



# McKelvey School of Engineering

**Spring Semester 2023**

**CSE463M: Digital Integrated Circuit Design and Architecture**

**Final Assign #4 – Final Report**

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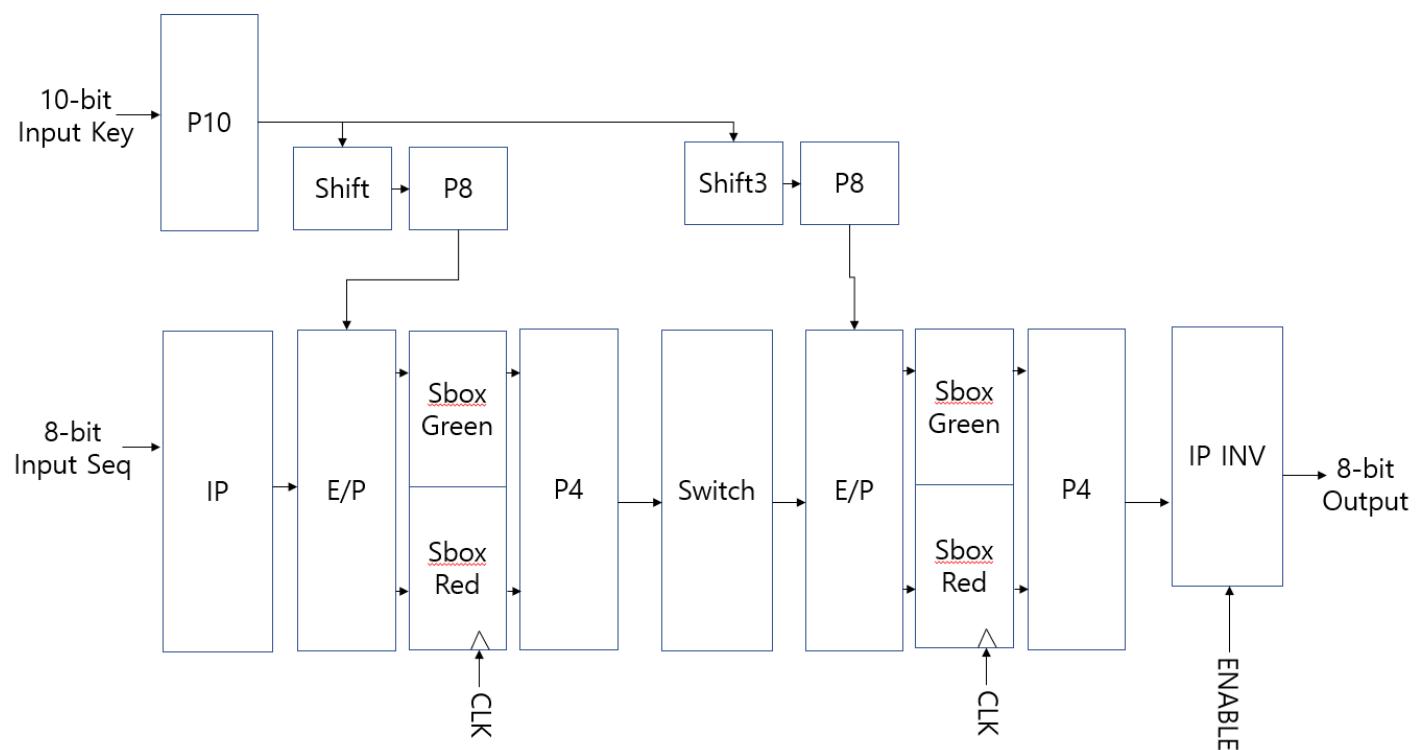
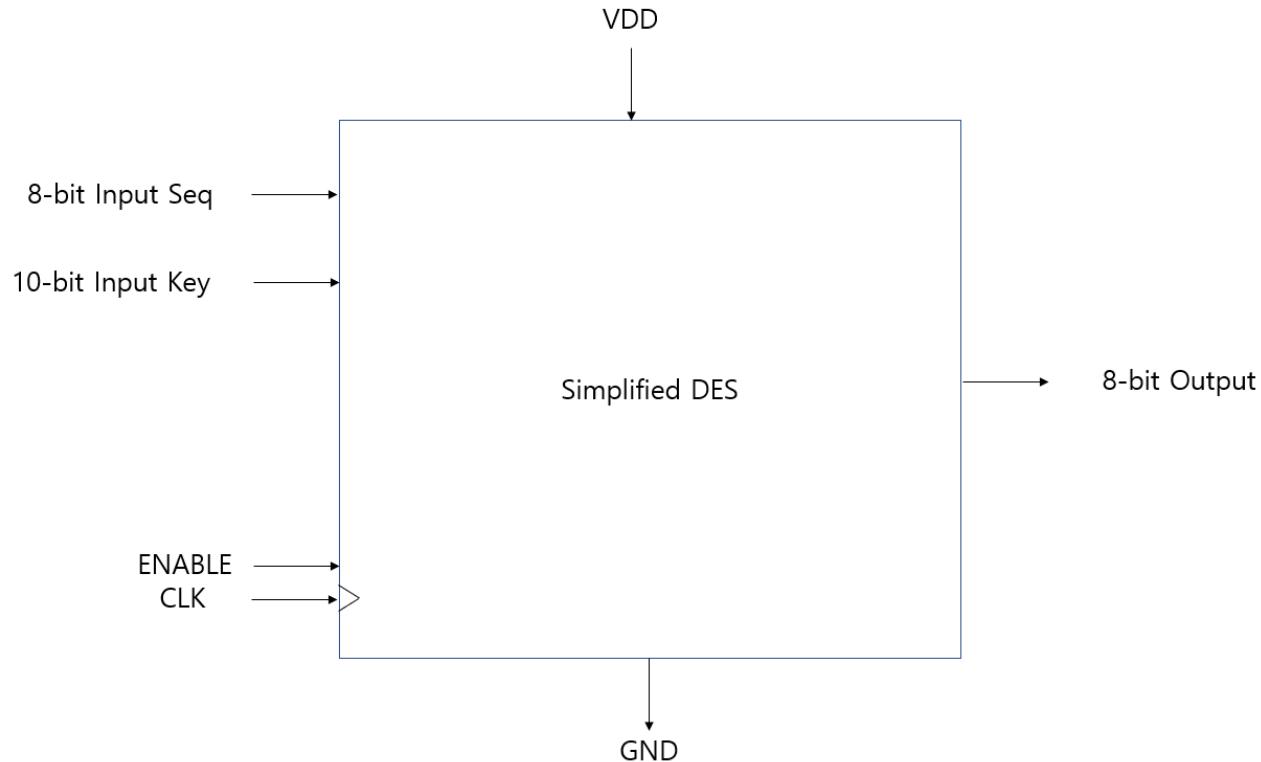
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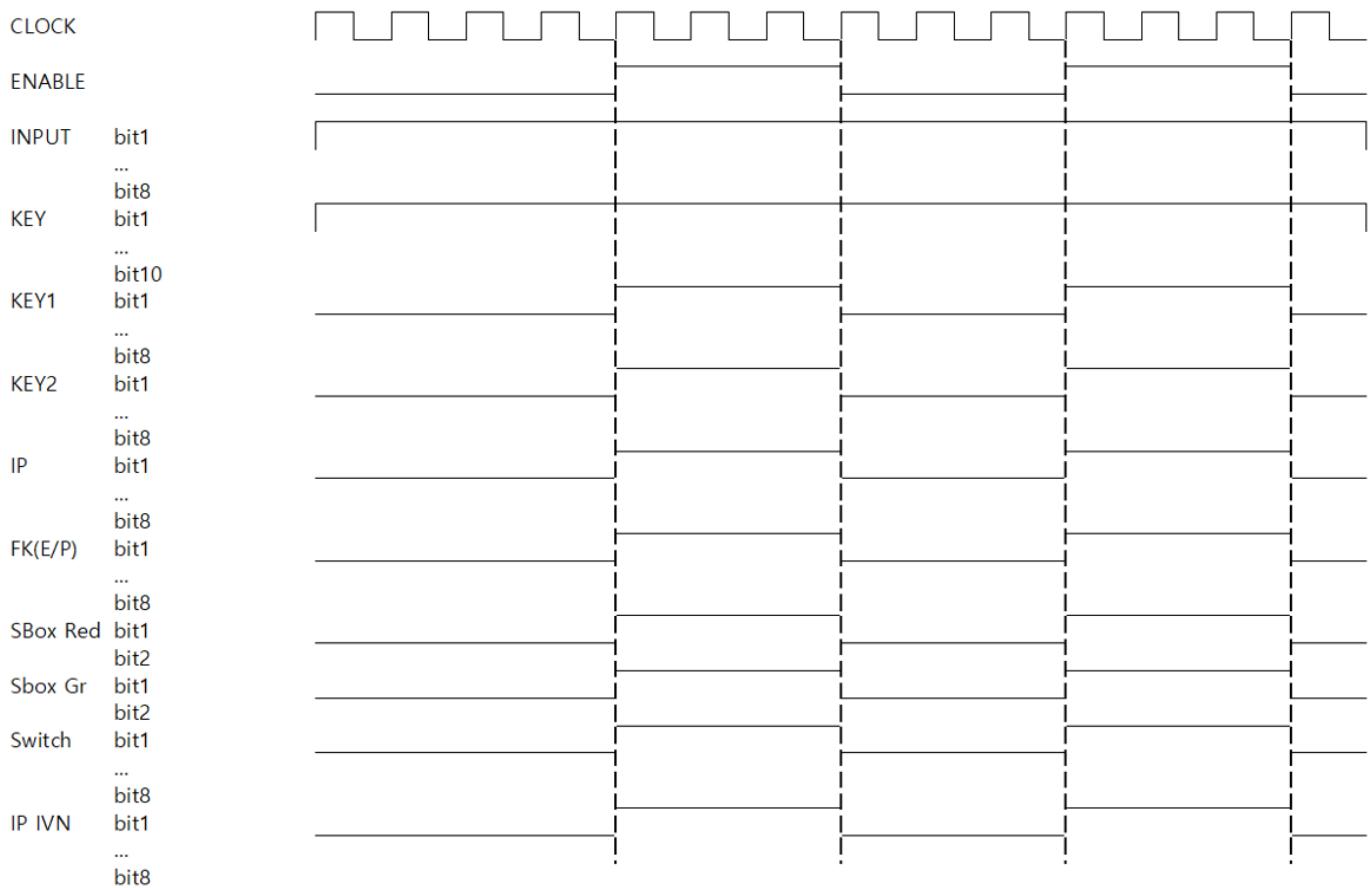
# 1. Objective of this project

- My team will design a CMOS chip that will perform simplified DES in hardware on 8-bit Input = 11101100 using 10-bit Input key k = 1100010110.

## 2. Block diagram



### 3. Anticipated timing diagram



## 4. List of all parts used in this project

- \* There are many parts to complete the Simplified DES.
- \* Below is the list of all parts.

