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### Summary

Several users may independently access a common communication channel using code division multiple access (CDMA) modulation. This multiaccess scheme does not use time- or frequency-allocation, and users may transmit without the delays inherent to multiaccess protocols. In the direct-detection optical CDMA channel, interference immunity is achieved by the assignment of rapidly varying, on-off waveforms. These waveforms, or signature sequences, are modulated by the data of each user and concentrate the transmitted energy into relatively short time intervals in each symbol period. The transmitted signals from the users are then combined on a common optical fiber. Single-user demodulation is (suboptimally) achieved by correlating the aggregate signal and the signature sequence of the desired user. As a result, the correlator output is the desired signal in additive interference, which is reduced through the use of signature-sequence sets with low cross-correlation. A correlator receiver of this type must know only the timing epoch of the desired user, and a common timing reference need not be sent to all transmitters.

In this work we derive <sup>has been derived</sup> the exact error rate for the noncoherent, optical matched-filter CDMA receiver, which decides for the data of a single user by comparing a photoelectron count to a threshold. The results differ from previous works ~~(1)(2)~~ in that they adhere fully to the semiclassical model of light and do not depend on limit theorems for large user groups or strong received optical fields. The analysis is valid for arbitrary quantum efficiencies, binary signature sequences, random gain distributions, and dark currents, and is broad in application. We describe noncoherent, optical CDMA modulation and consider <sup>(1)</sup> single-user demodulation based on a conditionally compound-Poisson observation <sup>(2)</sup>. We derive the probability mass function (PMF) of the observation under each hypothesis, and use them to determine the optimal threshold and minimum probability of error. What makes the

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analysis particularly interesting is the fact that while the formal representation of the PMF for a doubly-stochastic compound Poisson count is readily derived via conditioning, explicit forms are not common. Due to the particular nature of the MAI distribution, we are able to show that the PMF may be expressed as a straightforward summation. This expression is derived for independent and identically-distributed (iid) interferers having a distribution that includes the cases of user asynchronism and chip synchronism. It will be seen that the error rate expression is simplified when the distribution of the MAI is discrete. We take advantage of this fact to derive arbitrarily-tight bounds on the error rate which are considerably easier to compute than the exact error rate. We use the same bounding technique to derive arbitrarily-tight bounds on the error rate when the interferers' energies are not identical. We focus on [the special case of prime codes, equal energies, and unity-gain photodetectors in order to compare the optimal threshold and minimum error rate to those obtained using <sup>certain</sup> the approximations discussed above.] The approximation of perfect optical-to-electrical conversion yields poor estimates of the error rate and optimal threshold at moderate incident optical intensities and dark currents. Further, the combined approximations of perfect optical-to-electrical conversion and Gaussian-distributed MAI together yield an underestimate of the optimal threshold and an error rate that is neither an upper nor a lower bound. <sup>It has been</sup> We also show that when prime sequences are employed, the chip-synchronous approximation leads to an overestimate of the error rate. The validity of these approximations for larger optical powers is also discussed. (4)

## References

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