TÉCNICO
UNIVERSIDADE
DE LISBOA

HarvSense

Electrocap Pitch Deck

Group 29
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OUR TEAM

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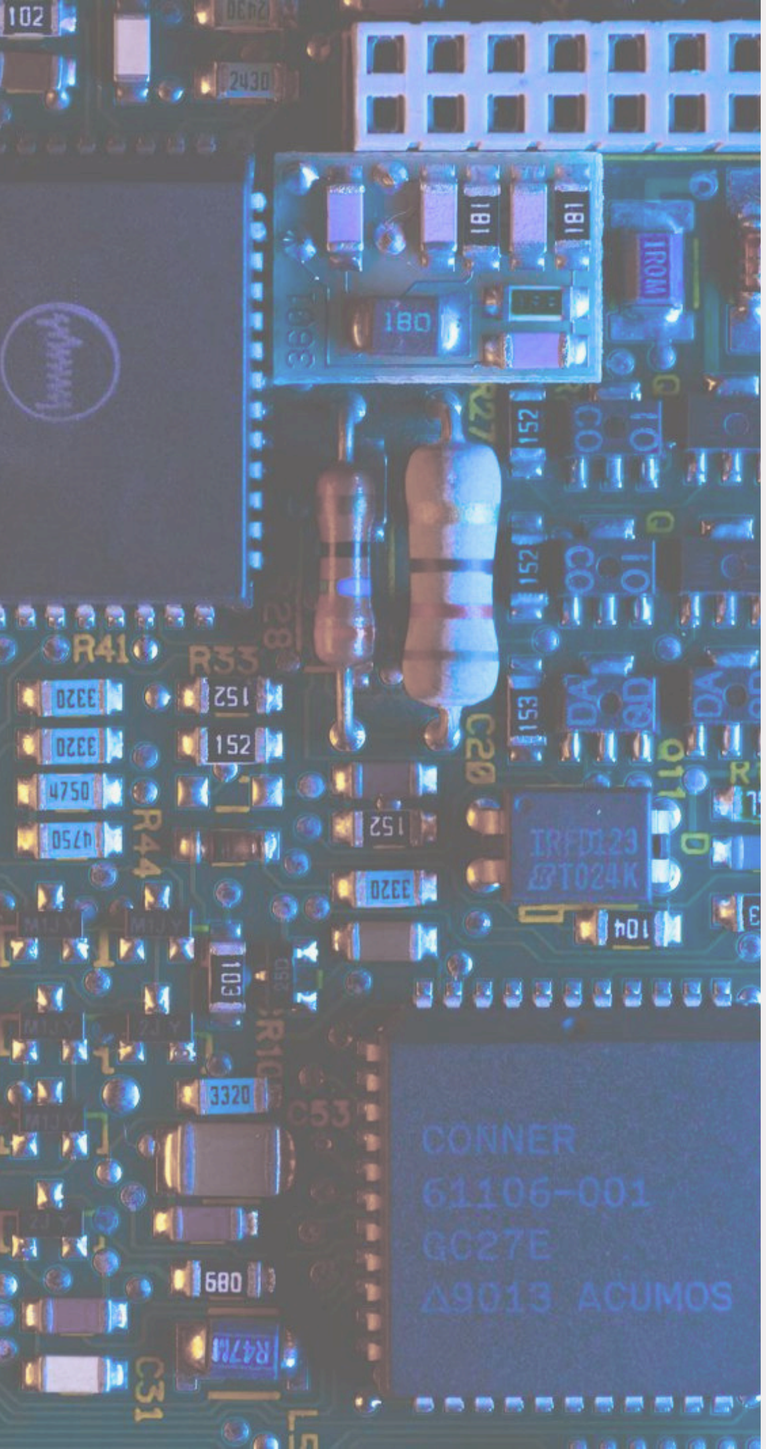
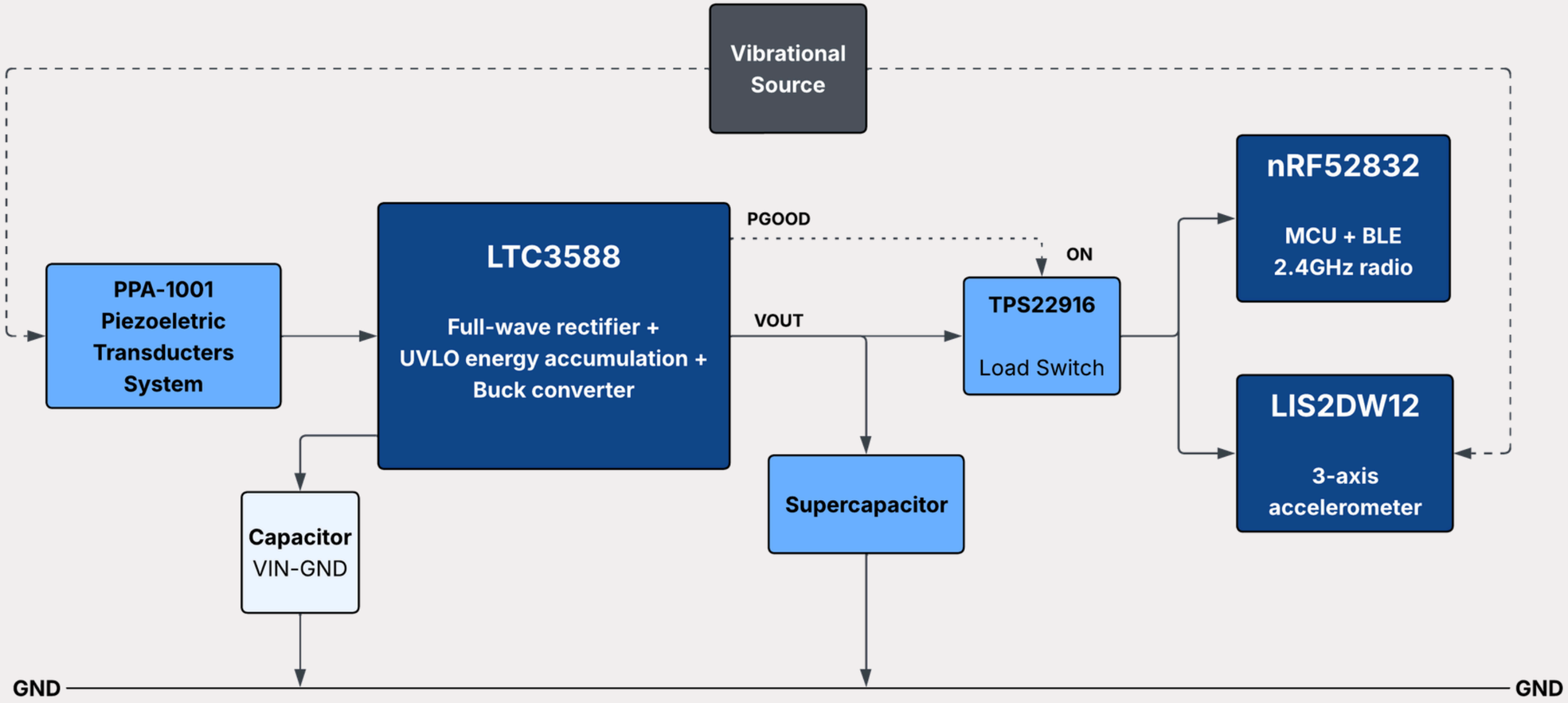


