A DIRECT SIMULATION OF SOLUTIONS FOR NONLINEAR RATE EQUATIONS OF DIRECTLY MODULATED SEMICONDUCTOR LASER

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The purpose of this paper is to solve the nonlinear rate equations of directly modulated semiconductor laser by direct simulation (numerical solution) where the rate equations are described the dynamic behavior of semiconductor laser because of optical field is depended on the time. The other side, the rate equations are described the interactions among photon density, carrier density, and the phase of photon. However, these equations are used to predict the nonlinear distortions which it is appeared in the performance of directly modulated semiconductor laser.

Целью работы является решение нелинейных уравнений полупроводникового лазера путем прямого численного моделирования. Скоростные уравнения описывают взаимодействия между плотности фотонов, плотность носителей, а также фазы фотона. Эти уравнения используются для прогнозирования нелинейных искажений, которые появляются при непосредственной модуляции полупроводникового лазера.

Introduction. The main application of semiconductor laser is as a source for optical systems in medicine and biology, where the output of the semiconductor lasers is modulated by applying the electrical signal either directly to the optical source or to the external modulator [1].

In direct modulation of the semiconductor laser, the injection current is composed of DC component plus number of frequency modulation signals occupying separate frequency band [1,2]. Due to inherent laser nonlinearity, energy is transferred to frequencies which are combinations of the original frequencies .these are nonlinearity distortions.

Theory. To predict the significance of the nonlinear distortion ,laser operation can be modeled by the rate equations, which must then be solved for situations where the drive current consist of bias term together with sinusoidal components representing the wanted multi- carrier modulation .the single mode laser rate equations may be written by symbolically as [3]:

$$\frac{dp}{dt} = \Gamma g_o(n - n_s)(1 - \xi p)p - \frac{p}{\tau_p} + \beta\Gamma_n\left(\frac{1}{r_n} + \beta_n + Cn^2\right),$$

$$\frac{dn}{dt} = \frac{I}{qv} - g_o(n - n_s)(1 - \xi p)p - n\left(\frac{1}{\tau_n} + \beta_n + Cn^2\right),$$

$$\frac{d\phi}{dt} = \frac{\alpha}{2} g_o(n - n_{th}),$$

where g_o is the optical gain coefficient ,ns the carrier density for which the gain is zero and ξ is the gain compression (or saturation) factor .the photon decay rate is considered in the terms of the photon lifetime t_p, the modal confinement factor Γ is used in defining the photon density, whilst the spontaneous recombination terms take into account both radiative and nonradiative recombination processes. Thus τ_n represents the nonradiative recombination lifetime, β the bimolecular recombination and C the anger recombination processes. Carrier injection is given by the current I, flowing through the active region, divided by the electronic charge q and the active volume V. φ is the phase of the photon, α is the line width enhancement factor and nth is the carrier threshold [3].

Result. To determine the nonlinear rate equations in equations are used, the rate equation about the phase of the photon will not be used here because the distortions affected by lasing frequency modulation (chirping) are out of concern. By using direct simulation, we can get on

first, second, and third orders of nonlinear transfer function of semiconductor laser as shown in the Figure below.

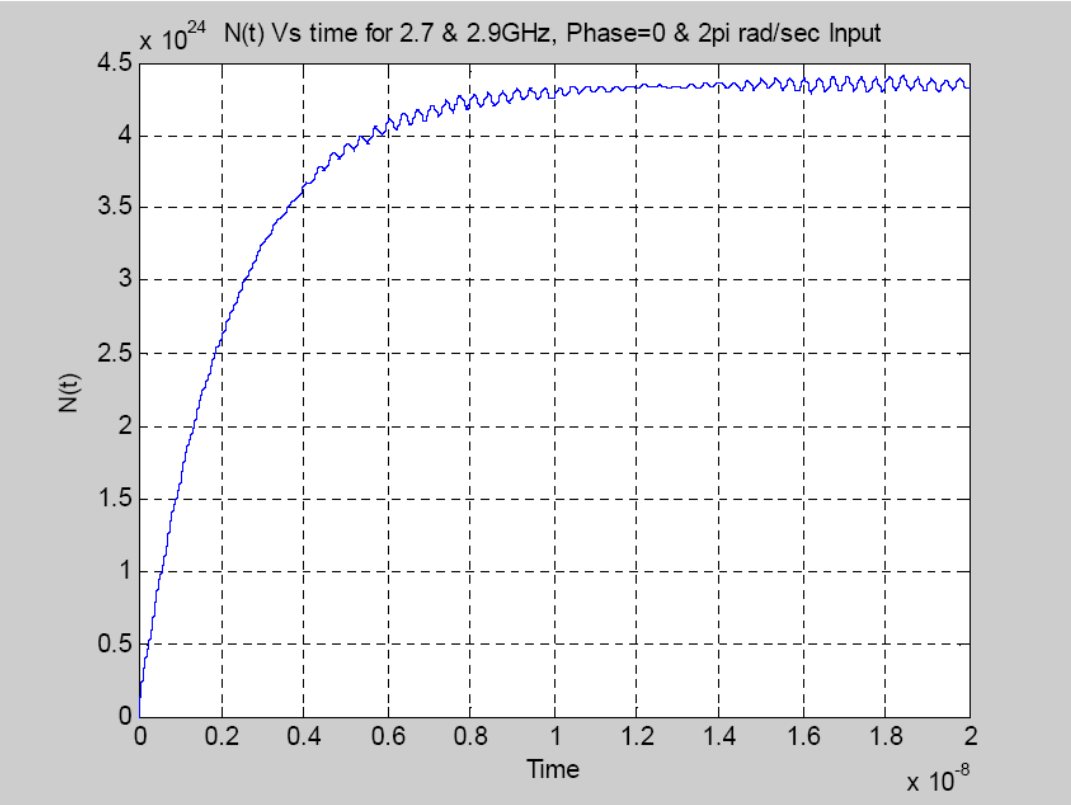

Figure (2-c) N(t) Vs time for 2.7 GHz and 2.9 GHz &phase=0 and 2π rad/sec input

Conclusion. By using the nonlinear rate equations, an approximate analysis has been presented for predicting the nonlinear distortion in performance of semiconductor laser where this distortions will effect on the photon density and carrier density. The Figure shows the optimum frequency modulation we can use to modulator the semiconductor laser to get frequency response having reduced distortions.

References. 1. T. Ikegami and Y. Suematsu, Direct modulation of semiconductor lasers – Electron. commun., Vol. 83-B, pp. 51-57, 2000. 2. R. S. Tucker and D.J. Pope Circuit modeling of effect of diffusion on damping in a narrow – stripe semiconductor laser, IEEE J.Quant. Electon,Vol.41, pp.1179-1185, 2005. 3. R. Sabella, M. Paciott and A.di Fonzo Impact of the non-linear distortions of different modulation schemes in analog CATV distribution systems, J. of light wave Technical , Vol. 11, No.6, pp.82-105, 1998.

ОЦЕНКА ПАРАМЕТРОВ ЭНЕРГЕТИЧЕСКОГО ВОЗДЕЙСТВИЯ АППАРАТНЫХ СРЕДСТВ ИНФОРМАЦИОННО-ВОЛНОВОЙ ТЕРАПИИ

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Received calculation appraisal of spectral density power radiation on frequencies 60…70 GHz fore technical means of information-wave therapy. Used calculation models excitement by a dielectric antenna by periodical spark discharge.