
nRF9E5 Evaluation Board

nRF9E5-EVBOARD

GENERAL DESCRIPTION

This document describes the **nRF9E5-EVBOARD** and its use with the Nordic Semiconductor **nRF9E5** Single Chip 433/868/915MHz RF Transceiver with embedded 8051 compatible microcontroller and 4 input 10 bit ADC. **nRF9E5-EVBOARDs** for operation at 433MHz and 868/915MHz are available. This document covers both versions.

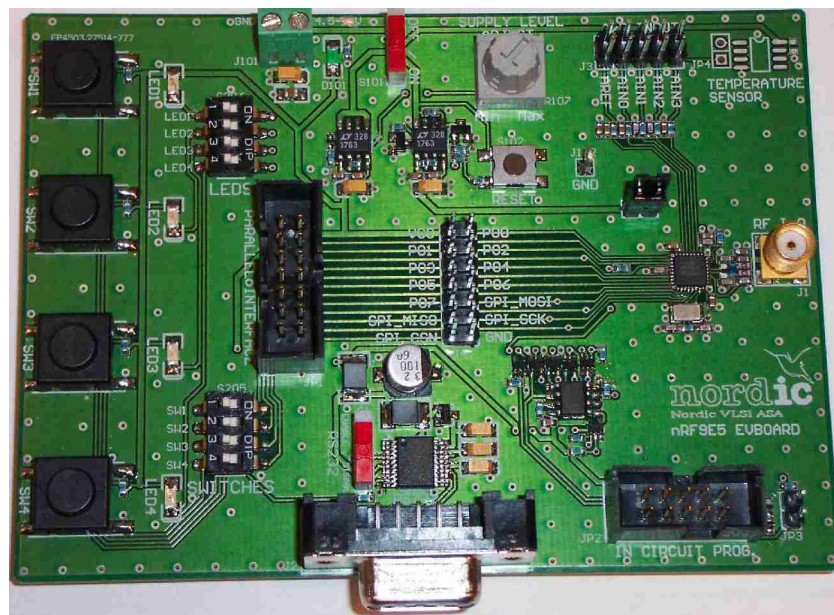


Figure 1: The **nRF9E5-EVBOARD**

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 **nRF9E5** Single Chip 433/868/915MHz RF Transceiver with embedded 8051 compatible microcontroller and 4 input 10 bit ADC has been developed to enable customers to test functionality, develop firmware, run communication and verify the performance parameters of the device. This document describes the usage of the **nRF9E5-EVBOARD**.

The **nRF9E5-EVBOARD** is intended for evaluation and development purposes only. It is not intended for incorporation into an end product.

GETTING STARTED

The **nRF9E5-EVBOARD** is shipped with an *EEPROM programmer and emulator dongle*. The *EEPROM programmer and emulator dongle* enables you to emulate a 4k serial SPI EEPROM and program the **nRF9E5-EVBOARD** on board SPI EEPROM through PC software.

The following equipment is needed to work efficiently with the **nRF9E5-EVBOARD**:

- PC with 2 free USB ports, running (supplied) *nRFPROG* PC software
- 2 *EEPROM programmer and emulator dongles* (supplied)
- A DC voltage supply (+4.5V to +12V)
- 2 standard male USB A/B cables (supplied)

To evaluate the performance of the device the following instrumentation should be available:

- Logic analyzer
- Ampere meter
- RF signal generator with GFSK modulation capability
- RF spectrum analyzer
- Low frequency, high accuracy signal generator (ADC tests)



EEPROM PROGRAMMER AND EMULATOR DONGLE DESCRIPTION

The *EEPROM programmer and emulator dongle* is fitted ‘on-top’ of the **nRF9E5-EVBOARD** as shown in (Figure 2). This interface enables you to:

- Emulate the external 4k serial SPI EEPROM needed by **nRF9E5** through the *nRFPROG* PC software.
- Program the EEPROM included on the **nRF9E5-EVBOARD**.

The *nRFPROG* software is documented in *nRFPROG GETTING STARTED* [1].

