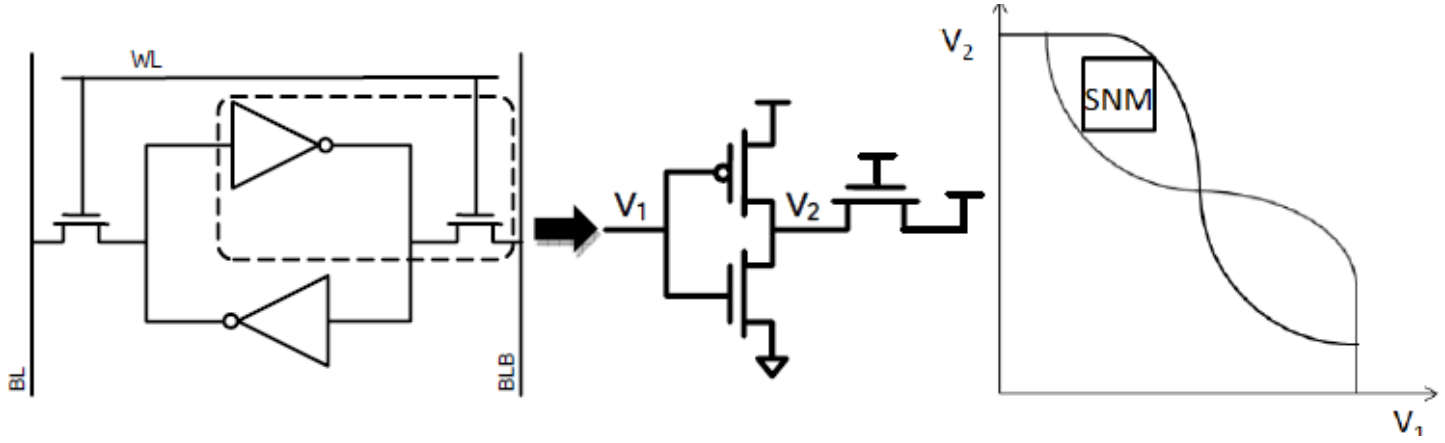
SRAM Static Characterization

Vishal Saxena, Boise State University
(vishalsaxena@boisestate.edu)

SRAM Read Static Noise Margin (SNM)

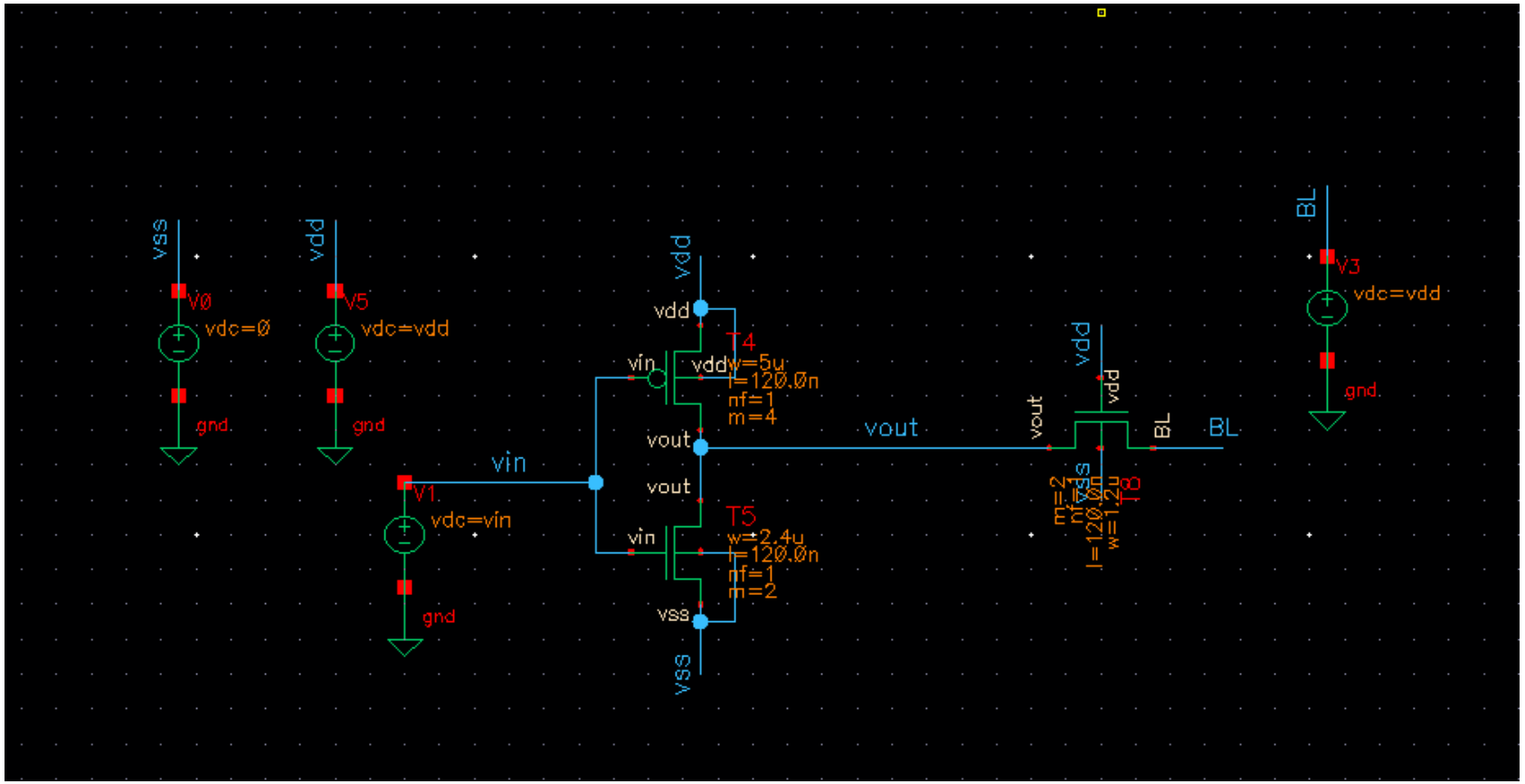
- During reads, WL and BL are held at V_{DD}
- Break the feedback from the cross-coupled inverters
- Plot voltage transfer characteristics (VTC) of the *inverter* in the half circuit as shown below (V_2 *vs* V_1)
- Use this plot to form the *butterfly curve* by overlapping the VTC with its inverse
  - Represents the two halves driving each other
  - Read SNM is the side of the largest square fitted in the butterfly curve