### # For basic operation

INVERTOR

NAND

XOR2

XOR4

### # For bit control

P10

P8

P4

SHIFT 1

SHIFT 3

EP

SWITCH

IP

IP Invert

### # For selection

2:1 mux

16:1 mux

### # For Enable

ENABLE

### # For CLK

D-LATCH

D Flip flop

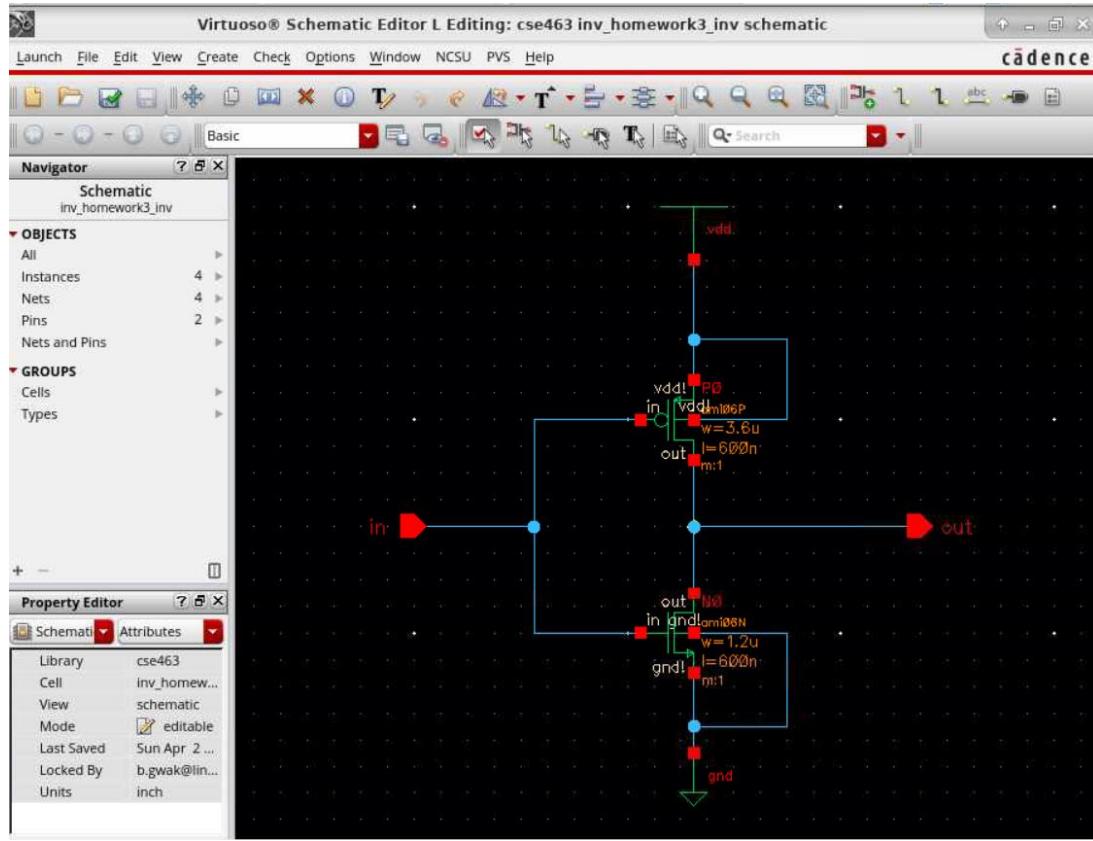
### # For SBox

SBox Red

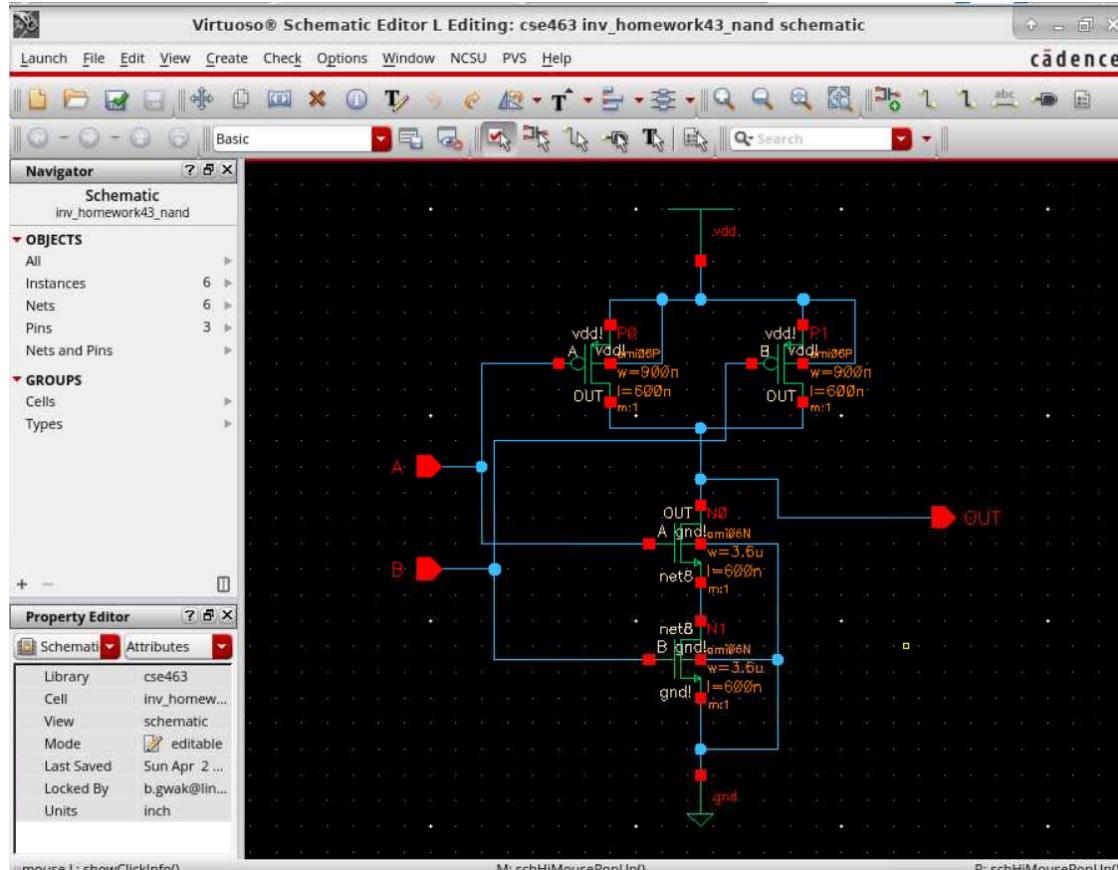
SBox Green

# 5. Schematic

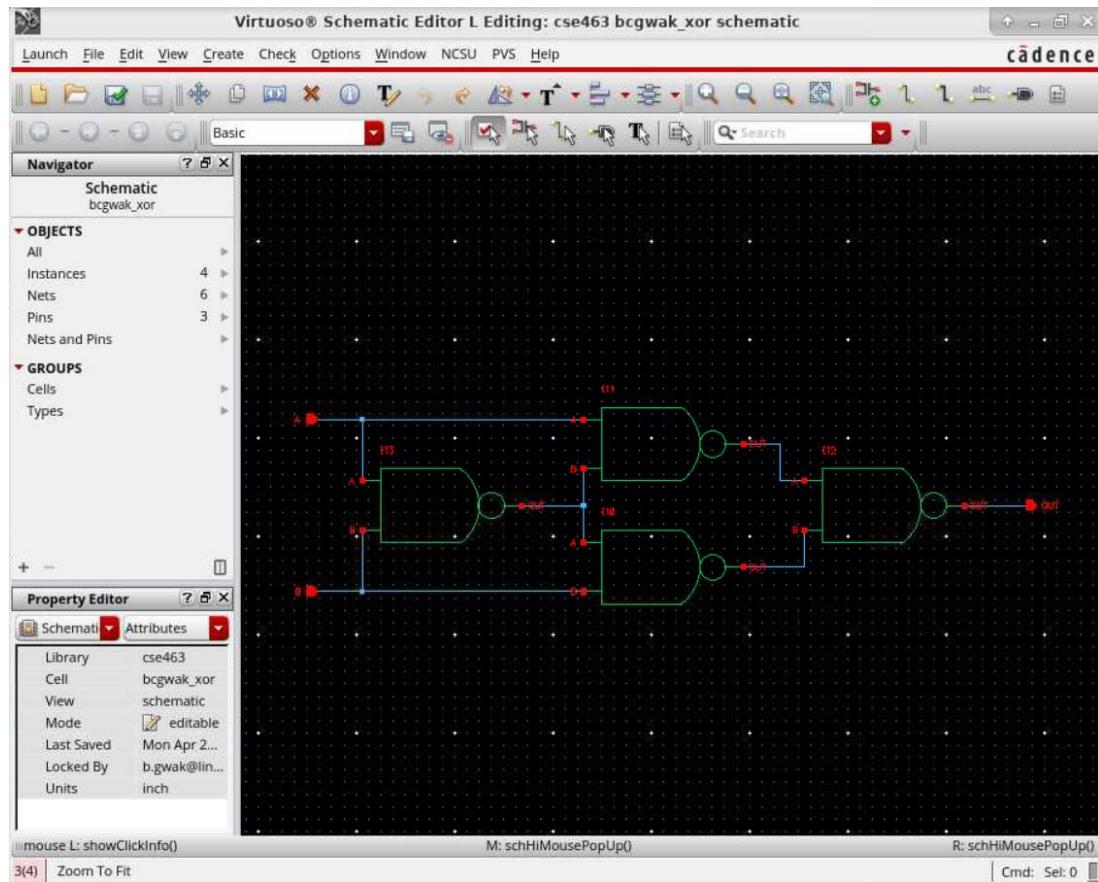
## \* INVERTOR



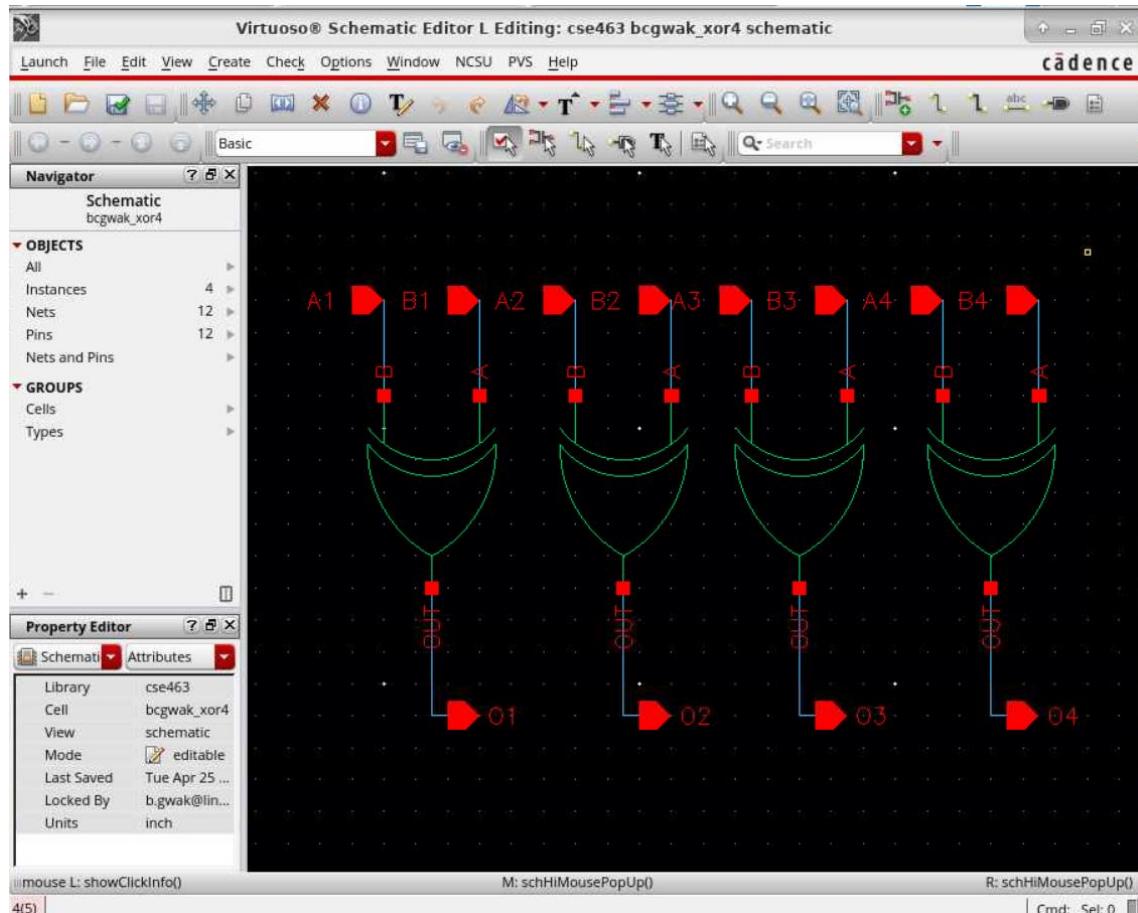
## \* NAND



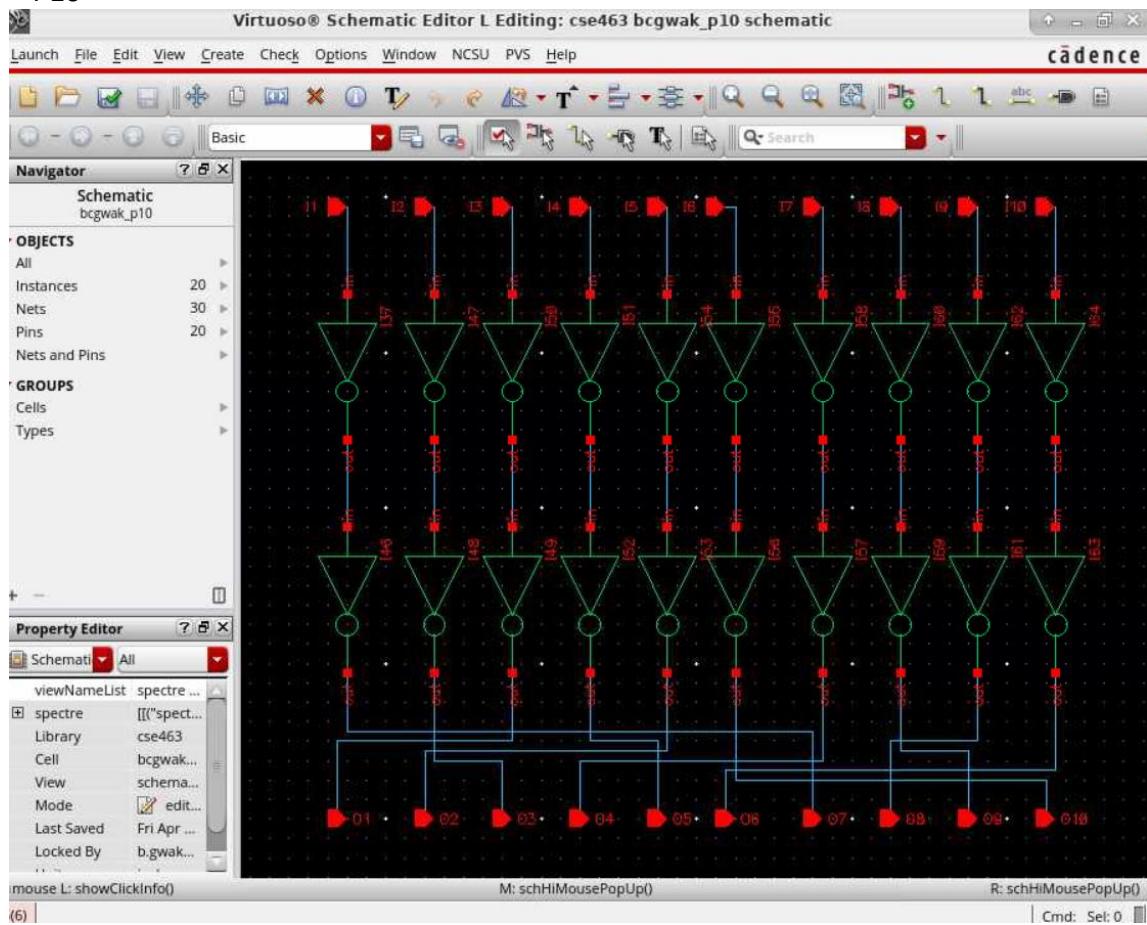
## \* XOR



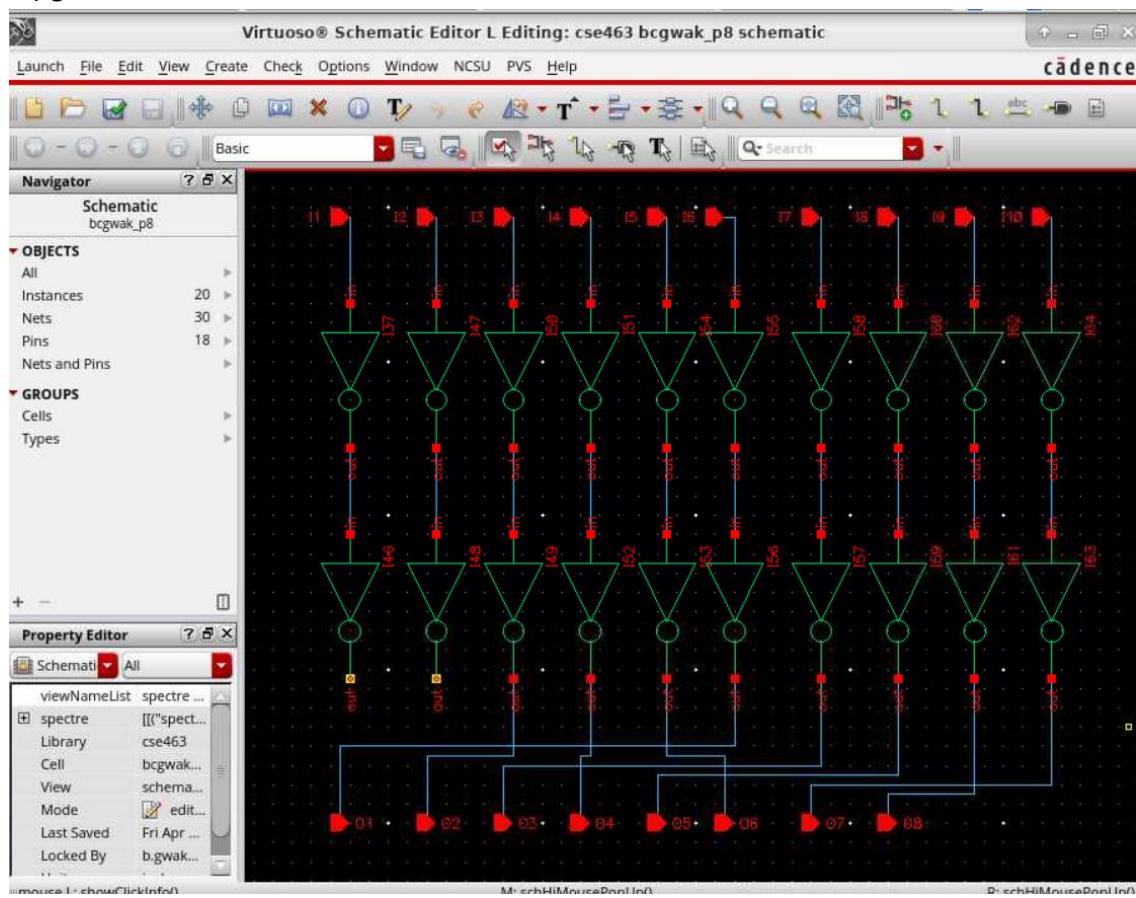
## \* XOR4



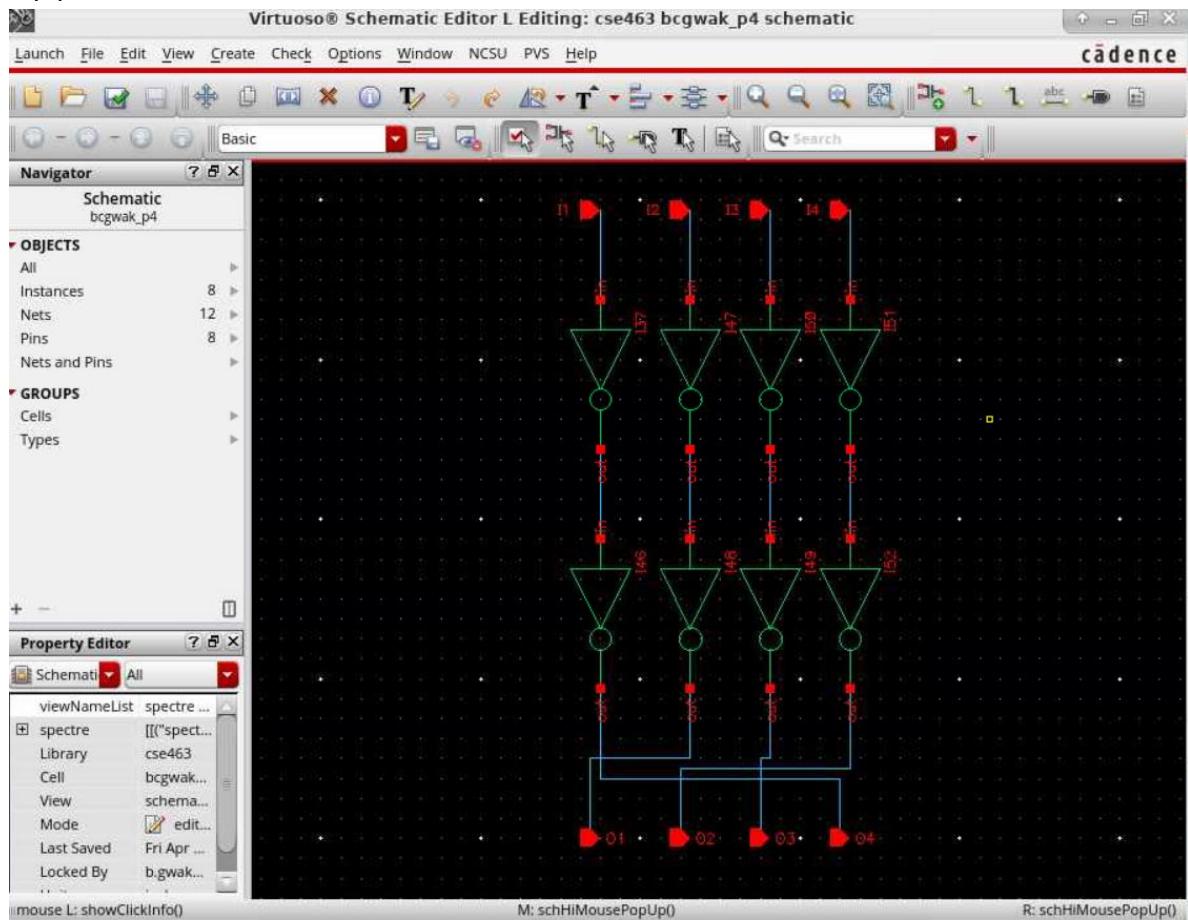
