Proiect

2025/2026

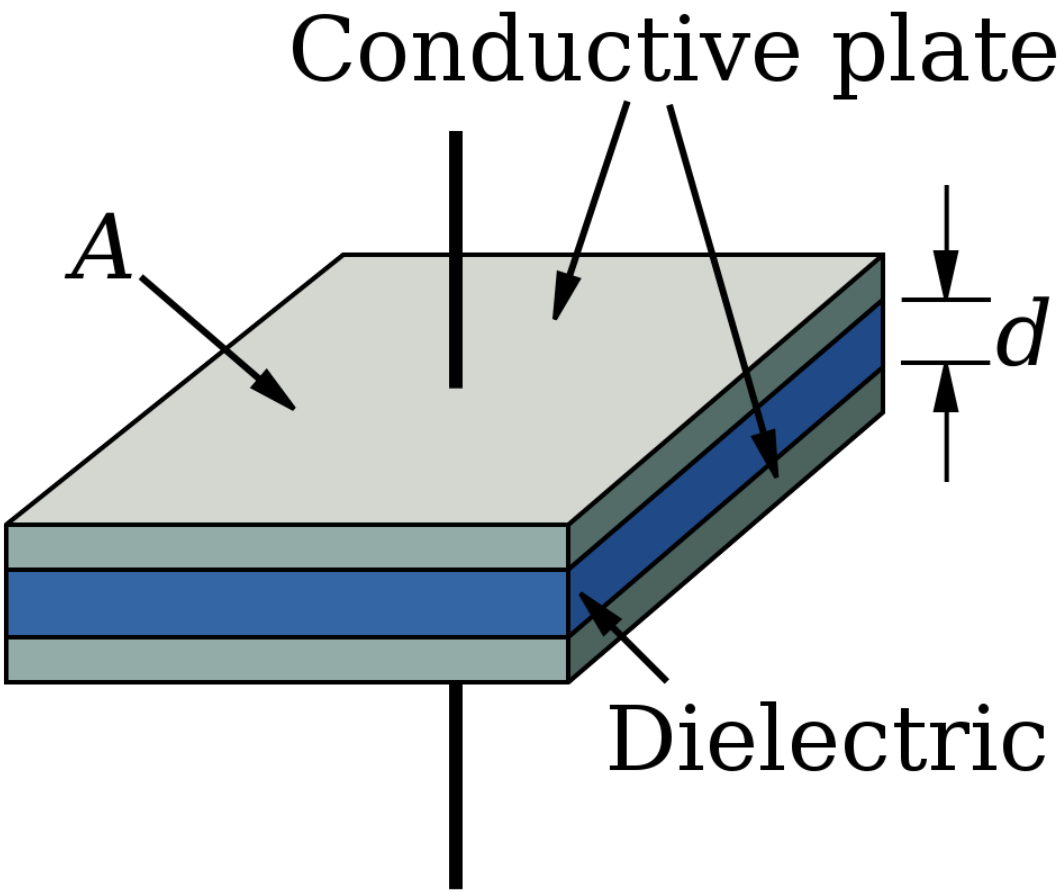
Circuite Integrate Monolitice pentru Microunde

Tema proiect

individuala

Condensator planar

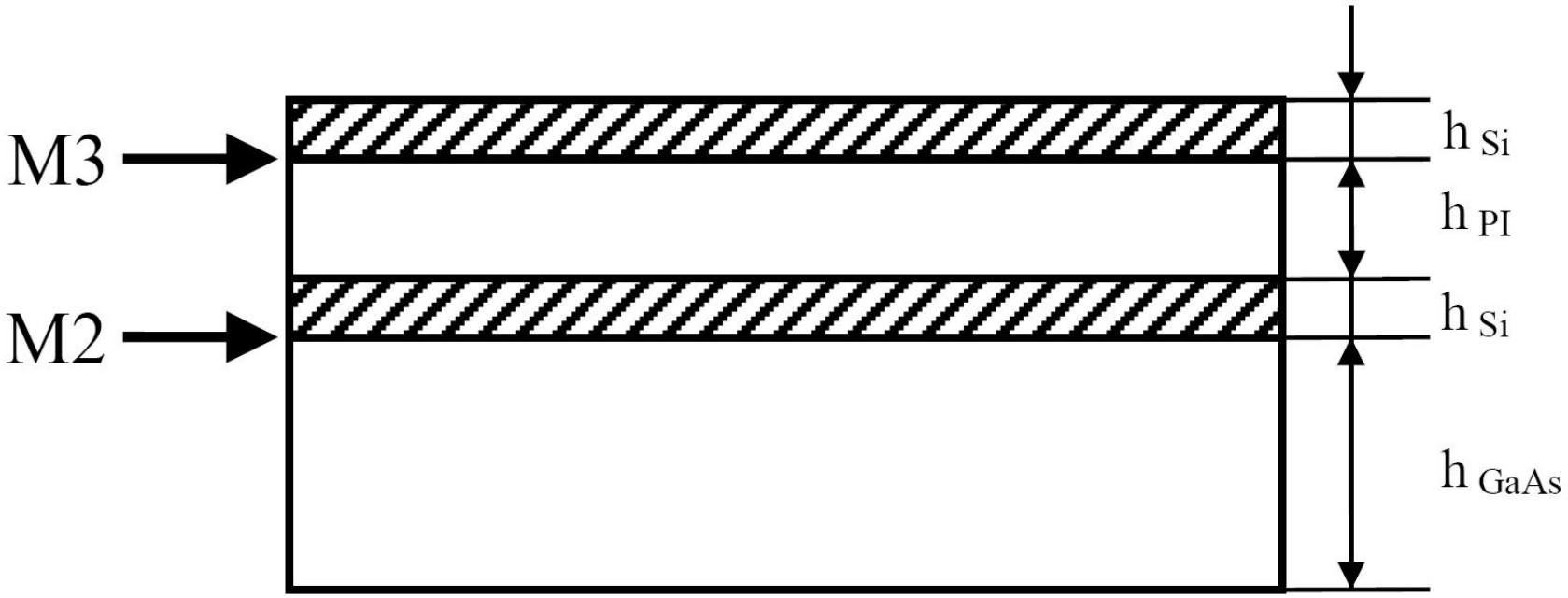
- doua armaturi plane paralele



$$C = \frac{\varepsilon \cdot A}{d}$$

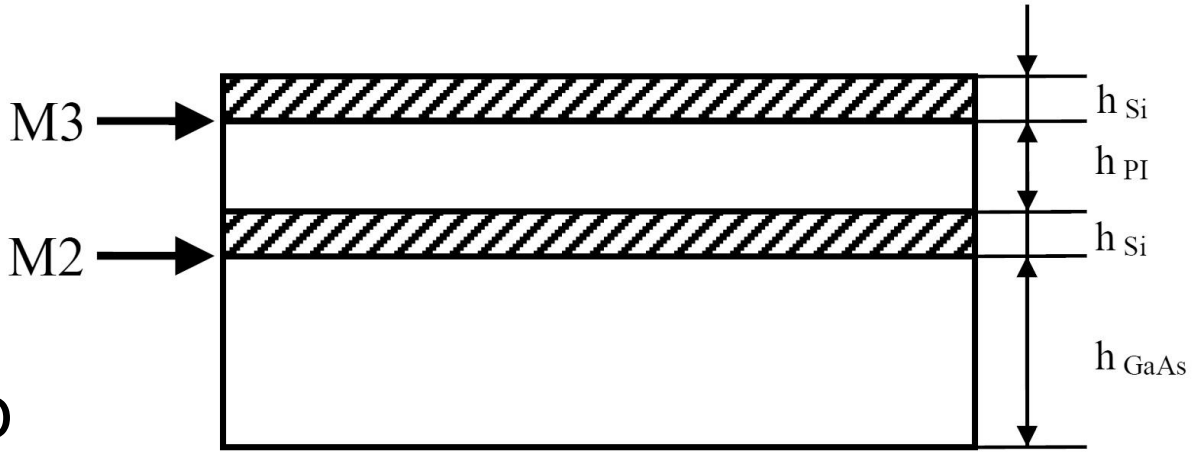
Realizare

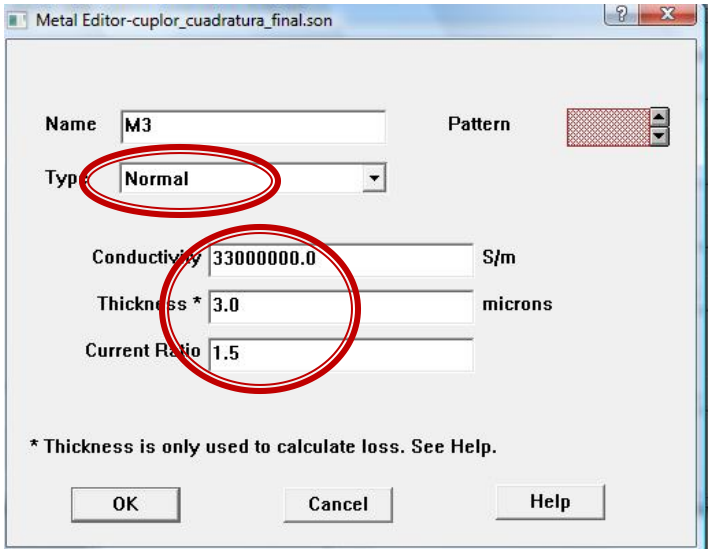
- structura tehnologiei (foundry) Plessey



