Wavelength Electronics™

FP SERIES

FPC SERIES

INSTRUCTION MANUAL

P O Box 865 • Bozeman, MT 59771 • Phone (406) 587-4910 • Fax (406) 587-4911 • email wavelength@imt net

TABLE OF CONTENTS

FEATURES

The FPC series of Laser Diode Drivers and Temperature Controllers offers any combination of the FPL and FPT series in one shielded package. In the following manual, "FPL" references the laser diode driver operation, and "FPT" references the temperature controller operation.

The FPL laser diode driver offers many unique features. These include:

- 250 mA, 500 mA, 1 Amp, 2.5 Amp and 5 Amp capacities
- Multiple Laser Diode protection schemes including:
  - Slow Start
  - Open Circuit Detection
  - Laser Diode Over Temperature Detection
  - Current Limit
  - FP Module Over Temperature Detection
  - Separate Power Inputs for Laser Diode to Limit Compliance Voltage
  - Mechanical Relay Shorts Laser Diode when FPL is Off
  - Error Sensing from FPT (TE Controller Module)
- Output Power Stability < 0.02% typical (24 hours)
- Operates all pin configurations of Laser Diodes
- Setpoint, Current Limit & Temp. Limit are user adjustable
- Low Profile Packaging
- Modulation in Constant Current and Constant Power
- Selectable modulation transfer function
- Selectable Photodiode sensitivity
- LED Indicators for easy troubleshooting
- Mounts to Metric or English Optical Breadboards
- Two Year Warranty

The FPT temperature controller offers many unique features. These include:

- Bipolar output, 2 or 4 Amps
- 10 V compliance with ± 15 VDC inputs
- Excellent stability
- "Smart" Integrator with full PID control
- Interfaces to Thermistors, IC sensors or RTDs
- Multiple Protection strategies
  - Sensor Open or Short Detection
  - TE cooler Current Limit
  - TE cooler Open Circuit Detection
  - FPT Over Temperature Detection
- Setpoint and Proportional Gain user adjustable
- Fully Adjustable Current Limit
- External Analog Input for spectroscopy or tunable laser diode control to scan temperature
- Mounts to Metric or English Optical Breadboards
- Two year Warranty

CUSTOMER SERVICE / WARRANTY

If you have any questions or comments, please call our technical staff at (406) 587-4910. Our hours are 8:00a.m. to 5:00p.m. MT.

Wavelength warrants this product for 2 years against defects in materials and workmanship when used within published specifications. This warranty extends only to purchaser and not to users of purchaser's products. If Wavelength receives written notice of such defects during the warranty period, we will either repair or replace products which prove to be defective. It is purchaser's responsibility to determine the suitability of the products ordered for it's own use. Wavelength makes no warranty concerning the fitness or suitability of its products for a particular use or purpose; therefore, purchaser should thoroughly test any product and independently conclude its satisfactory performance in purchaser's application. No other warranty exists either expressed or implied, and consequential damages are specifically excluded.

All products returned must be accompanied by a Return Material Authorization (RMA) number obtained from the Customer Service Department. Returned product will not be accepted for credit or replacement without our permission. Transportation charges or postage must be prepaid. All returned products must show invoice number and date and reason for return.

The FPC/FPL laser diode drivers can power Class IV laser diodes. Precautions should be taken to avoid exposure to the laser radiation. Do not stare directly into the beam or expose hands or other body parts to the beam. Before powering the laser diode, mount it securely and have beam dumps set up to catch both front and back facet outputs.

In the United States, the Food & Drug Administration is responsible for monitoring laser products. The FPC series has been registered as an OEM product. It does not comply with regulations. You must incorporate it into your system and that system must comply with federal regulations. Wavelength Electronics has experience with the government requirements. We can help you insure that your device is compliant. Please contact us if you have any questions.

POWER SUPPLY TURN ON:

CAUTION: Always apply V+ & V- by turning the AC power on at the power supply. Never use a toggle switch on the secondary of the power supply to apply V+ & V-. Since the two voltages may not come up simultaneously, you can damage the control electronics.

OPTIMIZE YOUR FPC

POWER SUPPLY AND NOISE:

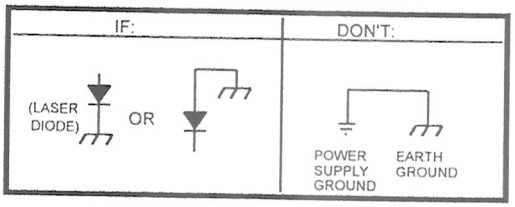
The control electronics are designed for low noise operation. The power supply you select will directly affect the noise performance of the driver. We recommend using regulated linear supplies for optimum performance. If you want to limit power consumption of the driver and increase safety of your laser diode, you can provide a ±12 or ±15V supply to the control electronics at low current and use a single supply at lower voltage to power the laser diode. [Page 14 describes how to connect power for either case.] For the temperature controller, if you use a separate supply for the TE cooler current, it can be unregulated. [Page 14 describes how to connect power for either case.] Depending on your requirements, you may be able to use a switching power supply for the thermoelectric. Each case must be evaluated as a switching power supply will affect noise, transient, and stability performance.
The following tables detail power supplies from Power One that properly operate the FPC series. You can contact the California plant at 1-(800) 678-9445:

DRIVER	DUAL POWER SUPPLY
FPL-250	HAD15-.4-A OR HAD12-.4-A
FPL-500	HBB15-1.5-A
FPL-1000	HBB15-1.5-A
FPL-2500	HCC15-3-A
FPL-5000	HDD15-5-A

TEMPERATURE CONTROLLER	POWER SUPPLY
FPT-2000	HCC15-3-A
FPT-4000	HDD15-5-A

GROUNDING:

CAUTION: The following chart details the difference between connecting grounds properly and improperly. **You can connect laser diode anode or cathode to earth ground, but DO NOT CONNECT POWER SUPPLY GROUND TO EARTH GROUND when earth grounding the laser.**

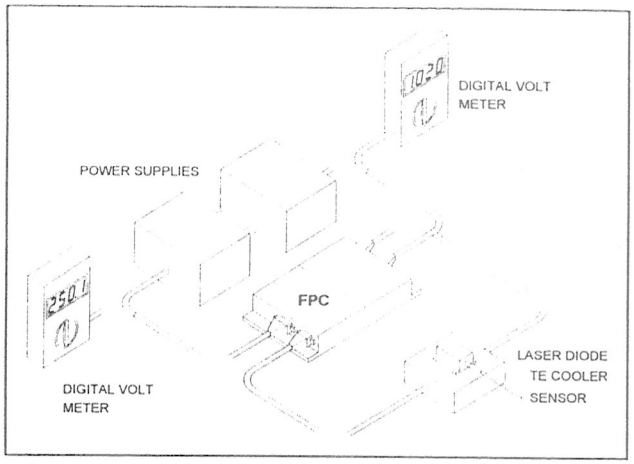


CAUTION: You may need to use separate power supplies for the laser diode driver and temperature controller sides of the FPC. If the TE cooler or thermistor is tied to the laser diode, you must use two separate power supplies and let each float independent of the other.

CAUTION! IF LASER DIODE AND PHOTODIODE ARE ISOLATED:

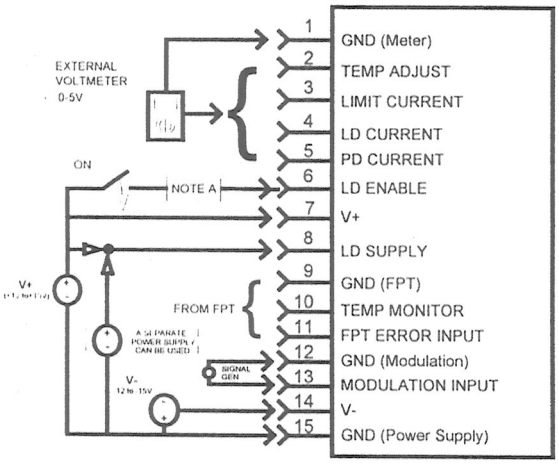
If you want to maintain isolation, tie a 1MΩ resistor between the laser diode anode and photodiode cathode. If isolation is not required, simply short the laser diode anode and photodiode cathode. If not tied, the photodiode voltage level can float beyond the input common mode voltage of the transimpedance amplifier, and the driver will not control properly.

The following is a sketch of the components you will need to operate the FPC, and a rough connection diagram. Much more detail is included in the PIN DESCRIPTION section, and you should review the entire manual before operating your TE cooler with the FPT or laser diode with the FPL.

