SPACE APPLICATION NOTE
ABOUT
SUBSTRATE 3D EXTRACTION
EXAMPLE3 (single/duo2)

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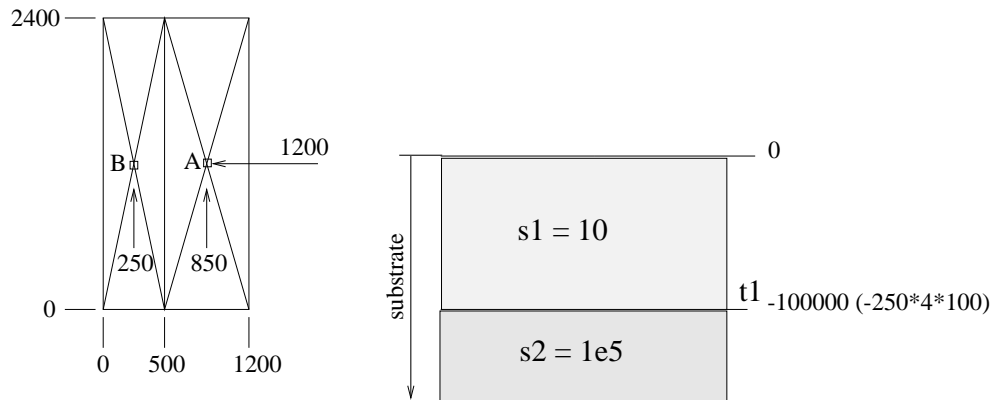Report ET-CAS 02-01-3
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1. EXAMPLE CELL: single

1.1 single.ldm

```
:: lambda = 0.01 micron
ms single
term cmf 125 154 278 313 a
box cmf 0 300 0 600
me
```


1.2 results

For the above configuration see listings in APPENDIX A to G.

The following results are for grounded substrate:

neumann_simulation_ratio=1e4			
spB-cx	spA-cx	res trunc.	res mean
--	600	12.72083k	12.71818k
50	650	12.07127k	12.06875k
100	700	12.06327k	12.06083k
150	750	12.07292k	12.07058k
200	800	12.08414k	12.08191k
250	850	12.09198k	12.08986k
300	900	12.09325k	12.09192k

spB-cx=250 spA-cx=850		
neumann_sim_ratio	res trunc.	res mean
1e5	12.09306k	12.09095k
1e4	12.09198k	12.08986k
1e3	12.08112k	12.07901k
1e2	11.97360k	11.97158k
1e1	10.99418k	10.99338k

2. EXAMPLE SETUP

See project directory:
```
jupiter ../Shadow/hp700.test/src/space/sub3term/GroundedSubstrate
```

2.1 .dmrc

```
302
./process/scmos_hfcal
0.01
```

2.2 space.green.s

```
unit vdimension 1e-6

conductors:
    condIN   : cmf      : cmf  : 0

contacts:
    cont_sub : cmf      : cmf @sub : 0

sublayers:
    epi         10      0
 #  epi2        40    -100
    substrate  1e5    -250
 #  metalization 1   -250
```

2.3 space.green.p

```
#min_divergence_term   10
#sub3d.use_old_images            on
#sub3d.use_lowest_medium         off
#sub3d.use_mean_green_values     on
#sub3d.merge_images              off

#sub3d.green_eps          0.002
#sub3d.mp_min_dist        22
#sub3d.max_green_terms  100
sub3d.max_be_area               inf
sub3d.be_window                 inf
sub3d.neumann_simulation_ratio  1e4

debug.print_green_init
debug.print_green_terms
#debug.print_green_gterms
```
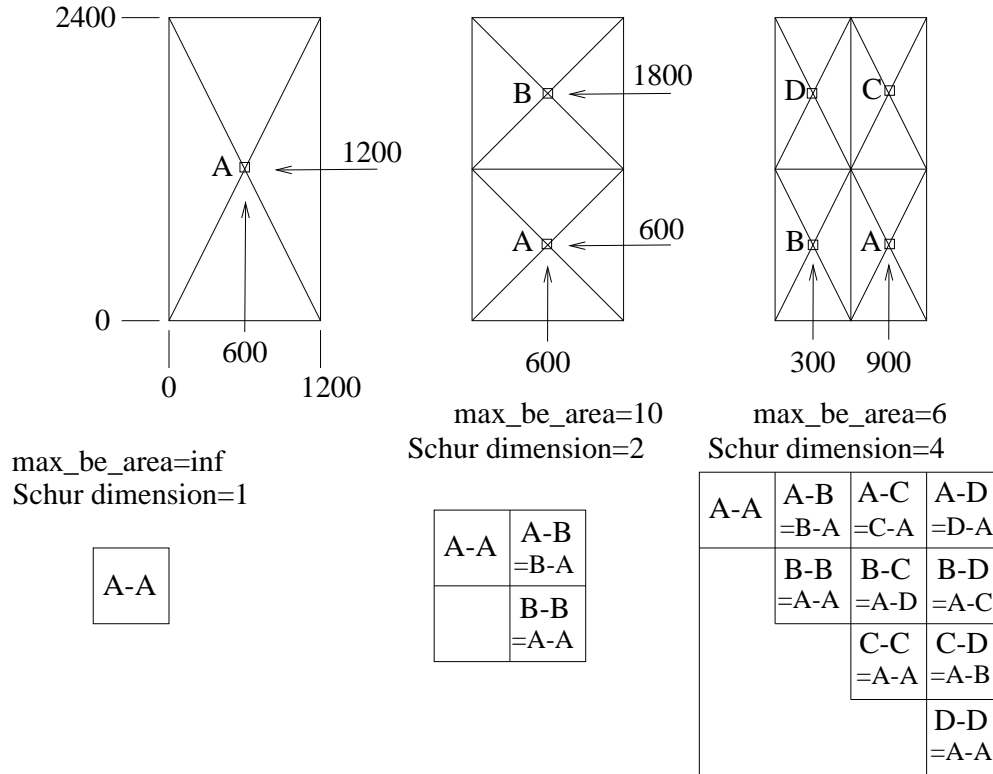
2.4 execution statement

```
space3d -vB -E space.green.t -P space.green.p single
```

