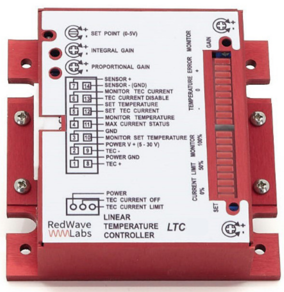
Linear Temperature Controllers
LTC25, LTC50 and LTC100



RedWave Labs Linear Temperature Controllers come in three versions: LTC25, LTC50 and LTC100 with maximum current capabilities of 2.5A, 5A and 10A respectively, single supply operation (+5 to 30V) and temperature stability down to 0.001K. All models feature a variable current limiter up to the maximum current, various sensor capabilities (thermistors, RTDs, AD590, LM335), variable P-I setting, LED monitors and remote shutdown.

Features	**Linear Temperature Control for Thermo-Electric Elements and Resistive Heaters**	
Applications	Laser, Detectors, Precision Instrument, OEM applications	
Specifications	Parameter	Value
Power	Single	+5 → 30 V (Vdd)
Input sensor	NTC, PTC thermistor	10µA, 100µA, 200µA,1 mA activation current
	AD590	1µA/K output, LTC has 10.0 KOhm load resistor
	RTDs	1mA, 10mA activation current
	LM135	10 mV/K output, 1 mA activation current
	Compliance voltage	Smaller of 5V or Vdd-0.5V
Temperature	Internal set point	11 turn potentiometer 0-5V, jumper selected
	External set point	0-5 V through 14 pin connector, jumper selected
	Stability over 1 hour	0.001 C (with 20 K thermistor)
Output	Bipolar current	+/-2.5A, +/-5A, +/-10A
	Current limit	Symmetrical 0 → Imax
	Compliance voltage	Vdd-2.5V (LTC-100), Vdd-1V (LTC-50), Vdd-0.5V (LTC-25) typical maximum value
	P-I control	Proportional (2-100 A/V) and Integral (0.55-5 A/(V x sec)
	Heat dissipation	60 W maximum without heatsink
	Security	Disable current if sensor voltage drops below 0.4V
	Connector	14 pin Molex MiniFit
Monitor	Current limit	10 bar LED 0 → Imax
	Set point error	Coarse indication of set point error with variable gain
Dimensions	W x H x D	89 x 89 x 28 mm
Weight		195 g
Storage Temp	-55 to 100 °C	
Operating Temp	-40 to 85 °C	

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Training and support

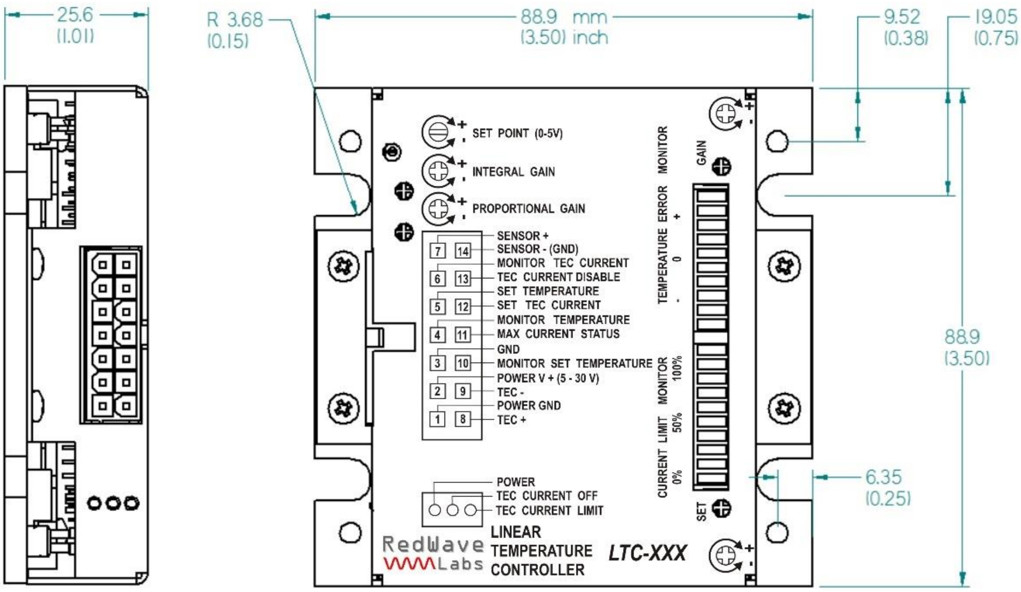
Remote training and support (via Skype) are available. Please contact info@redwavelabs.com for more information.

