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***Abstract*—We describe a receiver that performs O-CDMA decoding followed by PPM symbol detection that behaves like a radar quadrant receiver. Simulations determine the impact of multi-access interference on symbol detection for up to 32 users.**

I. Introduction

Pulse position modulation (PPM) is a powerful signaling technique because it allows a sequence of bits to be transmitted as a single symbol occupying a frame of M slots. The receiver performs a comparison test among all slots in a frame to make the slot decision and therefore determine the bit sequence. Unlike on-off-keying, thresholding is not required. Optical multi-access signaling can benefit from these advantages when PPM is combined with optical code division multiple access (O-CDMA) [1-6]. While the advantages of PPM/O-CDMA are well known, implementing a receiver that performs the comparison test can be difficult. This paper describes the concept and design of a differential array receiver for M-ary PPM/O-CDMA (M = 4), where the slot decision is outputted as (x,y) coordinates at the frame rate. Based on its similarity to radar detection, it is called a quadrant receiver. Simulations of the receiver explore the effect of multi-access interference (MAI) on the slot decisions.

II. Receiver Design

The implementation concept of the virtual quadrant receiver is shown in Figure 1. Various asynchronous users data modulate (with PPM) and O-CDMA encode their respective signals. These transmit through the O-CDMA network (often in a star configuration) where they are superimposed. At the receiver, the combined signals are first O-CDMA decoded with the code correlator and then processed for PPM detection. The processing implements the following control law or algorithm, which defines an estimate for the symbol slot position of any given frame:

$$Control\ Law: \quad (x,y) = \left((slot1 + slot2) - (slot3 + slot4), (slot1 + slot4) - (slot2 + slot3)\right) \tag{1}$$

Each slot in Eqn. (1) is the O-CDMA decoded signal with an applied relative delay: slot1 has been delayed by three slot times, slot2 has been delayed by two slot times, slot3 has been delayed by one slot time, and slot4 is not delayed. Slot addition is performed optically using combiners, while subtraction of slot sums are performed using differential detection. This control law gives the (x,y) coordinates of the symbol slot position decision. These coordinates can also be used to compute direction cosines and therefore the corresponding virtual quadrant. The control law may be enhanced by combining it with other comparison tests that retain the sample value.

III. Simulation Results and Discussion

In order to assess the performance of the virtual quadrant receiver, a PPM/O-CDMA system was designed based on 2D wavelength/time codes [7] and the O-CDMA Technology Demonstrator architecture [8]. An initial spreadsheet simulation was performed based on thirty-two 16-bit sequences (eight 4-ary frames). The 32 sequences were slot synchronous. The output of the simulation was used to compute Eqn. (1). Figure 2 shows the results of this algorithm for 1,4,8,12,16,20,24,28,and 32 concurrent users. Coordinates (±4,±4) is the single user starting point and variations from these points represent the change due to the MAI as users are added. The result resembles a constellation plot, as in other communication signaling schemes. Errors occur when the constellation strays beyond its initial quadrant. For the simulation, the errors in slot 4 appear to be subtle, since the comparison test is ambiguous as to which is the correct slot, especially at coordinate (0,0). There is no case for which the comparison test definitively selects an incorrect slot. A complete reduction of these errors could thus occur by combining this simple, hardware-implementable control law with one of the other decision schemes.

Acknowledgement

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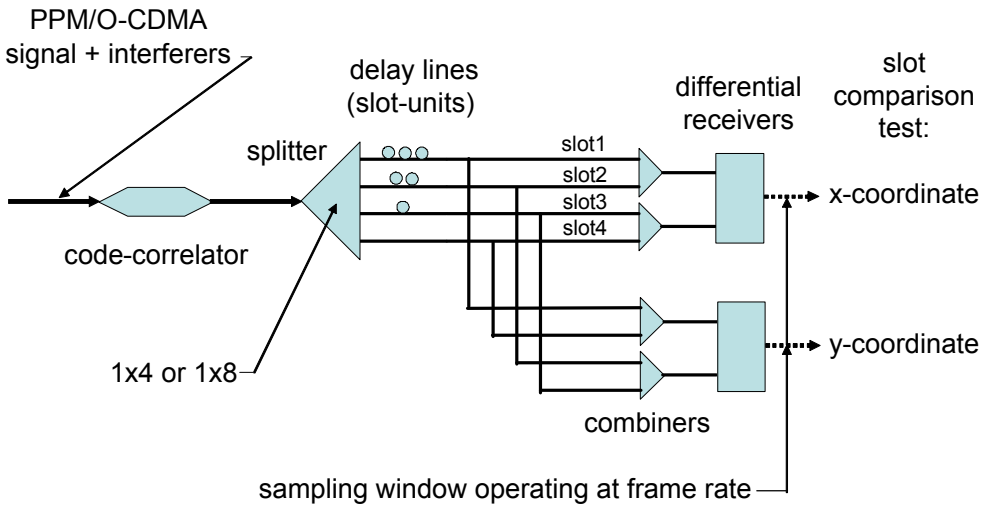

Figure 1. 4-ary PPM/O-CDMA Virtual Quadrant Receiver Concept.

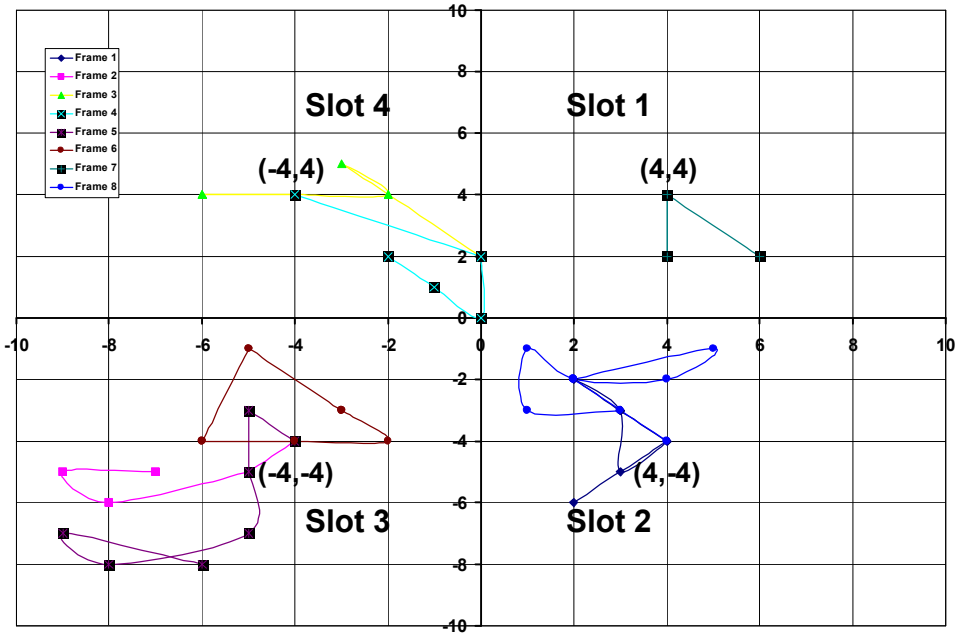

Fig 2. Constellation Plot of the Output of the Control Law for 1 to 32 Concurrent Users.