TPS6505x Design Guide

Michael Green

ABSTRACT

This document is a guide for designers to use when designing with the TPS6505x PMU.

The application report has 3 sections: an overview, schematic checklist, and PCB checklist.

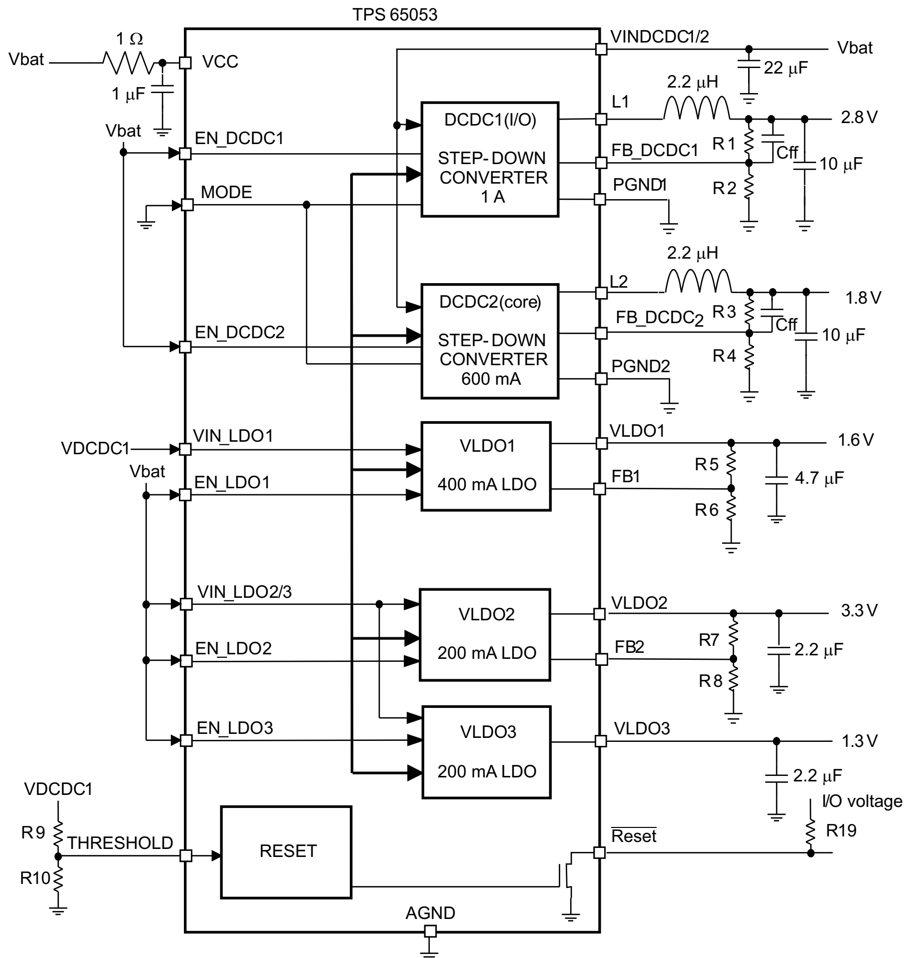
Contents

List of Figures

List of Tables

1 TPS6505x Overview

The TPS65053x has 2 DCDC buck regulators, 3 LDOs, and a reset output signal. The TPS6505x has 2 DCDC buck regulators, 4 LDOs, and a reset output signal.



1.1 Quick Checklist

- VCC input filter
- RESET pull-up
- Threshold resistor divider, if applicable
- LDOs
  - Input capacitor
  - Output Capacitor
- DCDCs
  - Input capacitor
  - Output Capacitor
  - Output Inductor
  - Feedback Resistors

2 Schematic Checklist

2.1 VCC Input Filter

The VCC pin supplies the digital and internal analog reference. The buck regulators will inject switching noise as is the nature of buck regulators; therefore, the VCC pin should be a filtered input. Use a 1-Ω resistor and 1-µF capacitor to form an RC low-pass filter.

2.2 RESET and Threshold

RESET is an output logic signal for supplying a reset or a power good signal to an external circuit or IC. RESET is an open-drain output and requires a pull-up resistor to any desired voltage. A 100-kΩ resistor is typical for most applications.

Threshold sets the voltage at which RESET comparator transitions from LOW to HIGH. To set the voltage, use a resistor divider from the desired voltage rail. Care should be taken in selecting the magnitude of the resistors. Larger resistance decreases the power loss through the divider while smaller resistance decreases noise susceptibility. Resistors between 20 kΩ and 300 kΩ are recommended.

2.3 LDOs

The LDOs require an input and output capacitor for proper regulation.

2.3.1 Capacitors

A ceramic 2.2-µF capacitor is recommended for both VINLDO1 and VINLDO2/3 for TPS65053x and VINLDO1, VINLDO2, and VINLDO3/4 for TPS6505x. For each output, a ceramic 4.7 µF capacitor is recommended.

Be sure to take into account the DC bias derating, thermal derating and manufacturing variance. It is recommended to use a ceramic capacitor of at least 2x the voltage rating as the voltage applied to the capacitor. Also, either X5R or X7R and ±10% or ±20% capacitors are recommended.

2.3.2 Feedback

If feedback resistors are required to set the LDO output voltage, use the following equation to calculate the recommended resistors for the divider input. For most applications, the feedback resistors should be in the 100-kΩ range.

$$R3 = R4 \times \left(\frac{Vout}{V_{REF\_LDO}} \right) - R4 \tag{1}$$

Where:

VREF_LDO = 1 V
R4 ≈ 100 kΩ

2.4 DCDC Regulators

The DCDC regulators require an input and output filter for proper regulation.

2.4.1 Capacitors

A ceramic 22-µF capacitor is recommended for both VINDCDC1/2. For each output, a ceramic 10 - 22 µF capacitor is recommended.

Be sure to take into account the DC bias derating, thermal derating and manufacturing variance. It is recommended to use a ceramic capacitor of at least 2x the voltage rating as the voltage applied to the capacitor. Also, either X5R or X7R and ±10% or ±20% capacitors are recommended.

2.4.2 Feedback

If feedback resistors are required to set the DCDC output voltage, use the following equation to calculate the recommended resistors for the divider input. For most applications, the feedback resistors should be in the 100-kΩ range.

$$R3 = R4 \times \left(\frac{Vout}{V_{REF\_LDO}} \right) - R4 \quad (2)$$

Where:

VREF_LDO = 0.6 V
R4 ≈ 100 kΩ

A feed forward capacitor maybe required for proper stability for the DCDC converter. Table 1 provides calculated feedback resistors and appropriate feed forward capacitors for several output voltages.

Table 1. Typical Resistor Values

OUTPUT VOLTAGE	R1	R2	NOMINAL VOLTAGE	TYPICAL CFF
3.3 V	680 kΩ	150 kΩ	3.32 V	47 pF
3.0 V	510 kΩ	130 kΩ	2.95 V	47 pF
2.85 V	560 kΩ	150 kΩ	2.84 V	47 pF
2.5 V	510 kΩ	160 kΩ	2.51 V	47 pF
1.8 V	300 kΩ	150 kΩ	1.80 V	47 pF
1.6 V	200 kΩ	120 kΩ	1.60 V	47 pF
1.5 V	300 kΩ	200 kΩ	1.50 V	47 pF
1.2 V	330 kΩ	330 kΩ	1.20 V	47 pF

2.4.3 Inductor

The two converters operate typically with 2.2-µH output inductor. Larger or smaller inductor values can be used to optimize the performance of the device for specific operating conditions. For output voltages higher than 2.8 V, an inductor value of 3.3 µH minimum should be selected, otherwise the inductor current will ramp down too fast causing imprecise internal current measurement and therefore increased output voltage ripple under some operating conditions in PFM mode.

The selected inductor has to be rated for its DC resistance and saturation current. The DC resistance of the inductance will directly influence the efficiency of the converter. Therefore, an inductor with the lowest DC resistance should be selected for highest efficiency.

Equation 3 calculates the maximum inductor current under static load conditions. The saturation current of the inductor should be rated higher than the maximum inductor current as calculated with Equation 3. This is recommended because during heavy load transient the inductor current will rise above the calculated value.

$$\Delta I_L = Vout \times \left(\frac{1 - \frac{Vout}{Vin}}{L \times f sw} \right)$$

$$I_{L max} = Iout_{max} + \frac{\Delta I_L}{2} \quad (3)$$

Where:

ΔI_L = Peak-to-peak inductor ripple current
fsw = Switching Frequency (2.25-MHz typical)
L = Inductor Value
I_{Lmax} = Maximum Peak Inductor current
$Iout_{max}$ = Maximum DC Inductor current

3 PCB Checklist

Use the following list to ensure a high-performance and efficient PCB:

- The input capacitors for the DCDC converters should be placed as close as possible to the VINDCDC1/2 pin and the PGND1 and PGND2 pins.
- The inductor of the output filter should be placed as close as possible to the device to provide the shortest switch node possible, reducing the noise emitted into the system and increasing the efficiency.
- Sense the feedback voltage from the output at the output capacitors to ensure the best DC accuracy. Feedback should be routed away from noisy sources such as the inductor. If possible, route on the opposing side as the switch node and inductor and place a GND plane between the feedback and the noisy sources or keep out from underneath them entirely.
- Place the output capacitors as close as possible to the inductor to reduce the feedback loop as much as possible. This ensures best regulation at the feedback point.
- Place the device as close as possible to the most demanding or sensitive load. The output capacitors should be placed close to the input of the load. This ensures the best AC performance possible.
- The input and output capacitors for the LDOs should be placed close to the device for best regulation performance.
- A common ground plane is recommended for the device layout. The AGND can be separated from the PGND but, a large low parasitic PGND is required to connect the PGNDx pins to the CIN and external PGND connections.

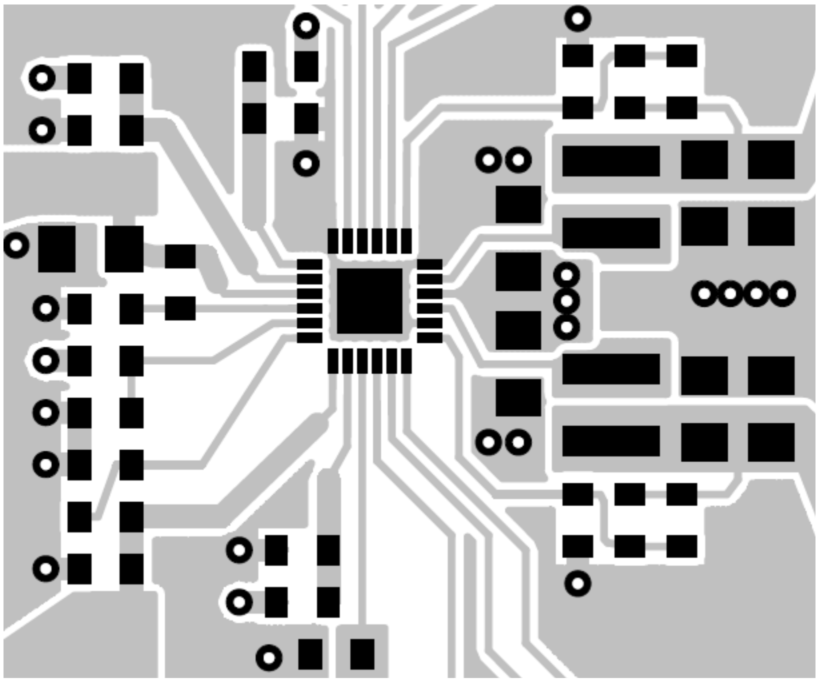


Figure 1. TPS6505x PCB

4 References

1. *TPS6505xx 5-Channel Power Management IC With Two Step-Down Converters and Three Low-Input Voltage LDOs* datasheet (SLVS754)
2. *6-Channel Power MGMT IC With Two Step-down Converters and 4 Low-input Voltage LDOs* datasheet (SLVS710)

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers' products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers' products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have ***not*** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products		**Applications**	
Audio	www.ti.com/audio	Automotive and Transportation	www.ti.com/automotive
Amplifiers	amplifier.ti.com	Communications and Telecom	www.ti.com/communications
Data Converters	dataconverter.ti.com	Computers and Peripherals	www.ti.com/computers
DLP® Products	www.dlp.com	Consumer Electronics	www.ti.com/consumer-apps
DSP	dsp.ti.com	Energy and Lighting	www.ti.com/energy
Clocks and Timers	www.ti.com/clocks	Industrial	www.ti.com/industrial
Interface	interface.ti.com	Medical	www.ti.com/medical
Logic	logic.ti.com	Security	www.ti.com/security
Power Mgmt	power.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Applications Processors	www.ti.com/omap	**TI E2E Community**	e2e.ti.com
Wireless Connectivity	www.ti.com/wirelessconnectivity		

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