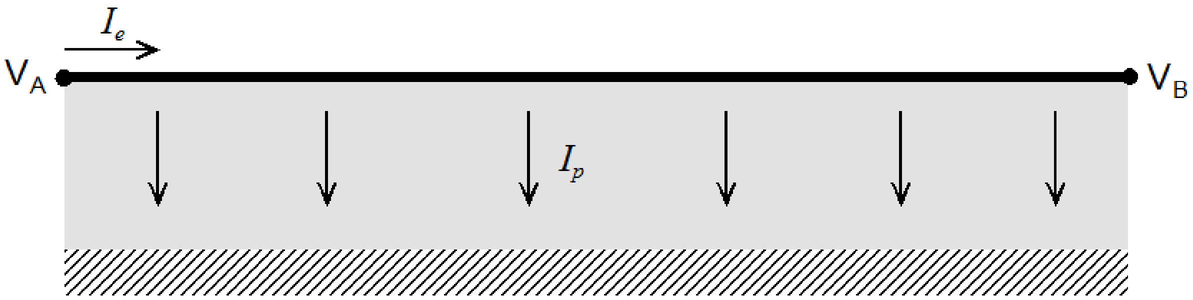
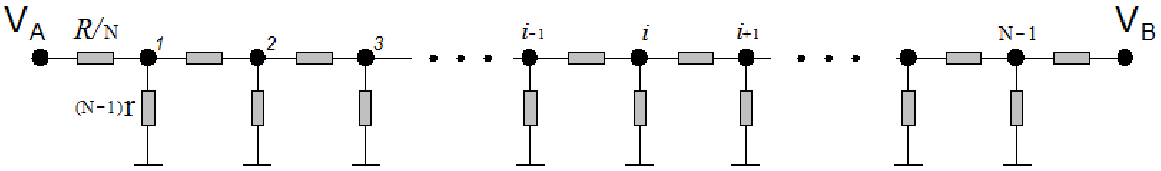
CÁLCULO NUMÉRICO E COMPUTACIONAL

AULAS de 05 e 12 MAIO 2014

SIMULAÇÃO DE SISTEMAS, DISCRETIZAÇÃO, SISTEMAS DE EQUAÇÕES LINEARES

EXEMPLO 1: Perdas elétricas em linha de corrente



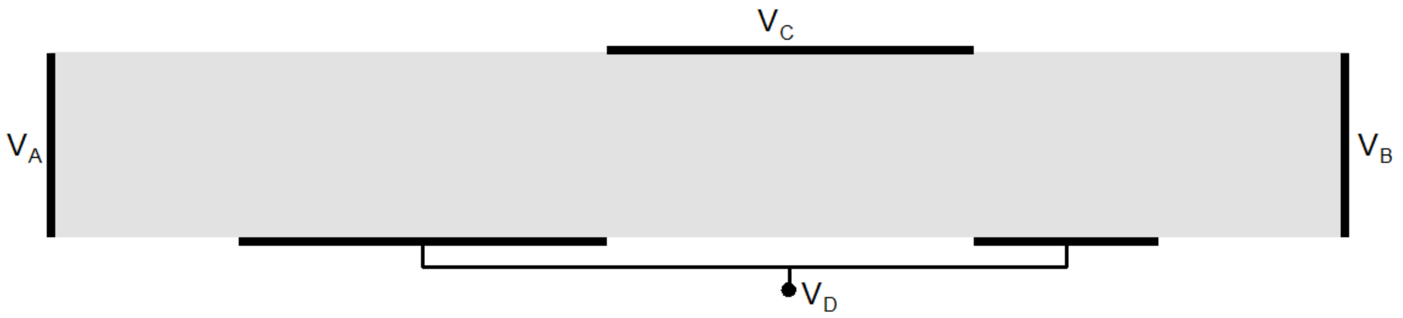


```
% EXEMPLO 1
clear all
R=1; r=10;
Va=1;Vb=0;
ind=0;

% N=2
N=2;ind=ind+1;
gama=2+(R/(2*r))
V=(Va+Vb)/gama
Ip=V/r
Ie=(Va-V)/(R/2)
p=100*(Ip/Ie)
X(ind)=N;Y(ind)=p;
X
X = 2
Y
Y = 4.7619

% N > 2
N=N+1;
ind=ind+1;
N
ind
gama=2+(R/(r*N*(N-1)))
for i=1:(N-1) A(i,i)=gama; end
for i=2:(N-1) A(i,i-1)=-1; end;
for i=1:(N-2) A(i,i+1)=-1; end;
A
B(1)=Va; B(N-1)=Vb;
for i=2:(N-2) B(i)=0; end;
B
B=B'
V=A\B
Ip=norm(V,1)/((N-1)*r)
Ie=(Va-V(1))/(R/N)
p=100*(Ip/Ie)
X(ind)=N;Y(ind)=p;
```

