High-Q Antennas with built-in coils

For Mobile Devices

Bahramzy, Pevand; Svendsen, Simon; Pedersen, Gert Frølund

Published in:
Antennas and Propagation Society International Symposium (APSURSI), 2014 IEEE

DOI (link to publication from Publisher):
10.1109/APS.2014.6904521

Publication date:
2014

Document Version
Early version, also known as pre-print

High-Q Antennas with built-in coils: for Mobile Devices

Pevand Bahramzy and Simon Svendsen
Intel Mobile Communication Denmark Aps
35 Lindholm Brygge, Noerresundby 9400, Denmark
email: {pevand.bahramzy,simon.svendsen}@intel.com

Pevand Bahramzy and Gert F. Pedersen
Section of Antennas, Propagation and Radio Networking (APNet)
Aalborg University, DK-9220 Aalborg, Denmark
email: {pb,gfp}@es.aau.dk

***Abstract*—Efficiency and isolation, at low frequencies (700 MHz), are two of the most important metrics for successful multi-communication implementation. This paper presents an antenna concept, that exhibits a very high isolation between high-Q Tx and Rx antennas at 700 MHz. Furthermore, it is shown how coils can be integrating into the antenna structure for obtaining better efficiency. It is shown that by integrated coils into the antenna structure, the efficiency can be improved by 2dB for each antenna.**

I. Introduction

The frequency spectrum for mobile communication is widened, ranging from 700 MHz to 3800 MHz [1], to support wide range of wireless technologies and provide high data rate. This poses enormous challenges to the design of antennas in small form factors due to the trade-off between size, bandwidth and efficiency [2]. In order to address this, it is proposed to separate the Transmitting (Tx) and Receiving (Rx) antennas [3]. In such a system, the Tx and Rx antennas only need to cover the requisite Long Term Evolution (LTE) channel Bandwidth (BW), which varies between 1.4 MHz and 20 MHz [1]. The frequency range of interest can then be covered through tuning.

Isolation becomes important when Tx and Rx antennas are separated. This paper shows an antenna concept, that exhibits a very high isolation between the high-Q Tx and Rx antennas at 700 MHz. Furthermore, it is shown how coils can be integrating into the antenna structure and thereby achieve improved efficiency.

II. Antennas with discrete coils

The antennas with discrete coils [4], shown in Figure 1, exhibits an isolation of better than -22 dB at 700 MHz. From the measured efficiency plot of the mock-up, depicted in Figure 2, it is seen that the peak efficiencies of the Tx and Rx antennas are -4.7 dB and -5.1 dB, respectively. The low efficiencies are to a great extent due to the big discrete coils (33 nH for Tx antenna and 30 nH for Rx antenna) applied to force the antenna elements into resonance at their respective frequencies.

III. Antennas with built-in coils

In Figure 3 it is illustrated how the coils can be integrated into the antenna structure and thereby enhance the efficiency. Since the integrated coils have air core, their Quality factor

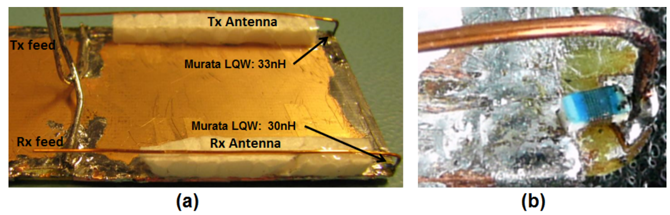

Fig. 1. Antenna mock-up with discrete coils. perspective view (a) and close-up of the discrete coils (b).

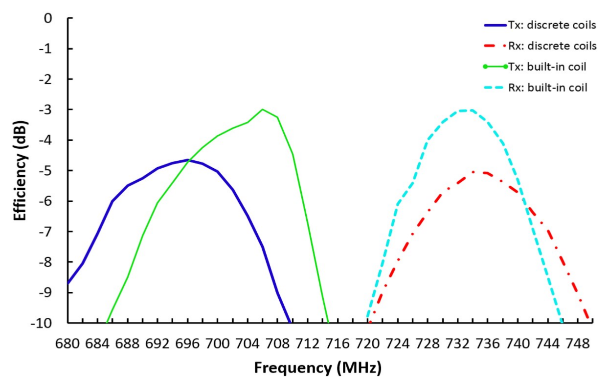

Fig. 2. Efficiency plot of antennas with discrete coils vs. built-in coils.

(Q) are expected to be much better compared to the discrete ones. Only three turns are used on each side of the Printed Circuit Board (PCB) to keep the 3.5 mm antenna height and similar antenna Q as in [4]. Therefore, it becomes necessary to position the antenna arms at both sides of the PCB (see Figure 3b) in order to force the antenna to the desired resonance frequency (Tx: 689-716 MHz, Rx: 728-746 MHz).

A. measurement results

Efficiency graphs of the antennas with integrated coils are, for the sake of comparison, shown in the same plot in Figure 2, where it is clearly seen that an improvement of 2 dB is obtained for each antenna. The measured S_{11}, S_{22} and S_{21} of the antennas with built-in coils are shown in Figure 4. The BW at SWR=3 for the Tx and Rx antennas are 22 MHz and 21 MHz, respectively. BW of the antennas have shrunk slightly

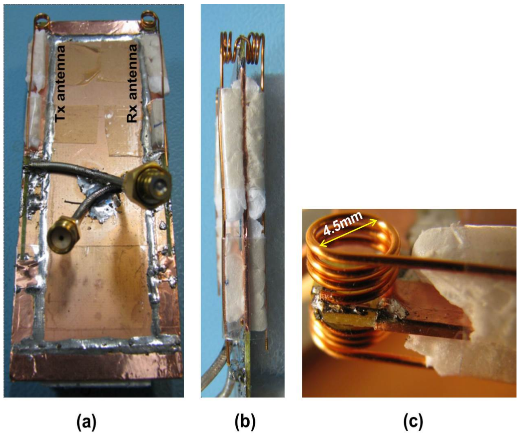

Fig. 3. Antenna mock-up with integrated coils. Top view (a), side view (b) and close-up of the integrated coils (c).

due to lower losses. As depicted in Figure 4, the worst case isolation is only -16.5 dB, which is 5.5 dB worse compared to the mock-up with discrete coils.

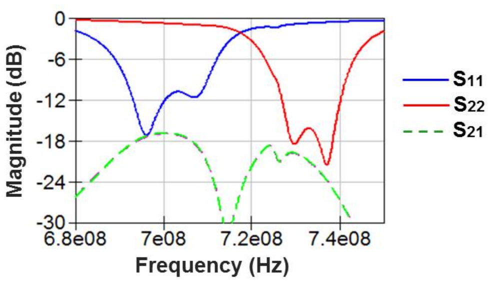

Fig. 4. Measured reflection coefficients (S_{11}, S_{22}) and coupling coefficient (S_{21}) of the Tx and Rx antennas, respectively.

IV. Improvement of Inductive Coupling Between Coils

From the theory of mutual inductance between coils [5], it is known that the amount of mutual inductance that links one coil to another depends very much on the relative positioning and angles of the two coils. Therefore, it is investigated experimentally whether the isolation degradation is due to the strong inductive coupling between the built-in coils of the two antennas. Due to the fixed PCB width, the two coils can not be moved farther apart from each other along the PCB width. In order to weaken the inductive coupling, one of the built-in coil is positioned perpendicular to the other (see Figure 5).

A. *measurement results*

The measured S_{11}, S_{22} and S_{21} are presented in Figure 6. The isolation is improved 1.5 dB due to the coils being at different angles. More isolation could be achieved by experimenting with the relative spacing of the two coils, e.g. moving one of the antenna to the opposite end along the length of PCB.

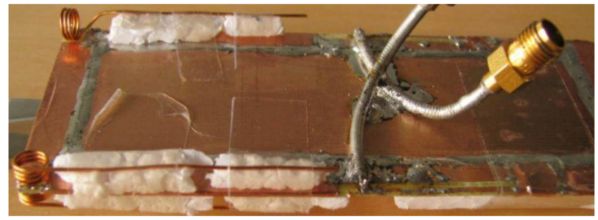

Fig. 5. Antenna mock-up with one built-in coil placed perpendicular to the other.

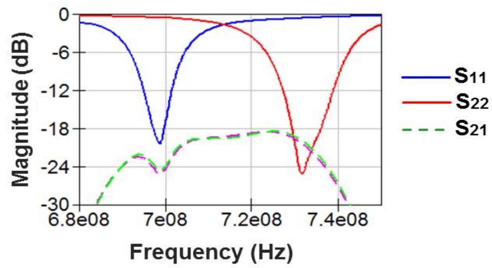

Fig. 6. Measured S-parameters of the mock-up with one built-in coil placed perpendicular to the other.

V. Conclusion

This paper presents antenna design of high-Q Tx and Rx antennas with a good isolation in between them. Moreover, it is shown how a coil can be integrated into the antenna structure for obtaining better efficiency. The efficiency improvement is shown to be 2 dB for each antenna. However, this improved efficiency is at the expense of lower antenna isolation. It is shown that the lower isolation is caused by the strong inductive coupling, which can be reduced by experimenting with the relative position or angles of the coils.

References

[1] 3GPP TS 36.101, LTE; Evolved Universal Terrestrial Radio Access (EUTRA); User Equipment (UE) radio transmission and reception, 2013.

[2] R. F. Harrington, Effect of Antenna Size on Gain, Bandwidth, and Efficiency, Journal of Research of the National Bureau of Standards-D. Radio Propagation, vol. 64D, no. 1, pp. 112, 1960.

[3] M. Pelosi, M. B. Knudsen and G. F. Pedersen, ”Multiple Antenna Systems With Inherently Decoupled Radiators”, IEEE transactions on antennas and propagation, vol. 60, no. 2, FEBRUARY 2012.

[4] P. Bahramzy and G. F. Pedersen, ”Isolation of High-Q Antennas for Mobile Handsets”, Antennas and Propagation Society International Symposium (APSURSI), 2013 IEEE.

[5] V. G. Welsby, ”The theory and design of inductance coils”, Macdonald 1960.