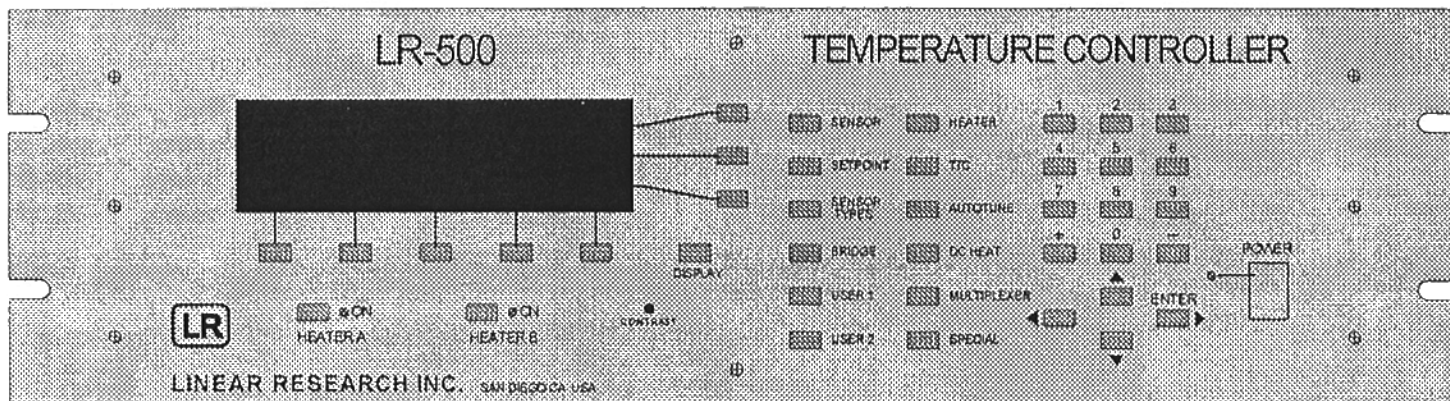


LR-500 TEMPERATURE CONTROLLER SPECIFICATIONS



LR-500 Family

LR-500 Unit.....	1	Bridge/1 Temperature Controller
LR-500 Unit + Second Sensor Options.....	2	Bridges/1 Temperature Controller
LR-500 + Unit + Dual Sensor Dual Heater ..	2	Bridges/2 Temperature Controllers
LR-500B Unit.....	1	Bridge Only
LR-500B-8X.....	1	Bridge with built in 8X Multiplexer
100 Watt Heater Option.....		Increases total power for heaters to 100 watts

Price/Performance Trade-Offs

You can buy a unit without options for the most economical price, or, order with options for increased performance. This allows the user to make trade-offs between initial price, initial performance, and **availability**.

The units can be upgraded in performance by future software options. All units have soft buttons which make any new software function work as if it was originally included with the unit.

Sensors Accepted

The unit directly measures all resistance and diode sensor types from all manufactures. This includes silicon and GaAlAs diodes, platinum resistors, germanium, carbon/carbon-glass resistors, rhodium iron, ruthenium oxide thermistors, metal oxynitride, and any other resistance-temperature detector whose values falls within 200mΩ to 20MΩ full scale.

At present, the LR-500 supports units of Ohms and Volts as setable, displayable, and measurable parameters for the sensor. Future options (field installable) will support additional units of Kelvin, Fahrenheit, and Celsius.

The sensor selection display screens allow the user to view all sensors that the unit currently supports. And, once a sensor type is selected with its soft button, a full screen dedicated to that particular sensor is shown next. The user can then (1) directly accept the sensor manufacturer's recommended excitation, thus immediately setting the bridge to that sensor, or, (2) the user can make a selection from the sensor power/resolution table shown.

Linear Research Inc.

Maximum Configuration

The unit can be configured by hardware options to a maximum configuration of two independent bridge-heater channels, both with high output powers.

In this dual heater configuration, the unit will control two completely separate high power independent thermal systems, or a single composite system with a coarse heater and fine heater. With the 100 watt option, the unit supports:

- (1) 50 watts max in Heater-A and 50 watts max in Heater-B simultaneously,
- (2) 90 watts max in Heater-A and 10 watts max in Heater B simultaneously,
- (3) the full 100 watts max in Heater-A with no Heater- B using its V-R current generator.