3. EXAMPLE SETUP-B

2400

A ← 1200

← 600

0

600

0   1200

max_be_area=inf
Schur dimension=1

A-A

B ← 1800

A ← 600

600

max_be_area=10
Schur dimension=2

A-A	A-B =B-A
	B-B =A-A

D   C

B   A

300   900

max_be_area=6
Schur dimension=4

A-A	A-B =B-A	A-C =C-A	A-D =D-A
	B-B =A-A	B-C =A-D	B-D =A-C
		C-C =A-A	C-D =A-B
			D-D =A-A

3.1 results

The following results are for grounded substrate (nLayers=2),
for different max_be_area values:

neumann_simulation_ratio=1e4				
max_be_area	dimension	res trunc.	# calc.	# needed
1	32	10.51425k	1024	-
2	16	10.72377k	256	-
4	8	11.08130k	64	8
6	4	11.47751k	16	4
10	2	12.05888k	4	2
inf	1	12.72083k	1	1

4. EXAMPLE SETUP-C: duo2
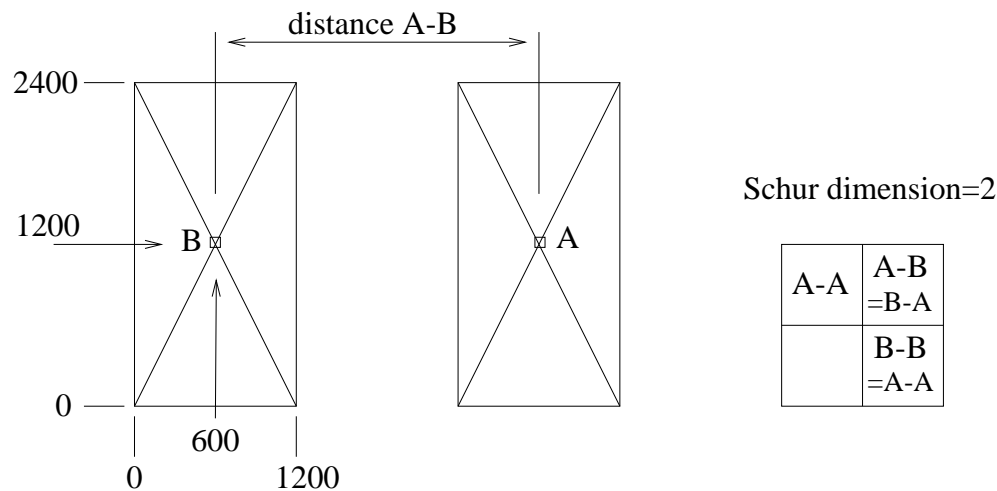
4.1 results

The following results are for grounded substrate (nLayers=2),
for different distance A-B values:

neumann_simulation_ratio=1e4		
distance A-B	res(1,2)	res(1,SUBSTR)
2400	60.78144k	15.27575k
3600	93.01417k	14.42918k
4800	125.6712k	13.99554k
6000	158.6319k	13.73445k
7200	192.1953k	13.55913k
8400	226.4985k	13.43303k

```
network duo2 ()
{
    res 226.4985k (1, 2);
    res 13.43303k (1, SUBSTR);
    res 13.43303k (2, SUBSTR);
}
```

