TECH NOTE

Nominal PID Constants for the LDT-5900 Series Precision Temperature Controller

INTRODUCTION

Temperature controllers incorporating full PID control loops allow great flexibility in optimizing the instrument for widely varying operating conditions. This flexibility comes at the price of time required for setup. Typically, several minutes to several hours are required to determine the PID constants needed for optimum system operation. Even with an auto-tune feature, 45 minutes or more may be needed to complete the auto-tune process for a single temperature setpoint. The purpose of this tech note is to provide the LDT-5900 user a collection of Proportional, Integral, and Derivative (PID) values that may be used with standard ILX Lightwave laser diode mounting fixtures. These values will allow the user to begin testing almost immediately upon connecting the equipment together and applying power.

Constants will be provided to allow operation at 10°C, 25°C, and 75°C with lasers attached to the following mounts: LDM-4407, LDM-4412, and LDM-4984, both with and without the TE-550 Case Temperature option. In all cases, the lasers used will be run at their nominal operating currents.

TEST SETUP

The general test setup is shown in Figure 1. An LDT-5948 was used to control the internal temperature of an NEL NLK1356STG butterfly packaged laser diode installed in an LDM-4984/TE550. An LDX-3525 supplied the laser drive current and was configured to provide 125 mA of constant current to the laser. The auto-tune process was performed both with the laser output on and off. This was done to see what effect the laser heat load would have on the auto-tune process since the thermal resistance between the internal TEC, laser, and thermistor is very small.

NOTE: one typically temperature stabilizes the laser before applying laser drive current to ensure thermal control is active and thermal runaway with potential damage to the laser will not happen. Laser operation without stabilized thermal control is not recommended.

There are cases where dual style temperature control is required when running a laser diode. For example, one may wish to cool the laser chip below ambient temperature in order to shorten the output wavelength or to increase the laser's efficiency. Doing this by cooling the laser's case can cause problems such as condensation. This problem may be avoided by cooling only the laser chip with the internal Peltier and keeping the case temperature at ambient. This process has the added benefit of removing any heat generated by the internal cooler. Using an LDT-5948 or LDT-5980 in this configuration to control the case temperature of the laser takes advantage of the instruments' 5A and 10A high power output. In this configuration, an LDT-5412 was used to control the internal temperature of the laser and the auto-tune process repeated.

FIGURE 1 – Test Setup

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The auto-tune function of the LDT-5948 was enabled to determine PID constants for the following conditions:

Internal Temperature with LDM-4984	Case Temperature	LDM-4984	LDM-4407	LDM-4412
Uncontrolled	10°C	√	√	√
Uncontrolled	25°C	√	√	√
Uncontrolled	75°C	√	√	√
10°C	Uncontrolled	√		
10°C	10°C	√		
10°C	25°C	√		
25°C	Uncontrolled	√		
75°C	Uncontrolled	√		
75°C	75°C	√		

When testing the LDM-4407 and LDM-4412 mounts, a Toshiba TOLD9462MC TO-56 packaged laser was used. The laser was driven at 30 mA to match the typical current value from the datasheet. Because this laser does not have a TEC incorporated into its package, tests differentiating internal laser temperature from external case temperature were not performed.

TEST RESULTS

Table 1 lists the PID values that were determined through testing and recommended for controlling the temperature of a butterfly packaged laser diode in an LDM-4984. NOTE – these values are not intended to provide maximum performance from the LDT-5948 or LDT-5980. They are a guide allowing a laser to be quickly brought to temperature. Adjustments of the constants will be required if overshoot is detrimental to the test or more flexibility in test parameters is required. Notice that different PID constants are required for different temperatures and the variability at the same temperature due to slightly different ambient conditions.

