Sensing conducted EMI in power lines for appliance disaggregation

Highlights: Overview of NILM, Past work, Conducted EMI as a unique/deterministic aspect

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Overview of NILM

Term: Non-Intrusive load monitoring (Origin 1981's G.Hart NILM paper)

Goal: Disaggregating different electrical appliances being operational in a building/home using a single point sensing solution.

Motivation:

- Reduce energy consumption in buildings by turning off 'non-critical' appliances.
- Provide appliance level energy consumption data to end consumer similar to telephone bill.
- Provide a feedback to grid/utilities about type of appliances being in use versus time of day.

Previous approaches in NILM

- Several electrical parameters like real power, reactive power, phase, current are used for disaggregation.
- Sampling rates are around 1 Hz and data is taken from a single point home/building level smart meter.
- After retrieving data at 1Hz several machine learning approaches like state based models are applied to disaggregate/differentiate between appliances being operational (time domain).
- These approaches are widely used with ability to disaggregate 70-80% of appliances (mostly power loads).
- Fails with complex appliances like SMPS driven appliances.

Insights in to NILM

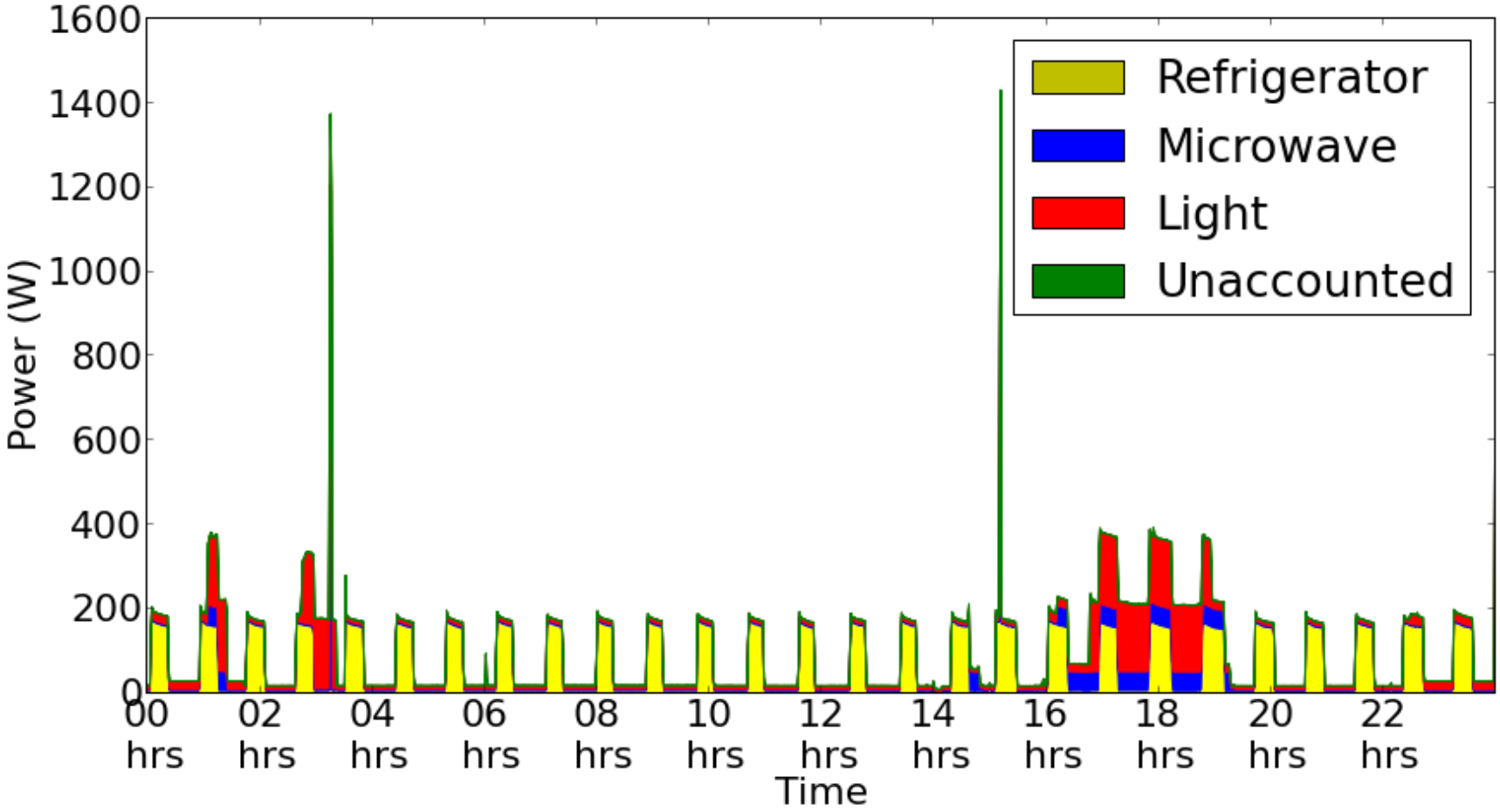
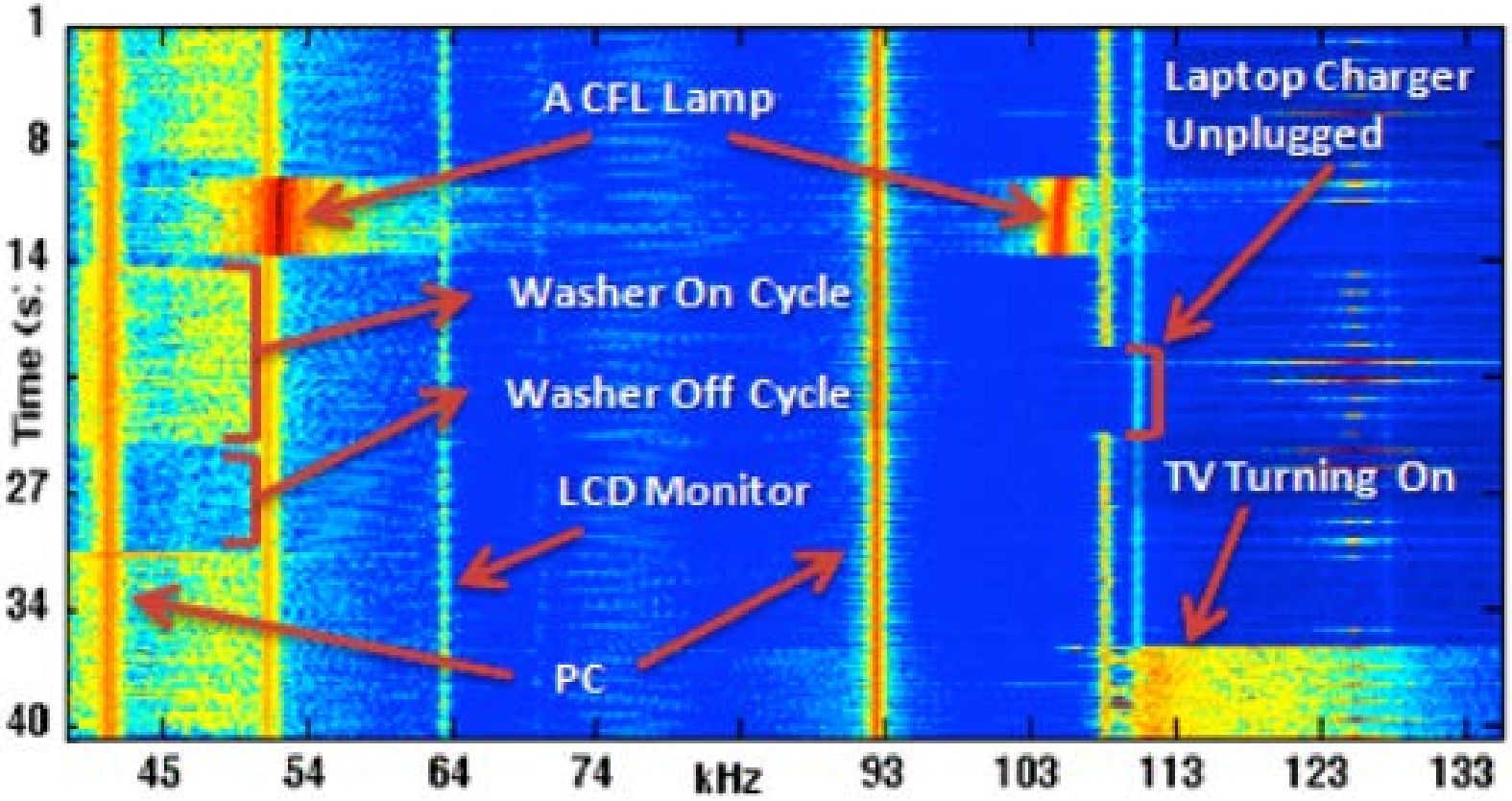


