

## **SINGLE-PHASE TWO SCR FIRING BOARD**

### **Datasheet and Applications Guide**

#### **Features Include:**

- **On-board diagnostic LED indicators**
  - **Feedback for solid-state over temperature sensing of SCR heatsink**
  - **Hard DC gate firing, suitable for firing large area devices**
  - **On-board optional Current Feedback Control – eliminates the need for an external controller**
  - **Improved logic implementation with state-of-the-art microcontroller**
  - **Optional on board Isolated current feedback inputs**
  - **Industry standard size, form factor and connector interface**
  - **Applications include Heater Control, Generator Field Rectifiers, Center Tapped Rectifiers, SCR / Diode Bridge Rectifiers, Rectifiers for DC Motor Armatures and Fields and AC Controllers**
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- The BAP3550 joins Applied Power Systems lineup of industry leading control boards for power electronics.
  - Based on the field proven 6 and 12 pulse SCR Controllers, the BAP3550 is an easy to use, reliable, economical choice for driving two SCRs in a variety of configurations.
  - The BAP3550 is a versatile single-phase SCR firing board with many advanced protection features and functions. It is the ideal firing circuit for industrial power supplies and motor and generator controllers. It can be used to phase control AC mains; soft-start high power systems or produce variable, current limited unregulated DC.
  - The BAP3550 is insensitive to mains voltage distortion. It features high gate isolation<sup>1</sup>, soft and instant start/stop functions and phase loss inhibit. Its form factor and size are industry standard and requires no additional cards to implement all of its functions. The optional BAP3542 Regulation Board can be used with the BAP3550 to construct a complete regulated power supply.

<sup>1</sup> Primary to secondary isolation of isolated gate drive transformer is 4.5kV RMS 1 Min.



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## Functional Description

### Signal Conditioning of Input Reference

The magnitude of the delay angle determines the point on the input waveform an SCR will be switched on. This controls the output voltage of a Center tapped rectifier (AC in, DC out) or an AC Controller (AC in, phase-controlled AC out). The BAP3550 will accept a voltage or a current that will allow the user to control the delay angle.

In order to provide a controlled and orderly start up sequence, the delay angle commanded by the user is not instantly applied to the SCRs at turn-on.

At start up, the delay angle is forced to the maximum value. When the SCR control signals are phase locked to the input reference, with no errors present, the delay angle will ramp down from the maximum value to the programmed value in approximately 400mS. While in operation, the SCR gate firing can be turned off using either the soft stop function (shorting J5-12 to J5-11) or the fast turn off feature (open the contact closure between J5-4 and J5-6). When the soft stop is used, the delay angle will ramp up to its maximum value in approximately 100mS. If the board is forced into a fast turn off condition, all SCR gate signals will be turned off within 1mS.

### Delay Angle Control

The default scaling for the Delay Angle Control input is: 0V or 0mA corresponds to maximum delay angle (minimum conduction angle) or zero output and 5V, 10V, or 20mA corresponds to minimum delay angle (maximum conduction angle) or maximum output. The maximum effective full-scale delay angle command range is limited to approximately  $5^\circ \leq \alpha \leq 175^\circ$ ; although this range can be decreased via adjustment of the BIAS (R31) and SPAN(R34) Potentiometers. See next section for further explanation.

The control input can be modified to accept a current input or a different scaling of the input voltage. See options for J4 Phase Angle Control later in this document.

### Bias/Span Functionality and Adjustment

The BIAS(R34) and SPAN(R31) potentiometers are made available to the customer for the purposes of fine tuning the adjustment range of the delay angle control.

In order to adjust the minimum conduction angle (maximum delay angle) permissible via the delay angle control input; adjust the delay angle control voltage such that the INHIBIT\_LED begins to extinguish, proceed to adjust R34 to obtain the desired MINIMUM output voltage or current of the system.

In order to adjust the maximum conduction angle (minimum delay angle); increase the delay angle control input to its maximum, proceed to adjust R31 to obtain the desired MAXIMUM output voltage or current of the system.

Repeat the above procedure as necessary in order to achieve the precise limits desired.

### 50/60 Hz Frequency Selection

Operation from 50 or 60 Hz mains may be selected via an onboard jumper. This feature is user settable via the population of jumper JP2. Left open, the board is set for 60Hz, shorted = 50Hz.

**Note:** If the state of the jumper is changed, the board must have its power cycled in order to correctly phase lock to the different mains frequency.

### Logic Implementation

All of the logic required to perform the delay angle control is contained on a single FPGA (Field Programmable Gate Array). Since it is programmable, it can be modified to adapt to customer needs in certain applications.

### DC Gate Drive

The BAP3550 comes equipped with DC gate drives, rather than picket fence drives, which offers improved performance in circuits with discontinuous load currents.

