Honors Thesis Proposal

Author: XXXXX XXXXXXX

Working Title

Increasing Isolation Between Closely Spaced Planar Tx/Rx Antennas

Abstract

Saturation caused by transmit antennas on compact communications and radar devices reduces sensitivity of receive subsystems. In order to increase isolation between antennas, this study will investigate current methods of reducing such coupling and propose new potential solutions through electromagnetic simulation as well as building and testing hardware.

Project Importance

As communications technology shrinks further and further, one of the hard limits on receive sensitivity is saturation from transmit antenna on the same device. Saturation due to antenna coupling decreases the effective range of receive devices as well as restricts the potential output power of transmit systems. This project will provide potential solutions to this issue, opening options for increasingly compact and sensitive communications and radar systems.

Project Overview

Electromagnetic coupling occurs when an electromagnetic field created by charges traveling through one medium creates electrical charge onto a separate medium. In circuits, this often takes the form of a high frequency signal in one wire or trace creating noise in an unrelated wire or trace. This kind of unwanted coupling degrades the performance of circuit, corrupting information or preventing desired signals altogether.

Compact planar antennas are especially susceptible to coupling. Not only do planar antennas often have significant sidelobes that cause signal to bleed over undesirably into another antenna, but often these planar antennas are built on the same printed circuit board, increasing the ease in which that coupling occurs. In a communication device or a radar, this means that the transmit signal can overwhelm the return signal that the receive antenna is looking for. Return signals are typically orders of magnitude smaller than a transmit signal, which leads to the effect called saturation, where the receive system cannot separate weak return signals from the transmit signal.

One of the most common ways to reduce coupling in circuits and antennas is to simply increase the distance between offending and victimized signal paths. Unfortunately, as market desires continue to push for smaller and smaller devices, this strategy of increasing distance will become unusable, and the problem of coupling must be solved in other ways. One existing technique to fix the problem is to use higher quality components. If the components create less noise, there is less noise to be coupled to vulnerable traces. The downside of this is the higher cost of more efficient, less noisy components, and this can only be used in circuit board technologies. However, higher quality components will not prevent the signal from the transmit antenna to couple to the receive antenna, and thus is ineffective when looking at only Tx/Rx coupling.

Other strategies for reducing coupling involve via stitching and shielding in printed circuit board technology or the use of specialized filtering networks or structures. Via stitching is a common and proven method of isolation, but it does not always reduce coupling enough. Specialized filtering networks have been shown to be more effective in some research cases. These may be composed of existing and proven components such as rat race couplers to subtract coupled noise out of a system, or they may use defected conductors to create tight band-reject filters that target a specific frequency of noise. Some research has also been done involving the use of electromagnetic band gap structures in printed circuit boards to also produce filtering effects.

There are a multitude of techniques that can potentially be used to reduce coupling in a system, but not all techniques will work for all systems. In particular, there is difficulty in reducing coupling between closely spaced planar antennas. Much of the current literature addresses coupling between printed circuit board layers and traces or tackles the problem at a higher system level. These techniques appear to work very well in their respective scenarios, but many are untested for their ability to isolate compact planar antennas.

This project aims to produce a design resource for engineers by analyzing the effectiveness of existing isolation (decoupling) techniques on compact planar Tx/Rx antennas. This project will begin by investigating the current literature on the subject matter. Using information and techniques discussed in the literature, this project attempt to duplicate each technique's decoupling results on compact planar Tx/Rx antennas. The techniques will be tested through a combination of full-wave electromagnetic simulation and actual testing of hardware. Each technique will then be analyzed according to their effectiveness in decoupling compact planar Tx/Rx antennas.

Current techniques for decoupling involving large machined metal structures and waveguides are generally well-understood, however they are not always the best solution, especially in the realm of compact and planar electronics. This project will add to the current body of knowledge by investigating, proposing, and testing small, lightweight, low-cost solutions, including a novel technique involving a conductive grating barrier.

Thesis Committee

Faculty Advisor – Dr. Karl Warnick

Dr. Warnick is an expert in RF and Microwave systems and leads the BYU Smart Antenna Systems (SAS) research group. He has much experience working to create low-cost solutions to expensive high frequency communication and radar systems as well as very large scale antenna array projects.

Faculty Reader – Dr. David Long

Dr. Long is an expert in the field of remote sensing and is the head of the BYU Microwave Earth Remote Sensing (MERS) laboratory. He is very familiar with the challenges of designing high frequency wireless systems as well as the problems in miniaturizing those systems.

Project Timeline

The dates below are the expected date of completion of each portion of this project.

Date of Completion	Milestone
1 November 2019	Literature Review
6 January 2019	Electromagnetic Simulations
10 February 2019	Hardware Testing of Methods
24 February 2019	Draft and Revise Thesis
10 March 2019	Defend Thesis

Funding

This project will not require any additional funding.

Honors

From: Brian Jeffs
Sent: Tuesday, October 15, 2019 11:24 AM
To: Honors
Cc: Jacob Bartschi
Subject: Faculty honors thesis reader for Jacob Bartschi

Dear Honors Program,

This note is to confirm that I have agreed to be a faculty reader for Jacob Barschi's honors thesis.

Brian Jeffs

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