Investigation of influence of thermal coefficients on 2-D WH/TS OCDMA code propagation in optical fiber

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In this paper we present an extension of our previous investigation [1] of the effect of environmental temperature variation on the bit error rate (BER) performance of multiwavelength 2-dimensional wavelength hopping time spreading optical code division multiple access (2D-WH/TS OCDMA) signals that utilises picosecond pulses for code formation. Using equations already derived in [1] for modelling the effects of temperature variation on autocorrelation signal resulting from the decoding of an incoherent 2D-WH/TS OCDMA encoded signal which consists of \( w \) wavelength pulses each having a pulsewidth of \( \tau \) after propagating in \( L \) (Km) of fibre, we arrive at the expression for the envelope of the resulting autocorrelation peak \( S_t \).

\[
S_t = \sum_{k=0}^{w-1} P_k \exp \left\{ -1.87 \left[ \frac{k}{\tau} \left[ D_{\text{temp}} \times \Delta T \times \Delta A \times L \right] \right] \right\} \tag{1}
\]

\( D_{\text{temp}} \) (ps/nm•km/°C) is the thermal coefficient of the fiber [2,3], \( \Delta T \) (°C) is the average change in temperature experienced by transmission fiber, \( \Delta A \) (nm) is the spectral spacing between 2D-WH/TS OCDMA code wavelengths pulses, and \( \Delta L \) (nm) is the pulse spectral line width of each wavelength pulse within the code.

Having obtained the maximum possible autocorrelation peak \( S_t \) for each degree of temperature change, we analysed the effect of this reduction in \( S_t \) with respect to temperature variation by substituting \( S_t \) for \( \Delta T \) in the equation for \( \text{Pe} \) (BER) as previously derived in [1] and we obtain the equation below

\[
P_e = \frac{1}{2} \sum_{j=0}^{S_t} (-1)^j \left( \frac{w}{2} \right)^j \left( 1 - \frac{\tau}{\Delta T} \right)^{\frac{j}{1-k}} \tag{2}
\]

Figure 1 shows the envelope of \( S_t \) for an 8 wavelength 2D-WH/TS OCDMA signal after propagation in a 10km optical fibre link \( D_{\text{temp}} = -0.0025 \) ps/nm•km/°C, \( \Delta A = 0.8nm \) and \( \Delta L = 1.4nm \), \( N_o = \) code length with initial pulsewidth of 2ps. Three different scenarios have been illustrated in the figure for \( \Delta T = 0, 10 \) and 20 degrees respectively.

![Fig. 1. Maximum obtainable autocorrelation peak (S_t) as \( \Delta T \) increases over a 10 km.](image1)

![Fig. 2. Minimum obtainable BER as \( \Delta T \) increases over a 10 km and 20 km link respectively with 32 simultaneous users.](image2)

To evaluate the effect of the \( \Delta T \) induced reduction in \( S_t \), the minimum possible bit error rate performance for \( K = 32 \) simultaneous users at 2.4Gb/s data rate was recorded from calculations obtained using Eq. 2 for \( \Delta T \) between 0 and 20°C over a 10km and 20km fiber optic link. The results are presented in Figure 2. We found that trade-offs must be made between number of simultaneous users and transmission distance in order to maintain performance.

References