MQSA-28-12S

Single Output

High Reliability DC-DC Converter

16-40V	16-50V	12V	0.42A	79% @ 0.21A / 82% @ 0.42A
Continuous Input	Transient Input	Output	Output	Efficiency

Full Power Operation: -55ºC to +125ºC

The MilQor® series of high-reliability DC-DC converters brings SynQor's field proven high-efficiency technology to the Military/Aerospeace industry. SynQor's innovative QorSeal® packaging approach ensures survivability in the most hostile environments. Compatible with the industry standard format, these converters operate at a fixed frequency, have no opto-isolators, and follow conservative component derating guidelines. They are designed and manufactureed to comply with a wide range of military standards.

Designed & Manufactured in the USA
Featuring QorSeal® Hi-Rel Assembly

Design Process

MQSA series converters are:
- Designed for reliability per NAVSO-P3641-A guidelines
- Designed with components derated per:
  - — MIL-HDBK-1547A
  - — NAVSO P-3641A

Qualification Process

MQSA series converters are qualified to:
- MIL-STD-810F
  - — consistent with RTCA/D0-160E
- SynQor's First Article Qualification
  - — consistent with MIL-STD-883F
- SynQor's Long-Term Storage Survivability Qualification
- SynQor's on-going life test

In-Line Manufacturing Process

- AS9100 and ISO 9001 certified facility
- Full component traceability
- Temperature cycling
- Constant acceleration
- 24, 96, 160 hour burn-in
- Three level temperature screening

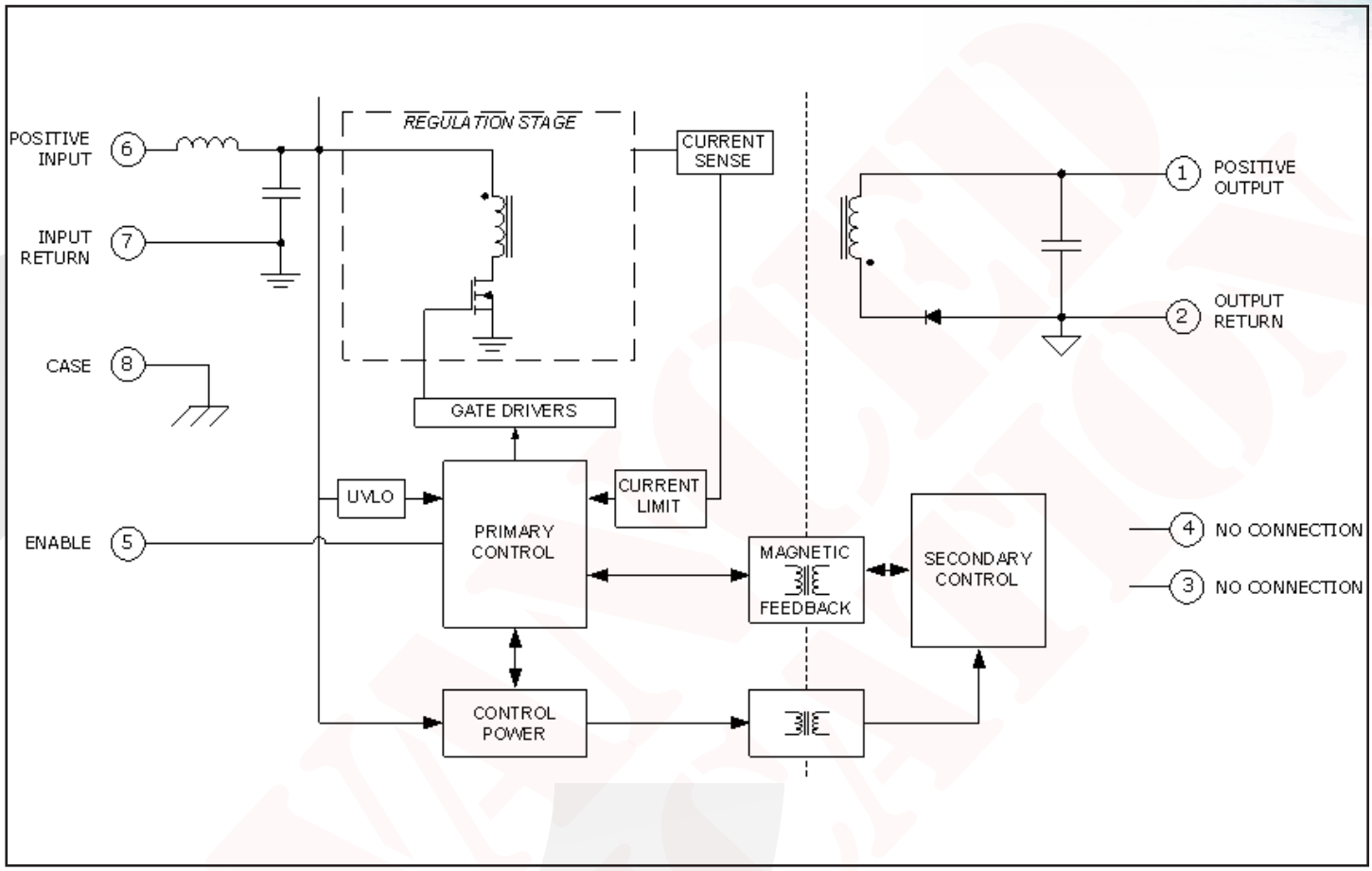
Features

- Primary referenced enable
- No opto-isolators
- Output over-voltage protection
- Continuous short circuit and overload protection
- Input under-voltage shutdown

