NAM12S06-D DC-DC Converter

Technical Manual

Issue 1.0

Date 2020-02-12

HUAWEI TECHNOLOGIES CO., LTD.

About This Document

Purpose

This document describes the NAM12S06-D (EN42PCDD) in terms of its physical structure, electrical characteristics, and simple application.

The figures provided in this document are for reference only.

Intended Audience

This document is intended for:

- Hardware engineers
- Software engineers
- System engineers
- Technical support engineers

Symbol Conventions

The symbols that may be found in this document are defined as follows.

Symbol	Description
DANGER	Indicates a hazard with a high level of risk which, if not avoided, will result in death or serious injury.
WARNING	Indicates a hazard with a medium level of risk which, if not avoided, could result in death or serious injury.
CAUTION	Indicates a hazard with a low level of risk which, if not avoided, could result in minor or moderate injury.
NOTICE	Indicates a potentially hazardous situation which, if not avoided, could result in equipment damage, data loss, performance deterioration, or unanticipated results. NOTICE is used to address practices not related to personal injury.
NOTE	Supplements the important information in the main text. NOTE is used to address information not related to personal injury, equipment damage, and environment deterioration.

Change History

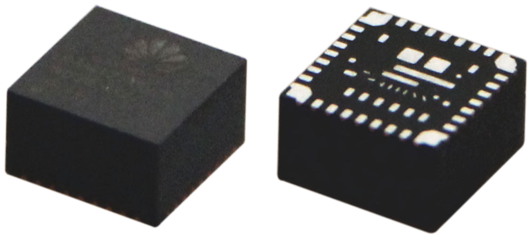
Changes between document issues are cumulative. The latest document issue contains all updates made in previous issues.

Issue 1.0 (2020-02-12)

This issue is the first official release.

Contents

1 Product Overview



The NAM12S06-D is a Power System in Package (PSiP) DC-DC converter with an input voltage range of 9 V to 14 V and the maximum output current of 6 A. Its output voltage can be adjusted within a range of 0.7 V to 5.4 V.

Mechanical Features

- SMT
- Dimensions (L x W x H): 7 x 7 x 4 mm (0.31 x 0.31 x 0.16 in.)
- Weight: 0.784 g

Control Features

- Remote on/off
- Output voltage trim

Operational Features

- Input voltage: 9–14 V
- Output current: 0–6 A
- Output voltage: 0.7–5.4 V
- Efficiency: 93.5% (V_{in} = 12 V, V_{out} = 5.4 V, I_{out} = 6 A)

Protection Features

- Input undervoltage protection
- Output overcurrent protection (hiccup mode)
- Output short circuit protection (hiccup mode)
- Output overvoltage protection (latch off)

Environmental Protection

- RoHS6 complaint, lead-free reflow soldering

Applications

- Servers
- Telecom and datacom
- Point of load regulation
- General purpose step-down DC/DC

