Paralleling power modules for high-current applications

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Introduction

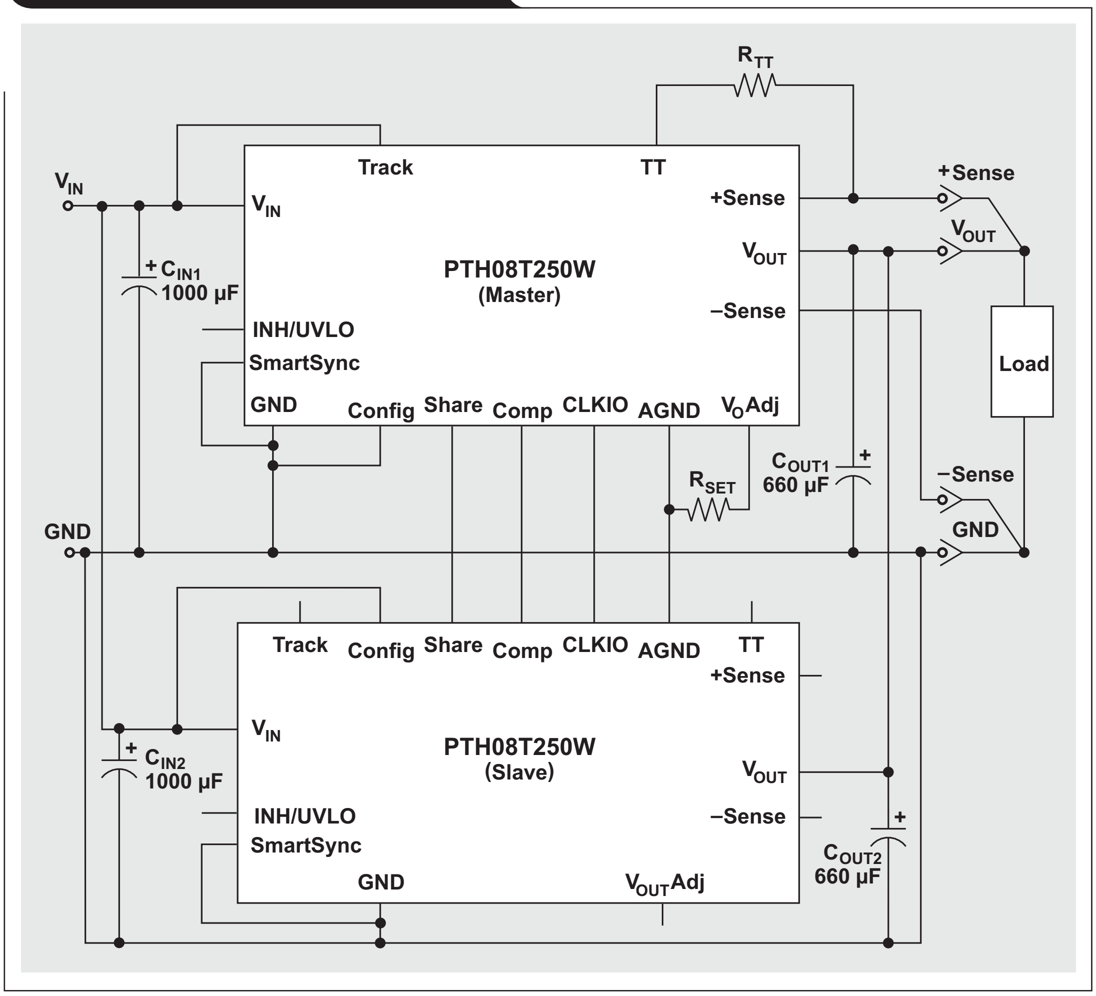
Powering servers and memory cards requires the generation of low supply voltages at very high DC currents approaching 100 A or more. In addition to the high-current-supply requirements, dynamic load requirements are extremely demanding. The load may quickly go from an inactive low-current state to a fully processing high-current state while requiring precise voltage regulation.

