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Remote Control System of Smart Appliances Based on Wireless Sensor Network

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ABSTRACT

Diversification of remote control mode is the inevitable trend of development of smart appliances. In this paper we designed and developed a remote control system of smart appliances based on ZigBee wireless sensor network, realizing the diversification of remote control mode of smart appliances. The ZigBee technology is used to form a control network of household appliances within the house, two remote control networks of Internet and SMS are set up with the network interface module and GSM module. Status of the home appliances can be queried and controlled through either the remote PC interface or mobile phones. The experimental results show that: the system is reliable and can realize the remote control and inquiry of household appliances. The system has the advantages of convenient in control, flexible in adding new devices.

INTRODUCTION

The advancement of remote control made development of smart appliances. The main object of this project is to provide a wireless communication link of home appliances to the remote user. This project is about controlling home appliances through wireless networks, there are two different approaches which controls the smart appliances, one through GSM network and other through Internet.

The complete project is divided into three sections Application section, Information processing section and controlling/monitoring section. Traditional way of closed system is also included by providing key at zigbee nodes. The operational parameters from application section is shared by zigbee to information processing section where these parameters are continually compared and the changed parameter values are transferred to the remote location from where we can control these smart appliances.

With the development of science and technology, Modern home environment is paid more and more attention. The number of functions has been growing; nevertheless smart appliances have formed "isolated islands" of the information, which become the bottleneck in the development of smart appliances. In addition operation near the appliances is required in traditional control mode, which limits the scope of activities. Sums up the development status and analyses exiting problems of remote control system of smart appliances and then puts forward that the future trends of system will be reflected in the following three aspects: Networking technology from wired to wireless, diversification of remote control mode, energy-saving and smart will lead the new trend.

Therefore, diversification of remote control mode is the inevitable trend of development of smart appliances. It's an important part of smart home. Remote control system of smart appliances mainly consists of two parts: household internal control network and remote control network. Traditional household internal control network is generally implemented through wiring. This method is not only troublesome but also has poor scalability. Wireless network technology becomes new trends with its simple and convenient networking. ZigBee technology characterizes good security, high reliability.

We have developed a remote control system of smart appliances based on wireless sensor network, applying the rapid developing mobile network and Internet to the field of remote control. The system uses a high-performing, low-costing, low-consuming chip LPC2148 as information processing center, without the high-costing PC as a local server. ZigBee technology is adopted to form household internal control network instead of the cumbersome wiring. This method requires no wiring, has a

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short installation period and is convenient to move and add network node. Traditional key an infrared control is included but reformed to make a diverse and various control modes. Each remote control mode has account login and information matching settings to add to security of the system.

SYSTEM ARCHITECTURAL DESCRIPTION

ARM7 Family

The ARM7 family includes the ARM7TDMI, ARM7TDMI-S, ARM720T, and ARM7EJ-S processors. The ARM7TDMI core is the industry's most widely used 32-bit embedded RISC microprocessor solution. Optimized for cost and power-sensitive applications, the ARM7TDMI solution provides the low power consumption, small size, and high performance needed in portable, embedded applications.

The ARM7TDMI-S core is the synthesizable version of the ARM7TDMI core, available in both VERILOG and VHDL, ready for compilation into processes supported by in-house or commercially available synthesis libraries. Optimized for flexibility and featuring an identical feature set to the hard macro cell, it improves time-to-market by reducing development time while allowing for increased design flexibility, and enabling >>98% fault coverage. The ARM720T hard macro cell contains the ARM7TDMI core, 8kb unified cache, and a Memory Management Unit (MMU) that allows the use of protected execution spaces and virtual memory. This macro cell is compatible with leading operating systems including Windows CE, Linux, palm OS, and SYMBIAN OS.

The ARM7EJ-S processor is a synthesizable core that provides all the benefits of the ARM7TDMI – low power consumption, small size, and the thumb instruction set – while also incorporating ARM's latest DSP extensions and Jazelle technology, enabling acceleration of java-based applications. Compatible with the ARM9™, ARM9E™, and ARM10™ families, and Strong-Arm® architecture software written for the ARM7TDMI processor is 100% binary-compatible with other members of the ARM7 family and forwards-compatible with the ARM9, ARM9E, and ARM10 families, as well as products in Intel's Strong ARM and xscale architectures. This gives designers a choice of software-compatible processors with strong price-performance points.