Model Naming Convention

NAM	12	S	06	–	D
1	2	3	4		5

1 — Non-isolated, analog, package type

2 — Input voltage: 12 V

3 — Single output

4 — Output current: 6 A

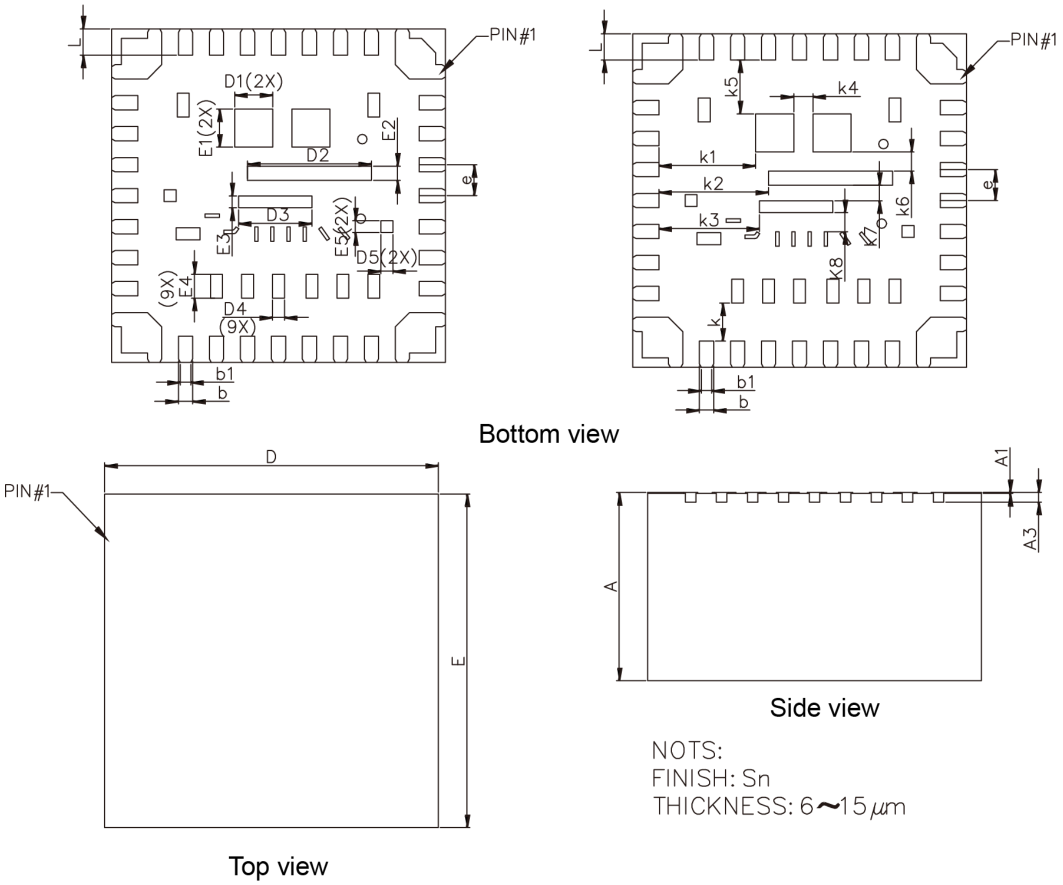
5 — Extension code

Mechanical Diagram

Figure 1-1 Mechanical diagram

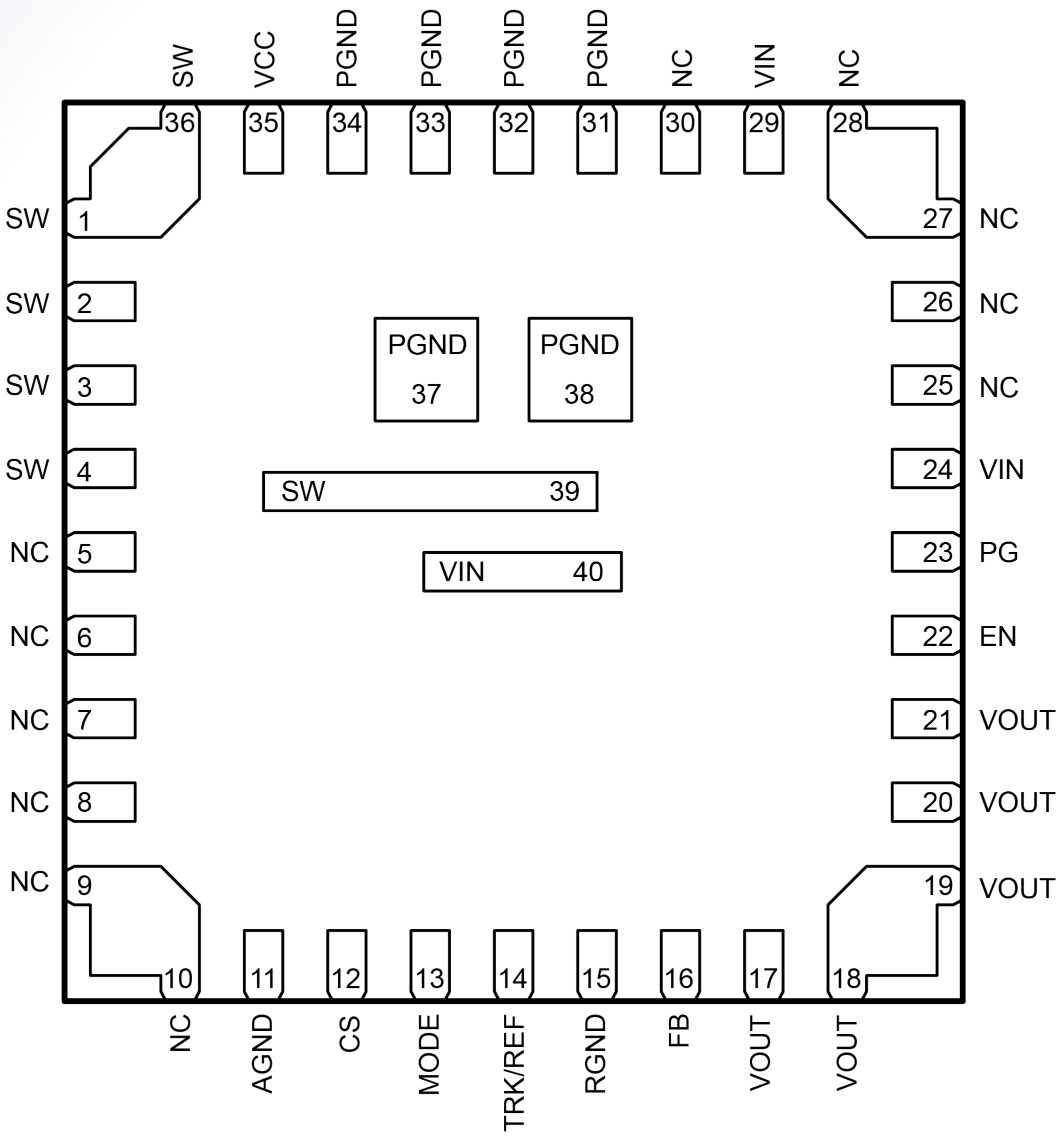
NOTE

1. Solder: Sn (thickness: 6–15 μm).



Symbol	Min.	Max.	Symbol	Min.	Max.
-	**Dimensions in Millimeters (Inches)**		-	**Dimensions in Millimeters (Inches)**	
A	3.900 (0.154)	4.000 (0.157)	E1	0.750 (0.030)	0.850 (0.033)
A1	0.000 (0.000)	0.050 (0.002)	E2	0.250 (0.010)	0.350 (0.014)
A3	0.203REF. (0.008REF.)		E3	0.200 (0.008)	0.300 (0.012)
b	0.250 (0.010)	0.350 (0.014)	E4	0.450 (0.018)	0.550 (0.022)
b1	0.220REF. (0.009REF.)		E5	0.200 (0.008)	0.300 (0.012)
D	6.900 (0.272)	7.100 (0.280)	K	0.800REF. (0.031REF.)	
D1	0.750 (0.030)	0.850 (0.033)	K1	2.030REF. (0.080REF.)	
D2	2.550 (0.100)	2.650 (0.104)	K2	2.300REF. (0.091REF.)	
D3	1.490 (0.059)	1.590 (0.063)	K3	2.110REF. (0.083REF.)	
D4	0.200 (0.008)	0.300 (0.012)	K4	0.400REF. (0.016REF.)	
D5	0.200 (0.008)	0.300 (0.012)	K5	1.130REF. (0.044REF.)	
e	0.650TYP. (0.026TYP.)		K6	0.400REF. (0.016REF.)	
L	0.474 (0.019)	0.626 (0.025)	K7	0.325REF. (0.013REF.)	
E	6.900 (0.272)	7.100 (0.280)	K8	0.400REF. (0.016REF.)	

Figure 1-2 Pin Description



Pin No.	Name	Function
1–4, 36, 39	SW	Switching node of the circuit. This pin is used to check the switching frequency.
5–10, 25–28, 30	NC	Not connected: These pins must be soldered to PCB but not electrically connected to each other or to any external signal, voltage, or ground. These pins may be connected internally. Failure to follow this guideline may result in device damage.
11	AGND	Signal ground. This pin needs to be connected to the PGND.
12	CS	Output overcurrent adjustment pin. It is connected to the ground through an 8.2 kΩ internal resistor. By default, this pin is left open.

Pin No.	Name	Function
13	MODE	Frequency adjustment pin. It is connected to the ground through a 59 kΩ internal resistor. The default frequency is 1 MHz.
14	TRK/REF	Soft-start setting pin. A soft-start capacitor is embedded in the converter. By default, this pin is left open.
15	RGND	Output ground.
16	FB	Output adjustment pin. The FB pin is referenced to 0.6 V. A resistor divider connecting the feedback to the output is used to set the desired output voltage.
17–21	Vout	Output pins. Connect these pins to loads and place output filter capacitors between these pins and PGND pins.
22	EN	Enable pin. A left open pin enables the device while a low level disables the device. A high level is not allowed. For details, see **Remote On/Off (EN)**.
23	PG	Power good signal. This is an open-drain signal. A pull-up resistor (connected to a DC voltage) is required to indicate high if the output voltage is within the regulation. There is about 1 ms delay from FB ≥ 92.5% to PGOOD pull-high.
24, 29, 40	Vin	Power input pins. Connect these pins to input power supply and place input filter capacitors between these pins and PGND pins.
31–34, 37, 38	PGND	Input and output power ground. Connect these pins to the ground electrode of the input and output filter capacitors.
35	VCC	Internal 3 V LDO output. The driver and control circuits are powered from this pin.

2 Electrical Specifications

2.1 Absolute Maximum Ratings

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
Input voltage (continuous)	-	-	16	V	When the input voltage is 16 V, the converter will not be damaged. Not all the characteristic parameters conform to the specifications.
Operating ambient temperature (T_A)	–40	-	105	°C	-
Storage temperature	–55	-	125	°C	-
Operating humidity	10	-	95	% RH	Non-condensing
External voltage applied to On/Off	-	-	5	V	-
Altitude	-	-	3000	m	-

2.2 Input Characteristics

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
Operating input voltage	9	12	14	V	-
Maximum input current	-	-	6	A	V_{in} = 0–14 V; I_{out} = I_{onom}
No-load loss	-	-	0.5	W	V_{in} = 12 V; V_{out} = 1.2 V; I_{out} = 0 A
Input capacitance	20	-	-	μF	Ceramic capacitor

2.3 Output Characteristics

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
Output voltage setpoint	–1.0	-	1.0	% V_{oset}	V_{in} = 12 V; I_{out} = 50%I_{onom};
Output voltage	0.7	-	5.4	V	$V_{in} - V_{out} \geq 2$ V
Output current	0	-	6	A	-
Line regulation	–1	-	1	%	V_{in} = 9–14 V; I_{out} = I_{onom}
Load regulation	–0.5	-	0.5	%	V_{in} = 12 V; I_{out} = I_{omin} – I_{onom}
Regulated voltage precision	–2	-	2	%	V_{in} = 9–14 V; I_{out} = I_{omin} – I_{onom}
Temperature coefficient	–0.02	-	0.02	%/°C	T_A = –40°C to +85°C
External capacitance	44	-	2000	µF	Ceramic capacitor
Output ripple and noise (peak to peak)	-	20	30	mV	$V_{out} \leq 1.2$ V Oscilloscope bandwidth: 20 MHz
	-	30	60	mV	$V_{out} > 1.2$ V Oscilloscope bandwidth: 20 MHz
Output voltage overshoot	-	-	5	%	Full range of V_{in}, I_{out}, and T_A
Output voltage delay time	-	3	10	ms	From V_{in} connection to 10% V_{out}
Output voltage rise time	-	2.3	10	ms	From 10% V_{out} to 90% V_{out}
Switching frequency	-	1000	-	kHz	-

2.4 Protection

Table 2-1 Input Protection

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
Input undervoltage protection threshold	5	6	7.35	V	-
Input undervoltage protection recovery threshold	6	7	8.72	V	-
Input undervoltage protection hysteresis	0.5	1.0	2	V	-

Table 2-2 Output Protection

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
Output overcurrent protection	110	-	200	%	Hiccup mode
Output short circuit protection	-	-	-	-	Hiccup mode
Output overvoltage protection	110	-	130	$\%V_{oset}$	Latch off

2.5 Dynamic Characteristics

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
Overshoot amplitude Recovery time	- -	- -	60 200	mV µs	$V_{out} \leq 1.2V$; Current change rate: 1 A/µs Load: 25%–50%–25%; 50%–75%–50%
Overshoot amplitude Recovery time	- -	- -	5 100	$\%V_{out}$ µs	$V_{out} > 1.2V$; Current change rate: 1 A/µs Load: 25%–50%–25%; 50%–75%–50%