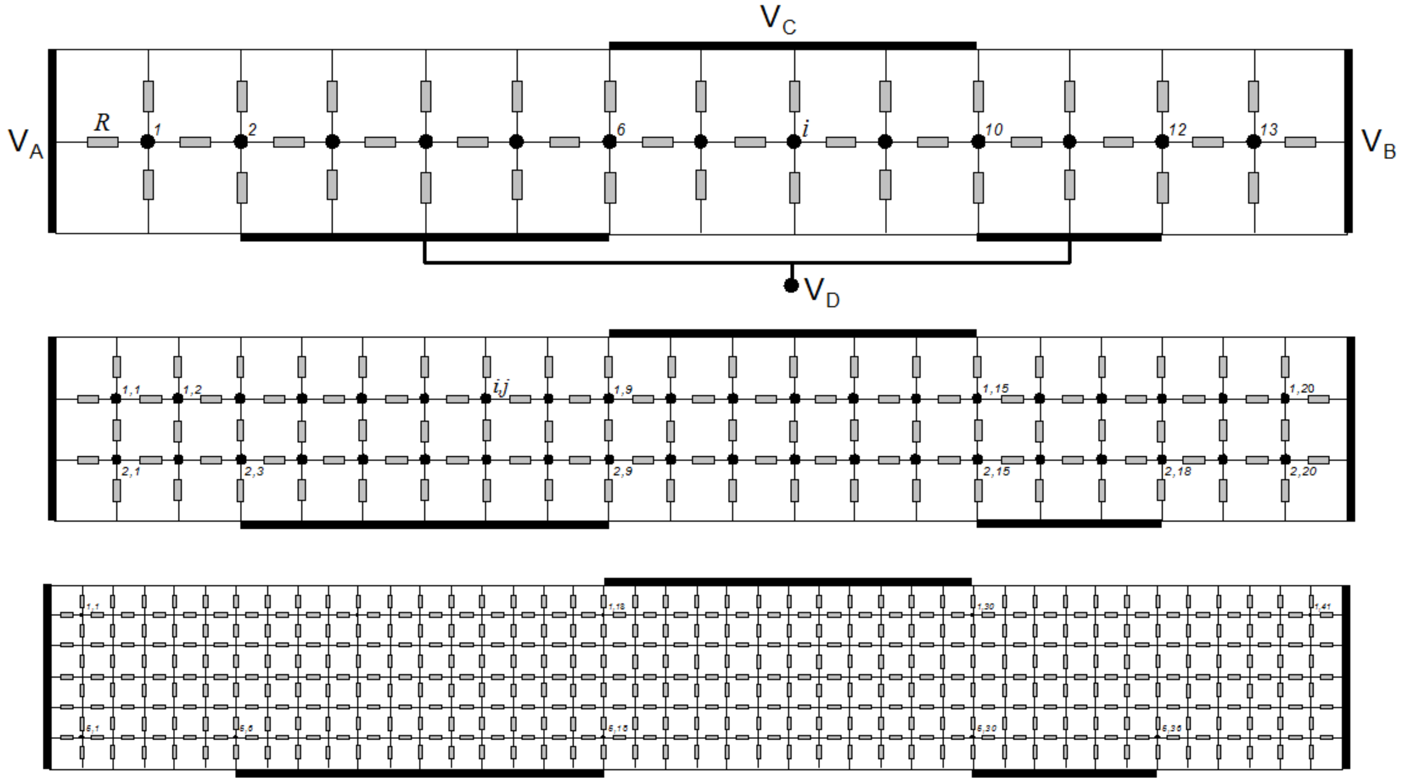
```
X
X =    2     3
Y
Y =   4.7619    4.7871
.
.
.
X =    2         3         4         5          6         7         8         9
Y = 4.7619   4.7871   4.7934   4.7960   4.7973   4.7980   4.7984   4.7987

X =   10        11        12        13        14        15
Y = 4.7990   4.7991   4.7992   4.7993   4.7994   4.7994

% PARA R=1 e r=5
X =       2         3         4         5         6         7         8         9
Y =   9.0909   9.1826   9.2059   9.2153   9.2200   9.2227   9.2243   9.2254

X =      10        11        12        13        14        15
Y =   9.2262   9.2268   9.2272   9.2276   9.2278   9.2280

% PARA R=1 e r=1
X =       2          3          4          5          6          7          8          9
Y =  33.3333  34.5455  34.8662  34.9966  35.0623  35.1000  35.1235  35.1393

X =     10         11         12         13         14         15
Y =  35.1503  35.1584  35.1644  35.1690  35.1727  35.1756

% PARA R=1 e r=0,5
X =      2          3          4          5          6          7          8          9
Y =  50.0000  52.6316  53.3477  53.6415  53.7899  53.8753  53.9288  53.9645

% PARA R=1 e r=0,1
X =     2          3          4          5          6          7          8          9
Y =  83.3333  88.6076  90.0507  90.6433  90.9430  91.1153  91.2233  91.2955
```

