QN8027 Hardware Application Note

October, 2009

Contents

REVISION HISTORY

REVISION	Summary of Changes	Date
0.1	Draft.	030109
0.21	Add PA reference circuit	062409
0.22	1. Change 'FMO' to 'RFO'; 2. Add the PA output result, amplify 15dB of the RF power.	062909
0.23	Change the QN8027 SANB reference design.	07/24/2009
0.24	1. In Figure 11: - Add a PA reference design schematic for QN8027 15cm antenna; - Add a note: "If VCC is in the range +2.8V~+3.3V, VIO may directly connect to VCC (pin3), if the voltage for VIO pin is bigger than +3.6V QN8027 will be damaged" on the reference schematic near the VIO pin - Add a note: " the bypass ripple cap C01 & C02 may be placed as near as possible to pin3 when pcb layout" on the reference schematic near the capacitor C01 & C02 - Add a note "it may be placed as near as possible to pin5 to reduce the parasitical inductor when pcb layout, the parasitical inductor may influence L4 value, ctm may fine tune L4 value from 100nH to 150nH to see which one is the best". On the reference schematic near the inductor L4 2. Add PCB layout guide in Section 2.11	08/31/2009
0.25	1. Correct a mistake about the PACAP calibration result on page 9. Change from 0x3f~0x00 to 0x1f~0x00; 2. Replace the Figure 1; 3. Modify the grammar and syntax.	10/22/2009

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1 Feature Overview

The QN8027 is a high performance, low power, single-chip stereo FM transmitter, designed for MP3 players, GPS. The QN8027 also supports RDS/RBDS data transmit.

1.1 Main Feature for QN8027

- 76MHz~108MHz full band tuning in
- Auto PA output power calibration
- RDS/RBDS transmit
- 12MHz/24MHz crystal support and 12MHz/24MHz external clock support

2 Hardware Design

This chapter describes the details of hardware design and schematic of reference design.

2.1 Power Supply

QN8027 is integrated LDO inside, and the VCC accepts the power supply voltage range from 2.7V~5.0V.

QN8027 has a pin 'VIO' which is used to define the I/O high voltage level. 'VIO' only accepts the voltage range 2.7V~3.3V.

The VCC power supply should be not larger than 3.3V, so that VCC and VIO can be connected together directly with the power supply. If the VCC power supply is larger than 3.3V, VIO should be connected with 3.3V voltage solely.

2.2 Control Interface

QN8027 uses I^{2}C bus to communication only. And I^{2}C process follows I^{2}C protocol.

QN8027 I^{2}C device address (7 bits) is 0x2C (0101100). When it comes to writing operation, it should be added '0' as the LSB of the address (0x58); when it comes to reading operation, it should be add '1' as the LSB of the address (0x59).

SDA pin is the data bus and SCL pin is the clock bus, on these two buses, the pull up registers are needed. And the registers values should be adjusted according to the I^{2}C rate.

