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Power Supply Solution Options for TI's 'C6000 Family of DSPs

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ABSTRACT

This application report describes available power supply solutions using several of TI's switching regulator controllers or low-dropout voltage regulators for single or multiple TMS320C62x/67x DSP applications.

1 Introduction

The TMS320C6000 family of digital signal processors (DSPs) are Texas Instruments' highest performance DSPs, ranging in operating frequency from 100 MHz to 300 MHz with an execution speed of up to 2000 MIPS. In order to maintain high performance and low power consumption a separate core and I/O supply must be supplied to the 'C6000. For the current generation of 'C6000 DSPs, the I/O supply is 3.3 V requiring less than 200 mA of current. The core supply requirement depends on the specific DSP and for the current generation of 'C6000 devices is either 1.8 V or 2 .5 V requiring from 700 mA to as much as 2.5 A.

In applications where a single-DSP is used, the overall power requirement is usually higher than what is required to power only the DSP. This is to supply the other circuitry associated with the application in addition to the DSP. The cost and the component count are also important for DSP users. In systems including more than one DSP, the overall power requirement is usually higher for the same reason as above. TI provides many solutions to cover higher output power. A table listing some of TI's power supply products for given output current requirements can be found at the web site
http://www.ti.com/sc/docs/msp/c6000.htm.

The table just mentioned shows solutions in terms of specific TI parts, for example, the TL5001A PWM controller or the TPS7233 LDO linear regulator, instead of complete power supply circuits. TI has several complete power supply solutions including schematics, bills of materials, PCB layouts, and measured test data that are not shown in the table. These solutions are readily available for customers and many of these solutions have evaluation modules (EVMs). These EVMs are preassembled and tested circuits designed for specific applications. Usually, there is a User's Manual to accompany each EVM; it is identified by a TI literature number, for example, SLVU005. The User's Manual includes a performance specification, input and output connection diagram, schematic, bill of materials, board layouts, test data and often includes design information to allow a user to modify the design if needed. Board layouts are included so that the designer can copy the power supply layout onto another PCB, which may include DSP(s) and other system circuitry. One example of an EVM available from Texas Instruments is the TL5001EVM-102. This EVM is a 5 V input to 2.5 V output, 3 A dc/dc converter using the TL5001 PWM controller. The associated User's Manual is TI Literature Number SLVU005.

However, a single table cannot deal with all the issues associated with selecting the proper power supply solution. This report presents several complete power supply solutions suitable for DSP applications and gives guidelines regarding how to select a power supply for a given system.

2 Power-Supply Solutions for Systems With Only 12-V Available

TI has several 12-V input DC/DC switching power supply solutions that provide a regulated output voltage with a specified output current rating. Some of these designs have an associated EVM or Evaluation Module. EVMs are available using the following controllers: one of the TPS56xx family, the TL5001, or the TPS5210.

Depending on the control circuit used in the power supply solution, TI offers the designer choices from very low cost power supplies to high efficiency high performance power supplies. For a fixed output voltage power-supply requiring high efficiency and/or superior transient response, one of the TPS56xx controllers should be considered. For a lower cost and reduced performance power supply solution, the designer should consider solutions using the TL5001 or TL5001A controller. If output voltage adjustability or droop compensation is required, the TPS5210 or TPS56100 based power supply solutions should be employed.

2.1 TPS56xx Based 12-V Input Power-Supply Solutions

Members of the TPS56xx family of controllers are high-performance fixed output voltage controllers in a PWP package. The xx in TPS56xx represents the output voltage, that is, TPS5633 is a 3.3-V output voltage controller. These controllers are generally used in dc/dc power supplies where superior output load transient response, input line transient response or high efficiency is required. Power supplies controlled by one of the TPS56xx family of controllers exhibit high performance and high efficiency while doing so at a very reasonable cost. See the *TPS5615, TPS5618, TPS5625, TPS5633 Synchronous Buck Hysteretic Regulator Controller* datasheet, literature number SLVS177A, for design information and complete details of the features regarding this controller.

Table 1 lists the EVMs based on the TPS56xx controllers. These EVMs operate with an input voltage ranging from 10.8-V to 13.2-V. The literature number for each entry is for the associated User's Guide.

