Introduction to Patents

Japanese Patent Publication No. 2007-248660

Ultra-Flat Optical Frequency Comb Signal Generator

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External view of the short-pulse light generator

Summary of the technology

The optical frequency comb generator is an optical signal generator having flat spectral characteristics, in which respective frequency components ideally have the same light intensity and are aligned at a certain interval along the frequency axis. When creating an optical frequency comb with a $LiNbO_3$ modulator, it is important to obtain an optical frequency comb with flat spectral characteristics. However if a $LiNbO_3$ modulator is driven with a large-amplitude signal, it is possible to obtain a phase-modulated beam due to the electro-optical effect. It is thus possible to obtain an optical frequency comb. However, the light intensity of each frequency component in the phase-modulated beam depends significantly on the magnitude of the driving signal, and the flat spectral characteristics cannot be obtained. This problem occurs because the light intensity of the highly modulated components in the optical signal generated obeys Bessel's function according to its order.

The present invention makes it possible to obtain an optical frequency comb with flat spectral characteristics by using a single Mach-Zehnder modulator having two phase modulators and by

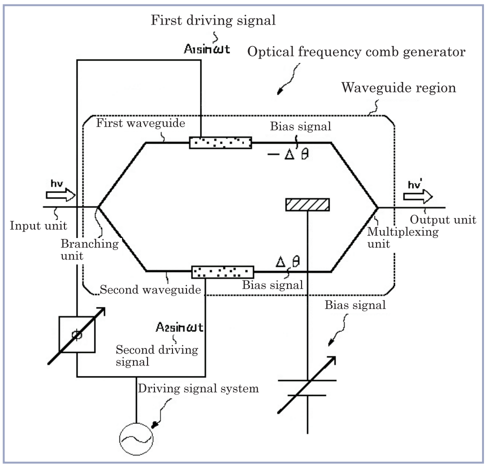


Fig. 1 Schematic view of the optical frequency comb generator

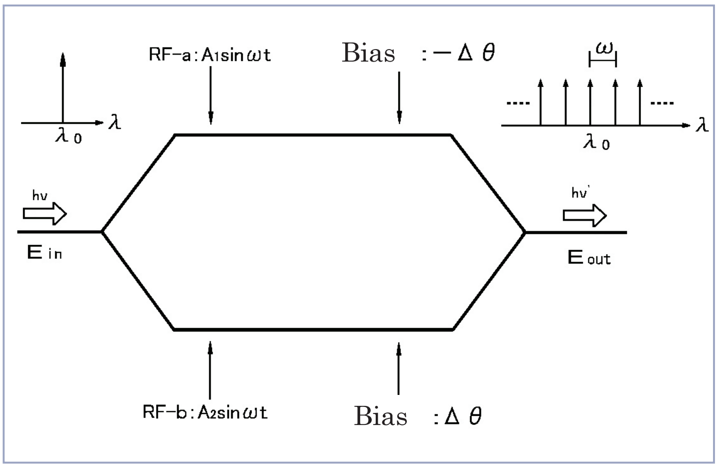
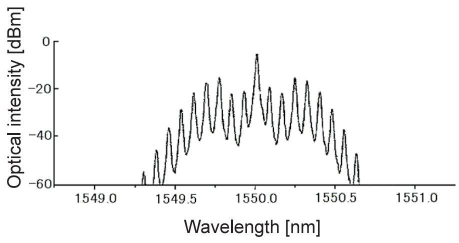
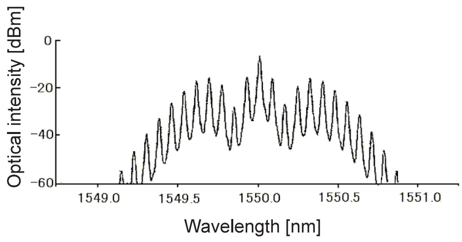