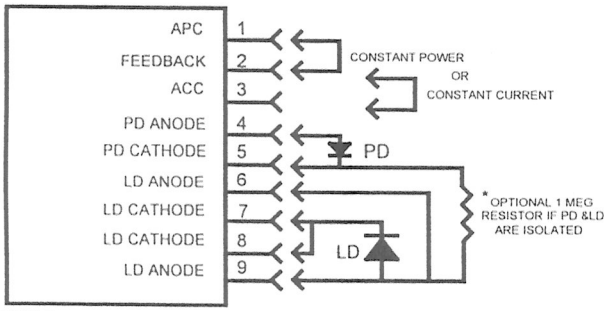


FPL LASER DIODE DRIVER CONNECTOR SETUP:

FPL INPUT CONNECTOR

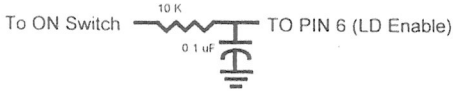


FPL OUTPUT CONNECTOR



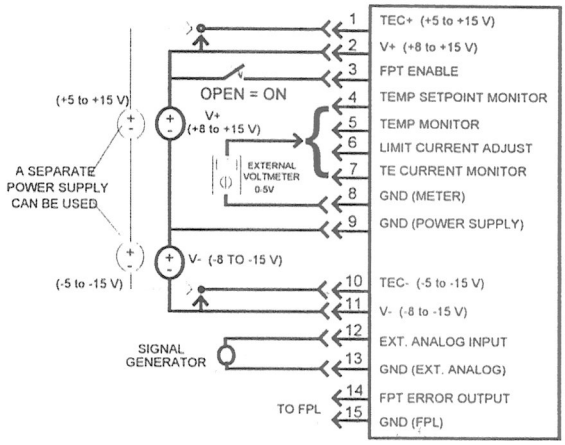
NOTE A

When connecting FPT to the FPL, the power supplies may not power up simultaneously. This RC circuit will slow start the LD ENABLE line and allow for both circuits to reach steady state operation. Adjust the R and C values to optimize for the power supplies used.

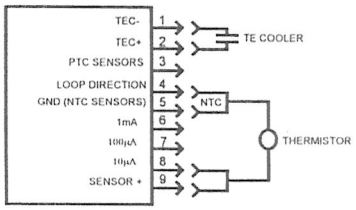


FPT TEMPERATURE CONTROLLER CONNECTOR SETUP:

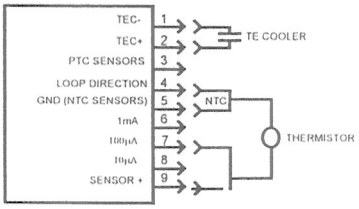
FPT INPUT CONNECTOR



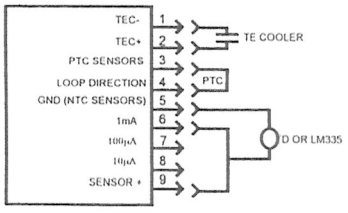
10 μA BIAS, NTC THERMISTOR



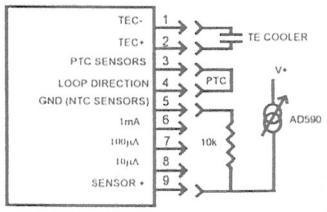
100 μA BIAS, NTC THERMISTOR



RTD OR LM335



AD590



FPL SERIES LASER DIODE DRIVER ELECTRICAL SPECIFICATIONS

Model Number	FPL-250	FPL-500	FPL-1000	FPL-2500	FPL-5000
Drive Current Output					
Output Current Range	**0 - 250 mA**	**0 - 500 mA**	**0 - 1 Amp**	**0 - 2.5 Amps**	**0 - 5 Amps**
Compliance Voltage ❶	> 6 V	> 6 V	> 6 V	> 6 V	> 6 V
Temperature Coefficient	< 100 ppm / °C	< 100 ppm / °C	< 100 ppm / °C	< 100 ppm / °C	< 100 ppm / °C
Short Term Stability (1 hr)	< 20 ppm	< 20 ppm	< 20 ppm	< 20 ppm	< 20 ppm
Long Term Stability (24 hrs.)	< 50 ppm	< 50 ppm	< 50 ppm	< 50 ppm	< 50 ppm
Noise and Ripple (μA rms)					
High Bandwidth Mode	< 5 μA	< 8 μA	< 10 μA	< 15 μA	< 20 μA
CW Mode ❷	< 1 μA	< 1 μA	< 3 μA	< 5 μA	< 5 μA
Current Limit Range	0 - 250 mA	0 - 500 mA	0 - 1 Amp	0 - 2.5 Amps	0 - 5 Amps
Current Limit Accuracy	10 mA	10 mA	10 mA	150 mA	150 mA
Photodiode Feedback					
Standard Range	50 - 2500 μA	50 - 2500 μA	50 - 2500 μA	50 - 2500 μA	50 - 2500 μA
Optional Range ❸	15 - 250 μA	15 - 250 μA	15 - 250 μA	15 - 250 μA	15 - 250 μA
Max. forward PD Bias voltage	0.125 V	0.125 V	0.125 V	0.125 V	0.125 V
Const. Power Output Stability	< 0.02 %	< 0.02 %	< 0.02 %	< 0.02 %	< 0.02 %
External Modulation (Constant Current)					
Input Impedance ❹	10 kΩ	10 kΩ	10 kΩ	10 kΩ	10 kΩ
Transfer Function	50 mA / V	100 mA / V	200 mA / V	500 mA / V	1000 mA / V
Optional Transfer Function ❸	5 mA / V	10 mA / V	20 mA / V	50 mA / V	100 mA / V
Bandwidth (3 dB) ❺					
High Bandwidth	DC - 300 kHz	DC - 200 kHz	DC - 150 kHz	DC - 100 kHz	DC - 50 kHz
CW Mode ❷	DC - 15 Hz	DC - 15 Hz	DC - 15 Hz	DC - 15 Hz	DC - 15 Hz
Depth of Modulation at 10kHz	90%	90%	90%	90%	90%
Power Supply Trip					
Power Up Trip Point ❻	11 V	11 V	11 V	11 V	11 V
Power Down Trip Point ❻	10 V	10 V	10 V	10 V	10 V

FPL GENERAL SPECIFICATIONS

Power Requirements ❼
±12 to ±15 VDC (±15.5V MAX)

Supply Current
200mA @ V+, 100mA @ V-
plus FPL's maximum LD current
@ Pin 8 on the input connector

Operating Temperature
0 to +50°C

Storage Temperature
-40 to +80°C

Connectors
9 and 15 pin D-sub receptacles
(cables need male plugs)

Warm-Up
1 hour to rated accuracy

Error Indicators
One green, one red LED

❶ Compliance Voltage will vary depending on power supply voltages; a maximum compliance voltage of 10 volts will be obtained with 15 volts input.

❷ When used with Model CAL-102 OR CAC-302 low-noise filter cable.

❸ Optional Photodiode Range and External Modulation Transfer Function must be specified at time of order.

❹ Impedance is 100kΩ when using the optional transfer function

❺ Modulation bandwidth in Constant Power mode will depend on photodiode response.

❻ The FPL series has internal control circuitry which turns the output on and off depending on voltage at pin 7 (V+ on the input connector). When the voltage reaches the power up voltage, the module soft starts the laser diode. When the voltage reaches the power down trip point, the module shunts current around the laser diode, powering it down in a controlled fashion.

❼ If thermistor and laser diode are case common, the FPL and FPT series power supplies must be isolated from each other.

FPT TEMPERATURE CONTROLLER ELECTRICAL SPECIFICATIONS

Model Number	FPT-2000	FPT-4000
Temperature Control		
Temp. Control Range, ❶	-99 to +150°C	-99 to +150°C
Short Term Stability, 1 hr. ❷	< 0.002°C	< 0.002°C
Long Term Stability, 24 hr. ❷	< 0.005°C	< 0.005°C
TE Cooler Output		
Bipolar Output Current	± **2 A**	± **4 A**
Compliance Voltage ❸	>± 8 V	>± 8 V
Maximum Output Power	20 W	40 W
Current Limit Range	50-2000 mA	50-4000 mA
Control Loop	Smart Integrator, Hybrid PID	Smart Integrator, Hybrid PID
Integrator Time Constant	0.5 seconds	0.5 seconds
Temperature Sensors		
Thermistor Types (2 wire)	NTC	NTC
Thermistor Sensing Current	10 µA & 100 µA	10 µA & 100 µA
Thermistor Range	1 kΩ - 500 kΩ	1 kΩ - 500 kΩ
IC Sensor Types ❹	AD590, LM335	AD590, LM335
IC Sensor Bias (LM335)	1 mA	1 mA
RTD Types (2 wire)	100, 500 or 1000 Ω	100, 500 or 1000 Ω
RTD Sensor Current	1 mA	1 mA

FPT GENERAL SPECIFICATIONS

Power Requirements ❺
±8 to ±15 VDC (±15.5V MAX)

Supply Current
200mA @ V+, 100mA @ V- plus FPTs maximum TE module output current @ Pins 1 and 10 on input connector

Operating Temperature
0 to +50°C

Storage Temperature
-40 to +80°C

Connectors
9 & 15 pin D-sub plugs (cables need female receptacles)

Warm-up
1 hour to rated accuracy

Power Indicator
One green, one red LED

❶ Temperature Range depends on the physical load, sensor type and TE module used.
❷ Stability quoted for a typical 10 kΩ thermistor at 100 µA sensing current.
❸ Compliance Voltage will vary depending on input voltages. A maximum compliance voltage of ±10 volts will be obtained with ±15 volts input.
❹ AD590 requires an external bias voltage and 10kΩ resistor.
❺ If thermistor and laser diode are case common, the FPL and FPT power supplies must be isolated from each other.

