HYBRID FREQUENCY/TIME DOMAIN FIELD THEORY BASED CAD OF MICROWAVE CIRCUITS

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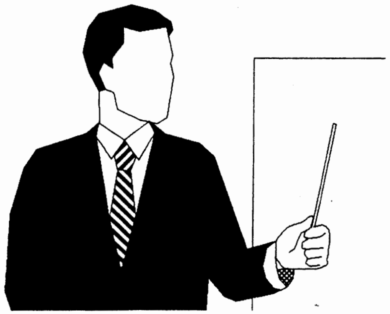
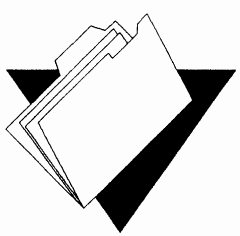
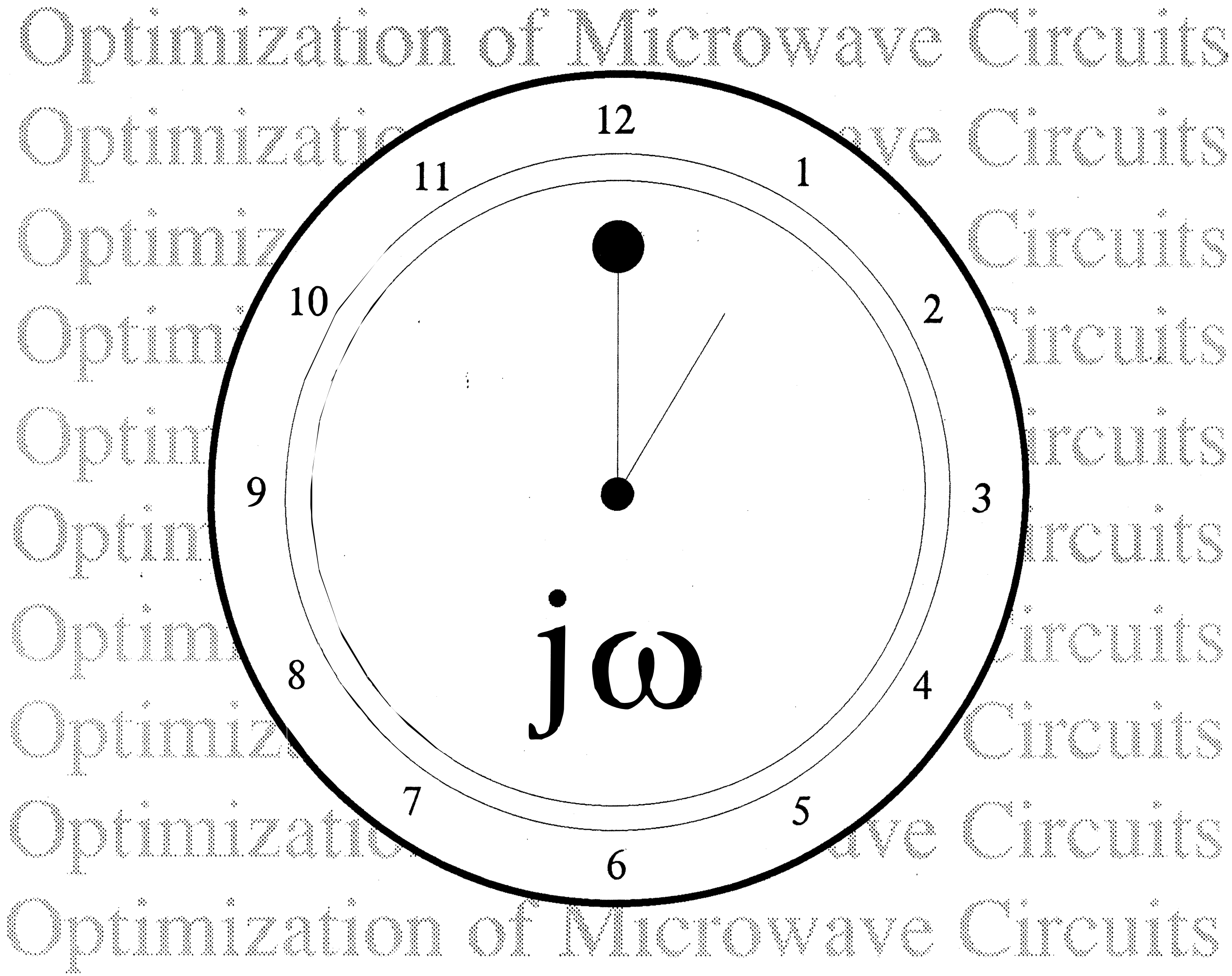
Outline



- The Essence of this Presentation
- Introduction
- Simulation Technique and Example
- Advantages and Disadvantages
- A DECmpp 12000 3D-TLM Algorithm
- DECmpp 12000 Constraints
- Conclusion