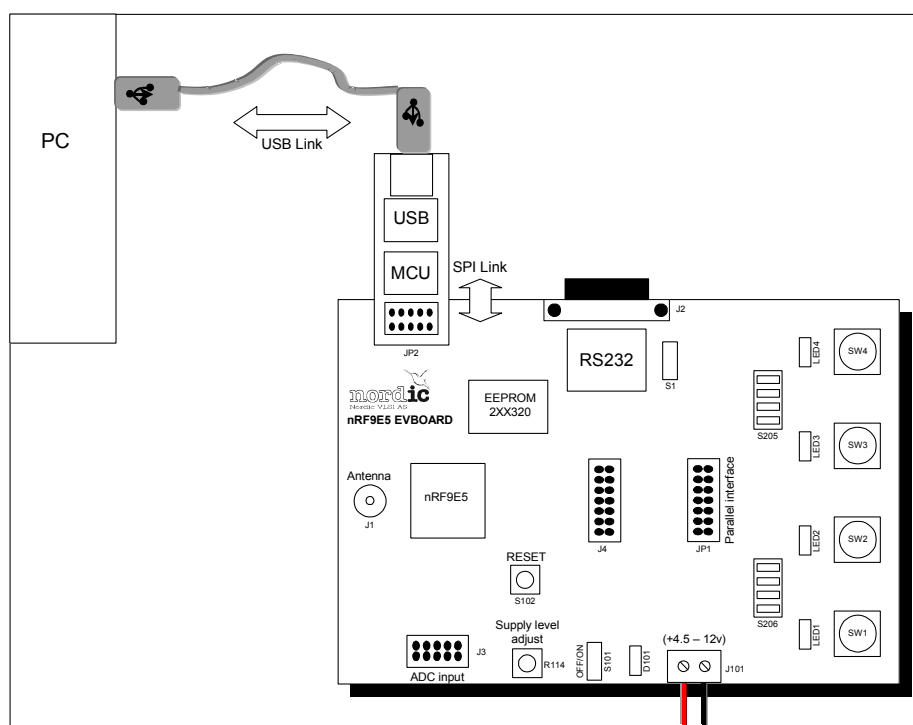


Figure 2: **nRF9E5-EVBOARD** with programming dongle

Emulating the external EEPROM needed by the **nRF9E5** will increase the flexibility and speed of SW development and de-bugging. When a program is running well, the EEPROM included on the **nRF9E5-EVBOARD** can be programmed, enabling the **nRF9E5-EVBOARD** to run stand-alone.

Power supply

Main power supply to the *EEPROM programmer and emulator dongle* is fed through the USB interface (J101) from the PC. Supply voltage to the **nRF9E5-EVBOARD** interface stage runs through J102 from the **nRF9E5-EVBOARD**. The *EEPROM programmer and*



nRF9E5 Evaluation Board

emulator dongle must hence be plugged in the **nRF9E5-EVBOARD** connector JP2 in order to have proper signal levels on J102.

nRF9E5-EVBOARD interface

The pin-out of the interface (J102) to the **nRF9E5-EVBOARD** can be found in Table 2 under the chapter **nRF9E5-EVBOARD DESCRIPTION** (EVBOARD connector JP2). The PC interface (J101) is a standard USB B-connector interface.

USB addressing (S101)

If both of the supplied *EEPROM programmer and emulator dongles* are connected to the same USB HUB (same PC), they need a unique USB address each.

On the *EEPROM programmer and emulator dongle*, switch S101 can be set to USB address 1 or 2, both to give the two boards a unique USB address for the HUB and an easy way to visually identify the two **nRF9E5-EVBOARDS**.

Remember that the address must be set prior to attaching the *EEPROM programmer and emulator dongles* to the USB HUB. This USB address will also be shown in the *nRFPROG* user interface to identify the two **nRF9E5-EVBOARDS**.



nRF9E5-EVBOARD DESCRIPTION

Appendix 1 shows the **nRF9E5-EVBOARD** circuit diagrams. The PCB layout and component placement is shown in Appendix 2. The component list is given in Appendix 3.

Figure 3 shows the block diagram of the **nRF9E5-EVBOARD**.