---

5. APPENDICES

APPENDIX A -- Results: normal substrate, nLayers=1

```
preprocessing single (phase 1 - flattening layout)
preprocessing single (phase 2 - removing overlap)
prepassing single for substrate resistance
greenInit: use_lowest_medium=1 use_old_images=0
greenInit: use_mean_green_values=0 merge_images=1
greenInit: use_multipoles=1 test_multipoles=0 min_divergence_term=30
greenInit: be_mode='collocation' FeModeGalerkin=0 FeModePwl=0
greenInit: reading dielectric specification
greenInit: i=1 m='SiO2' e=3.9 b=0
greenInit: i=2 m='air' e=0.001 b=250
greenInit: reading substrate specification
greenInit: i=1 m='epi' s=10 t=0
greenInit: greenType=2 nLayers=1 maxGreenTerms=1 collocationEps=0.001
strip 0 300 (add)
Schur dimension 2, maxorder 1
greenPwc: d=0 r=4800 sp1=(850,1200,0) sp2=(850,1200,0)
greenMpole: spo=(850,1200,0) spc=(850,1200,0) cnt=1 convRadius=1250 gs2111
greenMpole( 0, 1): value= 0.000488708 term= 0.000488708 eps=1.000000
greenPwc: CollocationGreenPwc(val= 0.000488708)
greenPwc: d=600 r=4800 sp1=(850,1200,0) sp2=(250,1200,0)
greenMpole: spo=(850,1200,0) spc=(250,1200,0) cnt=2 convRadius=1225.77 gs2111
greenMpole( 0, 1): value= 0.000246057 term= 0.000246057 eps=1.000000
greenPwc: CollocationGreenPwc(val= 0.000246057)
greenMpole: spo=(250,1200,0) spc=(850,1200,0) cnt=3 convRadius=1250 gs2111
greenMpole( 0, 1): value= 0.000251914 term= 0.000251914 eps=1.000000
greenPwc: CollocationGreenPwc(val= 0.000251914) val= 0.000248985
greenPwc: d=0 r=4800 sp1=(250,1200,0) sp2=(250,1200,0)
greenMpole: spo=(250,1200,0) spc=(250,1200,0) cnt=4 convRadius=1225.77 gs2111
greenMpole( 0, 1): value= 0.000544224 term= 0.000544224 eps=1.000000
greenPwc: CollocationGreenPwc(val= 0.000544224)
extracting single
extraction statistics for layout single:
        capacitances       : 0
        resistances        : 1
        nodes              : 2
        mos transistors    : 0
        bipolar vertical   : 0
        bipolar lateral    : 0
        substrate terminals : 1
        substrate nodes    : 1

overall resource utilization:
        memory allocation  : 0.188 Mbyte
        user time          :          0.0
        system time        :          0.0
        real time          :          2.6   2%

space3d: --- Finished ---

/* Date: 12-Apr-02 15:43:24 GMT */
network single (terminal a)
{
    res 12.13669k (a, SUBSTR);
}
```

