Building a Holistic System Demonstrator

Holistic Energy Harvesting Demonstrator

Alex Weddell
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Overview

- Vibration data: a resource for the community
- Introducing the application
- System requirements
- Detail of prototype design
- Test results
- The finished prototype in operation

Why?

- Nobody has deployed a tuneable energy harvester!

- Little data on real vibration dynamics

- By defining a real application, we find out what the real challenges are! Addressed by other themes

- Demands a 'holistic' view of the whole system...

Vibration Data

- No repository for long-term vibration data
- Only tables of 'typical' values
- Are they consistent?

Vibration source	A (m/s^2)	F_{peak}
Car engine compartment	12	200
Base of 3-axis machine tool	10	70
Blender casing	6.4	121
Clothes dryer	3.5	121
Person nervously tapping their heel	3	1
Car instrument panel	3	13
Door frame just after door closes	3	125
Small microwave oven	2.5	121
HVAC vents in office building	0.2–1.5	60
Windows next to a busy road	0.7	100
CD on notebook computer	0.6	75
Second story floor of busy office	0.2	100

Shad Roundy, Paul K. Wright, Jan Rabaey. "A Study of Low Level Vibrations as a Power Source for Wireless Sensor Nodes". *Computer Communications*, 26(11):1131-1144, July 2003.

Vibration Data

- First steps: looking at real, long-term vibration…
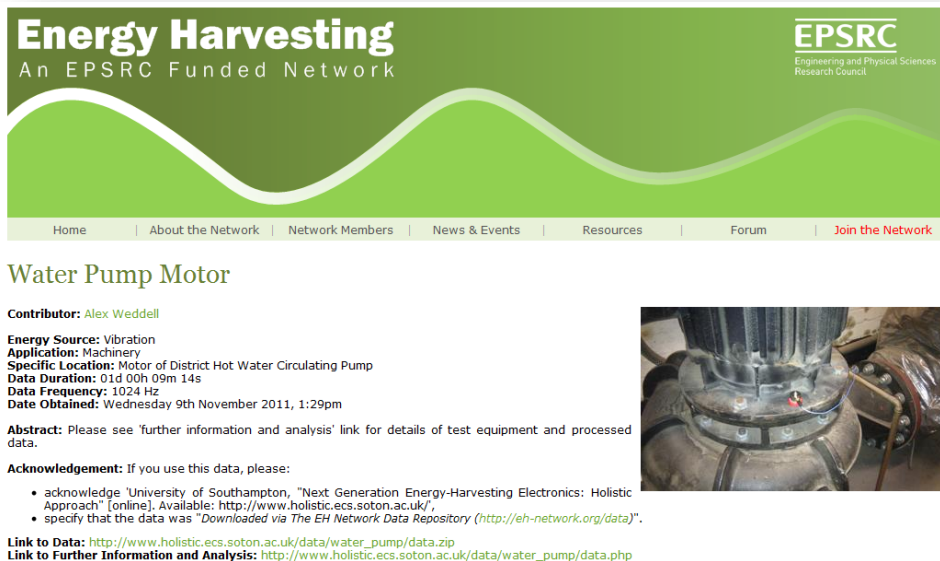
- Looking at *dynamics* of vibration aids design process

FFT interval 1s FFT length 1s Sample Rate 1024Hz Duration 3880s
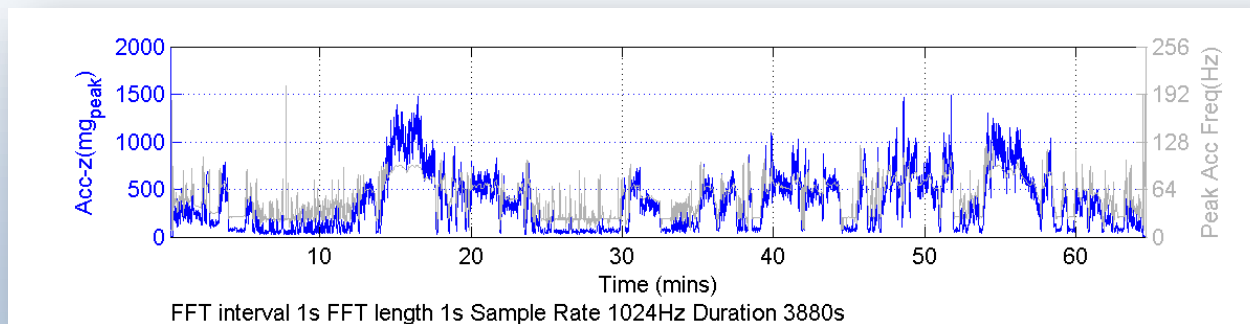
Vibration Data

