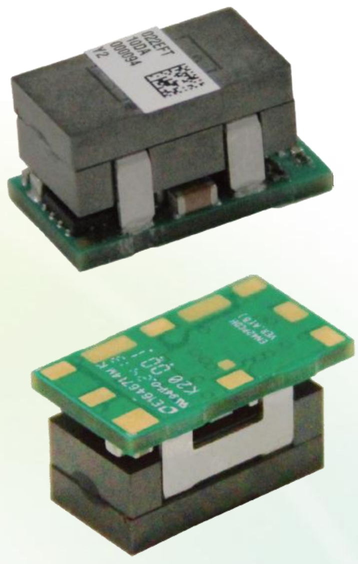
NAD12S20-A
DC-DC Converter Technical Manual V1.2

POL DC-DC Converter	9 - 14 V Input	0.7 - 2.0 V Output	20 A Current	Positive Logic

Description

The NAD12S20-A is a non-isolated DC-DC converter with an input voltage range of 9 V to 14 V and the maximum output current of 20 A. Its output voltage can be adjusted within a range of 0.7 V to 2.0 V.



NAD12S20-A

Operational Features

- Input voltage: 9 - 14 V
- Output current: 0 - 20 A
- Output voltage: 0.7 - 2.0 V
- Efficiency: 91.0 % (2.0 V, 20 A)

Mechanical Features

- SMT
- Dimensions: 20.32 mm x 11.43 mm (0.800 in. x 0.450 in.)
- Height: ≤10.80 mm (0.425 in.)
- Weight: about 6.8 g

Control Features

- Remote on/off
- Remote sense
- Output voltage trim

Protection Features

- Input undervoltage protection
- Output overcurrent protection (Hiccup mode)
- Output short circuit protection (Hiccup mode)
- Output overvoltage protection (Self-recovery)
- Overtemperature protection (Self-recovery)

Safety Features

- UL60950-1 and CSA C22.2 No. 60950-1-07
- RoHS6 compliant

Designation Explanation

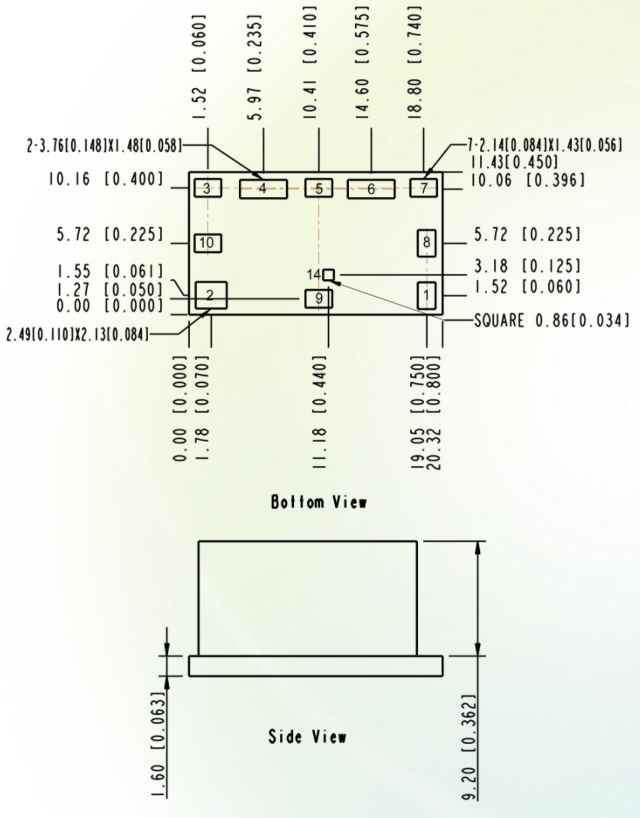
NAD	12	S	20	-A
1	2	3	4	5

1 — Non-isolated, analog, package type
2 — Input voltage: 12 V
3 — Single output
4 — Output current: 20 A
5 — Extension code

NOTE

EN42PCDH on the label of the module is the internal model used by the manufacturer.

Mechanical Diagram



Pin Description

Pin No.	Function
1	On/Off
2	V_{in}
3	NC
4	GND
5	Trim
6	V_{out}
7	VS+
8	VS-
9	PG
10	NC
14	SIG_GND

NOTE

1. All dimensions in mm [in.]
   Tolerances: x.x ± 0.5 mm [x.xx± 0.02 in.]
   x.xx ± 0.25 mm [x.xxx ± 0.010 in.]
2. Tolerances for the lengths and widths of all pads are x.xx ± 0.10 mm [x.xxx ± 0.004 in.].

Electrical Specifications

Conditions: T_A = -40°C to +85°C, V_{in} = 9 - 14 V DC, V_{out} = 0.7 - 2.0 V DC, unless otherwise notes.

Parameter	Output	Min.	Typ.	Max.	Units	Notes & Conditions
Absolute maximum ratings						
Input voltage(Continuous)	-	-	-	16	V	-
Operating ambient temperature	-	-40	-	85	ºC	See the thermal derating curve
Storage temperature	-	-55	-	125	ºC	-
Operating humidity	-	10	-	95	% RH	Non-condensing
External voltage applied to ON/OFF	-	-	-	5	V	-
Input characteristics						
Operating input voltage	-	9	12	14	V	-
Maximum input current	-	-	-	19	A	V_{in} = 0 - 14 V; I_{out} = 20 A
No-load loss	1.2 V	-	0.3	-	W	V_{in} = 12 V; I_{out} = 0 A
Input capacitance	-	220+30	220+30	-	µF	220 µF: polymer aluminum capacitor 30 µF: ceramic capacitor
Inrush transient	-	-	-	1	A²s	-
Output characteristics						
Output voltage set point	All	-	-	±1.0	$\%V_{oset}$	V_{in} = 12 V; I_{out} = 10 A; 0.1% tolerance resistor used to set output voltage
Output voltage	All	0.7	-	2.0	V	V_{in} = 9 - 14 V; I_{out} = 0 - 20 A
Output line regulation	All	-	-	±0.5	%	V_{in} = 9 - 14 V; I_{out} = 20 A
Output load regulation	All	-	-	±0.5	%	V_{in} = 12 V; I_{out} = 0 - 20 A
Regulated voltage precision	All	-	-	±2.0	%	V_{in} = 9 - 14 V; I_{out} = 0 - 20 A
Temperature coefficient	All	-	-	±0.02	%/°C	T_A = -40°C to +85°C (-40°F to +185°F)
External capacitance	All	470+66	470+66	5000	µF	470 µF: polymer tantalum capacitor 66 µF: ceramic capacitor 5000 µF: aluminum capacitor
Output current	All	0	-	20	A	-
Output ripple and noise (peak to peak)	≤1.2 V	-	20	30	mV	Oscilloscope bandwidth: 20 MHz
	>1.2 V	-	30	60	mV	
Output voltage overshoot	All	-	-	5	%	The whole range of V_{in}, I_{out} and T_A
Output voltage delay time	All	-	3	10	ms	From V_{in} connection to 10% V_{out}
Output voltage rise time	All	-	2	10	ms	From 10% V_{out} to 90% V_{out}
Switching frequency	All	-	400	-	kHz	-

Electrical Specifications

Conditions: T_A = -40°C to +85°C, V_{in} = 9 - 14 V DC, V_{out} = 0.7 - 2.0 V DC, unless otherwise notes.

Parameter	Output	Min.	Typ.	Max.	Units	Notes & Conditions
Protection characteristics						
Input undervoltage protection Startup threshold Shutdown threshold Hysteresis	All	6.6 5.0 1.0	7.8 6.2 1.6	8.6 7.0 2.0	V V V	-
Output overcurrent protection	All	22	-	38	A	Hiccup mode
Output short circuit protection	All	-	-	-	-	Hiccup mode
Output overvoltage protection	All	110	-	130	%	Self-recovery
Overtemperature protection Threshold Hysteresis	All	110 5	125 -	135 -	°C °C	Self-recovery The values are obtained by measuring the temperature of the PCB near the MOSFET.
Dynamic characteristics						
Overshoot amplitude Recovery time	≤1.2 V	- -	- -	60 200	mV µs	Current change rate: 1 A/µs Load: 25% - 50% - 25%; 50% - 75% - 50%
Overshoot amplitude Recovery time	>1.2 V	- -	- -	5 200	% µs	Current change rate: 1 A/µs Load: 25% - 50% - 25%; 50% - 75% - 50%
Efficiency						
100% load	0.7 V	81.0	82.5	-	%	V_{in} = 12 V; T_A = 25°C (77°F)
	0.8 V	82.0	83.5	-		
	0.9 V	83.5	85.0	-		
	1.0 V	84.5	86.0	-		
	1.2 V	86.5	88.0	-		
	1.5 V	87.5	89.0	-		
	1.8 V	89.0	90.5	-		
	2.0 V	89.5	91.0	-		
50% load	0.7 V	85.0	86.5	-		
	0.8 V	86.0	87.5	-		
	0.9 V	87.0	88.5	-		
	1.0 V	87.5	89.0	-		
	1.2 V	88.0	89.5	-		
	1.5 V	89.0	90.5	-		
	1.8 V	90.0	91.5	-		
	2.0 V	91.0	92.5	-		

Electrical Specifications

Conditions: T_A = -40°C to +85°C, V_{in} = 9 - 14 V DC, V_{out} = 0.7 - 2.0 V DC, unless otherwise notes.

Parameter	Output	Min.	Typ.	Max.	Units	Notes & Conditions
Other characteristics						
Remote on/off voltage Low level High level	-	-0.2 2.0	- -	0.5 5.0	V V	Positive Connecting to an external voltage is not allowed.
Reliability characteristics						
Mean time between failures (MTBF)	-	-	2.5	-	Million hours	Telcordia SR332 Method 1 Case3; V_{in} = 12 V; 80% load; Airflow = 1.5 m/s (300 LFM); T_A = 40°C (104°F)

Characteristic Curves

Conditions: T_A = 25°C (77°F), unless otherwise specified.