The EVMs described in the SLVU007 User's Guide are designed for two input voltages; 5 V and 12 V. These EVMs are capable of 12-V only operation but they require small changes to the circuit shown in the User's Guide. The input voltages on the schematic in Figure 1-2, page 1-7 of the User's Guide are called 12 V (connecting to connector pin J1-7) and Input (this is the 5-V input and connects to connector pins J1-5 and J1-6). The signals that are provided by the 5-V input need to be scaled down when the 12-V input is used to provide these signals. The specific signals are the INHIBIT signal (pin 22), LODRV (pin 10) and PWRGD (pin 28). For an example of a 12-V only input configuration, see Figure 18, page 19 of the current TPS5210 datasheet, Literature Number SLVS171A.

The same changes need to be implemented for the circuit described in the SLVU013 User's Guide for the SLVP111 to SLVP114 EVMs.

Table 1. TPS56xx 12-V Input Solutions Summary

EVM PART NUMBER	LITERATURE NUMBER	V_I RANGE (V)	Vo (V)	MAX LO (A)	ALL SMT	FULL LOAD EFFICIENCY	POWER STAGE
TPS5615EVM-115	SLVU007	11.4 – 13.2	1.5	8	No	83	Sync buck
TPS5618EVM-106	SLVU007	11.4 – 13.2	1.8	8	No	86	Sync buck
TPS5625EVM-105	SLVU007	11.4 – 13.2	2.5	8	No	88	Sync buck
TPS5633EVM-104	SLVU007	11.4 – 13.2	3.3	8	No	90	Sync buck
TPS5633EVM-111	SLVU013	10.8 – 13.2	3.3	6	Yes	90	Sync buck
TPS5625EVM-112	SLVU013	10.8 – 13.2	2.5	6	Yes	86	Sync buck
TPS5618EVM-113	SLVU013	10.8 – 13.2	1.8	6	Yes	83	Sync buck
TPS5615EVM-114	SLVU013	10.8 – 13.2	1.5	6	Yes	80	Sync buck

To decide which solution to select, the major differences are the following: The SLVP111-114 EVMs described in SLVU013 use only surface-mount components. The SLVP104/105/106/115 EVMs described in SLVU007 use a combination of surface mount and through-hole components. The all-surface-mount version has the same length, 2”, and width, 0.75”, but the height is significantly lower, 0.375” versus 0.6” for the through-hole version. The SLVP111-114 EVMs described in SLVU013 are rated for an output current of 6-A. The SLVP104/105/106/115 EVMs described in SLVU007 have an output current rating of 8-A. All of these EVMs are pin to pin compatible.

2.2 TL5001 Based 12-V Input Power-Supply Solutions

The TL5001 or TL5001A controller is a low-cost PWM controller in a space saving SO-8 package. This controller is generally used in dc/dc power supplies where cost and parts-count are the major design considerations. See the *TL5001, TL5001A, TL5001Y Pulse-Width-Modulation Control Circuits* datasheet, Literature Number SLVS084D, for design information and complete details of the features regarding this controller.

Table 2 lists the EVMs based on the TL5001 or TL5001A controllers. These EVMs operate with an input voltage ranging from 5.5-V minimum to 12-V maximum. The literature number for each entry is for the associated EVM User’s Guide.

Table 2. TL5001 12-V Input Solutions Summary

EVM PART NUMBER	LITERATURE NUMBER	V_I RANGE (V)	Vo (V)	MAX LO (A)	ALL SMT	FULL LOAD EFFICIENCY	POWER STAGE
TL5001EVM-089	SLVU001	5.5 – 12	3.3	3	No	87	Sync. Buck
TL5001EVM-097	SLVU002	5.5 – 12	3.3	2.5	No	85	Buck
			5	2.5	No	91	Buck

In addition to the EVMs listed above, there are two 12-V input designs given in the application report *Designing with the TL5001 PWM Controller*, Literature Number SLVA034A. Table 3 summarizes the two designs.