M. Fabbri USF 2014
Permitido o uso para fins educacionais mediante referência

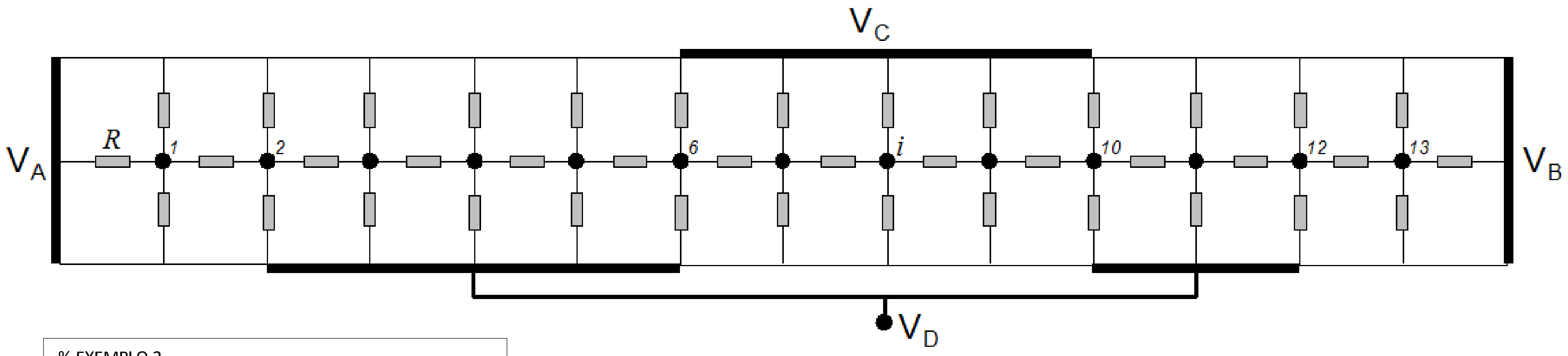
Distribuição de potencial em placa condutora



