International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 12, pp: 201-208 www.ijaem.net ISSN: 2395-5252

Smart Indoor Lighting with Smartphone Assistance

Said Ghalleb[1]
[1]*Technology Teacher in Secondary School, Ministry of Education, Tunisia*

Date of Submission: 14-11-2021 Date of Acceptance: 29-11-2021

ABSTRACT: The brave lighting management can gain energy and money. Monitoring and elimination the needless indoor lighting by human being can do some economies but practically is not that easy to follow and control lighting by human being twenty-four hour per days. The domestic field always wants to facilitate the way of life, but with economical. By the development of programmable electronics circuits like microcontrollers, all home automation needs may be possible and realizable. Therefore, we suggest in this paper a prototype of an automatic indoor lighting embedded system to manage the lights of a house. To concept a flexible system, we opted a modular structure. The system consists of two main parts; the first part, it's the hardware parts based on micro controller PIC16F877A communicate with a software platform. This part deal with some sensors like: infrared barriers, movement detector and LDR photo resistance to detect the luminosity state in the house's emplacements (rooms) to monitor the different room's lights; it is the central part in charge of processing all the user instructions. We can use an extra part if the rooms to be lighted are beyond our main hardware outputs (it is an additional hardware part based on Arduino nano). The next part consists of two a PC's graphical interface and an android application (PC's and Android GUI); the PC interface has several functions; divulging illumination states, guesstimate consumption and save. But the android application play a secondary service, its to force ON/OFF lighting by a person's indoor. Our system collects the information of the people presents at home and their emplacement indoor then localize their position and decide to light on or off every emplacement. Once the system make a change in the house's illumination, it'll be reported in real time to the GUI interface (software part) this part will save changes and guesstimate the consummated energy of every space(room) ant the total consumption. The communication between the hardware and software parts was made wirelessly XBee pro modules. The phone application interfere when a person indoor choose the manually wireless lighting from his Smartphone, without moving to the hardware lighting buttons.

KEYWORDS: Microchip PIC 16F877A, Photo resistance (LDR), Infrared Beams, Movement Detector, Arduino nano, XBee GUI Interface, Android Application.

I. INTRODUCTION

In the domestic domain, profit of numerous services and options that make our lives comfortable is very important, but also we have to think about the economy. The illumination during days, hours or forgetting the lamp turned on is a waste of energy and money.

We propose a smart system that control the access in and out through the main entrance, and detect the human being presence in every room, control the lighting states, estimate the energy expenditure, save the energy consumption in the database then generate estimate money related to the energy used. A smart system that control and check the movement in every room and turning off the empty room's light and save the lighting period of these rooms to date and hours. The saved information will be helpful the determinate if our expenditure of energy diminishes or not and what the room the most lighted and most consumptive.

II. PROPOSED SYSTEM

2.1 System's Model

In this study, the automatic lighting is the aim of our system and the economy of energy it's the main goal, but the system may play an alarm as a second function. The system function begins with movement detection in every room, determines the luminosity of the room, then decides to turn lights on or off. All detection of movement provokes the checkout of the number of persons indoor then verify if the alarm function was active; to alert a thief detection. If the alarm function was inactive; the system detects the room's electrical light state and the daylight in the room by the LDR and then decide the action that will execute (turning the light on or off). After detections and actions executed, the system displays the state of every

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room (with the state of the related output) of on the PC screen by GUI interface, update the energy consumed by every room, and then saves updates in the database. In case of saturation of the hardware outputs we can use the additional part based on arduino nano .

User can also make change of lighting state with the mobile application. We will expose in Fig. 1 below the overall architecture of the system to find out its different parts and components.

