nRF24Z1 RF layout nAN24-09

1. GENERAL

PCB layout files for single ended RF I/O layout has been made for the Nordic Semiconductor **nRF24Z1** Single Chip 2.4 GHz audio streamer [1].

The PCB layout files are compressed into the Zip archive format, and can be downloaded for free from the Nordic Semiconductor ASA web site: http://www.nordicsemi.no.

The Zip archive file includes a file named **readme.wri** that must be read before importing the files into PCB editors.

The described layout should be manufactured on standard 1.6mm double-sided FR4 printed circuit board (PCB).

2. RF LAYOUT FOR nRF24Z1

The nRF24Z1 has several I/O and control interfaces and can be operated both controlled from external microcontroller and standalone. What I/O options that are to be used and hence the layout around the digital I/O pins of the device will vary.
The following RF layouts include all necessary circuitry to design the radio part of a short-range wireless audio system based on **nRF24Z1**.

The RF layouts are all fitted with a single ended connection to a 50Ω antenna by using a differential to single ended matching network. The PCB layouts are using 0603 passive components.

The antenna connection point should be as close as possible to the output of the matching network. If this is not possible of practical reasons, the PCB track between the output of the matching network and the antenna connection should be carried out as a 50Ω microstrip line or a 50Ω coplanar waveguide.

Supply voltage and GND are also available at the perimeter of the RF layout. The supply voltage 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 voltage supply source to the RF and digital or other parts of the application circuitry.
Necessary digital control signals are available at the perimeter of the RF layout either to be connected to the digital part of customer applications or to be terminated if not used.

All RF PCB layouts presented in the following sections is found in the zip archive **PCB_nRF24Z1_single_netw_0603_v1-0.zip.** This archive is available for free in the development tools section of the nRF24Z1 page on the Nordic Semiconductor web site.

2.1. General purpose ATX

On the audio source side of a wireless audio link, the nRF24Z1 must be set up in ATX mode and hence become an audio transmitter. A general purpose schematic and layout where all digital lines are routed to the boundary of the layout is shown in Figure 1 and Figure 2.
The recommended external components are given in Table 1.

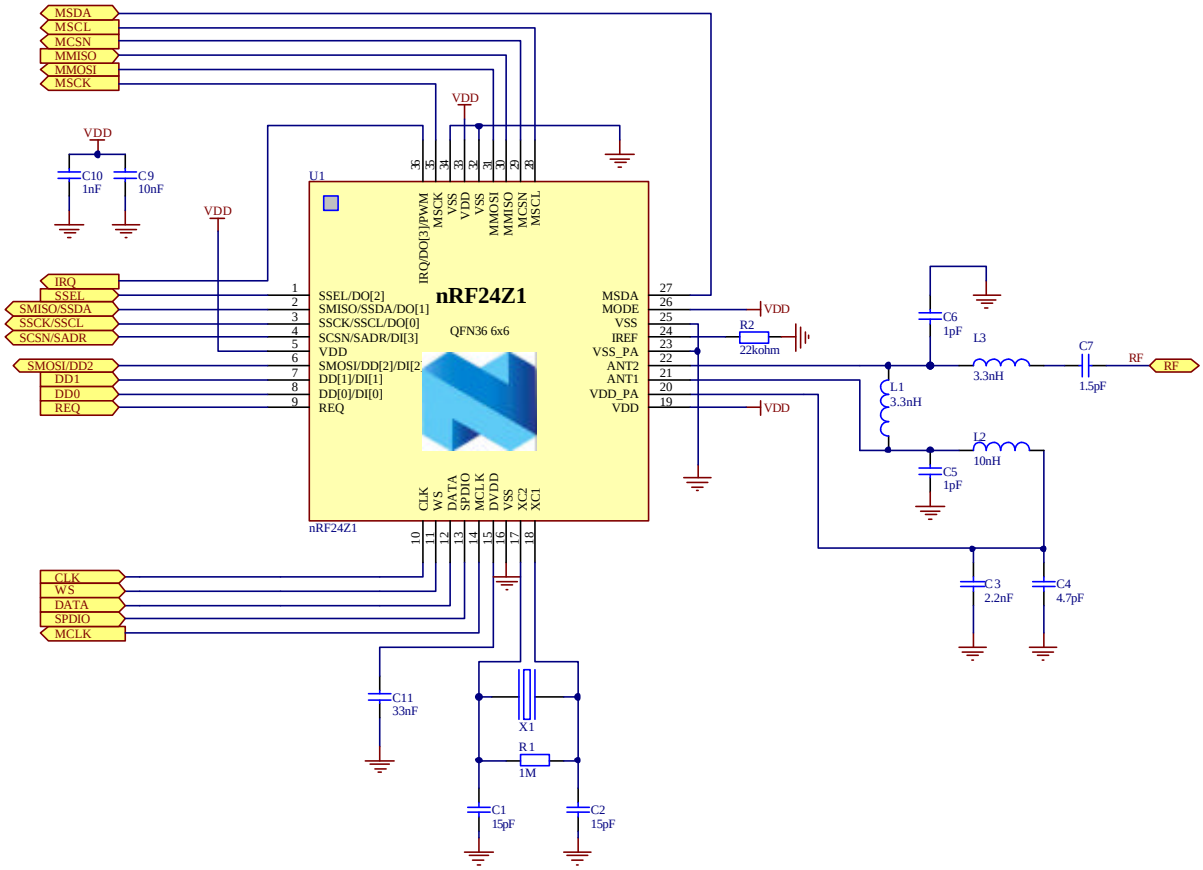
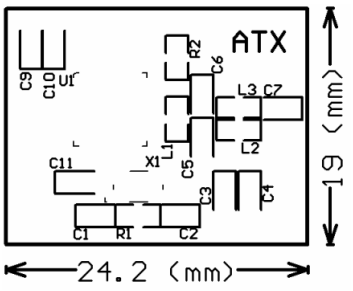
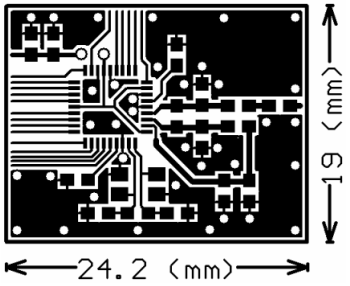


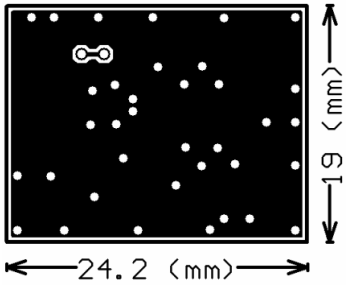
Figure 1 **nRF24Z1** ATX mode schematic including single ended 50Ω antenna connection



No components in bottom layer

Top silk screen





Top view

Bottom view

Figure 2 General purpose **nRF24Z1** ATX mode layout

Designator	Description	Footprint	Value	Tolerance	Unit
C1	Capacitor NP0	CC1608-0603	15	+/- 5%	pF
C2	Capacitor NP0	CC1608-0603	15	+/- 5%	pF
C3	Capacitor X7R	CC1608-0603	2.2	+/- 10%	nF
C4	Capacitor NP0	CC1608-0603	4.7	+/- 5%	pF
C5	Capacitor NP0	CC1608-0603	1.0	+/-0.1 pF	pF
C6	Capacitor NP0	CC1608-0603	1.0	+/-0.1 pF	pF
C7	Capacitor NP0	CC1608-0603	1.5	+/-0.25 pF	pF
C9	Capacitor X7R	CC1608-0603	10	+/- 10%	nF
C10	Capacitor X7R	CC1608-0603	1	+/- 10%	nF
C11	Capacitor X7R	CC1608-0603	33	+/- 10%	nF
L1	Chip inductor	CR1608-0603	3.3	TOKO LL1608-FSL series[1]	nH
L2	Chip Inductor	CR1608-0603	10	+/- 5%	nH
L3	Chip Inductor	CR1608-0603	3.3	TOKO LL1608-FSL series[1]	nH
R1	Resistor	CR1608-0603	1	+/- 10%	Mohm
R2	Resistor	CR1608-0603	22	+/- 1%	kohm
U1	2.4 GHz audio streamer	QFN36L/6x6	nRF24Z1		
X1	Crystal Cl=9pF, ESR < 100 ohm,	BT-XTAL	16	+/-30 ppm	MHz

Table 1 Component list for general purpose ATX (and ARX) **nRF24Z1** layout with single ended antenna matching network

[1] Inductor values are usually characterized at 100-250 MHz. Behavior at 2.4 GHz may vary significantly between different inductor product series and vendors, even though the given inductance is the same. Inductors from other TOKO series or other vendors may well be used, but antenna match performance MUST be verified as the inductor values may need to be changed. NOTE: The characteristics of one inductor series between production batches are WELL controlled, this is hence a task that only needs to be done during prototyping and when setting up second sources for production.

2.2. General purpose ARX

On the receiving side of the audio link one need a corresponding nRF24Z1 in ARX mode as an audio receiver.

The schematic and layout can be seen in Figure 3 and Figure 4. As can be seen, the only difference between the general purpose ATX and ARX layout are the connection of pin26 (MODE) and the direction and naming of some digital I/O pins.
The external components are hence as for the general purpose ATX layout shown in Table 1.

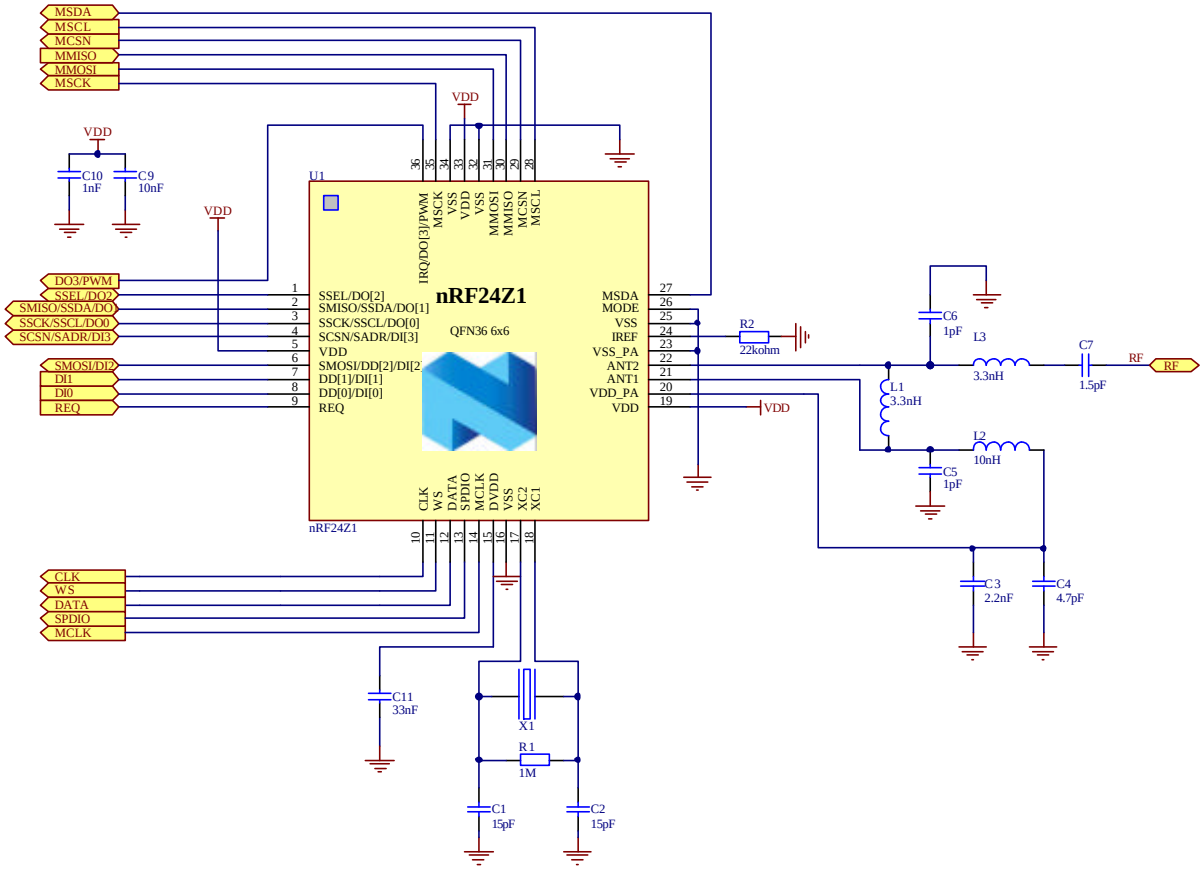
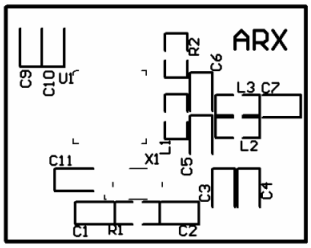
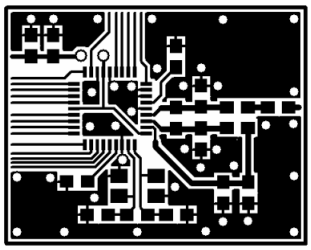


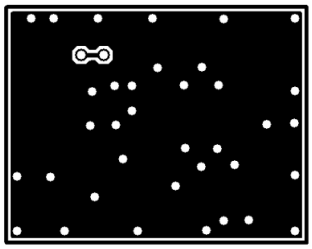
Figure 3 General purpose **nRF24Z1** ARX mode schematic



No components in bottom layer

Top silk screen





Top view

Bottom view

Figure 4 General purpose **nRF24Z1** ARX mode layout

3. Application specific nRF24Z1 layouts

As the nRF24Z1 has a number of I/O options and operational modes the general purpose layouts will have several I/O lines routed out that are not used in a given application. Therefore layouts that are examples of likely ways to use the nRF24Z1 are also included in the layout archive. Here only needed nRF24Z1 I/O signals are routed to the edge of the layout, all other I/O pins are either terminated (inputs) or left open (outputs).

3.1. ATX with external controlling MCU

This ATX layout utilizes the following nRF24Z1 I/O features/options

- I2S audio in
- SPI slave interface routed out to the edge for connection to an external microcontroller (allow external control of nRF24Z1)
- 2 general purpose inputs
- 1 interrupt output

The schematic and layout are shown in Figure 5 and Figure 6.
Components are listed in Table 2.

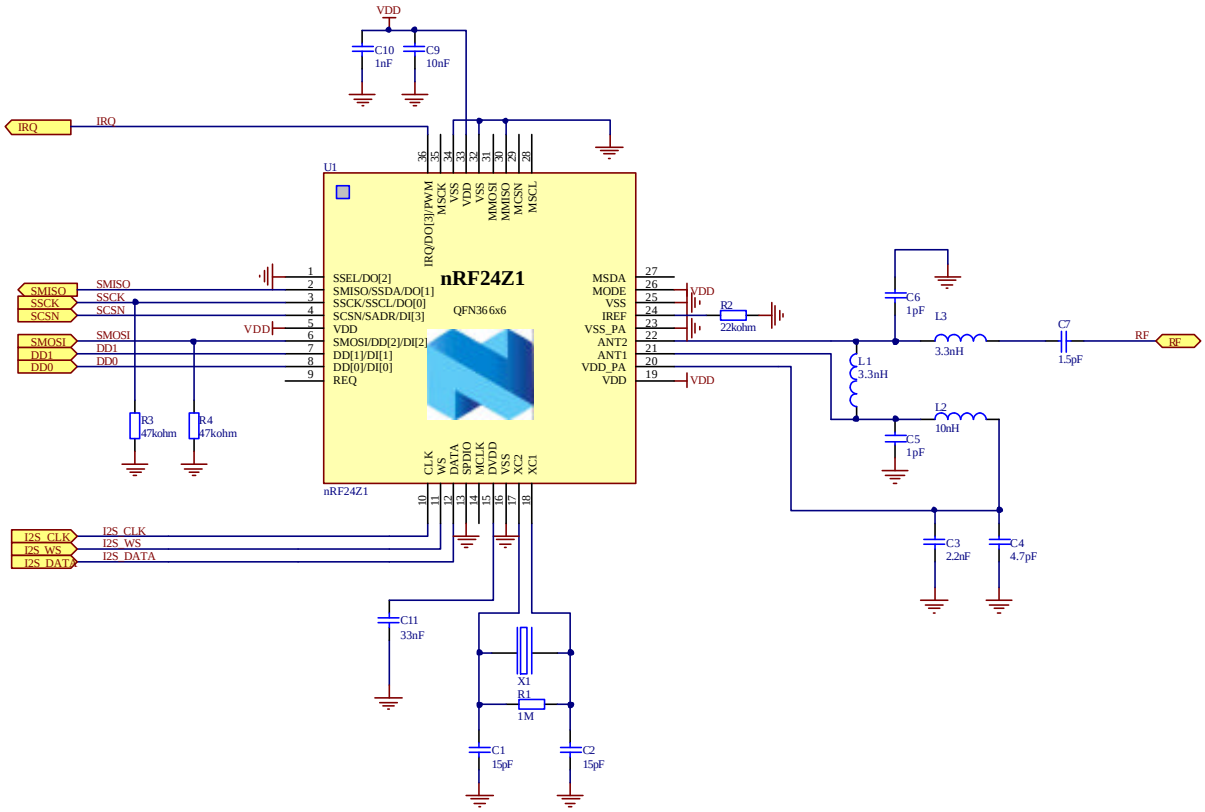
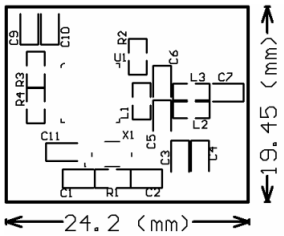
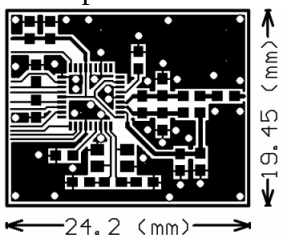


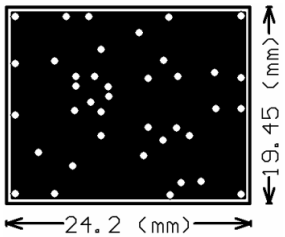
Figure 5 **nRF24Z1** ATX mode schematic for operation with external microcontroller



No components in bottom layer

Top silk screen





Top view

Bottom view

Figure 6 **nRF24Z1** ATX layout for use with external microcontroller

Designator	Description	Footprint	Value	Tolerance	Unit
nRF24Z1 core components:					
C1	Capacitor NP0	CC1608-0603	15	+/- 5%	pF
C2	Capacitor NP0	CC1608-0603	15	+/- 5%	pF
C3	Capacitor X7R	CC1608-0603	2.2	+/- 10%	nF
C4	Capacitor NP0	CC1608-0603	4.7	+/- 5%	pF
C5	Capacitor NP0	CC1608-0603	1.0	+/-0.1 pF	pF
C6	Capacitor NP0	CC1608-0603	1.0	+/-0.1 pF	pF
C7	Capacitor NP0	CC1608-0603	1.5	+/-0.25 pF	pF
C9	Capacitor X7R	CC1608-0603	10	+/- 10%	nF
C10	Capacitor X7R	CC1608-0603	1	+/- 10%	nF
C11	Capacitor X7R	CC1608-0603	33	+/- 10%	nF
L1	Chip inductor	CR1608-0603	3.3	TOKO LL1608-FSL series[1]	nH
L2	Chip Inductor	CR1608-0603	10	+/- 5%	nH
L3	Chip Inductor	CR1608-0603	3.3	TOKO LL1608-FSL series[1]	nH
R1	Resistor	CR1608-0603	1	+/- 10%	Mohm
R2	Resistor	CR1608-0603	22	+/- 1%	kohm
U1	2.4 GHz audio streamer	QFN36L/6x6	nRF24Z1		
X1	Crystal Cl=9pF, ESR < 100 ohm,	BT-XTAL	16	+/-30 ppm	MHz
Specific for this layout					
R3	Resistor	CC1608-0603	47	+/- 5%	kohm
R4	Resistor	CC1608-0603	47	+/- 5%	kohm

Table 2 Component list for general purpose ATX (and ARX) **nRF24Z1** layout with single ended antenna matching network

Note that the extra resistors are put in to ensure no extra leakage current in power down (R4) and that microcontroller RESET doesn't cause any unwanted changes on SPI interface (R3 keeps SSCK from floating.

[1] Inductor values are usually characterized at 100-250 MHz. Behavior at 2.4 GHz may vary significantly between different inductor product series and vendors, even though the given inductance is the same. Inductors from other TOKO series or other vendors may well be used, but antenna match performance MUST be verified as the inductor values may need to be changed. NOTE: The characteristics of one inductor series between production batches are WELL controlled, this is hence a task that only needs to be done during prototyping and when setting up second sources for production.

3.2. ARX with external EEPROM

This ARX utilizes the following nRF24Z1 I/O features and options:

- I2S audio out
- SPI EEPROM to enable stand alone operation.
- 8 (4+4) general purpose inputs and outputs that can be controlled from a linked ATX

Schematics and layout can be seen in Figure 7 and Figure 8, needed components are listed in Table 3.

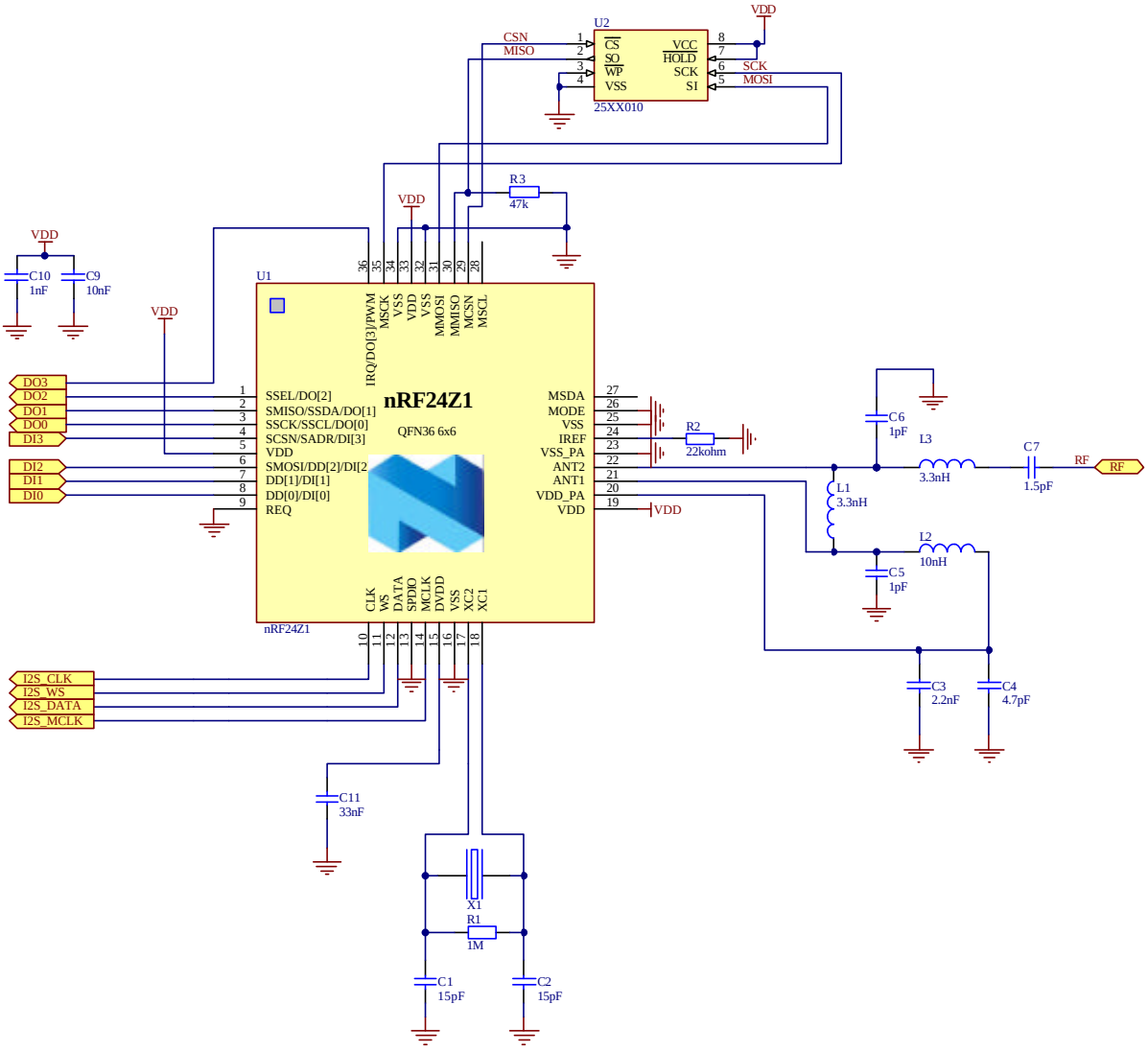
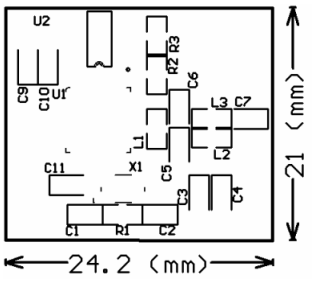
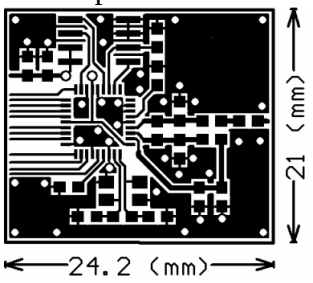


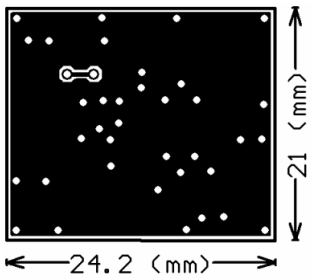
Figure 7 **nRF24Z1** ARX mode schematic for operation with external SPI EEPROM.



No components in bottom layer

Top silk screen





Top view

Bottom view

Figure 8 **nRF24Z1** ARX mode layout with external SPI EEPROM

Designator	Description	Footprint	Value	Tolerance	Unit
nRF24Z1 core components:					
C1	Capacitor NP0	CC1608-0603	15	+/- 5%	pF
C2	Capacitor NP0	CC1608-0603	15	+/- 5%	pF
C3	Capacitor X7R	CC1608-0603	2.2	+/- 10%	nF
C4	Capacitor NP0	CC1608-0603	4.7	+/- 5%	pF
C5	Capacitor NP0	CC1608-0603	1.0	+/-0.1 pF	pF
C6	Capacitor NP0	CC1608-0603	1.0	+/-0.1 pF	pF
C7	Capacitor NP0	CC1608-0603	1.5	+/-0.25 pF	pF
C9	Capacitor X7R	CC1608-0603	10	+/- 10%	nF
C10	Capacitor X7R	CC1608-0603	1	+/- 10%	nF
C11	Capacitor X7R	CC1608-0603	33	+/- 10%	nF
L1	Chip inductor	CR1608-0603	3.3	TOKO LL1608-FSL series[1]	nH
L2	Chip Inductor	CR1608-0603	10	+/- 5%	nH
L3	Chip Inductor	CR1608-0603	3.3	TOKO LL1608-FSL series[1]	nH
R1	Resistor	CR1608-0603	1	+/- 10%	Mohm
R2	Resistor	CR1608-0603	22	+/- 1%	kohm
U1	2.4 GHz audio streamer	QFN36L/6x6	nRF24Z1		
X1	Crystal Cl=9pF, ESR < 100 ohm,	BT-XTAL	16	+/-30 ppm	MHz
Specific for this layout					
R3	Resistor	CC1608-0603	47	+/- 5%	kohm
U2	SPI EEPROM	SO8			

Table 3 Components needed in nRF24Z1 ARX mode layout with external EEPROM

[1] Inductor values are usually characterized at 100-250 MHz. Behavior at 2.4 GHz may vary significantly between different inductor product series and vendors, even though the given inductance is the same. Inductors from other TOKO series or other vendors may well be used, but antenna match performance MUST be verified as the inductor values may need to be changed. NOTE: The characteristics of one inductor series between production batches are WELL controlled, this is hence a task that only needs to be done during prototyping and when setting up second sources for production.

4. REFERENCES

[1] Product Specification **nRF24Z1**, “Single chip 2.4 GHz audio streamer”, Nordic Semiconductor ASA.

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