Features

- RoHS lead-free solder and lead-solder-exempted products are available
- Industry-standard quarter-brick pin-out
- Delivers 240W at 94.5% efficiency
- Withstands 100V input transient for 100ms
- Fixed-frequency operation
- On-board input differential LC-filter
- Start-up into pre-biased load
- No minimum load required
- Meets Basic Insulation requirements
- Fully protected (OTP, OCP, OVP, UVLO)
- Positive or negative logic ON/OFF option
- Low height of 0.44" (11.18mm)
- Weight: 33.3g
- High reliability: MTBF = 14.3 million hours, calculated per Telcordia SR-332, Method I Case 1
- Approved to the following Safety Standards: UL/CSA60950-1, EN60950-1, and IEC60950-1 (In process)
- Designed to meet Class B conducted emissions per FCC and EN55022 when used with external filter
- All materials meet UL94, V-0 flammability rating

Applications

- Intermediate Bus Architectures
- Data communications/processing
- LAN/WAN
- Servers, Workstations

Benefits

- High efficiency – no heat sink required [1]
- Industry-standard $1/8^{th}$ brick footprint: 0.896" x 2.30" (2.06 in^2) - 38% smaller than conventional quarter-bricks

Description

The new high performance 20A SQE48T20120 DC-DC converter provides a high efficiency single output, in a $1/8^{th}$ brick package that is only 62% the size of the industry-standard quarter-brick. Specifically designed for operation in systems that have limited airflow and increased ambient temperatures, the SQE48T20120 converter utilizes the same pin-out and Input/Output functionality of the industry-standard quarter-bricks. In addition, a heat spreader feature is available (-xxxBx suffix) that provides an effective thermal interface for coldplate and heat sinking options.

The SQE48T20120 converter thermal performance is accomplished through the use of patented/patent-pending circuits, packaging, and processing techniques to achieve ultra-high efficiency, excellent thermal management, and a low-body profile.

Low-body profile and the preclusion of heat sinks minimize impedance to system airflow, thus enhancing cooling for both upstream and downstream devices. The use of 100% automation for assembly, coupled with advanced electronic circuits and thermal design, results in a product with extremely high reliability.

Operating from a wide-range 36-75V input, the SQE48T20120 converter provides a fully regulated 12V output voltage. Employing a standard power pin-out, the SQE48T20120 converter is an ideal drop-in replacement for existing high current eighth-brick and quarter-brick designs. Inclusion of this converter in a new design can result in significant board space and cost savings. The designer can expect reliability improvement over other available converters because of the SQE48T20120's optimized thermal efficiency.

[1] Baseplate/heat spreader option (suffix '-xxxBx') facilitates heatsink mounting to further enhance the unit's thermal capability.

Electrical Specifications

Conditions: T_A = 25 ºC, Airflow = 300 LFM (1.5 m/s), Vin = 48 VDC, Cin=100 µF, unless otherwise specified.

Parameter	Notes	Min	Typ	Max	Units
Absolute Maximum Ratings					
Input Voltage	Continuous	-0.3		80	VDC
	Transient (100ms)			100	VDC
Operating Temperature	Ambient (T_A)	-40		85	°C
	(Note: 1) Component (T_C)	-40		125	°C
(See Derating Curves)	Baseplate (T_B)	-40		105	°C
Storage Temperature		-55		125	°C
Isolation Characteristics					
I/O Isolation	w/o In/Out capacitor (suffix '-xxx**0**x')	2,250			VDC
Isolation Capacitance			200		pF
Isolation Resistance		10			MΩ
I/O Isolation	with In/Out capacitor (suffix '-xxx**K**x')	1,500			VDC
Isolation Capacitance			1,200	1,500	pF
Isolation Resistance		10			MΩ
Input to Baseplate	w/o In/Out capacitor (suffix '-xxx**B**x')	1,500			VDC
Output to Baseplate		1,500			VDC
Feature Characteristics					
Switching Frequency			450		kHz
Output Voltage Trim Range [2]			n/a		%
Remote Sense Compensation [2]			n/a		%
Output Overvoltage Protection (Non-latching)		110	120	130	%
Over Temperature Shutdown (Non-latching)	(Note: 1) Component (T_C)		130		°C
Auto-Restart Period	Applies to all protection features		300		ms
Turn-On Time from Vin	Time from UVLO to Vo=90%V_{OUT}(NOM) Resistive load		10		ms
Turn-On Time from ON/OFF Control	Time from ON to Vo=90%V_{OUT}(NOM) Resistive load		10		ms
Turn-On Time from Vin (w/ Co max.)	Time from UVLO to Vo=90%V_{OUT}(NOM) Resistive load, C_{EXT}=10,000µF load		12		ms
Turn-On Time from ON/OFF Control (w/ Co max.)	Time from ON to Vo=90%V_{OUT}(NOM) Resistive load, C_{EXT}=10,000µF load		12		ms
ON/OFF Control (Positive Logic)	Converter Off (logic low)	-20		0.8	VDC
	Converter On (logic high)	2.4		20	VDC
ON/OFF Control (Negative Logic)	Converter Off (logic low)	2.4		20	VDC
	Converter On (logic high)	-20		0.8	VDC

Additional Notes:

1. Reference Figure E for component (T_C and T_B) locations.
2. This functionality not provided, however the unit is fully regulated.

Electrical Specifications (continued)

Conditions: T_A = 25 ºC, Airflow = 300 LFM (1.5 m/s), Vin = 48 VDC, Cin=100 µF, unless otherwise specified.

