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AUTOMATION SYSTEM BASED ON FIELD PROGRAMMABLE GATE ARRAY

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ABSTRACT

Smart automation system is an evolution of human kind to a new era. These systems do all the jobs quickly and efficiently which saves time in our daily life, and in order to make these smart systems work more efficiently, faster and accurately we have used an FPGA Board (Field-Programmable Gate Array) in our thesis project. FPGA is an integrated circuit (IC) that allows programmer to create their own design in the field after manufacture and the core is able to operate different modules simultaneously. The main goal of our thesis is to implement four features that will save us from various accidents and wastage like home on fire or over flow of water and a little bit of smart security where we used PIR motion sensor, fire sensor and water sensor. In order to complete our desired project we had to work in three portions – compilation of module, synthesis and hardware implementation. FPGA board works digitally that lead us to converting all the sensor data or outputs to digital. We designed different modules for compiling different sensors on the FPGA board, then synthesis and hardware implementation were carried out accordingly. In spite of facing many challenges up to the hardware implementation we were successfully able to reach our desired goal.

INTRODUCTION

History of Automation System

Home automation began with labor-saving machines such as washing machines and vacuum cleaners. These instruments do all the jobs quickly and efficiently which saves time in our daily life. Self-sufficient electric or gas powered home utilizations became sustainable in the 1900s with the introduction of electric power distribution and led to the launching of washing machines (1904), water heaters (1889), refrigerators, sewing machines, dishwashers, and dryers. In 1975, the first all-purpose home automation network technology, was developed, it is a communication protocol for electronic devices. Soon after that came the wall switch module. Smart systems, began to increase in popularity in the early 2000s, different technologies began to develop. Smart systems very quickly and swiftly started to become a more reasonable option, and therefore a more feasible technology for consumers. Domestic technologies, Office security home networking, and other gadgets began to emerge more in the market and their availability increased. By 2012, in the United States, according to ABI Research, 1.5 million home automation systems were installed According to Li et. al. (2016) there are three generations of home automation:

1. Wireless technology with proxy server, e.g. Zigbee automation;
2. Artificial intelligence controls electrical devices, e.g. amazon echo;
3. Robot buddy "who" interacts with humans, e.g. Robot Rovio, Roomba.

Today's automation systems and its constraints

Nowadays smart homes and offices are mainly about security and protection. Our smart systems are viable, and they help to make sure that our homes and offices aren't consuming unnecessary energy. These systems also helps to alert us against dangerous hazards like fire and even signals us against intruders even though we are home or not. Even when we are far away we will still be connected to our homes, and when the house is occupied, the high level of automation enables more convenience, control and safety from any part of your property. All these advance features helped us to reduce our worries and increased our level of enjoyment. Current developments in home automation include remote mobile control, automated lights, automated thermostat adjustment, scheduling appliances, mobile/email/text notifications etc. Some of the constraints of the home automation system with Arduino and other microcontroller are the speed is less, does not work in parallel and its difficult to introduce it in the market.

Our system with FPGA

In our smart system we have implemented an FPGA Board, by using this board our system will work faster, efficiently and accurately than the other home automation systems. Our system consumes less power compared to the other home automation systems by operating all the features used simultaneously.

Motivation

Our motive was to create a smart sensing system that can work more efficiently and effectively as we are using more sophisticated board. There were several things which encouraged us to do the project with FPGA rather than other microcontrollers are:

- FPGA are not stuck to any hardware configuration, but the microcontrollers are stuck to the configuration that the supplier provides, they cannot be rewired.
- FPGA's code is executed in parallel and microcontroller is executed sequentially.
- FPGA is faster in more complex solutions and work more efficiently and accurately.
- FPGA has incredible flexibility on its price and lower power consumption.
- It has a vast range of capability and can be interfaced through different ports.
- It is easier to build desired system and design it on chip.

There are some reasons to choose this project;

- To make an easier hardware implementation for experiment
- Easy as a basic stage of abstraction and synthesis
- There are parallel operations with the sensors

AIM of the Thesis

The purpose of this thesis work is to introduce a smart system using the FPGA Board. In this research we have designed a smart sensing system using FPGA, which will keep the people safe from various accidents which can take place in their home or even offices where they spend most of their time. Another aim of our thesis work is to reduce power consumption. Through our work we will try to reduce power wastage, which is a major problem nowadays in our society. Every person loves their home, thus to protect their home and keep it safe everyone should take a few initiatives like protect the house from fire or water overflow etc. In our project we have included such features through which a person can easily detect whether their house caught an unwanted fire or if there is water flow from their water tank or washroom especially bathtub or

bucket. Most people often tend to forget to turn off the lights or fan of the room, so through our smart system we have even included a feature of automatic turning the lights and fan off of the room by using a motion sensor.

