High Efficiency DC/DC Power Module

MSN12AD12-MP

FEATURES:

- High Power Density Power Module
- Typical Load:10A for 0.6V ~ 2.5V
- Typical Load:8A for 3.3V ~ 5.5V
- Input Voltage Range from 4.5V to 16V
- Output Voltage Range from 0.6V to 5.5V
- 94.5% Peak Efficiency at 12Vin to 3.3Vout
- Protections (Non-Latch OCP, UVP, UVLO, OTP and Latch-Off for OVP)
- Differential Output Voltage Remote Sense
- Programmable Soft-Start
- Pre-Biased Output
- Forced CCM Operation
- Power Good Indication
- Output Voltage Tracking
- Size 8.6mm x 7.5mm x 6.5mm
- Pb-free (RoHS compliant)
- MSL 3, 245ºC Reflow

APPLICATIONS:

- General Buck DC/DC Conversion
- DC Distributed Power System
- Telecom and Networking Equipments
- Servers System

GENERAL DESCRIPTION:

The MSN12AD12-MP is a high frequency, high power density and complete DC/DC power module. The PWM controller, power MOSFETs and most of support components are integrated in one hybrid package.

The features of MSN12AD12-MP include constant-on-time (COT) control mode that provides fast transient response and eases loop stabilization. Besides, MSN12AD12-MP is an easy to use DC/DC power module, it only needs input/output capacitors, one voltage dividing resistor, one over current protection resistor and one resistor of MODE pin to perform properly.

The low profile and compact size enables utilization of space on the bottom or top of PC boards either for highly density point of load regulation to save the space and area. It is suitable for automated assembly by standard surface mount equipment and complies with Pb-free and RoHS compliance.

TYPICAL APPLICATION CIRCUIT & PACKAGE SIZE:

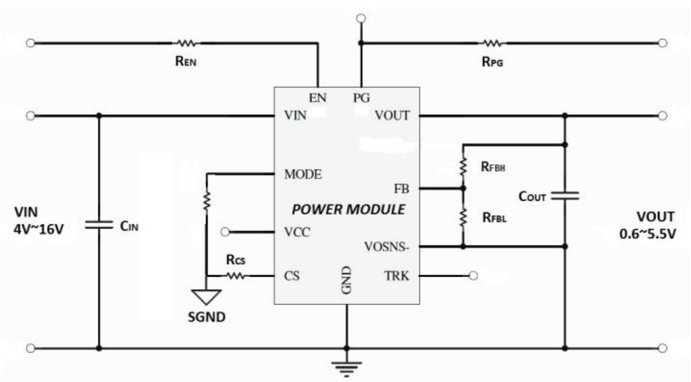


FIG.1 TYPICAL APPLICATION CIRCUIT

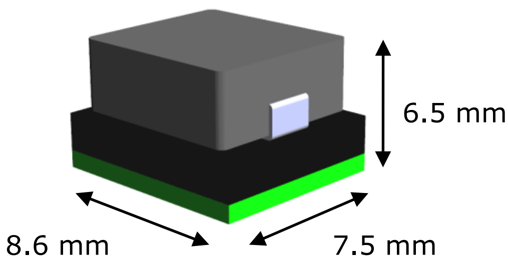


FIG.2 HIGH DENSITY POWER MODULE

ORDER INFORMATION:

Part Number	Ambient Temp. Range (°C)	Package (Pb-Free)	MSL	Note
MSN12AD12-MP	-40 ~ +85	LGA	Level 3	-

Order Code	Packing	Quantity
MSN12AD12-MP	Tape and reel	1000

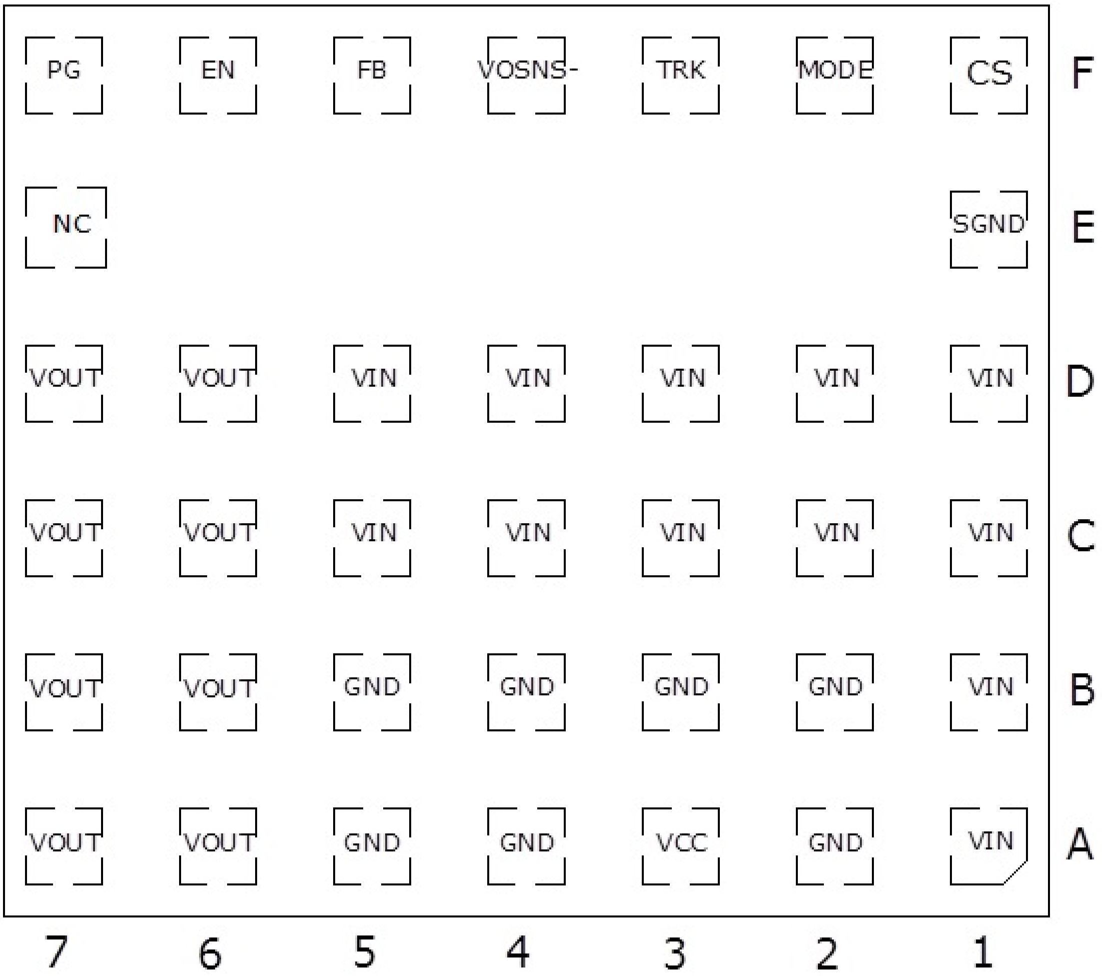
ELECTRICAL SPECIFICATIONS:

