# Code-selective RF photonic mixing for use in optical CDMA demultiplexers

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***Introduction:*** The need for multiple access techniques in local area networks has inspired interest in optical code division multiple access (OCDMA), however due to the absence of optical devices capable of adding or dropping channels based on their codes, such networks are generally of a broadcast and select nature. A recent demonstration of OCDMA add-drop multiplexers [1], requires that all channels be received at the photodetector, with undesired channels being cancelled 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 [2]. In this paper, we demonstrate a technique that coherently frequency shifts a direct sequence encoded optical channel by mixing it with an identically encoded RF local oscillator in a dual-electrode Mach-Zehnder modulator (DE-MZM). The spectral separation would reduce the effects of cumulative shot noise and speckle, and full code orthogonality is possible since the bipolar nature of the optical field is recognized by the frequency shifting process.

***System Description and Experimental Data:*** Figure 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. Using the subcarrier as an encoded optical carrier allows us to heterodyne the spectrum against the original un-encoded optical carrier to produce a microwave spectrum observable on an RF spectrum analyzer. The light source is a laser diode at $f_{oc}$ GHz coupled into a DE-MZM which is connected in upper single sideband (USB) configuration [3]. To begin with we apply a '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 analyzer as shown in Fig. 2a [3]. Applying a 1.5 MHz BPSK code C1(t) corresponding to the (1010) row of a 4x4 Hadamard matrix, to the 6 GHz frequency results in a 'noisy', encoded carrier at ($f_{oc}$+6) GHz observable at 6 GHz as shown in Fig. 2b. At the decoder, we apply a low modulation depth 3 GHz signal with code C2(t) to the second DE-MZM, also in USB configuration. This had the effect of up-shifting the signal at ($f_{oc}$+6) GHz to ($f_{oc}$+9) GHz [4]. The optical signal was then amplified and photodetected, and the signals at 6 GHz and 9 GHz were observed on an RF spectrum analyzer.