Table 3. TL5001 Application Report 12-V Input Solutions

EVM PART NUMBER	LITERATURE NUMBER	V_I RANGE (V)	Vo (V)	MAX LO (A)	ALL SMT	FULL LOAD EFFICIENCY	POWER STAGE
N/A	SLVU034A	10 – 15	5	3	No	82%	Buck
N/A	SLVU034A	10 – 15	3.3	3	No	75%	Buck

To decide which solution to select, the major differences are the following: The power stage of the SLVP089 EVM (described in SLVU001) is a synchronous buck giving better efficiency but more parts than the SLVP097 EVM (described in SLVU002). Both of these EVMs have a *maximum* input voltage of 12 V. If the *nominal* input voltage is 12 V, consider other power-supply options to allow for variations in the 12-V input voltage. The application circuits given in the application report *Designing with the TL5001 PWM Controller* can handle up to 15-V input voltage but there are no EVMs available for these designs.

2.3 TPS5210 Based 12-V Input Power-Supply Solutions

The TPS5210 controller is a programmable synchronous-buck regulator controller. An internal 5-bit DAC programs the output voltage to within a range of 1.3 V to 3.5 V. This controller is used in high performance DC/DC power supplies that are intended to power DSPs or Pentium II class and above microprocessors. The TPS5210 controller has all of the functions found in the TPS56xx family of controllers in addition to programmability and droop compensation. See the *TPS5210 Programmable Synchronous-Buck Regulator Controller* datasheet, Literature Number SLVS171A, for complete details of the features and design information regarding this controller.

Table 4 lists the EVMs based on the TPS5210 controller. The literature number for each entry is for the associated User's Guide.

Table 4. TL5210 Input Solutions Summary

EVM PART NUMBER	LITERATURE NUMBER	V_I RANGE (V)	Vo (V)	MAX LO (A)	ALL SMT	FULL LOAD EFFICIENCY	POWER STAGE
TPS5210EVM-116	SLVU011	11.4 – 13	Adj.	16	Yes	90% @ Vo = 2 V, Io = 10 A	Sync buck
TPS5210EVM-119	SLVU010	11.4 – 13	Adj.	16	Yes	90% @ Vo = 2 V, Io = 10 A	Sync buck

In addition to the EVMs listed above, there is a 12-V input, adjustable output voltage application circuit schematic included in the TPS5210 datasheet (Figure 18, page 19). To go along with the application circuit, there are five design options corresponding to maximum output current ratings of 4-A, 8-A, 12-A, 20-A, and 40-A. The maximum output current rating is primarily a function of the power stage components and a selection guide for these components for each of the five options is given in Table 2, page 20 of the datasheet.

To decide which solution to select, the major differences are the following: The SLVP116 EVM described in SLVU011 is designed to meet or exceed the Intel VRM 8.3 dc-dc converter electrical and mechanical specifications. The SLVP119 EVM described in SLVU010 is designed to meet or exceed the Intel VRM 8.3 dc-dc converter electrical specifications only. The circuit is laid out on one PWB with test points included to ease a lab environment evaluation of the power-supply. If a lower-current or a higher-current solution is required the five options given in the TPS5210 datasheet should be considered.

3 Power-Supply Solutions for Systems With Only 5-V Available

TI has several 5-V input DC/DC switching power supply solutions that provide a regulated output voltage with a specified output current rating. Some of these designs have an associated EVM. EVMs are available using the following controllers: TPS56100, the TL5001, one of the TPS56xx family, or the TPS5210 controller.

3.1 TPS56100 Based 5-V Input Power-Supply Solutions

The TPS56100 controller is a programmable synchronous-buck regulator controller that requires a single 5-V input voltage. An internal 5-bit DAC programs the output voltage to within a range of 1.3 V to 3.5 V. This controller is used in high performance DC/DC power supplies that are intended to power DSPs or Pentium II class and above microprocessors. The TPS56100 controller has all of the functions found in the TPS5210 controller. See the *TPS56100 High-Efficiency DSP Power Supply Controller for 5-V Input Systems* datasheet, Literature Number SLVS201, for complete details of the features and design information regarding this controller.

Table 5 lists the EVM based on the TPS56100 controller. The literature number is for the associated User's Guide.

