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How to Build Your Own NRF24L01+pa+lna Module

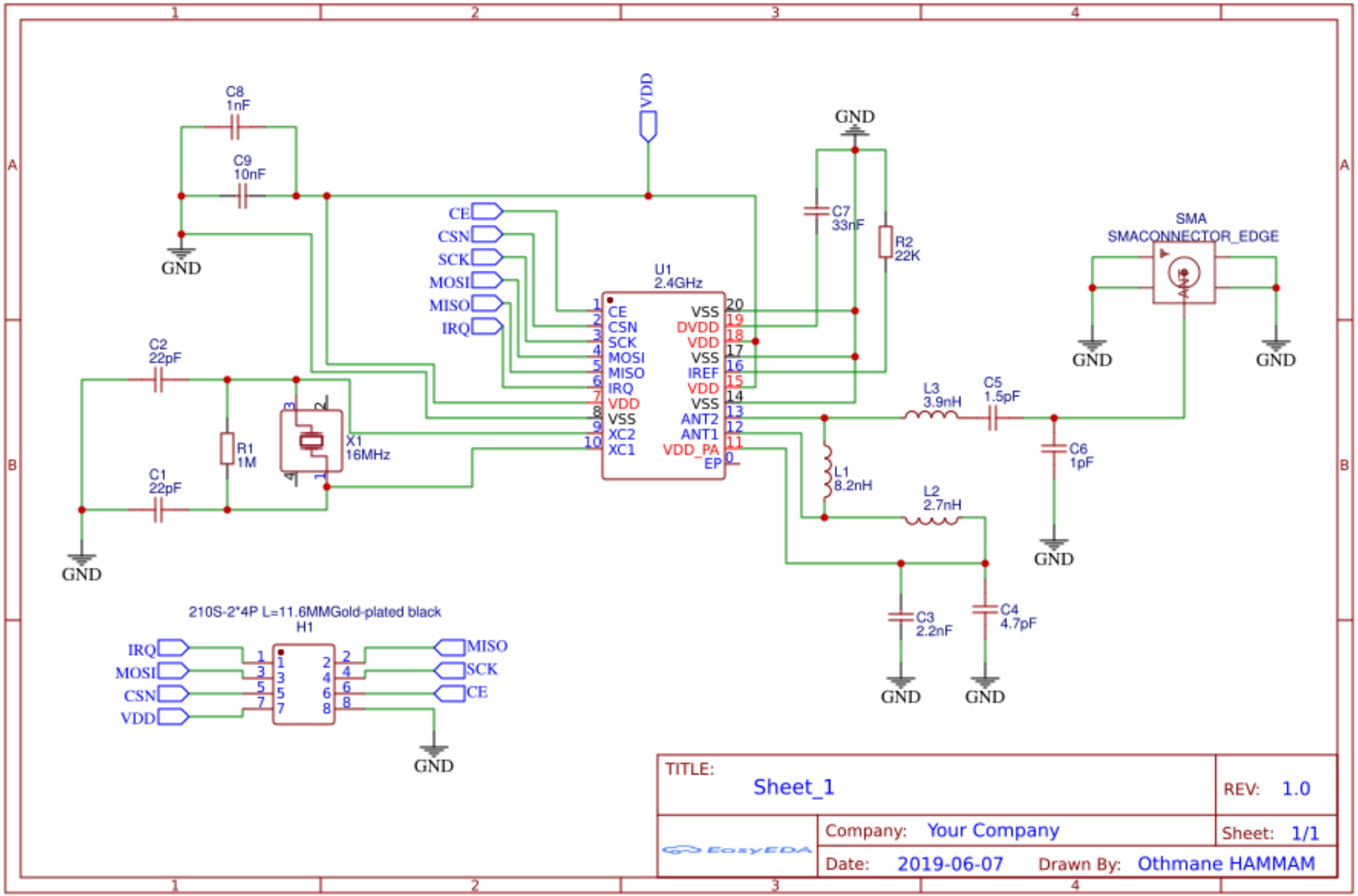
By othmaneh in CircuitsWireless

Introduction: How to Build Your Own NRF24L01+pa+lna Module

Nrf24L01 based module has been very popular, because it’s easy to implement in wireless communication projects. The module could be found u nder 1$ with a PCB printed version, or monopole Antenna.The problem with these cheap modules is that they have many issues and become eas ily defective. Mainly because the IC is not originally made by Nordicsemi, but also because of the poor printing quality of the PCBs.

Throughout this article I will show you how to build your own nrf24L01 based module, and how to add PA (Power amplifier), LNA (Low noise ampl ifier) to extend range and output power.

