SECONDARY-SIDE TOPOLOGIES FOR ISOLATED DC/DC CONVERTERS

It would seem that the Internet contains quite a bit of info on line-frequency rectifier topologies and the much, much more interesting isolated dc/dc converters are largely neglected- so please read ahead should you be interested :).

Isolated dc/dc converters come useful when either galvanic isolation is needed (for ground decoupling and/or safety standards) or the voltage conversion ratio is too high for a non-isolated topology (high voltage ratios result in excessively high power switch voltage/current requirements); practical voltage ratio limit for buck and boost converters is about 1:5. The standard topology for isolated converters is the phase-shifted bridge (shown below; H-bridge; each leg has 50% duty ratio) where the rms primary/secondary transformer voltage is proportional to the phase shift between the two half-bridges (primary transformer voltage is the red signal in the figure underneath the schematics). Transformer core is reset each cycle (magnetizing current is the green curve). All topologies shown here are buck-derived: output voltage is always lower than the input voltage divided by the transformer turns ratio (Nsecondary / Nprimary).

An H-bridge driving the primary transformer winding.
I used my Python script to make this figure.

There are four main rectifier topologies, all of which work with double-ended primary topologies (such as the phase-shifted H-bridge).

1. **Center-tapped rectifier**

   **Usage:**
   - Low output voltage/high output current rectification.
Medium power applications (kWs).

**Benefits:**
- Only one diode drop in current path.

**Disadvantages:**
- The need for two secondary windings.
- Diodes have to block the voltage seen across both secondary windings.

2. **Full-wave rectifier**

![Full-wave rectifier diagram]

**Usage:**
- High output voltage/low current rectification.
- Medium power applications (kWs).

**Benefits:**
- The most standard topology. Suitable for high output voltage applications.
- Rectifier diodes block just the secondary winding voltage (unlike in the center-tapped rectifier in which the diode has to block twice the secondary winding voltage).

**Disadvantages:**
- Two diode drops in current path.

3. **Current doubler rectifier**
Usage:
- Low output voltage/high current rectification.
- Medium power applications (kWs).

Benefits:
- Only one diode drop in current path.
- Halves the average value of rectified voltage and doubles the current with the same turns ratio as the full-wave and center-tapped rectifiers.
- The two output inductors can be designed to share the same core as the transformer.
- Both diodes have their anodes connected to the voltage node, which can greatly simplify the design of the synchronous current-doubler rectifier in which the rectifying diodes are replaced with MOSFETs to reduce conduction losses.

Disadvantages:
- The need for two inductors - each carries full output current.

4. Half-wave rectifier
Usage:

- Can be used in circuits with single-ended primary circuits (allow current only for one transformer voltage polarity).
- The winding magnetizing current must be reset by an external mechanism in such circuits.
- Generally low/medium-power applications (up to 1 kW).

Benefits:

- One diode drop only.
- Direct converters generally have higher power conversion efficiency than indirect converters (such as flyback). All four rectifier topologies are direct converters.

Disadvantages:

- In case of single-ended primary circuits: The magnetizing current must be reset by an additional mechanism (such as the use of a third winding).
- Does not optimally utilize the transformer (uses only one polarity).

The table below lists some basic properties of the four rectifiers (n = N_primary / N_secondary, d = phase shift [0% to 100%]):

<table>
<thead>
<tr>
<th></th>
<th>Center-tapped rectifier</th>
<th>Full-wave rectifier</th>
<th>Current doubler rectifier</th>
<th>Half-wave rectifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output voltage</td>
<td>Vin / n * d</td>
<td>Vin / n * d</td>
<td>Vin / n * d / 2</td>
<td>Vin / n * d / 2</td>
</tr>
<tr>
<td>Effective ripple current frequency</td>
<td>Fs * 2</td>
<td>Fs * 2</td>
<td>Fs * 2</td>
<td>Fs</td>
</tr>
<tr>
<td>Peak diode blocking voltage</td>
<td>2 * Vin / n</td>
<td>Vin / n</td>
<td>Vin / n</td>
<td>Vin / n</td>
</tr>
</tbody>
</table>