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DEVELOPMENT OF ZIGBEE BASED HOME AUTOMATION 1.2 PROFILE CONTROLLER FOR SMART HUB

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ABSTRACT

In this paper, we describe about the development of ZigBee controller which is based on Home Automation 1.2 Profile. The Home Automation systems provide easier communication between various electronic, electrical, and power devices as well as interactive interface for people to control their operation. These features are very helpful to optimize and to economize energy consumption whereby saved energy during some few years could make more money than Home Automation systems implementation cost. ZigBee Home Automation 1.2 Profile is one of the standards that can make every home a smarter, safer and more energy efficient environment for users. The main purpose of this prototype is to develop a common controller for the smart hubs which can control the end devices that supports Home Automation 1.2 Profile. It can be done by using EM357 ZigBee module and MSP430 Microcontroller.

KEYWORDS: *Home Automation 1.2 Profile, EM357 ZigBee Module, MSP430 Microcontroller*

I. INTRODUCTION

Now-a-days, the interest of people towards Smart Homes is increasing. Home Automation or Smart Home is the residential extension of building automation and involves the control and automation of lighting, heating, ventilation, air conditioning (HVAC), appliances, and security. Modern systems generally consist of switches and sensors connected to a central hub sometimes called a "gateway" from which the system is controlled with a user interface that is interacted either with a wall-mounted terminal, mobile phone software, tablet computer or a web interface [1]. Smart Home systems have captured several technologies so far and products have been available in the market. Despite over a decade long of disparate activities in the industry companies failed to make home automation as a popular technology. The reasons behind this failure are, many are worried about their privacy and security and also an expert hand is required is for installing these systems. Even after installation, working of these systems successfully is a question mark. In order to overcome some of these limitations wireless home automation system (WHAS) has been introduced and it has gained a considerable attention in the recent years.

The WHAS industry has changed drastically since the introduction of cheap computers and laptops. Moreover, revolutionary developments in the software industry have made the user interface of the WHAS cheap and user friendly. Now-a-days, WHAS can be monitored and controlled from a remote location at any time. There have been many solutions proposed for wireless home automation industry in the past few years. Some of them include Z-wave, Insteon, Waveins, Bluetooth, WiFi, and ZigBee. In this work we have focused on the ZigBee based WHAS.

II. THE ZIGBEE TECHNOLOGY

A comprehensive description of the ZigBee protocol can be found in the literatures [2, 3]. We have presented only a partial description of the ZigBee protocol in this section so that the readers have

enough background to understand the rest content of the paper. The ZigBee technology was introduced by the ZigBee Alliance [4]. The ZigBee technology has evolved based on a standardized set of solutions called 'layers'. These optimally designed layers have provided the ZigBee with unique features including low cost, easy implementation, reliable, low power, and high security.

The ZigBee was built on top of IEEE 802.15.4 standard [2]. The IEEE 802.15.4 standard defines the characteristics of the physical and Medium Access Control (MAC) layers for Wireless Personal Area Network (WPAN). Taking this standard as a "chassis" the ZigBee Alliance has defined the upper layers in the ZigBee standard. Devices are the main components of the WPAN. The devices have been categorically defined as (a) physical type, and (b) logical type. The physical type devices have been further classified into two types namely Full Function Device (FFD) and Reduced Function Device (RFD). Any device may act as a sensor node, control node, and composite device irrespective of its type. Only the routing functions of a network are performed by the FFDs.

Depending on their locations in a network the FFDs may have one or more child devices and they perform routing functions for these child devices. The RFDs do not perform routing function in a network and hence they cannot have any child device.

The logical type devices have been further classified as three types namely coordinator, router, and end device. Among these logical devices the coordinator is the most capable device, which forms the root of the network tree. There should be exactly one ZigBee coordinator in a network to initiate the formation of a network tree. It also acts as a bridge to other networks. The ZigBee end devices possess limited functionality to communicate with a coordinator or a router only; it cannot relay data for other devices. Due to this limited functionality the end devices can "sleep" for a significant amount of the time and hence can enjoy a long operating life.