APPENDIX B -- Results: normal substrate, nLayers=2

```
prepassing single for substrate resistance
greenInit: use_lowest_medium=1 use_old_images=0
greenInit: use_mean_green_values=0 merge_images=1
greenInit: use_multipoles=1 test_multipoles=0 min_divergence_term=10
greenInit: be_mode='collocation' FeModeGalerkin=0 FeModePwl=0
greenInit: reading substrate specification
greenInit: i=1 m='epi' s=10 t=0
greenInit: i=2 m='substrate' s=100000 t=-250
greenInit: greenType=2 nLayers=2 maxGreenTerms=500 collocationEps=0.001
strip 0 300 (add)
Schur dimension 2, maxorder 1
greenPwc: d=0 r=4800 sp1=(850,1200,0) sp2=(850,1200,0) A-A
greenMpole: spo=(850,1200,0) spc=(850,1200,0) cnt=1 convRadius=1250 gs2211
greenMpole( 0,  1): value= 0.000488708 term= 0.000488708 eps=1.000000
greenMpole( 1,  2): value= 0.000486709 term=-0.000002000 eps=0.004108
greenMpole( 2,  3): value= 0.000487708 term= 0.000001000 eps=0.002050
greenMpole( 3,  4): value= 0.000487042 term=-0.000000666 eps=0.001368
greenMpole( 4,  5): value= 0.000487541 term= 0.000000500 eps=0.001025
greenMpole( 5,  6): value= 0.000487142 term=-0.000000400 eps=0.000820
greenPwc: CollocationGreenPwc(val= 0.000487142)
greenPwc: d=600 r=4800 sp1=(850,1200,0) sp2=(250,1200,0) A-B
greenMpole: spo=(850,1200,0) spc=(250,1200,0) cnt=2 convRadius=1225.77 gs2211
greenMpole( 0,  1): value= 0.000246057 term= 0.000246057 eps=1.000000
greenMpole( 1,  2): value= 0.000244057 term=-0.000002000 eps=0.008193
greenMpole( 2,  3): value= 0.000245057 term= 0.000001000 eps=0.004079
greenMpole( 3,  4): value= 0.000244390 term=-0.000000666 eps=0.002726
greenMpole( 4,  5): value= 0.000244890 term= 0.000000500 eps=0.002040
greenMpole( 5,  6): value= 0.000244490 term=-0.000000400 eps=0.001634
greenMpole( 6,  7): value= 0.000244823 term= 0.000000333 eps=0.001360
greenMpole( 7,  8): value= 0.000244538 term=-0.000000285 eps=0.001167
greenMpole( 8,  9): value= 0.000244788 term= 0.000000250 eps=0.001020
greenMpole( 9, 10): value= 0.000244566 term=-0.000000222 eps=0.000907
greenPwc: CollocationGreenPwc(val= 0.000244566)
greenMpole: spo=(250,1200,0) spc=(850,1200,0) cnt=3 convRadius=1250 gs2211
greenMpole( 0,  1): value= 0.000251914 term= 0.000251914 eps=1.000000
greenMpole( 1,  2): value= 0.000249914 term=-0.000002000 eps=0.008001
greenMpole( 2,  3): value= 0.000250914 term= 0.000001000 eps=0.003984
greenMpole( 3,  4): value= 0.000250248 term=-0.000000666 eps=0.002662
greenMpole( 4,  5): value= 0.000250747 term= 0.000000500 eps=0.001992
greenMpole( 5,  6): value= 0.000250348 term=-0.000000400 eps=0.001596
greenMpole( 6,  7): value= 0.000250681 term= 0.000000333 eps=0.001328
greenMpole( 7,  8): value= 0.000250395 term=-0.000000285 eps=0.001139
greenMpole( 8,  9): value= 0.000250645 term= 0.000000250 eps=0.000996
greenPwc: CollocationGreenPwc(val= 0.000250645) val= 0.000247605
greenPwc: d=0 r=4800 sp1=(250,1200,0) sp2=(250,1200,0) B-B
greenMpole: spo=(250,1200,0) spc=(250,1200,0) cnt=4 convRadius=1225.77 gs2211
greenMpole( 0,  1): value= 0.000544224 term= 0.000544224 eps=1.000000
greenMpole( 1,  2): value= 0.000542225 term=-0.000002000 eps=0.003688
greenMpole( 2,  3): value= 0.000543224 term= 0.000001000 eps=0.001840
greenMpole( 3,  4): value= 0.000542558 term=-0.000000666 eps=0.001228
greenMpole( 4,  5): value= 0.000543058 term= 0.000000500 eps=0.000920
greenPwc: CollocationGreenPwc(val= 0.000543058)
extracting single

/* Date: 11-Apr-02 15:10:27 GMT */
network single (terminal a)
{
    res 12.09232k (a, SUBSTR);
}
```

APPENDIX C -- Results: grounded substrate, nLayers=2

```
prepassing single for substrate resistance
greenInit: use_lowest_medium=1 use_old_images=0
greenInit: use_mean_green_values=0 merge_images=1
greenInit: use_multipoles=1 test_multipoles=0 min_divergence_term=10
greenInit: be_mode='collocation' FeModeGalerkin=0 FeModePwl=0
greenInit: reading substrate specification
greenInit: i=1 m='epi' s=10 t=0
greenInit: i=2 m='metalization' s=1 t=-250
greenInit: sub3d.neumann_simulation_ratio=10000
greenInit: i=1 e=10 b=0
greenInit: i=2 e=0.001 b=250
greenInit: greenType=3 nLayers=2 maxGreenTerms=500 collocationEps=0.001
strip 0 300 (add)
Schur dimension 2, maxorder 1
greenPwc: d=0 r=4800 sp1=(850,1200,100000) sp2=(850,1200,100000)
greenMpole: spo=(850,1200,100000) spc=(850,1200,100000) cnt=1 convRadius=1250 gs3222
greenMpole( 0,  3): value= 0.000487659 term= 0.000487659 eps=1.000000
greenMpole( 1,  5): value= 0.000487160 term=-0.000000500 eps=0.001026
greenMpole( 2,  7): value= 0.000487326 term= 0.000000167 eps=0.000342
greenPwc: CollocationGreenPwc(val= 0.000487326)
greenPwc: d=600 r=4800 sp1=(850,1200,100000) sp2=(250,1200,100000)
greenMpole: spo=(850,1200,100000) spc=(250,1200,100000) cnt=2 convRadius=1225.77 gs3222
greenMpole( 0,  3): value= 0.000245032 term= 0.000245032 eps=1.000000
greenMpole( 1,  5): value= 0.000244532 term=-0.000000500 eps=0.002044
greenMpole( 2,  7): value= 0.000244699 term= 0.000000167 eps=0.000681
greenPwc: CollocationGreenPwc(val= 0.000244699)
greenMpole: spo=(250,1200,100000) spc=(850,1200,100000) cnt=3 convRadius=1250 gs3222
greenMpole( 0,  3): value= 0.000250889 term= 0.000250889 eps=1.000000
greenMpole( 1,  5): value= 0.000250389 term=-0.000000500 eps=0.001996
greenMpole( 2,  7): value= 0.000250555 term= 0.000000167 eps=0.000665
greenPwc: CollocationGreenPwc(val= 0.000250555) val= 0.000247627
greenPwc: d=0 r=4800 sp1=(250,1200,100000) sp2=(250,1200,100000)
greenMpole: spo=(250,1200,100000) spc=(250,1200,100000) cnt=4 convRadius=1225.77 gs3222
greenMpole( 0,  3): value= 0.000543170 term= 0.000543170 eps=1.000000
greenMpole( 1,  5): value= 0.000542670 term=-0.000000500 eps=0.000921
greenPwc: CollocationGreenPwc(val= 0.000542670)
extracting single

/* Date: 11-Apr-02 15:48:27 GMT */
network single (terminal a)
{
    res 12.09198k (a, SUBSTR);
}
```