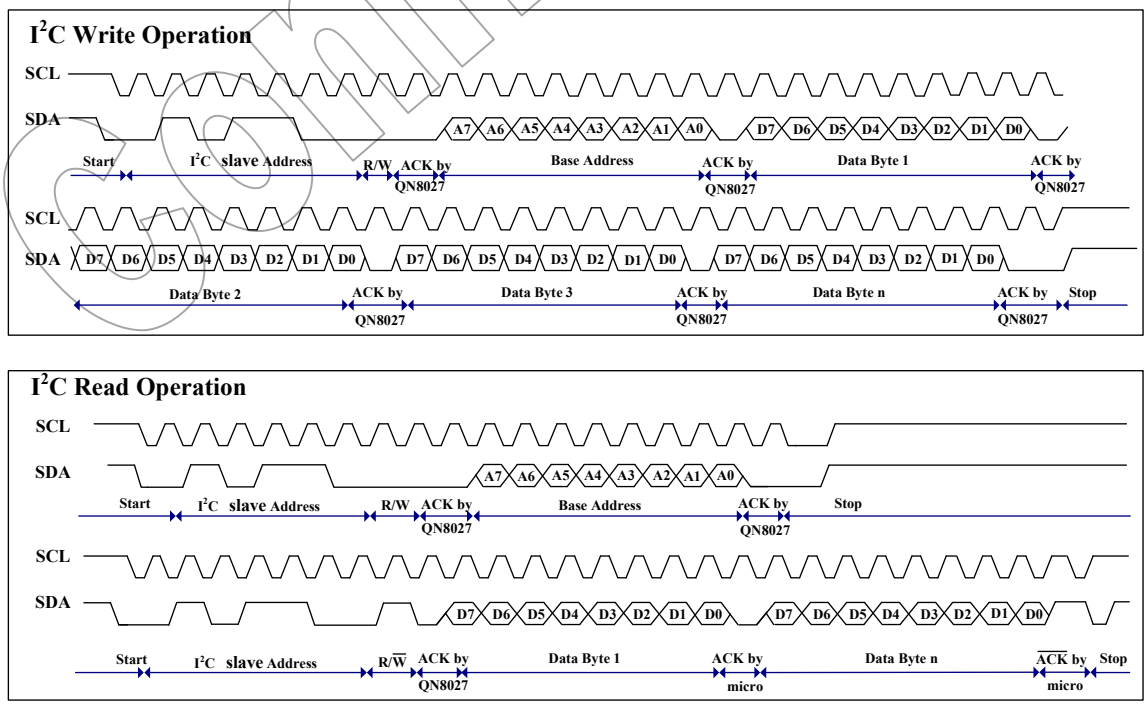

Figure 1. I^{2}C Write and Read Operation Timing

2.3 Clock Interface

Pin 1'XTAL2' and pin 2 'XTAL1' are used to crystal input. QN8027 accepts 12MHz and 24MHz crystals. And the crystals need 20pF load cap. The chip default setting is 24MHz crystal. If the crystal is changed, it needs to change some registers and recalibrate to make chip for the crystal setting.

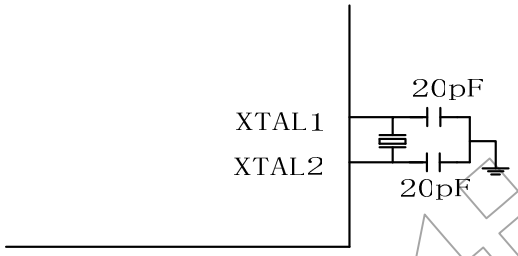

Figure 2. Crystal Input Interface

QN8027 accepts external clock input. It accepts square clock with the voltage range 0~UVIO and sin wave single-end and sin wave differential clock input (Figure 3). For sin wave single-end clock input, the voltage of the clock should be larger than 350mVpeak. With differential sin wave clock input, the clock input voltage should larger than 350mVp-p every endpoint (Figure 4).

If used external clock, XTAL1 pin is used to clock input.

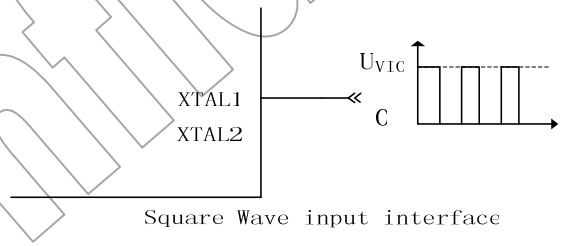

Figure 3. Square Wave Clock Input Interface

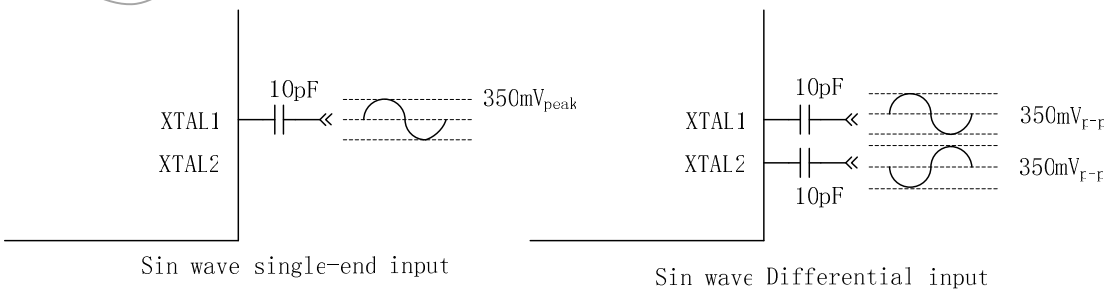

Figure 4. Sin Wave Clock Input Interface

2.4 Audio Input Interface

QN8027 has integrated VGA inside which can change the input impedance of 5k ohm, 10k ohm, 20k ohm and 40k ohm by registers control.

With default register setting, audio input only accepts maximum 1000mVp-p voltage. And audio input needs a capacitor to separate DC voltage. The suggested capacitor value is 4.7uF.

