Infineon 900V CoolMOS

---new benchmark of super junction MOSFET

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Never stop thinking

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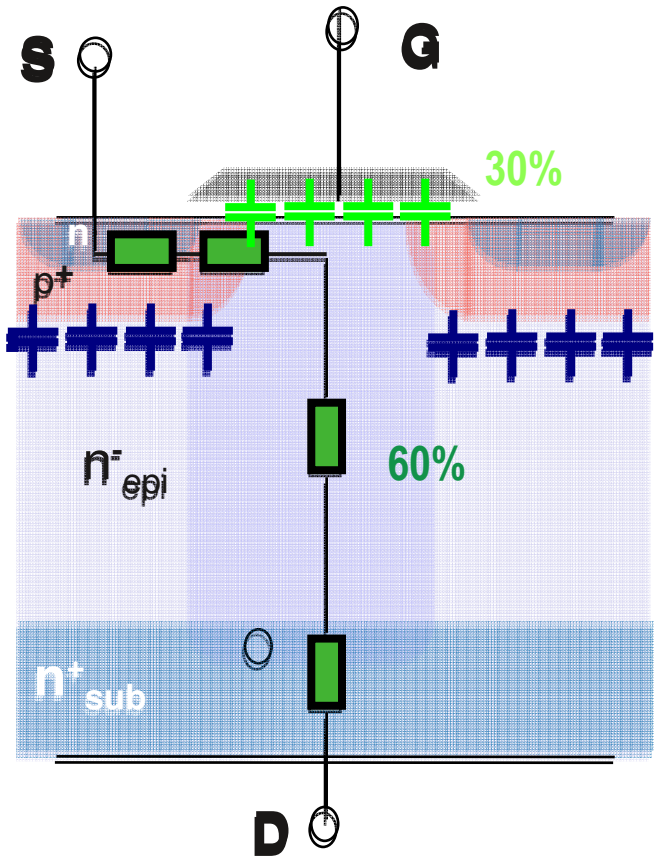
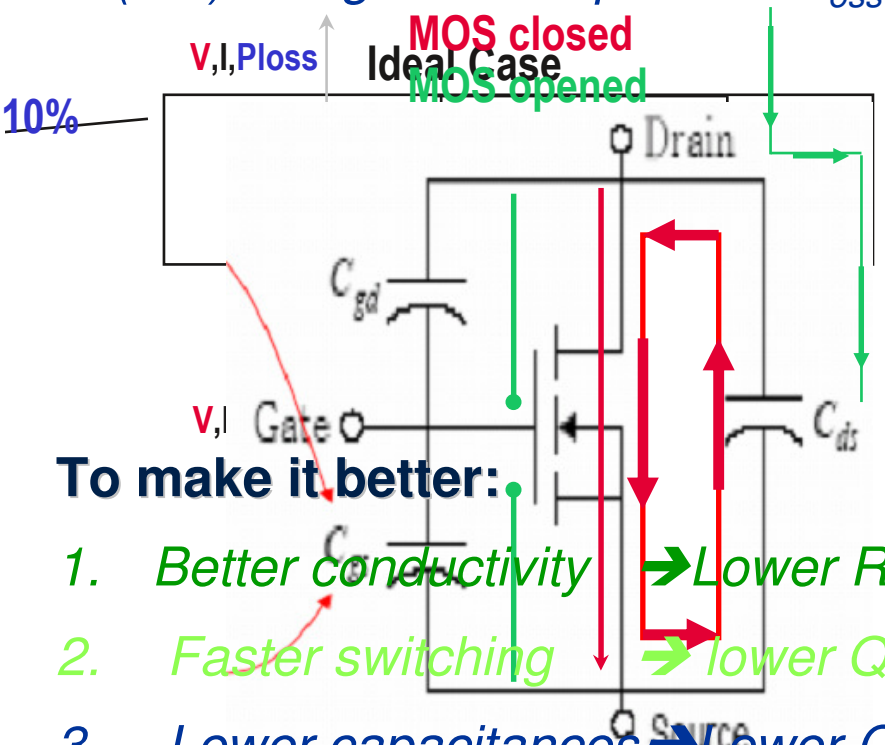
Roadmap of HV MOSFET



Losses come from

1. *Rdson: 60% conduction loss*
2. *Delay in on/off (Qg..):30% switching loss*
3. *(Dis)Charge Cds Cap.: 10% C_{oss} loss*



To make it better:

1. *Better conductivity → Lower Rdson*
2. *Faster switching → lower Qg*
3. *Lower capacitances → Lower Coss,etc*

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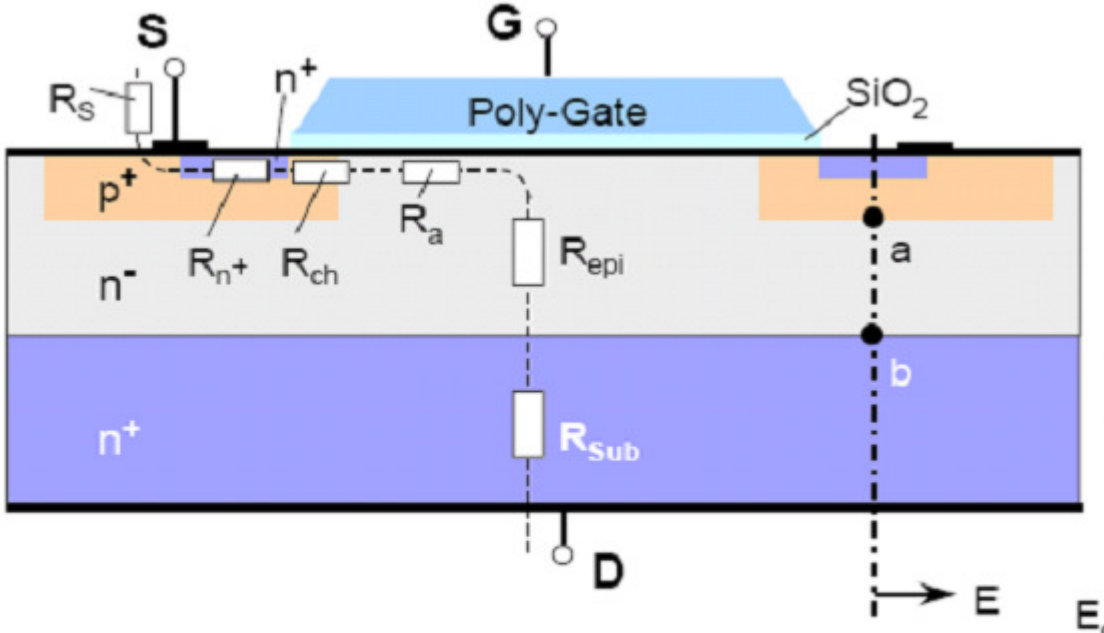
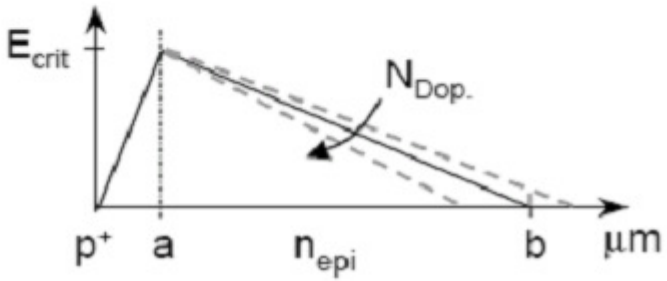
Resistance –Rdson, distribution of MOSFET



$R_{DS(on)}$					
V_{DS}	≈	30V	V_{DS}	≈	600V
R_S*	≈	7%	R_S	≈	0.5%
R_{n+}	≈	6%	R_{n+}	≈	0.5%
R_{ch}	≈	28%	R_{ch}	≈	1.5%
R_a	≈	23%	R_a	≈	0.5%
R_{epi}	≈	29%	R_{epi}	≈	96.5%
R_{Sub}	≈	7%	R_{Sub}	≈	0.5%

R_S* = packaging

$$R_{DS(on)} \sim V_{BR(DSS)}^{2.4 \ldots 2.6}$$



96.5% of $R_{DS(on)}$ for high voltage standard MOSFET determined by the epitaxial resistance

