Synchronous Rectifier in Flyback Converter

9F-5, No. 3-2, Park Street, Nankang District, (NKSP), Taipei, Taiwan, 115, R.O.C. Tel:886-2-2655-8178 Fax:886-2-2655-8468

A. Rectifier Circuit
B. Rectifier Concept
C. Synchronous Rectifier

C - 1 : Constant Frequency (CF)
Continuous Conduction Mode (CCM)
C - 2 : Constant Frequency (CF)
Discontinuous Conduction Mode (DCM)
C - 3 : Variable Frequency (VF)
Discontinuous Conduction Mode (DCM)
C - 4 : Variable Frequency (VF)
Zero-Voltage-Switched (ZVS)
Discontinuous Conduction Mode (DCM)

D. Power Loss Comparisons
E. Efficiency Curve

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A. Rectifier Circuit

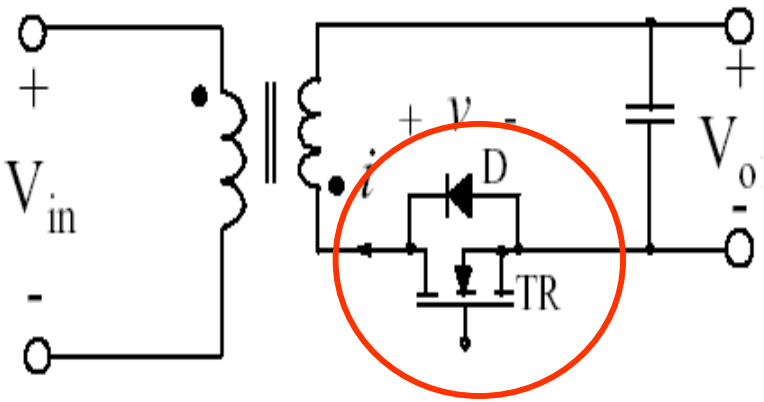

Fig1 : Flyback Converter with MOSFET

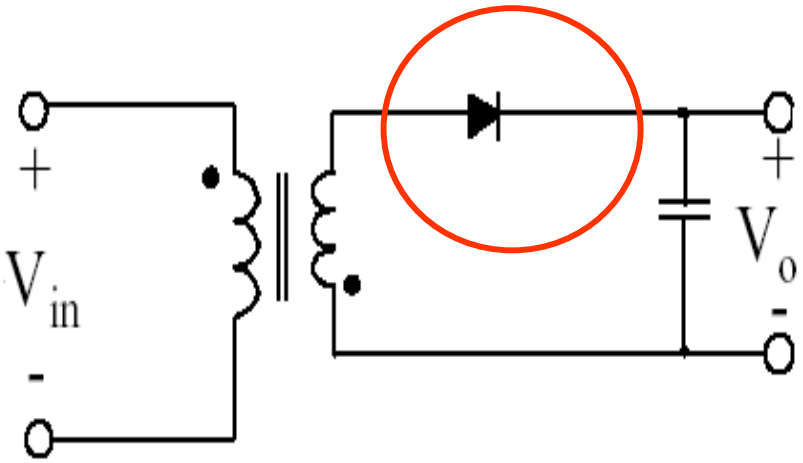

Fig2 : Flyback Converter with Diode

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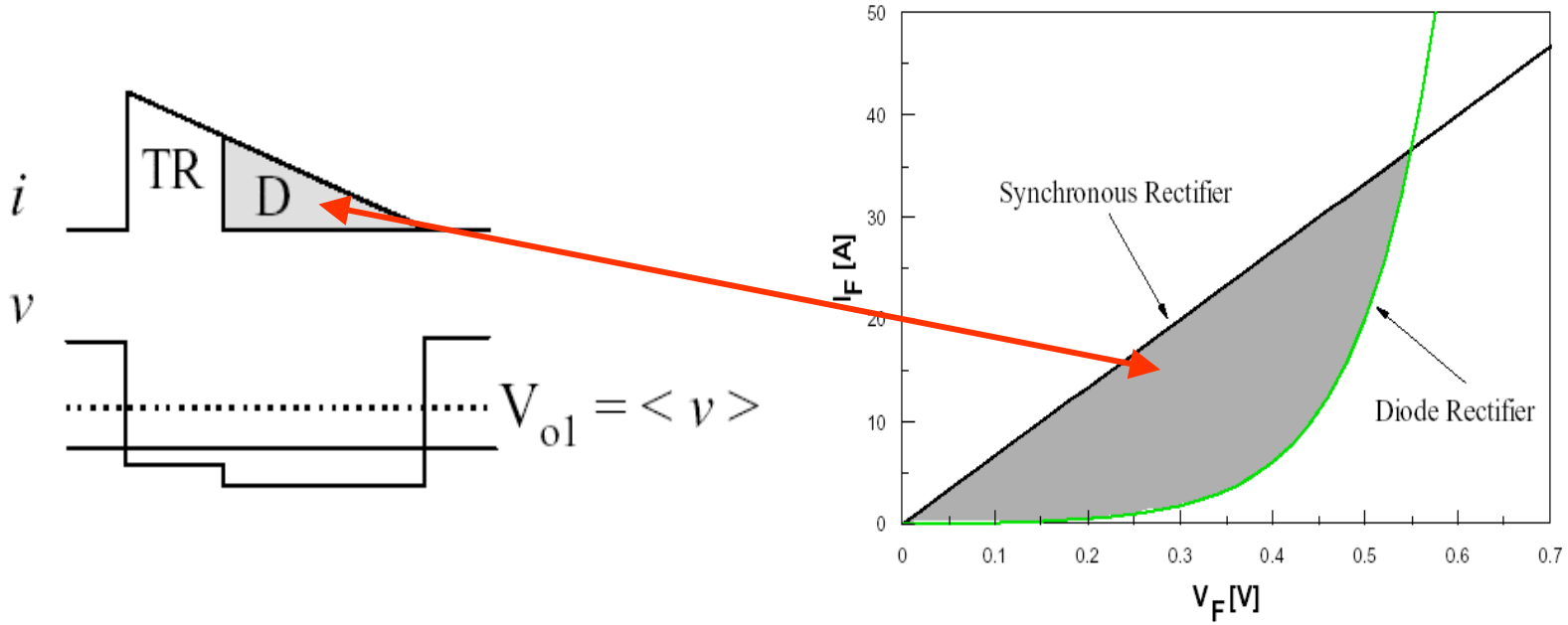
B. Rectifier Concept



The switching losses caused by the reverse recovery current of the body - diode will be dependent of the carried current in the instant in the which the voltage between anode and cathode reverses become negative

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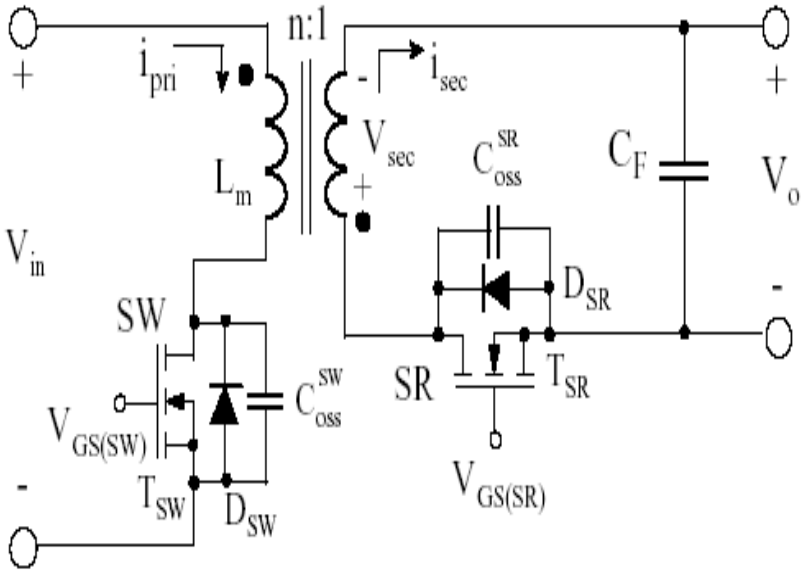
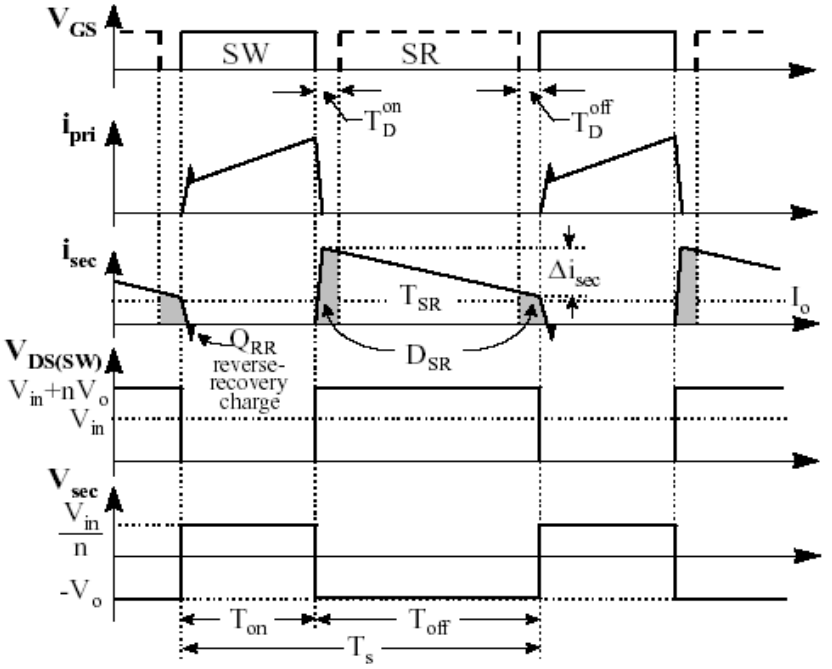
C. Synchronous Rectifier