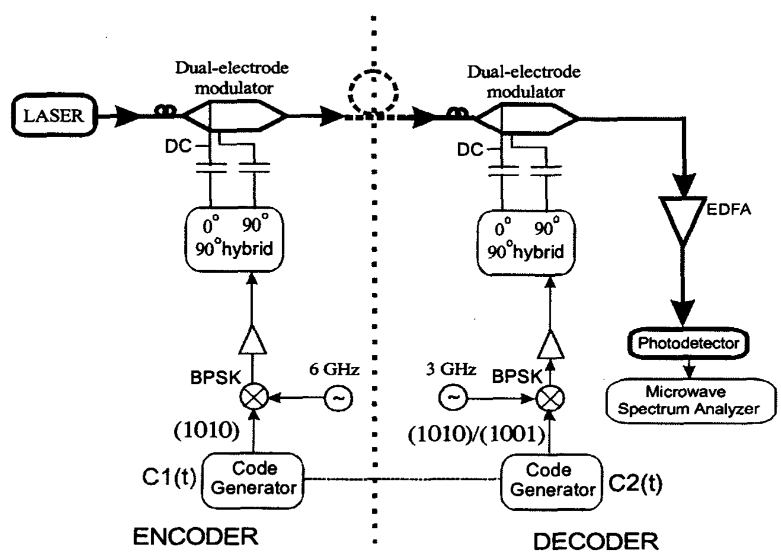


**Fig. 1** Block diagram of experimental setup

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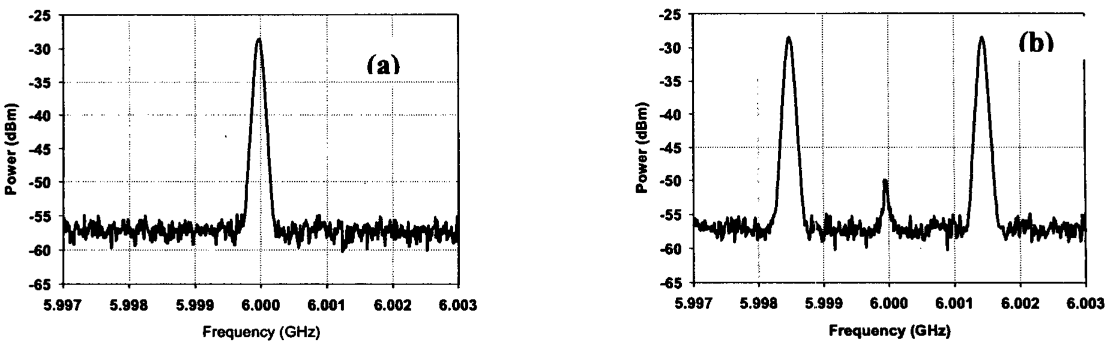


**Fig. 2** Signal obtained at 6 GHz after heterodyning with original optical carrier for a) 'pure', unencoded sub-carrier and b) 'noisy' sub-carrier encoded with 1.5 MHz chip-rate (1010) code.

We observed the signal at 9 GHz for two different cases of C2. *Case 1.* Code C2 is identical to C1, i.e. both were (1010) but delayed by an appropriate amount to compensate for the delay through the system. Fig 3a shows the 'pure' un-encoded carrier recovered at 9 GHz. The delay for C2 was tuned to get best carrier recovery. *Case 2.* Code C2 is chosen to be (1001) i.e. orthogonal to C1, and tuned to get best carrier suppression at 9 GHz, delayed by the same amount as in case 1. In Fig. 3b no carrier is seen at 9 GHz indicating that the up-shift is indeed code selective.

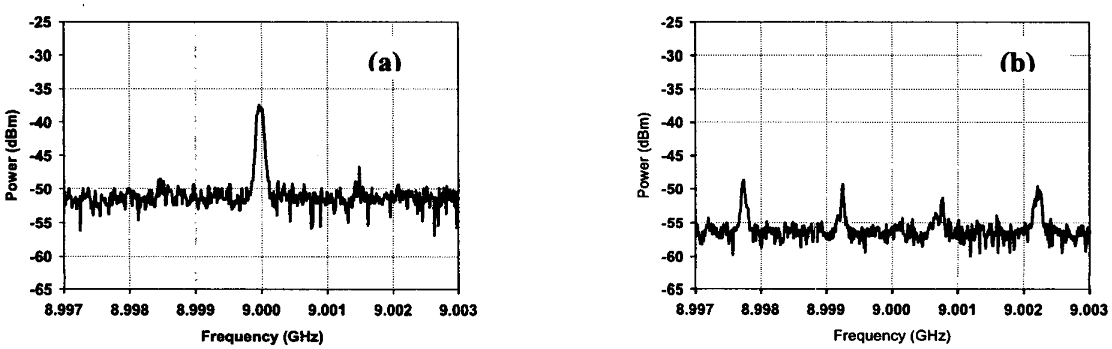


**Fig. 3** Signal obtained at 9 GHz after heterodyning with the original optical carrier when code C2(t) is a) (1010) i.e. identical to code C1(t) and b) (1001) i.e. orthogonal to C1(t). The carrier is recovered at 9 GHz when the codes are matched. Unmatched codes are rejected indicating the code-selectivity of the wavelength shift.

***Conclusions:*** These results confirm that we have demonstrated code selective wavelength conversion using RF photonic mixing in a DE-MZM. Unmatched channel rejection with the use of an orthogonal code was demonstrated. The bipolar nature of the optical field is recognized 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 the associated difficulties of optical phase locking and polarization tracking. The spectral separation of the desired channel could lead to reduction in the effects of cumulative shot noise and speckle, which is important in order to support more simultaneous users [3]. The ability to pick out a signal from a spectrum and frequency shift it based on it's code may have potential applications in routing techniques such as optical label switching.

## References

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