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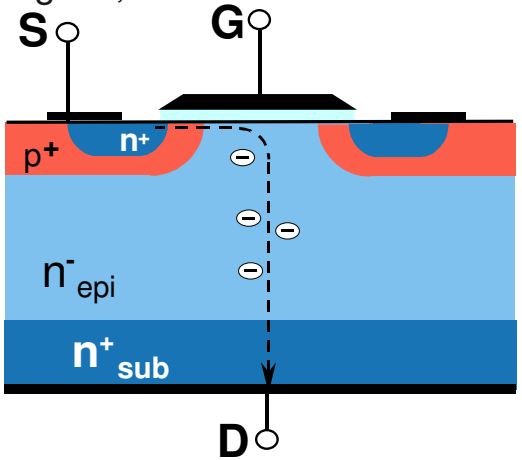
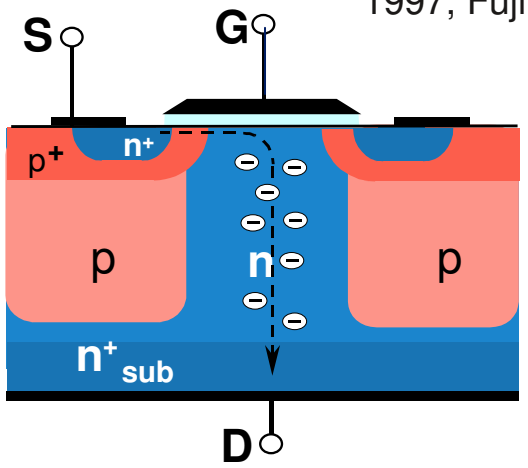
Super Junction Theorem

Power MOSFET	Cool MOS ™

1987,Chen Ming-Hu, China



1997, Fujihira, Japan



- By controlling the degree of doping and the thickness of these layers, according to the SJ theory, this structure operates as a pn junction with low on-resistance and high breakdown voltage.

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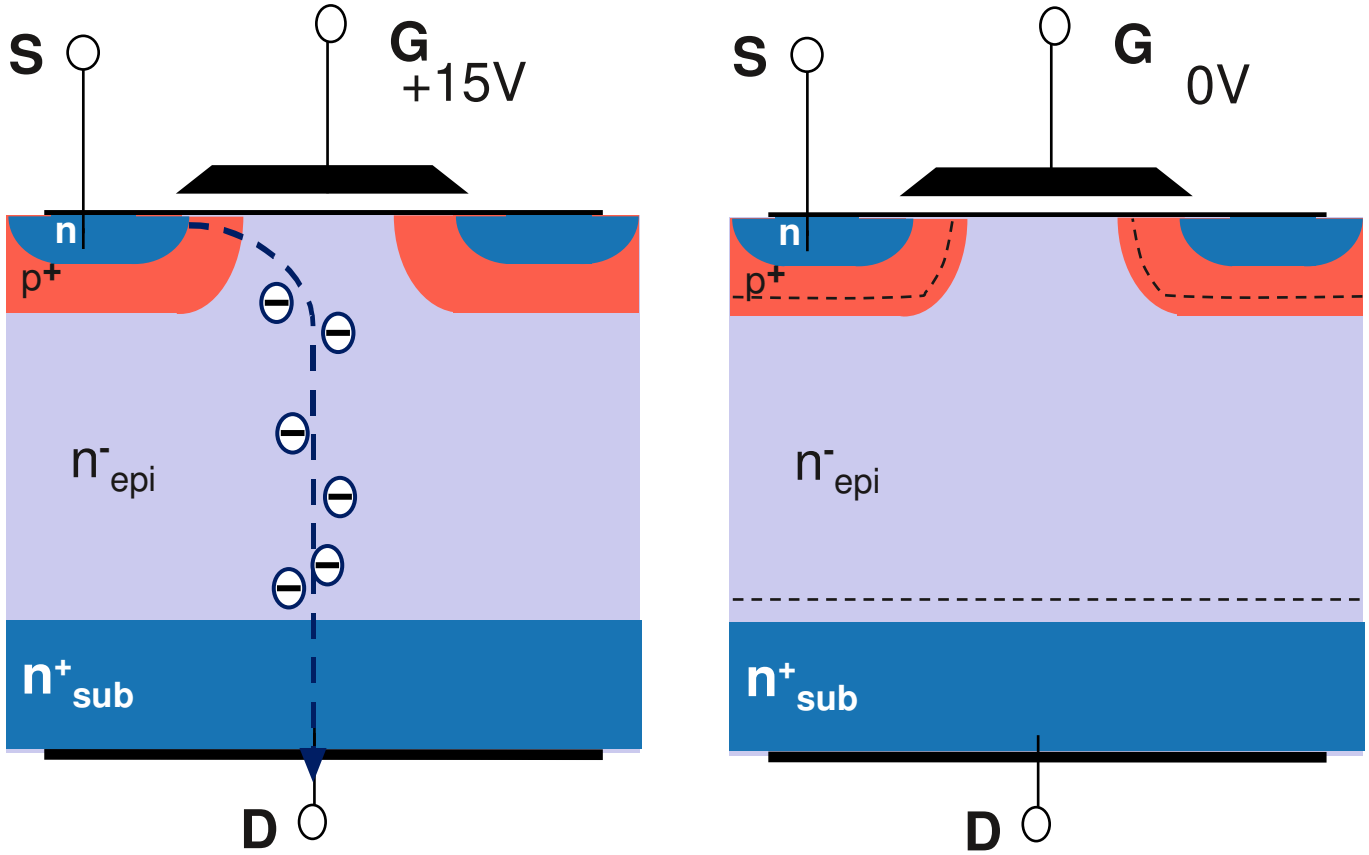
Standard MOSFET operating principle



Conducting state **Blocking state**

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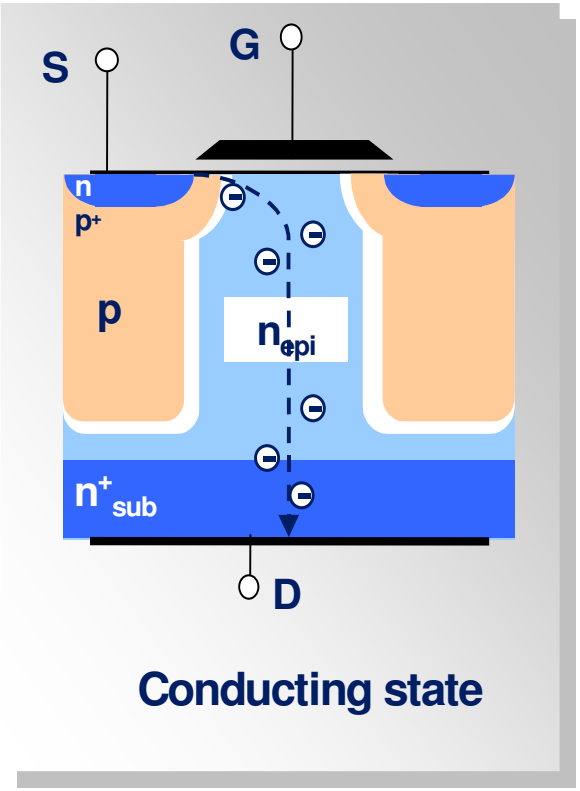
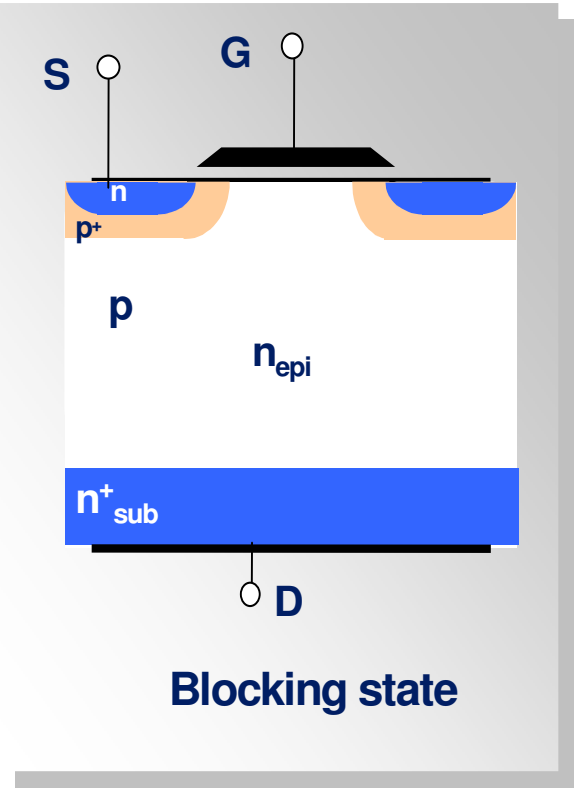
CoolMOS operating principle





