

Proiect

2025/2026

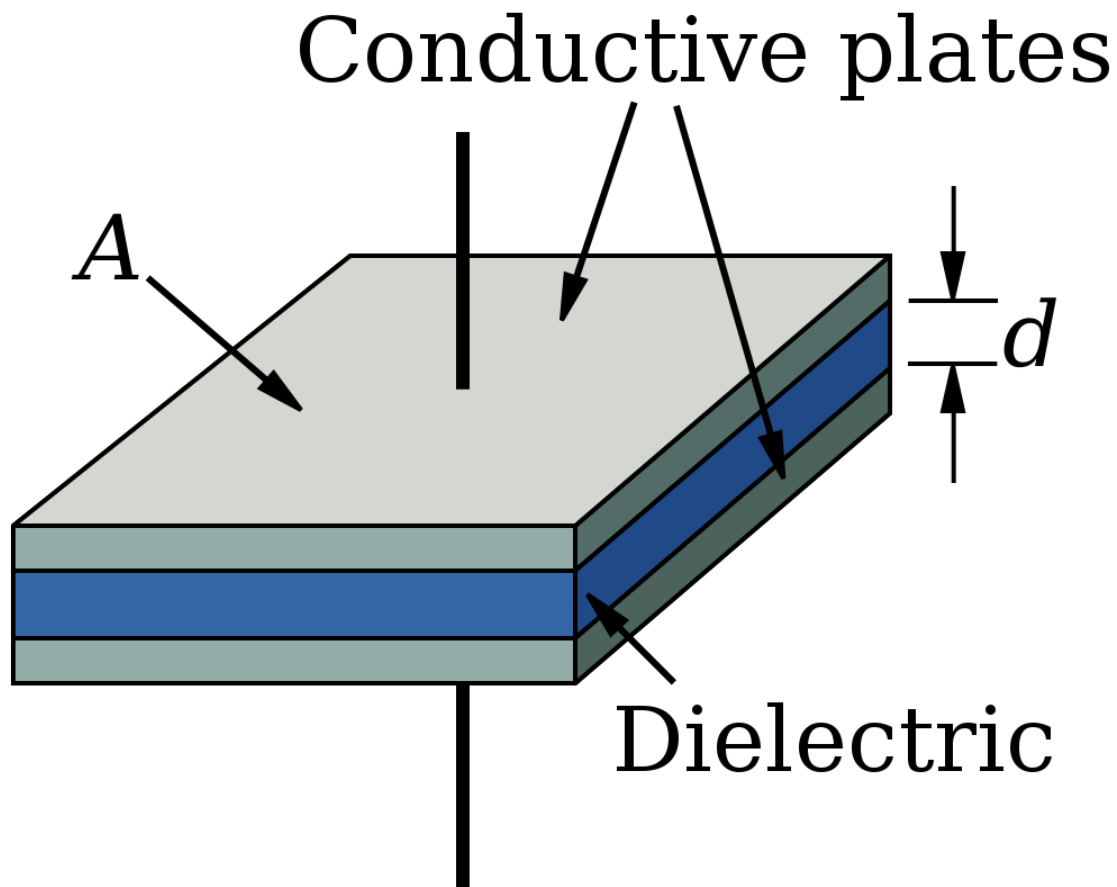
Circuite Integrate Monolitice pentru Microunde

Tema proiect

individuala

Condensator planar

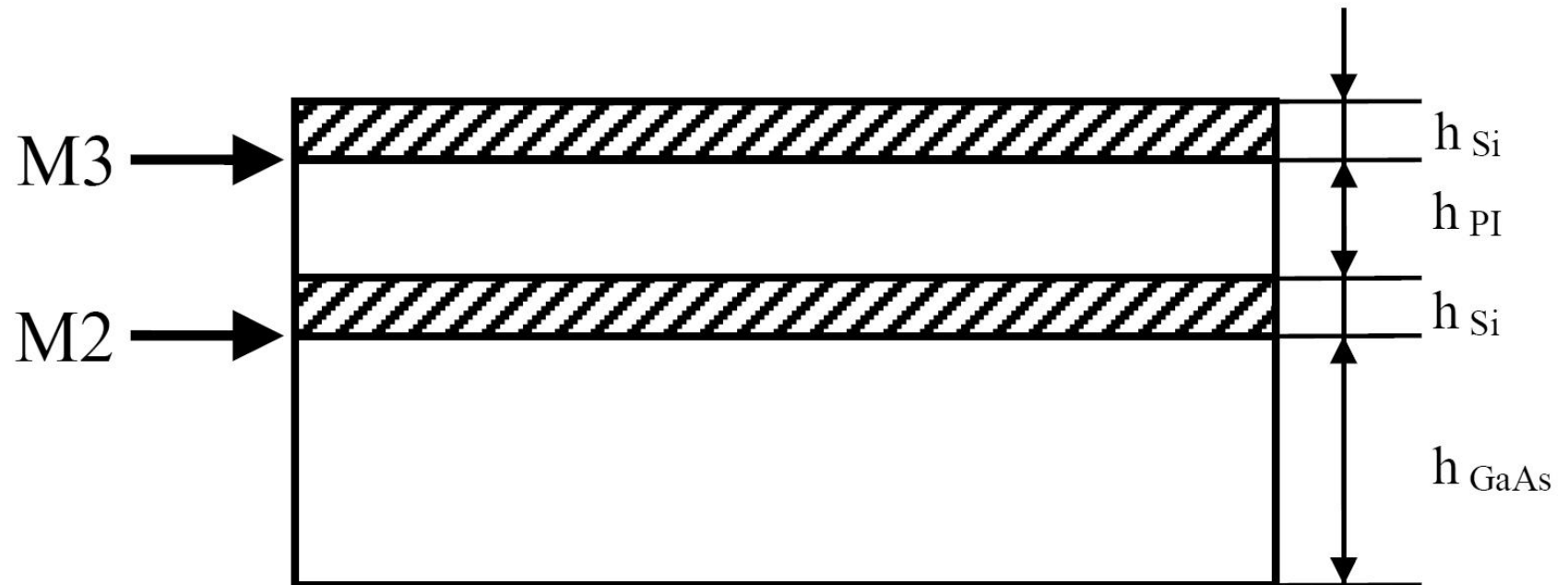
- doua armaturi plane paralele



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

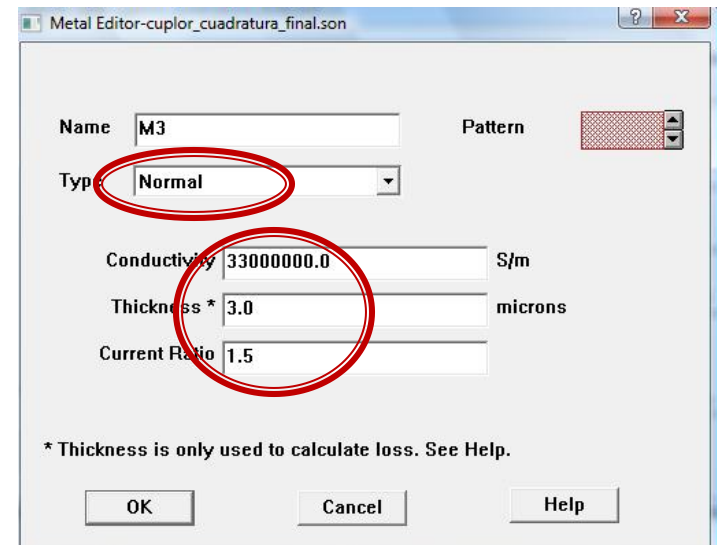
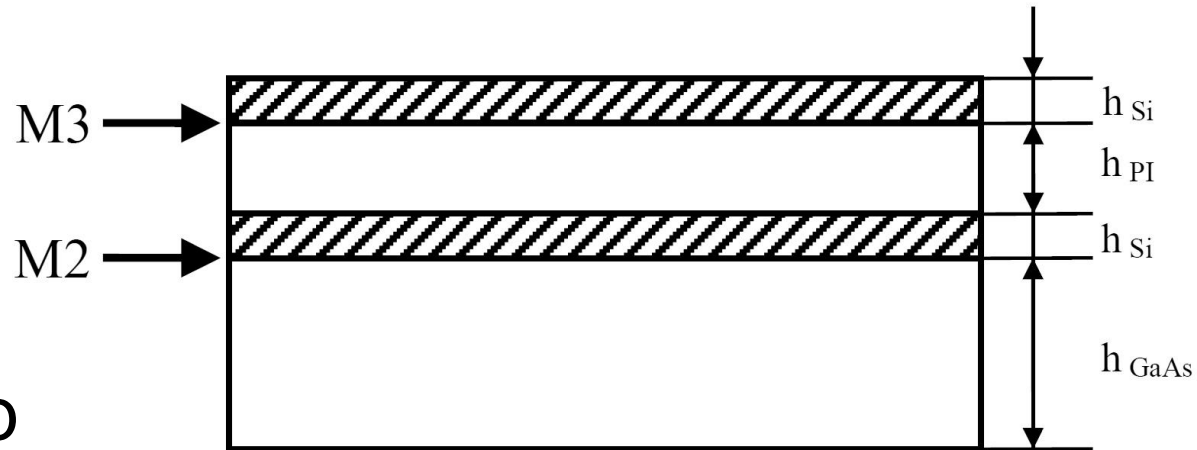
Realizare

