MULTI-WAVELENGTH, OPTICAL CODE-DIVISION-MULTIPLEXING BASED ON PASSIVE, LINEAR, UNITARY, FILTERS

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ABSTRACT

The opportunity exists to apply spread spectrum concepts into the enormous bandwidth of optical fibers. We introduce a new optical CDMA network architecture based on passive linear unitary filtering of the optical carrier signals.

1. INTRODUCTION

The opportunity exists to apply spread spectrum concepts into the enormous bandwidth of optical fibers. Recently we have seen the commercial emergence of spread-spectrum radio. In spite of radio being a relatively narrow band medium, the spread-spectrum concept has sufficient advantages in overall capacity and quality for it to compete commercially with conventional time-division-multiplexed cellular telephones.

Surely if spread spectrum is viable in a narrow band medium such as radio, it should be even more promising in a broadband medium such as optical fibers. Included among the usual advantages of coded communications, are the prospects for Tera-bit switching and very high speed parallel signal processing.

The form of optical code division multiplexing which we have in mind is different from previous proposals employing so-called "optical codes" [1-3], which are non-negative, and therefore cannot be truly orthogonal. Instead we propose an optical code division multiplexed system which is mathematically and conceptually similar to

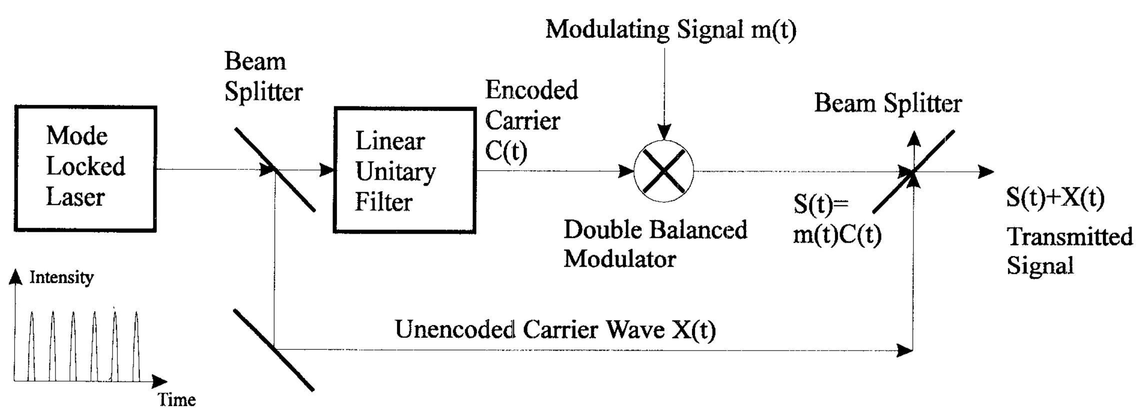

Fig.1 Transmitter Block Diagram

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radio code-division multiplexing. The specific hardware implementation however must match the opportunities in modern optical components, but also their limitations.

2. THE TRANSMITTER

Figure 1 shows the block diagram of the transmitter in the proposed architecture. The transmitter uses a mode locked laser to generate the unencoded carrier waves at multiples of the laser repetition frequency. The unencoded carrier is passed through a linear filter which basically does a unitary transform to generate a linear combination of the components of the unencoded carriers.

Each user has a different linear filter and therefore a different linear code which is truly orthogonal to the codes of all other users. It has been recently shown by Reck [4] et al that every unitary transformation can be implemented in optics using just mirrors, beam splitters and phase shifters. The encoded carrier is then modulated by the message signal through a double balanced modulator to obtain side bands on the modulated codes. All the user channel side bands and part of the unencoded carrier are combined together using a star coupler which is not shown in the block diagram. The unencoded carrier will be recovered at the receiver end to avoid the use of a local oscillator.

