

## 1. General

Gerber files for RF layouts have been made for Nordic VLSI's **nRF402** Single Chip 433MHz RF Transmitter [1]. Three different loop antennas for 433MHz have also been made available.

The Gerber files for each layout are compressed into the Zip archive format. The Zip archive files includes a file named **readme.wri** that must be read before importing the Gerber files into the PCB editor.

All described layouts should be fabricated on standard 1.6mm double-sided FR4 printed circuit board.

## 2. RF layout for nRF402

The RF layouts include all necessary circuitry to design the radio frequency part of a short range communication system based on **nRF402**. The transmitter data and control lines DIN, CS and PWR\_UP are available at the perimeter of the RF layout and should be connected to the digital part of a customer's application. +3V and GND are also available at the perimeter of the RF layout. The +3V for the RF part of the application circuit should be filtered separately from the supply voltages of any digital circuitry. Star routing is strictly recommended from the +3V supply source to the RF, digital or other parts of the application circuit.

All RF layouts presented below are equal except for the antenna connection circuitry. Solutions for differential connection to loop antenna and single ended connection to 50Ω antenna are presented.

### 2.1. Differential connection to loop antenna

Figure 1 shows the schematics for RF layout with differential connection to a loop antenna. The PCB layout is shown in Figure 2. The loop antenna layouts described in chapter 3 can easily be placed together with this RF layout. The connection points numbered 1, 2 and 3 on the loop antenna layouts should be connected exactly to the corresponding connection points numbered 1, 2 and 3 on the RF layout.

If the loop antenna of practical reasons has to be connected further away from the **nRF402**, the connection has to be symmetrical and the length of the PCB tracks must not exceed about 6cm. Since the loop antenna is a tuned antenna, the tuning of the antenna has to be checked in this case.

The Gerber files Zip archive filename is **PCB\_nRF402\_diff.zip**.



The recommended external components are as given in Table 1.

Component	Description	Size	Value	Tolerance	Units
C1	NP0 ceramic chip capacitor, (Crystal oscillator)	0603	22		pF
C2	NP0 ceramic chip capacitor, (Crystal oscillator)	0603	22		pF
C3	X7R ceramic chip capacitor, (Supply decoupling)	0603	4.7		nF
C4	NP0 ceramic chip capacitor, (Supply decoupling)	0603	100		pF
C5	X7R ceramic chip capacitor, (Supply decoupling)	1206	2.2		μF
C6	NP0 ceramic chip capacitor, (Supply decoupling)	0603	100		pF
L1	VCO inductor, $Q > 45$ @ 433 MHz	0603	22	±2%	nH
R1	1/8W chip resistor, (Crystal oscillator)	0603	1.0		MΩ
R3	1/8W chip resistor, (Transmitter power setting)	0603	22 <sup>1)</sup>		kΩ
X1	Crystal	-	4.000	<sup>2)</sup>	MHz

Table 1 Recommended External Components.

<sup>1)</sup> See [1].

<sup>2)</sup> See [1].

## 2.2. Single ended connection to 50Ω antenna by using a differential to single ended matching network

Figure 3 shows the schematics for RF layout with single ended connection to 50Ω antenna by using a differential to single ended matching network. The PCB layout is shown in Figure 4.

The antenna connection point should be as close as possible to the output of the matching network. If the PCB track between the output of the matching network and the antenna connection point of practical reasons has to exceed about 3cm, this track should be carried out as a 50Ω microstrip line. For a standard FR4 printed circuit board with 1.54mm substrate thickness and relative dielectric constant  $\epsilon_r \approx 4.45$  at 433MHz, the width of the microstrip line should be 3mm.

The Gerber files Zip archive filename is **PCB\_nRF402\_single\_netw-1\_1.zip**.

The recommended external components are as given in Table 1, except for the supply decoupling capacitor C6, with addition of the components in the differential to single ended matching network as given in Table 2.

Component	Description	Size	Value	Tolerance	Units
C6	X7R ceramic chip capacitor, (Supply decoupling)	0603	1		nF
C7	NP0 ceramic chip capacitor	0603	1.8	<±0.25	pF
C8	NP0 ceramic chip capacitor	0603	470		pF
C9	NP0 ceramic chip capacitor	0603	1.5	<±0.1	pF
L2	Chip inductor, SRF>433 MHz <sup>3)</sup>	0603	180	±10%	nH
L3	Chip inductor, $Q > 45$ @ 433 MHz	0603	22	±2%	nH
L4	Chip inductor, $Q > 45$ @ 433 MHz	0603	22	±2%	nH
L5	Chip inductor	0603	22	±2%	nH

Table 2 Recommended components in the differential to single ended matching network

<sup>3)</sup> See [1].