- An important resource for the community

- Available free of charge for download from the "Energy Harvesting Network" resources page

www.eh-network.org

Vibration Data

- Data available raw, and…

Application
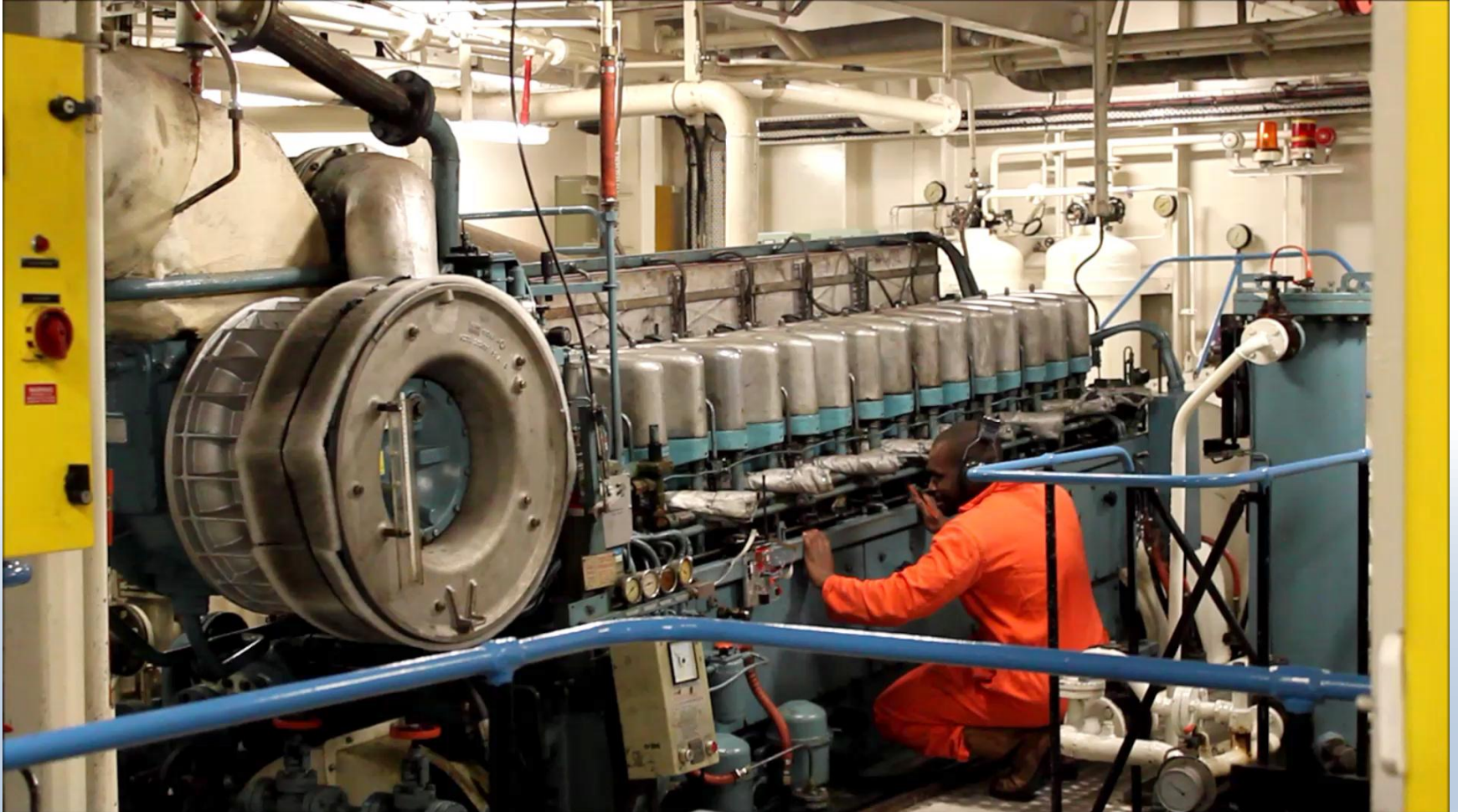
Application

Application

- Condition monitoring of a main engine
 - Voith-Schneider propulsion
  - 4 'fixed' engine speeds
  - Speeds drift over time, mechanically set
- Engine condition monitoring
  - Monitor vibration and temperature
  - e.g. detect bearing wear, imbalance
- Transmit wirelessly – no cabling to install
- Harvest energy from vibration at various frequencies

