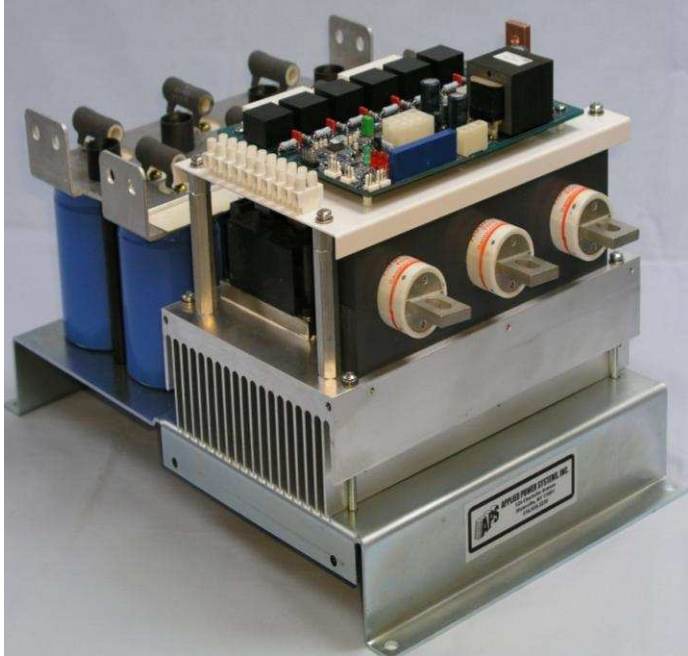


## SixPac™ Series of SCR AC Controller and DC Converters

### Complete Series of SCR Three-Phase Power Control Units



#### Features Include:

- **Compact, rugged construction**
- **Applications include:**
  - ❖ **Windmill Converters**
  - ❖ **Motor Starters**
  - ❖ **Motor Drives**
  - ❖ **Phase Control AC**
  - ❖ **Regulated DC Power Supplies**
- **Variable Output Voltage**
- **Output Ratings:**
  - ❖ **AC to 500A<sub>rms</sub>**
  - ❖ **DC to 600A<sub>DC</sub>**
- **10 to 750V<sub>AC</sub> Input Voltage**
- **40HZ to 80Hz Input Tracking with No Tuning**
- **Includes:**
  - ❖ **Filter Capacitor Bank**
  - ❖ **Input Fusing**
  - ❖ **Laminated Bus**
  - ❖ **Snubber Board**
  - ❖ **Current Sense**
  - ❖ **Forced Air Cooling**

The APS SixPac™ Series of power controllers are built on a rugged, compact, all-inclusive, economical base. They have a great deal of flexibility to provide OEMs with a fully functional set of power stages. They have been designed for long life in heavy-duty industrial applications. The SixPac™ includes three dual isolated SCR modules that can be configured as either a three-phase AC Controller (AC in, phase-controlled AC out) or a regulated DC Converter (AC in, regulated DC out). This versatile power stage can be applied to virtually any power application that needs phase controlled AC or regulated DC and includes solid-state motor starters, soft-start/soft-stop, variable speed drives, windmill alternator converters and regulated power supplies to name a few.

The isolated SCR modules are mounted on a high efficiency heatsink with input fusing, forced air cooling, and a capacitor filter bank (for regulated DC output). A snubber for the SCRs is available if  $dv/dt$  limiting is required. The compact design of our standard system measures approximately 18" wide by 10" long by 11"

high, including the cooling fan, fuses, Hall effect transducer, output bus, snubber board, SCR gate drive board, capacitor bank, etc.

The SixPac™ is available with input from 10V<sub>AC</sub> to 700V<sub>AC</sub>, input frequencies from 40 Hz to 80Hz without tuning (this means that input from variable frequency alternators is acceptable as long as the frequency is within limits). AC Controller output currents range from 50A<sub>RMS</sub> to over 500A<sub>RMS</sub>. Regulated Converter outputs range from 100A<sub>DC</sub> to over 600A<sub>DC</sub>.