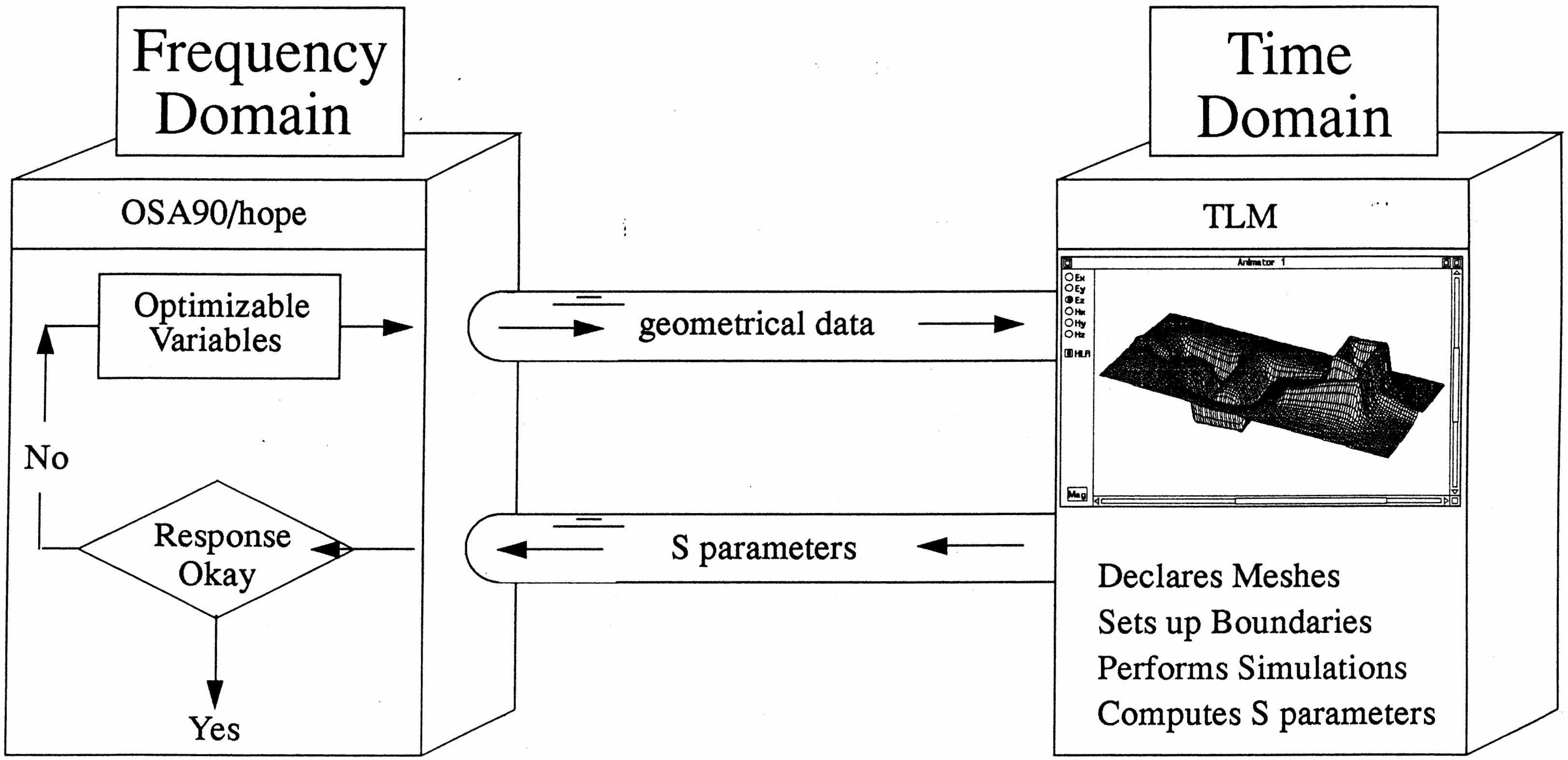
The Essence of this Presentation



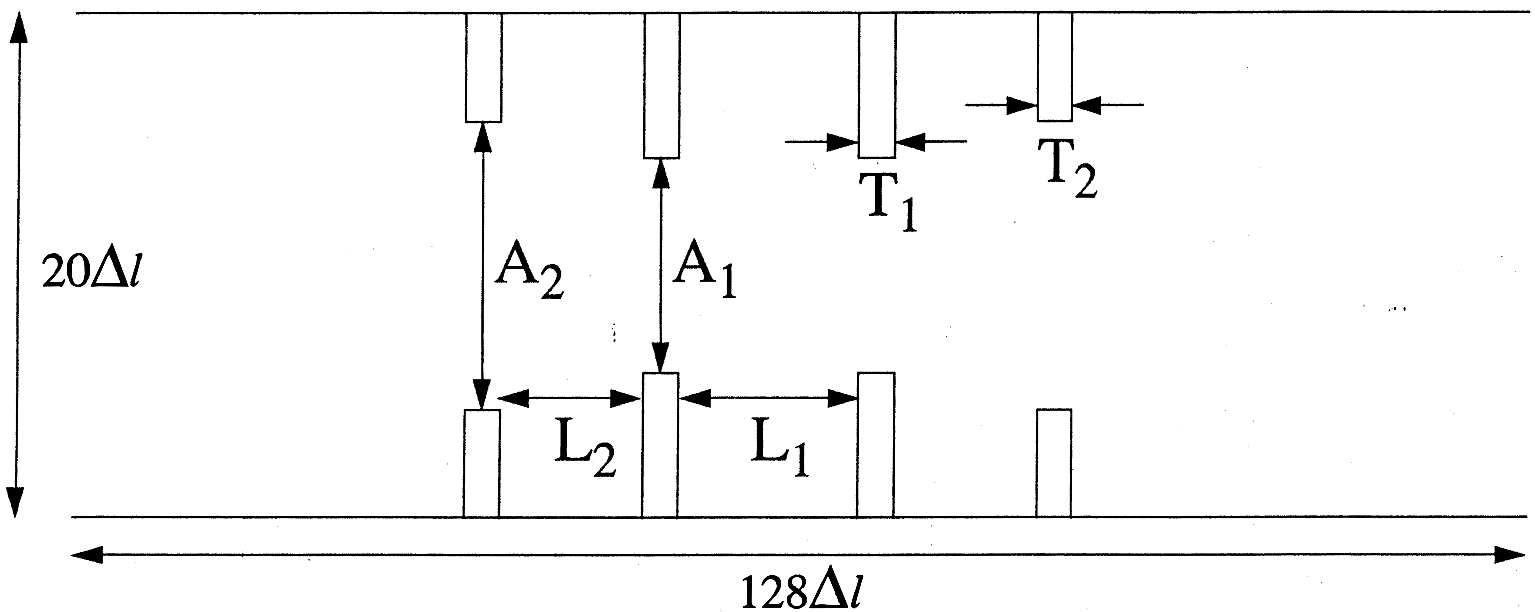
Introduction

- Field theory based microwave circuit CAD/CAM is mostly performed in the frequency domain.
- OSA90/hope is a commercially available CAD program that allows users to incorporate special elements into their circuit simulation using high speed UNIX pipe.
- Hence, OSA90/hope can run on its host machine and control external programs both in frequency and time domains running on other machines (such as DECmpp 12000).
- This paper presents a combination of OSA90/hope operating in the frequency domain with a TLM electromagnetic wave simulator operating in the time domain.