Absolute Maximum Ratings

Symbol	Parameter	Ratings	Unit
V_{dd}	Supply positive voltage	+5 → 30	V
T_{op}	Operational Temperature	-40 → 85	°C
T_{st}	Storage Temperature	-55 → 85	°C

Mechanical Information

Parameter	Value	Unit
Length	3.50 (88.9)	Inch (mm)
Width	3.50 (88.9)	Inch (mm)
Height	1.0 (25.4)	Inch (mm)
Weight	195	gram



Electrical Characteristics

Parameter	Comments	Value	Unit
SENSOR			
Type	Thermistor (NTC and PTC), RTDs, LM135/235/335, AD590		
Activation current		0.01, 0.1, 0.2, 1	mA
Compliance voltage		Smaller of Vdd−0.5 and 5	V
CONTROL			
Set point internal (SPi)	11 turn potentiometer CC increase; selection by jumper 5 of J3	0→5	V
Set point external (SPe)	External Voltage with transfer function 1V/V. Jumper 6 J3	0→5	V
Set point ext+int	Set voltage is equal to 0.5×(Spi+SPe)	0→5	V
Proportional Gain Gp	1 turn potentiometer	2→100	A/V
Integral Gain Gi	1 turn potentiometer	0.5→5	A(V×s)
Set point accuracy	20 KOhm thermistor, critically dump system	1	mV
Temperature stability	1 hour	0.001	°C
External control	Provides direct control of current: 1.5 V→3.5 V: -Imax→Imax; jumper 8 of J3		
Internal PI	Uses Proportional Gain Gp and Integral Gain Gi to control driving current		
Power current enable	Pin 13 J3; 0V enable; 5V disable		
POWER CURRENT			
Type			
Range	LTC-25, LTC-50, LTC-100 accordingly	+/-2.5,+/-5,+/-10	A
Current limit	1 turn potentiometer with LED bar indicator	Linear 0→100, symmetrical	%
Voltage compliance	LTC-25, LTC-50, LTC-100 accordingly	Vdd-0.5; Vdd-1; Vdd-2.5;	V
Master / slave capability	Slave unit can be driven from Actual TEC current monitor		
Heat dissipation	At 25°C	60	W
Shutdown mode current		60	mA
MONITOR SIGNALS AND INDICATORS			
Set point temperature	Fully buffered	0→Vdd−1.4	V
Actual point temperature	Fully buffered	0→Vdd−1.4	V
Actual TEC current	Fully buffered; 2.5 V “0” point	1.5→3.5	V
Actual TEC monitor transfer function		$2.5+A\times I_{actual}$ A=0.4 (LTC−25); A=0.2(LTC−50); A=0.1 (LTC−100)	V/A
Current limit monitor	10 Segment LED Bar	$0\rightarrow I_{max}$	A
Set point –Actual Temp Error	10 Segment LED Bar, Gain varies from 0.25V down to 0.05V per one segment		