Laser Diode Input Connector (15 pin D-sub)		Laser Diode Output Connector (9 pin D-sub)	
Pin #	Description	Pin #	Description
1	GND (For Pins 2-5)	1	Constant Power
2	Temp. Adjust Monitor	2	Feedback
3	Limit Current Monitor	3	Constant Current
4	LD Current Monitor	4	PD Anode
5	PD Current Monitor	5	PD Cathode
6	LD Enable	6, 9	LD Anode
7	V+	7, 8	LD Cathode
8	LD Supply		
9	GND (for pins 10 and 11)		
10	Temp. Monitor Input		
11	FPT Error Input		
12	GND (For pin 13)		
13	Modulation Input		
14	V-		
15	GND (High Current)		

Laser Diode Input Connector (15 pin receptacle)

Pins 1, 9, 12 GROUNDS- LOW CURRENT ONLY:

These pins provide access to the grounds of the monitor outputs and modulation and temperature inputs. While they are tied together, all grounds are starred on the PCB and you will optimize performance by using the ground pin paired with a specific function. **CAUTION: DO NOT USE ANY OF THESE GROUNDS FOR THE POWER SUPPLY. THEY ARE NOT DESIGNED TO CARRY MORE THAN 200mA.**

Pin 2 TEMP ADJUST MONITOR:

This output is used in setting the laser diode over temperature point. This output ranges from 0-5V. The setting will depend on the temperature sensor you are using. If you do not want to use either the FPT or TEC sensor output signal, you may provide a 0-5V signal from an appropriate temperature dependent sensor. Call our technical support team at (406) 587-4910 for more information on including an external temperature sensor.

Pin 3 LIMIT CURRENT MONITOR:

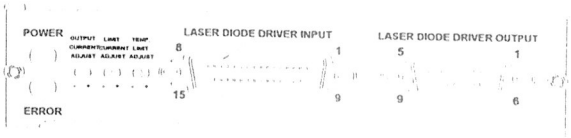
This output is used in setting the maximum current to the laser diode. The transfer function is 0.1mA/mV for 250mA, 500mA, and 1000mA current sources (FPL-250, FPL-500, FPL-1000). The transfer function is 1mA/mV for the FPL-2500 and FPL-5000.

Pin 4 LD CURRENT MONITOR:

This output is used to monitor the current through the laser diode. The transfer function is 0.1mA/mV for 250mA, 500mA, and 1000mA current sources (FPL-250, FPL-500, FPL-1000). The transfer function is 1mA/mV for the FPL-2500 and FPL-5000.

Pin 5 PD CURRENT MONITOR:

This output is used to monitor the current from the photodiode. The standard transfer function is 1μA/mV and 0.1μA/mV for the optional range.



Pin 6 LASER DIODE ENABLE:

This pin controls the status of the laser diode current source. If this input floats or is grounded, the laser diode will be disabled. To enable the laser diode, this voltage must be between 3V and V+. This can be as simple as connecting a switch between V+ (pin 7) and pin 6, or including a complex interlock system. Several errors are latched and require the enable input to be toggled.

When the laser diode current source is disabled, the laser diode is shorted by the mechanical relay, the output setpoint is brought to 0V, the current source is reduced to a low standby current, and the residual current is shunted through the control FET.

If the FPL is being used in conjunction with a FPT, a RC delay circuit shown on page 4 might need to be connected to the LD ENABLE pin depending on the power supply configurations.

Pin 7 V+ (+12 to +15V):

This input along with pin 14 (V-) and pin 15 (GND) provides power to the control electronics.

Pin 8 LD SUPPLY (+8 to +15):

This input along with pin 15 (GND) provides power to the laser diode current source. It can either be tied to pin 7 or a separate power supply can be used.

Pin 10 TEMP MONITOR INPUT:

This pin accepts a 0-5V temperature dependent voltage input (NTC) and is used to monitor the temperature of the laser diode. If the voltage at the pin falls below the setpoint voltage at pin 2, the unit will be disabled due to an OVER TEMPERATURE ERROR [see Page 8 for details]. If not used, this input should be allowed to float. [This pin can be configured for PTC sensors at the factory.] Pin 5 of the FPT (Temperature Monitor Output) can be attached to this input.

CAUTION: IF THE THERMISTOR OR TE COOLER IS CONNECTED TO THE LASER DIODE, DO NOT USE THIS INPUT UNLESS YOU EXTERNALLY OPTICALLY ISOLATE THE SIGNAL. ALSO, DO NOT OPERATE THE FPT AND FPL POWER SUPPLIES FROM THE SAME GROUND.

Pin 11 FPT ERROR INPUT:

If you are using an FPT series temperature controller, an error on the FPT will be coupled through this pin. An error is indicated when the voltage at this pin is less than 1.5V. If not used, this input should be allowed to float.

CAUTION: IF THE THERMISTOR OR TE COOLER IS CONNECTED TO THE LASER DIODE, DO NOT USE THIS INPUT UNLESS YOU EXTERNALLY OPTICALLY ISOLATE THE SIGNAL. ALSO, DO NOT OPERATE THE FPT AND FPL POWER SUPPLIES FROM THE SAME GROUND.

Pin 13 MODULATION INPUT:

This input is DC coupled to accept an analog control voltage. ***IF THIS INPUT IS NOT USED, TIE PIN 12 TO PIN 13 AT THE CONNECTOR.*** The frequency and duty cycle of the input will directly affect the laser diode, limited only by the 3dB frequency of the module [see Page 5 for specifications]. Two transfer functions are available. Specify the desired conversion at the time you order, or call our technical staff at (406) 587-4910 for instructions.

Pin 14 V- (-12 to -15V):

This input along with pin 7 (V+) and pin 15 (GND) provides power to the control electronics.

Pin 15 GND (High Current Return):

This pin along with pin 8 (LD SUPPLY) provides power to the laser diode. It is also used with pins 7 and 14 to power the control electronics. This is the only ground connection designed for high current.

Laser Diode Output Connector (9 pin receptacle)

Pins 1, 2, 3 CONSTANT POWER, FEEDBACK, CONSTANT CURRENT:

These pins configure the operating mode of the FPL and should be shorted at the connector. If pins 1 and 2 are shorted, the unit will run in Constant Power mode and a photodiode is required. If pins 2 and 3 are shorted, the driver will operate in Constant Current mode. If pin 2 is not connected to either pin 1 or 3, the laser diode cannot be enabled.

Pin 4 PD ANODE:

This pin should be connected to the photodiode anode.

Pin 5 PD CATHODE:

This pin should be connected to the photodiode cathode.

Pins 6 and 9 LD ANODE:

Both pins should be connected to the laser diode anode. The dual connections are designed to reduce the risk of an accidental open circuit to the laser diode. If the connector is rocked back and forth, the connection to the laser diode should remain unbroken.

Pins 7 and 8 LD CATHODE:

Both pins should be connected to the laser diode cathode. The dual connections are designed to reduce the risk of an accidental open circuit to the laser diode. If the connector is rocked back and forth, the connection to the laser diode should remain unbroken.

FPL ERROR AND INDICATOR LEDS

LED	*Standard Operation*	*Laser Disabled*	*Open Circuit*	*Over Temp*	*Current Limit*
Power (Green)	ON	FLASH (1 sec)	FLASH (1 sec)	FLASH (1 sec)	ON
Error (Red)	OFF	OFF	FLASH (1/2 sec)	FLASH (1 sec)	ON

OPEN CIRCUIT DETECTED:

If an open circuit of the laser diode is detected, the laser current source is disabled, and latches the relay across the laser diode outputs. The GREEN LED will flash at a one second interval and the RED LED will flash twice as fast. You have to toggle the enable (input pin 6) to restart the laser diode. This detection feature is designed to protect against accidental damage to the laser diode when first turning it on and to serve as an indicator of a wiring problem. **IF THE LASER DIODE OPEN CIRCUITS DURING OPERATION, THIS DETECTION CIRCUIT WILL PROTECT THE LASER DIODE ONLY IF THE CIRCUIT REMAINS OPEN WHEN THE PROTECTION CIRCUIT IS TURNING THE LASER OFF. THE LASER DIODE WILL LIKELY BE DESTROYED BY THE TRANSIENTS CAUSED BY AN OPEN CIRCUIT DURING OPERATION IF THE LASER DIODE IS CONNECTED AGAIN DURING THE OPEN CIRCUIT SHUT DOWN (APPROX. 200μSEC).** IT IS IMPERATIVE THAT GOOD CONNECTION BE MAINTAINED DURING LASER DIODE OPERATION.

LASER DIODE OVER TEMPERATURE DETECTED:

If you have interfaced the FPL to either the FPT or TEC series of temperature controllers, or provided an appropriate temperature dependent input [see Page 7 for details], and if the laser diode reaches the critical pre-set temperature limit, the current source is disabled and the relay latches across the laser diode. The GREEN LED and RED LED will flash at one second intervals. The laser diode Enable input must be toggled to restart the laser. This detection protects the laser diode from thermal runaway conditions and other temperature related problems.