All units come with our industry proven BAP1950 SCR Gate Firing Board. The BAP1950 board is a flexible three-phase SCR controller suited for industrial/commercial power supplies of any power level. It utilizes advanced FPGA control logic to increase reliability, circuit flexibility and reduce circuit component count. The BAP1950 is designed to keep the programmed delay angle constant over a wide input frequency range (40Hz to 80Hz). This universal input feature does not require tuning in applications

where the input mains frequency may vary, as in motor generator sets, windmill power generating equipment, and all field generating systems. The three-phase mains input is filtered by a unique signaling processing circuit that is not sensitive to harmonic distortion, input

voltage amplitude fluctuations, frequency variations or phase sequence.



**The SixPac™ configured as an AC-DC Converter, as in Figure 1, has the following features**

### **Phase Reference Sensing & Frequency Tracking**

An on board low pass filter is used to greatly reduce the harmonic content of the mains input used to generate the reference signals. The low pass filter attenuates the fifth harmonics above 60Hz, reducing delay angle errors from input line distortion. Additional circuitry actively forces the programmed delay angle to remain invariant over a mains input frequency from 40Hz to 80Hz. Therefore, operation of the SixPac™ in applications where frequency fluctuations occur regularly, i.e. when running from an alternator input powered by a diesel, gasoline or turbine engine; or when running from a system with an un-stabilized frequency is permissible. The programmed delay angle will remain constant over the frequency range from 40Hz to 80Hz with an accuracy of  $\pm 0.25^\circ$ .

### **Closed Loop Voltage Regulation**

The SixPac™, when supplied as a DC Converter, is equipped with circuitry to provide a regulated DC output, with adjustable voltage and current limits. The output is determined by a voltage reference that can be obtained from either an off board reference, the on board pot or an off board pot. The voltage reference is compared via an error amplifier to output voltage feedback that is processed through an isolation amplifier. Current feedback is brought back to the board via a connector (J11) that interfaces with an industry standard Hall Effect current transducer. An example of such an application is shown in Figure 1. Consult factory for output voltage scaling and error amplifier compensation networks to obtain the desired transient response and stability.

### **Soft-Start /Stop**

This circuit overrides the gate delay angle command. It is enabled by the power-on-reset feature or by contact closure inputs. SCR gating begins at the maximum delay angle limit and ramps down to the commanded delay angle at a rate determined by the soft-start time constant. The Soft-Stop feature, when activated by a contact closure, causes the SCR gate delay angle to ramp up from the command angle to the maximum delay angle limit before SCR gating is inhibited.

### **Fast Turn-off**

SCR gating is quickly enabled or inhibited ( $\sim 20\mu\text{Sec}$ ) on contact closure input.

### **Phase Loss Inhibit**

The phase loss circuit inhibits the SCR gate drive if a loss of phase voltage is detected. When voltage is restored, the soft-start circuit is engaged.

### **Overtemperature Inhibit**

SCR gating is instantaneously inhibited in an over temperature condition.

### **Gate Delay Transfer Function**

The gate delay is determined by a phase locked loop consisting of a summing junction, low pass filter, voltage-controlled oscillator and an application specific integrated circuit. The voltage-controlled oscillator frequency is locked to the mains frequency. The DC control voltage is inserted into the summing junction to set the SCR delay angle.

The SCR gate delay angle is controlled by an input signal between 0 and  $+5 V_{DC}$ . Gate delay angle is inversely proportional to this input signal. Minimum and maximum delay angles are determined for a given application and the proper offset resistor is selected from the provided resistor network.

### **DC Gate Drive**

The SixPac™ drives each SCR with direct current. The firing signal is an initial 2Amp pulse with a 500mA current for the duration of the conduction angle. The open circuit voltage is 24 Volts DC. This gate drive is suitable for driving large area SCRs in high  $di/dt$  applications.

### **Remote Voltage Control**

The output voltage of the power supply can be controlled remotely with an external pot (the minimum pot used in this application should be a 1K) or a 0 to 5V signal. This connector can be replaced with an on board 10K pot to control the power supply output voltage. The 5V reference at J10-1 has a limited

source capability of 10 mA. Therefore, it should not be used for any circuitry other than the pot.

