Transceiver module

TM2.4-1

TM2.4-2

User manual

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History

Document History

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0a	15.12.2006	F. Becker	draft
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Contents

Figures

Tables

1 Introduction

The transceiver modules TM2.4-1 and TM2.4-2 are modular devices to communicate in the 2.4 GHz ISM/SRD band. The modules are designed for OEM integration into customer systems for instance into medical and industrial wireless user interfaces (UI).

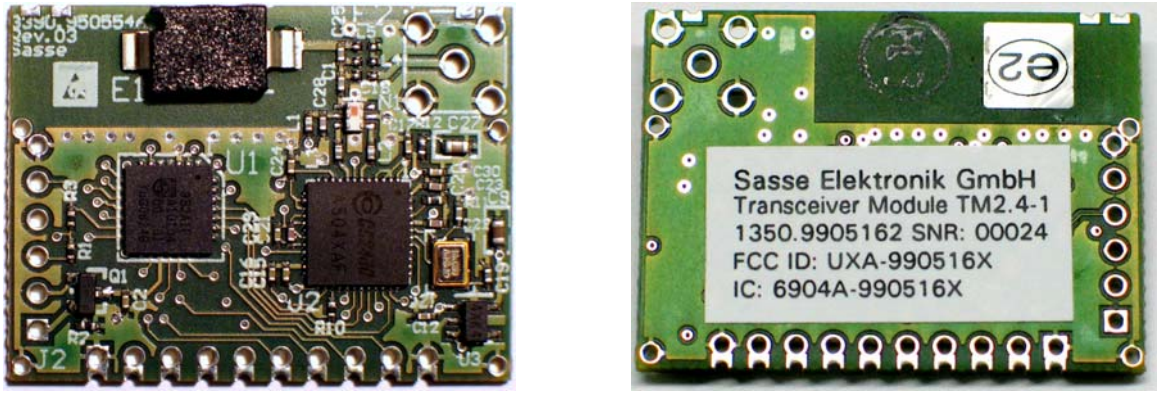


Fig. 1: Transceiver module TM2.4-1 (front – rear view)

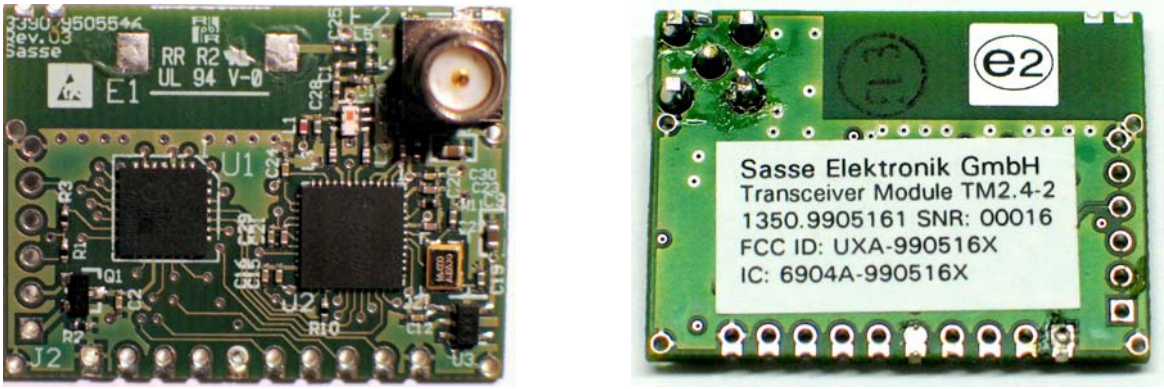


Fig. 2: Transceiver module TM2.4-2 (front – rear view)

1.1 Definitions and Abbreviations

1.1.1 Abbreviations

CSA	Canadian Standards Association
DTS	Digital transmission system
FCC	Federal Communications Commission (US government agency)
IC	Industry Canada
ISP	In system programming
HW	Hardware
PCB	Printed circuit board
SPI	Serial protocol interface
UI	User interface
SW	Software
RF	Radio frequency

1.2 References

[1] Data Sheet Chipcon CC2400, SWRS042, Texas Instruments, 2006

[2] User manual P89LPC932, Philips Semiconductors, Feb. 2003

[3] Specification CENTURION WCR2400, Laird Technology

[4] Specification EAD BT-Blade™

2 Product description

The transceiver modules TM2.4-1/2 are based on the Chipcon CC2400 single chip 2.4 GHz Low-Power RF transceiver [1], designed for low-power and low-voltage wireless applications. The RF transceiver is integrated with a baseband modem supporting data rates up to 1 Mbps.

The RF transceiver is combined with a µ-controller [2] as the user interface, a voltage regulator and an antenna on a small pcb, to get a modular design which fulfills the FCC requirements of a transceiver module.

A FCC approved transceiver module could be used in a variety of Part 15 devices without requiring those devices to obtain subsequent and separate FCC approvals.

The user interface allows to set the baudrate, the frequency channel and the output power of the transceiver and to send and receive data from the module. The application interface uses an SPI-bus.

2.1 Product versions

There are two different versions of the modules with respect to the antenna interface: the module is equipped with either an internal SMD-antenna or with an RP-SMA-connector to directly connect to a stud antenna or to connect indirectly to a cable antenna.

Attention: Only the type of antennas qualified by Sasse Elektronik GmbH, which have been tested with the approval measurements, may be used (see following table, see [3] and [4] for specification).

