CoolMOS™ CE for adapter application

October 2016

Agenda

1. CoolMOS™ CE for adapter
2. 35 W adapter reference design
3. 45 W adapter reference design
4. Success stories

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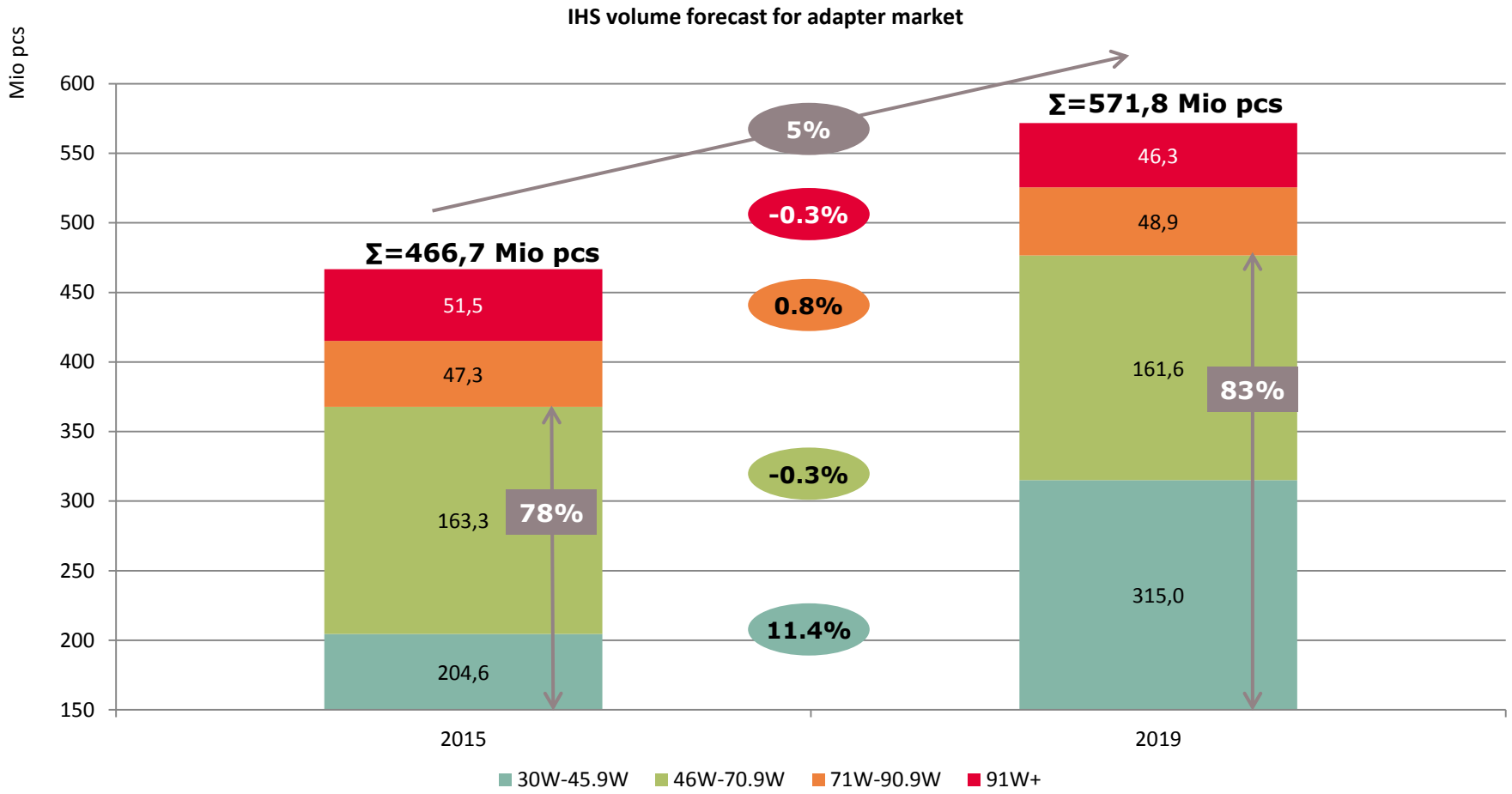
Adapter market reaches 571 mio pcs shipment in 2019 with CAGR of 5% with 83% below 70 W

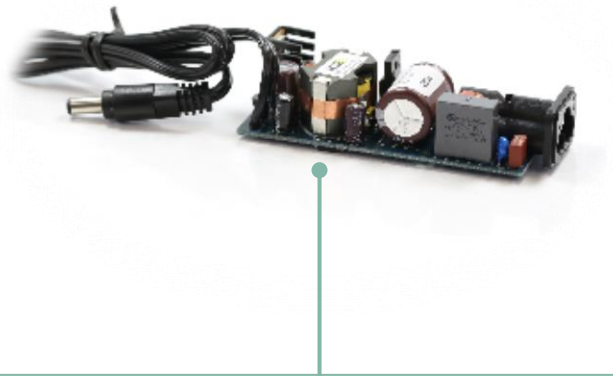


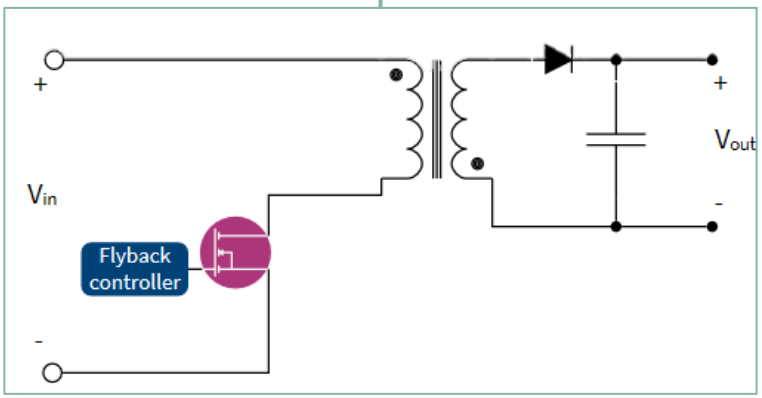
30–70 W contributes **83% (476.6 Mio pcs)** total adapter volume in 2019

Source: IHS_External_Power_Adapters_and_Chargers_2015

30-70 W adapter market is really huge and corresponds to 1.5x USA population

476 mio pcs 30-70 W adapters equipped with **flyback topology**





0.4x China population

1.5x USA population

20x Taiwan population

Source: IHS_External_Power_Adapters_and_Chargers_2015

We can be effectively cap 82% market by addressing top three applications

Notebook: 285 mio pcs

60%

Printers: 76,7 mio pcs

16%

Wireless charger: 74,9 mio pcs

15.7%

Hold on, let us have a look of the market trend before we really step into this market

Past	State of the art	Future
		
19 x 12,7 x **4,5** cm	9.4 x 4.2 x **2.8** cm	7.0 x 2.5 x **2.5** cm
1 W/inch^3	**6.7** W/in^3	**21.7** W/in^3
Single use purpose	Single use purpose	**Multi-use purpose** › Notebook › Tablet › Smartphone

Adapters are becoming smaller, smarter, and more powerful

Ohhh we have a problem, we can not use planar MOSFET to fulfill market trend due to …

Thermal & efficiency

- Market trend:
  - Leads to limited space for more power dissipation
  - Needs high efficiency MOSFET