**J10 Connector**

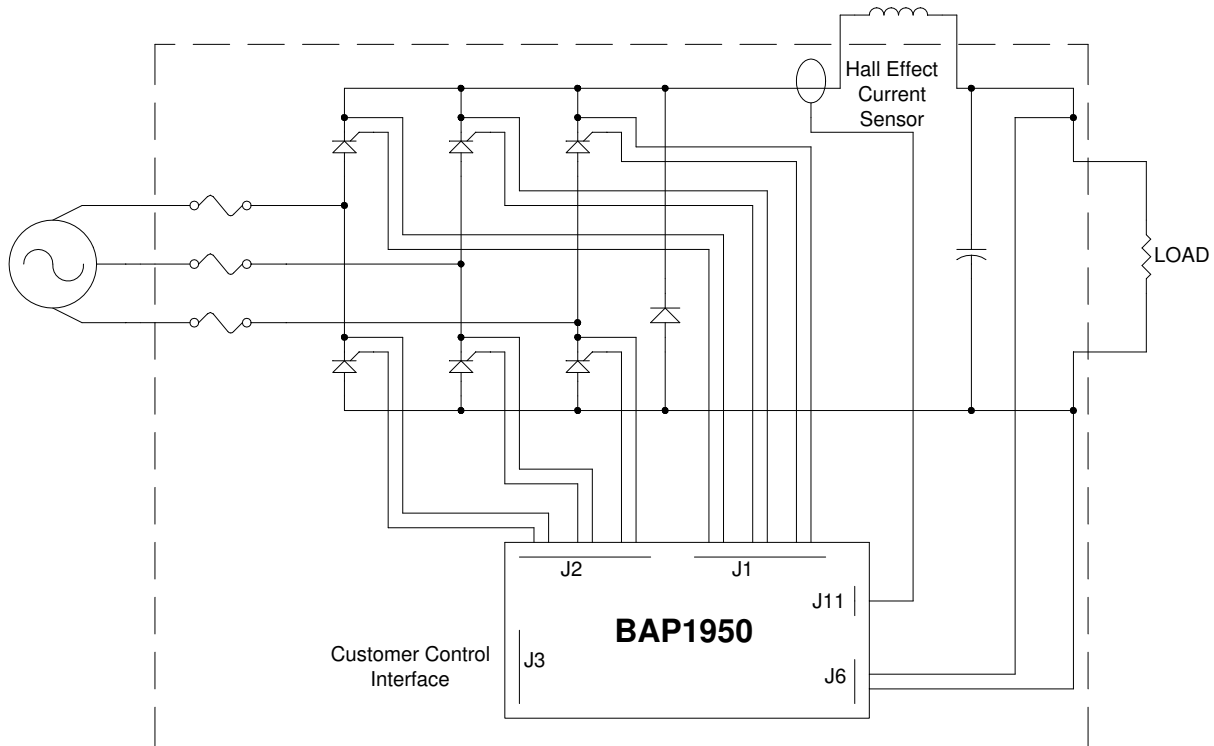
Pin	Signal Name	Description
1	5V Reference	Precision 5V reference created on board used to control output voltage; limited to 10 mA. Connected to the high side of the pot.
2	Pot Wiper	Connected to the wiper of an external pot. This pin can also be driven by a remote voltage source referenced to pin 3, where 0V is 0V on the output and 5V is the full-scale output.
3	GND	GND; Connected to the low side of the pot

**Current Limit Control**

The DC output of the power supply is brought back to the board via J6. An isolation amplifier attenuates the high voltage and isolates it from the output so that the feedback can be referenced to the signal ground.