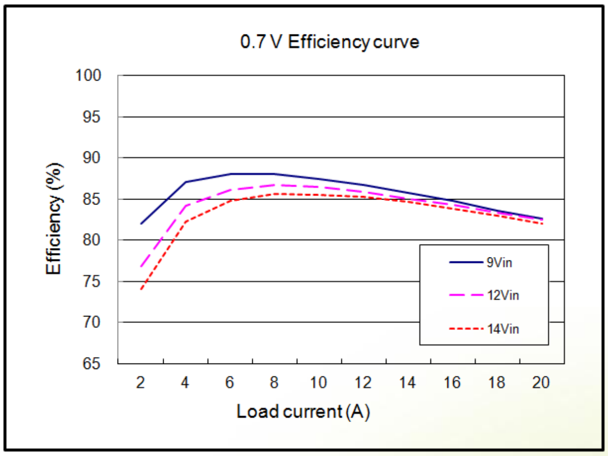


Figure 1: 0.7 V Efficiency

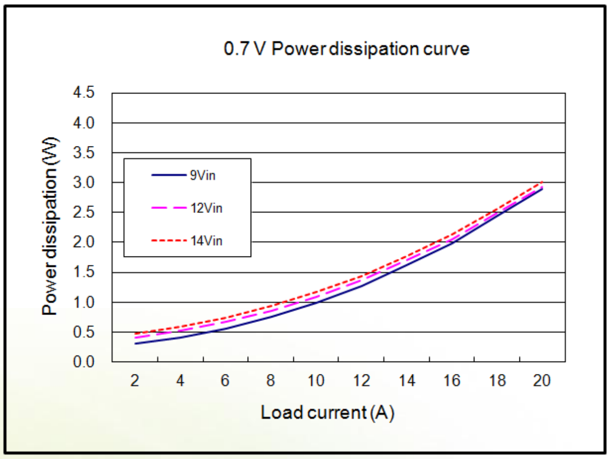


Figure 2: 0.7 V Power dissipation

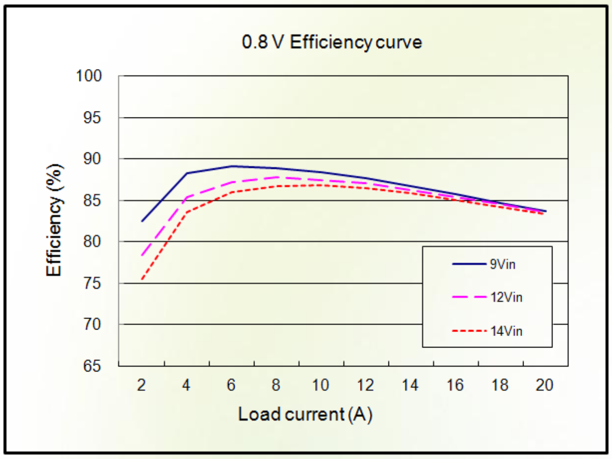


Figure 3: 0.8 V Efficiency

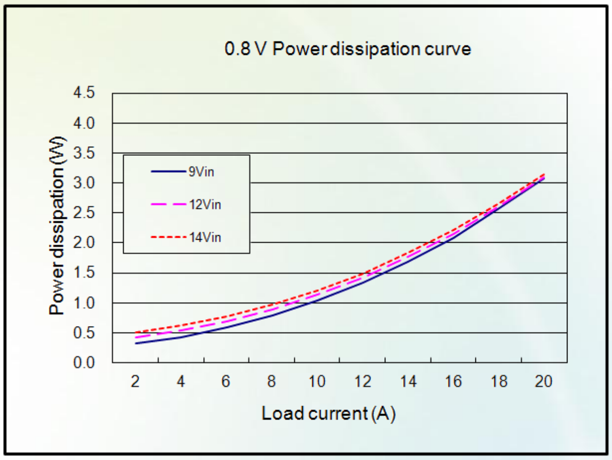


Figure 4: 0.8 V Power dissipation

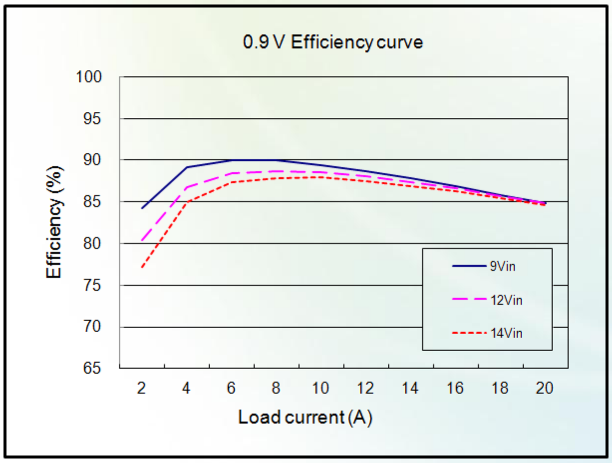


Figure 5: 0.9 V Efficiency

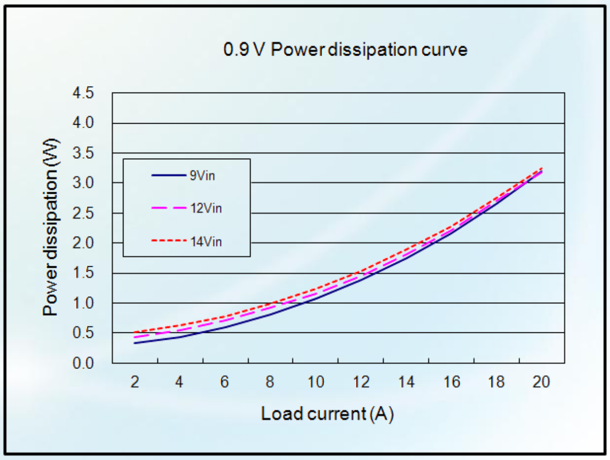


Figure 6: 0.9 V Power dissipation

Characteristic Curves

Conditions: T_A = 25°C (77°F), unless otherwise specified.