The protocol stacks defined by the ZigBee Alliance with respect to IEEE 802.15.4 standard protocol stacks are shown in Figure 7. The ZigBee architecture includes the Application Support (APS) sub-layer, ZigBee Device Object (ZDO), and user-defined application profile(s). The APS sub-layer's responsibilities include maintenance of some tables, which contain information used to enable matching and establish communication among the devices. During the discovery phase these tables are also used by a device to identify other devices that operate in the operating space. The ZDO determines the nature of the device (i.e., coordinator or FFD or RFD) in a network. It also replies to binding requests while ensuring a secured relationship between two devices. The user defined application refers to the end device that conforms to the ZigBee Standard.

The network layer assists the network to grow. This layer can handle a network consisting of up to 64000 nodes. The physical layer accommodates a high level of integration by using direct sequence technique. The Medium Access Control (MAC) layer permits to form several topologies without introducing complexity. The ZigBee devices have 64-bit addresses, with an option to enable shorter addresses to reduce packet size, and work in either of the two addressing modes namely star and peer-to-peer.

2.1. Home Automation 1.2 Profile

The ZigBee Alliance announced that the latest update to its Home Automation standard is now ready for product development. The Home Automation standard is one of several ZigBee application standards that provide flexible frameworks for designers of specific uses of the ZigBee wireless technology.

The standard permits the setup of a home-area network of ZigBee-enabled devices to monitor power usage, turn appliances on or off, control lighting, and monitor and control home devices from anywhere in the world via the Internet with a smart phone. It emphasizes easy DIY installation and uses ZigBee mesh networking feature to make it easy to add or remove controlled or monitored items. ZigBee uses the popular unlicensed 2.4-GHz spectrum and fully coexists with Wi-Fi to minimize interference.

The new 1.2 version of the standard adds several important new features that improve the battery life for security sensors to over seven years, standardize device pairing, and simplify installation and maintenance for consumers and installers alike. The new features should have a major impact on operational and device costs to service providers and quality of service (QoS) to consumers.

Some of the version 1.2 enhancements include support for new devices like door locks, smart appliances, and electrical measurement devices. These added features benefit consumers by integrating new devices and raising consumer awareness of energy usage without necessarily connecting to the electric utility.

III. RELATED WORK

The Zigbee controller system consists of EM357 Zigbee module and MSP430 Microcontroller. Initially we developed the ZigBee controller with ZigBee Cluster Commands (ZCL) by which we can control the third party end devices which support Home Automation 1.2 profile. By using those ZCL commands we developed the Zigbee APIs and wrote the code on the MSP430 microcontroller which is used as host controller. For testing purpose initially we send those Zigbee APIs from the PC hyper terminal and we observed the results by controlling third party devices from the hyper terminal of PC. Later we replace the hyper terminal by Wi-Fi module and entire system will be placed on Smart Hub.
The main objective is simple, efficient, and cost effective to detect and control third party ZigBee devices which support only Home Automation 1.2 Profile. The Smart Hub acts like a medium between the users (Mobile Application) and the end devices which supports Home Automation 1.2 profile (like On-Off devices, Thermostats, Multi Sensors etc). This can be done using ZigBee Controller along with the Host Controller (MSP430 Microcontroller). The Block Diagram of the system is shown below in Figure 1. It consists of MSP430 Host Microcontroller, EM357 ZigBee controller module and End ZigBee Home Automation 1.2 Profile supported devices.

