Design of a Small Inverted F Antenna for Low Frequencies

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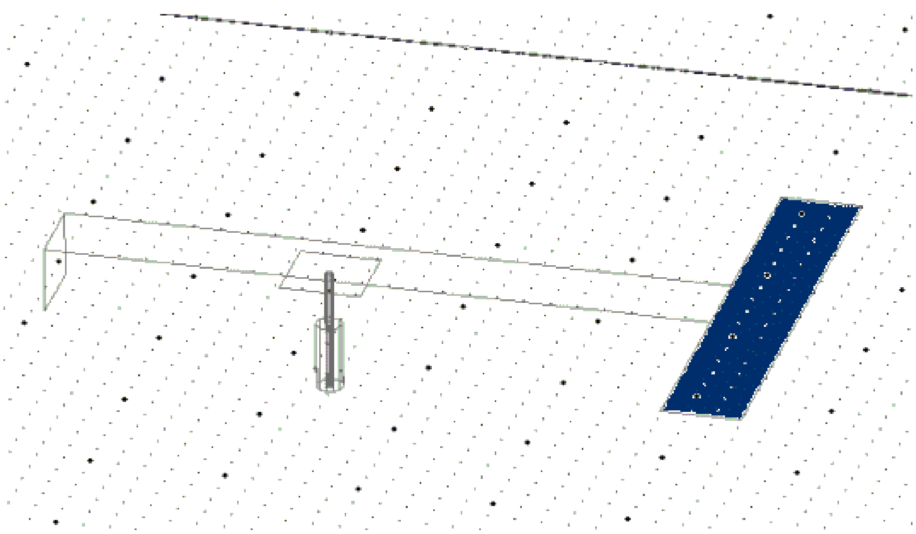
For years, patch antennas have been widely used for their low profile, low cost, and light weight.   In recent years, research has been made in order to improve the bandwidth while maintaining its small size. Many techniques such as direct (1), proximity (2), and aperture coupling, and feeding structure designs (3) have been used to adjust the bandwidth to the desired level. There have been many designs using dual bands (1) and tri- band antennas to cover the wide frequency span at the high band. However, there have been difficulties designing patch antennas operating at low frequencies due to their increased size and narrow bandwidth. Therefore, further research was conducted to create a small microstrip antenna operating at low frequencies.

The proposed antenna for an agricultural sensor network operates from 900 MHz to 925 MHz with 25 channels. The sensor network will be designed to be implemented in large crop fields or greenhouse. Developed at UC Berkeley (4), the easy-to-install sensor nodes, called “motes” will provide information on temperature humidity, sunlight intensity to help determine ideal growing conditions for the crops.

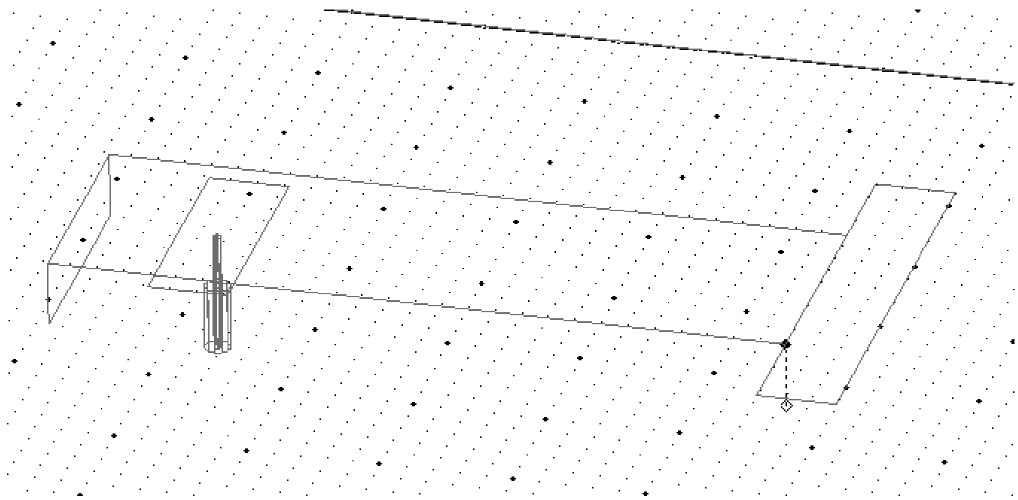
One of the purposes of the research was to explore new three dimensional antenna designs. Considered designs included microstrip antennas, multiple helical antennas, and wraparound antennas. Initially, a planar antenna design was chosen over a wire dipole antenna. To embed the antenna into the package for a portable, durable and waterproof mote, the antenna needed to be small and omni-directional. Starting from a typical magnetically-fed-L-shaped patch antenna, the left side of the patch was shorted with a ground plane. By shorting one side of the patch, the length of the antenna can be reduced from $\lambda / 2$ to This technique is widely used and the applied models are known as the “planar inverted F antennas” (PIFA). However, since as the frequency decreases, the wavelength increases. Since the wavelength is directly proportional to the length of the planar antenna (resonator), the proposed antenna was relatively large compared to the sensor mote and was not adequate for fabrication. Also for fabrication purposes, the antenna was capacitive feed was used.

To reduce the size, the length of the resonator was reduced, which lead to greater impedance (Z = cot()). As result, the capacitance decreased (). Shown in figure 1, a wide plate was added at the edge of the inverted F antenna to counter the reduction. By creating a T-shaped inverted F antenna, the length decreased dramatically. Also, due to its large radiating edge, the radiation efficiency was increased from 55 percent to 80 percent.



< Figure 1. T-shaped inverted F antenna>

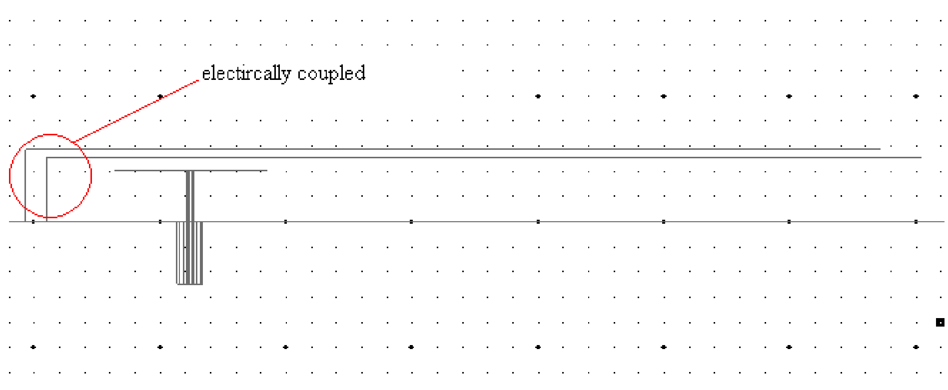
However, it was found that the antenna did not radiate at all. The results showed the model was acting as a transmission line. This was caused by the magnetic currents at the edge of the antenna. As the electromagnetic field was circulating at the wide plate located at the edge, the fields were canceling out and eventually leading to an insufficient radiation. By having a narrower edge by increasing the width of the resonator as shown in figure 2 below, the antenna radiated with 15 MHz and 1.5 dBi directivity.



< Figure2. Revised T-shaped inverted F antenna >

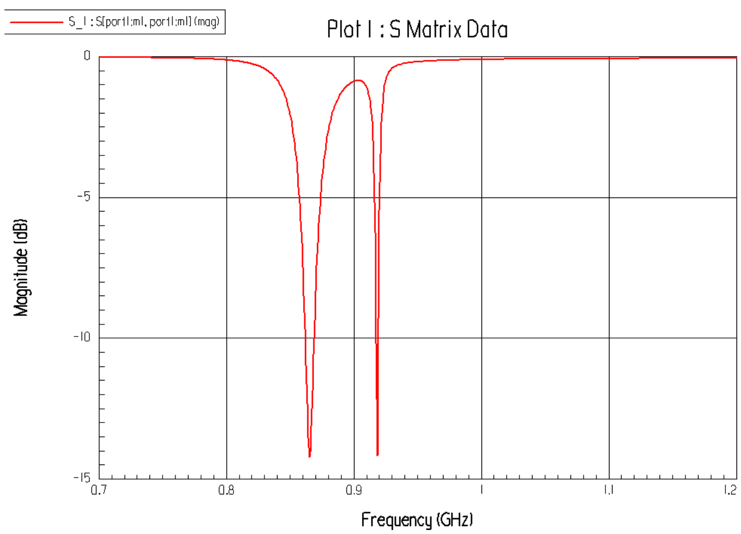
As result, the model radiated at the desired frequency with 15 MHz bandwidth and 1.5 dBi directivity.

To increase the bandwidth, a dual-band design approach was taken. As shown in figure 3, two electrically coupled resonators with varying length were stacked in to create a wide band.



< Figure3. Two electrically coupled T-shaped antenna>

The coupling was adjusted by the gap between the probes, distance between the shorted walls and the capacitive feed. However, as shown in figure 4, due to a very high Q, the bandwidth did not improve as intended. This was caused by the lack of coupling and the capacitance that was required to create a wide band was not possible due to fabrication reasons. Therefore, different approaches in creating an electrically small wide band antenna are being considered.



< Figure 4. Insertion loss of the two T-shaped antenna>

Acknowledgement

Research project partners for the design of an Agricultural Sensor Network, James Brad Dodson and Mike R. Arens are gratefully acknowledged.

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