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SEL0621: Experiência 4

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Instituto de Ciências Matemáticas e de Computação – ICMC
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Sumário

1 Introdução

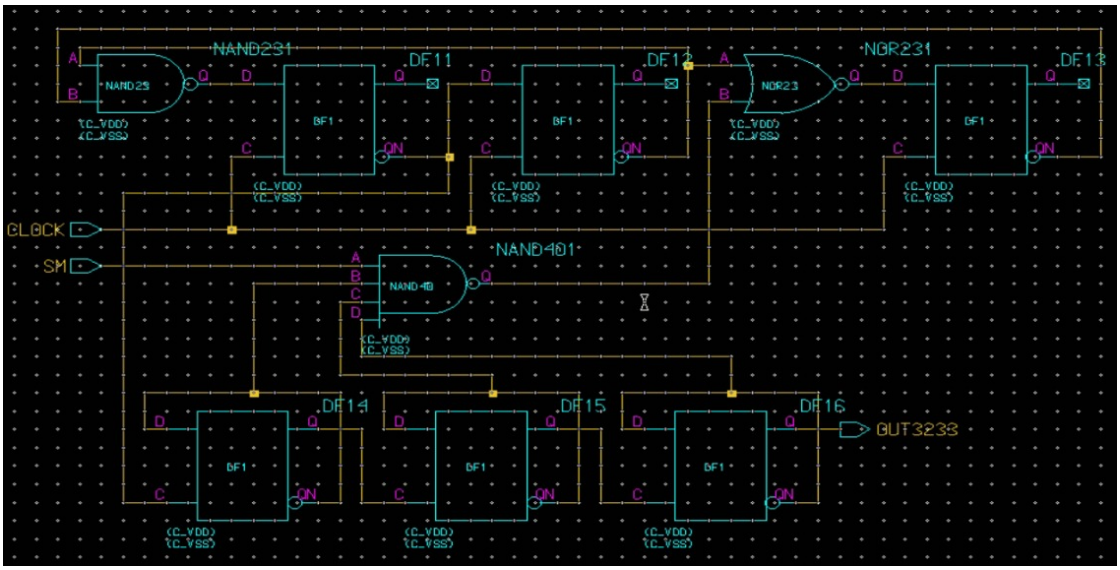
Neste experimento daremos continuidade nas analises relacionadas a máxima velocidade de operação para estabelecer a máxima frequência de operação, sendo que, o objeto de estudo a complementação do contador para o circuito completo Prescaler 32/33. Também verificaremos as ferramentas de auto posicionamento com ***autofloorplan*** e a execução dos roteamentos a partir do ***ROUTE > RUN***.

2 Questões

Questão 1: Considere o circuito da Figura 1 (circuito prescaler). Desenhe o circuito completo do esquemático da Fig. 1 utilizando as células DF1, NAND23, NOR23 e NAND40. Como sinais de entrada ele deve ter o clock e SM; como sinal de saída, saida32_33 (divide o clock por 32 ou 33)

Apresenta-se na figura 1 o circuito Prescaler 32/33.

Figura 1 – Esquemático do circuito Prescaler 32/33

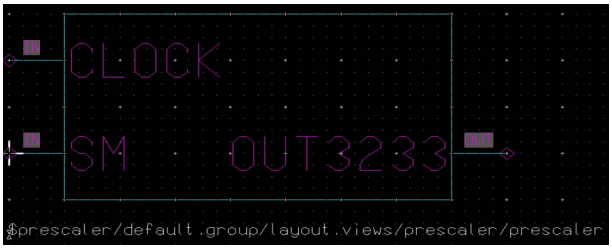


Fonte: Pelos próprios autores

Questão 2: Gere o símbolo para a célula e faça a verificação do esquemático e do símbolo. Certifiquese de que não haja erros ou mesmo warnings.

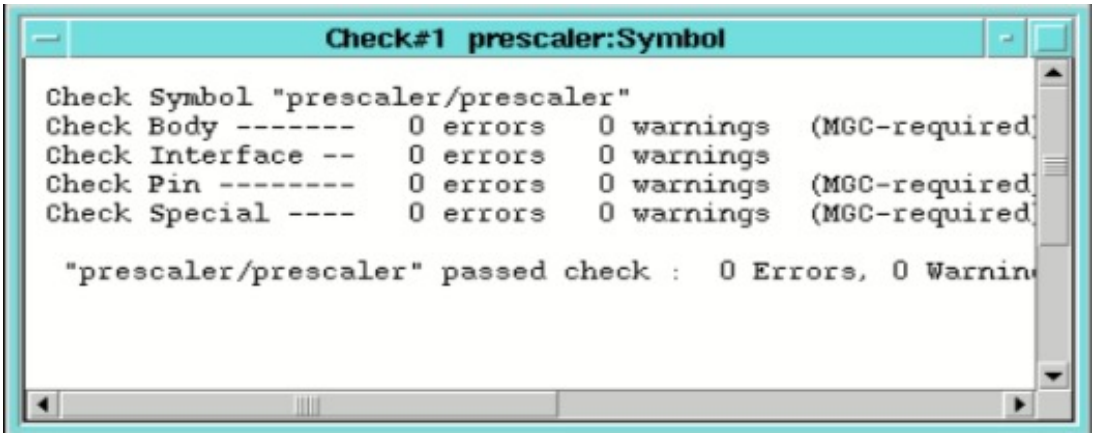
A seguir na figura 2 simbolo gerado para o circuito Prescaler e figura 3 com a verificação.

Figura 2 – Símbolo do circuito Prescaler 32/33



Fonte: Pelos próprios autores

Figura 3 – Verificação do símbolo para circuito Prescaler 32/33

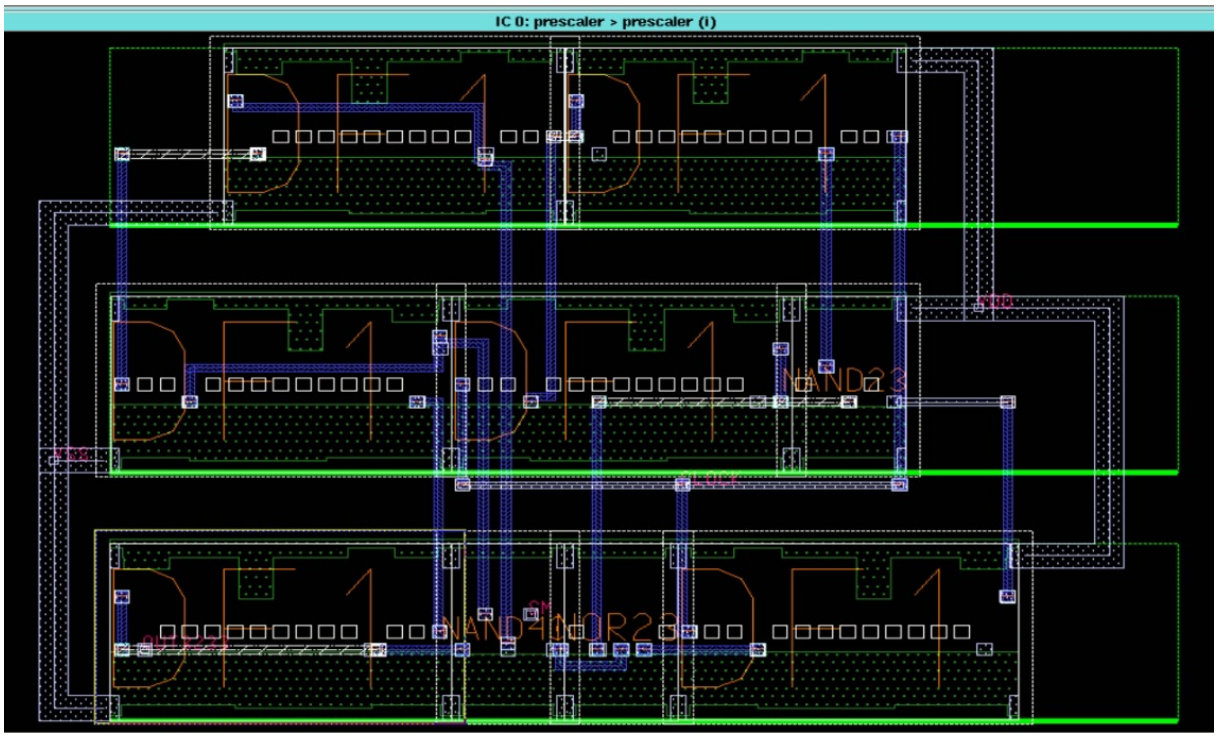


Fonte: Pelos próprios autores

Questão 3 - 6: Gere o layout do circuito a partir do SDL (utilize o designviewpoint e não o schematic). Passe o DRC e LVS

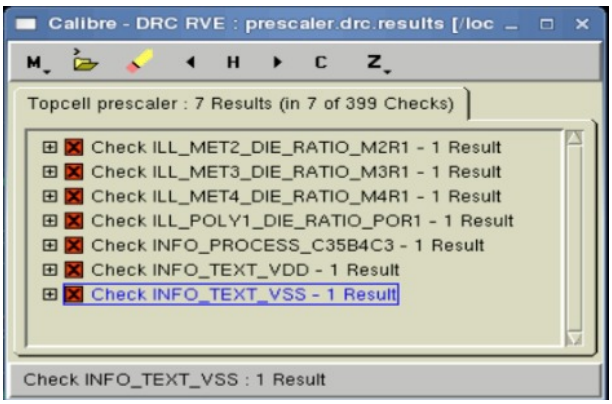
O Layout com todas as etapas dos itens 3 a 6 presente na figura 4, além da sua verificação DRC e LVS, nas figuras 5 e 6.

Figura 4 – *Layout* do circuito Prescaler 32/33



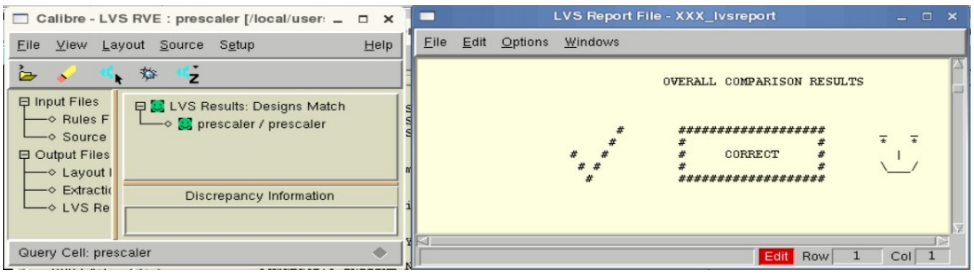
Fonte: Pelos próprios autores

Figura 5 – Verificação DRC para *Layout* do circuito Prescaler 32/33



Fonte: Pelos próprios autores

Figura 6 – Verificação LVS *Layout* do circuito Prescaler 32/33

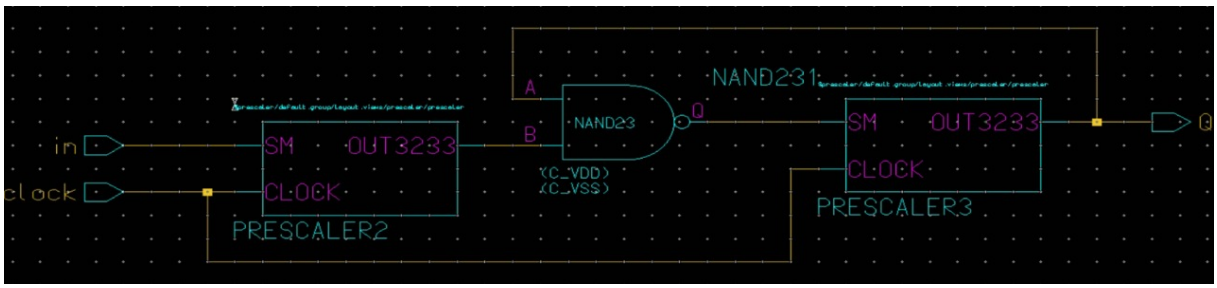


Fonte: Pelos próprios autores

Questão 7: Considere o circuito da Figura 2 (não tem função alguma, servindo apenas para ilustração). Desenhe o esquemático desse circuito utilizando a célula NAND23 e o prescaler anterior (faça as devidas checagens).

Conforme ilustrado na figura 5 do enunciado temos o esquemático presente na figura 7.

Figura 7 – Esquemático do circuito modificado Prescaler 32/33, figura 5 do enunciado

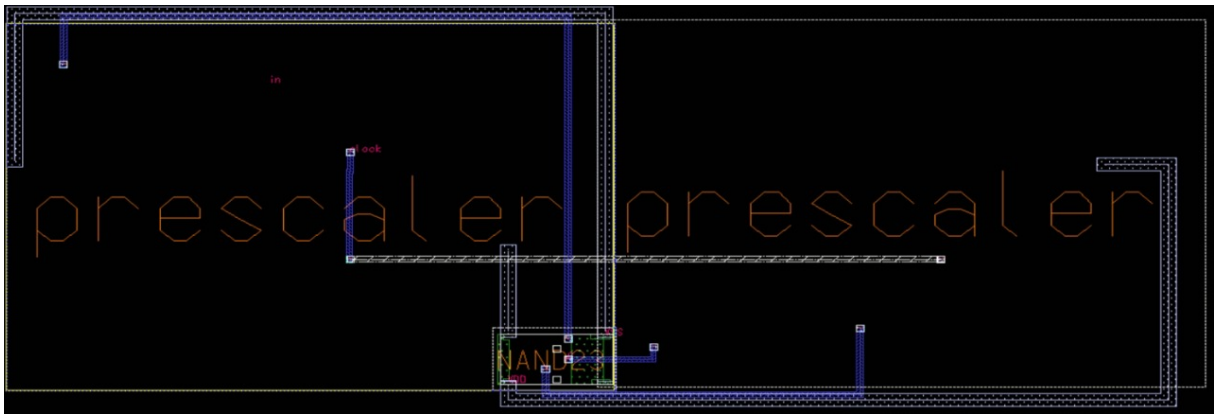


Fonte: Pelos próprios autores

Questão 9: Termine as conexões, adicione ports, faça o DRC e o LVS. Inclua no relatório o layout feito.

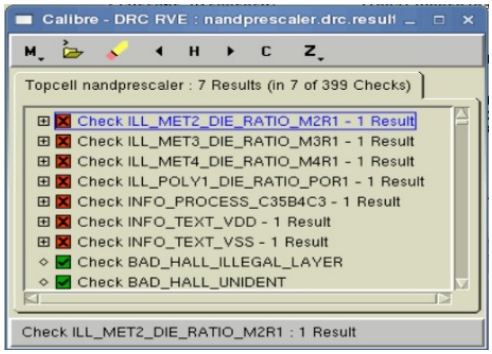
Após o item 8 geramos o *layout* presente na figura 8, além das verificações DRC e LSV presentes nas figuras 9 e 10

Figura 8 – *Layout* do circuito modificado Prescaler 32/33, figura 5 do enunciado



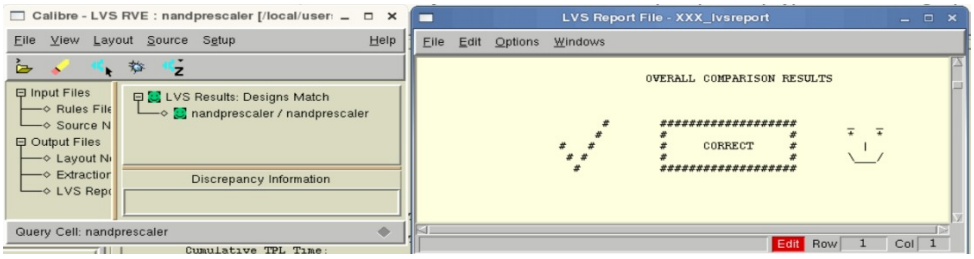
Fonte: Pelos próprios autores

Figura 9 – Verificação DRC - *Layout* do circuito modificado Prescaler 32/33, figura 5 do enunciado



Fonte: Pelos próprios autores

Figura 10 – Verificação LSV - *Layout* do circuito modificado Prescaler 32/33, figura 5 do enunciado

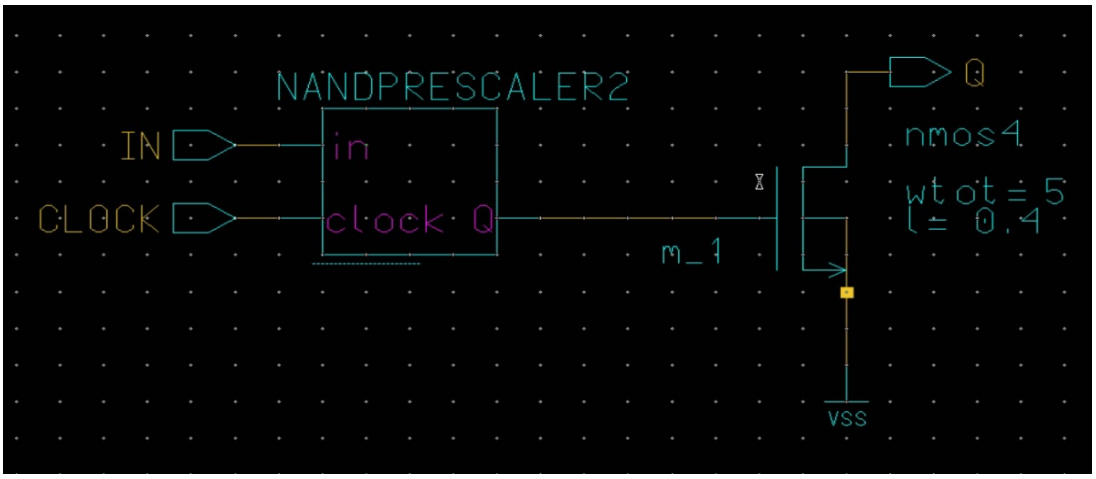


Fonte: Pelos próprios autores

Questão 10: Modifique o circuito adicionando um transistor na saída como indicado na Figura 3. Novamente gere o layout, adicione ports, faça o DRC e o LVS. Quais são os valores da saída quando o gate do transistor está "Alto" e quando está "Baixo"? Inclua no relatório o layout feito.

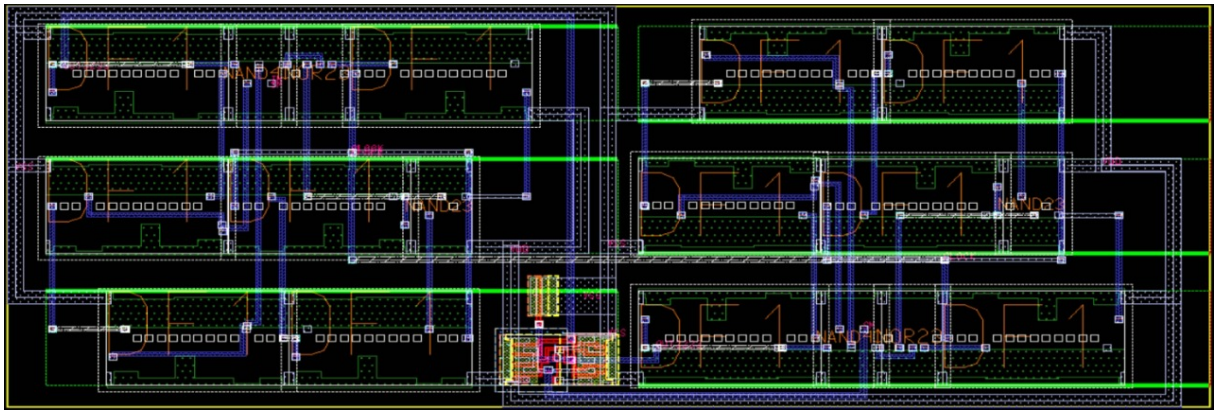
Estudaremos o circuito Prescaler com acréscimo do transistor TBJ na saída afim de verificar os valores na saída em nível lógico alto e baixo para o *gate*. Para isso, elaborou-se o esquemático e *layout* presentes nas figuras 11 e 12, além das verificações DRC e LVS presentes nas figuras 14 e 15.

Figura 11 – Esquemático do circuito modificado Prescaler 32/33, figura 8 do enunciado



Fonte: Pelos próprios autores

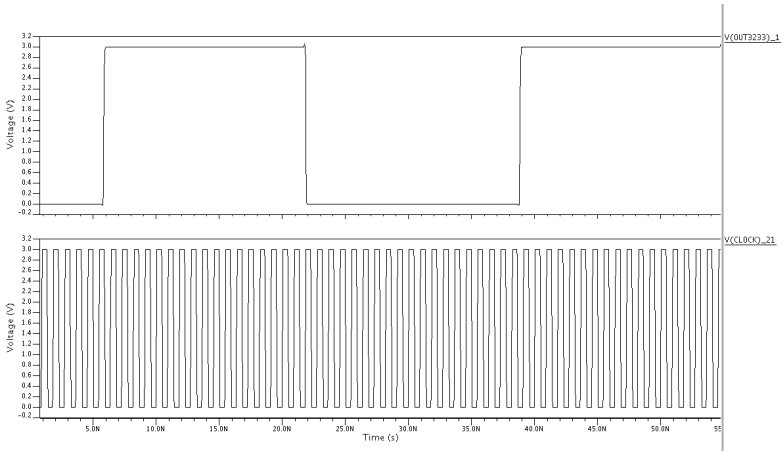
Figura 12 – *Layout* do circuito modificado Prescaler 32/33, figura 8 do enunciado



Fonte: Pelos próprios autores

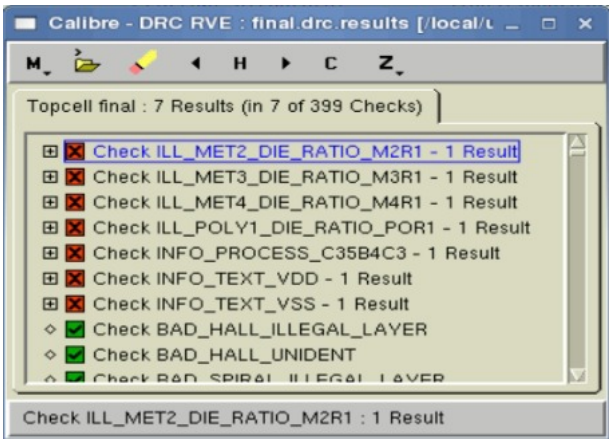
Verificou-se que se o *gate* do transistor estiver em nível lógico alto, o transistor conduz e a tensão em sua saída é igual à tensão em seu *source*. Se o *gate* estiver em nível lógico baixo, o transistor estará cortado, não havendo condução e assim, a saída ficará com alta impedância, como verificado na figura 14.