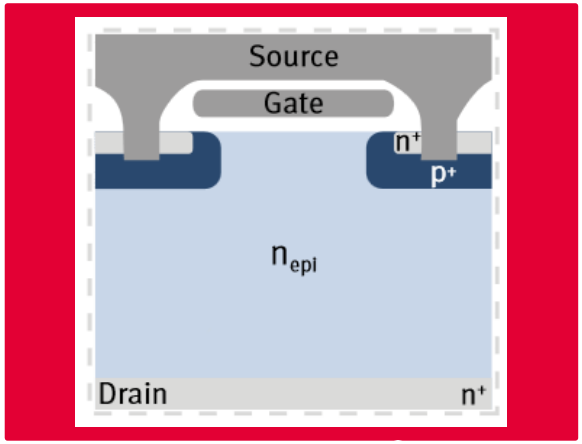
Planar MOSFET could not meet future thermal requirements due to its low efficiency

MOSFET fingerprint

- Market trend:
  - Leads to smaller form factor
  - Needs MOSFET with smaller fingerprint

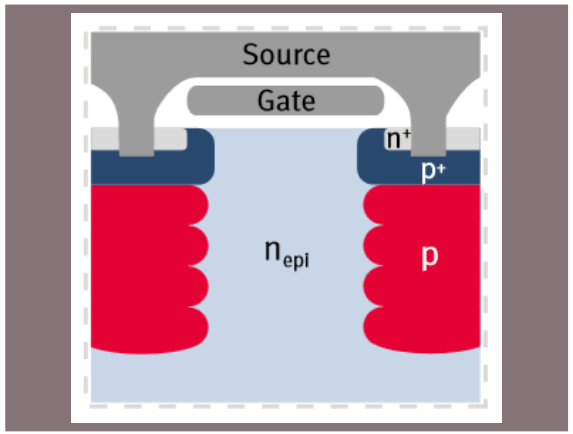
Planar MOSFET could not smaller form factor due to its big chip size

Wait a moment, CoolMOS™ CE could help you to overcome these challenges ….



Planar MOSFET

- High Q_g
- High switching losses
- Low switching speed
- Low efficiency
- Big fingerprint



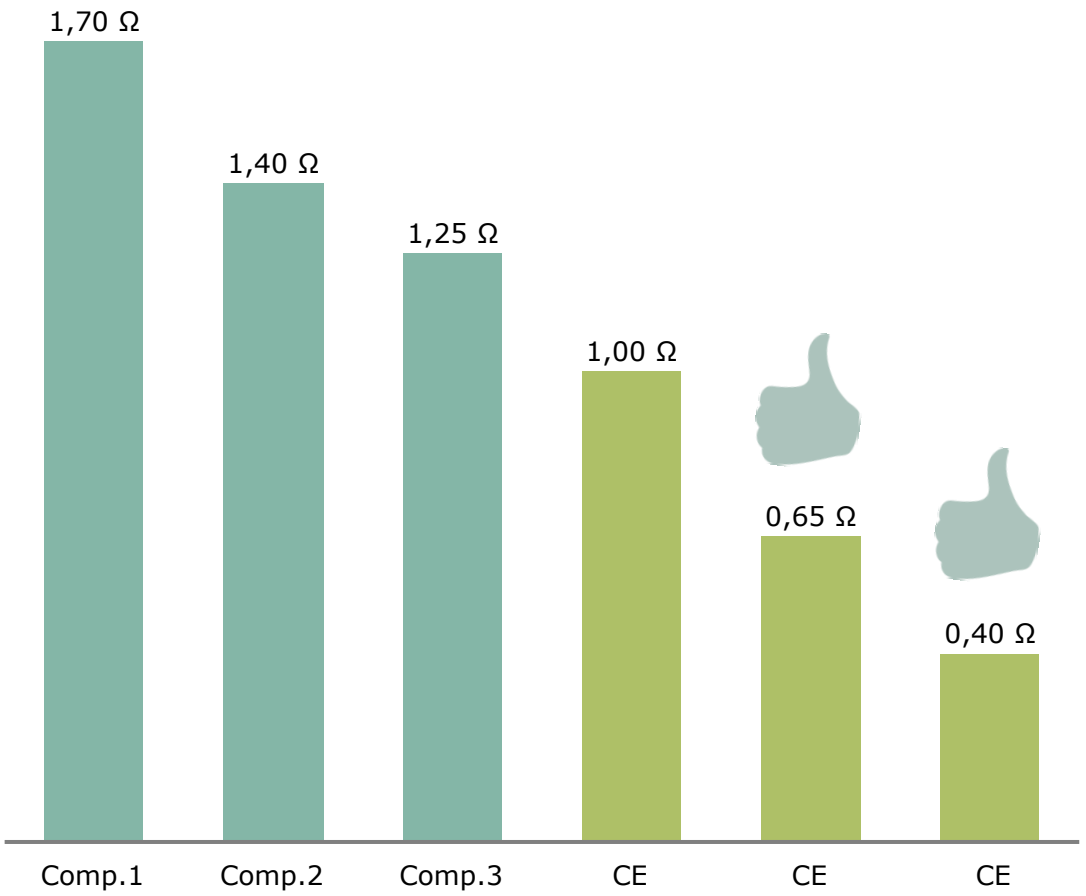
CoolMOS™ CE

- **Low** Q_g
- **Low** switching loss
- **Optimized** switching speed
- **better** efficiency
- **Smaller** fingerprint

CoolMOS™ CE offer better efficiency and smaller fingerprint

Let me show you an example …

Lowest DPAK $R_{DS(on)}$ for Planar MOSFET vs CoolMOS™ CE



MOSFET selection for slim adapter

- Thin SMD packages like DPAK
- $R_{DS(on)}$ not higher than 0,65 Ω due to thermal issue

⇨ **Planar MOSFET has no chance**

Well, still some doubt, let me give you a real life example from HP 45 W adapter …

