# Astrodyne

Now you have power.

500 Watt, High Efficiency, AC/DC Power Modules

# SMV-500


- Miniature 4.59” x 2.4” x 0.5.” Size
- High Power Density up to 90.78W/ Inch $^3$
- High Efficiency up to 90.5% at 230VAC (28V)
- Low Output Noise
- Metal Baseplate
- Thermal Protection
- Over Voltage Protection
- Current Limit/Short Circuit Protection
- Adjustable Output Voltage 60-120% of Vo, Set
- Remote Sense
- Power On Signal (ENA) Open Collector (10mA sink current). Low (ON) when output is present

**DESCRIPTION:**

AC-DC Converter SMV-xx-500 modules are high power density and high efficiency AC-DC converters designed for uses in telecom and other centralized modular and distributed power applications. All use metal baseplates, planar transformers, and surface mount construction to produce up to 500W maximum. Their surface-mount construction uses an insulated metal substrate baseplate construction, planar transformers and thermally conductive potting compound to produce up to 500W in a full brick package and is well suited for the most rigorous requirements of mil/aero COTS and other thermally challenging applications.

| Model Number | Output Voltage | Output Amps | Input Range | Max. Iin FL | Efficiency (Tb=25°C) | O/P Set Point |
|---|---|---|---|---|---|---|
| SMV-12-500 | 12 VDC | 42 | 85-264 VAC | 6.2A | 90.2% @ 230Vin | 11.76-12.24VDC |
| SMV-28-500 | 28 VDC | 18 | 85-265 VAC | 6.2A | 90.5% @ 230Vin | 27.44-28.56VDC |
| SMV-48-500 | 48 VDC | 10.5 | 85-265 VAC | 6.2A | 90.4% @ 230Vin | 47.04-48.96VDC |

*All specifications are typical at nominal input, full load, and 25DegC unless otherwise noted*

BAUART GEPRÜFT TYPE APPROVED TÜV Rheinland

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## ABSOLUTE MAXIMUM RATINGS (MIN TO MAX.)

| | |
|---|---|
| Input Power with No Damage | 312 VAC |
| Power Factor Correction | 0.95 min HL-LL and Full Load |
| Storage Temperature / Humidity | -55 to +125°C / 10 to 95% |
| Operating Temperature (Note 5) | -40 to 100°C |
| Operating Humidity | 20 to 95% |
| Output Power | 500 Watts |

## INPUT SPECIFICATIONS

| | |
|---|---|
| Input Voltage (AC(L) to AC(N) | 85-265 VAC |
| Input Frequency | 47-440 Hz |
| Input Current FL @ 100 Vin, FL | 6.2A max. |
| Inrush Current (Note 3) | 40A @ 265VAC |

## OUTPUT SPECIFICATIONS

| | |
|---|---|
| O/P Voltage, Current & Set Point | See Model Selection Chart PG. 1 |
| Line/Load Regulation (Note 7) | 12 V: 48mV, 28V: 56mV, 48V: 96mV |
| Ripple/Noise p-p max. (Note 1) | 10% of Vout |
| Dynamic Response (Note 6) | 25% - 50% - 75% Load |
| Peak Deviation: | 3% Vo, set |
| Settling Time | 300uS |
| Current Limit (Note 2) | 105-140% of Rated Load |
| Over Voltage Protection | 125-145% Vo, set, Io=0.5A, |
| | Inverter Shutdown Method |
| Over Temperature Protection | Shutdown: 110°C typ. |
| | Auto Recovery: 90°C min. |
| Efficiency (Tb=25°C, FL) | |
| 12 Vout: | 90.2% @ 110 Vin, 90.2% @ 230Vin |
| 28 Vout: | 90.5% @ 110 Vin, 90.4% @ 230Vin |
| 48 Vout: | 90.4% @ 110 Vin, 90.5% @ 230Vin |
| | See Figs. 4a, 4b & 4C |
| | **EFFICIENCY CURVES** |

## STRUCTURAL DYNAMICS

| | |
|---|---|
| Vibration | (Note 4) |
| Shock | 196.1mS² |

## ISOLATION SPECIFICATIONS

| | |
|---|---|
| Input-Output | 3000VAC, 60S |
| Input-Case | 2500VAC, 60S |
| Output-Case | 1500VDC, 60S |
| Input-Output Capacitance | 2000pF |
| Isolation Resistance | 100MΩ @ Tb=25°C & 70%RH |
| | Output to Baseplate-500VDC |

## GENERAL SPECIFICATIONS

| | |
|---|---|
| MTBF (Tb=40°C, 80%L, 230 Vin) | 12V: 1.6Mhrs, 28V: 1.47 Mhrs, |
| | 48V: 1.59 Mhrs |
| Weight | 7.2 oz (206g) |
| Dimensions (inches / mm) | 4.59 x 0.5 x2.4 / 116.8 x 12.7 x 61 |
| Safety Approvals | UL: UL 60950-1-07, 2nd Edition |
| | TUV: EN 60950-1:2006 |
| | CE: EN 60950-1:2006 |

