Power management for processor core voltage requirements

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Introduction

Today's high-performance processors have very stringent power requirements. Typically, the power requirements consist of at least two supply voltage requirements. One voltage requirement is for the processor core voltage, V_{CORE}, while the others are input-output voltage requirements, V_{IO}.

The core-voltage requirement ranges from 0.9 to 1.3 V and is usually defined by specific processor performance criteria. The latest core-supply voltage tolerance requirements are typically ±3%. The presence of large current transients makes the task of delivering reliable processor power even more challenging.

To meet these challenges, Texas Instruments (TI) introduces its plug-in power series of fast-transient-response power modules. These high-performance products have been designed to deliver reliable processor core power that is compact and cost-effective.

TMS320TCI648x digital signal processor power requirements

An example of a high-performance processor is TI's new TMS320TCI648x digital signal processor. Upon inspection of this product's datasheet and the associated power requirements, we find the following information.

Voltage tolerances, noise and transients

The voltage tolerances specified in the datasheet include all DC tolerances and the transient response of the power supply. These tolerances include the absolute maximum and minimum levels that must be maintained at the pins of the TCI6488 under all conditions. Special attention to the power supply solution is needed to achieve this level of performance, especially the 3% tolerance on the core power plane (V_{CORE}). In order to maintain the 3% tolerance at the pins, the tolerance must be a combination of the power supply DC output accuracy and the effect of transients. A reasonable goal for the DC power supply output accuracy is 1.5%, leaving 1.5% for the transients. At a nominal 1.0-V V_{CORE}, 3% tolerance is ±30 mV. This allows 15 mV of DC accuracy from the output of the power supply and another 15 mV due to transients.

With large current transients, a core-voltage requirement of ±3% tolerance and 1 V is nearly impossible to meet using a traditional solution. Usually, a custom-designed power module or an entirely discrete solution with an application specific-control design is required.

Second generation PTH series (T2) power modules

The new T2 series of plug-in power modules shown in Appendix A has a new patent-pending feature called TurboTrans™. TurboTrans technology allows the designer to customize the power module's control design to meet a target voltage-deviation specification. These T2 products offer the following three primary benefits.

Up to 8× reduction in output capacitance — Fewer capacitors means lower cost and saves board space. In applications with high load transients, these savings could easily be as much as the cost of the module itself.

Faster response to load transients — For a given value of output capacitance, the designer will see up to a 50% reduction in the peak deviation of the output voltage following a load transient.

Enhanced stability when used with ultra-low ESR capacitors — Designers can safely use the latest Oscon® polymer tantalum or *all-ceramic* output capacitors without stability concerns.

As part of the second-generation PTH products, a new line of ultra-fast-transient-response versions has been developed. These products were designed to meet the challenging power requirements of high-speed processors such as the TMS320TCI648x family. The control design is aggressively compensated beyond that of a standard T2 module. This provides an additional improvement in transient response and the lower cost associated with reduced output capacitance.

For example, let's examine the requirements of the TMS320TCI648x DSP above.

- Core voltage (V_{CORE}) = 1 V
- V_{CORE} tolerance = 3% (1.5% for DC tolerance and 1.5% for AC transients)
- Maximum current transition = 5 A
- Maximum peak voltage deviation with transients = $V_{CORE} \times 1.5\%$ = 15 mV
- **Output impedance requirement = 15 mV ÷ 5 A = 3 mV/A**

In order to meet the voltage tolerance requirement for the TMS320TCI648x, the power supply must have an output impedance of 3 mΩ or less. This requirement is beyond the capability of any standard, "off-the-shelf" power module.

Figure 1 shows that the competitive module cannot meet the 3-mΩ requirement. Even with a standard PTH08T240W module, the low-impedance requirement cannot be achieved without a large amount of capacitance. The PTH08T240F module, however, can meet the requirement with only 3000 µF of external output capacitance. Typical designs are shown in Appendix B.

Summary

TI's new line of ultra-fast-transient-response modules was designed to meet the challenging supply-voltage requirements of the latest system processors. These modules permit system designers to optimize transient performance while minimizing the need for output capacitance, thus optimizing board space and reducing system cost.

