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IoT sensors for modern structural health monitoring
A new frontier

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Project Idea

IoT technology for Structural Health Monitoring

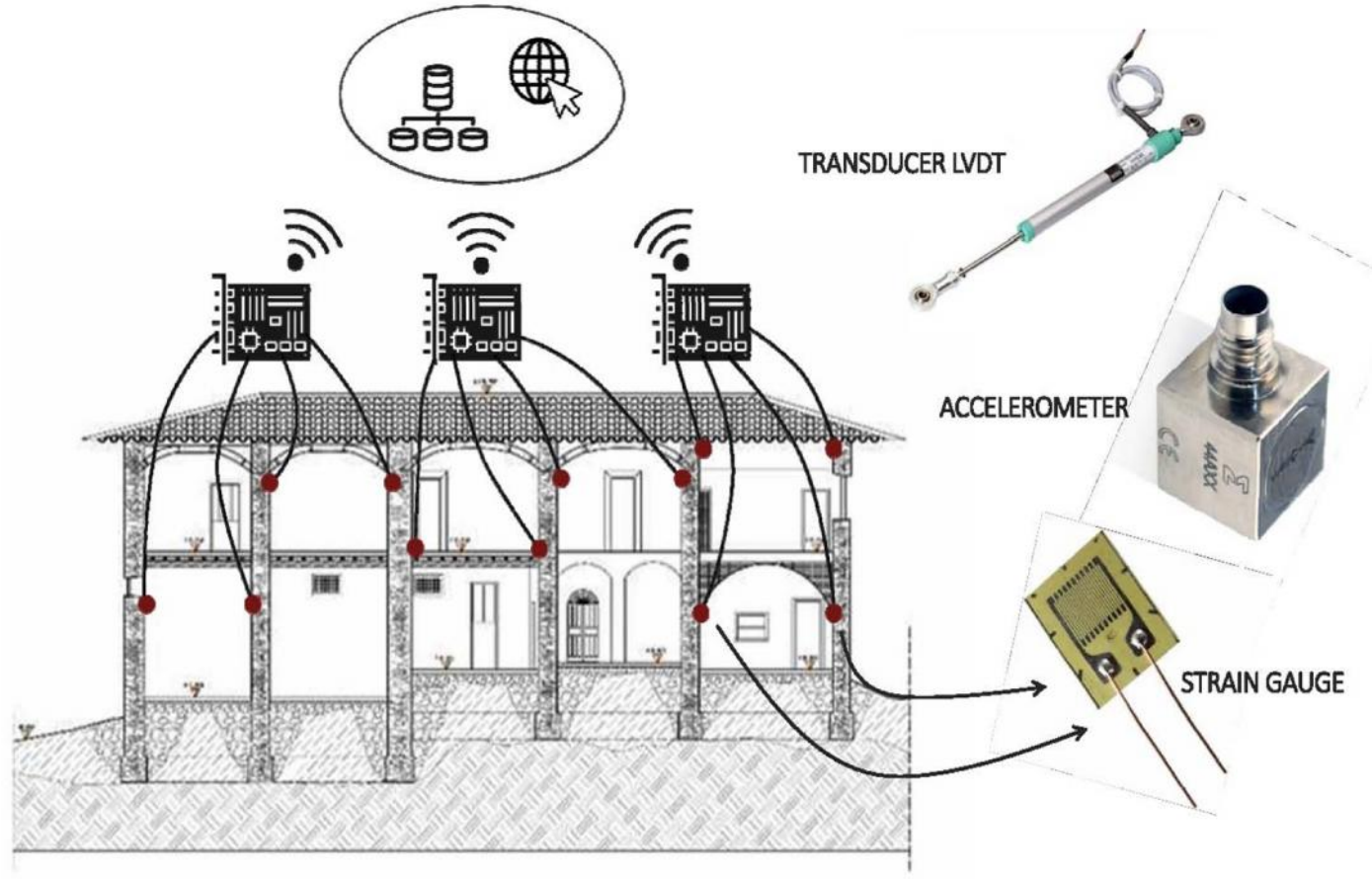
- Objectives:
  - to permanently assess the health of the structure through embedded monitoring
  - to define and realize affordable devices in order to achieve a lifelong health of the structure
  - to realize a tailored network in order to collect all these data and elaborate them

- Expected results
  - to indentify the right family of sensors able to deliver the desired performances and fulfil the predetermined objectives
  - to apply the monitoring system to some new building to be built and verify the results as case study

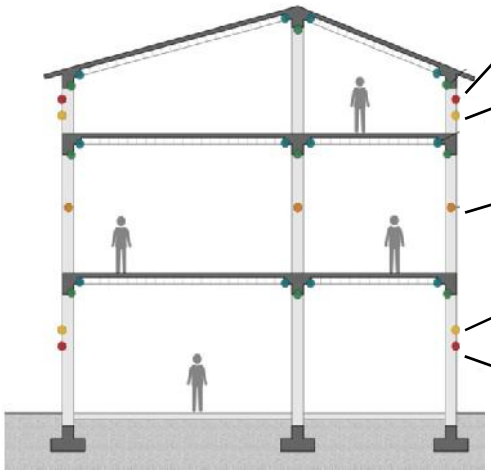
Earthquake damage to buildings, often due to the material decay and lack of maintenance

High costs and duration of repairing and reconstruction

Scenario of permanent monitoring system in a building



The buildings' structural safety today is for saving money (maintenance, durability, efficiency) and to save life in the extreme environmental or anthropic actions



ACCELERATION
Structure-integrated accelerometers for monitoring the dynamic response.

