Application Note

6-A DC/DC Buck Converter Selection Guide of Mid-range VIN

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ABSTRACT

Texas Instruments has broad products for power management designs. For middle-range input voltage (1.6 V - 28 V), 6 A output step-down DC/DC applications, TI provides many great hero products. To help users better make the decision and select a part designed for their applications, this application note introduces TI advanced features of buck converters, then compares TI latest parts specifications.

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1 Introduction

Middle-range input voltage (1.6 V - 28 V) power rails are common in industrial, automotive communication, personal electronics and enterprise markets. The step-down design to convert the middle-range input voltage to lower output voltage like 5 Vout/3.3 Vout/1.8 Vout/ are widely used in electrical applications.

In this article, latest TI mid-Vin 6 A buck parts are compared. Each part has its advantages and cam be an excellent choice than other parts in a special application. When users select a mid-Vin 6 A buck, this article provides the guidance to help them make a decision.

2 Features Description

This section describes some advanced features of TI buck converters.

2.1 Light Load Operation

Three operation modes of light load are mentioned in this application note.

Power Save Mode (PSM) can decrease the device switching frequency to improve efficiency at light load.

Out-of-Audio (OOA) mode is a unique control feature that keeps the switching frequency above audible frequency (20 Hz-20 KHz) with minimum reduction in efficiency, which prevents audio noise generation from the output capacitors and inductor. The *Understanding OOA™ Operation* application note describes the OOA details.

Forced Continuous Conduction Mode (FCCM) allows the inductor current to become negative in light load, the switching frequency is maintained, achieve small ripple at light load.

Table 2-1 lists the comparison between PSM, OOA, and FCCM mode.

Table 2-1. Comparison Between PSM, OOA, and FCCM Mode

Light Load Mode	PSM	OOA	FCCM
fsw	Low	Middle	High
Vout Ripple	Large	Middle	Small
Light Load Efficiency	High	Middle	Low
Suitable Applications	Require highlight load efficiency	Require high efficiency without audible noise in light load	Require almost fixed fsw and small Vout ripple across whole loading range

Besides, there is an ultra-low quiescent current (ULQ™) mode which enhances PSM mode efficiencies at very light load. ULQ™ mode is useful for prolong battery life in system standby mode.

2.2 Large Duty Operation

In the applications where Vout is close to Vin, large duty is needed to support normal regulation. Due to minimum off-time limit, if switching frequency does not change, the maximum duty-cycle is fixed. Large Duty Operation extends the high-side FET on-time, thus decreasing switching frequency and allowing large duty cycles to be maintained. The *Large Duty Cycle Operation With the TPS568230* application note describes the details.

Some parts support 100% duty-cycle mode, high-side FET is continuously switched on as long as the BOOT capacitor voltage is higher than preset UVLO threshold.

2.3 BST Cap Integrated

TPS56624x integrate the BST capacitor, helps users to save one BST cap component, but also makes the layout easy, improves thermal performance. The *TPS56X242/7 Optimize SOT563 Package Pin Out* application brief describes the details.

2.4 Voltage Identification Control

Some devices in the table apply the Voltage Identification control (VID) control, such as TPS566250, TPS5137x, using the logic pin input or I2C interface to achieve dynamic output change and meet processor's adaptive voltage requirements.

2.5 Output-voltage Tracking

For TPS54J06x, the SS/REFIN pin can be used as an analog input to accept an external reference. When an external voltage signal is applied to SS/REFIN pin, it acts as the reference voltage, thus the FB voltage follows this external voltage signal. *TPS54J06x* data sheet describes the details.

3 Control Modes Description

For the selection of devices, control mode is one important aspect which determines load transient performance, switching frequency accuracy and output accuracy.

Among 6 A converters in TI portfolio, the control modes can be easily divided into two categories: PCM/ACM and D-CAP2™/D-CAP3™.

3.1 PCM/ACM

Peak current mode (PCM) and internally compensated advanced current mode (ACM) are two commonly used control modes in TI fixed frequency buck regulators portfolio.

