

**Operating Manual: ISOVLCL-4 Voltage and Current
Revisions A, B, or C****Introduction**

The ISOVLCL-4 board is designed to be used in conjunction with an Enerpro firing board. The resulting assembly responds to a voltage signal¹ to provide synchronized gate firing pulses, while also adjusting the gate firing phase angle to regulate load voltage or current (automatic crossover).

1.0 Functions

The regulator board performs the following functions:

- Isolation of the voltage and current feedback signals from the control circuits.
- Pre-filtering and pre-amplification of the current feedback signal.
- Pre-filtering of the voltage feedback signal.
- Absolute value functions for the current and voltage feedback signals.
- Low pass post-filtering of the voltage and current feedback signals.
- Limit amplification of the current and voltage feedback signals.
- Diode-OR circuit for automatic crossover between voltage and current limiting.
- Over-current comparator operating on the pre-filtered and pre-amplified current signal.
- Over-voltage comparator operating on the pre-filtered voltage signal.
- Over-current, over-voltage, and manual trips can be configured for automatic or manual reset.
- Soft-start (adjustable) in response to an enable command.
- Load current and load voltage readout signals.

The voltage and current commands can be applied from an external voltage (or current source) or can be applied from within the board-mount potentiometers.

2.0 Applications and Special control modes.

The regulator assembly, firing board and regulator, is suitable for battery charges, electro-chemical process power supplies, magnet power supplies, motor controllers, etc.

SPECIAL CONTROL FUNCTIONS:

- Parallel voltage and current regulation loops.
- Outer voltage regulation loop and inner regulation loop.
- Slave and Master tandem regulation (with the use of a second ISOVLCL-4 board).

3.0 Board Mounted Connectors

This board has four Mate-N- Lok™ connectors to simplify maintenance and troubleshooting.

3.1. Voltage and Current Feedback (J1)

Voltage and current feedback interface is provided by a 4-position Mate-N-Lok™ horizontal connector² J1 as indicated below.

¹ Optionally, a current command can be used.

² Right-Angle or Horizontal connectors are installed as default for J1-J4, vertical connectors are also available upon request.

J1 plug: Voltage and Current feedback		
J1-1	Non-isolated voltage feedback	Input: Customer must supply a 0-4VDC (*) voltage feedback signal proportional to the maximum DC output.
J1-3	Non-isolated current feedback	Input: Customer must supply a 0-50mV (*) current feedback signal proportional to the maximum DC full load current.
J1-4	Non-isolated feedback (voltage and current) reference.	Input: Voltage and Current feedback reference or non-isolated common.
(*) Other input ranges available upon request.		

3.2. Open-collector monitoring status signals and manual Stop and Reset functions (J2).

Open-collector driving signals, manual reset and stop controls, along with a 24VDC source are available at J2, an 8-position Mate-N-Lok™ connector, as indicated below.

J2 plug: Open-collector status drivers, Stop and Reset.		
J2-1	Reset	Input: Manual reset normally used to start or restart the firing board after a trip condition is triggered. Board resets when this signal is momentarily set low (connected to board COM at J2-2).
J2-2	Isolated common	Output: Board common (COM) used for manual reset and stop.
J2-3	Stop	Input: Manual stop (inhibit) command to disable all firing. Command can be configured as a contact to ground or to 12V depending on the configuration of R45 and R46. See section 6.2
J2-4	+24V	Optional Output: 24VDC conveniently supplied as sourcing voltage to drive relays or lamps used to monitor tripping events.
J2-5 - J2-8	Open-Collector relay-driving monitoring signals.	Optional Outputs: 500mA status (open-collector) drives available to monitor the following conditions: J2-5 Current Trip J2-6 Voltage Trip J2-7 Manual Trip J2-8 Current or Voltage Limit (As specified by JU6 and JU7. See table 3).

3.3. Voltage and Current readouts (J3).

Voltage and current feedback readouts are available at J3, a 3-position Mate-N-Lok™ connector³ as indicated below.

