Equivalent Circuit Model

\[
V = \left( \frac{1}{D} \right) \left( V_s - D'V_p \right) \left( \frac{D^2R}{D^2R + R_L + DR_{on} + D'RP} \right)
\]

\[
\frac{V}{V_s} = \left( \frac{1}{D} \right) \left( 1 - \frac{D'V_p}{V_s} \right) \left( \frac{1}{1 + \frac{R_L + DR_{on} + D'RP}{D^2R}} \right)
\]

LTSpice Simulation

<table>
<thead>
<tr>
<th>L</th>
<th>C_{out}</th>
<th>f_s</th>
<th>\eta (Sim)</th>
</tr>
</thead>
<tbody>
<tr>
<td>22uH</td>
<td>22uF</td>
<td>200k</td>
<td>93.9%</td>
</tr>
</tbody>
</table>
LTSpice Simulation

Switching Transition
Power Diodes

Reverse Biased Diode
Forward Biased Diode

\[ q(t) = Q_0 \left( e^{\lambda V(t)} - 1 \right) \]

Charge control equation:
\[ \frac{dq(t)}{dt} = i(t) - \frac{q(t)}{\tau_L} \]

With:
\[ \lambda = 1/(26 \text{ mV}) \text{ at } 300 \text{ K} \]
\[ \tau_L = \text{ minority carrier lifetime} \]

(above equations don’t include current that charges depletion region capacitance)

Diode Stored Charge

In equilibrium: \( dq/dt = 0 \), and hence
\[ i(t) = \frac{q(t)}{\tau_L} = \frac{Q_0}{\tau_L} \left( e^{\lambda V(t)} - 1 \right) = I_0 \left( e^{\lambda V(t)} - 1 \right) \]
**Diode Turn-On**

Depletion region, reverse-biased

**Diode Turn-Off**

Removal of stored minority charge $q$
Diode Reverse Recovery

Diode Switching Waveforms
Datasheet RR Characteristics

Paralleling Diodes

Attempts to parallel diodes, and share the current so that \( i_1 = i_2 = \frac{i}{2} \), generally don’t work.

*Reason:* thermal instability caused by temperature dependence of the diode equation.

Increased temperature leads to increased current, or reduced voltage.

One diode will hog the current.

To get the diodes to share the current, heroic measures are required:

- Select matched devices
- Package on common thermal substrate
- Build external circuitry that forces the currents to balance