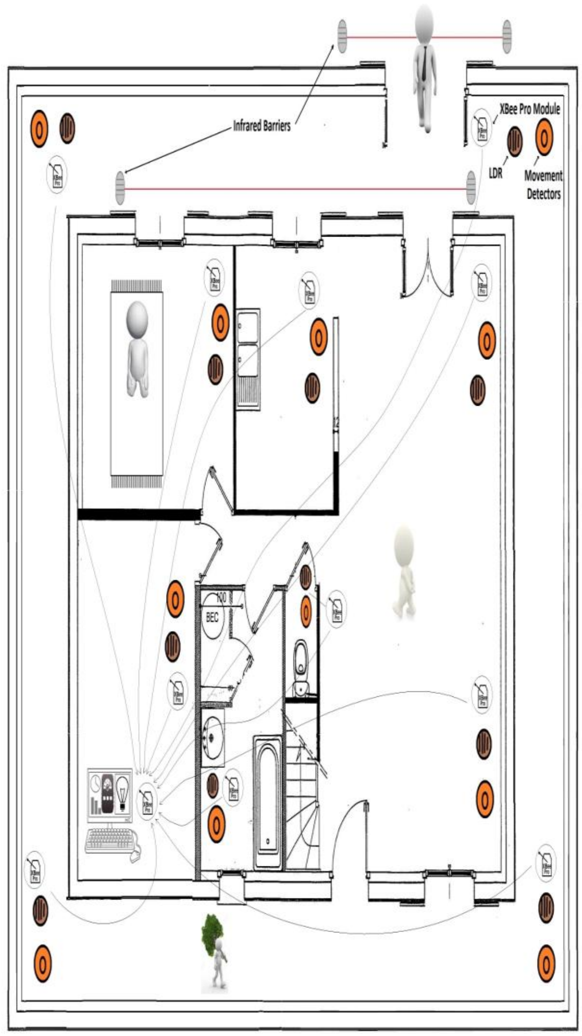

Fig.1 System's Model

As shown in Fig. 1 one our system is a modular structured system, composed of two parts; a repetitive part that equipped with sensors and a main one which control the access through the main house gate to verify the number of people in the house.

The detection of number of the person in the house not a very important purpose, all we need to know by this detection if nobody in the house (0 person in). This detection may be realized by different methods; we can use an infrared array as a people counter at the entrance of the building, but it is not a perfect solution because cannot recognize the direction of access [1][2].

2.2Block Diagram and Flow Chart

The initial description of our system functions and its different parts is well presented in the block diagram Fig. 2.

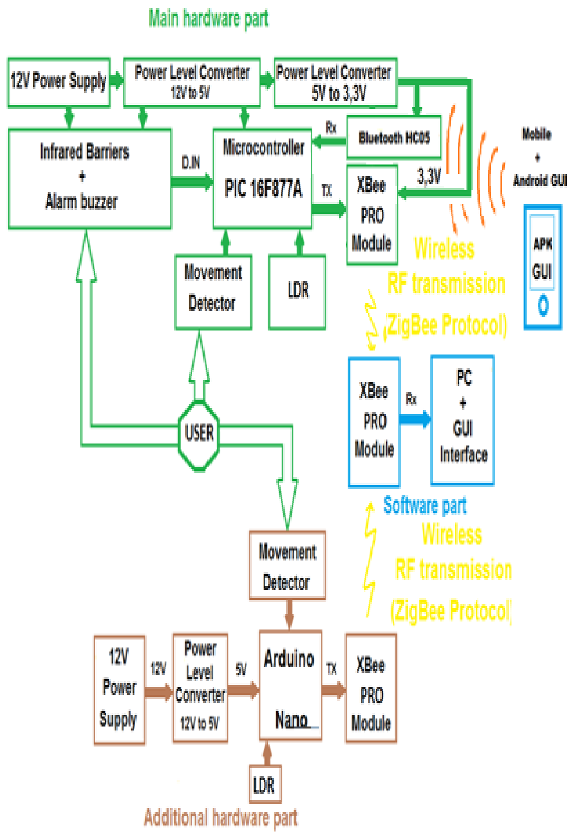

Fig.2 System's block diagram

The system consists of three parts in total (as shown in Fig. 2):

- Hardware part:

This part is devised in many hardware parts:

o Principal hardware part: it's the main hardware part of person detection (number of people indoor) and lighting management (presented with the green color in the block diagram in Fig. 2).

It's the essential part, if this part doesn't detect anybody and the number of users is zero, then

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is no automatic lighting change also it's the part responsible of starting alarm alert in case of alarm function was active.

o Second hardware part: the part presented with the brown color in the block diagram Fig. 2. This part has the same ability of lighting management as the participial part, but we can only use this part indoor because it can't count the number of people crossing the emplacement.

