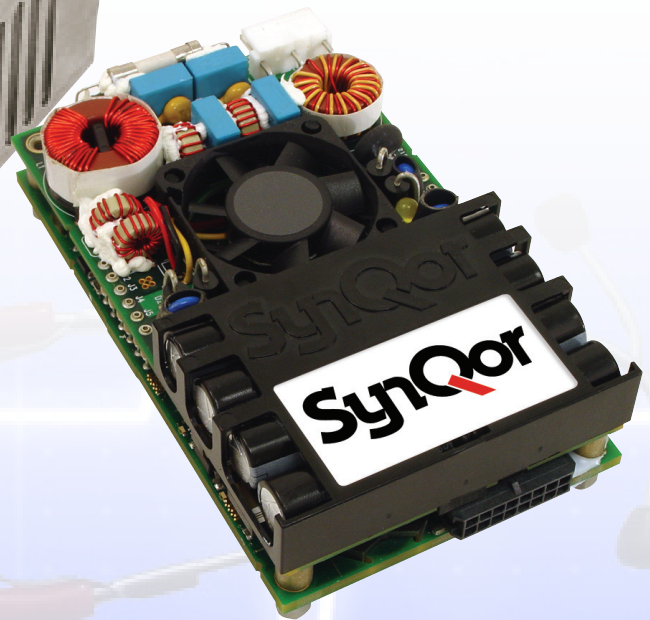


## Medical Grade AC/DC Power Supply With PFC

85-264 Vrms Input Voltage	12/24/36/48 V Semi-Regulated Output	400 W Output Continuous	500 W Output Transient	Up to 91 % Full Load Efficiency
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ACuQor®



### Product Features

- High efficiency (91% for 48 Vout Model at 400 W)
- Universal input voltage range
- Semi-regulated output for bus stability
- Parallel operation supported
- Integral fan cooling with speed control
- Active PFC; EN61000-3-2 compliant
- Low leakage; EN60601-1 compliant
- Low noise; EN55011 / EN55022 Class B compliant
- Medical EMI Compatibility:  
IEC 60601-1-2 ed 4.0 compliant
- Over-current, over-voltage, & over-temp protection
- DC Power Good / AC Power Good signals
- Remote enable input
- Fan status output / Fan enable input
- Small size: 3" x 5" x 1.45"(open frame)
- RoHS 6/6 compliant
- 5 V (250 mW) standby output



# Technical Specification

AC Input: 85-264 Vrms  
 DC Output: 12/24/36/48 V Semi-reg.  
 Power: 400 W  
 Grade: Medical

## ACuQor 400 W Series Electrical Characteristics

All specifications typical with  $T_A = 25\text{ }^\circ\text{C}$ , unless otherwise specified. Specifications subject to change without notice.