³ Right-Angle or Horizontal connectors are available in this board. Customer must specify vertical connectors if desired..

J3 plug: Voltage and current feedback readouts.		
J3-1	Voltage readout	Output: Proportional rectifier DC output voltage-readout (range 0.14-4.14VDC).
J3-2	Current readout	Output: Proportional rectifier DC output current-readout (range 0.14-2.14VDC).
J3-3	Isolated common or COM	Output: Board common (COM) used for reference for the voltage and current readouts.

3.4. Customer control I/O and Firing board interconnections (J4)

Control input power and required I/O interconnections with the corresponding firing board are available at J4, an 8-position Mate-N-Lok™ connector, as indicated below.

J4 plug: Customer control I/O and Firing board interconnections (J4)		
J4-1	Off-board Voltage Limit Command (E_L)	Input: Voltage or current external signal defining the voltage limit command (only when the board is configured for external E _L command)
J4-2	Off-board Current Limit Command (I_L)	Input: Voltage or current external signal defining the current limit command (only when the board is configured for external I _L command)
J4-3	SIG HI	Output: Regulator delay angle command output used to drive the corresponding firing board (range 0.85-5.85VDC).
J4-4	ES/NOT[I2]	Optional Output: Enable status relay driving signal, or Optional Input: Soft-Enable command. (See table 3 for jumper JU10 selection).
J4-5	NOT[I2]	Input: Soft-Enable command.
J4-6	+12V	Optional Output: Used to drive 12V monitoring circuitry (25mA max).
J4-7	Isolated board common or COM	Input: Board common (COM) used for reference for 30VDC control input power.
J4-8	+30V	Input: Control input power.

4.0 Current Limit Channel.

The rectifier output current is sensed by a 50mV⁴ shunt, low pass filtered (T=0.00022 seconds) and pre-amplified with a gain of 20. The result is a load referenced wideband current feedback signal having a full scale level of 20 x 0.05= 1.0VDC. The amplified signal is processed by a unity gain isolation amplifier to form a current feedback signal referenced to circuit board common. This signal is then amplified by a x2 gain precision rectifier and applied to the input of a limit amplifier. The limit amplifier has a gain of 4.6V/V and a low pass filter with a time constant of 0.33 seconds.

⁴ Optionally, a current command can be used.

The current channel limit amplifier and its associated coupling diode D6 operate in the same manner as the voltage channel described above. If the current channel limit amplifier output is at a lower voltage than the voltage channel limit amplifier, the current feedback channel dominates and dictates the SCR gate delay signal into the firing board.

5.0 Current Trip

The overcurrent comparator circuit responds to the current feedback signal at the output of the precision rectifier and to a current trip threshold voltage obtained from a board mounted trimpot. When the current feedback signal exceeds the trip threshold, the comparator output goes low, causing latch U5-7 to go high. This forward biases DN1F causing comparator U11-7 to go low and discharge soft-capacitor C14. (NOTE: When DN1F is forward biased, U9-7 goes low forward biasing D4 and causing the R terminal to go low). The C14 voltage is buffered and coupled by diode D7 to the common connection of RN5-1, the anodes of D10, and DN11 and the input of the x2 gain amplifier. The SIGH HI input to the firing board decreases to a low voltage in response to the overcurrent event, thus retarding the SCR gate delay angle and reducing the load current to a value less than the current trip threshold.

6.0 Current Trip Reset modes.

6.1 Automatic Current Reset

Reduced load current causes the output of the overcurrent comparator to snap back to the positive supply voltage rail applying a logic high to U5-7. Since the R of U5 is held low by U9-7, through D4, latch U5-7 is reset reverse biasing DN1F allowing the soft-start capacitor C14 to recharge through resistors R31 and R6. (NOTE: When DN1F is reversed biased, U9-7 goes high, reverse biasing D4 and returning R to a high state). If the rectifier load fault which caused the overcurrent persist, the current trip level will again be exceed and current will again be reset. This cycle will continue until the load fault is removed.