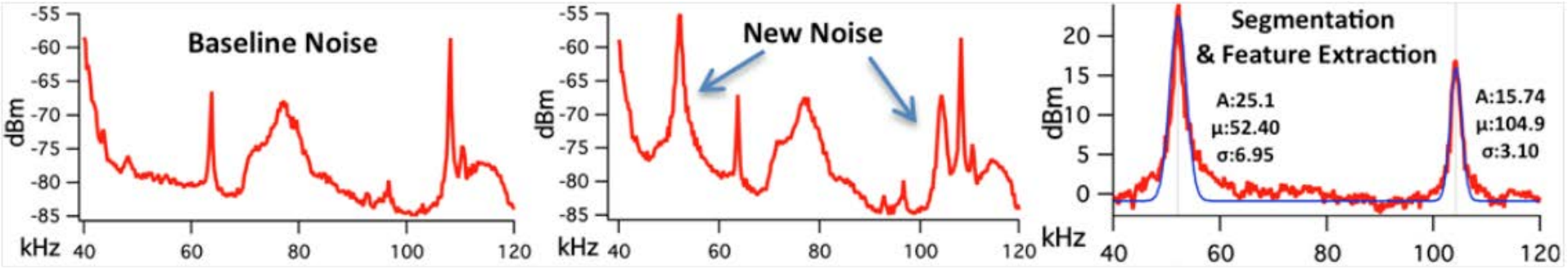
Image taken from NILM work done at IIITD

Recent work in NILM

- ElectriSense (2010): Using conducted EMI as a unique/distinguishing signal for disaggregation.
- Time domain signal for complex appliances is usually time-variant and hard to model but frequency domain HF EMI provides a deterministic signal.
- Able to differentiate among most of the complex appliances due to different switching frequencies of SMPS.
- Sampling rates are around 1Mhz (STFT was applied for analysis).

Frequency spectrogram





Appliance level modeling for EMI trace using Gaussian curve fitting

Proposed work

To study unique and distinct features in conducted EMI generated by multiple electrical appliances.

Specific test cases:

- Study impact of voltage fluctuations & building architecture on CE.
- Study dissimilar features in CE during w/ and w/o load.
- Study effect on CE of a single SMPS(EUT) for different loads.
- Analyze features and unique aspects in CM CE and DM CE for different electrical loads.
- Analyze response of EMI (constructive/destructive interference) w/o LISN.

*CE Conducted EMI *CM Common mode *DM Differential mode

Simple Buck Regulator (Open-loop)