45 W adapter

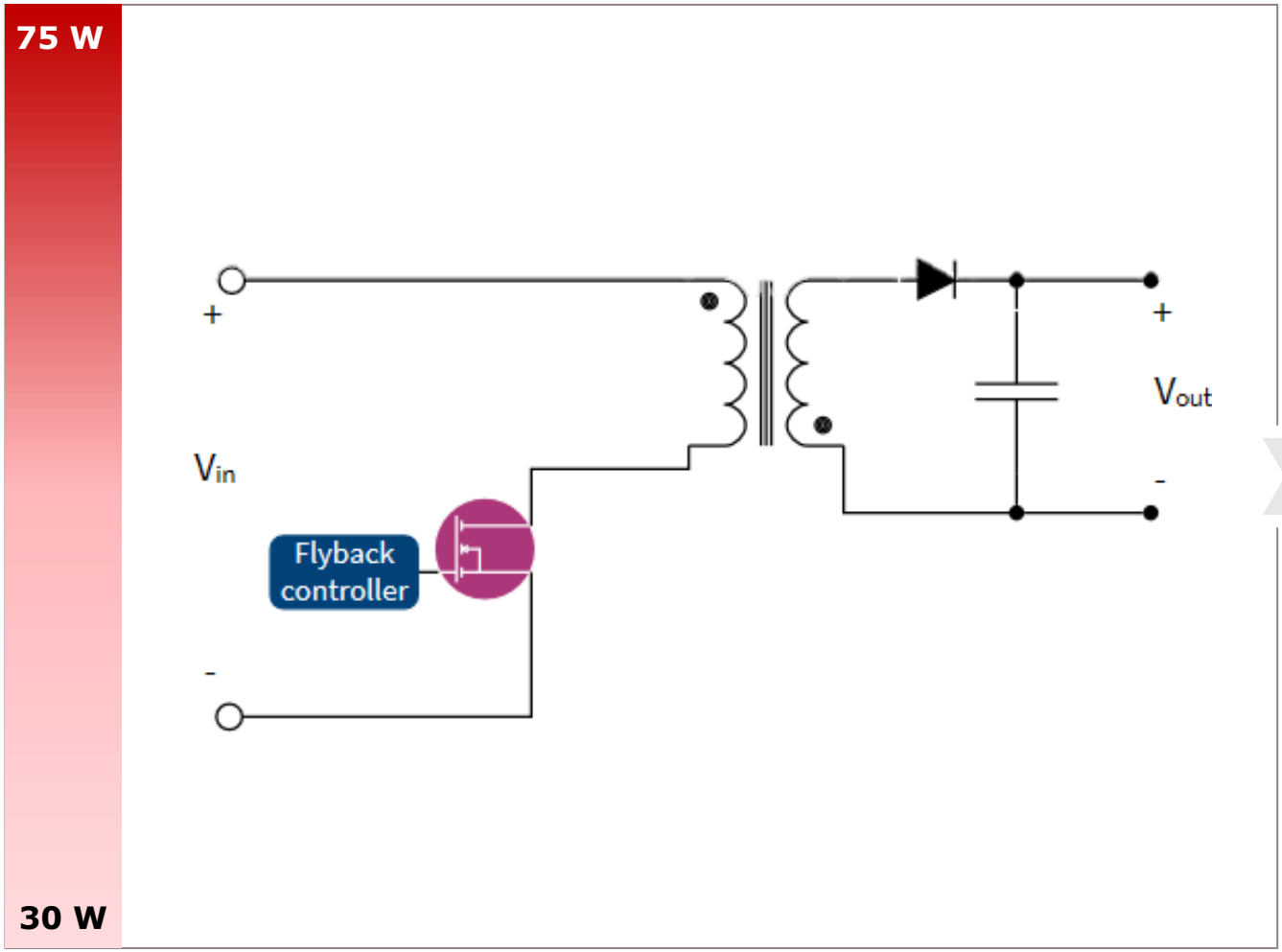
6.6 x 6.6 x 2.8 cm

Tear down

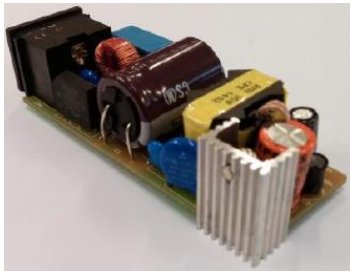
650 V, DPAK, 0.4 Ohm

No chance with Planar MOSFET

CoolMOS™ CE offers full solution for 30-70 W adapter applications based on quasi-resonant flyback



IFX 35 W adapter



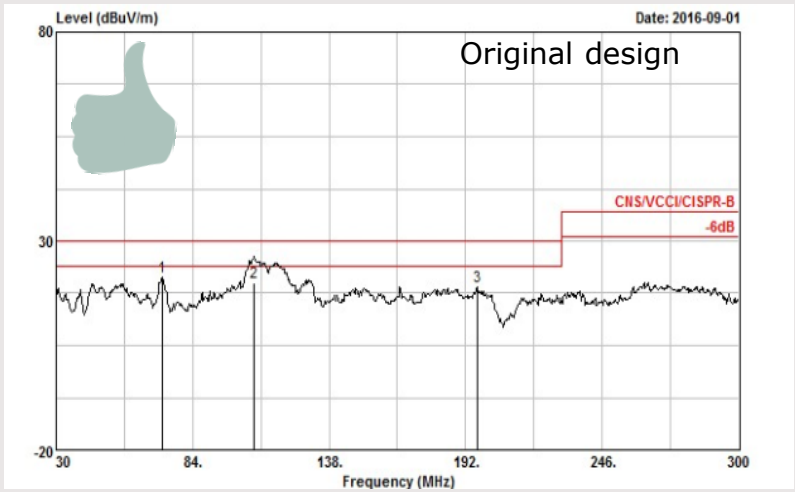
IPD60R650CE

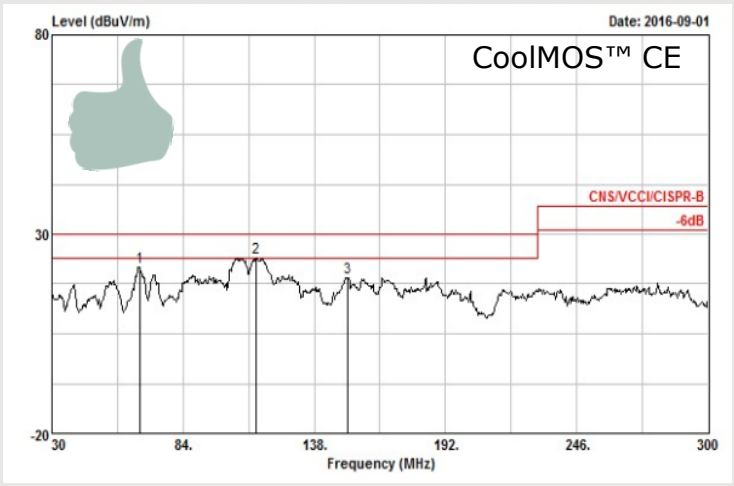
IFX 45 W adapter

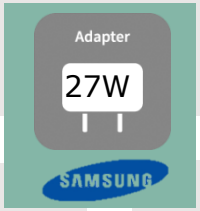
IPA60R650CE

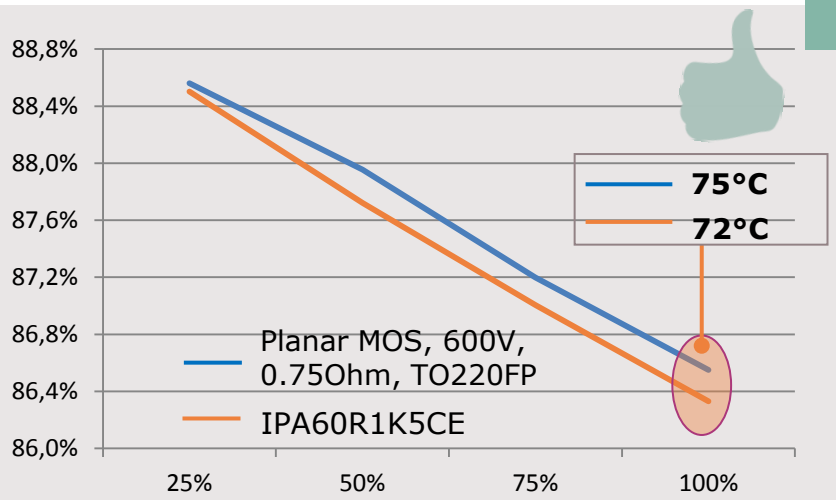
Infineon offers CoolMOS™ CE based **total solutions** for flyback adapter applications

We also offer you a solution to replace planar MOSFET in adapters standard flyback based









Original design

MOS: 600V, **0,75 Ω**, TO220FP Planar; Comp. 1

$R_{g,\,on}$:100 Ω

C_{DS}: 47 pF

Infineon solution

MOS: IPA60R1K5CE (**1.5 Ω**)

$R_{g,\,on}$:**200** Ω

C_{DS}: **100** pF

Cost down with higher CoolMOS™ CE $R_{DS(on)}$

Learn more with EMI design guide

CoolMOS™ CE selection guide for adapter application

Price

TO-220 FullPAK

Features:

- Standard FP
- Better thermal
- Easy to assemble

TO-220 FullPAK
Narrow Lead

Features:

- Enabling fully insert into PCB
- Better thermal
- Easy to assemble

TO-220 FullPAK
Wide Creepage

Features:

- Increased creepage distance
- Better thermal
- Easy to assemble

DPAK

Features:

- Standard DPAK
- Low assembly cost
- Better cost as compared to TO-220 FP

CoolMOS™ CE series for adapters 600 V portfolio

$R_{DS(ON)}$ [mΩ]	TO-220 FullPAK	TO-220 FullPAK Narrow Lead	TO-252 DPAK	TO-251 IPAK SL	TO-251 IPAK	SOT-223	TO-220 FullPAK Wide Creepage
3300			IPD60R3K4CE	IPS60R3K4CE	IPU60R3K4CE	IPN60R3K4CE	
2100			IPD60R2K1CE	IPS60R2K1CE	IPU60R2K1CE	IPN60R2K1CE	
1500	IPA60R1K5CE		IPD60R1K5CE	IPS60R1K5CE	IPU60R1K5CE	IPN60R1K5CE	
1000	IPA60R1K0CE		IPD60R1K0CE	IPS60R1K0CE	IPU60R1K0CE	IPN60R1K0CE	
800	IPA60R800CE	IPAN60R800CE	IPD60R800CE	IPS60R800CE			
650/600	IPA60R650CE	IPAN60R650CE	IPD60R650CE	IPS60R650CE			IPAW60R600CE
460	IPA60R460CE		IPD60R460CE	IPS60R460CE			
400/380	IPA60R400CE		IPD60R400CE	IPS60R400CE			IPAW60R380CE
280							IPAW60R280CE
190							IPAW60R190CE

Highly recommended for adapters

- 12 $R_{DS(on)}$ in 7 packages
- New SOT-223 products (mainly for lighting)
- TO-220 FP Wide Creepage (mainly for TV)

CoolMOS™ CE series for adapters 700 V/650 V portfolio

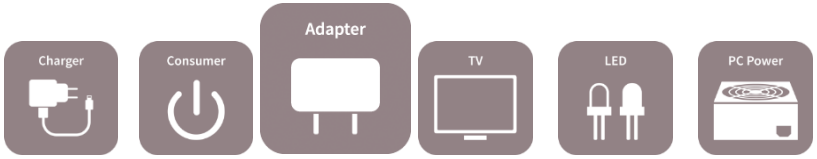
700 V

$R_{DS(ON)}$ [mΩ]	TO-262 I²PAK	TO-252 DPAK	TO-251 IPAK SL	TO-251 IPAK SL with ISO-Standoff	SOT-223	ThinPAK 5x6	TO-220 FullPAK Wide Creepage
2000/2100		IPD70R2K0CE	IPS70R2K0CE	IPSA70R2K0CE		IPL70R2K1CES	
1400/1500		IPD70R1K4CE	IPS70R1K4CE	IPSA70R1K4CE	IPN70R1K5CE		
950	IPI70R950CE	IPD70R950CE	IPS70R950CE	IPSA70R950CE			IPAW70R950CE
600		IPD70R600CE	IPS70R600CE	IPSA70R600CE			IPAW70R600CE

650 V

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

Highly recommended for adapters

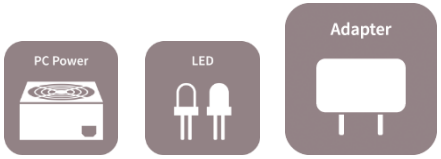


- 8 $R_{DS(on)}$ in 9 packages
- New SOT-223 products for charger
- 700 V products for charger/adapter

CoolMOS™ CE series for adapters 800 V portfolio

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

Highly recommended for adapters



- 6 $R_{DS(on)}$
- 3 packages
- Best fit for flyback

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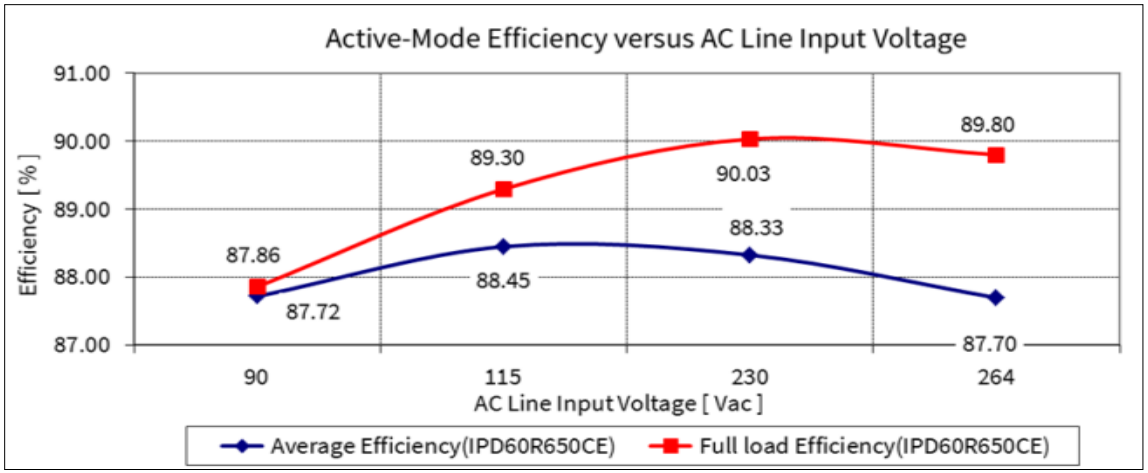
35 W IFX adapter
Passes typical efficiency regulation



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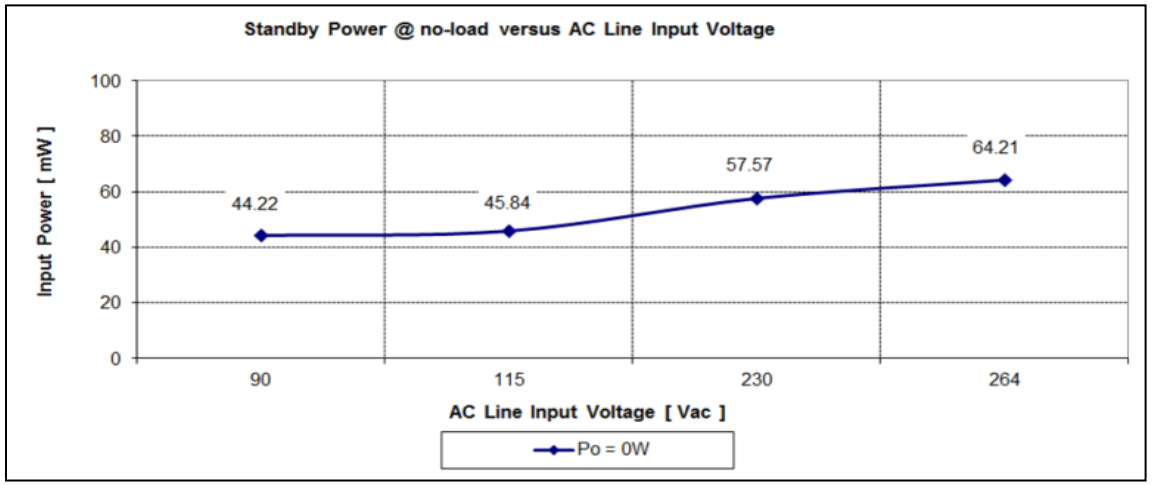


Good job!