SRAM Read Static Noise Margin (SNM)

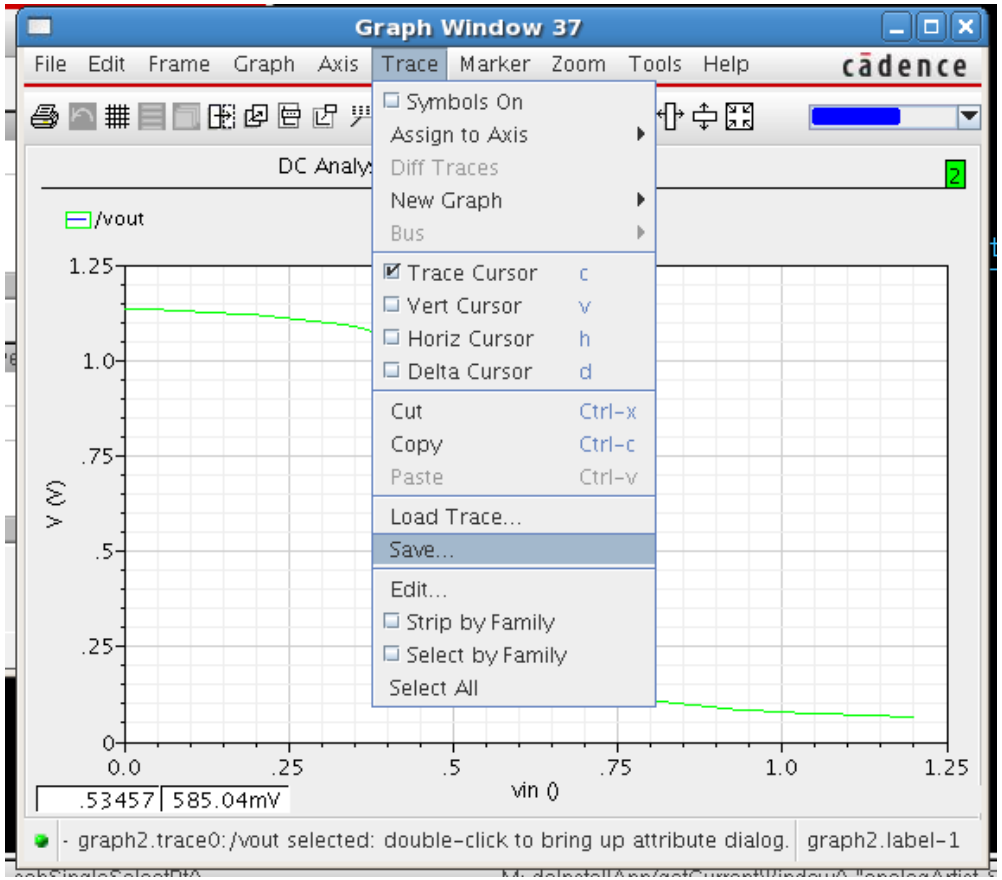
- Since it's difficult with Spectre to plot the inverse of the curve on the same graph
- Import the V_2 vs V_1 in MATLAB and do post-processing to generate the butterfly curve

