PRACTICAL WORK
PW5:
DESIGN OF A LINEAR AMPLIFIER AT 2GHZ USINKEYSIGHT ADS

- Student Help Manual for PW 3, 4 and 5

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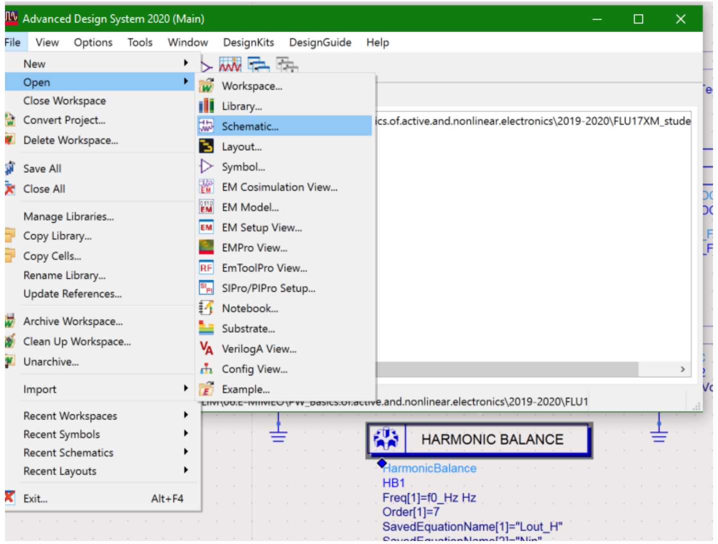
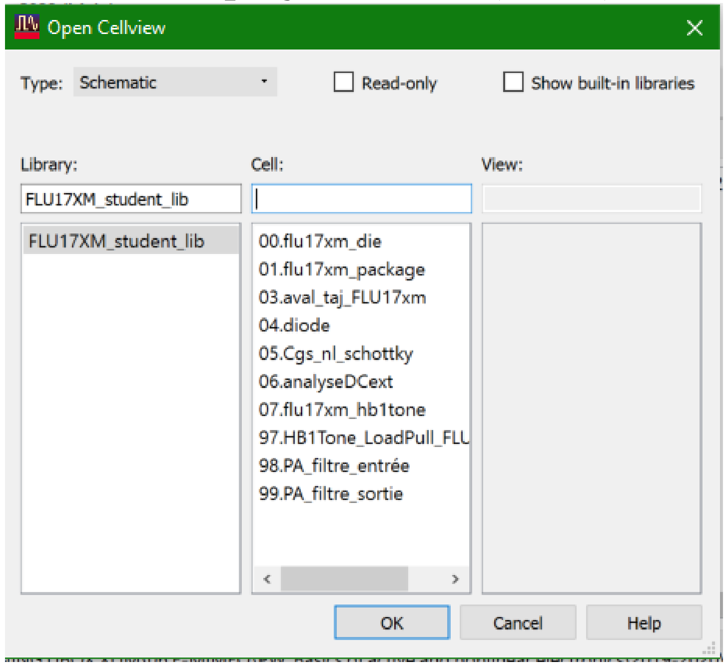
UNIVERSITATEA TEHNICĂ DIN CLUJ-NAPOCA

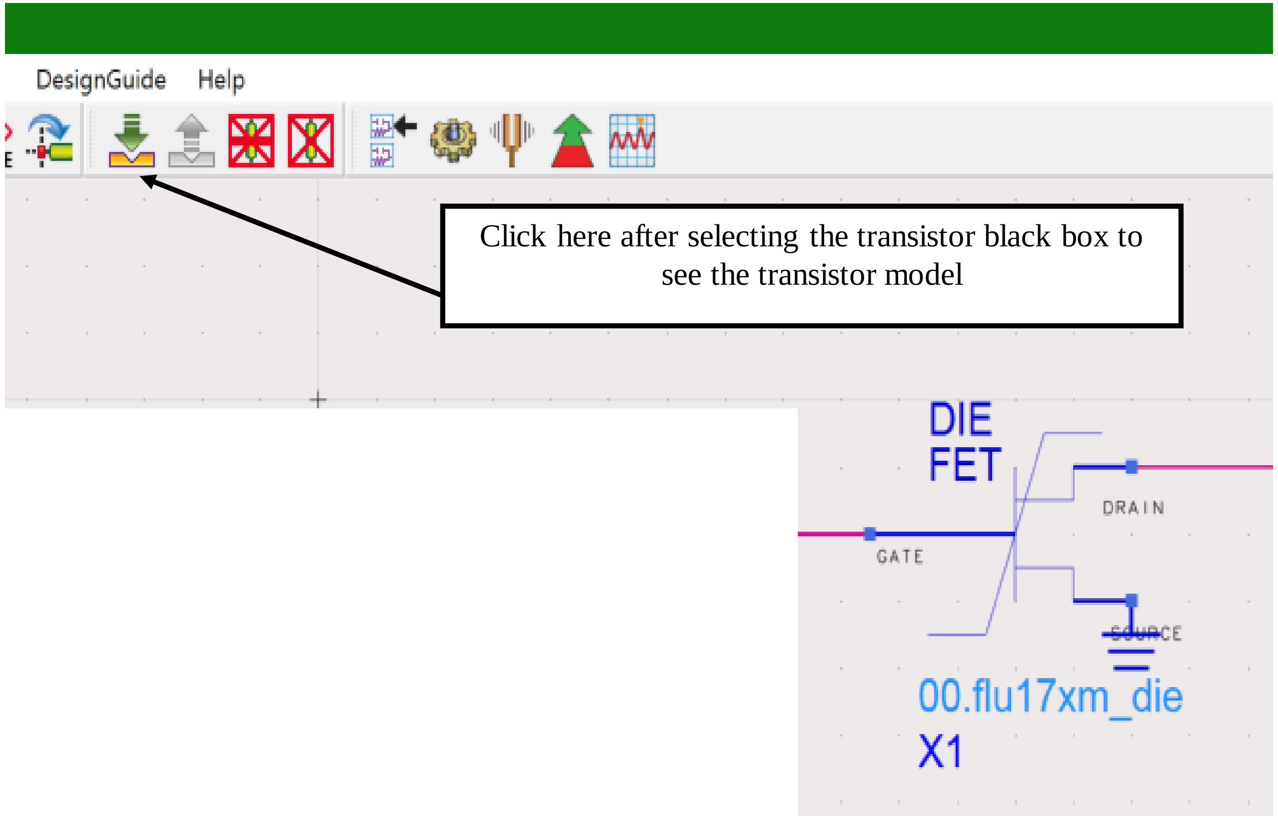
This booklet presents the architecture of the ADS project you will use.

After launching ADS, click on ***file/open Schematic*** to obtain the following list of schematics :

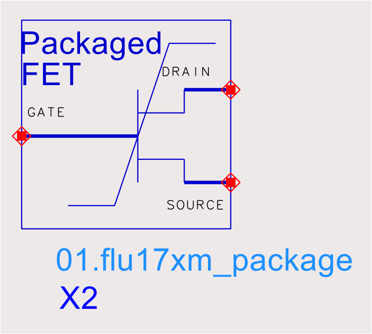


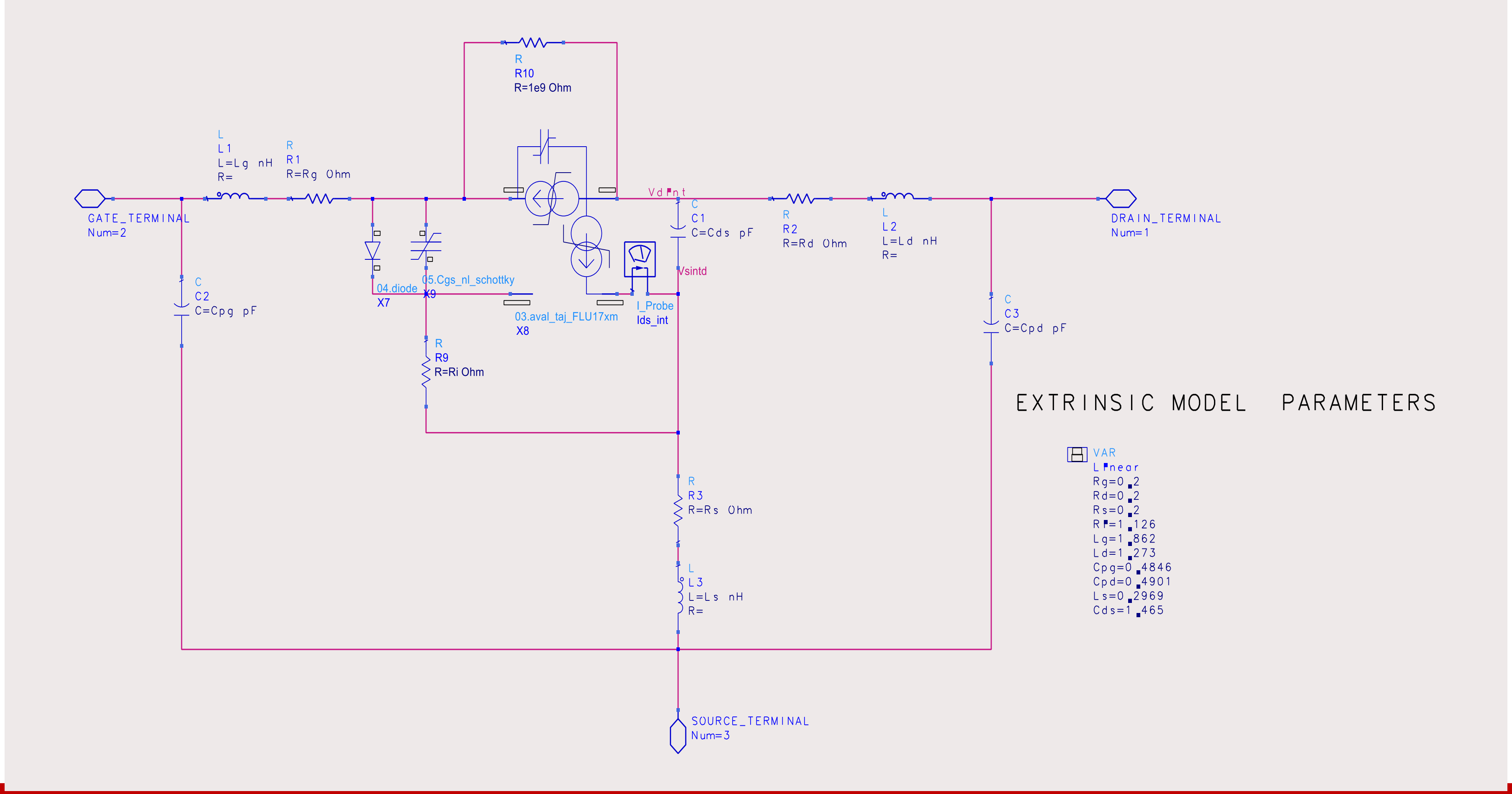
Each schematic file (*.dsn) is detailed hereafter as well as the corresponding data display window (*.dds).



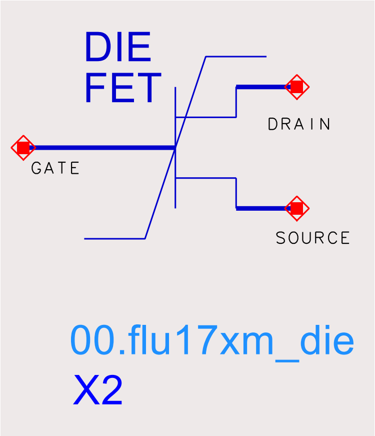

DesignGuide
Help
Click here after selecting the transistor black box to see the transistor model
DIE
FET
DRAIN
GATE
SOURCE
00.flu17xm_die
X1

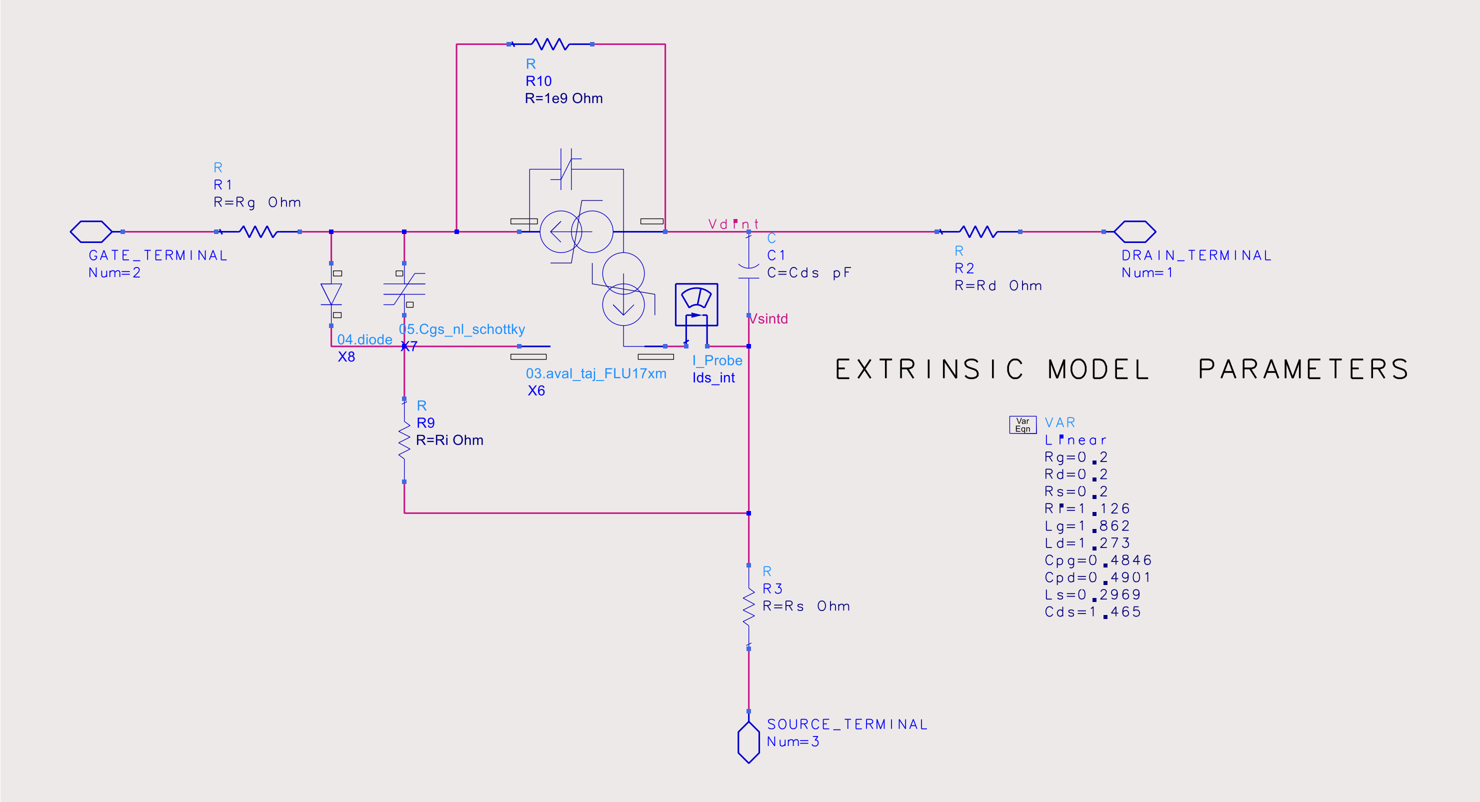
The *01.flu17xm_package.dsn* file defines the non-linear packaged model of the FET. The figure below represents the symbol associated to this model (and to this file). You can click on *Window/symbol* in the *Window* menu.



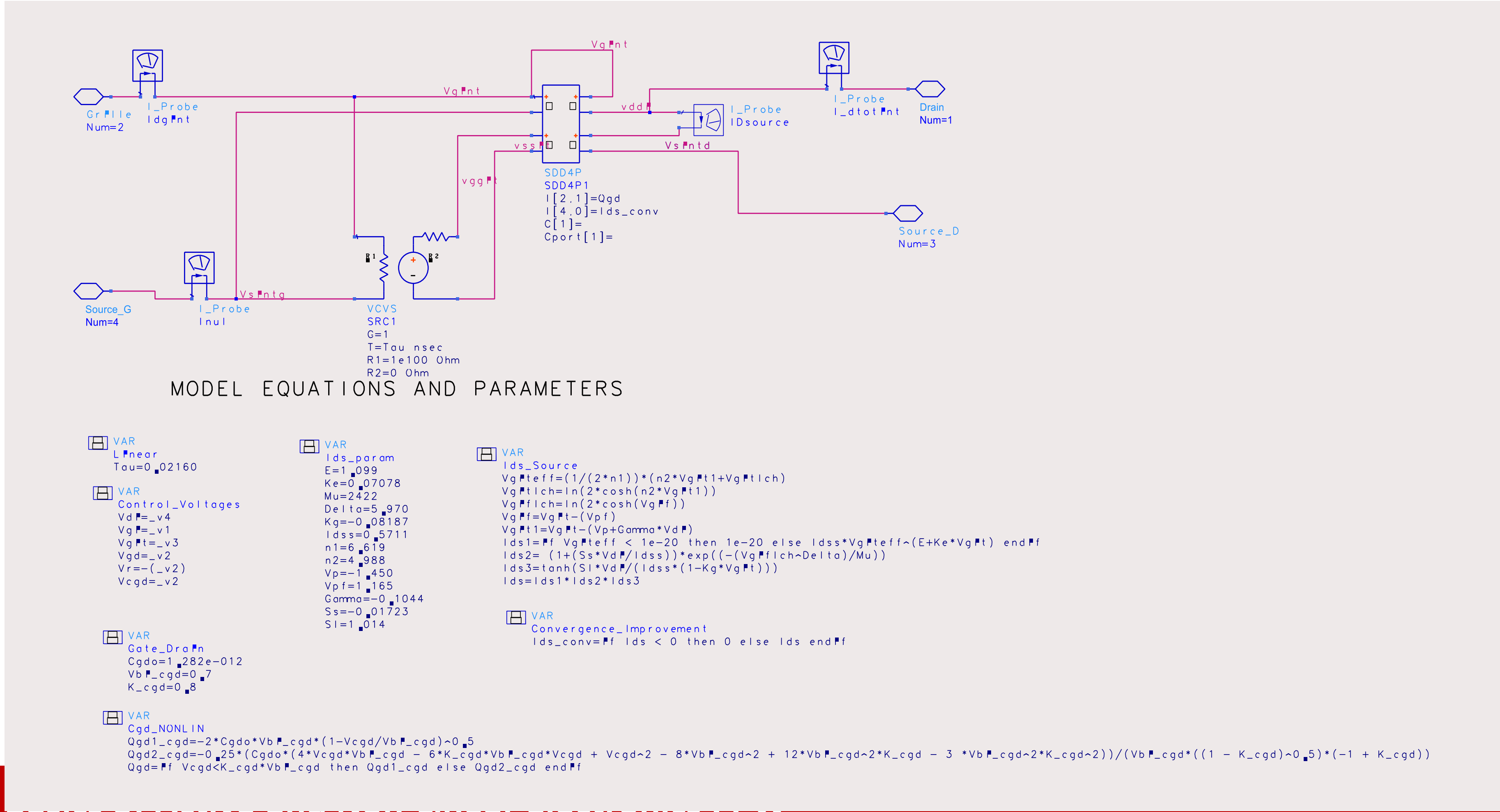


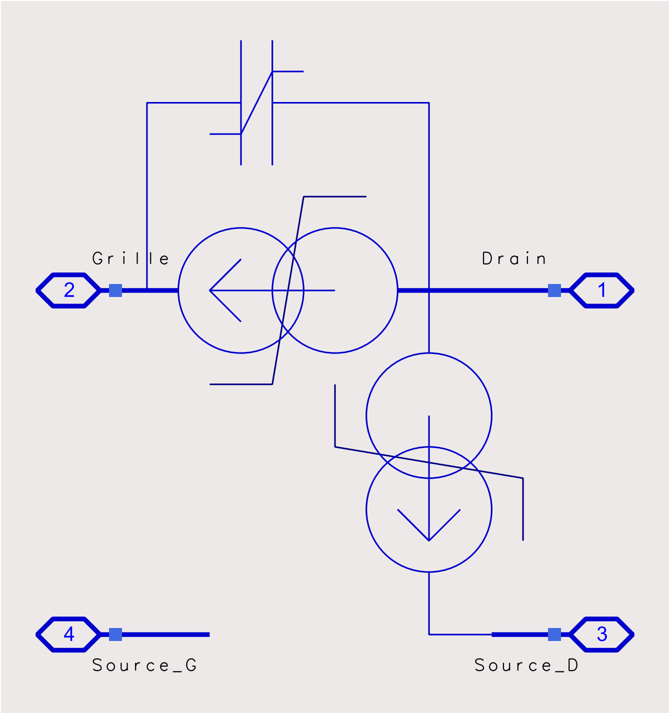
The *00.flu17xm_package.dsn* file defines the non-linear packaged model of the FET. The figure below represents the symbol associated to this model (and to this file). You can click on *Window/symbol* in the *Window* menu.



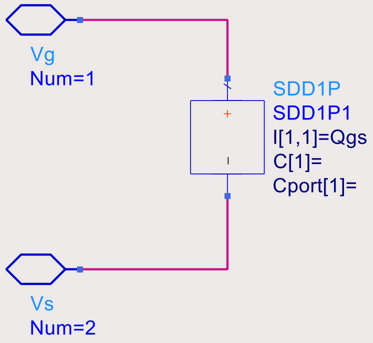


The *aval_taj.dsn* file defines the non-linear intrinsic model of the FET. The figure below represents the symbol associated to this model (and to this file). You can click on *Window/symbol* in the *Window* menu.





Cgs Non linear EQUATIONS AND PARAMETERS



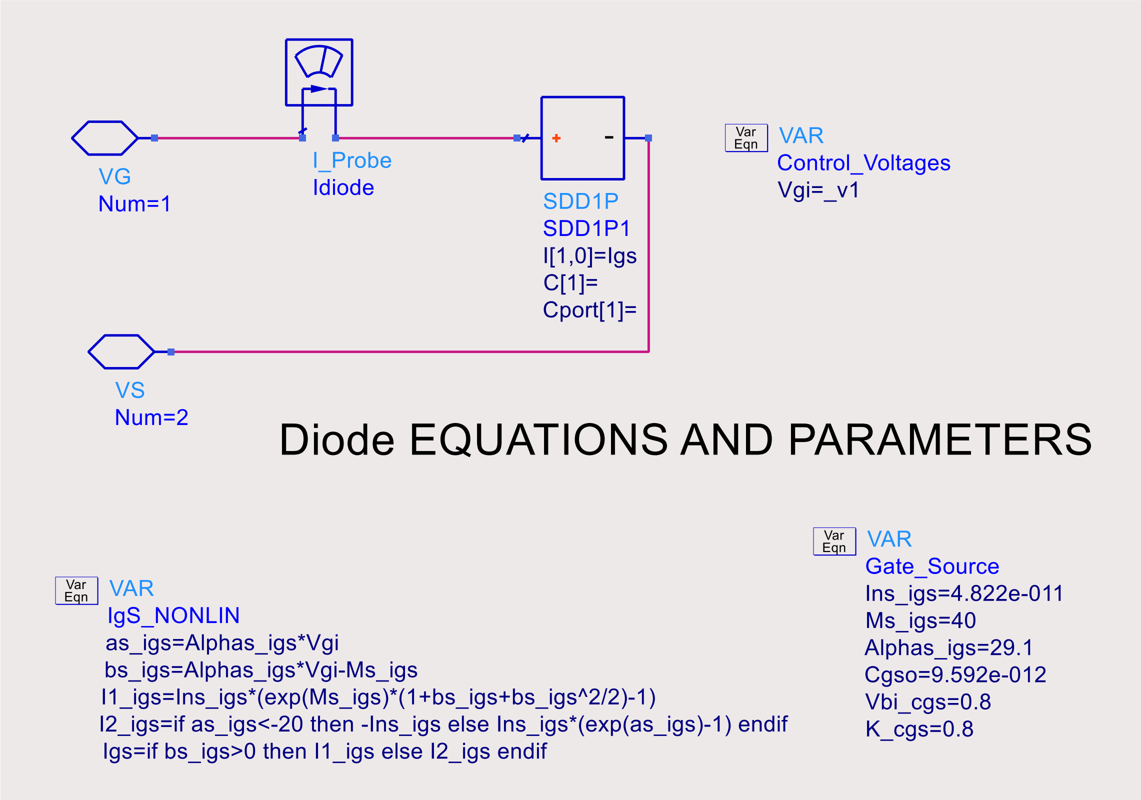
VAR
Control_Voltages
Vcgs=_v1

VAR
Gate_Source
Cgso=9.592e-012
Vbi_cgs=0.8
K_cgs=0.8

VAR
Cgs_NONLIN
Qgs1_cgs=-2*Cgso*Vbi_cgs*(1-Vcgs/Vbi_cgs)^0.5
Qgs2_cgs=-0.25*(Cgso*(4*Vcgs*Vbi_cgs - 6*K_cgs*Vbi_cgs*Vcgs + Vcgs^2 - 8*Vbi_cgs^2 + 12*Vbi_cgs^2*K_cgs - 3 *Vbi_cgs^2*K_cgs^2))/(Vbi_cgs*((1 - K_cgs)^0.5)*(-1 + K_cgs))
Qgs=if Vcgs<K_cgs*Vbi_cgs then Qgs1_cgs else Qgs2_cgs endif

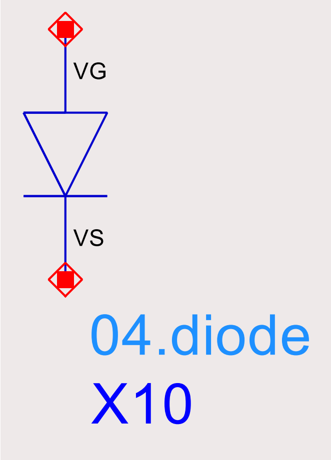
The *Cgs_nl_schottky.dsn* file defines the non-linear model of the C_{GS} capacitance of the FET.

Associated symbol



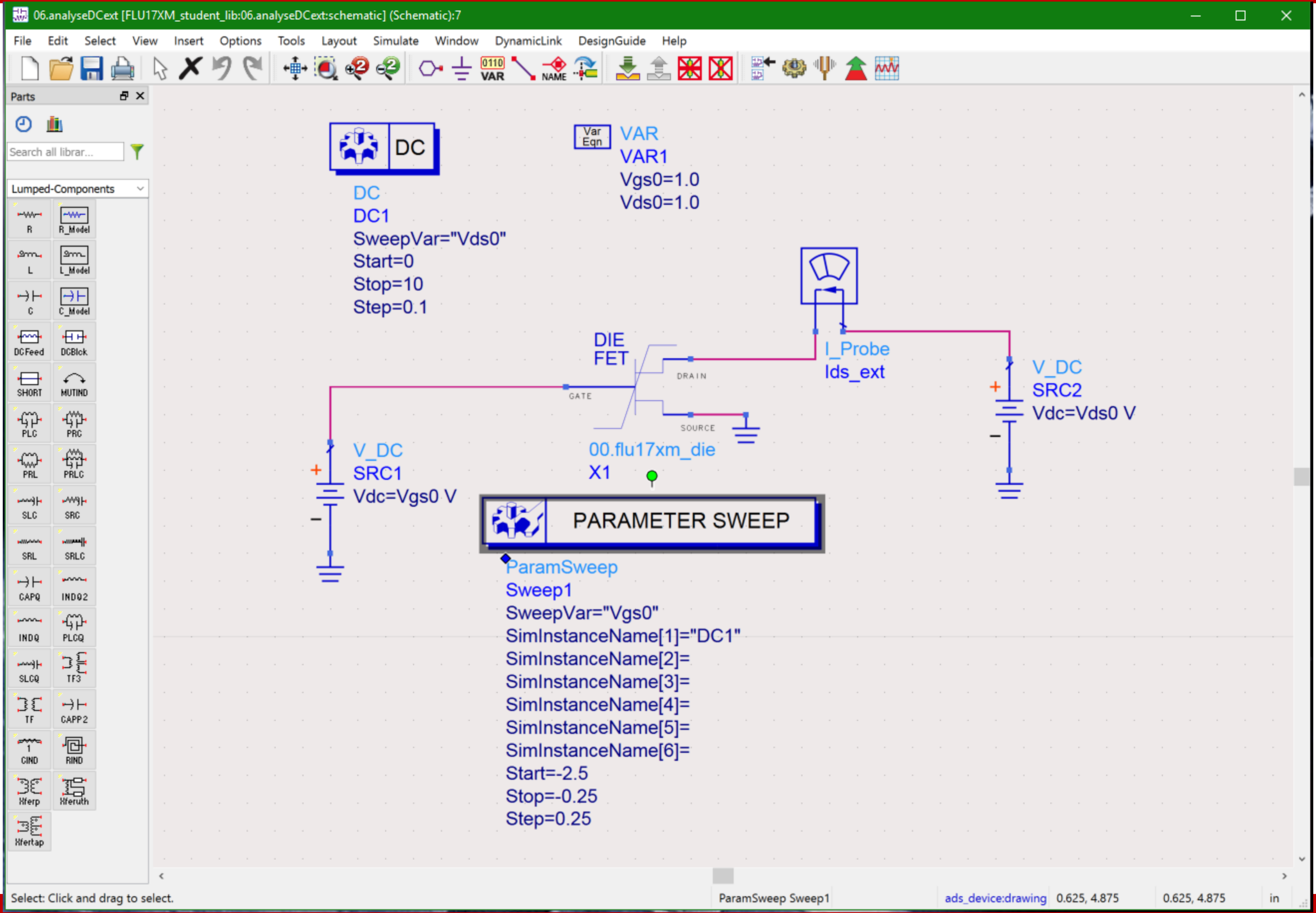
The *Diode.dsn* file defines the non-linear model of the input Diode of the FET.

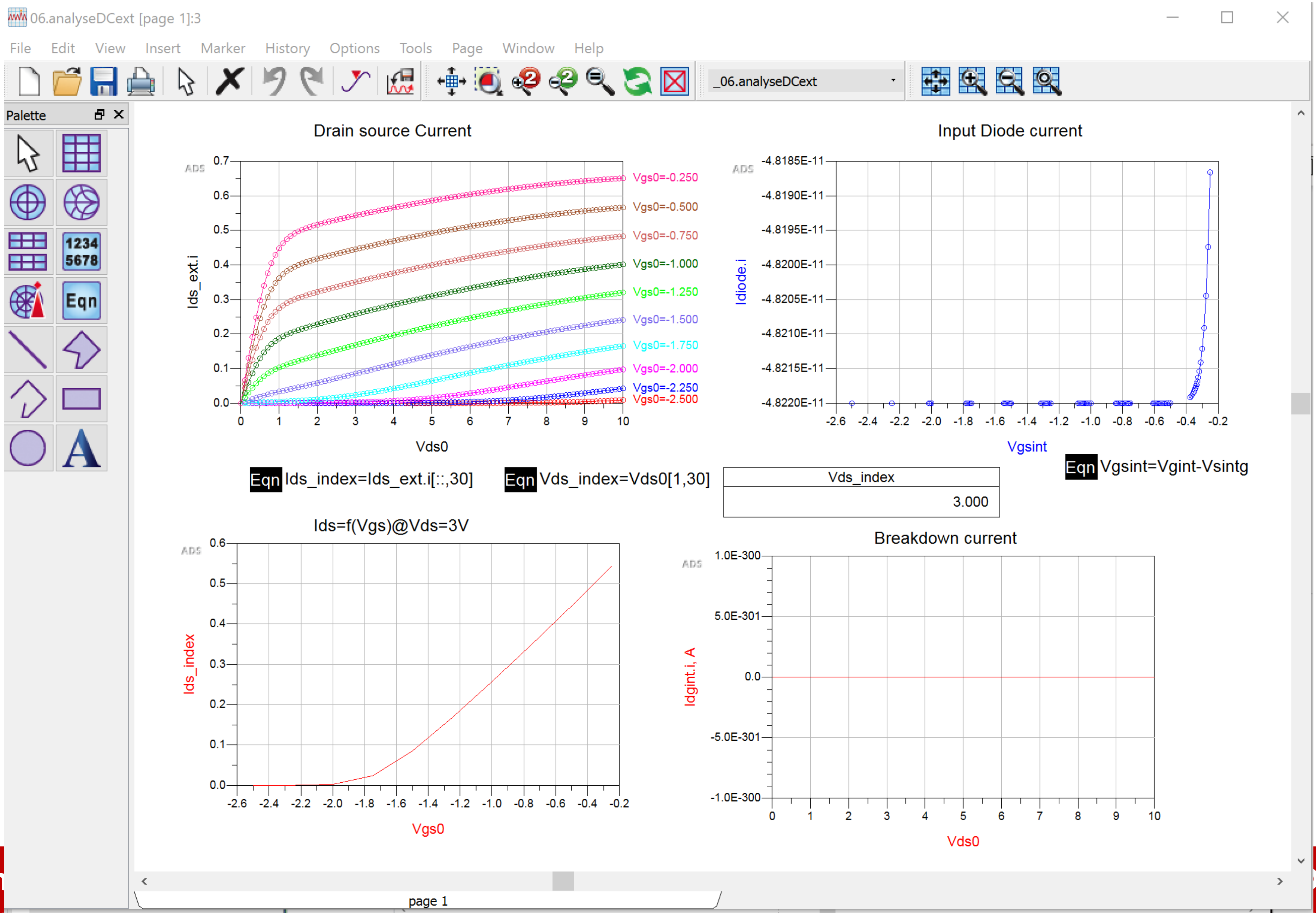
Associated symbol



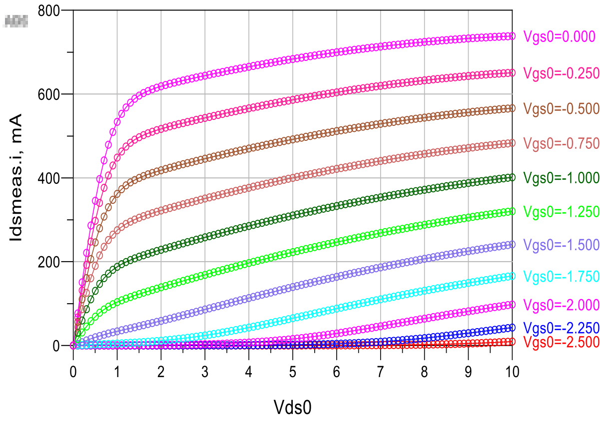
I/V Static Characteristics

Schematic to plot the extrinsic I/V curves of the Die transistor

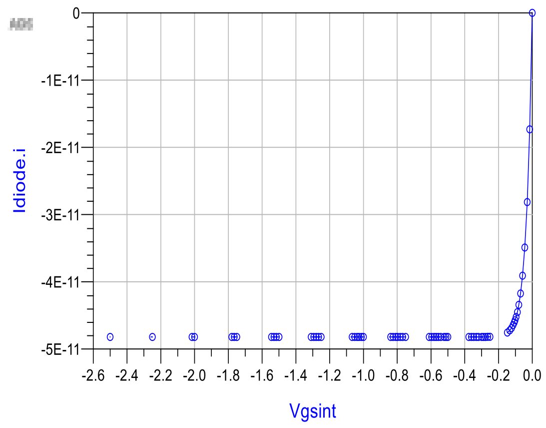



06.analyseDCext [page 1]:3
File Edit View Insert Marker History Options Tools Page Window Help
_06.analyseDCext
Palette
Drain source Current
Ids_ext.i
Vds0
Vgs0=-0.250
Vgs0=-0.500
Vgs0=-0.750
Vgs0=-1.000
Vgs0=-1.250
Vgs0=-1.500
Vgs0=-1.750
Vgs0=-2.000
Vgs0=-2.250
Vgs0=-2.500
Input Diode current
Idiode.i
Vgsint
Eqn Ids_index=Ids_ext.i[::,30]
Eqn Vds_index=Vds0[1,30]
Vds_index
3.000
Eqn Vgsint=Vgint-Vsintg
Ids=f(Vgs)@Vds=3V
Ids_index
Vgs0
Breakdown current
Idgint.i, A
Vds0
page 1

Drain Source Current



Input Diode Current



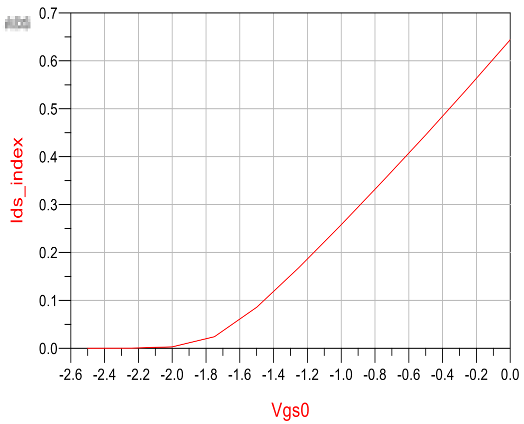
Eqn Ids_index=Idsmeas.i[::,30]   Eqn Vds_index=Vds0[1,30]

Vds_index
3.000

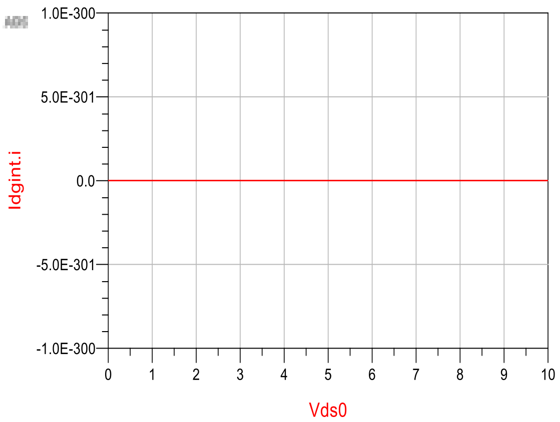
Eqn Vgsint=Vgint-Vsintg

Vds0	Idsmeas.i										
	...0=-2.500	...0=-2.250	...0=-2.000	...0=-1.750	...0=-1.500	...0=-1.250	...0=-1.000	...0=-0.750	...0=-0.500	...0=-0.250	...0=0.000
0.000	2.500 nA	2.250 nA	2.000 nA	1.750 nA	1.500 nA	1.250 nA	1000. pA	750.0 pA	500.0 pA	250.0 pA	0.0000 A
0.100	312.6 nA	3.492 uA	38.72 uA	425.2 uA	3.831 mA	15.57 mA	30.48 mA	44.15 mA	56.21 mA	66.90 mA	76.51 mA
0.200	651.9 nA	7.338 uA	81.70 uA	897.4 uA	7.905 mA	30.89 mA	59.73 mA	86.46 mA	110.3 mA	131.5 mA	150.7 mA
0.300	997.2 nA	11.29 uA	126.3 uA	1.389 mA	11.97 mA	45.15 mA	86.57 mA	125.5 mA	160.6 mA	192.3 mA	221.0 mA
0.400	1.333 uA	15.19 uA	170.7 uA	1.878 mA	15.84 mA	57.87 mA	110.2 mA	160.2 mA	206.1 mA	247.9 mA	286.2 mA
0.500	1.654 uA	18.95 uA	213.9 uA	2.356 mA	19.42 mA	68.85 mA	130.3 mA	190.1 mA	245.8 mA	297.4 mA	345.2 mA
0.600	1.962 uA	22.58 uA	256.1 uA	2.820 mA	22.71 mA	78.16 mA	147.0 mA	215.0 mA	279.5 mA	340.2 mA	397.1 mA
0.700	2.262 uA	26.15 uA	297.7 uA	3.276 mA	25.74 mA	85.99 mA	160.5 mA	235.3 mA	307.4 mA	376.2 mA	441.6 mA
0.800	2.562 uA	29.73 uA	339.5 uA	3.730 mA	28.55 mA	92.62 mA	171.5 mA	251.6 mA	329.9 mA	405.7 mA	478.8 mA
0.900	2.869 uA	33.41 uA	382.5 uA	4.191 mA	31.20 mA	98.30 mA	180.4 mA	264.5 mA	347.8 mA	429.4 mA	509.2 mA
1.000	3.189 uA	37.24 uA	427.5 uA	4.668 mA	33.75 mA	103.3 mA	187.7 mA	274.8 mA	361.9 mA	448.2 mA	533.6 mA
1.100	3.528 uA	41.32 uA	475.2 uA	5.166 mA	36.24 mA	107.7 mA	193.9 mA	283.1 mA	373.0 mA	462.9 mA	552.8 mA
1.200	3.892 uA	45.69 uA	526.4 uA	5.693 mA	38.69 mA	111.8 mA	199.1 mA	289.9 mA	381.8 mA	474.5 mA	567.8 mA
1.300	4.285 uA	50.41 uA	581.7 uA	6.253 mA	41.14 mA	115.5 mA	203.7 mA	295.6 mA	389.0 mA	483.6 mA	579.5 mA
1.400	4.712 uA	55.55 uA	641.8 uA	6.852 mA	43.59 mA	119.1 mA	207.9 mA	300.4 mA	394.9 mA	491.0 mA	588.8 mA
1.500	5.177 uA	61.17 uA	707.4 uA	7.494 mA	46.05 mA	122.6 mA	211.7 mA	304.8 mA	399.9 mA	497.0 mA	596.2 mA
1.600	5.686 uA	67.30 uA	779.1 uA	8.182 mA	48.54 mA	125.9 mA	215.3 mA	308.7 mA	404.3 mA	502.0 mA	602.2 mA
1.700	6.242 uA	74.03 uA	857.6 uA	8.920 mA	51.05 mA	129.1 mA	218.8 mA	312.3 mA	408.1 mA	506.3 mA	607.2 mA
1.800	6.852 uA	81.41 uA	943.6 uA	9.710 mA	53.59 mA	132.3 mA	222.1 mA	315.7 mA	411.7 mA	510.1 mA	611.4 mA
1.900	7.519 uA	89.51 uA	1.038 mA	10.56 mA	56.17 mA	135.5 mA	225.3 mA	318.9 mA	415.0 mA	513.6 mA	615.1 mA
2.000	8.252 uA	98.40 uA	1.141 mA	11.46 mA	58.76 mA	138.6 mA	228.5 mA	322.0 mA	418.1 mA	516.8 mA	618.5 mA
2.100	9.055 uA	108.2 uA	1.255 mA	12.43 mA	61.39 mA	141.7 mA	231.6 mA	325.1 mA	421.1 mA	519.8 mA	621.5 mA
2.200	9.935 uA	118.9 uA	1.379 mA	13.46 mA	64.04 mA	144.8 mA	234.6 mA	328.1 mA	424.0 mA	522.6 mA	624.4 mA
2.300	10.90 uA	130.7 uA	1.515 mA	14.55 mA	66.71 mA	147.8 mA	237.6 mA	331.0 mA	426.9 mA	525.4 mA	627.1 mA
2.400	11.96 uA	143.6 uA	1.664 mA	15.71 mA	69.40 mA	150.8 mA	240.6 mA	333.9 mA	429.7 mA	528.1 mA	629.7 mA
2.500	13.12 uA	157.8 uA	1.827 mA	16.93 mA	72.10 mA	153.8 mA	243.6 mA	336.7 mA	432.4 mA	530.7 mA	632.2 mA
2.600	14.40 uA	173.4 uA	2.006 mA	18.22 mA	74.82 mA	156.8 mA	246.5 mA	339.5 mA	435.1 mA	533.2 mA	634.6 mA
2.700	15.80 uA	190.6 uA	2.201 mA	19.58 mA	77.55 mA	159.8 mA	249.4 mA	342.3 mA	437.7 mA	535.7 mA	637.0 mA
2.800	17.33 uA	209.4 uA	2.415 mA	21.00 mA	80.29 mA	162.7 mA	252.3 mA	345.1 mA	440.3 mA	538.2 mA	639.3 mA
2.900	19.01 uA	230.1 uA	2.648 mA	22.49 mA	83.03 mA	165.7 mA	255.1 mA	347.8 mA	442.9 mA	540.7 mA	641.6 mA
3.000	20.86 uA	252.8 uA	2.902 mA	24.04 mA	85.78 mA	168.6 mA	258.0 mA	350.5 mA	445.5 mA	543.1 mA	643.9 mA
3.100	22.89 uA	277.8 uA	3.179 mA	25.66 mA	88.53 mA	171.5 mA	260.8 mA	353.2 mA	448.0 mA	545.5 mA	646.1 mA
3.200	25.11 uA	305.2 uA	3.481 mA	27.34 mA	91.29 mA	174.3 mA	263.6 mA	355.9 mA	450.5 mA	547.8 mA	648.3 mA
3.300	27.54 uA	335.2 uA	3.810 mA	29.08 mA	94.04 mA	177.2 mA	266.3 mA	358.5 mA	453.0 mA	550.1 mA	650.4 mA
3.400	30.22 uA	368.2 uA	4.166 mA	30.88 mA	96.78 mA	180.0 mA	269.1 mA	361.1 mA	455.5 mA	552.5 mA	652.6 mA
3.500	33.15 uA	404.4 uA	4.554 mA	32.73 mA	99.53 mA	182.9 mA	271.8 mA	363.7 mA	457.9 mA	554.7 mA	654.7 mA
3.600	36.36 uA	444.2 uA	4.973 mA	34.64 mA	102.3 mA	185.7 mA	274.5 mA	366.3 mA	460.4 mA	557.0 mA	656.8 mA
3.700	39.89 uA	487.8 uA	5.427 mA	36.59 mA	105.0 mA	188.4 mA	277.2 mA	368.8 mA	462.8 mA	559.2 mA	658.9 mA
3.800	43.76 uA	535.6 uA	5.918 mA	38.59 mA	107.7 mA	191.2 mA	279.8 mA	371.4 mA	465.1 mA	561.4 mA	660.9 mA
3.900	48.00 uA	588.1 uA	6.448 mA	40.63 mA	110.4 mA	193.9 mA	282.5 mA	373.9 mA	467.5 mA	563.6 mA	662.9 mA
4.000	52.65 uA	645.6 uA	7.018 mA	42.71 mA	113.1 mA	196.6 mA	285.1 mA	376.3 mA	469.8 mA	565.8 mA	664.9 mA
4.100	57.75 uA	708.6 uA	7.631 mA	44.82 mA	115.8 mA	199.3 mA	287.7 mA	378.8 mA	472.1 mA	567.9 mA	666.9 mA
4.200	63.35 uA	777.7 uA	8.288 mA	46.97 mA	118.5 mA	202.0 mA	290.3 mA	381.2 mA	474.4 mA	570.0 mA	668.8 mA
4.300	69.48 uA	853.4 uA	8.992 mA	49.15 mA	121.1 mA	204.7 mA	292.8 mA	383.7 mA	476.7 mA	572.1 mA	670.7 mA
4.400	76.21 uA	936.3 uA	9.744 mA	51.35 mA	123.8 mA	207.3 mA	295.4 mA	386.0 mA	478.9 mA	574.2 mA	672.6 mA
4.500	83.58 uA	1.027 mA	10.55 mA	53.58 mA	126.4 mA	209.9 mA	297.9 mA	388.4 mA	481.1 mA	576.2 mA	674.5 mA
4.600	91.67 uA	1.126 mA	11.40 mA	55.82 mA	129.0 mA	212.5 mA	300.4 mA	390.8 mA	483.3 mA	578.3 mA	676.3 mA

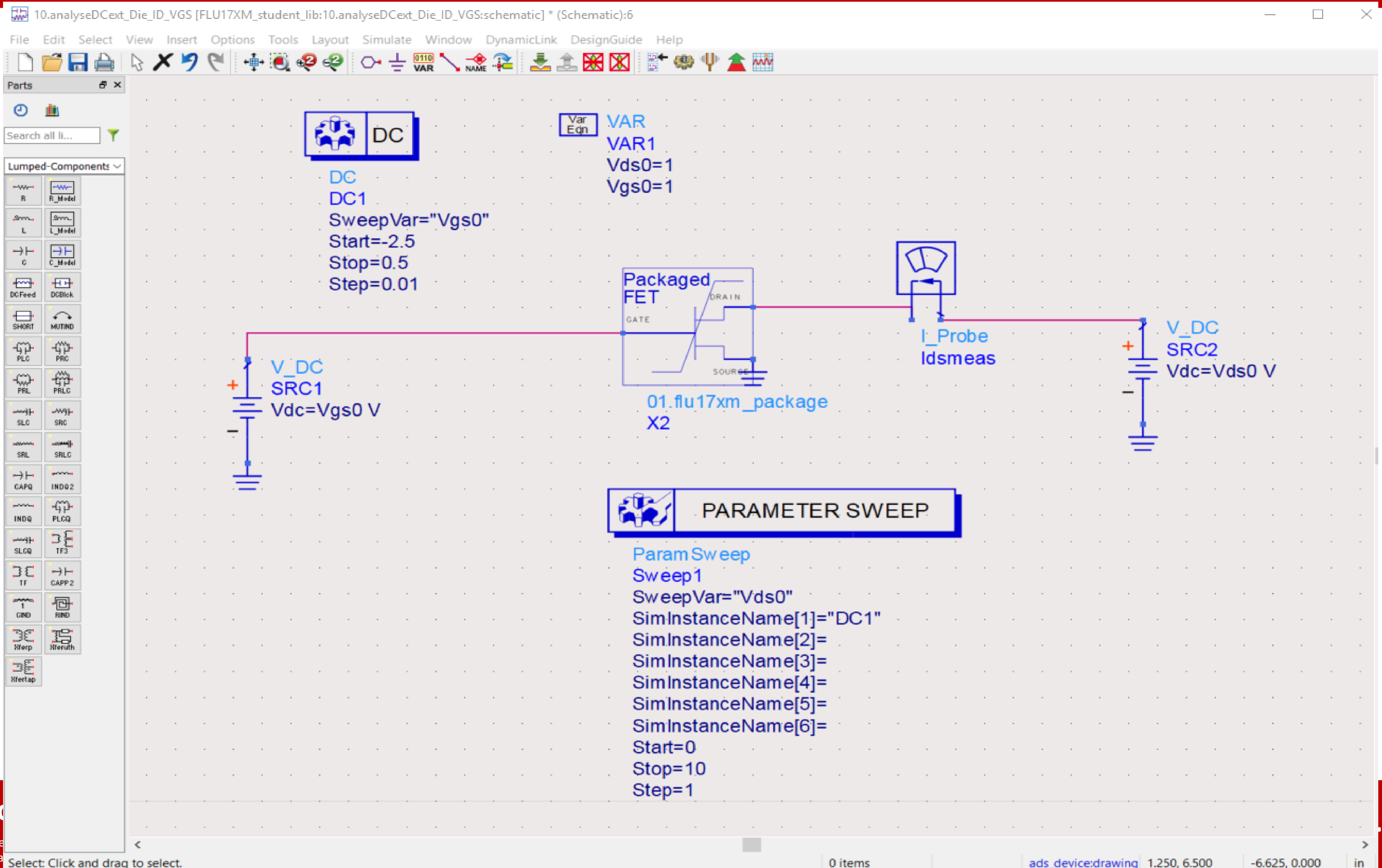
Ids=f(Vgs) @ Vds=3V



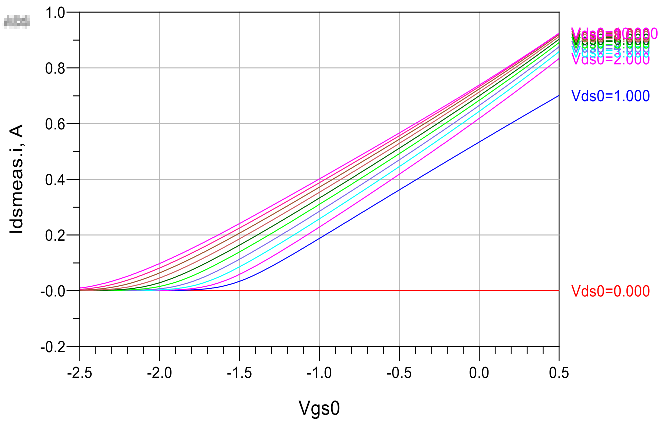
Breakdown Current



Schematic to plot the extrinsic I/V curves of the Packaged transistor



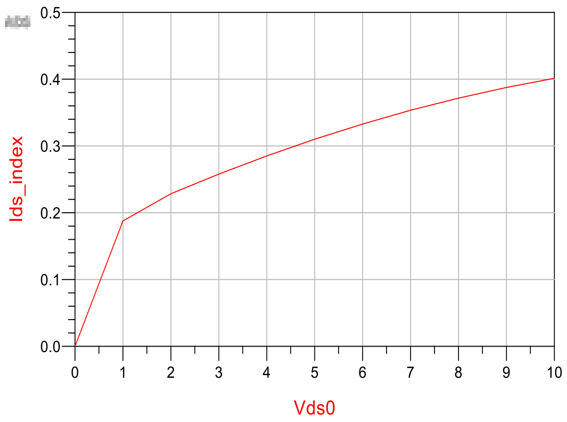
Drain Source Current



Eqn Ids_index=Idsmeas.i[::,150] Eqn Vgs_index=Vgs0[1,150]

