RECONFIGURABLE ANTENNAS FOR MICROWAVE IMAGING

ANKITA ADARSH MALHOTRA

BHARTI SCHOOL OF TELECOMMUNICATIONS TECHNOLOGY AND MANAGEMENT

INDIAN INSTITUTE OF TECHNOLOGY DELHI

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by

ANKITA ADARSH MALHOTRA

Bharti School of Telecommunications Technology and Management

Submitted

in fulfillment of the requirements of the degree of Doctor of Philosophy

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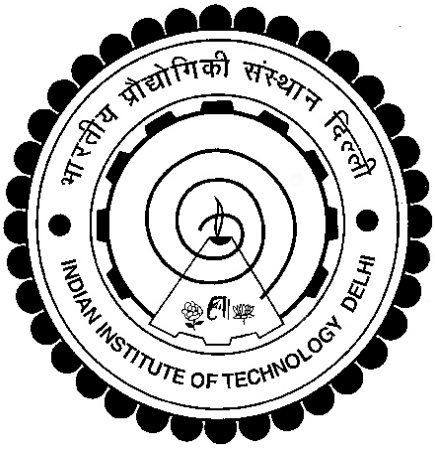

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DEDICATION

This dissertation is dedicated to my family (specially my husband) for their immense love and support and to my supervisor for his sincere advice, direction and counsel.

EPIGRAPH

"Take up one idea. Make that one idea your life - think of it, dream of it, live on that idea. Let the brain, muscles, nerves, every part of your body, be full of that idea, and just leave every other idea alone. This is the way to success"

… … … … … ….Swami Vivekananda

CERTIFICATE

This is to certify that the thesis entitled, **"RECONFIGURABLE ANTENNAS FOR MICROWAVE IMAGING",** being submitted by **Mrs. Ankita Adarsh Malhotra** for the award of the degree of **Doctor of Philosophy** to the, Bharti School of Telecommunications Technology and Management **Indian Institute of Technology Delhi**, New Delhi, is a record of bonafide research work carried out by her under my guidance and supervision.

Mrs. Ankita Adarsh Malhotra has fulfilled the requirements for the submission of this thesis, which to our knowledge has reached the requisite standard. The results contained in this thesis have not been submitted in part or in full to any other university or institute for the award of any degree or diploma.

Date:

Place: New Delhi

(Dr. Ananjan Basu)
Professor
Centre for Applied Research in Electronics
Indian Institute of Technology Delhi
Hauz Khas, New Delhi-110016, India

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Ankita Adarsh Malhotra

ABSTRACT

This dissertation presents design and analysis of stacked microstrip antennas and a reconfigurable stacked antenna for application in microwave imaging systems. The thesis is broadly divided into three parts. The first part of the thesis focuses on developing a far-field microwave imaging technique for metallic targets kept in a realistic noisy environment (without anechoic chamber). Standard waveguide antennas are used initially to study image reconstruction of regular and irregular shaped objects. Two-dimensional target scanning is done using randomly distributed sensors to generate an image.

Next part of thesis covers design and analysis of stacked microstrip antennas. Stacked microstrip antennas are designed to operate in microwave bands, and the focus here is on X-band and C-band. Stacked antenna properties and the effect of different design parameters are studied extensively. Further, circuit-level analysis of stacked antennas is done based on transmission-line model theory. A novel transmission-line model applicable to a large class of stacked antennas is developed with the exclusion of slot-coupling in the model, i.e. antennas without slots are considered. The model's response is found to be in agreement with simulated and measured results. The implementation of the developed model is further studied for reconfigurable X-band stacked antenna design. As the model describes the circuit-level behaviour of stacked antenna, it can be extended for arriving at an initial design of an arbitrary stacked antenna with desired response, through fast circuit-level optimizations. To validate this, a C-band stacked antenna is designed using the proposed transmission-line model which is further optimised using EM simulations to arrive at the final design.

The last part of the thesis concentrates on carrying out microwave imaging using designed stacked microstrip antennas operating in X-band and C-band. Several real-life metallic objects are considered as targets for performing microwave imaging in far-field region. Image reconstruction of individual targets kept in free-space is observed in the two frequency bands (X-band and C-band). Further, two targets are kept in free-space and imaged to observe the achievable resolution. Next, image reconstruction of targets, hidden behind dielectric material is studied.

Finally, imaging is done using frequency reconfigurable/switchable stacked antenna design that switches between X-band and C-band antenna through pin diodes (connected to a common feed line). Target information contained in these two different frequency bands is combined in two ways: in one way by adding image matrices, obtained in different bands individually; and in the other way by combining the received signals (in two different frequency bands) in frequency domain, to have more spectral information of the target. The study shows that image gets improved by using the first method, while second method still has scope for improvement.

सारांश

यह शोध स्टेकड माईक्रोस्ट्रिप एंटीना और रिकॉन्फ़िगरेबल स्टेकड एंटीना के डिजाइन एवं विश्लेषण को प्रस्तुत करते हुए इनकी उपयोगिता को माइक्रोवेव इमेजिंग प्रणाली में दर्शाता है"। इस शोध को मुख्य रूप से तीन भागों में बांटा गया है। थीसिस का पहला भाग दूर क्षेत्रों में शोर गूल / कोलाहल पूर्ण वातावरण में रखी हुई धातु की बनी वस्तुओं की माइक्रोवेव इमेजिंग विकसित करने की तकनीक / विधि के विकास पर केंद्रित है। स्टैंडर्ड वेव गाइड एंटीना का उपयोग, प्रारम्भ में नियमित और अनियमित आकार की वस्तुओं की छवि पुनर्निर्माण के अध्ययन करने हेतु किया गया है ।

अनियमित रूप से विभिन्न स्थानों पर लगाए हुए सेंसर के द्वारा दो आयामी लक्षय स्कैनिंग की गई है, लक्षय का बेहतर प्रतिबिम्ब उत्पन्न करनेके लिए थीसिस का अगला भाग स्टेकड माईक्रोस्ट्रिप एंटीना के डिजाइन और उसके विश्लेषण पर प्रकाश डालता हैं। स्टेकड माईक्रोस्ट्रिप एंटीना को माइक्रोवेव बैंड में काम करने के लिए तैयार किया गया हैं, और यहाँ ध्यान एक्स-बैंड और सी-बैंड क्षेत्रों पर है । यहां स्टैक्ड एंटीना के गुण और इसके अलग अलग डिजाइन मानकों के प्रभाव का विस्तृत रुप्प से अध्ययन किया जा रहा है। इसके अलावा, स्टेकड एंटीना के सर्किट स्तर का विश्लेषण संचार लाइन मॉडल सिद्धांत के आधार पर किया गया है । स्टेकड एंटीना के एक बड़े वर्ग पर प्रयोग करने के लिए एक नवीन संचार लाईन मॉडल को विकसित किया गया है जिससे बिना स्लॉट के सभी एंटीना का विशलेषण सम्भव है । मॉडल की प्रतिक्रिया को कृत्रिम और मापित परिणामों के अनुरूप पाया है। विकसित मॉडल के क्रियान्वयन हेतु रिलॉन्फिगरबल एक्स बैंड स्टेकड एंटीना के डिजाइन का पुन: अध्ययन किय जा रहा है । चूंकि यह मॉडल स्टेकड एंटीना के सर्किट स्तर के व्यवहार को बताता है, इसे आर्बीट्रिरी स्टेकड एंटीना के प्रारंभिक डिजाइन पर पहुंचने का पहला कदम माना जा सकता जो सर्किट स्तर अनुकूलन के अनुरूप इच्छित परिणाम दता है । इसे मान्य करने के लिए, एक सी-बैंड स्टेकड एंटीना जो प्रस्तावित संचरण लाइन मॉडल पर आधारित है, तथा उसमें ईएम सिमुलेशन का उपयोग किया गया है, अंतिम डिजाइन पर पहुंचने के लिए अनुकूलित थीसिस का अंतिम भाग माइक्रोवेव इमेजिंग पर केंद्रित है जिसमें स्टेकड माईक्रोस्ट्रिप एंटीना का प्रयोग करते हुए एक्स-बैंड और सी-बैंड क्षेत्रों में प्रचालित किया गया है ।कई धातु की वस्तुओं को माइक्रोवेव ईमेजिंग के लिए लक्षय के रूप में प्रयोग किया गया है । मुक्त अंतरिक्ष में रखे व्यक्तिगत लक्ष्यों की छवि पुनर्निर्माण दो आवृत्ति बैंड (एक्स-बैंड और सी-बैंड) में निरीक्षित की गई है तथा दो लक्षयों के प्रतिबिम्ब की प्राप्ति का भी निरीक्षण किया है । इसके अतिरिक्त किसी वस्तु के पीछे छिपे हुए लक्षयों के प्रतिबिम्ब की प्राप्ति का भी निरीक्षण किया गया है । अंतत:, दो क्षेत्रों में काम करने वाले रिकोंफिग्रेबल एंटेना द्वारा विभिन्न लक्षयों का प्रतिबिम्ब प्रापत किया गया है । इसमें दो अलग – अलग क्षेत्रों में उपलब्ध लक्ष्यों की सूचना को जोडा गया है । ऐसा करने से हमें किसी भी लक्षय के बेहतर प्रतिबिम्ब की प्राप्ति हुई है ।

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