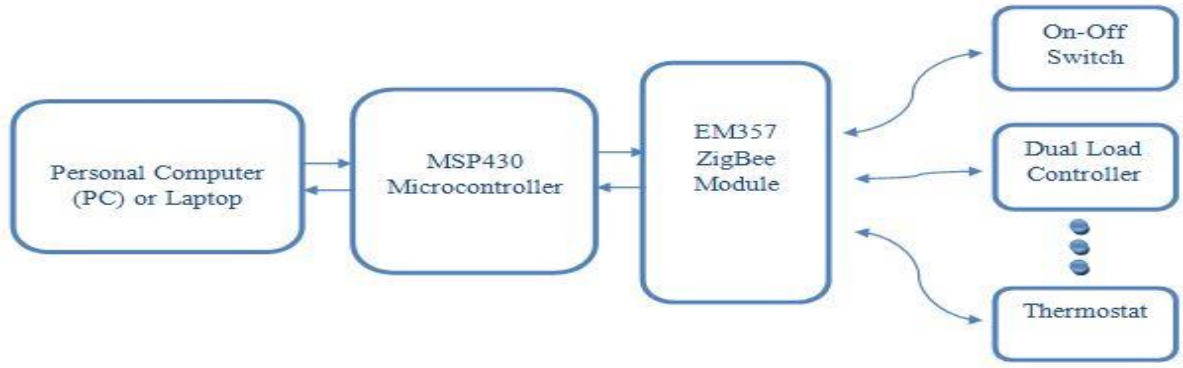


Figure 1. Block diagram of system with ZigBee Home Automation 1.2 profile supported third party devices

IV. DESCRIPTION OF HARDWARE

Now, we are going to discuss about the EM357 ZigBee Module, MSP430x Microcontroller and Wi-Fi Module in this part.

4.1 EM357 Zigbee Module Interfacing

A wireless technology like Zigbee (XBEE pro) works on standard IEEE 802.15.4 protocol [5] & operates on unlicensed bands worldwide at the frequency ranging from 2.400-2.484GHz, 902-928MHz and 868.0-868.6MHz. It is Low cost, low power (3.3Volts), and can provide up to 65000 nodes with an AES encryption standard for communication, this is the main advantage of Zigbee (Fig. 7) [5].
The EM35x Module **(**Figure 3) contains the Ember EM35x System-on-Chip (SoC) solution providing a complete radio and microcontroller solution. All modules are pin-compatible, and they can be directly attached to a Breakout Board.
The EM35x module is used together with the Development Kit Breakout Board to prototype customer hardware, and to develop and debug application software.

Figure 2. EM35X Module (ZICM357SP2-1)

EM357 Mini Modules ZICM357SP2-1 is based on the Ember EM357 ZigBee compliant SoC radio IC. The IC is a single-chip solution, compliant with ZigBee specifications and IEEE 802.15.4, a complete wireless solution for all ZigBee applications. The IC consists of an RF transceiver with the baseband modem, a hardwired MAC and an embedded 32-bit ARM® Cortex™-M3 microcontroller with internal RAM (12kB) and Flash (192kB) memory. The device provides numerous general-purpose I / O pins and peripheral functions such as timers and UARTs. There are totally 33 edge I/O interfaces.

4.2 MSP430 Microcontroller Interfacing

The MSP430 controller can act as sensor hub and monitor user stimuli and vital system parameters like battery health and temperature, while power-hungry application processor and touch screen controller are turned off [6]. The microcontroller can then "wake up" the system based on a user input or on a fault condition that requires CPU intervention.
Compared to the MSP430F522x, the MSP430F525x provides up to four times more RAM (32KB) and double the serial interfaces (four USCI_A and four USCI_B). The MSP430F525x also features four 16-bit timers, a high-performance 10-bit analog-to-digital converter (ADC), a hardware multiplier, DMA, a comparator, and a real-time clock (RTC) module with alarm capabilities. The MSP430F525x consumes 290 µA/MHz (typical) in active mode running from flash memory, and it consumes 1.6 µA (typical) in standby mode (LPM3). The MSP430F525x can switch to active mode in 3.5 µs (typical), which makes it a great fit for "always-on" low-power applications.
Key benefits of the MSP430F525x are as follows:

- Up to 32KB of RAM allows complex sensor hub algorithms and high levels of aggregation such as keyboard control and power management.
- Four USCI_A and four USCI_B allow for eight concurrent dedicated hardware serial interfaces (for example, four I^2C and four SPI) for fast and robust communication to sensors or peripheral devices.
- Up to 35 I/Os that can be used in the 1.8-V voltage rail.