DISCRETIZAÇÃO E SUCESSIVO REFINAMENTO



EXEMPLO 2: Resolvendo a discretização unidimensional

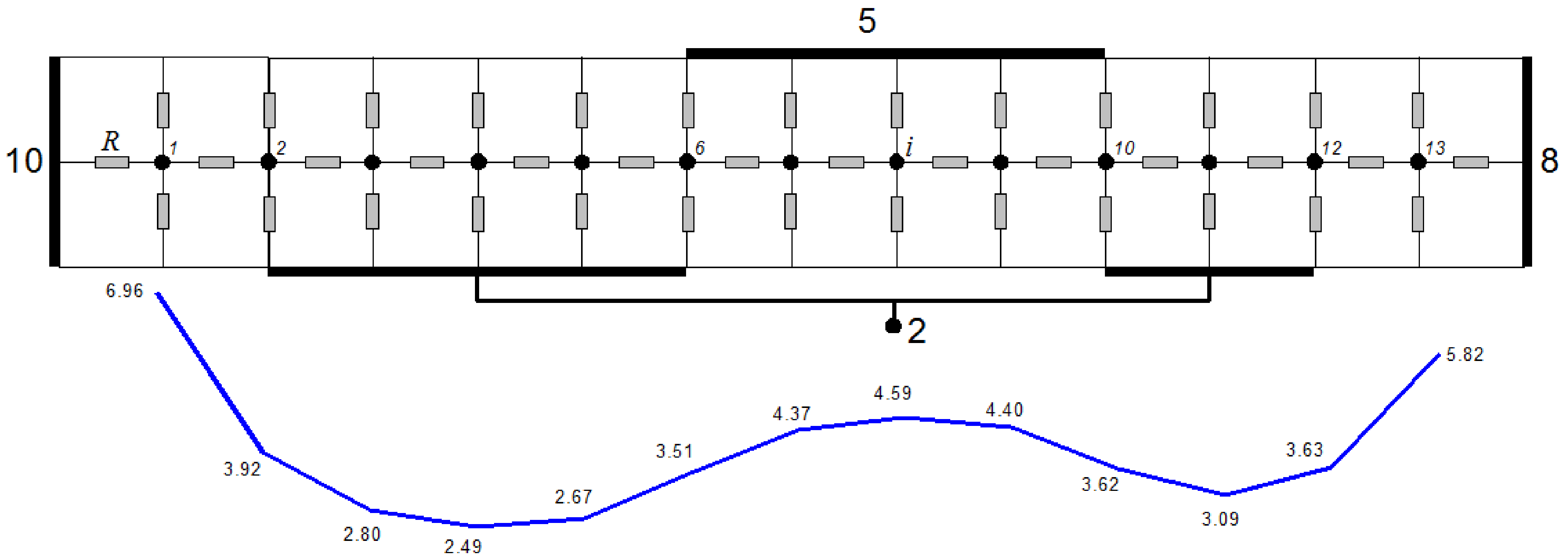


```
% EXEMPLO 2

Va=10;Vb=8;Vc=5;Vd=2;
for i=1:13 alfa(i)=0; end
for i=6:10 alfa(i)=1; end
for i=1:13 beta(i)=0; end
for i=2:6 beta(i)=1; end
for i=10:12 beta(i)=1; end
for i=1:13 A(i,i)=2+alfa(i)+beta(i); end
for i=2:13 A(i,i-1)=-1; end;
for i=1:12 A(i,i+1)=-1; end;

A =

   2  -1   0   0   0   0   0   0   0   0   0   0   0
  -1   3  -1   0   0   0   0   0   0   0   0   0   0
   0  -1   3  -1   0   0   0   0   0   0   0   0   0
   0   0  -1   3  -1   0   0   0   0   0   0   0   0
   0   0   0  -1   3  -1   0   0   0   0   0   0   0
   0   0   0   0  -1   4  -1   0   0   0   0   0   0
   0   0   0   0   0  -1   3  -1   0   0   0   0   0
   0   0   0   0   0   0  -1   3  -1   0   0   0   0
   0   0   0   0   0   0   0  -1   3  -1   0   0   0
   0   0   0   0   0   0   0   0  -1   4  -1   0   0
   0   0   0   0   0   0   0   0   0  -1   3  -1   0
   0   0   0   0   0   0   0   0   0   0  -1   3  -1
   0   0   0   0   0   0   0   0   0   0   0  -1   2
```

```
B(1)=Va; B(13)=Vb;
for i=2:12 B(i)=alfa(i)*Vc+beta(i)*Vd; end;
B=B'
B =

    10
     2
     2
     2
     2
     7
     5
     5
     5
     7
     2
     2
     8
```