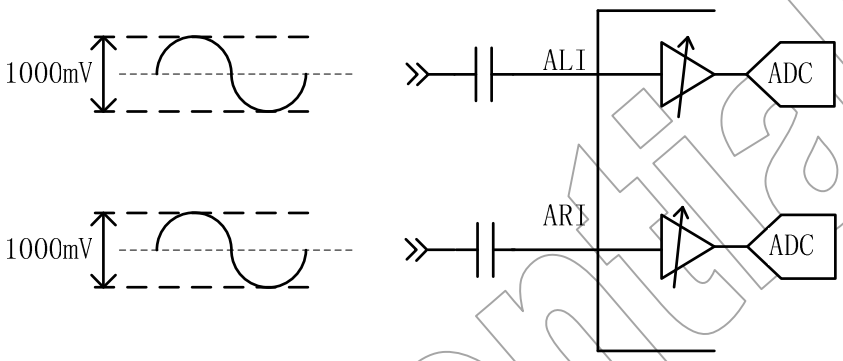

Figure 5. Audio Input Interface

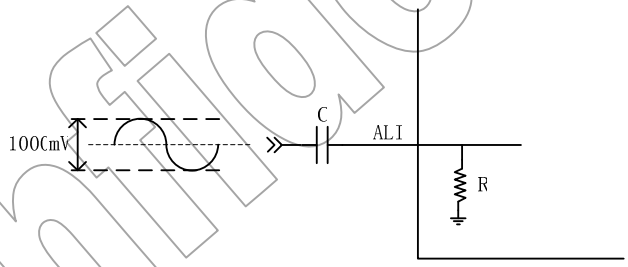

Figure 6. Audio Input 1000mVp-p voltage

From the Figure 5 and Figure 6, the capacitor and the import impedance build up a high pass filter structure. And the low cut-off frequency is: $f_c = \frac{1}{2\pi RC}$; in order to get a good frequency response at low frequency, the capacitor value is suggested to 4.7uF.

2.5 Differential Audio Input Reference Circuit

In order to further improve the common mode noise restrain and build up a low-pass filter in the front-end of audio input, we provide a reference design for differential audio input circuit.

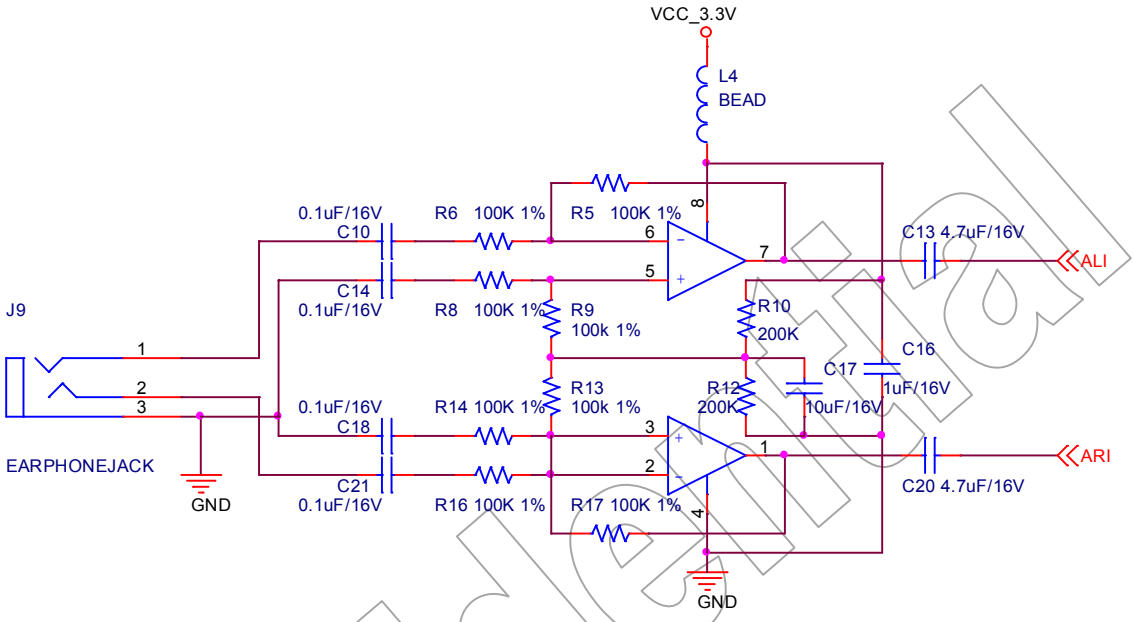

Figure 7. Reference Design of Differential Audio Input

2.6 FM Transmitter Antenna Interface

QN8027 uses auto turn for every channel with the integrated adjustable capacitor and can make the PA output voltage to get maximum value at every channel.