Image reproduced from http://en.wikipedia.org/wiki/File:VSPreal.jpg
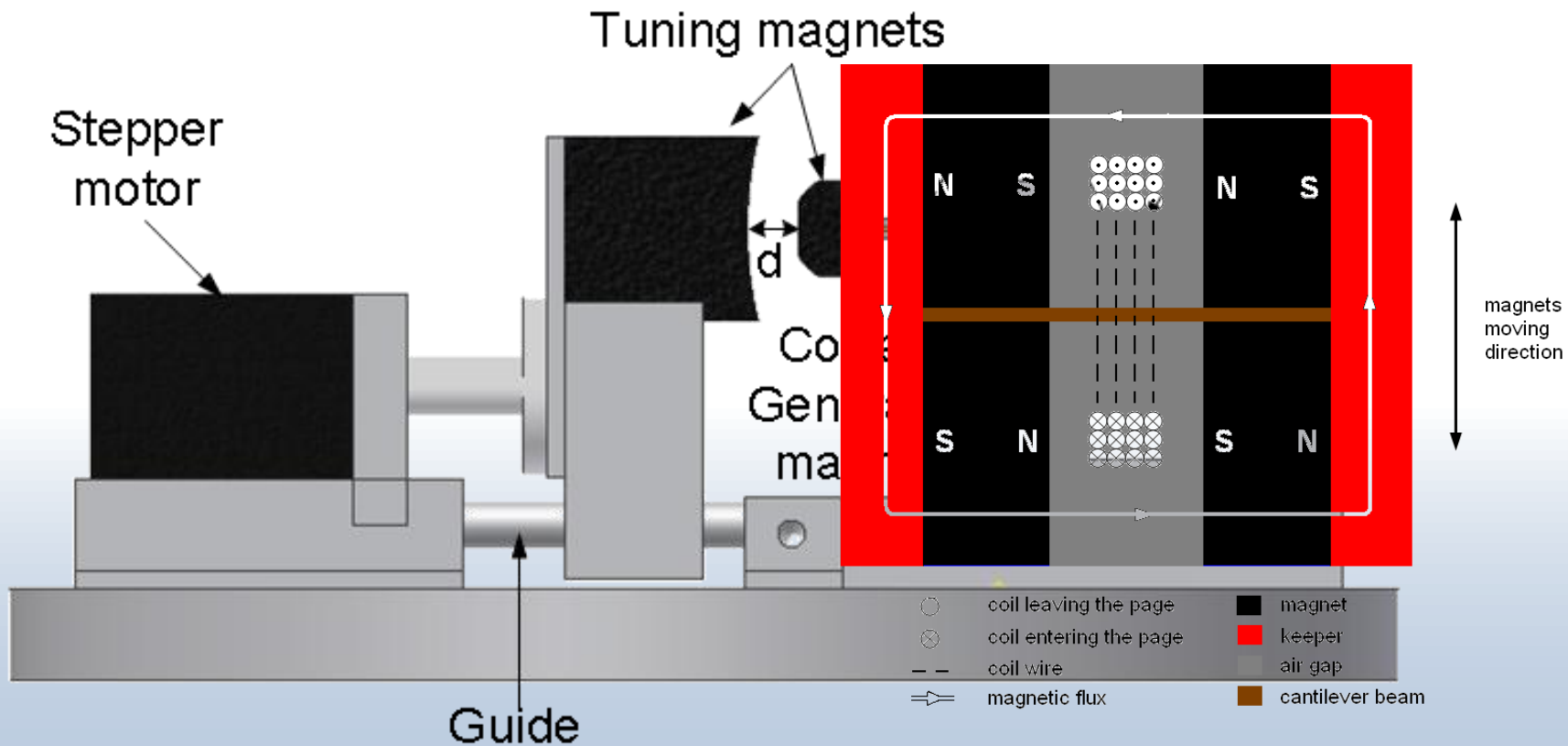
Data from Two Ferries
