HAL
open science

Effect of Injection Current on Signal Strength in a Single-Mode Laser Diode Optical Feedback Interferometer Subject to Weak Feedback

Jalal Al Roumy, Julien Perchoux, Yah Leng Lim, Thomas Taimre, Aleksandar D. Rakić, Thierry Bosch

To cite this version:

Jalal Al Roumy, Julien Perchoux, Yah Leng Lim, Thomas Taimre, Aleksandar D. Rakić, et al.. Effect of Injection Current on Signal Strength in a Single-Mode Laser Diode Optical Feedback Interferometer Subject to Weak Feedback. CLEO Europe, OSA, Jun 2015, Munich, Germany. hal-01260512

HAL Id: hal-01260512

https://hal.science/hal-01260512v1

Submitted on 22 Jan 2016

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Effect of Injection Current on Signal Strength in a Single-Mode Laser Diode Optical Feedback Interferometer Subject to Weak Feedback

***Jalal Al Roumy*[1,2], *Julien Perchoux*[1,2], *Yah Leng Lim*[3], *Thomas Taimre*[4], *Aleksandar D. Rakić*[3], *Thierry Bosch*[1,2]**

1. *CNRS, LAAS, 7 Avenue du Colonel Roche, F-31400 Toulouse, France*
2. *Univ de Toulouse, INP, LAAS, F-31400 Toulouse, France*
3. *School of Information Technology and Electrical Engineering, The University of Queensland, QLD 4072, Australia*
4. *School of Mathematics and Physics, The University of Queensland, QLD 4072, Australia*

Optical feedback interferometry (OFI) sensing is widely deployed in industrial and laboratory environments, due to its simple and low-cost optical setup compared to conventional interferometry techniques, in many sensing applications such as: the measurement of displacement, distance, velocity and vibration [1]. OFI signals can be acquired either through the observation of the power fluctuations with a monitoring photodiode implemented on the rear facet of the laser diode (PD signals) or by the amplification of the variations in the laser diode voltage (LV signals) [2]. In both methods, maximum signal-to-noise-ratio (SNR) should be maintained to achieve the best performance of the sensor.

In this paper, we present a simple analytical model based on Lang and Kobayashi rate equations [3]. The model suggests a significant difference in injection current dependence of the strengths of the two interferometric signals. The PD signal is linearly dependent on injection current while the LV signal depends on the slope efficiency and the temperature. For an ideal laser diode, where slope efficiency is constant, the LV signal should remain constant. However, in practice slope efficiency decreases with the increase of injection current, as shown in Fig. 1a, due to thermal effects [4], resulting in the decrease of the LV signal with injection current.

The model was validated in a set of experiments on a distributed feedback (DFB) laser diode and a vertical-cavity surface-emitting laser (VCSEL), with the results presented here belonging to the DFB laser diode. Fig. 1b shows the measured PD signal and two model curves with the curve modelled with the behavioural slope efficiency showing good agreement with measurement over a wide range of injection current levels. Similarly, Fig. 1c shows the measured LV signal and two model curves with a monotonic decrease observed in both the measured signal and the curve modelled with the behavioural slope efficiency.

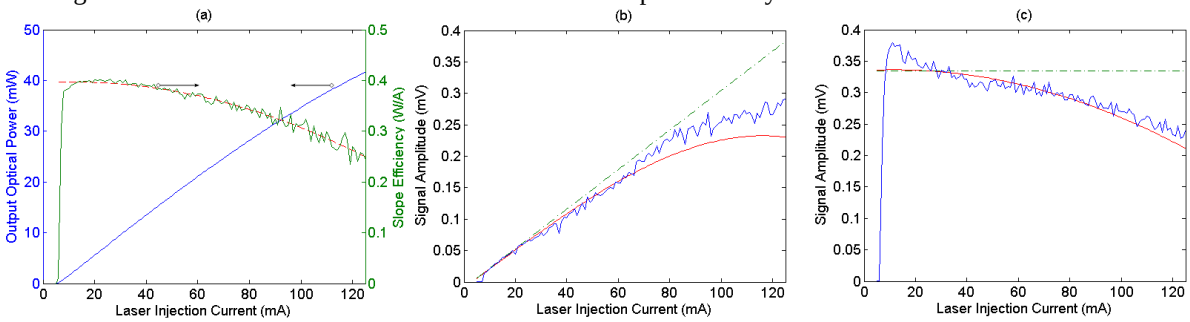

Fig. 1 a) Measured L-I curve (left axis, blue solid line) and slope efficiency curve (right axis, green solid line). A third-order polynomial was fitted to the measured L-I curve and the resulting fitted slope efficiency is shown (red broken line). b) and c) Dependence of the PD and LV signals strengths on injection current: measured (blue solid); modelled (constant slope efficiency of an ideal laser diode, green broken); modelled (behavioural slope efficiency, red solid).

The model provides important insight into the radically different biasing strategies to maximise the PD and LV signals strengths. PD signal is maximum at higher injection currents while LV signal is maximum just above the laser threshold.

References

[1] T. Bosch, C. Bes, L. Scalise, and G. Plantier, "Optical Feedback Interferometry," Encyclopedia Sens. **X**, 1-20 (2006).
[2] R. Juskaitis, N. P. Rea, and T. Wilson, "Semiconductor Laser Confocal Microscopy," App. Opt. **33**, 578-584 (1994).
[3] R. Lang and K. Kobayashi, "External Optical Feedback Effects on Semiconductor Injection Laser Properties," IEEE J. Quantum Electron. **16**, 347-355 (1980).
[4] L. A. Coldren, S. W. Corzine, and M. L. Mashanovitch, *Diode Lasers and Photonic Integrated Circuits*, 2nd ed. (Wiley, 2012).