Fig. 2 Schematic diagram of the optical frequency comb generator

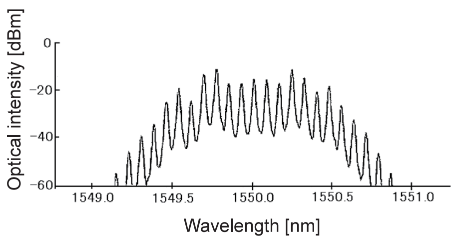
multiplexing the beams emitted from the two phase modulators. The optical phase modulator modifies the optical phase of the input signals, which means that only optical signals having an optical phase modified by a certain distance from those of the input optical signals are generated. However, in addition to the signals modified by a certain distance, the optical phase modulators generate an optical spectrum containing multiple beams that differ in frequency as noise. As a result, the optical intensity of the multiple frequency components varies according to Bessel's function mentioned above. It is possible to obtain an optical frequency comb with flat spectral characteristics from a single optical modulator by multiplexing optical signals emitted from two optical phase modulators and by using the frequency components output as noise and appropriately adjusting the light intensity of the frequency components.



a: Output signal when driven only with RF-a



b: Output signal when driven only with RF-b



c: Output signal when driven with RF-a and RF-b

Fig. 3 Example of the spectrum of optical combs

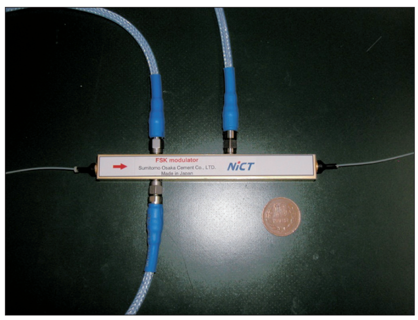


Fig. 4 External view of the FSK modulator

Applications

The "comb" in the optical frequency comb generator takes its name from the waveform of the light emitted, which is similar to the shape to comb. Recently there has been increasing interest in optical frequency comb-generating technology that has a function of generating multiple optical frequency components with frequencies that vary at a constant interval. An optical frequency comb generator that can generate such an optical frequency comb can be used as a wavelength multiplex light source in wavelength-division multiplexing systems or as a short-pulse light source for ultrahigh-speed optical transmission and measurement. In addition, study is underway concerning the application of the optical frequency comb generator as an optical frequency standard for absolute frequency measurement, for the remote supply of locally oscillated signals in the microwave or millimeter-wave frequency range, and as a control signal for array antennas used in astronomical observation systems such as radio telescopes. In particular, the ALMA Radio Telescope has a spatial resolution ten times greater than those of the Hubble space telescope and Subaru telescope (designed to unlock the secrets of the universe, installed in the highlands of the Atacama Desert in northern Chile at an altitude of 5,000 m) and has 66 antennas installed at intervals of up to 18.5 km. Multiple signals from the antennas are multiplexed in a radio interferometer to provide high spatial resolution. The superior stability of the standard signal plays a very important role in ensuring the performance of the entire ALMA Radio Telescope system. In the case of standard high-speed signals having a frequency of over 100 GHz, it is necessary to send the signals over long distances while ensuring that the turbulence remains within 1 sec/300,000 years. In addition, it is very important that the standard signal source has superior phase stability. For this reason, the base signal is generated by an atomic clock. The ALMA Radio Telescope system uses fiber-optic radio technology to send high-speed signals using light, as it is difficult to send the high-speed signals of remote antennas through conventional copper wires or waveguide. This optical comb made it possible to develop new optical signal generating-transmitting technology that satisfies the stability, frequency range and accuracy required to ensure the performance of the ALMA Radio Telescope system.

Conclusion

This optical frequency comb contains two phase (FSK) modulators that were presented earlier in this column (Journal of NICT, Vol. 53, No. 3). It is our great pleasure for the people in charge of this column that this high-performance device was developed based on the patented technologies accumulated at NICT. Our desire is to facilitate the use of NICT's technology in various applications, including cutting-edge devices and home appliances.

(Article written by SAWADA Fumitake, Expert, Research Results and Intellectual Property Management Office, Outcome Promotion Department)

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