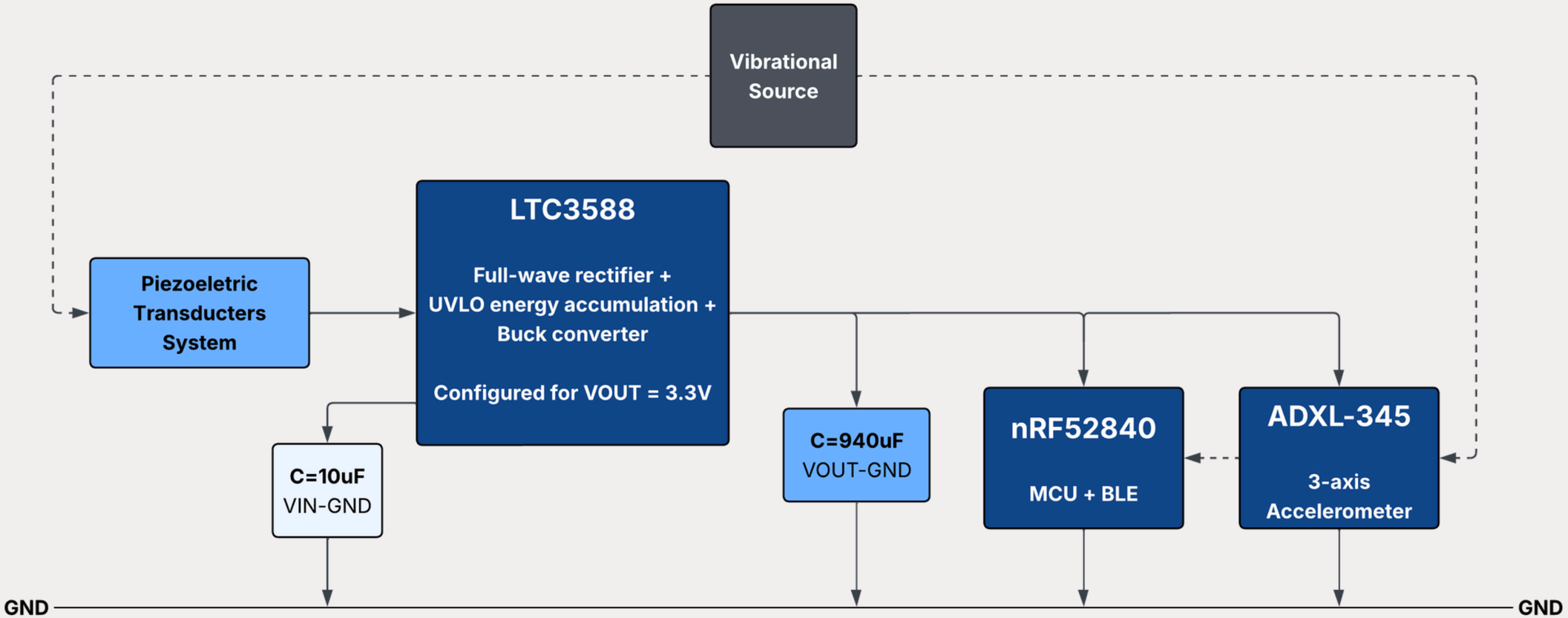
PROBLEM DEFINITION

- Structural Health Monitoring (SHM) is essential to ensure the safety and longevity of critical infrastructure (such as bridges, buildings, and wind turbines)
- SHM sensors typically rely on batteries or cables
- In remote locations, installation and maintenance becomes expensive and limits scalability
- These structures generate continuous mechanical vibrations and it is possible to convert them into electricity via energy harvesting to power sensors!