Main Connector Characteristics

PIN#	Abbreviation	Name	Description
1	Power GND .	Power Ground/ Negative Power Pin	Power Ground for TEC power. Electrically connected to Pin 3 (Monitor GND) and Pin 14 (Sensor GND). Pin1 is the only pin that can be used for the return path of the TEC (Heater) driving current
2	Power V+	Positive power supply/ Positive power pin	Positive Power Supply for TEC power. LTC can use any single power supply +5→ +30 V. Using a power supply lower than 5 V (with a cooling/heating element connected) and higher than 30V can result in permanent damage to the unit
3	GND	Monitor Ground pin	Pin is used for monitoring circuits. This pin must not be connected to the Power Ground (Pin1).
4	Monitor Temperature	Temperature Monitor Pin	Fully buffered Actual Temperature. Output range is the smaller of 0→Vdd-1.4V and 0→5V. Ext
5	Set Temperature	Temperature Set Pin	Pin is used to set the External Temperature. Selected by jumpers. Voltage range 0→5V
6	Monitor TEC current	Monitor TEC current	Pin provides voltage corresponding to the actual TEC(heater) current. Range $2.5+A\times I_{actual}$ (A=0.4; 0.2; 0.1 for LTC-25; LTC-50 and LTC-100 accordingly)
7	Sensor+	Sensor Positive	Positive pin for the sensor current supply and sensing
8	TEC+	Positive TEC Power PIN	Positive Thermo-electric cooler power pin. For Resistive Heaters one side of the heater should be connected to the TEC+ or TEC- pin and the other side should be connected to the same power supply as Pin 2(Power V+). Correct heating polarity will depend on the sensor (NTC or PTC). Correct feedback direction can be adjusted with Jumpers 1-4 (Positive/Negative sensor) of J3.
9	TEC-	Negative TEC	Negative Thermo-electric Cooler pin. For Resistive Heaters one side of the heater should be connected to the TEC+ or TEC- pin and the other side should be connected to the same power supply as Pin 2(Power V+). Correct heating polarity will depend on the sensor (NTC or PTC). Correct feedback direction can be adjusted with Jumpers 1-4 (Positive/Negative sensor) of J3.
10	Monitor Set Temperature	SET Temperature Monitor Pin	Fully buffered Set Temperature. Output range smaller of 0→Vdd-1.4V and 0→5V.
11	Max Current Status	Max Current Status Reached Pin	0V – normal operation; +5V if current limit (any side) is reached
12	Set TEC Current	Set TEC current Pin	Used to set TEC current directly if internal PI control is disabled (J3 Jumper 7 OFF) and external TEC control is enabled (J3 Jumper 8 ON). One of Jumpers 7 or 8 has to be ON. Both jumpers in ON and both jumpers in OFF position could damage LTC and cooling/heating element. Transfer function is I=B× (2.5-Vset) A/V where B=2.5(LTC-25), B=5(LTC-50) and B=10 (LTC-100).
13	Set TEC Current	External TEC current disable Pin	0V-TEC enable; +5V-TEC current disable.
14	Sensor- (GND)	Sensor negative Pin	Sensor negative pin is connected internally to the Power Ground but is not able to carry high current. This pin should not be used for the main current return.

The LTC Main Connector is a Molex Mini-Fit p/n 39-30-0140. The mating connector is a Molex Mini-Fit p/n 39-01-2145 with crimp pins Molex p/n 39-00-0207 or 39-00-0079 for high current (up to 13 A). The Molex suggested crimping tool p/n 63819-0900 can be purchased, e.g. from Digikey Inc (www.digikey.com).

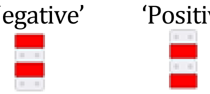
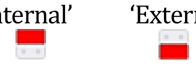
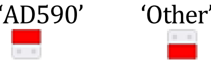
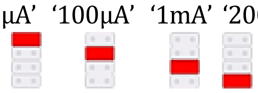
Status LED

Status LEDs are used for fast visual assessment of the LTC status. The LED status indicator has 3 separate LEDs located on the same side as main connector. The default LED colour is red; this can be varied in customized versions.

LED	Abbreviation	Name	Description
Bottom	Power	Power connected indicator	LED is ON once power is connected.
Mid	TEC Current Off	TEC Current disable indicator	LED is ON if either: i) external TEC disable signal is applied to PIN 13 of the Main connector; or ii) sensor voltage drops below 0.4V (safety condition to prevent thermal runway if the sensor is disconnected)
Top	TEC Current Limit	TEC Current limit indicator	LED is ON when Current limit (positive or negative) is reached.

Jumper settings (Connector J3)

Overall jumper setting (J3) are summarized below together with shipping (default) settings. We can provide different default settings on request.

