High Frequency Power Electronics

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ECE 581 Lecture 2
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Charge Storage
IGBT Current Tailing

Example: buck converter with IGBT

\[ P_{sw} = \int_{t_{sw}}^{t_{en}} p_{sw}(t) \, dt = (W_{on} + W_{off}) \, t \]

Fundamentals of Power Electronics

Chapter 4: Switch realization

IGBT Switching Loss: Datasheet

FIGURE 6. TURN-OFF ENERGY LOSS vs COLLECTOR-TO-EMITTER CURRENT

FIGURE 16. INDUCTIVE SWITCHING TEST CIRCUIT

C. Wibawa, "Ultra-Fast 1200 V IGBT: Reduce Switching and Conduction Losses"
Schottky Diode

<table>
<thead>
<tr>
<th>$L$</th>
<th>$C_{out}$</th>
<th>$f_s$</th>
<th>Diode</th>
<th>$\eta$ (Sim)</th>
</tr>
</thead>
<tbody>
<tr>
<td>22uH</td>
<td>22uF</td>
<td>202k</td>
<td>Si (FR)</td>
<td>93.9%</td>
</tr>
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<td>Si Schottky</td>
<td>96.9%</td>
</tr>
</tbody>
</table>

Simulation Waveforms
Switching Transition

MOSFET Stored Charge
MOSFET Cross Section

MOSFET Depletion capacitance
Device Capacitances

\[ E_{\text{in}} = \frac{1}{2} C_{\text{in}} V^2 \]

\[ E_{\text{ch}} = \frac{1}{2} C_{\text{ch}} V^2 \]

\[ C_{\text{in}} \approx C_{\text{out}} \]

\[ V \text{ is unchanged during switching transition} \]

\[ f_1(t) = 0 \quad \forall \text{on} \]

\[ f_2(t) = V \quad \forall \text{off} \]

\[ t = t_{\text{on}} \]

\[ V_{\text{on}} = V_{\text{ch}} \]

\[ V_{\text{off}} = V_{\text{in}} \]

\[ t = t_{\text{off}} \]

\[ V_{\text{off}} = V_{\text{ch}} \]

\[ t = t_{\text{on}} \]

\[ V_{\text{on}} = V_{\text{in}} \]

\[ t = t_{\text{off}} \]

\[ V_{\text{off}} = V_{\text{ch}} \]