Analog MUX & Column Decoder Design for APS Matrix Readout

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TESYS Project, Summer Semester 2008

Under the guidance of

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&

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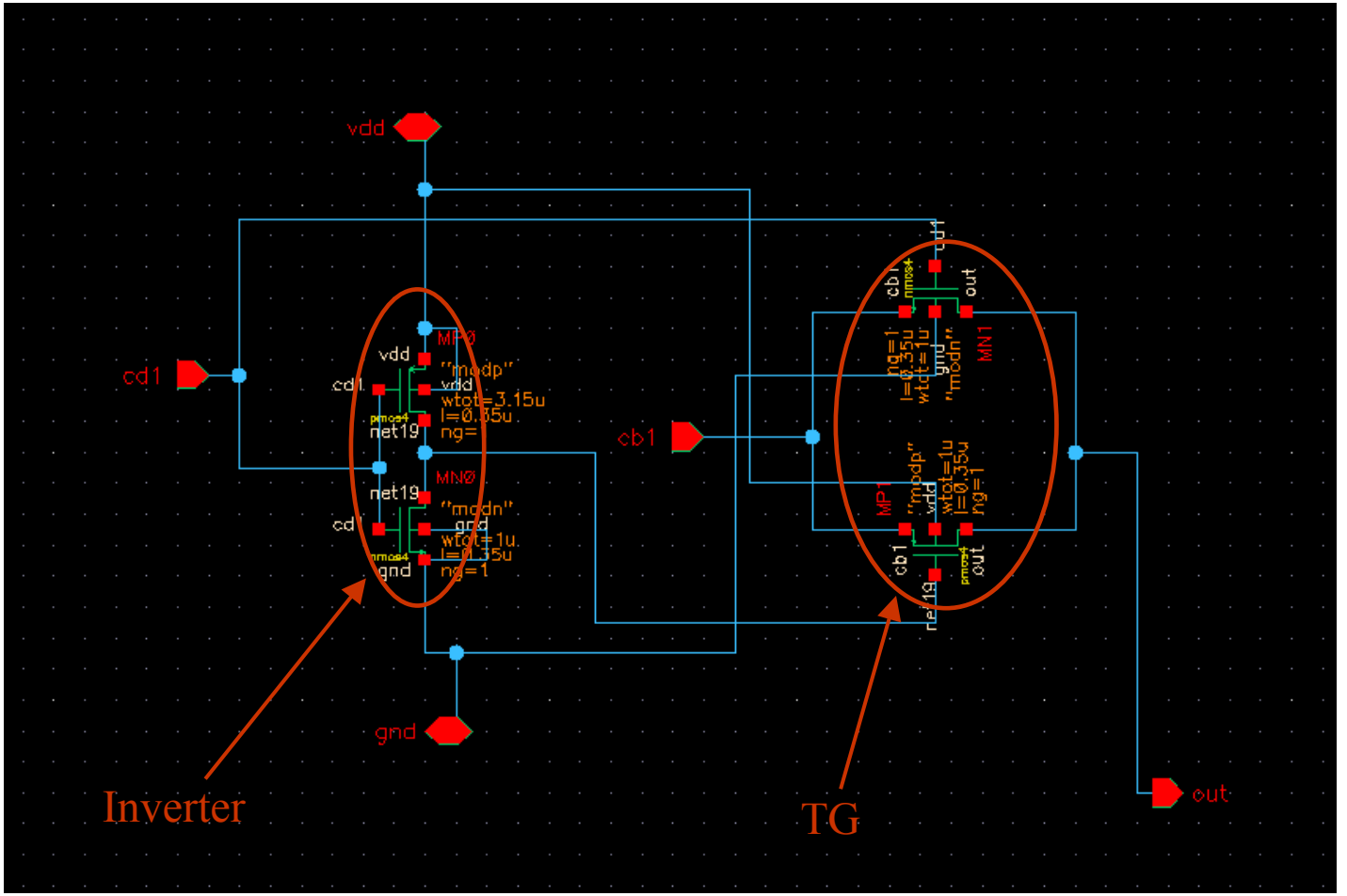
Overview of the Presentation

- Introduction
- Analog MUX Design
- Column Decoder Design
- Analog MUX and Decoder in APS Matrix Simulation (Global Project)
- Global Project Overview (Source Mr. Juergen Hornberger)
- Results
- Conclusion
- Reference

Introduction

- Goal - design an Analog MUX and a 4-16 bit Column decoder for a APS sensor column output selection and read out
- Area constraint provided is 15µ x 300µ for MUX and 40 µ x 400µ for Column Decoder
- The basic approach of Schematic, simulation, device sizing to Layout is followed
- Technology used is 0.35µ (4 Metal Layers) form Austriamicrsystems

Analog MUX Schematic (Single Cell)



Design Approximation for a Single Cell

- Inverter

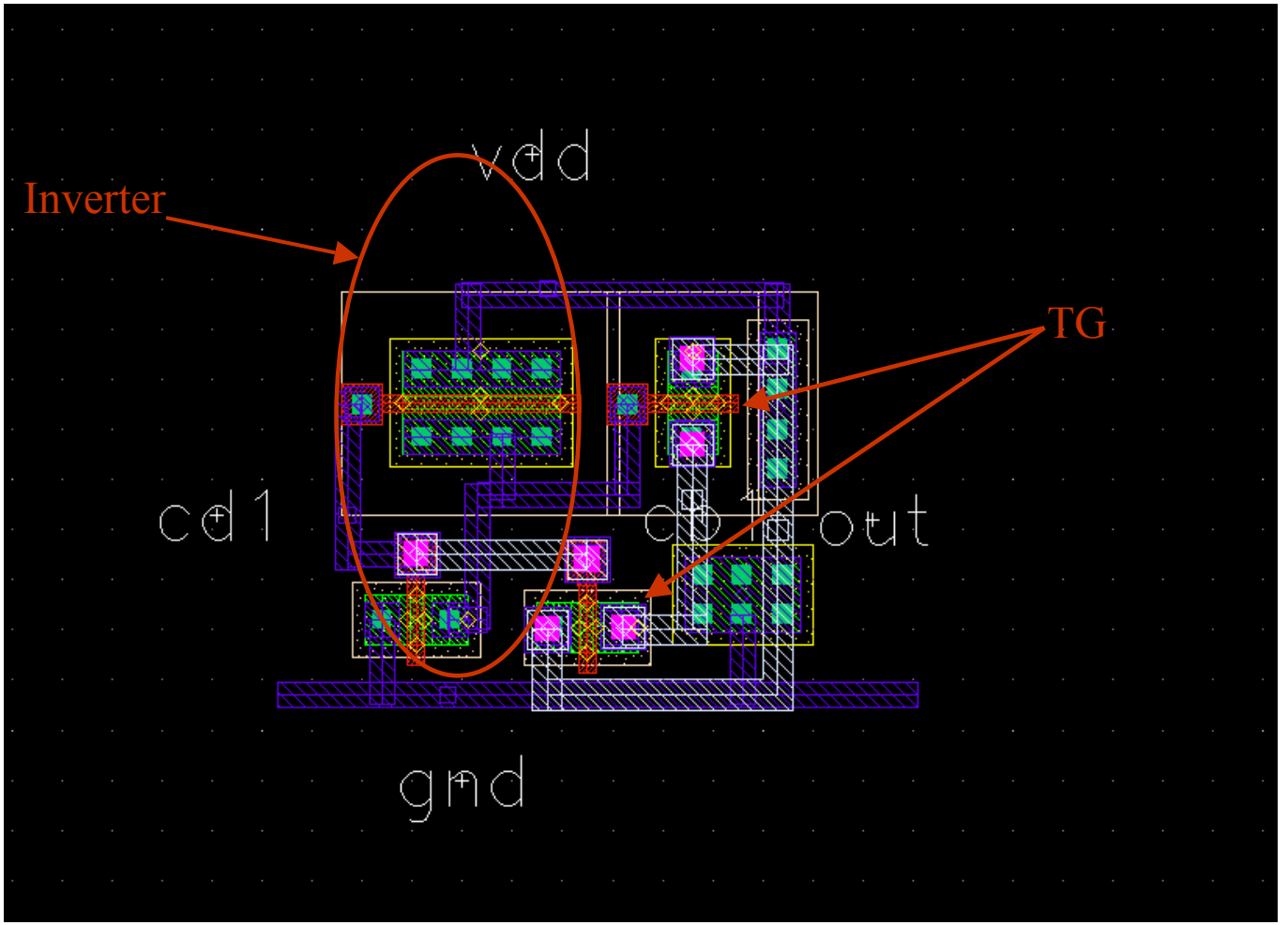
  P-MOS: 3.15µ/0.35µ

  N-MOS: 1µ/0.35µ
- Transmission Gate (TG)

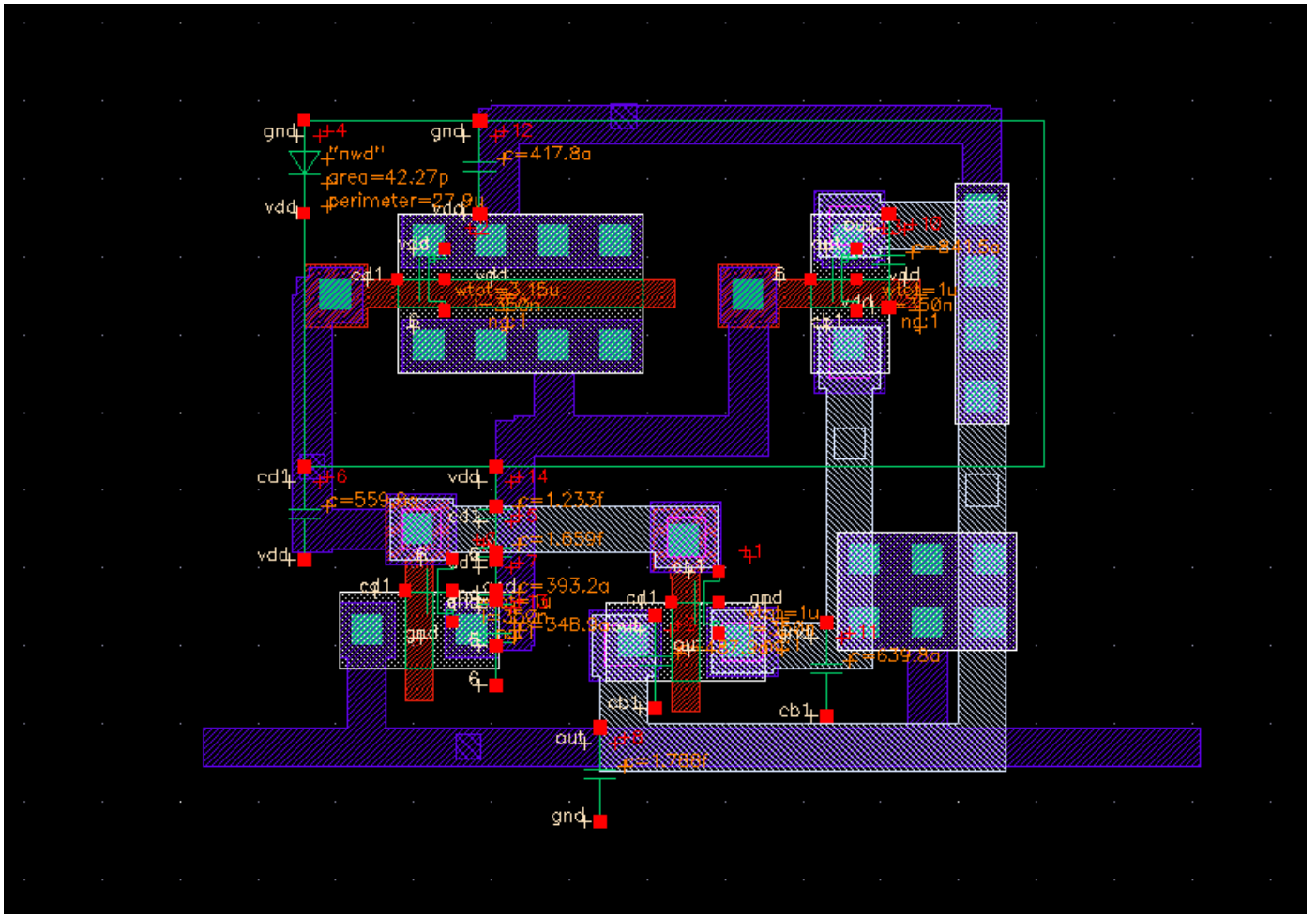
  P-MOS: 1µ/0.35µ

  N-MOS:1µ/0.35µ
- TG acts as an analog switch, so it has to be kept small dimensions to reduce the delay also for a better readout time (W/L of TG is inversely proportional to read out time)