2.6 Efficiency

Parameter	Min.	Typ.	Max.	Units	Notes & Conditions
50% load	70	72.5	-	%	V_{in} = 12 V; V_{out} = 0.7 V; T_A = 25°C (77°F)
	72	75.5	-	%	V_{in} = 12 V; V_{out} = 0.8 V; T_A = 25°C (77°F)
	75	77.5	-	%	V_{in} = 12 V; V_{out} = 0.9 V; T_A = 25°C (77°F)
	77	79.5	-	%	V_{in} = 12 V; V_{out} = 1.0 V; T_A = 25°C (77°F)
	79	81.5	-	%	V_{in} = 12 V; V_{out} = 1.2 V; T_A = 25°C (77°F)
	82	84.5	-	%	V_{in} = 12 V; V_{out} = 1.5 V; T_A = 25°C (77°F)
	84	86.5	-	%	V_{in} = 12 V; V_{out} = 1.8 V; T_A = 25°C (77°F)
	87	89	-	%	V_{in} = 12 V; V_{out} = 2.5 V; T_A = 25°C (77°F)
	88	90.5	-	%	V_{in} = 12 V; V_{out} = 3.3 V; T_A = 25°C (77°F)
	90	92.5	-	%	V_{in} = 12 V; V_{out} = 5.0 V; T_A = 25°C (77°F)
	91	93	-	%	V_{in} = 12 V; V_{out} = 5.4 V; T_A = 25°C (77°F)
100% load	70	72.5	-	%	V_{in} = 12 V; V_{out} = 0.7 V; T_A = 25°C (77°F)
	72	75.5	-	%	V_{in} = 12 V; V_{out} = 0.8 V; T_A = 25°C (77°F)
	75	77.5	-	%	V_{in} = 12 V; V_{out} = 0.9 V; T_A = 25°C (77°F)
	77	79.5	-	%	V_{in} = 12 V; V_{out} = 1.0 V; T_A = 25°C (77°F)
	80	82	-	%	V_{in} = 12 V; V_{out} = 1.2 V; T_A = 25°C (77°F)

Parameter	Min.	Typ.	Max.	Units	Notes & Conditions
	82	84.5	-	%	V_{in} = 12 V; V_{out} = 1.5 V; T_A = 25°C (77°F)
	84	86.5	-	%	V_{in} = 12 V; V_{out} = 1.8 V; T_A = 25°C (77°F)
	87	89	-	%	V_{in} = 12 V; V_{out} = 2.5 V; T_A = 25°C (77°F)
	89	91	-	%	V_{in} = 12 V; V_{out} = 3.3 V; T_A = 25°C (77°F)
	91	93	-	%	V_{in} = 12 V; V_{out} = 5.0 V; T_A = 25°C (77°F)
	91	93.5	-	%	V_{in} = 12 V; V_{out} = 5.4 V; T_A = 25°C (77°F)

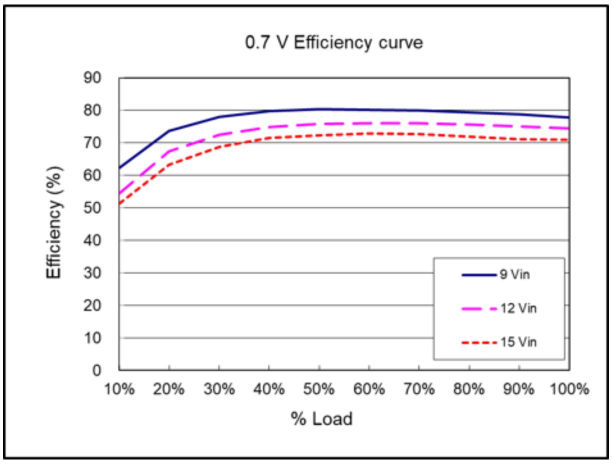
2.7 Other Characteristics

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
Remote On/Off voltage low level	–0.2	-	0.5	V	Positive logic
Remote On/Off voltage high level	2.0	-	5.0	V	
Mean time between failures (MTBF)	-	2.5	-	Million hours	Telcordia, SR332 Method 1 Case 3; 80% load; normal input; rated output; airflow rate = 1.5 m/s (300 LFM); T_A = 40°C

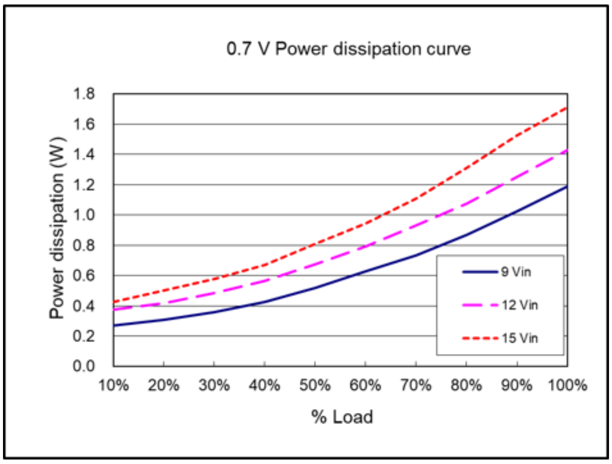
3 Characteristic Curves

3.1 Efficiency and Power Dissipation Curves

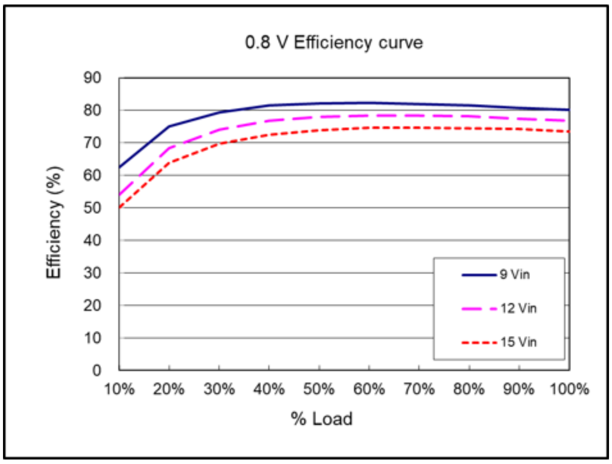
Conditions: T_A = 25°C, unless otherwise specified



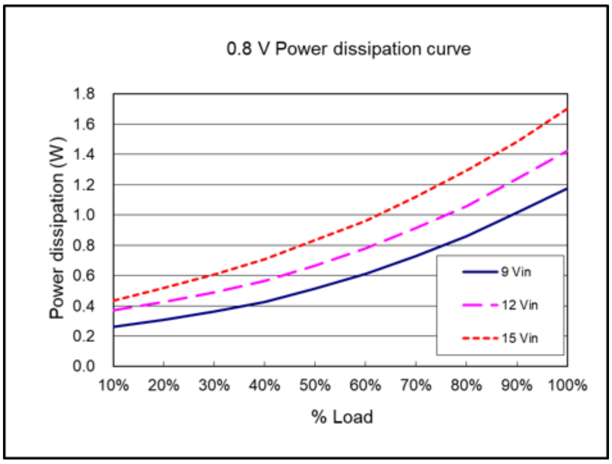
Efficiency curve (V_{out} = 0.7 V)



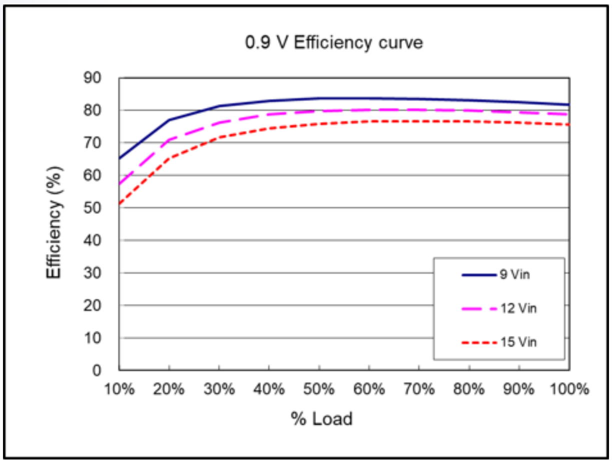
Power dissipation curve (V_{out} = 0.7 V)



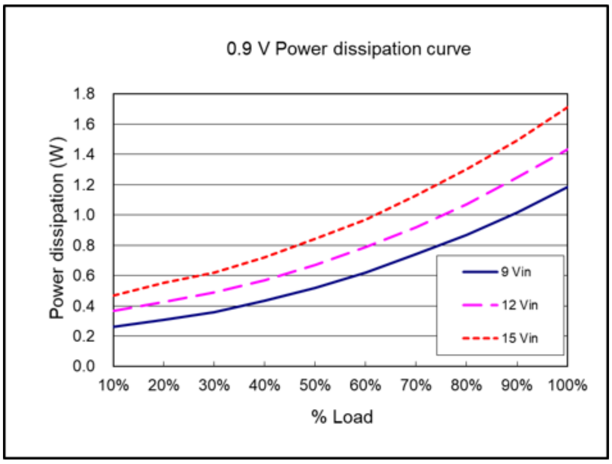
Efficiency curve (V_{out} = 0.8 V)



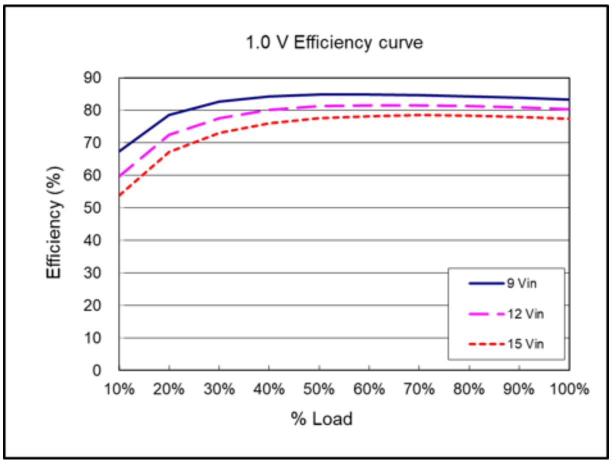
Power dissipation curve (V_{out} = 0.8 V)