Parameter	Notes	Min	Typ	Max	Units
Input Characteristics					
Operating Input Voltage Range		36	48	75	VDC
Input Undervoltage Lockout					
Turn-on Threshold		33	34.5	35.5	VDC
Turn-off Threshold		31	33	34.5	VDC
Lockout Hysteresis Voltage		1.0	2.0		VDC
Maximum Input Current	Po = 240W @ 36VDC In			7.1	ADC
Input Standby Current	Vin = 48V, converter disabled		14	20	mA
Input No Load Current (No load on the output)	Vin = 48V, converter enabled		80		mA
Input Reflected-Ripple Current, i_C	Vin = 48V, 25 MHz bandwidth, Po=240W (Fig. 10)		400	550	mA_{PK-PK}
			130	250	mA_{RMS}
Input Reflected-Ripple Current, i_S	Vin = 48V, 25 MHz bandwidth, Po=240W (Fig. 10)		25	50	mA_{PK-PK}
			10	20	mA_{RMS}
Input Voltage Ripple Rejection	120 Hz		45		dB
Output Characteristics					
Output Voltage Setpoint	V_{IN}=48V, I_{OUT}=0Amps, T_A=25°C	11.76	12.00	12.24	VDC
Output Regulation					
Over Line	I_{OUT}=20Amps, T_A=25°C		±12	±24	mV
Over Load	V_{IN}=48V, , T_A=25°C		±6	±12	mV
Output Voltage Range	Over line, load and temperature	11.64		12.36	VDC
Output Ripple and Noise – 25 MHz bandwidth	I_{OUT}=20Amps, C_{EXT} =10 µF tantalum + 1 µF ceramic		50	100	mV_{PK-PK}
			25	50	V_{RMS}
Admissible External Load Capacitance	I_{OUT}=20Amps (resistive) C_{EXT} ESR	0 [1] 1		10,000	µF mOhm
Output Current Range		0		20	ADC
Current Limit Inception	Non-latching	20.5	25	28	ADC
RMS Short-Circuit Current	Non-latching Short = 10 mΩ		10	12.5	A_{RMS}
Dynamic Response					
Load Change 50%-75%-50% of I_{OUT} Max (di/dt = 0.1 A/µs)	C_{EXT} = 10µF tantalum + 1µF ceramic		75	140	mV
Settling Time to 1% of V_{OUT}			30	50	µs
Efficiency					
@ 100% Load	48V_{IN}, T_A=25°C, 300LFM		94.5		%
@ 50% Load	48V_{IN}, T_A=25°C, 300LFM		95		%

Additional Notes:

[1] See *"Input & Output Impedance"*, Page 4.

Environment and Mechanical Specifications

Environmental					
Operating Humidity	Non-condensing			95	%
Storage Humidity	Non-condensing			95	%
Mechanical					
Weight		33.3			
Vibration	GR-63-CORE, Sect. 5.4.2	1			g
Shocks	Half Sinewave, 3-axis	50			g
Reliability					
MTBF	Telcordia SR-332, Method I Case 1 50% electrical stress, 40°C components	14.3			MHrs
EMI and Regulatory Compliance					
Conducted Emissions	CISPR 22 B with external EMI filter network				

Operations

Input and Output Impedance

These power converters have been designed to be stable with no external capacitors when used in low inductance input and output circuits.

However, in some applications, the inductance associated with the distribution from the power source to the input of the converter can affect the stability of the converter. A 100 µF tantalum capacitor with an ESR < 1 Ω across the input is recommended to ensure stability of the converter over all operating conditions.

In many end applications, a high capacitance value is applied to the converter's output via distributed decoupling capacitors. The power converter will exhibit stable operation with external load capacitance up to 10,000 µF.

ON/OFF (Pin 2)

The ON/OFF pin is used to turn the power converter on or off remotely via a system signal. There are two remote control options available, positive and negative logic, with both referenced to Vin(-). A typical connection is shown in Figure A.

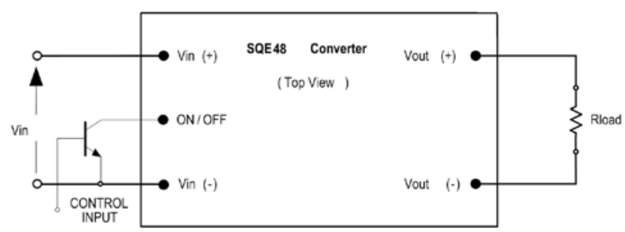


Fig. A: Typ. Circuit configuration for ON/OFF function.

The positive logic version turns on when the ON/OFF pin is at logic high and turns off when at logic low. The converter is on when the ON/OFF pin is left open. See the Electrical Specifications for logic high/low definitions.

The negative logic version turns on when the pin is at logic low and turns off when the pin is at logic high. The ON/OFF pin can be hard wired directly to Vin(-) to enable automatic power up of the converter without the need of an external control signal.

The ON/OFF pin is internally pulled up to 5V through a resistor. A properly de-bounced mechanical switch, open-collector transistor, or FET can be used to drive the input of the ON/OFF pin. The device must be capable of sinking up to 0.2 mA at a low level voltage of ≤ 0.8 V. An external voltage source (±20 V maximum) may be connected directly to the ON/OFF input, in which case it must be capable of sourcing or sinking up to 1 mA depending on the signal polarity. See the Startup Information section for system timing waveforms associated with use of the ON/OFF pin.

Protection Features

Input Undervoltage Lockout (UVLO)

Input undervoltage lockout is standard with this converter. The converter will shut down when the input voltage drops below a pre-determined voltage.

The input voltage must be typically 35V for the converter to turn on. Once the converter has been turned on, it will shut off when the input voltage drops typically below 33V. This feature is beneficial in preventing deep discharging of batteries used in telecom applications.

