Introduction to Isolated Topologies

TI Literature Number: SLUP357
© 2016, 2017 Texas Instruments Incorporated

Power Seminar topics and online power training modules are available at:ti.com/psds
Introduction to Isolated Topologies

Chris Sarli, Power Design Services Engineer
Agenda

• What is isolation and Why do we use it?
• Identifying types of Isolation
• Isolated Topologies
What is Isolation?

Types of Isolation
• Inductive Isolation
• Capacitive Isolation
• Optical Isolation
Identify the types of Isolation
Topologies Typical Operating Ranges

• Flyback: <100W
• Flybuck: <10W
• Forward: 100W to 250W
• Half Bridge: 250W to 500W
• Full Bridge: 400W to 1 kW+
Flyback Converter

Recommended for less than 100W output

- 3 Components = Low Cost
- Stores Energy during ON
- Delivers Energy during OFF
Flyback Converter

Recommended for less than 100W output

Transformer acts as a Load, Storing Energy
Flyback Converter

Recommended for less than 100W output

Transformer acts as a Source, Delivering Energy
Fly-Buck Converter

Recommended for less than 10W output
Fly-Buck Converter

Recommended for less than 10W output
Forward Converter

Recommended for between 100W and 250W output

- Secondary resembles Buck
- 6 Components (single switch)
- Delivers power during ON and OFF
Forward Converter

Recommended for between 100W and 250W output
Forward Converter

Recommended for between 100W and 250W output

Texas Instruments - 2016/17 Power Supply Design Seminar
Forward Converter

Recommended for between 100W and 250W output
## Forward Converter

<table>
<thead>
<tr>
<th></th>
<th>1-Switch</th>
<th>2-Switch</th>
<th>Active Clamp</th>
</tr>
</thead>
<tbody>
<tr>
<td># of FETs</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>FET Voltage</td>
<td>$2 \times V_{IN}$</td>
<td>$V_{IN}$</td>
<td>$V_{IN} / (1-D)$</td>
</tr>
<tr>
<td>Q2 Current</td>
<td>N/A</td>
<td>$I_{PRIMARY}$</td>
<td>$I_{MAGNETIZING}$</td>
</tr>
<tr>
<td>Snubber</td>
<td>Y</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>50% Duty Limit</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
</tr>
</tbody>
</table>

![1-Switch Diagram](image1)

![2-Switch Diagram](image2)

![Active Clamp Diagram](image3)
Half-Bridge

Recommended for between 250W and 500W output

- 6 Components + Cap Div
- Double ended (symmetric)
- 4 Switching states
Half-Bridge

Recommended for between 250W and 500W output
Half-Bridge

Recommended for between 250W and 500W output
Half-Bridge

Recommended for between 250W and 500W output
Half-Bridge

Recommended for between 250W and 500W output
Half-Bridge LLC

Recommended for between 250W and 500W output

Resonant Inverter
Switch network
Resonant tank circuit
Rectifier

Resonant Converter

Vin_{dc} →

V_{out_{dc}} ↑
**Half-Bridge LLC**

Recommended for between 250W and 500W output

- Primary current = sine wave plus magnetizing current
- Secondary = sine wave
- Switching frequency = \( L_r C_r \) resonant
Half-Bridge LLC

Recommended for between 250W and 500W output

Source

Complex, but yields excellent Efficiency

Texas Instruments - 2016/17 Power Supply Design Seminar
Full-Bridge

Recommended for 400W to 1kW+ output

- 8 Components
- Double ended (symmetric)
- 4 Switching states
- Q1/Q3 gate drives tied
- Q2/Q4 gate drives tied
Full-Bridge