Type	Selection	Jumpers	Description
'Negative / Positive'	J3 'Negative'	Jumper 1 ON/OFF	Default option: 'Negative' 'Negative' 'Positive' 
	J3 'Positive'	Jumper 2 OFF/ON	
	J3 'Negative'	Jumper 3 ON/OFF	
	J3 'Positive'	Jumper 4 OFF/ON	
'Set Point' 'Internal / External / Dual'	J3 'Internal'	Jumper 5 ON/OFF/ON	Default option: 'Internal' 'Internal' 'External' 'Dual' 
	J3 'External'	Jumper 6 OFF/ON/ON	
'PI Control' 'Internal / External'	J3 'Internal'	Jumper 7 ON/OFF	Default option: 'Internal' 'Internal' 'External' 
	J3 'External'	Jumper 8 OFF/ON	
'Sensors' 'AD590 / Other'	J3 'AD590'	Jumper 9 ON/OFF	Default option: 'Other' 'AD590' 'Other' 
	J3 'Other'	Jumper 10 OFF/ON	
'Sensors' 10µA / 100µA / 1mA / 200µA	J3 '10µA'	Jumper 11 ON/OFF/OFF/OFF	Default option: '100µA' '10µA' '100µA' '1mA' '200µA' 
	J3 '100µA'	Jumper 12 OFF/ON/OFF/OFF	
	J3 '1mA'	Jumper 13 OFF/OFF/ON/OFF	
	J3 '200µA'	Jumper 14 OFF/OFF/OFF/ON	

Set Point

The LTC has 3 options to operate with set points. The most common options are to use an internal set point with the 11-turn potentiometer or to use an external voltage applied to Pin 5 of the Main connector.

Type	Selection	Jumpers	Description
Internal (11-turn potentiometer)	J3	Jumper 5 ON Jumper 6 OFF	Internal set point: 0→ 5V set by 11 turn potentiometer located in top right corner of the cover. Voltage is increased in CW direction
External	J3	Jumper 5 OFF Jumper 6 ON	External set point: 0→ 5V set by Pin 5 Main Connector
Joint: Internal and External	J3	Jumper 5 ON Jumper 6 ON	Set voltage is equal to 0.5 × (SP_{int} + SP_{ext}). For example, if the internal and external are both equal to 2.5V then the resulting set point is still 2.5V

PI Control

The LTC has 2 options to control the temperature feedback loop: Internal and External. Internal PI control covers the vast majority of systems and the P and I control potentiometers can be adjusted to obtain the optimal PI. External PI control can be used if the user has a digital PID implementation elsewhere.

Control	Selection	Jumpers	Description
Internal Proportional	J3	Jumper 7 ON Jumper 8 OFF	Internal Proportional Gain setting 2-100 A/V with ¾ turn linear potentiometer. Gain is increased in CW direction. Shipped with Proportional Gain=20 A/V.
Internal Integral	J3	Jumper 7 ON Jumper 8 OFF	Internal Integral Gain setting 0.55-5 A/(×sec)V with ¾ turn linear potentiometer. Gain is increased in CW direction. Shipped with Integral Gain=0.5 A/(V×sec)
External	J3	Jumper 7 OFF Jumper 8 ON	External control of TEC/heater current through Pin 12 of the Main Connector. Transfer function is I=B×(2.5−V_{set}) A/V where B=2.5(LTC-25), B=5(LTC-50) and B=10 (LTC-100). Maximum current is limited by the current limit setting. If Vset is outside 1.5V → 3.5V range but less than Vdd, no damage will occur.

Proportional and Integral gains can be measured using 3 test points (Common 'C', Proportional 'P', and Integral 'I') on the top right corner close to the P and I potentiometers. The Proportional gain (A/V) can be calculated using the value of the resistance between 'C' and 'P' test points and expressed in kOhm:

$$G_{prop} = \frac{400 - 2 \times R_m}{4 + 1.98 \times R_m}$$

where R_m is the measured resistance.

The Integral gain(A/(V× sec)) can be calculated using the same approach:

$$G_{in} = 0.5 + \frac{4.5}{1 + R_m}$$

Current Limit

Current limit is set by the ¾ turn potentiometer located in bottom left corner (top view). Close to it, the LEDx10 bar of running single LEDs is used to monitor actual current limit. If there is no indicator, the current limit is close to 0% and the Current Limit potentiometer should be turned slightly in CW direction. In the table below Current Limit is expressed in %. For absolute current limits, the maximum current for the given LTC model should be multiplied by the percentage value given in the table below.