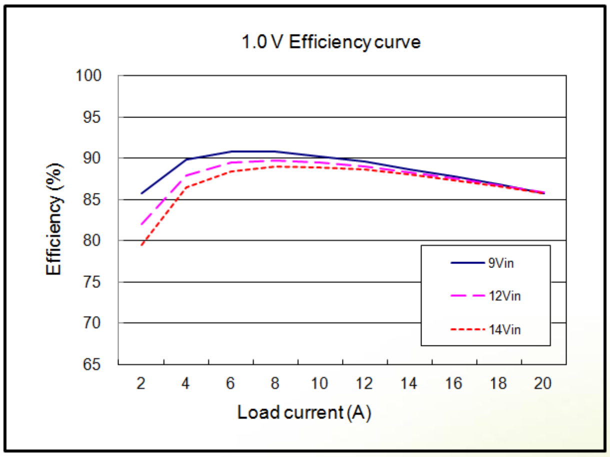


Figure 7: 1.0 V Efficiency

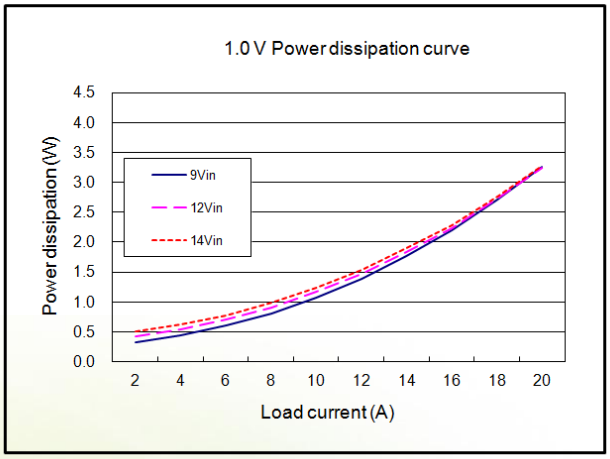


Figure 8: 1.0 V Power dissipation

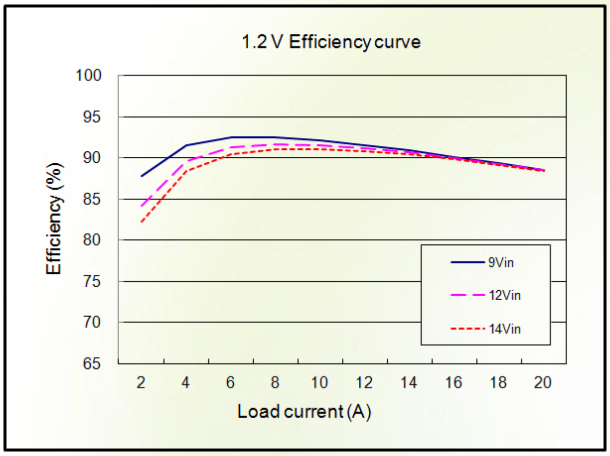


Figure 9: 1.2 V Efficiency

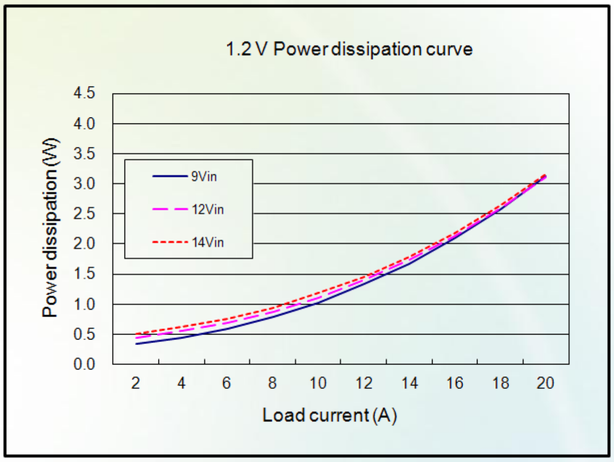


Figure 10: 1.2 V Power dissipation

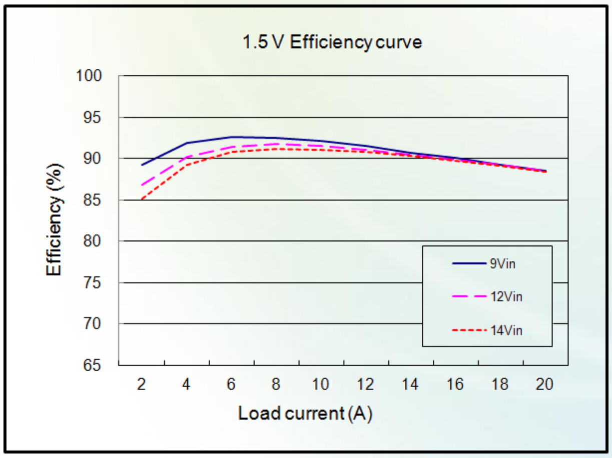


Figure 11: 1.5 V Efficiency

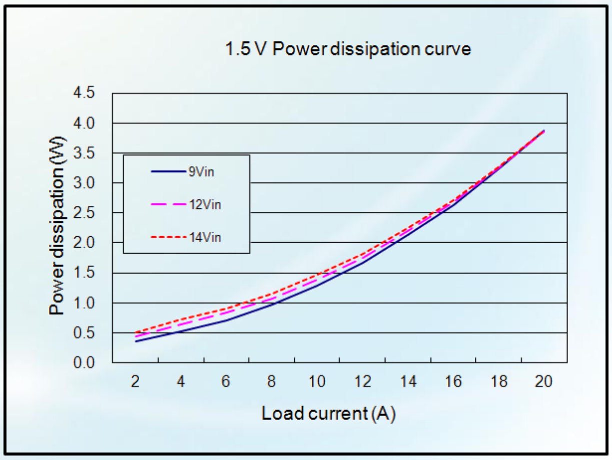


Figure 12: 1.5 V Power dissipation

Characteristic Curves

Conditions: T_A = 25°C (77°F), unless otherwise specified.

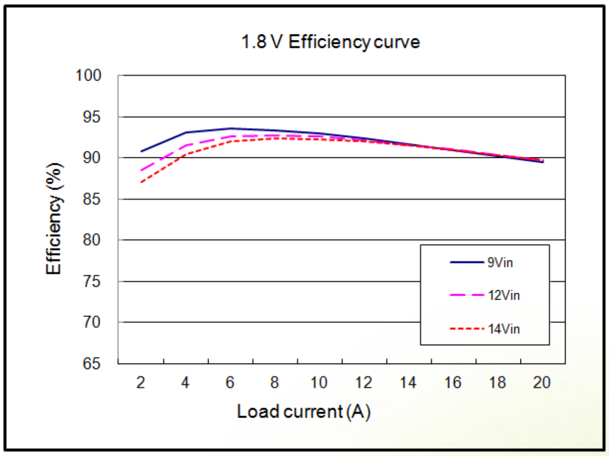


Figure 13: 1.8 V Efficiency

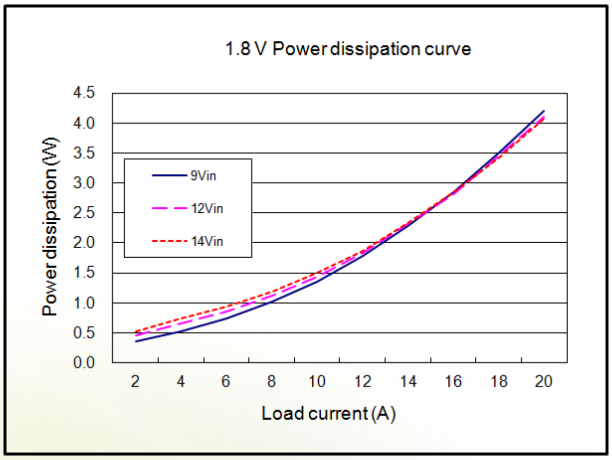


Figure 14: 1.8 V Power dissipation

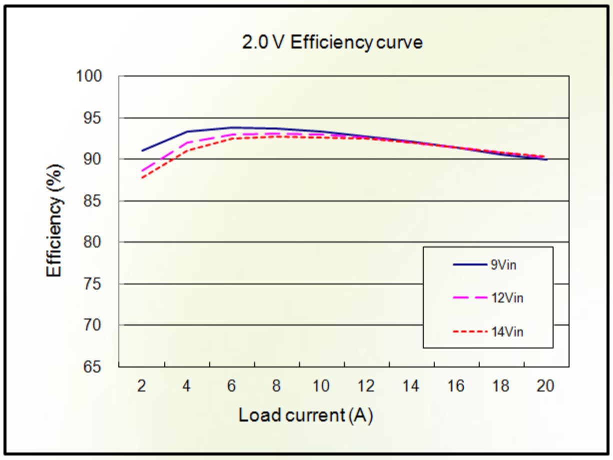


Figure 15: 2.0 V Efficiency

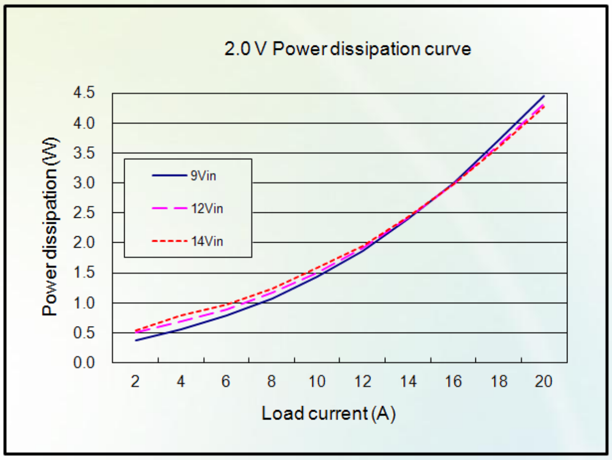


Figure 16: 2.0 V Power dissipation

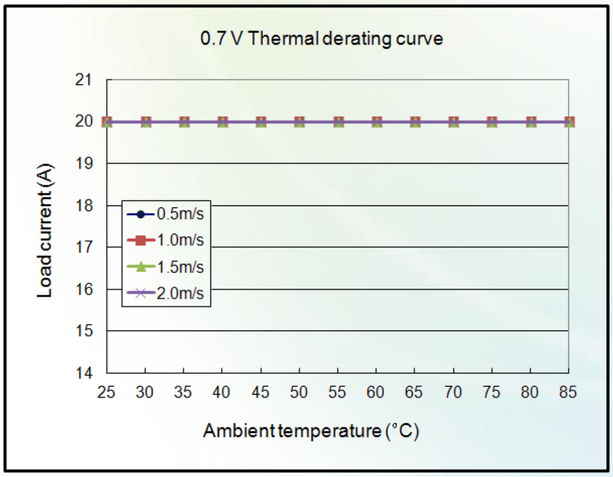


Figure 17: Thermal derating with airflow from pin7 to pin3 (V_{in} = 12 V; V_{out} = 0.7 V)

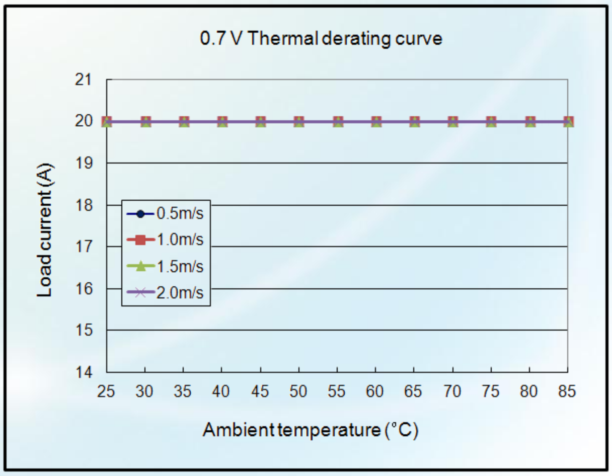


Figure 18: Thermal derating with airflow from pin1 to pin7 (V_{in} = 12 V; V_{out} = 0.7 V)

Characteristic Curves

Conditions: T_A = 25°C (77°F), unless otherwise specified.