Output Overcurrent Protection (OCP)

The converter is protected against overcurrent or short circuit conditions. Upon sensing an overcurrent condition, the converter will shut down.

Once this occurs, it will enter hiccup mode and attempt to restart approximately every 300 ms with an approximate duty cycle of 5%. The attempted restart will continue indefinitely until the overload or short circuit condition is removed.

Once the output current is brought back into its specified range, the converter automatically exits the hiccup mode and resumes normal operation

Output Overvoltage Protection (OVP)

The converter will shut down if the output voltage across Vout(+) and Vout(-) exceeds the threshold of the OVP circuitry. The OVP circuitry contains its own reference, independent of the output voltage regulation loop. Once the converter has shut down, it will attempt to restart every 300 ms until the OVP condition is removed.

Overtemperature Protection (OTP)

The converter will shut down under an overtemperature condition to protect itself from overheating caused by operation outside the thermal derating curves, or operation in abnormal conditions such as system fan failure. The converter will automatically restart after it has cooled to a safe operating temperature.

Safety Requirements

The converters are safety approved to UL/CSA60950-1, EN60950-1, and IEC60950-1. Basic Insulation is provided between input and output.

The converters have no internal fuse. If required, the external fuse needs to be provided to protect the converter from catastrophic failure. Refer to the “Input Fuse Selection for DC/DC converters” application note on www.power-one-com for proper selection of the input fuse. Both input traces and the chassis ground trace (if applicable) must be capable of conducting a current of 1.5 times the value of the fuse without opening. The fuse must not be placed in the grounded input line.

Abnormal and component failure tests were conducted with the input protected by a 10A fuse. If a fuse rated greater than 10A is used, additional testing may be required. To protect a group of converters with a single fuse, the rating can be increased from the recommended value above.

Electromagnetic Compatibility (EMC)

EMC requirements must be met at the end-product system level, as no specific standards dedicated to EMC characteristics of board mounted component dc-dc converters exist. However, Power-One tests its converters to several system level standards, primary of which is the more stringent EN55022, Information technology equipment - Radio disturbance characteristics - Limits and methods of measurement.

An effective internal LC differential filter significantly reduces input reflected ripple current, and improves EMC.

With the addition of a simple external filter, the SQE48T20120 converter will pass the requirements of Class B conducted emissions per EN55022 and FCC requirements. Refer to Figures 14 – 15 for typical performance with external filter.

Startup Information (using negative ON/OFF)

Scenario #1: Initial Startup From Bulk Supply
ON/OFF function enabled, converter started via application of V_{IN}. See Figure B.

Time	Comments
t_0	ON/OFF pin is ON; system front-end power is toggled on, V_{IN} to converter begins to rise.
t_1	V_{IN} crosses undervoltage Lockout protection circuit threshold; converter enabled.
t_2	Converter begins to respond to turn-on command (converter turn-on delay).
t_3	Converter V_{OUT} reaches 100% of nominal value.

For this example, the total converter startup time (t_3- t_1) is typically 12 ms.

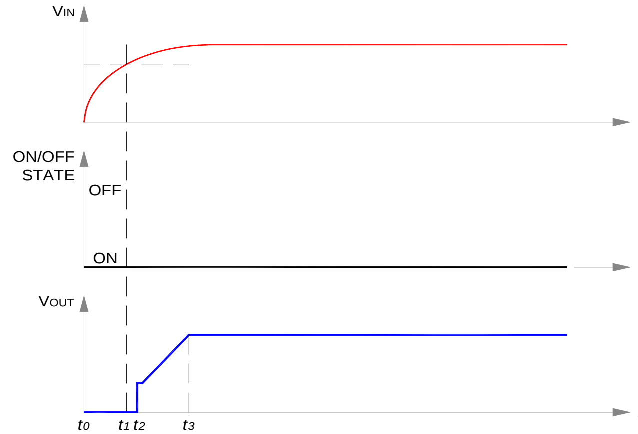


Fig. B: Startup scenario #1.

Scenario #2: Initial Startup Using ON/OFF Pin
With V_{IN} previously powered, converter started via ON/OFF pin. See Figure C.

Time	Comments
t_0	V_{INPUT} at nominal value.
t_1	Arbitrary time when ON/OFF pin is enabled (converter enabled).
t_2	End of converter turn-on delay.
t_3	Converter V_{OUT} reaches 100% of nominal value.

For this example, the total converter startup time (t_3- t_1) is typically 12 ms.

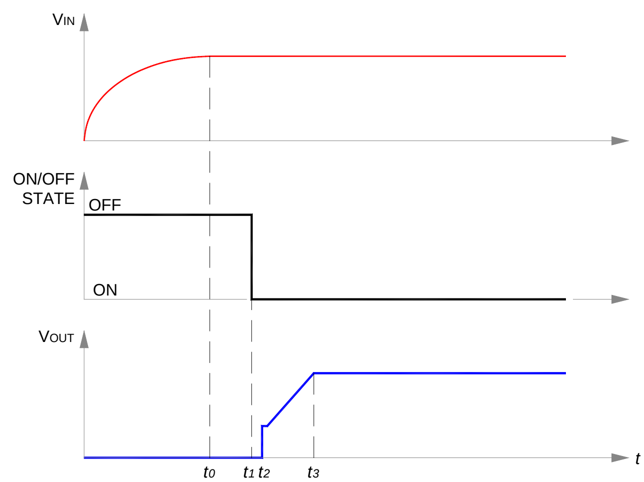


Fig. C: Startup scenario #2.

