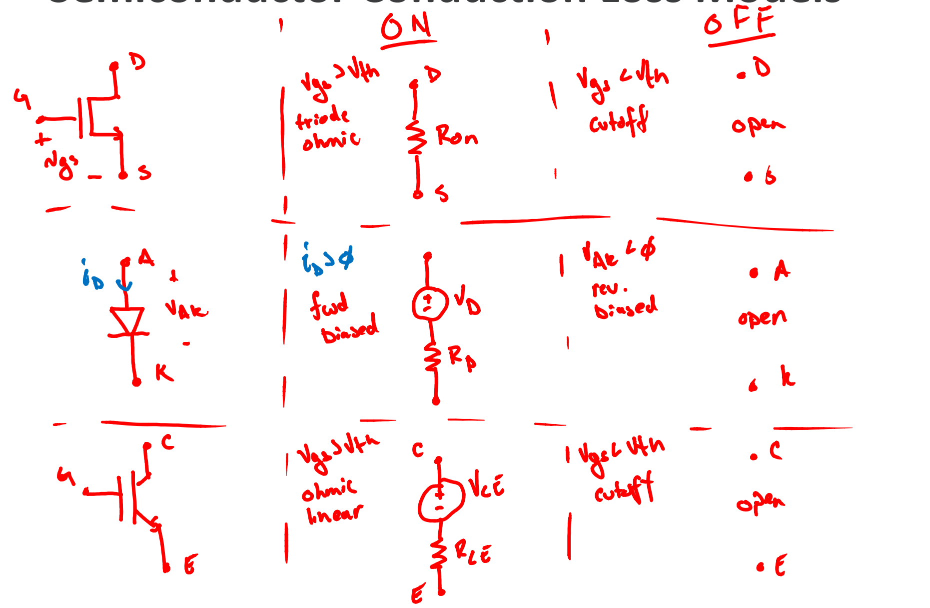
Semiconductor Conduction Loss Models



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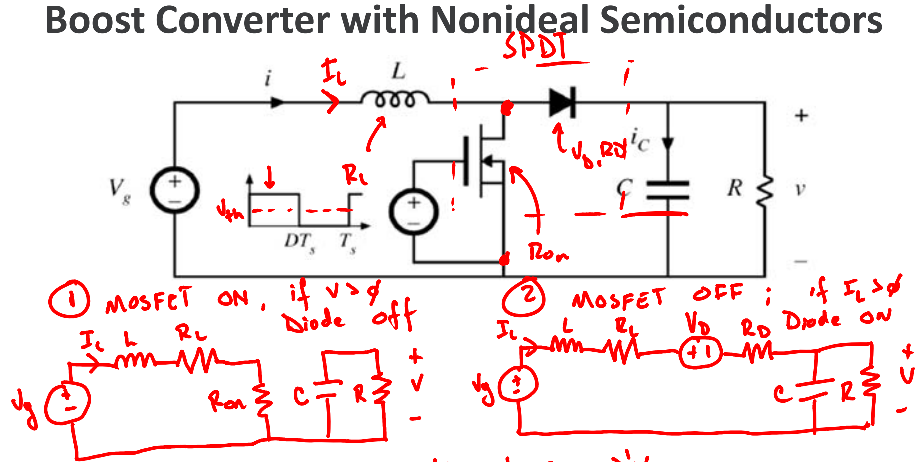
Boost Converter with Nonideal Semiconductors



$$\langle v_L \rangle = 0 = V_g - I_L R_L - D I_L R_{on} - D' V_D - D' I_L R_D - D' V$$

$$\langle i_C \rangle = 0 = D' I_L - \frac{V}{R}$$

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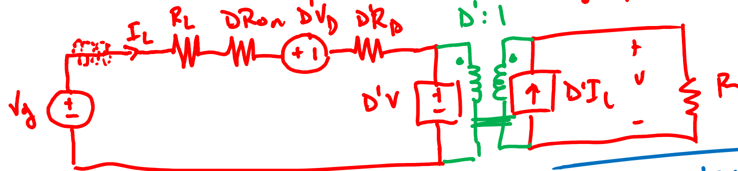

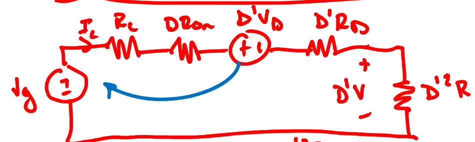

Side note:

$P_{approx} = I_{L,DC}^2 R_L$

$P_{act} = I_{L,rms}^2 R_L$

$$D'V = (V_g - D'V_D) \frac{D'^2 R}{R_L + DR_{on} + D'R_D + D'^2 R}$$

$$M = \frac{V}{V_g} = M(D)_{ideal}\,\eta = \left(\frac{1}{D'}\right)\left(1 - \frac{D'V_D}{V_g}\right) \frac{1}{1 + \frac{R_L + DR_{on} + D'R_D}{D'^2 R}}$$

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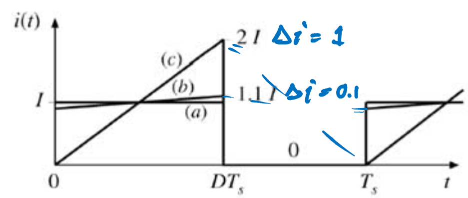
Average vs RMS Currents

- Model uses average currents and voltages
- To correctly predict power loss in a resistor, use rms values
- Result is the same, provided ripple is small

MOSFET current waveforms, for various ripple magnitudes:



Inductor current ripple	MOSFET rms current	Average power loss in R_{on}
→ (a) $\Delta i = 0$	$I\sqrt{D}$	$D\,I^2 R_{on}$
(b) $\Delta i = 0.1\,I$	$(1.00167)\,I\sqrt{D}$	$(1.0033)\,D\,I^2 R_{on}$ → $\varepsilon_{r} = 0.3\%$
(c) $\Delta i = I$	$(1.155)\,I\sqrt{D}$	$(1.3333)\,D\,I^2 R_{on}$ → $\varepsilon_{r} = 33\%$

One way: Use Appendix A

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Summary of Chapter 3

1. The dc transformer model represents the primary functions of any dc-dc converter: transformation of dc voltage and current levels, ideally with 100% efficiency, and control of the conversion ratio M via the duty cycle D. This model can be easily manipulated and solved using familiar techniques of conventional circuit analysis.
2. The model can be refined to account for loss elements such as inductor winding resistance and semiconductor on-resistances and forward voltage drops. The refined model predicts the voltages, currents, and efficiency of practical nonideal converters.
3. In general, the dc equivalent circuit for a converter can be derived from the inductor volt-second balance and capacitor charge balance equations. Equivalent circuits are constructed whose loop and node equations coincide with the volt-second and charge balance equations. In converters having a pulsating input current, an additional equation is needed to model the converter input port; this equation may be obtained by averaging the converter input current.