If an SCR loses its holding current when being driven with a picket fence, the SCR will turn off and may not turn on again until it is turned on with the higher current leading edge pulse of the next turn on transition. The DC drive keeps current flowing into the gate so that the SCR will continue to be commanded on for the entire time that the SCR can be in conduction.

The current waveform sourced to each SCR gate is an initial 2 Amp peak pulse (rising at a rate of approximately  $1A/\mu S$ ) approximately  $10\mu S$  wide, followed by 500mA of DC holding current for the remainder of the turn-on signal. The open circuit voltage applied to the gate is 24 volts, which enables the BAP3550 to drive large area devices under high di/dt conditions.

### Options for Powering the Board

There are several options for applying power to the BAP3550. The 10VA center tapped Control Transformer T3 can be driven by 120 VAC or 240 VAC via pins 7 and 8 on connector J6. There are jumpers between T2 and J6 that configure the board to accept either of these inputs. The transformer can also be powered by a 24VAC source as well via J5-1 and J5-2. In this condition the turns ratio of transformer T2 is determined by the magnitude of the input source.

### Fault Detection and Shut Down Sequence

In open loop mode, the delay angle is controlled directly by the delay angle control signal supplied by the user at J5-10 or by adjusting a pot installed in the J4 location. In open loop mode with current feedback, the delay angle is controlled by the output current loops. It can be turned off fast by removing the contact closure between J5-4 and J5-6 or ramped down slowly by shorting J5-12 to J5-11. Either of these conditions will turn on the RED INHIBIT LED.

If one or all of the input phases are lost, the PHASE LOSS LED is illuminated and a fast turn off is initiated which inhibits all gate signals within 1mS. When the lost phase is restored, the unit will ramp up to the programmed delay angle in 400mS. If the optional temperature sensing circuit is used, the OVERTEMP LED will be illuminated and the gate signals are inhibited 1mS after the over temperature threshold is exceeded. The default value for the over temperature threshold is 90°C. The gate signals will ramp up to the programmed value after the heatsink temperature drops to 85°C. This value of thermal hysteresis can be modified to suit the customer's requirements.

### Customer Interface

The BAP3550 employs both Industry standard Mate-N-Lok™ as well as MTA-100 IDC type connectors that allow for a convenient interface with the SCR gates and control signals. The mates for these connectors are supplied with the board along with all pertinent pin terminations.

### J1 Pinout (optional RS485 Comm Link)

Pin	Signal Name	Description
1	485+	RS485 Driver
2	485-	RS485 Receiver
3	GND	Reference for RS485 Differential Communications

**J2**

Not for customer use, factory firmware programming

**J3- Current Feedback**

The value of current at which the power supply will fold back can be adjusted via the potentiometer R1.

The BAP3550 allows the user to incorporate this feature in both a standalone open loop or in a closed loop mode when used in conjunction with the BAP3540. Current feedback provided at J3 by an industry standard open loop LEM™ type hall effect sensor and the current limit controlling pot (R1) is all that is required to operate in this mode.

Rotating R1 to the fully CW position will result in maximum output current, determined by the size of the hall effect sensor and feedback scaling on the BAP3550. Rotating the pot CCW will reduce the amount of current output from the SCRs. This feature allows the BAP3550 to operate as a current source in open or closed loop mode<sup>2</sup>.

Pin	Signal Name	Description
1	+15VDC	+15VDC
2	-15VDC	-15VDC
3	Current Feedback	Voltage proportional to the current sensed
4	GND	GND

<sup>2</sup> Current Mode Control- For current mode control, short J4-1 to J4-2, control output current by varying R1.

### J4 Phase Angle Control

The BAP3550 is factory configurable to accept 0-5Vdc, 0-10VDC or 4-20mA delay angle control inputs. Consult factory for custom options.

Pin	Signal Name	Description
1	5V	Precision 5V reference created on board used to control phase delay angle; limited to 10 mA. Connected to the high side of the external pot
2	Phase angle Control	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. Options for external sources include 0-5V, 0-10V 4-20mA.
3	GND	GND; Connected to the low side of the pot