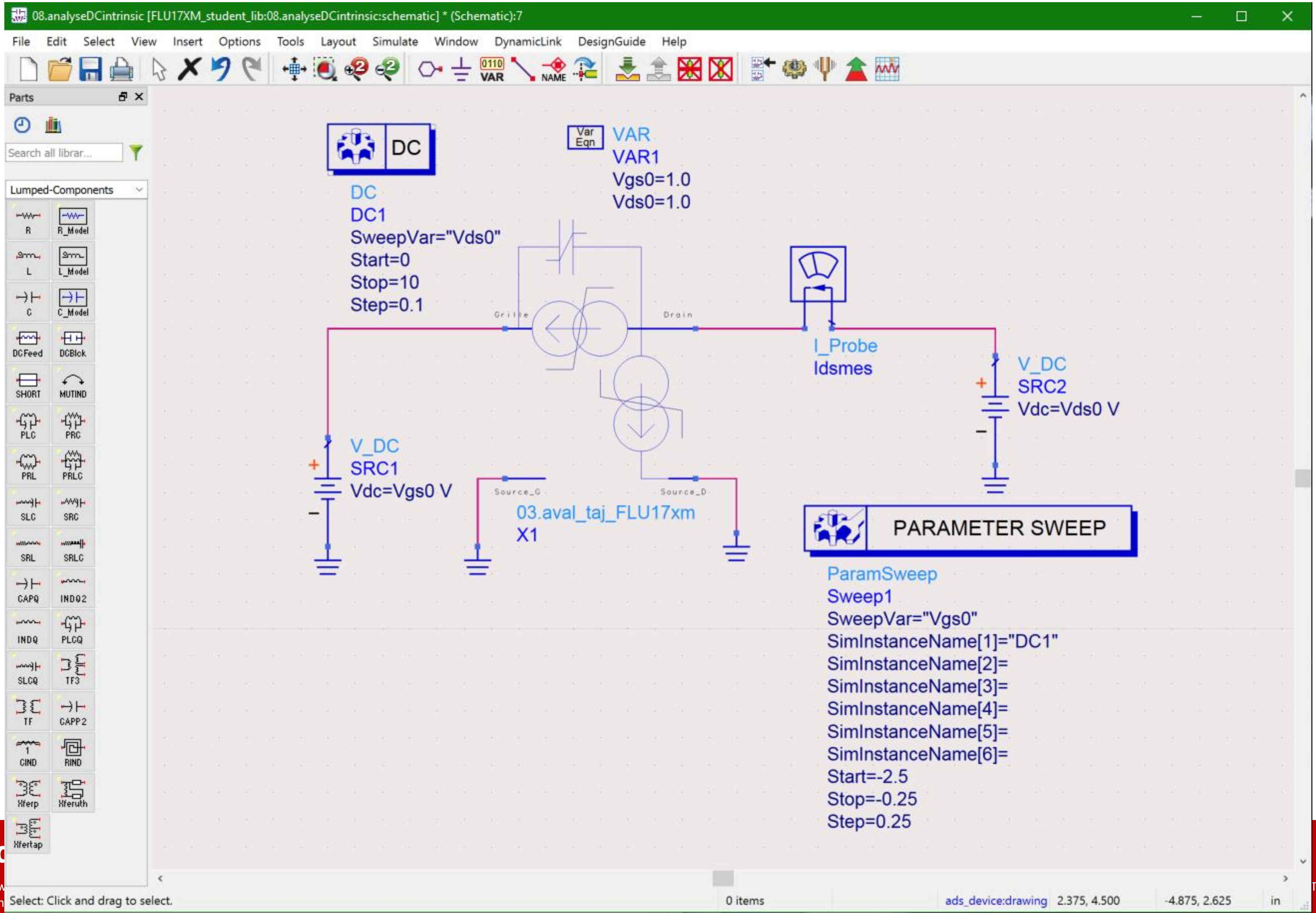
Vgs_index
-1.000

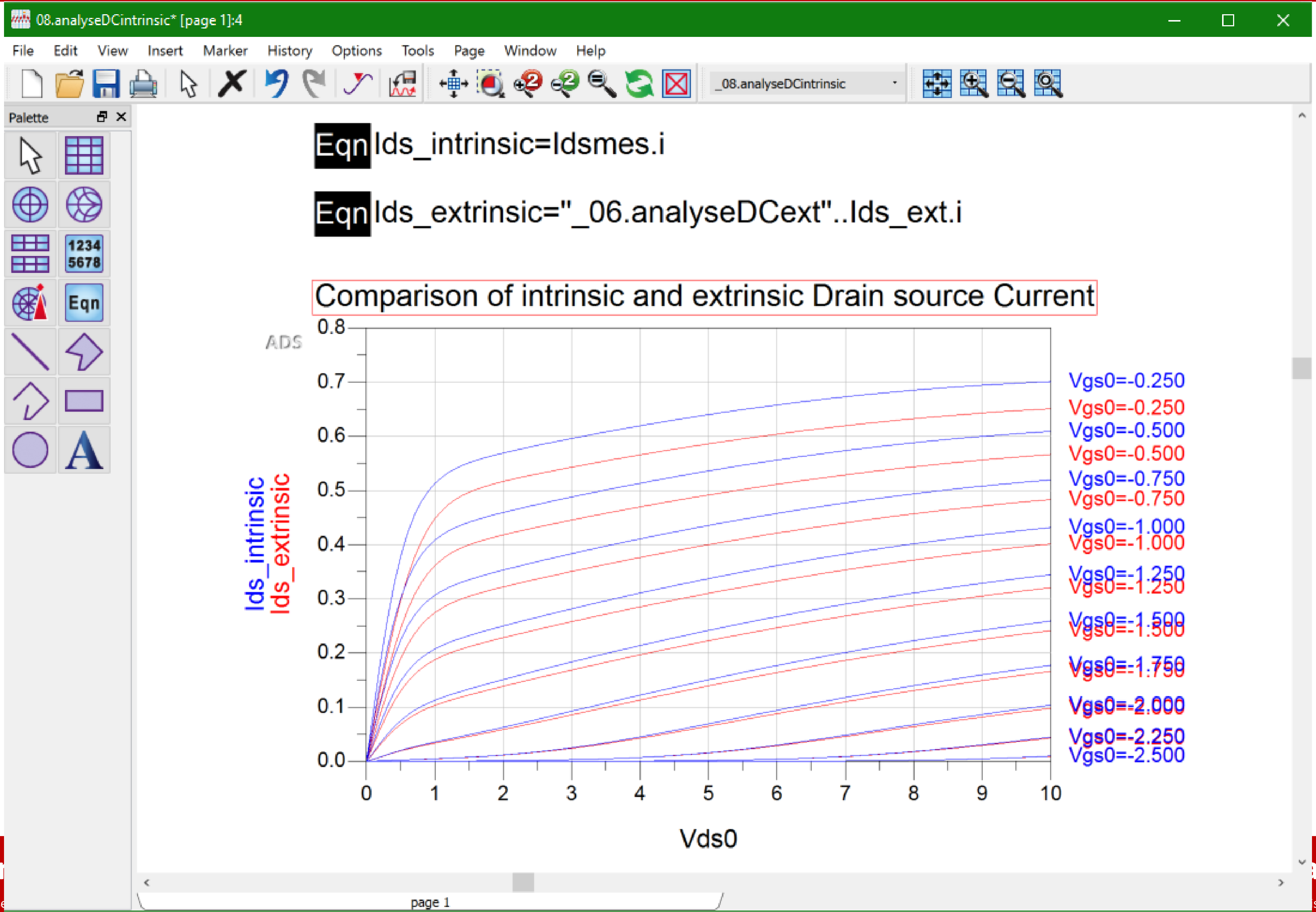
Ids=f(Vds) @ Vgs=-1V



Vgs0	Idsmeas.i										
	Vds0=0.000	Vds0=1.000	Vds0=2.000	Vds0=3.000	Vds0=4.000	Vds0=5.000	Vds0=6.000	Vds0=7.000	Vds0=8.000	Vds0=9.000	Vds0=10.000
-2.500	2.500 nA	3.189 uA	8.252 uA	20.86 uA	52.65 uA	132.6 uA	332.5 uA	825.6 uA	2.002 mA	4.593 mA	9.464 mA
-2.490	2.490 nA	3.520 uA	9.118 uA	23.07 uA	58.26 uA	146.8 uA	368.2 uA	913.7 uA	2.209 mA	5.034 mA	10.24 mA
-2.480	2.480 nA	3.886 uA	10.07 uA	25.50 uA	64.46 uA	162.5 uA	407.7 uA	1.011 mA	2.437 mA	5.510 mA	11.06 mA
-2.470	2.470 nA	4.289 uA	11.13 uA	28.20 uA	71.31 uA	179.9 uA	451.3 uA	1.118 mA	2.686 mA	6.024 mA	11.93 mA
-2.460	2.460 nA	4.734 uA	12.29 uA	31.17 uA	78.89 uA	199.1 uA	499.5 uA	1.236 mA	2.959 mA	6.578 mA	12.85 mA
-2.450	2.450 nA	5.225 uA	13.58 uA	34.46 uA	87.26 uA	220.3 uA	552.8 uA	1.366 mA	3.257 mA	7.174 mA	13.82 mA
-2.440	2.440 nA	5.767 uA	15.00 uA	38.09 uA	96.52 uA	243.8 uA	611.7 uA	1.510 mA	3.582 mA	7.813 mA	14.83 mA
-2.430	2.430 nA	6.364 uA	16.57 uA	42.10 uA	106.8 uA	269.8 uA	676.7 uA	1.667 mA	3.936 mA	8.497 mA	15.89 mA
-2.420	2.420 nA	7.023 uA	18.30 uA	46.53 uA	118.1 uA	298.5 uA	748.4 uA	1.841 mA	4.322 mA	9.227 mA	17.00 mA
-2.410	2.410 nA	7.750 uA	20.21 uA	51.43 uA	130.6 uA	330.2 uA	827.6 uA	2.031 mA	4.741 mA	10.01 mA	18.15 mA
-2.400	2.400 nA	8.551 uA	22.32 uA	56.83 uA	144.4 uA	365.2 uA	915.0 uA	2.240 mA	5.195 mA	10.83 mA	19.36 mA
-2.390	2.390 nA	9.435 uA	24.65 uA	62.80 uA	159.6 uA	403.9 uA	1.011 mA	2.469 mA	5.687 mA	11.71 mA	20.61 mA
-2.380	2.380 nA	10.41 uA	27.22 uA	69.40 uA	176.5 uA	446.6 uA	1.118 mA	2.720 mA	6.219 mA	12.64 mA	21.91 mA
-2.370	2.370 nA	11.48 uA	30.05 uA	76.68 uA	195.1 uA	493.8 uA	1.235 mA	2.995 mA	6.792 mA	13.62 mA	23.25 mA
-2.360	2.360 nA	12.67 uA	33.18 uA	84.72 uA	215.7 uA	545.9 uA	1.363 mA	3.296 mA	7.410 mA	14.65 mA	24.64 mA
-2.350	2.350 nA	13.98 uA	36.64 uA	93.60 uA	238.4 uA	603.4 uA	1.505 mA	3.624 mA	8.073 mA	15.74 mA	26.07 mA
-2.340	2.340 nA	15.42 uA	40.45 uA	103.4 uA	263.5 uA	666.8 uA	1.661 mA	3.981 mA	8.784 mA	16.88 mA	27.55 mA
-2.330	2.330 nA	17.01 uA	44.65 uA	114.2 uA	291.2 uA	736.8 uA	1.833 mA	4.371 mA	9.544 mA	18.07 mA	29.07 mA
-2.320	2.320 nA	18.76 uA	49.29 uA	126.2 uA	321.7 uA	814.0 uA	2.021 mA	4.794 mA	10.36 mA	19.31 mA	30.63 mA
-2.310	2.310 nA	20.69 uA	54.42 uA	139.4 uA	355.5 uA	899.2 uA	2.228 mA	5.254 mA	11.22 mA	20.61 mA	32.23 mA
-2.300	2.300 nA	22.82 uA	60.07 uA	153.9 uA	392.8 uA	993.0 uA	2.454 mA	5.752 mA	12.14 mA	21.96 mA	33.87 mA
-2.290	2.290 nA	25.17 uA	66.30 uA	170.0 uA	433.9 uA	1.096 mA	2.703 mA	6.292 mA	13.11 mA	23.36 mA	35.55 mA
-2.280	2.280 nA	27.76 uA	73.19 uA	187.8 uA	479.3 uA	1.210 mA	2.975 mA	6.874 mA	14.14 mA	24.80 mA	37.27 mA
-2.270	2.270 nA	30.62 uA	80.78 uA	207.3 uA	529.4 uA	1.336 mA	3.272 mA	7.502 mA	15.23 mA	26.30 mA	39.03 mA
-2.260	2.260 nA	33.77 uA	89.15 uA	229.0 uA	584.6 uA	1.473 mA	3.597 mA	8.177 mA	16.37 mA	27.85 mA	40.82 mA
-2.250	2.250 nA	37.24 uA	98.40 uA	252.8 uA	645.6 uA	1.625 mA	3.952 mA	8.903 mA	17.57 mA	29.44 mA	42.65 mA
-2.240	2.240 nA	41.07 uA	108.6 uA	279.1 uA	712.8 uA	1.792 mA	4.338 mA	9.680 mA	18.83 mA	31.08 mA	44.51 mA
-2.230	2.230 nA	45.29 uA	119.8 uA	308.2 uA	786.8 uA	1.975 mA	4.759 mA	10.51 mA	20.14 mA	32.77 mA	46.41 mA
-2.220	2.220 nA	49.95 uA	132.2 uA	340.2 uA	868.5 uA	2.176 mA	5.216 mA	11.40 mA	21.52 mA	34.50 mA	48.34 mA
-2.210	2.210 nA	55.08 uA	145.9 uA	375.6 uA	958.4 uA	2.397 mA	5.711 mA	12.34 mA	22.94 mA	36.28 mA	50.30 mA
-2.200	2.200 nA	60.73 uA	161.0 uA	414.6 uA	1.057 mA	2.638 mA	6.249 mA	13.34 mA	24.43 mA	38.09 mA	52.30 mA
-2.190	2.190 nA	66.97 uA	177.7 uA	457.6 uA	1.167 mA	2.903 mA	6.830 mA	14.40 mA	25.97 mA	39.95 mA	54.32 mA
-2.180	2.180 nA	73.85 uA	196.1 uA	505.0 uA	1.287 mA	3.193 mA	7.457 mA	15.53 mA	27.56 mA	41.84 mA	56.37 mA
-2.170	2.170 nA	81.42 uA	216.3 uA	557.3 uA	1.419 mA	3.509 mA	8.133 mA	16.71 mA	29.21 mA	43.78 mA	58.46 mA
-2.160	2.160 nA	89.78 uA	238.7 uA	615.0 uA	1.564 mA	3.855 mA	8.861 mA	17.95 mA	30.90 mA	45.75 mA	60.57 mA
-2.150	2.150 nA	98.99 uA	263.3 uA	678.5 uA	1.724 mA	4.232 mA	9.641 mA	19.26 mA	32.65 mA	47.76 mA	62.71 mA
-2.140	2.140 nA	109.1 uA	290.5 uA	748.5 uA	1.899 mA	4.643 mA	10.48 mA	20.63 mA	34.45 mA	49.80 mA	64.88 mA
-2.130	2.130 nA	120.3 uA	320.5 uA	825.6 uA	2.091 mA	5.090 mA	11.37 mA	22.06 mA	36.30 mA	51.88 mA	67.08 mA
-2.120	2.120 nA	132.7 uA	353.5 uA	910.6 uA	2.303 mA	5.576 mA	12.32 mA	23.55 mA	38.19 mA	53.99 mA	69.30 mA
-2.110	2.110 nA	146.3 uA	390.0 uA	1.004 mA	2.534 mA	6.102 mA	13.34 mA	25.10 mA	40.13 mA	56.14 mA	71.55 mA
-2.100	2.100 nA	161.3 uA	430.1 uA	1.107 mA	2.788 mA	6.673 mA	14.42 mA	26.71 mA	42.11 mA	58.31 mA	73.82 mA
-2.090	2.090 nA	177.8 uA	474.4 uA	1.221 mA	3.066 mA	7.290 mA	15.56 mA	28.38 mA	44.13 mA	60.52 mA	76.12 mA
-2.080	2.080 nA	196.0 uA	523.2 uA	1.345 mA	3.370 mA	7.956 mA	16.76 mA	30.11 mA	46.19 mA	62.75 mA	78.44 mA

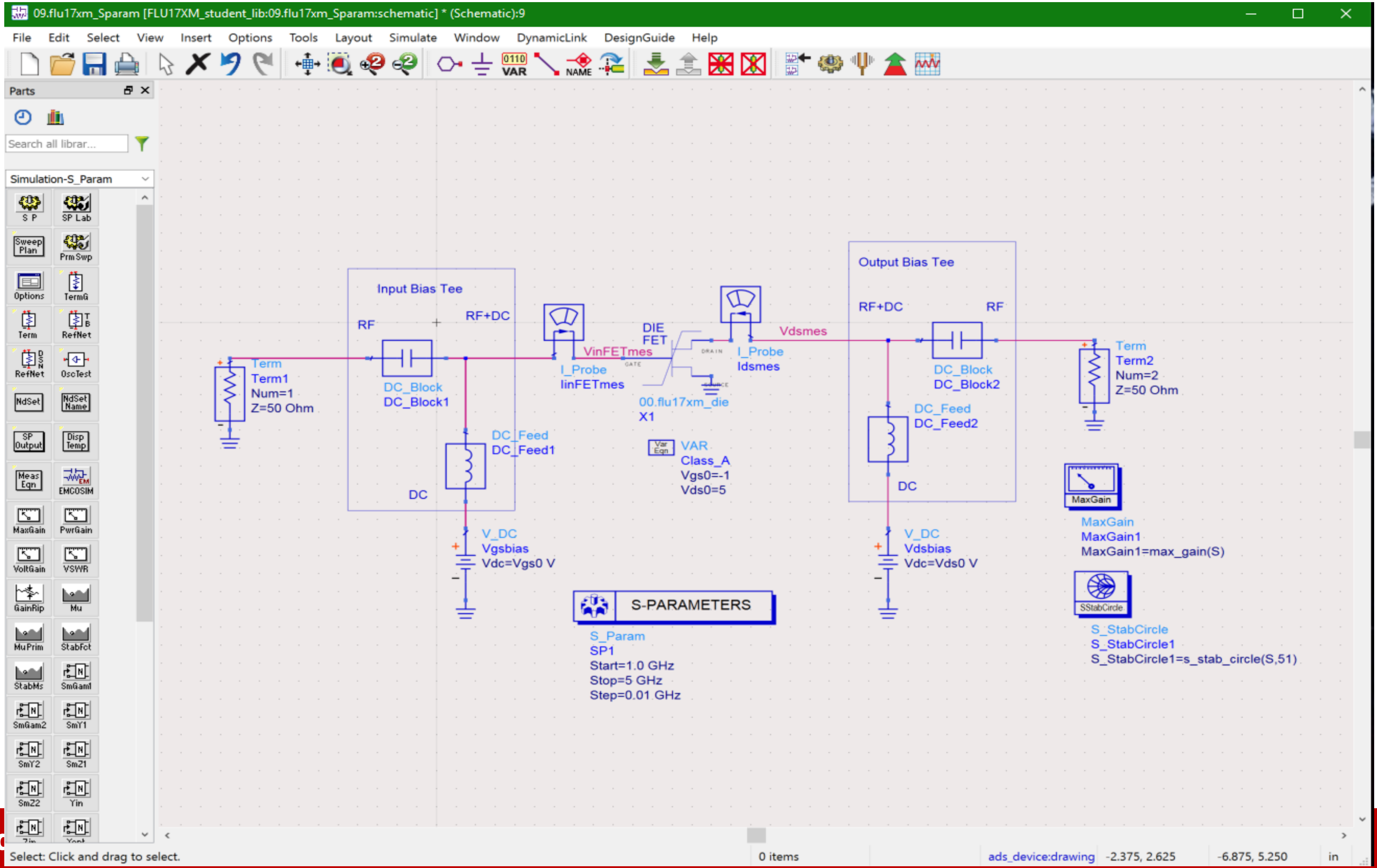
Schematic to plot the intrinsic I/V curves of the Die transistor




08.analyseDCintrinsic* [page 1]:4
File Edit View Insert Marker History Options Tools Page Window Help
_08.analyseDCintrinsic
Palette
Eqn Ids_intrinsic=Idsmes.i
Eqn Ids_extrinsic="_06.analyseDCext"..Ids_ext.i
Comparison of intrinsic and extrinsic Drain source Current
ADS
Ids_intrinsic
Ids_extrinsic
Vds0
Vgs0=-0.250
Vgs0=-0.250
Vgs0=-0.500
Vgs0=-0.500
Vgs0=-0.750
Vgs0=-0.750
Vgs0=-1.000
Vgs0=-1.000
Vgs0=-1.250
Vgs0=-1.250
Vgs0=-1.500
Vgs0=-1.500
Vgs0=-1.750
Vgs0=-1.750
Vgs0=-2.000
Vgs0=-2.250
Vgs0=-2.500
page 1

S Parameter Characteristics

Schematic to plot the S parameter curves of the Die transistor



m1
freq=1.800GHz
S(1,1)=0.890 / -158.855
impedance = 3.013 - j9.300

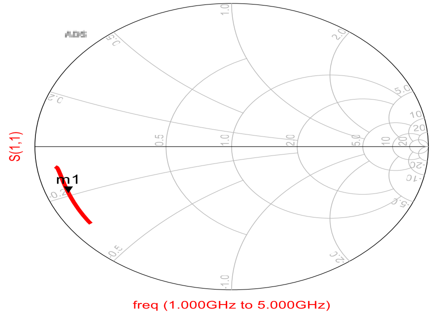
freq	m1	indep(m1)
1.800 GHz	0.890 / -158.855	1.800E9

Eqn Z11calc=50*(1+m1)/(1-m1)

freq	Z11calc	Z11calc
1.800 GHz	3.013 - j9.300	9.776 / -72.051

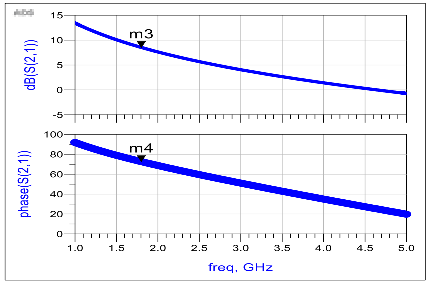
Eqn Linmatch_H=-imag(m1)/(2*pi*indep(m1))

freq	Linmatch_H
1.800 GHz	2.839E-11

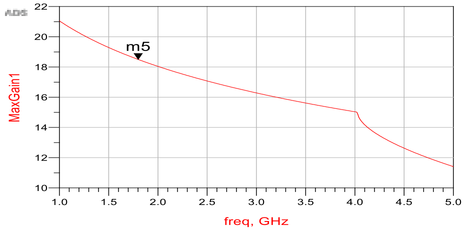


m3
freq=1.800GHz
dB(S(2,1))=8.528

m4
freq=1.800GHz
phase(S(2,1))=72.605

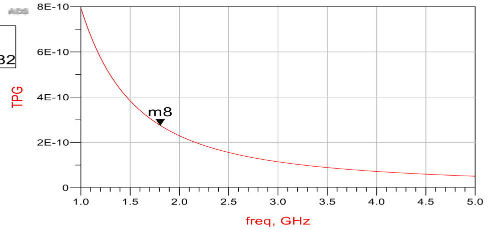


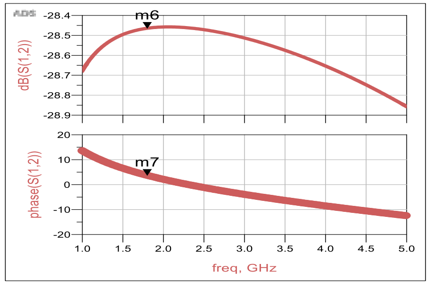
m5
freq=1.800GHz
MaxGain1=18.496



Eqn TPG=-1/(2*pi)*diff(S(2,1))

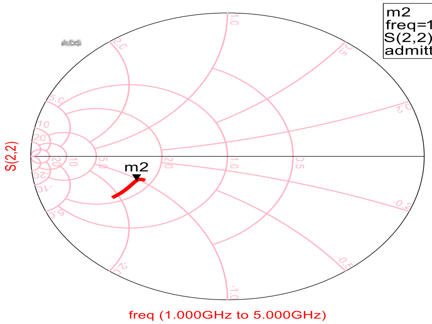
m8
freq=1.805GHz
TPG=2.752E-10 / 105.182





m6
freq=1.800GHz
dB(S(1,2))=-28.464

m7
freq=1.800GHz
phase(S(1,2))=3.734



m2
freq=1.800GHz
S(2,2)=0.492 / -159.975
admittance = 0.048 + j0.021

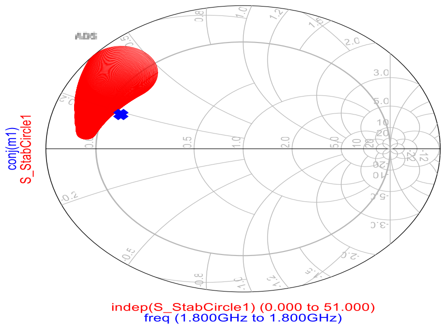
freq	m2	indep(m2)
1.800 GHz	0.492 / -159.975	1.800E9

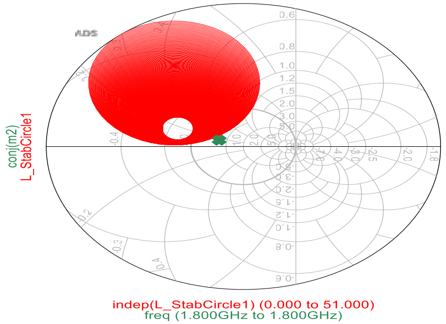
Eqn Z22calc=50*(1+m2)/(1-m2)

freq	Z22calc	Z22calc
1.800 GHz	17.511 - j7.774	19.159 / -23.938

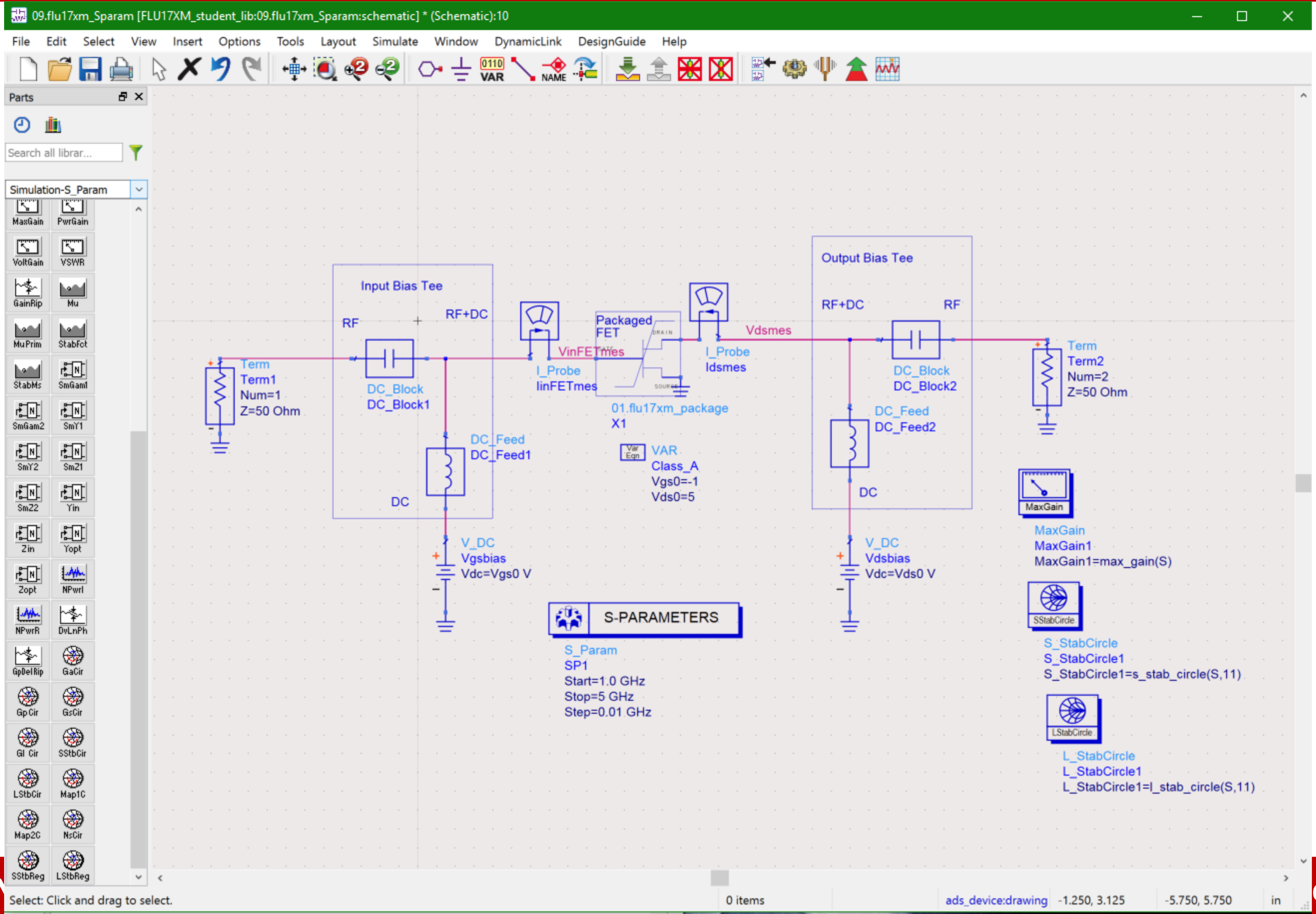
Eqn Loutmatch_H=-imag(m2)/(2*pi*indep(m2))

freq	Loutmatch_H
1.800 GHz	1.488E-11





Schematic to plot the S parameter curves of the Packaged transistor



m1
freq=1.800GHz
S(1,1)=0.727 / 150.231
impedance = 8.438 + j12.936

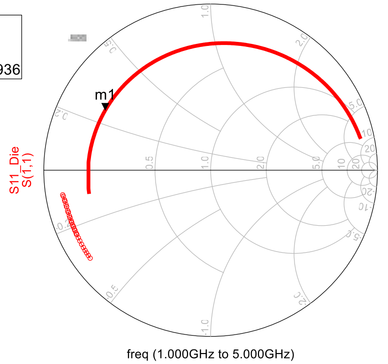
freq	m1	indep(m1)
1.800 GHz	0.727 / 150.231	1.800E9

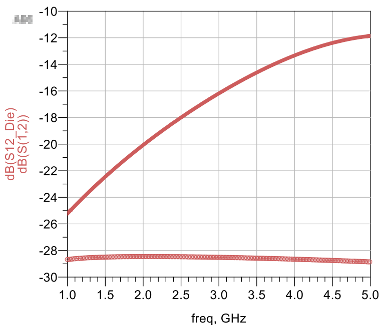
Eqn Z11calc=50*(1+m1)/(1-m1)

freq	Z11calc	Z11calc
1.800 GHz	8.438 + j12.936	15.444 / 56.883

Eqn Linmatch_H=-imag(m1)/(2*pi*indep(m1))

freq	Linmatch_H
1.800 GHz	-3.193E-11



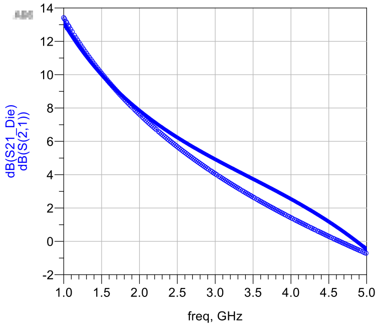


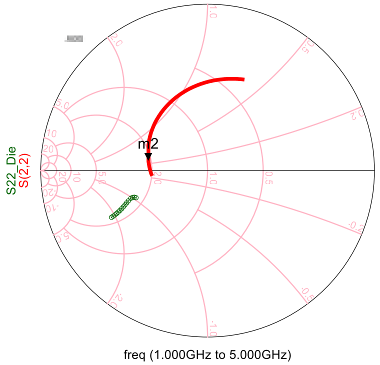
Eqn S11_Die="_11.flu17xm_Die_Sparam"..S(1,1)

Eqn S12_Die="_11.flu17xm_Die_Sparam"..S(1,2)

Eqn S21_Die="_11.flu17xm_Die_Sparam"..S(2,1)

Eqn S22_Die="_11.flu17xm_Die_Sparam"..S(2,2)





m2
freq=1.800GHz
S(2,2)=0.360 / 170.039
admittance = 0.041 - j0.006

freq	m2	indep(m2)
1.800 GHz	0.360 / 170.039	1.800E9

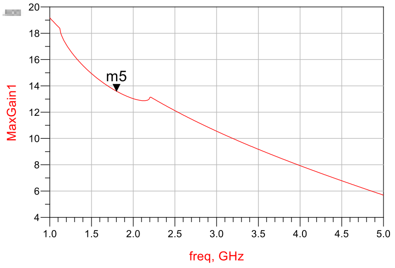
Eqn Z22calc=50*(1+m2)/(1-m2)

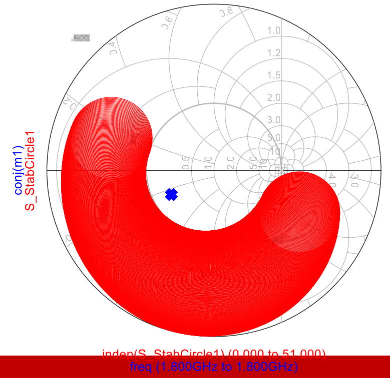
freq	Z22calc	Z22calc
1.800 GHz	23.648 + j3.388	23.890 / 8.153

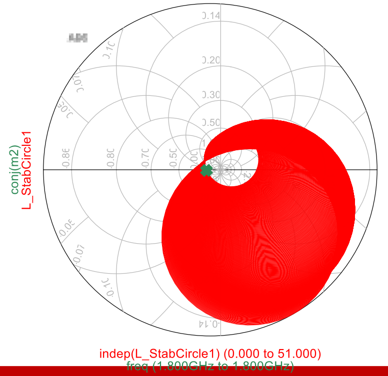
Eqn Loutmatch_H=-imag(m2)/(2*pi*indep(m2))

freq	Loutmatch_H
1.800 GHz	-5.511E-12

m5
freq=1.800GHz
MaxGain1=13.593

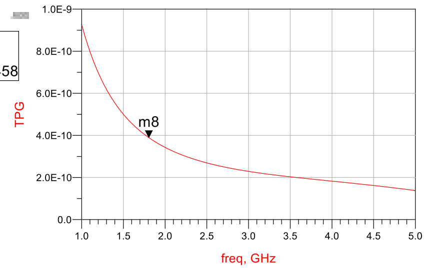






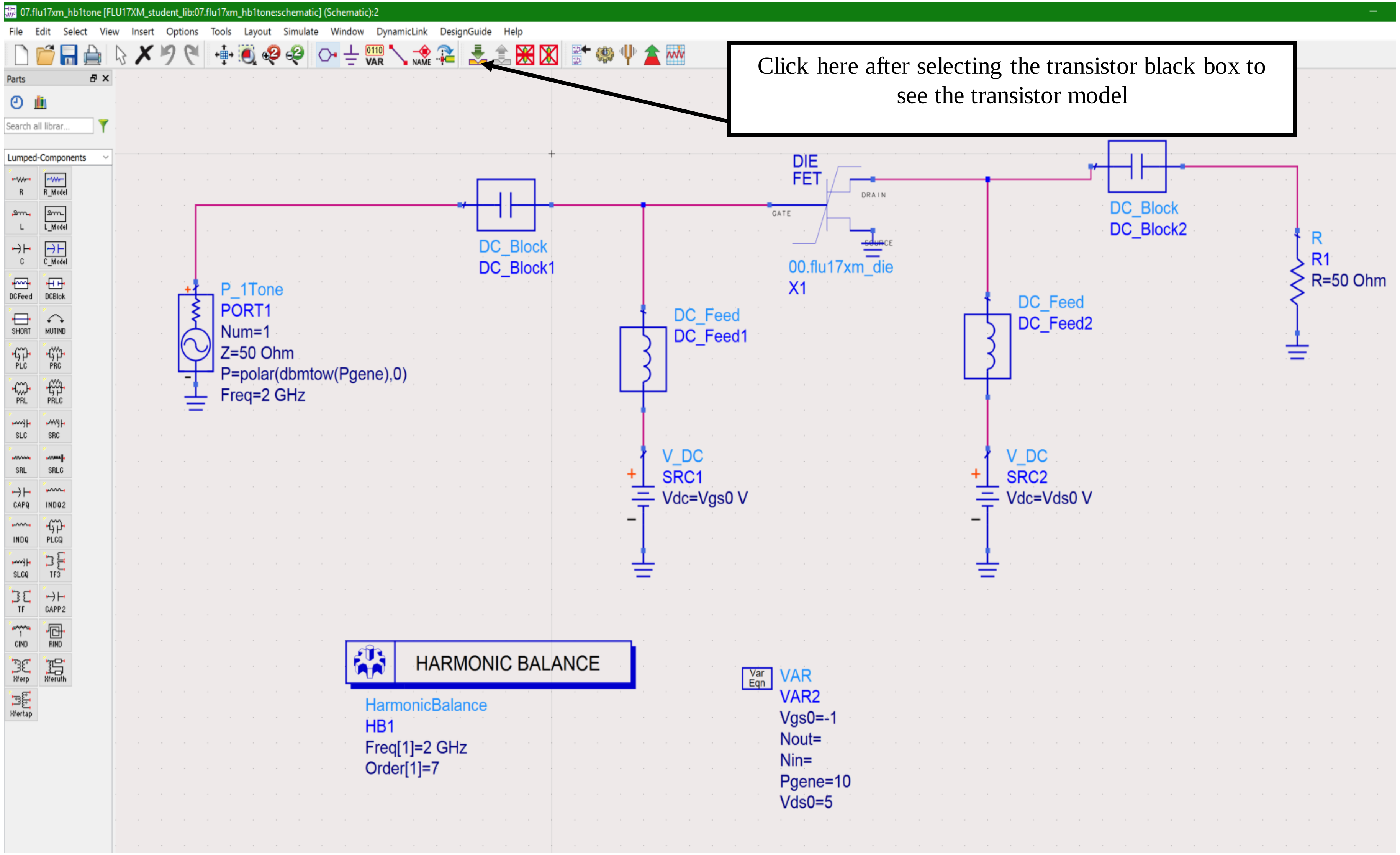
Eqn TPG=-1/(2*pi)*diff(S(2,1))

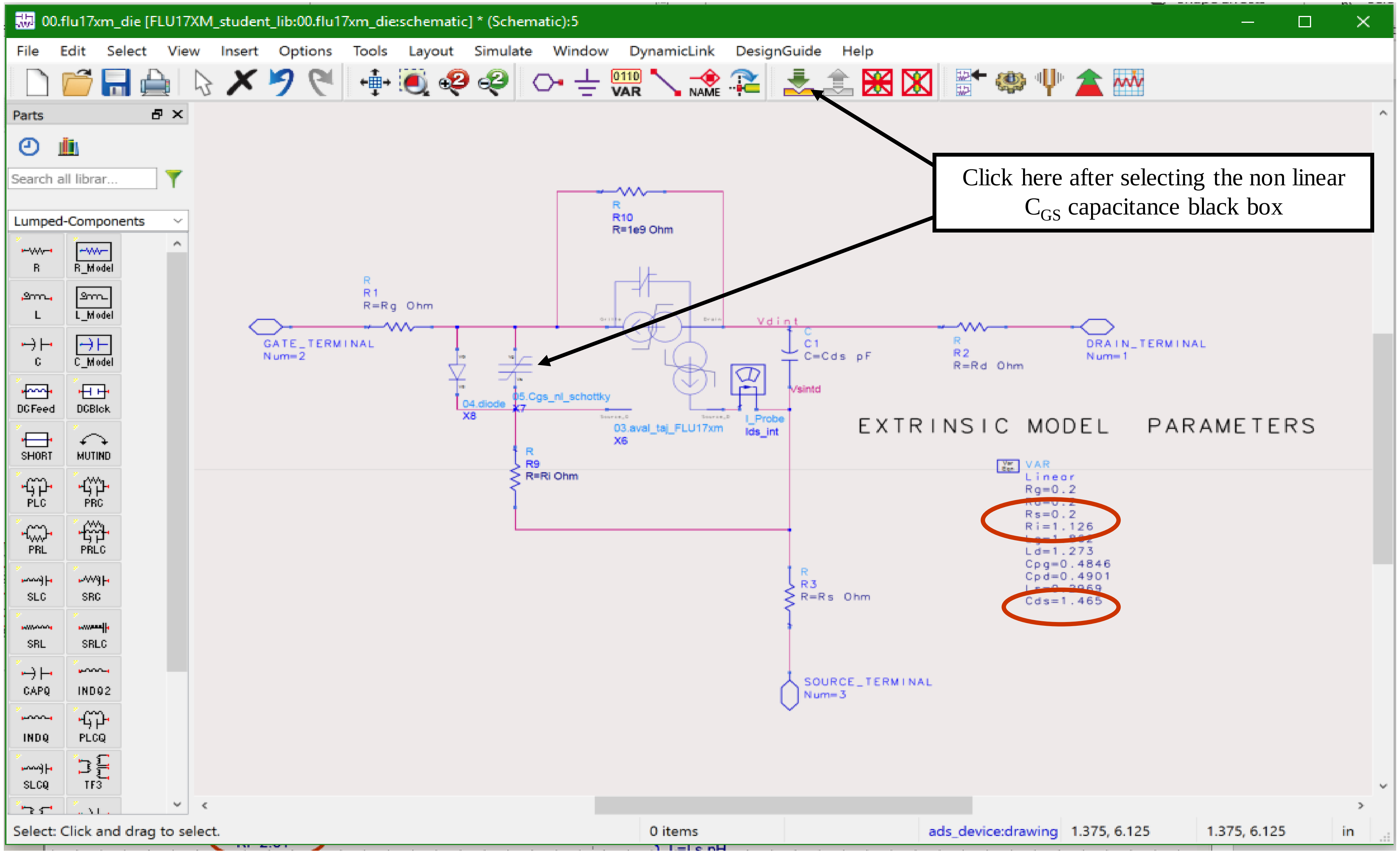
m8
freq=1.805GHz
TPG=3.893E-10 / 87.458

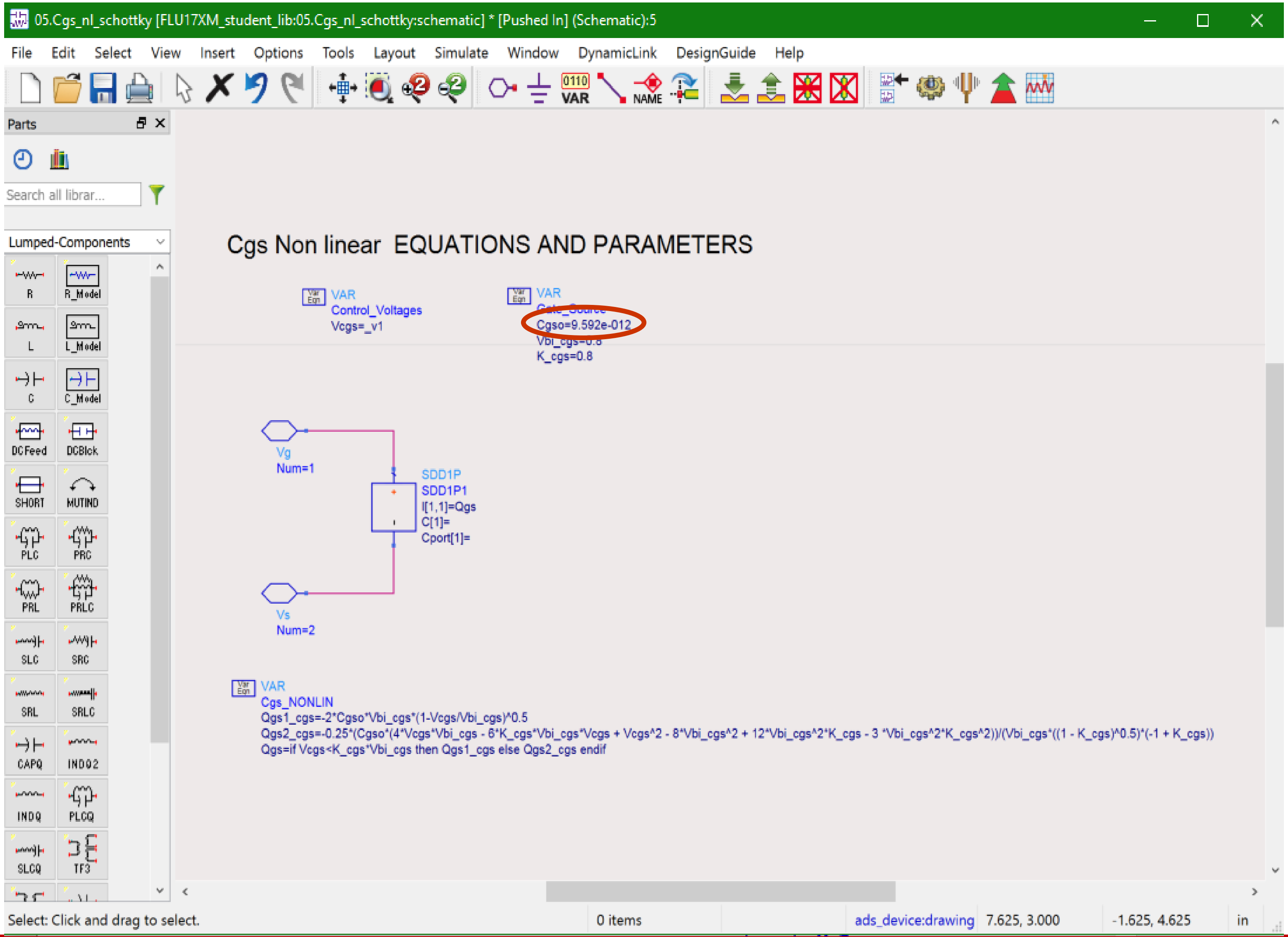


PA Design with Die transistor and Lumped components

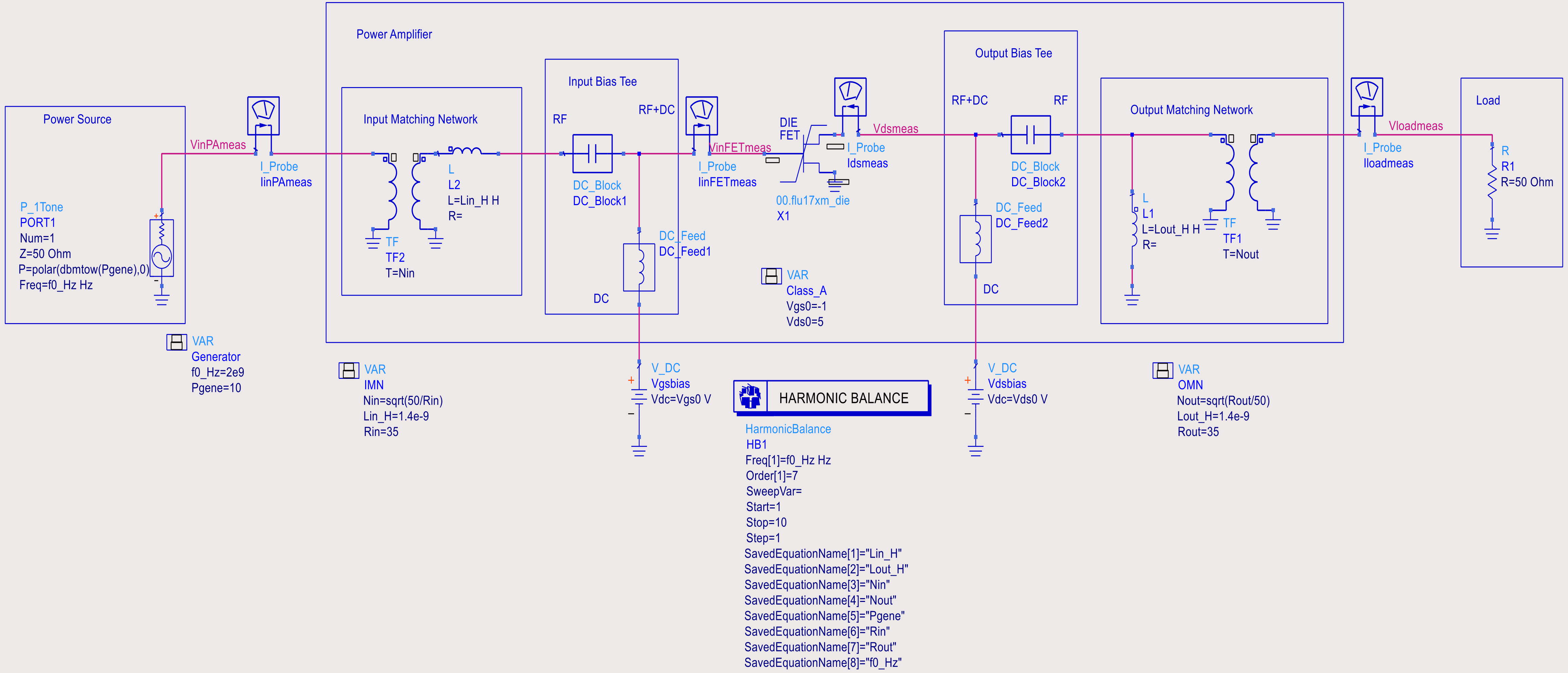
Click here after selecting the transistor black box to see the transistor model




00.flu17xm_die [FLU17XM_student_lib:00.flu17xm_die:schematic] * (Schematic):5
File Edit Select View Insert Options Tools Layout Simulate Window DynamicLink DesignGuide Help
Click here after selecting the non linear C_{GS} capacitance black box
R10
R=1e9 Ohm
R1
R=Rg Ohm
GATE_TERMINAL
Num=2
Vdint
C1
C=Cds pF
R2
R=Rd Ohm
DRAIN_TERMINAL
Num=1
04.diode
X8
05.Cgs_nl_schottky
X7
03.aval_taj_FLU17xm
X6
I_Probe
Ids_int
EXTRINSIC MODEL PARAMETERS
VAR
Linear
Rg=0.2
Rs=0.2
Ri=1.126
Ld=1.273
Cpg=0.4846
Cpd=0.4901
Cds=1.465
R9
R=Ri Ohm
R3
R=Rs Ohm
SOURCE_TERMINAL
Num=3
Select: Click and drag to select.
0 items
ads_device:drawing



05.Cgs_nl_schottky [FLU17XM_student_lib:05.Cgs_nl_schottky:schematic] * [Pushed In] (Schematic):5
File Edit Select View Insert Options Tools Layout Simulate Window DynamicLink DesignGuide Help
Parts
Search all librar...
Lumped-Components
R
R_Model
L
L_Model
C
C_Model
DCFeed
DCBlck
SHORT
MUTIND
PLC
PRC
PRL
PRLC
SLC
SRC
SRL
SRLC
CAPQ
INDQ2
INDQ
PLCQ
SLCQ
TF3
Cgs Non linear EQUATIONS AND PARAMETERS
VAR
Control_Voltages
Vcgs=_v1
VAR
Cgso=9.592e-012
K_cgs=0.8
Vg
Num=1
SDD1P
SDD1P1
I[1,1]=Qgs
C[1]=
Cport[1]=
Vs
Num=2
VAR
Cgs_NONLIN
Qgs1_cgs=-2*Cgso*Vbi_cgs*(1-Vcgs/Vbi_cgs)^0.5
Qgs2_cgs=-0.25*(Cgso*(4*Vcgs*Vbi_cgs - 6*K_cgs*Vbi_cgs*Vcgs + Vcgs^2 - 8*Vbi_cgs^2 + 12*Vbi_cgs^2*K_cgs - 3 *Vbi_cgs^2*K_cgs^2))/(Vbi_cgs*((1 - K_cgs)^0.5)*(-1 + K_cgs))
Qgs=if Vcgs<K_cgs*Vbi_cgs then Qgs1_cgs else Qgs2_cgs endif
Select: Click and drag to select.
0 items
ads_device:drawing
7.625, 3.000
-1.625, 4.625
in


Power Amplifier
Power Source
P_1Tone
PORT1
Num=1
Z=50 Ohm
P=polar(dbmtow(Pgene),0)
Freq=f0_Hz Hz
VinPAmeas
I_Probe
IinPAmeas
VAR
Generator
f0_Hz=2e9
Pgene=10
Input Matching Network
TF
TF2
T=Nin
L
L2
L=Lin_H H
R=
VAR
IMN
Nin=sqrt(50/Rin)
Lin_H=1.4e-9
Rin=35
Input Bias Tee
RF
RF+DC
DC_Block
DC_Block1
DC_Feed
DC_Feed1
DC
V_DC
Vgsbias
Vdc=Vgs0 V
I_Probe
IinFETmeas
VinFETmeas
DIE
FET
00.flu17xm_die
X1
Vdsmeas
I_Probe
Idsmeas
VAR
Class_A
Vgs0=-1
Vds0=5
HARMONIC BALANCE
HarmonicBalance
HB1
Freq[1]=f0_Hz Hz
Order[1]=7
SweepVar=
Start=1
Stop=10
Step=1
SavedEquationName[1]="Lin_H"
SavedEquationName[2]="Lout_H"
SavedEquationName[3]="Nin"
SavedEquationName[4]="Nout"
SavedEquationName[5]="Pgene"
SavedEquationName[6]="Rin"
SavedEquationName[7]="Rout"
SavedEquationName[8]="f0_Hz"
Output Bias Tee
RF+DC
RF
DC_Block
DC_Block2
DC_Feed
DC_Feed2
DC
V_DC
Vdsbias
Vdc=Vds0 V
Output Matching Network
L
L1
L=Lout_H H
R=
TF
TF1
T=Nout
VAR
OMN
Nout=sqrt(Rout/50)
Lout_H=1.4e-9
Rout=35
Vloadmeas
I_Probe
Iloadmeas
Load
R
R1
R=50 Ohm

Eqn VinPA_f0=VinPAmeas[1]
Eqn VoutPA_f0=Vloadmeas[1]

Eqn IinPA_f0=IinPAmeas.i[1]
Eqn IoutPA_f0=Iloadmeas.i[1]

Eqn VinPA_DC=mag(VinFETmeas[0])
Eqn VoutPA_DC=mag(Vdsmeas[0])

Eqn IinPA_DC=mag(IinFETmeas.i[0])
Eqn IoutPA_DC=mag(Idsmeas.i[0])

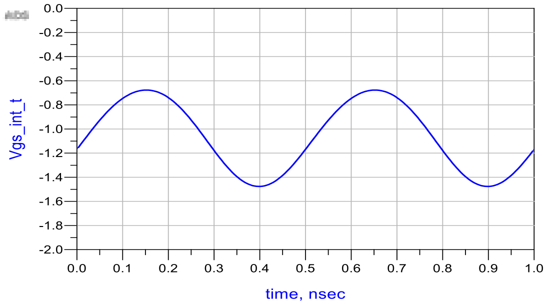
Eqn PinPA_f0_mW=0.5*1000*real(VinPA_f0*conj(IinPA_f0))
Eqn PinPA_f0_dBm=10*log10(PinPA_f0_mW)
Eqn PoutPA_f0_mW=0.5*1000*real(VoutPA_f0*conj(IoutPA_f0))
Eqn PoutPA_f0_dBm=10*log10(PoutPA_f0_mW)
Eqn PDC_mW=1000*(VinPA_DC*IinPA_DC+VoutPA_DC*IoutPA_DC)

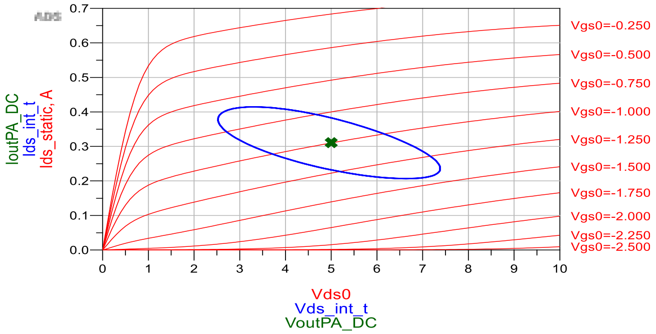
Eqn GPA_f0=PoutPA_f0_mW/PinPA_f0_mW
Eqn GPA_f0_dB=10*log10(GPA_f0)
Eqn PaddPA_f0_mW=PoutPA_f0_mW-PinPA_f0_mW
Eqn PaddPA_f0_dBm=10*log10(PaddPA_f0_mW)
Eqn Drain_Efficiency=PoutPA_f0_mW/PDC_mW*100
Eqn PAE=PaddPA_f0_mW/PDC_mW*100

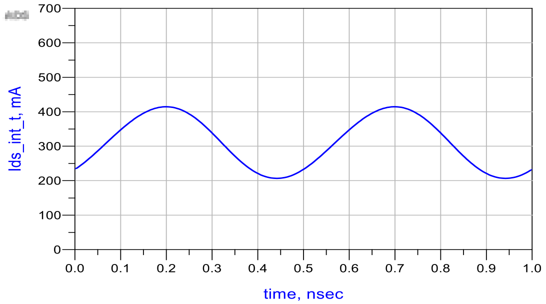
Eqn ZinFET_f0=VinFETmeas[1]/IinFETmeas.i[1]
Eqn ZinPA_f0=VinPAmeas[1]/IinPAmeas.i[1]
Eqn GamainFET_f0=(ZinFET_f0-50)/(ZinFET_f0+50)
Eqn GamainPA_f0=(ZinPA_f0-50)/(ZinPA_f0+50)

PinPA_f0_mW	PoutPA_f0_mW	GPA_f0	PDC_mW	Drain_Efficiency	PAE
0.045	82.285	1816.913	1554.143	5.295	5.292

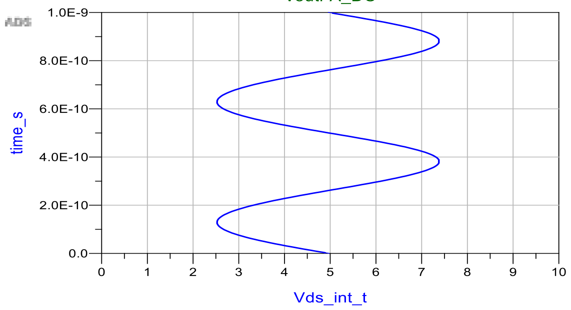
PinPA_f0_dBm	PoutPA_f0_dBm	GPA_f0_dB	PDC_mW	Drain_Efficiency	PAE
-13.440	19.153	32.593	1554.143	5.295	5.292

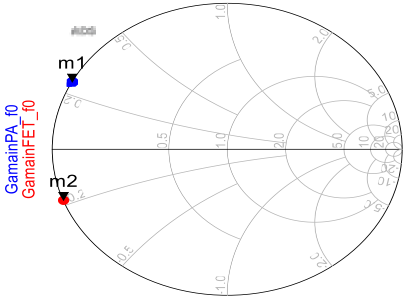






Eqn Ids_static="_06.analyseDCext"..Ids_int.i
Eqn time_s=ts(freq)
Eqn Vds_int=Vdint-Vsintd
Eqn Vds_int_t=ts(Vds_int)
Eqn Vgs_int_t=ts(Vgint-Vsintg)
Eqn Ids_int_t=ts(Ids_int.i)



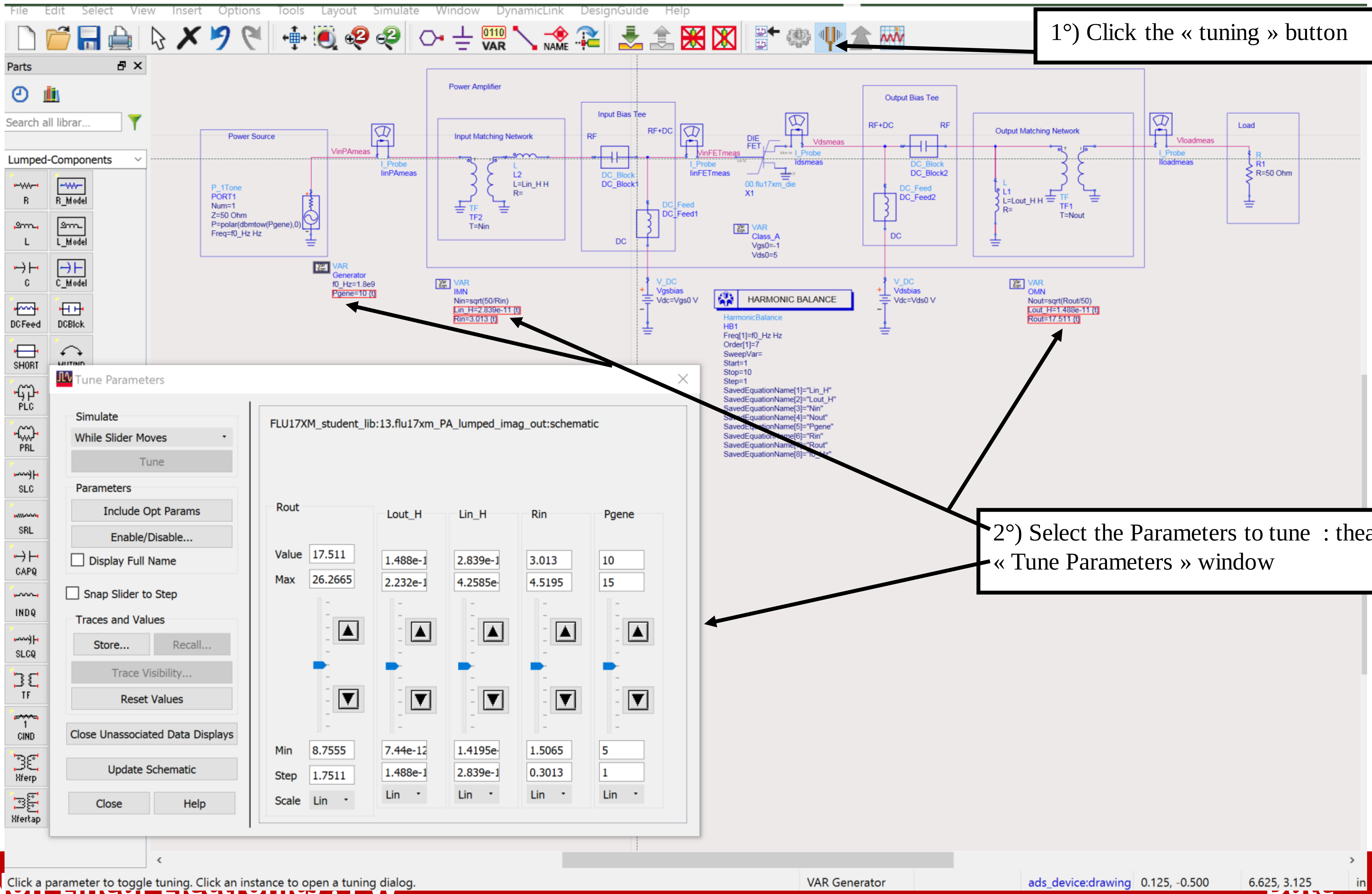


ZinFET_f0	GamainFET_f0
0.042 - j9.045	0.998 / -159.492

ZinPA_f0	GamainPA_f0
0.060 + j12.211	0.998 / 152.552

m2
indep(m2)=0
GamainFET_f0=0.998 / -159.492
impedance = Z0 * (8.417E-4 - j0.181)

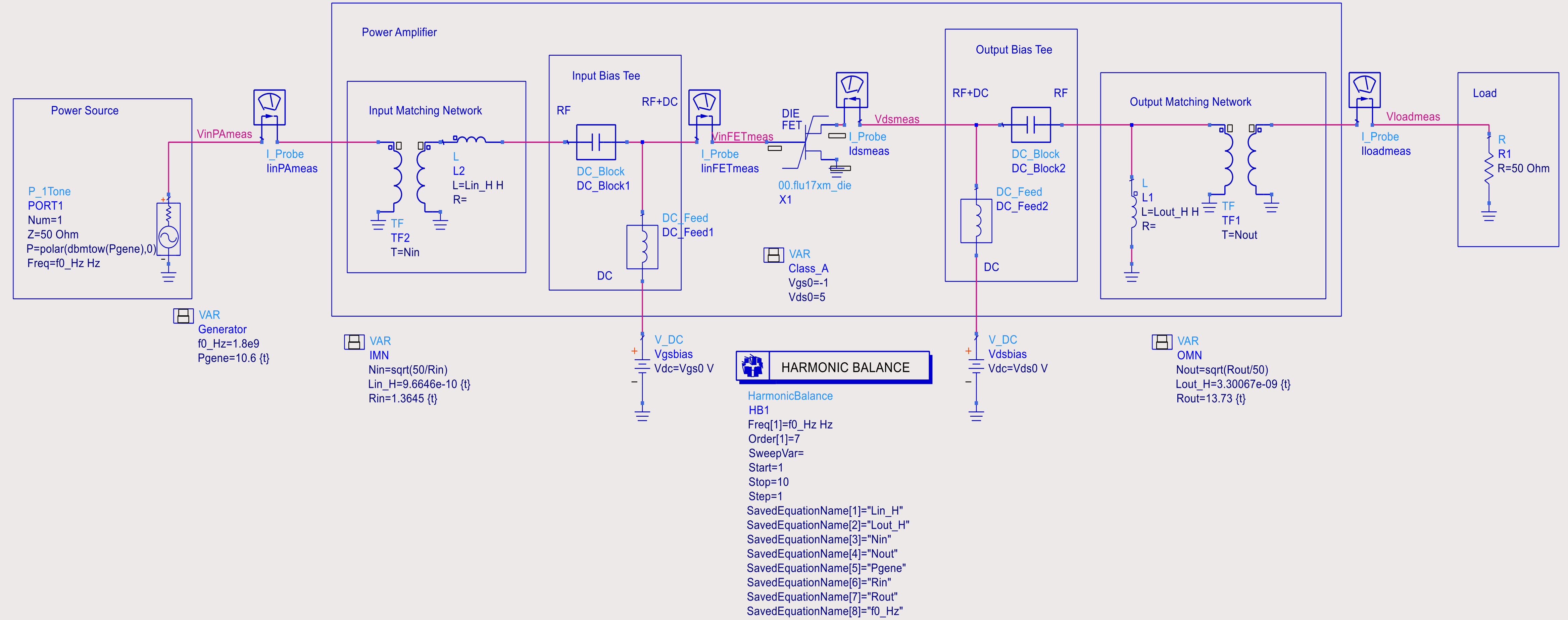
m1
indep(m1)=0
GamainPA_f0=0.998 / 152.552
impedance = Z0 * (0.001 + j0.244)



1°) Click the « tuning » button

2°) Select the Parameters to tune : theay appear in the « Tune Parameters » window

After the tuning of the 5 parameters



Results after the tuning of the 5 parameters to maxipise the output power of the PA.

