Application Note

8-A DC/DC Buck Converter Selection Guide of Mid-range VIN (1.5 V - 28 V)

Miranda Gu, Andrew Xiong, Yuchang Zhang, Lishuang Zhao

ABSTRACT

Texas Instruments has a broad range of products for power management designs. For middle-range input voltage (1.5 V - 28 V), 8 A output step-down DC/DC applications, TI provides several great products. To assist with the decision and selection of a desired part for applications, this application note introduces TI advanced features of buck converters and also compares TI's latest parts specifications.

Table of Contents

List of Tables

Trademarks

ULQ™D-CAP2™D-CAP3™ are trademarks of Texas Instruments.
All trademarks are the property of their respective owners.

1 Introduction

Middle-range input voltage (1.5 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 into a 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 8 A buck parts are compared. Each part has their advantages and can be more designed for than other parts in a special application. When users select a mid-Vin 8 A buck, this article can provide 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
Designed for Applications	Require high light-load efficiency	Require high efficiency without audible noise in light load	Require almost fixed fsw and small Vout ripple across whole loading range

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.

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

3.1 PCM and 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 could provide better switching frequency accuracy, which could 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 solution 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™ and D-CAP3™

The term D-CAP means the current information is **D**irect connection to the output **CAP**acitor. 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	1/2 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 1.5 V≤ Vin ≤ 20 V, 8 A buck converters.

Table 4-1. 1.5 V ≤ Vin ≤ 20 V, 8 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
TPS568231 *New*	**3.8**-17V (w/ bias); 4.5-17V (w/o bias)	20 V	0.6 V**±1%**	0.6-5.5 V	**7.8/3.2mΩ**	400k, 800k, **1.2MHz**	Yes	PSM, FCCM	7.1/9.4A	Non-latch	D-CAP3™	QFN-18, 3.5x3.5	Optional external 5 V bias;
TPS568215	4.5-17 V	20 V	0.6 V**±1%**	0.6-5.5 V	19/9.4mΩ	400k, 800k, **1.2MHz**	Yes	PSM, FCCM	7.1/9.4A	Non-latch	D-CAP3™	QFN-18, 3.5x3.5	Optional external 5 V bias;
TPS568215OA	4.5-17 V	20 V	0.6 V**±1%**	0.6-5.5 V	19/9.4mΩ	400k, 800k, **1.2MHz**	Yes	OOA, FCCM	7.1/9.4A	Non-latch	D-CAP3™	QFN-18, 3.5x3.5	Optional external 5 V bias;
TPS568230	4.5-18 V	22 V	0.6 V+1.8%, -1.3%	0.6-7 V	19.5/9.5 mΩ	600k, 800k, **1 MHz**	Yes	PSM, OOA, FCCM	9.8A	Non-latch	D-CAP3™	QFN-20, 3x3	Large duty operation; ULQ™ mode;
TPS543820 *New*	4-18 V	20 V	0.5 V**±0.5%**	0.5-7 V	25/6.5mΩ	500k- **2.2 MHz**	Selectable SS time	FCCM	7.4/10.4A	Non-latch	ACM	QFN-14, 2.5x3	Sync to external clock;
TPS543820E *New*	4-18 V	20 V	0.5 V**±0.5%**	0.5-7 V	25/6.5mΩ	500k- **2.2 MHz**	Selectable SS time	FCCM	7.4/10.4A	Non-latch	ACM	QFN-14, 2.5x3	Sync to external clock; Supports defense, aerospace and medical applications
TPS54824	4.5-17 V	19 V	0.6 V**±0.8%**	0.6-**12 V**	14.1/6.1 mΩ	200k-**1.6 MHz**	Yes	FCCM	11.4A	Non-latch	PCM	QFN-18, 3.5x3.5	Sync to external clock; 100% duty operation;
TPS54821	**1.6**-17 V (w/ bias); 4.5-17 V (w/o bias)	20	0.6 V**±1%**	0.6-**15 V**	26/19mΩ	200k-**1.6 MHz**	Yes	FCCM	11.5A	Non-latch	PCM	QFN-14, 3.5x3.5	Sync to external clock; 100% duty operation;
TPS53513	**1.5**-18 V (w/ bias)	**30**	0.6 V**+0.5%, -0.7%**	0.6-5.5 V	13.8/5.9 mΩ	250k-**1 MHz**	No SS	PSM, FCCM	Adjustable, max 12 A	Latch	D-CAP3™	QFN-28, 4.5x3.5	
TPS568236 *New*	4.5-18 V	22 V	0.6 V±1.5%	0.6-5.5 V	22/11mΩ	600 kHz	Yes	PSM, FCCM	11 A	Non-latch	D-CAP3™	QFN-12, 2x3	Large duty operation; ULQ™ mode;

Table 4-2 shows key feature comparison of 1.5 V≤ Vin ≤ 28 V, 8 A buck converters.

