Tuning Application Note for FXR.XX Series of Antennas

1. Introduction

The following is a method for selecting the correct tuning capacitor value for tuning the FXR.XX series of NFC antennas. It has been verified through experiment and provides a good starting read range which can be further fine-tuned if necessary.

Note: This technique only works when you have a NFC antenna with a known inductance as a starting point. It is intended to provide a basis for tuning when you are swapping in your current NFC antenna with one of the FXR.XX antennas for superior read range.

2. Theory

In order to achieve resonance, the inductive reactance must equal the capacitive reactance so that the imaginary part of the impedance is zero.

$$x_c = x_L$$

After the swapping NFC antennas, the inductive reactance has changed and so must the capacitive reactance. Substituting in the appropriate expressions for reactance, we arrive at:

$$\frac{1}{\omega C} = \omega L$$

Where C is the shunt tuning capacitor value needed, L is the inductance of the FXR.XX antenna, and ω is the angular frequency.

Solving for C,

$$C = \frac{1}{\omega^2 L}$$

For a given inductance antenna, this is the value of the shunt tuning capacitor needed to bring the resonance to 13.56 MHz, the standard NFC communication frequency.

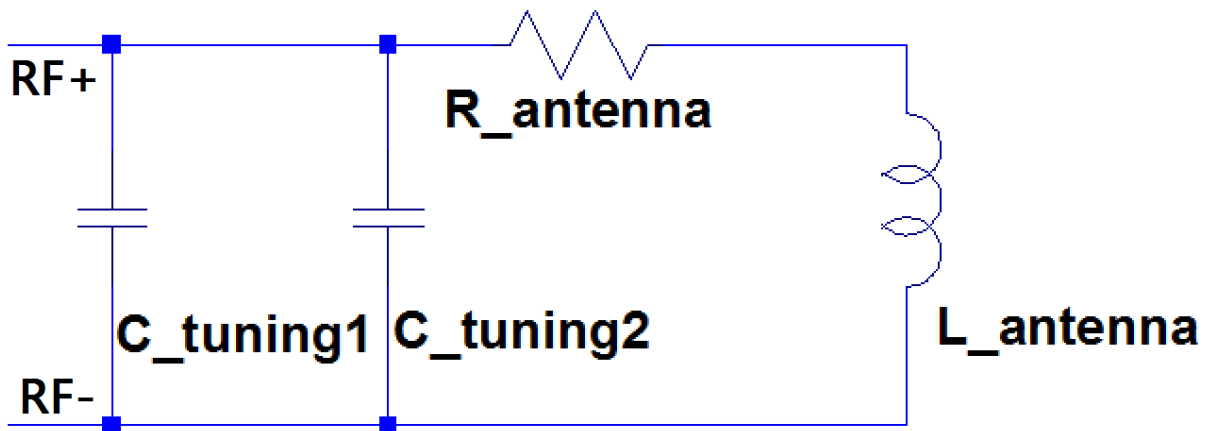The tuning circuit/antenna environment is represented by the following tuning circuit:

Figure 1: Circuit diagram for the NFC antenna tuning network

Where two capacitors are used to form the capacitance value needed, in order to minimize equivalent series resistance and provide a stronger approximation of the ideal capacitor. That is,

$$C = C_{tuning1} + C_{tuning2}$$

3. Experiment

This technique was put to the test by attempting to tune the CR95HF RF transceiver board that comes with the ST Micro M24LR-DISCOVERY kit by swapping out the current PCB NFC antenna with the FXR.05, FXR.07, & FXR.08 and creating three separate tuning circuits for each.

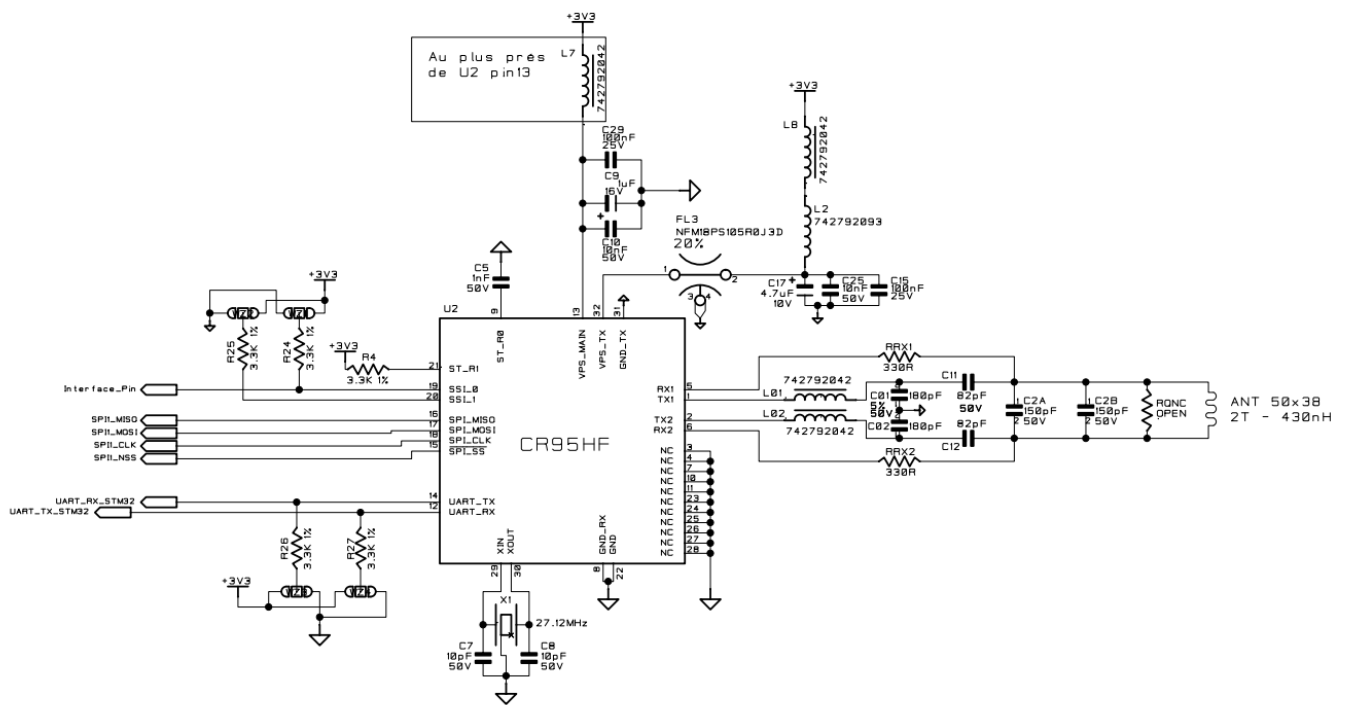The circuit diagram for CR95HF RF transceiver board is as follows:

Figure 2: CR95HF RF transceiver board circuit board

The two components used for tuning in the CR95HF are C2A & C2B, as shown above. These are the values of C_tuning1 & C_tuning2 for the circuit given in Figure 1 and will be the values we change when implementing a FXR.XX antenna.

For example, to implement the FXR. 07 we calculate the value C as follows:

Given that the inductance of the FXR.07 is 6.4 µH:

$$C = \frac{1}{\left(2\pi \cdot 13.56\,MHz\right)^2 \left(6.4\,\mu H\right)}$$

$$C = 21.52 \text{ pF}$$

So the current series tuning capacitors values, C2A & C2B, are changed from 150pF to 11pF to provide a total capacitance, C, of 22 pF. This was verified by experiment as a tuning capacitor value of 22 pF provided the largest read range, 4.4 cm, with the Tag-it HFI Plus RI-I02-112 (76 x 48 mm) reader tag.

Additional testing has shown this technique provides an easy way to implement one of the FXR.XX series of NFC antennas. Tuning values and read ranges for the FXR.05, FXR.07, & FXR.08 are provided in the table below:

	FXR.05	FXR.07	FXR.08
Antenna Inductance (µH)	15.9	6.4	4.5
Total Tuning Capacitance (pF)	8.664	21.524	30.613
C_tuning1 (pF)	4.3	11	15
C_tuning2 (pF)	4.3	11	15
Measured Read Range (cm)	2	4.4	5

Additionally, it was seen that the geometry of the NFC antenna vs. reader tag plays an important role in read range distance. The NFC antenna and reader tag should have similar area and shape so that the maximum number of magnetic field lines are being captured by the NFC antenna/reader tag network. This is evidenced by the fact that the FXR.05, with a diameter of 26.4 mm, has the smallest read range distance

with the rectangular Tag-it HFI Plus RI-I02-112 (76 x 48 mm) reader tag. Whereas FXR.07 & FXR.08 have an area closer to the Tag-it HFI Plus RI-I02-112 reader tag (1625 mm^2 & 1990mm^2 vs. 3504 mm^2). This results in more field lines being captured and consequently more energy being transferred.

As evidenced by the results above, any FXR.XX antenna can be tuned to a particular NFC application by using the proper tuning circuit and choosing the FXR.XX with the right geometry for the reader tag in question.