The PA structure of QN8027 needs an inductor at the outside of the chip, which is used to produce a resonant circuit with the integrated capacitor, and it also provides a DC back circuit for the PA output.

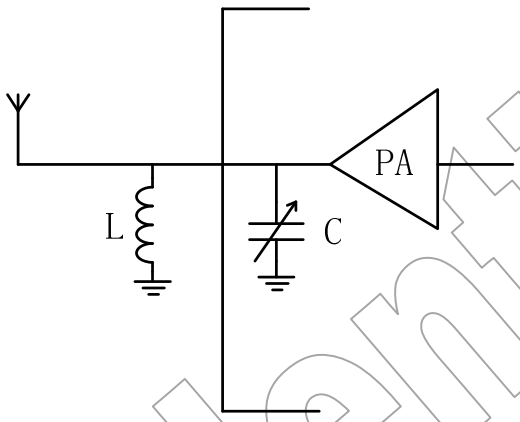

Figure 8. PA output circuit

According to the chip design, the inductor should be assembled as close as possible to the chip.

The integrated capacitor is adjustable and according to the polynomial $f = \frac{1}{2\pi\sqrt{LC}}$, in order to covers the frequency range from 76MHz ~ 108MHz, the 150nH inductor is suggested. And this inductor value will modify according the equivalent serial capacitor which induct from the board layout and the antenna type.

To judge whether the inductor has covered the full span, reg30 can be used. Set the RF frequency of 76MHz and read the reg30 value, then set RF frequency of 108MHz and read reg30 value, if both two reg30 values are in range 0x1f~0x00, it means the inductor can cover the full span. Otherwise, it is necessary to change the inductor value to cover the full span.

2.7 Difference between Qn8000 and QN8027

- QN8000 only accepts 7.6MHz crystal; QN8027 accepts 12MHz/24MHz crystal.
- QN8000 uses 2 wire and 3wire control interface; QN8027 only uses I^2C control interface. QN8000 and QN8027 have different device ID.
- QN8000 RFO can connect to antenna; QN8027 RFO needs an inductor about 150nH across to GND nearby the RFO pin.

2.8 Power Amplifier Circuit for QN8027

QN8027 has an integrated power amplifier. If the output power still can't meet the requirement, it can be added an external power amplifier outside of the chip RFO pin.

The circuit is shown as following:

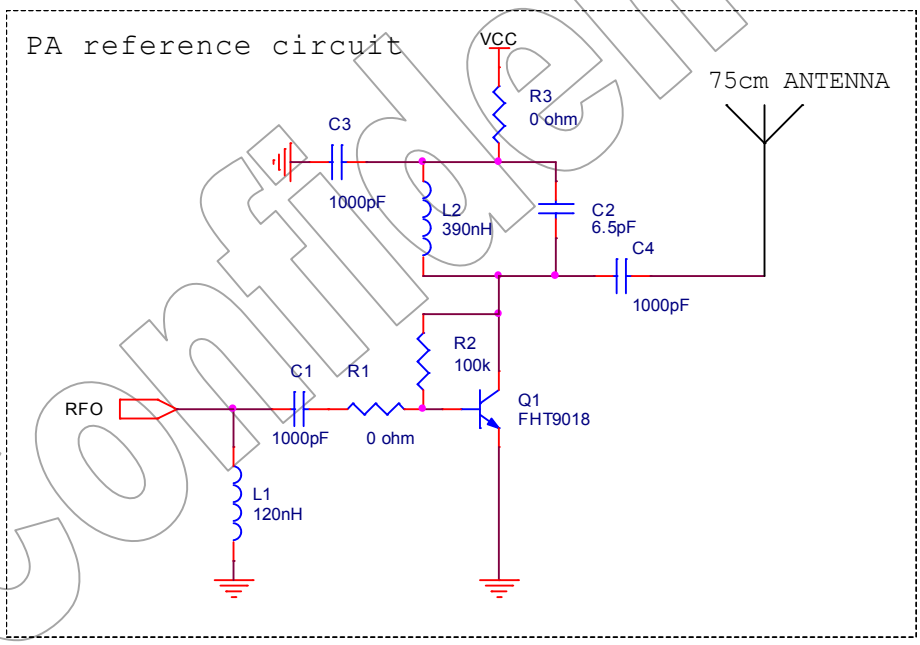

Figure 9. External PA Reference Circuit for 75cm Antenna

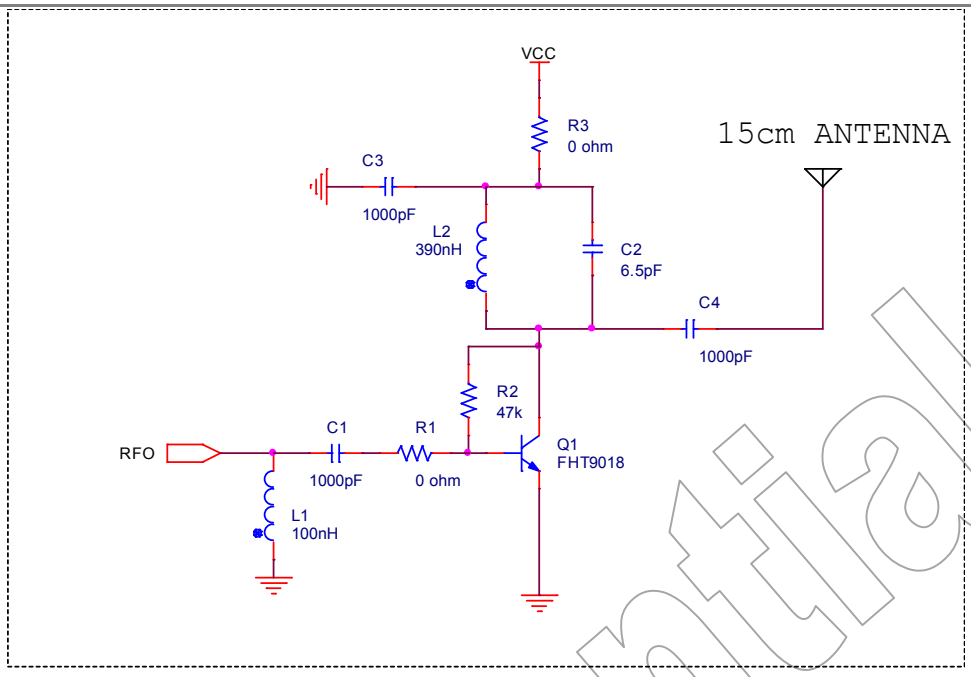

Figure 10. External PA Reference Circuit for 15cm Antenna

***Note: in the Figure 10, RFO connects to the pin 5 of QN8027 directly.**

The reference circuit is designed based on QN8027 EVB with the PA circuit, RF output power increases about 15dB. When the circuit is used on practical product, the parameters of the components need do a little modify according to the layout of the FM transmitter output trace.

