

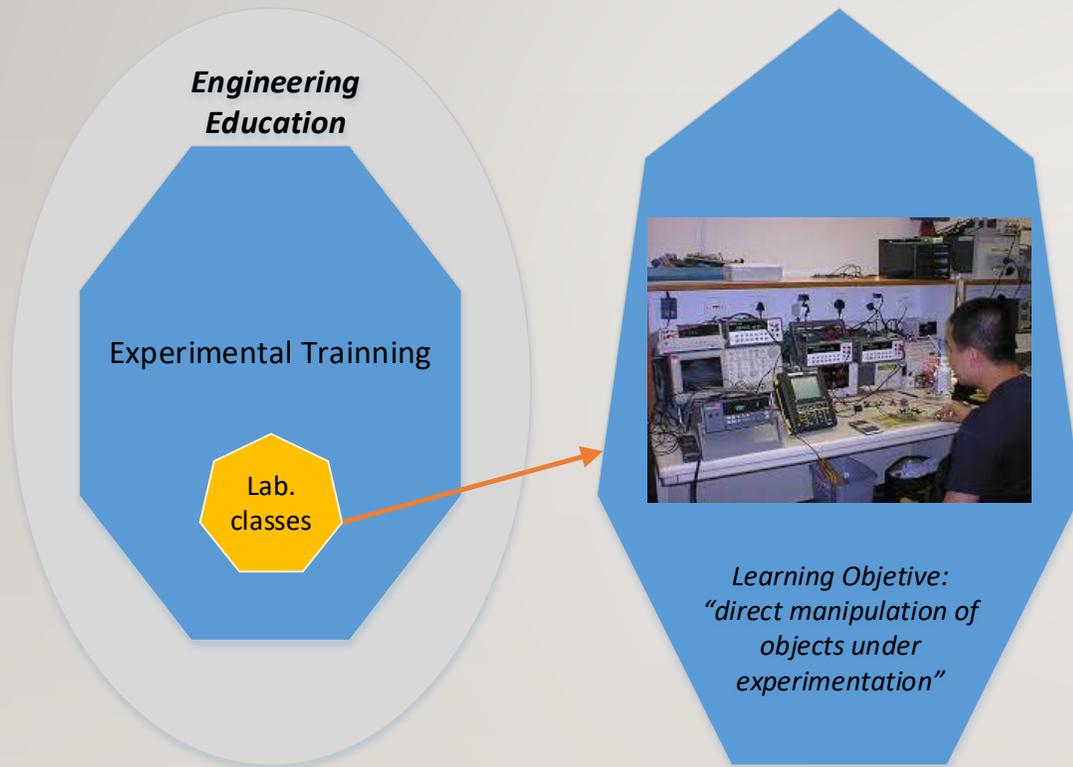
A SUSTAINABLE APPROACH TO LABORATORY EXPERIMENTATION

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INTRODUCTION



"A sustainable system is one that consumes the resources strictly necessary to obtain the desired effect"

But... Traditionally these type of labs consumes a **LOT OF RESOURCES !** (waste of components, lack of versatility, operational expenses- requires a lot of facilities, etc.-)

In many situations they can be *classified as a week sustainable solution !*

Solution: *Remote labs !*

LAB EXPERIMENTS WITH ELECTRONIC CIRCUITS

- In engineering students must acquire technical skills !
- The traditional Hands-On lab is a common solution but.... despite the equipment is traditionally protected against misuse, components can be often destroyed, by exceeding the maximum limits stated by the manufacturers, which can lead to a waste of components, and therefore a decrease on the sustainability essence !
- The use of remote labs can be considered as a sustainable solution able to provide the technical skills for engineering students.
- Remote labs completely satisfy 3 learning objectives of the experimental work:
 - Experiment. “Devise an experimental approach, specify appropriate equipment and procedures, implement these procedures, and interpret the resulting data to characterize an engineering material, component, or system.”
 - Learn from Failure. “Identify unsuccessful outcomes due to faulty equipment, parts, code, construction, process, or design, and then re-engineer effective solutions”
 - Creativity. “Demonstrate appropriate levels of independent thought, creativity, and capability in real-world problem solving.”