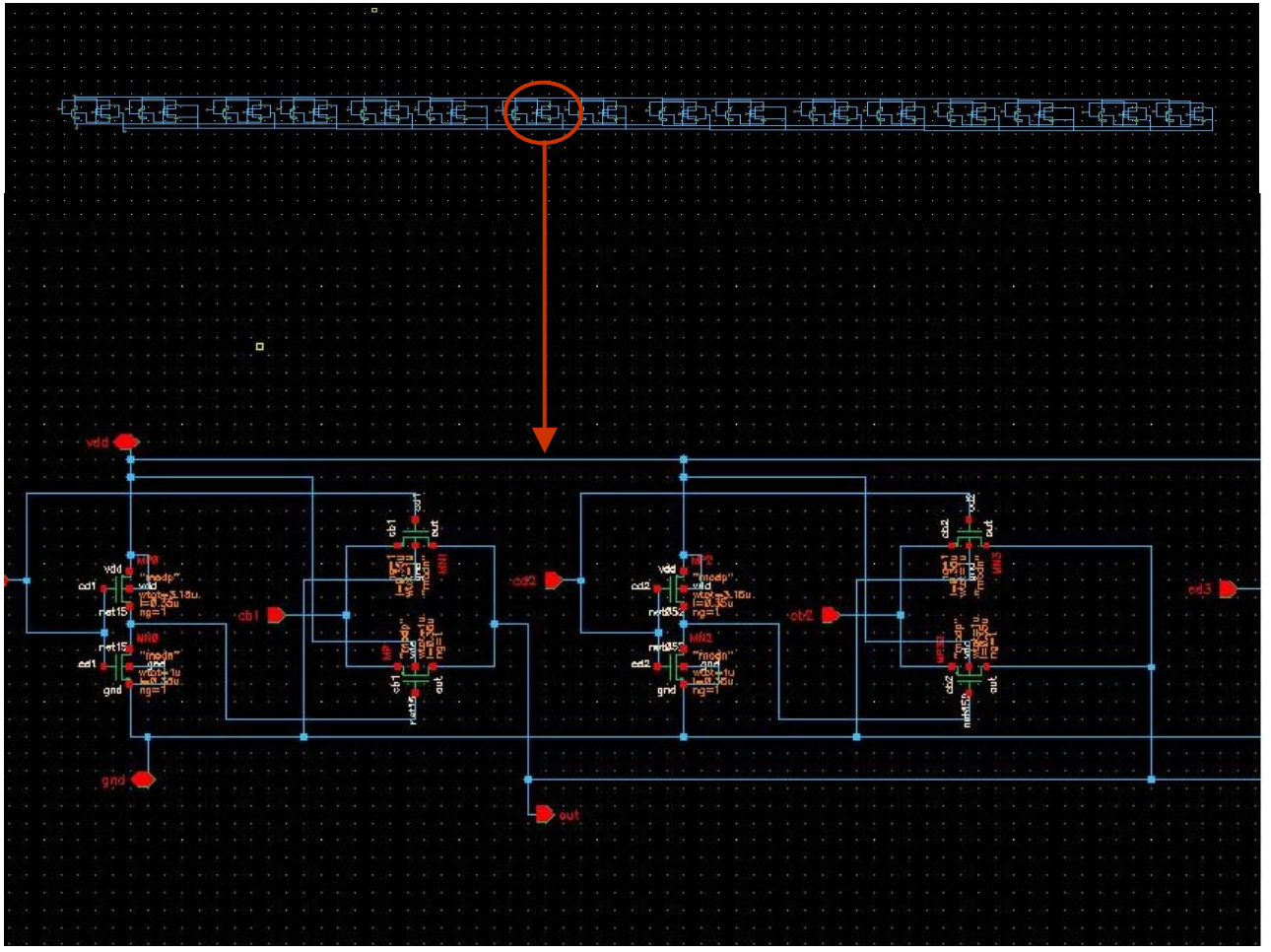
Analog MUX Single Cell Layout



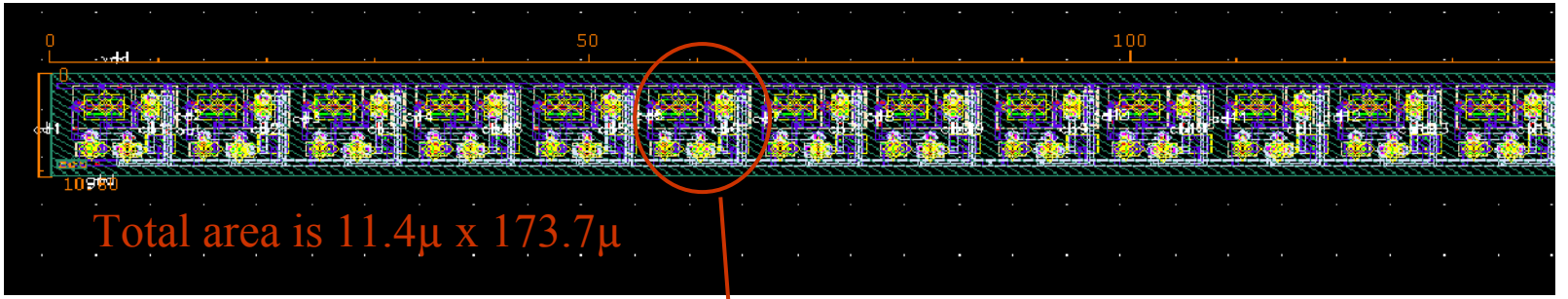
Analog MUX Single Cell Extracted

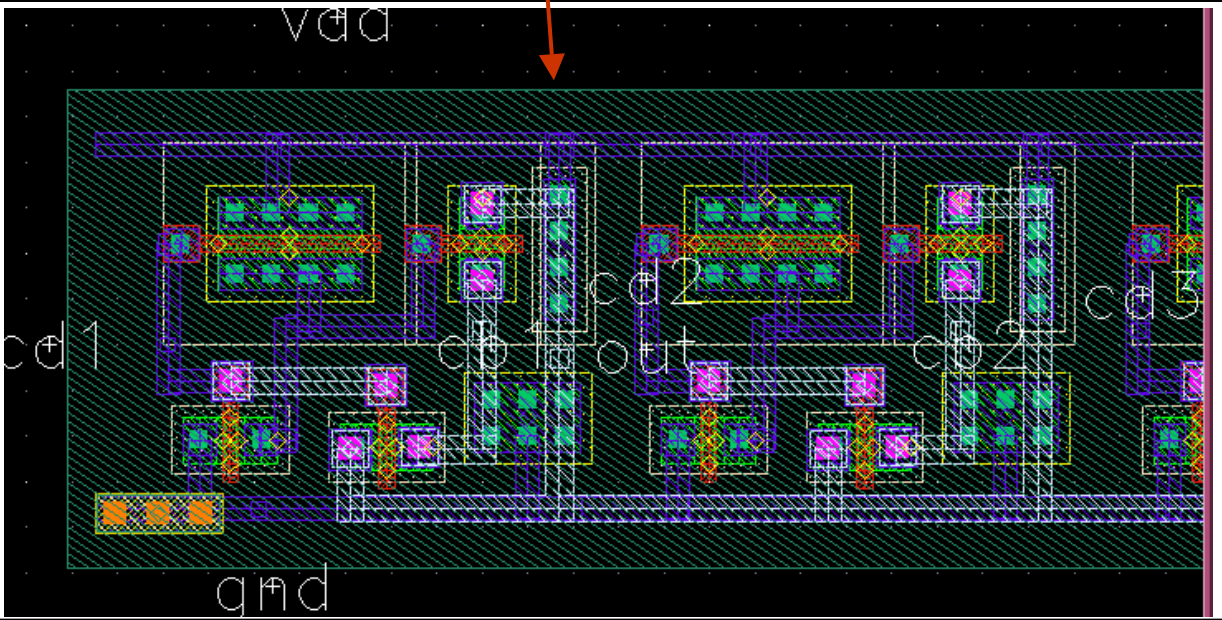


Analog MUX Schematic



Analog MUX Layout





11.4µ

LVS Check

/export/users/sens9/LVS/si.log

File Help 47

```
Warning: Unknown device "lat3" on a permuteDevice command.
Warning: Unknown device "vert15" on a permuteDevice command.
Warning: Unknown device "vert10" on a permuteDevice command.
Warning: Unknown device "vert5" on a permuteDevice command.
Warning: Unknown device "pmosm4" on a permuteDevice command.
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Warning: Unknown device "nmosm4" on a permuteDevice command.
Warning: Unknown device "nmosh6" on a permuteDevice command.
Warning: Unknown device "nmosh4" on a permuteDevice command.
Warning: Unknown device "ng" on a permuteDevice command.
Warning: Unknown device "cvar" on a permuteDevice command.
Warning: Unknown device "csandwt" on a permuteDevice command.
Warning: Unknown device "cpoly" on a permuteDevice command.
Warning: Unknown device "zd2sm24" on a permuteDevice command.
Warning: Unknown device "pd" on a permuteDevice command.