2.9 Schematic of QN8027 Reference Design

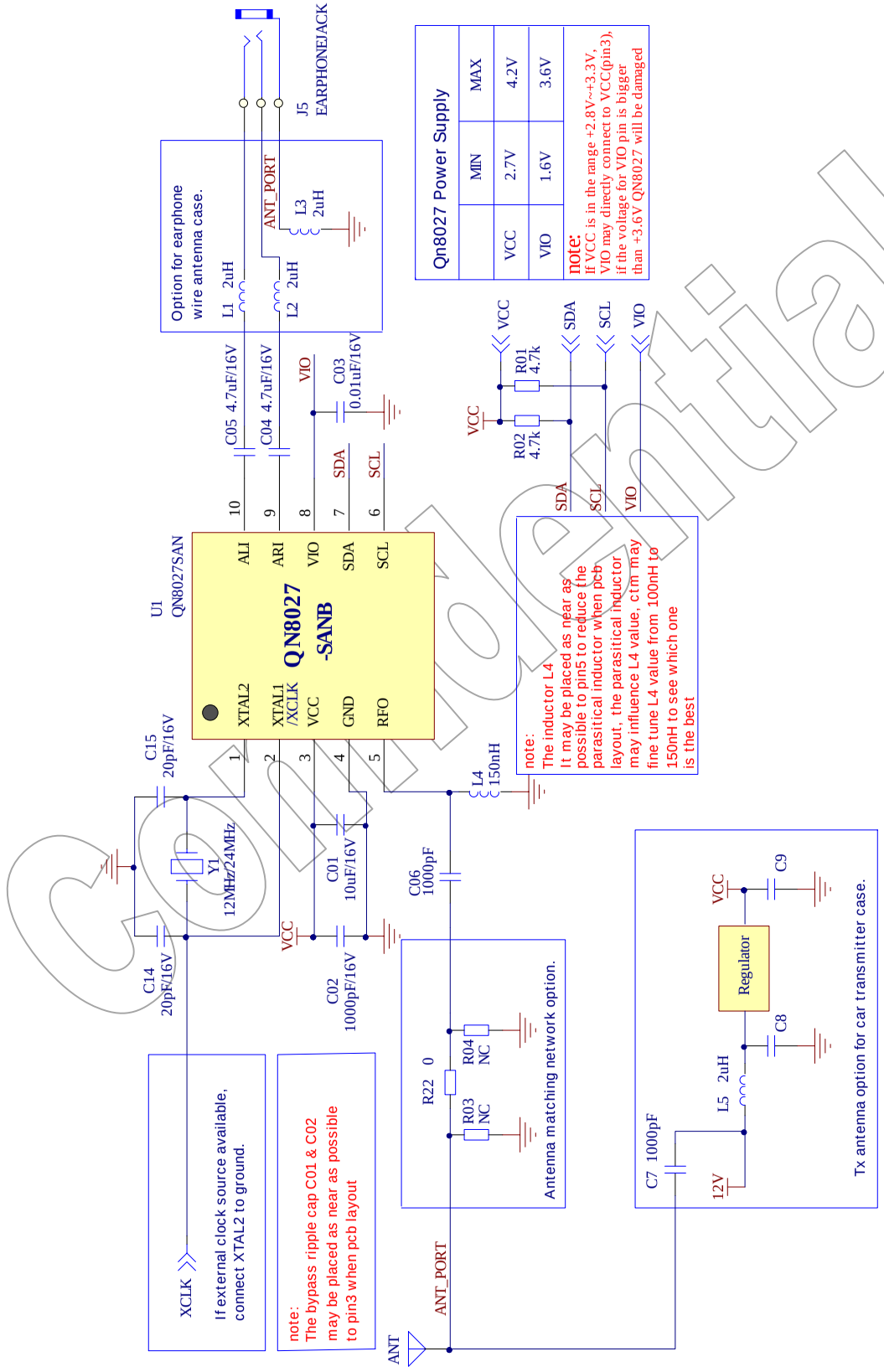

Figure 11. Schematic of QN8027 Reference Design

2.10 PCB Layout for QN8027

The example layout as show in the following:

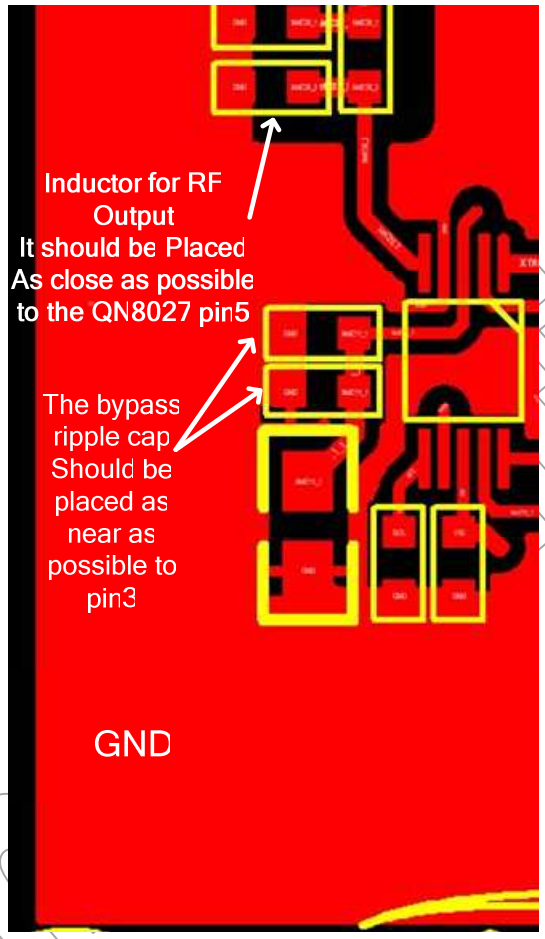

Figure 12. Top Layer

The RF output inductor should be placed to the chip pin5 and the bypass ripple cap should be placed to pin3 as close as possible.

Close to the QN8027 chip, there should be a large area of GND copper which help to eradiate the FM high frequency signal.

