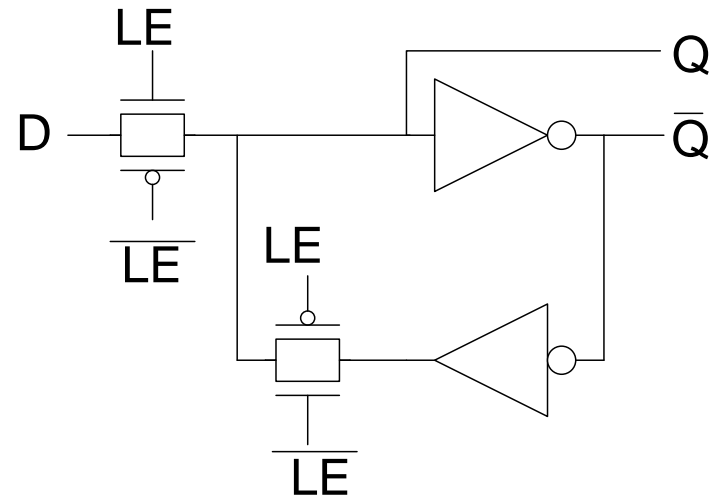
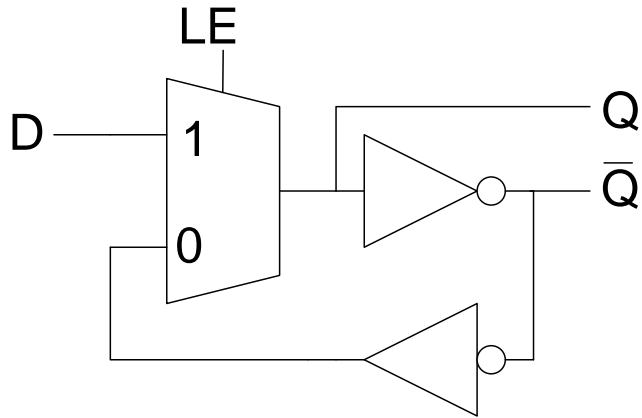
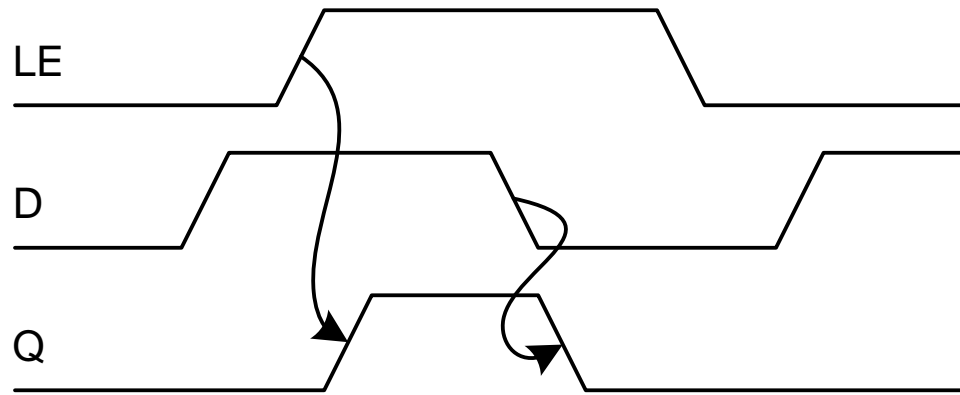
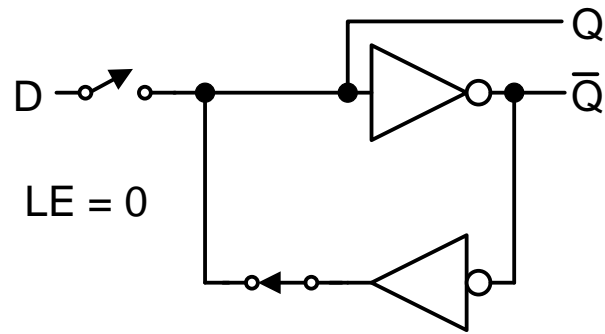
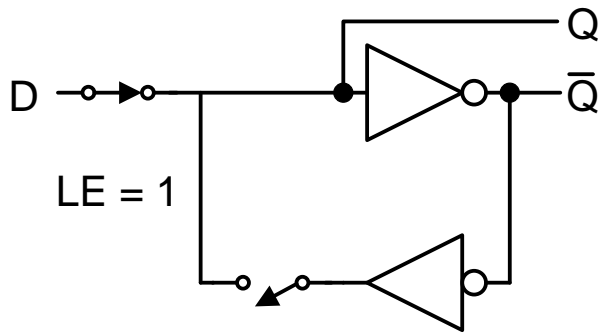


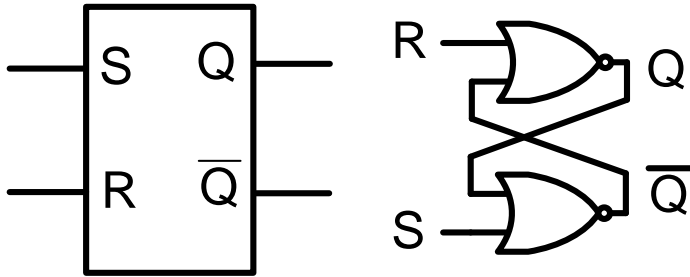
Flip-Flopovi i memorije

Standard sequential circuits – D latch

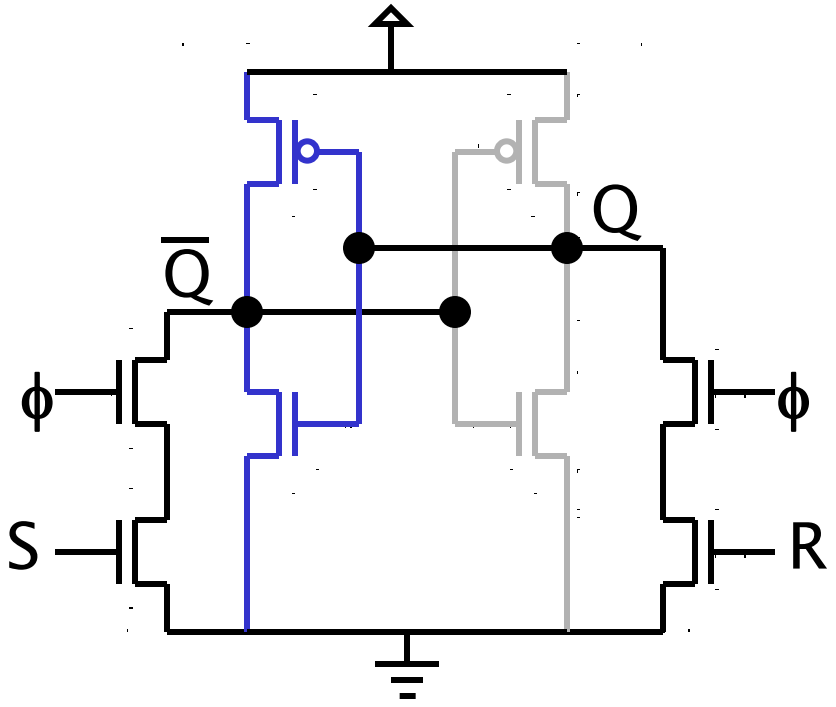
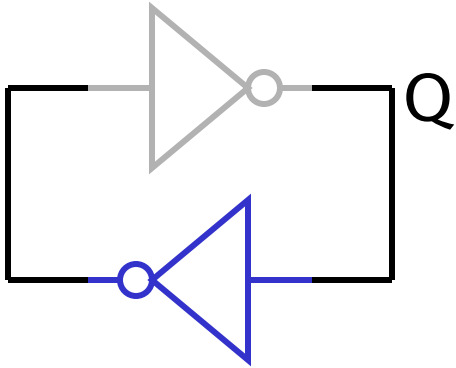




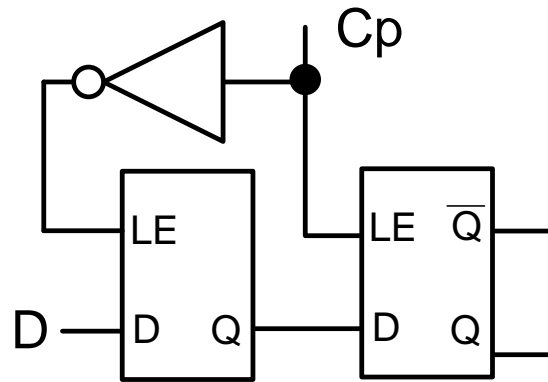
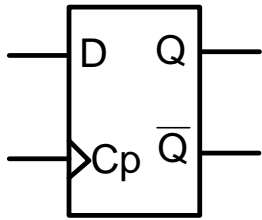
Standard sequential circuits – SR latch



R	S	Q[n+1]
0	0	Q[n]
0	1	1
1	0	0
1	1	?

