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**nRF905 Evaluation board**

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**nRF905-EVBOARD**

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**GENERAL DESCRIPTION**

This document describes the **nRF905-EVBOARD** and its use with the Nordic Semiconductor **nRF905** Single Chip 433/868/915MHz RF Transceiver. **nRF905-EVBOARDS** for operation at 433MHz and 868/915MHz are available. This document covers both versions.



Figure 1: The **nRF905-EVBOARD**

**NOTE:**

The layout, bill of material and schematics shown in this document describes the hardware of the actual EVBOARD.

Please refer to the latest version of the device product specification for the latest recommended layout, bill of material and schematics.



## INTRODUCTION

The Evaluation Board for the **nRF905** Single Chip 433/868/915MHz RF Transceiver has been developed to enable customers to test functionality, run communication and verify the performance parameters of the device. This document describes the usage of the **nRF905-EVBOARD** and suggests some test benches for performance tests.

The **nRF905-EVBOARD** is intended for evaluation purposes only. It is not intended for incorporation into an end product.

## GETTING STARTED

The **nRF905-EVBOARD** is supplied with a configuration board, the *nRF USB Configurator Board*. The *nRF USB Configurator Board* enables you to configure and run ShockBurst™ communication with **nRF905** via the **nDP (Nordic Development Platform)** configuration and control software for PC. When the *nRF USB Configurator Board* is removed, the full **nRF905** digital interface is available for any micro controller unit (MCU) through a flat cable connector.

To test the **nRF905** device to its full extent, the following instrumentation should be at your disposal:

- PC, running (supplied) the **nDP (Nordic Development Platform)** configuration and control software for PC
- *nRF USB Configurator Board* (supplied) or other micro controller board
- A +1.9 V to +3.6V DC voltage supply
- Logic analyzer
- Ampere meter
- RF signal generator with GFSK modulation capability
- RF spectrum analyzer



## nRF905-EVBOARD DESCRIPTION

Appendix 1 shows the **nRF905-EVBOARD** circuit diagram. The PCB layout and component placement is shown in Appendix 2. The component list is given in Appendix 3.

Figure 2 shows the block diagram of the **nRF905-EVBOARD**.

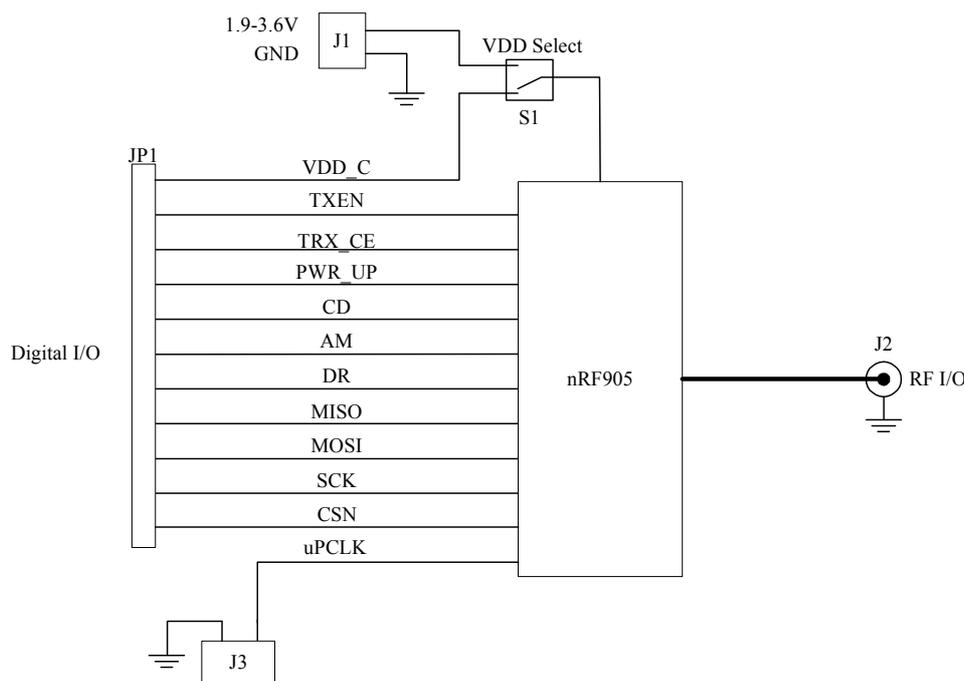


Figure 2: Block diagram of the **nRF905-EVBOARD**

### Power supply

Power and ground can be applied to the **nRF905-EVBOARD** either by feed from the MCU board through the data interface JP1 or through a separate power connector J1. The “VDD Select” switch (S1) selects which connector to use. If VDD is not fed in through JP1 (pin 15), S1 functions as an ordinary ON/OFF switch.

