Application Report

A Topical Index of TI Low Power Buck DC/DC Application Notes

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ABSTRACT

This report aims to be a convenient guide to the many Texas Instruments application notes that discuss aspects of low power DC/DC buck (TPS and TLV62xxx) converters, from topology basics to specific applications and designs. The application notes are categorized by topic and their content is briefly summarized to allow the reader to quickly find relevant information for any issue of interest. Each application note referenced in this document is identified by its title and unique TI literature number. A link to the each note's location on the www.ti.com website is provided, where the discussed document can be downloaded.

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1 Introduction

This application report targets application designers and other users of TI products, looking for a handy overview of available technical information on TI low power DC/DC converters, from architecture fundamentals to concrete applications and designs. An extensive compilation of relevant TI application notes is presented below, together with a short summary of the discussed content. Each application note is arranged by topic and identified by its title and unique TI literature number. To access the documents online or download them for personal use, click on the document number tag (for example: slvaxxx) which will direct you to the documents' location on www.ti.com. This application report is regularly maintained to ensure that the available information is up-to-date.

For assistance with low power DC/DC product selection, circuit design and simulation, refer to the DC/DC Switching Regulators Power Quick Search and the WEBENCH® Design Center tool available on www.ti.com.

For any question that those reports cannot answer, contact the TI E2E™ Community. (Note that this link requires a secure log-in.)

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3 Fundamentals of Switchmode DC/DC Converters

In this section, several application notes discussing the principles of switching regulators and their architecture are presented.

Understanding Buck Power Stages In Switchmode Power Supplies: SLVA057

This application report addresses the fundamentals of buck power stage but does not cover control circuits. Detailed steady-state and small-signal analysis of the buck power stage operating in continuous and discontinuous mode are presented. Variations in the standard buck power stage and a discussion of power stage component requirements are included.

Switching Regulator Fundamentals: SNVA559

This paper details the operating principles of commonly used switching converter types, which is the buck converter topology. It provides circuit examples that illustrate some of the applications of buck regulators.

Basic Calculation of a Buck Converter's Power Stage: SLVA477

This application report discusses the basic configuration of a buck converter and gives the formulas to calculate the power stage of a buck converter built with an integrated circuit having an integrated switch and operating in continuous conduction mode.

4 Basics of the DCS-Control™ Topology

This section provides insight into the DCS-control™ topology, a proprietary regulation topology implemented in many products of the TI low power DC/DC converter portfolio.

High-efficiency, Low-ripple DCS-Control™ Offers Seamless PWM/power-save Transitions: SLYT531

This article discusses how the DCS-Control™ topology works, demonstrating its low output-voltage ripple in power-save mode, its superb transient response, and its seamless mode transitions.

Understanding Frequency Variation in the DCS-Control™ Topology: SLYT646

This document explains the principles behind the DCS-control™ topology switching frequency variation. It shows that while the switching frequency does vary, this variation is understood, controlled, and usually sufficient for automotive and other frequency-sensitive applications.

5 Design and Layout Support

This section summarizes notes to support the reader to make sensible design choices, selecting the appropriate components and passives, optimizing the PCB layout, and fine-tuning the solution to meet the application's requirements.

QFN/SON PCB Attachment Application Report: SLUA271

Quad flat-pack no-leads (QFNs) and small-outline no leads (SONs) are leadless packages with electrical connections made via lands on the bottom side of the component to the surface of the connecting substrate (PCB, ceramic). This application report presents users with introductory information about attaching QFN/SON devices to printed circuit boards (PCBs).

Five Steps to a Great PCB Layout for a Step-Down Converter: SLYT614

This article details a five-step procedure to design a good PCB layout for any TPS62xxx integrated-switch, step-down converter.

Design Considerations for a Resistive Feedback Divider in a DC/DC Converter: SLYT469

This article discusses the design considerations for the resistive divider in a feedback system and how the divider affects a converter's efficiency, output voltage accuracy, noise sensitivity, and stability.

Optimizing Resistor Dividers at a Comparator Input: SLVA450

This application report discusses several key factors involved with selecting optimally-sized resistors commonly used at the input to a comparator to set a threshold voltage on switching regulator devices, considering efficiency and voltage accuracy constraints.

Optimizing Transient Response of Internally Compensated DC-DC Converters with Feedforward Capacitor: SLVA289

This application report describes how to choose the feedforward capacitor value (Cff) of internally compensated dc-dc power supplies to achieve optimum transient response. The described procedure in this application report provides guidance in optimizing transient response by increasing converter bandwidth while retaining acceptable phase margin. This document is intended for all power supply designers who want to Optimize the Transient Response of a working, Internally Compensated DC-DC Converter.

Choosing an Appropriate Pull-up and Pull-down Resistor for Open Drain Outputs: SLVA485

This application report discusses when to use a pull-up or pull-down resistor at open drain outputs commonly found on ICs, for example Power Good (PG), the factors that should be considered when selecting a pull-up or pull-down resistor, and how to calculate a valid range for the value of the resistor.

Achieving a Clean Startup by Using a DC/DC Converter With a Precise Enable-pin Threshold: SLYT730

Most DC/DC Converters contain an enable (EN) pin input that is used to control the startup behavior. This article explains some common EN-pin threshold specifications found in device data sheets and describes several application circuits that provide a clean startup, with or without using a converter with a precise EN-pin threshold.

Extending the Soft Start Time Without a Soft Start Pin: SLVA307

In battery-powered equipment, extending the soft-start time can be crucial to a glitch-free start-up. Especially toward the end of a battery's life, the voltage drop and increasing impedance of the battery from excessive inrush current into the power supply can be a problem. This application report demonstrates a simple circuit that extends the soft start time and reduces the inrush current, taking the examples of the TPS6107x family of boost converters.

Adjusting the Soft-start Time of an Integrated Power Module: SLYT669

This paper demonstrates three simple and low-cost solutions to adjust the soft-start time of an integrated power module and provide clean, acceptable start-up in applications with special soft-start requirements, particularly in FPGAs, which have lots of output capacitance or may draw large currents during the soft-start time.

Sequencing and Tracking With the TPS621-Family and TPS821-Family: SLVA470

This application note describes how to use the EN, PG, and SS/TR pins in tracking and sequencing applications.

Understanding the Absolute Maximum Ratings of the SW Node: SLVA494

This application note explains the operation of a synchronous buck converter, demonstrates why the SW node negative rating might be exceeded during switching operation, gives guidance for properly measuring the SW node voltage, and provides good layout practices for synchronous buck converters.

Minimizing Ringing at the Switch Node of a Boost Converter: SLVA255

This application report explains how to use proper board layout and/or a snubber to reduce high-frequency ringing at the switch node of any switching converter, using a boost converter as an example.

I_Q: What It Is, What It Isn't, and How to Use It: SLYT412

This article defines I_Q and how it is measured, explains what I_Q is not and how it should not be used, and gives design considerations on how to use I_Q while avoiding common measurement errors.

The Forgotten Converter (Charge Pumps): SLPY005

This white paper discusses the pros and cons of charge-pump converter topologies, provides industrial and personal electronics application examples, and covers component-selection guidelines.

6 Thermal Considerations

This section concentrates on giving a basic understanding of package thermal metrics and their real world application, along with specific package or device discussions.

Semiconductor and IC Package Thermal Metrics: SPRA953

Many thermal metrics exist for semiconductor and integrated circuit packages. Often, these thermal metrics are misapplied by those who try to use them to estimate junction temperatures in their systems. This very helpful document describes traditional and new thermal metrics and puts their application in perspective with respect to system-level junction temperature estimation.

Techniques for Thermal Analysis of Switching Power Supply Designs: SNVA207

This application note provides thermal power analysis techniques for analyzing the power IC. It includes analytical, simulation and hands-on approaches to estimating the IC temperature in a design.

An Accurate Thermal-Evaluation Method for the TLV62065: SLVA658

This application report is a basic overview of thermal evaluation and provides an accurate evaluation method of junction temperature in a real application. This method is proven to be easy to use and have good accuracy through measurements on the TLV62065.

Improving the Thermal Performance of a MicroSiP™ Power Module: SLYT724

Power module data sheets usually state their thermal-performance properties, but they are frequently based on a Joint Electron Devices Engineering Council (JEDEC) standard PCB, which generally does not match what is possible in the actual application. This article explains JEDEC's PCB design and compares it to various real-world PCB designs that demonstrate the impact of PCB design on the thermal performance of a MicroSiP™ power module.

TPS62366x Thermal and Device Lifetime Information: SLVA525

In this note, we investigate and quantify the potential reliability impact of temperature-dependent electromigration on wafer-level chip-scale (WCSP) packages, taking TI's TPS62366x (4-A peak output current) DC/DC Converter family as an example.

7 Controlling EMI

In switching power supplies, electromagnetic interference (EMI) noise is unavoidable due to the switching actions of the semiconductor devices and resulting discontinuous currents. EMI control is one of the more difficult challenges in switching power supplies design. This section defines and discusses electromagnetic interference and describes ways to mitigate its effects.

EMI/RFI Board Design: SNLA016

This generic application note defines electromagnetic interference and describes how it relates to the performance of a system. It looks at examples of inter-system noise and intra-system noise and presents techniques that can be used to ensure electromagnetic compatibility throughout a system and between systems.

Simple Success With Conducted EMI From DC/DC Converters: SNVA489

This paper details conducted EMI characteristics and mitigation techniques in switching power supplies.

Layout Tips for EMI Reduction in DC/DC Converters: SNVA638

This application note explores how the layout of your DC/DC power supply can significantly affect the amount of EMI that it produces. It will discuss several variations of a layout, analyze the results, and provide answers to some common EMI questions.

8 Device-Specific Technical Discussions

This paragraph focuses on technical considerations regarding specific devices from our portfolio. The matters discussed in those notes may not be applicable to alternative part numbers unless noted otherwise.

Optimizing the TPS62130, TPS62140, TPS62150 and TPS62160 Output Filter: SLVA463

Optimizing the TPS62175 Output Filter: SLVA543

Optimizing the TPS62090 Output Filter: SLVA519

The DCS-Control™ topology used in the devices discussed in those notes allows for a wider range of inductor and output capacitor values than traditional voltage mode controlled buck converters. More lenience can therefore be tolerated in choosing inductor and output capacitor values to accomplish specific design goals, such as transient response, loop stability, maximum output current, or output voltage ripple, based on an application's needs.

Feedforward Capacitor to Improve Stability and Bandwidth of TPS621 and TPS821-Family: SLVA466

A common method to improve the stability and bandwidth of a power supply is to use a feedforward capacitor. This improvement can be measured in both the transient response and bode plot of the new circuit. This application report details two design strategies for optimizing the feedforward capacitor value to improve transient response and circuit stability.

Optimizing TPS6206x External Component Selection: SLVA441

This report describes how to select the proper feedforward capacitor value to match a wide range of LC output filter values and optimize the application for smaller solution size, faster load-step response, lower output voltage ripple, increased output current, and/or increased control loop stability.

TPS62130A Differences to TPS62130: SLVA644

This short report describes the difference in how the power good pin is controlled between the TPS62130A and TPS62130 devices.

TPS6208x and TLV6208x Devices Comparison: SLVA803

This application report presents an overview of the differences among the TPS6208x devices, which are part of a family of high frequency synchronous step-down converters available in a 2-mm × 2-mm QFN package.

Output Voltage Selection for the TPS62400 Family of Buck Converters: SLVA254

The TPS624xx family of dual output DC/DC Converters has adjustable output voltages, which can be programmed with an external resistor divider network to set the output voltage during power up. Then, after power up, the output voltage can be changed via software to several predefined values. This application report explains how to determine the output voltage of the TPS62400 after power up and the software adjustable range of voltages.

9 Calculation, Simulation and Measurement Techniques

This section presents an overview of techniques to perform accurate calculations, simulations and measurements of the performance of a low power DC/DC converter in an application.

Calculating Efficiency: SLVA390

This application report provides a step-by-step procedure for calculating buck converter efficiency and power dissipation at operating points not provided by the data sheet.

Output Ripple Voltage for Buck Switching Regulator: SLVA630

In this application report, the analytical model for the output voltage waveform and peak-to-peak ripple voltage for buck is derived. This model is validated against SPICE TINA-TI simulations.

Accurately Measuring Efficiency of Ultralow-I_Q Devices: SLYT558

This article reviews the basics of measuring efficiency, discusses common mistakes in measuring the light-load efficiency of ultralow-I_Q devices and demonstrates how to overcome them in order to get accurate efficiency measurements.

Performing Accurate PFM Mode Efficiency Measurements: SLVA236

This note describes guidelines that assist the user in acquiring accurate PFM mode efficiency measurements.

How to Measure the Loop Transfer Function of Power Supplies: SNVA364

This application report shows how to measure the critical points of a bode plot with only an audio generator (or simple signal generator) and an oscilloscope. The method is explained in an easy to follow step-by-step manner so that a power supply designer can start performing these measurements in a short amount of time.

Simplifying Stability Checks: SLVA381

This application report explains a method for verifying relative stability of a circuit by showing the relationship between phase margin in an AC loop response and ringing in a load-step analysis.

How to Measure the Control Loop of DCS-Control™ Devices: SLVA465

This application report reviews the basics of measuring control loops, and discusses the changes for the family of DCS-Control™ devices.

HS Load/Line Transient Jigs and App Rpt for Testing POL Regulators: SNOA895

This application note discusses good practice and fundamentals for transient analysis in the lab, and describes the construction of some improved transient test devices.

10 DC/DC Converter Applications

This section gathers application notes concentrating on specific applications and design implementations of low power DC/DC converters. Example circuits are presented and their performance optimization is discussed.

Step-Down LED Driver With Dimming With the TPS621-Family and TPS821-Family: SLVA451

This application report demonstrates the TPS621x0 family as a small, simple, and easy way to implement a high-brightness LED driver.

Testing Tips for Applying External Power to Supply Outputs Without an Input Voltage: SLYT689

Powering a step-down (buck) converter with a voltage on the output and without a voltage on the input is an atypical application scenario that raises a flag for special considerations. This article explains the main concerns and their mitigation strategies.

Efficient Super-Capacitor Charging with TPS62740: SLVA678

The TI Design PMP9753 shows a concept to buffer energy in a super capacitor and therefore decouple load peaks from the battery. This application note helps designers to calculate and define the parameters like minimum and maximum voltage levels, storage capacitor size or maximum battery current.

Low-Noise CMOS Camera Supply: SLVA672

This application note describes how to design a highly efficient, low-noise CMOS Camera power supply solution based on switching regulators without the need of any additional filtering.

Step-Down Converter With Input Overvoltage Protection: SLVA664

This application report describes an input overvoltage protection circuit using a highly efficient and small step-down converter like TPS62130. It also details the design and selection of the key components and provides measurement results showing the performance of the circuit.

Step-Down Converter with Cable Voltage Drop Compensation: SLVA657

Output voltages of DC/DC converters typically are precisely regulated at the location the feedback divider is connected. In case of longer connections to the load, a voltage drop which depends on the load current must be expected. This application report describes a circuit where compensation is done by adjusting the output voltage of the converter to match the voltage drop along the cables.

Using the TPS62150 in a Split Rail Topology: SLVA616

This application report demonstrates a method of generating a split rail (bipolar +/- output voltages) supply with the TPS62150.

Using the TPS6215x in an Inverting Buck-Boost Topology: SLVA469

Using the TPS62175 in an Inverting Buck Boost Topology: SLVA542

These application reports are a how-to guide on using TI synchronous buck converters in an inverting buck-boost topology, where the output voltage is inverted or negative with respect to ground. The presented solutions are based on devices designed for many applications, such as standard 12-V rail supplies, embedded systems, and portable applications.

Powering the MSP430 From a High Voltage Input Using the TPS62122: SLVA335

This application example is presented to help designers and others who are using the MSP430 in a system with an input voltage range from 3.6 V to 15 V, and who are concerned with maintaining high efficiency and long battery life. Power requirements, illustrated schematic, operation waveforms and bill of materials are included.

Voltage Margining Using the TPS62130: SLVA489

This application report demonstrates a simple circuit that provides a ±5% margining function. This permits testing for high- and low-voltage margining for product evaluation.

11 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision * (April 2018) to Revision A (June 2021)	Page
• Updated the numbering format for tables, figures and cross-references throughout the document...................	2