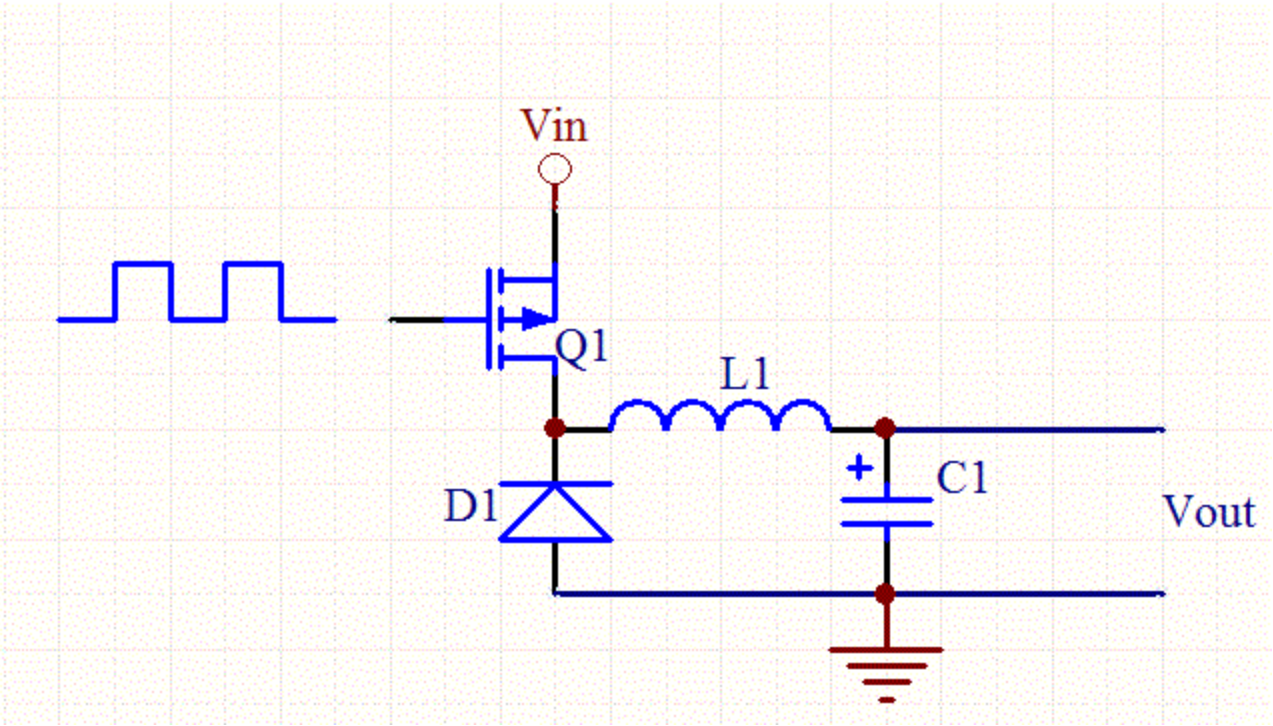
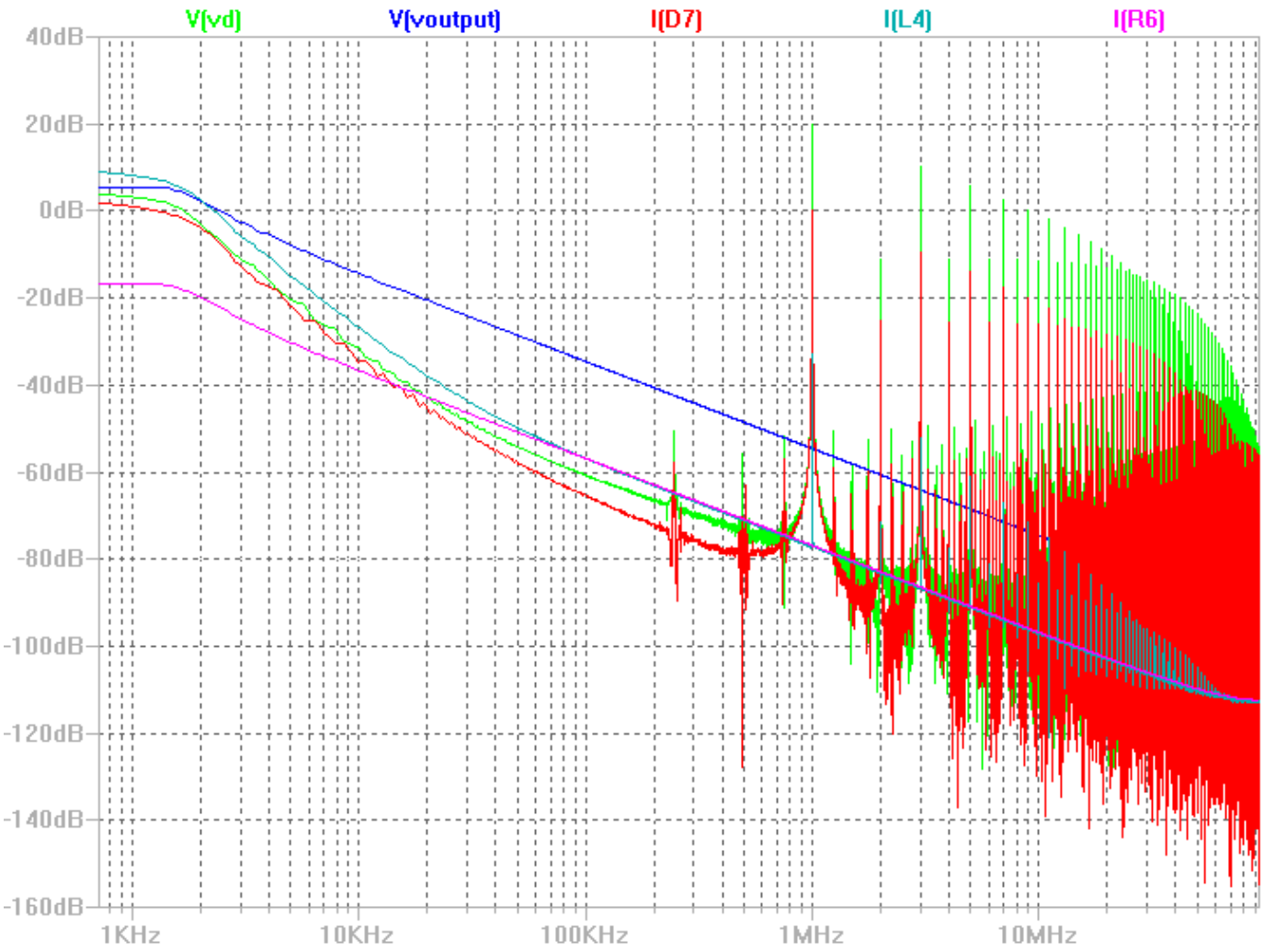


Image Courtesy:
http://www.daycounter.com/LabBook/BuckConverter/Buck-Converter-Equations.phtml

Frequency Domain Analysis



Frequency Domain Analysis