STRAIN / STRESS
Monitoring of local stresses by means of strain gauges installed inside the structural members.

TEMPERATURE
Monitoring of the temperature inside the structural members for system calibration.

HUMIDITY /pH
Measurement of humidity and acidity of concrete to assess the risk of oxidation/corrosion.

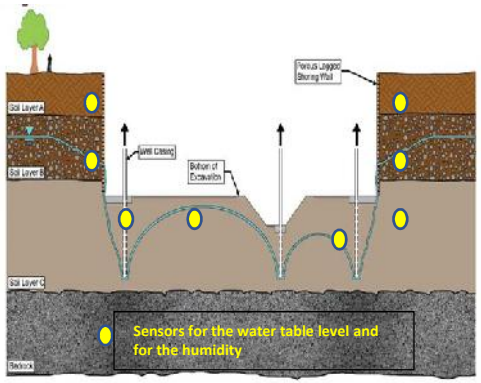
OXIDATION
Monitoring of the level of oxidation of steel bars in reinforced concrete.

LOCAL WIRELESS CONNECTION

Local archive:
All sensors are connected to the monitoring system by a WiFI connection. Immediate and systematic check with portable WiFi devices during inspections on-site

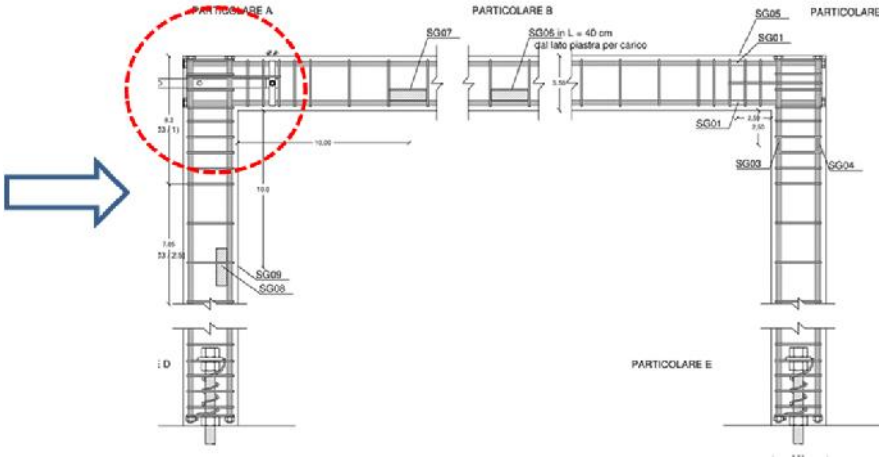
REMOTE WIRELESS CONNECTION

The system is permanently connected to the internet Cloud database data transfer

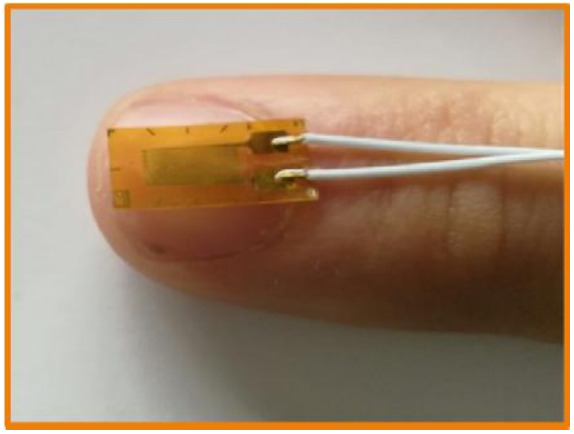


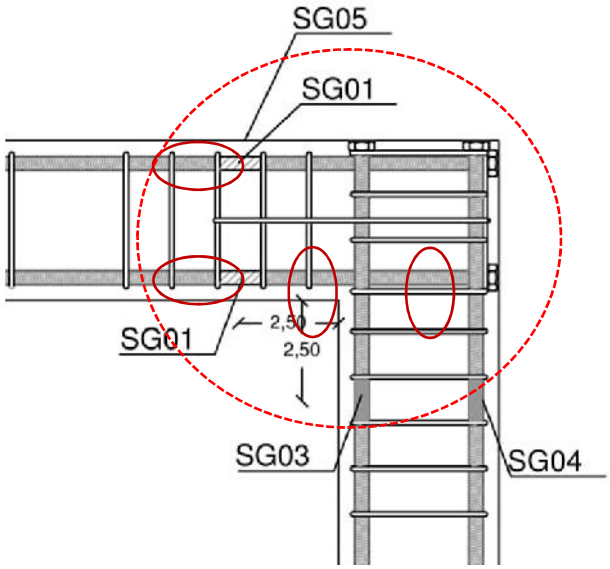
Permanent control, also after built the foundations and the retaing walls, of the water table under the raft and behind the bulkhead. The monitoring system will give information also on the seasonal excursion of the water level, and on the occasional leakage from the pipelines, as well as on the situation during possible flooding.