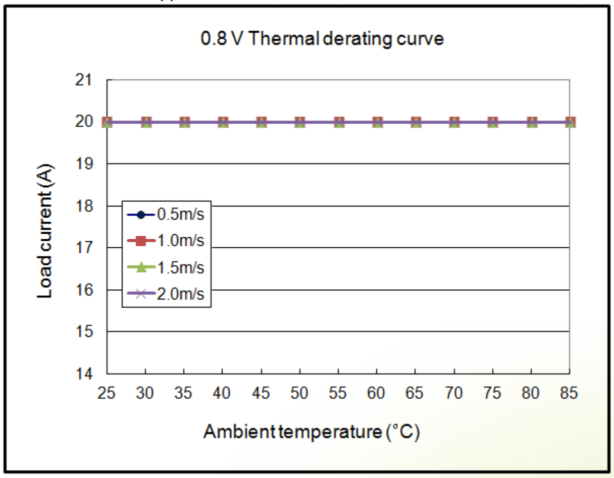


Figure 19: Thermal derating with airflow from pin7 to pin3 (V_{in} = 12 V; V_{out} = 0.8 V)

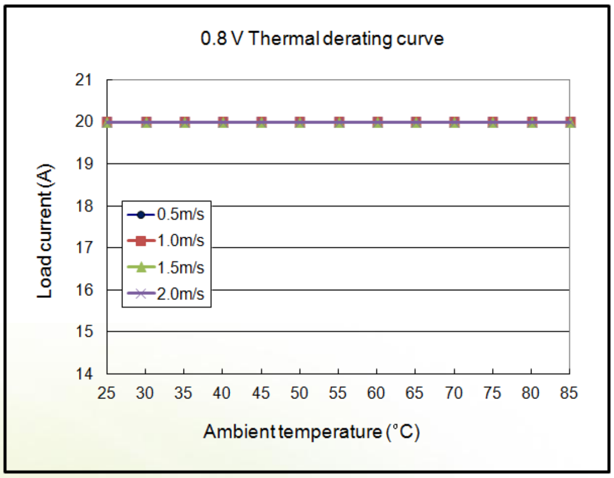


Figure 20: Thermal derating with airflow from pin1 to pin7 (V_{in} = 12 V; V_{out} = 0.8 V)

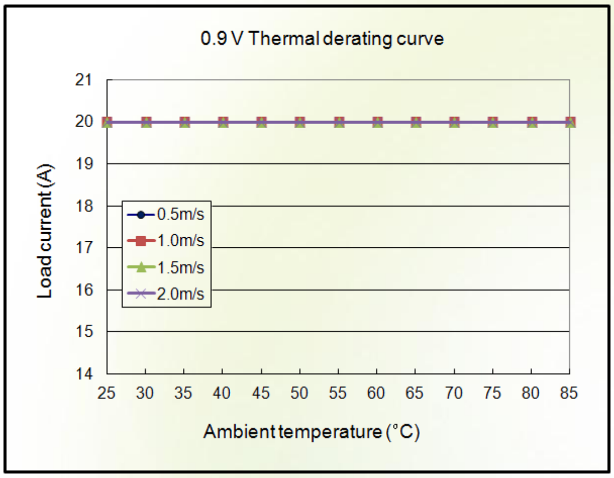


Figure 21: Thermal derating with airflow from pin7 to pin3 (V_{in} = 12 V; V_{out} = 0.9 V)

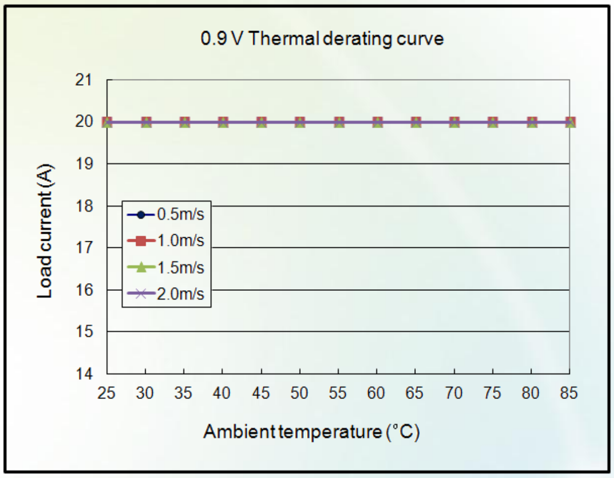


Figure 22: Thermal derating with airflow from pin1 to pin7 (V_{in} = 12 V; V_{out} = 0.9 V)

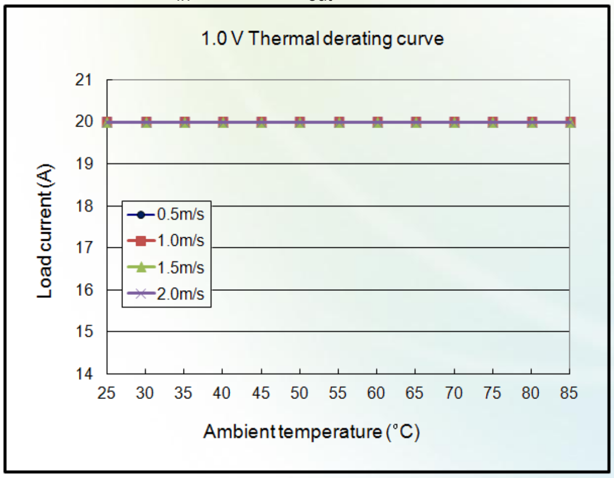


Figure 23: Thermal derating with airflow from pin7 to pin3 (V_{in} = 12 V; V_{out} = 1.0 V)

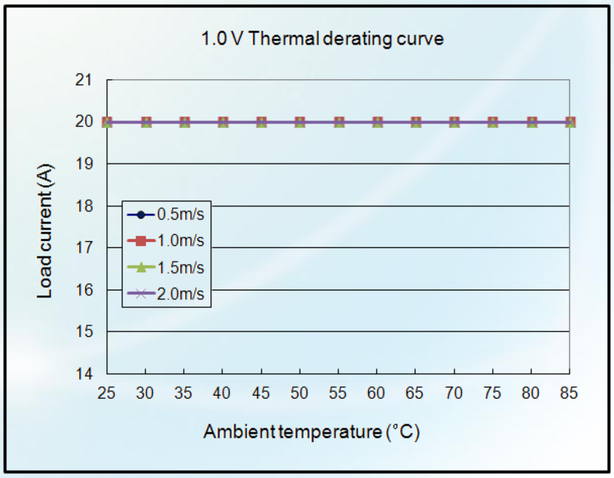


Figure 24: Thermal derating with airflow from pin1 to pin7 (V_{in} = 12 V; V_{out} = 1.0 V)

Characteristic Curves

Conditions: T_A = 25°C (77°F), unless otherwise specified.

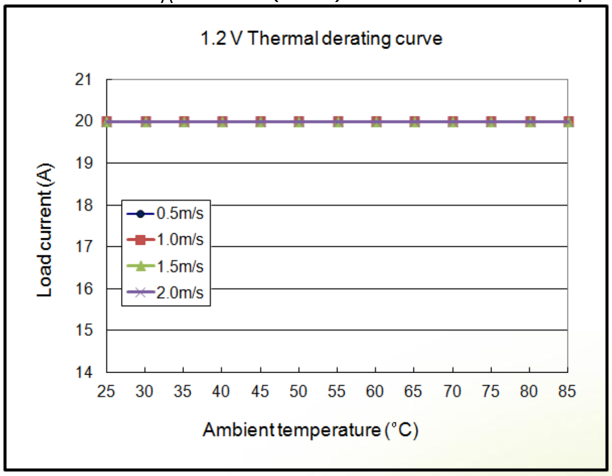


Figure 25: Thermal derating with airflow from pin7 to pin3 (V_{in} = 12 V; V_{out} = 1.2 V)

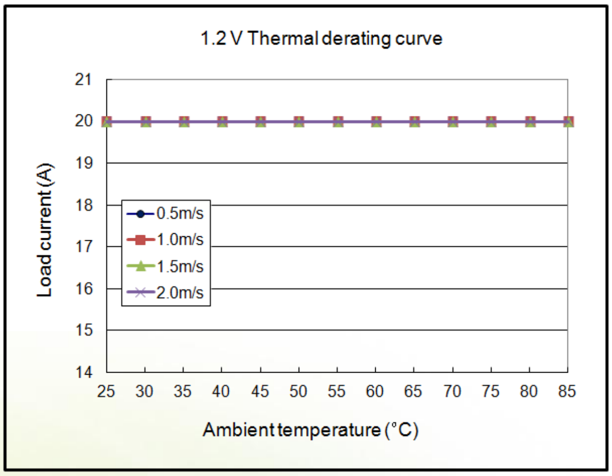


Figure 26: Thermal derating with airflow from pin1 to pin7 (V_{in} = 12 V; V_{out} = 1.2 V)

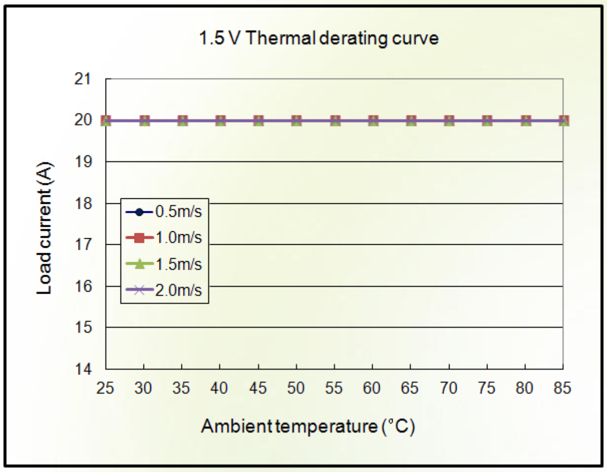


Figure 27: Thermal derating with airflow from pin7 to pin3 (V_{in} = 12 V; V_{out} = 1.5 V)

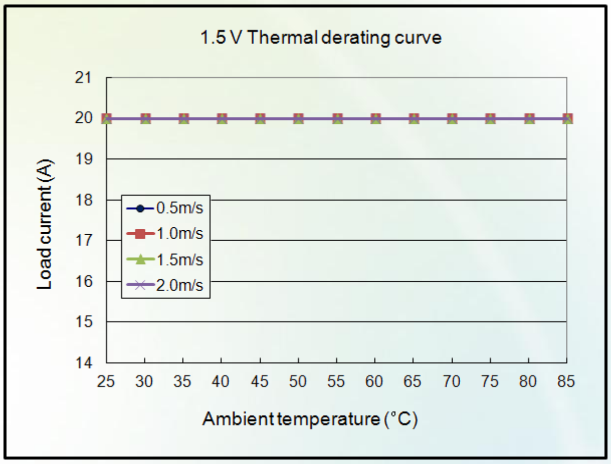


Figure 28: Thermal derating with airflow from pin1 to pin7 (V_{in} = 12 V; V_{out} = 1.5 V)

