

FPT SERIES

INSTRUCTION MANUAL

TABLE OF CONTENTS

Features	2
Customer Service / Warranty	2
Optimize Your FPT	3
Quick Start	3
Electrical Specifications	4
General Specifications	4
Pin Descriptions	5
Errors and Indicator LEDs	6
Operating Procedures	6
Theory of Operation	8
Troubleshooting.....	9
Thermistor Data	11
System Configuration Guide	12
Mechanical Dimensions	12

FEATURES

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

The 'FP' series provides complete laser diode control with both laser diode drivers and temperature controllers. The 'FPT' temperature controllers are individually packaged in a compact, connectorized metal housing. The 'FPL' laser diode drivers are also available in this package.

If you need complete control, the 'FPC' series combines any two units in one low profile, shielded enclosure.

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 its 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.

OPTIMIZE YOUR FPT

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 controller. We recommend using regulated linear supplies for optimum performance. If you use a separate supply for the TE cooler current, it can be unregulated. [Page 7 details how to connect power for both cases.] The following table lists power supplies from Power One that properly operate the FPT series. You can contact the California plant at 1-(800) 678-9445:

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

Depending on your requirements, you may be able to use a switching power supply. Each case must be evaluated as a switching power supply will affect noise, transient, and stability performance.

GROUNDING:

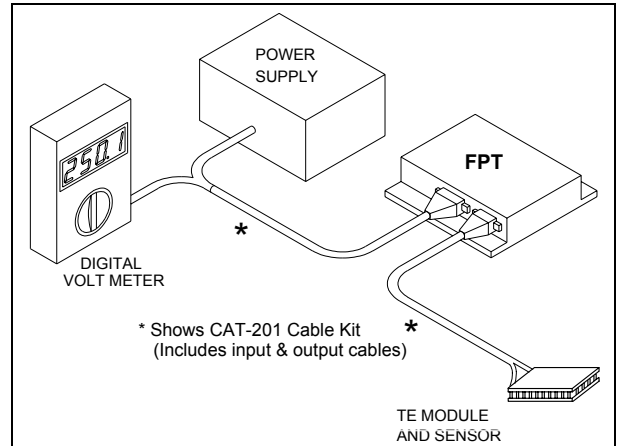
CAUTION: If you plan to operate the FPT with an FPL, you may need to use separate power supplies. If the TE cooler or thermistor are connected to the laser diode, you must use two separate power supplies and let each float independent of the other.

POWER SUPPLY TURN ON:

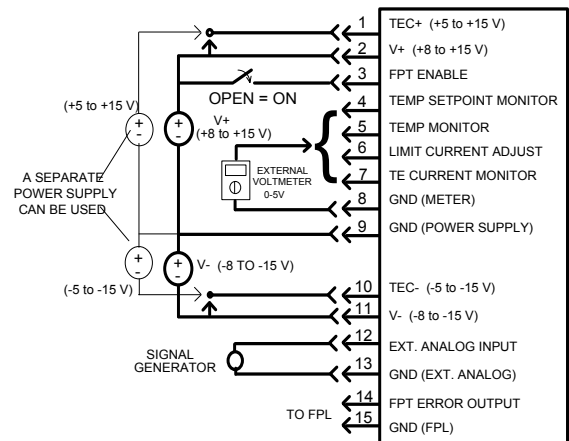
CAUTION: Always apply V+ & V- by turning the AC power on at the power supply. Never use a toggle switch on the secondary of the power supply to apply V+ & V-. Since the two voltages may not come up simultaneously, you can damage the control electronics.

QUICK START

The following is a sketch of the components you will need to operate the FPT, 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 module with the FPT.

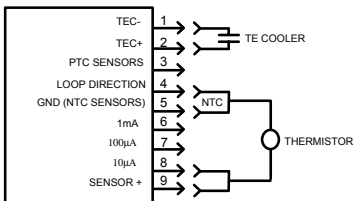


FPT INPUT CONNECTOR

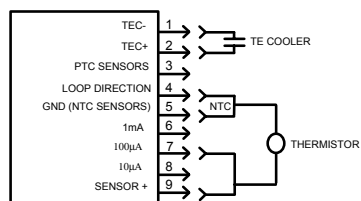


FPT OUTPUT CONFIGURATIONS:

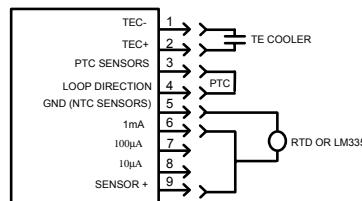
10 μ A BIAS, NTC THERMISTOR



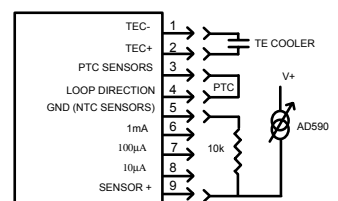
100 μ A BIAS, NTC THERMISTOR



RTD OR LM335



AD590



FPT TEMPERATURE CONTROLLER ELECTRICAL SPECIFICATIONS

Model Number	FPT-2000	FPT-4000
Temperature Control		
Temp. Control Range, ①	-99 to +150°C	-99 to +150°C
Short Term Stability, 1 hr. ②	< 0.002°C	< 0.002°C
Long Term Stability, 24 hr. ②	< 0.005°C	< 0.005°C
TE Cooler Output		
Bipolar Output Current	± 2 A	± 4 A
Compliance Voltage ③	>± 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 ④	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 ⑤ ±8 to ±15 VDC (±15.5V MAX)	Weight < 0.6 lbs, <0.3kg	Connectors 9 & 15 pin D-sub plugs (cables need female receptacles)
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	Warm-up 1 hour to rated accuracy
Size (H x W x D) 1.0" x 4.25" x 3.5" 25.4 x 108 x 89mm	Storage Temperature -40 to +80°C	Power Indicator One green, one red LED

- ① Temperature Range depends on the physical load, sensor type and TE module used.
- ② Stability quoted for a typical 10 kΩ thermistor at 100 µA sensing current.
- ③ Compliance Voltage will vary depending on input voltages. A maximum compliance voltage of ±10 volts will be obtained with ±15 volts input.
- ④ AD590 requires an external bias voltage and 10kΩ resistor.
- ⑤ If thermistor and laser diode are case common, the FPL and FPT power supplies must be isolated from each other.

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.

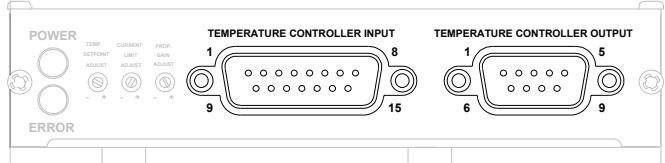
Pin 4 TEMP SETPOINT MONITOR: This output is used in setting the temperature setpoint of the sensor. Depending on the type of sensor used, this voltage can range from 0-5V and should match the voltage across the sensor when it is at the desired temperature.

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 $\pm 10V$. If this input is not used, connect pins 12 and 13 at the input connector. Do not jumper these pins 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 shorted. **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 through 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+.

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.

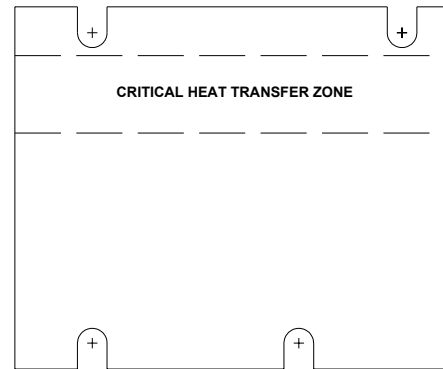
CURRENT LIMIT:

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.

OPERATING PROCEDURES

1. ESTABLISH THERMAL CONTROL

A heat sink must be properly attached to the FPT 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 module for optimum performance.



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

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

where P_{UNIT} 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 either pin 1 or 10 of the input connector (TEC+, TEC-), and V_{TEC} is the voltage across the TE Cooler.