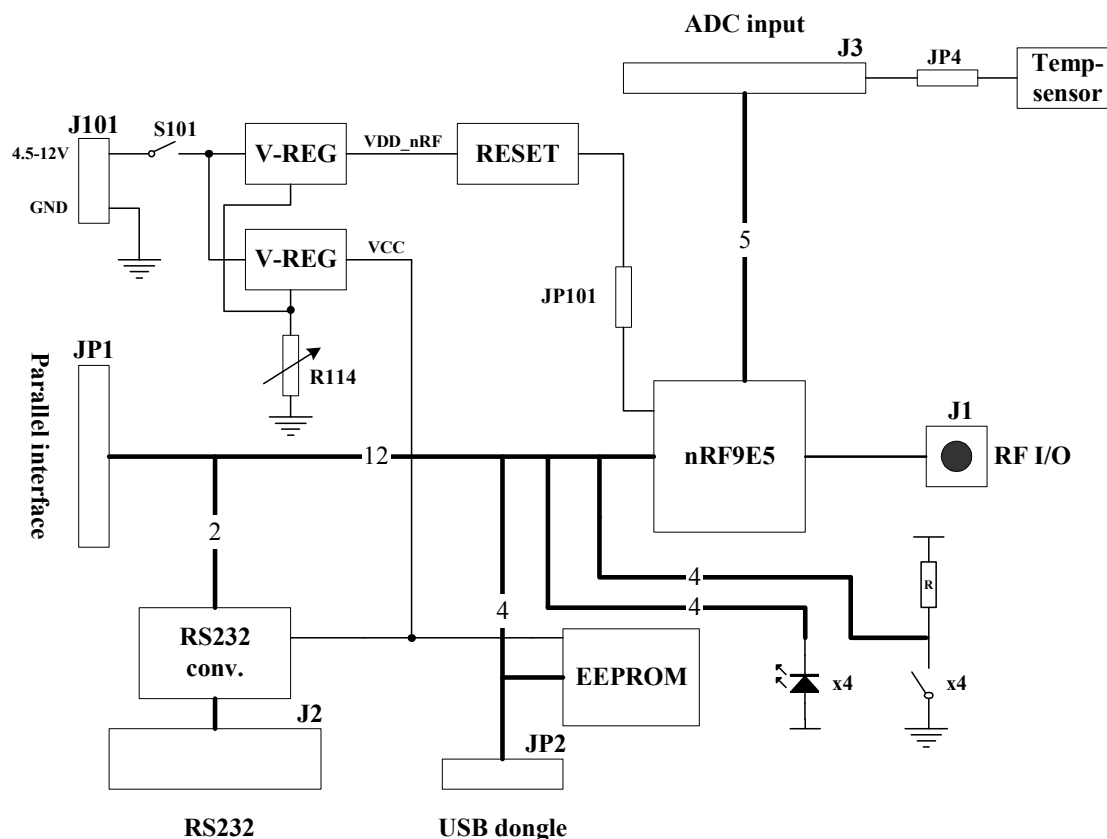


Figure 3: Block diagram of the **nRF9E5-EVBOARD**

Power supply (J101)

Power supply and ground is applied to the **nRF9E5-EVBOARD** via connector J101. Two on board adjustable voltage regulators (U102 and U103) are included, allowing an input voltage range from **+4.5V to +12V** at connector J101. The output voltages from the voltage regulators (VDD_nRF and VCC) are simultaneously adjusted from +1.8V to +3.6V by the use of the dual gang potentiometer R114, and the voltage levels can be measured on header JP101. There is one voltage regulator (U102) for the **nRF9E5** device, and one voltage regulator (U103) for the rest of the circuitry on the board.

Power switch S101 turns the **nRF9E5-EVBOARD** main power on and of. The green LED D101 is lit when power is on. Note that if the output voltages from the voltage regulators are adjusted to a low voltage level, the light from the LED will be weak.



Digital I/O ports

All signals in digital I/O ports 0 and 1 of the 8051 controller can be accessed through JP1 (Parallel Interface). The pin-out is listed in Table 1.

JP1 pin #	nRF9E5 port#	Signal name	Functionality
1	-	GND	
2	P1.3	EECSN (P1.3)	GPIO / EEPROM CSN
3	P1.0	SCK (P1.0)	SPI clock / T2
4	P1.2	MISO (P1.2)	SPI datain / GPIO
5	P1.1	MOSI (P1.1)	SPI dataout / GPIO
6	P0.7	P07	GPIO / PWM
7	P0.6	P06	GPIO / T1
8	P0.5	P05	GPIO / T0
9	P0.4	P04	GPIO / INT1_N
10	P0.3	P03	GPIO / INT0_N
11	P0.2	P02	GPIO / TXD (UART)
12	P0.1	P01	GPIO / RXD (UART)
13	P0.0	P00	GPIO / GTIMER
14	-	VCC	Output voltage from regulator U103

Table 1: **nRF9E5-EVBOARD**, JP1 pin-out

These signals are also available for measurements on header J4. The signal names are found on the PCB silkscreen.

UART / RS232 (J2)

The **nRF9E5** UART is fed to an on board RS232 converter in addition to the parallel interface connector JP1.

The converted RS232 signal is available at connector J2, which is a standard 9-pin female DSUB for connection to PC or other equipment.

Switch S1 disables the RS232 converter and tri-states its outputs. This enables the **nRF9E5** UART to be accessed through JP1.

NOTE:

The RS232 converter will also shut down and tri-state the outputs if a RS232 plug is not present in J2.

EEPROM

The **nRF9E5-EVBOARD** is fitted with a standard 2xx320 SPI EEPROM for program code (U2). The EEPROM is accessed through the **nRF9E5** SPI master found on digital I/O port 1 (P1).

On the **nRF9E5-EVBOARD** the SPI and control signals are all buffered (U5-U8). This buffering is not needed in a final application, but utilized on the **nRF9E5-EVBOARD** to



nRF9E5 Evaluation Board

avoid overloading the P1 port and enabling in circuit programming of the on board EEPROM.

As the **nRF9E5** features an SPI master it must be overridden by the *EEPROM programmer and emulator dongle* when the **nRF9E5-EVBOARD** on board EEPROM is to be programmed.

JP2 interfaces the programming *EEPROM programmer and emulator dongle* that is shipped with the **nRF9E5-EVBOARDS**. This external EEPROM emulator and programmer eases the development of firmware, and enables the user to download new firmware through an USB interface.

If it is desirable to program the external EEPROM from the **nRF9E5** a jumper must be mounted on header JP3. The *EEPROM programmer and emulator dongle* must be removed from JP2 when doing this.

The pin out of JP2 is listed in Table 2.

Pin number	Pin name	Comment
1	VCC / VL	Output voltage from regulator U103
2	VER	nRF9E5-EVBOARD rev. code
3	CCTRL	CS override for EEPROM programming
4	CSN	Chip select from nRF9E5
5	SO	SPI data out
6	WPN	On board EEPROM write protect
7	SI	SPI data in
8	SCK	SPI clock
9	RESET	nRF9E5 reset
10	GND	System GND

Table 2 **nRF9E5-EVBOARD** JP2 pin out

RF I/O (J1)

For convenient connection of the differential antenna output/input pins to a single ended antenna or 50Ω test equipment, a differential to single ended matching network is included. This network matches the 50Ω single ended antenna or 50Ω test equipment impedance at the SMA connector J1 to the recommended differential load impedance at the **nRF9E5**'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 **nRF9E5-EVBOARD** have the tightest tolerances available. This is done to minimize the influence of component variations in the matching network during **nRF9E5** 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.