APPENDIX D -- Results: grounded substrate, nLayers=2 (new/mean diff)

```
8c8
< greenInit: use_mean_green_values=0 merge_images=1
> greenInit: use_mean_green_values=1 merge_images=1
28c28
< greenPwc: CollocationGreenPwc(val= 0.000487326)
> greenPwc: CollocationGreenPwc(val= 0.000487243)
34c34
< greenPwc: CollocationGreenPwc(val= 0.000244699)
> greenPwc: CollocationGreenPwc(val= 0.000244616)
39c39
< greenPwc: CollocationGreenPwc(val= 0.000250555) val= 0.000247627
> greenPwc: CollocationGreenPwc(val= 0.000250472) val= 0.000247544
69c69
<     res 12.09198k (a, SUBSTR);
>     res 12.08986k (a, SUBSTR);
```

APPENDIX E -- Results: grounded substrate, nLayers=2 (new/old diff)

```
7c7
< greenInit: use_lowest_medium=1 use_old_images=0
> greenInit: use_lowest_medium=1 use_old_images=1
9c9
< greenInit: use_multipoles=1 test_multipoles=0 min_divergence_term=10
> greenInit: use_multipoles=1 test_multipoles=0 min_divergence_term=30
25,28c25,168
< greenMpole( 2,  7): value= 0.000487326 term= 0.000000167 eps=0.000342
< greenPwc: CollocationGreenPwc(val= 0.000487326)
---
> greenMpole( 0,  2): value= 2.438540602 term= 2.438540602 eps=1.000000
> greenMpole( 1,  4): value=-0.002011812 term=-2.440552414 eps=1213.111439
> greenMpole( 2,  6): value= 0.001320157 term= 0.003331969 eps=2.523919
> greenMpole( 3,  8): value= 0.000070910 term=-0.001249247 eps=17.617343 <----
> greenMpole( 4, 10): value= 0.000737043 term= 0.000666133 eps=0.903791
> greenMpole( 5, 12): value= 0.000320793 term=-0.000416250 eps=1.297566 <----
> greenMpole( 6, 14): value= 0.000606164 term= 0.000285371 eps=0.470782
> greenMpole( 7, 16): value= 0.000398122 term=-0.000208042 eps=0.522557 <----
> greenMpole( 8, 18): value= 0.000556599 term= 0.000158476 eps=0.284723
> greenMpole( 9, 20): value= 0.000431824 term=-0.000124775 eps=0.288949 <----
> greenMpole(10, 22): value= 0.000532632 term= 0.000100808 eps=0.189264
> greenMpole(11, 24): value= 0.000449482 term=-0.000083150 eps=0.184991
> greenMpole(12, 26): value= 0.000519244 term= 0.000069762 eps=0.134354
  ...
> greenMpole(139,280): value= 0.000487023 term=-0.000000503 eps=0.001034
> greenMpole(140,282): value= 0.000487519 term= 0.000000496 eps=0.001018
> greenMpole(141,284): value= 0.000487030 term=-0.000000489 eps=0.001004
> greenMpole(142,286): value= 0.000487512 term= 0.000000482 eps=0.000989
> greenPwc: CollocationGreenPwc(val= 0.000487512)
31,34c171,371
< greenMpole( 2,  7): value= 0.000244699 term= 0.000000167 eps=0.000681
< greenPwc: CollocationGreenPwc(val= 0.000244699)
---
> greenMpole( 0,  2): value= 1.225283582 term= 1.225283582 eps=1.000000
> greenMpole( 1,  4): value=-0.002254421 term=-1.227538003 eps=544.502614
> greenMpole( 2,  6): value= 0.001077528 term= 0.003331948 eps=3.092216
> greenMpole( 3,  8): value=-0.000171717 term=-0.001249244 eps=7.275034 <----
> greenMpole( 4, 10): value= 0.000494415 term= 0.000666132 eps=1.347313
> greenMpole( 5, 12): value= 0.000078166 term=-0.000416250 eps=5.325219 <----
> greenMpole( 6, 14): value= 0.000363537 term= 0.000285371 eps=0.784986
> greenMpole( 7, 16): value= 0.000155495 term=-0.000208042 eps=1.337929 <----
> greenMpole( 8, 18): value= 0.000313972 term= 0.000158476 eps=0.504747
> greenMpole( 9, 20): value= 0.000189197 term=-0.000124775 eps=0.659500 <----
> greenMpole(10, 22): value= 0.000290005 term= 0.000100808 eps=0.347609
> greenMpole(11, 24): value= 0.000206855 term=-0.000083150 eps=0.401974 <----
> greenMpole(12, 26): value= 0.000276617 term= 0.000069762 eps=0.252199
> greenMpole(13, 28): value= 0.000217248 term=-0.000059369 eps=0.273279 <----
> greenMpole(14, 30): value= 0.000268386 term= 0.000051139 eps=0.190541
> greenMpole(15, 32): value= 0.000223877 term=-0.000044509 eps=0.198810 <----
> greenMpole(16, 34): value= 0.000262968 term= 0.000039090 eps=0.148651
> greenMpole(17, 36): value= 0.000228363 term=-0.000034604 eps=0.151532 <----
> greenMpole(18, 38): value= 0.000259212 term= 0.000030848 eps=0.119009
> greenMpole(19, 40): value= 0.000231539 term=-0.000027672 eps=0.119515 <----
> greenMpole(20, 42): value= 0.000256502 term= 0.000024963 eps=0.097319
> greenMpole(21, 44): value= 0.000233870 term=-0.000022632 eps=0.096772
  ...
> greenMpole(196,394): value= 0.000244771 term= 0.000000250 eps=0.001023
