

## A COMPARISON OF SEVERAL SELF-STRUCTURING ANTENNA TEMPLATES

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Successful operation of a self-structuring antenna (SSA) depends both on the large number of available antenna states, and the underlying characteristics of the antenna template. For example, if an antenna template is too small, an SSA likely won't perform well for low frequency applications, regardless of the switch states. Another possibility is that an SSA template is of appropriate size; in this case, the performance of the antenna depends on both the switch states and the configuration of the antenna elements. Up to this point, the effect of the underlying characteristics of the antenna template, i.e., the configuration of the antenna elements, has not been thoroughly studied. This paper looks to characterize the effect of the SSA template layout, using measured data such as standing wave ratio (SWR), antenna patterns, and input impedance. By finding the effect of template layout on the performance of the SSA, guidelines can be created by which future layouts can be designed. Through this process, self-structuring antenna templates can be custom designed to better fit particular applications.

This paper uses measured performance criteria to compare and contrast several SSA template designs. These designs include a "standard", linearly spaced SSA template, as described in previous work, a variation based on a log-periodic design, and several templates that are fairly application specific. The application specific templates are configured such that all switches and control hardware are aligned along one edge of the template. This allows the SSA to be used in applications where the placement of both the feed network and the switches are desired to be hidden away.

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**1. Commission and session topic:** B1.1 Antenna Analysis and Design

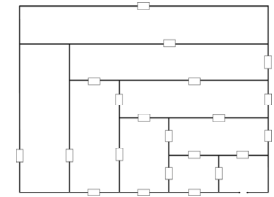
**2. Required presentation equipment:** PowerPoint display

**3. Corresponding author:**

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**6. New knowledge contributed by paper:** This is the first comprehensive comparison of differing self-structuring antenna template designs utilizing measured data.

**7. Relationship to previous work:** Self-structuring antennas were introduced by the authors at the 2000, 2001, and 2002 URSI National Radio Science Meetings. The basic operation and analysis of the antenna were described in these papers.



# **A Comparison of Several Self-Structuring Antenna Templates**

**B.T. Perry, J.A. Nanzer\*, E.J. Rothwell, L.C. Kempel**

**Michigan State University**

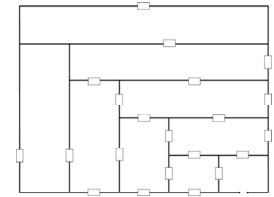
**J.E. Ross, John Ross and Associates**

**L.L. Nagy, Delphi Research Labs**

**URSI B Session 56**

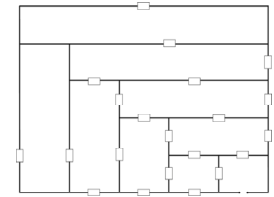
**Tuesday June 24, 8:20 am, Knox**

## Overview of Presentation



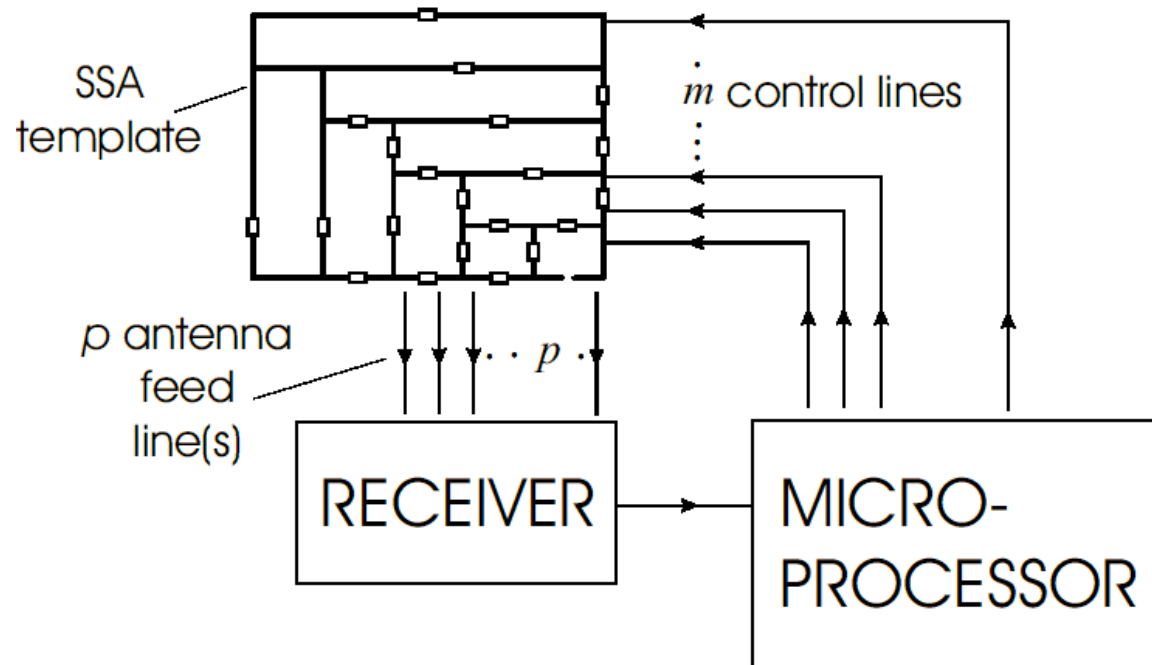
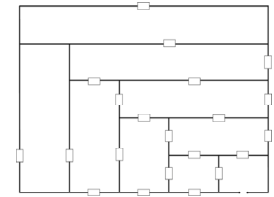
- **Introduction to Self-Structuring Antennas (SSAs)**
- **Description of templates**
- **Measured SWR results**
- **Measured pattern results**
- **Conclusions**

# Self-Structuring Antenna Concept

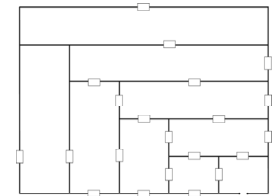


- **Self-Structuring Antenna system:**
  - **Re-optimizes itself when its electromagnetic environment changes**
  - **Arranges itself into a large number of possible antenna configurations**
  - **Uses information from a receiver or sensor to determine fitness of each configuration and determines future configurations**
  - **Searches through possible configurations using binary search routine such as;**
    - Genetic algorithms (GAs)**
    - Simulated annealing (SA)**
    - Ant colony optimization (ACO)**

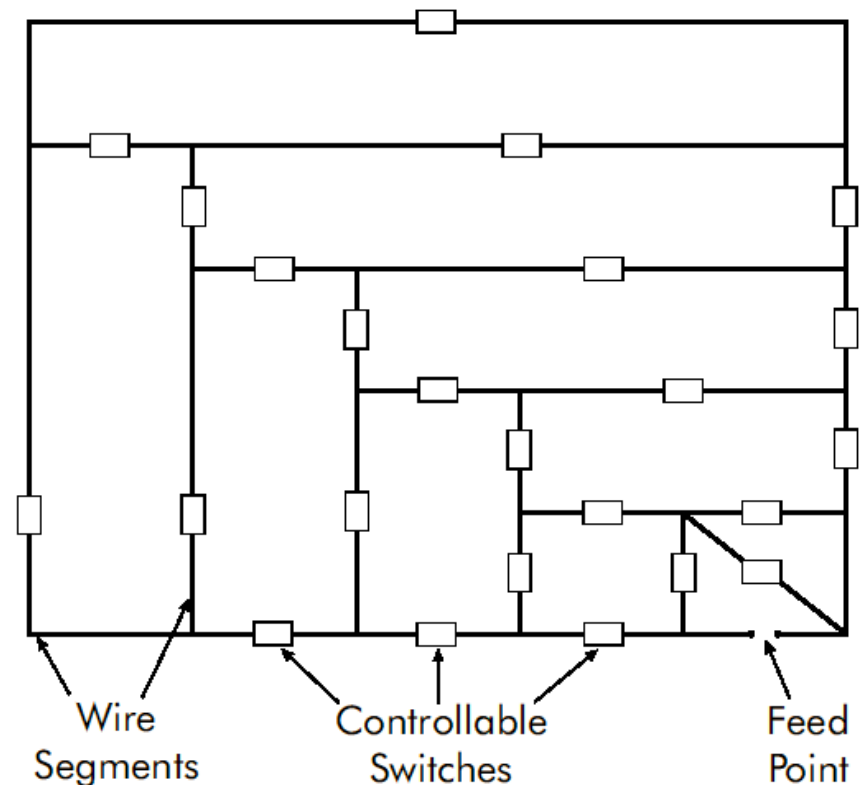
# Self-Structuring Antenna (SSA)



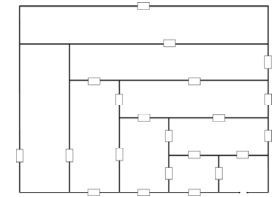
# Self-Structuring Antenna Template



- A self-structuring antenna template is comprised of a large number of wire segments or patches interconnected by controllable switches
- For each configuration, the states of the switches determine the electrical characteristics of the antenna
- For a template with  $n$  switches, there are  $2^n$  possible configurations
- An asymmetric topology provides more diversity and less repeated states than a symmetric topology



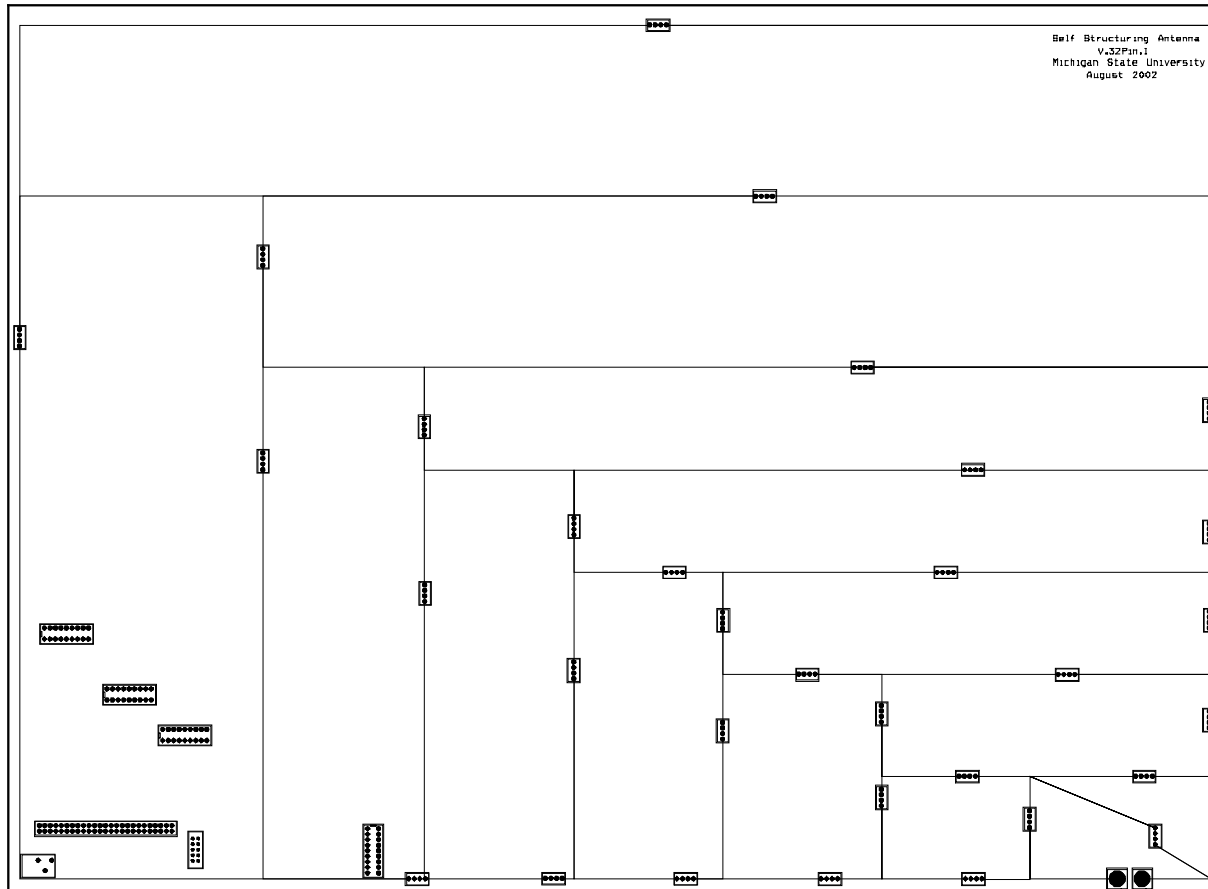
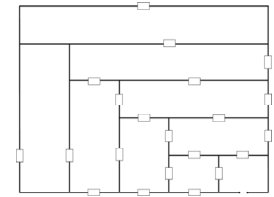
## Templates studied



- **Four different templates were studied**
  - **“Standard” template**
  - **Log-periodic design**
  - **Edge-switch template 1**
  - **Edge-switch template 2**
- **Templates with switches located along the edge may prove more useful for automotive applications**
- **Templates with switches concentrated near the feed may be less affected by switch failures**

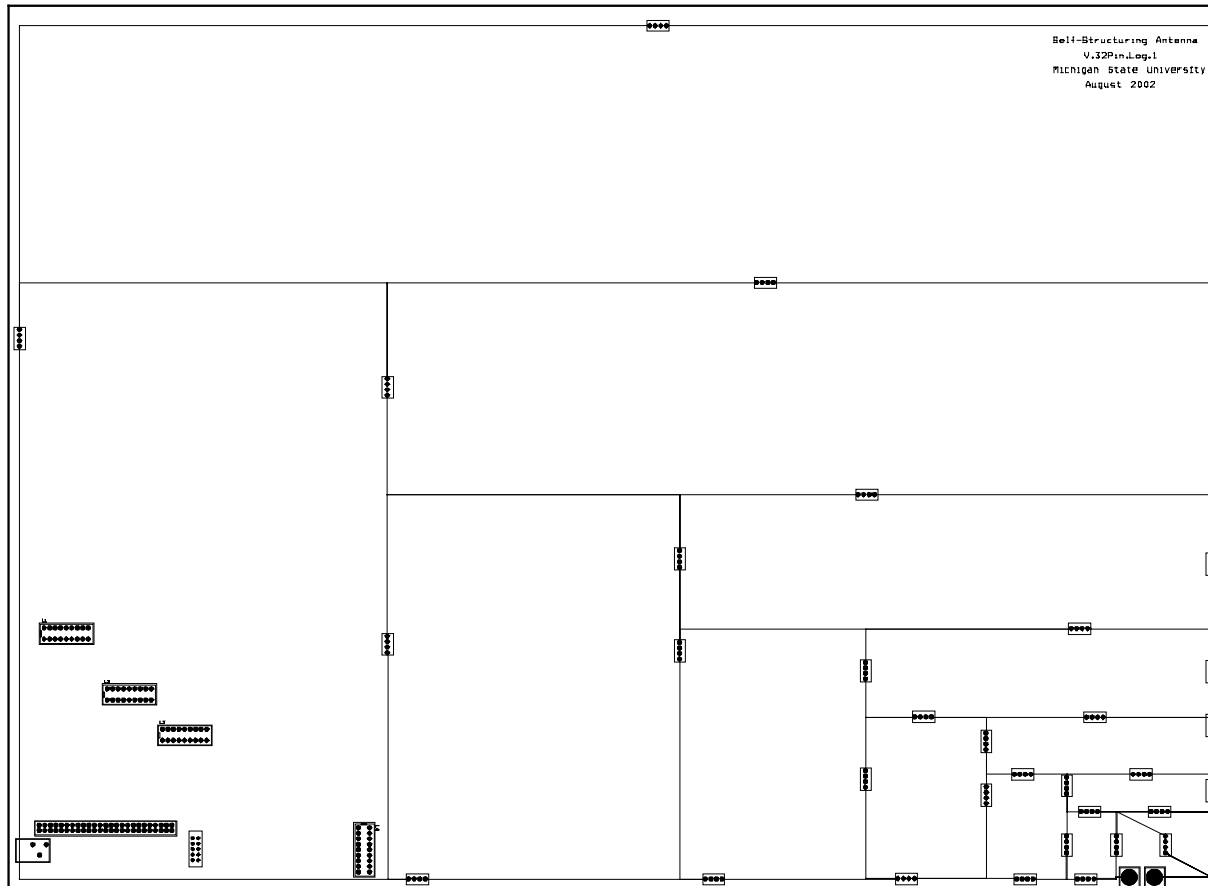
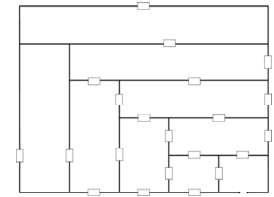


# Templates studied



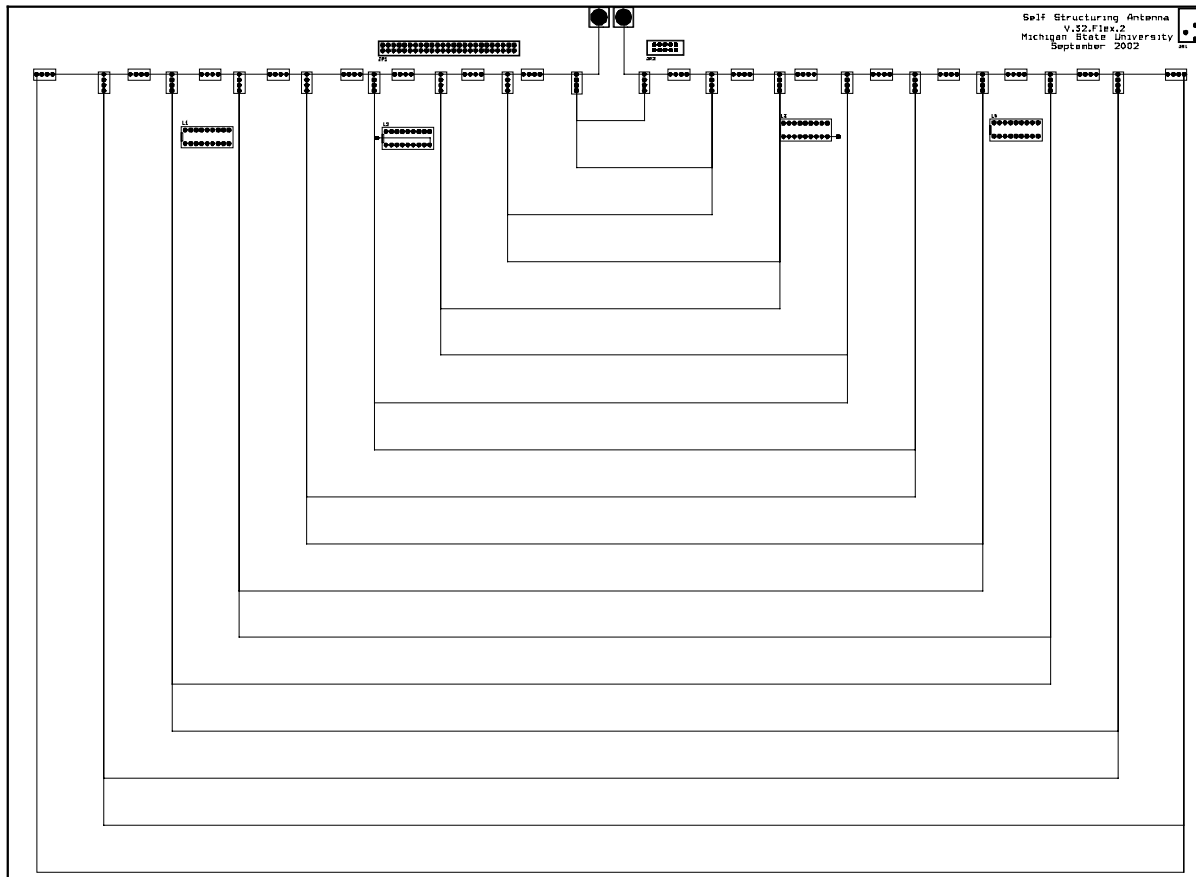
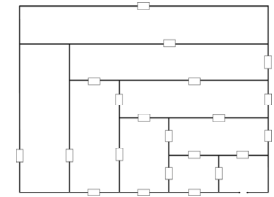
- “Standard” template
- 32 switches = 4.3 billion combinations
- 16`` x 22``

# Templates studied



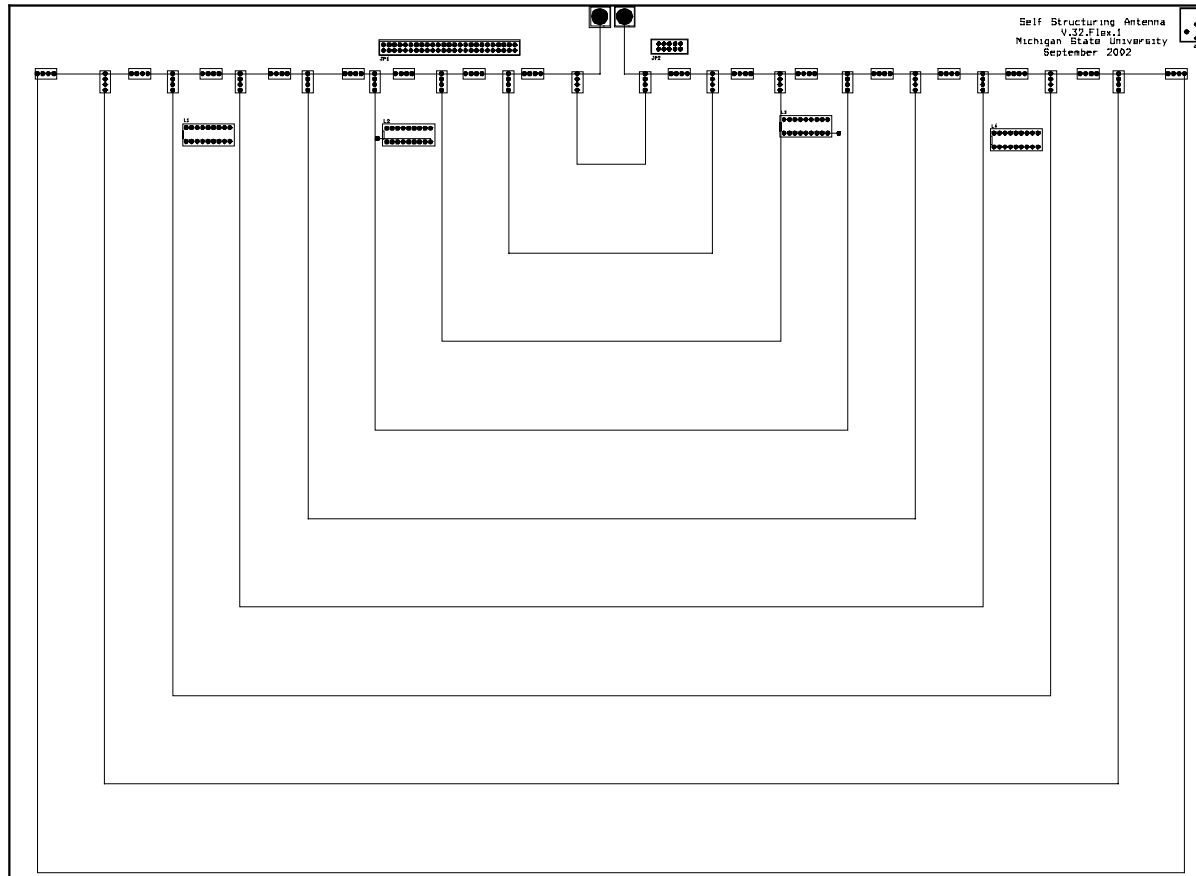
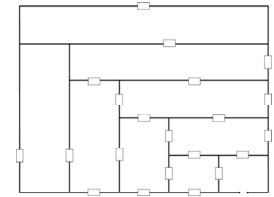
- Log-periodic template
- 32 switches
- 16'' x 22''

# Templates studied



- **Edge-switched Type 1**
- **32 switches**
- **16'' x 22''**

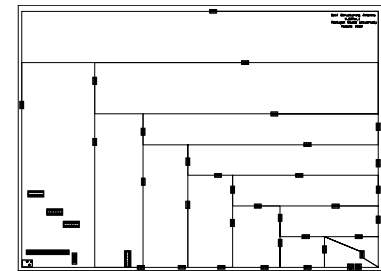
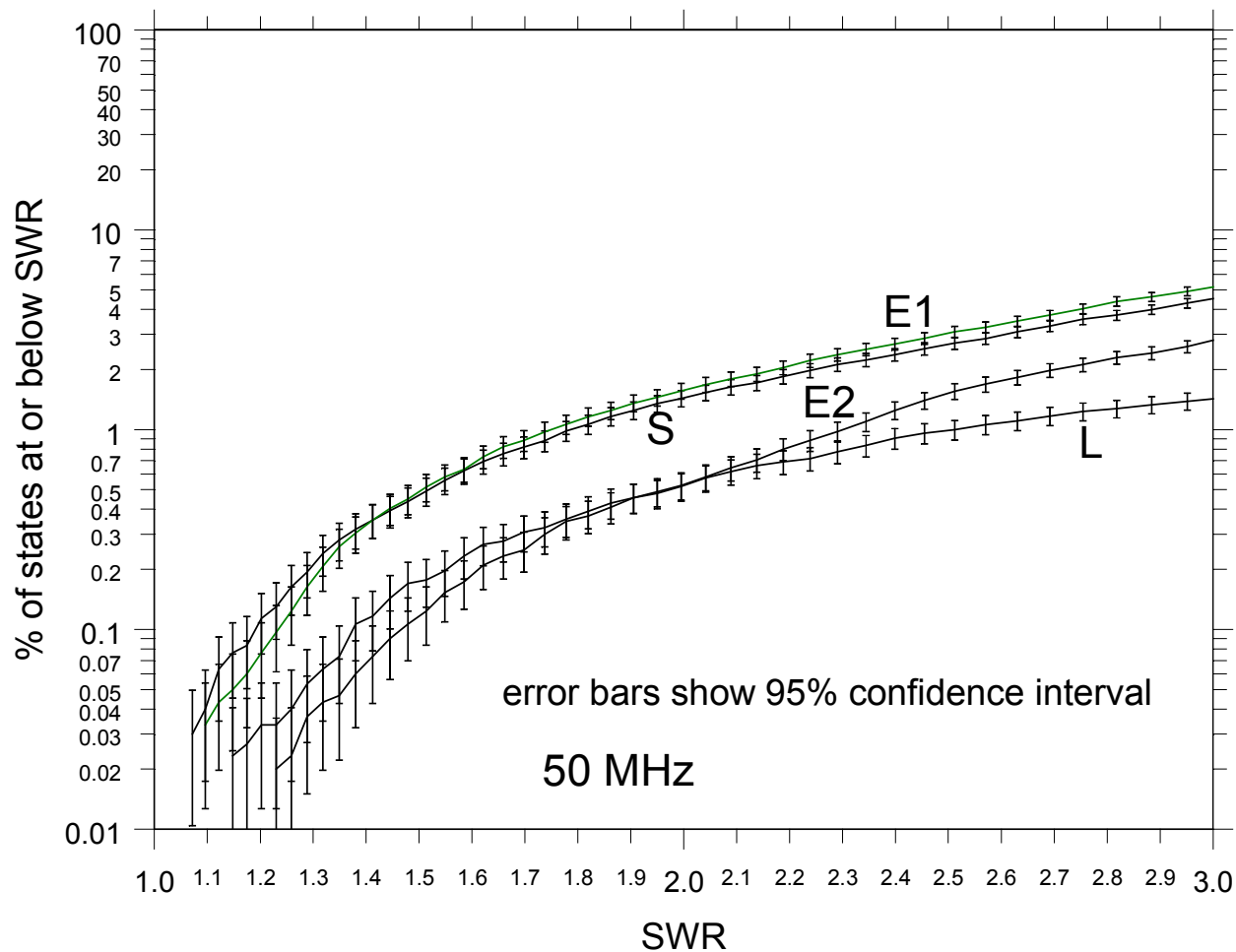
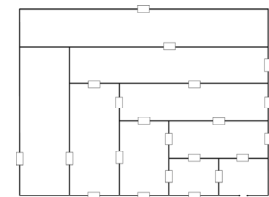
# Templates studied



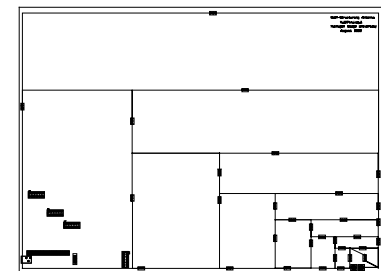
- **Edge-switched Type 2**
- **32 switches**
- **16'' x 22''**



# SWR measurements

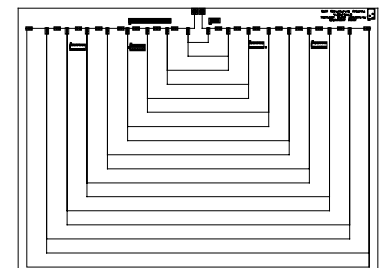
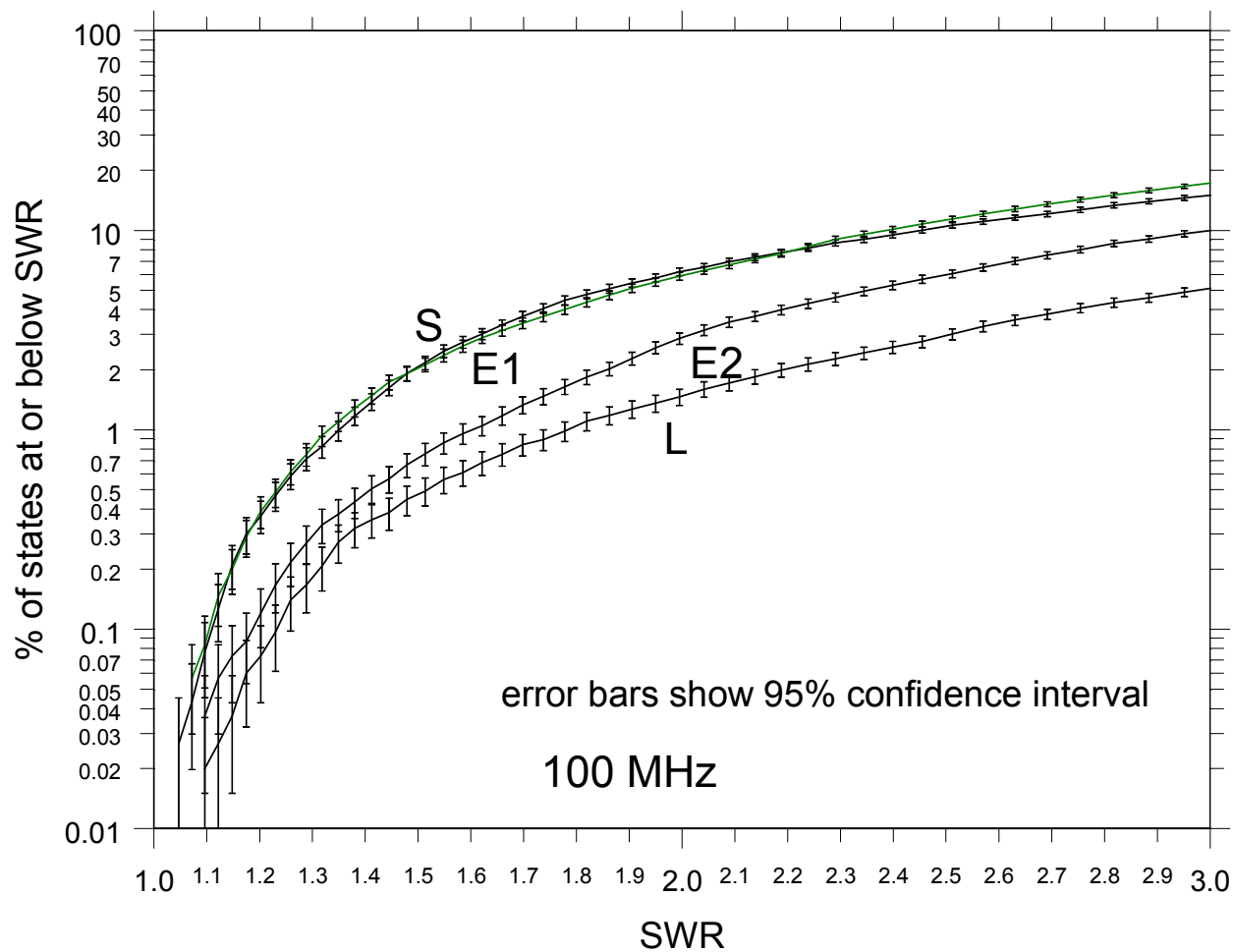
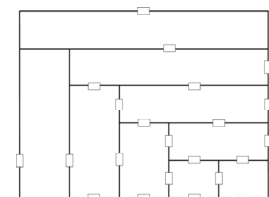


Standard

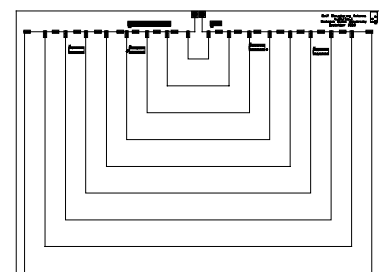


Log-periodic

# SWR measurements

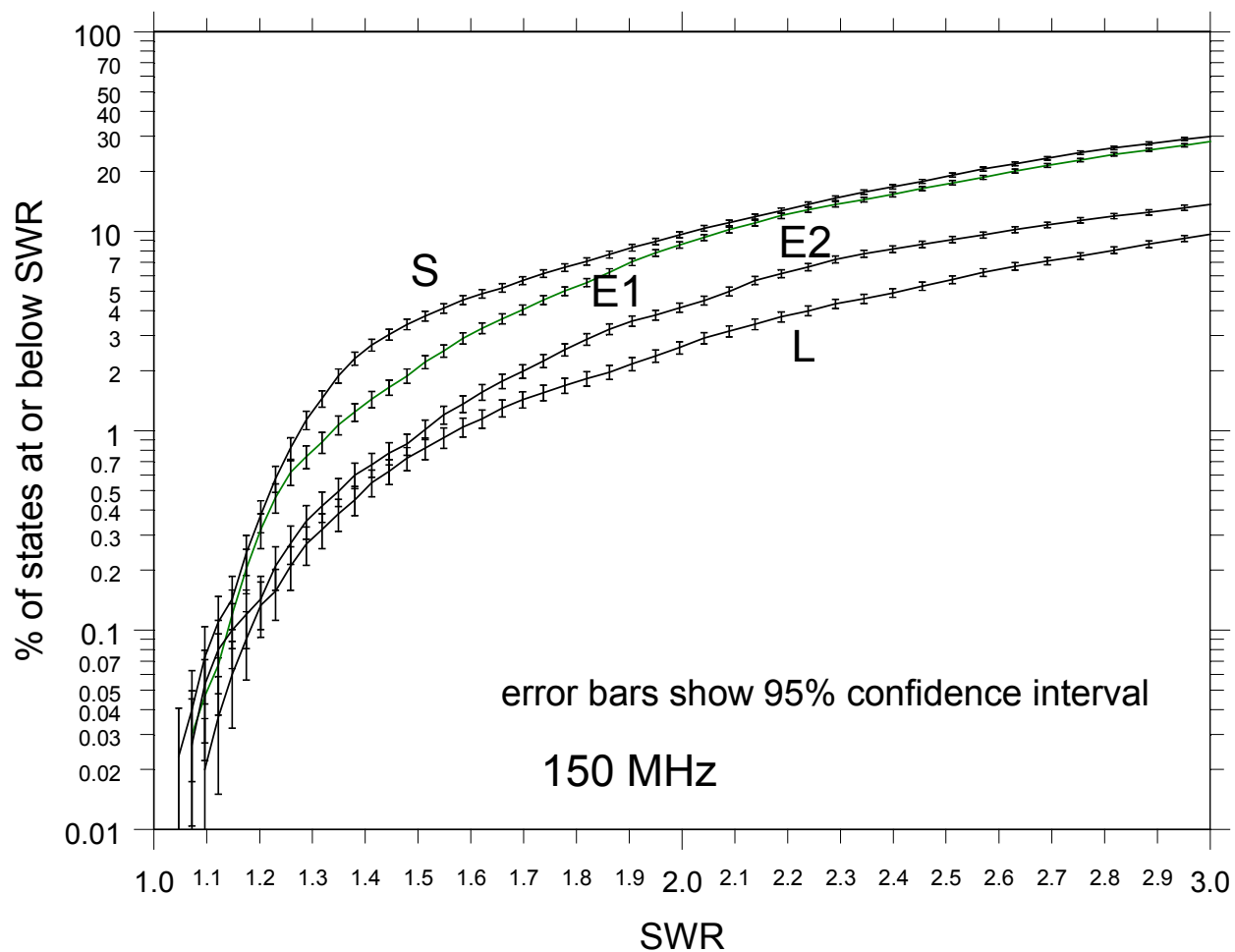
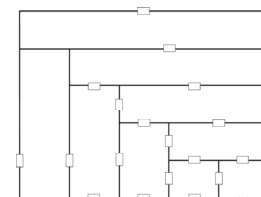


Edge 1



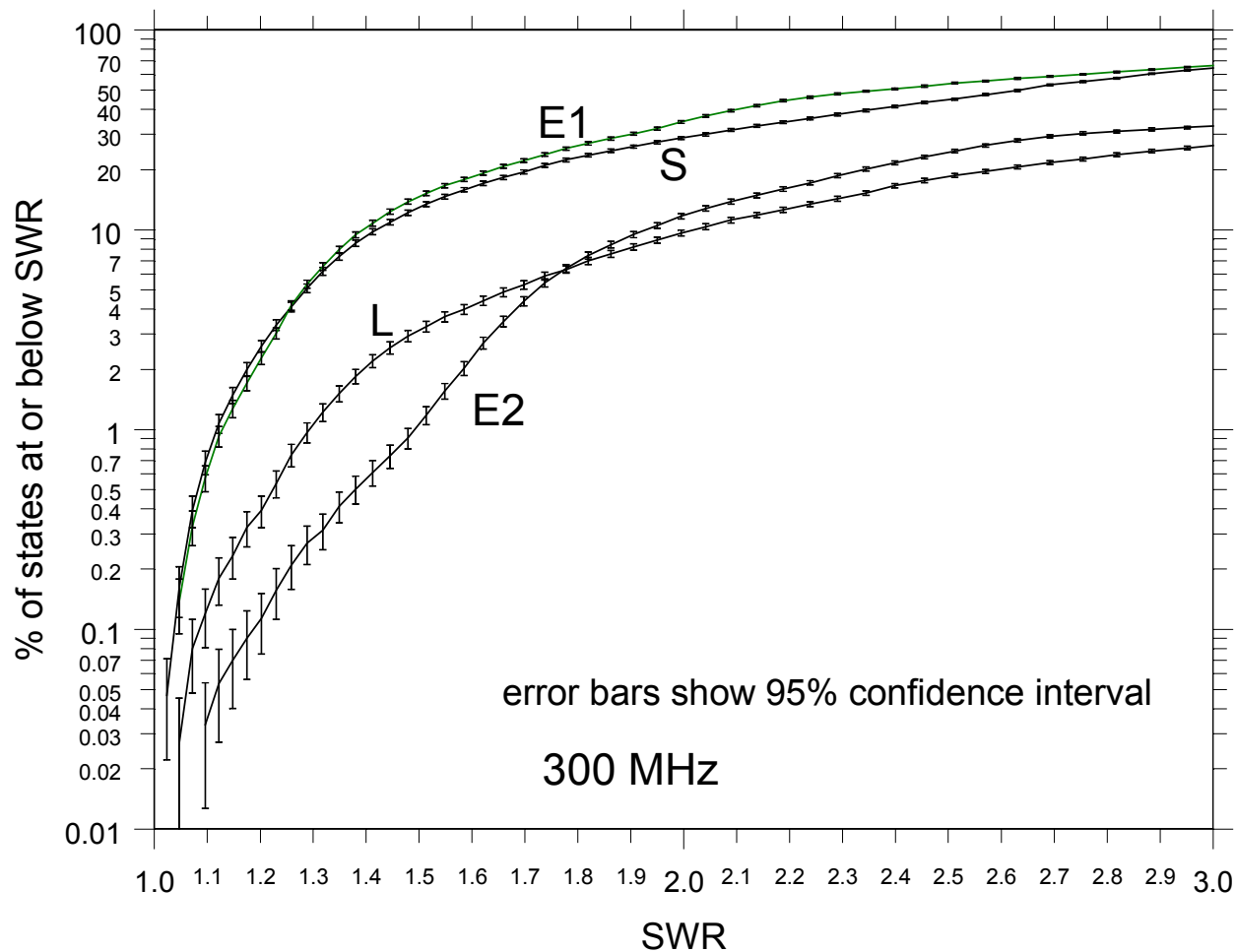
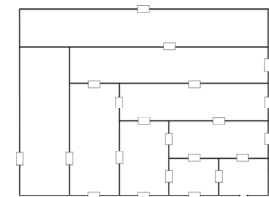
Edge 2

# SWR measurements

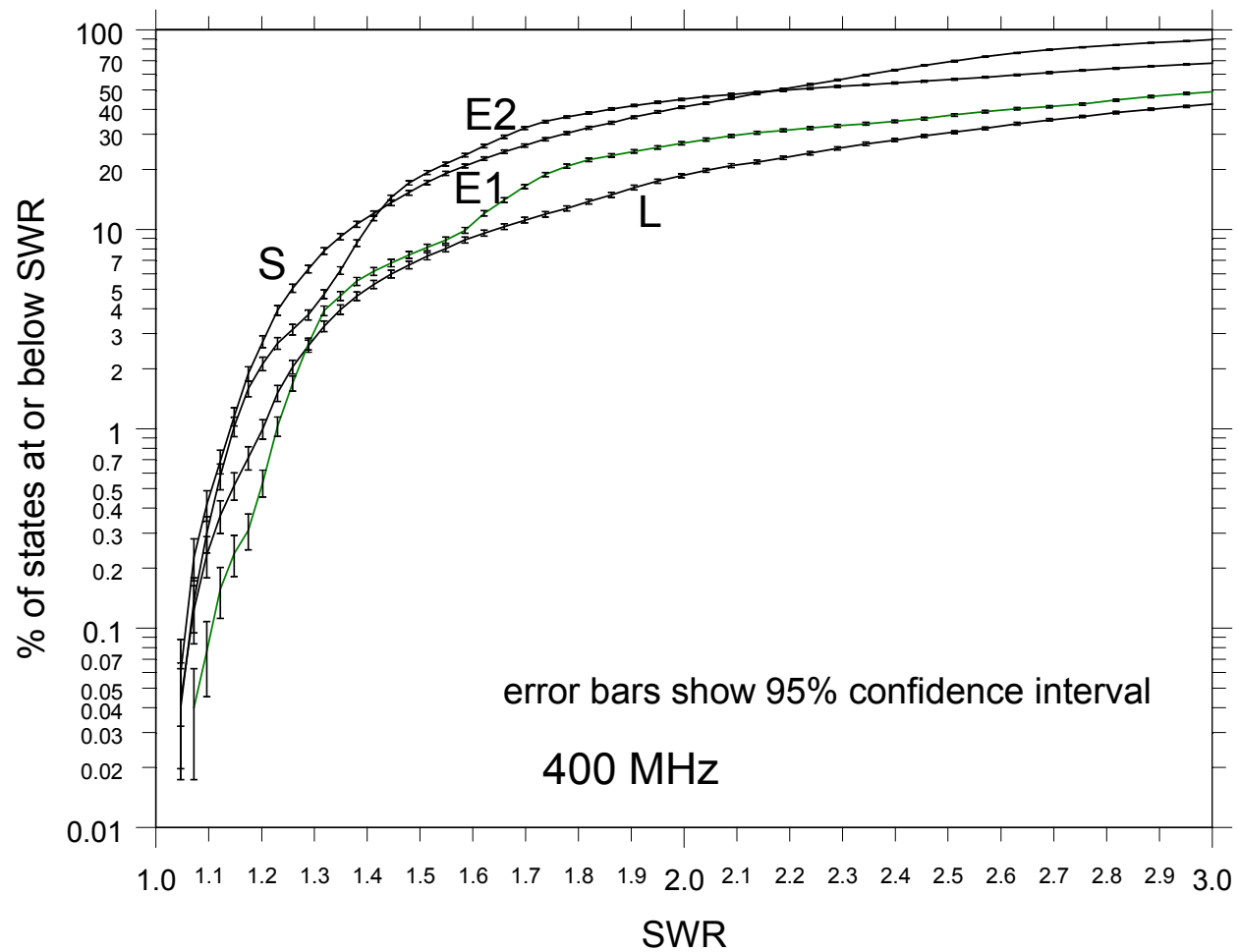
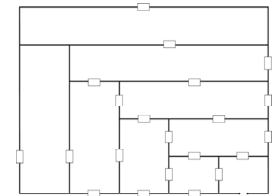




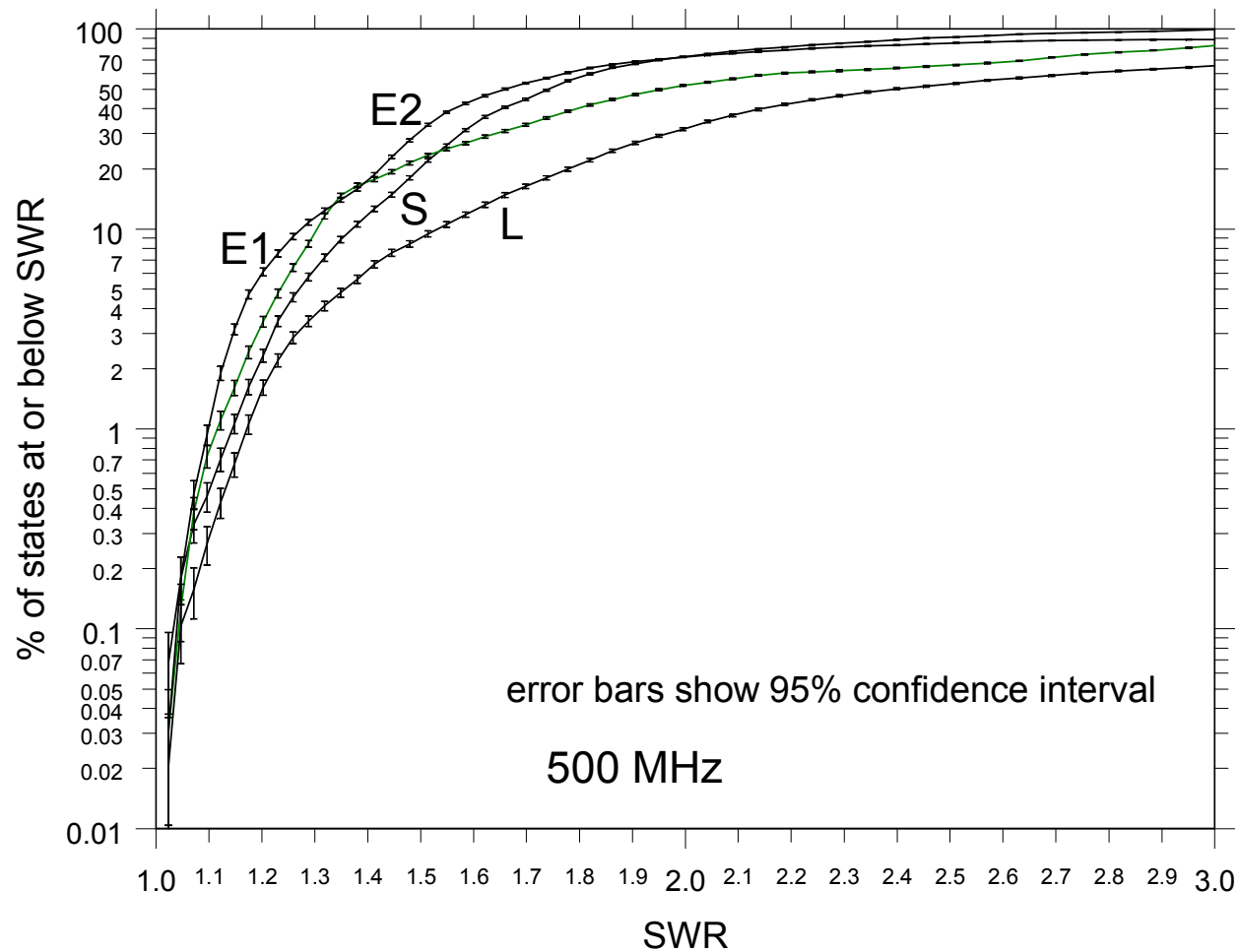
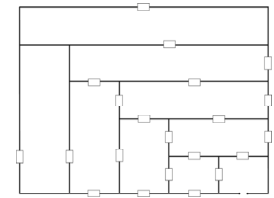
# SWR measurements



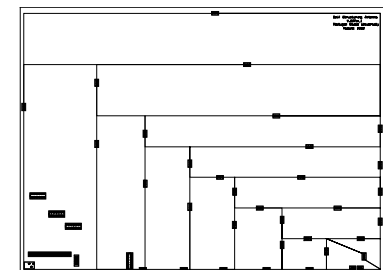
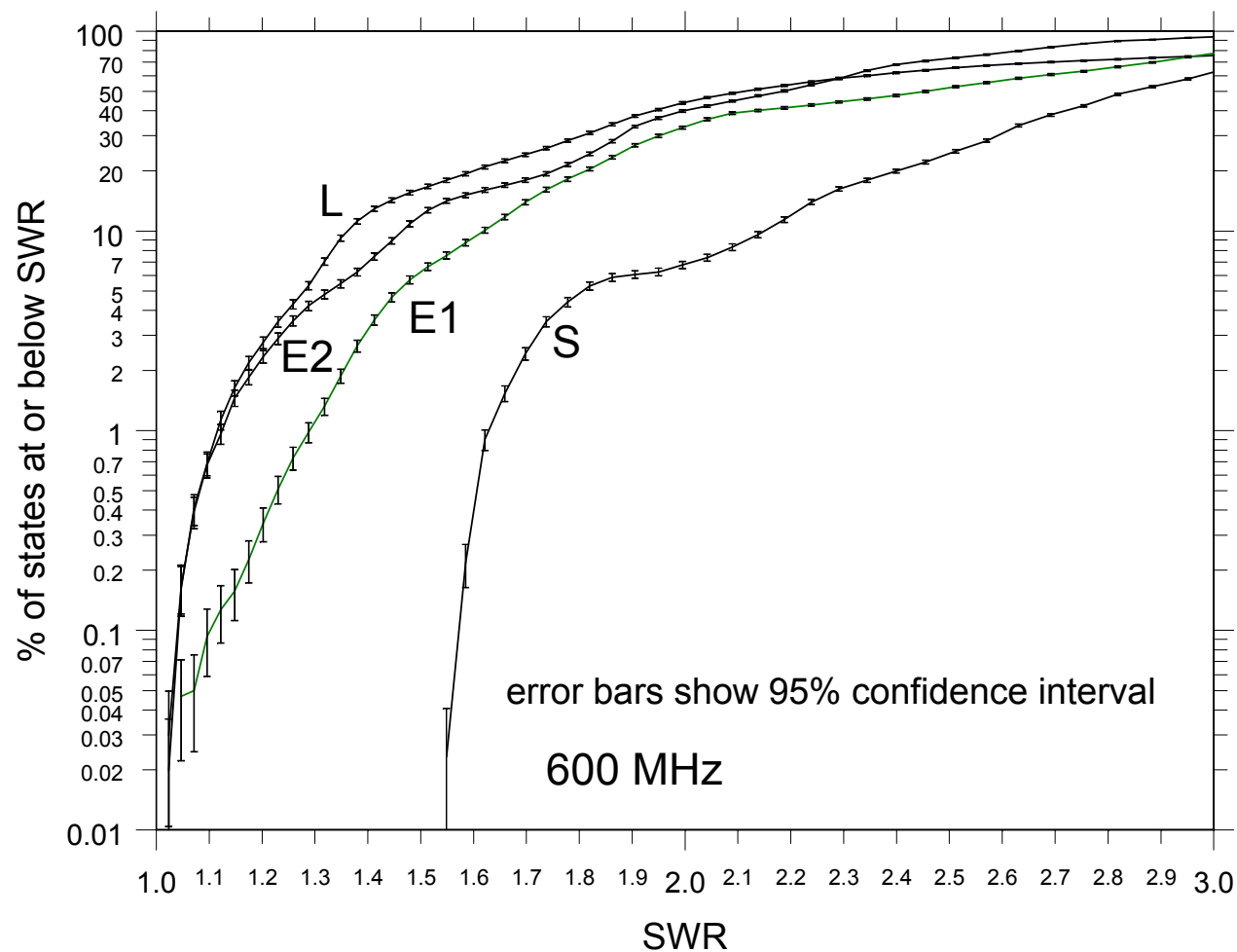
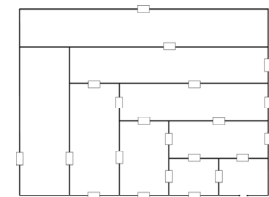
# SWR measurements



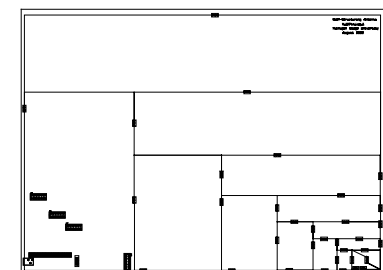
# SWR measurements



# SWR measurements

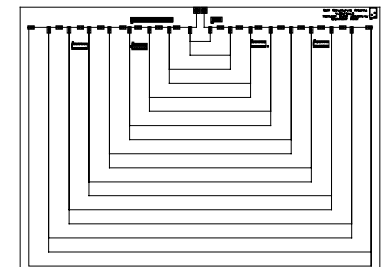
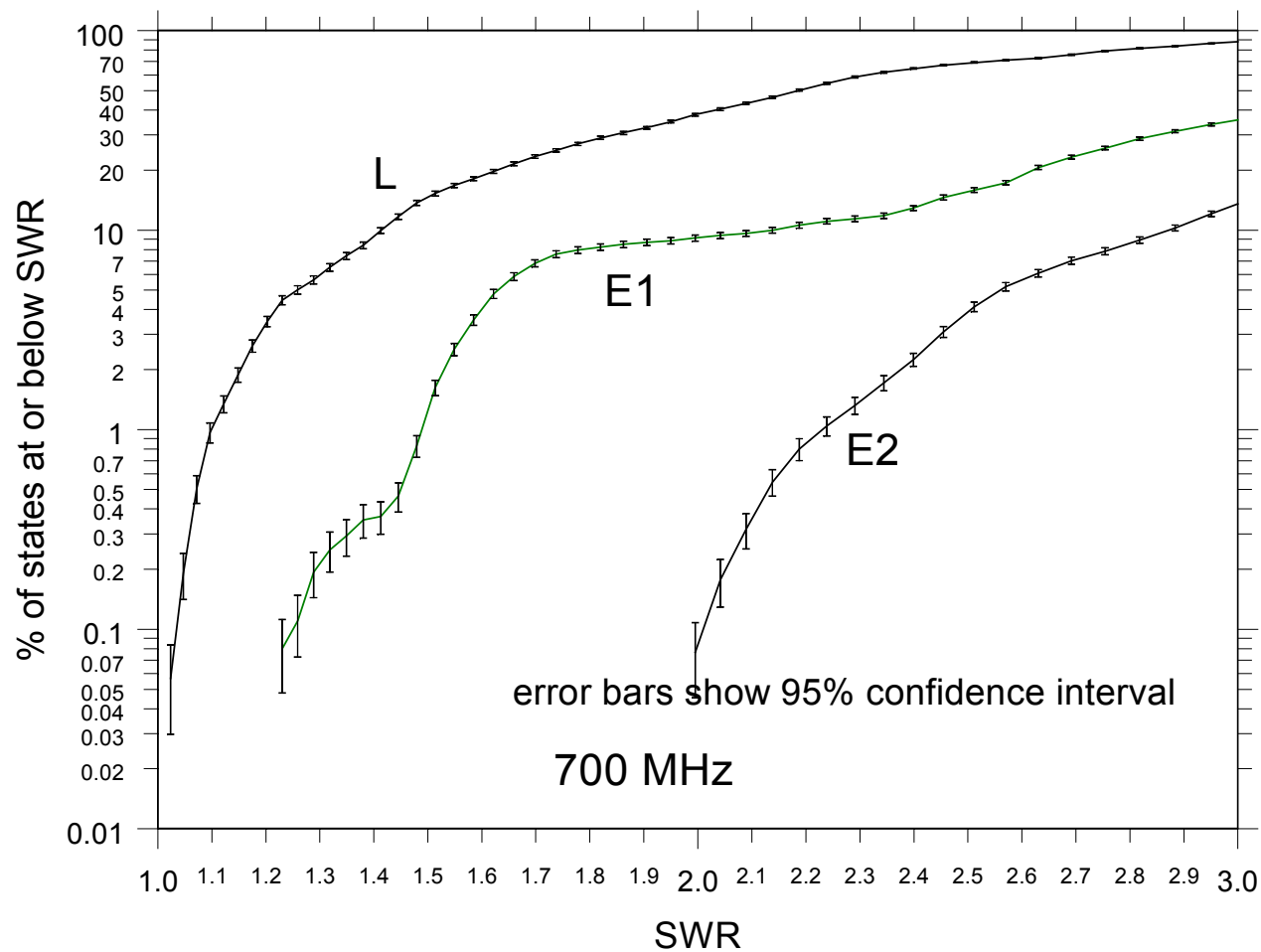
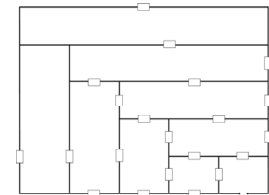


Standard

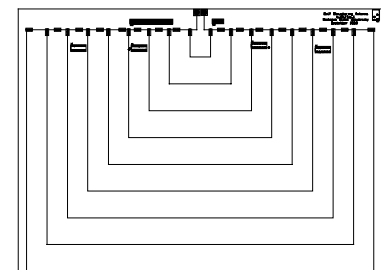


Log-periodic

# SWR measurements

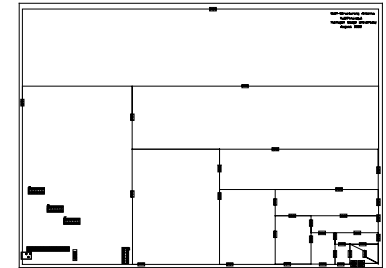
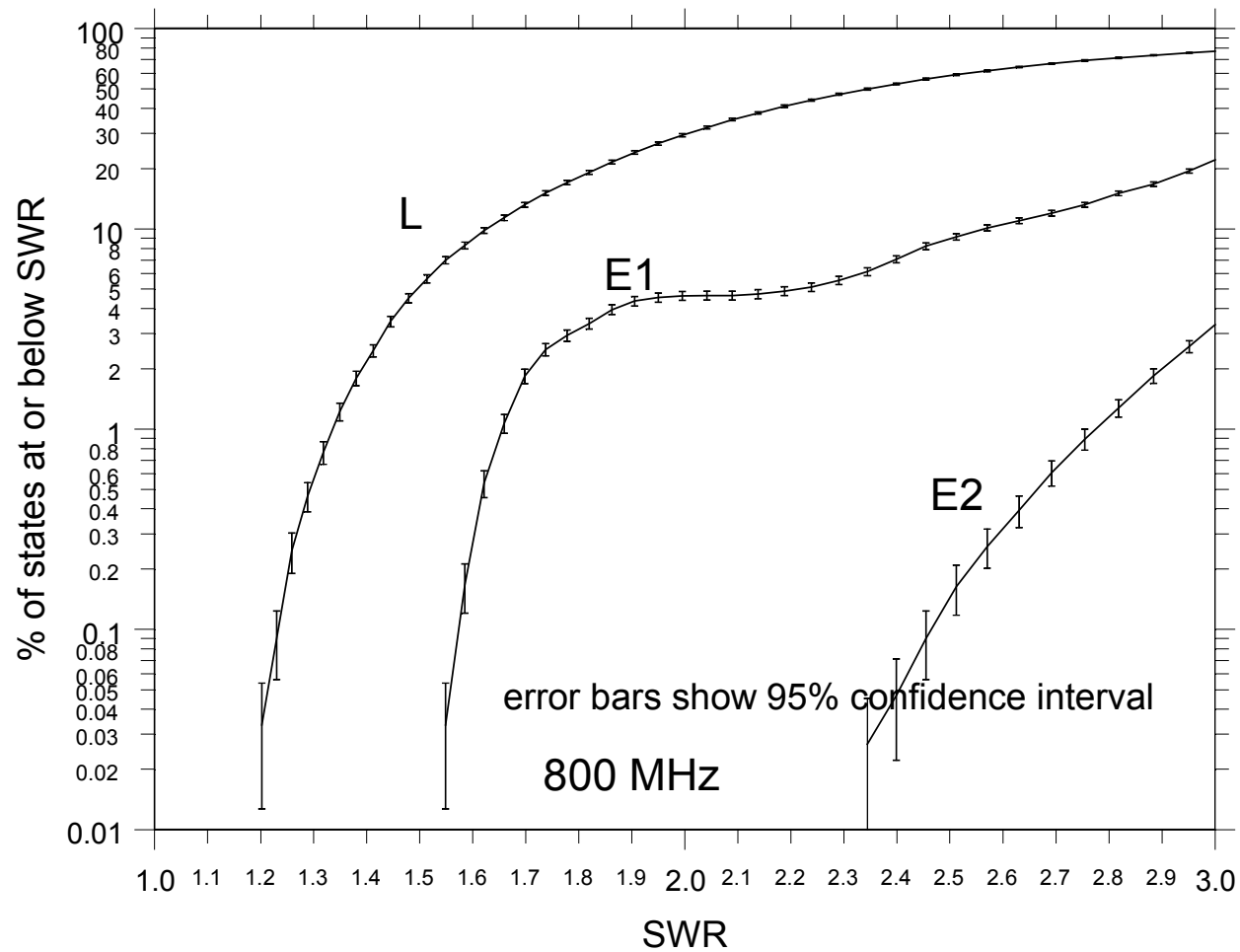
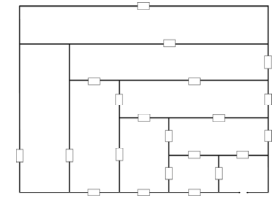


Edge 1



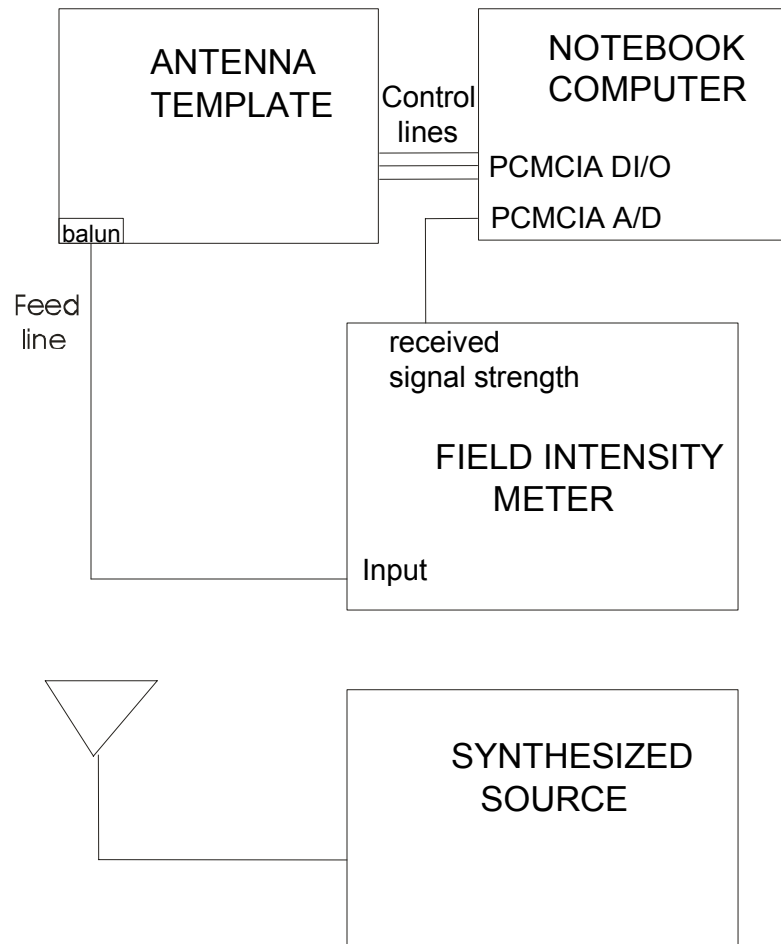
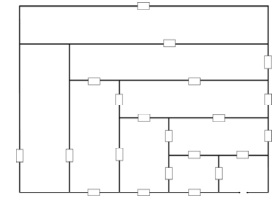
Edge 2

# SWR measurements



Log-periodic

# Pattern measurements

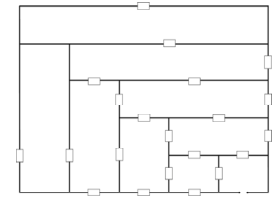


## •Two types of measurements:

- o Optimize at specific angle, then measure pattern with settings fixed
- o Optimize at each angle

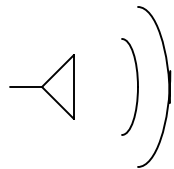
## •Optimization:

- o Standard GA
- o Population of 100
- o 10 generations followed



## 0 Reference angle setup (view looking down)

Transmitting  
antenna



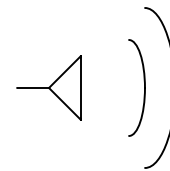
SSA



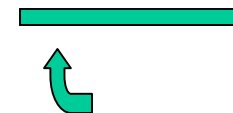
Front of SSA

Zero deg

Transmitting  
antenna



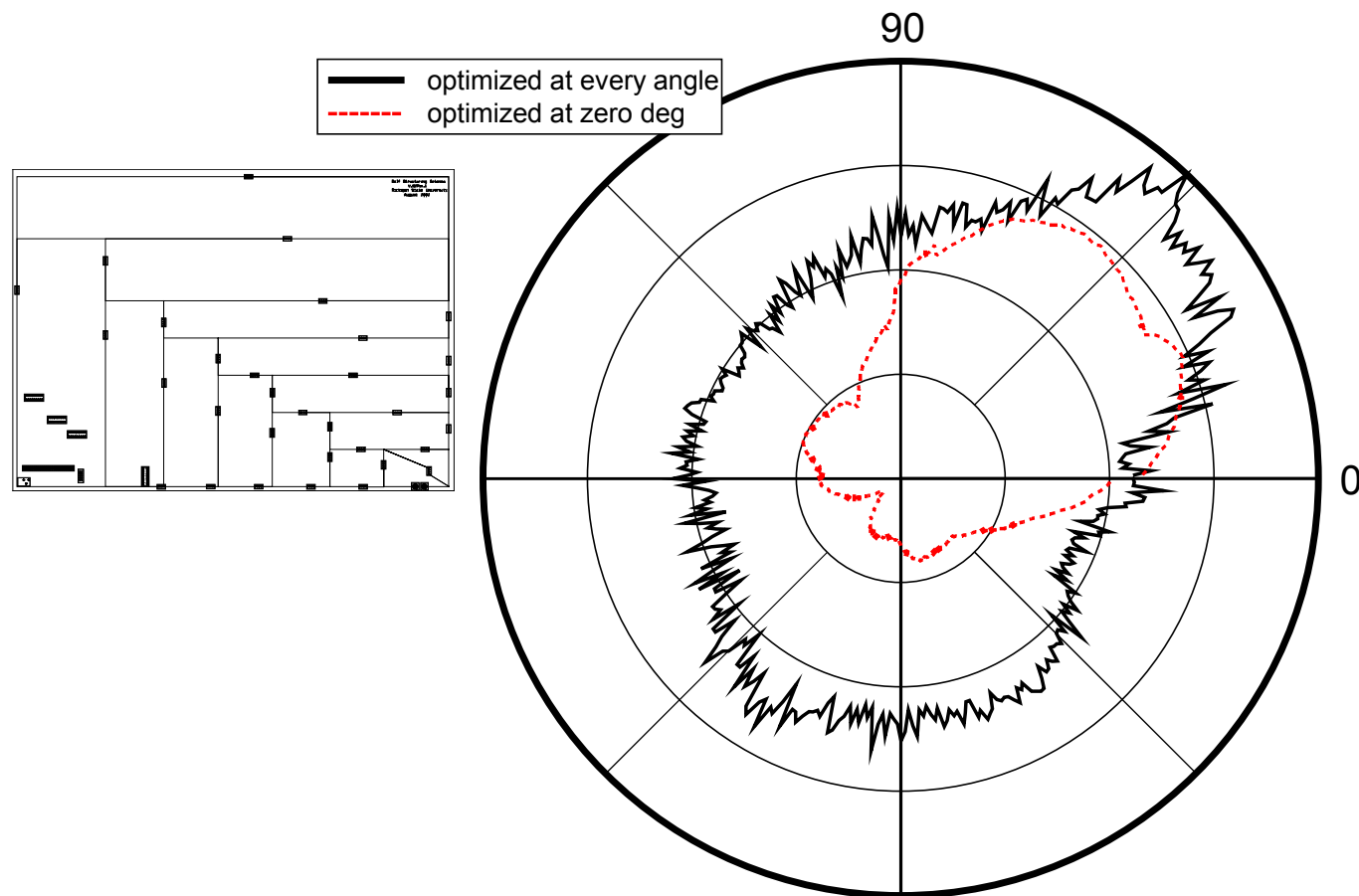
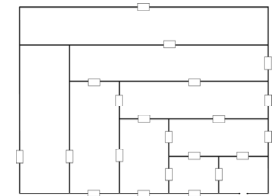
Front of SSA



90 deg

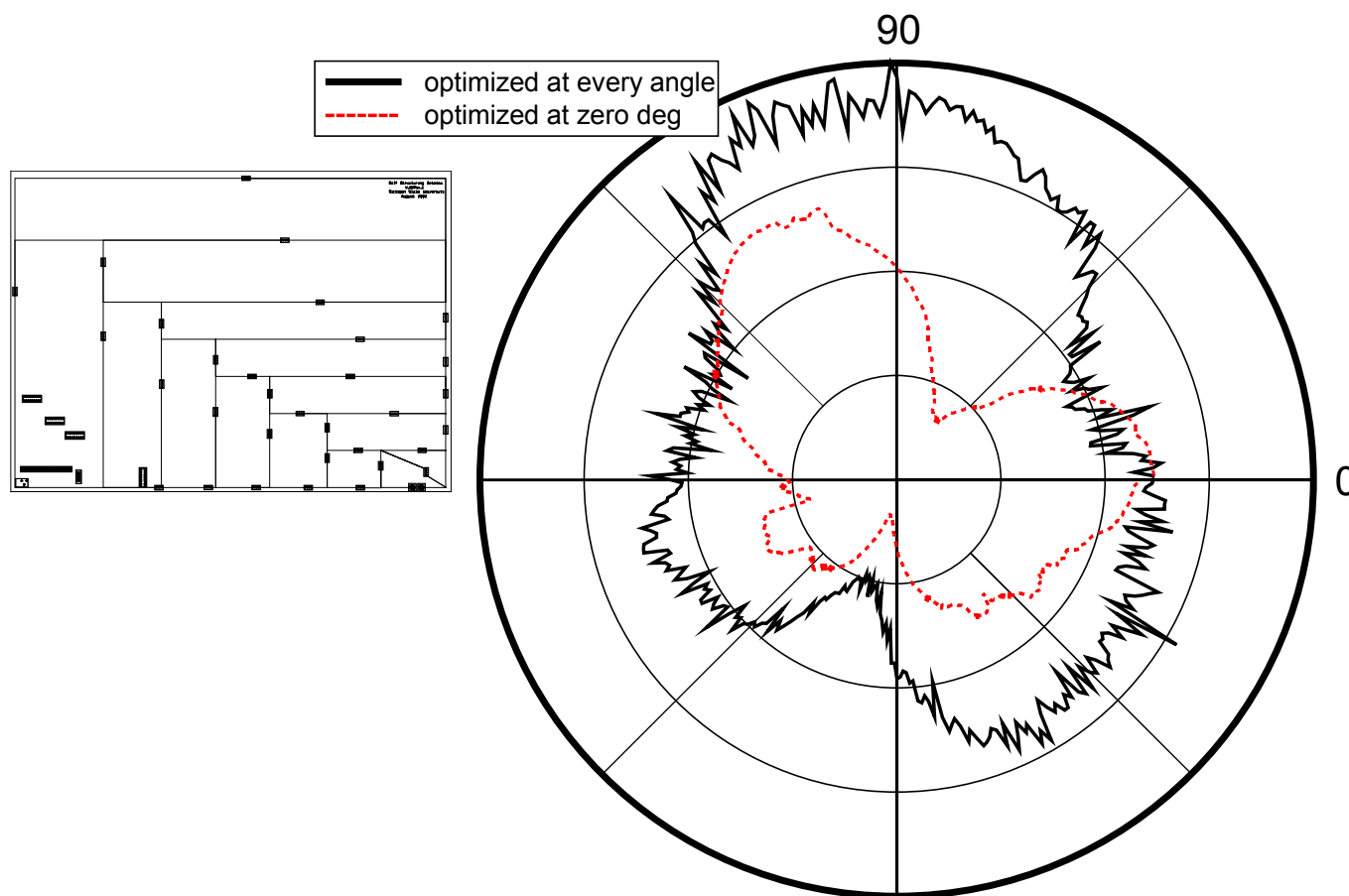
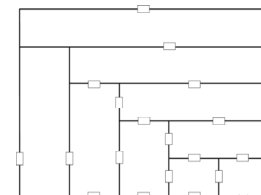


# Pattern measurements



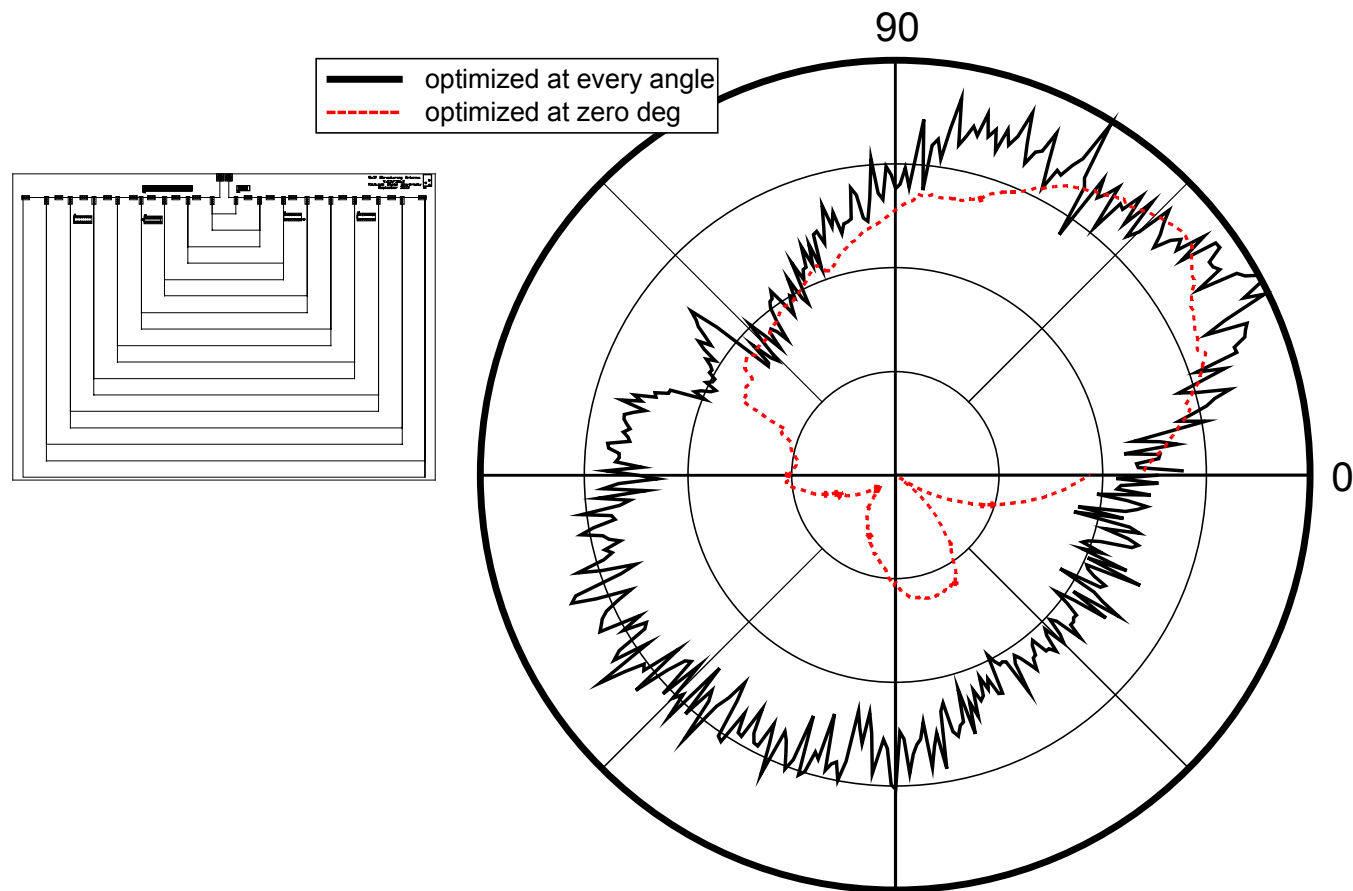
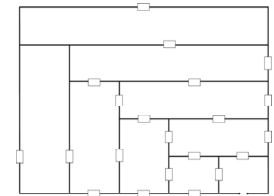
Standard template 400 MHz vertical polarization

# Pattern measurements



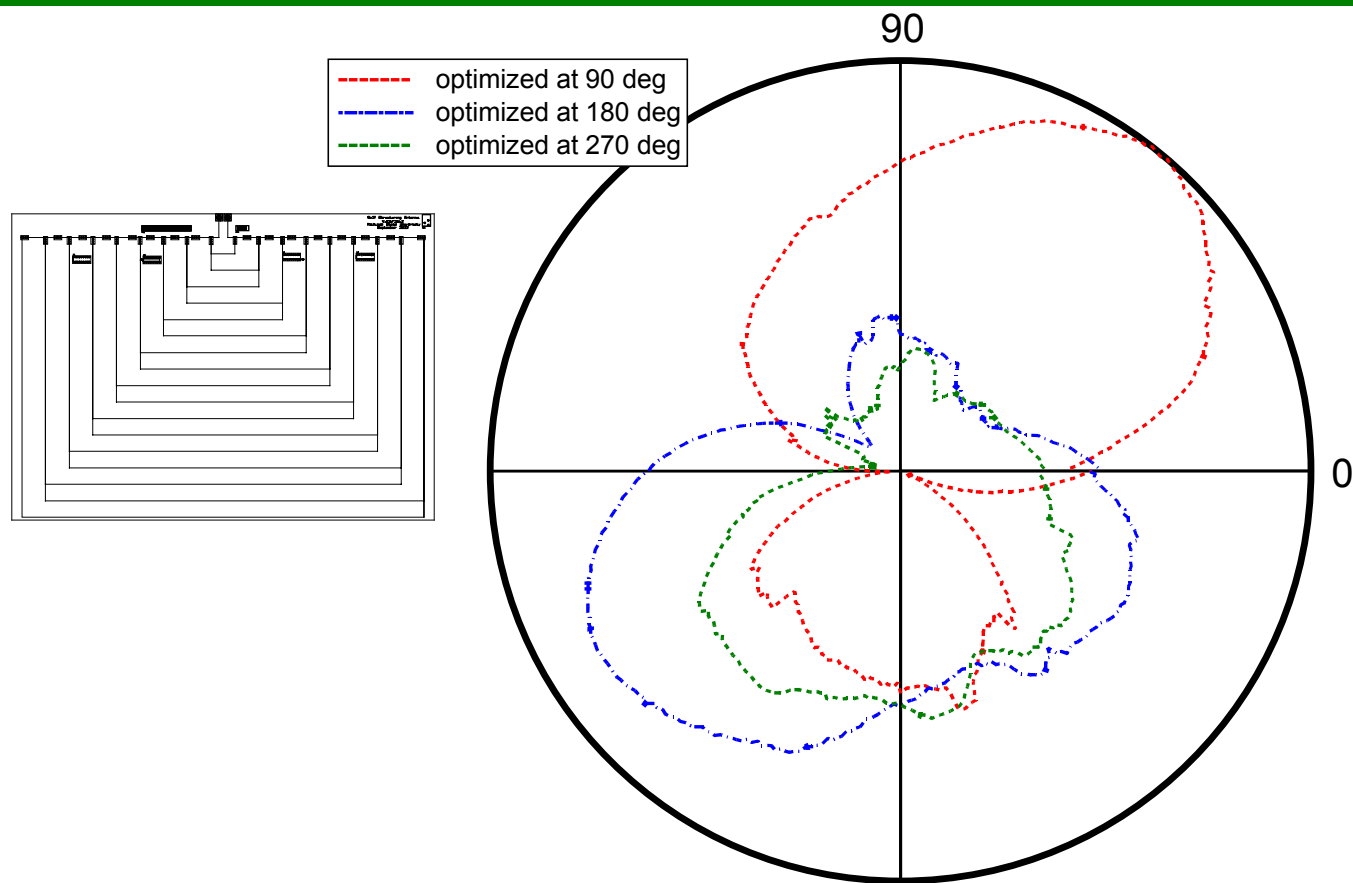
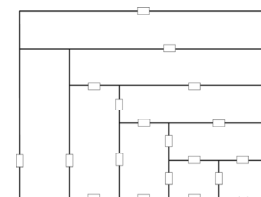
Standard template 400 MHz horizontal polarization

# Pattern measurements



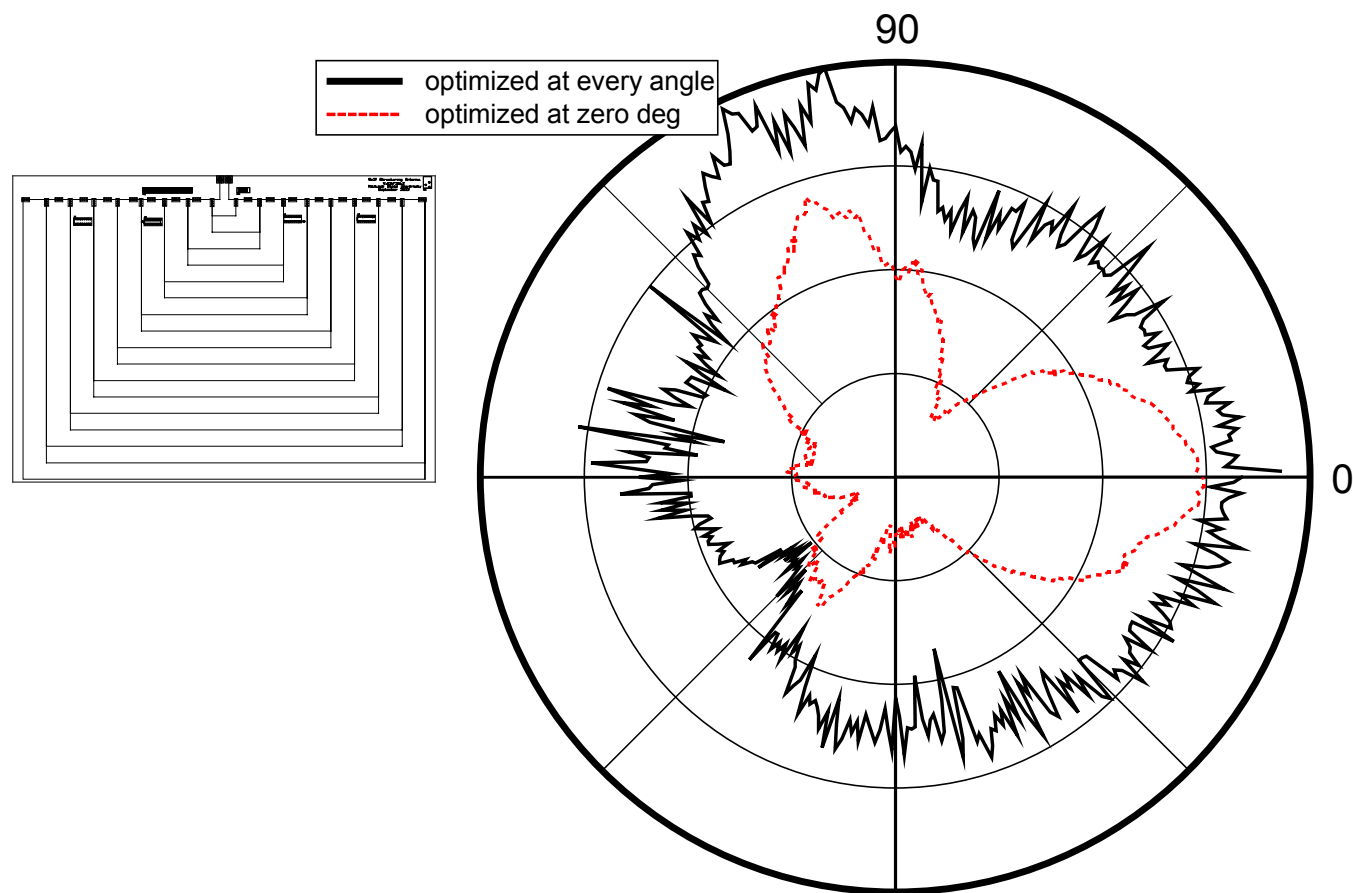
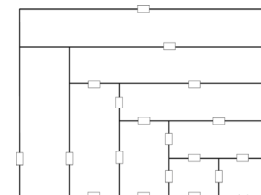
Edge Type 1 template 400 MHz vertical polarization

# Pattern measurements



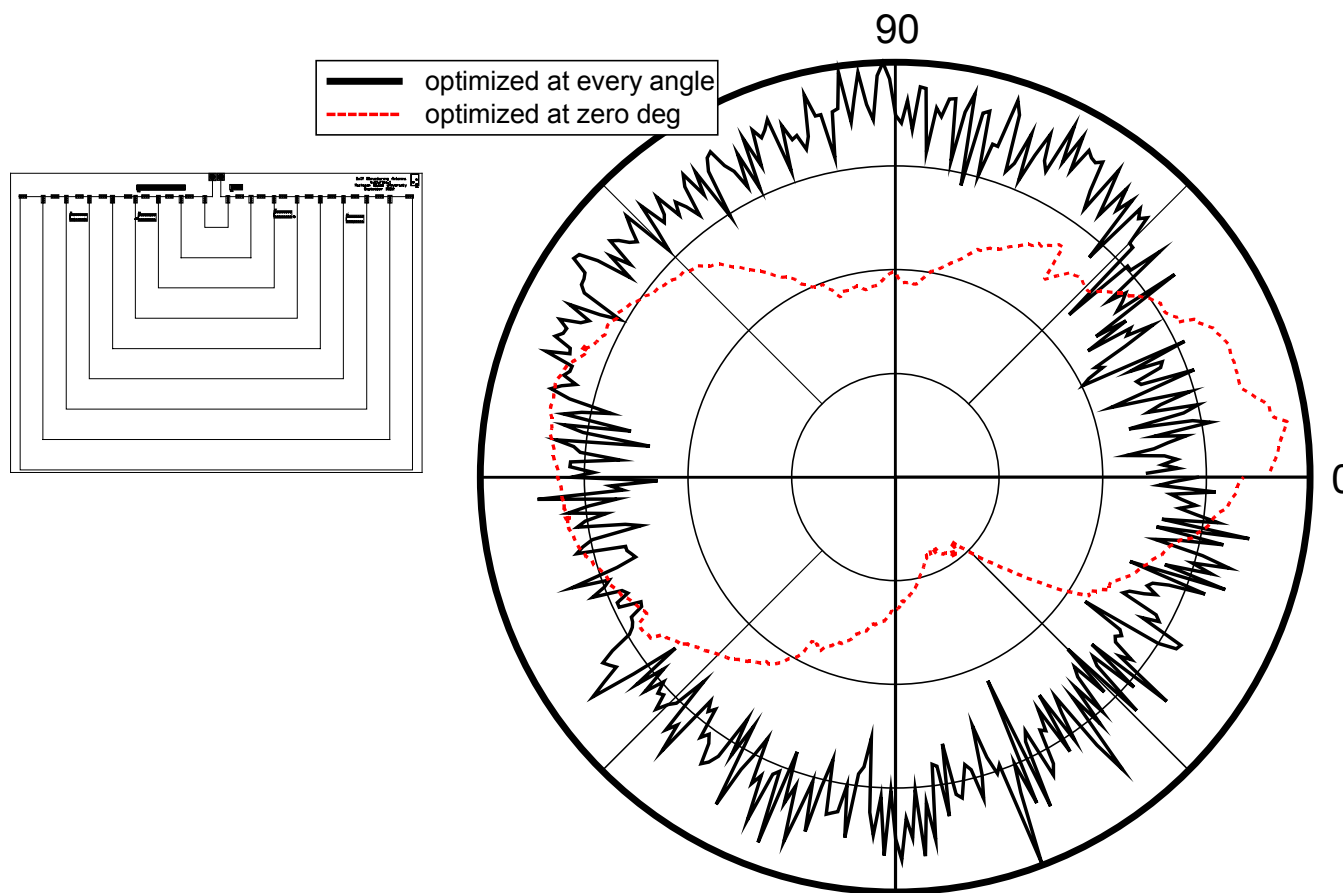
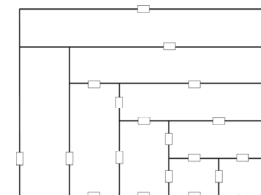
Edge Type 1 template 400 MHz vertical polarization

# Pattern measurements



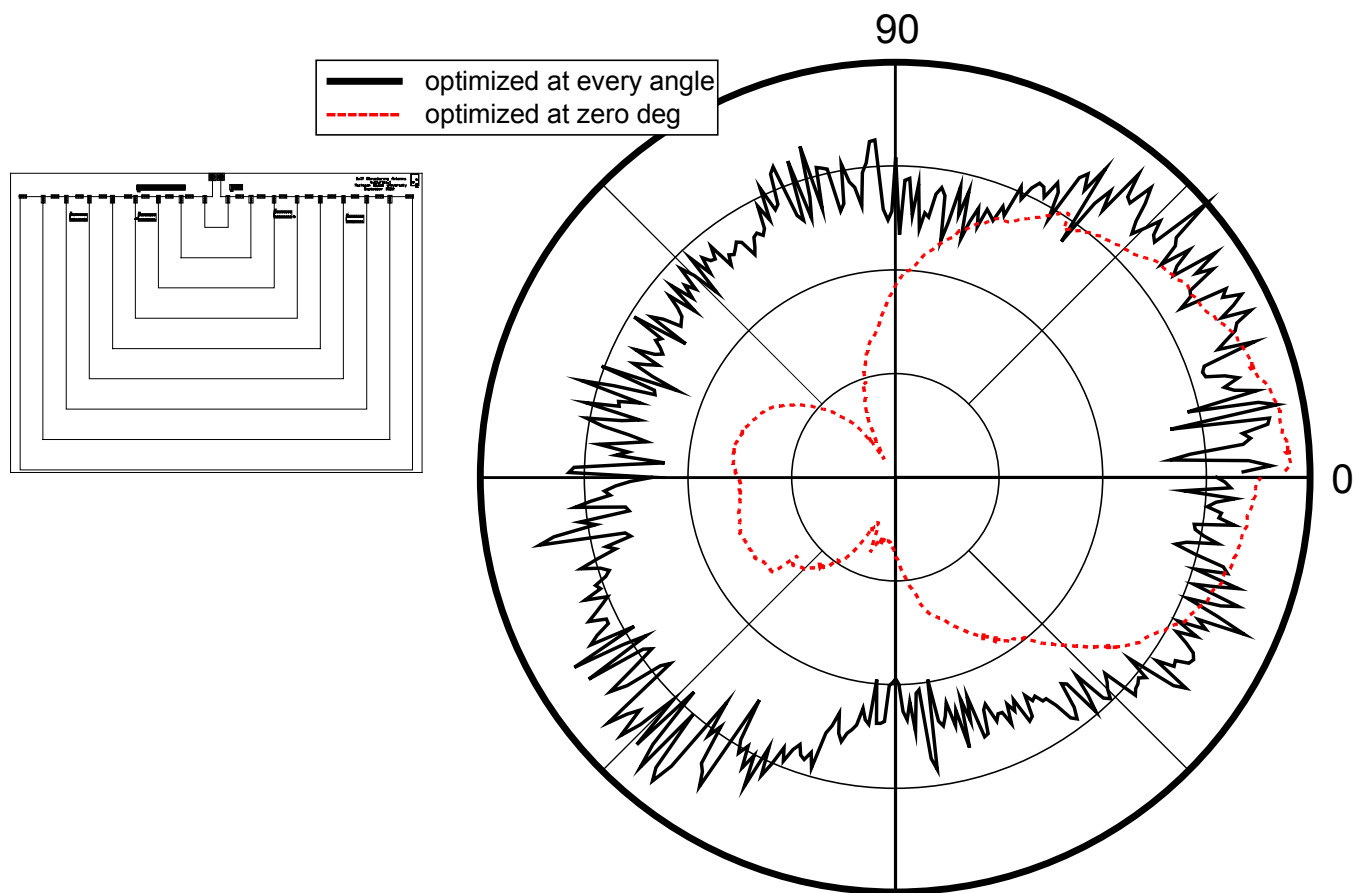
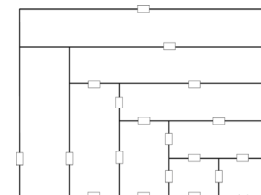
Edge Type 1 template 400 MHz horizontal polarization

# Pattern measurements



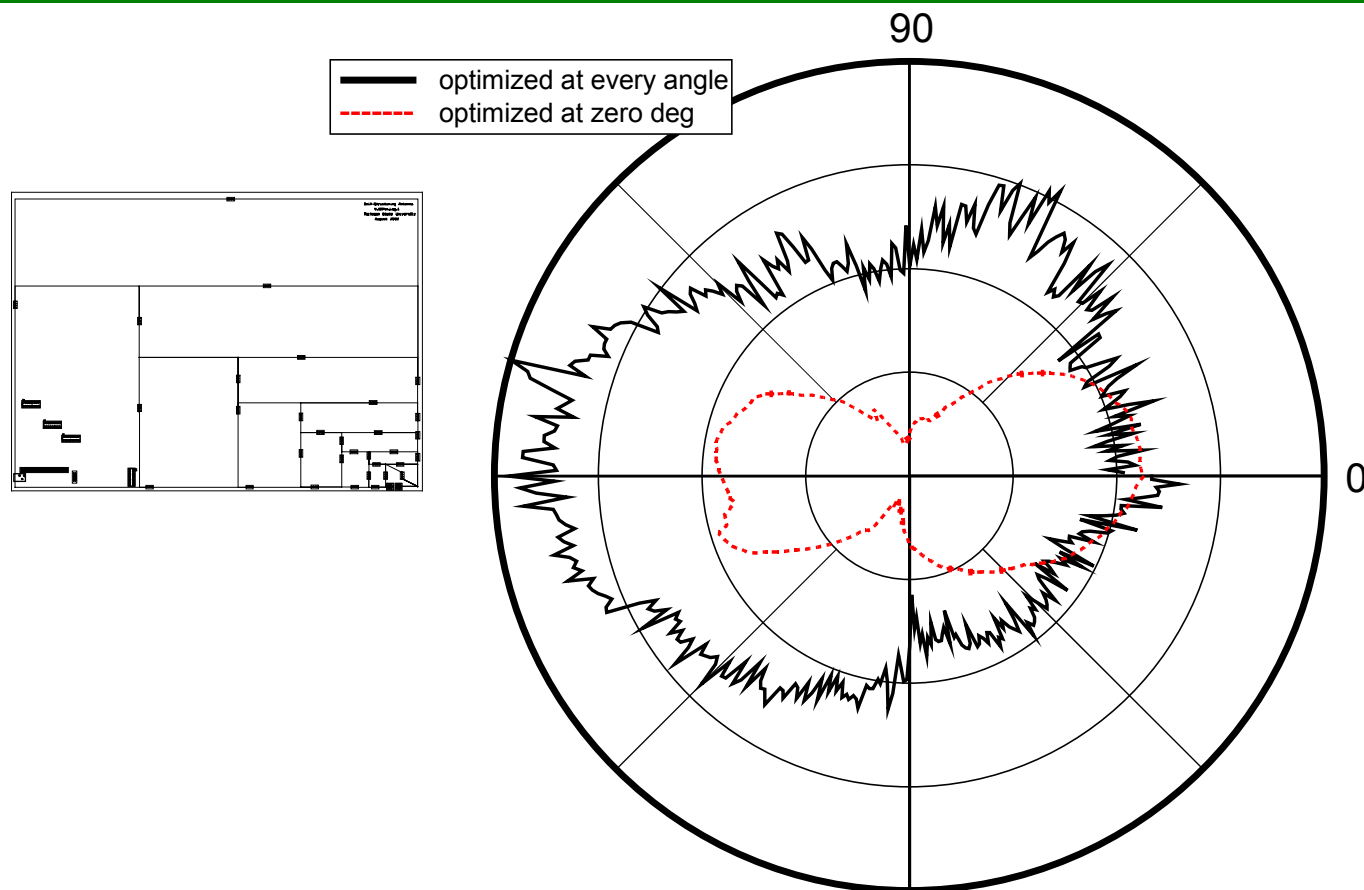
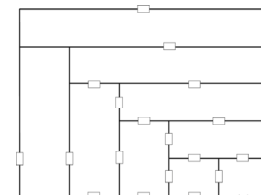
Edge Type 2 400 MHz vertical polarization

# Pattern measurements



Edge Type 2 template 400 MHz horizontal polarization

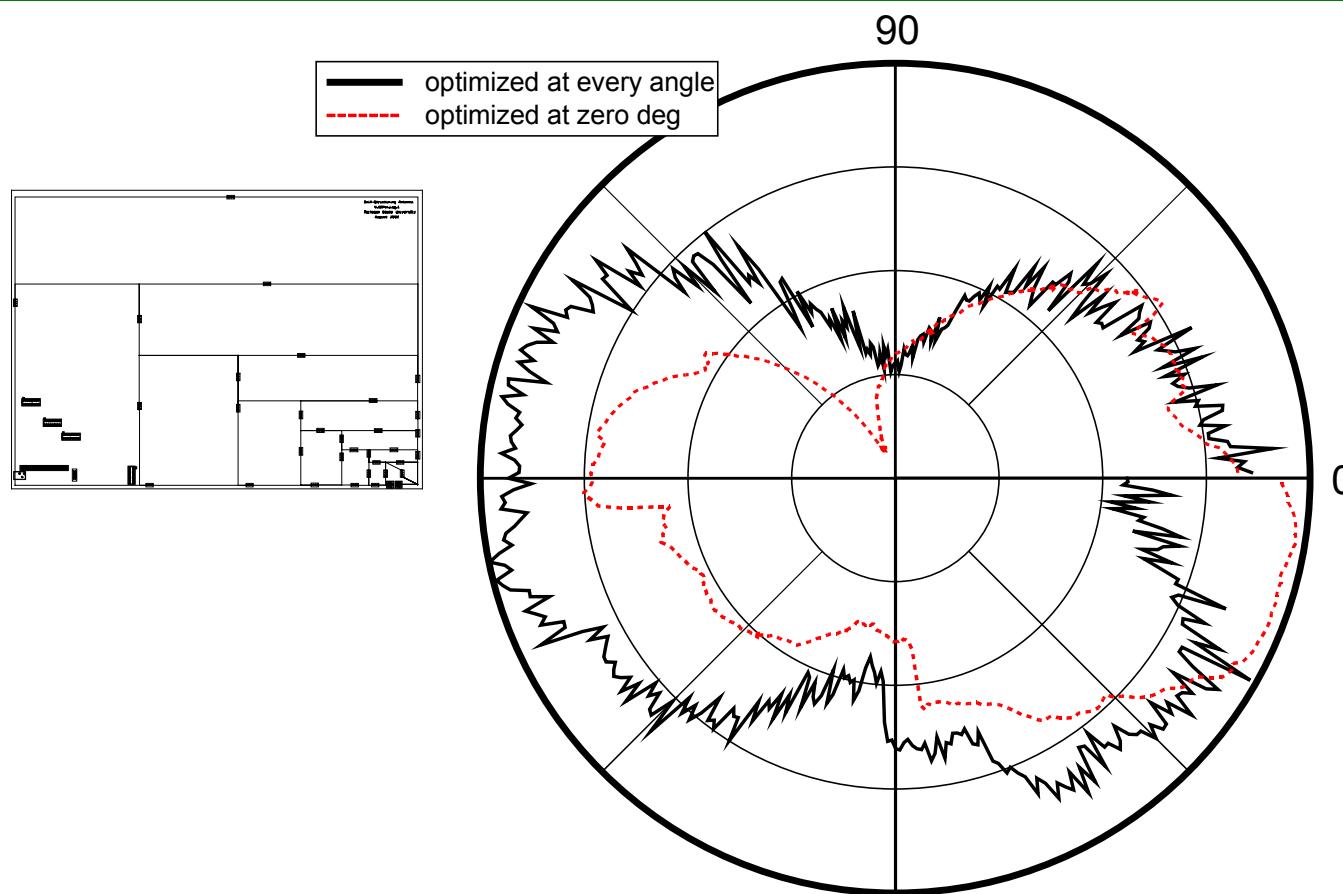
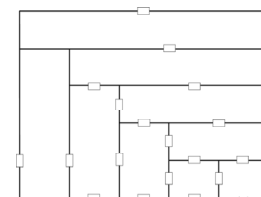
# Pattern measurements



Log-periodic 400 MHz vertical polarization

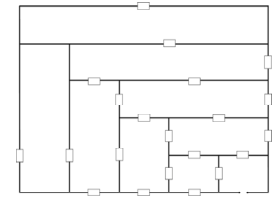


# Pattern measurements



Log-periodic 400 MHz horizontal polarization

## Conclusions



- **SWR**
  - **Type 1 Edge-switched template has performance equal to Standard design**
  - **Type 2 Edge-switched template has performance inferior to edge-switched Type 1 design at most frequencies**
  - **Log-periodic design has poorer low-frequency performance, but superior high-frequency performance**
  
- **Patterns**
  - **All templates work well when optimized at all angles**
  - **Pattern can be steered to some extent by optimizing in a specific direction**