Fixed frequency control modes can provide better switching frequency accuracy, which can offer low EMI / noise via true fixed frequency, but at the cost of a slower transient response compared with D-CAP™ control mode with adaptive constant on time (COT) control method.

Peak current mode control with a fixed-frequency modulator requires Type II compensation circuitry to achieve acceptable bandwidth and phase margins for stability, increasing design complexity, size and cost.

Internally compensated advanced current mode (ACM) is a control topology proposed by TI based on PCM control scheme. It addresses a major challenge of PCM – especially in high frequency operation – is the minimum on time required to properly sense the current information to overcome large noise compared to the small sensed signal. Furthermore, it could achieve larger signal-to-noise ratio to achieve multi-megahertz switching frequency and could offer better load transient performance with internal compensation.

3.2 D-CAP2™/D-CAP3™

The term D-CAP means the current information is Direct connection to the output CAPacitor. TI's first D-CAP™ controller, the TPS51116, was realized by combining a controller with a constant on-time modulator. Today, TI has a family of products featuring various modulators and next-generation forms of the original D-CAP™ control.

The first generation D-CAP™ requires large ESR at the output bulk cap to stabilize the loop. D-CAP2™ doesn't have this requirement, supports the output ceramic capacitors with internal phase compensation. An internal inductor ripple current "emulator" circuit is used to generate a sufficient ramp for D-CAP2™ control to compare the output voltage vs. the reference voltage to determine whether to turn the PWM on or not.

D-CAP3™ also supports the output ceramic capacitors with internal phase compensation. D-CAP3™ mode improves the output voltage set-point accuracy by implementing specialized circuits to remove the half time ramp magnitude.

3.3 Control Modes Comparison

Table 3-1 shows a brief comparison of the control modes.

Table 3-1. Comparison of Control Modes

	ACM	PCM	D-CAP2™	D-CAP3™
DC Accuracy	Best	Best	½ ripple DC offset	Good
Compensation	Internal	External/Internal	Internal	Internal
Frequency Accuracy	Best	Best	Good at Steady State	Good at Steady State
Predictable EMI Freq	Best	Best	Good	Good
Transient	Good	Good	Best	Best
Stackable	Yes	Yes	N/A	N/A
Sync Method	Edge Trigger	Edge Trigger	No	No
Noise susceptibility(Jitter)	Best	Good	Good	Good

4 Specifications Comparison

Table 4-1 shows key feature comparison of 1.6 V≤ Vin ≤ 20 V, 6 A buck converters.

