

Implementing ZigBee®/IEEE 802.15.4 Solutions Based on Radiocrafts modules

by Ø. Nottveit

Introduction

Radiocrafts offers a family of miniature modules intended for radio networks based on the IEEE 802.15.4 and ZigBee standards. This application note discusses issues related to implementing a product using these modules. A basic knowledge of the ZigBee standard is assumed in the following discussion.

Radiocrafts offers complete module solutions with application firmware or pure hardware solutions that support several firmware development platforms, as described in the following.

Hardware solutions

Radiocrafts offers two different compact ZigBee-ready module platforms; the RC2201-series and the RC2300-series. The RC2201-series is the first generation module with an Atmel AVR microcontroller (MCU) together with the CC2420 TI/Chipcon RF transceiver. The RC2300-series is the second generation module based on the CC2430 system-on-chip (SoC) from Texas Instruments.

The RC2201HP is similar to the RC2201, but does include a power amplifier, switches and extra filtering for increased output power and communication range.

What do the modules contain?

An overview of what the modules contain is shown in table below.

Module	Microcontroller	Tranceiver	Antanna options	Power amplifier
RC2300	CC2430 (8051)	CC2430	External/chip antenna	No
RC2301	CC2431 (8051)	CC2431	External/chip antenna	No
RC2201HP	ATmega1281	CC2420	External/chip antenna	Yes
RC2200 (obsolete)	ATmega128L	CC2420	External/chip antenna /MMCX connector	No
RC2201	ATmega1281	CC2420	External/chip antenna /MMCX connector	No
RC2202	ATmega325	CC2420	External/chip antenna /MMCX connector	No
RC2204	ATmega64L	CC2420	External/chip antenna /MMCX connector	No

Firmware solutions

When developing the firmware you can chose to base it on an IEEE 802.15.4 PHY/MAC or on a complete ZigBee stack. Both variants are available and can be downloaded for free from Texas Instruments (www.ti.com) when used with Radiocrafts modules. For detailed information on this, see the chapters on tools below. The difference in the two stack options are illustrated in Figure 1. The 802.15.4 specifies a link between two devices including the physical layer and the medium access layer. The ZigBee protocol stack adds the network layer for routing/mesh and the application layer for interoperability between devices.

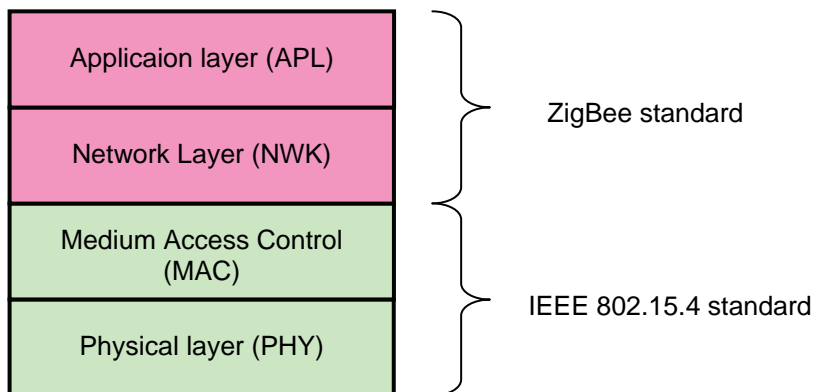


Figure 1. IEEE 802.15.4 and ZigBee protocol stack

ZigBee protocol stack

The ZigBee protocol stack recommended for our modules is the industry leading Z-stack from Texas Instruments. The IEEE 802.15.4 compatible MAC firmware (TI-MAC) can be used by customers that don't need the ZigBee mesh functionality. Both stacks can be downloaded free of charge from the TI website and comes as IAR projects. Complete documentation on the stacks is included in the download files.

What tools do I need to develop my own application on the RC230x series?

We recommend starting with one of the RC2300DK demo kits including demo boards that can be used for prototyping.

Several FW development tools can be used, but the EW8051 workbench from IAR is recommended as it's the only one supported by TI at the moment.

For programming and debugging Radiocrafts recommend the FlashPro-CC from Elprotronic (<http://www.elprotronic.com/flashproCC.html>).

As an option to the FlashPro-CC, the SmartRF04-EB from TI can also be used for programming and debugging. It is delivered with the CC2430 development kits from TI.

What tools do I need to develop my own application on the RC220x series?

We recommend starting with one of the RC2200DK demo kits including demo boards (DB) that can be used for prototyping.

There are several compilers available for the Atmel microcontrollers, among others the IAR compiler. For a complete overview of this please check the Atmel website (<http://www.atmel.com/products/AVR/thirdparty.asp>).

For programming the devices, one can do that from the compiler or use a dedicated program like AVR-studio (<http://www.atmel.com/avrstudio>).

For in-circuit programming and debugging a HW dongle is also required. Radiocrafts recommend the AVR JTAGICE mkII for that purpose. This is available through Atmel distributors.

The RC2201HP is a high power version of the RC220x series. It comes with an ATmega1281 MCU, and the SW and tools required developing the firmware is the same as for the RC220x series.

The Atmel AVR studio is used to download the compiled (hex file) into the microcontroller through the JTAG port. It can also be used for code debugging. The JTAGICE is connected between the PC USB port and the RC2200DB demo board JTAG connector (standard 10 pins connector) for programming / debugging. No extra cabling is needed.

Low power and battery operation

In a mesh network, do note that it is only a Reduced Functionality Device (RFD), i.e. the End Device, which can operate on battery power utilizing all power down features in the protocol and in the MCU itself. The Coordinator and all Routers must be powered all the time in a mesh network!

The RC220x and RC230x include a 32 kHz low power real-time clock (RTC) oscillator and several digital inputs with interrupt capability. These features can be used to wake the controller from sleep mode to active mode based on events. Using an interrupt pin for the light remote control is an obvious example. The start-up time of the module is in the order of 1-2 ms.

Issues on interoperability

In order to ensure interoperability between products from different manufacturers, several important points must be handled by the system architect, which is not specified in the ZigBee protocol itself. Some of these points are discussed below.

IEEE addressing

It is required that every node in the ZigBee network has a unique ID. This must be a 64 bit IEEE MAC address, same as used in Ethernet. A 24-bit Unique Organisation Identifier (UOI) address can be bought from the IEEE organization and will give a virtually unlimited number of devices by providing a 40 bits serial number.

All RC230x modules from Radiocrafts are shipped with a unique IEEE MAC address.

PAN ID

Each network must have a unique PAN ID. The ZigBee standard does not specify how this ID is chosen or given to a network. This is the sole responsibility of the application. Products from different manufactures must have the same PAN ID in order to inter-operate.

Radio channel selection

16 different radio channels are specified in the 2.45 GHz frequency band for ZigBee. For two devices to communicate they must use the same channel. The ZigBee standard does not specify how this channel is set or chosen in a network. This is the sole responsibility of the application. Products from different manufactures must have means to select the same channel in order to inter-operate.

Products made for 2.45 GHz will not be able to communicate with products made for 868/915 MHz even if both are using the ZigBee standard. 868 / 915 MHz are not global license-free frequencies and are not likely to be supported by many manufactures.

Security

ZigBee specify encryption based on symmetric key with AES-128. It provides authentication and encryption at MAC, NWK and application levels.

The distribution of keys is the sole responsibility of the application. Products from different manufactures must have means to select the same keys in order to inter-operate if using encryption.

Product approvals

There are two distinct approval regimes:

1. National regulations that must be met
2. Conformance Certification according to the ZigBee standard

First, national regulations are different from country to country. Some countries require the final product to be tested and approved by certified laboratories, while others work with self-declaration scheme. This kind of approval has nothing to do with the ZigBee standard. These regulations do not only apply for the RF transmission, but also EMC and safety of the product in general. See Texas Instruments AN001 for more information on this.

The RC220x and RC230x are designed to meet all national regulations for world-wide use.

Second, approval according to the ZigBee standard is required in order to make products from different manufacturers compatible. There are two types of ZigBee compliant products. Either it's compliant with a public profile (like HA and AMI) or it is compliant with a manufacturer specific profile. To have a product compliant to a manufacturer specific profile the profile must be registered with the ZigBee Alliance and given a profile identification number (Profile ID).

The steps involve in getting a ZigBee Compliant Product are:

- Become a member of the ZigBee Alliance
- Submit your product to certification at one of the two approved test houses
 - TUV Rheinland Group
 - National Technical Systems, Inc.
- The test report is sent to the ZigBee Alliance together with your application and gets a ZigBee compliant product approval there.

For more details on the certification process see ZigBee Alliance website. (www.zigbee.com)

Document Revision History

Document Revision	Changes
1.0	First release
2.0	Updated information on hardware and firmware offerings
3.0	Updated to include RC2300 and RC2201HP + general updates.

Trademarks

ZigBee® is a registered trademark of the ZigBee Alliance.

Contact Information

Web site: www.radiocrafts.com

Email: radiocrafts@radiocrafts.com
sales@radiocrafts.com
support@radiocrafts.com

Address:

Radiocrafts AS
Sandakerveien 64
NO-0484 OSLO
NORWAY

Tel: +47 4000 5195

Fax: +47 22 71 29 15