Simulation Technique



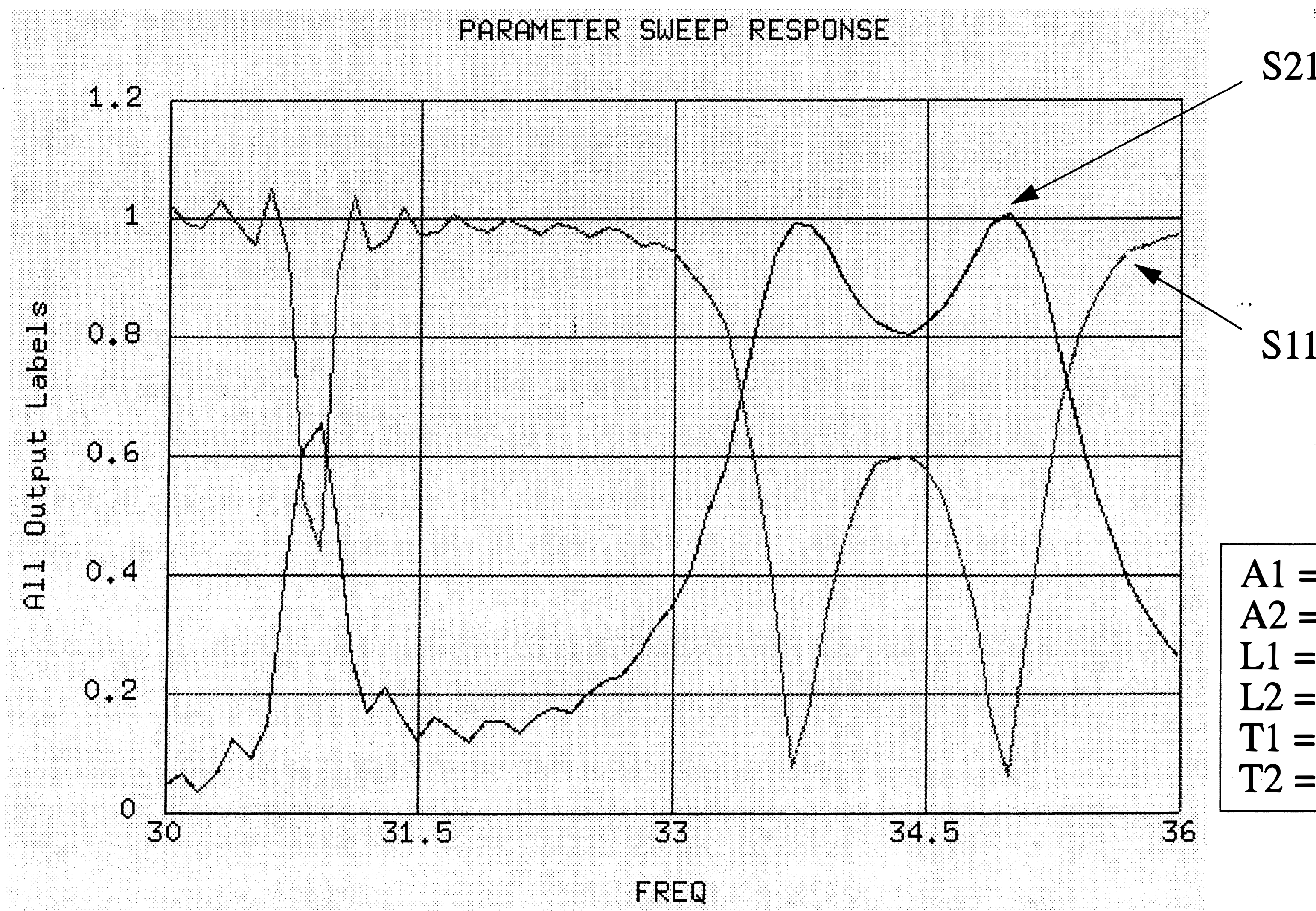
Simulation Example



A bandpass filter in the WR28 rectangular waveguide, $\Delta l = 0.3556$ mm. Using single precision floating operation, the mesh requires 50K