Higher doped columns act like a „short“ across the drift region

⇨ extremely low RDSon

With applied V_{DS}, the space charge region extends across the entire epi-layer

⇨ very low effective doping

⇨ high breakdown voltage

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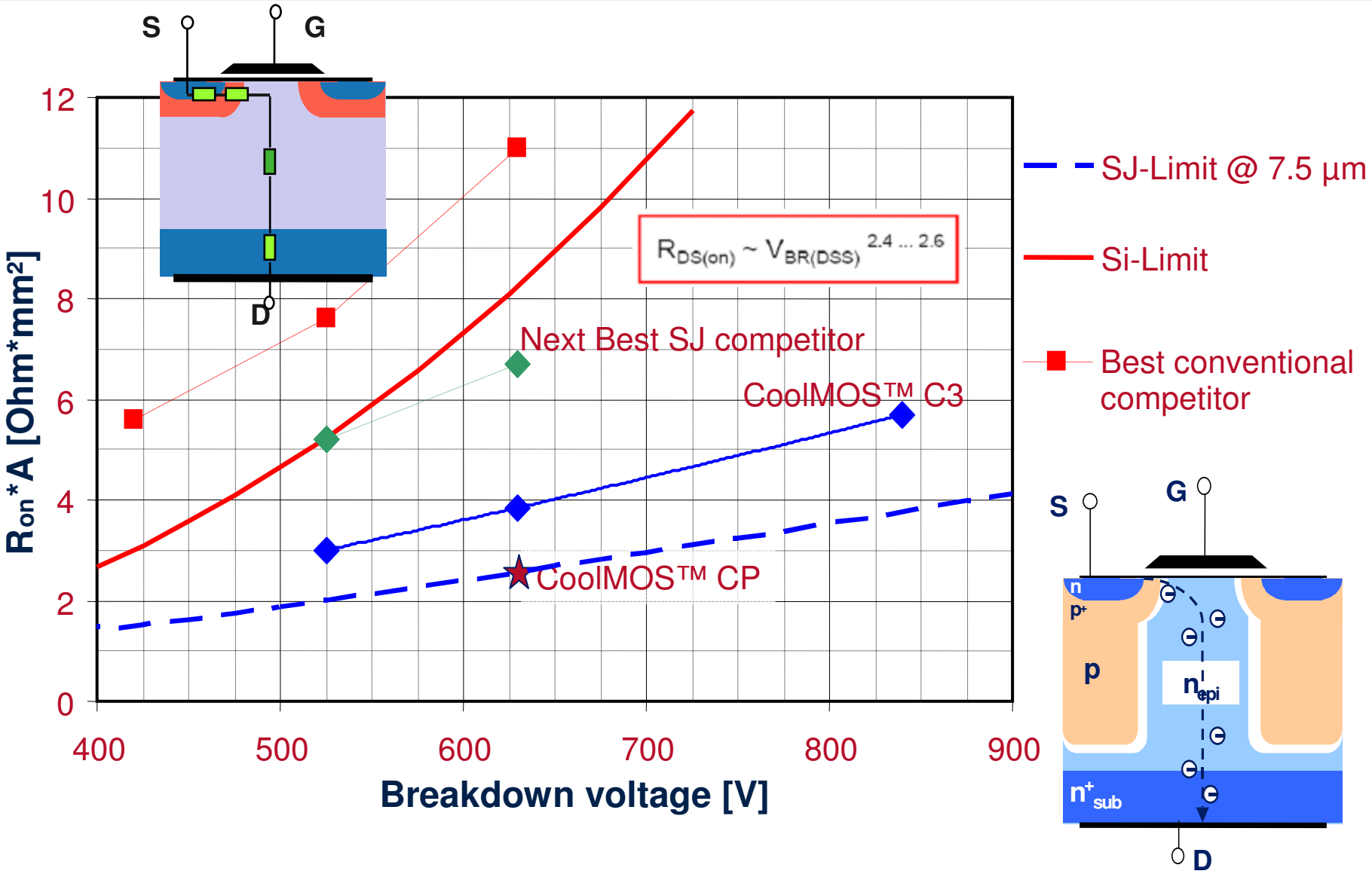
CoolMOS : Lowest area-specific Rds(on)



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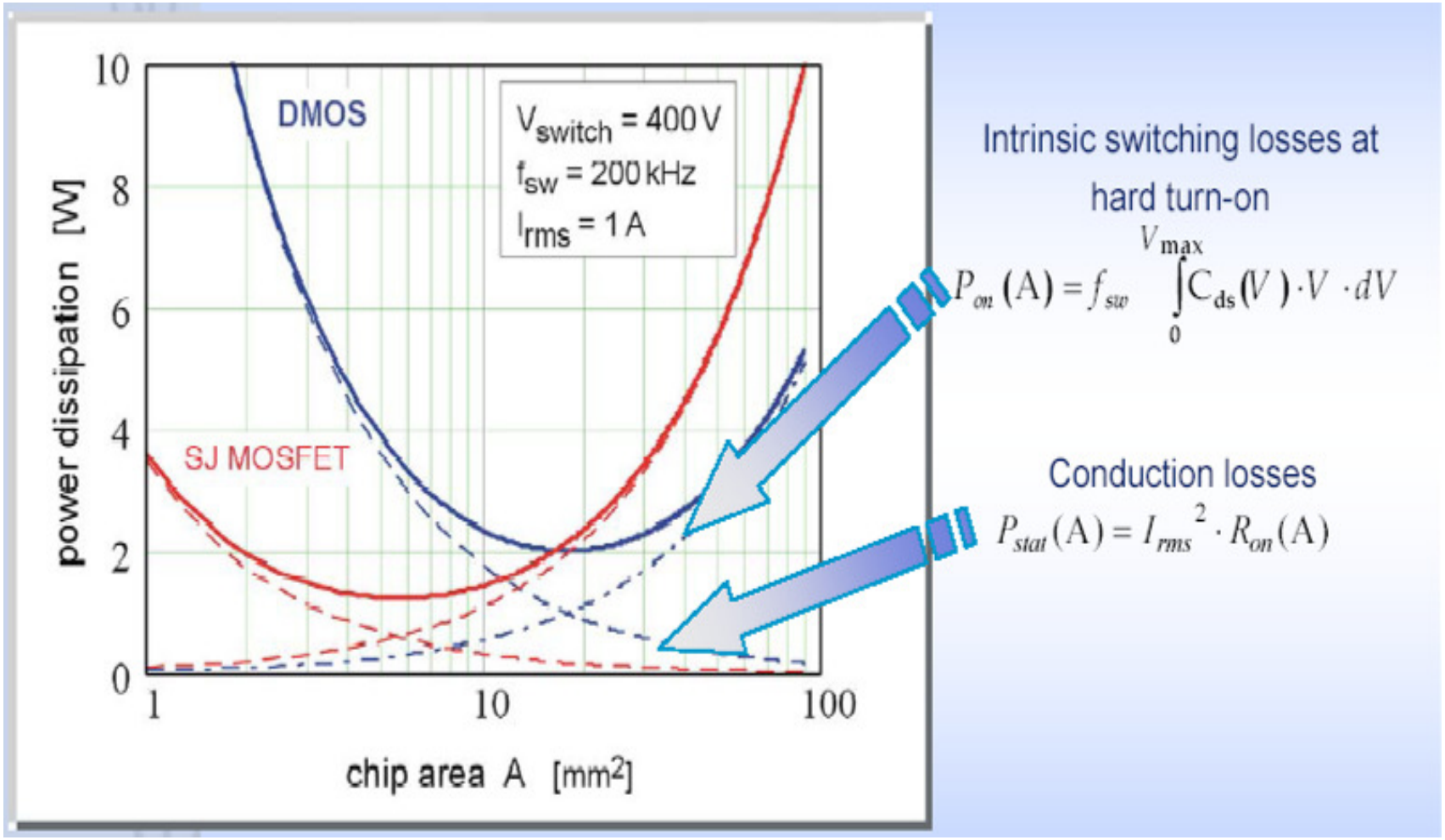
CoolMOS – Less Power Dissipation



There is an optimum chip size for minimum total power dissipation.