SOLUTION OVERVIEW



OUR PROTOTYPE

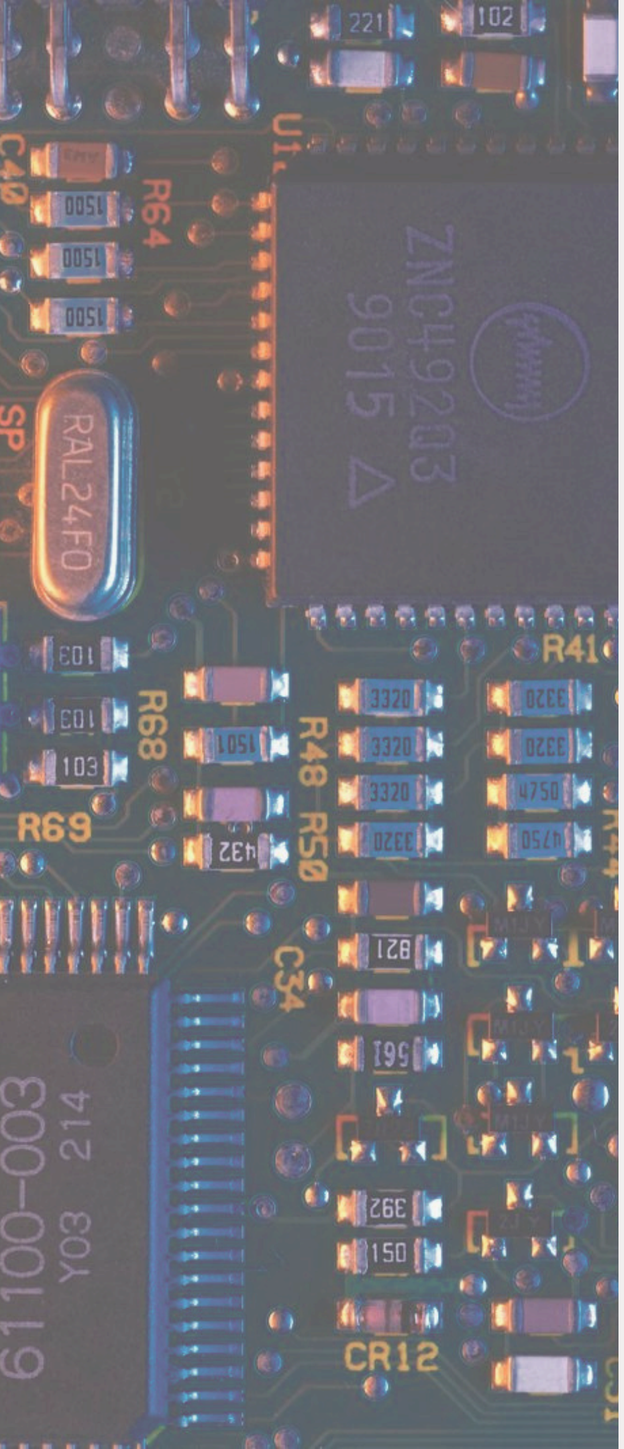


HOW DOES IT WORK?

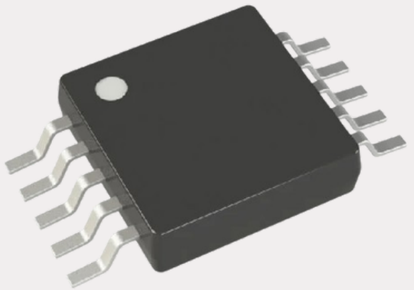
- Both systems harvest mechanical vibration energy using piezoeletric transducers. The AC signal generated by these elements is rectified and managed by the LTC3588, which regulates the output voltage.

- In a **developded prototype**, once enough energy is available, the regulated supply powers the load through a load switch, controlled by the LTC3588's PGOOD signal. This ensures that the MCU and accelerometer only turn on when the supply voltage is stable. The supercapacitor stores harvested energy and provides a stable energy reserve for the MCU, accelerometer and BLE transmission bursts.

- In **our prototype**, to reduce system complexity, the LTC3588 directly supplies the microcontroller and the accelerometer. The ADXL345 measures vibration and sends the data to the XIAO nRF52840, which processes it and transmit it via BLE.



LTC3588EMSE-1#PBF

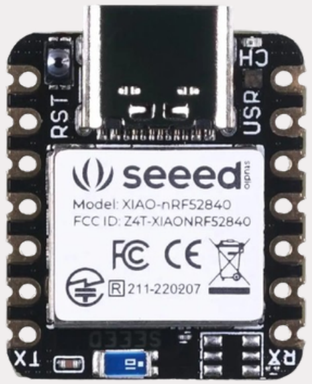


- Energy harvesting integrated circuit with an internal bridge **rectifier** and integrated **buck converter**

- It receives AC energy from the piezo, rectifies it, accumulates energy on the input side, and regulates the output to 3.3V

How it works:

- It utilizes a UVLO (Under-Voltage Lockout) mode with hysteresis, allowing energy to accumulate before activating the buck converter - making it ideal for energy harvesting applications

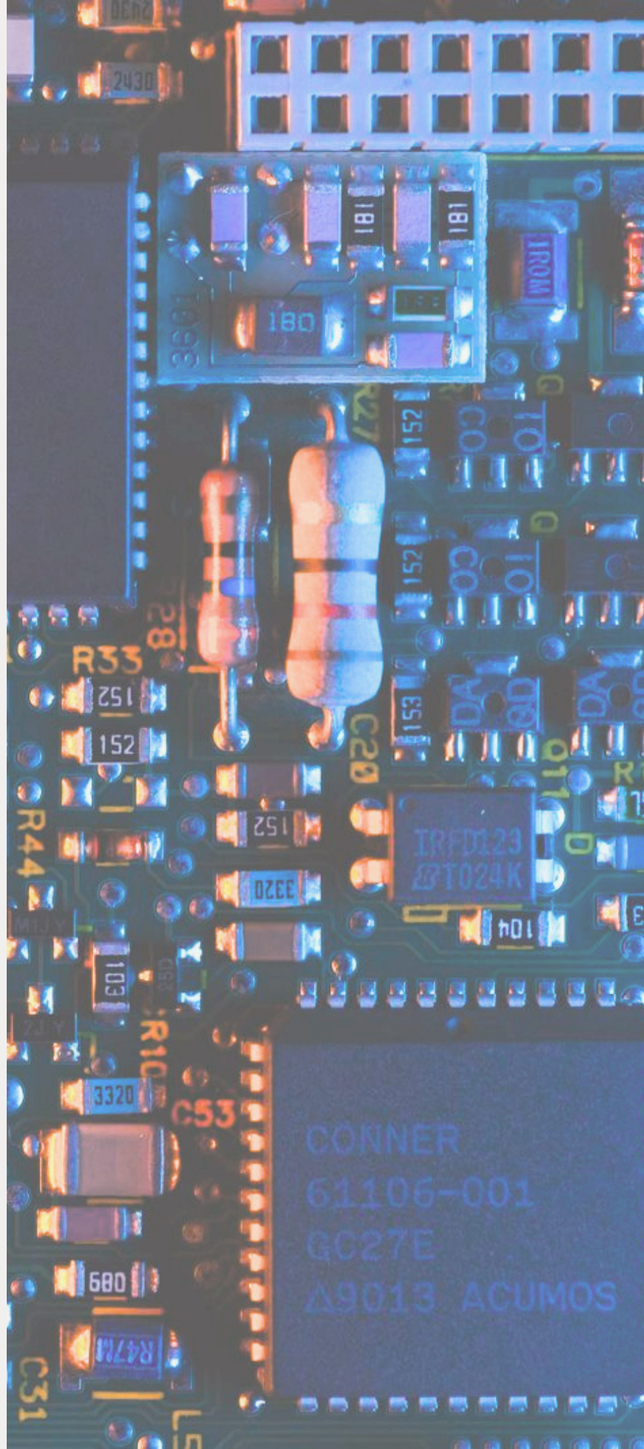


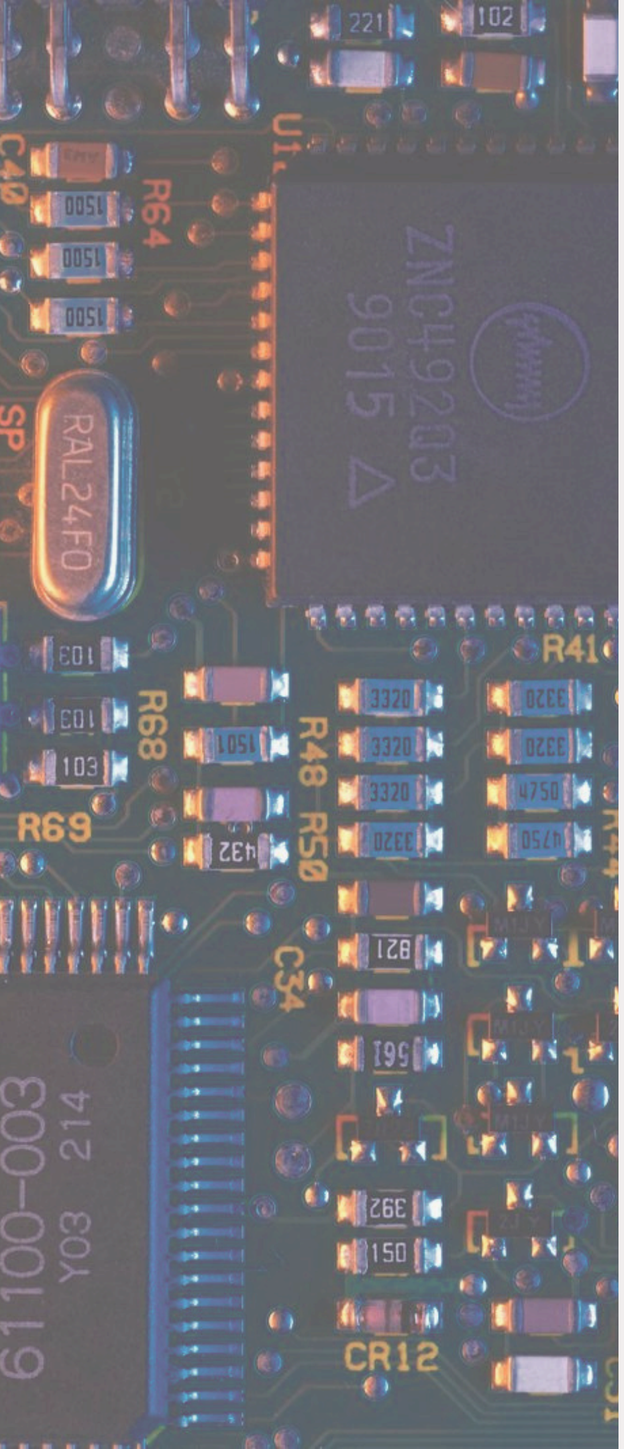
nRF52840

- Powered from the regulated 3.3V rail generated by the energy harvesting stage
- Interfaces with the ADXL345 through SPI to acquire vibration data
- Provides Bluetooth Low Energy capability needing 4.3mA, allowing the system to transmit data wirelessly with intervals of 1s

How it works:

- It remains in a low-power state (200uA) since energy is limited, wakes up to read the accelerometer, applies the FFT to the measured data, and transmits it via Bluetooth Low Energy





ADXL-345

- Low power 3-axis digital accelerometer used to measure vibration
- Provides acceleration data for the X, Y and Z axes without requiring external ADC conversion

How it works:

- It senses dynamic acceleration due to motion or vibration, converts it internally to digital data, and sends the samples to the microcontroller for processing