Current Limit	Current Limit Monitor
0	No bar illuminated
10%	Transition to the 1st bar
20%	Transition to the 2nd bar
30%	Transition to the 3rd bar
40%	Transition to the 4th bar
50%	Transition to the 5th bar
60%	Transition to the 6th bar
70%	Transition to the 7th bar
80%	Transition to the 8th bar
90%	Transition to the 9th bar
100%	Fully open CW direction

Set Point Error Monitor

A LEDx10 bar monitors the actual error between set point and actual sensor voltage. The Error Monitor Gain can be set from 0.25V down to 0.05 V per one LED bar. The Error monitor Gain is increased in CW direction. Please note that the Error Monitor is a coarse monitoring tool and proper monitoring should be done using Pins 4 and 3 (GND and Temperature Monitor Pins) on the main connector.

Sensor options

Five different setting have been implemented to accommodate various temperature sensors available on the market today. AD590 requires an external voltage to operate properly; all other sensors require constant current activation.

Type	Selection	Jumpers	Description
AD590	J3 'AD590'	Jumper 9 ON	AD590 is a voltage activated sensor. For proper AD590 sensor operation, the negative pin of AD590 should be connected to Pin 14 (Main connector) and the positive pin of AD590 should be connected to the Vdd. AD590 nominal output is 1µA/K. The LTC (all models) has a 10 KOhm load resistor so 293K will produce 2.93V voltage.
	J3 'OTHER'	Jumper 10 OFF	
	J3 '10µA'	Jumper 11 OFF	
	J3 '100µA'	Jumper 12 OFF	
	J3 '1mA'	Jumper 13 OFF	
	J3 '200µA'	Jumper 14 OFF	
10 µA, Thermistors PTC and NTC	J3 'AD590'	Jumper 9 OFF	10 µA setting is used for resistive sensors (thermistors) both PTC and NTC types. For example, 100 kOhm thermistor will produce 1.00V at 10µA current sensing.
	J3 'OTHER'	Jumper 10 ON	
	J3 '10µA'	Jumper 11 ON	
	J3 '100µA'	Jumper 12 OFF	
	J3 '1mA'	Jumper 13 OFF	
	J3 '10mA'	Jumper 14 OFF	
100 µA, Thermistors PTC and NTC	J3 'AD590'	Jumper 9 OFF	100 µA setting is used for resistive sensors (thermistors) both PTC and NTC types.
	J3 'OTHER'	Jumper 10 ON	
	J3 '10µA'	Jumper 11 OFF	
	J3 '100µA'	Jumper 12 ON	

	J3 '1mA'	Jumper 13 OFF	
	J3 '200µA'	Jumper 14 OFF	
1 mA, RTDs, LM135/235/335 Thermistors PTC and NTC	J3 'AD590'	Jumper 9 OFF	1 mA setting is used for resistive sensors (thermistors and RTDs) and LM135/235/335 IC type temperature sensors.
	J3 'OTHER'	Jumper 10 ON	
	J3 '10µA'	Jumper 11 OFF	
	J3 '100µA'	Jumper 12 OFF	
	J3 '1mA'	Jumper 13 ON	
	J3 '200µA'	Jumper 14 OFF	
200 µA, RTDs	J3 'AD590'	Jumper 9 OFF	200 µA setting is used for resistive sensors (thermistors) both PTC and NTC types.
	J3 'OTHER'	Jumper 10 ON	
	J3 '10µA'	Jumper 11 OFF	
	J3 '100µA'	Jumper 12 OFF	
	J3 '1mA'	Jumper 13 OFF	
	J3 '200 µA'	Jumper 14 ON	

Sensor failsafe operation

If the sensor voltage drops below 0.4V then the TEC power current is disabled, the 'TEC current disable' LED is ON and Pin 6 of Main Connector (TEC Current Monitor) goes to 2.5V (No current). Once the sensor voltage goes above the threshold then normal operation resumes automatically.

Sensor PTC and NTC choices

The LTC has an option for the user to select the type of sensor (Negative or Positive Temperature Coefficient) with the J3 jumper selection. This allows to adjust the feedback system polarity response. Users can choose between two options: i) set point – actual sensor voltage, and ii) actual sensor voltages – set point. The feedback polarity adds an additional degree of flexibility to wiring.