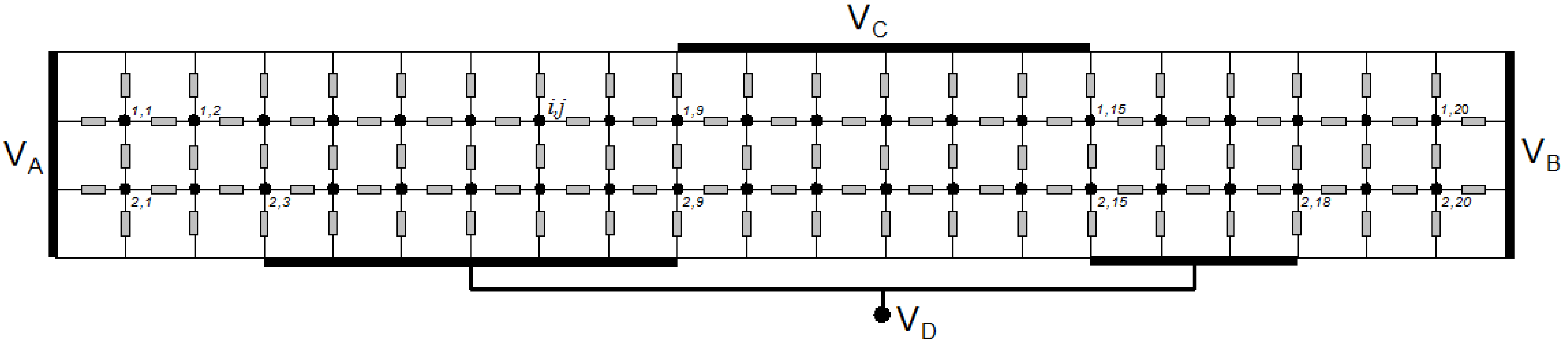
```
V=A\B

V =
    6.9608
    3.9215
    2.8038
    2.4899
    2.6660
    3.5080
    4.3660
    4.5901
    4.4042
    3.6224
    3.0855
    3.6342
    5.8171

plot(V)
```

M. Fabbri USF 2014



Resultados da simulação unidimensional para os potenciais em cada ponto da placa condutora.

EXEMPLO 3: Resolvendo a discretização bidimensional iterando a solução entre duas linhas