> greenMpole(197,396): value= 0.000244523 term=-0.000000248 eps=0.001013
> greenMpole(198,398): value= 0.000244768 term= 0.000000245 eps=0.001002
> greenMpole(199,400): value= 0.000244525 term=-0.000000243 eps=0.000992
> greenPwc: CollocationGreenPwc(val= 0.000244525)
```

```
36,39c373,570
< greenMpole( 2,  7): value= 0.000250555 term= 0.000000167 eps=0.000665
< greenPwc: CollocationGreenPwc(val= 0.000250555) val= 0.000247627
---
> greenMpole( 0,  2): value= 1.254569203 term= 1.254569203 eps=1.000000
> greenMpole( 1,  4): value=-0.002248563 term=-1.256817766 eps=558.942617
> greenMpole( 2,  6): value= 0.001083384 term= 0.003331947 eps=3.075499
> greenMpole( 3,  8): value=-0.000165860 term=-0.001249244 eps=7.531917 <----
> greenMpole( 4, 10): value= 0.000500272 term= 0.000666132 eps=1.331540
> greenMpole( 5, 12): value= 0.000084022 term=-0.000416250 eps=4.954039 <----
> greenMpole( 6, 14): value= 0.000369394 term= 0.000285371 eps=0.772540
> greenMpole( 7, 16): value= 0.000161352 term=-0.000208042 eps=1.289366 <----
> greenMpole( 8, 18): value= 0.000319828 term= 0.000158476 eps=0.495504
> greenMpole( 9, 20): value= 0.000195053 term=-0.000124775 eps=0.639698 <----
> greenMpole(10, 22): value= 0.000295861 term= 0.000100808 eps=0.340728
> greenMpole(11, 24): value= 0.000212711 term=-0.000083150 eps=0.390907 <----
> greenMpole(12, 26): value= 0.000282474 term= 0.000069762 eps=0.246970
> greenMpole(13, 28): value= 0.000223104 term=-0.000059369 eps=0.266105 <----
> greenMpole(14, 30): value= 0.000274243 term= 0.000051139 eps=0.186472
> greenMpole(15, 32): value= 0.000229734 term=-0.000044509 eps=0.193742 <----
> greenMpole(16, 34): value= 0.000268824 term= 0.000039090 eps=0.145412
> greenMpole(17, 36): value= 0.000234220 term=-0.000034604 eps=0.147743 <----
> greenMpole(18, 38): value= 0.000265068 term= 0.000030848 eps=0.116379
> greenMpole(19, 40): value= 0.000237396 term=-0.000027672 eps=0.116567 <----
> greenMpole(20, 42): value= 0.000262359 term= 0.000024963 eps=0.095147
> greenMpole(21, 44): value= 0.000239727 term=-0.000022632 eps=0.094408
> greenMpole(22, 46): value= 0.000260340 term= 0.000020613 eps=0.079177
> greenMpole(23, 48): value= 0.000241487 term=-0.000018852 eps=0.078068
   ...
> greenMpole(193,388): value= 0.000250374 term=-0.000000258 eps=0.001032
> greenMpole(194,390): value= 0.000250630 term= 0.000000256 eps=0.001020
> greenMpole(195,392): value= 0.000250377 term=-0.000000253 eps=0.001010
> greenMpole(196,394): value= 0.000250627 term= 0.000000250 eps=0.000999
> greenPwc: CollocationGreenPwc(val= 0.000250627) val= 0.000247576
42,44c573,708
< greenMpole( 1,  5): value= 0.000542670 term=-0.000000500 eps=0.000921
< greenPwc: CollocationGreenPwc(val= 0.000542670)
---
> greenMpole( 0,  2): value= 2.716121090 term= 2.716121090 eps=1.000000
> greenMpole( 1,  4): value=-0.001956303 term=-2.718077393 eps=1389.395058
> greenMpole( 2,  6): value= 0.001375667 term= 0.003331970 eps=2.422075
> greenMpole( 3,  8): value= 0.000126421 term=-0.001249247 eps=9.881674 <----
> greenMpole( 4, 10): value= 0.000792553 term= 0.000666133 eps=0.840489
> greenMpole( 5, 12): value= 0.000376303 term=-0.000416250 eps=1.106155 <----
> greenMpole( 6, 14): value= 0.000661675 term= 0.000285371 eps=0.431287
> greenMpole( 7, 16): value= 0.000453633 term=-0.000208042 eps=0.458613 <----
> greenMpole( 8, 18): value= 0.000612109 term= 0.000158476 eps=0.258902
> greenMpole( 9, 20): value= 0.000487334 term=-0.000124775 eps=0.256036
> greenMpole(10, 22): value= 0.000588142 term= 0.000100808 eps=0.171401
> greenMpole(11, 24): value= 0.000504992 term=-0.000083150 eps=0.164656
   ...
> greenMpole(131,264): value= 0.000542502 term=-0.000000568 eps=0.001046
> greenMpole(132,266): value= 0.000543061 term= 0.000000559 eps=0.001029
> greenMpole(133,268): value= 0.000542511 term=-0.000000551 eps=0.001015
> greenMpole(134,270): value= 0.000543053 term= 0.000000542 eps=0.000998
> greenPwc: CollocationGreenPwc(val= 0.000543053)
68c732
<     res 12.09198k (a, SUBSTR); /* new */
>     res 12.09543k (a, SUBSTR); /* old */

Note: I have set min_divergence_term=30 to forcome false divergence stops (see <---).
      By min_divergence_term=10, res=10.64889k.
      By maxGreenTerms =100,     res=12.07560k.
      By collocationEps=0.002,   res=12.09392k.
```