**J5 Control Interface**

Pin	Signal Name	Description
1	24VAC INPUT/OutPut	20mA for customer use, Board may also be powered via a 24VAC aux source.
2	24VAC INPUT/OutPut	20mA for customer use, Board may also be powered via a 24VAC aux source.
3	24VDC	50mA available for customer use.
4	INHIBIT contact closure to 5/15VDC enables board	Shorting this to pin 6 or 7 enables the board. Letting it float will disable gating signals within 1mS
5	N/C	
6	15VDC	25mA available for customer use.
7	5VDC	25mA available for customer use.
8	GND	Reference for BAP3550A control circuitry including delay angle control, therefore it must be tied to reference for delay angle control if external source is used.
9	INHIBIT ANNUNCIATE	Normally low through a 100Ω resistor. Transitions high in a Fast turn off (J5-4 goes high), in an out of phase lock condition, phase loss condition or over temperature condition
10	PHASE ANGLE CONTROL	0 to 5 V analog input to control delay angle. 0V → Max Delay Angle; 5V→Min Delay Angle <sup>3</sup>
11	GND	Reference for BAP3550A control circuitry including delay angle control, therefore it must be tied to reference for delay angle control if external source is used.
12	SOFT STOP	When it transitions from a contact closure to pin 11 to an open circuit the delay angle ramps down from maximum to programmed value. If the board is running, when it transitions from an open circuit to a contact closure to pin 11, the delay angle ramps up from the programmed value to the max value.

**J6 -SCR Interface/ Input Power**

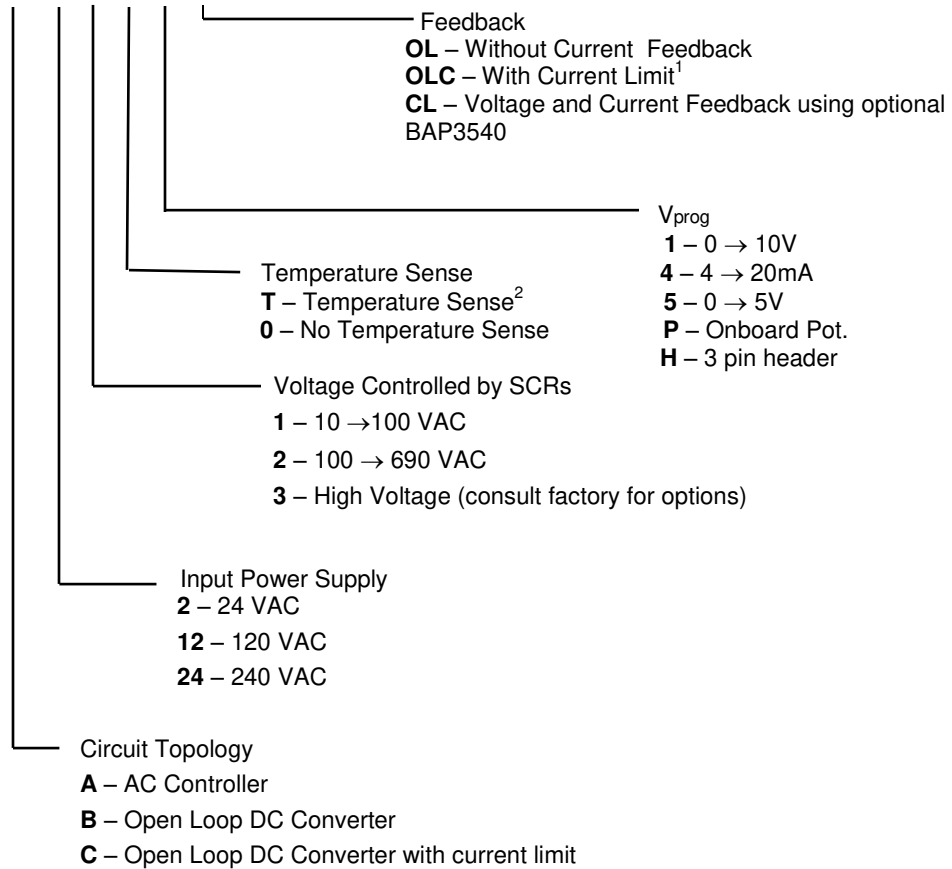
Connector J6 is an 8 position Mate-N-Lok™ connector which serves as the interface between the two galvanically isolated DC gate drives as well as the on board power supply/phase sense.

<b>Pin</b>	<b>Signal Name</b>	<b>Description</b>
<b>1</b>	<b>SCR1 Gate</b>	<b>SCR1 Load Connected Cathode-Gate</b>
<b>2</b>	<b>SCR1 Cathode</b>	<b>SCR1 Load Connected Cathode-Cathode</b>
<b>3</b>	<b>N/C</b>	
<b>4</b>	<b>SCR2 Gate</b>	<b>SCR2 Line Connected Cathode-Gate</b>
<b>5</b>	<b>SCR2 Cathode</b>	<b>SCR2 Line Connected Cathode-Cathode</b>
<b>6</b>	<b>N/C</b>	
<b>7</b>	<b>120VAC Power input</b>	<b>115/230 VAC or 240/480 VAC input to center-tapped Transformer T3</b>
<b>8</b>	<b>120VAC Power input</b>	<b>115/230 VAC or 240/480 VAC input to center-tapped Transformer T3</b>