• Telecommunication part: it's the coordinator part between the hardware and software parts; .This part consists of three common XBee modules and Bluetooth HC05 module, it's well exposed with the yellow and orange colors in Fig. 2.

• Software part: This part consists of graphic interface (installed on PC) and android application (installed on Android Smartphone) as presented in Fig. 2 (with the blue color). The PC's software IHM allow to user to check out the lighting state, history, and consumed energy estimation and the android application allow to user to change illumination state decided by the hardware part (wirelessly by Blutooth).

The tow hardware parts communicate with the software part through the Radio Frequency ZigBee protocol (presented with yellow color in Fig. 2). The software part has to display the received data to update lighting state. To guarantee a right update of the energy estimation, a real time communication realized between the electronics hardware parts.

The Android application has the priority to turn ON/OFF the lights depending on user needs; any Bluetooth order received by HC05 module via the Smartphone application inverse the lighting state of the selected emplacement

We can sum up the system functionality by the flow chart presented in Fig. 3.

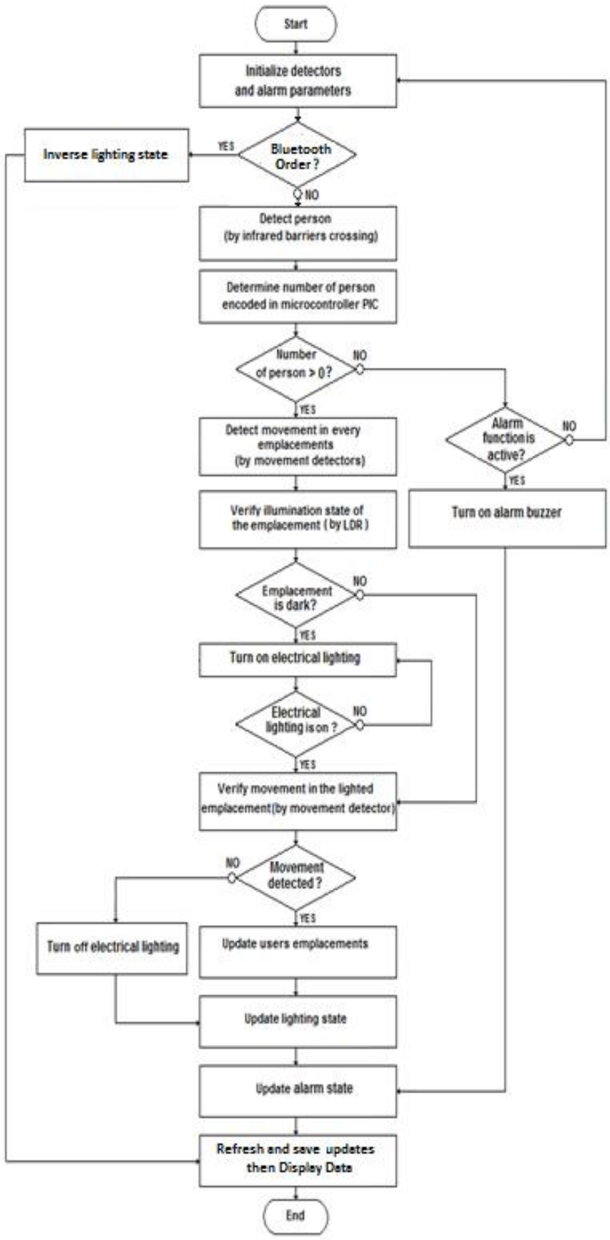

Fig. 3 Flow Chart

III. HARDWARE PART

The hardware part composed of many subsystems; start with the power supply system to the RF communication part [2].

3.1 Power supply

The main entry access detector need multi-voltage levels; the infrared barriers and the alarm buzzer need a 12V to function normally, the microcontroller operating voltage is 5V and both of the XBee and Bluetooth HC05 modules need 3.3V as operating

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voltage. The optimal solution is to supply the whole system with 12VDC then shift it to the two others values. Next to the 12V we associate a 7805 regulator to have a steady 5V. This category of regulator can converts input-power limited to 35V into steady 5V[4]. The same method applied to the XBee module since it operates at 3.3V, but the voltage regulator switches to LM1117 modifiable out-voltage IC[3]. The Room's movements checker and lighting management need the same components and same method to be feed with power except XBee module operating voltage (3.3V) offered by the PIN number 17 and GND of arduino nano[2].