Table 5. TPS56100 5-V Input Solutions Summary

EVM PART NUMBER	LITERATURE NUMBER	V_I RANGE (V)	Vo (V)	MAX LO (A)	ALL SMT	FULL LOAD EFFICIENCY	POWER STAGE
TPS56100EVM-128	SLVU0	4.5 – 5.5	3.3	6	Yes	84%	Sync buck

In addition to the EVM listed above, there is a 5-V input, adjustable output voltage application circuit schematic included in the TPS56100 datasheet (Figure 20, page 23). To go along with the application circuit, there are four design options corresponding to a maximum output current rating of 4-A, 8-A, 12-A, and 20-A. The maximum output current rating is primarily a function of the power stage components and a selection guide for these components for each of the four options is given in Table 2, page 24 of the datasheet.

To decide which solution to select, note that the major difference between all the solutions given in this section is the maximum output current rating. Relative to the EVM listed above, if a lower-current or a higher-current solution is required, the four options given in the TPS56100 datasheet should be considered. However, there are no EVMs available for the four options given in the TPS56100 datasheet.

3.2 TPS56xx Based 5-V Input Power-Supply Solutions

The TPS56xx family of switching power-supply regulators is specifically designed to address the rapidly transitioning load currents of systems using digital signal processors. The TPS56xx uses 12 V to optimally drive and support this stringent circuit environment. In order to use the TPS56xx controller in systems that have only 5-V available, it is up to the power supply designer to derive 12 V from the 5 V available in the system. The application report *Providing a DSP Power Solution From 5-V or 3.3-V Only System*, Literature Number SLVA069 describes how to combine the TPS56xx and TPS6734 devices to provide a power supply solution.

By following the directions given in the application report above, all of the 12-V input solutions using the TPS56xx given in Section 2.1 can be implemented in 5-V only systems.

3.3 TL5001 Based 5-V Input Power-Supply Solutions

The TL5001 or TL5001A controller is a low-cost PWM controller in a space saving SO-8 package. This controller is generally used in DC/DC power supplies where low cost and parts-count are major concerns. . See the *TL5001, TL5001A, TL5001Y Pulse-Width-Modulation Control Circuits* datasheet, Literature Number SLVS084D, for complete details of the features and design information regarding this controller.

Table 6 lists the EVMs that are based on the TL5001 or TL5001A controllers. These EVMs operate with an input voltage ranging from 4.5-V minimum to 9-V maximum. The literature number for each entry is for the associated EVM User's Guide.

Table 6. TL5001 5-V Input Solutions Summary

EVM PART NUMBER	LITERATURE NUMBER	V_I RANGE (V)	Vo (V)	MAX LO (A)	ALL SMT	FULL LOAD EFFICIENCY	POWER STAGE
TL5001EVM-087	SLVU003A	4.5 – 7	3.3	3	No	87 %	Buck
TL5001EVM-101	SLVU005	4.5 – 9	3.3	3	Yes	88 %	Buck
TL5001EVM-102	SLVU005	4.5 – 9	2.5	3	Yes	82 %	Buck
TL5001EVM-103	SLVU005	4.5 – 9	1.8	3	Yes	77 %	Buck
TL5001AEVM-108	SLVU014	4.5 – 6	3.3	3	Yes	78 %	Buck
TL5001AEVM-109	SLVU014	4.5 – 6	2.5	3	Yes	75 %	Buck
TL5001AEVM-110	SLVU014	4.5 – 6	1.8	3	Yes	70 %	Buck

In addition to the EVMs listed above, there is a 5-V input design given in the application report *Designing with the TL5001 PWM Controller*, Literature Number SLVA034A. Table 7 The summarizes the design.

Table 7. TL5001 Application Report 5-V Input Solutions

EVM PART NUMBER	LITERATURE NUMBER	V_I RANGE (V)	Vo (V)	MAX LO (A)	ALL SMT	FULL LOAD EFFICIENCY	POWER STAGE
N/A	SLVA034A	4.75 – 5.25	3.3	0.75	No	84%	Buck

The TL5001 (non-A) controls the EVMs described by the SLVU005 User's Guide and use a precision, external reference for improved output voltage setpoint accuracy of typically 1%. The TL5001A controls the EVMs described by the SLVU014 User's Guide but use the 3% tolerance internal reference voltage and consequently have fewer components.