Method to tune the parameters

1) Tune first Lout_H
2) Tune Secondly Rout
3) Modify Pgene if required
4) Tune again Lout_H
5) Tune again Rout
6) Tune then Lin_H to cancel Imag(ZinPA)
7) Tune Secondly Rin (To match ZinPA=50Ω)
8) Modify Pgene if required
9) Tune again Lout_H if required
10) Tune again Rout if required
11) Tune again Lin_H to cancel Imag(ZinPA)
12) Tune again Rin (To match ZinPA=50Ω)
13) Repeat again step 8 to 12 to maximise the Gain or the output power or the PAE

Eqn VinPA_f0=VinPAmeas[1]
Eqn VoutPA_f0=Vloadmeas[1]
Eqn IinPA_f0=IinPAmeas.i[1]
Eqn IoutPA_f0=Iloadmeas.i[1]

Eqn VinPA_DC=mag(VinFETmeas[0])
Eqn VoutPA_DC=mag(Vdsmeas[0])
Eqn IinPA_DC=mag(IinFETmeas.i[0])
Eqn IoutPA_DC=mag(Idsmeas.i[0])

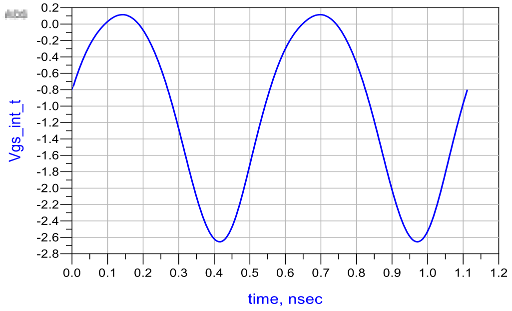
Eqn PinPA_f0_mW=0.5*1000*real(VinPA_f0*conj(IinPA_f0))
Eqn PinPA_f0_dBm=10*log10(PinPA_f0_mW)
Eqn PoutPA_f0_mW=0.5*1000*real(VoutPA_f0*conj(IoutPA_f0))
Eqn PoutPA_f0_dBm=10*log10(PoutPA_f0_mW)
Eqn PDC_mW=1000*(VinPA_DC*IinPA_DC+VoutPA_DC*IoutPA_DC)

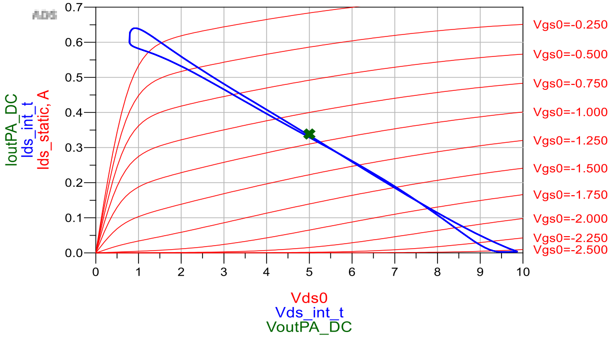
Eqn GPA_f0=PoutPA_f0_mW/PinPA_f0_mW
Eqn GPA_f0_dB=10*log10(GPA_f0)
Eqn PaddPA_f0_mW=PoutPA_f0_mW-PinPA_f0_mW
Eqn PaddPA_f0_dBm=10*log10(PaddPA_f0_mW)
Eqn Drain_Efficiency=PoutPA_f0_mW/PDC_mW*100
Eqn PAE=PaddPA_f0_mW/PDC_mW*100

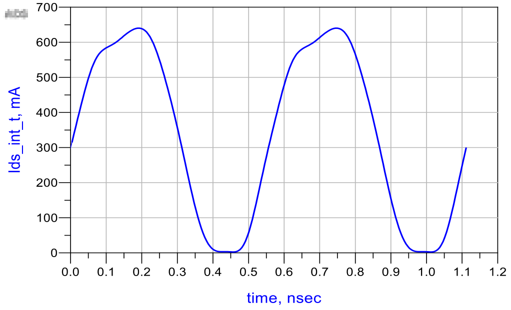
Eqn ZinFET_f0=VinFETmeas[1]/IinFETmeas.i[1]
Eqn ZinPA_f0=VinPAmeas[1]/IinPAmeas.i[1]
Eqn GamainFET_f0=(ZinFET_f0-50)/(ZinFET_f0+50)
Eqn GamainPA_f0=(ZinPA_f0-50)/(ZinPA_f0+50)

PinPA_f0_mW	PoutPA_f0_mW	GPA_f0	PDC_mW	Drain_Efficiency	PAE
11.482	790.611	68.859	1692.671	46.708	46.030

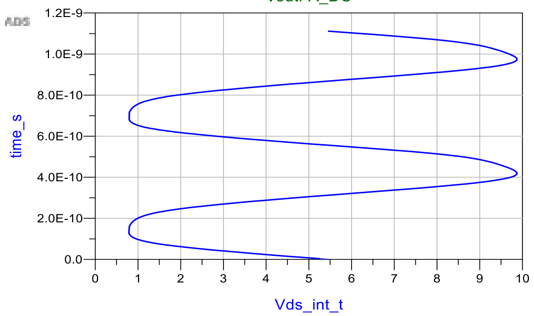
PinPA_f0_dBm	PoutPA_f0_dBm	GPA_f0_dB	PDC_mW	Drain_Efficiency	PAE
10.600	28.980	18.380	1692.671	46.708	46.030

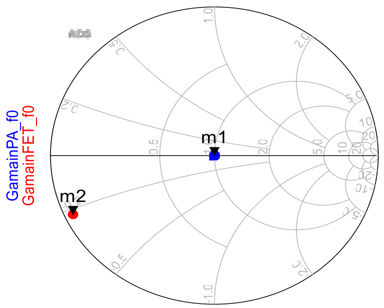






Eqn Ids_static="_06.analyseDCext"..Ids_int.i
Eqn time_s=ts(freq)
Eqn Vds_int=Vdint-Vsintd
Eqn Vds_int_t=ts(Vds_int)
Eqn Vgs_int_t=ts(Vgint-Vsintg)
Eqn Ids_int_t=ts(Ids_int.i)



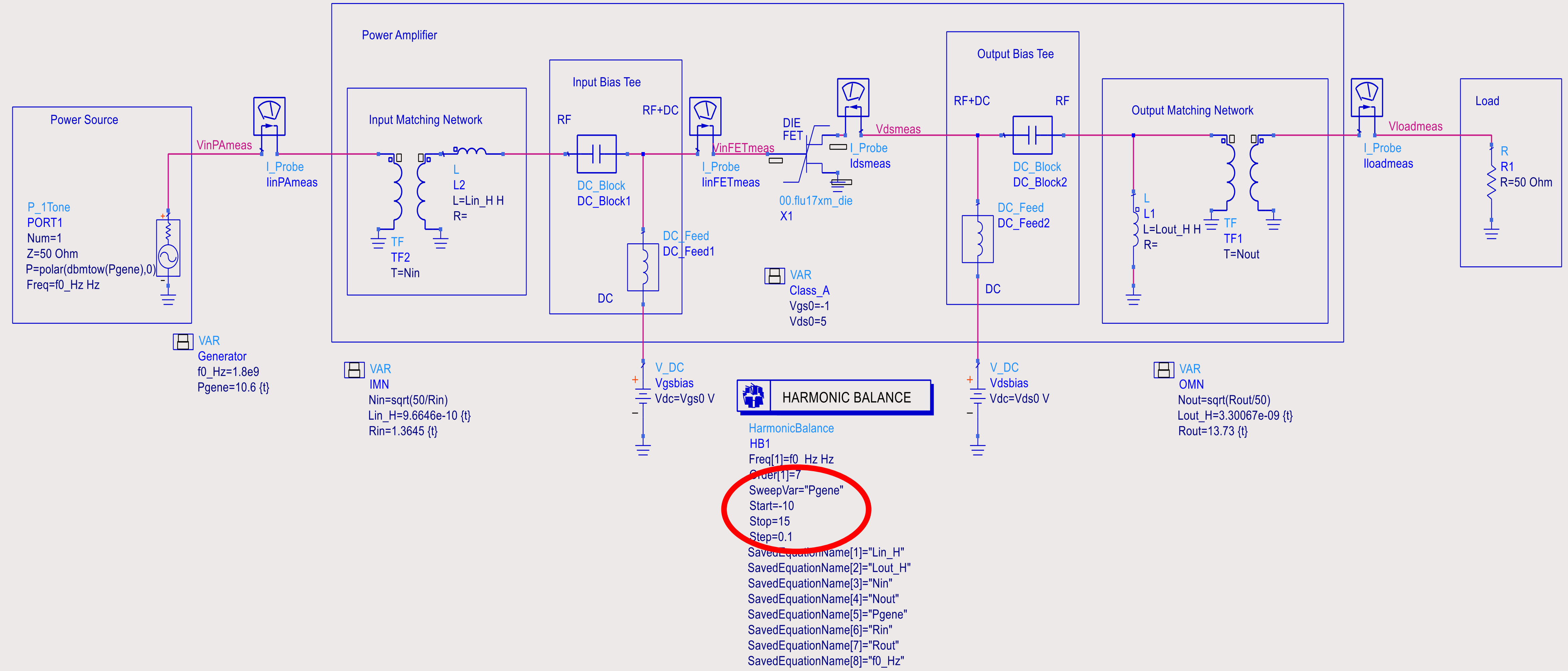


ZinFET_f0	GamainFET_f0
1.365 - j10.931	0.949 / -155.320

ZinPA_f0	GamainPA_f0
50.024 - j0.004	2.428E-4 / -8.749

m2
indep(m2)=0
GamainFET_f0=0.949 / -155.320
impedance = Z0 * (0.027 - j0.219)

m1
indep(m1)=0
GamainPA_f0=2.428E-4 / -8.749
impedance = Z0 * (1.000 - j7.390E-5)


Power Amplifier
Power Source
P_1Tone
PORT1
Num=1
Z=50 Ohm
P=polar(dbmtow(Pgene),0)
Freq=f0_Hz Hz
VinPAmeas
I_Probe
IinPAmeas
Input Matching Network
L
L2
L=Lin_H H
R=
TF
TF2
T=Nin
Input Bias Tee
RF
RF+DC
DC_Block
DC_Block1
DC_Feed
DC_Feed1
DC
VinFETmeas
I_Probe
IinFETmeas
DIE
FET
00.flu17xm_die
X1
Vdsmeas
I_Probe
Idsmeas
VAR
Class_A
Vgs0=-1
Vds0=5
Output Bias Tee
RF+DC
RF
DC_Block
DC_Block2
DC_Feed
DC_Feed2
DC
Output Matching Network
L
L1
L=Lout_H H
R=
TF
TF1
T=Nout
I_Probe
Iloadmeas
Vloadmeas
Load
R
R1
R=50 Ohm
VAR
Generator
f0_Hz=1.8e9
Pgene=10.6 {t}
VAR
IMN
Nin=sqrt(50/Rin)
Lin_H=9.6646e-10 {t}
Rin=1.3645 {t}
V_DC
Vgsbias
Vdc=Vgs0 V
HARMONIC BALANCE
HarmonicBalance
HB1
Freq[1]=f0_Hz Hz
rder[1]=7
SweepVar="Pgene"
Start=-10
Stop=15
Step=0.1
SavedEquationName[1]="Lin_H"
SavedEquationName[2]="Lout_H"
SavedEquationName[3]="Nin"
SavedEquationName[4]="Nout"
SavedEquationName[5]="Pgene"
SavedEquationName[6]="Rin"
SavedEquationName[7]="Rout"
SavedEquationName[8]="f0_Hz"
V_DC
Vdsbias
Vdc=Vds0 V
VAR
OMN
Nout=sqrt(Rout/50)
Lout_H=3.30067e-09 {t}
Rout=13.73 {t}

Eqn VinPA_f0=VinPAmeas[1]

Eqn VoutPA_f0=Vloadmeas[1]

Eqn IinPA_f0=IinPAmeas.i[1]

Eqn IoutPA_f0=Iloadmeas.i[1]

Eqn VinPA_DC=mag(VinFETmeas[0

Eqn VoutPA_DC=mag(Vdsmeas[0])

Eqn IinPA_DC=mag(IinFETmeas.i[0])

Eqn IoutPA_DC=mag(Idsmeas.i[0])

Eqn PinPA_f0_mW=0.5*1000*real(VinPA_f0*conj(IinPA_f0))

Eqn PinPA_f0_dBm=10*log10(PinPA_f0_mW)

Eqn PoutPA_f0_mW=0.5*1000*real(VoutPA_f0*conj(IoutPA_f0))

Eqn PoutPA_f0_dBm=10*log10(PoutPA_f0_mW)

Eqn PDC_mW=1000*(VinPA_DC*IinPA_DC+VoutPA_DC*IoutPA_DC)

Eqn GPA_f0=PoutPA_f0_mW/PinPA_f0_mW

Eqn GPA_f0_dB=10*log10(GPA_f0)

Eqn PaddPA_f0_mW=PoutPA_f0_mW-PinPA_f0_mW

Eqn PaddPA_f0_dBm=10*log10(PaddPA_f0_mW)

Eqn Drain_Efficiency=PoutPA_f0_mW/PDC_mW*100

Eqn PAE=PaddPA_f0_mW/PDC_mW*100

Eqn ZinFET_f0=VinFETmeas[1]/IinFETmeas.i[1]

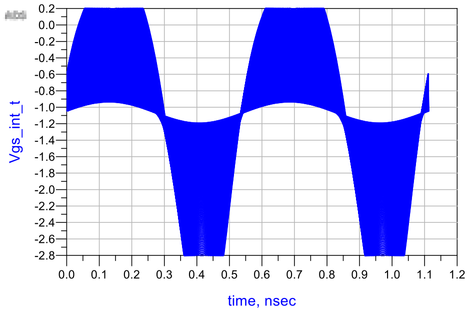
Eqn ZinPA_f0=VinPAmeas[1]/IinPAmeas.i[1]

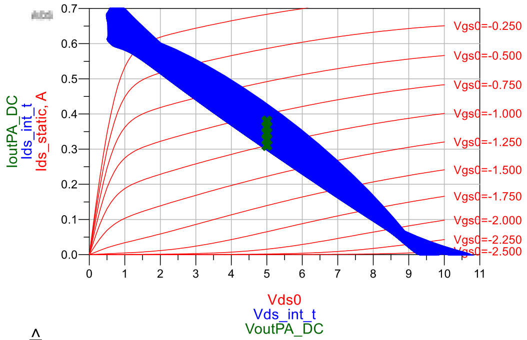
Eqn GamainFET_f0=(ZinFET_f0-50)/(ZinFET_f0+50)

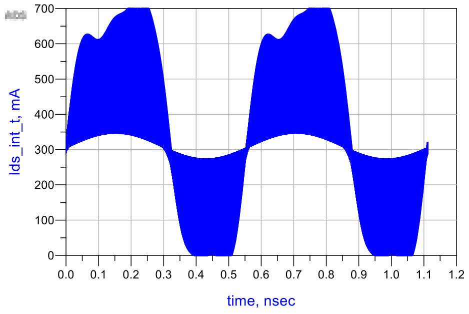
Eqn GamainPA_f0=(ZinPA_f0-50)/(ZinPA_f0+50)

Pgene	PinPA_f0_mW	...tPA_f0_mW	GPA_f0	PDC_mW	...in_Efficiency	PAE
-10.000	0.099	9.234	92.811	1551.479	0.595	0.589

Pgene	...PA_f0_dBm	...tPA_f0_dBm	GPA_f0_dB	PDC_mW	...in_Efficiency	PAE
-10.000	-10.022	9.654	19.676	1551.479	0.595	0.589







Eqn Ids_static="_06.analyseDCext"..Ids_int.i

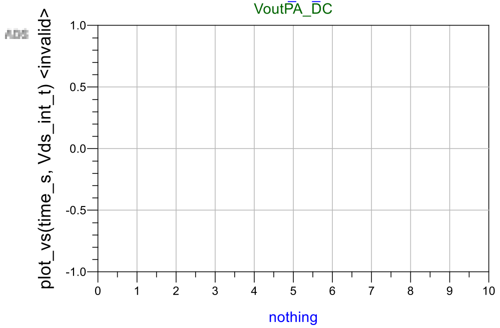
Eqn time_s=ts(freq)

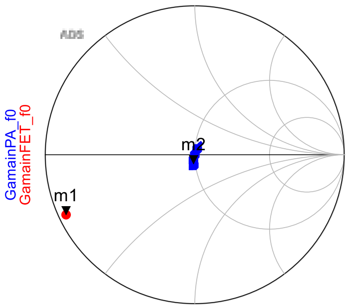
Eqn Vds_int=Vdint-Vsintd

Eqn Vds_int_t=ts(Vds_int)

Eqn Vgs_int_t=ts(Vgint-Vsintg)

Eqn Ids_int_t=ts(Ids_int.i)





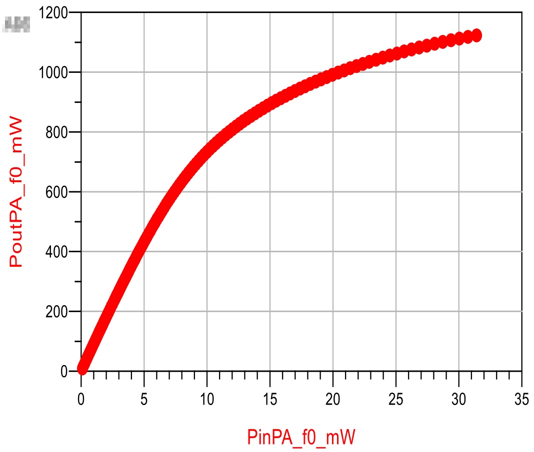
Pgene	ZinFET_f0	...ainFET_f0
-10.000	1.332 - j11....	0.951 / -154...
-9.900	1.332 - j11....	0.951 / -154...

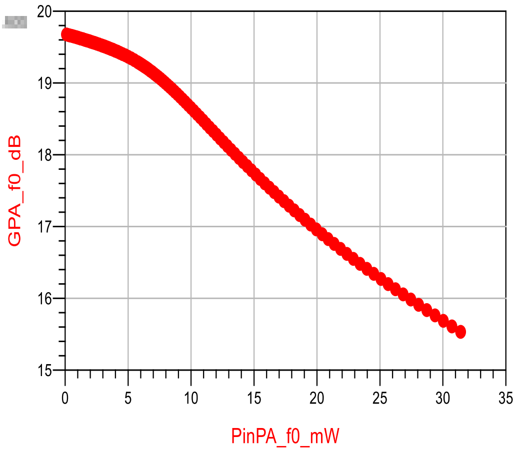
Pgene	ZinPA_f0	...mainPA_f0
-10.000	48.798 - j6....	0.071 / -95....
-9.900	48.798 - j6....	0.071 / -95....

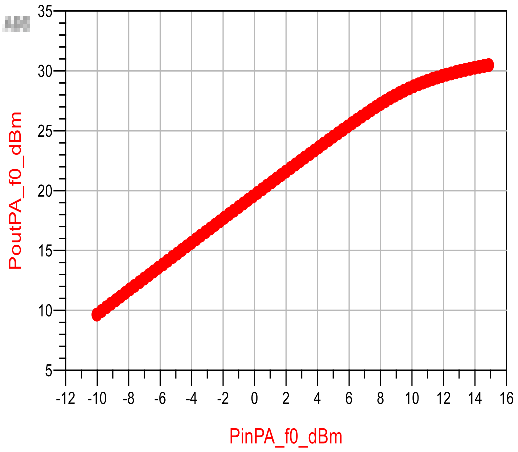
Pgene (-10.000 to 15.000)

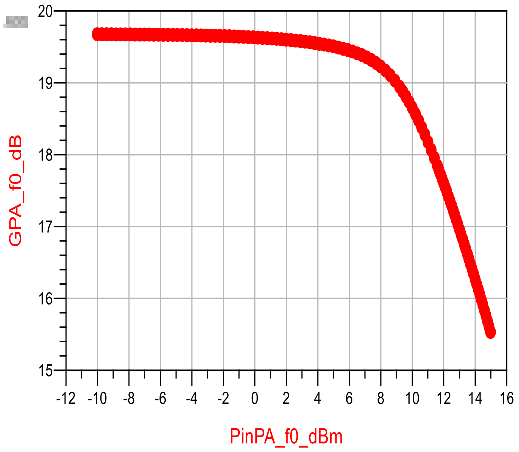
m1
Pgene=-1.879E-14
GamainFET_f0=0.950 / -154.969
impedance = Z0 * (0.027 - j0.222)

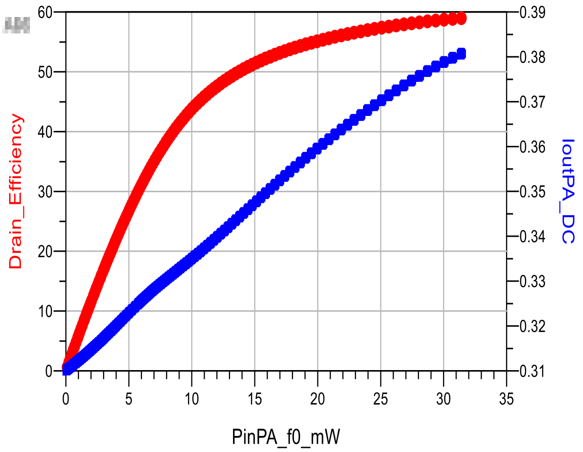
m2
Pgene=-1.879E-14
GamainPA_f0=0.061 / -97.558
impedance = Z0 * (0.977 - j0.118)

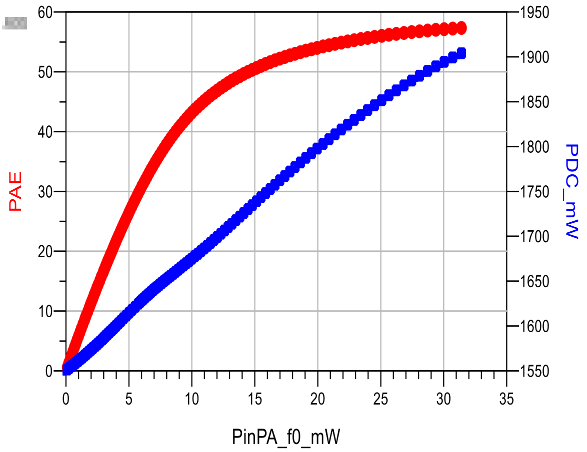

PoutPA_f0_mW
PinPA_f0_mW

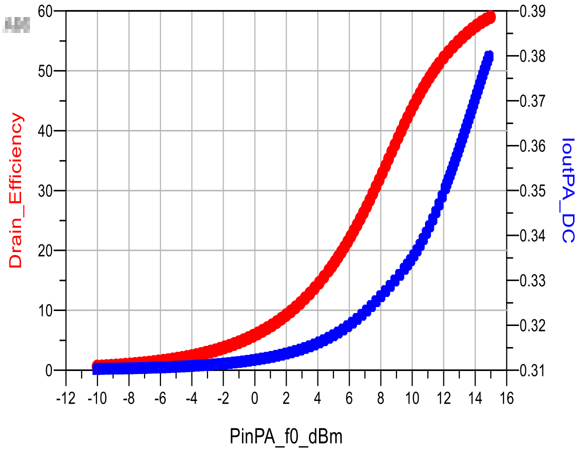

GPA_f0_dB
PinPA_f0_mW

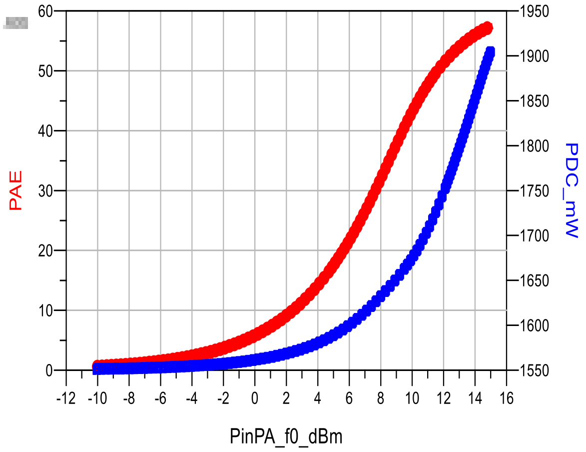

PoutPA_f0_dBm
PinPA_f0_dBm


GPA_f0_dB
PinPA_f0_dBm

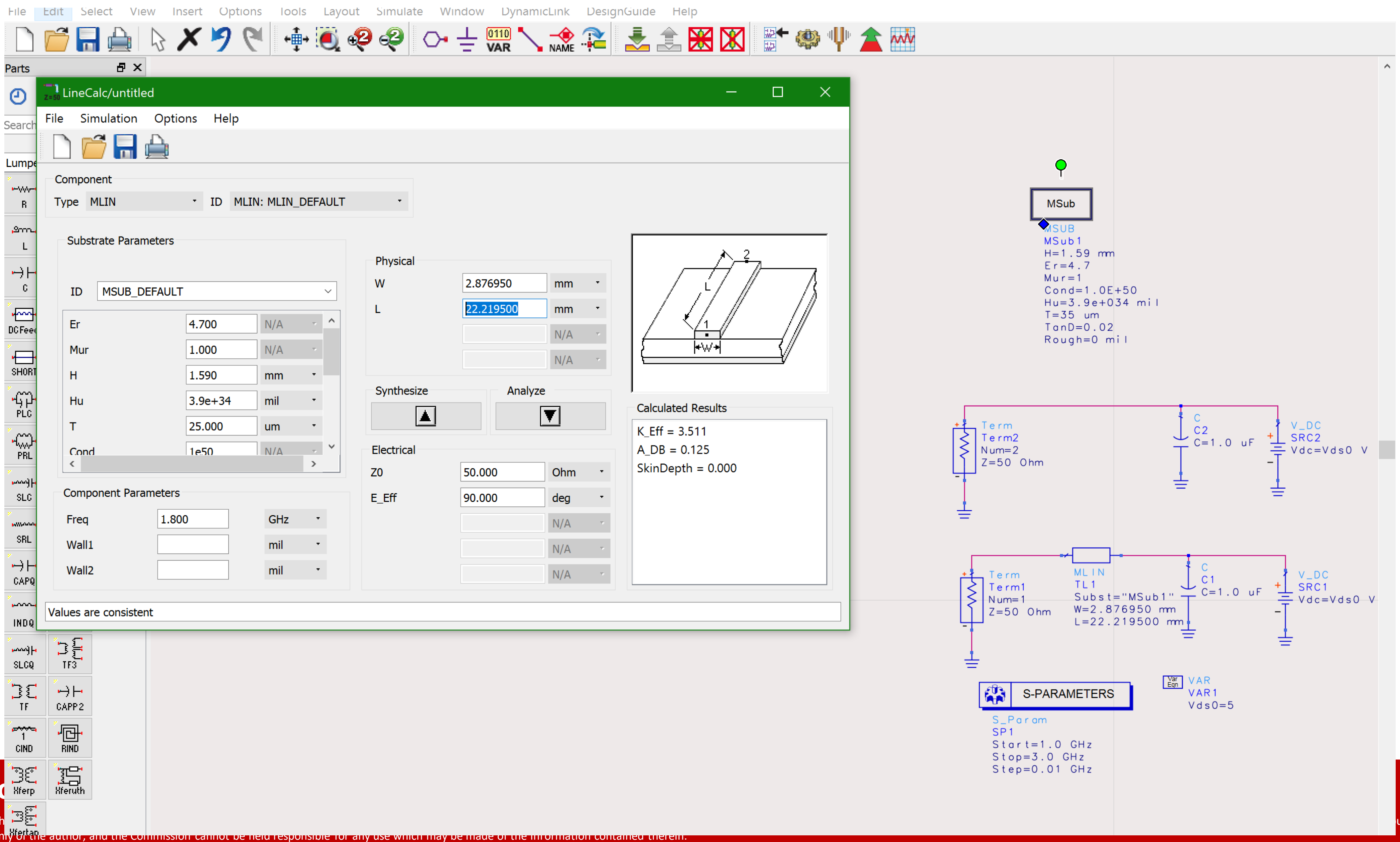

Drain_Efficiency
IoutPA_DC
PinPA_f0_mW

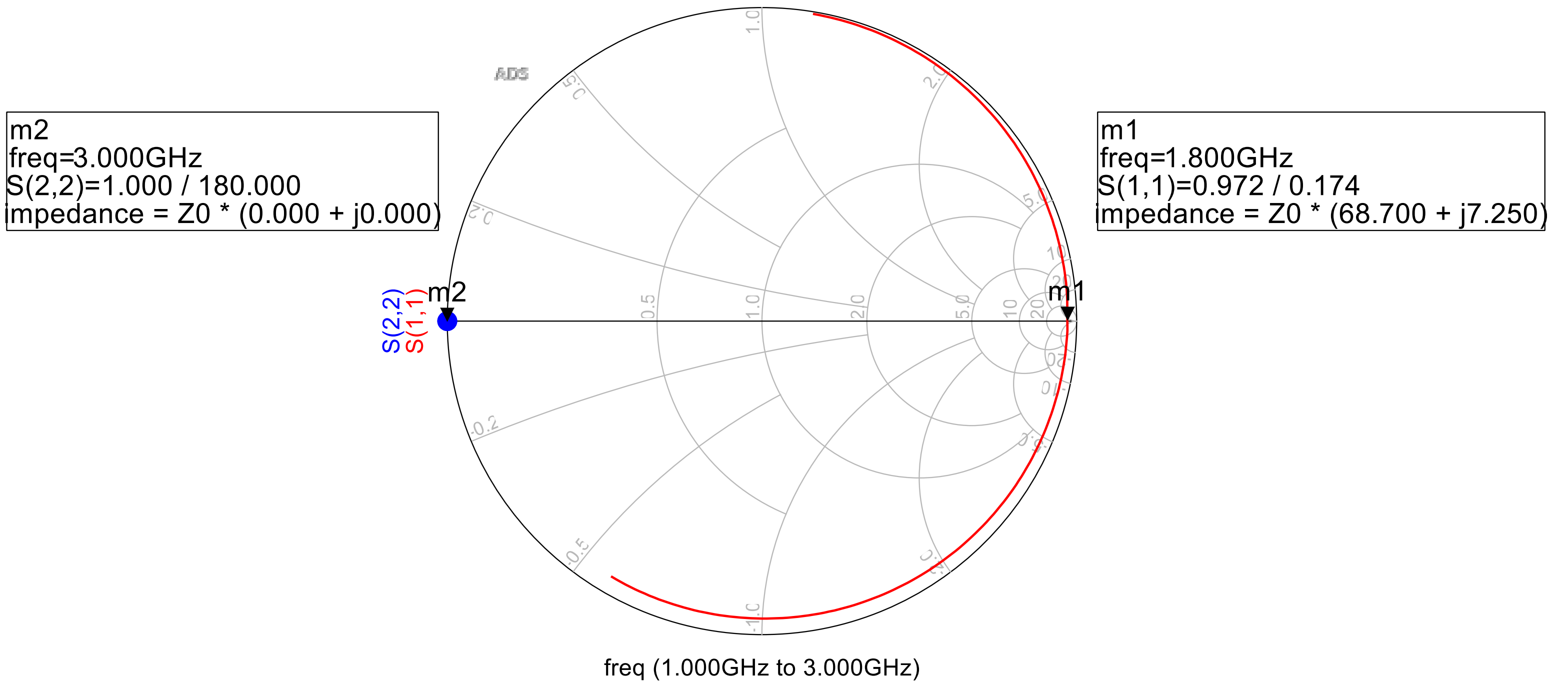

PAE
PDC_mW
PinPA_f0_mW

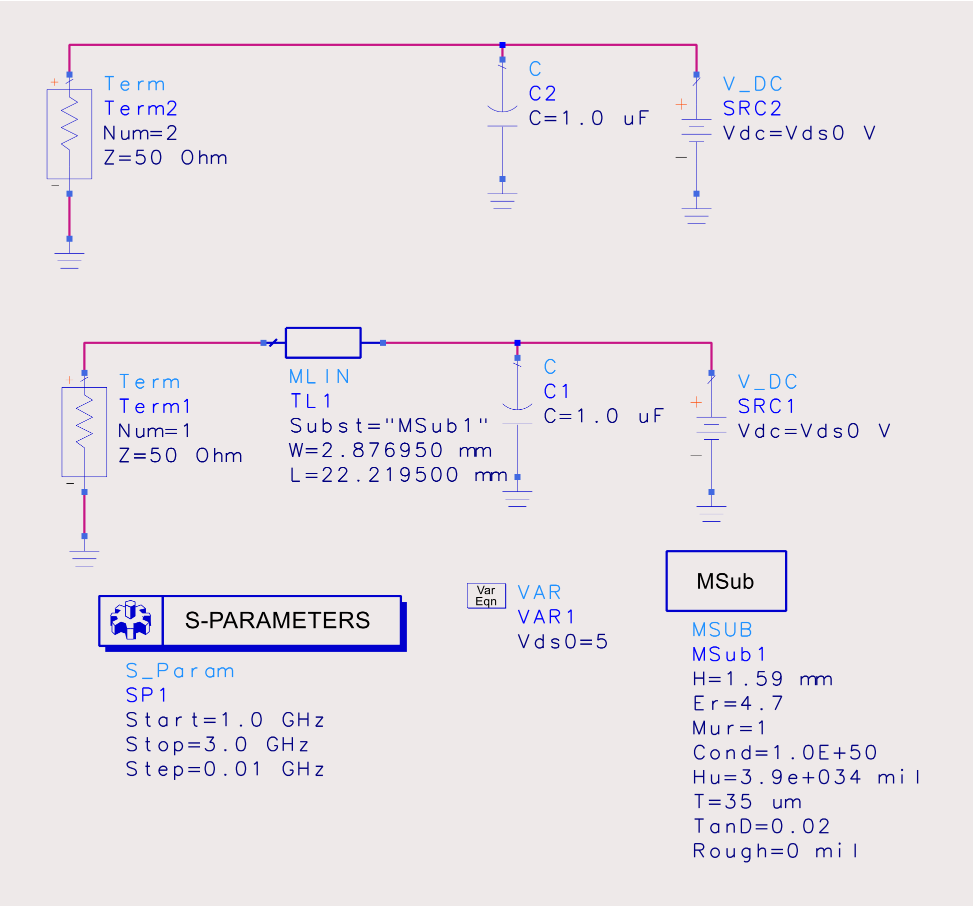

Drain_Efficiency
IoutPA_DC
PinPA_f0_dBm


PAE
PDC_mW
PinPA_f0_dBm

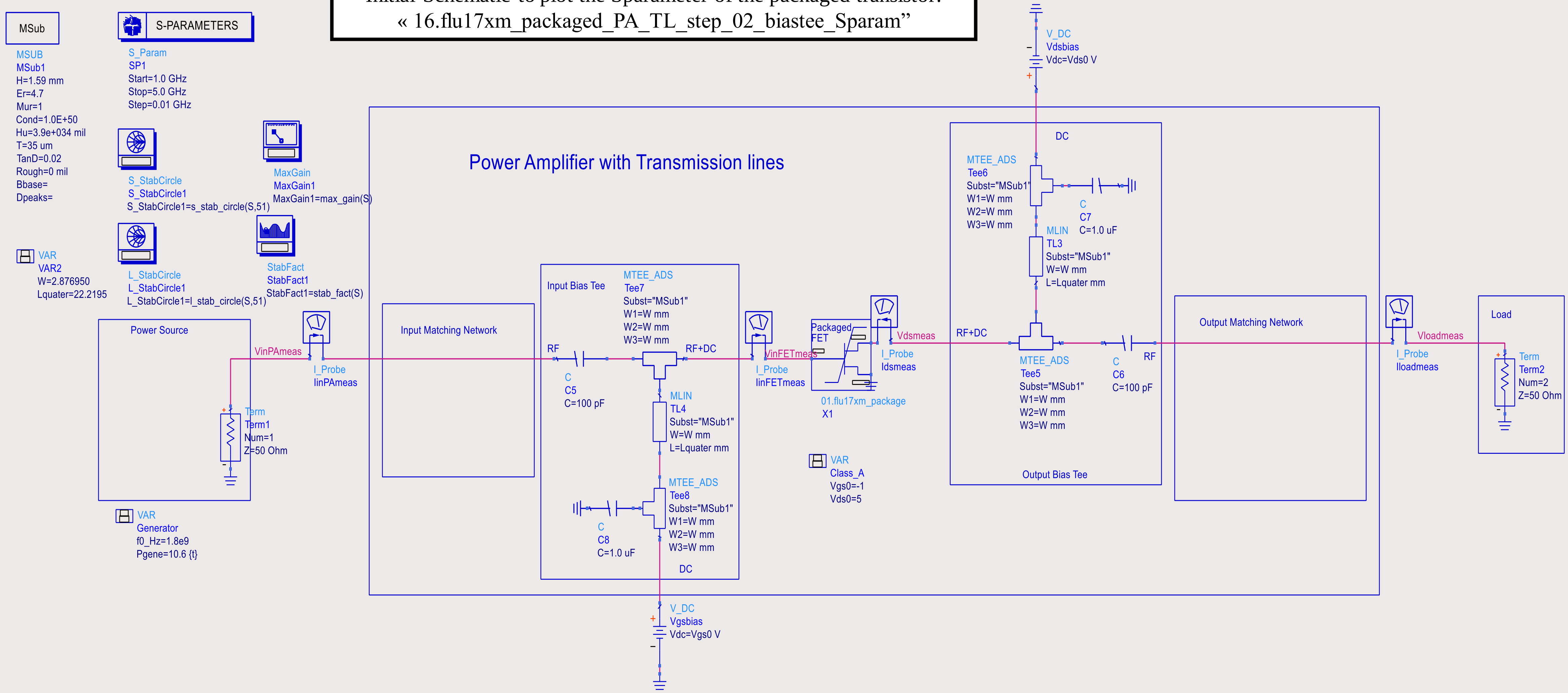
PA Design with the packaged transistor and transmission Lines


File Edit Select View Insert Options Tools Layout Simulate Window DynamicLink DesignGuide Help
Parts
LineCalc/untitled
File Simulation Options Help
Component
Type MLIN
ID MLIN: MLIN_DEFAULT
Substrate Parameters
ID MSUB_DEFAULT
Er 4.700 N/A
Mur 1.000 N/A
H 1.590 mm
Hu 3.9e+34 mil
T 25.000 um
Cond 1e50 N/A
Component Parameters
Freq 1.800 GHz
Wall1 mil
Wall2 mil
Physical
W 2.876950 mm
L 22.219500 mm
Synthesize
Analyze
Electrical
Z0 50.000 Ohm
E_Eff 90.000 deg
Calculated Results
K_Eff = 3.511
A_DB = 0.125
SkinDepth = 0.000
Values are consistent
MSub
MSUB
MSub1
H=1.59 mm
Er=4.7
Mur=1
Cond=1.0E+50
Hu=3.9e+034 mil
T=35 um
TanD=0.02
Rough=0 mil
Term
Term2
Num=2
Z=50 Ohm
C
C2
C=1.0 uF
V_DC
SRC2
Vdc=Vds0 V
Term
Term1
Num=1
Z=50 Ohm
MLIN
TL1
Subst="MSub1"
W=2.876950 mm
L=22.219500 mm
C
C1
C=1.0 uF
V_DC
SRC1
Vdc=Vds0 V
S-PARAMETERS
S_Param
SP1
Start=1.0 GHz
Stop=3.0 GHz
Step=0.01 GHz
VAR
VAR1
Vds0=5


ADS
m2
freq=3.000GHz
S(2,2)=1.000 / 180.000
impedance = Z0 * (0.000 + j0.000)
m1
freq=1.800GHz
S(1,1)=0.972 / 0.174
impedance = Z0 * (68.700 + j7.250)
S(2,2)
S(1,1)
freq (1.000GHz to 3.000GHz)


Term
Term2
Num=2
Z=50 Ohm
C
C2
C=1.0 uF
V_DC
SRC2
Vdc=Vds0 V
Term
Term1
Num=1
Z=50 Ohm
MLIN
TL1
Subst="MSub1"
W=2.876950 mm
L=22.219500 mm
C
C1
C=1.0 uF
V_DC
SRC1
Vdc=Vds0 V
S-PARAMETERS
S_Param
SP1
Start=1.0 GHz
Stop=3.0 GHz
Step=0.01 GHz
VAR
VAR1
Vds0=5
MSub
MSUB
MSub1
H=1.59 mm
Er=4.7
Mur=1
Cond=1.0E+50
Hu=3.9e+034 mil
T=35 um
TanD=0.02
Rough=0 mil

Initial Schematic to plot the Sparameter of the packaged transistor:
« 16.flu17xm_packaged_PA_TL_step_02_biastee_Sparam”

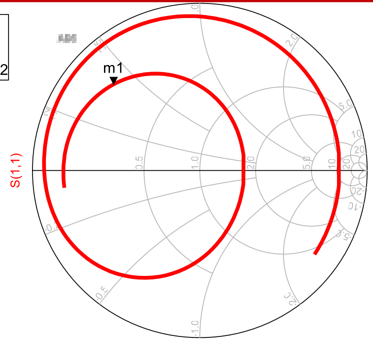


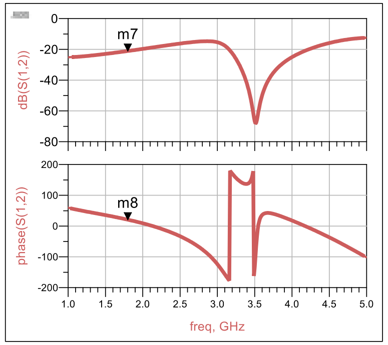
m1
freq=1.800GHz
S(1,1)=0.728 / 134.942
impedance = 9.174 + j20.142

freq	m1	indep(m1)
1.800 GHz	0.728 / 134.942	1.800E9

Eqn Z11calc=50*(1+m1)/(1-m1)

freq	Z11calc	Z11calc
1.800 GHz	9.174 + j20.142	22.133 / 65.512



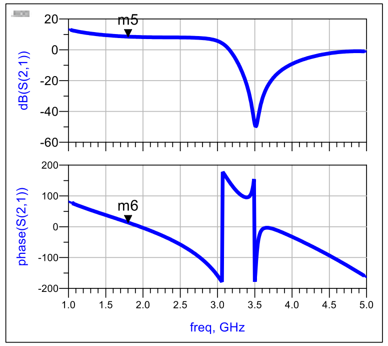


m7
freq=1.800GHz
dB(S(1,2))=-21.069

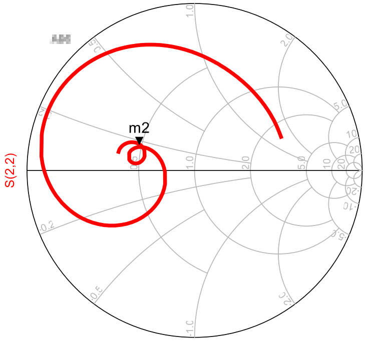
m8
freq=1.800GHz
phase(S(1,2))=20.654

m5
freq=1.800GHz
dB(S(2,1))=8.535

m6
freq=1.800GHz
phase(S(2,1))=13.656



m2
freq=1.800GHz
S(2,2)=0.366 / 154.521
impedance = 24.142 + j8.769

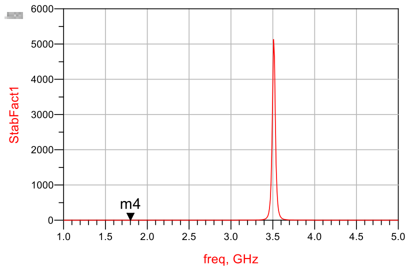


freq	m2	indep(m2)
1.800 GHz	0.366 / 154.521	1.800E9

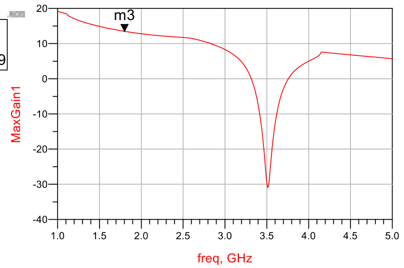
Eqn Z22calc=50*(1+m2)/(1-m2)

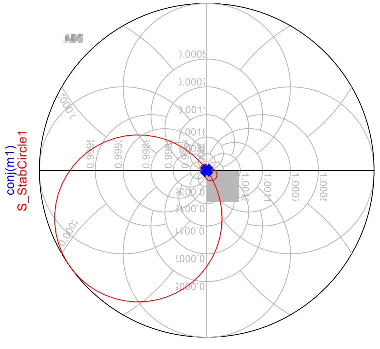
freq	Z22calc	Z22calc
1.800 GHz	24.142 + j8.769	25.685 / 19.963

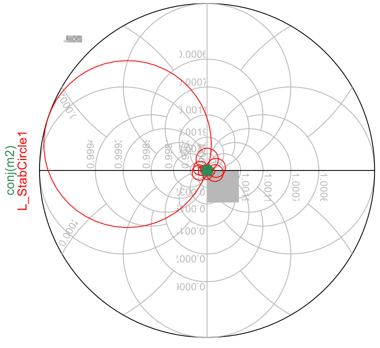
m4
freq=1.800GHz
StabFact1=1.047



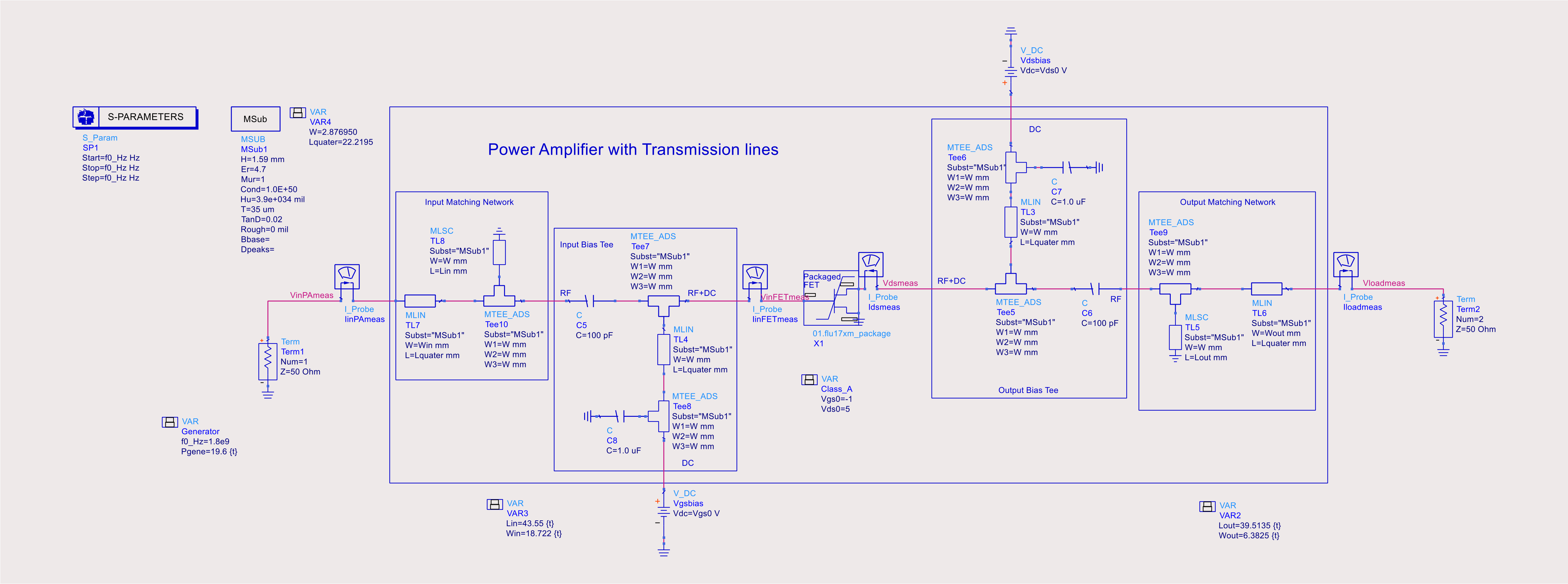
m3
freq=1.800GHz
MaxGain1=13.469







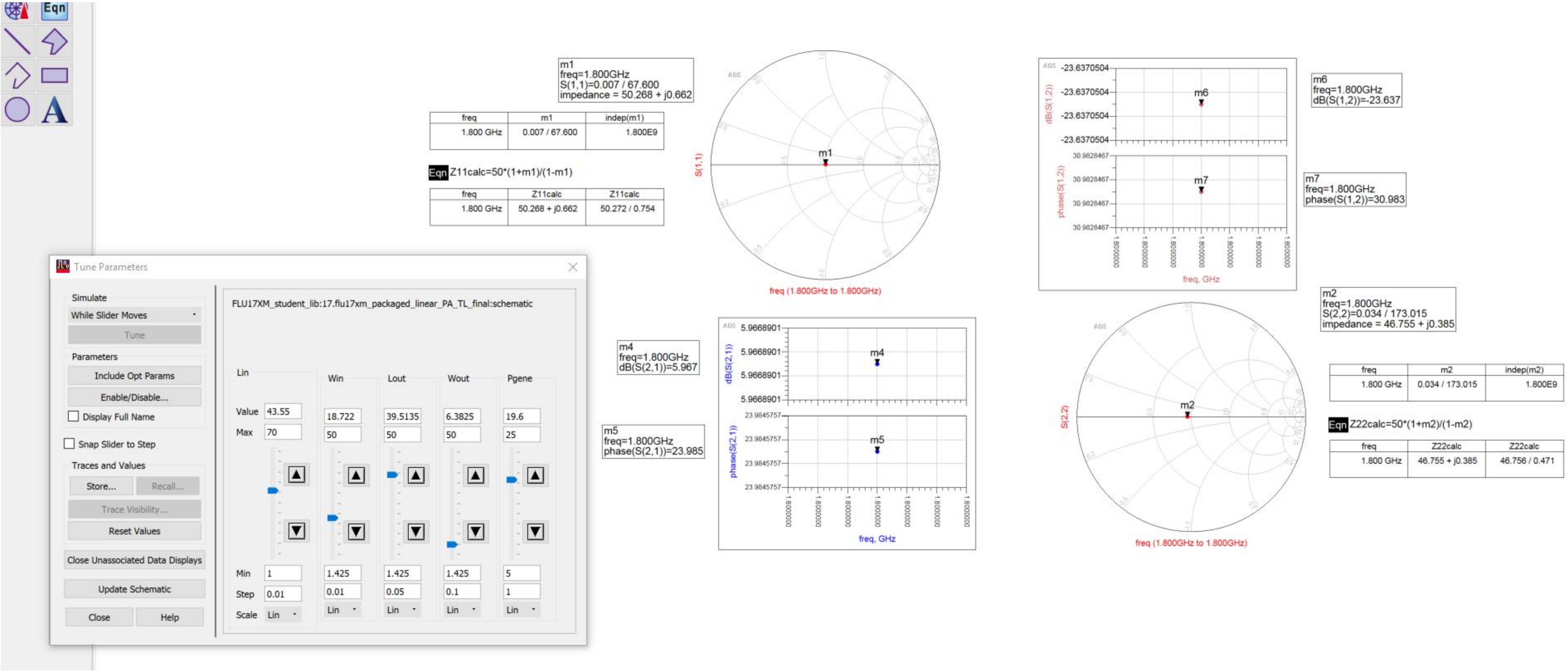
Final Schematic to design a linear PA : « 17.flu17xm_packaged_linear_PA_TL_final”



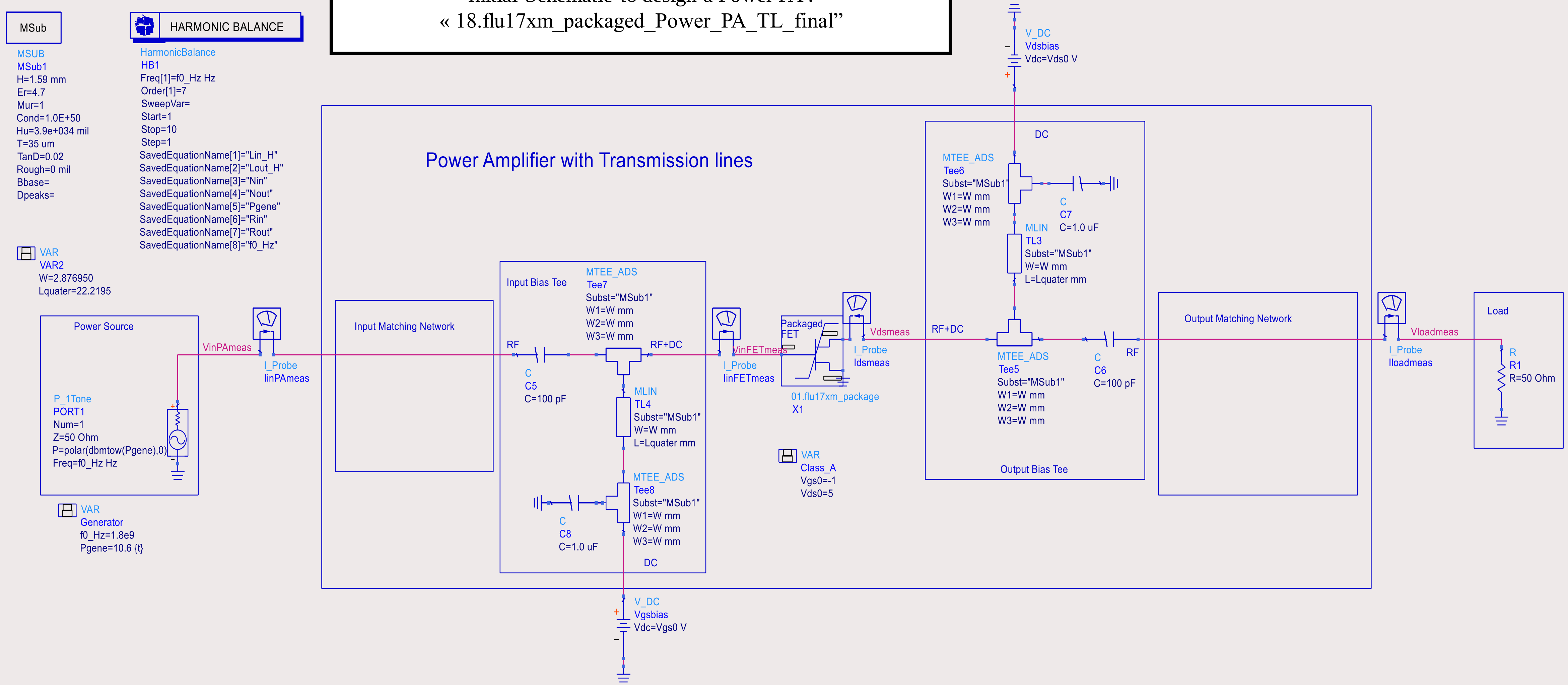
Results after the tuning of the 4 parameters to match the PA.

