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Low-power Wireless Security System in the Home Automation

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Abstract: Wired networking has been used in home automation for many years and proven to be reliable. Wireless has only recently become a viable option for home automation thanks to improved reliability and reduced cost. Today there are many scenarios where wireless is a viable and preferable option, such as hard-to-wire or expensive-to-wire locations, interconnecting multiple buildings, and need for mobility.

The home automation system is usually installed in building that monitors and controls devices like environment and energy managing, appliances switching, fire alarming as well as access and security controlling. For design the hardware of wireless security system, the electronic component CC1101 of Texas Instruments has been selected as the core of the device RF receiver / transmitter with frequency 433 Mhz. This is a modern component, low-cost, low power and it was designed specifically for wireless applications and suitable for connection control devices in the home automation. This idea has been being realized at a project KC03.DA12/11-15 in the University of Engineering and Technology, Vietnam National University in Hanoi.

Keywords: Wireless networking, building automation, RF transmitter, microcontroller, SPI interface.

1. Introduction

All buildings have some form of mechanical and electrical services in order to provide the facilities necessary for maintaining a comfortable working environment. The buildings today not only tend to have modern design, they are also equipped with many high-technology equipment. The designed home automation system includes subsystems as follows:

- HVAC subsystem (Heating, Ventilating, Air - Conditioning) with sensors of temperature, humidity, air flow and carbon dioxide provides automatic cooling, ventilation and drying control for a specific zone in the house.

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- Lighting subsystem controls lamps using local push buttons, moving detection or based on illumination level (darkness).
- Appliances control subsystem permits to turn on and off specified devices from inside and outside of the building by SMS messages or via internet. Efficient using of these appliances enables to minimize cost and preserve the environment.
- Energy management subsystem measures the electric consumption like HVAC, lighting, water pumping subsystems. Consumption measurements transfer regularly the power consumption data to a central computer.
- Electronic security system monitors doors, windows and all areas in the house. The system is equipped with magnetic- sensors, glass-breaking sensors, gas detector and all possible intrusions can be detected and signified by SMS messages or via the webserver. Security cameras permit the manager to watch what is going on around a building.

The main advantages of designed home automation system are economy of maintenance and running costs, time saving, increased level of comfort and safety. An efficient home automation system brings us greater levels of convenience in our living environments.

2. Hardware design

The wireless Security System is designed with CC1101, this is a low-cost sub-1GHz transceiver designed for very low-power wireless applications. A simplified block diagram of CC1101 is shown in Figure 1.

The received RF signal is amplified by the low-noise amplifier (LNA) and down converted in quadrature (I and Q) to the intermediate frequency (IF). At IF, the I/Q signals are digitized by the ADCs. Automatic gain control (AGC), fine channel filtering, demodulation, and bit/packet synchronization are performed digitally [1].

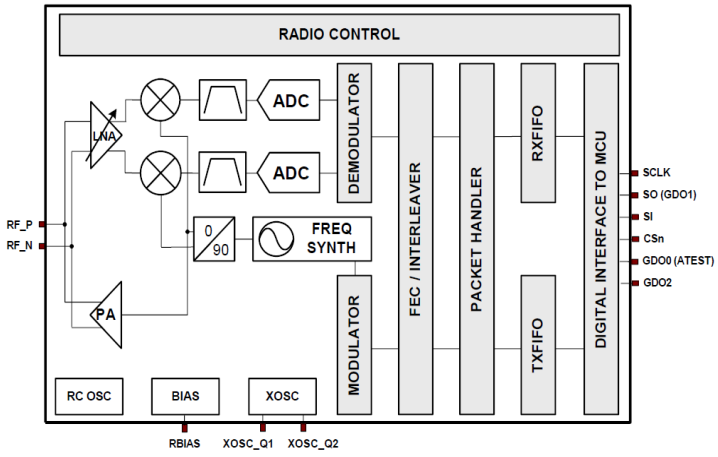

Figure 1. CC1101 Block Diagram [2].

The transmitter part of CC1101 is based on direct synthesis of the RF frequency. The frequency synthesizer includes a completely on-chip LC VCO and a 90 degree phase shifter for generating the I and Q LO signals to the down-conversion mixers in receive mode [3].

A crystal is to be connected to XOSC_Q1 and XOSC_Q2. The crystal oscillator generates the reference frequency for the synthesizer, as well as clocks for the ADC and the digital part.

A 4-wire SPI serial interface is used for configuration and data buffer access.

The digital baseband includes support for channel configuration, packet handling, and data buffering.

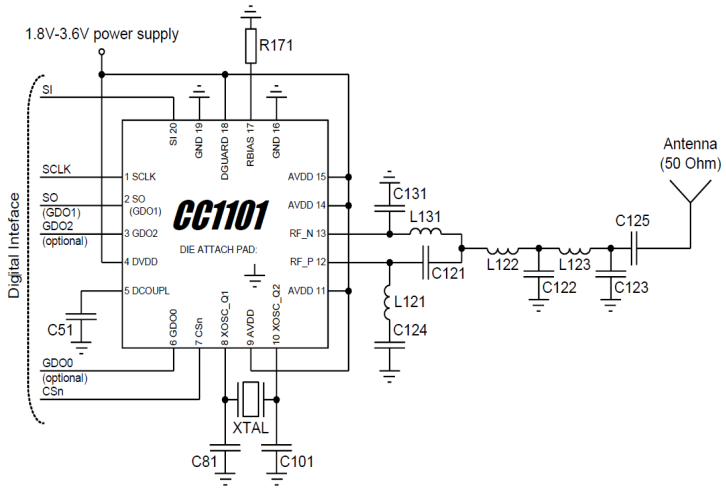

Figure 2. Typical Circuit with IC CC1101 with frequency 433 MHz.

The brief hardware features of RF sensor's board in the security system are as follows:

- CPU: Low-power 8-bit Microcontroller Atmega8, crystal 8 MHz, 32-lead TQFP [4].
- Memory: 8k Bytes Flash, 512K Bytes Internal SRAM, 512K Bytes EEPROM
- 8-channel ADC in TQFP, Eight Channels 10-bit Accuracy
- Byte-oriented Two-wire Serial Interface and supports SPI interface
- High sensitivity in -116 dBm at 0.6 kBaud, 433 MHz, 1% packet error rate.
- Low current consumption (14.7 mA in RX,
- 1.2 kBaud, 868 MHz)
- Programmable output power up to +12
- dBm for all supported frequencies
- 200 nA sleep mode current consumption
- Operating Voltages: 3.3 VDC.

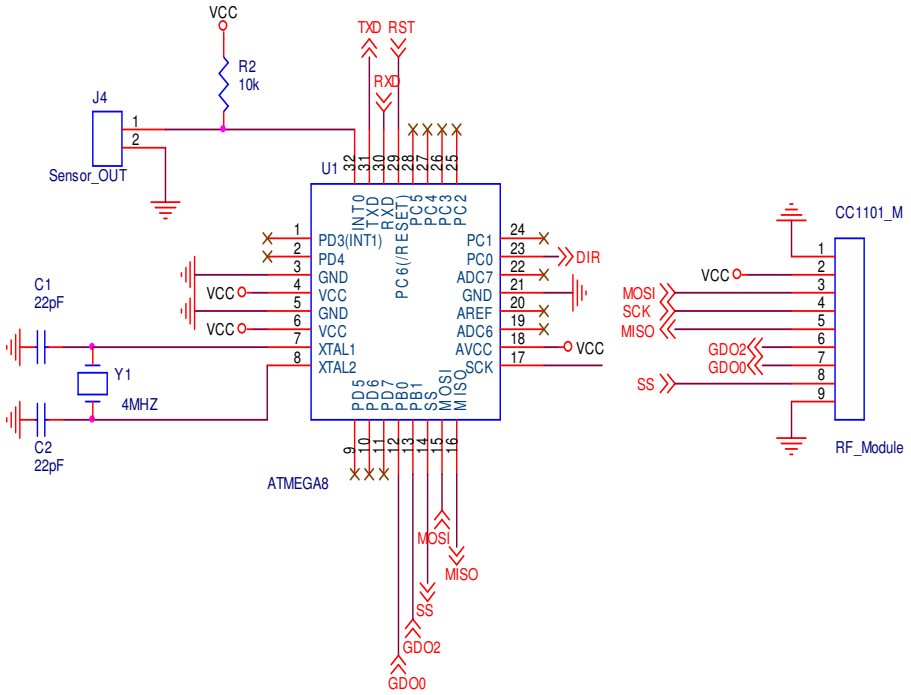

Figure 3. Microcontroller Atmega8 connector to CC1101 module.

3. Functions of embedded software

The source program was written in C language and compiled with AVR CodeVision C compiler. It is an IDE for AVR chips having built-in software for STK200 compatible programmer. CC1101 is configured via a simple 4-wire SPI compatible interface (MISO, MOSI, CLK and SS) where CC1101 is the slave [5]. This interface is also used to read and write buffered data. All transfers on the SPI interface are done most significant bit first. All transactions on the SPI interface start with a header byte containing a R/$\overline{W}$ bit, a burst access bit (B), and a 6-bit address (A5 – A0) [6].

The SS pin must be kept low during transfers on the SPI bus. If SS goes high during the transfer of a header byte or during read/write from a register, the transfer will be cancelled. The timing for the address and data transfer on the SPI interface is shown in Figure 4. When SS is pulled low, the MCU must wait until CC1101 MISO pin goes low before starting to transfer the header byte. This indicates that the crystal is running.

CC1101has be configured using the Smart RF Studio software to obtain optimum register settings and evaluate performance and functionality. The optimum register setting might differ from the default value. After a reset all registers that shall be different from the default value therefore needs to be programmed through the SPI interface [7].

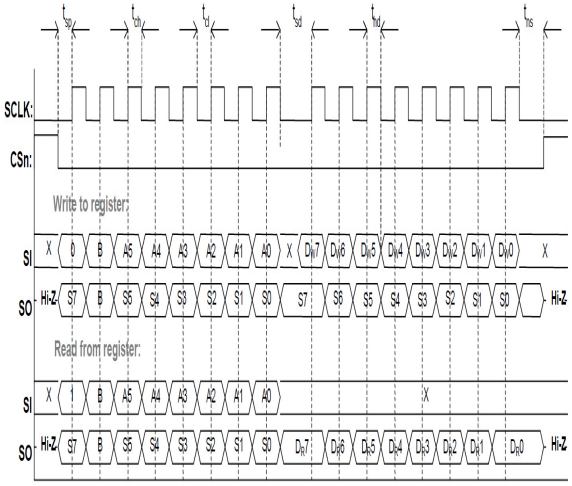

Figure 4. Configuration Registers Write and Read Operations.

The embedded software in our project had been developed with more than 8000 instructions and ensures the following functions:

- Periodical scanning the of the signal from sensor's board (digital inputs and reading of the values from analog inputs).
- Ensuring the wireless communication in 433 MHz frequency between the sensor's board and floor control unit in the home automation system.
- Testing, if the analog values run over the limit or digital inputs change from high to low (PIR sensor and magnetic contactors are active), it will dial and send SMS to other user-defined mobile phone.
- Active the electrical appliances and actuator according the define algorithm.

4. Conclusion

In this report, the hardware schematic and embedded software development were provided to be an exemplary design and programming of AVR microcontrollers with RF transceivers. The designed board improves the microcontroller communication capability. For the real world, the designed sensor's board can work as data acquisition module in home automation or cost-effectively module integrated to alarm system.

5. Acknowledgement

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