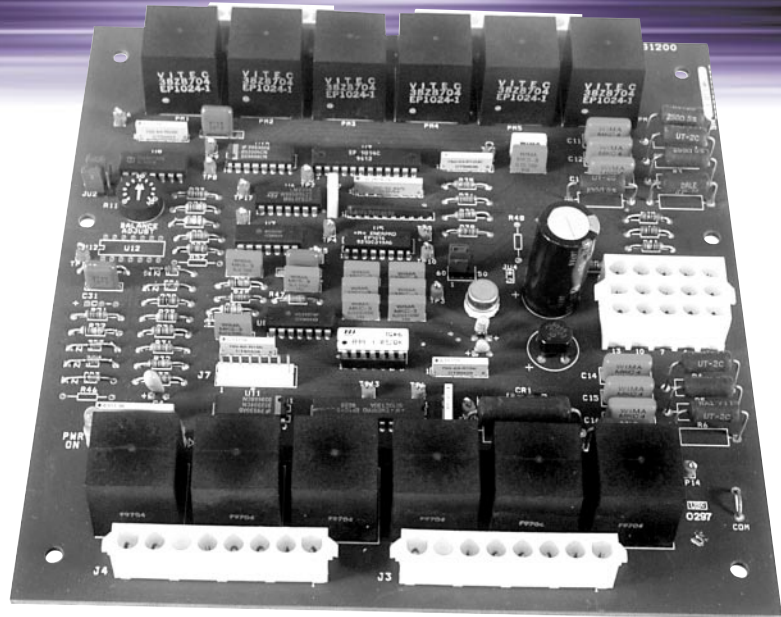


Twelve-Pulse Firing Board

- For 12-Pulse Converters or Controllers
- Virtually eliminates 5th and 7th harmonics
- NEW Balance Circuit minimizes DC ripple voltage and supply current imbalance
- Complete, self-contained control package option
- Designed for panel mounting
- Complete SCR Assemblies also available



Enerpro Model FCOG-1200 firing boards supply delayed, hard-firing gating pulses for parallel or series connected 12-pulse converters or ac controllers. The twelve gate outputs are spaced at 30° intervals as required to eliminate the 5th and 7th harmonics of the ac input current.

A new phase balance circuit has been added to help compensate for unequal supply transformer's secondary impedance and open circuit voltage. This assures balanced loading of the transformer secondaries, minimum mains current harmonics and minimum dc output ripple voltage.

Standard features include power-on reset, soft-start and soft-stop, phase loss inhibit and instant inhibit. Gate delay angle transfer function is configurable for your application.

The Model FCOG-1200 Firing Board is designed to handle mains voltage up to 600Vac. It contains the thyristor gate delay determinator logic (including Enerpro's proprietary LSI circuitry) and the thyristor gate pulse transformers and associated circuitry on a single board.

In addition, Enerpro engineers can design and produce a complete system to your specifications, including SCRs, heat sinks, regulator boards and firing package.

12-Pulse Firing Packages

The Enerpro FCOG-1200 (single board/600Vac) twelve-pulse firing package employs a six-phase, phase-locked-loop to achieve precise 30°, equidistant gating and excellent bandwidth. This unique, power quality enhancing power control device employs Enerpro's proprietary firing circuitry incorporating LSI technology, first introduced in 1983 and firmly established as the North American industry standard. It is designed with built-in features to simplify your controller or converter design.

Power-On Reset

The power-on reset feature prevents unscheduled thyristor gating when 3 \emptyset power is applied to the thyristors or when 1 \emptyset power is applied to the circuit board power supply. The power-on reset circuit activates the soft-start circuit.

Soft-Start & Soft-Stop

The soft-start circuit overrides the gate delay angle command. It is activated by contact closure input or via the power-on reset feature. Gating commences 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 contact closure, causes the gate delay angle to ramp up from the command angle to the maximum delay angle limit before gating is inhibited.

Phase Loss Inhibit

The phase loss circuit removes thyristor gate drive if loss of phase voltage due to a blown fuse or other cause is detected. When the mains voltage is restored, the soft-start circuit is engaged.

Instant Inhibit

Thyristor gating is instantly enabled or inhibited upon contact closure input.

Operational Details

Gate Delay Transfer Function

The thyristor gate delay is controlled by a 0 to 5 Vdc input signal. Gate delay angle varies in negative proportion to the command voltage. Minimum and maximum delay angles are selected for the specified application. An input resistor network is provided to accommodate offset voltage or current input control signals.