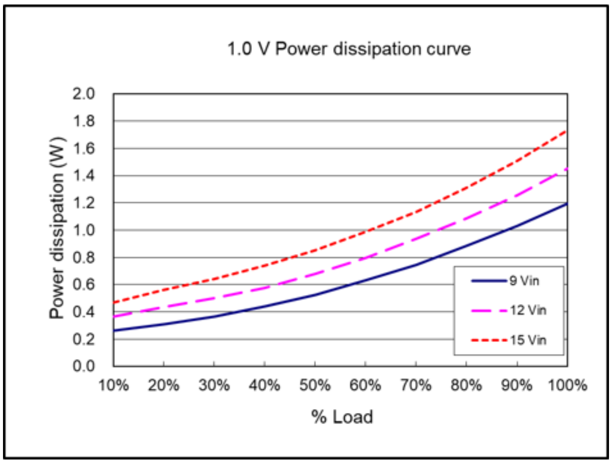
Efficiency curve (V_{out} = 0.9 V)



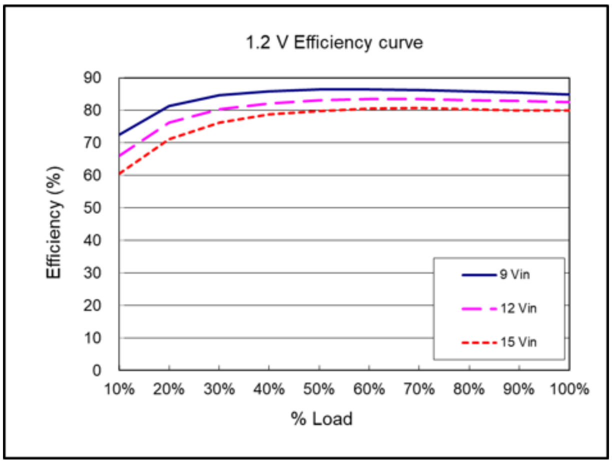
Power dissipation curve (V_{out} = 0.9 V)



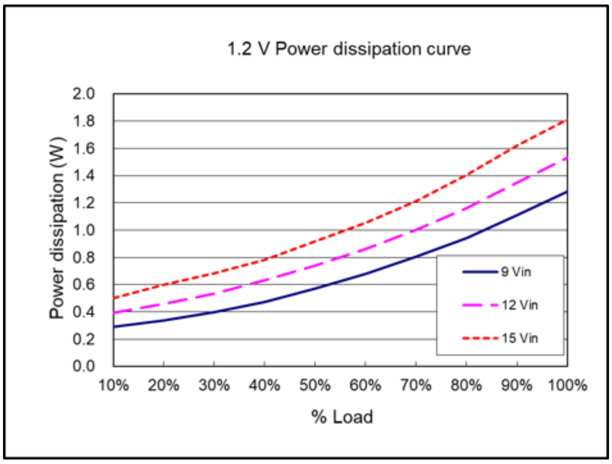
Efficiency curve (V_{out} = 1.0 V)



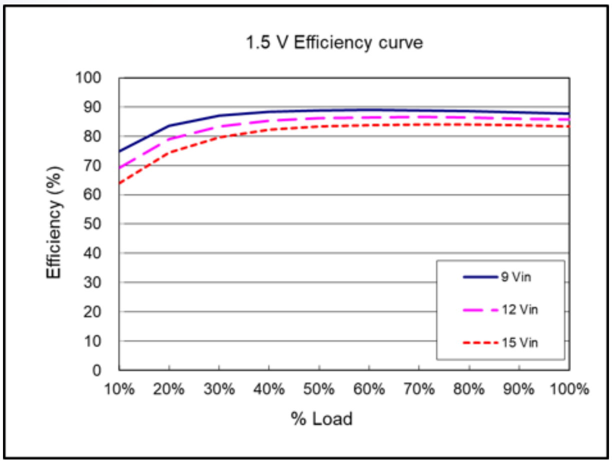
Power dissipation curve (V_{out} = 1.0 V)



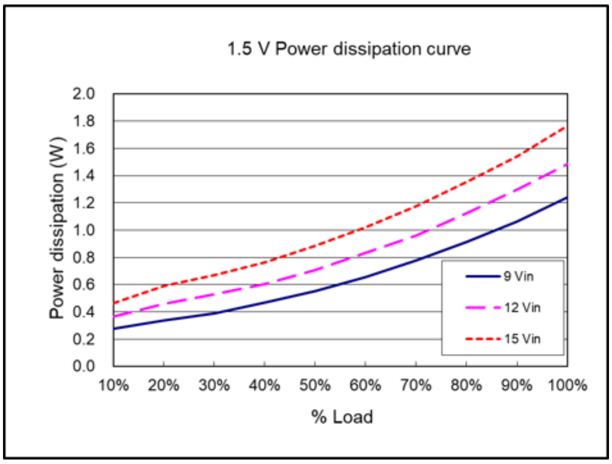
Efficiency curve (V_{out} = 1.2 V)



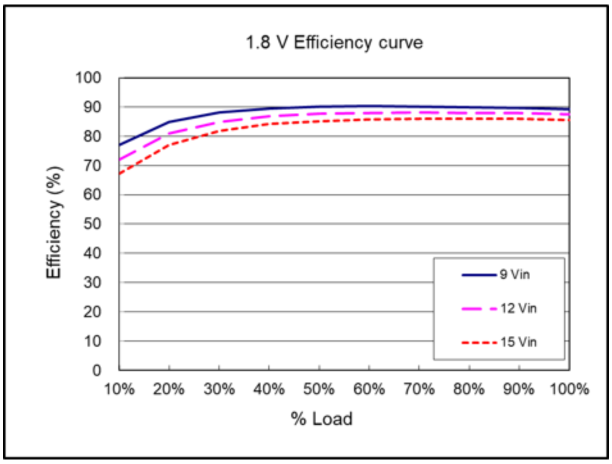
Power dissipation curve (V_{out} = 1.2 V)



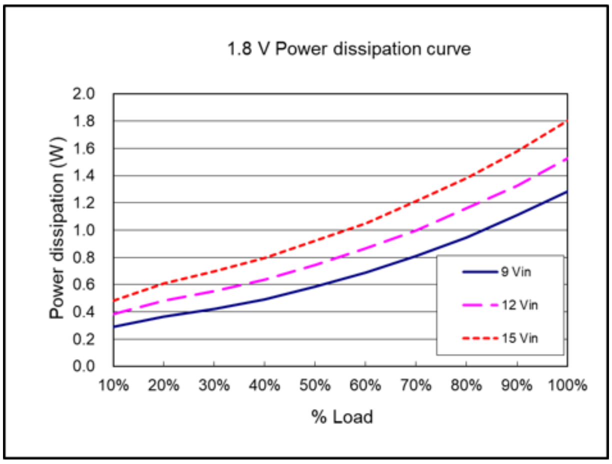
Efficiency curve (V_{out} = 1.5 V)



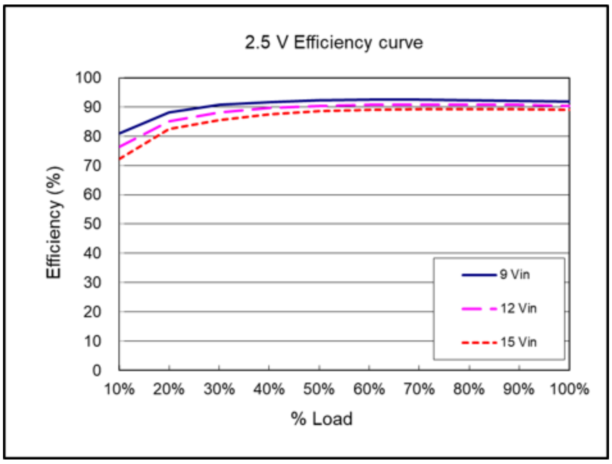
Power dissipation curve (V_{out} = 1.5 V)



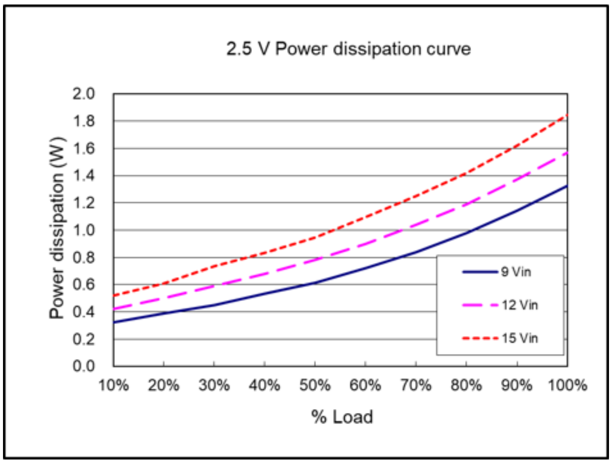
Efficiency curve (V_{out} = 1.8 V)