CAUTION: Do not operate at or near absolute maximum rating listed for extended periods of time. This stress may adversely impact product reliability and result in failures outside of warranty.

Parameter	Description	Min.	Typ.	Max.	Unit
■ Absolute Maximum Ratings					
VIN to GND	Continuous	-	-	+18	V
SW to GND	Continuous	-0.3	-	VIN+0.3	V
VCC to GND		-	-	+4.5	V
EN to GND	Continuous	-	-	+16	V
All other pins to GND		-0.3	-	+4.3	V
Tc	Operating case temperature	-	-	+110	℃
Tj	Operating junction temperature	-40	-	+125	℃
Tstg	Storage temperature	-40	-	+125	℃
■ Thermal Information					
$R_{th}(j_{choke}\text{-}a)$(1)	Thermal resistance from junction to ambient (note 1)	-	13	-	℃/W
■ Recommendation Operating Ratings					
VIN	Input Supply Voltage	+4.5	-	+16.0	V
VOUT	Adjusted Output Voltage	+0.6	-	+5.5	V
Ta	Ambient Temperature	-40	-	+85	℃

NOTES:
1. $R_{th}(j_{choke}\text{-}a)$ is measured with the component mounted on an effective thermal conductivity test board on 0 LFM condition. The test board size is 80mm×80mm×1.6mm with 4 layers, 2oz per layer. The test condition is complied with JEDEC EIJ/JESD 51 Standards.

PIN CONFIGURATION:



TOP VIEW

PIN DESCRIPTION:

Symbol	Pin No.	Description
VIN	A1, B1, C1~5, D1~5	Power input pin. It needs to be connected to input rail. It also needs to be connected to thermal dissipation layer by vias connection.
VCC	A3	Internal 3V LDO output. The driver and control circuits are powered from the VCC voltage.
GND	A2,A4~5, B2~5	System ground. All voltage levels are referenced to the pins. All pins should be connected together with a ground plane
VOUT	A6~7, B6~7, C6~7, D6~7	Power output pin. It needs to be connected to output rail. It also needs to be connected to thermal dissipation layer by vias connection.
SGND	E1	Analog ground. Select AGND as the control circuit reference point.
NC	E7	No connect.
CS	F1	Current limit. Connect a resistor to ground to set the current limit trip point.
MODE	F2	Connect a 60.4KΩ resistor to SGND for 1MHz force CCM operation.
TRK	F3	External tracking voltage input. The input signal of this pin is the tracking reference for the module output voltage. Otherwise, place a decoupling ceramic capacitor between TRK and VOSNS- as close to the module as possible. The capacitance of this capacitor determines the soft start time.
VOSNS-	F4	Remote sense negative input. Connect VOSNS- to the negative side of the voltage sense point directly. Short VOSNS- to GND if the remote sense is not used.
FB	F5	Feedback. Connect a resistor between this pin and VOSNS- for adjusting output voltage. Place this resistor as closely as possible to this pin and VOSNS-.
EN	F6	Enable – to pull the pin higher than 1.22V Disable – to pull the pin lower than 0.8V
PG	F7	Power good output. PG is an open-drain signal. A pull-up resistor connected to VCC to indicate a logic high signal if the output voltage is within regulation.

ELECTRICAL SPECIFICATIONS: (Cont.)

Conditions: T_A = 25 ºC, unless otherwise specified. Test Board Information: 80mm×80mm×1.6mm, 4 layers 2 oz. The output ripple and transient response measurement is short loop probing and 20MegHz bandwidth limited. Cin =22uF/25V/1206/X7R MLCC * 2 pcs, Cout = 47uF/10V/1210/X7R MLCC * 3 pcs.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
■ Input Characteristics						
$I_{in(VIN)}$	Input supply bias current	Vin = 12V, Vout = 1.8V, Iout = 0A, 1MHz	-	27	-	mA
$I_{S(VIN)}$	Input supply current	Vin = 12V, Vout = 1.8V, Iout = 10A, 1MHz	-		-	A
■ Output Characteristics						
$I_{OUT(DC)}$	Output continuous current range	Vin=12V, Vout=1.8V	0	-	10	A
$\Delta V_{OUT}/\Delta V_{IN}$	Line regulation	Vin = 4.5V to 16V Vout = 1.8V, Iout = 10A	-	0.5	-	%
$\Delta V_{OUT}/\Delta I_O$	Load regulation	Vin = 12V Vout = 1.8V, Iout = 0~10A	-	0.5	-	%
$V_{OUT(AC)}$	Output ripple voltage	Vin = 12V, Vout = 1.8V Iout = 10A	-	14	-	mVp-p
$V_{O,set}$	Output voltage set point	Vin=12V, Vout=1.8V with 0.1% resistor	-1.0		+1.0	%Vo,set
F_{SW}	Switching Frequency	MODE connect a 60.4KΩ to SGND	800	1000	1200	KHz
■ Enable Signal						
V_{ENABLE}	Logic high threshold Voltage	Module On	1.17	1.22	1.27	V
	Logic low threshold Voltage	Module Off	-	-	0.8	V
■ Power Good						
V_{PGH}	Power good high threshold	FB Voltage	>96%	-	<110%	V_{REF}
V_{PGL}	Power good low threshold	FB Voltage	<88%	-	>120%	
V_{PG}	Power good sink current capability	I_{PG} = 1mA	-	-	0.8	V
PG_{TD}	Power good low to high delay	After V_{REF} rise > 95%	0.63	0.9	1.17	mS

ELECTRICAL SPECIFICATIONS: (Cont.)

