Meteorological Applications of Patch Antenna Arrays on LCP

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http://weather.unisys.com/satellite/sat_wv_us_loop-12.html
Background: The purpose of dual frequency, dual-polarization radar is to provide a multidimensional image of meteorological phenomena in order to obtain more complete data sets for long term climatic study.
Schematic Diagram of a Dual-Polarized Antenna Array

2x2 Array

4x2 Array
Dual Polarization - 14 GHz 1x2 Array
Superstrate Configuration, Metal
Thickness - 18 microns, Perfect
Conductor, Infinite Ground plane
Dual Polarization Radiation Patterns radiate along two axes.

Isosurface: Electric field, z component  Boundary: boundary_plot

http://www.uk.comsol.com/showroom/animations/
Research Purpose

The goal of this project is to develop dual-frequency (14/35 GHz), dual-polarization radar and radiometers to be used to monitor precipitation patterns in order to improve our scientific understanding of the Earth’s environmental systems and investigate their response to natural and man-made changes. In addition, LCP will be evaluated as a substrate for production of microstrip antenna arrays.
Advantages of LCP in Microstrip Antenna Arrays

Liquid crystal polymer has a unique combination of electrical, mechanical and chemical characteristics which make it suitable for large antenna array applications. Its extremely flexible nature and its ability to be laminated makes it suitable for radars required in space missions.
Design and Testing Materials and Methods

- The project requires both design and fabrication solutions. For design purposes, 2.5D and full wave electromagnetic solvers such as EM-Picasso and Ansoft HFSS are used.
- Fabrication involves photolithographic and multilayer building techniques and is performed in the Georgia Tech MiRC cleanroom.
- Radiation pattern characterization and other measurements are carried out in GEDC high frequency measurement labs.
Georgia Electronic Design Center (GEDC) Anechoic Testing Chamber
Return Loss – 14 GHz Array

E-Plane Radiation Pattern – 14 GHz Array

Return Loss – 35 GHz Array

E-Plane Radiation Pattern – 35 GHz Array

Return loss and polar-coordinate graph data provided courtesy of Ramanan Bairavasubramanian
Conclusion

• LCP is a suitable substrate material for microstrip radar antenna arrays.
• Radiation Patterns and Return Loss Data indicate the viability in function and performance of patch antenna arrays on LCP substrate.
The Next Step

- Apart from the antenna arrays, phase shifters and micro-electro-mechanical (MEMS) switches have also been developed on LCP substrates.
- The next step is to identify methods to integrate the individual components to realize a full scanning array.
My Role In the Process and Personal Reflection

- Schedule conflicts and equipment difficulties prevented me assuming a more active role than I would have preferred in the research and development process. However, the knowledge and skills acquired have made the program an outstanding success for me.

- As a result of my participation in the program I acquired a full understanding of modern physics applications and their direct impact on every human being’s life.

- In addition, every day brought forth a new concept or application that will be incorporated into my physics classroom in order to more adequately prepare my students for their future academic endeavors.
Acknowledgements

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AM Radio: Applications of Radio Waves in Modern Technology

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GaTech STEP-UP Summer 2005
Purpose

- This lesson is designed as a unit in which students will examine the components that are used to make a primitive AM radio.
- This lesson is designed so that students examine each main component on an individual basis, and then learn how each component performs a function when combined in a complex circuit.
- This will be done in order to take the mystery out of what the components are made of and how they work.
Materials and Methods

• This unit will consist of a combination of lectures, inquiry labs, theoretical exploration, and construction projects.

• Most materials will consist of things found readily around the house such as copper wire, batteries, aluminum foil, graphite pencil cores, and wax paper.

• It is also designed to be student motivated, with each student learning at their own pace.

• This unit is designed to encompass approximately two weeks, but may be modified to fit curriculum guidelines.
Georgia Performance Standards

This unit encompasses a great number of the purposed Georgia Performance Standards.

Because of its highly hands-on and analytical nature, all of the science process standards are covered.

In addition, because of its highly integrated pyramid learning structure it covers most of the EM content standards.
Lesson Schedule

Broken down over approximately 12 days, this unit is highly versatile in its range and depth.

The first few days are directed toward identifying key aspects, concepts, and components in modern radio technology.

Students will begin by learning about electromagnetic waves and each individual component.
Proposed Schedule Outline

- Day 1 – “How Radio Works”
- Day 2 – Building an Extremely Simple AM Receiver
- Days 3-7 – The Structure and Function of Radio Components in Circuits
- Days 8-9 – Constructing a Homemade AM Receiver
- Days 10-12 – Constructing a complex AM Receiver
Extremely Simple AM Receiver
Homemade AM Receiver
Complex AM Receiver
Assessment

• This Unit addresses the needs of multiple learning styles as it incorporates many different approaches to teaching and learning the same concept.

• A combination of project rubrics, informal assessment (question and answer), and formal assessment (lab reports, objective quizzes, and tests) is suggested.

• A tracking poster is a suggested segment assessment technique and classroom management tool.
Extension

• Further extension of this unit is possible in many different directions of modern physics concepts and applications

• In addition, this unit provides excellent opportunity for further projects and summary tasks (Ex. Students could build their own radios entirely from homemade parts, test different antenna designs, troubleshoot a failed system, dissect an old stereo and contrast it with new ones, etc.)
Summary

This is a long-term and highly integrated unit consisting of a large portion of the EM portion of the high school physics curriculum. As it is proposed, it should take the burden of teaching off of the instructor and shift it to the student while simultaneously maintaining and increasing student interest. Successful completion of the unit will empower each student with long-lasting tangible and intangible products that may be readily and easily assessed.