

# **PROJECT: Signal Detection for Digital Communication Systems with ISI or CCI**

ECE6603: Advanced Digital Communications  
School of Electrical and Computer Engineering  
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In this project, you need to select one of the following five techniques to deal with intersymbol interference (ISI) or co-channel interference (CCI) in digital communication systems, then use one or two simulation examples to study the performance of signal detection, and write a report.

## **Criteria for the Report**

- The report should have an abstract, no more than 50 words, to summarize the technique and the simulation results.
- The report should explain the principle of the technique you have chosen without using too much mathematics.
- You should describe the simulated system and provide all parameters so that others can repeat your simulation.
- A couple of figures should be included to demonstrate the performance of the selected techniques.
- The report should not exceed 4 pages, including all figures and references.

## **Topics**

### **Topic 1: MMSE linear (LE), decision-feedback (DFE), and maximum likelihood sequence estimation (MLSE)**

The following are classical papers in MMSE LE and DFE, and MLSE. Read all of them carefully and simulate a communication system with ISI with these three approaches.

- [1] T. Berger and D. W. Tufts, "Optimum pulse amplitude modulation - Part I: Transmitter-receiver design and bounds from information theory," IEEE Trans. on Inf. The., IT-13, April 1967.
- [2] J. Salz, "Optimum mean-square decision feedback equalization," Bell Syst. Tech. Jour., vol. 52, pp. 1341-1373, Oct. 1973.
- [3] G. D. Forney, Jr. "Maximum-likelihood sequence estimation of digital sequences in the presence of intersymbol interference," IEEE Trans. on Inf. The., IT-18: pp. 363-378, May 1972.

- [4] G. Ungerboeck, "Adaptive maximum-likelihood receiver for carrier-modulated data-transmission systems," IEEE Trans. on Comm., vol.22: pp. 624-636, May 1974.

### **Topic 2: Blind channel equalization for time-invariant channels**

Blind equalization can equalize channel using statistics of the channel output, without using training or pilot sequences. Reference [1] introduced a class of blind algorithms, called Godard Algorithms (GA). The special case of  $p=2$  is also called constant modulus algorithm (CMA). Reference [2] investigated the global convergence property of CMA, while Reference [3] demonstrated the local- or ill-convergence properties. Using simulation examples to show the local and global convergence properties of the CMA blind equalizers.

- [1] D. N. Godard, "Self-recovering equalization and carrier tracking in two-dimensional data communication systems," IEEE Trans. on Comm., COM-28: pp. 1867-1875, Nov. 1980.
- [2] G. J. Foschini, "Equalization without altering or detecting data," AT&T Tech. J., pp. 1885-1911, Oct. 1985.
- [3] Y. Li and Z. Ding, "Convergence analysis of finite length blind adaptive equalizers," IEEE Trans. on Sig. Proc., vol. 43, pp. 2120-2129, September 1995.

### **Topic 3: Receive diversity for frequency selective channels**

Receive antenna array is a powerful tool to improve the performance of digital communications over fading channels. Use simulation example to demonstrate the performance of receiver diversity for frequency selective fading channels and compare it with a system without receive diversity.

- [1] P. Balaban and J. Salz. "Optimum diversity combining and equalization in digital data transmission with applications to cellular mobile radio--Part I: theoretical considerations," IEEE Trans. on Comm., COM-40: pp. 885-894, May 1992.
- [2] P. Balaban and J. Salz. "Optimum diversity combining and equalization in digital data transmission with applications to cellular mobile radio--Part II: numerical results," IEEE Trans. on Comm., COM-40: pp. 895-907, May 1992.
- [3] Y. Li and Z. Ding, "A simplified approach to optimum diversity combining and equalization in digital data transmission," IEEE Trans. on Comm., COM-43: pp. 2285-2288, Aug. 1995.

### **Topic 4: Interference cancellation for flat fading channels**

Receiver antenna arrays can be also used in cellular systems to suppress co-channel interference. The following three papers studied the impact of receiver antenna arrays to mobile systems. Using a simulation example to show the co-channel interference of adaptive antenna arrays for a flat fading wireless channel.

- [1] J. H. Winters, "Signal acquisition and tracking with adaptive arrays in the digital mobile radio system IS-136 with flat fading," IEEE Trans. on Veh. Tech., vol.42: pp. 377-384, Nov. 1993.
- [2] J. H. Winters, R. D. Gitlin, and J. Salz, "The impact of antenna on the capacity of wireless communication systems," IEEE Trans. on Comm., COM-42: pp. 1740-1751, Feb./March/April 1994.
- [3] R. L. Cupo, G. D. Golden, C. C. Martin, K. L. Sherman, N. R. Sollenberger, J. H. Winters, and P. W. Wolmainsky, "A four-element adaptive antenna array for IS-136 PCS base stations," Proc. of IEEE Vehicular Tech. Conf., May 1997, pp. 1577-1581.

### **Topic 5: Signal detection for multicarrier or OFDM systems**

Multicarrier or Orthogonal Frequency Division Multiplexing (OFDM) is an effective approach to combat ISI. Reference [1] introduced the concepts of OFDM. References [2] and [3] presented channel estimation for coherent detection. Use a simulation example to compare an OFDM system with coherent and different detection, respectively.

- [1] S. B. Weinstein and P. M. Ebert, "Data transmission by frequency-division multiplexing using the discrete Fourier transform," IEEE Trans. on Comm. Tech., COM-19: pp. 628-634, Oct. 1971.
- [2] O. Edfors, M. Sandell, J.-J. van de Beek, S. K. Wilson, and P. O. Borjesson, "OFDM channel estimation by singular value decomposition," IEEE Trans. on Comm., vol. 46, pp.~931-939, July 1998.
- [3] Y. (G.) Li, L. J. Cimini, Jr., and N. R. Sollenberger, "Robust channel estimation for OFDM systems with rapid dispersive fading channels," IEEE Trans. on Comm., vol. 46, pp. 902-915, July 1998.