Conditions: T_A = 25 ºC, unless otherwise specified. Test Board Information: 80mm×80mm×1.6mm, 4 layers 2 oz.
The output ripple and transient response measurement is short loop probing and 20MegHz bandwidth limited.
Cin =10uF/25V/1206/X7R MLCC * 3 pcs, Cout = 47uF/10V/1210/X7R MLCC * 3 pcs.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
■ Protection Characteristics						
OVP	Output over voltage protection		113%	116%	119%	V_{REF}
UVP	Output under voltage protection		77%	80%	83%	
T_{SD}	Thermal shutdown temperature			160		℃
T_{SD-HY}	Thermal shutdown hysteresis			30		℃
OCP	Over current protection	Vin=12V, Vout= 0.6V ~ 2.5V Rcs=4.87KΩ		12.5		A
		Vin=12V, Vout= 3.3V ~ 5V Rcs=5.6KΩ		11		A

TYPICAL PERFORMANCE CHARACTERISTICS: (VOUT=1.0V)

Conditions: T_A = 25 ºC, unless otherwise specified. Test Board Information: 80mm×80mm×1.6mm, 4 layers 2 oz.
The output ripple and transient response measurement is short loop probing and 20MegHz bandwidth limited.
Cin =10uF/25V/1206/X7R MLCC * 3 pcs, Cout = 47uF/10V/1210/X7R MLCC * 3 pcs.
The following figures provide the typical characteristic curves at 1.0Vout.

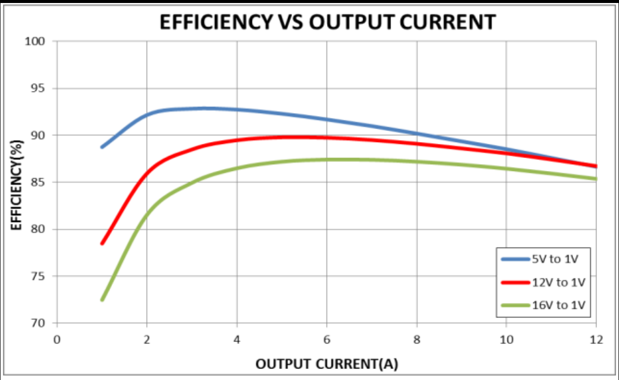


FIG.3 EFFICIENCY V.S. LOAD CURRENT (VIN=12V, VOUT=1.0V)

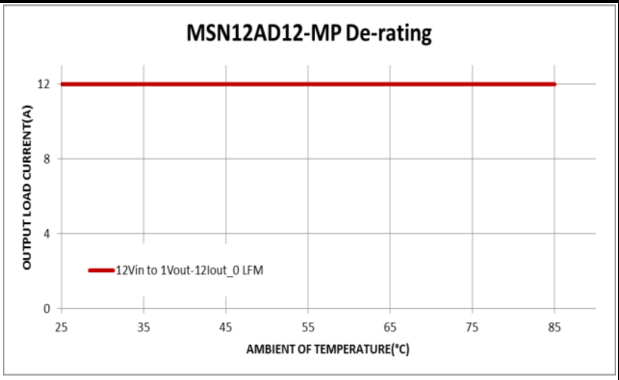


FIG.4 DE-RATING CURVE (VIN=12V, VOUT=1.0V)

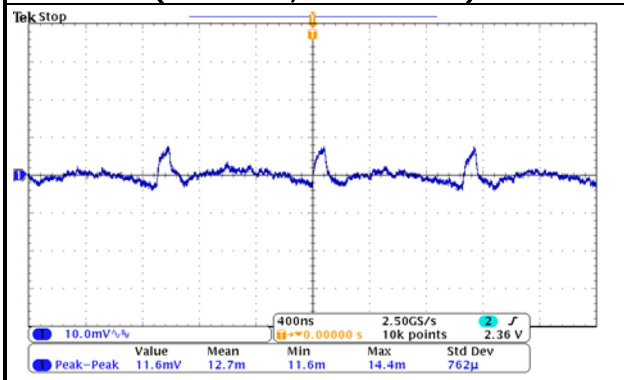


FIG.5 OUTPUT RIPPLE (VIN=12V, IOUT=0A)

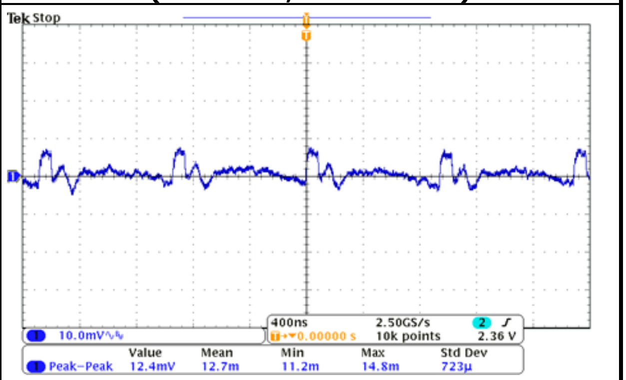


FIG.6 OUTPUT RIPPLE (VIN=12V, IOUT=10A)