Scenario #3: Turn-off and Restart Using ON/OFF Pin
With V_{IN} previously powered, converter is disabled and then enabled via ON/OFF pin. See Figure D.

Time	Comments
t_0	V_{IN} and V_{OUT} are at nominal values; ON/OFF pin ON.
t_1	ON/OFF pin arbitrarily disabled; converter output falls to zero; turn-on inhibit delay period (300 ms typical) is initiated, and ON/OFF pin action is internally inhibited.
t_2	ON/OFF pin is externally re-enabled. **If (t_2- t_1) ≤ 300 ms**, external action of ON/OFF pin is locked out by startup inhibit timer. **If (t_2- t_1) > 300 ms**, ON/OFF pin action is internally enabled.
t_3	Turn-on inhibit delay period ends. If ON/OFF pin is ON, converter begins turn-on; if off, converter awaits ON/OFF pin ON signal; see Figure F.
t_4	End of converter turn-on delay.
t_5	Converter V_{OUT} reaches 100% of nominal value.

For the condition, **(t_2- t_1) ≤ 300 ms**, the total converter startup time (t_5- t_1) is typically 312ms. For **(t_2- t_1) > 300 ms**, startup will be typically 125ms after release of ON/OFF pin.

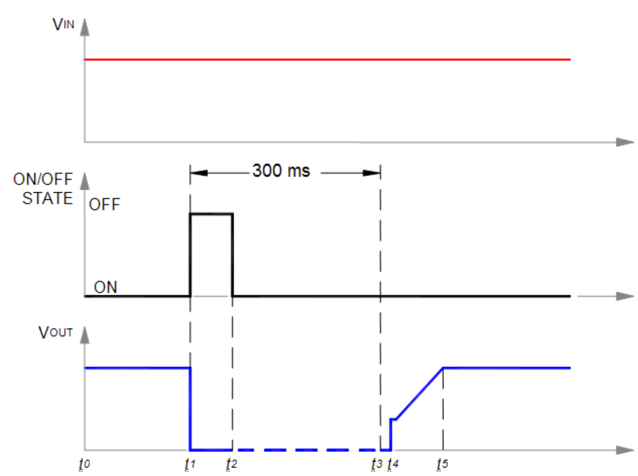


Fig. D: Startup scenario #3.

Characterization

General Information

The converter has been characterized for many operational aspects, to include thermal derating (maximum load current as a function of ambient temperature and airflow), efficiency, startup and shutdown parameters, output ripple and noise, transient response to load step-change, overcurrent, and short circuit.

The following pages contain specific plots or waveforms associated with the converter. Additional comments for specific data are provided below.

Test Conditions

All data presented were taken with the converter soldered to a test board, specifically a 0.060" thick printed wiring board (PWB) with four layers. The top and bottom layers were not metalized. The two inner layers, comprised of two-ounce copper, were used to provide traces for connectivity to the converter.

The lack of metallization on the outer layers as well as the limited thermal connection ensured that heat transfer from the converter to the PWB was minimized. This provides a worst-case but consistent scenario for thermal derating purposes.

All measurements requiring airflow were made in the vertical and horizontal wind tunnel using Infrared (IR) thermography and thermocouples for thermometry.

Ensuring components on the converter do not exceed their ratings is important to maintaining high reliability. If one anticipates operating the converter at or close to the maximum loads specified in the derating curves, it is prudent to check actual operating temperatures in the application. Thermographic imaging is preferable; if this capability is not available, then thermocouples may be used. The use of AWG #36 gauge thermocouples is recommended to ensure measurement accuracy. Careful routing of the thermocouple leads will further minimize measurement error. Refer to Figure E for the optimum measuring thermocouple location.

Thermal Derating – Air Cooled

Load current vs. ambient temperature and airflow rates are given in Figures 1 - 3. Ambient temperature was varied between 25°C and 85°C, with airflow rates from 30 to 500LFM (0.15 to 2.5m/s).

For each set of conditions, the maximum load current was defined as the lowest of:

(i) The output current at which any FET junction temperature does not exceed a maximum temperature of 125°C as indicated by the thermal measurement

(ii) The output current at which the temperature at the thermocouple locations T_C and T_{C1} do not exceed 125°C and 110°C respectively. (Figure E)

(iii) The nominal rating of the converter (20A/240W).

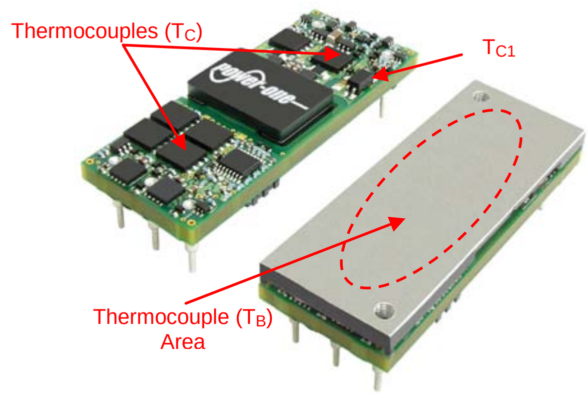


Fig. E: Locations of the thermocouples for thermal testing.

Thermal Derating – Baseplate Cooled (p/n: -xGxBx)

The maximum load current rating vs. baseplate temperature is provided in Figure 4.
The ambient temperature was maintained ≤ 85°C, with an airflow rate of ≤ 30LFM (≤ 0.15m/s).

Thermocouple measurements were maximized, as above, to the following limits:
$T_C \leq 125°C$, $T_{C1} \leq 110°C$ & $T_B \leq 105°C$.
The user should design for $T_B \leq 105°C$.