MAIN OUTPUT SPECIFICATIONS			ENVIRONMENTAL CHARACTERISTICS		
Output power (continuous) (5 s transient)	85-132/170-264 Vrms 85-132/170-264 Vrms 132-170 Vrms	400 W 500 W See Figure 10	Thermal performance	Operating ambient (see Figure 9) Non-operating ambient	0 °C to +70 °C -40 °C to +85 °C
Nominal DC output voltage (at 250W) (Semi-regulated)	12 Vout 24 Vout 36 Vout 48 Vout	12.4 V 25 V 37.5 V 50 V	Relative humidity	Non-condensing	5-95% RH
Efficiency (see figs. 1, 3, 5, 7)	12 Vout, 115 Vrms, 400 W 48 Vout, 115 Vrms, 400 W 12 Vout, 230 Vrms, 400 W 48 Vout, 230 Vrms, 400 W	88% typ. 90% typ. 89% typ. 91% typ.	Altitude	Operating Operating	10,000 ft max. 30,000 ft max.
Hold-up time (to -20%)	12 Vout 24 / 36 / 48 Vout	16 ms @ 400 W 20 ms @ 400 W	Random vibration	5-500 Hz	0.03 g2/Hz
Maximum load capacitance	12 Vout 24 Vout 36 Vout 48 Vout	16,000 µF 8,000 µF 4,000 µF 2,000 µF	Shock	Half-sine, 10 ms, 3 axes	20 g peak
Output ripple voltage	Switching frequency (20 MHz BW) Twice line frequency (at 300W)	0.5% p-p 5.0% p-p	EMC CHARACTERISTICS		
Turn-on delay		2 s max.	Conducted emissions	EN55011 and EN55022, FCC part15	Level B
Transient response	Iout steps from 50-75% At 0.2 A/µs	3% typ / 6% max. dev. 100 ms recovery	Line frequency harmonics	EN61000-3-2	Class A
Overvoltage protection	Cyclic restart	110-120%	Voltage fluctuations	EN61000-3-3	Clause 5b
Short circuit protection	Cyclic operation	115% rated Iout	ESD air	EN61000-4-2	Level 4, +/-15kV
Total regulation	Over line, load and temperature	±6.0%	See following details		Perf Criteria A, AC Input Connections Perf Criteria B, DC Output Connections
Auxillary Output	Always on (See Note 1)	5 V @ 50 mA	ESD contact	EN61000-4-2	Level 4, +/-8kV
Thermal protection	Automatic recovery	+125 °C (PCB Temp)	Radiated immunity	EN61000-4-3	Perf Criteria A; HCP, VCP, Case Level 3, 10V/m
REMOTE_ENABLE	Input Low Voltage Input High Voltage	0.45 V (max) 4.15 V (min)			IEC60601-1-2 Ed.4 Table 4 28 V/m IEC60601-1-2 Ed.4 Table 9 Perf Criteria A
INPUT SPECIFICATIONS			Fast transients	EN61000-4-4	Level 3, 100kHz rep, AC input leads IEC60601-1-2 Ed.4 Table 5 Perf Criteria A
AC input voltage	Universal range	85-264 Vrms	Line surge immunity	EN61000-4-5	Level 3 Perf Criteria B
Input frequency		47-63 Hz	Conducted immunity	EN61000-4-6	Level 3 Perf Criteria A
Input current	115 Vrms @ 400 W 230 Vrms @ 400 W	4 Arms 2 Arms	Power freq. mag. field	EN61000-4-8	30 A/m IEC60601-1-2 Ed.4 Table 4 Perf Criteria A
Power factor		>0.98	Voltage dip immunity	EN61000-4-11	0% Ut; See following details 0.5 cycle 45° increments 0% Ut; 1 cycle 70% Ut; 0.5s IEC60601-1-2 Ed.4 Table 5 Perf Criteria A, Load Dependent
Input surge current	264 Vrms (cold start)	40 A max.	Voltage interruptions	EN61000-4-11	0% Ut; 5s IEC60601-1-2 Ed.4 Table 5 Perf Criteria B
Internal input fuses	Both AC lines	6.3 A			
GENERAL SPECIFICATIONS			NOTES:		
Fundamental ripple freq.	Input Output	500 kHz 250 kHz	1. Derate 1 mA per °C above 50 °C ambient temperature.		
Audible noise	Fan speed varies with temp.	39 dBA @ 1 m max.	2. Leakage currents see page 3.		
Weight (EA) (EC)		343 g (12.1 oz) 446 g (15.7 oz)			
MTBF	MIL-217 Demonstrated	343.6 kHours TBD kHours			
ISOLATION SPECIFICATIONS					
Isolation voltage	Input to output Input to ground Output to ground (BF & CF ) Output to ground (CFD)	4000 Vrms 1500 Vrms 1500 Vrms 5000 Vpulse			
Insulation resistance	Output to ground	10 MΩ min.			
Leakage currents		See Note 2			



# Technical Specification

AC Input: 85-264 Vrms  
 DC Output: 12/24/36/48 V Semi-reg.  
 Power: 400 W  
 Grade: Medical

## EMC Immunity Testing Details

### ESD EN61000-4-2

For ESD tests applied directly to the DC output, one of the methods called out in IEC 61000-4-2 section 7.1.3 must be used to bleed off charge between successive ESD events. For example, the cable with 2 x 470kOhm resistors used for this purpose during coupling plane tests can be duplicated and connected from DC output to protective earth (PEGND). Discharges must not be applied directly to any circuits other than the case (for encased models), the AC input connections, and the DC output connections. For ESD protection in equipment, it is important to follow the ACuQor Installation Instructions provided with each unit in regards to clearance. Those instructions are repeated here for emphasis. CF and CFD models, in particular, may experience high DC output voltages with respect to protective earth (PEGND) due to their low capacitance/low-leakage design if ESD pulses are directly applied. Maintaining adequate clearance will prevent arcing from ACuQor DC output circuitry to other user circuits and chassis.

### Voltage Dips EN61000-4-11

The following table details the DC output loading conditions and performance criteria for AC input voltage dip tests.

## ACuQor 300/400/500W Performance

Test Condition	DC Load	Criteria
0% UT; 0.5 cycle at 0, 45, 90, 135, 180, 225, 270 and 315 degrees	0 to 400 W > 400 W	A B
0% UT; 1 cycle at 0 degrees	0 to 350 W > 350 W	A B
70% UT; 25/30 cycles (0.5s) at 0 degrees	0 to 450 W > 450 W	A B
0% UT; 250/300 cycles (5s) at 0 degrees	All loading	B

Note: 300W models limited to 400W transients

## Leakage Currents

AC Leakage Current from Input to Earth	AC Line Connection	Normal Condition	Open Neutral Fault
ACuQor Typical at 110% nominal input voltage 60 Hz	240 V L-N, 1 phase	125 µA	250 µA
	208 V L-L, 120 V L-N, 1 of 3 phases	65 µA	130 µA
	240 V L-N-L, 120 V L-N, split phase	65 µA	130 µA

AC Leakage Current from Output to Earth	Model	Normal Condition	Open Earth Fault	AC Backdrive Fault
ACuQor Typical at 264 Vac 60 Hz input	AQ . . BF . .	2 µA	36 µA	125 µA
	AQ . . CF . .	2 µA	6 µA	18 µA

For convenience, the following tables show limits allowed by various standards:

AC Leakage Current from Input to Earth	Standard	Normal Condition	Open Neutral Fault
Maximum Allowed per Standard	IEC60601-1	500 µA	1000 µA
	NFPA 99 2005	300 µA	—
	IEC60950	3500 µA	—

AC Leakage Current from Output to Earth	Contact Type	Normal Condition	Open Earth Fault	AC Backdrive Fault
Maximum Allowed per IEC60601-1	BF	100 µA	500 µA	5000 µA
	CF	10 µA	50 µA	50 µA

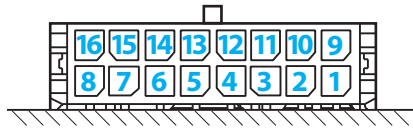
Table 1: Leakage Currents

## Standard Testing Certifications

### SAFETY AGENCY CERTIFICATIONS

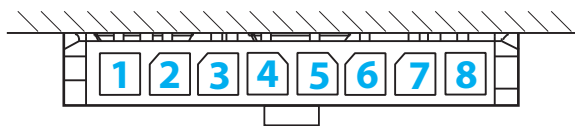
- UL 60601-1
- CAN/CSA C22.2 No. 601.1-M90
- EN 60601-1
- IEC 60601-1
- ANSI/AAMI ES60601-1
- CE Marked
- Meets NFPA 99 2005 300 µA earth leakage

## CONNECTOR DETAILS



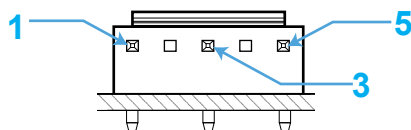
### OUTPUT CONNECTOR PINOUT (top side)

Pin 1	FAN_GOOD	Open collector with internal 5V pullup. See Figure A. Pulsed low on fan failure, 100ms, 50% duty. Short to VOUT(-) to disable fan.
Pin 2	AC_POWER_GOOD	Open collector with internal 5V pullup. See Figure B. Pulled low on AC power dropout.
Pin 3	DC_POWER_GOOD	Open collector with internal 5V pullup. See Figure B. Pulled low during startup ramp and within 5 °C of temperature shutdown threshold.
Pin 4	5V_STANDBY	5 V @ 50 mA available whenever AC power is applied.
Pin 5	VOUT(+)	Positive Output Voltage.
Pin 6	VOUT(+)	Positive Output Voltage.
Pin 7	VOUT(+)	Positive Output Voltage.
Pin 8	VOUT(+)	Positive Output Voltage.
Pin 9	Reserved	Reserved for future use.
Pin 10	Reserved	Reserved for future use.
Pin 11	REMOTE_ENABLE	Logic input. See Figure C. Pull high to enable main output.
Pin 12	VOUT(-)	Negative Output Voltage.
Pin 13	VOUT(-)	Negative Output Voltage.
Pin 14	VOUT(-)	Negative Output Voltage.
Pin 15	VOUT(-)	Negative Output Voltage.
Pin 16	VOUT(-)	Negative Output Voltage.



### 12 V OUTPUT CONNECTOR PINOUT (bottom side)

Pin 1	VOUT(+)	Positive Output Voltage.
Pin 2	VOUT(+)	Positive Output Voltage.
Pin 3	VOUT(+)	Positive Output Voltage.
Pin 4	VOUT(+)	Positive Output Voltage.
Pin 5	VOUT(-)	Negative Output Voltage.
Pin 6	VOUT(-)	Negative Output Voltage.
Pin 7	VOUT(-)	Negative Output Voltage.
Pin 8	VOUT(-)	Negative Output Voltage.



### INDIVIDUAL INPUT CONNECTOR PINOUT

Pin 1	Ground
Pin 3	AC Neutral
Pin 5	AC Line

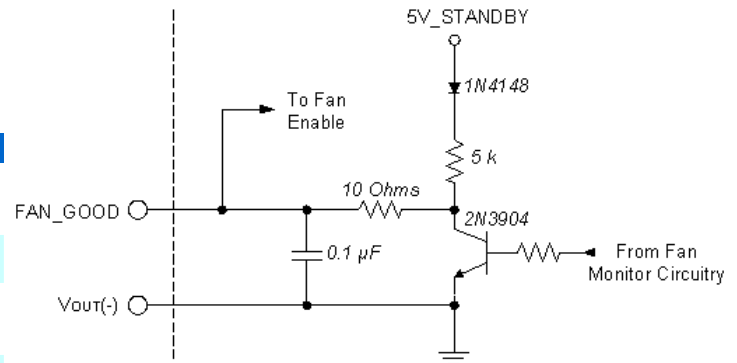


Figure A: Fan status output / Fan enable input interface circuitry.

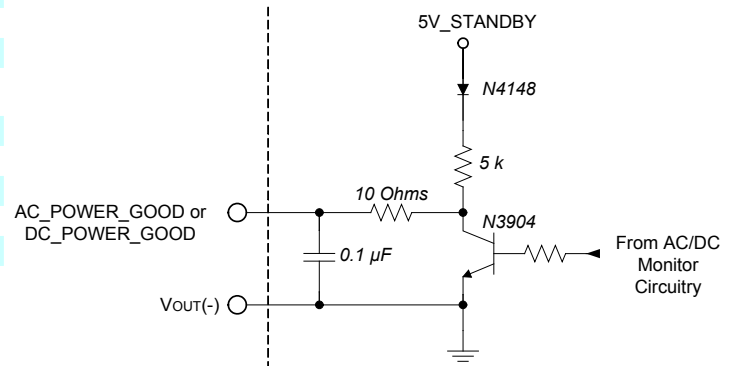


Figure B: Power good interface circuitry.