Paralleling power modules

A stand-alone, dual-phase power module like the Texas Instruments (TI) PTH08T250W can supply up to 50 A of output load current. However, the PTH08T250W incorporates TI's TPS40140 stackable-controller feature that allows the outputs of multiple modules to be connected in parallel, thereby producing a reliable solution capable of supplying a load current of 100 A or more.

Configuring a PTH08T250W as a master and each additional module as a slave allows start-up and transient conditions to be controlled by a single module. Figure 1 shows a typical two-module solution where all of the features and inputs are controlled by the master device while the slave inputs are left open.

Figure 1. Typical two-module solution



Considerations for paralleling PTH08T250W modules

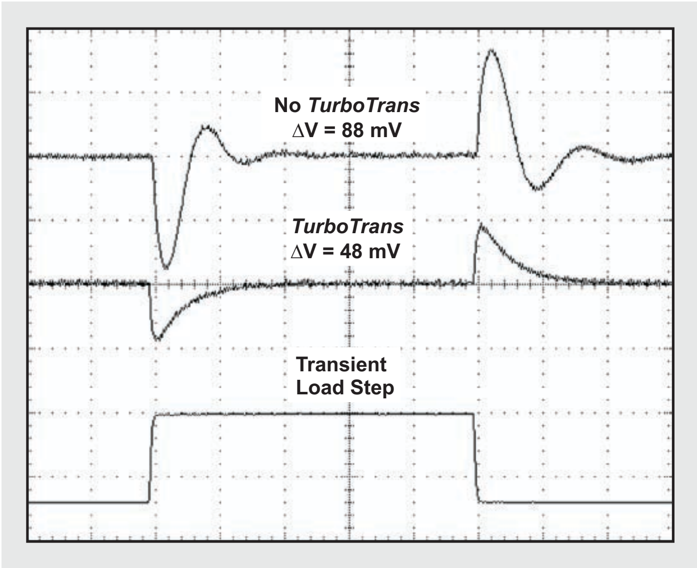
Input and output capacitors

When multiple PTH08T250W modules are paralleled, the amount of capacitance must be enough to filter the input and output and meet the transient requirements of the high-current application. The amount of capacitance must be calculated for a single module and then multiplied by the number of parallel modules.

Each device requires a 16-V, 1000-µF, OS-CON capacitor along with three to four 16-V, 22-µF, X5R ceramic capacitors directly at the input pins of the module. The ceramic capacitors are required to reduce any ripple and switching noise across the input bus.

The required output capacitance must be determined by the transient requirement of the application. The maximum current step required by the load must be divided by the number of modules being paralleled. The *TurboTrans*™ graphs in the datasheet should then be used to determine the amount of output capacitance per module. High-quality, low-ESR polymer-tantalum or OS-CON output capacitors are required for this application. A list of approved capacitors is included in the PTH08T250W datasheet.

Figure 2. Transient response to load step with and without *TurboTrans*



TurboTrans technology

The PTH08T250W power module features *TurboTrans* technology, which allows a power-supply designer to adjust the module to meet a specific transient-load requirement. The *TurboTrans* feature is set only on the master module with a single resistor, R_{TT}. The result is a high-current application with faster transient response, increased stability, and less output capacitance to meet tight requirements for output-voltage deviation. The benefits of *TurboTrans* are shown in Figure 2. The transient response to a load step is shown with and without the *TurboTrans* feature.

Parallel connections

When multiple modules are operated in parallel, the control of each device feature is set only on the master device. A device is configured as a master by connecting the Config pin to the power GND. All slave devices must connect the Config pin to V_{IN}. The slave devices must leave all other control pins open (connect the SmartSync pin to the GND). See Table 1 for pin connections of the master and slave modules.