Read SNM Test Bench



Read SNM Test Bench

- Select and save the trace as a .csv file, say Vout.csv
- Start Matlab in the same directory
- Can also use Excel
- Either import the .csv file and plot yourselves OR
- Use the script in the following slides



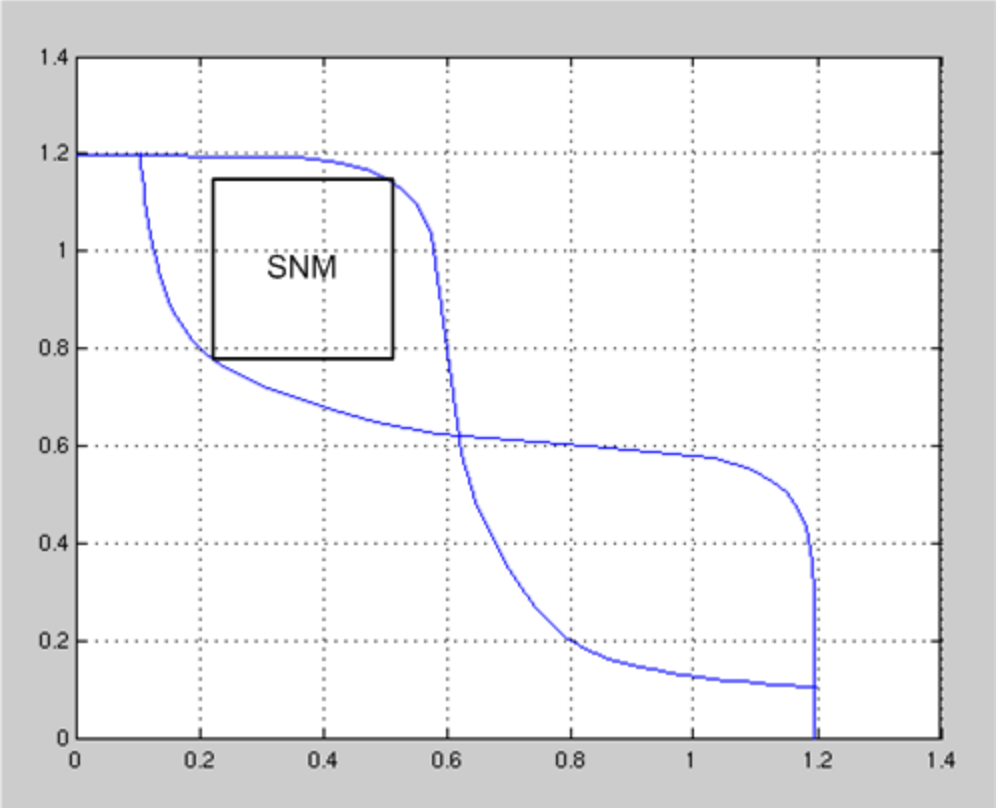
Matlab Script to plot Butterfly Curves

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Script to plot SRAM Butterfly curve
%
% Save the vin vs vout DC sweep plot in the Spectre as a
% CSV file 'Vout.csv'
% Run this script in the same directory as the CSV file
% The file uses the function importfile
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

importfile('Vout1.csv');  % Change filename appropriately

% vin is the first column
vin  = data(:,1);

% vout is the second column
vout = data(:,2);

figure()
plot(vin, vout);
hold on; grid on;
plot(vout, vin);

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

Matlab Importfile Function

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

function importfile(fileToRead1)
%IMPORTFILE(FILETOREAD1)
%  Imports data from the specified file
%  FILETOREAD1:  file to read

% Import the file
newData1 = importdata(fileToRead1);

% Create new variables in the base workspace from those fields.
vars = fieldnames(newData1);
for i = 1:length(vars)
    assignin('base', vars{i}, newData1.(vars{i}));
End