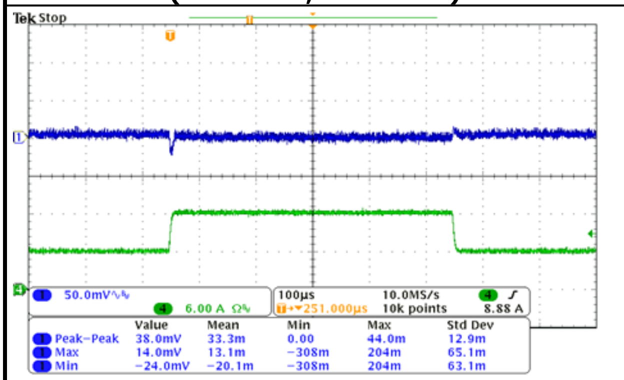


FIG.7 TRANSIENT RESPONSE (VIN=12V, 50% to 100% LOAD STEP)

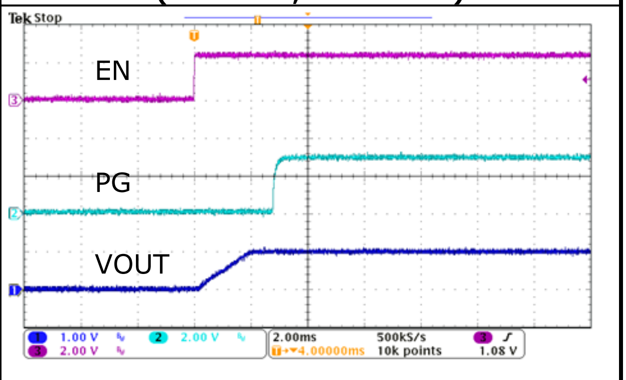


FIG.8 TURN-ON (VIN=12V, IOUT=10A)

TYPICAL PERFORMANCE CHARACTERISTICS: (VOUT=1.8V)

Conditions: T_A = 25 ºC, unless otherwise specified. Test Board Information: 80mm×80mm×1.6mm, 4 layers 2 oz.
The output ripple and transient response measurement is short loop probing and 20MegHz bandwidth limited.
Cin =10uF/25V/1206/X7R MLCC * 3 pcs, Cout = 47uF/10V/1210/X7R MLCC * 3 pcs.
The following figures provide the typical characteristic curves at 1.8Vout.

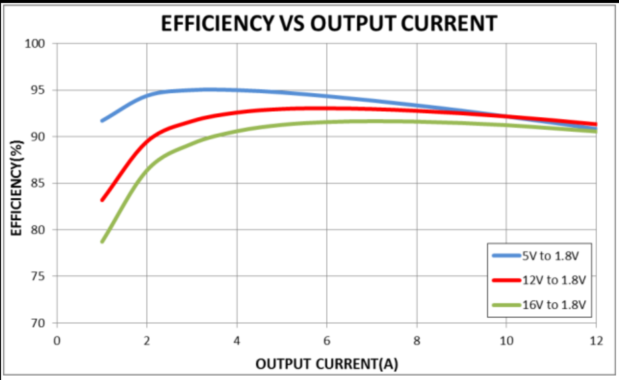


FIG.9 EFFICIENCY V.S. LOAD CURRENT (VIN=12V, VOUT=1.8V)

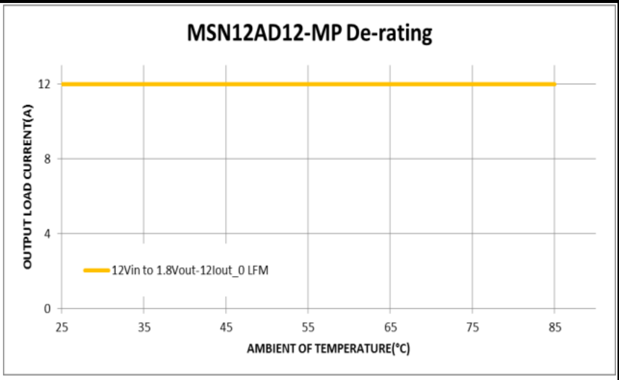


FIG.10 DE-RATING CURVE (VIN=12V, VOUT=1.8V)

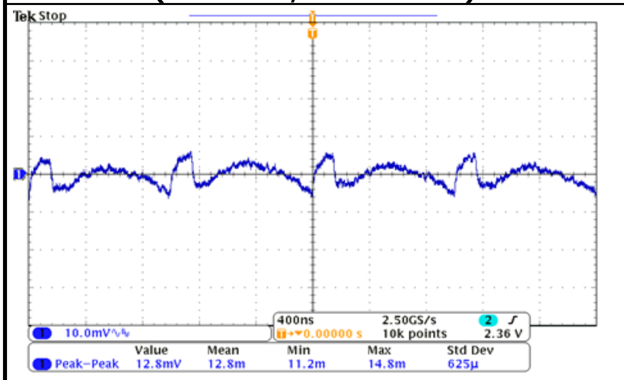


FIG.11 OUTPUT RIPPLE (VIN=12V, IOUT=0A)

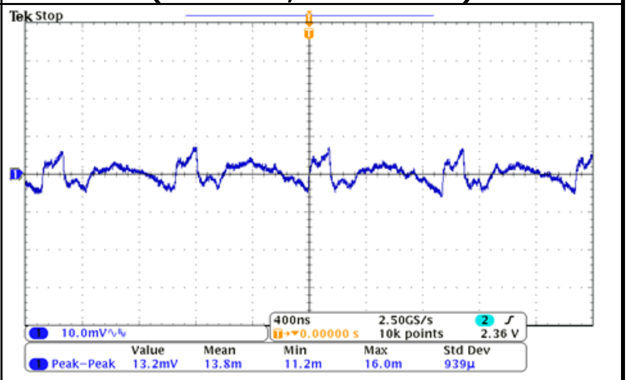


FIG.12 OUTPUT RIPPLE (VIN=12V, IOUT=10A)