Modelare

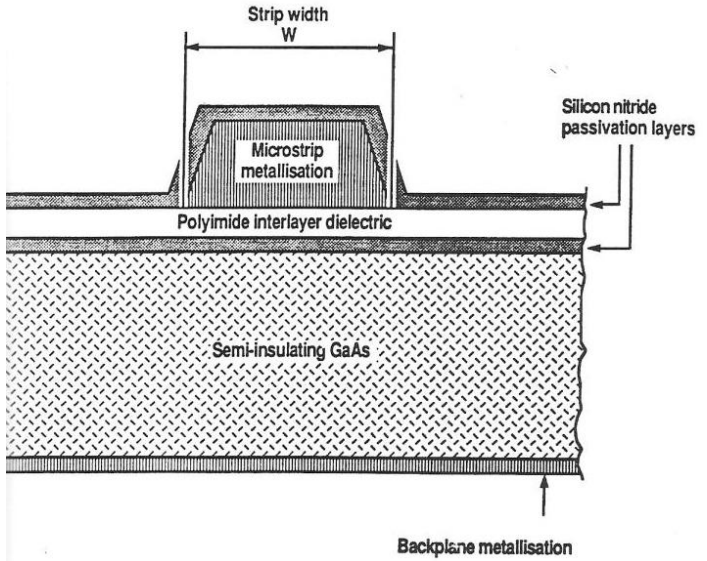
- Structuri
  - cu 3 straturi
  - cu 5 straturi
- Metalizare h=0
  - Ideal
  - Normal