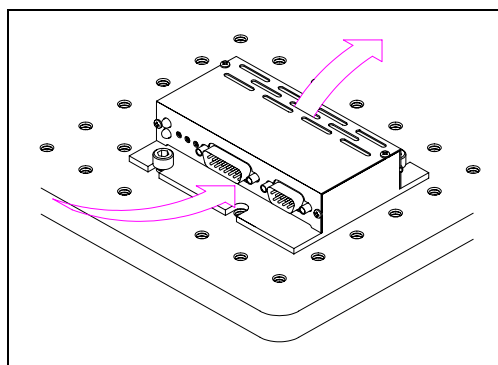
Now calculate the allowed rate of temperature increase:

$$RATE = 70 / P_{UNIT} \text{ where Rate is in } ^\circ\text{C/W.}$$

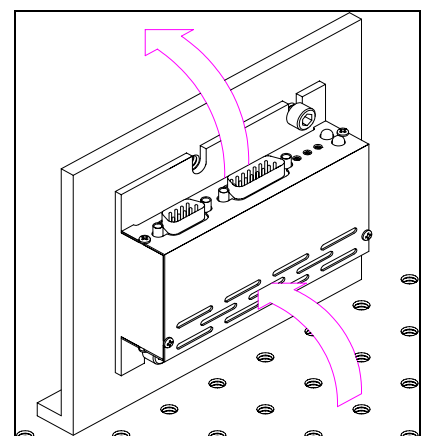
For example, if P_{UNIT} is 60W, RATE is 70/60 or 1.17°C/W. Adding a safety factor, you should select a heatsink with 0.9°C/W rating.

The following drawings show two methods of mounting the FPT such that air flow is properly maintained.

HORIZONTAL MOUNTING



VERTICAL MOUNTING



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 10 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 OUTPUT (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 100 μ A or 10 μ A. To operate with a 100 μ A reference current, short pins 7 and 9. To operate with a 10 μ A 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 10k Ω 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.

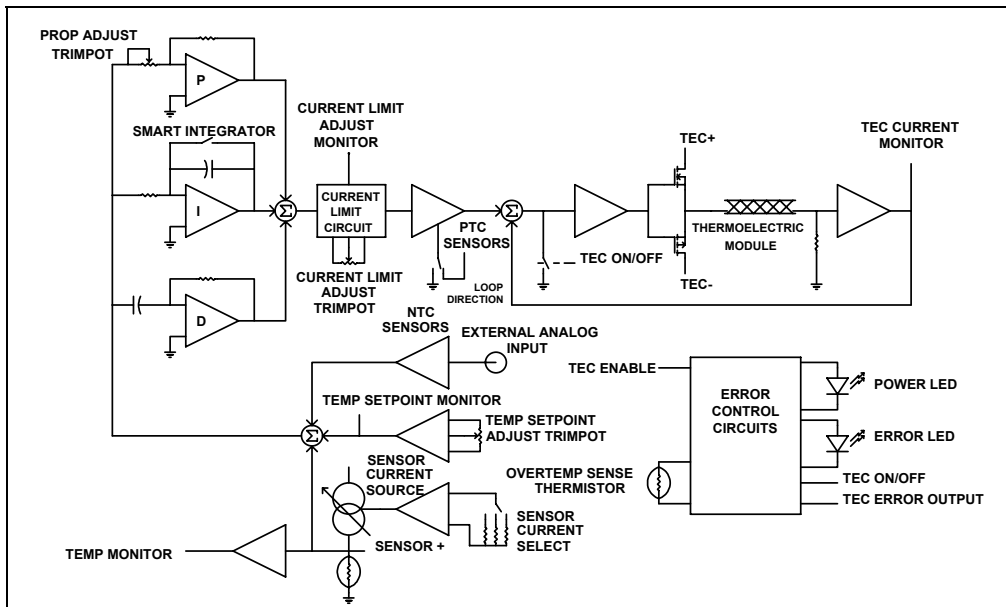
5. SET UP OPERATING TEMPERATURE

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.

THEORY OF OPERATION



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 voltage 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 small ❷	Increase heatsink on TE Cooler or increase airflow over heatsink

