CoolMOS™ CE Selection Guide

High voltage MOSFETs for consumer applications
500 V, 600 V, 650 V, 700 V and 800 V

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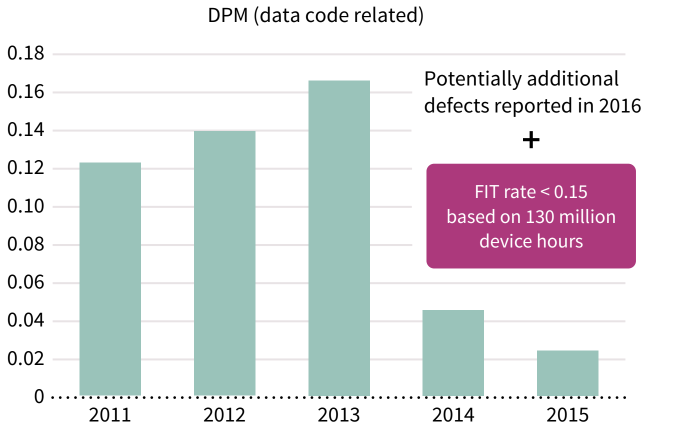
Powering a green world with CoolMOS™ CE

Content

CoolMOS™ CE – overview

CoolMOS™ CE is a product family launched by Infineon to address consumer and lighting applications. It offers benefits in efficiency and thermal behavior versus standard MOSFETs and has been optimized for ease-of-use and cost-competitiveness, while at the same time delivering state-of-the-art performance and Infineon quality and supply security. Powered by Infineon multi-source program, CoolMOS™ CE is determined to support customers' success in various consumer markets by full FAE (field application engineer) support, short lead time and fast quote response.



CoolMOS™ comes with a DPM of less than 0.1 and FIT rate of less than 0.15

CoolMOS™ quality - benchmark in short term and long term reliability

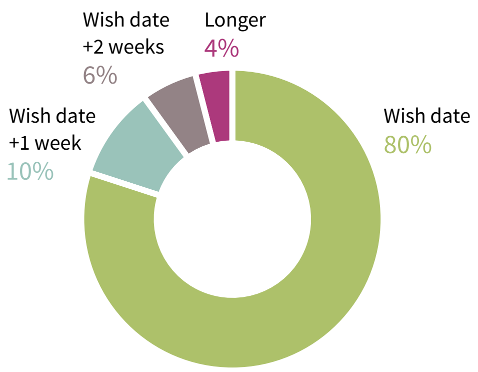
CoolMOS™ technology is legendary in the industry differentiated for its high quality, which has been proven over the past years across billions of devices shipped with continuous improved DPM down to less than 0.10 DPM. Infineon has implemented firm and proven measures from the beginning with design-for-quality program and continuous improvement in production. There is a constant proactive collaboration among technology, design, quality, reliability and manufacturing teams to achieve this result. This effort is above and beyond the fact that all Infineon sites are ISO/TS16949 certified.

CoolMOS™ supply chain – delivery reliability, flexibility and supply security

Our customers value CoolMOS™ not only for its technical merits but also for the outstanding delivery reliability: once a CoolMOS™ order date is committed, more than 96 percent of orders are shipped at or before the committed date. And CoolMOS™ orders are committed to more than 80 percent to the date that the customers request. Security of supply and flexibility to demand changes are focus targets and enabled by a well balanced production network. For example more than 90 percent of our products are qualified for production in at least two back end locations and more than 80 percent of the volumes in two wafer fabs. This enables CoolMOS™ supply chain to react fast to changes in customer and market requirements.

Delivery reliability: ship date = committed date

Delivery capability: confirm customers' wish date



≥ 96% of CoolMOS™ orders are shipped by the committed date and ≥ 80% of wish dates can be met

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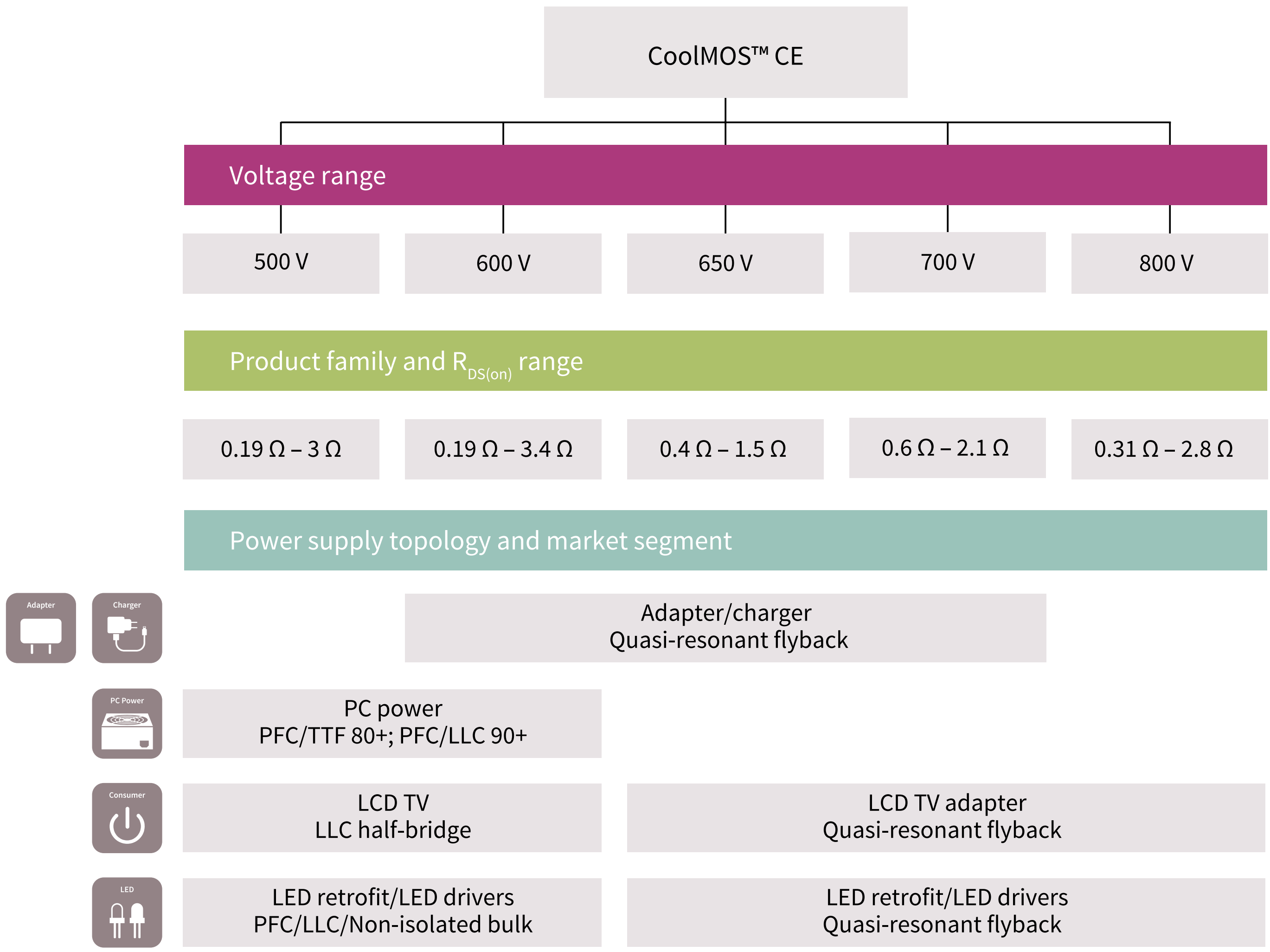

This selection guide takes you to explore the advantages of CoolMOS™ CE in charger, adapter, TV and lighting applications

Reasons to choose CoolMOS™ CE

Non-technical benefits provided by CoolMOS™ CE	
Product portfolio	We own a broad portfolio covering five voltage classes in both through-hole and surface-mount packages.
Capacity	We own the world's largest capacity for power devices, with three dedicated frontends and four backends. Thanks to factors such as the continued investment in our production facilities, we ensure a secure supply during a market upswing.
Lead time	We understand consumer and lighting market dynamics and offer a lead time for middle-sized orders of 4-6 weeks.
Delivery performance	Our supply chain performance is constantly greater than or equal to 96 percent (adhering to the customer committed date).
Quality	Our field failure rates are as low as 0.1 PPM.
Design-in support	We have a large field application engineering team dedicated to providing professional and flexible support for your design.

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CoolMOS™ CE – smartphone and tablet chargers

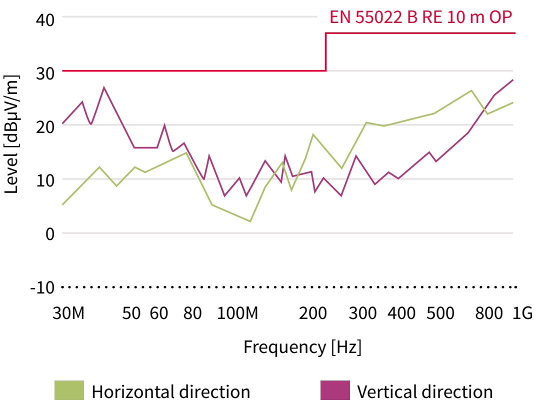
Chargers for smartphones and tablets as well as other mobile applications demand for a growing output power at same or smaller form factors, leading to increasing power density, and stringent requirements on thermal management, EMI emissions and overall system cost. For example, many OEMs request a device temperature less than 90°C with an open case and close case temperature less than 50°C.

Infineon recommends its series of 700 V CoolMOS™ CE superjunction MOSFETs for this application, which are used by leading charger OEMs and design houses in their charger applications. Compared to planar MOSFETs the 700 V CoolMOS™ CE offers reduced switching and thus higher efficiency while passing EMI standards and ringing requirements. Several reference designs have been developed by Infineon to help customers to simplify charger design and thus providing fast time-to-market (see reference design selection table at end of section).

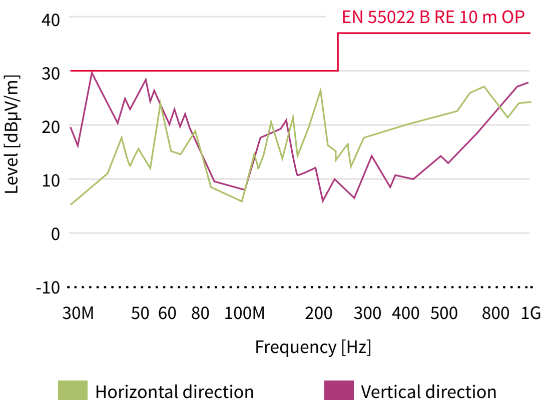
Value proposition of 700 V CoolMOS™ CE:
- High efficiency, meeting application requirements
- More than enough safety margin in thermals, for 10 W-25 W chargers
- Good EMI performance – meets the EMI EN55022B standard without extra design-in effort
- Easy-to-use product due to good controllability via gate resistor
- Large breakdown voltage of nominal 700 V (and additional guard band typical) for safety on voltage spikes

Infineon recommends CoolMOS™ CE in 700 V for charger applications to secure sufficient margin for voltage spikes. CoolMOS™ CE products are also available in 650 V and 600 V for use in less sensitive designs.