CURRENT LIMIT:

If this condition exists, the output current feedback loop is saturated so the current through the laser diode is driven only by the limit circuit. Both LEDs will be lit.

MODULE OVER TEMPERATURE:

Since the FPL is configured to use custom heatsinking, a thermistor is embedded in the case near the components that are subject to thermal problems if the heat of the module is not properly dissipated. If the module temperature exceeds 100°C, the laser diode will be disabled, but not latched off. Once the FPL cools down, the laser current will slow start to the set point.

FPT PIN DESCRIPTIONS

FPT Input Connector (15 pin D-sub)		FPT Output Connector (9 pin D-sub)	
Pin #	Description	Pin #	Description
1	TEC+	1	TEC-
2	V+	2	TEC+
3	FPT Enable	3	PTC Sensor
4	Temp Setpoint Monitor	4	Loop Direction
5	Temp Monitor	5	GND (NTC Sensor)
6	Limit Current Adjust	6	1mA
7	TE Current Monitor	7	100µA
8	GND (For pins 4-7)	8	10µA
9	GND (High Current Return)	9	Sensor +
10	TEC-		
11	V-		
12	External Analog Input		
13	GND (For pin 12)		
14	FPT Error Output		
15	GND (For pin 14)		

FPT Input Connector (15 pin plug)

Pins 8, 13, 15 GROUNDS- LOW CURRENT ONLY: These pins provide access to the grounds of the monitor outputs and external analog input and temperature inputs. While they are tied together, all grounds are starred on the PCB and you will optimize performance by using the ground pin paired with a specific function. **CAUTION: DO NOT USE ANY OF THESE GROUNDS FOR THE POWER SUPPLY. THEY ARE NOT DESIGNED TO CARRY MORE THAN 200mA.**

Pin 1 TEC+ (+5 to +15V): This input along with pin 10 (TEC-) and pin 9 (GND) provides power to the TE Cooler. It can either be tied to pin 2 or a separate power supply can be used.

Pin 2 V+ (+8 to +15V): This input along with pin 11 (V-) and pin 9 (GND) provides power to the control electronics.

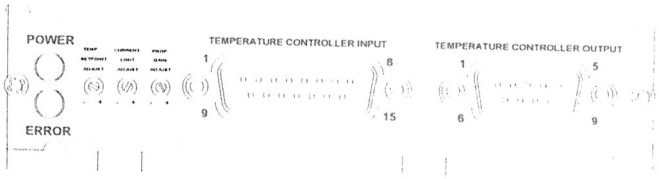
Pin 3 FPT ENABLE: This pin controls the status of the TE cooler current source. If this input floats or is grounded, the TE Cooler will be enabled. To enable the current to the TE Cooler, this voltage must be less than 2.5V. When the TE Cooler current source is disabled, the current source is reduced to a low standby current.

Pin 4 TEMP SETPOINT MONITOR: This output is used in setting the temperature setpoint of the sensor. Depending on the type of sensor used, this voltage can range from 0-5V and should match the voltage across the sensor when it is at the desired temperature.

Pin 5 TEMP MONITOR: This output is used to monitor the voltage, and therefore temperature, of the sensor. When controlled, the sensor voltage will equal the voltage set at pin 4.

Pin 6 LIMIT CURRENT ADJUST: This output is used in setting the maximum current to the TE Cooler. The transfer function is 1mA/mV.

Pin 7 TE COOLER CURRENT MONITOR: This output is used to monitor the current through the TE Cooler. The transfer function is 1mA/mV.



Pin 9 GND (High Current Return): This pin along with pins 1 and 10 (TEC+ and TEC-) provides power to the TE Cooler. It is also used with pins 2 and 11 (V+ and V-) to power the control electronics. This is the only ground connection designed for high current.

Pin 10 TEC- (-5 to -15V): This input along with pin 1 (TEC+) and pin 9 (GND) provides power to the TE Cooler. It can either be tied to pin 11 or a separate power supply can be used.

Pin 11 V- (-8 to -15V): This input along with pin 2 (V+) and pin 9 (GND) provides power to the control electronics.

Pin 12 EXTERNAL ANALOG INPUT: This input is DC coupled to accept an analog control voltage in the range of ±10V. If this input is not used, tie pin 12 to pin 13 at the input connector. Do not jumper with wires longer than 6". The transfer function for this input is 1 V/V.

Pin 14 FPT ERROR OUTPUT: If you are using an FPL series laser diode driver, an error on the FPT will be coupled through this pin. An error is indicated when this pin is less than 1.5V.

IF THE THERMISTOR OR TE COOLER IS CONNECTED TO THE LASER DIODE, DO NOT USE THIS OUTPUT UNLESS YOU EXTERNALLY OPTICALLY ISOLATE THE SIGNAL. ALSO, DO NOT OPERATE THE FPT AND FPL POWER SUPPLIES FROM THE SAME GROUND.

FPT Output Connector (9 pin plug)

Pin 1 TEC-: This pin should be connected to the negative input of the TE Cooler.

Pin 2 TEC+: This pin should be connected to the positive input of the TE Cooler.

Pins 3, 4, 5 PTC SENSORS, LOOP DIRECTION, GND (NTC SENSORS): These pins are used to determine the direction of the feedback loop. If an RTD, LM335, or AD590 will be used, pins 3 and 4 should be shorted, indicating that PTC Sensors are in use. If thermistors (or other NTC sensors) are being used, pins 4 and 5 should be tied. CAUTION: Connections between pins 3 & 4 or 4 & 5 must be made at the output connector. Do not jumper these pins with wires longer than 6".

Pins 6, 7, 8, 9 1mA, 100µA, 10µA, SENSOR +: These pins are used to determine the reference current through the temperature sensor. If pins 6 and 9 are connected, 1mA of current will flow through the sensor. Likewise, if pins 7 and 9 are tied, 100µA flows, and if pins 8 and 9 are tied, 10µA flows though the sensor. For a thermistor, either pin 7 or 8 should be tied to pin 9. For an LM335 or RTD, pin 6 should be tied to pin 9. For an AD590, a 10kΩ resistor should be tied between pins 5 and 9, the negative terminal of the AD590 should be tied to pin 9, and the positive terminal to V+.

FPT ERRORS AND INDICATOR LEDs

LED	Standard Operation	TE Current Disabled	Sensor Open or Short	Open Circuit	Current Limit
Power (Green)	ON	FLASH (1 sec)	FLASH (1 sec)	ON	ON
Error (Red)	OFF	ON or OFF	FLASH (1 sec)	FLASH (1/2 sec)	ON

SENSOR OPEN OR SHORT:

If the temperature input voltage is greater than 5V or less than 0.1V, the FPT interprets that the sensor is either open or shorted. The bipolar current source will be temporarily disabled and the event will trigger an FPT error output signal that can interface to the FPL. This error is not latched; if the error is removed, current will flow again through the TE Cooler.

OPEN CIRCUIT DETECTED:

If an open circuit at the TE Cooler is detected, the POWER LED will remain green and the ERROR LED will flash red at a 0.5 second rate. The event will trigger an FPT error output signal that can interface to the FPL.

MODULE OVER TEMPERATURE:

Since the FPT is configured to use custom heatsinking, a thermistor is embedded in the case near the components that are subject to thermal problems if the heat of the module is not properly dissipated. If the module temperature exceeds 100°C, the TE cooler will be disabled, but not latched off. Once the FPT cools down, the current to the TE cooler will slow start. The event will trigger an FPT error output signal that can interface to the FPL.

CURRENT LIMIT:

If this condition exists, only the limit current will flow through the TE Cooler. If the output is disabled, the current limit error may be triggered.

SYSTEM CONFIGURATION GUIDE

FPL, FPT, FPC SERIES STANDARD CONFIGURATIONS AND SELECTION GUIDE: Any combination of two controllers (FPL Laser Diode Driver or FPT TE Temperature Controller) will mount inside the FPC package.

Please contact factory for special configurations.