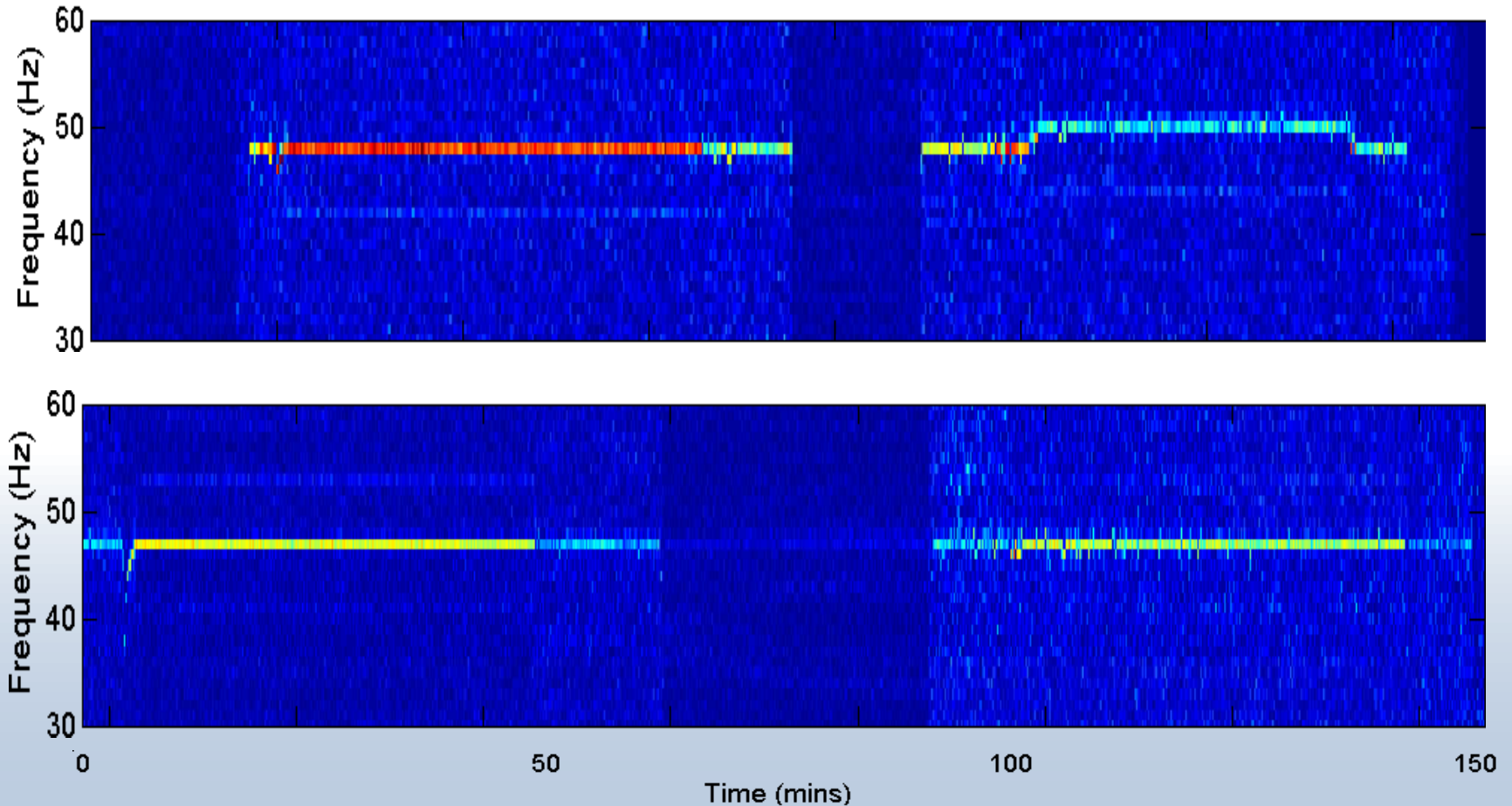
Red = 1000 mg_{pk}
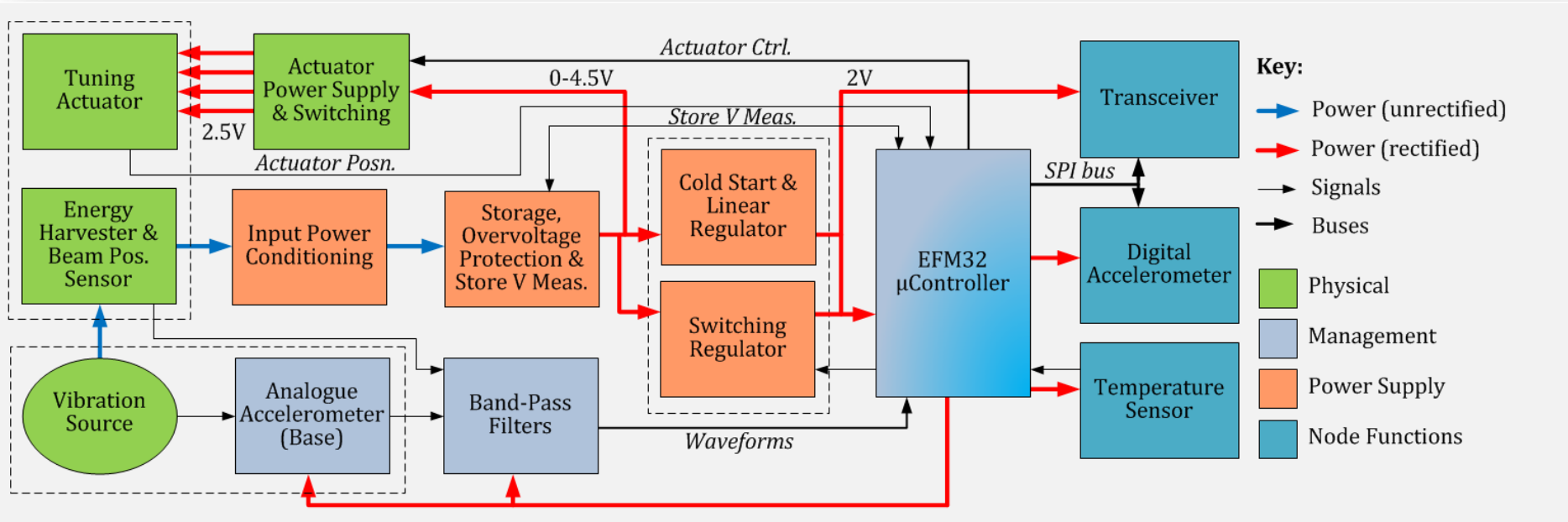
System Requirements

