Application Brief

How to Approach a Power-Supply Design – Part 2

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The first installment of this series, *How to Approach a Power-Supply Design – Part 1*, describes how important it is to have a good specification for properly designing a power supply. This application brief outlines which parameters of a specification (see Figure 1) influence the decision for certain topologies.

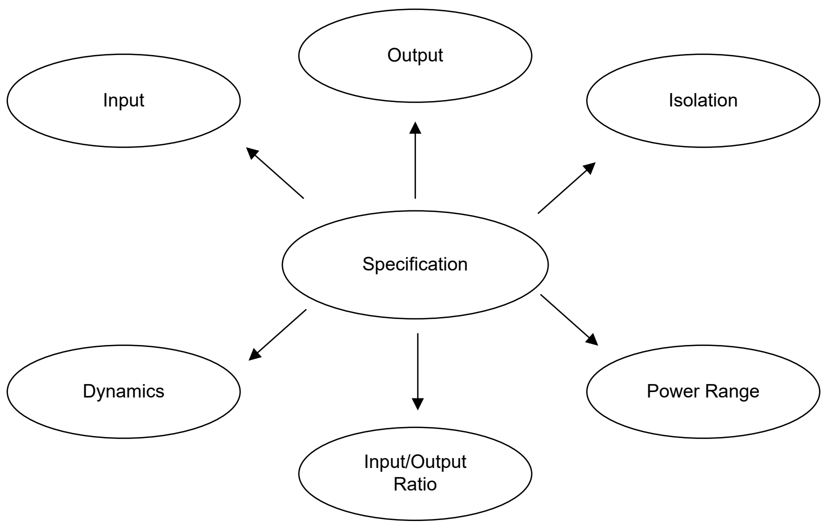

Figure 1. Parameters of a Specification Which Can Influence the Decision of a Certain Topology

When an application does not require an isolation barrier between the input and the output, the ratio between V_{IN} and V_{OUT}, the ripple requirements for input and output voltage, and the maximum output power usually determine which topology to choose. Buck, boost, buck-boost, single-ended primary inductance converter (SEPIC), and Zeta are the most common non-isolated power-supply topologies for power ranges up to 250 W. The buck converter steps down the input voltage and the boost converter steps the input voltage up. Buck-boost, SEPIC, and Zeta can have an input voltage that is equal to, smaller, or greater than their output voltage. If the input voltage in a design has a different sign compared to the output voltage, choose the inverting buck-boost or Ćuk converter. For both topologies, the absolute value of the input voltage can be equal to, smaller, or greater than the absolute value of the output voltage.

Table 1 lists the relationship between input voltage and output voltage and the typical power range for the non-isolated topologies mentioned. If the application needs more than the output power limit shown in Table 1, it can make sense to parallel two or more interleaved converter stages or use an isolated topology (see Table 2), because these are already intended for greater power levels.

Table 1. Overview of Non-Isolated Topologies

Topology	Relationship Between Input and Output Voltage	Typical Output Power Limit
Buck	$V_{IN} \geq V_{OUT}$	100 W
Boost	$V_{IN} \leq V_{OUT}$	100 W
Buck-boost	$V_{IN} \leq V_{OUT}$ and $V_{IN} \geq V_{OUT}$	100 W (two switches), 250 W (four switches)
SEPIC	$V_{IN} \leq V_{OUT}$ and $V_{IN} \geq V_{OUT}$	50 W
Zeta	$V_{IN} \leq V_{OUT}$ and $V_{IN} \geq V_{OUT}$	50 W
Inverting buck-boost	$\lvert V_{IN}\rvert \leq \lvert V_{OUT}\rvert$ and $\lvert V_{IN}\rvert \geq \lvert V_{OUT}\rvert$	100 W
Ćuk	$\lvert V_{IN}\rvert \leq \lvert V_{OUT}\rvert$ and $\lvert V_{IN}\rvert \geq \lvert V_{OUT}\rvert$	50 W

Isolated topologies can step their input voltage up or down. The output voltage can be positive or negative. By adding extra transformer windings, it is also possible to generate more than just a single output voltage. Flyback, forward, push-pull, half-bridge, and full-bridge converters are the most common isolated topologies. The most common way to minimize losses for these topologies is to have the converters operate in a resonant or quasi-resonant mode. Resonant converters take advantage of zero voltage switching (ZVS) or zero current switching (ZCS). Examples are quasi-resonant flyback, active clamp flyback or forward, inductor-inductor-converter (LLC) half-bridge, and full-bridge, and phase-shifted full-bridge. Table 2 shows the power ranges for different isolated topologies.

Table 2. Overview of Isolated Topologies

Topology	Relationship Between Input and Output Voltage	Typical Output Power Limit
Fly-buck	$V_{IN} \geq V_{OUT,\ pri,}$	10 W
Flyback	$V_{IN} \leq \lvert V_{OUT}\rvert$ and $V_{IN} \geq \lvert V_{OUT}\rvert$	150 W
Forward	$V_{IN} \leq \lvert V_{OUT}\rvert$ and $V_{IN} \geq \lvert V_{OUT}\rvert$	250 W
Push-pull	$V_{IN} \leq \lvert V_{OUT}\rvert$ and $V_{IN} \geq \lvert V_{OUT}\rvert$	500 W
Half bridge	$V_{IN} \leq \lvert V_{OUT}\rvert$ and $V_{IN} \geq \lvert V_{OUT}\rvert$	500 W
Full bridge	$V_{IN} \leq \lvert V_{OUT}\rvert$ and $V_{IN} \geq \lvert V_{OUT}\rvert$	> 500 W

If very thorough load transients can occur at the output of the converter, it is important to know that good dynamic behavior is not possible with a flyback topology operating in continuous conduction mode. This is because the right half plane zero (RHPZ) in the transfer function of the converter typically limits the bandwidth to frequencies below 5 kHz for this type of converter. The bandwidth of the opto-isolator, which is usually necessary for the output voltage feedback path of isolated topologies, can be another drawback for transient response behavior. If the power supply really needs very good transient response behavior, but you have to use a different topology than a buck converter, a two-stage approach can be the best option. Another option is placing the controller on the secondary side of the power supply.

The buck, boost, SEPIC, and flyback topologies can be used as power factor correction (PFC) circuits. The most common choice is PFC boost.

Part 3 of this series, covers buck, boost, and buck-boost converters.

Additional Resources

- Design your power stage with Power Stage Designer.
- Download the *Power Topologies Handbook* and *Power Topologies Quick Reference Guide*.