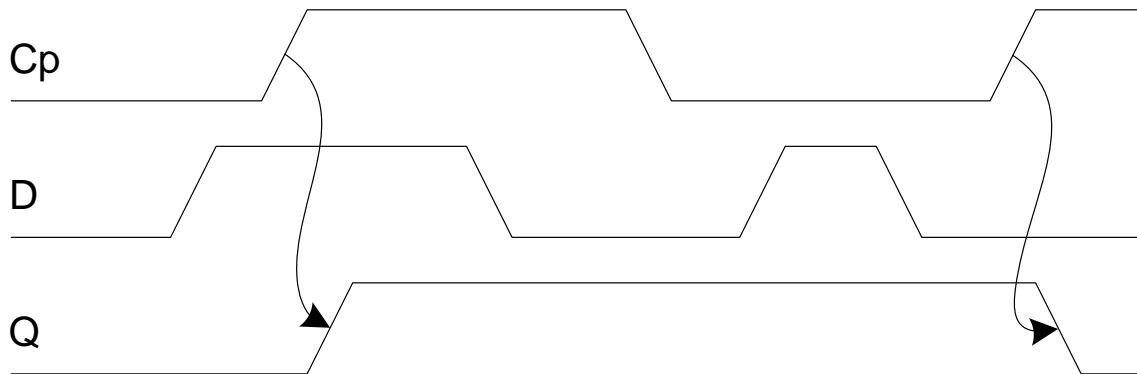
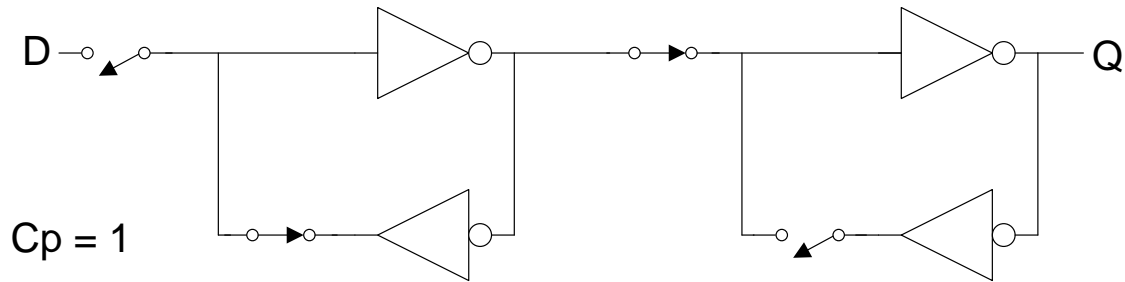
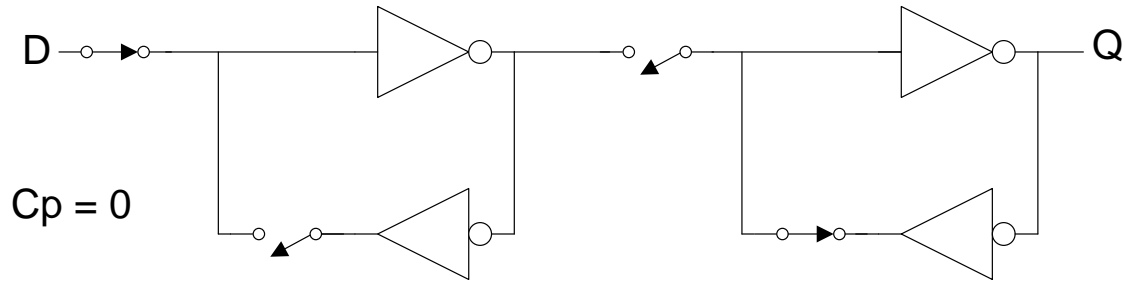


Standard sequential circuits – D FF

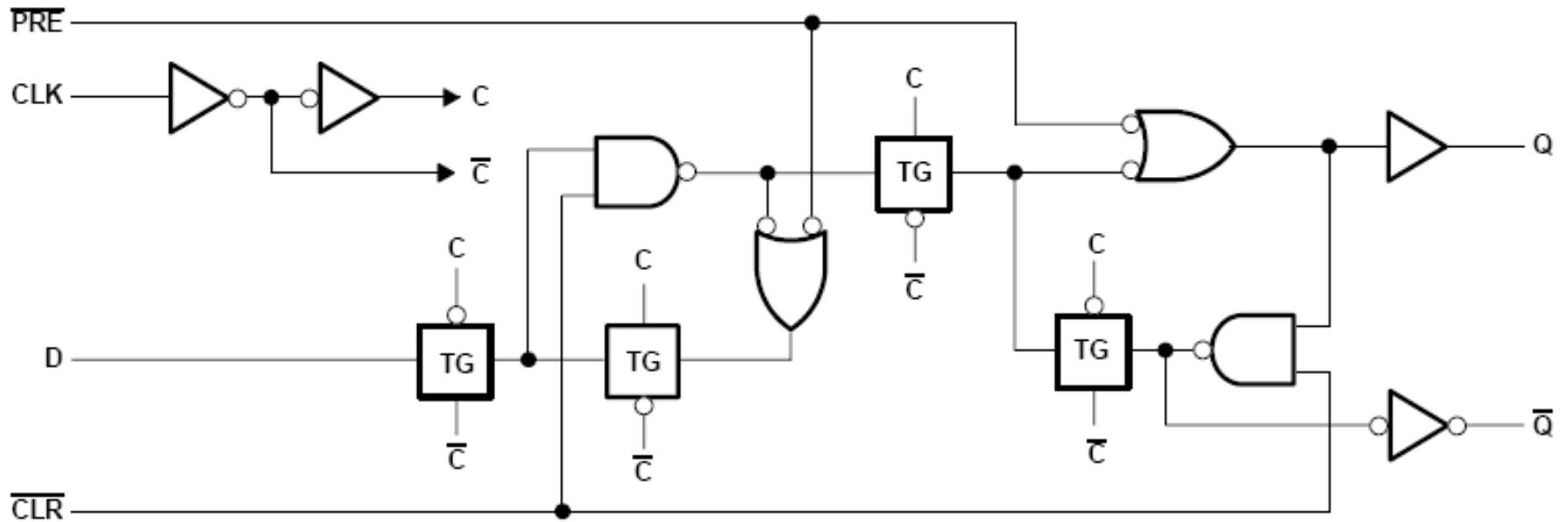
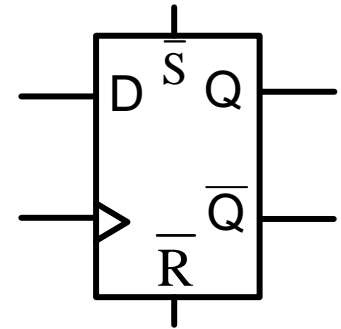


D	Cp	Q[n+1]
x	0	Q[n]
0	0 → 1	0
1	0 → 1	1
x	1	Q[n]

D FF master-slave operation

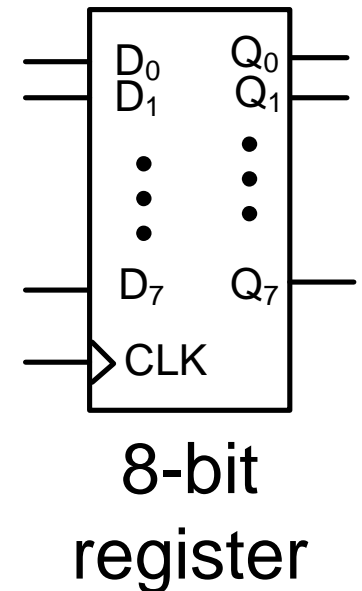
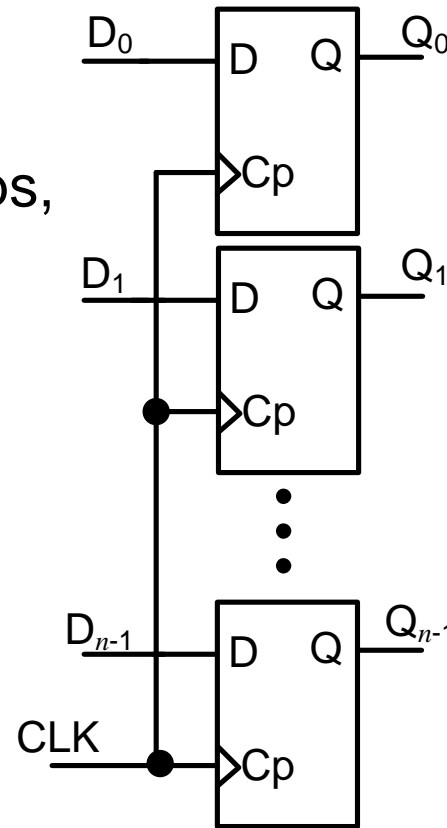


D FF with preset and clear



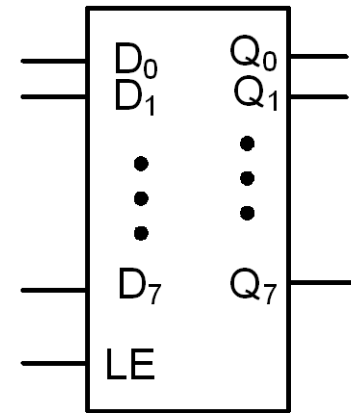
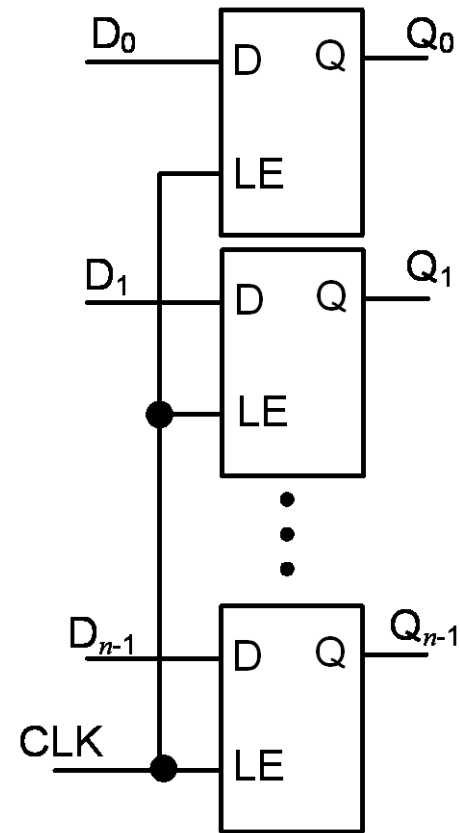
Registers