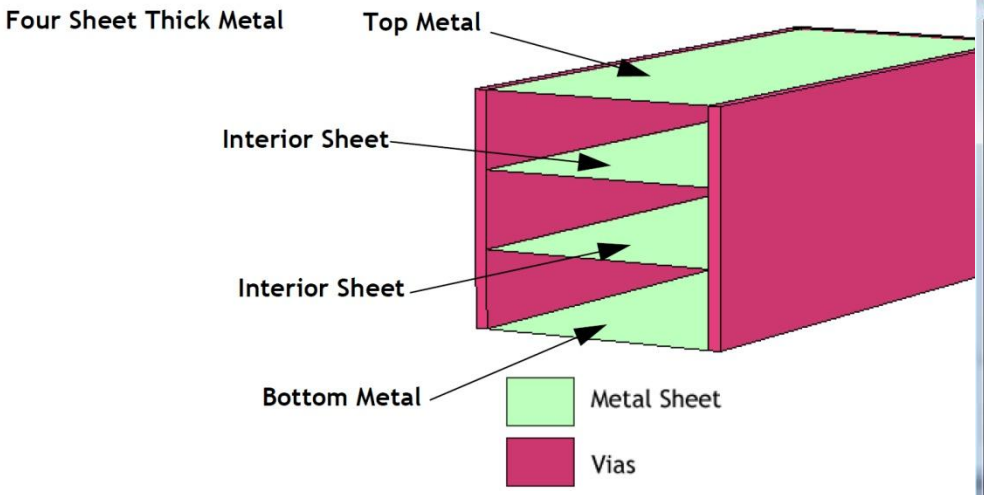


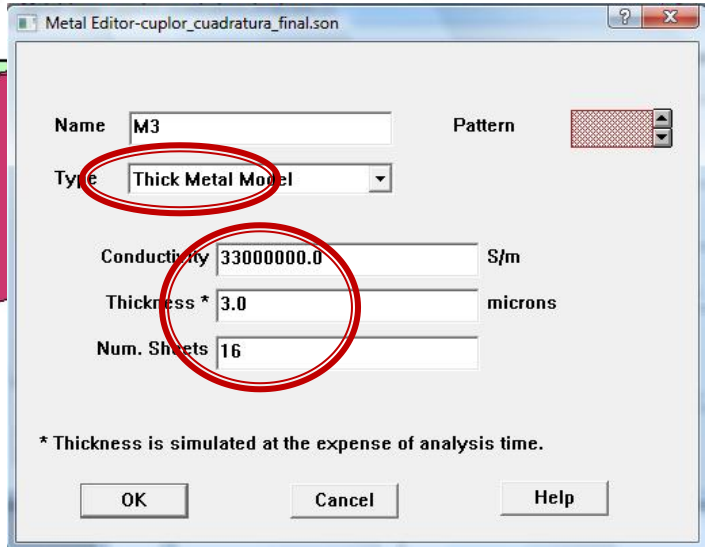


Modelare supliment

- Structuri
  - cu 9 straturi
- Metalizare h≠0
  - Thick

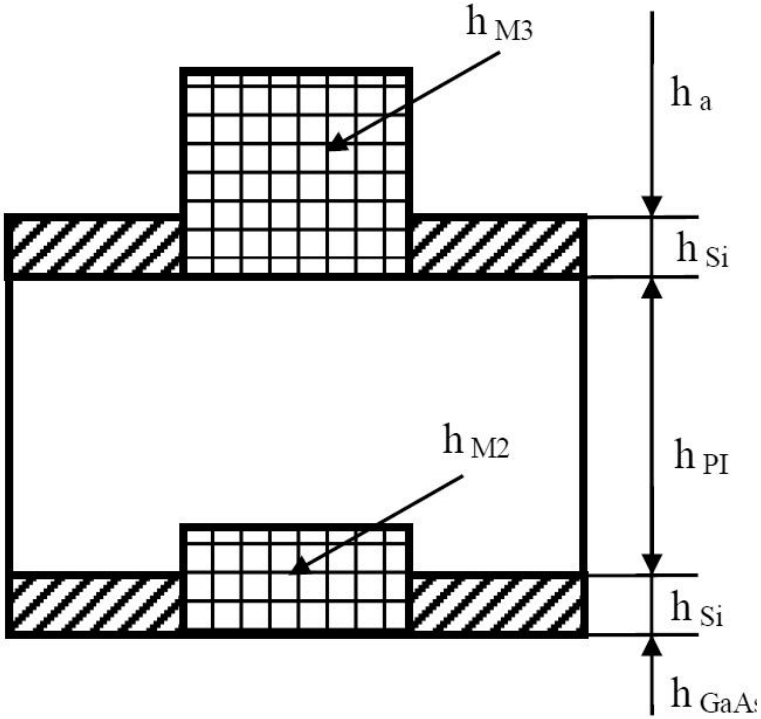


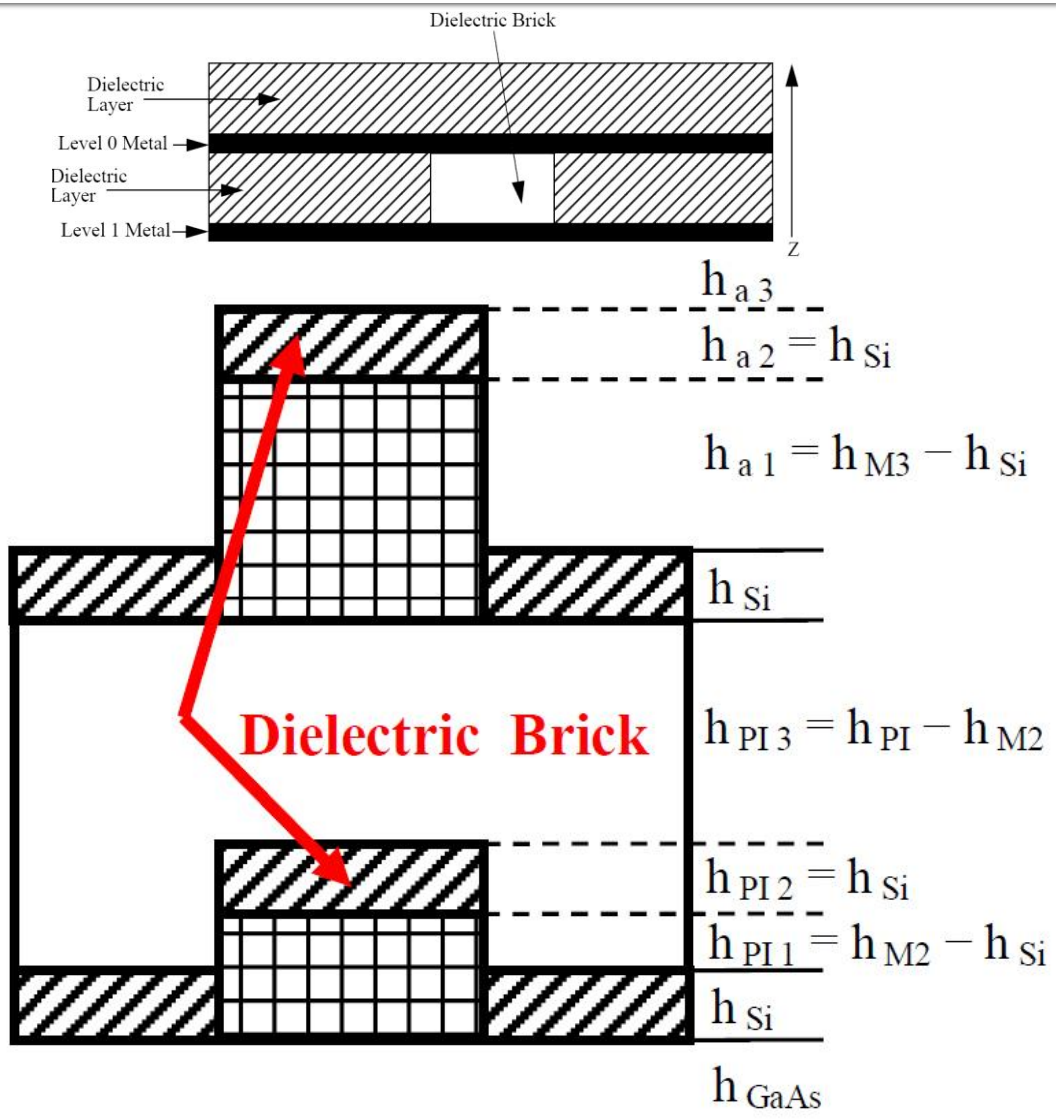




Modelare supliment

- Structuri
  - cu 5 -> 9+ straturi





Parametri

Nr.	Material	ε_r	tan δ	σ[S/m]	R_{sq}[mΩ/sq]	h[μm]
1	GaAs	12.85	$0.3 \cdot 10^{-3}$			200
2	Si_3N_4	7.2	$15 \cdot 10^{-3}$			0.13
3	PI	3.4	$55 \cdot 10^{-3}$			1.8
4	M2			$3.6 \cdot 10^{7}$	55	0.5
5	M3			$3.3 \cdot 10^{7}$	10	3

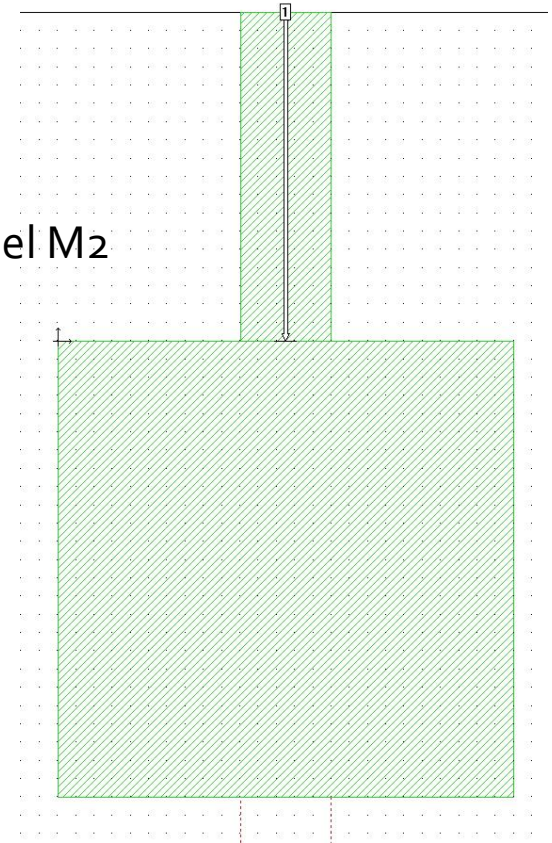
$$R = \frac{\rho \cdot l}{S} = \frac{l}{\sigma \cdot w \cdot h} = \frac{1}{\sigma \cdot h} \cdot \frac{l}{w} = R_{sq} \cdot \frac{l}{w} \qquad l = w \rightarrow R = R_{sq}$$