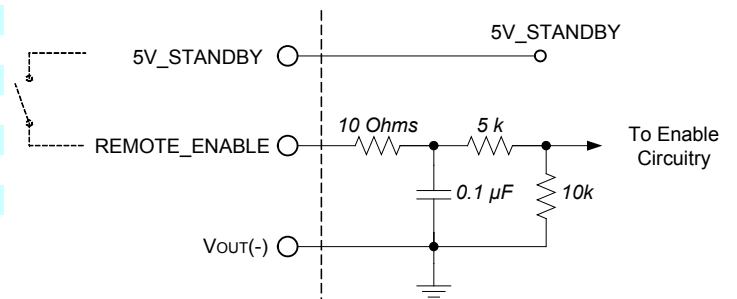


Figure C: Remote enable interface circuitry.

### MATING CONNECTORS

Connector	Type	Contact
OUTPUT (16 pins)	Molex 430251600	Molex 430300008*
12V_OUTPUT (8 pins)	Molex 436450800	Molex 430300008*
INPUT	JST VHR-5N	JST SVH-41T-P1.1

\* Each contact rated for a maximum of 5.5 A.



**EFFICIENCY, DERATING, AND VOUT DROOP CURVES**

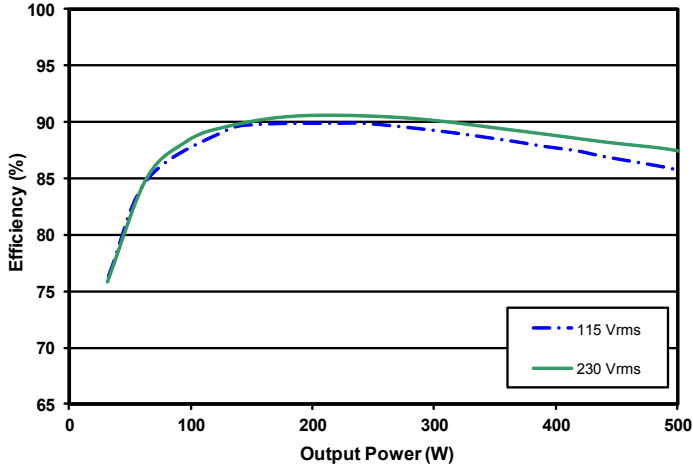


Figure 1: 12 V<sub>OUT</sub> efficiency curves.

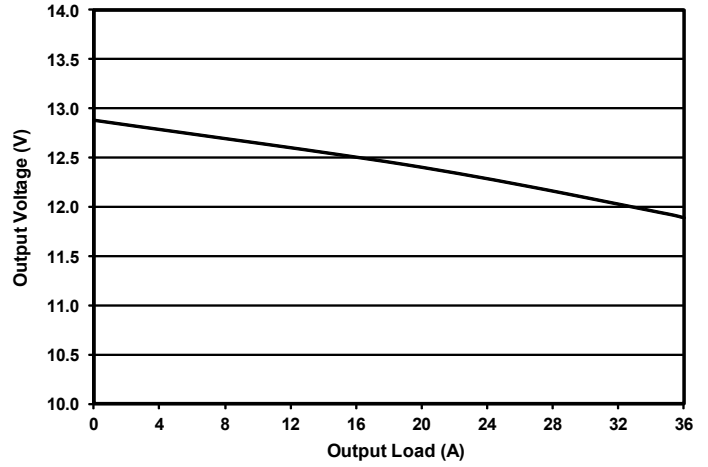


Figure 2: 12 V<sub>OUT</sub> droop characteristic.

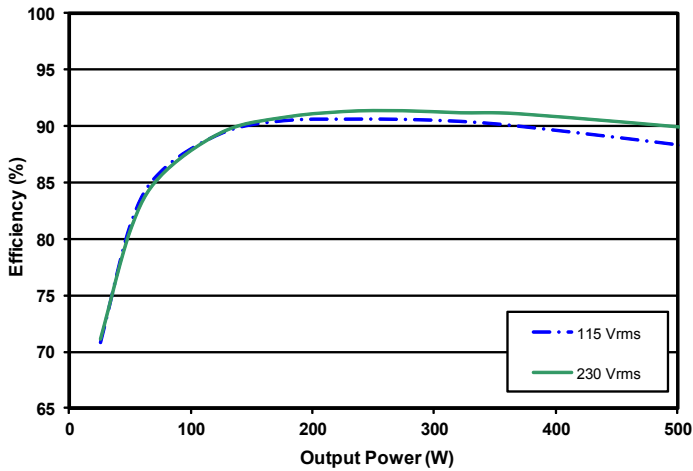


Figure 3: 24 V<sub>OUT</sub> efficiency curves.