C - 1 : Constant Frequency (CF) Continuous Conduction Mode (CCM)





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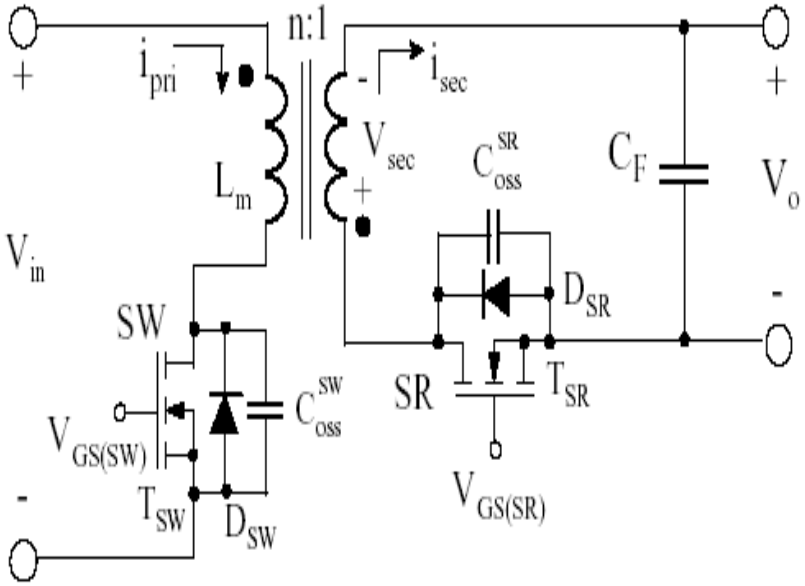
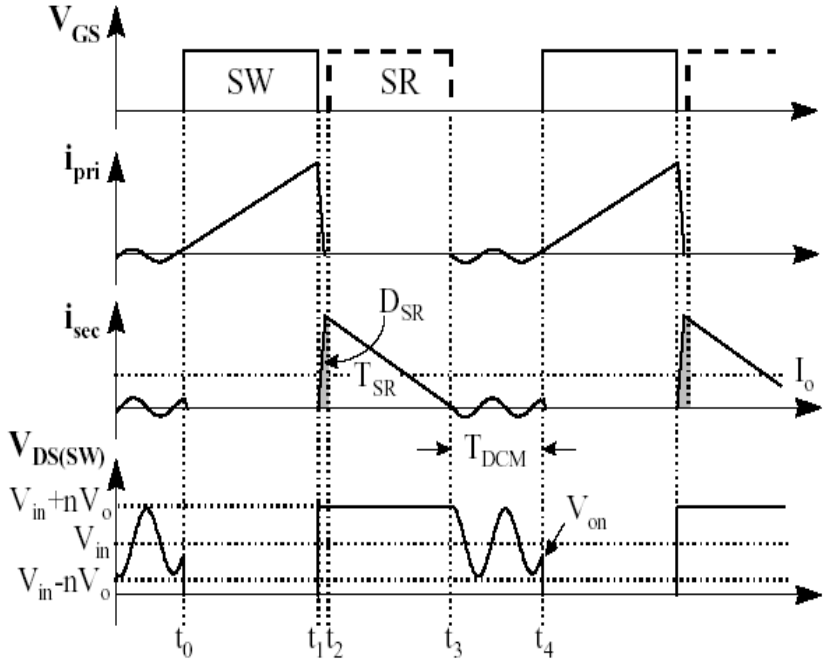
C. Synchronous Rectifier