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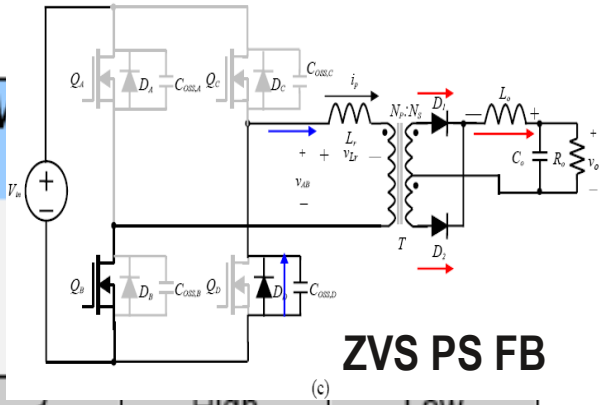
CoolMOS™ Series & History

	Market entry	Voltage class [V]	Special characteristic	V		
CoolMOS™ S5	1998	600	Low RDSon, Switching speed close to standard MOSFETs			
CoolMOS™ C3	2001	500/600/ 650/800	Fast switching speed, symmetrical rise/fall time at Vgs=10V	3	High	Low
CoolMOS™ CFD	2004	600	Fast body diode, Qrr 1/10th of C3 series	4	High	Low
CoolMOS™ CP	2005	500/600	Ultra-low RDSon, ultra-low Qg, very fast switching speed	3	High	Low



Infineon P/N	Series	Rdson Max. (Ω)	Qg typ. (nC)	Rg typ. (Ω)	Qrr typ. (µC)
SPP20N60C3	C3	0.19	87	0.54	11
SPP20N60CFD	CFD	0.22	95	0.54	1
IPP60R199CP	CP	0.19	32	2	5.5

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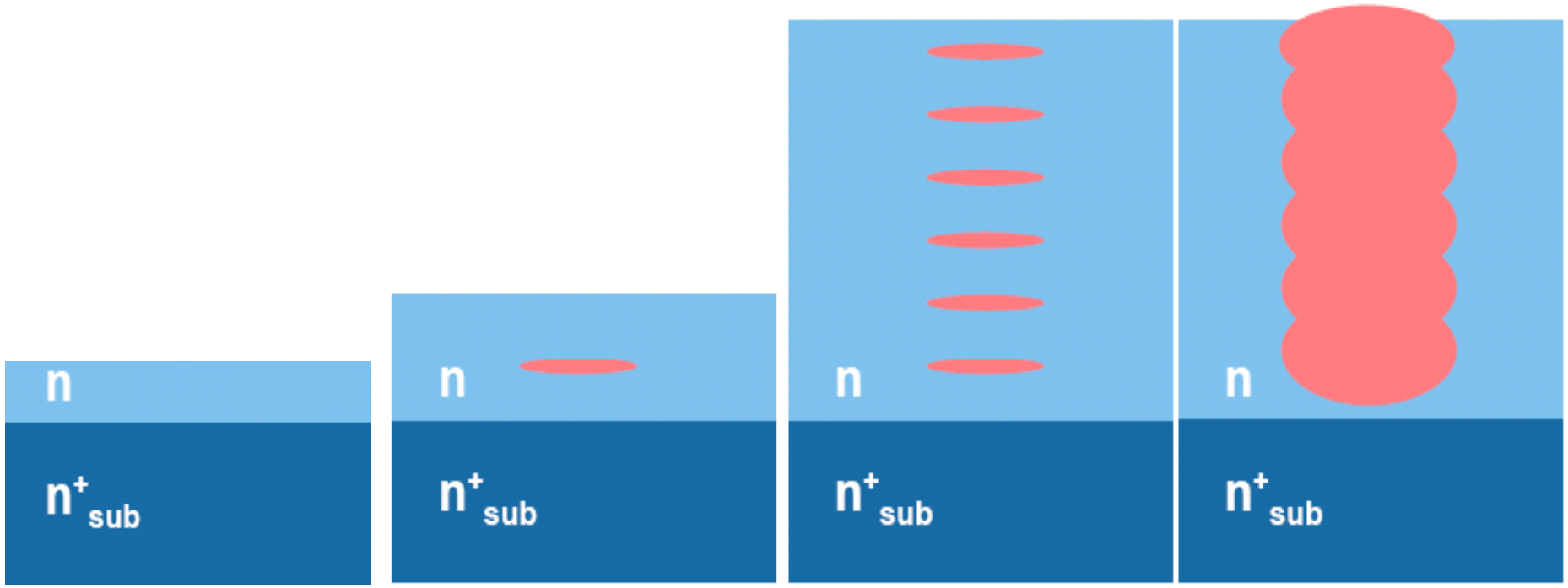
CoolMOS
basic manufacture process



Substrate wafer, first epitaxial layer

Boron-I, deposition of epi layer

Subsequent implantation and epi steps

Diffusion and cell technology

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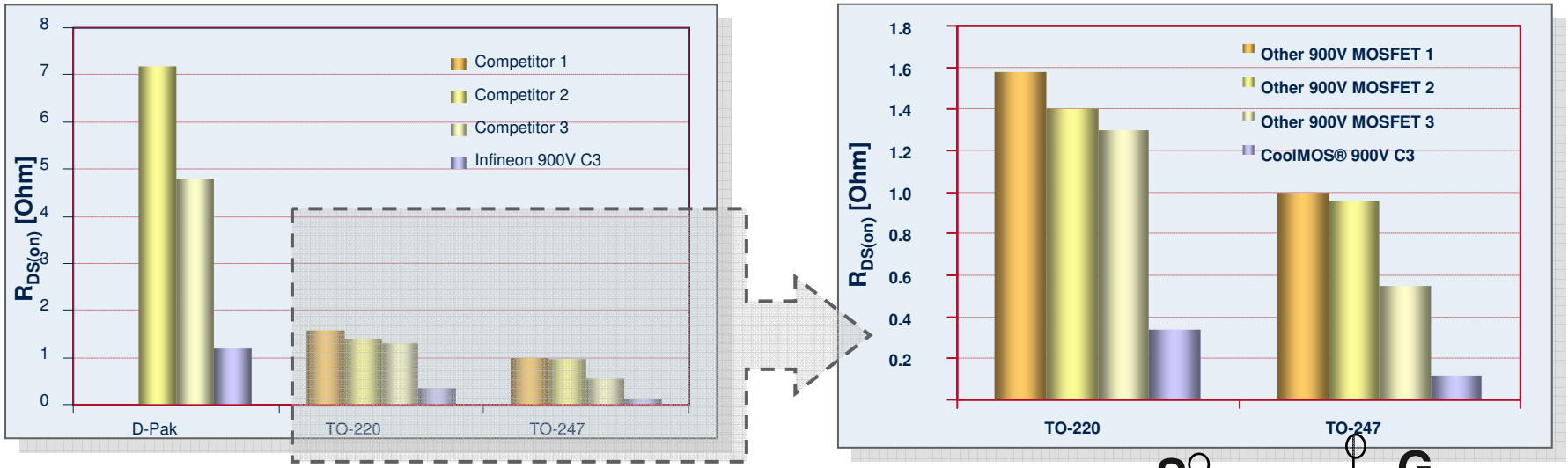
Rdson per package

Lowest Rdson achieved at specific package with CoolMOS 900V !