10 W design: IPS65R1K5CE
EN 55022 B radiated HF-field
30 MHz – 1 GHz position

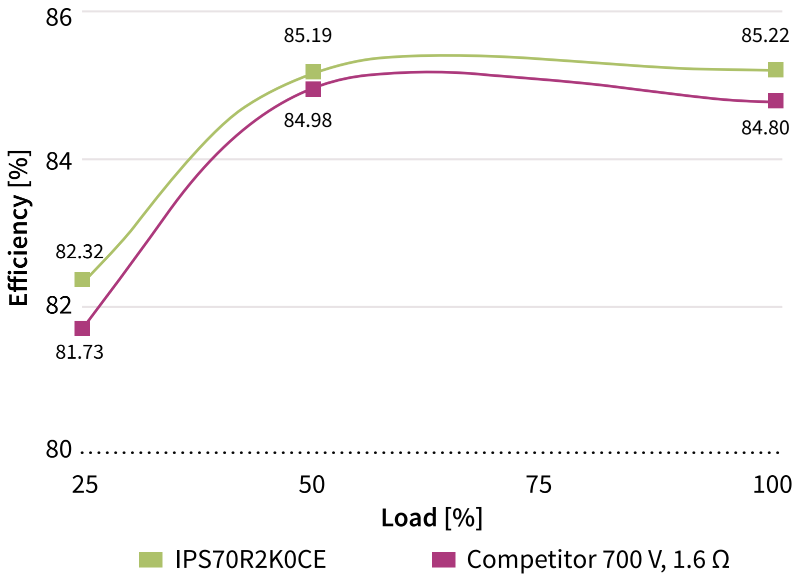


15 W design: IPS65R1K0CE
EN 55022 B radiated HF-field
30 MHz – 1 GHz position

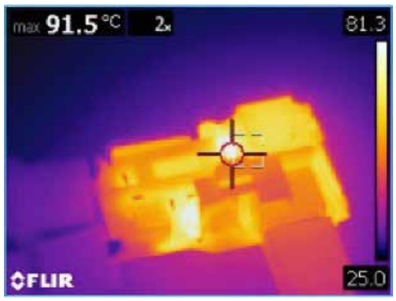


This figure shows the CoolMOS™ CE EMI performance in 10 W and 15 W charger applications. Maximum EMI limits are indicated in the figure. CoolMOS™ CE could meet the EMI requirement thus offering design in flexibilities.

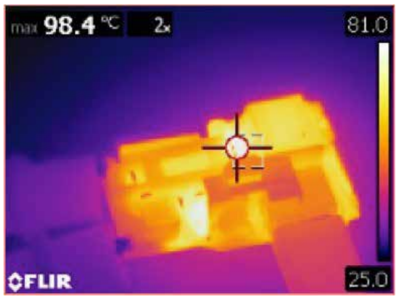
15 W QC 2.0 charger powered by IPS70R2K0CE



IPS70R2K0CE

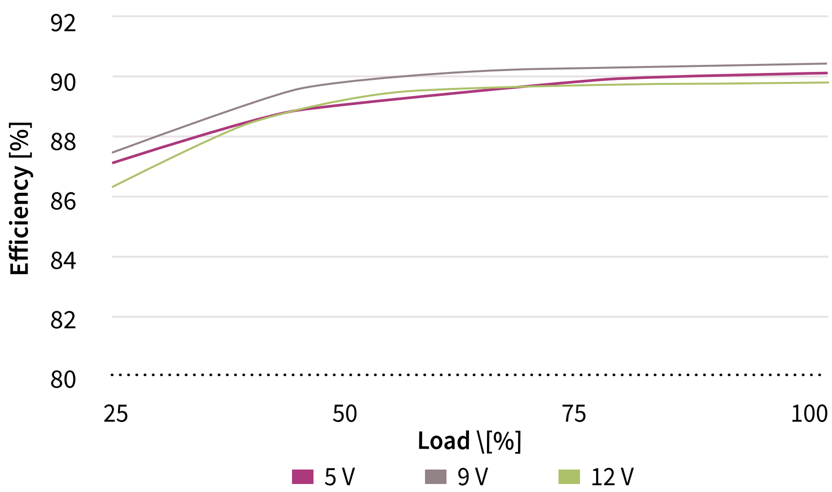


Competitor 700 V, 1.6 Ω



Infineon CoolMOS™ CE offers higher efficiency and better thermals than planar MOSFETs: When replacing a 1.6 Ω planar MOSFET with an Infineon 2.0 Ω CoolMOS™ CE in a 15 W QC 2.0 charger we measured ≥0.2 percent efficiency improvement. At the same time, the MOSFET temperature was 7°C cooler, showing a clear benefit of using CoolMOS™ CE for charger applications.

Infineon's 24 W QC 2.0 charger powered by IPS70R950CE



Infineon's 24 W quick charger

DEMO_24W_QUICKCHARGER

Also for 24 W quick chargers CoolMOS™ CE offers excellent efficiency, e.g., with the IPS70R950CE. Besides efficiency it passes other spec requirements. The board is orderable through Infineon's sample center.

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CoolMOS™ CE – package options for charger application

IPAK Short Lead and DPAK
Standard packages used in chargers today with excellent reliability and wide usage in the industry

IPAK Short Lead with Isolation Standoff:
Innovative package for charger applications providing a defined standoff between package and PBC

I²PAK
Larger package with better thermal performance than IPAK short lead for more than 20 W charger application. The package carries higher cost yet saves efforts in heat sinking

SOT-223
Highly cost optimized surface-mount package with small footprint. The SOT-223 shows slightly worse thermal performance than DPAK, however this can be compensated with little effort by offering a slightly larger copper area (~15 mm²) around the package for heatsinking on the PCB (see page 14, lighting application)

ThinPAK 5x6
Very flat package (0.8 mm height) package targeting slim charger solutions. Bottom side cooling is applied by many customers, but heat sinking through the top side is also possible

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IPAK Short Lead with Isolation Standoff
The new IPAK Short Lead with Mold Stopper will provide a defined standoff between package body and PCB for proper cleaning after wave soldering to avoid leakage current on board level. Mold bumps at the bottom of the package body allow to fully insert the MOSFET into the PCB leaving a well-defined isolation distance of 0.3 mm between the PCB and package body. Creepage distance is increased and production yield is improved as area between package and PCB can effectively be cleaned.

CoolMOS™ CE solutions for charger application

CoolMOS™ CE portfolio for charger – 700 V recommended for most designs

$R_{DS(on)}$ [mΩ]	[W]	TO-262 (I^2PAK)	TO-251 (IPAK Short Lead)	TO-251 (IPAK Short Lead with ISO Standoff)	TO-252 (DPAK)	ThinPAK 5x6	SOT-223
600	> 20		IPS70R600CE	IPSA70R600CE	IPD70R600CE		
950/1000	18-25	IPI70R950CE	IPS70R950CE	IPSA70R950CE	IPD70R950CE		IPN70R1K0CE
1400/1500	10-18		IPS70R1K4CE	IPSA70R1K4CE	IPD70R1K4CE		IPN70R1K5CE
2000/2100	< 10		IPS70R2K0CE	IPSA70R2K0CE	IPD70R2K0CE	IPL70R2K1CES	
General proposal		For 18 W-25 W charger	Standard package for charger	Standard package for charger	For slim charger	For slim charger	Low cost/thermal adjustment needed

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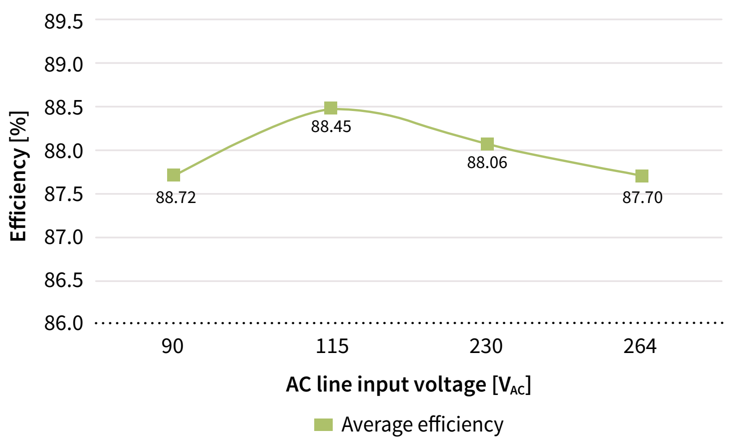
CoolMOS™ CE – notebook adapters

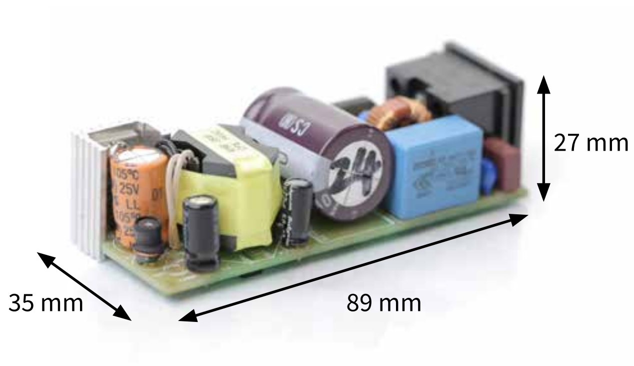
The CoolMOS™ CE series has been widely chosen by leading OEMs in notebook adapters. With ease-of-use, cost competitiveness and short lead time as well as corresponding reference designs, customers can easily design CoolMOS™ CE products in their adapters and have a faster time-to-market.

Value proposition of 600 V and 650 V CoolMOS™ CE for adapters

- High efficiency exceeding values achieved with planar MOSFETs
- Good thermals, especially for high density, small form factor designs
- High breakdown voltage corridor – typical breakdown voltage by far exceeds specified max. value and is higher than typical MOSFETs from other vendors
- Easy-to-use product due to good controllability via gate resistor

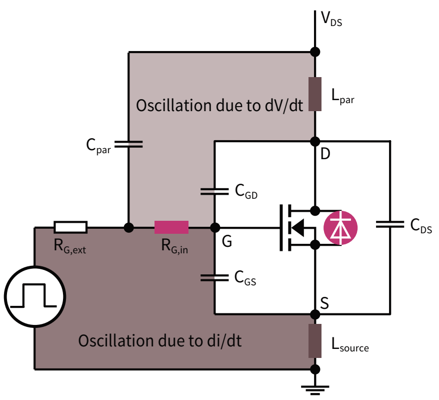
Infineon's 35 W adapter powered by IPD60R650CE:
Active-mode efficiency versus AC line input voltage





REF-35W Adapter

Infineon's 35 W adapter reference design has been powered by IPD60R650CE, which offers an efficiency of more than 87 percent and a peak power of 45 W for 2 ms. The dynamic load response is only ±2 percent and standby power is below 100 mW. Customers could modify this board according to their requirements, gaining time-to-market. The board is orderable through Infineon's sample center.



