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Operating Manual: OP-0100  
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## **Operating Manual: Model CTRCT-1 Current Trip/Regulator with Current Transformer Feedback Circuit Board (Revision C)**

### **Introduction**

This manual is intended to familiarize the user with the salient features of the circuit board. Typical connection diagrams and a troubleshooting guide are also provided.

### **References**

1. E128, Schematic Diagram: General Purpose 3Ø Firing Circuit
2. E168, Schematic Diagram: 1Ø 4-SCR Bipolar Firing Circuit
3. E211, Schematic Diagram: 1Ø 2-SCR Firing Circuit/Regulator
4. E207, Schematic Diagram: Current Trip/Regulator, CT Feedback PWA
5. OP-0102, Operations Manual: FCOG6100 6-SCR General Purpose Firing Board
6. OP-0105, Operations Manual: FCRO2100 2-SCR 1Ø Firing Circuit
7. OP-0106, Operations Manual: FCRO4100 4-SCR 1Ø Firing Circuit
8. Bourbeau, F.J., "Phase Control Thyristor Firing Circuit: Theory and Applications", Power Quality '89, Long Beach, California

### **Product Description**

#### **1.0 Application**

The CTRCT-1 Current Trip/Regulator with Current Transformer (CT) Feedback board operates in conjunction with Enerpro designed firing circuit boards to provide regulated load current. Either the FCRO2100 1Ø firing circuit or the FCRO4100 4-SCR 1Ø firing circuit is used in 1Ø ac-ac controllers (antiparallel SCR's) and 1Ø ac-dc converter (e.g., bridge) applications while the FCOG6100 general purpose 3Ø firing circuit is used in the corresponding 3Ø application. The resulting two-board assembly responds to either a voltage or milliamp current signal to provide synchronized gate firing pulses for single phase two and four SCR circuits or three phase three and six SCR circuits while also adjusting the gate firing phase angle to regulate the load current. An over-current trip feature is also provided to shut down the system in the case of a momentary short circuit. The system may be manually reset or may be automatically reset after an adjustable time delay.

Options include a maintained contact run/stop switch and a current limit operating mode rather than the current regulator mode. The application range is also enhanced by the use of additional Enerpro boards. These boards extend the usage to the gating of:

- paralleled SCR's
- four-quadrant converters
- twelve-pulse converters
- sequence reversing controllers<sup>1</sup>
- remote operation of SCRs

<sup>1</sup> 3Ø circuits only.

## 2.0 Board Mounted Connectors

The CTRCT-1 circuit board is completely connectorized, using AMP Universal Mate-N-Lok™ right angle headers<sup>2</sup>, to simplify maintenance and troubleshooting. Mating plugs and contacts are included with the circuit board and require a U-barrel crimper for proper installation. An overview of each connector pin function is provided below:

**J1**

Pin	Label	Function
1	+12	+12Vdc control power from the firing board
2	+12	+12Vdc control power from the firing board
3	Reset	Momentarily connecting +12Vdc to this point will enable SCR gating and/or reset over-current trip
4	SIG HI	Phase angle command signal to the firing board
5	COM	Circuit common
6	Stop	Momentarily removing common from this point will inhibit SCR gating
7	COM	Circuit common
8	+30	+30Vdc control power from the firing board

**J2**

Pin	Label	Function
1 – 3	from CTs	Current transformer feedback is applied here

**J3**

Pin	Label	Function
1	I <sub>F</sub>	Current feedback. This can either be an input (from a customer provided source), or an output to an additional current circuit.
2	COM	Circuit common
3	Current Command	The customer supplied current command is applied here
4	<NOT>I1	Instant Inhibit connection to the firing board
5	<NOT>I2	Soft Inhibit connection to the firing board

## 3.0 Current Feedback

Three phase CT current is input to J2 pins 1, 2 & 3 on the CTRCT-1. (Single phase CT current can be input on any two pins of J2). The phasing is unimportant since the ac currents will be converted into a dc equivalent.

A portion of the current in each mains phase appears across the secondary of a CT (e.g., with a 200:5 CT, and one primary turn, 1/40<sup>th</sup> of the mains current appears on the secondary). This mains current flows into the CTRCT-1 board where it is rectified by a 3Ø bridge consisting of CR1 – CR6. The rectified current is then converted to a voltage signal, I<sub>F</sub>, by burden resistor R4. R4 is chosen, as outlined below, so that I<sub>F</sub> = 1.00V at full load.

$$\begin{aligned} \text{1Ø Circuits: } R4 &= (\text{CT ratio}) \sqrt{2}/I_L \\ \text{3Ø Circuits: } R4 &= (\text{CT ratio}) / (1.28 * I_L) \\ \text{where } I_L &= \text{full load current} \end{aligned}$$

<sup>2</sup> Vertical headers are available upon request.

