvs}}{N_{pa}*V_{zvs}}$
- $T_{delay} = \frac{\mathrm{pi}}{2} * \sqrt{L_p * C_{eqv}}$

- Patent: [US9673718B2]

XDPS21071 digital FFR flyback controller value

Customers' driver	Infineon offers	Customers' benefits
Performance	Zero voltage switching	› Reduce switching loss › **High efficiency of > 90%**
	Frequency law optimization	› Optimize efficiency across various line/load condition › **High 4-point average efficiency** of > 90% surpassing regulatory standard
	Active bust mode operation with multiple entry/exit threshold	› **Surpassed regulatory efficiency** of @ 10% load with 4% margin › **Surpassed no-load input power regulatory standard** with < 25 mW › **Free of acoustic noise** light load control scheme
Ease of design	Integrated dual MOSFET gate drive	› No messy external MOSFET gate driver › Save BOM cost and count
	Easy ZVS implementation with an external 60V n-channel MOSFET	› ZVS MOSFET shared **common ground** with controller › **Easy to drive** and no expensive high side driver needed › **Low cost and widely available** off the shelf 60V MOSFET
Robustness	VCS offset	› Different overload threshold for different output › **Fail safe mechanism** to limit output power in the event of failure with PD controller
	CrCM operation with valley detection	› Avoid CCM operation › **No potential of shoot-through** with SR MOSFET

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XDP™ digital control key values for customer

Customers' driver	Infineon's offers	Customers' benefits
High power density	› Patented innovative Zero voltage switching scheme › Demonstrated 65 W adapter with 15 W/in^3	› High efficiency enable small form factor design
Low system BOM	› Minimum BOM adders compared to alternative high density solution available	› Cost competitive high density adapters
Platform approach	› Highly configurable IC parameters supported by .dp vision GUI	› Easy use of ICs for various model design supporting customer platform strategy
Reliability & system robustness	› Comprehensive IC protection features › Digital application set points are independent on PCB components	› Increased system robustness › Minimized field failure rate

REF_XDPS21071_45W1 : XDPS21071 based 45 W USB-PD charger

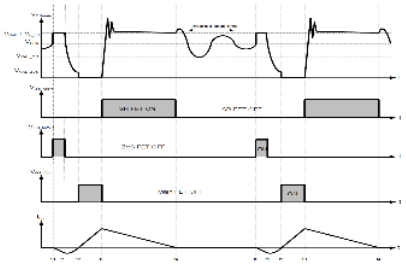
XDPS21071 – 45 W high power density charger

- Power density: 22 W/inch^3 uncased
- Operating frequency up to 140 kHz
- Efficiency up to >90% @ 230 V_{AC} input
- Planer transformer design to improve the production capabilities
- Full USB-PD capability
- Supports up to 60 W output power

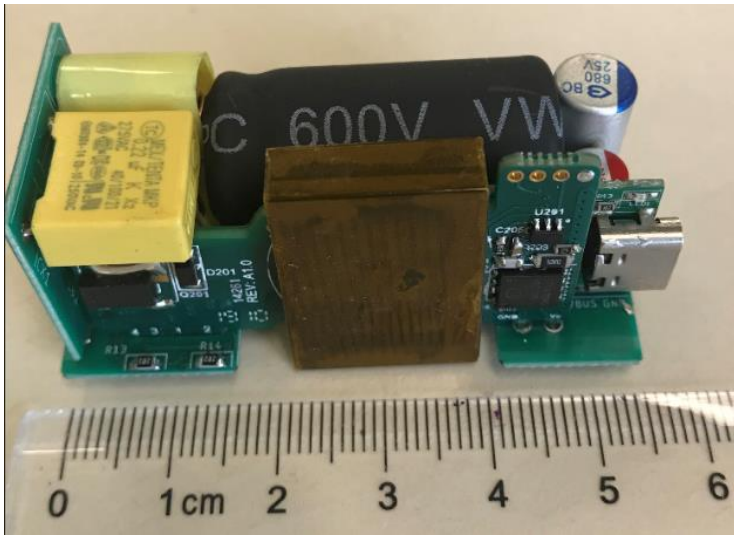
- Planar transformer for slim design
  - Noise cancellation through winding structure without shielding layer
  - Reduce copper losses
  - Good coupling, low leakage (<1.5%), low snubber losses

IPN70R360P7S  BSC0805LS

- Zero Voltage Switching (ZVS) operation
  - Use low side auxiliary MOSFET to achieve ZVS
  - No high-side driver
  - Low voltage rating of aux MOSFET
  - Very similar to conventional fixed frequency flyback
    - Fixed frequency with frequency reduction
    - High efficiency for different V_{out} and light load operation



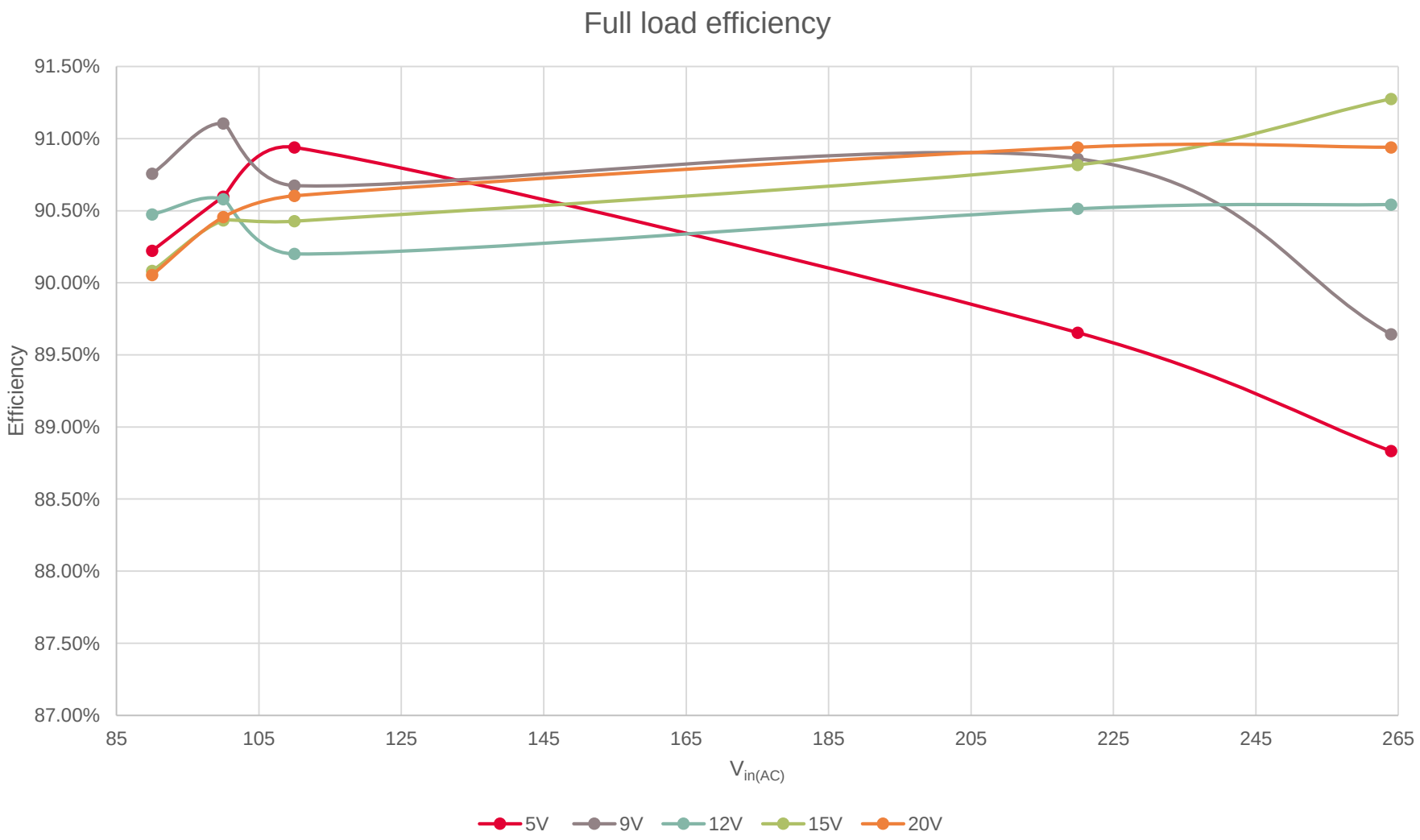
REF_XDPS21071_45W1



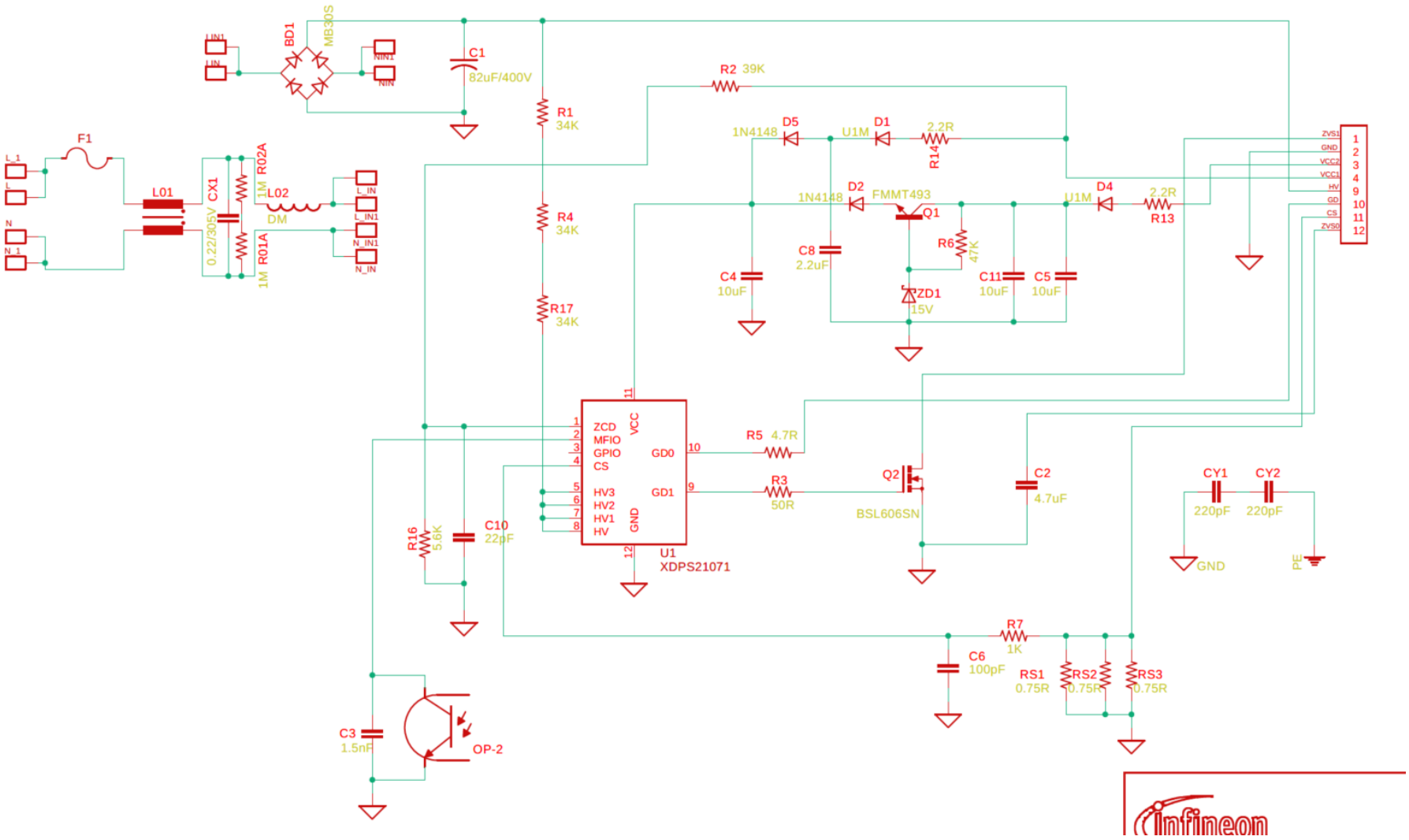
Functionality	Part name	Number of pcs
Primary PWM controller	XDPS21071	1
Primary HV MOSFET	IPD70S360P7	1
Secondary synchronous rectifier MOSFET	BSC0805LS	1
Load switch	ISZ0901NLS	1
ZVS MOSFET	BSL606SN	1

› PCB size L55 mm * W25 mm*H25 mm (21.5 W/inch³ PCBA)

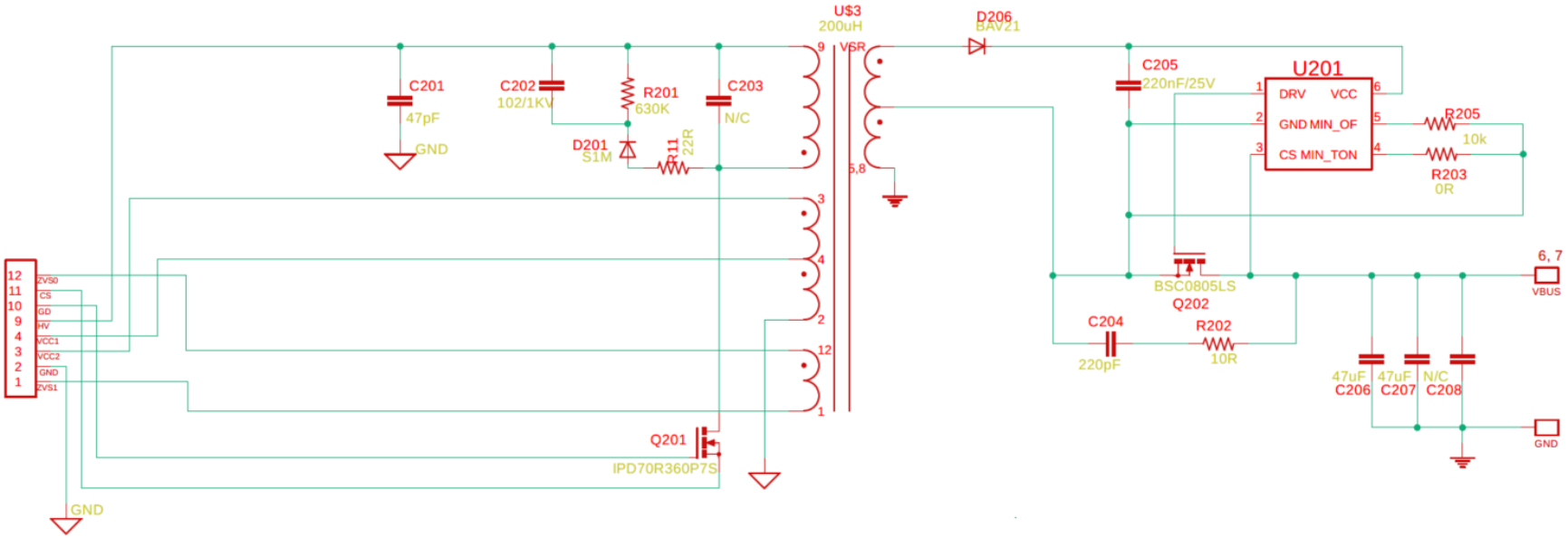
Full load efficiency



Schematic primary board

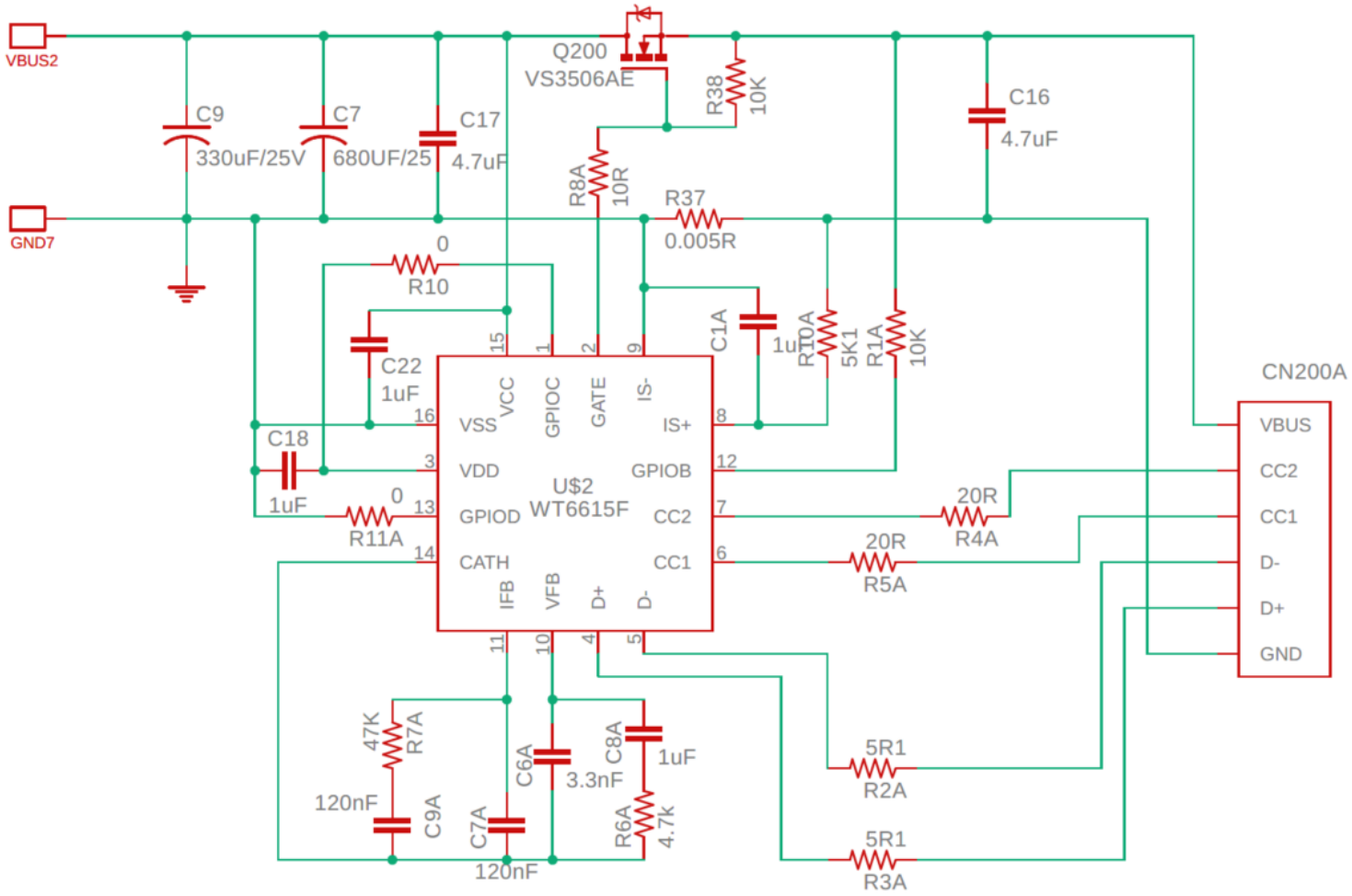


Schematic-transformer / SR

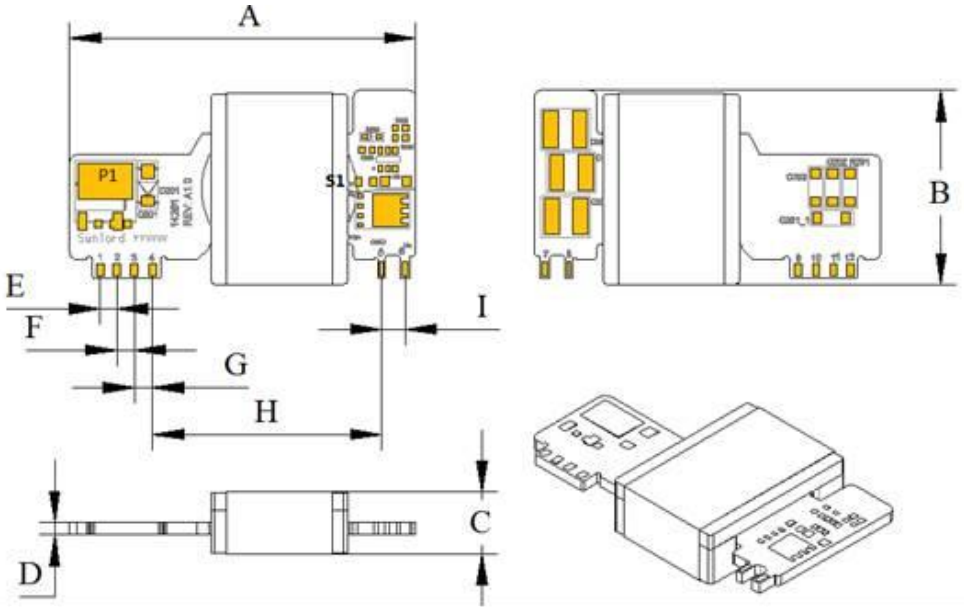


› SR IC NCP4306DADZZ

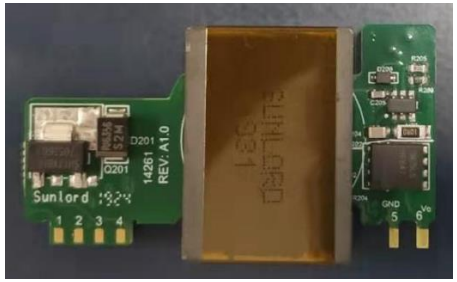
PD daughter board schematics



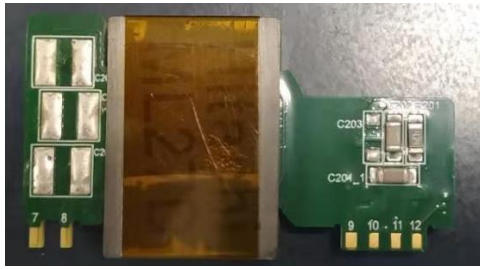
Planar transformer



- 6 layer PCB,3oz copper
- F_{sw} = 140 kHz
- EIQ25, core material ML27D
- Ae = 90mm²
- Np:Ns:Naux1:Naux2:Nzvs = 14:2:2:4:1
- Lp = 200 uH



- Top view



- Bottom view

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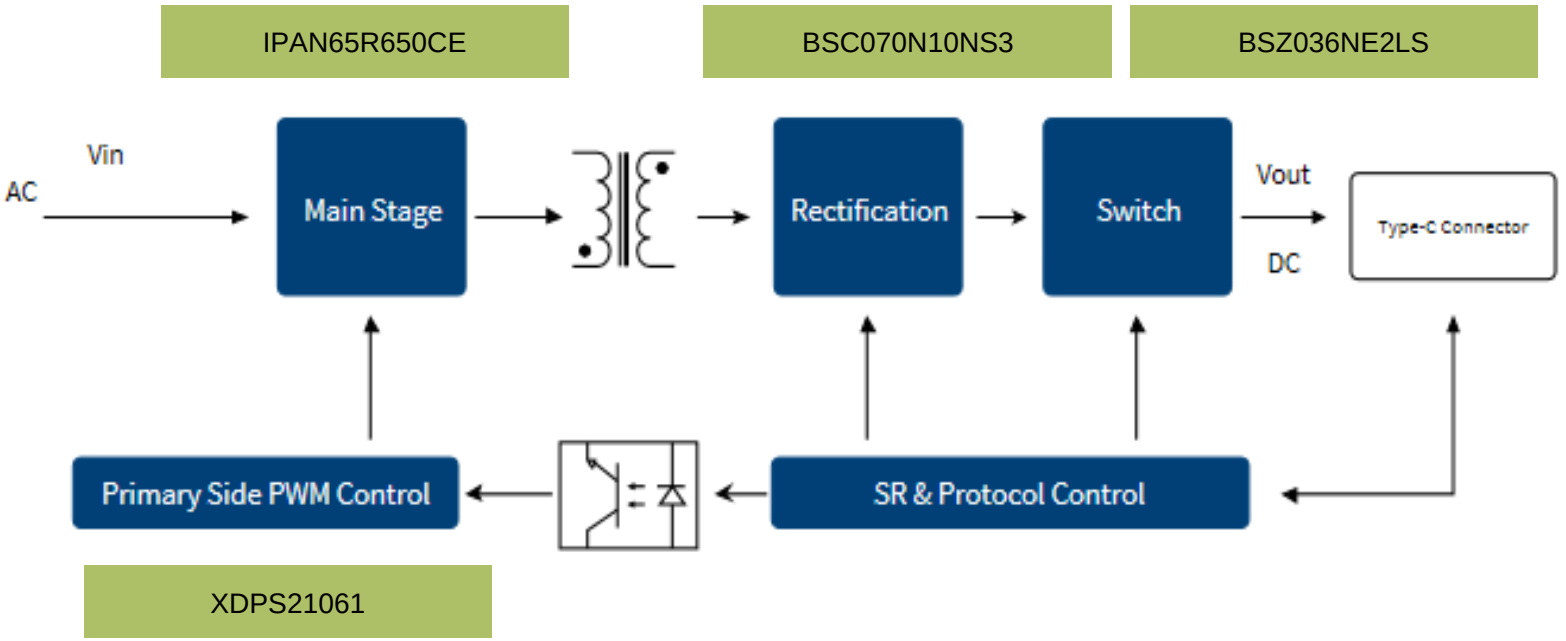
Success case
XDPS21061 digital full solution

Infineon's digital solution (XDP™/CoolMOS™/OptiMOS™) enables customer to be the leader in smart phone quick charging market

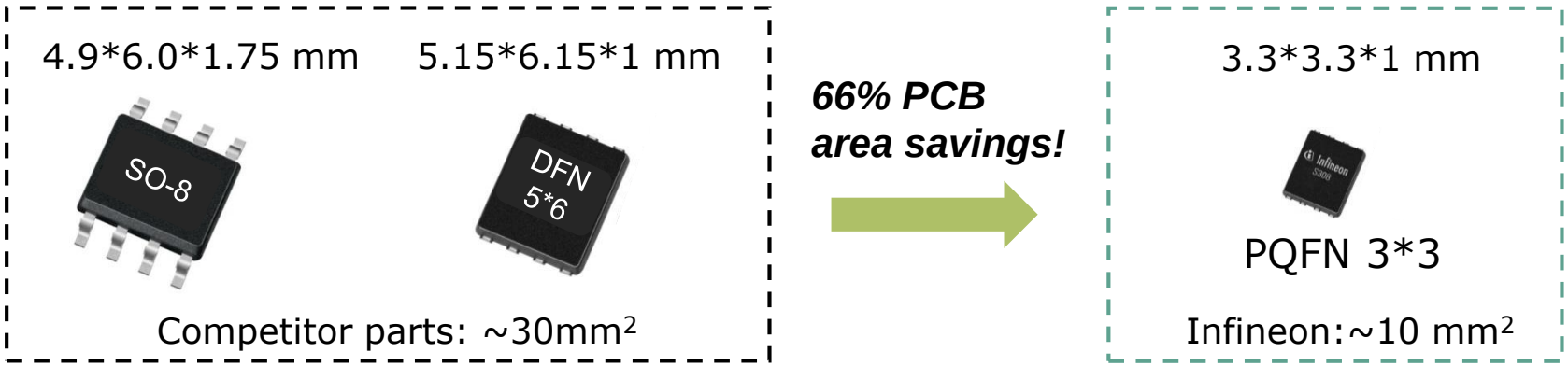


Success case
PQFN3*3 SR MOSFET in 18 W charger

BSZ0602LS BW in 18 W QC3.0 charger project:

- Proactively promote the value of BSZ0602LS
  - 3*3 small package, saving PCB area
  - 3*3 package, lower cost & better delivery support
  - OptiMOS™ PD platform, increasing efficiency by reducing switching loss
- Close support on the concern of thermal dissipation

BSZ0602LS	
Package	PQFN3*3
$R_{DS(on)\ max}$ @V_{GS} = 10 V (mΩ)	7
$R_{DS(on)\ max}$ @V_{GS} = 4.5 V (mΩ)	9.4
V_{DS}	80 V



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Support material

Collaterals and brochures

- Product briefs
- Selection guides
- Application brochures
- Presentations
- Press releases, Ads

Technical Material

- Application notes
- Technical articles
- Simulation models
- Datasheets, MCDS files
- PCB design data

Videos and online courses

- Technical videos
- Online courses
- Product information

- www.infineon.com/charger
- www.infineon.com/adapter
- www.infineon.com/USB-PD
- www.infineon.com/xdps21071
- www.infineon.com/p7
- www.infineon.com/OptiMOS™

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Key takeaways

- Fast charging will dominate smartphone, tablet and notebook adapter markets
- USB-PD will bring excellent user experience and convenience – **Infineon will be the reliable partner & supplier**

Infineon specific **MOSFETs and controllers** to enhance customers market positioning by improving power density, cost optimization and differentiation:

1. Keep high-runner parts promotion for fast charging
2. Focus on SMD package (DPAK/SOT-223) for nominal charger/adapter
3. Differentiate high performance solution with XDP™ digital controls

Part of your life. Part of tomorrow.