Application Note

Configuring Output Voltage for TPSM8290x Family of Buck Modules at 1MHz in Auto PFM/PWM Mode

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ABSTRACT

TPSM8290x family of ICs is high efficiency, low I_Q synchronous step-down dc-dc converter module available in MicroSiP package. These modules are available in current ratings of 1A (TPSM82901), 2A (TPSM82902) and 3A (TPSM82903). This application note is an extension of in datasheet and explains in detail, various voltage configurations that are applicable for 1MHz Auto PFM/PWM operation. Extending the operating range of these modules at 1MHz enables achieving better efficiency at low loads compared to 2.5MHz. It also precisely highlights the input and output voltage range and load current, enabling the use of these modules in various applications.

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Trademarks

1 Introduction

This application note highlights the operating conditions applicable for the TPSM8290x family of ICs. These operating conditions are only applicable to Auto PFM/PWM mode at 1MHz operation. For 2.5MHz switching frequency, all 3 parts i.e. TPSM82901, TPSM82902 and TPSM82903 perform as mentioned in **Table 7-1** in the datasheet. Here is the table from datasheet for reference

CAUTION

For each operating mode and switching frequency, the following V_{OUT} range is recommended:

Table 7-1. Recommended V_{OUT} Ranges with Respect to MODE and F_{SW}

Mode	F_{SW} (MHz)	V_{OUT}
Auto PFM/PWM	1 MHz	0.4 V < V_{OUT} < 2.0 V
Forced PWM	1 MHz	0.4 V < V_{OUT} < 2.0 V
Auto PFM/PWM with AEE	2.5 MHz	0.4 V < V_{OUT}< 5.5 V
Forced PWM	2.5 MHz	2.0 V < V_{OUT} < 5.5 V

Failure to follow the recommended V_{OUT} ranges causes the device to malfunction.

For 1MHz there are some constraints that originate as a function of inductor saturation, derating of the inductor and the FET current limit. These constraints hold true for different test cases. This is demonstrated through an example in the following section

2 Detailed Description

2.1 Inductor Specifications for TPSM8290x

The relevant inductor specifications used in the module are given below:

L= **1uH**

Rated current (Itemp) (Based on Temperature rise) = **3.3A**

Rated current (Isat) (Based on Inductance change) = **4.7A**

2.2 Current limit for TPS8290x family if ICs

The current limits for all 3 devices are mentioned below for reference

- TPSM82901

V_I = 3 V to 17 V, T_J = -40°C to +125°C, Typical values at V_I = 12.0 V and T_A = 25°C,unless otherwise noted

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{LIM}	High-side FET current limit	TPSM82901	2.6	3.4	4.3	A
	Low-side FET current limit	TPSM82901	2.4	2.8	3.2	A
I_{LIM_SINK}	Low-side FET sink current limit		1.3	1.7	2.5	A

- TPSM82902

V_I = 3 V to 17 V, T_J = -40°C to +125°C, Typical values at V_I = 12.0 V and T_A = 25°C,unless otherwise noted

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{LIM}	High-side FET current limit	TPSM82902	3.6	4.4	5.3	A
	Low-side FET current limit	TPSM82902	3.4	3.8	4.2	A
I_{LIM_SINK}	Low-side FET sink current limit		1.3	1.7	2.5	A

- TPSM82903

V_I = 3 V to 17 V, T_J = -40°C to +125°C, Typical values at V_I = 12.0 V and T_A = 25°C,unless otherwise noted

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{LIM}	High-side FET current limit		4.1	4.9	5.8	A
	Low-side FET current limit		3.8	4.3	4.7	A
I_{LIM_SINK}	Low-side FET sink current limit		1.3	1.7	2.5	A

3 Design Example

Let us try to demonstrate whether **TPSM82903** can be operated for the following conditions

Parameter	Value
Min. Input Voltage (V_{in_min})	9V
Max. Input Voltage (V_{in_max})	13.2 (12V+10%)
Output voltage (V_{out_max})	5.2V
Output current	1.1A (1A+10%)
Fsw	1MHz
L_nominal	1uH
L_derated	0.76uH (considering 20% derating on 95% of the actual inductor value)

Step1: Calculate Ton

$$T_{ON} = \frac{V_{OUT}}{V_{IN}} * \frac{1}{f_{sw}} \quad (1)$$

$$T_{ON} = 394ns \quad (2)$$

Step 2: Calculate peak inductor current in pulse skip mode, ILPSM

$$IL_{PSM(peak)} = \frac{(V_{IN} - V_{OUT})}{L} * T_{ON} \quad (3)$$

$$IL_{PSM(peak)} = 4.14A \quad (4)$$

With no load, the converter is in PSM (Pulse Skip Mode). The inductor peak current should not cross **4.1A** which is the minimum value for High-side FET current limit of TPSM82903. This parameter determines the range of voltage for which the module can be operated.

