Single-Channel Compressive Sampling of Electrical Data for Non-Intrusive Load Monitoring

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(full citation details in [1])

a place of mind
THE UNIVERSITY OF BRITISH COLUMBIA

Electrical and Computer Engineering

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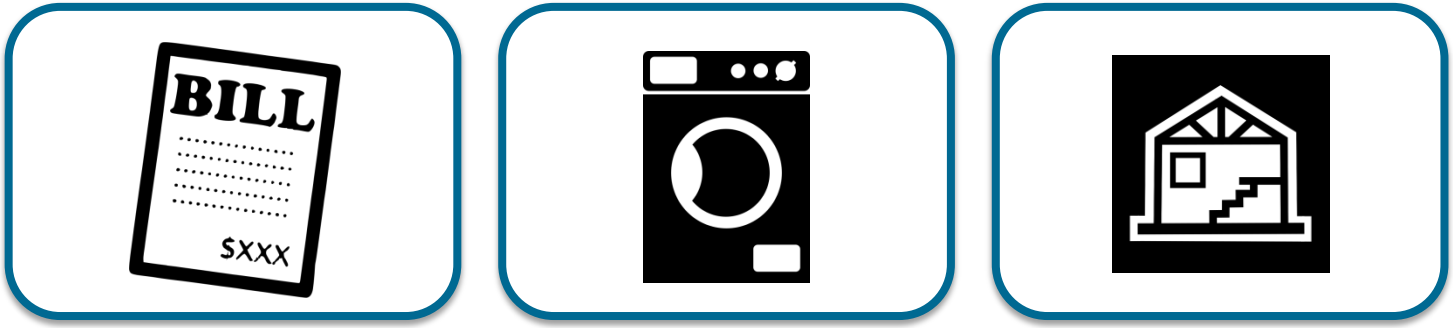
Using Appliance-Specific Energy Data



Consumer feedback

Utility company research

“Green” building design

Obtaining Appliance-Specific Energy Data

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Intrusive

Hardware Intensive

- Expensive
- Inconvenient

Non-intrusive [2]

Software Intensive

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Very-High-Rate NILM

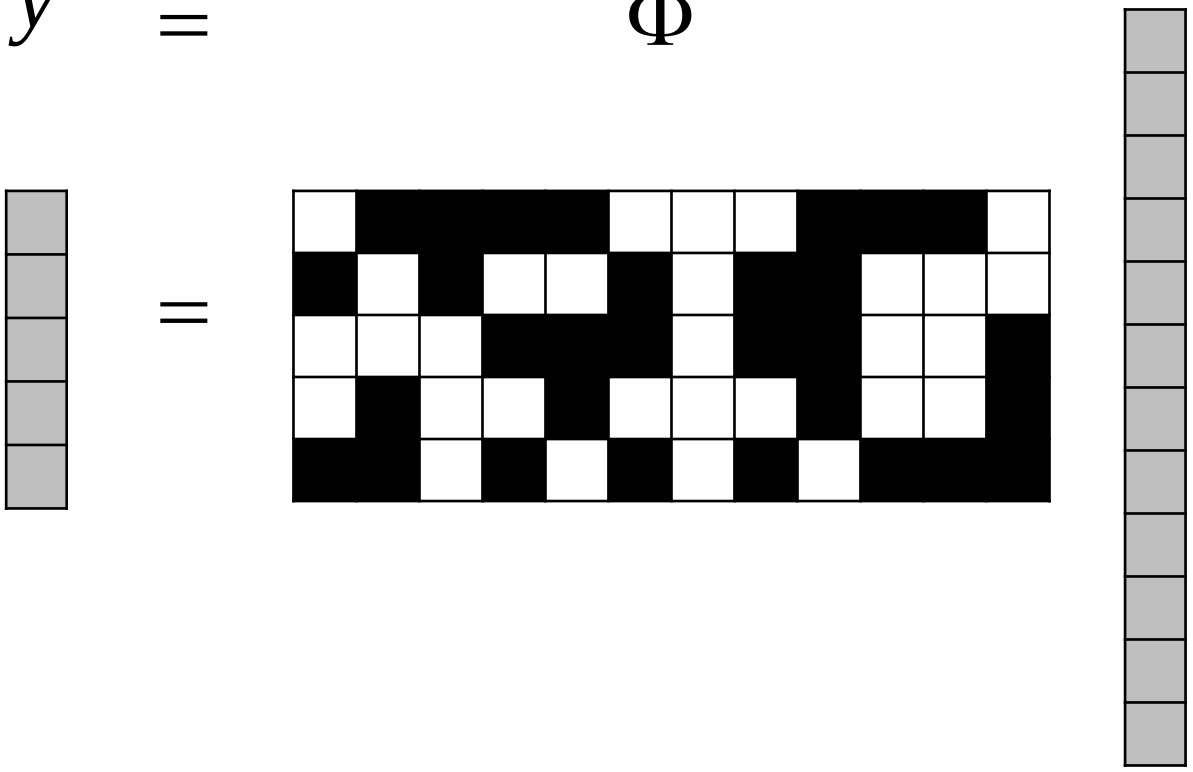
- Why very-high-rate data?
  - More information, more loads, more applications
- What makes this challenging?
  - Large amount of data, little time