Method to tune the parameters

1) Tune first Lout
2) Tune Secondly Wout
3) Tune then Lin to cancel Imag(ZinPA)
4) Tune Secondly Win (To match ZinPA=50Ω)
5) Tune again Lout_H if required
6) Tune again Rout if required
7) Tune again Lin_H to cancel Imag(ZinPA)
8) Tune again Rin (To match ZinPA=50Ω)
9) Repeat again step 5 to 8 to better match the PA



Initial Schematic to design a Power PA :
« 18.flu17xm_packaged_Power_PA_TL_final”



Eqn VinPA_f0=VinPAmeas[1]

Eqn VoutPA_f0=Vloadmeas[1]

Eqn IinPA_f0=IinPAmeas.i[1]

Eqn IoutPA_f0=Iloadmeas.i[1]

Eqn VinPA_DC=mag(VinFETmeas[0])

Eqn VoutPA_DC=mag(Vdsmeas[0])

Eqn IinPA_DC=mag(IinFETmeas.i[0])

Eqn IoutPA_DC=mag(Idsmeas.i[0])

Eqn PinPA_f0_mW=0.5*1000*real(VinPA_f0*conj(IinPA_f0))

Eqn PinPA_f0_dBm=10*log10(PinPA_f0_mW)

Eqn PoutPA_f0_mW=0.5*1000*real(VoutPA_f0*conj(IoutPA_f0))

Eqn PoutPA_f0_dBm=10*log10(PoutPA_f0_mW)

Eqn PDC_mW=1000*(VinPA_DC*IinPA_DC+VoutPA_DC*IoutPA_DC)

Eqn GPA_f0=PoutPA_f0_mW/PinPA_f0_mW

Eqn GPA_f0_dB=10*log10(GPA_f0)

Eqn PaddPA_f0_mW=PoutPA_f0_mW-PinPA_f0_mW

Eqn PaddPA_f0_dBm=10*log10(PaddPA_f0_mW)

Eqn Drain_Efficiency=PoutPA_f0_mW/PDC_mW*100

Eqn PAE=PaddPA_f0_mW/PDC_mW*100

Eqn ZinFET_f0=VinFETmeas[1]/IinFETmeas.i[1]

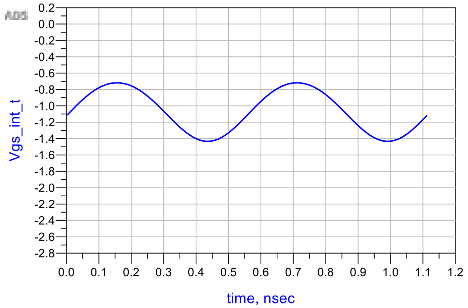
Eqn ZinPA_f0=VinPAmeas[1]/IinPAmeas.i[1]

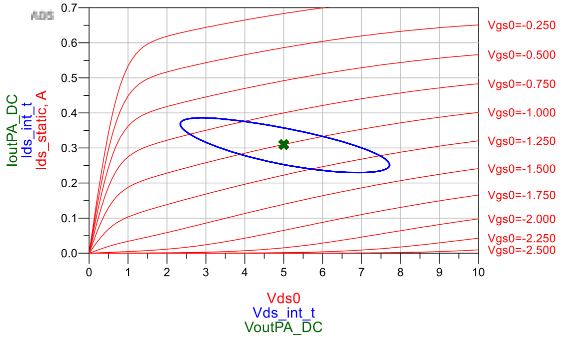
Eqn GamainFET_f0=(ZinFET_f0-50)/(ZinFET_f0+50)

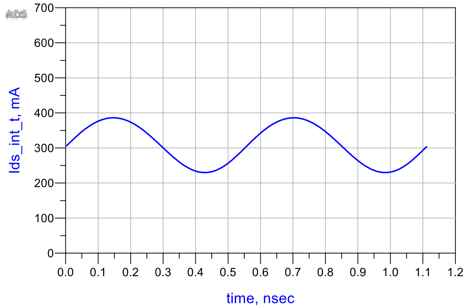
Eqn GamainPA_f0=(ZinPA_f0-50)/(ZinPA_f0+50)

PinPA_f0_mW	PoutPA_f0_mW	GPA_f0	PDC_mW	Drain_Efficiency	PAE
5.381	81.252	15.099	1548.953	5.246	4.898

PinPA_f0_dBm	PoutPA_f0_dBm	GPA_f0_dB	PDC_mW	Drain_Efficiency	PAE
7.309	19.098	11.790	1548.953	5.246	4.898







Eqn Ids_static="_06.analyseDCext"..Ids_int.i

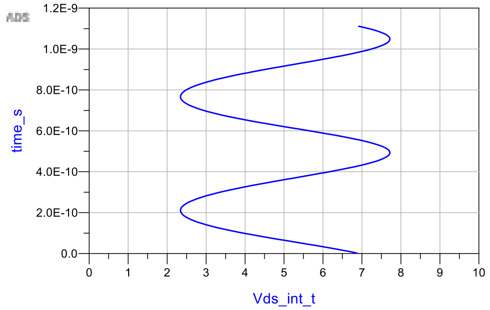
Eqn time_s=ts(freq)

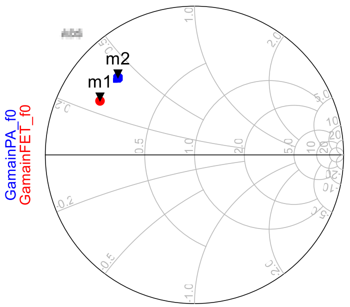
Eqn Vds_int=Vdint-Vsintd

Eqn Vds_int_t=ts(Vds_int)

Eqn Vgs_int_t=ts(Vgint-Vsintg)

Eqn Ids_int_t=ts(Ids_int.i)





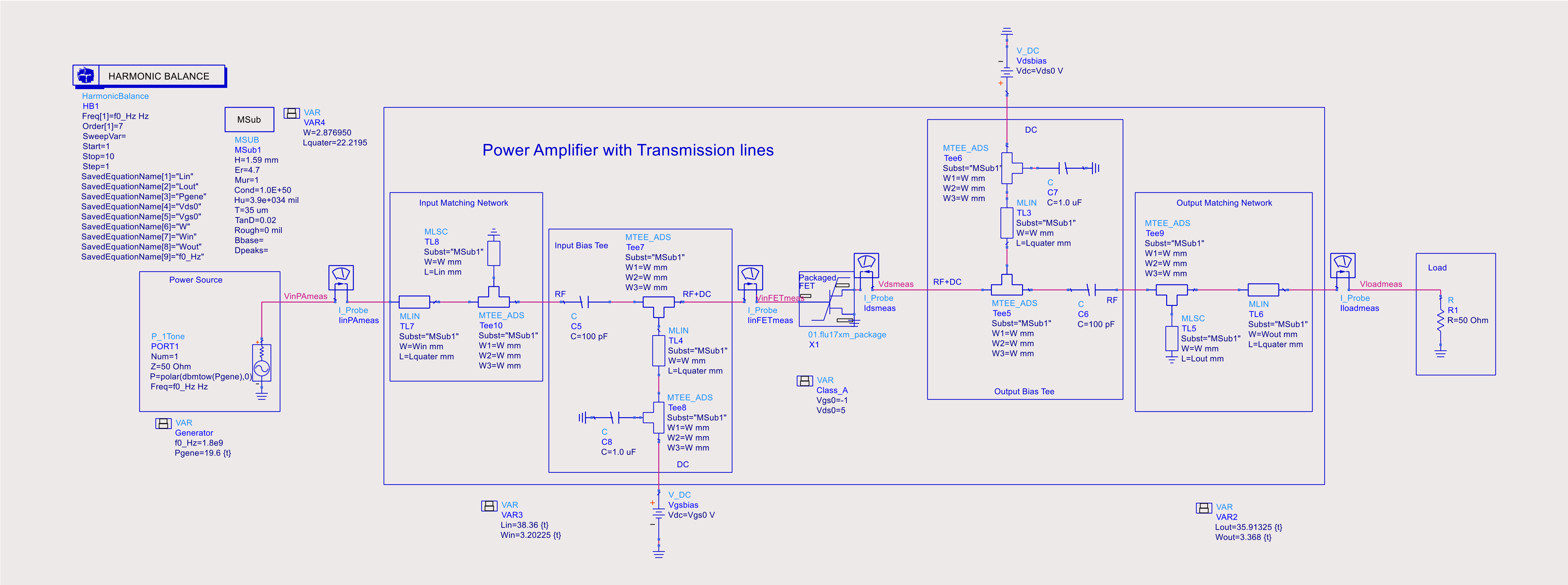
ZinFET_f0	GamainFET_f0
8.359 + j12.951	0.729 / 150.212

ZinPA_f0	GamainPA_f0
9.161 + j20.229	0.729 / 134.772

m1
indep(m1)=0
GamainFET_f0=0.729 / 150.212
impedance = Z0 * (0.167 + j0.259)

m2
indep(m2)=0
GamainPA_f0=0.729 / 134.772
impedance = Z0 * (0.183 + j0.405)

Final Schematic to design a Power PA : « 18.flu17xm_packaged_Power_PA_TL_final”



Results after the tuning of the 5 parameters to maximise the output power of the PA.

Method to tune the parameters

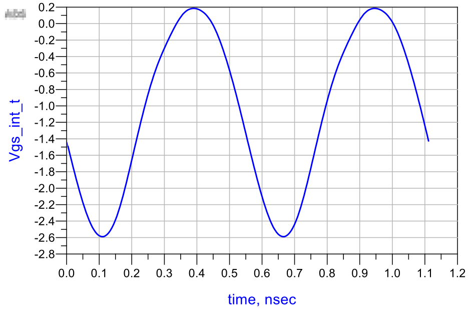
1) Tune first Lout
2) Tune Secondly Wout
3) Modify Pgene if required
4) Tune again Lout
5) Tune again Wout
6) Tune then Lin to cancel Imag(ZinPA)
7) Tune Secondly Win (To match ZinPA=50Ω)
8) Modify Pgene if required
9) Tune again Lout_H if required
10) Tune again Rout if required
11) Tune again Lin_H to cancel Imag(ZinPA)
12) Tune again Rin (To match ZinPA=50Ω)
13) Repeat again step 8 to 12 to maximise the Gain or the output power or the PAE

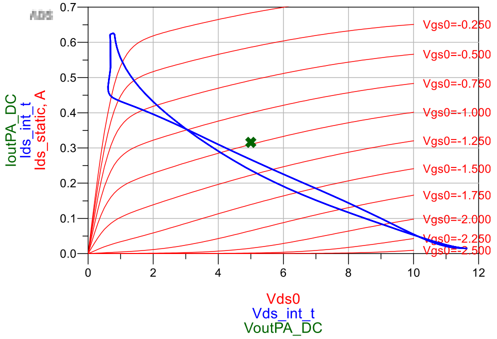
Eqn VinPA_f0=VinPAmeas[1]
Eqn VoutPA_f0=Vloadmeas[1]
Eqn IinPA_f0=IinPAmeas.i[1]
Eqn IoutPA_f0=Iloadmeas.i[1]
Eqn VinPA_DC=mag(VinFETmeas[0])
Eqn VoutPA_DC=mag(Vdsmeas[0])
Eqn IinPA_DC=mag(IinFETmeas.i[0])
Eqn IoutPA_DC=mag(Idsmeas.i[0])
Eqn PinPA_f0_mW=0.5*1000*real(VinPA_f0*conj(IinPA_f0))
Eqn PinPA_f0_dBm=10*log10(PinPA_f0_mW)
Eqn PoutPA_f0_mW=0.5*1000*real(VoutPA_f0*conj(IoutPA_f0))
Eqn PoutPA_f0_dBm=10*log10(PoutPA_f0_mW)
Eqn PDC_mW=1000*(VinPA_DC*IinPA_DC+VoutPA_DC*IoutPA_DC)
Eqn GPA_f0=PoutPA_f0_mW/PinPA_f0_mW
Eqn GPA_f0_dB=10*log10(GPA_f0)
Eqn PaddPA_f0_mW=PoutPA_f0_mW-PinPA_f0_mW
Eqn PaddPA_f0_dBm=10*log10(PaddPA_f0_mW)
Eqn Drain_Efficiency=PoutPA_f0_mW/PDC_mW*100
Eqn PAE=PaddPA_f0_mW/PDC_mW*100

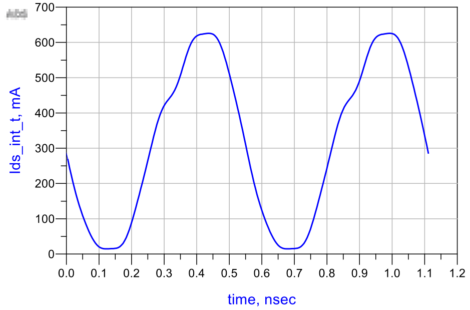
Eqn ZinFET_f0=VinFETmeas[1]/IinFETmeas.i[1]
Eqn ZinPA_f0=VinPAmeas[1]/IinPAmeas.i[1]
Eqn GamainFET_f0=(ZinFET_f0-50)/(ZinFET_f0+50)
Eqn GamainPA_f0=(ZinPA_f0-50)/(ZinPA_f0+50)

PinPA_f0_mW	PoutPA_f0_mW	GPA_f0	PDC_mW	Drain_Efficiency	PAE
91.201	851.197	9.333	1580.144	53.868	48.097

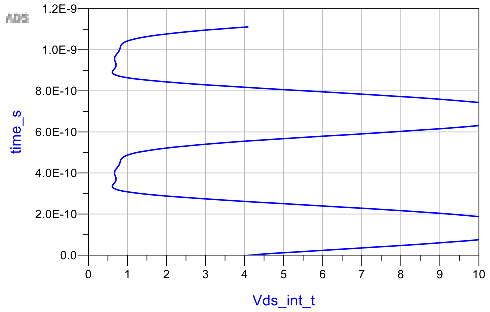
PinPA_f0_dBm	PoutPA_f0_dBm	GPA_f0_dB	PDC_mW	Drain_Efficiency	PAE
19.600	29.300	9.700	1580.144	53.868	48.097

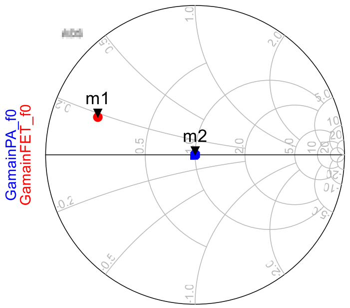






Eqn Ids_static="_06.analyseDCext"..Ids_int.i
Eqn time_s=ts(freq)
Eqn Vds_int=Vdint-Vsintd
Eqn Vds_int_t=ts(Vds_int)
Eqn Vgs_int_t=ts(Vgint-Vsintg)
Eqn Ids_int_t=ts(Ids_int.i)





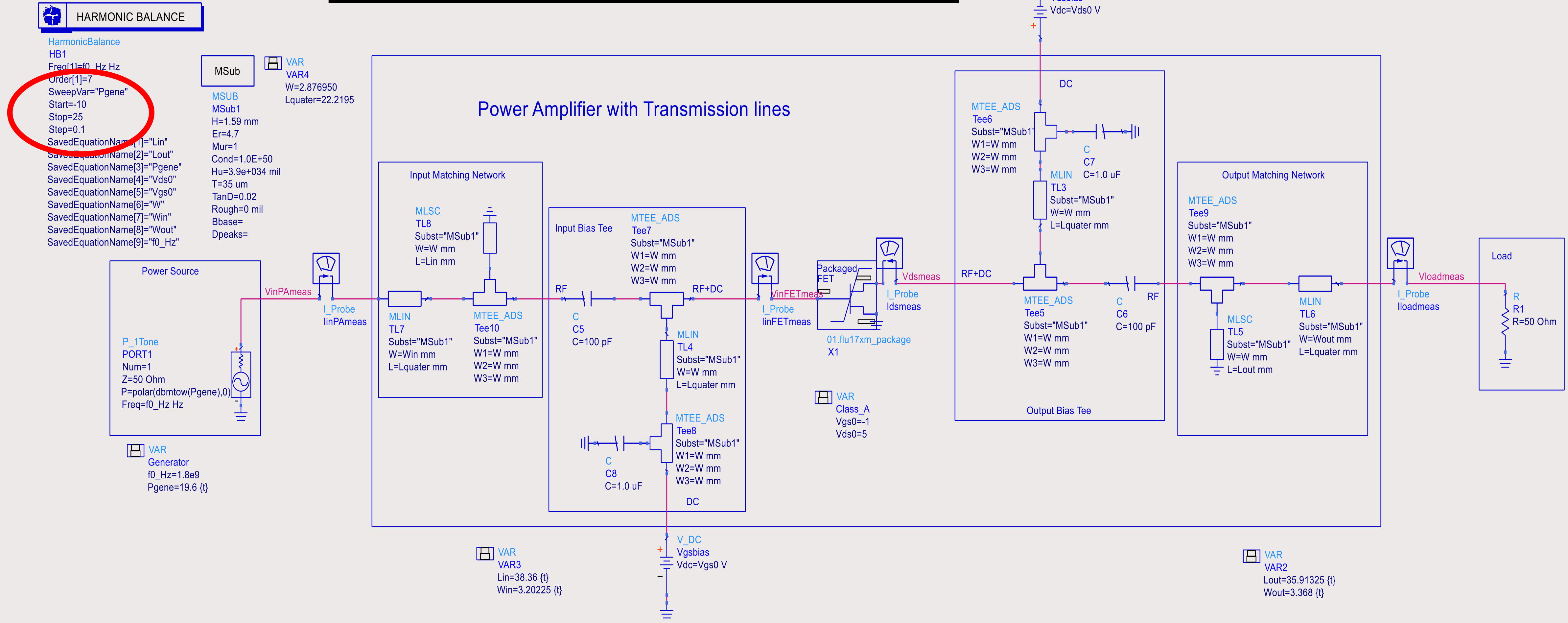
ZinFET_f0	GamainFET_f0
9.197 + j9.053	0.698 / 158.795

ZinPA_f0	GamainPA_f0
50.017 - j0.011	2.058E-4 / -32.816

m1
indep(m1)=0
GamainFET_f0=0.698 / 158.795
impedance = Z0 * (0.184 + j0.181)

m2
indep(m2)=0
GamainPA_f0=2.058E-4 / -32.816
impedance = Z0 * (1.000 - j2.231E-4)

Schematic to plot the power charcateristics of the designed Power PA :
« 18.flu17xm_packaged_Power_PA_TL_final”



Eqn VinPA_f0=VinPAmeas[1]

Eqn VoutPA_f0=Vloadmeas[1]

Eqn IinPA_f0=IinPAmeas.i[1]

Eqn IoutPA_f0=Iloadmeas.i[1]

Eqn VinPA_DC=mag(VinFETmeas[0])

Eqn VoutPA_DC=mag(Vdsmeas[0])

Eqn IinPA_DC=mag(IinFETmeas.i[0])

Eqn IoutPA_DC=mag(Idsmeas.i[0])

Eqn PinPA_f0_mW=0.5*1000*real(VinPA_f0*conj(IinPA_f0))

Eqn PinPA_f0_dBm=10*log10(PinPA_f0_mW)

Eqn PoutPA_f0_mW=0.5*1000*real(VoutPA_f0*conj(IoutPA_f0))

Eqn PoutPA_f0_dBm=10*log10(PoutPA_f0_mW)

Eqn PDC_mW=1000*(VinPA_DC*IinPA_DC+VoutPA_DC*IoutPA_DC)

Eqn GPA_f0=PoutPA_f0_mW/PinPA_f0_mW

Eqn GPA_f0_dB=10*log10(GPA_f0)

Eqn PaddPA_f0_mW=PoutPA_f0_mW-PinPA_f0_mW

Eqn PaddPA_f0_dBm=10*log10(PaddPA_f0_mW)

Eqn Drain_Efficiency=PoutPA_f0_mW/PDC_mW*100

Eqn PAE=PaddPA_f0_mW/PDC_mW*100

Eqn ZinFET_f0=VinFETmeas[1]/IinFETmeas.i[1]

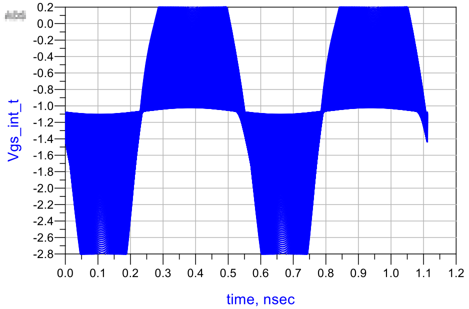
Eqn ZinPA_f0=VinPAmeas[1]/IinPAmeas.i[1]

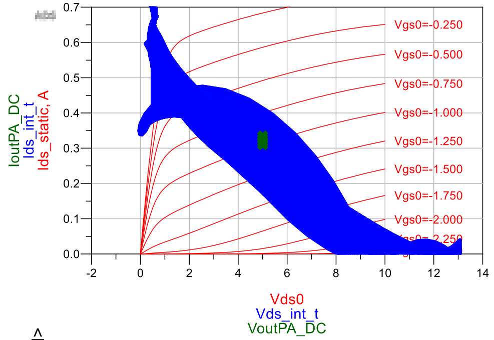
Eqn GamainFET_f0=(ZinFET_f0-50)/(ZinFET_f0+50)

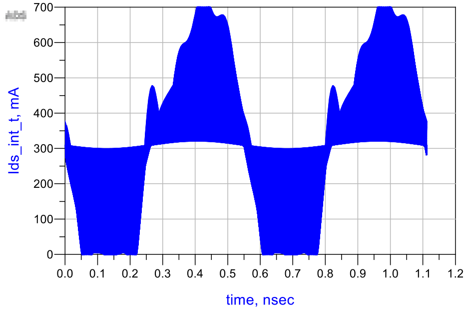
Eqn GamainPA_f0=(ZinPA_f0-50)/(ZinPA_f0+50)

Pgene	PinPA_f0_mW	...tPA_f0_mW	GPA_f0	PDC_mW	...in_Efficiency	PAE
-10.000	0.100	1.112	11.174	1550.420	0.072	0.065

Pgene	...PA_f0_dBm	...tPA_f0_dBm	GPA_f0_dB	PDC_mW	...in_Efficiency	PAE
-10.000	-10.021	0.461	10.482	1550.420	0.072	0.065







Eqn Ids_static="_06.analyseDCext"..Ids_int.i

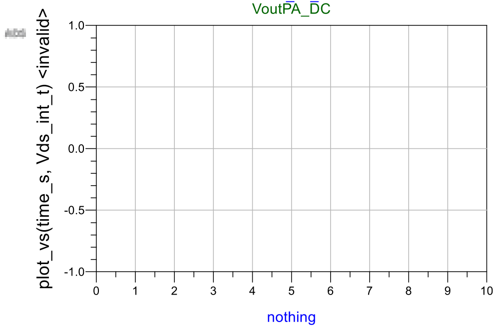
Eqn time_s=ts(freq)

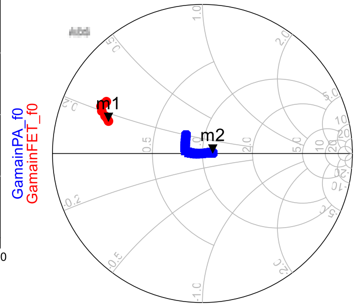
Eqn Vds_int=Vdint-Vsintd

Eqn Vds_int_t=ts(Vds_int)

Eqn Vgs_int_t=ts(Vgint-Vsintg)

Eqn Ids_int_t=ts(Ids_int.i)





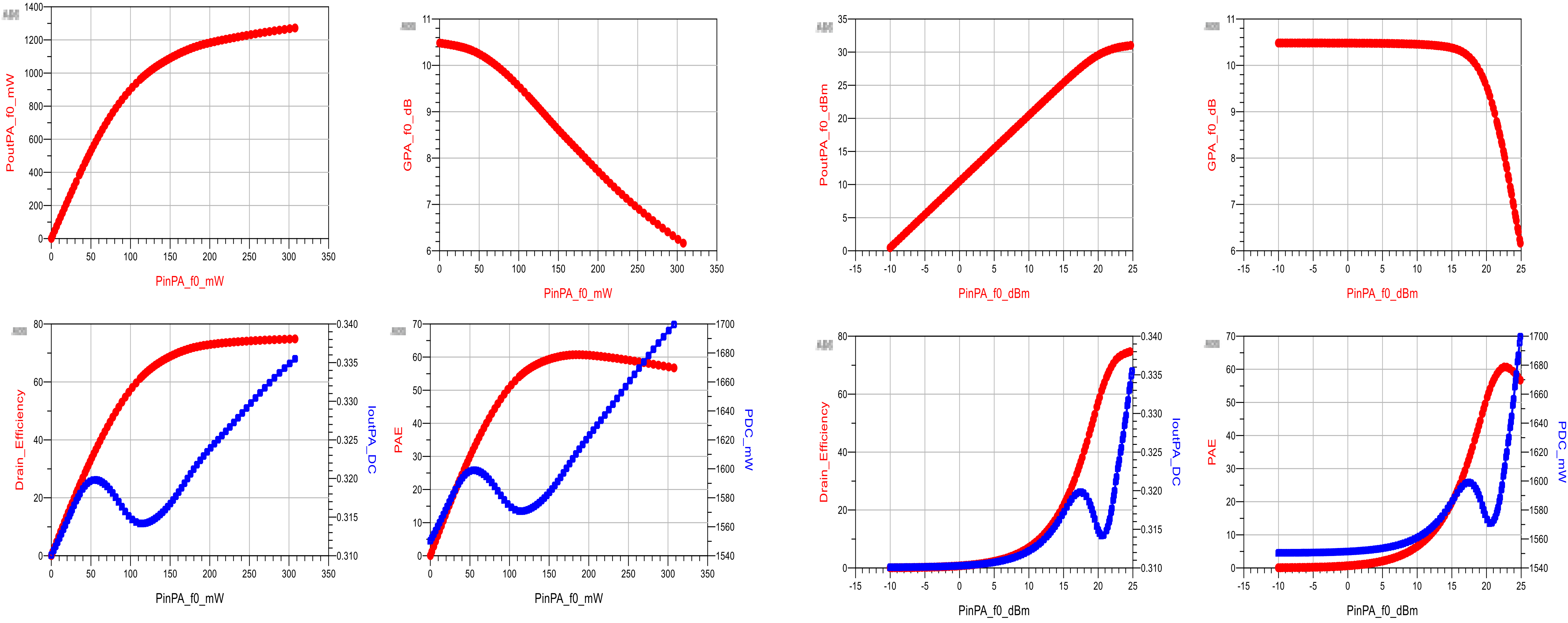
Pgene (-10.000 to 25.000)

m1
Pgene=-1.879E-14
GamainFET_f0=0.663 / 160.907
impedance = Z0 * (0.208 + j0.161)

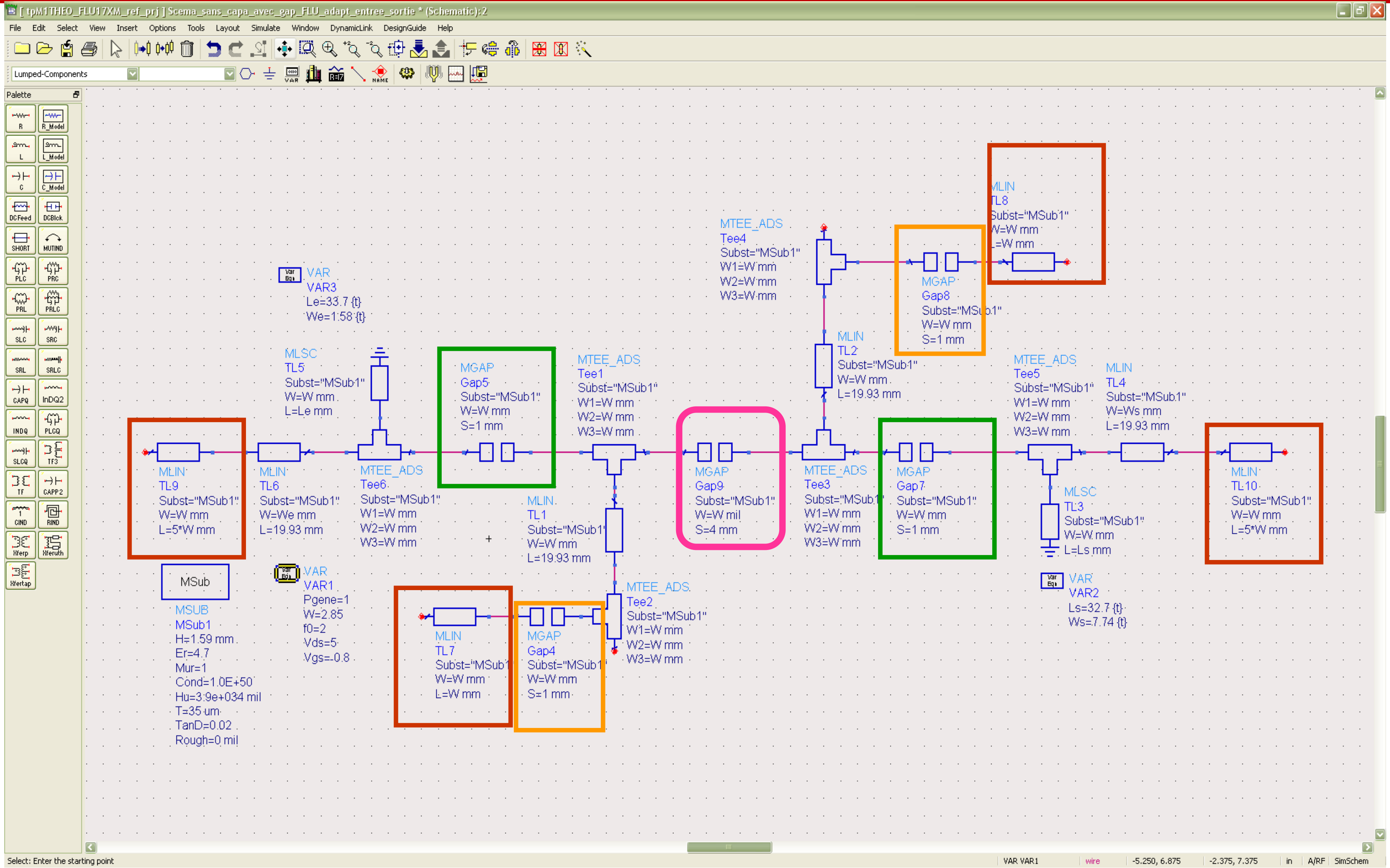
m2
Pgene=-1.879E-14
GamainPA_f0=0.068 / 2.946
impedance = Z0 * (1.147 + j0.008)

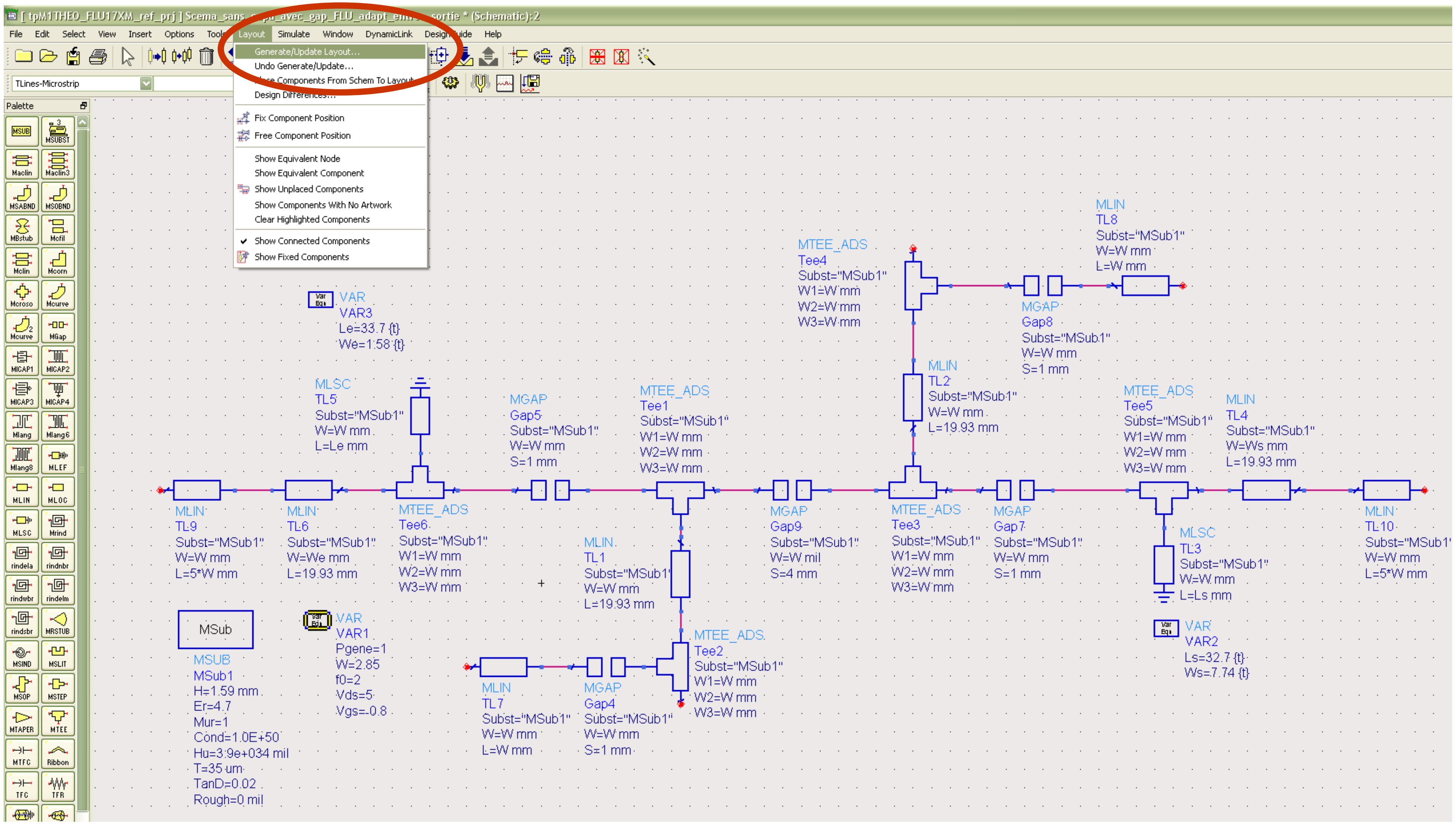
Pgene	ZinFET_f0	...ainFET_f0
-10.000 -9.900	10.409 + j8.... 10.409 + j8....	0.663 / 160.... 0.663 / 160....

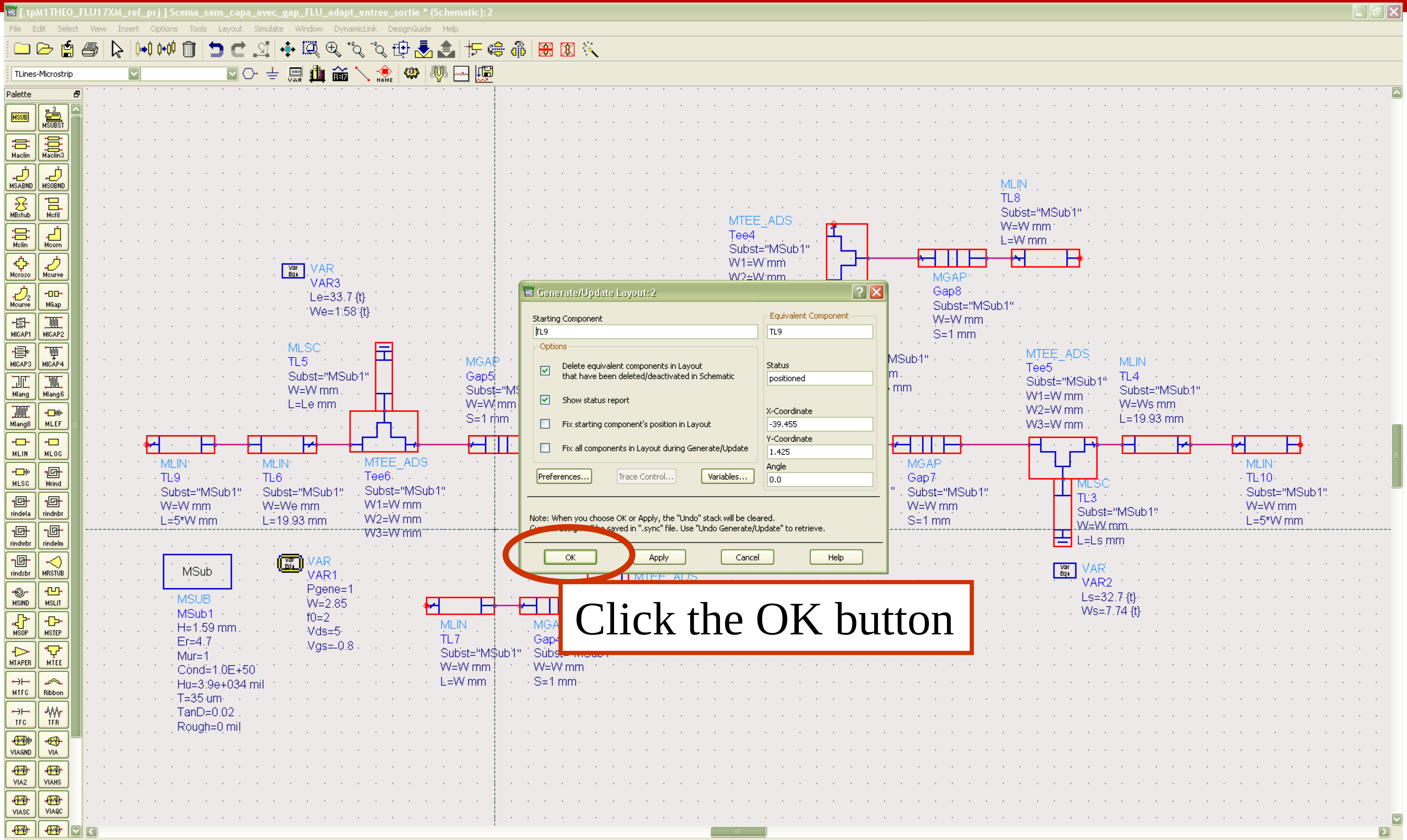
Pgene	ZinPA_f0	...mainPA_f0
-10.000 -9.900	57.370 + j0.... 57.370 + j0....	0.069 / 2.855 0.069 / 2.855


PoutPA_f0_mW
PinPA_f0_mW
GPA_f0_dB
PinPA_f0_mW
PoutPA_f0_dBm
PinPA_f0_dBm
GPA_f0_dB
PinPA_f0_dBm
Drain_Efficiency
IoutPA_DC
PinPA_f0_mW
PAE
PDC_mW
PinPA_f0_mW
Drain_Efficiency
IoutPA_DC
PinPA_f0_dBm
PAE
PDC_mW
PinPA_f0_dBm

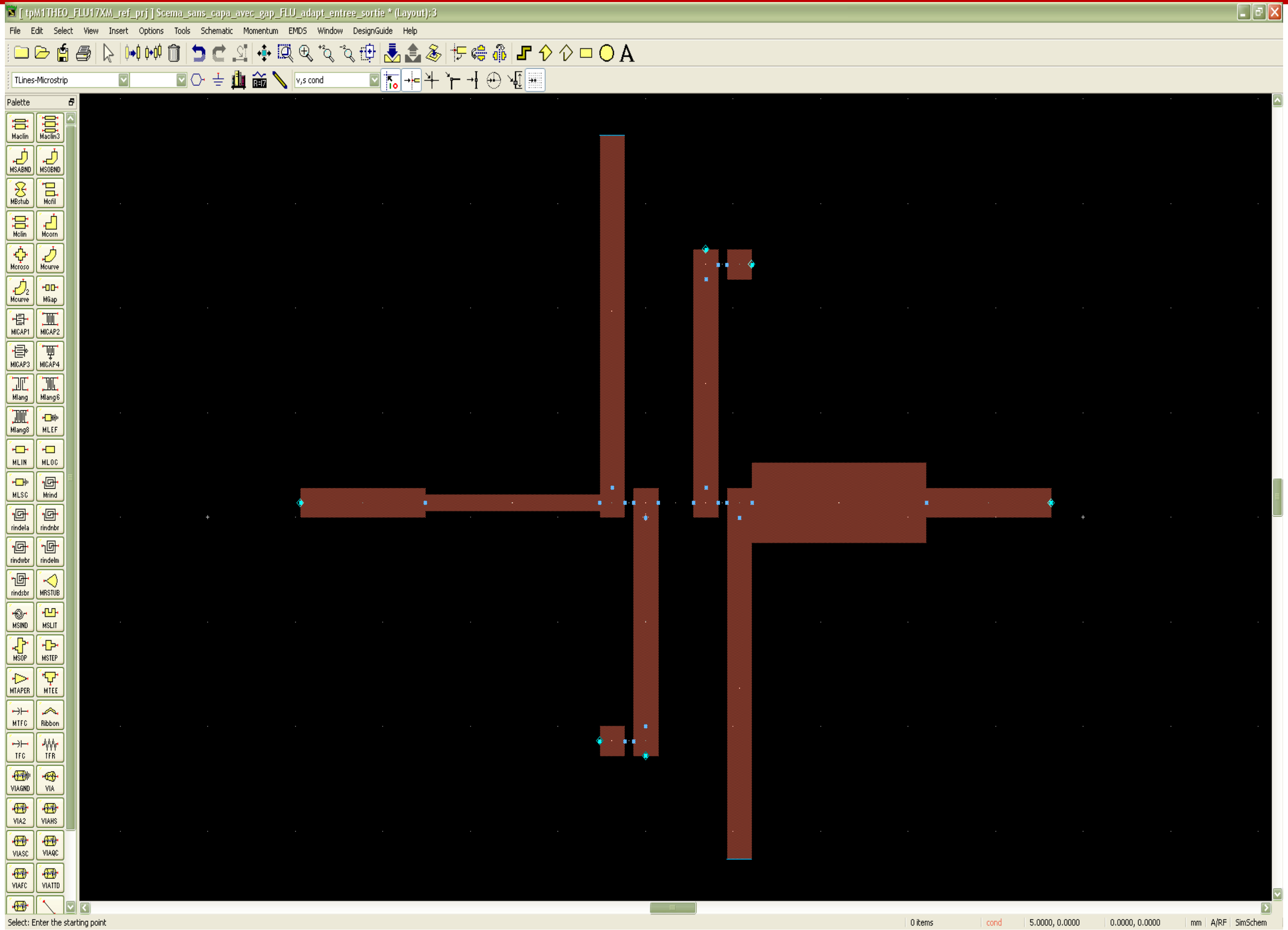
Layout of the PA Design with the packaged transistor and transmission Lines

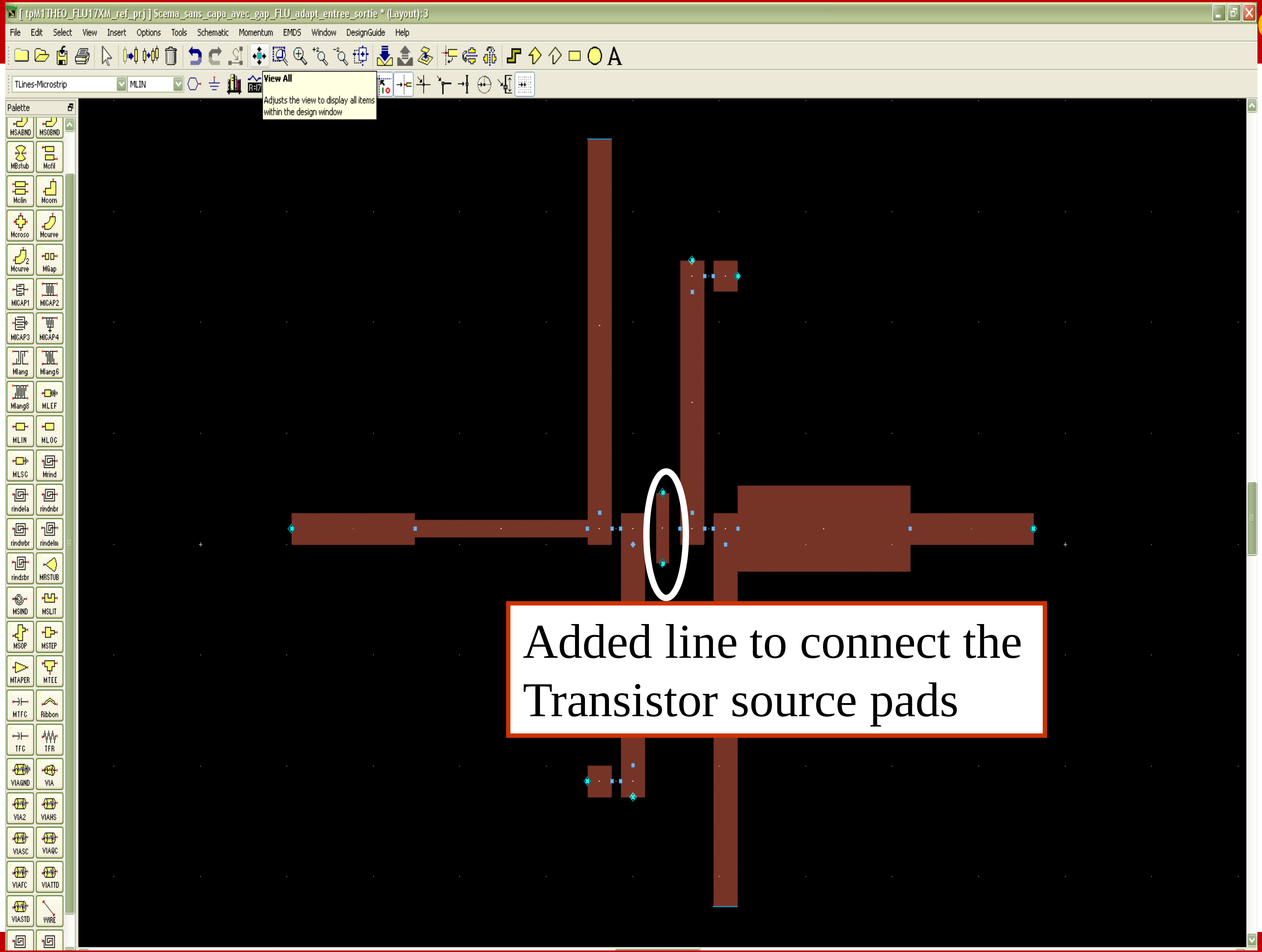

[tpM1THEO_FLU17XM_ref_prj] Scema_sans_capa_avec_gap_FLU_adapt_entree_sortie * (Schematic):2
File Edit Select View Insert Options Tools Layout Simulate Window DynamicLink DesignGuide Help
Lumped-Components
Palette
VAR
VAR3
Le=33.7 {t}
We=1.58 {t}
MLSC
TL5
Subst="MSub1"
W=W mm
L=Le mm
MGAP
Gap5
Subst="MSub1"
W=W mm
S=1 mm
MTEE_ADS
Tee1
Subst="MSub1"
W1=W mm
W2=W mm
W3=W mm
MTEE_ADS
Tee4
Subst="MSub1"
W1=W mm
W2=W mm
W3=W mm
MLIN
TL8
Subst="MSub1"
W=W mm
L=W mm
MGAP
Gap8
Subst="MSub1"
W=W mm
S=1 mm
MLIN
TL2
Subst="MSub1"
W=W mm
L=19.93 mm
MTEE_ADS
Tee5
Subst="MSub1"
W1=W mm
W2=W mm
W3=W mm
MLIN
TL4
Subst="MSub1"
W=Ws mm
L=19.93 mm
MLIN
TL9
Subst="MSub1"
W=W mm
L=5*W mm
MLIN
TL6
Subst="MSub1"
W=We mm
L=19.93 mm
MTEE_ADS
Tee6
Subst="MSub1"
W1=W mm
W2=W mm
W3=W mm
MLIN
TL1
Subst="MSub1"
W=W mm
L=19.93 mm
MGAP
Gap9
Subst="MSub1"
W=W mil
S=4 mm
MTEE_ADS
Tee3
Subst="MSub1"
W1=W mm
W2=W mm
W3=W mm
MGAP
Gap7
Subst="MSub1"
W=W mm
S=1 mm
MLSC
TL3
Subst="MSub1"
W=W mm
L=Ls mm
MLIN
TL10
Subst="MSub1"
W=W mm
L=5*W mm
MSub
MSUB
MSub1
H=1.59 mm
Er=4.7
Mur=1
Cond=1.0E+50
Hu=3.9e+034 mil
T=35 um
TanD=0.02
Rough=0 mil
VAR
VAR1
Pgene=1
W=2.85
f0=2
Vds=5
Vgs=-0.8
MLIN
TL7
Subst="MSub1"
W=W mm
L=W mm
MGAP
Gap4
Subst="MSub1"
W=W mm
S=1 mm
MTEE_ADS
Tee2
Subst="MSub1"
W1=W mm
W2=W mm
W3=W mm
VAR
VAR2
Ls=32.7 {t}
Ws=7.74 {t}
Select: Enter the starting point
VAR VAR1
wire
-5.250, 6.875
-2.375, 7.375
in
A/RF
SimSchem