Step 3: Calculate IL_{max} and IL_{min} @ V_{in_max}

$$IL_{max} = I_{out} + \frac{\Delta IL}{2} \quad (5)$$

$$IL_{max} = 1.1 + \frac{4.14}{2} = 3.17A \quad (6)$$

$$IL_{min} = I_{out} - \frac{\Delta IL}{2} \quad (7)$$

$$IL_{min} = 1.1 - \frac{4.14}{2} = -0.97A \quad (8)$$

Negative IL_{min} implies that the converter is in DCM mode for 1.1A load current. Hence, we would have to use DCM formula to calculate duty cycle given below.

$$V_{OUT} = V_{IN} * \left[\frac{2*D}{D + \sqrt{D^2 + \frac{8*L}{R*T}}} \right] \quad (9)$$

Calculating for D, we get

$$D = 0.29 \quad (10)$$

Step 4: Calculate IL_{max} with D value from step 3

$$IL_{max} = \frac{V_{IN} - V_{OUT}}{L \times f_{SW}} \times D \quad (11)$$

$$IL_{max} = 3.16A \quad (12)$$

The peak current is 3.16A which is lower than both rated and saturation current limit of the inductor.

Hence, for the given operating condition, the peak current at no load neither exceeds the current limit of the HSFET nor the rated current of the inductor.

4 Applicable operating conditions at 1MHz for TPSM8290x ICs

Using the approach in **Section 3**, the table below has been populated for all TPSM8290x ICs

Applicable operating conditions for TPSM82901

Vin	**Vout**		
	≤ 2V	**> 2V - ≤ 3.3V**	**≤ 5V**
3V <Vin ≤ 6V	≤ 1A	≤ 1A	**x**
6V < Vin ≤ 9V	≤ 1A	≤ 1A	**x**
9V < Vin ≤ 12V	≤ 1A	≤ 1A	**x**
12V < Vin ≤ 17V	≤ 1A	**x**	**x**

A 10% margin on the input voltage and load current is considered.

Applicable operating conditions for TPSM82902

Vin	**Vout**		
	≤ 2V	**> 2V - ≤ 3.3V**	**5 - 5.2V**
3V < Vin ≤ 6V	≤ 2A	≤ 2A	**x**
6V < Vin ≤ 9V	≤ 2A	≤ 2A	≤ 1.5A
9V < Vin ≤ 12V	≤ 2A	≤ 1.5A	**x**
12V < Vin ≤ 17V	≤ 2A	**x**	**x**

A 10% margin on the input voltage and load current is considered.

Applicable operating conditions for TPSM82903

Vin	**Vout**		
	≤ 2V	**> 2V - ≤ 3.3V**	**5 - 5.2V**
3V < Vin ≤ 6V	≤ 3A	≤ 3A	**x**
6V < Vin ≤ 9V	≤ 3A	≤ 2.5A	≤ 2.2A
9V < Vin ≤ 12V	≤ 3A	≤ 2.2A	≤ 1A
12V < Vin ≤ 17V	≤ 3A	≤ 2.2A	**x**

A 10% margin on the input voltage and load current is considered.

5 Summary

TPSM8290x family of ICs can be configured in 1MHz, Auto PFM/PWM mode for various output voltages and load current based on input voltage range, catering to a wide range of applications.

6 References

1. TPSM82901, 1-A, 3-V to 17-V, High Efficiency and Low IQ Buck Converter Module in a MicroSiPTM Package with an Integrated Inductor datasheet
2. TPSM82902, 2-A, 3-V to 17-V, High Efficiency and Low IQ Buck Converter Module in a MicroSiPTM Package with an Integrated Inductor datasheet
3. TPSM82903, 3-A, 3-V to 17-V, High Efficiency and Low IQ Buck Converter Module in a MicroSiPTM Package with an Integrated Inductor datasheet (Rev. B)
4. TPSM8290x Step-Down Converter Evaluation Module User's Guide

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