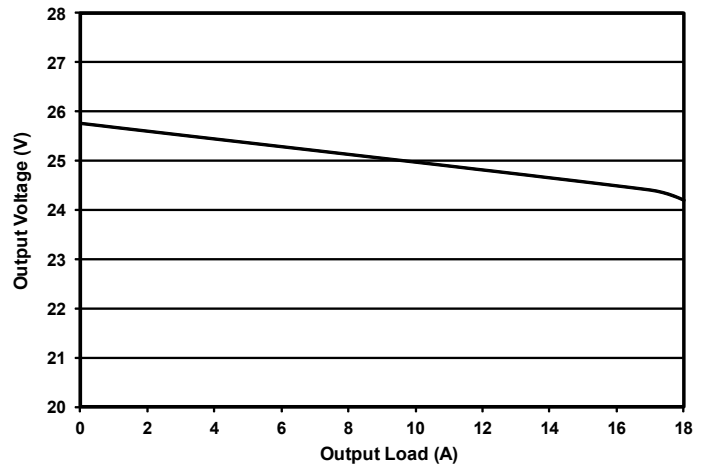


Figure 4: 24 V<sub>OUT</sub> droop characteristic.

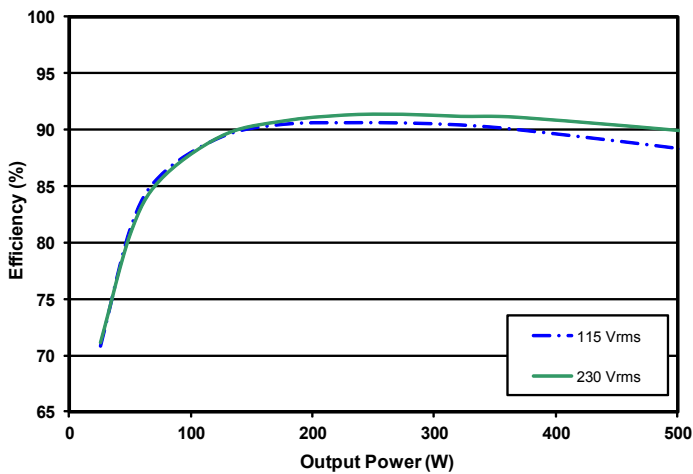


Figure 5: 36 V<sub>OUT</sub> efficiency curves.

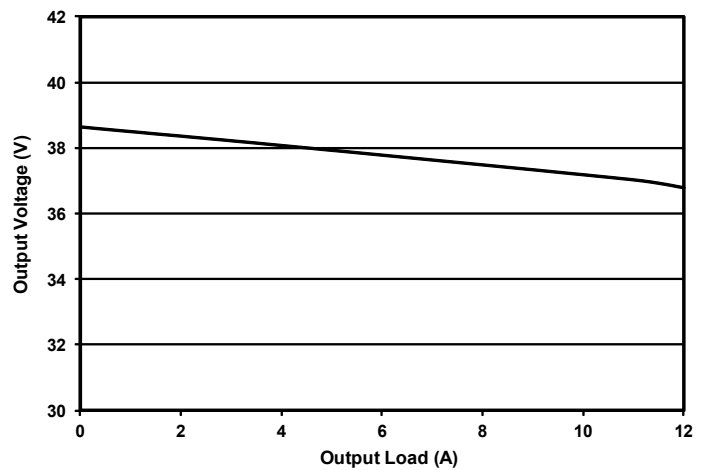


Figure 6: 36 V<sub>OUT</sub> droop characteristic.



**EFFICIENCY, DERATING, AND VOUT DROOP CURVES**

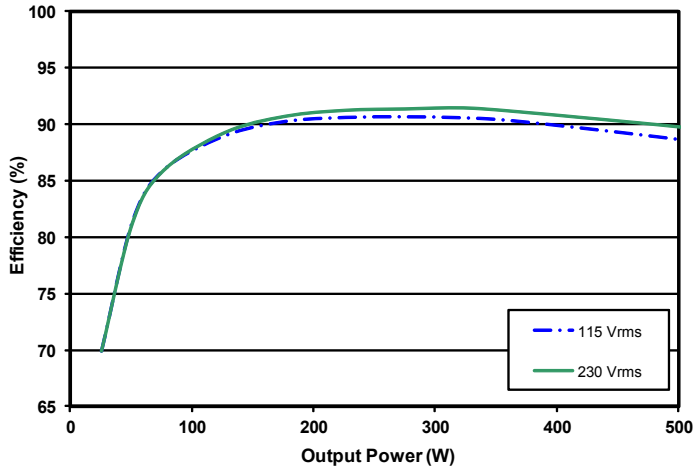


Figure 7: 48 V<sub>OUT</sub> efficiency curves.