**J8 Connector**

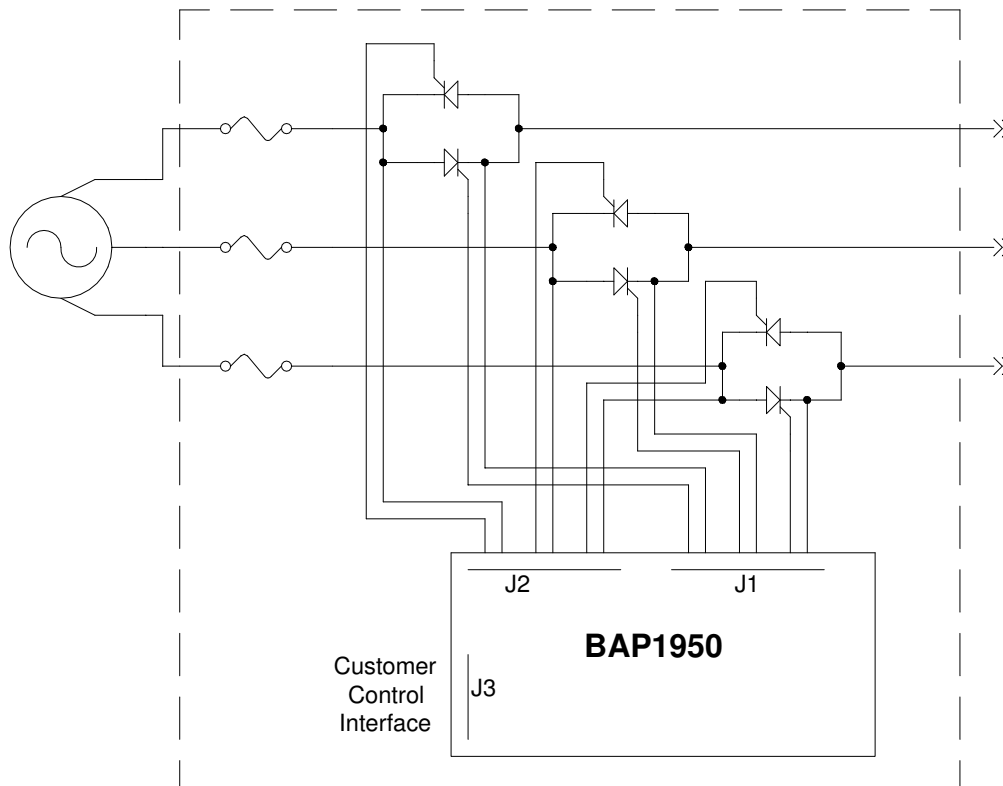
Pin	Signal Name	Description
1	High Side	To external high side of pot
2	Pot Wiper	To external pot wiper (10kΩ)
3	GND	To external pot low side