Figure 3. MSP430F5255 Controller

V. SOFTWARE DETAILS

5.1 Ember Desktop

Ember Desktop network analyzer utility is the most integrated ZigBee® network application development and debugging tool available to OEMs today. By providing developers a complete view of the network in a graphical interface, the network analyzer helps to significantly accelerate the creation of ZigBee applications. The network analyzer is built on the popular open source Eclipse IDE framework to ensure easy creation and use of additional plug-ins. The below figure shows the Ember Desktop working window.

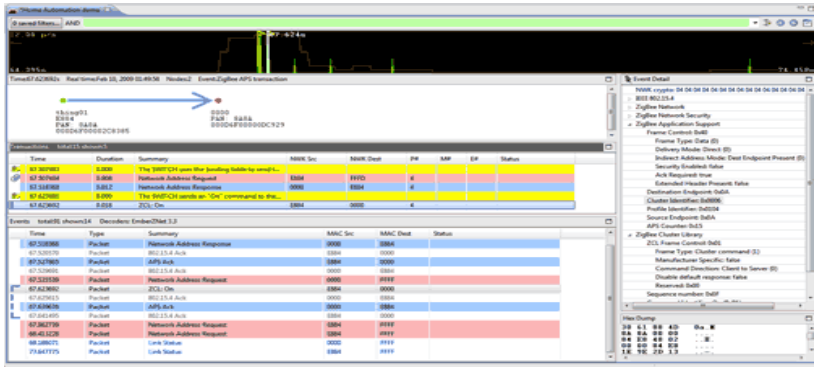


Figure 4. Ember Desktop

5.2 EmberZNet Stack

The EmberZNet PRO ZigBee networking protocol stack is a complete ZigBee protocol software package containing all the elements required for robust and reliable mesh networking applications on Silicon Labs Ember platforms.

The ZigBee Protocol stack which contains different layers is shown in the Figure 6.

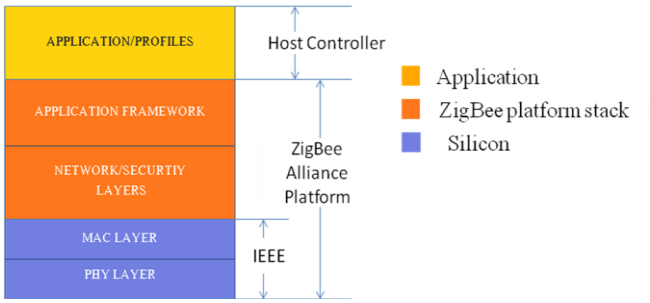


Figure 5. ZigBee Protocol Stack

5.3 IAR Embedded Workbench

IAR Embedded Workbench is a complete debugger and C/C++ compiler tool chain for building and debugging embedded applications based on various microcontrollers.

Debugger is a fully integrated debugger for source and disassembly level debugging with support for complex code and data breakpoint.

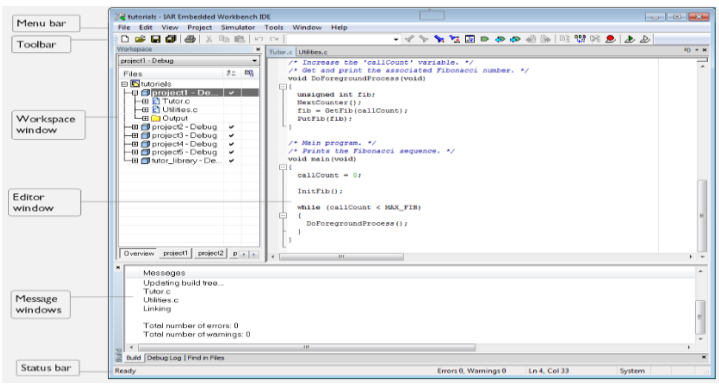


Figure 6. IAR Embedded Workbench IDE Window

5.4 Code Composer Studio

Code Composer Studio is an integrated development environment (IDE) that supports TI's Microcontroller (like MSP Low Power MCUs, C2000 Real-time MCUs and C3x/4x DSPs etc.) and Embedded Processors portfolio. Code Composer Studio comprises a suite of tools used to develop and debug embedded applications. It includes an optimizing C/C++ compiler, source code editor, project build environment, debugger, profiler, and many other features.