Step 1: Typical Application Circuit


C8
1nF
C9
10nF
GND
VDD
GND
C7
33nF
R2
22K
CE
CSN
SCK
MOSI
MISO
IRQ
U1
2.4GHz
CE
CSN
SCK
MOSI
MISO
IRQ
VDD
VSS
XC2
XC1
VSS
DVDD
VDD
VSS
IREF
VDD
VSS
ANT2
ANT1
VDD_PA
EP
SMA
SMACONNECTOR_EDGE
GND
GND
C2
22pF
R1
1M
X1
16MHz
C1
22pF
GND
L3
3.9nH
C5
1.5pF
C6
1pF
GND
L1
8.2nH
L2
2.7nH
C3
2.2nF
C4
4.7pF
GND
GND
210S-2*4P L=11.6MMGold-plated black
H1
IRQ
MOSI
CSN
VDD
MISO
SCK
CE
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Company: Your Company
Sheet: 1/1
Date: 2019-06-07
Drawn By: Othmane HAMMAM
EasyEDA

Here is the typical circuit for an nrf24L01 based module; this one is commonly used in commercial modules based on this chip. The circuit contain s some decoupling capacitors connected between VDD and ground. 16 MHZ crystal oscillator is used and must fulfil the specifications found in th e datasheet. ANT1 and ANT2 provide RF output to the antenna, according to datasheet a 15ohm+j88ohm load is recommended for a maximum o utput power of 0dbm, a 50ohm load impedance can be obtained by fitting a matching network, ANT1 and ANT2 have a DC path to VDD_PA (more about this later). Finally an SMA connector connects the circuit to a dipole antenna.

Step 2: Adding a Front End Module to Increase Power and Range

Mode	TXEN	RXEN
TX active	1	x
RX active	0	1
Shutdown	0	0

1 "1" denotes high voltage state (> 1.2 V)
"0" denotes low voltage stage (< 0.3 V) at control pins
"X" denotes do not care: either "1" or "0" can be applied

The circuit discussed above have 4 levels of output power: 0dBm, -6dBm, -12dBm, -18dBm. Power level controls directly range, of course there is other characteristics related to the antenna (impedance, Power rate, type …) and to the propagation environment, but let's focus on the module it self.

To extend output power a front end module could be used. I found this RFX2401C from Skyworks Solutions just perfect; it's a 2.4GHZ ZigBee/ISM front-end module, with 50ohm input and output ports, 25db of small signal gain and 22dBm of saturated output power (All of these characteristics are related to Transmit mode). Skyworks offers also an evaluation board which help to prototype easily with their IC.