- structura tehnologiei (foundry) Plessey



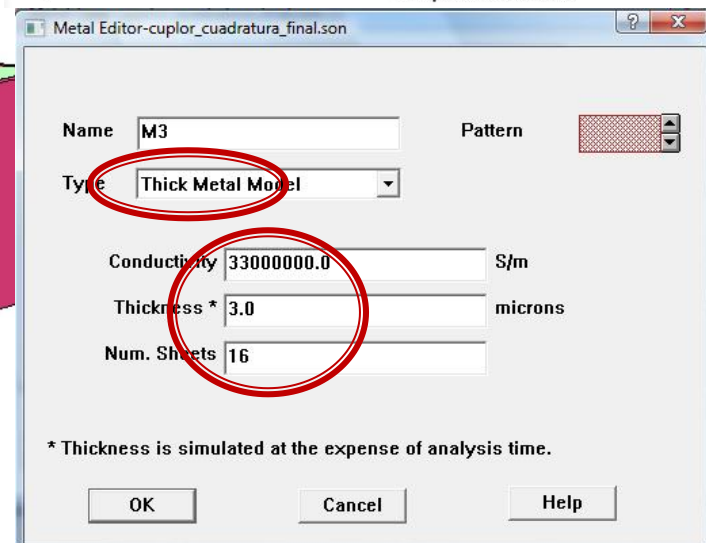
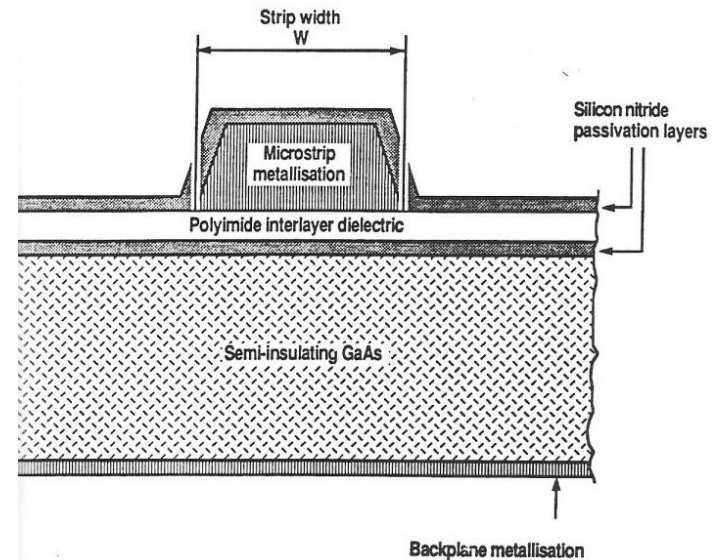
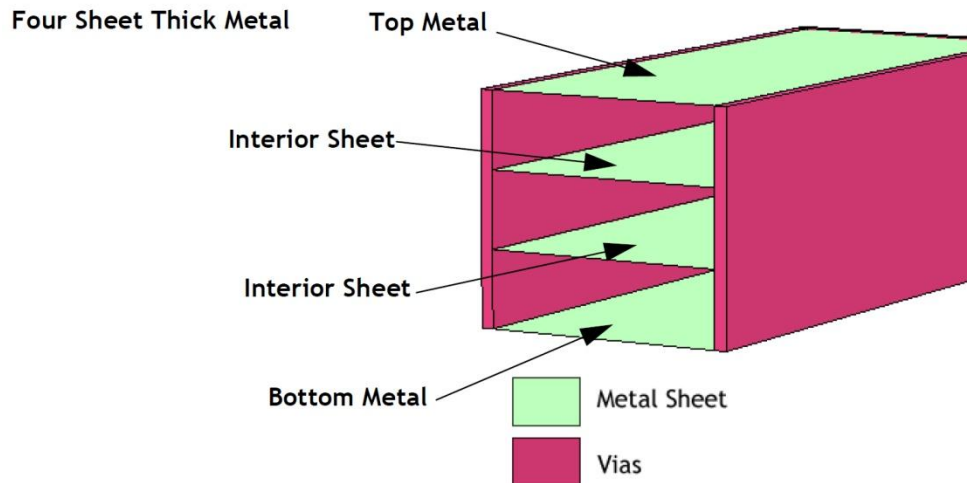
Modelare