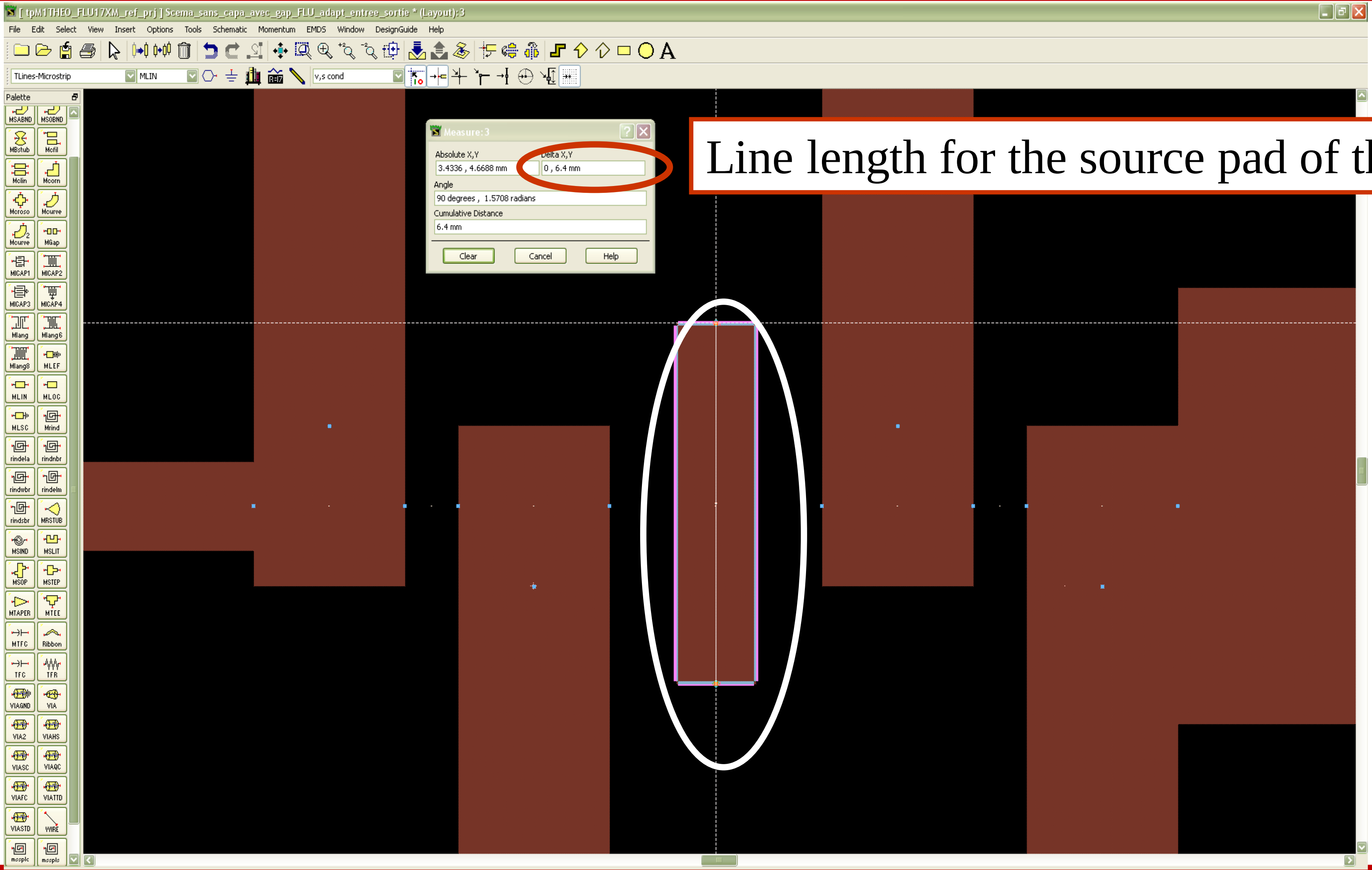

Layout
Generate/Update Layout...
Undo Generate/Update...
Design Differences...
Fix Component Position
Free Component Position
Show Equivalent Node
Show Equivalent Component
Show Unplaced Components
Show Components With No Artwork
Clear Highlighted Components
Show Connected Components
Show Fixed Components
TLines-Microstrip
Palette
VAR
VAR3
Le=33.7 {t}
We=1.58 {t}
MLSC
TL5
Subst="MSub1"
W=W mm
L=Le mm
MGAP
Gap5
Subst="MSub1"
W=W mm
S=1 mm
MTEE_ADS
Tee1
Subst="MSub1"
W1=W mm
W2=W mm
W3=W mm
MTEE_ADS
Tee4
Subst="MSub1"
W1=W mm
W2=W mm
W3=W mm
MLIN
TL8
Subst="MSub1"
W=W mm
L=W mm
MGAP
Gap8
Subst="MSub1"
W=W mm
S=1 mm
MLIN
TL2
Subst="MSub1"
W=W mm
L=19.93 mm
MTEE_ADS
Tee5
Subst="MSub1"
W1=W mm
W2=W mm
W3=W mm
MLIN
TL4
Subst="MSub1"
W=Ws mm
L=19.93 mm
MLIN
TL9
Subst="MSub1"
W=W mm
L=5*W mm
MLIN
TL6
Subst="MSub1"
W=We mm
L=19.93 mm
MTEE_ADS
Tee6
Subst="MSub1"
W1=W mm
W2=W mm
W3=W mm
MLIN
TL1
Subst="MSub1"
W=W mm
L=19.93 mm
MGAP
Gap9
Subst="MSub1"
W=W mil
S=4 mm
MTEE_ADS
Tee3
Subst="MSub1"
W1=W mm
W2=W mm
W3=W mm
MGAP
Gap7
Subst="MSub1"
W=W mm
S=1 mm
MLSC
TL3
Subst="MSub1"
W=W mm
L=Ls mm
MLIN
TL10
Subst="MSub1"
W=W mm
L=5*W mm
MSub
MSUB
MSub1
H=1.59 mm
Er=4.7
Mur=1
Cond=1.0E+50
Hu=3.9e+034 mil
T=35 um
TanD=0.02
Rough=0 mil
VAR
VAR1
Pgene=1
W=2.85
f0=2
Vds=5
Vgs=-0.8
MLIN
TL7
Subst="MSub1"
W=W mm
L=W mm
MGAP
Gap4
Subst="MSub1"
W=W mm
S=1 mm
MTEE_ADS
Tee2
Subst="MSub1"
W1=W mm
W2=W mm
W3=W mm
VAR
VAR2
Ls=32.7 {t}
Ws=7.74 {t}



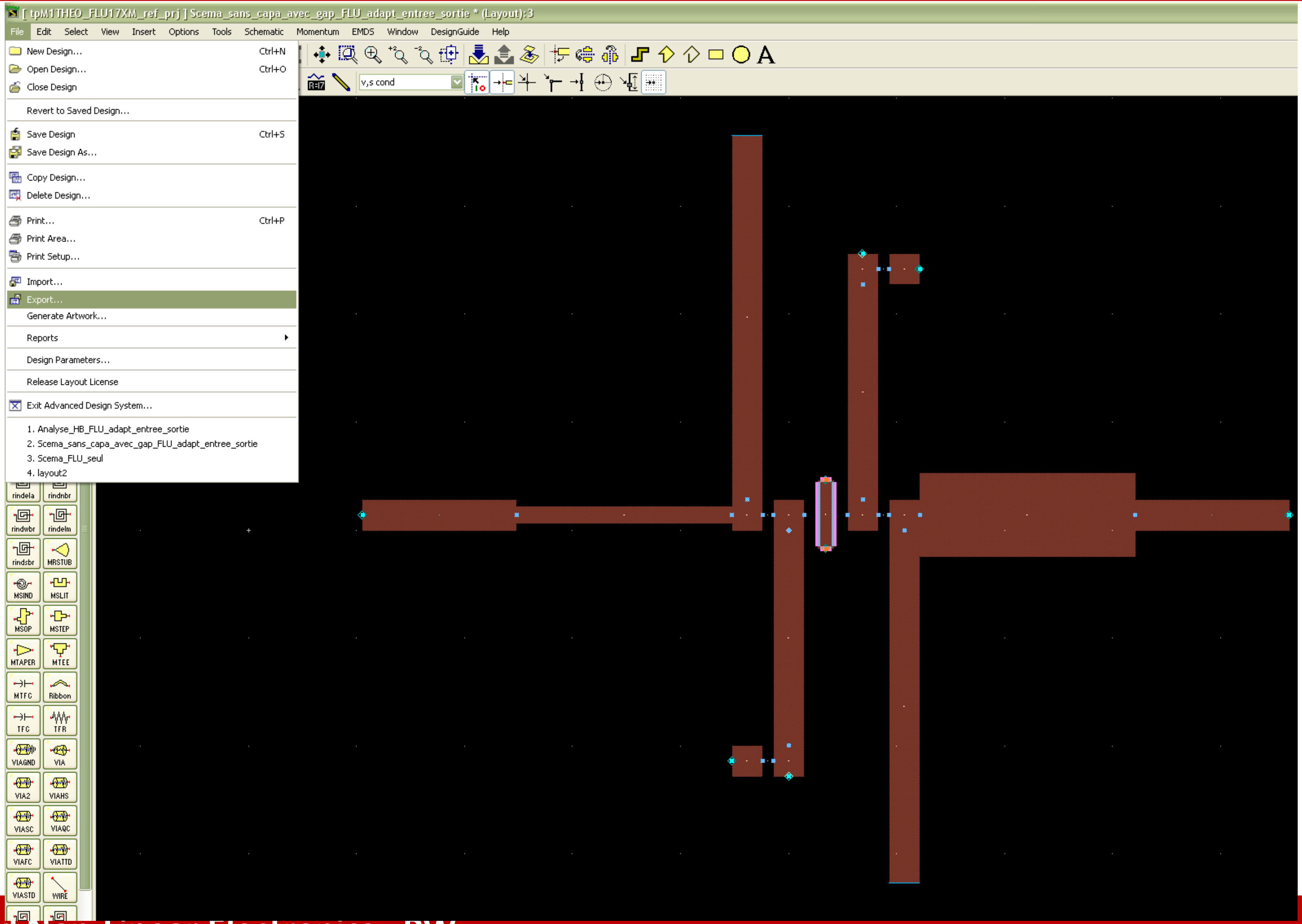
Click the OK button

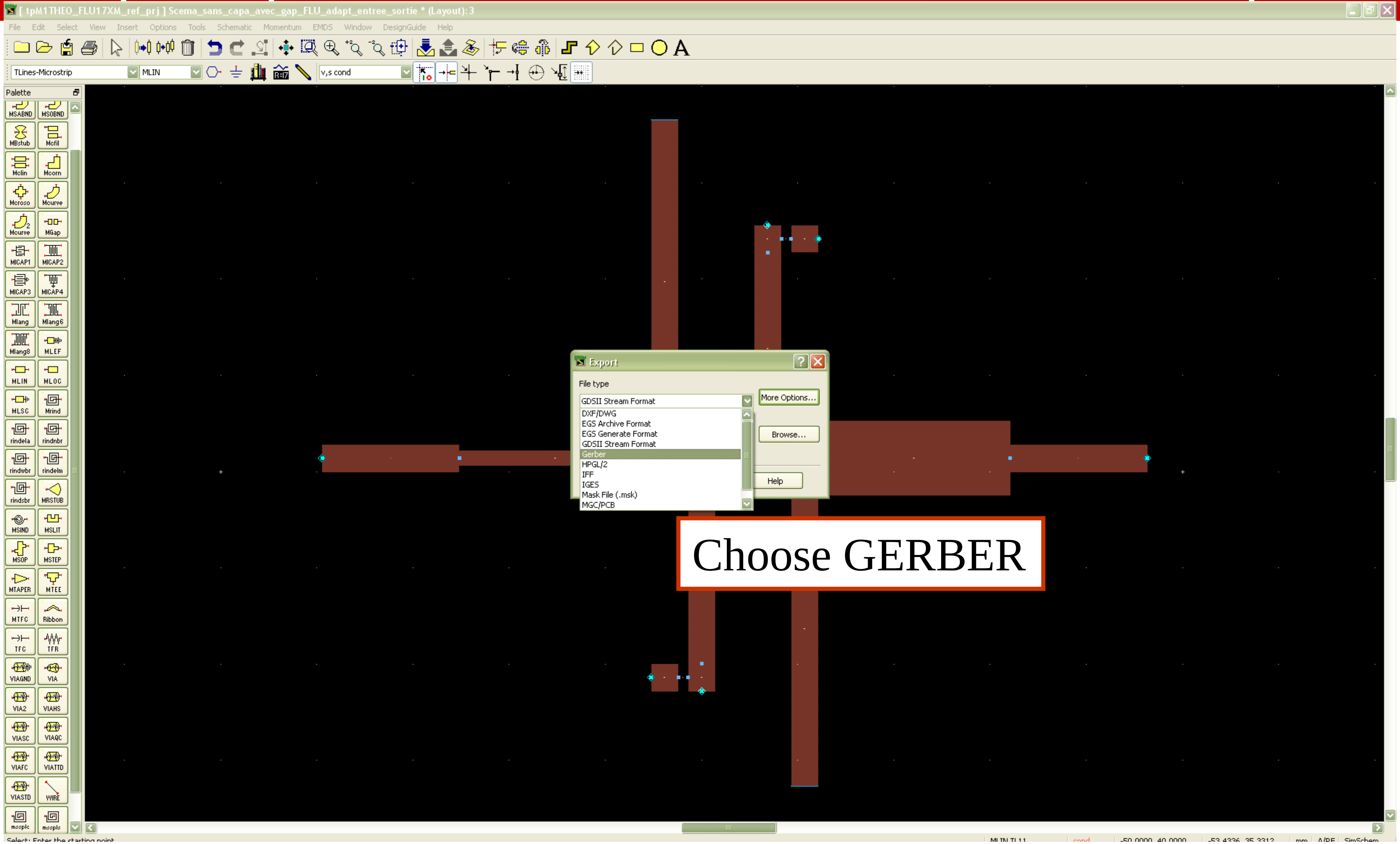

[tpM1THEO_FLU17XM_ref_prj] Scema_sans_capa_avec_gap_FLU_adapt_entree_sortie * (Layout):3
File Edit Select View Insert Options Tools Schematic Momentum EMDS Window DesignGuide Help
TLines-Microstrip
Palette
Select: Enter the starting point

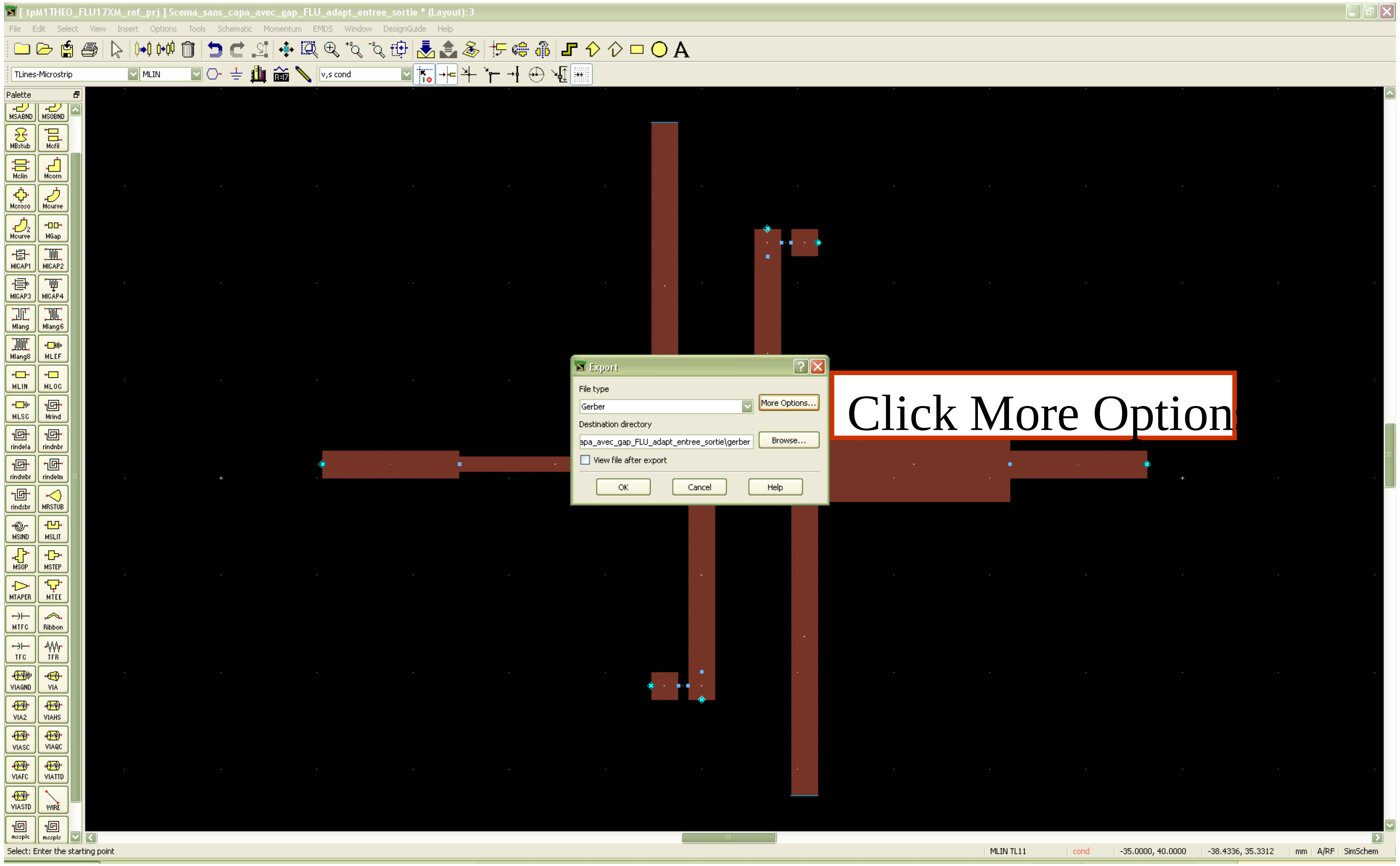

[tpM1THEO_FLU17XM_ref_prj] Scema_sans_capa_avec_gap_FLU_adapt_entree_sortie * (Layout):3
File Edit Select View Insert Options Tools Schematic Momentum EMDS Window DesignGuide Help
TLines-Microstrip
MLIN
View All
Adjusts the view to display all items within the design window
Palette
Added line to connect the Transistor source pads

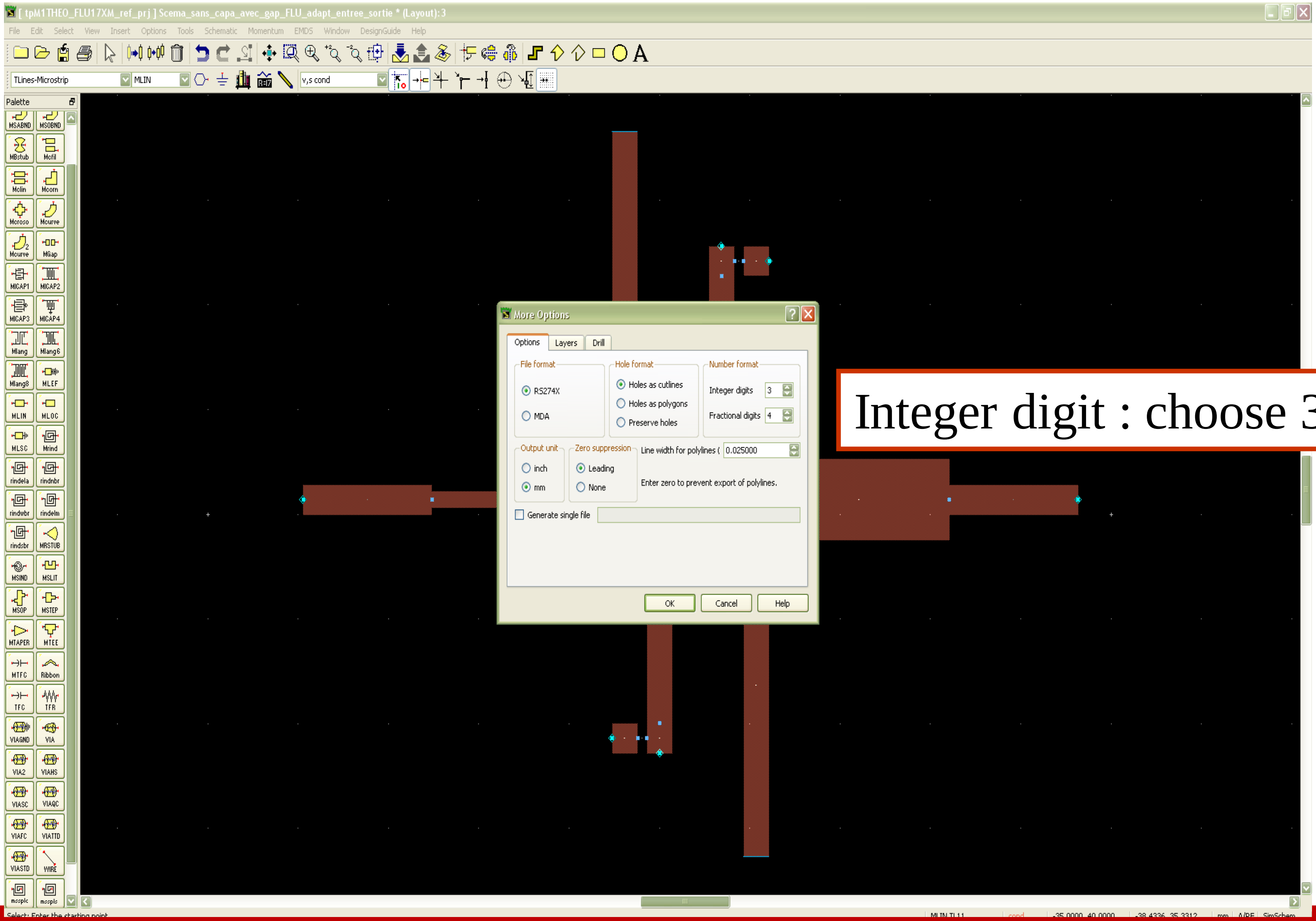


Line length for the source pad of the transistor

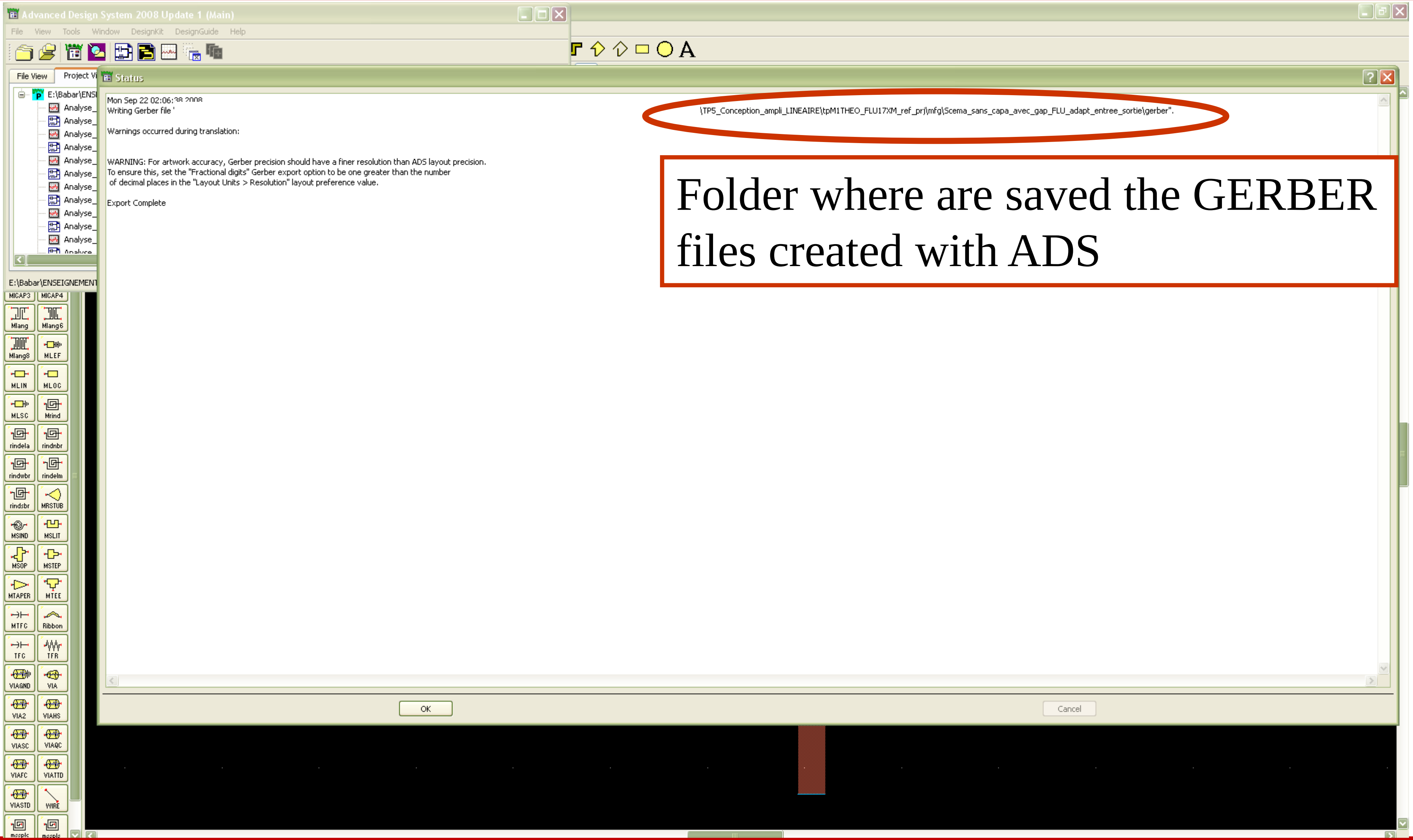

[tpM1THEO_FLU17XM_ref_prj] Scema_sans_capa_avec_gap_FLU_adapt_entree_sortie * (Layout):3
File
Edit
Select
View
Insert
Options
Tools
Schematic
Momentum
EMDS
Window
DesignGuide
Help
New Design... Ctrl+N
Open Design... Ctrl+O
Close Design
Revert to Saved Design...
Save Design Ctrl+S
Save Design As...
Copy Design...
Delete Design...
Print... Ctrl+P
Print Area...
Print Setup...
Import...
Export...
Generate Artwork...
Reports
Design Parameters...
Release Layout License
Exit Advanced Design System...
1. Analyse_HB_FLU_adapt_entree_sortie
2. Scema_sans_capa_avec_gap_FLU_adapt_entree_sortie
3. Scema_FLU_seul
4. layout2
v,s cond
rindela
rindnbr
rindwbr
rindelm
rindsbr
MRSTUB
MSIND
MSLIT
MSOP
MSTEP
MTAPER
MTEE
MTFC
Ribbon
TFC
TFR
VIAGND
VIA
VIA2
VIAHS
VIASC
VIAQC
VIAFC
VIATTD
VIASTD
WIRE


Export
File type
GDSII Stream Format
DXF/DWG
EGS Archive Format
EGS Generate Format
GDSII Stream Format
Gerber
HPGL/2
IFF
IGES
Mask File (.msk)
MGC/PCB
More Options...
Browse...
Help
Choose GERBER

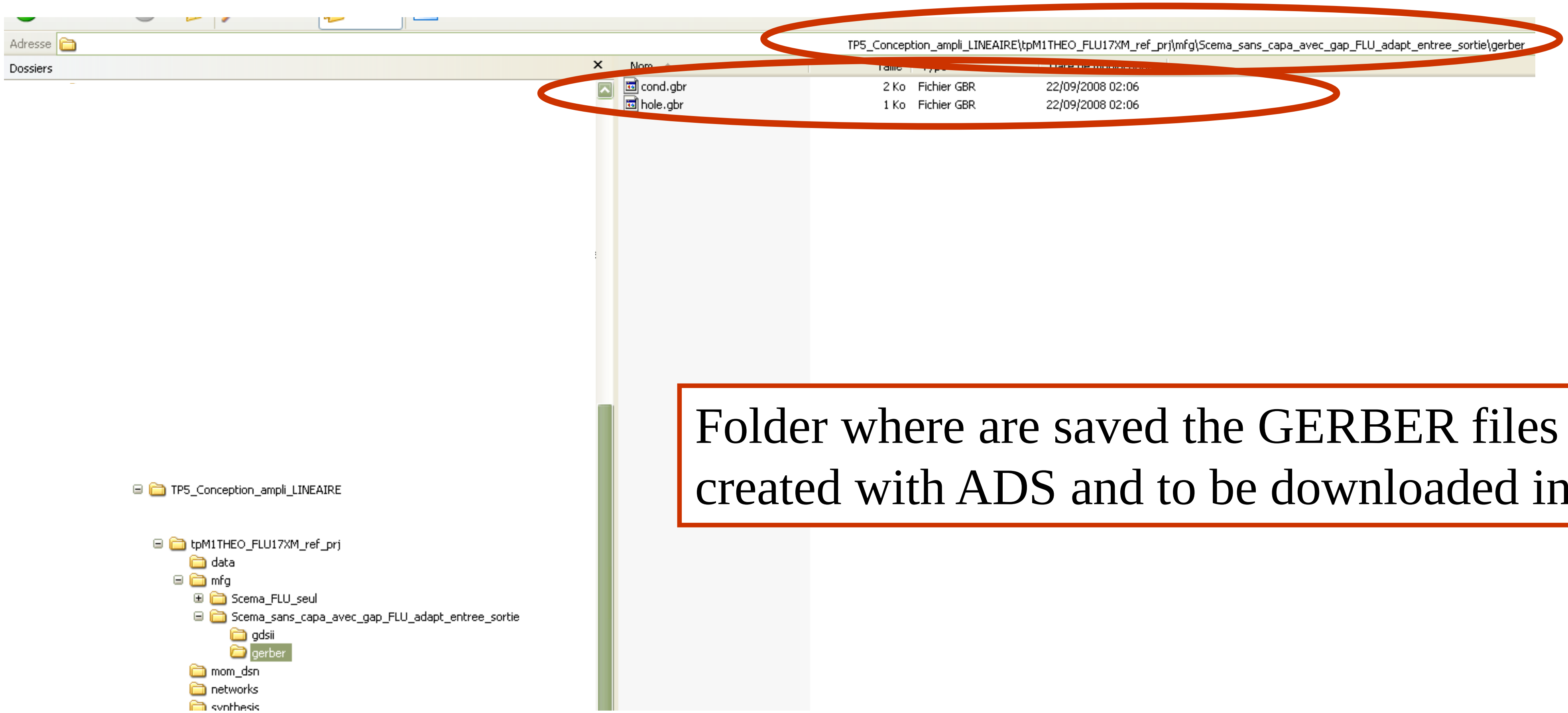

Export
File type
Gerber
More Options...
Destination directory
Browse...
View file after export
OK
Cancel
Help
Click More Option



Integer digit : choose 3

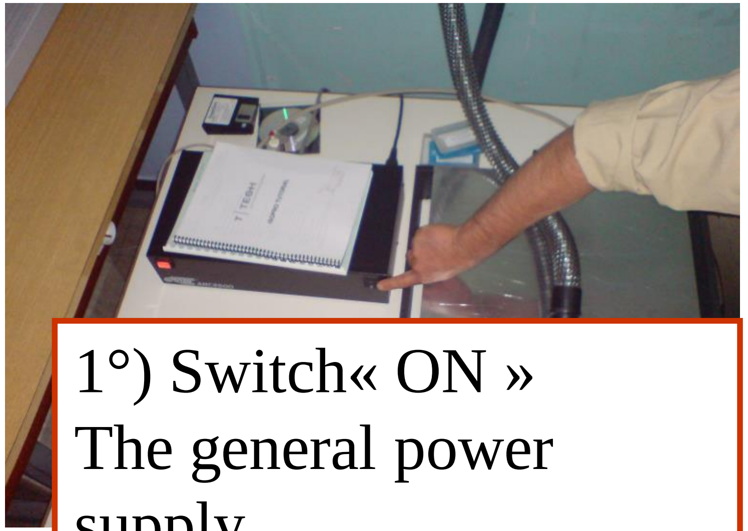


Folder where are saved the GERBER files created with ADS

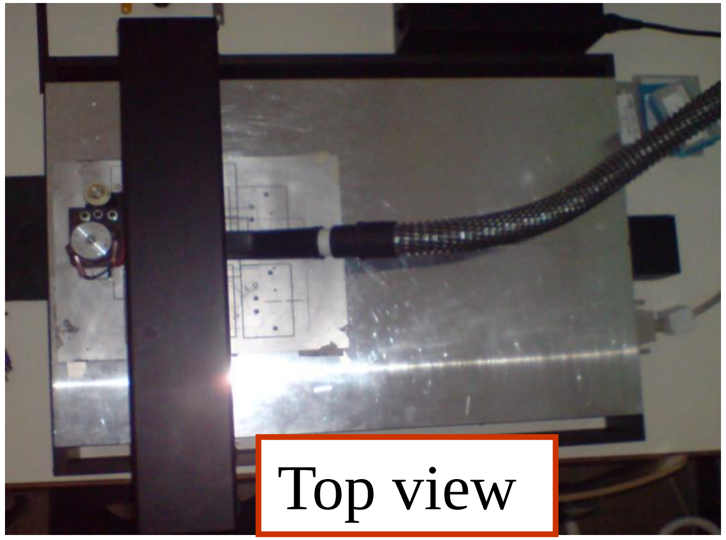


Folder where are saved the GERBER files created with ADS and to be downloaded in ISOPRO

Front view

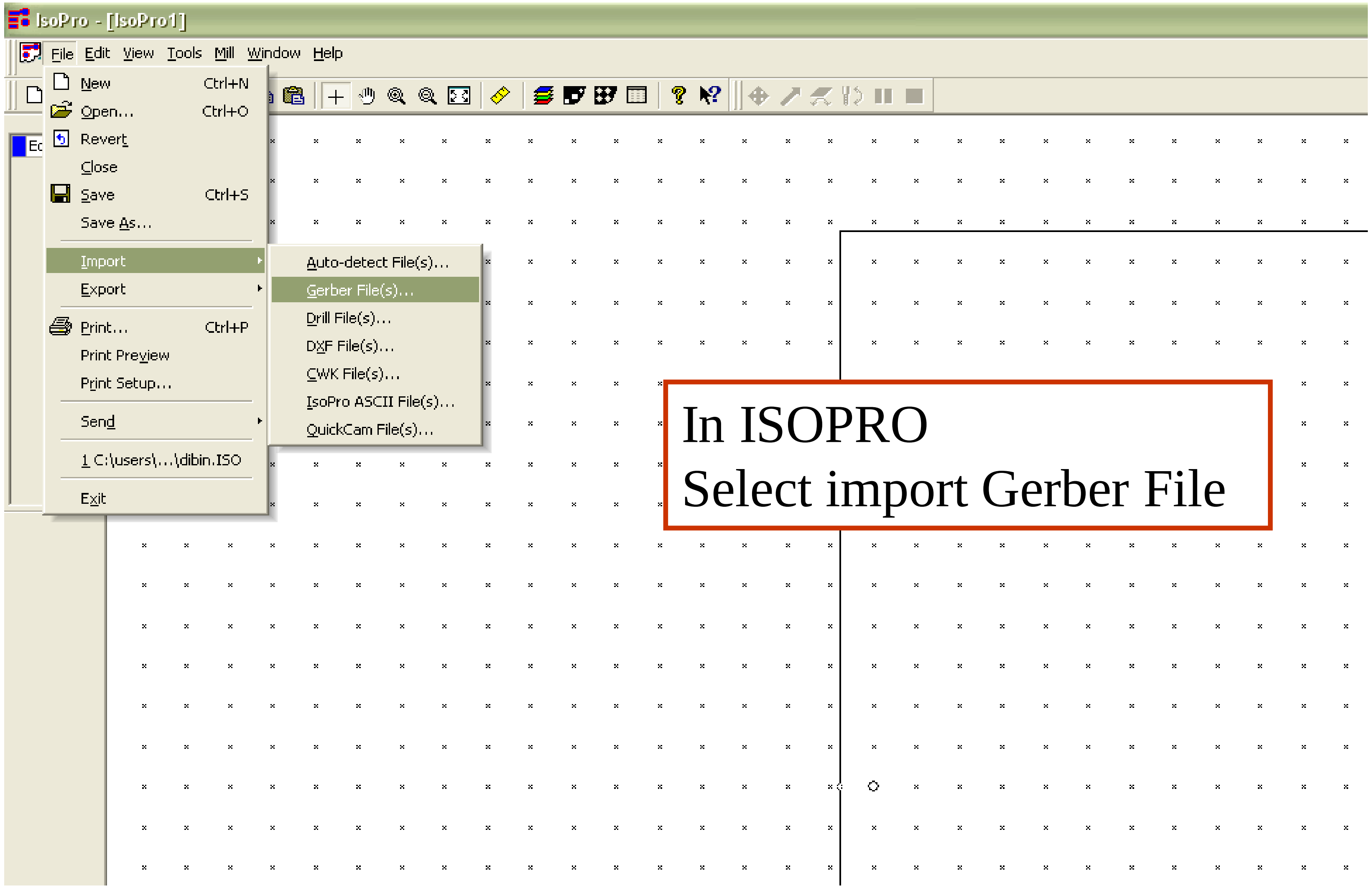


1°) Switch« ON »
The general power supply

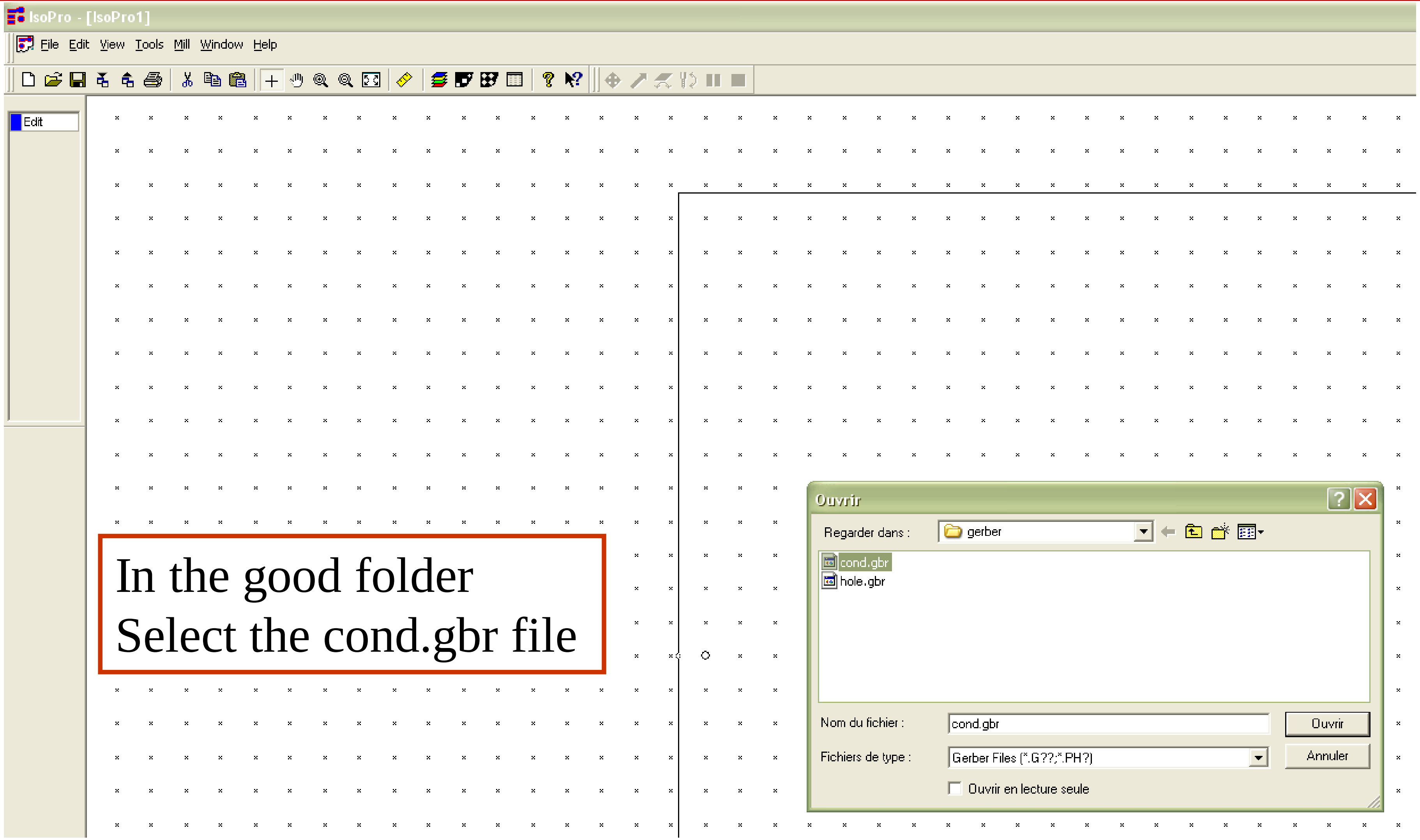


Top view

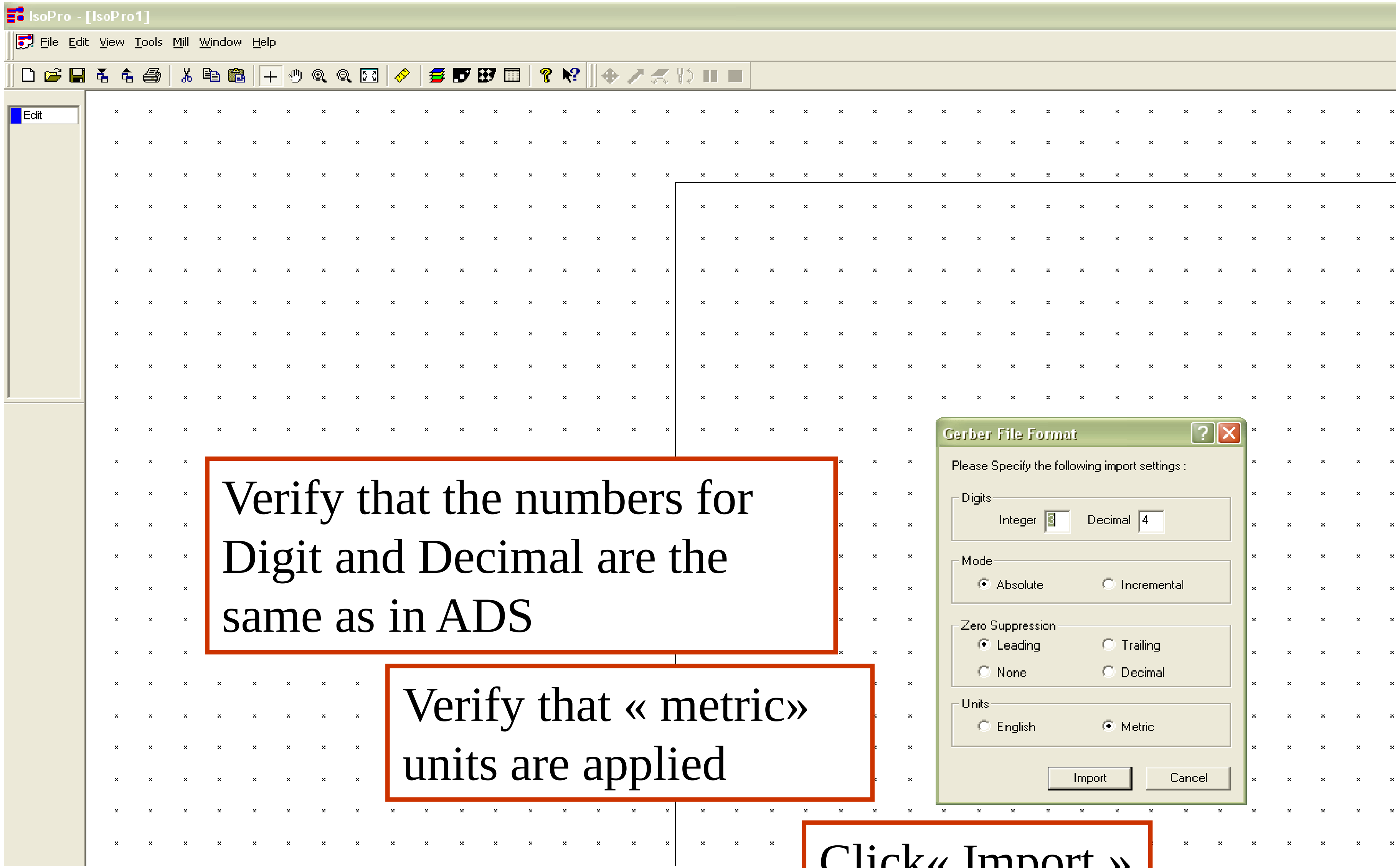
2°) Press "ON"
Solenoid rear face



In ISOPRO
Select import Gerber File



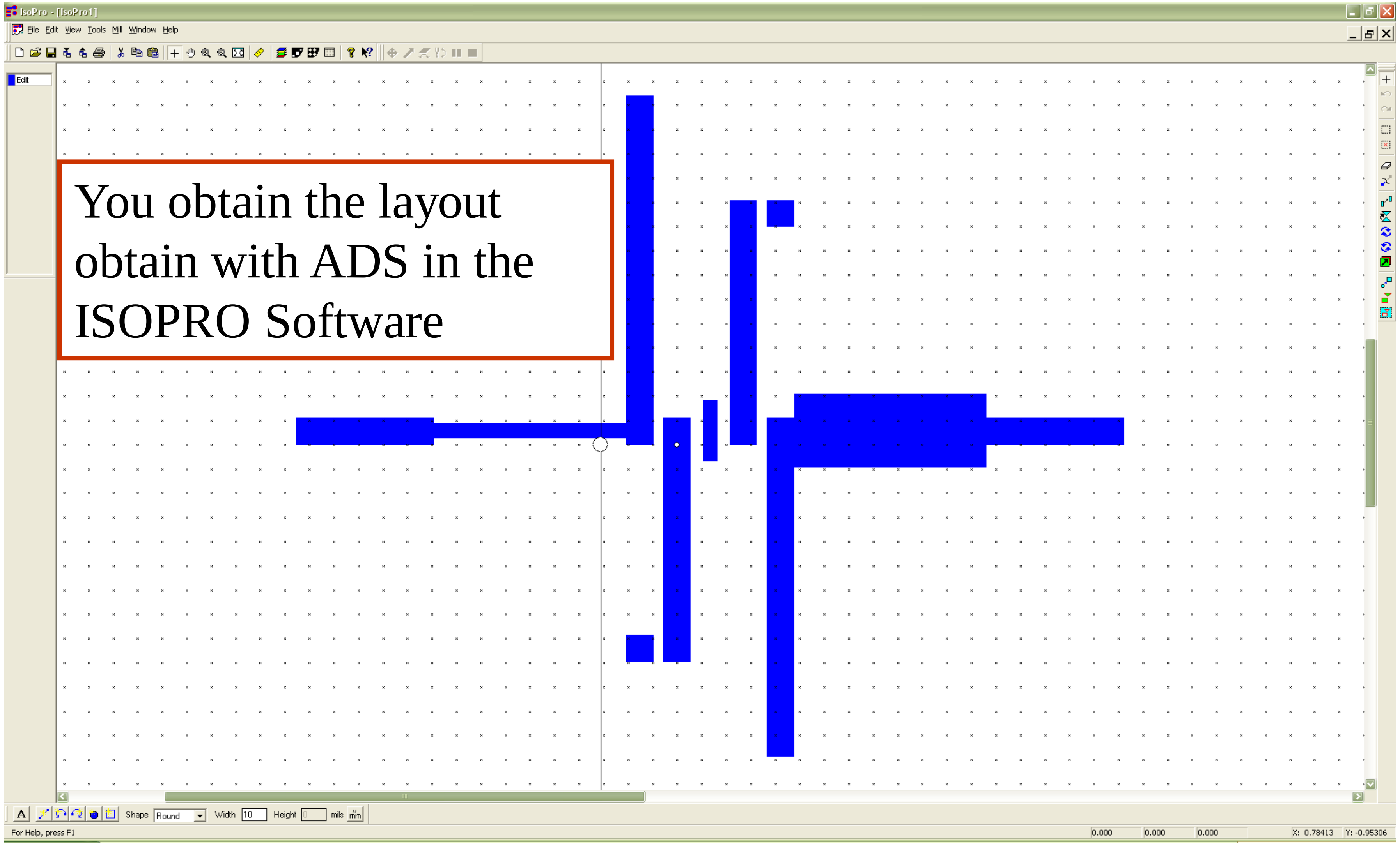
In the good folder
Select the cond.gbr file



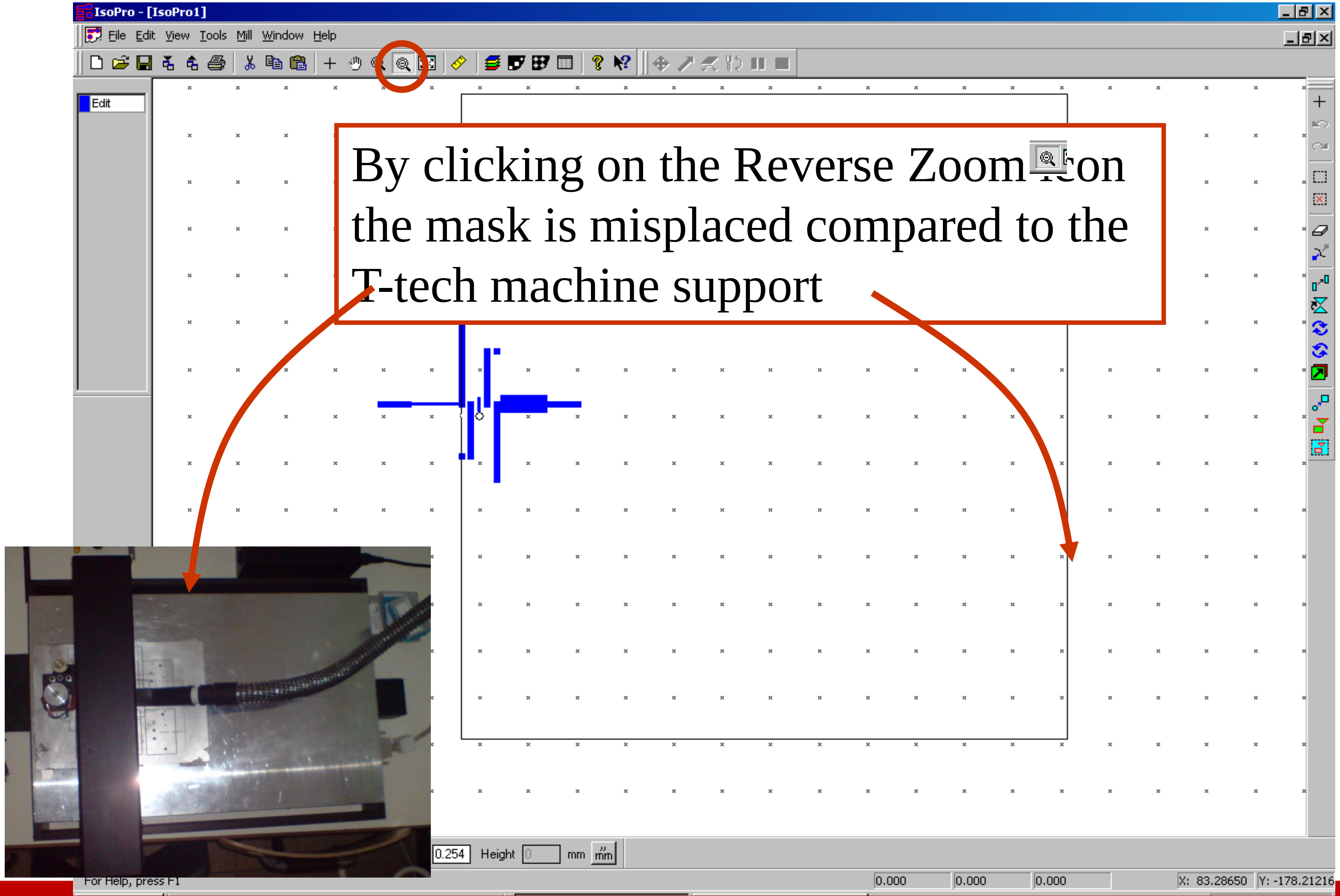
Verify that the numbers for Digit and Decimal are the same as in ADS

Verify that « metric» units are applied

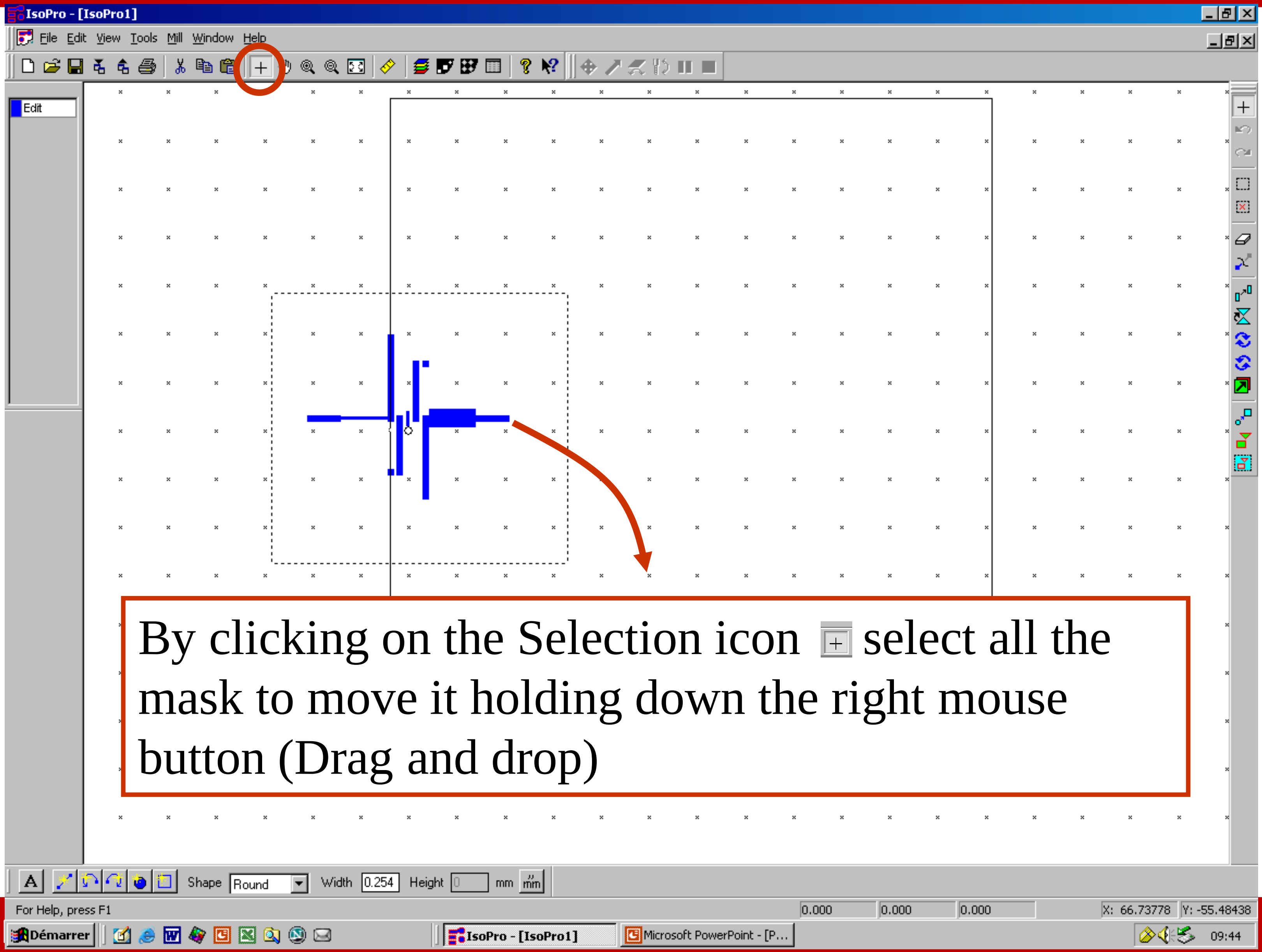
Click« Import »



