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| **Task 1836.063, Powerline Communications  for enabling smart grid applications** |
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## sIGNIFICANCE AND OBJECTIVES

Powerline communication (PLC) systems have been deployed to provide two-way communications between local utilities and smart meters for smart grid applications. Communication performance of PLC systems is limited by non-Gaussian noise. In this project, we aim to improve communication efficiency and reliability of PLC systems in non-Gaussian noise.

## TECHNICAL APPROACH

We first study the structure of powerline noise by statistically analyzing and modeling the noise properties in both time and frequency domains, based on several field measurements. We then study transmitter and receiver techniques to improve the communication throughput and reliability in the presence of non-Gaussian noise. We develop real-time PLC testbeds to take noise measurements, and to quantify communication performance vs. complexity tradeoffs of various noise mitigation algorithms.

## SUMMARY OF RESULTS

Our field measurements with Aclara and Texas Instruments on outdoor medium-voltage (MV) and low-voltage (LV) power lines have shown that cyclostationary noise is the dominant noise component in the 3--500 kHz band for narrowband PLC (Figure 1). Based on field measurements, we propose a linear periodically varying system model to characterize the temporal and spectral properties of the noise. The proposed noise model has been accepted to IEEE P1901.2 standard.



Figure 1: Spectrogram and time-domain trace of powerline noise collected at a LV site near St. Louis, Missouri USA.

To improve the robustness of PLC systems in the presence of cyclostationary noise, we propose noise mitigation algorithms at PLC receivers, which estimate and subtract the noise from received signals. In simulations, our proposed methods have achieved up to 6dB SNR gains over conventional PLC systems (Figure 3).



Figure 3: Coded bit error rate (BER) performance of our proposed sparse Bayesian learning (SBL) algorithms in comparison with conventional PLC systems with frequency-domain (FDI) or time-domain (TDI) interleaving.

We have developed three testbeds in the project:

(1) Real-time PLC testbed to evaluate communication performance vs. complexity tradeoffs of various transmitter and receiver algorithms;

(2) Real-time FPGA implementation of a PLC receiver over an impulsive noise channel; and

(3) G3-PLC testbed for powerline noise measurement.

**Keywords:** powerline communications, smart grid, cyclostationary noise, noise mitigation, testbed

## INDUSTRY interactionS

Conference call every other week with TI and separately with Freescale.  Jing Lin was a summer 2013 intern at TI, and Karl Nieman was a summer 2013 intern at Freescale.

## MAJOR PAPERS/PATENTS

[1] Lin et al, "Impulsive Noise Mitigation in Powerline Communications Using Sparse Bayesian Learning", *IEEE JSAC,* 2013.

[2] Nassar et al, "Local Utility Powerline Communications in the 3-500 kHz Band: Channel Impairments, Noise, and Standards”, *IEEE Signal Processing Magazine,* 2012.

[3] Nieman et al, "FPGA Implementation of a Message-Passing OFDM Receiver for Impulsive Noise Channels”, *IEEE Asilomar* 2013.