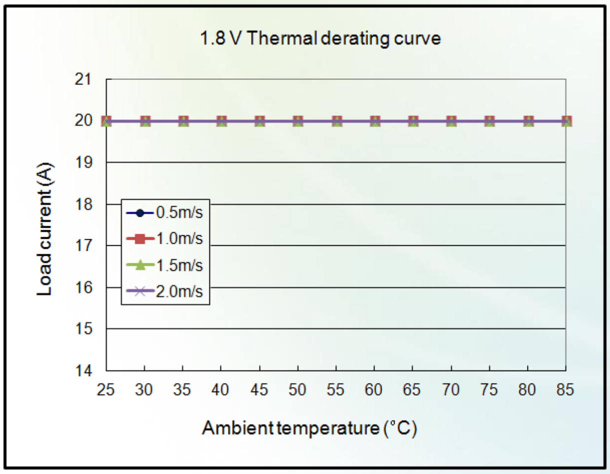


Figure 29: Thermal derating with airflow from pin7 to pin3 (V_{in} = 12 V; V_{out} = 1.8 V)

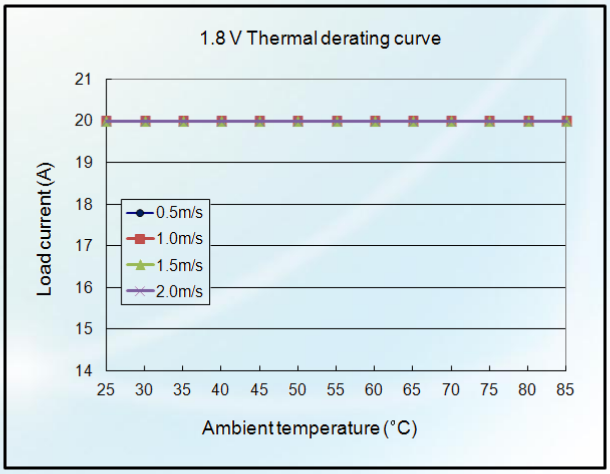


Figure 30: Thermal derating with airflow from pin1 to pin7 (V_{in} = 12 V; V_{out} = 1.8 V)

Characteristic Curves

Conditions: T_A = 25°C (77°F), unless otherwise specified.

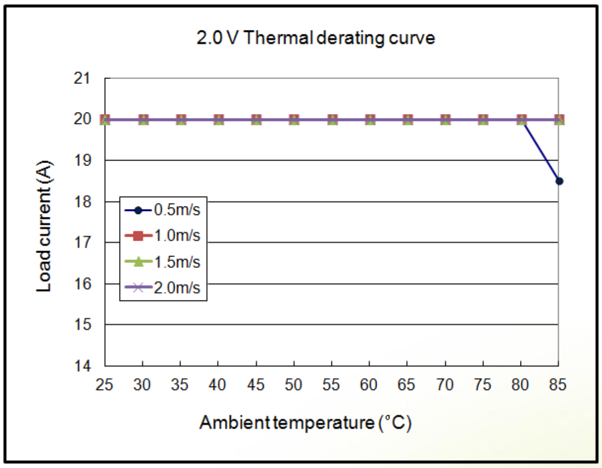


Figure 31: Thermal derating with airflow from pin7 to pin3 (V_{in} = 12 V; V_{out} = 2.0 V)

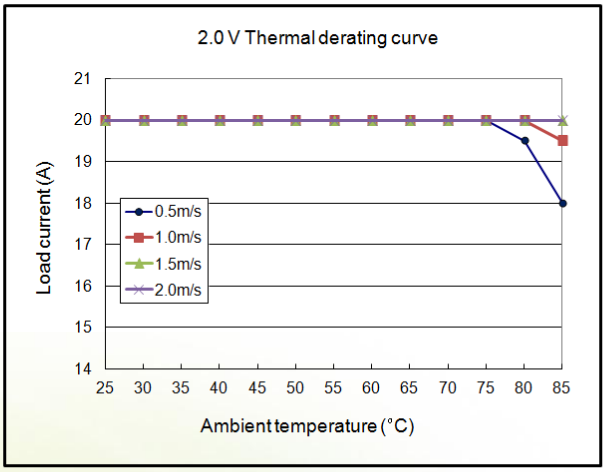


Figure 32: Thermal derating with airflow from pin1 to pin7 (V_{in} = 12 V; V_{out} = 2.0 V)

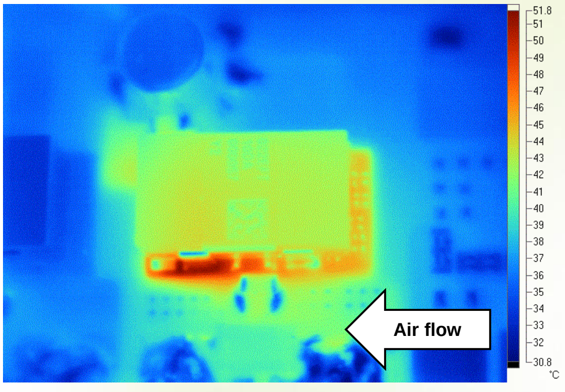


Figure 33: Thermal plot with airflow from pin7 to pin3 (T_A = 25°C [77°F]; Airflow = 1 m/s [200 LFM]; V_{in} = 12 V; V_{out} = 0.7 V; I_{out} = 20 A)

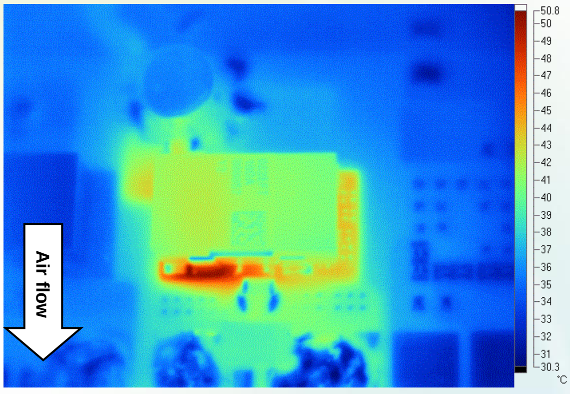


Figure 34: Thermal plot with airflow from pin1 to pin7 (T_A = 25°C [77°F]; Airflow = 1 m/s [200 LFM]; V_{in} = 12 V; V_{out} = 0.7 V; I_{out} = 20 A)

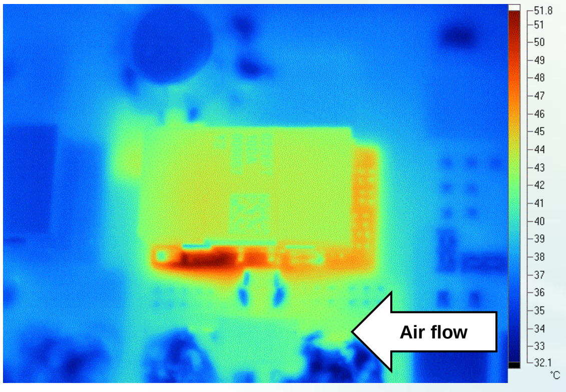


Figure 35: Thermal plot with airflow from pin7 to pin3 (T_A = 25°C [77°F]; Airflow = 1 m/s [200 LFM]; V_{in} = 12 V; V_{out} = 0.9 V; I_{out} = 20 A)

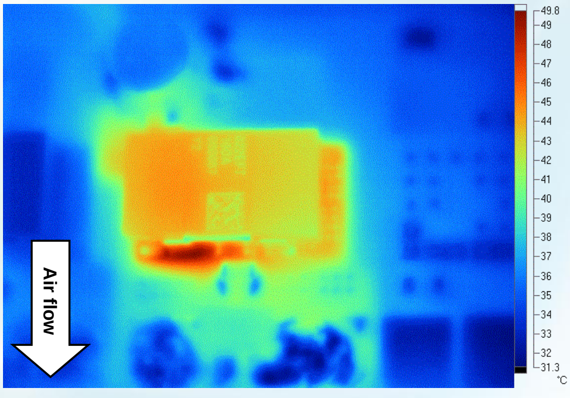


Figure 36: Thermal plot with airflow from pin1 to pin7 (T_A = 25°C [77°F]; Airflow = 1 m/s [200 LFM]; V_{in} = 12 V; V_{out} = 0.9 V; I_{out} = 20 A)

Characteristic Curves

Conditions: T_A = 25°C (77°F), unless otherwise specified.