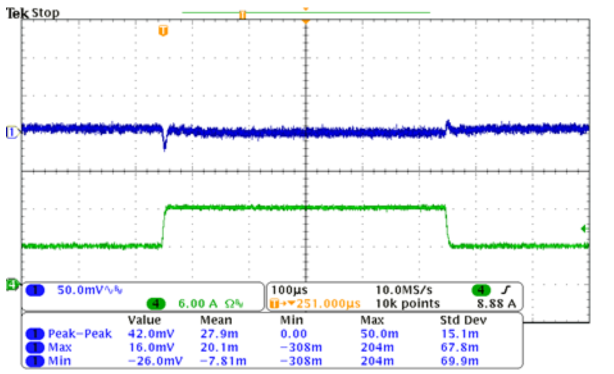


FIG.13 TRANSIENT RESPONSE (VIN=12V, 50% to 100% LOAD STEP)

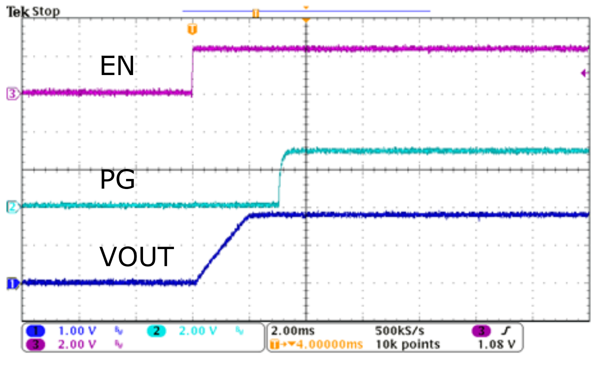


FIG.14 TURN-ON (VIN=12V, IOUT=10A)

TYPICAL PERFORMANCE CHARACTERISTICS: (VOUT=3.3V)

Conditions: T_A = 25 ºC, unless otherwise specified. Test Board Information: 80mm×80mm×1.6mm, 4 layers 2 oz.
The output ripple and transient response measurement is short loop probing and 20MegHz bandwidth limited.
Cin =10uF/25V/1206/X7R MLCC * 3 pcs, Cout = 47uF/10V/1210/X7R MLCC * 3 pcs.
The following figures provide the typical characteristic curves at 3.3Vout.

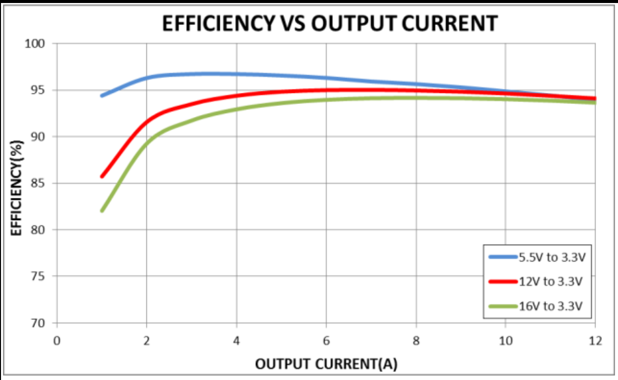


FIG.15 EFFICIENCY V.S. LOAD CURRENT (VIN=12V, VOUT=3.3V)

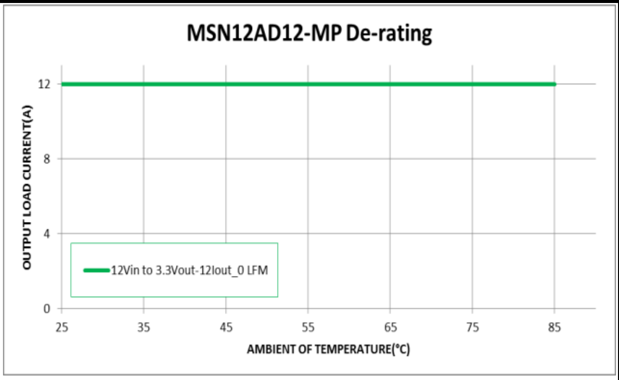


FIG.16 DE-RATING CURVE (VIN=12V, VOUT=3.3V)

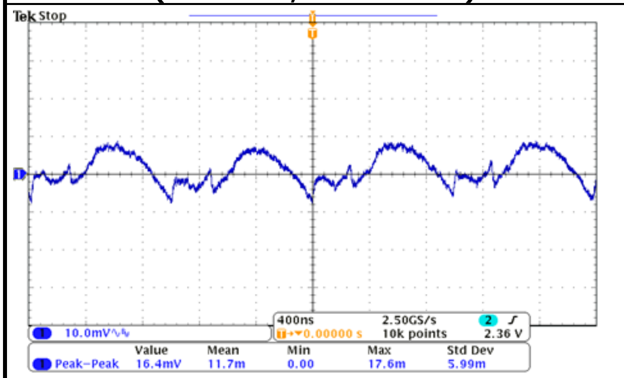


FIG.17 OUTPUT RIPPLE (VIN=12V, IOUT=0A)

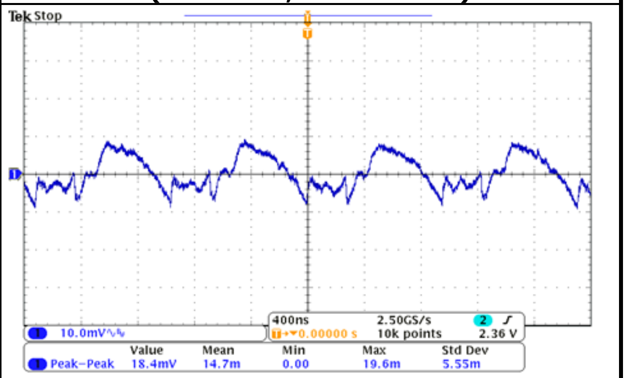


FIG.18 OUTPUT RIPPLE (VIN=12V, IOUT=10A)

