Isolated DC/DC Converters.

These notes should be read in conjunction with the application note: “Switching Power Supply Topology Review” by Lloyd Dixon of Texas Instruments which provides a very good overview of the main dc/dc converter variants.

All of the basic dc/dc converters have isolated variants in which a transformer is added.

Reasons for transformer isolation:

1. Safety – To ensure there is no direct connection between a hazardous input voltage and a low voltage output.

2. Voltage step up / step down. Operation at extreme duty cycles can be inefficient – using a transformer to provide the voltage step up / down rather than the duty cycle allows for operation at a more efficient point. In any case ratios of more than 20:1 are hard to achieve without a transformer.

3. Incompatible Grounds – In some applications it is not feasible to use the same ground for different parts of a circuit in such cases isolated power supplies are required to separate the ground rails.

Commercial applications of Isolated and non-isolated DC/DC converters:

Non-Isolated Converters:
Buck Converters are commonly non-isolated converters – often used to step down from a 24V or 48V rail (typical telecom voltages) to 5V or 12V etc. Typically both input and output voltages are low so no isolation is required. Small buck converters (called voltage regulator modules or VRMs) are often used to generate a low voltage at the point of use – for example on a PC motherboard a VRM is used to generate the 1.5V supply for the microprocessor.

A major difficulty with Boost converters is that there is a direct path from input to output via the diode so it is impossible to implement intelligent current limiting. For this reason many boost converters are used as pre-regulators to provide a stable high voltage DC rail from which another regulator (with current limiting) will provide the desired output voltage. A very important use of boost converters in power factor correcting pre-regulators for AC-DC converters. This is possible because the positions of switch and inductor in a boost converter allow direct control over the input current.

Non-Isolated Flyback converters are rarely used. One disadvantage is the negative output voltage. Another is the fact that diode and switch both see high peak voltage (Vin+Vout) and high peak currents. In addition the inductor current is high being the sum of Iin+Iout. All of this means that the non-isolated flyback is expensive and even if a negative output voltage is required it is usually cheaper to use an isolated converter.
**Isolated Converters**

The flyback converter comes into its own in isolated form. The position of the inductor between input and output makes it the easiest converter to add a transformer to. At low power levels this makes up for the disadvantage of high peak voltages and currents. In discontinuous mode operation the transformer coupled flyback is easy to control and can supply multiple outputs from the same transformer. It is the most common topology for isolated dc/dc applications of up to 200W.

At power levels above 200W the high peak currents and voltages make the flyback design expensive so some form of continuous mode buck derived topology is preferable. The forward converter is simple and can be used from 200W to 1kW. It has the disadvantage that duty cycle is limited to 50% resulting in poor transformer utilisation. At power levels above 1kW continuous mode half bridge or full bridge configurations allow better utilisation of the transformer.
Developing an Isolated Flyback Topology:

Step 1:

Step 2:

Step 3:

Notes:
- Switch moved to ground rail
- L1 incorporated into Traffo Magnetising Inductance
- Traffo secondary and diode rearranged for positive output voltage
Question

A transformer coupled flyback power supply is used to generate a 24V output from a 230V ac supply. Maximum output current is 5Amps. The converter is to be operated in discontinuous mode. A switching frequency of 40kHz has been selected and the duty cycle is to be limited to ensure discontinuous operation. You may assume that the mosfet and the diodes are ideal and have no voltage drop when conducting.

1. Vds of the Mosfet is to be kept below 400V. Calculate the transformer turns ratio required.

2. Calculate the inductance required and the peak mosfet current.

3. Sketch the following waveforms for full load operation: Mosfet Voltage and Current, Output Diode Voltage and Current.