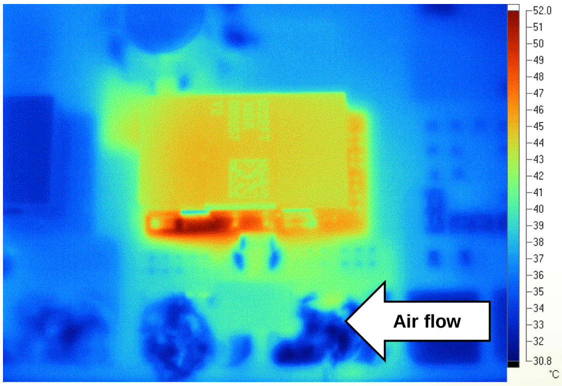


Figure 37: Thermal plot with airflow from pin7 to pin3 (T_A = 25°C [77°F]; Airflow = 1 m/s [200 LFM]; V_{in} = 12 V; V_{out} = 1.0 V; I_{out} = 20 A)

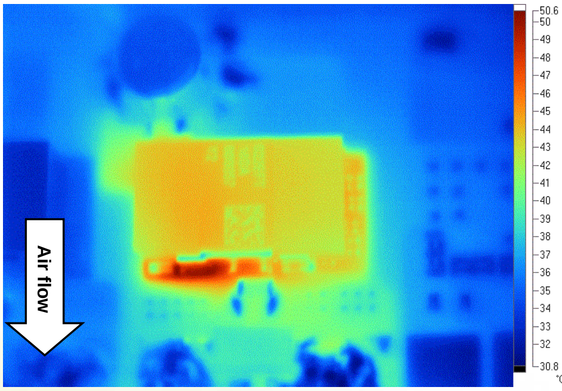


Figure 38: Thermal plot with airflow from pin1 to pin7 (T_A = 25°C [77°F]; Airflow = 1 m/s [200 LFM]; V_{in} = 12 V; V_{out} = 1.0 V; I_{out} = 20 A)

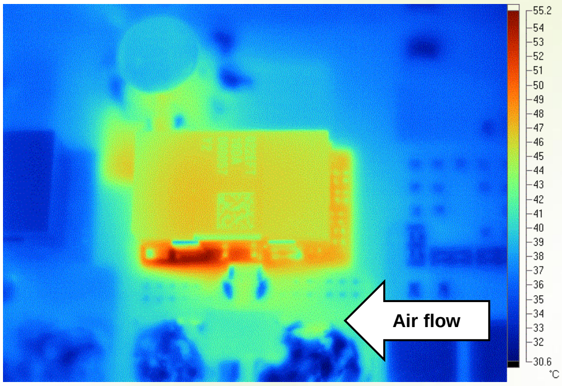


Figure 39: Thermal plot with airflow from pin7 to pin3 (T_A = 25°C [77°F]; Airflow = 1 m/s [200 LFM]; V_{in} = 12 V; V_{out} = 1.2 V; I_{out} = 20 A)

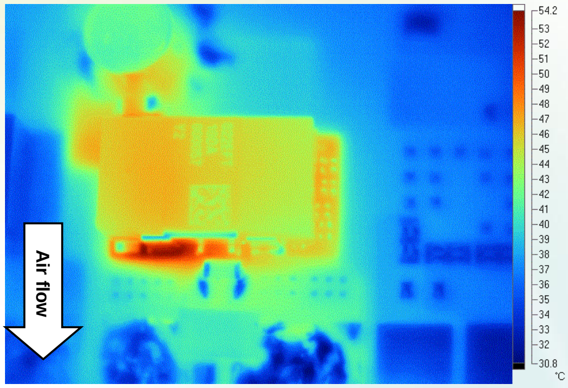


Figure 40: Thermal plot with airflow from pin1 to pin7 (T_A = 25°C [77°F]; Airflow = 1 m/s [200 LFM]; V_{in} = 12 V; V_{out} = 1.2 V; I_{out} = 20 A)

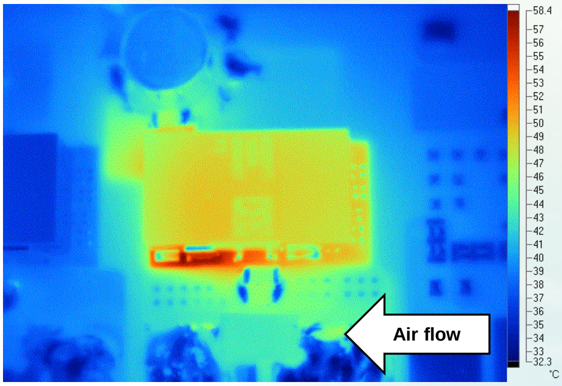


Figure 41: Thermal plot with airflow from pin7 to pin3 (T_A = 25°C [77°F]; Airflow = 1 m/s [200 LFM]; V_{in} = 12 V; V_{out} = 1.8 V; I_{out} = 20 A)

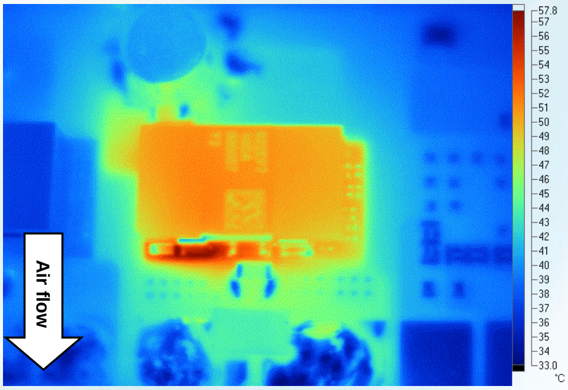


Figure 42: Thermal plot with airflow from pin1 to pin7 (T_A = 25°C [77°F]; Airflow = 1 m/s [200 LFM]; V_{in} = 12 V; V_{out} = 1.8 V; I_{out} = 20 A)

Characteristic Curves

Conditions: T_A = 25°C (77°F), unless otherwise specified.

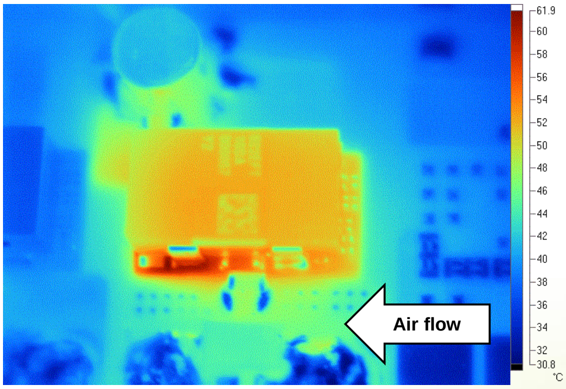


Figure 43: Thermal plot with airflow from pin7 to pin3 (T_A = 25°C [77°F]; Airflow = 1 m/s [200 LFM]; V_{in} = 12 V; V_{out} = 2.0 V; I_{out} = 20 A)

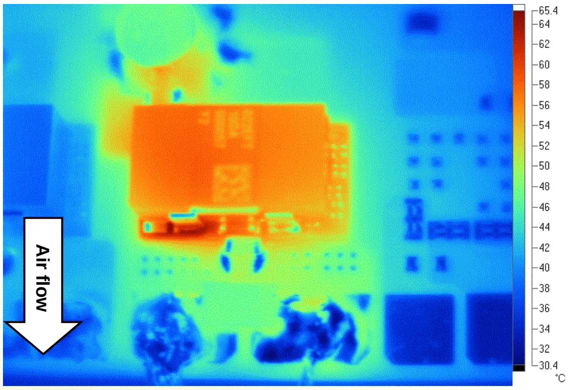


Figure 44: Thermal plot with airflow from pin1 to pin7 (T_A = 25°C [77°F]; Airflow = 1 m/s [200 LFM]; V_{in} = 12 V; V_{out} = 2.0 V; I_{out} = 20 A)

Typical Waveforms

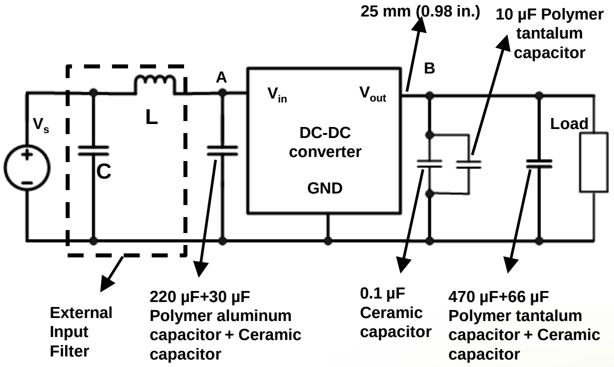


Figure 45: Test set-up diagram

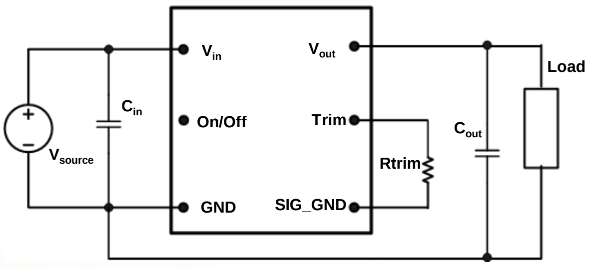


Figure 46: Application guidance

NOTE

1. Measure the output voltage ripple at B (25 mm [0.98 in.] away from the V_{out} pin) shown in Figure 45.
2. During the test of input reflected ripple current, the input terminal must be connected to the external input filter (include a 12 μH inductor and a 220 μF electrolytic capacitor), which is not required in other tests.
3. Test board: D x W = 200 mm x 110 mm, 1oz, 4 layers.

NOTE

Do not connect the GND and SIG_GND pins outside the converter.

To ensure the stable operating of the converter, the proper capacitors must be add to the input and output terminals.

