Radioelectronics and Communications Systems
Vol. 48, No. 9, pp. 38–41, 2005

Izvestiya VUZ. Radioelektronika
Vol. 48, No. 9, pp. 54–59, 2005
UDC 621.396

THE DYNAMIC AND ENERGY CHARACTERISTICS OF SPONTANEOUS RADIATION OF THE TRANSMITTING CHANNEL IN CO_2-LASER

A. Yu. Koziratskii

Military Institute of Radioelectronics, Voronezh, Russia

The paper establishes basic regularities in behavior and time dependence of intensity of spontaneous radiation of various quantum transitions of an active medium, their mutual impact in the process of pumping (the pre-generation period), radiation (the generation period) and restoration of the active medium (post-generation period).

Based on the model of formation of spontaneous radiation [1], let us first investigate the delay time of the generated pulse with respect to the current flow pumping pulse as a function of pressure. Figure 1 illustrates the results of simulation using this model. Having compared the obtained results with the experiment [2], we may assert that the model maps the actual processes with sufficient accuracy.

The delay of the generated pulse relative to the start of the current flow pulse varies from 1 to 3 μs depending on the pressure value.

At the same time, the shape of the generated pulse (especially, the leading edge steepness) depends substantially on the pressure. As the pressure grows, the steepness of the leading edge increases as well, however, we also face a considerable growth of start-oscillation time and the spontaneous radiation power (Fig. 2).

The start-oscillation time may be about 1 μs while the maximal power — from 5 to 7% of the peak power of the main radiation. All this demands a more detailed study of establishment of the spontaneous radiation characteristics when the transmitting channel operates under various conditions. Figure 3 presents plotted dependencies of the discharge current (i_{dis}), inverse population density ($\Delta y = n_b - n_{\mathrm{p}}$) and output radiation ($U_{CU}$) on time for typical characteristics of the transmitting channel of a laser means working in the pulse conditions and the free oscillation mode of operation.

When calculating the dependencies before the time instant when $\Delta y > \Delta y_{\mathrm{thr}}$, we used two equations — (16) and (17) from [1] and, when meeting the condition $\Delta y \geq \Delta y_{\mathrm{thr}}$, only a single equation (6) was used — both for describing the changes in populations of the levels, and for output radiation description.

It follows from analysis of the dependencies that nearly 30% of the pulse radiation energy corresponds to spontaneous radiation. Moreover, the post-generation radiation is most powerful (about 90%) while the pre-generation spontaneous radiation makes only 10% of the pulse energy. If the energy in a pulse is 1 to 3 joules, the pre-generation spontaneous radiation is 0.1–0.6 J.

The dynamics of rise of spontaneous radiation power can be broken in two peculiar stages (areas) (see Fig. 4).

The first stage corresponds to the radiation (spontaneous type) rising only due to purely spontaneous transitions from the upper to lower laser level. Since the inverse population density at this stage is negative and grows slowly, the increase in the spontaneous radiation is rather slow. When the populations of the lower and upper laser levels become equal to each other ($\Delta y = 0$), the rise becomes more intensive. Moreover, while at the first stage the spontaneous radiation grows linearly, at the second stage the growth obeys a nonlinear law and depends on three factors: (a) an increase in the number of

REFERENCES

1. A. Yu. Koziratskii, Izv. VUZ. Radioelektronika, Vol. 47, No. 9, pp. 67–73, 2004.
2. V. Yu. Baranov et al., Kvantovaya Elektronika, Vol. 3, No. 3, pp. 651–652, 1976.
3. V. I. Masychev, V. G. Plotnichenko, and V. K. Sysoyev, Kvantovaya Elektronika, Vol. 9, No. 11, pp. 2303–2305, 1982.
4. N. N. Vorob'yov, M. G. Galushkin, Ye. P. Glotov, V. G. Lyapishev, V. I. Rodionov, A. M. Seryogin, N. V. Cheburkin, and S. K. Chekin, Kvantovaya Elektronika, Vol. 11, No. 7, pp. 1454–1458, 1984.
5. B. F. Kuntsevitch, A. N. Pisarchik, and V. V. Churakov, Zhurnal Prikladnoy Spektroskopii [Journal of Applied Spectroscopy], Vol. 54, No. 5, pp. 744–752, 1991.

7 June 2004