Figura 13 – Tensões de saída e *source* para verificar o comportamento dos nível lógicos do *gate*



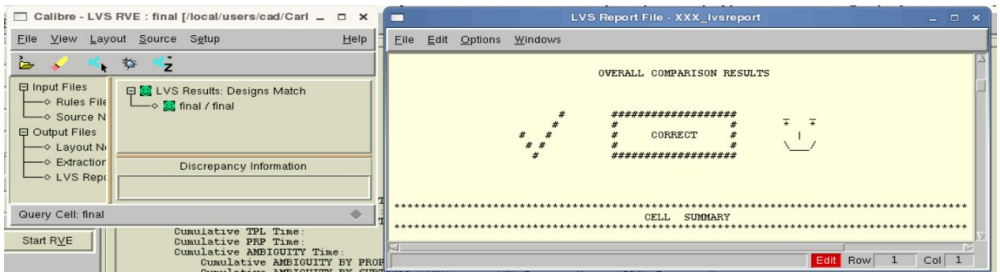
Fonte: Pelos próprios autores

Figura 14 – Verificação DRC - *Layout* do circuito modificado Prescaler 32/33, figura 8 do enunciado



Fonte: Pelos próprios autores

Figura 15 – Verificação LVS - *Layout* do circuito modificado Prescaler 32/33, figura 8 do enunciado



Fonte: Pelos próprios autores

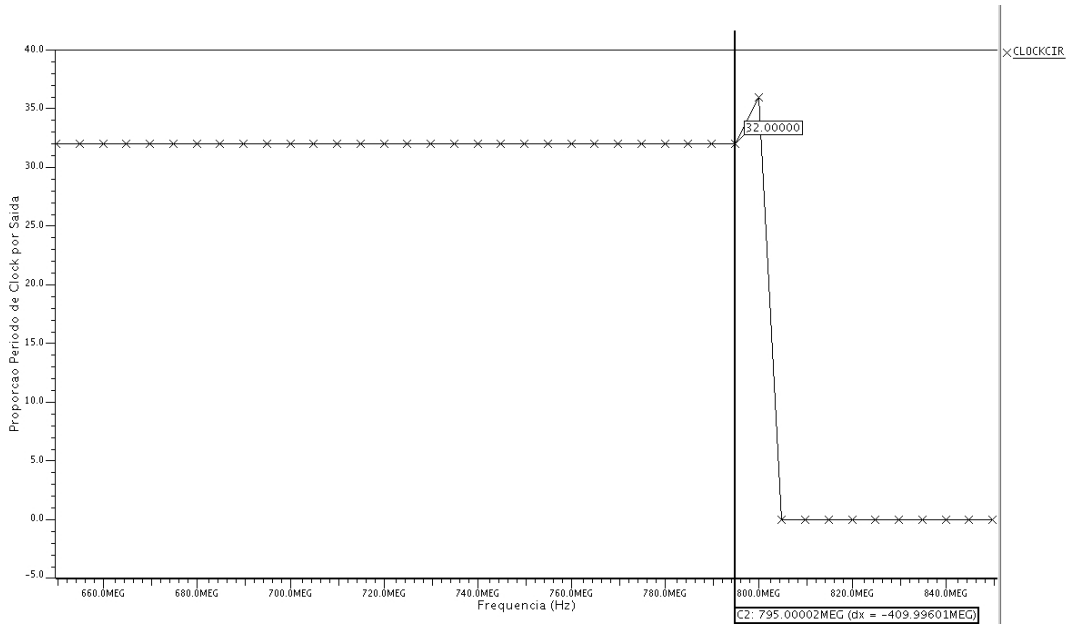
Questão 11: Voltando ao circuito da Figura 1, extrair a partir do esquemático o netlist e determinar a máxima velocidade para os modelos típico e worstspeed (o circuito deve dividir o clock por 32, para SM = "0", ou por 33, para SM = "1"). Use o comando measure, compare as frequências obtidas nos dois modelos e comente os resultados.

Idem a pratica anterior usaremos a proporção do período de entrada e *clock* para excursionar o frequência máxima de operação. E conforme o enunciado devemos observar a relação igual a 32 para SM=0 e 33 para o SM=1.

Para extração a partir do esquemático.

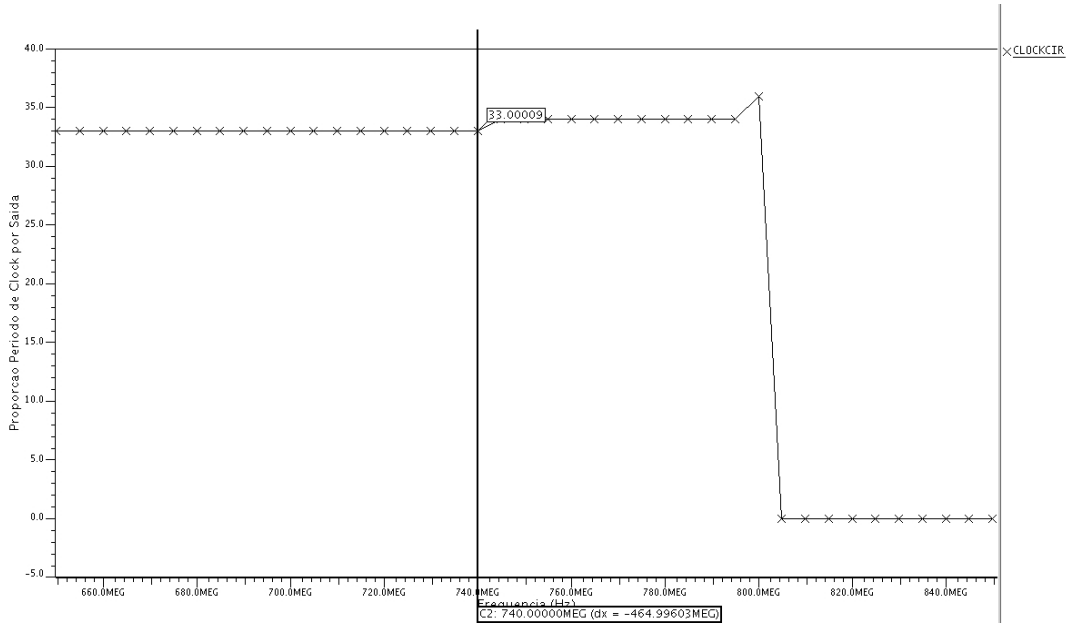
Modelo *Worst Speed:* Apresenta-se nas figuras 18 e 19, logo temos a frequência máxima de operação para **SM=0 de 0,795GHz** e para para **SM=1 de 0,740GHz**.

Figura 16 – *Worst Speed* - Curva proporção do período do *clock* e saída para SM=0



Fonte: Pelos próprios autores

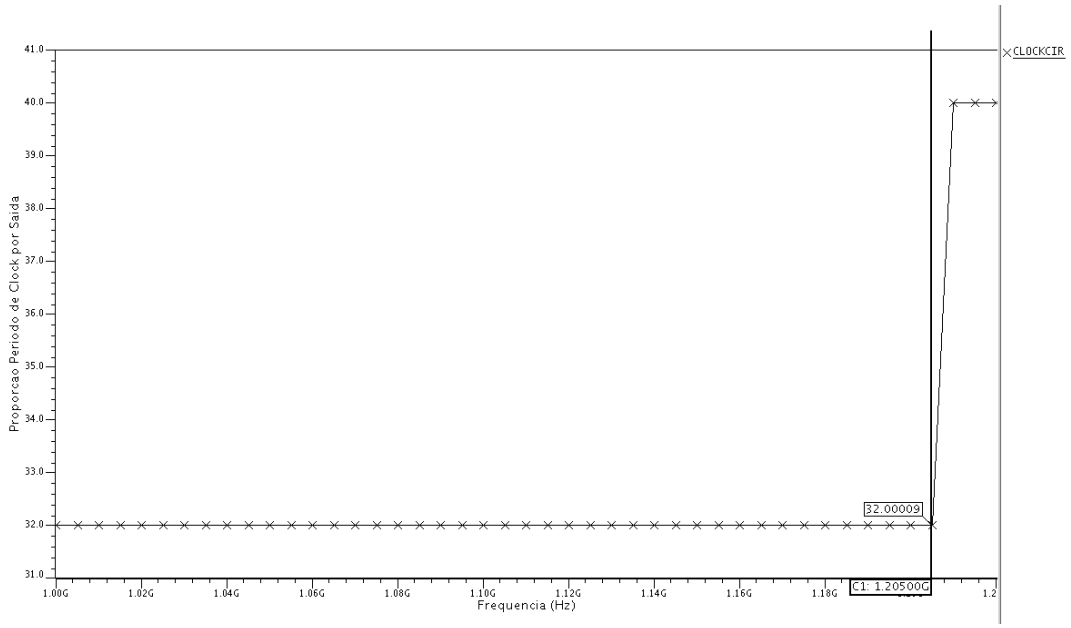
Figura 17 – *Worst Speed* - Curva proporção do período do *clock* e saída para SM=1



Fonte: Pelos próprios autores

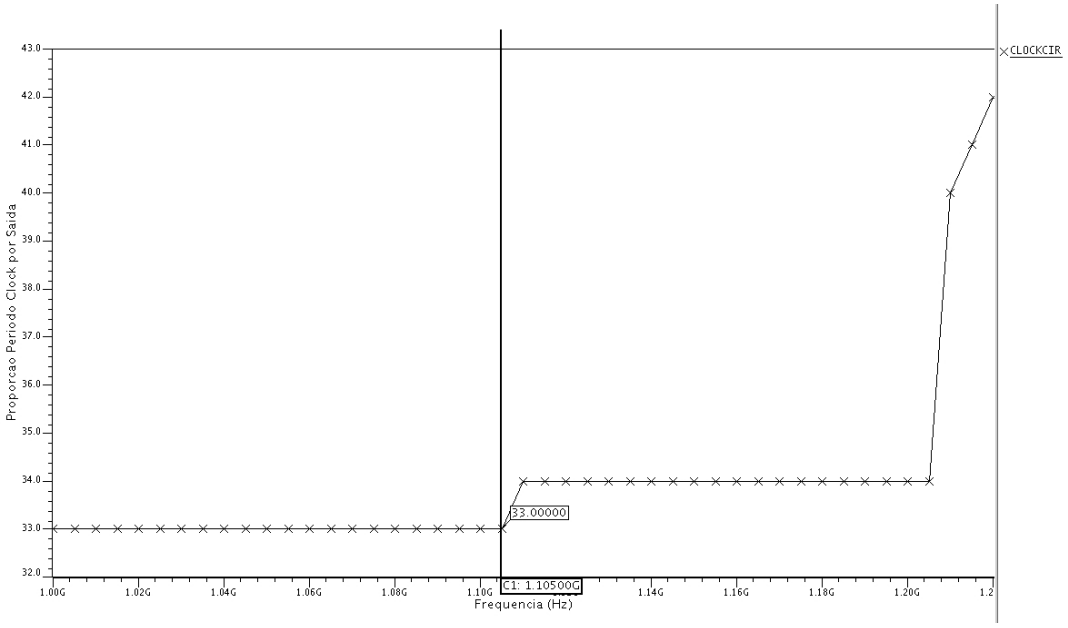
Modelo típico: Apresenta-se nas figuras 18 e 19, logo temos a frequência máxima de operação para **SM=0 de 1,205GHz** e para para **SM=1 de 1,105GHz**.

Figura 18 – Típico - Curva proporção do período do *clock* e saída para SM=0



Fonte: Pelos próprios autores

Figura 19 – Típico - Curva proporção do período do *clock* e saída para SM=1



Fonte: Pelos próprios autores

Apresenta-se a seguir o *netlist* extraído a partir do esquemático.

```
.CONNECT GROUND 0
* Globals.
.global VDD VSS
* Component pathname : $GATES/invb_core:param#8
.subckt INVB_CORE_PARAM#8  Q A
        MN2 Q A VSS VSS MODN w=5.000000e-07 l=3.500000e-07 as=4.250000e-13
+  ad=4.250000e-13 ps=2.200000e-06 pd=2.200000e-06 nrs=8.500000e-01 nrd=8.500000e-01
        MP2 Q A VDD VDD MODP w=1.000000e-06 l=3.500000e-07 as=8.500000e-13
+  ad=8.500000e-13 ps=2.700000e-06 pd=2.700000e-06 nrs=4.250000e-01 nrd=4.250000e-01
.ends INVB_CORE_PARAM#8
* Component pathname : $GATES/invb_core:param#7
.subckt INVB_CORE_PARAM#7  Q A
        MN2 Q A VSS VSS MODN w=4.000000e-07 l=3.500000e-07 as=3.400000e-13
+  ad=3.400000e-13 ps=2.100000e-06 pd=2.100000e-06 nrs=1.062500e+00 nrd=1.062500e+00
        MP2 Q A VDD VDD MODP w=8.000000e-07 l=3.500000e-07 as=6.800000e-13
+  ad=6.800000e-13 ps=2.500000e-06 pd=2.500000e-06 nrs=5.312500e-01 nrd=5.312500e-01
.ends INVB_CORE_PARAM#7
* Component pathname : $GATES/tgate_core
.subckt TGATE_CORE  OUT EN EP IN
        MN1 OUT EN IN VSS MODN w=1.000000e-06 l=3.500000e-07 as=8.500000e-13
+  ad=8.500000e-13 ps=2.700000e-06 pd=2.700000e-06 nrs=4.250000e-01 nrd=4.250000e-01
        MP1 OUT EP IN VDD MODP w=1.000000e-06 l=3.500000e-07 as=8.500000e-13
```

```
+  ad=8.500000e-13 ps=2.700000e-06 pd=2.700000e-06 nrs=4.250000e-01 nrd=4.250000e-01
.ends TGATE_CORE
* Component pathname : $GATES/inv_core
.subckt INV_CORE  OUT IN
        MP1 OUT IN VDD VDD MODP w=1.600000e-06 l=3.500000e-07 as=1.360000e-12
+  ad=1.360000e-12 ps=3.300000e-06 pd=3.300000e-06 nrs=2.656250e-01 nrd=2.656250e-01
        MN1 OUT IN VSS VSS MODN w=1.000000e-06 l=3.500000e-07 as=8.500000e-13
+  ad=8.500000e-13 ps=2.700000e-06 pd=2.700000e-06 nrs=4.250000e-01 nrd=4.250000e-01
.ends INV_CORE
* Component pathname : $GATES/clinva_core
.subckt CLINVA_CORE  Q A C CN
        MP1 NET10 CN VDD VDD MODP w=1.600000e-06 l=3.500000e-07 as=1.360000e-12
+  ad=1.360000e-12 ps=3.300000e-06 pd=3.300000e-06 nrs=2.656250e-01 nrd=2.656250e-01
        MP0 Q A NET10 VDD MODP w=1.600000e-06 l=3.500000e-07 as=1.360000e-12
+  ad=1.360000e-12 ps=3.300000e-06 pd=3.300000e-06 nrs=2.656250e-01 nrd=2.656250e-01
        MN1 NET18 C VSS VSS MODN w=1.000000e-06 l=3.500000e-07 as=8.500000e-13
+  ad=8.500000e-13 ps=2.700000e-06 pd=2.700000e-06 nrs=4.250000e-01 nrd=4.250000e-01
        MN0 Q A NET18 VSS MODN w=1.000000e-06 l=3.500000e-07 as=8.500000e-13
+  ad=8.500000e-13 ps=2.700000e-06 pd=2.700000e-06 nrs=4.250000e-01 nrd=4.250000e-01
.ends CLINVA_CORE
* Component pathname : $CORELIB/DF1
.subckt DF1  Q QN C D
        X_I54 CN C INVB_CORE_PARAM#8
        X_I53 CI CN INVB_CORE_PARAM#7
        X_I55 X CN CI NET55 TGATE_CORE
        X_I56 NET48 CI CN NET47 TGATE_CORE
        X_I57 X CI CN NET63 TGATE_CORE
        X_I58 NET63 NET48 INV_CORE
        X_I59 Q NET57 INV_CORE
        X_I60 QN NET55 INV_CORE
        X_I61 NET47 NET63 INV_CORE
        X_I62 NET55 NET57 INV_CORE
        X_I63 NET57 X INV_CORE
        X_I52 NET48 D CN CI CLINVA_CORE
.ends DF1
* Component pathname : $GATES/nor2_core
.subckt NOR2_CORE  OUT A B
        MP1 OUT A NET17 VDD MODP w=9.600000e-06 l=3.500000e-07 as=8.160000e-12
+  ad=8.160000e-12 ps=1.130000e-05 pd=1.130000e-05 nrs=4.427083e-02 nrd=4.427083e-02
        MP2 NET17 B VDD VDD MODP w=9.600000e-06 l=3.500000e-07 as=8.160000e-12
+  ad=8.160000e-12 ps=1.130000e-05 pd=1.130000e-05 nrs=4.427083e-02 nrd=4.427083e-02
        MN1 OUT B VSS VSS MODN w=3.000000e-06 l=3.500000e-07 as=2.550000e-12
```

```
+  ad=2.550000e-12 ps=4.700000e-06 pd=4.700000e-06 nrs=1.416667e-01 nrd=1.416667e-01
        MN2 OUT A VSS VSS MODN w=3.000000e-06 l=3.500000e-07 as=2.550000e-12
+  ad=2.550000e-12 ps=4.700000e-06 pd=4.700000e-06 nrs=1.416667e-01 nrd=1.416667e-01
.ends NOR2_CORE
* Component pathname : $CORELIB/NOR23
.subckt NOR23  Q A B
        X_I1 Q B A NOR2_CORE
.ends NOR23
* Component pathname : $GATES/nand4_core
.subckt NAND4_CORE  OUT A B C D
        MP1 OUT A VDD VDD MODP w=8.000000e-07 l=3.500000e-07 as=6.800000e-13
+  ad=6.800000e-13 ps=2.500000e-06 pd=2.500000e-06 nrs=5.312500e-01 nrd=5.312500e-01
        MP3 OUT C VDD VDD MODP w=8.000000e-07 l=3.500000e-07 as=6.800000e-13
+  ad=6.800000e-13 ps=2.500000e-06 pd=2.500000e-06 nrs=5.312500e-01 nrd=5.312500e-01
        MP2 OUT B VDD VDD MODP w=8.000000e-07 l=3.500000e-07 as=6.800000e-13
+  ad=6.800000e-13 ps=2.500000e-06 pd=2.500000e-06 nrs=5.312500e-01 nrd=5.312500e-01
        MP4 OUT D VDD VDD MODP w=8.000000e-07 l=3.500000e-07 as=6.800000e-13
+  ad=6.800000e-13 ps=2.500000e-06 pd=2.500000e-06 nrs=5.312500e-01 nrd=5.312500e-01
        MN2 NET35 B NET27 VSS MODN w=2.000000e-06 l=3.500000e-07 as=1.700000e-12
+  ad=1.700000e-12 ps=3.700000e-06 pd=3.700000e-06 nrs=2.125000e-01 nrd=2.125000e-01
        MN1 OUT A NET35 VSS MODN w=2.000000e-06 l=3.500000e-07 as=1.700000e-12
+  ad=1.700000e-12 ps=3.700000e-06 pd=3.700000e-06 nrs=2.125000e-01 nrd=2.125000e-01
        MN3 NET27 C NET23 VSS MODN w=2.000000e-06 l=3.500000e-07 as=1.700000e-12
+  ad=1.700000e-12 ps=3.700000e-06 pd=3.700000e-06 nrs=2.125000e-01 nrd=2.125000e-01
        MN4 NET23 D VSS VSS MODN w=2.000000e-06 l=3.500000e-07 as=1.700000e-12
+  ad=1.700000e-12 ps=3.700000e-06 pd=3.700000e-06 nrs=2.125000e-01 nrd=2.125000e-01
.ends NAND4_CORE
* Component pathname : $CORELIB/NAND40
.subckt NAND40  Q A B C D
        X_I3 Q A B C D NAND4_CORE
.ends NAND40
* Component pathname : $GATES/nand2_core
.subckt NAND2_CORE  OUT A B
        MP1 OUT A VDD VDD MODP w=4.800000e-06 l=3.500000e-07 as=4.080000e-12
+  ad=4.080000e-12 ps=6.500000e-06 pd=6.500000e-06 nrs=8.854167e-02 nrd=8.854167e-02
        MP2 OUT B VDD VDD MODP w=4.800000e-06 l=3.500000e-07 as=4.080000e-12
+  ad=4.080000e-12 ps=6.500000e-06 pd=6.500000e-06 nrs=8.854167e-02 nrd=8.854167e-02
        MN1 OUT A NET13 VSS MODN w=5.970000e-06 l=3.500000e-07 as=5.074500e-12
+  ad=5.074500e-12 ps=7.670000e-06 pd=7.670000e-06 nrs=7.118928e-02 nrd=7.118928e-02
        MN2 NET13 B VSS VSS MODN w=6.000000e-06 l=3.500000e-07 as=5.100000e-12
+  ad=5.100000e-12 ps=7.700000e-06 pd=7.700000e-06 nrs=7.083333e-02 nrd=7.083333e-02
.ends NAND2_CORE
```

```
* Component pathname : $CORELIB/NAND23
.subckt NAND23  Q A B
        X_I1 Q A B NAND2_CORE
.ends NAND23
* MAIN CELL: Component pathname : $prescaler/default.group/logic.views/prescaler
        X_DF11 N$217 N$219 CLOCK N$206 DF1
        X_DF16 OUT3233 N$216 N$214 N$216 DF1
        X_DF15 N$214 N$215 N$213 N$215 DF1
        X_DF14 N$213 N$218 N$219 N$218 DF1
        X_DF13 N$211 N$212 CLOCK N$208 DF1
        X_DF12 N$209 N$210 CLOCK N$219 DF1
        X_NOR231 N$208 N$210 N$207 NOR23
        X_NAND401 N$207 SM N$218 N$215 N$216 NAND40
        X_NAND231 N$206 N$210 N$212 NAND23
*** Idem aos comando do Experimento 3
*** Parametros
.Param tensao=3v
.Param F=0.2G P='1/F'

*** Tensoes estabelecidas
Vdd VDD GROUND DC tensao
.CONNECT VSS 0
Vclock CLOCK GROUND PULSE(0 3.0 0 '0.1*P' '0.1*P' '0.4*P' P)

*** Conexao do circuito
*** Caso SM = 1
.CONNECT SM VDD
*** Caso SM = 0
*.CONNECT SM 0

*** Tempo de propagacao de subida e descida
.meas tran Pout   trig v(OUT3233) val=tensao/2 rise=2 targ v(OUT3233) val=tensao/2 rise=3
.meas tran PClock trig v(CLOCK) val=tensao/2 rise=2 targ v(CLOCK) val=tensao/2 rise=3
.meas tran clockCir PARAM='Pout/Pclock'

*** Explorando curva simples - Para escolher melhor janela de simulacao
*.tran 0 '100*P' 0 'P/10' sweep F INCR 0.05G 0.4G 1.3G

*** Escursionando frequencia em busca da maxima - Tipico
*.tran 0 '100*P' 0 'P/10' sweep F INCR 0.005G 1.0G 1.22G
****************************************
```

```
*** Escursionando frequencia em busca da maxima - WS
.tran 0 '80*P' 0 'P/10' sweep F INCR 0.005G 0.65G 0.85G
****************************************

.probe tran V(CLOCK) V(OUT3233)

*.include Model35_Eldo
.include cmos53ws.mod

.end
```