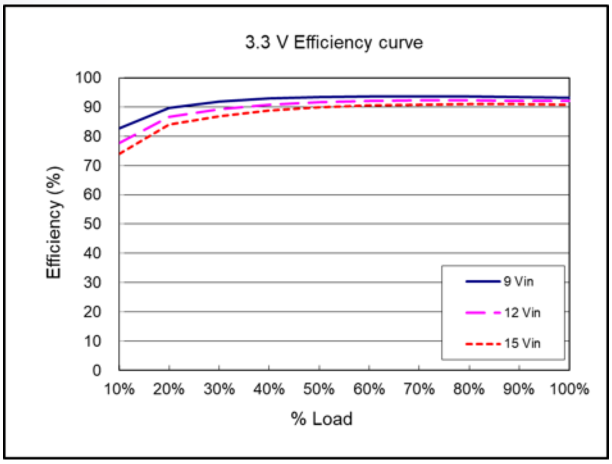
Power dissipation curve (V_{out} = 1.8 V)



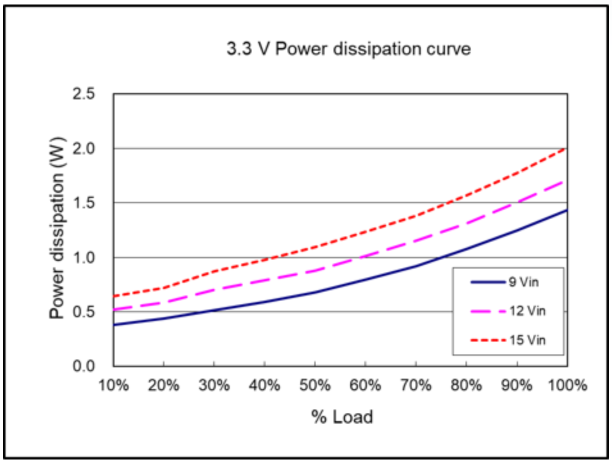
Efficiency curve (V_{out} = 2.5 V)



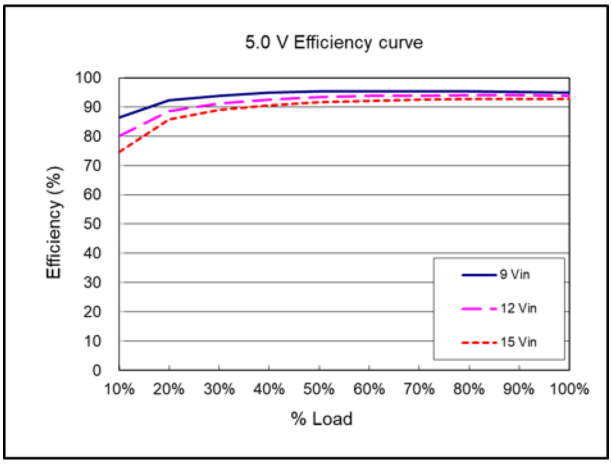
Power dissipation curve (V_{out} = 2.5 V)



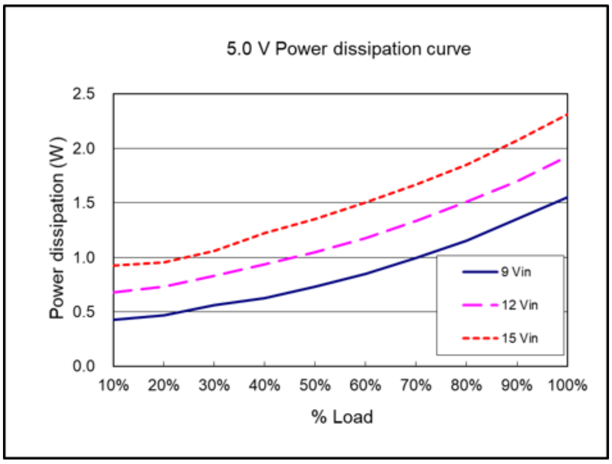
Efficiency curve (V_{out} = 3.3 V)



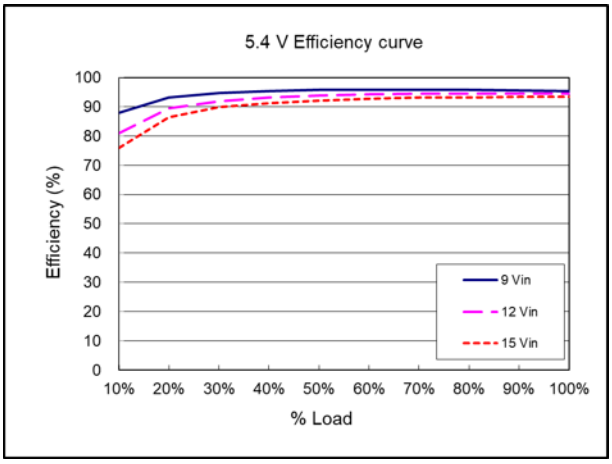
Power dissipation curve (V_{out} = 3.3 V)



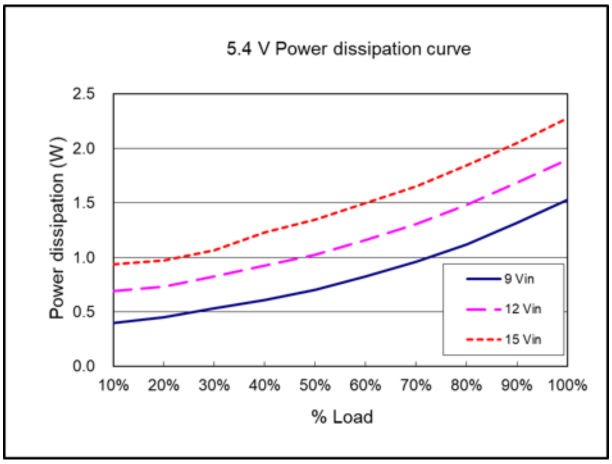
Efficiency curve (V_{out} = 5.0 V)



Power dissipation curve (V_{out} = 5.0 V)



Efficiency curve (V_{out} = 5.4 V)

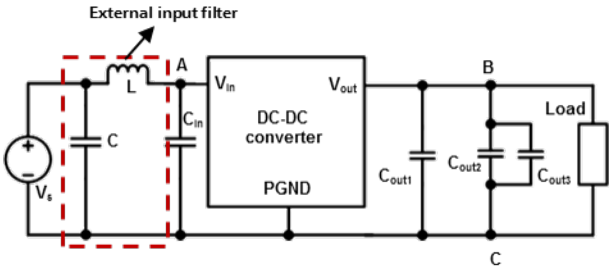


Power dissipation curve (V_{out} = 5.4 V)

4 Typical Waveforms

4.1 Test Setup Diagram & Fundamental Circuit Diagram

Figure 4-1 Test setup diagram



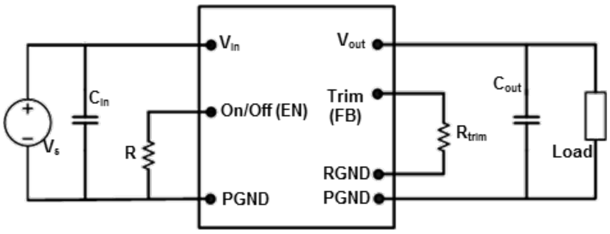
C_{in}: The 20 μF ceramic capacitor is recommended.

C_{out1}: The 44 μF ceramic capacitor is recommended.

C_{out2}: The 0.1 μF ceramic capacitor is recommended.

C_{out3}: The 10 μF polymer tantalum capacitor is recommended.

Figure 4-2 Application circuit



R: 20 kΩ

C_{in}: The 20 μF ceramic capacitor is recommended.

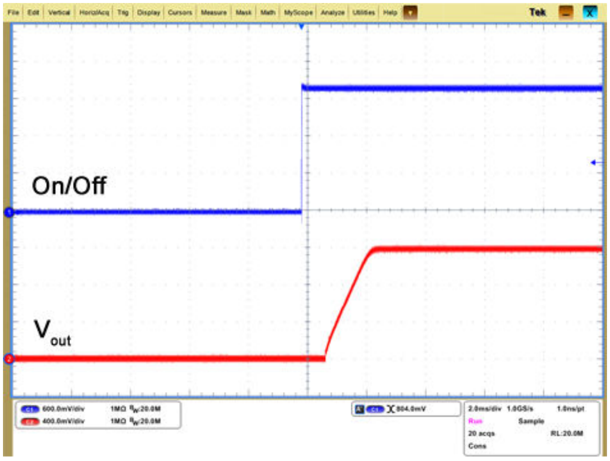
C_{out}: The 44 μF ceramic capacitor is recommended.