Warning: Unknown device "nwd" on a permuteDevice command.
Warning: Unknown device "nd" on a permuteDevice command.

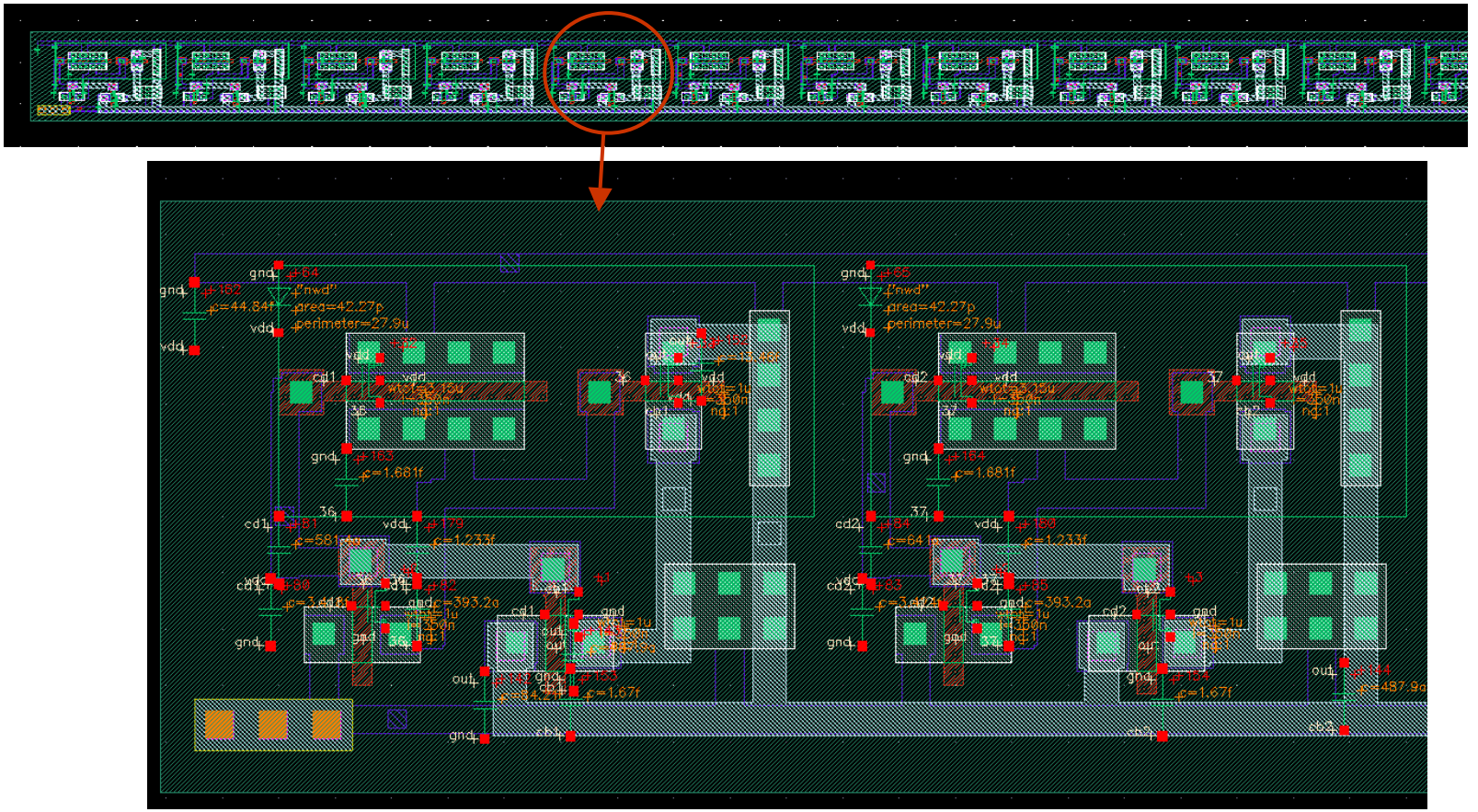
The net-lists match.

                            layout  schematic
                               instances
        un-matched             0       0
        rewired                0       0
        size errors            0       0
        pruned                 0       0
        active                 64      64
        total                  64      64

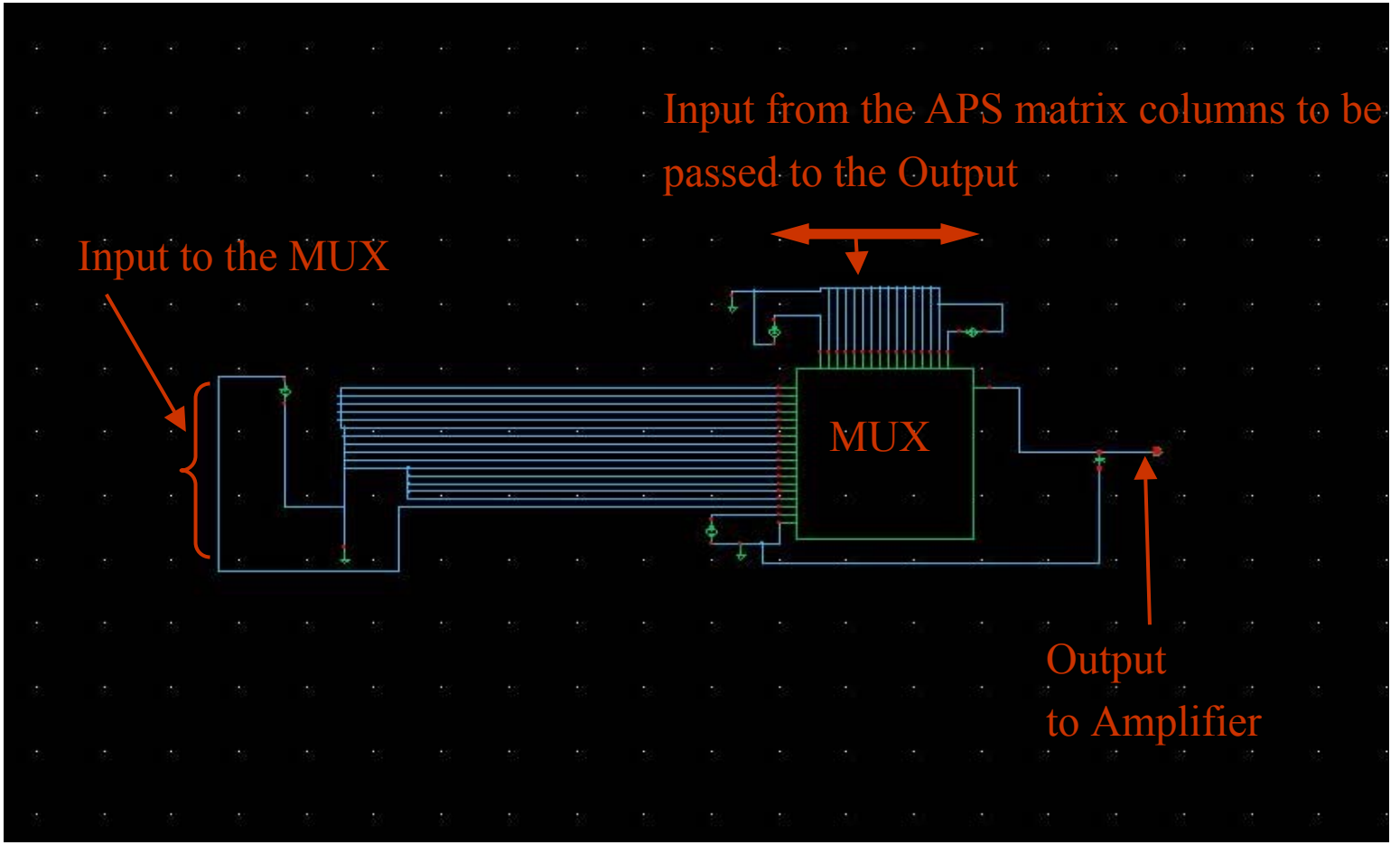
                                 nets
        un-matched             0       0
        merged                 0       0
        pruned                 0       0
        active                 51      51
        total                  51      51

                               terminals
        un-matched             0       0
        matched but
        different type         0       0
        total                  35      35
End comparison:      Nov 14 17:13:00 2008
```

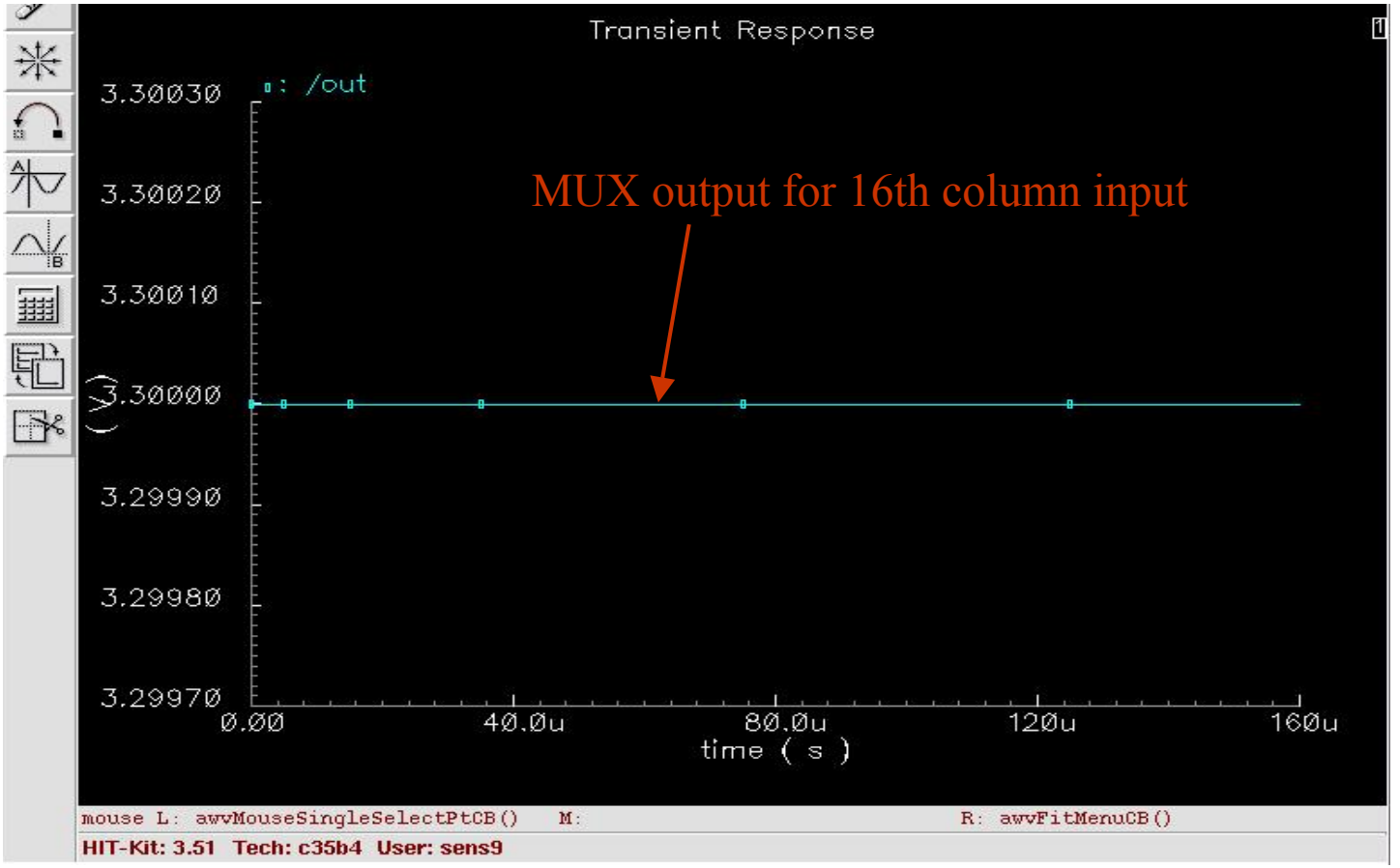
Analog MUX Extracted



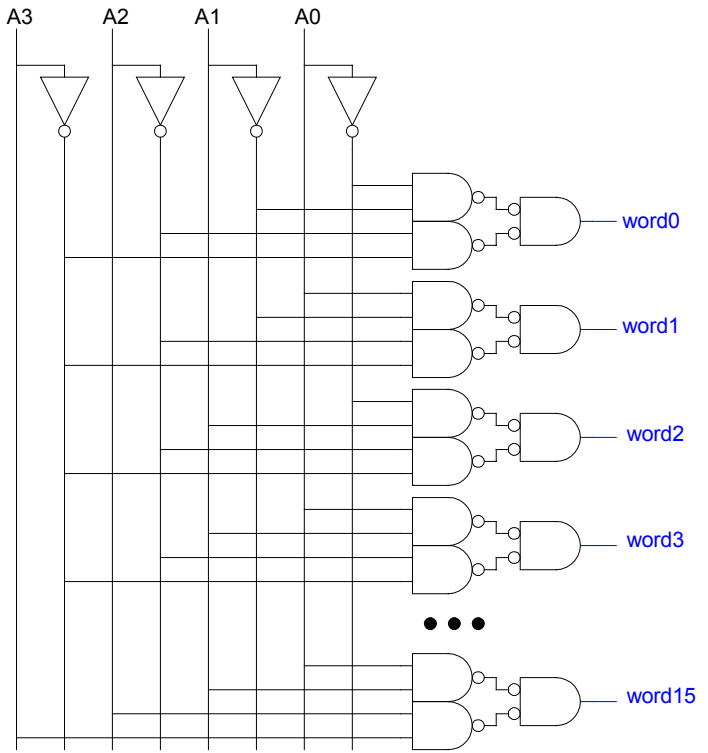
Analog MUX Simulation Set Up



Simulation Output (Extracted)



