RFID (NFC) Antenna Design for Dedicated Mobile Applications at 88 MHz Frequency

Amit Gupta, Sudeep Baudha, Brajesh Mishra

Abstract*— *Near field communication (NFC) is a set of standards for smart phones and similar devices to establish radio communication with each other by touching them together or bringing them into close proximity, usually no more than a few centimeters. Present and anticipated applications include contactless transactions, data exchange, and simplified setup of more complex communications such as Wi-Fi Communication is also possible between an NFC device and an unpowered NFC chip, called a "tag" Later part of paper discuss about the RFID antenna which is tuned on 88 MHz frequency, this frequency is not yet allotted for any mobile application, so if allotted on such frequency the communication might become revolutionary. New designs with new results and all other parameters to describe the antenna design in detail.

I. INTRODUCTION

The increasing interest in using Near Field Communications (NFC) technology at 13.5MHz is growing rapidly in the area of contactless payments, as well as numerous other applications, between devices that are within 10cm distance apart. However, there is growing concern that the use of such devices for contactless payments invites problems with regards to using metallic objects in the vicinity of the two devices to act as “rogue” antennas, which eavesdrop information during a financial transaction is taking place. This paper presents aspects of designing H-antennas both for the two devices communicating while also identifying the means by which rogue antennas can be created by exploiting real life metallic structures. In this paper, a shopping trolley is taken as an example. The first part of this paper will focus upon the design of NFC antennas for communication between two devices within proximity less than 10cm apart. Such example in the case of contactless payments would be a mobile handset communicating with a vending device, such as a ticket machine or credit card payment terminal in a café. Applying theory analyzed for such antennas, the paper will then go on to analyze the potential use of a shopping trolley to act as a rogue antenna from which information could potentially be eaves dropped.

II. NFC ANTENNA DESIGN THEORY

A typical example of magnetic coupling loop antennas, otherwise known as “H-antennas”, is illustrated in figure 1. The two ends of such an antenna are connected to a radio frequency (RF) transceiver with a capacitor placed across in parallel. The DC resistance at the input can be assumed to be zero while as the frequency increases, it will create an inductance such that a circuit model for such an antenna can be represented as that shown in figure 2 where the Antenna is represented as an inductor [2]. The parallel capacitor is then connected to the load of the transceiver, which will in this case be assumed to be purely resistive. Were there to be a reactive component at the transceiver input, it can be easily cancelled out by applying a series, negative reactance so therefore need not be considered. Many publications in the literature assume the inductance to be constant over frequency, though observations from measurement using a network analyzer find it to be the case that inductance will change at lower frequencies.

Figure 3 shows measured results using a vector network analyzer, where the inductance reduces to a constant value after about 1MHz. Where the frequency is low, the loop effectively resembles a short circuit where the inductance would be expected to fall to zero. However, due to precision required in such circumstances, an accurate value of inductance cannot be resolved. In this paper the inductance will be considered as frequency dependent and is therefore denoted, $L(f)$ or $L(w)$ where relevant, where f is the frequency and w is the angular frequency equal to 2pf. This will become more important when the inductance values for a rogue antenna are considered. For any loop antenna to resonate, it is well known that the parallel capacitance to be applied can be derived as follows:

$$C = \frac{1}{(2\pi f_0)^2 L(f_0)}$$

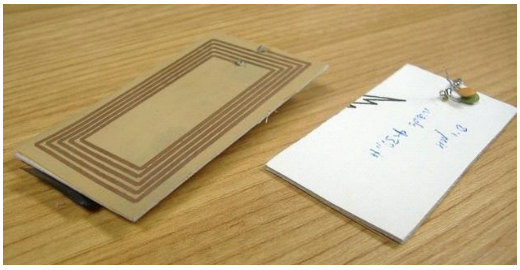

Fig.1 Coil Antenna

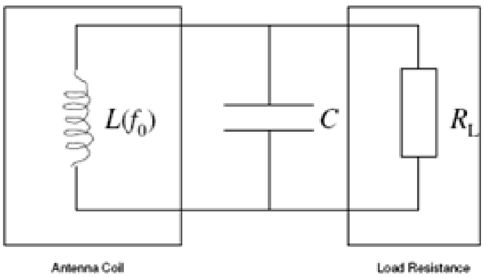

Fig.2 circuit model of H antenna

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Amit Gupta, Department of Electronics & Communication, Gyan Ganga College of technology, Jabalpur (M.P)
Sudeep Baudha, Department of Electronics & Communication, Gyan Ganga College of technology, Jabalpur (M.P)
Brajesh Mishra, Department of Electronics & Communication, Gyan Ganga College of technology, Jabalpur (M.P)

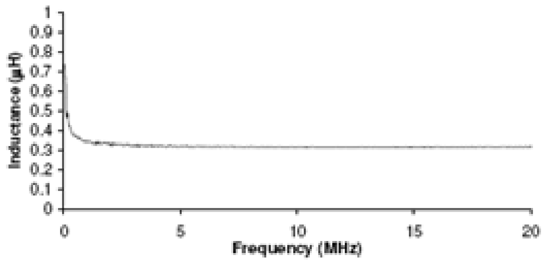

Fig. 3 Measured values of inductance over frequency

At the resonant frequency, the transceiver connected to the antenna has a load resistance, R_L, where in receive mode it will have the following system frequency response function, based on the ratio of the load voltage, V_L, across the load resistance compared to the input voltage effectively resulting from the current flowing in the loop antenna, V_{in}, is defined as follows:

$$\frac{V_L}{V_{in}} = \frac{1}{1+\frac{j\omega L(\omega)}{R_L}-\omega^2 LC}$$

One important point to realize from this is that maximum power transfer at the resonant frequency, w0, will reduce to:

$$\frac{V_L}{V_{in}} = \frac{R_L\sqrt{C}}{j\sqrt{L(\omega_0)}}$$

thus requiring a low inductance in order to maximize gain with as high load resistance as possible. The magnitude of this equation is also equal to the Q factor of the system, that will depend on a low value of L and a high value of R_L. For transmit mode, the transfer function relating the voltage across the antenna, V_A, which is now a reactive load, to the source voltage, V_S, that is now in parallel with R_L, is as follows:

$$\frac{V_A}{V_S} = \frac{1}{jR_L\left(\omega C-\frac{1}{\omega L(\omega)}\right)+1}$$

III. BLOCK DIAGRAM OF THE PROPOSED NFC TRANSCEIVER

To realize NFC devices, implementation of active and passive mode of NFC protocol with passive RFID protocols is required. An NFC chipset consists of a digital block including digital controller and host interface, and an analog front end part with external antenna matching circuit as shown
in figure:

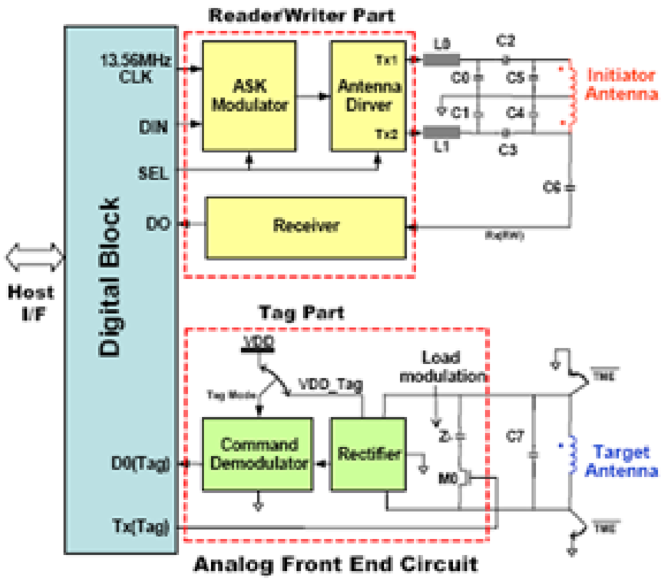

Fig.4 Block dig of NFC transceiver

The host interface of the chipset should be designed to support maximum baud rate of 424kbps. The analog front end part is composed of two analog/RF circuits and matching circuits for Initiator and Target antennas. The reader/writer part is for transmitting RF signal when operating active and passive NFC mode and RFID reader mode. The Tag part is both for target operation of NFC protocol and passive RFID tag mode. The conventional NFC chipset could not support RFID tag mode when external power is not supplied, because it has only one antenna both for NFC mode and RFID mode [5]. RFID tag mode must support standard of 13.56MHz smartcard such as ISO/IEC14443 type A/B, or ISO/IEC15693[1-4]. The key differences between target of passive NFC mode and RFID tag is operating distance, data rate, and host interface.

IV. SIMULATION USING ADS

The designed coil antenna has 10 numbers of turns in units of 100x50.

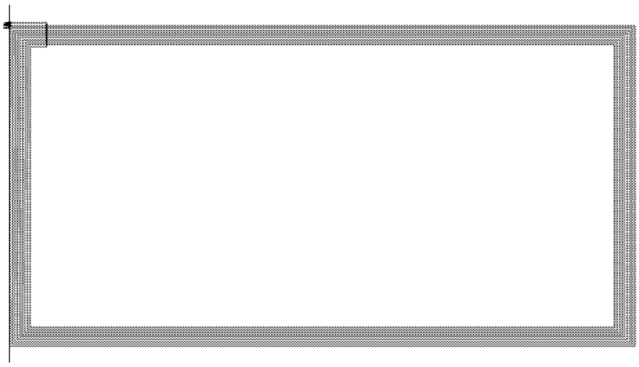

Fig. 5 Schematic diagram of the antenna coil

It has got lumped ports to deal with power supply. The gap between the coils is 1 mm and the thickness of the coil is also 1 mm.

ADS view of designed coil:-

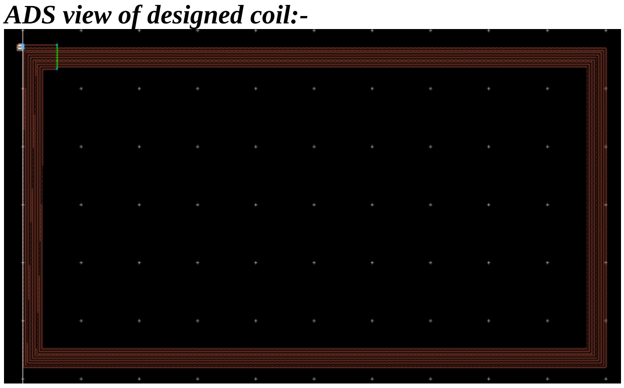

Fig. 6 ADS coil design

Return losses achieved by simulation:-

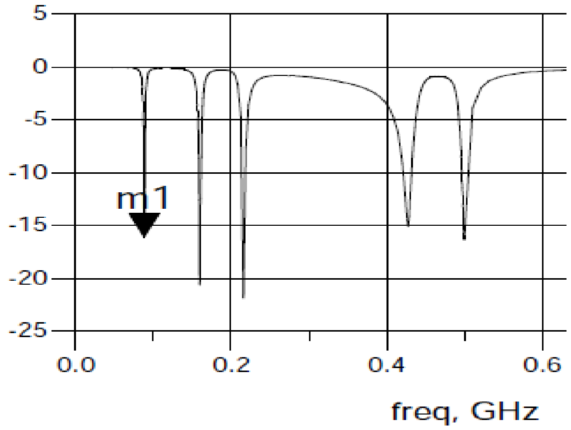

Fig.7 Return losses

-16.04 dB is achieved at 88 MHz frequency. ***Smith chart:-***

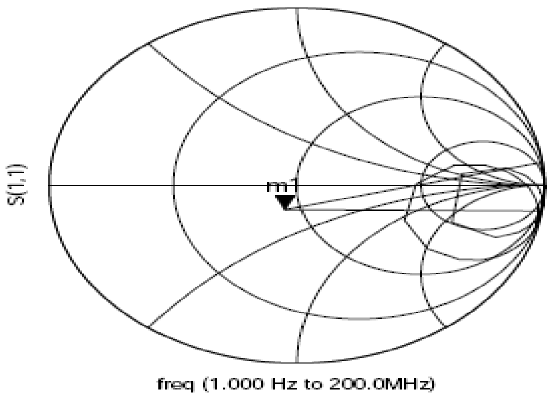

Fig 8 Smith chart for the coil antenna

3-D plot:-

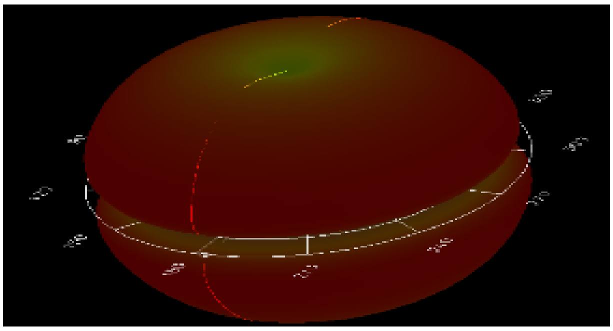

Fig. 9. 3 dimensional view

The Input impedance (ZL) in the schematic of the ADS with lumped elements:-

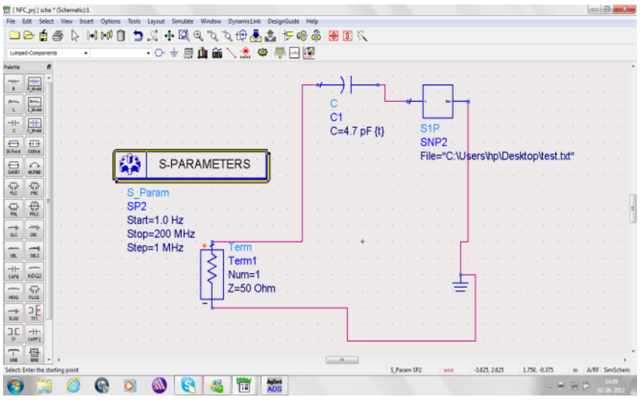

Fig. 10 S-parameter matching circuit

Gain parameter achieved:-

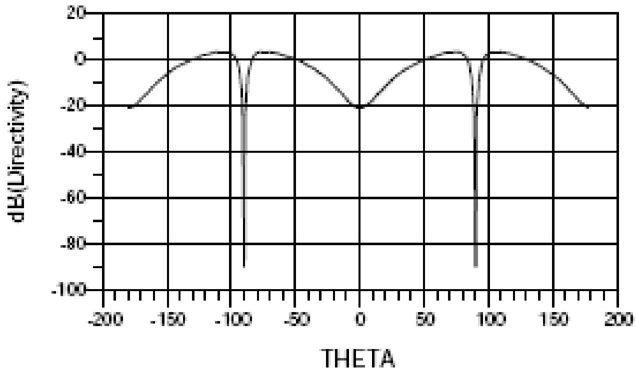

Fig. 11 Gain & directivity

V. CONCLUSION

This paper shows the basic parameters of NFC system and antenna design, including all the circuits and values required for designing the antenna.

In later part the simulation work has been shown which was done using ADS software. With the help of this software many parameters have been taken out eg. Antenna design, Return losses, S-Parameters, Gain, Directivity & 3-D plot. The existing NFC system provides a distance of 3-4 Cms. Maximum between two NFC tags with return losses in range of -8 dB.

With this new design of 13.5 Mhz RFID antenna, it will double the distance than before that means two NFC tags can communicate with more than double distance as compared to what they are currently using. This will be helpful in several NFC applications which enhance the transmission and overall efficiency of the system.

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AUTHORS PROFILE

Amit Gupta: E (EC) from GGITS, JABALPUR .M. Tech. (Under Persuation) Digital Communication, GGCT, JABALPUR.Research Work:-Antenna Designing.

Sudeep Baudha: B.E. (EC) GEC,Ujjain.M.Tech. (Microwave EnggIIT Kharagpur. search Work :- Antenna Designing

Brajesh Mishra BE (EC) from GGITS, Jabalpur. M.Tech. (UnderPersuation) DigitalCommunication, GGCT, Jabalpur.Research Work:-Antenna Designing.