# Medium power stabilized laser diode

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## ABSTRACT

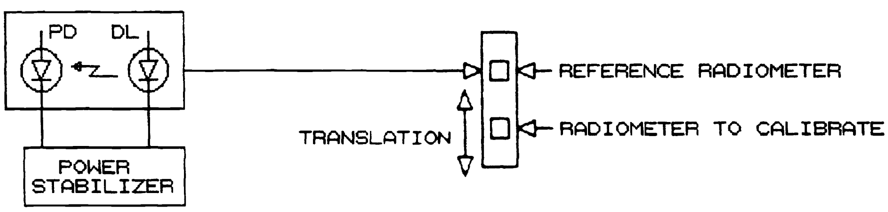
Power stabilized DL's represent today convenient sources for radiometric applications, as transfer laboratory standards. Stability measurements were carried out and reported by other authors for different time intervals, **but only for low optical power levels (max. 16 mW).** For calibrating usual optical radiometers, such low emited power DL's are useless. This paper reports stability measurements carried out on several collimated DL's with $\lambda$ around 980 nm and emitted power **up to 265 mW in near-field / 150 mW in far-field.** Stabilities of the order 1e-4 for short-time intervals (tens of seconds) and 1e-3 for medium-time intervals (1 hour) were found for a non-thermostated structure, having the control photodiode (PD) in the same enclosure with the DL (at the rear of the structure). The corresponding stabilities for an external control PD resulted of the order 1e-5 for both short and medium time intervals. The schematic of the optical power stabilizer is presented.

**Key words:** diode laser, control photodiode, optical power, stability

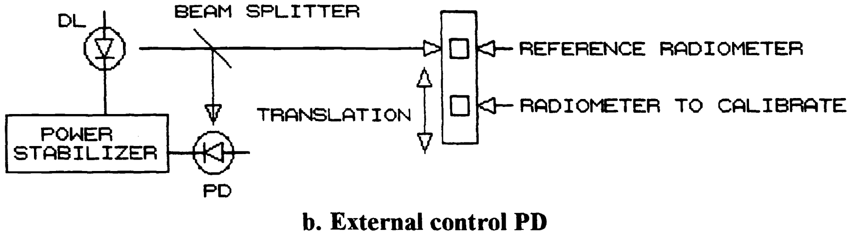
## 1. INTRODUCTION

If one has to calibrate an optical radiometer by comparison to a reference one, a transfer standard of emitted power is needed. Power stabilized laser DL's represent today convenient sources for radiometric applications, as power transfer standards. This type of laser is maybe the easiest to power-stabilize. It also allows optical power tuning, this feature being a very convenient one. A higher emitted power also becomes more and more necessary, **but only small power stabilized DL's have been reported - max. 16 mW[1,2]. In this paper an order of magnitude higher optical stabilized emitted power DL's are reported.**

Power stabilization is achieved by a feedback loop. The control element is a PD, which can be placed in the same enclosure with the DL (internal PD), behind it (as the DL emits at both ends), or separately (external PD). The two situations are represented in Fig. 1 a and b.




**a. Internal control PD**




**b. External control PD**

**Fig. 1.**



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Internal control PD leads to a compact structure, but it requires structure temperature stabilization, which is usually achieved by a Peltier cooler[1,2], as its responsivity is temperature dependent.

External control PD is somehow more "uncomfortable", but the DL requires only a heat sink (or even a fan for more powerful devices), if the temperature drift of the central λ is not important. This is true for flat spectral response of the reference radiometer and of the radiometer to calibrate (specific to most of thermal detectors). In this case, a control PD must be chosen with a moderate or small slope of the spectral response at the central λ of the DL. As this paper further demonstrates, these were easy tasks. The external control PD is thus more versatile, especially if a high power DL is used (up to 20 - 50 W today). For such DL's, it would be difficult to built an internal PD which would not saturate.

## 2. PRINCIPLE OF POWER STABILITY MEASUREMENT

As a measure of stability the standard deviation relative to the average of several power values was chosen[1,3]:

$$SdtDev_{ST} = \sqrt{\frac{\sum_{1}^{n}(P_i - Avg)^2}{n-1}} \tag{1}$$

$$Stability_{ST} = \frac{SdtDev_{ST}}{Avg} \tag{2}$$

For short therm intervals (ST) the relation (2) is used straightforward (that is why the ST index was used). For medium time intervals (MT) several measurement equally-time spaced cycles are performed. All cycles contain the same number of values $n$ and an average power is calculated for each cycle:

$$Avg_j = \frac{\sum_{i=1}^{n} P_{ij}}{n} \tag{3}$$

where $j = \overline{1,m}$ is the cycle number. The average (3) is the "representative power" for cycle $j$ [1,3]. For all cycles the global average and standard deviation are finally calculated and then the MT stability:

$$Avgavg = \frac{\sum_{j=1}^{m} Avg_j}{m} \tag{4}$$

$$SdtDev_{MT} = \sqrt{\frac{\sum_{j=1}^{m}\left(Avg_j - Avgavg\right)^2}{m-1}} \tag{5}$$

$$Stability_{MT} = \frac{SdtDev_{MT}}{Avgavg} \tag{6}$$

## 3. EXPERIMENTAL RESULTS

We have used 3 buried heterostructure double quantum well InGaAs/InGaAsP/InGaAs DL's with the central emission λ around 980 nm. The devices could emit up to 1.3W (the most powerful) of cw radiation for an injection current of 1 A, but