\* P10



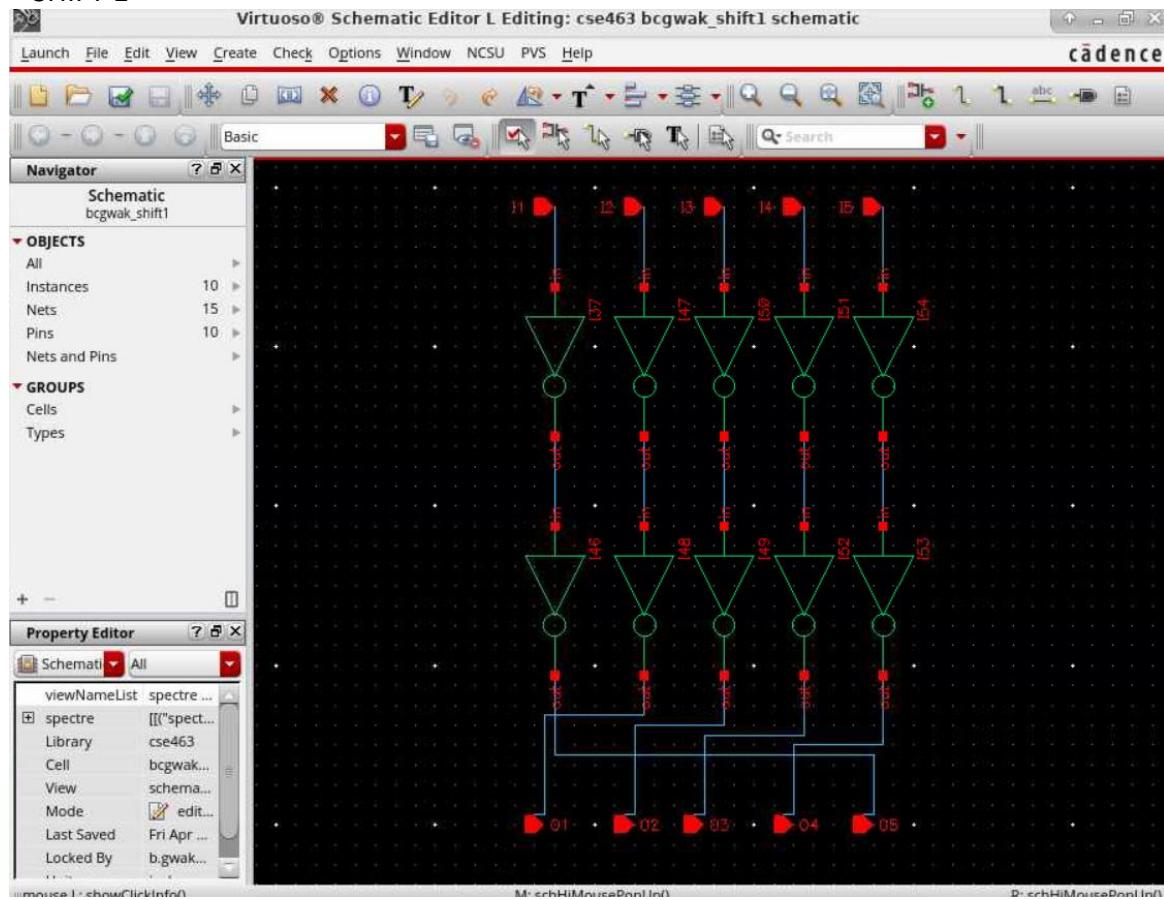
\* P8



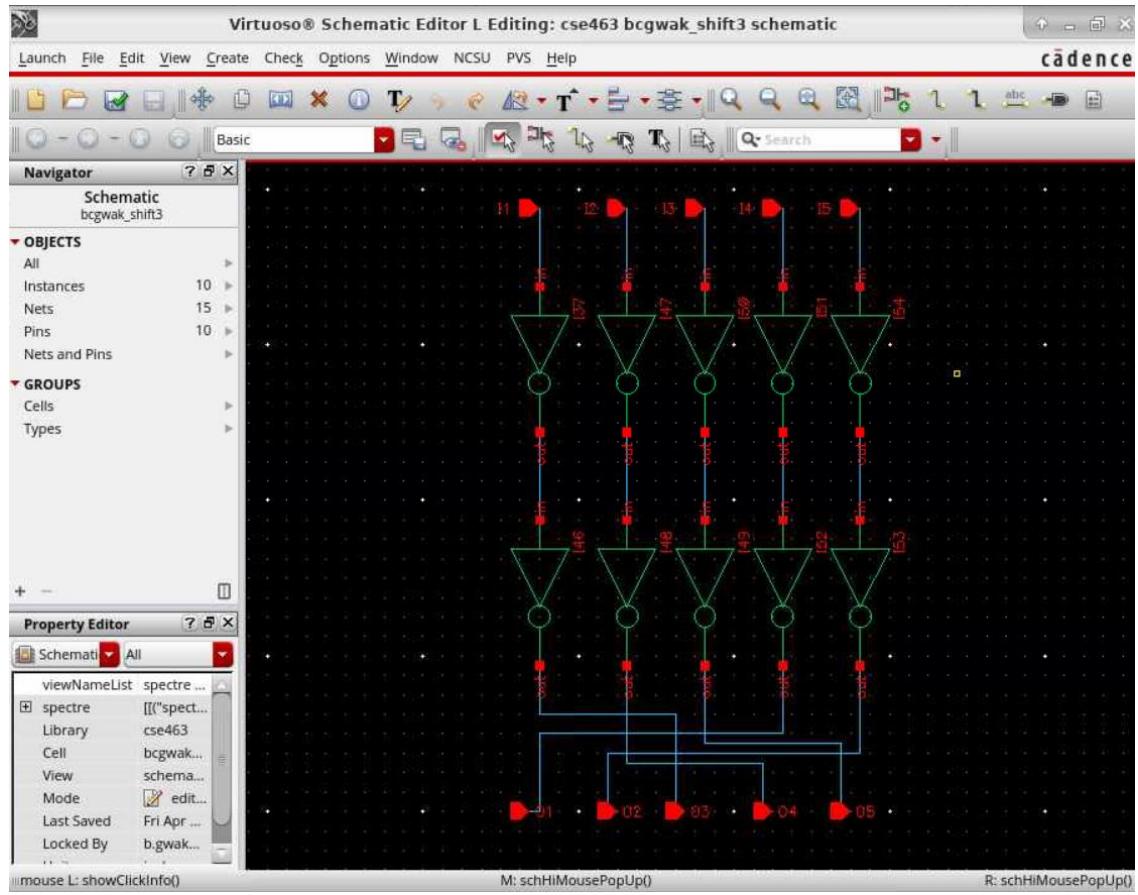
\* P4



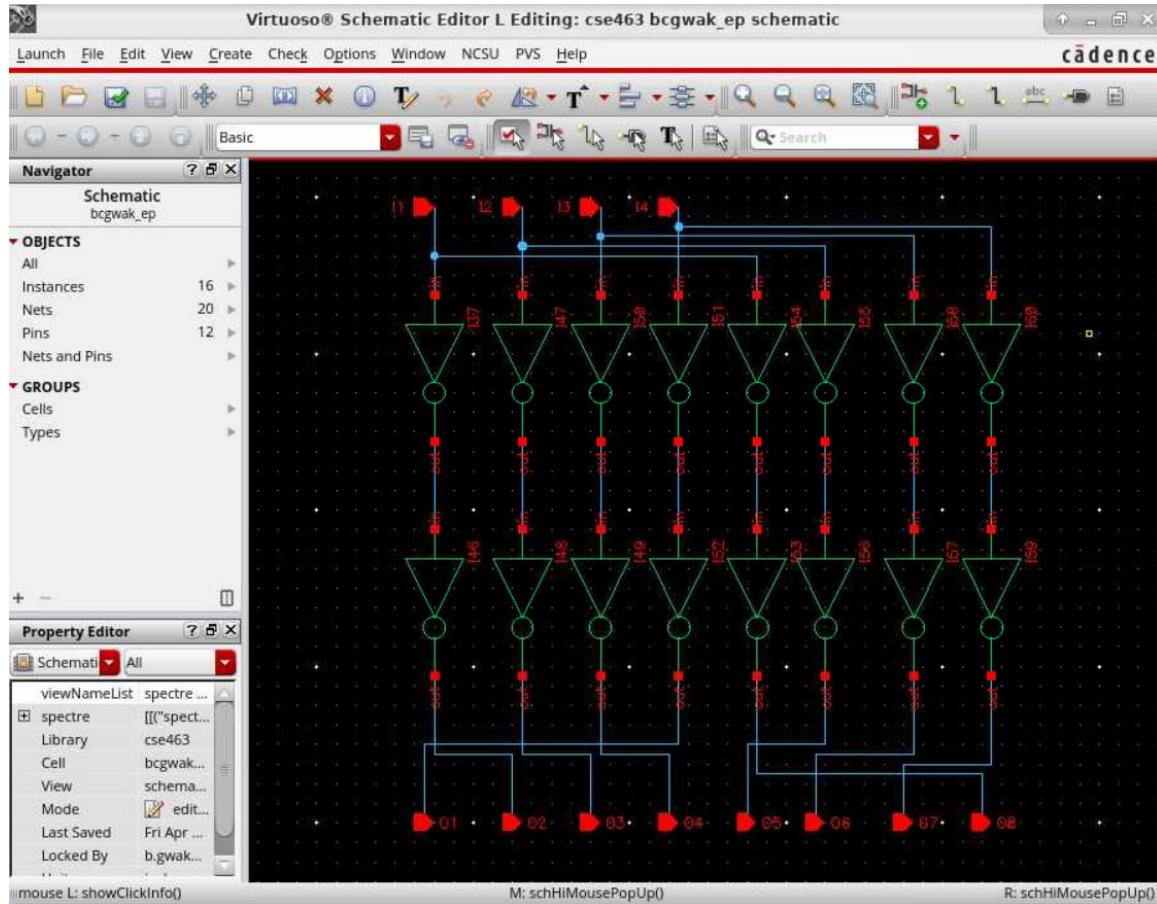
\* SHIFT 1



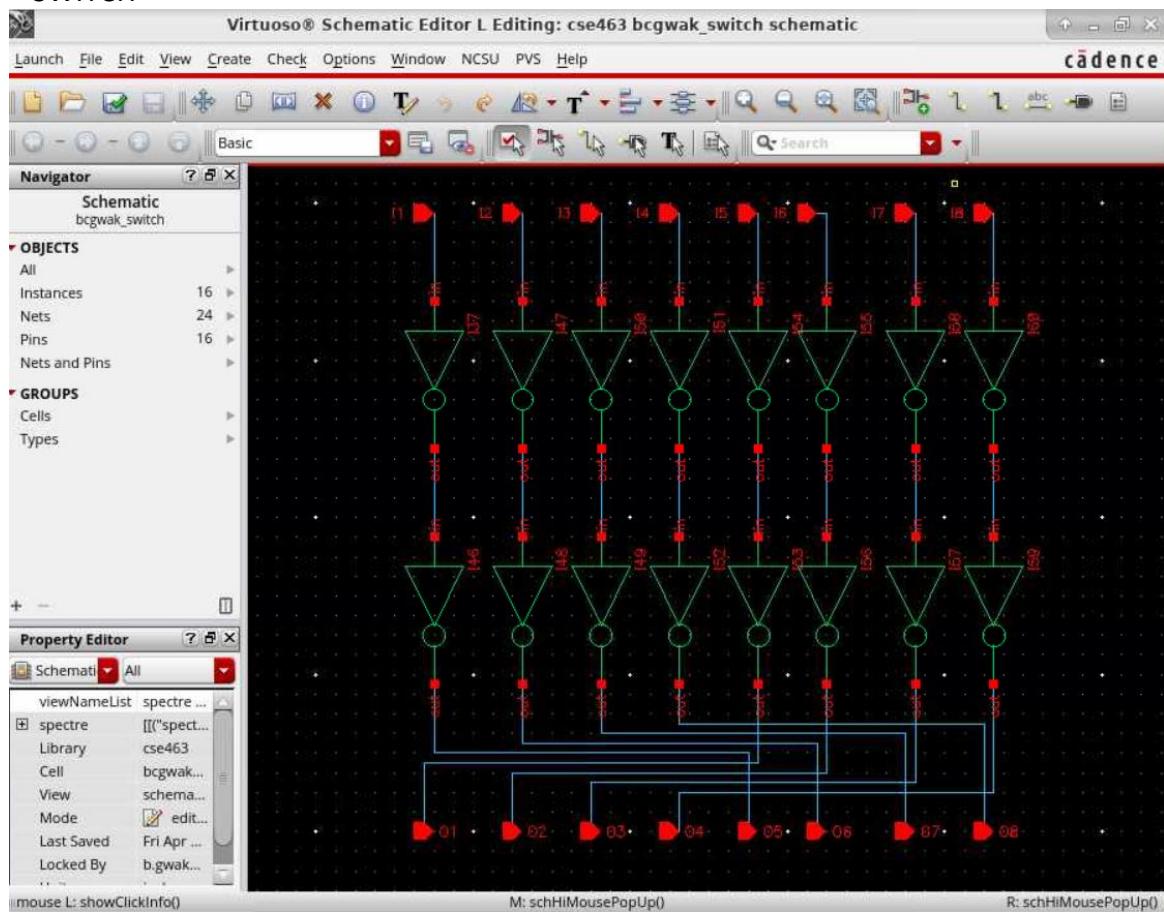
### \* SHIFT 3



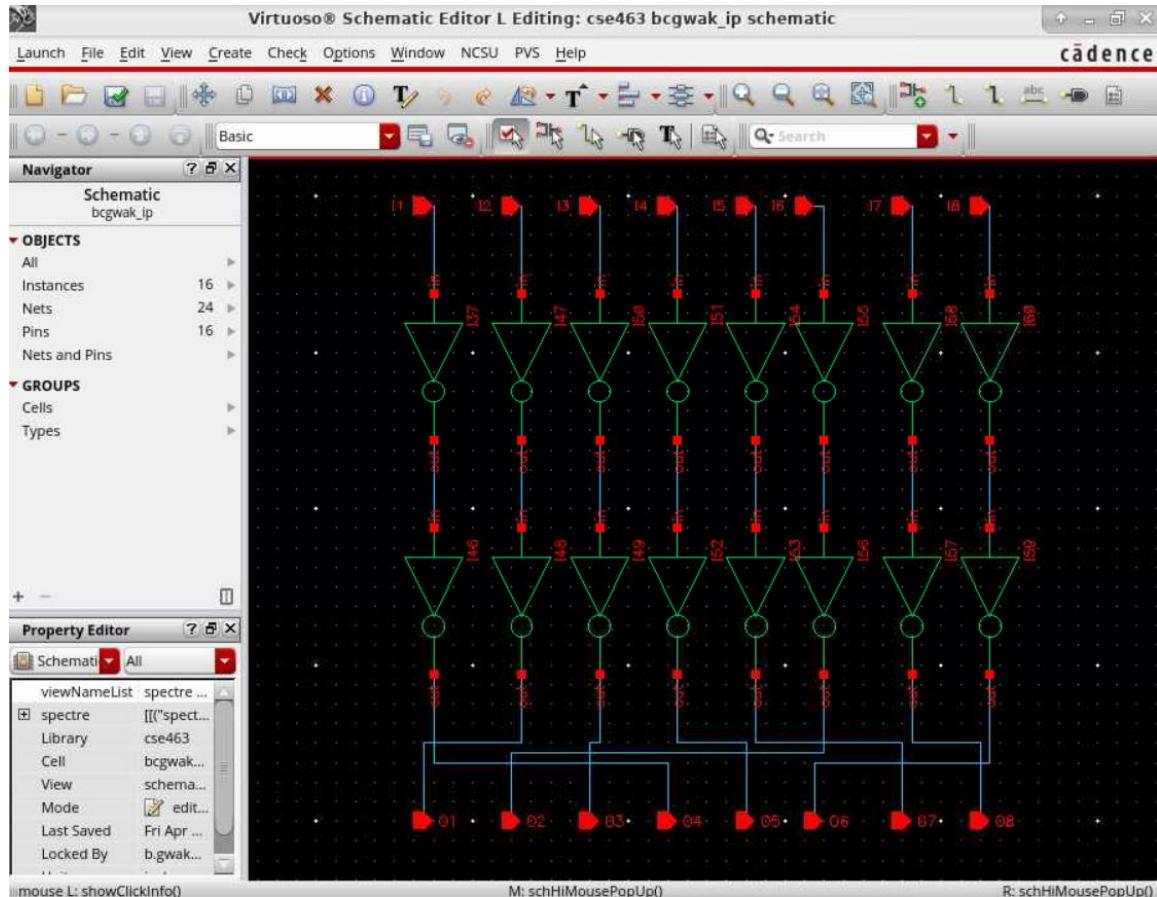
### \* EP



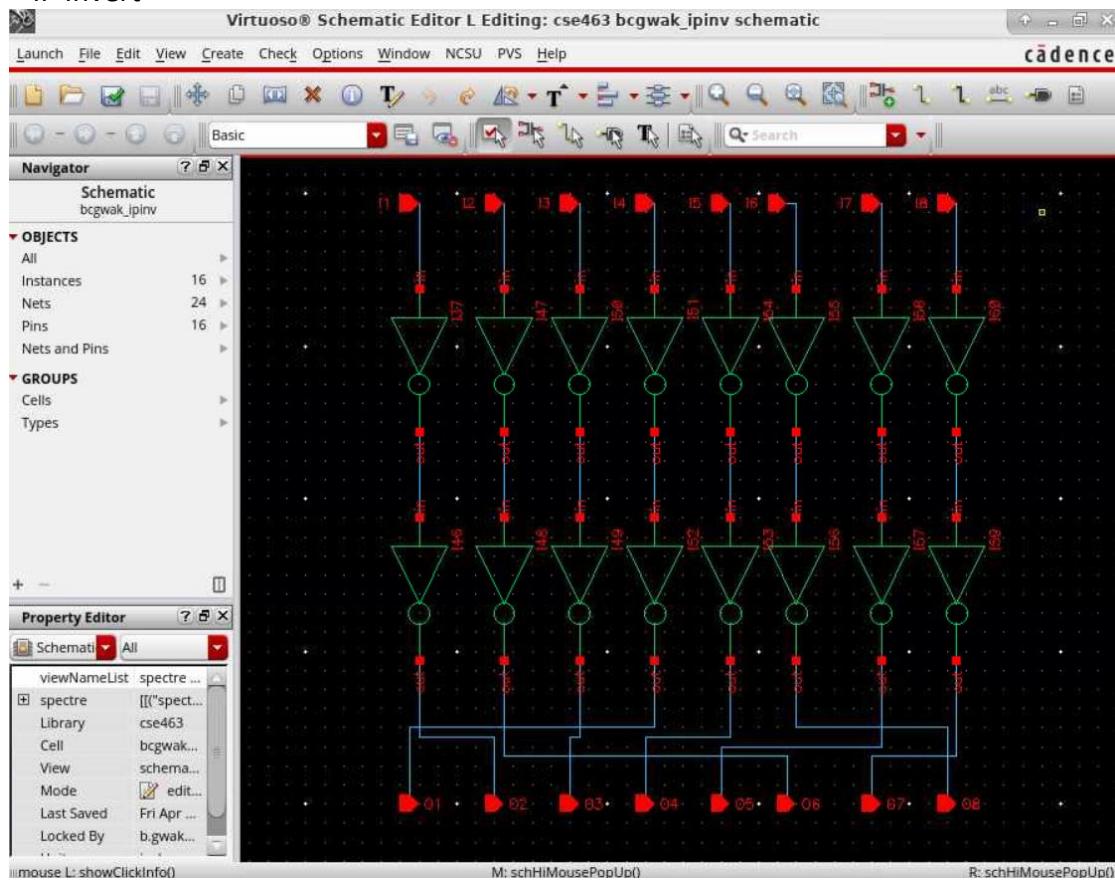
## \* SWITCH



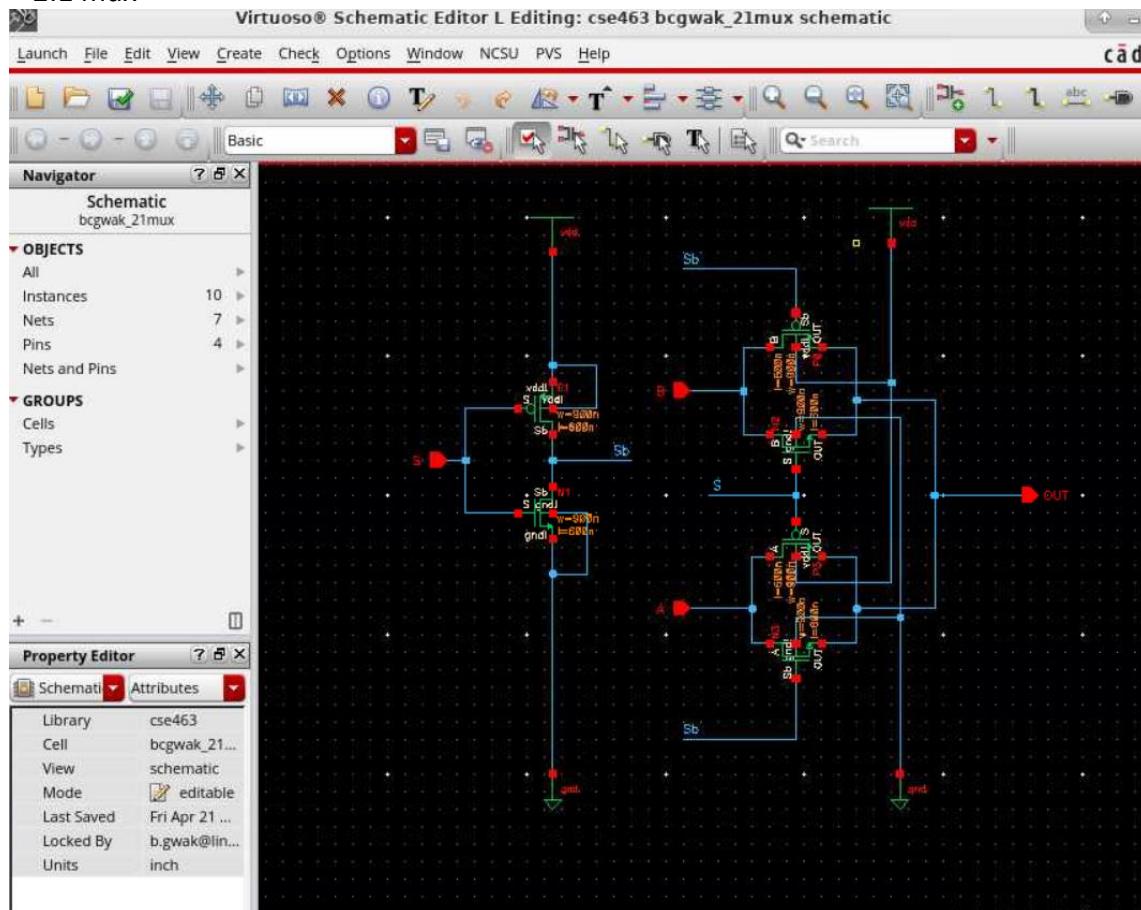
## \* IP



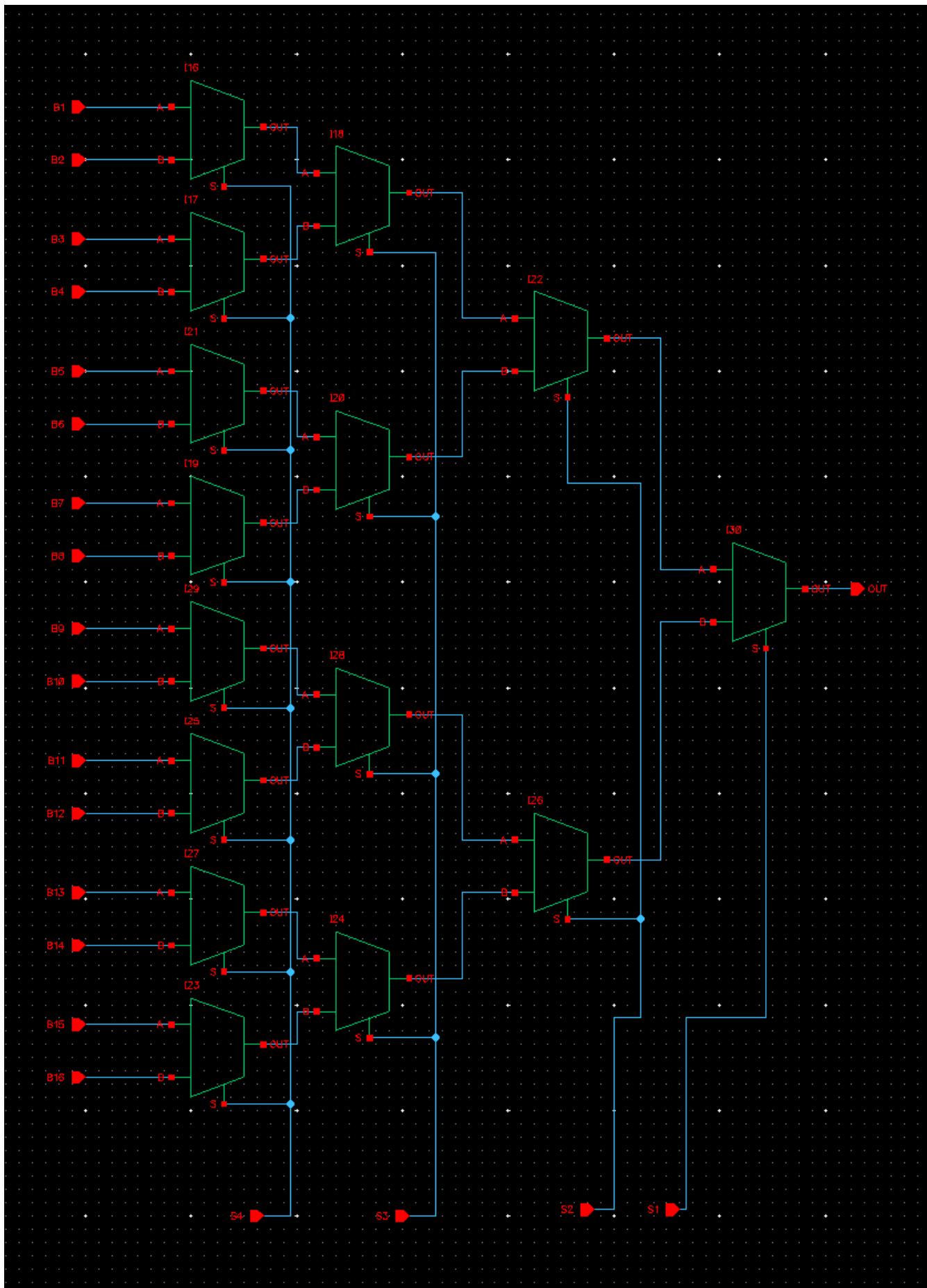
## \* IP Invert



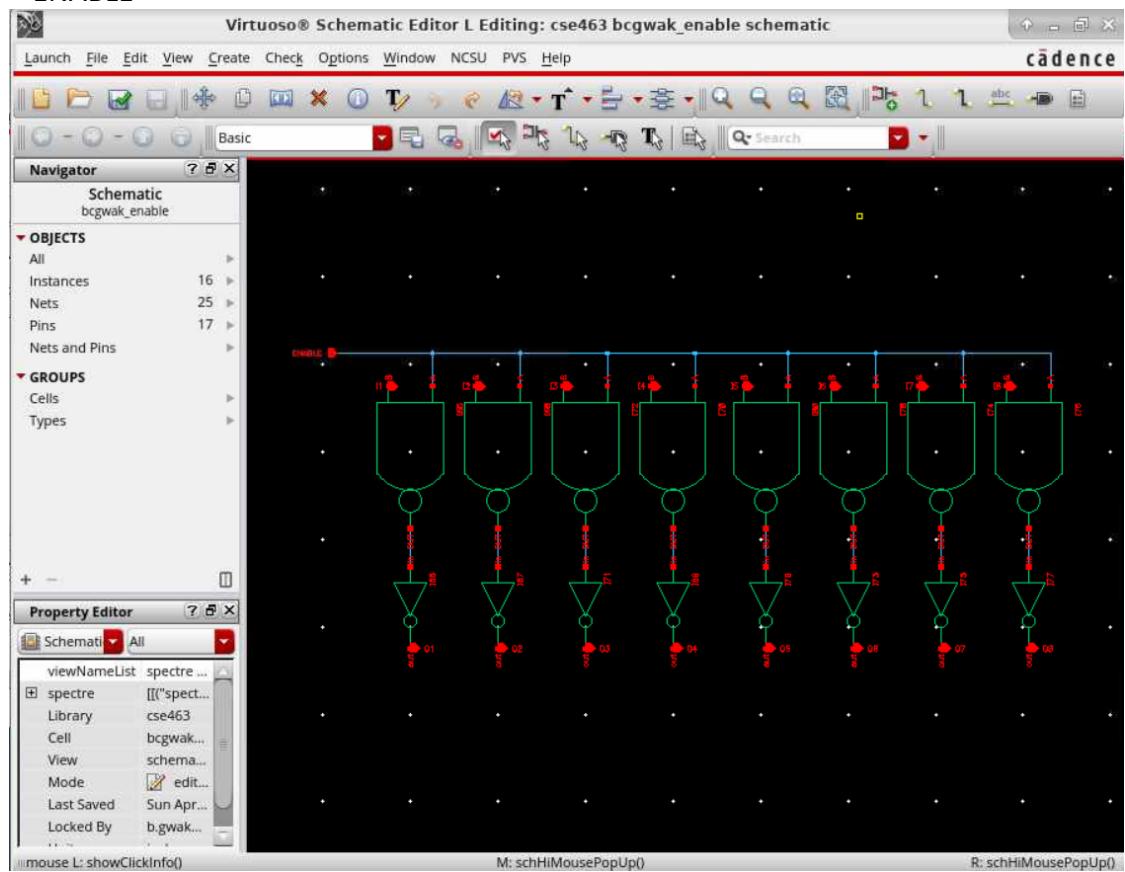
## \* 2:1 mux



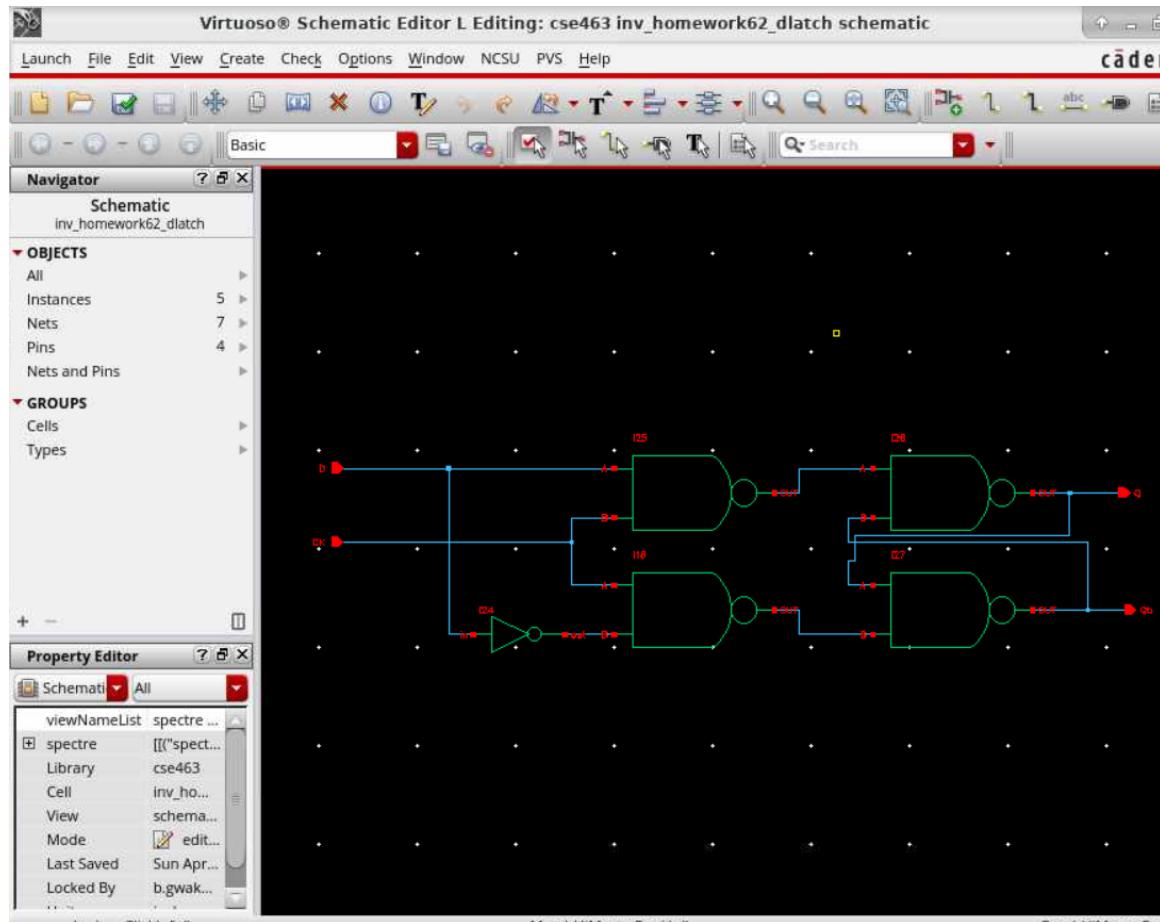
\* 16:1 mux



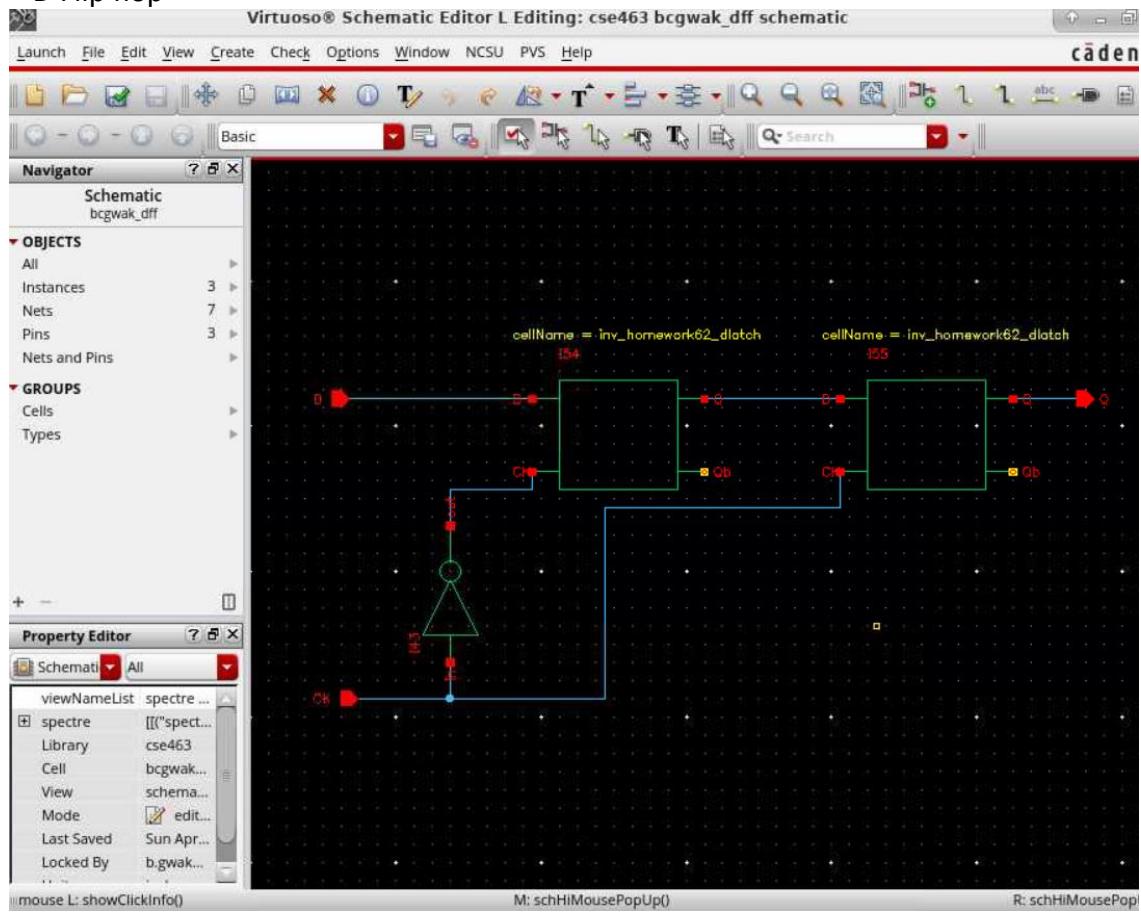