3.2 Infrared barriers

The multi- infrared beam infrared barrier installed at the main gates to notice access. To obtain optimal performance of the IR Barrier: both transmitter and receiver are to be adjusted correctly so that the beam issued from the transmitter meets properly with the receiver[5]. In our system we exploit the commercial barrier GUARDALL SBT 30F with the characteristics presented in table -1.
Since the detection achieved just by the simultaneous crossing of the both infrared beams, we opted double successive barriers to trace the access direction [2].

Table -1 GUARDALL SBT 60F technical characteristics[6]

Operating voltage	11 V to 28 V DC
Consumption	70mA
Infrared beams	2 beams
Detection	Simultaneous crossing of the 2 beams
Max range	60
Installation	Outdoor / indoor
Dimensions	196,5 X 82 X 73,5 mm

3.3 Movement detector

The movement detection is the aim of our system since it's the responsible part automatic lighting; we opted to use the commercial infrared detector ELKRON IRA12. The sensor equipped with a High-density lens with three selectable coverage areas; volumetric, long-term, curtain when the uniform sensitivity optical system allows detection capabilities independent of distance or position in the spots of view (Elkron patent). The shade of the lens prevents false alarms that could be triggered if the sensitive element is affected by white light rays. The technical characteristic of the detector is clearly presented in table -2.

Table -2 Technical characteristic of ELKRON IRA12 [7]

Operating voltage	9 V to 15 V DC
Consumption at 12 VDC	11 mA to 17 mA max
Detection	12 m (Wide angle or curtain lens) 20 m (Long-range lens)
Max range	20 m
Weight	80 g
Dimensions	85 x 70 x 50 mm

3.4 Photo resistance (LDR05)

It is a semiconductor dipole without junction, the resistance of which varies when is exposed to light within a certain wavelength range [8], to more efficacy the sensor (photo resistance) was used in a tension deviser circuit, the graph resistance=f (illumination) is well presented in Fig. 4.

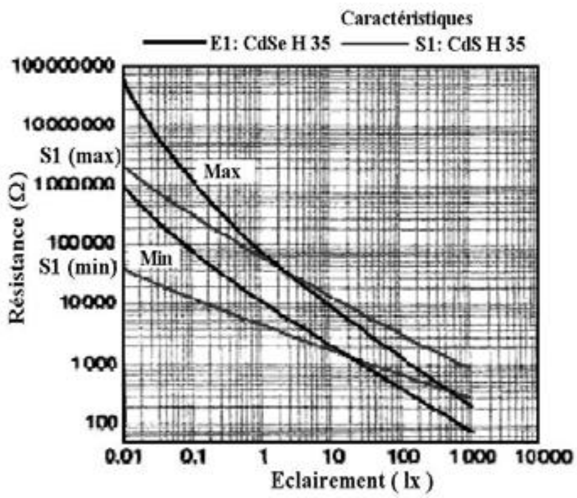

Fig. 4 Characteristic of the photo-resistance LDR05[8]

3.5 Microcontroller

The PIC16F877A microcontroller selected in this work is a Microchip manufactured microcontroller by 14.3K program memory, its EEPROM data references is 256 bytes, with RAM of 368 bytes, 33 I/0 and eight 10-bit A/D converter. It supports many interfaces as UAR and MSSP(SPI/I2C), its operating voltage range from 2V to 5.5V, thus it is perfect to be used like an embedded system[9].

3.6 Arduino Nano Pro

The arduino nano is an open source board based on ATmega328 microcontroller and large margin of 32 KB program memory, this arduino board have more than supply ground pin and two more then output voltage levels (5V énd3V) it's perfect

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as independent or related embedded system (independent system or subsystem).

3.7 Hardware design

We used the PROTEUS professional software in the PCB conception (ISIS and ARES) to design and simulate the system's hardware part. The schematic diagram and PCB layout was clearly exposed in figure Fig. 5 and Fig. 6.