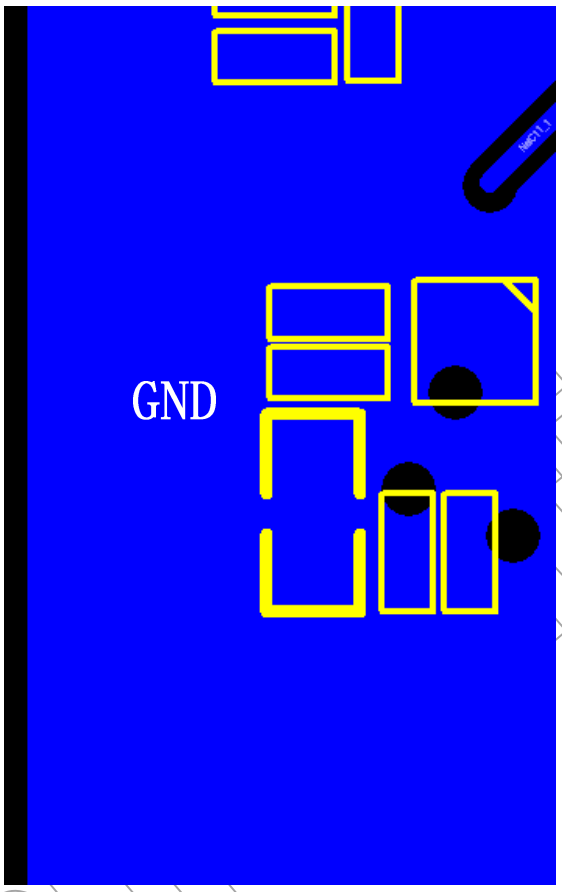

Figure 13. Bottom Layer

Under the chip and the RF signal trace, there need an integrative GND copper. This copper will help to increase the high frequency signal integrity and also help to eradiate the FM high frequency signal.