C - 2 : Constant Frequency (CF) Discontinuous Conduction Mode (DCM)





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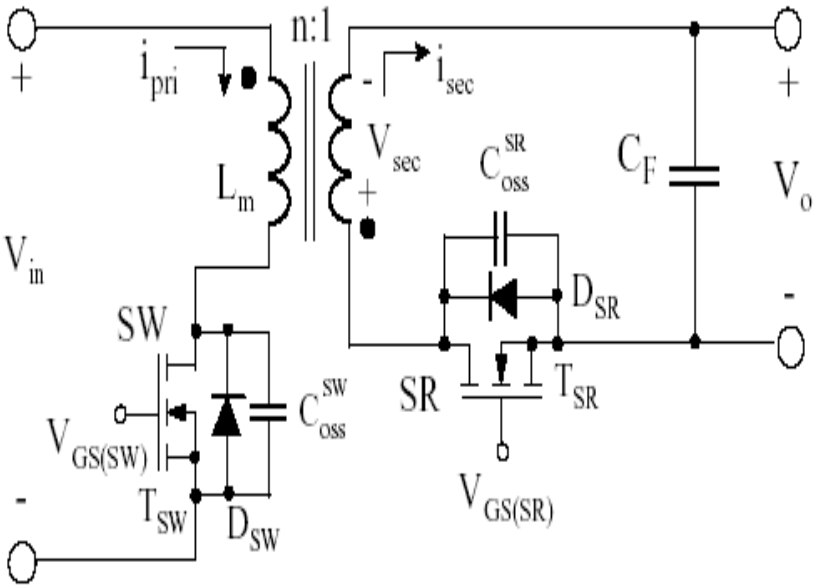
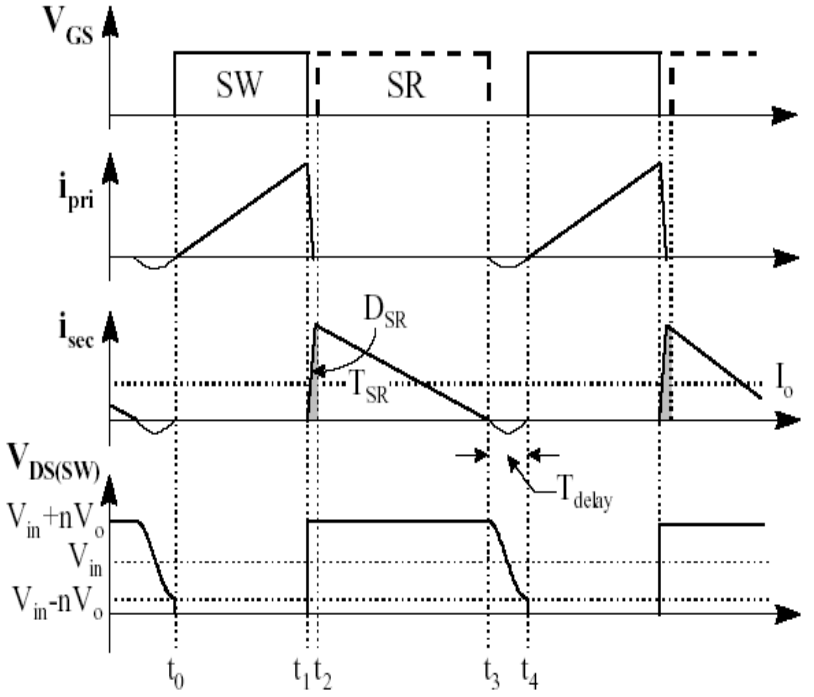
C. Synchronous Rectifier

C - 3 : Variable Frequency (VF) Discontinuous Conduction Mode (DCM)