Meet EU CoC Ver. 5 Tier 2 and DOE EPS requirement

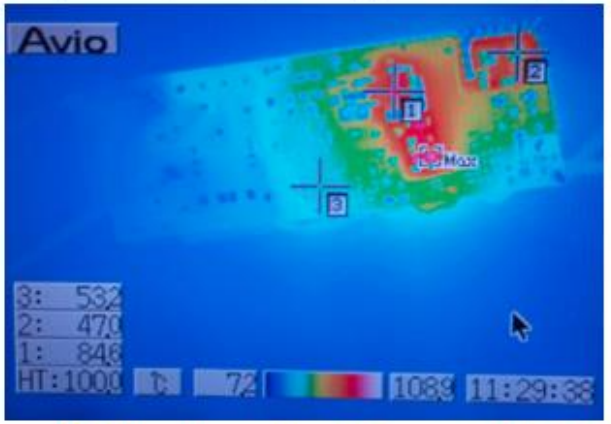
35 W IFX adapter passing typical thermal requirements

(PCB top side, 90 V_{AC} & full load)

(PCB bottom side, 90 V_{AC} & full load)

Good job!

(PCB top side, 264 V_{AC} & full load)

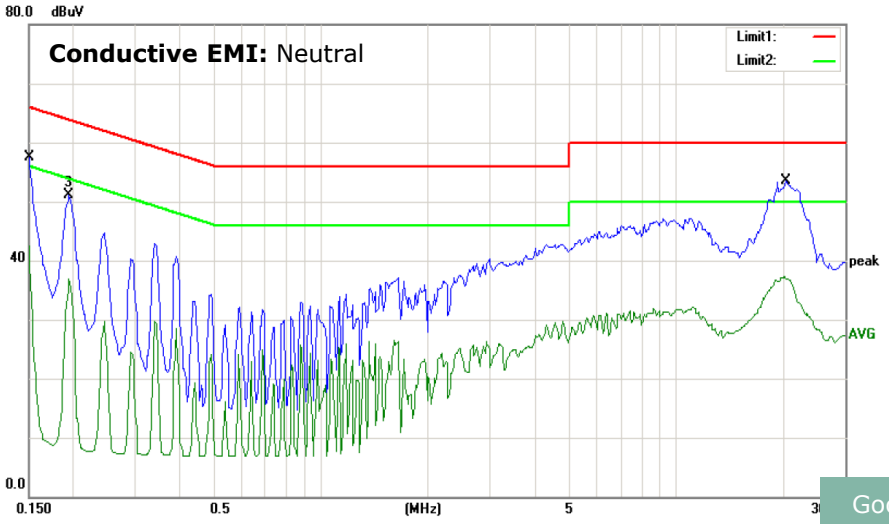


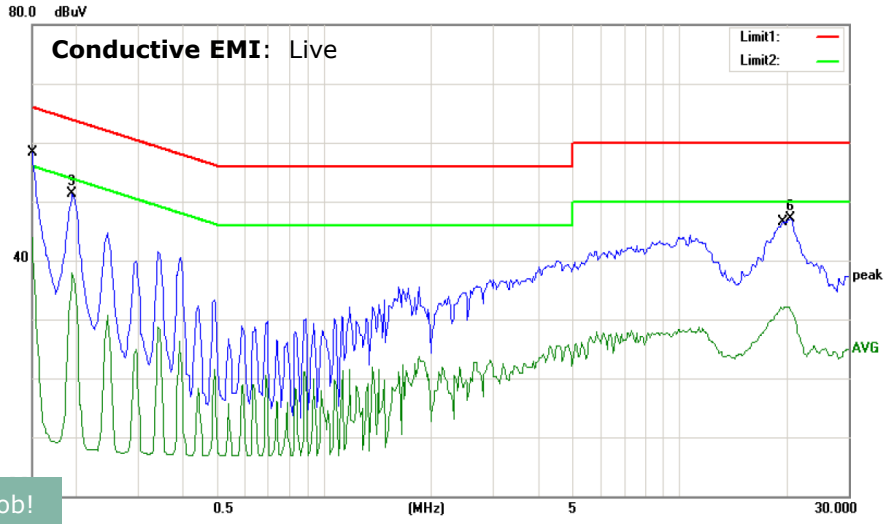
(PCB bottom side, 264 V_{AC} & full load)

