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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 \( S_{t} \):

\[
S_{t} = \sum_{k=0}^{W-1} p_{k} \exp \left\{ -2.77 \left[ \frac{k[D_{\text{temp}} \times \Delta T \times N \times L]}{\tau} \right] \right\}
\]  

(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 \( \Delta \lambda \) (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 \( \theta \) in the equation for \( P_{e} \) (BER) as previously derived in [1] and we obtain the equation below

\[
P_{e} = \frac{1}{2} \sum_{j=0}^{\text{St}} \left\{ (-1)^{j} \right\} \left( \frac{W}{1 - j \frac{N}{W}} \right)^{k-1}
\]  

(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 (\( D_{\text{temp}} = -0.0025\text{ ps/nm•km/°C} \), \( \Delta A = 0.8\text{nm} \) and \( \Delta \lambda = 1.4\text{nm} \), \( N_{w} = \text{code length} \) ) with initial pulsewidth of 2ps. Three different scenarios have been illustrated in the figure for \( \Delta T = 0, 10 \) and \( 20 \) degrees respectively.

![Figure 1](image1.png)

**Fig. 1.** Maximum obtainable autocorrelation peak (\( S_{t} \)) as \( \Delta T \) increases over a 10 km.

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.

![Figure 2](image2.png)

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

References