

Optoelectronic Oscillators for Communication Systems

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The low-loss wide-bandwidth capability of optoelectronic oscillators have attracted great attention in recent years for the transmission and processing of microwave signals for applications in high-frequency signal generation in various optical and RF systems, allowing the development of high-capacity radio-over-fiber communication network systems.

Here we describe an optoelectronic oscillator configuration incorporating a semiconductor nanoelectronic component, the resonant tunnelling diode (RTD), capable to self-oscillate at microwave frequencies, that can generate both microwave and intensity modulated optical signals in the GHz region. The RTD self-sustained oscillations are a consequence of the nonlinear negative differential resistance (NDR) region of RTD current-voltage characteristic. That is, when DC biased in the NDR region the RTD provides electric gain to the system to buildup electrical oscillations at frequencies up to hundreds of GHz. Under external injection it is capable of synchronization operation and signal amplification. When integrated with optical waveguides and laser diodes, the RTD oscillator augments the devices' functionalities, giving rise, for example, to a new kind of optoelectronic oscillators with both electrical and optical inputs and output ports allowing operating modes with high interest in communication applications.

The optoelectronic oscillator configuration discussed here is composed of two optoelectronic components, a RTD embedded in a semiconductor optical waveguide, the RTD-OW, and a laser diode. Its operation principle is as follows. The RTD-OW works as a photo-detector with a built-in electric oscillator that is controlled by light wave sub-carriers. It functions as an optical-to-RF converter at optical communication wavelengths, detecting and amplifying optical sub-carrier signals, and recovering the original transmitted RF signal.

Connecting the RTD-OW in series with a laser diode, the RTD-OW current oscillations drive the laser diode producing optical sub-carriers. When externally perturbed by RF signals in the electrical input port of the oscillator, the RTD locks to the RF signal and electrical-to-optical RF conversion is obtained. The RTD-OW oscillator together with laser diode circuit configuration can be used for injection-locking, up-conversion, and down-conversion of both electrical and optical reference signals. The applications cover a wide range of photonic and RF systems such as optical signal processing and RF photonics.

This paper describes the development of these novel microwave photonic devices as optical transmitters and receivers, pointing their applications, and suggests potential future developments, including optical/electrical conversion for the next generation of radio-over-fiber networks.

References:

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