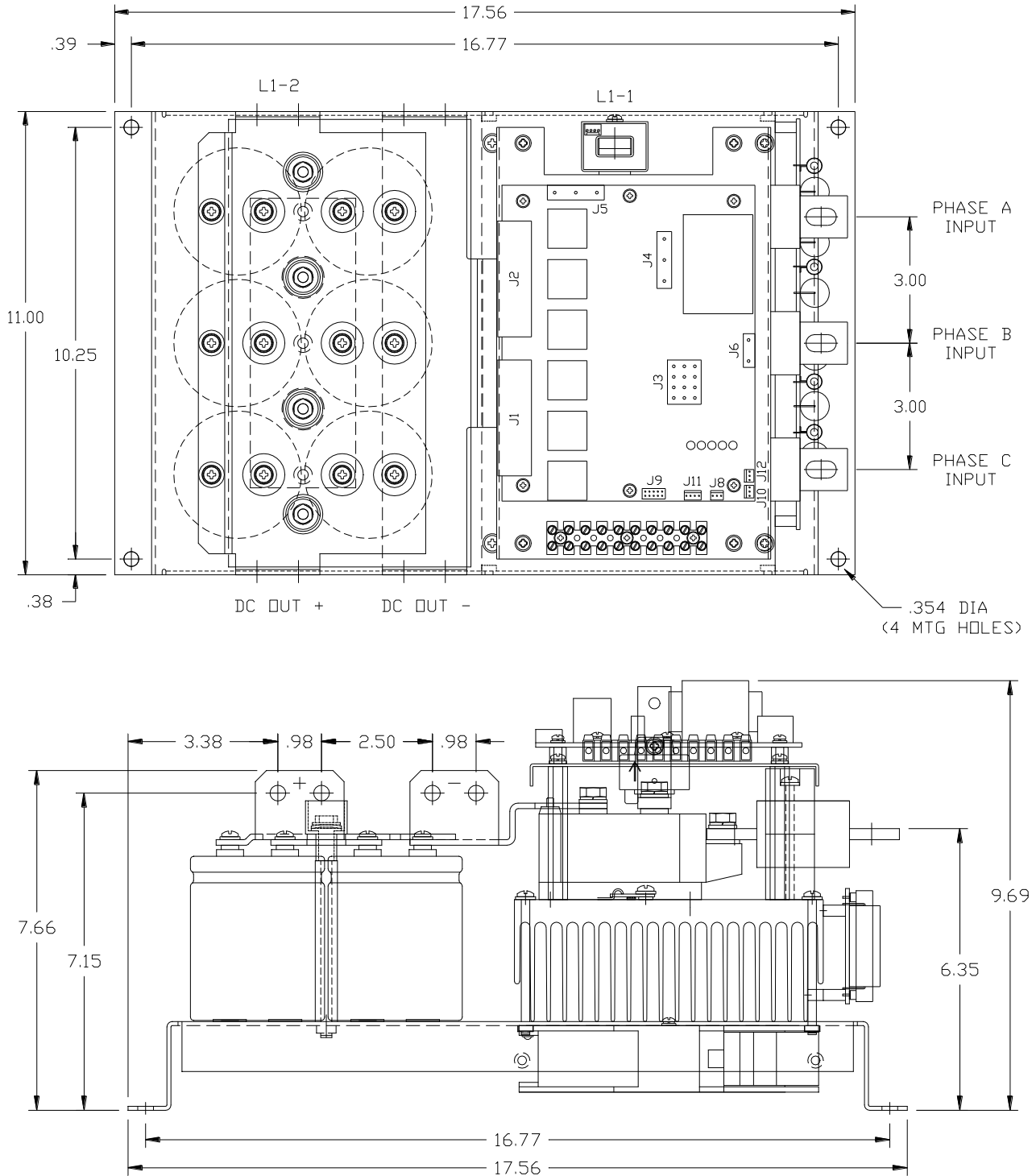
**Figure 1:** SixPac™ as an AC to DC Converter with regulation (voltage and current feedback)

**TB1 Connector Customer Interface for an AC to DC Converter AC to AC Controller Applications**

Pin	Pin Function	Description
1	120V/208V AC	From J4 on BAP1950 board
2	120V/208V AC	From J4 on BAP1950 board
3	N/C	Not Used
4	Fast Turn-off	Shorting this pin to pin 10 enables the power supply. Letting this pin float will disable the power supply within 20 $\mu$ Sec.
5	Soft Start/Stop	When opened from GND (pin 6 or 9), the delay angle ramps down from maximum to the preprogrammed value. If supply is running when the pin is shorted (to pin 6 or 9), the delay angle ramps up from the programmed value to the maximum value.
6	GND	Reference for BAP1950 control circuitry including delay angle control, therefore it must be tied to reference for delay angle control
7	Inhibit Enunciate	Normally low through a 1k resistor. Transitions high in a Fast turn off or in an out of phase lock condition.
8	Delay Angle Control	0 to 5 V analog input to control delay angle, when operating in OPEN LOOP mode. 0V $\rightarrow$ Max Delay Angle; 5V $\rightarrow$ Min Delay Angle
9	GND	Reference for BAP1950 control circuitry including delay angle control, therefore it must be tied to reference for delay angle control
10	+5V DC	Up to 50mA for customer use