NOTE

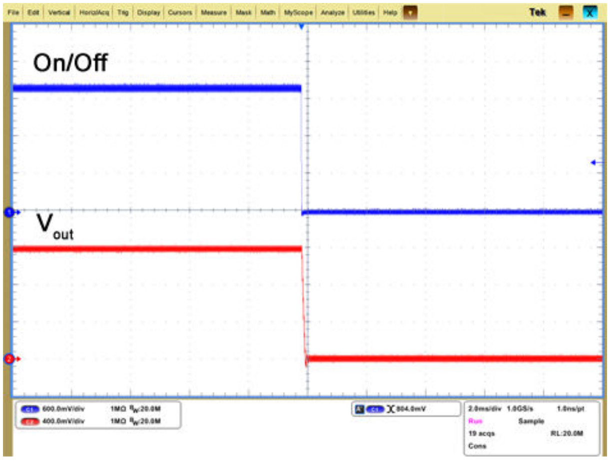
1. During the test of input reflected ripple current, the input must be connected to an external input filter (including a 12 μH inductor and a 220 μF electrolytic capacitor), which is not required in other tests.
2. Points B and C, which are used for testing the output voltage ripple, are 25 mm (0.98 in.) away from the $V_{out}(+)$ pin and the $V_{out}(-)$ pin, respectively.

4.2 Turn-on/Turn-off

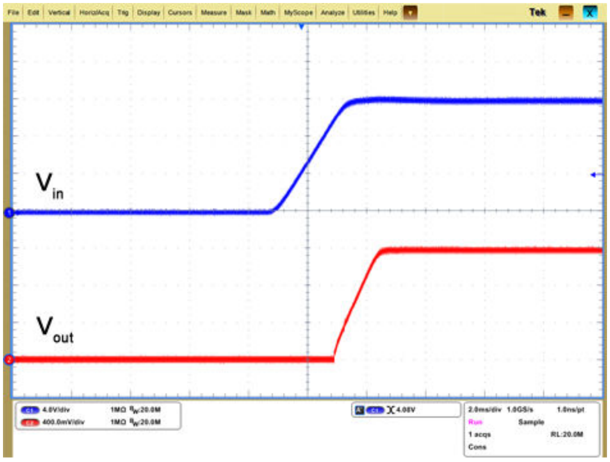
Conditions: T_A = 25°C, V_{in} = 12 V, V_{out} = 1.2 V



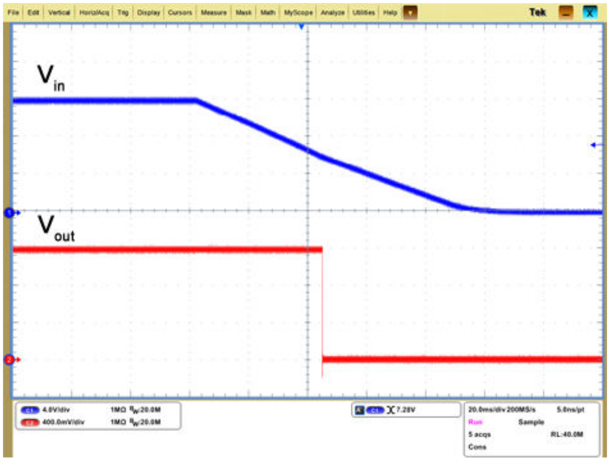
Startup from On/Off



Shutdown from On/Off

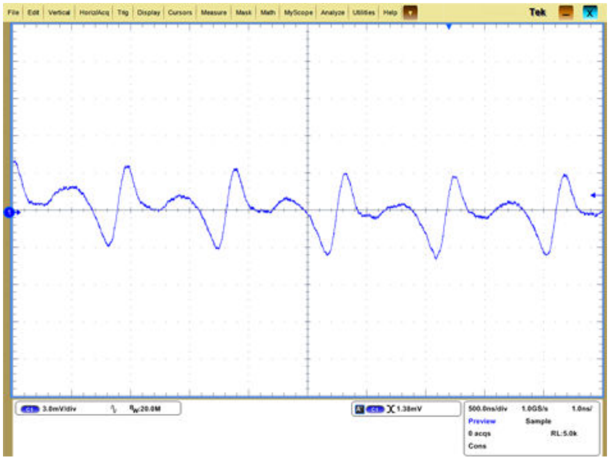


Startup by power-on



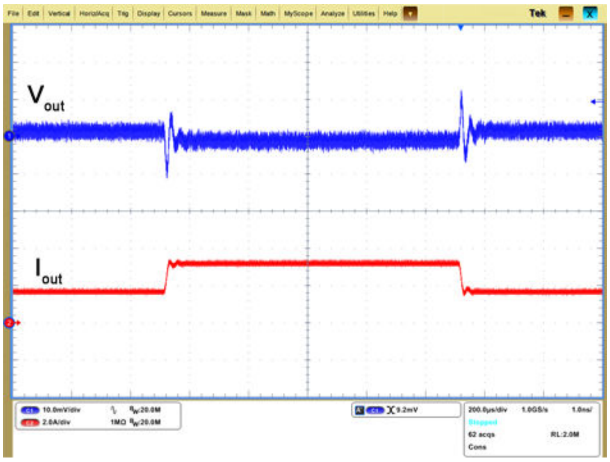
Shutdown by power-off

4.3 Output voltage ripple

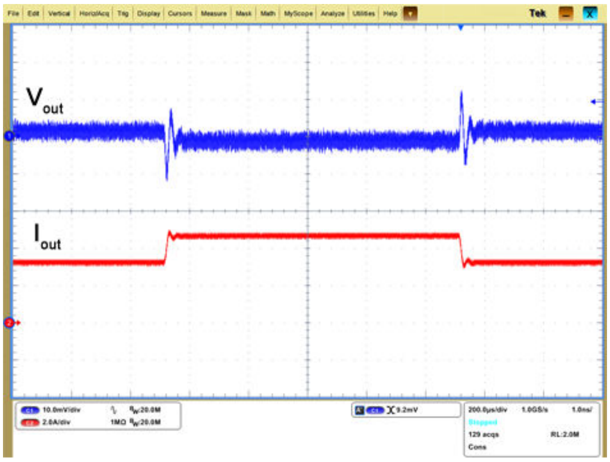


Output voltage ripple (for points B and C in the test set-up diagram, V_{in} = 12 V, V_{out} = 1.2 V, I_{out} = 6 A)

4.4 Output Voltage Dynamic Response

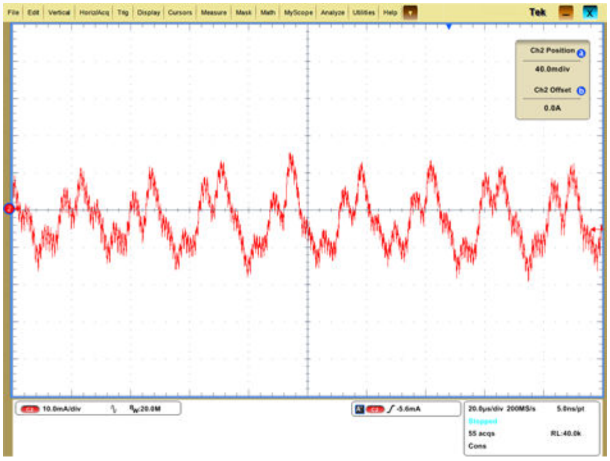


Load: 25%–50%–25%, di/dt = 1 A/µs



Load: 50%–75%–50%, di/dt = 1 A/µs

4.5 Input reflected ripple current



Input reflected ripple current (for point A in the test set-up diagram, V_{in} = 12 V, V_{out} = 1.2 V, I_{out} = 6 A)

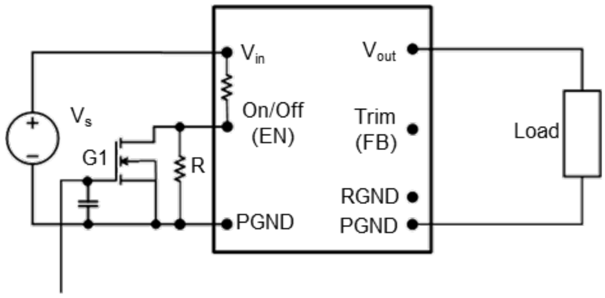
5 Control Features

5.1 Remote On/Off

EN Pin Level	Status
Low level	Off
High level	On

It is recommended that the On/Off pin be controlled using an open collector transistor or a similar device.

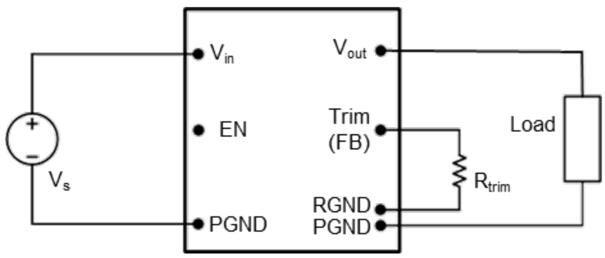
Figure 5-1 Circuit configuration for On/Off function



5.2 Output Voltage Trim

The output voltage can be adjusted by connecting an external resistor between the Trim (FB) pin and the RGND pin.