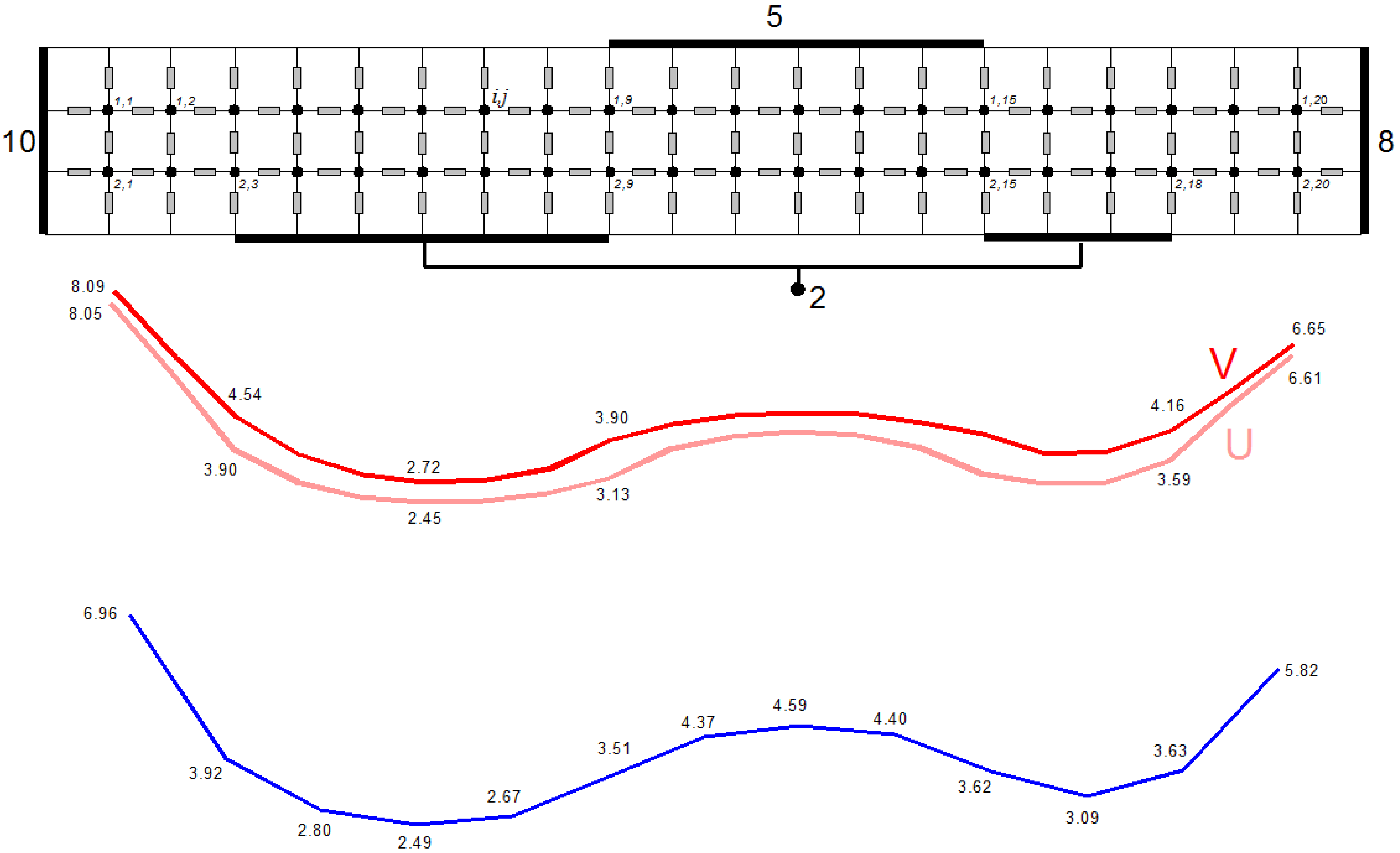
```
% EXEMPLO 3
clear all
Va=10;Vb=8;Vc=5;Vd=2;
for i=1:20 alfa(i)=0; end
for i=9:15 alfa(i)=1; end
for i=1:20 beta(i)=0; end
for i=3:9 beta(i)=1; end
for i=15:18 beta(i)=1; end

for i=1:2 U(i)=Va; end
for i=3:9 U(i)=Vd; end
for i=10:14 U(i)=Vc; end
for i=15:18 U(i)=Vd; end
for i=19:20 U(i)=Vb; end
U=U'
```

```
for i=1:20 A(i,i)=3+alfa(i); end
for i=2:20 A(i,i-1)=-1; end;
for i=1:19 A(i,i+1)=-1; end;

B(1)=U(1)+ Va; B(20)= U(20)+ Vb;
for i=2:19 B(i)=alfa(i)*Vc + U(i); end;
B=B'
V=A\B
for i=1:20 A(i,i)=3+beta(i); end
B(1)=V(1)+ Va; B(20)= V(20)+ Vb;
for i=2:19 B(i)=beta(i)*Vd + V(i); end;
U=A\B
Vold=V
Uold=U
for i=1:20 A(i,i)=3+alfa(i); end
B(1)=U(1)+ Va; B(20)= U(20)+ Vb;
for i=2:19 B(i)=alfa(i)*Vc + U(i); end;
V=A\B
for i=1:20 A(i,i)=3+beta(i); end
B(1)=V(1)+ Va; B(20)= V(20)+ Vb;
for i=2:19 B(i)=beta(i)*Vd + V(i); end;
U=A\B
epsV(1)=norm(V-Vold,2)
epsU(1)=norm(U-Uold,2)
```

```
iter=1
iter=iter+1
Vold=V
Uold=U
for i=1:20 A(i,i)=3+alfa(i); end
B(1)=U(1)+ Va; B(20)= U(20)+ Vb;
for i=2:19 B(i)=alfa(i)*Vc + U(i); end;
V=A\B
for i=1:20 A(i,i)=3+beta(i); end
B(1)=V(1)+ Va; B(20)= V(20)+ Vb;
for i=2:19 B(i)=beta(i)*Vd + V(i); end;
U=A\B
epsV(iter)=norm(V-Vold,2)
epsU(iter)=norm(U-Uold,2)
.
.
.
```

```
epsV = 2.2995   0.5701   0.1736   0.0589   0.0219   0.0088   0.0038   0.0017   0.0008
epsU = 1.0368   0.2896   0.0927   0.0327   0.0125   0.0051   0.0022   0.0010   0.0005

 U' =  8.0520    6.0612    3.8994    2.9957    2.5936    2.4456    2.4733    2.6793
       3.1283    3.9343    4.3204    4.4435    4.3519    4.0060    3.2511    2.9509
       3.0289    3.5924    5.1760    6.6071

 V' =  8.0948    6.2323    4.5405    3.4898    2.9330    2.7157    2.7682    3.1157
       3.8996    4.3543    4.5832    4.6583    4.6063    4.4149    4.0474    3.5236
       3.5723    4.1645    5.3287    6.6453
```