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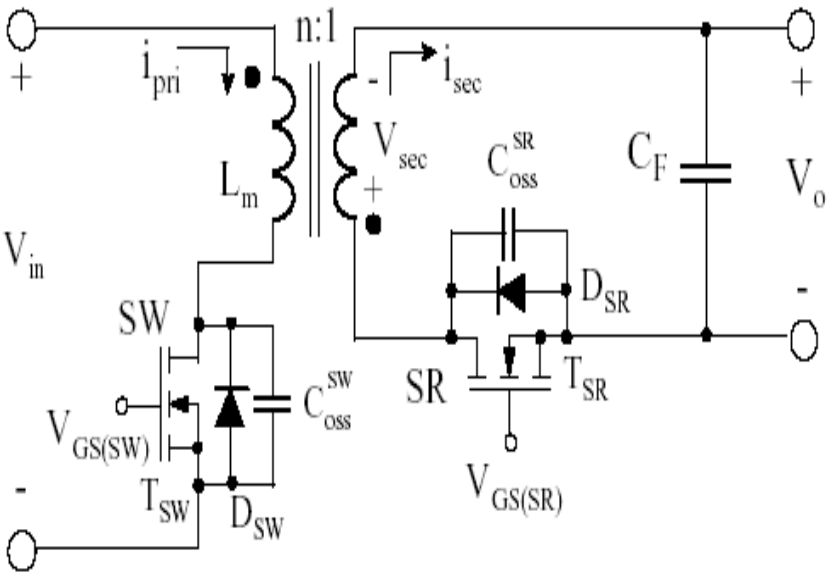
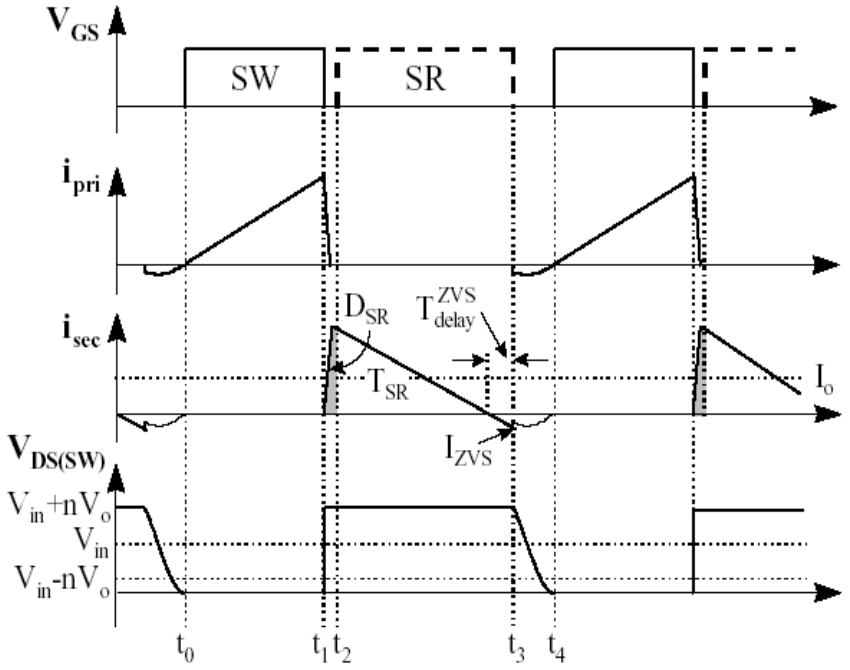
C. Synchronous Rectifier

C - 4 : Variable Frequency (VF) Zero-Voltage-Switched (ZVS) Discontinuous Conduction Mode (DCM)





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D. Power Loss Comparisons

		CF CCM	CF DCM	VF DCM	VF ZVS DCM
P_{cond}	DR	$V_F I_o$	$V_F I_o$	$V_F I_o$	not possible to implement
	SR	$R_{DS(on)}\left[\frac{I_o^2}{1-D}+\frac{\Delta I_{inc}^2(1-D)}{12}\right] + V_D I_D (T_D^{on}+T_D^{off}) f_s$	$R_{DS(on)}\frac{4I_o^2}{3(1-D)}$	$R_{DS(on)}\frac{4I_o^2}{3(1-D)}$	$R_{DS(on)}\frac{4I_o^2}{3(1-D)} + \frac{I_{ZVS}\,2I_o + I_{ZVS}(1-D)}{3}$
$P_{sw} = P_{off}+P_{RR}$	DR*	$\left[\frac{C_T}{2}(V_o+\frac{V_{in}}{n})^2+Q_{RR}^{DR}(V_o+\frac{V_{in}}{n})\right]f_s$	0	0	not possible to implement
	SR	$\left[\frac{C_{oss}^{SR}}{2}(V_o+\frac{V_{in}}{n})^2+Q_{RR}^{SR}(V_o+\frac{V_{in}}{n})\right]f_s$	0	0	0
$P_{cap(SW)}$	DR	$\frac{C_{oss}^{SW}}{2}(V_{in}+nV_o)^2 f_s$	$\frac{C_{oss}^{SW}}{2}V_{on}^2 f_s$	$\frac{C_{oss}^{SW}}{2}(V_{in}-nV_o)^2 f_s$	not possible to implement
	SR	$\frac{C_{oss}^{SW}}{2}(V_{in}+nV_o)^2 f_s$	$\frac{C_{oss}^{SW}}{2}V_{on}^2 f_s$	$\frac{C_{oss}^{SW}}{2}(V_{in}-nV_o)^2 f_s$	0