Decoder Design

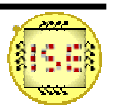


Truth Table

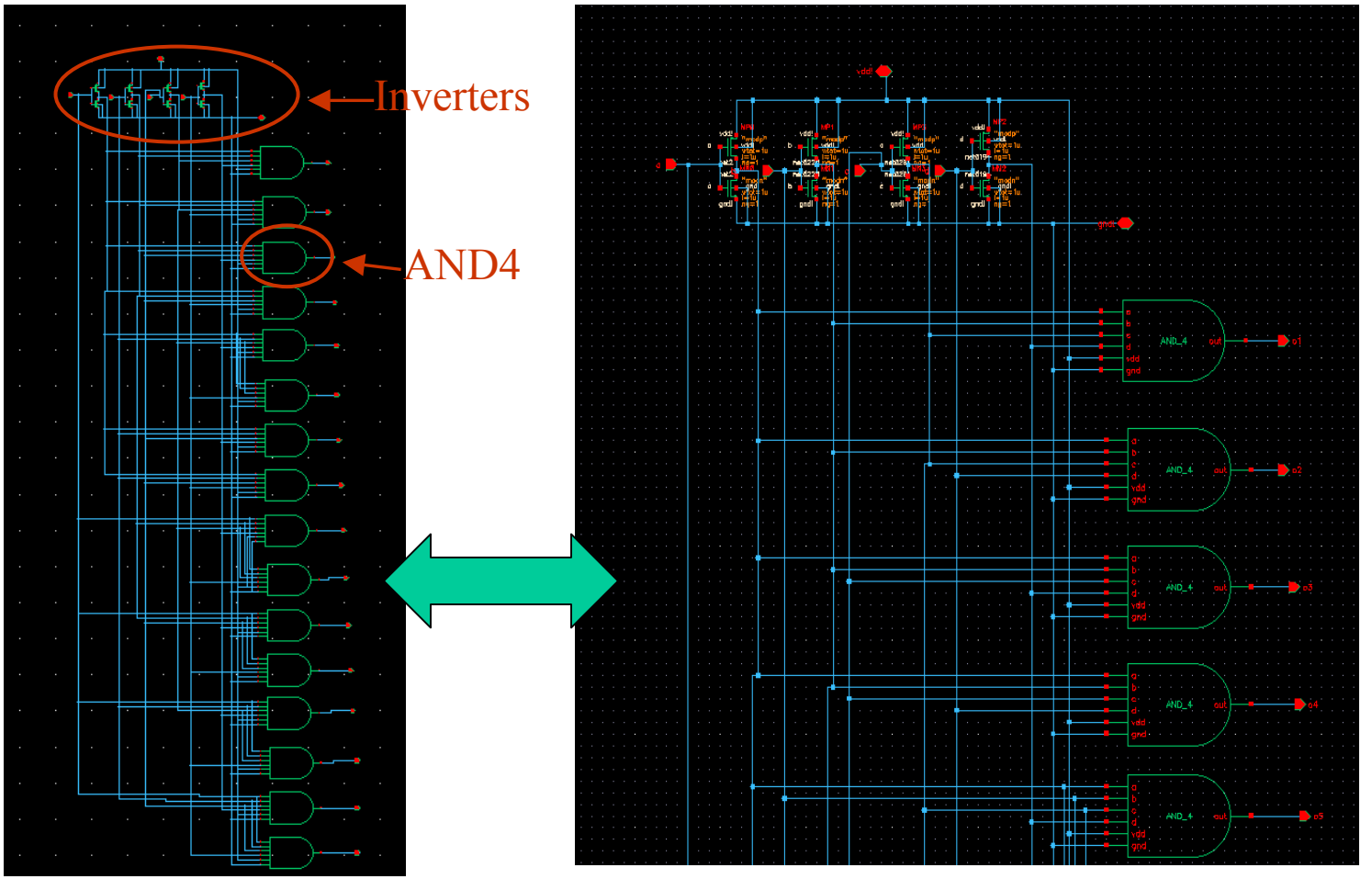
A	B	C	D	Out
0	0	0	0	0000000000000001
0	0	0	1	0000000000000010
0	0	1	0	0000000000000100
0	0	1	1	0000000000001000
:	:	:	:	:
:	:	:	:	:
:	:	:	:	:
1	1	1	0	0100000000000000
1	1	1	1	1000000000000000

Design Approximations

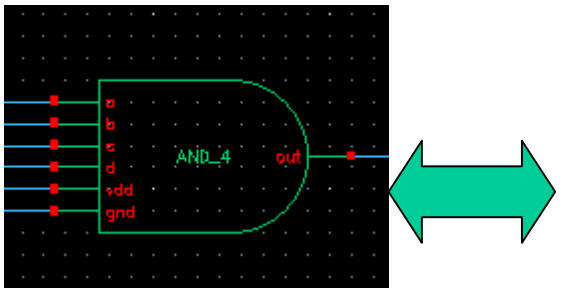
- The geometrical constraint (area constraint) provided by Global layout designer was 40µ x 400µ
- Also the plan of including an ADC to the Global layout requires the Decoder design to be made as compact as possible
- The W/L for each transistor is made 1µ/ 1µ for ensuring enough driving strength (to reduce offset of AND4 for 0 at the input)

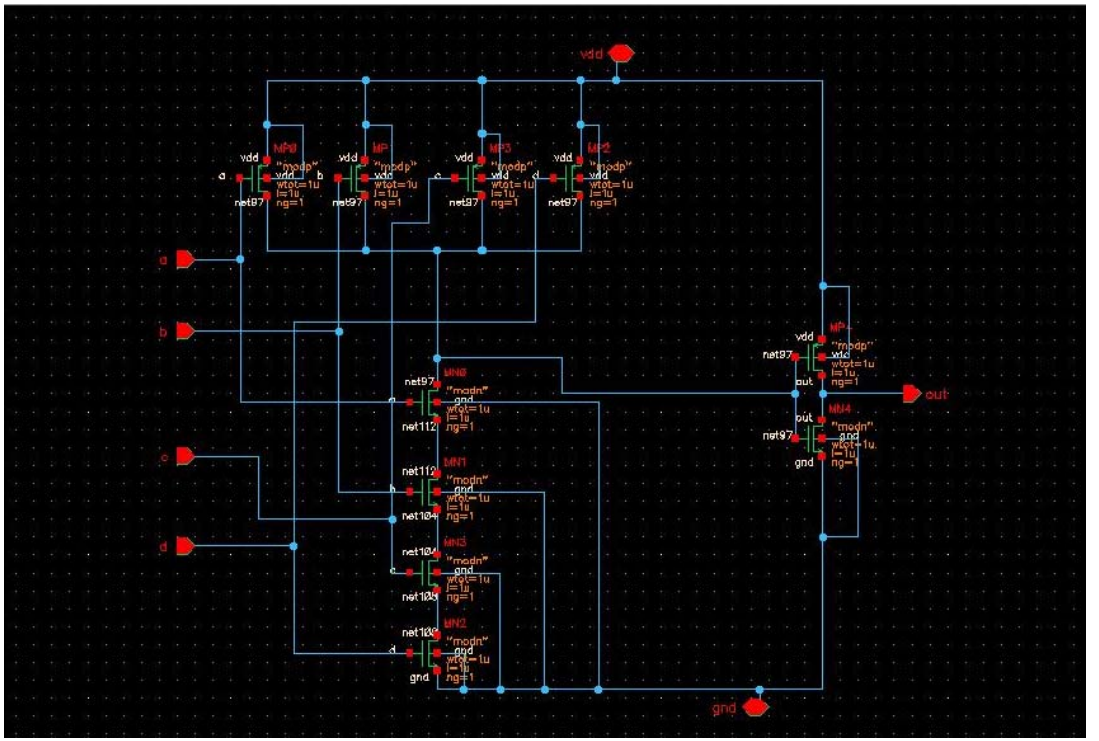


Decoder Design (Schematic)

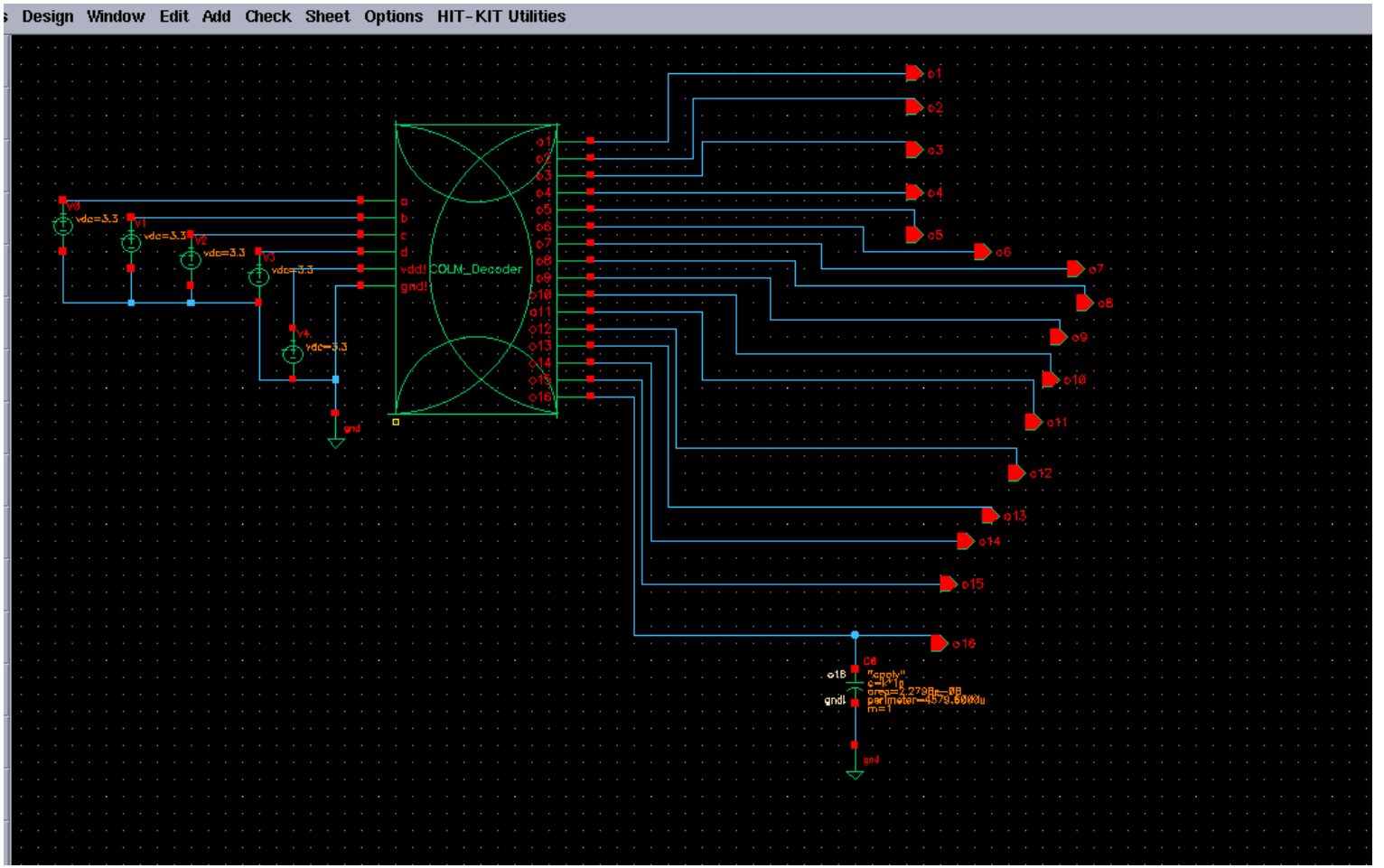


Decoder Schematic (AND4)