RDS(on) per Package

120mOhm in TO-247

340mOhm in TO-220

1200mOhm in DPak

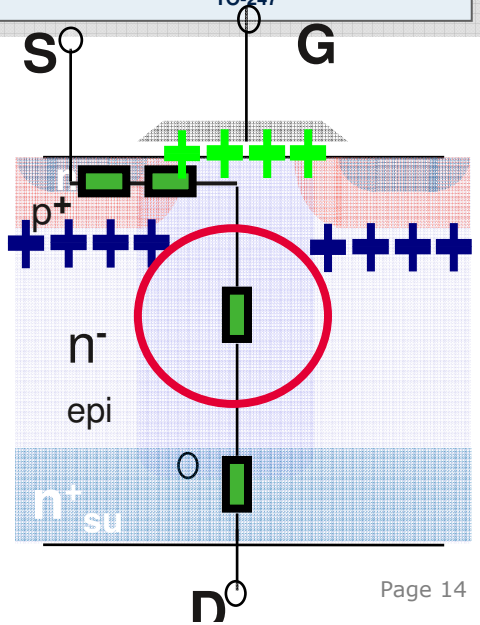


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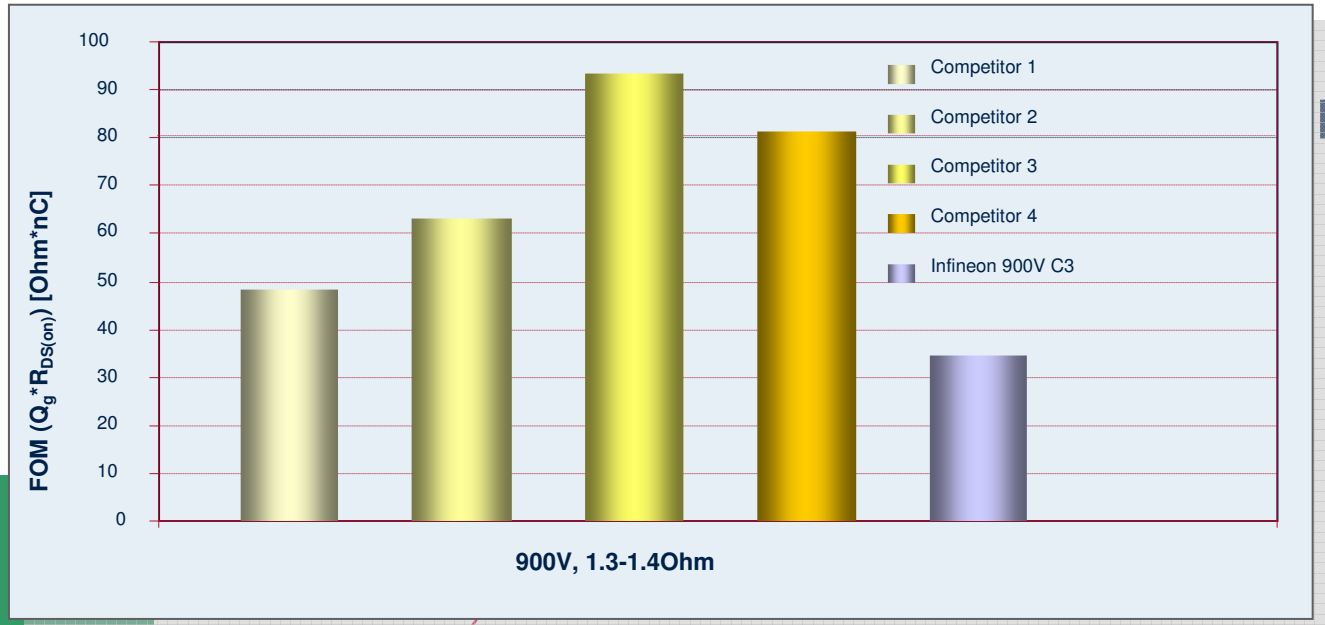
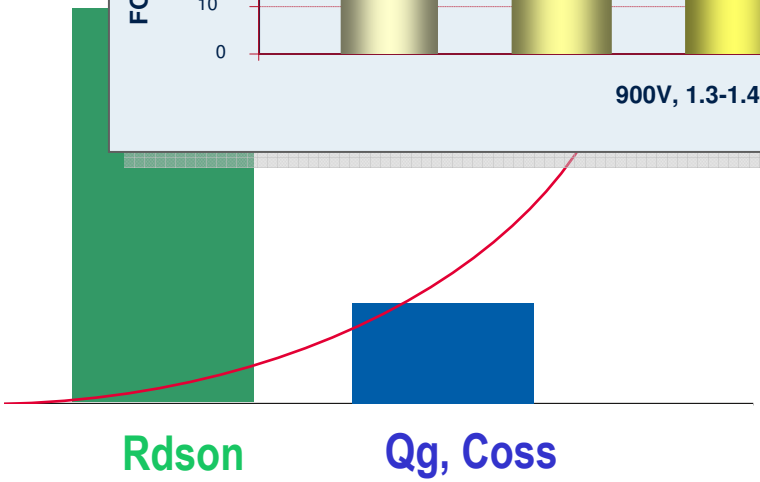
Figure of Merit (FoM)

Lowest FOM enables lowest conduction, driving and switching losses!



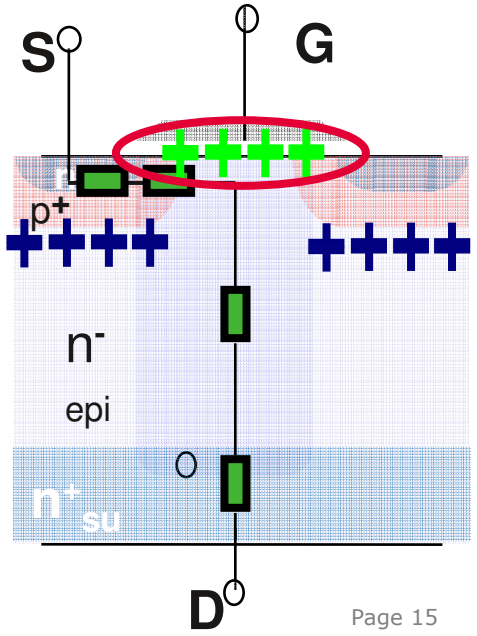


$FoM = R_{DS(on)} * Qg$

RDS(on) ➔conduction loss

Qg ➔switching loss

Unit: **Ω·nC**



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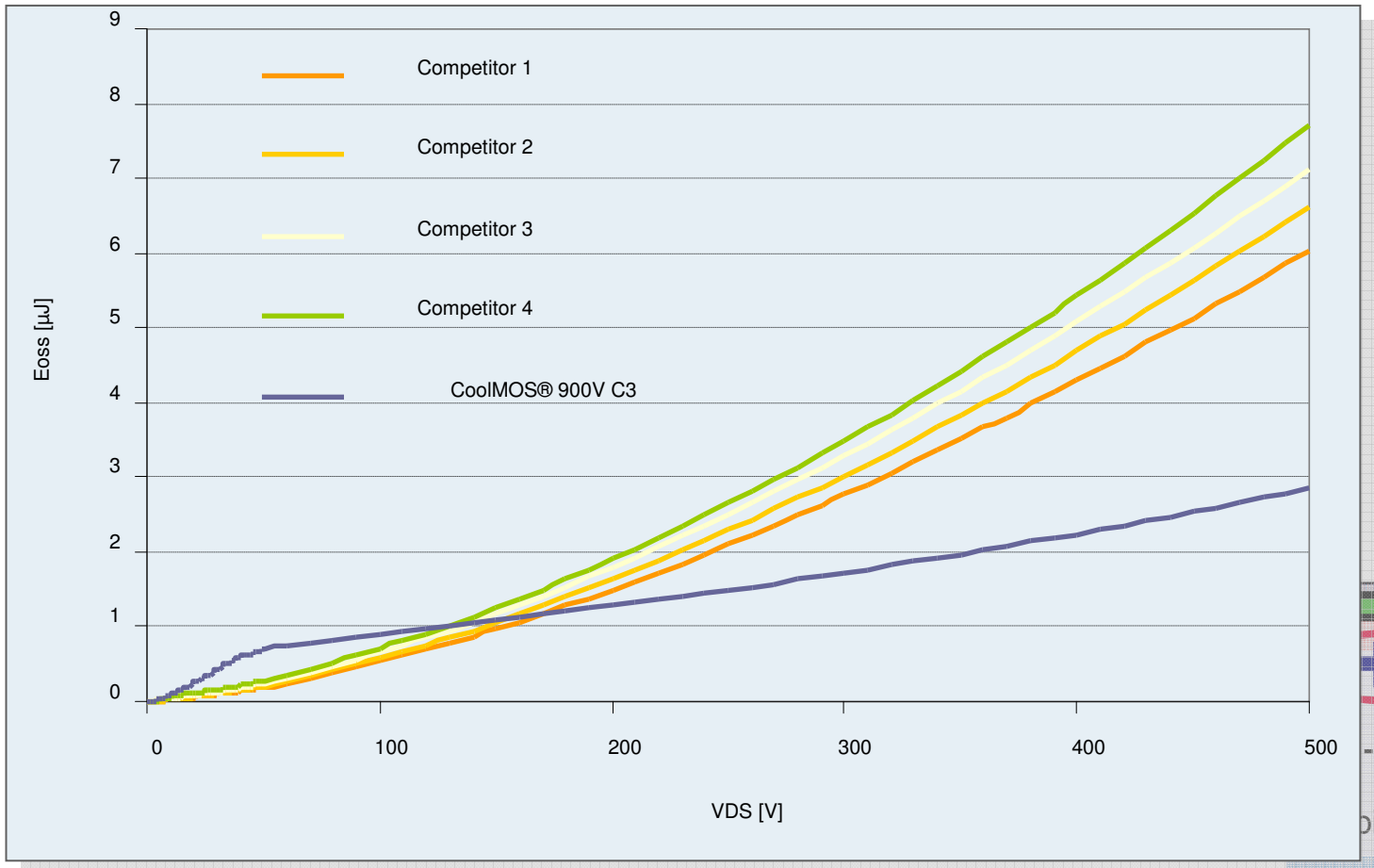
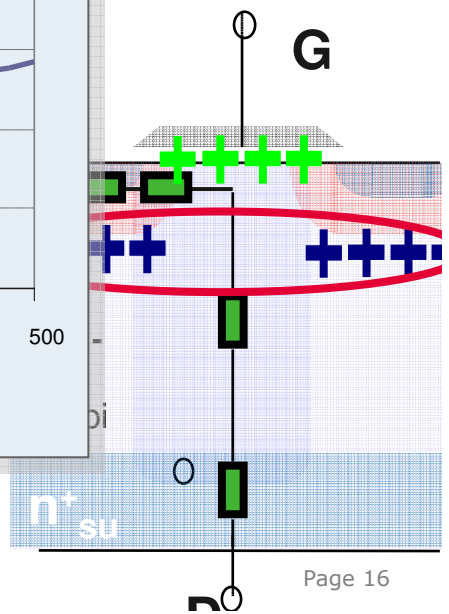
Eoss (Energy stored in the output Capacitance)

