to be optimised for a specific application and it is clear that increasing the number of confidence levels helps in better optimisation of γ.

Conclusion: The proposed adaptive Chase algorithm can achieve comparable performance as the Chase-2 algorithm with significantly reduced complexity. Compared to other algorithms that limit the number of checked test patterns [5–7], the proposed algorithm is less complex and simpler to execute, owing to two aspects; first, appropriate selection of the demodulator threshold in order to discriminate between received bit reliabilities, and secondly, limiting the number of reviewed codewords.

The proposed algorithm, at $BER = 10^{-5}$, when optimised during iterative decoding can achieve 60 and 15% of complexity reduction over the Chase-2 algorithm and Kaneko algorithm, respectively; and with only 0.5 dB coding gain loss, it gives a 70 and a 25% complexity reduction, respectively.

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Code-selective frequency shifting by RF photonic mixing in a dual-electrode Mach-Zehnder modulator

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Code-selective frequency shifting by RF photonic mixing that may be used to demultiplex direct sequence encoded CDMA signals in the optical domain has been demonstrated. The technique exploits the bipolar nature of the optical field without requiring an optical local oscillator, and spectrally isolates the desired channel before photodetection.

Introduction: There has been considerable interest in optical code division multiple access (CDMA) schemes for optical local area networks [1]. CDMA permits a number of different users to occupy the same bandwidth by using orthogonal codes. However, due to the absence of an optical device capable of adding or dropping channels based on their codes, optical CDMA networks are generally of a broadcast and select nature. Optical code division add-drop multiplexers, such as the one reported in [2], perform the add-drop function by receiving all channels at the photodetector, and canceling undesired channels due to orthogonal coding. Receiving all channels at once from within the same bandwidth causes deleterious effects such as cumulative shot noise and speckle, which can seriously limit the number of simultaneous users [3].

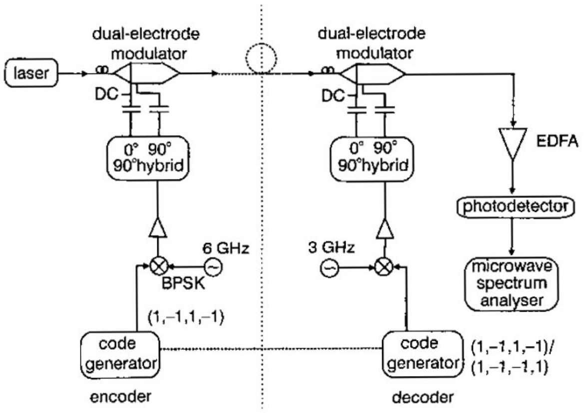

Fig. 1 *Experimental setup used to demonstrate code-selective frequency shifting*

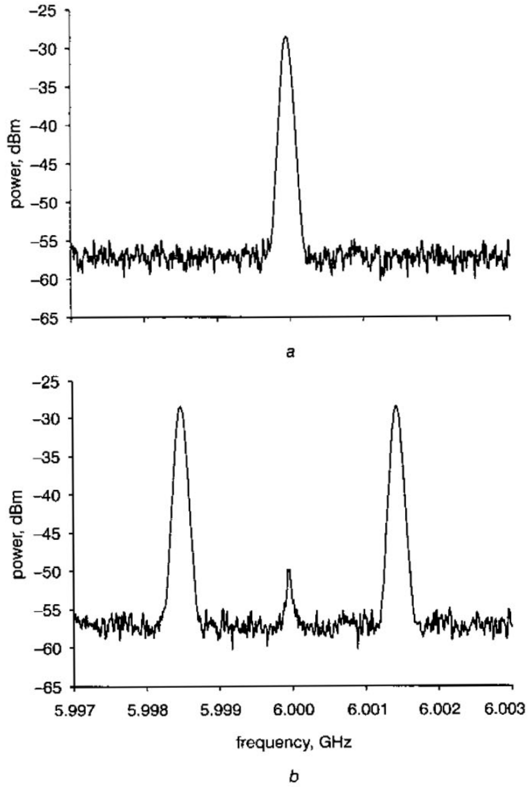

Fig. 2 *Signal obtained at 6 GHz after heterodyning with original optical carrier, for 'pure', unencoded subcarrier and 'noisy' subcarrier encoded with 1.5 MHz chip rate (1, −1, 1, −1) code*

a 'Pure' unencoded subcarrier
b 'Noisy' subcarrier encoded

In this Letter, we demonstrate a technique that has the potential to solve these problems. We use a dual-electrode Mach-Zehnder modulator (DE-MZM) to coherently frequency shift a direct sequence (DS) encoded optical channel by mixing it with an identically encoded microwave local oscillator. The use of a microwave local oscillator as opposed to an optical one is a key feature of our design, since it avoids the stringent requirements and complicated schemes that necessarily accompany the use of an optical local oscillator. We show through a simple experiment that only the channel with the matching code gets shifted. This channel can be separated by an optical filter, or by an electrical filter after photodetection. The spectral separation reduces the effects of cumulative shot noise and speckle, and full code orthogonality is possible since the bipolar nature of the optical field is recognised by the frequency shifting process.