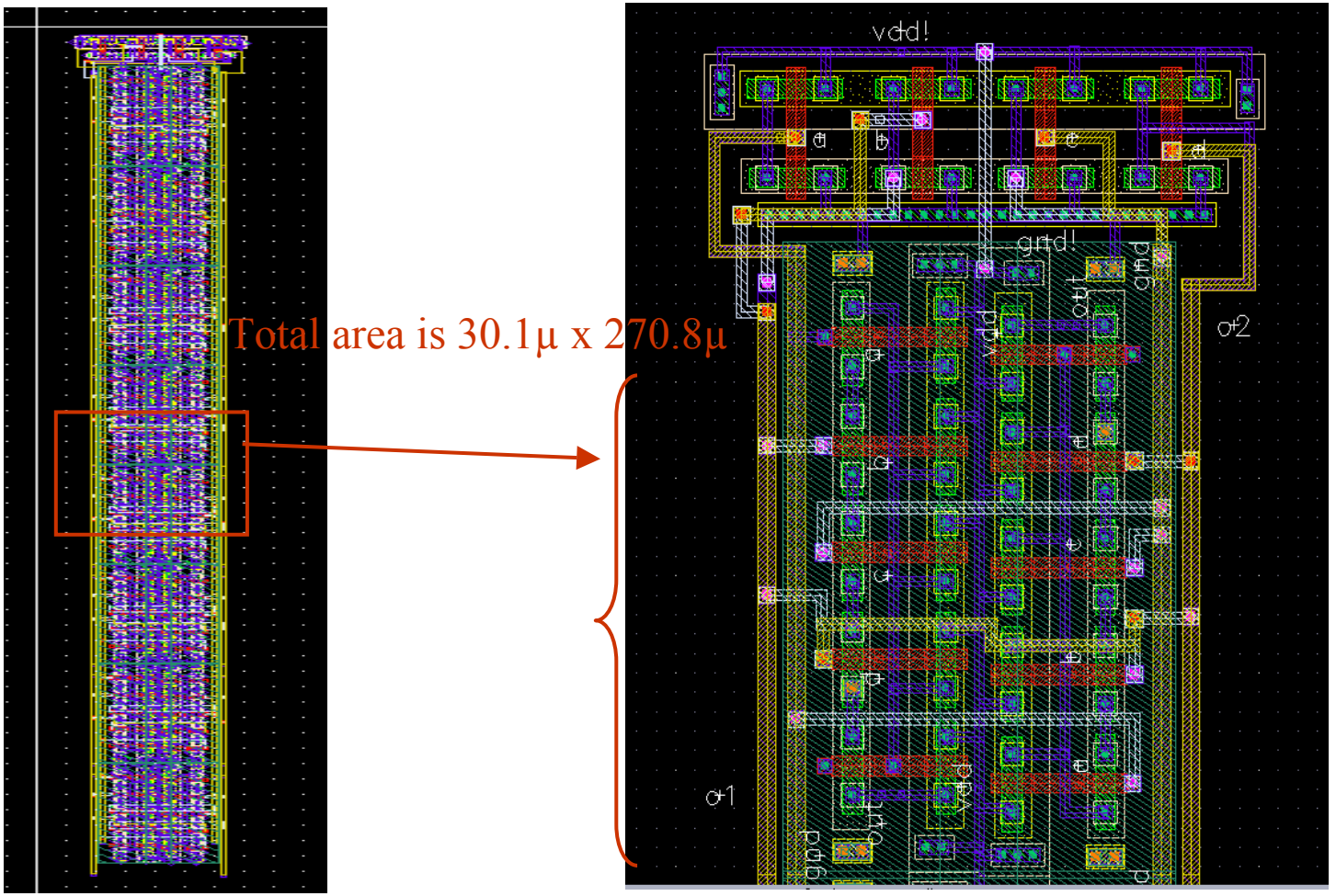




Decoder Simulation Set Up



Decoder Layout



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Warning: Unknown device "nd" on a permuteDevice command.

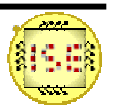
The net-lists match.

                            layout  schematic
                               instances
       un-matched              0       0
       rewired                 0       0
       size errors             0       0
       pruned                  0       0
       active                  168     168
       total                   168     168

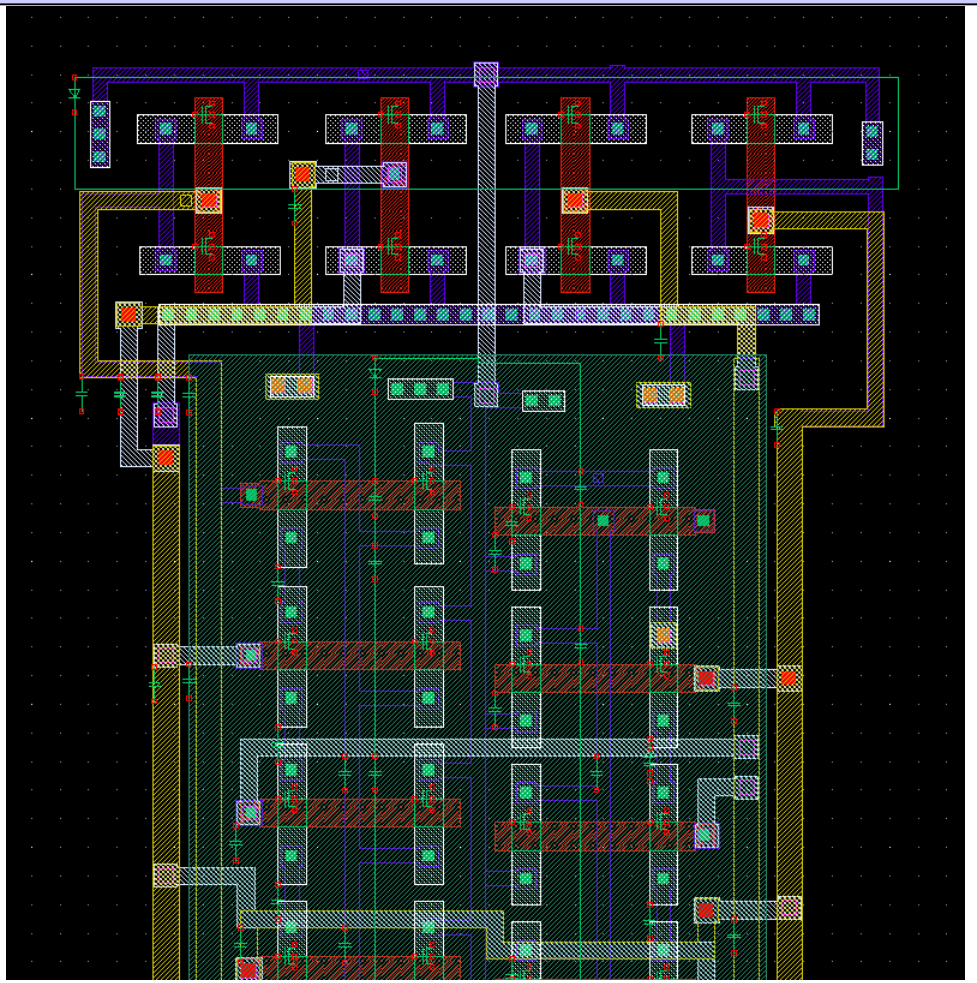
                                 nets
       un-matched              0       0
       merged                  0       0
       pruned                  0       0
       active                  90      90
       total                   90      90

                               terminals
       un-matched              0       0
       matched but
       different type          0       0
       total                   22      22
End comparison:      Nov 14 17:14:34 2008