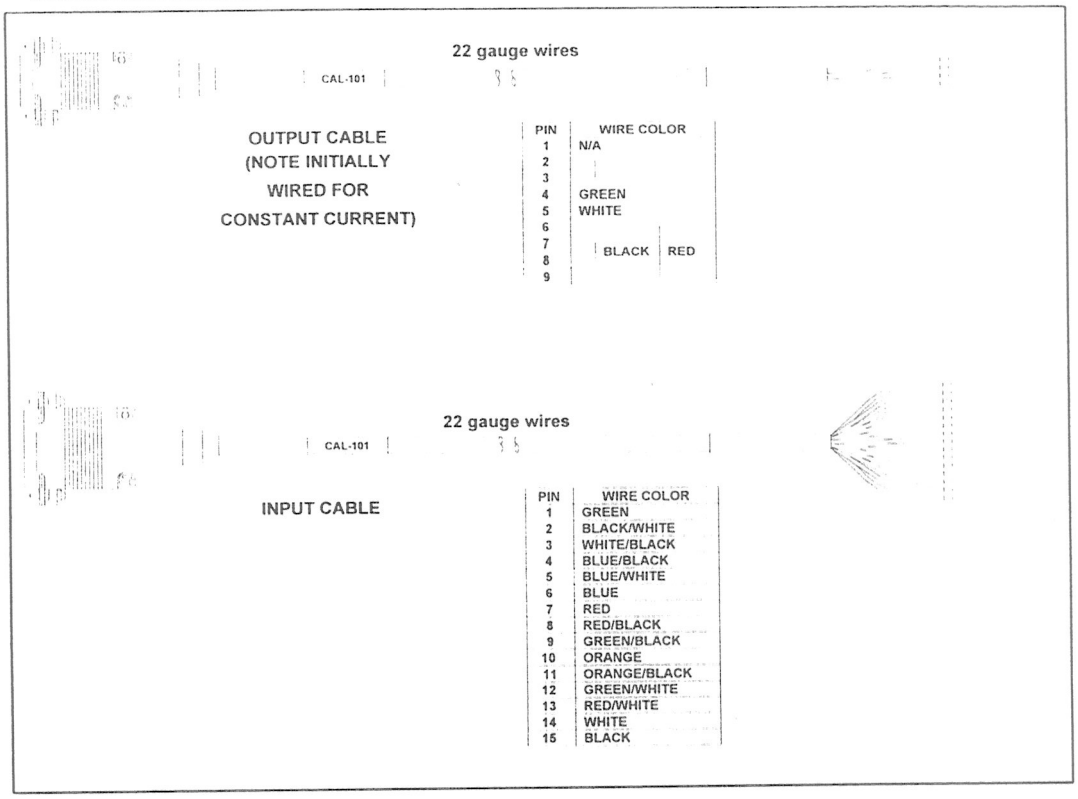
Laser Diode / TE Temp. Controller guide for FPC combination modules:	*Laser Diode Driver* **FPL-250** *250 mA*	*Laser Diode Driver* **FPL-500** *500 mA*	*Laser Diode Driver* **FPL-1000** *1 Amp*	*Laser Diode Driver* **FPL-2500** *2.5 Amp*	*Laser Diode Driver* **FPL-5000** *5 Amp*
2 Amp TE Temp. Controller **FPT-2000**	**FPC-250-2**	**FPC-500-2**	**FPC-1000-2**	**FPC-2500-2**	**FPC-5000-2**
4 Amp TE Temp. Controller **FPT-4000**	**FPC-250-4**	**FPC-500-4**	**FPC-1000-4**	**FPC-2500-4**	**FPC-5000-4**

ACCESSORIES AVAILABLE FOR SYSTEM DEVELOPMENT: Three types of accessories are available, connector kits, cable assemblies and low noise cable assemblies. Connector kits include the appropriate 9 pin & 15 pin D-sub connectors, hoods and hardware. Cable assemblies include one meter of unterminated cable assembled with connector kits. Low noise cable assemblies add a filter for reducing noise when used with most FPL Laser Diode Drivers in CW mode.

	FPL	FPT	FPC
Connector Kits	CKL-100	CKT-200	CKC-300
Cable Assy.	CAL-101	CAT-201	CAC-301
Low-Noise Cable Assy.	CAL-102	Not available	CAC-302

The following page details the cables and their pinouts.

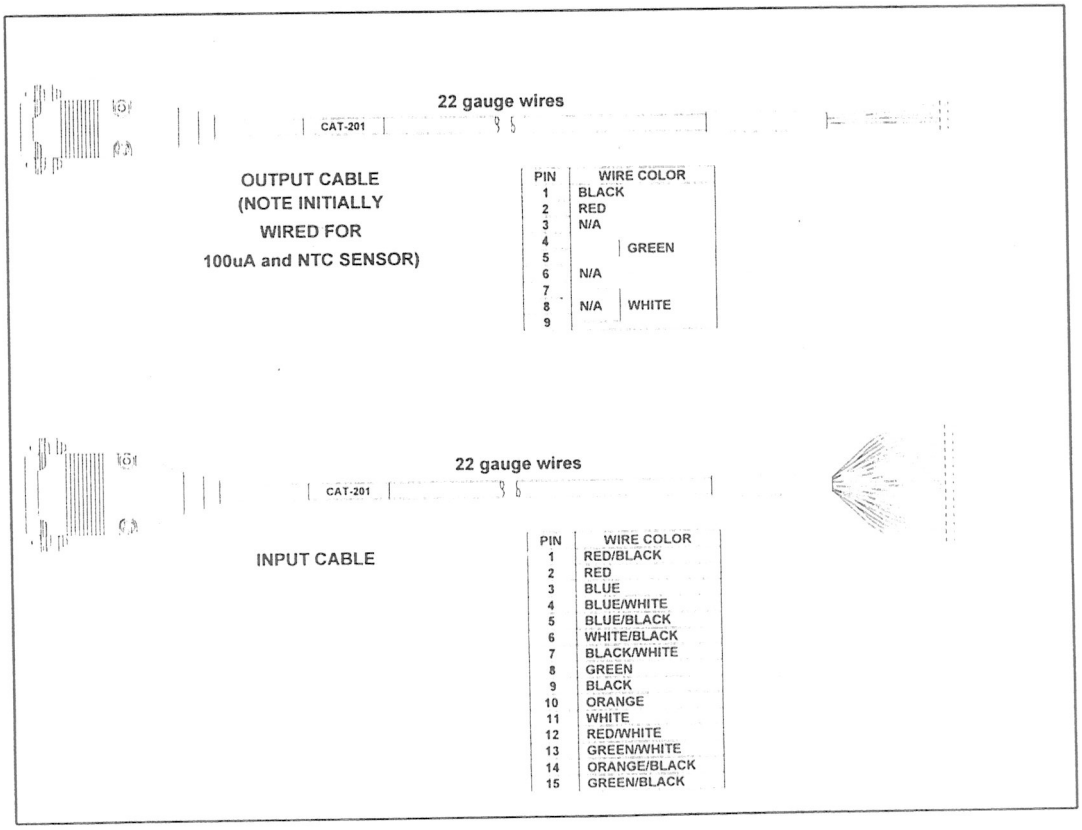
CAL-101 FPL CABLE ASSEMBLY



PIN	WIRE COLOR
1	N/A
2	
3	
4	GREEN
5	WHITE
6	
7	BLACK
8	RED
9	

PIN	WIRE COLOR
1	GREEN
2	BLACK/WHITE
3	WHITE/BLACK
4	BLUE/BLACK
5	BLUE/WHITE
6	BLUE
7	RED
8	RED/BLACK
9	GREEN/BLACK
10	ORANGE
11	ORANGE/BLACK
12	GREEN/WHITE
13	RED/WHITE
14	WHITE
15	BLACK

CAT-201 FPT CABLE ASSEMBLY



PIN	WIRE COLOR
1	BLACK
2	RED
3	N/A
4	
5	GREEN
6	N/A
7	
8	N/A WHITE
9	

PIN	WIRE COLOR
1	RED/BLACK
2	RED
3	BLUE
4	BLUE/WHITE
5	BLUE/BLACK
6	WHITE/BLACK
7	BLACK/WHITE
8	GREEN
9	BLACK
10	ORANGE
11	WHITE
12	RED/WHITE
13	GREEN/WHITE
14	ORANGE/BLACK
15	GREEN/BLACK

Note: The CAC-301 is the combination of one CAL-101 and one CAT-201 cable assemblies.

The FPC/FPL laser diode drivers can power Class IV laser diodes. Precautions should be taken to avoid exposure to the laser radiation. Do not stare directly into the beam or expose hands or other body parts to the beam. Before powering the laser diode, mount it securely and have beam dumps set up to catch both front and back facet outputs.

In the United States, the Federal Drug Administration is responsible for monitoring laser products. These products must comply with certain requirements in order to be sold to an end user. The FPC/FPL series has been registered as an OEM product. It does not comply with regulations. You must incorporate it into your system and that system must comply with federal regulations. Wavelength Electronics has experience with the government requirements. We can help you insure that your device is compliant. Please contact us if you have any questions.

1. ESTABLISH THERMAL CONTROL

A heatsink must be properly attached to the FPC in order to remove heat from the module. The following drawing shows where the heat sensitive components are located. Thermally conductive grease should be used between the heatsink and the critical heat transfer zone for optimum performance.

First, calculate the maximum power that will be dissipated by the FPL unit with one of the following equations:

For FPL-250, 500, 1000:

$$P_{FPLunit} = [V_{LDsupply} - V_{load}]*I_{lim} + [I_{lim} - I_{load}]*V_{load} + \frac{(I_{lim})^2 + (I_{load})^2}{2}$$

For FPL-2500, 5000:

$$P_{FPLunit} = [V_{LDsupply} - V_{load}]*I_{lim} + [I_{lim} - I_{load}]*V_{load} + \frac{(I_{lim})^2 + (I_{load})^2}{10}$$

where $P_{FPLunit}$ is the power dissipated in the FPL in watts, I_{lim} is the limit current for the laser diode in amps, V_{load} is the voltage across the laser diode during operation in volts, and $V_{LDsupply}$ is the voltage at pin 8 on the input connector.

