A Linear Thermoelectric Cooler Temperature Controller for Fiber Optic Lasers

by Jim Williams

An article in an earlier issue of this magazine described a switched mode temperature controller for fiber optic lasers.[1] This previous effort combined high efficiency switching regulator characteristics with precision, closed loop control. This article offers a different approach to temperature control using the LT1970 in a linear circuit instead of a switching regulator circuit.

The most distinguishing requirement of laser temperature control is that the controller must be able to extract heat as well as supply it. This necessitates Peltier-effect based thermoelectric heater coolers (TEC) located within the laser module—a feature usually included in the laser module by the laser manufacturer.

In most cases the switching based approach is preferable to maintain high efficiency. Occasionally a linear controller is desirable because it eliminates inductors and saves space. A trade off in the linear approach is heat dissipation, which makes it useful in applications where space is premium, and the extra heat is manageable.

Figure 1 shows the linear controller. The LTC2053 chopper stabilized instrumentation amplifier extracts an error signal from a bridge network. One bridge leg is a thermistor temperature sensor located within the laser module. The amplifier provides gain, defined by the 10M/24.9K ratio, and feeds a power output stage. The LT1970, augmented by Q1 and Q2, forms a 2A driver for the TEC. Current limiting is provided by the LT1970 sensing across the 0.05Ω shunt, protecting the laser. Here, the current limit points, set by the voltages at VCSINK and VCSRC pins, are identical for sourcing and sinking current. Different programming voltages would permit asymmetric limits.

The power stage, operating at a gain of three to ensure Q1–Q2 saturation capability, drives the TEC. The TEC's thermal feedback to the bridge located thermistor closes a control loop, stabilizing the laser module temperature. The bipolar power supply

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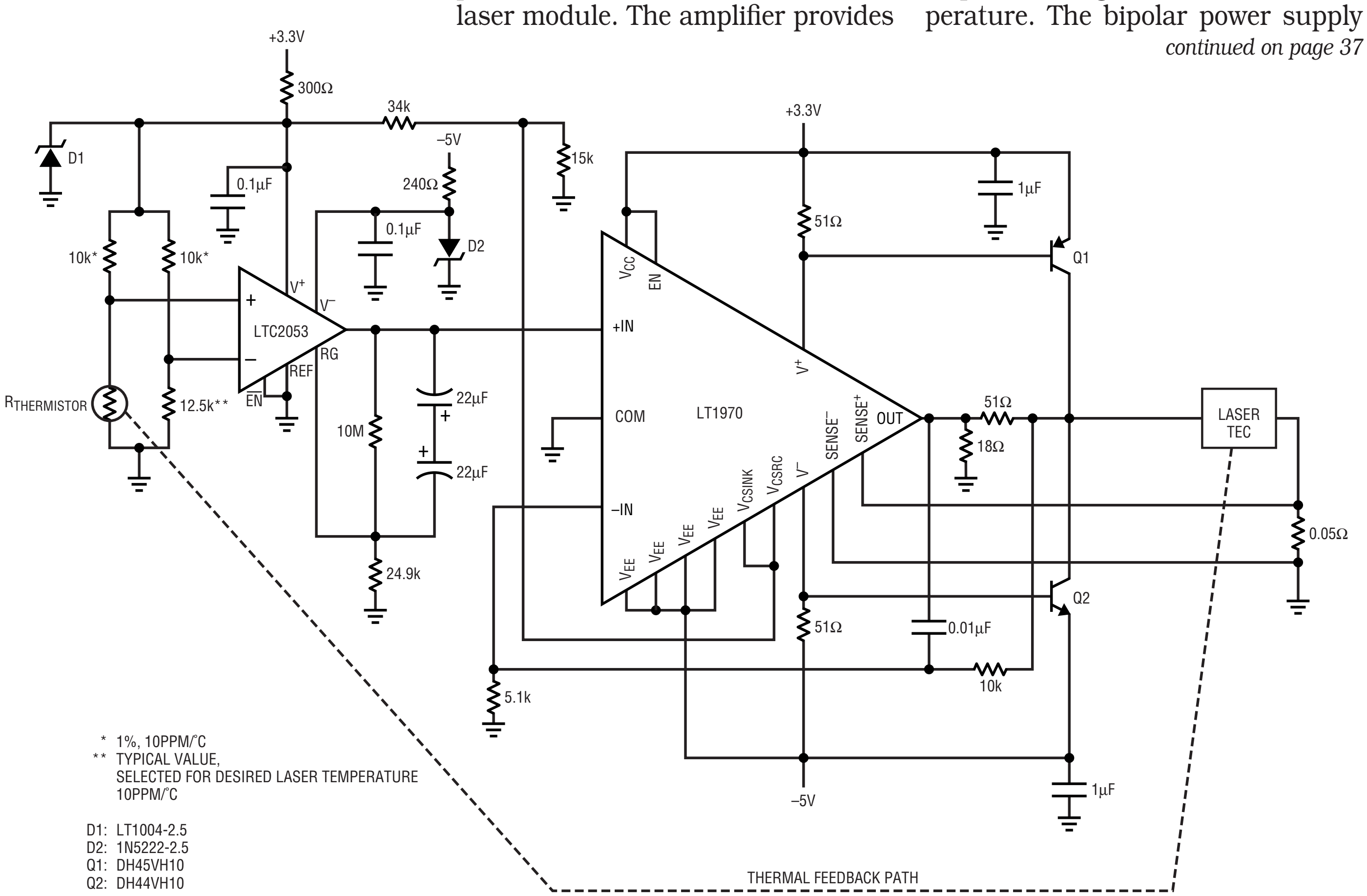