- n -bit register is a set of n D flip-flops, one per bit
- Data inputs are D_0, D_1, \dots, D_{n-1}
- Data outputs are Q_0, Q_1, \dots, Q_{n-1}
- Common Clock for all flip-flops
- Optional preset or clear



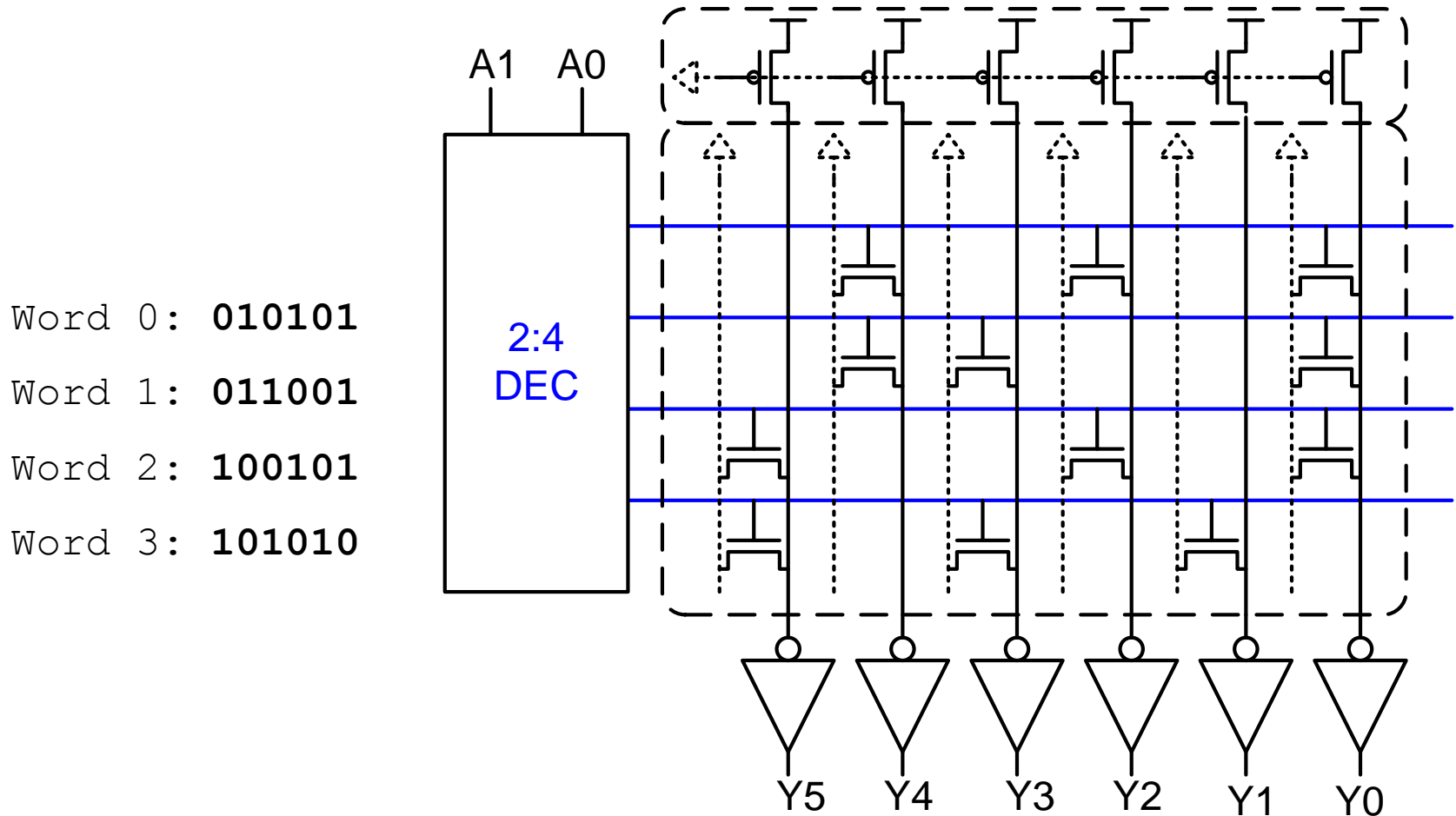
n bit latch

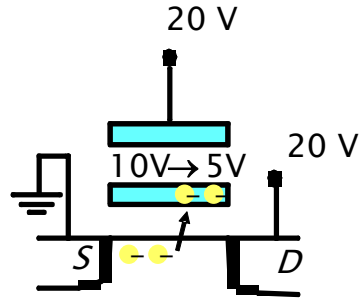
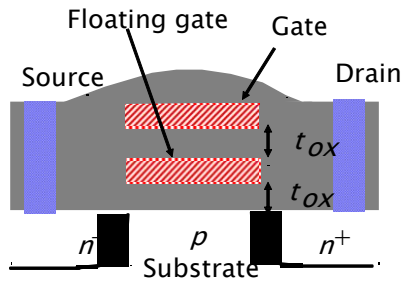
- n -bit latch is a set of n single bit latches, one per bit
- Data inputs are D_0, D_1, \dots, D_{n-1}
- Data outputs are Q_0, Q_1, \dots, Q_{n-1}
- Common LE for all latches
- Optional preset or clear



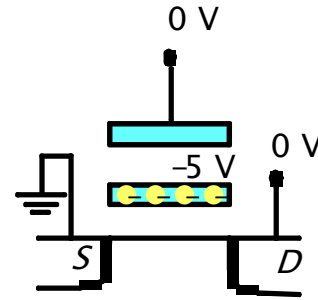
**8-bit
latch**

ROM 4 × 6bit

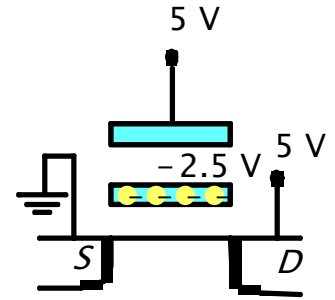




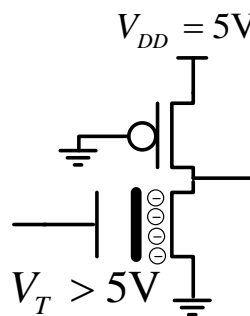
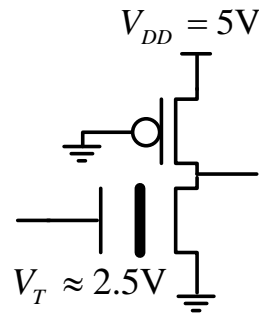
Avalanche injection.