Related Web sites

power.ti.com
dsp.ti.com
www.ti.com/sc/device/PTH08T240F
www.ti.com/sc/device/PTH08T240W

Figure 1. Transient response versus capacitance chart

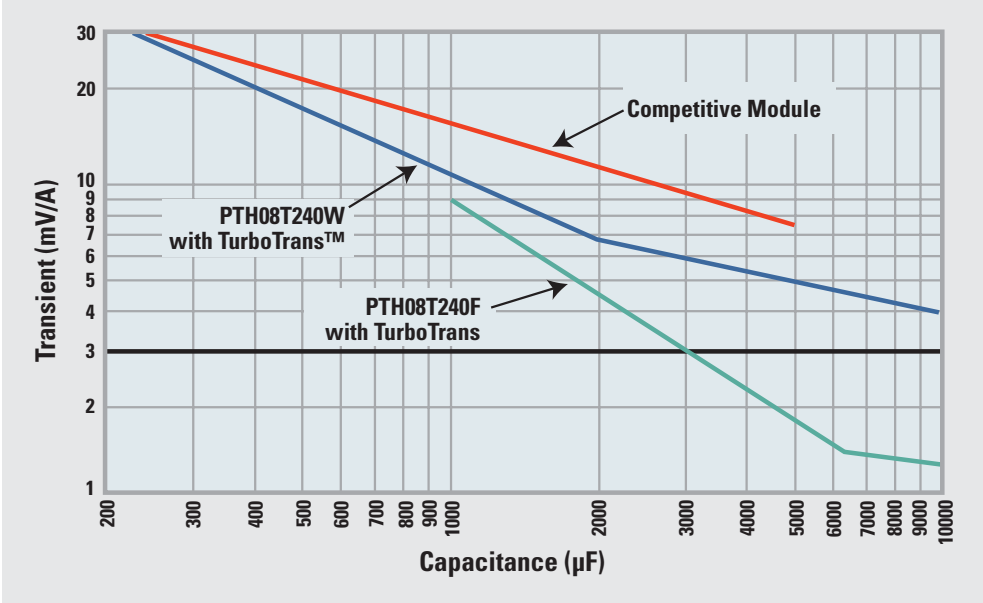


Figure 1 compares the output impedance characteristics of a standard T2 module, PTH08T240W; a fast-transient-response module, PTH08T240F; and a similarly rated competitive product.

Appendix A: T2 product selection tables

Standard – T2 non-isolated point-of-load modules

V_{IN} (V)	DESCRIPTION	3 A	6 A	10 A	16 A	30 A	50 A
+3.3	T2 PTH	**PTH04T260W**	**PTH04T230W**	**PTH04T240W**	**PTH04T220W**	PTH04T210W	
+5	T2 PTH	**PTH04T260W**	**PTH04T230W**	**PTH04T240W**	**PTH04T220W**	**PTH05T210W**	
		PTH08T260W	**PTH08T230W**	**PTH08T240W**	**PTH08T220W**		
+12	T2 PTH	**PTH08T260W**	**PTH08T230W**	**PTH08T240W**	**PTH08T220W**	**PTH08T210W**	**PTV08T250W**

Released products are listed in **bold red**.

Ultra-fast transient response – T2 non-isolated point-of-load modules

V_{IN} (V)	DESCRIPTION	3 A	6 A	10 A	16 A	30 A	50 A
+3.3	T2-F PTH	PTH04T260F	PTH04T230F	PTH04T240F	PTH04T220F	PTH04T210F	
+5	T2-F PTH	PTH04T260F	PTH04T230F	PTH04T240F	PTH04T220F	PTH05T210F	
		PTH08T260F	PTH08T230F	**PTH08T240F**	PTH08T220F		
+12	T2-F PTH	PTH08T260F	PTH08T230F	PTH08T240F	PTH08T220F	PTH08T210F	PTV08T250F

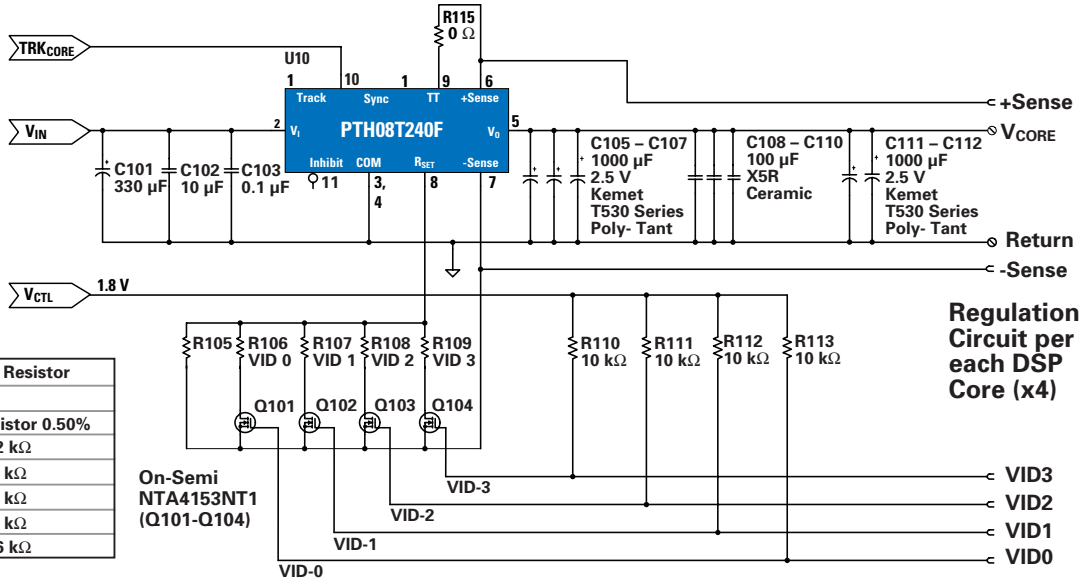
Released products are listed in **bold red**. Depending on the business opportunity and system requirements, additional products may be developed upon request.