Figure shows the ARM7TDMI Core Diagram. The ARM7TDMI core is based on the Non Neumann architecture with a 32-bit data bus that carries both instructions and data. Load, store, and swap instructions can access data from memory. Data can be 8-bit, 16-bit, and 32-bit

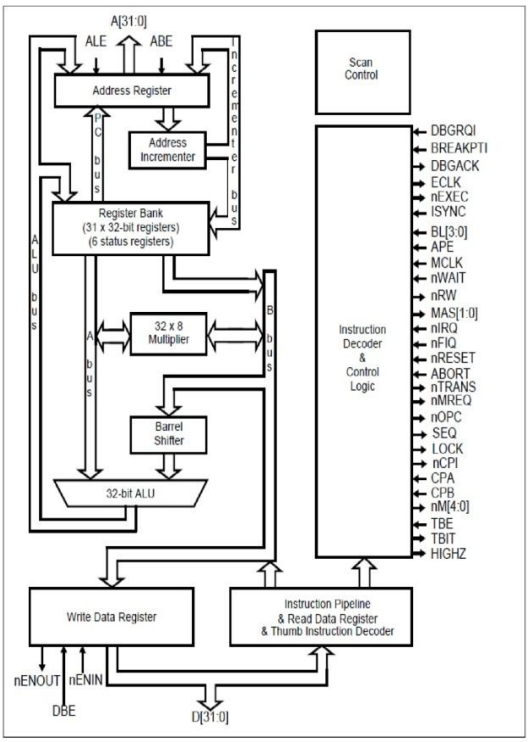

Fig. *ARM7 TDMI Core Diagram*

The ARM7TDMI core uses a three-stage pipeline to increase the flow of instructions to the processor. This allows multiple simultaneous operations to take place and continuous operation of the processing

and memory systems.

The ARM7TDMI memory interface is designed to allow optimum performance potential and minimize memory usage. Speed critical control signals are pipelined to allow system control functions to exploit the fast-burst access modes supported by many memory technologies.

Processor States

The ARM7TDMI processor can be in one of two states:

- ARM state
- THUMB STATE

In ARM state, 16 general registers and one or two status registers are accessible at any one time. The ARM state register set contains 16 directly accessible registers: R0 to R15. All of these except R15 are general-purpose, and may be used to hold either data or address values.

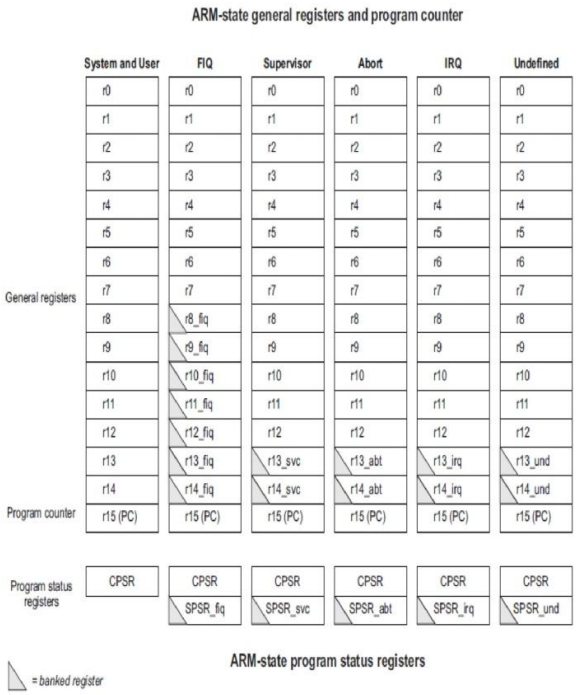

Fig. *Register Organization in ARM state*

THUMB State

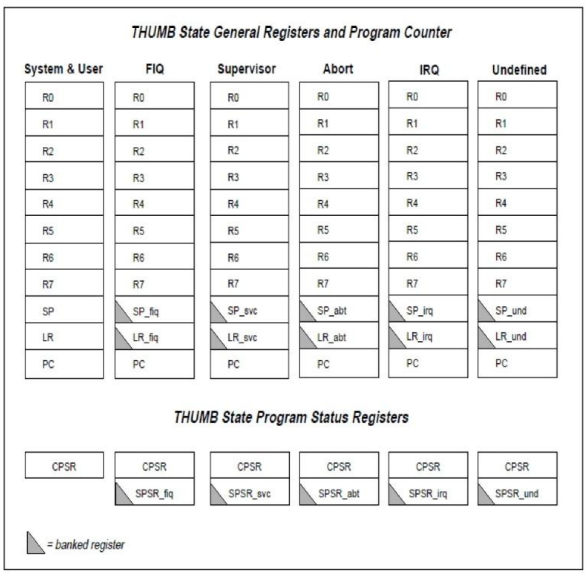

Fig. *Register Organization in THUMB state*

System Issues and Third Party Support

This section contains:

- JTAG debug
- AMBA bus architecture

JTAG Debug

The internal state of the ARM7TDMI is examined through a JTAG-style serial interface. This allows instructions to be serially inserted into the pipeline of the core without using the external data bus. For example, when in debug state, a Store-Multiple (STM) instruction can be inserted into the pipeline. This exports the contents of the ARM7TDMI registers. This data can be serially shifted out without affecting the rest of the system.

AMBA Bus Architecture

The ARM7 Thumb family processors are designed for use with the Advanced Microcontroller Bus Architecture (AMBA) multi-master on-chip bus architecture. AMBA is an open standard that describes a strategy for the interconnection and management of functional blocks that makes up a System-on-Chip (SoC).

The AMBA specification defines three buses:

- Advanced System Bus (ASB)
- Advanced High-performance Bus (AHB)
- Advanced Peripheral Bus (APB).

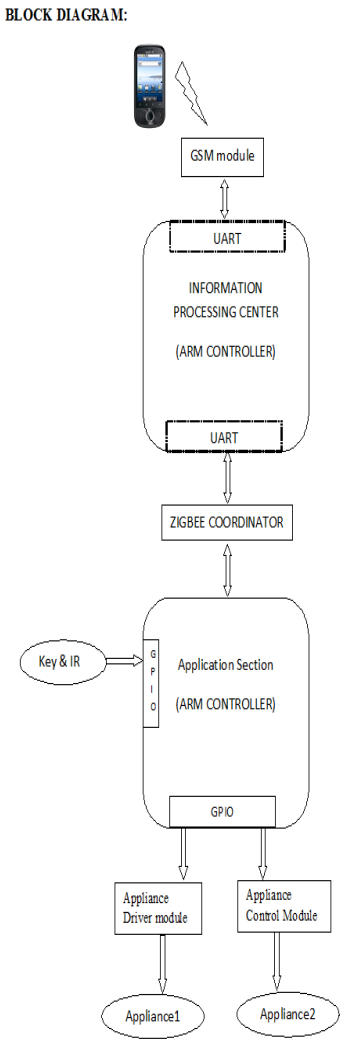

Fig. *Project Design*

ASB and AHB are used to connect high-performance system modules. APB offers a simpler interface for low-performance peripherals.

Using the ARMv7 architecture, ARM can strengthen its position as a low-power/performance leader while conquering new markets to carry its cores up in high performance and down in the low-cost high-volume domain of the microcontroller ARM designs the technology that lies at the heart of advanced digital products, from wireless, networking and consumer entertainment solutions to imaging, automotive, security and storage devices.

ARM's comprehensive product offering includes 16/32-bit RISC microprocessors, data engines, 3D processors, digital libraries, embedded memories, peripherals, software and development tools, as well as analog functions and high-speed connectivity products.

MODULES DESCRIPTION

LPC2148 Microcontroller

LPC2148 microcontroller board based on a 16-bit/32-bit ARM7TDMI-S CPU with real-time emulation and embedded trace support, that combine microcontrollers with embedded high-speed flash memory ranging from 32 kB to 512 kB. A 128-bit wide memory interface and unique accelerator architecture enable 32-bit code execution at the maximum clock rate. For critical code size applications, the alternative 16-bit Thumb mode reduces code by more than 30% with minimal performance penalty. The meaning of LPC is Low Power Low Cost microcontroller. This is 32 bit microcontroller manufactured by Philips semiconductors (NXP).

Features

- 16bit/32bit ARM7TDMI-S microcontroller in a tiny LQFP64 package.
- 40kB of on-chip static RAM and 512kB of on chip flash memory.
- In System programming/In application programming via on chip boot loader software.
- USB 2.0 full speed compliant device controller with 2kB of endpoint RAMS.
- In addition, the LPC2148 provides 8kB of on chip RAM accessible to USB by DMA.
- Two 10-bit ADCs provide a total of 14 analog inputs, with conversion times as low as 2.44 ms per channel.
- Single 10-bit DAC provides variable analog output.
- Two 32-bit timers/external event counters (with four capture and four compare channels each), PWM unit (six outputs) and watchdog.
- Low power Real-Time Clock (RTC) with independent power and 32 kHz clock input.
- Up to 45 of 5 V tolerant fast general purpose I/O pins in a tiny LQFP64 package.
- Up to 21 external interrupt pins available.
- 60 MHz maximum CPU clock available from programmable on-chip PLL with settling time of 100 ms.
- On-chip integrated oscillator operates with an external crystal from 1 MHz to 25 MHz and Power saving modes includes Idle and Power-down.
- Individual enable/disable of peripheral functions as well as peripheral clock scaling for additional power optimization.
- Processor wake-up from Power-down mode via external interrupt or BOD.
- CPU operating voltage range of 3.0 V to 3.6 V (3.3 V ± 10 %) with 5 V tolerant I/O.

ZIGBEE

The XBee/XBee-PRO RF Modules are designed to operate within the ZigBee protocol and support the unique needs of low-cost, low-power wireless sensor networks. The modules require minimal

power and provide reliable delivery of data between remote devices. The modules operate within the ISM 2.4 GHz frequency band and are compatible with the following:

- XBee RS-232 Adapter
- XBee RS-232 PH (Power Harvester) Adapter
- XBee RS-485 Adapter
- XBee Analog I/O Adapter
- XBee Digital I/O Adapter
- XBee Sensor Adapter
- XBee USB Adapter
- XStick
- Connect Port X Gateways
- XBee Wall Router.

The XBee/XBee-PRO ZB firmware release can be installed on XBee modules. This firmware is compatible with the ZigBee 2007 specification, while the ZNet 2.5 firmware is based on Ember's proprietary "designed for ZigBee" mesh stack (EmberZNet 2.5). ZB and ZNet 2.5 firmware are similar in nature, but not over-the-air compatible. Devices running ZNet 2.5 firmware cannot talk to devices running the ZB firmware.

The XBee modules were designed to mount into a receptacle (socket) and therefore do not require any soldering when mounting it to a board. The XBee-PRO Development Kits contain RS- 232 and USB interface boards which use two 20-pin receptacles to receive modules

Key Features

- High Performance, Low Cost
- Advanced Networking & Security
- Low Power
- Easy-to-Use

UART Data Flow

Devices that have a UART interface can connect directly to the pins of the RF module as shown in the figure below.

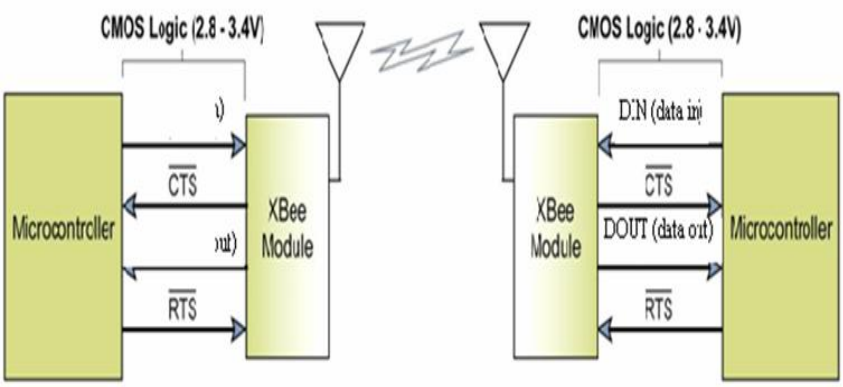

Fig1. *Zigbee UART Dataflow*

Data enters the module UART through the DIN (pin 3) as an asynchronous serial signal. The signal should idle high when no data is being transmitted. Each data byte consists of a start bit (low), 8 data bits (least significant bit first) and a stop bit (high). The following figure illustrates the serial bit pattern of data passing through the module.

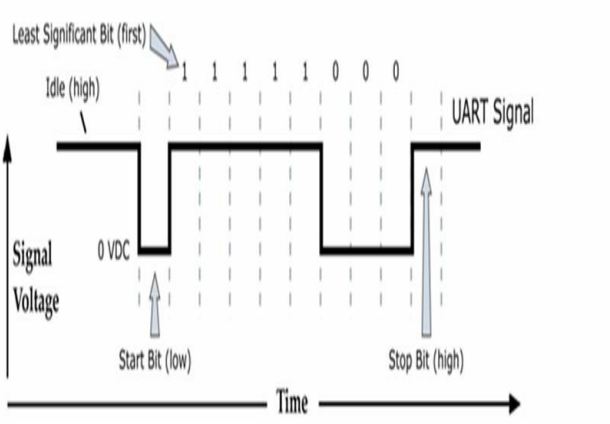

Fig. *Serial Data Format*

The module UART performs tasks, such as timing and parity checking, that are needed for data communications. Serial communications depend on the two UARTs to be configured with compatible settings (baud rate, parity, start bits, stop bits, data bits).

GSM

Global system for mobile communication (GSM) is a globally accepted standard for digital cellular communication. GSM is the name of a standardization group established in 1982 to create a common European mobile telephone standard that would formulate specifications for a pan-European mobile cellular radio system operating at 900 MHz's GSM provides recommendations, not requirements. The GSM specifications define the functions and interface requirements in detail but do not address the hardware. The reason for this is to limit the designers as little as possible but still to make it possible for the operators to buy equipment from different suppliers. The GSM network is divided into three major systems: the switching system (SS), the base station system (BSS), and the operation and support system (OSS). The basic GSM network elements are shown in below *figure*

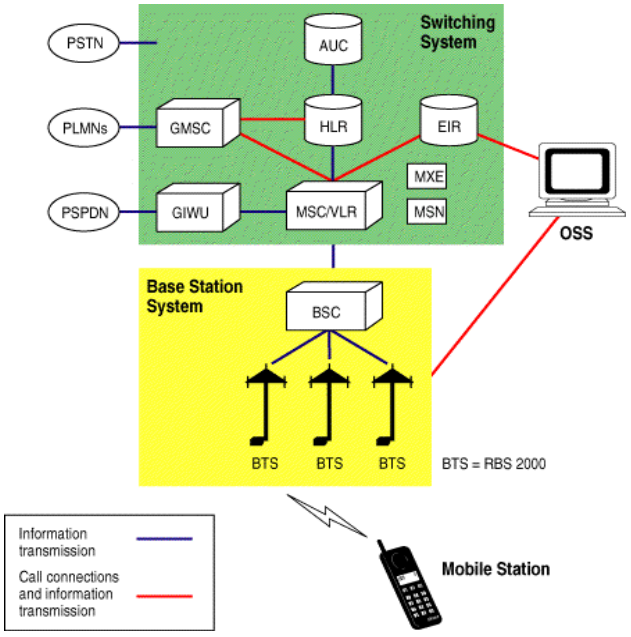

Fig. *GSM Network Elements*

A GSM modem is a wireless modem that works with a GSM wireless network. A wireless modem behaves like a dial-up modem. The main difference between them is that a dial-up modem sends and receives data through a fixed telephone line while a wireless modem sends and receives data through radio waves.

A GSM modem can be an external device or a PC Card / PCMCIA Card. Typically, an external GSM modem is connected to a computer through a serial cable or a USB cable. A GSM modem in the form of a PC Card / PCMCIA Card is designed for use with a laptop computer. It should be inserted into

one of the PC Card / PCMCIA Card slots of a laptop computer. Like a GSM mobile phone, a GSM modem requires a SIM card from a wireless carrier in order to operate.

As mentioned in earlier sections of this SMS tutorial, computers use AT commands to control modems. Both GSM modems and dial-up modems support a common set of standard AT commands. You can use a GSM modem just like a dial-up modem.

CONCLUSION

On the basis of thorough research of ZigBee protocol, and GSM communication technology, we design and develop two types of remote control method using ARM-7 based on the high-performing, high-code-density kernel as the information processing center and adopting ZigBee module to form household internal control. We also develop a succinct functional interface in host computer.

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