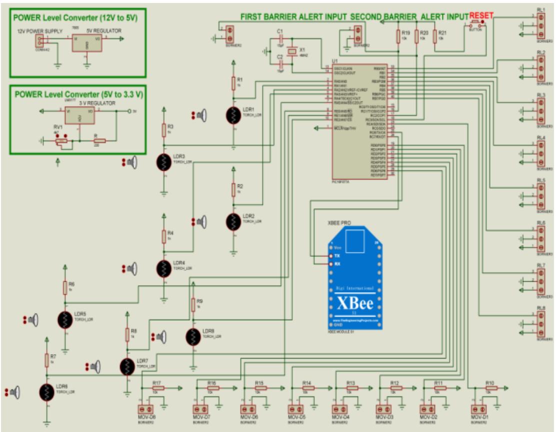

Fig. 5 Simulation schematic diagram

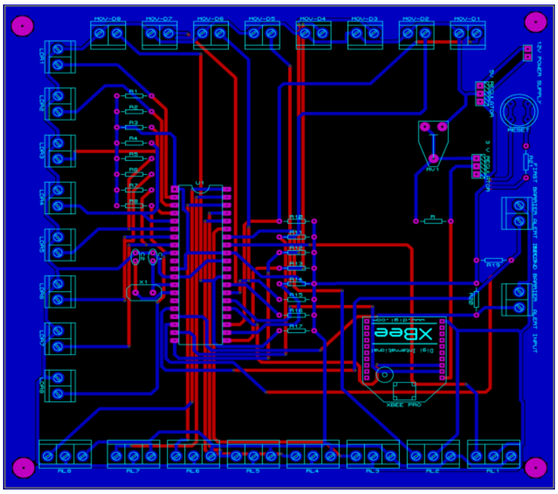

Fig. 6 PCB schematic diagram

3.8 Relays interface

In order to control various lighting lamps with a different various tension levels we choose to exclude the integration of the relays from the main hardware PCB that's making the system more flexible, it's up to the electrician to choose the right commercial relay module depending on the lamps to be lighted (during the electricity installation). In case of an old installation user can choose his compatible relay module, its depending on the integration space.

3.9Bluetooth emplacement

The Bluetooth HC05 range is around 10 meters so we opted to wire it from external emplacement through a connector on the designed PCB (as exposed in figure Fig. 5 and Fig. 6).

IV. TRANSMISSON PART

The main system's parts communicate via ZigBee protocol using XBee modules; It is a high-level communication device which is used to create a personal and low power digital network (PAN). It is based on standard IEEE 802.15.4 and its low power the transmission distance limits up to 100 meters and can exceed this distance with the XBee Pro module. It has a defined transmission rate of 256 Kb/sec. The purpose of ZigBee is to transmit signal wirelessly from transmitters (hardware parts) to receiver(software part)[10].

Since the main serial PINS of the microcontroller (RX/TX) was occupied by the XBee module, we choose to adapt a software serial communication between the HC05 Bluetooth module and the microcontroller.

V. SOFTWARE PART

5.1 PC software part

The main software part (PC GUI) receives the data via ZigBee protocol (XBee module) through XBee serial to USB adapter. It's the part responsible of saving lighting and alarm data. The software offers many options like alarm settings and consumed energy estimation. The principal interface of the software is presented in Fig. 7.

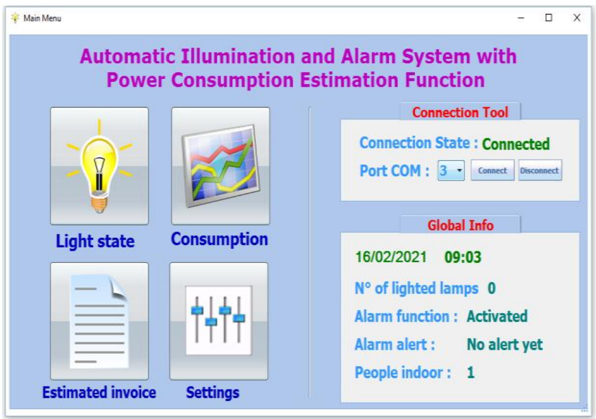

Fig. 7 Principal software interface

The main interface allows for users to cheek lighting state of the whole house (all connected lamps), review the history of consumption, estimate the invoice of connected lamps (connected lamps charge) and setting alarm parameters. The setting window is well exposed in Fig. 8.