Permanent monitoring
at critical points of the structure, in order to give a continuous information of the stress level due to the acting loads and of the behavior of the structure to the external events.



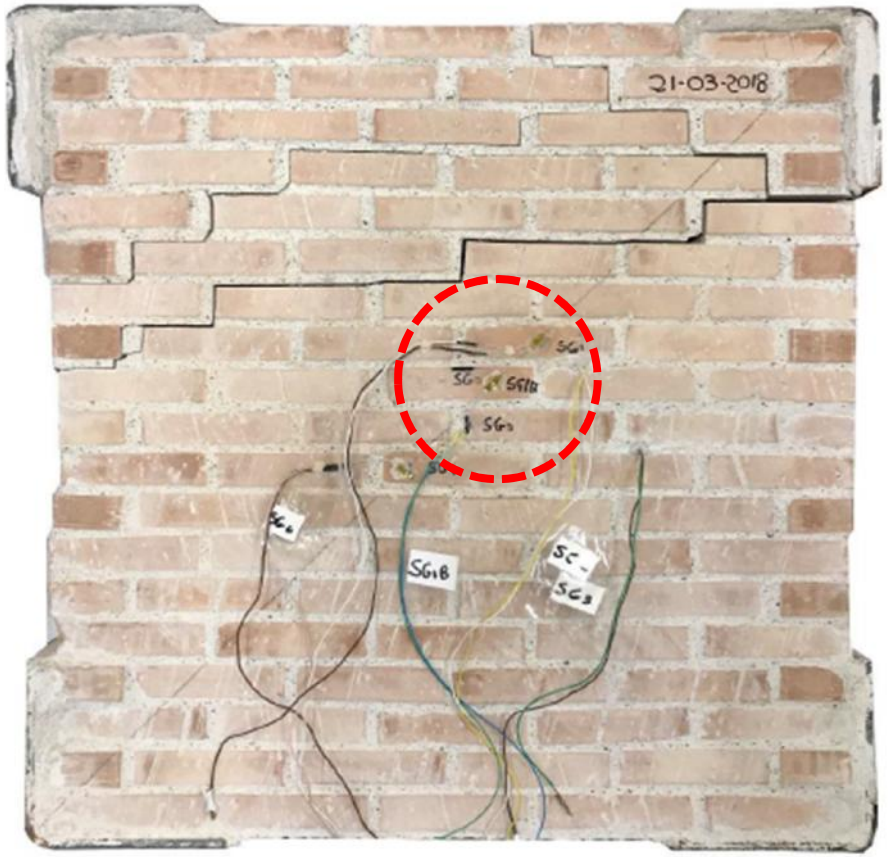
PERMANENT MONITORING

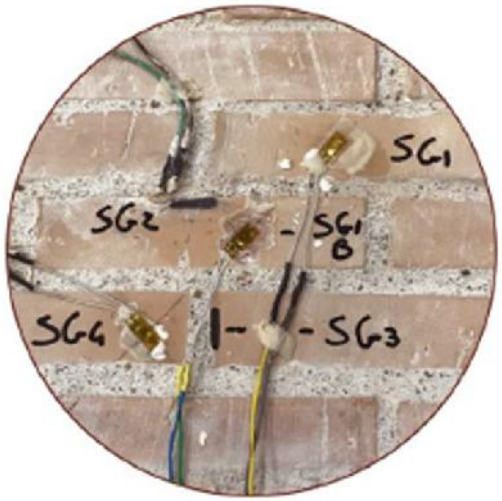