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



Modelare supliment

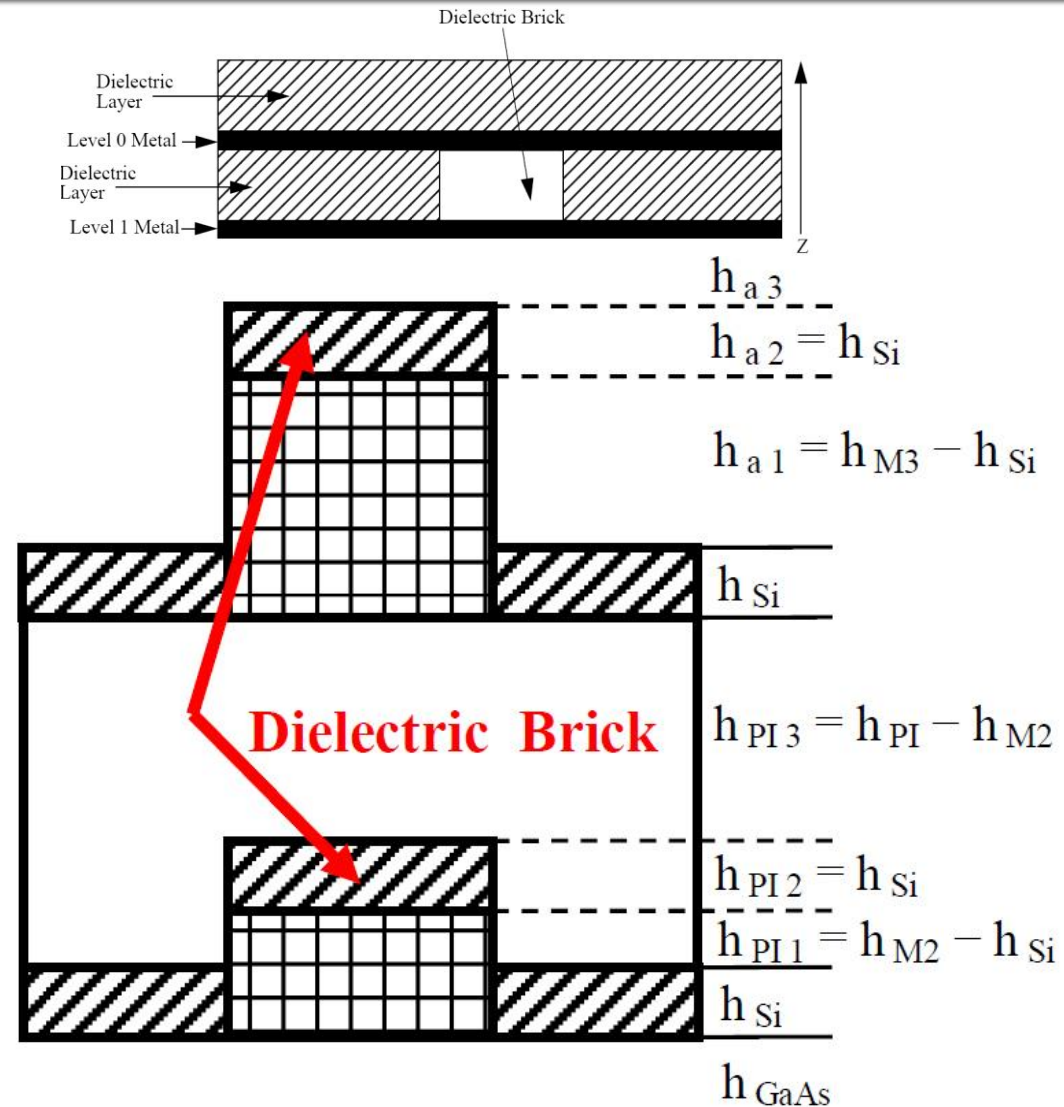
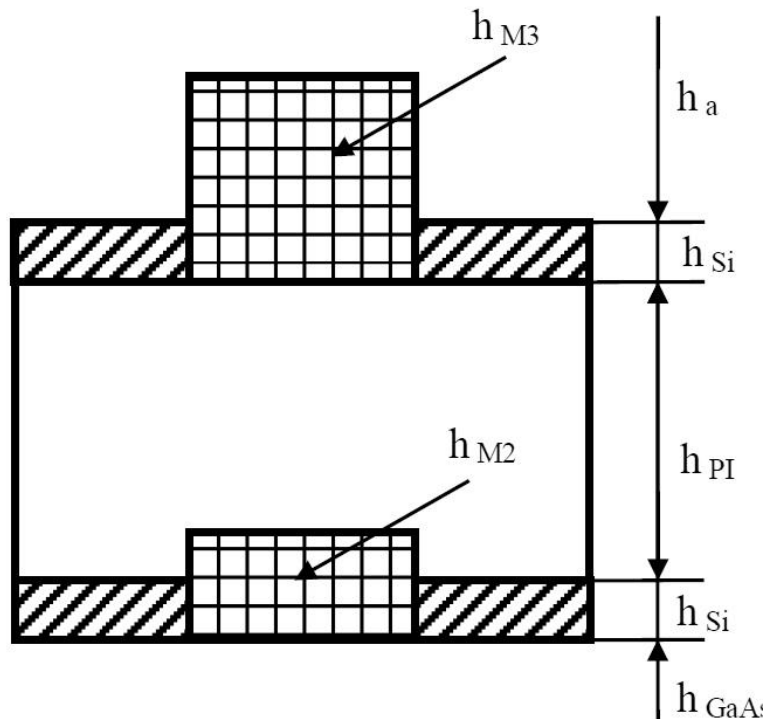
- Structuri
 - cu 9 straturi
- Metalizare $h \neq 0$
 - Thick



Modelare supliment

■ Structuri

- cu 5 -> 9+ straturi



Parametri

Nr.	Material	ϵ_r	$\tan \delta$	$\sigma[\text{S/m}]$	$R_{sq}[\text{m}\Omega/\text{sq}]$	$h[\mu\text{m}]$
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

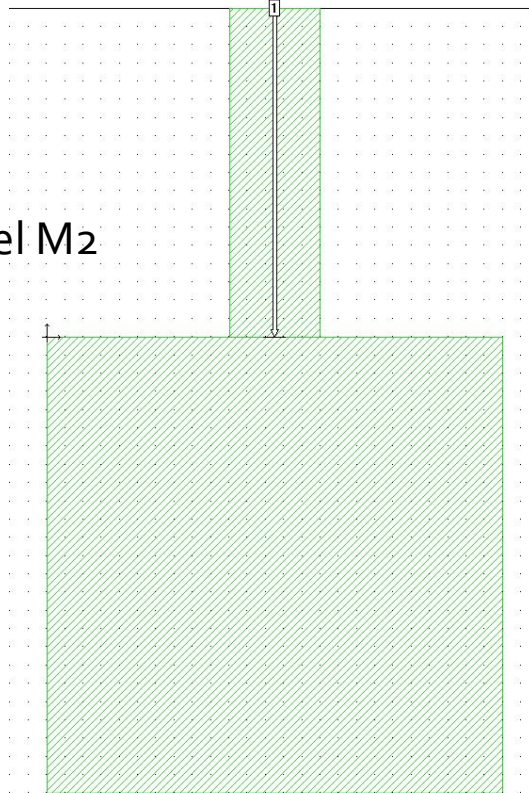
$$R = \frac{\rho \cdot l}{S} = \frac{l}{\sigma \cdot w \cdot h} = \frac{1}{\sigma \cdot h} \cdot \frac{l}{w} = R_{sq} \cdot \frac{l}{w} \quad l = w \rightarrow R = R_{sq}$$

