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## POWER SOURCES

### SIMPLE RULES FOR PCB MOUNTING OF DC TO DC CONVERTERS

By Robert Marcetti

Modular DC-DC converter components offer power system designers many advantages such as small size, ease of design, high power density, and high efficiency. But all of these advantages can be nullified by improper management of EMI, careless placement and mounting of components, casual running of leads, inappropriate use of ground planes, or unsuitable grounding techniques. Each application has its own transient, noise, and thermal environments that can pose problems requiring detailed analysis and design attention.

The power architect who observes the simple rules cited, however, will avoid most of the problems caused by noise and heat and will have a safer and more reliable power system.

**Rule 1 — Control transients and noise:** Many environments are susceptible to power-line transients, such as those caused by motors, generators, fluorescent lighting, elevators, and lightning. It is important that the transient input voltage rating of the converter not be exceeded. Input attenuator modules or surge suppressors, in combination with appropriate filtering, should be used in off-line applications or in applications where source transients may be induced by load changes, blown fuses, or any other temporary over-voltage condition. The surge suppressor should be between the converter and the fuse so a sustained over-voltage condition will open the fuse.

**Conducted noise —** Conducted noise is the AC current flowing between the source voltage and the

power supply, and it includes both common mode and normal mode noise.

Common-mode noise is a function of the  $dv/dt$  across the main switch in the converter and the effective input-to-baseplate capacitance and input-to-output capacitance of the converter. This current circulates from the converter via the power input leads to the DC source and returns via the grounded baseplate or output lead connections. As a result, a potentially large loop area is created which, if not controlled, can generate magnetic fields. The most effective means to reduce common-mode current is to bypass both input leads to the baseplate with 'Y' capacitors (C2, C3 in Figure 1), keeping the leads as short as possible to reduce parasitic inductance. If it is necessary to meet the requirements of FCC/VDE A or B, a common-mode choke (L1) is commonly used.

Normal mode conducted noise (sometimes called differential-mode noise) is produced

by currents, at the input power terminals, which are opposite in direction or phase with respect to each other. Some converters have an internal normal mode LC filter which, in conjunction with a small external capacitor, reduces normal mode conducted noise. The external capacitor should be placed close to the module to reduce cross-sectional area. The loop cross-sectional area of normal (differential) mode current flowing between the source and C1 should also be kept as small as possible. Since differential mode input currents are by definition opposite in phase, twisting the input leads not only minimizes the area, it also cancels the noise.

**Rule 2: Observe good mechanical practices. Board layout —** The components should be arranged on the PC board to help achieve noise and thermal management objectives. Don't, for example, compromise thermal management by placing components that block the flow of air over the converter.

Place components to minimize trace lengths, keep bypass capacitors as close to the converters as possible, and avoid lead crossovers. These steps will prevent both EMI and thermal problems.

**Converter mounting —** Mounting the converter to the PC board should be done using module standoffs at manufacturer —recommended locations. This will provide a low-impedance electrical connection between the baseplate and earth ground and alleviate potential stress on the converter pins.

**Conductor spacing and widths —** To minimize IR drops, conductors should be as short as possible, and the widths and thicknesses of conductors

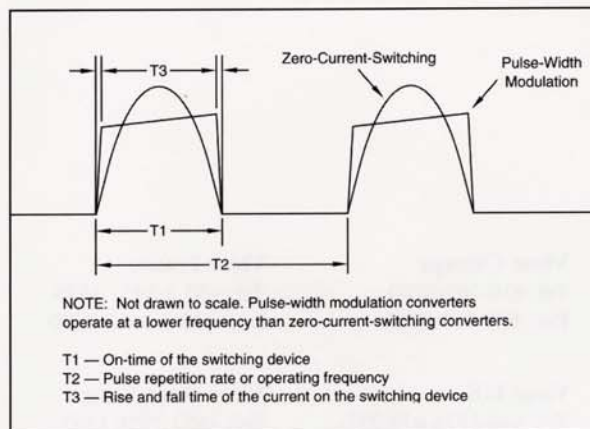


Figure 1. Current waveforms produced by zero-current switching and pulse-width modulation.

need to be appropriately sized for the currents to be encountered. Charts, such as those provided in MIL-STD-275C, provide baseline recommendations for current-carrying capacity and sizes of etched copper and conductors for various temperature rises above ambient.

**Rule 3: Manage thermal considerations.** The first step toward effective thermal management of a power system is to select a converter with the highest efficiency you can find that meets all design criteria.

There are three methods of heat removal: **Radiation** — Unlikely to be a dominant heat transfer mechanism, radiation is usually neglected. When hotter components are present near the converter, however, a barrier such as sheet metal should be erected between them to minimize its effect.

**Conduction** — The converter should be connected to a heat-conducting member

such as a metal chassis or a heat sink with fins. Ensure that the interface between the converter baseplate and the heat-conducting member is flat and clean. Use a thermal compound or pad between the converter baseplate and the heat-conducting member. Tighten the connection with the manufacturer's recommended torque and torquing procedure.

**Convection** — Free convection from a dissipative surface such as a heat sink requires the selection and connection (see previous paragraph) of a suitable heatsink. Forced convection requires the selection of a heatsink/fan combination. While it's not possible on this article to cover thermal management in detail, manufacturers of converters provide thermal design curves for their products.

**Rule 4: Heed safety standards. Shock** — Good grounding is essential to safety. In fact,

agency compliance requires that the baseplate be grounded or made inaccessible. The purpose of the ground, however, is to provide an unambiguous lowest impedance return path for current. Proper grounding is necessary to control EMI and ensure stable operation of the power converter.

**Fusing** — A fuse, usually rated at a manufacturer-recommended percentage of worst-case input current should be inserted in the (+) input lead of a DC-DC converter. This will protect the converter and the rest of the printed circuit board from overcurrent damage and satisfy safety agency requirements with respect to overcurrent protection.

Most module suppliers offer applications engineering support to help with designs.

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