of RAM. The optimization goal is:

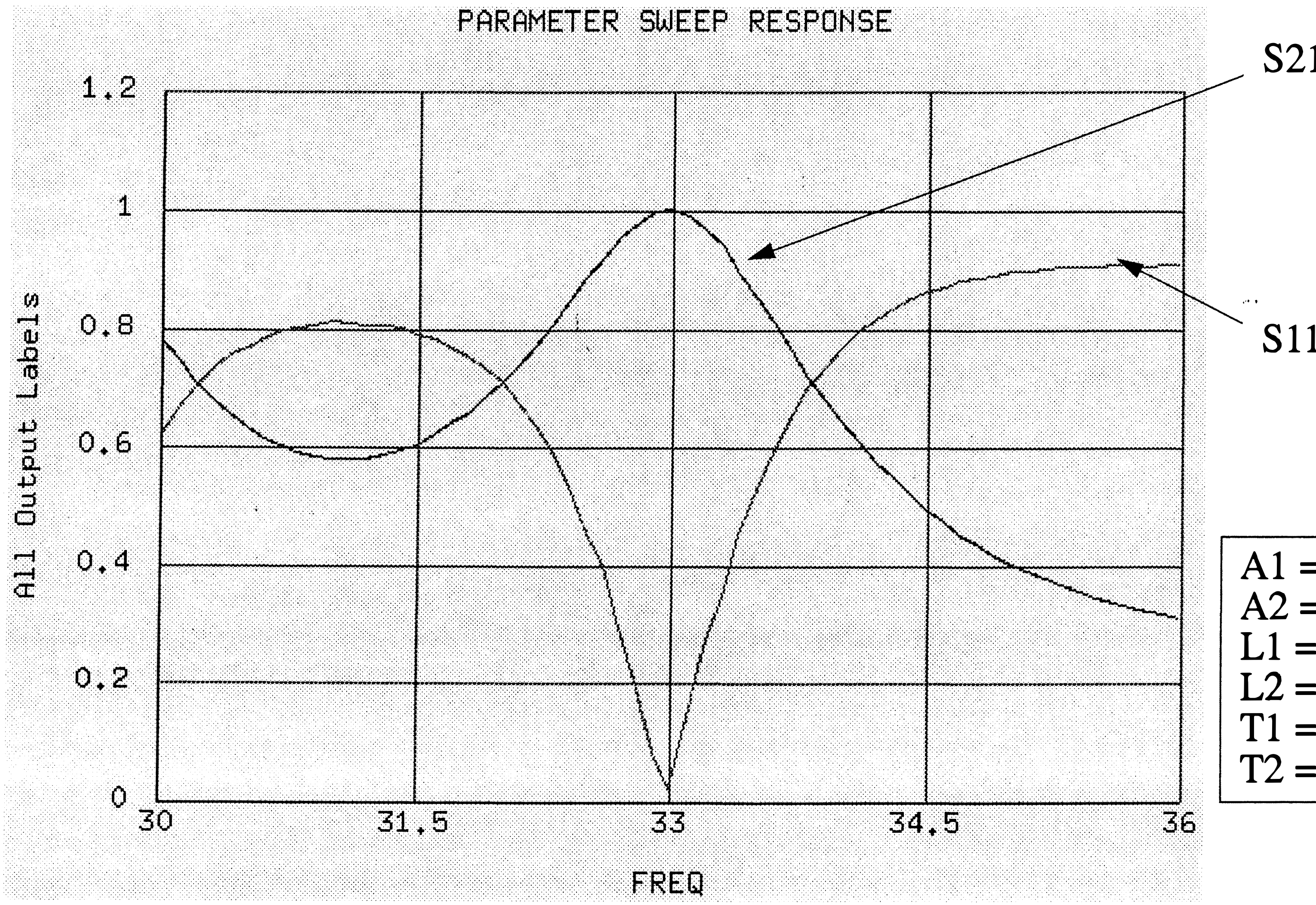
30.0 to 32.0 GHz step 0.1 GHz	S11=1	S21=0	weight=1
32.5 to 33.5 GHz step 0.1 GHz	S11=0	S21=1	weight=2
34.0 to 36.0 GHz step 0.1 GHz	S11=1	S21=0	weight=1