Simulare

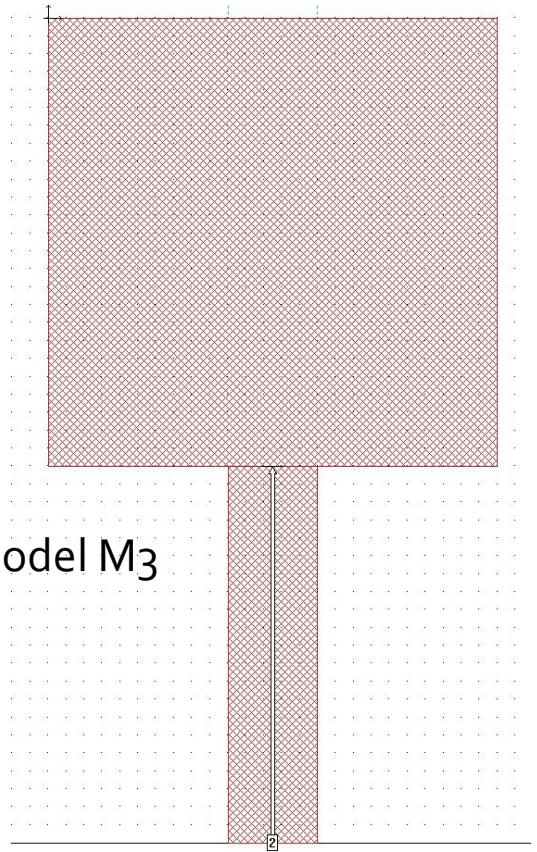
Modelare

- Linii de 50Ω
- Reference plane

Model M2

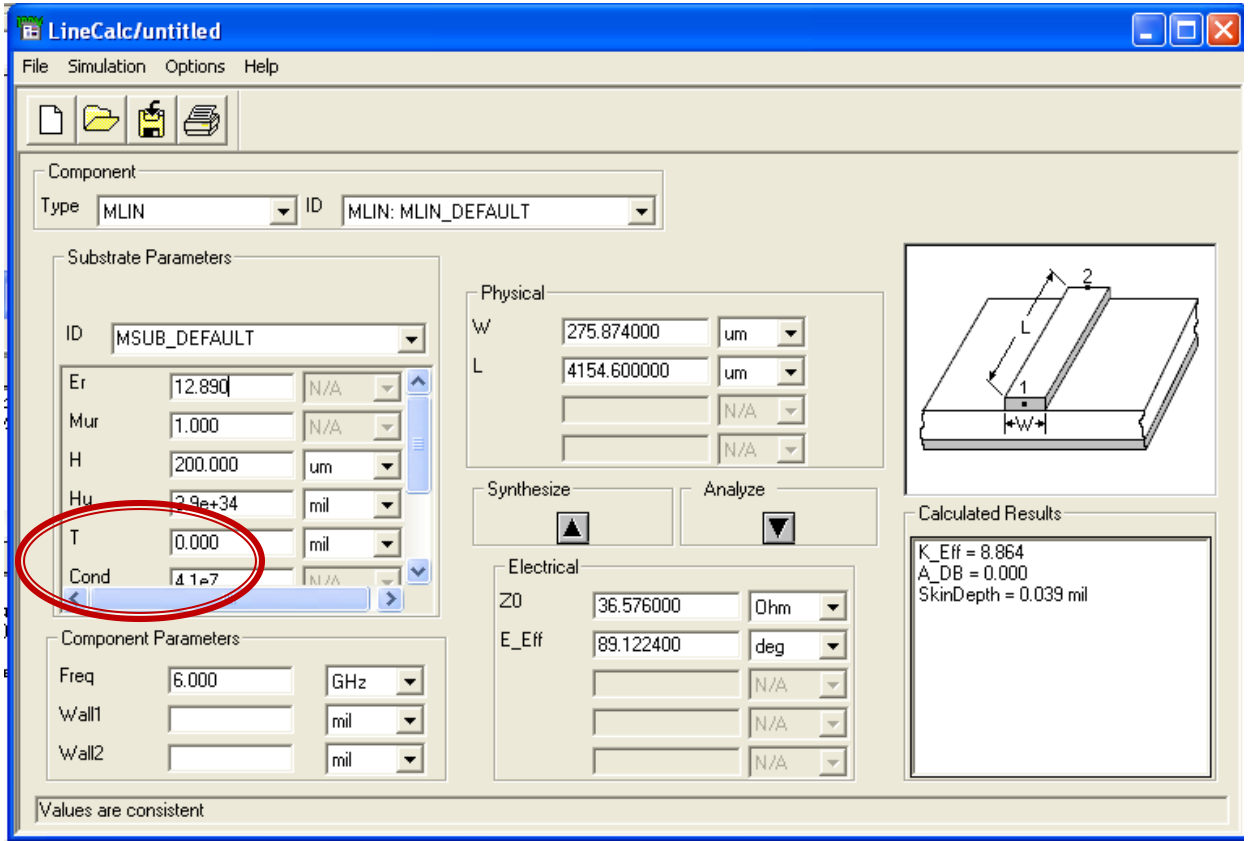


Model M3



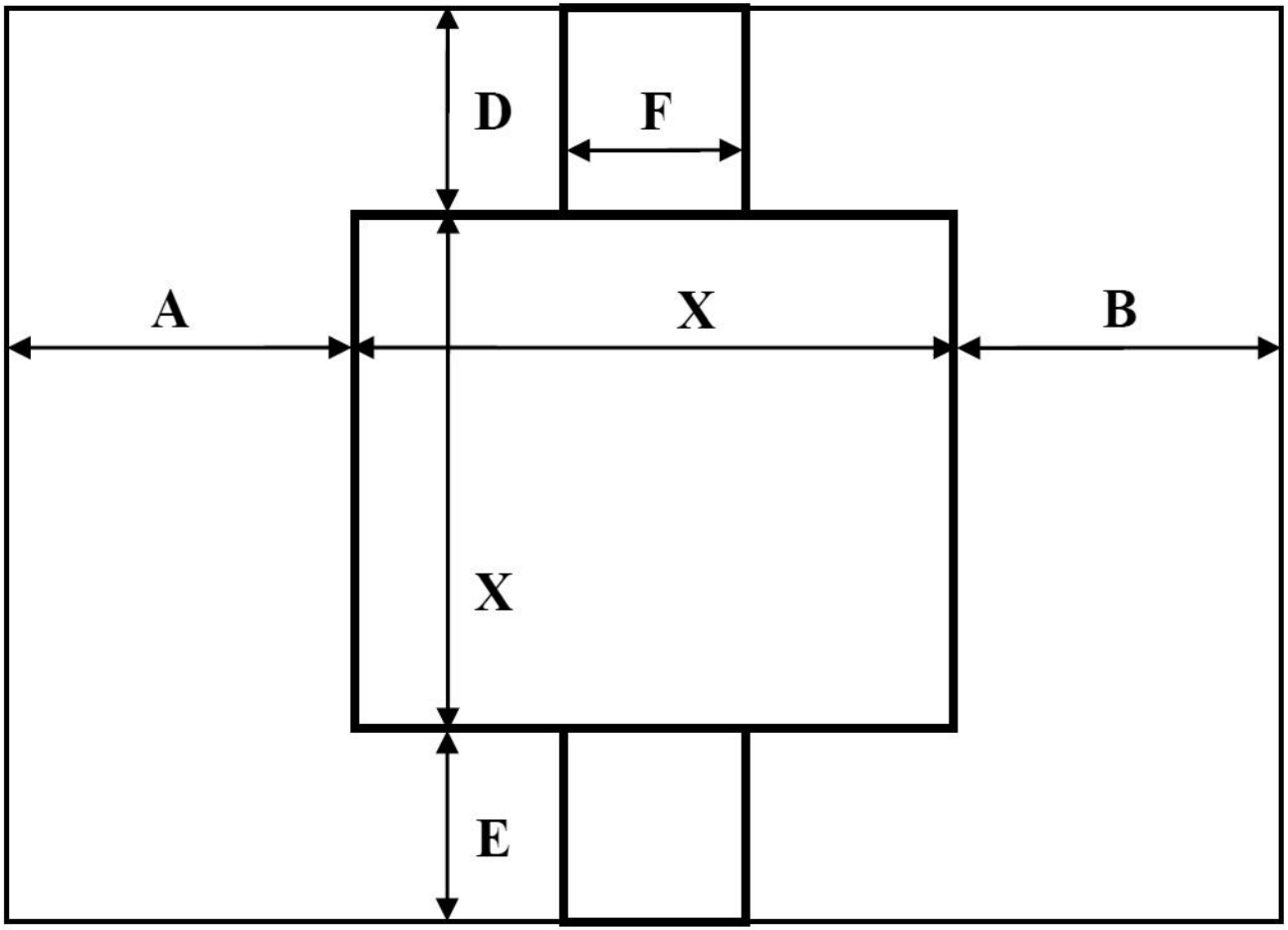
Modelare

- Linii de 50Ω -> Linecalc
- Thickness/Conductivity



Dimensionare

- Box Size/Cell Size



$$X = m \cdot \Delta x$$

$$X = n \cdot \Delta y$$

$$\Delta x = \Delta y$$

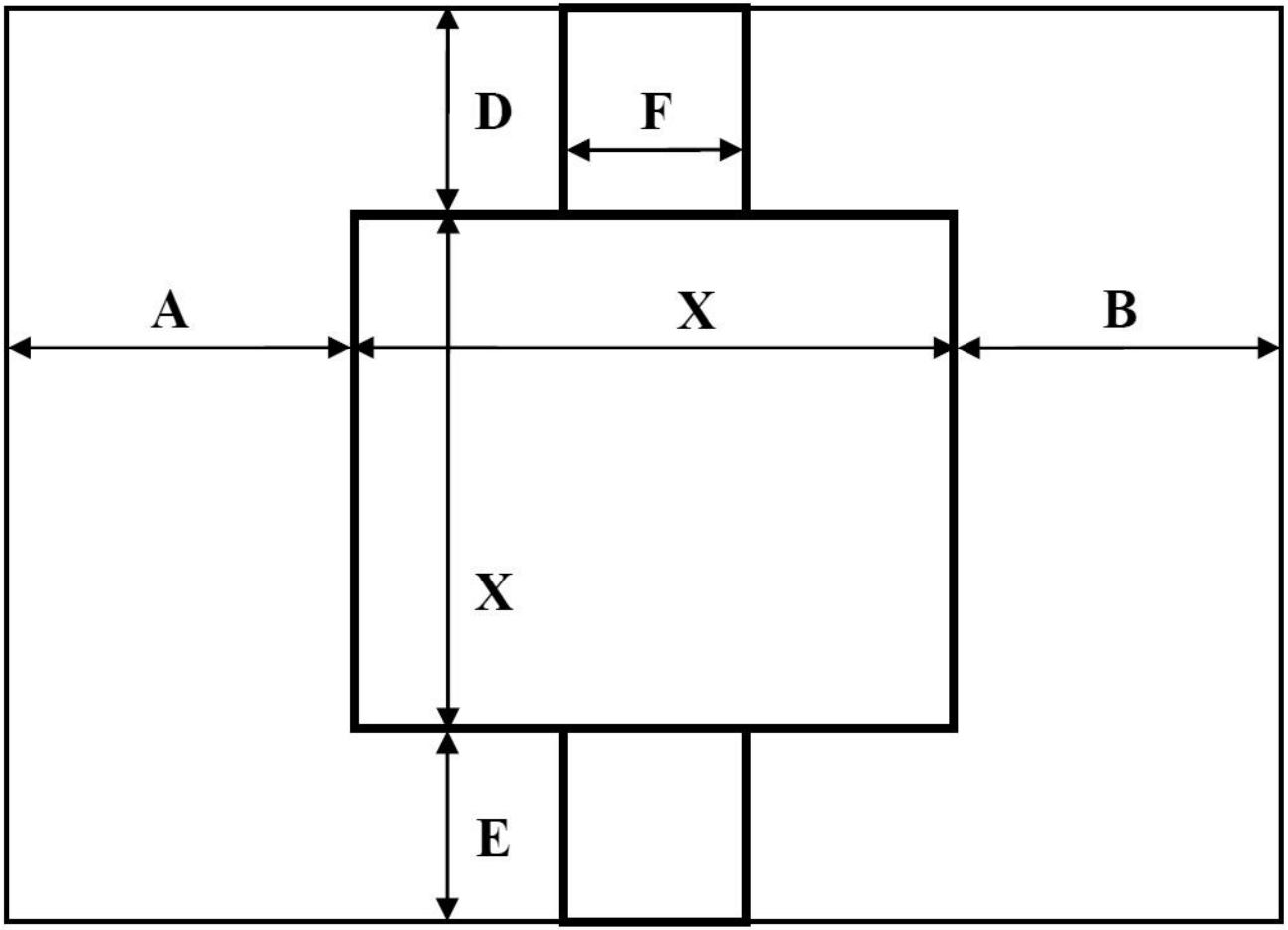
$$m = n = 2^p$$

$$W = H = 2 \cdot X$$

$$W = H = 2^{p+1} \cdot \Delta x$$

Dimensionare

- Box Size/Cell Size



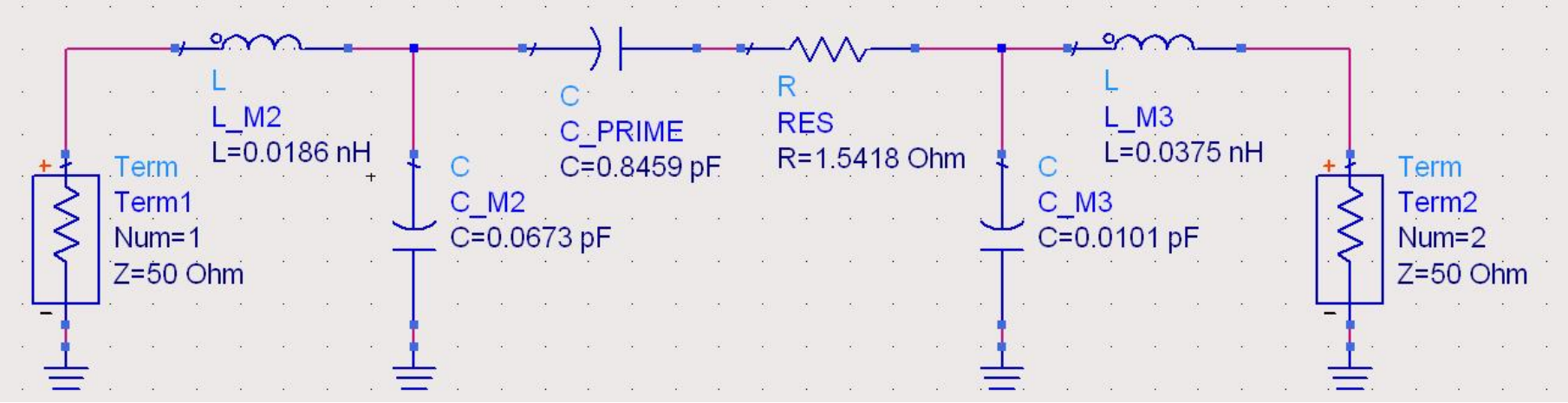
$$F \approx s \cdot \Delta x$$
$$\Delta x = \Delta y$$

$$F \neq s \cdot \Delta x$$
$$\Delta x = \Delta y / 2,4,8$$

Circuit echivalent

Circuit echivalent

- Sonnet ofera parametrii S
- Schema echivalenta e schema care ofera aceeasi parametri S
- ~~Curs~~: Schema + Relatii de calcul valori



Valori initiale

