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Research paper

Intelligent Management System for Home Appliances A conceptual approach using Hardware Description Language

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Abstract

IoT (Internet of Things) is an emerging trend in the market and smart appliances are a subset of IoT. The IoT helps integrate digital and wireless technologies in home or kitchen appliances. Furthermore, M2M (Machine to Machine) communication is likely to create a key opportunity in the smart appliances market. Smart appliances are the next generation of home appliances that have the ability to receive, interpret, and act on a signal received from a user. This paper is a demonstration of designing a multipurpose remotely controlled system for electrical household appliances. The project simulation design is carried out by Hardware Description Language (HDL) programming.

Keywords: *Internet of Things(IoT); Machine to Machine (M2M; Hardware Description Language*

1. Introduction

The internet of things (IOT) can be defined as a development of having network connectivity which will allow for process of sending and receiving data in all devices connected in the network. Current technology oriented development caused IOT becomes highly demanded trend in many applications. Among others are the smart appliances. Smart appliances are devices which can communicate with tablets or smartphones that allows users to control these appliances remotely. Smart appliances are designed in such a way that they can communicate information directly to the user for efficient and productive use of electricity. These appliances are also known as intelligent appliances due to the ability of measuring and controlling the use of energy. Smart appliances can be of the type smart home appliances, smart kitchen appliances, and services. Smart home appliances are then further classified into washers, dryers, air conditioners, water heaters, lighting devices, and security devices. As for smart kitchen appliances are the refrigerators, coffee makers, kettles, dish washers, ovens, cooktops, and cookers.

Due to an increase of interest in connected appliances and in relation to the growing use of smartphones, the use of the Internet of things-related products is considered useful. Smart and connected appliances are certainly an option and in demand for certain individuals to fit the so called modern lifestyles. The available systems in the market are designed to suit specific needs of target consumer. Thus, none has been offered with the ability to control entire household appliances. A conceptual approach of this Smart Home Appliance system is designed using hardware description language, VHDL with aims of offering ability to control many appliances at home such the air conditioning unit, refrigerator, electric stove, iron and water heater.

This paper presents a Smart Home Appliance System concept using VHDL, a requirement for Digital Logic Design subject in Faculty of Electrical Engineering, Universiti Teknologi MARA (UiTM), Shah Alam. For this work the aim is to design a one centrally controlled system that can be used to automatically switch on or off any household appliances using remote devices which allows the users to control these appliances remotely as well as the system by providing safe, secure and efficient use of electricity. Simulation result is presented to justify the conceptual design of the smart home system control.

2. Literature Study

2.1 Smart Home

Research on smart homes began in the late 1980's with the intent on making homes more intelligent. Smart home can be defined as dwelling incorporating a communications network that connects the key electrical appliances and services, and allows them to be remotely controlled, monitored or accessed (Nicola King, 2003).

Yang Song et.al (2012), in their work studied the smart home scenarios based on the internet of things. Typical smart home solutions were discussed in this report. Among others, the networking technology was analyzed such as Wifi and LTE-based system. Simulation findings of the paper formulated that issues surrounding smart home efficiency are the deployment density, increasing frequency isolation or reducing the transmit power.

The work by Husin, Ngahdiman, N.M.Z Hashim, Y.Yusop and Jaafar (2013) developed a smart controlling system for home appliances by using Global System for Mobile Communications (GSM). The GSM Modem is used for enabling people to remotely control the switching via Short Messaging System (SMS). This system will enable user to control their home appliances by using

SMS. According to several surveys that had been conducted, almost half of those surveyed, 45% are interested in having the sort of functions offered by a smart home.

Liu Ningqin et.al (2013) reported their design and implementation of smart home control system that based on ARM considering the LAN and WAN environment. Through these two different environments smart home will be able to be controlled using computers and Android smart phones. This architecture offers the possibility of controlling smart home through computers and Androids smart phones simultaneously. Expansion of appliances to be attached to the system is also made possible by simple modification on the program control.