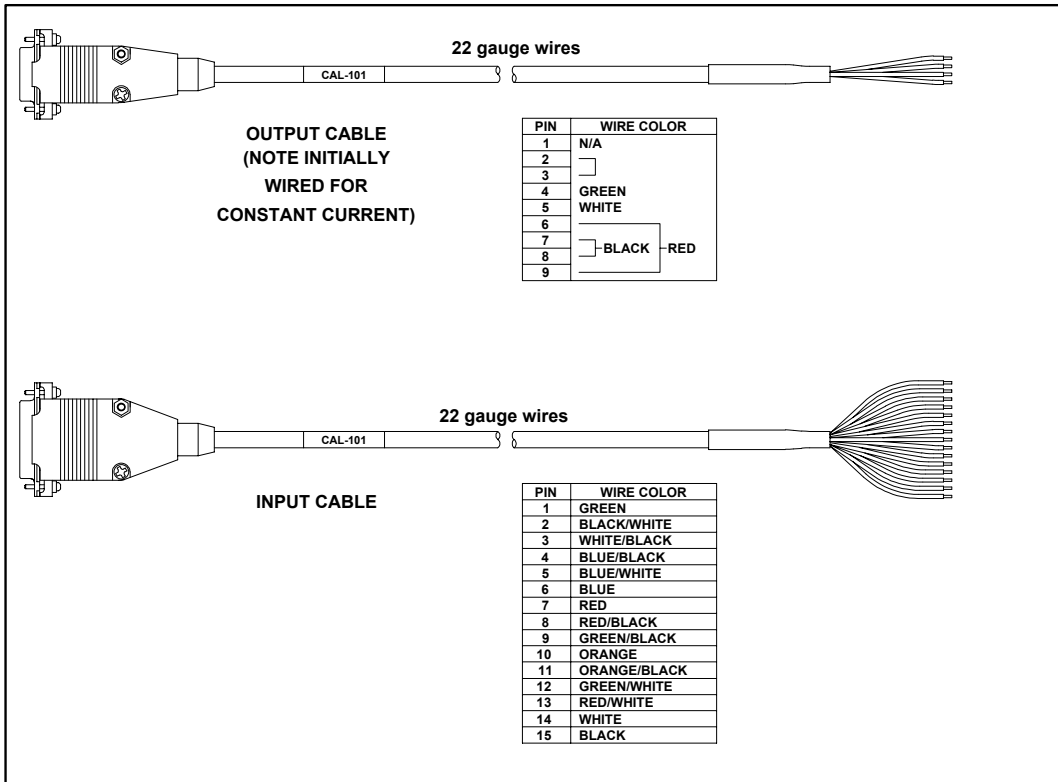
❶ The TE Cooler operates on the Peltier, bi-metal junction effect. One side of the junction is cool; one is hot. Typically, TE Coolers are not efficient, so energy is converted to heat within the cooler. If the heat being removed from the load and the self-generated heat is not properly removed through 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.

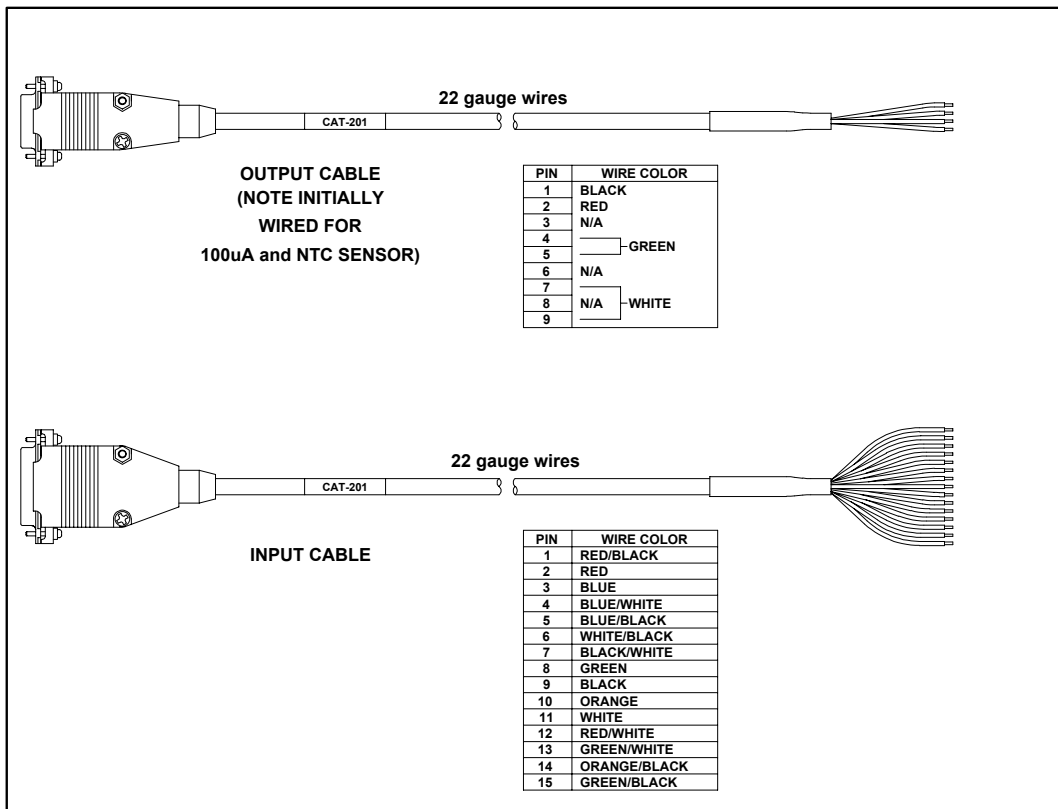
TECHNICAL SUPPORT (406) 587-4910

The following details the cables and their pinouts.