Valorile elementelor din model pot fi calculate cu formule furnizate de producator, în functie de dimensiunile layout-ului. În cazul acestui condensator dimensiunea considerată este lungimea armăturii de pe metalizarea M2, exprimată în µm.

Formulele pentru C_prime, RES, C_M2 şi C_M3 sunt polinoame de forma :

$$y = ax^n + b \tag{1.1}$$

Unde x este dimensiunea layout, iar valorile coefcienţilor sunt în tabelul 1.

Tabelul 1

y	C_Prime(pF)	RES(Ω)	C_M2(pF)	C_M3(pF)
a	2.81417×10^{-5}	310156	1.982851×10^{-5}	3.262996×10^{-7}
n	1.943606	-2.424696	1.521669	1.884238
b	0.010967	0.724728	4.343976×10^{-3}	2.981967×10^{-3}

Valori initiale

Formulele pentru L_M2 şi L_M3 sunt polinoame de gradul 5 :

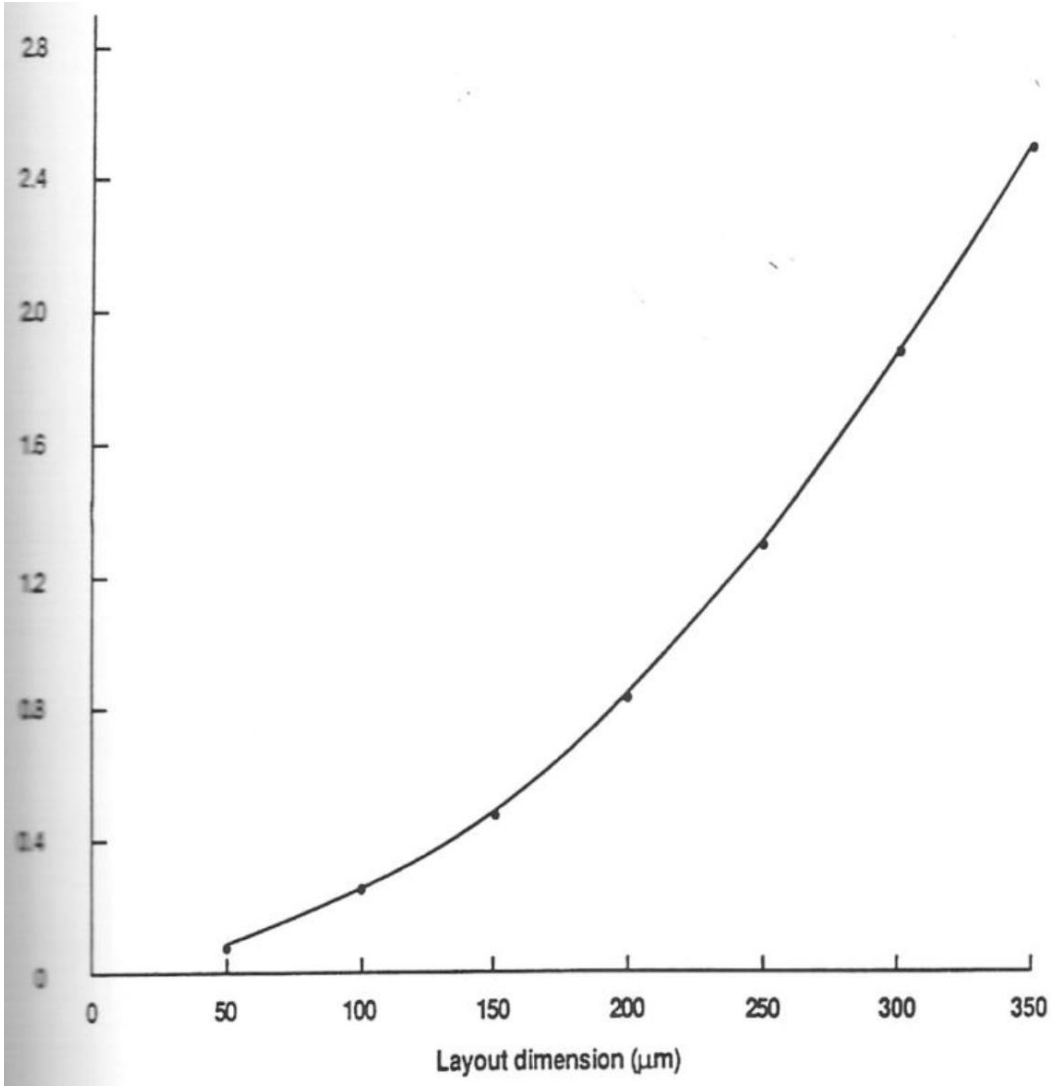
$$y = ax^5 + bx^4 + cx^3 + dx^2 + ex + f \qquad (1.2)$$

Unde x este din nou dimensiunea layout, în microni, iar coeficientii sunt daţi în tabelul 2.