## CONTROL SPECIFICATIONS

| | |
|---|---|
| Turn-on Time | 3S max., 90% Vo, set, FL |
| Trim Adjustment Range | 60-120% w the following Caps. |
| | 2000uF/25V (12V); |
| | 940uF/35V (28V); |
| | 440uF/100V (48V) |
| | Tb=25°C See Fig. 1 **TRIM CiRCUIT** |
| Hold Up Time | 20mSec. min. with Cap. 780uF |
| | (C10 & C11 in Fig.3) |

## NOTES (SEE NEXT PAGE)

## NOTES

1.Bandwidth 5Hz to 20MHz and with filter 4.7nF MLCC series 50Ω (12, 28V) 100Ω (48V) min.

Output Capacitors:

12V: 1000uF*2, TC≥ -20°C, 1000uF*4

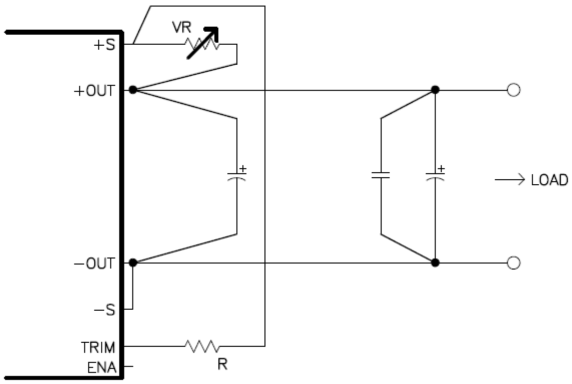
28V: 470uF*2, TC≥ -20°C, 470uF*4, TC≤ -20°C

48V: 220uF*2, TC≥ -20°C, 220uF*4, TC≤ -20°C

2. Current Limit inception point Vo=90% of Vo, set @ Tb-25°C; Auto recovery.
3. Turn on @ 265Vin, External Components are needed for operation Refer to Fig. 3 for application circuit.
4. Sine Wave, 10-55Hz (Sweep for 1 min.), Amplitude 0.825mm Constant (Max. 0.5g) X, Y. Z 1 Hour each, non operating
5. Temperature measurement shall be taken from the baseplate (Tb). See Fig. 2 for location definition .
6. 0.1A/uS; with cap 940uF/35V (28V); 440uF/100V (48V) Tb=25°C, Vin=200VAC
7. Line = LL-HL, Load = NL-FL, Measured in typical Milli Volts (mV)

**TRIM CIRCUIT:**

Output Voltage Adjusted by using external resistor and/or variable resistor:



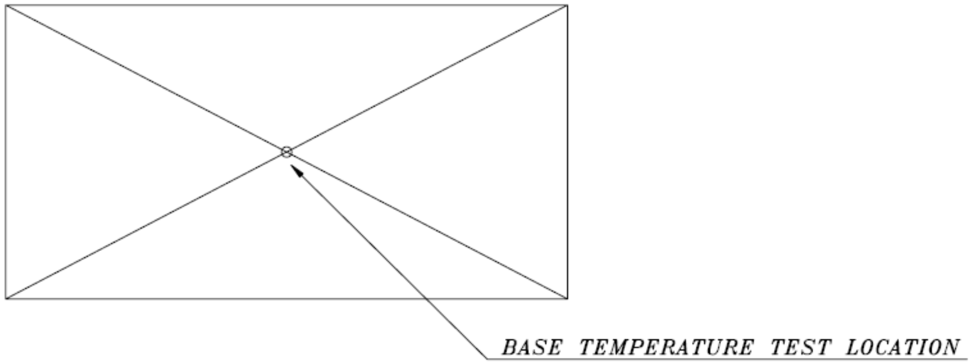

For 12Vout, R=12.7Kohm $VR = 1.103 Vo_{trim} - 8.488$ (UNIT:KΩ )

For 28Vout, R=35.7Kohm $VR = 2.709\left(\frac{Vo_{trim}}{2.469} - 1\right) - 15.692$ (UNIT: KΩ)