CAL-101 FPL CABLE ASSEMBLY



CAT-201 FPT CABLE ASSEMBLY



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

MODEL TCS610

10kΩ Thermistor (at 25 °C)

10μA TEMPERATURE RANGE: -45°C TO +13°C

100μA TEMPERATURE RANGE: -8°C TO +50°C

TEMP °C	R _T (Ω)	VOLT (V) (10μA)	VOLT (V) (100μA)	TEMP °C	R _T (Ω)	VOLT (V) (10μA)	VOLT (V) (100μA)	TEMP °C	R _T (Ω)	VOLT (V) (10μA)	VOLT (V) (100μA)
-45	473200	4.732		-13	65260	0.652		19	13070		1.307
-44	441800	4.418		-12	61750	0.617		20	12490		1.249
-43	412600	4.126		-11	58450	0.584		21	11940		1.194
-42	385600	3.856		-10	55340	0.553		22	11420		1.142
-41	360500	3.605		-9	52420	0.524		23	10920		1.092
-40	337200	3.372		-8	49670	0.496	4.967	24	10450		1.045
-39	315500	3.155		-7	47080	0.470	4.708	25	10000		1.000
-38	295400	2.954		-6	44640	0.446	4.464	26	9572		0.957
-37	276700	2.767		-5	42340	0.423	4.234	27	9165		0.916
-36	259300	2.593		-4	40170	0.401	4.017	28	8777		0.877
-35	243100	2.431		-3	38120	0.381	3.812	29	8408		0.840
-34	228000	2.280		-2	36200	0.362	3.620	30	8056		0.805
-33	213900	2.139		-1	34380	0.343	3.438	31	7721		0.772
-32	200800	2.008		0	32660	0.326	3.266	32	7402		0.740
-31	188600	1.886		1	31040	0.310	3.104	33	7098		0.709
-30	177200	1.772		2	29510	0.295	2.951	34	6808		0.680
-29	166500	1.665		3	28060	0.280	2.806	35	6531		0.653
-28	156600	1.566		4	26690	0.266	2.669	36	6267		0.626
-27	147300	1.473		5	25400	0.254	2.540	37	6015		0.601
-26	138600	1.386		6	24180	0.241	2.418	38	5774		0.577
-25	130500	1.305		7	23020	0.230	2.302	39	5545		0.554
-24	122900	1.229		8	21920	0.219	2.192	40	5326		0.532
-23	115800	1.158		9	20890	0.208	2.089	41	5116		0.511
-22	109200	1.092		10	19900	0.199	1.990	42	4916		0.491
-21	103000	1.030		11	18970	0.189	1.897	43	4725		0.472
-20	97130	0.971		12	18090	0.180	1.809	44	4543		0.454
-19	91660	0.916		13	17260	0.172	1.726	45	4368		0.436
-18	86540	0.865		14	16470		1.647	46	4201		0.420
-17	81730	0.817		15	15710		1.571	47	4041		0.404
-16	77220	0.772		16	15000		1.500	48	3888		0.388
-15	72980	0.729		17	14320		1.432	49	3742		0.374
-14	69000	0.690		18	13680		1.368	50	3602		0.360

You can approximate the response of a thermistor with the Steinhart-Hart Equation. The A, B, and C values listed in the table apply to the following equation. The coefficients are optimized for the ranges covered by the reference currents.

$$\frac{1}{(T)} = A + B \times \ln R + C \times (\ln R)^3$$

where R is in ohms and T is in Kelvin.

10μA	100μA
A= 1.1235E-03	A= 1.1279E-03
B= 2.3500E-04	B= 2.3429E-04
C= 8.4538E-08	C= 8.7298E-08

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

MECHANICAL DIMENSIONS

The following are sketches of the FPT 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.