**Ordering Information**

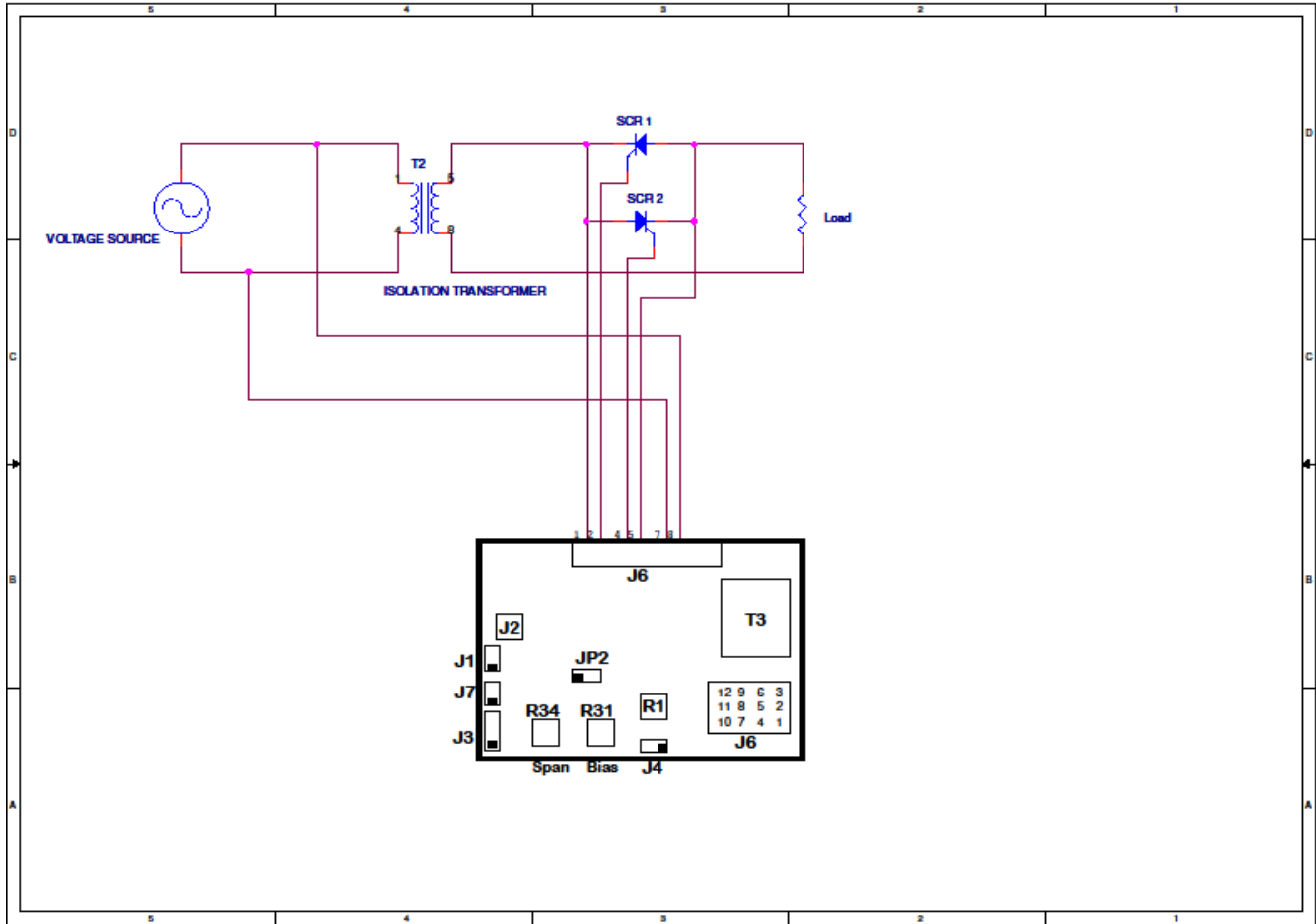
**BAP3550-X-XX-X-X-X-XX**



<sup>1</sup> **Closed loop option requires the following information:**

1. Full scale output voltage (1kVdc max.)
2. Maximum output current
3. Current sensor being used (mfg. and part number)
4. How will output voltage and current limits be controlled?
  - a. If using potentiometers, are they to be on-board or off-board?
  - b. If providing voltages, what is full-scale voltage?

<sup>2</sup> Consult factory for Over Temperature threshold settings – heatsink Over Temperature set-point can be set between 40°C and 100°C. BAP2161A-3 Temp Sensor is available as an option for mounting on heatsink.



Typical Applications

AC Controller