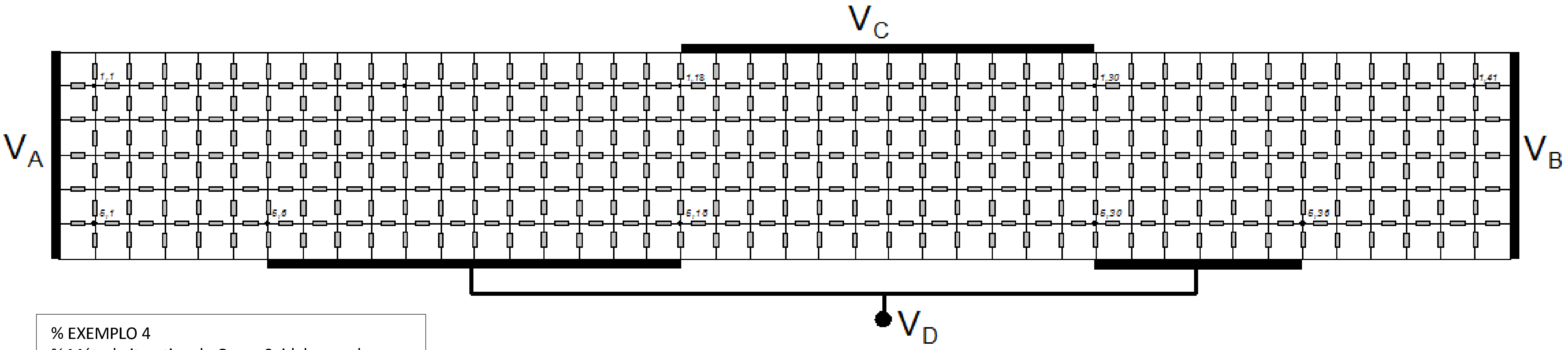
M. Fabbri USF 2014
Permitido o uso para fins educacionais mediante referência



Comparação entre os resultados unidimensional e bidimensional com duas linhas.

M. Fabbri USF 2014
Permitido o uso para fins educacionais mediante referência

EXEMPLO 4: Resolvendo a discretização bidimensional com cinco linhas por iterações de Gauss-Seidel



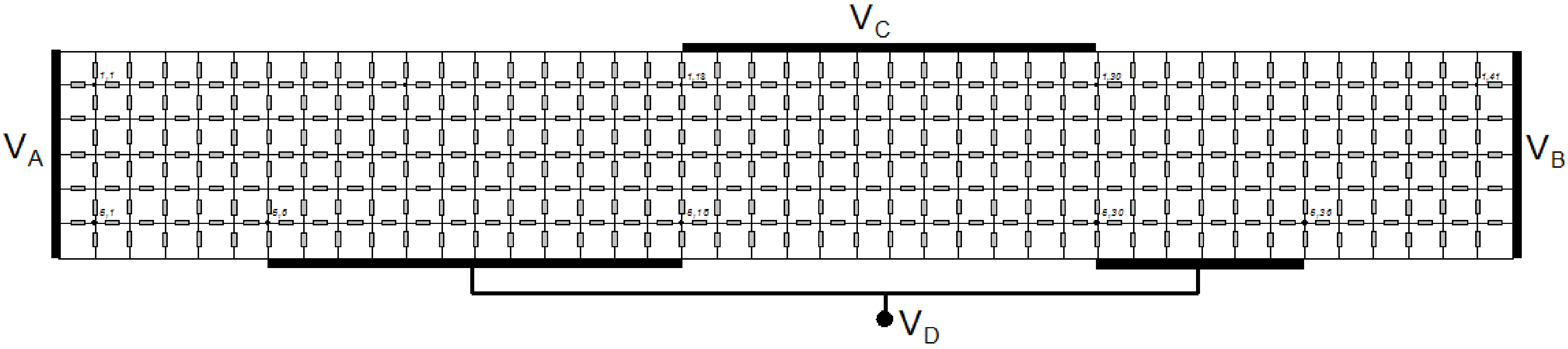
```
% EXEMPLO 4
% Método iterativo de Gauss-Seidel por colunas
clear all
% parâmetros do problema
Va=10;Vb=8;Vc=5;Vd=2;
% parâmetros do método numérico
eps_max = 0.001;
itmax = 200;
% arquivo de saida
fileout = 'v001.txt';
% MATRIZES alfa e beta
for i=1:5
  for j=1:41
    alfa(i,j)=1;
  end
end
for j=1:17 alfa(1,j)=0; end
for j=31:41 alfa(1,j)=0; end
for i=1:5
  for j=1:41
    beta(i,j)=1;
  end
end
for j=1:5 beta(5,j)=0; end
for j=19:29 beta(5,j)=0; end
for j=37:41 beta(5,j)=0; end
```