- Wireless sensor to operate on a ferry engine
  - Able to sense vibration/temperature and transmit
- Tuneable harvester
  - Frequency range: 42-55Hz
  - Max Amplitude 1.5 g_{pk}
- Approx. energy budget: 1mW
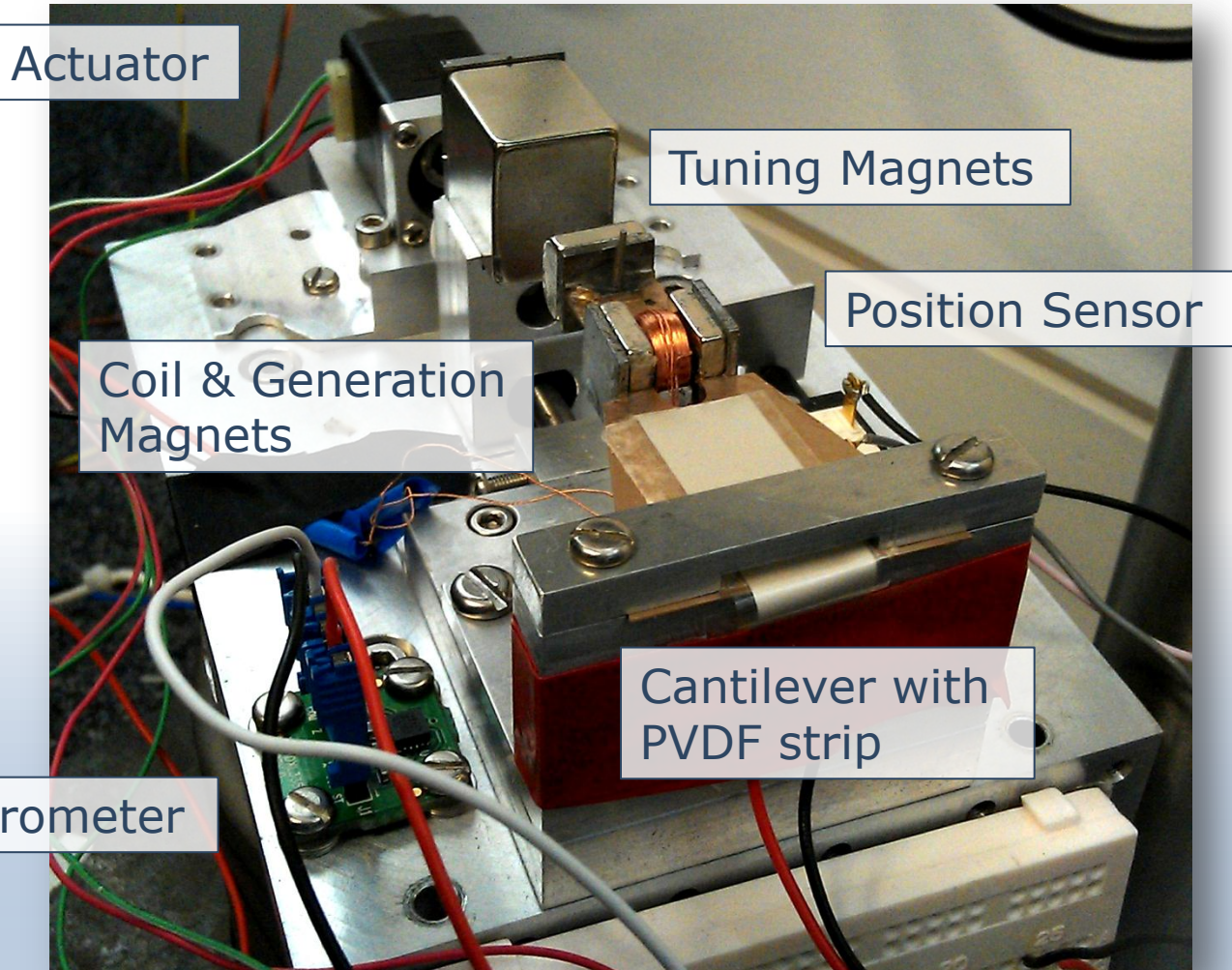- Able to cold-start
- Adaptive operation