### NOTE:

When VDD is fed from the *nRF USB Configurator Board* through JP1, the supply voltage is fixed at +3V.

### Digital I/O

All digital I/O signals of the **nRF905** device can be accessed through connector JP1 for easy connection to the *nRF USB Configurator Board*, MCU evaluation boards or other control circuitry. To operate the **nRF905**, a MCU must be present for device configuration and control. The pin-out is listed in Table 1.



Pin #	Signal name
1	CSN
2	GND
3	SCK
4	MOSI
5	MISO
6	DR
7	AM
8	CD
9	Pull Up
10	GND
11	PWR_UP
12	TRX_CE
13	TXEN
14	Not used
15	VDD
16	GND

Table 1: nRF905-EVBOARD, JP1 pin-out

The microprocessor clock output  $\mu$ PCLK is available on a separate connector J3. Please see the nRF905 product specification for further details.

### Reference crystal

The nRF905-EVBOARD has a 16 MHz reference crystal fitted. The nRF905 must hence be configured for 16 MHz crystal operation in order to work.

### RF I/O

For convenient connection of the differential antenna output/input pins to a single ended antenna or  $50\Omega$  test equipment, a differential to single ended matching network is included. This network matches the  $50\Omega$  single ended antenna or  $50\Omega$  test equipment impedance at the SMA connector J2 to the recommended differential load impedance at the nRF905's RF I/O stage (pins ANT1 & ANT2). The employed matching network introduces an insertion loss of approximately 1-2dB at 433/868/915MHz. The components utilized in the single ended matching network on the nRF905-EVBOARD have the tightest tolerances available. This is done to minimize the influence of component variations in the matching network during nRF905 RF performance tests. In a final application less accurate and hence lower cost components can be utilized if some variation in output power and sensitivity can be accepted.



## nRF USB CONFIGURATION BOARD DESCRIPTION

The *nRF USB Configurator Board* is fitted “on-top” (Figure 3) of the **nRF905-EVBOARD** and controls the **nRF905** via the **nDP** PC software. The **nDP** software is documented in the *Nordic Development Platform User Guide* [1].

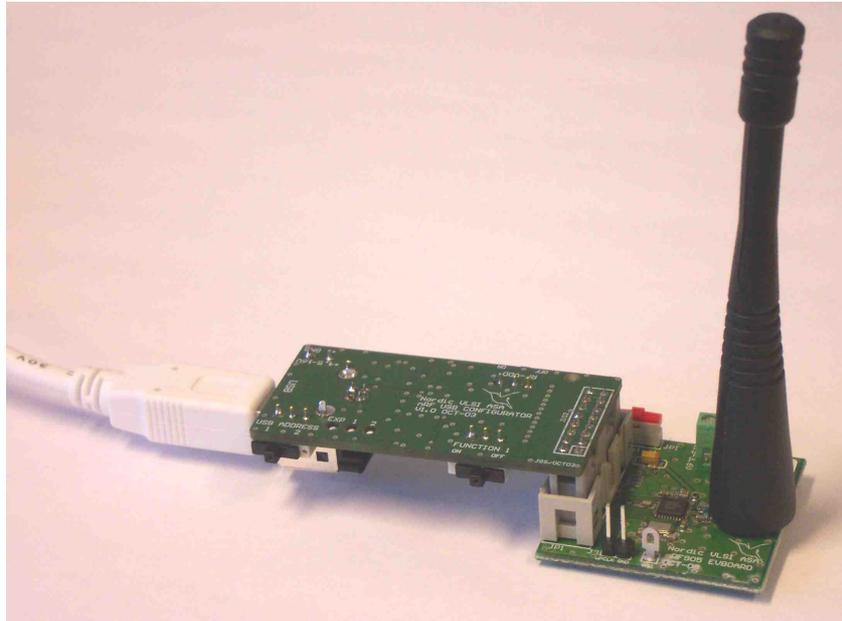


Figure 3: **nRF905-EVBOARD** with *nRF USB Configurator Board*

The *nRF USB Configurator Board* is meant as an aid in the early stages of evaluation and protocol testing. It facilitates device configuration and ShockBurst™ communication.

### Power supply

In normal use the *nRF USB Configurator Board* is connected to the USB port of a PC. Main power supply to the *nRF USB Configurator Board* is fed through the USB interface connector “USB” from the PC. The power supply is regulated on board to +3V. This voltage can also be fed to the **nRF905-EVBOARD** by setting the “RF-VDD” switch to ON.