The linear filters used in this system, apart from being the encoders for different channels, can also be used for some linear computations such as fourier transforms etc.. Because photons obey the superposition principle, instead of carrying out the operations sequentially as in digital computers, most of the linear computation can be parallized in a photonic system. This has significant implications for applications such as those involving image transformation because part of the computational load can be moved from the electronic system to the optical system.

One way to implement the double balanced modulator is to use an optical phase modulator inserted between two 50/50 biconical fused fiber beam splitters as shown in Fig. 3. By setting the phase modulation constant k_θ small, it can be shown that the modulator output will be the product of the carrier signal and the message signal.

3. THE RECEIVER

The receiver block diagram is shown in Figure 2. It takes the multiplexed signal side bands from different users and the unencoded carrier as the input. The multiplexed signal side bands are separated from the unencoded carrier signal by a

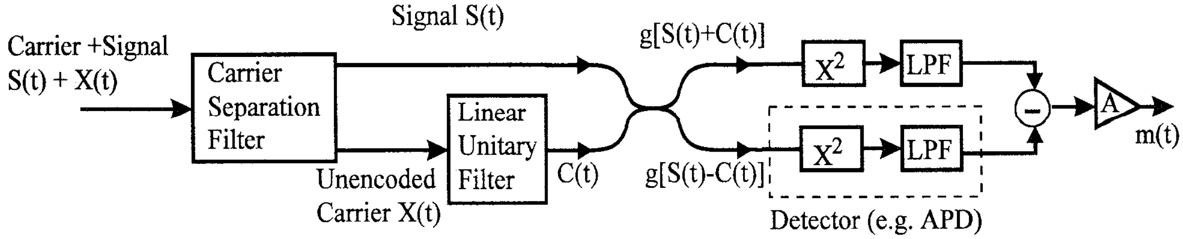

Fig.2 Receiver Block Diagram

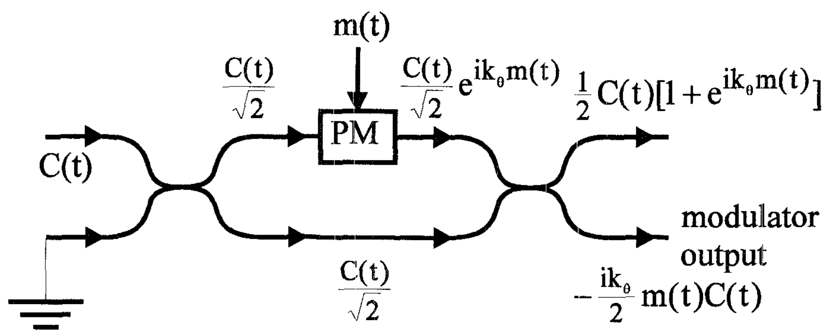

Fig. 3 An example implementation of a double balanced modulator

Fabry-Perot type filter which has very narrow pass bands centered at the pure carrier frequencies. By transmitting the unencoded carrier to the receiver and recovering it by the carrier separation filter, we can avoid the use of the local oscillator for signal detection which involves complicated phase locking mechanism and polarization tracking in the optical domain. The unencoded carrier and the signal side bands suffer the same phase shift, dispersion and polarization changes because they travel the same path. It thus maintains the CDMA system complexity to be compatible with a WDM system.

The code for the desired channel is generated from the recovered unencoded carrier by the same linear filter used in the transmitter. The multiplexed signal side bands and the carrier code are then passed to a double balanced mixer to obtain the message signal out. The double balanced mixer is composed of a 50/50 coupler and two square-law detectors which also function as low pass filters. The double balanced modulator output will give the product of the code and the multiplexed signal side bands. Because of the orthogonality between the codes, all the side bands from other channels will be rejected except the one which has the correct code.

3. CONCLUSION

To summarize, we proposed a novel optical CDMA architecture that uses truly orthogonal codes based on a passive linear filtering concept which in addition to code generation can also be explored for other linear computations in the optical domain. The proposed system involves no high speed coherent optical devices and uses direct detection at its output. The system complexity is compatible to a WDM system.

4. REFERENCES

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