Simulare

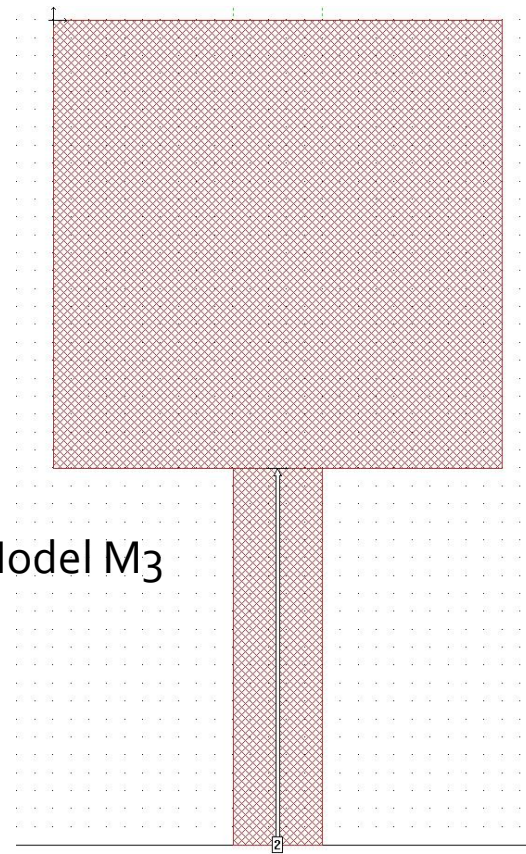
Modelare

- Linii de 50Ω
- Reference plane

Model M2

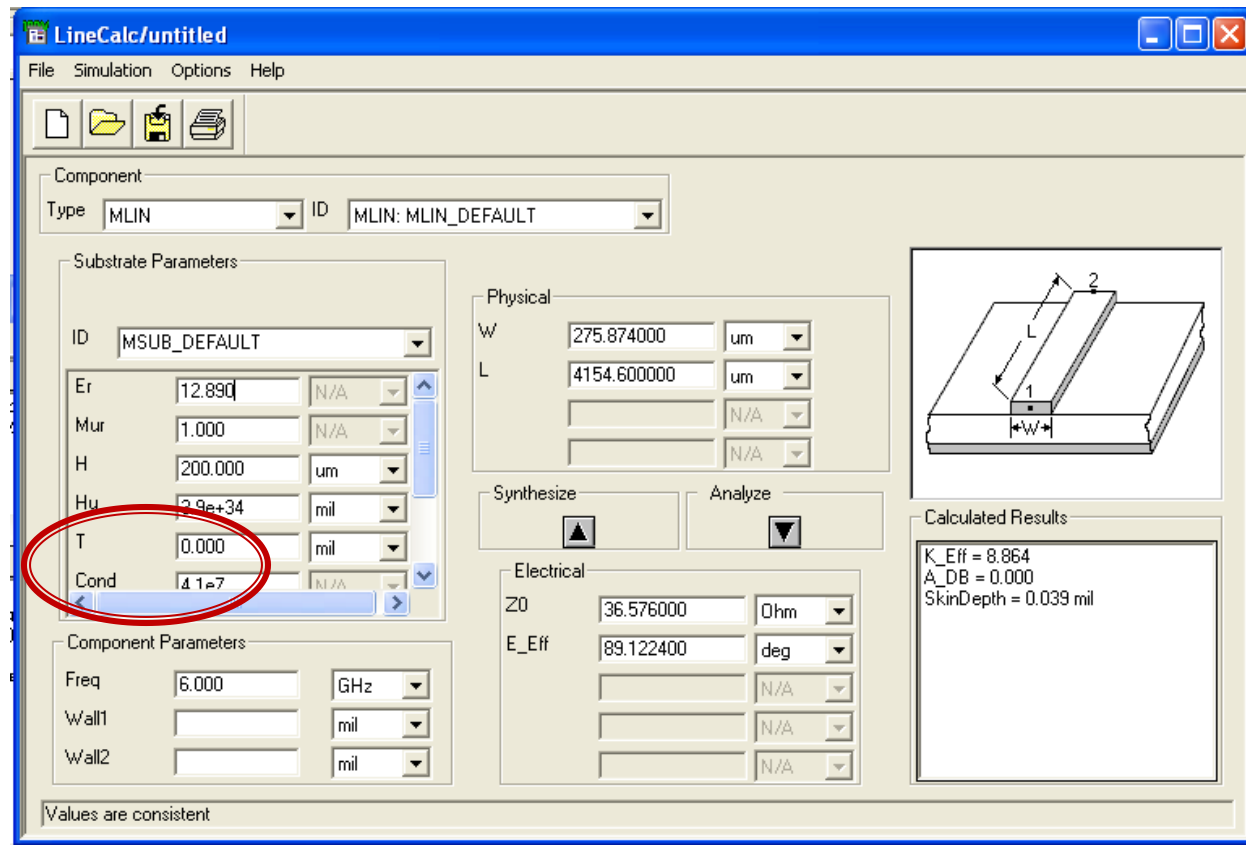


Model M3



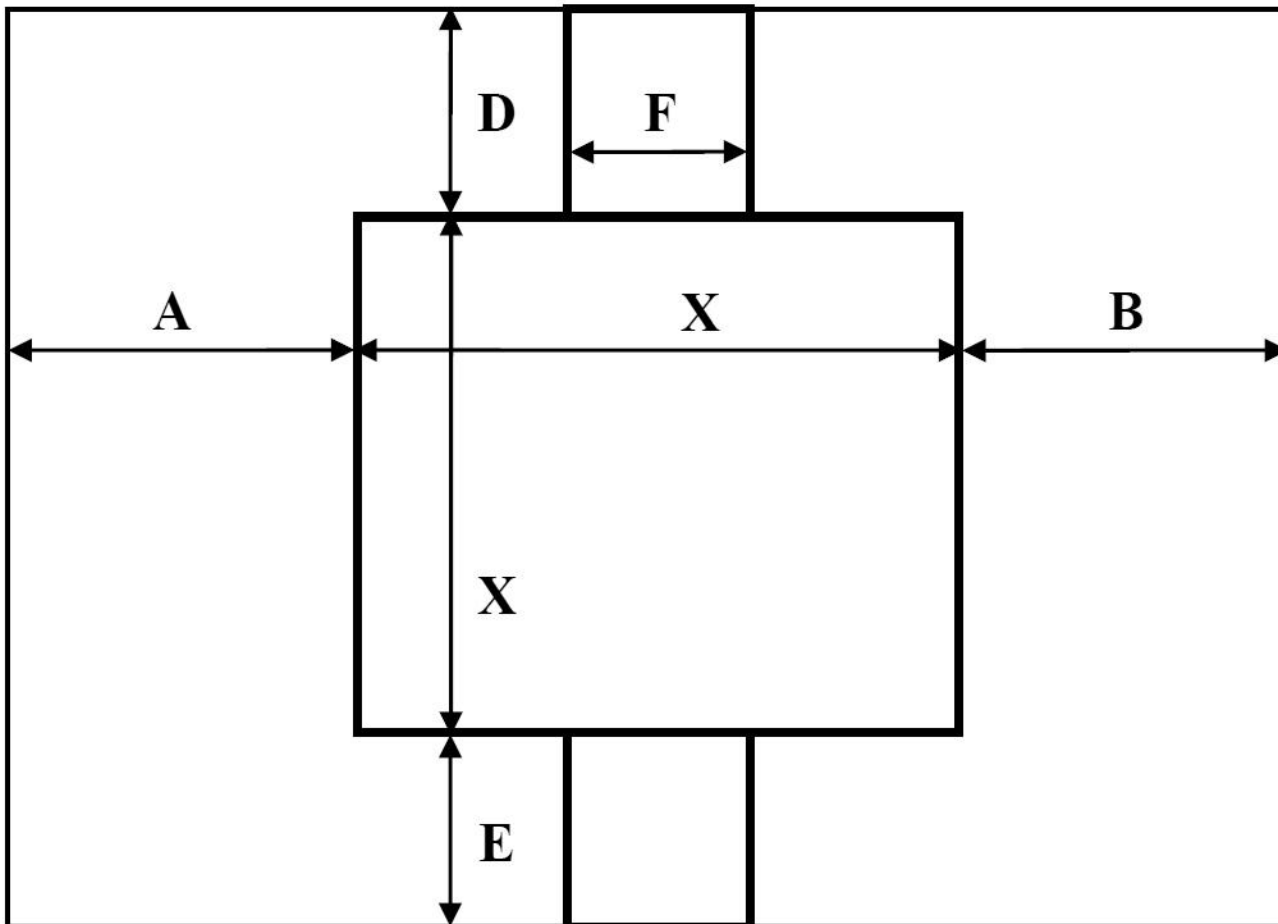
Modelare

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



Dimensionare

■ Box Size/Cell Size



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

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

$$\Delta x = \Delta y$$

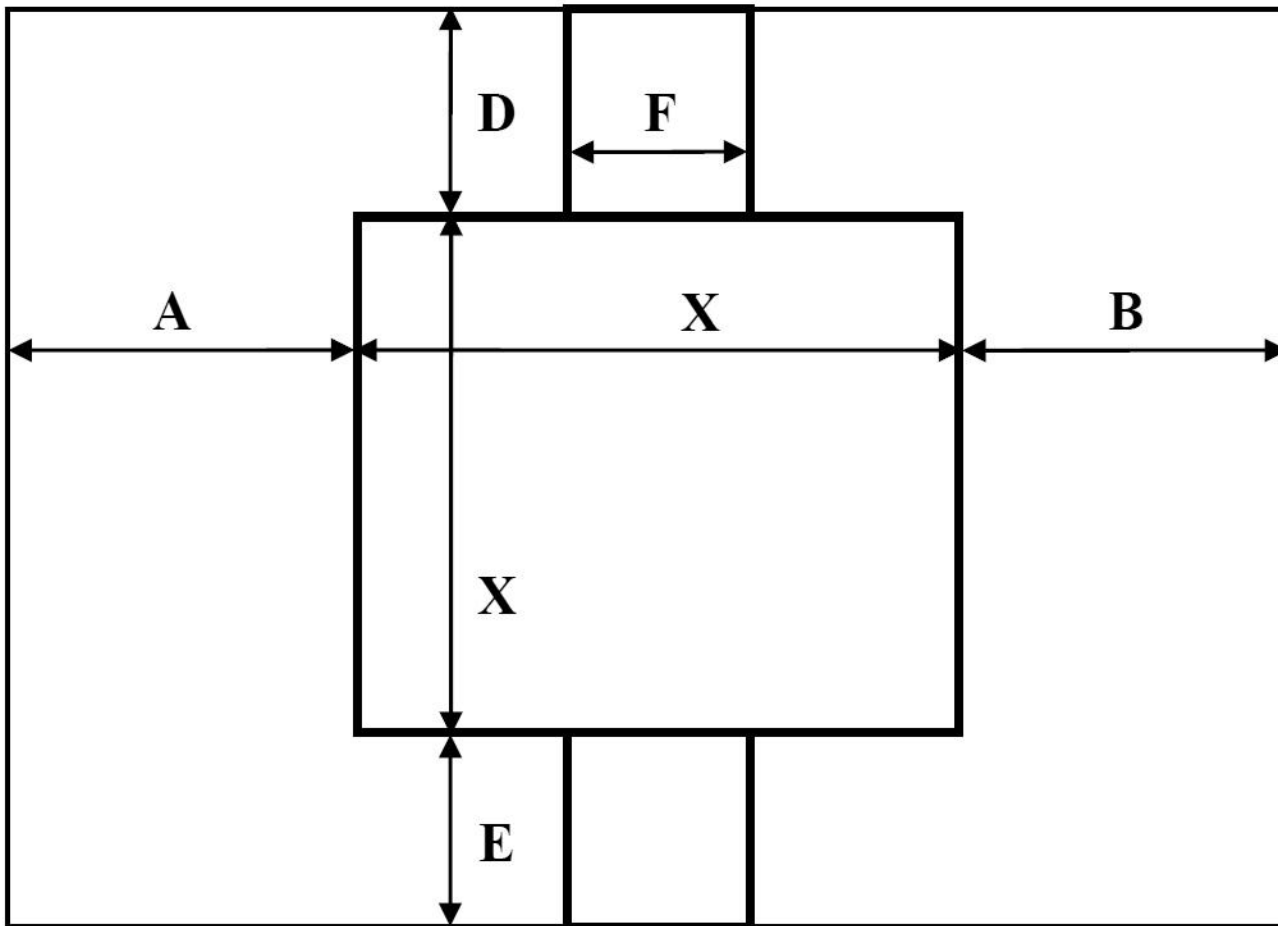
$$m = n = 2^p$$

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

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