Capacitor	Recommend capacitor
C_{in}	220 μF: polymer aluminum capacitor 30 μF: ceramic capacitor
C_{out}	470 μF: polymer tantalum capacitor 66 μF: ceramic capacitor

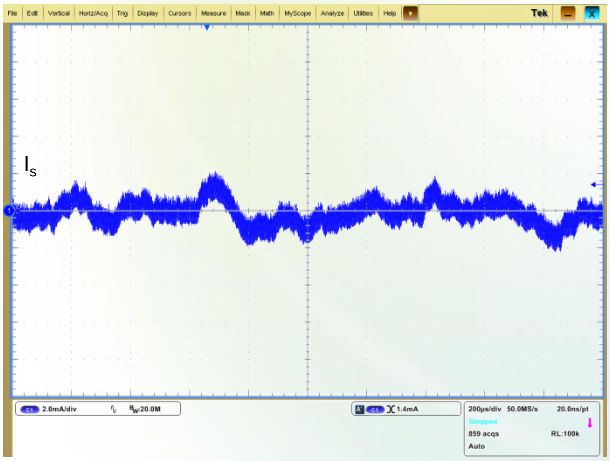


Figure 47: Input reflected ripple current
(for point A in the test set-up diagram, V_{in} = 12 V, V_{out} = 1.2 V, I_{out} = 20 A)

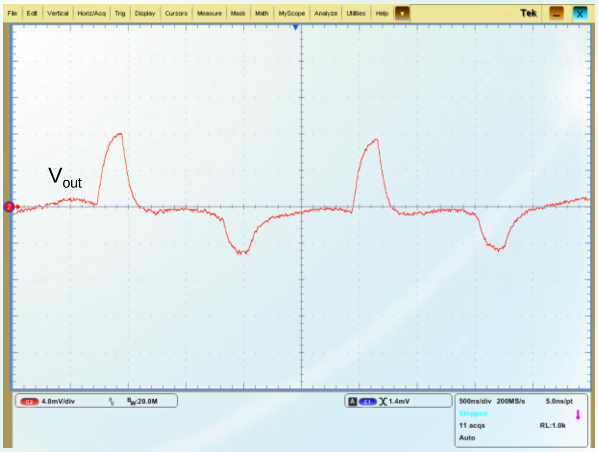


Figure 48: Output voltage ripple
(for point B in the test set-up diagram, V_{in} = 12 V, V_{out} = 1.2 V, I_{out} = 20 A)

Typical Waveforms

Conditions: T_A = 25°C (77°F), V_{in} = 12 V.

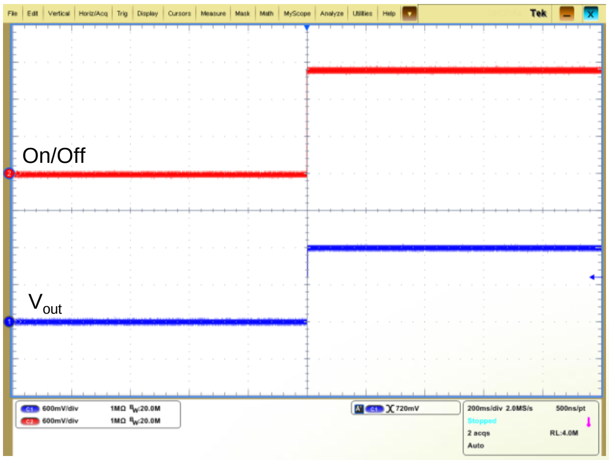


Figure 49: Startup from On/Off

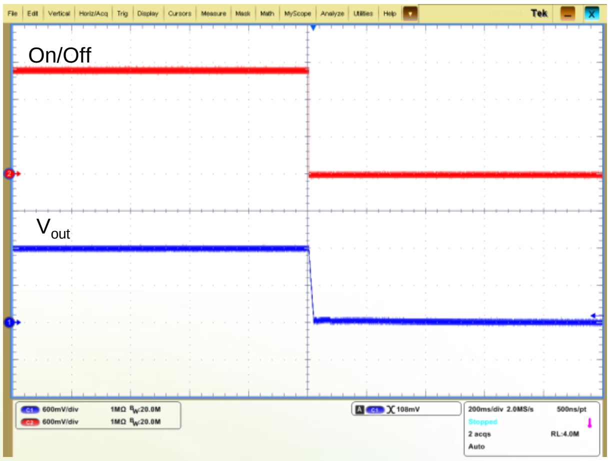


Figure 50: Shutdown from On/Off

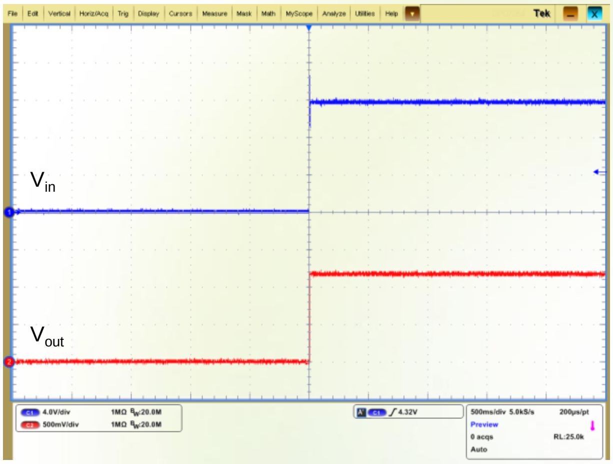


Figure 51: Startup by power on

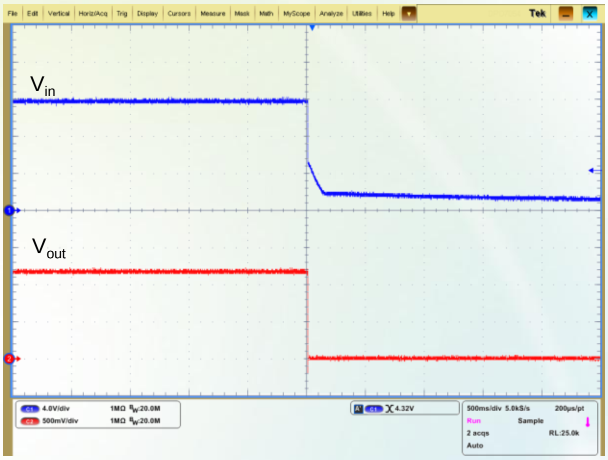


Figure 52: Shutdown by power off

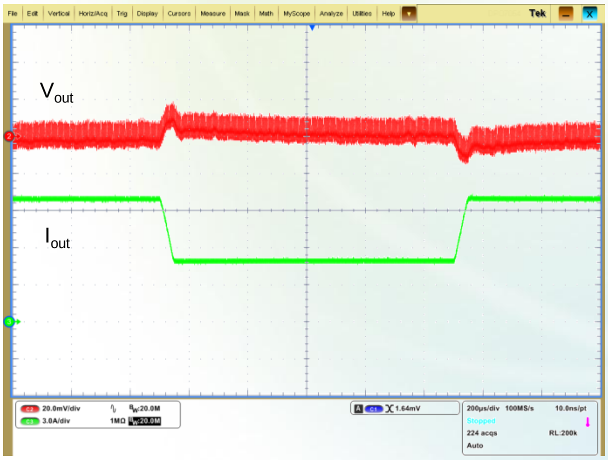


Figure 53: Output voltage dynamic response
(Load: 25% - 50% - 25%, di/dt = 1 A/μs)

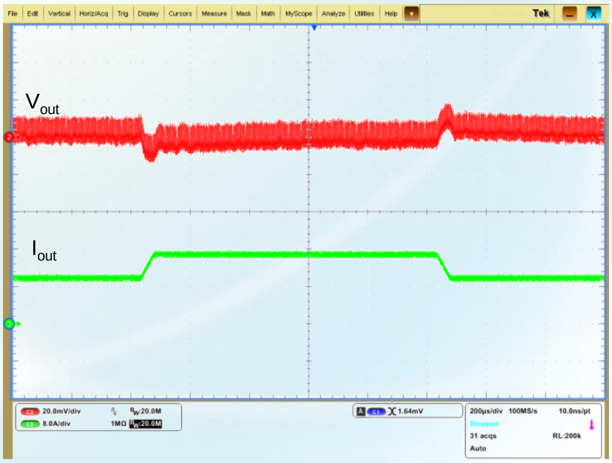


Figure 54: Output voltage dynamic response
(Load: 50% - 75% - 50%, di/dt = 1 A/μs)

Remote On/Off

Logic Enable	On/Off Pin Level	Status
Positive logic	Low level	Off
	Left open	On

It is recommended to control the On/Off pin with an open collector transistor or similar device.

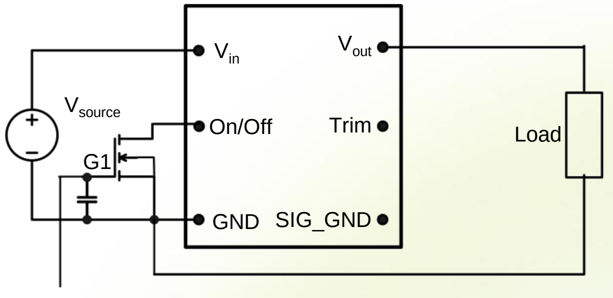


Figure 55: Circuit configuration for On/Off function

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

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

V_{out} (V)	R_{trim} (kΩ)
0.7 V	120
0.9 V	40
1.0 V	30
1.2 V	20
1.8 V	10
2.0 V	8.57

Output Voltage Trim

Output voltage can be adjusted by installing an external resistor between the Trim pin and the SIG_GND pin.

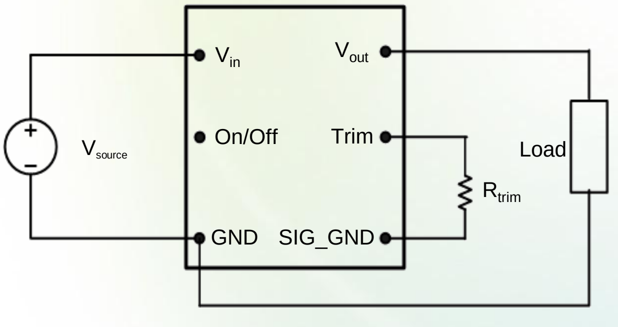


Figure 56: R_{trim} external connections

The relationship between R_{trim} and V_{out}:

$$R_{trim} = \left[\frac{12}{V_{out} - 0.6}\right] \text{k}\Omega$$

Remote Sense

The remote sense feature compensates for the voltage drop between the output pins of the converter and the load. The Sense should be connected at the load or at the point where regulation is required. The maximum compensation voltage is 0.1 V.

If the remote sense function is disabled, leave the Sense open.

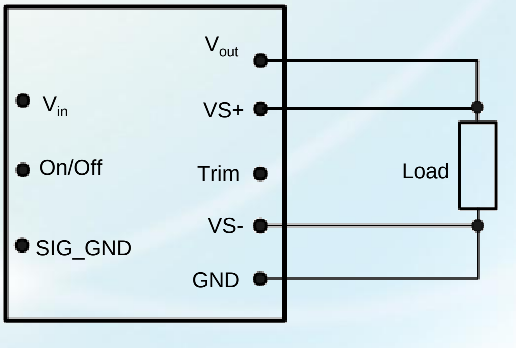


Figure 57: Configuration diagram for remote sense

Input Undervoltage Protection

The converter will shut down after the input voltage drops below the undervoltage protection threshold for shutdown. The converter will start to work again after the input voltage reaches the input undervoltage protection threshold for startup. For the Hysteresis, see the ***Protection characteristics***.

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 voltage directly across the output pins exceeds the output overvoltage protection threshold, the converter will stop working to protect the converter and the load. The converter will automatically resumes normal operation after the over voltage condition is removed.

Overtemperature Protection

A temperature sensor on the converter senses the average temperature of the module. It protects the converter from being damaged at high temperatures. When the temperature exceeds the Overtemperature protection threshold, the output will shut down. It will allow the converter to turn on again when the temperature of the sensed location falls by the value of ***Overtemperature Protection Hysteresis***.

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.

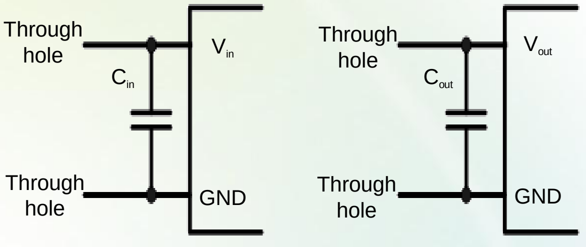


Figure 58: Recommend PCB layout

Qualification Testing

Parameter	Units	Condition
High Accelerated Life Test (HALT)	4	Lowest operating temperature: -60°C (-76°F); highest operating temperature: 120°C (248°F); vibration limit: 40 G
Power Temperature Cycle Test (PTC)	16	Rated input voltage, 50% - 80% load; 1000 temperature cycles between -40°C (-40°F) and + 55°C 131°F) with the temperature change rate of 5°C (41°F) - 10°C (50°F) per minute; Lasting for 30 minutes both at -40°C (-40°F) and + 55°C (131°F)
Temperature Humidity Bias (THB)	16	Maximum input voltage; 85°C (185°F); 85% RH; 1000 operating hours under lowest load power
High Temperature Operation Bias (HTOB)	16	Rated input voltage; air flow: 0.5 m/s (100 LFM) to 5 m/s (1000 LFM); 1000 operating hours under 50% - 80% load power; air temperature: 45°C (113°F) - 55°C (131°F)

Thermal Consideration

Thermal Test Point

Sufficient airflow should be provided to ensure reliable operating of the converter. Therefore, thermal components are mounted on the converter to dissipate heat to the surrounding environment by conduction, convection and radiation. Decide proper airflow to be provided by measuring the temperature of the PCB near the MOSFET as shown in Figure 59 to protect the converter against overtemperature. The Overtemperature protection threshold is also obtained based on thermal test point.

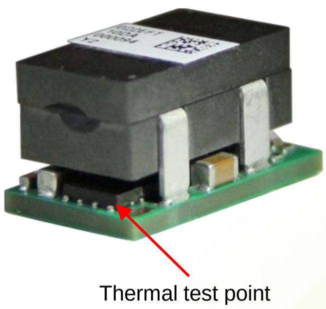


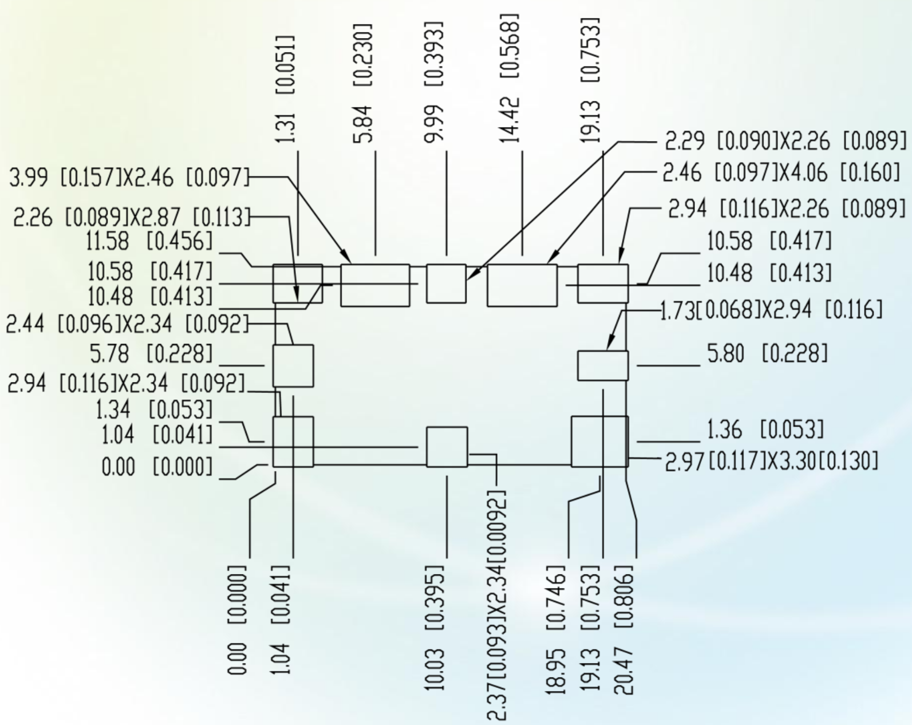
Figure 59: Thermal test point

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): $P_d = P_o(1- η)/η$

Recommended Pad Layout

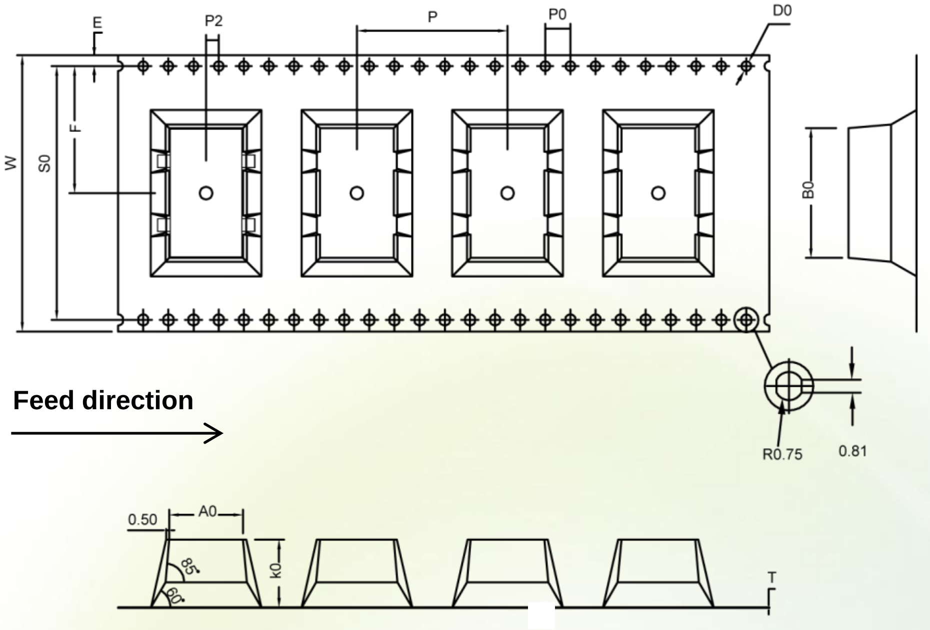
Unit of measurement: mm [in.]



Package Information

The converters are supplied in tape & reel as standard. The following figure shows the tape dimensions.

Unit of measurement: mm [in.]



ITEM	W	A0	B0	K0	P	F	E	S0	D0	P0	P2	T
DIM	44.00	11.85	20.75	10.90	24.00	20.20	1.75	40.40	1.50	4.00	2.00	0.5
TOLE	+0.30 -0.30	+0.10 -0.10	+0.10 -0.10	+0.10 -0.10	+0.10 -0.10	+0.10 -0.10	+0.10 -0.10	+0.10 -0.10	+0.10 -0.00	+0.10 -0.10	+0.10 -0.10	+0.05 -0.05

Moisture Sensitivity Level (MSL) Rating

The converters have a MSL rating of 2a.

Mechanical Consideration

Soldering

The converter is compatible with reflow soldering techniques. No wave soldering and hand soldering is allowed.

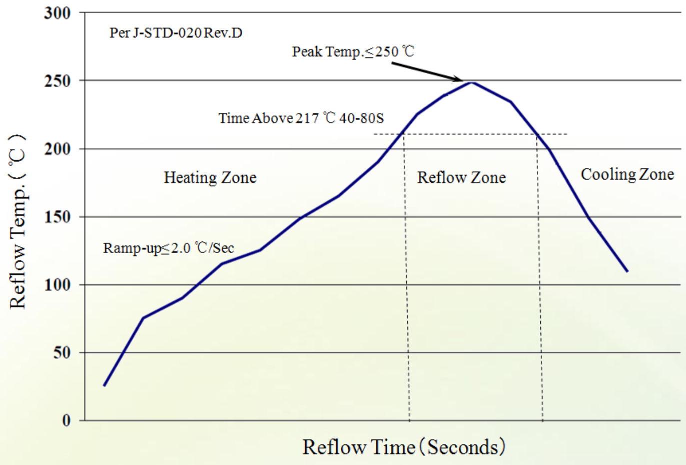


Figure 60: Recommended reflow profile using lead-free solder

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