Optimization for EMI and efficiency/thermals
EMI and efficiency/thermals need a careful trade-off in notebook adapters – better efficiency/thermals require faster switching, which leads to worse EMI, e.g., due to the oscillations triggered by a high dV/dt (di/dt). With a small adjustment this challenge can be overcome. We recommend our customers to optimize EMI when designing-in high voltage superjunction MOSFETs by:

- Adding additional drain-source capacitor C_{DS}, e.g., 100 pF
- Adjusting external R_G, e.g., 5 Ω–30 Ω
- Optimizing PCB layout for short path from controller to MOSFET gate and a small loop inductance
- Adjusting EMI filter (only if other measures are insufficient)

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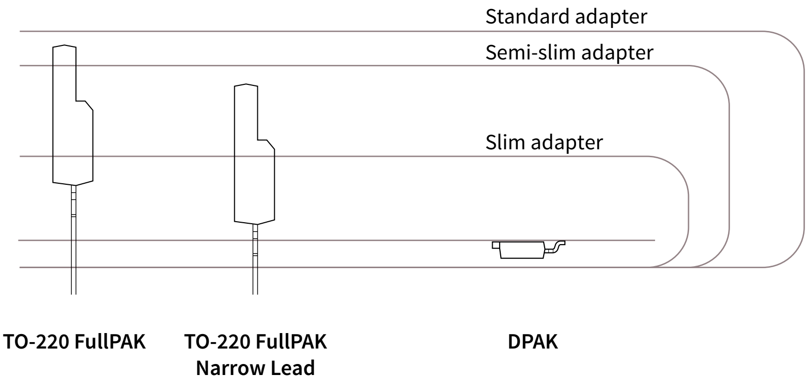
EMI optimization for a 45 W adapter

	Radiation (db) in vertical direction			
	115 V_{AC}	Frequency [MHz]	230 V_{AC}	Frequency [MHz]
IPA60R800CE	-2.18*	187.78	-1.67*	186.22
Competitor A (planar MOS)	-7.74*	120.13	-8.72	161.13
IPA60R800CE C_{DS}: 100 pF	-8.17*	182.24	-8.80*	183.28

* Quasi-peak



The figure above shows a typical example of adjusting EMI. It has been done on a common 45 W adapter from the market, using a planar MOSFET. Simply replacing the planar MOSFET with IPA60R800CE leads to a worse EMI performance. However, adding a 100 pF C_{DS} significantly improves the EMI while meeting other specifications such as efficiency, temperature, etc.

CoolMOS™ CE – Package options for notebook adapter application (35 W-65 W)

TO-220 FullPAK
Standard package used in adapters today

TO-220 FullPAK Narrow Lead
Package for semi-slim adapter solution, where height is smaller compared to standard adapters. The legs of the TO-220 FullPAK Narrow Lead package have been modified with standoff height reduced from about 3.3 mm to approximately 1.8 mm such that the leads can be fully inserted into the PCB without any production concerns. As a result, MOSFET height is reduced while creepage distance is preserved

DPAK
The DPAK solution has no concerns on the package height for semi-slim and slim adapter solutions, as its height is far below the allowed height, and it is on the other side of the package, meaning space saving and power density increasing, however better thermal management is required

CoolMOS™ CE portfolio for 30 W to 65 W adapter

Voltage class [V]	$R_{DS(on)}$ [mΩ]	TO-220 FullPAK	TO-252 DPAK	TO-220 FullPAK Narrow Lead
600	400	IPA60R400CE	IPD60R400CE	
	460	IPA60R460CE	IPD60R460CE	
	650	IPA60R650CE	IPD60R650CE	IPAN60R650CE
	800	IPA60R800CE	IPD60R800CE	IPAN60R800CE
650	400	IPA65R400CE	IPD65R400CE	
	650	IPA65R650CE	IPD65R650CE	IPAN65R650CE
General proposal		For standard adapter	For slim adapter	For semi-slim adapter

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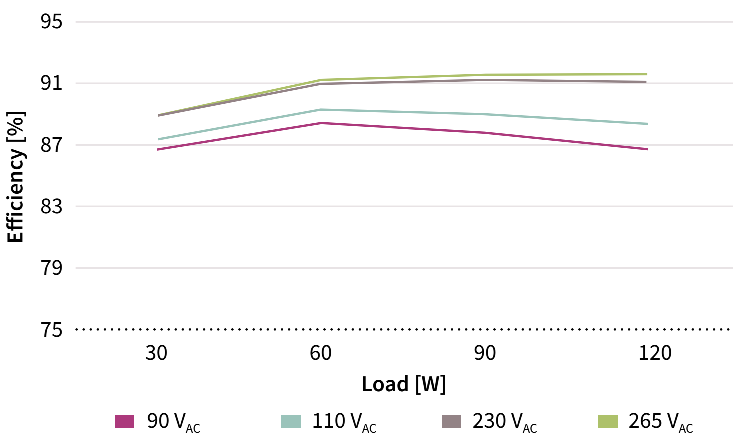
CoolMOS™ CE – TV sets

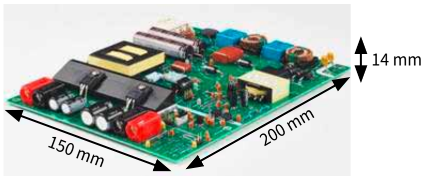
CoolMOS™ CE offers a wide range of products for the TV SMPS application and is selected by the world's leading TV manufacturers due to high quality, reliability and ease-of-use. Together with XDP™ digital power, OptiMOS™, EiceDRIVER™ and other components from Infineon, we offer system solutions as demonstrated by a wide range of reference designs. Our dedication for TV application has been further demonstrated by developing 600 V CoolMOS™ CE in TO-220 FullPAK Wide Creepage products mainly for TV application.

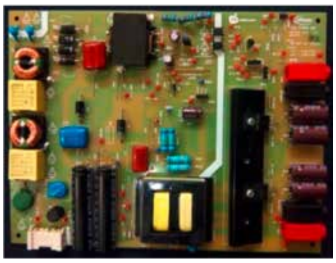
Value proposition of 500 V, 600 V, 650 V and 700 V CoolMOS™ CE for TV applications:

For the AC-DC power supply in TV applications, CoolMOS™ CE devices come in different voltage classes of 500 V, 600 V, 650 V and 700 V so as to be used in both PFC and LLC stages. The CoolMOS™ CE devices are offered in different packages such as TO-220 FullPAK, TO-220 FullPAK Wide Creepage, DPAK and SOT-223. This variety enables customer to use these packages in different stages of the power supply to ease the PCB layout design and manufacturing. As an example, the TO-220 FullPAK can be used in the top-side PFC stage and the DPAK or SOT-223 can be used in the bottom side LLC stage making the layout simpler, and efficiently meeting the thermal and EMI requirements. When CoolMOS™ CE devices are driven with optimal gate driving techniques, they exhibit low temperature rise and provide high efficiency performance. These devices are robust and are capable of withstanding higher stress under fault conditions. This high reliability feature makes them suitable for operation in environments which have unstable power conditions. As an example, the stress on the PFC MOSFETs can be high under input line transient or faulty load conditions. The CoolMOS™ CE devices safely carry high peak currents until the PWM controller responds to the transient condition.

Infineon's 120 W TV SMPS design powered by IPD60R400CE and IPD60R1K5CE







DEMO-IDP2302-120W

Infineon offers a reference design for a 120 W TV SMPS which combines the advantages of XDP™ digital power and CoolMOS™ CE to offer the state-of-the-art performance, where IDP2302 is used to control system, and IPD60R400CE and IPD60R1K5CE are used in the PFC and LLC stages respectively. It is a slim design and cost optimized for customers.

CoolMOS™ CE portfolio for TV

Voltage class [V]	500		600			650		700
$R_{DS(on)}$ [mΩ]	TO-220 FullPAK	TO-252 (DPAK)	TO-220 FullPAK	TO-252 (DPAK)	TO-220 FullPAK Wide Creepage	TO-220 FullPAK	TO-252 (DPAK)	TO-220 FullPAK Wide Creepage
190	IPA50R190CE				IPAW60R190CE			
280	IPA50R280CE	IPD50R280CE			IPAW60R280CE			
800	IPA50R800CE	IPD50R800CE	IPA60R800CE	IPD60R800CE				
400/380	IPA50R380CE	IPD50R380CE	IPA60R400CE	IPD60R400CE	IPAW60R380CE	IPA65R400CE	IPD65R400CE	
500/460	IPA50R500CE	IPD50R500CE	IPA60R460CE	IPD60R460CE				
650/600	IPA50R650CE	IPD50R650CE	IPA60R650CE	IPD60R650CE	IPAW60R600CE	IPA65R650CE	IPD65R650CE	IPAW70R600CE
950/1000	IPA50R950CE	IPD50R950CE	IPA60R1K0CE	IPD60R1K0CE		IPA65R1K0CE	IPD65R1K0CE	IPAW70R950CE
1500/1400		IPD50R1K4CE	IPA60R1K5CE	IPD60R1K5CE		IPA65R1K5CE	IPD65R1K5CE	
General proposal	PFC: 190 mΩ – 600 mΩ LLC: 400 mΩ – 1500 mΩ		PFC: 190 mΩ – 600 mΩ LLC: 400 mΩ – 1500 mΩ Flyback: 400 mΩ – 1500 mΩ			Flyback: 400 mΩ – 1500 mΩ		Flyback

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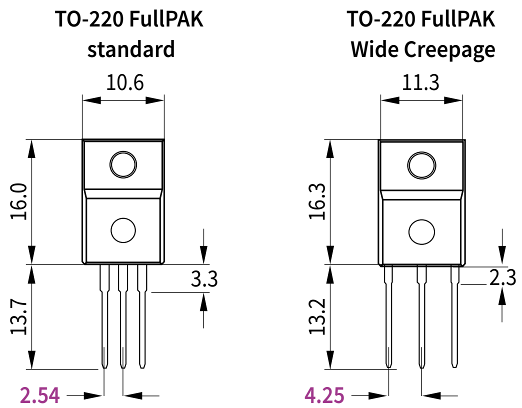
New TO-220 FullPAK Wide Creepage package for CoolMOS™



Wider creepage for applications susceptible to pollution

The TO-220 FullPAK Wide Creepage increases the creepage distance to 4.25 mm compared to 2.54 mm for a standard TO-220 package. It fully meets requirements of the EN60664-1 standard that requires at least 3.6 mm for open frame electrical power supplies which are often found in LED TV, PC power or industrial power supplies: in these applications, air vents in the external casing to allow some air flow which will assist in cooling the internal components. This makes the inside susceptible to pollutants such as dust particles. These pollutants reduce the effective creepage between pins. High voltage arcing can destroy the MOSFET used in SMPS when the pollutants reduce the effective creepage distance.