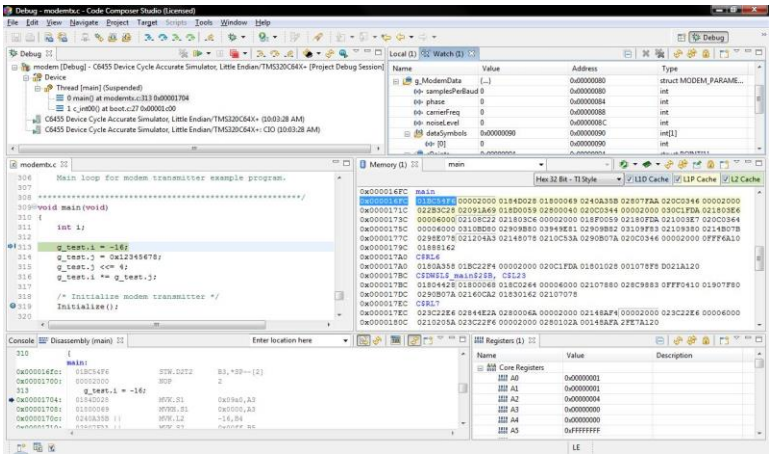


Figure 7. Code Composer Studio IDE Window

Detailed flow for the working of whole system shown in Figure 8.

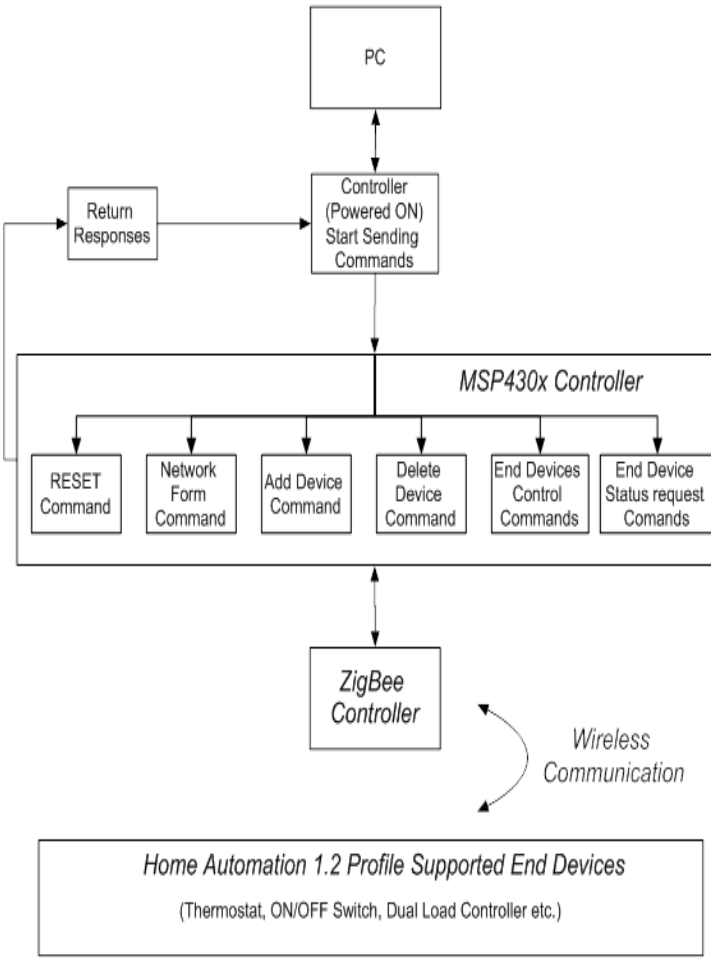
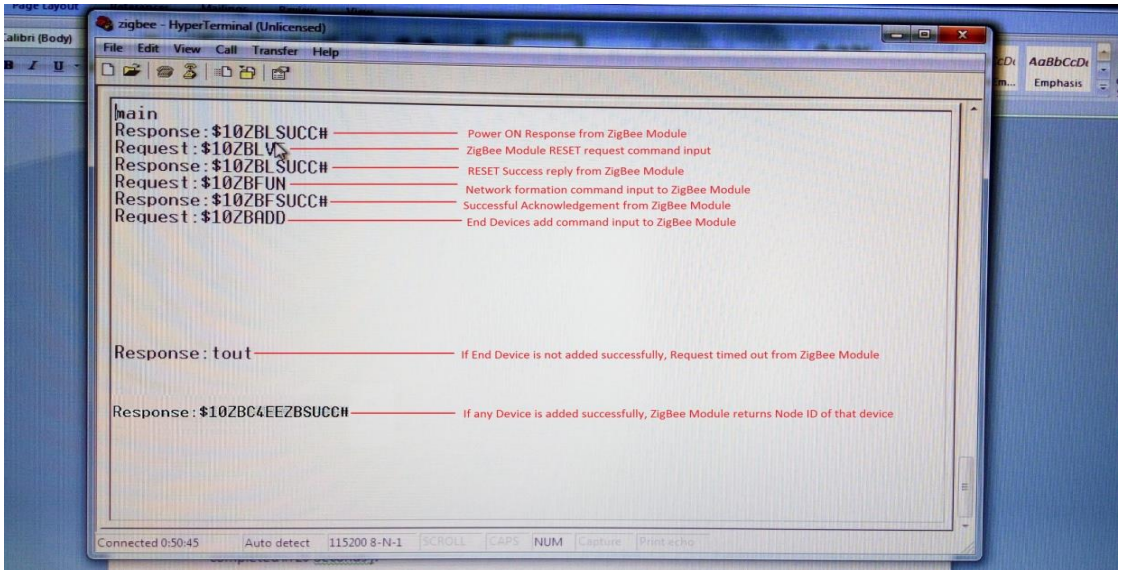


