AUTONOMOUS SENSOR NETWORKS

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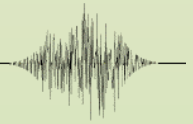
NiPS Laboratory

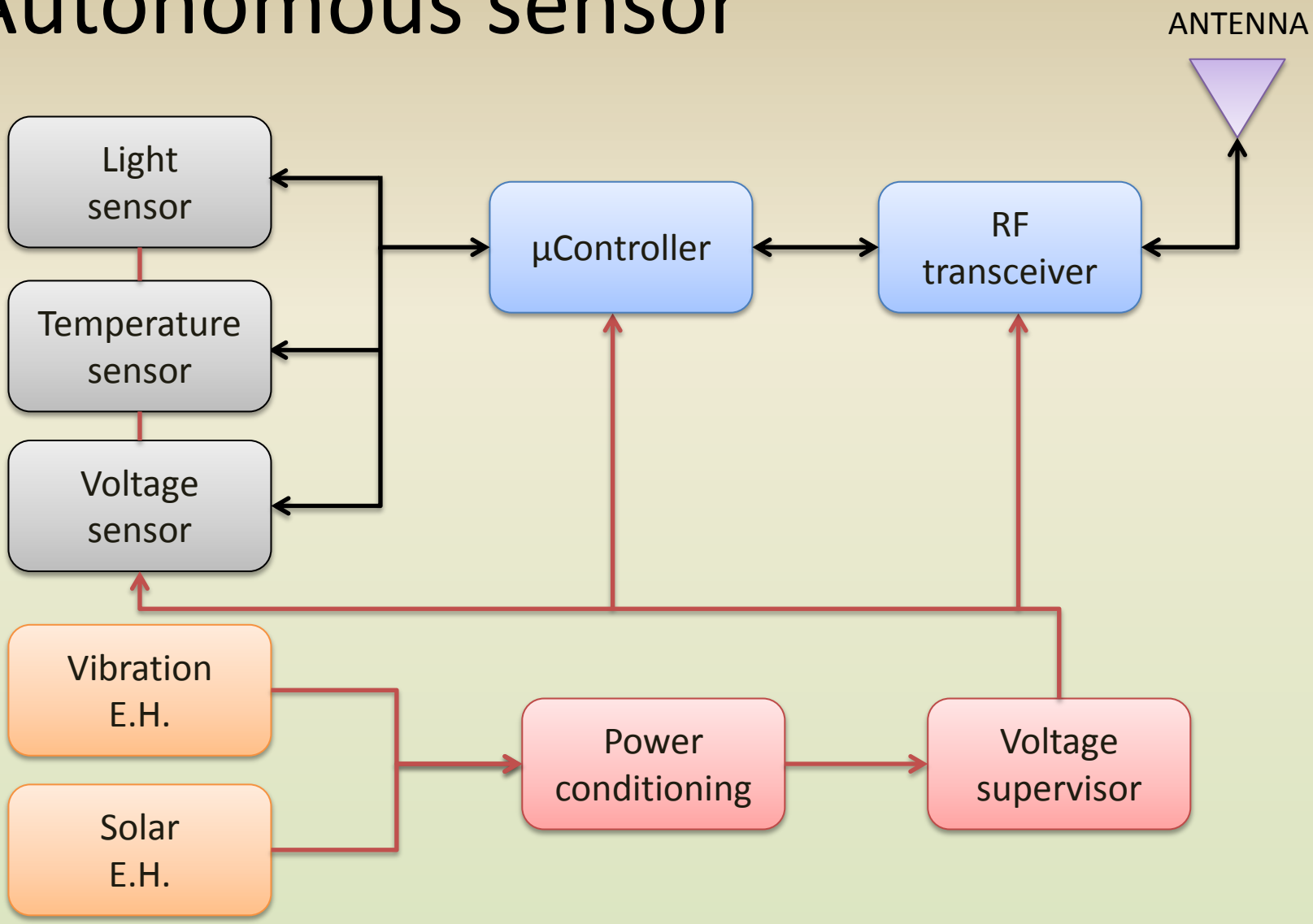
Noise in Physical Systems



Outline

- Autonomous sensors
- Network topologies
- Operating modes
- Block diagram of a sensor
- Extreme low power
- Piezoelectric nergy harvester
- HAT2: current requirements
- Conclusions