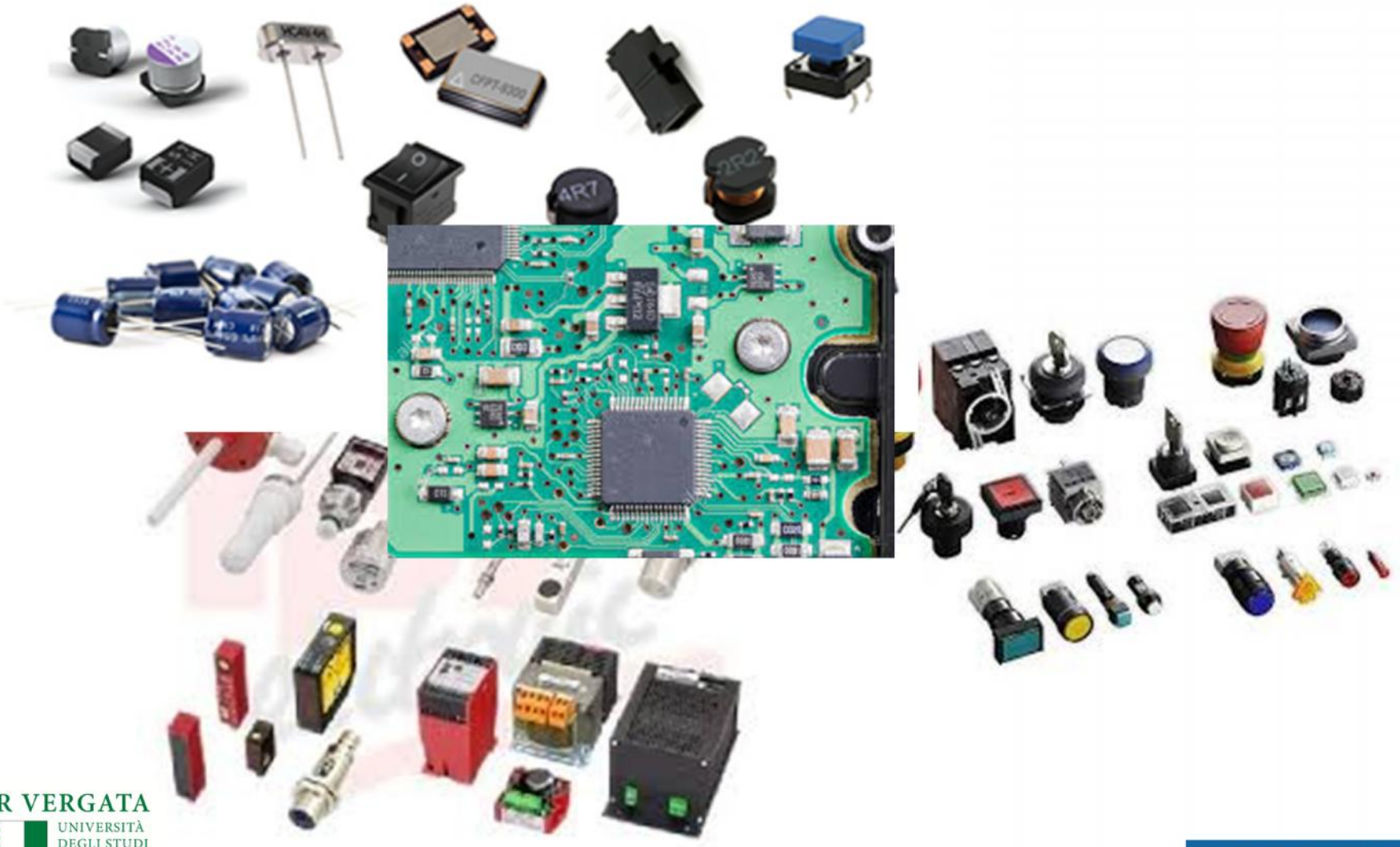
I o T - *Internet of (every)Thing*

Protecting and monitoring also Cultural-Heritage Monuments



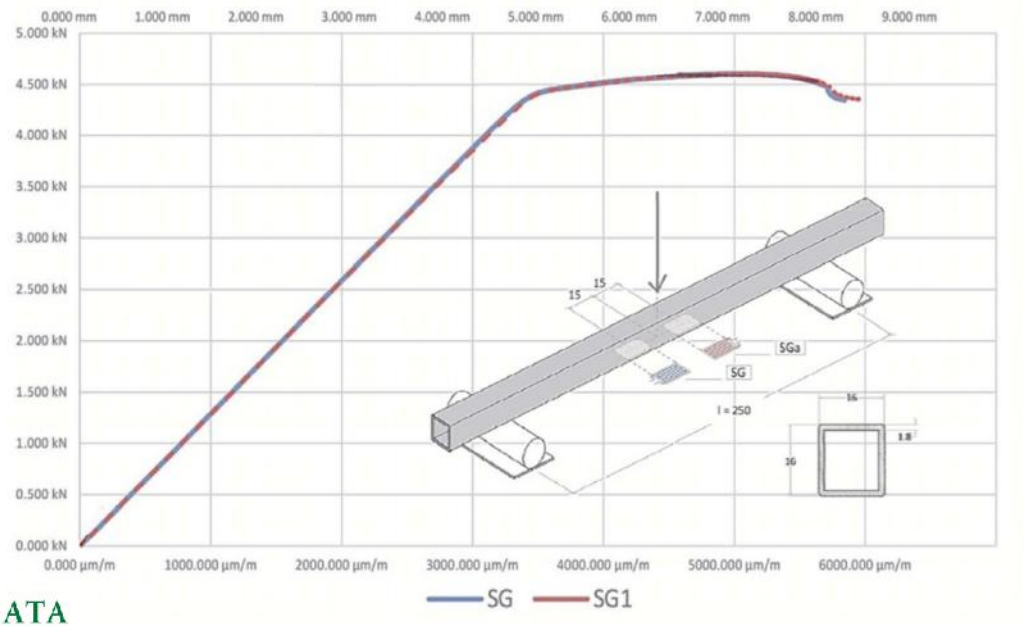


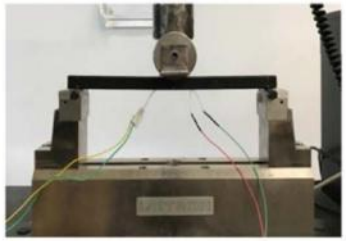
Electronic miniaturized components, available and cheap ($$)