## \* ENABLE



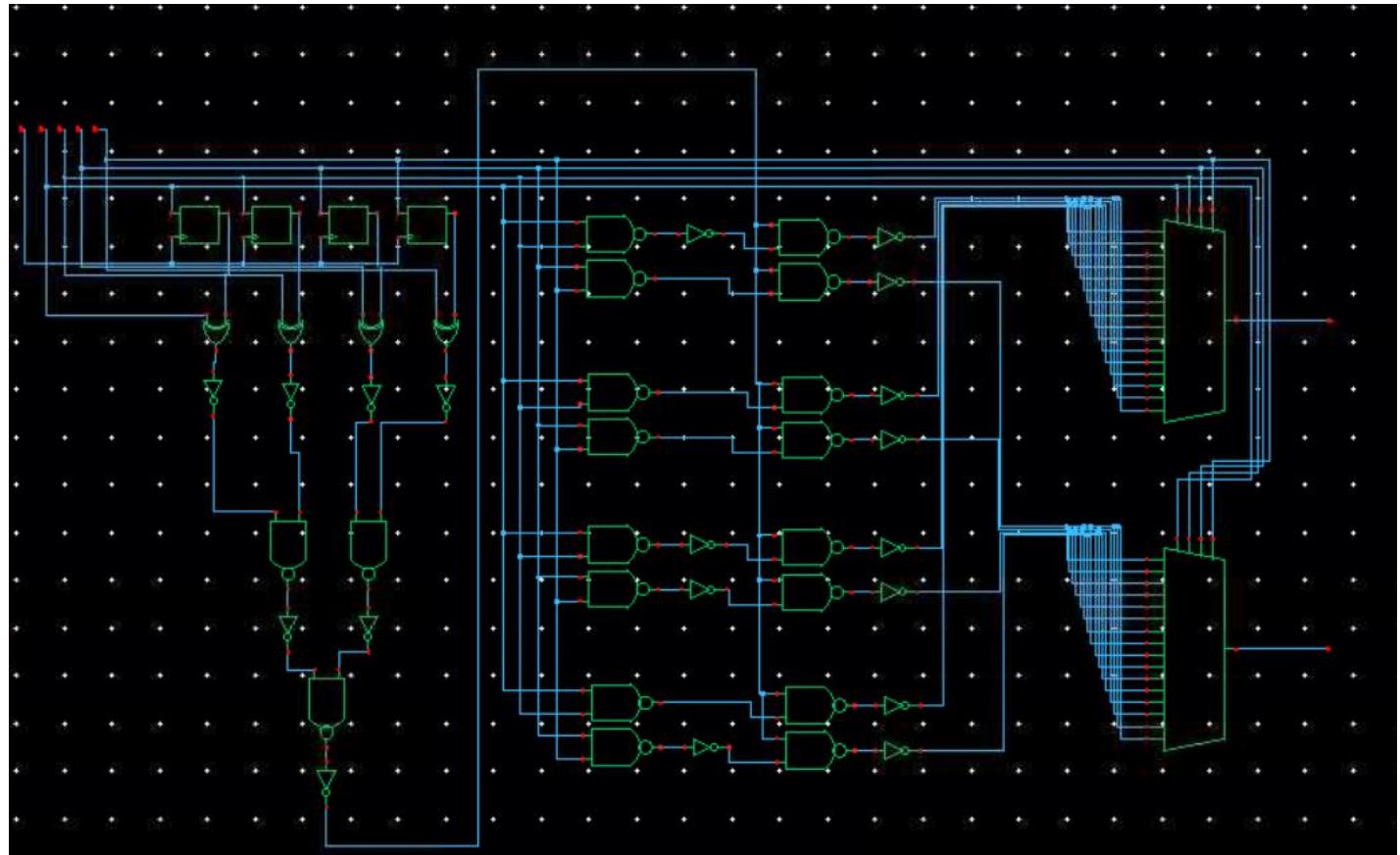
## \* D-LATCH



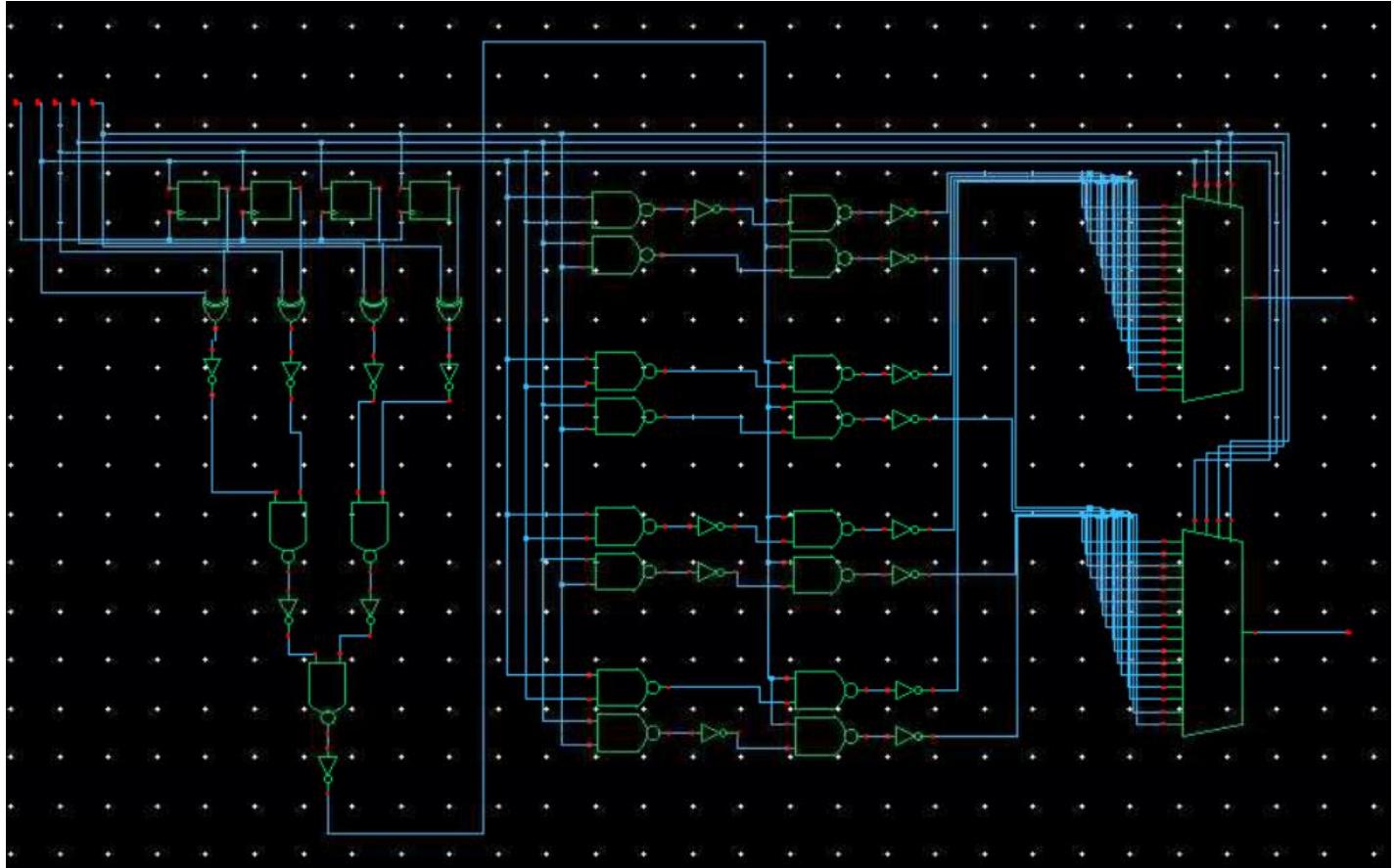
## \* D Flip flop



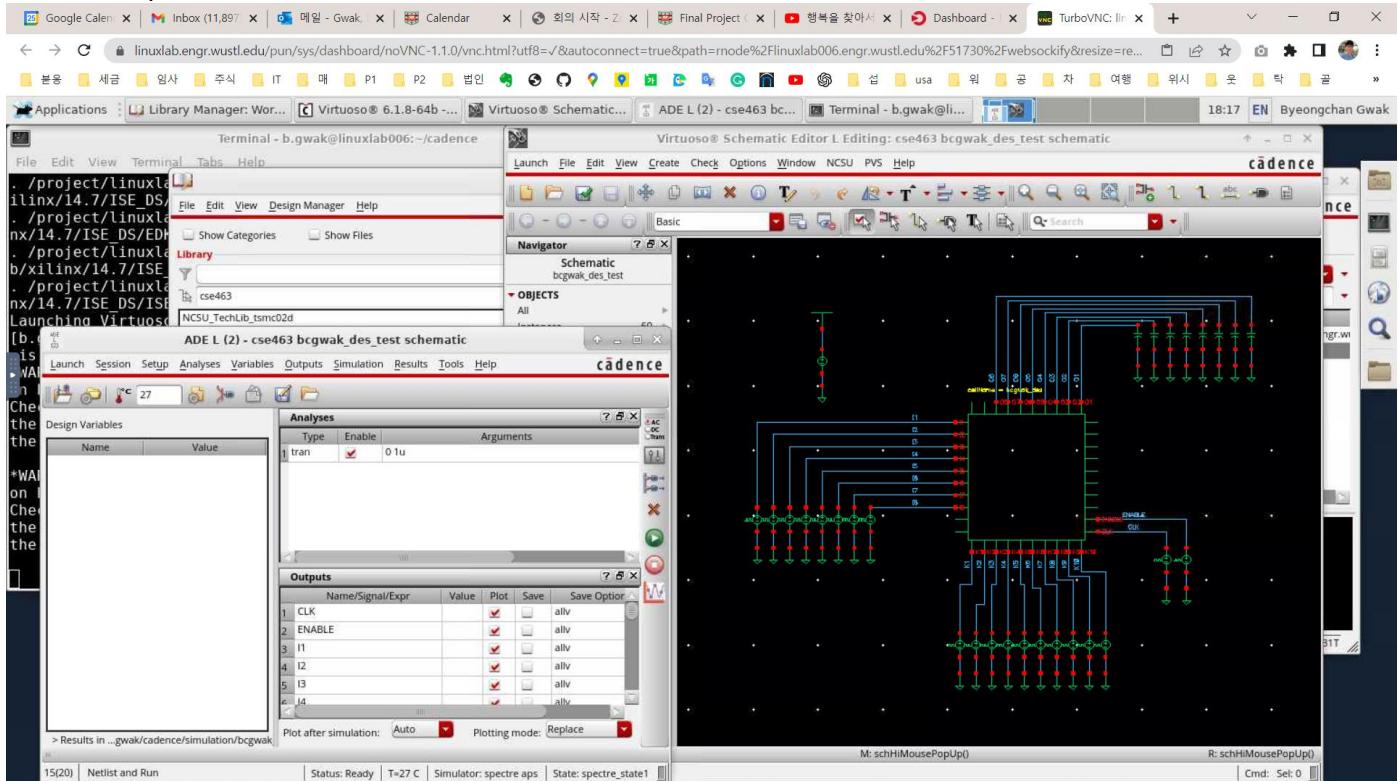
## \* SBox Red



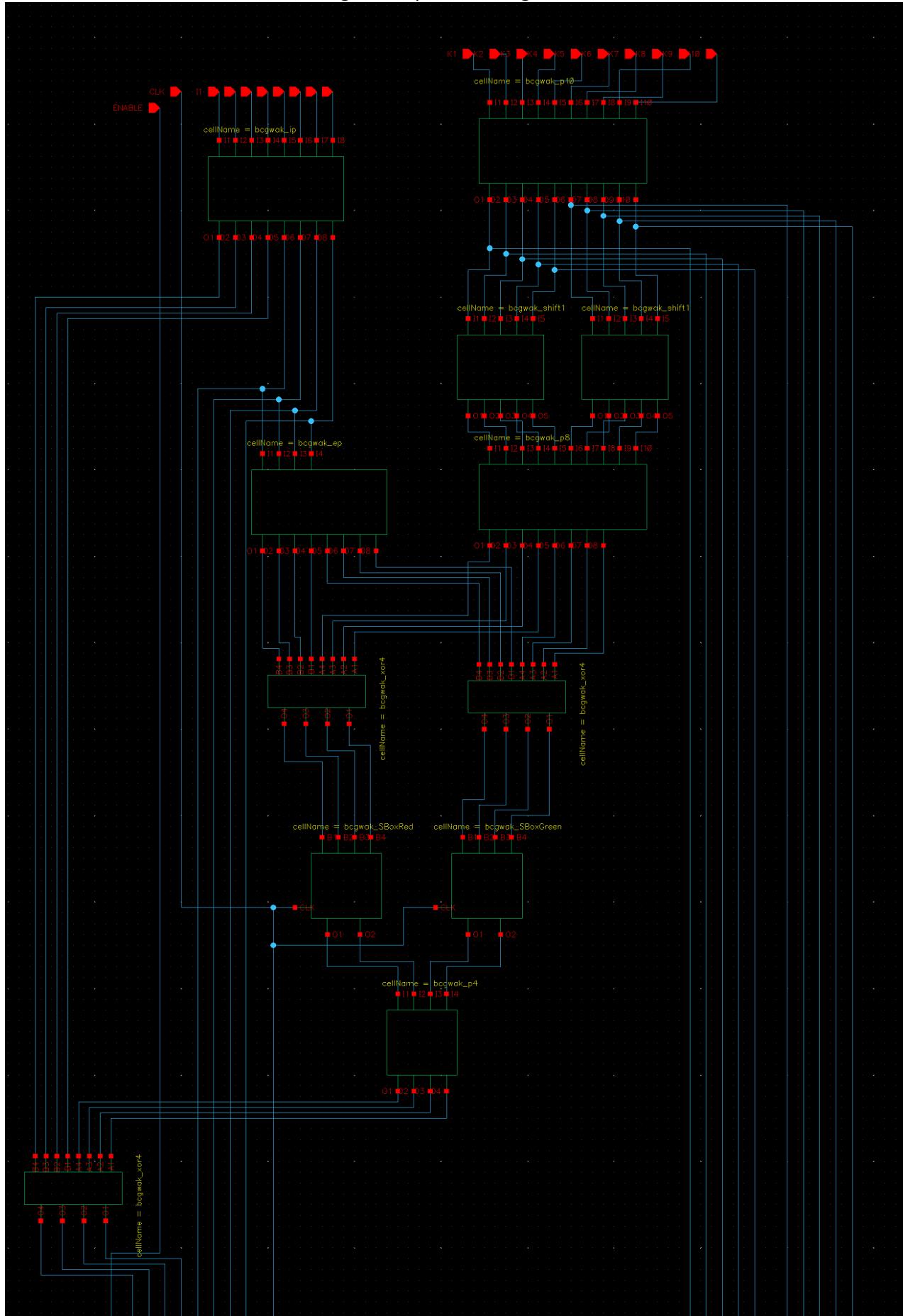
## \* SBox Green



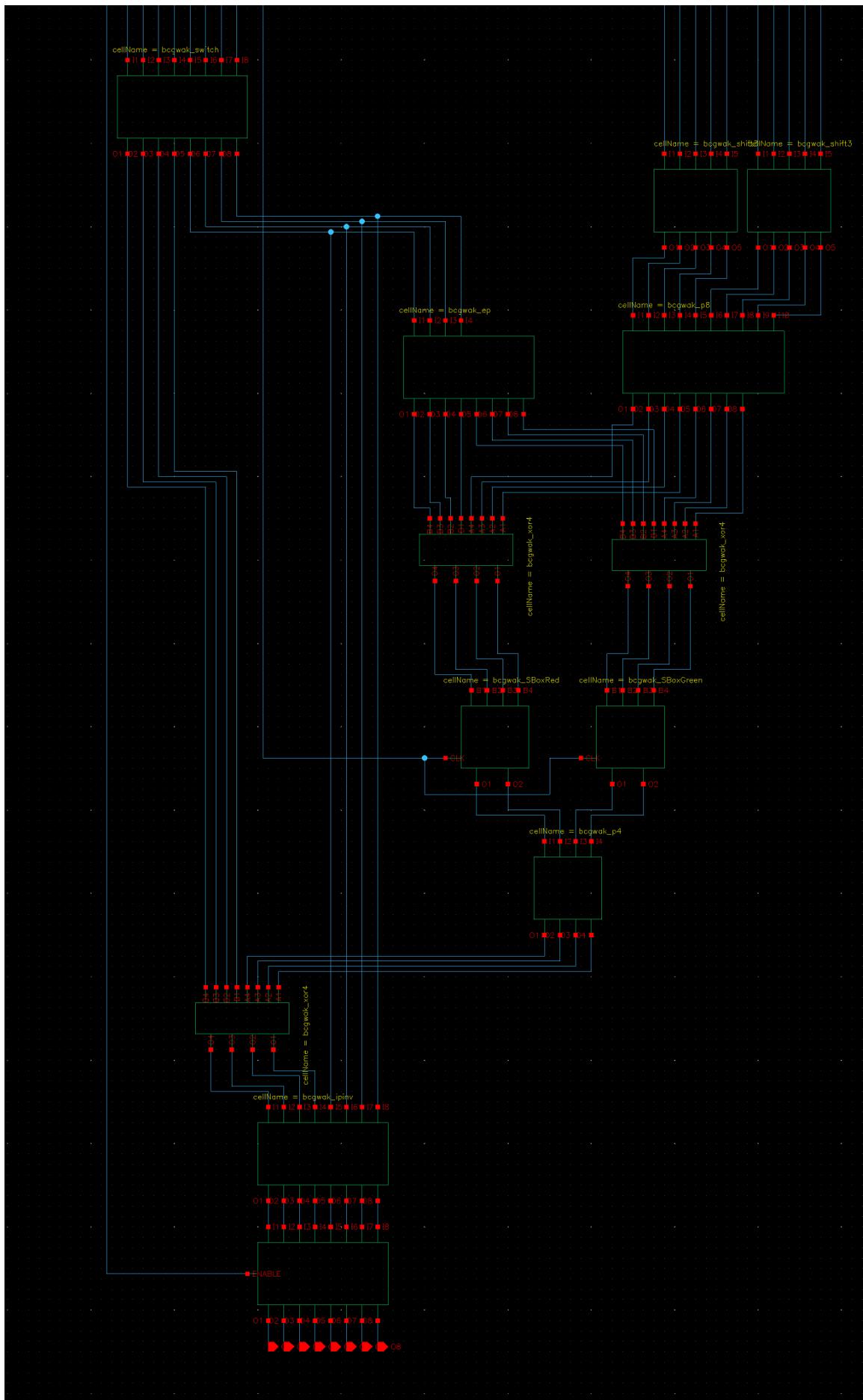
## \* Test setup for the DES.



\* Whole DES schematic. It's a bit long and I split the image file in half. Below is the first one.

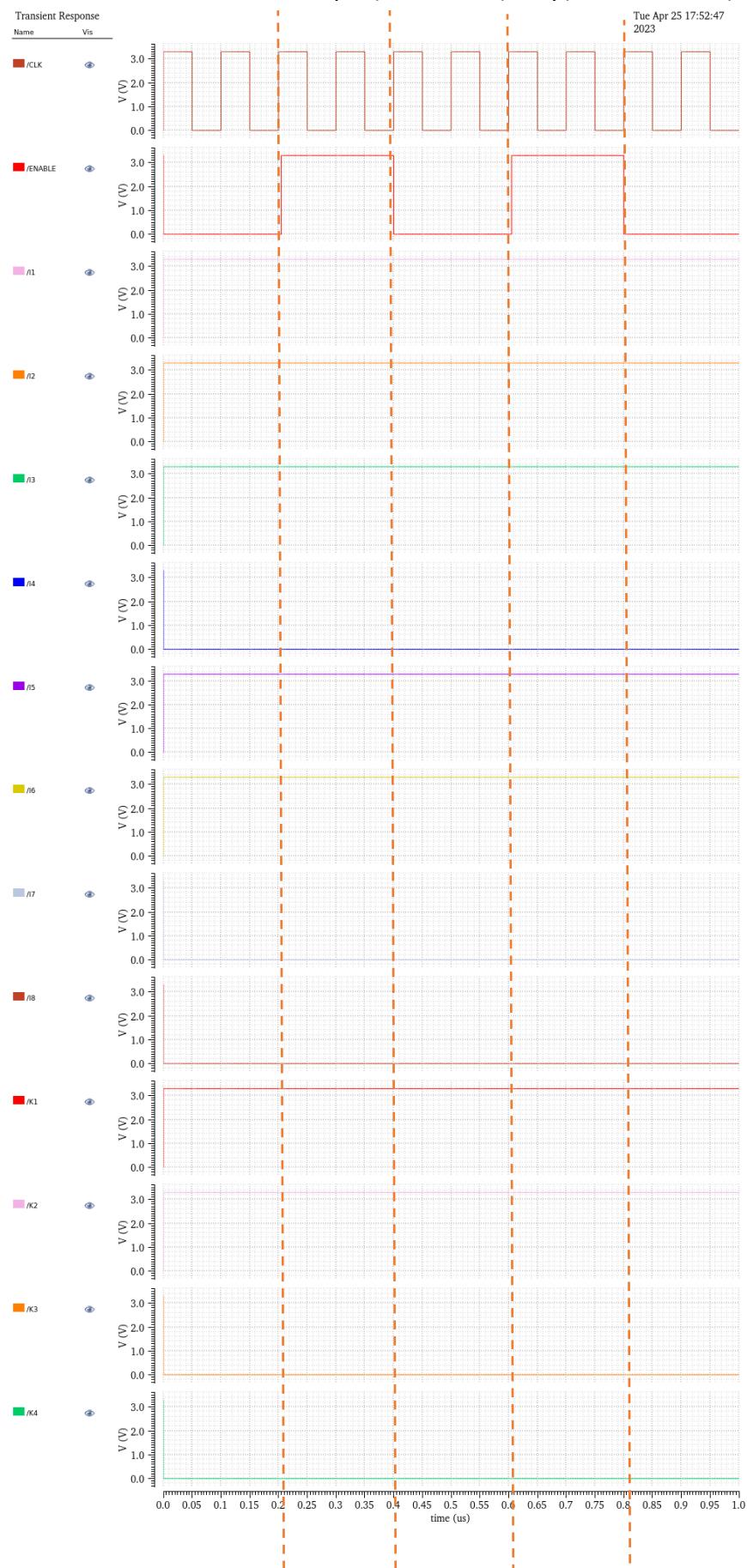


\* Below is the second half.



# 6. Schematic timing diagram result

\* Test result: CLK, ENABLE, Input(I1, I2, ..., I8), Key(K1, K2, ..., K10), Output(O1, O2, ..., O8)