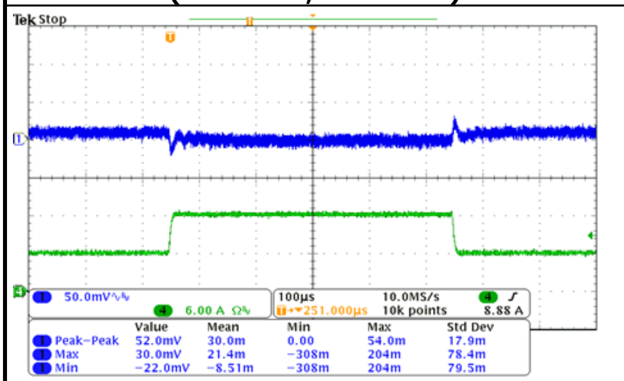


FIG.19 TRANSIENT RESPONSE (VIN=12V, 50% to 100% LOAD STEP)

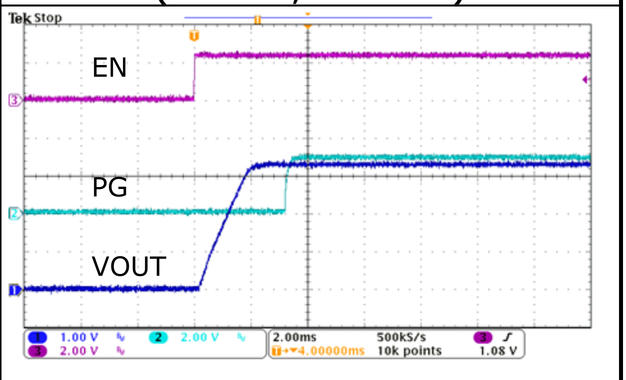


FIG.20 TURN-ON (VIN=12V, IOUT=10A)

TYPICAL PERFORMANCE CHARACTERISTICS: (VOUT=5.0V)

Conditions: T_A = 25 ºC, unless otherwise specified. Test Board Information: 80mm×80mm×1.6mm, 4 layers 2 oz.
The output ripple and transient response measurement is short loop probing and 20MegHz bandwidth limited.
Cin =10uF/25V/1206/X7R MLCC * 3 pcs, Cout = 47uF/10V/1210/X7R MLCC * 3 pcs.
The following figures provide the typical characteristic curves at 5.0Vout.

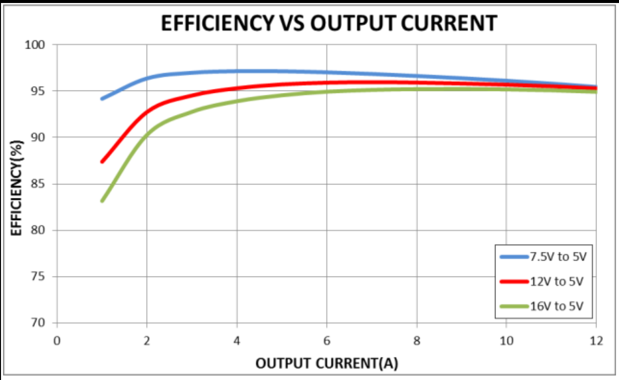


FIG.21 EFFICIENCY V.S. LOAD CURRENT (VIN=12V, VOUT=5.0V)

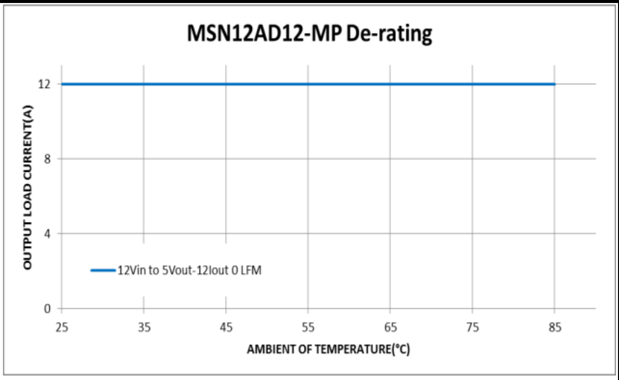


FIG.22 DE-RATING CURVE (VIN=12V, VOUT=5.0V)

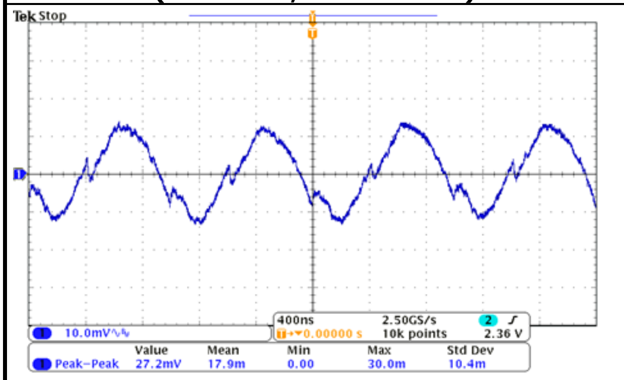


FIG.23 OUTPUT RIPPLE (VIN=12V, IOUT=0A)

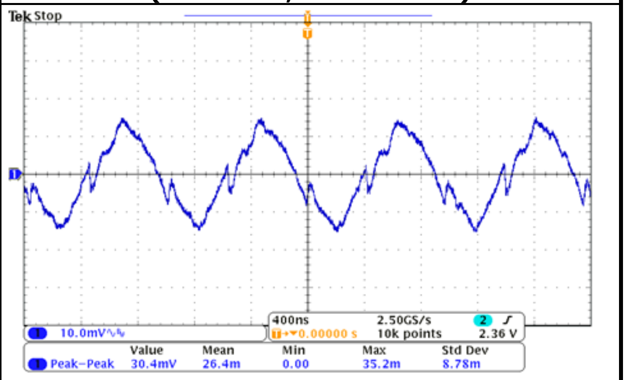


FIG.24 OUTPUT RIPPLE (VIN=12V, IOUT=10A)