Eoss is reduced by a factor of two or more!





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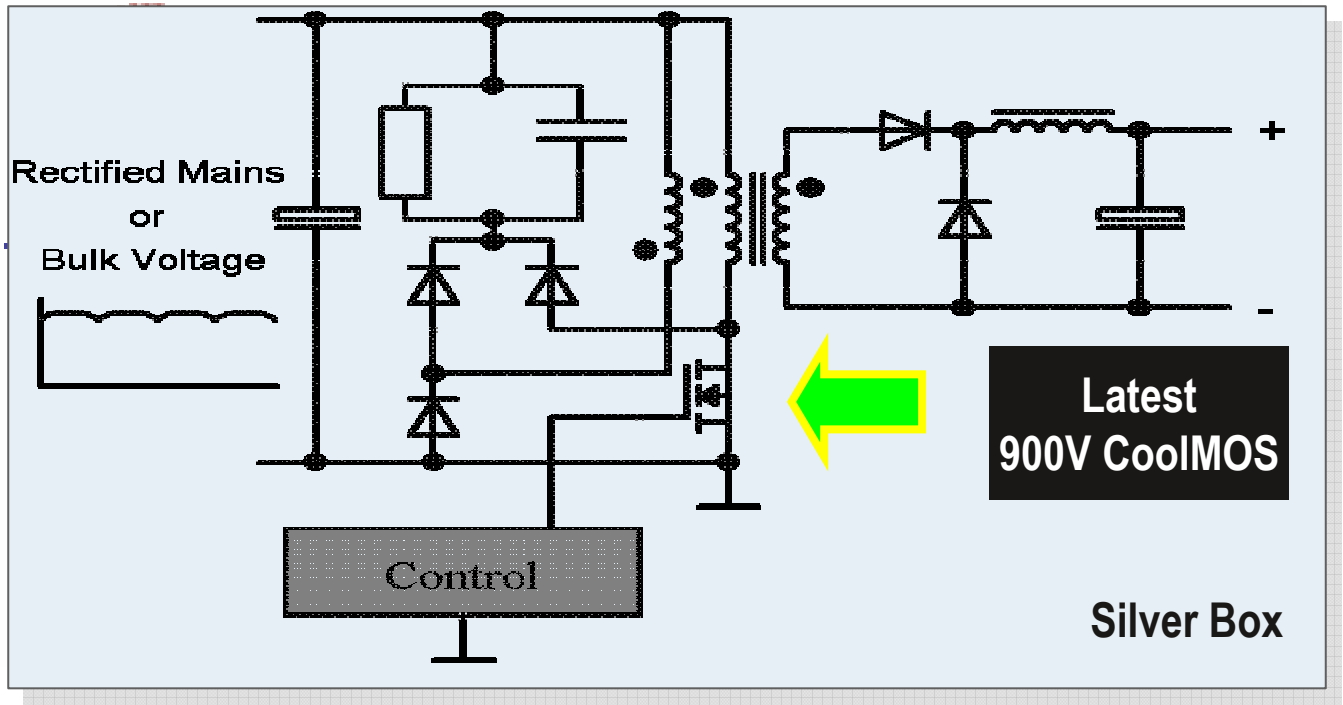
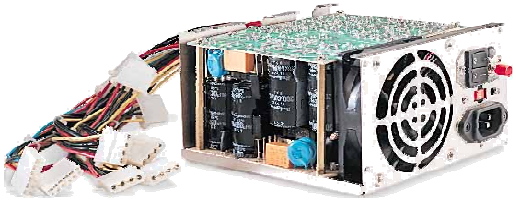
PC silver box with STF topology



Benefits (STF vs TTF) on 500W silver box:



Higher efficiency: +0.7% with BiC TO220

Lower costs (only one FET, no clamping diodes and pulse transformer)

Easier design (no high-side drive, easier board layout)

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Loss comparison between TTF & STF

Losses	TTF with 200mΩ/600V	STF with 500mΩ/900V	STF with 340mΩ/900V
Conduction	6.5W	8.1W	5.5W
Output capacitance	2.8W	1.0W	2.1W
Switching	7.3W	4.7W	4.7W
Demagnetizing winding	---	0.5W	0.5W
Total losses	**16.6W**	**14.3W**	**12.8W**

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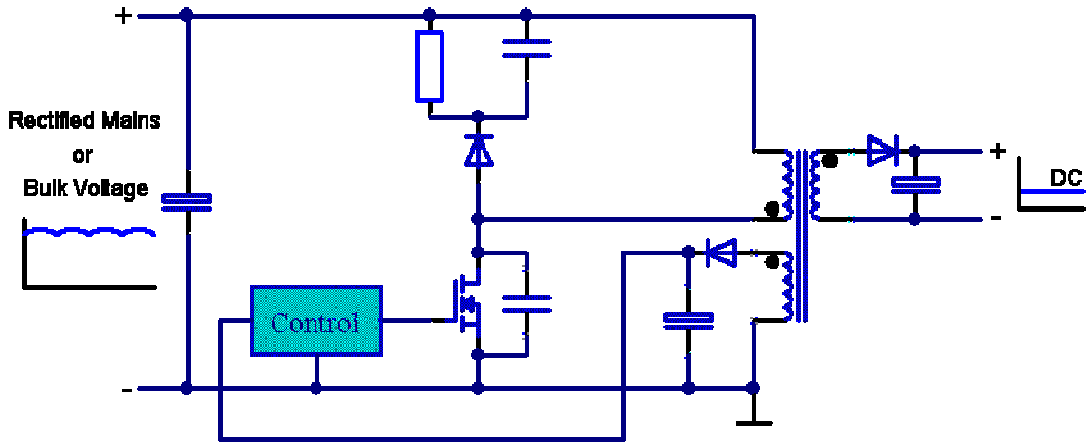
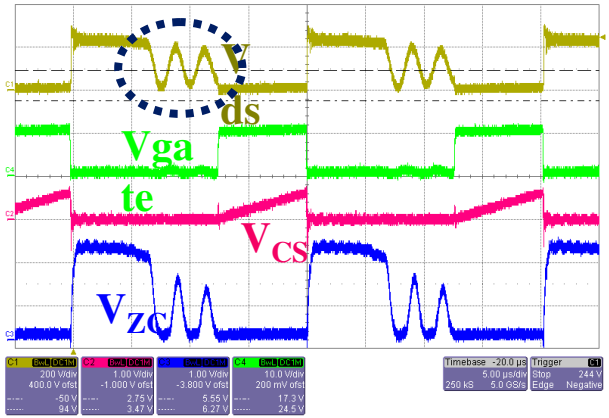
Consumer power supply

- Quasi-resonant Flyback stage for LVD TV
  Output: 200W 24V





No need for MOSFET paralleling with 900V CoolMOS!

