Harmonic and intermodulation distortions and noise associated with two-tone modulation of high-speed semiconductor lasers

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PHYSICS OF WAVE PHENOMENA
Volume: 24 **Issue:** 1 **Pages:** 64-72
DOI: 10.3103/S1541308X16010131
Published: JAN 2016
View Journal Impact

Abstract

We present results of modeling and simulation of the harmonic and intermodulation distortions as well as the intensity noise of high-speed semiconductor lasers under two-tone modulation. Multiple quantum-well lasers are considered, which are characterized by large differential gain and a modulation bandwidth of about 25GHz. The study is based on the rate equation model of semiconductor lasers excited by injection current with two sinusoidal tones separated by a radio frequency. The modulated laser signal is modeled in both the time and frequency domains. The time domain characteristics include the fluctuating waveform, while the frequency domain characteristics include the frequency spectrum of the relative intensity noise (RIN), carrier-to-noise ratio, modulation response, harmonic distortion, and the second- and third-order intermodulation distortions (IMD2 and IMD3). The analysis is performed for three frequencies of 5, 15, and 24 GHz, which are, respectively, lower, comparable, and higher than the laser relaxation frequency. The range of the modulation depth covers the regimes of small and large-signal modulation. We show that both RIN and IMD3 of two-modulated laser are minimum when the modulation frequency is 5GHz, and maximum when the modulation frequency is 24 GHz. The second-order harmonic distortion, IMD2, and IMD3 values are larger in the vicinity of relaxation oscillations and increase with the modulation index, especially under large-signal modulation.

Keywords

KeyWords Plus: SURFACE-EMITTING LASERS; TRANSMISSION; INTENSITY; DIODES

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Funding

Funding Agency	Grant Number
Deanship of Scientific Research (DSR), King Abdulaziz University, Jeddah	G-1436-130-235
DSR	

View funding text

Publisher

ALLERTON PRESS INC, 18 WEST 27TH ST, NEW YORK, NY 10001 USA

Categories / Classification

Research Areas: Physics

Web of Science Categories: Physics, Multidisciplinary

Document Information

Document Type: Article

Language: English

Accession Number: WOS:000374408400013

ISSN: 1541-308X

eISSN: 1934-807X

Journal Information

Impact Factor: Journal Citation Reports

Other Information

IDS Number: DJ7RI

Cited References in Web of Science Core Collection: 29

Times Cited in Web of Science Core Collection: 1