Initial Response (34 seconds/iteration)



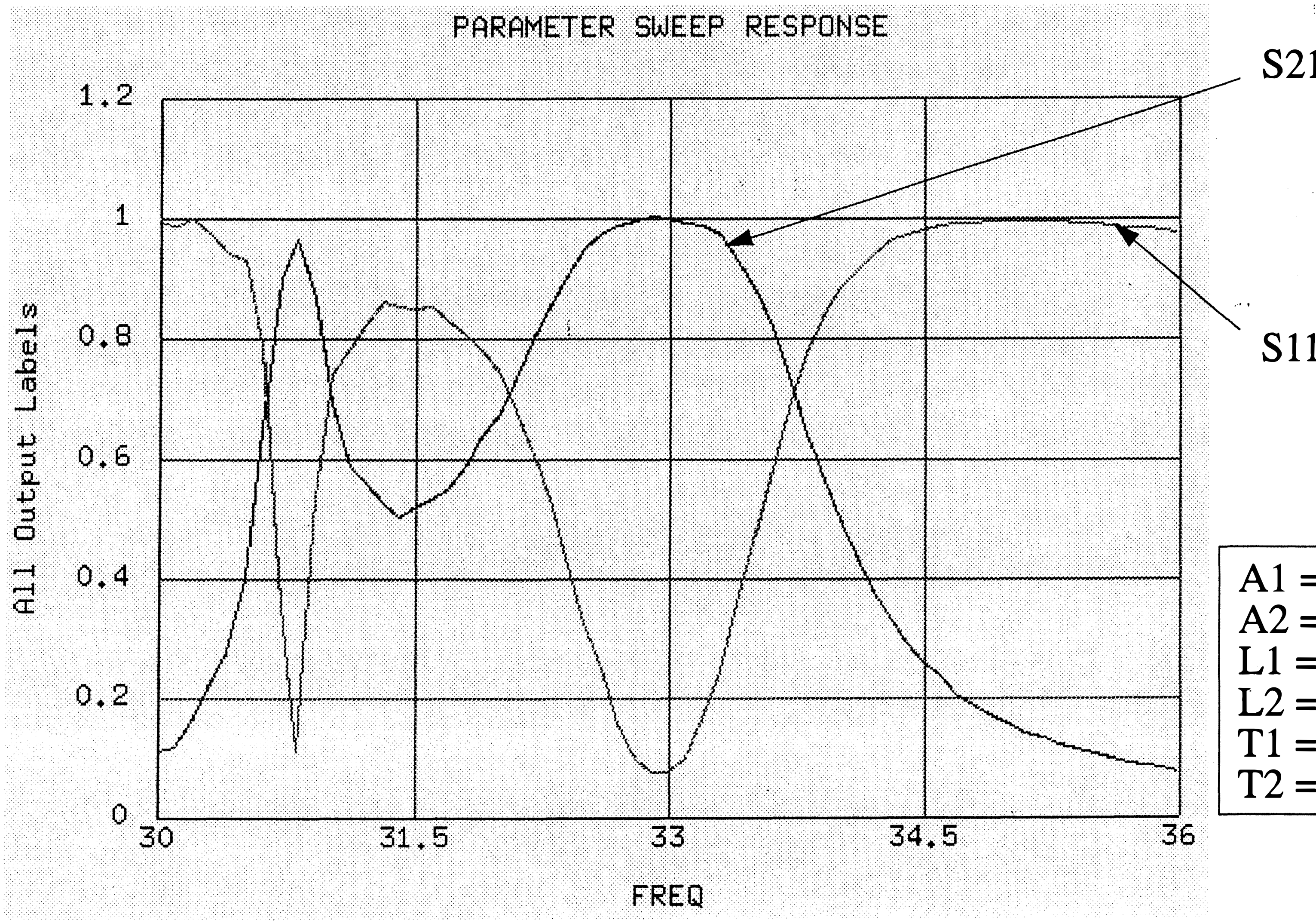
A1 = 10
A2 = 10
L1 = 13
L2 = 11
T1 = 4
T2 = 4

Intermediate Response (30 Iterations)