* Note that for Schottky rectifiers, $Q_{RR} \approx 0$.

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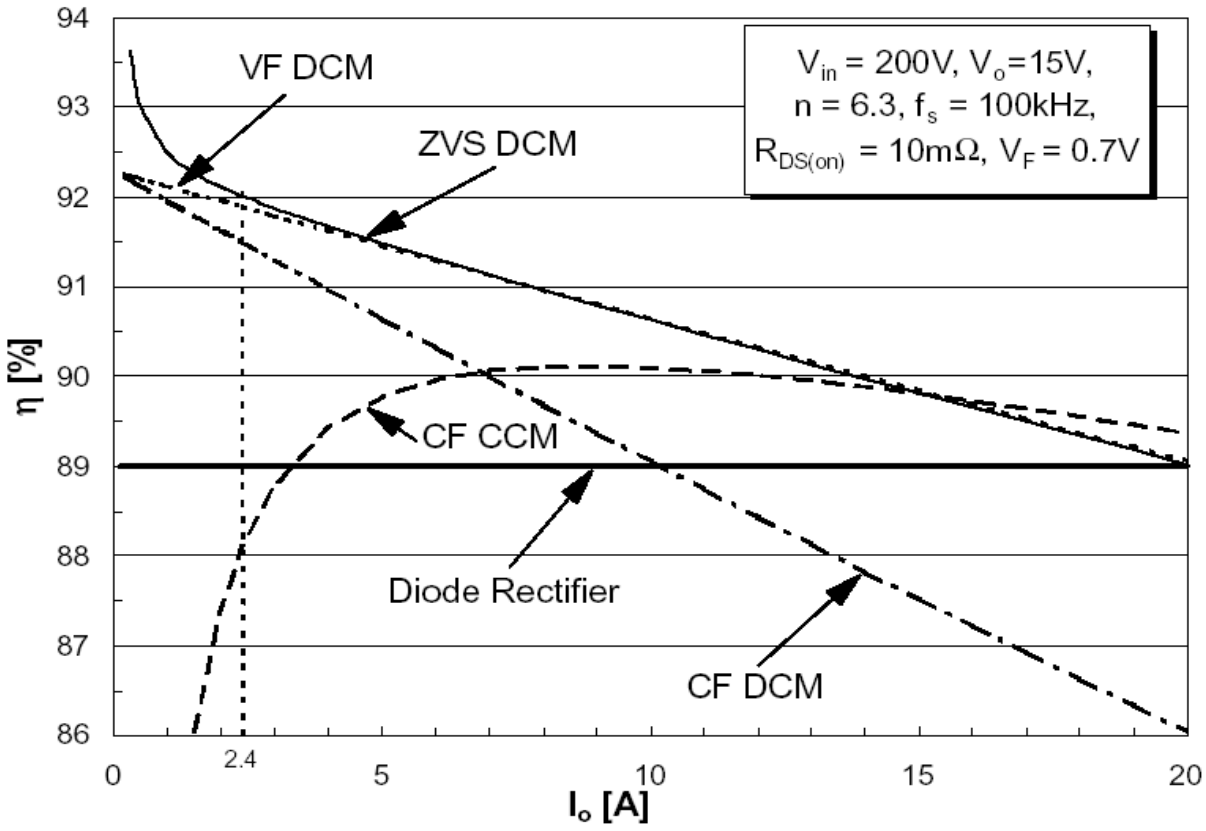
E. Efficiency Curve



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