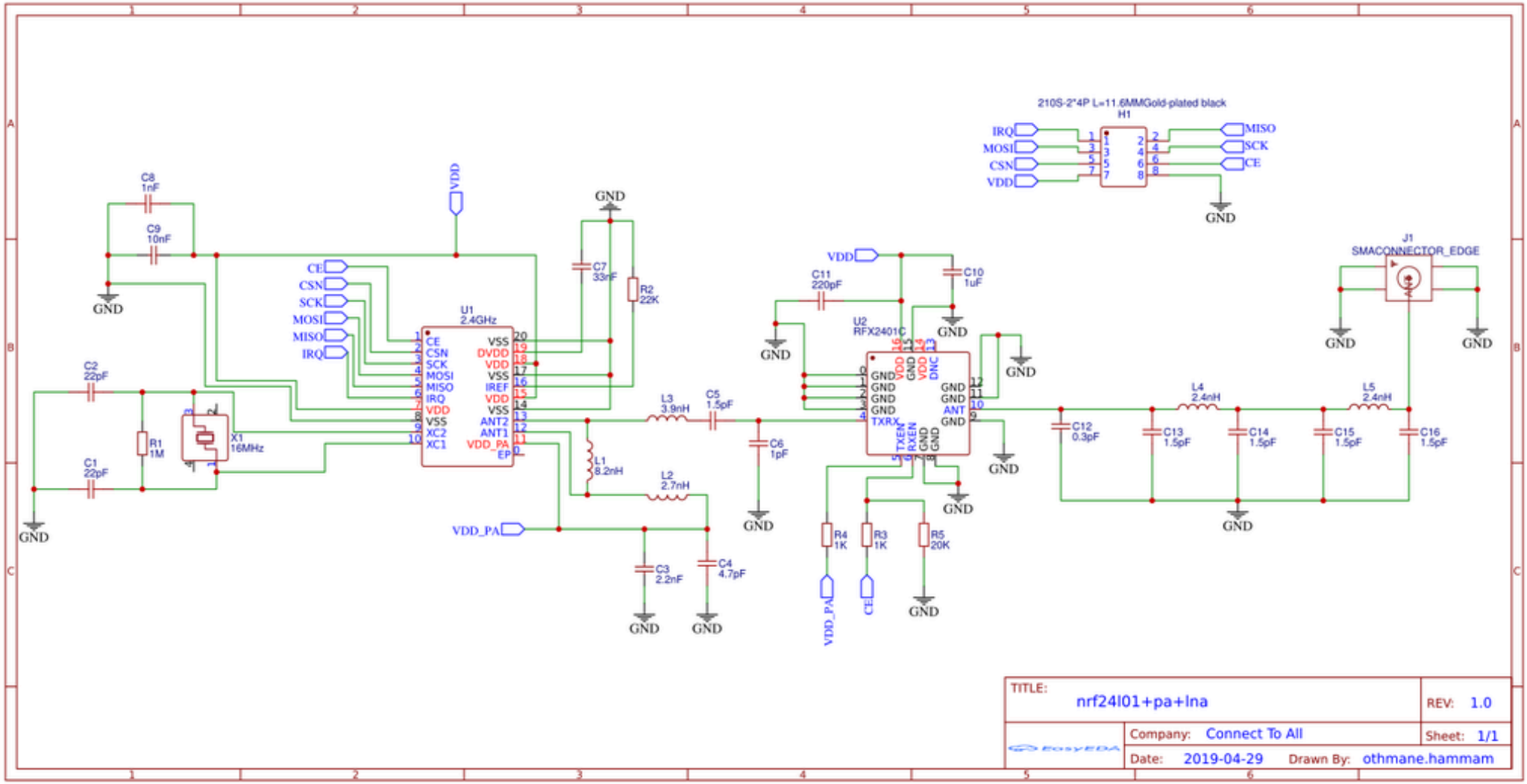
This module has a relatively simple control logic (See logic table). To activate receiving (RX mode), TXEN should be pulled LOW and RXEN pulle d HIGH and to activate transmission (TX mode) TXEN pulled HIGH the state of RXEN isn't important. According to nrf24L01 datasheet CE pin mu st be pulled HIGH whenever the transceiver has to enter RX mode. Using an oscilloscope I've measured the state of VDD_PA pin, it turns out that it's HIGH whenever the Transceiver is in TX mode and LOW in RX mode. This way TXEN should be connected to VDD_PA and RXEN to CE

Step 3: Bill of Material

Designator	Manufacturer Part	Manufacturer	Footprint	Quantity
U1	NRF24L01P-R	NORDIC	QFN-20_4X4X05P	1
U2	RFX2401C	SKYWORKS	QFN-16_3X3X05P	1
X1	SMD-3225_4P16M12pf10ppm	TAE	SMD-3225_4P	1
C1,C2	0402N220F500CT	Huaxin S&T	0402'	2
R1	0402WGF1004TCE	UniOhm	0402'	1
L1	LQG15HS8N2J02D	MuRata	0402'	1
L2	CS0402-2N7J-S	Chilisin	0402'	1
L3	CS0402-3N9J-S	Chilisin Elec	0402'	1
C3	GRM155R71H222KA01D	MuRata	0402'	1
C4	C1005NP0479CGTS	Darfon Elec	0402'	1
C5,C13,C14,C15,C16	RF15N1R5B500CT	Huaxin S&T	0402'	5
C6	CC0402BRNPO9BN1R0	YAGEO	0402'	1
C7	CC0402KRX7R9BB333	YAGEO	0402'	1
C8	GRM155R71H102KA01D	MuRata	0402'	1
C9	GRM155R71H103KA88D	MuRata	0402'	1
R2	RC0402FR-0722KL	YAGEO	0402'	1
C10	GRM155R61C105KA12D	MuRata	0402'	1
C11	GCM1555C1H221JA16D	Murata Electronics	0402'	1
C12	GJM1555C1HR30WB01D	MuRata	0402'	1
L4,L5	LQW15AN2N4B00D	MuRata	0402'	2
R3,R4	RC0402FR-071KL	YAGEO	0402'	2
R5	AC0402FR-0720KL	YAGEO	0402'	1
H1	210S-2*4P L=11.6MMGold-plated black	Ckmtw	210S-2.54-2X4P	1
J1	Edge-Launch SMA Connector for 1.6mm PCB	adafruit	SMA_EDGELAUNCH	1