How The Controller Works

In the maximum configuration, the LR-500 has two true AC or DC resistance bridges measuring two sensors. Each bridge uses a 1Hz rounded square wave excitation current in AC mode. Each bridge has a low noise preamp. A DC excitation mode is used for diode excitation and, if desired, for the bridge's higher excitation voltages. Sensors are connected in a 4-wire configuration. The output of each bridge is measured every 16 milliseconds by a dedicated 24 bit analog to digital converter. Then, a 32 bit microprocessor calculates a "difference", or delta temperature signal, from the stored set temperature and the measured sensor value. The microprocessor processes each delta signal with LRI's Proportional-Integral-Derivative (PID) digital processing algorithm.

The algorithm's output for each of the two bridge channels is converted to an analog signal every 16 milliseconds by a true 20 bit digital-to-analog converter (DAC). These two analog signals drive two high power DC current (or V-R, type) generators. Each heater out current generator drives a heater resistor heating the thermal system and forcing that system's sensor to its set temperature.

Computer Interfaces

The LR-500 includes both IEEE-488 and RS-232 interfaces that control and monitor all features.

Bridge Section

The bridge generates a constant magnitude AC (or DC) sensor excitation current. The current generator has "infinite" impedance to virtually eliminate "loading" of the current source due to line resistance and sensor contact resistance. Sensor voltage, "excitation voltage", varies proportionally with sensor resistance being zero for a zero ohm sensor and maximum at full scale of resistance range.

Each bridge's (1) excitation current, (2) full scale excitation voltage, and (3) full scale sensor resistance parameters are selectable from (1) 10na to 1ma, (2) 200 μ V to 2V, and (3) 200m Ω to 20M Ω , in decade steps. A 6VDC range is also included for diodes. Thus, the bridge has 29 useable range/excitations combinations. This enables the user to make trade-offs in sensor power and sensor resolution. Each bridge channel can, of course, be used as a stand alone general purpose AC resistance bridge, greatly enhancing the versatility of the unit with R-set, R, and delta-R available at the display screen and digital interface input/outputs.

The bridge uses constant AC current and not constant AC voltage excitation. The bridge's lower AC excitation voltage ranges, of 200 μ V/20K Ω and 2mV/200K Ω full scale, give good performance and minimum sensor self-heating with negative temperature coefficient type sensors operating at low cryogenic temperatures. Thus, constant voltage excitation is not needed.

By design, the bridge's high impedance current generator in combination with its high input impedance preamp will reject and not support circulating DC currents induced by thermal EMF voltages. Thus, virtually no sensor heating results from thermal EMF's.

AC excitation eliminates false sensor values caused by sensor lead EMF voltages adding to the true sensor voltage. The preamp is designed to greatly reject the ever present common mode signal which is caused by sensor excitation current flowing through sensor contact resistance and line resistance.

RESISTANCE BRIDGE RANGES

		V, EXCITATION VOLTAGE FULL SCALE, RMS				
		200 μ V	2mV	20mV	200mV	2V
I, FIXED AC EXCITATION CURRENT RMS	10nA	20K Ω	200K Ω	2M Ω	20M Ω	--
	100nA	2K Ω	20K Ω	200K Ω	2M Ω	20M Ω
	1 μ	200 Ω	2K Ω	20K Ω	200K Ω	2M Ω
	10 μ A	20 Ω	200 Ω	2K Ω	20K Ω	200K Ω
	100 μ A	2 Ω	20 Ω	200 Ω	2K Ω	20K Ω
	1mA	200m Ω	2 Ω	20 Ω	200 Ω	2K Ω
R, RESISTANCE RANGE, FULL SCALE						

AC Operation on All 29 Permutations, DC Operation on 17 Permutations of the 2mV to 2V Ranges, DC Diode Sensor Operation on all 2VDC Ranges or the 6VDC range Not Shown

Front Panel Display Screen

The LR-500 has an easy to use large display screen with soft buttons. The unit uses no cryptic codes, no scrolling through lists of single word pop-up menus, and no rotating knobs to take you through a long single path of small displays. Instead, the LR-500 uses a great many full display screens. Parameters to be selected, are displayed on 1 or 2 full screens, allowing you to see many choices at once, and in most cases, everything that is available.