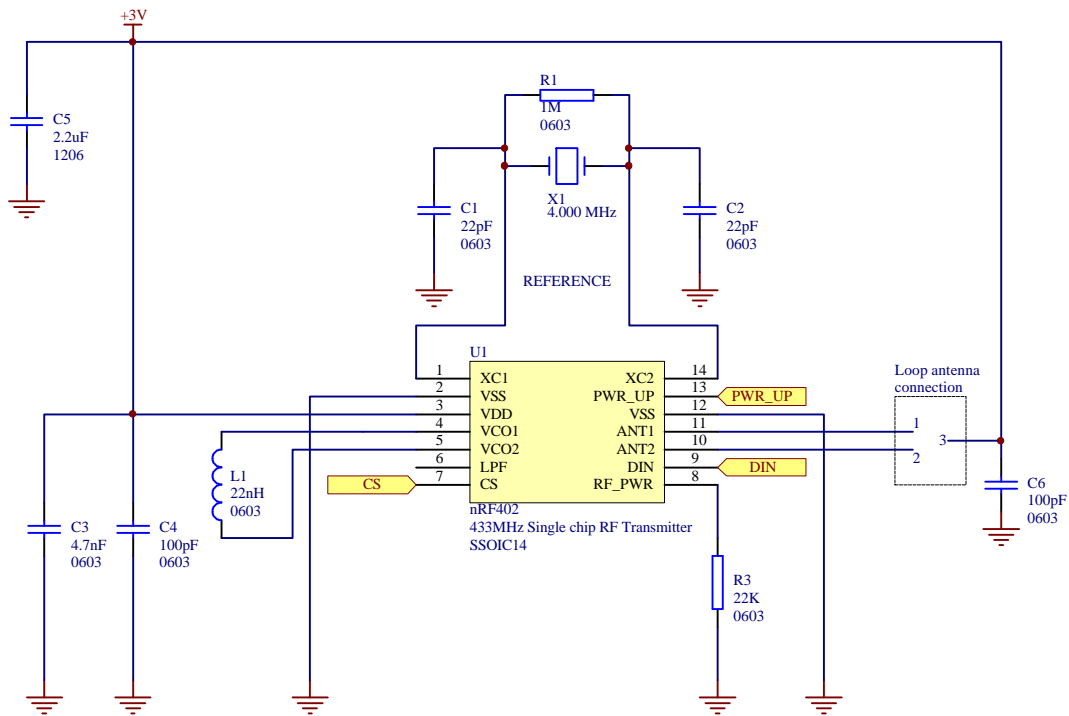


Figure 1. Schematics for RF layout with differential connection to a loop antenna

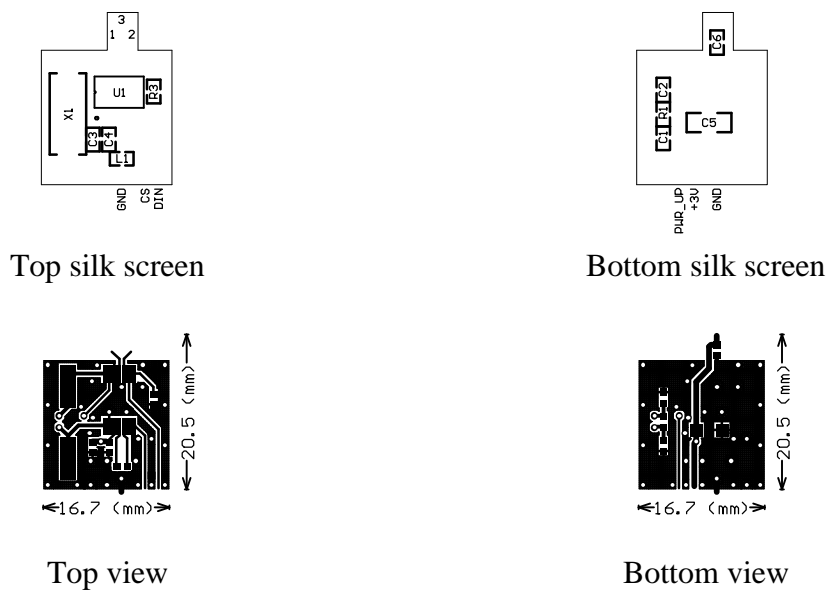


Figure 2. RF layout with differential connection to a loop antenna



**nRF402 RF and antenna layout**

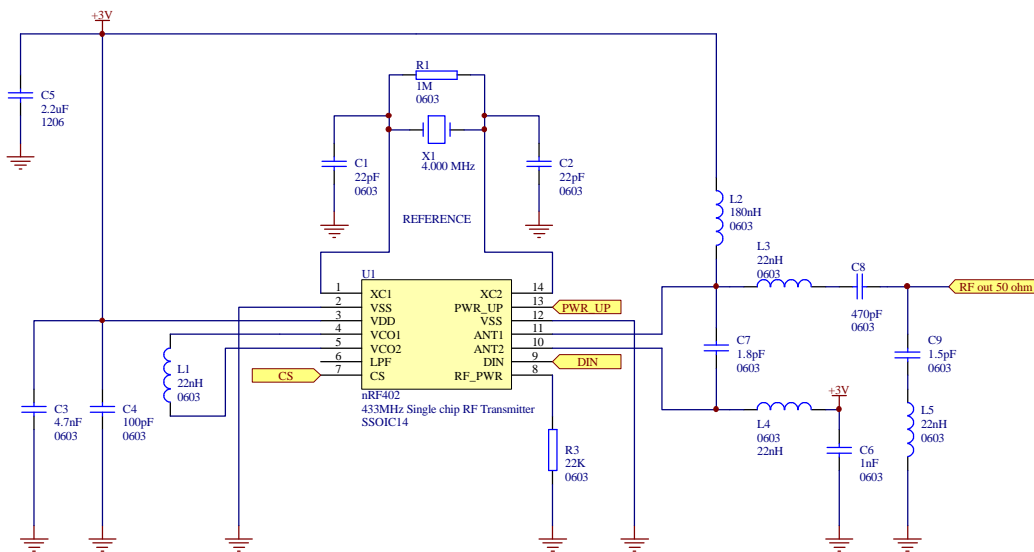
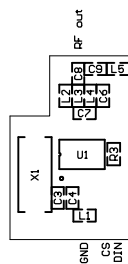
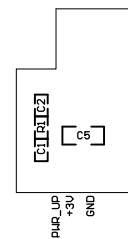


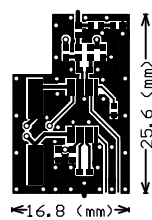
Figure 3. Schematics for RF layout with single ended connection to 50Ω antenna by using a differential to single ended matching network



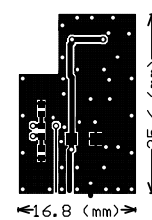
Top silk screen



Bottom silk screen



Top view



Bottom view

Figure 4. RF layout with single ended connection to 50Ω antenna by using a differential to single ended matching network



### 3. Loop antenna layouts

A loop antenna with T-match [2] is a good solution for low cost and small size radio modules. Three different layout solutions for small rectangular loop antennas are described below.

Figure 5 shows the geometry of the designed rectangular loop antennas.

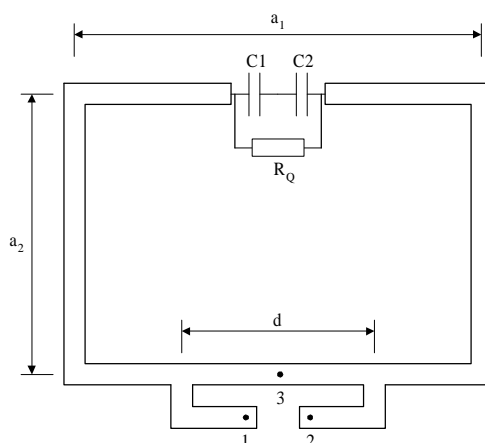


Figure 5. Geometry of rectangular loop antenna

The loop antenna physical parameters are

- $a_1$  = loop antenna length [mm]
- $a_2$  = loop antenna width [mm]
- $d$  = feed length [mm]
- $b$  = width of loop conductor

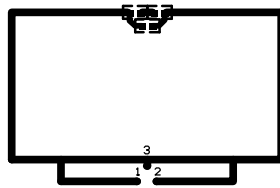
Each antenna is tuned to a resonance frequency of 433MHz with chip capacitors  $C1$  and  $C2$ . For the designed loop antennas, these capacitors should have tolerances better than 5%. The resistor  $R_Q$  controls the  $Q$ -value of the antenna. All loop antennas are tuned to approximately  $400\Omega$  with a T-match. The width of the loop conductor for all of the loop antennas is 1mm. There is no ground plane beneath the antennas.

Table 3 shows a summary of the designed loop antennas.

Loop antenna $a_1 \times a_2$ [mm]	Feed length $d$ [mm]	C1		C2		$R_Q^{4)}$ [k $\Omega$ ]	Q-value	$Z_0$ [ $\Omega$ ]
		Value [pF]	Tolerance [pF]	Value [pF]	Tolerance [pF]			
18x10	22	5.6	$\pm 0.25$	10	$\pm 0.25$	18	55	400
25x15	21.5	3.3	$\pm 0.1$	5.6	$\pm 0.25$	18	55	400
35x20	22.5	1.8	$\pm 0.1$	4.7	$\pm 0.1$	68	68	380

Table 3 Summary of the loop antennas

<sup>4)</sup> Thick film chip resistor with resistance tolerance 5% or better.







#### **4. References**

1. Product Specification **nRF402**, “433MHz Single Chip RF Transmitter”, Nordic VLSI ASA.
2. Application note **nAN400-03**, “Small loop antennas”, Nordic VLSI ASA.



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Application Note. Revision Date : 29.02.2000.

Application Note order code : 290200-nAN400-06

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**YOUR NOTES**



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