6.2 Manual Current Reset

The manual reset operation is enabled by removing D4 on the ISOVLCL-4 regulator via jumper JU8. The manual reset mode of operation is the same as the automatic mode except since D4 is omitted, the reset command must be obtained via J2-1. This is normally accomplished by use of a momentary contact or logic low (a momentary connection to board common).

NOTE:

Install R46 and omit R45 to STOP (J2 position 3) the firing board by closing a contact to ground.
Install R45 and omit R46 to STOP (J2 position 3) the firing board by closing a contact to +12V

7.0 Voltage Limit Channel.

The attenuated rectifier output signal is processed by a single pole low pass filter ($T=0.35$ seconds) and unity gain isolation amplifier to form a feedback signal referenced to circuit board common. This signal is then amplified by a x2 gain precision rectifier and applied to the input of a limit amplifier. The limit amplifier has a gain of 4.6V/V and the low pass filter time constant of 0.01 seconds.

The limit amplifier responds to the difference between the voltage feedback signal and the voltage limit command. When this difference is positive, the voltage limiter output decreases from a quiescent level of approximately 11 V. The limit amplifier output is coupled via diode D8 to pull –up resistor RN5-A. The common connection of RN5-A and the anode of diode D6 responds to that diode which is conductive; in this case, voltage limit diode D8. The diode common point voltage is amplified by a x2 gain non-inverting amplifier and applied through coupling resistor R34 to the corresponding Enerpro firing board. This is the SCR gate delay command voltage, designated as SIG HI.

8.0 Voltage Trip

The overvoltage comparator circuit responds to the voltage feedback signal at the output of the precision rectifier and to a voltage trip threshold voltage obtained from a board-mounted trimpot. When the voltage feedback signal exceeds the trip threshold, the comparator output goes low, causing latch U5-3 to go high. This forward biases DN1E causing comparator U7-7 to go low and discharge soft-start capacitor C14 (Note: When DN1E is forward biased, U9-7 goes low forward biasing D4 and causing the R terminal to go low). The C14 voltage is buffered and coupled by diode DN8 to the common connection of RN5A, the anode of diode D6, and the input to the x2 gain amplifier. The SIG HI input to the firing board decreases to a low voltage in response to the overcurrent event, thus retarding the SCR gate delay angle and reducing the load current to a value less than the voltage trip threshold.

9.0 Voltage Trip Reset modes.

These features are the same as for the current trip.

10.0 Soft-Stop and Soft-Start functions.

10.1. SOFT-STOP

The soft-start capacitor, C14, will be discharged, thereby reducing the rectifier output current to zero, by a logic zero condition applied to the cathode of diode D10 (J4-5). This inhibit signal is designated as NOT [I₂].

10.2. SOFT-START

The soft-stat capacitor, C14, will charge through R31, R6, and R44 when a logic one condition is applied to the cathode of D10 (J4-5). R6 can be adjusted in order to vary the resistive term and obtain a soft-start time range of one to three seconds. Note: the time constant is only effective until the output of comparator U11-7 reaches approximately 5.4Vdc.

11.0 Special Control Configurations

11.1. Parallel Voltage and Current regulation loops.

- Install JU1 &JU9, omit JU3.
- Apply voltage and current commands to J4-1 and J4-2 from on-board supply or externally. Refer to table 3 (Jumpers JU2 and JU4).

11.2. Outer voltage regulation loop and inner regulation loop.

- Omit JU1 and C19, install JU3 and JU9.

- Apply voltage command to J4-1 and current limit reference to J4-2. The current limit reference must be current sinking with impedance of less than 2 K Ohms.

11.3. Slave and Master tandem regulation (a second ISOVLCL-4 board is needed).

Master Board Configuration

- Configure parallel voltage and current regulation loops as specified above.
- Adjust the voltage command to obtain the desired load voltage with the current command at 100%, or adjust the current command to obtain the desired load current with voltage command at 100%.