3.4 TL5210 Based 5-V Input Power-Supply Solutions

The TPS5210 controller is a programmable synchronous-buck regulator controller specifically designed to address the rapidly transitioning load currents of systems using Pentium II class and above microprocessors. Similar to the TPS56xx controller, the TPS5210 uses 12 V to optimally drive and support this circuit environment. In order to use the TPS56xx controller in systems that have only 5-V available, it is up to the power supply designer to derive 12 V from the 5 V available in the system. The application report *Providing a DSP Power Solution From 5-V or 3.3-V Only System*, Literature Number SLVA069 describes how to combine the TPS56xx and TPS6734 devices to provide a power supply solution.

By following the directions given in the application report above, all of the 12-V input solutions using the TPS5210 given in Section 2.3 can be implemented in 5-V only systems.

3.5 Other 5-V Input Power-Supply Solutions

In addition to the single output designs mentioned previously, there are three 5-V input designs given in two separate application reports.

The application report *Low Cost Power Solution for TMS320C6201 DSP Applications*, Literature Number SLVA046 describes a 5-V input two output power solution. The two outputs are 2.5-V at a maximum output current of 3 A and 3.3 V at a maximum output current of 0.75 A. This power supply solution uses an SLVP102 (or SLVP109) EVM circuit described previously to provide 2.5 V and uses a TPS7133 LDO linear regulator to provide 3.3 V. This power supply solution is specifically intended for the TMS320C6201 DSP. This solution also addresses the power-supply sequencing required for the ‘C6201 DSP.

The application report *TPS5625 Working With TMS320C6201 Applications*, Literature Number SLVA047 describes a 5-V input, two output power solution. The two outputs are 2.5-V at a maximum output current of 8 A and 3.3 V at a maximum output current of 3 A for high current DSP applications. This power supply solution uses an SLVP105 EVM circuit described previously to provide 2.5 V and uses an SLVP101 EVM circuit to provide 3.3 V. This power supply solution is specifically intended for the TMS320C6201 DSP. This solution also addresses the power-supply sequencing required for the ‘C6201 DSP. Since this solution uses a TPS5625 controller, a 12-V supply for the TPS5625 is required. If 12 V is not available, see Section 3.3 for a solution using the TPS6734 to provide 12 V from the available 5-V input power.

The application report *TMS320C62x/67x Power Supply Solutions for 1-2 DSPs: Using the TL5001A and TPS7133*, Literature Number SLVA066 describes a 5-V input two output power solution. The two outputs are 1.8-V (can be modified for 2.5 V) at a maximum output current of 3 A and 3.3 V at a maximum output current of 0.5 A. This power supply solution is available for evaluation and the EVM number is TL5001AEVM-122. This power supply solution uses a TL5001A based power supply to provide 1.8 V and uses a TPS7133 LDO linear regulator to provide 3.3 V. This power supply solution is applicable to all of the ‘C62x and ‘C67x DSPs. This solution also addresses the required power-supply sequencing for the DSP(s).

4 Power-Supply Solutions for Systems With Only 3.3-V Available

TI has several 3.3-V input DC/DC switching power supply solutions that provide a regulated output voltage with a specific output current rating. Some of these designs have an associated EVM. EVMs are available using the following controllers, the TPS56xx family or the TPS5210 controller.

4.1 TPS56xx Based 3.3-V Input Power-Supply Solutions

The TPS56xx family of switching power-supply regulators is specifically designed to address the rapidly transitioning load currents of systems using digital signal processors. The TPS56xx uses 12 V to optimally drive and support this stringent circuit environment. In order to use the TPS56xx controller in systems that have only 3.3-V available, it is up to the power supply designer to derive 12 V from the 3.3 V available in the system. The application report *Providing a DSP Power Solution From 5-V or 3.3-V Only System*, Literature Number SLVA069 describes how to combine the TPS56xx and TPS6734 devices to provide a power supply solution.

By following the directions given in the application report above, all of the 12-V input solutions using the TPS56xx given in Section 2.1 can be implemented in 3.3-V only systems.