Table 4-2. 1.5 V ≤ Vin ≤ 28 V 8 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
TPS51383 *New*	4.5-24 V	28 V	±1.5%	3.36 V	22/11mΩ	600 kHz	No SS	PSM, OOA	11 A	Latch	D-CAP3™	QFN-12, 2x3	w/ 3.3 V LDO; ULQ™ mode;
TPS51386 *New*	4.5-24 V	28 V	0.6 V±1.5%	0.6-5.5 V	22/11mΩ	600 kHz	Yes	PSM, OOA	11 A	Latch	D-CAP3™	QFN-12, 2x3	Large duty operation; ULQ™ mode;
TPS51385 *New* **(7A)**	4.5-24 V	28 V	0.6 V±1.5%	0.6-5.5 V	22/11mΩ	1 MHz	Yes	PSM, OOA	8.8A	Latch	D-CAP3™	QFN-12, 2x3	Large duty operation; ULQ™ mode;
TPS51393*	4.5-24 V	26 V	±1.5%	3.36 V	19.5/9.5mΩ	625 kHz	No SS	OOA	9.6A	Latch	D-CAP3™	QFN-20, 3x3	w/ 3.3 V LDO; ULQ™ mode;
TPS51395*	4.5-24 V	26 V	±1.6%	5.1 V	19.5/9.5mΩ	625 kHz	No SS	OOA	9.6A	Latch	D-CAP3™	QFN-20, 3x3	w/ 5 V LDO; ULQ™ mode; Large duty operation;
TPS51393P*	4.5-24 V	26 V	±1.5%	3.36 V	19.5/9.5 mΩ	610 kHz	No SS	PSM	9.6A	Latch	D-CAP3™	QFN-20, 3x3	w/ 3.3 V LDO; ULQ™ mode;
TPS51395P*	4.5-24 V	26 V	±1.6%	5.1 V	19.5/9.5 mΩ	610 kHz	No SS	PSM	9.6A	Latch	D-CAP3™	QFN-20, 3x3	w/ 5 V LDO; ULQ™ mode; Large duty operation;
TPS51396A	4.5-24 V	26 V	0.6 V+1.8%, -1.3%	0.6-7 V	19.5/9.5mΩ	600k,800 k,**1 MHz**	Yes	PSM, OOA	9.8A	Latch	D-CAP3™	QFN-20, 3x3	Large duty operation; ULQ™ mode;
TPS568330*	4.5-23 V	26 V	0.6 V+1.8%, -1.3%	0.6-7 V	19.5/9.5mΩ	600k,800 k,**1 MHz**	Yes	**PSM, OOA, FCCM**	9.8A	Non-latch	D-CAP3™	QFN-20, 3x3	Large duty operation; ULQ™ mode;
TPS51363	3-22 V	**30 V**	0.6 V**±1%**	0.6-2 V	20/10mΩ	400 k, 800 kHz	Yes	PSM	8/12A	Latch	D-CAP2™	QFN-28, 3.5x4.5	Remote sense;
TPS53318	1.5-22 V (w/ bias)	**30 V**	0.6 V**±1%**	0.6-5.5 V	-	250k-**1 MHz**	Selectable SS time	PSM, FCCM	Adjustable, max 10.5A	Latch	D-CAP™	QFN-22, 6x5	
TPS56837 *New*	4.5-**28 V**	**32 V**	0.6 V±1.5%	0.6-**13 V**	20.4/9.5mΩ	500k,800 k,**1.2MHz**	Yes	PSM	7.2/9.6A	Non-latch	D-CAP3™	QFN-10, 3x3	Large duty operation; ULQ™ mode;
TPS56838 *New*	4.5-**28 V**	**32 V**	0.6 V±1.5%	0.6-**13 V**	20.4/9.5mΩ	500k,800 k,**1.2MHz**	Yes	FCCM	7.2/9.6A	Non-latch	D-CAP3™	QFN-10, 3x3	Large duty operation; ULQ™ mode;
TPS56836 *New*	4.5-**28 V**	**32 V**	0.6 V±1.5%	0.6-**13 V**	20.4/9.5mΩ	500k,800 k,**1.2MHz**	Yes	OOA	7.2/9.6A	Non-latch	D-CAP3™	QFN-10, 3x3	Large duty operation; ULQ™ mode;

PG: Power Good.

SS: Soft-start.

OC: Overcurrent.

UV: Undervoltage.

OV: Overvoltage.

* Contact TI local sales team for device more information.

5 Summary

This application note introduces TI advanced features of buck converters, including light load operation, large duty operation, and different control modes. The application note also compares TI's latest 8-A Mid-range Vin Buck Converters specifications.

6 References

- Texas Instruments, *Understanding OOA Operation*, application note.
- Texas Instruments, *Large Duty Cycle Operation With the TPS568230*, application note.