Type	Selection	Jumpers	Description
'Negative'	J3 'Negative'	Jumper 1 ON	Operation for NTC sensors and normal operation of the TEC
	J3 'Positive'	Jumper 2 OFF	
	J3 'Negative'	Jumper 3 ON	
	J3 'Positive'	Jumper 4 OFF	
'Positive'	J3 'Negative'	Jumper 1 OFF	Operation for PTC sensors and normal operation of the TEC
	J3 'Positive'	Jumper 2 ON	
	J3 'Negative'	Jumper 3 OFF	
	J3 'Positive'	Jumper 4 ON	

Power dissipation

LTC controllers have been designed to handle 60 Watt power dissipation without heat sink under normal atmospheric conditions. Users must calculate the maximum heat load on the controller properly before starting continuous operation. Typical steps to calculate maximum heat load are given below

- Obtain the load curve of the load as function of the current. Typically most of the TECs or resistive heaters follow a standard ohmic law: $U_{load} = R_{load} \times I$, but non-linear loads could cause variations.
- Measure supply voltage U_{dd}.

- Calculate dissipated power $P=I \times (U_{dd}-U_{load})$ over the full current range from 0 to I_{max}. Dissipated power must be below 60 W over the full range of current. If at some point dissipated power exceeds 60 W then the LTC Controller should be mounted on an external heatsink.

Installation

We recommend a first time use of the LTC with a high power load resistor (at least 50W rating) as TEC load and a potentiometer as sensor. The potentiometer should be connected to pins 7 (Sensor+) and 14 (GND) and the load resistor connected to pins 8 and 9. Such a set-up will enable a system check before connecting to the laser temperature controller system and risking potential damages.

Cable LTC-CBL (optional)

Optional cable LTC-CBL wiring is summarized in the table below. LTC-CBL is an optional item, normal shipment includes a mating connector of the Main Connector and a set of crimp pins.

PIN#	Abbreviation	Cable Color	Comment
1	Power GND	Black AWG 18	Twisted pair with pin 2
2	Power V+	Red AWG 18	Twisted pair with pin 1
3	GND	Green	Defence standard signal cable 8 core
4	Monitor Temperature	White	Defence standard signal cable 8 core
5	Set Temperature	Black	Defence standard signal cable 8 core
6	Monitor TEC current	Brown	Defence standard signal cable 8 core
7	Sensor+	Red	Defence standard signal cable 2 core
8	TEC+	White AWG 18	Twisted pair with pin 9
9	TEC-	Blue AWG 18	Twisted pair with pin 8
10	Monitor Set Temperature	Yellow	Defence standard signal cable 8 core
11	Max Current Status	Red	Defence standard signal cable 8 core
12	Set TEC Current	Blue	Defence standard signal cable 8 core
13	TEC Current Disable	Violet	Defence standard signal cable 8 core
14	Sensor- (GND)	Blue	Defence standard signal cable 2 core

Certification

RedWave Labs Ltd certifies that: i) the parts and/or materials were produced in conformance with all contractually applicable Government and/or Buyer's specifications as referenced in, or furnished with, the above purchase order and ii) all processes required in the production of these parts and/or materials are listed and were performed by a facility or by personnel specifically approved or certified by the seller's cognizant government quality control agency when such approval or certification is required by an applicable specification. RedWave Labs products are not authorized for use in safety-critical applications (such as life support) where a failure of the product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use of the products.

Warranty and returns

Linear Temperature Controllers are warrantied against defects in materials and workmanship for a period of 180 days from date of shipment. During the warranty period RedWave Labs Ltd will replace or repair products which prove to be defective or damaged. Our warranty shall not apply to defects or damages resulting from: i) misuse of the product or ii) operation beyond specifications detailed in the current manual.

Return procedure

Customers must obtain a valid RMA number by contacting RedWave Labs prior to the return. In all cases the customer is responsible for duty fees incurred on all received shipments and on all international returns for both warranty and non-warranty items; the customer is responsible for any duties, brokers fees or freight charges deemed chargeable to RedWave Labs Ltd.

Revisions

Manual Revision A.3: change in option 4 of input sensor activation current from 10mA to 200µA; updated product photo