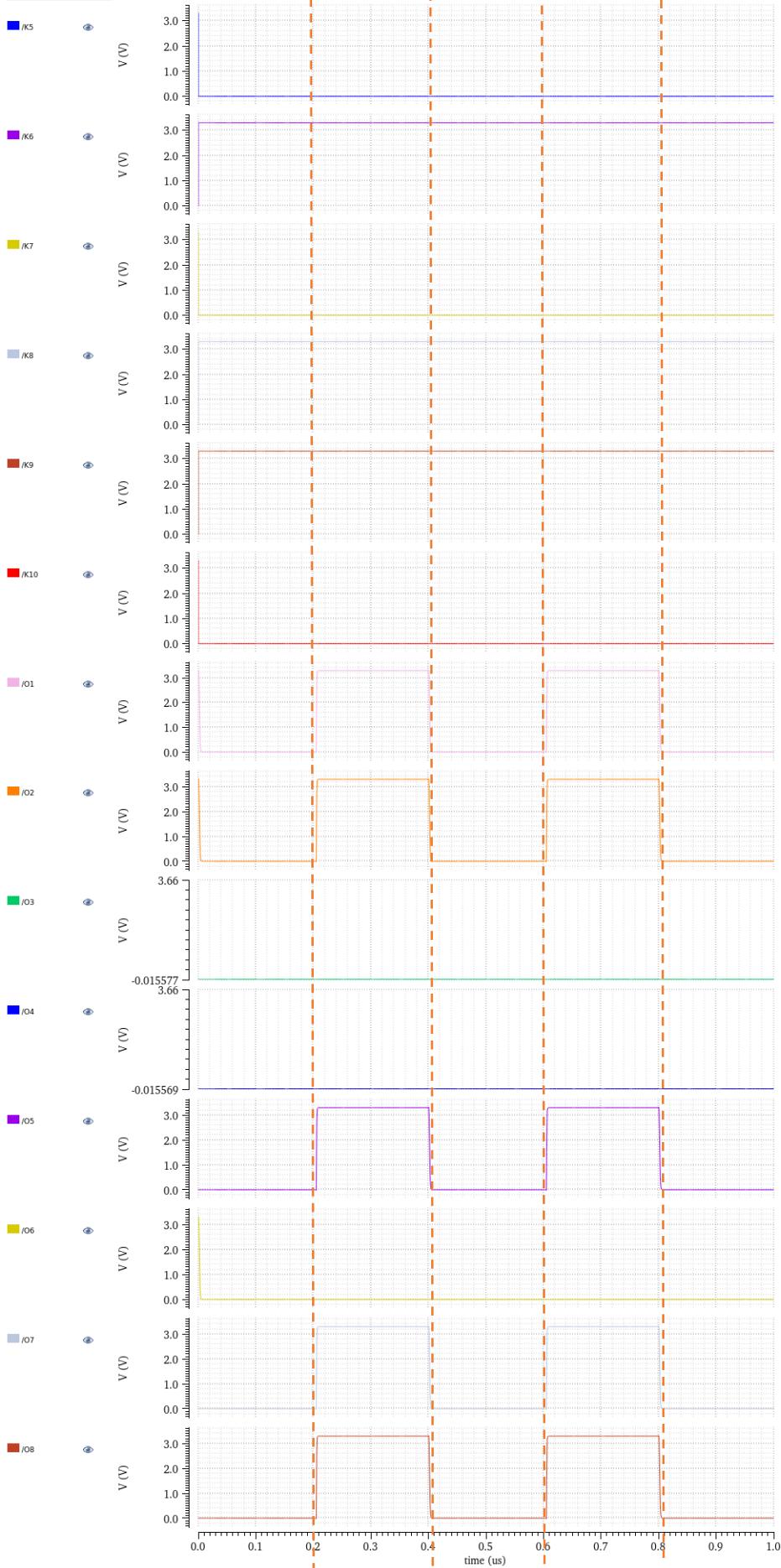
## Transient Response

Name Vis

Tue Apr 25 17:52:47

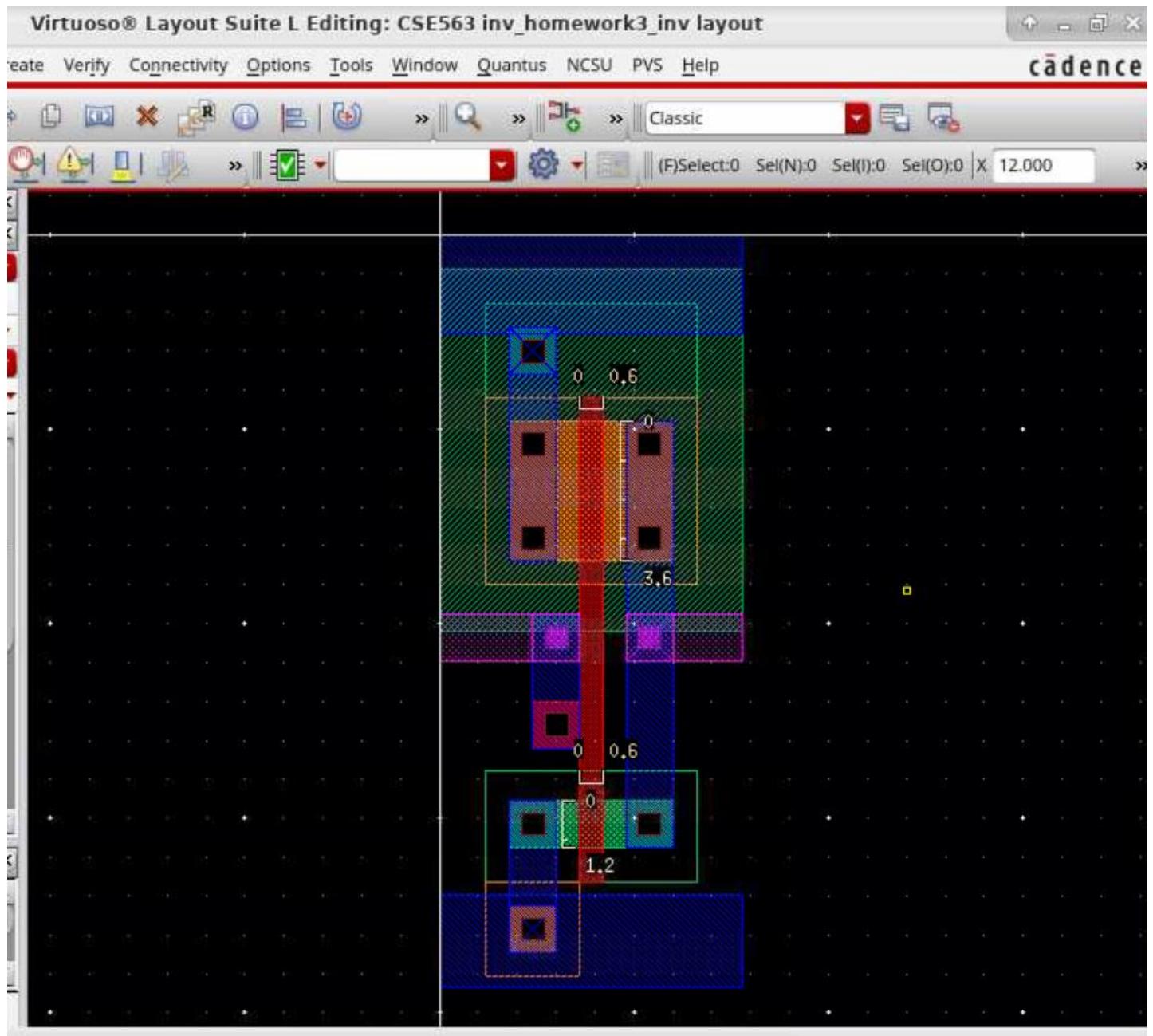
1

2023

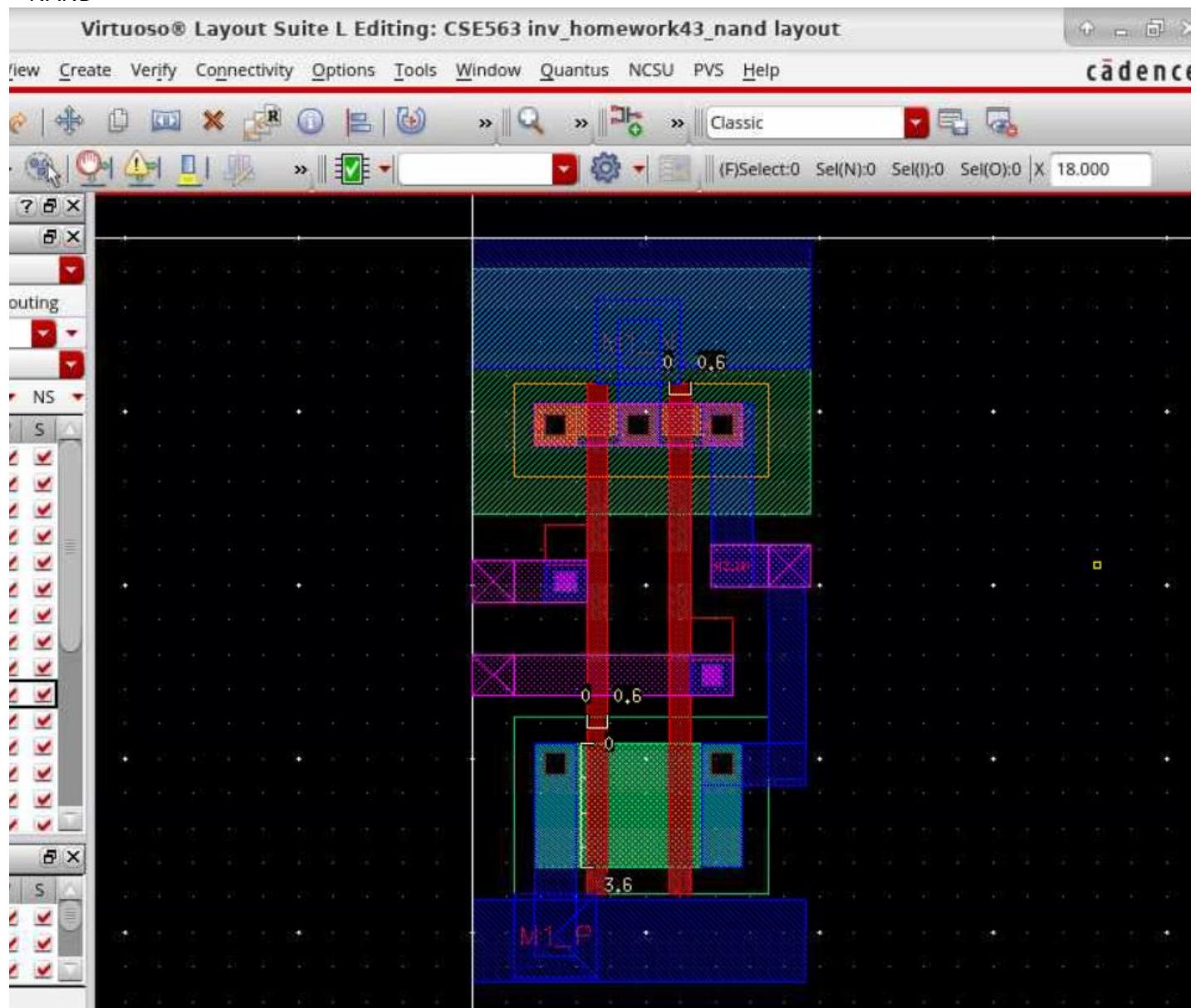


## 7. Layout

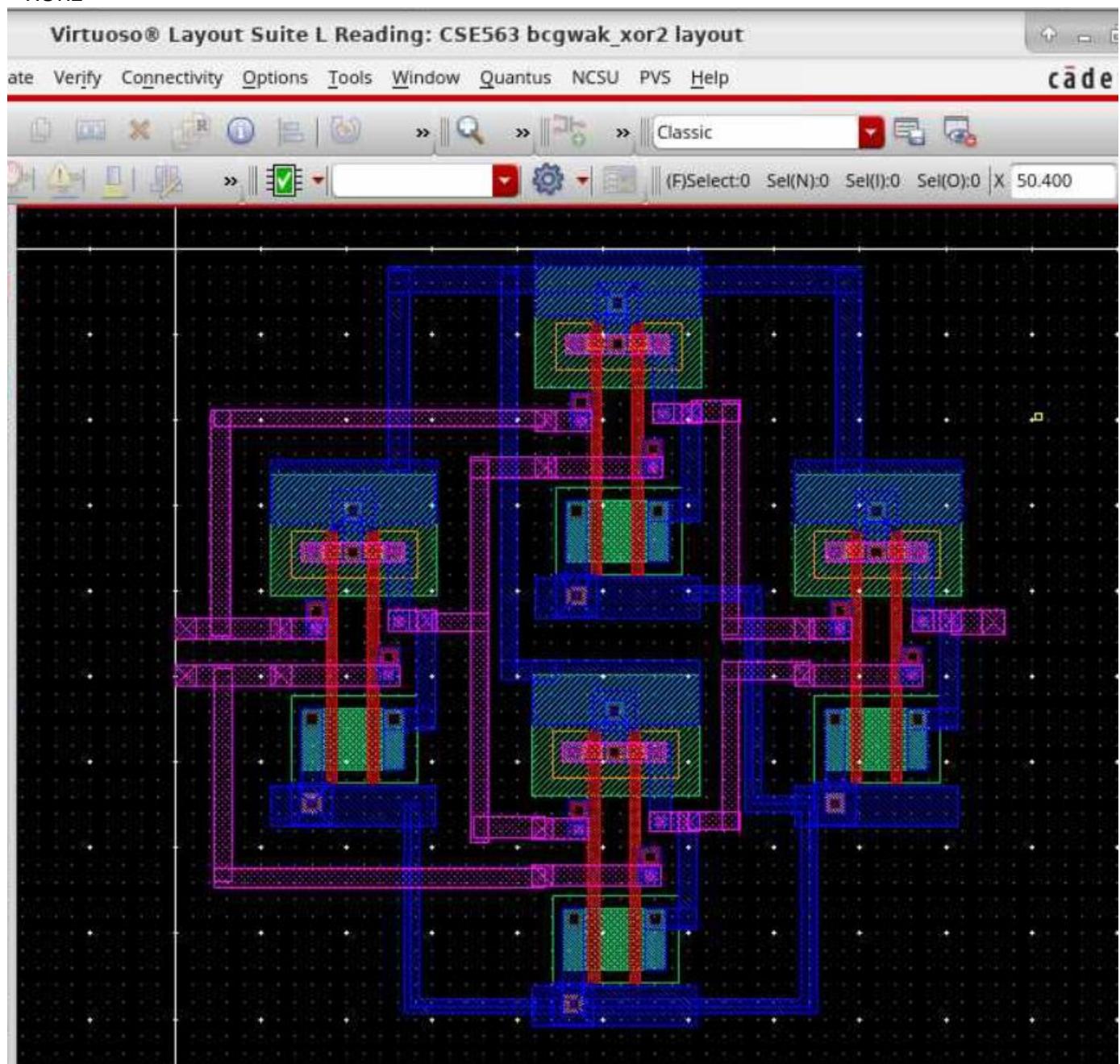
\* INVERTOR



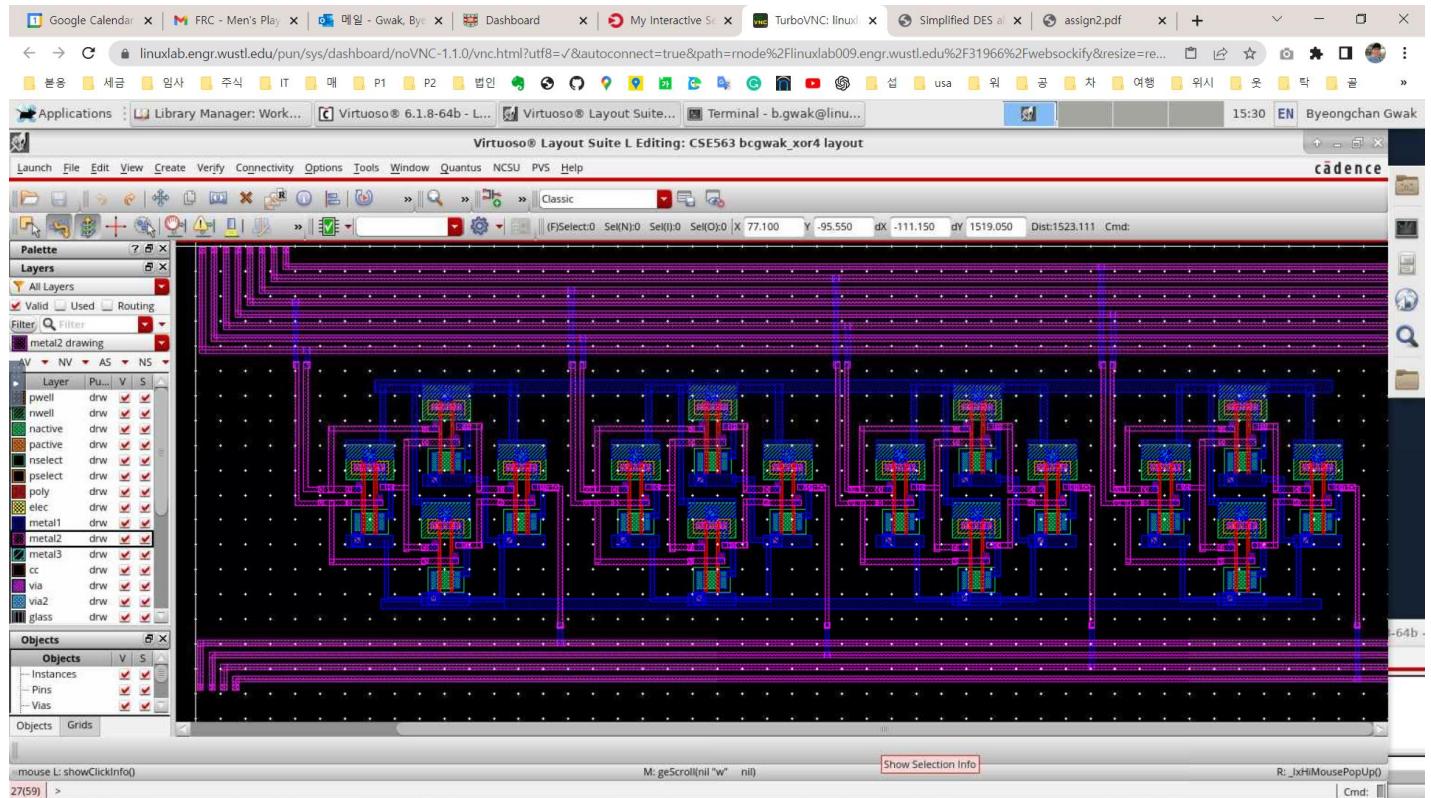
\* NAND



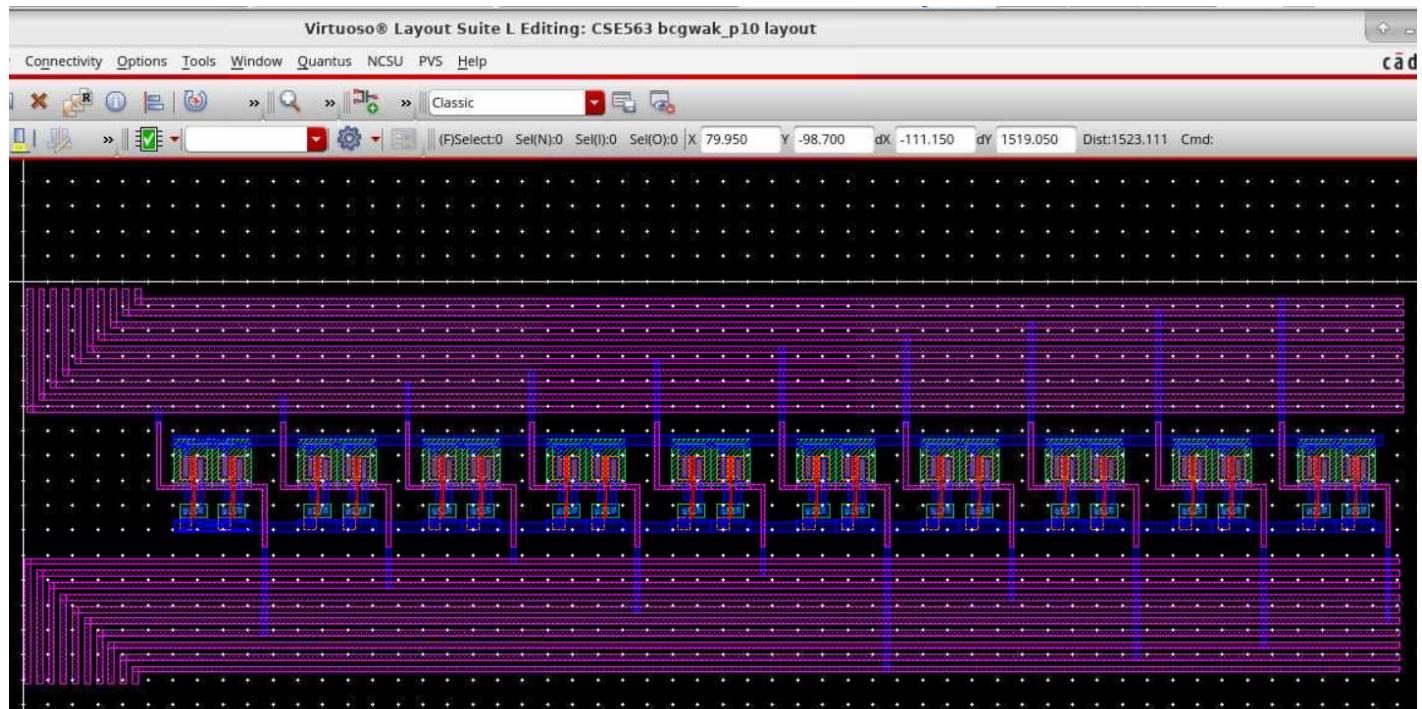
\* XOR2



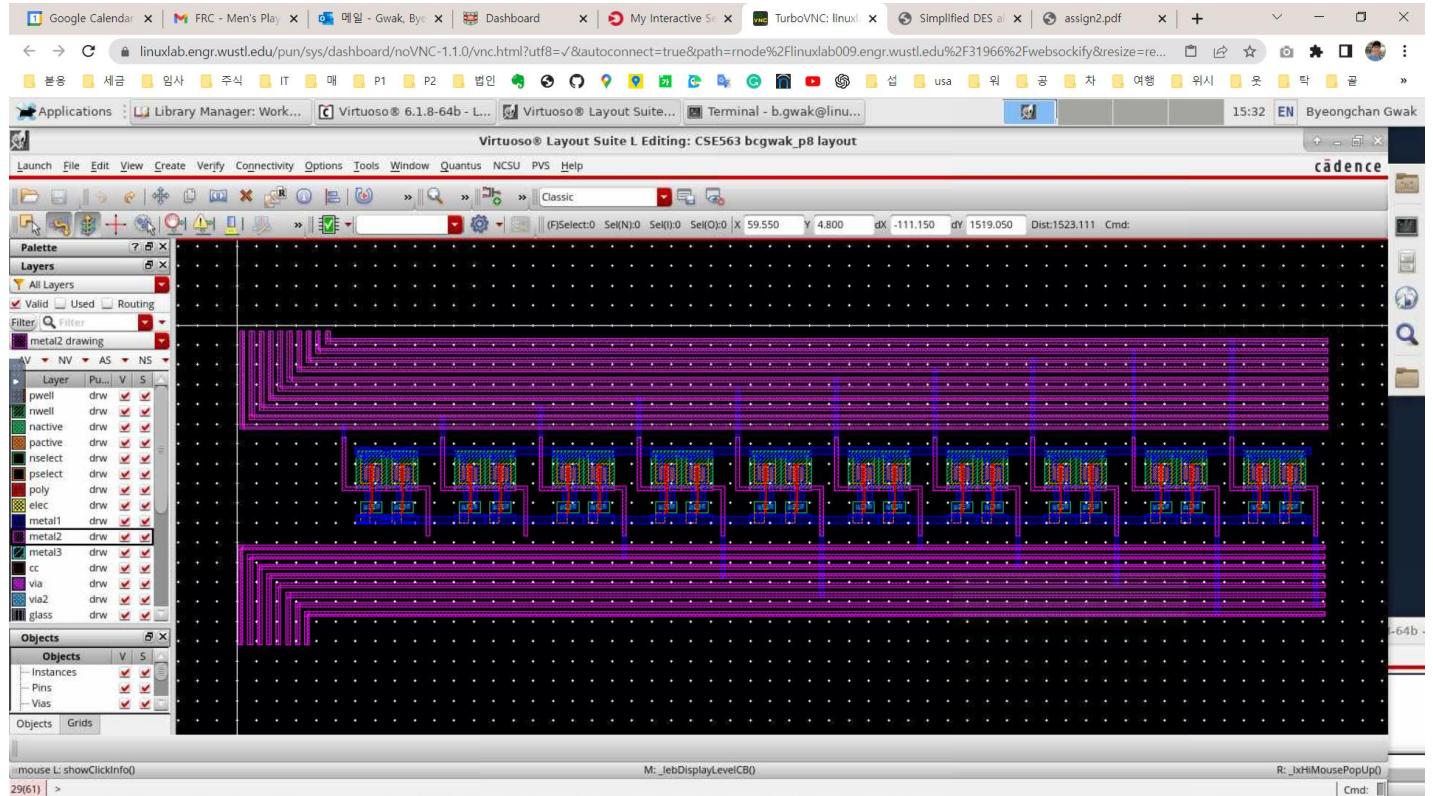
## \* XOR4



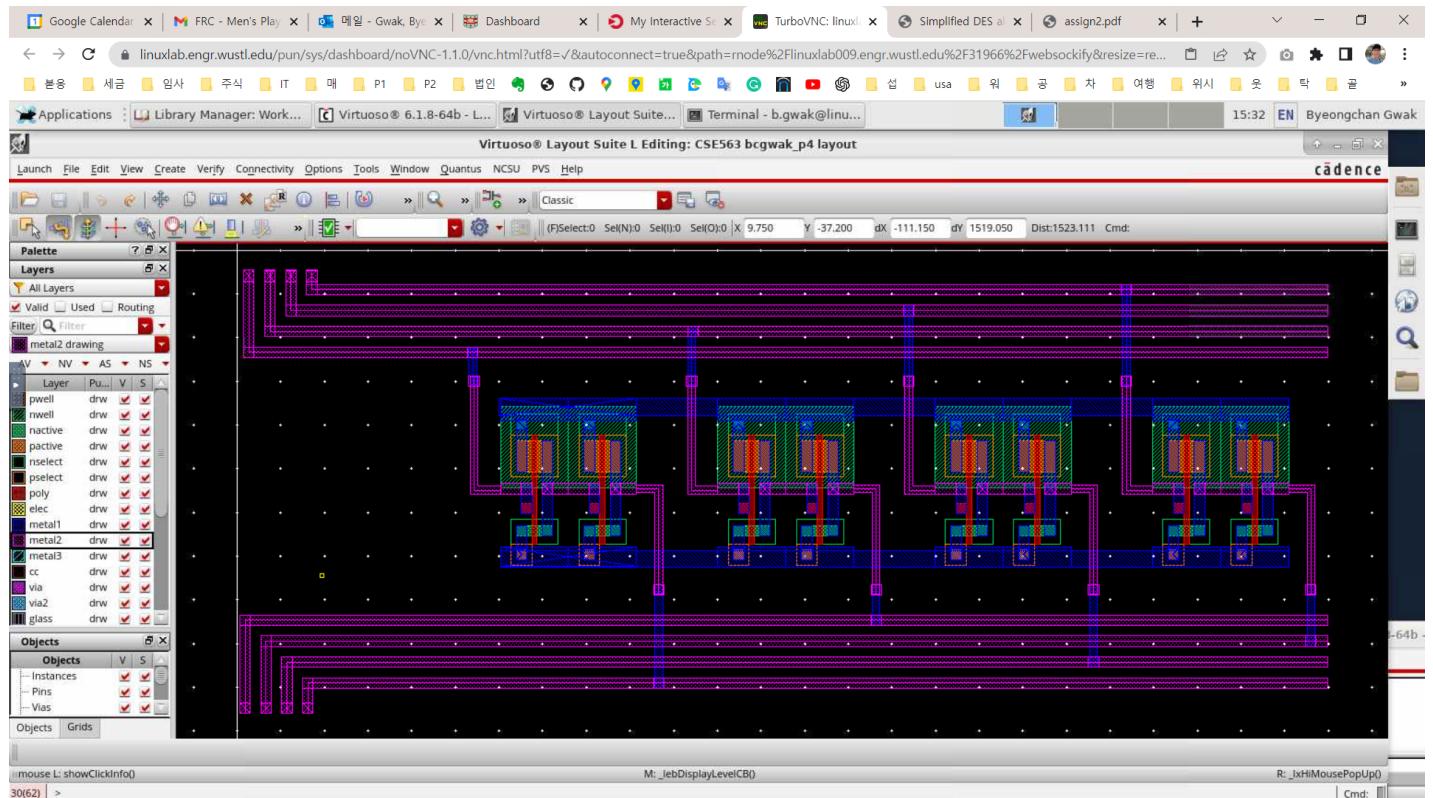
## \* P10



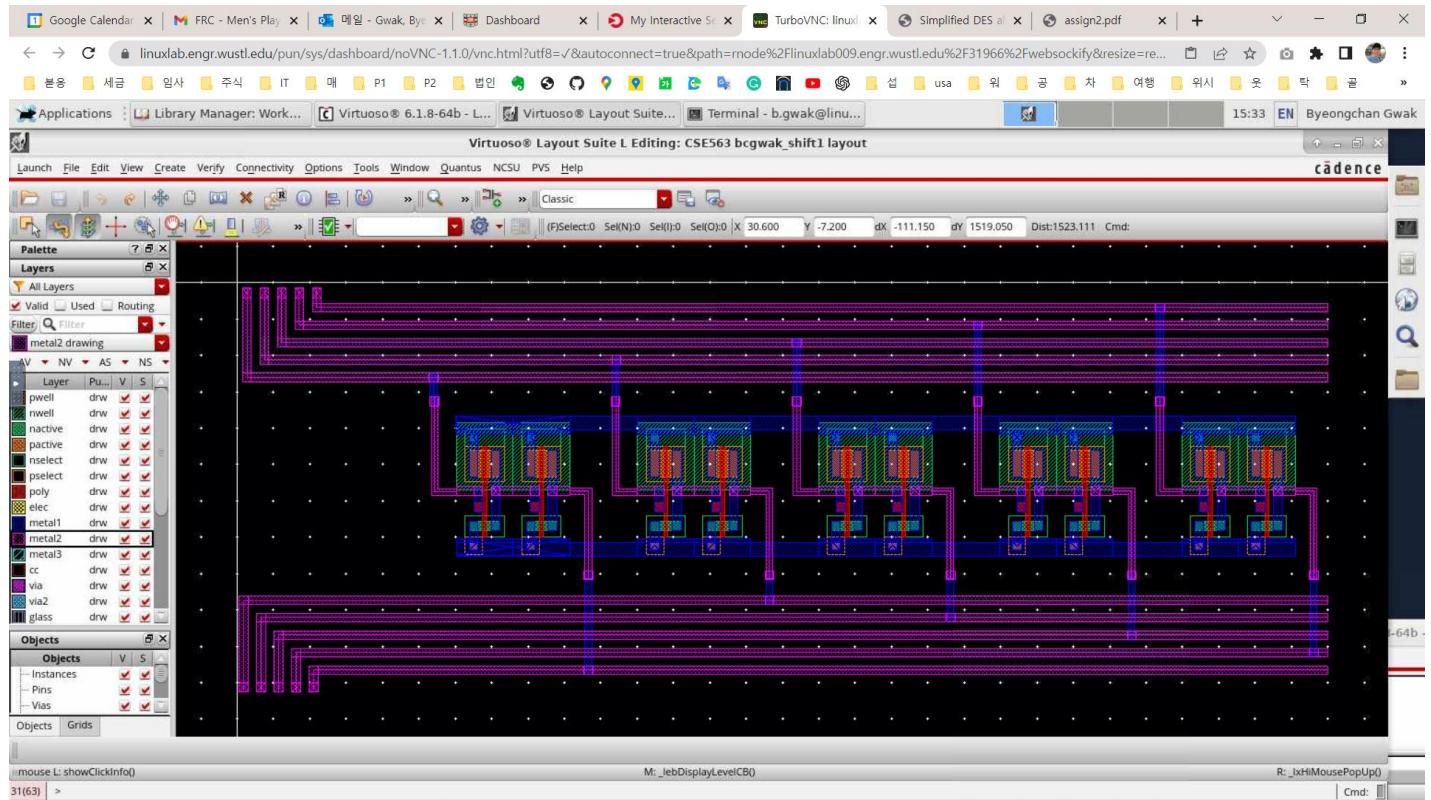
\* P8



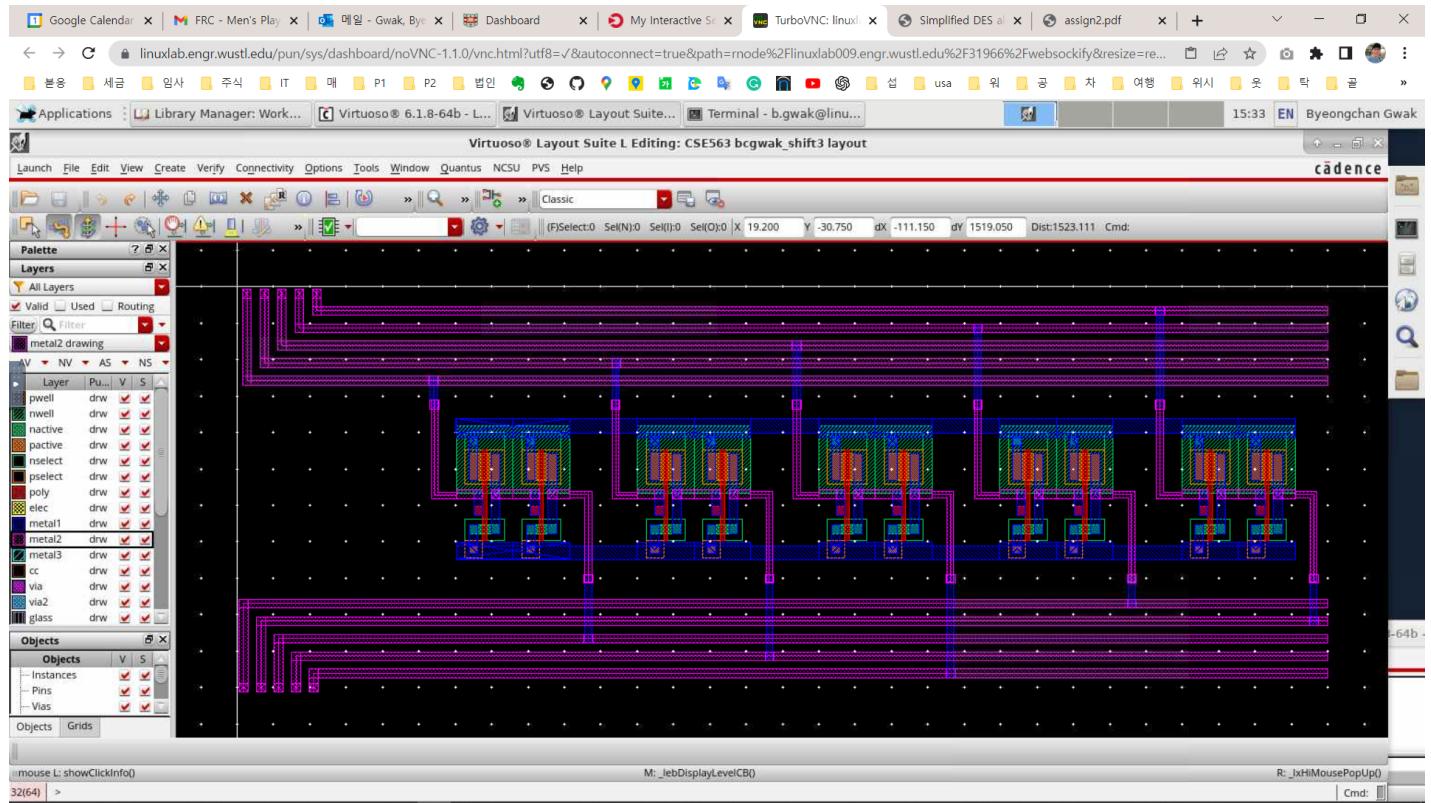
\* P4



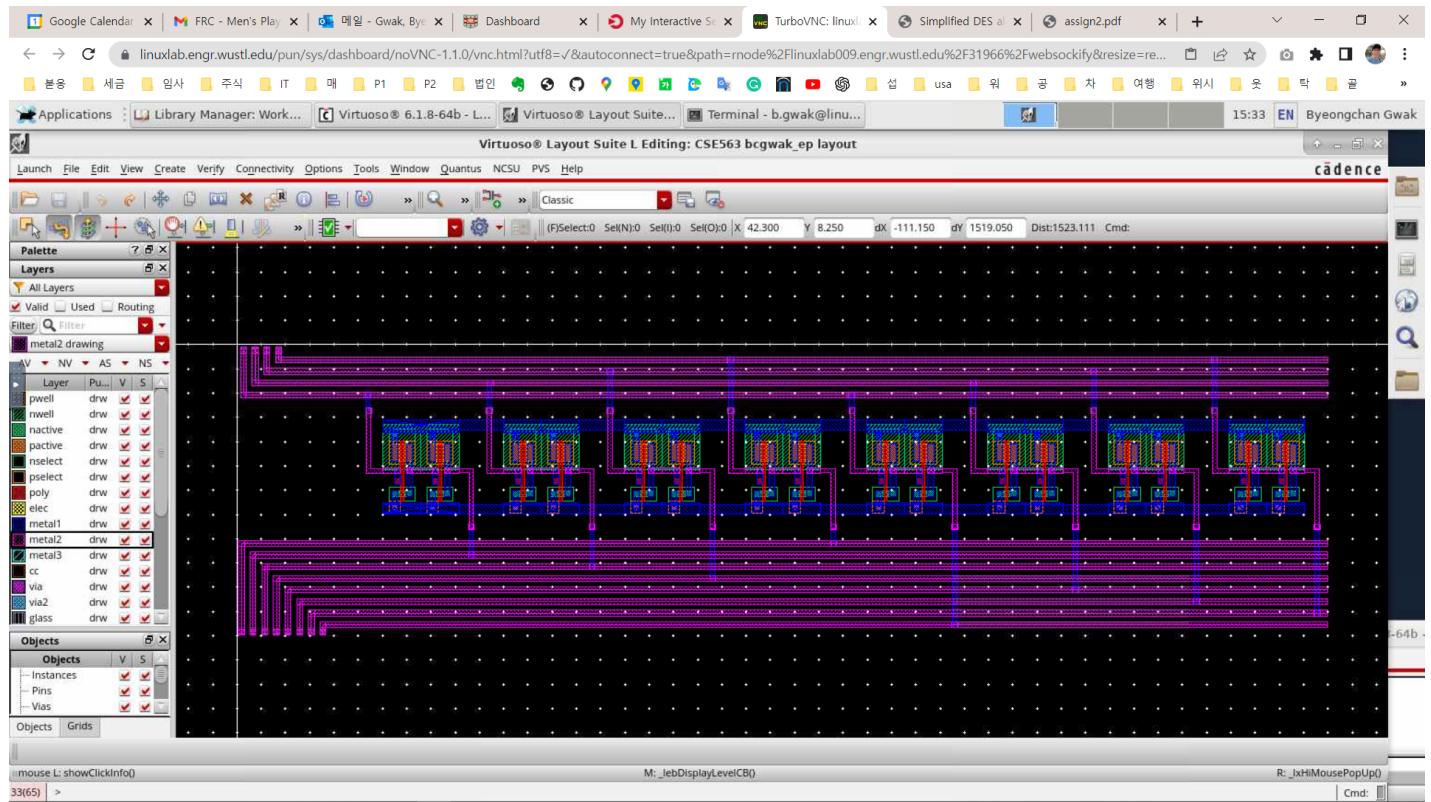
## \* SHIFT 1



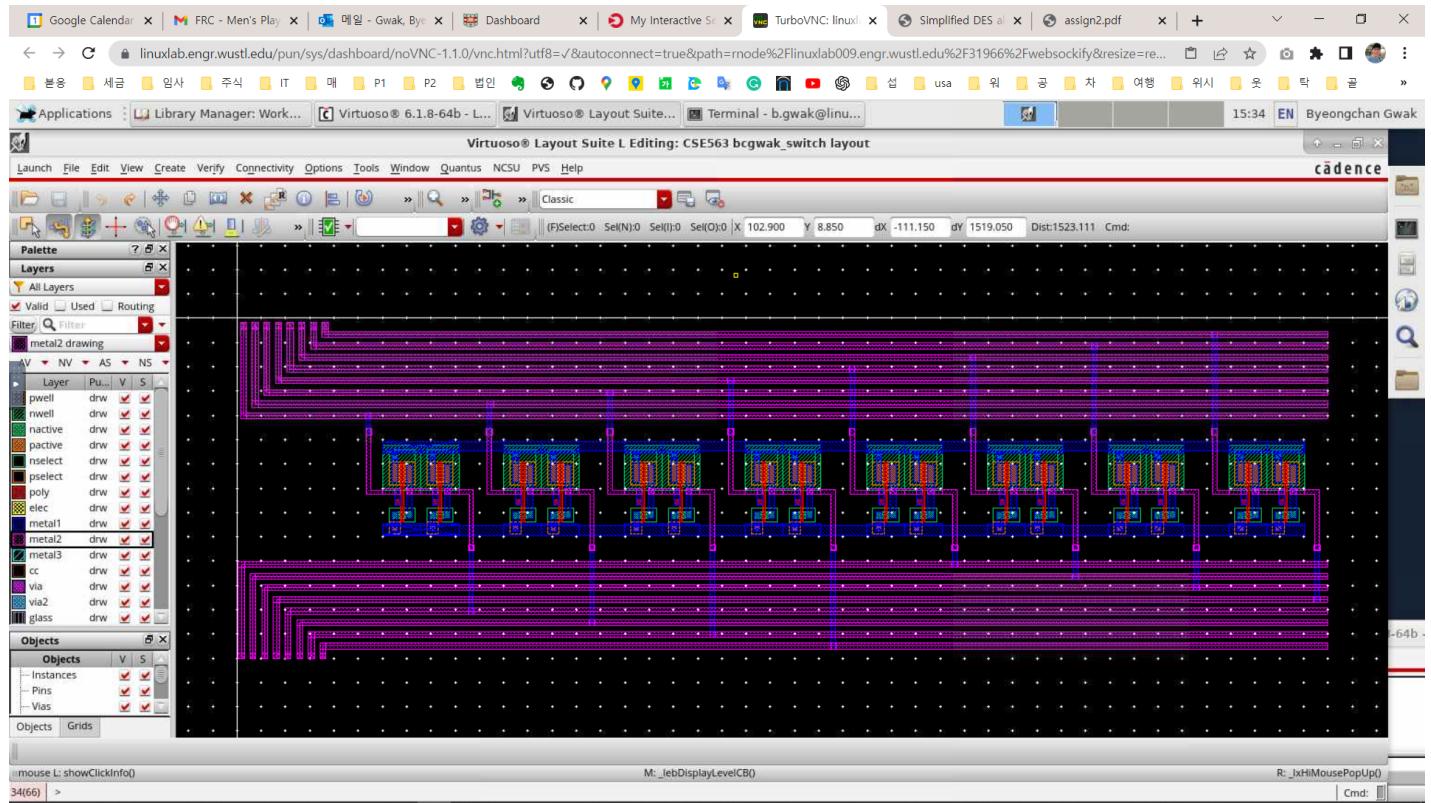
## \* SHIFT 3



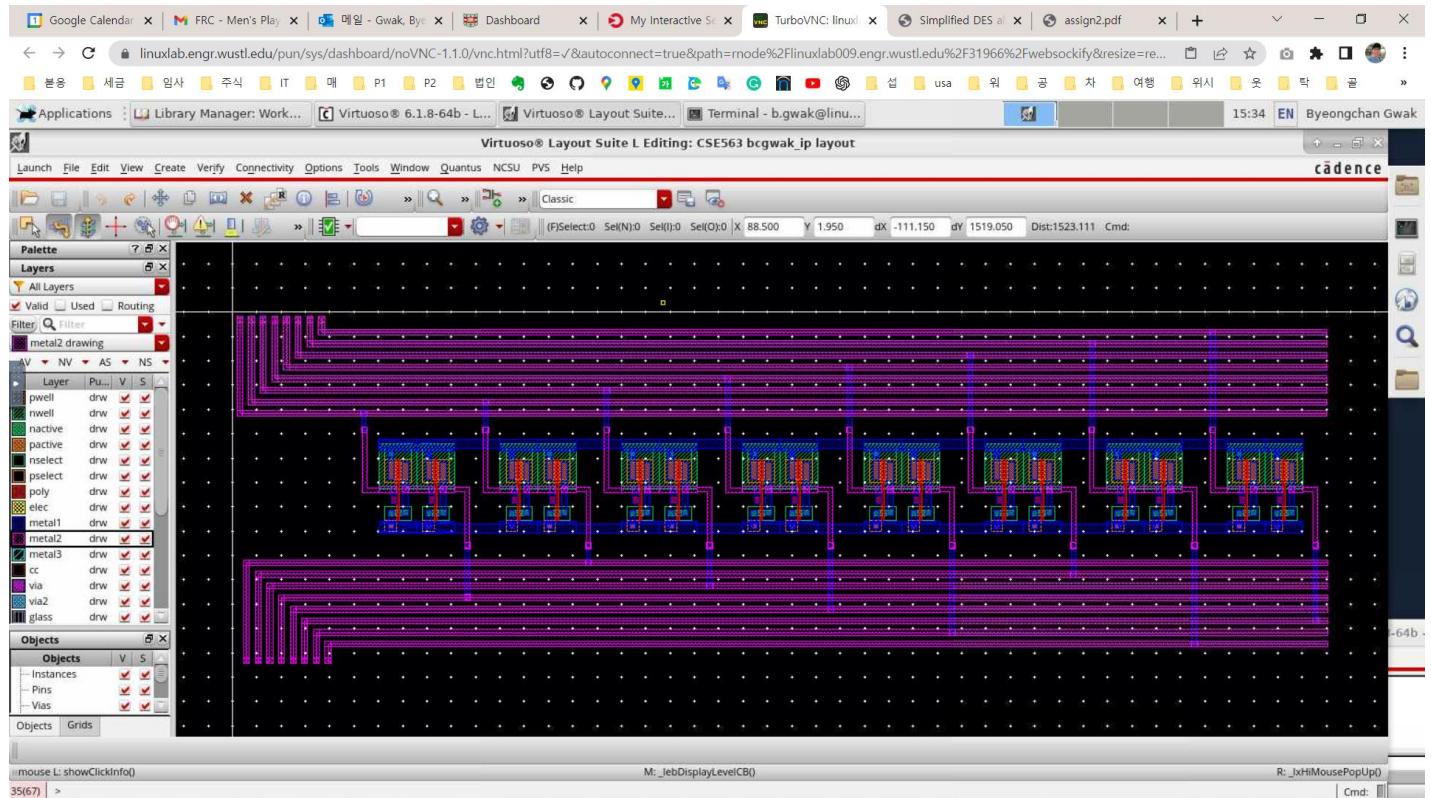
## \* EP



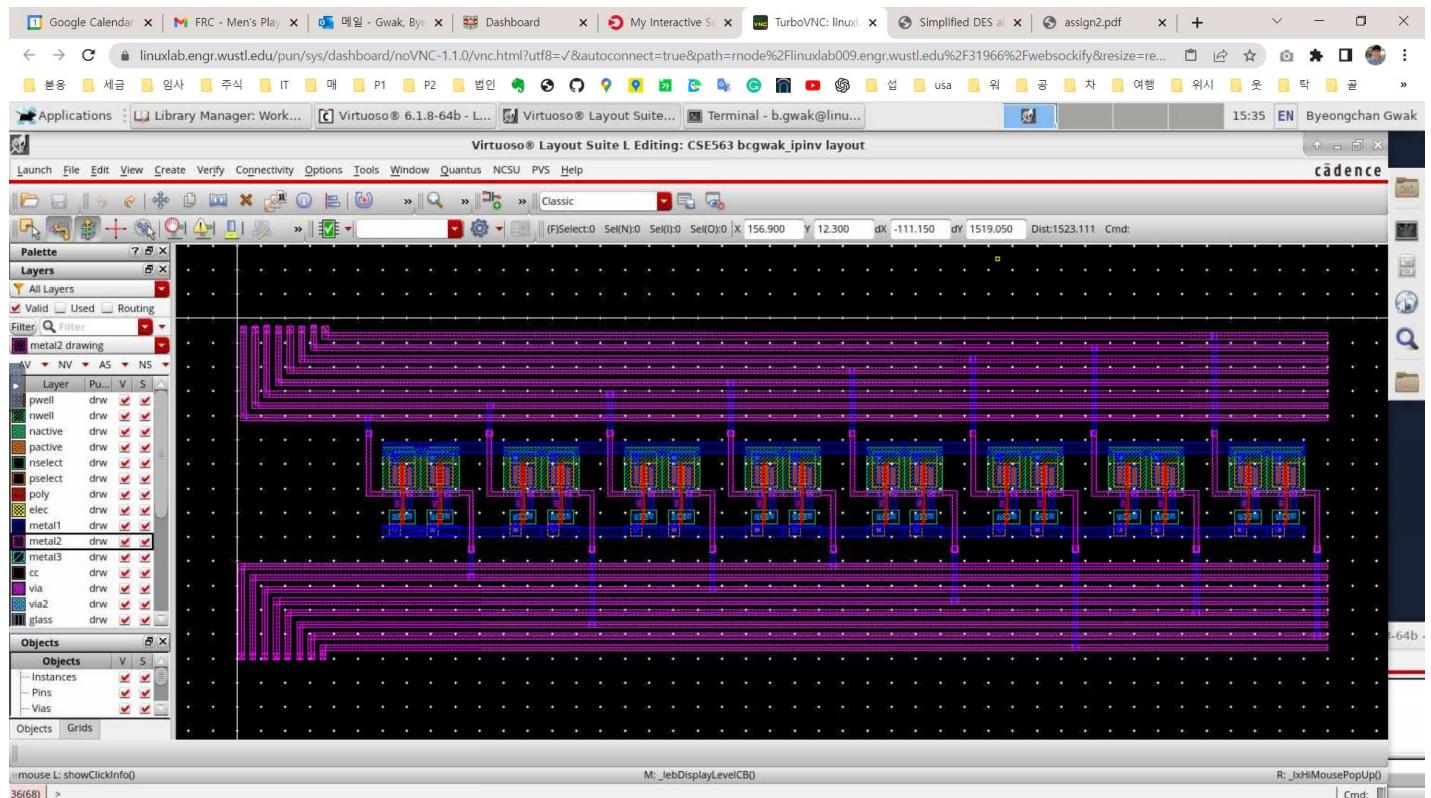
## \* SWITCH



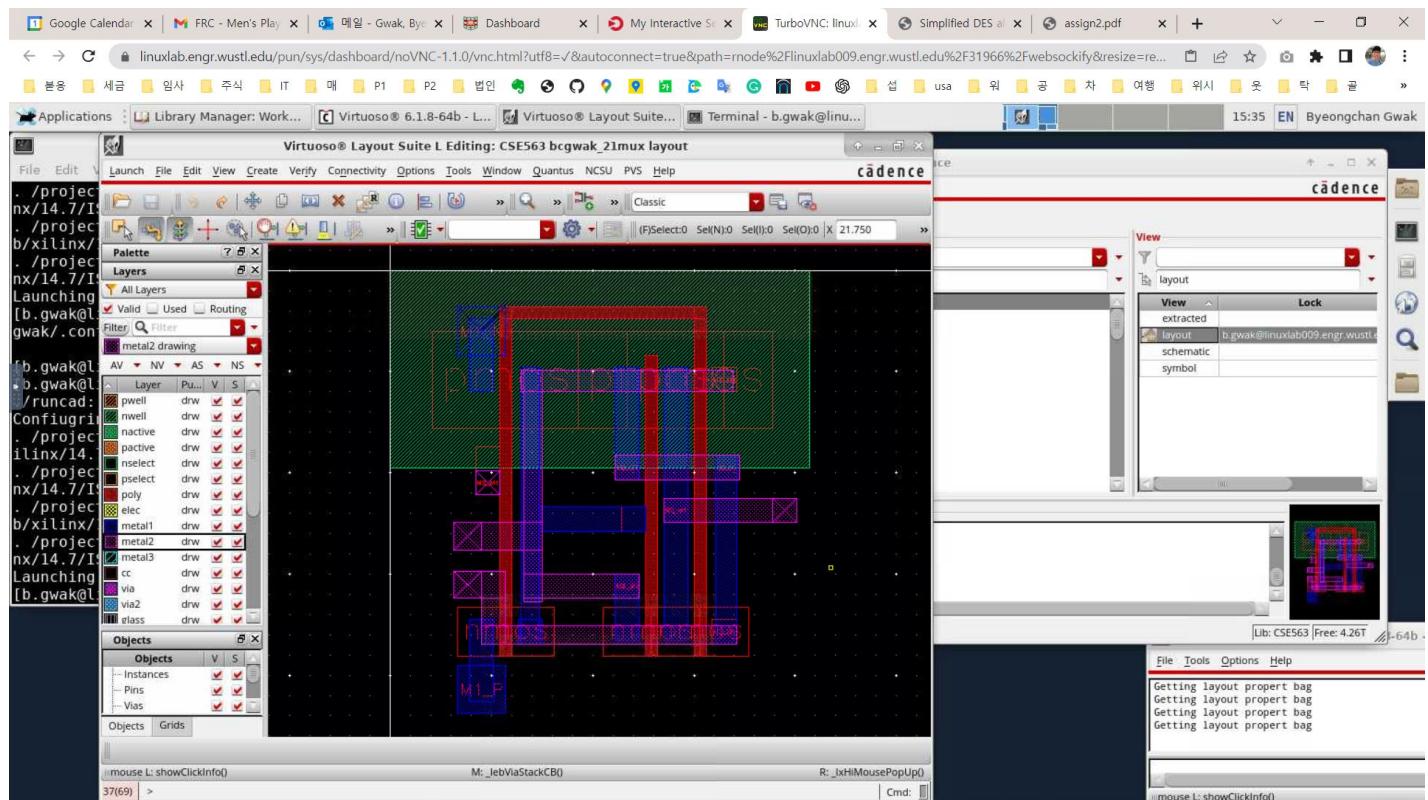
## \* IP



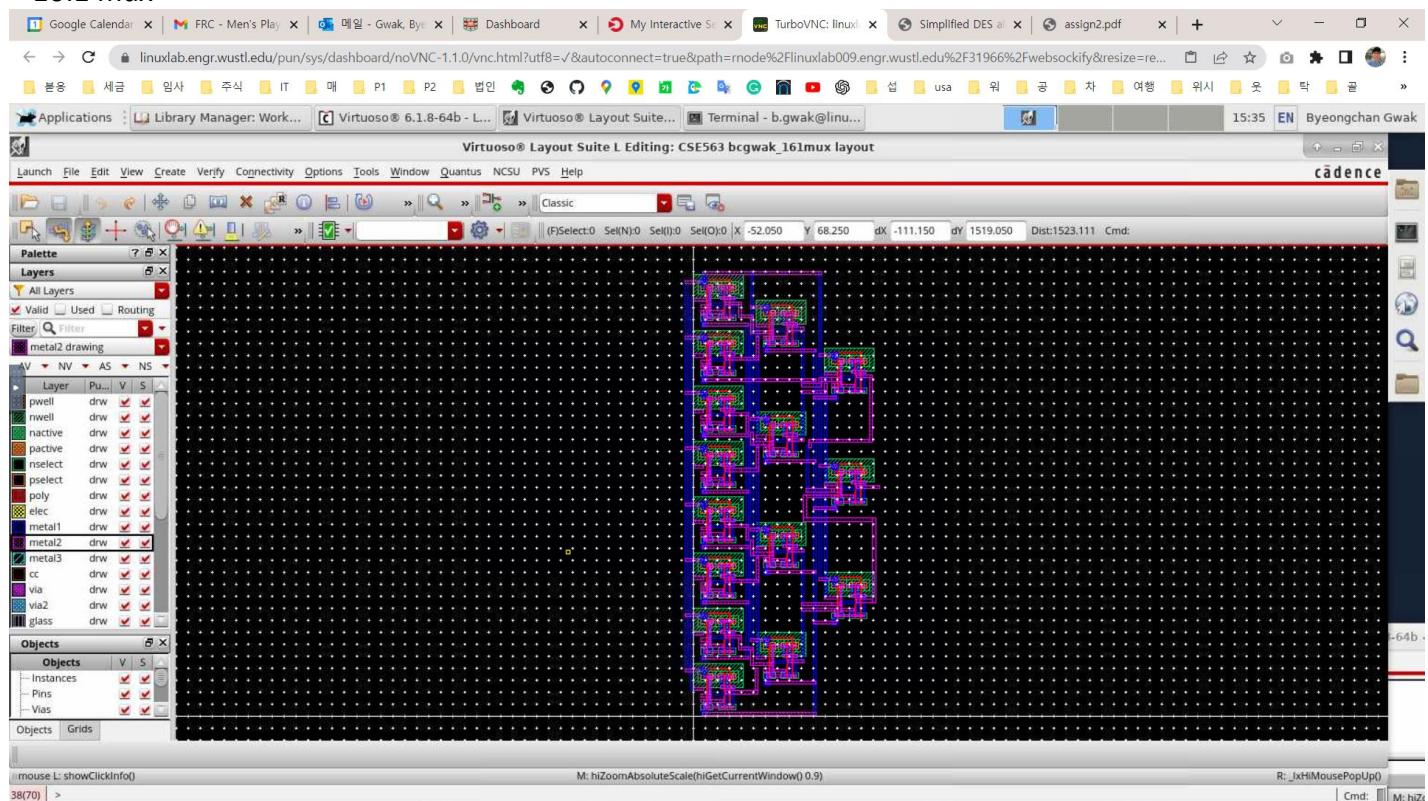
## \* IP Invert



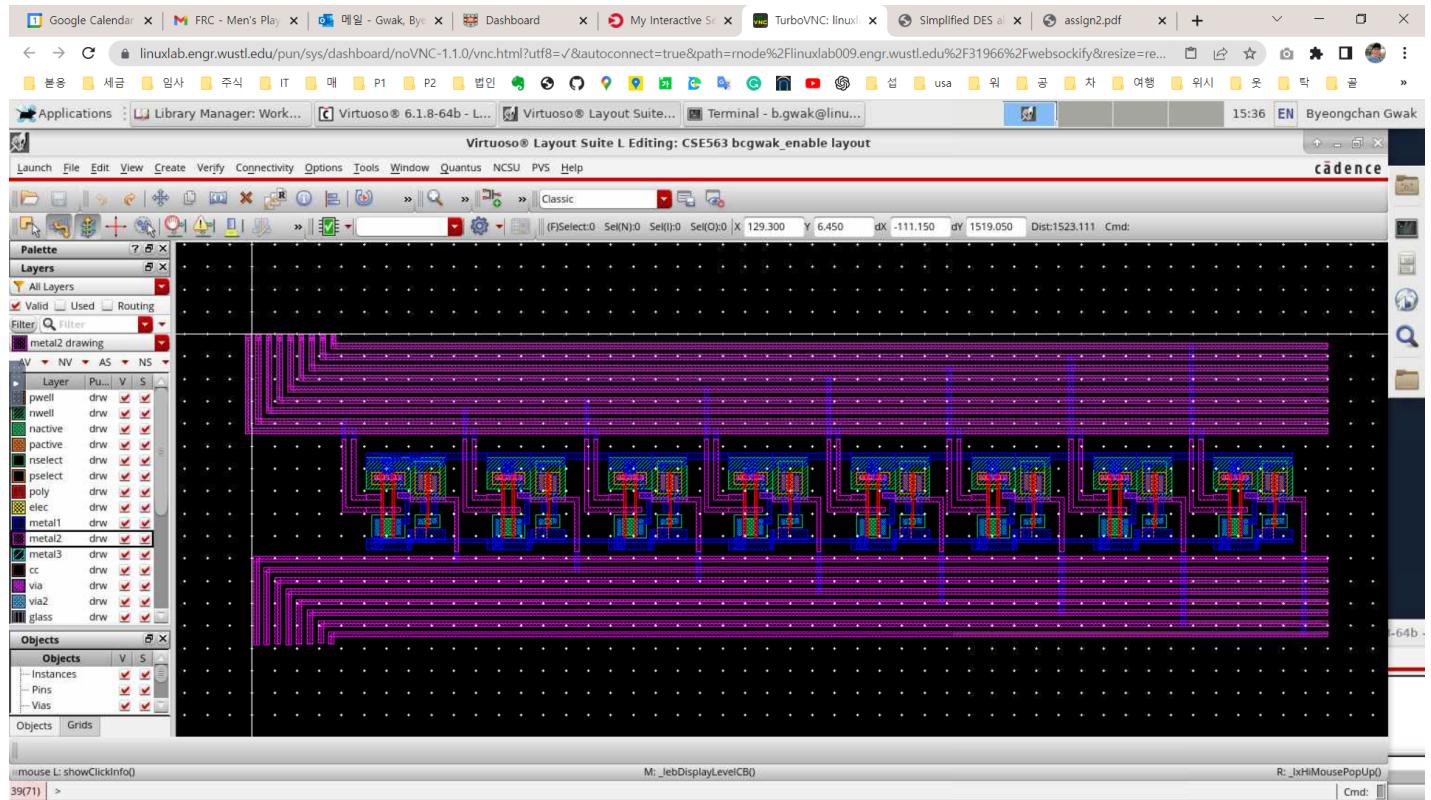
## \* 2:1 mux



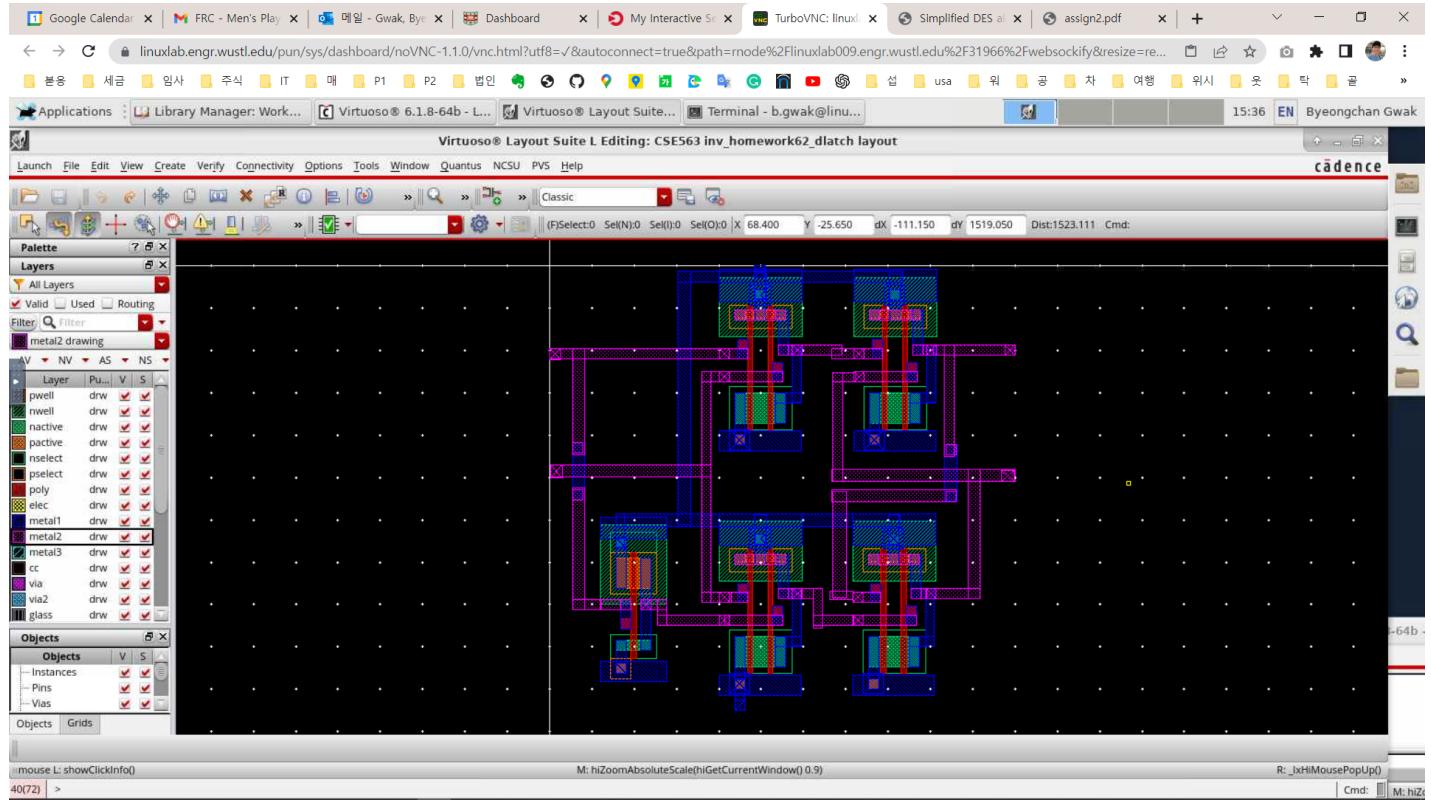
## \* 16:1 mux



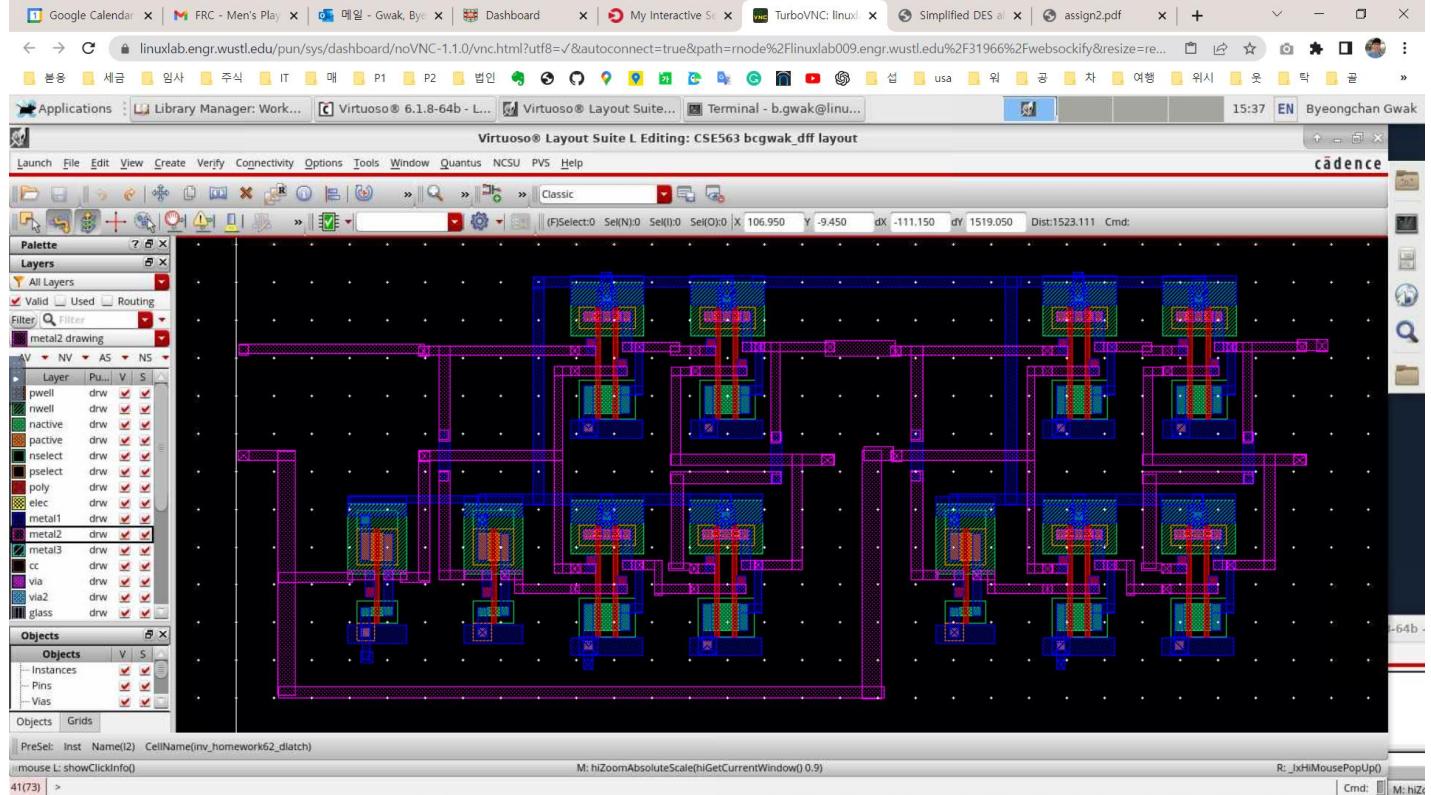
## \* ENABLE



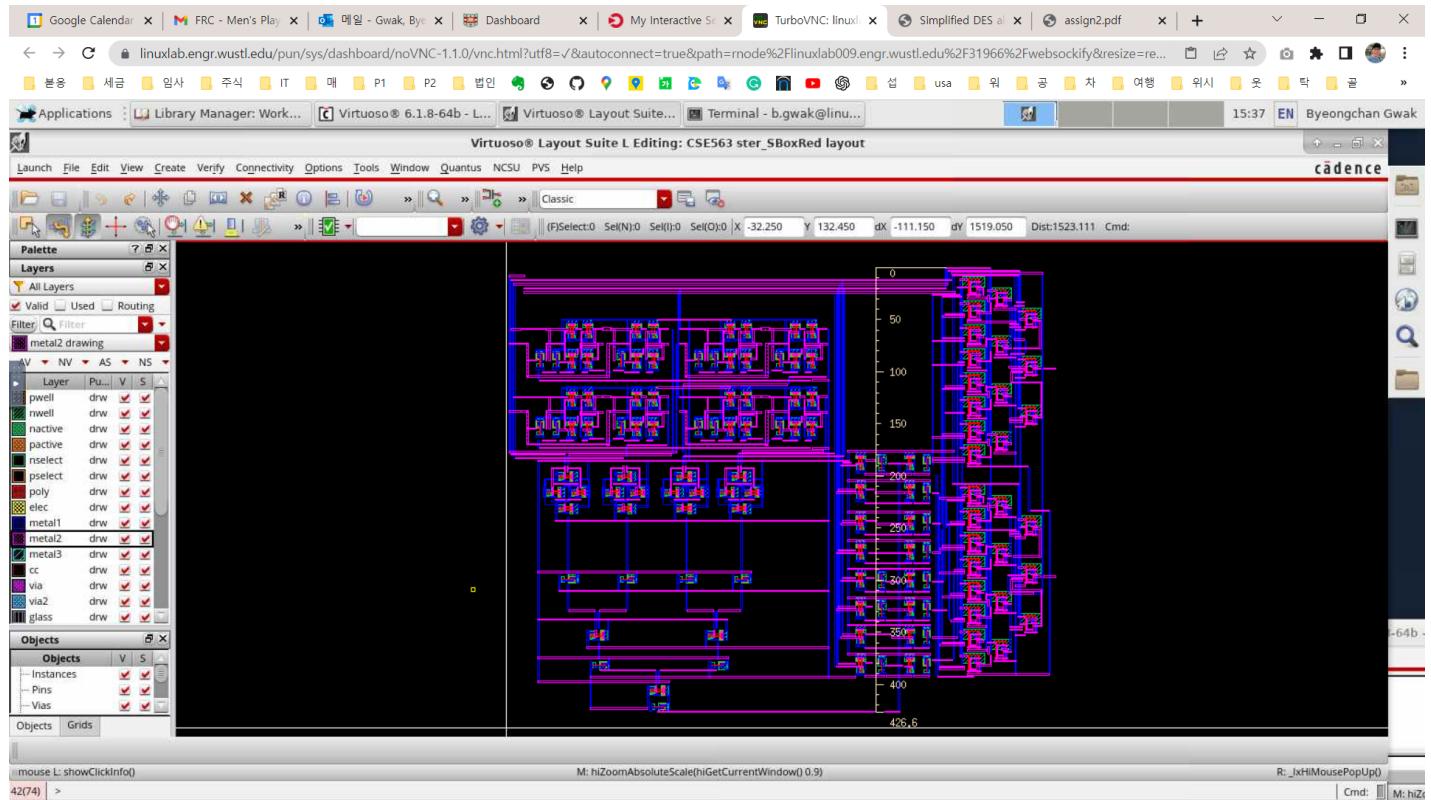
## \* D-LATCH



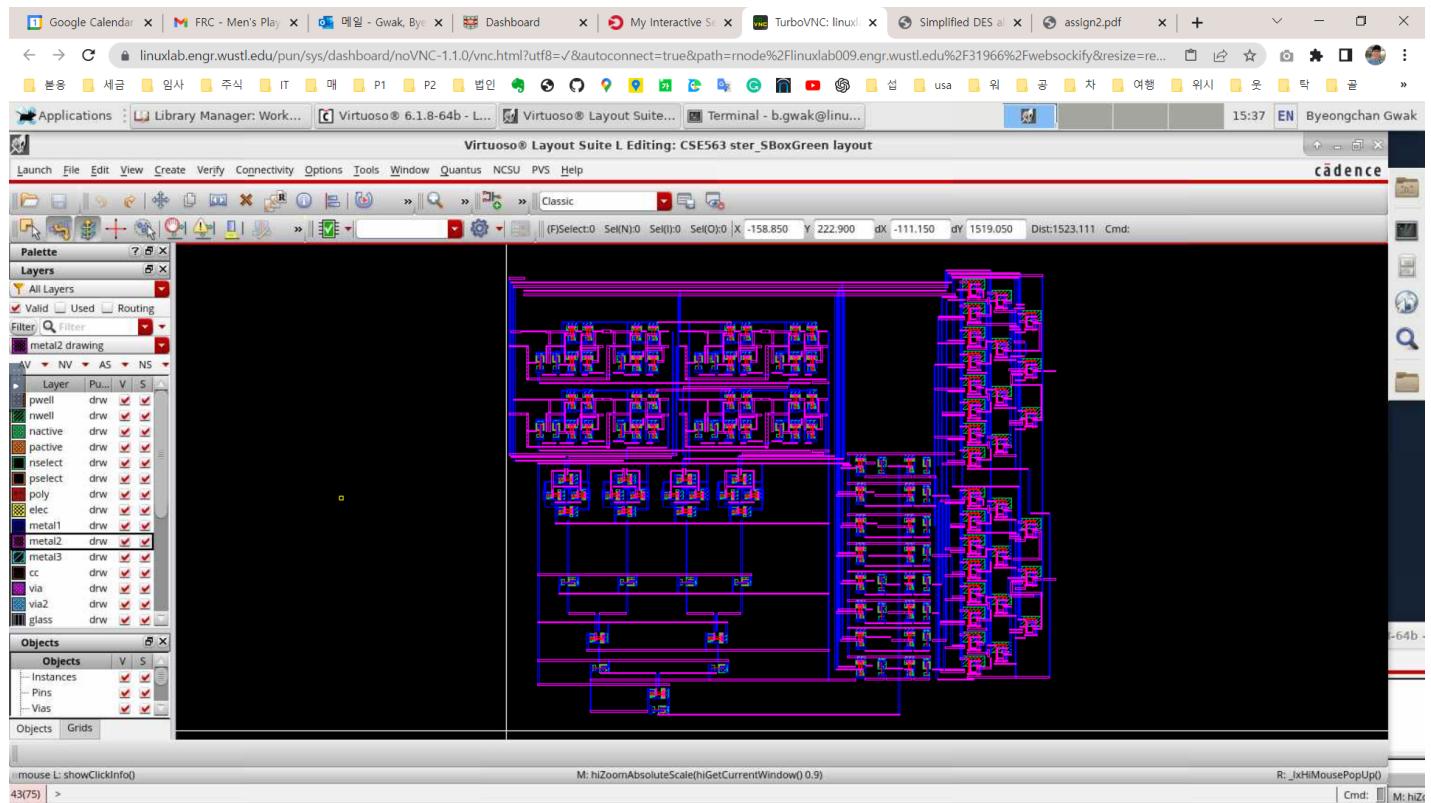
## \* D Flip flop



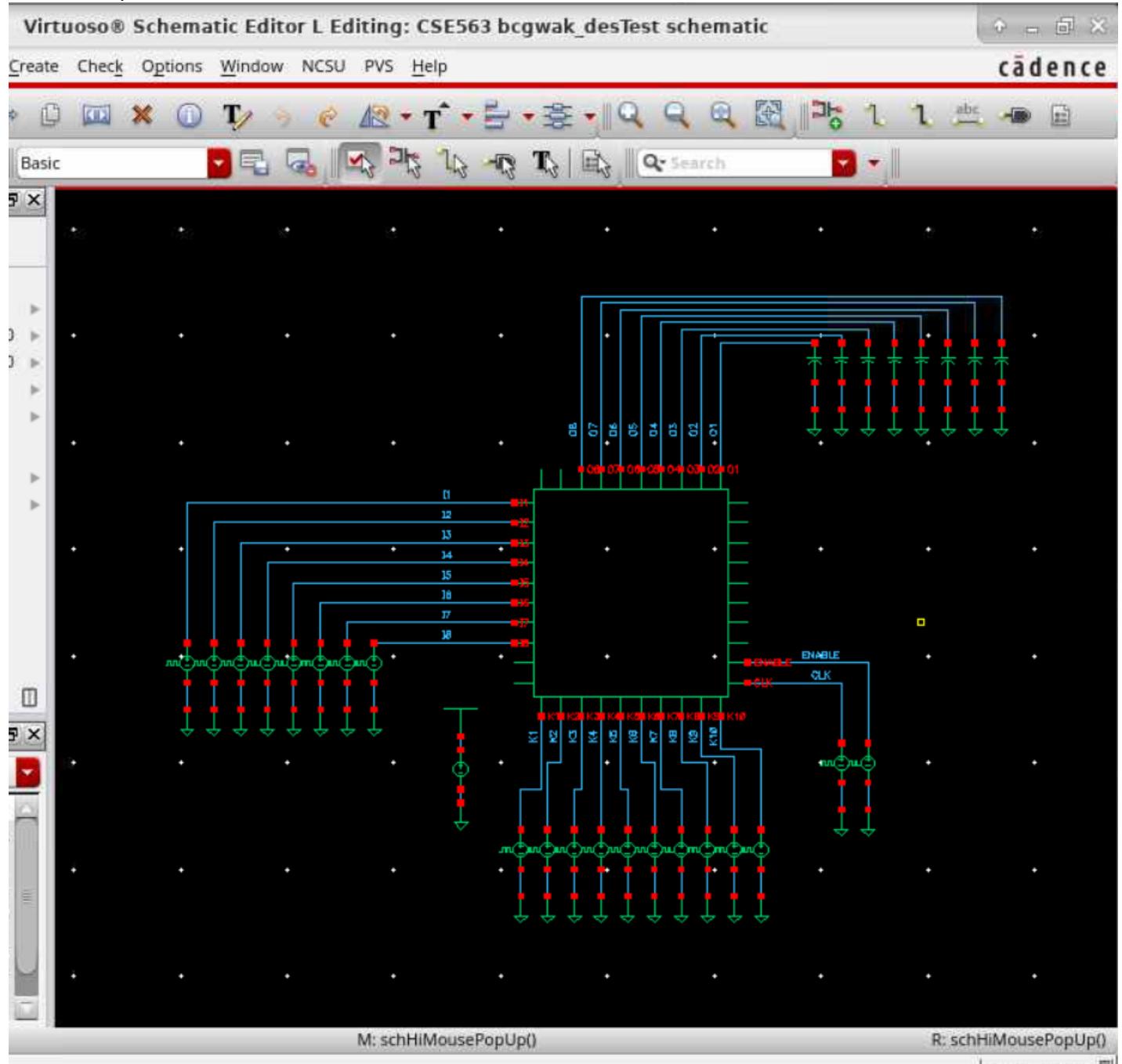
## \* SBox Red



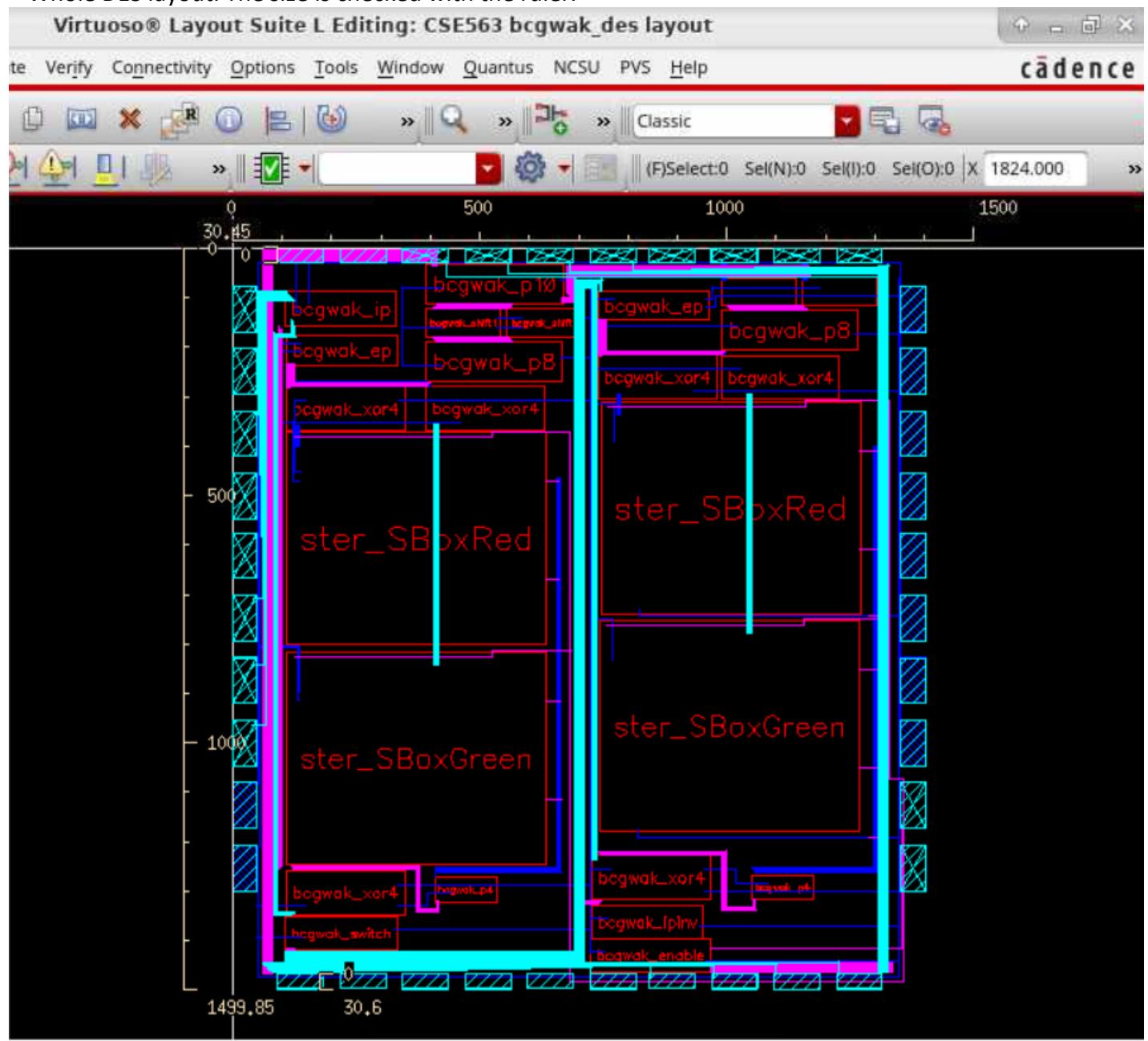
## \* SBox Green

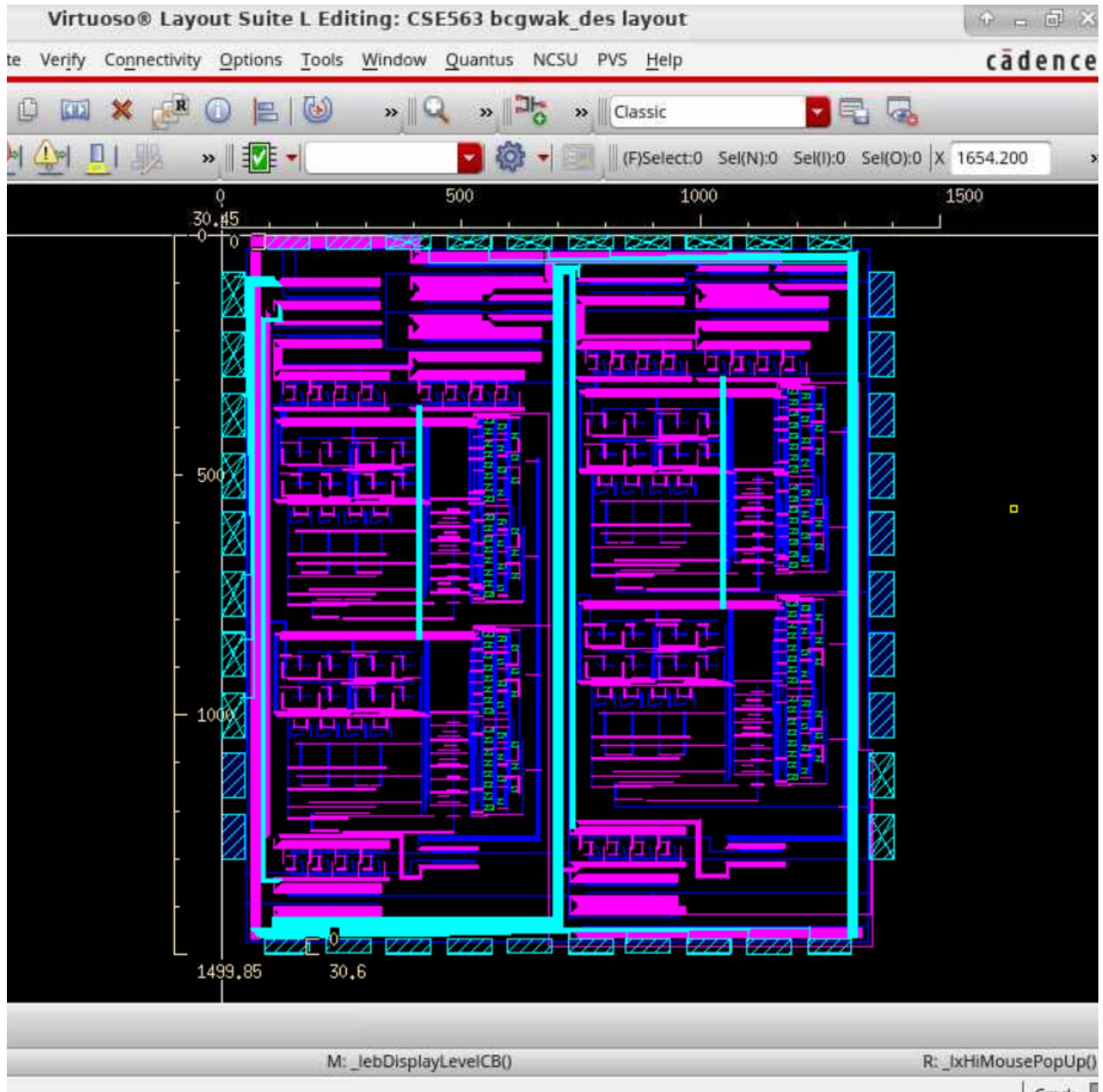


\* Test setup for the DES.



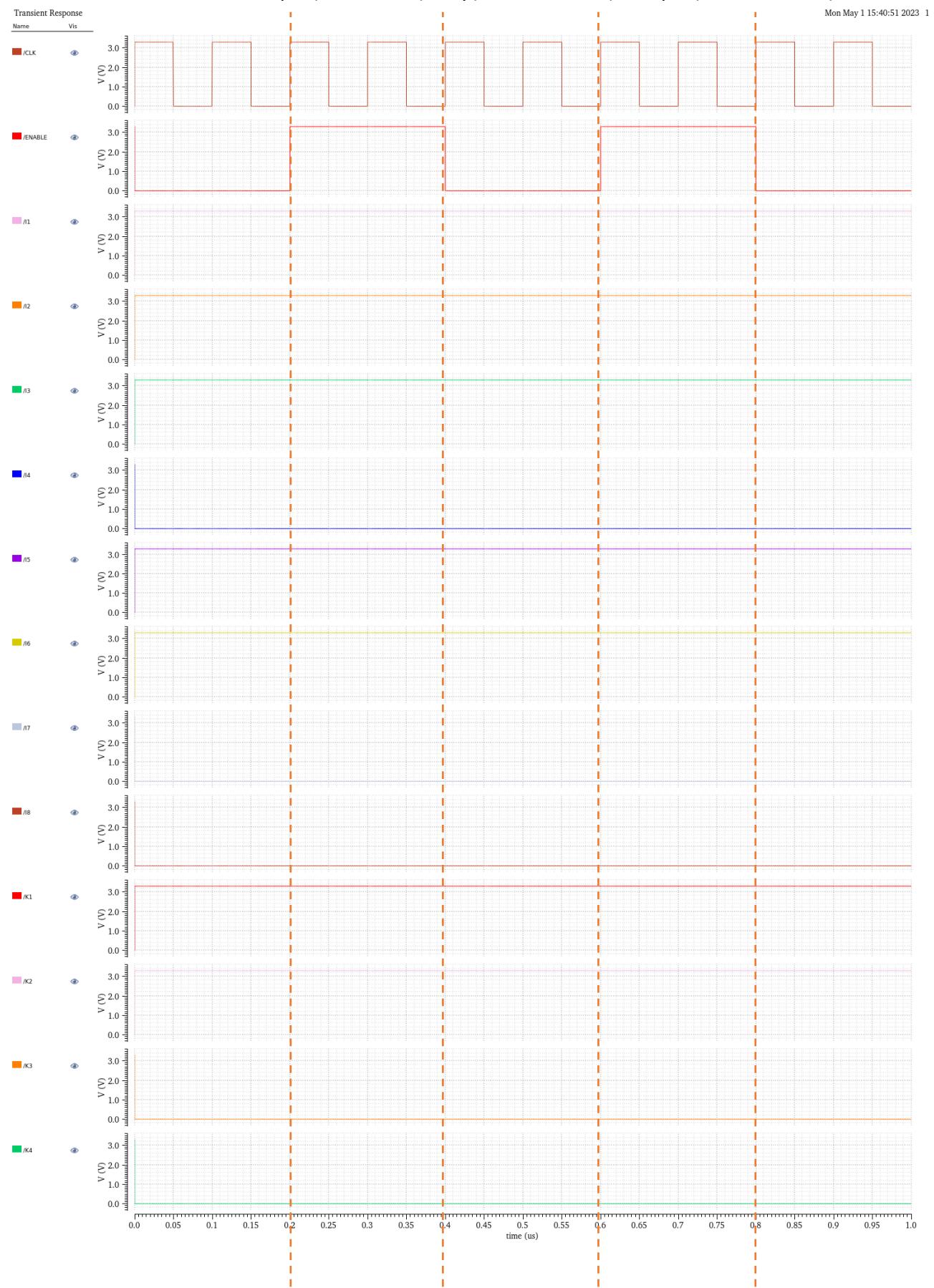
\* Whole DES layout. The size is checked with the ruler.

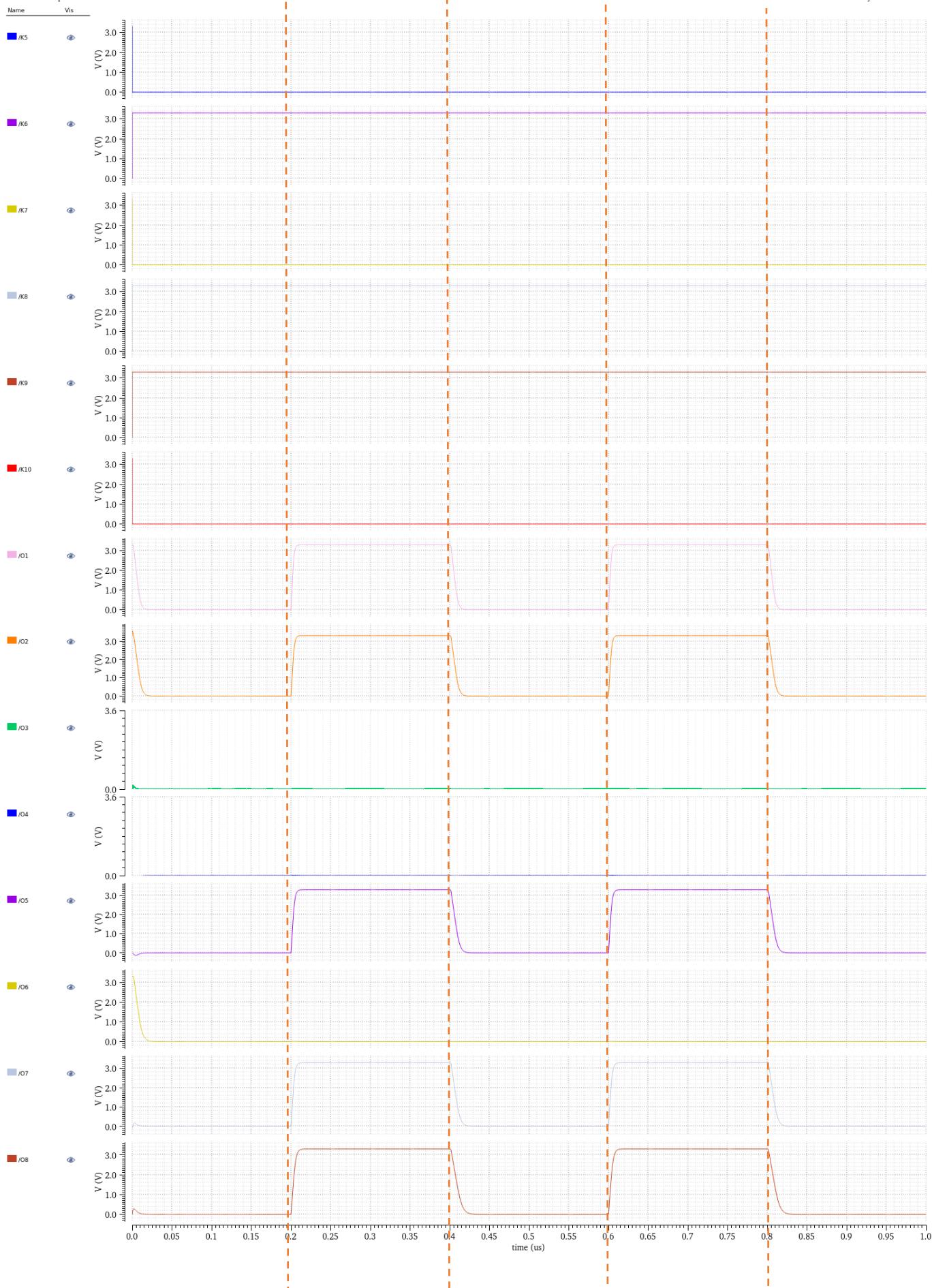




# 8. Layout timing diagram result

\* Test result: CLK, ENABLE, Input(I1, I2, ..., I8), Key(K1, K2, ..., K10), Output(O1, O2, ..., O8)





## 9. Investigation of how fast CLOCK signal can be(CSE563)

- The current clock rate is 10 MHz, or 100 ns. What needs to be considered to increase the clock speed is the parasitic capacitance. Looking at the graph above, the delay due to parasitic capacitance is about 10 ns. In the end, it is concluded that even if CLOCK is increased as much as possible, it is difficult to reduce it to less than 10 ns.

## 10. DRC & LVS result

### + DRC result

```
DRC started at Wed May 3 07:58:46 2023
```

```
Validating hierarchy instantiation for:  
library: CSE563  
cell: bcgwak_des  
view: layout  
Rules come from library NCSU_TechLib_ami06.  
Rules path is divaDRC.rul.  
Inclusion limit is set to 1000.  
Parsing drcExtractRules of "/project/linuxlab/cadence/CDK/ncsu-cdk-1.6.0.beta/lib/NCSU_TechLib_ami06/divaDRC.rul"...  
Optimizing rules...  
removing unused task: nwellResEdge = geomGetEdge(nwellRes coincident nwell)  
removing unused task: polyResEdge = geomGetEdge(polyRes coincident poly)  
removing unused task: elecEdge = geomGetEdge(elec)  
removing unused task: padEdge = geomGetEdge(pad)  
removing unused task: ccEdge = geomGetEdge(cc)  
removing unused task: gselectEdge = geomGetEdge(gselect)  
removing unused task: gwellEdge = geomGetEdge(gwell)  
removing unused task: nwellRes = geomButting(geomAnd(res_id nwell) nBulk (keep == 2))  
removing unused task: polyRes = geomButting(geomAnd(res_id poly) fieldPoly (keep == 2))  
removing unused task: NwPdiode = geomAnd(dio_id geomOutside(nwell pNotOhmic))  
removing unused task: PNdiode = geomAnd(dio_id geomOutside(pNotOhmic poly))  