Tabelul 2

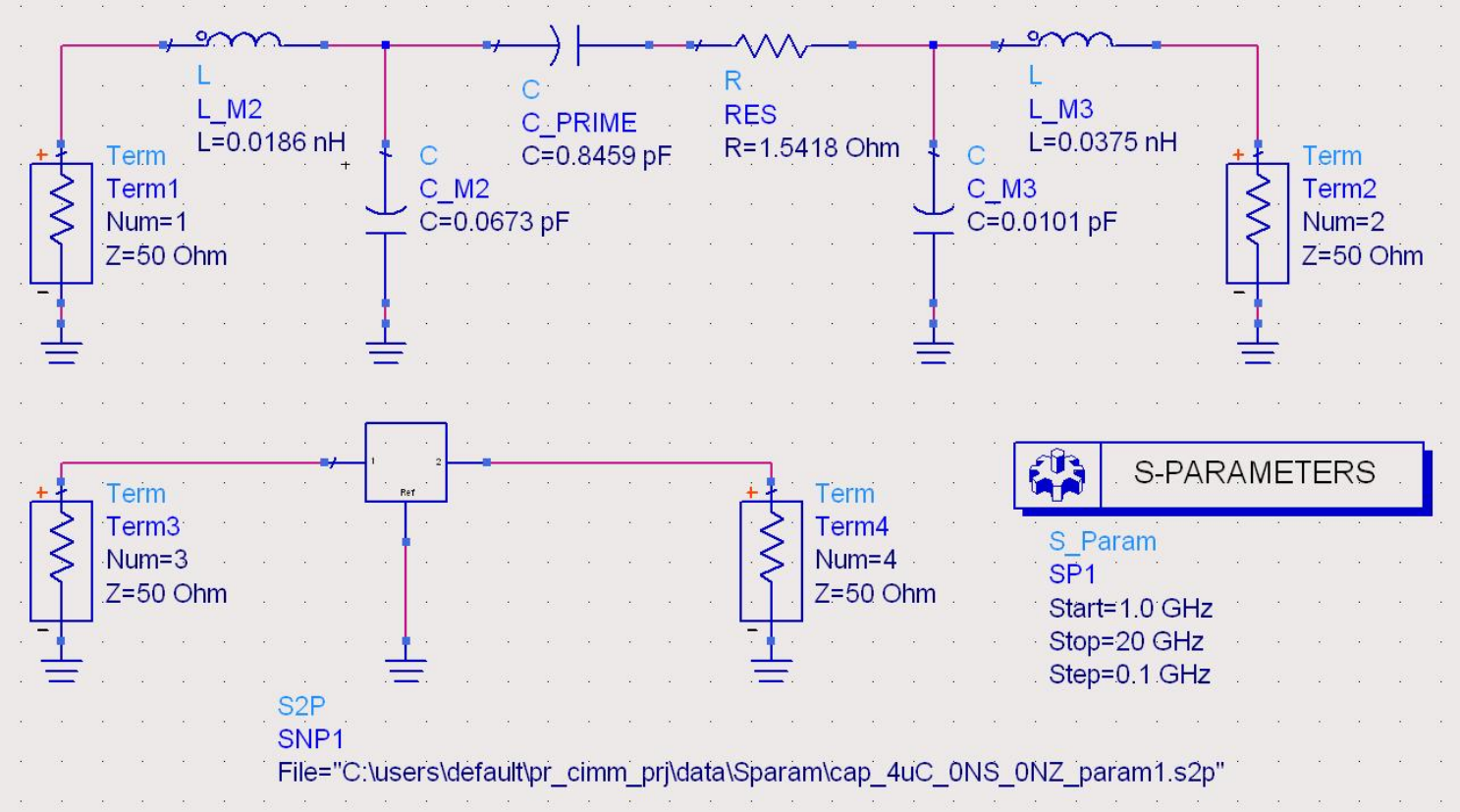
y	L_M2(nH)	L_M3(nH)
a	1.199327×10^{-13}	7.223189×10^{-14}
b	$-1.425209 \times 10^{-10}$	$-1.086451 \times 10^{-10}$
c	5.925084×10^{-8}	5.791041×10^{-8}
d	-9.977216×10^{-6}	-1.352713×10^{-5}
e	7.61417×10^{-4}	1.548175×10^{-3}
f	-0.018913	-0.043643

Capacitate [pF]



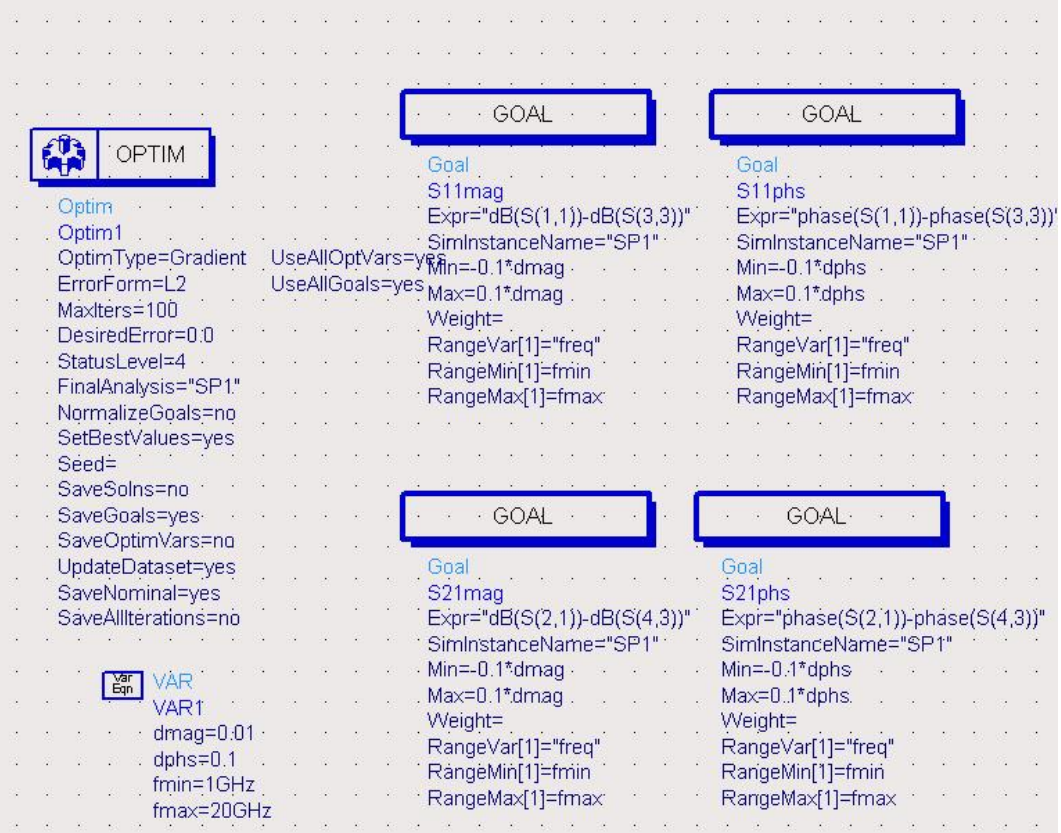
Circuit echivalent

- Optimizare in ADS pentru suprapunerea intre parametrii S pentru schema si parametrii S obtinuti (export) din Sonnet