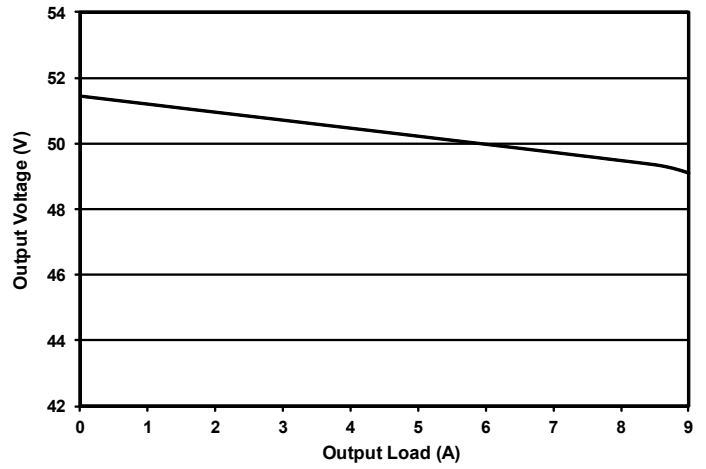


Figure 8: 48 V<sub>OUT</sub> droop characteristic.

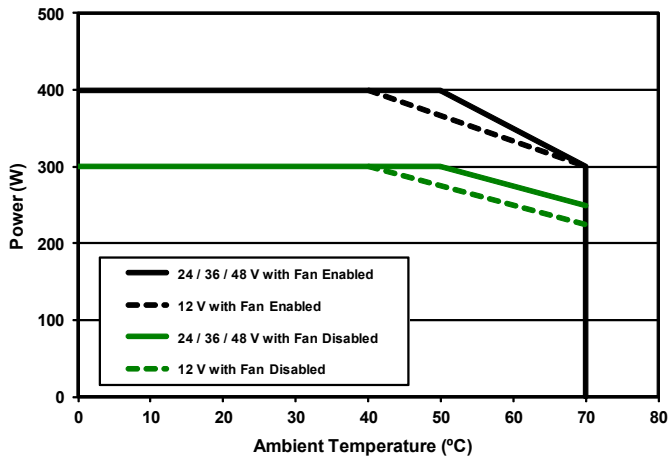


Figure 9: Continuous power derating curve in natural convection.

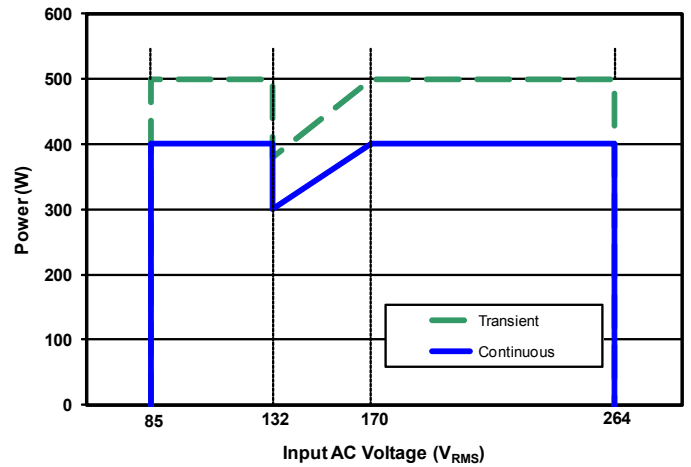


Figure 10: Rated output power vs Input AC Voltage.