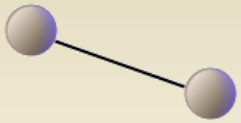
Autonomous sensor



Network topologies

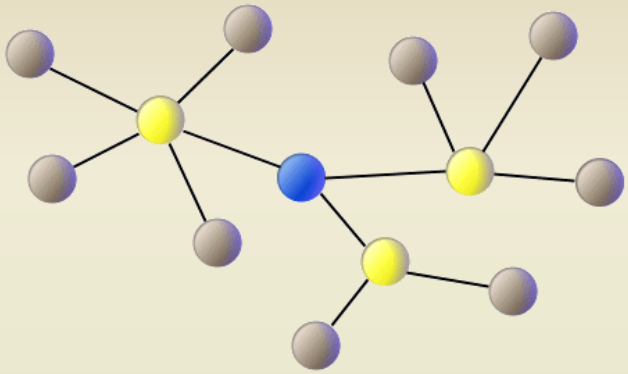
HAT2

Peer to Peer Network

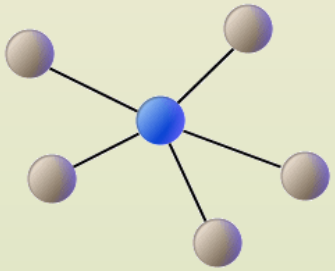


(Sensor, Controller, Actuator, etc.)

Cluster Network



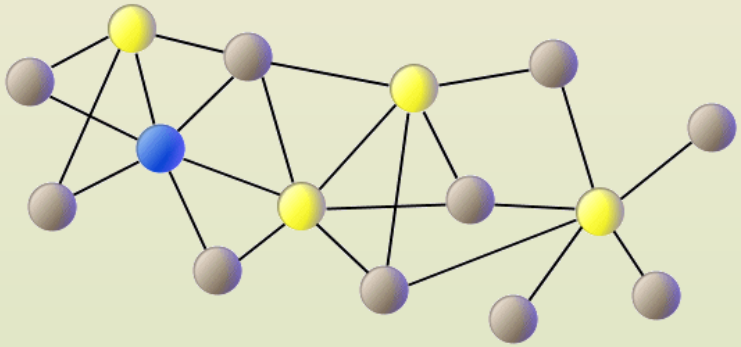
Star Topology Network



Reduced Function Device (Sensor, Controller, Actuator, etc.)

PAN Coordinator

Mesh Network



Reduced Function Device (Sensor, Controller, Actuator, etc.)

PAN Coordinator

Full Function Device (Performs network routing functions)

Reduced Function Device (Sensor, Controller, Actuator, etc.)

PAN Coordinator

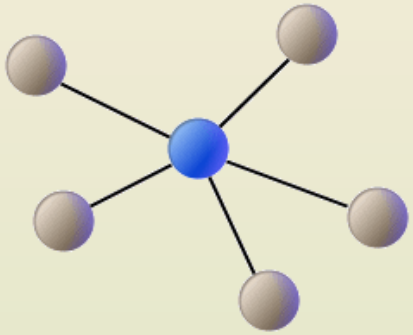
Full Function Device (Performs network routing functions)

HAT2: operating modes

- Low power wireless sensor networks

$$P_{RF} \leq 10\,mW \quad typical$$

- Star topology



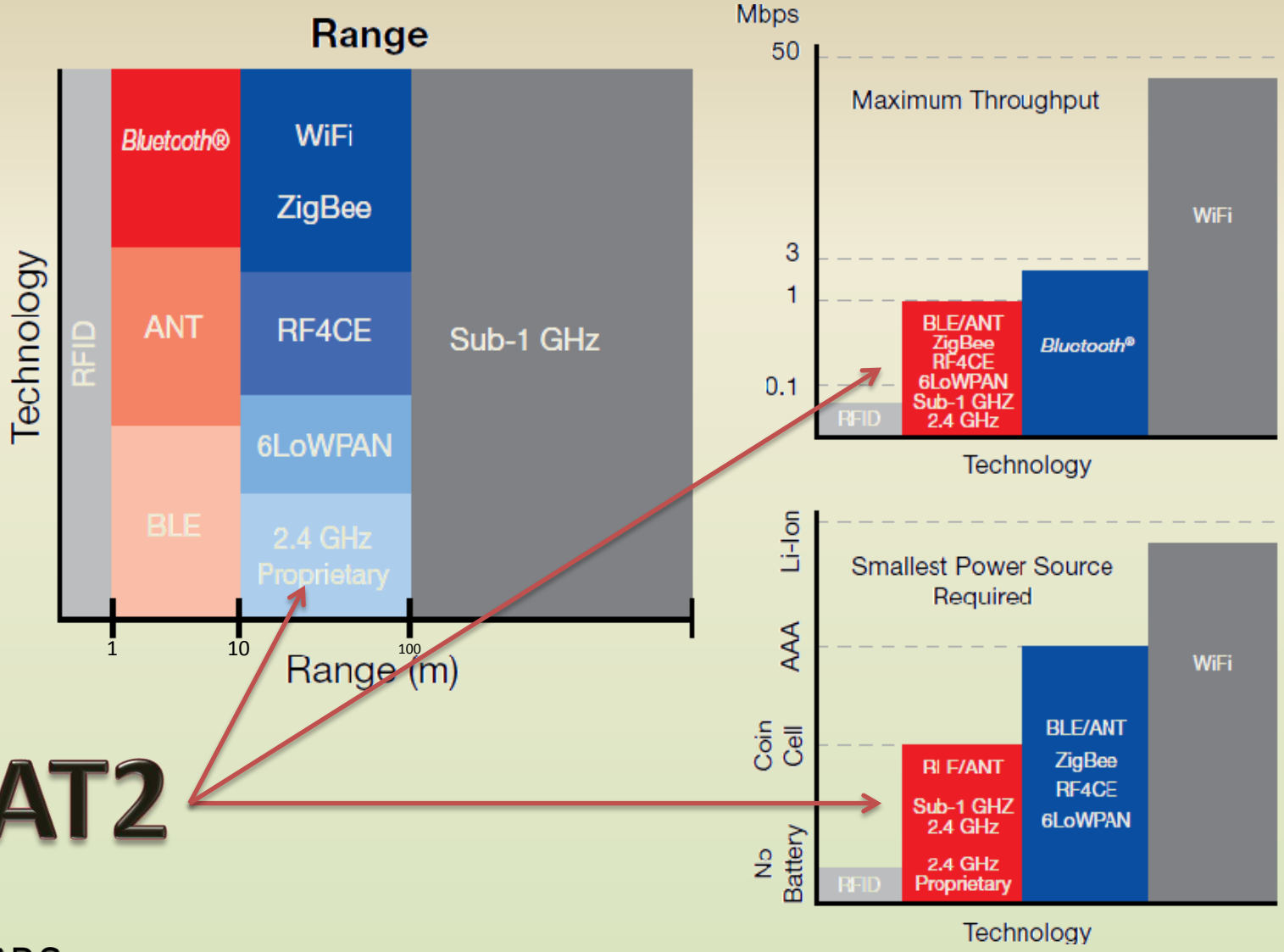
- Low duty cycle

$$\delta \leq 1\% \quad typical$$

- Short range

$$D \leq 50\,m \quad typical$$

Radio frequency transceiver

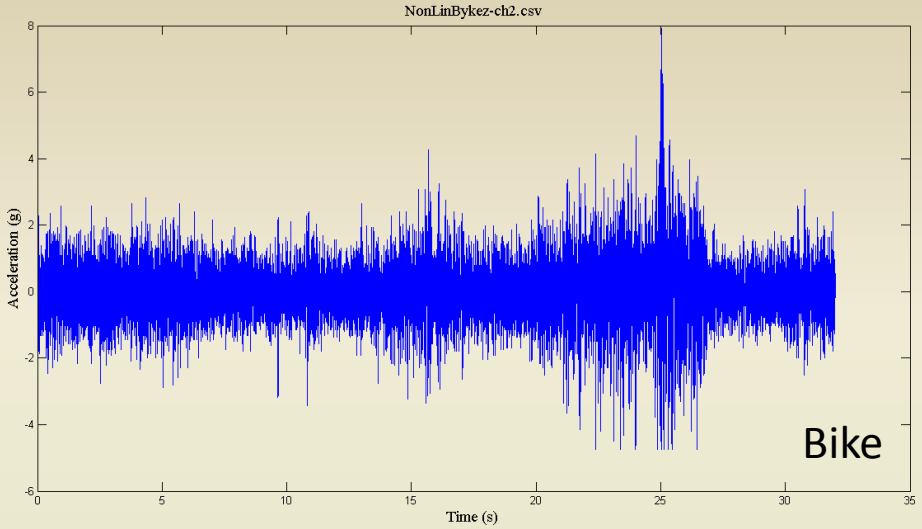


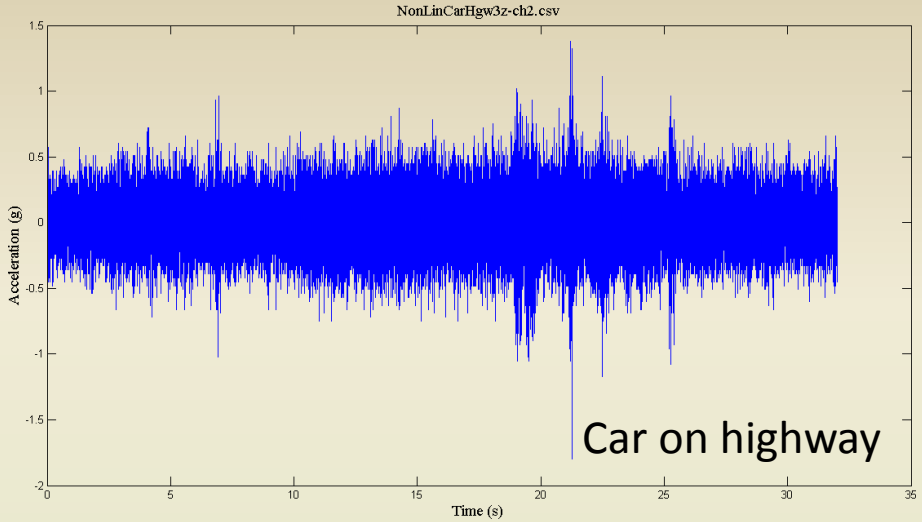
HAT2

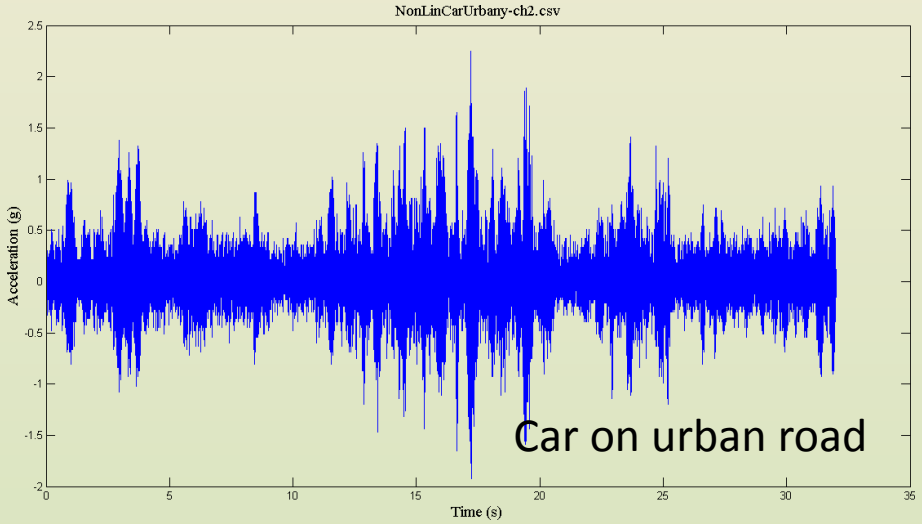
Extreme low power devices

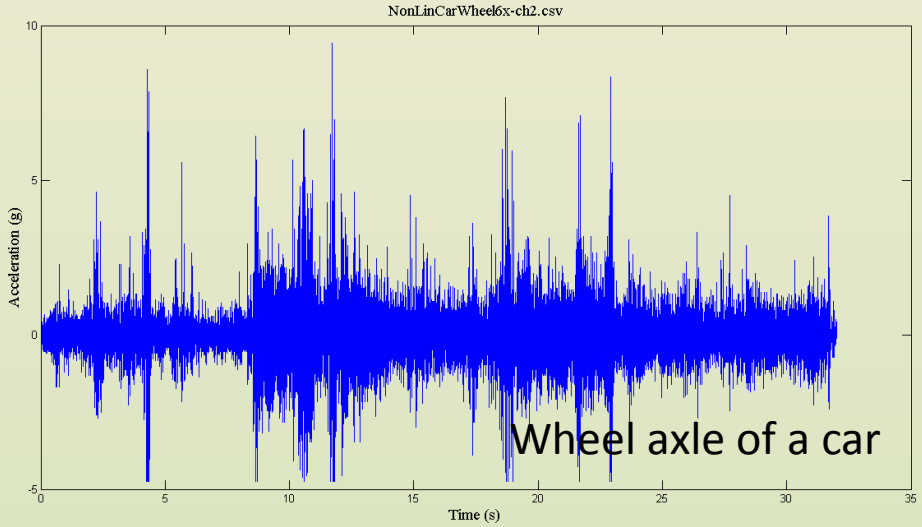
- µController: PIC24F16KA102
- Low Supply Voltage Range: 1.8 V to 3.6 V
- Ultra-Low Power Consumption
  - Active Mode: 195 µA per MHz
  - < 0.4 µA sleep mode + watchdog
- Ultra-Fast Wake-Up from Sleep Mode: 1 µs
- 16-Bit RISC Architecture
- 10-Bit 500-ksps Analog-to-Digital converter

Non-linear Energy Harvester

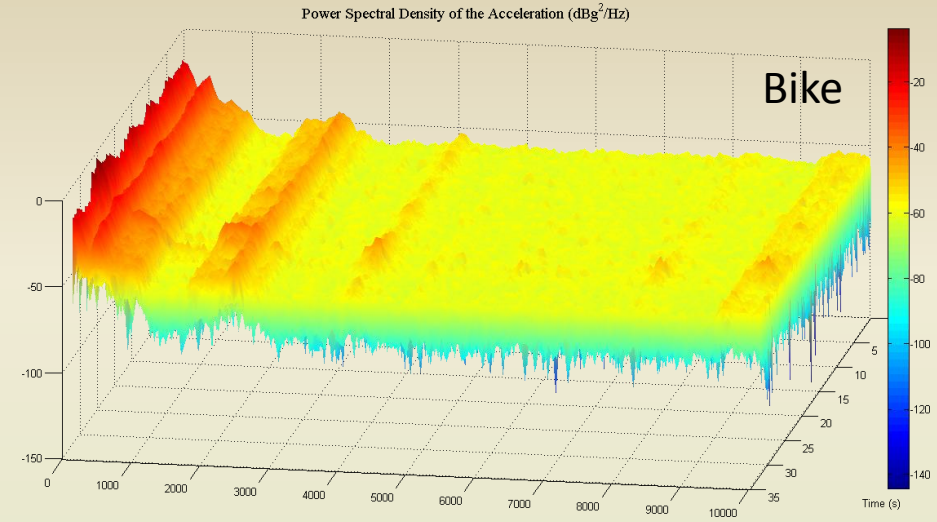


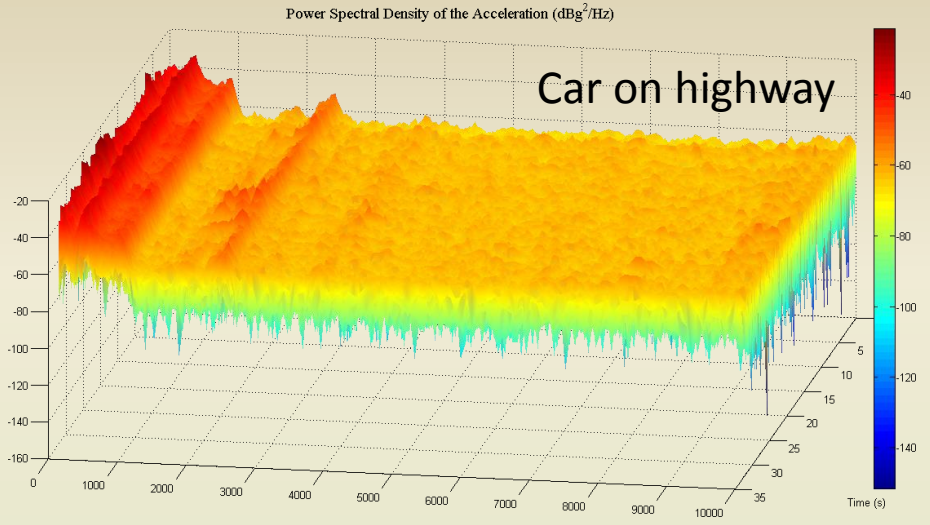


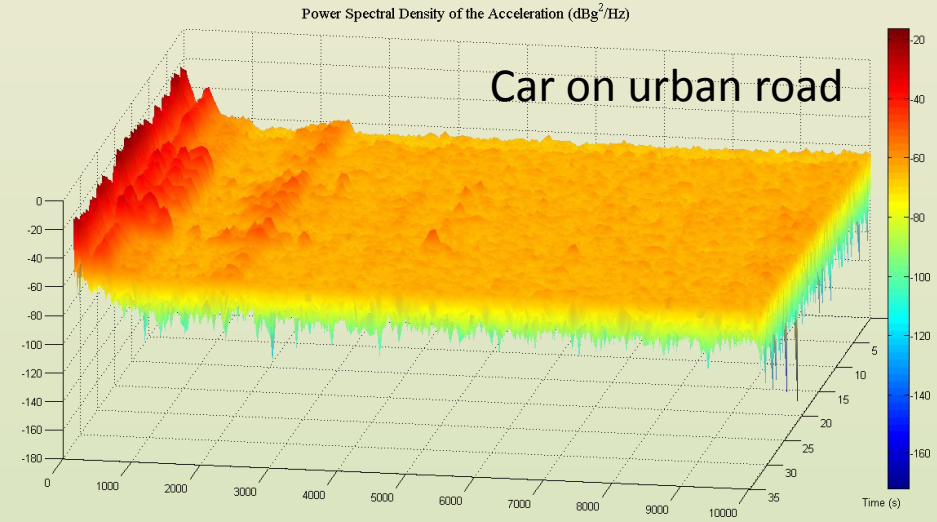


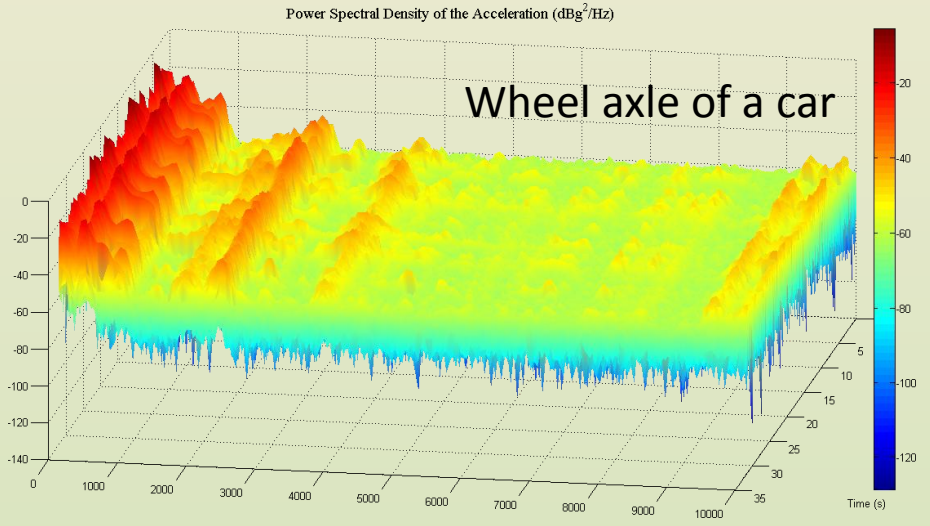


Non-linear Energy Harvester









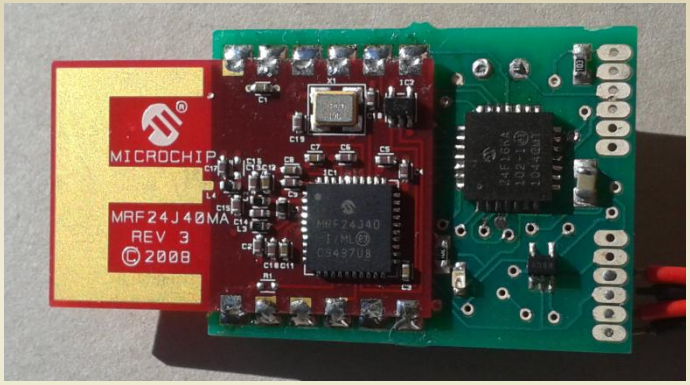
Non-linear Energy Harvester

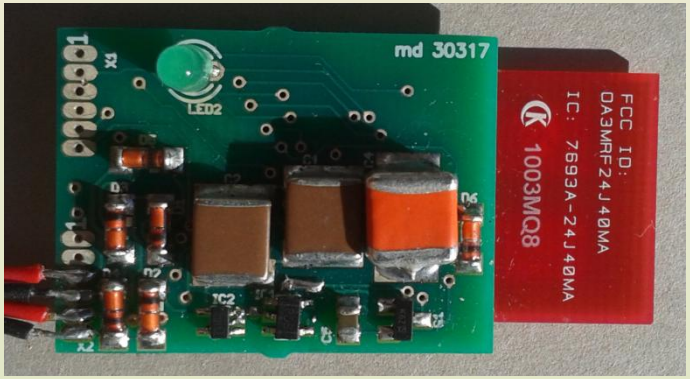
Double layer piezoelectric cantilever: 2.74” x 0.67” x 0.032”

VIBRATION	ACCEL. g_{RMS}	RMS VOLTAGE LINEAR MODE	RMS VOLTAGE NON-LINEAR MODE	RMS POWER LINEAR MODE	RMS POWER NON-LINEAR MODE
BICYCLE	**0.848**	**3.594 V**	**4,621 V**	**0,718 mW**	**1,187 mW**
CAR ON HIGHWAY	0,180	0.386 V	0.652 V	0,008 mW	0,024 mW
CAR ON URBAN ROAD	0,307	1.966 V	2.160 V	0,215 mW	0,259 mW
WHEEL AXLE	**0,844**	**2,337 V**	**4,518 V**	**0,304 mW**	**1,134 mW**

HAT2: PIC24 + MRF24J40

Small Vibration Powered
Wireless Temperature
And Light Sensor
Operating On 2,4 Ghz ISM Band





Small enclosure: 60 x 35 x 25 mm
2 solar cells: 20 x 25 mm, Pmax = 8 mW @ 3,9 V
1 piezoelectric non-linear vibrations harvester

HAT2: PIC24 + MRF24J40

RTX Power Up

TX Start:
Payload: 8 byte

≈ 15 mA @ 3,3 V

µController: sleep
0,36 µA @ 3,3 V

Conclusions

- An autonomous hybrid wireless sensor, working only with the energy coming from vibration and light, has been designed, realized and tested.

- The use of non-linear bi-stable energy harvester is fundamental to increase the power efficiency conversion of the vibration energy harvester.

- Using energy harvesting technologies the system can work without any foreseeable limitation and, most importantly, no maintenance is required.

Thank you!