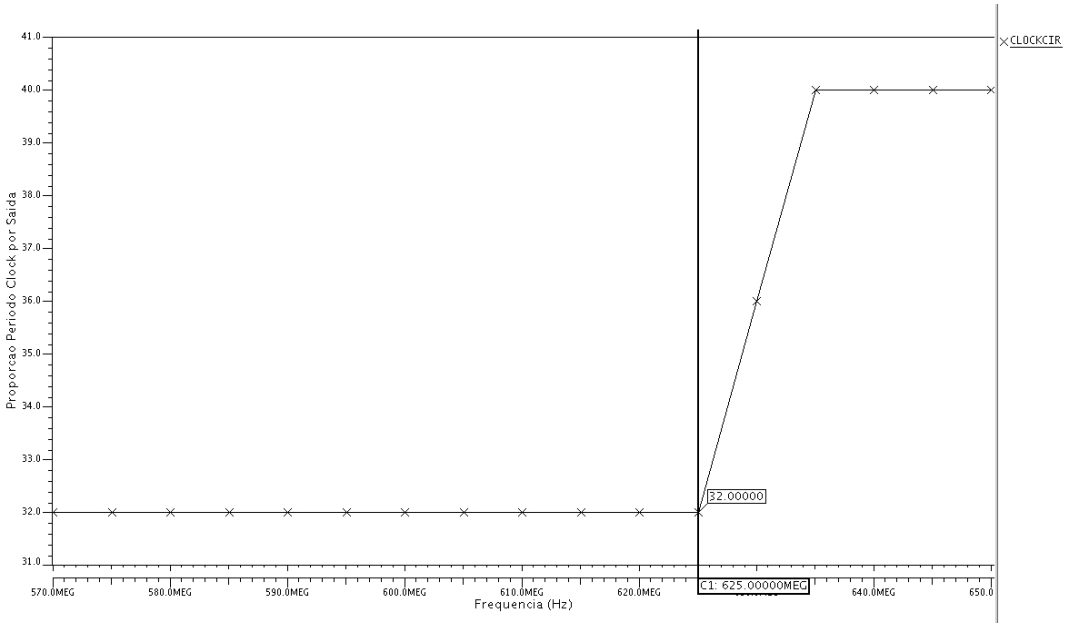
Questão 12: A partir do layout do circuito da Figura 1, extrair o circuito para simulação com apenas capacitores. Determinar a máxima velocidade do circuito para o modelo típico e para o modelo worstspeed.

Conforme o enunciado devemos observar a relação igual a 32 para SM=0 e 33 para o SM=1.

Para extração a partir do *Layout* C+CC.

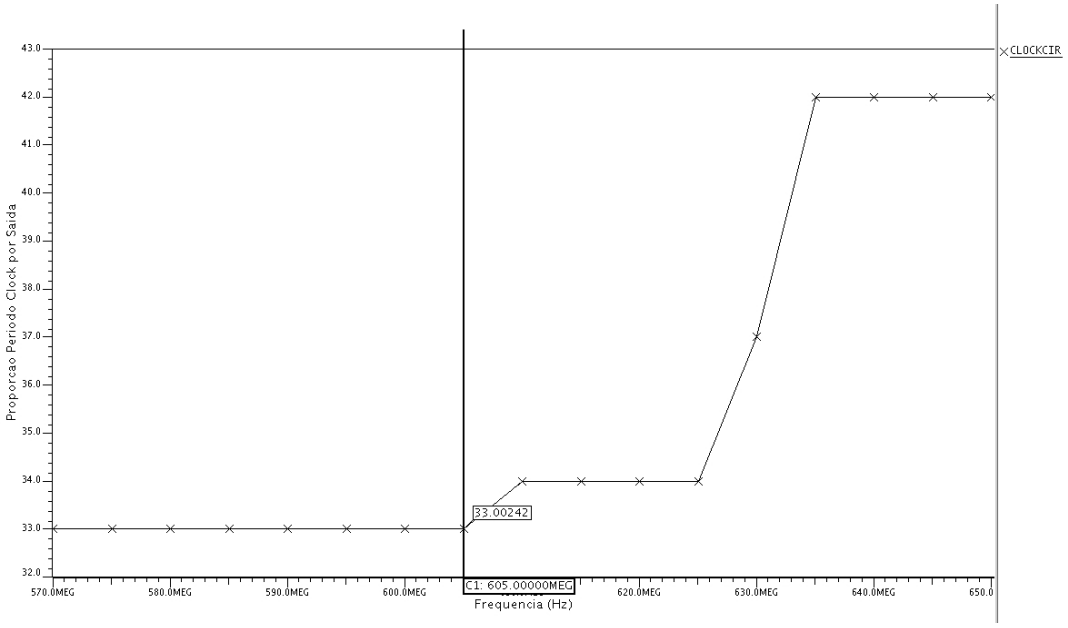
Modelo *Worst Speed:* Apresenta-se nas figuras 22 e 23, logo temos a frequência máxima de operação para **SM=0 de 0,625GHz** e para para **SM=1 de 0,605GHz**.

Figura 20 – *Worst Speed* - Curva proporção do período do *clock* e saída para SM=0



Fonte: Pelos próprios autores

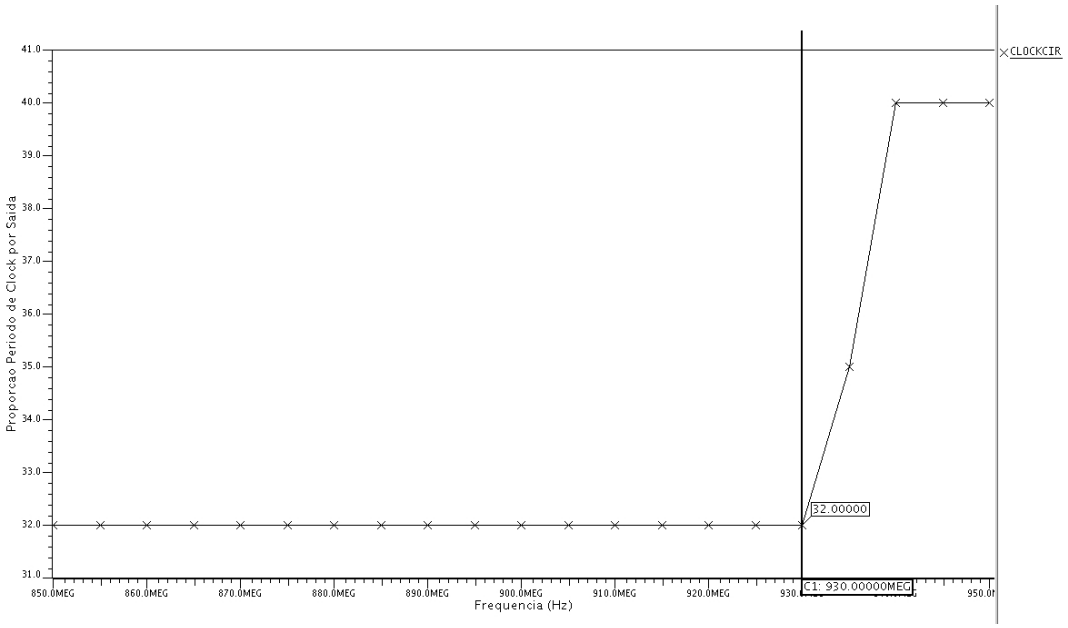
Figura 21 – *Worst Speed* - Curva proporção do período do *clock* e saída para SM=1



Fonte: Pelos próprios autores

Modelo típico: Apresenta-se nas figuras 22 e 23, logo temos a frequência máxima de operação para **SM=0 de 0,930GHz** e para para **SM=1 de 0,895GHz**.

Figura 22 – Típico - Curva proporção do período do *clock* e saída para SM=0

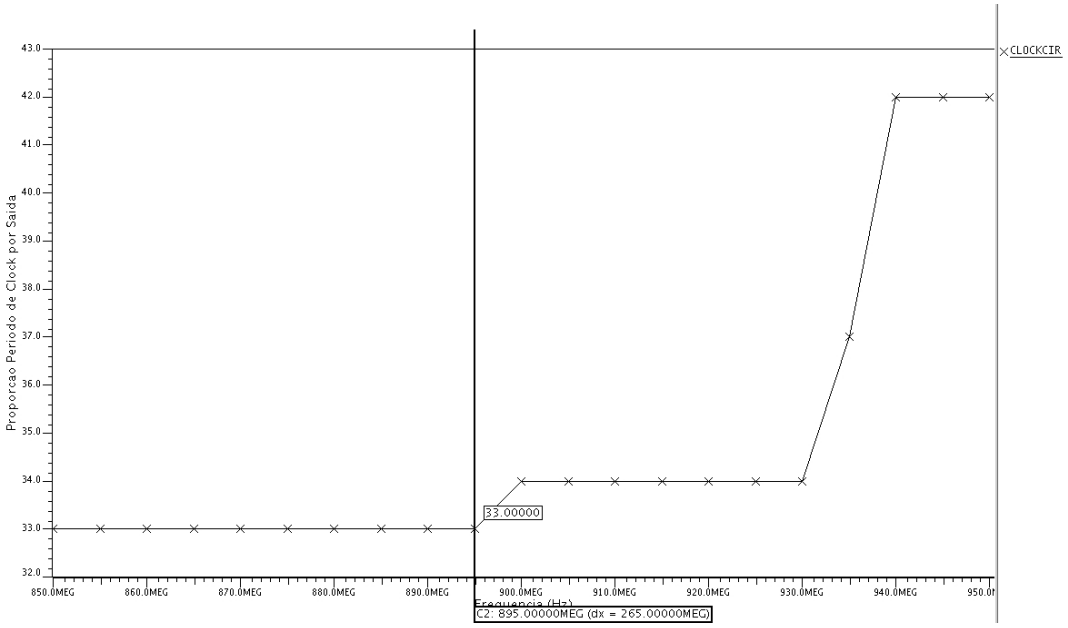


Fonte: Pelos próprios autores

Apresenta-se a seguir o *netlist* extraído a partir do *Layout* C+CC.

```
* File: prescaler.pex.netlist
```