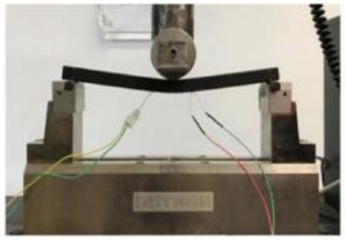


Validation of the proposed approach

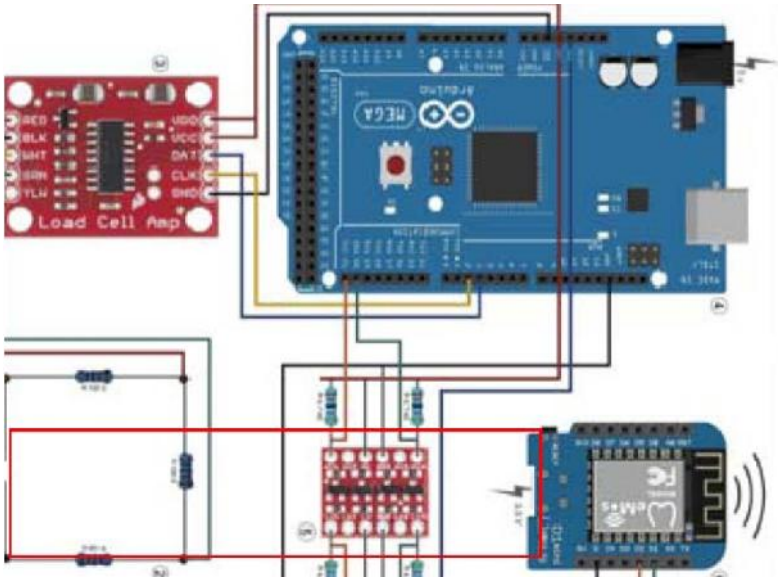
Comparison between traditional laboratory equipment and compact low-cost device designed by the authors

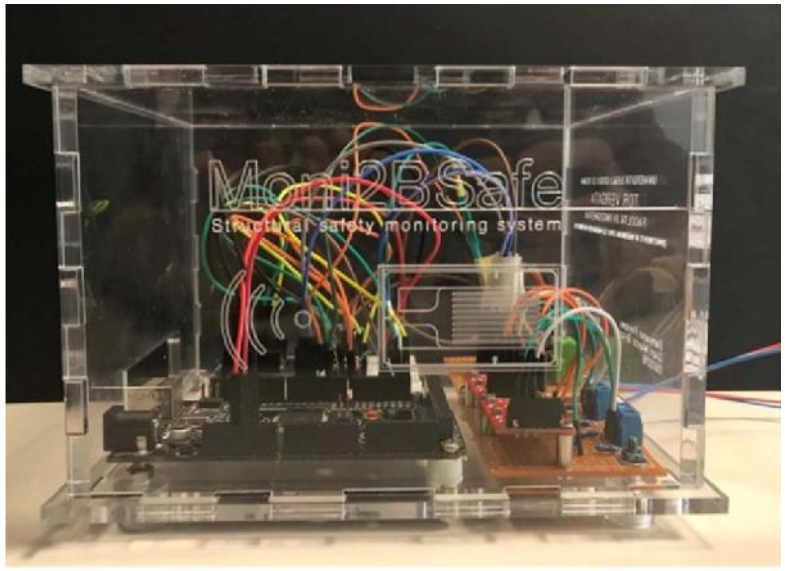


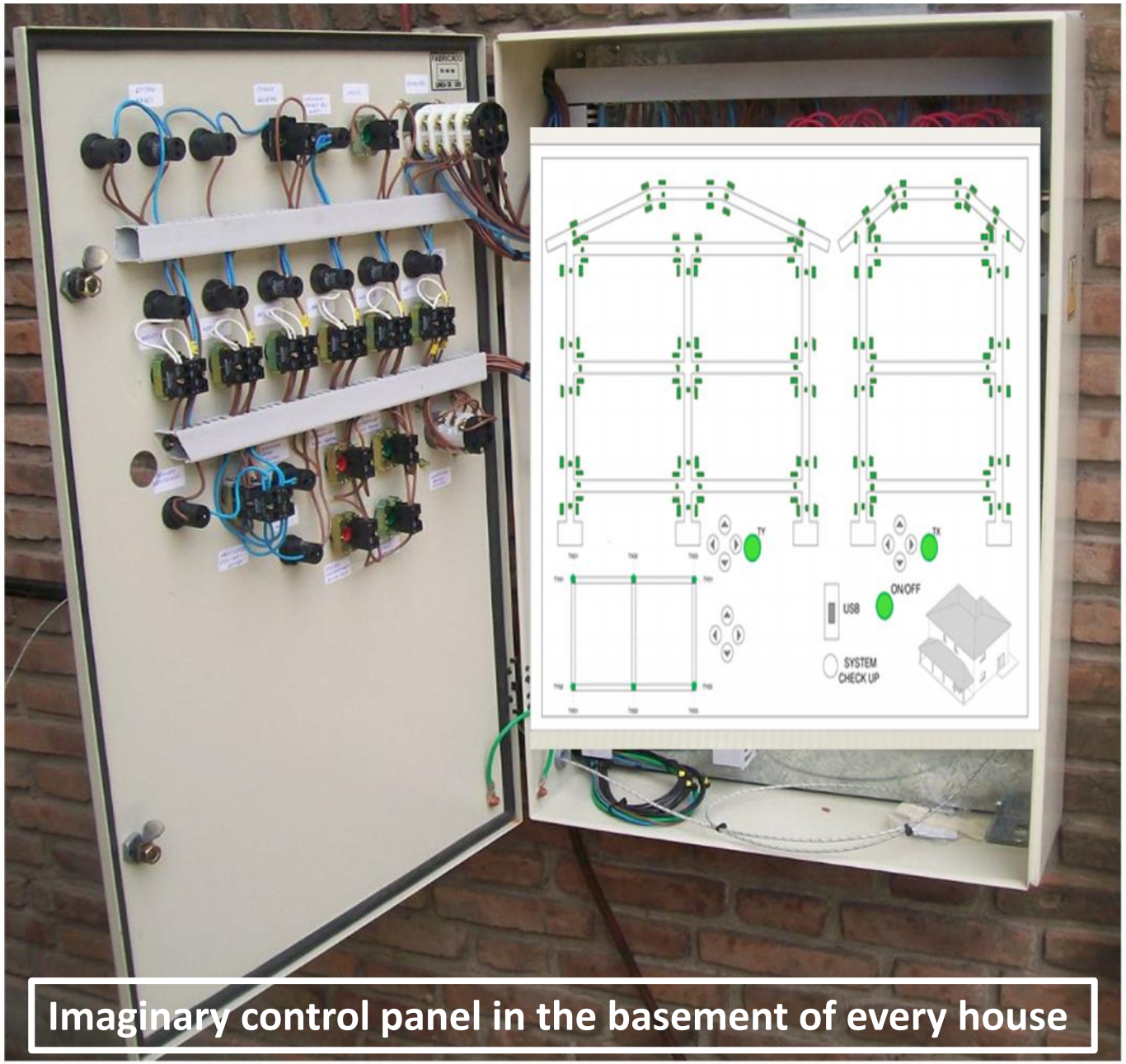




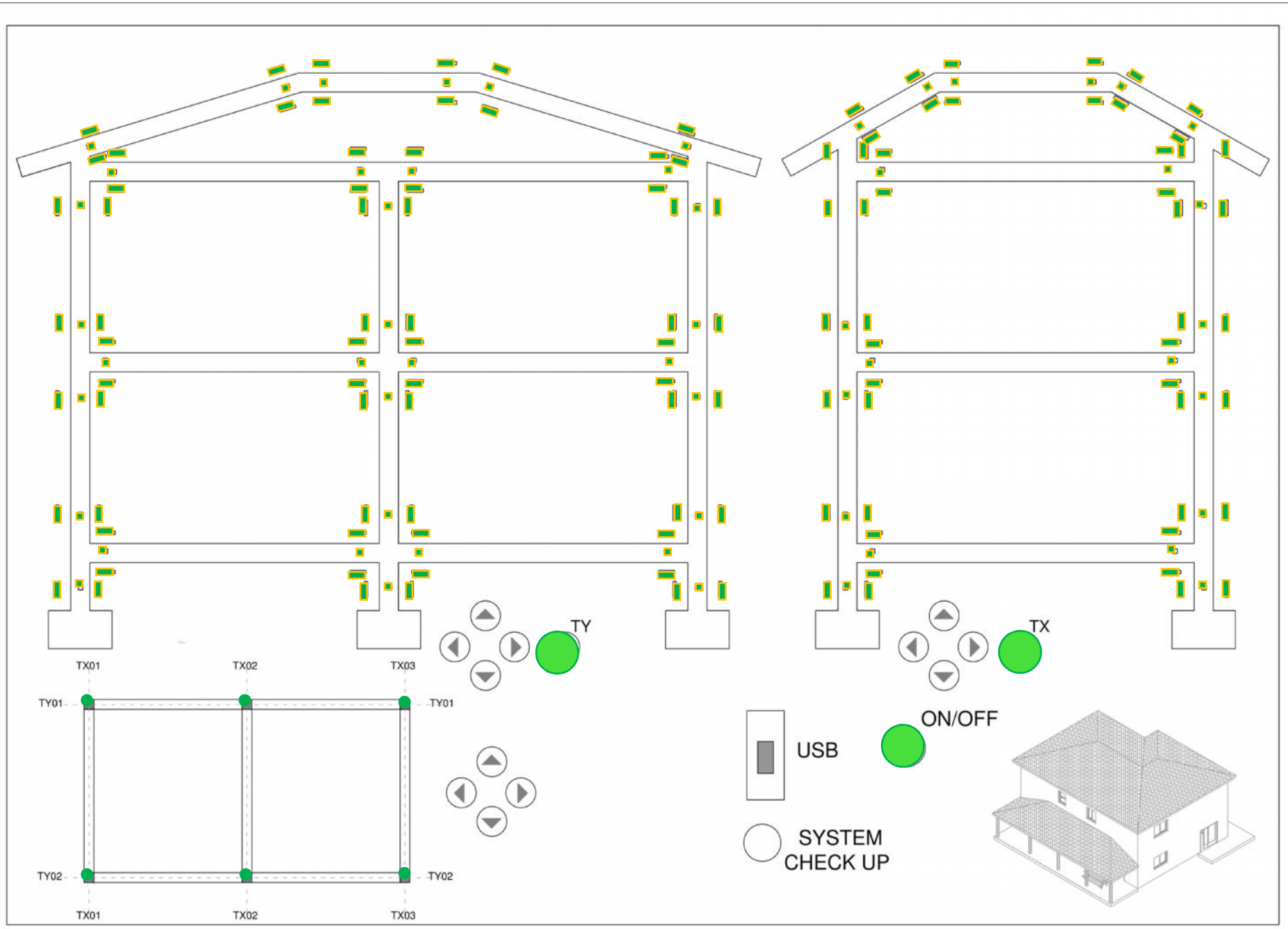
Typical device developed within this project







Imaginary control panel in the basement of every house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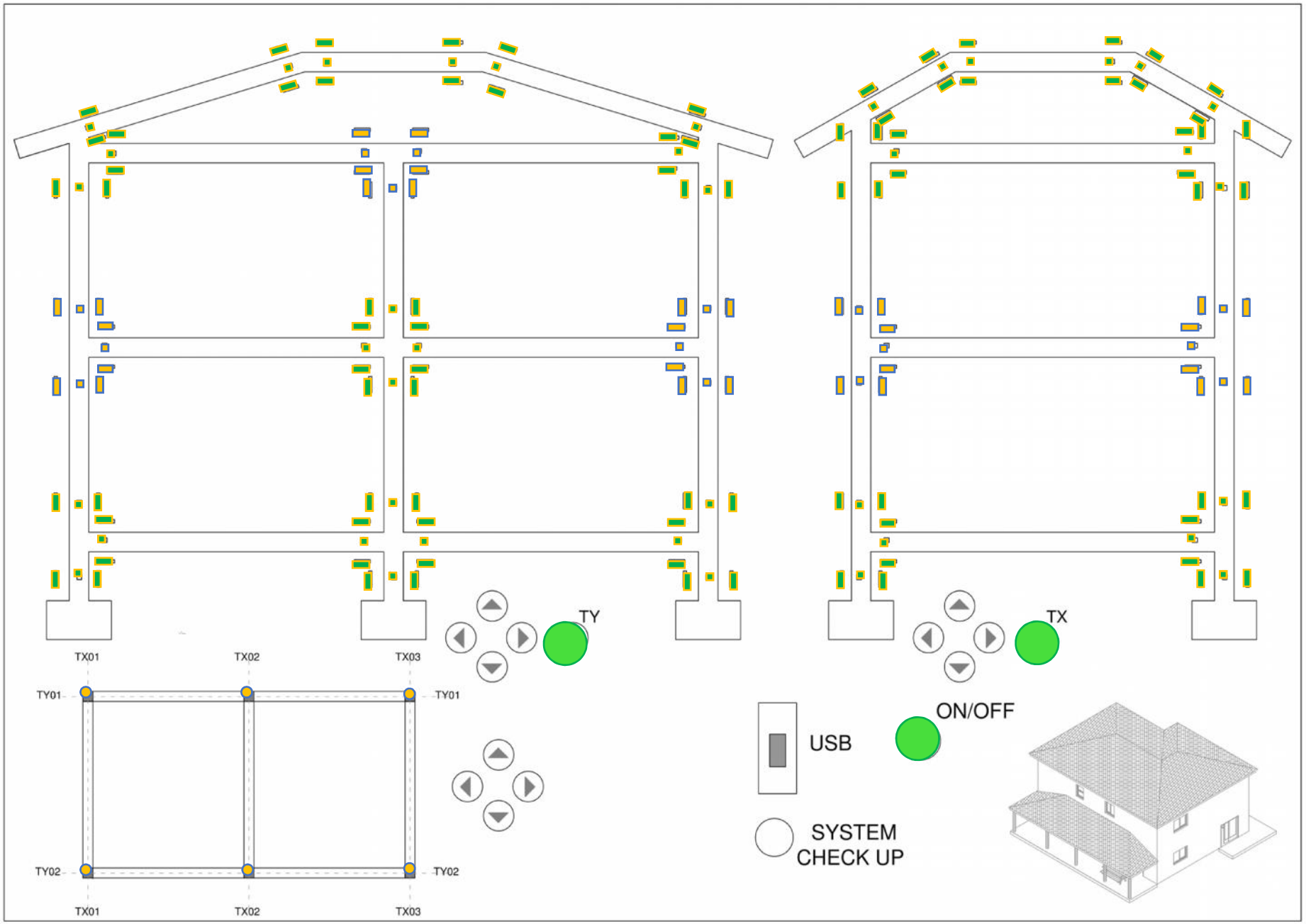
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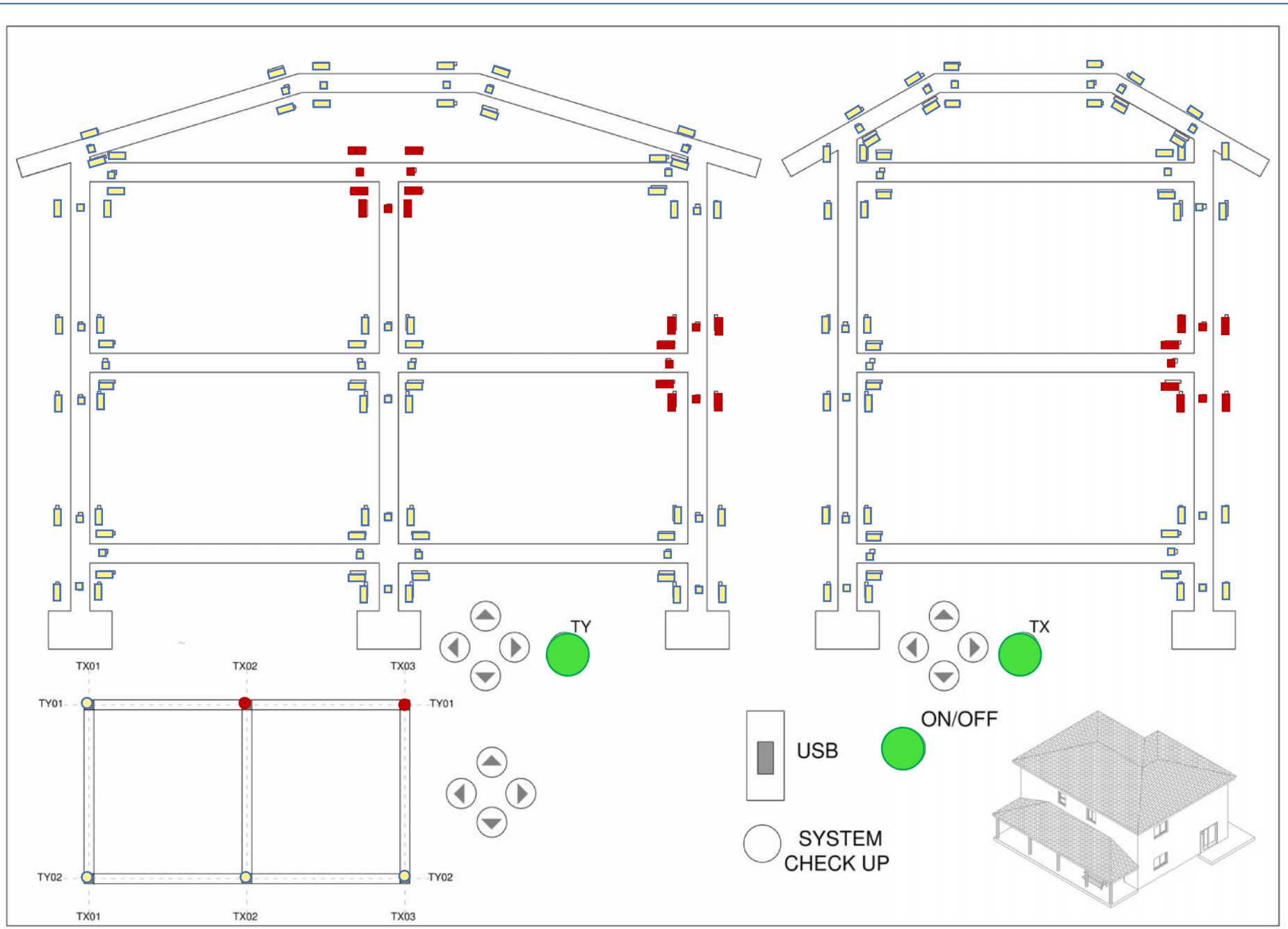
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SMART BUILDING -> SAFE BUILDING