MOSFET Temperature: **84.4°C** **84.6°C**

CoolMOS™ CE shows decent thermal performance in adapter application

35 W IFX adapter - passing typical EMI requirements with 6 dB margin





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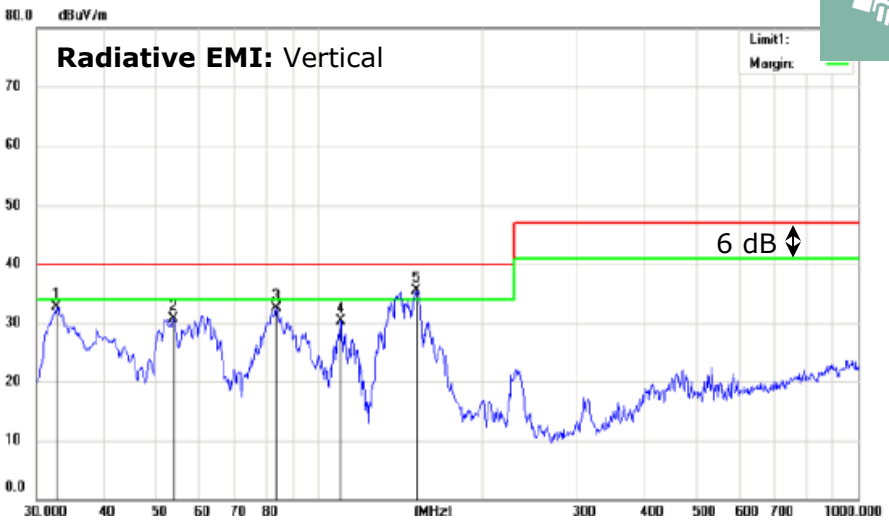
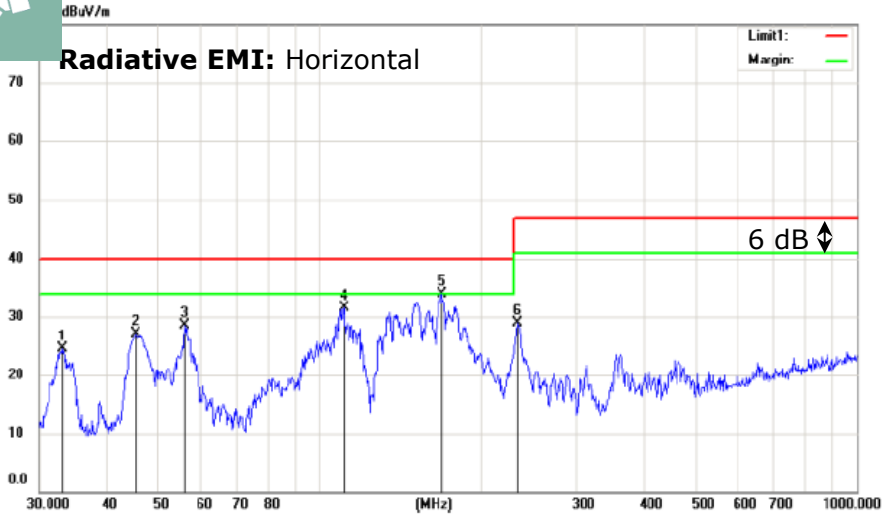
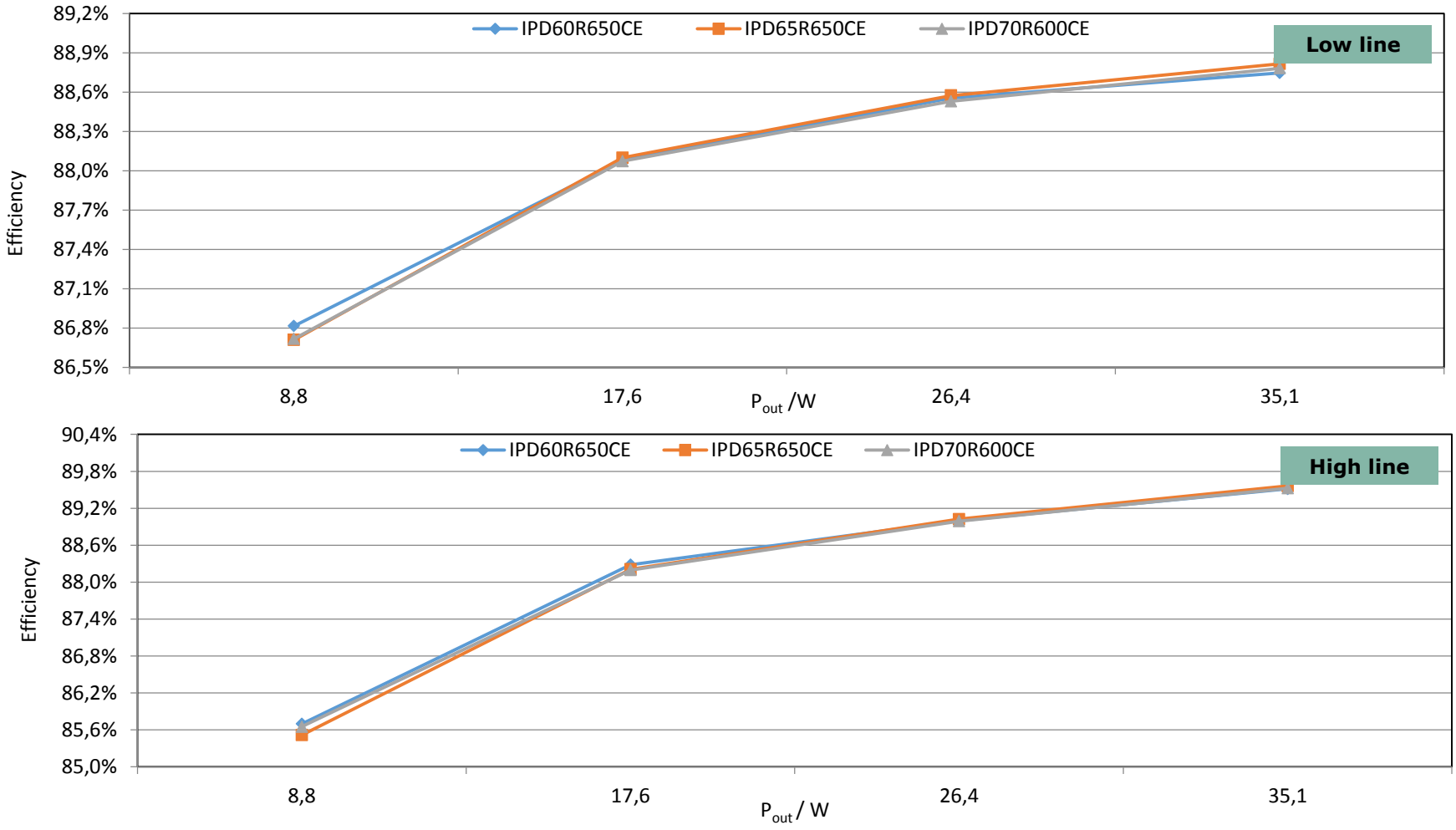




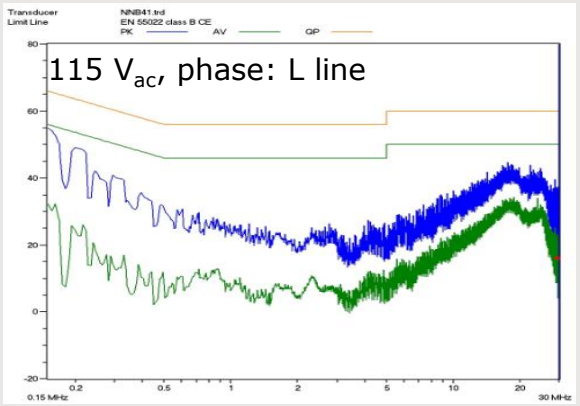
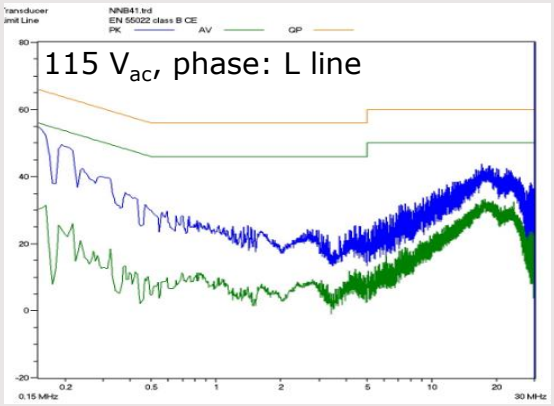
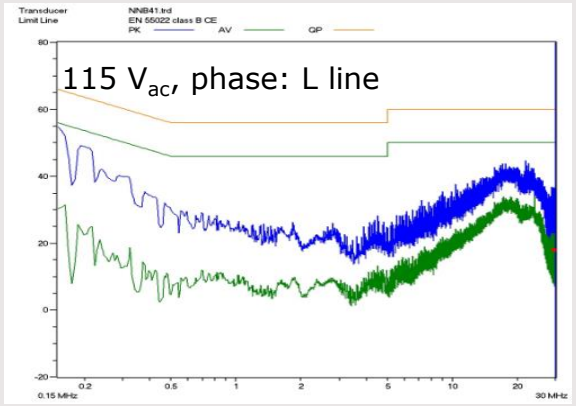
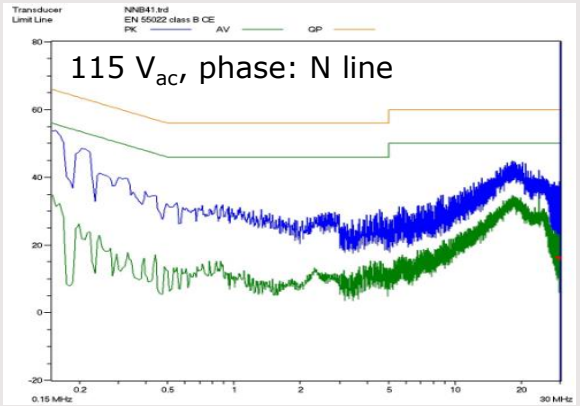
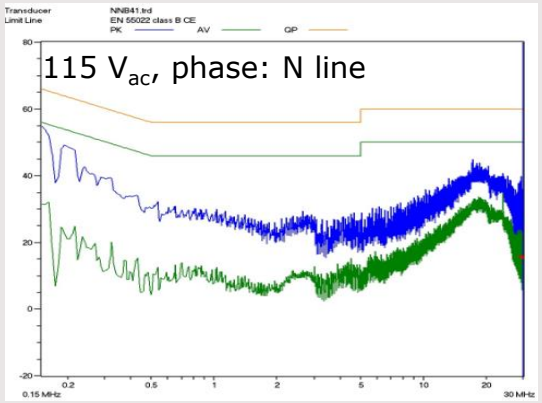
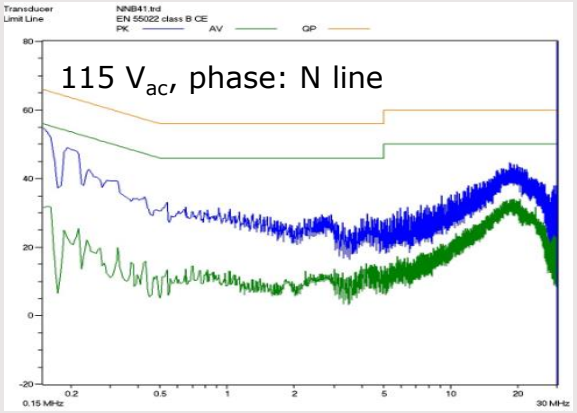
230Vac