Figura 23 – Típico - Curva proporção do período do *clock* e saída para SM=1



Fonte: Pelos próprios autores

```
* Created: Fri Oct 22 10:21:39 2021
* Program "Calibre xRC"
* Version "v2006.2_16.16"
*
*** Configuracao Simulacao
.option measDGT=8
.options ingold=1
.option MSGNODE = 0
.CONNECT GROUND 0

mM0 21 2 VSS VSS MODN L=3.5e-07 W=2e-06 AD=8e-13 AS=1.7e-12 PD=8e-07
+ PS=3.7e-06 NRD=0.2125 NRS=0.2125
mM1 22 7 21 VSS MODN L=3.5e-07 W=2e-06 AD=8e-13 AS=8e-13 PD=8e-07 PS=8e-07
+ NRD=0.2125 NRS=0.2125
mM2 23 8 22 VSS MODN L=3.5e-07 W=2e-06 AD=8e-13 AS=8e-13 PD=8e-07 PS=8e-07
+ NRD=0.2125 NRS=0.2125
mM3 9 SM 23 VSS MODN L=3.5e-07 W=2e-06 AD=1.75e-12 AS=8e-13 PD=3.75e-06
+ PS=8e-07 NRD=0.2125 NRS=0.2125
mM4 10 4 VSS VSS MODN L=3.5e-07 W=3e-06 AD=2.42375e-12 AS=2.93e-12 PD=1.8e-06
+ PS=5.05e-06 NRD=0.126866 NRS=0.126866
mM5 VSS 9 10 VSS MODN L=3.5e-07 W=3e-06 AD=4.4375e-12 AS=2.42375e-12
+ PD=5.95e-06 PS=1.8e-06 NRD=0.126866 NRS=0.126866
mM6 11 4 17 VSS MODN L=3.5e-07 W=3e-06 AD=1.0395e-12 AS=2.69e-12
+ PD=5.64607e-07 PS=5.05e-06 NRD=0.126866 NRS=0.126866
```

```
mM7 17 4 11 VSS MODN L=3.5e-07 W=2.975e-06 AD=2.18304e-12 AS=1.03175e-12
+ PD=1.73099e-06 PS=5.60393e-07 NRD=0.12782 NRS=0.12782
mM8 VSS 12 17 VSS MODN L=3.5e-07 W=3e-06 AD=1.0225e-12 AS=2.19946e-12
+ PD=5.5e-07 PS=1.74401e-06 NRD=0.126866 NRS=0.126866
mM9 17 12 VSS VSS MODN L=3.5e-07 W=3e-06 AD=2.69e-12 AS=1.0225e-12 PD=5.05e-06
+ PS=5.5e-07 NRD=0.126866 NRS=0.126866
mM10 VDD 2 9 VDD MODP L=3.5e-07 W=8e-07 AD=4e-13 AS=6.8e-13 PD=1e-06
+ PS=2.5e-06 NRD=0.53125 NRS=0.53125
mM11 9 7 VDD VDD MODP L=3.5e-07 W=8e-07 AD=4e-13 AS=4e-13 PD=1e-06 PS=1e-06
+ NRD=0.53125 NRS=0.53125
mM12 VDD 8 9 VDD MODP L=3.5e-07 W=8e-07 AD=4e-13 AS=4e-13 PD=1e-06 PS=1e-06
+ NRD=0.53125 NRS=0.53125
mM13 9 SM VDD VDD MODP L=3.5e-07 W=8e-07 AD=6.8e-13 AS=4e-13 PD=2.5e-06
+ PS=1e-06 NRD=0.53125 NRS=0.53125
mM14 24 4 VDD VDD MODP L=3.5e-07 W=4.8e-06 AD=1.15875e-12 AS=3.685e-12
+ PD=4.5e-07 PS=6.15e-06 NRD=0.0825243 NRS=0.0825243
mM15 10 9 24 VDD MODP L=3.5e-07 W=4.8e-06 AD=3.45687e-12 AS=1.15875e-12
+ PD=2.025e-06 PS=4.5e-07 NRD=0.0825243 NRS=0.0825243
mM16 25 9 10 VDD MODP L=3.5e-07 W=4.8e-06 AD=1.15875e-12 AS=3.45687e-12
+ PD=4.5e-07 PS=2.025e-06 NRD=0.0825243 NRS=0.0825243
mM17 VDD 4 25 VDD MODP L=3.5e-07 W=4.8e-06 AD=3.9625e-12 AS=1.15875e-12
+ PD=6.15e-06 PS=4.5e-07 NRD=0.0825243 NRS=0.0825243
mM18 11 4 VDD VDD MODP L=3.5e-07 W=2.4e-06 AD=1.2e-12 AS=2.04e-12 PD=1e-06
+ PS=4.1e-06 NRD=0.177083 NRS=0.177083
mM19 VDD 4 11 VDD MODP L=3.5e-07 W=2.4e-06 AD=1.2e-12 AS=1.2e-12 PD=1e-06
+ PS=1e-06 NRD=0.177083 NRS=0.177083
mM20 11 12 VDD VDD MODP L=3.5e-07 W=2.4e-06 AD=1.2e-12 AS=1.2e-12 PD=1e-06
+ PS=1e-06 NRD=0.177083 NRS=0.177083
mM21 VDD 12 11 VDD MODP L=3.5e-07 W=2.4e-06 AD=2.04e-12 AS=1.2e-12 PD=4.1e-06
+ PS=1e-06 NRD=0.177083 NRS=0.177083
mX22_M0 VSS 5 X22_2 VSS MODN L=3.5e-07 W=5e-07 AD=5.375e-13 AS=5.9e-13
+ PD=1.97222e-06 PS=2.7e-06 NRD=0.85 NRS=0.85
mX22_M1 X22_3 X22_2 VSS VSS MODN L=3.5e-07 W=4e-07 AD=5.7e-13 AS=4.3e-13
+ PD=2.8e-06 PS=1.57778e-06 NRD=1.0625 NRS=1.0625
mX22_M2 X22_15 X22_2 VSS VSS MODN L=3.5e-07 W=1e-06 AD=2.25e-13 AS=7.45e-13
+ PD=4.5e-07 PS=2.7e-06 NRD=0.425 NRS=0.425
mX22_M3 X22_5 2 X22_15 VSS MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=2.25e-13
+ PD=1e-06 PS=4.5e-07 NRD=0.425 NRS=0.425
mX22_M4 X22_6 X22_3 X22_5 VSS MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=5e-13
+ PD=1e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX22_M5 VSS X22_7 X22_6 VSS MODN L=3.5e-07 W=1e-06 AD=5.125e-13 AS=5e-13
+ PD=1.025e-06 PS=1e-06 NRD=0.425 NRS=0.425
```

```
mX22_M6 X22_7 X22_5 VSS VSS MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=5.125e-13
+ PD=1e-06 PS=1.025e-06 NRD=0.425 NRS=0.425
mX22_M7 X22_X X22_3 X22_7 VSS MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=5e-13
+ PD=1e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX22_M8 X22_10 X22_2 X22_X VSS MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=5e-13
+ PD=1e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX22_M9 VSS X22_9 X22_10 VSS MODN L=3.5e-07 W=1e-06 AD=5.875e-13 AS=5e-13
+ PD=1.175e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX22_M10 X22_9 X22_X VSS VSS MODN L=3.5e-07 W=1e-06 AD=1.215e-12 AS=5.875e-13
+ PD=4.1e-06 PS=1.175e-06 NRD=0.425 NRS=0.425
mX22_M11 VSS X22_9 OUT3233 VSS MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=7.45e-13
+ PD=1e-06 PS=2.7e-06 NRD=0.425 NRS=0.425
mX22_M12 2 X22_10 VSS VSS MODN L=3.5e-07 W=1e-06 AD=8.5e-13 AS=5e-13
+ PD=2.7e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX22_M13 VDD 5 X22_2 VDD MODP L=3.5e-07 W=1e-06 AD=1.16944e-12 AS=7.45e-13
+ PD=2.86111e-06 PS=2.7e-06 NRD=0.425 NRS=0.425
mX22_M14 VDD X22_2 X22_3 VDD MODP L=3.5e-07 W=8e-07 AD=9.35556e-13 AS=7.55e-13
+ PD=2.28889e-06 PS=3.1e-06 NRD=0.53125 NRS=0.53125
mX22_M15 X22_5 X22_2 X22_6 VDD MODP L=3.5e-07 W=1e-06 AD=5e-13 AS=1.355e-12
+ PD=1e-06 PS=4.1e-06 NRD=0.425 NRS=0.425
mX22_M16 X22_16 2 X22_5 VDD MODP L=3.5e-07 W=1.6e-06 AD=3.6e-13 AS=8e-13
+ PD=4.5e-07 PS=1.6e-06 NRD=0.265625 NRS=0.265625
mX22_M17 VDD X22_3 X22_16 VDD MODP L=3.5e-07 W=1.6e-06 AD=1.31625e-12
+ AS=3.6e-13 PD=3.3e-06 PS=4.5e-07 NRD=0.265625 NRS=0.265625
mX22_M18 VDD X22_7 X22_6 VDD MODP L=3.5e-07 W=1.6e-06 AD=9.1125e-13
+ AS=1.25e-12 PD=1.725e-06 PS=3.7e-06 NRD=0.217949 NRS=0.217949
mX22_M19 X22_7 X22_5 VDD VDD MODP L=3.5e-07 W=1.6e-06 AD=1.25e-12
+ AS=9.1125e-13 PD=3.7e-06 PS=1.725e-06 NRD=0.217949 NRS=0.217949
mX22_M20 X22_X X22_2 X22_7 VDD MODP L=3.5e-07 W=1e-06 AD=5e-13 AS=7.45e-13
+ PD=1e-06 PS=2.7e-06 NRD=0.425 NRS=0.425
mX22_M21 X22_10 X22_3 X22_X VDD MODP L=3.5e-07 W=1e-06 AD=8.5e-13 AS=5e-13
+ PD=2.7e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX22_M22 VDD X22_9 X22_10 VDD MODP L=3.5e-07 W=1.6e-06 AD=9.025e-13
+ AS=1.455e-12 PD=1.6e-06 PS=4e-06 NRD=0.217949 NRS=0.217949
mX22_M23 X22_9 X22_X VDD VDD MODP L=3.5e-07 W=1.6e-06 AD=1.335e-12
+ AS=9.025e-13 PD=3.85e-06 PS=1.6e-06 NRD=0.217949 NRS=0.217949
mX22_M24 VDD X22_9 OUT3233 VDD MODP L=3.5e-07 W=1.6e-06 AD=8e-13 AS=1.36e-12
+ PD=1e-06 PS=3.3e-06 NRD=0.265625 NRS=0.265625
mX22_M25 2 X22_10 VDD VDD MODP L=3.5e-07 W=1.6e-06 AD=1.36e-12 AS=8e-13
+ PD=3.3e-06 PS=1e-06 NRD=0.265625 NRS=0.265625
mX23_M0 VSS 1 X23_2 VSS MODN L=3.5e-07 W=5e-07 AD=5.375e-13 AS=5.9e-13
+ PD=1.97222e-06 PS=2.7e-06 NRD=0.85 NRS=0.85
```

```
mX23_M1 X23_3 X23_2 VSS VSS MODN L=3.5e-07 W=4e-07 AD=5.7e-13 AS=4.3e-13
+ PD=2.8e-06 PS=1.57778e-06 NRD=1.0625 NRS=1.0625
mX23_M2 X23_15 X23_2 VSS VSS MODN L=3.5e-07 W=1e-06 AD=2.25e-13 AS=7.45e-13
+ PD=4.5e-07 PS=2.7e-06 NRD=0.425 NRS=0.425
mX23_M3 X23_5 7 X23_15 VSS MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=2.25e-13
+ PD=1e-06 PS=4.5e-07 NRD=0.425 NRS=0.425
mX23_M4 X23_6 X23_3 X23_5 VSS MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=5e-13
+ PD=1e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX23_M5 VSS X23_7 X23_6 VSS MODN L=3.5e-07 W=1e-06 AD=5.125e-13 AS=5e-13
+ PD=1.025e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX23_M6 X23_7 X23_5 VSS VSS MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=5.125e-13
+ PD=1e-06 PS=1.025e-06 NRD=0.425 NRS=0.425
mX23_M7 X23_X X23_3 X23_7 VSS MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=5e-13
+ PD=1e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX23_M8 X23_10 X23_2 X23_X VSS MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=5e-13
+ PD=1e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX23_M9 VSS X23_9 X23_10 VSS MODN L=3.5e-07 W=1e-06 AD=5.875e-13 AS=5e-13
+ PD=1.175e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX23_M10 X23_9 X23_X VSS VSS MODN L=3.5e-07 W=1e-06 AD=1.215e-12 AS=5.875e-13
+ PD=4.1e-06 PS=1.175e-06 NRD=0.425 NRS=0.425
mX23_M11 VSS X23_9 5 VSS MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=7.45e-13 PD=1e-06
+ PS=2.7e-06 NRD=0.425 NRS=0.425
mX23_M12 7 X23_10 VSS VSS MODN L=3.5e-07 W=1e-06 AD=8.5e-13 AS=5e-13
+ PD=2.7e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX23_M13 VDD 1 X23_2 VDD MODP L=3.5e-07 W=1e-06 AD=1.16944e-12 AS=7.45e-13
+ PD=2.86111e-06 PS=2.7e-06 NRD=0.425 NRS=0.425
mX23_M14 VDD X23_2 X23_3 VDD MODP L=3.5e-07 W=8e-07 AD=9.35556e-13 AS=7.55e-13
+ PD=2.28889e-06 PS=3.1e-06 NRD=0.53125 NRS=0.53125
mX23_M15 X23_5 X23_2 X23_6 VDD MODP L=3.5e-07 W=1e-06 AD=5e-13 AS=1.355e-12
+ PD=1e-06 PS=4.1e-06 NRD=0.425 NRS=0.425
mX23_M16 X23_16 7 X23_5 VDD MODP L=3.5e-07 W=1.6e-06 AD=3.6e-13 AS=8e-13
+ PD=4.5e-07 PS=1.6e-06 NRD=0.265625 NRS=0.265625
mX23_M17 VDD X23_3 X23_16 VDD MODP L=3.5e-07 W=1.6e-06 AD=1.31625e-12
+ AS=3.6e-13 PD=3.3e-06 PS=4.5e-07 NRD=0.265625 NRS=0.265625
mX23_M18 VDD X23_7 X23_6 VDD MODP L=3.5e-07 W=1.6e-06 AD=9.1125e-13
+ AS=1.25e-12 PD=1.725e-06 PS=3.7e-06 NRD=0.217949 NRS=0.217949
mX23_M19 X23_7 X23_5 VDD VDD MODP L=3.5e-07 W=1.6e-06 AD=1.25e-12
+ AS=9.1125e-13 PD=3.7e-06 PS=1.725e-06 NRD=0.217949 NRS=0.217949
mX23_M20 X23_X X23_2 X23_7 VDD MODP L=3.5e-07 W=1e-06 AD=5e-13 AS=7.45e-13
+ PD=1e-06 PS=2.7e-06 NRD=0.425 NRS=0.425
mX23_M21 X23_10 X23_3 X23_X VDD MODP L=3.5e-07 W=1e-06 AD=8.5e-13 AS=5e-13
+ PD=2.7e-06 PS=1e-06 NRD=0.425 NRS=0.425
```

```
mX23_M22 VDD X23_9 X23_10 VDD MODP L=3.5e-07 W=1.6e-06 AD=9.025e-13
+ AS=1.455e-12 PD=1.6e-06 PS=4e-06 NRD=0.217949 NRS=0.217949
mX23_M23 X23_9 X23_X VDD VDD MODP L=3.5e-07 W=1.6e-06 AD=1.335e-12
+ AS=9.025e-13 PD=3.85e-06 PS=1.6e-06 NRD=0.217949 NRS=0.217949
mX23_M24 VDD X23_9 5 VDD MODP L=3.5e-07 W=1.6e-06 AD=8e-13 AS=1.36e-12
+ PD=1e-06 PS=3.3e-06 NRD=0.265625 NRS=0.265625
mX23_M25 7 X23_10 VDD VDD MODP L=3.5e-07 W=1.6e-06 AD=1.36e-12 AS=8e-13
+ PD=3.3e-06 PS=1e-06 NRD=0.265625 NRS=0.265625
mX24_M0 VSS 3 X24_2 VSS MODN L=3.5e-07 W=5e-07 AD=5.375e-13 AS=5.9e-13
+ PD=1.97222e-06 PS=2.7e-06 NRD=0.85 NRS=0.85
mX24_M1 X24_3 X24_2 VSS VSS MODN L=3.5e-07 W=4e-07 AD=5.7e-13 AS=4.3e-13
+ PD=2.8e-06 PS=1.57778e-06 NRD=1.0625 NRS=1.0625
mX24_M2 X24_15 X24_2 VSS VSS MODN L=3.5e-07 W=1e-06 AD=2.25e-13 AS=7.45e-13
+ PD=4.5e-07 PS=2.7e-06 NRD=0.425 NRS=0.425
mX24_M3 X24_5 8 X24_15 VSS MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=2.25e-13
+ PD=1e-06 PS=4.5e-07 NRD=0.425 NRS=0.425
mX24_M4 X24_6 X24_3 X24_5 VSS MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=5e-13
+ PD=1e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX24_M5 VSS X24_7 X24_6 VSS MODN L=3.5e-07 W=1e-06 AD=5.125e-13 AS=5e-13
+ PD=1.025e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX24_M6 X24_7 X24_5 VSS VSS MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=5.125e-13
+ PD=1e-06 PS=1.025e-06 NRD=0.425 NRS=0.425
mX24_M7 X24_X X24_3 X24_7 VSS MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=5e-13
+ PD=1e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX24_M8 X24_10 X24_2 X24_X VSS MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=5e-13
+ PD=1e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX24_M9 VSS X24_9 X24_10 VSS MODN L=3.5e-07 W=1e-06 AD=5.875e-13 AS=5e-13
+ PD=1.175e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX24_M10 X24_9 X24_X VSS VSS MODN L=3.5e-07 W=1e-06 AD=1.215e-12 AS=5.875e-13
+ PD=4.1e-06 PS=1.175e-06 NRD=0.425 NRS=0.425
mX24_M11 VSS X24_9 1 VSS MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=7.45e-13 PD=1e-06
+ PS=2.7e-06 NRD=0.425 NRS=0.425
mX24_M12 8 X24_10 VSS VSS MODN L=3.5e-07 W=1e-06 AD=8.5e-13 AS=5e-13
+ PD=2.7e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX24_M13 VDD 3 X24_2 VDD MODP L=3.5e-07 W=1e-06 AD=1.16944e-12 AS=7.45e-13
+ PD=2.86111e-06 PS=2.7e-06 NRD=0.425 NRS=0.425
mX24_M14 VDD X24_2 X24_3 VDD MODP L=3.5e-07 W=8e-07 AD=9.35556e-13 AS=7.55e-13
+ PD=2.28889e-06 PS=3.1e-06 NRD=0.53125 NRS=0.53125
mX24_M15 X24_5 X24_2 X24_6 VDD MODP L=3.5e-07 W=1e-06 AD=5e-13 AS=1.355e-12
+ PD=1e-06 PS=4.1e-06 NRD=0.425 NRS=0.425
mX24_M16 X24_16 8 X24_5 VDD MODP L=3.5e-07 W=1.6e-06 AD=3.6e-13 AS=8e-13
+ PD=4.5e-07 PS=1.6e-06 NRD=0.265625 NRS=0.265625
```

```
mX24_M17 VDD X24_3 X24_16 VDD MODP L=3.5e-07 W=1.6e-06 AD=1.31625e-12
+ AS=3.6e-13 PD=3.3e-06 PS=4.5e-07 NRD=0.265625 NRS=0.265625
mX24_M18 VDD X24_7 X24_6 VDD MODP L=3.5e-07 W=1.6e-06 AD=9.1125e-13
+ AS=1.25e-12 PD=1.725e-06 PS=3.7e-06 NRD=0.217949 NRS=0.217949
mX24_M19 X24_7 X24_5 VDD VDD MODP L=3.5e-07 W=1.6e-06 AD=1.25e-12
+ AS=9.1125e-13 PD=3.7e-06 PS=1.725e-06 NRD=0.217949 NRS=0.217949
mX24_M20 X24_X X24_2 X24_7 VDD MODP L=3.5e-07 W=1e-06 AD=5e-13 AS=7.45e-13
+ PD=1e-06 PS=2.7e-06 NRD=0.425 NRS=0.425
mX24_M21 X24_10 X24_3 X24_X VDD MODP L=3.5e-07 W=1e-06 AD=8.5e-13 AS=5e-13
+ PD=2.7e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX24_M22 VDD X24_9 X24_10 VDD MODP L=3.5e-07 W=1.6e-06 AD=9.025e-13
+ AS=1.455e-12 PD=1.6e-06 PS=4e-06 NRD=0.217949 NRS=0.217949
mX24_M23 X24_9 X24_X VDD VDD MODP L=3.5e-07 W=1.6e-06 AD=1.335e-12
+ AS=9.025e-13 PD=3.85e-06 PS=1.6e-06 NRD=0.217949 NRS=0.217949
mX24_M24 VDD X24_9 1 VDD MODP L=3.5e-07 W=1.6e-06 AD=8e-13 AS=1.36e-12
+ PD=1e-06 PS=3.3e-06 NRD=0.265625 NRS=0.265625
mX24_M25 8 X24_10 VDD VDD MODP L=3.5e-07 W=1.6e-06 AD=1.36e-12 AS=8e-13
+ PD=3.3e-06 PS=1e-06 NRD=0.265625 NRS=0.265625
mX25_M0 VSS CLOCK X25_2 VSS MODN L=3.5e-07 W=5e-07 AD=5.375e-13 AS=5.9e-13
+ PD=1.97222e-06 PS=2.7e-06 NRD=0.85 NRS=0.85
mX25_M1 X25_3 X25_2 VSS VSS MODN L=3.5e-07 W=4e-07 AD=5.7e-13 AS=4.3e-13
+ PD=2.8e-06 PS=1.57778e-06 NRD=1.0625 NRS=1.0625
mX25_M2 X25_15 X25_2 VSS VSS MODN L=3.5e-07 W=1e-06 AD=2.25e-13 AS=7.45e-13
+ PD=4.5e-07 PS=2.7e-06 NRD=0.425 NRS=0.425
mX25_M3 X25_5 3 X25_15 VSS MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=2.25e-13
+ PD=1e-06 PS=4.5e-07 NRD=0.425 NRS=0.425
mX25_M4 X25_6 X25_3 X25_5 VSS MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=5e-13
+ PD=1e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX25_M5 VSS X25_7 X25_6 VSS MODN L=3.5e-07 W=1e-06 AD=5.125e-13 AS=5e-13
+ PD=1.025e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX25_M6 X25_7 X25_5 VSS VSS MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=5.125e-13
+ PD=1e-06 PS=1.025e-06 NRD=0.425 NRS=0.425
mX25_M7 X25_X X25_3 X25_7 VSS MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=5e-13
+ PD=1e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX25_M8 X25_10 X25_2 X25_X VSS MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=5e-13
+ PD=1e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX25_M9 VSS X25_9 X25_10 VSS MODN L=3.5e-07 W=1e-06 AD=5.875e-13 AS=5e-13
+ PD=1.175e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX25_M10 X25_9 X25_X VSS VSS MODN L=3.5e-07 W=1e-06 AD=1.215e-12 AS=5.875e-13
+ PD=4.1e-06 PS=1.175e-06 NRD=0.425 NRS=0.425
mX25_M11 VSS X25_9 18 VSS MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=7.45e-13 PD=1e-06
+ PS=2.7e-06 NRD=0.425 NRS=0.425
```

```
mX25_M12 4 X25_10 VSS VSS MODN L=3.5e-07 W=1e-06 AD=8.5e-13 AS=5e-13
+ PD=2.7e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX25_M13 VDD CLOCK X25_2 VDD MODP L=3.5e-07 W=1e-06 AD=1.16944e-12 AS=7.45e-13
+ PD=2.86111e-06 PS=2.7e-06 NRD=0.425 NRS=0.425
mX25_M14 VDD X25_2 X25_3 VDD MODP L=3.5e-07 W=8e-07 AD=9.35556e-13 AS=7.55e-13
+ PD=2.28889e-06 PS=3.1e-06 NRD=0.53125 NRS=0.53125
mX25_M15 X25_5 X25_2 X25_6 VDD MODP L=3.5e-07 W=1e-06 AD=5e-13 AS=1.355e-12
+ PD=1e-06 PS=4.1e-06 NRD=0.425 NRS=0.425
mX25_M16 X25_16 3 X25_5 VDD MODP L=3.5e-07 W=1.6e-06 AD=3.6e-13 AS=8e-13
+ PD=4.5e-07 PS=1.6e-06 NRD=0.265625 NRS=0.265625
mX25_M17 VDD X25_3 X25_16 VDD MODP L=3.5e-07 W=1.6e-06 AD=1.31625e-12
+ AS=3.6e-13 PD=3.3e-06 PS=4.5e-07 NRD=0.265625 NRS=0.265625
mX25_M18 VDD X25_7 X25_6 VDD MODP L=3.5e-07 W=1.6e-06 AD=9.1125e-13
+ AS=1.25e-12 PD=1.725e-06 PS=3.7e-06 NRD=0.217949 NRS=0.217949
mX25_M19 X25_7 X25_5 VDD VDD MODP L=3.5e-07 W=1.6e-06 AD=1.25e-12
+ AS=9.1125e-13 PD=3.7e-06 PS=1.725e-06 NRD=0.217949 NRS=0.217949
mX25_M20 X25_X X25_2 X25_7 VDD MODP L=3.5e-07 W=1e-06 AD=5e-13 AS=7.45e-13
+ PD=1e-06 PS=2.7e-06 NRD=0.425 NRS=0.425
mX25_M21 X25_10 X25_3 X25_X VDD MODP L=3.5e-07 W=1e-06 AD=8.5e-13 AS=5e-13
+ PD=2.7e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX25_M22 VDD X25_9 X25_10 VDD MODP L=3.5e-07 W=1.6e-06 AD=9.025e-13
+ AS=1.455e-12 PD=1.6e-06 PS=4e-06 NRD=0.217949 NRS=0.217949
mX25_M23 X25_9 X25_X VDD VDD MODP L=3.5e-07 W=1.6e-06 AD=1.335e-12
+ AS=9.025e-13 PD=3.85e-06 PS=1.6e-06 NRD=0.217949 NRS=0.217949
mX25_M24 VDD X25_9 18 VDD MODP L=3.5e-07 W=1.6e-06 AD=8e-13 AS=1.36e-12
+ PD=1e-06 PS=3.3e-06 NRD=0.265625 NRS=0.265625
mX25_M25 4 X25_10 VDD VDD MODP L=3.5e-07 W=1.6e-06 AD=1.36e-12 AS=8e-13
+ PD=3.3e-06 PS=1e-06 NRD=0.265625 NRS=0.265625
mX26_M0 VSS CLOCK X26_2 VSS MODN L=3.5e-07 W=5e-07 AD=5.375e-13 AS=5.9e-13
+ PD=1.97222e-06 PS=2.7e-06 NRD=0.85 NRS=0.85
mX26_M1 X26_3 X26_2 VSS VSS MODN L=3.5e-07 W=4e-07 AD=5.7e-13 AS=4.3e-13
+ PD=2.8e-06 PS=1.57778e-06 NRD=1.0625 NRS=1.0625
mX26_M2 X26_15 X26_2 VSS VSS MODN L=3.5e-07 W=1e-06 AD=2.25e-13 AS=7.45e-13
+ PD=4.5e-07 PS=2.7e-06 NRD=0.425 NRS=0.425
mX26_M3 X26_5 11 X26_15 VSS MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=2.25e-13
+ PD=1e-06 PS=4.5e-07 NRD=0.425 NRS=0.425
mX26_M4 X26_6 X26_3 X26_5 VSS MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=5e-13
+ PD=1e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX26_M5 VSS X26_7 X26_6 VSS MODN L=3.5e-07 W=1e-06 AD=5.125e-13 AS=5e-13
+ PD=1.025e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX26_M6 X26_7 X26_5 VSS VSS MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=5.125e-13
+ PD=1e-06 PS=1.025e-06 NRD=0.425 NRS=0.425
```

```
mX26_M7 X26_X X26_3 X26_7 VSS MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=5e-13
+ PD=1e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX26_M8 X26_10 X26_2 X26_X VSS MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=5e-13
+ PD=1e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX26_M9 VSS X26_9 X26_10 VSS MODN L=3.5e-07 W=1e-06 AD=5.875e-13 AS=5e-13
+ PD=1.175e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX26_M10 X26_9 X26_X VSS VSS MODN L=3.5e-07 W=1e-06 AD=1.215e-12 AS=5.875e-13
+ PD=4.1e-06 PS=1.175e-06 NRD=0.425 NRS=0.425
mX26_M11 VSS X26_9 19 VSS MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=7.45e-13 PD=1e-06
+ PS=2.7e-06 NRD=0.425 NRS=0.425
mX26_M12 3 X26_10 VSS VSS MODN L=3.5e-07 W=1e-06 AD=8.5e-13 AS=5e-13
+ PD=2.7e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX26_M13 VDD CLOCK X26_2 VDD MODP L=3.5e-07 W=1e-06 AD=1.16944e-12 AS=7.45e-13
+ PD=2.86111e-06 PS=2.7e-06 NRD=0.425 NRS=0.425
mX26_M14 VDD X26_2 X26_3 VDD MODP L=3.5e-07 W=8e-07 AD=9.35556e-13 AS=7.55e-13
+ PD=2.28889e-06 PS=3.1e-06 NRD=0.53125 NRS=0.53125
mX26_M15 X26_5 X26_2 X26_6 VDD MODP L=3.5e-07 W=1e-06 AD=5e-13 AS=1.355e-12
+ PD=1e-06 PS=4.1e-06 NRD=0.425 NRS=0.425
mX26_M16 X26_16 11 X26_5 VDD MODP L=3.5e-07 W=1.6e-06 AD=3.6e-13 AS=8e-13
+ PD=4.5e-07 PS=1.6e-06 NRD=0.265625 NRS=0.265625
mX26_M17 VDD X26_3 X26_16 VDD MODP L=3.5e-07 W=1.6e-06 AD=1.31625e-12
+ AS=3.6e-13 PD=3.3e-06 PS=4.5e-07 NRD=0.265625 NRS=0.265625
mX26_M18 VDD X26_7 X26_6 VDD MODP L=3.5e-07 W=1.6e-06 AD=9.1125e-13
+ AS=1.25e-12 PD=1.725e-06 PS=3.7e-06 NRD=0.217949 NRS=0.217949
mX26_M19 X26_7 X26_5 VDD VDD MODP L=3.5e-07 W=1.6e-06 AD=1.25e-12
+ AS=9.1125e-13 PD=3.7e-06 PS=1.725e-06 NRD=0.217949 NRS=0.217949
mX26_M20 X26_X X26_2 X26_7 VDD MODP L=3.5e-07 W=1e-06 AD=5e-13 AS=7.45e-13
+ PD=1e-06 PS=2.7e-06 NRD=0.425 NRS=0.425
mX26_M21 X26_10 X26_3 X26_X VDD MODP L=3.5e-07 W=1e-06 AD=8.5e-13 AS=5e-13
+ PD=2.7e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX26_M22 VDD X26_9 X26_10 VDD MODP L=3.5e-07 W=1.6e-06 AD=9.025e-13
+ AS=1.455e-12 PD=1.6e-06 PS=4e-06 NRD=0.217949 NRS=0.217949
mX26_M23 X26_9 X26_X VDD VDD MODP L=3.5e-07 W=1.6e-06 AD=1.335e-12
+ AS=9.025e-13 PD=3.85e-06 PS=1.6e-06 NRD=0.217949 NRS=0.217949
mX26_M24 VDD X26_9 19 VDD MODP L=3.5e-07 W=1.6e-06 AD=8e-13 AS=1.36e-12
+ PD=1e-06 PS=3.3e-06 NRD=0.265625 NRS=0.265625
mX26_M25 3 X26_10 VDD VDD MODP L=3.5e-07 W=1.6e-06 AD=1.36e-12 AS=8e-13
+ PD=3.3e-06 PS=1e-06 NRD=0.265625 NRS=0.265625
mX27_M0 VSS CLOCK X27_2 VSS MODN L=3.5e-07 W=5e-07 AD=5.375e-13 AS=5.9e-13
+ PD=1.97222e-06 PS=2.7e-06 NRD=0.85 NRS=0.85
mX27_M1 X27_3 X27_2 VSS VSS MODN L=3.5e-07 W=4e-07 AD=5.7e-13 AS=4.3e-13
+ PD=2.8e-06 PS=1.57778e-06 NRD=1.0625 NRS=1.0625
```