APPENDIX F -- Results: grounded substrate, nLayers=3 (2 spiders)

```
prepassing single for substrate resistance
greenInit: use_lowest_medium=1 use_old_images=0
greenInit: use_mean_green_values=0 merge_images=1
greenInit: use_multipoles=1 test_multipoles=0 min_divergence_term=30
greenInit: be_mode='collocation' FeModeGalerkin=0 FeModePwl=0
greenInit: reading substrate specification
greenInit: i=1 m='epi' s=10 t=0
greenInit: i=2 m='epi2' s=40 t=-100
greenInit: i=3 m='metalization' s=1 t=-250
greenInit: sub3d.neumann_simulation_ratio=10000
greenInit: i=1 e=40 b=0
greenInit: i=2 e=10 b=150
greenInit: i=3 e=0.001 b=250
greenInit: greenType=3 nLayers=3 maxGreenTerms=500 collocationEps=0.001
strip 0 300 (add)
Schur dimension 2, maxorder 1
greenPwc: d=0 r=4800 sp1=(850,1200,100000) sp2=(850,1200,100000)
greenMpole: spo=(850,1200,100000) spc=(850,1200,100000) cnt=1 convRadius=1250 gs3322
greenMpole( 0,  2): value= 0.000243854 term= 0.000243854 eps=1.000000
greenMpole( 1,  9): value= 0.000486061 term= 0.000242207 eps=0.498306
greenMpole( 2, 22): value= 0.000485946 term=-0.000000115 eps=0.000237
greenPwc: CollocationGreenPwc(val= 0.000485946)
greenPwc: d=600 r=4800 sp1=(850,1200,100000) sp2=(250,1200,100000)
greenMpole: spo=(850,1200,100000) spc=(250,1200,100000) cnt=2 convRadius=1225.77 gs3322
greenMpole( 0,  2): value= 0.000122528 term= 0.000122528 eps=1.000000
greenMpole( 1,  9): value= 0.000243434 term= 0.000120906 eps=0.496668
greenMpole( 2, 22): value= 0.000243319 term=-0.000000115 eps=0.000473
greenPwc: CollocationGreenPwc(val= 0.000243319)
greenMpole: spo=(250,1200,100000) spc=(850,1200,100000) cnt=3 convRadius=1250 gs3322
greenMpole( 0,  2): value= 0.000125457 term= 0.000125457 eps=1.000000
greenMpole( 1,  9): value= 0.000249291 term= 0.000123834 eps=0.496745
greenMpole( 2, 22): value= 0.000249176 term=-0.000000115 eps=0.000462
greenPwc: CollocationGreenPwc(val= 0.000249176) val= 0.000246247
greenPwc: d=0 r=4800 sp1=(250,1200,100000) sp2=(250,1200,100000)
greenMpole: spo=(250,1200,100000) spc=(250,1200,100000) cnt=4 convRadius=1225.77 gs3322
greenMpole( 0,  2): value= 0.000271612 term= 0.000271612 eps=1.000000
greenMpole( 1,  9): value= 0.000541572 term= 0.000269960 eps=0.498475
greenMpole( 2, 22): value= 0.000541457 term=-0.000000115 eps=0.000213
greenPwc: CollocationGreenPwc(val= 0.000541457)
extracting single
extraction statistics for layout single:
        capacitances       : 0
        resistances        : 1
        nodes              : 2
        mos transistors    : 0
        bipolar vertical   : 0
        bipolar lateral    : 0
        substrate terminals : 1
        substrate nodes    : 1

space3d: --- Finished ---

/* Date: 12-Apr-02 15:51:34 GMT */
network single (terminal a)
{
    res 12.04912k (a, SUBSTR);
}
```