Efficiency

Figure 5 shows the efficiency vs. load current plot for ambient temperature (T_A) of 25ºC, airflow rate of 300LFM (1.5m/s) with vertical mounting and input voltages of 36V, 48V, 65V and 75V.

Power Dissipation

Figure 6 shows the power dissipation vs. load current plot for T_A=25ºC, airflow rate of 300LFM (1.5m/s) with vertical mounting and input voltages of 36V, 48V, 65V and 75V.

Startup

Output voltage waveforms, during the turn-on transient using the ON/OFF pin for full rated load currents (resistive load) are shown with and without external load capacitance in and, respectively.

Ripple and Noise

Figure 10 shows the output voltage ripple waveform, measured at full rated load current with a 10µF tantalum and a 1µF ceramic capacitor across the output. Note that all output voltage waveforms are measured across the 1µF ceramic capacitor.

The input reflected-ripple current waveforms are obtained using the test setup shown in Figure 11 The corresponding waveforms are shown in Figure 12 and Figure 13.

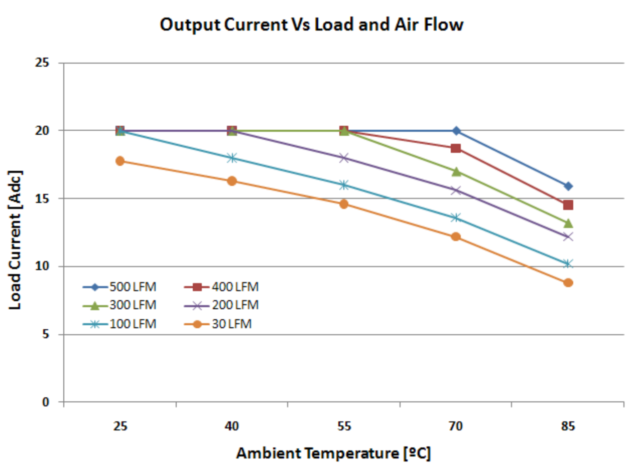


Figure 1. Available load current vs. ambient air temperature and airflow rates for SQE48T20120 converter mounted vertically with air flowing from pin 3 to pin 1, MOSFET temperature ≤ 125 °C, Vin = 48 V.

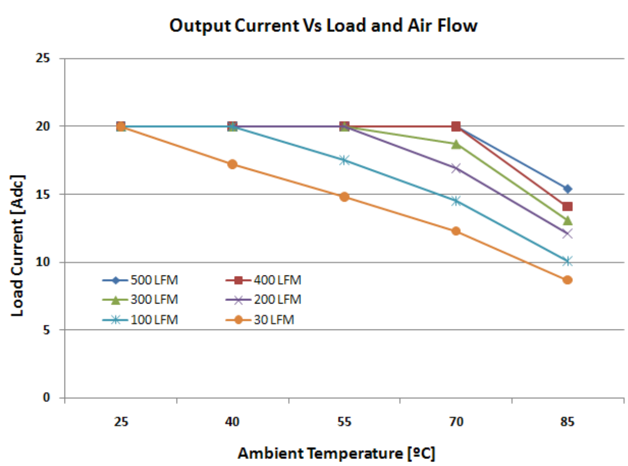


Figure 2. Power derating of SQE48T20120 converter with baseplate option and 0.25" tall horizontal-fin heatsink. (Conditions: same as Fig. 1)

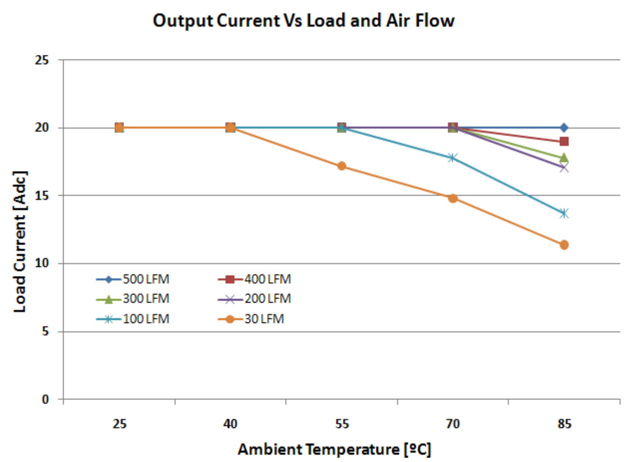


Figure 3. Power derating of SQE48T20120 converter with baseplate option and 0.91" tall horizontal-fin heatsink. (Conditions: same as Fig. 1)

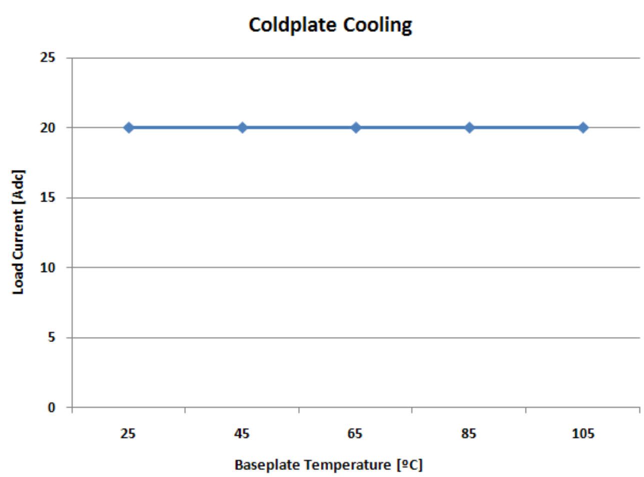


Figure 4. Power derating of SQE48T20120 converter with baseplate option and coldplate cooling. (Conditions: $T_B \leq 105°C$, $T_A \leq 85°C$, Air velocity ≤ 30LFM (≤ 0.15m/s), Vin = 48 V.

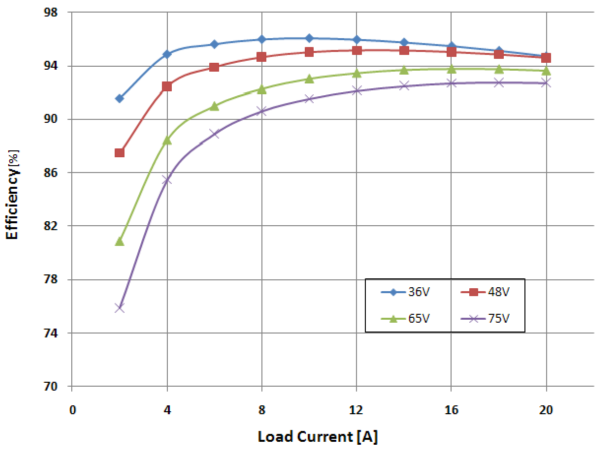


Figure 5. Efficiency vs. load current and input voltage for SQE48T20120 converter mounted vertically with air flowing from pin 3 to pin 1 at 300 LFM (1.5 m/s) and T_A = 25°C.

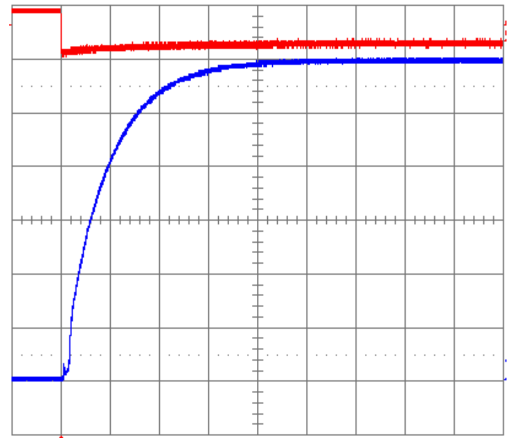


Figure 7. Turn-on waveform at full rated load current (resistive) with 10,000 uF output capacitor at Vin = 48V, triggered via ON/OFF pin. Top trace: ON/OFF signal (10V/div.). Bottom trace: Output voltage (2V/div.). Time scale: 5ms/div.

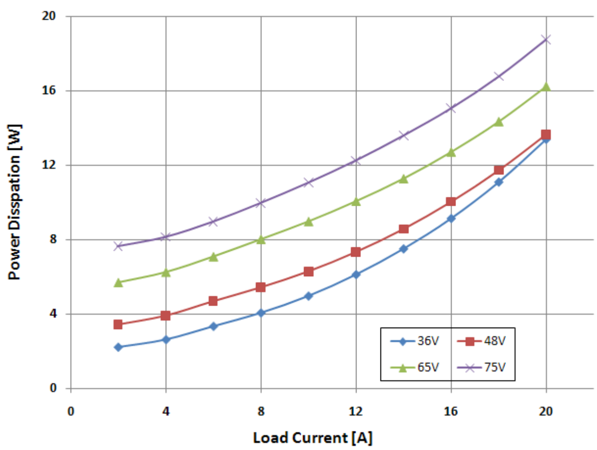


Figure 6. Power dissipation vs. load current and input voltage for SQE48T20120 converter mounted vertically with air flowing from pin 3 to pin 1 at 300 LFM (1.5 m/s) and T_A = 25°C.

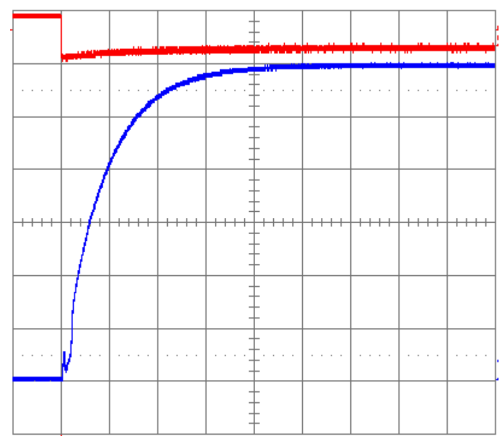


Figure 8. Turn-on waveform at full rated load current (resistive) with 10uF tant. + 1uF cer. output capacitor at Vin = 48V, triggered via ON/OFF pin. Top trace: ON/OFF signal (10V/div.). Bottom trace: Output voltage (2V/div.). Time scale: 5ms/div.

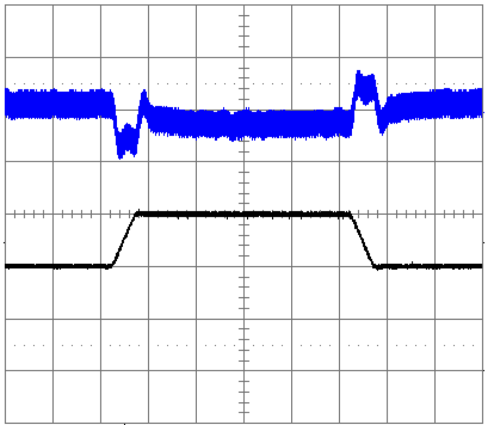


Figure 9. Output voltage response to load current step-change (10A – 15A – 10A) at Vin = 48 V. Top trace: output voltage (100mV/div.) Bottom: load current (5A/div.). Current slew rate: 0.1 A/µs. Time scale: 0.1ms/div. Co = 10µF tantalum + 1µF ceramic