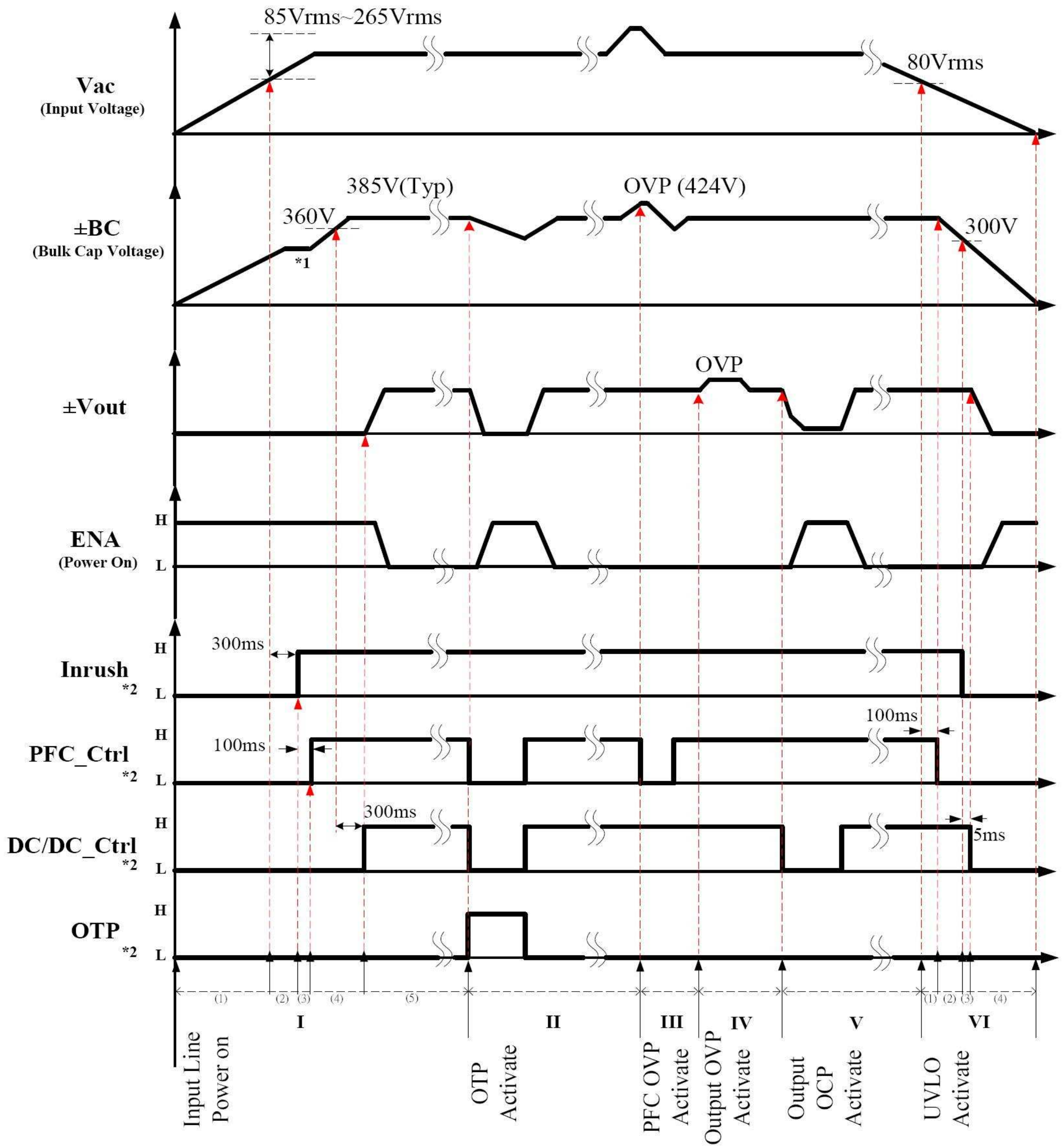
For 48Vout, R=42.2Kohm $VR = \left(\frac{Vo_{trim}}{1.472}\right) - 19.532$ (UNIT:KΩ )

Fig1 The schematic of output voltage adjusted by using external resistor and/or variable resistor.

**BASEPLATE MEASURE POINT:**



## AC/DC Block Sequence Time Chart :




**Note:**

*1: The voltage of bulk capacitor should be more than the rectification of 95% input voltage before inrush is high. The twenty times of RC time constant must be less than 300mS. Otherwise internal transistor of the unit could be damaged by inrush current. The time constant is equal to the product of the bulk capacitor and the external resistor.

*2: It is the internal signal of unit.
Inrush: Bypass signal for external resistor. Please refer to the description of each region.
PFC_Ctrl: Turn on/off signal. When signal is high, the PFC converter turns on. If it is low, the converter turns off.
DC/DC_Ctrl: Turn on/off signal. When signal is high, the DC/DC converter turns on. If it is low, the converter turns off.
OTP: Turn on/off signal. When signal is high, the over temperature protection is action.

**The Description For Each Region Of Time Sequence：**

◆ **Region I**：

(1) The input voltage is under 85Vrms, so the unit has no output and the ENA signal is high (open collector).

(2) Input under voltage lockout (UVLO) action. The unit starts the turn on sequence. When the input voltage reaches 85Vac and it delays 300mS, the inrush signal changes from low to high.

When the inrush signal is low, the internal transistor of the unit between R terminal and +BC terminal is open. Therefore, the inrush current can be suppressed by external resistor. When the inrush signal is high, the internal transistor of unit is short. Therefore, the external resistor is by-passed by internal transistor.

The voltage of bulk capacitors (±BC) should be more than 95% of the rectification input voltage before inrush signal changes to high. If not, the unit could be damaged by inrush current.