Table 1: Types of modules and qualified antennas

Model no.	Type	Comment
1350.9905162	FM2.4-1	module with internal SMD-antenna (Laird Technologies CENTURION BlackChip WIC2450-A,)
1350.9905161	FM2.4-2	module with ext. antenna RP-SMA-female connector
6160.9817215	Laird Technologies (CENTURION) WCR2400SMRP	flexible rod antenna (8cm), RP-SMA-male connector, clutch with 360° rotation, antenna gain 1.0 dBi
6160.9817216	EAD FBT35009-RS-1K5	BT-Blade™ antenna with 1,5m-RG174-Cable and RP-SMA-male connector, antenna gain 2.0 dBi

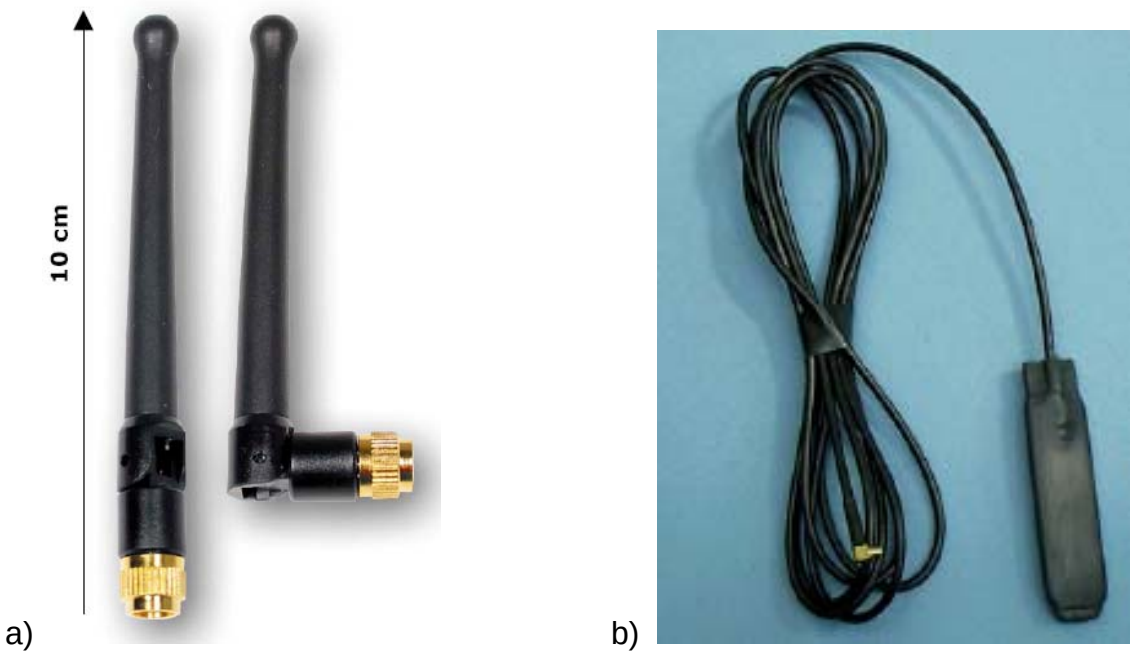


Fig. 3: approved antennas

a) model no. 6160.9817215 (Laird Technologies WCR2400-SMRP)
b) model no. 6160.9817216 (EAD BT-Blade™, with cable 1,5m)

2.2 Block diagram

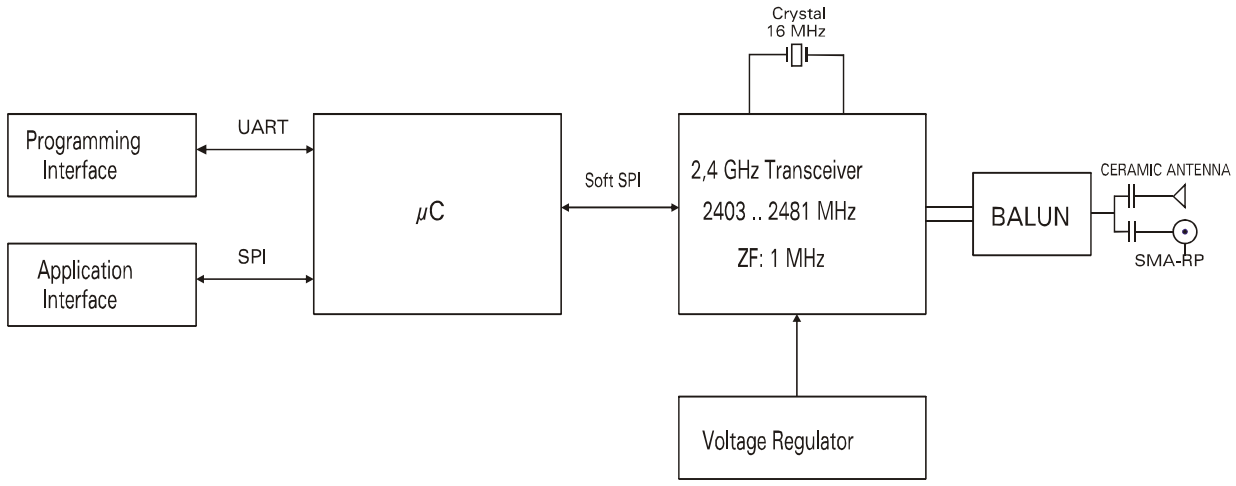


Fig. 4: Block diagram of Transceiver Module

2.3 Technical data

Radio Specifications

Operating Band	2403-2481 MHz
Radio Type	RF transceiver with baseband modem
Channel Bit Rate	10 kbps, 250 kbps and 1 Mbps over-the-air data rates
Modulation	FSK modulation
Certification Type	DTS device per FCC 15.247 and ETS 300-328
RF power	+0 dBm maximum, -25 dBm minimum
Receiver Sensitivity	High sensitivity (-87 dBm @ 1Mbps, BER=10^{-3})
Spurious Output	EN300 328, EN 300 440, FCC CFR47 part 15 and ARIB STD-T66

General

Input Voltage	+3,3V ±10%
Current Consumption	30 mA typical operating, 40 µA power down
Operating Temp Range	-40 C to + 70 C
Humidity	95% Non-condensing
RF Connector	Reverse-Polarity (RP)-SMA
Application Connector	10 pin pcb connector with 4 Wire SPI-bus
Size	appr. 35 x 26 x 5 mm (with SMA-antenna)

