Ultra Stable Semiconductor Laser Current Source

Françoys Aubé., Martin Quenneville, Martin Chamberland Ph.D., John Tessitore

Telops,Inc.
100 – 2600, avenue St-Jean-Baptiste
Québec, (Québec), Canada G2E 6J5
Tel. : (418) 864-7808 Ext: 414
Fax. : (418) 864-7843
francoys.aube@telops.com

Abstract: Life-test for high reliability laser pumps demands highly stable current sources. Telops has engineered a novel current source that meets stabilities of 200 ppm/1000hr. This paper presents the design and assessment of performance.

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1. Design baseline establishment

The design of a stable controllable current source requires the assessment of two key factors that affect the performance: time and temperature. First, a circuit topology must be designed to encompass a minimum number of electronic components. Reducing the component count diminishes the task of managing uncertainties in the stability budget. Secondly, the circuit must be operating in a stable thermal environment. The proposed design is intended to be used along with regulated cooling water system featuring a temperature stability of +/-1ºC. The cooling water is consequently used as a "thermalization" media for the circuit.

Table 1 below summarizes the current source stability requirements, the components individual drifts and the calculated performances of the whole system. The listed requirements are those mandatory to make the difference between accurate long term aging analysis of a pump laser versus the effect of the current variation on the associated optical power. The second section of Table 1, summarizes the intrinsic drift with temperature of the 5 components involved in the current drift budget. Drift contributions of the other components of the system are "nulled" by design through the PI feedback loop topology of the current source.

Table 1, Requirements and drift contributors

	Item	Value	Unit
Requirements	**Temperature fluctuations**	1	+/- °C
	Stability 1h	0.0001	A
	Stability 1000h	0.0005	A
	Stability 1h	50	ppm
	Stability 1000h	250	ppm
	Current drive Imax	2	A
Components drifts	**DAC Temp drift**	10.8	ppm/°C
	Shunt Temp drift	15	ppm/°C
	Voltage reference Temp drift	10	ppm/°C
	Amplifier offset drift	4	ppm/°C
	Amplifier gain drift	35	ppm/°C
	Voltage reference hysteresis	40	ppm
	Voltage Reference drift 1000h	50	ppm
Worse conditions drift	**Stability 1h (1°C excursion)**	80	ppm
	Stability 1000h (1°C excursion)	130	ppm
	Stability 1h (1°C excursion)	0.0002	A
	Stability 1000h (1°C excursion)	0.0003	A

The contribution of each of the 5 generic components is carefully integrated in a worse case model (all errors unsigned and added together) instead of the classical RSS often used. The "shunt", a feedback element for current measurement is the most critical element of the system based on its 1:1drift correlation to temperature. Therefore a low temperature coefficient (15 ppm/ºC) "bulk metal" resistors was selected to meet the overall design criteria.

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After the components were chosen and the detailed design was achieved, two 3 Amperes current sources were implemented on a 2 layer circuit board to validate the design. Test data recorded over the 1000-hour criteria time using recording DMMs demonstrated that the design challenge was met.

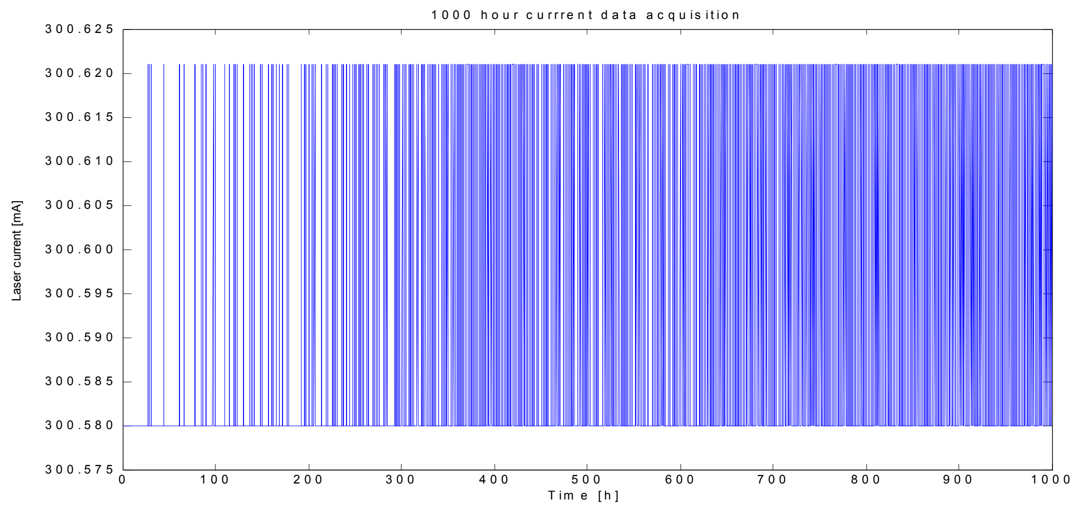

Figure 1, 1000 hr Current data

Long term data shown in Figure 1 and the summary in Table 2 demonstrates the performance of the current source. The current excursion represents only ±1.5 ADC counts (16-bit) of the measurement sub-system and demonstrated 41µA pk-pk excursion over 1000h. One can conclude that this novel current source design in meeting expectations.

Table 2, 1000hr Current source statistics

	Value	Unit
Average Current	300.578	mA
RMS Current noise	10	uA
PkPk Current drift	41	uA
ppm Current drift	136	ppm

2. Final implementation of the proven circuit

Telops integrated this design solution onto a 16-independent current source board. This multiple current source board was made to interface with a Telops microcontroller board developed for semiconductor laser burn-in and life-test applications. The microcontroller board controls other circuitry with this ultra-stable approach for the control of the semiconductor laser's thermal environment and the measurement of all device characteristics (optical power, voltage, current, temperature, etc) then transfers all data via an Ethernet link to the integrated software and data management computer.

This design enabled Telops to supply multiple test stations for the simultaneous qualification testing of several hundred "high reliability" pump laser modules used in submarine, space and other critical applications.