TRADITIONAL LABORATORIES (HANDS-ON LABS)

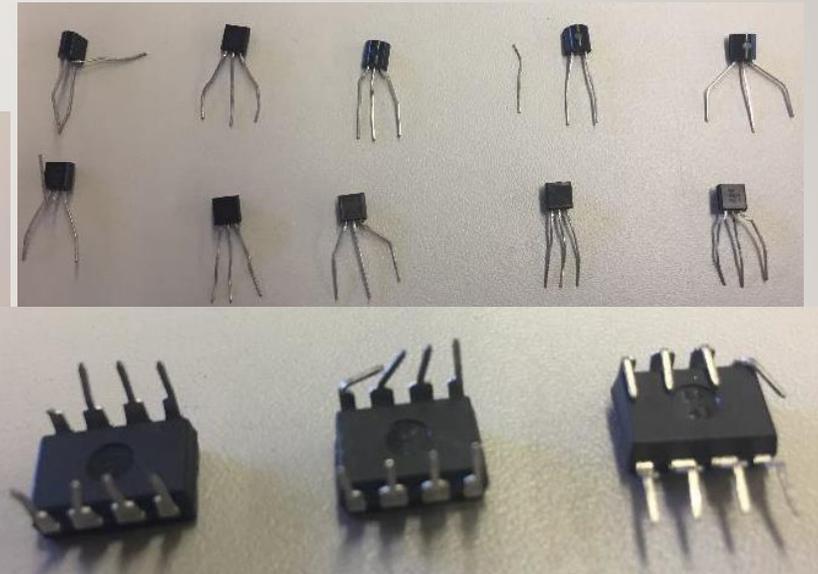
- Students implement the circuit on a breadboard but they traditionally have little experience, and tend to confuse components, which may lead to their damage !
- Can be implemented some solutions to decrease that waste, but....



Organizing the lab classes

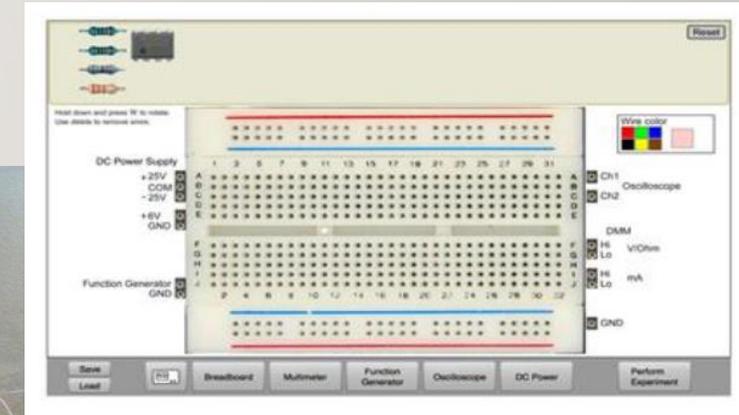
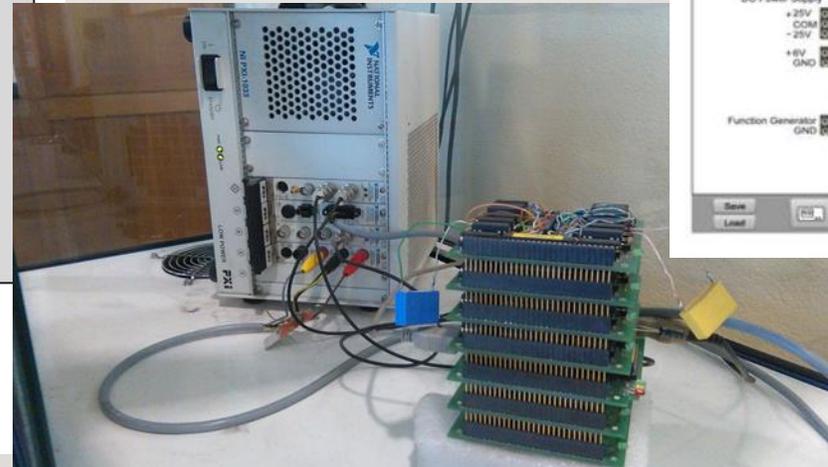
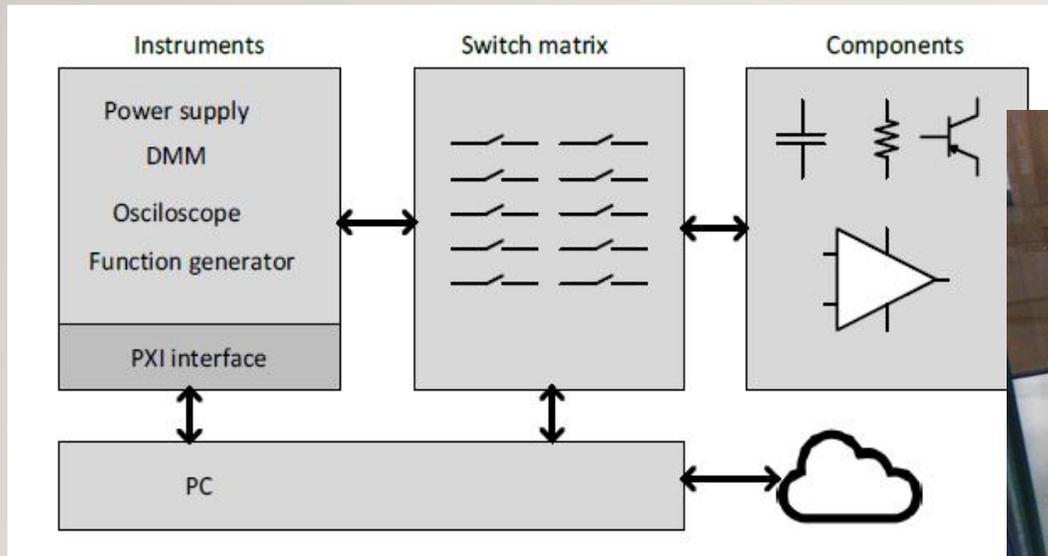


Damaged components (waste ! – low sustainability !)



THE VISIR REMOTE LAB

- Remote Laboratory for electrical and electronic experiments.
- The best and most well-known remote laboratory, with over than 100 technical and scientific publications !
- Initially developed in Karlskrona - Sweden and is currently installed in Bilbao and Madrid (Spain), Porto (Portugal), Villach and Vienna (Austria); Madras (India), Batumi (Georgia), Settat (Morocco), Rosario and Santiago del Estero (Argentina), Araranguá, Florianópolis and Rio de Janeiro (Brazil) and San José (Costa Rica).



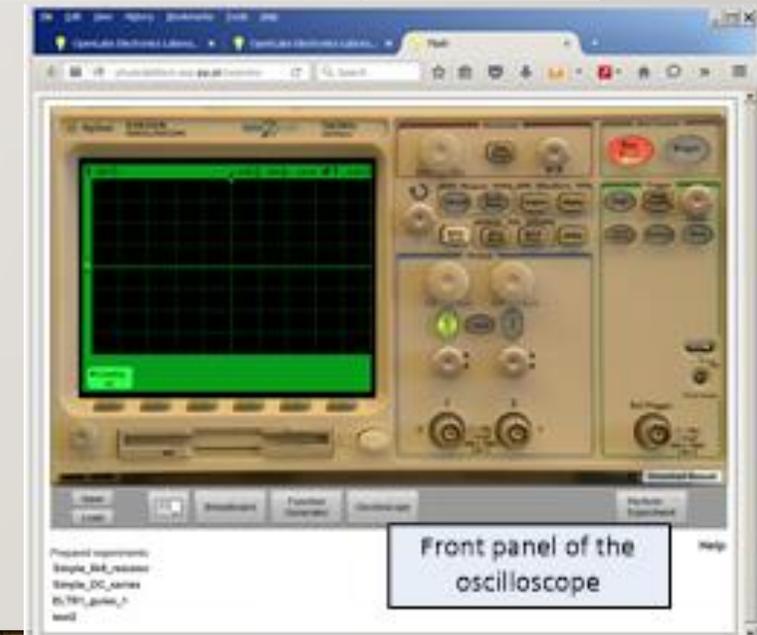
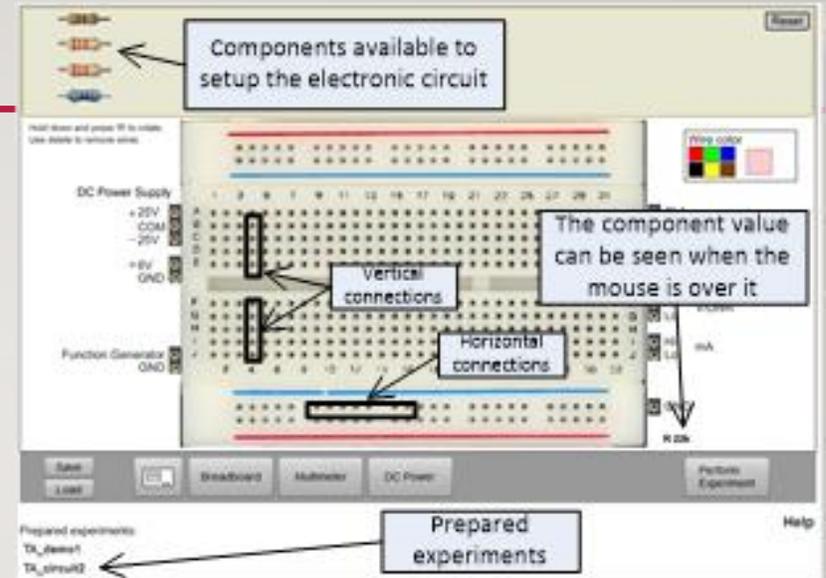
The VISIR interface used by students to setup electronic circuits.

The VISIR block diagram and the implemented system.

THE VISIR REMOTE LAB

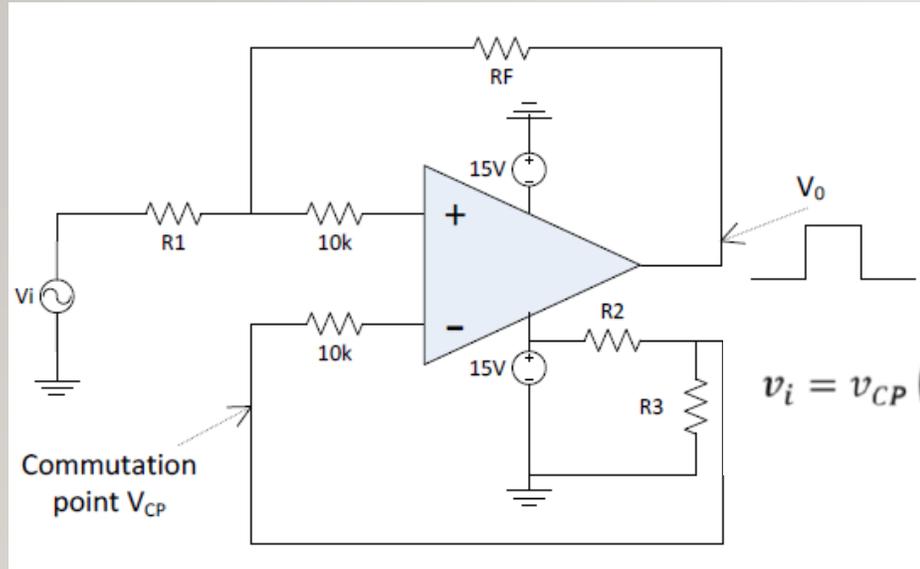
- With VISIR students perform experiments in the same way as they do in a traditional hands-on laboratory:
 - The student places the components on the breadboard and connect them to the power supply and / or to other equipment, and presses the "Run Experiment" button;
 - Remotely the VISIR configures the switch matrix to execute the entire circuit structure, configures the equipment, makes the measurements and sends the results back to the student.
- With a remote lab such as VISIR....
 - Students do not have the opportunity of damaging the components as they traditionally do in a hands-on lab.
 - Components have a very long lifetime duration.

A Typical Schmitt Trigger electronic experiment was prepared in the VISIR for a course named Applied Electronics (ELEAPL) held at the Polytechnic of Porto – School of Eng.



CASE STUDY

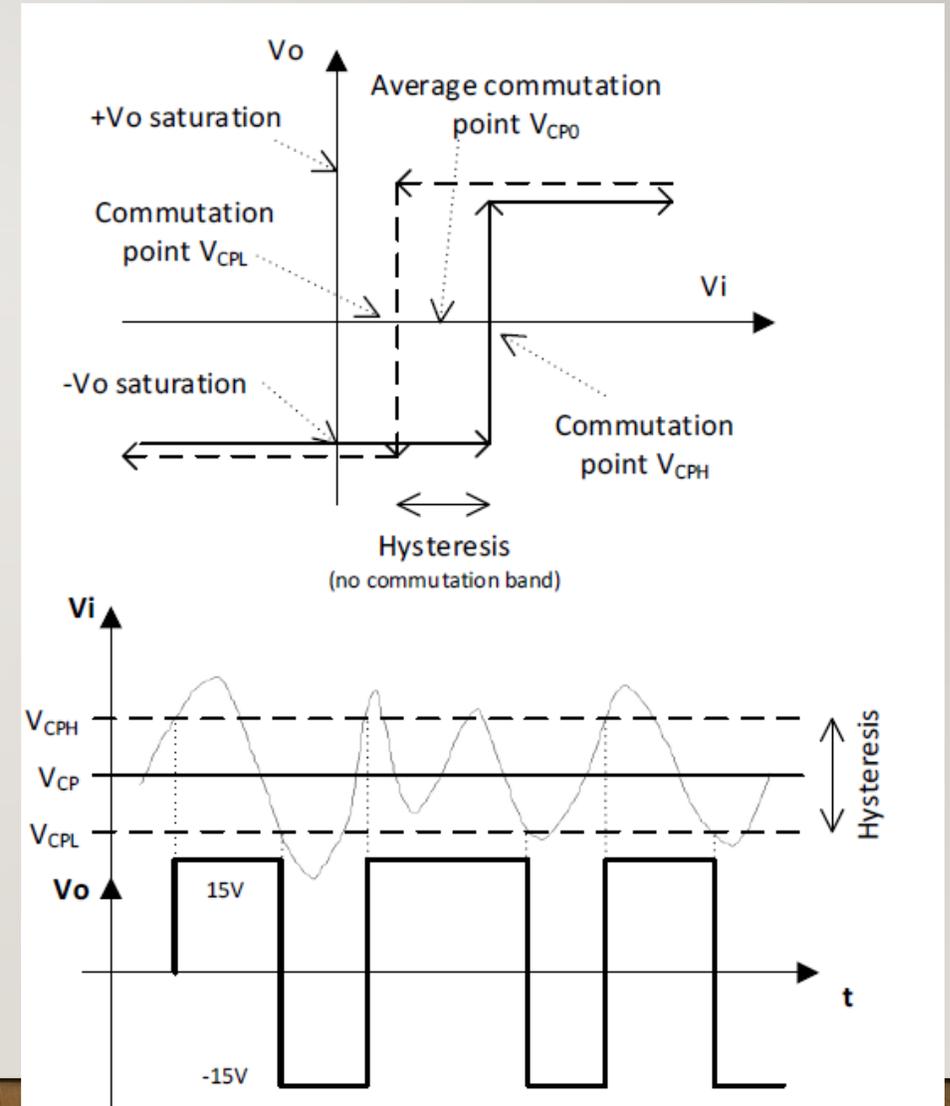
- The Schmitt Trigger experimente.



$$v_i = v_{CP} \left(\frac{R_F + R_1}{R_F} \right) - \frac{R_1}{R_F} v_o$$

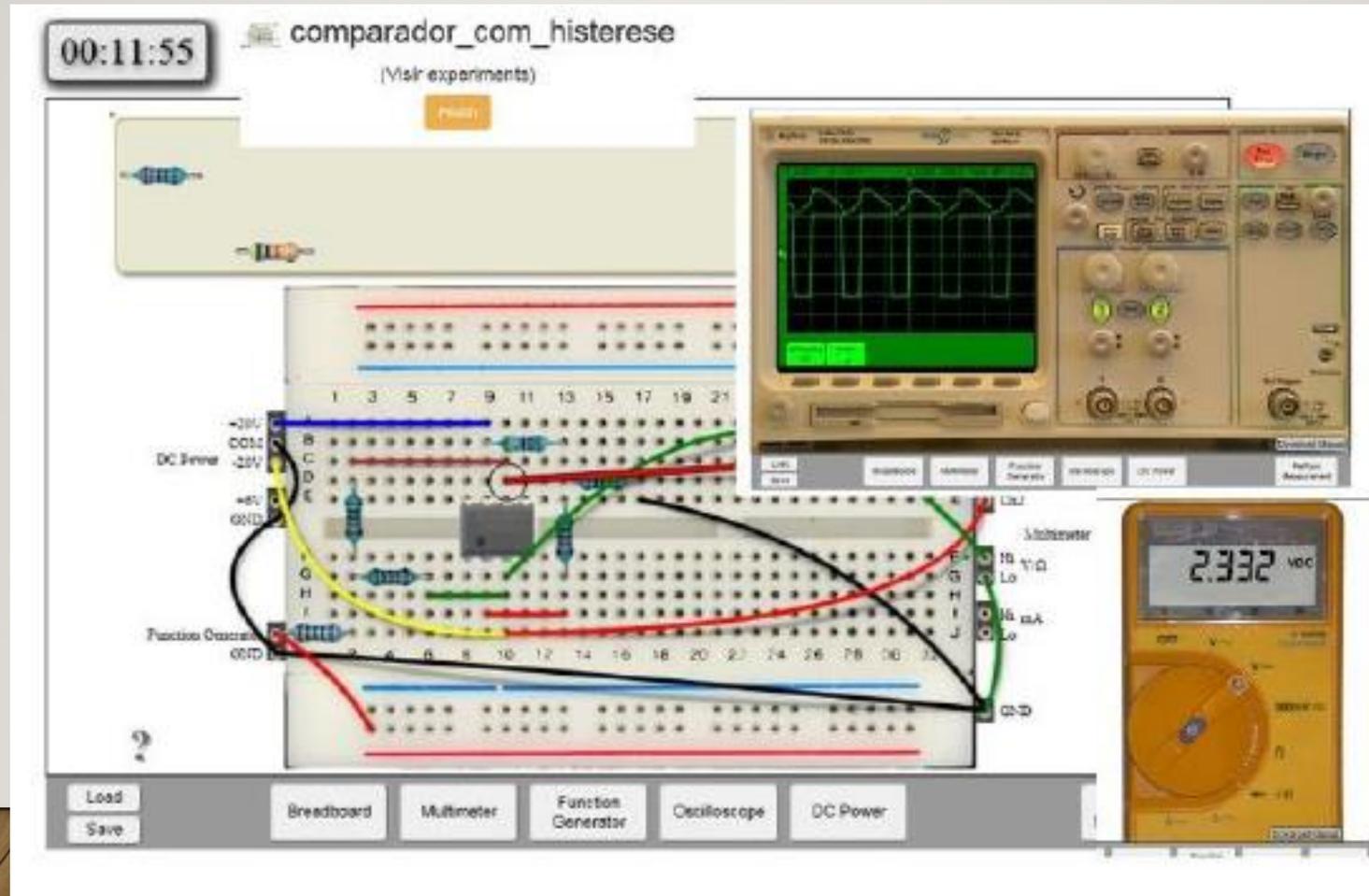
$$v_i > v_{CP} \left(\frac{R_F + R_1}{R_F} \right) - \frac{R_1}{R_F} (-15) \rightarrow v_{CPH} = v_i$$

$$v_i < v_{CP} \left(\frac{R_F + R_1}{R_F} \right) - \frac{R_1}{R_F} (+15) \rightarrow v_{CPL} = v_i$$



THE GUIDE PROVIDED TO STUDENTS

- During the classes of ELEAPL (Applied Electronics Course) students follow a guide where they were invited to setup the circuit using the PSpice software and the VISIR.



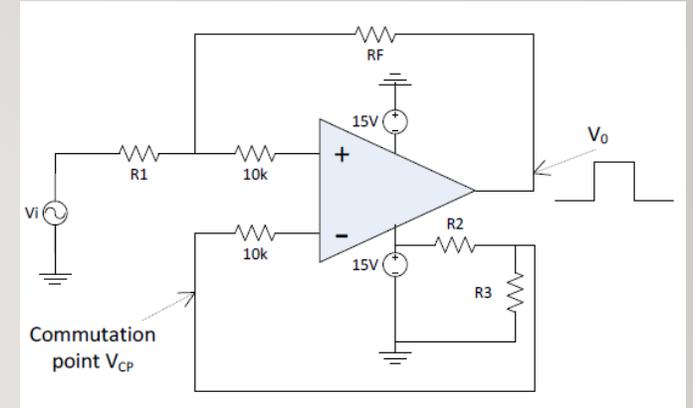
COSTS ANALYSIS

- Comparing the use a traditional hands-on lab and the VISIR for the Case study

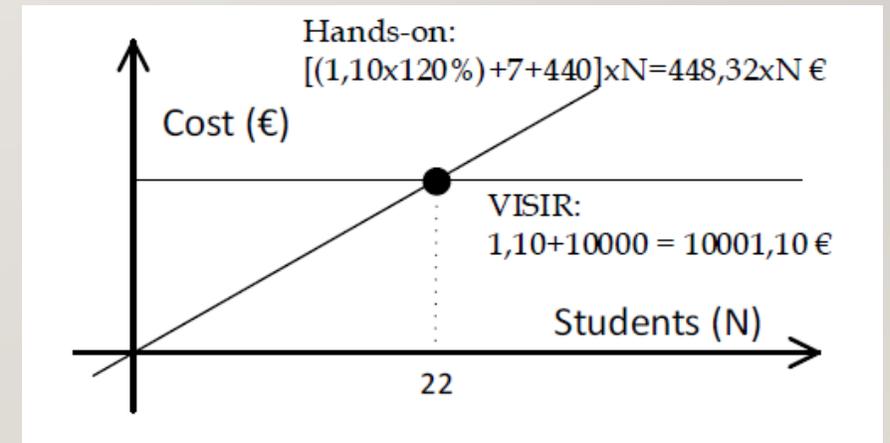
	Quantity	Unit price (€)	Total (€)
Resistors	6	0,10	0,60
AmpOp	1	0,50	0,50
Bread Board	1	7,0	7,0
Function Generator	1	100,00	100,00
Oscilloscope	1	240,00	240,00
Power source	1	50,00	50,00
MultiMeter	1	50,00	50,00
Total (without component waste)			448,10

Associated cost for setting up the Schmitt Trigger experiment.

Indicative graph of costs associated to the Schmitt Trigger experiment: hands-on lab vs VISIR remote lab.



Considering 20% of component waste per experiment;
Considering the VISIR cost of about (10000 €)



CONCLUSION

- The experimental work is fundamental for every engineering course.
- Hands-on Labs are usually associated to a huge waste of components !
- Remote labs can overcome those waste of components and they typically provide more flexibility in the students'/teachers' access to a remote experiment !
- VISIR is a very well known remote lab able to complement and, in some situations, replace the traditional hands-on labs.
- The case study demonstrate that using a remote lab can be interesting for a cost reduction and, therefore, as a sustainable solution in engineering education !specially when the number of students are high.