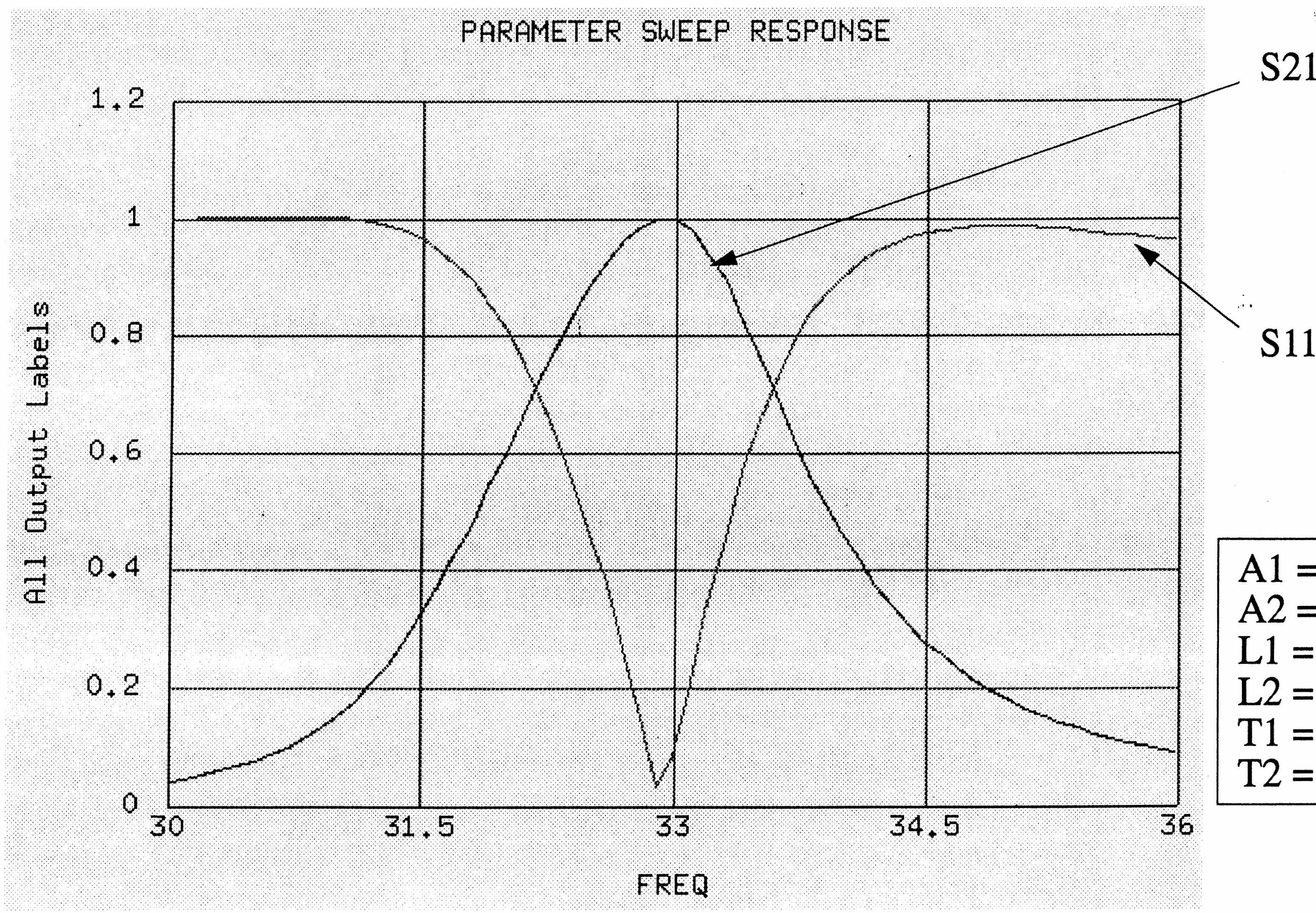
A1 = 13
A2 = 11
L1 = 14
L2 = 13
T1 = 2
T2 = 2

Intermediate Response (60 Iterations)



A1 = 8
A2 = 10
L1 = 15
L2 = 13
T1 = 2
T2 = 1

Optimized Result (180 Iterations)



A1 = 6
A2 = 11
L1 = 15
L2 = 13
T1 = 1
T2 = 1

Some Data of Interest

Computer	CPU time (sec.)
Toshiba T5200/100	6500
IBM Model 90 XP486	1250
DEC RISC Model 5000	352
IBM RS6000 Model 350	117
HP 9000 Serial 700 Model 755	88
DECmpp 12000	12

- Execution time of the TLM field simulation module on various computers. The number of iterations is 4000 and the mesh size is 128×64, which represents a full use of a DECmpp 12000 with 8K of processors.

- DECmpp 12000 is about 7 times faster than HP 9000 Serial 7000 Model 755.

Estimated 3D Requirements

- The difference in simulation speed between our 2D and 3D simulators for a 20×128 mesh is about 4 times.

- The memory requirement for a 3D-TLM simulation is 180K bytes.

- It is possible to use 3D simulation, say for a 10×20×128 mesh, for the previous example; the estimated execution time per iteration and memory requirement would be:

  10×4×34 = 1360 seconds, and

  10×180 = 1800 K bytes.

