Antenna Anechoic Chamber Project

Electrical Engineering Department
College of Engineering
Cal Poly San Luis Obispo

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Presentation Topics

- Chamber development group
- Donation of antenna chamber materials and equipment
  - Deskin Research Corp., San Jose, CA
- Donation of chamber foam and RF equipment
  - Raytheon: El Segundo, CA and Tucson, AZ
- Student labor support
  - Cal Poly EE Dept
  - Summer Grant Program; Center for Teaching and Learning, Cal Poly

For more info: http://www.ee.calpoly.edu/~darakaki/ChamberLinks.htm
Presentation Topics

• Tour of CSUN anechoic chamber
  – Tapered design
  – Foam arrangement
  – Positioner mounting, rotating platform
  – RF equipment, antennas

• Chamber construction

• Individual student projects
  – Chamber calibration, operation
  – Laboratory course experiments
  – Antenna development
  – Interdepartmental involvement
  – Use by on-campus projects
Anechoic Chamber Group

Newlyn Hui    Al Lubiano    Chris Brito
Anechoic Chamber Group
Chamber Development

- EE Department Antenna Anechoic Chamber
  - Foam and equipment donation from Deskin Research, San Jose, CA
    - Donated materials, equipment
      - Wedge foam for side walls: 596ft²
      - Pyramidal foam for source & facing walls: 64ft²
      - Azimuthal positioner
      - Positioner controller, SA model 4131-1
      - Source horn stand
      - 5 pairs of standard gain horns
      - Tunnel diode detector
Antenna Chamber Inventory

Foam Wedge x75
2x2 ft
Antenna Chamber Inventory

Source Antenna Positioner
Antenna Chamber Inventory
Antenna Chamber Inventory

NARDA 644 (2.6-3.95 GHz)

NARDA 614

NARDA 643 (3.95-5.85 GHz)

NARDA 642 (5.4-8.2 GHz)

NARDA 641 (7.05-10 GHz)

Scientific Atlanta 12A-26 (26.5-40 GHz)
Antenna Chamber Inventory

Diode detector on receive horn
Antenna Chamber Inventory

Foam Donation – Raytheon (El Segundo, CA)

130 panels of 2’ x 2’ x 4’ pyramid foam
Antenna Chamber Inventory

Foam Donation – Raytheon (El Segundo, CA)

Foam block panels

Foam blocks
Antenna Chamber Inventory

Azimuthal Positioner Donation – Raytheon (Tucson, AZ)

Azimuthal positioner with antenna mast base
Chamber Development

• Anechoic chamber tour at CSU Northridge; November 20, 2003
  – Toured CSUN’s anechoic chamber
  – CSUN Professor Sembiam Rengarajan hosted the tour: he is assisting us with chamber development
  – Future collaborations with the CSUN EE Department
CSUN Tour
CSUN Tour

Tapered Chamber

Chamber Exterior

Chamber Interior
CSUN Tour

Foam Arrangement

Corner

Sidewall
CSUN Tour

Azimuthal Positioner

Rotating Platform

Motor Location
CSUN Tour

RF Equipment / Antennas

Receive Horn

UHF Horn
CSUN Tour

Outdoor Range

Log Periodic

Positioner on a Track
EE Dept Anechoic Chamber

- Anechoic chamber development
  - Secured on-campus room to house chamber
    - 04-113 (ARDFA)
  - Room preparations
    - HVAC line re-routing
    - Light panel placement
  - Determined overall chamber dimensions (rectangular chamber)
    - Required far-zone distances
    - Maximum specular angle
EE Dept Anechoic Chamber

04/113 Room Dimensions and Chamber Location

Chamber Location

- Width: 19'7"
- Depth: 10'1"
- Height: 7'4"
- Length: 29'8"
- Ceiling: 30'6"
EE Dept Anechoic Chamber

Chamber Dimensions

- Removable Plywood Floor: 17/8"
- Quiet Zone: 17/8"
- Chamber Dimensions:
  - Length: 20'61/4"
  - Width: 10'51/4"
  - Height: 10'11/2"
  - Door: 20'21/2"
EE Dept Anechoic Chamber

- Anechoic chamber development
  - Construction plan
    - Cubicle partitions used for chamber walls
    - Source antenna mount and hole in source wall
    - Raised floor construction
    - Specular region calculation and layout
    - Supporting structures for ceiling panels
    - Foam preparation (pyramids)
    - Plywood panels to hold foam (sidewalls, ceiling)
    - Final assembly
EE Dept Anechoic Chamber
EE Dept Anechoic Chamber

Source Hole

Source Stand
EE Dept Anechoic Chamber

Specular Region Calculation

- Width: 20’2”
- Height: 10’1”
- Major Axis: 12’1.4”
- Minor Axis: 7’3.6”
- Distance to Specular Region: 90”
EE Dept Anechoic Chamber

Specular Region Layout
EE Dept Anechoic Chamber

Foam Preparation
EE Dept Anechoic Chamber

Foam Panel Base Mounting to Plywood Sheets
EE Dept Anechoic Chamber

Attaching Trimmed Pyramids to Secured Foam Bases
EE Dept Anechoic Chamber

Raised Floor Construction and Picture Frame Foam
EE Dept Anechoic Chamber

Panel Installation
Building the Chamber
EE Dept Anechoic Chamber
EE Dept Anechoic Chamber

• Anechoic Chamber Projects
  – Calibration and Operation
    • Foam reflectivity
    • Quiet zone scanning probe
    • Positioner – VNA (vector network analyzer) synchronization software
  – Applications
    • Laboratory course experiments: EE 533, 401
    • EMC/EMI calibration and testing
    • Broadband antenna analysis and design
    • 80211 laptop antenna design
Absorber Testing

• Purpose of Testing Foam

  – Determine how well foam absorbs EM energy

  – Foam placement and orientation in chamber

  – Big picture of how the chamber will perform based on foam performance

Chris Brito
Absorber Testing

- Manufacturer’s data on foam performance is limited

- Testing can provide information on a variety of variables
  - Frequency
  - Shape
  - Angle
  - Polarization
  - Orientation

Chris Brito
The Quiet Zone

- What is the Quiet Zone?