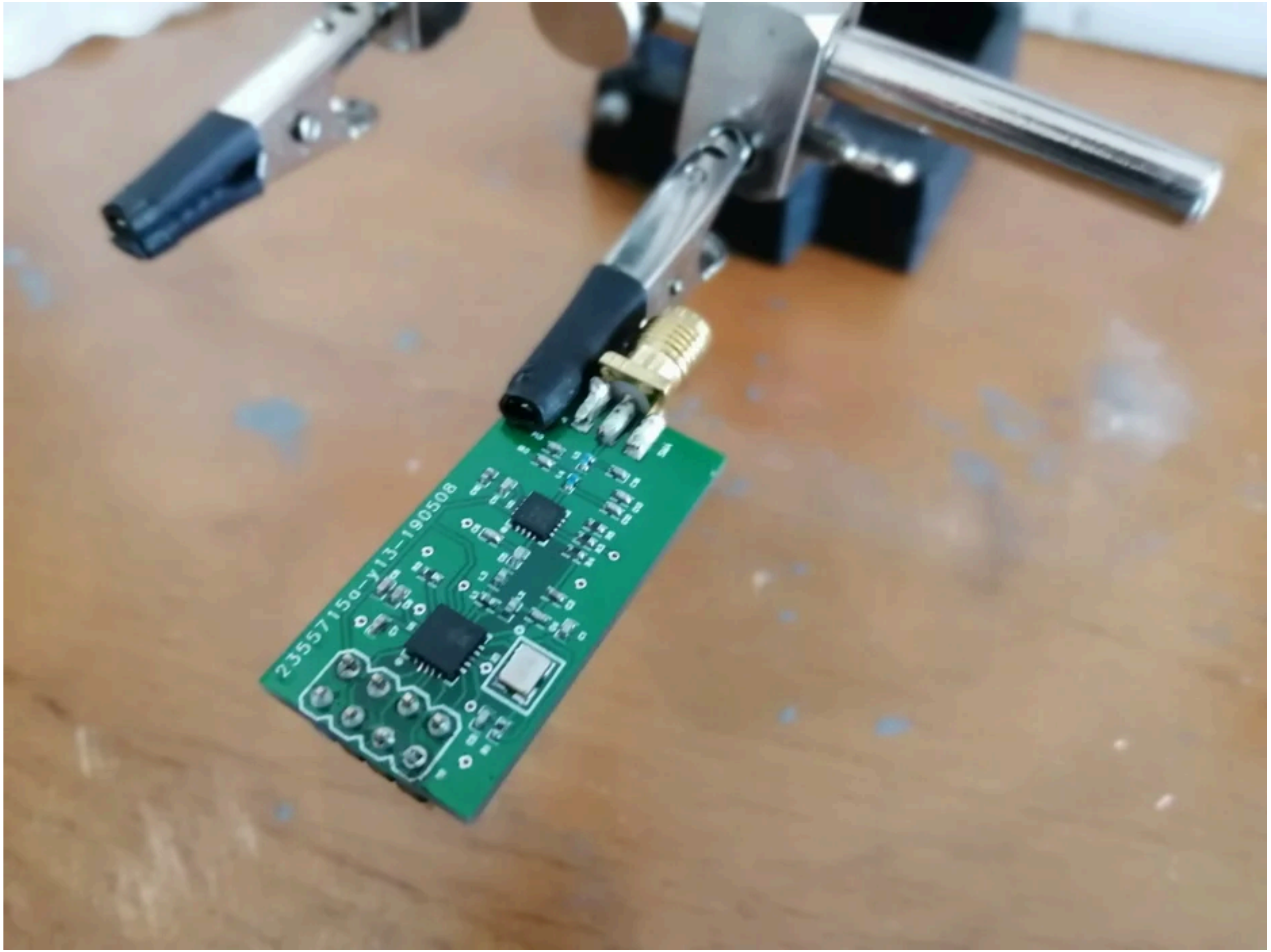
This table contains the list of componenets you need to build this circuit, I've ordered them at: https://lcsc.com/

Step 4: Schematics



This is the typical circuit of our transceiver with its RF output connected to the front end module; this one receives commands from VDD_PA and CE pins, some decoupling capacitors where added. The output is connected to a discrete LC filter with an SMA connector at the end.

Step 5: Conclusion and Improvements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after extracting gerber files I ordered 10 pcb and did soldering using a stencil and reflow station.

It turns out that making such an RF circuit require taking any possible electromagnetic interference into account, especially when performing pcb r outing. It is strongly recommended a non-vented shield and connect this one to ground, which helps reducing capacitive and magnetic coupling b etween the module and its environment.