Power Electronics Education
Electronic Book

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Tutorial 6: Non-isolated DC-DC Converters with Real Components

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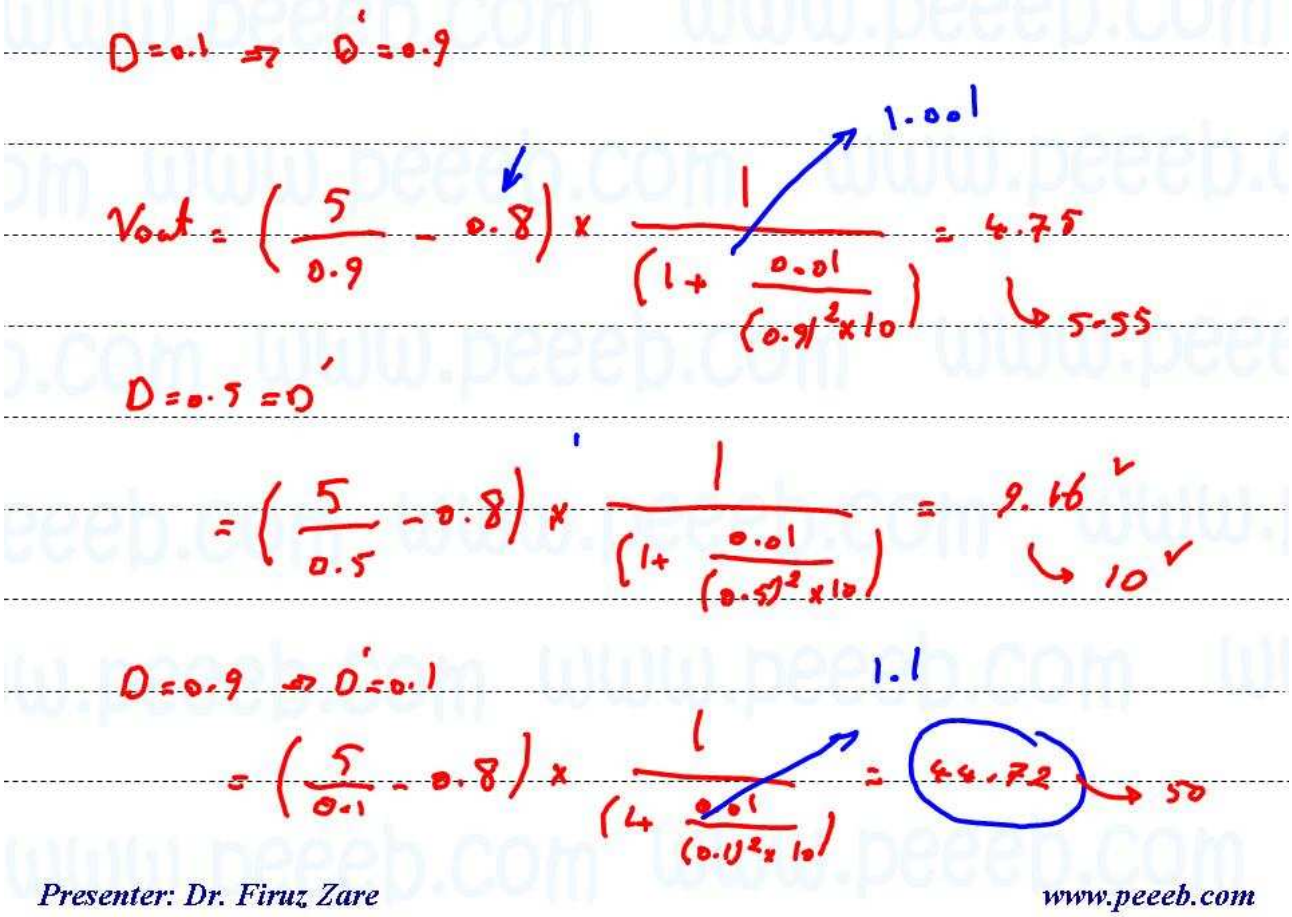
Q1: In a boost converter with V_{in}=5 V, R= 10 Ohms, R_L=0.01 Ohms and V_D=0.8 V, what are output voltages for D=[0.1, 0.5, 0.9] when the converter operates in CCM?

$$\frac{V_{out}}{V_{in}} = \frac{1}{D'K_{Boost}} - \frac{DV_S}{D'K_{Boost}V_{in}} - \frac{V_D}{K_{Boost}V_{in}} \qquad K_{Boost} = \left(1 + \left[\frac{R_{in} + R_L + (DR_S + D'R_D)}{D'^2 R}\right]\right)$$

$$V_{out} = \left(\frac{V_{in}}{D'} - V_D\right) \times \frac{1}{K_{Boost}}$$

$$K_{Boost} = \left(1 + \frac{R_L}{D'^2 \times R}\right)$$


D = 0.1 ⇒ D' = 0.9
Vout = (5/0.9 − 0.8) × 1/(1 + 0.01/(0.9)² × 10)
1.001
= 4.75
↳ 5.55
D = 0.5 = D'
= (5/0.5 − 0.8) × 1/(1 + 0.01/(0.5)² × 10)
= 9.16 ✓
↳ 10 ✓
D = 0.9 ⇒ D' = 0.1
1.1
= (5/0.1 − 0.8) × 1/(1 + 0.01/(0.1)² × 10)
= 44.72
↳ 50

Q2: What are duty cycles for a buck-boost converter to generate V_{out}=24V when 12<V_{in}<48. The converter operates in CCM and V_S=2.4V, V_D=0.8V.

$$\frac{V_{out}}{V_{in}} = \frac{D}{D'K_{Buck-Boost}} - \frac{DV_S}{D'K_{Buck-Boost}V_{in}} - \frac{V_D}{K_{Buck-Boost}V_{in}}$$

$$K_{Buck-Boost} = 1 + \frac{1}{D'^2 R}\left(D(R_{in} + R_S + R_L) + D'(R_D + R_L)\right)$$

$\simeq 1$

$$V_{out} = V_{in} \times \frac{D}{D'} - \frac{D}{D'} \times V_S - V_D$$

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$$24 = \frac{D}{1-D} \times 12 - \frac{D}{1-D} \times 2.4 - 0.8$$

$$24.8 = \frac{D}{1-D} \times 9.6 \Rightarrow D \simeq 0.72$$

$$0.352 < D < 0.72$$

$$24 = \frac{D}{1-D} \times 48 - \frac{D}{1-D} \times 2.4 - 0.8$$

$$24.8 = \frac{D}{1-D} \times 45.6 \Rightarrow D = 0.352$$