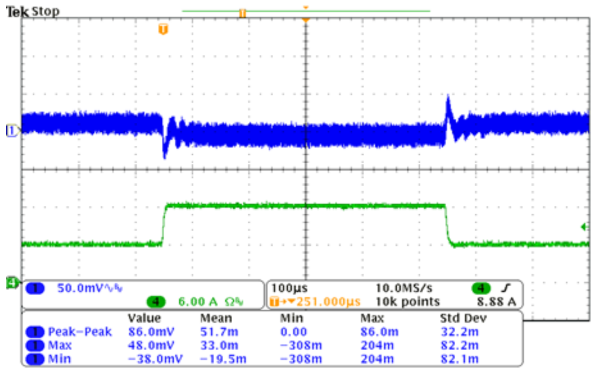


FIG.25 TRANSIENT RESPONSE (VIN=12V, 50% to 100% LOAD STEP)

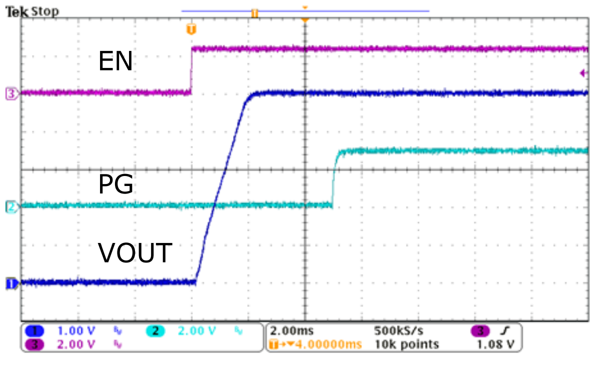


FIG.26 TURN-ON (VIN=12V, IOUT=10A)

APPLICATIONS INFORMATION:

SAFETY CONSIDERATION:

Certain applications and/or safety agencies may require fuses at the inputs of power conversion components. Fuses should also be used when there is the possibility of sustained input voltage reversal which is not current limited. For greatest safety, we recommend a fast blow fuse installed in the ungrounded input supply line. The installer must observe all relevant safety standards and regulations. For safety agency approvals, install the converter in compliance with the end-user safety standard.

INPUT FILTERING:

The module should be contacted to as low AC impedance source supply and a highly inductive source or line inductance can affect the stability of the module. An input capacitor must be placed directly to the input pin of the module, to minimize input ripple voltage and ensure module stability.

OUTPUT FILTERING:

To reduce output ripple and improve the dynamic response to as step load change, the additional capacitor at the output must be used. Low ESR polymer and ceramic capacitors are recommended to improve the output ripple and dynamic response of the module.

OUTPUT VOLTAGE PROGRAMMING:

The Module has an internal 0.6V reference voltage, The output voltage can be programmed by the dividing resistor R_{FBH} and R_{FBL}, and division resistor needs to be closed as possible to the VOSNS+ pin, FB pin and VOSNS- pin. A value of between 100Ω and 3.4kΩ is highly recommended for both resistors. Assume RFBH set 976 ohm, The output voltage can be calculated as shown in Equation 1 and the resistance according to typical output voltage is shown in TABLE 1.

$$VOUT = 0.6 \times \left(1 + \frac{R_{RBH}}{R_{FBL}}\right) \qquad \text{(EQ.1)}$$

VOUT	1.0V	1.2V	1.5V	1.8V	2.5V	3.3V	5V
Rtrim(ohm)	1464	976	650.7	488	308.2	216.9	133.1

TABLE 1

APPLICATIONS INFORMATION: (Cont.)

SOFT START TIME PROGRAMMING:

The minimum soft-start time is limited at 1ms. It can be increased by adding a SS capacitor between TRK pin and VOSNS- pin. The total SS capacitor value can be determined with Equation 2:

$$C_{SS}(nF) = \frac{T_{SS}(ms) \times 36(uA)}{0.6(V)} - 22nF \qquad \text{(EQ.2)}$$

OUTPUT VOLTAGE TRACKING AND REFERENCE:

The Module provides an analog input pin (TRK) to track another power supply or accept an external reference. When an external voltage signal is connected to TRK, it acts as a reference for the Module output voltage. The FB voltage follows this external voltage signal exactly, and the soft-start settings are ignored. The TRK input signal can be in the range of 0.3V to 1.4V. During the initial start-up, the TRK must reach at least 600mV first to ensure proper operation. After that, it can be set to any value between 0.3V and 1.4V.

POWER GOOD (PG):

The Module has a power good (PG) output. PG is the open-drain of a MOSFET. Connect PG to VCC or another external voltage source less than 3.6V through a pull-up resistor (typically 10kΩ). After applying the input voltage, the MOSFET turns on, so PG is pulled to GND before TRK is ready. After the FB voltage reaches 92.5% of the REF voltage, PG is pulled high after a 0.8ms delay.

When the FB voltage drops to 80% of the REF voltage, or exceeds 116% of the nominal REF voltage, PG is latched low. PG can only be pulled high again after a new soft start.

If the input supply fails to power the Module, PG is clamped low, even though PG is tied to an external DC source through a pull-up resistor.

APPLICATIONS INFORMATION: (Cont.)

UVLO (ENABLE) PROGRAMMING:

The Module turns on when EN goes high; the Module turns off when EN goes low. EN cannot be left floating for proper operation.

EN can be connected a resistor divider from VIN to AGND used to program the input voltage (UVLO thresholds). The resistor divider values can be determined with Equation 4:

$$V_{UVLO} = 1.22V \times \frac{R_{ENH} + R_{ENL}}{R_{ENL}} \qquad \text{(EQ.4)}$$

When only R_{ENH} is connected to Vin without R_{ENL}, then R_{ENH} should be chosen so that the maximum current going to EN is 30μA, R_{ENH} can be calculated with Equation 5:

$$R_{ENH}(K\Omega) = \frac{V_{IN-MAX}(V)}{0.03(mA)} \qquad \text{(EQ.5)}$$

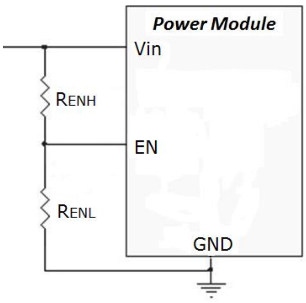


FIG.27 PROGRAM EN CIRCUIT

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APPLICATIONS INFORMATION: (Cont.)

THERMAL CONSIDERATIONS:

All of thermal testing condition is complied with JEDEC EIJ/JESD 51 Standards. Therefore, the test board size is 80mm×80mm×1.6mm with 4 layers. The case temperature of module sensing point is shown as FIG.28. Then $Rth(j_{choke}\text{-}a)$ is measured with the component mounted on an effective thermal conductivity test board on 0 LFM condition. The Module is designed for using when the case temperature is below 110°C regardless the change of output current, input/output voltage or ambient temperature.

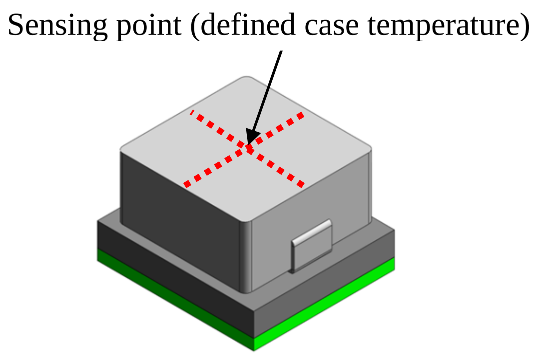

FIG.28 CASE TEMPERATURE SENSING POINT

APPLICATIONS INFORMATION: (Cont.)

REFLOW PARAMETERS:

Lead-free soldering process is a standard of making electronic products. Many solder alloys like Sn/Ag, Sn/Ag/Cu, Sn/Ag/Bi and so on are used extensively to replace traditional Sn/Pb alloy. Here the Sn/Ag/Cu alloy (SAC) are recommended for process. In the SAC alloy series, SAC305 is a very popular solder alloy which contains 3% Ag and 0.5% Cu. It is easy to get it. FIG.29 shows an example of reflow profile diagram. Typically, the profile has three stages. During the initial stage from 70°C to 90°C, the ramp rate of temperature should be not more than 1.5°C/sec. The soak zone then occurs from 100°C to 180°C and should last for 90 to 120 seconds. Finally the temperature rises to 230°C to 245°C and cover 220°C in 30 seconds to melt the solder. It is noted that the time of peak temperature should depend on the mass of the PCB board. The reflow profile is usually supported by the solder vendor and user could switch to optimize the profile according to various solder type and various manufactures' formula.

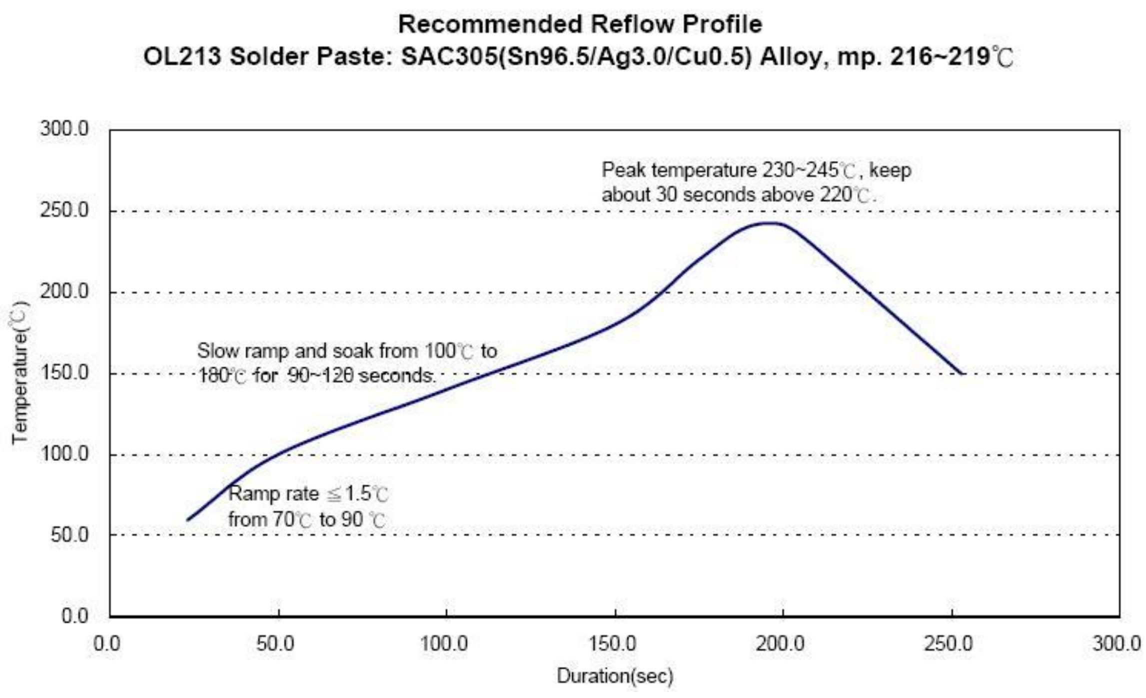

FIG.29 RECOMMENDATION REFLOW PROFILE

REVERSION HISTORY:

Date	Revision	Changes
2017.10.16	00	Release the preliminary datasheet.
2018.03.14	01	Add de-rating curve
2018.05.28	02	1、Update page 2 EN max rating 2、Correct page 3, 4 pin define 3、Update page 5~6 Spec. 4、Update page 13 EN (UVLO) information
2018.07.10	03	1、Update typical output current from 12A to 8A~10A