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mX27_M2 X27_15 X27_2 VSS VSS MODN L=3.5e-07 W=1e-06 AD=2.25e-13 AS=7.45e-13
+ PD=4.5e-07 PS=2.7e-06 NRD=0.425 NRS=0.425
mX27_M3 X27_5 10 X27_15 VSS MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=2.25e-13
+ PD=1e-06 PS=4.5e-07 NRD=0.425 NRS=0.425
mX27_M4 X27_6 X27_3 X27_5 VSS MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=5e-13
+ PD=1e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX27_M5 VSS X27_7 X27_6 VSS MODN L=3.5e-07 W=1e-06 AD=5.125e-13 AS=5e-13
+ PD=1.025e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX27_M6 X27_7 X27_5 VSS VSS MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=5.125e-13
+ PD=1e-06 PS=1.025e-06 NRD=0.425 NRS=0.425
mX27_M7 X27_X X27_3 X27_7 VSS MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=5e-13
+ PD=1e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX27_M8 X27_10 X27_2 X27_X VSS MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=5e-13
+ PD=1e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX27_M9 VSS X27_9 X27_10 VSS MODN L=3.5e-07 W=1e-06 AD=5.875e-13 AS=5e-13
+ PD=1.175e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX27_M10 X27_9 X27_X VSS VSS MODN L=3.5e-07 W=1e-06 AD=1.215e-12 AS=5.875e-13
+ PD=4.1e-06 PS=1.175e-06 NRD=0.425 NRS=0.425
mX27_M11 VSS X27_9 20 VSS MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=7.45e-13 PD=1e-06
+ PS=2.7e-06 NRD=0.425 NRS=0.425
mX27_M12 12 X27_10 VSS VSS MODN L=3.5e-07 W=1e-06 AD=8.5e-13 AS=5e-13
+ PD=2.7e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX27_M13 VDD CLOCK X27_2 VDD MODP L=3.5e-07 W=1e-06 AD=1.16944e-12 AS=7.45e-13
+ PD=2.86111e-06 PS=2.7e-06 NRD=0.425 NRS=0.425
mX27_M14 VDD X27_2 X27_3 VDD MODP L=3.5e-07 W=8e-07 AD=9.35556e-13 AS=7.55e-13
+ PD=2.28889e-06 PS=3.1e-06 NRD=0.53125 NRS=0.53125
mX27_M15 X27_5 X27_2 X27_6 VDD MODP L=3.5e-07 W=1e-06 AD=5e-13 AS=1.355e-12
+ PD=1e-06 PS=4.1e-06 NRD=0.425 NRS=0.425
mX27_M16 X27_16 10 X27_5 VDD MODP L=3.5e-07 W=1.6e-06 AD=3.6e-13 AS=8e-13
+ PD=4.5e-07 PS=1.6e-06 NRD=0.265625 NRS=0.265625
mX27_M17 VDD X27_3 X27_16 VDD MODP L=3.5e-07 W=1.6e-06 AD=1.31625e-12
+ AS=3.6e-13 PD=3.3e-06 PS=4.5e-07 NRD=0.265625 NRS=0.265625
mX27_M18 VDD X27_7 X27_6 VDD MODP L=3.5e-07 W=1.6e-06 AD=9.1125e-13
+ AS=1.25e-12 PD=1.725e-06 PS=3.7e-06 NRD=0.217949 NRS=0.217949
mX27_M19 X27_7 X27_5 VDD VDD MODP L=3.5e-07 W=1.6e-06 AD=1.25e-12
+ AS=9.1125e-13 PD=3.7e-06 PS=1.725e-06 NRD=0.217949 NRS=0.217949
mX27_M20 X27_X X27_2 X27_7 VDD MODP L=3.5e-07 W=1e-06 AD=5e-13 AS=7.45e-13
+ PD=1e-06 PS=2.7e-06 NRD=0.425 NRS=0.425
mX27_M21 X27_10 X27_3 X27_X VDD MODP L=3.5e-07 W=1e-06 AD=8.5e-13 AS=5e-13
+ PD=2.7e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX27_M22 VDD X27_9 X27_10 VDD MODP L=3.5e-07 W=1.6e-06 AD=9.025e-13
+ AS=1.455e-12 PD=1.6e-06 PS=4e-06 NRD=0.217949 NRS=0.217949
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mX27_M23 X27_9 X27_X VDD VDD MODP L=3.5e-07 W=1.6e-06 AD=1.335e-12
+ AS=9.025e-13 PD=3.85e-06 PS=1.6e-06 NRD=0.217949 NRS=0.217949
mX27_M24 VDD X27_9 20 VDD MODP L=3.5e-07 W=1.6e-06 AD=8e-13 AS=1.36e-12
+ PD=1e-06 PS=3.3e-06 NRD=0.265625 NRS=0.265625
mX27_M25 12 X27_10 VDD VDD MODP L=3.5e-07 W=1.6e-06 AD=1.36e-12 AS=8e-13
+ PD=3.3e-06 PS=1e-06 NRD=0.265625 NRS=0.265625
c_10 1 0 1.98411f
c_26 2 0 1.63375f
c_43 3 0 1.4008f
c_65 4 0 1.97389f
c_79 5 0 1.05021f
c_102 CLOCK 0 5.07417f
c_122 7 0 1.03448f
c_144 8 0 1.77897f
c_157 9 0 0.980134f
c_169 10 0 0.849176f
c_183 11 0 0.9348f
c_193 12 0 2.38779f
c_264 VSS 0 27.1899f
c_271 OUT3233 0 0.15992f
c_278 SM 0 0.348062f
c_348 VDD 0 338.058f
c_356 17 0 0.185789f
c_363 18 0 0.15992f
c_370 19 0 0.165263f
c_377 20 0 0.165263f
c_398 X22_2 0 2.86069f
c_409 X22_3 0 1.293f
c_419 X22_5 0 0.471943f
c_428 X22_6 0 0.113633f
c_438 X22_7 0 0.349226f
c_450 X22_X 0 0.398805f
c_458 X22_9 0 0.613787f
c_468 X22_10 0 1.26873f
c_480 X23_2 0 2.92756f
c_491 X23_3 0 1.30519f
c_501 X23_5 0 0.48294f
c_510 X23_6 0 0.127323f
c_520 X23_7 0 0.333807f
c_532 X23_X 0 0.411526f
c_540 X23_9 0 0.626199f
c_552 X23_10 0 1.2573f
```

```
c_565 X24_2 0 2.85674f
c_576 X24_3 0 1.29577f
c_586 X24_5 0 0.476252f
c_595 X24_6 0 0.119073f
c_605 X24_7 0 0.352571f
c_617 X24_X 0 0.411526f
c_625 X24_9 0 0.626199f
c_635 X24_10 0 1.27758f
c_652 X25_2 0 2.83018f
c_666 X25_3 0 1.29281f
c_678 X25_5 0 0.471306f
c_689 X25_6 0 0.114556f
c_700 X25_7 0 0.33091f
c_712 X25_X 0 0.398805f
c_720 X25_9 0 0.613873f
c_733 X25_10 0 1.25822f
c_746 X26_2 0 2.88141f
c_757 X26_3 0 1.30516f
c_767 X26_5 0 0.482931f
c_776 X26_6 0 0.119073f
c_786 X26_7 0 0.352571f
c_797 X26_X 0 0.411526f
c_805 X26_9 0 0.626199f
c_816 X26_10 0 1.2653f
c_831 X27_2 0 2.87781f
c_842 X27_3 0 1.3015f
c_852 X27_5 0 0.48294f
c_861 X27_6 0 0.127323f
c_871 X27_7 0 0.333807f
c_882 X27_X 0 0.411526f
c_890 X27_9 0 0.626199f
c_900 X27_10 0 1.28431f
*
.include "prescaler.pex.netlist.PRESCALER.pxi"
*
*** Idem aos comando do Experimento 3
*** Parametros
.Param tensao=3v
.Param F=0.2G P='1/F'

*** Tensoes estabelecidas
Vdd VDD GROUND DC tensao
```

```
.CONNECT VSS 0
Vclock CLOCK GROUND PULSE(0 3.0 0 '0.1*P' '0.1*P' '0.4*P' P)

*** Conexao do circuito
*** Caso SM = 1
*.CONNECT SM VDD
*** Caso SM = 0
.CONNECT SM 0

*** Tempo de propagacao de subida e descida
.meas tran Pout   trig v(OUT3233) val=tensao/2 rise=2 targ v(OUT3233) val=tensao/2 rise=3
.meas tran PClock trig v(CLOCK) val=tensao/2 rise=2 targ v(CLOCK) val=tensao/2 rise=3
.meas tran clockCir PARAM='Pout/Pclock'

*** Explorando curva simples - Para escolher melhor janela de simulacao
*.tran 0 '100*P' 0 'P/10' sweep F INCR 0.05G 0.4G 1.3G

*** Escursionando frequencia em busca da maxima - Tipico
*.tran 0 '100*P' 0 'P/10' sweep F INCR 0.005G 0.85G 0.95G
*****************************************

*** Escursionando frequencia em busca da maxima - WS
.tran 0 '100*P' 0 'P/10' sweep F INCR 0.005G 0.57G 0.65G
*****************************************

.probe tran V(CLOCK) V(OUT3233)

*.include Model35_Eldo
.include cmos53ws.mod

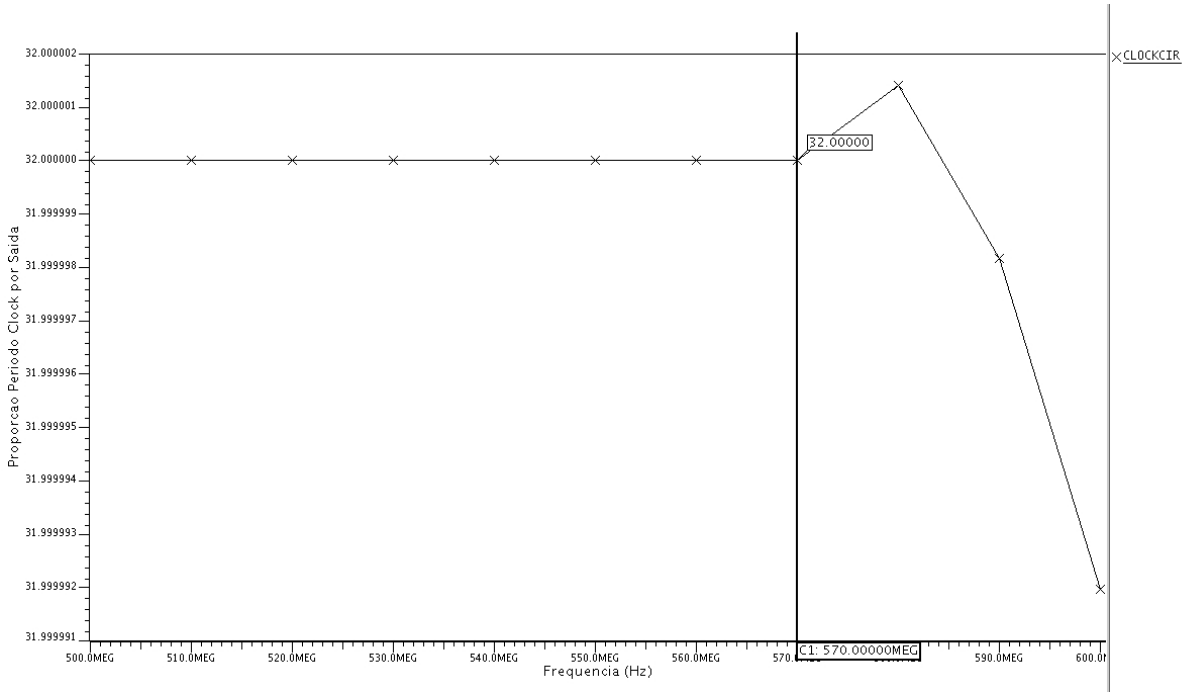
.end
```

Questão 13: Extrair agora o circuito para simulação com capacitores e resistores. Determinar a máxima velocidade do circuito para o modelo típico e para o modelo worstspeed

Para extração a partir do *Layout* R+C+CC.

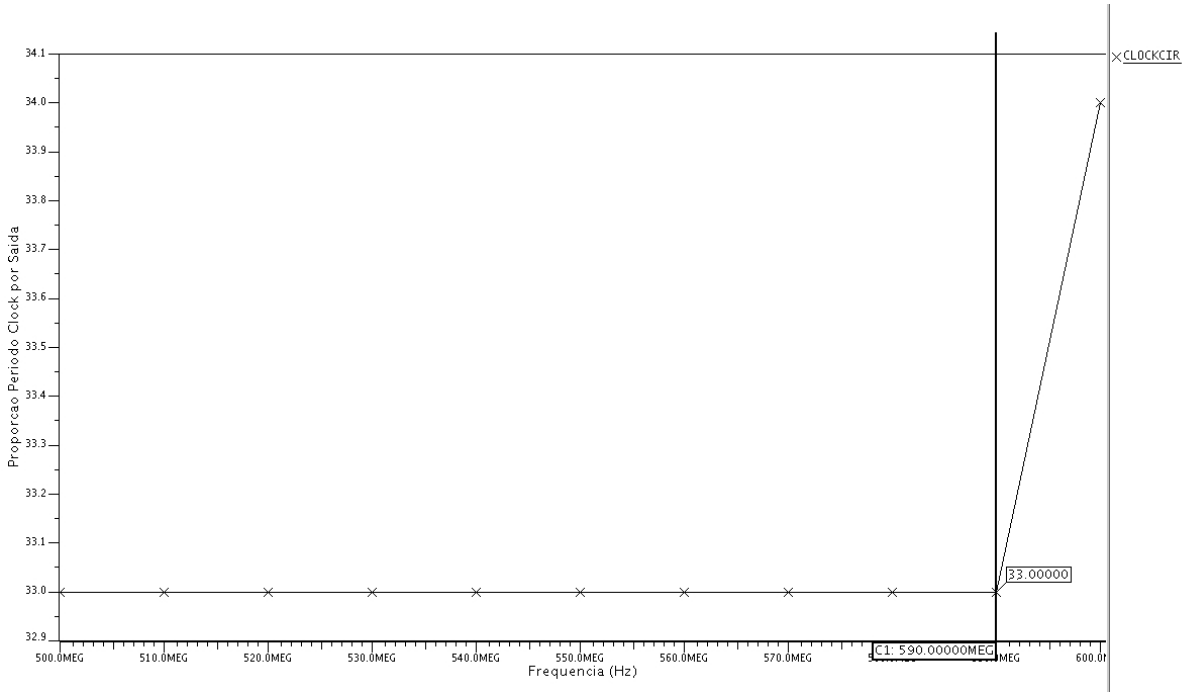
Modelo *Worst Speed:* Apresenta-se nas figuras 26 e 27, logo temos a frequência máxima de operação para **SM=0 de 0,570GHz** e para para **SM=1 de 0,590GHz**.

Figura 24 – *Worst Speed* - Curva proporção do período do *clock* e saída para SM=0



Fonte: Pelos próprios autores

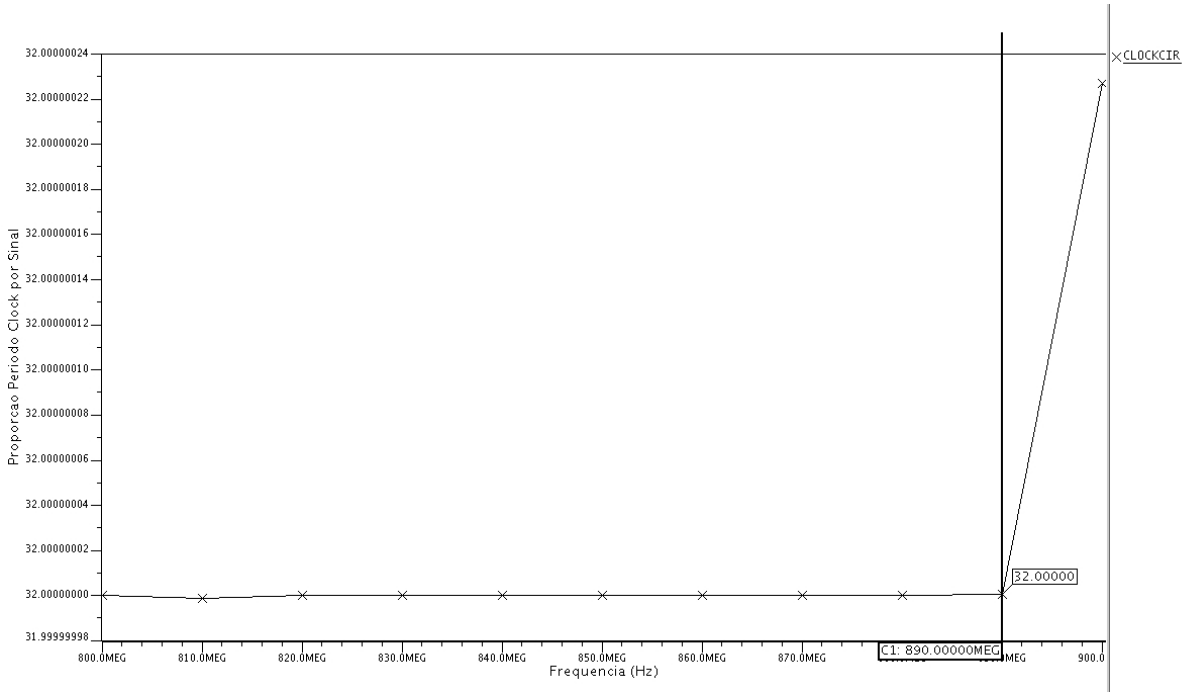
Figura 25 – *Worst Speed* - Curva proporção do período do *clock* e saída para SM=1



Fonte: Pelos próprios autores

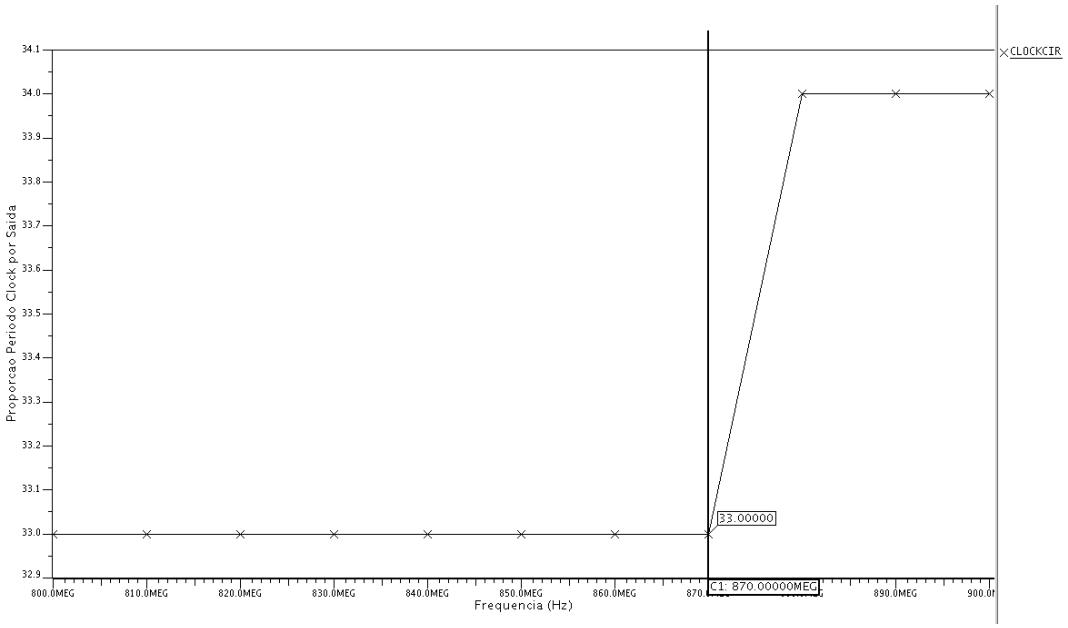
Modelo típico: Apresenta-se nas figuras 26 e 27, logo temos a frequência máxima de operação para **SM=0 de 0,890GHz** e para para **SM=1 de 0,870GHz**.

Figura 26 – Típico - Curva proporção do período do *clock* e saída para SM=0



Fonte: Pelos próprios autores

Figura 27 – Típico - Curva proporção do período do *clock* e saída para SM=1



Fonte: Pelos próprios autores

Apresenta-se a seguir o netlist extraído a partir do Layout R+C+CC.