Removing programming voltage leaves charges trapped

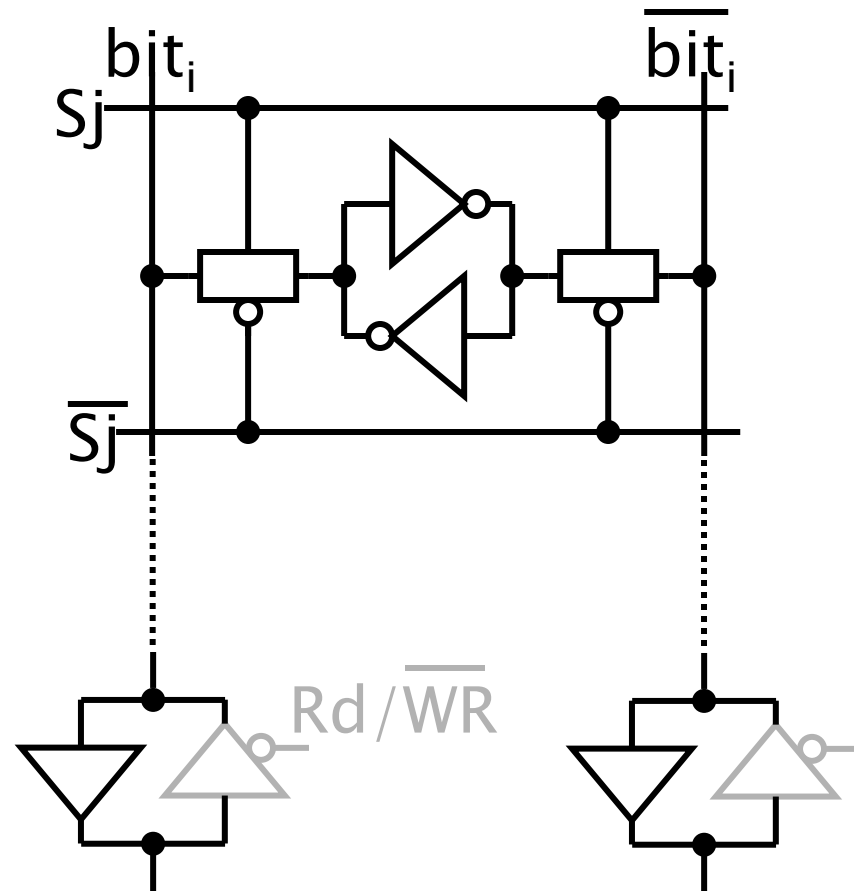


Programming results in higher V_T



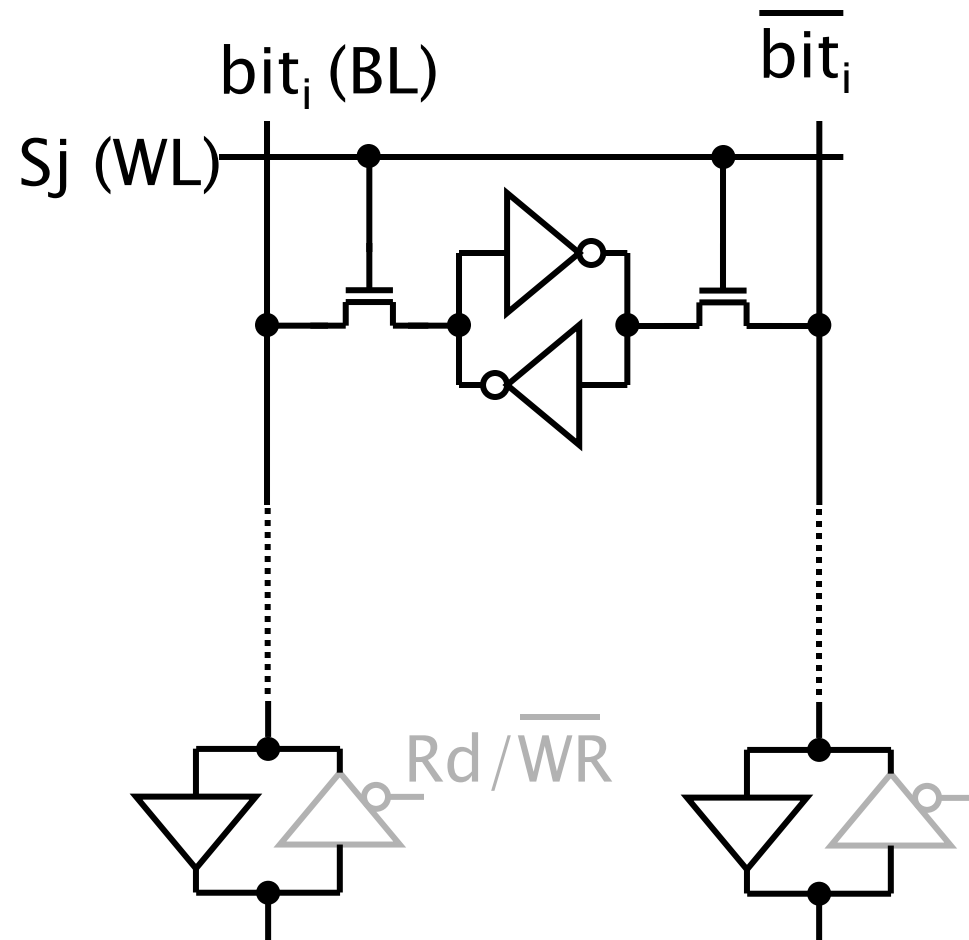
Memory Cell: Static RAM (8 transistors)

- 8-transistor cell
 - Bit_i is the data bus
 - S_j is the word line
- **Bus drivers**
 - Sense Amplifier (inverter with high gain) used for fast switching
 - Make sure inverters in cell are weaker than the combination of “write buffer” and pass transistor



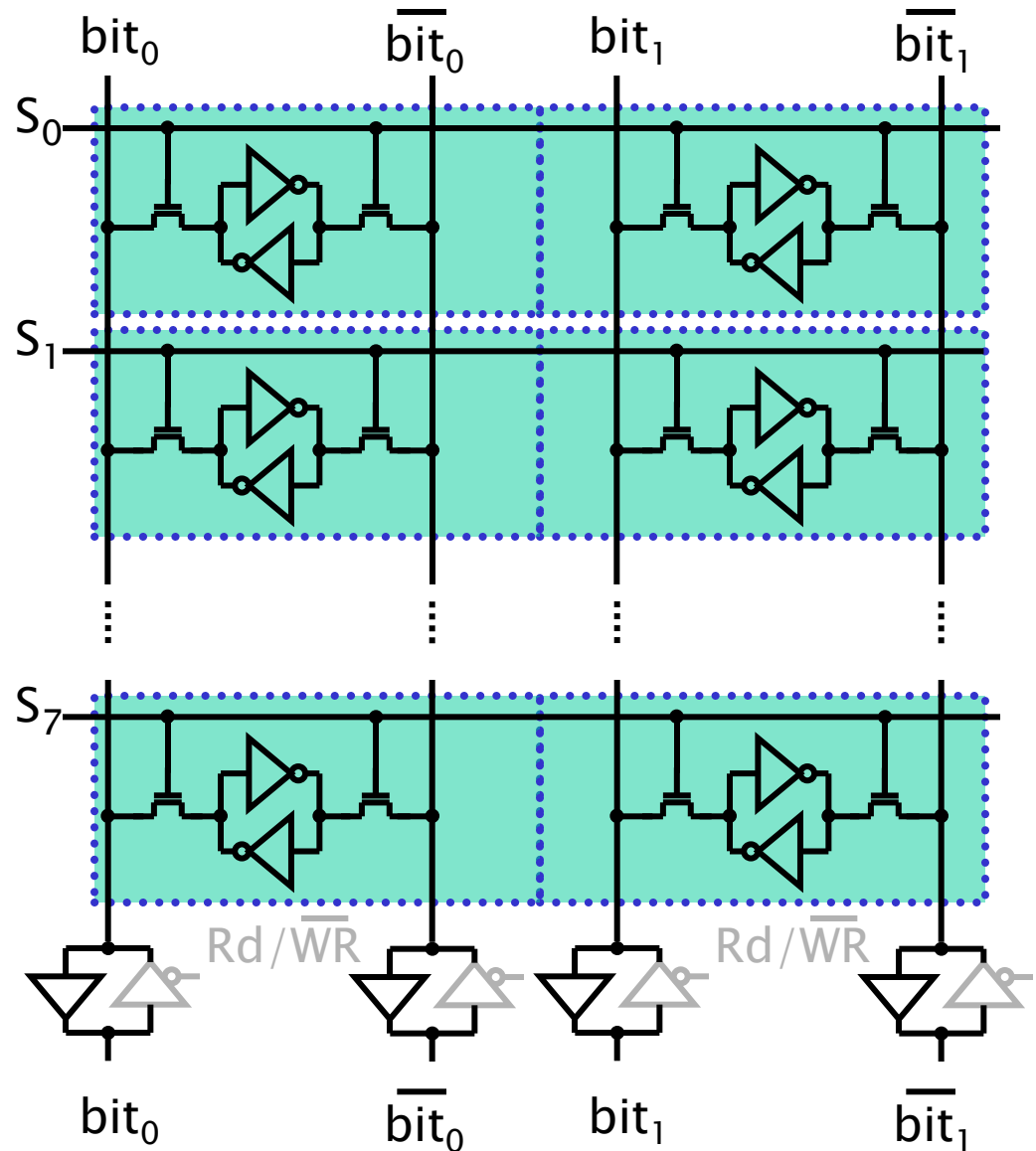
Memory Cell: Static RAM (6 transistors)

- 6-transistor cell
 - Must adjust inverters for input coming through n-type pass gate
- Bus drivers
 - Must adjust senseAmp for input coming through n-type pass gate
 - Harder to drive 1 than 0 through write buffer (high resistance via n-transistor)
 - One side is sending 0 anyway (bit or bit') → written correctly



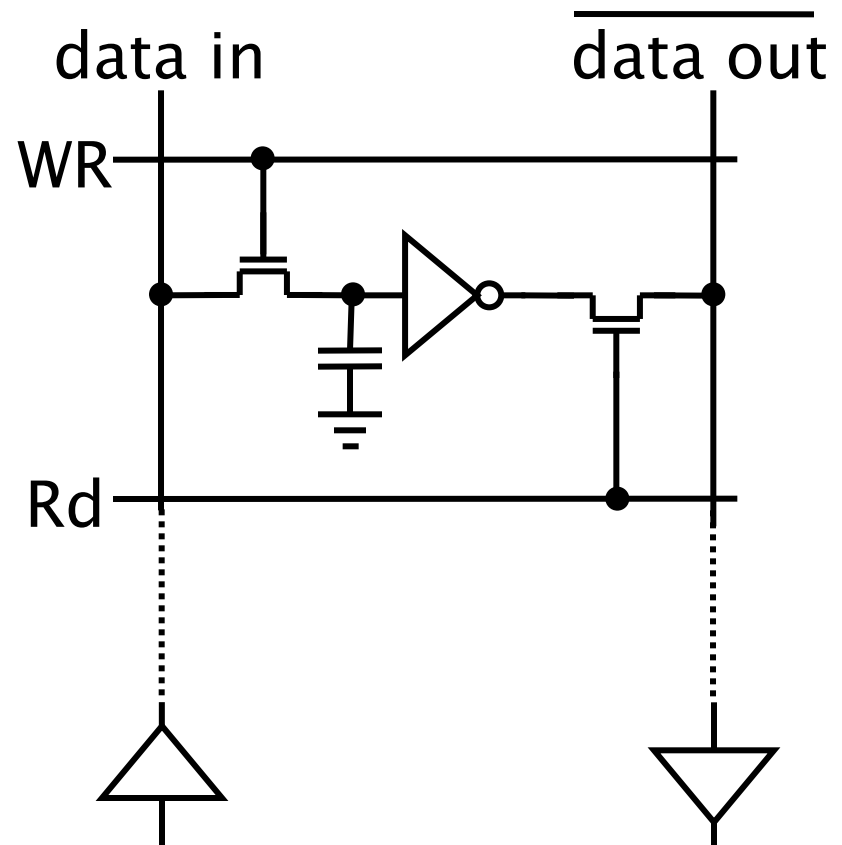
6-Transistor Memory Array

- 8 words deep RAM,
2 bits wide words
- To write to word j :
 - Set $S_j=1$, all other S lines to 0
 - Send data on the global $bit_0, \bar{bit}_0, bit_1, \bar{bit}_1$
- To read word k :
 - Set $S_k=1$, all other S lines to 0
 - Sense data on bit_0 and bit_1 .