Available Approaches

- Naive Sampling
- Compression [3,4]
- Event Detection [5,6]
- Compressed Sensing
  - Has been proposed by [7]
  - We explore alternative ways to implement this method

Compressed Sensing (CS) [8,9]

$$y = \Phi x$$



CS: Sparse Vectors

$$x \approx \Psi s$$

electrical signal — sparsity basis — sparse vector

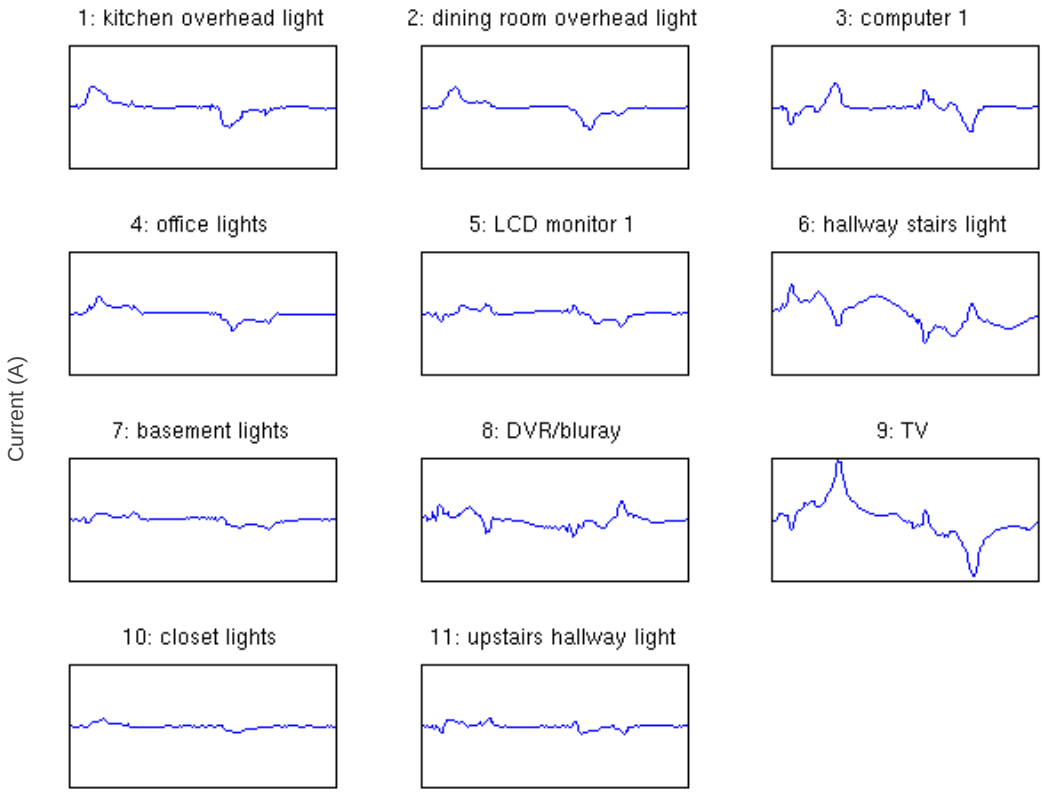
$$y = \Phi x \approx \Phi \Psi s$$

compressed measurements — sensing matrix

$$\underset{s}{\text{minimize}} \ \|s\|_1$$

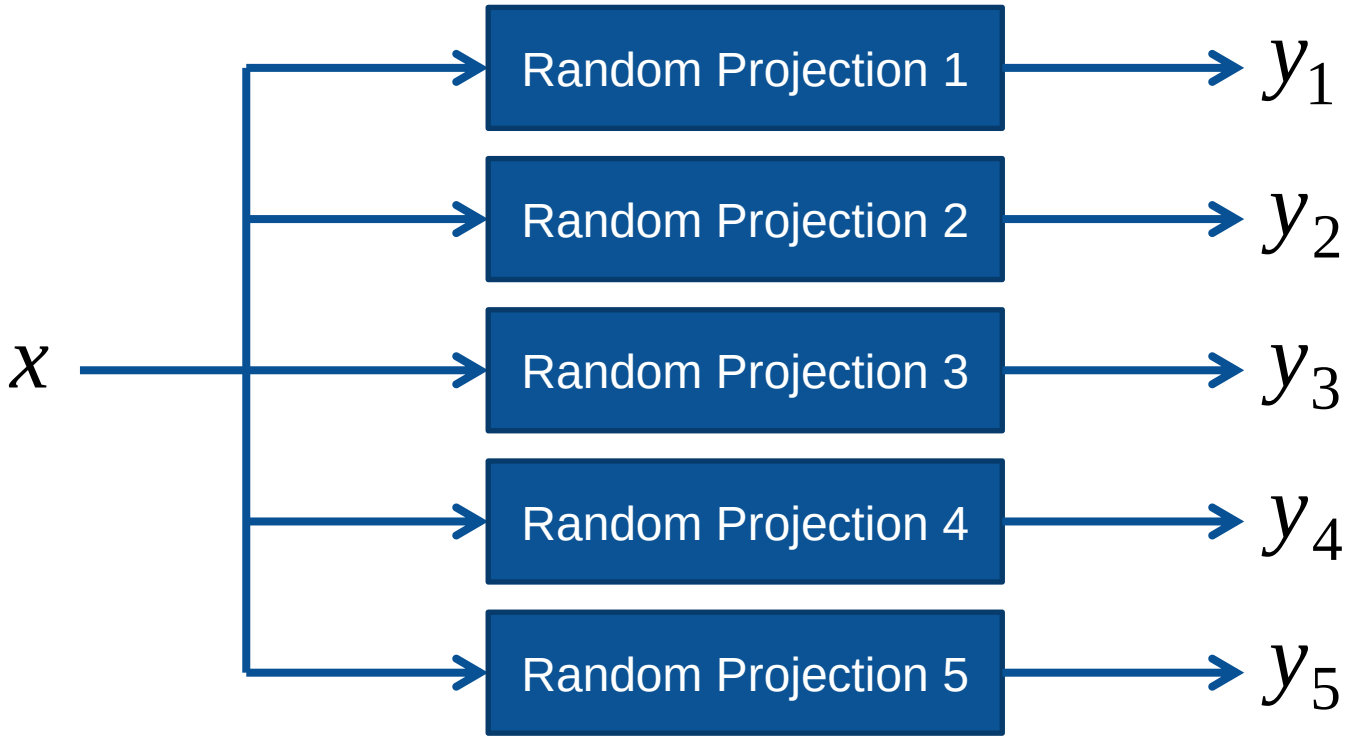
$$\text{subject to} \ \|y - \Phi\Psi s\|_2^2 < \delta$$

Using the Load Basis [7]



Here we extracted waveforms from the BLUED dataset [10].

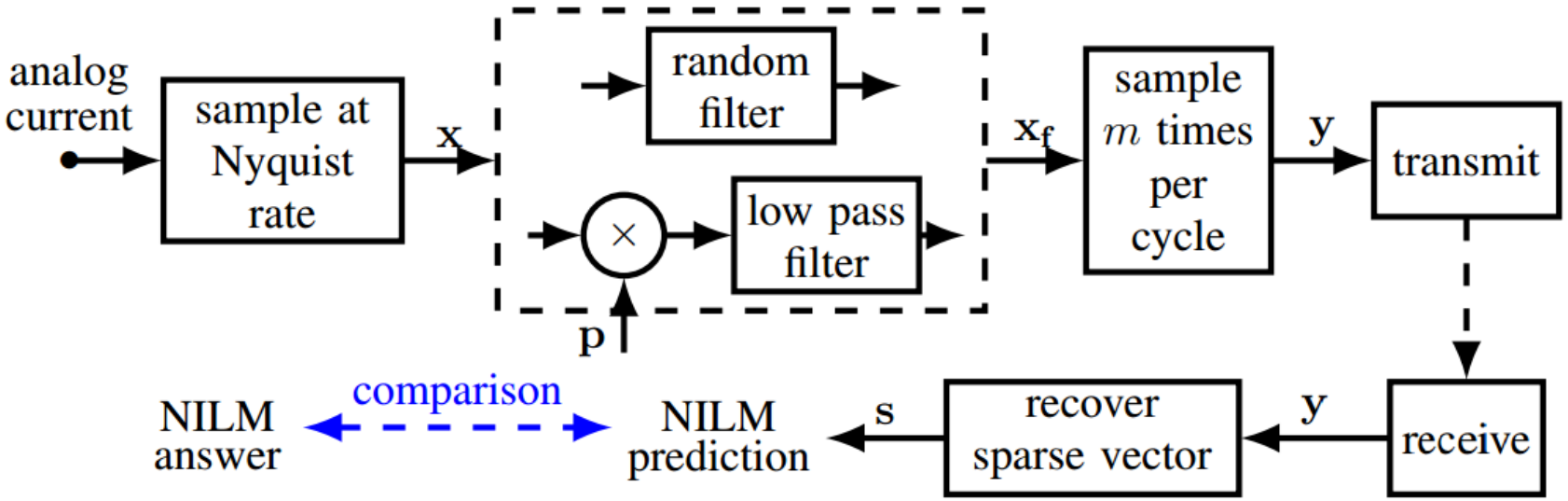
CS: Hardware Realization



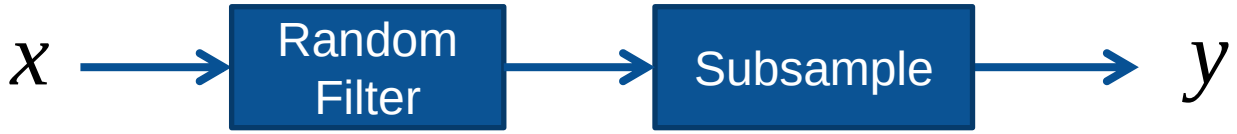
Our Contribution: Exploring single-channel CS for NILM.

How: Random filtering or demodulation.

CS: Hardware Realization



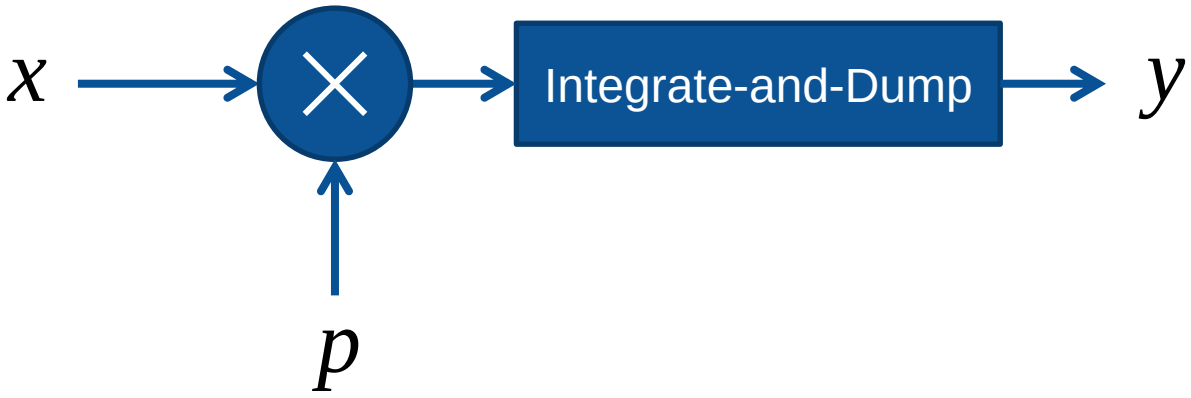
Option 1: Random Filtering [11]



Random Filter Sensing Matrix:

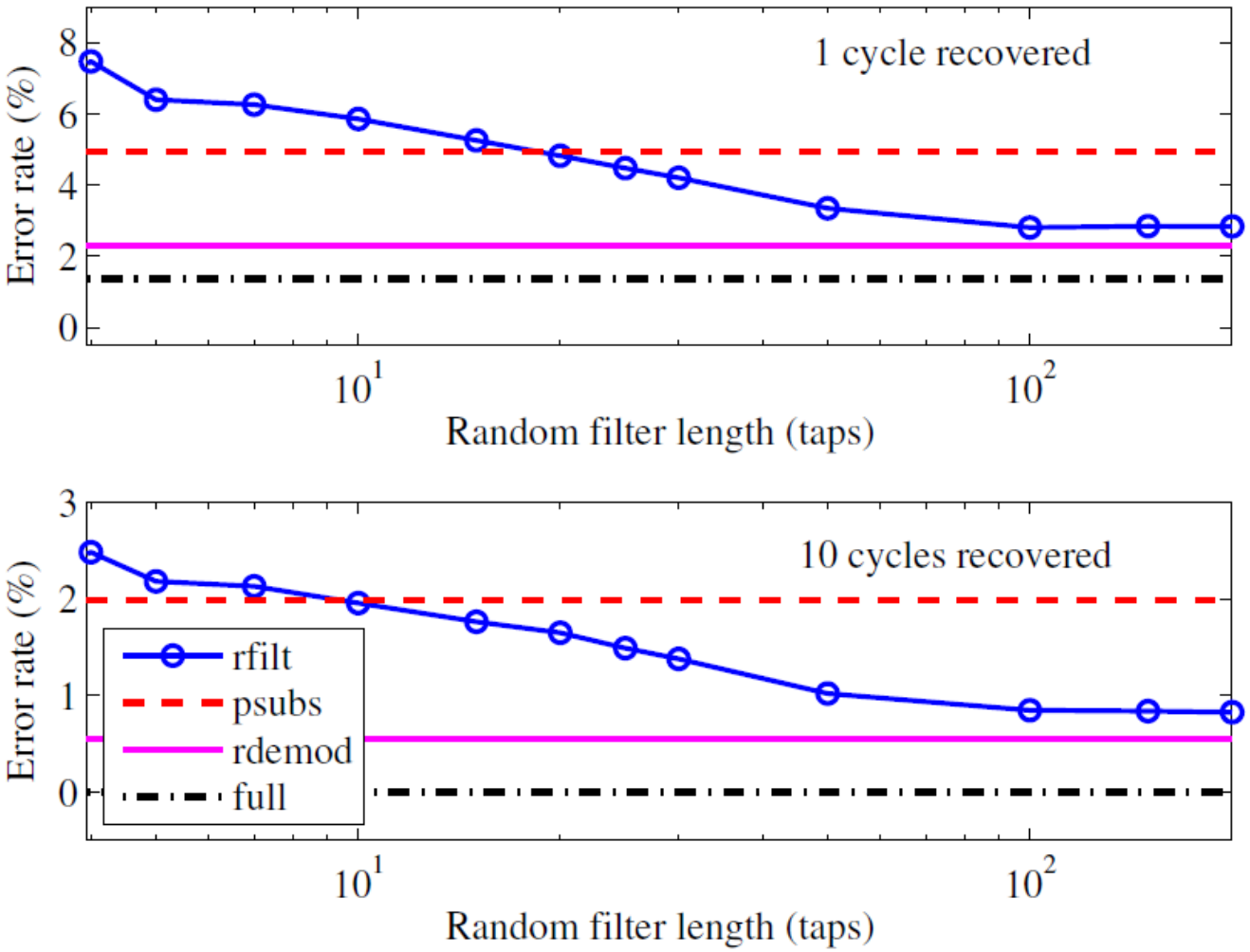
$$\begin{bmatrix} h_3 & h_2 & h_1 & 0 & 0 & 0 & 0 \\ 0 & 0 & h_3 & h_2 & h_1 & 0 & 0 \\ 0 & 0 & 0 & 0 & h_3 & h_2 & h_1 \end{bmatrix}$$

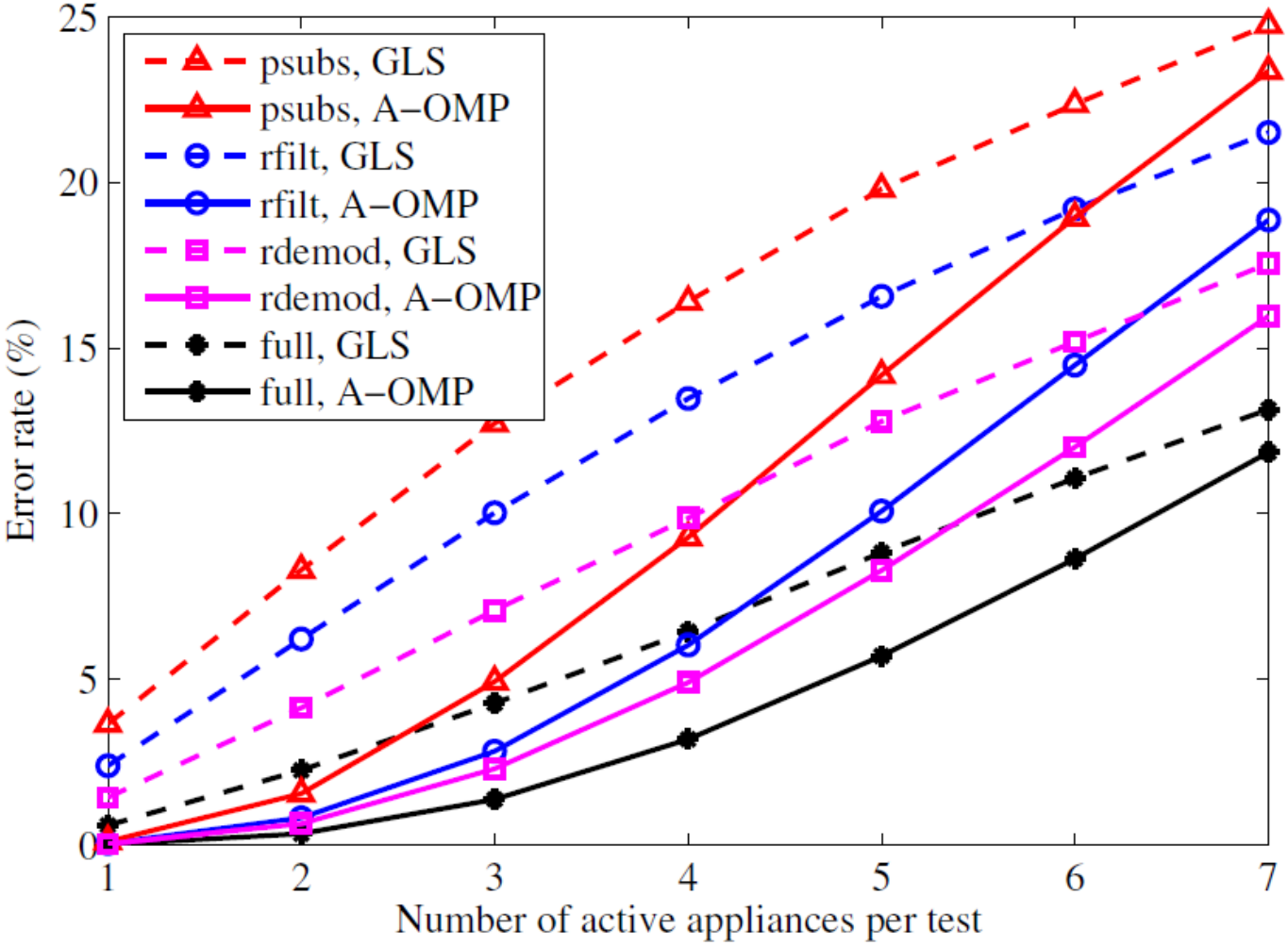
Option 2: Random Demodulation [12-14]



Random Demodulation Sensing Matrix:

$$\begin{bmatrix} 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 \end{bmatrix} \begin{bmatrix} p_1 & 0 & \dots & 0 \\ 0 & p_2 & \dots & 0 \\ \vdots & \vdots & & \vdots \\ 0 & 0 & \dots & p_9 \end{bmatrix}$$





Outcomes

- Random filtering and demodulation:
  - Use lower sampling rate than Nyquist
  - Require fewer sampling channels than traditional CS
  - Perform better than direct subsampling

- These make ***very-high-rate NILM methods more feasible*** by allowing a more practical sampling implementation.

Thank you!

References

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