```
* File: prescaler.pex.netlist
* Created: Fri Oct 22 10:23:53 2021
```

```
* Program "Calibre xRC"
* Version "v2006.2_16.16"
*
.include "prescaler.pex.netlist.pex"
*** Configuracao Simulacao
.option measDGT=8
.options ingold=1
.option MSGNODE = 0
.CONNECT GROUND 0

mM0 21 N_2_M0_g N_VSS_M0_s N_VSS_X22_M0_b MODN L=3.5e-07 W=2e-06 AD=8e-13
+ AS=1.7e-12 PD=8e-07 PS=3.7e-06 NRD=0.2125 NRS=0.2125
mM1 22 N_7_M1_g 21 N_VSS_X22_M0_b MODN L=3.5e-07 W=2e-06 AD=8e-13 AS=8e-13
+ PD=8e-07 PS=8e-07 NRD=0.2125 NRS=0.2125
mM2 23 N_8_M2_g 22 N_VSS_X22_M0_b MODN L=3.5e-07 W=2e-06 AD=8e-13 AS=8e-13
+ PD=8e-07 PS=8e-07 NRD=0.2125 NRS=0.2125
mM3 N_9_M3_d N_SM_M3_g 23 N_VSS_X22_M0_b MODN L=3.5e-07 W=2e-06 AD=1.75e-12
+ AS=8e-13 PD=3.75e-06 PS=8e-07 NRD=0.2125 NRS=0.2125
mM4 N_10_M4_d N_4_M4_g N_VSS_M4_s N_VSS_X22_M0_b MODN L=3.5e-07 W=3e-06
+ AD=2.42375e-12 AS=2.93e-12 PD=1.8e-06 PS=5.05e-06 NRD=0.126866 NRS=0.126866
mM5 N_VSS_M5_d N_9_M5_g N_10_M4_d N_VSS_X22_M0_b MODN L=3.5e-07 W=3e-06
+ AD=4.4375e-12 AS=2.42375e-12 PD=5.95e-06 PS=1.8e-06 NRD=0.126866 NRS=0.126866
mM6 N_11_M6_d N_4_M6_g N_17_M6_s N_VSS_X22_M0_b MODN L=3.5e-07 W=3e-06
+ AD=1.0395e-12 AS=2.69e-12 PD=5.64607e-07 PS=5.05e-06 NRD=0.126866 NRS=0.126866
mM7 N_17_M7_d N_4_M7_g N_11_M6_d N_VSS_X22_M0_b MODN L=3.5e-07 W=2.975e-06
+ AD=2.18304e-12 AS=1.03175e-12 PD=1.73099e-06 PS=5.60393e-07 NRD=0.12782
+ NRS=0.12782
mM8 N_VSS_M8_d N_12_M8_g N_17_M7_d N_VSS_X22_M0_b MODN L=3.5e-07 W=3e-06
+ AD=1.0225e-12 AS=2.19946e-12 PD=5.5e-07 PS=1.74401e-06 NRD=0.126866
+ NRS=0.126866
mM9 N_17_M9_d N_12_M9_g N_VSS_M8_d N_VSS_X22_M0_b MODN L=3.5e-07 W=3e-06
+ AD=2.69e-12 AS=1.0225e-12 PD=5.05e-06 PS=5.5e-07 NRD=0.126866 NRS=0.126866
mM10 N_VDD_M10_d N_2_M10_g N_9_M10_s N_VDD_X22_M13_b MODP L=3.5e-07 W=8e-07
+ AD=4e-13 AS=6.8e-13 PD=1e-06 PS=2.5e-06 NRD=0.53125 NRS=0.53125
mM11 N_9_M11_d N_7_M11_g N_VDD_M10_d N_VDD_X22_M13_b MODP L=3.5e-07 W=8e-07
+ AD=4e-13 AS=4e-13 PD=1e-06 PS=1e-06 NRD=0.53125 NRS=0.53125
mM12 N_VDD_M12_d N_8_M12_g N_9_M11_d N_VDD_X22_M13_b MODP L=3.5e-07 W=8e-07
+ AD=4e-13 AS=4e-13 PD=1e-06 PS=1e-06 NRD=0.53125 NRS=0.53125
mM13 N_9_M13_d N_SM_M13_g N_VDD_M12_d N_VDD_X22_M13_b MODP L=3.5e-07 W=8e-07
+ AD=6.8e-13 AS=4e-13 PD=2.5e-06 PS=1e-06 NRD=0.53125 NRS=0.53125
mM14 24 N_4_M14_g N_VDD_M14_s N_VDD_X22_M13_b MODP L=3.5e-07 W=4.8e-06
+ AD=1.15875e-12 AS=3.685e-12 PD=4.5e-07 PS=6.15e-06 NRD=0.0825243 NRS=0.0825243
```

```
mM15 N_10_M15_d N_9_M15_g 24 N_VDD_X22_M13_b MODP L=3.5e-07 W=4.8e-06
+ AD=3.45687e-12 AS=1.15875e-12 PD=2.025e-06 PS=4.5e-07 NRD=0.0825243
+ NRS=0.0825243
mM16 25 N_9_M16_g N_10_M15_d N_VDD_X22_M13_b MODP L=3.5e-07 W=4.8e-06
+ AD=1.15875e-12 AS=3.45687e-12 PD=4.5e-07 PS=2.025e-06 NRD=0.0825243
+ NRS=0.0825243
mM17 N_VDD_M17_d N_4_M17_g 25 N_VDD_X22_M13_b MODP L=3.5e-07 W=4.8e-06
+ AD=3.9625e-12 AS=1.15875e-12 PD=6.15e-06 PS=4.5e-07 NRD=0.0825243 NRS=0.0825243
mM18 N_11_M18_d N_4_M18_g N_VDD_M18_s N_VDD_X23_M13_b MODP L=3.5e-07 W=2.4e-06
+ AD=1.2e-12 AS=2.04e-12 PD=1e-06 PS=4.1e-06 NRD=0.177083 NRS=0.177083
mM19 N_VDD_M19_d N_4_M19_g N_11_M18_d N_VDD_X23_M13_b MODP L=3.5e-07 W=2.4e-06
+ AD=1.2e-12 AS=1.2e-12 PD=1e-06 PS=1e-06 NRD=0.177083 NRS=0.177083
mM20 N_11_M20_d N_12_M20_g N_VDD_M19_d N_VDD_X23_M13_b MODP L=3.5e-07
+ W=2.4e-06 AD=1.2e-12 AS=1.2e-12 PD=1e-06 PS=1e-06 NRD=0.177083 NRS=0.177083
mM21 N_VDD_M21_d N_12_M21_g N_11_M20_d N_VDD_X23_M13_b MODP L=3.5e-07
+ W=2.4e-06 AD=2.04e-12 AS=1.2e-12 PD=4.1e-06 PS=1e-06 NRD=0.177083 NRS=0.177083
mX22_M0 N_VSS_X22_M0_d N_5_X22_M0_g N_X22_2_X22_M0_s N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=5e-07 AD=5.375e-13 AS=5.9e-13 PD=1.97222e-06 PS=2.7e-06 NRD=0.85
+ NRS=0.85
mX22_M1 N_X22_3_X22_M1_d N_X22_2_X22_M1_g N_VSS_X22_M0_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=4e-07 AD=5.7e-13 AS=4.3e-13 PD=2.8e-06 PS=1.57778e-06 NRD=1.0625
+ NRS=1.0625
mX22_M2 X22_15 N_X22_2_X22_M2_g N_VSS_X22_M2_s N_VSS_X22_M0_b MODN L=3.5e-07
+ W=1e-06 AD=2.25e-13 AS=7.45e-13 PD=4.5e-07 PS=2.7e-06 NRD=0.425 NRS=0.425
mX22_M3 N_X22_5_X22_M3_d N_2_X22_M3_g X22_15 N_VSS_X22_M0_b MODN L=3.5e-07
+ W=1e-06 AD=5e-13 AS=2.25e-13 PD=1e-06 PS=4.5e-07 NRD=0.425 NRS=0.425
mX22_M4 N_X22_6_X22_M4_d N_X22_3_X22_M4_g N_X22_5_X22_M3_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=5e-13 AS=5e-13 PD=1e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX22_M5 N_VSS_X22_M5_d N_X22_7_X22_M5_g N_X22_6_X22_M4_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=5.125e-13 AS=5e-13 PD=1.025e-06 PS=1e-06 NRD=0.425
+ NRS=0.425
mX22_M6 N_X22_7_X22_M6_d N_X22_5_X22_M6_g N_VSS_X22_M5_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=5e-13 AS=5.125e-13 PD=1e-06 PS=1.025e-06 NRD=0.425
+ NRS=0.425
mX22_M7 N_X22_X_X22_M7_d N_X22_3_X22_M7_g N_X22_7_X22_M6_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=5e-13 AS=5e-13 PD=1e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX22_M8 N_X22_10_X22_M8_d N_X22_2_X22_M8_g N_X22_X_X22_M7_d N_VSS_X22_M0_b
+ MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=5e-13 PD=1e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX22_M9 N_VSS_X22_M9_d N_X22_9_X22_M9_g N_X22_10_X22_M8_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=5.875e-13 AS=5e-13 PD=1.175e-06 PS=1e-06 NRD=0.425
+ NRS=0.425
mX22_M10 N_X22_9_X22_M10_d N_X22_X_X22_M10_g N_VSS_X22_M9_d N_VSS_X22_M0_b
```

```
+ MODN L=3.5e-07 W=1e-06 AD=1.215e-12 AS=5.875e-13 PD=4.1e-06 PS=1.175e-06
+ NRD=0.425 NRS=0.425
mX22_M11 N_VSS_X22_M11_d N_X22_9_X22_M11_g N_OUT3233_X22_M11_s N_VSS_X22_M0_b
+ MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=7.45e-13 PD=1e-06 PS=2.7e-06 NRD=0.425
+ NRS=0.425
mX22_M12 N_2_X22_M12_d N_X22_10_X22_M12_g N_VSS_X22_M11_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=8.5e-13 AS=5e-13 PD=2.7e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX22_M13 N_VDD_X22_M13_d N_5_X22_M13_g N_X22_2_X22_M13_s N_VDD_X22_M13_b MODP
+ L=3.5e-07 W=1e-06 AD=1.16944e-12 AS=7.45e-13 PD=2.86111e-06 PS=2.7e-06
+ NRD=0.425 NRS=0.425
mX22_M14 N_VDD_X22_M13_d N_X22_2_X22_M14_g N_X22_3_X22_M14_s N_VDD_X22_M13_b
+ MODP L=3.5e-07 W=8e-07 AD=9.35556e-13 AS=7.55e-13 PD=2.28889e-06 PS=3.1e-06
+ NRD=0.53125 NRS=0.53125
mX22_M15 N_X22_5_X22_M15_d N_X22_2_X22_M15_g N_X22_6_X22_M15_s N_VDD_X22_M13_b
+ MODP L=3.5e-07 W=1e-06 AD=5e-13 AS=1.355e-12 PD=1e-06 PS=4.1e-06 NRD=0.425
+ NRS=0.425
mX22_M16 X22_16 N_2_X22_M16_g N_X22_5_X22_M15_d N_VDD_X22_M13_b MODP L=3.5e-07
+ W=1.6e-06 AD=3.6e-13 AS=8e-13 PD=4.5e-07 PS=1.6e-06 NRD=0.265625 NRS=0.265625
mX22_M17 N_VDD_X22_M17_d N_X22_3_X22_M17_g X22_16 N_VDD_X22_M13_b MODP
+ L=3.5e-07 W=1.6e-06 AD=1.31625e-12 AS=3.6e-13 PD=3.3e-06 PS=4.5e-07
+ NRD=0.265625 NRS=0.265625
mX22_M18 N_VDD_X22_M18_d N_X22_7_X22_M18_g N_X22_6_X22_M18_s N_VDD_X22_M13_b
+ MODP L=3.5e-07 W=1.6e-06 AD=9.1125e-13 AS=1.25e-12 PD=1.725e-06 PS=3.7e-06
+ NRD=0.217949 NRS=0.217949
mX22_M19 N_X22_7_X22_M19_d N_X22_5_X22_M19_g N_VDD_X22_M18_d N_VDD_X22_M13_b
+ MODP L=3.5e-07 W=1.6e-06 AD=1.25e-12 AS=9.1125e-13 PD=3.7e-06 PS=1.725e-06
+ NRD=0.217949 NRS=0.217949
mX22_M20 N_X22_X_X22_M20_d N_X22_2_X22_M20_g N_X22_7_X22_M20_s N_VDD_X22_M13_b
+ MODP L=3.5e-07 W=1e-06 AD=5e-13 AS=7.45e-13 PD=1e-06 PS=2.7e-06 NRD=0.425
+ NRS=0.425
mX22_M21 N_X22_10_X22_M21_d N_X22_3_X22_M21_g N_X22_X_X22_M20_d N_VDD_X22_M13_b
+ MODP L=3.5e-07 W=1e-06 AD=8.5e-13 AS=5e-13 PD=2.7e-06 PS=1e-06 NRD=0.425
+ NRS=0.425
mX22_M22 N_VDD_X22_M22_d N_X22_9_X22_M22_g N_X22_10_X22_M22_s N_VDD_X22_M13_b
+ MODP L=3.5e-07 W=1.6e-06 AD=9.025e-13 AS=1.455e-12 PD=1.6e-06 PS=4e-06
+ NRD=0.217949 NRS=0.217949
mX22_M23 N_X22_9_X22_M23_d N_X22_X_X22_M23_g N_VDD_X22_M22_d N_VDD_X22_M13_b
+ MODP L=3.5e-07 W=1.6e-06 AD=1.335e-12 AS=9.025e-13 PD=3.85e-06 PS=1.6e-06
+ NRD=0.217949 NRS=0.217949
mX22_M24 N_VDD_X22_M24_d N_X22_9_X22_M24_g N_OUT3233_X22_M24_s N_VDD_X22_M13_b
+ MODP L=3.5e-07 W=1.6e-06 AD=8e-13 AS=1.36e-12 PD=1e-06 PS=3.3e-06 NRD=0.265625
+ NRS=0.265625
```

```
mX22_M25 N_2_X22_M25_d N_X22_10_X22_M25_g N_VDD_X22_M24_d N_VDD_X22_M13_b MODP
+ L=3.5e-07 W=1.6e-06 AD=1.36e-12 AS=8e-13 PD=3.3e-06 PS=1e-06 NRD=0.265625
+ NRS=0.265625
mX23_M0 N_VSS_X23_M0_d N_1_X23_M0_g N_X23_2_X23_M0_s N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=5e-07 AD=5.375e-13 AS=5.9e-13 PD=1.97222e-06 PS=2.7e-06 NRD=0.85
+ NRS=0.85
mX23_M1 N_X23_3_X23_M1_d N_X23_2_X23_M1_g N_VSS_X23_M0_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=4e-07 AD=5.7e-13 AS=4.3e-13 PD=2.8e-06 PS=1.57778e-06 NRD=1.0625
+ NRS=1.0625
mX23_M2 X23_15 N_X23_2_X23_M2_g N_VSS_X23_M2_s N_VSS_X22_M0_b MODN L=3.5e-07
+ W=1e-06 AD=2.25e-13 AS=7.45e-13 PD=4.5e-07 PS=2.7e-06 NRD=0.425 NRS=0.425
mX23_M3 N_X23_5_X23_M3_d N_7_X23_M3_g X23_15 N_VSS_X22_M0_b MODN L=3.5e-07
+ W=1e-06 AD=5e-13 AS=2.25e-13 PD=1e-06 PS=4.5e-07 NRD=0.425 NRS=0.425
mX23_M4 N_X23_6_X23_M4_d N_X23_3_X23_M4_g N_X23_5_X23_M3_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=5e-13 AS=5e-13 PD=1e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX23_M5 N_VSS_X23_M5_d N_X23_7_X23_M5_g N_X23_6_X23_M4_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=5.125e-13 AS=5e-13 PD=1.025e-06 PS=1e-06 NRD=0.425
+ NRS=0.425
mX23_M6 N_X23_7_X23_M6_d N_X23_5_X23_M6_g N_VSS_X23_M5_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=5e-13 AS=5.125e-13 PD=1e-06 PS=1.025e-06 NRD=0.425
+ NRS=0.425
mX23_M7 N_X23_X_X23_M7_d N_X23_3_X23_M7_g N_X23_7_X23_M6_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=5e-13 AS=5e-13 PD=1e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX23_M8 N_X23_10_X23_M8_d N_X23_2_X23_M8_g N_X23_X_X23_M7_d N_VSS_X22_M0_b
+ MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=5e-13 PD=1e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX23_M9 N_VSS_X23_M9_d N_X23_9_X23_M9_g N_X23_10_X23_M8_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=5.875e-13 AS=5e-13 PD=1.175e-06 PS=1e-06 NRD=0.425
+ NRS=0.425
mX23_M10 N_X23_9_X23_M10_d N_X23_X_X23_M10_g N_VSS_X23_M9_d N_VSS_X22_M0_b
+ MODN L=3.5e-07 W=1e-06 AD=1.215e-12 AS=5.875e-13 PD=4.1e-06 PS=1.175e-06
+ NRD=0.425 NRS=0.425
mX23_M11 N_VSS_X23_M11_d N_X23_9_X23_M11_g N_5_X23_M11_s N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=5e-13 AS=7.45e-13 PD=1e-06 PS=2.7e-06 NRD=0.425 NRS=0.425
mX23_M12 N_7_X23_M12_d N_X23_10_X23_M12_g N_VSS_X23_M11_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=8.5e-13 AS=5e-13 PD=2.7e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX23_M13 N_VDD_X23_M13_d N_1_X23_M13_g N_X23_2_X23_M13_s N_VDD_X23_M13_b MODP
+ L=3.5e-07 W=1e-06 AD=1.16944e-12 AS=7.45e-13 PD=2.86111e-06 PS=2.7e-06
+ NRD=0.425 NRS=0.425
mX23_M14 N_VDD_X23_M13_d N_X23_2_X23_M14_g N_X23_3_X23_M14_s N_VDD_X23_M13_b
+ MODP L=3.5e-07 W=8e-07 AD=9.35556e-13 AS=7.55e-13 PD=2.28889e-06 PS=3.1e-06
+ NRD=0.53125 NRS=0.53125
mX23_M15 N_X23_5_X23_M15_d N_X23_2_X23_M15_g N_X23_6_X23_M15_s N_VDD_X23_M13_b
```