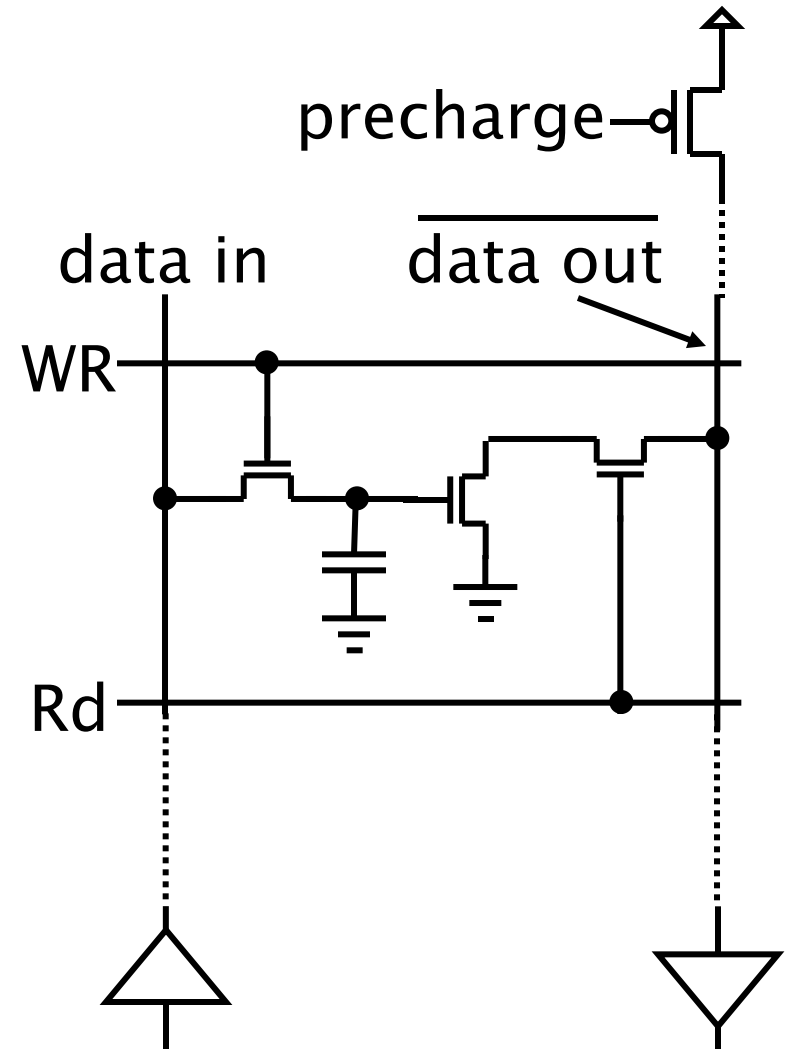
Dynamic RAM 4-Transistor Cell

- 4-transistor cell
- Dynamic charge storage must be refreshed
- Dedicated busses for reading and writing



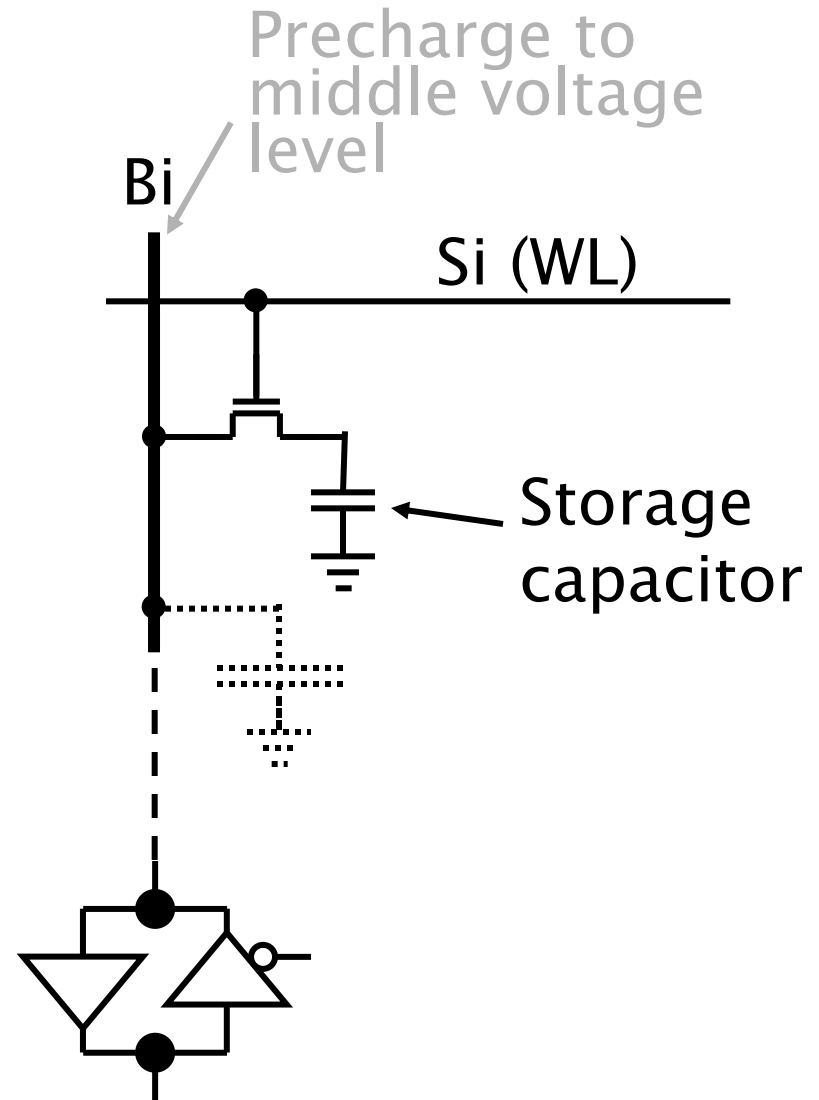
Dynamic RAM 3-Transistor Cell

- 3-transistor cell
 - No p-type transistors yield a very compact layout for cell
 - No V_{dd} connection
 - Sense Amplifier must be able to quickly detect dropping voltage

