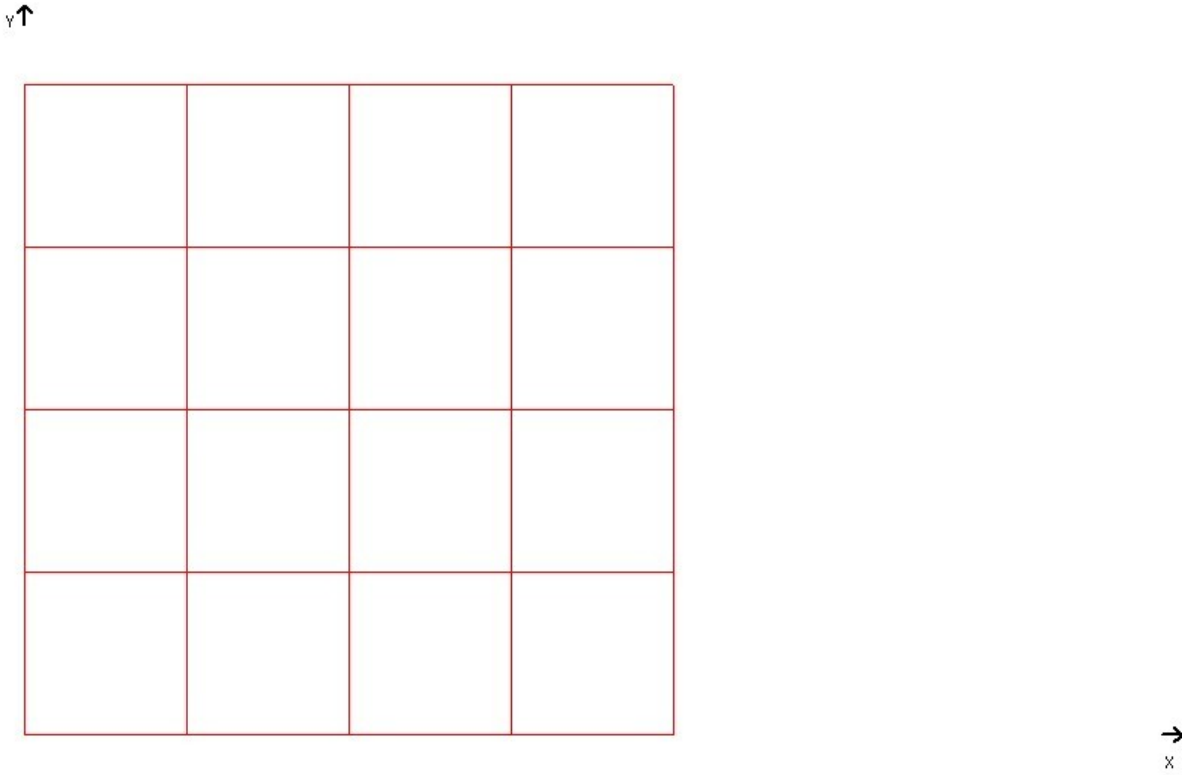
TecAt Plus 6

Example: metallic fence not grounded to the substation grid

preliminary edition: May 21, 2016

1. Soil and grid for this example

Let's consider, for simplicity, a soil with uniform resistivity of 100 Ohm.m and a grid of 20 x 20 meters, with 50 mm² cables, buried at a depth of 0,50 m and with 4 meshes in each direction, initially without the fence:



2. Resistance

Calculating the resistance of the grid on this soil, we get:

```
Dados do Projeto:
Projeto:   Cerca
Cliente:
Data:      20/05/2016
Local:

N° de camadas: 1
    camada #1: 100 [Ohm.m] x 10 [m]
    camada #2: 100 [Ohm.m]

Tempo de processamento: 0,016 s
Resistência da Malha [Ohm] =    2,38
Máximo potencial da Malha [V] = 2383,23
```

condutores:

Nr.	X1(m)	Y1(m)	Z1(m)	X2(m)	Y2(m)	Z2(m)	Raio(mm)	NSub	Tipo cabos
1	0,0	0,0	0,5	20,0	0,0	0,5	4,0	5	A
2	0,0	5,0	0,5	20,0	5,0	0,5	4,0	5	A
3	0,0	10,0	0,5	20,0	10,0	0,5	4,0	5	A
4	0,0	15,0	0,5	20,0	15,0	0,5	4,0	5	A
5	0,0	20,0	0,5	20,0	20,0	0,5	4,0	5	A
6	0,0	0,0	0,5	0,0	20,0	0,5	4,0	5	A
7	5,0	0,0	0,5	5,0	20,0	0,5	4,0	5	A
8	10,0	0,0	0,5	10,0	20,0	0,5	4,0	5	A
9	15,0	0,0	0,5	15,0	20,0	0,5	4,0	5	A
10	20,0	0,0	0,5	20,0	20,0	0,5	4,0	5	A

3. Touch potential, grid without fence

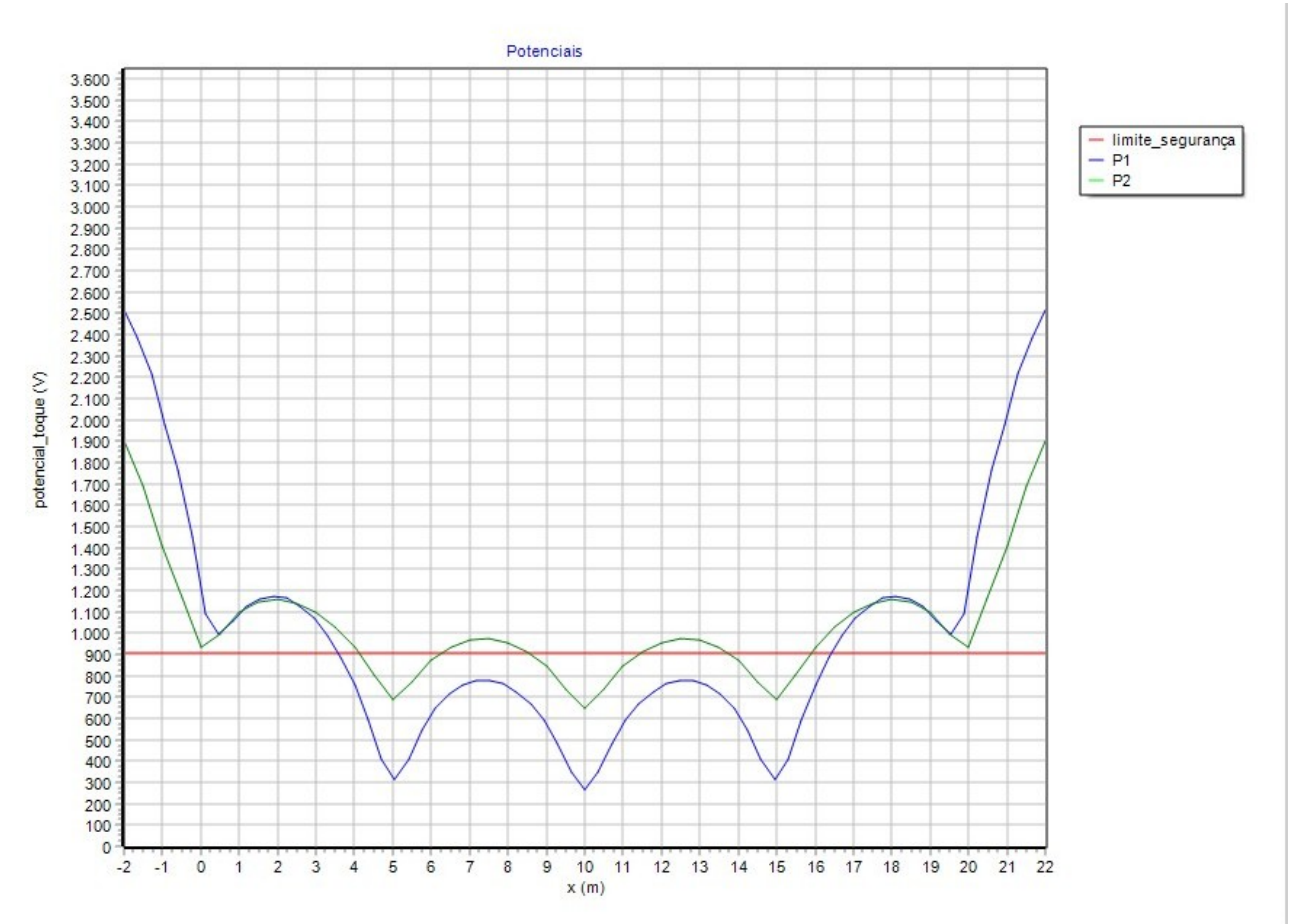
3.1 Admissible touch potential

Considering current of 2 kA, time of fault of 0,5 seconds, operator weight 70 kgf, we have:

- Without gravel layer: 255 V
- With 0,10 m of gravel: 905 V

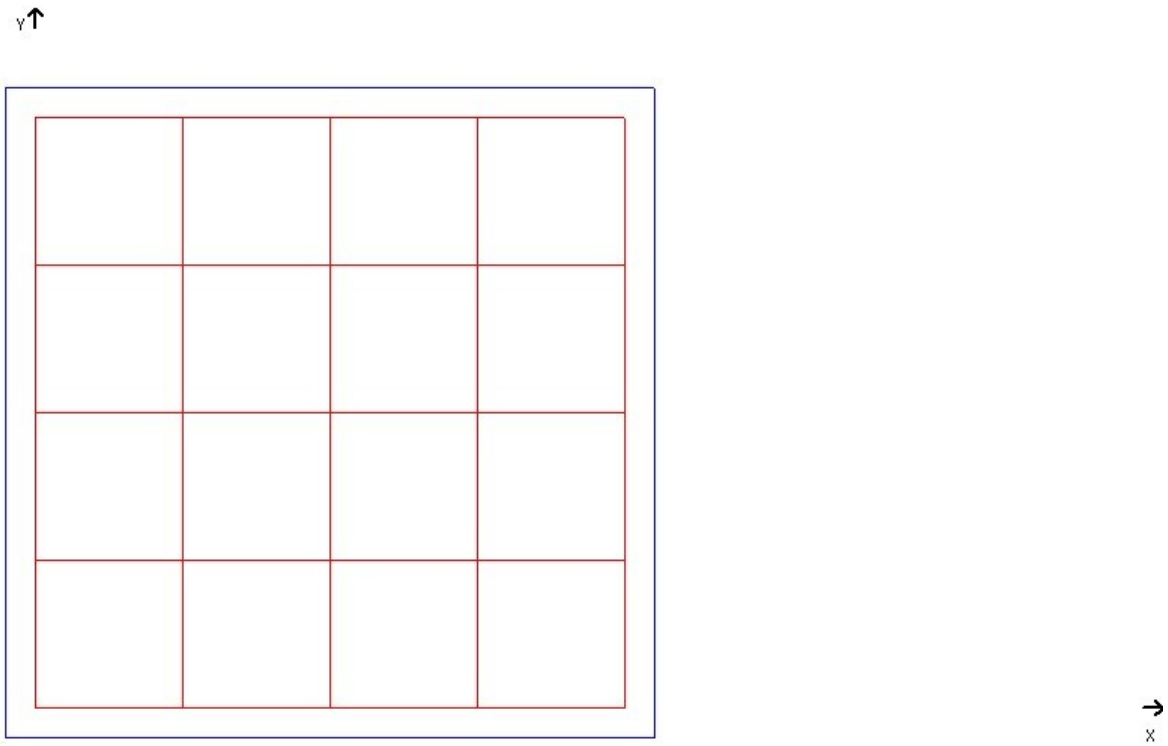
3.2 Touch Potential

Considering one line crossing the grid at the diagonal and another parallel to the X axis at Y = 2,5 m, we have:



4. Adding the fence

Let's now add a metallic fence around the substation, 1 meter distant of the grid; assuming the rebars of the fence foundation is equivalent to a 120 mm² cable buried at a depth of 0,15 m:



On **TecAt**, these are named **passive** electrodes, as they do not contribute to dissipate the fault current to the soil as the connected grid (**active**) electrodes; **TecAt** also has **return** electrodes, not used for this example.

4.1 Resistance and potential elevation of the grid

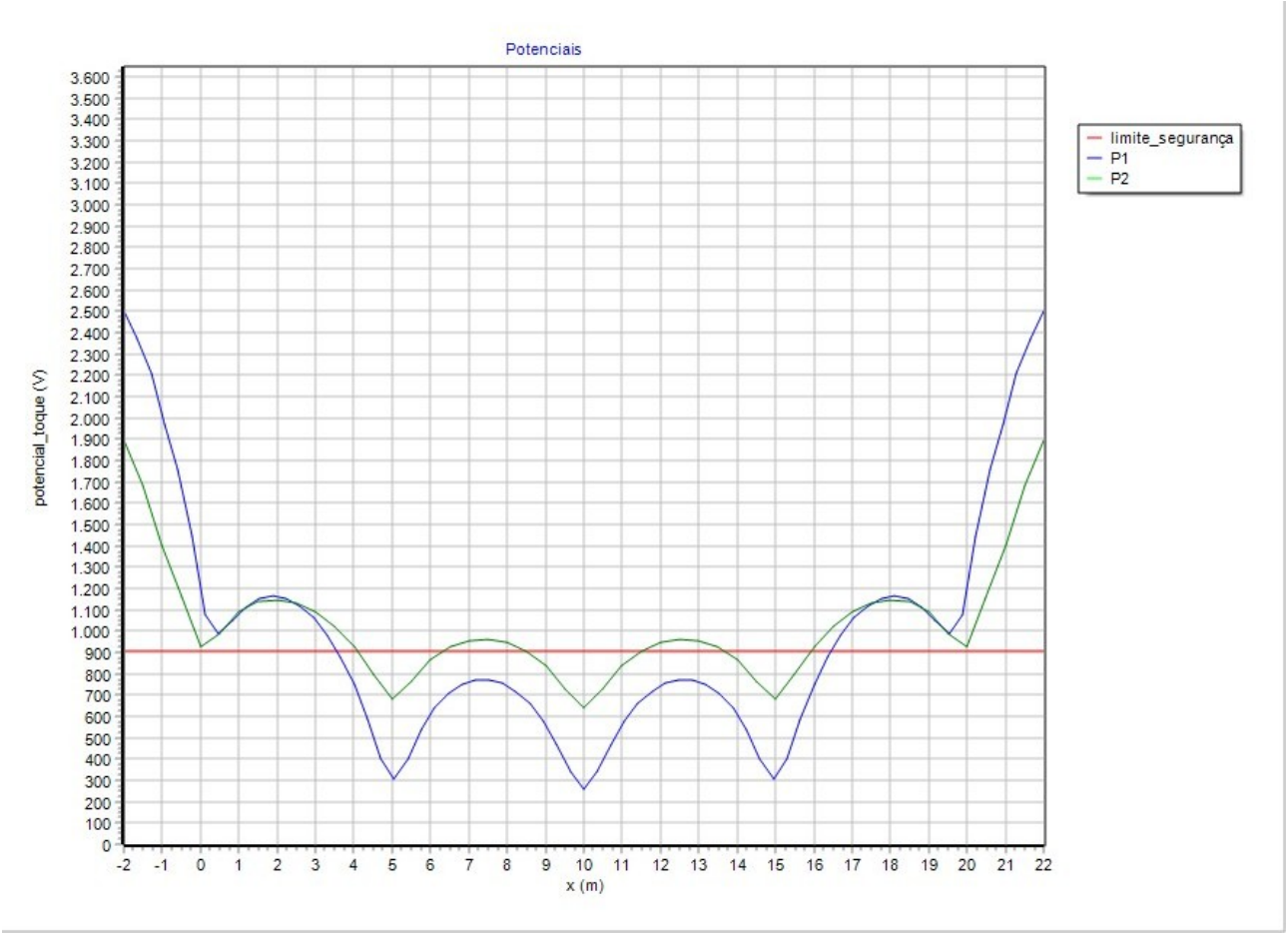
```
Dados do Projeto:
Projeto:   Cerca
Cliente:
Data:      20/05/2016
Local:

N° de camadas: 1
    camada #1: 100 [Ohm.m] x 10 [m]
    camada #2: 100 [Ohm.m]

Tempo de processamento: 0,000 s
Resistência da Malha [Ohm] =    2,38
Máximo potencial da Malha [V] = 4758,55
elevacao_potencial_passivo = 3277,8 V
diferenca_ativo_passivo = 1480,7 V
corrente_atraves_passivo = 52,8 A

condutores:
Nr.    X1(m)      Y1(m)      Z1(m)      X2(m)      Y2(m)      Z2(m)    Raio(mm)  NSub Tipo
cabos
  1       0,0        0,0        0,5       20,0        0,0        0,5        4,0       5  A
  2       0,0        5,0        0,5       20,0        5,0        0,5        4,0       5  A
```