```
+ MODP L=3.5e-07 W=1e-06 AD=5e-13 AS=1.355e-12 PD=1e-06 PS=4.1e-06 NRD=0.425
+ NRS=0.425
mX23_M16 X23_16 N_7_X23_M16_g N_X23_5_X23_M15_d N_VDD_X23_M13_b MODP L=3.5e-07
+ W=1.6e-06 AD=3.6e-13 AS=8e-13 PD=4.5e-07 PS=1.6e-06 NRD=0.265625 NRS=0.265625
mX23_M17 N_VDD_X23_M17_d N_X23_3_X23_M17_g X23_16 N_VDD_X23_M13_b MODP
+ L=3.5e-07 W=1.6e-06 AD=1.31625e-12 AS=3.6e-13 PD=3.3e-06 PS=4.5e-07
+ NRD=0.265625 NRS=0.265625
mX23_M18 N_VDD_X23_M18_d N_X23_7_X23_M18_g N_X23_6_X23_M18_s N_VDD_X23_M13_b
+ MODP L=3.5e-07 W=1.6e-06 AD=9.1125e-13 AS=1.25e-12 PD=1.725e-06 PS=3.7e-06
+ NRD=0.217949 NRS=0.217949
mX23_M19 N_X23_7_X23_M19_d N_X23_5_X23_M19_g N_VDD_X23_M18_d N_VDD_X23_M13_b
+ MODP L=3.5e-07 W=1.6e-06 AD=1.25e-12 AS=9.1125e-13 PD=3.7e-06 PS=1.725e-06
+ NRD=0.217949 NRS=0.217949
mX23_M20 N_X23_X_X23_M20_d N_X23_2_X23_M20_g N_X23_7_X23_M20_s N_VDD_X23_M13_b
+ MODP L=3.5e-07 W=1e-06 AD=5e-13 AS=7.45e-13 PD=1e-06 PS=2.7e-06 NRD=0.425
+ NRS=0.425
mX23_M21 N_X23_10_X23_M21_d N_X23_3_X23_M21_g N_X23_X_X23_M20_d N_VDD_X23_M13_b
+ MODP L=3.5e-07 W=1e-06 AD=8.5e-13 AS=5e-13 PD=2.7e-06 PS=1e-06 NRD=0.425
+ NRS=0.425
mX23_M22 N_VDD_X23_M22_d N_X23_9_X23_M22_g N_X23_10_X23_M22_s N_VDD_X23_M13_b
+ MODP L=3.5e-07 W=1.6e-06 AD=9.025e-13 AS=1.455e-12 PD=1.6e-06 PS=4e-06
+ NRD=0.217949 NRS=0.217949
mX23_M23 N_X23_9_X23_M23_d N_X23_X_X23_M23_g N_VDD_X23_M22_d N_VDD_X23_M13_b
+ MODP L=3.5e-07 W=1.6e-06 AD=1.335e-12 AS=9.025e-13 PD=3.85e-06 PS=1.6e-06
+ NRD=0.217949 NRS=0.217949
mX23_M24 N_VDD_X23_M24_d N_X23_9_X23_M24_g N_5_X23_M24_s N_VDD_X23_M13_b MODP
+ L=3.5e-07 W=1.6e-06 AD=8e-13 AS=1.36e-12 PD=1e-06 PS=3.3e-06 NRD=0.265625
+ NRS=0.265625
mX23_M25 N_7_X23_M25_d N_X23_10_X23_M25_g N_VDD_X23_M24_d N_VDD_X23_M13_b MODP
+ L=3.5e-07 W=1.6e-06 AD=1.36e-12 AS=8e-13 PD=3.3e-06 PS=1e-06 NRD=0.265625
+ NRS=0.265625
mX24_M0 N_VSS_X24_M0_d N_3_X24_M0_g N_X24_2_X24_M0_s N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=5e-07 AD=5.375e-13 AS=5.9e-13 PD=1.97222e-06 PS=2.7e-06 NRD=0.85
+ NRS=0.85
mX24_M1 N_X24_3_X24_M1_d N_X24_2_X24_M1_g N_VSS_X24_M0_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=4e-07 AD=5.7e-13 AS=4.3e-13 PD=2.8e-06 PS=1.57778e-06 NRD=1.0625
+ NRS=1.0625
mX24_M2 X24_15 N_X24_2_X24_M2_g N_VSS_X24_M2_s N_VSS_X22_M0_b MODN L=3.5e-07
+ W=1e-06 AD=2.25e-13 AS=7.45e-13 PD=4.5e-07 PS=2.7e-06 NRD=0.425 NRS=0.425
mX24_M3 N_X24_5_X24_M3_d N_8_X24_M3_g X24_15 N_VSS_X22_M0_b MODN L=3.5e-07
+ W=1e-06 AD=5e-13 AS=2.25e-13 PD=1e-06 PS=4.5e-07 NRD=0.425 NRS=0.425
mX24_M4 N_X24_6_X24_M4_d N_X24_3_X24_M4_g N_X24_5_X24_M3_d N_VSS_X22_M0_b MODN
```

```
+ L=3.5e-07 W=1e-06 AD=5e-13 AS=5e-13 PD=1e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX24_M5 N_VSS_X24_M5_d N_X24_7_X24_M5_g N_X24_6_X24_M4_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=5.125e-13 AS=5e-13 PD=1.025e-06 PS=1e-06 NRD=0.425
+ NRS=0.425
mX24_M6 N_X24_7_X24_M6_d N_X24_5_X24_M6_g N_VSS_X24_M5_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=5e-13 AS=5.125e-13 PD=1e-06 PS=1.025e-06 NRD=0.425
+ NRS=0.425
mX24_M7 N_X24_X_X24_M7_d N_X24_3_X24_M7_g N_X24_7_X24_M6_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=5e-13 AS=5e-13 PD=1e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX24_M8 N_X24_10_X24_M8_d N_X24_2_X24_M8_g N_X24_X_X24_M7_d N_VSS_X22_M0_b
+ MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=5e-13 PD=1e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX24_M9 N_VSS_X24_M9_d N_X24_9_X24_M9_g N_X24_10_X24_M8_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=5.875e-13 AS=5e-13 PD=1.175e-06 PS=1e-06 NRD=0.425
+ NRS=0.425
mX24_M10 N_X24_9_X24_M10_d N_X24_X_X24_M10_g N_VSS_X24_M9_d N_VSS_X22_M0_b
+ MODN L=3.5e-07 W=1e-06 AD=1.215e-12 AS=5.875e-13 PD=4.1e-06 PS=1.175e-06
+ NRD=0.425 NRS=0.425
mX24_M11 N_VSS_X24_M11_d N_X24_9_X24_M11_g N_1_X24_M11_s N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=5e-13 AS=7.45e-13 PD=1e-06 PS=2.7e-06 NRD=0.425 NRS=0.425
mX24_M12 N_8_X24_M12_d N_X24_10_X24_M12_g N_VSS_X24_M11_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=8.5e-13 AS=5e-13 PD=2.7e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX24_M13 N_VDD_X24_M13_d N_3_X24_M13_g N_X24_2_X24_M13_s N_VDD_X24_M13_b MODP
+ L=3.5e-07 W=1e-06 AD=1.16944e-12 AS=7.45e-13 PD=2.86111e-06 PS=2.7e-06
+ NRD=0.425 NRS=0.425
mX24_M14 N_VDD_X24_M13_d N_X24_2_X24_M14_g N_X24_3_X24_M14_s N_VDD_X24_M13_b
+ MODP L=3.5e-07 W=8e-07 AD=9.35556e-13 AS=7.55e-13 PD=2.28889e-06 PS=3.1e-06
+ NRD=0.53125 NRS=0.53125
mX24_M15 N_X24_5_X24_M15_d N_X24_2_X24_M15_g N_X24_6_X24_M15_s N_VDD_X24_M13_b
+ MODP L=3.5e-07 W=1e-06 AD=5e-13 AS=1.355e-12 PD=1e-06 PS=4.1e-06 NRD=0.425
+ NRS=0.425
mX24_M16 X24_16 N_8_X24_M16_g N_X24_5_X24_M15_d N_VDD_X24_M13_b MODP L=3.5e-07
+ W=1.6e-06 AD=3.6e-13 AS=8e-13 PD=4.5e-07 PS=1.6e-06 NRD=0.265625 NRS=0.265625
mX24_M17 N_VDD_X24_M17_d N_X24_3_X24_M17_g X24_16 N_VDD_X24_M13_b MODP
+ L=3.5e-07 W=1.6e-06 AD=1.31625e-12 AS=3.6e-13 PD=3.3e-06 PS=4.5e-07
+ NRD=0.265625 NRS=0.265625
mX24_M18 N_VDD_X24_M18_d N_X24_7_X24_M18_g N_X24_6_X24_M18_s N_VDD_X24_M13_b
+ MODP L=3.5e-07 W=1.6e-06 AD=9.1125e-13 AS=1.25e-12 PD=1.725e-06 PS=3.7e-06
+ NRD=0.217949 NRS=0.217949
mX24_M19 N_X24_7_X24_M19_d N_X24_5_X24_M19_g N_VDD_X24_M18_d N_VDD_X24_M13_b
+ MODP L=3.5e-07 W=1.6e-06 AD=1.25e-12 AS=9.1125e-13 PD=3.7e-06 PS=1.725e-06
+ NRD=0.217949 NRS=0.217949
mX24_M20 N_X24_X_X24_M20_d N_X24_2_X24_M20_g N_X24_7_X24_M20_s N_VDD_X24_M13_b
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```
+ MODP L=3.5e-07 W=1e-06 AD=5e-13 AS=7.45e-13 PD=1e-06 PS=2.7e-06 NRD=0.425
+ NRS=0.425
mX24_M21 N_X24_10_X24_M21_d N_X24_3_X24_M21_g N_X24_X_X24_M20_d N_VDD_X24_M13_b
+ MODP L=3.5e-07 W=1e-06 AD=8.5e-13 AS=5e-13 PD=2.7e-06 PS=1e-06 NRD=0.425
+ NRS=0.425
mX24_M22 N_VDD_X24_M22_d N_X24_9_X24_M22_g N_X24_10_X24_M22_s N_VDD_X24_M13_b
+ MODP L=3.5e-07 W=1.6e-06 AD=9.025e-13 AS=1.455e-12 PD=1.6e-06 PS=4e-06
+ NRD=0.217949 NRS=0.217949
mX24_M23 N_X24_9_X24_M23_d N_X24_X_X24_M23_g N_VDD_X24_M22_d N_VDD_X24_M13_b
+ MODP L=3.5e-07 W=1.6e-06 AD=1.335e-12 AS=9.025e-13 PD=3.85e-06 PS=1.6e-06
+ NRD=0.217949 NRS=0.217949
mX24_M24 N_VDD_X24_M24_d N_X24_9_X24_M24_g N_1_X24_M24_s N_VDD_X24_M13_b MODP
+ L=3.5e-07 W=1.6e-06 AD=8e-13 AS=1.36e-12 PD=1e-06 PS=3.3e-06 NRD=0.265625
+ NRS=0.265625
mX24_M25 N_8_X24_M25_d N_X24_10_X24_M25_g N_VDD_X24_M24_d N_VDD_X24_M13_b MODP
+ L=3.5e-07 W=1.6e-06 AD=1.36e-12 AS=8e-13 PD=3.3e-06 PS=1e-06 NRD=0.265625
+ NRS=0.265625
mX25_M0 N_VSS_X25_M0_d N_CLOCK_X25_M0_g N_X25_2_X25_M0_s N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=5e-07 AD=5.375e-13 AS=5.9e-13 PD=1.97222e-06 PS=2.7e-06 NRD=0.85
+ NRS=0.85
mX25_M1 N_X25_3_X25_M1_d N_X25_2_X25_M1_g N_VSS_X25_M0_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=4e-07 AD=5.7e-13 AS=4.3e-13 PD=2.8e-06 PS=1.57778e-06 NRD=1.0625
+ NRS=1.0625
mX25_M2 X25_15 N_X25_2_X25_M2_g N_VSS_X25_M2_s N_VSS_X22_M0_b MODN L=3.5e-07
+ W=1e-06 AD=2.25e-13 AS=7.45e-13 PD=4.5e-07 PS=2.7e-06 NRD=0.425 NRS=0.425
mX25_M3 N_X25_5_X25_M3_d N_3_X25_M3_g X25_15 N_VSS_X22_M0_b MODN L=3.5e-07
+ W=1e-06 AD=5e-13 AS=2.25e-13 PD=1e-06 PS=4.5e-07 NRD=0.425 NRS=0.425
mX25_M4 N_X25_6_X25_M4_d N_X25_3_X25_M4_g N_X25_5_X25_M3_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=5e-13 AS=5e-13 PD=1e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX25_M5 N_VSS_X25_M5_d N_X25_7_X25_M5_g N_X25_6_X25_M4_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=5.125e-13 AS=5e-13 PD=1.025e-06 PS=1e-06 NRD=0.425
+ NRS=0.425
mX25_M6 N_X25_7_X25_M6_d N_X25_5_X25_M6_g N_VSS_X25_M5_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=5e-13 AS=5.125e-13 PD=1e-06 PS=1.025e-06 NRD=0.425
+ NRS=0.425
mX25_M7 N_X25_X_X25_M7_d N_X25_3_X25_M7_g N_X25_7_X25_M6_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=5e-13 AS=5e-13 PD=1e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX25_M8 N_X25_10_X25_M8_d N_X25_2_X25_M8_g N_X25_X_X25_M7_d N_VSS_X22_M0_b
+ MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=5e-13 PD=1e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX25_M9 N_VSS_X25_M9_d N_X25_9_X25_M9_g N_X25_10_X25_M8_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=5.875e-13 AS=5e-13 PD=1.175e-06 PS=1e-06 NRD=0.425
+ NRS=0.425
```

```
mX25_M10 N_X25_9_X25_M10_d N_X25_X_X25_M10_g N_VSS_X25_M9_d N_VSS_X22_M0_b
+ MODN L=3.5e-07 W=1e-06 AD=1.215e-12 AS=5.875e-13 PD=4.1e-06 PS=1.175e-06
+ NRD=0.425 NRS=0.425
mX25_M11 N_VSS_X25_M11_d N_X25_9_X25_M11_g N_18_X25_M11_s N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=5e-13 AS=7.45e-13 PD=1e-06 PS=2.7e-06 NRD=0.425 NRS=0.425
mX25_M12 N_4_X25_M12_d N_X25_10_X25_M12_g N_VSS_X25_M11_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=8.5e-13 AS=5e-13 PD=2.7e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX25_M13 N_VDD_X25_M13_d N_CLOCK_X25_M13_g N_X25_2_X25_M13_s N_VDD_X23_M13_b
+ MODP L=3.5e-07 W=1e-06 AD=1.16944e-12 AS=7.45e-13 PD=2.86111e-06 PS=2.7e-06
+ NRD=0.425 NRS=0.425
mX25_M14 N_VDD_X25_M13_d N_X25_2_X25_M14_g N_X25_3_X25_M14_s N_VDD_X23_M13_b
+ MODP L=3.5e-07 W=8e-07 AD=9.35556e-13 AS=7.55e-13 PD=2.28889e-06 PS=3.1e-06
+ NRD=0.53125 NRS=0.53125
mX25_M15 N_X25_5_X25_M15_d N_X25_2_X25_M15_g N_X25_6_X25_M15_s N_VDD_X23_M13_b
+ MODP L=3.5e-07 W=1e-06 AD=5e-13 AS=1.355e-12 PD=1e-06 PS=4.1e-06 NRD=0.425
+ NRS=0.425
mX25_M16 X25_16 N_3_X25_M16_g N_X25_5_X25_M15_d N_VDD_X23_M13_b MODP L=3.5e-07
+ W=1.6e-06 AD=3.6e-13 AS=8e-13 PD=4.5e-07 PS=1.6e-06 NRD=0.265625 NRS=0.265625
mX25_M17 N_VDD_X25_M17_d N_X25_3_X25_M17_g X25_16 N_VDD_X23_M13_b MODP
+ L=3.5e-07 W=1.6e-06 AD=1.31625e-12 AS=3.6e-13 PD=3.3e-06 PS=4.5e-07
+ NRD=0.265625 NRS=0.265625
mX25_M18 N_VDD_X25_M18_d N_X25_7_X25_M18_g N_X25_6_X25_M18_s N_VDD_X23_M13_b
+ MODP L=3.5e-07 W=1.6e-06 AD=9.1125e-13 AS=1.25e-12 PD=1.725e-06 PS=3.7e-06
+ NRD=0.217949 NRS=0.217949
mX25_M19 N_X25_7_X25_M19_d N_X25_5_X25_M19_g N_VDD_X25_M18_d N_VDD_X23_M13_b
+ MODP L=3.5e-07 W=1.6e-06 AD=1.25e-12 AS=9.1125e-13 PD=3.7e-06 PS=1.725e-06
+ NRD=0.217949 NRS=0.217949
mX25_M20 N_X25_X_X25_M20_d N_X25_2_X25_M20_g N_X25_7_X25_M20_s N_VDD_X23_M13_b
+ MODP L=3.5e-07 W=1e-06 AD=5e-13 AS=7.45e-13 PD=1e-06 PS=2.7e-06 NRD=0.425
+ NRS=0.425
mX25_M21 N_X25_10_X25_M21_d N_X25_3_X25_M21_g N_X25_X_X25_M20_d N_VDD_X23_M13_b
+ MODP L=3.5e-07 W=1e-06 AD=8.5e-13 AS=5e-13 PD=2.7e-06 PS=1e-06 NRD=0.425
+ NRS=0.425
mX25_M22 N_VDD_X25_M22_d N_X25_9_X25_M22_g N_X25_10_X25_M22_s N_VDD_X23_M13_b
+ MODP L=3.5e-07 W=1.6e-06 AD=9.025e-13 AS=1.455e-12 PD=1.6e-06 PS=4e-06
+ NRD=0.217949 NRS=0.217949
mX25_M23 N_X25_9_X25_M23_d N_X25_X_X25_M23_g N_VDD_X25_M22_d N_VDD_X23_M13_b
+ MODP L=3.5e-07 W=1.6e-06 AD=1.335e-12 AS=9.025e-13 PD=3.85e-06 PS=1.6e-06
+ NRD=0.217949 NRS=0.217949
mX25_M24 N_VDD_X25_M24_d N_X25_9_X25_M24_g N_18_X25_M24_s N_VDD_X23_M13_b MODP
+ L=3.5e-07 W=1.6e-06 AD=8e-13 AS=1.36e-12 PD=1e-06 PS=3.3e-06 NRD=0.265625
+ NRS=0.265625
```

```
mX25_M25 N_4_X25_M25_d N_X25_10_X25_M25_g N_VDD_X25_M24_d N_VDD_X23_M13_b MODP
+ L=3.5e-07 W=1.6e-06 AD=1.36e-12 AS=8e-13 PD=3.3e-06 PS=1e-06 NRD=0.265625
+ NRS=0.265625
mX26_M0 N_VSS_X26_M0_d N_CLOCK_X26_M0_g N_X26_2_X26_M0_s N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=5e-07 AD=5.375e-13 AS=5.9e-13 PD=1.97222e-06 PS=2.7e-06 NRD=0.85
+ NRS=0.85
mX26_M1 N_X26_3_X26_M1_d N_X26_2_X26_M1_g N_VSS_X26_M0_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=4e-07 AD=5.7e-13 AS=4.3e-13 PD=2.8e-06 PS=1.57778e-06 NRD=1.0625
+ NRS=1.0625
mX26_M2 X26_15 N_X26_2_X26_M2_g N_VSS_X26_M2_s N_VSS_X22_M0_b MODN L=3.5e-07
+ W=1e-06 AD=2.25e-13 AS=7.45e-13 PD=4.5e-07 PS=2.7e-06 NRD=0.425 NRS=0.425
mX26_M3 N_X26_5_X26_M3_d N_11_X26_M3_g X26_15 N_VSS_X22_M0_b MODN L=3.5e-07
+ W=1e-06 AD=5e-13 AS=2.25e-13 PD=1e-06 PS=4.5e-07 NRD=0.425 NRS=0.425
mX26_M4 N_X26_6_X26_M4_d N_X26_3_X26_M4_g N_X26_5_X26_M3_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=5e-13 AS=5e-13 PD=1e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX26_M5 N_VSS_X26_M5_d N_X26_7_X26_M5_g N_X26_6_X26_M4_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=5.125e-13 AS=5e-13 PD=1.025e-06 PS=1e-06 NRD=0.425
+ NRS=0.425
mX26_M6 N_X26_7_X26_M6_d N_X26_5_X26_M6_g N_VSS_X26_M5_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=5e-13 AS=5.125e-13 PD=1e-06 PS=1.025e-06 NRD=0.425
+ NRS=0.425
mX26_M7 N_X26_X_X26_M7_d N_X26_3_X26_M7_g N_X26_7_X26_M6_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=5e-13 AS=5e-13 PD=1e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX26_M8 N_X26_10_X26_M8_d N_X26_2_X26_M8_g N_X26_X_X26_M7_d N_VSS_X22_M0_b
+ MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=5e-13 PD=1e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX26_M9 N_VSS_X26_M9_d N_X26_9_X26_M9_g N_X26_10_X26_M8_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=5.875e-13 AS=5e-13 PD=1.175e-06 PS=1e-06 NRD=0.425
+ NRS=0.425
mX26_M10 N_X26_9_X26_M10_d N_X26_X_X26_M10_g N_VSS_X26_M9_d N_VSS_X22_M0_b
+ MODN L=3.5e-07 W=1e-06 AD=1.215e-12 AS=5.875e-13 PD=4.1e-06 PS=1.175e-06
+ NRD=0.425 NRS=0.425
mX26_M11 N_VSS_X26_M11_d N_X26_9_X26_M11_g N_19_X26_M11_s N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=5e-13 AS=7.45e-13 PD=1e-06 PS=2.7e-06 NRD=0.425 NRS=0.425
mX26_M12 N_3_X26_M12_d N_X26_10_X26_M12_g N_VSS_X26_M11_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=8.5e-13 AS=5e-13 PD=2.7e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX26_M13 N_VDD_X26_M13_d N_CLOCK_X26_M13_g N_X26_2_X26_M13_s N_VDD_X24_M13_b
+ MODP L=3.5e-07 W=1e-06 AD=1.16944e-12 AS=7.45e-13 PD=2.86111e-06 PS=2.7e-06
+ NRD=0.425 NRS=0.425
mX26_M14 N_VDD_X26_M13_d N_X26_2_X26_M14_g N_X26_3_X26_M14_s N_VDD_X24_M13_b
+ MODP L=3.5e-07 W=8e-07 AD=9.35556e-13 AS=7.55e-13 PD=2.28889e-06 PS=3.1e-06
+ NRD=0.53125 NRS=0.53125
mX26_M15 N_X26_5_X26_M15_d N_X26_2_X26_M15_g N_X26_6_X26_M15_s N_VDD_X24_M13_b
```