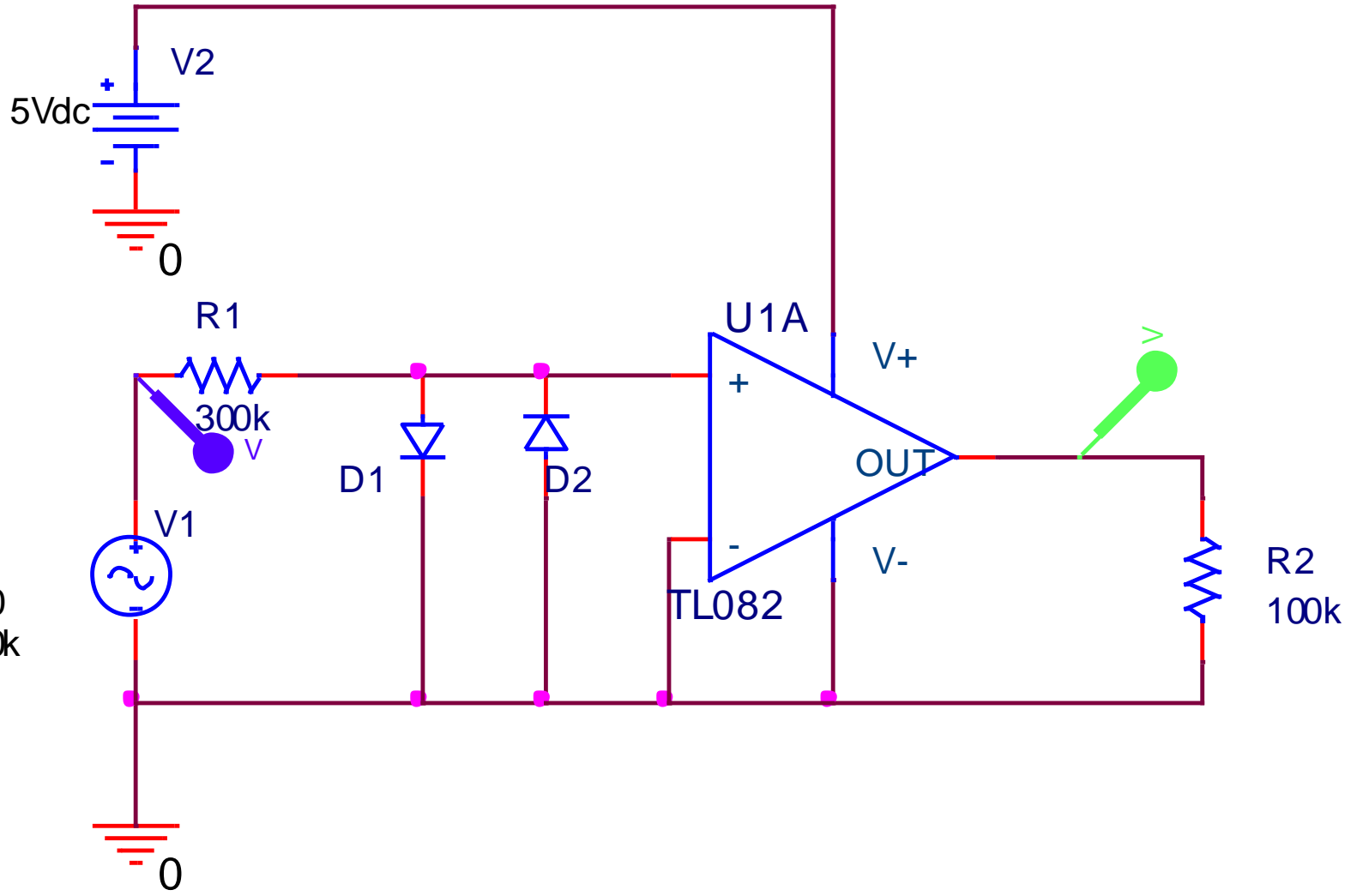


Dynamic RAM 1-Transistor Cell

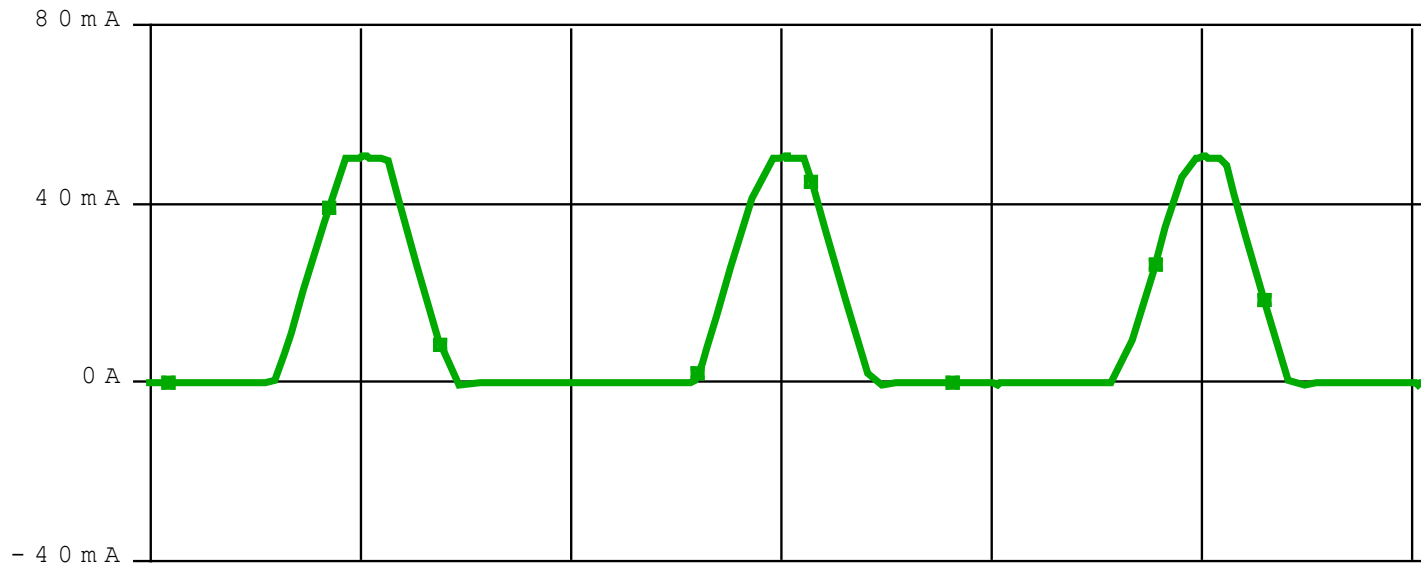
- 1-transistor cell
 - Storage capacitor is source of cell transistor
 - Special processing steps to make the storage capacitor large
 - Charge sharing with bus capacitance ($C_{\text{cell}} \ll C_{\text{bus}}$)
 - Extra demand on sense amplifier to detect small changes
 - Destructive read (must write immediately)



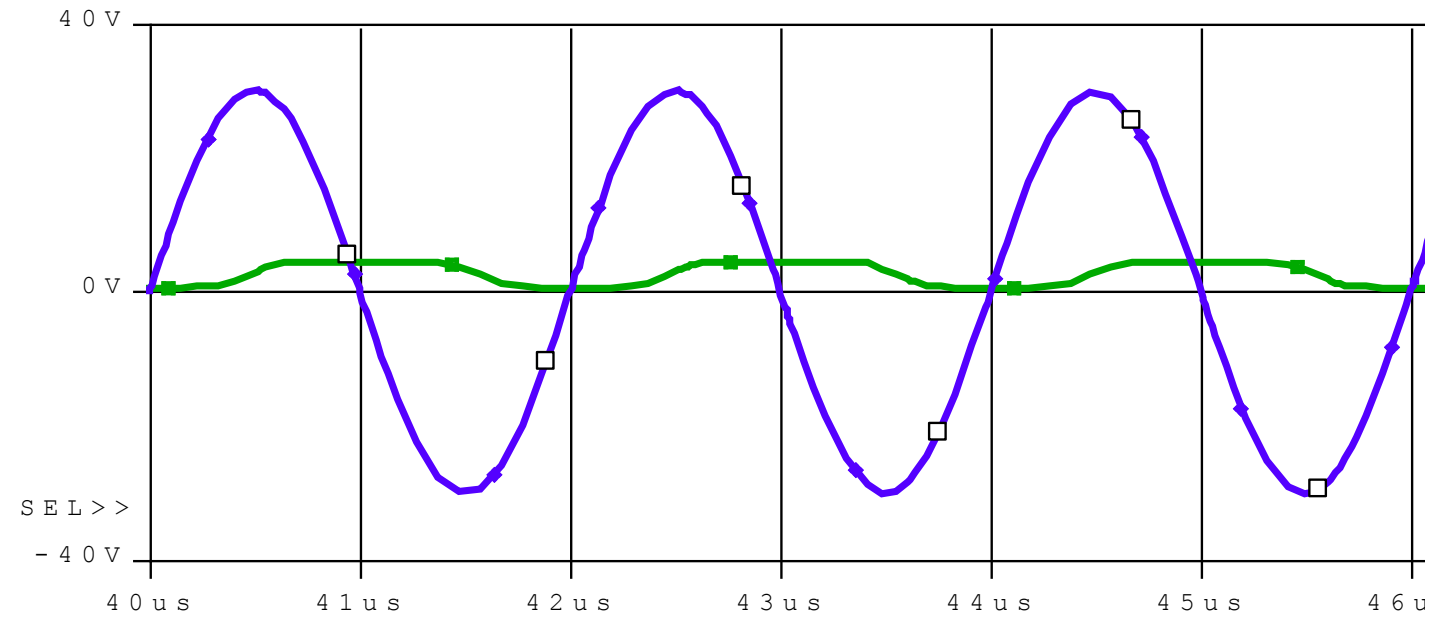
Komparatori



VOFF = 0
VAMPL = 30
FREQ = 500k



□ I (V 2)

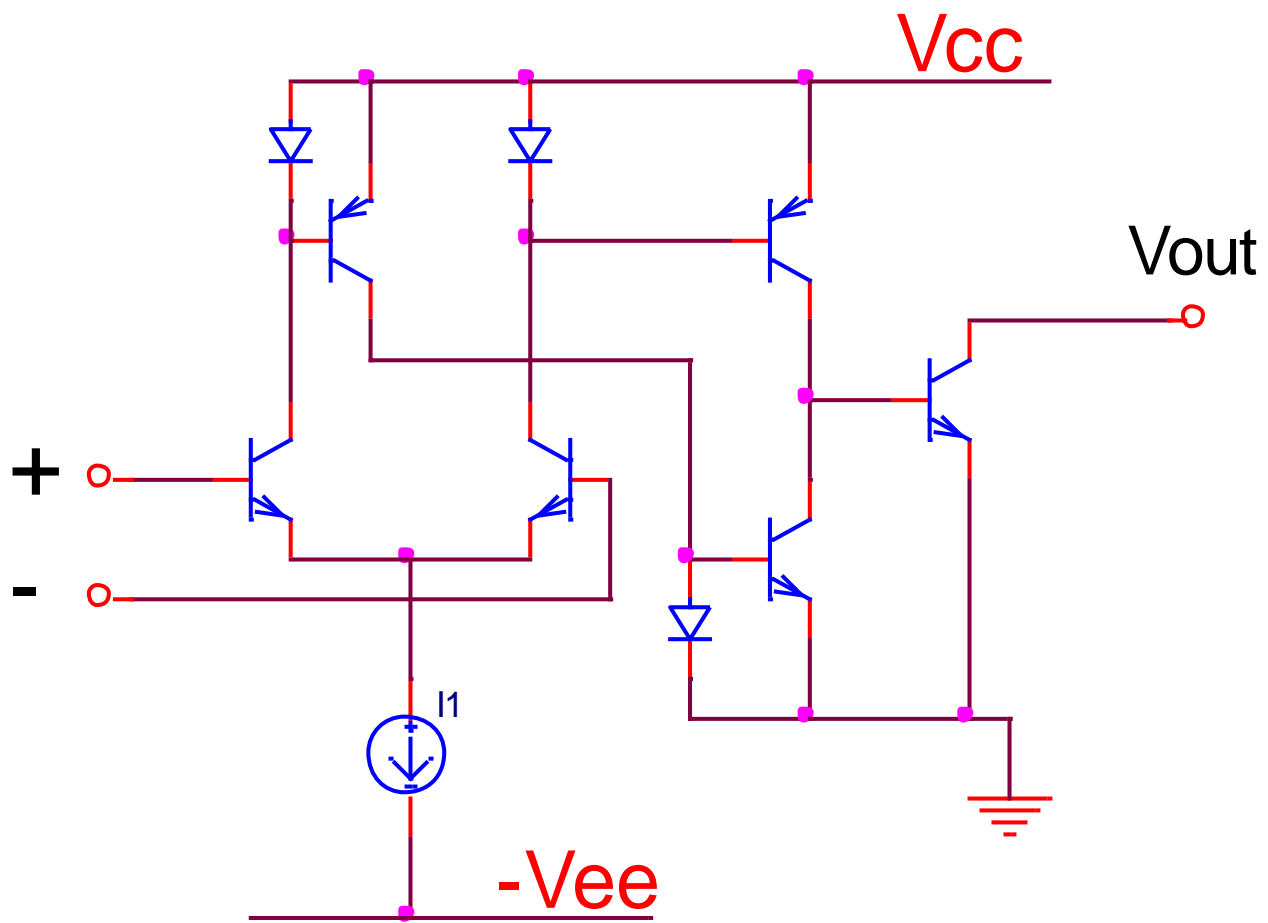


□ V (R 2 : 1) ◆ V (R 1 : 1)