2.11 AN Example of PCB Layout

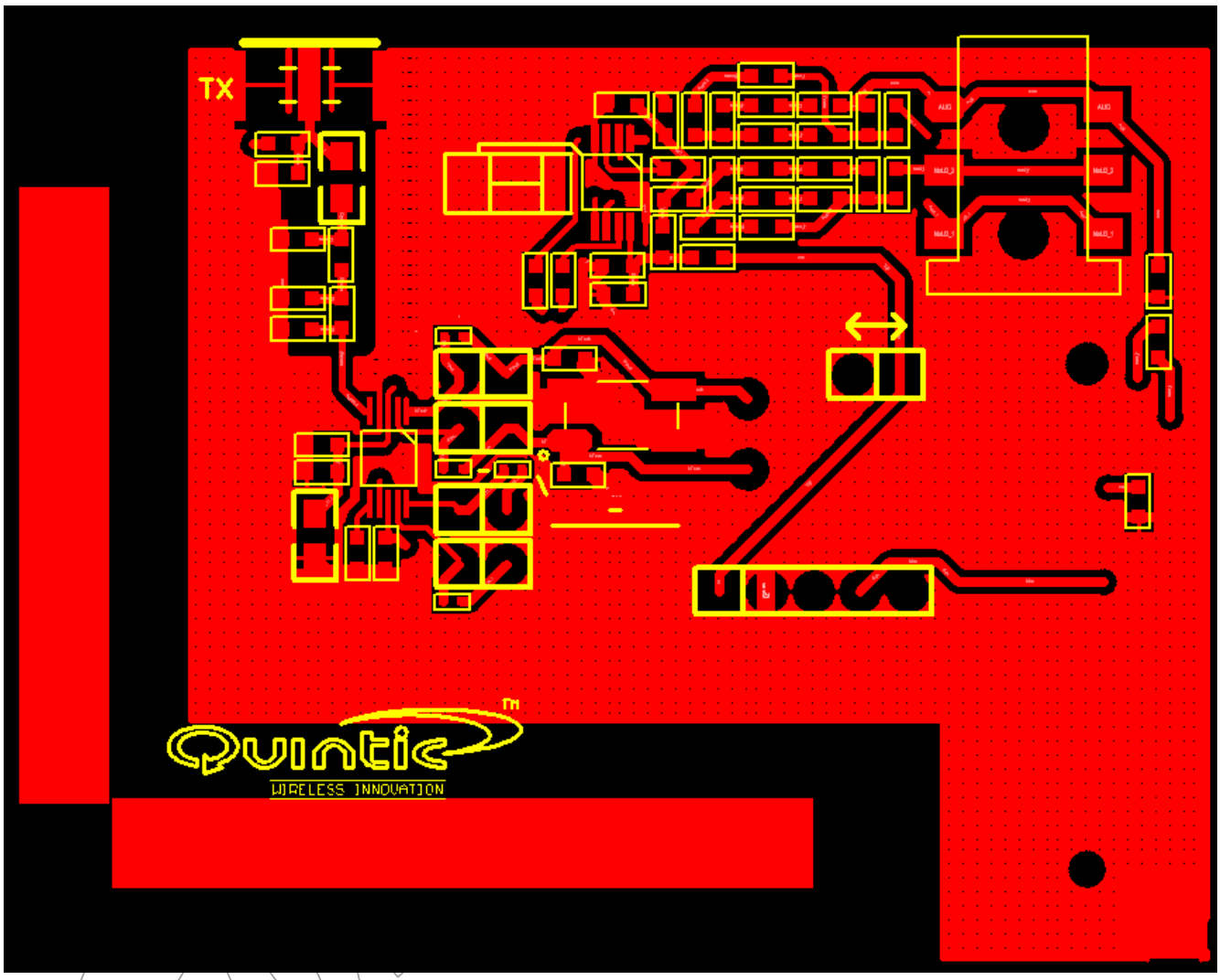

Figure 14. Top Layer

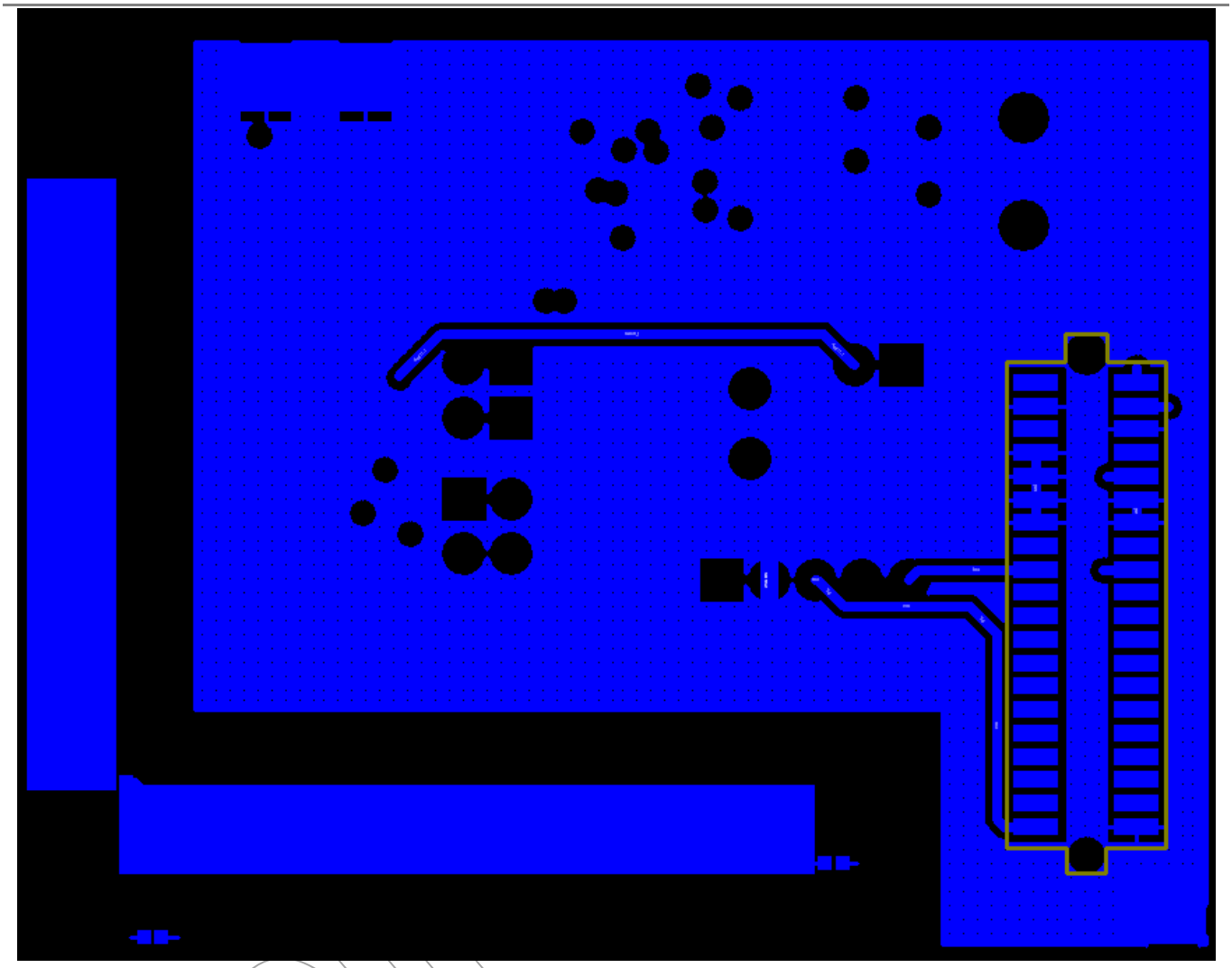

Figure 15. Bottom Layer

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