35 W IFX adapter
Offers flexibility in MOSFET for derating



No significant efficiency difference between 600 V, 650 V, and 700 V MOSFET

35 W IFX adapter
Offers flexibility in MOSFET for derating

IPD60R650CE	IPD65R650CE	IPD70R600CE
		
		

No significant efficiency difference between 600 V, 650 V, and 700 V MOSFET

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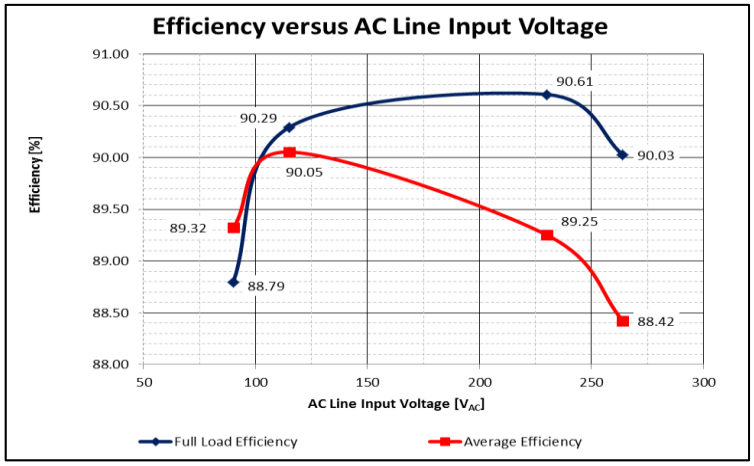
45 W IFX adapter
Passes typical efficiency regulation



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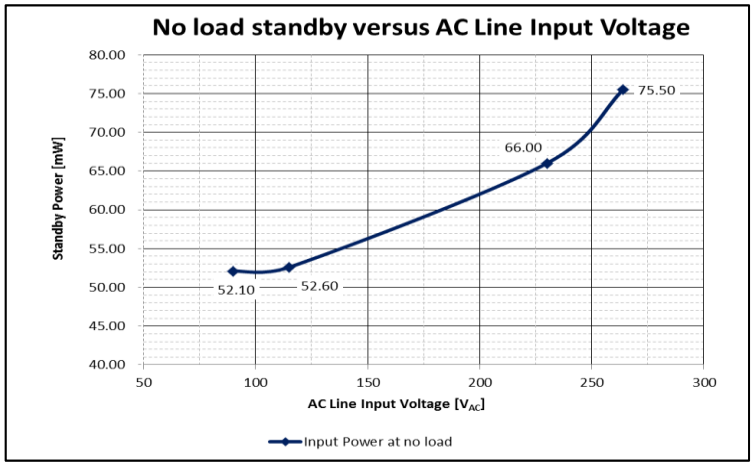
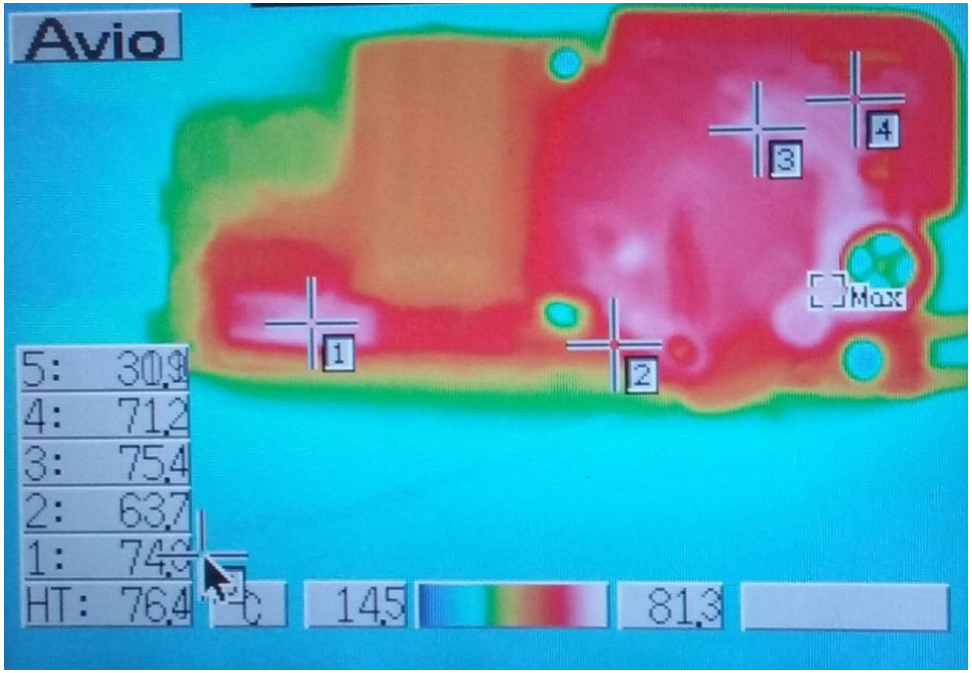


Good job!

Meet EU CoC Ver. 5 Tier 2 and DOE EPS requirement

45 W IFX adapter
passing typical thermal requirements



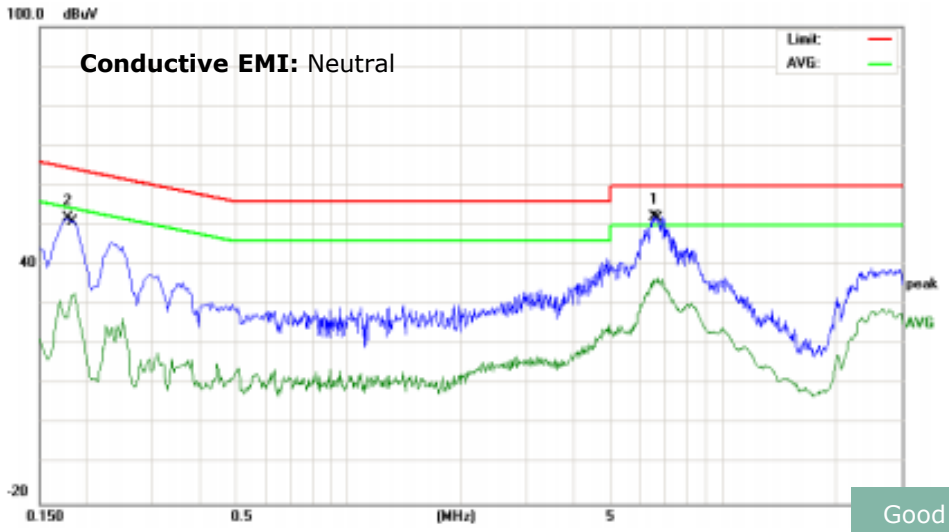
Infrared thermal image of REF-45W ADAPTER (PCB top side, 100 V_{AC} & Full load)