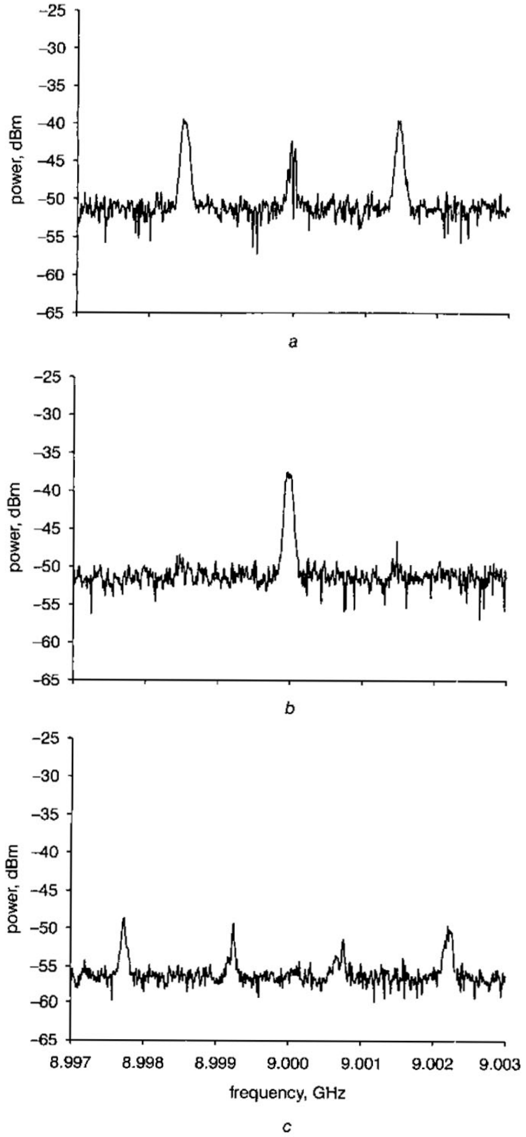

Fig. 3 *Signal obtained at 9 GHz obtained after heterodyning with original optical carrier*

a When code C_2 is $(1,1,1,1)$, i.e. no code is applied
b When code C_2 is $(1,-1,1,-1)$, i.e. identical to code C_1
c When code C_2 is $(1,-1,-1,1)$, i.e. orthogonal to C_1
Carrier recovered at 9 GHz when codes are matched. Unmatched codes are rejected, confirming the code-selectivity of the frequency shift

System description and experimental data: Fig. 1 shows a block diagram of the experimental setup. For experimental convenience we do not encode the optical carrier itself, but impose an encoded subcarrier on it, which we then treat as the encoded optical carrier. This allows us to heterodyne the spectrum against the original unencoded optical carrier to produce a spectrum observable on an RF spectrum analyser. The light source used is a laser diode at f_{oc} GHz (1550 nm). The light is coupled into a DE-MZM through a polarisation controller. The two terminals of the quadrature biased DE-MZM are then connected to the two outputs of a 90° hybrid as shown in Fig. 1. This has the effect of generating an upper sideband (USB) while suppressing the lower one [4].

First, we apply a low power, 'pure', unencoded 6 GHz single tone to the first DE-MZM with no code imposed. This results in a pure tone at $(f_{oc}+6)$ GHz observable at 6 GHz on the spectrum analyser as shown in Fig. 2*a*. Applying a 1.5 MHz chip rate BPSK code $C_1(t)$ corresponding to the $(1,-1,1,-1)$ row of a 4×4 Hadamard matrix to the 6 GHz frequency results in a 'noisy' encoded carrier at $(f_{oc}+6)$ GHz as shown in Fig. 2*b*.

At the decoder, the signal is mixed with a 3 GHz microwave carrier encoded with a code $C_2(t)$, applied to the dual-electrode modulator in USB configuration. This has the effect of upshifting the signal at $(f_{oc}+6)$ GHz to $(f_{oc}+6+3)=(f_{oc}+9)$ GHz while simultaneously suppressing the downshifted version [5]. The optical signal is then detected by an Agilent lightwave converter with a conversion gain of 300 V/W. The signal at 9 GHz is observed on an RF spectrum analyser.

We observe the signal at 9 GHz for three different cases of $C_2(t)$. *Case 1*: Code $C_2(t)$ is not applied, i.e. it is a $(1,1,1,1)$ code. Fig. 3*a* shows that in this case, the noisy encoded carrier is just upshifted to 9 GHz and no decoding takes place. *Case 2*: Code $C_2(t)$ is identical to C_1, i.e. both are $(1,-1,1,-1)$ but appropriately delayed to compensate for the delay through the system. Fig. 3*b* shows the 'pure' unencoded carrier recovered at 9 GHz. The delay for C_2 is tuned to get best carrier recovery. *Case 3*: Code C_2 is chosen to be $(1,-1,-1,1)$, i.e. orthogonal to C_1. In Fig. 3*c* no carrier is seen at 9 GHz, indicating the upshift is indeed code-selective. Two phase-locked signal generators were used to generate the codes.

Conclusions: These results confirm that we have demonstrated code-selective frequency shifting using RF photonic mixing in a DE-MZM. Unmatched channel rejection with the use of an orthogonal code has been demonstrated. The bipolar nature of the optical field is recognised since the frequency shift happens before photodetection, thus allowing full code orthogonality. A coherent effect has been achieved without the use of an optical local oscillator and its associated difficulties. The spectral separation of the desired channel leads to reduction in the effects of cumulative shot noise and speckle, which is important in order to support more simultaneous users [3]. This method could be used in the optical domain demultiplexing of direct sequence microwave CDMA signals carried over fibre. The ability to distinguish a signal based on its code in the optical domain might be useful in optical routing schemes or to add more functionality to RF over fibre systems.

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