(3) When the inrush signal is high and then delays 100mS, the PFC_Ctrl signal changes from low to high. Which means the PFC converter turns on and the ±BC will be boosted to 385Vdc (Typ).

(4) When the PFC_Ctrl is high as well as ±BC reaches 360V and then delays 300mS, the DC/DC_Ctrl signal will change from low to high. After the steps mentioned the output voltage of unit starts to increase to specified voltage level.

(5) When the output voltage of DC9010-690G reaches 13.7V (Typ) at start up, the ENA signal is pulled low to indicate that unit finished the turn on sequence.
The unit finished the turn on sequence through the steps above.

◆ **Region II**：The over temperature protection (OTP) action. When the baseplate temperature (refer to spec. figure 2) of the unit rises to 110℃(Typ), both PFC and DC/DC converters turns off and the output shuts down. When the baseplate temperature decreases to 90℃(Min), the output auto-recovers.

◆ **Region III**：PFC output over voltage protection (OVP) action. When ±BC is over 424V (Typ), the PFC converter turns off. The PFC output voltage auto-recovers if the failure is removed.

◆ **Region IV**：Output OVP action. The output OVP mode is clamped.

- **Region V**：Output over current protection (OCP) action. When the output current of the unit is over limitation, the output voltage steps down. If the failure mode is removed, the output voltage auto-recovers.

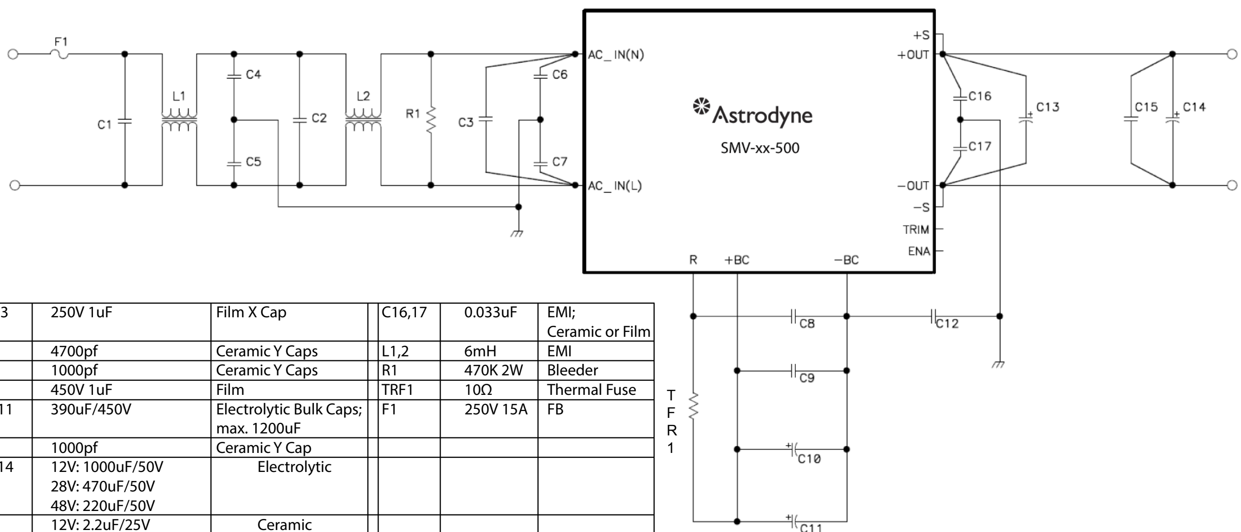
- **Region VI**：

  (1) Input UVLO action. When the input voltage is under 80Vac (Typ) , the PFC_Ctrl signal changes from high to low, which means that the PFC converter turns off. After ±BC reduces to 300V, the inrush signal changes from high to low at the same time.

  (2) When the inrush is low and delays 5mS, the DC/DC_Ctrl changes from high to low, which means the DC/DC converter turns off.

  (3) When the output voltage of DC9010-690G decreases to 13.7V (Typ), the ENA signal changes from low to high.
  The unit turns off through the steps of region VI.

## APPLICATION CIRCUIT:




| | | | | | |
|---|---|---|---|---|---|
| C1,2,3 | 250V 1uF | Film X Cap | C16,17 | 0.033uF | EMI; Ceramic or Film |
| C4,5 | 4700pf | Ceramic Y Caps | L1,2 | 6mH | EMI |
| C6,7 | 1000pf | Ceramic Y Caps | R1 | 470K 2W | Bleeder |
| C8,9 | 450V 1uF | Film | TRF1 | 10Ω | Thermal Fuse |
| C10,11 | 390uF/450V | Electrolytic Bulk Caps; max. 1200uF | F1 | 250V 15A | FB |
| C12 | 1000pf | Ceramic Y Cap | | | |
| C13,14 | 12V: 1000uF/50V<br>28V: 470uF/50V<br>48V: 220uF/50V | Electrolytic | | | |
| C15 | 12V: 2.2uF/25V<br>28V, 48V: 2.2uF/100V | Ceramic | | | |

Fig. 3 Application Circuit.

**<u>Application Circuit Instructions</u>**

**F1:** This power module has no internal fuse. Use an external fuse to acquire each Safety Standard and to further improve safety. Further, Fast-Blow type fuses must be used per one module. Also, In-rush Surge current flows during line throw-in. Be sure to check $I^2t$ rating of external switch and external fuse.

**Recommended External Fuse: 15A**

Select fuse based on rated voltage, rated current and surge capability.

1. Voltage Ratings:
   100VAC Line: AC125V
   200VAC Line: AC250V
2. Current Ratings:
   Rated current is determined by the maximum input current based on operating conditions and can be calculated using the following formula:

$$Iin\ (max.) = \frac{Pout}{Vin \times Eff \times PF}\ (Arms)$$

Iin (max.): Maximum Input Current
Pout: Maximum Output Power
Vin: Minimum Input Voltage
Eff: Efficiency
PF: Power Factor

**C1,2,3: 1uF (Safety Approved "X" Film Capacitor):** Ripple current flows through this capacitor. When selecting capacitor, be sure to check the allowable maximum ripple current rating. Verify the actual ripple current flowing through this capacitor by doing actual measurement.
**Recommended Voltage Rating: 250VAC** Note: Connect C3 as near as possible to the input terminals of the power module.

**C4,5: 4,700pF (Ceramic "Y" Capacitor):** Add ceramic capacitor as an EMI/EMS counter measure. Be sure to consider leakage current of your equipment when adding this capacitor. High withstand voltages are applied across this capacitor depending on the application. Select capacitors with high withstand voltage ratings.

**C6,7: 1,000pF (Ceramic "Y" Capacitor):** Add ceramic capacitor as an EMI/EMS counter measure. Be sure to consider leakage current of your equipment when adding this capacitor. High withstand voltages are applied across this capacitor depending on the application. Select capacitors with high withstand voltage ratings.

**C8,9: 1uF (Film Capacitor):** Ripple current flows through this capacitor. When selecting capacitor, be sure to check the allowable maximum ripple current rating. Verify the actual ripple current flowing through this capacitor by doing actual measurement.
**Recommended Voltage Rating: 450VAC** Note: Select capacitor with more than 3A (rms) rating. Connect C8,9 as near as possible to the input terminals of the power module.

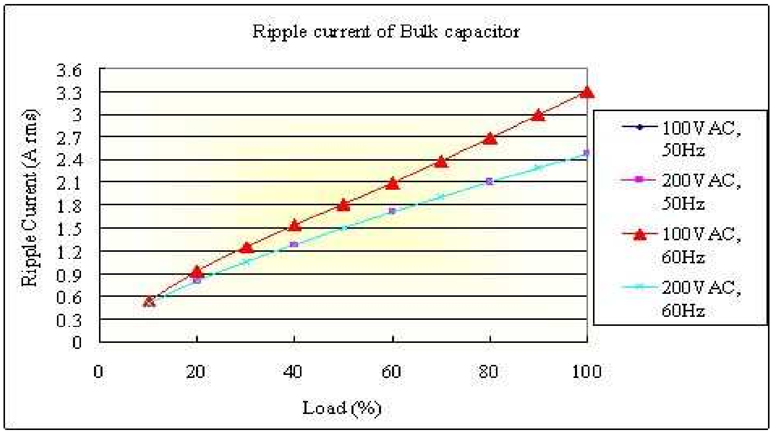



Fig. 4 Bulk cap ripple current requirement vs. Output load

**R2**: Inrush current limit. Resistance can be calculated by formula below. Suggest to choose resistance >10ohm.

$$R = \frac{Vin_{rms} * \sqrt{2}}{Ir, pk}$$

$Vin_{rms}$: Input voltage

$Ir,pk$: Inrush current peak value.

Sufficient inrush energy withstand capacity is required. Required energy capacity can be calculated below and suggest having some design margin.

$$\frac{1}{2} C_{bulk} * (\sqrt{2} Vin_{rms})^2$$

$Cbulk$: Bulk capacitance (C10&C11)

$Vin_{rms}$: Input voltage.

The selected inrush resistor R2 have to meet the formula below, if the resistor value over the limitation may cause the brick damage.

$$R < \frac{300mS}{20 * C_{bulk}}$$

$Cbulk$: Bulk capacitance (C10&C11)

**C10,11 (390uF x 2 PCs in parallel; Electrolytic Bulk Capacitors)** Boost voltage bulk capacitor is determined by boost voltage ripple voltage, ripple current and hold-up time. Select capacitor value such that boost voltage ripple voltage does not exceed 15Vp-p.
**Recommended Voltage Rating: 450VDC**
**Recommended Total Capacitor: 390uF to 1,200uF**

Notes: 1) When ambient temperature is -20ºC or less, AC ripple of boost voltage, output ripple voltage and start-up characteristics might increase or be affected due to ESR characteristics of the bulk capacitors. Therefore, verify above characteristics by actual evaluation.
2) Do not connect capacitors with more than the above capacitance value as this would result in power module damage.

**C12: 1,000pF (Ceramic “Y” Capacitor):** Part of EMI filter. Choose safety approved “Y” capacitor.

**C13,14: 470uF/50V x 2 PCs in parallel; (220uF/100V for 48V Output) Electrolytic Capacitor:** Take note of the maximum allowable ripple current of the electrolytic capacitor used. Especially for sudden load current changes, verify actual ripple current and make sure that allowable maximum ripple current is not to be exceeded. Note: Connect capacitors within 50mm from the output terminals +V and -V of the power module.

**C15: 2.2uF/100V (Ceramic Capacitor):** Connect chip ceramic capacitor within 50mm from the output terminals +V and -V of the power module to reduce output spike noise. Also, note that output spike voltage may vary depending on the wiring pattern of the printed circuit board.

**C16,17: 0.033uF (Ceramic or Film Capacitor):** Connect ceramic or film capacitor as EMI/EMS counter measure and to reduce spike noise. Note: High Voltage is applied across this capacitor during withstand voltage test depending on the applicatiion. Connect these capacitors as near as possible to the output terminals of the power module.

**L1,2: 6mH:** Add common mode choke coil as EMI/EMS counter measure. When using multiple modules, connect coil to each module. Note: Depending on the input filter used, noise might increase or power module might malfunction due to filter resonance.

**R1: 470KΩ (Bleeder Resistor):** Connect bleeder resistor across ACL and ACN terminals.

**TFR1: 10 to 100Ω:** By connecting a thermal fuse resistor across R and +BC terminals as shown in fig. 3, in-rush current during line throw-in can be suppressed. Failures due to in-rush current such as melting of external fuse, welding of relay or switch connecting joints or shutdown of No Fuse Breakers (NFB) can occur. Therefore, be sure to connect this external thermal fuse resistor. Note: This module will not operate without this external resistor.

**Selection Method of External Resistor TFR1:**
1) Calculating Resistance Value for TFR1: Resistance can be calculated by the following formula:

$$R = \frac{Vin}{Irush}\ (\Omega)$$

R: Resistance Value for External TFR1
Vin: Input Voltage converted to DC value
= Input Voltage (rms) x $\sqrt{2}$
Irush: Input surge current value

2) Required Surge Current Rating: Sufficient surge current withstand capability is required for external TFR1. Required Surge Current Rating can be selected by $I^2t$. (Current squared multiplied by time)

$$I^2t = \frac{Co \times Vin^2}{2 \times R}\ (A^2s)$$

$I^2t$: Current squared multiplied by time
Co: Booster Voltage Bulk Capacitance
Vin: Input Voltage converted to DC value
= Input Voltage (rms) x $\sqrt{2}$
R: Resistance Value for External TFR1

## INPUT VOLTAGE DROPOUT TRANSIENT IMMUNITY:

The output voltage should immune input voltage dropout. The allowable dropout time is related to output power and bulk capacitance (C10&C11) and Vo. Dropout time is longer with higher capacitance or lower output power. But the maximum allowable dropout time is **60mS** regardless of capacitance and output power. The formula of allowable dropout time is shown below.

$$C_{bulk} = \frac{2(P_o * T_{holdup}) * 1000}{(385^2 - 300^2) * 0.92}$$ For Vo≦ 48V

$$C_{bulk} = \frac{2(P_o * T_{holdup}) * 1000}{(385^2 - (300 * Vo / 48)^2) * 0.92}$$ For Vo>48V

*Cbulk*: Bulk capacitance (uF)

*Po*: Output power (W)

*Tholdup*: Allowable dropout time (mS)

For example, if required dropout time is 20mS at Po=500W, Vo=12V, the Cbulk capacitance must higher than 475uF, Note that capacitance tolerance need to take into account and must fulfill the minimum capacitance 390*2uF requirement for -40degC operation. Note that the maximum allowable dropout time is 60mS even the calculation result over 60mS.

## EFFICIENCY CURVE: (12V):

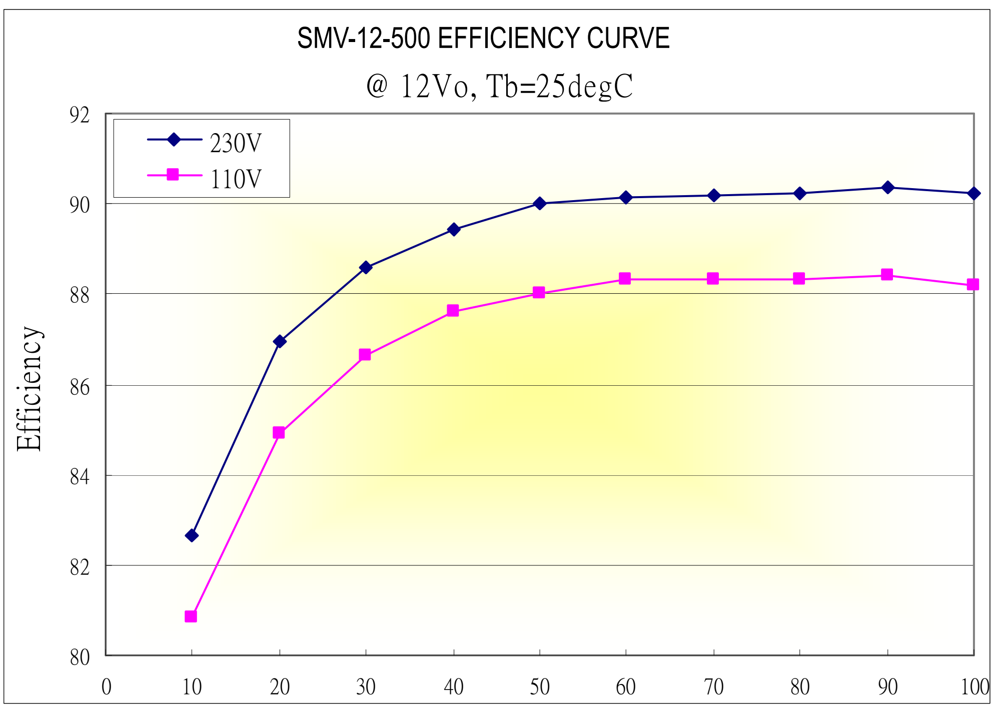



**Fig. 4a Efficiency curve**

**(28V):**

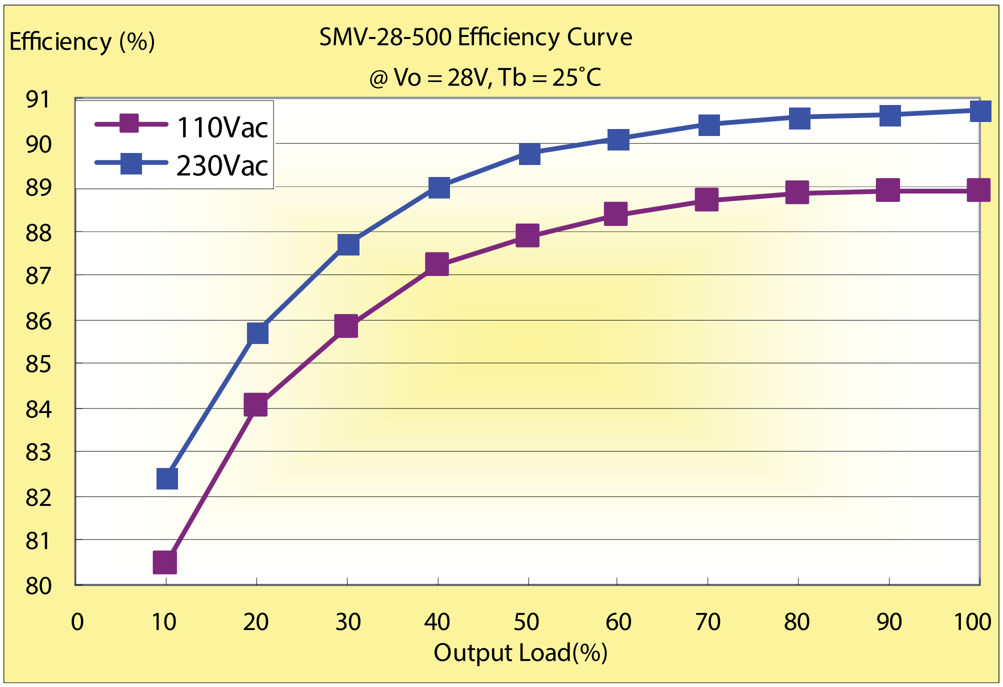



**Fig. 4b Efficiency curve**

**(48V):**

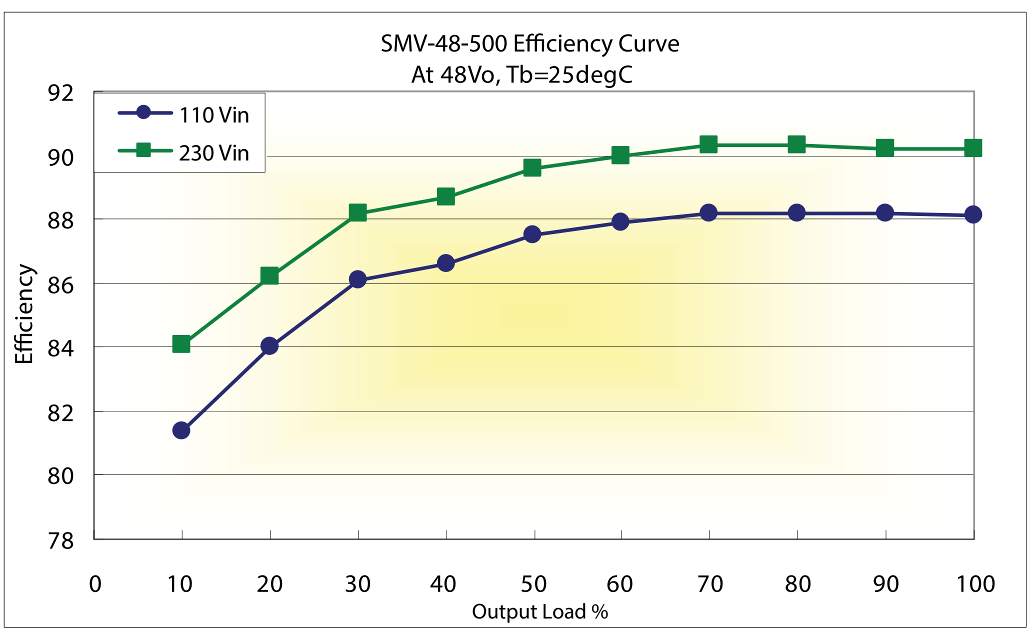



**Fig. 4c Efficiency curve**

## MECHANICAL DIMENSIONS

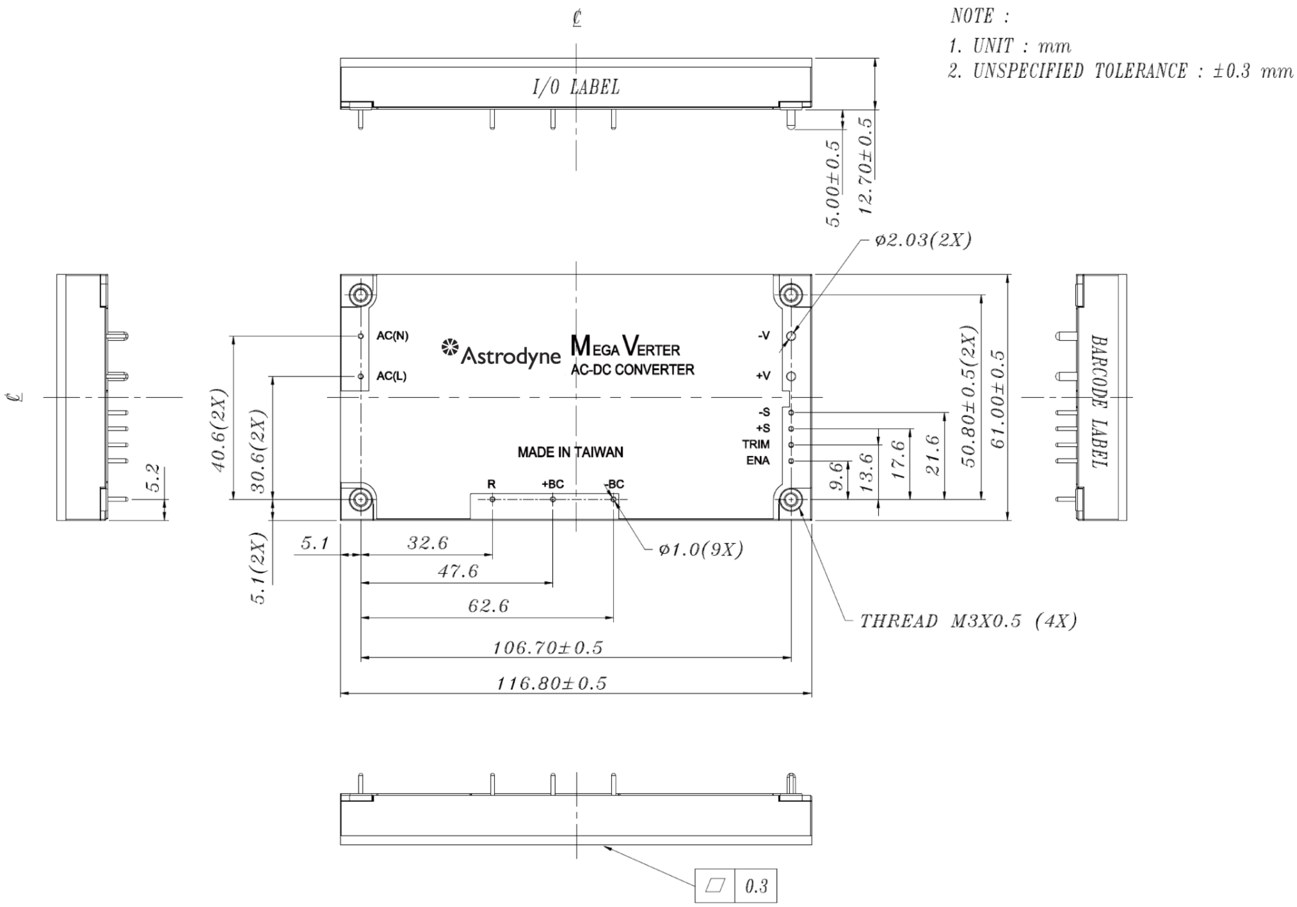



Fig. 5 Outline drawing.