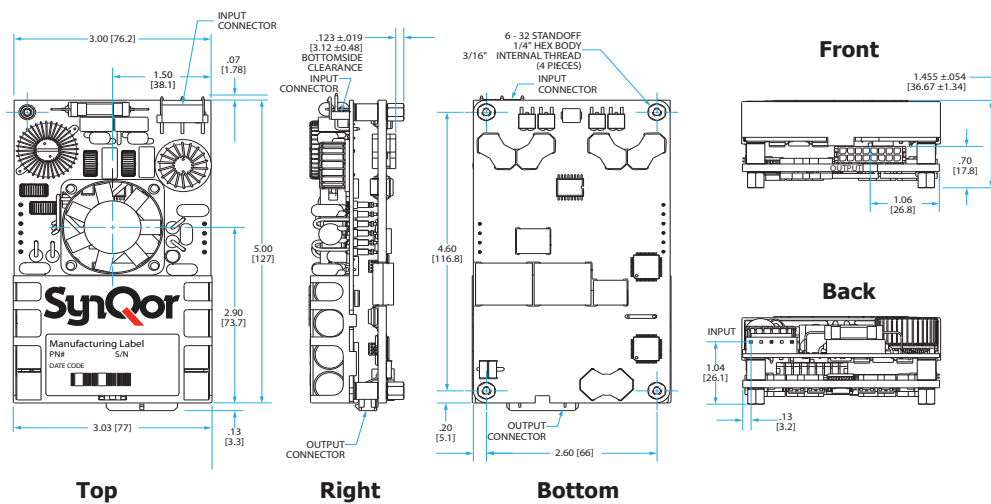


# Technical Specification

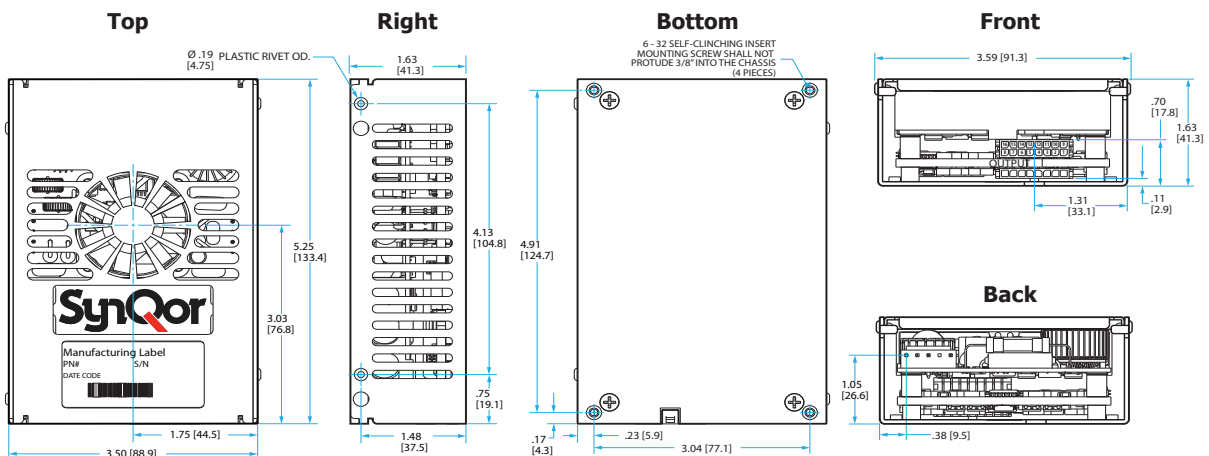
AC Input: 85-264 Vrms  
 DC Output: 12/24/36/48 V Semi-reg.  
 Power: 400 W  
 Grade: Medical

## MECHANICAL DRAWINGS

### (1 Module Open Frame Version — E Package Type)



### (1 Module Encased Version — E Package Type)



#### NOTES (applies to all mechanicals)

- 1) Recommended screw tightening torque of 6 in.lbs
  - 2) Undimensioned components are shown for visual reference only
  - 3) All dimensions in inches [mm]
- Tolerances:       x.xx in ± 0.02  
                       x.xxx in ± 0.010



# Technical Specification

**AC Input:** 85-264 Vrms  
**DC Output:** 12/24/36/48 V Semi-reg.  
**Power:** 400 W  
**Grade:** Medical

## PARALLEL OPERATION - MULTIPLE UNITS

The following table summarizes the recommended wiring to operate multiple units in parallel. As a rule, units wired in parallel behave the same as single units. Any specification will remain unchanged that is expressed in units of voltage, time, frequency, or efficiency. Specifications expressed in terms of power, current, or capacitance, should be scaled by the number of units wired in parallel.

ACuQor units are individually calibrated at the factory, so that the output voltage vs. output current characteristic is always consistent (see Vout droop characteristic figures). As such, multiple units will share output current accurately. Full current is guaranteed from a bank of multiple units wired in parallel.

Output Connector Signal	Suggested Connection	Behavior with Multiple Units
REMOTE_ENABLE	Wire in parallel	Inputs activated simultaneously
FAN_GOOD	"	Wired-OR outputs – can be pulled low by any unit during an abnormal condition.
AC_POWER_GOOD	"	"
DC_POWER_GOOD	"	"
VOUT(+), VOUT(-)	"	"
12V_STANDBY*	"	"
5V_STANDBY	Do not wire in parallel	Fully regulated characteristic does not support current sharing. If placed in parallel, only the output with the highest set-point will drive current.

\*Note: Triple output models only.





AC Input: 85-264 Vrms  
 DC Output: 12/24/36/48 V Semi-reg.  
 Power: 400 W  
 Grade: Medical

## INSTALLATION INSTRUCTIONS

**General:** ACuQor AC-DC power supplies are intended for use as components in medical and industrial equipment. ACuQor units must be properly installed within end use equipment before they can be safely applied as described in this document. The suitability of the ACuQor/equipment combination must be verified through end product investigation.

**Mounting:** Refer to the Mechanical Drawings section. ACuQor units are provided with threaded stainless-steel stand-offs or inserts for mounting. This mounting hardware is internally connected to the input connector protective-earth terminal for functional-earth EMC control. Any orientation (vertical, horizontal, etc.) may be used. Adequate air space should be provided over the fan intake (top) and exhaust (sides) to allow for exchange of cooling air. ACuQor is designed for a pollution degree 2 environment. The suitability of the enclosed ACuQor mechanical assemblies must be verified through end product investigation.

**Open-frame models:** A minimum of 5 mm electrical clearance should be allowed from the connector ends, the top and sides of open-frame models. A minimum 5 mil polyester Mylar film sheet attached to the mounting surface is required to allow some deflection and to meet defibrillation proof insulation requirements.

**Encased models:** A minimum of 5 mm electrical clearance should be allowed from the connector ends of encased models.

**Input:** Refer to the Connector Details section for input connector wiring. ACuQor products require a single phase AC power source of 100-240V 50/60Hz nominal. Refer to nameplate label for input current ratings. A protective-earth connection is also required. Minimum wire size of 18 AWG (0.8mm<sup>2</sup>) is recommended. Both sides of the AC line are internally fused (see table for specific models). These fuses are not user replaceable.