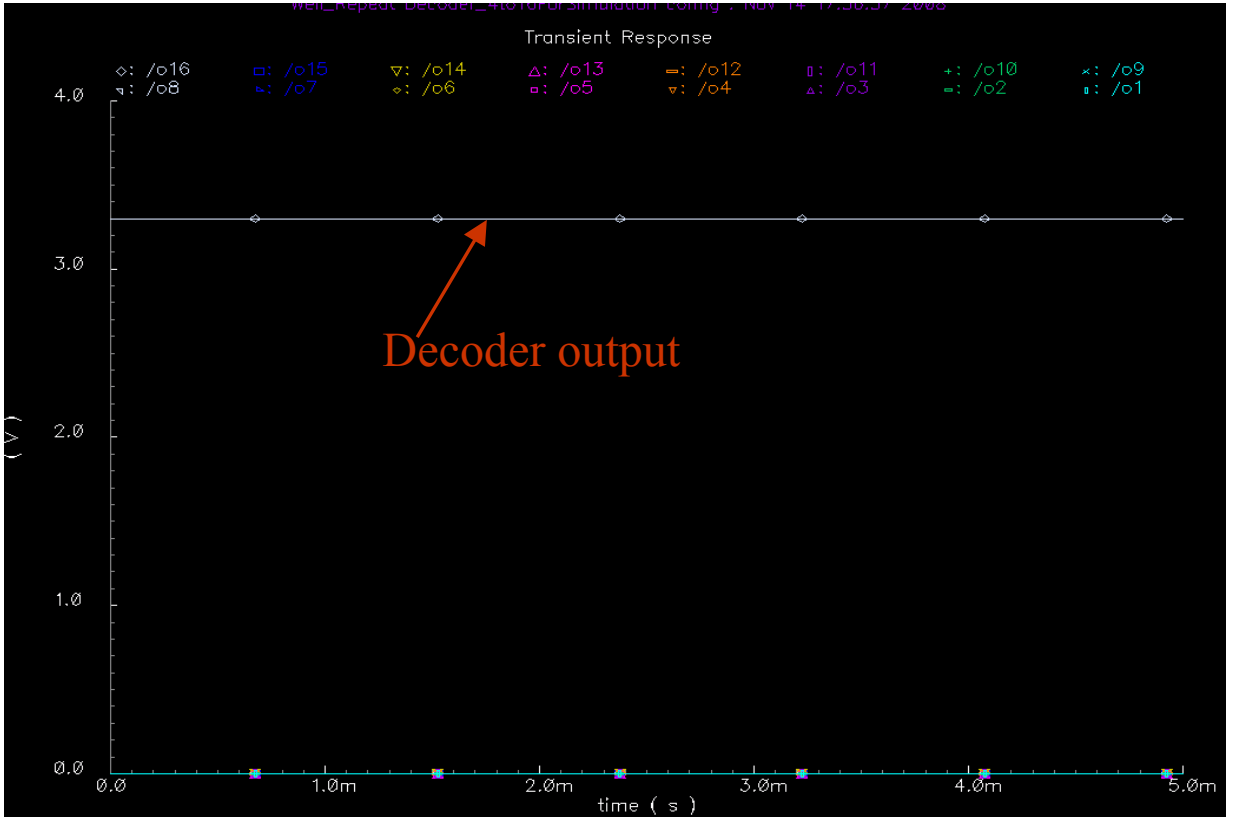

Comparison program completed successfully.
```

Decoder Extracted View

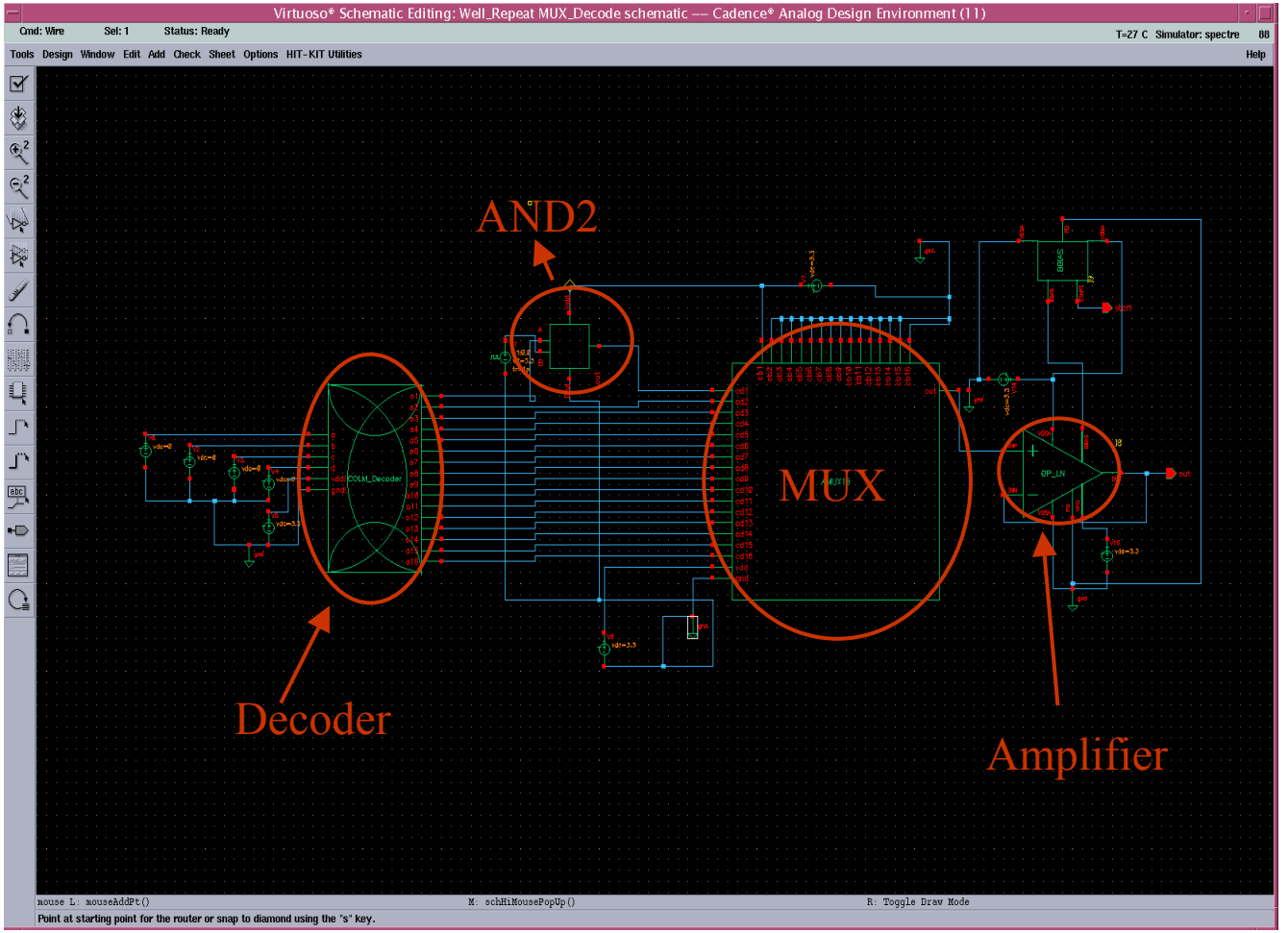


Decoder Simulation (Extracted)

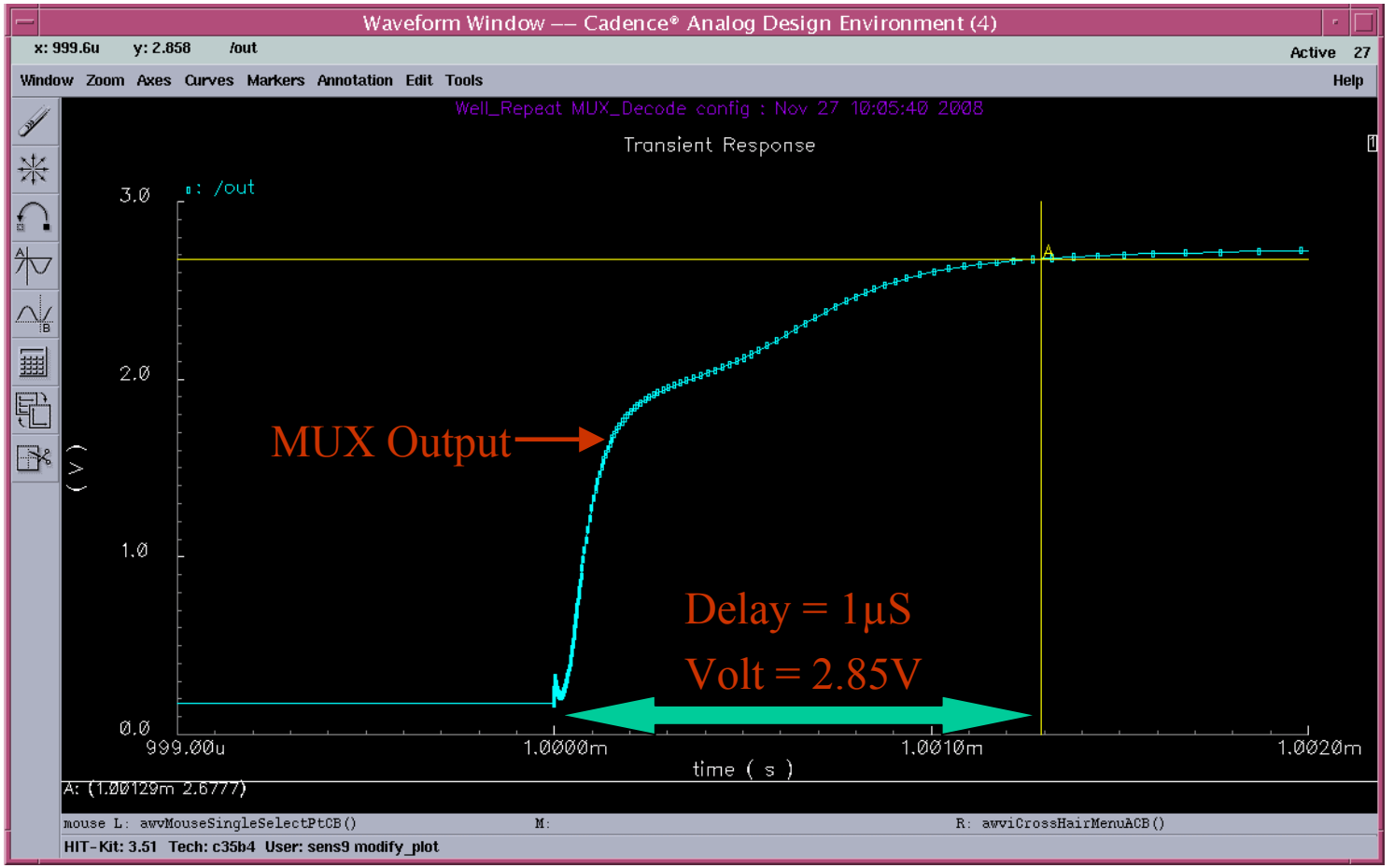


Out put at 16th output pin

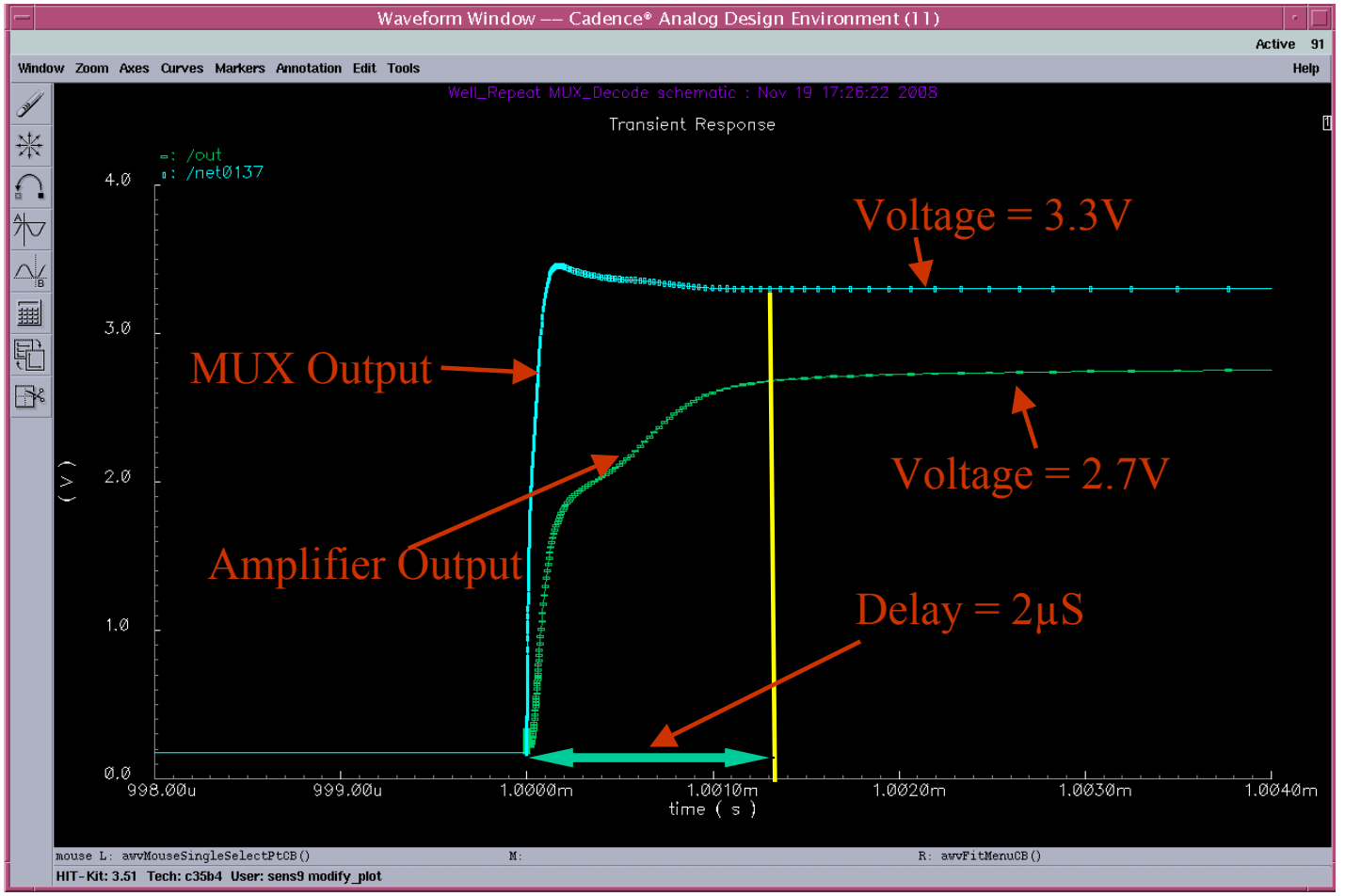
Delay analysis (Schematic)



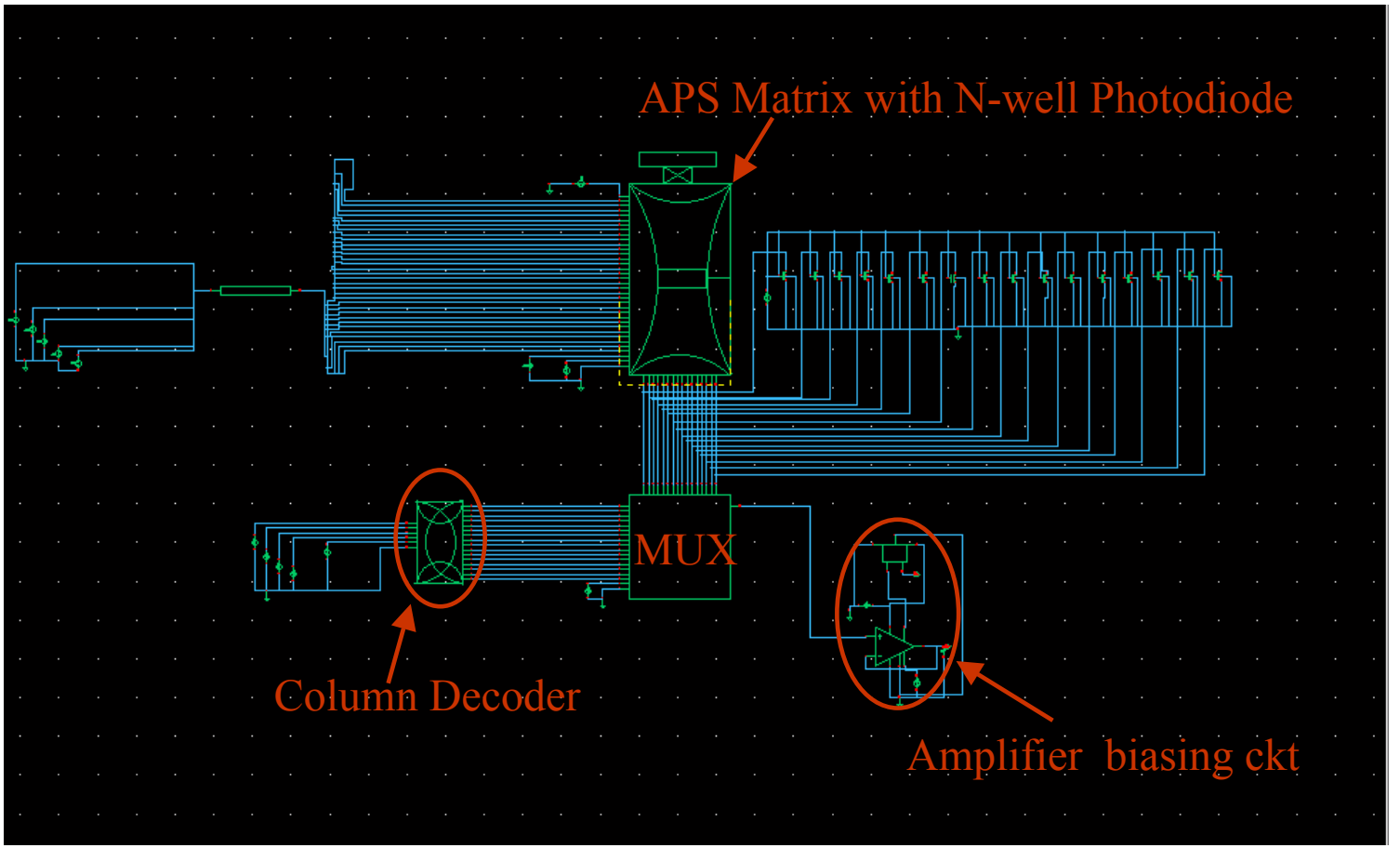
Simulation with a Load Capacitance (C=0pF)



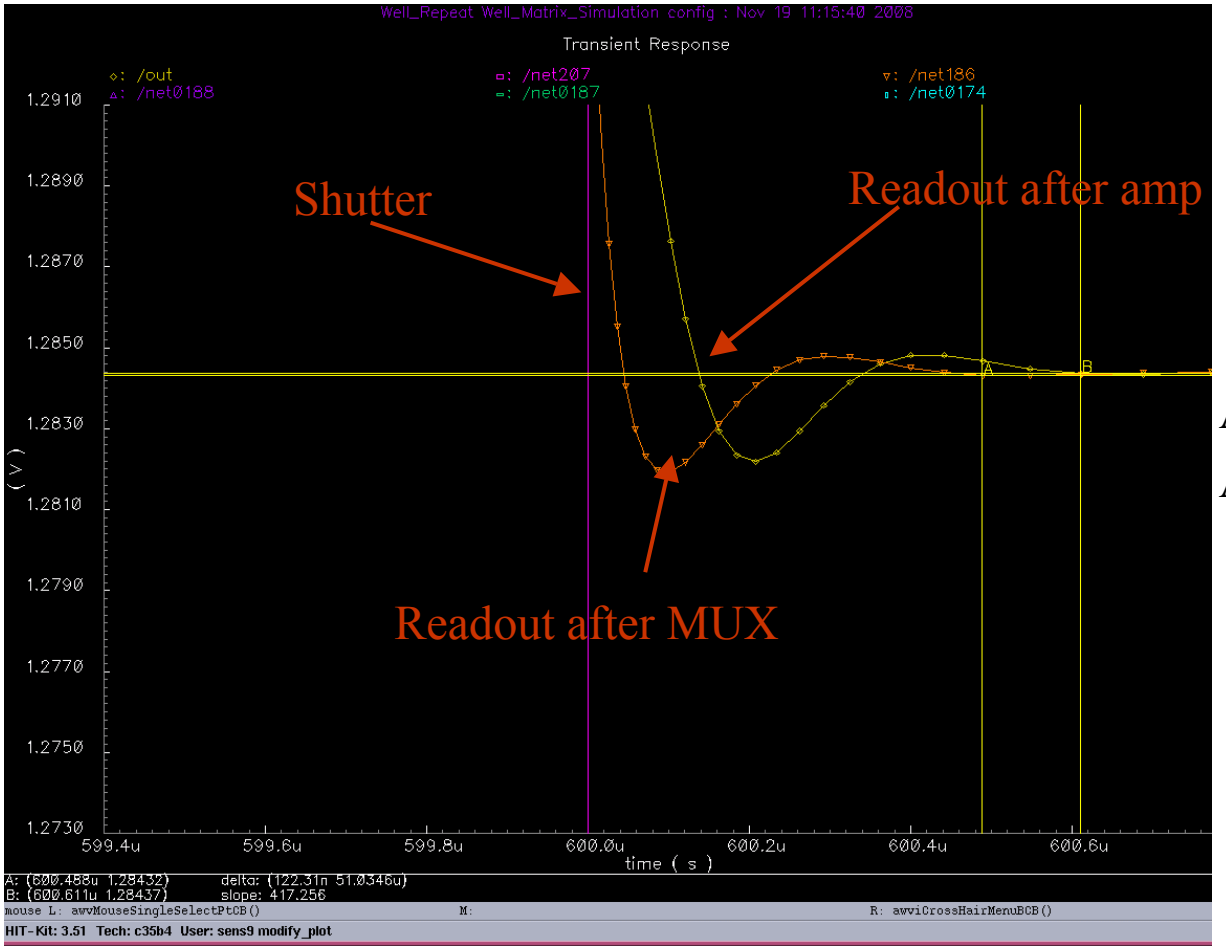
Simulation with a Load Capacitance (C=15pF)



APS Matrix simulation with MUX & Decoder (Schematic)



APS matrix Readout time measurement (Extracted)

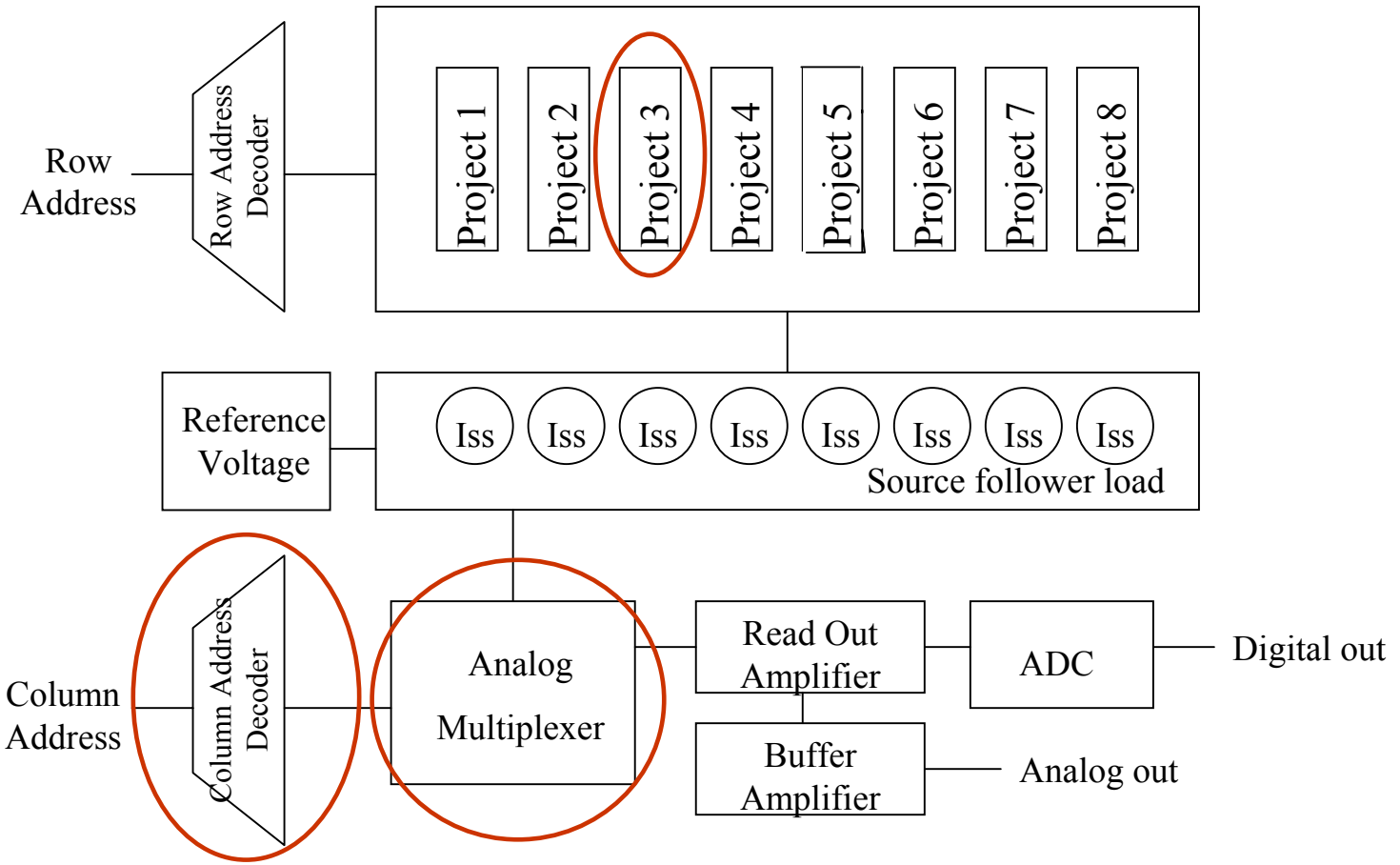


Readout time

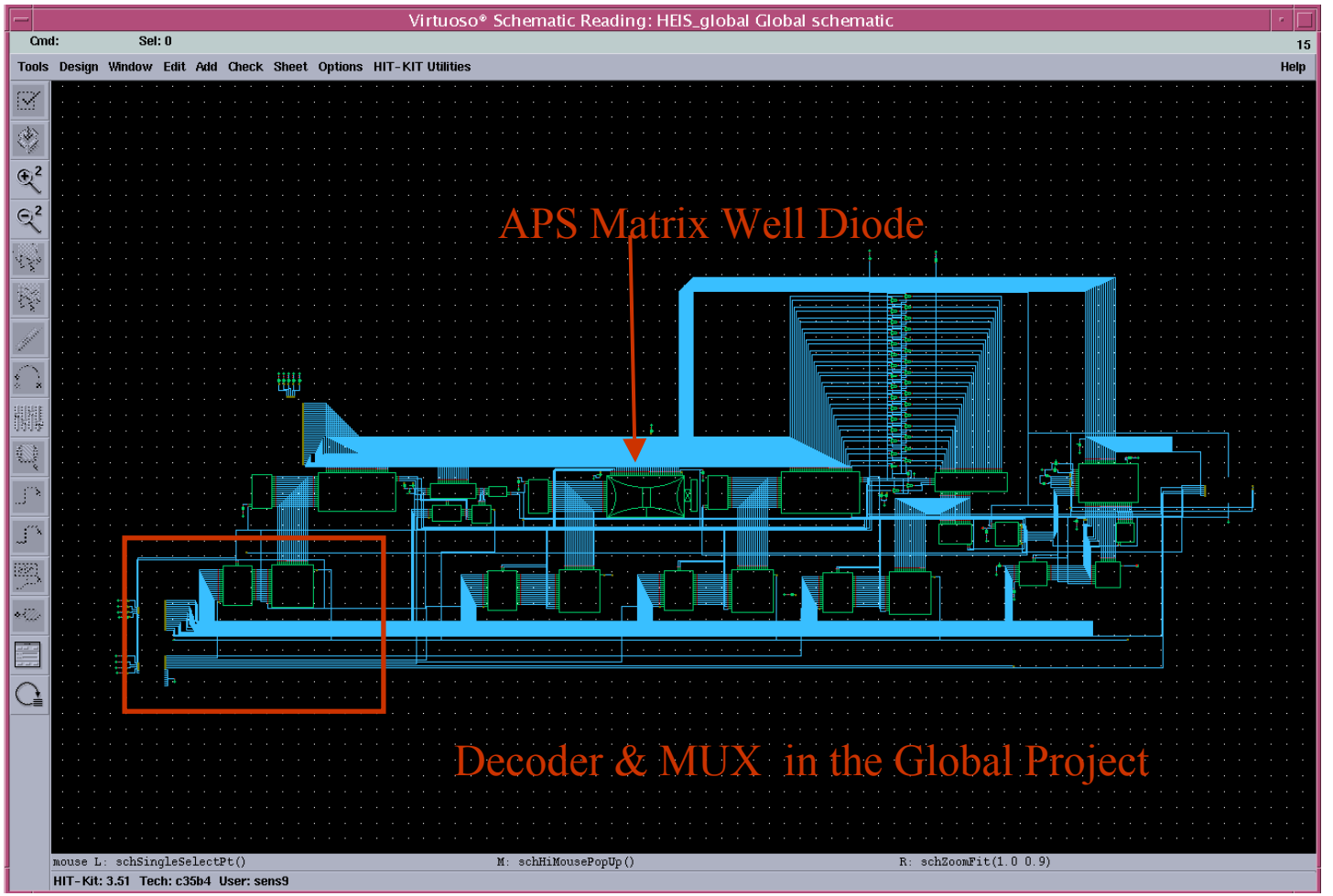
After MUX=500nS

After Amp =600nS