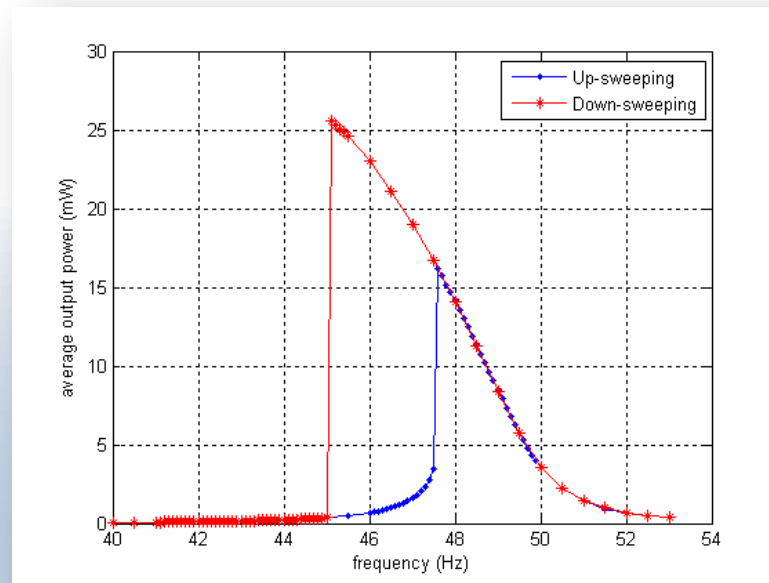# Tuneable Generator Design
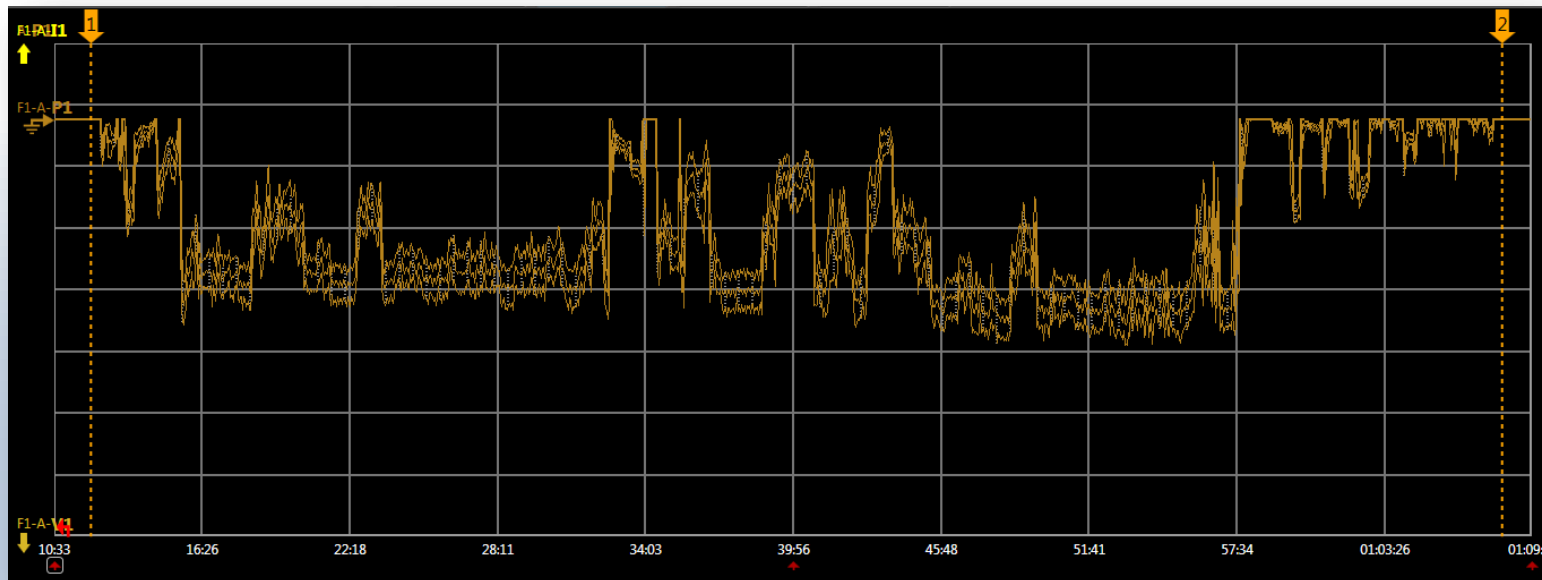
System Topology