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

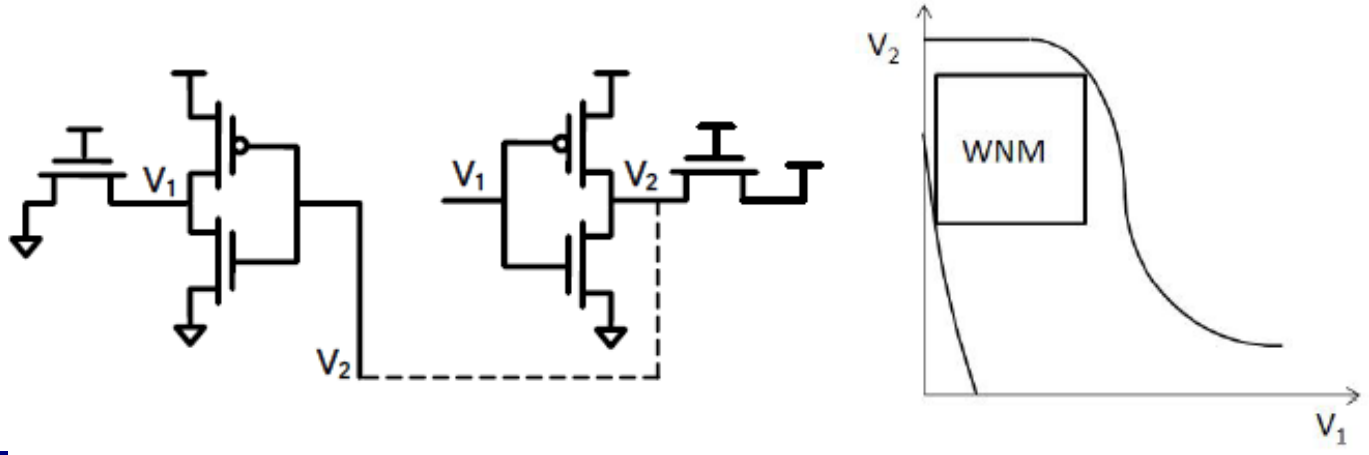
Read Butterfly Plot



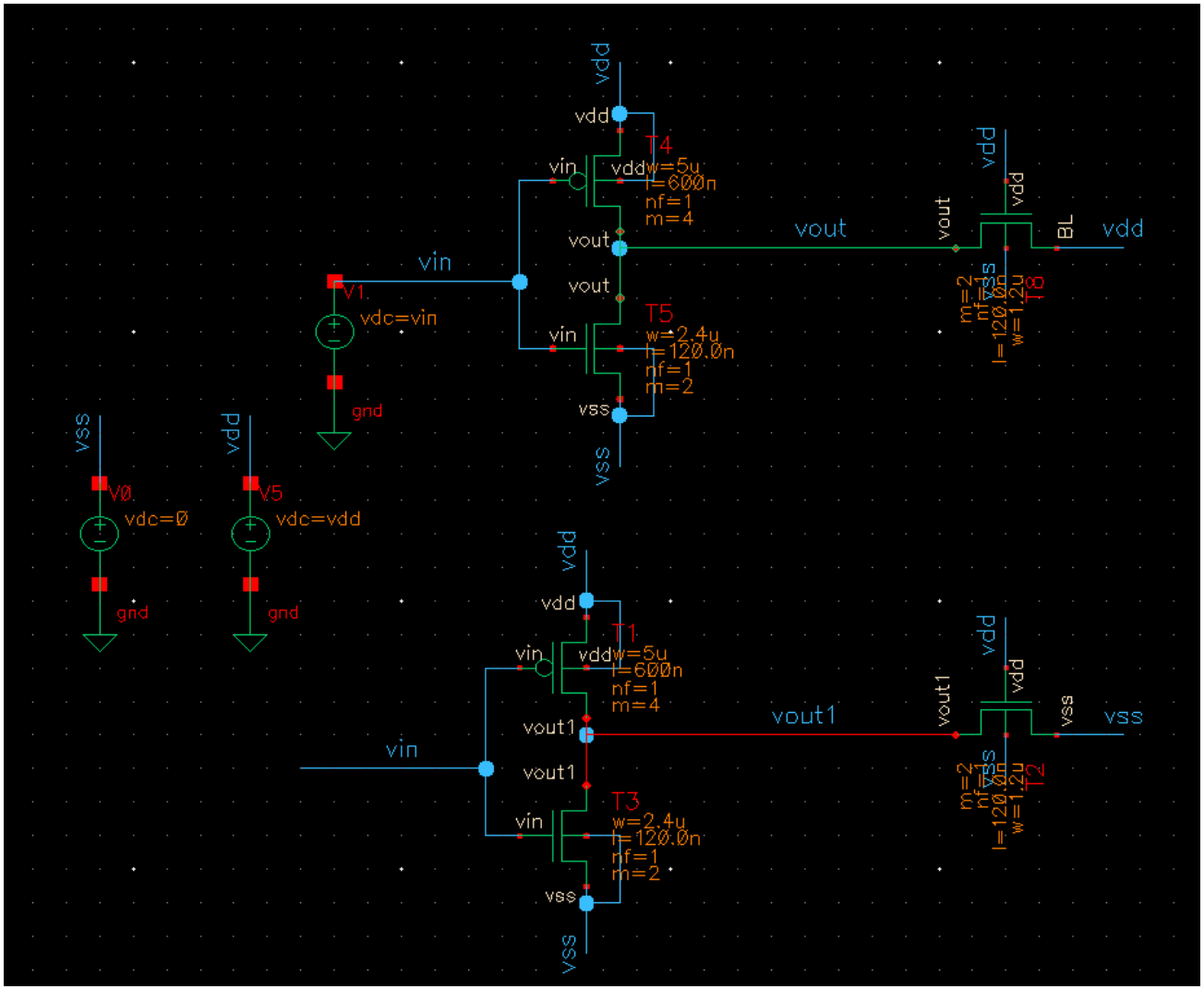
- Fit the largest square in the butterfly
  - Two stable states (0 and 1)
- A higher SNM indicates better read stability

SRAM Write Noise Margin (WNM)

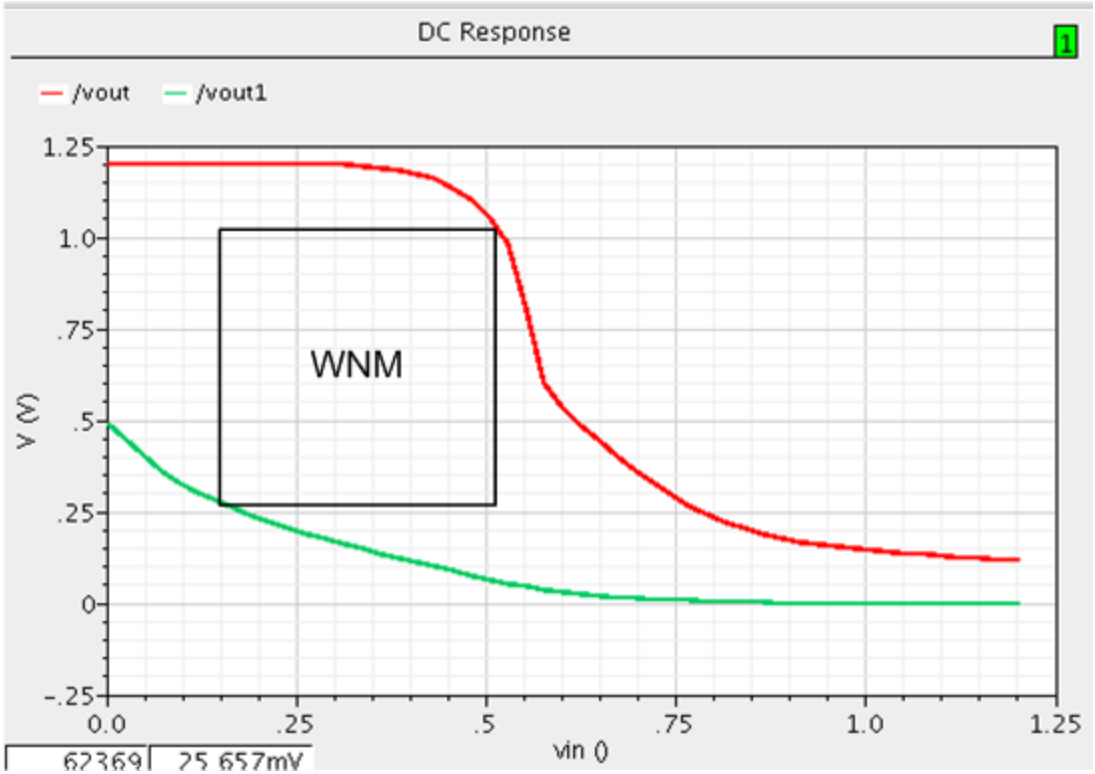
- During a write, WL is at $V_{DD,}$ and the data is driven onto the BLs
- Break the feedback from the cross-coupled inverters
- Plot voltage transfer characteristics (VTCs) of the *inverter* in the half circuit as shown below (V_2 *vs* V_1 and V_1 *vs* V_2)
- Here, VTCs of the two halves are not the same
  - Since one of the BL is driven to V_{DD} and other to 0 (asymmetry).
  - Write NM is the side of the largest square fitted in between the two curves



Write NM Test Bench



Write Butterfly Plot



- Fit the largest square between the curves
  - Two stable states (0 and 1)
- A higher WNM indicates better write stability