The TO-220 FullPAK Wide Creepage reduces system cost by offering an alternative to frequently used approaches to increase creepage distance: the application of potting, the usage of sleeves, pre-bending of leads and other workarounds come at an extra cost of estimated 2-5 USD cents. This cost and the additional process steps can be removed with the Wide Creepage package.

Benefits

- Wide creepage of 4.25 mm to avoid arcing even in polluted environment
- Cost savings of 2-5 USD cent in creepage protection by removing additional process steps
- Fully automated PCB assembly eliminating process variation
- FullPAK benefit of isolation, lower package capacitances, lower EMI

CoolMOS™ CE offers 500 V, 600 V, 650 V and 700 V products in TO-220 FullPAK, TO-252 (DPAK) and TO-220 FullPAK Wide Creepage for TV SMPS solutions. For the PFC section 500 V/600 V products with an $R_{DS(on)}$ between 190 mΩ and 600 mΩ are preferred. We recommend 400 mΩ to 1500 mΩ 500 V/600 V products in the LLC section. For flyback 400 mΩ to 1500 mΩ 600 V/ 650 V parts are recommended for customer design.

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CoolMOS™ CE for lighting applications

Good efficiency, ease-of-use and EMI performance at an attractive cost position make the CoolMOS™ CE series the product of choice for LED drivers or LED tubes in buck, flyback, PFC and LLC topology. Its benefits include an improvement in efficiency and thermal behavior compared to standard MOSFETs.

CoolMOS™ products aimed at lighting bring the benefits of highest quality and delivery reliability as outlined in the overview section for the CoolMOS™ portfolio. However, the CoolMOS™ CE series has been defined with a particular focus on the customers' needs, for an attractive price and fastest supply availability.

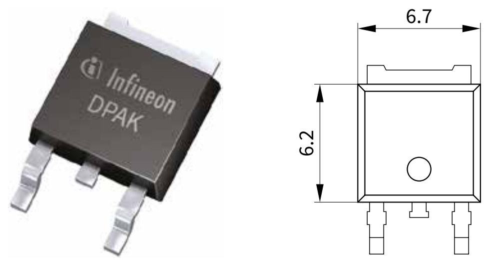
CoolMOS™ CE in SOT-223 package

With the rapid conversion from CFL to LED lighting, customer requirements are rapidly changing: On the one hand, power levels are further decreasing, while on the other hand, increasing cost pressure compels power designers to optimize designs to a fraction of a cent. The completion of the CoolMOS™ CE portfolio with the SOT-223 package is Infineon's answer to this challenge: It facilitates a further reduction in BOM cost – and additional footprint optimization in some designs – with only a minor compromise in terms of thermal behavior.

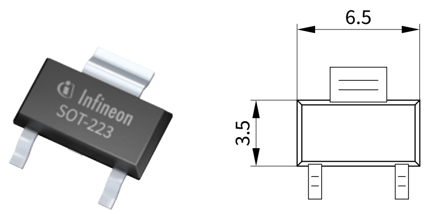
SOT-223 as drop-in replacement for DPAK at a lower cost

The SOT-223 package with a decapped middle pin is fully compatible with the footprint of a DPAK, therefore allowing one-on-one drop-in replacements and second sourcing.

DPAK



SOT-223



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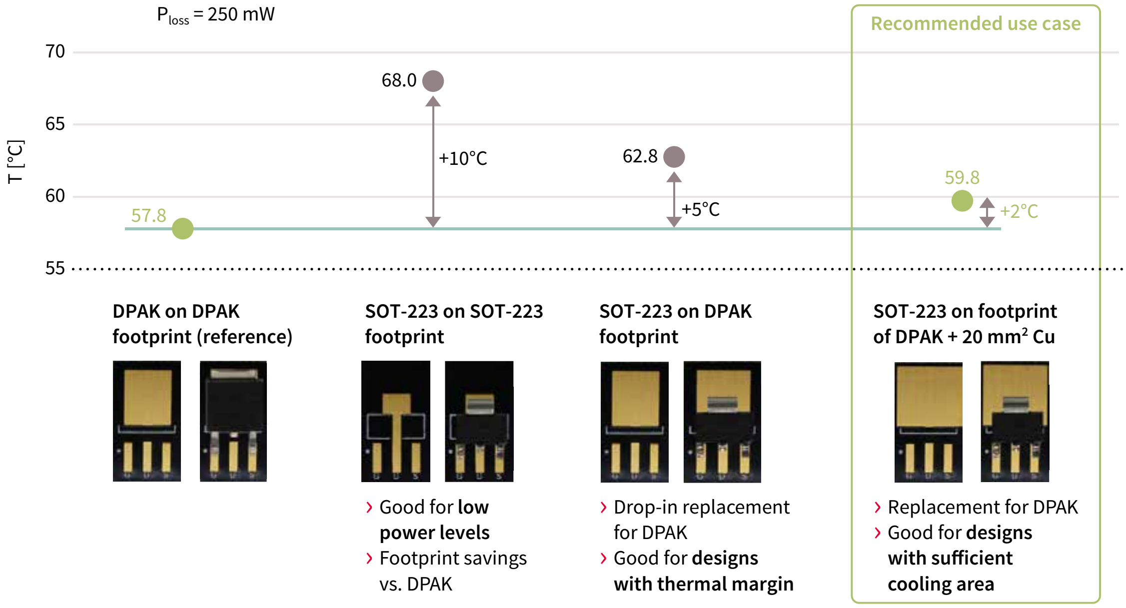
Thermal behavior – on a par with DPAK

The thermal behavior of the SOT-223 primarily depends on the layout of the board where the package is used and on the power consumed. We have measured the thermals in a test environment and compared them with a simulation. Compared to a DPAK positioned on a typical DPAK footprint, the SOT-223 displays the following thermal behavior:



- **Same footprint as DPAK** – when mounted on a standard DPAK footprint, the SOT-223 package shows a temperature elevated by 4–5 K. This behavior makes the SOT-223 suitable for designs with a thermal margin
- **Footprint of DPAK plus ~20 mm² additional copper area** – in many designs, the MOSFET is mounted on a larger Cu area which serves as a heatsink embedded in the PCB. As soon as 20 mm² Cu or more is available in addition to the DPAK footprint, the temperature increase is no more than 2–3 K above DPAK and the SOT-223 can be used as a drop-in replacement
- **SOT-223 on SOT-223 footprint** – when mounted on the SOT-223 footprint without an additional surrounding Cu area, the package leads to a 10 °C temperature increase compared to a DPAK. This means that the option of space savings via the SOT-223 is only useful for very low power applications

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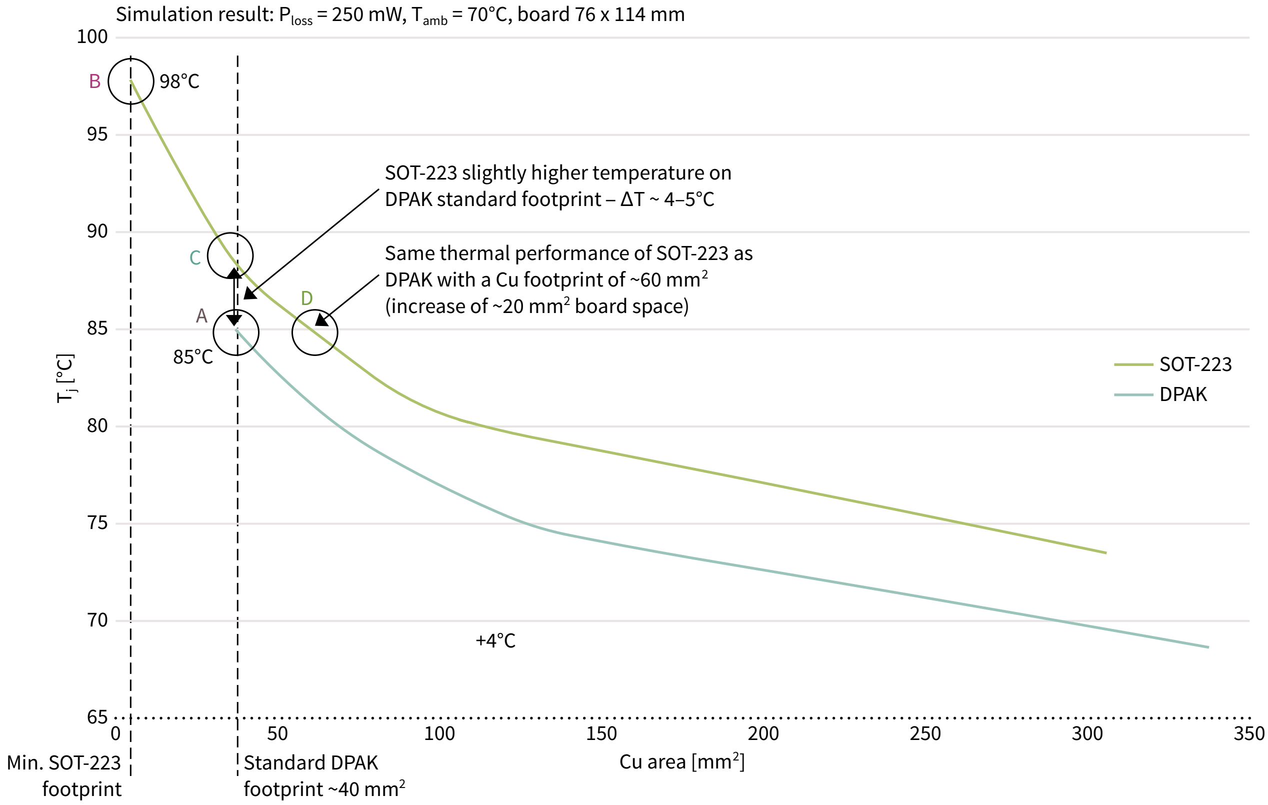
Thermal behavior – on a par with DPAK



The laboratory findings on thermal behavior are confirmed by a thermal simulation with $T_{ambient}$ = 70°C and P_{loss} = 250 mW. The size of the copper area in the footprint is shown on the x-axis, while the y-axis displays the temperature of the package top side. In the case of an SOT-223 on DPAK footprint, the 4–5 K temperature increase over DPAK is confirmed. But when used in conjunction with an enlarged copper area of ~20 mm², a temperature increase of 2–3 K is measured.