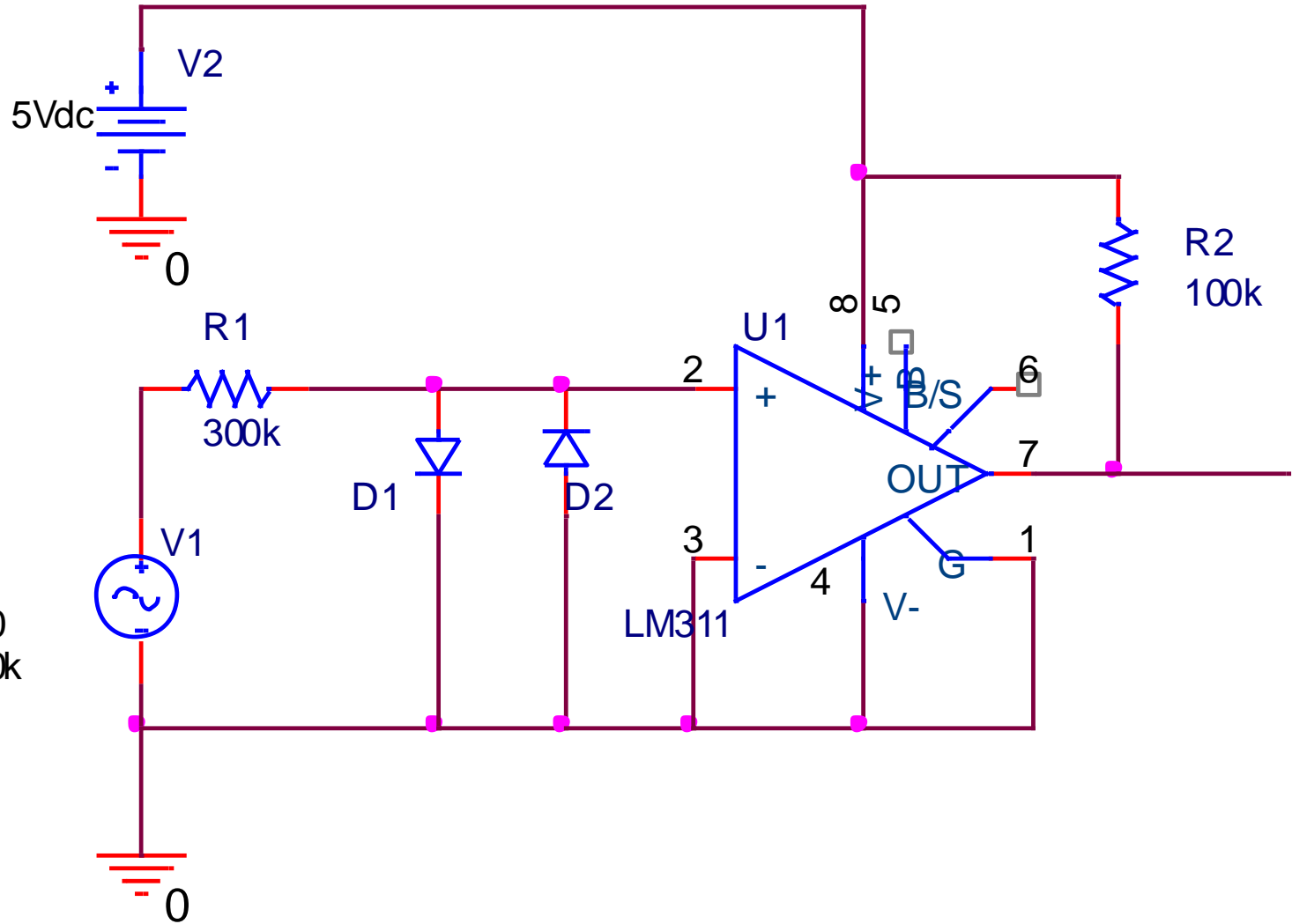
Time

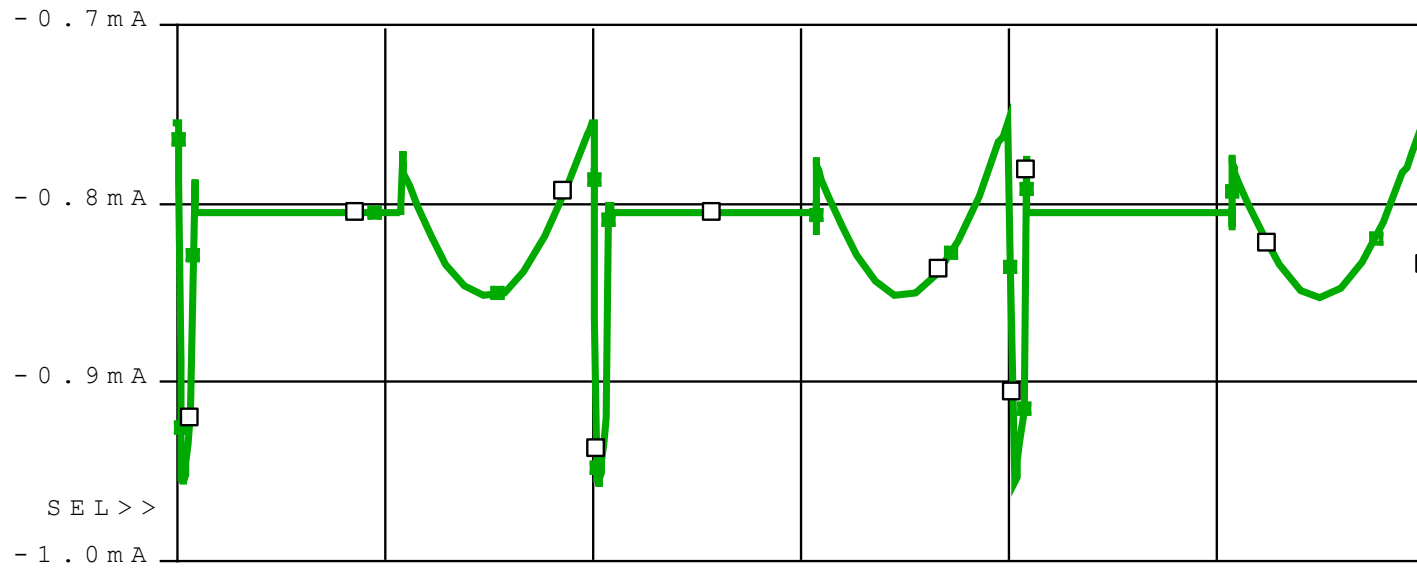
Diferencijalni komparator

- Po strukturi pojačavač
- Identičan simbol kao kod operacionog pojačavača
- sličan raspored pinova na integrisanom kolu kao kod operacionog pojačavača
- Interna struktura različita

