



CoolMOS[™] SJ MOSFETs benefits

in hard and soft switching SMPS topologies

www.infineon.com/coolmos



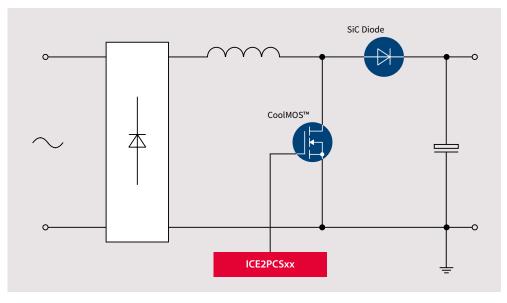
CoolMOS[™] benefits

Hard and soft switching topologies, applications and suitable CoolMOS™ families

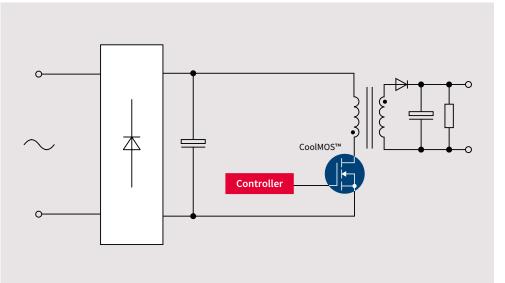
	CoolMOS [™] series	Efficiency = CoolMOS™ C7			Efficiency = 600 V CoolMOS™ C7	
	Price/perfc	ormance = 600 V, 700 V, 800 V and 950 V Co CoolMOS™ C6/E6/CE/P6		Price/performance = CoolMOS™ P7 CoolMOS™ C6/E6/CE/P6	CoolMOS™ CFD2/CFD7	
	SMPS switching topologies					
		Hard switching topologies			Soft swite	hing topologies
	P		PW	M	1	PWM
	P	Two transistor forward (TTF/ITTF)	Flyback/ quasi-resonant flyback	LLC	ZVS phase-shift	
	DCM	ССМ	 		Half-bridge Full-bridge	Full-bridge
	Applications					
Server	 	Server/telecom			1 1 1	Server/telecom
EV-Charging	, 	EV charging			EV	charging
Lighting - Or - - Or - - I I	Adapter		 	Adapter/ LED lighting	LED street lighting	
PC Power		PC Silver box PFC	PC Silver box 80 +		PC Silver box 90 +	
Smart metering	 		 	Smart meter	1	
SMPS	 	i	 	 	l I	UPC
	 		 	LCD) TV	

Examples of hard and soft switching topologies

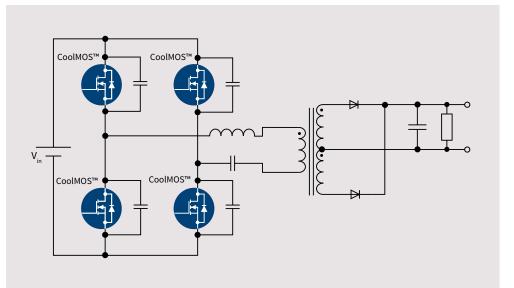
Hard switching: Power factor correction circuit



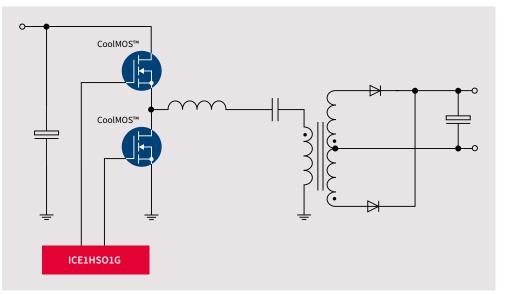
Hard switching: Quasi-resonant flyback circuit



Soft switching: ZVS phase-shift full-bridge



Soft switching: LLC half-bridge



Hard switching

What is hard switching?

- > Hard switching occurs when there is an overlap between voltage and current when switching the transistor on and off.
- > This overlap causes energy losses which can be minimized by increasing the di/dt and dv/dt.
- > However, fast changing di/dt or dv/dt causes EMI to be generated. Therefore the di/dt and dv/dt should be optimized to avoid EMI issues.