removing unused task: NPdiode = geomAnd(dio_id geomOutside(nNotOhmic poly))  
removing unused task: m3m2Cap = geomAnd(geomAnd(metal2 metal3) cap_id)  
removing unused task: m2m1Cap = geomAnd(geomAnd(metal1 metal2) cap_id)  
removing unused task: m1sCap = geomAnd(geomAndNot(metal1 poly) cap_id)  
removing unused task: m1pCap = geomAnd(geomAnd(poly metal1) cap_id)  
removing unused task: pChannelCap = geomButting(pChannel pDiff (keep == 1))  
removing unused task: nChannelCap = geomButting(nChannel nDiff (keep == 1))  
removing unused task: pChannelTran = geomButting(pChannel pDiff (keep == 2))  
removing unused task: nChannelTran = geomButting(nChannel nDiff (keep == 2))  
removing unused task: Space = geomNot(geomOr(active poly elec))  
removing unused task: pElecChannelCap = geomButting(pElecChannel pDiff (keep == 1))  
removing unused task: nElecChannelCap = geomButting(nElecChannel nDiff (keep == 1))  
removing unused task: pElecChannelTran = geomButting(pElecChannel pDiff (keep == 2))  
removing unused task: nElecChannelTran = geomButting(nElecChannel nDiff (keep == 2))  
removing unused task: pElecChannel = geomOutside(geomAnd(pNotOhmic elec) poly)  
removing unused task: nElecChannel = geomOutside(geomAnd(nNotOhmic elec) poly)  
removing unused task: pChannel = geomOutside(geomAnd(pNotOhmic poly) elec)  
removing unused task: nChannel = geomOutside(geomAnd(nNotOhmic poly) elec)  
removing unused task: dio_id = geomOr("dio_id")  
removing unused task: cap_id = geomOr("cap_id")  
removing unused task: nolpe = geomOr("nolpe")  
removing unused task: bknd = geomBknd()  
Running layout DRC analysis  
Flat mode  
Full checking.  
executing: nodrc = geomOr("nodrc")  
executing: gwell = geomOr(geomAndNot(("gwell" "drawing") nodrc))  
executing: nwell = geomOr(geomAndNot(("nwell" "drawing") nodrc))  
executing: pwell = geomOr(geomAndNot(("pwell" "drawing") nodrc))  
executing: nactive = geomOr(geomAndNot(("nactive" "drawing") nodrc))
```

```

executing: pactive = geomOr(geomAndNot("pactive" "drawing") nodrc)
executing: active = geomOr(geomAndNot("active" "drawing") nodrc) nactive pactive)
executing: gselect = geomOr(geomAndNot("gselect" "drawing") nodrc))
executing: nselect = geomOr(geomAndNot("nselect" "drawing") nodrc))
executing: pselect = geomOr(geomAndNot("pselect" "drawing") nodrc))
executing: poly = geomOr(geomAndNot("poly" "drawing") nodrc))
executing: metal1 = geomOr(geomAndNot("metal1" "drawing") nodrc))
executing: cc = geomOr(geomAndNot("cc" "drawing") nodrc))
executing: metal2 = geomOr(geomAndNot("metal2" "drawing") nodrc))
executing: via = geomOr(geomAndNot("via" "drawing") nodrc))
executing: glass = geomOr(geomAndNot("glass" "drawing") nodrc))
executing: pad = geomOr(geomAndNot("pad" "drawing") nodrc))
executing: res_id = geomOr("res_id")
executing: metal3 = geomOr(geomAndNot("metal3" "drawing") nodrc))
executing: via2 = geomOr(geomAndNot("via2" "drawing") nodrc))
executing: highres = geomOr(geomAndNot("highres" "drawing") nodrc))
executing: elec = geomOr(geomAndNot("elec" "drawing") nodrc))
executing: ce = geomOr(geomOr(geomAndNot(("ce" "drawing") nodrc)) geomAnd(cc elec))
executing: cp = geomOr(geomOr(geomAndNot(("cp" "drawing") nodrc)) geomAnd(cc geomAndNot(poly ce)))