3	0,0	10,0	0,5	20,0	10,0	0,5	4,0	5	A
4	0,0	15,0	0,5	20,0	15,0	0,5	4,0	5	A
5	0,0	20,0	0,5	20,0	20,0	0,5	4,0	5	A
6	0,0	0,0	0,5	0,0	20,0	0,5	4,0	5	A
7	5,0	0,0	0,5	5,0	20,0	0,5	4,0	5	A
8	10,0	0,0	0,5	10,0	20,0	0,5	4,0	5	A
9	15,0	0,0	0,5	15,0	20,0	0,5	4,0	5	A
10	20,0	0,0	0,5	20,0	20,0	0,5	4,0	5	A
11	-1,0	-1,0	0,1	21,0	-1,0	0,1	7,3	4	P
12	-1,0	21,0	0,1	21,0	21,0	0,1	7,3	4	P
13	-1,0	-1,0	0,1	-1,0	21,0	0,1	7,3	4	P
14	21,0	-1,0	0,1	21,0	21,0	0,1	7,3	4	P

As we now have the passive electrodes, **TecAt Plus** returns not only the GPR (ground potential rise), but also the potential elevation on the passive electrode; this way, if an operator touches the fence with one hand and, with the other, touches a grounded structure or equipment, he'll get a potential difference of 1480,7 V.

Note also that, as expected, the passive electrode doesn't change the grid resistance.