A/D input (J3)

The 4 external ADC inputs and the external ADC reference voltage (AREF) are fed through header J3. The signals are single ended, and in header J3 each input is paired with a GND.



nRF9E5 Evaluation Board

All inputs are low pass filtered through first order RC units, the cut off is 3.2 MHz. The AREF is similarly filtered with a cut of frequency of 1.5 kHz.

RESET

Since the **nRF9E5** device has no external reset pin, the separate voltage regulator (U102) for the **nRF9E5** device has a shut-down feature to ensure a controlled shut-off of VDD_nRF and hence reset, during firmware debugging.

A **nRF9E5** reset is generated either by pressing the RESET push-button (S102) on the board, manually through the PC software or by downloading new software to the EEPROM emulator.

This external reset circuitry is not necessary in a final application since the **nRF9E5** then will be the system master and features power on, watch dog and interrupt reset routines.

nRF9E5 voltage and current measurements (JP101)

To enable measurement of **nRF9E5** current consumption a header JP101 is put on the **nRF9E5** supply line. The jumper on this header is never to be removed, except when replaced by an ampere meter for measurements. The exact supply voltage (VDD_nRF) to the **nRF9E5** can also be measured on JP101.

Temperature Sensor

The **nRF9E5-EVBOARD** includes a National Semiconductor LM35DZ temperature sensor. This sensor can be connected to the AIN3 input of the ADC by mounting a jumper on header JP4.

The temperature sensor has an output voltage that is linearly proportional to the Celsius (Centigrade) temperature. Output voltage level is $V_{OUT} = 0mV + 10mV/°C$ in the operating temperature range 0°C to +100°C of the sensor.

User LEDs

The **nRF9E5-EVBOARD** includes 4 yellow LEDs (LED1-LED4). The LEDs can be connected to the **nRF9E5** digital I/O port P0 (P0.0, P0.2, P0.4 and P0.6) by the use of the four positions DIP switch S206.

NOTE:

Each pin in digital I/O port P0 may sink or source a high current. Even numbered bits will sink high current when the corresponding bit in P0_DRV is set, whereas odd numbered bits will source high current when the corresponding bit in P0_DRV is set. For further details, please see the **nRF9E5** Product Specification.



User Push-buttons

The **nRF9E5-EVBOARD** includes 4 push-button switches (SW1-SW4). The push-buttons can be connected to the **nRF9E5** digital I/O port P0 (P0.1, P0.3, P0.5 and P0.7) by the use of the four positions DIP switch S205.

REFERENCES

[1] nRFPROG GETTING STARTED, Nordic Semiconductor document,
<http://www.nordicsemi.no>