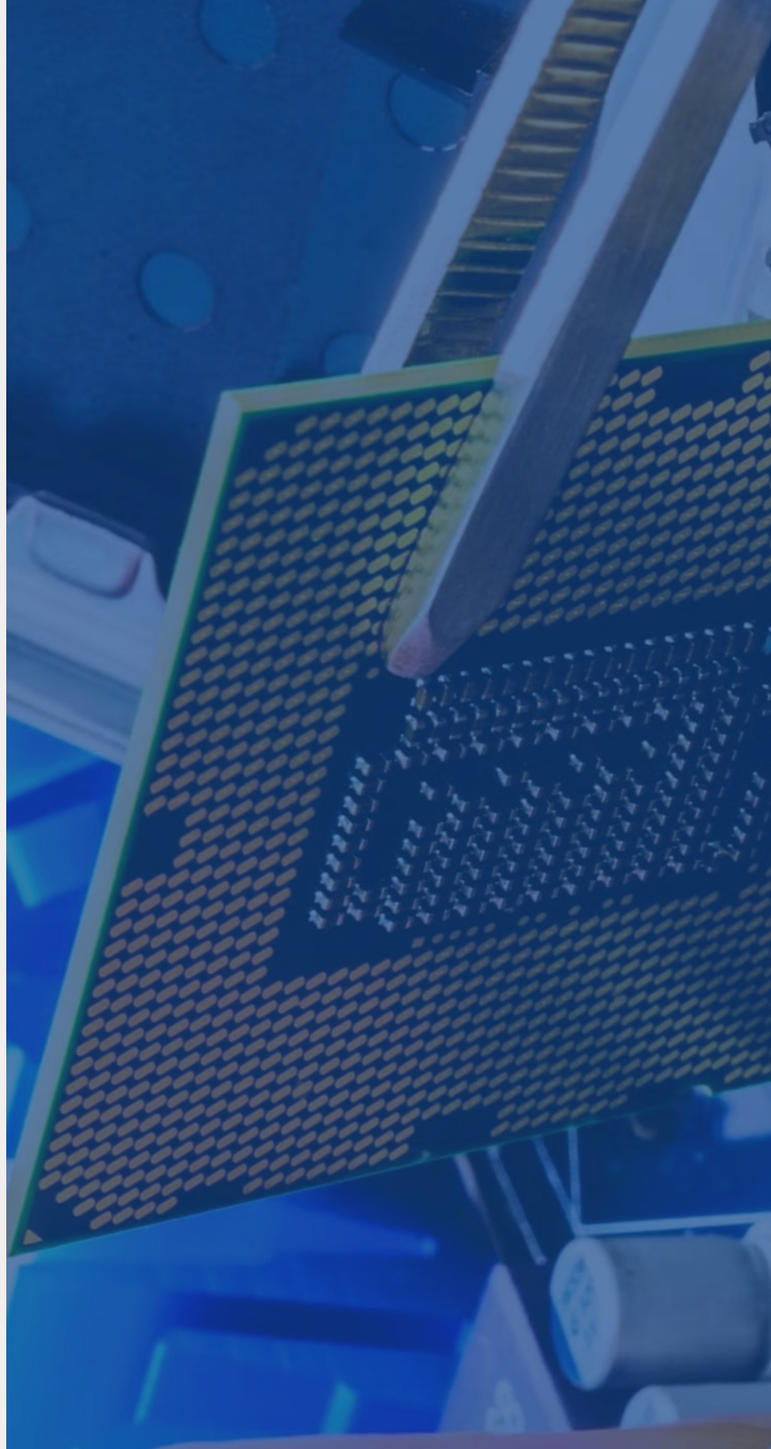
SOLUTION BENEFICIARIES

Who does it benefit?

- Asset owners and operators
- Operation and maintenance (O&M) companies
- Regulators and insurance companies

Why?

- Eliminates battery replacements and periodic interventions
- Reduces cabling and enables additional measurement points
- Continuous monitoring: allows for condition-based maintenance and action before failures occur
- Coverage of remote locations



BUT WHAT COULD THE PRODUCT PREDICT?

- Loss of **structural rigidity**, which decreases the structure's natural frequency. In the DFT, this effect is observed as the main peak shifting towards lower frequencies.

- Increase in **internal damping**, which causes the vibration to decay faster. In the DFT, the main peak has lower amplitude and may become more wider and flatter, reflecting greater energy dissipation.

- Appearance of **nonlinearities**, such as cracks or other structural defects. In the DFT, the main peak may shift towards higher frequencies, and secondary peaks or harmonics may appear, showing that the response is no longer purely linear.

WHAT COULD THE PRODUCT PREDICT?

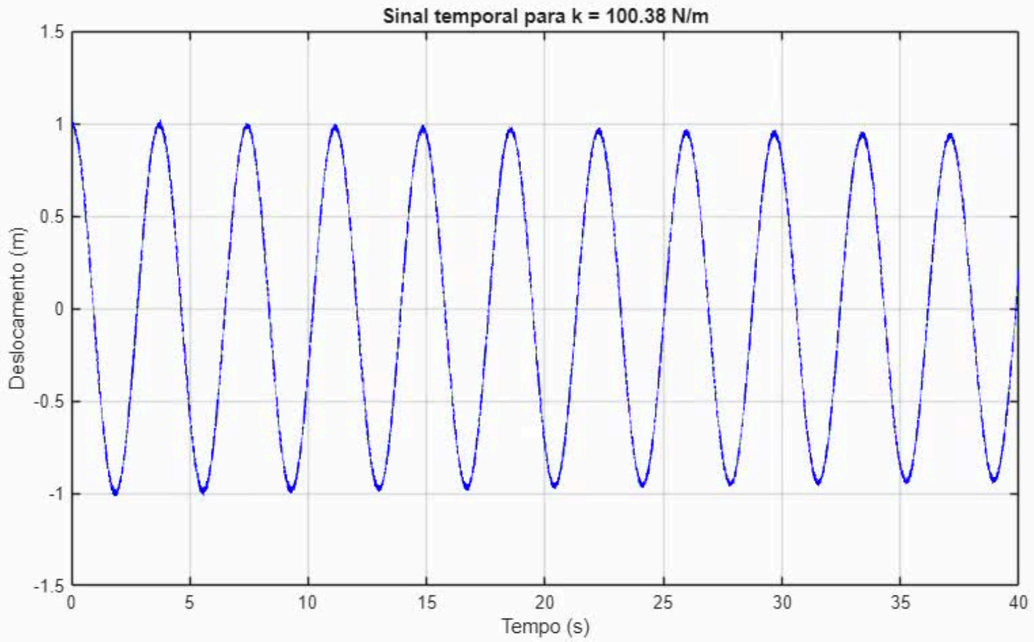
To better study these problems, we can model the structure as mass-spring-damper system with a possible cubic nonlinearity, described by following equation:

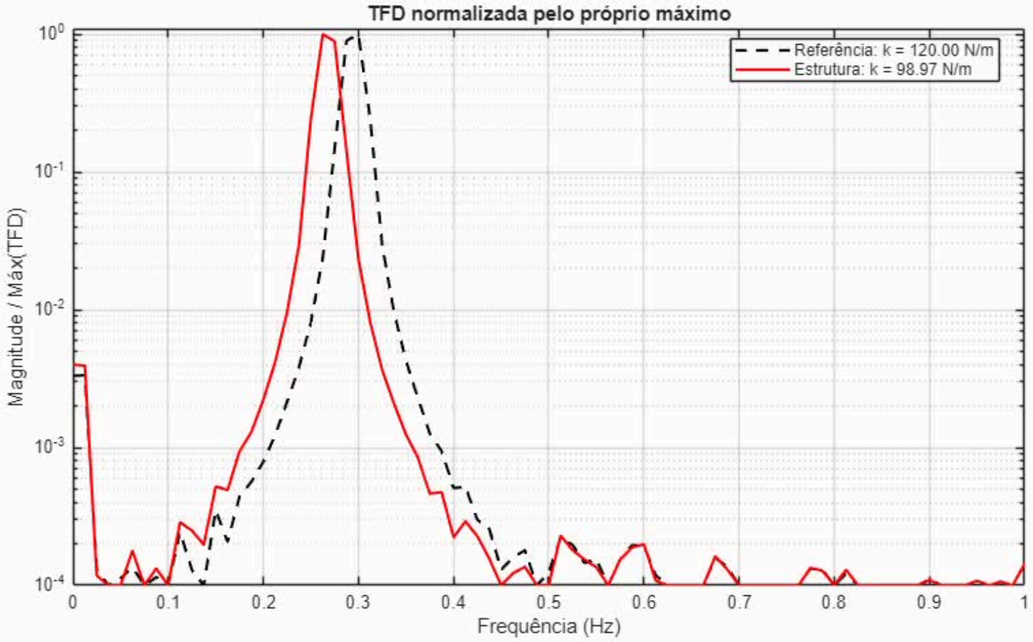
$$m\ddot{x} + c\dot{x} + kx + \alpha x^3 = 0$$

where:

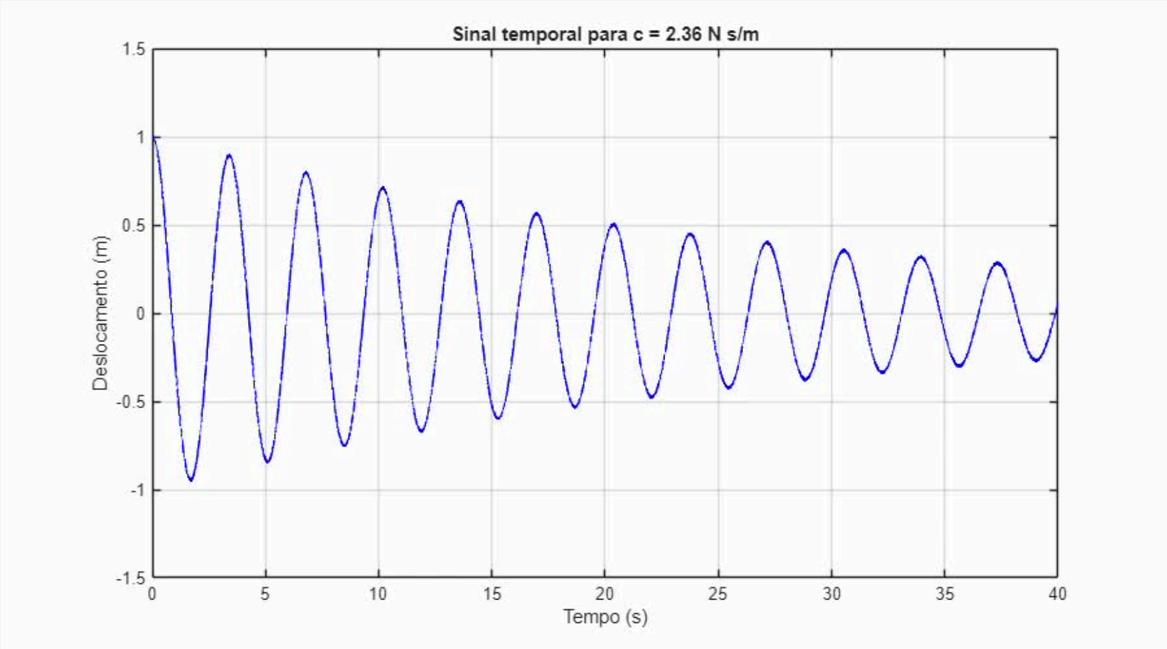
- *m* represents the structure's mass
- *c* represents the damping coeficient
- *k* represents the structure's rigidity
- α represents the intensity of the cubic nonlinearity
- x represents the structure's position