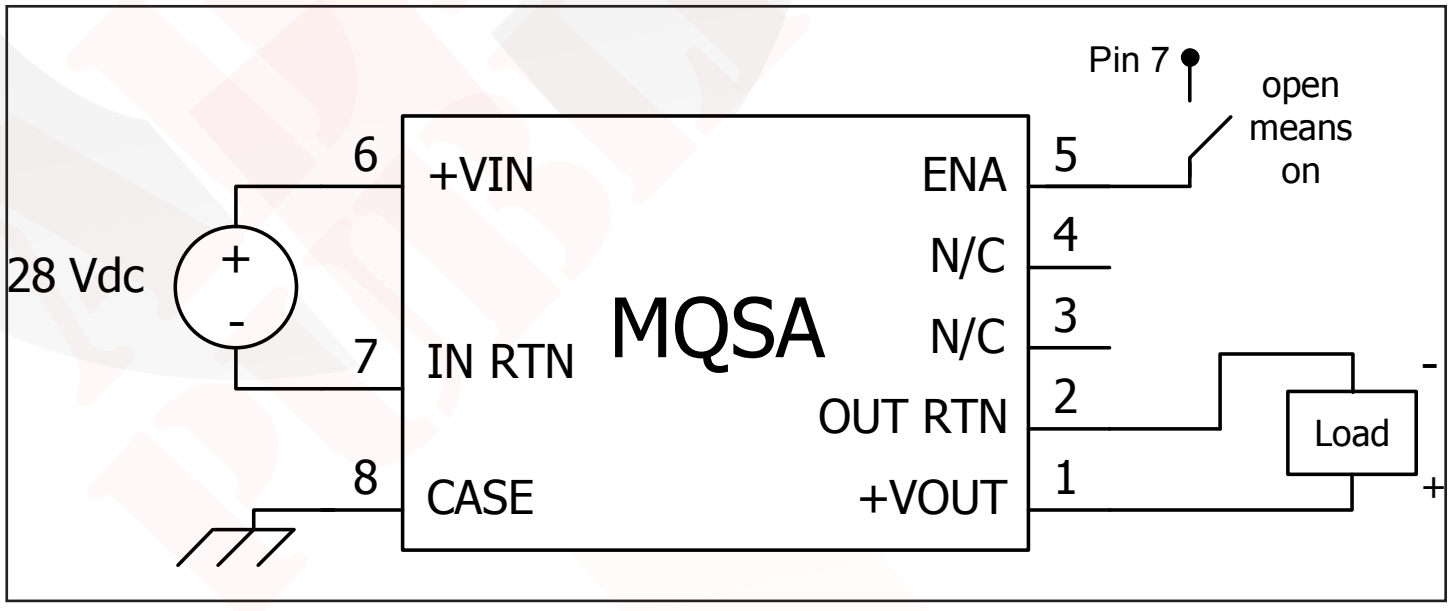
Specification Compliance

MQSA series converters (with MQHE filter) are designed to meet:
- MIL-HDBK-704-8 (A through F)
- RTCA/DO-160 Section 16, 17, 18
- MIL-STD-1275 (B, D) for V_{IN} > 16V
- DEF-STAN 61-5 (part 6)/(5, 6) for V_{IN} > 16V
- MIL-STD-461 (C, D, E, F)
- RTCA/DO-160(E, F, G) Section 22

BLOCK DIAGRAM



TYPICAL CONNECTION DIAGRAM



MQSA-28-12S ELECTRICAL CHARACTERISTICS

Parameter Specifications subject to change without notice	Min.	Typ.	Max.	Units	Notes & Conditions Vin=28V dc ±5%, Iout=0.42A, CL=0µF, free running (see Note 10) unless otherwise specified	Group A Subgroup (see Note 8)
ABSOLUTE MAXIMUM RATINGS						
Input Voltage						
Non-Operating			60	V		
Operating			60	V	See Note 1	
Reverse Bias (Tcase = 125ºC)			-0.8	V		
Reverse Bias (Tcase = -55ºC)			-1.2	V		
Isolation Voltage (I/O to case, I to O)						
Continuous	-500		500	V		
Transient (≤100µs)	-800		800	V		
Operating Case Temperature	-55		125	ºC	HB Grade Products, See Notes 2 & 13	
Storage Case Temperature	-65		135	ºC		
Lead Temperature (20s)			300	ºC		
Voltage at ENA1	-1.2		50	V		
INPUT CHARACTERISTICS						
Operating Input Voltage Range	16	28	40	V	Continuous	1, 2, 3
"	16	28	50	V	Transient, 1s	
Input Under-Voltage Shutdown					See Note 3	
Turn-On Voltage Threshold	14.00	14.60	15.20	V		1, 2, 3
Turn-Off Voltage Threshold	12.00	12.85	13.70	V		1, 2, 3
Shutdown Voltage Hysteresis		1.75		V		
Maximum Input Current			0.40	A	Vin = 16V; Iout = 0.42A	
No Load Input Current (operating)		15	30	mA		1, 2, 3
Disabled Input Current		2	4	mA	Vin = 16V, 28V, 50V; ENA	1, 2, 3
Input Terminal Current Ripple (pk-pk)		30	55	mA	Bandwidth = 100kHz – 10MHz; see Figure 14	1, 2
OUTPUT CHARACTERISTICS						
Output Voltage Set Point (Tcase = 25ºC)	11.88	12.00	12.12	V	Vout at sense leads	1
Output Voltage Set Point Over Temperature	11.82	12.00	12.18	V	"	2, 3
Output Voltage Line Regulation	-30		30	mV	" ; Vin = 16V, 28V, 40V; Iout=0.42A	1, 2, 3
Output Voltage Load Regulation	-40		40	mV	" ; Vout @ (Iout=0A) - Vout @ (Iout=0.42A)	1, 2, 3
Total Output Voltage Range	11.76	12.00	12.24	V	"	1, 2, 3
Output Voltage Ripple and Noise Peak to Peak		15	75	mV	Bandwidth = 10MHz; CL=11µF	1, 2, 3
Operating Output Current Range	0		0.42	A		1, 2, 3
Operating Output Power Range	0		5.0	W		1, 2, 3
Output DC Current-Limit Inception	0.5	0.8	1.1	A	See Note 3	1, 2, 3
Maximum Output Capacitance			15	µF		See Note 4
DYNAMIC CHARACTERISTICS						
Output Voltage Deviation Load Transient					See Note 5	
For a Pos. Step Change in Load Current	-600	-300		mV	Total Iout step = 0.21A to 0.42A, 0.042A to 0.21A; CL=11µF	4, 5, 6
For a Neg. Step Change in Load Current		300	600	mV	"	4, 5, 6
Output Voltage Deviation Line Transient					Vin step = 16V to 50V; CL=11µF; see Note 6	
For a Pos. Step Change in Line Voltage	-150		150	mV		
For a Neg. Step Change in Line Voltage	-150		150	mV		
Turn-On Transient						
Output Voltage Rise Time		10		ms	Vout = 1.2V to 10.8V; Full Resistive Load	4, 5, 6
Output Voltage Overshoot		0	2	%	Resistive load	See Note 4
Turn-On Delay, Rising Vin		2.0		ms	ENA = 5V; see Note 7	4, 5, 6
Turn-On Delay, Rising ENA		2.0	5.0	ms	See Note 7	4, 5, 6
EFFICIENCY						
Iout = 0.42 A (16 Vin)	78	82		%		
Iout = 0.42 A (28 Vin)	78	82		%		1, 2, 3
Iout = 0.42 A (40 Vin)	78	82		%		

MQSA-28-12S ELECTRICAL CHARACTERISTICS (Continued)

Parameter Specifications subject to change without notice	Min.	Typ.	Max.	Units	Notes & Conditions Vin=28V dc ±5%, Iout=0.42A, CL=0µF, free running (see Note 10) unless otherwise specified	Group A Subgroup (see Note 8)
ISOLATION CHARACTERISTICS						
Isolation Voltage					Dielectric strength	
Input RTN to Output RTN	500			V		1
Any Input Pin to Case	500			V		1
Any Output Pin to Case	500			V		1
Isolation Resistance (in rtn to out rtn)	100			MΩ		1
Isolation Resistance (any pin to case)	100			MΩ		1
Isolation Capacitance (in rtn to out rtn)		22		nF		1
FEATURE CHARACTERISTICS						
Switching Frequency (free running)	500	550	600	kHz		See Note 4
Enable Control (ENA)						
Off-State Voltage			0.8	V		1, 2, 3
Module Off Pulldown Current	80			µA	Current drain required to ensure module is off	See Note 4
On-State Voltage	2			V		1, 2, 3
Module On Pin Leakage Current			20	µA	Imax draw from pin allowed with module still on	See Note 4
Pull-Up Voltage	3.2	4.0	4.8	V	See Figure A	
RELIABILITY CHARACTERISTICS						
Calculated MTBF (MIL-STD-217F2)						
GB @ Tcase = 70ºC		TBD		10^3 Hrs.		
AIF @ Tcase = 70ºC		TBD		10^3 Hrs.		
WEIGHT CHARACTERISTICS						
Device Weight		15.7		g		

Electrical Characteristics Notes

1. Derate output power to 50% of rated power at Tcase = 135ºC.
2. Low state of input voltage must persist for about 200µs to be acted on by the shutdown circuitry.
3. Current limit inception is defined as the point where the output voltage has dropped to 90% of its nominal value. Features Description section.
4. Parameter not tested but guaranteed to the limit specified.
5. Load current transition time ≥ 0.01A/µs.
6. Line voltage transition time ≥ 100µs.
7. Input voltage rise time ≤ 250µs.
8. Only the ES and HB grade products are tested at three temperatures. The C grade products are tested at one temperature. Please refer to the ESS table for details.
9. These derating curves apply for the ES and HB grade products. The C grade product has a maximum case temperature of 70ºC and a maximum junction temperature rise of 20ºC above TCASE.
10. The specified operating case temperature for ES grade products is -45ºC to 100ºC. The specified operating case temperature for C grade products is 0ºC to 70ºC.

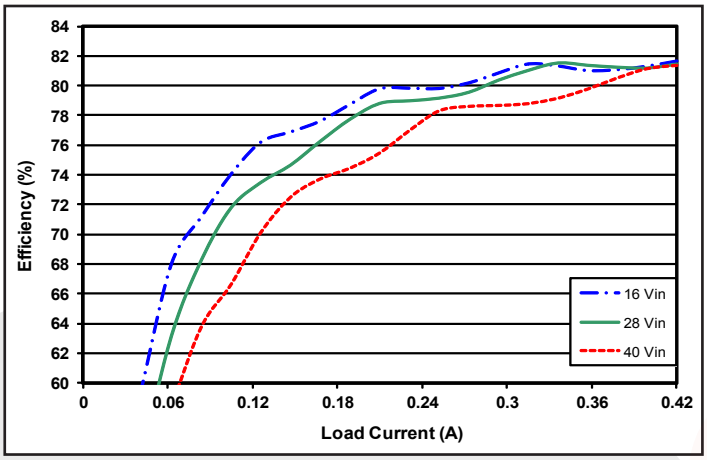


***Figure 1**: Efficiency at nominal output voltage vs. load current for minimum, nominal, and maximum input voltage at Tcase=25°C.*

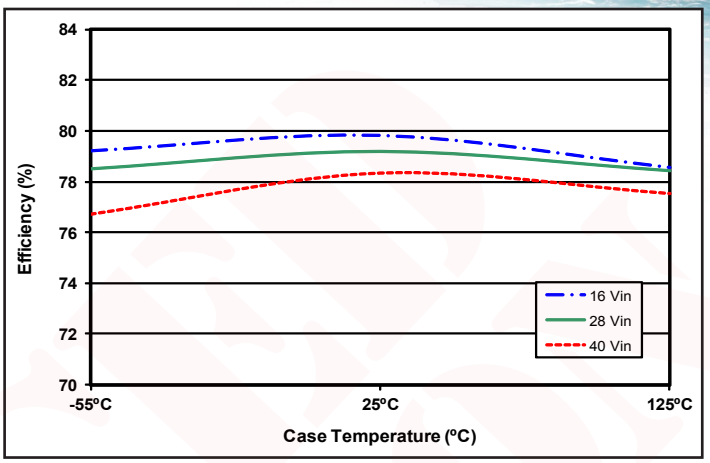


***Figure 2**: Efficiency at nominal output voltage and 60% rated power vs. case temperature for input voltage of 16V, 28V, and 40V.*

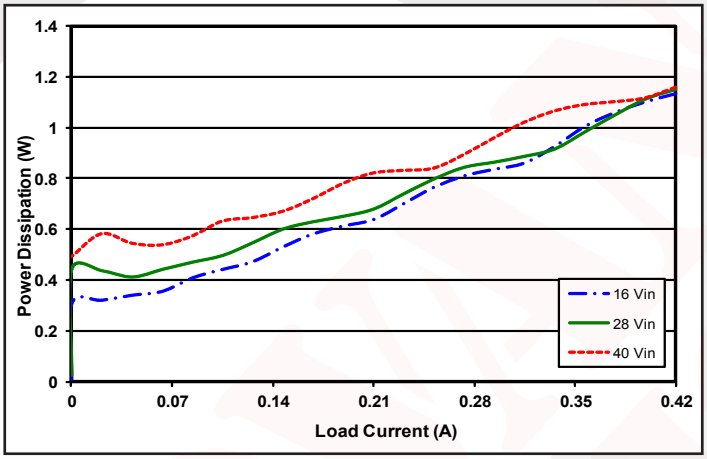


***Figure 3**: Power dissipation at nominal output voltage vs. load current for minimum, nominal, and maximum input voltage at Tcase=25°C.*

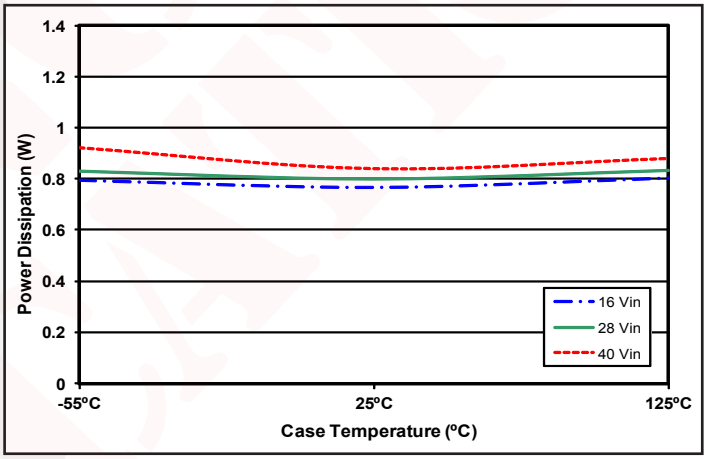


***Figure 4**: Power dissipation at nominal output voltage and 60% rated power vs. case temperature for input voltage of 16V, 28V, and 40V.*

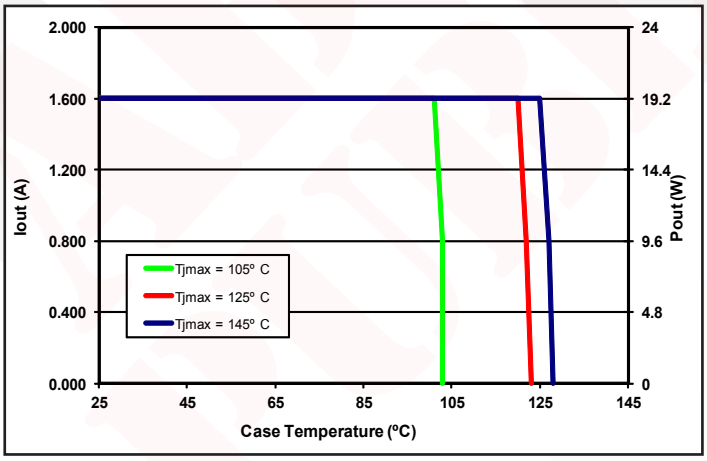


***Figure 5**: Output Current / Output Power derating curve as a function of Tcase and the Maximum desired power MOSFET junction temperature at Vin = 28V (see Note 9).*

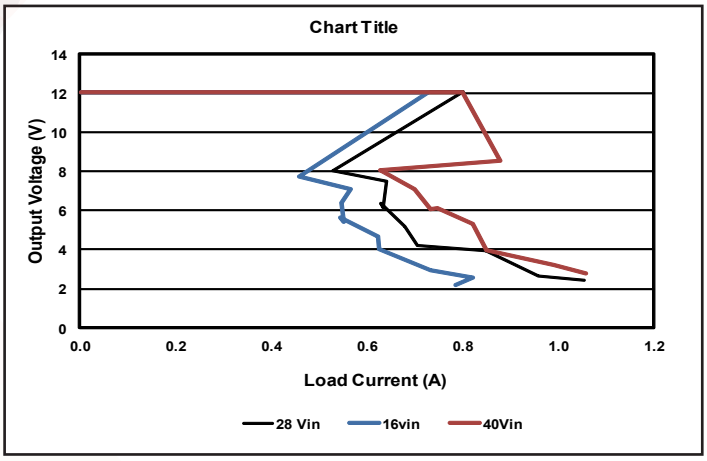


***Figure 6:** Output voltage vs. load current showing typical current limit curves at Vin = 28V.*

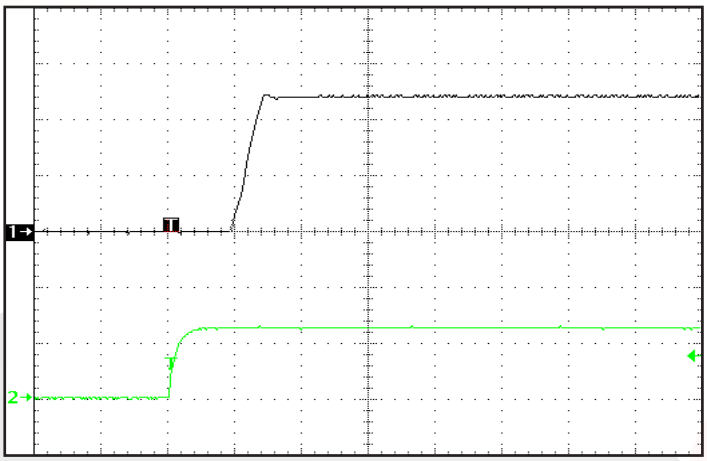


***Figure 7**: Turn-on transient at full resistive load and zero output capacitance initiated by ENA1. Input voltage pre-applied. Ch 1: Vout (5V/div) (5mS/div). Ch 2: ENA1 (2V/div).*

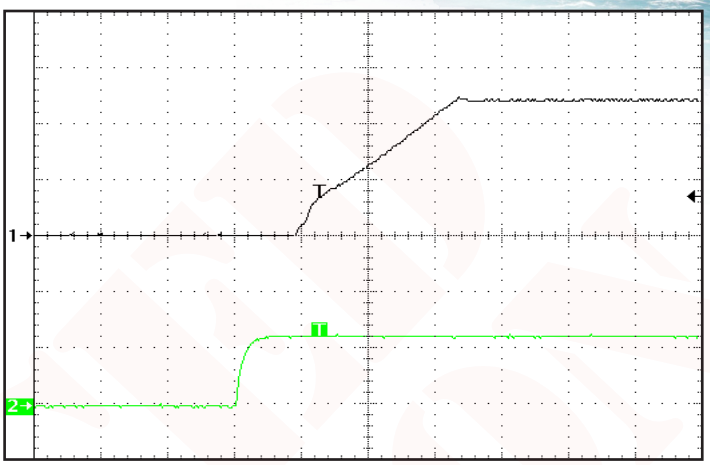


***Figure 8**: Turn-on transient at full resistive load and 26uF output capacitance initiated by ENA1. Input voltage pre-applied. Ch 1: Vout (5V/div) (5mS/div). Ch 2: ENA1 (2V/div).*

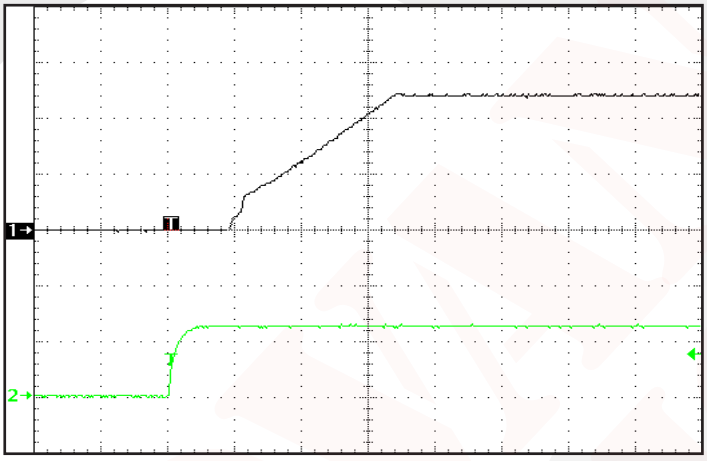


***Figure 9**: Turn-on transient at full resistive load and zero output capacitance initiated by Vin. ENA1 previously high. Ch 1: Vout (5V/div). Ch 2: Vin (20V/div).*

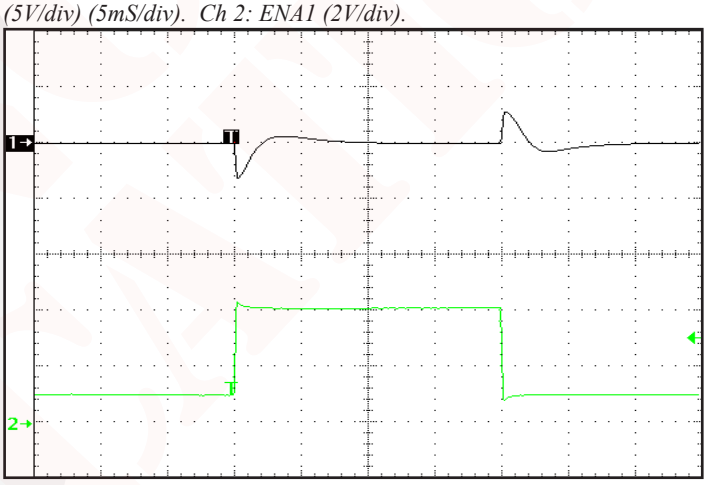


***Figure 10**: Output voltage response to step-change in load current 10%-50%-10% of Iout (max). Ch 1: Vout (500mV/div) (2mS/div). Ch 2: Iout (100mA/div).*

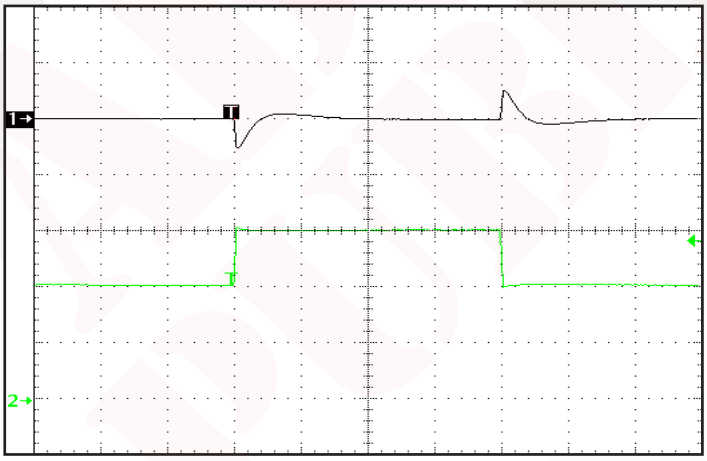


***Figure 11**: Output voltage response to step-change in load current 50%-75%-50% of Iout (max). Ch 1: Vout (200mV/div) (2mS/div). Ch 2: Iout (100mA/div).*

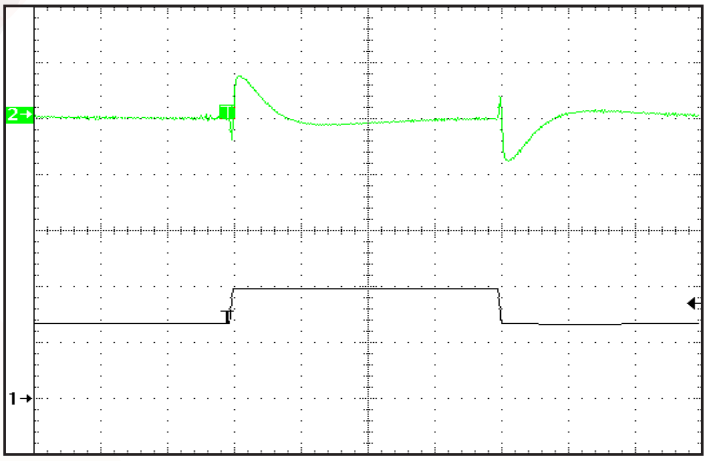


***Figure 12**: Output voltage response to step-change in input voltage (28V - 40V - 28V). Ch 1: Vin(20V/div). Ch 2: Vo (50mV/div).*

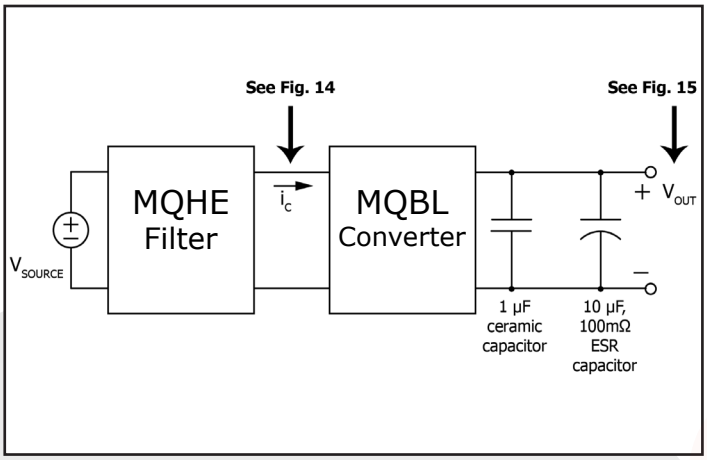


***Figure 13**: Test set-up diagram showing measurement points for Input Terminal Ripple Current (Figure 14) and Output Voltage Ripple (Figure 15).*

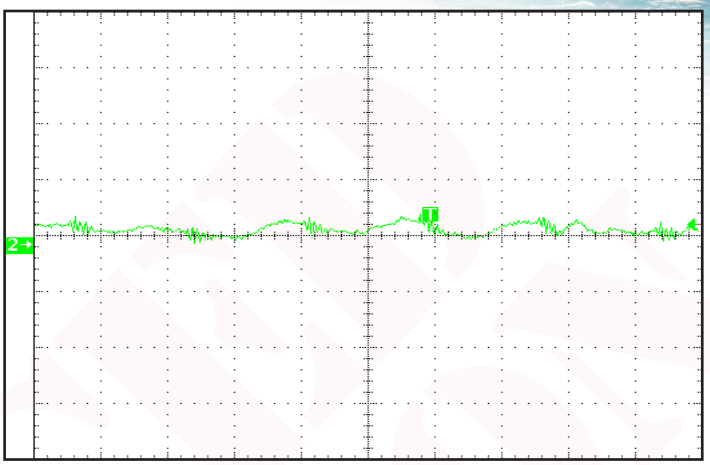


***Figure 14**: Input terminal current ripple, ic, at full rated output current and nominal input voltage with SynQor MQ filter module (5mA/div). Bandwidth: 20MHz. See Figure 13.*

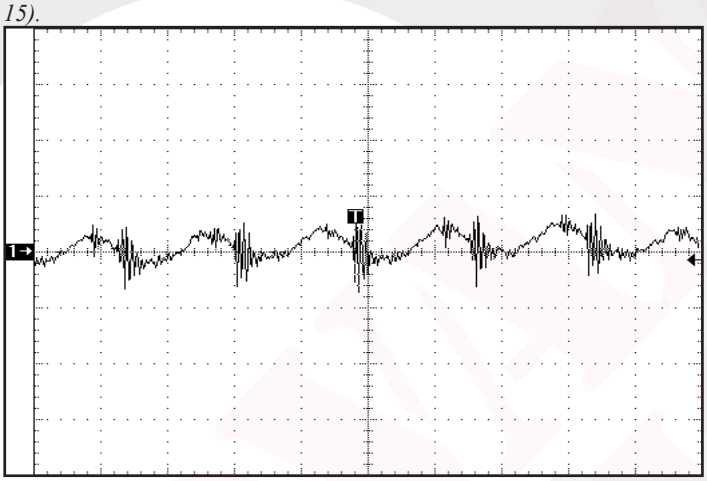


***Figure 15**: Output voltage ripple, Vout, at nominal input voltage and rated load current (10mV/div). Bandwidth: 20MHz. See Figure 13.*

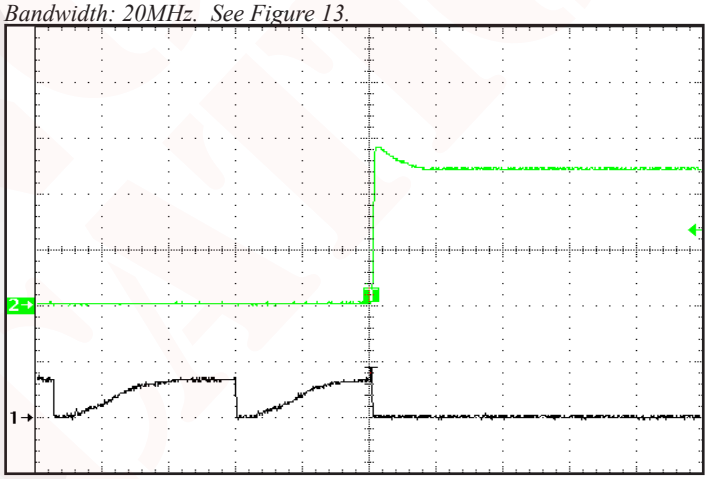


***Figure 16**: Rise of output voltage after the removal of a short circuit across the output terminals. Ch 1: Vout (5V/div). Ch 2: Iout (5A/div).*

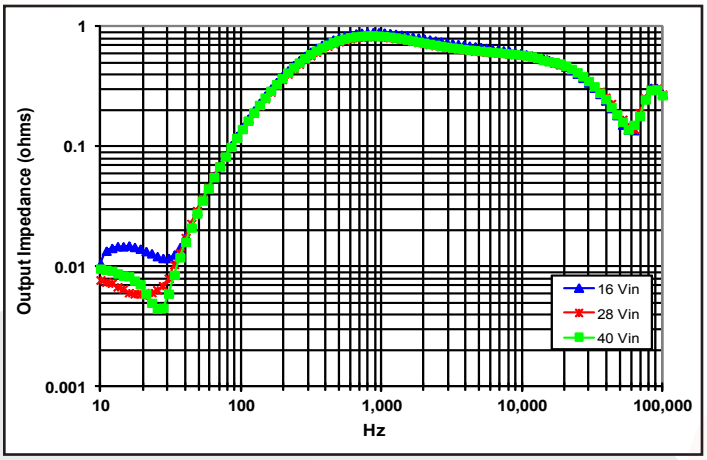


***Figure 17**: Magnitude of incremental output impedance (Zout = vout/iout) for minimum, nominal, and maximum input voltage at full rated power.*

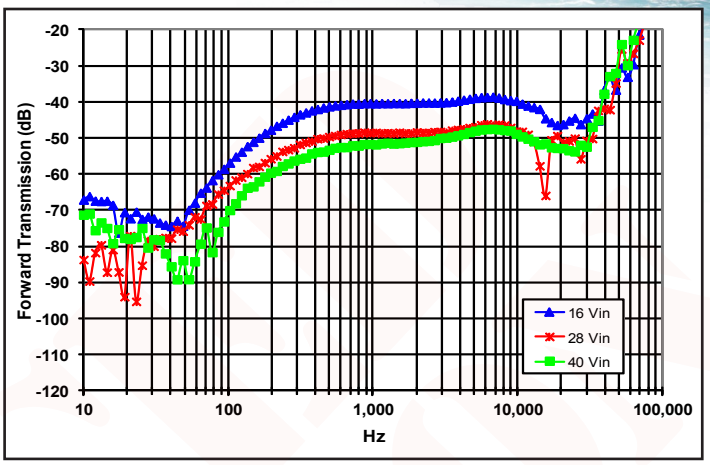


***Figure 18**: Magnitude of incremental forward transmission (FT = vout/vin) for minimum, nominal, and maximum input voltage at full rated power.*

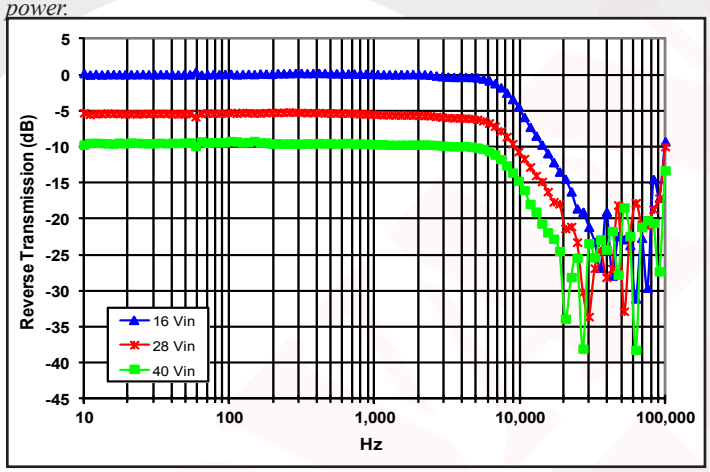


***Figure 19**: Magnitude of incremental reverse transmission (RT = iin/iout) for minimum, nominal, and maximum input voltage at full rated power.*

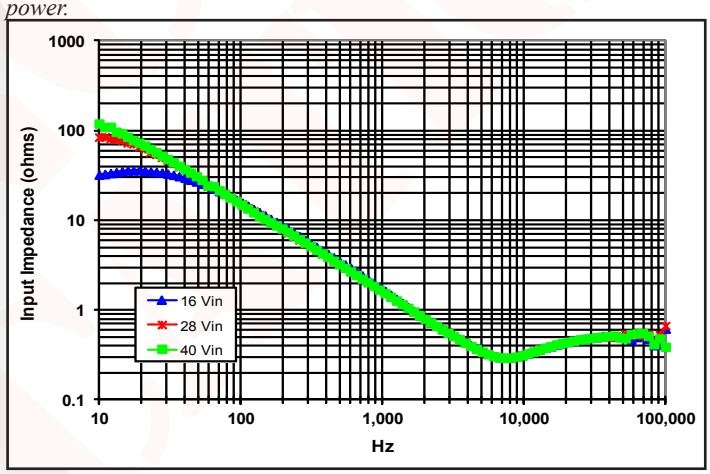


***Figure 20**: Magnitude of incremental input impedance (Zin = vin/iin) for minimum, nominal, and maximum input voltage at full rated power.*

BASIC OPERATION AND FEATURES

The MQSA DC/DC converter uses a single stage power conversion topology. A flyback-converter is used to keep the output voltage constant over variations in line, load, and temperature. The converter switches at a fixed frequency for predictable EMI performance. Rectification of the output is accomplished with diodes.

An input under-voltage shutdown feature with hysteresis is provided, as well as an output over-voltage limit. There is also an output current limit that is nearly constant as the load impedance decreases. When a load fault is removed, the output voltage rises exponentially to its nominal value with minimal overshoot.

The following sections describe the use and operation of additional control features provided by the MQSA converter.

CONTROL FEATURES

ENABLE: The MQSA converter has one enable pin, ENA (pin 5), which is referenced with respect to the converter's input return (pin 7). It must have a logic high level for the converter to be enabled; a logic low inhibits the converter.

The enable pin is internally pulled high so that an open connection will enable the converter. Figure A shows the equivalent circuit looking into the enable pin. It is TTL compatible and has hysteresis.

SHUT DOWN: The MQSA converter will shut down in response to only three conditions: ENA input low, VIN input below under-voltage shutdown threshold, and output voltage above the output over-voltage threshold.

INPUT UNDER-VOLTAGE SHUTDOWN: The MQSA converter has an under-voltage shutdown feature that ensures the converter will be off if the input voltage is too low. The input voltage turn-on threshold is higher than the turn-off threshold.

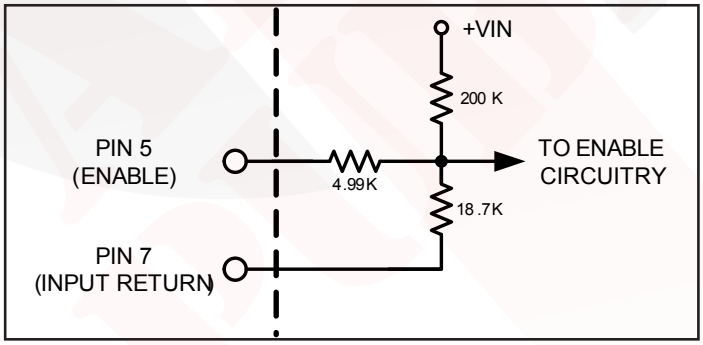


Figure A: *Circuit diagram shown for reference only, actual circuit components may differ from values shown for equivalent circuit.*

OUTPUT OVER-VOLTAGE SHUTDOWN: The MQSA converter will shut down if the voltage at its power output pins ever exceeds about 130% of the nominal value.

CURRENT LIMIT: In the event of excess load, the MQSA converter will quickly reduce its output voltage to keep the load current within safe limits.

If the converter is connected to an external heatsink, the heatsink will help to make the converter's case top a uniform temperature. How well it does so depends on the thickness of the heatsink and on the thermal conductance of the interface layer (e.g. thermal grease, thermal pad, etc.) between the case and the heatsink. Unless this is done very well, it is important not to mistake the heatsink's temperature for the maximum case temperature. It is easy for them to be as much as 5-10ºC different at full power and at high temperatures. It is suggested that a thermocouple be attached directly to the converter's case through a small hole in the heatsink when investigating how hot the converter is getting. Care must also be made to ensure that there is not a large thermal resistance between the thermocouple and the case due to whatever adhesive might be used to hold the thermocouple in place.

INPUT SYSTEM INSTABILITY: This condition can occur because any dc-dc converter appears incrementally as a negative resistance load. A detailed application note titled "Input System Instability" is available on the SynQor website which provides an understanding of why this instability arises, and shows the preferred solution for correcting it.

THERMAL CONSIDERATIONS: Figure 5 shows the suggested Power Derating Curves for this converter as a function of the case temperature and the maximum desired power MOSFET junction temperature. All other components within the converter are cooler than its hottest MOSFET, which at full power is no more than 20ºC higher than the case temperature directly below this MOSFET.

The Mil-HDBK-1547A component derating guideline calls for a maximum component temperature of 105ºC. Figure 5 therefore has one power derating curve that ensures this limit is maintained. It has been SynQor's extensive experience that reliable long-term converter operation can be achieved with a maximum component temperature of 125ºC. In extreme cases, a maximum temperature of 145ºC is permissible, but not recommended for long-term operation where high reliability is required. Derating curves for these higher temperature limits are also included in Figure 5. The maximum case temperature at which the converter should be operated is 135ºC.

CONSTRUCTION AND ENVIRONMENTAL STRESS SCREENING OPTIONS

Screening	Consistent with MIL-STD-883F	C-Grade (specified from 0 °C to +70 °C)	ES-Grade (specified from -45 °C to +100 °C)	HB-Grade (specified from -55 °C to +125 °C)
Element Evaluation		No	Yes	Yes
Internal Visual	*	Yes	Yes	Yes
Temperature Cycle	Method 1010	No	Condition B (-55 °C to +125 °C)	Condition C (-65 °C to +150 °C)
Constant Acceleration	Method 2001 (Y1 Direction)	No	500g	Condition A (5000g)
Burn-in	Method 1015	24 Hrs @ +125 °C	96 Hrs @ +125 °C	160 Hrs @ +125 °C
Final Electrical Test	Method 5005 (Group A)	+25 °C	-45, +25, +100 °C	-55, +25, +125 °C
Mechanical Seal, Thermal, and Coating Process		Full QorSeal	Full QorSeal	Full QorSeal
External Visual	2009	*	Yes	Yes
Construction Process		QorSeal	QorSeal	QorSeal
* Per IPC-A-610 Class 3				

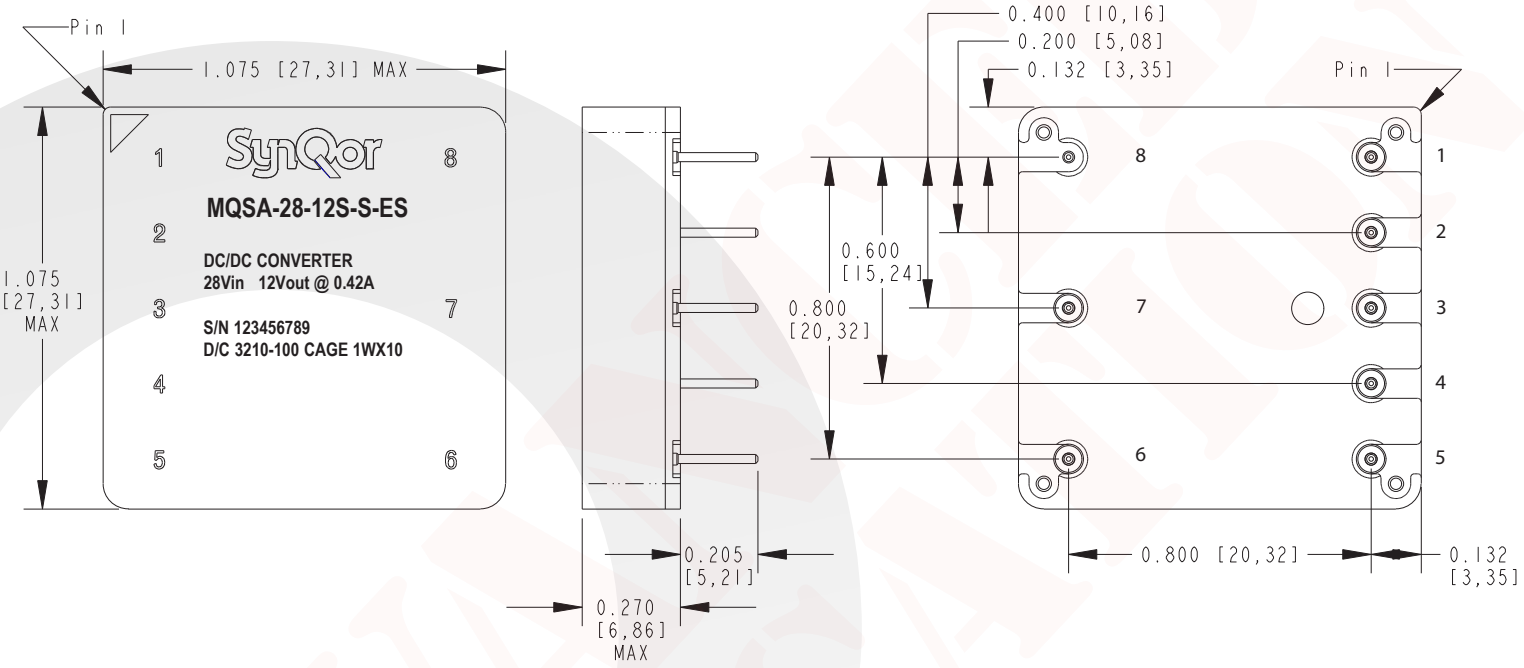
MilQor converters and filters are offered in three variations of environmental stress screening options. All MilQor converters use SynQor's proprietary QorSeal® Hi-Rel assembly process that includes a Parylene-C coating of the circuit, a high performance thermal compound filler, and a nickel barrier gold plated aluminum case. Each successively higher grade has more stringent mechanical and electrical testing, as well as a longer burn-in cycle. The ES- and HB-Grades are also constructed of components that have been procured through an element evaluation process that pre-qualifies each new batch of devices.