Table 1. Master and slave pin connections

PIN NAME	MASTER	SLAVE
V_{IN}	Connect to the input bus.	Connect to the input bus.
V_{OUT}	Connect to the output bus.	Connect to the output bus.
GND	Connect to the common power GND.	Connect to the common power GND.
INH/UVLO	Use for inhibit control and UVLO adjustment. If unused, leave open-circuit.	No connection. Leave open-circuit.
V_{OUT} Adjust	Use to set the output voltage. Connect R_{SET} resistor between this pin and AGND.	No connection. Leave open-circuit.
+Sense	Connect to the output voltage either at the load or at the module.	No connection. Leave open-circuit.
–Sense	Connect to the output GND either at the load or at the module.	No connection. Leave open-circuit.
Track	Connect to Track control. If unused, connect to V_{IN}.	No connection. Leave open-circuit.
TurboTrans	Connect *TurboTrans* resistor, R_{TT}, between this pin and +Sense pin.	No connection. Leave open-circuit.
SmartSync	Connect to an external clock. If unused, connect to GND.	Connect to the common power GND.
Config	Connect to the common power GND.	Connect to the input bus.
Share	Connect to pin 2 of the slave.	Connect to pin 2 of the master.
Comp	Connect to pin 3 of the slave.	Connect to pin 3 of the master.
AGND	Connect to pin 4 of the slave.	Connect to pin 4 of the master.
CLKIO	Connect to pin 5 of the slave.	Connect to pin 5 of the master.

Board layout

Special attention must be paid to the board layout for a parallel application. The amount of board space, the number of layers, and the amount of copper will determine the amount of current each solution can deliver. A careful layout is required to keep the interconnection pins as clean as possible.

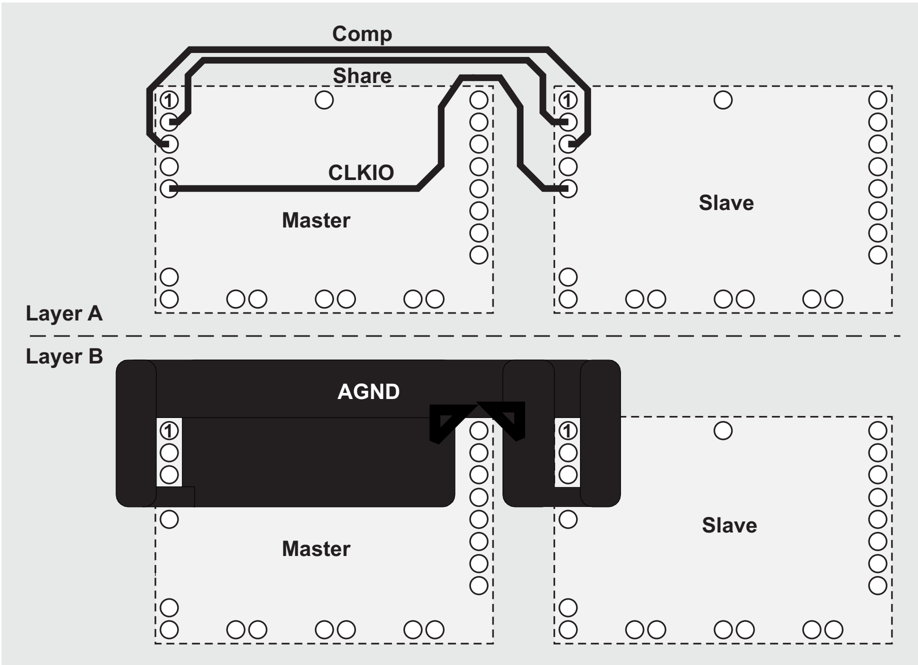
The power planes, V_{IN}, V_{OUT}, and GND, must be routed to the power pins in a tight, short, and wide path. Keeping the V_{IN} plane from running above or below the V_{OUT} plane wherever possible will help reduce overall switching noise. Keeping a short and tight path from the output of each module to the load is required to minimize losses.