Figure 1. Two amplifiers form a thermoelectric temperature cooler for a fiber optic laser module. The linear approach eliminates inductors. As low as 0.01°C control stability over a wide ambient temperature swing is achievable.

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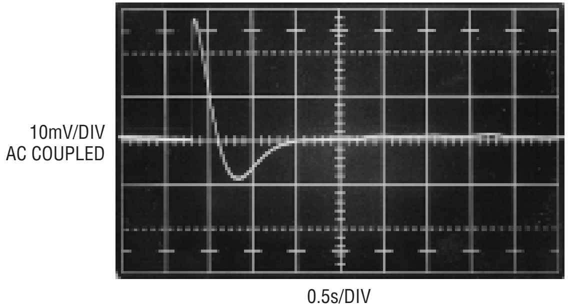

Figure 2: Optimized gain-bandwidth results in nearly critically damped response with settling in 1.5 seconds

Figure 3. 10-hour cooling mode stability measured in an environment that steps 20˚C above ambient every hour. Data shows the resulting 0.0035˚C peak-to-peak variation, indicating a thermal gain of 5700.

permits positive or negative TEC bias, allowing either heating or cooling in response to feedback loop demands. The temperature control set point is fixed by the bridge resistor value adjacent to the thermistor, in this case 12.5kΩ. Alternately, a DAC controlled potential, supplied to the LTC2053 – input, can establish the set point.

The considerable feedback lag due to thermal time constants requires loop compensation. Loop gain-bandwidth is set at the LTC2053 by the 10M–24.9k ratio and the associated feedback capacitor. Various laser modules have different thermal characteristics, mandating care in setting loop gain-bandwidth values. Optimal performance is determined by observing loop response to 0.10°C temperature setpoint step changes while adjusting gain-bandwidth values. Figure 2, the amplified thermistor bridge difference, shows a nearly critically damped response to such step inputs, indicating proper loop compensation.[2] Once optimized, this controller can easily maintain 0.01°C stability under widely varying ambient temperature conditions. Figure 3's strip-chart recording measures cooling mode stability against an environment that steps 20°C above ambient every hour over 10 hours.[3] The data shows .0035°C resulting variation, indicating a thermal gain of 5700.

Notes:

1. "A Thermoelectric Cooler Temperature Controller for Fiber Optic Lasers" Linear Technology Magazine, pg. 10–13, September 2001. See also LTC Application Note 89, with the same title but considerably more detail.
2. This forum must suffer brevity. Those finding this discussion intolerably brief are commended to LTC Application Note 89, where thermal loop optimization techniques are treated in an appropriately studious manner.
3. That's right, *a strip-chart* recording. Stubborn, locally based aberrants persist in their use of such archaic devices, forsaking more modern alternatives. Technical advantage could account for this choice, although deeply seated cultural bias may be a factor.