### Midterm Exam

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**Hands-‐on; spend majority of course time on lab work**

**Design-‐oriented introduction to the analysis, modeling, and testing of power electronics**

**Fabrication of the multiple switched-‐mode power converters**

**Analog and digital control systems**

**Realize a functioning, sub-‐kW electric vehicle**

**Compete to achieve best performance of EV drive train**

For more information, contact:
Prof. Daniel Costinett, daniel.costinett@utk.edu
Realize a fully functional electric vehicle drivetrain
Flyback Converter:
Buck-Boost Derived

Flyback Transformer

- A two-winding inductor
- Symbol is same as transformer, but function differs significantly from ideal transformer
  - Energy is stored in magnetizing inductance
  - Magnetizing inductance is relatively small

- Current does not simultaneously flow in primary and secondary windings
- Instantaneous winding voltages follow turns ratio
- Instantaneous (and rms) winding currents do not follow turns ratio
- Model as (small) magnetizing inductance in parallel with ideal transformer
Flyback Waveforms

$\langle v_m \rangle = \frac{V_0}{V_m} \left( 1 - \frac{V_0}{V_m} \right)$

$\langle i_c \rangle = -\frac{V_0}{R} + \frac{V_m}{R}$

$\langle i_a \rangle = 0$

$\langle i_{la} \rangle = \frac{V_m}{R}$

Flyback Equivalent Circuit Model
Flyback Reverse Recovery

\[ V_{\text{loss}} = \left( V_g + \frac{V}{n} \right) \left( I_{\text{intra}} + nQ_r \right) \]

Flyback Equivalent Circuit Model

\[
\begin{align*}
\langle i_d \rangle &= D\bar{i}_{\text{in}} + \frac{t_c I_{\text{in}}}{T_s} + \frac{nQ_r}{T_s} \\
\langle V_m \rangle &= \left( \text{the same} \right) \\
\langle i_e \rangle &= i - \frac{V}{n} + \frac{t_c I_{\text{in}}}{n} - \frac{Q_r}{T_s} - \frac{\text{tunction}}{n T_s} \\
\langle P_1 \rangle &= V_g \left( \frac{I_{\text{intra}}}{T_s} + \frac{nQ_r}{T_s} \right) \\
\langle P_2 \rangle &= V \left( \frac{Q_r}{T_s} + \frac{I_{\text{intra}}}{T_s} \right) \\
\langle P_1 + P_2 \rangle &= \frac{1}{T_s} \left( V_g + \frac{V}{n} \right) \left( nQ_r + I_{\text{intra}} \right)
\end{align*}
\]
High Step-Up Conversion Ratios

Boost Converter

Flyback, \( n=100 \)

Switch Ratings

\[ V_{\text{on}} = 100 \text{V} \]
\[ I_{\text{on}} = 100 \text{A} \]

\[ S = \text{“Switch Stress”} = V_{\text{on}} I_{\text{on}} \]
\[ S = 10 \text{kVA} \]
\[ P > 100 \text{W} \]