All units in this series have eight undesignated "soft buttons" surrounding the display screen. Their function/title is shown in the screen, not printed on the front panel. The soft button's titles can, and usually are, changed with each screen displayed, thus allowing nearly an infinite number of titles and command functions. In addition to the titled soft buttons, the display screen also supports over 250 characters of printed text, and/or graphics.

Linear Research Inc.

One interesting display screen shows two extra large bar graph meters (a heater-out meter and a delta-T temperature null meter). They can easily be seen from across a room. The delta-T's span can be amplified about the null point by soft button selection to give amplifications of X1, X10, or X100. This allows the user to see at a glance and in graphic mode if the system is completely at null and settled at its set temperature.

Soft buttons also allow for unlimited future screens that will be included with future software options minimizing obsolescence.

Heater Section

Each heater current generator makes use of low noise linear power circuitry. Each has 29 different full scale output current ranges from 2mA to 1A* in 10 equally spaced steps per decade of current. *2A for Heater-A with the 100 watt option and 31 ranges. Compliance voltage is -50VDC. These are all true ranges with each range using the full 20 bits of digital resolution from the DAC.

In addition to the heater DC current generator, a low power V-R heater output can also be selected to drive a low power heater or otherwise act as an output. The V-R mode has 8 ranges and uses an op-amp's voltage output in series with a selectable limiting resistor of 3K Ω to 10M Ω in 1-3-10 steps with -10VDC compliance voltage. Thus the V-R has 8 output heater current ranges from 1 μ A to 3mA that are useful for lower temperatures where minimum heater power is required. Each V-R range has 20 bits of resolution.

Grounded Heater Drive. One side of the heater is driven by the current or V-R source. The other side is returned to chassis ground inside the LR-500. This greatly helps eliminate power supply noise and ripple voltages from being coupled into the cryostat and heater area. Temperature controllers with ungrounded heaters have disadvantages. They require power supply filters to eliminate ripple and noise, and output short circuits to ground may cause hardware failures or blow fuses. The LR-500 has no such disadvantages. The LR-500's heater output may be short circuited to ground indefinitely without harm to the unit. The voltage at the heater output in I or V-R modes, is measured with a 12 bit ADC. It may be displayed on the heater out bar graph meter and is available at the computer interface. Useful for monitoring for heater compliance voltage saturation or for determining actual heater output power.

Tables included show (1) the LR-500's single channel configuration heater's two modes of operation, and (2) the two channel configuration heater's four modes of operation.

In the dual channel/dual heater configuration for example, if 0.3 watts of power is needed in Heater-B, simply use the 10 watt mode (or 5 watt mode) for Heater-B and set Heater-B's current to give 1 watt maximum power in the heater resistance to cover the 0.3 watts needed. This eliminates the need for the Heater-B output to go to the V-R mode. Thus, the low amount of power that the V-R mode can deliver is not a disadvantage. Because the 10 or 5 watt mode can always be used instead. This reserves the V-R mode for truly low temperature/low power output requirements.

Linear Research Inc.

The unit will support output currents of 0.02A, 0.06A, 0.2A, 0.6A, and 2A for output powers of 0.1w, 1w, 10w, and 100w into a 25Ω heater, will also support output currents of 0.01A, 0.03A, 0.1A, 0.3A, and 1A for output powers of 0.05w, 0.5w, 5w, and 50w into 50Ω heater, etc. These current out ranges are all sub-sets of the LR-500 set of 32 heater current out ranges. Thus, heater out ranges of most all other commercially available temperature controllers are sub-sets of the LR-500's capabilities. This allows LR-500 compatibility with existing installed heater resistors.

With so many heater currents available, the LR-500 can deliver any amount of power needed at a mid-range heater current for best operation. With the LR-500, you don't have to work at the top of a low heater current, with possible clipping of peak output power or get stuck having to work at the bottom of a high heater current with loss of resolution and the danger of a transient full power output signal giving an enormous power overshoot.

With the LR-500's 20 bits of output resolution and its 32 heater ranges, future software will allow the unit to make incremental up/down heater range changes to keep operation continually at mid-scale heater when sweeping temperature.

HEATER OUTPUT MODES

Heater output modes, zero to full power. All modes are front panel or interface selectable.