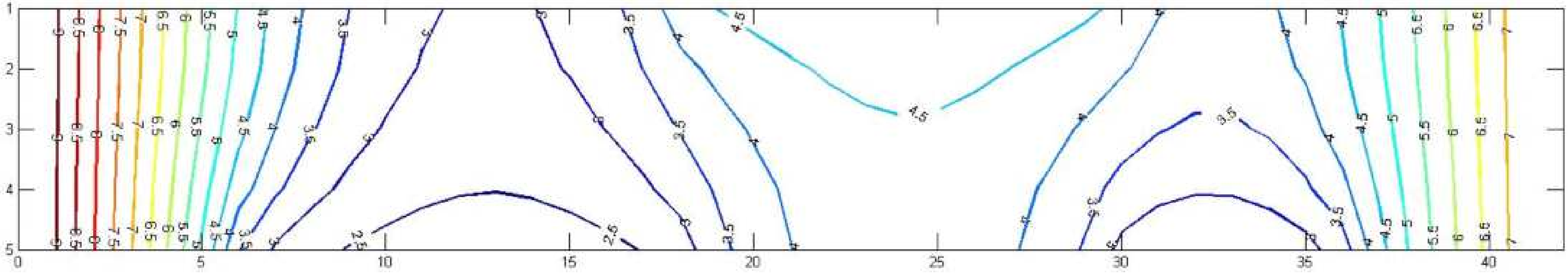
```
% INICIALIZAÇÃO
for i=1:5
  for j=1:5 V(i,j)=Va; end
  for j=6:18 V(i,j)=Vd; end
  for j=19:30 V(i,j)=Vc; end
  for j=31:36 V(i,j)=Vd; end
  for j=37:41 V(i,j)=Vb; end
end;
% ITERAÇÕES
iter = 0;
converged=0;
while iter < itmax
  iter = iter + 1
  Vold = V;
  for j=1:41
    for i=1:5
      if j==1 a=Va; else a=V(i,j-1); end
      if j==41 b=Vb; else b=V(i,j+1);end
      if i==1 c=Vc; else c=V(i-1,j); end
      if i==5 d=Vd; else d=V(i+1,j); end
      V(i,j)=(a + b + alfa(i,j)*c + beta(i,j)*d)/(2 + alfa(i,j) + beta(i,j));
    end
  end
```

```
% V
  eps(iter)=norm(V-Vold,2);
  disp(sprintf('eps(%g)=%g',iter,eps(iter)));
  pause;
  if eps(iter) < eps_max
    disp(sprintf(' *** CONVERGED ***'));
               converged=1;
               break;
  end
end
if converged == 0
  disp(sprintf('max number of iterations (%g) exceeded'));
 end

% write result do disk
if converged ==1
  save(fileout, 'V', '-ASCII');
  disp(sprintf('matrix V wrote in file %s', fileout));
end
```

```
% TO LOAD DATA TO MATLAB:
%   X = load('v001.txt', '-ASCII');
% TO DISPLAY THE CONTOUR PLOT
% contour(V);
% OBS.: maybe you´ll have to mark the 'reverse' option for the y axis, in the plot edit tools
```

M. Fabbri USF 2014
Permitido o uso para fins educacionais mediante referência





Resultados da simulação: equipotenciais no interior da placa condutora.