3 Hardware

3.1 Dimensions

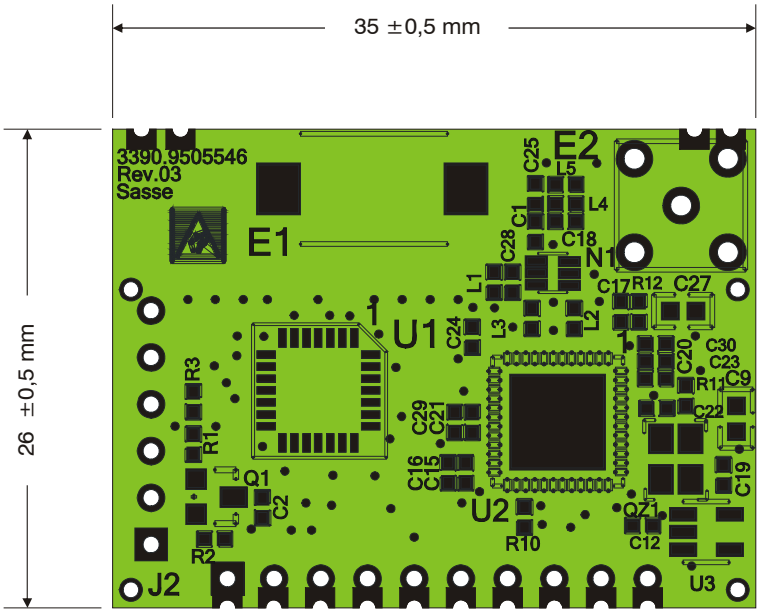


Fig. 5: Dimensions of Transceiver Module pcb

The size of the tranceiver modules is 26 ± 0,5mm x 35 ± 0,5 mm.

The module height of the TM2.4-1 (with SMD-antenna) is appr. 5 mm (incl. pcb-board), the height of the RP-SMA-connector of module TM2.4-2 is appr. 12 mm. Outside the SMD-antenna resp. the antenna connector the module height is < 3 mm.

3.2 Interfaces, Pin assignments

The transceiver modules are designed to be soldered directly to the users's motherboard via soldering pads P1 to P14.

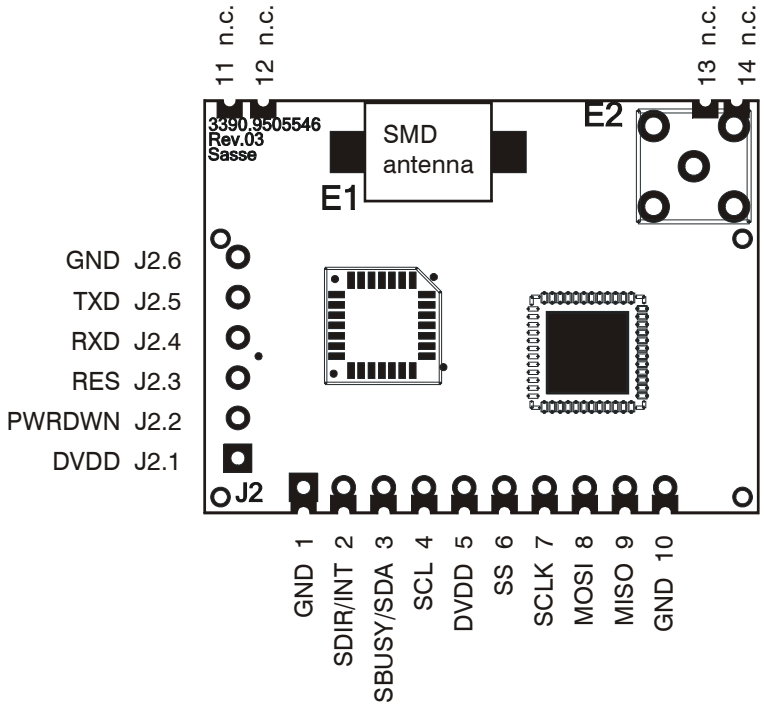


Fig. 6: Pinning of module TM2.4-1 (front view)

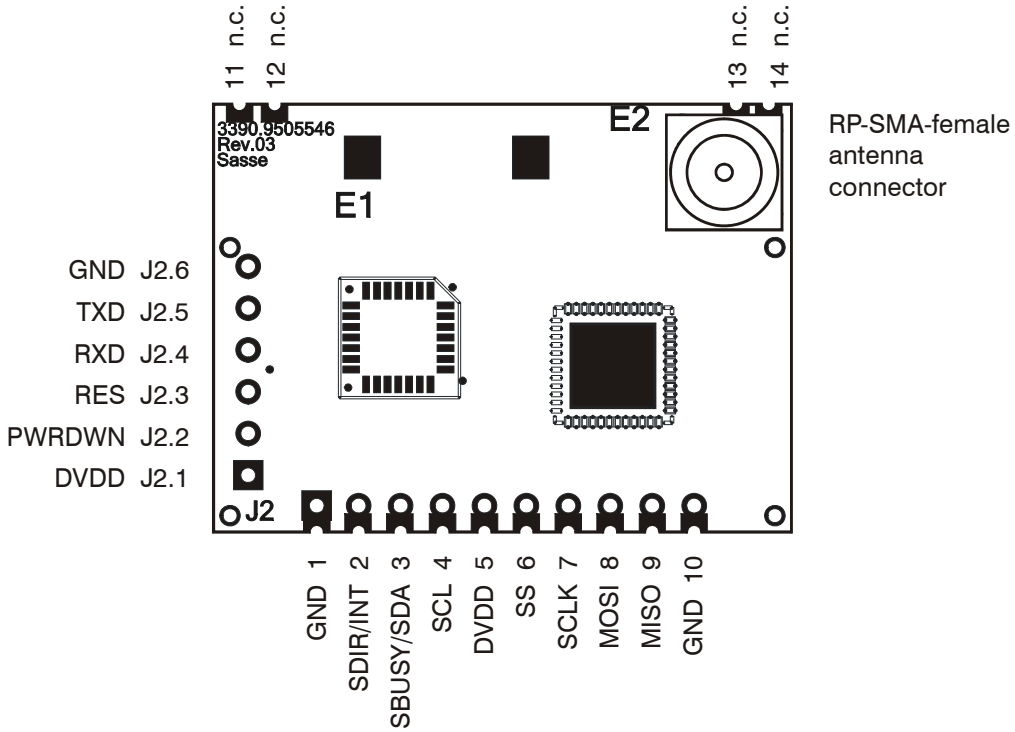


Fig. 7: Pinning of module TM2.4-2 (front view)

3.2.1 Application interface

For interfacing the TM2.4-2 (with external antenna port) an inverse SMA connector RP-SMA-female is provided.