Reduced voltage stress on sec. side diode or sync.rec MOSFET!

Premium efficiency: +0.7% Efficiency vs. 600V/650 V MOSFET*

+0.2% Efficiency vs. 800V MOSFET*

*compared to CoolMOS in 200W/24V output Qr Flyback stage

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Comparison with different MOSFET

	650V 500mΩ CoolMOS	800V 500mΩ CoolMOS	900V 500mΩ CoolMOS
Duty Cycle at $V_{in,min}$ and max load	18%	27%	**32%**
Peak current	4.8 A	3.1 A	**2.7 A**
Conduction losses	1.35 W	0.90W	**0.76 W**
Turn-on-losses	0.17 W	0.09 W	**0**
Turn-off-losses	1.4 W	0.9 W	**0.8 W**
Voltage stress on secondary side diode	91 V	57V	**48V**
Total losses	6.6 W	5.6 W	**5.2 W**
Efficiency loss	3.31 %	2.80 %	**2.61 %**

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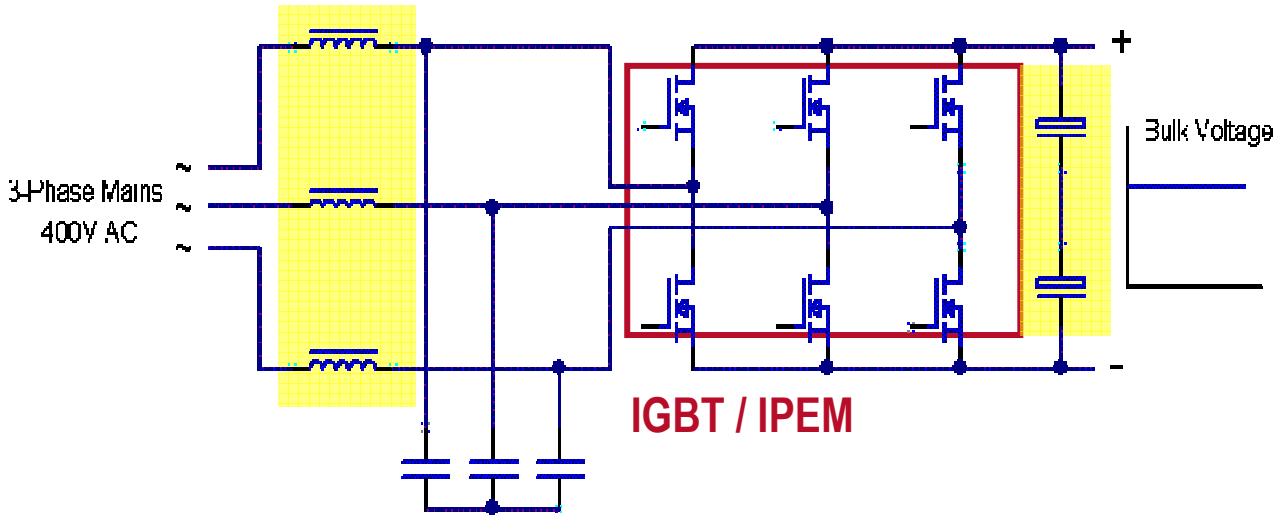
3 phase Industry converter



BiC TO247 with 120mOhm available

One BiC TO-247 per position offers:

- **Significantly better efficiency vs IGBT solution up to 8 kW**
- **Switching frequencies in 100kHz range possible, hence reduction of line filter and audible noise reduction**

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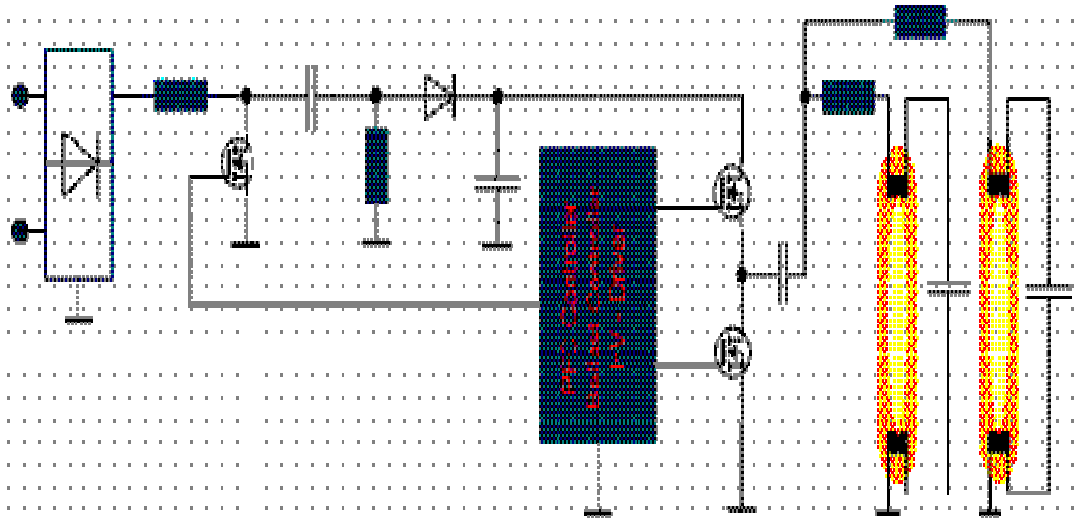
Lighting Ballast



- **SEPIC in PFC avoids inrush current and improves surge capability.**
- **3-Phase Supply of Lamp Ballasts requires a higher voltage capability.**
- **Ballasts for Flat Fluorescent Lamps require higher voltage capability**

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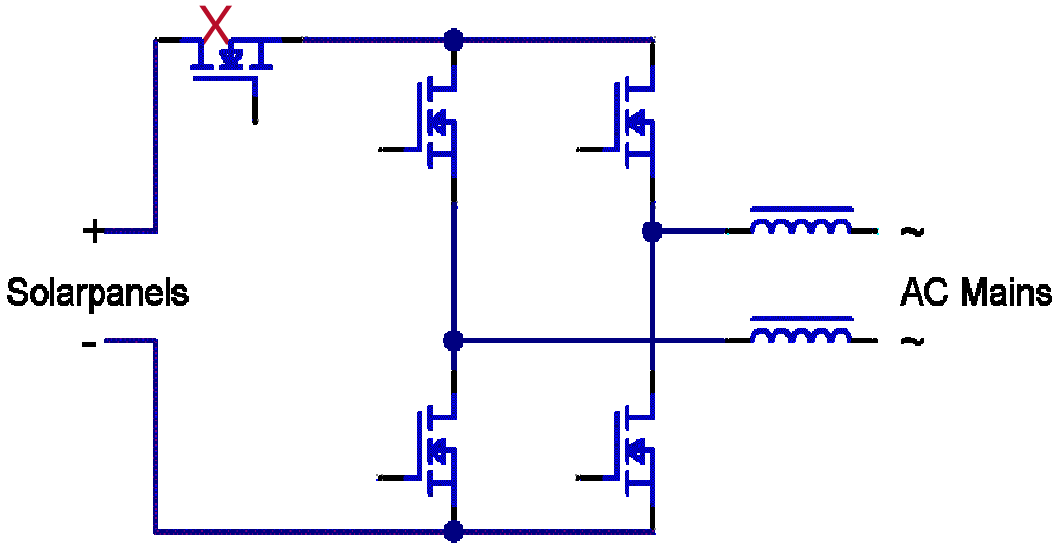
Photovoltaic applications