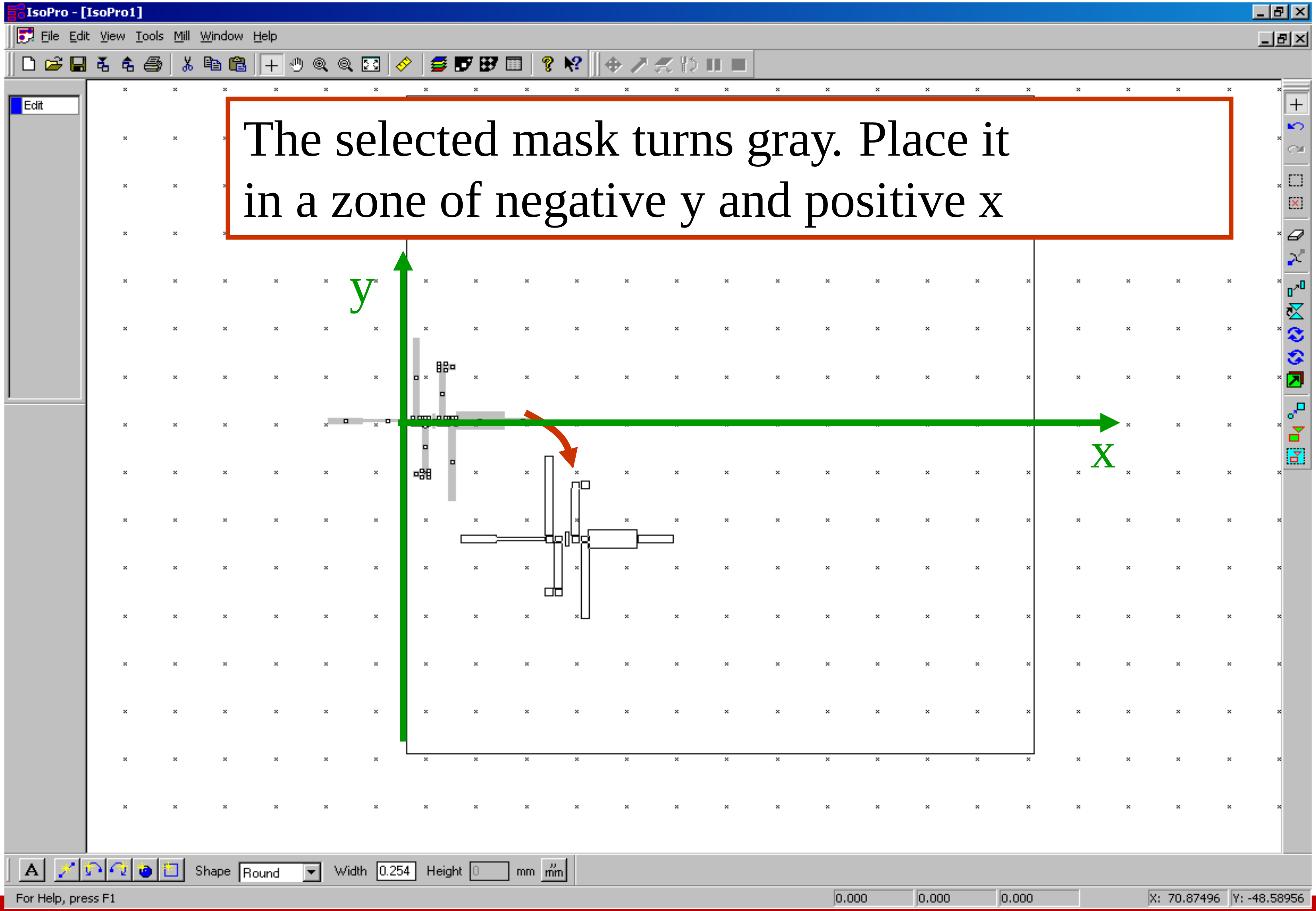
You obtain the layout obtain with ADS in the ISOPRO Software



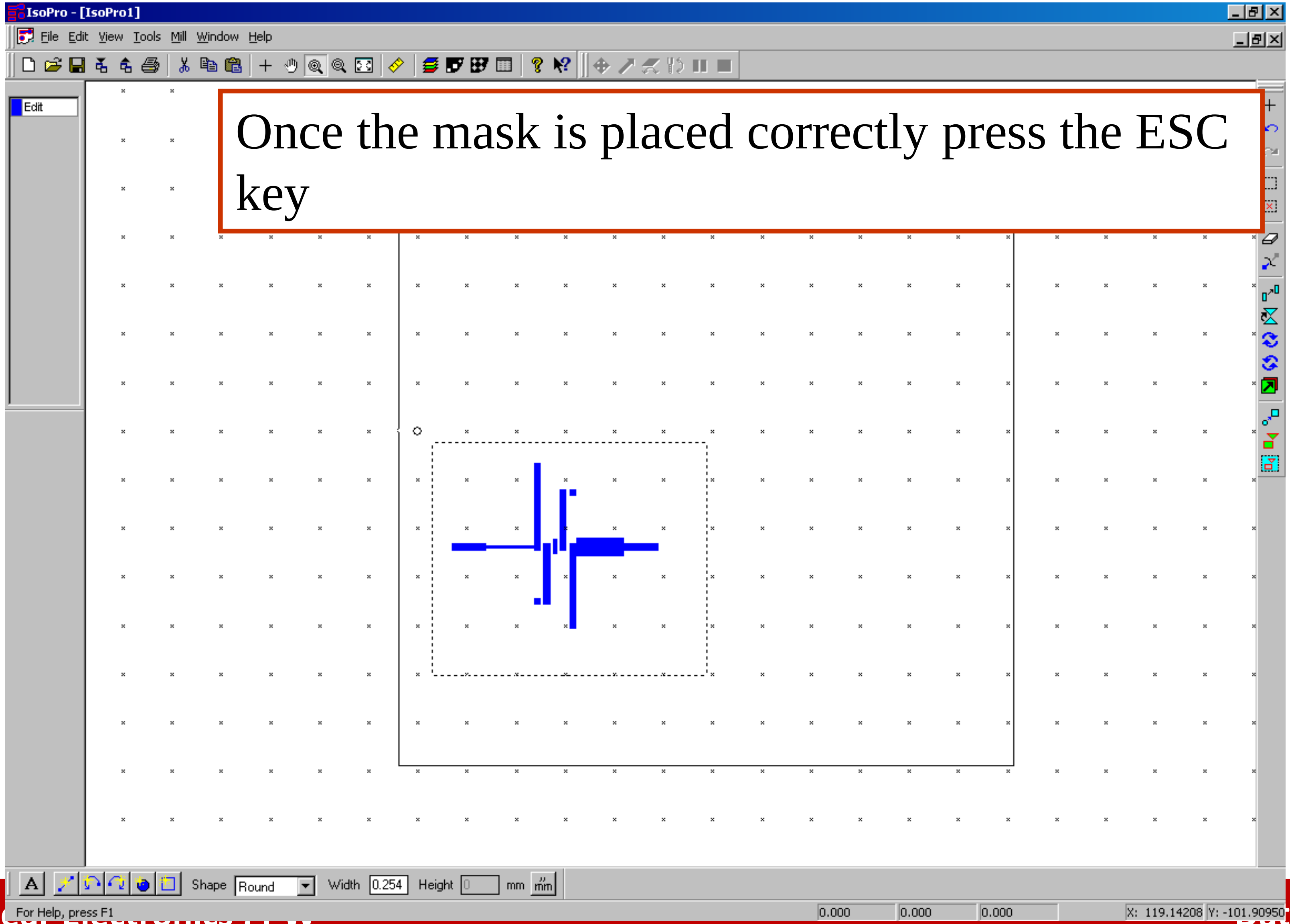
By clicking on the Reverse Zoom icon the mask is misplaced compared to the T-tech machine support

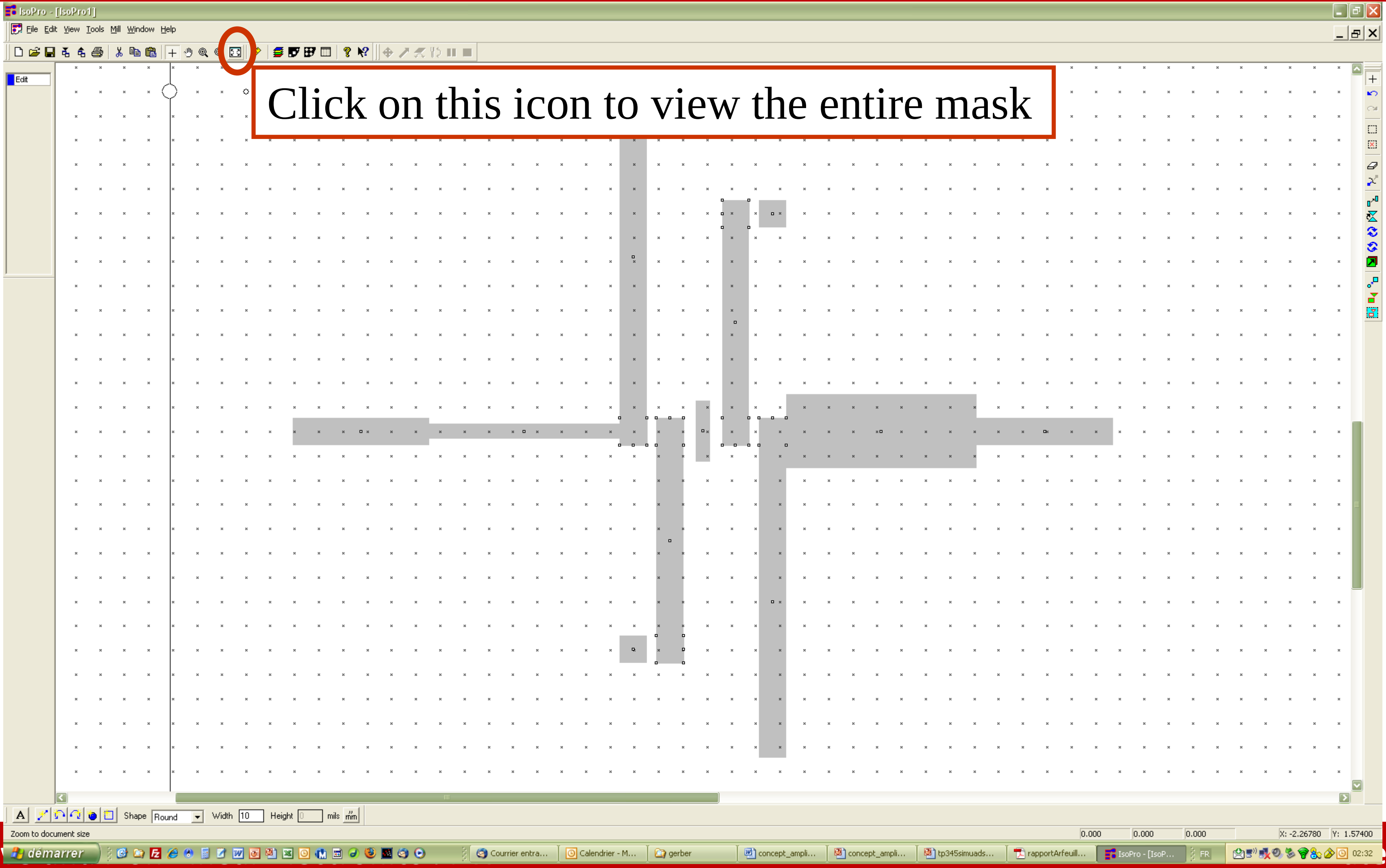


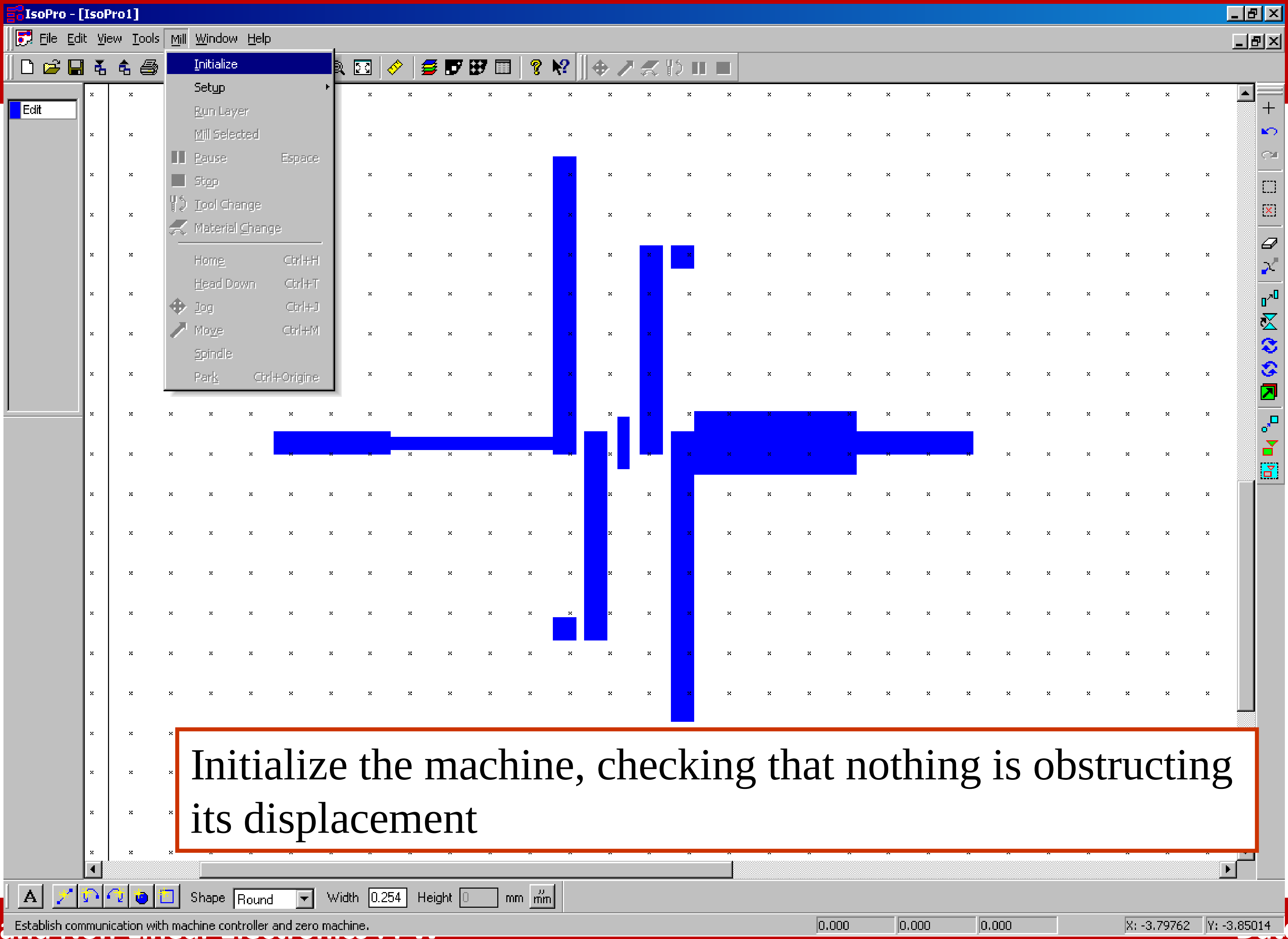
By clicking on the Selection icon select all the mask to move it holding down the right mouse button (Drag and drop)


IsoPro - [IsoPro1]
File Edit View Tools Mill Window Help
Edit
The selected mask turns gray. Place it
in a zone of negative y and positive x
y
x
Shape Round Width 0.254 Height 0 mm
For Help, press F1
0.000 0.000 0.000
X: 70.87496 Y: -48.58956

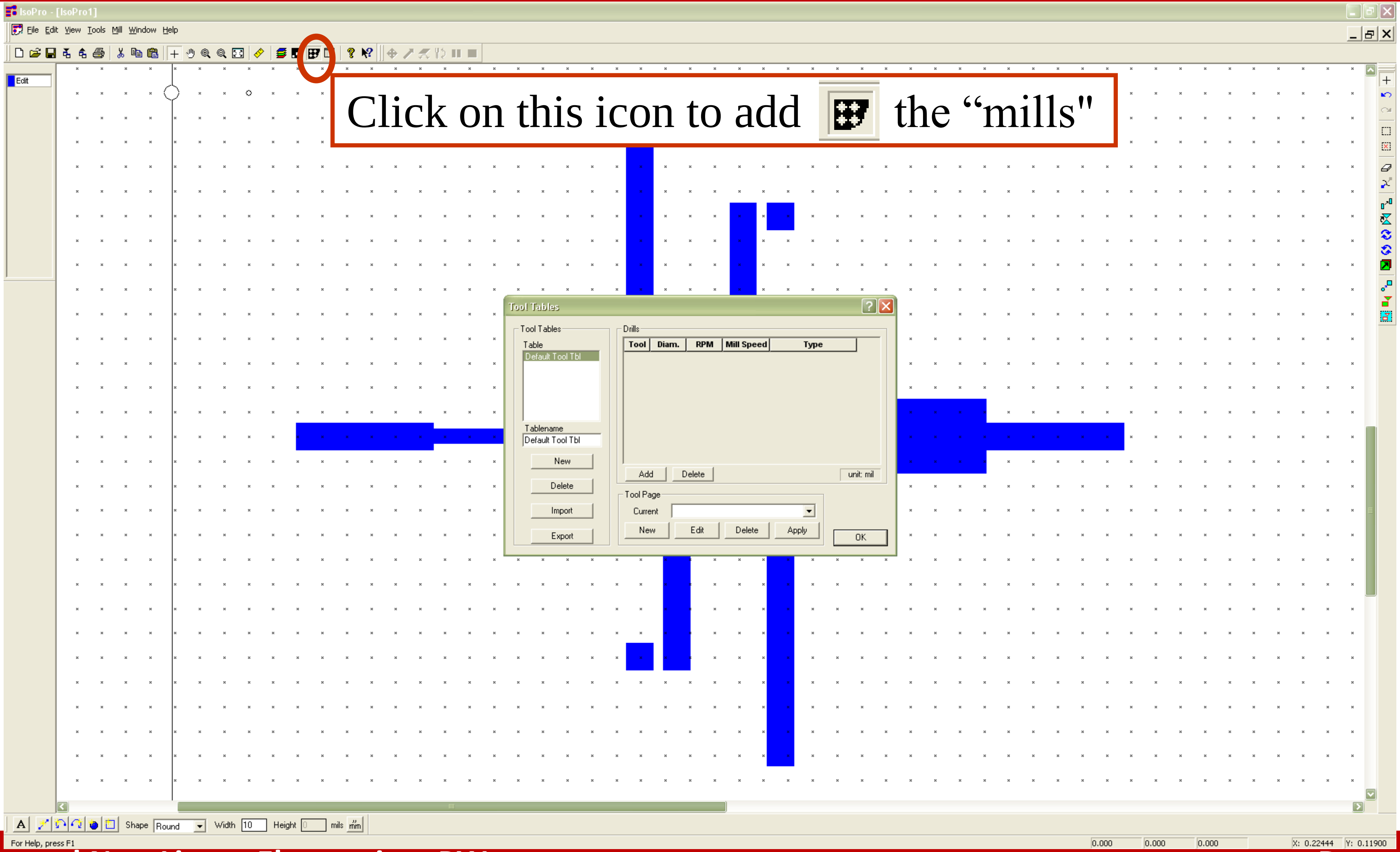
Once the mask is placed correctly press the ESC key



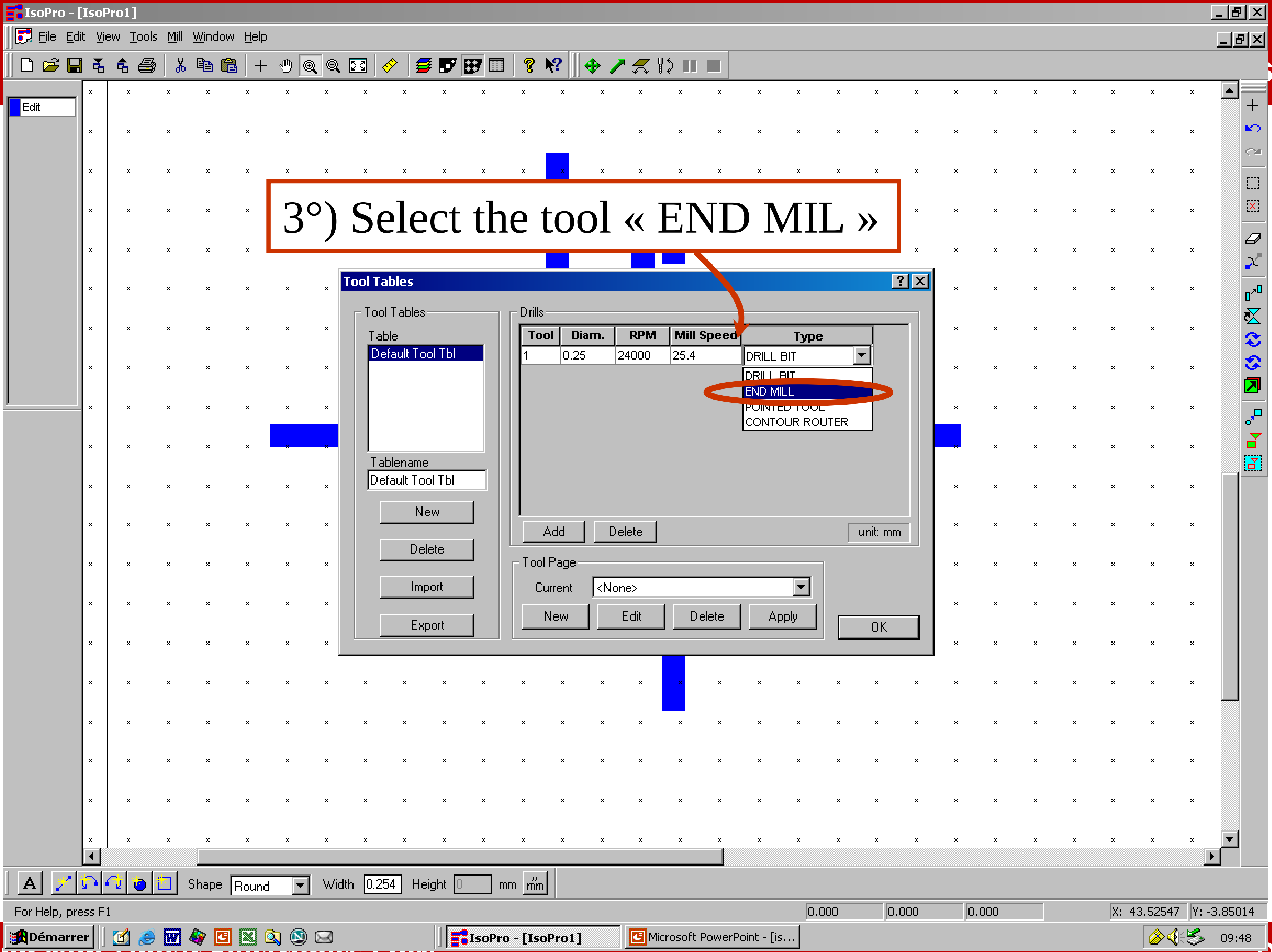

IsoPro - [IsoPro1]
File Edit View Tools Mill Window Help
Edit
Click on this icon to view the entire mask
Shape Round Width 10 Height mils
Zoom to document size

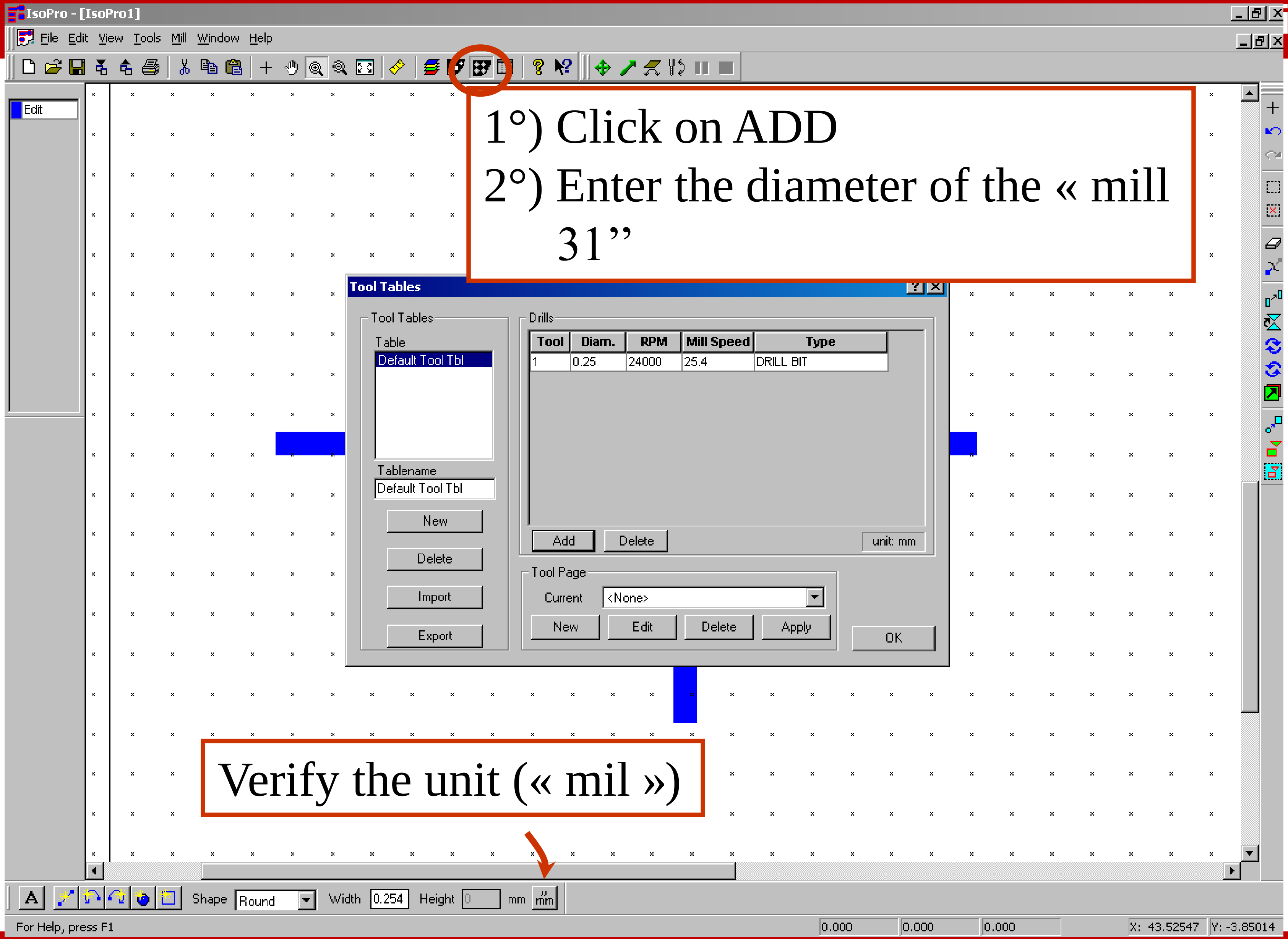


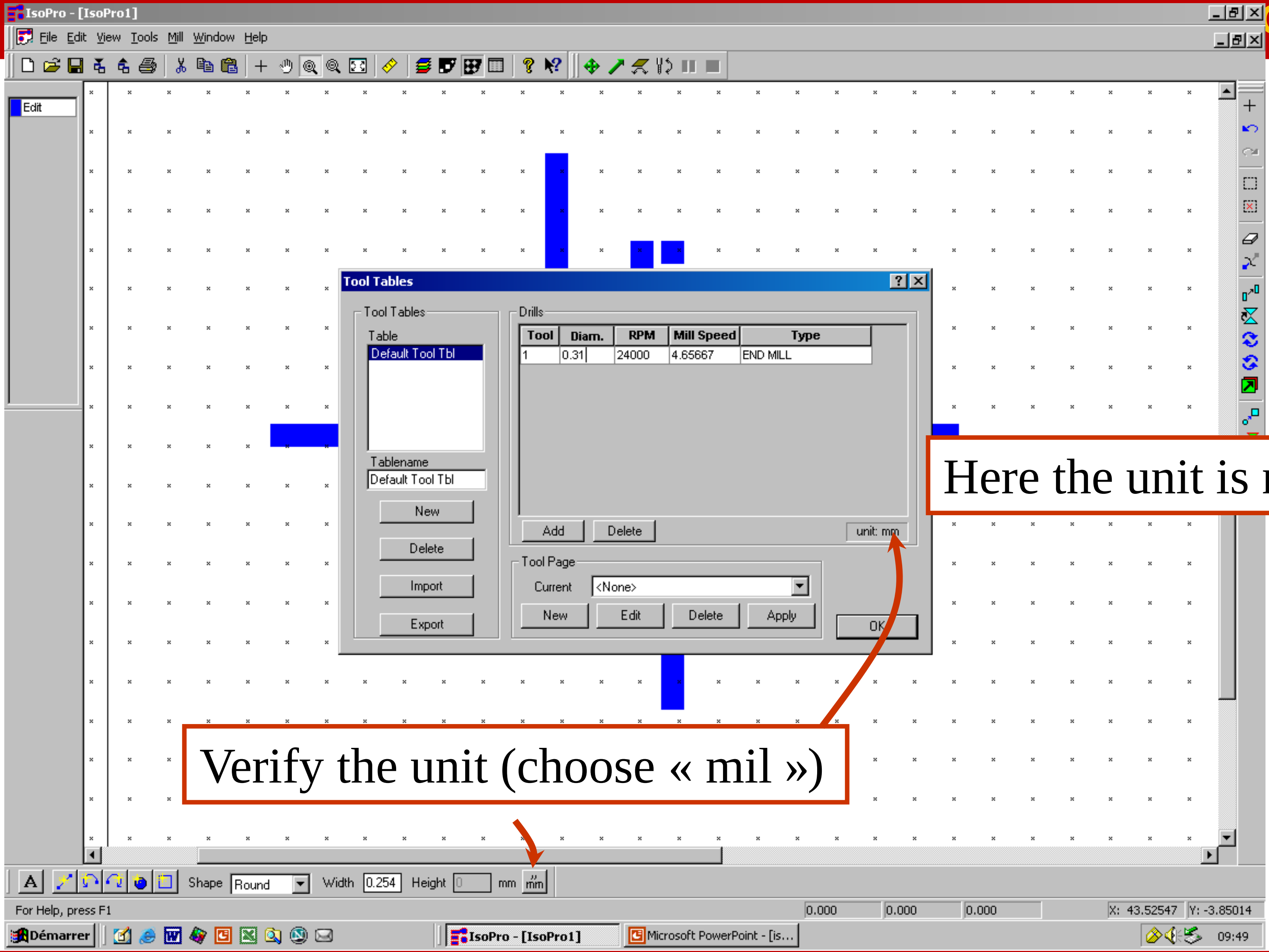
Initialize the machine, checking that nothing is obstructing its displacement


Click on this icon to add the “mills"
IsoPro - [IsoPro1]
File Edit View Tools Mill Window Help
Tool Tables
Tool Tables
Table
Default Tool Tbl
Tablename
Default Tool Tbl
New
Delete
Import
Export
Drills
Tool
Diam.
RPM
Mill Speed
Type
Add
Delete
unit: mil
Tool Page
Current
New
Edit
Delete
Apply
OK
Shape
Round
Width
10
Height
mils
For Help, press F1

3°) Select the tool « END MIL »

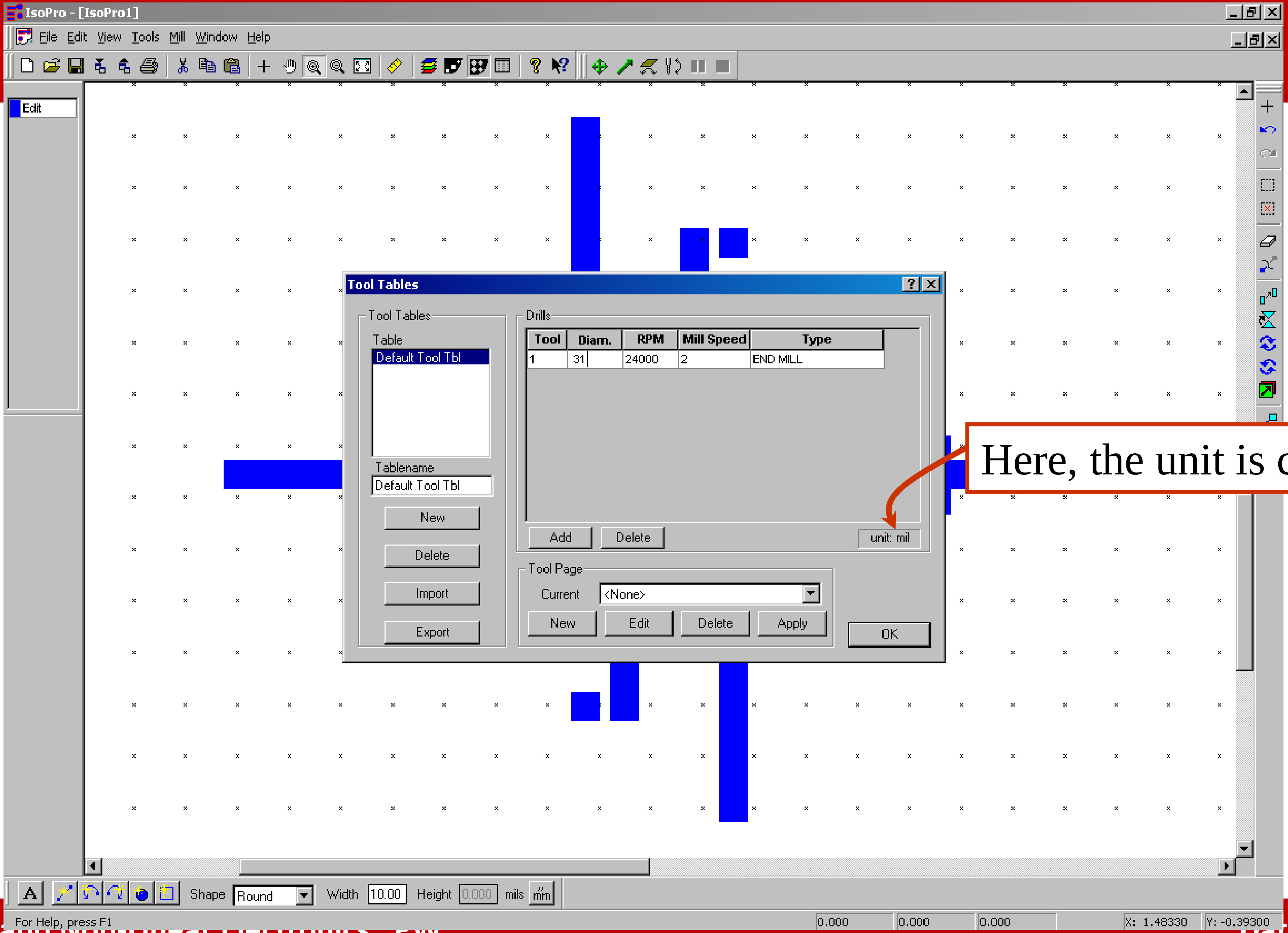



IsoPro - [IsoPro1]
File Edit View Tools Mill Window Help
Edit
1°) Click on ADD
2°) Enter the diameter of the « mill 31”
Tool Tables
Tool Tables
Table
Default Tool Tbl
Tablename
Default Tool Tbl
New
Delete
Import
Export
Drills
Tool | Diam. | RPM | Mill Speed | Type
1 | 0.25 | 24000 | 25.4 | DRILL BIT
Add
Delete
unit: mm
Tool Page
Current
<None>
New
Edit
Delete
Apply
OK
Verify the unit (« mil »)
Shape
Round
Width
0.254
Height
mm
For Help, press F1
X: 43.52547
Y: -3.85014

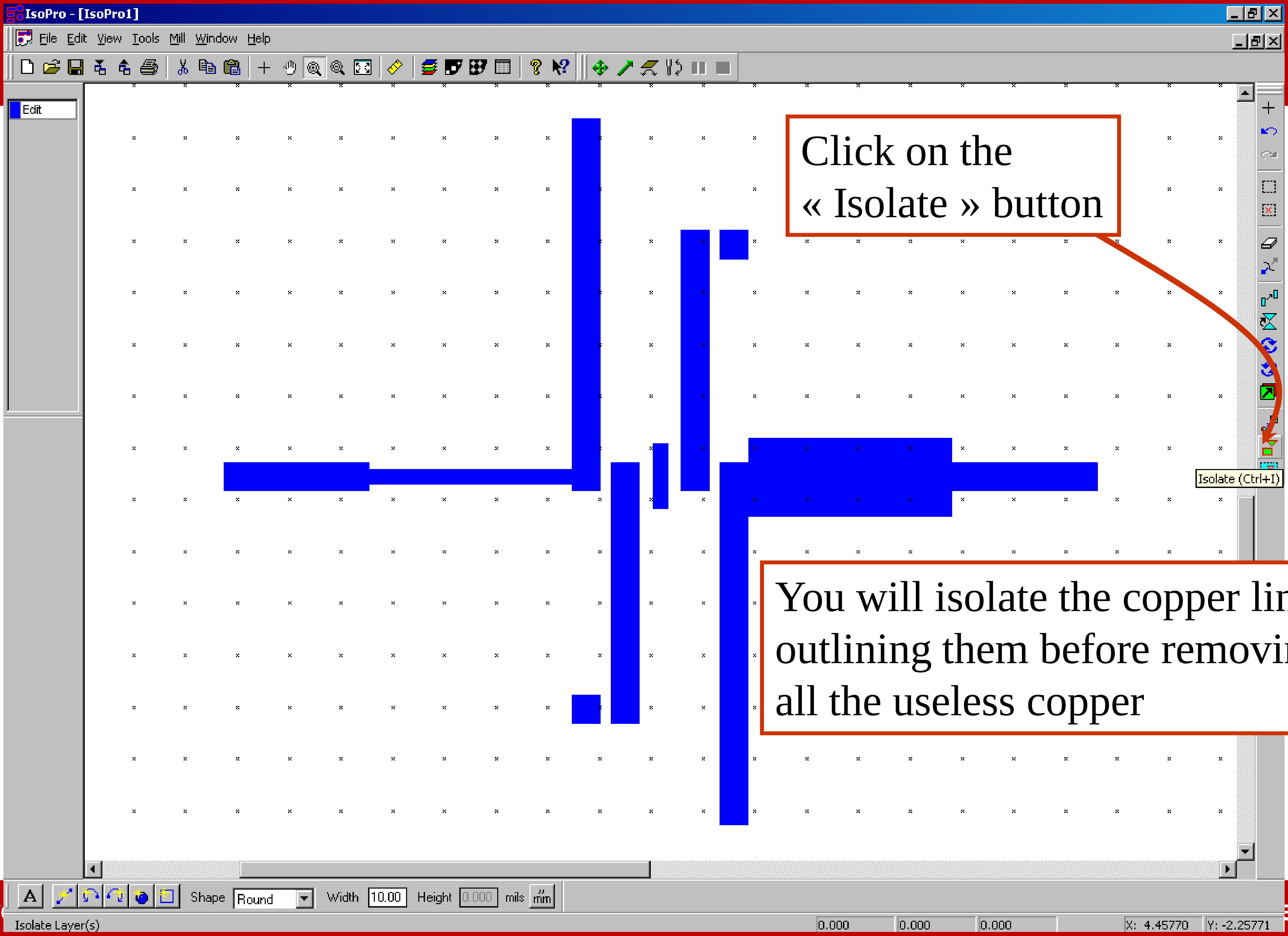


Here the unit is not correct

Verify the unit (choose « mil »)



Here, the unit is correct

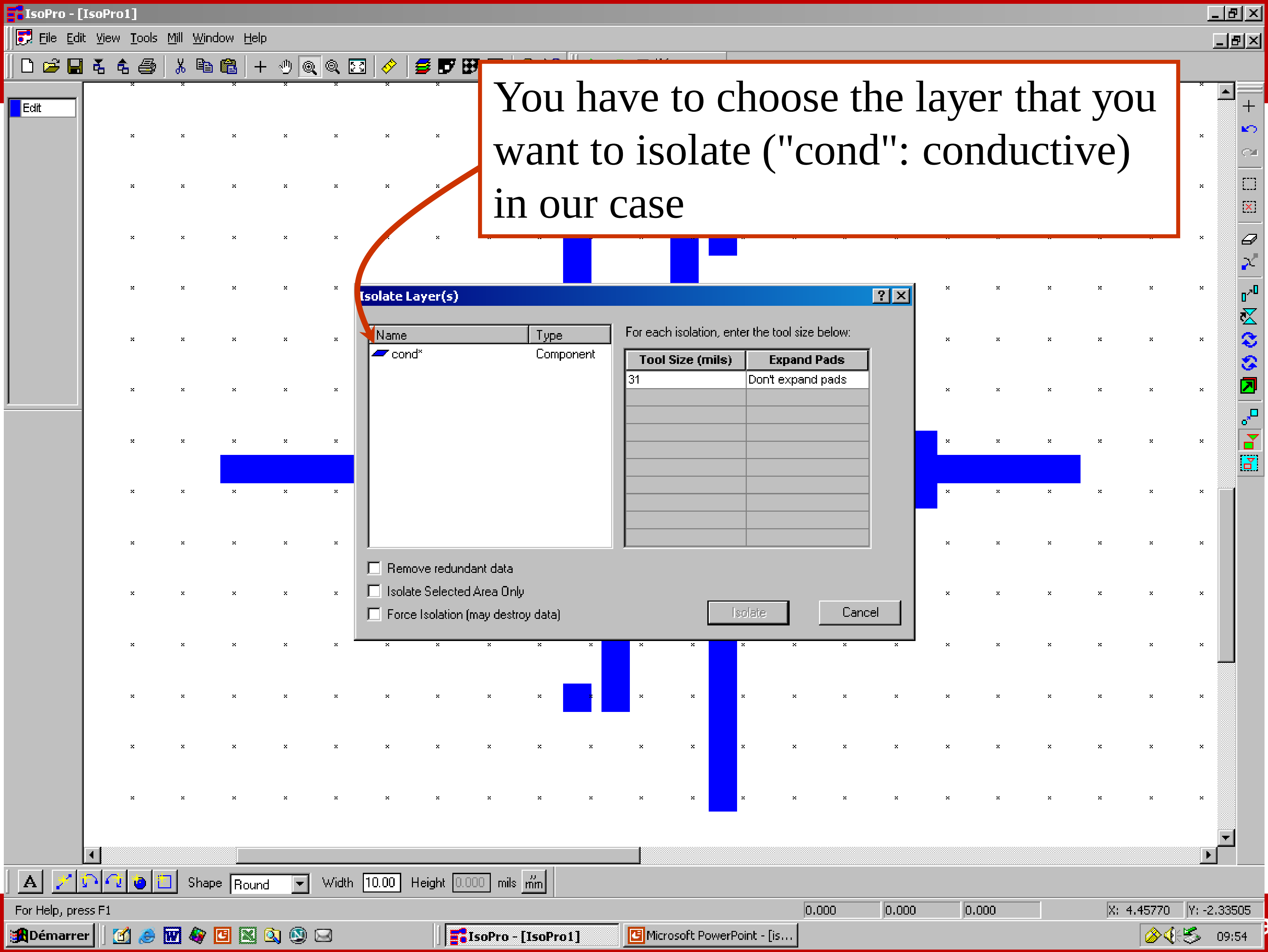


Click on the « Isolate » button

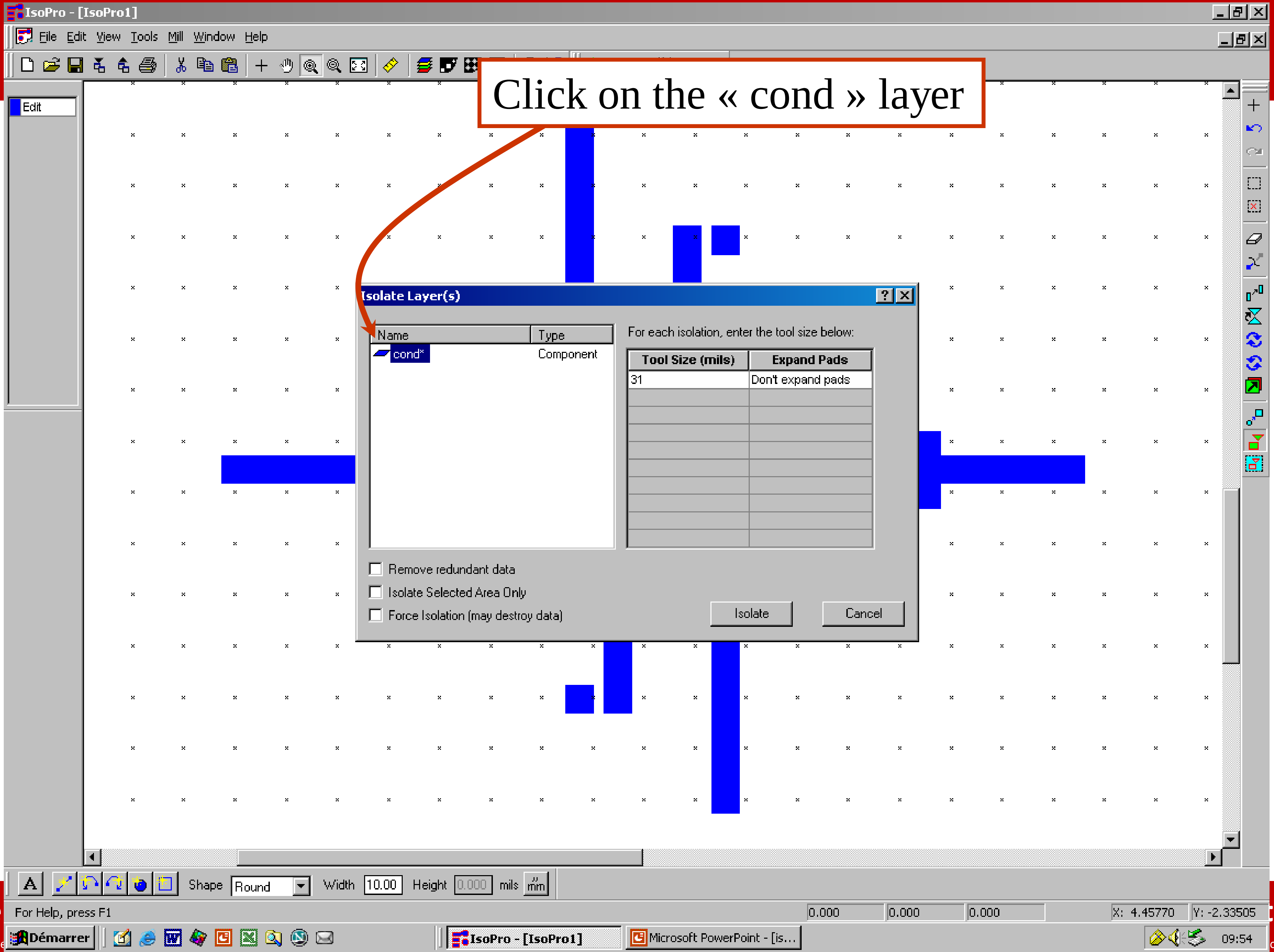
You will isolate the copper lines by outlining them before removing all the useless copper

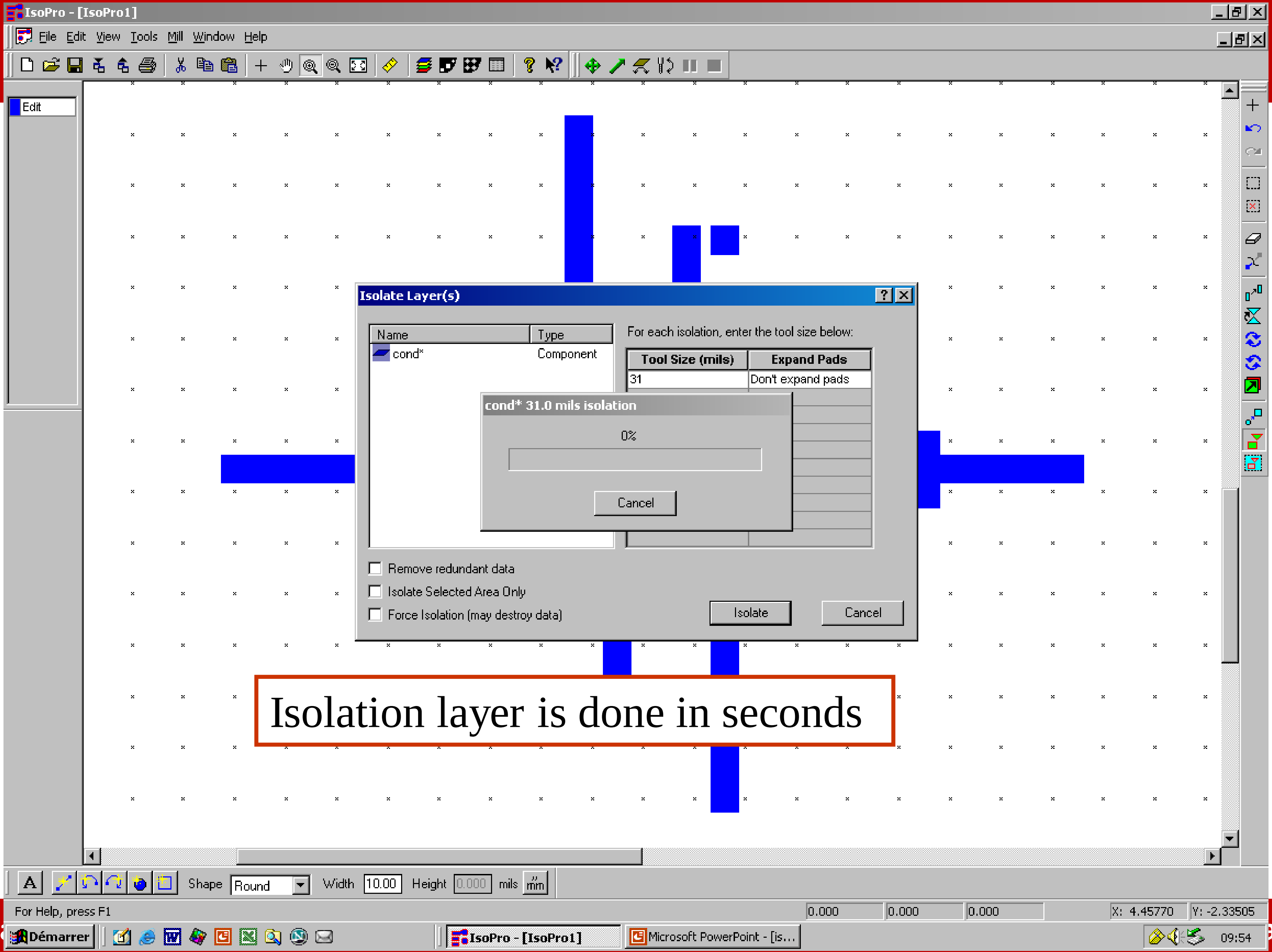
Basics of Activ… …e

You have to choose the layer that you want to isolate ("cond": conductive) in our case