Yogen Liang and Shiming Wan (2014) presented a design of smart home control system by implementing the used of microprocessor and GSM module. The embedded system reported in this work featured GUI based monitoring of home appliances with additional of monitoring surrounding temperature and humidity.

A thorough analysis on smart home is presented by Zhang Jinglu and Chen Lili (2015). They reported the internet of things smart home control design considering the in depth details of principle operation of smart home control system. The proposed design is by implementing wireless application that reduce the needs to have wiring and thus offers reliability in the design.

The growing technological development craves people to have better home comfort and lifestyles. Smartphones and tablets serve as compulsory needs offering users the activation of a specific function at their fingertips. Smart home concept is proven can be traced back more than twenty years in history as people demanding for comforting lifestyles. All these literatures are supporting evidences that surround the current interest towards having smart home system. The implementation technology used for smart home system is varied. In lieu to that, hardware description language is used in this paper to design and simulate the smart home system.

2.2 Design Concept of Home Appliances System

Hardware description language (HDL) is an approach to model and design digital hardware. Widely used HDL is the VHDL and Verilog. HDL is an alternative way of describing digital systems other than the schematic capture. HDL is preferable as compared to schematic capture due to several reasons. In logic synthesis, HDL offers advantage in reducing the development time and cost in which it promotes design reuse and more flexibility in hardware technology changes. HDL also offers higher level of abstraction. Abstraction is referred to the hierarchical design of the systems. This is useful in the case of handling complexity of larger design. HDL allows for a digital system to be designed and debugged at higher level of abstraction with gates, flip flops and standard MSI building blocks.

Both schematic capture and HDL description may co-occur. The long term trend in digital design is to mix the design entry. Schematic capture is used to describe part of the design and another part may employ the use of HDL (Mohamed Khalil Hani, 2007).

Using VHDL, several different level of a digital system can be described such as the behavioral, data flow and structural. With the use of VHDL, top-down design methodology is employed in the process. For that the system is first specified at a high level and tested with a simulator. Debugging takes place during this process so that the designed can be gradually refined which will lead to structural description that related to actual hardware implementation. The design of VHDL is technology independent. Current state of design technology using VHDL can be used for starting point of design technology in the future. Most VHDL can be used for simulation and logic synthesis even though its initial design is meant for hardware documentation language (Charles H. Roth and Lizy Kurian John, 2008).

3. Results and discussion

3.1 HDL Design

Finite State Machine (FSM) is widely used in digital design for its typical utilization as core for a datapath controller unit (Mohamed Khalil Hani, 2007). FSM can be modeled in HDL by using algorithmic state machine (ASM). From ASM the flow of the system can be observed and thus made possible to be converted into HDL programming. Figure 1 depicts the VHDL modeling of the FSM of the system. And figure 2 (a) and (b) show the design using ASM chart.

The design is made by implementing the concept of finite state machine (FSM). ASM representation of a Finite State Machine suitable for FSMs with larger number of inputs and outputs compared to FSMs expressed using state diagrams and state table. For this system six states are defined in the architecture of the written VHDL. Each individual state defined will test for each of the appliances attached to the system.