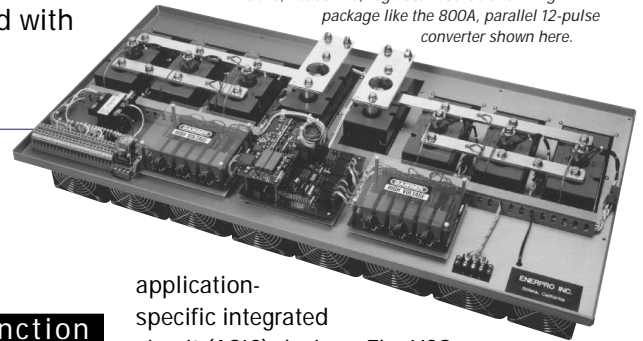
Phase Reference Sensing

Low level phase reference signals are produced by precision resistor attenuator networks and low-pass filters on the two sets of 30° phase-displaced 3 \emptyset mains voltages. The mains voltages are accessed at the thyristor gate pulse transformer windings connected to each of the six phases. The attenuated mains voltage reference signals are processed by low-pass filters with 6dB attenuation and 60° phase shift at the mains frequency. These filters remove distortion from the reference signals caused by non-linear loading of the mains by the thyristor converter/controller. The reference signals are then selected by means of CMOS switches to cancel the 60° filter phase shift and, in turn, are applied to voltage comparators to produce phase reference inputs to the phase-locked-loop of the gate delay determinator circuit.

Gate Delay Determinator

The gate delay determinator is a six phase phase-locked-loop (PLL) consisting of a summing junction, low-pass filter, voltage controlled oscillator (VCO) and two digital

Enerpro can design and produce a complete 12-pulse system to your specifications, including SCRs, heat sinks, regulator boards and firing package like the 800A, parallel 12-pulse converter shown here.



application-specific integrated circuit (ASIC) devices. The VCO frequency is locked to the power line frequency. The dc control voltage is injected into the summing junction to vary the thyristor gate delay angle.

Gate Drive Outputs

Twelve isolated and 30° spaced hard-firing thyristor gate pulse outputs are provided. The twelve gate command logic signals produced by the ASIC devices are applied to pulse amplifiers which actuate pulse transformers via pulse-shaping RC networks.

Phase Balance Circuit

Ideally, the phase shift transformer that powers the two six-pulse thyristor bridges provide two sets of three phase voltages that are equal in amplitude and phase shifted by 30°. However, common transformer imperfections cause small open circuit voltage unbalance, impedance unbalance, and a slight deviation from the 30° phase shift. When two paralleled six-pulse bridges combine to make the twelve-pulse rectifier, the result is unbalanced bridge currents of the twelve-pulse converters, presence of ac mains current 5th and 7th harmonics, and dc ripple voltage at six times the ac mains frequency on the converter outputs.

Enerpro's upgraded FCOG-1200 provides three methods (on-board manual, on-board auto, external auto) of trimming nominal 30° group delay angle to optimize the

Maximum Ratings

■ AC Mains Voltage (Vac)	600
■ Pulse Transformer Hipot (Vac), 1 min	3500
■ Gate Delay Command Voltage (Vdc)	-15 to +15
■ Board Supply Voltage (Vac)	28
■ Available Current (mAdc):	
+30V / +40 Vdc	300
+24 Vdc	20
+12 Vdc	5
+5 Vdc	5
■ Operating Temperature (°C)	0 to 70
■ Storage Temperature (°C)	-55 to +150