Then, calculate the maximum power that will be dissipated by the FPT unit with the following equation:

$$P_{FPTunit} = [V_{TE} - V_{TEC}]*I_{lim} + \frac{(I_{lim})^2}{10}$$

where $P_{FPTunit}$ is the power dissipated in the FPT in watts, I_{lim} is the limit current for the TE Cooler in amps, V_{TE} is the voltage input at either pin 1 or 10 of the input connector (TEC+, TEC-), and V_{TEC} is the voltage across the TE Cooler.

Add $P_{FPLunit}$ and $P_{FPTunit}$ to find $P_{FPCunit}$ (the power dissipated in the FPC in watts).

$$P_{FPCunit} = P_{FPLunit} + P_{FPTunit}$$

Now, calculate the allowed rate of temperature increase with:

$$RATE = \frac{70}{P_{FPCunit}}$$

where RATE is in °C/W.

For example, if $P_{FPCunit}$ is 60W, RATE is 70/60 or 1.17°C/W. Adding a safety factor, in this example, you should select a heatsink with 0.9°C/W rating.

2. WIRE FPT 15 PIN INPUT CONNECTOR

⚠ **CAUTION**: Always apply V+ & V- by turning the AC power on at the power supply. Never use a toggle switch on the secondary of the power supply to apply V+ & V-. Since the two voltages may not come up simultaneously, you can damage the control electronics.

First, wire the 15 pin input receptacle. If you are using a prebuilt cable assembly, refer to page 12 for the wire color legend. You can use one power supply for both the control electronics and TE Cooler current, or use separate power supplies. For one power supply:

Short V+ to TEC+ (pin 2 to pin 1) and short V- to TEC- (pin 11 to pin 10). Connect the positive supply (+8 to +15V) to pin 2, the negative supply (-8 to -15V) to pin 11, and GND to pin 9.

Otherwise, to use two power supplies:
Connect one positive power supply (+8 to +15V) to pin 2, one negative supply (-8 to -15V) to pin 11, and GND to pin 9. Connect the second bipolar power positive supply to pin 1 (TEC+, +5 to +15V), the negative supply to pin 10 (TEC-, -5 to -15V), and GND to pin 9.

After the power supply is wired, add the connection to FPT ENABLE (pin 3).

If you are interfacing to an FPL, make the FPT ERROR OUPUT (pin 14) connection now. Tie pin 11 of the FPL input cable to pin 14 of the FPT input cable (FPT ERROR OUTPUT) and tie pin 9 of the FPL input cable (GND) to pin 15 of the FPT input cable. Also make the connection to the TEMP MONITOR INPUT. Tie pin 10 of the FPL to pin 5 (TEMP MONITOR) of the FPT. **NOTE: IF THE THERMISTOR OR TE COOLER IS TIED TO THE LASER DIODE, THE POWER SUPPLIES OF THE FPT AND FPL MUST BE SEPARATE, AND THESE SIGNALS MUST BE EXTERNALLY OPTICALLY ISOLATED.**

If you will externally control the temperature setpoint, connect the signal to pins 12 and 13 (GND) of the FPT input connector. For monitoring purposes, have a DVM available to read pins 4-7. Pin 8 should be tied to the common input of the DVM.

3. WIRE FPT 9 PIN OUTPUT CONNECTOR

First, configure the output for your sensor.

THERMISTOR

Short pins 4 and 5 at the output connector. Depending on the value of thermistor and the temperature range you will be operating over, select operation with either 100µA or 10µA. To operate with a 100µA reference current, short pins 7 and 9. To operate with a 10µA reference current, short pins 8 and 9. Wire the thermistor between pins 4 and 9.

LM335 or RTD

Short pins 3 and 4 at the output connector. Short pins 6 and 9 to operate with a 1mA bias current. Tie the sensor between pins 5 and 6.

AD590

Connect a 10kΩ resistor between pins 9 and 5. Tie pin 9 to the negative terminal of the AD590 and V+ to the positive terminal.

4. INSTALL TE COOLER AND SET UP CURRENT LIMIT

Connect the TE Cooler between pins 1 (TEC-) and 2 (TEC+). Monitor pin 6 of the input connector with the DVM. Using the 1 mA/mV transfer function, calculate the proper voltage for the maximum current flow through the TE Cooler. [This should be below the maximum specification of the cooler.] With the TE Cooler disabled, rotate the middle potentiometer clockwise until the DVM reads the desired voltage.

5. SET UP OPERATING TEMPERATURE

Monitor pin 4 (TEMP SETPOINT MONITOR) of the input cable with the DVM. Based on your selection of sensor, determine the voltage across the sensor when it is at the desired operating temperature. This should be between 0.1V and 5V. Enable current to the TE Cooler. Slowly adjust the TEMP SETPOINT ADJUST potentiometer until the voltage monitored by the DVM is at the calculated level. The unit will be in CURRENT LIMIT until the temperature is close to the setpoint.

6. ADJUST PROPORTIONAL TERM

The proportional term is optimized for small loads. If the load does not settle, then adjust the proportional gain potentiometer to optimize for overshoot and settling. Once the proportional gain is adjusted, briefly disable the output to reset the integrator time constant.

7. WIRE FPL 15 PIN INPUT CONNECTOR

First, wire the 15 pin input plug. If you are using a prebuilt cable assembly, refer to page 12 for the wire color legend. You can use one power supply for both the control electronics and laser diode current, or use separate power supplies.
For one power supply:

Short V+ to LD SUPPLY (pin 7 to pin 8). Connect V+ (+12 to 15 V) to pin 7, V- (-12 to -15 V) to pin 14, and GND to pin 15.

Otherwise, to use two power supplies:

Connect V+ (+12 to 15 V) to pin 7, V- (-12 to -15 V) to pin 14, and GND to pin 15. Connect the second power supply (lower voltage, high current) to pin 8 (LD SUPPLY).

After the power supply is wired, add the connection to LD ENABLE (pin 6). See the special note in the Quick Start section when combining an FPL laser diode driver and FPT thermoelectric controller.

If you are interfacing to the FPT, make the FPT ERROR INPUT connection now. Tie pin 11 of the FPL input cable to pin 14 of the FPT input cable (FPT ERROR OUTPUT) and tie pin 9 of the FPL input cable (GND) to pin 15 of the FPT input cable. Also make the connection to the TEMP MONITOR INPUT. Tie pin 10 of the FPL to pin 5 (TEMP MONITOR) of the FPT. NOTE: IF THE THERMISTOR OR TE COOLER IS TIED TO THE LASER DIODE, THE POWER SUPPLIES OF THE FPT AND FPL MUST BE SEPARATE, AND THESE SIGNALS MUST BE EXTERNALLY OPTICALLY ISOLATED.

If you will modulate the laser diode, connect the signal to pins 13 and 12 (GND) of the FPL input connector. ***IF THE MODULATION INPUT WILL NOT BE USED, TIE PIN 13 TO PIN 12 AT THE INPUT CONNECTOR.***

For monitoring purposes, have a DVM available to read pins 2-5. Pin 1 should be tied to the common input of the DVM.

8. WIRE FPL 9 PIN OUTPUT CONNECTOR

First, configure the mode of operation. If you will run in Constant Power mode, short pins 1 and 2 together. Leave pin 3 floating. Connect the photodiode to pins 4 and 5. If you will run in Constant Current mode, short pins 2 and 3 together and leave pin 1 floating.

If the laser diode and photodiode are isolated and you want to maintain isolation, tie a 1MΩ resistor between the laser diode anode and photodiode cathode. If isolation is not required, simply short the laser diode anode and photodiode cathode. If not tied, the photodiode voltage level can float beyond the input common mode voltage of the transimpedance amplifier, and the driver will not control properly.

9. SET UP CURRENT LIMIT ROUGHLY

Monitor pin 3 of the input connector with the DVM. Using the appropriate transfer function (0.1mA/mV for FPL-250, FPL-500, and FPL-1000 or 1mA/mV for FPL-2500 and FPL-5000), calculate the proper voltage for the maximum current flow through the laser diode. [This should be well below the damage threshold of the diode.] With a jumper instead of the laser diode installed, and the laser diode enabled, rotate the middle potentiometer clockwise until the DVM reads the desired voltage.

10. SET UP TEMPERATURE LIMIT

Monitor pin 2 of the input connector with the DVM. Determine the voltage the temperature sensor will produce at the maximum operating temperature of the laser diode and rotate the potentiometer on the right [TEMP LIMIT ADJUST] clockwise until the DVM reads the desired voltage. Now power down the unit.

11. INSTALL LASER DIODE AND SET UP OPERATING CURRENT

Without power applied to the unit, connect the laser diode anode to pins 6 and 9 of the output connector. Connect the cathode to pins 7 and 8.

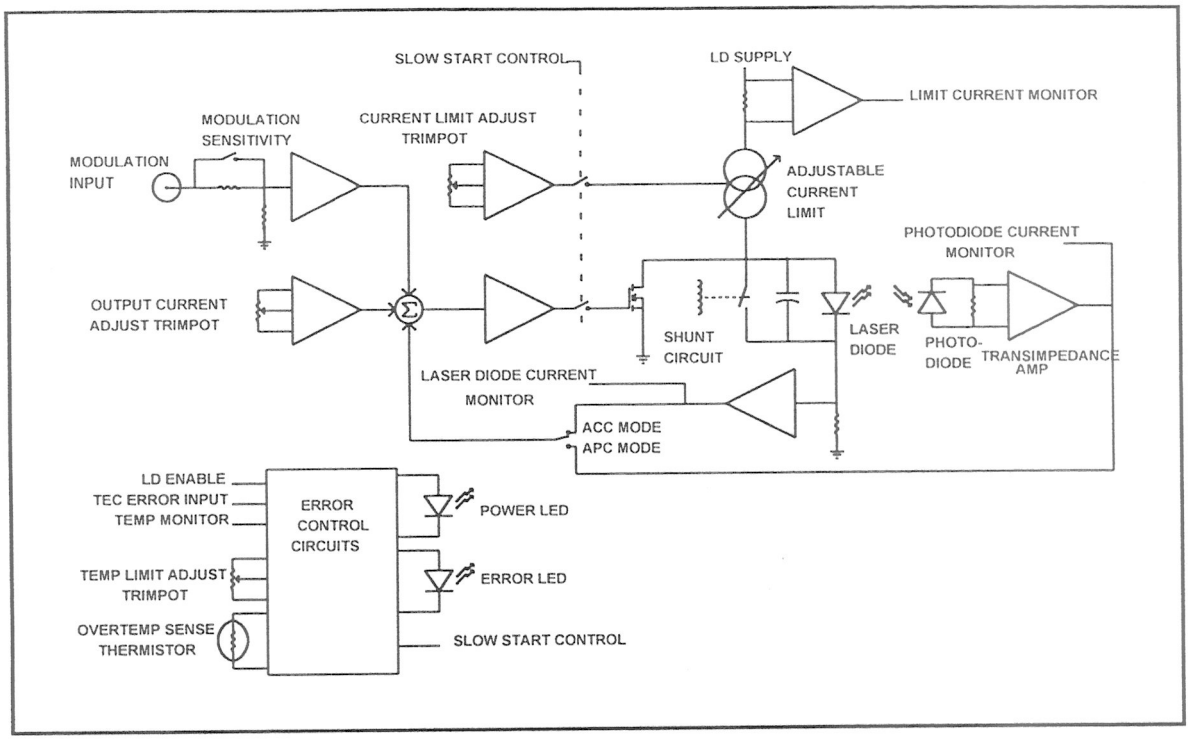
Constant Current Mode

Monitor pin 4 (LD CURRENT MONITOR) of the input cable with the DVM. Using the appropriate transfer function (0.1mA/mV for FPL-250, FPL-500, and FPL-1000 or 1mA/mV for FPL-2500 and FPL-5000), calculate the voltage reading for the desired laser diode operating current. Make sure the potentiometer on the left is rotated fully counter clockwise then power on the unit. Enable the laser diode and slowly adjust the OUTPUT CURRENT potentiometer until the voltage monitored by the DVM is at the calculated level. Now go to the LIMIT CURRENT ADJUST potentiometer and slowly adjust it counter clockwise (lower) until the red ERROR LED comes on, indicating that the current limit is now set to the operating level. Turn the limit potentiometer clockwise until the red ERROR LED goes out, and your current limit is set. See Errors and Indicator LED's on page 8 and Troubleshooting Section on page 17 if the laser diode driver will not power up.

Constant Power Mode

Monitor pin 5 (PD CURRENT MONITOR) of the input cable. Using the 1 μA/mV transfer function, calculate the voltage reading for the desired photodiode operating current. Make sure the potentiometer on the left is rotated fully counter clockwise then power on the unit. Enable the laser diode and slowly adjust the OUTPUT CURRENT potentiometer until the voltage monitored by the DVM is at the calculated level. Now go to the LIMIT CURRENT ADJUST potentiometer and slowly adjust it counter clockwise (lower) until the red ERROR LED comes on, indicating that the current limit is now set to the operating level. Turn the limit potentiometer clockwise until the red ERROR LED goes out, and your current limit is set. See Errors and Indicator LED's on page 8 and Troubleshooting Section on page 17 if the laser diode driver will not power up.

THEORY OF OPERATION - LASER DIODE DRIVER



ADJUSTABLE CURRENT LIMIT

One of the most important features of the FPL laser diode driver is its adjustable current limit. The current limit sets the highest allowable current to the laser diode and is typically set well below the damage threshold of the laser diode. A twelve turn trimpot is used to adjust the current limit current source. An internal sense resistor between the LD Supply voltage and adjustable current limit current source is used to monitor the limit current.

To simplify power supply requirements, the LD Supply voltage can be the same potential as the positive supply voltage V+. If a triple output power supply is used, then the LD Supply voltage can be tied to the low voltage, high current output. This reduces the power dissipated in the FPL, and the LD Supply is reduced limiting the maximum voltage that can be supplied to the laser diode.

LASER DIODE CONTROL

The FPL laser diode driver can control the laser diode in constant current mode or in constant optical power mode. Either mode is selected by connecting the feedback input to the corresponding feedback variable. In Constant Current mode, the feedback variable is a voltage which corresponds to the amount of current through the laser diode. This voltage is generated by a sense resistor in the laser diode current path.

In Constant Power mode, the feedback variable is a voltage which corresponds to the amount of current through the laser diode's monitor photodiode. A fully differential transimpedance amplifier is used to sense the photodiode current. With a differential transimpedance amplifier, any of the laser diode/photodiode pin configurations can be used.

The adjustable limit current source provides current to the output stage. Two current paths are available for the current to flow to ground. One path is through the laser diode and current sense resistor. The other path is through a shunt control MOSFET. The shunt control MOSFET behaves like a voltage controlled impedance which the feedback circuit controls to vary the current to the laser diode. When the setpoint exceeds the limit current, the shunt control MOSFET goes into a high impedance state and the current through the laser diode is entirely controlled by the limit current source. This condition is detected as the Current Limit Error and is indicated when the ERROR LED is solid RED.

The output setpoint is the sum of the OUTPUT CURRENT ADJUST [twelve turn trimpot] and the modulation input. The OUTPUT CURRENT ADJUST trimpot can be used to set the bias current level through the laser diode while the modulation input is used to dither the current around this bias level. An alternate method of control is to reduce the OUTPUT CURRENT ADJUST trimpot to zero and control the output entirely through the modulation input. The modulation input's transfer function can be altered internally to reduce its sensitivity.

LASER DIODE PROTECTION STRATEGIES

Several laser diode protection strategies are used in the FPL series of laser diode drivers. These include slow start on/off control, laser diode open circuit detection, laser diode thermal runaway detection, thermo-electric cooler failure, and detection of laser diode driver overheating.

When the FPL laser diode driver is disabled, the adjustable limit current source is brought to a low standby current to reduce power consumed in the off state, a mechanical relay shorts the laser diode to provide a very low impedance across the laser diode, and the output setpoint is reduced to zero with the shunt control MOSFET in a very low impedance state to shunt away any residual limit current. The FPL is in this state when the POWER LED is flashing green at a one second rate.

As soon as the FPL laser diode driver is enabled, the adjustable limit current source is brought to its preset level. The mechanical relay is opened, and the shunt control MOSFET slowly changes from a low impedance state to a high impedance state, slow starting current to the laser diode. The FPL will enable the laser after an initial 3 second delay. The FPL is enabled when the power LED is a solid green.

The FPL laser diode drivers sense open circuits in the laser diode path. When an open circuit is detected, the driver is disabled and latched in the off state until the LD Enable pin is toggled off and then on. An open circuit error flashes the ERROR LED at a 1/2 second rate. In most cases, the laser diode will be protected from an open circuit when an open circuit is detected during the slow start enable state. Even though open circuits can be detected during the normal operation of the laser diode driver, the fast bounce of the laser diode being disconnected can eliminate the open circuit detect circuitry's ability to shut the output off before a transient damages the laser diode.

When the FPL laser diode driver is used in conjunction with an FPT or TEC temperature controller, it can reduce laser diode failures due to improper temperature control of the laser diode. The mean lifetime of a laser diode is reduced when operated at temperatures above ambient. The FPL laser diode driver can be configured to disable the laser diode driver current until the temperature of the laser diode drops below a preset level [TEMP LIMIT ADJUST trimpot]. If a temperature limit is detected, the output will be disabled and the ERROR LED will flash red at one second intervals. The LD Enable pin must be toggled off and then on again to enable the driver.

An additional feature only available when used with the FPT temperature controller uses the FPT Error input to disable the laser diode. When a TE open circuit or temperature sensor open/short circuit is detected, or a module overheat error occurs in the FPT, the FPT error input goes low, disabling the laser diode driver. When these error conditions are corrected, the laser diode driver is reenabled and slow started.

The FPL uses an imbedded thermistor to sense whether the module heatsink is sufficient. If the module's chassis temperature exceeds the maximum allowed temperature, then the laser diode is disabled. The POWER LED remains green because this state may correct itself. At that time the laser diode will be enabled and slow started. This protection feature also protects the laser diode driver module.