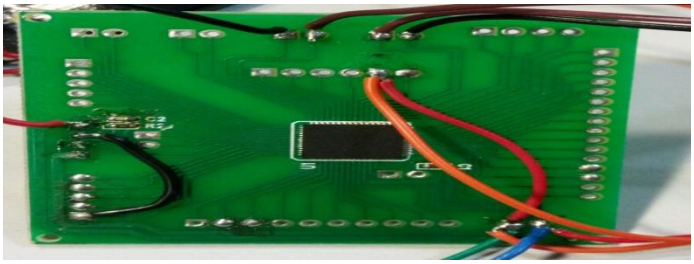
Figure 8. Work Flow the entire System

VI. RESULTS



PC Hyper Terminal Output Screen

MAX232 Board



MSP430 Microcontroller Board

ZigBee Module Board

Figure 9. Overview of entire system

VII. CONCLUSION

This Work describes the development of ZigBee controller with Home Automation 1.2 profile for Smart Hubs. The hardware and software which is used is explained in a detailed way. This ZigBee Controller can be used in any Smart Hubs to control the End devices and also used separately in homes by sending the control commands through Personal Computer. Further improvement to this work is addition of Wi-Fi module, So that the end devices can be controlled locally as well as remotely

REFERENCES

[1]. Z. Shunyang X. Du, J. Yongping and W. Riming, "Realization of Home Remote Control Network Based on ZigBee", Proceedings of the 8th International Conference on Electronic Measurement and Instruments, (2007), August 16-18, Xian, China.
[2]. A Fang, X. Xu, W. Yang and L. Zhang, "The Realization of Intelligent Home by ZigBee Wireless Network Technology", Proceedings of the 2009 Pacific-Asia Conference on Circuit, Communications and System, (2009), May 16-17, Chengdu, China.
[3]. http://www.zigbee.org/zigbeealliance/
[4]. http://www.ti.com/product/MSP430F5255

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