Dimensionare

■ Box Size/Cell Size



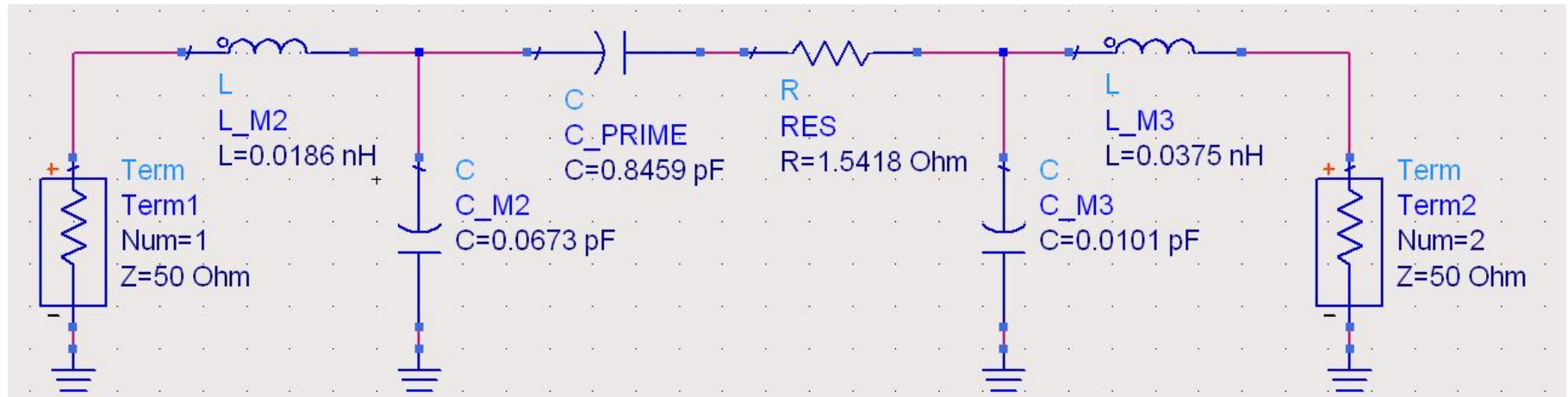
$$F \approx s \cdot \Delta x$$
$$\Delta x = \Delta y$$

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

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 și C_M3 sunt polinoame de forma :

$$y = ax^n + b \quad (1.1)$$

Unde x este dimensiunea layout, iar valorile coeficienților 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 și L_M3 sunt polinoame de gradul 5 :

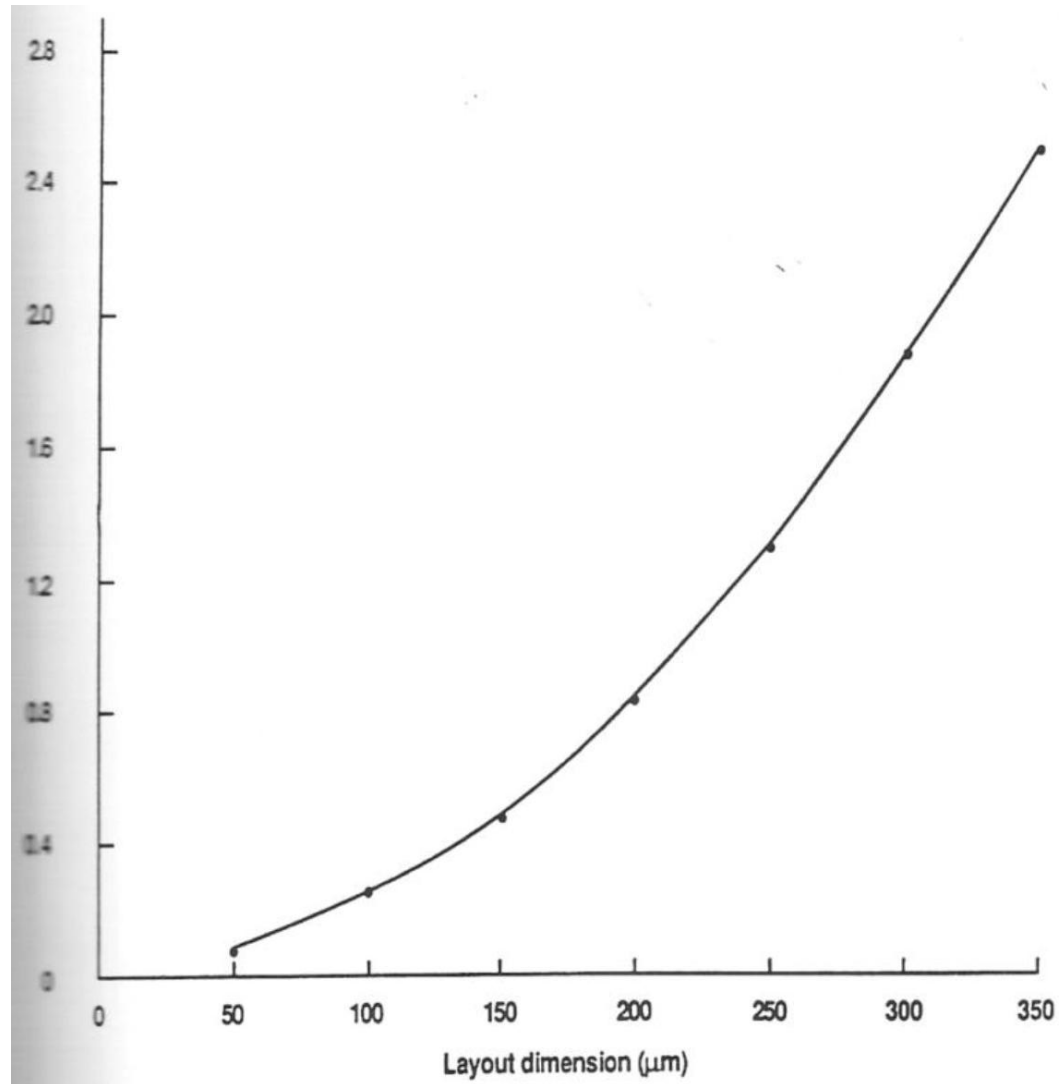
$$y = ax^5 + bx^4 + cx^3 + dx^2 + ex + f \quad (1.2)$$