	Mount:	LDM-4984/TE-550		
	Controlled Component:	Internal TEC		
	Other Conditions:	Case Temperature Uncontrolled		
Temperature Setpoint	Proportional Term	Integral Term	Derivative Term	Comments
10°C	0.25	0.033	0.001	Laser drive current disabled
25°C	0.44	0.714	0.001	Laser drive current enabled
25°C	0.58	0.867	0.001	Laser drive current disabled
75°C	2.31	3.936	0.001	Laser drive current disabled

TABLE 1

Table 2 lists the PID values that were determined through testing and are recommended for controlling the case temperature of a butterfly laser in an LDM-4984 with the TE 550 Case Temperature option. Because of the larger thermal load, either due to physical size or the laser output being enabled, the control loop needs to be “stronger” to drive to the required temperature. This is evidenced by the larger values for P, I, and D, shown in the table.

	Mount:	LDM-4984/TE-550			
	Controlled Component:	External TEC (Case Temperature)			
Internal Temperature Sepoint	Case Temperature Setpoint	Proportional Term	Integral Term	Derivative Term	Comments
Uncontrolled	10°C	8.09	3.400	3.894	Laser drive current disabled
Uncontrolled	25°C	39.89	7.793	2.537	Laser drive current disabled
Uncontrolled	75°C	74.75	25.134	4.463	Laser drive current disabled
10°C	25°C	54.26	10.966	2.625	Laser drive current enabled
10°C	10°C	10.11	3.936	3.500	Laser drive current enabled
25°C	25°C	43.08	7.069	2.362	Laser drive current enabled
75°C	75°C	75.33	29.095	4.463	Laser drive current enabled

TABLE 2

Table 3 summarizes the PID constants when an LDM-4407 is used. Again, different PID values are suggested if different temperature setpoints more than a few degrees away are to be used. Different PID values for different temperature setpoints minimizes any underdamping or overdamping that may occur in the temperature control loop.

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Mount:	LDM-4984/TE-550				
Controlled Component:	External TEC (Case Temperature)				
Internal Temperature Sepoint	**Case Temperature Setpoint**	**Proportional Term**	**Integral Term**	**Derivative Term**	**Comments**
Uncontrolled	10°C	8.09	3.400	3.894	Laser drive current disabled
Uncontrolled	25°C	39.89	7.793	2.537	Laser drive current disabled
Uncontrolled	75°C	74.75	25.134	4.463	Laser drive current disabled
10°C	25°C	54.26	10.966	2.625	Laser drive current enabled
10°C	10°C	10.11	3.936	3.500	Laser drive current enabled
25°C	25°C	43.08	7.069	2.362	Laser drive current enabled
75°C	75°C	75.33	29.095	4.463	Laser drive current enabled

TABLE 3

Repeating the procedure with an LDM-4412 produced a different series of constants summarized in Table 4.

Mount:	LDM-4412			
Controlled Component:	Case Temperature			
Temperature Setpoint	**Proportional Term**	**Integral Term**	**Derivative Term**	**Comments**
10°C	10.46	0.5	4.769	Laser drive current disabled
25°C	15.84	0.680	5.512	Laser drive current disabled
75°C	55.0	7.7	5.5	Laser drive current disabled

Table 4

TABLE 4

CONCLUSION

In all cases shown, the PID constants change markedly depending on temperature setpoint. This is due in part to the change in efficiency of the TEC modules that occurs when they are heating as opposed to cooling. Also, repeating the auto-tune process for the same temperature setpoint and mount does not imply identical PID constants will be generated. This is because the exact same thermal conditions will not be present when the auto-tune process is re-run. Typically the heatsink will be at a different temperature leading to a different control efficiency.

For more information, refer to Application Note 20, “PID Control Loops in Thermoelectric Temperature Controllers,” and Application Note 21, “High Performance Temperature Control in Laser Diode Test Applications,” which are available from the ILX Lightwave website.

If temperature cycling with more than a few degrees difference in temperature is required, it is recommended that different PID values be entered for each temperature. By doing this, rapid shifts in temperature are possible, otherwise, oscillations or offsets in the resultant temperature can occur.