Project II

(Academic Year 2022/2023)

Project Title:

SMART METERING SWITCH FOR HOME AUTOMATION

Supervisor(s) Name(s) and Department affiliation

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Project definition

Context: Energy efficiency is crucial in today's society. The worldwide struggle for decarbonization and the recent climb in energy prices have led to a continuous search for effective ways to reduce energy consumption.
One of the most effective ways to reduce domestic energy costs is to identify the primary sources of consumption and use intelligent technologies to optimize their operation. This can be achieved through home automation solutions.
Home automation uses smart devices to monitor and control home devices (such as lighting, heating, appliances, etc.) in an optimized way.

Having the ability to measure the consumption of home devices and turn them on or off remotely or according to specific rules (such as avoiding peak periods, in which energy is more expensive) can provide an important reduction in energy bills. Simple actions, such as automatically shutting down any heating in the morning and automatically turning it on just before people get home, can have an important impact not only on power consumption, but also on comfort.

Objective: Your objective in this project is to develop a smart switch device with metering capabilities for home automation. The developed device can have 2 alternative configurations, from which you can choose (examples in Fig. 1):

1. A power plug or power strip, which must be connectable to a power plug and provide secondary power plug(s) into which loads can be connected.
2. A device that can be installed in the domestic switchboard, with input power terminals and output(s) that can power specific circuit(s) in the switchboard.

Fig. 1 – commercial examples of smart metering power switches (you can use different designs)

The device must be able to measure the voltage and current being supplied to the load(s) or circuit(s) connected to it and calculate the supplied power in real time. The device must also be able to switch its output(s) on and off. The device must be connected to the internet and the user must be able to control it and view its current state and measurements remotely. The system should be designed to be as cheap, safe and versatile as possible.

To successfully complete this project, you need to complete the following main tasks:

1. Select/design the current and voltage measurement circuits and signal conditioning to enable reading the signal with a microcontroller.
2. Select a circuit for switching the output circuit(s) on/off, using relay(s) or analogous device(s).
3. Use a microcontroller of your choosing to acquire the voltage and current signals and control the switching circuit.
4. Assemble and test a working prototype of the smart switch.
5. Connect the device to the internet, allowing the user to monitor the voltage, current, power and state of the device (on/off) remotely in real-time. The user must also be able to turn the device on/off remotely.

Requirements (list of requirements by classes: Mandatory/additional)

Mandatory requirements:

1. The device must be able to read the voltage and current of at least 1 circuit and calculate their RMS values and the active power (with an acceptable refresh rate).
2. The device must be able to safely switch at least 1 circuit on/off (230V).
3. The device must include an indicator of its current state (on/off) and a switch/button to locally alter it.
4. The device must be accessible through the internet. You can use whatever technology you prefer (wifi/ethernet connection, Bluetooth or zigbee connected to a hub, etc..). To make the device accessible online, you can develop your own web interface, use a freely available cloud service or use an open-source home automation platform, for example.
5. The user must be able to see the voltage, current and power readings and the state of the device (on/off) remotely in real-time, as well as turn the device on/off (using an internet connected PC or mobile phone).

Optional requirements:

Optionally, your project can be improved with one or more of the following features:

- Ability to turn the device on/off at specific times or if a maximum current or power level is exceeded (these predefined levels must be defined through the remote interface).
- Displaying the evolution of the voltage, current and power over time (time plot) in the remote interface.
- Displaying the voltage and current waveforms in addition to their RMS value.
- Safety mechanisms, such as temperature monitoring.
- Design and fabrication of custom printed circuit boards (PCBs) to optimize the cost, size and form of the device.

- Calculation of power quality parameters, such as power factor and THD.
- Ability to measure/control more than 1 circuit (by creating a multi-output device, or several single-output devices that can be controlled from the same platform).
- Development of a smart algorithm combining several monitored/controlled circuits, to avoid exceeding a predefined maximum overall power (in all channels). If this power level is exceeded, one of the active channels is turned off to keep the power within acceptable levels. You can optimize this algorithm to select which channel to turn off first according to different criteria.
- Any other optimization or feature the team considers useful.

Deliverables (list of expected deliverables for successful completion of the proposal)

Technical reports:

The engineering team must deliver the following technical elements:

D1.Action – Project proposal (should include the strategy for achieving the objectives and a plan of action with a timeline).
D2.MTR – Mid-term technical report about the design and the implementation.
D3.BR – Midterm budget report.
D4.DEMO – Demonstration of the working prototype (hardware and software).
D5.FTR – Final technical report of the protype.
D6.FBR – Final budget report for the protype.
D7.CPTR – Report on analysis and optimization of the Cost/Performance relation.

Dissemination material:

The engineering team must produce the following dissemination material:

D8.WEB – Webpage with the project and team information.
D9.OP – Presentation for oral communication (15 min) of the full developed protype system.
D10.VIDEO – One-minute video showing the full developed protype in operation and demonstrating the achievement of different requirements.
D11.TM – Technical manual.