Slave Board Configuration

- Remove jumpers JU5 and JU9.
- Remove current limit amplifier proportional gain resistor R27.
- Set the voltage command to 100%

11.4. Voltage and Current Limit Commands

The voltage and current limit commands (on-board or external, depending on JU2 and JU4. See table 3) could have one of the following ranges;

E_L & I_L : Standard 0-12V

- R28 and R30 must be omitted.

E_L & I_L : 4-20mA range

- Voltage command: R28 must be installed (249 Ohms)
- Current command: R30 must be installed (249 Ohms).

E_L & I_L : Customer-Specific

- R28 and R30 must be omitted.
- Voltage command: R29 must be selected for desired input voltage range.
- Voltage command: R36 must be selected for desired input voltage range.

12.0 LEDs, Test Points, and Jumpers.

Please refer to the following tables to obtain a better understanding of the functions and features for the board LEDs, test points, and configuration jumpers.

Table 1. LED Indicators (PDs)

PD1: POWER	GREEN	Indicates (ON) when control input is applied (30V at J4 pin 8).
PD2: MANUAL TRIP	RED	Turns on when a manual trip condition has been triggered. This condition requires that the board is configured for a "manual trip" reset and not for an "auto" reset.
PD3: VOLTAGE TRIP	RED	Turns on when a voltage trip condition has been triggered.
PD4: VOLTAGE LIMIT	YELLOW/ AMBER	Turns on to indicate that the load is being voltage regulated.
PD5: CURRENT TRIP	RED	Turns on when a current trip condition has been triggered.
PD6: CURRENT LIMIT	YELLOW /AMBER	Turns on to indicate that the load is being current regulated.
PD7: SOFT START	RED	Turns on temporarily when the regulator soft enables the firing board either by a user's command or by the clearance of an auto or manual trip.

Table 2. Test Points (TPs)

TP1	Isolated voltage feedback	Provides the corresponding isolated voltage feedback used by the regulator for PID control (range 0.14 to 4.14VDC)
TP2	Voltage Limit Amplifier Output	Provides the output of the voltage limit amplifier driving SIG HI when the regulator is voltage-regulating the load.
TP3	Isolated current feedback	Provides the corresponding isolated current feedback used by the regulator for PID control (range 0.14 to 2.14VDC)
TP4	Current Limit Amplifier Output	Provides the output of the current limit amplifier driving SIG HI when the regulator is current-regulating the load.
TP5	Regulator Output or SIG HI	Provides the resultant output regulating signal that controls the firing board in the system (range 0.77 to 6.06VDC).
TP6	Voltage Limit Threshold	Provides the voltage limit threshold, adjusted by the customer. This is the signal being compared to the output of the voltage limit amplifier.
TP7	Soft-Start	Provides the soft-start charging curve when the board is soft-started
TP8	Current Limit Threshold	Provides the current limit threshold, adjusted by the customer. This is the signal being compared to the output of the current limit amplifier.

Table 3. Jumpers (TPs)