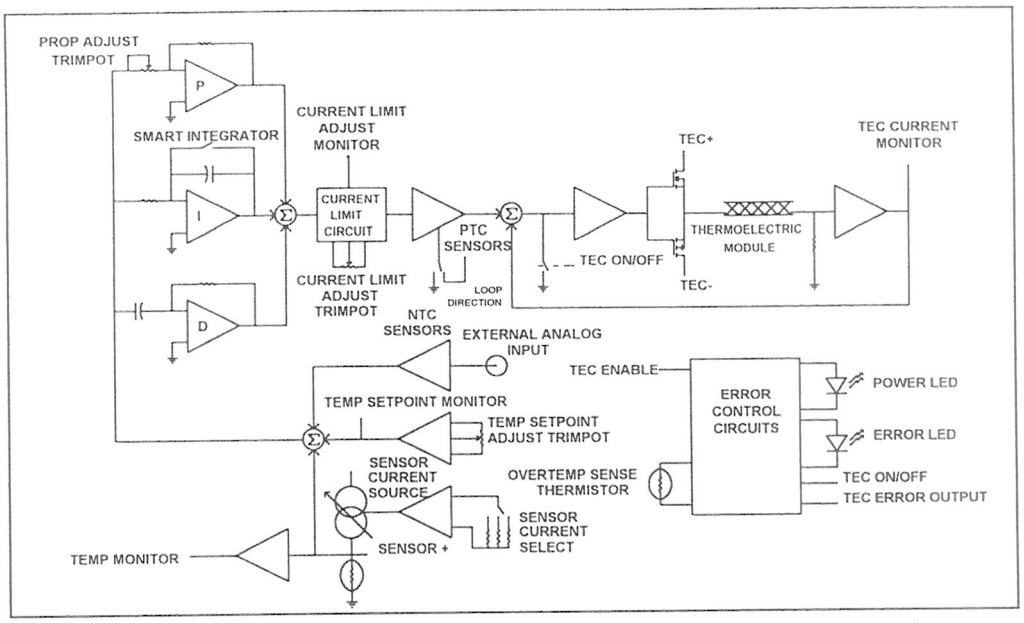
TROUBLESHOOTING

Several of the common problems people encounter with operating laser diodes are listed below. If this information does not solve your problem, please call our technical support team at (406) 587-4910.

SYMPTOM	PROBLEM	SOLUTION
Laser diode turns on and off	Heatsink to FPL is inadequate so embedded thermistor is shutting unit down	Increase heatsink mass or increase airflow over heatsink
	There is poor thermal contact between heatsink and FPL	Make sure thermal grease makes good contact with critical heatsink area on module and heatsink
Laser diode does not come on, enable light is green, no error lights are on	Improper wiring of laser diode	Check wiring, monitor pin 4 on the FPL input connector to see if any current is flowing
	Laser is damaged	Monitor the photodiode current, if it is less than 20μA, replace laser diode
Open circuit error condition	Laser diode circuit is open	Check cables and connectors
Limit error condition	Photodiode is damaged or laser has degraded with time	Replace laser diode
	Limit current is set too low	Slightly increase limit set point
	Connection to photodiode is open	Check cables and connectors
Over temperature error	TE module error	Refer to FPT troubleshooting guide

TECHNICAL SUPPORT (406) 587-4910

THEORY OF OPERATION - TEMPERATURE CONTROLLER



SENSOR CURRENT SOURCE

A small, fixed current is driven through the sensor (typically a thermistor) which produces a corresponding voltage dependent on the resistance of the sensor. The FPT has three selectable sensor current ranges, which allows its use with many different types of sensors. The LM335 linear semiconductor sensor uses the sensor current source as a bias.

PID LOOP CONTROL

The difference (or error signal) between the sensor voltage and the sum of the TEMP SETPOINT MONITOR voltage and analog input voltage is fed to a PID circuit.

The 'P' stands for Proportional Gain. The circuit will multiply the error signal by the proportional gain. The FPT gain ranges from 2 to 50.

The 'I' stands for Integrator. The integrator will charge to a voltage until the difference signal is zero. The charging rate is determined by the integrator time constant which is fixed at 500msec. If the load takes too long to reach temperature, the integrator winds up, or in other words, charges until it reaches the supply votage rails and saturates the amplifier. This has the effect of forcing the controller to overshoot the desired setpoint. The FPT series of temperature controllers implements an integrator shorting switch which reduces this effect. The integrator is shorted until the temperature of the load is close to the desired setpoint temperature. When close, the switch opens and the difference signal is reduced to zero.

The 'D' stands for Differentiator. The differentiator adds more gain when the difference signal varies quickly. This has the effect of eliminating overshoot and dampens ringing due to the integrator lagging phase.

OUTPUT CURRENT STAGE

The sum of the P, I, and D terms feeds the output stage. This consists of a voltage controlled current source, a current limit circuit, a phase reversal circuit, and an on/off circuit. The current limit is controlled by the CURRENT LIMIT ADJUST trimpot. This limits the level of voltage to the voltage controlled current source. When the FPT is in current limit, the red ERROR LED stays on. The phase reversal circuit allows the loop to control using both NTC (negative temperature coefficient) and PTC (positive temperature coefficient) sensors without changing the output leads. The on/off circuit brings the voltage input to the voltage controlled current source to zero, reducing the output current to a standby level.

TE COOLER PROTECTION STRATEGIES

Several protection strategies are used in the FPT series of temperature controllers. These protection strategies include thermoelectric module open circuit detect, sensor open or sensor short detect, and thermoelectric cooler controller over temperature detection.

When the FPT is disabled, the output current is reduced to a low standby current. When the FPT is enabled, the output current is controlled by the PID loop and is limited by the CURRENT LIMIT ADJUST.

The FPT will sense open circuits in the thermoelectric output load. When an open circuit occurs, the ERROR LED will flash red at a 1/2 second rate. The output is not disabled and when the open circuit error is corrected, the controller will function as normal. The FPT also senses when the output has reached its maximum output power with the open circuit sense. This error forces the FPT ERROR OUTPUT low and when used in conjunction with the FPL laser diode drivers, turns the diode driver off.

The FPT also detects that the sensor has open circuited or short circuited. When this error occurs, the output is disabled and the ERROR LED flashes red at a one second rate. This error also forces the FPT ERROR OUTPUT low.

The FPT uses an imbedded thermistor to sense whether the module is properly heatsunk. If the module's chassis exceeds the maximum allowed temperature, then the temperature controller current source is disabled. The POWER LED remains green because this state may correct itself. This protection feature also protects the temperature controller module. Additionally, this error forces the FPT ERROR OUTPUT low.

TROUBLESHOOTING

Several of the common problems people encounter with operating TE Coolers and laser diodes are listed below. If this information does not solve your problem, please call our technical support team at (406) 587-4910.

SYMPTOM	PROBLEM	SOLUTION
Laser diode does not turn on	FPT ERROR	Correct FPT error
Open/Short Sensor Error	Connection to sensor is open	Check cables and connectors
	Sensor has failed	Replace sensor
	Thermistor voltage out of range	Review reference current setting and desired operating temperature
	IC sensor reverse biased	Check wiring of sensor
Open Circuit on TE Cooler	Connections to TE Cooler open	Check cables and connectors
	Compliance Voltage Limited	Increase Supply Voltage
	TE Cooler has failed	Replace TE Cooler
TE Limit light stays on after warm up period	Load is too large	Reduce mass of object to be cooled
	TE Cooler overheating (going into thermal runaway) ❶	Increase heatsink on TE Cooler or increase airflow over heatsink
	Current limit set too low, module cannot use full capacity	Increase Current Limit Setting to maximum TE Cooler spec.
Load won't settle- Short term cycling (<1 minute)	Thermistor voltage out of range	Review reference current setting and desired operating temperature
	P term improperly set	Adjust the P term
Load won't settle- Long term variations	Sensor not located properly	Move sensor closer to or further from TE Cooler
	Load too large	Reduce mass of object to be cooled
	Current limit set too low, module cannot use full capacity	Increase Current Limit Setting
	Sensor not making good thermal contact	Remount Sensor
Unit heats, not cools	TE Cooler wired in reverse	Switch TE Cooler connections
	NTC, PTC sensor configured in reverse	Review output connector wiring
	TE Cooler in thermal runaway ❶	Increase heatsink on TE Cooler or increase airflow over heatsink
Cannot reach desired temperature	TE Cooler heatsink too hot or too small ❷	Increase heatsink on TE Cooler or increase airflow over heatsink

❶ The TE Cooler operates on the Peltier, bi-metal junction effect. One side of the junction is cool; one is hot. Typically, TE Coolers are not efficient, so energy is converted to heat within the cooler. If the heat being removed from the load and the self-generated heat is not properly removed through heatsinking, the cooler goes into a state called thermal runaway. The temperature sensor will feedback information that the load must be cooled, so more current is passed through the TE Cooler in an attempt to cool the load and sensor. Because the heat is not properly removed, the cooler simply heats more and loses its cooling capacity. It is therefore imperative to properly cool the TE Cooler itself with heatsinks or airflow.

❷ The general rule of thumb is that a TE Cooler cannot support a temperature differential of greater than 50°C. The temperature difference is measured between the TE Cooler heatsink and the load.

MECHANICAL DIMENSIONS

The following are sketches of the FPL as viewed from the top and front. The mounting holes are designed for use with 1/4-20 screws, but can be used with smaller screws with the proper selection of washer.