Optimizare

- Optimizare in ADS pentru suprapunerea intre parametrii S pentru schema si parametrii S obtinuti (export) din Sonnet



Optimizare

- Optimizare in ADS pentru suprapunerea intre parametrii S pentru schema si parametrii S obtinuti (export) din Sonnet

Var Eqn

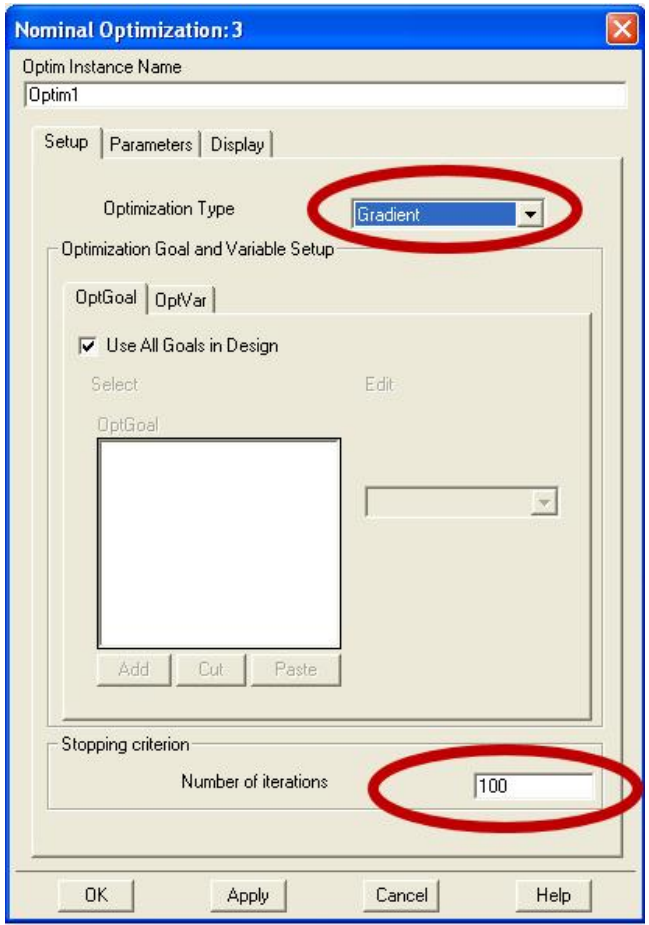
```
VAR
VAR1
dmag=0.001
dphs=0.01
fmin=1GHz
fmax=20GHz
```

GOAL

```
Goal
S21mag
Expr="dB(S(2,1))-dB(S(4,3))"
SimInstanceName="SP1"
Min=-1*dmag
Max=dmag
Weight=
RangeVar[1]="freq"
RangeMin[1]=fmin
RangeMax[1]=fmax
```

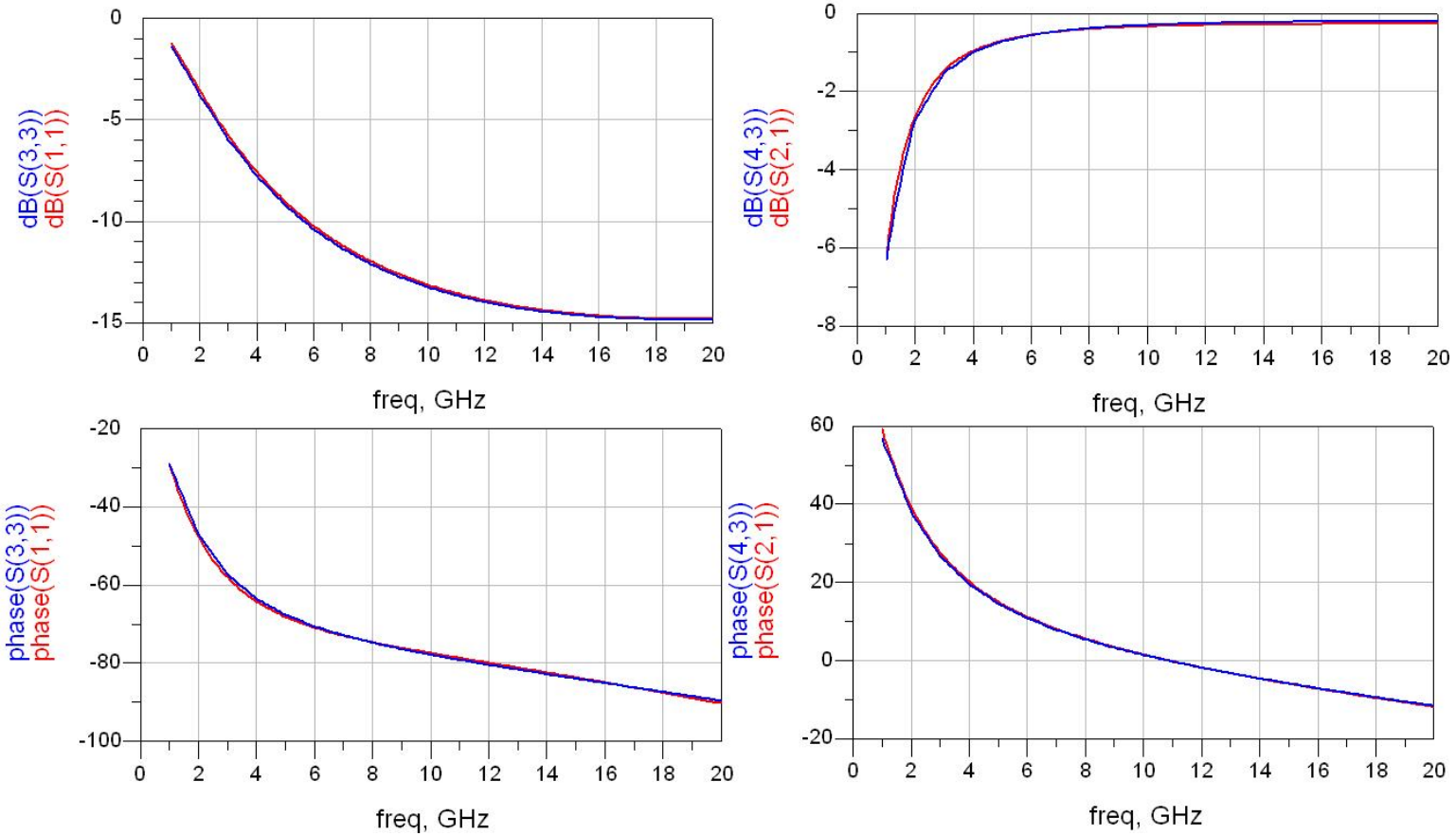
GOAL

```
Goal
S21phs
Expr="phase(S(2,1))-phase(S(4,3))"
SimInstanceName="SP1"
Min=-1*dphs
Max=dphs
Weight=
RangeVar[1]="freq"
RangeMin[1]=fmin
RangeMax[1]=fmax
```



Circuit echivalent

- Suprapunerea **trebuie** sa tina cont de fapttul ca sunt numere complexe: modul / faza