The +Sense and –Sense connections must be routed to the load in a direct path, closely coupled with one another. The layout around these traces should be isolated as much as possible to avoid picking up switching noise. Additionally, connecting the ±Sense lines through a surface-mount resistor to the load allows a 1- to 2-Ω resistor to be placed in the sense path to aid in filtering.

The three interconnection traces (Share, Comp, and CLKIO) must be isolated from the rest of the board to keep switching noise from aggravating the signals to the slave modules. The AGND should act as a shield and be run on an adjacent layer to the other three traces. Care must be taken in routing the CLKIO trace to keep it slightly away from the Comp trace to reduce the chance of the clock pulses disturbing the Comp signal. See Figure 3 for an example layout of the interconnection pins. The three interconnection traces are routed on one layer, and the AGND is routed as a copper area that shields the three traces on an adjacent layer.

When multiple modules are operated in parallel, an eight-layer layout with 2-oz. copper is recommended to improve thermal conduction. Increased copper thickness is required to distribute the higher current over the power planes. Increased airflow is also strongly recommended to help the copper remove the heat associated with the higher-power solution.

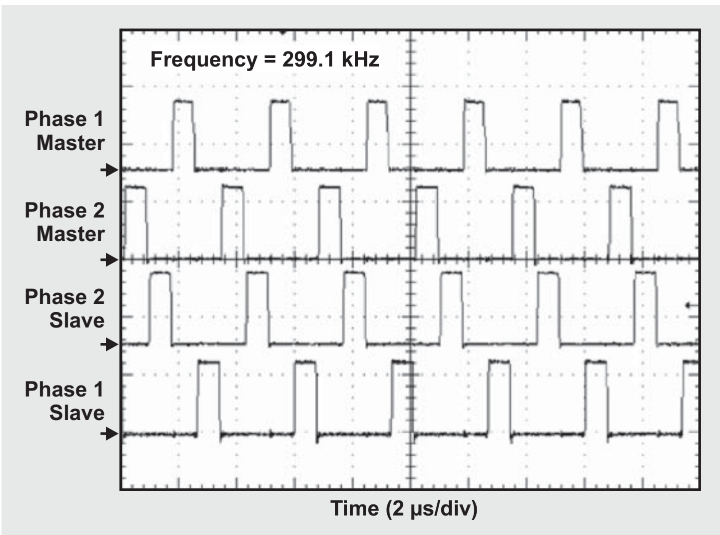
Figure 3. Example board layout of interconnection pins



Four-phase operation

When operated in parallel, the slave modules are synchronized to the frequency of the master. Each PTH08T250W is a two-phase device; each phase operates 180º out of phase. Placing two modules in parallel results in a four-phase operation by shifting the slave-module phases by 90º (see Figure 4). However, driving the master with an external frequency via SmartSync eliminates the 90º phase shift.

Figure 4. Four-phase operation



Four-phase operation results in a reduction of input and output voltage ripple. Each phase draws current from the input source out of phase, minimizing source loading. Four-phase operation also adds to the already exceptional transient response of the module, responding more quickly and delivering current more evenly to the load.

When multiple PTH08T250W modules operate in parallel, all slave modules operate in phase with one another, 90º out of phase with the master. Once again, driving the master with an external frequency eliminates the 90º phase shift.

PTH08T250W features

The PTH08T250W operates over a wide 4.5- to 14-V input-voltage range and generates a positive output voltage of 0.7 to 3.6 V. Additionally, the PTH08T2xxW family of power modules is designed to meet a very tight 1.5% DC tolerance, deliver exceptional transient response, and have the ability to synchronize to an external frequency.

This article also applies to the PTH08T255W, a spin-off of the PTH08T250W designed to produce a 5-V, 40-A output. The PTH08T255W operates over an 8- to 14-V input-voltage range, and the output voltage can be set from 3.0 to 5.25 V.

Related Web sites

power.ti.com
www.ti.com/sc/device/PTH08T250W
www.ti.com/sc/device/PTH08T255W

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

TI Worldwide Technical Support

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