Gain optimization of a fiber-optic link with an external electrooptical modulator and erbium doped fiber amplifier

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Abstract—Gain optimization of a radio-frequency fiber-optic link by biasing an external modulator to the transmission minimum was studied. The increase in the gain by up to 5 dB as compared with the conventional quadrature point operation was demonstrated. Dependences of nonlinear distortions on the bias voltage of the electrooptical modulator were investigated.

Keywords—radio-frequency fiber-optic link; gain, electrooptical modulator; microwave photonics

Microwave fiber-optic links offer many advantages over coaxial cables and other metal guides. These are very low transmission losses (~ 1 dB/km), large bandwidths, small weight, and a high degree of immunity to radiation and electromagnetic interference. The main drawbacks of these links are a limited dynamic range performance because of a low gain and nonlinear distortions. It has been shown that maximal transmission coefficient (gain) and minimal nonlinear distortions in microwave fiber-optic links correspond to the quadrature bias point of the external electrooptical modulator [1]. A fairly low gain (≈ -20 dB) in this case is mainly caused by the photodetector saturation due to a high power in the unmodulated carrier which does not convey meaningful information.

In this report we analyze the gain increase obtained by biasing the voltage applied to the external electrooptical modulator to a low transmission and by amplifying the amplitude-modulated optical signal by an optical amplifier operating near its saturation. Theoretical analysis showed that this provided an increase in the optical signal modulation depth and, as a consequence, an increase in the maximum link gain limited by the photodetector saturation current.

The gain optimization of the fiber-optic link with an external electrooptical modulator and an erbium doped fiber amplifier was performed. The increase in the link gain of up to 5 dB as compared with the conventional quadrature point operation was experimentally demonstrated. The shift of the bias from the quadrature point (the center of the linear transfer function part) inevitably resulted in an increase in nonlinear distortions. The nonlinear distortions were monitored by measuring the second and third harmonics. A minor increase in the nonlinear distortions (0.5 %) was observed for the relative bias voltage shift (0.5Vr) corresponding to the maximum gain.

Fig. 1. Nonlinear distortions (Kmd, squares) and gain (Gmd, triangles) of a radio-frequency fiber-optic link as functions of relative shift of bias voltage (V = (V0-Vmd)/Vr) of external electrooptical modulator. Solid lines are calculated theoretical dependences.

Theoretical dependences of gain and nonlinear distortion coefficient on the bias voltage of the external electrooptical modulator were calculated. They were found to be in a good agreement with the experimental data.

The results can be useful for the emerging technology of radiophotonics taking advantages of optical methods for generation, transmission, transformation, and processing of analog radiofrequency signals.

REFERENCES