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Conclusions

- IoT is rapidly developing in civil engineering structures, with capillary diffusion

- Despite of the promising advantages due to miniaturization and low cost, it is necessary to invest in research aimed at validating these new devices for quality, accuracy, and durability

- Our research is pointing in this direction as proved by a few devices already realized and successfully tested

Summary

GOAL

A structural safety monitoring system, other than detecting the presence of structural damage, and thus assessing the serviceability of the building after ordinary or exceptional events, it can provide objective data on the vulnerability, or even just on its current conditions, by evaluating the *stress state*, the *dynamic response*, and the *integrity of structural materials.*

THE SYSTEM

The monitoring system is realized during building erection by installing a number of sensing devices (sensors), which are suitable to measure the physical quantities of interest, in order to estimate the current state of materials and, consequently, the actual strength of structural members, with the aim of assessing the overall safety of the building.

The operating monitoring system is integrated in the structure since the beginning of its life cycle, with sensors installed in the most important locations, and data-collection devices able to transfer remotely the values measured inside structural elements.

Each data-collection device, appearing as a small box placed on a beam or a pillar, is connected to a subset of sensors, those placed at the closest reference locations, and it is connected by a local network to the main data-processing unit.

The system can be considered as an Internet of Things (IoT) applied to building structures

Comments

- The large quantity of collected data every day, month, year, in long term will result in an extraordinary archive, a source of information in order to check the behavior of the structure continuously, including specific events, earthquake, vibrations, overload…

- By assessing the behavior of the structure it possible to analyze, offline, the life-long evolution and changes of the structure, in order to evaluate and understand in detail cyclic events, and provide earlier countermeasure in degenerative situations.

ADVANTAGES

- Great control on whole structure, by using tailored, specific and smart software;
- Optimization of the maintenance activity
- Increased safety level
- Alarm signal or alert at the critical state, as well as standard condition
- Negligible installation and maintenance cost for the monitoring system, encouraging large diffusion of the system

An approximate evaluation of the cost for this kind of monitoring system range between 1-2 % of the total cost of the building, but involves more important economic gain, considering the non-stop activity and the more effective maintenance.