MIL-STD-810F Qualification Testing

MIL-STD-810F Test	Method	Description
Fungus	508.5	Table 508.5-I
Altitude	500.4 - Procedure I	Storage: 70,000ft. / 2 Hr. duration
	500.4 - Procedure II	Operating; 70,000ft. / 2 Hr. duration; Ambient Temperature
Rapid Decompression	500.4 - Procedure III	Storage: 8,000ft. to 40,000ft.
Acceleration	513.5 - Procedure II	Operating - 15g's
Salt Fog	509.4	Storage
High Temperature	501.4 - Procedure I	Storage: 135°C / 3 hrs
	501.4 - Procedure II	Operating: 100°C / 3 hrs
Low Temperature	502.4 - Procedure I	Storage: -65°C / 4 hrs
	502.4 - Procedure II	Operating: -55°C / 3 hrs
Temperature Shock	503.4 - Procedure I - C	Storage: -65°C to 135°C; 12 cycles
Rain	506.4 - Procedure I	Wind Blown Rain
Immersion	512.4 - Procedure I	Non-Operating
Humidity	507.4 - Procedure II	Aggravated cycle @ 95% RH (Figure 507.5-7 aggravated temp - humidity cycle, 15 cycles)
Random Vibration	514.5 - Procedure I	10-2000 Hz, PSD level of 1.5 g2/Hz(54.6grms), duration = 1 hr/axis
Shock	516.5 - Procedure I	20g's peak, 11ms, Functional Shock (Operating no load) (saw tooth)
	516.5 - Procedure VI	Bench Handling Shock
Sinusoidal vibration	514.5 - Category 14	Rotary wing aircraft - helicopter, 4hrs/axis, 20g's (sine sweep from 10 - 500HZ)
Sand and Dust	510.4 - Procedure I	Blowing Dust
	510.4 - Procedure II	Blowing Sand

First Article Testing consistent with MIL-STD-883F

MIL-STD-883F Test	Method	Description
Electrical Tests	5005	
Physical Dimensions test	2016	
Resistance to Solvents test	2015.13	
Solderability test	2003.8	
Lead Integrity test	2004.5	
Salt Atmosphere test	1009.8	Condition “A”
Adhesion of Lead Finish test	2025.4	
Altitude Operation test	1001	Condition “C”
ESD Sensitivity	3015.7	Class 2
Stabilization Bake test	1008.2	Condition “C”
Vibration Fatigue test	2005.2	Condition “A”
Random Vibration test	2026	Condition “II K”
Sequential Test Group #1		
Life Test – Steady State test	1005.8	
Life Test – Intermittent Duty test	1006	
Sequential Test Group #2		
Temperature Cycle test	1010.8	Condition “C”
Constant Acceleration test	2001.2	Condition “A”
Sequential Test Group #3		
Thermal Shock test	1011.9	Condition “B”
Temperature Cycle test	1010.8	Condition “C”
Moisture Resistance test	1004.7	With Sub cycle
Sequential Test Group #4		
Mechanical Shock test	2002.4	Condition “B”
Variable Frequency Vibration test	2007.3	Condition “A”



NOTES

1) Pins 0.025" (0.64mm) diameter

2) Pins Material: Copper Alloy
Finish: Gold over Nickel Plate

3) All dimensions in inches (mm)
Tolerances: x.xx +/-0.02 in. (x.x +/-0.5mm)
x.xxx +/-0.010 in. (x.xx +/-0.25mm)

4) Weight: 0.55 oz (15.7 g) typical

5) Workmanship: Meets or exceeds IPC-A-610 Class III

6) Print Labeling on Top Surface per Product Label Format Drawing

PIN DESIGNATIONS

Pin #	Function
1	Positive output
2	Output return
3	No Connection
4	No Connection
5	Enable
6	Positive input
7	Input return
8	Case

Ordering Information

MilQor Converter FAMILY MATRIX

The tables below show the array of MilQor converters available. When ordering SynQor converters, please ensure that you use the complete part number according to the table in the last page. Contact the factory for other requirements.

	Single Output				Dual Output †		
	5V (05S)	12V (12S)	15V (15S)	28V (28S)	5V (05D)	12V (12D)	15V (15D)
MQSA-28 16-40Vin Cont. 16-50Vin 1s Trans.* Absolute Max Vin = 60V	1A	0.42A	0.33A	0.18A	1A Total	0.42A Total	0.33A Total
MQSA-28E 16-70Vin Cont. 16-80Vin 1s Trans.* Absolute Max Vin =100V	1A	0.42A	0.33A	0.18A	1A Total	0.24A Total	0.33A Total

	Single Output											Dual Output †		
	1.5V (1R5S)	1.8V (1R8S)	2.5V (2R5S)	3.3V (3R3S)	5V (05S)	6V (06S)	7.5V (7R5S)	9V (09S)	12V (12S)	15V (15S)	28V (28S)	5V (05D)	12V (12D)	15V (15D)
MQBL-28 16-40Vin Cont. 16-50Vin 1s Trans.* Absolute Max Vin = 60V	8A	8A	8A	6A	4A	3.3A	2.6A	2.2A	1.6A	1.3A	0.7A	4A Total	1.6A Total	1.3A Total
MQBL-28E 16-70Vin Cont. 16-80Vin 1s Trans.* Absolute Max Vin =100V	8A	8A	8A	6A	4A	3.3A	2.6A	2.2A	1.6A	1.3A	0.7A	4A Total	1.6A Total	1.3A Total

Check with factory for availability.
†80% of total output current available on any one output.
*Converters may be operated at the highest transient input voltage, but some component electrical and thermal stresses would be beyond MIL-HDBK-1547A guidelines.

Ordering Information

PART NUMBERING SYSTEM

The part numbering system for SynQor's MilQor DC-DC converters follows the format shown in the table below.

Not all combinations make valid part numbers, please contact SynQor for availability. See the Product Summary web page for more options.

Example: MQSA-28-12S-S-ES

Model Name	Input Voltage Range	Output Voltage(s)		Package Outline/ Pin Configuration	Screening Grade
		Single Output	Dual Output		
MQSA	28 28E	05S 12S 15S 28S	05D 12D 15D	S	C ES HB

APPLICATION NOTES

A variety of application notes and technical white papers can be downloaded in pdf format from the SynQor website.

Contact SynQor for further information and to order:

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Boxborough, MA 01719
USA

Warranty

SynQor offers a two (2) year limited warranty. Complete warranty information is listed on our website or is available upon request from SynQor.