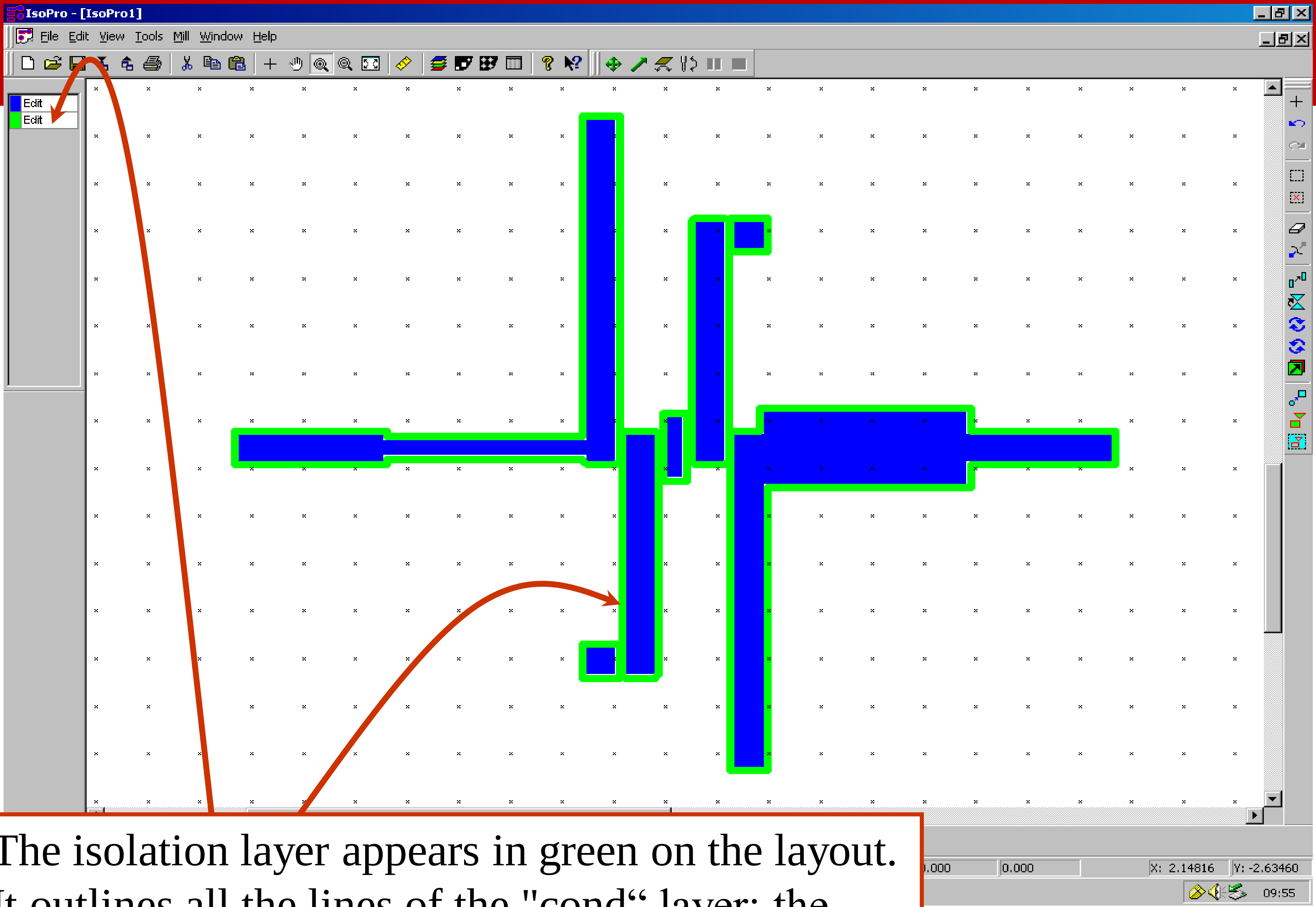


Click on the « cond » layer

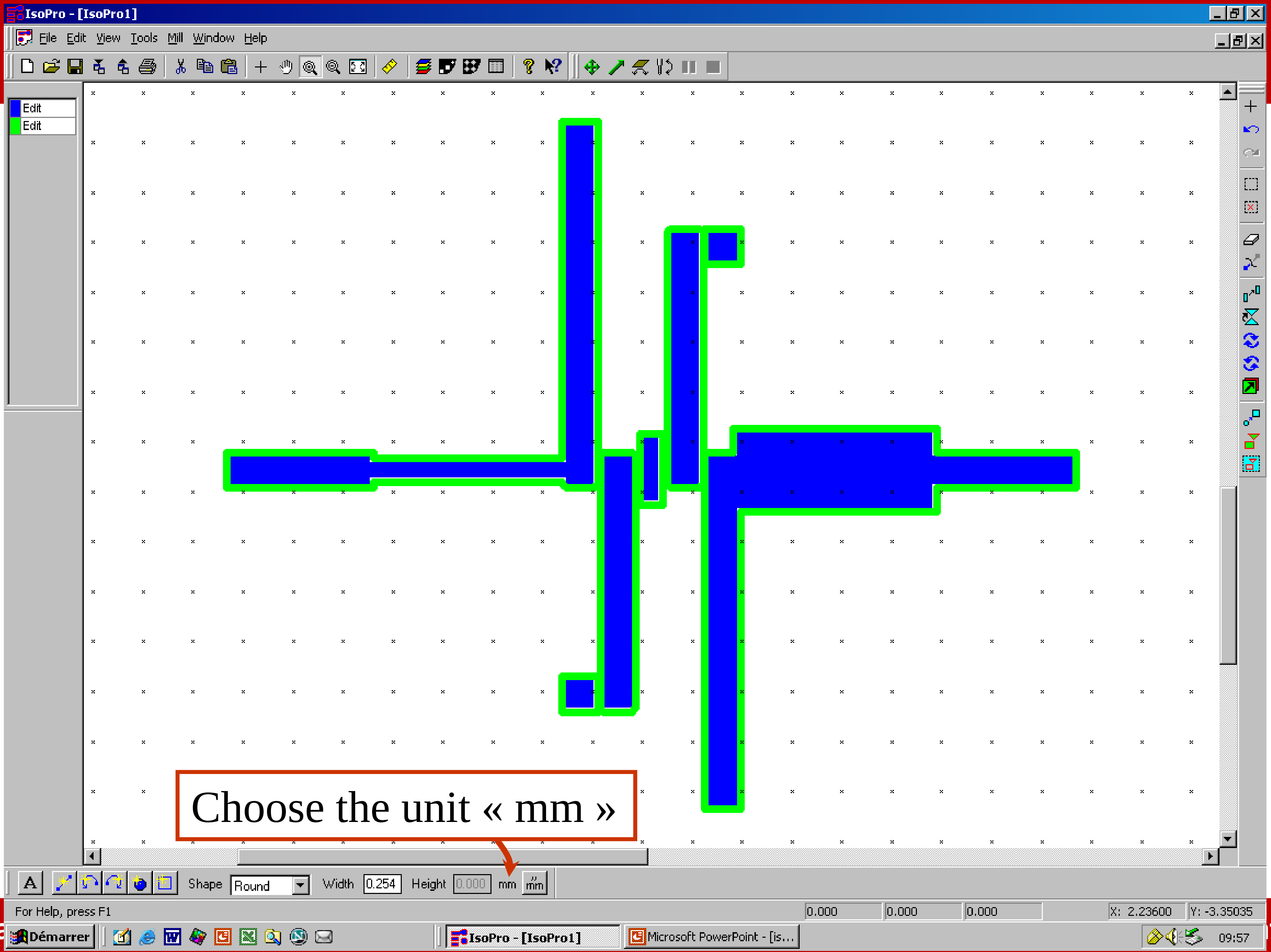




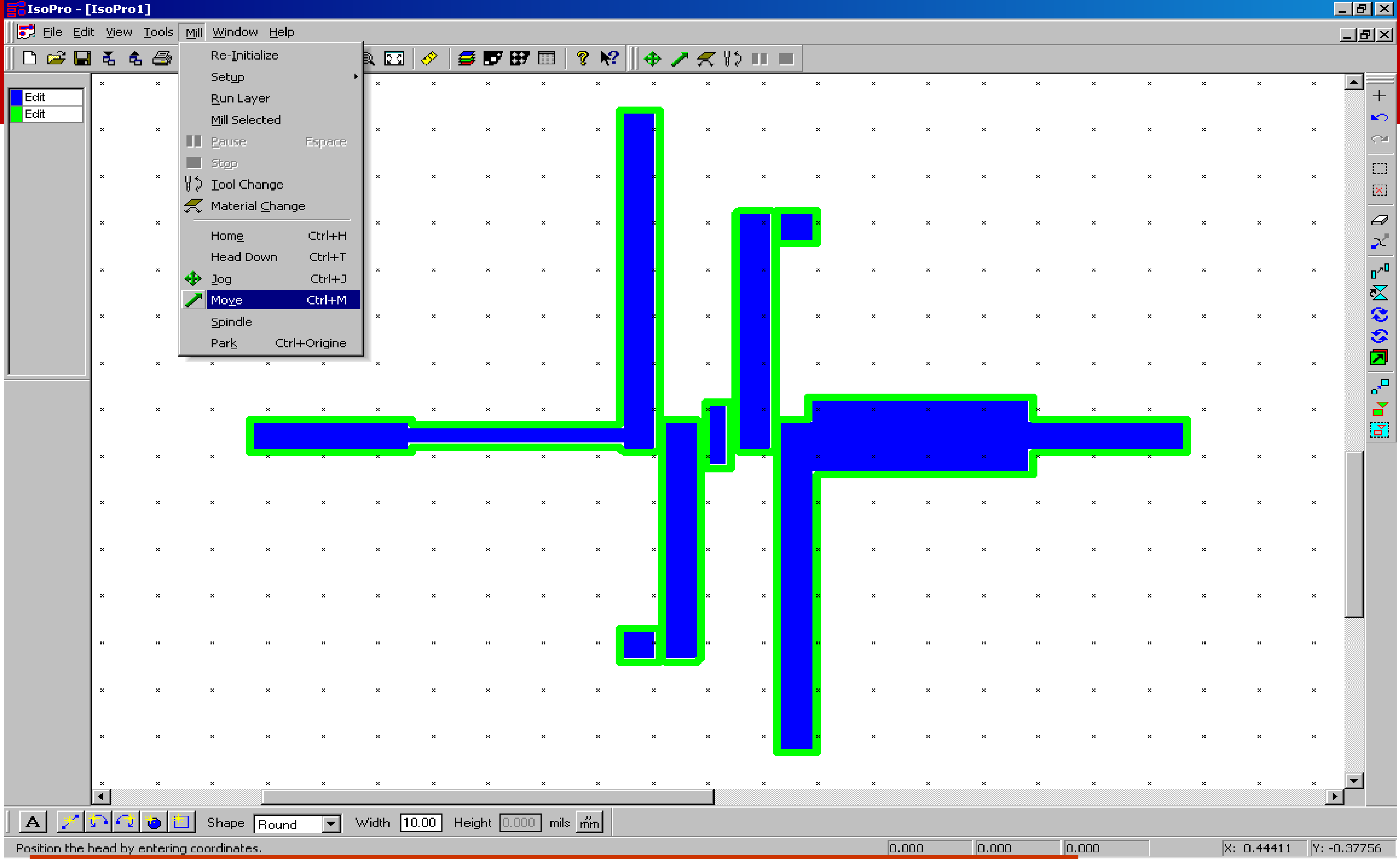
Isolation layer is done in seconds



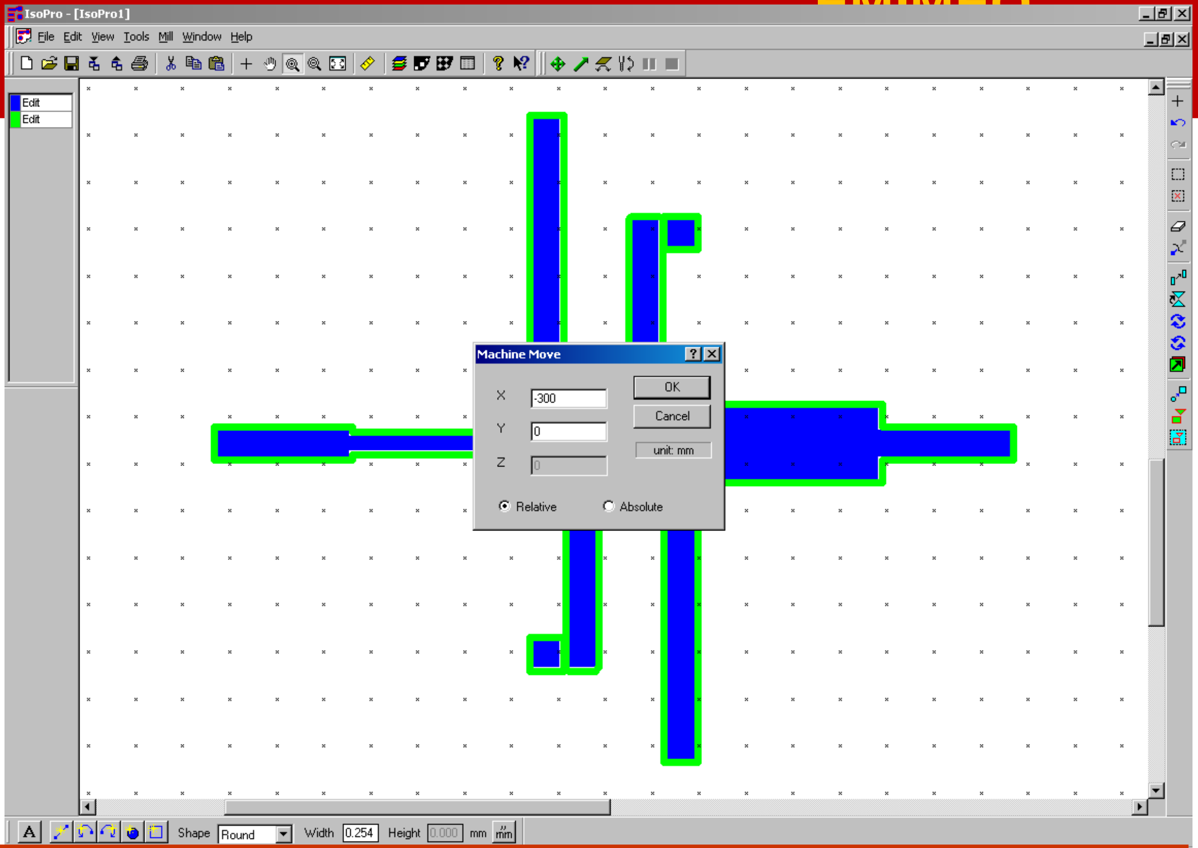
The isolation layer appears in green on the layout. It outlines all the lines of the "cond“ layer: the copper will be removed by the selected “Edit”



Basics of Active a… te

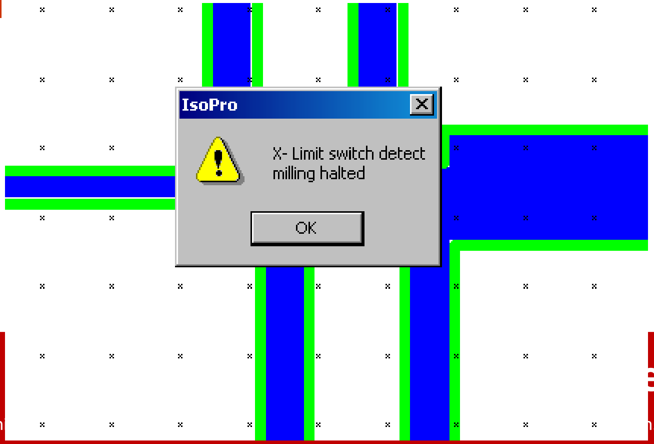


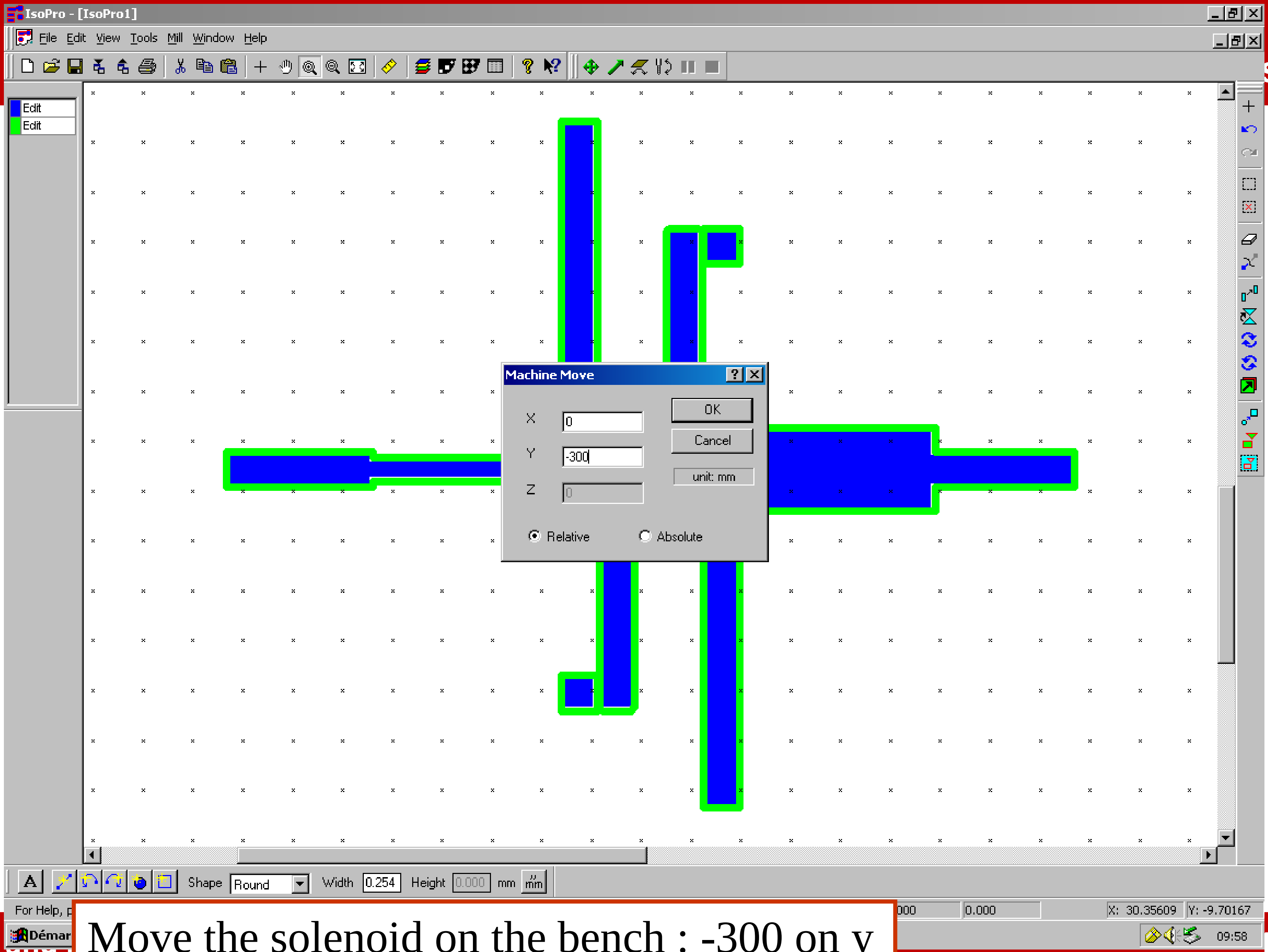
You will install the mill in the solenoid. For that, move the solenoid out of the table. Select the menu Mill / Move



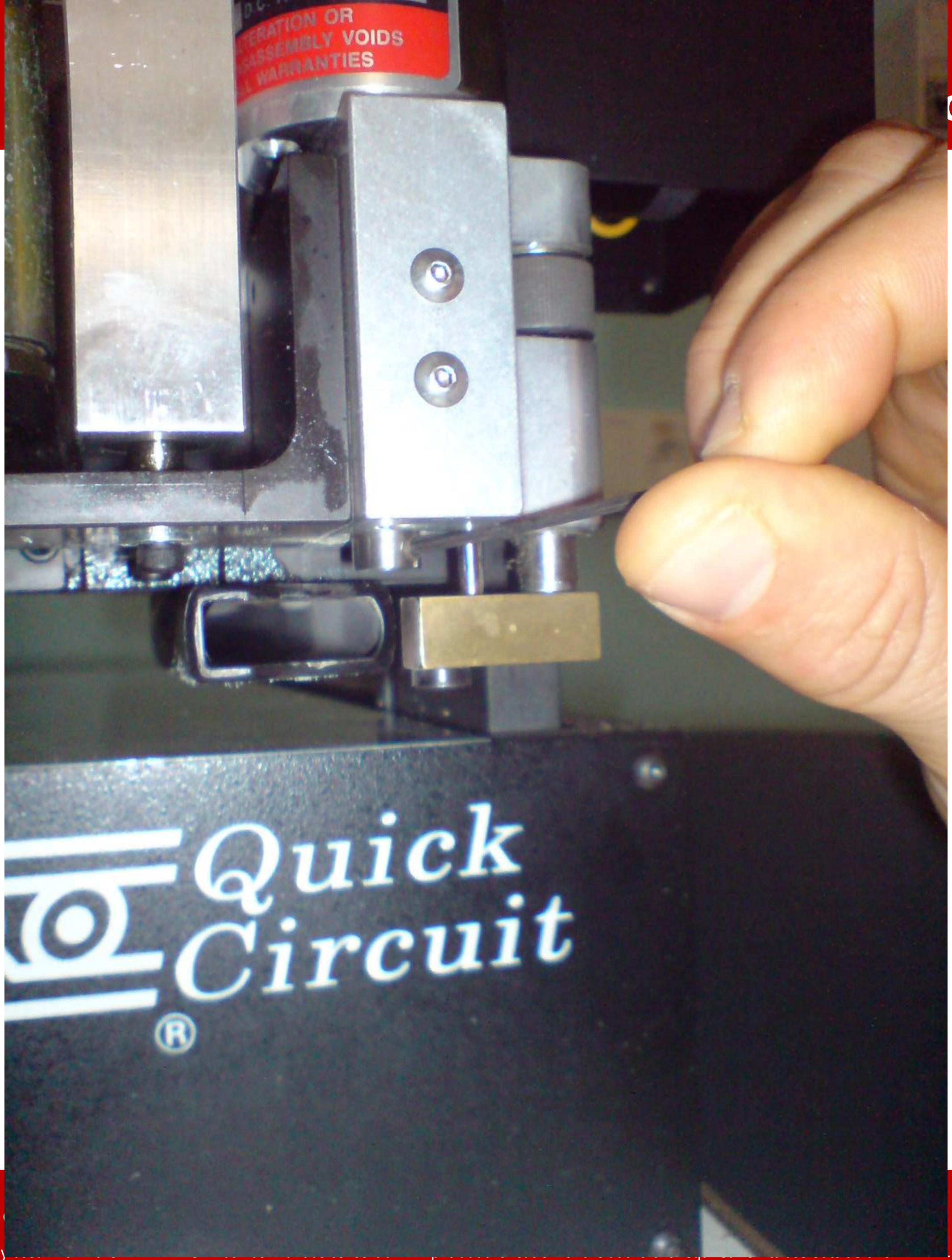
Move the solenoid on the bench : -300 on the x

The following normal message appears meaning you want to go too far away => go to the next step.





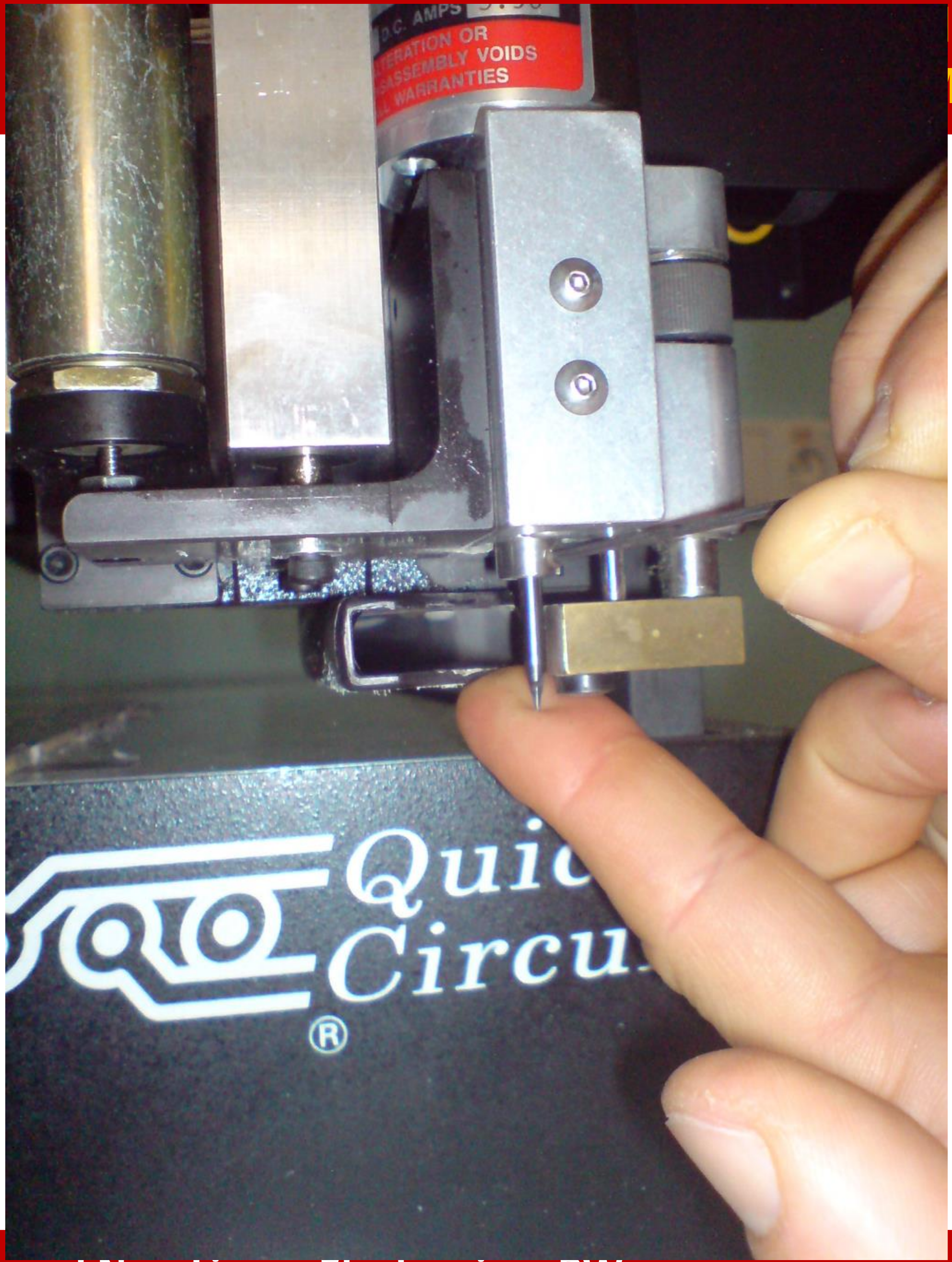
Move the solenoid on the bench : -300 on y



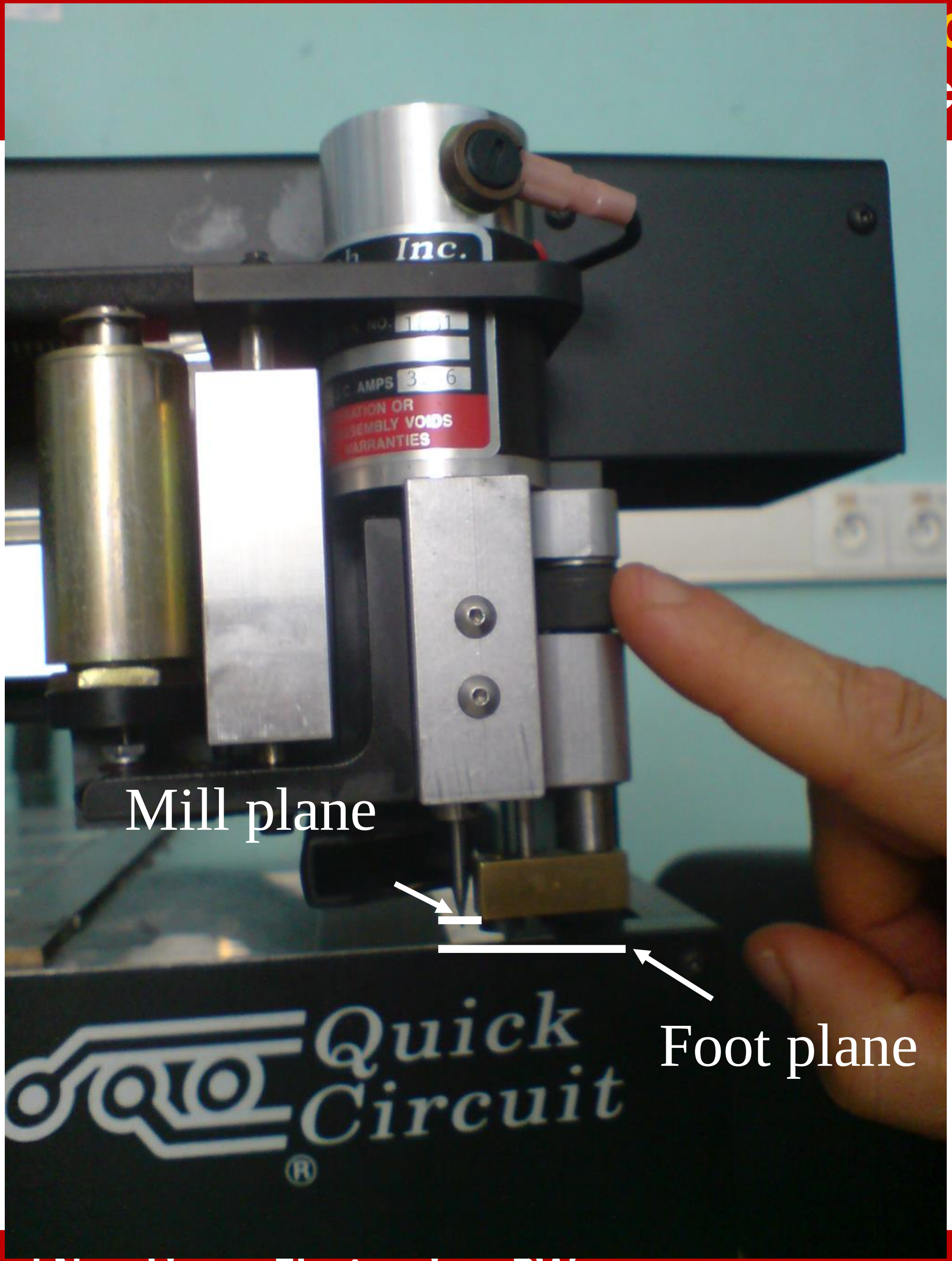
The solenoid and chuck are outside the machine.

Unscrew the clamping screw with a wrench.

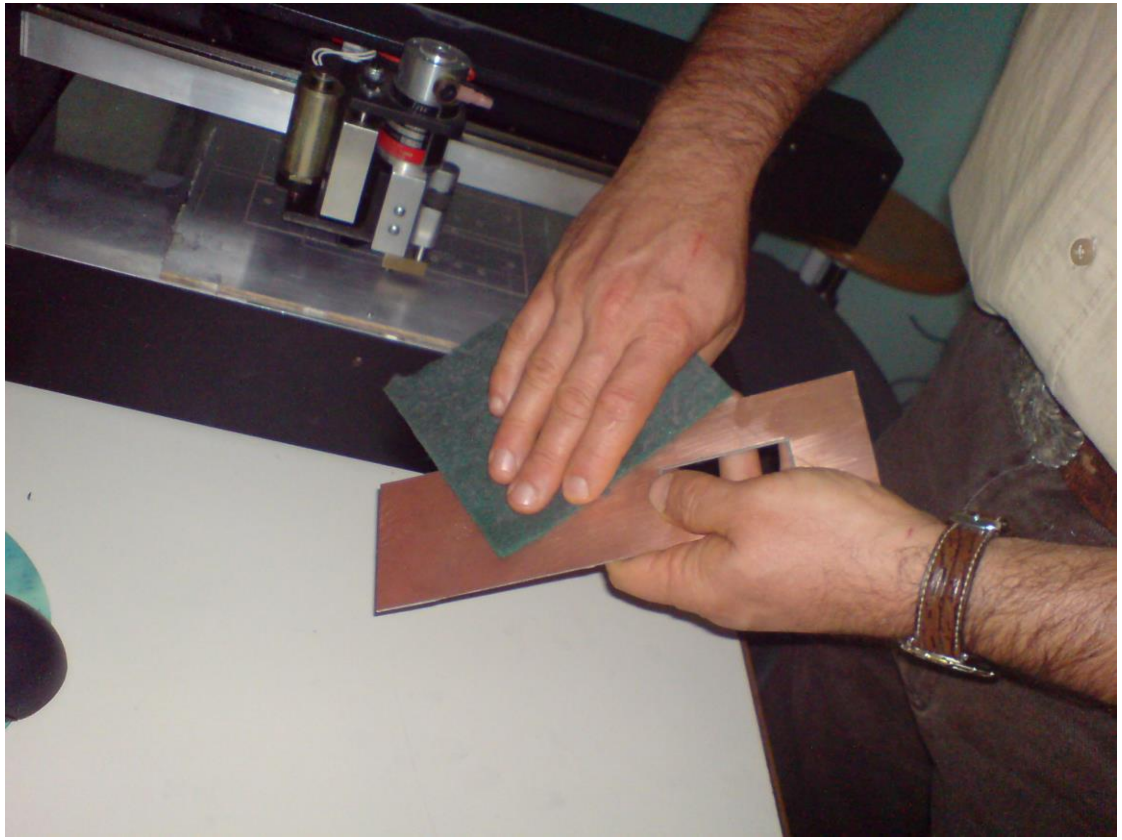
Insert the selected mill into the chuck



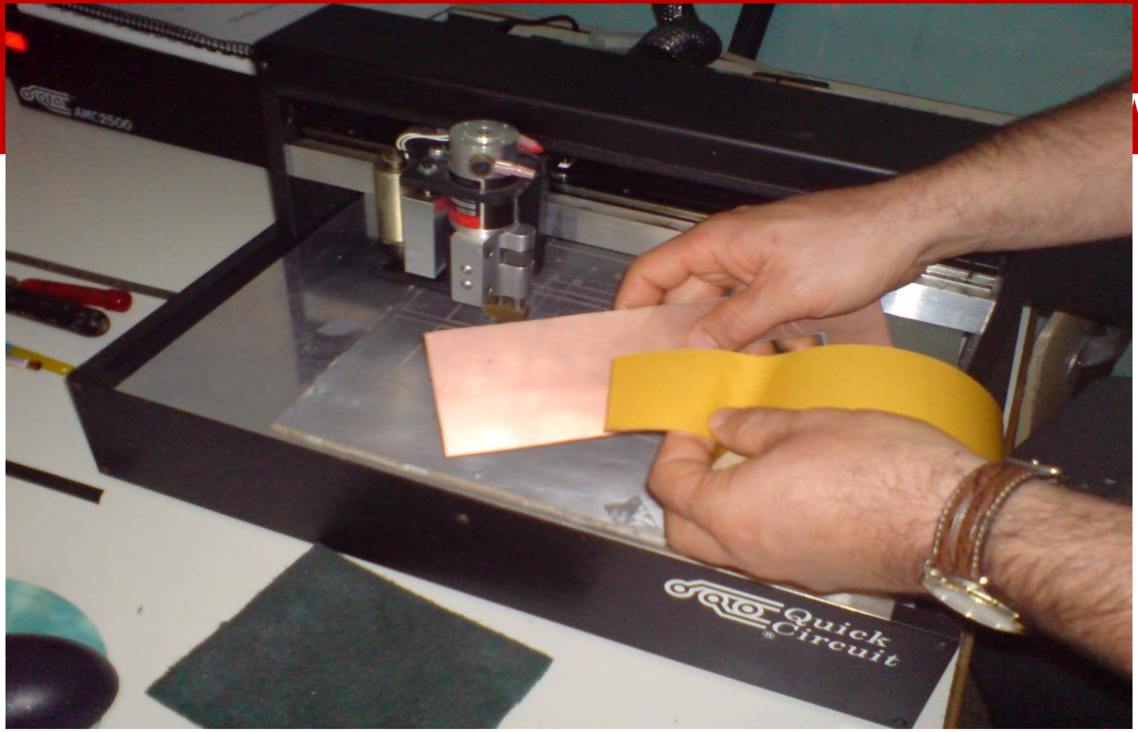
Hold the mill in the chuck and tighten the clamping screw with the wrench.

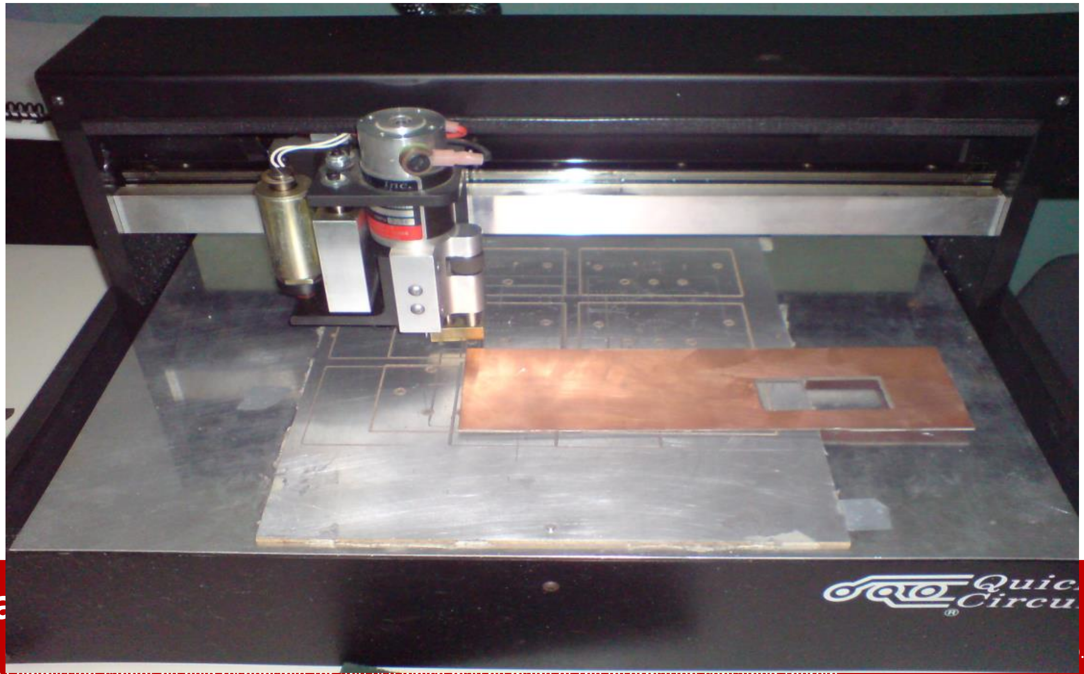


Use the screw on the side of the solenoid so that the foot is placed under the mill.



Take a piece of FR4 plate and clean it

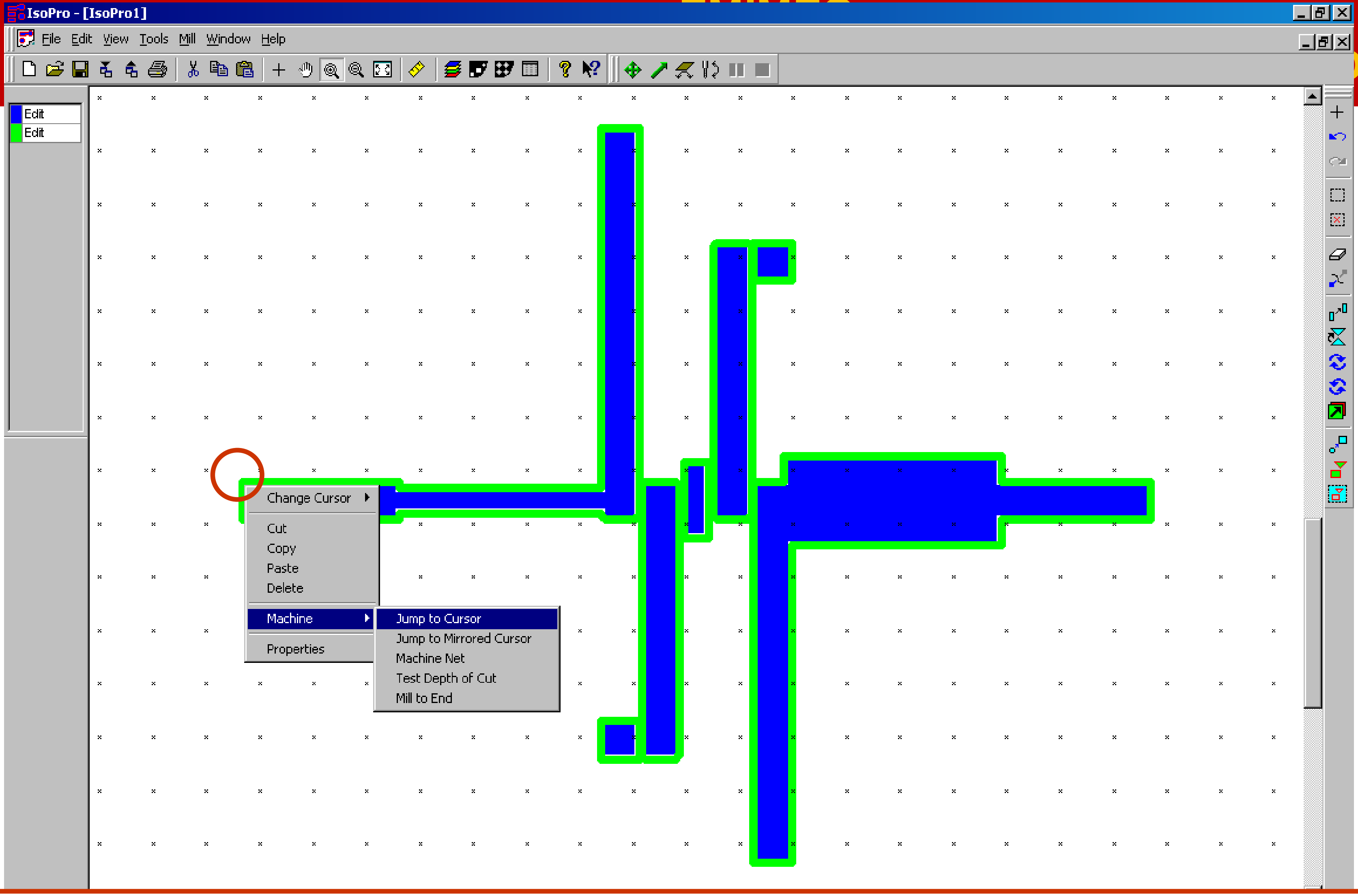




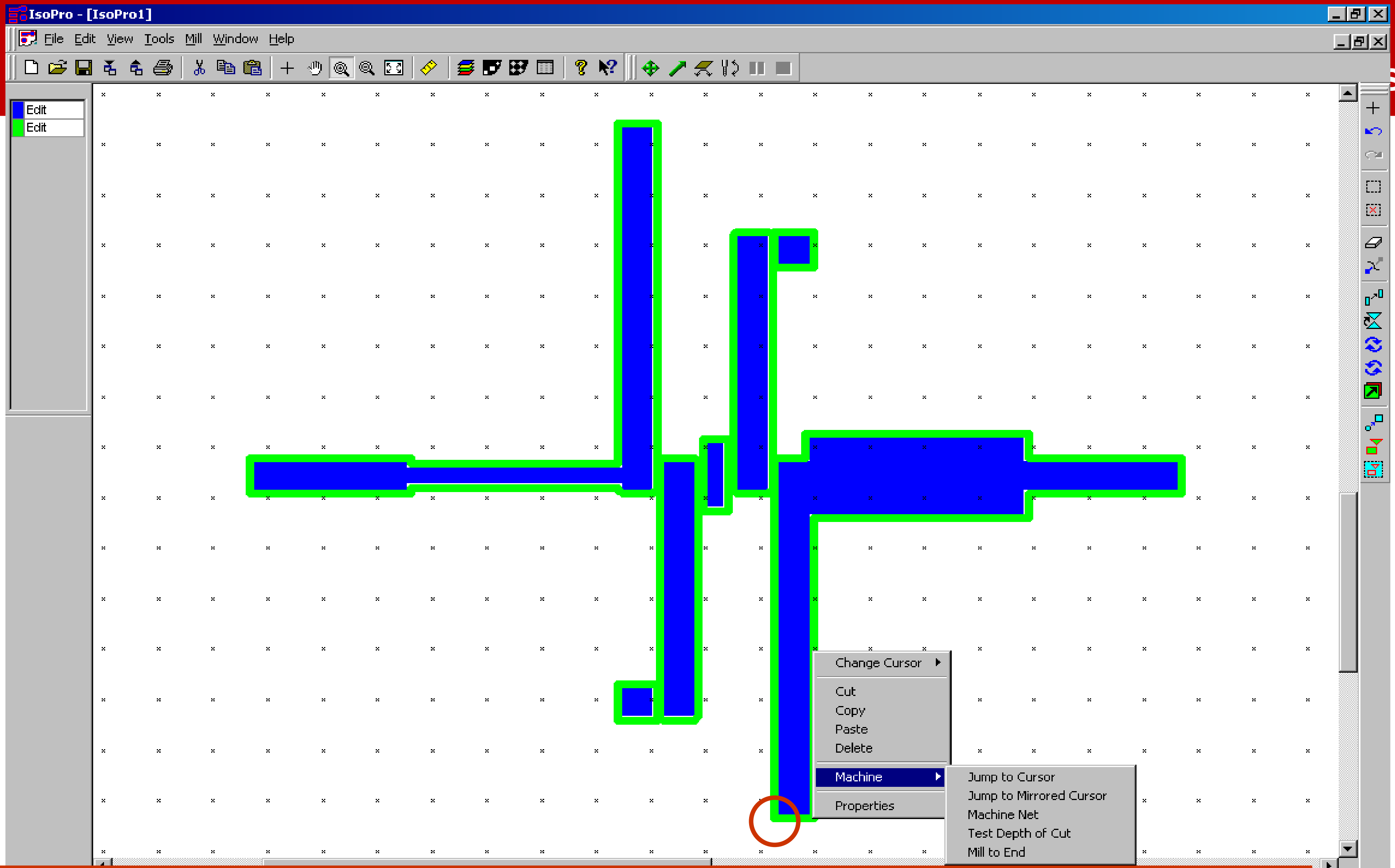
After moving the solenoid : +600 in y,

Use double-sided tape to glue your FR4 layer to the engraving table.

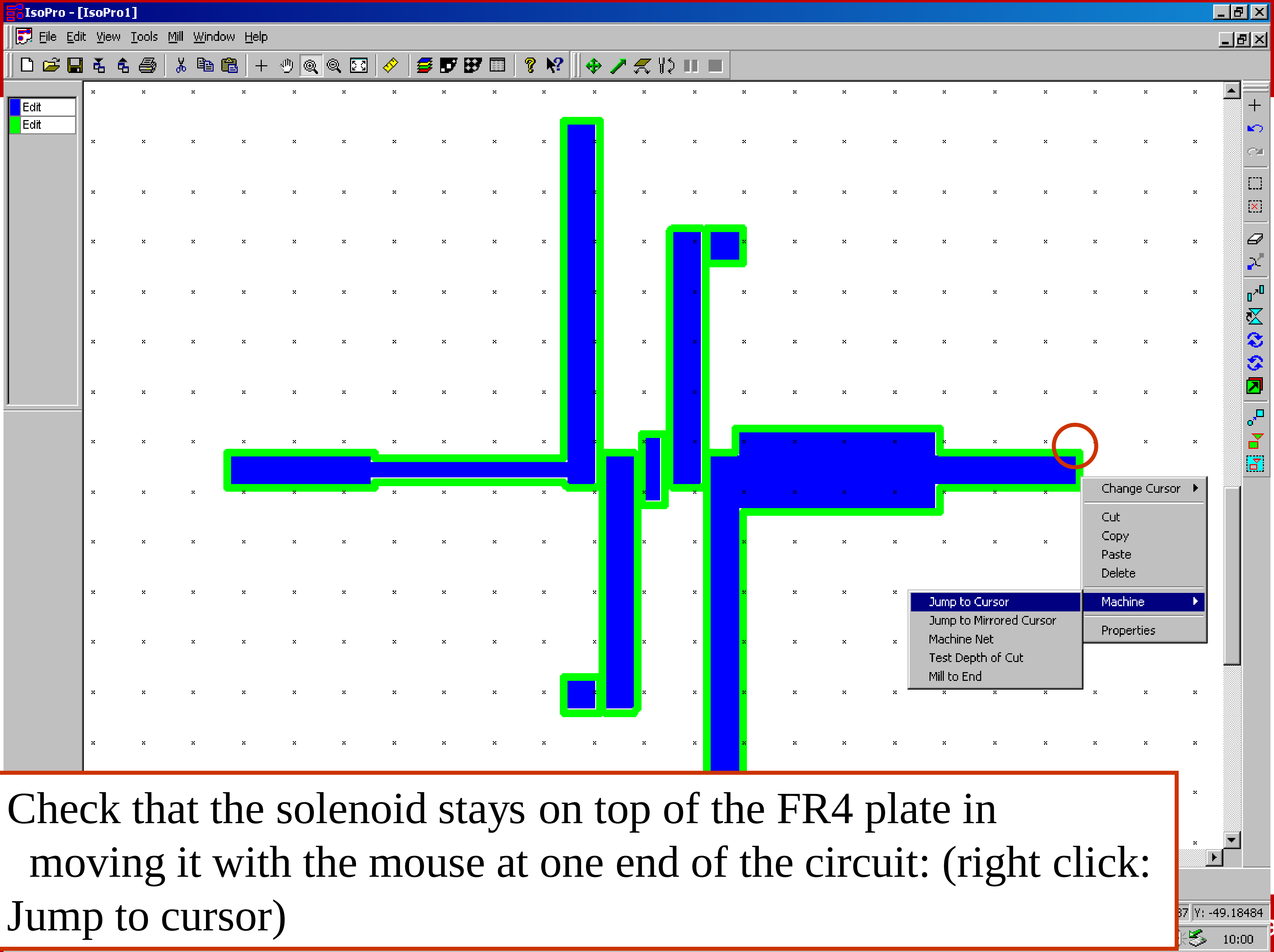
Make sure the location of the plate coincides with the location of the mask on ISOPRO



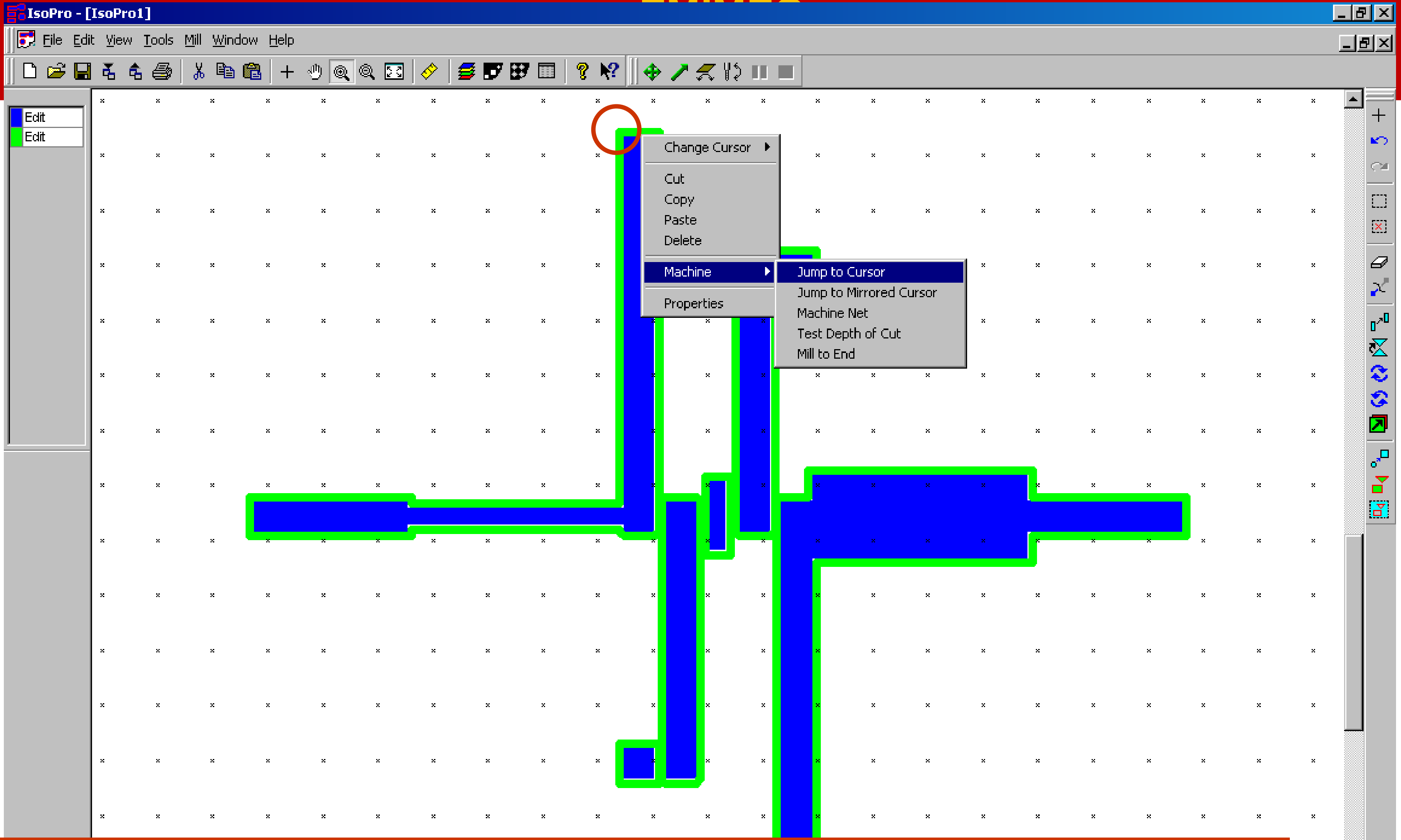
Check that the solenoid stays on top of the FR4 plate by moving it with the mouse at one end of the circuit: (right click: Jump to cursor)



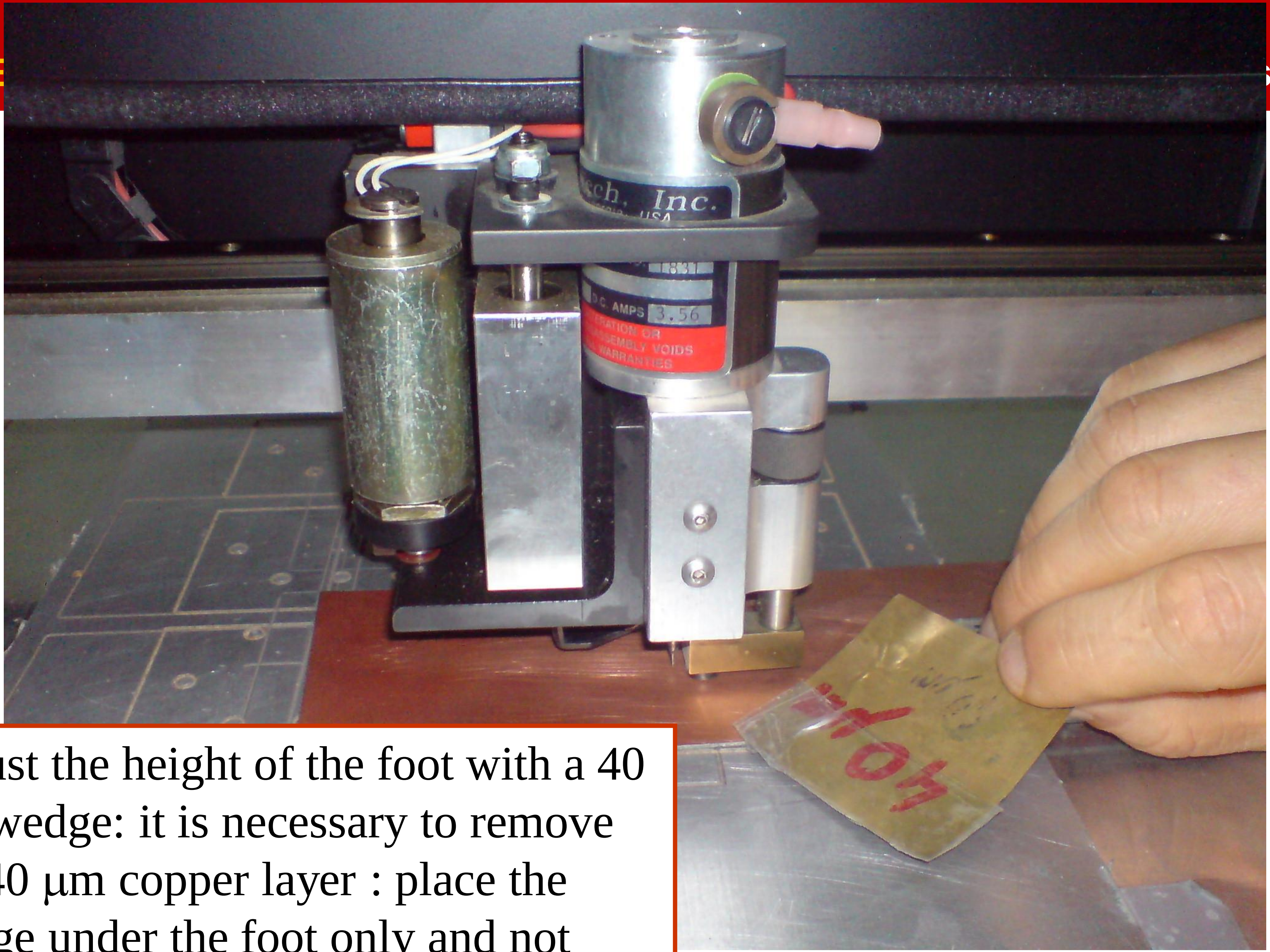
Check that the solenoid stays on top of the FR4 plate in moving it with the mouse at one end of the circuit: (right click: Jump to cursor)



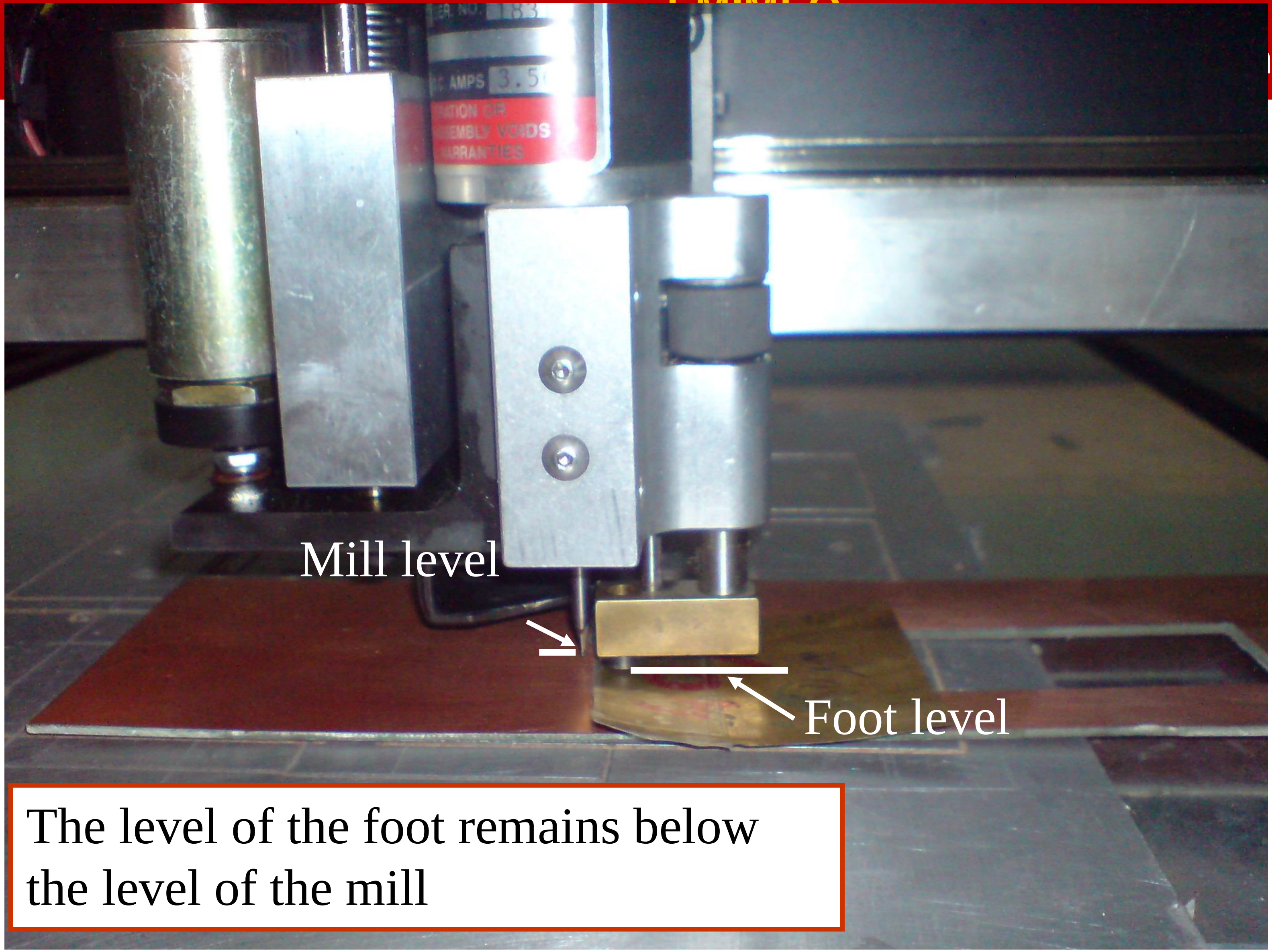
Check that the solenoid stays on top of the FR4 plate in moving it with the mouse at one end of the circuit: (right click: Jump to cursor)