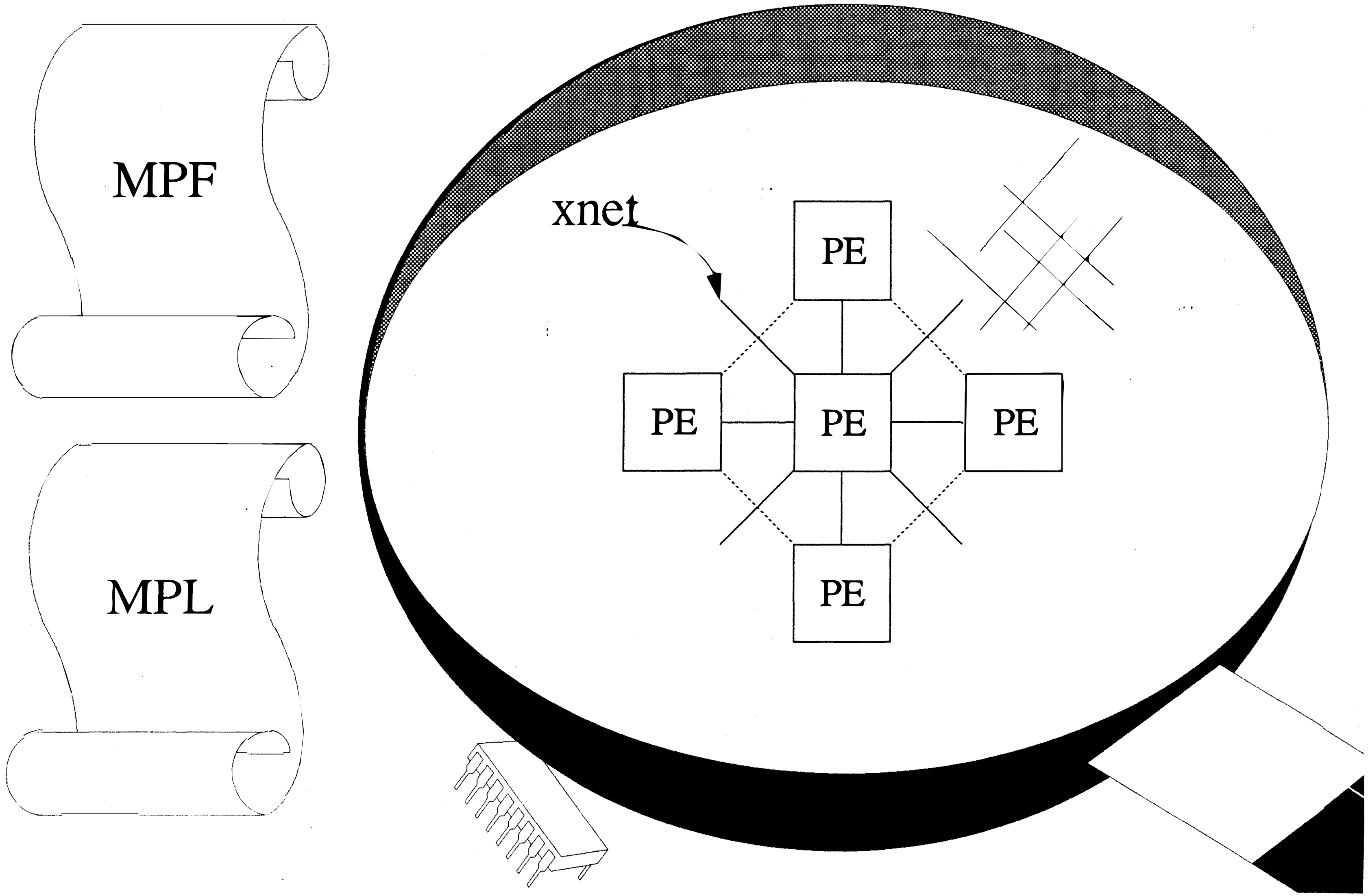
Advantages

- A single time domain field analysis yields information at an arbitrary number of frequency points within the desired bandwidth.
- Band limited excitation can be used to reduce unwanted frequency components with a corresponding gain in computer time, i.e. faster convergence.
- The computer expenditure depends mainly on the size of the computational domain and not on the complexity of the geometry.