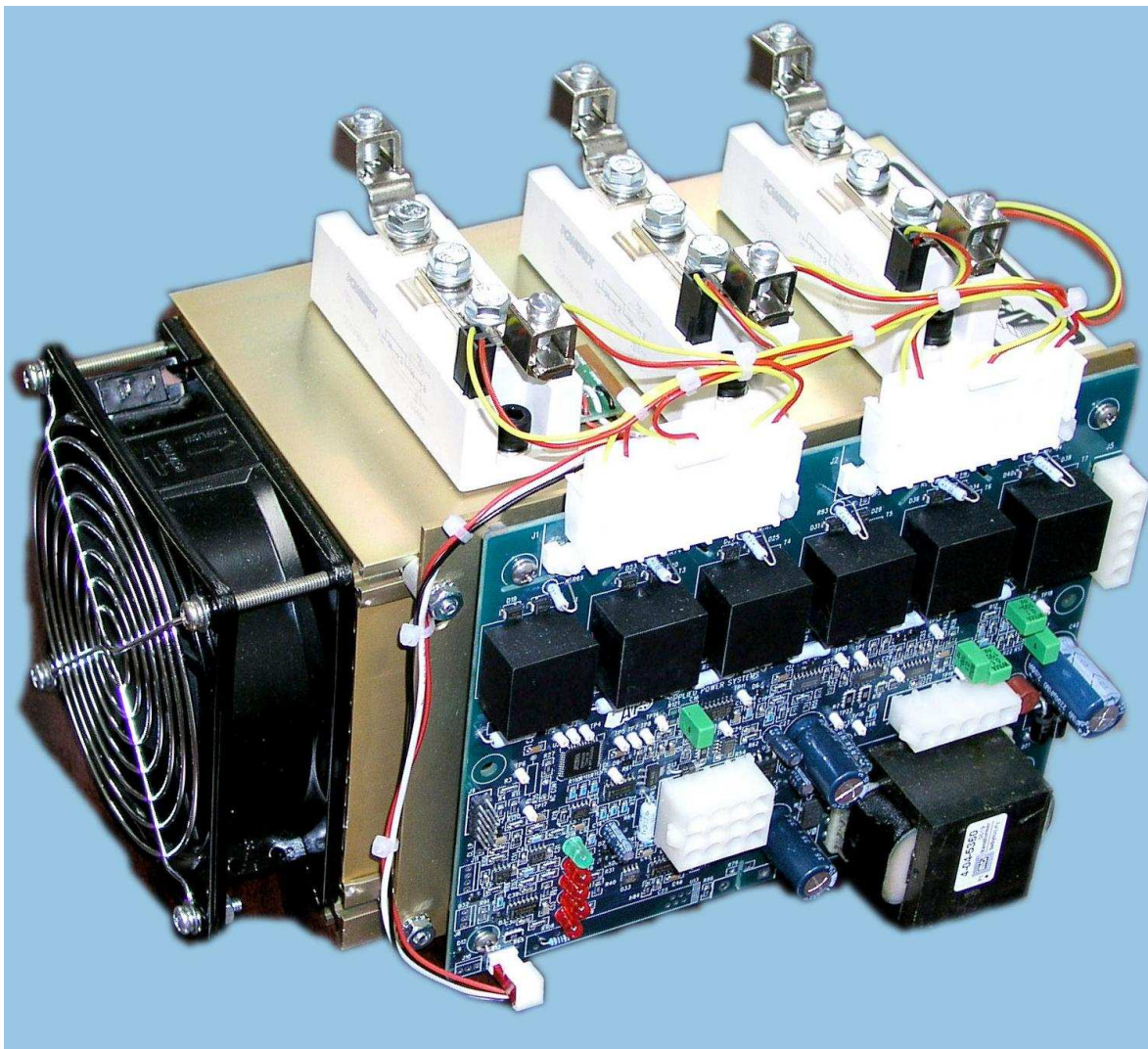


**Figure 2:** SixPac™ as an AC Controller.



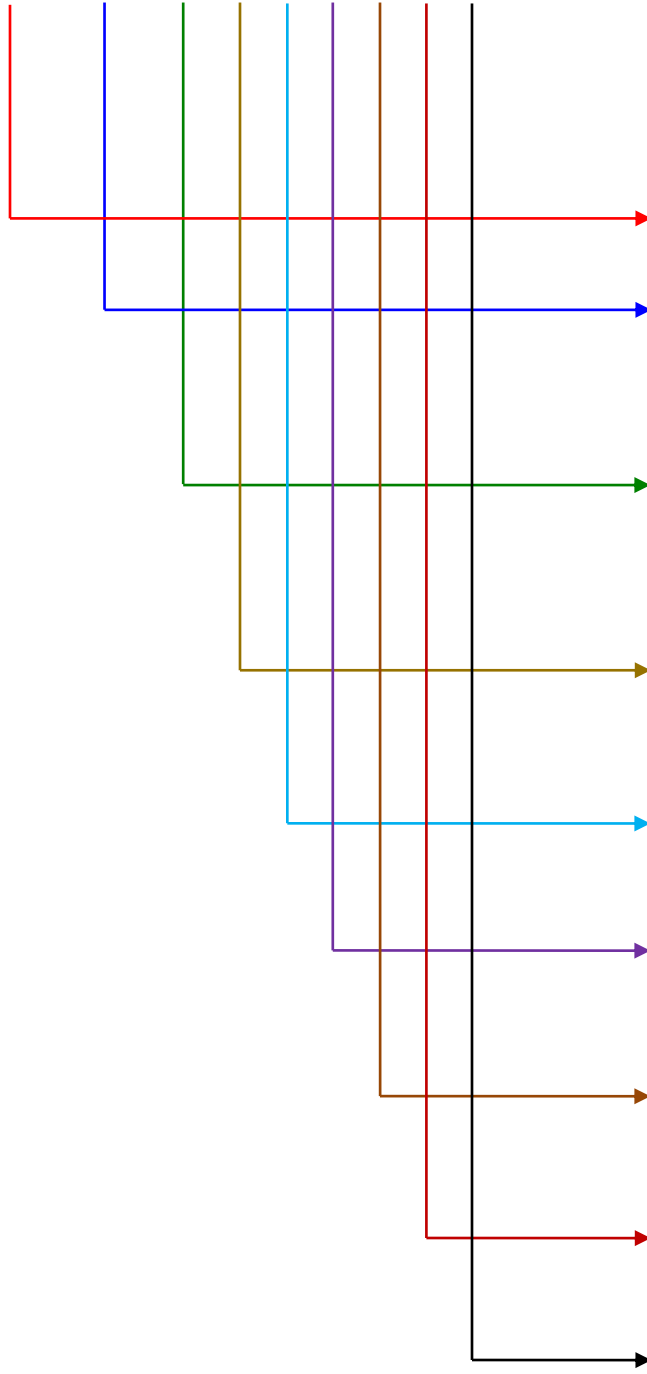
**Figure 3:** Mechanical configuration for the DC Converter rated at 400A output at 40°C ambient.

Output Current Ratings				
SixPac™ Size	AC Controller		DC Converter	
	Load (Amps)	Fuse Rating	Load (Amps)	Fuse Rating
60	50	60	100	100
90	75	90	150	150
150	150	175	300	300
250	300	350	400	400



**SixPac™ Part Numbering System**

CAP-6678 **XXX** **XXX** **XX** **X** **X** **X** **X** **X** **X**



<b>Code</b>	<b>Input AC Voltage</b>
	3 digit number of input AC <sub>RMS</sub> voltage

<b>Code</b>	<b>Load Current</b>
	3 digit number – 050 to 600

<b>Code</b>	<b>Output Configuration</b>
AC	AC Output
DC1	DC Output – Open Loop
DC2	DC Output – Closed Loop
HC	Half Control DC Output
NC	No Control DC Output

<b>Code</b>	<b>Heatsink</b>
A	“A” Frame Heatsink
X	XM7 Heatsink
H	High Efficiency

<b>Code</b>	<b>Filter Capacitor Bank</b>
0	No Cap Bank
1	Includes Cap Bank

<b>Code</b>	<b>Fuses</b>
0	No Fuses
1	Includes Fuses

<b>Code</b>	<b>Cooling Fan/Blower</b>
0	No Fan or Blower
F	Fan Included
B	Blower Included

<b>Code</b>	<b>Snubber Board</b>
0	Not included
1	Included

<b>Code</b>	<b>Freewheeling Diode</b>
0	No Freewheeling Diode
1	Includes a Freewheeling Diode