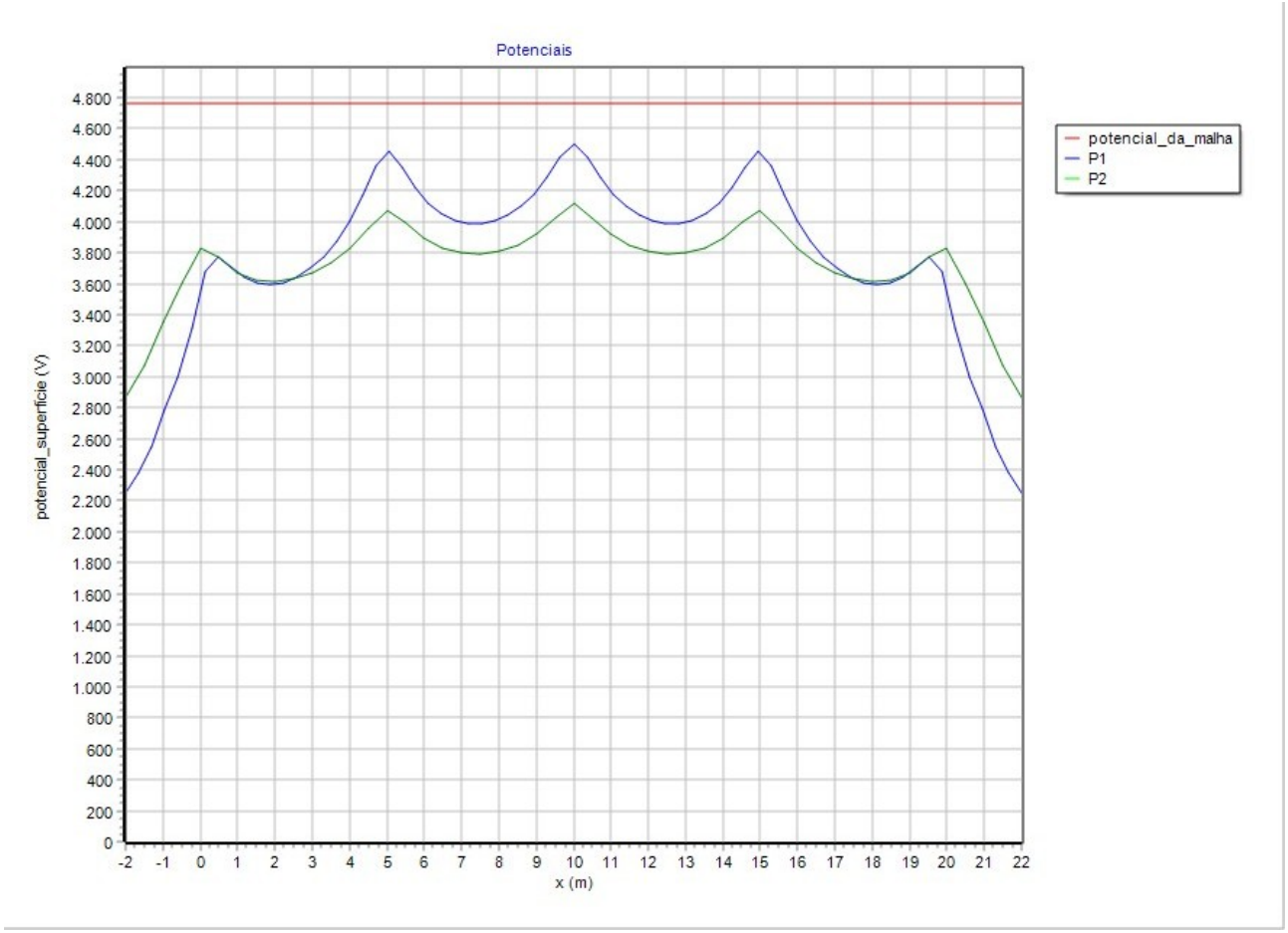
4.2 Touch potentials



Again, the presence of the passive electrode doesn't affect the grid performance.

4.3 Touch on the fence

The touch potential outside the fence (critical situation) will then be the difference between the potential on the passive electrode (potential on the hand) and the surface potential at 1 m outside the fence, or -2 on our scale, where the feet would be.