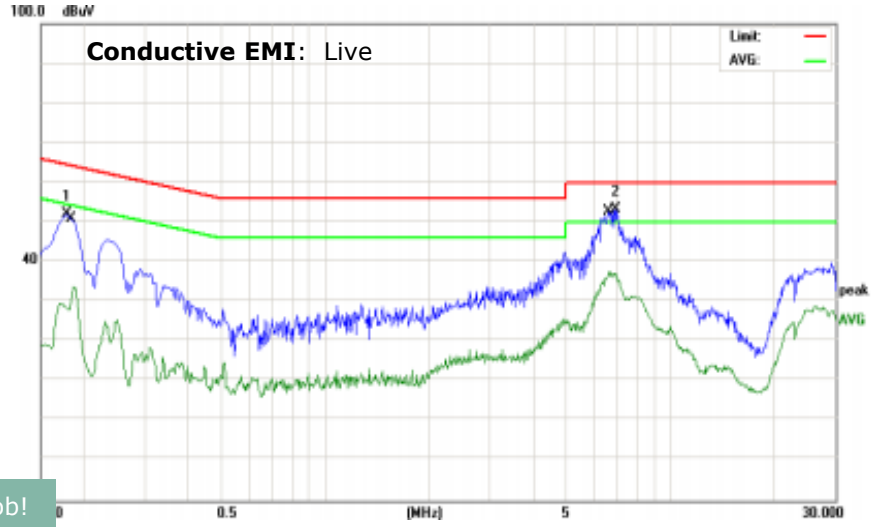
No.	Component	100 V_{AC} & 45 W load (°C)
1	DB1 (Bridge diode)	74
2	**Q1 (Primary MOSFET)**	**63.7**
3	T1 (Transformer)	75.4
4	D2 (Secondary Diode)	71.2
5	Ambient	30.9

Good job!

CoolMOS™ CE shows decent thermal performance in adapter application

45 W IFX adapter - passing typical EMI requirements with 6 dB margin





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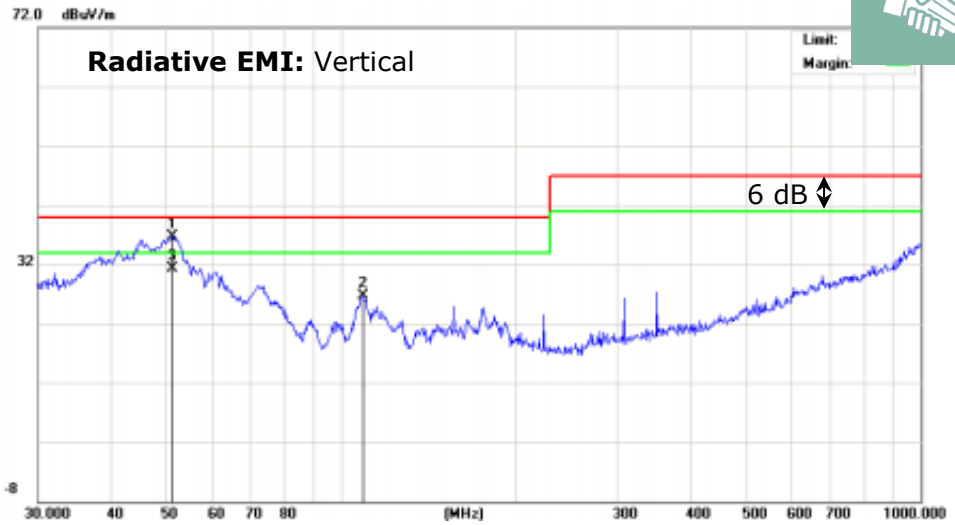

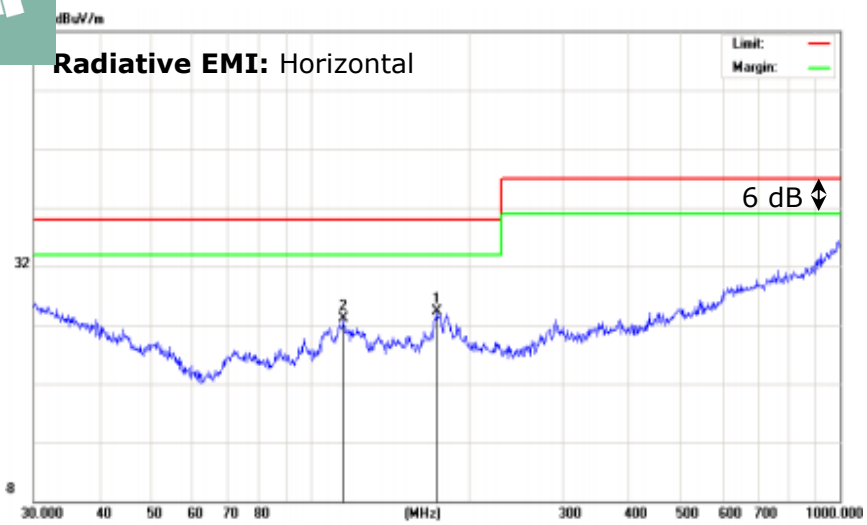

230Vac

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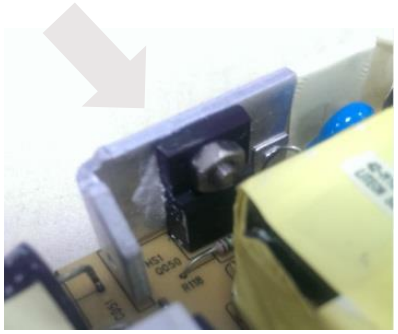
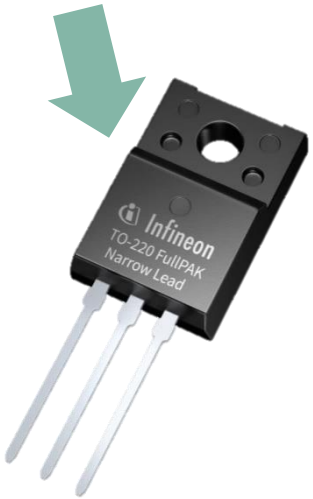
Success story
Notebook adapter – IPAN60R650CE

Customer:	Leading Taiwan adapter OEM
Application:	45W Notebook Adaptor
IFX Part Numbers:	CoolMOS™ CE TO-220 FullPAK Narrow Lead IPAN60R650CE
Competitor:	Competitor T, 600V, TO220FP, 0,65Ω Planar MOS
SOP:	July 2016
BW value:	0.5 M EUR





What made us win:

- Under customer pain in strict adapter height reduction
- New package helps customers solve height challenge
- Long turn attractive price roadmap Vs Planar MOSFET
- Develop customer knowhow to solve EMI issue during early project development

To which type of projects can this success story replicated?

- Addressing all the adapter manufactures
- Shifting market from Planar MOSFET to Super-junction MOSFET

This case proves that EMI is controllable and super-junction MOSFET is market trend for adapter application

Part of your life. Part of tomorrow.

Infineon