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

Tabelul 2

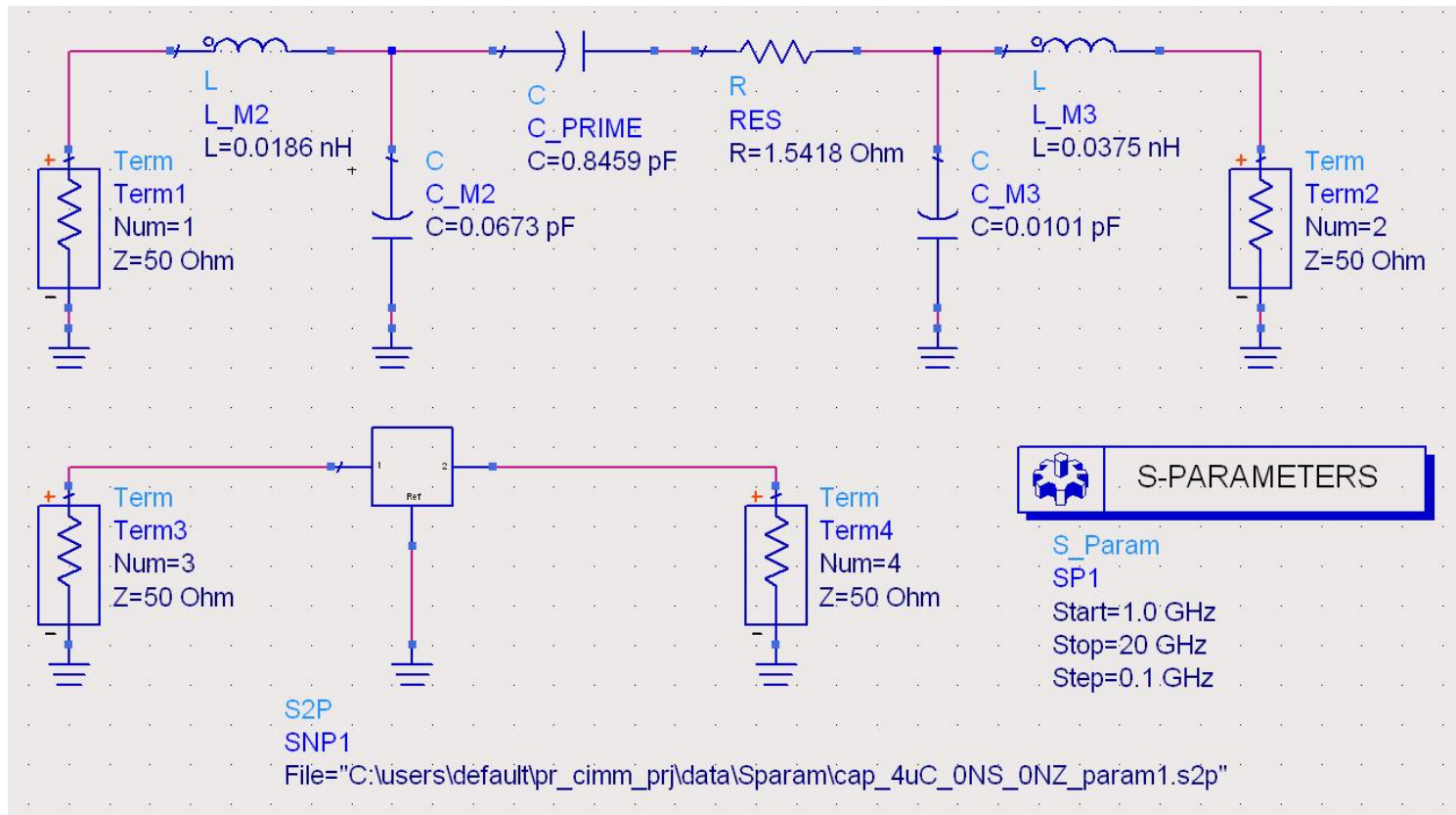
y	L_M2(nH)	L_M3(nH)
a	1.199327×10^{-13}	7.223189×10^{-14}
b	$-1.425209 \times 10^{-10}$	$-1.086451 \times 10^{-10}$
c	5.925084×10^{-8}	5.791041×10^{-8}
d	-9.977216×10^{-6}	-1.352713×10^{-5}
e	7.61417×10^{-4}	1.548175×10^{-3}
f	-0.018913	-0.043643

Capacitance [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

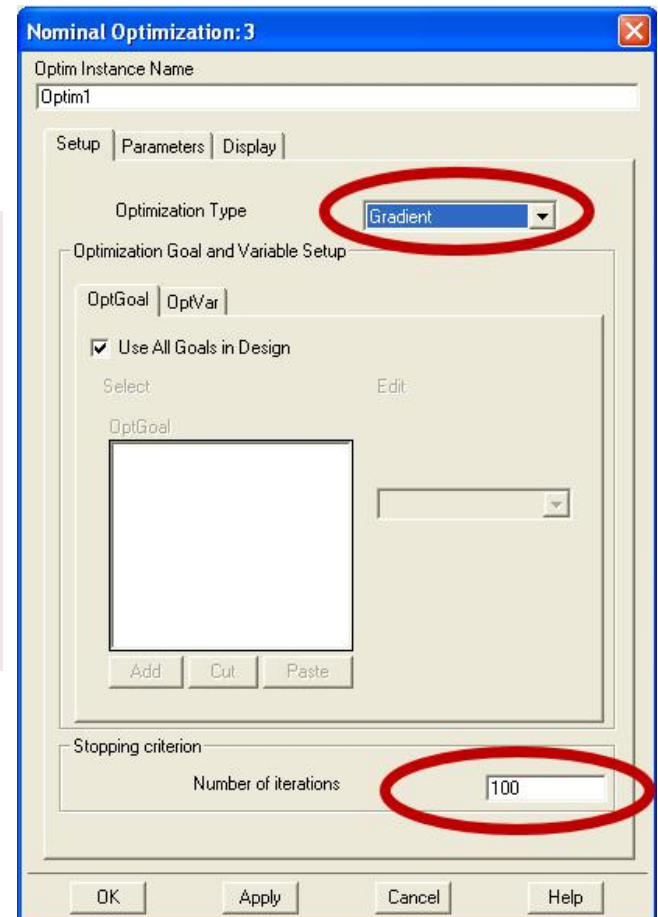
The screenshot displays the ADS Optimizer interface with the following configuration:

- OPTIM** (Optimizer Settings):
 - Optim1
 - OptimType=Gradient
 - ErrorForm=L2
 - MaxIters=100
 - DesiredError=0.0
 - StatusLevel=4
 - FinalAnalysis="SP1"
 - NormalizeGoals=no
 - SetBestValues=yes
 - Seed=
 - SaveSolns=no
 - SaveGoals=yes
 - SaveOptimVars=no
 - UpdateDataset=yes
 - SaveNominal=yes
 - SaveAllIterations=no
- VAR** (Variables):
 - VAR1
 - dmag=0.01
 - dphs=0.1
 - fmin=1GHz
 - fmax=20GHz
- GOAL** (Goals):
 - GOAL 1:**
 - Goal: S11mag
 - Expr="dB(S(1,1))-dB(S(3,3))"
 - SimInstanceName="SP1"
 - Min=-0.1*dmag
 - Max=0.1*dmag
 - Weight=
 - RangeVar[1]="freq"
 - RangeMin[1]=fmin
 - RangeMax[1]=fmax
 - GOAL 2:**
 - Goal: S11phs
 - Expr="phase(S(1,1))-phase(S(3,3))"
 - SimInstanceName="SP1"
 - Min=-0.1*dphs
 - Max=0.1*dphs
 - Weight=
 - RangeVar[1]="freq"
 - RangeMin[1]=fmin
 - RangeMax[1]=fmax
 - GOAL 3:**
 - Goal: S21mag
 - Expr="dB(S(2,1))-dB(S(4,3))"
 - SimInstanceName="SP1"
 - Min=-0.1*dmag
 - Max=0.1*dmag
 - Weight=
 - RangeVar[1]="freq"
 - RangeMin[1]=fmin
 - RangeMax[1]=fmax
 - GOAL 4:**
 - Goal: S21phs
 - Expr="phase(S(2,1))-phase(S(4,3))"
 - SimInstanceName="SP1"
 - Min=-0.1*dphs
 - Max=0.1*dphs
 - Weight=
 - RangeVar[1]="freq"
 - RangeMin[1]=fmin
 - RangeMax[1]=fmax

Optimizare

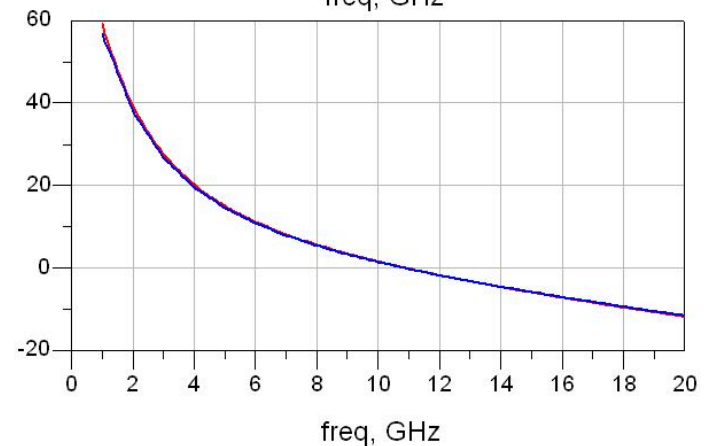
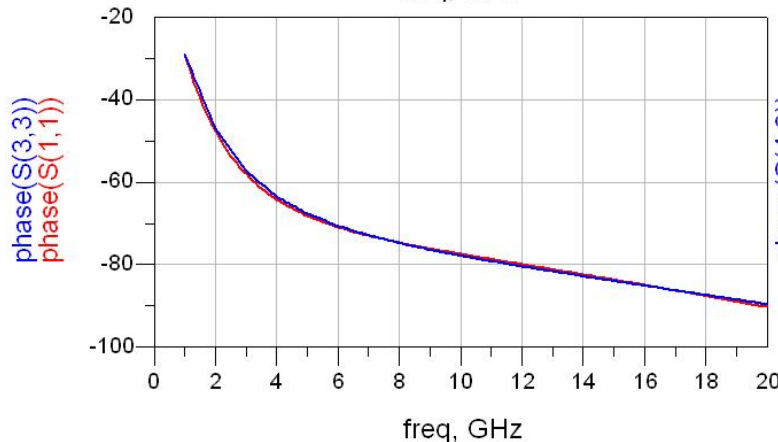
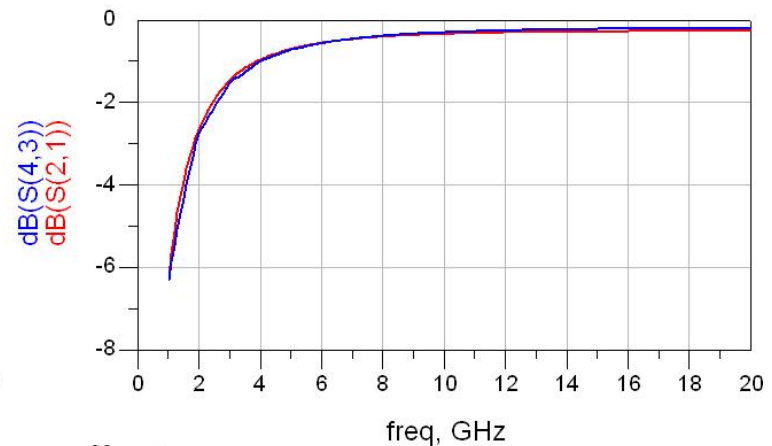
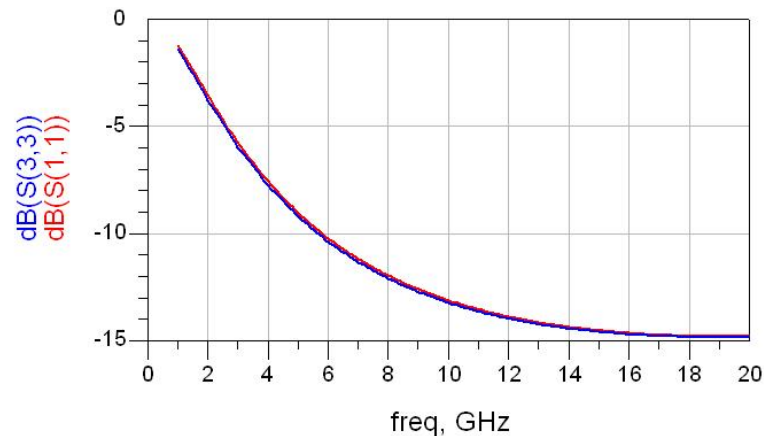
- Optimizare in ADS pentru suprapunerea intre parametrii S pentru schema si parametrii S obtinuti (export) din Sonnet

Var Eqn	VAR	GOAL	GOAL
	VAR1	Goal	Goal
	dmag=0.001	S21mag	S21phs
	dphs=0.01	Expr="dB(S(2,1))-dB(S(4,3))"	Expr="phase(S(2,1))-phase(S(4,3))"
	fmin=1GHz	SimInstanceName="SP1"	SimInstanceName="SP1"
	fmax=20GHz	Min=-1*dmag	Min=-1*dphs
		Max=dmag	Max=dphs
		Weight=	Weight=
		RangeVar[1]="freq"	RangeVar[1]="freq"
		RangeMin[1]=fmin	RangeMin[1]=fmin
		RangeMax[1]=fmax	RangeMax[1]=fmax