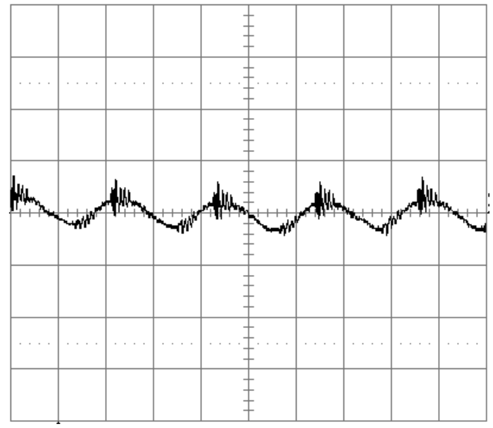


Figure 12. Input reflected-ripple current, i_S (50 mA/div.), measured through 1 µH at the source at full rated load current and Vin = 48 V. Refer to Figure 11 for test setup. Time scale: 1 µs/div.

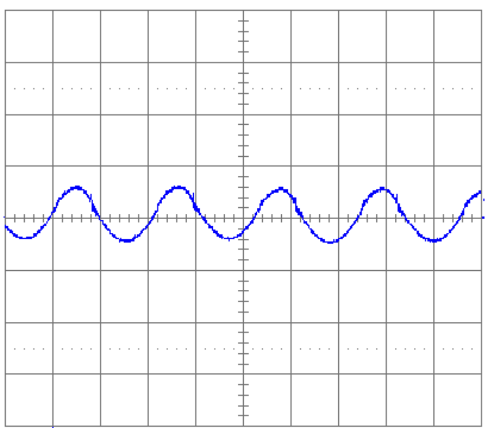


Figure 10. Output voltage ripple (50 mV/div.) at full rated load current into a resistive load with Co = 10µF tantalum + 1µF ceramic and Vin = 48V. Time scale: 1µs/div.

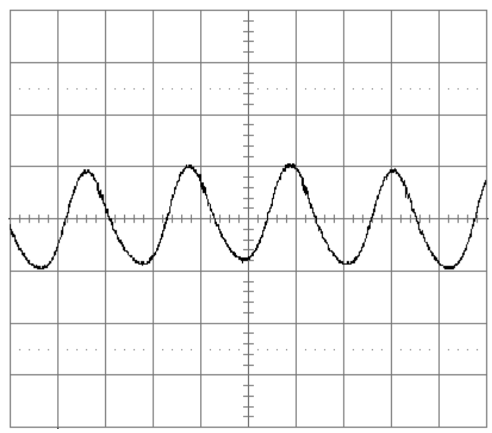


Figure 13. Input reflected ripple-current, i_C (200 mA/div.), measured at input terminals at full rated load current and Vin = 48 V. Refer to Figure 11 for test setup. Time scale: 1 µs/div.

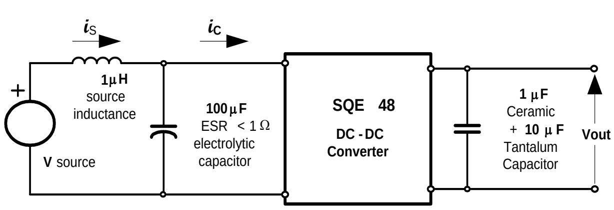
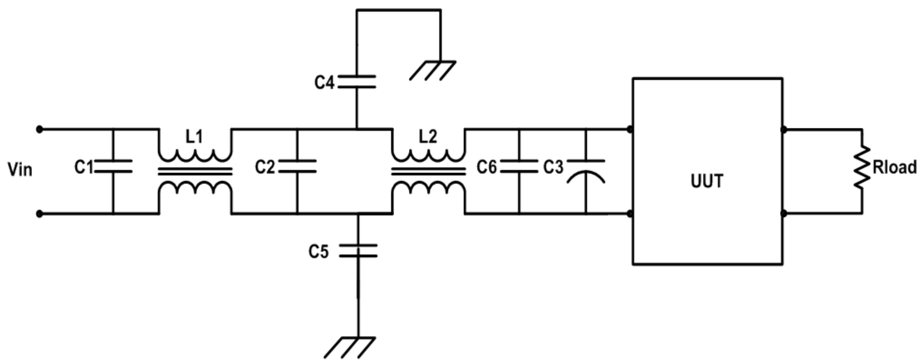


Figure 11. Test setup for measuring input reflected ripple currents, i_c and i_s.



Comp. Des.	Description
C1, C2, C6	(2EA, 6 capacitors) 1uF, 100V ceramic cap
C3	33uF, 100V electrolytic cap
L1, L2	0.59mH, Pulse P0353NL
C4, C5	2,200Pf, ceramic cap

Figure 14. Typical input EMI filter circuit to attenuate conducted emissions.