Table 4-1. 1.6 V ≤ Vin ≤ 20 V, 6 A Buck Converters Comparison

Part Number	Vin Range	ABS Vin	Vref (full temp range)	Vout Range	HS/LS FETs Rds_on	Fsw	PG/SS Pin	Light Load Operation	OC Limit	UV/OV Recovery	Control Mode	Package	Other Features
TPS54J060	**2.7**-16 V (w/ bias); 4-16 V (w/o bias)	18 V	0.9 V±**1%**	0.9-5.5 V	22/**8.5**mΩ	600 k, 1.1 M, **2.2 MHz**	Yes	PSM, FCCM	Adjustable, up to **9.5A**	Latch	D-CAP3™	QFN-14, 2x3	Output-voltage tracking;
TPS54J061	**2.7**-16 V (w/ bias); 4-16 V (w/o bias)	18 V	0.6 V±**1%**	0.6-5.5 V	22/**8.5**mΩ	600 k, 1.1 M, **2.2 MHz**	Yes	PSM, FCCM	Adjustable, up to **9.5A**	Non-latch	D-CAP3™	QFN-14, 2x3	Output-voltage tracking;
TPS566231	3-18 V	20 V	0.6V±1.5%	0.6-7V	**20.8**/10.6mΩ	600kHz	No PG	PSM	7.4A	Non-latch	D-CAP3™	QFN-9, **1.5x2**	ULQ™ mode; Large duty operation;
TPS566231P	3-18V	20V	0.6V±1.5%	0.6-7V	**20.8**/10.6mΩ	600kHz	No SS	PSM	7.4A	Non-latch	D-CAP3™	QFN-9, **1.5x2**	ULQ™ mode; Large duty operation;
TPS566238	3-18V	20V	0.6V±1.5%	0.6-7V	**20.8**/10.6mΩ	600kHz	No PG	FCCM	7.4A	Non-latch	D-CAP3™	QFN-9, **1.5x2**	Large duty operation;
TPS566238P	3-18V	20V	0.6V±1.5%	0.6-7V	**20.8**/10.6mΩ	600kHz	No SS	FCCM	7.4A	Non-latch	D-CAP3™	QFN-9, **1.5x2**	Large duty operation;
TPS566242 ***New***	3-16V	18V	0.6V±1.5%	0.6-7V	27.7/14.8mΩ	600kHz	No PG and SS	PSM	7.4A	Non-latch	D-CAP3™	SOT563-6, **1.6x1.6**	BST cap integrated; Large duty operation;
TPS566247 ***New***	3-16 V	18V	0.6V±1.5%	0.6-7V	27.7/14.8mΩ	600 kHz	No PG and SS	FCCM	7.4A	Non-latch	D-CAP3™	SOT563-6, **1.6x1.6**	BST cap integrated; Large duty operation;
TPS566235	4.5-18V	20V	0.6V±1.5%	0.6-7V	25/12mΩ	600kHz	No SS	**PSM, OOA, FCCM**	7.6A	Non-latch	D-CAP3™	QFN-13, 3*2	ULQ™ mode;
TPS543620 ***New***	4-18V	20V	0.5V±**0.5%**	**0.5**-7V	25/**6.5**mΩ	500k,750k, 1M,1.5M, **2.2MHz**	Selectable SS time	FCCM	4.2/7.3A	Non-latch	ACM	QFN-14, 2.5x3	Sync to external clock;
TPS54620	**1.6**-17V (w/ bias); 4.5-17V (w/o bias)	20V	0.8V±**1%**	0.8-15V	26/19mΩ	200k-**1.6MHz**	Yes	FCCM	10A	Non-latch	PCM	QFN-14, 3.5x3.5	Sync to external clock;
TPS54622	**1.6**-17V (w/ bias); 4.5-17V (w/o bias)	20V	0.6V**±1%**	0.6-15V	26/19mΩ	200k-**1.6MHz**	Yes	FCCM	10A	Non-latch	PCM	QFN-14, 3.5x3.5	Sync to external clock;

Table 4-1. 1.6 V ≤ Vin ≤ 20 V, 6 A Buck Converters Comparison (continued)

