

RC2400/RC2400HP Firmware Development User Manual

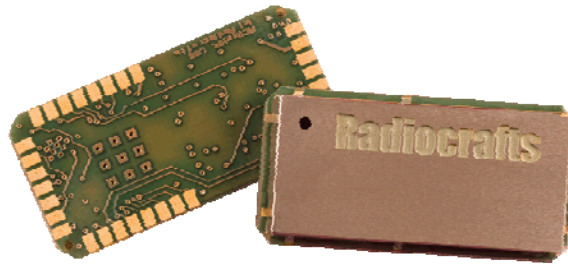


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Introduction

This document with references includes all required information to develop a customer-specific firmware solution on the RC2400/RC2400HP hardware platforms.

Documentation structure

This document is one part of the documentation for the module. The data sheet describes the electrical parameters, RF performance, footprint and PCB layout and regulatory information. Depending on the selected FW solution, additional User Manuals should be used. The available documents for the RC2400 product series are:

- RC2400/RC2400HP Data sheet
- RC2400/RC2400HP Firmware Development User Manual (this document)
- RC2400/RC2400HP-ZNM User Manual - Details on how to use the ZNM (ZigBee(R) Network Management) module with preloaded ZigBee Pro stack and API through serial interface.

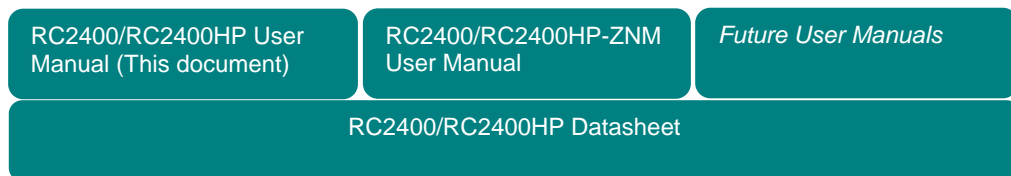


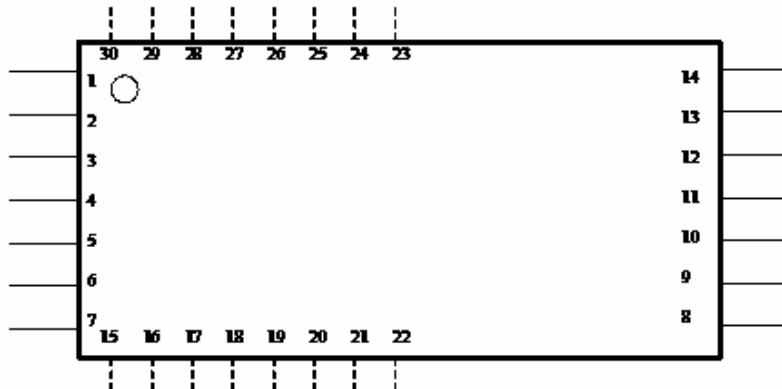
Figure 1 Document structure

Quick Product Introduction

The RC2400 series of modules are compliant with the IEEE 802.15.4 standard used by ZigBee PRO, 6LoWPAN and a number of other standards operating on IEEE 802.15.4. The module together with the TI Z-stack or any other ZigBee network implementation is a powerful combination for any ZigBee profile and application. The module contains qualified RF hardware and enough processor power to run the complete ZigBee mesh network protocol for a full function device including the application.

Using a pre-qualified module is the fastest way to make a ZigBee product with shortest time to market. With all the RF HW and MCU resources you need in a 100% RF tested and pre-qualified module the qualification and approval process is shortest possible. No RF design or expertise is required to add powerful wireless networking to any product. In the simplest case like a home light remote control you only need an external battery and a pushbutton.

Pin Assignment

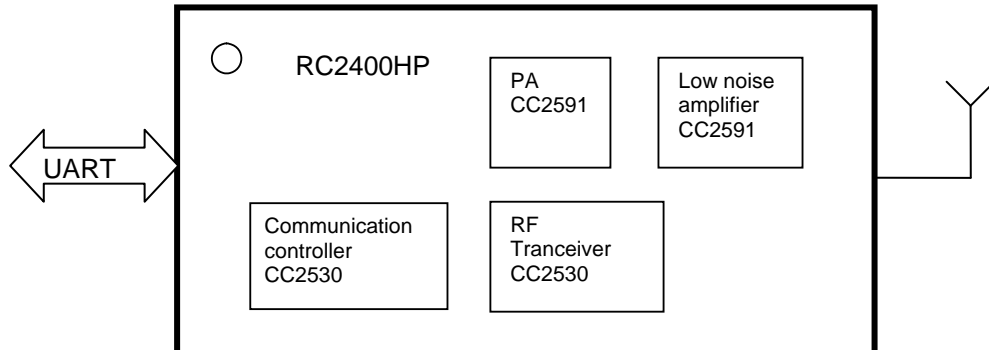


Pin Description

Pin no	Pin name	Description
1	GND	System ground
2	CTS/P0_4	CC2530 P0 [4]
3	RTS/P0_5/	CC2530 P0 [5]
4	P0_1	CC2530 P0 [1]
5	TXD/P0_3	CC2530 P0 [3]
6	RXD/P0_2	CC2530 P0 [2]
7	GND	System ground
8	GND	System ground
9	RF	RF I/O connection to antenna
10	GND	System ground
11	NC	Not Connected
12	RESET	CC2530 RESET_N. Active Low
13	VCC	Supply voltage input. Internally regulated.
14	GND	System ground
15	P0_7	CC2530 P0 [7]/HGM for RC2400HP
16	P1_2	CC2530 P1 [2]
17	P0_6	CC2530 P0 [6]
18	P2_0	CC2530 P2 [0]
19	P2_1/DD	Debug Data P2 [1]. Debug interface is used for programming.
20	P2_2/DC	Debug Clock P2 [2]. Debug interface is used for programming.
21	P0_0	CC2530 P0 [0]
22	P1_3	CC2530 P1 [3] /EN for RC2400HP
23	P2_4/32kHz_Q1	Internal 32 kHz crystal oscillator. Do not connect. (P2.4 if no crystal)
24	P2_3/32kHz_Q2	Internal 32 kHz crystal oscillator. Do not connect. (P2.3 if no crystal)
25	P1_7	CC2530 P1 [7]/GIO/UART RX
26	P1_6	CC2530 P1 [6]/GIO/UART TX
27	P1_5	CC2530 P1 [5]/GIO/UART RTS
28	P1_4	CC2530 P1 [4]/GIO/UART CTS
29	P1_1	CC2530 P1 [1] with optional ADC input. LED driver/PA_EN for RC2400HP
30	P1_0	CC2530 P1 [0] with optional ADC input. LED Driver

Note 3: Pins 17 and 18 are suggested as I2C interface. They can be configured otherwise, but are connected to an internal EEPROM with I2C address = 000. It is recommended to leave these pins as I2C. Sensors and actuators or any other I2C device can be connected to these pins and accessed from the module.

Block Diagram



Embedded resources

MCU: Enhanced single-cycle 8051 with 256 kB Flash
PHY/MAC: Texas Instruments (TI) CC2530, and CC2591 for RC2400HP
Connection between CC2530 and CC2591 are as follows.

CC2530	CC2591
P1_1	PA_EN
P1_3	EN
P0_7	HGM

Firmware: Not included, but ZigBee and IEEE 802.15.4 firmware can be downloaded for free from www.ti.com.
For 6LoWPAN stack please contact sales@radiocrafts.com.

For module with preloaded ZigBee stack see RC2400-ZNM, ZigBee Network Module.

Circuit Description

The module contains an IEEE 802.15.4 compliant SoC RF transceiver, internal EEPROM (optional), high speed oscillator and an RTC 32 kHz oscillator.

The module includes two USART that are configurable as either SPI or UART. Totally 19 I/O pins are available to the user. 8 pins can be used for the internal 8-12 bit A/D converter. All of the pins have interrupt features.

The MCU provides several low power modes which can be utilized to reduce the current consumption in battery operated applications. An optional internal 32 kHz crystal oscillator can be used for real-time clock and timer applications.

The module has an internal POR circuit and a brown out detector, but it is still highly recommended to add an external power supervisory circuit to ensure a proper reset when a power fault has occurred.

For further details on the SoC transceiver (TI CC2530 and CC2591), please consult the respective data sheet.

I/O resources

The module has 19 digital I/O pins, but in case of RC2400HP or with the inclusion of RTC the pin number available for application is slightly lower. They are shown in the table below together with the additional I/O feature associated with them

PIN	Port/ Function	2	3	4	5	6	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
		P0_4	P0_5	P0_1	P0_2	P0_3	P0_7	P1_2	P0_6	P2_0	P2_1	P2_2	P0_0	P1_3	P2_4	P2_3	P1_7	P1_6	P1_5	P1_4	P1_1	P1_0
ADC		X	X	X	X	X	X		X				X									
USART0 SPI		SS	C	MI	MO																	
AI2								SS										MO		MI		
USART0 UART		CT	RT		RX	TX													TX	RX		
AI2								CT														
USART1 SPI		MO	MI		SS	C												MI	MO	C	SS	
AI2																						
USART1 UART		TX	RX		CT	RT												RX	TX	RT	CT	
AI2																						
Timer1		2	3		0	1			4													
AI2							3	0	4												1	2
Timer3														0								
AI2																						
Timer4																						
AI2										0												
32 kHz XOSC																						
DEBUG											DC	DD										
CC2591 CTRL in RC2400HP																						PA_EN

IEEE 802.15.4

The IEEE 802.15.4 standard provides a worldwide standard for Personal Area Networks and short distance wireless networks for low data rate solutions with long battery life and low complexity. The standard defines a Physical layer (PHY) and a Medium Access Control layer (MAC). There are two active versions of the standard: IEEE 802.15.4-2003 and IEEE 802.15.4-2006 where the 2003 version is a basis for the ZigBee protocol. The typical applications are meter reading, home and building automation, industrial control and monitoring systems, wireless sensor networks, remote controls and consumer electronics.

The module complies with the IEEE 802.15.4 standard operating in the 2.45 GHz band. It uses direct sequence spread spectrum (DSSS) with 2 Mc/s chip rate giving a raw data rate of 250 kbit/s. 16 channels are available in the 2.45 GHz band named channel 11 – 26 (channels 0-10 are reserved for use in the 868 and 915 MHz bands).

For more information on the standard, please consult www.ieee802.org/15/pub/TG4.html

The ZigBee Protocol

The ZigBee Alliance is an association of companies working together to enable reliable, cost-effective, low-power, wirelessly networked, monitoring and control products based on an open global standard. The ZigBee Alliance is a rapidly growing, non-profit industry consortium of leading semiconductor manufacturers, technology providers, OEMs and end-users worldwide. Membership is open to all. The ZigBee Alliance, in collaboration with the IEEE, is defining the network, security, and application layers above the IEEE 802.15.4 PHY and MAC layers. This cooperation has resulted in an easy-to-use, industry standard wireless network platform optimised for wireless monitoring and control applications.

The ZigBee standard defines a Network Layer and an Application Layer on top of IEEE 802.15.4. The network layer includes routing, security etc. while the application layer defines binding and other support for application.

The applications are specified in profiles to ensure multi-vendor interoperability. Current public profile includes:

- Smart Energy - SE (Profile for Smart Meter reading)
- Building Automation - CBA
- Home Automation - HA
- Health Care - HC
- Telecom Services - TA
- Remote Control - RF4CE

Manufacturer specific profiles can also be made.

The current version of the ZigBee standard is 2007. The standard defines two different stack feature sets:

- ZigBee Feature set
- ZigBee PRO feature set

In order to sell a product containing ZigBee technology, the seller must be a member (adaptor or higher) of the ZigBee alliance.

For more information about the ZigBee Alliance and the ZigBee standard, please consult www.zigbee.org.

ZigBee implementation: Developing with Z-stack

Z-stack™ from Texas Instruments is a free ZigBee PRO compliant stack for RC2400/RC2400HP. See www.ti.com/z-stack for stack download and full documentation package.

The stack is supported for IAR EW8051. For info on revisions supported see z-stack documentation. See www.iar.com for trial versions and licences.

The Z-stack also includes example application for general applications and examples for Smart Energy (SE) devices.

For debugging and programming a module the CC-debugger from TI is recommended. It is included in the demo kit and can also be bought online here:

<http://focus.ti.com/docs/toolsw/folders/print/cc-debugger.html>

Modification of Z-stack for RC2400/RC2400HP (Z-stack rev 2.3.0)

For RC2400 the z-stack 2.3.0 can be used without modification.

For RC2400HP the compile directive for `HAL_PA_LNA` must be activated. This can be done in `hal_board_cfg.h` line 64.

In addition one control signal for CC2591 control must be moved from pin P1_4 to P1_3. This is done by modifying `OBSSEL4` to `OBSSEL3` in `mac_radio_defs.c`

In addition the register `MDMTEST0` must be altered for optimum performance at high output power levels. This is by inserting `MDMTEST0 |= 0xB0;` in `mac_mcu.h` line 186

For successful compilation of the code

```
uint8 OSC_32KHZ = ((P1_2) ? 0x00 : 0x80); \
```

must be inserted in `hal_board_cfg.h` line 320

Packet sniffer

For evaluating and testing an application on network level a packet sniffer is a useful tool. We recommend using the following combination:

- Texas Instruments Packet Sniffer (PC tool)
- CC-debugger
- RC2400DB / RC2400HP-DB (DB=Demo Board)

Optionally any other HW with RC2400/RC2400HP module + programming/debugging connector can be used as the physical sniffer.

P.nbr.	Time (us)	Length	Frame control field	Sequence number	Dest. PAN	Dest. Address	Source PAN	Source Address	Beacon request	LOI	FCS
RX 5	+10890705 =55994647	10	Type Sec Pnd Ack.req PAN_compr CMD 0 0 0 0	0xEC	0x9FFF	0xFFFF				184	OK
RX 6	+2396 =55997043	28	Type Sec Pnd Ack.req PAN_compr BCH 0 0 0 0	0x18	0x9DEE	0x0000			Superframe specification	GTS fields	Beacon payload
RX 7	+511420 =56508463	21	Type Sec Pnd Ack.req PAN_compr CMD 0 0 1 0	0xED	0x9DEE	0x0000	0x00124B0001098094	0x0000			Association request
RX 8	+1056 =56509519	5	Type Sec Pnd Ack.req PAN_compr ACK 0 0 0 0	0xED						132	OK
RX 9	+495246 =57004765	18	Type Sec Pnd Ack.req PAN_compr CMD 0 0 1 1	0xEE	0x9DEE	0x0000	0x00124B0001098094		Data request	184	OK
RX 10	+960 =57005725	5	Type Sec Pnd Ack.req PAN_compr ACK 0 1 0 0	0xEE						132	OK
RX 11	+2398 =57008123	27	Type Sec Pnd Ack.req PAN_compr CMD 0 0 1 1	0x75	0x9DEE	0x00124B0001098094	0x00124B0001001E75				Short addr Assoc. status
RX 12	+1248 =57009371	5	Type Sec Pnd Ack.req PAN_compr ACK 0 0 0 0	0x75						132	OK

Figure 2 Screenshot from packet sniffer connected to a Radiocrafts demo board

6LoWPAN

6LoWPAN is an acronym for IPv6 over LoW power Wireless Personal Area Network and is a standard for transmitting IPv6 packets over IEEE 802.15.4 compliant radios. The standard is open and maintained by the 6LoWPAN working group with in IETF.

RC2400/RC2400HP is compliant with 6LoWPAN and a stack is available from third parties.

Document Revision History

Document Revision	Changes
1.0	First release

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