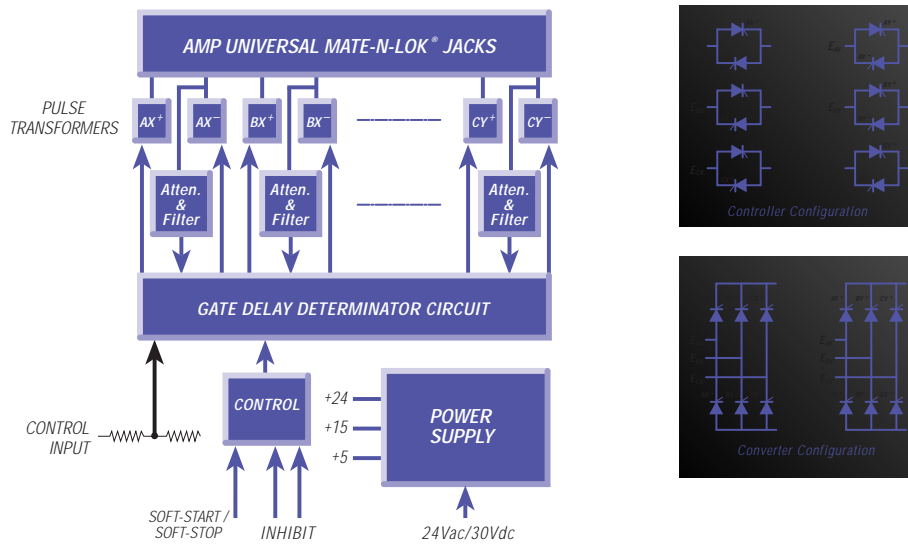
Electrical Characteristics

■ Gate Delay Command Voltage Range (Vdc)*	0 to 5
■ Delay Angle Range (deg)*	6 to 174
■ Phase Reference Angle Bias (deg)	0 or 30
■ 3dB Bandwidth (Hz)	167
■ Delay Angle Tracking (deg):	
Same Polarity	120 ± 0.5
Different Phase	180 ± 0.5
■ Soft-Start Range (s)	0.05 to 5.0
■ Power-Down Range (s)	0.05 to 10.0
■ First Gate Pulse:	
Short Circuit Current (A)	1.8
■ First Gate Pulse:	
Initial Rate-of-Rise (A/μs)	1.0
Open Circuit Voltage (V)	14
■ Sustaining Gate Pulse:	
Short Circuit Current (A)	0.5
Open Circuit Voltage (V)	7
■ Gate Pulse Width (μs):	
60 Hz	24 to 26
50 Hz	20 to 22
■ Gate Burst Width (deg)	120
■ Number of Gate Pulses	384

* or as customer specified

Mechanical Specifications

■ Printed Circuit Board Dimensions (mm)	191 x 194
--	-----------



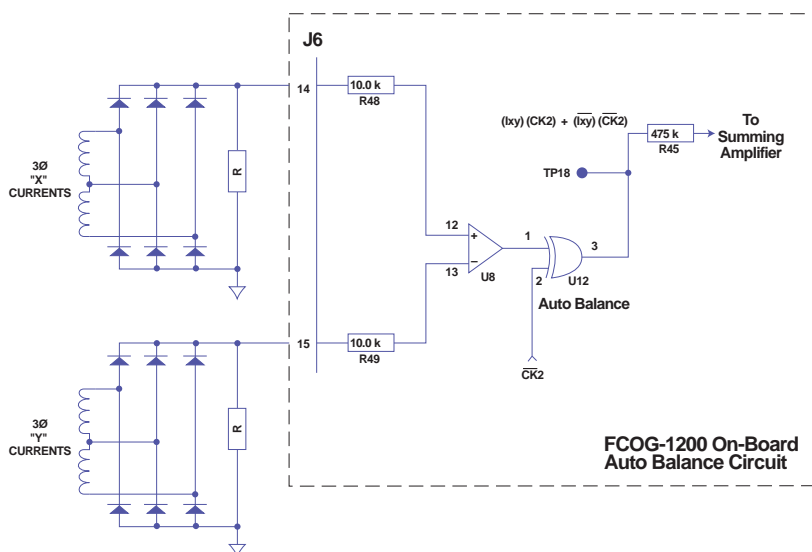
rectifier performance. The 30° delay angle trim balances the parallel bridge currents, ensuring full utilization of the phase shift transformer secondary winding. Mains current harmonics and dc ripple voltage are also minimized.

The on-board manual balance is the default and the simplest means of control. After adjusting the overall gate delay angle to a desired DC output current, the balance trimpot can then be rotated to equalize the AC input currents, or the DC output currents of each six-pulse converter resulting in a balanced twelve-pulse converter.

The on-board auto balance control method provides active control of the 30° delay that results in the optimization of the circuit at all DC output currents.

As seen in the figure below, two customer-provided feedback signals (derived from the bridge AC input currents or individual bridge output currents) along with the injection of a high frequency square wave into the Voltage Controlled Oscillator (VCO) summing amplifier help equalize the bridge input currents which result in optimum system performance.

The external auto balance control is ideal where a regulator is present in the circuit. This allows the regulator designer to incorporate the feedback rectifiers (if required) and current regulators into a single board and simplify the system wiring.



Electro-Mechanical Details

Board Configuration

The FCOG-1200 is a single board configuration containing power supply, thyristor gate delay determinator logic, thyristor gate pulse transformers and associated circuitry.

Power Supply

The FCOG-1200 power supply operates from an external 24Vac, 15VA, 1 $\frac{1}{2}$ power source. Each power supply provides unregulated (nominal 30 Vdc) and regulated (12 and 5 Vdc) dc voltage.

Printed Circuit Boards

All printed circuit boards are fabricated from 2.36mm (.093") thick G10 epoxy-glass FR4 laminate by a UL registered fabricator.



ENERPRO, Inc.
5780 Thornwood Drive
Goleta, CA 93117 (USA)
(800) 576-2114
Telephone: (805) 683-2114
Fax: (805) 964-0798
Email: info@enerpro-inc.com
www.enerpro-inc.com

Ordering Guide