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Appendix

Verilog code for flame sensor:

```
module flame(out,in); input
in;
output out; not
b(out,in);
endmodule
```

Verilog code for water sensor:

```
module motion(out1,in1); output
out1;
input in1; reg
out1;
always @(in1)
begin if(in1)
```

```
out1 <= 1'b1; else out1
<= 1'b0; end

endmodule
```

Verilog code for door lock:

```
moduledoor_lock (a,b,c,d,e,out1);
inputa,b,c,d,e;
output out1; wire
out1; wirea,b,c,d,e;
assign out1 = a?(b?(0):(c?(0):(d?(0):(e?(1):(0))))):(0);
endmodule
```

Verilog code for motion sensor:

Verilog code for counter module:

```
module counter(clk,motion,count); input
motion;
inputclk; outputreg[31:0]
count;

always @(posedgeclk) begin
if(motion==0) begin
count<= count+1;
endelse begin
count<=0; end
end endmodule
```

Verilog code for control light module:

```
module light(light,led,); output
light;
wire out2; input
[3:0]led;

assign out2=led[3]?(led[2]?(led[1]?(led[0]?(1):(0)):(0)):(0)):(0); not
n(light,out2);
endmodule
```

Verilog code for merging:

```
module final_project(out,outp,in,inp,a,b,c,d,e,out1,osc_clk,motion,button,led,light); input
in,inp,a,b,c,d,e,osc_clk,motion,button;
output out,outp,out1,led,light;
wire[3:0]led;water_sensorm1(.outp(outp),.inp(inp)); flame m2 (.out(out),.in(in));
door_lock m3(.a(a),.b(b),.c(c),.d(d),.e(e),.out1(out1));
counter_top m4(.osc_clk(osc_clk),.motion(motion),.button(button),.led(led),.light(light));

endmodule
```

HC-SR501 PIR MOTION DETECTOR

Product Description

HC-SR501 is based on infrared technology, automatic control module, using Germany imported LHI778 probe design, high sensitivity, high reliability, ultra-low-voltage operating mode, widely used in various auto-sensing electrical equipment, especially for battery-powered automatic controlled products.

Specification:

- Voltage: 5V – 20V
- Power Consumption: 65mA
- TTL output: 3.3V, 0V
- Delay time: Adjustable (.3->5min)
- Lock time: 0.2 sec
- Trigger methods: L – disable repeat trigger, H enable repeat trigger
- Sensing range: less than 120 degree, within 7 meters
- Temperature: – 15 ~ +70
- Dimension: 32*24 mm, distance between screw 28mm, M2, Lens dimension in diameter: 23mm

Application:

Automatically sensing light for Floor, bathroom, basement, porch, warehouse, Garage, etc, ventilator, alarm, etc.

Features:

Automatic induction: to enter the sensing range of the output is high, the person leaves the sensing range of the automatic delay off high, output low.

photosensitive control (optional, not factory-set) can be set photosensitive control, day or light intensity without induction.

- Temperature compensation (optional, factory reset): In the summer when the ambient temperature rises to 30 ° C to 32 ° C, the detection distance is slightly shorter, temperature compensation can be used for performance compensation.
- Triggered in two ways: (jumper selectable)
  - non-repeatable trigger: the sensor output high, the delay time is over, the output is automatically changed from high level to low level;
- repeatable trigger: the sensor output high, the delay period, if there is human activity in its sensing range, the output will always remain high until the people left after the delay will be high level goes low (sensor module detects a time delay period will be automatically extended every human activity, and the starting point for the delay time to the last event of the time).
- With induction blocking time (the default setting: 2.5s blocked time): sensor module after each sensor output (high into low), followed by a blockade set period of time, during this time period sensor does not accept any sensor signal. This feature can be achieved sensor output

time “and” blocking time “interval between the work can be applied to interval

detection products; This function can inhibit a variety of interference in the process of load switching. (This time can be set at zero seconds – a few tens of seconds).

- Wide operating voltage range: default voltage DC4.5V-20V.
- Micropower consumption: static current <50 microamps, particularly suitable for battery-powered automatic control products.
- Output high signal: easy to achieve docking with the various types of circuit.

Adjustment:

- Adjust the distance potentiometer clockwise rotation, increased sensing distance (about 7 meters), on the contrary, the sensing distance decreases (about 3 meters).

- Adjust the delay potentiometer clockwise rotation sensor the delay lengthened (300S), on the contrary, shorten the induction delay (5S).

