Frequency-modulated tunable lasers enable long-range signal transmission

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Optically filtering the light from distributed Bragg reflector lasers facilitates 100Gbit Ethernet applications.

The recent rapid growth in Internet traffic requires an increase in the number of operational channels in dense wavelength-division multiplexing (DWDM) systems, simultaneously allowing a larger number of data streams on the same optical fiber. Widely tunable lasers have been developed to construct DWDM systems at low cost. Such lasers can provide backups and replacements for fixed-wavelength light sources, thus reducing inventory costs.

Additional modulators are required for wide operational wavelength ranges and for high-speed and long-distance transmissions. Recently, a chirp-managed laser (CML), composed of a distributed-feedback (DFB) laser and an optical filter, was developed for transmission over distances greater than 200km. Long-range transmission is enabled by satisfying the optical minimum-shift keying condition (a form of continuous phase modulation). Therefore, CML arrays are demonstrably useful for construction of widely tunable transmitters. However, this technique requires a radio-frequency switch for electrical-channel selection, hence increasing the cost and size. On the other hand, monolithic integration of the lasers, modulators, and other functional components will allow construction of low-cost transmitter arrays. CML components are therefore promising building blocks for transmitter arrays. However, thermal crosstalk will cause modulation of adjacent lasers.

To overcome these problems, we propose a novel transmitter consisting of a frequency-modulated distributed Bragg reflector (DBR) laser and an optical filter. Reverse-voltage modulation of the laser phase-control region enables us to obtain fast refractive-index modulation and seems to generate less thermal crosstalk than current modulation of a DFB laser. Figure 1 is a schematic representation of a transmitter consisting of a widely tunable superstructure grating (SSG)-DBR laser and an optical filter. Figure 2 shows characteristic ‘eye diagrams’ (used to visualize the waveforms) for the proposed transmitter for a 10Gbit/s NRZ (non-return to zero) signal after transmission of 180km. The lasing wavelength was changed from 1531.9 to 1558.7nm by adjusting the current entering the front SSG. The bias and modulation voltage were fixed at −0.54 and 1.8V, respectively, thus demonstrating the compatibility of the proposed modulation scheme with a widely tunable laser. We used the series connection of the Mach–Zehnder interferometer filter with an etalon.

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bandwidth at 3dB of 13.5GHz. Figure 2 shows that a clear eye opening was observed for a wide tuning range.

Figure 3 shows bit-error-rate measurements obtained at a lasing wavelength of 1540.6nm. The power penalty was negligibly small after transmission for 40 and 80km, but it increased with transmission distance from 100 to 180km. However, error-free transmission with a power penalty of only 2.2dB was achieved even after 180km.

We have therefore successfully demonstrated the monolithic integration of a 100Gbit/s throughput (4×25Gbit/s) laser array, as shown in Figure 4. By optically filtering the output light from the frequency-modulated laser, we observed a clear eye opening after transmission for 40km of a 25Gbit/s NRZ signal. This indicates that the proposed frequency-modulated DBR laser arrays are very suitable for construction of low-cost laser arrays for 100Gbit Ethernet (100GbE) applications. Thus, these lasers have two advantages, including high-speed modulation without limits to the relaxation-oscillation frequency and easy construction of transmitter arrays. We will try to fabricate 100Gbit/s serial-modulation lasers for 100GbE use in arrays containing more than 10 transmitters for eventual application in a DWDM network.
References