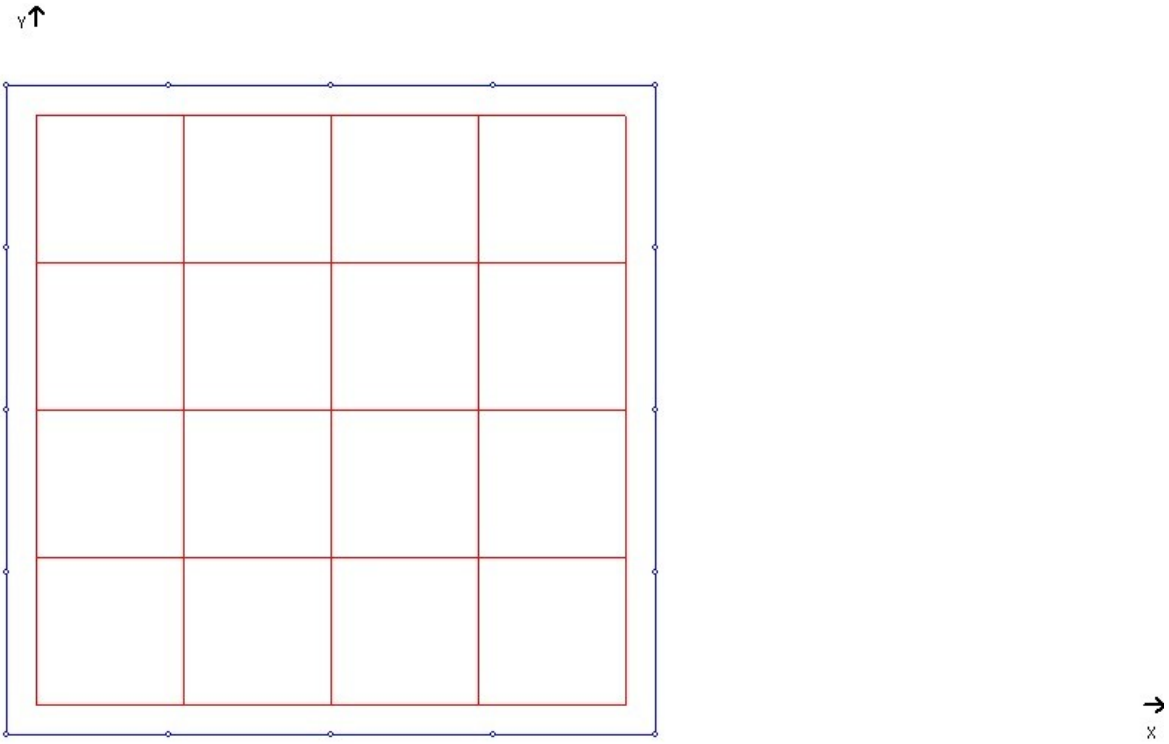


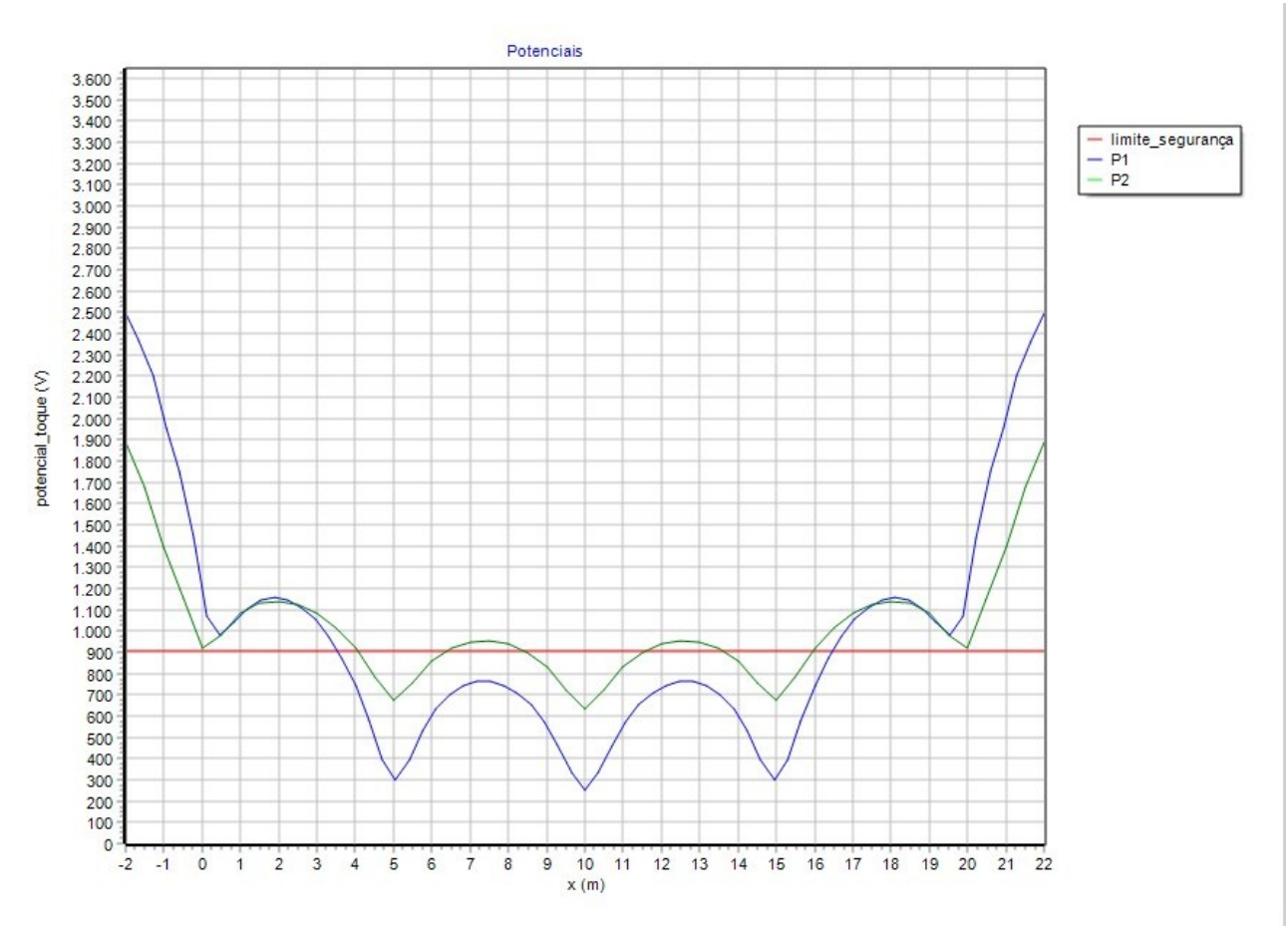
On the longitudinal direction (green line) we have the value of 2900 V at surface for X = -2 (foot potential) and 3277,8 V on the hand (potential elevation on passive electrode), resulting on a touch potential of 377,8 V.

Como normalmente não temos brita do lado de fora da SE, esse potencial de toque está acima do admissível de 255 V, resultando ainda numa situação de perigo, embora menor que no caso da cerca estar aterrada na malha.

5. Fence with vertical foundation

On item 4 above, for simplification, we assumed the fence foundation as being only parallel to the ground (rebars of the foundation beam), but usually there are also some small vertical foundation, so let's add "rods" of 0,8 meters of depth, 4 of them on each side:





As can be seen, the values don’t differ significantly from the situation on item 4.

6. Conclusion

The example above shows the behavior of touch potentials on a metallic fence not grounded to the substation grid, at 1 m distance from it. With this configuration and this soil (different stratifications could give different results), there's a better result than the option of install the fence above the last electrode of the grid and ground it.

Other possibilities can be tested, like grounding the fence but locating it inside the perimeter of the grid - or extending the grid under and out the fence; we could also add a layer of gravel also outside the fence or, better yet, an asphalt layer. The solution adopted depends also on other factors, like the possibility or not of add any element (gravel, asphalt or grid extension) outside the limits of the substation: if it's located on the city, for example, there could be legal constraints for that.

As always, we recommend to not adopt one solution as standard just because it has a good performance on one site, as the results can vary with the soil stratification of each place.

* * *