### NOTE:

The signal levels on the digital interface connector “DEVICE” to the **nRF905-EVBOARD** will follow the regulated +3V supply of the *nRF USB Configurator Board*. If a separate power supply is fed to the **nRF905-EVBOARD** (“RF-VDD” switch must be OFF), verify that the supply level on the *nRF USB Configurator Board* never exceeds the supply level on the **nRF905-EVBOARD**.

To be able to utilize the full power supply range of the **nRF905** a MCU with similar supply range must be utilized.



### User LEDs

The *nRF USB Configurator Board* includes 3 user LEDs (marked “1”, “2” and “3” on the PCB silkscreen). The functionality of these LEDs is dynamic and will be described when used together with the **nDP**.

### User switch

The *nRF USB Configurator Board* includes one user switch (marked “FUNCTION 1” on the PCB silkscreen). The functionality of this switch is dynamic and will be described when used together with the **nDP**.

### nRF905-EVBOARD interface

The pin-out of the digital interface connector “DEVICE” to the **nRF905-EVBOARD** can be found under the **nRF905-EVBOARD** description, Table 1.

### USB interface

The interface to the PC is a standard USB interface.

### USB addressing

On the *nRF USB Configurator Board*, switch “USB ADDRESS” can be set to USB address 1 or 2. This is used as an easy way to visually identify the two **nRF905-EVBOARDS**.



### nRF905 EVALUATION MEASUREMENTS

ETSI document **EN 300 220-1** describes the technical characteristics and test methods for radio equipment to be used in the 433MHz and 868MHz ISM bands (Europe). The US Federal Communications Commission (FCC) standard **CFR47, Part 15** describes the technical characteristics and test methods for radio equipment to be used in the 260MHz – 470MHz band and the 902MHz – 928MHz band (North America).

The parameters that are directly related to the approval of equipment operating in the above mentioned frequency bands are:

- Carrier frequency and RF output power (conducted)
- Effective radiated power (radiated)
- Modulation bandwidth
- Spurious emissions (in transmit mode)
- Spurious radiation (in receive mode)

In addition, the following measurements are of interest to the user:

- Bit Error Rate (BER) as a function of RF input level (receiver sensitivity)
- RX/TX peak current consumption

When measuring performance related parameters, losses in differential to single ended matching network, connectors and cables must be taken into account. These losses are typically in the order of 2 – 4 dB @ 433/868/915MHz.

In this document you can find test benches for measurements of some of the parameters mentioned above which is easily done with the **nRF905-EVBOARD** together with the *nRF USB Configurator Board* and the **nDP** software. Also, the **nDP** has an in-built feature for easy range testing between two **nRF905-EVBOARDS**.



**RF FREQUENCY / OUTPUT POWER AND TX PEAK CURRENT**

The test bench for RF frequency and output power measurements is shown Figure 4.

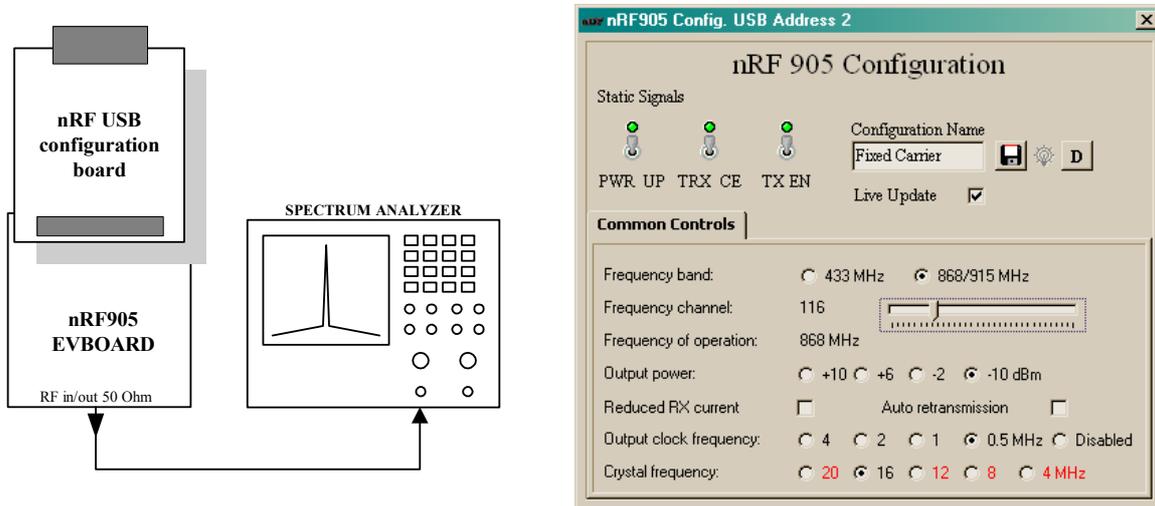


Figure 4 RF frequency and output power test bench

**RF frequency and output power**

Do the following arrangements:

- Connect the RF I/O port (SMA connector J2) of a **nRF905-EVBOARD** to the input of a spectrum analyzer using a 50Ω coaxial cable
- Connect a *nRF USB Configurator Board* to the **nRF905-EVBOARD**
- Launch the **nDP** on a PC
- Connect the *nRF USB Configurator Board* to the PC, using the USB cable
- The **nDP** should now launch a **nRF905** Configuration window
- Double click on the “**Fixed Carrier**” in the **nDP** configuration database access list
- The **nDP** should now launch a **nRF905** Configuration “**Fixed Carrier**” window as shown in Figure 4

In the **nRF905** Configuration “**Fixed Carrier**” window, do the following settings:

- Set **PWR\_UP**, **TRX\_CE** and **TX\_EN** ON (green “LEDs” in the **nRF905** Configuration “**Fixed Carrier**” window)
- Set **Crystal frequency** to 16 MHz (the **nRF905-EVBOARD** has a 16 MHz reference crystal fitted)
- Select **Frequency band**, 433 MHz or 868/915 MHz (the **nRF905-EVBOARD** is made for either 433 MHz or 868/915 MHz)
- Select wanted **Frequency channel** and **Output power**
- Set **Auto retransmission** OFF (leave check box un-checked)



## **nRF905 Evaluation Board**

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The **nRF905** will now transmit a fixed carrier on a frequency channel and with an output power according to the chosen settings, until **PWR\_UP**, **TRX\_CE** or **TX\_EN** is set OFF (red “LEDs” in the **nRF905** Configuration window).

### **Peak current consumption TX**

If power supply is fed to J1 on the **nRF905-EVBOARD**, the peak current consumption in transmit mode can also be measured while the device is active.



**TX MODULATION BANDWIDTH/ SPURIOUS EMISSION**

The test bench for TX modulation bandwidth and spurious emission measurements is shown Figure 5.

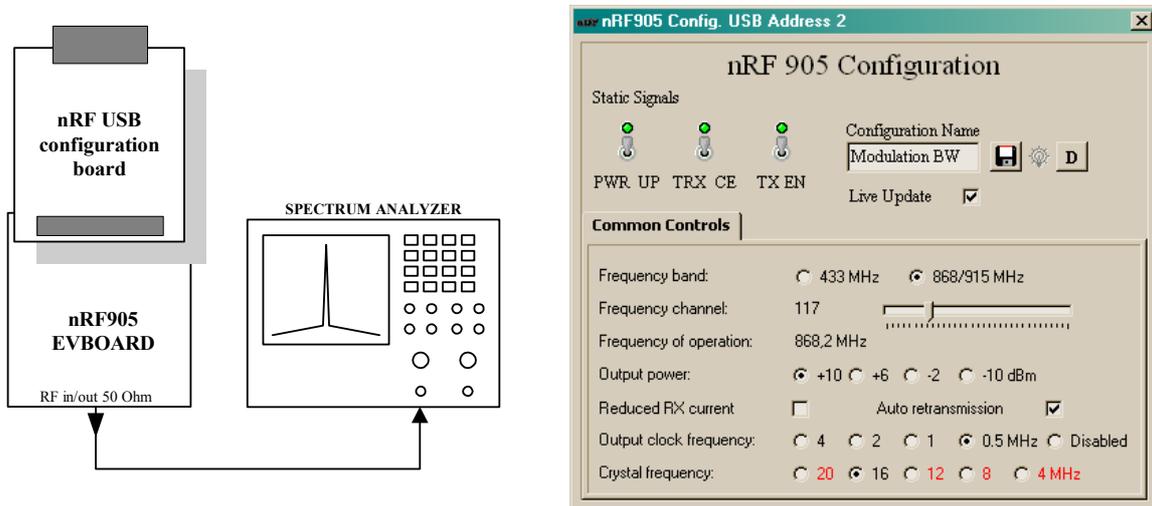


Figure 5 TX modulation bandwidth and spurious emission test bench

**TX modulation bandwidth**

Do the following arrangements:

- Connect the RF I/O port (SMA connector J2) of a **nRF905-EVBOARD** to the input of a spectrum analyzer using a 50Ω coaxial cable
- Connect a *nRF USB Configurator Board* to the **nRF905-EVBOARD**
- Launch the **nDP** on a PC
- Connect the *nRF USB Configurator Board* to the PC, using the USB cable
- The **nDP** should now launch a **nRF905** Configuration window
- Double click on the “**Modulation BW**” in the **nDP** configuration database access list
- The **nDP** should now launch a **nRF905** Configuration “**Modulation BW**” window as shown in Figure 5

In the **nRF905** Configuration “**Modulation BW**” window, do the following settings:

- Set **PWR\_UP**, **TRX\_CE** and **TX\_EN** ON (green “LEDs” in the **nRF905** Configuration “**Modulation BW**” window)
- Set **Crystal frequency** to 16 MHz (the **nRF905-EVBOARD** has a 16 MHz reference crystal fitted)
- Select **Frequency band**, 433 MHz or 868/915 MHz (your **nRF905-EVBOARD** is made for either 433 MHz or 868/915 MHz)
- Select wanted **Frequency channel** and **Output power**
- Set **Auto retransmission** ON (leave check box checked)



## **nRF905 Evaluation Board**

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The **nRF905** is now put into TX ShockBurst™ mode and transmits a modulated carrier on a frequency channel and with an output power according to the chosen settings, until **PWR\_UP**, **TRX\_CE** or **TX\_EN** is set OFF (red “LEDs” in the **nRF905** Configuration window).

### **TX spurious emission**

To test spurious output level, utilize the TX modulation bandwidth procedure. Shift the center frequency and span of the spectrum analyzer to look at the frequency band of interest.

Remember that actual spurious emission data is specified with an antenna included. Adding an antenna will change the conducted values measured in this procedure depending on the antenna gain and frequency response characteristics.



COMMUNICATION RANGE

The nDP has an in-built feature for easy range testing between two nRF905-EVBOARDS.

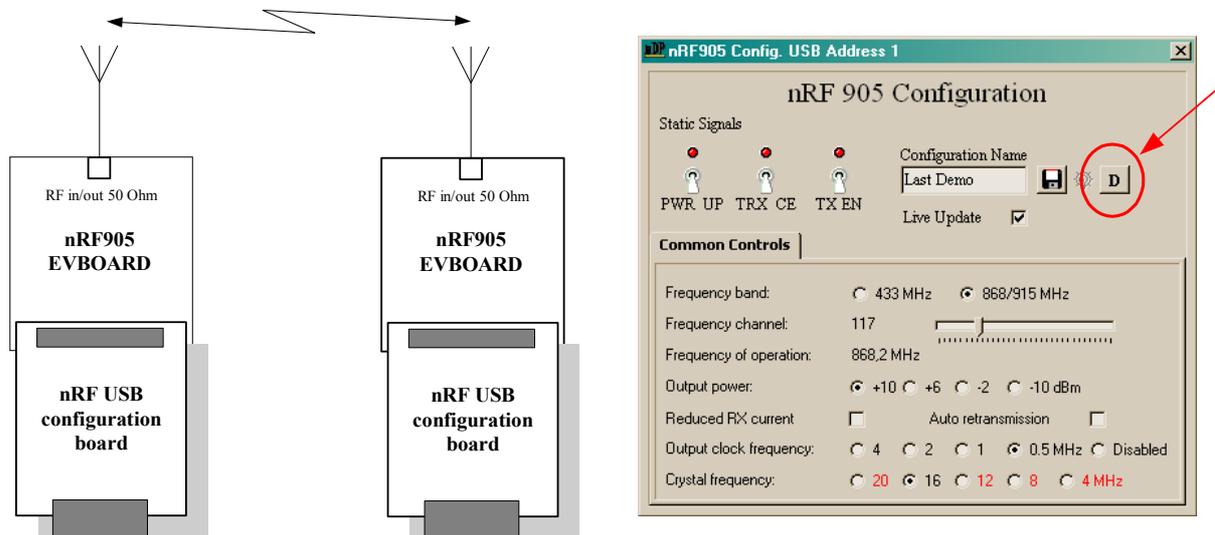


Figure 6 Communication range test set-up

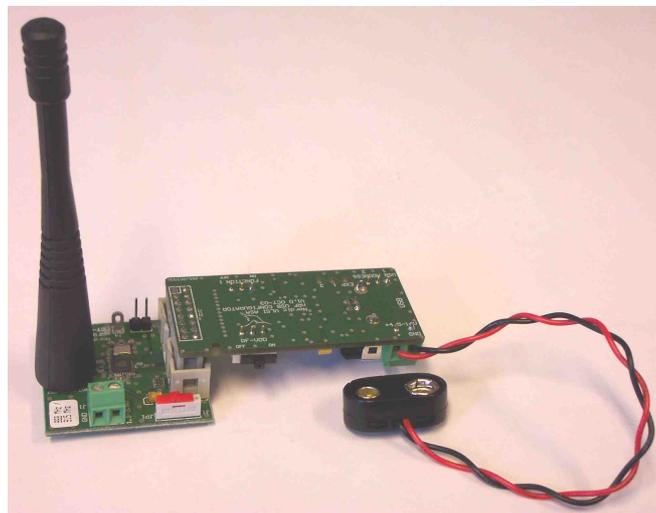


Figure 7 nRF905-EVBOARD with nRF USB Configurator Board and battery connector

Do the following arrangements:

- Connect a 9V battery to the connector marked “+4.5-16V” on both nRF USB Configurator Boards
- Connect both nRF USB Configurator Boards to a nRF905-EVBOARD
- Launch the nDP on a PC

**nRF905 Evaluation Board**

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- Connect one of the *nRF USB Configurator Boards* to the PC, using the USB cable
- The **nDP** should now launch a **nRF905** Configuration window
- In the **nRF905** Configuration window, do the following settings:
  - Select **Frequency band**, 433 MHz or 868/915 MHz (your **nRF905-EVBOARD** is made for either 433 MHz or 868/915 MHz)
  - Select wanted **Frequency channel** and **Output power**
  - Select if you want to used **Reduced RX current** or not (check or un-check the check box)
  - When ready, press the **D** button as shown in Figure 6
- The settings you have chosen will be saved as “**Last Demo**” in the **nDP** configuration database
- Disconnect the *nRF USB Configurator Board* from the PC
- This *nRF USB Configurator Board* together with the **nRF905-EVBOARD** should now be powered from the 9V battery

Then:

- Connect the other *nRF USB Configurator Board* to the PC, using the USB cable
- The **nDP** should now launch a **nRF905** Configuration window
- Double click on the “**Last Demo**” in the **nDP** configuration database access list
- The same configuration as you used with the previous board should now be loaded
- Press the **D** button in the **nRF905** Configuration window
- Disconnect the *nRF USB Configurator Board* from the PC
- This *nRF USB Configurator Board* together with the **nRF905-EVBOARD** should now be powered from the 9V battery

Then:

- Connect an antenna (e.g the supplied ¼ wave monopole antenna) to both of the **nRF905-EVBOARDS**
- Put one **nRF905-EVBOARD** in TX ShockBurst™ mode by setting the “Function 1” switch to ON
- Put the other **nRF905-EVBOARD** in RX ShockBurst™ mode by setting the “Function 1” switch to OFF

When the set-up and configuration as explained above is finished, the **nRF905-EVBOARD** in TX ShockBurst™ mode will transmit packets with 32 bits address (default address is used), one byte payload and 16 bits CRC. The payload is an incremented packet number that loops around from 0 to 99. The packet transmission rate is 500 packets/sec. LED 1 on this board will flash when the board is transmitting.

The **nRF905-EVBOARD** in RX ShockBurst™ mode will receive the packets from the board in TX ShockBurst™ mode. The received payload is used to calculate the packet loss ratio, and the packet loss ratio is visualized with LED 1, LED 2 and LED 3 in the following manner:



## nRF905 Evaluation Board

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- When all LEDs are lit, the packet loss ratio is < 5%
- When two LEDs are lit, the packet loss ratio is < 25%
- When only one LED is lit, the packet loss ratio is < 50%
- When no LEDs are lit, the packet loss ratio is > 50%

The LEDs are updated every hundredth packet received, five times/second.

### NOTE:

The **nRF905-EVKIT** is NOT intended to be a reference on maximum range achievable with **nRF905** devices in a communication system. The gain of the antennas used together with the **nRF905-EVBOARDS** severely affects the achievable range in the described test. Be aware of that the performance of a  $\frac{1}{4}$  wave monopole antenna as contained in the **nRF905-EVKIT** is very dependent on size of the available ground plane, and that the loss of antenna gain because of an under-sized ground plane can be considerable. A  $\frac{1}{4}$  wave monopole antenna connected directly to connector J2 on the **nRF905-EVBOARD** has only the board itself as ground plane and this ground plane is also offset with respect to the antenna, and hence the antenna is not operating in ideal conditions.

Also remember that environmental conditions like obstacles and objects in the path between the transmitter and receiver antennas will decrease the range.

## REFERENCES

[1] Nordic Development Platform User Guide, Nordic Semiconductor ASA document, <http://www.nordicsemi.no>



Appendix 1 - nRF905 Evaluation Board, Circuit diagram

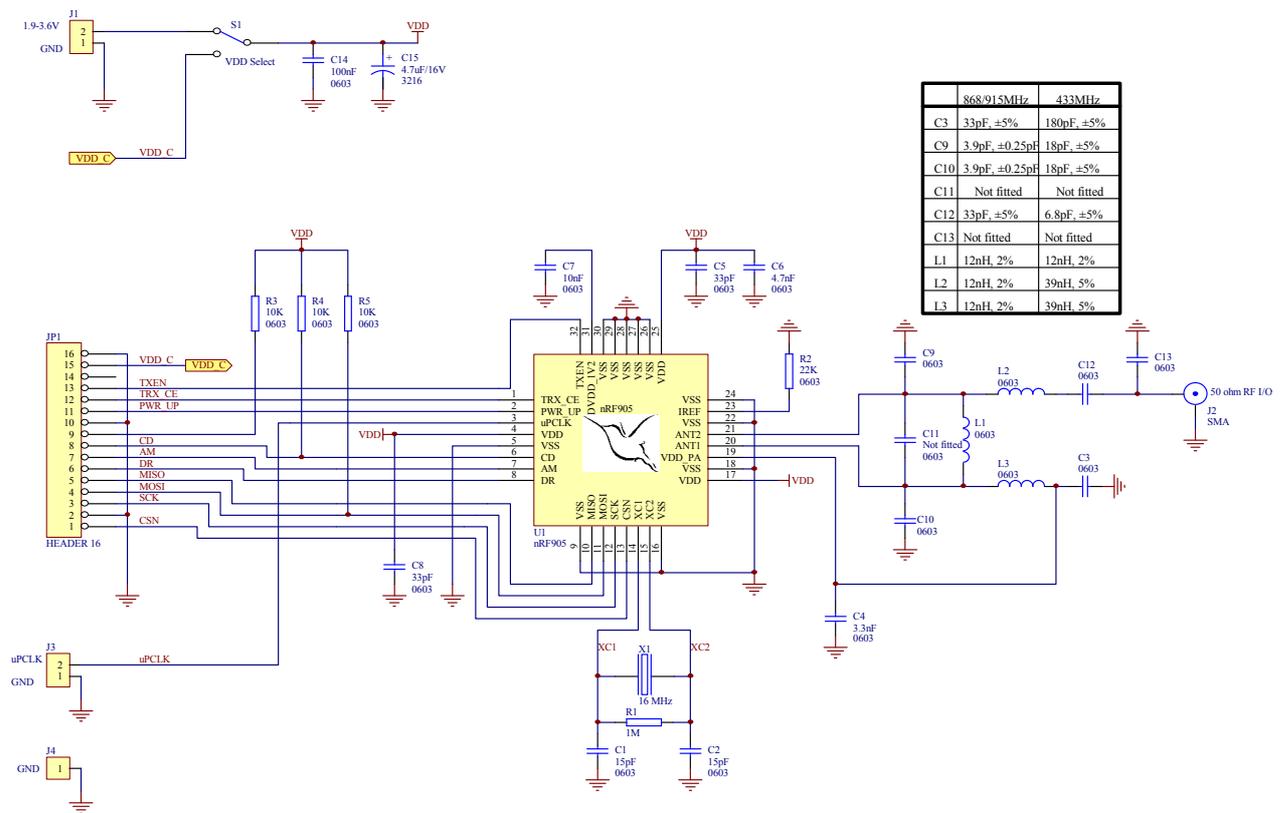
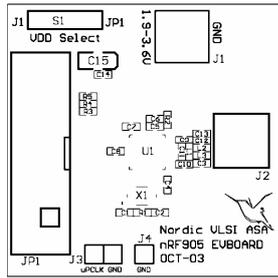
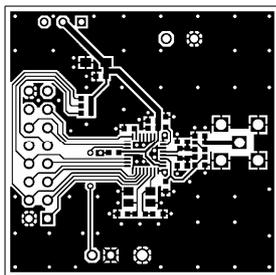


Figure A.1.1 nRF905-EVBOARD, Circuit diagram.

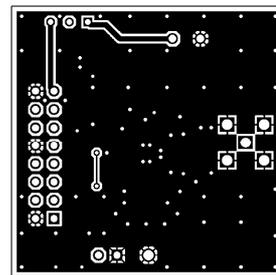


Top silkscreen

No components in bottom layer



Top signal layer



Bottom signal layer

Figure A.2.1 nRF905-EVBOARD, PCB layout

The **nRF905-EVBOARD** is manufactured on a 1.6mm thick, 2 layer FR4 substrate.



Appendix 3 - nRF905 Evaluation Board, Component list

Designator	Description	Part Type	Footprint	Comments
C1	Capacitor ceramic	15pF, ±5%, 50V, NPO	0603	
C2	Capacitor ceramic	15pF, ±5%, 50V, NPO	0603	
C3	Capacitor Ceramic @ 433MHz @ 868/915MHz	180pF, +/-5%, 50V, NP0 33pF, +/-5%, 50V, NP0	0603	
C4	Capacitor Ceramic	3.3nF, +/-10%, 50V, X7R	0603	
C5	Capacitor Ceramic	33pF, +/-5%, 50V, NP0	0603	
C6	Capacitor Ceramic	4.7nF, +/-10%, 50V, X7R	0603	
C7	Capacitor Ceramic	10nF, +/-10%, 50V, X7R	0603	
C8	Capacitor Ceramic	33pF, +/-5%, 50V, NP0	0603	
C9	Capacitor Ceramic @ 433MHz @ 868/915MHz	18pF, +/-5%, 50V, NP0 3.9pF, ±0.25pF, 50V, NP0	0603	
C10	Capacitor Ceramic @ 433MHz @ 868/915MHz	18pF, +/-5%, 50V, NP0 3.9pF, ±0.25pF, 50V, NP0	0603	
C11			0603	Not fitted
C12	Capacitor Ceramic @ 433MHz @ 868/915MHz	6.8pF, +/-5%, 50V, NP0 33pF, +/-5%, 50V, NP0	0603	
C13	Capacitor Ceramic @ 433MHz @ 868/915MHz	Not fitted Not fitted	0603	
C14	Capacitor Ceramic	100nF, +/-10%, 50V, X7R	0603	
C15	Capacitor Tantalum	4.7µF, +/-20%, 16V	3216	
J1	Power supply connector		through-hole	
J2	RF I/O	SMA	through-hole	
J3	µPCLK output	2 pin header	through-hole	
J4	Test point		through-hole	GND for test equipment
JP1	Digital I/O	Flat cable connector 16 pin	through-hole	
L1	Wire wound chip inductor @ 433MHz: SRF>433MHz @ 868/915MHz: SRF>915MHz	12nH, +/-2% 12nH, +/-2%	0603	
L2	Wire wound chip inductor @ 433MHz: SRF>433MHz @ 868/915MHz: SRF>915MHz	39nH, +/-5% 12nH, +/-2%	0603	
L3	Wire wound chip inductor @ 433MHz: SRF>433MHz @ 868/915MHz: SRF>915MHz	39nH, +/-5% 12nH, +/-2%	0603	
R1	Resistor	1M	0603	1%
R2	Resistor	22k	0603	1%
R3	Resistor	10k	0603	1%
R4	Resistor	10k	0603	1%
R5	Resistor	10k	0603	1%
S1	Slide switch, VDD Select		through-hole	
U1	Nordic Semiconductor, 433/868/915MHz RF Transceiver	<b>nRF905</b>	QFN32L/5x5	
X1	Toyocom Devices, 16MHz crystal	TSX-10A	SMD	LxWxH = 4.0x2.5x0.8mm, C <sub>L</sub> =9pF, ESR < 100Ω, tolerance + temperature drift < +/- 30 ppm

Table A.3.1 nRF905-EVBOARD, Component list



**DEFINITIONS**

<b>Product specification</b>
This Evaluation Board documentation contains final product specifications. Nordic Semiconductor ASA reserves the right to make changes at any time without notice in order to improve design and supply the best possible product.
<b>Limiting values</b>
Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Specifications sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.
<b>Application information</b>
Where application information is given, it is advisory and does not form part of the specification.

Table 2: Definitions

Nordic Semiconductor ASA reserves the right to make changes without further notice to the product to improve reliability, function or design. Nordic Semiconductor does not assume any liability arising out of the application or use of any product or circuits described herein.

**LIFE SUPPORT APPLICATIONS**

These products are not designed for use in life support appliances, devices, or systems where malfunction of these products can reasonably be expected to result in personal injury. Nordic Semiconductor ASA customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify Nordic Semiconductor ASA for any damages resulting from such improper use or sale.

Product specification, revision date : 23.06.2006

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**Main Office:**

Vestre Rosten 81, N-7075 Tiller, Norway  
Phone: +47 72 89 89 00, Fax: +47 72 89 89 89

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