PRODUCT SPECIFICATION



Appendix 1 - nRF9E5 Evaluation Board, Circuit diagram

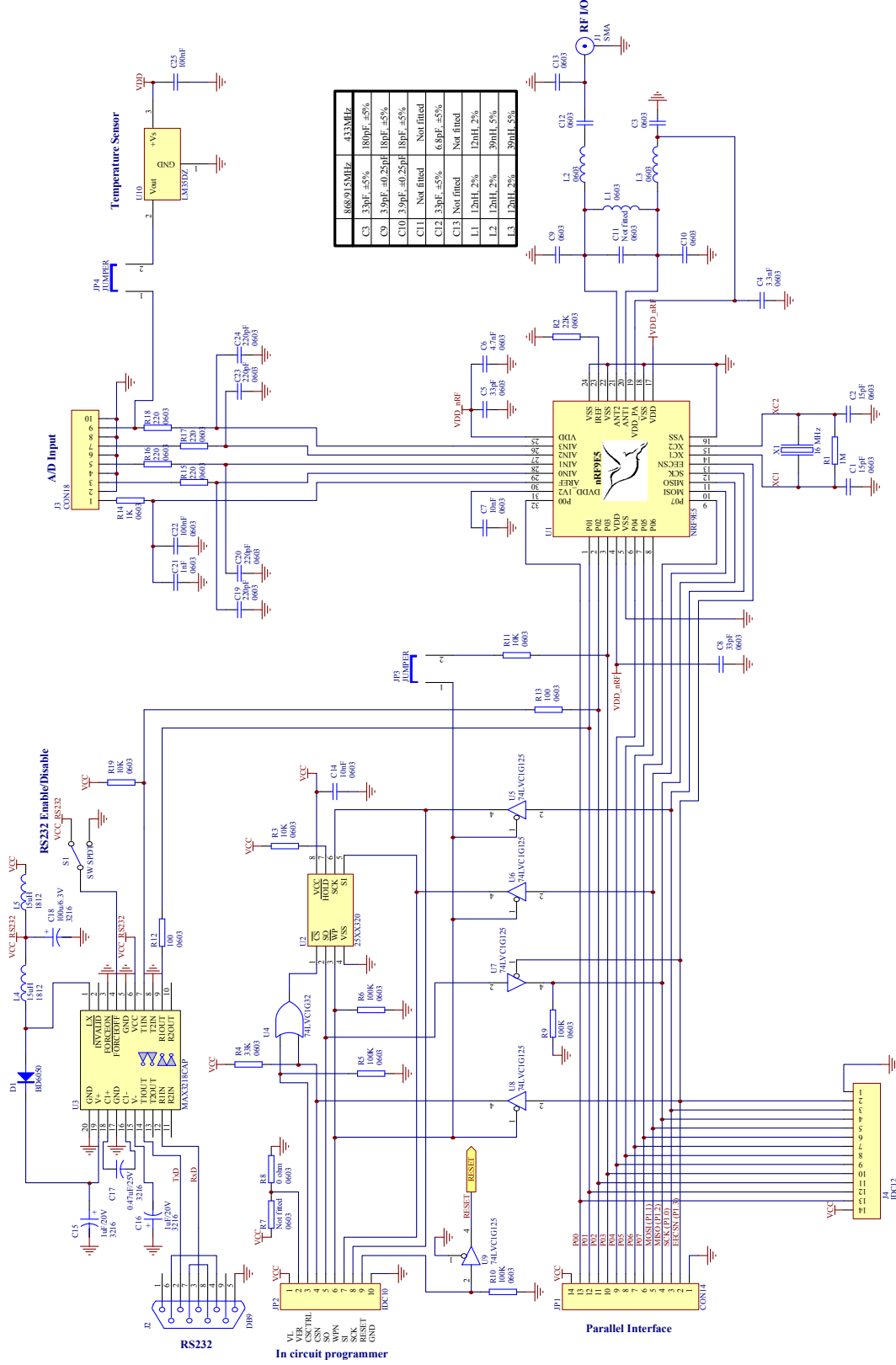


Figure A.1.1. nRF9E5-EVBOARD, Main circuitry

PRODUCT SPECIFICATION



Appendix 1 - nRF9E5 Evaluation Board, Circuit diagram

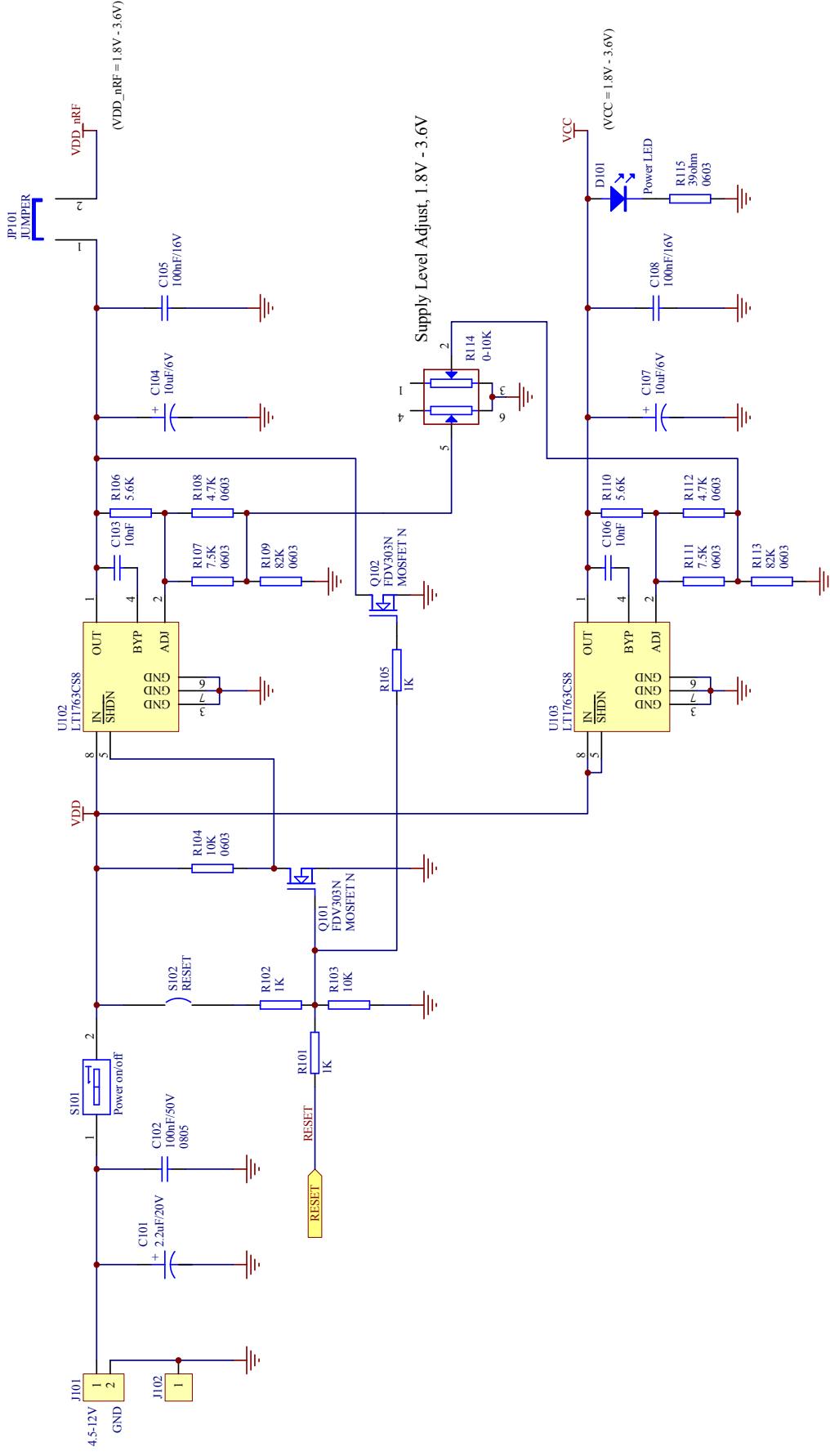


Figure A.1.2. nRF9E5-EVBOARD, Power supply and RESET.

PRODUCT SPECIFICATION



Appendix 1 - nRF9E5 Evaluation Board, Circuit diagram

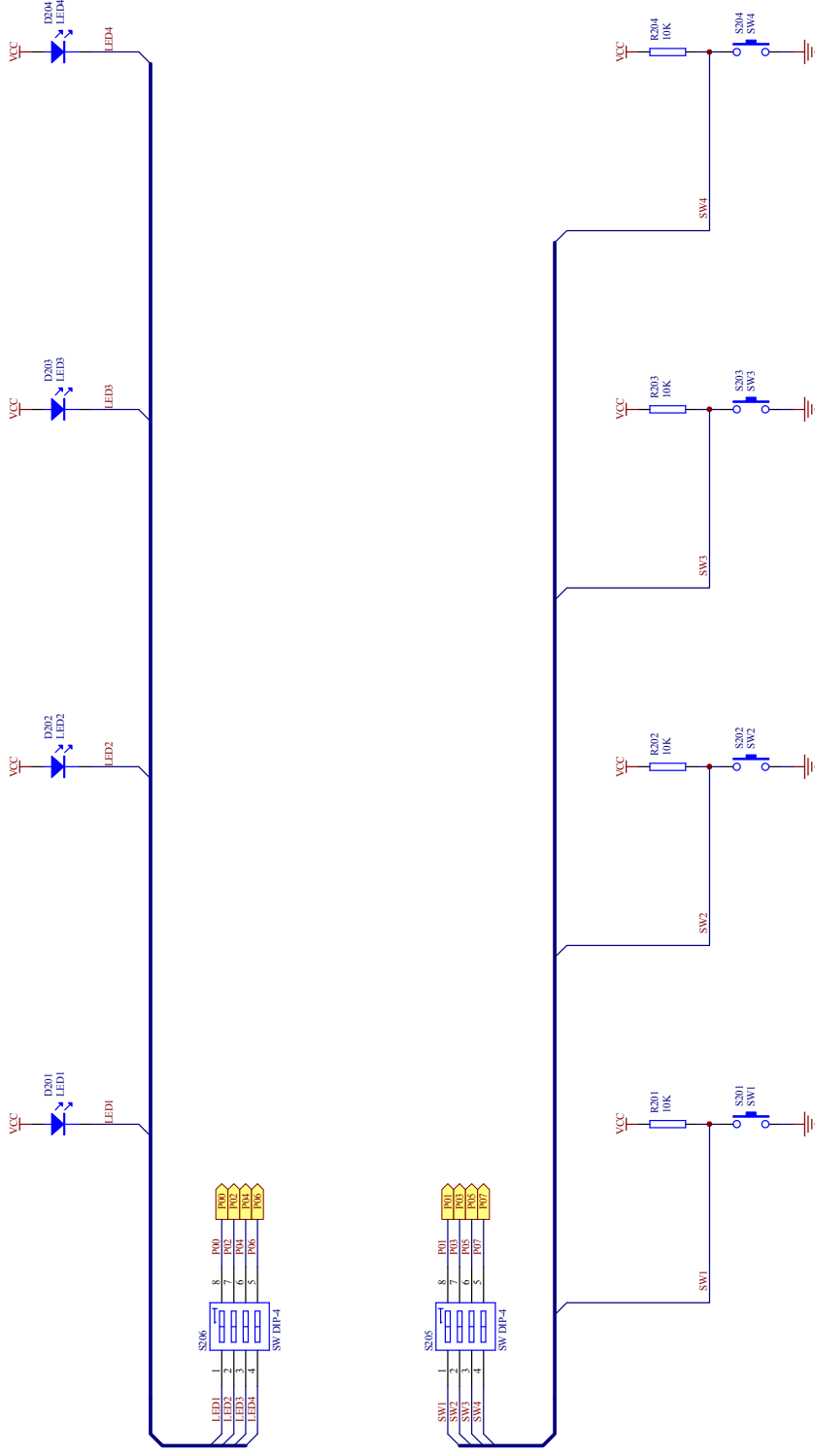
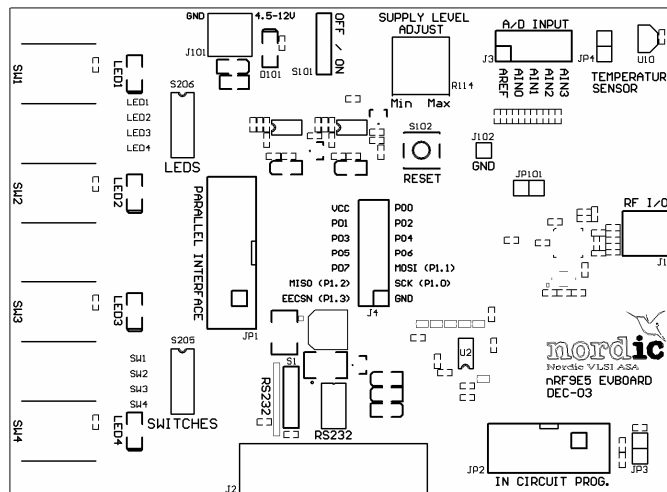


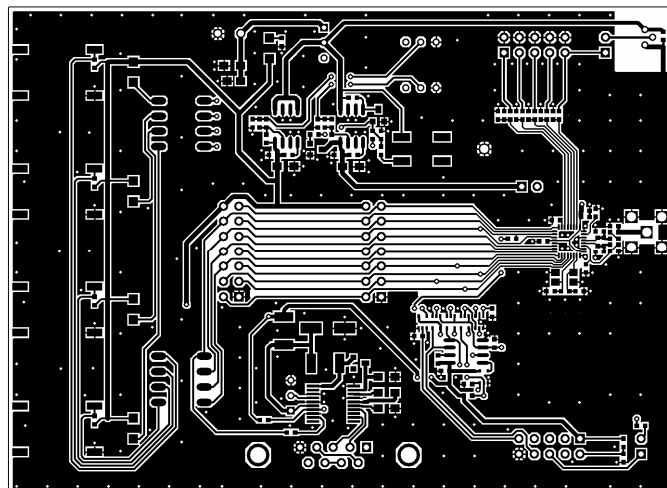
Figure A.1.3. nRF9E5-EVBOARD, LEDs and Switches



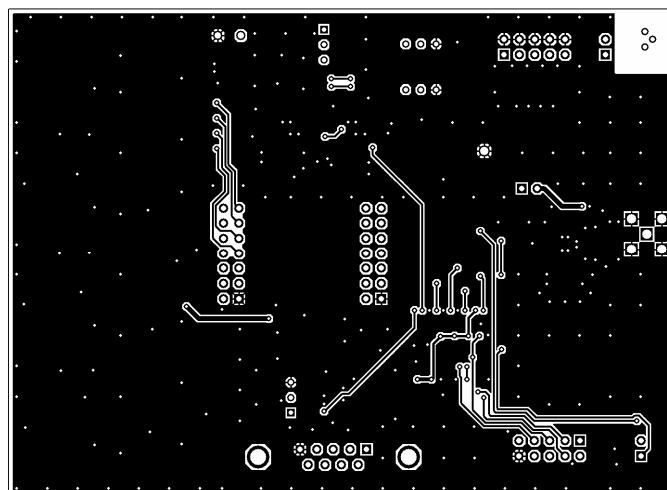
Appendix 2 - nRF9E5 Evaluation Board, PCB layout



a) Top silk screen



a) Top view



a) Bottom view

Figure A.2.1. nRF9E5-EVBOARD, PCB layout

The nRF9E5-EVBOARD is manufactured on a 1.6mm thick, 2 layer FR4 substrate.



Appendix 3 - nRF9E5 Evaluation Board, Component list

Designator	Description	Part Type	Footprint	Comment
C1	Capacitor Ceramic	15pF, +/-5%, 50V, NP0	0603	
C2	Capacitor Ceramic	15pF, +/-5%, 50V, NP0	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	10nF, +/-10%, 50V, X7R	0603	
C15	Capacitor Tantalum	1.0µF, +/-20%, 20V	3216	
C16	Capacitor Tantalum	1.0µF, +/-20%, 20V	3216	
C17	Capacitor Tantalum	0.47µF, +/-20%, 35V	3216	
C18	Capacitor Electrolytic	100µF, +/-20%, 6.3V	SMD	
C19	Capacitor Ceramic	220pF, +/-5%, 50V, NP0	0603	
C20	Capacitor Ceramic	220pF, +/-5%, 50V, NP0	0603	
C21	Capacitor Ceramic	1nF, +/-10%, 50V, X7R	0603	
C22	Capacitor Ceramic	100nF, +/-10%, 50V, X7R	0603	
C23	Capacitor Ceramic	220pF, +/-5%, 50V, NP0	0603	
C24	Capacitor Ceramic	220pF, +/-5%, 50V, NP0	0603	
C25	Capacitor Ceramic	100nF, +/-10%, 50V, X7R	0603	
C101	Capacitor Tantalum	2.2µF, +/-20%, 20V	3216	
C102	Capacitor Ceramic	100nF, +/-10%, 50V, X7R	0805	
C103	Capacitor Ceramic	10nF, +/-10%, 50V, X7R	0603	
C104	Capacitor Tantalum	10µF, +/-20%, 6V	3216	
C105	Capacitor Ceramic	100nF, +/-10%, 50V, X7R	0603	
C106	Capacitor Ceramic	10nF, +/-10%, 50V, X7R	0603	
C107	Capacitor Tantalum	10µF, +/-20%, 6V	3216	
C108	Capacitor Ceramic	100nF, +/-10%, 50V, X7R	0603	
D1	Shottky diode	BD6050	SOT-23D	
D101	LED, Green		1206	
D201	LED, Yellow		1206	
D202	LED, Yellow		1206	
D203	LED, Yellow		1206	
D204	LED, Yellow		1206	
J1	RF I/O	SMA	through-hole	
J2	RS232 connector	9 pin DSUB	through-hole	
J3	ADC input	2x5 pin header	through-hole	



Appendix 3 - nRF9E5 Evaluation Board, Component list

Designator	Description	Part Type	Footprint	Comment
J4	Test connector	2x7 pin header	through-hole	
J101	Power supply connector		through-hole	
J102	Test point		through-hole	GND for test equipment
JP1	Parallel interface connector	Flat cable connector 14 pin	through-hole	
JP2	In circuit prog. connector	Flat cable connector 10 pin	through-hole	
JP3	Jumper connection	2 pin header	through-hole	
JP4	Jumper connection	2 pin header	through-hole	
JP101	Jumper connection	2 pin header	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	
L4	Inductor	15uH	1812	Saturation current > 350 mA, R < 1 ohm
L5	Inductor	15uH	1812	Saturation current > 350 mA, R < 1 ohm
Q101	DMOS N-Channel	FDV303N	SOT-23	
Q102	DMOS N-Channel	FDV303N	SOT-23	
R1	Resistor	1M	0603	1%
R2	Resistor	22k	0603	1%
R3	Resistor	10k	0603	1%
R4	Resistor	33k	0603	1%
R5	Resistor	100k	0603	1%
R6	Resistor	100k	0603	1%
R7	Resistor		0603	Not fitted
R8	Resistor	0 ohm	0603	1%
R9	Resistor	100k	0603	1%
R10	Resistor	100k	0603	1%
R11	Resistor	10k	0603	1%
R12	Resistor	100	0603	1%
R13	Resistor	100	0603	1%
R14	Resistor	1k	0603	1%
R15	Resistor	220	0603	1%
R16	Resistor	220	0603	1%
R17	Resistor	220	0603	1%
R18	Resistor	220	0603	1%
R19	Resistor	10k	0603	1%
R101	Resistor	1k	0603	1%
R102	Resistor	1k	0603	1%
R103	Resistor	10k	0603	1%
R104	Resistor	10k	0603	1%
R105	Resistor	1k	0603	1%
R106	Resistor	5.6k	0603	1%
R107	Resistor	7.5k	0603	1%
R108	Resistor	4.7k	0603	1%
R109	Resistor	82k	0603	1%



Appendix 3 - nRF9E5 Evaluation Board, Component list

Designator	Description	Part Type	Footprint	Comment
R110	Resistor	5.6k	0603	1%
R111	Resistor	7.5k	0603	1%
R112	Resistor	4.7k	0603	1%
R113	Resistor	82k	0603	1%
R114	Dual gang potentiometer	0-10k	through-hole	
R115	Resistor	39	0603	1%
R201	Resistor	10k	0603	1%
R202	Resistor	10k	0603	1%
R203	Resistor	10k	0603	1%
R204	Resistor	10k	0603	1%
S1	Slide switch, RS232 Enable/Disable		through-hole	
S101	Slide switch, Power on/off		through-hole	
S102	Tact switch, RESET		SMD	
S201	Keyboard switch, SW1		SMD	
S202	Keyboard switch, SW2		SMD	
S203	Keyboard switch, SW3		SMD	
S204	Keyboard switch, SW4		SMD	
S205	Four positions DIP switch		SMD	
S206	Four positions DIP switch		SMD	
U1	Nordic Semiconductor, 433/868/915MHz RF Transceiver with MCU and ADC	nRF9E5	QFN32L/5x5	
U2	4 kbyte serial EEPROM with SPI interface	25XX320	SO-8	
U3	Maxim, RS-232 Transceiver	MAX3218CAP	SSO-20	
U4	OR gate	74LVC1G32	SOT353-5	
U5	Bus buffer/line driver	74LVC1G125	SOT353-5	
U6	Bus buffer/line driver	74LVC1G125	SOT353-5	
U7	Bus buffer/line driver	74LVC1G125	SOT353-5	
U8	Bus buffer/line driver	74LVC1G125	SOT353-5	
U9	Bus buffer/line driver	74LVC1G125	SOT353-5	
U10	National Semiconductor, temperature sensor	LM35DZ	TO-92	
U102	Linear Technology, adjustable LDO voltage regulator	LT1763CS8	SO-8	
U103	Linear Technology, adjustable LDO voltage regulator	LT1763CS8	SO-8	
X1	Toyocom Devices, 16MHz crystal	TSX-10A	SMD	LxWxH = 4.0x2.5x0.8mm, C _L =9pF, ESR < 100 ohm, tolerance + temperature drift < +/- 30 ppm
	Jumper	Short circuit for JP3		
	Jumper	Short circuit for JP4		
	Jumper	Short circuit for JP101		

Table A.3.1: nRF9E5-EVBOARD, Component list



DEFINITIONS

Product specification
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.
Limiting values
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.
Application information
Where application information is given, it is advisory and does not form part of the specification.

Table 3: 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

Visit the Nordic Semiconductor ASA website at <http://www.nordicsemi.no>