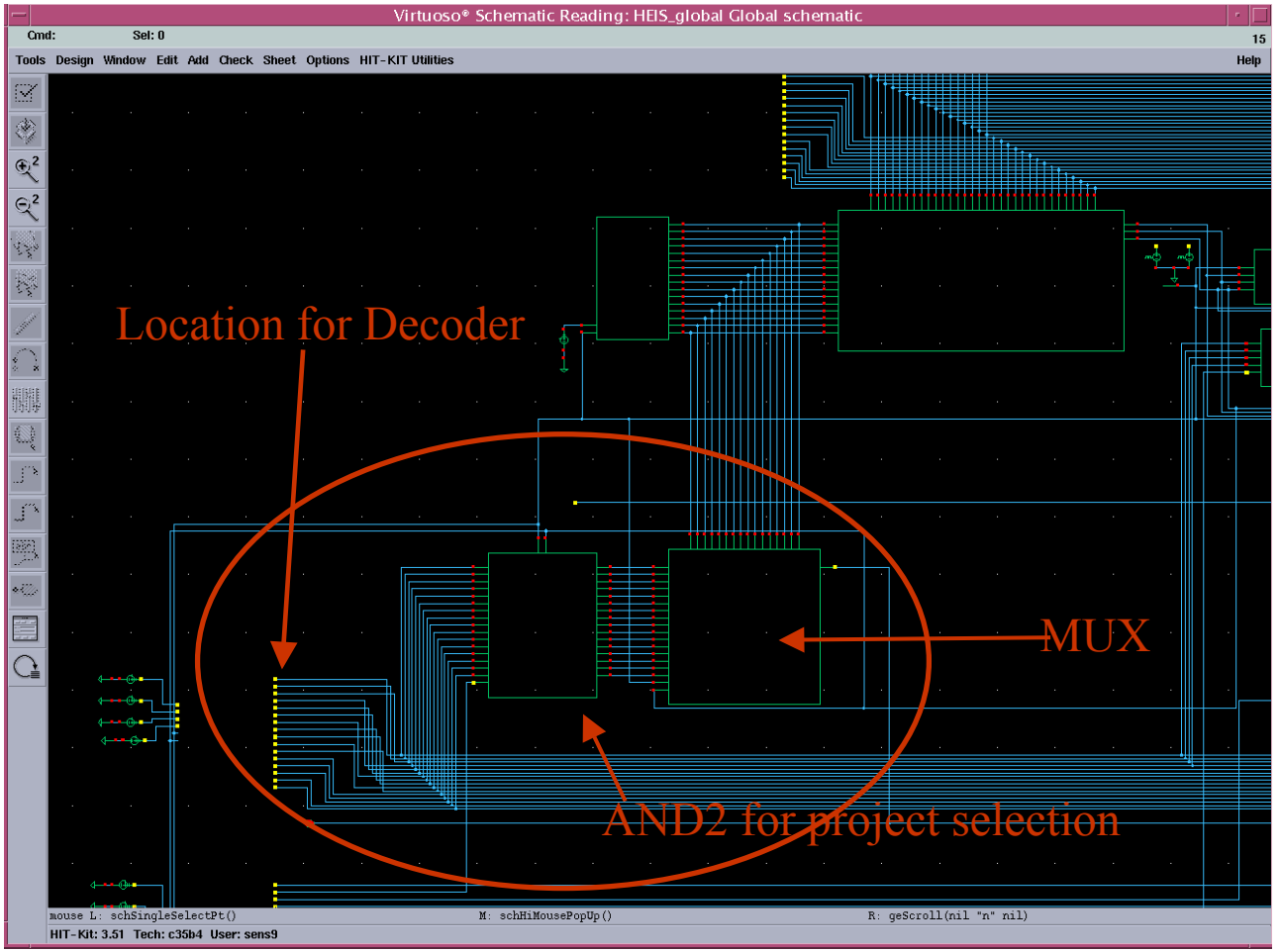
Global Project



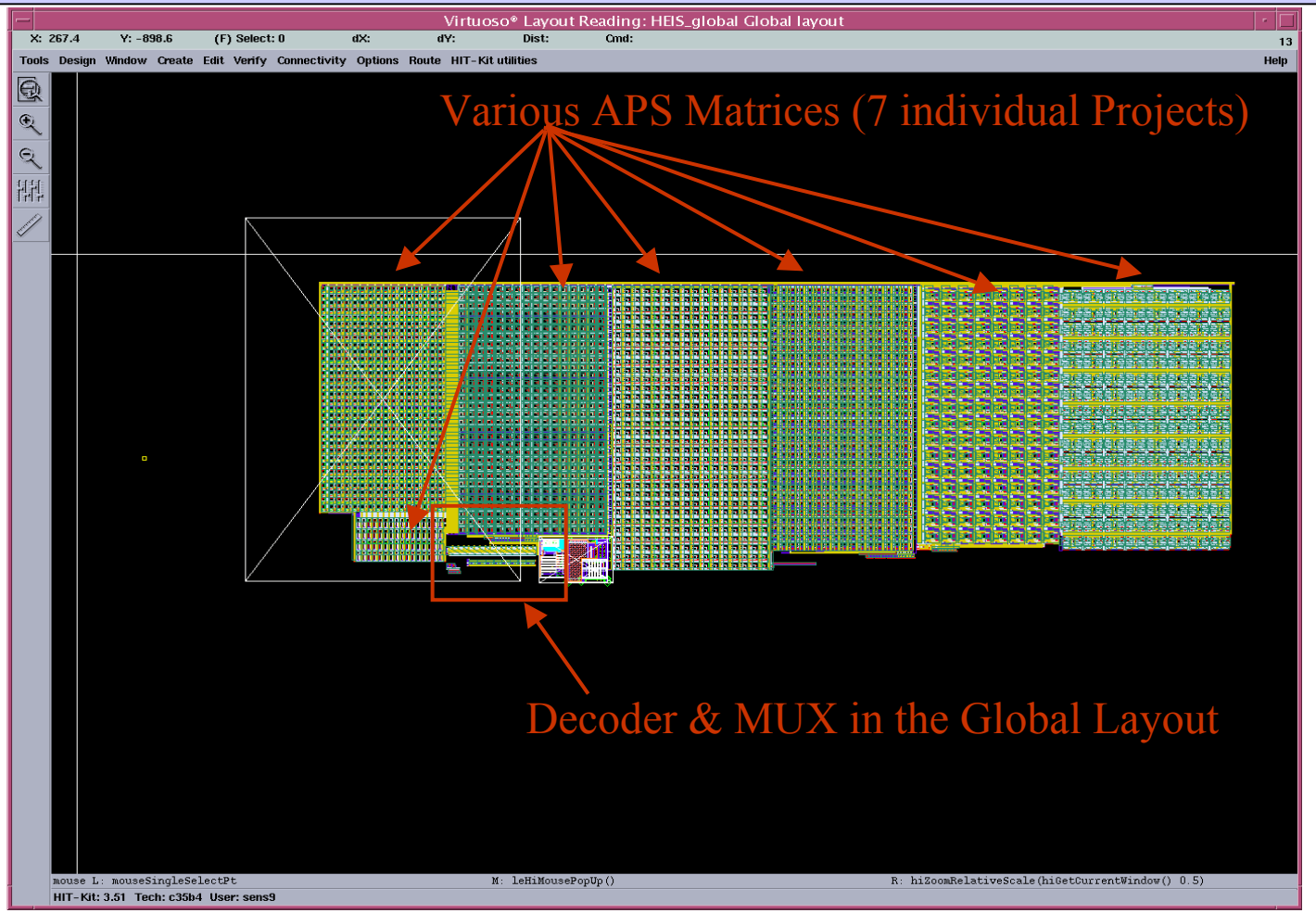
Global Project (Schematic)



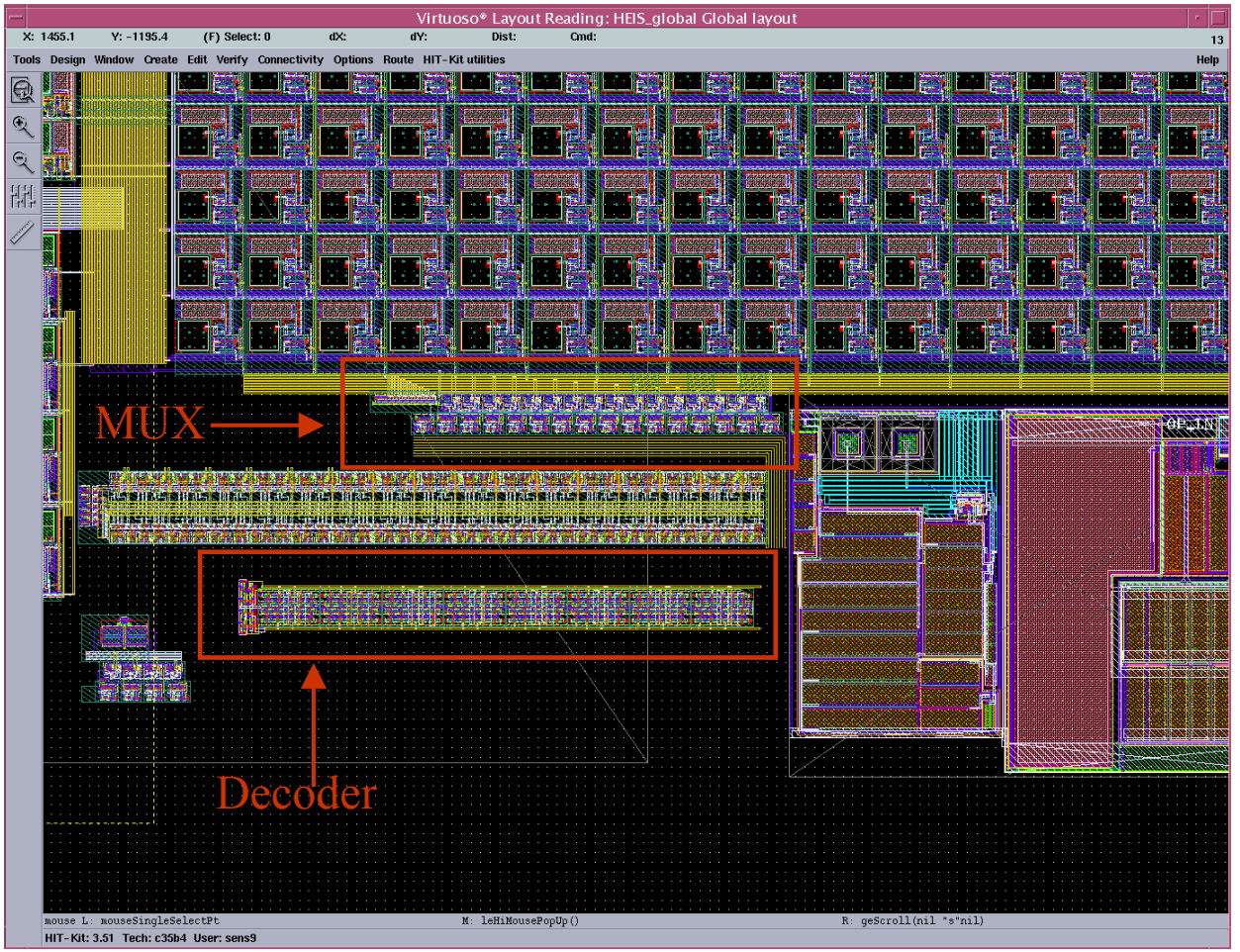
Global Project (Schematic)



Global Project (Layout)

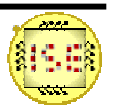


Global Project (Layout)



Results

- Column Decoder & Analog MUX are successfully designed and tested with an APS matrix
- Readout time obtained are, 500nS (after MUX) & 600nS (after Amplifier)
- Total design area for MUX is 11.4µ x 173.7µ
- Total Design area for Decoder is 30.1µ x 270.8µ
- Delay for the switching from 0 to 3.3Vfor MUX & Decoder are 1µS and 2µS respectively
- Approximate Frame rate obtained is 270.12 FPS
- Output voltage = 1.18V (for I_{photo}=500pA)



Conclusion

- An analog MUX and Column Decoder are successfully designed for effective use in APS sensor Readout
- Readout time obtained by inclusion of the designed components are almost same as the results obtained by using standard cells for simulation.
- Aspect ratios are kept 1µ/1µ in Decoder design in order to save area (for inclusion of ADC in the global layout)
- A better and compact designing may be obtained by careful placing and routing of the components at the cost of increase in area and delay

Reference

- Lecture slides of HEIS and TESYS by Prof. Andreas Koenig (TU Kaiserslautern)
- Lecture slides from Harvey Mudd College (Introduction to CMOS VLSI Design)
- Digital Integrated Circuits, Jan M. Rabaey
- www.wikipedia.org

MUX & Decoder Design

Thank You For Your Attention !