

Power Tips: Trade-offs in Designing a Universal AC Input Power Supply



Robert Taylor



The alternating current (AC) line voltage around the world varies in terms of voltage and frequency. The U.S. and Japan supply voltages are around 100V, while Europe and China use ~220V. The frequency across the world also varies from ~50 to 60Hz.

Having a device that works all over the world is pretty convenient. Many devices take advantage of this concept, such as mobile phone chargers and laptop supplies. However, when was the last time you took a big-screen TV on a flight with you from the U.S. to Europe? In that case, it does not make much sense. Larger items that require high power and do not need to travel from zone to zone can take advantage of having a power supply that is specifically designed for the input voltage range.

There are a number of factors to consider which involve the AC input range when designing a power supply:

- Size.
- Cost.
- Performance.
- Regional regulatory markings.

- Electromagnetic interference (EMI).
- Power factor correction (PFC).

A supply designed to operate over the universal AC input range (85-265V) will be more expensive, larger and less efficient than one designed to operate over a certain range (high line or low line). It is also costly for the product to pass the regulatory checks in each region where it will be sold. If the device is only going to be used in Europe, why spend the extra money to qualify it in China? There are also some regions which require special qualifications, such as power factor correction, that other regions don't. Adding a PFC circuit to a product that only gets used in the U.S. can be a large, unnecessary expense.

As an example of power supply configurations, let's consider a 250W audio amplifier for a home theater. [Table 1](#) lists some of the trade-offs of the power supply configurations.

Table 1. Power Supply Parameters for a 250W Design

250W supply configuration	Input capacitor value (μF)	Input capacitor voltage (V)	MOSFET voltage (V)	MOSFET $R_{\text{ds(ON)}}$ ($\text{m}\Omega$)	Relative cost
Universal input	330	400	650	150	3x
Low line	330	200	450	150	1x
High line	150	400	650	600	1.5x
Voltage switch	330 x 2	200	650	600	1.7x

[Table 1](#) takes into account the differences between the configurations. The most important result is in the relative cost. There could be up to a 3x price difference for a universal line configuration. In addition to the cost, there will also be differences in performance, size and complexity.

In some cases it really makes sense to use a universal input, but in many cases you can realize great benefits by using separate supplies.

Additional Resources

- Explore more [power-supply topics](#).
- Find a Power Tips [video](#) to help with your next design challenge.

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#) or other applicable terms available either on [ti.com](https://www.ti.com) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2023, Texas Instruments Incorporated