H-Bridge for solar inverters



Higher overall efficiency by MOSFET

Smaller system size due to higher switching frequency

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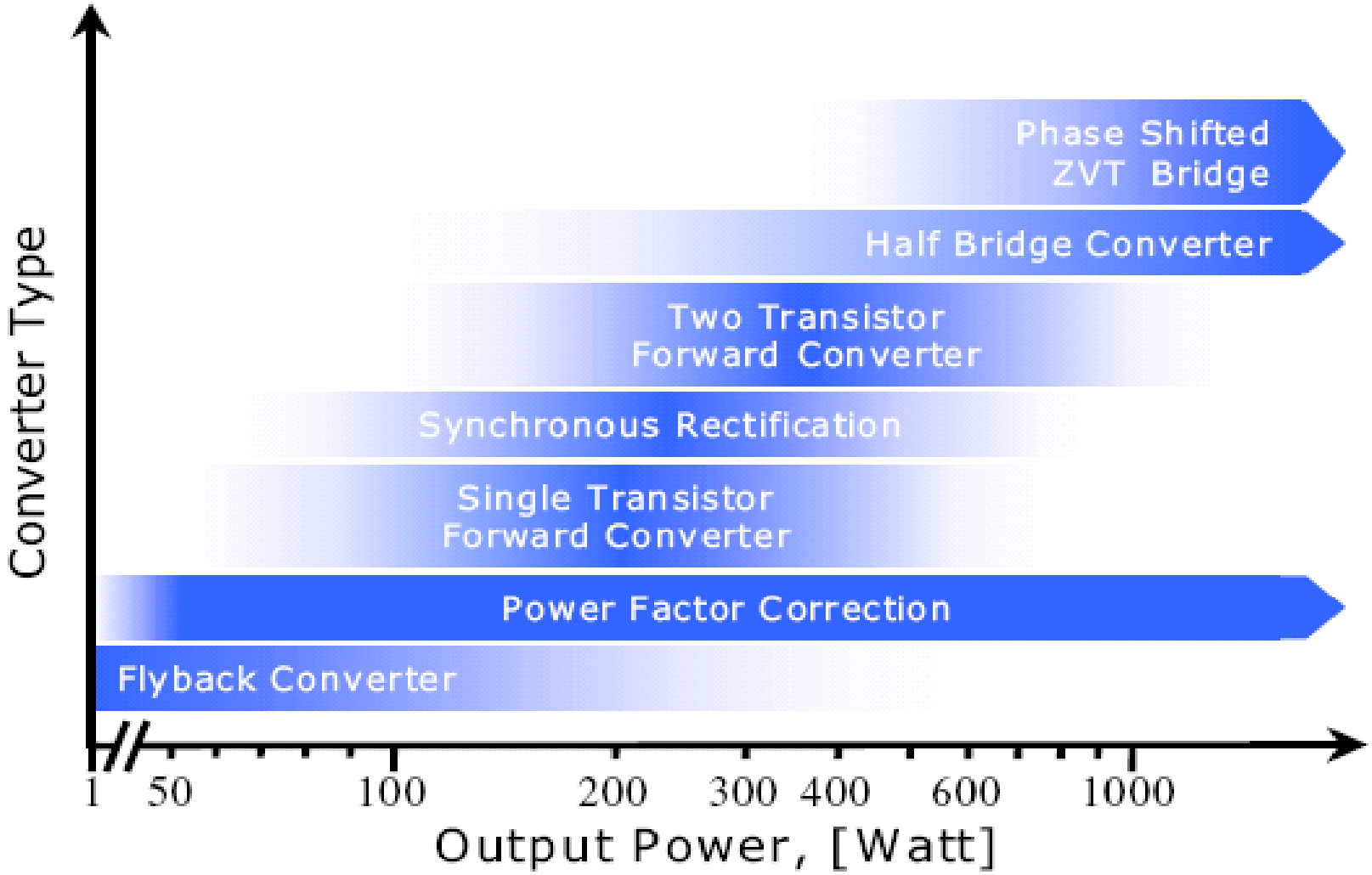
CoolMOS™ Selection

- SMPS topologies versus output power



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Recommended table for major applications

Application	PFC	PWM hard switching	PWM resonant switching
Topology	Conventional, Interleaved	TTF, ITTF, Flyback, Half-bridge	ZVS phase shift, res. HB, SRC, LLC
Adapter **ATX power supplies** **Server / Telecom** **LCD / PDP TV** **Lighting ballasts**	CoolMOS™ C3* CoolMOS™ CP**		CoolMOS™ CFD
	* Easy to design in ** Takes additional care for design-in		Highest reliability

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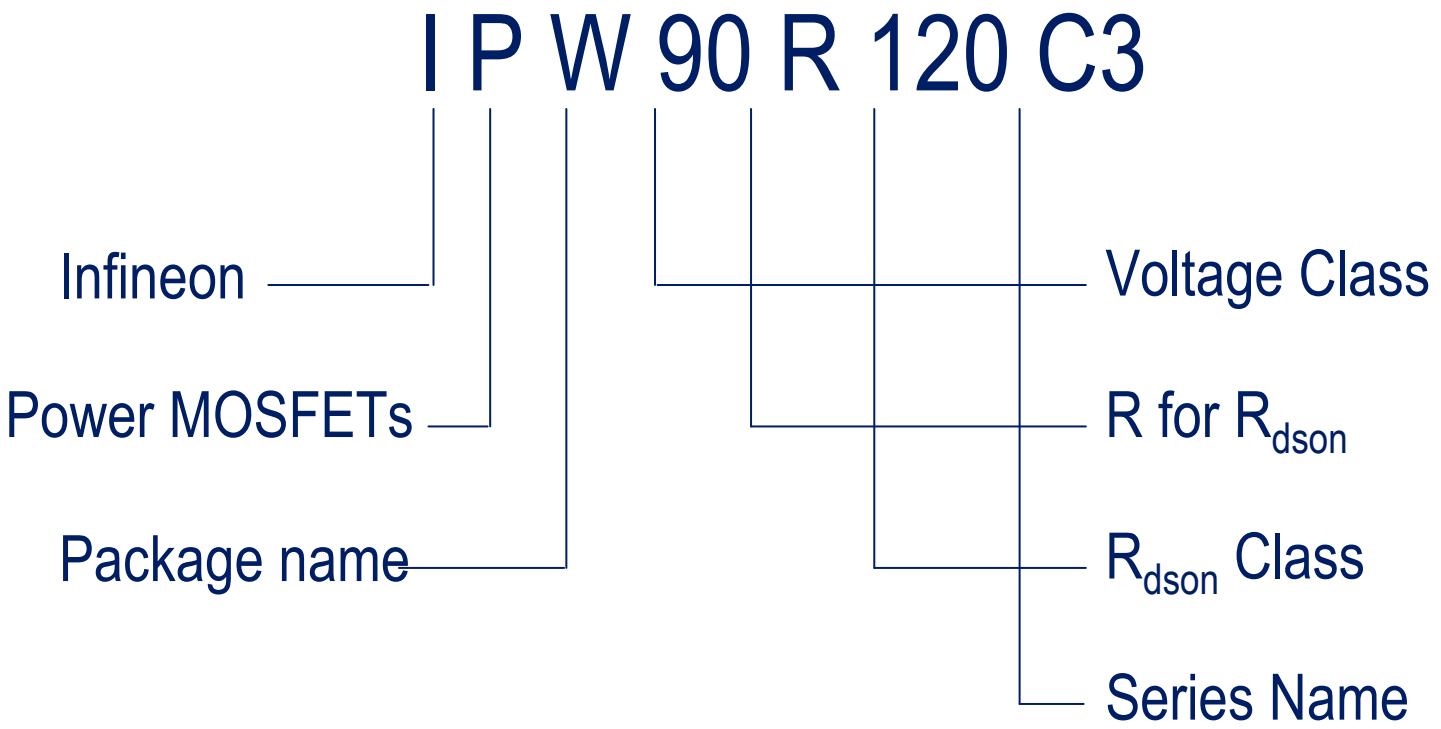
CoolMOS™ 900V Naming system



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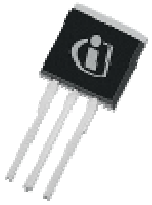
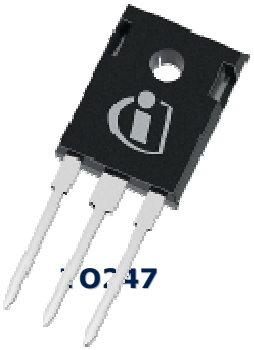
CoolMOS 900V product portfolio

	DPak	I²Pak	TO220FP	TO220	TO247
120mOhm					IPW90R120C3
340mOhm		IPI90R340C3		IPP90R340C3	IPW90R340C3
500mOhm		IPI90R500C3	IPA90R500C3	IPP90R500C3	IPW90R500C3
800mOhm		IPI90R800C3	IPA90R800C3	IPP90R800C3	IPW90R800C3
1000mOhm		IPI90R1k0C3	IPA90R1k0C3	IPP90R1k0C3	IPW90R1k0C3
1200mOhm	IPD90R1k2C3	IPI90R1k2C3	IPA90R1k2C3	IPP90R1k2C3	IPW90R1k2C3

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