Table 2: Pin assignments of application interface J1

Pin	Signal	Comment
1	GND	0V
2	SDIR/INT	Wakeup signal
3	SBUSY/SDA	Handshake signal “BUSY”
4	SCL	Packet handling control signal
5	DVDD	+3,3V ±10% @ 30 mA
6	SS	SPI Chip-Select (Slave-Select)
7	SCLK	SPI Clock
8	MOSI	SPI Data (Master Out Slave In)
9	MISO	SPI Data (Master In Slave Out)
10	GND	0V
11	n.c.	only used for mechanical fixation
12	n.c.	only used for mechanical fixation
13	n.c.	only used for mechanical fixation (don’t connect for TM2.4-2)
14	n.c.	only used for mechanical fixation (don’t connect for TM2.4-2)

3.2.2 Programming interface

The pins of connector J2 are for programming of the integrated µ-controller via UART. This terminal may only be used for programming and debugging purposes by the manufacturer. There may be no access to these ports by the user. The ISP function uses five pins (DVDD, GND, TXD, RXD, and RES).

The UART is also used for test purposes (i.e. RX test mode).

UART settings: 9600 Baud, 8N1, no handshake

The pin assignment is solely for information.

Table 3: Pin assignments of programming interface J2

Pin	Signal	Comment
1	DVDD	+3,3V ±10% @ 30 mA
2	PWRDWN	Power down
3	RES	Reset
4	RXD	UART RxD (3V TTL)
5	TXD	UART TxD (3V TTL)
6	GND	0V

3.3 Power supply

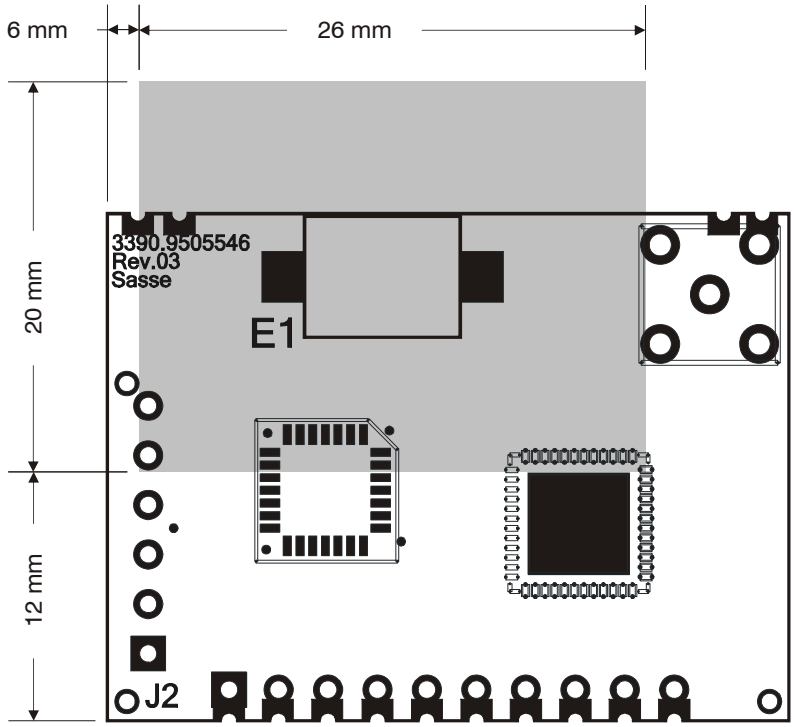
The power supply is nominal +3,3V ±10% @ 30 mA at full operation, @ 40 µA at power down.

The transceiver module has its own power supply regulation. This is intended to ensure that the module will comply with Part 15 requirements regardless of the design of the power supplying circuitry in the device into which the module is installed.

3.4 Mounting instructions

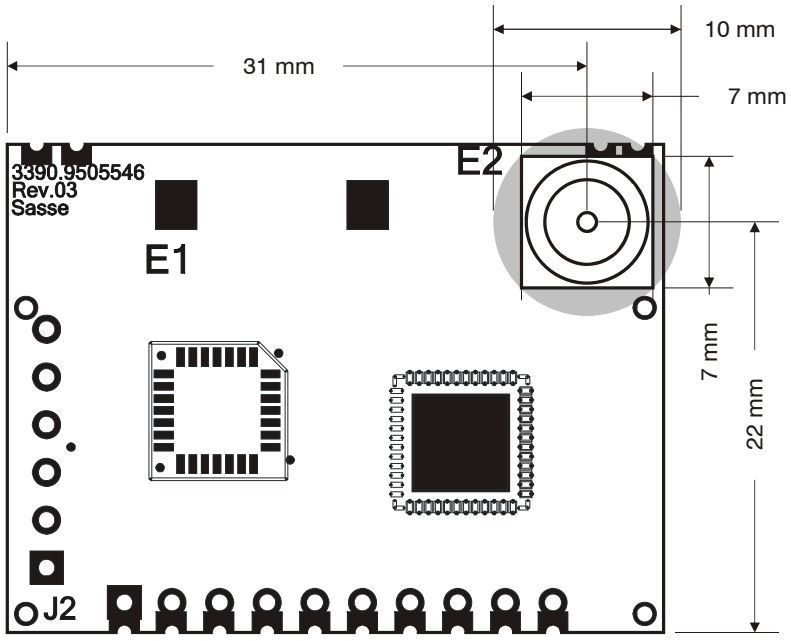
Placing the transceiver modules TM2.4-1/2 onto the user's pcb the following suggestions should be paid attention to

- there should be no tracks or vias beneath the module pcb. If there are tracks or vias on the outer layer of the motherboard pcb beneth the transceiver module, adequate electrical isolation is neccessary.
- in an area of appr. 8 mm around the SMD-antenna of the TM2.4-1 any tracks (inner or exterior layers) or any electrically conductive structures must be avoided (see Fig. 8). There should also be no conductive coated housings or housings with conductive materials close to the antenna.
- if the TM2.4-2 is used, there should be an opening in the motherboard around the antenna pins (see Fig. 9).
- the pad-layout in Fig. 10 should be observed



avoid metallic structures around SMD-antenna (shaded area)

Fig. 8: Motherboard layout for module TM2.4-1



opening in motherboard for antenna connector (shaded area)

Fig. 9: Motherboard layout for module TM2.4-2

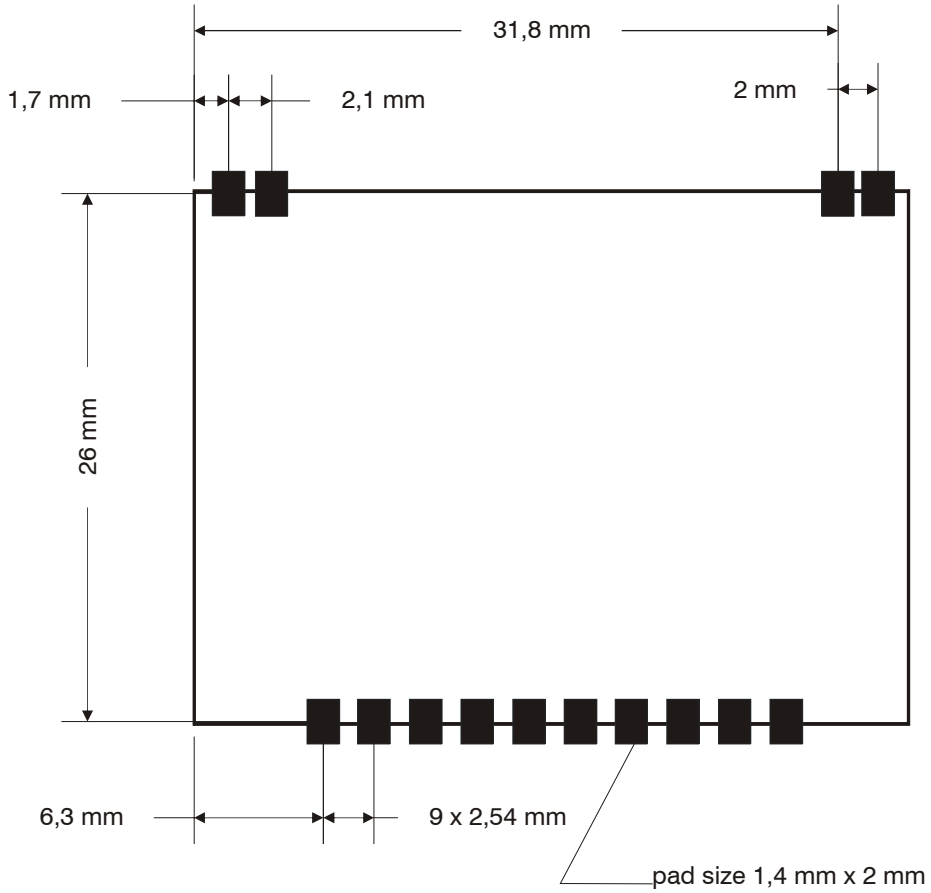


Fig. 10: Recommended pad layout for user's PCB

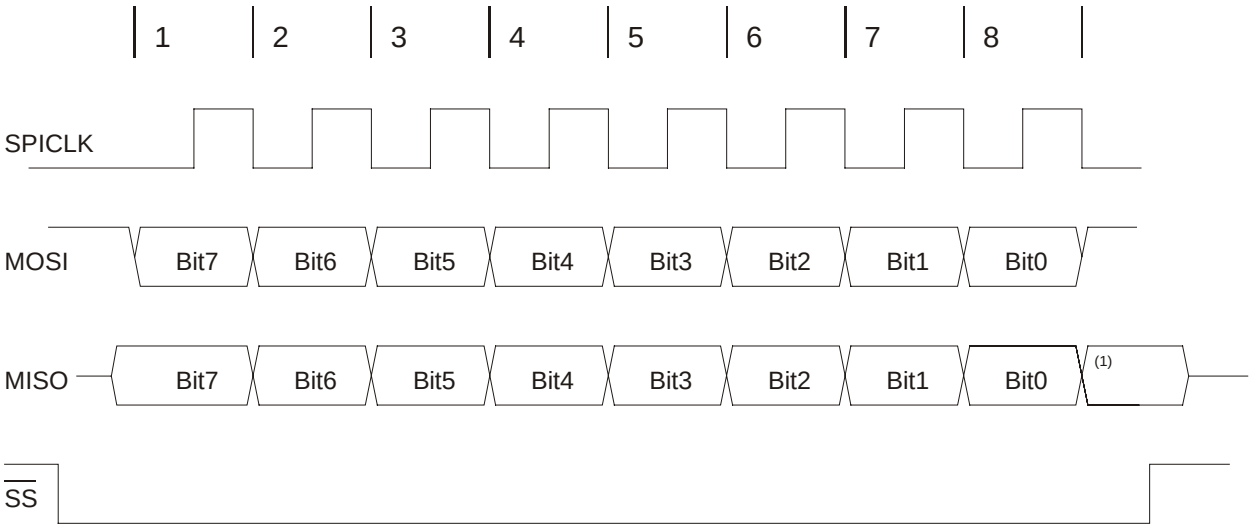
4 Software

4.1 Application interface

4.1.1 SPI-bus

The application interface of the tranceiver module to the motherboard µ-controller is SPI. The µ-controller of the transceiver module is configured in Slave mode, so the motherboard µ-controller must be SPI master.

The max. baudrate is 1,8 Mbit/s.



(1): Not defined

Fig. 11: SPI Waveform

4.1.2 Control signals

4.1.2.1 Signal „SBUSY/SDA“

A logic-low level of the output „SBUSY/SDA“ signals that the transceiver module is ready to receive commands via its SPI bus.

4.1.2.2 Signal „SDIR/INT“

Signal to wake up the transceiver module from power down mode.

When the transceiver module is in total power down mode, the oscillator of the module´s µ-controller is stopped and the RF-IC **CC2400** is turned off.

The only way to wake up the µ-controller is a logic-low pulse of the signal „SDIR/INT“:

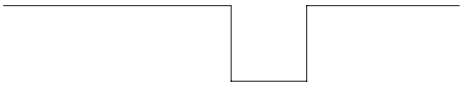


Fig. 12: Wake-up from power down signal

A following high-to-low transition of the output „SBUSY/SDA“ signals that the transceiver module is ready again to receive commands via its SPI bus.

4.1.2.3 Signal „SCL“

In receive mode, the SCL pin will go low when a RF data packet has been received.
The data packet has to be fetched by the host controller with the GET_PACKET command.
A data length of zero indicates an unvalid data packet (i.e. CRC error).

Fig. 13: Data packet received signal

4.1.3 Command set

There is a set of specific commands to communicate with the transceiver module:

Table 4: Command set

COMMAND	VALUE	DESCRIPTION
SET_RF_PARAMS	0x11	Set RF parameters
SET_SLEEPMODE	0x12	Set module in power down mode
SET_IDLE_STATE	0x13	Set module IDLE state
SET_RX_STATE_PACKET	0x14	Set module RX state (packet mode)
SET_RX_STATE_STREAM	0x15	Not yet implemented
GET_PACKET	0x16	Get data packet from module
SEND_PACKET	0x17	Send data packet to module
GET_STREAM	0x18	Not yet implemented
SEND_STREAM	0x19	Not yet implemented
SET_TX_STATE_PACKET	0x1A	Set module TX state (packet mode)
SET_TX_STATE_STREAM	0x1B	Not yet implemented
SET_TX_TESTMODE	0x1C	Set TX testmode (unmodulated carrier)
SET_TX_TESTMODE_MOD	0x1D	Set TX testmode (modulated carrier)
SET_RX_TESTMODE	0x1E	Set RX testmode
GET_RSSI	0x1F	Get RSSI

4.1.3.1 SET_RF_PARAMS (0x11)

Set the RF-Baudrate, channel number and the power step.

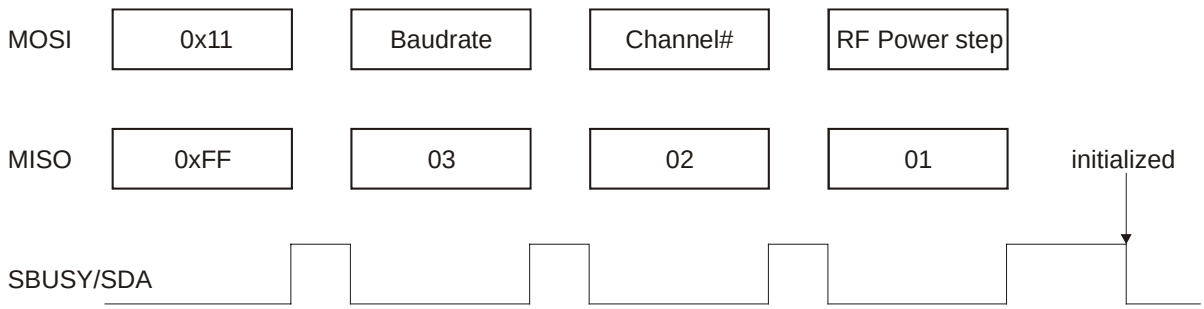


Fig. 14: Command timing SET_RF_PARAMS

The TM2.4-1/2 use a list of channels which span the range from 2403 up to 2481 MHz. The channel number is set as a parameter via the user interface. The occupied bandwidth depends on the selected baud rate and is max. appr. 1,5 MHz.

Table 5: Frequency channels

Channel #	Nomial Frequency [MHz]	Comment
1	2403	
2	2404	
3	2405	
...	=<chan# + 2402>	
31	2433	default
...	=<chan# + 2402>	
79	2481	

Table 6: Baud rates

Baudrate	RF baud rate	Comment
100	1 MBaud	default
25	250 kBaud	
1	10 kBaud	

Table 7: Output Power steps

RF Power step	RF Output Power	Comment
0	-25 dBm	
1	-15 dBm	
2	-10 dBm	
3	-7,5 dBm	
4	-5,2 dBm	
5	-3,4 dBm	
6	-1,7 dBm	
7	0 dBm	Default

4.1.3.2 SET_SLEEPMODE (0x12)

Set the transceiver module into sleep mode (total power down).

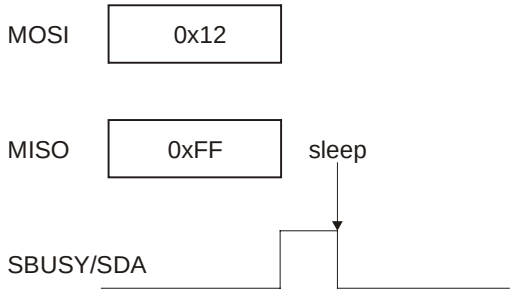


Fig. 15: Command timing SET_ SLEEPMODE

4.1.3.3 SET_IDLE_STATE (0x13)

Set the transceiver module into IDLE state (no TX state, no RX state; see [1]).

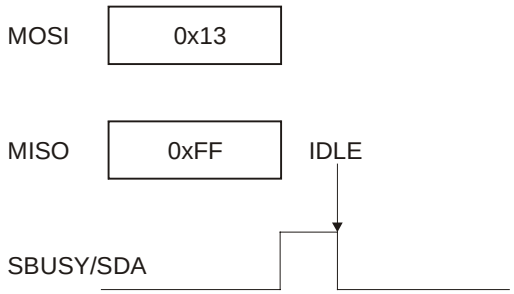


Fig. 16: Command timing SET_ IDLE_STATE

4.1.3.4 SET_RX_STATE_PACKET (0x14)

Set the transceiver module into RX state (see [1]).

The module is now able to receive a RF data packet

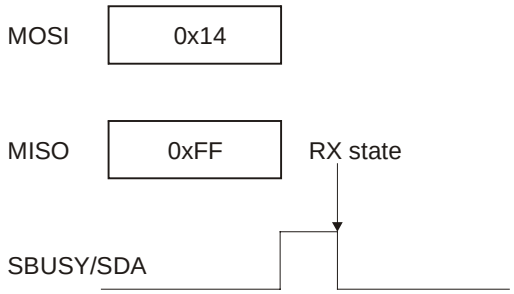


Fig. 17: Command timing SET_ RX_STATE_PACKET

4.1.3.5 SET_TX_STATE_PACKET (0x1A)

Set the transceiver module into TX state (see [1]).

The module is now able to send a RF data packet

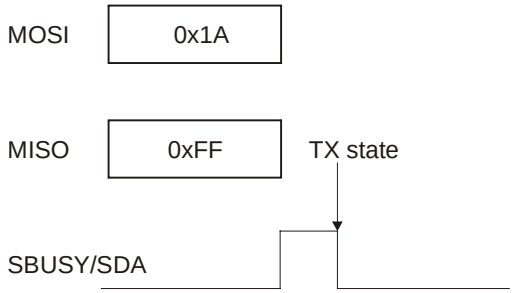


Fig. 18: Command timing SET_ TX_STATE_PACKET

4.1.3.6 GET_PACKET (0x16)

Get the received RF data packet from the transceiver module.

The module returns the packet length n in the second transmission of the GET_PACKET command. The host controller must send further n GET_PACKET commands to the module to get the complete data packet.

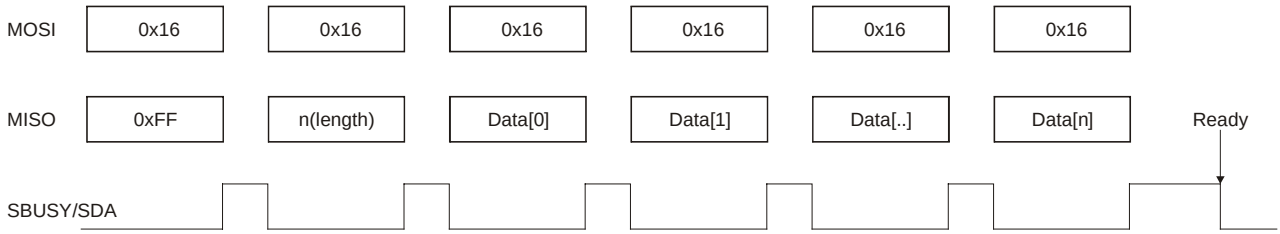


Fig. 19: Command timing GET _PACKET

4.1.3.7 SEND_PACKET (0x17)

Send a data packet to the transceiver module.

The maximum number of data bytes that can be sent to the RF-IC **CC2400** is 32. Since the first byte of the RF data packet contains the length of the data packet, only 31 bytes of payload data can be sent to the module.

The packet length n must be sent in the second transmission of the SEND_PACKET command. The host controller must send further n data bytes to the module to send the complete data packet. After completion the RF data package will be sent.

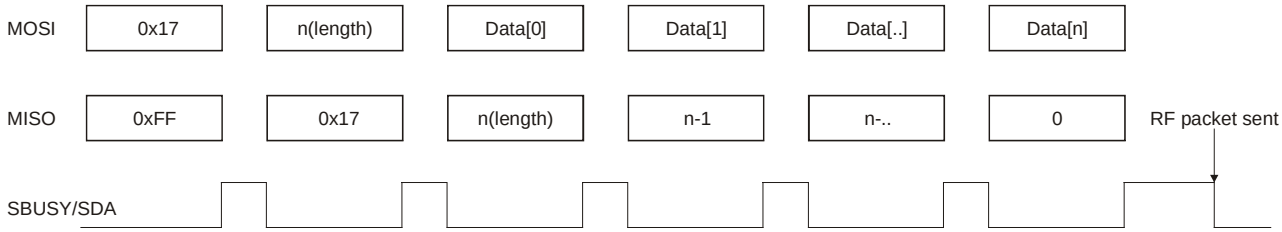


Fig. 20: Command timing SEND _PACKET

4.1.3.8 SET_TX_TESTMODE (0x1C)

Set the transceiver module into TX test mode (RF carrier only).

The module sets the RF-IC **CC2400** into TX state and sends a continuous ***unmodulated*** RF test signal with the specified carrier frequency and RF ouput power.

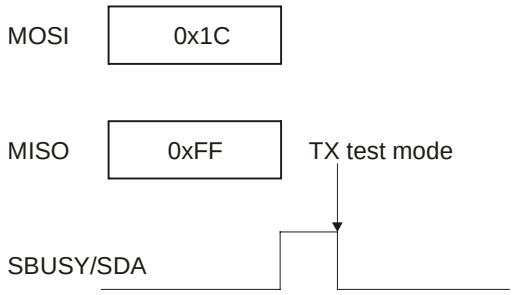


Fig. 21: Command timing SET_ TX_ TESTMODE

4.1.3.9 SET_TX_TESTMODE_MOD (0x1D)

Set the transceiver module into TX test mode (modulated, with pseudo random data).

The module sets the RF-IC **CC2400** into TX state and sends a continuous ***modulated*** RF test signal with the specified carrier frequency and RF ouput power.

The **CC2400** has a built-in test pattern generator that can generate a PN9 pseudo random sequence. The PN9 generator is used for transmission of ‘real-life’ data when measuring modulation bandwidth or occupied bandwidth.

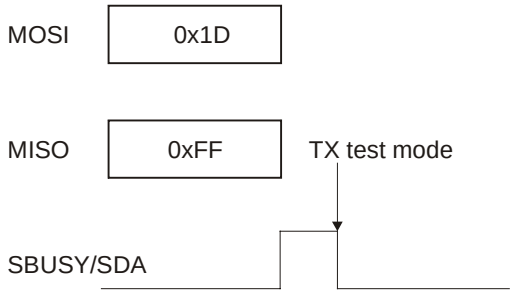


Fig. 22: Command timing SET_ TX_ TESTMODE_MOD

4.1.3.10 SET_RX_TESTMODE (0x1E)

Set the transceiver module into RX test mode.

The module sets the RF-IC **CC2400** into RX state with the specified carrier frequency. The **CC2400** has a built-in RSSI (Received Signal Strength Indicator). The RSSI reading provides a measure of the signal power entering the RF input.

The module sends the RSSI value via its UART (see 3.2.2).

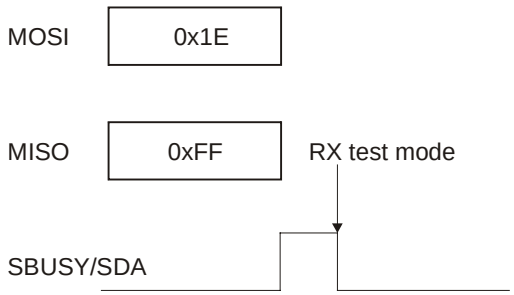


Fig. 23: Command timing SET_ RX_ TESTMODE

4.1.3.11 GET_RSSI (0x1F)

Get the current RSSI value.

The module sets the RF-IC **CC2400** into RX state with the specified carrier frequency. The **CC2400** has a built-in RSSI (Received Signal Strength Indicator). The RSSI reading provides a measure of the signal power entering the RF input.

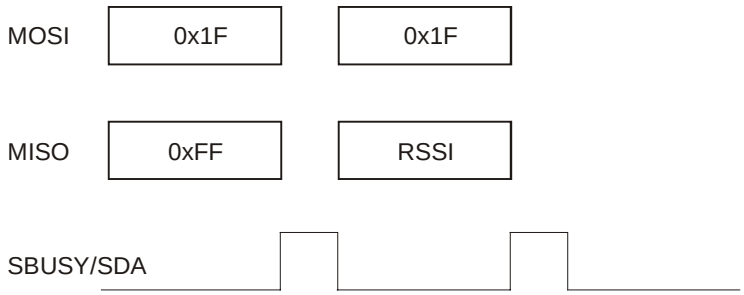


Fig. 24: Command timing GET_RSSI

4.2 Programming interface

In-System Programming is performed without removing the microcontroller from the system. The In-System Programming facility consists of a series of internal hardware resources coupled with internal firmware to facilitate remote programming of the LPC932 through the serial port (see [2]) by using the programming software FLASHMAGIC.

Flashmagic is a very popular (and free) utility to program many Philips devices, including the P89LPC932. It is available at http://www.esacademy.com/software/flashmagic/.

5 Regulatory information

5.1 Caution

Warning: Changes or modifications made to this equipment not expressly approved by Sasse Elektronik GmbH - the party responsible for compliance - could void the user's authority to operate the equipment.

5.2 Compliance information

This device complies with Part 15 of the FCC Rules and with RSS-210 of Industry Canada.

Operation is subject to the following two conditions:

(1) this device my not cause harmful interference, and

(2) this device must accept any interference received, including interference that may cause undesired operation.

Note:

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

5.2.1 Documentation requirement for the OEM

The user's device shall bear the above statement in a conspicuous location on the device, or when the device is so small or for such use that it is not practicable to place the above statement on it, the above information (including the **Note:**) shall be placed in a

prominent location in the instruction manual or pamphlet supplied to the user or, alternatively, shall be placed on the container in which the device is marketed.

5.3 RF-Exposure statement

The radiated output power of the transceiver modules TM2.4-1 and TM2.4-2 is far below the FCC radio frequency exposure limits. Nevertheless, the modules shall be used in such a manner that the potential for human contact during normal operation is minimized.

The TM2.4-1 and TM2.4-2 modules contain a portable modular transmitter. Thus there must be a separation of at least 2.5 cm between the antenna and the body of the user or nearby persons, excluding hands, wrists, feet, and ankles.

Any notification to the end user of installation or removal instructions about the integrated radio module as well as instructions about reprogramming the integrated controller is not allowed.

5.4 Labelling requirements for the OEM

The transceiver modules are labeled with its own FCC ID and IC ID numbers.

Table 8: FCC ID and IC ID

Module	Model-No	FCC ID	IC ID
TM2.4-1	1350.9905162	FCC ID: UXA-990516X	IC: 6904A-990516X
TM2.4-2	1350.9905161	FCC ID: UXA-990516X	IC: 6904A-990516X

The FCC-ID and the IC-ID are usually no longer visible, when the modules are integrated onto a user‘s pcb into a user‘s device. In this case the outside of the device into which the module is installed must also display a label referring to the enclosed module. This exterior label can use wording such as the following:

Contains Transmitter Module
FCC ID: UXA-990516X
IC: 6904A-990516X

or

Contains FCC ID: UXA-990516X
IC: 6904A-990516X

Any similar wording that expresses the same meaning may be used.

6 Order information

Product	Order number
Transceiver module FM2.4-1	1350.9905162
Transceiver module FM2.4-2	1350.9905161
Antenna WCR2400-SMRP	6160.9817215
Antenna FBT35009-RS-1K5, cable 1,5m	6160.9817216

Replacement components	Order number
n.a.	

Price list: on request

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