APPENDIX G -- Results: grounded substrate, nLayers=3 (1 spider)

```
prepassing single for substrate resistance
greenInit: use_lowest_medium=1 use_old_images=0
greenInit: use_mean_green_values=0 merge_images=1
greenInit: use_multipoles=1 test_multipoles=0 min_divergence_term=3
greenInit: be_mode='collocation' FeModeGalerkin=0 FeModePwl=0
greenInit: reading substrate specification
greenInit: i=1 m='epi' s=10 t=0
greenInit: i=2 m='epi2' s=40 t=-100
greenInit: i=3 m='metalization' s=1 t=-250
greenInit: sub3d.neumann_simulation_ratio=10000
greenInit: i=1 e=40 b=0
greenInit: i=2 e=10 b=150
greenInit: i=3 e=0.001 b=250
greenInit: greenType=3 nLayers=3 maxGreenTerms=500 collocationEps=0.001
strip 0 300 (add)
Schur dimension 1, maxorder 0
greenPwc: d=0 r=4800 sp1=(600,1200,100000) sp2=(600,1200,100000)
greenMpole: spo=(600,1200,100000) spc=(600,1200,100000) cnt=1 convRadius=1341.64 gs3322
greenMpole( 0,  2): value= 0.000200005 term= 0.000200005 eps=1.000000
greenMpole( 1,  9): value= 0.000398372 term= 0.000198367 eps=0.497944
greenMpole( 2, 22): value= 0.000398257 term=-0.000000115 eps=0.000289
greenPwc: CollocationGreenPwc(val= 0.000398257)
extracting single
extraction statistics for layout single:
        capacitances        : 0
        resistances         : 1
        nodes               : 2
        mos transistors     : 0
        bipolar vertical    : 0
        bipolar lateral     : 0
        substrate terminals : 1
        substrate nodes     : 1

overall resource utilization:
        memory allocation  : 0.188 Mbyte
        user time           :         0.0
        system time         :         0.0
        real time           :         0.2  25%

space3d: --- Finished ---

/* Date: 12-Apr-02 16:07:18 GMT */
network single (terminal a)
{
    res 12.67691k (a, SUBSTR);
}

-------------------------------------------------------------------------------
t= -10 res=12.02694k (2, 22): value=0.000377837 eps=0.000648
t= -50 res=12.60892k (2, 22): value=0.000396121 eps=0.000273
t=-100 res=12.67691k (2, 22): value=0.000398257 eps=0.000289
t=-125 res=12.68890k (2, 13): value=0.000398634 eps=0.000719
t=-150 res=12.69902k (3, 38): value=0.000398951 eps=0.000255
t=-200 res=12.71611k (5, 88): value=0.000399488 eps=0.000828
t=-240 res=12.74526k (7,212): value=0.000400404 eps=0.003870 (divergence stop)
-------------------------------------------------------------------------------
```