executing: ca = geomOr(geomOr(geomAndNot(("ca" "drawing") nodrc)) geomAnd(cc geomAndNot(active ...
executing: nActive = geomAnd(active nselect)
executing: pActive = geomAnd(active pselect)
executing: nBulk = geomOr(nwell)
executing: pBulk = geomOr(geomNot(nwell) geomAndNot(pwell nwell))
executing: nOhmic = geomAnd(nActive nwell)
    nNotOhmic = geomAndNot(nActive nwell)
executing: pOhmic = geomAndNot(pActive nwell)
    pNotOhmic = geomAnd(pActive nwell)
executing: nDiff = geomAndNot(nNotOhmic geomOr(poly elec))
executing: pDiff = geomAndNot(pNotOhmic geomOr(poly elec))
executing: nDiffContact = geomAnd(ca nDiff)
executing: pDiffContact = geomAnd(ca pDiff)
executing: nOhmicContact = geomAnd(ca nOhmic)
executing: pOhmicContact = geomAnd(ca pOhmic)
executing: Gate = geomAnd(geomOr(nNotOhmic pNotOhmic) poly)
executing: fieldPoly = geomAvoiding(poly Gate)
executing: elecGate = geomAnd(geomOr(nNotOhmic pNotOhmic) elec)
executing: fieldElec = geomAvoiding(elec elecGate)
executing: CapacitorElec = geomInside(elec poly)
executing: TransistorElec = geomOverlap(elec geomNot(poly))
executing: fieldPoly = geomAndNot(fieldPoly res_id)
executing: poly = geomAndNot(poly res_id)
executing: fieldElec = geomAndNot(fieldElec geomOr(res_id highres))
executing: elecRes = geomButting(geomAnd(res_id elec) fieldElec (keep == 2))
executing: elecHighres = geomButting(geomAnd(highres elec) fieldElec (keep == 2))
executing: elec = geomAndNot(elec geomOr(res_id highres))
executing: nBulk = geomAndNot(nBulk res_id)
executing: nwell = geomAndNot(nwell res_id)
executing: geomConnect((via nOhmicContact nOhmic nwell nBulk metal1) (via pOhmicContact pOhmic ...
executing: dubiousData(("gwell" "drawing") "Improperly formed shape - gwell")
executing: dubiousData(("nwell" "drawing") "Improperly formed shape - nwell")
executing: dubiousData(("pwell" "drawing") "Improperly formed shape - pwell")
executing: dubiousData(("active" "drawing") "Improperly formed shape - active, nactive or pactive")
executing: dubiousData(("gselect" "drawing") "Improperly formed shape - gselect")
executing: dubiousData(("nselect" "drawing") "Improperly formed shape - nselect")
executing: dubiousData(("pselect" "drawing") "Improperly formed shape - pselect")
executing: dubiousData(("poly" "drawing") "Improperly formed shape - poly")
executing: dubiousData(("metal1" "drawing") "Improperly formed shape - metal1")
executing: dubiousData(("ca" "drawing") "Improperly formed shape - ca")
executing: dubiousData(("cp" "drawing") "Improperly formed shape - cp")
executing: dubiousData(("metal2" "drawing") "Improperly formed shape - metal2")
executing: dubiousData(("via" "drawing") "Improperly formed shape - via")
executing: dubiousData(("glass" "drawing") "Improperly formed shape - glass")
executing: saveDerived(geomGetNon45(gwell) "Non-Manhattan shape - gwell")
executing: saveDerived(geomGetNon45(nwell) "Non-Manhattan shape - nwell")
executing: saveDerived(geomGetNon45(pwell) "Non-Manhattan shape - pwell")
executing: saveDerived(geomGetNon45(active) "Non-Manhattan shape - active, nactive or pactive")
executing: saveDerived(geomGetNon45(gselect) "Non-Manhattan shape - gselect")
executing: saveDerived(geomGetNon45(nselect) "Non-Manhattan shape - nselect")