```
+ MODP L=3.5e-07 W=1e-06 AD=5e-13 AS=1.355e-12 PD=1e-06 PS=4.1e-06 NRD=0.425
+ NRS=0.425
mX26_M16 X26_16 N_11_X26_M16_g N_X26_5_X26_M15_d N_VDD_X24_M13_b MODP
+ L=3.5e-07 W=1.6e-06 AD=3.6e-13 AS=8e-13 PD=4.5e-07 PS=1.6e-06 NRD=0.265625
+ NRS=0.265625
mX26_M17 N_VDD_X26_M17_d N_X26_3_X26_M17_g X26_16 N_VDD_X24_M13_b MODP
+ L=3.5e-07 W=1.6e-06 AD=1.31625e-12 AS=3.6e-13 PD=3.3e-06 PS=4.5e-07
+ NRD=0.265625 NRS=0.265625
mX26_M18 N_VDD_X26_M18_d N_X26_7_X26_M18_g N_X26_6_X26_M18_s N_VDD_X24_M13_b
+ MODP L=3.5e-07 W=1.6e-06 AD=9.1125e-13 AS=1.25e-12 PD=1.725e-06 PS=3.7e-06
+ NRD=0.217949 NRS=0.217949
mX26_M19 N_X26_7_X26_M19_d N_X26_5_X26_M19_g N_VDD_X26_M18_d N_VDD_X24_M13_b
+ MODP L=3.5e-07 W=1.6e-06 AD=1.25e-12 AS=9.1125e-13 PD=3.7e-06 PS=1.725e-06
+ NRD=0.217949 NRS=0.217949
mX26_M20 N_X26_X_X26_M20_d N_X26_2_X26_M20_g N_X26_7_X26_M20_s N_VDD_X24_M13_b
+ MODP L=3.5e-07 W=1e-06 AD=5e-13 AS=7.45e-13 PD=1e-06 PS=2.7e-06 NRD=0.425
+ NRS=0.425
mX26_M21 N_X26_10_X26_M21_d N_X26_3_X26_M21_g N_X26_X_X26_M20_d N_VDD_X24_M13_b
+ MODP L=3.5e-07 W=1e-06 AD=8.5e-13 AS=5e-13 PD=2.7e-06 PS=1e-06 NRD=0.425
+ NRS=0.425
mX26_M22 N_VDD_X26_M22_d N_X26_9_X26_M22_g N_X26_10_X26_M22_s N_VDD_X24_M13_b
+ MODP L=3.5e-07 W=1.6e-06 AD=9.025e-13 AS=1.455e-12 PD=1.6e-06 PS=4e-06
+ NRD=0.217949 NRS=0.217949
mX26_M23 N_X26_9_X26_M23_d N_X26_X_X26_M23_g N_VDD_X26_M22_d N_VDD_X24_M13_b
+ MODP L=3.5e-07 W=1.6e-06 AD=1.335e-12 AS=9.025e-13 PD=3.85e-06 PS=1.6e-06
+ NRD=0.217949 NRS=0.217949
mX26_M24 N_VDD_X26_M24_d N_X26_9_X26_M24_g N_19_X26_M24_s N_VDD_X24_M13_b MODP
+ L=3.5e-07 W=1.6e-06 AD=8e-13 AS=1.36e-12 PD=1e-06 PS=3.3e-06 NRD=0.265625
+ NRS=0.265625
mX26_M25 N_3_X26_M25_d N_X26_10_X26_M25_g N_VDD_X26_M24_d N_VDD_X24_M13_b MODP
+ L=3.5e-07 W=1.6e-06 AD=1.36e-12 AS=8e-13 PD=3.3e-06 PS=1e-06 NRD=0.265625
+ NRS=0.265625
mX27_M0 N_VSS_X27_M0_d N_CLOCK_X27_M0_g N_X27_2_X27_M0_s N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=5e-07 AD=5.375e-13 AS=5.9e-13 PD=1.97222e-06 PS=2.7e-06 NRD=0.85
+ NRS=0.85
mX27_M1 N_X27_3_X27_M1_d N_X27_2_X27_M1_g N_VSS_X27_M0_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=4e-07 AD=5.7e-13 AS=4.3e-13 PD=2.8e-06 PS=1.57778e-06 NRD=1.0625
+ NRS=1.0625
mX27_M2 X27_15 N_X27_2_X27_M2_g N_VSS_X27_M2_s N_VSS_X22_M0_b MODN L=3.5e-07
+ W=1e-06 AD=2.25e-13 AS=7.45e-13 PD=4.5e-07 PS=2.7e-06 NRD=0.425 NRS=0.425
mX27_M3 N_X27_5_X27_M3_d N_10_X27_M3_g X27_15 N_VSS_X22_M0_b MODN L=3.5e-07
+ W=1e-06 AD=5e-13 AS=2.25e-13 PD=1e-06 PS=4.5e-07 NRD=0.425 NRS=0.425
```

```
mX27_M4 N_X27_6_X27_M4_d N_X27_3_X27_M4_g N_X27_5_X27_M3_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=5e-13 AS=5e-13 PD=1e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX27_M5 N_VSS_X27_M5_d N_X27_7_X27_M5_g N_X27_6_X27_M4_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=5.125e-13 AS=5e-13 PD=1.025e-06 PS=1e-06 NRD=0.425
+ NRS=0.425
mX27_M6 N_X27_7_X27_M6_d N_X27_5_X27_M6_g N_VSS_X27_M5_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=5e-13 AS=5.125e-13 PD=1e-06 PS=1.025e-06 NRD=0.425
+ NRS=0.425
mX27_M7 N_X27_X_X27_M7_d N_X27_3_X27_M7_g N_X27_7_X27_M6_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=5e-13 AS=5e-13 PD=1e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX27_M8 N_X27_10_X27_M8_d N_X27_2_X27_M8_g N_X27_X_X27_M7_d N_VSS_X22_M0_b
+ MODN L=3.5e-07 W=1e-06 AD=5e-13 AS=5e-13 PD=1e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX27_M9 N_VSS_X27_M9_d N_X27_9_X27_M9_g N_X27_10_X27_M8_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=5.875e-13 AS=5e-13 PD=1.175e-06 PS=1e-06 NRD=0.425
+ NRS=0.425
mX27_M10 N_X27_9_X27_M10_d N_X27_X_X27_M10_g N_VSS_X27_M9_d N_VSS_X22_M0_b
+ MODN L=3.5e-07 W=1e-06 AD=1.215e-12 AS=5.875e-13 PD=4.1e-06 PS=1.175e-06
+ NRD=0.425 NRS=0.425
mX27_M11 N_VSS_X27_M11_d N_X27_9_X27_M11_g N_20_X27_M11_s N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=5e-13 AS=7.45e-13 PD=1e-06 PS=2.7e-06 NRD=0.425 NRS=0.425
mX27_M12 N_12_X27_M12_d N_X27_10_X27_M12_g N_VSS_X27_M11_d N_VSS_X22_M0_b MODN
+ L=3.5e-07 W=1e-06 AD=8.5e-13 AS=5e-13 PD=2.7e-06 PS=1e-06 NRD=0.425 NRS=0.425
mX27_M13 N_VDD_X27_M13_d N_CLOCK_X27_M13_g N_X27_2_X27_M13_s N_VDD_X22_M13_b
+ MODP L=3.5e-07 W=1e-06 AD=1.16944e-12 AS=7.45e-13 PD=2.86111e-06 PS=2.7e-06
+ NRD=0.425 NRS=0.425
mX27_M14 N_VDD_X27_M13_d N_X27_2_X27_M14_g N_X27_3_X27_M14_s N_VDD_X22_M13_b
+ MODP L=3.5e-07 W=8e-07 AD=9.35556e-13 AS=7.55e-13 PD=2.28889e-06 PS=3.1e-06
+ NRD=0.53125 NRS=0.53125
mX27_M15 N_X27_5_X27_M15_d N_X27_2_X27_M15_g N_X27_6_X27_M15_s N_VDD_X22_M13_b
+ MODP L=3.5e-07 W=1e-06 AD=5e-13 AS=1.355e-12 PD=1e-06 PS=4.1e-06 NRD=0.425
+ NRS=0.425
mX27_M16 X27_16 N_10_X27_M16_g N_X27_5_X27_M15_d N_VDD_X22_M13_b MODP
+ L=3.5e-07 W=1.6e-06 AD=3.6e-13 AS=8e-13 PD=4.5e-07 PS=1.6e-06 NRD=0.265625
+ NRS=0.265625
mX27_M17 N_VDD_X27_M17_d N_X27_3_X27_M17_g X27_16 N_VDD_X22_M13_b MODP
+ L=3.5e-07 W=1.6e-06 AD=1.31625e-12 AS=3.6e-13 PD=3.3e-06 PS=4.5e-07
+ NRD=0.265625 NRS=0.265625
mX27_M18 N_VDD_X27_M18_d N_X27_7_X27_M18_g N_X27_6_X27_M18_s N_VDD_X22_M13_b
+ MODP L=3.5e-07 W=1.6e-06 AD=9.1125e-13 AS=1.25e-12 PD=1.725e-06 PS=3.7e-06
+ NRD=0.217949 NRS=0.217949
mX27_M19 N_X27_7_X27_M19_d N_X27_5_X27_M19_g N_VDD_X27_M18_d N_VDD_X22_M13_b
+ MODP L=3.5e-07 W=1.6e-06 AD=1.25e-12 AS=9.1125e-13 PD=3.7e-06 PS=1.725e-06
```

```
+ NRD=0.217949 NRS=0.217949
mX27_M20 N_X27_X_X27_M20_d N_X27_2_X27_M20_g N_X27_7_X27_M20_s N_VDD_X22_M13_b
+ MODP L=3.5e-07 W=1e-06 AD=5e-13 AS=7.45e-13 PD=1e-06 PS=2.7e-06 NRD=0.425
+ NRS=0.425
mX27_M21 N_X27_10_X27_M21_d N_X27_3_X27_M21_g N_X27_X_X27_M20_d N_VDD_X22_M13_b
+ MODP L=3.5e-07 W=1e-06 AD=8.5e-13 AS=5e-13 PD=2.7e-06 PS=1e-06 NRD=0.425
+ NRS=0.425
mX27_M22 N_VDD_X27_M22_d N_X27_9_X27_M22_g N_X27_10_X27_M22_s N_VDD_X22_M13_b
+ MODP L=3.5e-07 W=1.6e-06 AD=9.025e-13 AS=1.455e-12 PD=1.6e-06 PS=4e-06
+ NRD=0.217949 NRS=0.217949
mX27_M23 N_X27_9_X27_M23_d N_X27_X_X27_M23_g N_VDD_X27_M22_d N_VDD_X22_M13_b
+ MODP L=3.5e-07 W=1.6e-06 AD=1.335e-12 AS=9.025e-13 PD=3.85e-06 PS=1.6e-06
+ NRD=0.217949 NRS=0.217949
mX27_M24 N_VDD_X27_M24_d N_X27_9_X27_M24_g N_20_X27_M24_s N_VDD_X22_M13_b MODP
+ L=3.5e-07 W=1.6e-06 AD=8e-13 AS=1.36e-12 PD=1e-06 PS=3.3e-06 NRD=0.265625
+ NRS=0.265625
mX27_M25 N_12_X27_M25_d N_X27_10_X27_M25_g N_VDD_X27_M24_d N_VDD_X22_M13_b
+ MODP L=3.5e-07 W=1.6e-06 AD=1.36e-12 AS=8e-13 PD=3.3e-06 PS=1e-06 NRD=0.265625
+ NRS=0.265625
*
.include "prescaler.pex.netlist.PRESCALER.pxi"
*** Idem aos comando do Experimento 3
*** Parametros
.Param tensao=3v
.Param F=0.2G P='1/F'

*** Tensoes estabelecidas
Vdd VDD GROUND DC tensao
.CONNECT VSS 0
Vclock CLOCK GROUND PULSE(0 3.0 0 '0.1*P' '0.1*P' '0.4*P' P)

*** Conexao do circuito
*** Caso SM = 1
*.CONNECT SM VDD
*** Caso SM = 0
.CONNECT SM 0

*** Tempo de propagacao de subida e descida
.meas tran Pout   trig v(OUT3233) val=tensao/2 rise=2 targ v(OUT3233) val=tensao/2 rise=3
.meas tran PClock trig v(CLOCK) val=tensao/2 rise=2 targ v(CLOCK) val=tensao/2 rise=3
.meas tran clockCir PARAM='Pout/Pclock'
```

```
*** Explorando curva simples - Para escolher melhor janela de simulacao
*.tran 0 '100*P' 0 'P/10' sweep F INCR 0.05G 0.4G 1.3G

*** Escursionando frequencia em busca da maxima - Tipico
.tran 0 '120*P' 0 'P/10' sweep F INCR 0.01G 0.8G 0.9G
*****************************************

*** Escursionando frequencia em busca da maxima - WS
*.tran 0 '100*P' 0 'P/10' sweep F INCR 0.01G 0.5G 0.6G
*****************************************

.probe tran V(CLOCK) V(OUT3233)

.include Model35_Eldo
*.include cmos53ws.mod
.end
```

Questão 14: A partir do datasheet dos blocos que compõe o prescaler estime o máximo clock que o circuito poderia suportar.

Considerando o circuito Prescaler composto por duas partes: divisor 4/5 e o restante, considerando os cálculos do tempo de atraso para o divisor 4/5 basta verificar o tempo de atraso de propagação os 3 componente DF3. Reaproveitando os cálculos realizados no experimento 3 desta disciplina, temos:

Neste item faremos uso do circuito presente na figura 28.

Novamente consideraremos o *slope* de 0,05 e o pior caso como sendo de subida. Logo resumiremos os tempos propagação de atraso de subida na tabela 1.

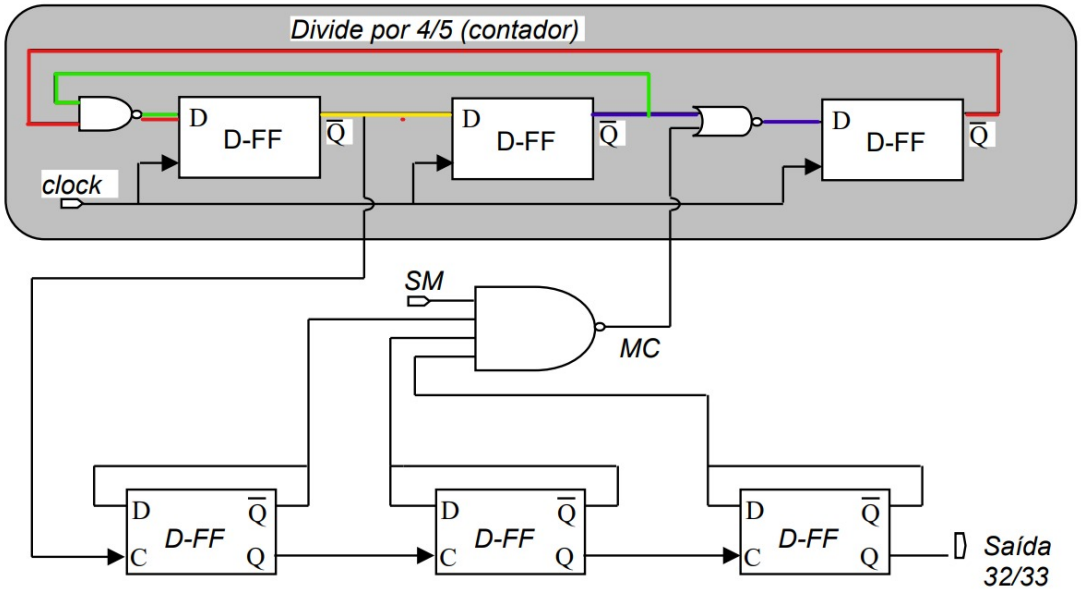
Tabela 1 – Tabela tempo de atraso de propagação de subida para os componentes do circuito contador 4/5

Componente - Pino	**Capacitância[pF]**	**Atraso de Subida [ns]**
DF1 - D	0,001	0,66
DF1 - D	0,320	2,29
NOR23 - A,B	0,003	0,07
NOR23 - A,B	0,960	1,60
NAND23 - A	0,003	0,04
NAND23 - A	0,960	1,67
NAND23 - B	0,003	0,08
NAND23 - B	0,960	1,70

Fonte: Pelos próprios autores a partir de (CORPORATION, 2005)

Com o caminho selecionado calculamos a aproximação linear considerando a capa-

Figura 28 – Divisor 4/5 (contador) parte do circuito *Prescaler* 32/33



Fonte: Modificado do enunciado

citancia de saída para seleção correta de tempo de atraso de propação de subida para cada trecho. Em que os trechos *flip-flop1* (DF1) é conectado a DF2 (caminho Amarelo), DF2 conectado a DF1 (caminho Verde), DF3 conectado a DF1 (caminho Vermelho), e, por fim, o DF2 conectado ao DF3 (caminho Azul), respectivamente, T_{DF11_DF12}, T_{DF12_DF11}, T_{DF13_DF11} e T_{DF12_DF13}, ressalva-se que entre os *flip-flop* existe portas NOR e NAND que serão consideradas tempos invermediarios para cada um dos quatro trechos.

Trecho 1: caminho Amarelo

$$T_{DF11\_DF12} = \frac{x - 0,66}{2,29 - 0,66} = \frac{0,005 - 0,001}{0,32 - 0,001} \Rightarrow x = 0{,}680 \text{ ns}$$

Trecho 2: caminho Verde Este trecho é composto pela conexão *flip-flop* 2 com NAND e este com *flip-flop* 1, logo temos:

$$T_{DF12\_DF11} = T_{DF12\_NAND23} + T_{NAND23\_DF11}$$

$$T_{DF12\_NAND23} = \frac{x - 0,66}{2,29 - 0,66} = \frac{0,041 - 0,001}{0,32 - 0,001} \Rightarrow x = 0{,}864 \text{ ns}$$

$$T_{NAND23\_DF11} = \frac{y - 0,08}{1,70 - 0,08} = \frac{0,005 - 0,003}{0,96 - 0,003} \Rightarrow y = 0{,}083 \text{ ns}$$

$$T_{DF12\_DF11} = 0,864 + 0,083 = 0{,}947 \text{ ns}$$

Trecho 3: caminho Vermelho

Este trecho é composto pela conexão *flip-flop* 3 com NAND e este com *flip-flop* 1, logo temos:

$$T_{DF13\_DF11} = T_{DF13\_NAND23} + T_{NAND23\_DF11}$$

$$T_{DF13\_NAND23} = \frac{x - 0,66}{2,29 - 0,66} = \frac{0,020 - 0,001}{0,32 - 0,001} \Rightarrow x = 0{,}757 \text{ ns}$$

$$T_{NAND23\_DF11} = \frac{y - 0,08}{1,70 - 0,08} = \frac{0,005 - 0,003}{0,96 - 0,003} \Rightarrow y = 0{,}083 \text{ ns}$$

$$T_{DF13\_DF11} = 0,757 + 0,083 = 0{,}840 \text{ ns}$$

Trecho 4: caminho Azul

Este trecho é composto pela conexão *flip-flop* 2 com NAND e este com *flip-flop* 3, logo temos:

$$T_{DF12\_DF13} = T_{DF12\_NOR23} + T_{NOR23\_DF13}$$

$$T_{DF12\_NOR23} = \frac{x - 0,66}{2,29 - 0,66} = \frac{0,020 - 0,001}{0,32 - 0,001} \Rightarrow x = 0{,}762 \text{ ns}$$

$$T_{NAND23\_DF11} = \frac{y - 0,08}{1,70 - 0,08} = \frac{0,005 - 0,003}{0,96 - 0,003} \Rightarrow y = 0{,}073 \text{ ns}$$

$$T_{DF12\_DF11} = 0,757 + 0,083 = 0{,}835 \text{ ns}$$

$$F = \frac{1}{max(trecho1, trecho2, trecho3, trecho4)} = \frac{1}{T_{DF12\_DF11}} = \frac{1}{0,947} \approx 1,056GHZ$$

Considerando que para o restante do circuito além do divisor 4/5, temos que o maior tempo de atraso de propagação na subida é no valor de **0,680ns** entre componentes DF3. Portanto a velocidade máxima do circuito é descrito pelo trecho 2:

$$F_{max} = \frac{1}{trecho2} = \frac{1}{0,947} \approx 1,056GHZ$$

Questão 15: Monte uma tabela com os resultados obtidos nos exercícios 11, 12, 13 e 14. Compare e comente os resultados.

Assim como as analises feitas para as distintas maneiras de extração do circuito, organizamos a tabela 2 e 3 para a máxima velocidade do circuito considerando o pior tempo e o tipico, além da condição do estado de SM.

Tabela 2 – Tabela com máxima frequência de operação para a proporção *out* e *clock* para entrada com estado SM=0

Extração	**Frequência - Tip. [GHz]**	**Frequência - W.S. [GHz]**
Teórico	1,056	—
Esquemático	1,105	0,740
C+CC	0,895	0,605
R+C+CC	0,890	0,590

Fonte: Pelos próprios autores

Tabela 3 – Tabela com máxima frequência de operação para a proporção *out* e *clock* para entrada com estado SM=1

Extração	**Frequência - Tip. [GHz]**	**Frequência - W.S. [GHz]**
Teórico	1,056	—
Esquemático	1,205	0,795
C+CC	0,930	0,625
R+C+CC	0,870	0,570

Fonte: Pelos próprios autores

De maneira análoga ao experimento 3 desta disciplina, verificou-se que que o modelo típico e *Worst Speed* apresentaram a relação esperada, pois trata-se de cenários de operação cada um com sua velocidade, já referente a maneira de obter o *netlist* os valores seguiram a mesma tendência de máxima frequência e maneiras de extração, visto que o esquemático (modelo mais simplificado) apresenta valores próximos do teórico, e C+CC e R+C+CC mais lentos conforme a adição de mais componentes parasitas aproximando-se da realidade.

Referências

CORPORATION, M. G. *Mentor Graphics Corporation*. [S.l.], 2005. Disponível em: <http://web.engr.uky.edu/~elias/tutorials/Eldo/eldo_ur.pdf>. Acesso em: 20 Jul. 2021. Citado na página 44.