CoolMOS™ CE SOT-223 product portfolio

$R_{DS(ON)}$ [mΩ]	500 V	600 V	650 V	700 V
3400		IPN60R3K4CE		
3000	IPN50R3K0CE			
2000/2100	IPN50R2K0CE	IPN60R2K1CE		
1400/1500	IPN50R1K4CE	IPN60R1K5CE	IPN65R1K5CE	IPN70R1K5CE
950/1000	IPN50R950CE	IPN60R1K0CE		IPN70R1K0CE
800	IPN50R800CE			
650	IPN50R650CE			

CoolMOS™ CE – demonstrator boards

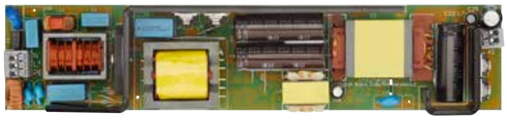
ICL8201 demoboard with 500 V CoolMOS™

End application: 5 W-10 W LED lamp

Parameter	Value
Output power	7.5 W
Input voltage	90 V_{AC}–265 V_{AC}
Frequency	50 Hz/60 Hz
Power factor	> 0.95 at low line > 0.80 at high line
THD	< 20% at low line < 30% at high line
Efficiency	85%
Output voltage	33 V_{DC}–47 V_{DC}
Output current	180 mA
Infineon order code [1]	EVALLEDICL8201F1 / SP001339448

ICL5101 demoboard with 600 V CoolMOS™ [2]

End applications: indoor and outdoor high power LED lighting, high-bay and low-bay lighting, street lighting, parking garages and area lighting, office panel and shop lighting



Parameter	Value
Output power	110 W
Input voltage	85 V_{AC}–305 V_{AC}
Output voltage	54 V_{DC}
Output current	2060 mA
Efficiency	~ 94%
Power factor	> 99%
THD	< 10%
TAmbient	80°C–100°C
Infineon order code [1]	EVALLEDICL5101E1 / SP001296078

ICL8201 demoboard with 650 V CoolMOS™

End application: Single end cap T8 form factor LED lamp

Parameter	Value
Output power	18 W
Input voltage	170 V_{AC}–277 V_{AC}
Frequency	50 Hz
Power factor	> 0.95
THD	< 20%
Efficiency	> 90%
Output voltage	55 V_{DC}–75 V_{DC}
Output current	270 mA
Infineon order code [1]	EVALLEDICL8201F2 / SP001339450

ICL8105 demoboard with 800 V CoolMOS™ [3]

End application: Electronic control gear for LED luminaires (20 W–80 W)

Parameter	Value
Output power	40 W
Nominal input voltage	90 V–300 V~
Input overvoltage	310 V~
Output voltage	15 V–45 V
Output overvoltage threshold	50 V
Output current	880 mA
Efficiency	< 91%
Power factor	> 0.95
THD	< 16%
Infineon order code: [1]	EVALLEDICL8105F2 / SP001296076
20 W-80 W version:	EVALLEDICL8105E1 / SP001296074

[1] Go to our website for more specific information about the demoboard
[2] Also suitable for 500 V due to excellent V_{bulk} regulation and error protection
[3] Launch in 09/2016, higher efficiency and lower price

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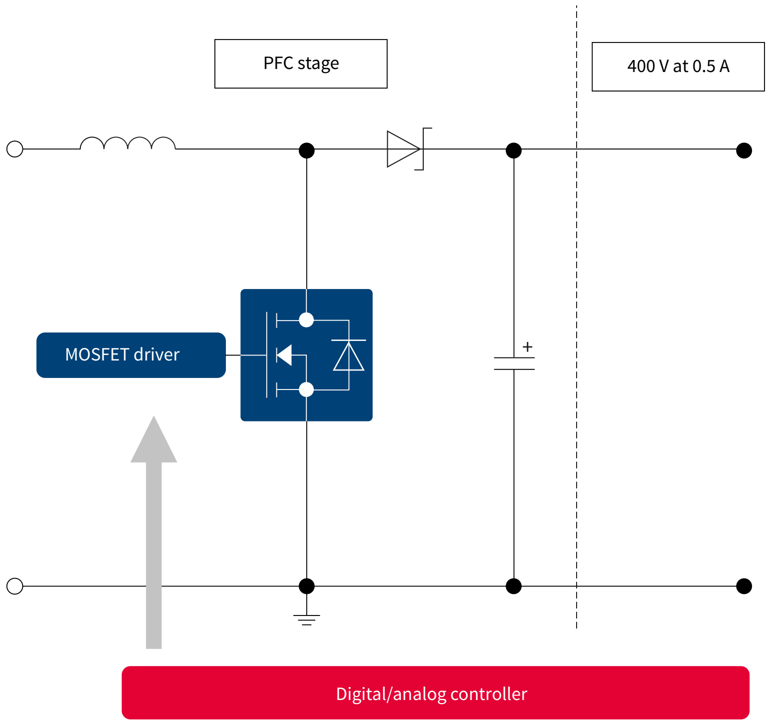
CoolMOS™ CE – target topologies

Single switch topologies – boost/PFC

Typically used in high power adapters, PC power, TV power supplies front-end



Design equations for MOSFET selection
$V_{DS} = V_{out}$
$I_D = I_{out} * 1 / (1\text{-}D)$
$V_{DS\_FET} = 1.5 * V_{DS}$ (with derating for all variables on board)
$R_{DS(on)}$ max. 25°C for acceptable power dissipation in MOSFET package $= (1.5 * P_{device}) / (I_{pk}{}^2 * D)$. I_{pk} is derated value of I_D to cover all worst case operation conditions. $I_{pk} = 1.5 * I_D$
$P_{device} = (T_j - T_a) / R_{thJA}$

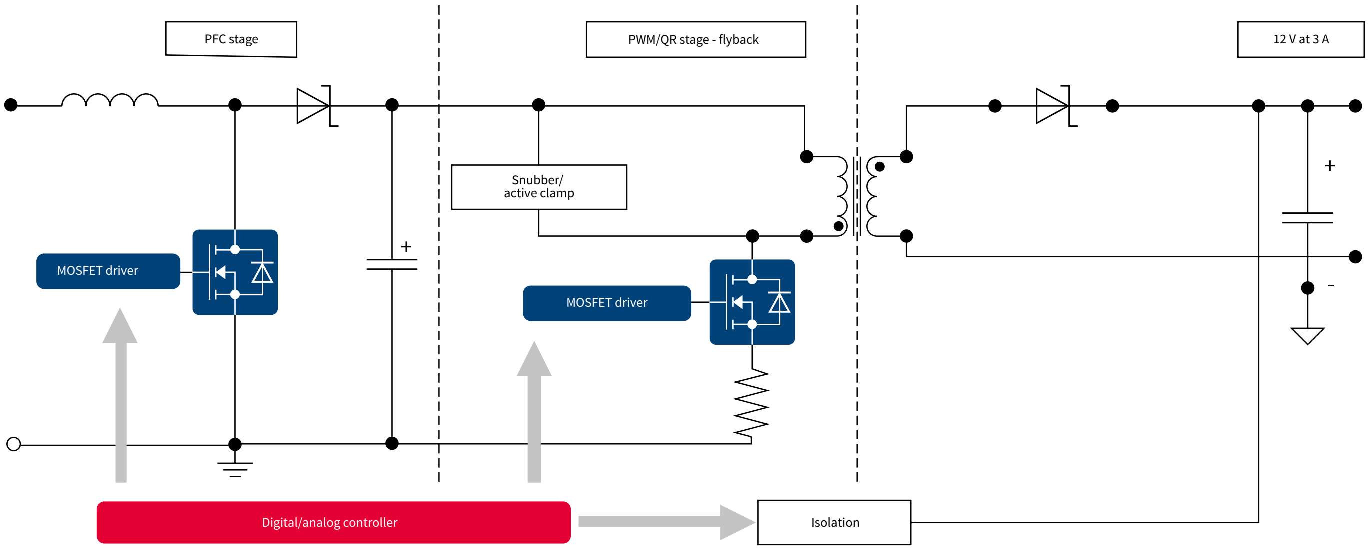
Output power [W]	Input voltage [V]	PFC output load current at 400 V output voltage [A]	CoolMOS™ CE device options
200	85 V_{AC}…265 V_{AC}	0.60	IPx60R400CE*
150	85 V_{AC}…265 V_{AC}	0.40	IPx60R460CE
100	85 V_{AC}…265 V_{AC}	0.30	IPx60R650CE
75	85 V_{AC}…265 V_{AC}	0.20	IPx60R800CE

* Two in parallel

CoolMOS™ CE – target topologies

Quasi-resonant flyback topologies

Typically used in chargers, adapters, auxiliary power supplies



Design equations for MOSFET selection
$V_{DS} = V_{in} + VR$, where $VR = (0.8 * V_{out} * (NP / NS))$
$I_D = V_{in} * ton / L_p$
$V_{DS\_FET} = 1.5 * V_{DS}$ (with derating for all variables on board)
$R_{DS(on)}$ max. 25°C for acceptable power dissipation in MOSFET package $= (1.5 * P_{device}) / (I_{pk}^2 * D)$. I_{pk} is derated value of I_D to cover all worst case operation conditions. $I_{pk} = 1.5 * I_D$
$P_{device} = (T_j - T_a) / R_{thJA}$

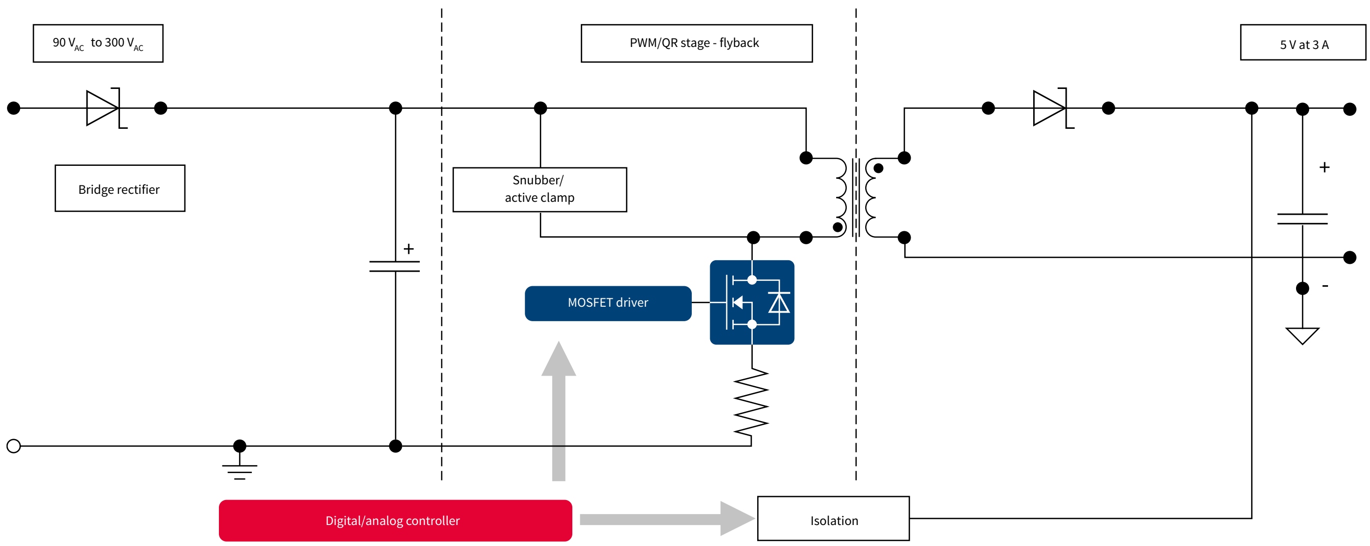
Selection is based for 85 V_{AC} to 265 V_{AC} input voltage, 100 kHz switching frequency. Reflected voltage (VR) design greatly affects MOSFET V_{DS} selection criteria. Mode of operation – CCM (continuous conduction mode) or DCM (discontinuous conduction mode) also affects MOSFET $R_{DS(on)}/I_D$ selection criteria.