Figure 5-2 R_{trim} external connections



Relationship between R_{trim} and V_{out}:

$$R_{trim} = \left[\frac{1.2}{V_{out} - 0.6}\right] k\Omega$$

NOTE

The output voltage varies depending on R_{trim}. Note that the trim resistor tolerance directly affects the output voltage accuracy. It is recommended that ±1% trim resistors be used.

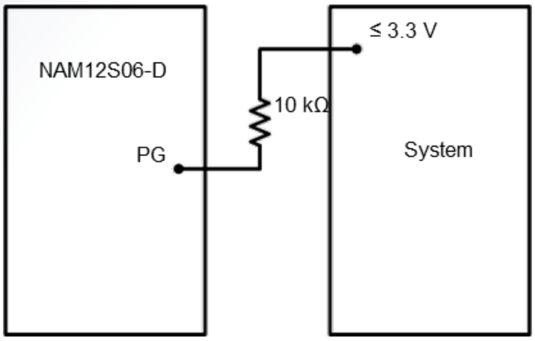
The following table describes the mapping between V_{out} and R_{trim}.

V_{out} (V)	R_{trim} (kΩ)
0.7	12
0.8	6
0.9	4
1.0	3
1.2	2
1.5	1.3333
1.8	1
2.5	0.6315
3.3	0.4444
5.0	0.2727
5.4	0.25

5.3 Power Good Signal (PG)

The power good (PG) signal is pulled up to Vin or a fixed level not exceeding 3.3 V through a 10 kΩ resistor when in use. If the PG function is not required, the pin is left open.

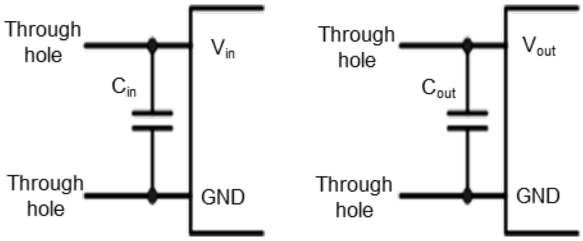
Figure 5-3 Configuration diagram of PG



5.4 PCB Layout Considerations

To ensure the filtering effects, place the C_{in} and C_{out} symmetrically near the pins. The following figure shows the cable hole layouts at the input and output terminals.

Figure 5-4 Recommended PCB layout



6 Protection Features

Input Undervoltage Protection

The converter will shut down if the input voltage drops below the undervoltage protection threshold. The converter will start to work again if the input voltage reaches the input undervoltage recovery threshold.

Output Overcurrent Protection

The converter equipped with current limiting circuitry can provide protection from an output overload or short circuit condition. If the output current exceeds the output overcurrent protection set point, the converter enters hiccup mode. When the fault condition is removed, the converter will automatically restart.

Output Overvoltage Protection

When the output voltage exceeds the output overvoltage protection threshold, the converter will enter latch off mode. The converter will resume normal operation after the converter restart.

7 Qualification Testing

Precondition test required for test items 1–8: Visual inspection → Electrical test → C-SCAN → Bake (125°C, 24 h) → Moisture soaking → Reflow (3 cycles, 260°C) → Visual inspection → Electrical test → C-SCAN.

No.	Test Item	Condition
1	High temperature storage life test	125°C, 1000 h
2	Unbiased highly accelerated stress test	130°C, 85% RH, 96 h
3	Thermal shock	1000 temperature cycles between –55°C and +125°C with the temperature change rate of 40°C per minute; lasting for 30 minutes both at –55°C and +125°C
4	Temperature humidity bias	Maximum input voltage; 85°C; 85% RH; 1500 operating hours under lowest load power
5	High temperature operating life test	Rated input voltage; airflow rate: 0.5 m/s (100 LFM) to 5 m/s (1000 LFM); ambient temperature 85°C; 1000 operating hours; 100% load
6	Power and temperature cycling test	Rated input voltage; airflow rate: 0.5 m/s (100 LFM) to 5 m/s (1000 LFM); ambient temperature between –40°C and +100°C; 1000 cycles under 50% load
7	Highly accelerated life test	Low temperature limit: –60°C; high temperature limit: 110°C; vibration limit: 40 G; temperature slope: 40°C per minute; vibration frequency range: 20–2000 Hz
8	Solderability	Steam aging: 8 h, Pb-free, (245±5)°C, (5±0.5)s
9	Temperature cycle test (daisy chain)	–40°C to 125°C; number: 500/700/1000 cycles; no power on; ramp rate 10°C – 20°C/min
10	Stress test (daisy chain)	4 points bending, 1 mm/min, daisy chain, R change > 20%

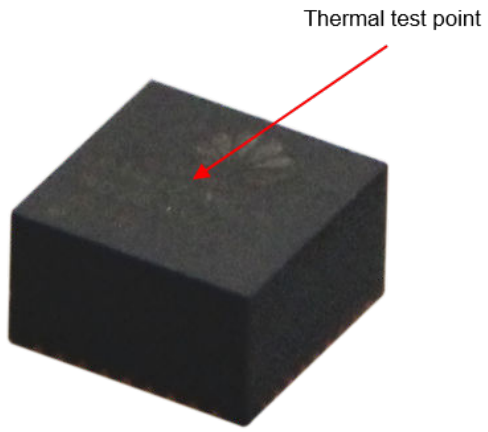
No.	Test Item	Condition
11	Drop test (daisy chain)	X1/X2/Y1/Y2/Z1/Z2 plane, 5 pulses/plane, 0.5 ms duration, 1500G peak acceleration, 30 drops
12	High temperature warpage test (shadow moire)	Temperature range: 25°C–300°C
13	Crystal dendrite test	100°C, running for nine days, Vcc full load
14	ESD	HBM 2000 V, CDM 500 V
15	Moisture and dust	Dust accumulated for three days (30 mg/ m^3), steady damp heat (95% RH, 40°C), cyclic damp heat for 2 days
16	High temperature storage life test	125°C, 1000 h
17	Autoclave	121°C, 100% RH, 1 bar above atmosphere, 96 h
18	Tin whisker test	Air temperature: –55°C to 85°C; hold time: 5–10 minutes, 3 cycles/h; test time: 1000 h
19	Long life test	Air temperature: 85°C; 100% load; test time: 6 months

8 Thermal Consideration

Thermal Test Point

Sufficient airflow should be provided to ensure reliable operating of the converter. Therefore, thermal components are mounted on the top surface of the converter to dissipate heat to the surrounding environment by conduction, convection, and radiation. Proper airflow can be verified by measuring the temperature at the surface of the converter.