Instructions for use:

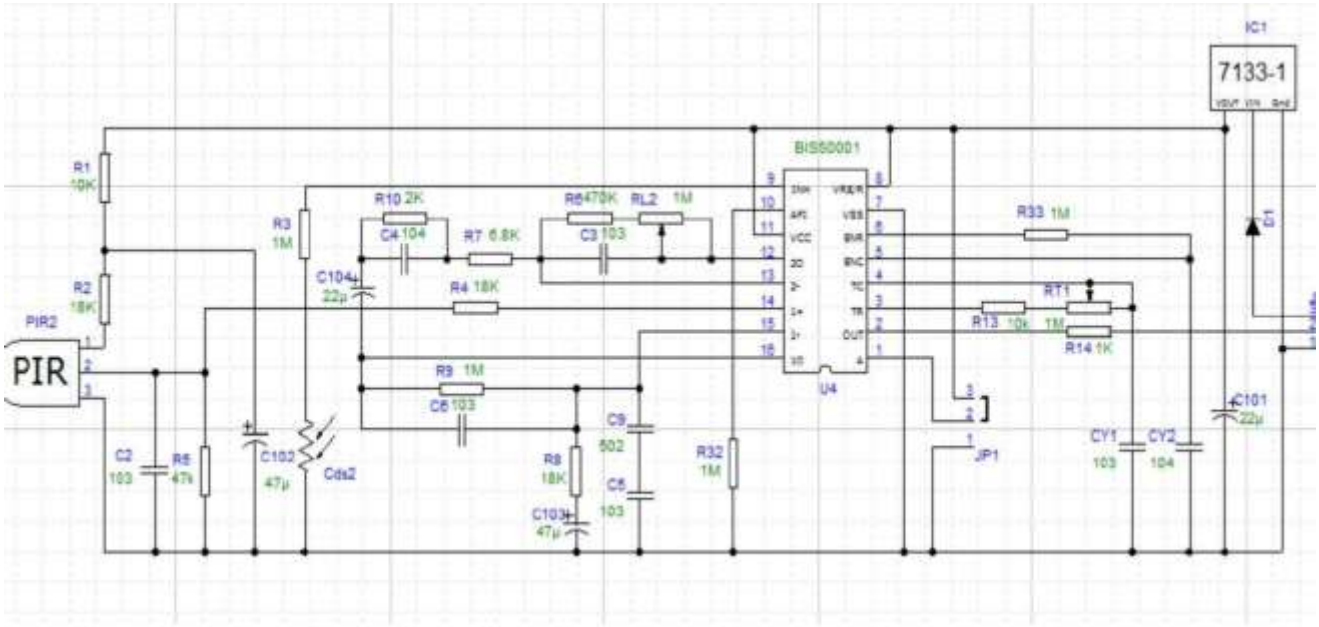
- Sensor module is powered up after a minute, in this initialization time intervals during this module will output 0-3 times, a minute later enters the standby state
- Should try to avoid the lights and other sources of interference close direct module surface of the lens, in order to avoid the introduction of interference signal malfunction; environment should avoid the wind flow, the wind will cause interference on the sensor.

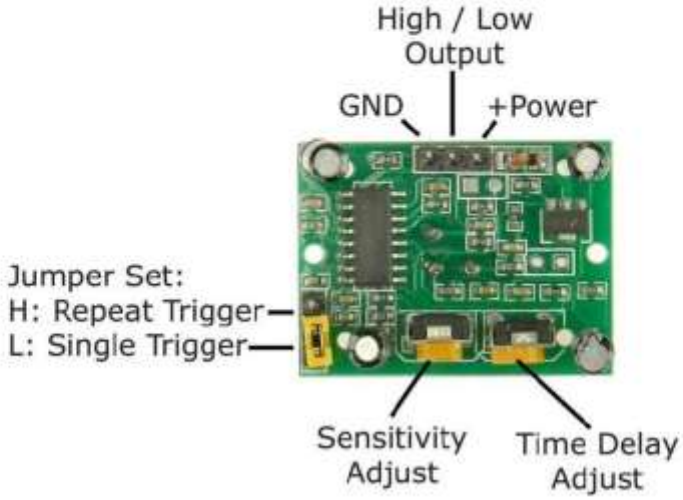
- Sensor module with dual probe, the probe window is rectangular, dual (A B) in both ends of the longitudinal direction
  - so when the human body from left to right or right to left through the infrared spectrum to reach dual time, distance difference, the greater the difference, the more sensitive the sensor,

  - when the human body from the front to the probe or from top to bottom or from bottom to top on the direction traveled, double detects changes in the distance of less than infrared spectroscopy, no difference value the sensor insensitive or does not work;

- The dual direction of sensor should be installed parallel as far as possible in inline with human movement. In order to increase the sensor angle range, the module using a circular lens also makes the probe surrounded induction, but the left and right sides still up and down in both directions sensing range, sensitivity, still need to try to install the above requirements

HC-SR501 PIR MOTION DETECTOR


IC1
7133-1
BISS0001
PIR
PIR2
R1 10K
R2 18K
R3 1M
R10 2K
C4 104
R7 6.8K
R6 470K
RL2 1M
C3 103
C104 22µ
R4 18K
R9 1M
C6 103
C9 502
C5 103
C103 47µ
R8 18K
R32 1M
C2 103
R5 47k
C102 47µ
Cds2
U4
R33 1M
RT1
R13 10k
R14 1K
JP1
CY1 103
CY2 104
C101 22µ
D1


High / Low
Output
GND
+Power
Jumper Set:
H: Repeat Trigger
L: Single Trigger
Sensitivity
Adjust
Time Delay
Adjust