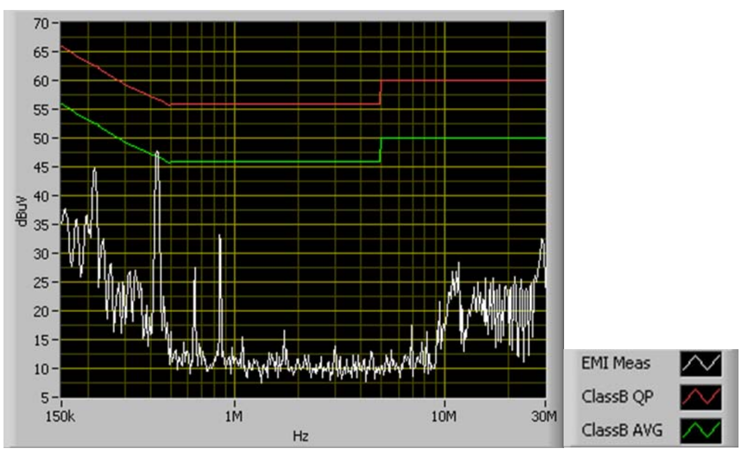
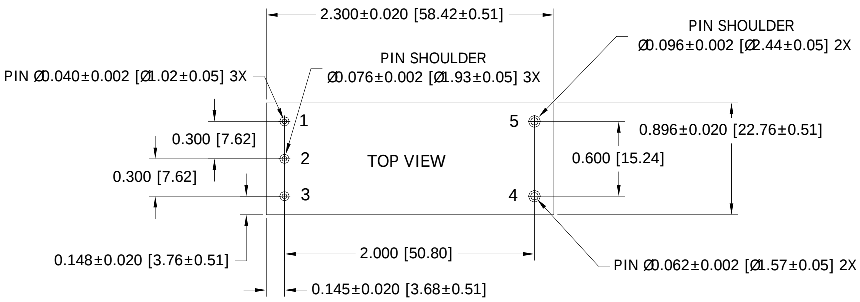


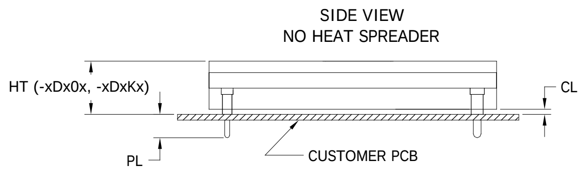
Figure 15. Input conducted emissions measurement (Typ.) of SQE48T20120.
Conditions: V_{IN}=48VDC, I_{OUT} = 20AMPS

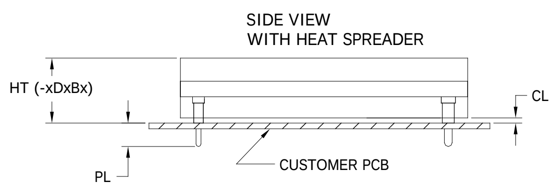
Physical Information

SQE48T Pinout (Through-hole)



Pad/Pin Connections	
Pad/Pin #	**Function**
1	V_{IN} (+)
2	ON/OFF
3	V_{IN} (-)
4	V_{OUT} (-)
5	V_{OUT} (+)





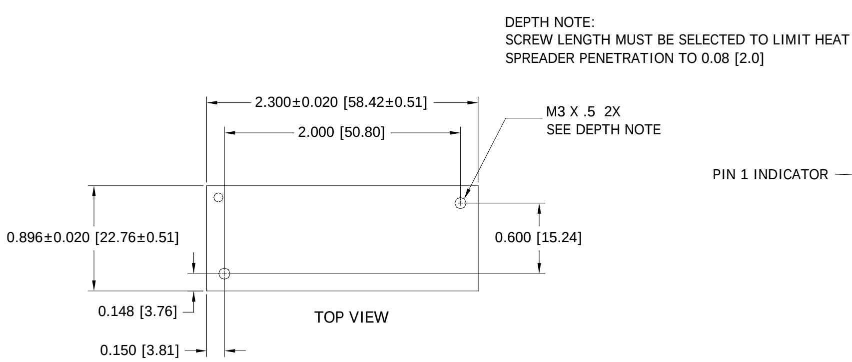
SQE48T Platform Notes

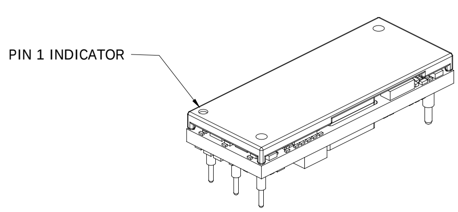
- All dimensions are in inches [mm]
- Pins 1-3 are Ø 0.040" [1.02] with Ø 0.076" [1.93] shoulder
- Pins 4 and 5 are Ø 0.062" [1.57] with are Ø 0.096" [2.44] shoulder
- Pin Material: Brass Alloy 360
- Pin Finish: Tin over Nickel

Height [HT]		Min Clearance [CL]	Special Features
D	0.440" [11.18] Max	0.028" [0.71]	0 K
	0.500" +/-0.020 [12.70 +/-0.51]	0.028" [0.71]	B

Pin Option	Pin Length [PL]
	±0.005" [±0.13]
A	0.188" [4.78]
B	0.145" [3.68]

Heat Spreader Interface Information





Converter Part Numbering/Ordering Information

Product Series	Input Voltage	Mounting Scheme	Rated Current	Output Voltage		ON/OFF Logic	Maximum Height [HT]	Pin Length [PL]	Special Features	RoHS
SQE	**48**	**T**	**20**	**120**	**-**	**N**	**D**	**A**	**B**	**G**
One-Eighth Brick Format	36-75 V	T ⇒ Through-hole	20 ⇒ 20 ADC	120 ⇒ 12V		N ⇒ Negative P ⇒ Positive	D ⇒ 0.440" for –xxx0x –xxxKx 0.520" for –xxxBx	Through hole A ⇒ 0.188" B ⇒ 0.145"	0 ⇒ 2250VDC isolation, no CM cap K ⇒ 1500VDC isolation, (w/CM cap.) B ⇒ Baseplate option + '0' above	No Suffix ⇒ RoHS lead-solder-exemption compliant G ⇒ RoHS compliant for all six substances

The example above describes P/N SQE48T20120-NDABG: 36-75V input, through-hole, 20A@12V output, negative ON/OFF logic, maximum height of 0.52", 0.188" pin length, 2250VDC isolation, integral heat spreader (Baseplate) and RoHS compliant for all 6 substances. Consult factory for availability of other options.

Notes:

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