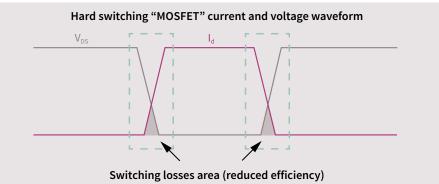
To minimize the EMI effects and to improve efficiency, an improved hard switching technique called quasi-resonant switching was developed (mainly seen in flyback converters).

What is quasi-resonant (valley) switching?

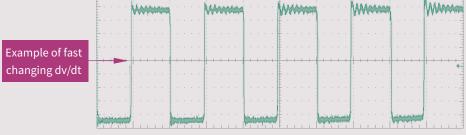
- > The transistor is turned on when the voltage across drain and source is at a minimum (in a valley) in order to minimize the switching losses and to improve efficiency.
- > Switching the transistor when the voltage is at a minimum helps reduce the hard switching effect which causes EMI.
- Switching when a valley is detected rather than at a fixed frequency introduces frequency jitter. This has the benefit of spreading the RF emissions spectrum and reducing EMI overall.

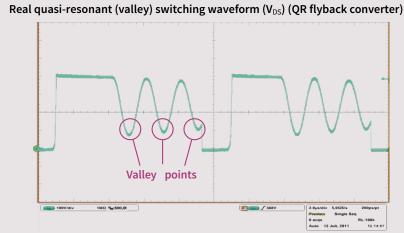
Infineon CoolMOS[™] series recommendations for hard switching topologies

 For hard switching applications Infineon recommends CoolMOS[™] C7/G7 and CoolMOS[™] P7









In order to minimize the switching losses, the turn on must be done in the V_{DS} "valleys"

Soft switching (resonant)

What is soft (resonant) switching?

- > Soft switching begins one electrical parameter to zero (current or voltage) before the switch is turned on or off. This has benefits in terms of losses.
- > The smooth resonant switching waveforms also minimize EMI.
- > Common topologies like phase- shifted ZVS and LLC are soft switched only at turn-on.

What is the difference between zero voltage switching (ZVS) and zero current switching (ZCS)?

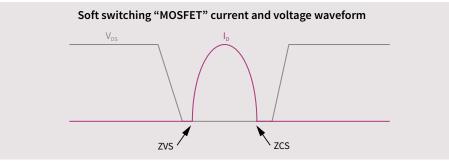
- > As both names imply either voltage or current within the transistor is zero before switching occurs.
- For ZVS, the transistor will be turned in at zero V_{DS} voltage to reduce the turn on switching loss.
- For ZCS, the transistor will be turned off at zero I_D current to reduce the turn off switching loss.

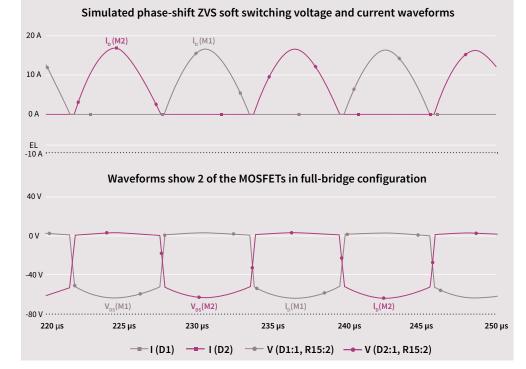
Why is there a need for a rugged or fast body diode?

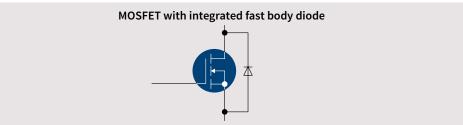
> Most resonant circuits are half- or full-bridge topologies (2 or 4 transistors). As transistors are switched on and off, energy can be left in the transistor and this can cause failure. Due to switching times if this only happens occasionally a rugged body diode is sufficient (CoolMOS[™] P7). If due to fast transition times it happens continually then a fast body diode is required to make sure all the energy will leave the transistor (CoolMOS[™] CFD7 series).

Infineon CoolMOS[™] series recommendations for soft switching (resonant) topologies

For soft switching applications such as phase-shifted ZVS and LLC, Infineon recommends either 600 V CoolMOS[™] CFD7 or 600 V CoolMOS[™] P7 series.