SINGLE CHANNEL

LR-500 UNIT

MODE	HEATER A
1	50W
2	V-R

(No heater B)

LR-500 UNIT, PLUS
LR-500-100W HTR OPTION

MODE	HEATER A
1	50W
2	V-R

(No heater B)

DUAL CHANNEL

LR-500 UNIT, PLUS
LR-500-2SEN/2HTR OPTION

MODE	HEATER A	HEATER B
1	50W	V-R
2	45W	5W
3	25W	25W
4	V-R	V-R

LR-500 UNIT, PLUS LR-500-2SEN/2HTR
OPTION, AND LR-500-100W HTR OPTION

MODE	HEATER A	HEATER B
1	50W	V-R
2	45W	5W
3	25W	25W

Thermal Time Constant, TTC

Thermal Time Constant, and TTC, are LRI proprietary term(s). TTC is defined as that unique time value in seconds, for a given heater-thermal mass-sensor sub-system, that marks the initial open loop 3db down roll-off point in a sub-system of the Bode plot of relative gain Vs frequency, where gain is the ratio of the incremental sensor-out voltage to the incremental heater-in voltage. This TTC parameter incorporates and can generate both integral (I) and derivative (D) values from LRI's equation relating TTC to I and D. Thus simplifying the tuning of a thermal system.

Auto-Tune

In auto-tune mode, the LR-500 automatically finds the optimum TTC and gain, then derives PID values. An optimum heater output range may also be found in auto-tune mode if requested.

Manual Tune

Auto-tuning is the mode of choice. Manual tuning is available, if the user prefers, right after auto-tuning to modify or verify the thermal optimization. Manual tuning is easy to use since the user need only input a TTC value and a gain value. The LR-500 calculates I, D and P. A special display screen with increment and decrement soft buttons allow for quick and easy manual tuning.

No Plug-In Boards

There is no hardware that you have to add or change in the field to make a unit function in all of its modes. There are no plug-in-boards. No special connectors are needed for different type of sensors, or to change heater modes. Sensor types can be randomly mixed as multiplexer inputs.

Trademarks

All LRI display screen layouts including the designated locations of the soft buttons in the display and graphic button icons are trade dress proprietary intellectual property of LRI and may not be copied or used in any other product by others without prior written permission of LRI. "Thermal Time Constant" and "TTC" are trademarks of LRI.

LR-500 FEATURES

BRIDGE FEATURES

- AC mode all ranges, AC or DC mode on higher ranges
- Constant current excitation
- Excitation voltage listed for R=100% of range. Excitation voltage varies directly with sensor R value
- Excitation Current: 10na TO 1ma in decade steps
- Excitation Voltage: 200 μ TO 2V in decade steps
- Ranges: 200m Ω TO 20M Ω in decade steps
- AC Excitation is 1Hz rounded square wave
- Preamp is high input impedance, low noise
- Dedicated ADC for each bridge, 24 bits ADC conversions every 16ms
- True Multi-Range Bridge
- High common mode rejection
- Bridge amplifiers use precision resistor for Low Drift
- 2VDC and 6VDC ranges for diode sensors

PROCESSOR FEATURES

- 32 Bit microprocessor
- 256K byte FLASH PROM allows software upgrade
- 128K byte RAM sufficient memory for future software upgrades
- PID temperature controller algorithm

HEATER OUTPUT FEATURES

- 25 Watts with 1 Amp, Heater=25 Ω
- 50 Watts with 1 Amp, Heater=50 Ω
- 100 Watts with 2A, Heater=25 Ω
- Output may be short circuited to ground infinitely
- 20 bit DAC all ranges, all modes
- Least count bit of current out resolvable and not buried in noise
- 31 Heater out current ranges, each 20 bits resolution 0 to 100%
- All heater output ranges setable 0 to 100% in open loop mode
- Other manufacturer's heater output currents are sub-sets of the LR-500 set. Hence, LR-500 is compatible with most existing installed heater resistors
- Heater Currents: 2mA to 1A Out in 28 equal spaced ranges, 10 step spacing per decade of current to 2A with 31 ranges with 100 Watt option
- Current range compliance voltage: -50VDC
- 12 bit ADC monitors heater voltage, actual instantaneous heater power out.
- V-R Currents: 1 μ A to 3mA, 8 each, in 1-3-10 steps
- V-R compliance voltage: -10VDC
- One side of heater returned to ground inside the LR-500