4.2 TPS5210 Based 3.3-V Input Power-Supply Solutions

The TPS5210 controller is a programmable synchronous-buck regulator controller specifically designed to address the rapidly transitioning load currents of systems using Pentium II class and above microprocessors. Similar to the TPS56xx controller, the TPS5210 uses 12 V to optimally drive and support this circuit environment. In order to use the TPS56xx controller in systems that have only 3.3-V available, it is up to the power supply designer to derive 12 V from the 3.3 V available in the system. The application report *Providing a DSP Power Solution From 5-V or 3.3-V Only System*, Literature Number SLVA069 describes how to combine the TPS56xx and TPS6734 devices to provide a power supply solution.

By following the directions given in the application report above, all of the 12-V input solutions using the TPS5210 given in Section 2.3 can be implemented in 3.3-V only systems.

In order to maintain high performance and low power consumption the TMS320C6000 series of digital signal processors (DSPs) require a separate core and I/O supply. For the current generation of ’C6000 DSPs, the I/O supply is 3.3 V. The core supply requirement depends on the specific DSP and for the current generation of ’C6000 devices is either 1.8 V or 2.5 V. Since the core and I/O sections of the DSPs have separate power inputs, the order that the core and I/O power supplies attain their final voltage is important for proper operation of the DSPs. The ‘C6000 series of DSPs require that the core supply be powered up first with the I/O supply powered up after the core supply is present.

The sequencing requirements stated more explicitly are as follows:

Core first, I/O second power-supply sequencing

On system power-up, the core supply should be powered up first, or at the same time as the I/O buffers supply. This is to ensure that the I/O buffers have

valid inputs from the core before the output buffers are powered up, thus preventing bus contention with other chips on the board.

On system power-down, the I/O buffers supply should be powered down first, or at the same time as the core supply.

There are many possible power supply configurations for powering TI's new, multivoltage DSPs depending on the voltage(s) available from the system for use as input power and the configuration of the DSP application (i.e., how many DSPs, how much other circuitry, etc.). The application report *Power-Supply Sequencing Solutions for Dual Supply Voltage DSPs*, Literature Number SLVA073 presents options for *sequencing* of the two power supply voltages for DSP applications. This report addresses sequencing solutions for the following: 3.3 V only available input power, greater than 3.3 V available input power, and12 V only available input power (a special case of greater than 3.3 V).

5 Supply Voltage Supervision and Power-On-Reset

After power-on, a digital system must be forced into a definite initial state. Digital signal processors (DSPs), microcomputers, and microprocessors have a reset input for this purpose. A circuit that generates a reset signal must monitor the supply voltage(s) powering the system.

Power supply problems such as spikes, surges, and brownout (a slowly falling supply voltage) can lead to system failures if a simplistic power-on-reset scheme (for example, an RC network) is used. Noise spikes on the supply can cause unwanted full or partial resets, and brownout can give rise to indeterminate system states if normal power is restored from a partial supply failure. Not all reset schemes work the same.

To prevent power supply problems from causing digital systems to malfunction, the following features are required from the reset generation circuit:

- Accurate detection of a voltage drop below the critical voltage
- Generation of a reset signal when the supply voltage is not in the allowed range
- Keeping the reset signal active for a definite time after the supply voltage has returned to its nominal value to ensure proper initialization of the microprocessor or DSP.

For these applications, Texas Instruments has developed a range of Supply Voltage Supervisors (SVSs) which meet the above requirements.

Two Texas Instruments publications *TLC77xx Series of BiCMOS Supply Voltage Supervisors*, Literature Number SLVAE03 and *Supply Voltage Supervisor TL77xx Series*, Literature Number SLVAE04 give detailed discussions of power supply problems and describe the uses of SVS devices in general, and the TL77xx and TLC77xx series in particular.

The application report *TPS382x Microprocessor Supervisory Circuits With Watchdog Function in SOT-23 Package*, Literature Number SLVA039 introduces micropower supply voltage supervisors (SVS), discusses their benefits, and describes design methods and precautions for their use.

The application report *TPS3305 and TPS3307 Supervising DSP and Processor Applications*, Literature Number SLVA056 describes the TPS3305 and TPS3307 Supply Voltage Supervisor (SVS) families of devices. The report gives a general introduction to reset generators followed by an overview of the technical parameters and the special features of the TPS330x. Each feature is discussed separately. Measurements make it easy to understand SVS principles of operation. Typical applications that increase system reliability, such as supervising a dual-voltage DSP, are included. Layout and design issues are also discussed.