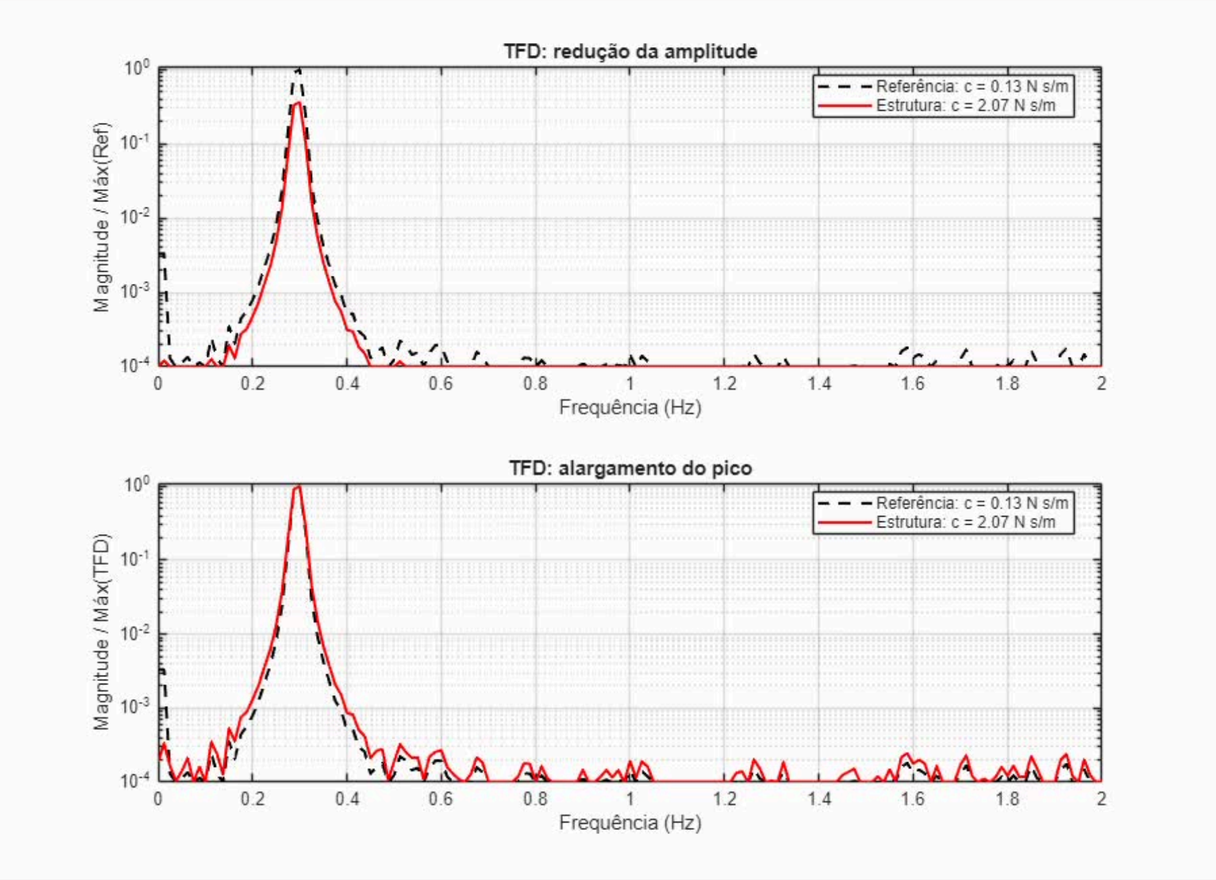
LOSS OF STRUCTURAL RIGIDITY



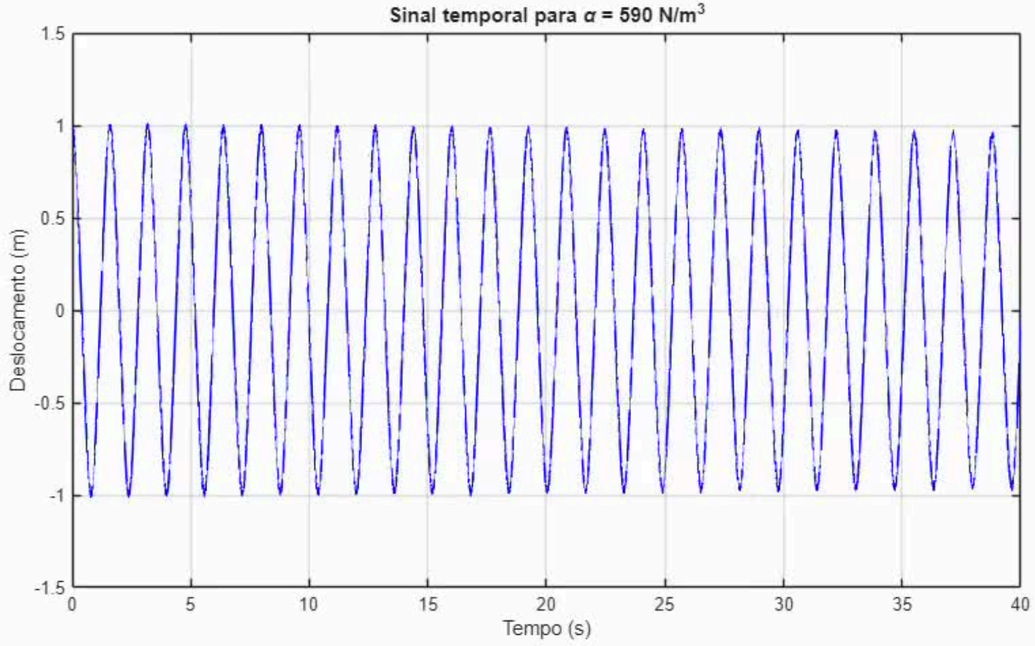


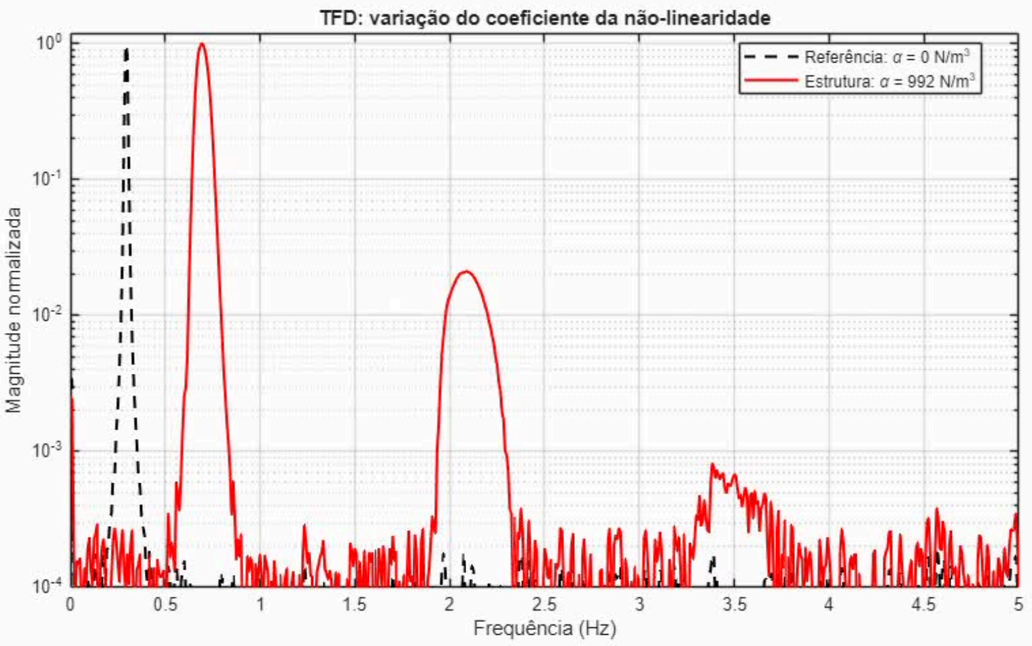
INCREASE OF INTERNAL DAMPING





APPEARANCE OF NONLINEARITIES





PREVIOUS WORK

Structural Health Monitoring today relies predominantly on

- Battery-powered sensor networks
- Wired power and data infrastructures

Existing energy harvesting technologies

- Primarily designed for low-power IoT applications
- Not optimised for continuous and distributed structural monitoring
- Limited integration with structural dynamics and civil infrastructure constraints

PARTNER - MOLDATA

- Industrial partner for application-oriented validation and mechanical integration support. Moldata provided access to CNC machinery and a realistic operating environment for vibration characterization and prototype testing

- On March 18th, Moldata hosted a data collection session focused on measuring the CNC machine head's vibration profile, namely resonance frequency and oscillation amplitude, to support piezoelectric transducer sizing

- On May 6th, CNC vibration data collection at Moldata to power prototype development