Zener diode, CR7, protects the circuit from voltage spikes of more than 15Vdc. The current feedback signal is then input to the current trip circuit and to the current regulator circuit.

#### 4.0 Current Command

The current command signal is applied to J3-3 on the CTRCT-1 board. The default value of the current command signal is 0.0 to 5.0Vdc<sup>3</sup>. Optional dropping resistor, R14, may be installed to convert a milliamp (e.g., 0-10mA) signal to the proper voltage. If an alternate current command voltage level is desired, select R15 so that the maximum voltage at TP9 is 2.5Vdc.

The applied current command signal is attenuated by the SPAN potentiometer, R3 and R15. This attenuated value is then further reduced by a voltage divider formed by RN3-7 and RN4-7 and applied to the non-inverting input of the error amplifier, U1-7. The SPAN potentiometer, R3, is adjusted to provide the desired maximum output current with a maximum current command applied.

The addition of C6 to the current command circuit will increase the system response to a changing current command signal.

#### 5.0 Stop/Reset Commands

Several modes of control are possible for enabling and inhibiting SCR gating and for resetting an overcurrent trip:

5.1. **Start.** Start-up may be engaged either by momentary contact closure (pushbutton) or application of control power (120Vac start) to the firing board. In either case, current is ramped up from zero to the commanded level at a rate which depends upon the firing board soft-start time constant<sup>4</sup>.

In the 120Vac start mode (PP1-3 = Open, PP1-4 = Closed) the application of control power causes a momentary logic 1 on the reset as C3 conducts from the 12Vdc supply through RN2-3 and RN2-6 & 7. This momentary logic 1 ensures that the latches are reset and allows the gate firing board to be enabled.

In the pushbutton start mode (PP1-3 = Closed, PP1-4 = Open) the application of control power causes a momentary logic 1 on the U2-6 set pin as C3 conducts from the 12Vdc supply through RN2-1 and the external common connection at J1-6, if present. This ensures that the latches are set and that the gate firing board is inhibited.

5.2. **Reset.** An overcurrent trip diagnostic shutdown may be reset either automatically or manually, by pushbutton.

Manual reset is accomplished by momentarily closing a contact between the 12Vdc supply and the reset pin at J1-3. Momentarily connecting 12Vdc to the reset pin causes the reset on U2-7 to be pulled high through RN2-3. In addition, pulling the U2-7 reset high forward biases CR14 and pulls the reset of U2-3 high. This resets the latches, assuming the set pins are low, and enables the gate firing board..

<sup>3</sup> +5Vdc control power is available on either J4-7 on the FCRO4100 1Ø firing board or at J3-7 on the FCOG6100 3Ø firing board.

<sup>4</sup> Please see the respective firing boards operations manual, reference 5, 6, or 7.

5.3. **Stop.** Manual shutdown is initiated by opening a contact between circuit common and the stop pin at J1-6.

The shutdown mode initiated by a manual shutdown or an overcurrent trip diagnostic shutdown is selected using PP1. Instant-off (PP1-1 = Open, PP1-2 = Closed) will immediately inhibit SCR gating while the soft-off mode (PP1-1 = Closed, PP1-2 = Open) will ramp the current to zero before inhibiting.

#### Summary of PP1 Settings

NO.	FUNCTION	PLUG POSITION (X = Closed, O = Open)			
		1	2	3	4
1	SOFT-ON, INSTANT-OFF	X	O	-	-
2	SOFT-ON, SOFT-OFF	O	X	-	-
3	PUSH-BUTTON START	-	-	X	O
4	120VAC START	-	-	O	X

#### 6.0 Current Trip Stage

Operational Amplifier (OP Amp) U1-1 serves as the current trip comparator. The non-inverting input of U1-1 is connected to If via a RC network consisting of RN4-1 and C4. This RC network serves to provide some isolation and filtering of the current feedback signal prior to its application to the comparator. The delay associated with this circuit is approximately 3.3msec. The inverting input of U1-1 is tied to the wiper of the TRIP potentiometer, R1. Adjusting R1 between 0 and 100% sets the current trip threshold at 0 to 220% of full load current.

An If level greater than the current trip threshold causes a logic 1 to be applied to the Set input of the Overcurrent Trip Latch, U2-2. This in turn causes the Q output to latch high until the Reset is pulled high. Current then flows through diode CR11 to raise the inverting input of comparator U1-14 to a level above the non-inverting input of 2.2Vdc. This results in U1-14 being driven to logic 0 state, which causes the firing board gating to inhibit.

The Overcurrent Trip Latch may be reset either manually or automatically. Automatic reset is enabled by the installation of CR10, CR13 and C2. The delay period before reset is determined by the time constant of R13 and C2 as follows:

$$t \approx (R13)(C2)(0.205)$$

Where t = time in msec, R is in kΩ and C is in μF.

Note: Normally installed values result in  $t \approx 620$ msec.

#### 7.0 Current Regulator Stage

The current feedback signal is also connected to the inverting input of OP Amp U1-7, where it is added to the bias level established by the BIAS potentiometer, R2. The amplified error between this summed voltage signal and the attenuated Current Command signal is formed by U1-7.

The resulting error voltage is attenuated by R11 and the SCR firing board input shunt resistor to form a 0.0 to 6.0Vdc Gate Delay Command voltage.

The level of current command reaching the OP-Amp U1-7 is determined by the Current Command input level and the SPAN potentiometer, R3, setting. An increase in the SPAN potentiometer setting results in an increase in the Gate Delay Command and a corresponding

increase in the load current. The response time to step changes in the Current Command input can be modified by changing C6.

## **8.0 Current Limiting Operation (Optional Configuration)**

Current limit operation is enabled by installing diode CR8 in place of resistor R11. Resistor R16 is then installed to provide a constant Gate Delay Command voltage level under non-limiting conditions. Optionally, R16 may be omitted and an external Gate Delay Command applied to J1-4 through a series resistance of at least 1.5kΩ.

In this mode OP-Amp U1-7 will sink current through CR8 to pull down the Gate Delay Command as required to maintain the maximum level corresponding to the load current commanded by the Current Command signal.

## **9.0 Increased Stability Margin (Optional Configuration)**

Changing R11 to 56.8kΩ and C7 to 0.15μF on the CTRCT-1 board while removing R41 and R52 from the FCOG6100 3Ø Firing Board will create a lead-lag network at the FCOG6100 gate delay command input. These values can then be altered to obtain the desired system response time.

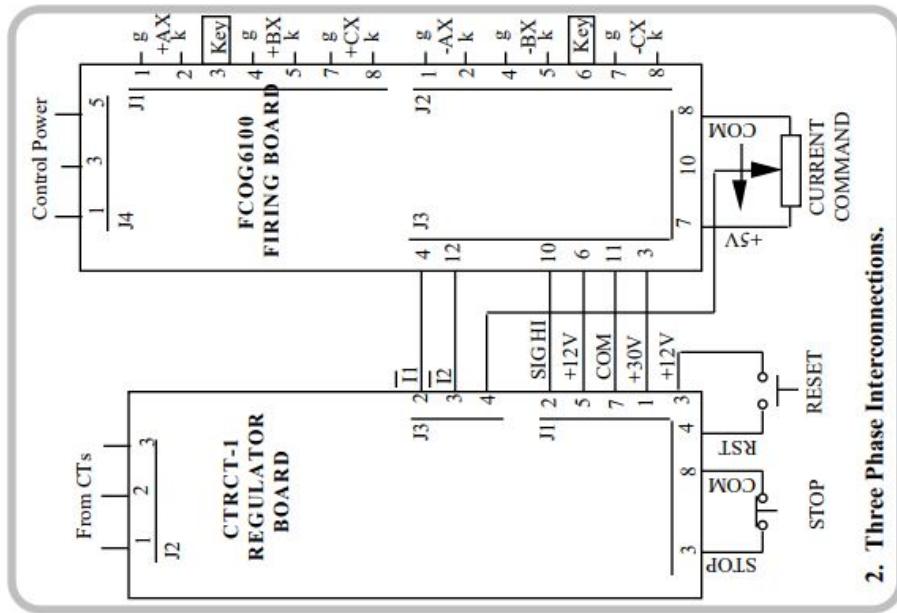
## **ELECTRICAL SPECIFICATION**

The electrical specifications of the CTRCT-1 Current Trip/Regulator with CT Feedback Board are summarized in the table below. Part numbers refer to E207 Revision C.

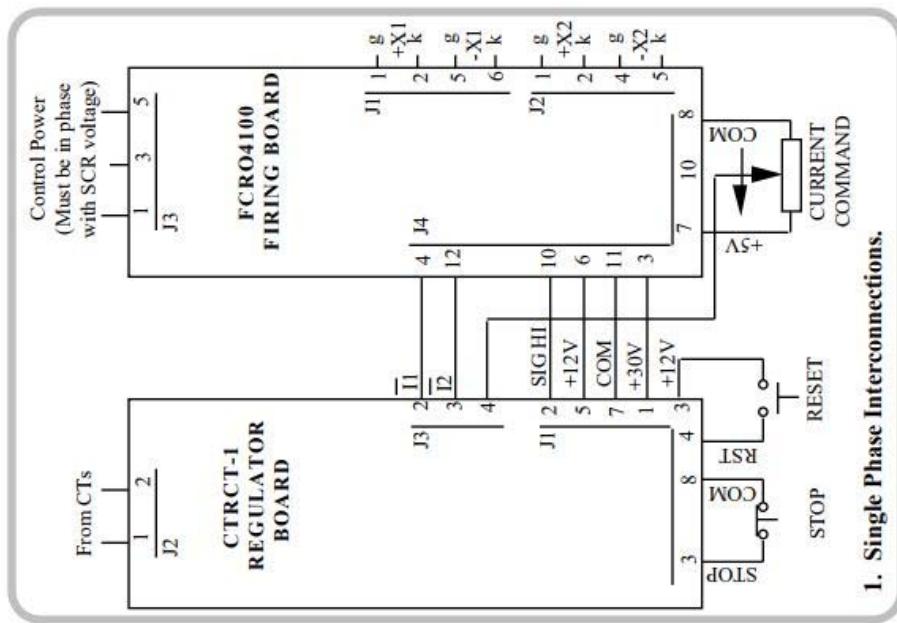
<b>Characteristic</b>	<b>Performance Requirement</b>	<b>Supporting Information</b>
1)CT Feedback	1.0Aac maximum.	
2)Current Command Signal	0.0Vdc to 5.0Vdc control signal. Load resistance is 9.99kΩ.	Option: A Shunt resistance (R14) across signal inut can be selected for milliamp control signal.
3)Current feedback level	1.0Vdc at full load current.	Determined by circuit configuration, CT ratio, and R4 value.
4) Ambient Temperature	0° to 70°C	

## CIRCUIT BOARD INTERCONNECTION DIAGRAM

The following connection diagrams are included to provide an overview of the interconnections required between the CTRCT-1 Regulator Board and the Enerpro Firing Board (FCRO4100 or FCOG6100). Please contact Enerpro if there are any questions regarding the installation of these boards in your specific application.



2. Three Phase Interconnections.



1. Single Phase Interconnections.

## TROUBLESHOOTING GUIDE

The following table provides a list of possible fault conditions and the most likely courses of action required to obtain proper operation. The symptoms described will generally only occur upon initial installation and are provided to assist you during this crucial stage.

<b>Symptom</b>	<b>Possible Cause</b>	<b>Corrective Action</b>
No Power On indication	<ul style="list-style-type: none"> <li>• No control power applied</li> <li>• Improper interconnection between circuit boards</li> </ul>	<ul style="list-style-type: none"> <li>• Apply power</li> <li>• Verify +30V and COM connections</li> </ul>
Unit comes on full upon start-up	<ul style="list-style-type: none"> <li>• No current feedback</li> </ul>	<ul style="list-style-type: none"> <li>• Verify current transformer feedback is connected</li> <li>• Verify that R4 has been installed</li> </ul>
Unit will not provide minimum output	<ul style="list-style-type: none"> <li>• BIAS potentiometer adjusted incorrectly</li> </ul>	<ul style="list-style-type: none"> <li>• Adjust the BIAS potentiometer to obtain desired minimum output</li> </ul>
Unit will not reach full output	<ul style="list-style-type: none"> <li>• Feedback level too high</li> <li>• SPAN potentiometer adjusted incorrectly</li> <li>• Current Command level too low</li> </ul>	<ul style="list-style-type: none"> <li>• Verify that R4 is selected to provide 1.0Vdc feedback</li> <li>• Adjust SPAN potentiometer toward 100%</li> <li>• Ensure voltage at TP9 reaches 2.5Vdc</li> </ul>
Unit will not Start	<ul style="list-style-type: none"> <li>• No COM connection to the STOP command</li> </ul>	<ul style="list-style-type: none"> <li>• Connect COM to STOP command (J1-6)</li> </ul>
Unit automatically resets	<ul style="list-style-type: none"> <li>• Automatic Reset is selected</li> <li>• +12V is applied to the RESET connection</li> </ul>	<ul style="list-style-type: none"> <li>• Remove C2, CR10 &amp; CR13</li> <li>• Disconnect +12Vdc from the RESET connection (J1-3)</li> </ul>