Circuit echivalent

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



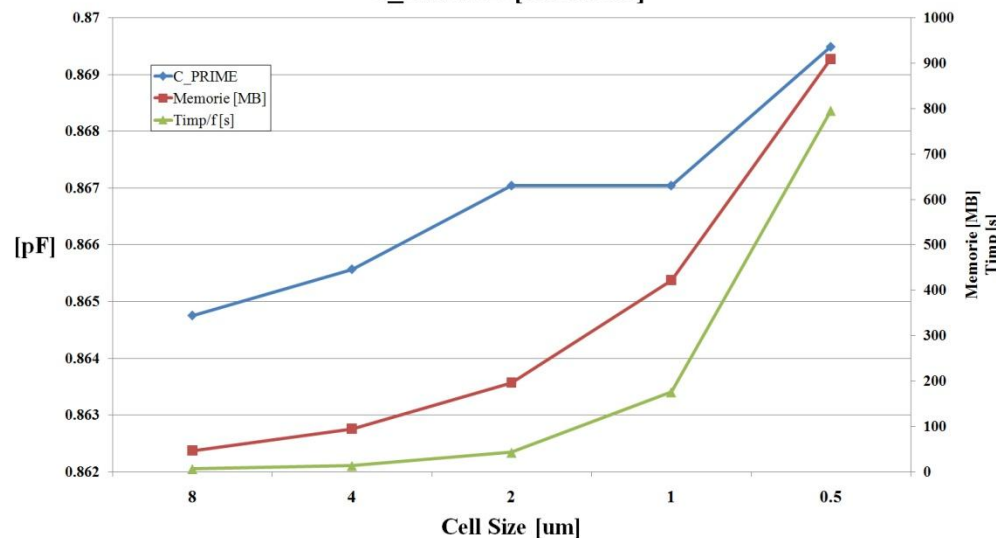
Convergenta

Convergenta

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

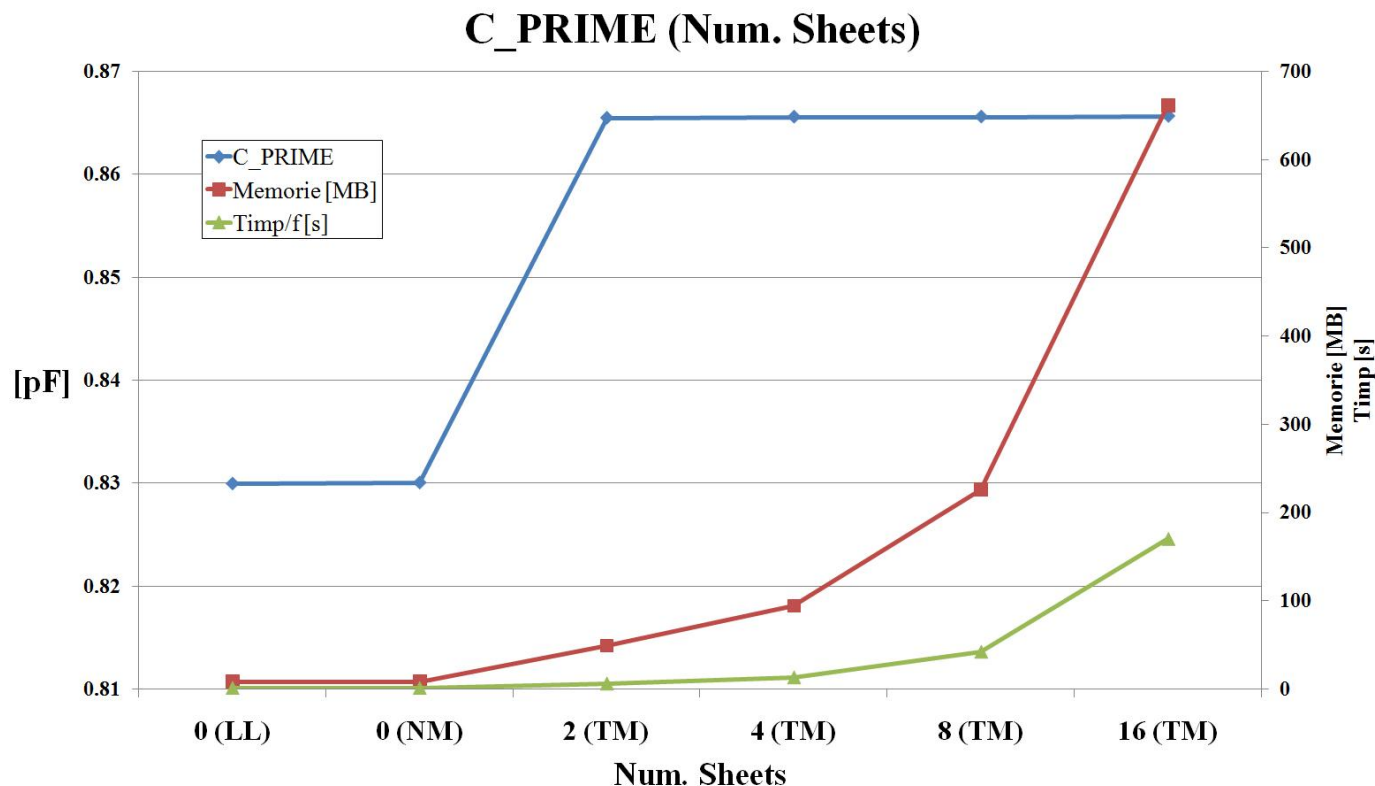
$$\Delta x, \frac{\Delta x}{2}, \frac{\Delta x}{4}, \frac{\Delta x}{8} \dots$$

C_{PRIME} [Cell Size]



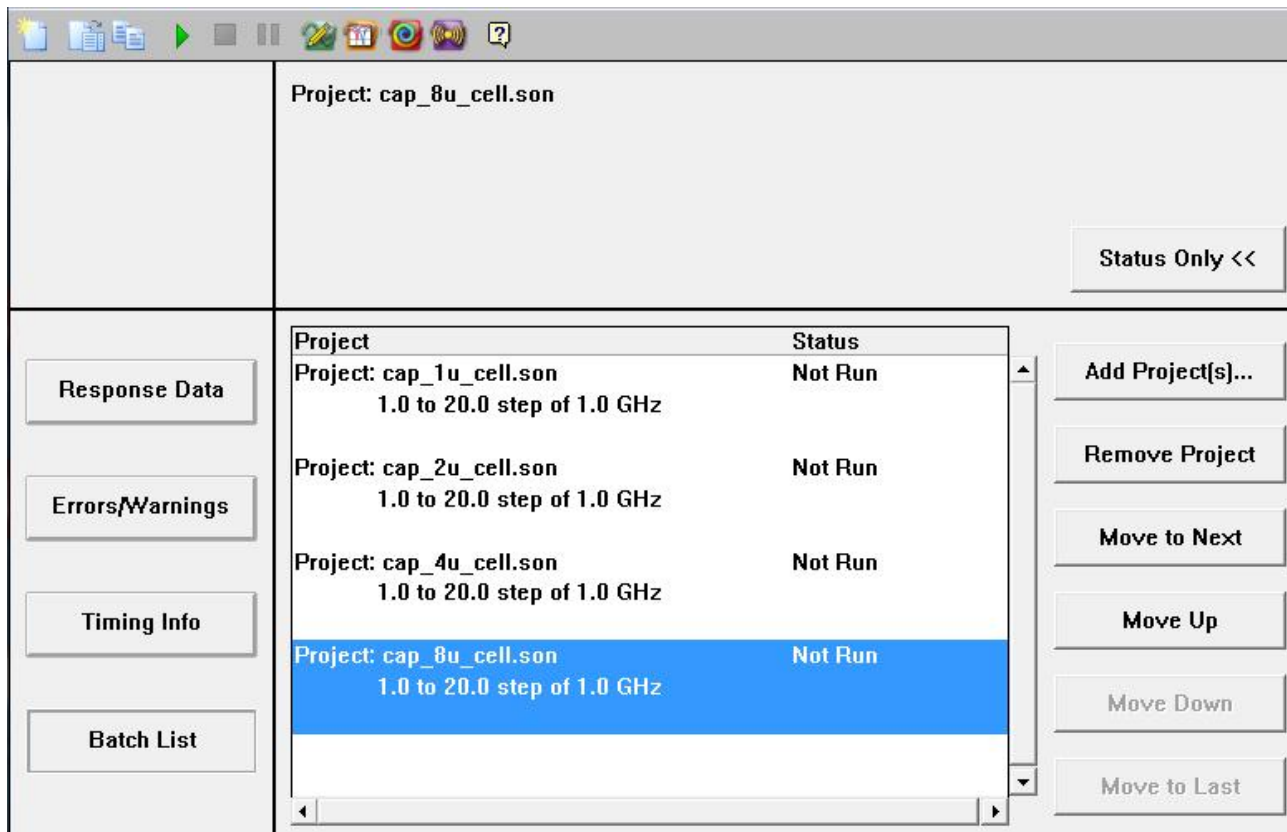
Exemplu

- 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

- Laboratorul de microunde si optoelectronica
- <http://rf-opto.etti.tuiasi.ro>
- rdamian@etti.tuiasi.ro