**OUTPUT:** Refer to the Connector Details section for output connector wiring and signal I/O functionality. Refer to nameplate label for output current ratings. Main DC output (Vout+, Vout-) pins should use 20 AWG (0.5mm<sup>2</sup>) wire size. Individual main output pins should not be loaded to more than 5.5 A. For currents greater than 5.5 A, multiple main output pins/wires must be used in parallel. All signal I/O pins are referenced to Vout-.

**EMC:** ACuQor products have been tested to the EMC specifications listed in the Electrical Characteristics section. However, end use equipment must be tested to verify EMC compliance.

**Hipot Testing:** ACuQor products are rated for Hipot testing levels of 1500 Vac input to protective-earth, 1500 Vac output to protective-earth, and 4000 Vac input to output. When performing the 4000 Vac input to output test, the test voltage must be balanced evenly 2000 Vac input and output to protective-earth. Two oppositely phased test voltage sources or a single test voltage source with external balancing impedances (capacitors) may be used to prevent overstressing input or output to protective-earth insulation per IEC60601-1 2005 sub clause 8.8.1 and IEC60601-1 1990 sub clause 20.4 g.

**Patient Contact:** ACuQor models include versions designed for BF and CF patient contact application per IEC60601-1. These ACuQor models provide reinforced insulation at the DC output voltage level and basic insulation at the 240 Vac level from output to protective-earth. Note that equipment and wiring may add to system leakage currents so that the end product must be tested for compliance. Refer to the Electrical Characteristics section for typical ACuQor input and output leakage currents. In addition, ACuQor defibrillation rated models comply with the minimum output to protective-earth creepage/clearance requirement and defibrillator pulse test of IEC60601-1.

MODEL	Input Fuses (in Both AC Lines)
AQ0300	Littelfuse 6.3A 250V 21606.3XEP
AQ0400	Littelfuse 6.3A 250V 21606.3XEP
AQ0500	Littelfuse 10.0A 250V 216010XEP



**PART NUMBERING SYSTEM**

The part numbering system for SynQor's ACuQor AC/DC power supplies follows the format shown in the table below. Not all combinations make valid part numbers, please contact SynQor for availability.

Family	Output Power	Grade	Range	Output Voltage	Package Type	Thermal Design	Options
<b>AQ:</b> ACuQor series of AC-DC semi-regulated output power supplies	<b>0300:</b> 300 W <b>0400:</b> 400 W <b>0500:</b> 500 W	M: (Medical)	<b>4:</b> 4th Generation EMC Universal (85-264 VRMS)	12: 12 V 1T: 12 V / 5 & 12 V STBY 24: 24 V 2T: 24 V / 5 & 12 V STBY 36: 36 V 3T: 36 V / 5 & 12 V STBY 48: 48 V 4T: 48 V / 5 & 12 V STBY	E: (3"x5")	<b>A:</b> Open frame <b>C:</b> Encased	<b>Medical Grade:</b> <b>BF:</b> BF isolation rating <b>CF:</b> CF isolation rating <b>CFD:</b> CF isolation rating defibrillator proof

Example: AQ0400M412ECBF

**ACCESSORIES**

SynQor offers a series of assemblies that can be ordered according to the table below. Mechanical drawings for these accessories are available for download in pdf format from the SynQor website.

Part Number	Description
<b>AQ-CBL-INPUT1C</b>	Input mating cable with pre-stripped wire ends (36" long).
<b>AQ-CBL-OUT1C</b>	Output mating cables with pre-stripped wire ends (18" long).
<b>AQ-CBL-OUT1CD</b>	Same as AQ-CBL -OUT1C with an additional 8-pins connector.
<b>AQ-CBL-OUT2C</b>	Output mating cable with connectors on both ends (18" long).
<b>AQ-CBL-OUT2CD</b>	Same as the AQ-CBL-OUT2C with an additional 8-pins connector.
<b>AQ-INSUL1M</b>	Single module bottom-side Mylar insulator for open frame mounting
<b>AQ-EVAL-PRL3</b>	Evaluation board for up to three paralleled modules.

**APPLICATION NOTES**

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

- [Online Application Notes](#)
- [Online Library of Technical White Papers](#)
- [SynQor website.](#)

**Contact SynQor for further information and to order:**

**Phone:** 978-849-0600  
**Toll Free:** 888-567-9596  
**Fax:** 978-849-0602  
**E-mail:** power@synqor.com  
**Web:** www.synqor.com  
**Address:** 155 Swanson Road  
 Boxborough, MA 01719  
 USA

**PATENTS**

SynQor holds numerous U.S. patents, one or more of which apply to most of its power conversion products. Any that apply to the product(s) listed in this document are identified by markings on the product(s) or on internal components of the product(s) in accordance with U.S. patent laws. SynQor's patents include the following:

6,545,890    6,594,159    6,894,468    6,896,526    6,927,987    7,050,309  
 7,085,146    7,119,524    7,765,687    7,787,261    8,149,597    8,644,027  
 9,143,042

**WARRANTY**

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