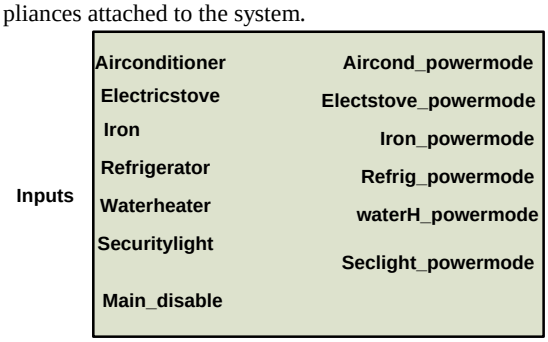
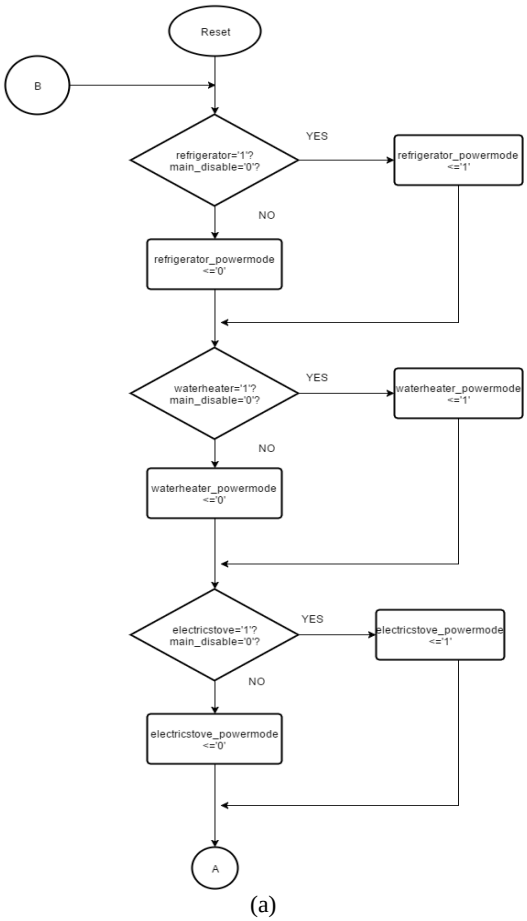
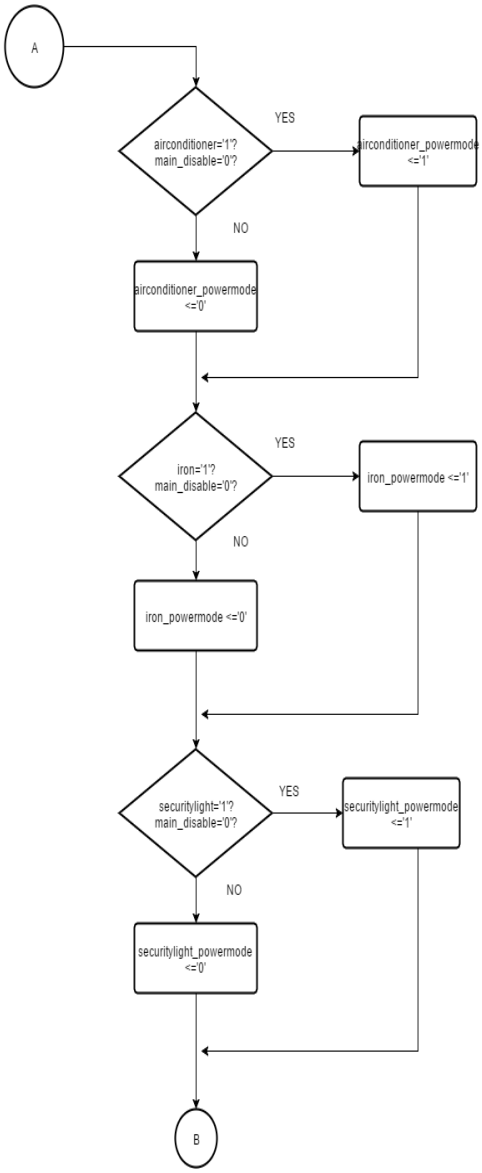


Figure 1: VHDL Modeling of system



(a)



(b)

Figure 2 (a), ((b): ASM Chart

Figure 3 depicts a diagram of technology schematic generated by Xilinx ISE VHDL. From the figure, it can be observed that each defined state machine in the conceptual design is implemented using Look-up-table (LUT). LUT defines the functional blocks of the system by describing output for given input(s) of the system. By having LUTs the system can be mapped into FPGA for hardware implementation. However, this paper only reported the behavioral simulation of the designed system using XILINX ISE simulation tools.