Figure 8-1 Thermal test point



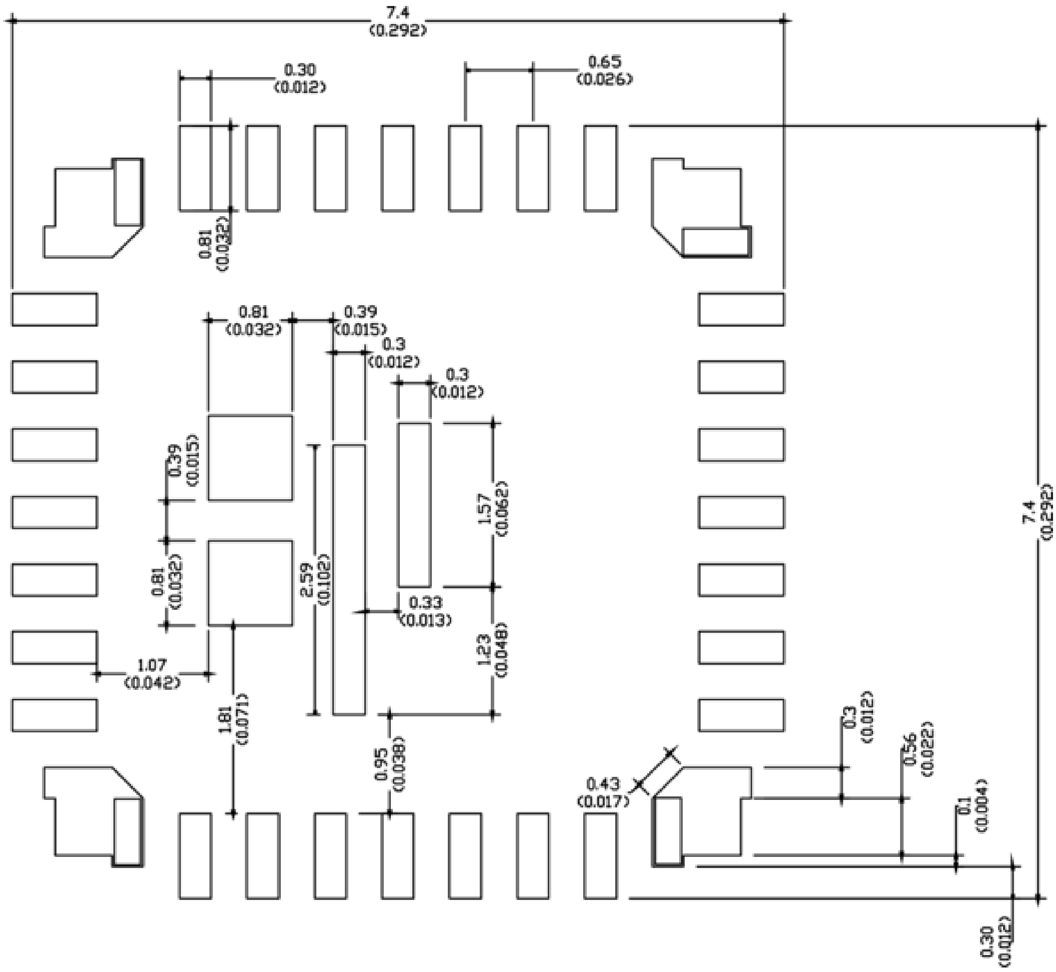
Power Dissipation

The converter power dissipation is calculated based on efficiency. The following formula reflects the relationship between the consumed power (P_d), efficiency (η), and output power (P_o): $P_d = P_o (1 – η)/η$

9 Encapsulation Size Diagram

Unit of measurement: mm [in.]

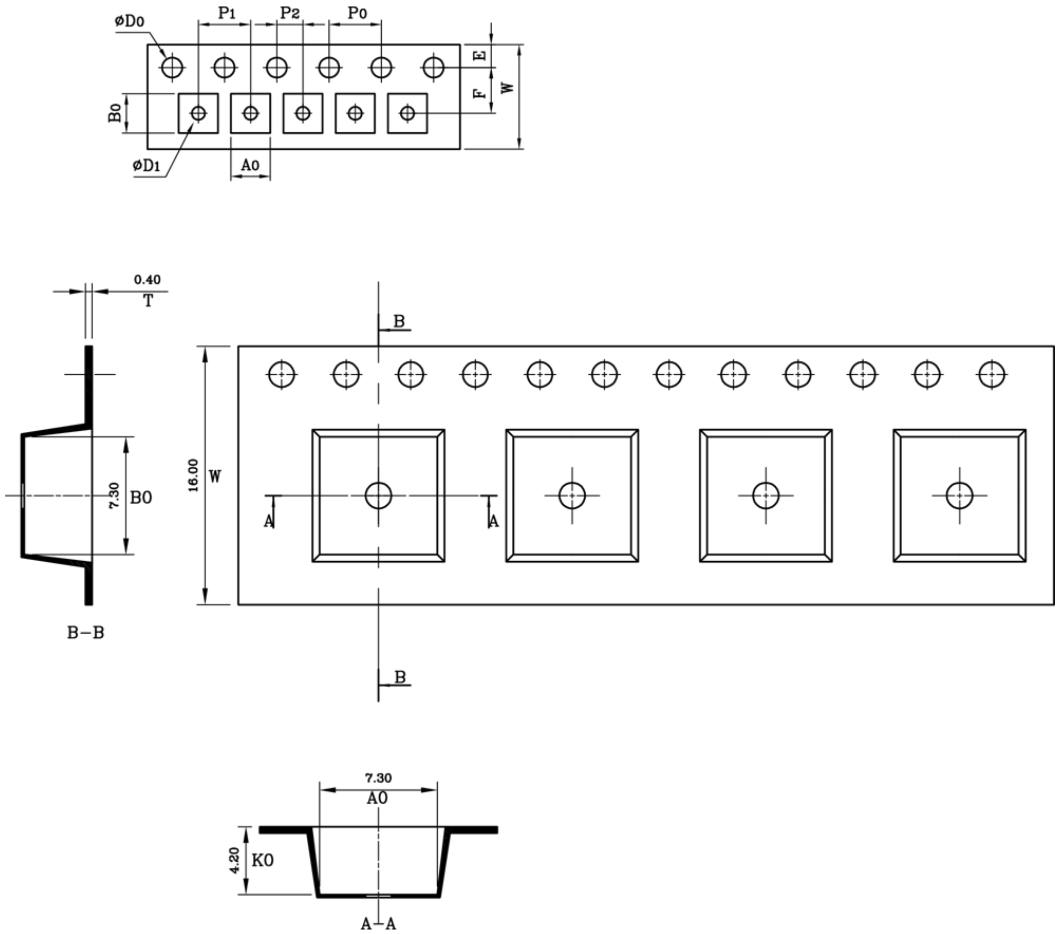
Figure 9-1 Encapsulation Size Diagram



10 Package Information

The converter is supplied in tape and reel packaging. The following figure shows the tape dimensions.

Unit of measurement: mm



Item	W	P1	E	F	P0	P2	10P0
Specifications	16.00±0.30	12.0±0.10	1.75±0.1	7.5±0.10	4±0.1	2±0.10	40±0.2
Item	A0	B0	K0	T	D0	D1	-
Specifications	7.30±0.10	7.30±0.10	4.20±0.10	0.40±0.05	1.54+0.10	1.5+0.25	-

NOTE

1. Carrier tape color: black
2. Property: antistatic
3. Material: PS
4. Thickness: 0.40 mm

11 Mechanical Consideration

Surface Mount Information

The converter uses a PSiP structure and is designed for a fully automated assembly process.

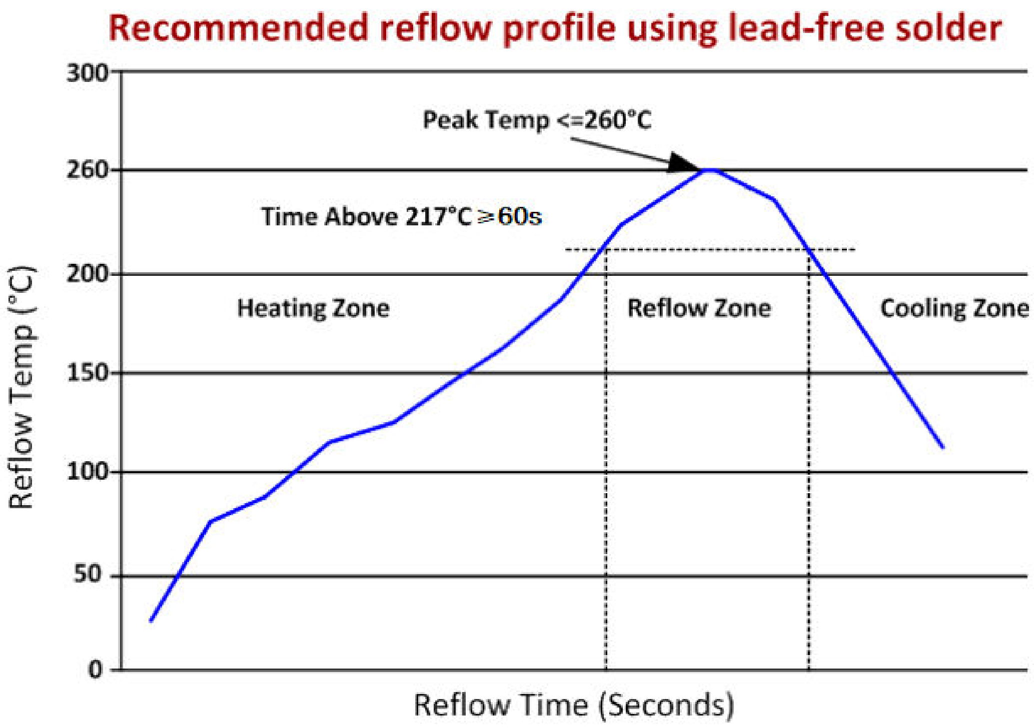
The flat surface of the label on the large inductor can be the patch mounting surface. The converter weight can be borne by a standard surface mount device (SMD). For most SMDs, the converter is heavy, and mounting on the capacitor surface will cause deviation. The solution is to optimize the model and size of the suction nozzle and increase the mounting speed and vacuum pressure.

The label meets all the requirements for surface mount processing, as well as safety standards, and is able to withstand reflow temperatures of up to 300°C. The label also carries product information such as product code and manufacturing date.

Soldering

The converter supports reflow soldering techniques. Wave soldering and hand soldering are not allowed. During the reflow process, the peak temperature must not exceed 260°C at any time.

Figure 11-1 Recommended reflow profile using lead-free solder



Moisture Resistance Requirements

Store and transport the converter as required by the MSL rating 3 specified in the IPC/JEDEC J-STD-033.

The surface of a soldered converter must be clean and dry. Otherwise, the assembly, test, or even reliability of the converter will be negatively affected.

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