Recommended for 400W to 1kW+ output
Full-Bridge

Recommended for 400W to 1kW+ output
Full-Bridge

Recommended for 400W to 1kW+ output
Full-Bridge

Recommended for 400W to 1kW+ output
# Topologies Summary

<table>
<thead>
<tr>
<th>Topology</th>
<th>Power Level</th>
<th>Benefits</th>
<th>Drawbacks</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flybuck</td>
<td>&lt;10 W</td>
<td>Simple to design</td>
<td>Lower Accuracy regulation</td>
<td>Lowest</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Small form factor</td>
<td>Duty Cycle limited to &lt;50% to maintain decent regulation</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No optocoupler FB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flyback</td>
<td>&lt;100 W</td>
<td>Low parts count</td>
<td>Poor efficiency at high power levels</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Single magnetic</td>
<td>High peak currents</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wide input-voltage range</td>
<td>Cross regulation problems</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low output power</td>
<td>High-voltage power switch</td>
<td></td>
</tr>
<tr>
<td>1 Switch</td>
<td>100 W to 250 W</td>
<td>Medium output power</td>
<td>Limited input range</td>
<td>Moderate</td>
</tr>
<tr>
<td>Forward</td>
<td></td>
<td>Good cross regulation with coupled inductor</td>
<td>Power switch = 2 ( V_{\text{IN}} )</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Potential for &gt;50% duty-cycle</td>
<td>Transformer reset</td>
<td></td>
</tr>
</tbody>
</table>
## Topologies Summary

<table>
<thead>
<tr>
<th>Topology</th>
<th>Power Level</th>
<th>Benefits</th>
<th>Drawbacks</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Half-Bridge</td>
<td>250 W to 500 W</td>
<td>- Medium output power&lt;br&gt;  - Power switch = $V_{IN}$&lt;br&gt;  - Coupled inductor&lt;br&gt;  - Max duty-cycle &lt; 100%</td>
<td>- Limited input range&lt;br&gt;  - High-side drive&lt;br&gt;  - Volt-second balance of transformer&lt;br&gt;  - Center-tapped secondary</td>
<td>Moderate to High</td>
</tr>
<tr>
<td>Full Bridge</td>
<td>&gt;400 W</td>
<td>- Resonant switching can improve efficiency&lt;br&gt;  - Power switch = $V_{IN}$&lt;br&gt;  - Coupled inductor&lt;br&gt;  - Very high output power&lt;br&gt;  - Max duty-cycle &lt; 100%&lt;br&gt;  - Efficient transformer design</td>
<td>- 4-power switches&lt;br&gt;  - Top FET drive&lt;br&gt;  - Volt-second balance</td>
<td>High</td>
</tr>
</tbody>
</table>

**Moral of the Story:**
The more components that you have to share the load,<br>The more power your converter can provide.
Topology Design Aides

Power Supply Topologies Chart

Power Stage Designer
IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as “components”) are sold subject to TI’s terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI’s terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers’ products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers’ products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI’s goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or “enhanced plastic” are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have not been so designated is solely at the Buyer’s risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

### Products

- **Audio**
  - www.ti.com/audio
- **Amplifiers**
  - amplifier.ti.com
- **Data Converters**
  - dataconverter.ti.com
- **DLP® Products**
  - www.dlp.com
- **DSP**
  - dsp.ti.com
- **Clocks and Timers**
  - www.ti.com/clocks
- **Interface**
  - interface.ti.com
- **Logic**
  - logic.ti.com
- **Power Mgmt**
  - power.ti.com
- **Microcontrollers**
  - microcontroller.ti.com
- **RFID**
  - www.ti-rfid.com
- **OMAP Applications Processors**
  - www.ti.com/omap
- **Wireless Connectivity**
  - www.ti.com/wirelessconnectivity

### Applications

- **Automotive and Transportation**
  - www.ti.com/automotive
- **Communications and Telecom**
  - www.ti.com/communications
- **Computers and Peripherals**
  - www.ti.com/computers
- **Consumer Electronics**
  - www.ti.com/consumer-apps
- **Energy and Lighting**
  - www.ti.com/energy
- **Industrial**
  - www.ti.com/industrial
- **Medical**
  - www.ti.com/medical
- **Security**
  - www.ti.com/security
- **Space, Avionics and Defense**
  - www.ti.com/space-avionics-defense
- **Video and Imaging**
  - www.ti.com/video

**Mailing Address:** Texas Instruments, Post Office Box 655303, Dallas, Texas 75265

**Copyright © 2016, Texas Instruments Incorporated**