TEAM CONTRIBUTIONS

António Zarco

- Poster
- Circuit refinement and final documentation

Lourenço Reis

- Pitch Deck
- Hardware implementation and component integration

Pedro António

- Data acquisition
- Hardware-firmware integration

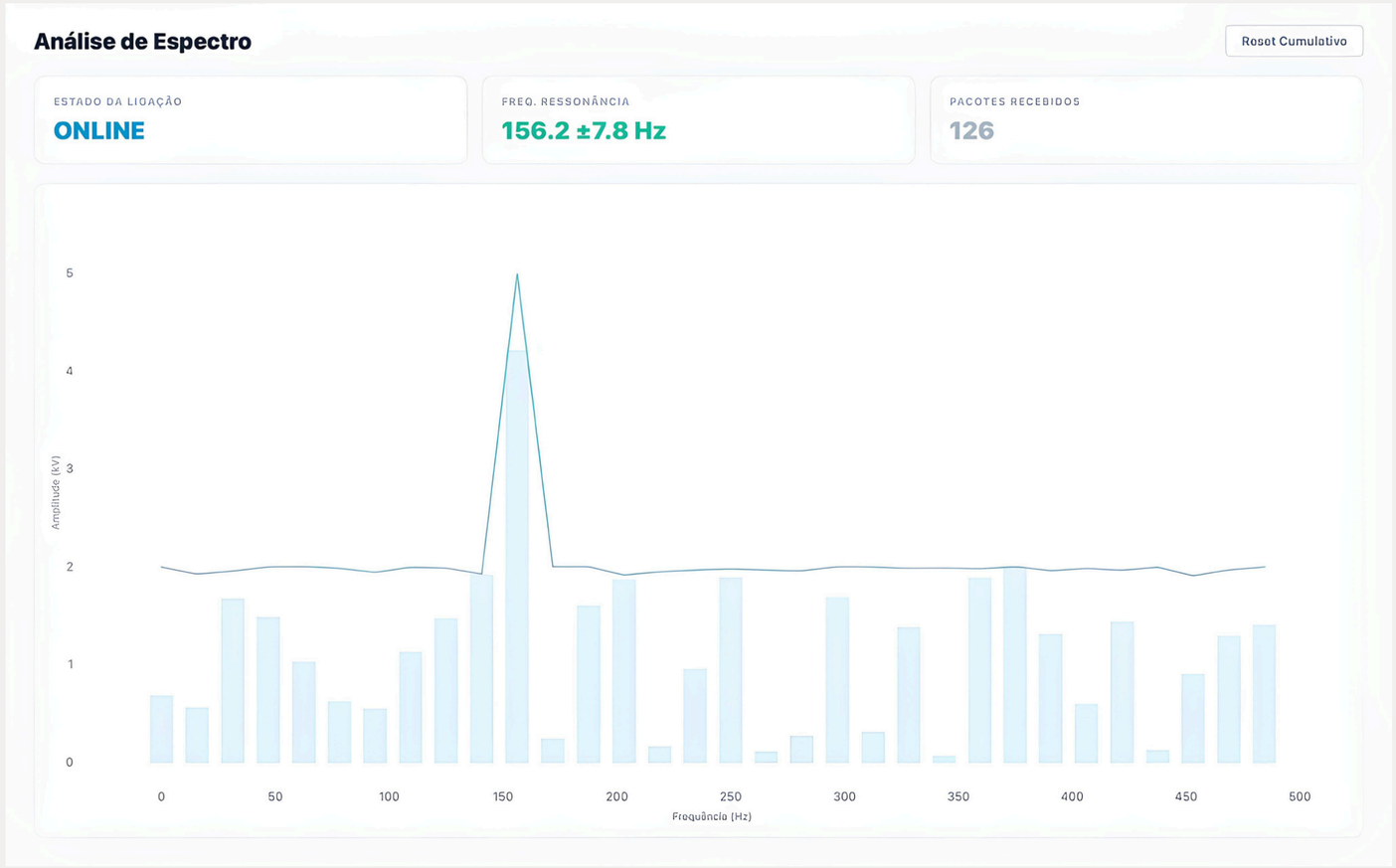
Guilherme Gameiro

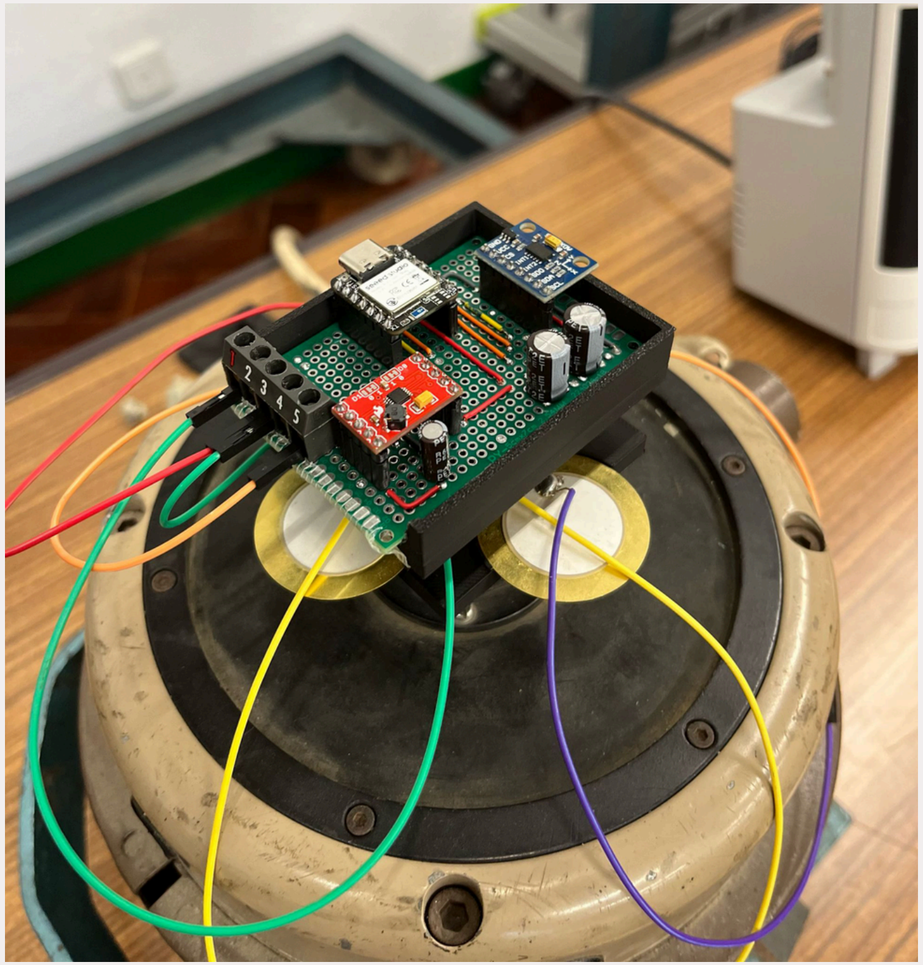
- System validation and performance analysis
- Dashboard

Manuel Clemente

- Video & Blogue
- Prototype base 3D modeling

RESULTS - DASHBOARD AND PROTOTYPE





THANK YOU!

For more information: