SMART ELECTRIC BLINDS

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ABSTRACT

Over 40% of primary energy is used for building applications and purposes. Control of electric blinds according to energy criteria can easily provide significant energy savings, particularly for well-oriented buildings.

A smart system for managing electric window blinds based on solar radiation and room occupancy is proposed. It regulates the incoming light and heat to realize energy savings by using electronic sensors. The system is low cost, modular, stand alone and easy to use (plug and play). This flexible wireless solution applies to both houses of excellent quality in terms of thermal protection and old buildings with poor thermal insulation.

The low cost system is composed of several wireless battery-powered electronic modules communicating through radio frequency (ISM 2.4 GHz, maximum transmission range of 100 meters). The system is optimized to reduce the electrical consumption of the electronic modules, so that the batteries need to be replaced only once a year.

The proposed solution is used throughout the year, in winter as well as in summer. In cold sunny weather, open electric blinds during the day and closed blinds at night can exploit each room as a solar energy storing system. In warm seasons, the reverse operation improves the thermal comfort of the residents by trying to reduce the air conditioning costs.

In addition to this, users can customize the settings according to their needs and wishes through the user interface.

The electric blinds of each room are controlled independently as each room has its own solar gain, attendance and orientation. The electric blind control system has several important benefits such as comfort optimization, adjustment according to room occupancy, independent control of each room (self-determining system), use and anticipation of solar gain and, as a result, the saving of energy!

Different tests and experiments have confirmed that energy requirements can be reduced up to 25% for well-oriented buildings.

INTRODUCTION

A smart system to manage electric blinds based on solar radiation and room occupancy is an efficient energy saver all year round.

In winter, intelligent blinds remain open to let free solar energy into the building during the day, thus reducing energy requirements for heating. Once the sun has set, the blinds are closed, reducing heat loss and continuing to save on the energy required for heating.

In summer, closed blinds during the day help keep excessive heat out of the building, which can noticeably cut the need for air conditioning. In the evening, opening the windows and the blinds allows the building to flush any heat build-up, again reducing the need for air conditioning.

If automated and controlled correctly, smart blinds can reduce energy requirements by 25%, while increasing the comfort of the residents!

CONCEPT

The proposed system consists of two electronic modules (E_P and E_S), emitting radio frequency signals from the occupancy sensor and the solar sensor. A central module with user interface (LCD + Keyboard) allows the user to customize the settings. Several control algorithms are implemented in this core module. It also handles the coordination between the different RF modules. Finally, the module R acts directly on the electric motor of the blinds upon received RF signals.

The following figures show the position of various electronic modules inside each room and outside of the building.

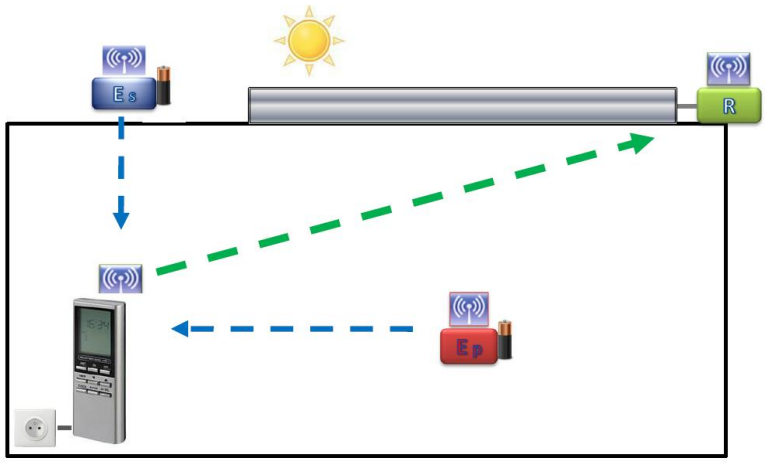

Figure 1: Electronic RF modules inside and outside of the room.

Figure 2: Electronic RF modules outside of the building.

PROTOTYPE

The communication network is a low-cost, low-power wireless embedded solution based on ZigBee communication protocol. The XBee radio frequency module operates within the ISM 2.4 GHz frequency band and an electric current of 40 mA in transmission mode and 10 μA in sleep mode.

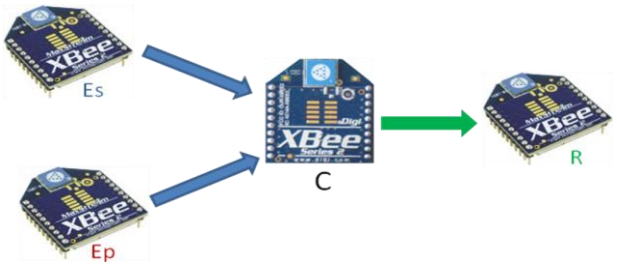

Figure 3: Device connectivity using multipoint wireless networks.

The two transmitter modules (E_p and E_s) installed inside and outside of the building contain a RF module (XBee), a sensor (occupancy or solar) and a battery supply. The receiver module (R) mounted directly on the motor blinds contains a XBee device, electronic relays and a 230 VAC line power. The central module (C) contains a XBee device, a microcontroller with implemented algorithms, a user interface (LCD + Keyboard), a real time clock (RTC), a temperature sensor to display the room temperature and a 230 VAC line power.

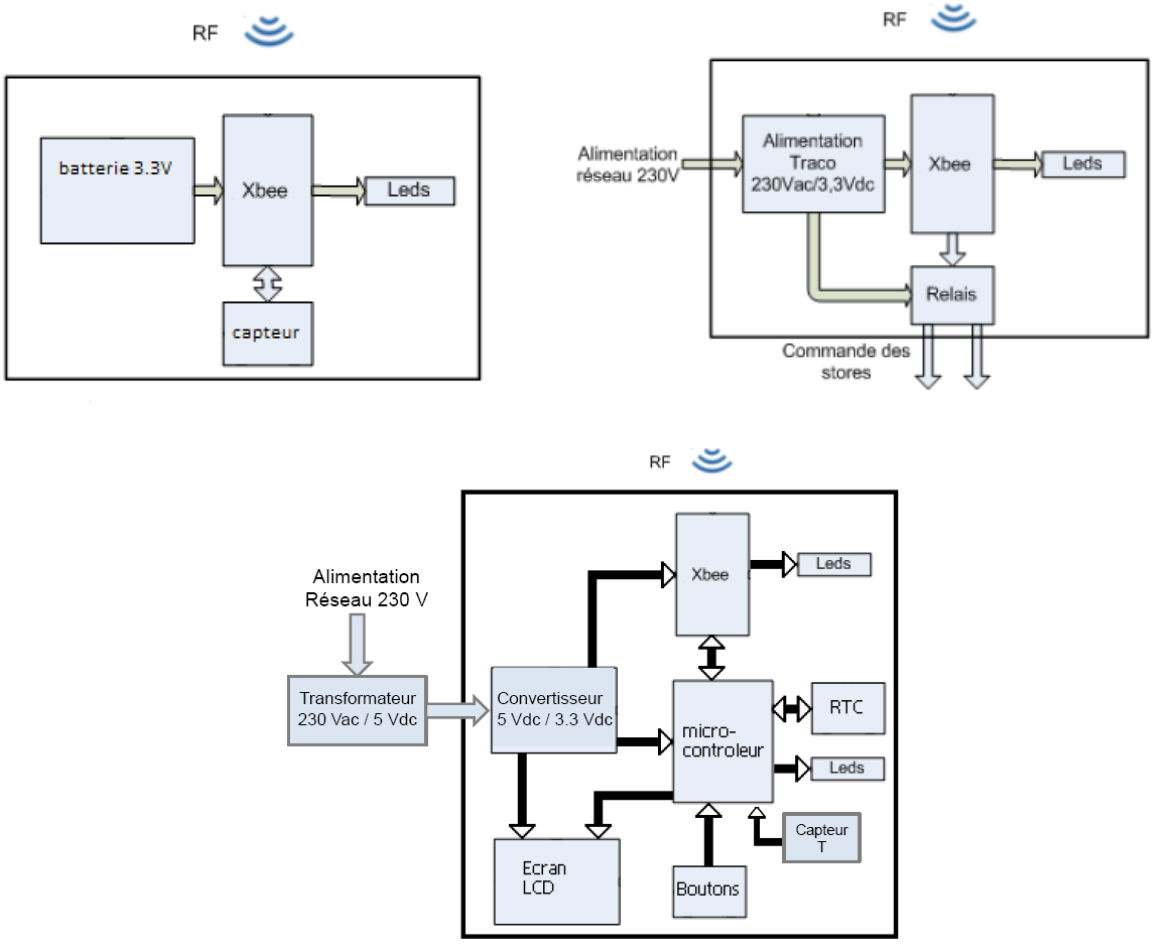

Figure 4: Block diagram of various electronic wireless modules E_p, E_s, R and C.

Figure 5: Stand alone prototype to control electric blinds.

CONTROL ALGORITHMS

Three operating modes are available: **Manual**, **Save Energy** and **Astro**.

In **Manual mode**, the users can manage the blinds as they wish by using different keys (▲,▼, ■). This mode is launched either by the user, with the switch on the central module, or automatically, when a presence is detected in the room.

Save Energy mode regulates the incoming light and heat to realize energy savings by using occupancy and solar sensors. This mode runs automatically when the room is not occupied.

In winter		
IF sunny **AND** room not occupied	→	Save Energy mode > Open electric blinds
IF cloudy **AND** room not occupied	→	Save Energy mode > Close electric blinds
IF room occupied	→	Manual mode
In summer		
IF sunny **AND** room not occupied	→	Save Energy mode > Close electric blinds
IF cloudy **AND** room not occupied	→	Save Energy mode > Open electric blinds
IF room occupied	→	Manual mode

Astro mode manages the electric blinds according to sunrise and sunset times, using for example a local sunrise/sunset calendar. This mode can also be customized according to the user's wishes, e.g. by shifting the calendar.

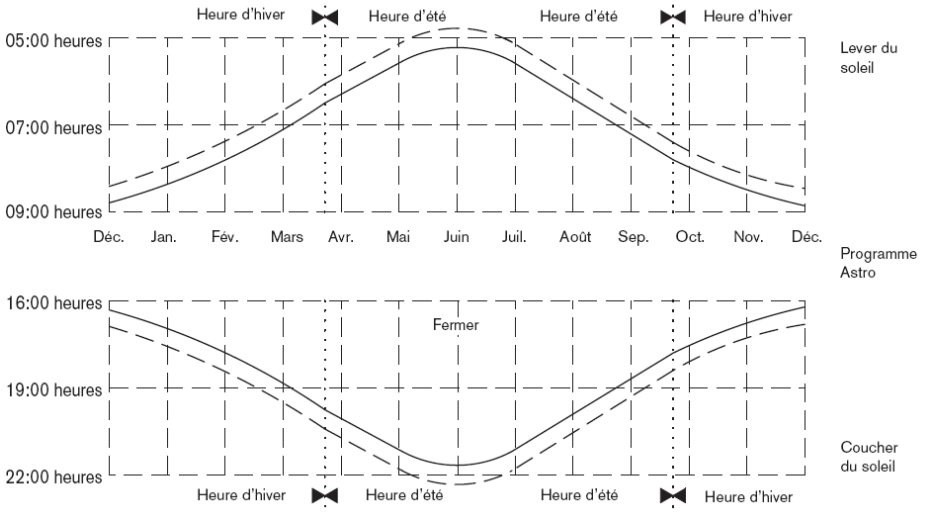

Figure 6: Sunrise/sunset calendar used in 'Astro mode' to manage electric blinds.

RESULTS

Comparative tests were made at the HES-SO Valais in Sion, in two adjacent similar classrooms of almost the same size and orientation. The rooms are interchangeable as the electronic modules can easily be moved from one room to another. Measurements were done using voltage and temperature data-loggers, as well as heat meters on the radiators of the 2 rooms.

The following figure shows how the room with smart stores benefits by storing the winter solar energy all afternoon while the sunlight is sufficient. Consequently, the heating demand is significantly reduced and the thermostatic valves are closed most of the time, as the temperature in the room remains high enough.

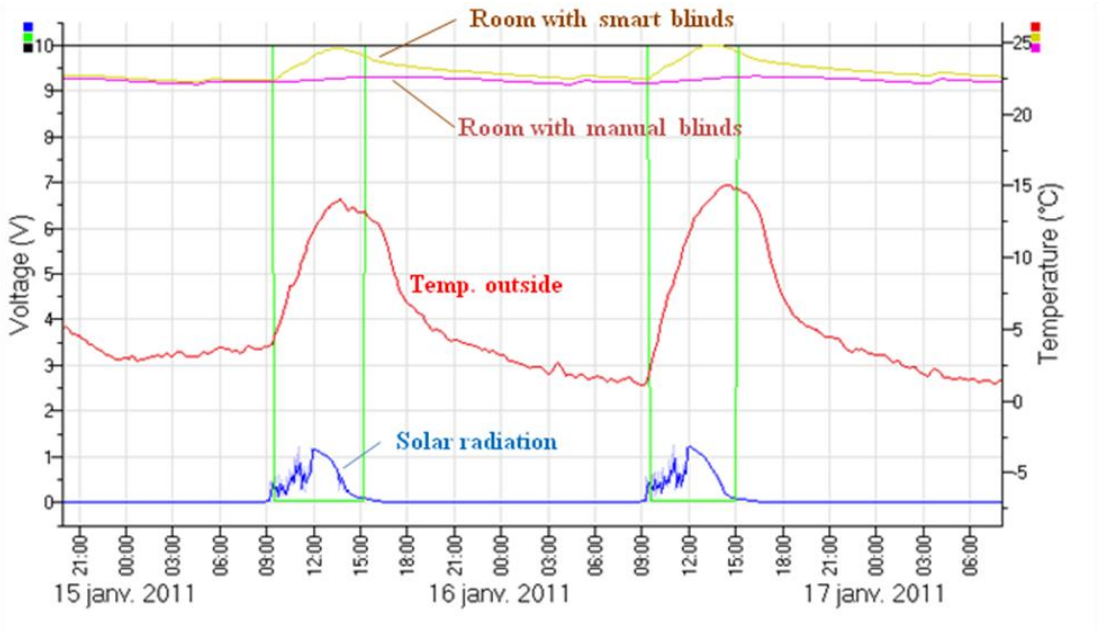

Figure 7: Comparative tests in 2 similar classrooms, during a weekend in January.

In summer, on the contrary, the smart blinds protect the room from unwanted solar gain, by blocking the sun's rays during hot days. Figure 8 shows how a good control of the shading system can improve thermal comfort by reducing overheating and glare.

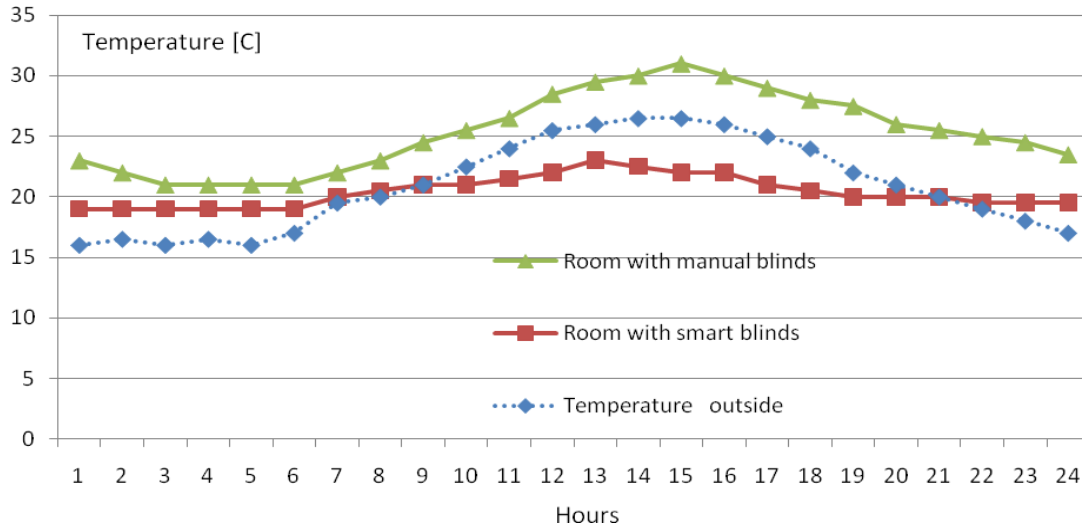

Figure 8: Comparative tests in summer, with the filtering effect of blinds.

CONCLUSION

An intelligent system for managing electric blinds not only helps to prevent overheating and glare, but also allows important energy savings. In summer, when the sun is shining and it's hot outside, blinds are worth their weight in gold. They can reduce solar radiation levels and produce a pleasant room temperature, which reduces the amount of electrical energy used to cool rooms. In winter, an intelligently controlled system brings the solar energy into the room, thereby cutting heating costs.

Comparative tests have shown that during the cold season:

- Energy gains up to 25% can be achieved during sunny days when rooms are less occupied and the **Save Energy mode** runs.
- When rooms are more occupied, a comparison of energy savings is more difficult because of user interference on the blinds. In the best case, during sunny days when the windows are closed and the various modules perform correctly, energy savings up to 15% are observed.

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