Output power [W]	Output voltage [V]	Turns ratio NP/NS	Primary inductance DCM [uH]	Primary inductance CCM [uH]	CoolMOS™ CE device options DCM	CoolMOS™ CE device options CCM
120	19	6	71	143	IPx65R650CE	IPx65R650CE
100	24	5	107	214	IPx65R650CE	IPx65R1k0CE
75	19	6	107	214	IPx65R650CE	IPx65R1k0CE
50	12	10	107	214	IPx65R650CE	IPx65R1k0CE
36	12	10	143	286	IPx70R600CE	IPx70R1K4CE
25	9	13	143	286	IPx70R950CE	IPx70R1K4CE
15	5	24	143	286	IPx70R950CE	IPx70R1K4CE
10	5	24	214	429	IPx70R1K4CE	IPx70R1K4CE
5	5	24	429	857	IPx70R2K0CE	IPx70R1K4CE

CoolMOS™ CE – target topologies

Wide input range flyback topologies

Typically used in LED drivers and adapters



Design equations for MOSFET selection
$V_{DS} = V_{in} + VR$, where $VR = (0.8 * V_{out} * (NP / NS))$
$I_D = V_{in} * ton / L_p$
$V_{DS\_FET} = 1.5 * V_{DS}$ (with derating for all variables on board)
$R_{DS(on)}$ max. 25°C for acceptable power dissipation in MOSFET package = $(1.5 * P_{device}) / (I_{pk}^2 * D)$. I_{pk} is derated value of I_D to cover all worst case operation conditions. $I_{pk} = 1.5 * I_D$
$P_{device} = (T_j - T_a) / R_{thJA}$

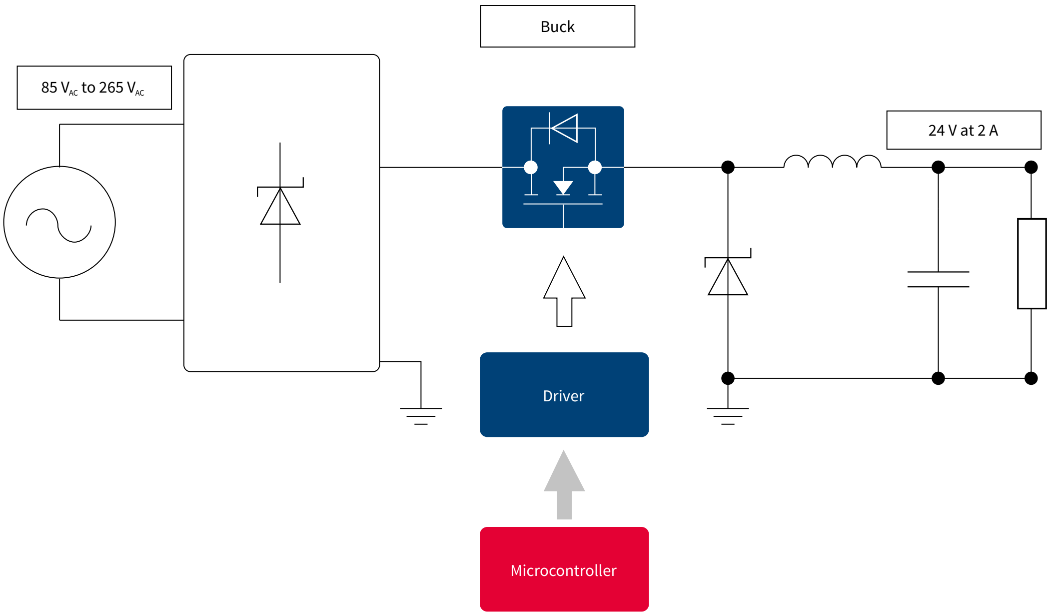
Selection is based for 85 V_{AC} to 300 V_{AC} input voltage, 100 kHz switching frequency. Reflected voltage (VR) design affects MOSFET V_{DS} selection criteria. 800 V devices allow greater VR range. Mode of operation – CCM (continuous conduction mode) or DCM (discontinuous conduction mode) also affects MOSFET $R_{DS(on)}/I_D$ selection criteria.

Output power [W]	Output voltage [V]	Turns ratio NP/NS	Primary inductance DCM [uH]	Primary inductance CCM [uH]	CoolMOS™ CE device options DCM	CoolMOS™ CE device options CCM
150	24	5	71	143	IPA80R310CE	IPA80R460CE
100	24	5	107	214	IPA80R310CE	IPA80R650CE
50	12	10	107	214	IPA80R310CE	IPA80R650CE
36	12	10	143	286	IPA80R460CE	IPA80R1K0CE
25	9	13	143	286	IPA80R460CE	IPA80R1K0CE
15	5	24	143	286	IPA80R460CE	IPA80R1K0CE
10	5	24	214	429	IPA80R650CE	IPA80R1K4CE
5	5	24	429	857	IPA80R1K0CE	IPx80R2K8CE

CoolMOS™ CE – target topologies

Single switch topologies – buck

Typically used in LED drivers, motor controllers, high power adapters, TV power supplies front-end



Design equations for MOSFET selection
$V_{DS} = V_{in}$
$I_D = I_{out}$
$V_{DS\_FET} = 1.5 * V_{DS}$ (with derating for all variables on board)
$R_{DS(on)}$ max. 25°C for acceptable power dissipation in MOSFET package $= (1.5 * P_{device}) / (I_{pk}^2 * D)$. I_{pk} is derated value of I_D to cover all worst case operation conditions

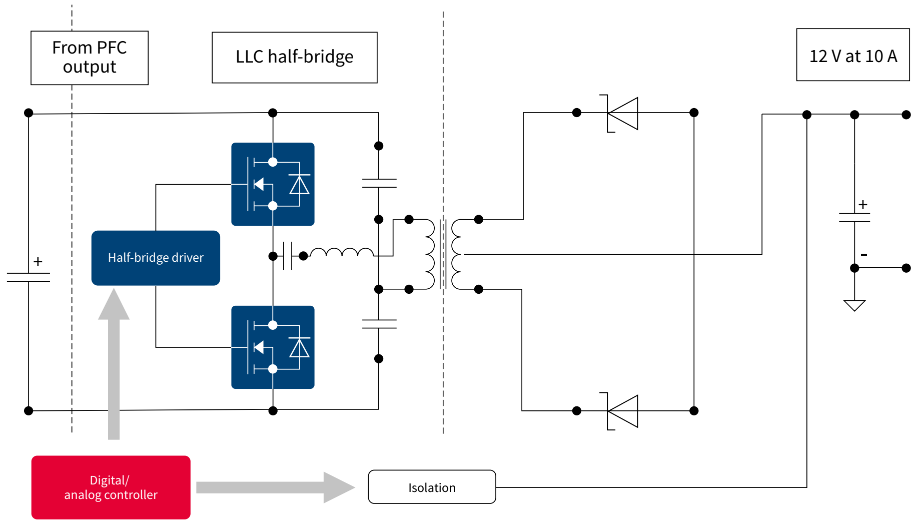
Input voltage [V]	Output load current [A]	Output power [W]	CoolMOS™ CE device options
110 V_{AC}	7	200	IPx50R190CE*
110 V_{AC}	6	180	IPx50R280CE*
85 V_{AC}…265 V_{AC}	5	150	IPx60R400CE
85 V_{AC}…265 V_{AC}	4	120	IPx60R460CE
85 V_{AC}…265 V_{AC}	4	100	IPx60R650CE
85 V_{AC}…265 V_{AC}	3	75	IPx60R650CE
85 V_{AC}…265 V_{AC}	3	50	IPx60R1k0CE
85 V_{AC}…265 V_{AC}	2	25	IPx60R1k5CE
85 V_{AC}…265 V_{AC}	2	10	IPx60R2k1CE
85 V_{AC}…265 V_{AC}	1	5	IPx60R3k4CE

* Two in parallel

CoolMOS™ CE – target topologies

Two switch topologies – half-bridge LLC
Typically used in PC power and TV power supplies

The ideal MOSFET for the LLC converter would allow for zero dead time (maximum power transfer) and no conduction loss. Hence selecting a lower $R_{DS(on)}$ MOSFET will help lower condition losses. Since LLC operates fully in ZVS-mode (given appropriate MOSFET Q_G, Q_{oss}, selected Q_{max} and m-values – and ample pre-programmed deadtime), switching loss caused by E_{oss} can be considered negligible, and to this extent, E_{oss} is not a critical MOSFET parameter for LLC.



Design equations for MOSFET selection
$V_{DS} = V_{in}$
$I_D = I_{out}$ * (NS / NP)
V_{DS_FET} = 1.5* V_{DS} (with derating for all variables on board)
$R_{DS(on)}$ max. 25°C for acceptable power dissipation in MOSFET package = (1.5 * P_{device}) / (I_{pk}^2 * D). I_{pk} is derated value of I_D to cover all worst case operation conditions

In LLC topology, the MOSFET body diode could potentially experience hard current commutation in abnormal conditions, if steps are not taken specifically to avoid this either by a good control scheme or additional circuitry in the topology. The CoolMOS™ CE addresses the potential issue of reverse recovery of body diode by employing a self-snubbing scheme causing the channel to partially turn on at high dV/dt (induced by C_{GD}/C_{GS} voltage divider) in order to prevent avalanche breakdown, thus providing the extra measure of protection during hard body diode commutation.

Input voltage V_{DC} [V]	Output voltage [V]	Output voltage V_o [V]	Rac [Ω]	Lr [uH]	Lp [uH]	Cr [nF]	600 V CoolMOS™ CE device options	500 V CoolMOS™ CE device options
400	250	24	128	109	356	20	IPx60R400CE	IPx50R380CE
400	200	24	160	136	445	16	IPx60R460CE	IPx50R500CE
400	150	24	213	181	594	12	IPx60R650CE	IPD50R650CE
400	100	24	320	272	890	8	IPx60R800CE	IPD50R800CE
400	75	24	427	363	1187	6	IPx60R1k0CE	IPD50R950CE

Infineon support for high voltage MOSFETs

Useful links and helpful information

Further information, datasheets and documents

- www.infineon.com/ce
- www.infineon.com/coolmos
- www.infineon.com/coolmos-500V
- www.infineon.com/coolmos-600V
- www.infineon.com/coolmos-650V-700V
- www.infineon.com/coolmos-800V
- www.infineon.com/powermosfet-simulationmodels

Videos

- www.infineon.com/mediacenter

500 V CoolMOS™ CE ACTIVE & PREFERRED

$R_{DS(on)}$ [mΩ]	TO-220	TO-220 FullPAK	TO-220 FullPAK Narrow Lead	TO-247	TO-252 (DPAK)	TO-251 (IPAK)	TO-251 (IPAK Short Lead)	SOT-223
190	IPP50R190CE	IPA50R190CE		IPW50R190CE				
280	IPP50R280CE	IPA50R280CE		IPW50R280CE	IPD50R280CE			
380	IPP50R380CE	IPA50R380CE			IPD50R380CE			
500	IPP50R500CE	IPA50R500CE	IPAN50R500CE		IPD50R500CE			
650		IPA50R650CE			IPD50R650CE			IPN50R650CE
800		IPA50R800CE			IPD50R800CE			IPN50R800CE
950		IPA50R950CE			IPD50R950CE	IPU50R950CE		IPN50R950CE
1400					IPD50R1K4CE	IPU50R1K4CE		IPN50R1K4CE
2000					IPD50R2K0CE	IPU50R2K0CE		IPN50R2K0CE
3000					IPD50R3K0CE	IPU50R3K0CE		IPN50R3K0CE

600 V CoolMOS™ CE ACTIVE & PREFERRED

$R_{DS(on)}$ [mΩ]	TO-220 FullPAK	TO-220 FullPAK Wide Creepage	TO-220 FullPAK Narrow Lead	TO-252 (DPAK)	TO-251 (IPAK)	TO-251 (IPAK Short Lead)	SOT-223
190		IPAW60R190CE					
280		IPAW60R280CE					
380		IPAW60R380CE					
400	IPA60R400CE			IPD60R400CE		IPS60R400CE	
460	IPA60R460CE			IPD60R460CE		IPS60R460CE	
600		IPAW60R600CE					
650	IPA60R650CE		IPAN60R650CE	IPD60R650CE		IPS60R650CE	
800	IPA60R800CE		IPAN60R800CE	IPD60R800CE		IPS60R800CE	
1000	IPA60R1K0CE			IPD60R1K0CE	IPU60R1K0CE	IPS60R1K0CE	IPN60R1K0CE
1500	IPA60R1K5CE			IPD60R1K5CE	IPU60R1K5CE	IPS60R1K5CE	IPN60R1K5CE
2100				IPD60R2K1CE	IPU60R2K1CE	IPS60R2K1CE	IPN60R2K1CE
3400				IPD60R3K4CE	IPU60R3K4CE	IPS60R3K4CE	IPN60R3K4CE

650 V CoolMOS™ CE ACTIVE & PREFERRED

$R_{DS(on)}$ [mΩ]	TO-220	TO-220 FullPAK	TO-220 FullPAK Narrow Lead	TO-252 (DPAK)	TO-251 (IPAK)	TO-251 (IPAK Short Lead)	SOT-223
400		IPA65R400CE		IPD65R400CE		IPS65R400CE	
650		IPA65R650CE	IPAN65R650CE	IPD65R650CE		IPS65R650CE	
1000		IPA65R1K0CE		IPD65R1K0CE		IPS65R1K0CE	
1500		IPA65R1K5CE		IPD65R1K5CE		IPS65R1K5CE	IPN65R1K5CE

700 V CoolMOS™ CE ACTIVE & PREFERRED

$R_{DS(on)}$ [mΩ]	TO-220	TO-220 FullPAK Wide Creepage	TO-262 (I^2PAK)	TO-252 (DPAK)	TO-251 (IPAK Short Lead with ISO Standoff)	TO-251 (IPAK Short Lead)	SOT-223	ThinPAK 5x6
600		IPAW70R600CE		IPD70R600CE	IPSA70R600CE	IPS70R600CE		
950		IPAW70R950CE	IPI70R950CE	IPD70R950CE	IPSA70R950CE	IPS70R950CE		
1000							IPN70R1K0CE	
1400				IPD70R1K4CE	IPSA70R1K4CE	IPS70R1K4CE		
1500							IPN70R1K5CE	
2000				IPD70R2K0CE	IPSA70R2K0CE	IPS70R2K0CE		
2100								IPL70R2K1CES

800 V CoolMOS™ CE ACTIVE

$R_{DS(on)}$ [mΩ]	TO-220	TO-220 FullPAK	TO-247	TO-252 (DPAK)	TO-251 (IPAK)	TO-251 (IPAK Short Lead)
310		IPA80R310CE				
460		IPA80R460CE				
650		IPA80R650CE				
1000		IPA80R1K0CE		IPD80R1K0CE	IPU80R1K0CE	
1400		IPA80R1K4CE		IPD80R1K4CE	IPU80R1K4CE	
2800				IPD80R2K8CE	IPU80R2K8CE	

www.infineon.com/ce

CoolMOS™ CE portfolio package overview

Package	Voltage [V]	$R_{DS(on)}$ [mΩ]									
		0-59	60-89	90-149	150-199	200-299	300-400	401-600	601-899	900-1500	>1500
SOT-223	500								650/800	950/1400	2000/3000
	600									1000/1500	2100/3400
	650									1500	
	700									1000/1500	
TO-247	500				190	280					
IPAK	600									1000/1500	2100
	800									1000/1400	2800
IPAK Short Lead	600						400	460	650/800	1000/1500	2100/3400
	650						400		650	1000/1500	
	700							600		950/1400	2000
IPAK Short Lead with ISO Standoff	700							600		950/1400	2000
DPAK	500					280	380	500	650/800	950/1400	2000/3000
	600						400	460	650/800	1000/1500	2100/3400
	650						400		650	1000/1500	
	700							600		950/1400	2000
	800									1000/1400	2800
I^2PAK	700									950	
TO-220 FullPAK	500				190	280	380	500	650/800	950	
	600						400	460	650/800	1000/1500	
	650						400		650	1000/1500	
	800						310	460	650	1000/1400	
TO-220 Standard	500				190	280	380	500			
TO-220 FullPAK Narrow Lead	500							500			
	600								650/800		
	650								650		
TO-220 FullPAK Wide Creepage	600				190	280	380	600			
	700							600		950	
ThinPAK 5x6	700										2100

ACTIVE & PREFERRED   ACTIVE

www.infineon.com/ce

500 V CoolMOS™ CE

Superjunction MOSFET					
CoolMOS™ CE	**STMicroelectronics**	**Alpha and Omega Semiconductor**	**Vishay**	**Fuji Electric**	**Toshiba**
IPA50R950CE					
IPA50R800CE	STF8NM50N	AOTF8T50P	SiHFI840G SiHF8N50D	FMV08N50E	
IPA50R650CE	STF10NM50N				
IPA50R500CE	STF11NM50N	AOTF12N50	SiHFIB7N50A	FMV12N50E FMV12N50ES	
IPA50R380CE		AOTF14N50	SiHF16N50C	FMV16N50E FMV16N50ES	
IPA50R280CE	STF19NM50N		SiHF18N50D	FMV20N50E FMV21N50ES	
IPA50R190CE	STF23NM50N				
IPP50R500CE	STP11NM50N		SiHP12N50C	FMP12N50E FMP12N50ES	TK12A50D
IPP50R380CE	STP12NM50		SiHP12N50E	FMP16N50E FMP16N50ES	TK13A50D
IPP50R280CE	STP19NM50N		SiHP15N50E	FMP20N50E FMP20N50ES	TK18A50D
IPP50R190CE	STP23NM50N		SiHP20N50E		
IPD50R3K0CE		AOD3N50	SiHFR420		TK3P50D
IPD50R2K0CE					
IPD50R1K4CE		AOD6N50	SiHD5N50D		TK5P50D
IPD50R950CE					TK7P50D
IPD50R800CE	STD8NM50N	AOD9N50			
IPD50R650CE	STD10NM50N				
IPD50R500CE	STD11NM50N				
IPD50R380CE	STD14NM50N		SiHD12N50E		
IPD50R280CE					
IPU50R3K0CE		AOU3N50	SiHFU420		
IPU50R2K0CE					
IPU50R1K4CE			SiHU5N50D		
IPU50R950CE					
IPW50R280CE	STW19NM50N	AOK22N50	SiHG460B		
IPW50R190CE	STW23NM50N		SiHFP31N50L		

600 V CoolMOS™ CE

Superjunction MOSFET								
CoolMOS™ CE	**Fairchild Semiconductor**	**STMicroelectronics**	**STMicroelectronics**	**Toshiba**	**Alpha and Omega Semiconductor**	**Vishay**	**MagnaChip Semiconductor chip**	**NCE Micro- and Nanotechnology**
IPA60R1K5CE			STF5N60M2					NCE60R1K2F
IPA60R1K0CE		STF7NM60N	STF7N60M2	TK5A60W	AOTF4S60			NCE60R900F
IPA60R800CE		STF9NM60N	STF9N60M2	TK6A60W			MMF60R750PTH	
IPA60R650CE	FCPF600N60Z	STF10NM60N	STF10N60M2	TK7A60W	AOTF7S60	SiHF7N60E	MMF60R580PTH	NCE60R540F
IPA60R460CE			STF12N60M2	TK8A60W	AOTF11S60			
IPA60R400CE	FCPF380N60	STF13NM60N	STF13N60M2	TK10A60W		SiHF12N60E	MMF60R360PTH	NCE60R360F
IPD60R3K4CE								
IPD60R2K1CE								NCE60R2K2K
IPD60R1K5CE			STD5N60M2					NCE60R1K2K
IPD60R1K0CE	FCD900N60Z	STD7NM60N	STD7N60M2	TK5P60W	AOD4S60			NCE60R900K
IPD60R800CE		STD9NM60N	STD9N60M2	TK6P60W				
IPD60R650CE	FCD600N60Z	STD10NM60N	STD10N60M2	TK7P60W	AOD7S60	SiHD7N60E	MMD60R580PRH	NCE60R540K
IPD60R460CE			STD12N60M2	TK8P60W				
IPD60R400CE		STD13NM60N	STD13N60M2	TK10P60W	AOD11S60		MMD60R360PRH	NCE60R360K
IPU60R3K4CE								
IPU60R2K1CE								NCE60R2K2I
IPU60R1K5CE			STU5N60M2					NCE60R1K2I
IPU60R1K0CE		STU7NM60N	STU7N60M2		AOU4S60			NCE60R900I
IPS60R3K4CE								
IPS60R2K1CE								
IPS60R1K5CE								
IPS60R1K0CE	FCU900N60Z			TK5Q60W	AOI4S60		MMIS60R900PTH	
IPS60R800CE				TK6Q60W				
IPS60R650CE				TK7Q60W		SiHU7N60E		
IPS60R460CE				TK8Q60W				
IPS60R400CE				TK10Q60W	AOI11S60			

Planar MOSFET					
STMicroelectronics	Vishay	Huajing Rectifier	Silan	MagnaChip Semiconductor	Fairchild Semiconductor
		CS8N50F A9R	SVF840F	MDF7N50BTH	FDPF8N50NZ
	IRFI840G	CS10N50F A9R	SVF9N50F	MDF10N50TH	FQPF9N50C
				MDF12N50BTH	FDPF12N50T
STF13NK50Z	IRFIB7N50A	CS13N50F A9R	SVF13N50F	MDF13N50BTH	FDPF12N50NZ
STP14NK50ZFP		CS15N50F A9R	SVF18N50F	MDF16N50GTH	FDPF16N50
STF20NK50Z			SVF20N50F	MDF18N50BTH	FDPF18N50
STP11NK50Z		CS13N50 A8R	SVF13N50T	MDP13N50BTH	FDP12N50NZ
STP14NK50Z		CS15N50 A8R		MDP16N50GTH	
STP20NK50Z			SVF18N50T	MDP18N50BTH	FDP18N50
STD3NK50Z	IRFR420			MDD3N50GRH	
STD5NK50Z			SVF830D	MDD5N50RH	FDD5N50
STD6NK50Z			SVF840D		FDD6N50
					FDD8N50NZ
	IRFU420	CS3R50 A3			FQU4N50TU_WS
					FQU3N50C
		CS830 A3RD	SVF830M	MDIS5N50TH	
STW20NK50Z	IRFP460B				
	IRFP31N50L				

		Planar MOSFET					
Silikron Semiconductor	Lonten	Toshiba	STMicroelectronics	Huajing Rectifier	Silan	MagnaChip Semiconductor	Fairchild Semiconductor
		TK5A60D		CS6N60F A9TY	SVF6N60F	MDF6N60BTH	
SSF7N60F	LSDO4N60	TK9A60D		CS8N60F A9H	SVF10N60F	MDF8N60BTH	
SSF10N60F		TK10A60D	STP10NK60ZFP	CS10N60F A9HD	SVF11N60F	MDFS10N60DTH	FDPF10N60NZ
SSF7NS60F	LSD07N60	TK11A60D	STP13NK60ZFP	CS12N60F A9HD		MDF11N60TH	FDPF12N60NZ
		TK13A60D		CS20N60F A9H	SVF18N60F		
SSF11NS60F	LSD11N60F	TK15A60D				MDF15N60GTH	FDPF17N60NT
	LSG02N60						
SSF5N60D			STD4NK60Z	CS6N60 A4TY	SVF5N60D	MDD4N60BRH	FDD5N60NZ
	LSG03N60		STD5NK60Z	CS6N60 A4D	SVF6N60D	MDD6N60GRH	FDD7N60NZ
	LSG04N60						
SSF7NS60D	LSG07N60						
SSF11NS60D	LSG11N60						
				CS3N60 A3			
SSF5N60G			STD4NK60Z-1	CS6N60 A3TY	SVF5N60MJ		
SSF6N60G				CS6N60 A3D	SVF6N60MJ		FDU7N60NZTU
						MDI4N60BTH	
						MDI6N60BTH	

650 V CoolMOS™ CE

	Superjunction MOSFET					
CoolMOS™ CE	STMicroelectronics	STMicroelectronics	Toshiba	Alpha and Omega Semiconductor	Vishay	NCE Micro- and Nanotechnology
IPA65R1K5CE		STF6N65M2	TK5A65W			
IPA65R1K0CE		STF9N65M2	TK6A65W			NCE65R900F
IPA65R650CE		STF11N65M2	TK8A65W		SiHF6N65E	NCE70R540F
IPA65R400CE	STF15NM65N	STF16N65M2	TK11A65W	AOTF11S65	SiHF12N65E	NCE65R360F
IPD65R1K5CE		STD6N65M2	TK5P65W			
IPD65R1K0CE		STD9N65M2	TK6P65W			NCE65R900K
IPD65R650CE		STD11N65M2	TK8P65W	AOD7S65	SiHD6N65E	NCE70R540K
IPD65R400CE	STD11NM65N	STD16N65M2	TK11P65W			NCE65R360K
IPS65R1K5CE		STU6N65M2	TK5Q65W			
IPS65R1K0CE		STU9N65M2	TK6Q65W			NCE65R900L
IPS65R650CE		STU11N65M2	TK8Q65W	AOI7S65	SiHU6N65E	NCE65R540I
IPS65R400CE		STU16N65M2	TK11Q65W			

700 V CoolMOS™ CE

	Superjunction MOSFET							Planar MOSFET
CoolMOS™ CE	CoolMOS™ CE (IPAK Short Lead with ISO Standoff)	MagnaChip Semiconductor	NCE Micro- and Nano-technology	Silikron Semiconductor	Lonten	SemiHow	Taiwan Semiconductor Manufacturing	Huajing Rectifier
IPD70R2K0CE			NCE70R2K2K					CS6N70 A4D-G
IPD70R1K4CE		MMD70R1K4PRH	NCE70R1K2K	SSF5NS70D		HCD6N70S	TSM70N1R4CP	
IPD70R950CE		MMD70R900PRH	NCE70R900K		LSG04N70		TSM70N900CP	
IPD70R600CE		MMD70R600PRH	NCE70R540K		LSG07N70	HCD70R600S	TSM70N600CP	
IPS70R2K0CE	IPSA70R2K0CE		NCE70R2K2I	SSF6N70G				CS6N70
IPS70R1K4CE	IPSA70R1K4CE	MMIS70R1K4PTH	NCE70R1K2I	SSF5NS70G		HCU6N70S	TSM70N1R4CH	
IPS70R950CE	IPSA70R950CE	MMIS70R900PTH	NCE70R900I	SSF7NS70UG	LSH04N70		TSM70N900CH	
IPS70R600CE	IPSA70R600CE		NCE70R540I		LSH07N70	HCU70R600S	TSM70N600CH	
IPI70R950CE					LSF04N70			

CoolMOS™ CE in SOT-223 package

		Superjunction MOSFET									
CoolMOS™ CE SOT-223	CoolMOS™ CE DPAK	Fairchild Semiconductor	STMicro electronics	STMicro electronics	Toshiba	Alpha and Omega Semi-conductor	Vishay	MagnaChip Semiconductor	Fuji Electric	NCE Micro- and Nano-technology	Silikron Semi-conductor
IPN70R1K5CE	IPD70R2K0CE									NCE70R2K2K	
IPN70R1K5CE	IPD70R1K4CE							MMD70R1K4PRH		NCE70R1K2K	SSF5NS70D
IPN65R1K5CE	IPD65R1K5CE			STD6N65M2	TK5P65W						SSF5NS65UD
IPN60R3K4CE	IPD60R3K4CE										
IPN60R2K1CE	IPD60R2K1CE									NCE60R2K2K	SSF5N60D
IPN60R1K5CE	IPD60R1K5CE			STD5N60M2						NCE60R1K2K	
IPN60R1K0CE	IPD60R1K0CE	FCD900N60Z	STD7NM60N	STD7N60M2	TK5P60W	AOD4S60				NCE60R900K	
IPN50R3K0CE	IPD50R3K0CE					AOD3N50	SiHFR420				
IPN50R2K0CE	IPD50R2K0CE										
IPN50R1K4CE	IPD50R1K4CE					AOD6N50	SiHD5N50D				
IPN50R950CE	IPD50R950CE										
IPN50R800CE	IPD50R800CE		STD8NM50N			AOD9N50					
IPN50R650CE	IPD50R650CE		STD10NM50N								

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		Planar MOSFET				
Silikron Semiconductor	Lonten	Toshiba	Alpha and Omega Semiconductor	Huajing Rectifier	Silan	MagnaChip Semiconductor
SSF7N65F		TK5A65D	AOTF7N65	CS7N65FB9D	SVF7N65F	MDF7N65BTH
SSF5NS65UF	LSD04N65	TK7A65D	AOTF10N65	CS10N65F A9R	SVF10N65F	MDF10N65BTH
	LSD07N65	TK11A65D	AOTF12N65	CS12N65F A9H	SVF18N65F	MDF11N65BTH
SSSF11NS65UF	LSD11N65F	TK13A65D	AOTF18N65			
SSF5NS65UD	LSG03N65		AOD7N65	CS7N65 A4R		
	LSG04N65					
	LSG07N65					
	LSG11N65F					
SSF5NS65G	LSH03N65		AOI7N65	CS7N65 A3R		MDI6N65BTH
	LSH04N65					
SSF7NS65G	LSH07N65					
	LSH11N65F					

800 V CoolMOS™ CE

	Superjunction MOSFET							Planar MOSFET	
CoolMOS™ CE	Fairchild Semiconductor	STMicroelectronics	STMicroelectronics	Toshiba	MagnaChip Semiconductor chip	NCE Micro- and Nanotechnology	Taiwan Semiconductor Manufacturing	Toshiba	STMicroelectronics
IPA80R1K4CE	FCPF1300N80Z		STF6N80K5					TK10A80E	STP7NK80ZFP
									STP8NK80ZFP
IPA80R1K0CE	FCPF850N80Z	STF7NM80	STF8N80K5		MMF80R900PTH	NCE80R900F		TK10A80E	STP10NK80ZFP
IPA80R650CE	FCPF650N80Z		STF10N80K5	TK10A80W	MMF80R650PTH				
IPA80R460CE	FCPF400N80Z	STF11NM80	STF13N80K5	TK12A80W	MMF80R450PTH				
IPA80R310CE	FCPF290N80	STF18NM80	STF23N80K5	TK17A80W					
IPD80R2K8CE	FCD2250N80Z		STD4N80K5						
IPD80R1K4CE	FCD1300N80Z		STD6N80K5						
IPD80R1K0CE	FCD850N80Z	STD7NM80	STD8N80K5	TK6P80W	MMD80R900PRH	NCE80R900K	TSM80N950CP		
IPU80R2K8CE	FCU2250N80Z		STU4N80K5						
IPU80R1K4CE									
IPU80R1K0CE	FCU850N80Z		STU8N80K5	TK6Q80W		NCE80R900I	TSM80N950CH		

				Planar MOSFET							
Lonten	SEMIHOW	Silan	Taiwan Semiconductor Manufacturing	Toshiba	STMicro electronics	Vishay	Alpha and Omega Semiconductor	Huajing Rectifier	Silan	MagnaChip Semiconductor	Fairchild Semiconductor
								CS6N70 A4D-G			
	HCD6N70S		TSM70N1R4CP								
LSG03N65							AOD7N65	CS7N65 A4R			
LSG02N60											
					STD4NK60Z			CS6N60 A4TY	SVF5N60D	MDD4N60BRH	FDD5N60NZ
LSG03N60					STD5NK60Z			CS6N60 A4D	SVF6N60D	MDD6N60GRH	FDD7N60NZ
LSG04N60		SVS4N60D									
				TK3P50D	STD3NK50Z	IRFR420				MDD3N50GRH	
				TK5P50D	STD5NK50Z				SVF830D	MDD5N50RH	FDD5N50
				TK7P50D	STD6NK50Z				SVF840D		FDD6N50
											FDD8N50NZ

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Notes

Notes

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