CoolMOS[™] product portfolio

	ThinPAK 8x8	ThinPAK 5x6	TO-Leadless	DDPAK	TO-252 DPAK	TO-263 D ² PAK	TO-220	TO-220 FullPAK	TO-220 FullPAK Wide Creepage	FullPAK		TO-251 IPAK SL	TO-251 I ² PAK	TO-247	TO-247 4pin	IPAK SL with	SOT-223
CoolMOS™			S IIIIIII			and the second s			T	No. 10	- TT	F		S Interess	S Stream	ISO lead standoff	1
500 V CE					\checkmark		\checkmark	\checkmark		✓	\checkmark			✓			\checkmark
600 V CE					\checkmark			\checkmark	\checkmark	\checkmark	\checkmark	\checkmark					\checkmark
600 V C6/E6		\checkmark			✓	✓	\checkmark	\checkmark					\checkmark	\checkmark			
600 V C7/G7	✓		\checkmark	✓	✓	\checkmark	\checkmark	\checkmark						\checkmark	\checkmark		
600 V P6	✓	\checkmark			\checkmark		\checkmark	\checkmark						\checkmark			
600 V CFD							\checkmark	\checkmark					\checkmark	✓			
600 V CFD7	✓				✓	✓	\checkmark	\checkmark						✓			
600 V P7	✓				✓	✓	\checkmark	\checkmark						\checkmark	\checkmark		
600 V P7S					 ✓ 			\checkmark	✓								\checkmark
650 V CE					\checkmark			\checkmark		\checkmark		\checkmark					\checkmark
650 V C6/E6	✓	\checkmark					\checkmark	\checkmark					\checkmark	\checkmark			
650 V C7/G7	✓		✓		✓	✓	\checkmark	✓						✓	✓		
650 V CFD2	✓				✓	✓	\checkmark	\checkmark					\checkmark	✓			
700 V CE					✓							 ✓ 					\checkmark
700 V P7		∕*			 ✓ 			\checkmark		✓		\checkmark				✓	\checkmark
800 V CE					\checkmark			\checkmark			\checkmark						
800 V P7		∕*			✓		\checkmark	\checkmark		\checkmark	\checkmark	✓		\checkmark			\checkmark
950 V P7					✓			\checkmark				 ✓ 					\checkmark

Hard switching Hard/soft switching * Kelvin source configuration

■ Soft switching ✓ Standard parts



Hard switching	650 V CoolMOS™ C7/G7:	NEW! Fastest switching series, best suited for high efficiency at hard switching topologies.
Hard/soft switching	CoolMOS™ E6:	CoolMOS™ C3 replacement series optimized for DCM applications in PFC and PWM. Improved low load efficiency over CoolMOS™ C3.
la internet in the second	CoolMOS™ C6:	CoolMOS™ C3 replacement series. Improved low load efficiency, also with improved "rugged" diode for use in cost sensitive soft switching topologies as well as hard switching.
	CoolMOS™ P6:	Price/performance series, suitable for hard and soft switching.
	600 V CoolMOS™ C7/G7:	NEW! Fastest switching series, suitable for hard switching topologies and soft switching.
	CoolMOS™ CE:	Right fit for consumer applications with competitive cost, fast delivery and high quality for use in hard and soft switching topologies.
	600 V CoolMOS™ P7:	Replacement for P6, price/ performance series, suitability for wide range of applications in hard and soft switching topologies
	700 V/800 V/950 V CoolMOS™ P7:	Replacement for CE/C3, designed and optimized for flyback topologies
Soft switching	CoolMOS™ CFD:	Original fast body diode series suitable for hard commutation resonant soft switching topologies.
J	CoolMOS™ CFD2:	CoolMOS™ CFD replacement series. Improved low load efficiency and improved fast body diode control enabling lower EMI and overshoot voltage.
		Suitable for hard commutation resonant soft switching topologies.
	CoolMOS™ CFD7:	NEW! Replacement of CoolMOS™ CFD2 for new designs, improved efficiency and BIC robustness; suitable for hard commutation resonant soft switching topologies

For more information on individual CoolMOS[™] parts in the above different series, please go to www.infineon.com/coolmos

Where to buy

Infineon distribution partners and sales offices: www.infineon.com/wheretobuy



Mobile product catalog

Mobile app for iOS and Android.

Service hotline

Infineon offers its toll-free 0800/4001 service hotline as one central number, available 24/7 in English, Mandarin and German.

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- > China, mainland 4001 200 951 (Mandarin/English)
- > India 000 800 4402 951 (English)
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- > Other countries 00* 800 951 951 951 (English/German)
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