Dual band switched-parasitic antenna for communications and direction finding

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DUAL BAND SWITCHED-PARASITIC WIRE ANTENNAS FOR COMMUNICATIONS AND DIRECTION FINDING

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Wire dipole and monopole switched-parasitic antennas have been designed to operate at 900 and 1900 MHz simultaneously. The array consists of a centre driven element circled by four parasitic elements symmetrically arranged. DC levels applied to p.i.n. diodes on each parasitic element allow full 360 degree coverage in the horizontal plane. The design of the antenna was undertaken using the genetic algorithm technique with the NEC2 solver. The design was optimised for element spacing and lumped impedance size and position. The cost function included the input impedance and directional characteristics at both frequencies. The final design has a front to back ratio of approximately 15 dB, S_{11} less than -35 dB and 360 degree coverage of within 1.5 dB of the main lobe gain for both frequencies.

1 Introduction

Switched-parasitic antennas can be used as low cost, high speed, smart antennas. The technology has been applied to both wire and patch antennas [1-6]. To date, the methodology has only been applied to single frequency systems. The major difficulty in applying the technique to dual band antennas lies in the design of parasitic elements that respond appropriately to both frequencies without an excessive number of switching elements. The development of this technique for monopole wire elements involves the location of a lumped impedance element in the wire that allows near resonance operation at both frequencies, and still with a single switch position at the base. When this switch is open circuit, then the element must be out of resonance for both frequencies. Once the basic monopole element has been designed, the overall system can be optimised for input impedance and directional performance.

2 Dual frequency monopole wire element

A single wire monopole element of length *l*, is located perpendicular to a conducting ground plane of infinite extent. It has a lumped impedance *Z* located at position *z* along its length and is driven at its base (Figure 1). The lumped impedance loading technique has been used previously for increasing the bandwidth of wire antenna structures [7]. The impedance of this antenna element can be calculated using NEC2 code [8]. The over-all length of the antenna would be approximately $\lambda/4$ for the lower frequency; i.e. at 900 MHz, *l* = 83.3 mm. When a near-resonant parasitic element is located close to the driven element, the resonant frequency is decreased, and so there is some advantage in reducing the element length to a value less than $\lambda/4$. Thus using an antenna length of approximately 80 mm, the position *z* and value *Z* of the lumped (RLC) element in the wire was optimised for S_{11} performance at the two frequencies.

The results of this optimisation process were: R = 20 Ω, L = 21 nH, C = 1.5 pF, *l* = 79 mm, and *z* = 44 mm. The S_{11} across the two bands is given in Figure 2. The dual resonance condition is clearly seen with S_{11} = -22 dB and S_{11} = -23 dB for 900 MHz and 1900 MHz respectively. The –10 dB impedance bandwidth is 100 MHz and 220 MHz for these two

frequencies. The effective bandwidth of the antenna can be increased further by the presence of nearby parasitic elements and an increase in the radius of the wire.

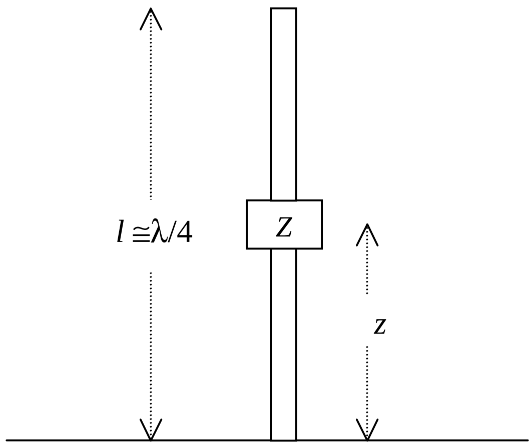

Figure 1: Dual frequency monopole (length *l*) with lumped impedance *Z* located at position *z*.

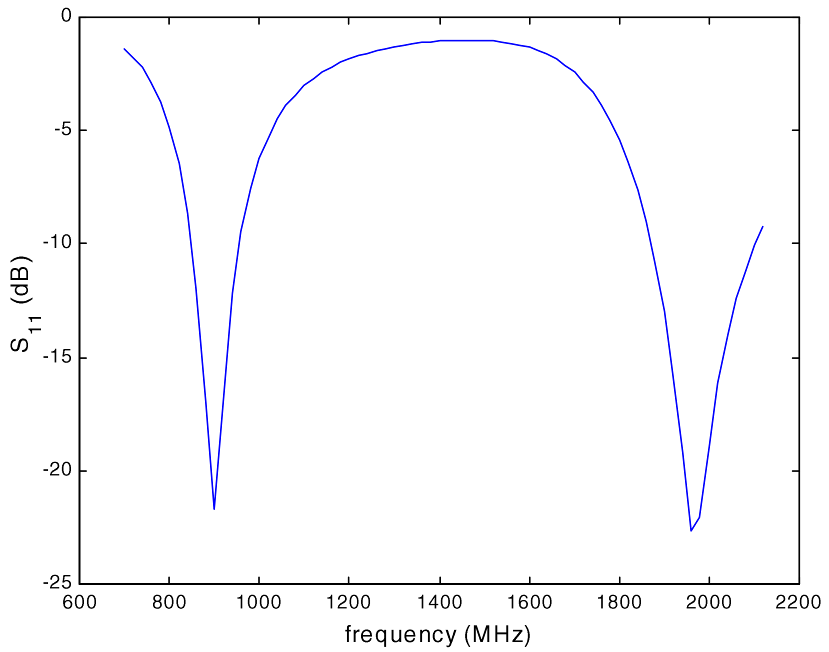

Figure 2: S_{11} variation across the frequency band for the monopole element shown in Figure 1. The two minimum values correspond to the operating frequencies of 900 MHz and 1900 MHz.

3 Switched parasitic antenna array

Figure 3 shows the arrangement for a five element, monopole array. The centre element is the driven element and the others are parasitic elements with p.i.n. diodes at their base. The application of a suitable bias voltage creates an RF connection to the ground plane and the elements are close to resonance for both frequencies. In optimising this arrangement, the radius of the circle of parasitic elements was adjusted to obtain a minimum S_{11} value, maximum front to back ratio, and a 45 degree gain of within –3dB of the main beam. This optimisation was conducted for both frequencies simultaneously. In this manner the coverage of the antenna for all switch positions is within 3dB of the main beam gain.

The final solution obtained using genetic algorithm optimisation was a ring radius of 29 mm resulting in a front to back ratio of approximately 15 dB for both centre frequencies. The S_{11} values at the two frequencies were less than –30 dB (Figure 4). The polar patterns of the antenna for both frequencies and one switch position are given in Figure 5. The gain at $\pm$ 45 degrees is within 1.5 dB of the main lobe ensuring full 360 degree coverage is possible with very little loss in sensitivity.

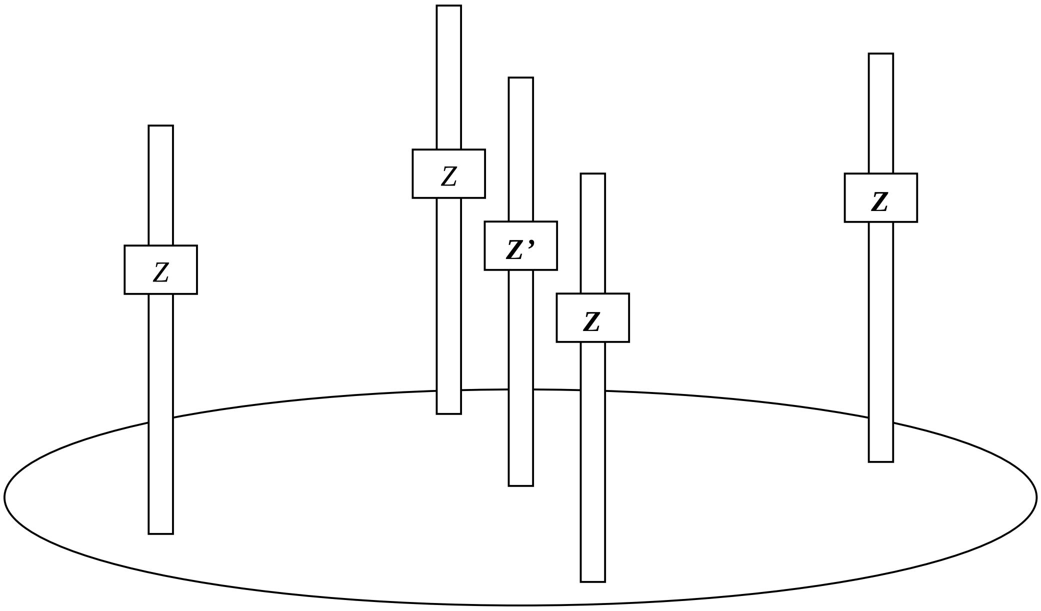

Figure 3: Five element switched-parasitic monopole antenna with lumped impedances for dual frequency operation. The centre element is connected to the RF electronics and the other four elements are connected to the control circuitry.

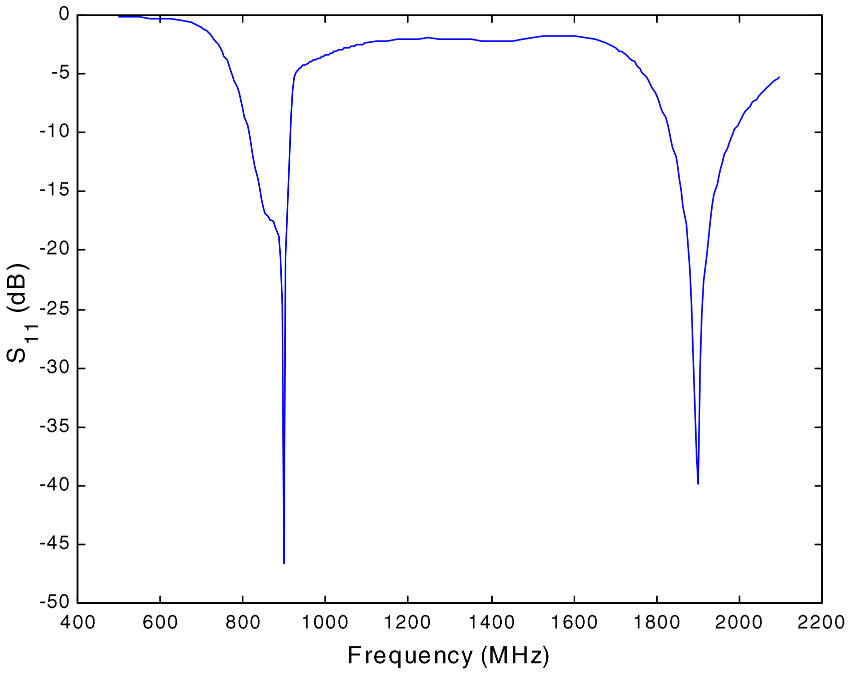

Figure 4: S_{11} variation with frequency for the five element monopole antenna illustrated in Figure 3.

4 Conclusions

A five element, dual frequency switched-parasitic antenna has been optimised for input impedance and antenna directivity to ensure maximum response for the two frequency bands of operation. Using electronic control, the main beam of the antenna can be switched to one of four possible directions ensuring 360 degree coverage in the H plane. The variation in the gain is less than 1.5 dB for all possible angles in the horizontal plane.

This design offers all of the advantages associated with switched parasitic antennas including small foot-print, low cost, high speed beam switching, and can be used for dual band direction finding and communications applications.

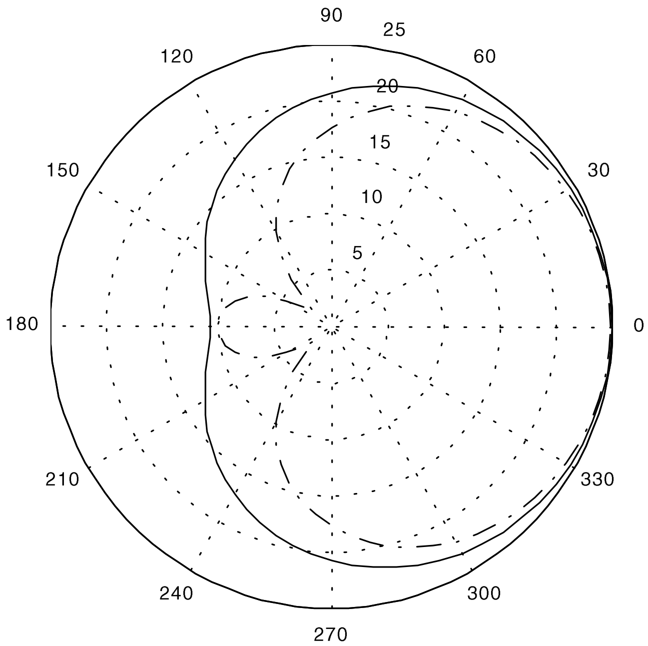

Figure 5: H plane radiation pattern at 900 MHz and 1900 MHz for the optimised, five element, switched parasitic antenna described in Figure 3. The gain has been normalised to 25dB and is given in dB.

Acknowledgements

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