Appendix B: Faraday DSP's scaled core expanded designs

PTH08T240F Transient Performance Data (Kemet T530 Series - Polymer Tantalum Bulk Capacitors)

Output Voltage Truth Table				
VID3	VID2	VID1	VID0	V_{CORE}
0	0	0	0	0.900 V
0	0	0	1	0.913 V
0	0	1	0	0.927 V
0	0	1	1	0.940 V
0	1	0	0	0.953 V
0	1	0	1	0.967 V
0	1	1	0	0.980 V
0	1	1	1	0.993 V
1	0	0	0	1.007 V
1	0	0	1	1.020 V
1	0	1	0	1.033 V
1	0	1	1	1.047 V
1	1	0	0	1.060 V
1	1	0	1	1.073 V
1	1	1	0	1.087 V
1	1	1	1	1.100 V

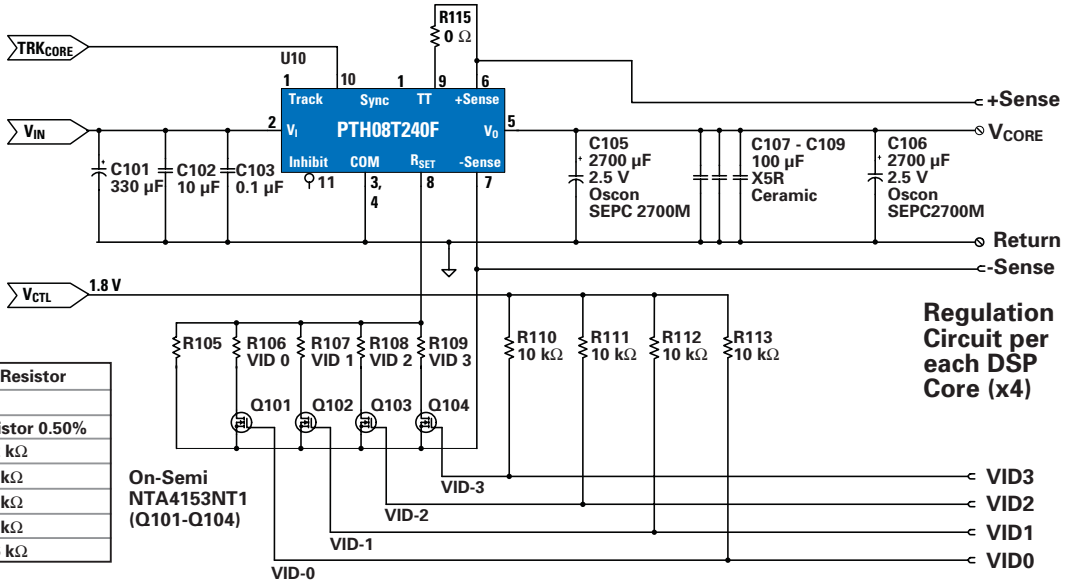
	VID Identification Resistor	
	Component	
VID Code	Designator	Resistor 0.50%
no code	R105	31.2 kΩ
VID 0(LSB)	R106	453 kΩ
VID 1	R107	229 kΩ
VID 2	R108	117 kΩ
VID 3(MSB)	R109	57.6 kΩ



PTH08T240F Transient Performance Data (OSCON SEPC Series Bulk Output Capacitors)

Output Voltage Truth Table				
VID3	VID2	VID1	VID0	V_{CORE}
0	0	0	0	0.900 V
0	0	0	1	0.913 V
0	0	1	0	0.927 V
0	0	1	1	0.940 V
0	1	0	0	0.953 V
0	1	0	1	0.967 V
0	1	1	0	0.980 V
0	1	1	1	0.993 V
1	0	0	0	1.007 V
1	0	0	1	1.020 V
1	0	1	0	1.033 V
1	0	1	1	1.047 V
1	1	0	0	1.060 V
1	1	0	1	1.073 V
1	1	1	0	1.087 V
1	1	1	1	1.100 V

	VID Identification Resistor	
	Component	
VID Code	Designator	Resistor 0.50%
no code	R105	31.2 kΩ
VID 0(LSB)	R106	453 kΩ
VID 1	R107	229 kΩ
VID 2	R108	117 kΩ
VID 3(MSB)	R109	57.6 kΩ



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