```

```
executing: saveDerived(geomGetNon45(pselect) "Non-Manhattan shape - pselect")
executing: saveDerived(geomGetNon45(poly) "Non-Manhattan shape - poly")
executing: saveDerived(geomGetNon45(metal1) "Non-Manhattan shape - metal1")
executing: saveDerived(geomGetNon45(ca) "Non-Manhattan shape - ca")
executing: saveDerived(geomGetNon45(cp) "Non-Manhattan shape - cp")
executing: saveDerived(geomGetNon45(metal2) "Non-Manhattan shape - metal2")
executing: saveDerived(geomGetNon45(via) "Non-Manhattan shape - via")
executing: saveDerived(geomGetNon45(glass) "Non-Manhattan shape - glass")
executing: offGrid(gwell gridRes "(SCMOS Inst) Edge not on grid")
executing: offGrid(nwell gridRes "(SCMOS Inst) Edge not on grid")
executing: offGrid(pwell gridRes "(SCMOS Inst) Edge not on grid")
executing: offGrid(active gridRes "(SCMOS Inst) Edge not on grid")
executing: offGrid(gselect gridRes "(SCMOS Inst) Edge not on grid")
executing: offGrid(nselect gridRes "(SCMOS Inst) Edge not on grid")
executing: offGrid(pselect gridRes "(SCMOS Inst) Edge not on grid")
executing: offGrid(poly gridRes "(SCMOS Inst) Edge not on grid")
executing: offGrid(metal1 gridRes "(SCMOS Inst) Edge not on grid")
executing: offGrid(ca gridRes "(SCMOS Inst) Edge not on grid")
executing: offGrid(cp gridRes "(SCMOS Inst) Edge not on grid")
executing: offGrid(metal2 gridRes "(SCMOS Inst) Edge not on grid")
executing: offGrid(via gridRes "(SCMOS Inst) Edge not on grid")
executing: offGrid(glass gridRes "(SCMOS Inst) Edge not on grid")
executing: dubiousData(("metal3" "drawing") "Improperly formed shape - metal3")
executing: dubiousData(("via2" "drawing") "Improperly formed shape - via2")
executing: saveDerived(geomGetNon45(metal3) "Non-Manhattan shape - metal3")
executing: saveDerived(geomGetNon45(via2) "Non-Manhattan shape - via2")
executing: offGrid(metal3 gridRes "(SCMOS Inst) Edge not on grid")
executing: offGrid(via2 gridRes "(SCMOS Inst) Edge not on grid")
executing: dubiousData(("elec" "drawing") "Improperly formed shape - elec")
executing: dubiousData(("ce" "drawing") "Improperly formed shape - ce")
executing: saveDerived(geomGetNon45(elec) "Non-Manhattan shape - elec")
executing: saveDerived(geomGetNon45(ce) "Non-Manhattan shape - ce")
executing: offGrid(elec gridRes "(SCMOS Inst) Edge not on grid")
executing: offGrid(ce gridRes "(SCMOS Inst) Edge not on grid")
executing: nwellEdge = geomGetEdge(nwell)
executing: pwellEdge = geomGetEdge(pwell)
executing: activeEdge = geomGetEdge(active)
executing: nselectEdge = geomGetEdge(nselect)
executing: pselectEdge = geomGetEdge(pselect)
executing: polyEdge = geomGetEdge(poly)
executing: metal1Edge = geomGetEdge(metal1)
executing: caEdge = geomGetEdge(ca)
executing: cpEdge = geomGetEdge(cp)
executing: metal2Edge = geomGetEdge(metal2)
executing: viaEdge = geomGetEdge(via)
executing: glassEdge = geomGetEdge(glass)
executing: highresEdge = geomGetEdge(highres)
executing: ceEdge = geomGetEdge(ce)
executing: metal3Edge = geomGetEdge(metal3)
executing: via2Edge = geomGetEdge(via2)
executing: nBulkEdge = geomGetEdge(nBulk)
executing: pBulkEdge = geomGetEdge(pBulk)
executing: nOhmicEdge = geomGetEdge(nOhmic)
executing: pOhmicEdge = geomGetEdge(pOhmic)
executing: nNotOhmicEdge = geomGetEdge(nNotOhmic)
executing: pNotOhmicEdge = geomGetEdge(pNotOhmic)
executing: GateEdge = geomGetEdge(Gate)
executing: fieldPolyEdge = geomGetEdge(fieldPoly)
executing: CapacitorElecEdge = geomGetEdge(CapacitorElec)
executing: TransistorElecEdge = geomGetEdge(TransistorElec)
executing: elecHighresEdge = geomGetEdge(elecRes coincident elec)
executing: saveDerived(geomAndNot(active geomOr(nselect pselect)) "(DBM Rule 1.1) Active must b...")
executing: saveDerived(geomAnd(poly nOhmic) "(DBM Rule 2.0) Poly cannot overlap ohmic diffusion")
executing: saveDerived(geomAnd(poly pOhmic) "(DBM Rule 2.0) Poly cannot overlap ohmic diffusion")
executing: saveDerived(geomAnd(elec nOhmic) "(DBM Rule 2.1) Elec cannot overlap ohmic diffusion")
executing: saveDerived(geomAnd(elec pOhmic) "(DBM Rule 2.1) Elec cannot overlap ohmic diffusion")
executing: saveDerived(geomAnd(pactive nselect) "(DBM Rule 3.1) Pactive and Nselect may not ove...")
executing: saveDerived(geomAnd(nactive pselect) "(DBM Rule 3.2) Nactive and Pselect may not ove...
executing: saveDerived(geomAnd(active elec) "(DBM Rule 4.0, AMI 0.6um) Elec and active may not ...
```

```

executing: drc(nwellEdge (width < (lambda * 12.0)) errMesg)
    drc(nwellEdge (notch < (lambda * 6.0)) errMesg)
executing: drc(pwellEdge (width < (lambda * 12.0)) errMesg)
    drc(pwellEdge (notch < (lambda * 6.0)) errMesg)
executing: drc(nwell (sep < (lambda * 18.0)) diffNet errMesg)
    drc(nwell (sep < (lambda * 6.0)) sameNet errMesg)
executing: drc(pwell (sep < (lambda * 18.0)) diffNet errMesg)
    drc(pwell (sep < (lambda * 6.0)) sameNet errMesg)
executing: saveDerived(geomAnd(nwell pwell) "(SCMOS Rule 1 note) n-wells and p-wells may not ov...
executing: drc(activeEdge (width < (lambda * 3.0)) errMesg)
    drc(activeEdge (sep < (lambda * 3.0)) errMesg)
    drc(activeEdge (notch < (lambda * 3.0)) errMesg)
executing: drc(nNotOhmicEdge nBulkEdge (sep < (lambda * 6.0)) errMesg)
executing: drc(pNotOhmicEdge pBulkEdge (sep < (lambda * 6.0)) errMesg)
executing: drc(pBulkEdge nNotOhmicEdge (enc < (lambda * 6.0)) errMesg)
executing: drc(nBulkEdge pNotOhmicEdge (enc < (lambda * 6.0)) errMesg)
executing: drc(nBulkEdge nOhmicEdge (enc < (lambda * 3.0)) errMesg)
executing: drc(nOhmicEdge pBulkEdge (sep < (lambda * 3.0)) errMesg)
executing: drc(pOhmicEdge nBulkEdge (sep < (lambda * 3.0)) errMesg)
executing: drc(pBulkEdge pOhmicEdge (enc < (lambda * 3.0)) errMesg)
executing: drc(nNotOhmicEdge pOhmicEdge ((0 < sep) < (lambda * 4.0)) errMesg)
executing: drc(pNotOhmicEdge nOhmicEdge ((0 < sep) < (lambda * 4.0)) errMesg)
executing: drc(polyEdge (width < (lambda * 2.0)) errMesg)
    drc(polyEdge (sep < (lambda * 3.0)) errMesg)
    drc(polyEdge (notch < (lambda * 3.0)) errMesg)
executing: drc(polyEdge activeEdge (enc < (lambda * 2.0)) errMesg)
    drc(activeEdge polyEdge (enc < (lambda * 3.0)) errMesg)
    drc(polyEdge activeEdge (sep < (lambda * 1.0)) errMesg)
executing: drc(nselectEdge geomGetEdge(polyEdge inside pNotOhmic) (sep < (lambda * 3.0)) (app >...
executing: drc(nselectEdge geomGetEdge(polyEdge inside nNotOhmic) (enc < (lambda * 3.0)) (app >...
executing: drc(pselectEdge geomGetEdge(polyEdge inside nNotOhmic) (sep < (lambda * 3.0)) (app >...
executing: drc(pselectEdge geomGetEdge(polyEdge inside pNotOhmic) (enc < (lambda * 3.0)) (app >...
executing: drc(geomOr(nselectEdge pselectEdge) activeEdge (sep < (lambda * 2.0)) errMesg)
    drc(geomOr(nselectEdge pselectEdge) activeEdge (enc < (lambda * 2.0)) errMesg)
executing: drc(nselectEdge caEdge (sep < (lambda * 1.0)) errMesg)
    drc(nselectEdge caEdge (enc < (lambda * 1.0)) errMesg)
executing: drc(pselectEdge caEdge (sep < (lambda * 1.0)) errMesg)
    drc(pselectEdge caEdge (enc < (lambda * 1.0)) errMesg)
executing: saveDerived(geomButting(geomAnd(ca nselect) geomAnd(ca pselect)) errMesg)
executing: drc(nselectEdge (width < (lambda * 2.0)) errMesg)
    drc(nselectEdge (sep < (lambda * 2.0)) errMesg)
    drc(nselectEdge (notch < (lambda * 2.0)) errMesg)
executing: drc(pselectEdge (width < (lambda * 2.0)) errMesg)
    drc(pselectEdge (sep < (lambda * 2.0)) errMesg)
    drc(pselectEdge (notch < (lambda * 2.0)) errMesg)
executing: saveDerived(geomAnd(nselect pselect) errMesg)
executing: drc(cpEdge (width < (lambda * 2.0)) errMesg)
    drc(cpEdge (sep < (lambda * 3.0)) errMesg)
    drc(cpEdge (notch < (lambda * 3.0)) errMesg)
executing: drc(cp (area > ((lambda * 2.0 * (lambda * 2.0)) + (lambda * 0.1 * (lambda * 0.1)))) ...
executing: drc(polyEdge cpEdge (enc < (lambda * 1.0)) errMesg)
    drc(cpEdge polyEdge (sep < (lambda * 5.0)) errMesg)
executing: saveDerived(geomAndNot(cp poly) errMesg)
executing: saveDerived(geomAndNot(cc geomOr(poly elec active)) errMesg)
executing: drc(cpEdge GateEdge (sep < (lambda * 2.0)) errMesg)
executing: drc(cpEdge activeEdge (sep < (lambda * 2.0)) errMesg)
executing: saveDerived(geomAnd(cp active) errMesg)
executing: saveDerived(geomGetLength(drc(cpEdge activeEdge (sep < (lambda * 3.0))) (length > (l...
executing: drc(caEdge (width < (lambda * 2.0)) errMesg)
    drc(caEdge (sep < (lambda * 3.0)) errMesg)
    drc(caEdge (notch < (lambda * 3.0)) errMesg)
executing: drc(ca (area > ((lambda * 2.0 * (lambda * 2.0)) + (lambda * 0.1 * (lambda * 0.1)))) ...
executing: drc(activeEdge caEdge (enc < (lambda * 1.0)) errMesg)
    drc(caEdge activeEdge (sep < (lambda * 5.0)) errMesg)
executing: saveDerived(geomAndNot(ca active) errMesg)
executing: drc(caEdge GateEdge (sep < (lambda * 2.0)) errMesg)
executing: saveDerived(geomAnd(ca Gate) errMesg)
executing: drc(caEdge fieldPolyEdge (sep < (lambda * 2.0)) errMesg)
executing: saveDerived(geomAnd(ca fieldPoly) errMesg)

```

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executing: saveDerived(geomGetLength(drc(caEdge fieldPolyEdge (sep < (lambda * 3.0))) (length >...
executing: drc(caEdge cpEdge (sep < (lambda * 4.0)) errMesg)
executing: saveDerived(geomAnd(ca cp) errMesg)
executing: drc(metal1Edge (width < (lambda * 3.0)) errMesg)
    drc(metal1Edge (sep < (lambda * 3.0)) errMesg)
    drc(metal1Edge (notch < (lambda * 3.0)) errMesg)
executing: drc(metal1Edge cpEdge (enc < (lambda * 1.0)) errMesg)
executing: drc(metal1Edge caEdge (enc < (lambda * 1.0)) errMesg)
executing: saveDerived(geomAndNot(cp metal1) errMesg)
executing: saveDerived(geomAndNot(ca metal1) errMesg)
executing: drc(viaEdge (width < (lambda * 2.0)) errMesg)
    drc(viaEdge (sep < (lambda * 3.0)) errMesg)
executing: drc(via (area > ((lambda * 2.0 * (lambda * 2.0)) + (lambda * 0.1 * (lambda * 0.1))))...
executing: drc(metal1Edge viaEdge (enc < (lambda * 1.0)) errMesg)
executing: saveDerived(geomAndNot(via metal1) errMesg)
executing: drc(metal2Edge (width < (lambda * 3.0)) errMesg)
    drc(metal2Edge (sep < (lambda * 3.0)) errMesg)
    drc(metal2Edge (notch < (lambda * 3.0)) errMesg)
executing: drc(metal2Edge viaEdge (enc < (lambda * 1.0)) errMesg)
executing: saveDerived(geomAndNot(via metal2) errMesg)
executing: BondingGlass = geomInside(glass pad)
    ProbeGlass = geomOutside(glass pad)
executing: saveDerived(geomStraddle(glass pad))
executing: BondingPad = geomAndNot(geomSize(BondingGlass 6.0) geomHoles(BondingGlass))
executing: ProbePad = geomAndNot(geomSize(ProbeGlass 6.0) geomHoles(ProbeGlass))
executing: Pad = geomOr(BondingPad ProbePad)
executing: BondingPadEdge = geomGetEdge(BondingPad not_over "nodrc")
executing: ProbePadEdge = geomGetEdge(ProbePad not_over "nodrc")
executing: PadEdge = geomGetEdge(Pad not_over "nodrc")
executing: Metal3EdgeNearPad = geomGetEdge(geomOr(geomGetByLayer("metal3" "glass" 36.0)) not_over ...
executing: Metal2EdgeNearPad = geomGetEdge(geomOr(geomGetByLayer("metal2" "glass" 36.0)) not_over ...
executing: Metal1EdgeNearPad = geomGetEdge(geomOr(geomGetByLayer("metal1" "glass" 21.0)) not_over ...
executing: PolyEdgeNearPad = geomGetEdge(geomOr(geomGetByLayer("poly" "glass" 21.0)) not_over ...
executing: ActiveEdgeNearPad = geomGetEdge(geomOr(geomGetByLayer("active" "glass" 21.0)) not_over ...
executing: ElecEdgeNearPad = geomGetEdge(geomOr(geomGetByLayer("elec" "glass" 21.0)) not_over ...
executing: drc(BondingPadEdge (width < 60.0) "(SCMOS Rule 10.1) bonding pad width: 60 um")
executing: drc(ProbePadEdge (width < 20.0) "(SCMOS Rule 10.2) probe pad width: 20 um")
executing: drc(Metal3EdgeNearPad glassEdge (enc < 6.0) "(SCMOS Rule 10.3) pad enclosure of glas...
executing: saveDerived(geomAndNot(glass metal3) "(SCMOS Rule 10.3) pad enclosure of glass: 6 um")
executing: drc(PadEdge Metal3EdgeNearPad (sep < 30.0) "(SCMOS Rule 10.4) pad to unrelated metal...
executing: drc(PadEdge Metal2EdgeNearPad (sep < 30.0) "(SCMOS Rule 10.4) pad to unrelated metal...
executing: drc(PadEdge Metal1EdgeNearPad (sep < 15.0) "(SCMOS Rule 10.5) pad to unrelated metal...
executing: drc(PadEdge PolyEdgeNearPad (sep < 15.0) "(SCMOS Rule 10.5) pad to unrelated poly sp...
executing: drc(PadEdge ActiveEdgeNearPad (sep < 15.0) "(SCMOS Rule 10.5) pad to unrelated activ...
executing: drc(PadEdge ElecEdgeNearPad (sep < 15.0) "(SCMOS Rule 10.5) pad to unrelated elec sp...
executing: drc(CapacitorElecEdge (width < (lambda * 7.0)) errMesg)
    drc(CapacitorElecEdge (sep < (lambda * 3.0)) errMesg)
    drc(CapacitorElecEdge (notch < (lambda * 3.0)) errMesg)
executing: drc(polyEdge CapacitorElecEdge (enc < (lambda * 5.0)) errMesg)
executing: drc(CapacitorElecEdge nBulkEdge (sep < (lambda * 2.0)) errMesg)
    drc(nBulkEdge CapacitorElecEdge (enc < (lambda * 2.0)) errMesg)
executing: drc(CapacitorElecEdge pBulkEdge (sep < (lambda * 2.0)) errMesg)
    drc(pBulkEdge CapacitorElecEdge (enc < (lambda * 2.0)) errMesg)
executing: saveDerived(geomStraddle(CapacitorElec nBulk) errMesg)
executing: saveDerived(geomStraddle(CapacitorElec pBulk) errMesg)
executing: drc(CapacitorElecEdge activeEdge (sep < (lambda * 2.0)) errMesg)
executing: saveDerived(geomAnd(CapacitorElec active) errMesg)
executing: drc(CapacitorElecEdge cpEdge (sep < (lambda * 6.0)) errMesg)
executing: drc(geomGetEdge("elec") geomGetEdge("metal3") (sep < (lambda * 2.0)) errMesg)
executing: saveDerived(geomOverlap(metal3 elec diffNet) errMesg)
executing: drc(geomGetEdge("elec") geomGetEdge("metal2") (sep < (lambda * 2.0)) errMesg)
executing: saveDerived(geomOverlap(metal2 elec diffNet) errMesg)
executing: drc(geomGetEdge("elec") geomGetEdge("metal1") (sep < (lambda * 2.0)) errMesg)
executing: saveDerived(geomOverlap(metal1 elec diffNet) errMesg)
executing: drc(TransistorElecEdge (width < (lambda * 2.0)) errMesg)
    drc(TransistorElecEdge (sep < (lambda * 3.0)) errMesg)
    drc(TransistorElecEdge (notch < (lambda * 3.0)) errMesg)
executing: drc(TransistorElecEdge activeEdge (enc < (lambda * 2.0)) errMesg)
    drc(TransistorElecEdge activeEdge (sep < (lambda * 1.0)) errMesg)

```

```

executing: drc(TransistorElecEdge polyEdge (sep < (lambda * 2.0)) errMesg)
    drc(TransistorElecEdge polyEdge (ovlp < (lambda * 2.0)) errMesg)
executing: drc(TransistorElecEdge cpEdge (sep < (lambda * 3.0)) errMesg)
executing: saveDerived(geomAnd(TransistorElec cp) errMesg)
executing: drc(TransistorElecEdge caEdge (sep < (lambda * 3.0)) errMesg)
executing: saveDerived(geomAnd(TransistorElec ca) errMesg)
executing: drc(ceEdge (width < (lambda * 2.0)) errMesg)
    drc(ceEdge (sep < (lambda * 3.0)) errMesg)
    drc(ceEdge (notch < (lambda * 3.0)) errMesg)
executing: drc(ce (area > ((lambda * 2.0 * (lambda * 2.0)) + (lambda * 0.1 * (lambda * 0.1)))) ...
executing: drc(CapacitorElecEdge ceEdge (enc < (lambda * 3.0)) errMesg)
executing: drc(TransistorElecEdge ceEdge (enc < (lambda * 2.0)) errMesg)
executing: saveDerived(geomAndNot(ce elec) "(SCMOS Rules 13.3,13.4) electrode enclosure of cont...
executing: drc(ceEdge polyEdge (sep < (lambda * 3.0)) errMesg)
executing: saveDerived(geomOutside(geomAnd(ce poly) CapacitorElec) errMesg)
executing: drc(ceEdge activeEdge (sep < (lambda * 3.0)) errMesg)
executing: saveDerived(geomAnd(ce active) errMesg)
executing: drc(via2Edge (width < (lambda * 2.0)) errMesg)
    drc(via2Edge (sep < (lambda * 3.0)) errMesg)
executing: drc(via2 (area > ((lambda * 2.0 * (lambda * 2.0)) + (lambda * 0.1 * (lambda * 0.1))))...
executing: drc(metal2Edge via2Edge (enc < (lambda * 1.0)) errMesg)
executing: saveDerived(geomAndNot(via2 metal2) errMesg)
executing: drc(metal3Edge (width < (lambda * 5.0)) errMesg)
    drc(metal3Edge (sep < (lambda * 3.0)) errMesg)
    drc(metal3Edge (notch < (lambda * 3.0)) errMesg)
executing: drc(metal3Edge via2Edge (enc < (lambda * 2.0)) errMesg)
executing: saveDerived(geomAndNot(via2 metal3) errMesg)
executing: drc(highresEdge (width < (lambda * 4.0)) errMesg)
    drc(highresEdge (sep < (lambda * 4.0)) errMesg)
    drc(highresEdge (notch < (lambda * 4.0)) errMesg)
executing: drc(highresEdge caEdge (sep < (lambda * 2.0)) errMesg)
executing: drc(highresEdge cpEdge (sep < (lambda * 2.0)) errMesg)
executing: saveDerived(geomAnd(highres ca) errMesg)
executing: saveDerived(geomAnd(highres cp) errMesg)
executing: drc(highresEdge activeEdge (sep < (lambda * 2.0)) errMesg)
executing: drc(highresEdge geomGetEdge(geomAndNot(elec geomButting(elec elecHighres))) (sep < (...))
executing: saveDerived(geomButting(elecHighres geomAndNot(elec elecHighres) (ignore == 2)) errM...
executing: saveDerived(geomAnd(elecHighres nwell) "(SCMOS Rule 27.6) resistor must be outside w...
executing: saveDerived(geomAnd(elecHighres active) "(SCMOS Rule 27.6) resistor must be outside ...
executing: drc(elecHighresEdge (width < (lambda * 5.0)) errMesg)
    drc(elecHighresEdge (sep < (lambda * 7.0)) errMesg)
    drc(elecHighresEdge (notch < (lambda * 7.0)) errMesg)
executing: drc(highresEdge elecHighresEdge (enc < (lambda * 2.0)) errMesg)
DRC started.....Wed May 3 07:58:46 2023
completed ....Wed May 3 07:58:54 2023
CPU TIME = 00:00:02 TOTAL TIME = 00:00:08
***** Summary of rule violations for cell "bcgwak_des layout" *****
Total errors found: 0

```

## + LVS result

```
@(#)$CDS: LVS version 6.1.8-64b 08/09/2022 19:10 (sjfhw317) $
```

Command line: /project/engineering/cadence21/IC618/tools.lnx86/dfII/bin/64bit/LVS -dir /home/warehouse/b.gwak/cadence/LVS -l -s -t /home/warehouse/b.gwak/cadence/LVS/layout /home/warehouse/b.gwak/cadence/LVS/schematic

Like matching is enabled.

Net swapping is enabled.

Using terminal names as correspondence points.

Net-list summary for /home/warehouse/b.gwak/cadence/LVS/layout/netlist

count	
1334	nets
30	terminals
1432	pmos
1432	nmos

Net-list summary for /home/warehouse/b.gwak/cadence/LVS/schematic/netlist

count	
1334	nets

```
30      terminals
1432    pmos
1432    nmos
```

Terminal correspondence points

N1325	N61	CLK
N1336	N60	ENABLE
N1324	N10	I1
N1323	N11	I2
N1322	N12	I3
N1321	N13	I4
N1320	N14	I5
N1319	N15	I6
N1318	N16	I7
N1316	N17	I8
N1345	N47	K1
N1335	N39	K10
N1344	N46	K2
N1343	N44	K3
N1342	N43	K4
N1341	N42	K5
N1340	N41	K6
N1339	N40	K7
N1338	N38	K8
N1337	N45	K9
N1334	N54	O1
N1333	N51	O2
N1332	N52	O3
N1331	N53	O4
N1330	N55	O5
N1329	N50	O6
N1327	N49	O7
N1326	N48	O8
N1317	N1	gnd!
N1328	N0	vdd!

Devices in the netlist but not in the rules:

pcapacitor

Devices in the rules but not in the netlist:

cap nfet pfet nmos4 pmos4

The net-lists match.

layout schematic

instances

un-matched	0	0
rewired	0	0
size errors	0	0
pruned	0	0
active	2864	2864
total	2864	2864

nets

un-matched	0	0
merged	0	0
pruned	0	0
active	1334	1334
total	1334	1334

terminals

un-matched	0	0
matched but different type	0	0
total	30	30

```
devbad.out:  
netbad.out:  
mergenet.out:  
termbad.out:  
prunenet.out:  
prunedev.out:  
audit.out:  
  
Probe files from /home/warehouse/b.gwak/cadence/LVS/layout  
devbad.out:  
netbad.out:  
mergenet.out:  
termbad.out:  
prunenet.out:  
prunedev.out:  
audit.out:
```