- Why is the quiet zone important in antenna measurement?

- Requirements for a Quiet Zone

Al Lubiano
The Quiet Zone Probe

- Probe Antenna
- Rails
- Lead screw
- Base plate for antenna mounting (manual rotation of antenna possible)
- Stepper Motor

Al Lubiano
The Quiet Zone Probe

Orientation used in the transverse test positions of the Free Space VSWR test.
The Quiet Zone Probe

Orientation used in the longitudinal test positions of the Free Space VSWR test.

Al Lubiano
Antenna Measurement System

Original System

RF Detection PC Card

Newlyn Hui

Calculations

Polar Plots

Radiation Patterns
Test Setup Block Diagram

Newlyn Hui
Graphical User Interface

- New Test Measurement System

- Project Tools
  - GPIB
  - LabVIEW

Newlyn Hui
Use LabVIEW to interface between the Network Analyzer and Positioner Controller.

Measure antenna radiation patterns and construct polar plots.

Use MATLAB to compare measurements with theoretical results.
Antenna Measurement
Lab Course

- Antenna Polarization
- Radiation Patterns
- Image Theory

Sam Parker
Antenna Measurement Lab Course

- Phased Arrays
- Frequency Response
- Broadband Antennas
- Design Projects

Sam Parker
Fields & Waves
Lab Course

• Wave polarization
• Reflection and refraction of a plane electromagnetic wave at a dielectric interface
Experiments

Wave Polarization
Understanding polarization characteristics of linearly polarized electromagnetic plane waves.

Patrick Cheung
Experiments

Plane Wave Characteristics
Reflection and refraction of an electromagnetic plane wave

Transmitter on fixed arm
Conductor or Dielectric Material
Receiver on rotatable arm

Patrick Cheung
EMC Studies

- Radiated EMI Testing
- Conductive EMI Testing
- Radiated Susceptibility Testing
Broadband Patch Antenna

- Design a Broadband Patch Antenna
- Simulate its performance in XFDTD
- Fabricate the patch antenna and its matching network
- Test its actual performance in the anechoic chamber

Near Field Transient response of a rectangular patch antenna. Simulation done in Remcom’s XFDTD

Danny Colles
Mobile Wireless ATM/IP Network

– Asynchronous Transfer Mode (ATM)/Internet Protocol (IP)
– Design and simulate antenna subsystem using industry software
– Build the subsystem using 802.11 (Wireless LAN) RF transceiver and antenna
– Test subsystem in Anechoic Chamber to measure radiation patterns, gain and efficiency
– Compare test results to product specifications

Santos Najar
Mobile Wireless ATM/IP Network

Figure 1 Mobile Wireless ATM/IP Network Prototype
Wireless Data Antenna

- Linear Polarization
- 2.4 GHz
  - 802.11b (11Mbps)
  - 802.11g (54Mbps)
- 5.2–5.8 GHz
  - 802.11a (54Mbps)

Figure 2 Etenna Corporation Edgewave Wireless Data Antenna

Santos Najar
Wireless Data Antenna

Figure 3 Etenna Corporation Edgewave Wireless Data Antenna

Santos Najar
Wireless Data Antenna

Figure 4 Edgewave Wireless Data Antenna Radiation Pattern

Antenna mounted on side of display panel

A1.3 – Total gain contour plot (dBi) at 2.42 GHz on a laptop.

Frequency = 2420MHz

$G_{\text{max}} = 5.205\, \text{dB}$, $G_{\text{avg}} = 0.414\, \text{dB}$

Santos Najar
Interdepartmental Projects at Cal Poly

Cal Poly, Polysat Program

UHF Antenna
EE Dept Anechoic Chamber

• Anechoic chamber, present support
  – Cal Poly EE Dept
  – Cal Poly Summer Services Grant Program
  – Raytheon Systems Company
  – JPL: consulting services
  – Others??

• Anechoic chamber, future work
  – Chamber calibration and operating procedures
  – Associated multidisciplinary projects
  – Support for on-campus projects
EE Dept Anechoic Chamber

• Anechoic chamber, equipment needs
  – Cables, adapters (N-type, BNC, SMA, etc.)
    20’, 25’ length cables, GPIB cables
  – Antenna probes
    • 2GHz to 18GHz
      – Biconical, helical, phased arrays, Yagi’s, patch antennas, standard gain horns, …
    • 30MHz to 1GHz
      – EMI probes (biconical, log periodic, loops, …)
  – Vector Network Analyzers (HP8510, 8530, 8720, PNA)
    • Calibration kits
  – Power detectors, meters
  – Antenna measurement system
    • Synchronized RF sources, LO, mixers, controller
Current Group Morale