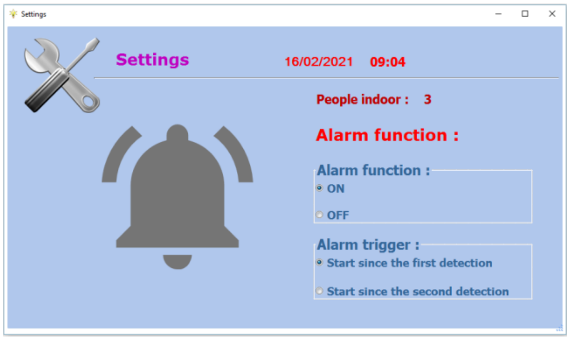

Fig. 8 Alarm settings window

5.2 Android Mobile application

The Android software part is a Multilanguage android application like exposed in Fig. 9, the application Support the tow most usual language in Tunisia (French and Arabic) to help users to remote controlling the lighting state of every room in the house with their familiar language as presented in Fig 10, Fig 11 and Fig 12..

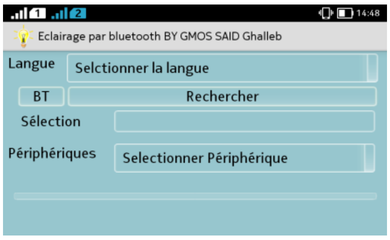

Fig. 9 First settings window of the Application

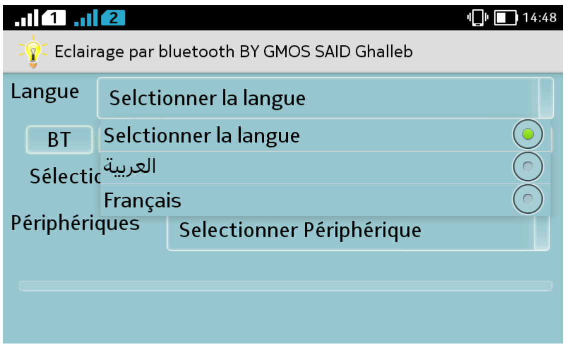

Fig. 10 Application's Language settings

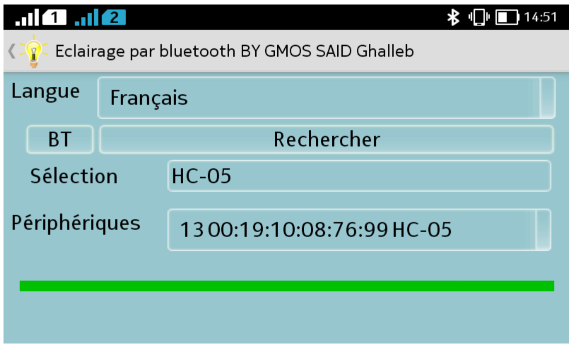

Fig. 11 Application's Language settings

By setting the parameters, the Android application allow user to connect to our system (by Bluetooth module) and admit the change of lithing of all indoors rooms like shown in Fig. 12 and Fig. 13.

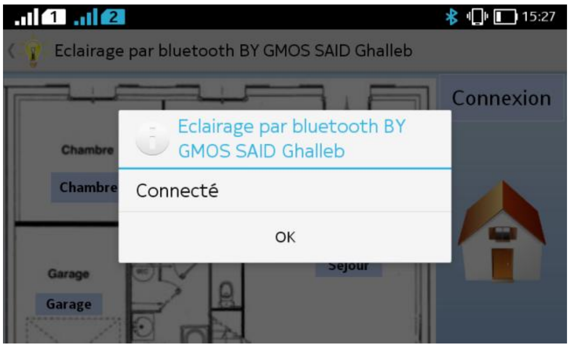

Fig. 12 Connecting the Appliction to our system

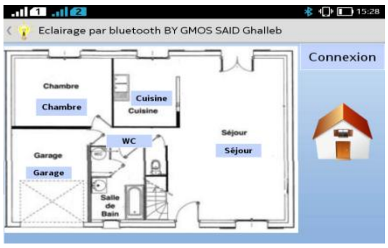

Fig. 13 Lighting controling interface

VI. RESULTS

After more than four days testing this system in our house with eight emplacements we get these results exposed in Fig. 14 and Fig. 15 below.

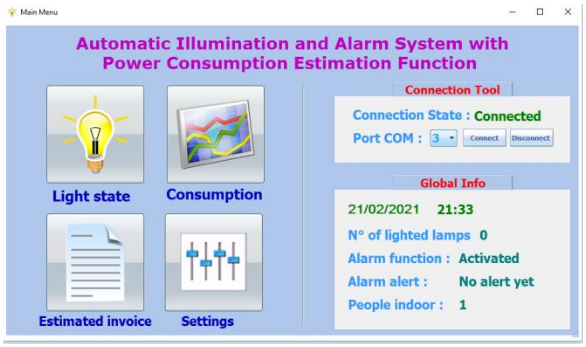

Fig. 14 Outcome result in the main window

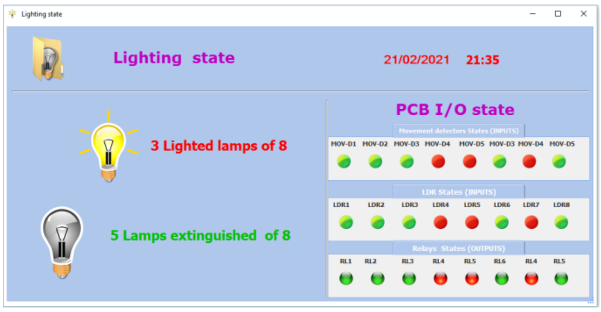

Fig. 15 Lighting state

The energy consumed in those four days is presented in the Fig. 16; it's the result of all lighted lamps.

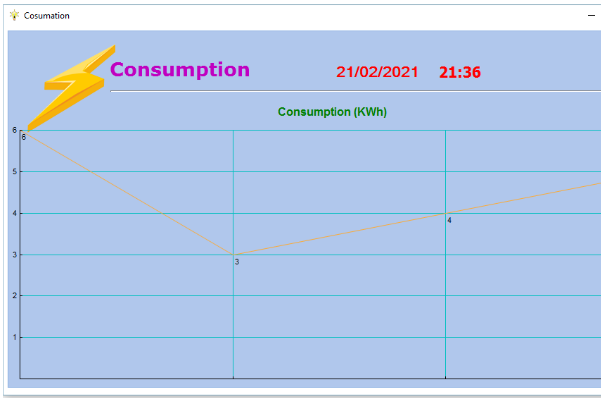

Fig. 16 Energy consumption

The count of energy consumption is based on two parameters; the first is the lamps puissances and the second one is the lighting period of every lamp this period reflect the lamp consumption and the estimated invoice. In our test used all lamps with the same puissance (100 W) and the lighting on time reflect the energy consumption of ever lamp as shown in Fig. 17.

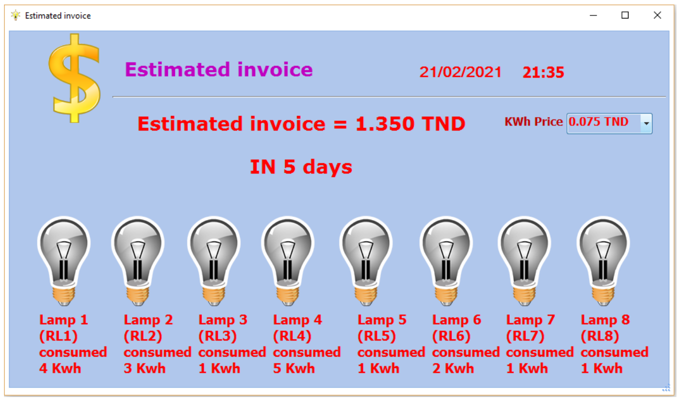

Fig. 17 The estimated invoice and lamps consumption

The count of estimated invoice it is so simple, the user just sets the price of kWh and the software calculates the total automatically as shown in Fig. 17.

VII. CONCLUSION

The objective of this project has been achieved; our system controlled well the lights in our house automatically, and estimates the lighting fee with success. The problem of forgetting the light on is well eliminated by our smart lighting system. All the system components functioned perfectly and the Android application successed to well controled the lighting via Bluetooth. As perspective, we can add a wide area network to control the lighting of our system through the internet.

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