Part Number	Vin Range	ABS Vin	Vref (full temp range)	Vout Range	HS/LS FETs Rds_on	Fsw	PG/SS Pin	Light Load Operation	OC Limit	UV/OV Recovery	Control Mode	Package	Other Features
TPS54622-EP	**1.6**-17V (w/ bias); 4.5-17V (w/o bias)	20V	0.6V**±1%**	0.6-15V	26/19mΩ	200k-**1.6MHz**	Yes	FCCM	10A	Non-latch	PCM	QFN-14, 3.5x3.5	Sync to external clock; Support defense, aerospace, and medical applications
TPS54623	**1.6**-17V (w/ bias); 4.5-17V (w/o bias)	20V	0.6V**±1%**	0.6-15V	26/19mΩ	200k-**1.6MHz**	Yes	PSM	10A	Non-latch	PCM	QFN-14, 3.5x3.5	Sync to external clock;
TPS62184	4-17V	20V	0.8V**±1%**	0.9-1.8V	27/21mΩ	Depends on Vin & Vout	Yes	PSM	4.2A (each phase)	Non-latch	PCM	BGA-24, 2.1x3.1	Low Iq; Dual-phase; 100% duty operation
TPS62180	4-15V	17V	0.8V**±1%**	0.9-6V	27/21mΩ	Depends on Vin & Vout	Yes	PSM	4.7A (each phase)	Non-latch	PCM	BGA-24, 2.1x3.1	Low Iq; Dual-phase; 100% duty operation
TPS62182	4-15V	17V	**±1%**	3.3V	27/21mΩ	Depends on Vin & Vout	Yes	PSM	4.7A (each phase)	Non-latch	PCM	BGA-24, 2.1x3.1	Low Iq; Dual-phase; 100% duty operation
TPS54628	4.5-18V	20V	0.765V±1.8%	0.76-5.5V	36/28mΩ	650kHz	No PG	PSM	7.3A	Non-latch	D-CAP2™	HSOP-8, 4.9x3.9	
TPS54627	4.5-18V	20V	0.765V±1.8%	0.76-5.5V	36/28mΩ	650kHz	No PG	FCCM	7.3A	Non-latch	D-CAP2™	HSOP-8, 4.9x3.9	
TPS56628	4.5-18V	20V	0.765V±1.8%	0.76-5.5V	36/28mΩ	650kHz	No SS	PSM	7.3A	Non-latch	D-CAP2™	HSOP-8, 4.9x3.9	
TPS566250	4.5-17V	19V	0.6V±1.6%	0.6-1.87V	44/23mΩ	650kHz	No	PSM	9.5A	Non-latch	D-CAP2™	HSOP-8, 4.9x3.9	VID control through I2C;
TPS54625 **(6.5A)**	4.5-18V	20V	0.765V±1.8%	0.76-5.5V	36/28mΩ	650kHz	Yes	FCCM	8.2A	Latch	D-CAP2™	HTSSOP-14, 5x6.4	
TPS54626 **(6.5A)**	4.5-18V	20V	0.765V±1.8%	0.76-5.5V	36/28mΩ	650kHz	Yes	PSM	8.2A	Latch	D-CAP2™	HTSSOP-14, 5x6.4	

Table 4-2 shows key feature comparison of 3 V≤ Vin ≤ 28 V, 6 A buck converters.

Table 4-2. 3 V < Vin ≤ 28 V 6 A Buck Converters Comparison

Part Number	Vin Range	ABS Vin	Vref (full temp range)	Vout Range	HS/LS FETs Rds_on	Fsw	PG/SS Pin	Light Load Operation	OC Limit	UV/OV Recovery	Control Mode	Package	Other Features
TPS566335*	4.5-23V	25 V	0.6V±1.5%	0.6-7V	25/12 mΩ	600 kHz	No SS	PSM, OOA, FCCM	7.6 A	Non-latch	D-CAP3™	QFN-13, 3x2	
TPS51371* (6.5 A)	3-24 V (w/ bias)	26 V	±1.5%	0.7-1.05 V	27/12 mΩ	600 kHz	No SS	PSM	7.6 A	Latch	D-CAP3™	QFN-13, 3x2	2-bit VID control; ULQ™mode
TPS51372* (6.5 A)	3-24 V (w/ bias)	26 V	±1.5%	0.7-1.8 V	27/12 mΩ	600 kHz	No SS	PSM	7.6 A	Latch	D-CAP3™	QFN-13, 3x2	2-bit VID control; ULQ™mode
TPS56637	4.5-**28 V**	**32 V**	0.6 V±1.5%	0.6-**13 V**	26/12mΩ	500kHz	No SS	PSM, FCCM	7.5 A	Non-latch	D-CAP3™	QFN-10, 3x3	

PG: Power Good.

SS: Soft-start.

OC: Overcurrent.

UV: Undervoltage.

OV: Overvoltage.

*: Contact TI local sales team for device more information.

5 References

- Texas Instruments, *TPS56X242/7 Optimize SOT563 Package Pin Out*, application brief.
- Texas Instruments, *Large Duty Cycle Operation With the TPS568230*, application note.
- Texas Instruments, *Understanding OOA™ Operation*, application note.

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