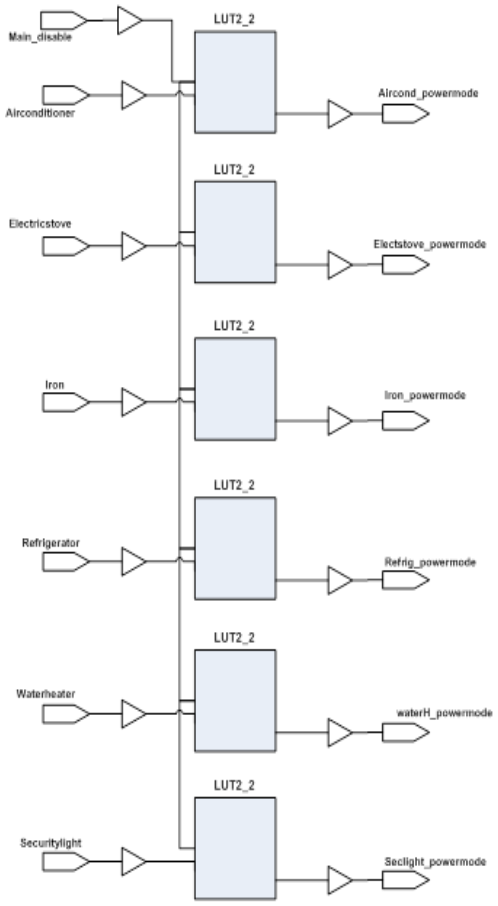


Figure 3: Technology Schematic

3.2 HDL Simulation

To simulate the VHDL design, testbench is applied to test for the system to function properly as planned. Figure 3 shows testbench waveform used to test the design. This testbench will provide series of inputs for the system and thus the respond or output of the system can be observed as shown in Figure 4.

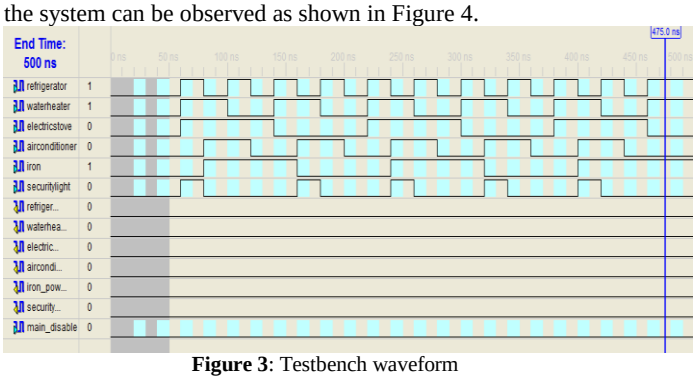


Figure 3: Testbench waveform

The behavioral simulation displays respond of the design system which is used to verify and justify that the system function according to the requirement. Simulation result shows that the design system responds correctly to the inputs applied. The sample testbench inputs applied to turn on refrigerator, water heater and iron. In the simulated behavioral waveform, the three appliances are turned on following the series of inputs applied.

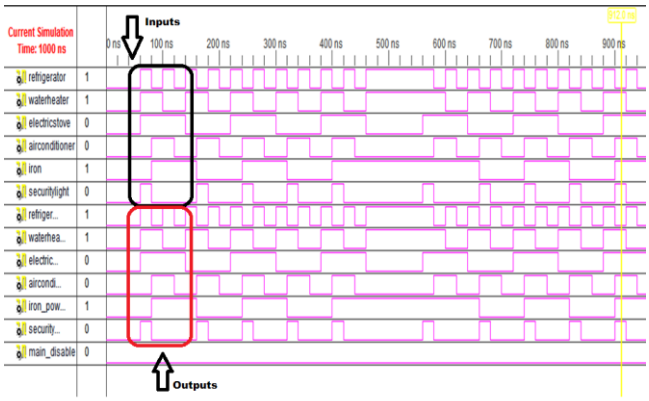


Figure 4: Behavioural Simulation

4. Conclusion

Smart Home Appliance System concept has been designed and simulated using Hardware Description Language for partial requirement of Digital Logic Design subject taught in Universiti Teknologi MARA. The design is implemented in VHDL and simulated with XILINX ISE simulation tools. Simulated results confirmed the system behavior acted upon to the requirement of the planned system. Despite the conceptual design is successfully simulated in VHDL further improvision can be employed on the design to justify its functionality in hardware implementation.

Acknowledgement

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