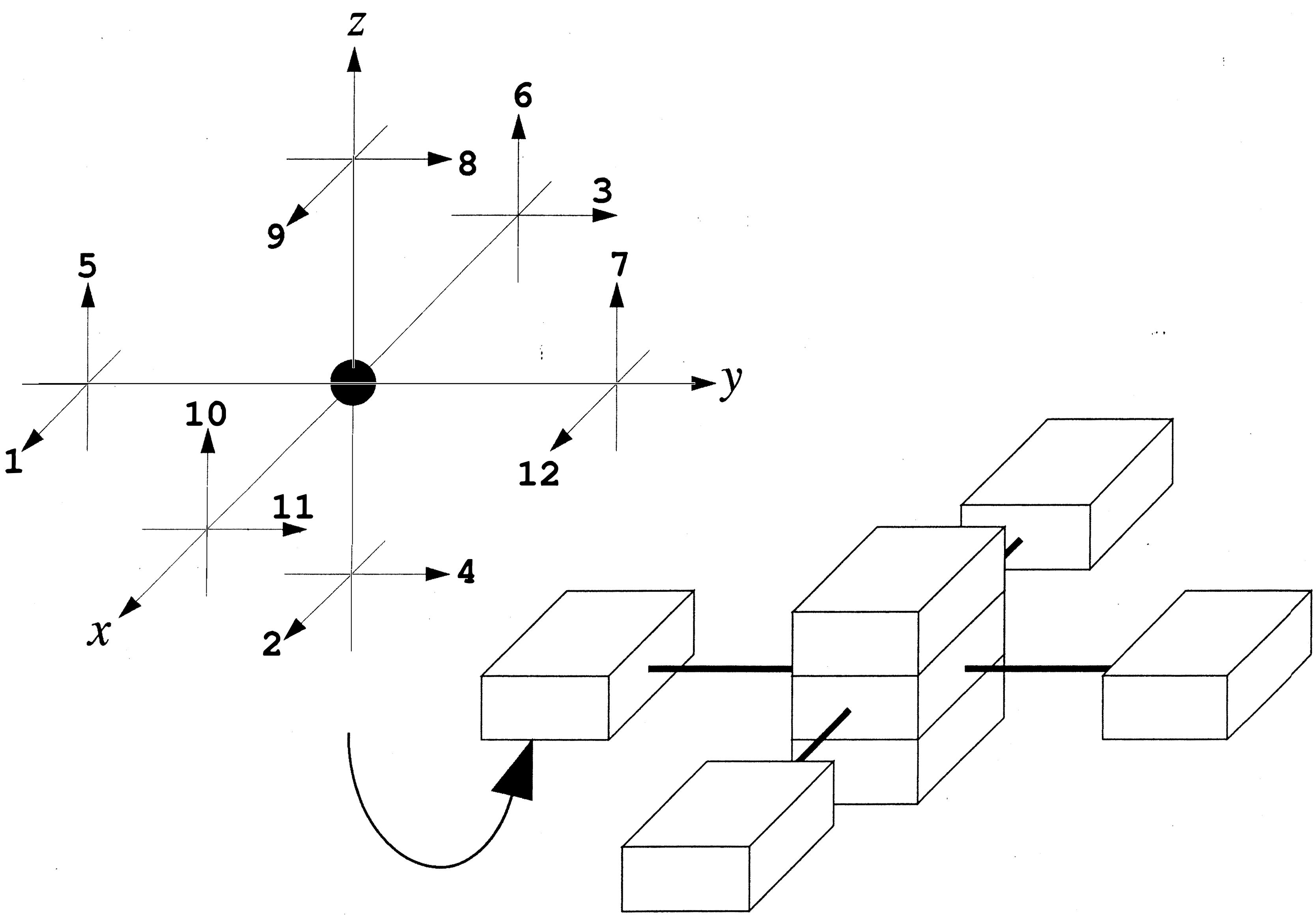
Disadvantages

- Practitioners must grasp both the frequency and time domain concepts.
- There are no standard protocols for pipe communication in CAD/CAM system, which makes porting of the field simulators among them difficult.
- Powerful computers, preferably computers with massively parallel processors, with large amounts of memory and fast CPU are needed to run the field-based simulator.

The DECmpp 12000



3D-TLM Mesh

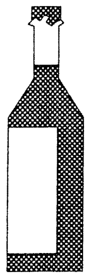


3D-TLM Transfer Algorithm

Parallel

```
for (z=0;z<z_size;z++){
  if (node[z].rx==NULL_REFL){
    swap(node[z].v6,xnetW[1].node[z].v10);
    swap(node[z].v3,xnetW[1].node[z].v11);
  }
  if (node[z].ry==NULL_REFL){
    swap(node[z].v5,xnetN[1].node[z].v7);
    swap(node[z].v1,xnetN[1].node[z].v12);
  }
  if (node[z].rZ==NULL_REFL){
    swap(node[z].v8,node[z+1].v4);
    swap(node[z].v9,node[z+1].v2);
  }
}
```

DECmpp 12000 Constraints



- The DECmpp 12000 must be driven by a DEC station front-end. Hence OSA90/hope must communicate with the DECmpp 12000 via internet. This is a bottle neck for small to medium size problems.

- The dimensions of the problem must fit the dimension of the processor array in order to realize the machine's full computing power.

- Researchers must re-write the CPU time intensive serial algorithms into parallel ones.

Conclusion

- Successful linking of time domain electromagnetic field simulator (TLM) with a frequency domain CAD program (OSA90/hope) via datapipe has been demonstrated.
- The network piping feature allows OSA90/hope to control the TLM simulators which may run on massively parallel computers or workstations.
- The computational effort required for time domain simulation is larger than that for a specialized frequency domain simulator, however, it is independent of the geometrical complexity and offers considerably more flexibility. Further work is directed towards development of a more efficient TLM-Pipe software.

Any Questions?