nRF24LU1 Reference Design
"Compact USB Dongle for wireless peripherals"

User Guide v1.0

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Revision History

Date	Version	Description
September 2007	1.0	

Content

1   Introduction

This document describes the nRF24LU1 USB Dongle reference design with the Nordic Semiconductor nRF24LU1 Embedded nRF24L01 compatible RF Transceiver with USB. Figure 1 shows the nRF24LU1 USB Dongle reference design.

Figure 1 - nRF24LU1 USB Dongle

The nRF24LU1 USB Dongle has been developed as a complete reference design for the nRF24LU1. It is a production ready design that has Gerber files and Altium Designer 6 files that can be used in their current form or modified to develop your own design. The reference design is USB certified and has been EMC tested. RF qualification test reports and USB compliance report are included on the CD.

The nRF24LU1 will typically be used in a USB dongle for mouse, keyboard, remote control, data collection and transfer, communication with peripheral units etc.

The nRF24LU1 has built in the nRF24L01 compatible transceiver, making it a perfect match for nRF24L01 based equipment. In addition to the transceiver, the nRF24LU1 has a full speed USB 2.0 compliant device controller, an 8-bit 8051 MCU and 16kB of flash memory. The voltage regulator is integrated in the nRF24LU1, so the nRF24LU1 can be supplied directly from the USB.

The key features are:
- Reference design for a compact USB dongle for wireless peripherals
- Production ready
- Compact form factor
   - 12 × 23mm excluding USB connector
   - 12 × 32mm including USB connector
- FCC, ETSI and USB qualified
- Full-speed USB 2.0 (up to 12 Mbps) compliant device controller
- Fully nRF24L01™ compliant 2 Mbps 2.4GHz RF transceiver
- Powerful enhanced 8051 microcontroller
- 16 kbytes of embedded flash memory
- 2 kbytes of SRAM
- Low active components count; the nRF24LU1 and a single 16MHz crystal
- Very compact low cost PCB antenna and matching network
- Seamless integration with nRF24LU1 Software Development Kit.
- Complete set of deliverables including design files, BOM and comprehensive documentation
- Supports application development directly on the dongle

2   Content of the nRF24LU1 Reference Design

This chapter describes the content of the nRF24LU1 Reference Design. In addition to the nRF24LU1 USB dongle, the reference design kit contains tools for programming the flash of the nRF24LU1.
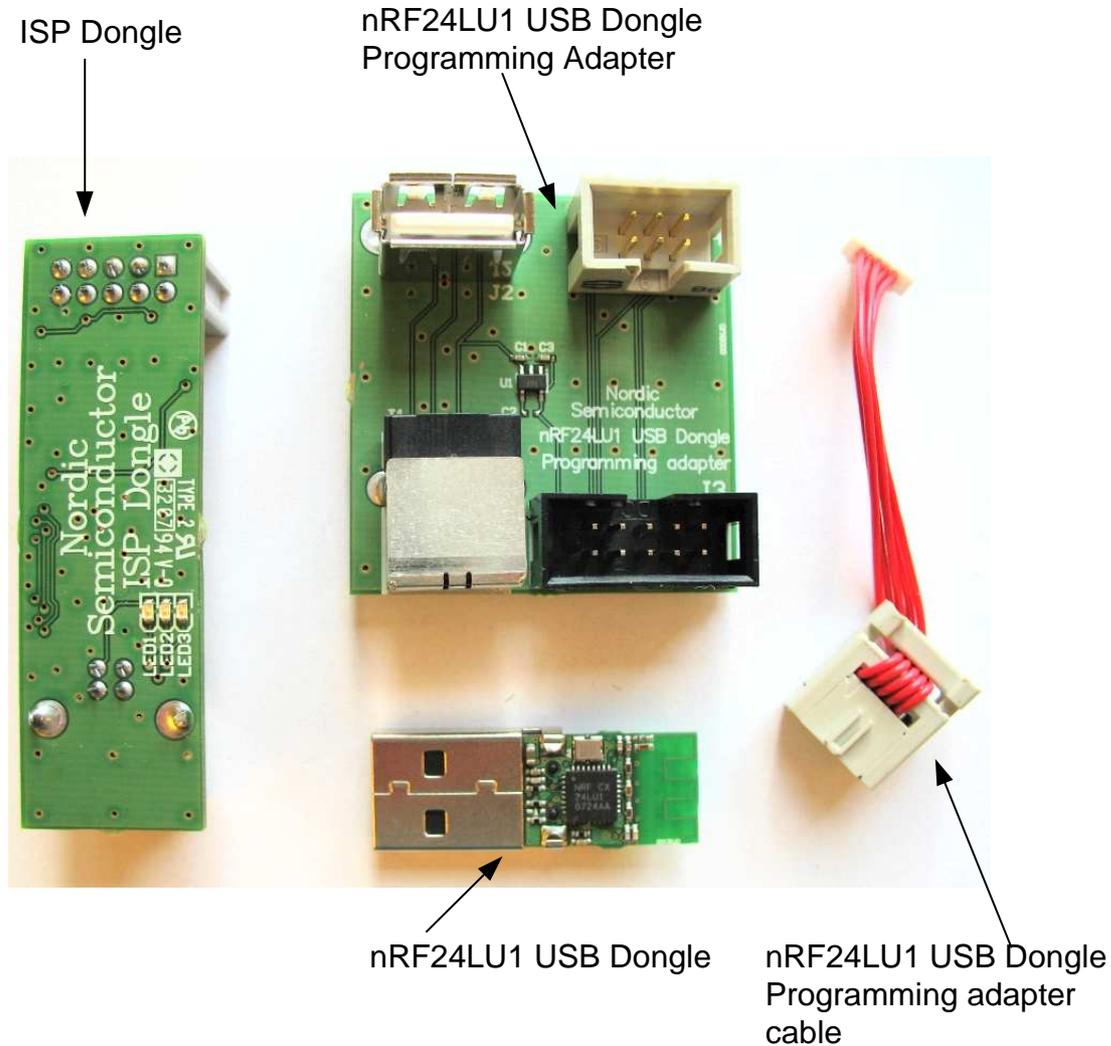

Figure 2: Hardware content of the nRF24LU1 Reference Design

The Reference Design consists of the following:

2.1 Hardware

- 1 nRF24LU1 USB Dongle, board version 1.0
- 1 nRF24LU1 USB Dongle Programming Adapter, board version 1.0
- 1 nRF24LU1 USB Dongle Programming Adapter cable
- 1 ISP Dongle

2.2 Software

All software is supplied on the packaged CD.

- nRF24LU1 Configuration and Evaluation Suite (CES), v1.0, build 1926. Installed by running "nRF24LU1_DK_v1.0_setup.exe." The program file is named "LU1Config.exe."
- nRF24LU1 Flash Programmer application, v1.2, build 1891. Installed by running "nRF24LU1_SDK_v1.2_setup.exe." The program file is named "LU1Prog.exe."
- nRF24LU1 Software Development Kit, v1.2. Installed by running "nRF24LU1_SDK_v1.2_setup.exe."
- nRF2601 Wireless Desktop Protocol, v.1.1. Installed by running "WDP_v1.1_setup.exe."
- Evaluation version of Keil c51 compiler and µvision IDE

All nRF24LU1 are pre-programmed with the Configuration and Evaluation Suite Firmware v1.0.

2.3 Documentation

All documentation is supplied on the packaged CD and a hardcopy of both Getting Started Guides are also packaged.

The following documentation are available in the document folder on the CD:

- nRF24LU1 Development Kit User Guide
- nRF24LU1 USB Dongle Reference Design User Guide
- nRF24LU1 Development Kit Getting Started
- nRF24LU1 USB Dongle Reference Design Getting Started
- nRF24LU1 RF qualification reports for FCC and ETSI.
- nRF24LU1 USB compliance test report

The following documentation is available as part of the software installation packets above:

- Software Developer Guide
- FS2 Installation
- Keil License

Note: Bill Of Materials (BOM) for all hardware is specified in the documentation.

2.4 Accessories

The following accessories are available:
- 2 USB (A-B) cables
- 1 CD containing Documentation, Software, and PCB layout files

3 How to use the reference design

The USB dongle can be used as a development platform as it is.

To start using the reference design, the first step is normally to develop the firmware. The nRF24LU1 Software Development Kit, SDK, is a good starting point. It has libraries and code examples that can be used as a base for your own code. You can even use the Wireless Desktop Protocol, WDP, as it is, and just develop the other end of the link.

The reference design is ready to be used as is. Gerber files are available for a production ready design. So for a complete USB dongle, you do not have to change the design at all.

You may want to add housing to the design. When the housing is designed, it is important to avoid any metal in the antenna end of the dongle. The antenna might be affected by the housing. It is important to check performance with the PCB inside the plastic housing, and tune the antenna if necessary. Most plastics will not alter the antenna performance, but this must in all cases be tested.

The programming connector, J2, is not needed if the nRF24LU1 is programmed before mounting. So in mass production, this connector can be omitted.

If you want to do changes to the design, Nordic Semiconductor provides Altium Designer 6 files, complete with library files, and Gerber files. These files are included on the kit CD.

4 nRF24LU1 USB Dongle Schematics

The nRF24LU1 USB Dongle is based on the schematic in the nRF24LU1 Product Specification. Figure 2 shows the nRF24LU1 USB Dongle circuit diagram. The PCB layout is shown in Appendix 1. The bill of material, BOM, is given in Appendix 2.
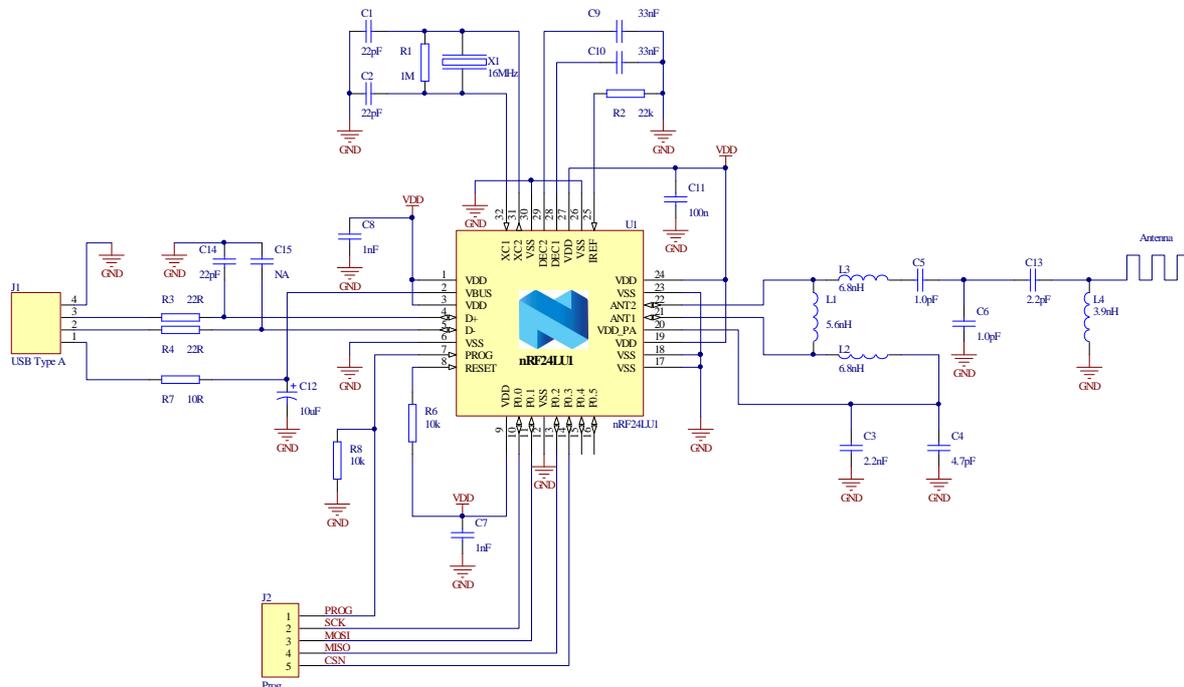

Figure 3: nRF24LU1 USB Dongle schematics

4.1 Power supply

The nRF24LU1 is connected to the USB 5V supply through a 10ohm resistor. nRF24LU1 has a built in voltage regulator that supplies internal circuitry. No extra power regulator is needed in this design. The VDD pins are only for internal decoupling. They are connected together and decoupling capacitors are placed close to the VDD pins, as recommended in the product specification.

4.2 Matching network

The matching network is the components between the two ANT pins on the nRF24LU1 and the antenna. Its function is impedance transformation and filtering. To make the USB Dongle as small as possible, the layout of the matching network is changed from the reference layout in the nRF24LU1 Product Specification. The component values are different to compensate for the changed layout. If the layout is used as in this document, the component values can be used as specified in the BOM. It must be stressed that if the layout is changed, the matching network and the antenna must be tuned for optimum performance. The component values in this design are very sensitive to layout changes. If the layout must be changed, the matching network layout from the nRF24LU1 product specification is recommended.

4.3 Antenna

The antenna is a quarter wave meander type on PCB. The antenna impedance is matched to the 50ohm output in the matching network with the use of L4 and C13. When the nRF24LU1 USB Dongle is connected to a PC, the PC will add a significant ground plane to the nRF24LU1 USB Dongle. This

means than any antenna measurements must be done with the dongle connected to the PC. Of course not all PC's are equal, so there will be compromises. The antenna in this design is tuned for this layout only. If the layout is changed, the antenna must be tuned. The reference design is delivered without housing. For a real product, some kind of housing for the dongle is needed. The presence of the housing material can have some impact on the antenna. This can be compensated by changing the values of L4 and C13 so that the antenna is resonant at the correct frequency. The exact component values must be determined by measurements.

5   nRF24LU1 USB DONGLE PCB Specification

To keep the size as small as possible, a 4 layer, 0.8mm board is used. The material is standard FR4. Components are mounted on both sides of the board. To shield the RF part from the other side components, there is an inner ground plane. The antenna is dependent of a ground plane. Since the board has components on both sides, there is little space left for ground plane on the outer layers.

Figure 4 shows the stack up of the board. The nRF24LU1 is mounted on layer 1. To keep the distance between the RF components to ground as large as possible, layer 3 is used an inner ground plane. This will reduce parasitic capacitance as much as possible.

Layer 1
Prepreg 0.115mm
Layer 2
0.508mm FR-4
Layer 3
Prepreg 0.115mm
Layer 4

Figure 4 - board stack up

6 Flash programming

The FLASH in the nRF24LU1 can be programmed using the nRF24LU1 USB Dongle Programming Adapter, se *Figure 5.* The size of the dongle does not allow a full sized connector to be placed on the PCB, so a 5 pin, 1mm pitch connector is used instead. The Programming adapter just acts an connection between the ISP Dongle from Nordic and the nRF24LU1 USB Dongle.

Figure 5 - nRF24LU1 USB Dongle programming adapter

The ISP dongle uses level shifters to adapt the logic levels to the device to be programmed. The ISP dongle must then have access to the same voltage level as the device to be programmed. Since the connector, J2, on the nRF24LU1 USB Dongle only have 5 pins, there is no direct access to the VDD of the nRF24LU1. The 5v VBUS is regulated down to 3.0v on the Programming Adapter and will give the level shifters on the ISP dongle the same voltage as on the nRF24LU1 USB Dongle. The ground connection is done via the USB plug. To avoid increased noise due to ground loops, it is important to place the nRF24LU1 USB Dongle directly into the Programming Adapter and not use an USB extension cable between the Programming Adapter and the nRF2LU1 USB Dongle.

The nRF24LU1 USB Dongle connects to the Programming adapter as in *Figure 6.* The ISP Dongle is connected to J2 on the programming adapter. Both the ISP Dongle and the USB Connector on the Programming Adapter, J2, needs to have a PC USB connection.

Figure 6 - nRF24LU1 USB Dongle Programming Adapter assembly

The nRF24LU1 Flash Programmer program must then be installed on the PC. When the program is started, the following screen will appear:
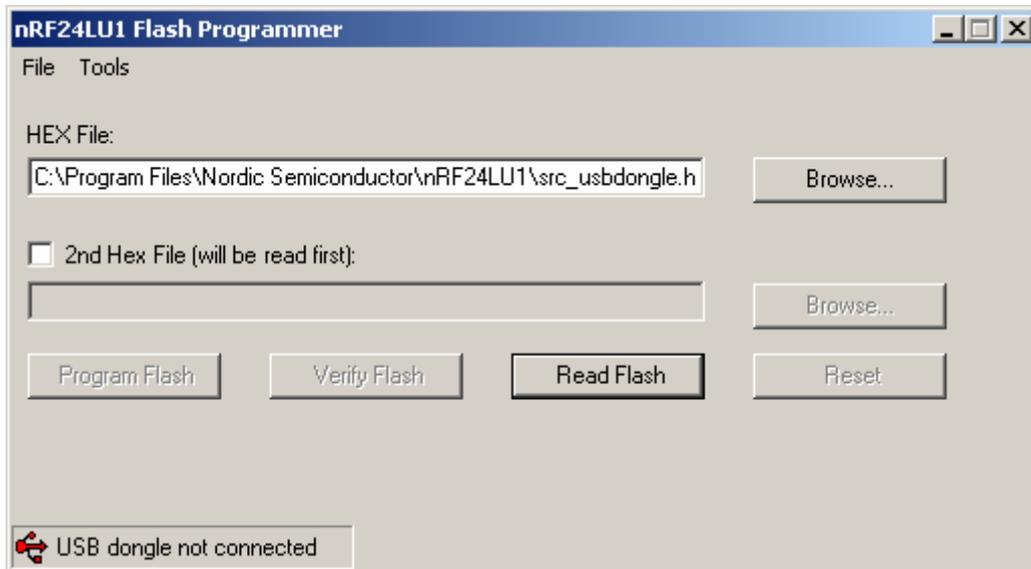

Figure 7 - nRF24LU1 Flash Programmer

When the ISP Dongle is connected to the USB port, the text "USB Dongle not connected" will change to "USB Dongle connected" and the USB symbol will turn green.

Choose the .HEX file with the "Browse" button and press "Program Flash". A blue progress bar will appear. The FLASH is first programmed and then verified. A box will appear if the verification fails.

7 Configuration and evaluation suite

The nRF24LU1 USB dongle is configured with the configuration and evaluation suite (CES.) The use of this is described in detail in the nRF24LU1 Development Kit User Guide available on the CD.
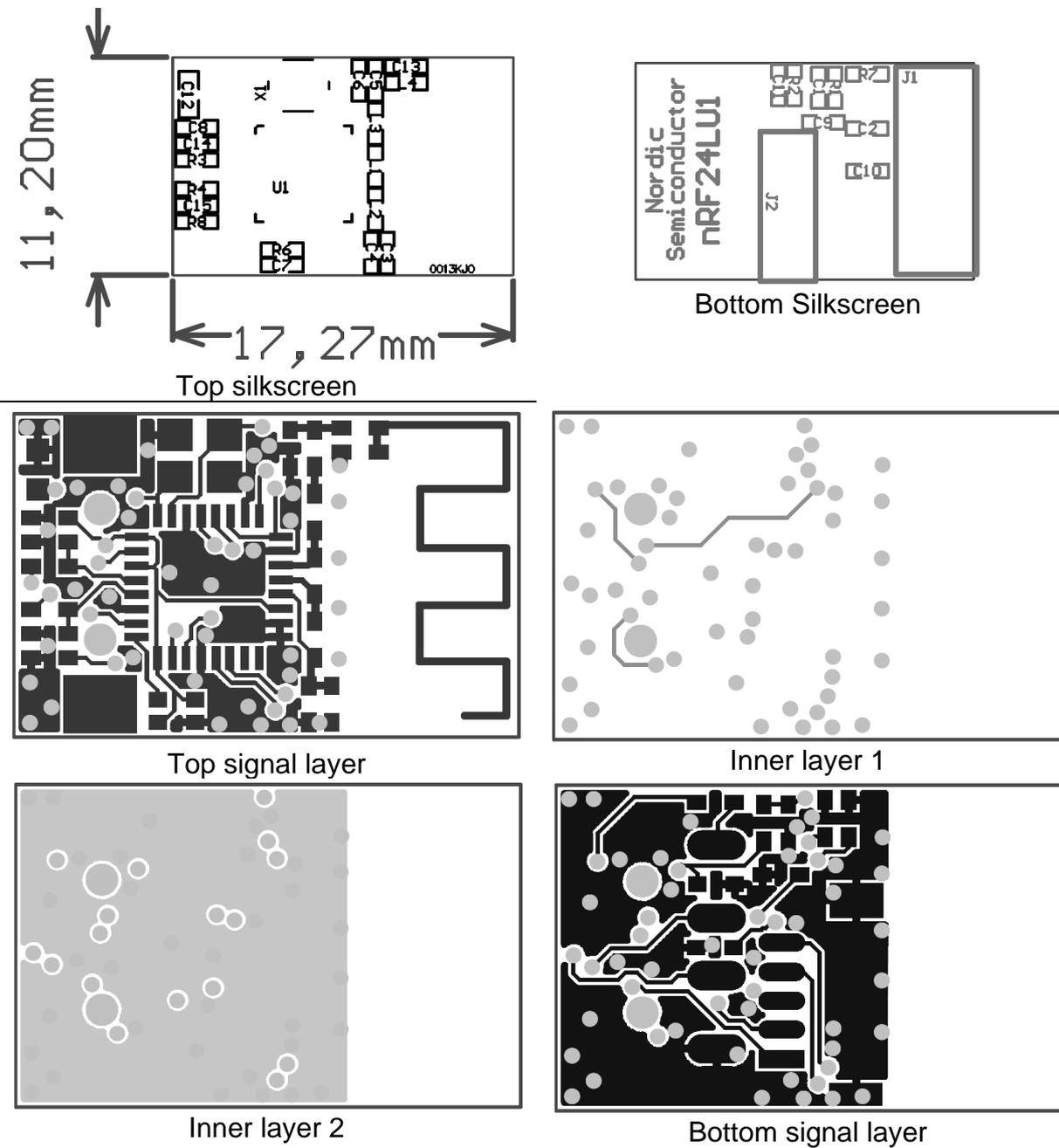
APPENDIX 1: PCB layout

Top silkscreen

Bottom Silkscreen

Top signal layer

Inner layer 1

Inner layer 2

Bottom signal layer

Figure 8 - nRF24LU1 USB Dongle layout

APPENDIX 2: Bill of material

Designator	Value	Footprint	Comment
C1, C2	22pF	0402	NP0 +/-2%
C3	2.2nF	0402	X7R +/-10%
C4	4.7pF	0402	NP0 +/-2%
C5, C6	1.0pF	0402	NP0 +/-2%
C7, C8	10nF	0402	X7R +/-10%
C9, C10	33nF	0402	X7R +/-10%
C11	100n	0402	X7R +/-10%
C12	10uF	0603	X5R +/-20%. 6.3v
C13	2.2pF	0402	NP0 +/-2%
C14	22pF		NP0 +/-2%
C15	NA		
J1	Molex 48037	USD SMD	USB Type A
J2	JST BM05B-SRSS-TB	SH-5	1mm connector SH-series
L1	5.6nH	0402	Chip Inductor +/-5%, Murata LQP15-series
L2, L3	6.8nH	0402	Chip Inductor +/-5%, Murata LQP15-series
L4	3.9nH	0402	Chip Inductor +/-5%, Murata LQP15-series
R1	1M	0402	5%
R2	22k	0402	1%
R3, R4	22R	0402	5%
R6, R8	10k	0402	5%
R7	10R	0402	5%
U1	nRF24LU1	QFN32L/5x5	Nordic Semiconductor
X1	16MHz	XTAL 2520	Epson Toyocom FA-20H 16MHz, CL=12pF, +/-20ppm
PCB	0004KJO		

Table 1 - nRF24LU1 USB Dongle Bill of Material.