Tuneable Generator

Challenges

- Amplitude and frequency changes
- Tuning – the 'cliff edge'
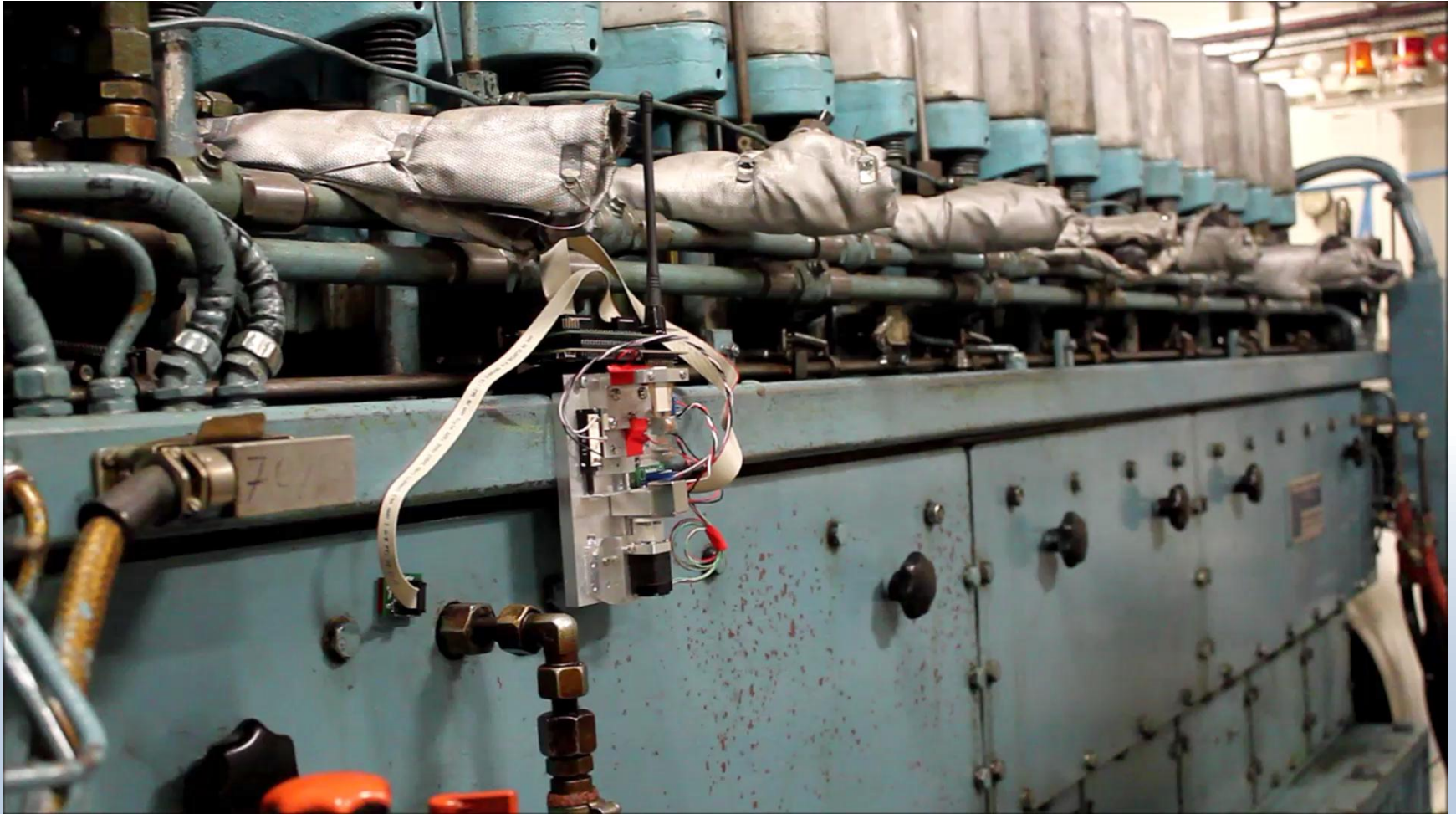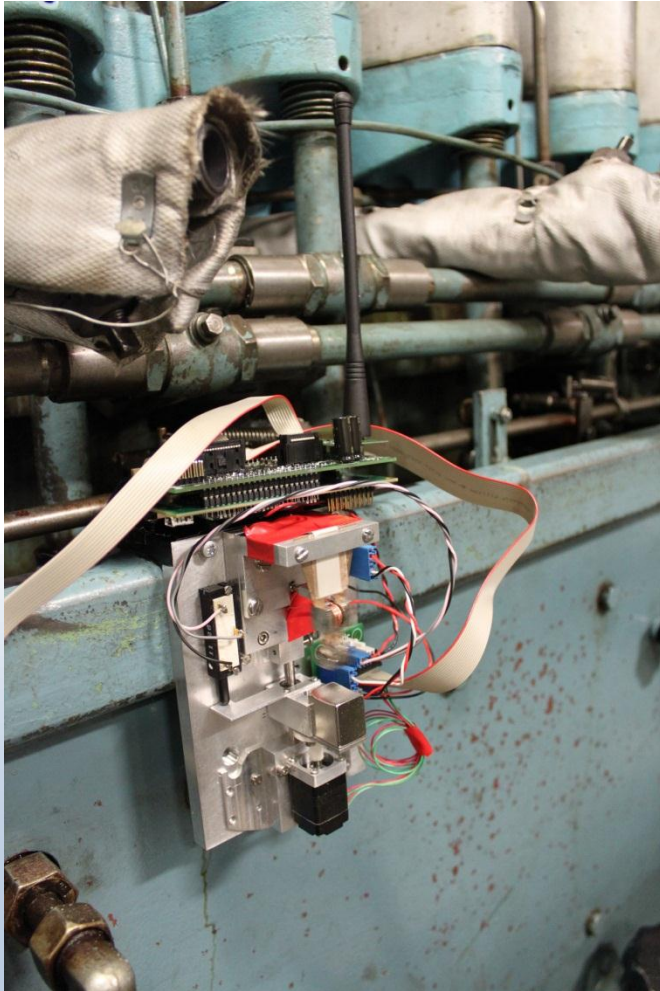- Resilience to high vibration levels

Results

- Automatically tuned (update every 30 s)
- Bridge rectifier into 3.0 V load (SMU)
- Power: average 3.8 mW, peak 7.9 mW
- Against average 2.2 mW, peak 8.1 mW (no tuning)

The Finished Prototype

The Finished Prototype

- Tuneable energy harvester
- Able to cold-start and control its own operation
- Able to sense and transmit wirelessly
- Harvests ~3.8mW
- Adaptive operation
- First deployment of a tuneable energy harvester!

holistic
energy harvesting

Acknowledgment

Questions?