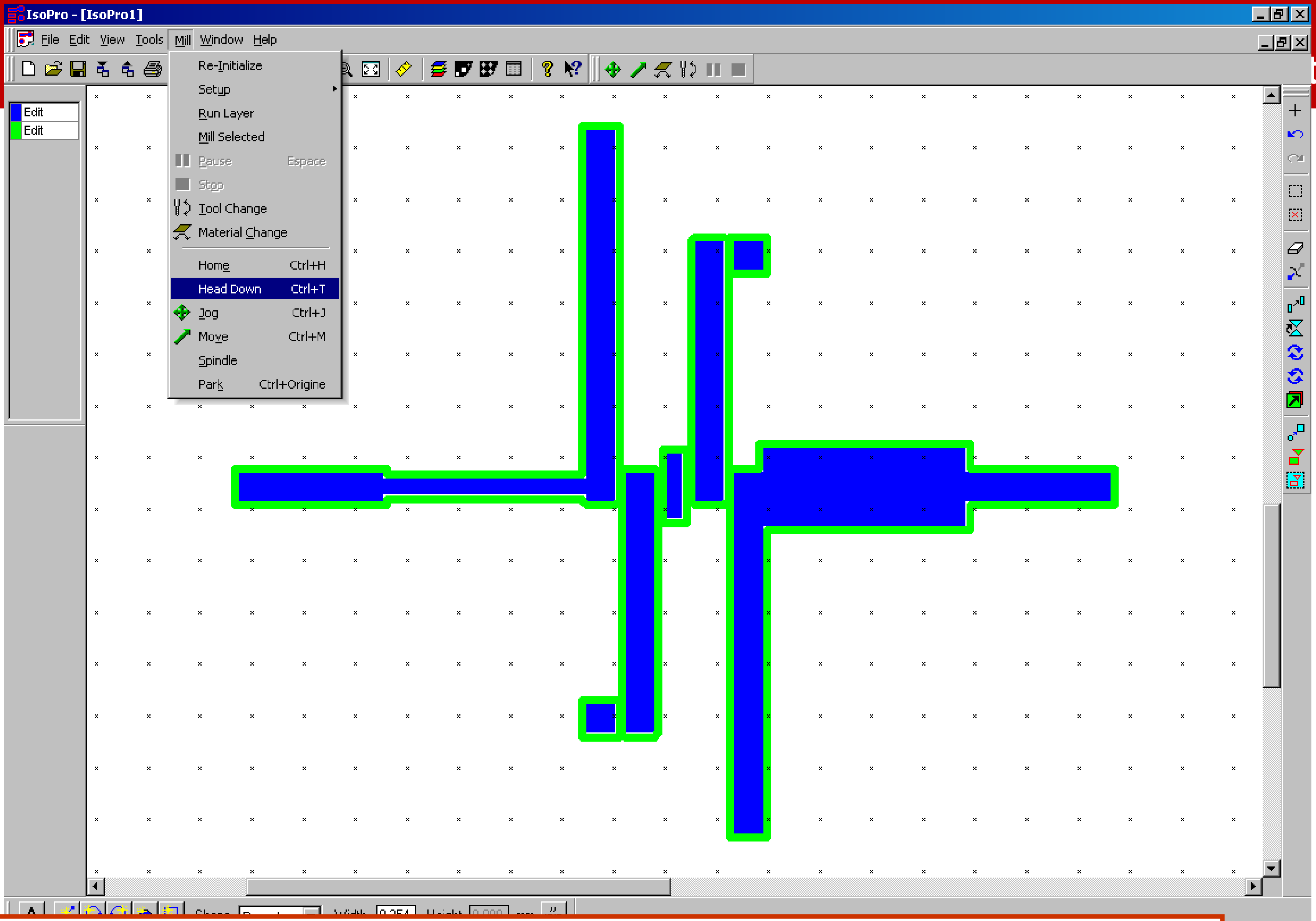


Check that the solenoid stays on top of the FR4 plate in moving it with the mouse at one end of the circuit: (right click: Jump to cursor)

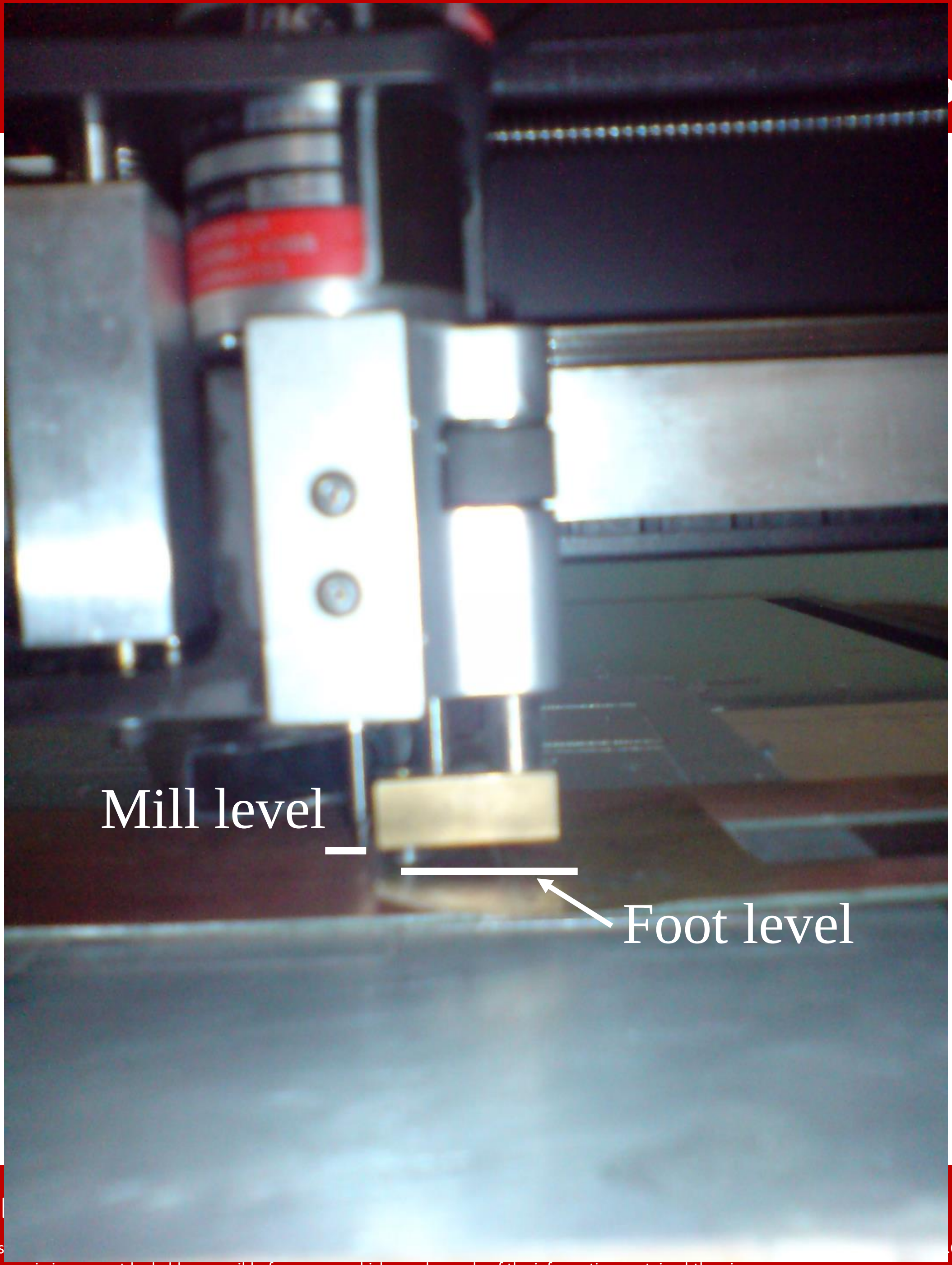


Adjust the height of the foot with a 40 μm wedge: it is necessary to remove the 40 μm copper layer : place the wedge under the foot only and not under the mill


Mill level
Foot level
The level of the foot remains below the level of the mill

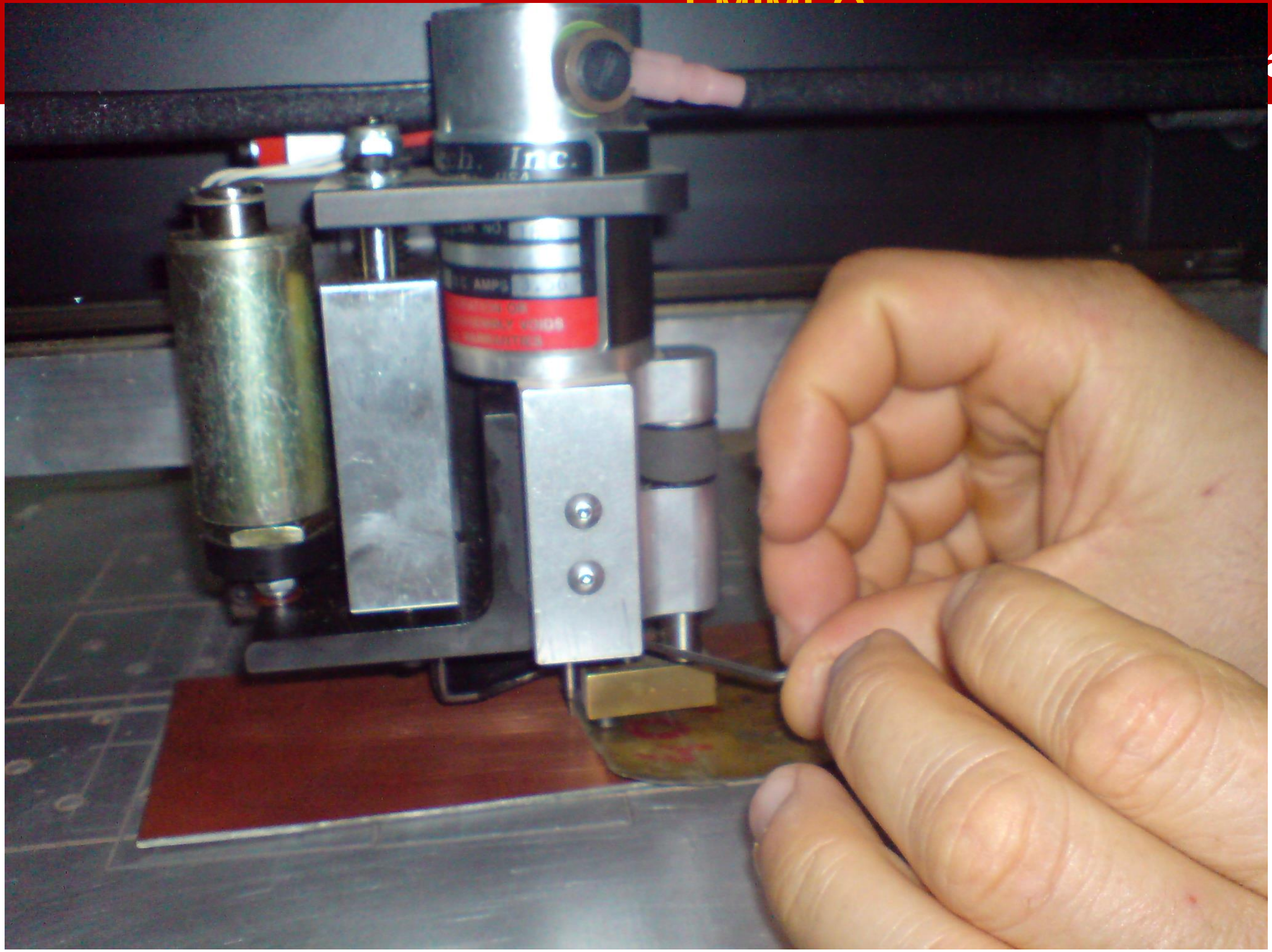


Lower the foot of the solenoid by clicking Mill / Head Down

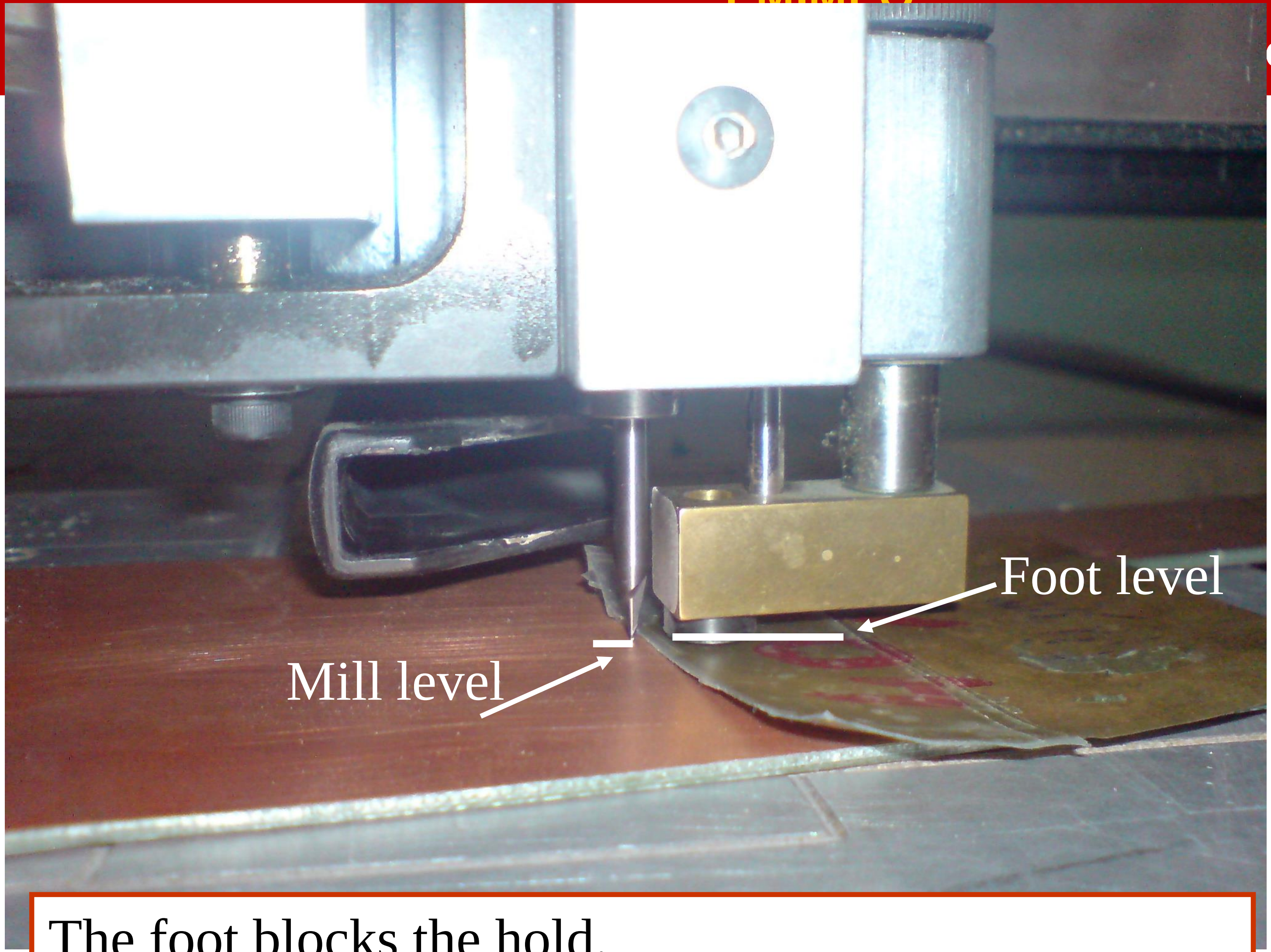


The foot blocks the hold.

The mill is always above the foot.

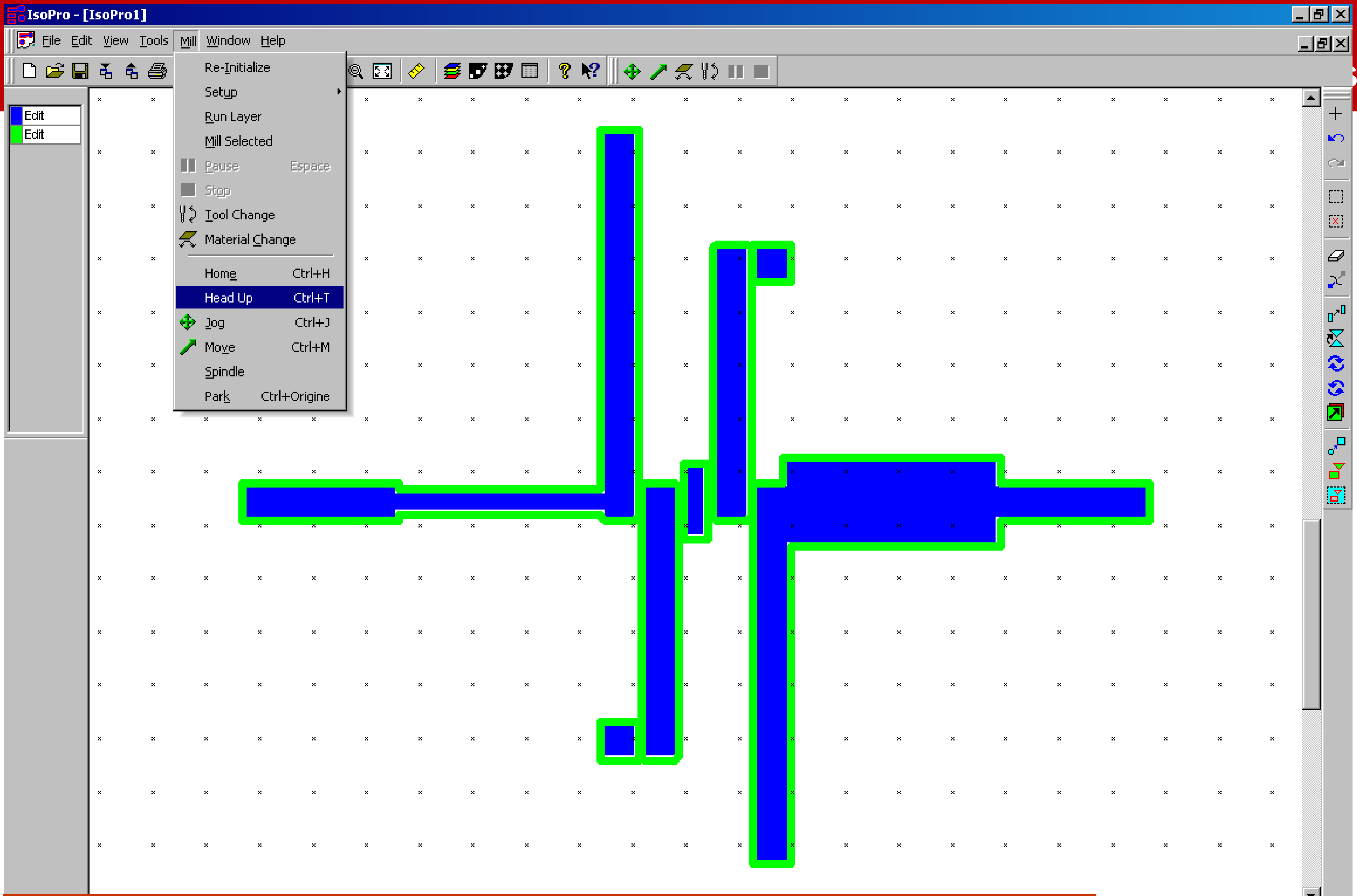


Lower the mill by unscrewing the clamping screw and tapping the solenoid

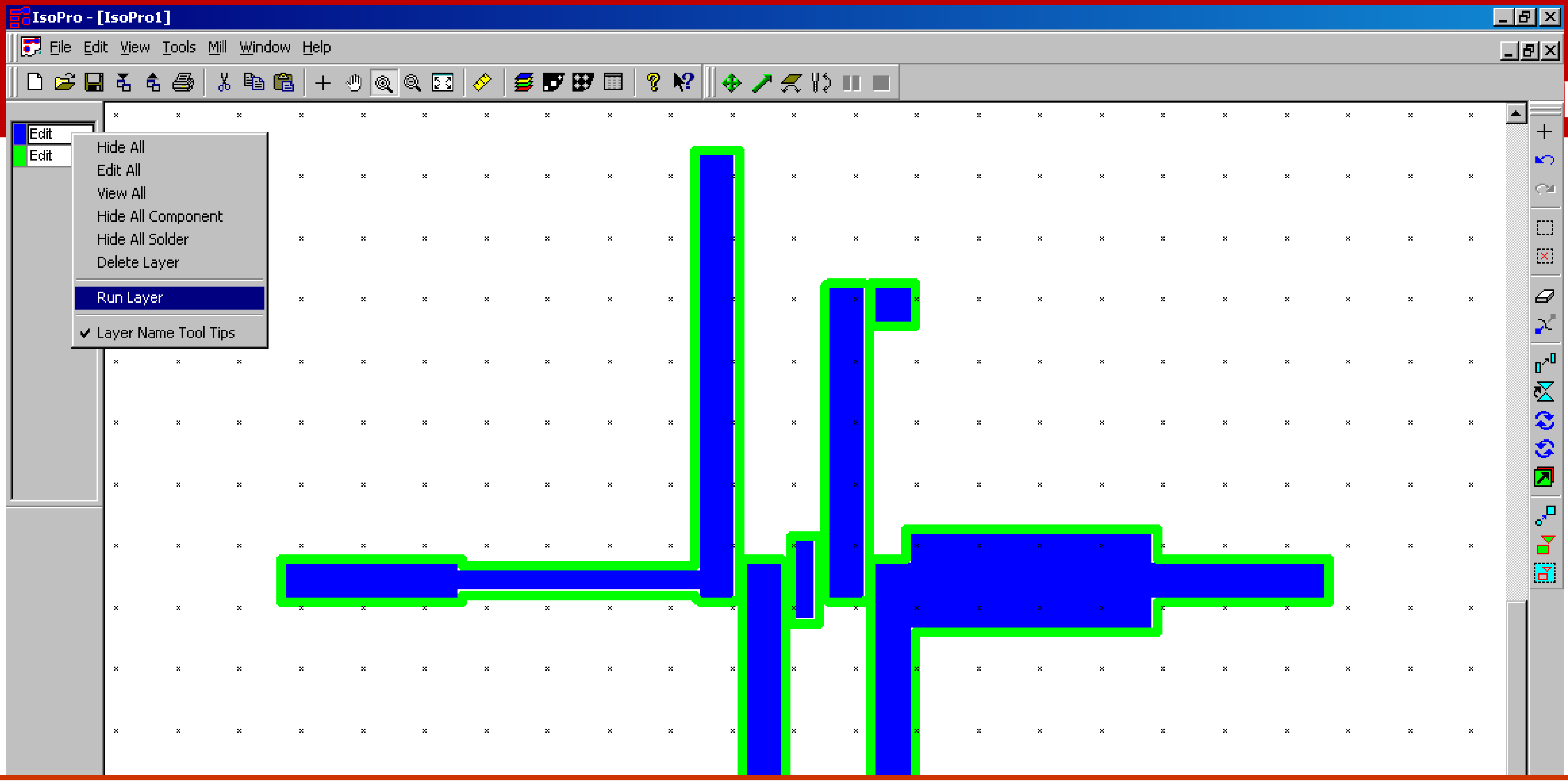


The foot blocks the hold.

The mill is now below the foot level.

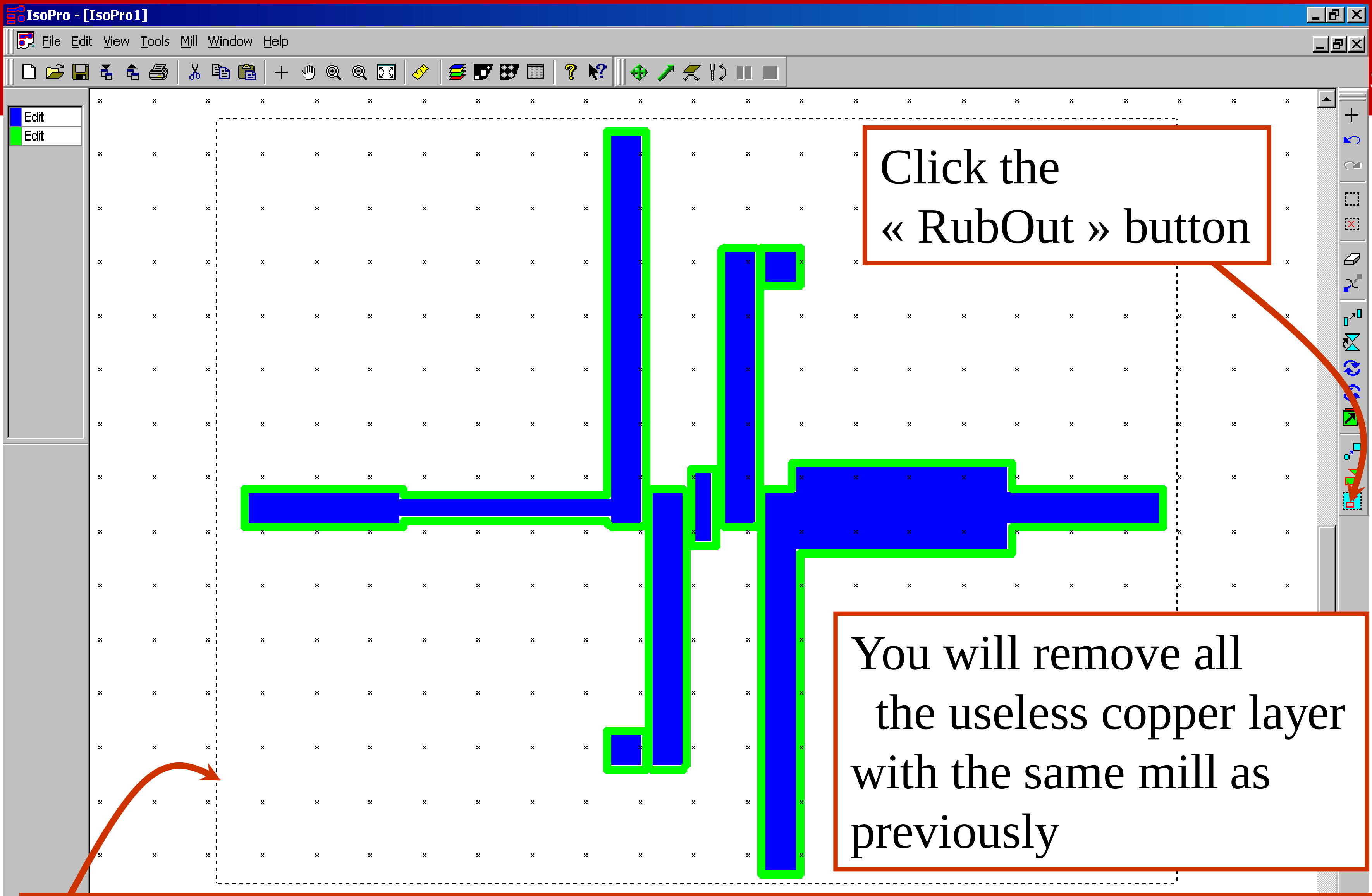


Lift the foot of the solenoid and the mill by clicking on Mill / Head up



Bring the mouse to the left menu and the green layer: click button right and select RUN LAYER: the vacuum starts, the mill rotates and the machine will outline the lines.

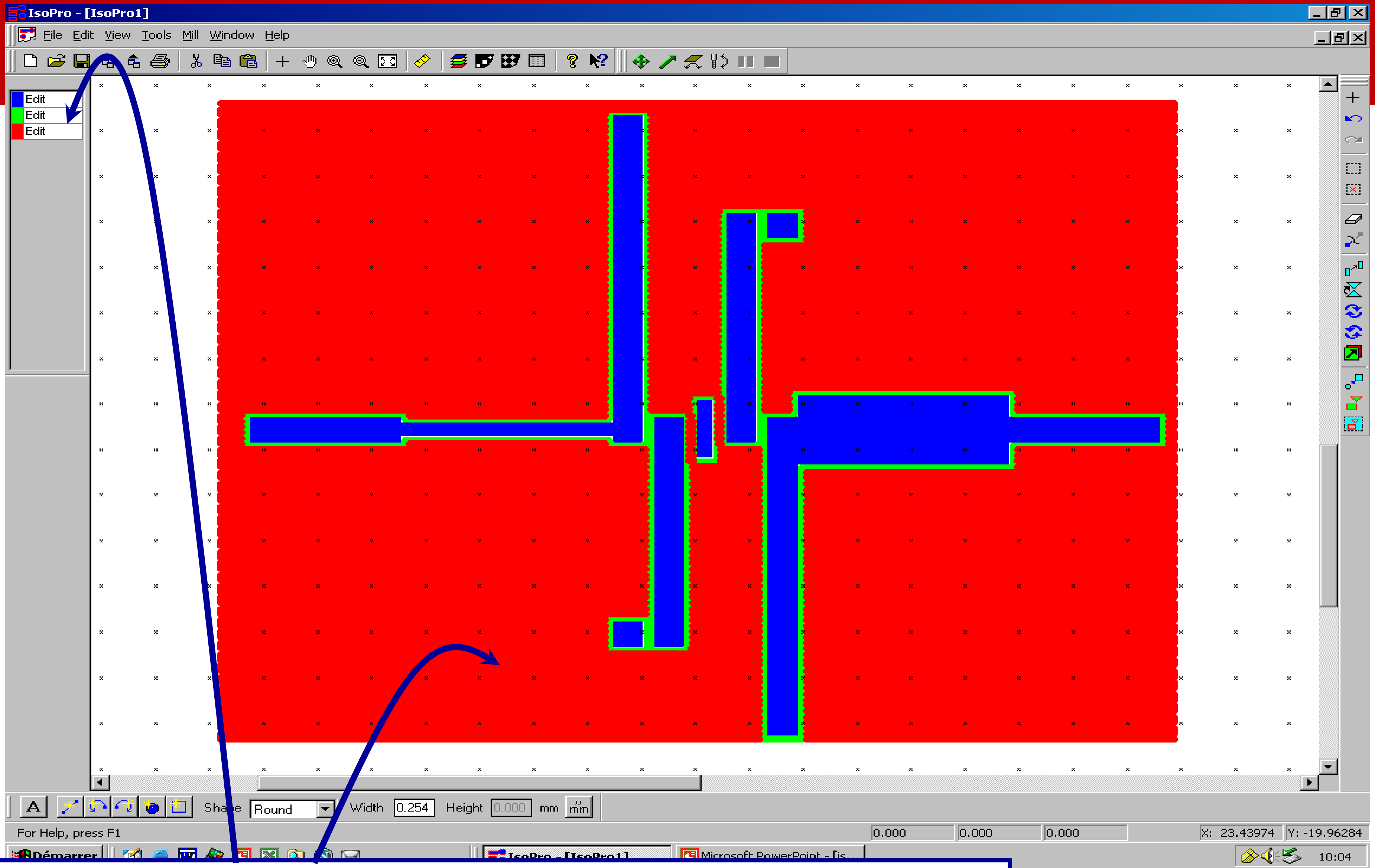
If it does not work the first time, select RUN LAYER a second time.



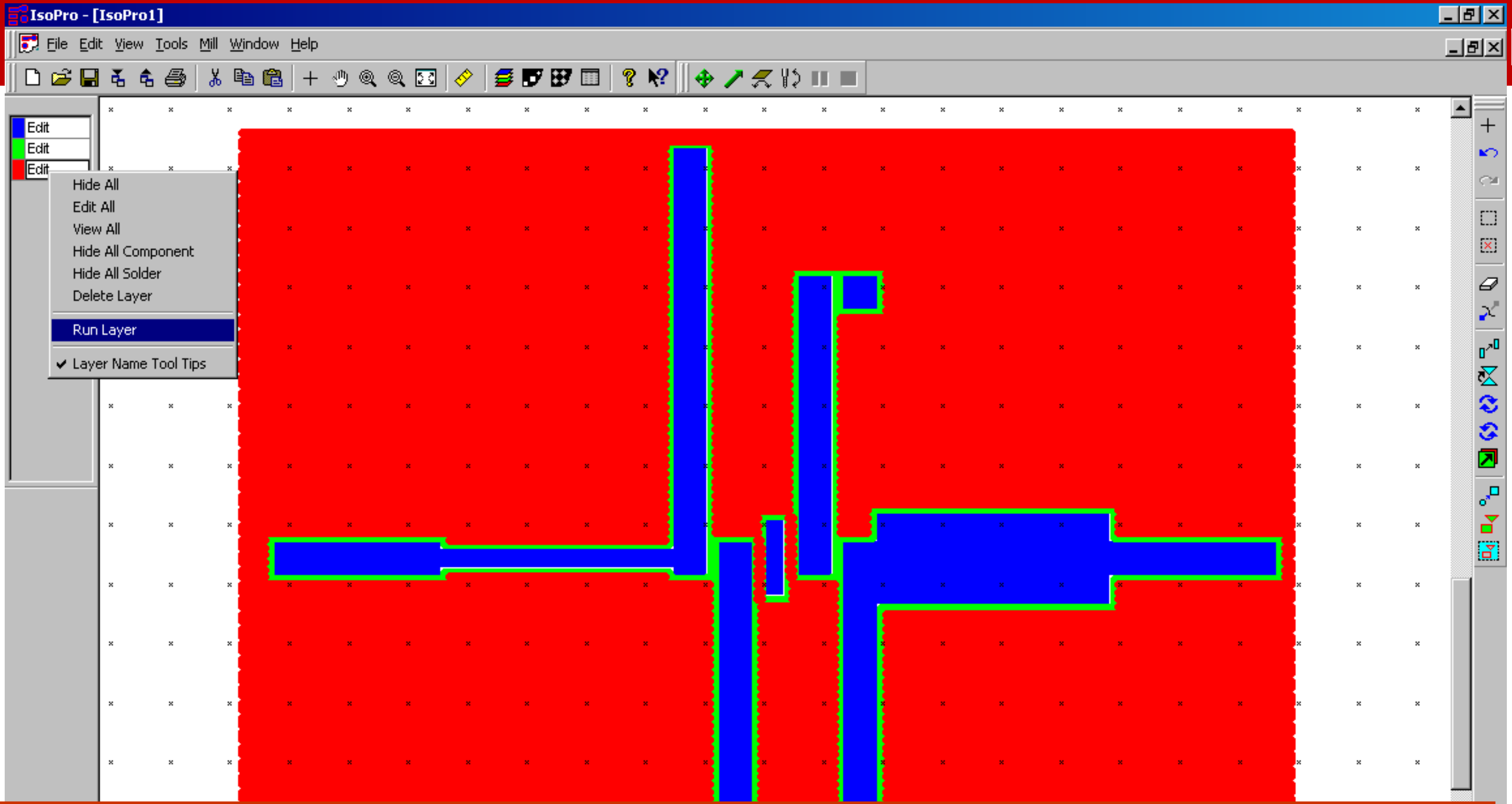
Click the « RubOut » button

You will remove all the useless copper layer with the same mill as previously

Draw with the mouse the area of copper you wish to remove: Left and right boundaries near lines. Leave some margin up and down



The layer of "Rub Out" appears in red on the layout and in the menu at the top left



Bring the mouse to the left menu and the red layer: click button right and select RUN LAYER: the vacuum starts, the mill rotates and the machine will remove unnecessary copper.

If it does not work the first time, select RUN LAYER a second time.

Once the copper layer is removed:

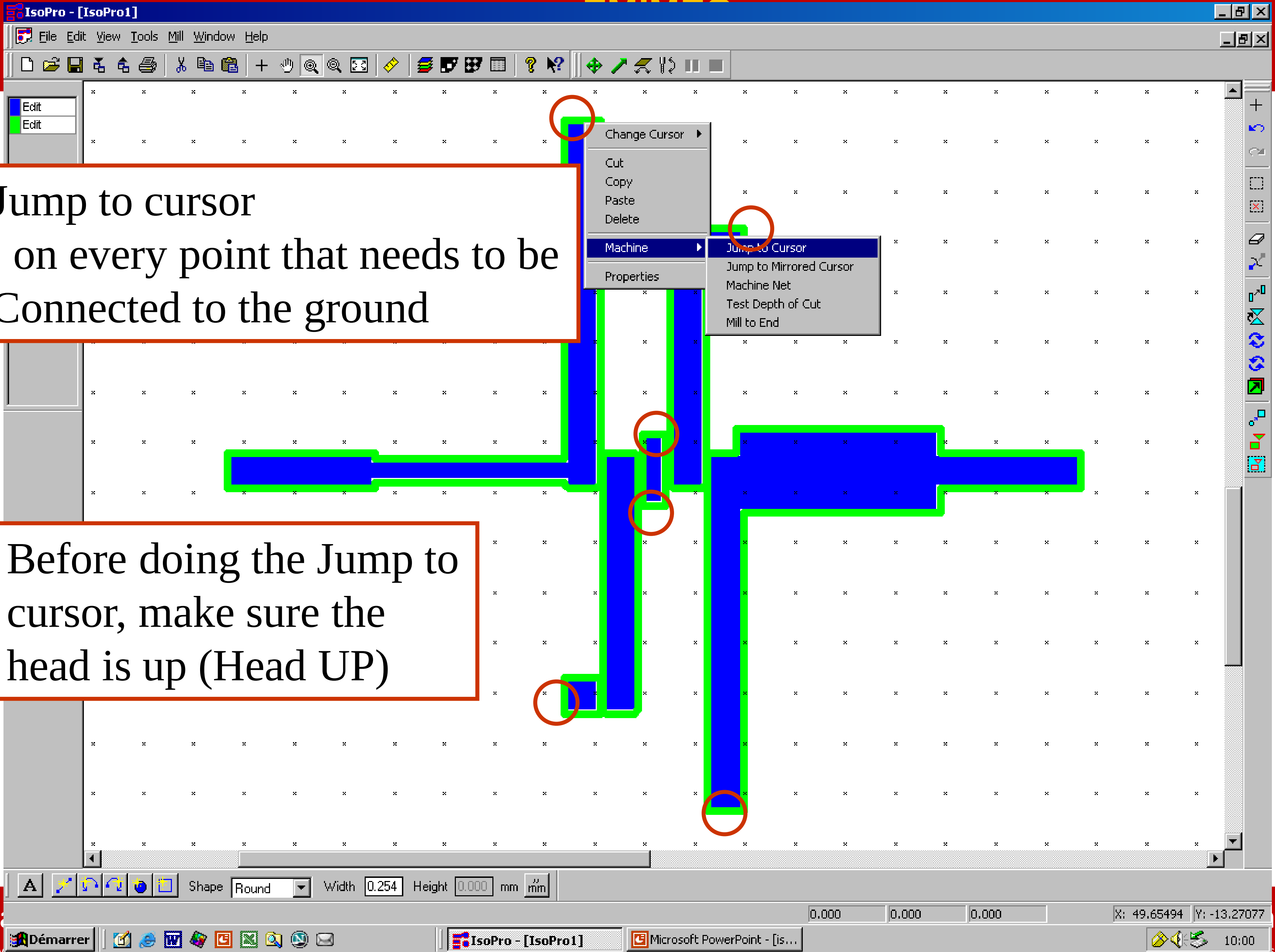
1°) move the bench and the solenoid as previously in $x = -300$ then $y = -300$

2°) when the chuck is out of the table, unscrew the clamping screw and remove the mill. Replace it immediately in its box.

3°) Replace the mill with a drill bit (Drill bit) which will allow to make the holes for the ground and screw the tightening screw.

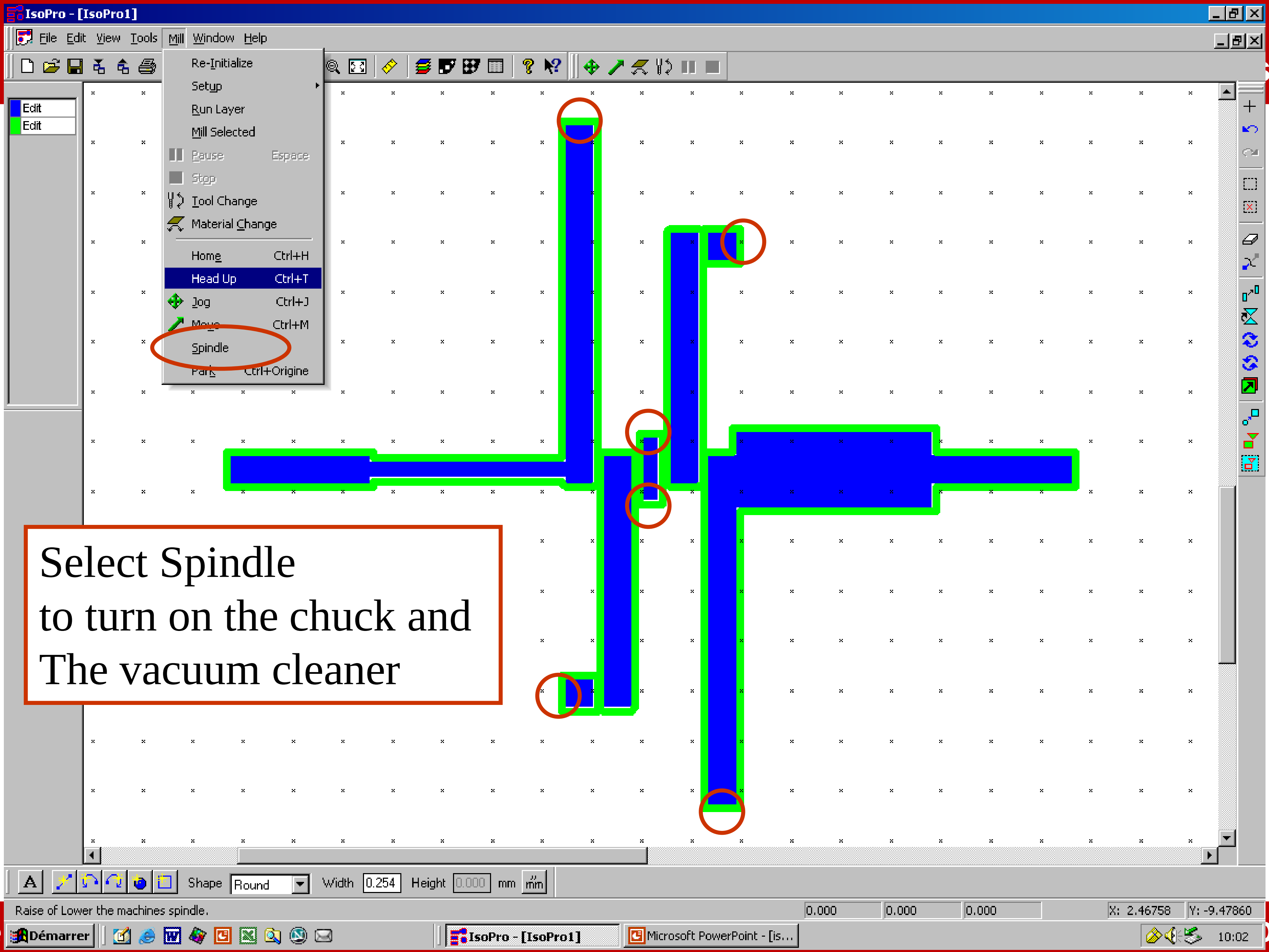
4°) adjust the depth of the drill using a plate of FR4 + 2 wedges (20 and 40µm). Proceed as explained previously for adjusting the depth of the mill.

Another solution: you can also use the small drill in the room. In this case, in step 2 simply remove the mill and screw back the clamping screw then go to step 4 of the "Once copper layer removed" slide below

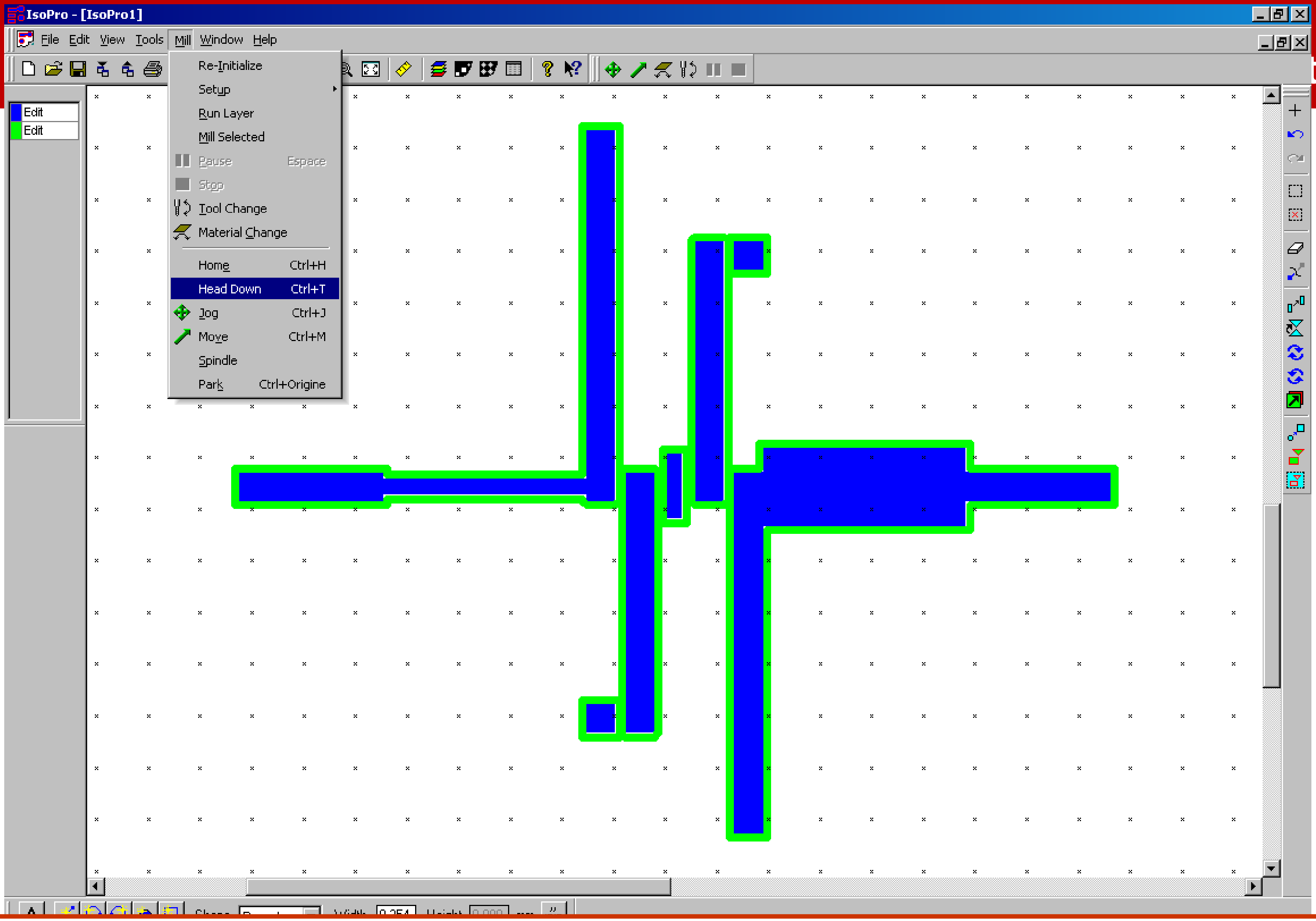


Jump to cursor
on every point that needs to be
Connected to the ground

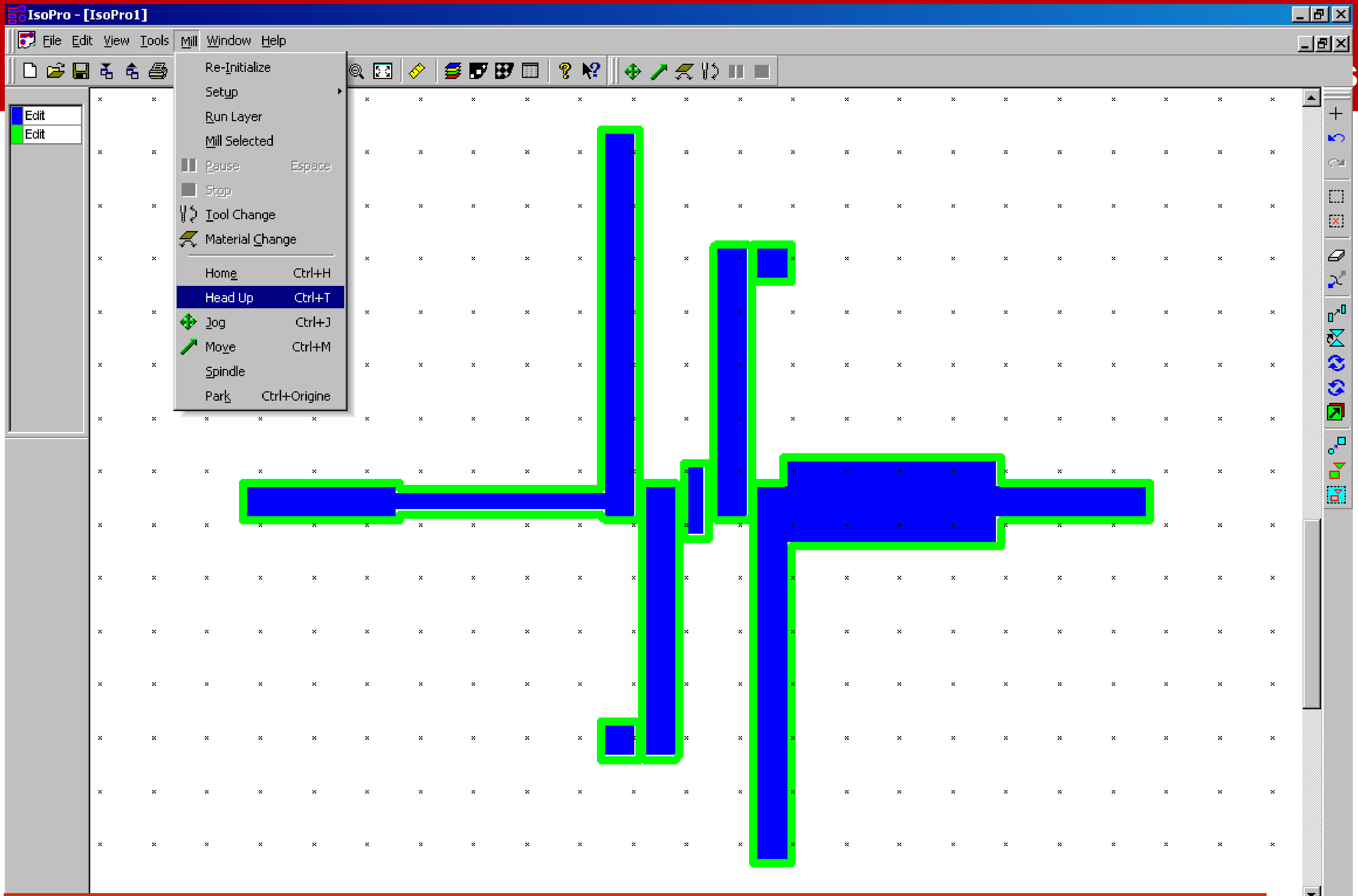
Before doing the Jump to cursor, make sure the head is up (Head UP)



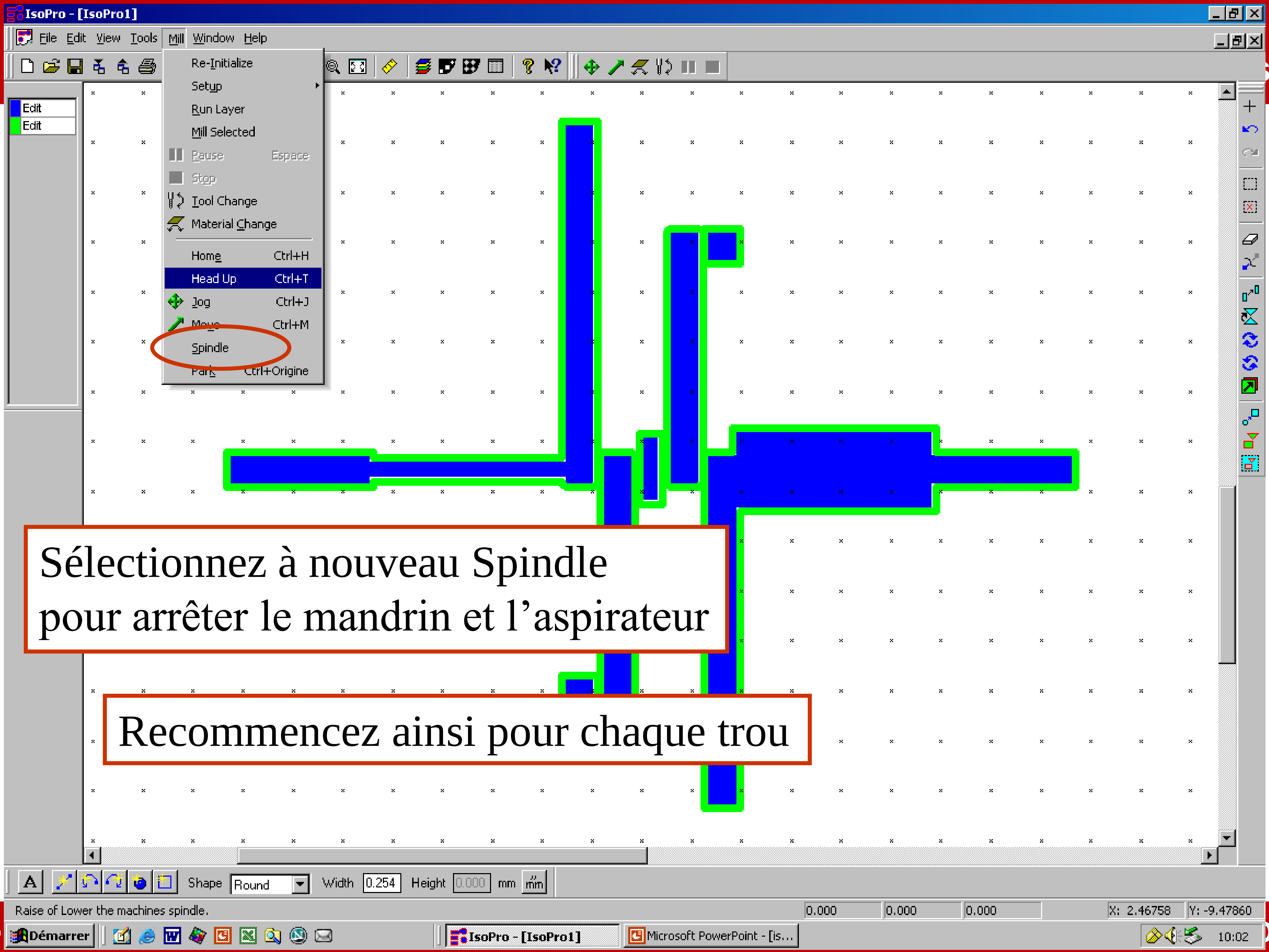
Select Spindle
to turn on the chuck and
The vacuum cleaner



Faites descendre le pied du solénoïde en cliquant sur Mill/Head Down



Faites remonter le pied du solénoïde et la mèche en cliquant sur Mill/Head up : le trou est percé.



Sélectionnez à nouveau Spindle pour arrêter le mandrin et l'aspirateur

Recommencez ainsi pour chaque trou

Once the copper layer is removed:

1°) move the bench and the solenoid as previously in x = -300 then y = -300

2°) when the chuck is out of the table, unscrew the clamping screw and remove the drill. Replace it immediately in its box.

3°) screw back the clamping screw

4°) move the bench and the solenoid as previously in x = +600.

5°) Unplug the vacuum at the back of the bench

6°) select Spindle and vacuum the chips on your plate

7°) Select Spindle again to stop vacuuming

8°) Clean your plate with the "scotch brite“

9°) peel off your FR4 plate from the table with a screwdriver

10°) Peel off the double-sided tape on the back of the plate and clean it with the "scotch brite"

11°) Look for soldering components: capacitors, transistors, ground wire, power supply wires, connectors

12°) Pass the wires in the ground holes and weld.

13°) Solder the other components.

The PA is complete: you must get: