devices of the converter. Minimization of the total silicon area required to realize the power semiconductor devices. Comparing the voltage and current stresses imposed on the active This suggests evaluating candidate converter approaches by semiconductor devices often dominate the other sources of loss. Conduction and switching losses associated with the active semiconductor devices. Largest single cost in a converter is usually the cost of the active.

6.4.1. Switch stress and switch utilization
Total active switch stress \( S \)

In a converter having \( k \) active semiconductor devices, the total active switch stress \( S \) is defined as

\[
S = \sum_{j=1}^{k} V_j I_j
\]

where

- \( V_j \) is the peak voltage applied to switch \( j \),
- \( I_j \) is the rms current applied to switch \( j \) (peak current is also sometimes used).

In a good design, the total active switch stress is minimized.
Active switch utilization is a function of converter operating point.

Active switch utilization is a quantity to be maximized.

Active switch utilization is the converter output power obtained per unit of active switch stress, which is a converter figure-of-merit, while maximizing the output power of the converter.

The active switch utilization $U$ is defined as

$$\frac{\frac{P_{\text{load}}}{d}}{} = U$$
Conduction devices:

\[ \left( D^I \right) \left( \frac{u}{L} + s^I \right) = \text{sum} \int_0^t D^I \int_0^t s^I d \Lambda = S \]

Switch stress S is

\[ \frac{D^I \cdot s^I}{\text{load}} = D^I = \text{sum} \int_0^t D^I \]

RMS value is with \( i_s \)

Transistor current coincides

\[ \frac{D^A}{s^A} = \frac{u}{A} + s^A = \text{sum} \int_0^t D^A \]

Load voltage equal to \( s^A \) plus the reflected transistor blocks voltage \( A \)

During subinterval 2, the

\[ \text{CCM flyback example: Determination of } S \]
CCM Flyback Example: Determination of $u$

\[ \frac{d^2 u}{dt^2} + \frac{u}{\Lambda} + \frac{s}{\Lambda} = 0 \]

Hence switch utilization $\Omega$ is

\[ (d^2 I) \left( \frac{u}{\Lambda} + \frac{s}{\Lambda} \right) = \int_{t_0}^{t} I^2 d\tau \]

Previously derived expression for $S$:

\[ \frac{u}{I} \Lambda \\frac{dA}{dt} = \frac{p_{load}}{1 - I} \]

Terms of $A$ and $I$:

Express load power $P_{load}$ in
For given $V, V', P_{\text{loss}}$, the designer can arbitrarily choose $D$. The turns ratio $n$ must then be chosen according to:

$$n = \frac{V'}{V} \frac{D'}{D}$$

Single operating point leads to large $D$, small $D$ leads to large transistor current.

Flyback example: switch utilization $U(D)$

![Graph showing $U(D)$ relationship]
<table>
<thead>
<tr>
<th>$i_0$</th>
<th>$i_1$</th>
<th>$\frac{2}{d+1}$</th>
<th>$\frac{2}{d}$</th>
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</thead>
<tbody>
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<td>0</td>
<td>1</td>
<td>$\frac{2}{d+1}$</td>
<td>$\frac{2}{d}$</td>
</tr>
<tr>
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<td>$\frac{2z}{d}$</td>
<td>0.353</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>$\frac{2z}{d}$</td>
<td>0.353</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>$\frac{3z}{d}$</td>
<td>0.355</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>$\infty$</td>
<td>$\frac{d}{d}$</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>$\frac{d}{d}$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Converter</th>
<th>$\max n_i$ $U_i$</th>
<th>$\max U_i$</th>
<th>$\max \frac{U_i}{d}$</th>
<th>$\max \frac{U_i}{(d)}$</th>
<th>$\max \frac{U_i}{(d)\max}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boost</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buck</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Table 6.1: Active switch utilizations of some common dc-dc converters, single operating point.

Comparison of some common converters
Transformer turns ratio can be chosen to optimize design.

\[ N \geq 0.35 \]

Buck-derived transformer-isolated converters

Transformer isolation leads to reduced switch utilization.

Close to 1

Can operate with high switch utilization (approaching ∞) when \( P \) is

Boost converter

Close to 1

Can operate with high switch utilization (approaching 1) when \( D \) is

Buck converter

Increasing the range of operating points leads to reduced switch utilization.

Switch utilization: Discussion
Isolation can be obtained without penalizing switch utilization boost.
Nonisolated converters have lower switch utilization than buck or
single-operating-point optimum occurs at \( D = \frac{1}{3} \)
\( \gamma \geq 0.385 \)
Nonisolated and isolated versions of buck-boost, SEPIC, and CUK

Discussion
Converter: $1 - $10 per KW of output power.

Typical cost of active semiconductor devices in an isolated dc-dc reliable operation. Typical derating factors are 0.5 - 0.75 (voltage derating factor) and (current derating factor) are required to obtain values are less than $1/KVA

Product of rated blocking voltage and rms current in $/KVA. Typical semiconductor device cost per rated KVA = cost of device divided by (semiconductor device cost per rated KVA)

\[
\text{Switch factor} \times \text{Converter factor} \times \text{Voltage derating factor} = \frac{\text{per KW output power}}{\text{semiconductor cost}}
\]

Active semiconductor cost vs. Switch utilization
Principle of volt-second balance: Inductance must obey all of the usual rules for inductors, including the inductance in parallel with an ideal transformer. The magnetizing transformer, the transformer can be modeled as a magnetizing transformers, and several are listed in this chapter.

1. For understanding the operation of most converters containing connection of the load. An infinite number of converters are possible, consistent with their origins. AC outputs can be obtained by differential buck and boost converters. The properties of these converters are the buck-boost and Cuk converters arise from cascade connections of the boost converter can be viewed as an inverse buck converter, while.

Summary of Key Points
Summary of Key Points
Summary of key points

5. In the conventional forward converter, the transformer is reset while the transistor is off. The transformer magnetizing inductance operates in the discontinuous conduction mode, and the maximum duty cycle is limited.

6. The flyback converter is based on the buck-boost converter. The flyback transformer is actually a two-winding inductor, which stores and transfers energy.

7. The transformer turns ratio is an extra degree-of-freedom which the designer can choose to optimize the converter design. Use of a computer spreadsheet is an effective way to determine how the choice of turns ratio affects the component voltage and current stresses.

8. Total active switch stress, and active switch utilization, are two simplified figures-of-merit which can be used to compare the various converter circuits.

Chapter 6: Converter circuits