JU1	Jumper must be installed for parallel voltage and current regulation loops. It is removed for an outer voltage regulation loop and an inner current regulation loop.
JU2	Jumper is installed for on-board voltage limit command (adjusted via voltage limit potentiometer R3). Remove this jumper for external voltage limit command.
JU3	Jumper must be installed for an outer voltage regulation loop and an inner current regulation loop. It is removed for parallel voltage and current regulation loops.
JU4	Jumper is installed for on-board current limit command (adjusted via current limit potentiometer R5). Remove this jumper for external current limit command.
JU5	Jumper must be removed when two ISOVLCL- boards re used in a master and slave configuration. Install it for parallel voltage and current regulation loops.
JU6	Jumper is installed when an open collector driving signal at J2 positon 8 is used to monitor if the board is operating in current regulation. Jumper JU7 must be omitted.
JU7	Jumper is installed when an open collector driving signal at J2 positon 8 is used to monitor if the board is operating in voltage regulation. Jumper JU6 must be omitted.
JU8	Jumper must be installed for automatic latch reset (automatically cleared in the event of current or voltage trip condition). Remove for manual reset.
JU9	Jumper must be removed when two ISOVLCL-4 boards are used in a master and slave configuration. Install it for parallel voltage and current regulation loops.
JU10	This two-position jumper/switch is used to select one of the two signals available at J4 position 4. JU10: Jumper installed in positions 1 and 2: Enable Status signal. This signal is used to determine if the board is enabled or inhibited. JU10: Jumper installed in positions 2 and 3: Soft Inhibit/Enable signal. This signal is used to soft enable or soft inhibit the firing board.
JU11	Jumper must be installed to offer an optional 12VDC output to drive external monitoring circuitry such as relays or LEDs. The maximum current available is only 25mA.

13.0 Electrical Specifications

Table 4. General Specifications.

Maximum Ratings		
Isolation Voltage	2000 V peak	
Operating temperature range	-5 C to 85 C	
Operating temperature range	-5 C to 85 C	
Board DC supply voltage	24-32 VDC (30VDC nominal)	
12 V regulator output current	25 mA (30 VDC supply)	
5 V reference output current	5 mA (30 VDC supply)	
Status Drives	500mA per transistor.	
Electrical Characteristics		
Delay angle command signal, SIG HI	0.85-5.85 V	
Voltage and Current Limit Command	0-12V, 0-10V, 4-20mA (or as specified)	
Soft-start/stop time	0.04 – 2.0 s (configurable)	
Functions		
Current	Limit	Yes
	Regulation	Yes
	Trip	Yes
Voltage	Limit	Yes
	Regulation	Yes
	Trip	Yes
On-board Indication	Limit/Regulation	Yes
	Trip	Yes
External Indication	Limit/Regulation	Yes
	Trip	Yes
Trip Latch		Yes
Compatible with Polarity Reversing Systems		Yes
Board dimensions	191 x 152 x 18 mm (L x W x D)	
Minimum creepage distance between isolated circuits	18 mm	
Conformal coating	per MIL-1-46058, Type UR	

14.0 Installation and Checkout

The following procedure should be followed to ensure proper operation of this board prior to the application of mains power to the SCR unit or firing board.

14.1. Ensure that the power is off. Wire plugs, P1, and P4 to the regulator.

- **P1:** Verify the correct resistor attenuator ratio for voltage feedback and the correct current feedback (shunt feedback) according to the configuration of the ISOVLCL-4 board.
- **P4:** Verify that J4 positions J4-1(E_L), J4-2(I_L) are configured and connected as desired (on-board or external command) and also verify that J4-3(SIG HI), J4-5 (NOT [I2]), J4-7 (COM), and J4- 8(+30) are properly installed and connected to the firing board.

14.2. Energize the corresponding Enerpro firing board to supply the appropriate control input voltage on J4-8 (24 VDC or 30 VDC). Verify that the firing board inhibited before power is applied to it.

14.3. Verify the presence of regulated +12 VDC \pm 5% at J4 position 6 (check both pins on jumper JU11 is this jumper is not installed) and regulated +5 VDC \pm 5% at the output or "O" terminal of voltage regulator VR1.

14.4. Energize the mains voltage. This will clear the phase loss condition in the firing board. Verify that the PLL is in lock (verify that the Phase Loss or PL LED in the corresponding firing board is off).

14.5. Vary the voltage and current limit commands at J4-1 and J4-2 and verify at TP5 that SIG HI changes accordingly from 0.9V to 5.9VDC. Observe that the gate delay angle at the firing board also changes accordingly. If SIG HI responds to changes in the voltage and current limit commands, the board is working ok.

14.6. Turn off all power.