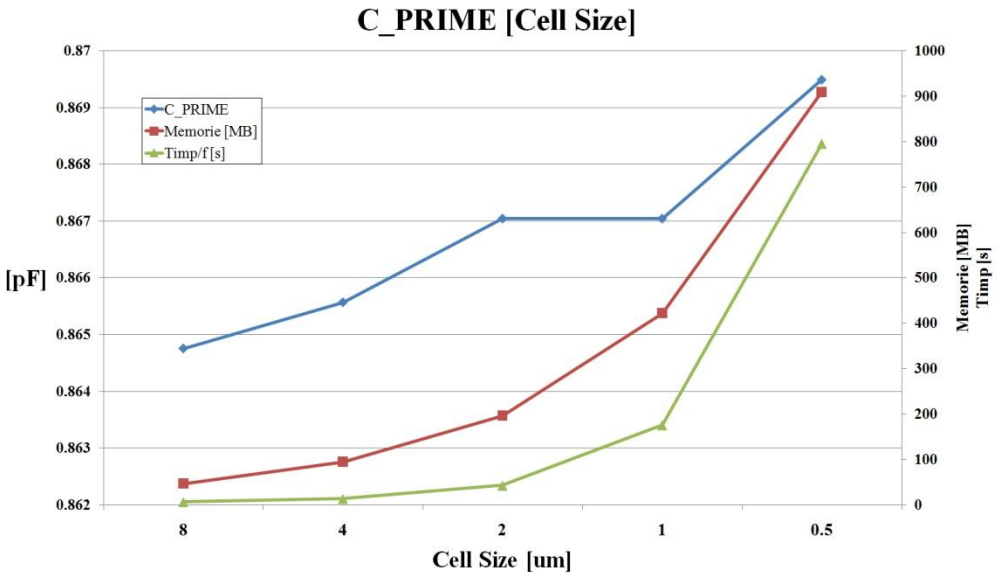


Convergenta

Convergenta

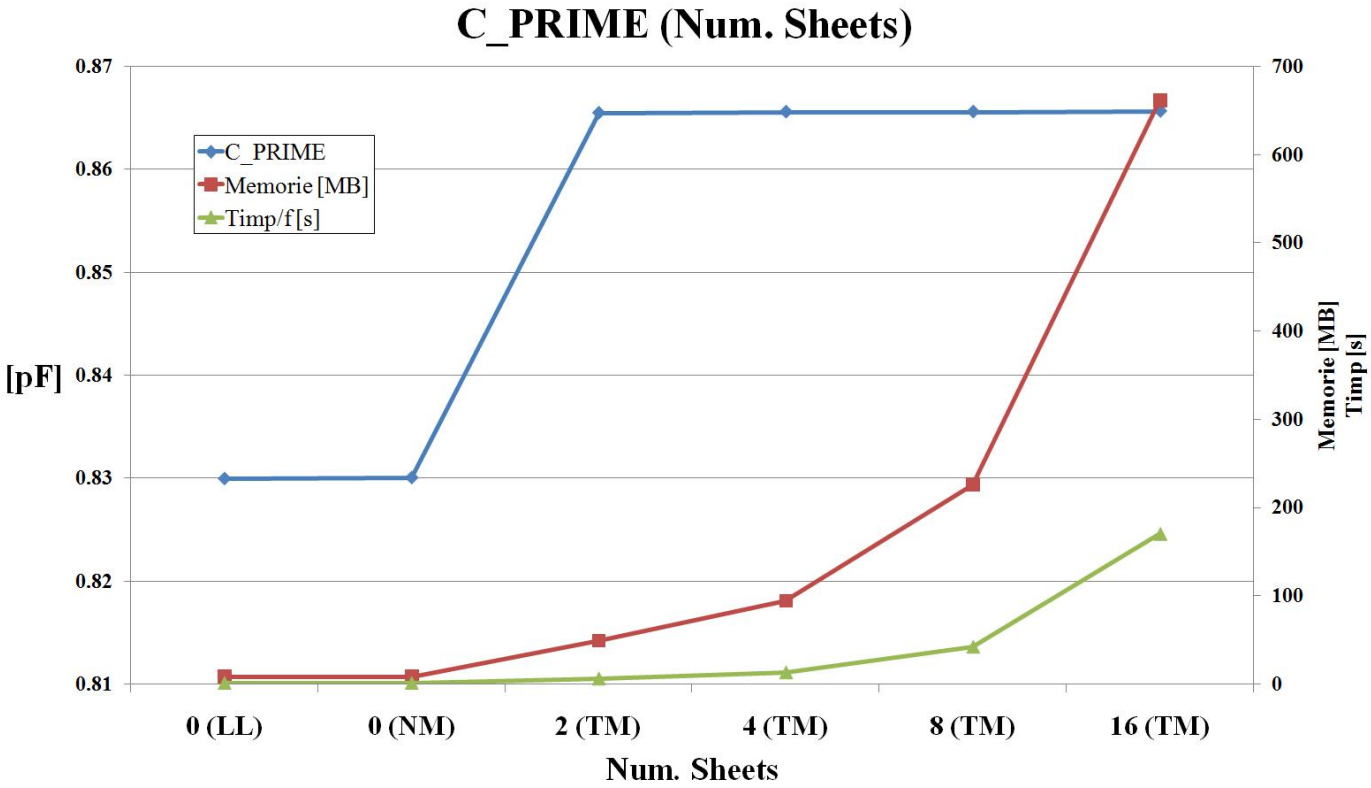
- Controlati cum se modifica elementele din schema (C_{PRIME}) la modificarea celulei
- Macar 3 pasi necesari pentru nota maxima

$$\Delta x, \frac{\Delta x}{2}, \frac{\Delta x}{4}, \frac{\Delta x}{8} \ldots$$



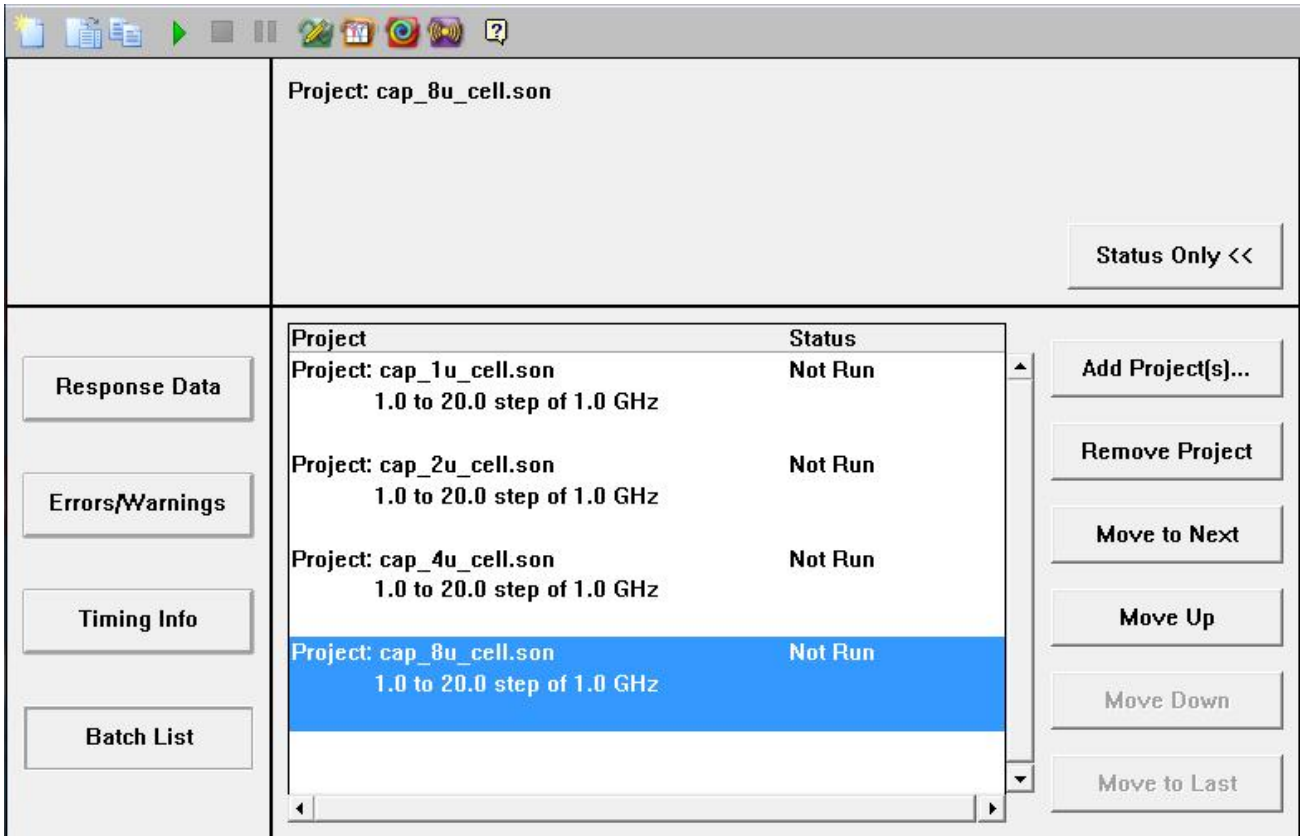
Exemplu

- Afisat si necesarul de timp/memorie
- Analizele cu detalii suplimentare necesita timp (**de calcul**) semnificativ mai mare (exponential/putere)



Calcul automat

- Utilizarea “Batch List” pentru rularea succesiva a mai multor simulari cand calculatorul este neutilizat



Contact

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