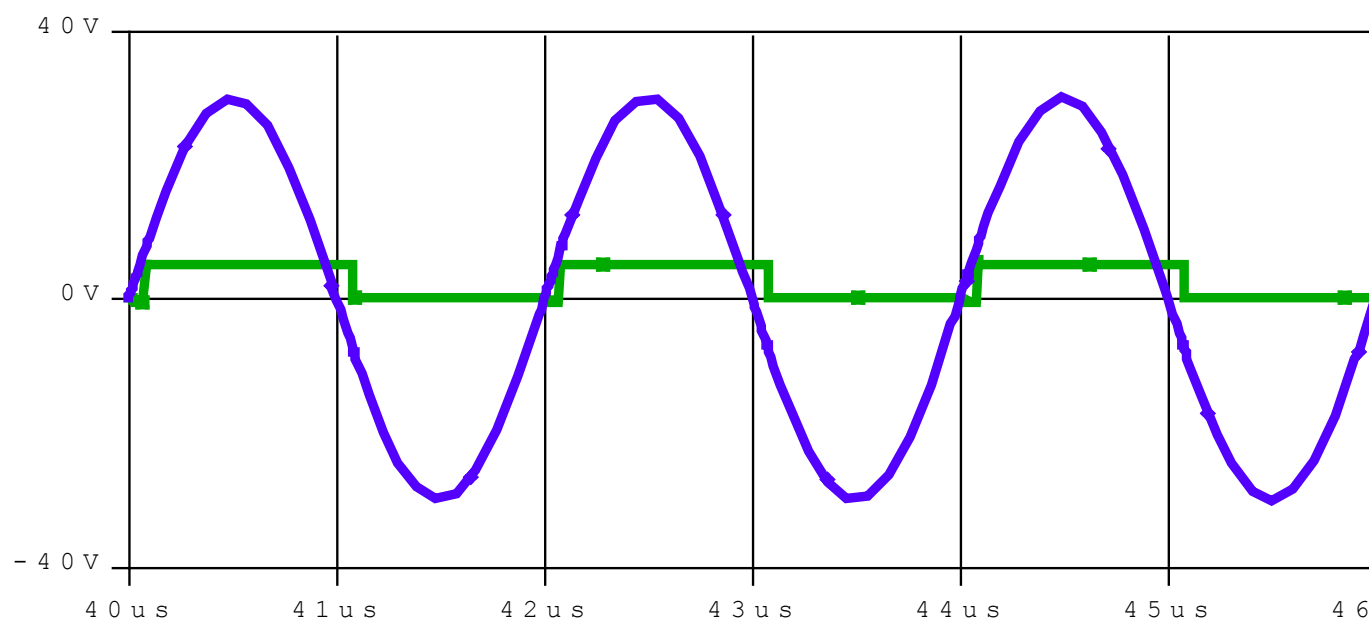


V_{OFF} = 0
V_{AMPL} = 30
FREQ = 500k



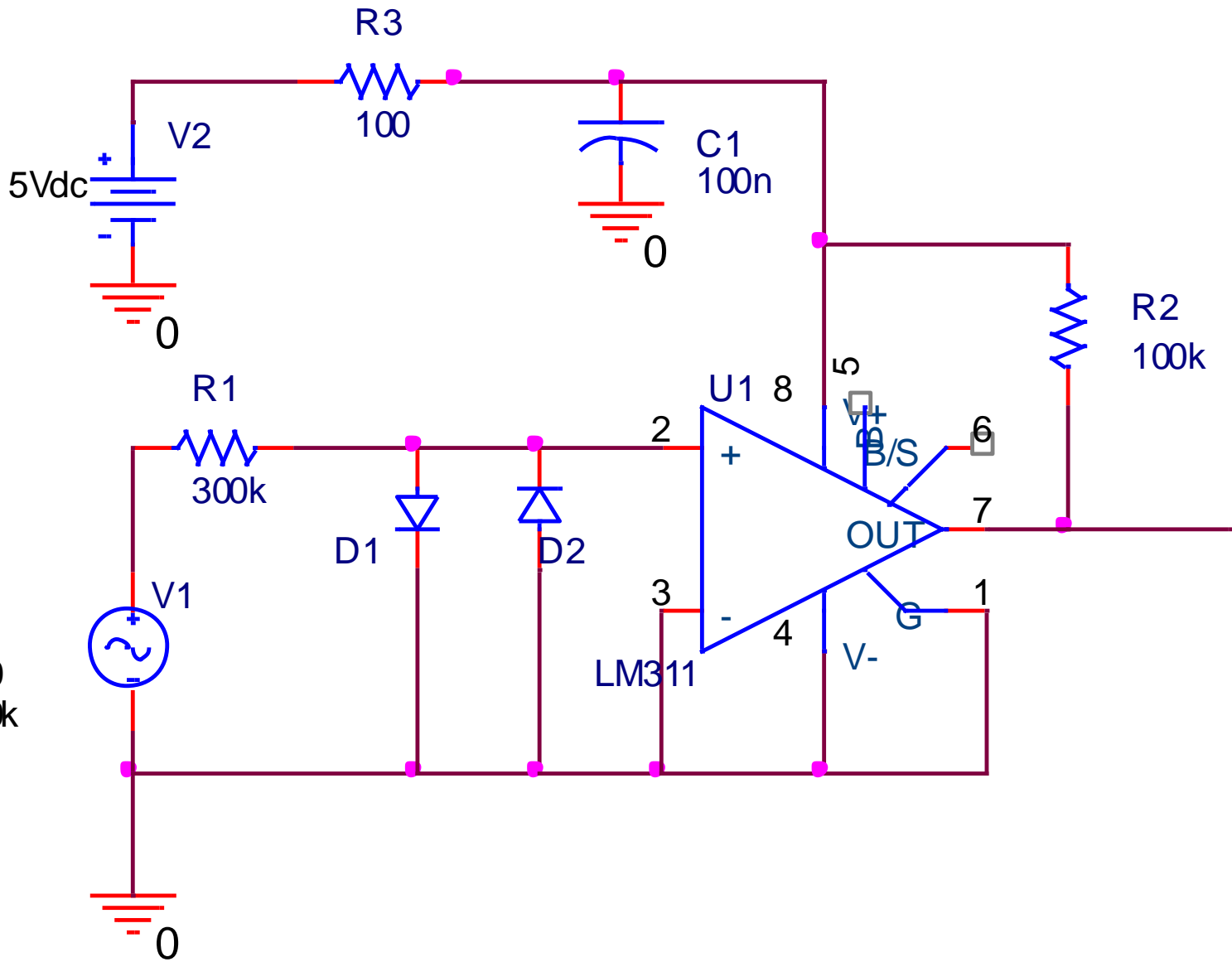


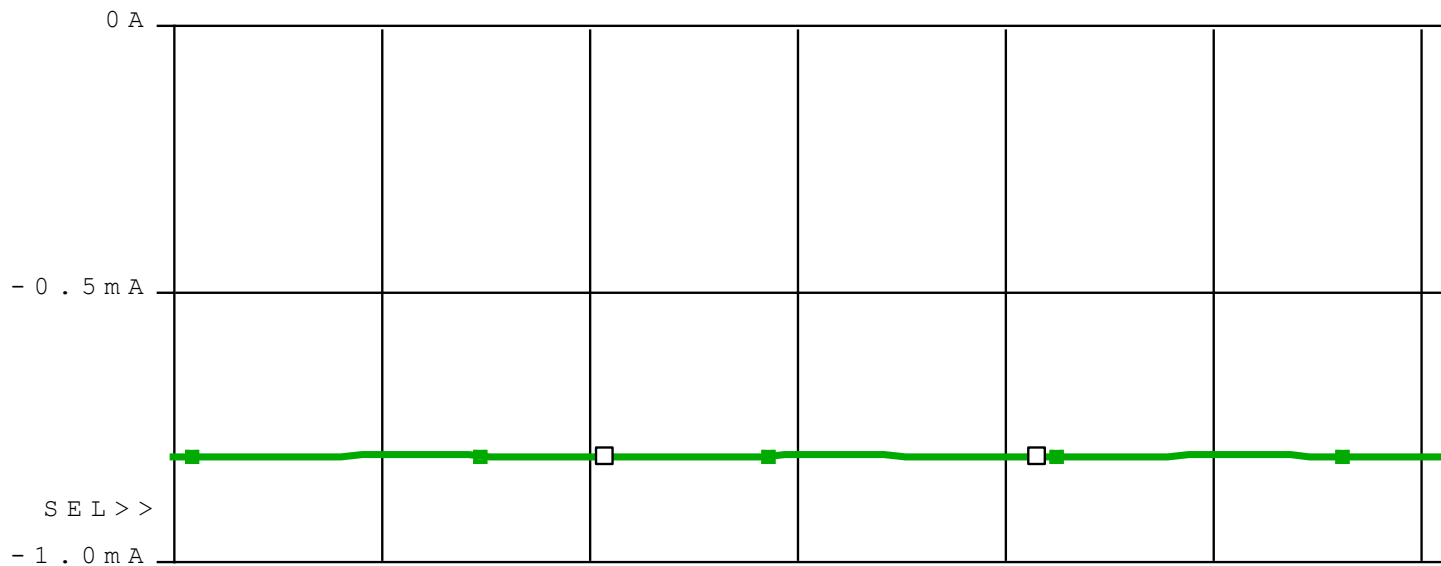
□ I (V 2)



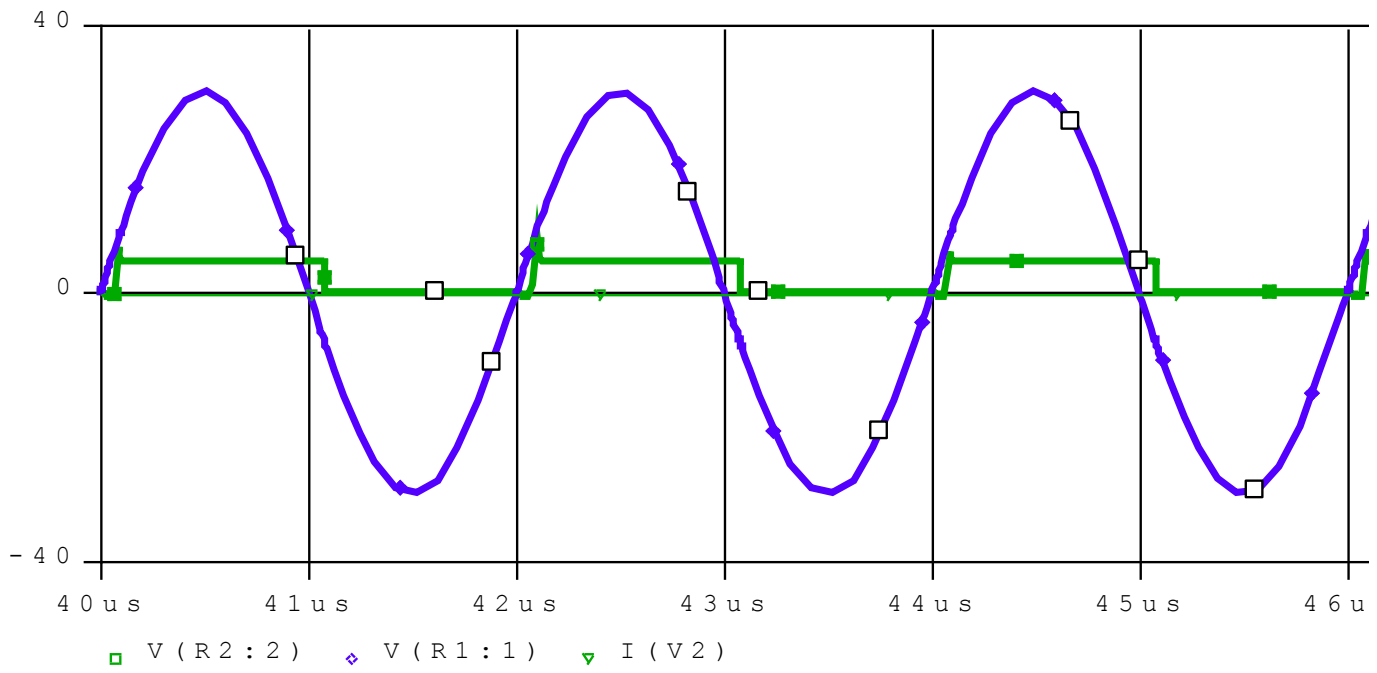
□ V (R 2 : 2) ◆ V (R 1 : 1)

Time





□ I (V 2)



Time

Operacioni pojačavač

- Ne radi dobro funkciju komparatora
- Radi dobro sa negativnom povratnom spregom

Komparator

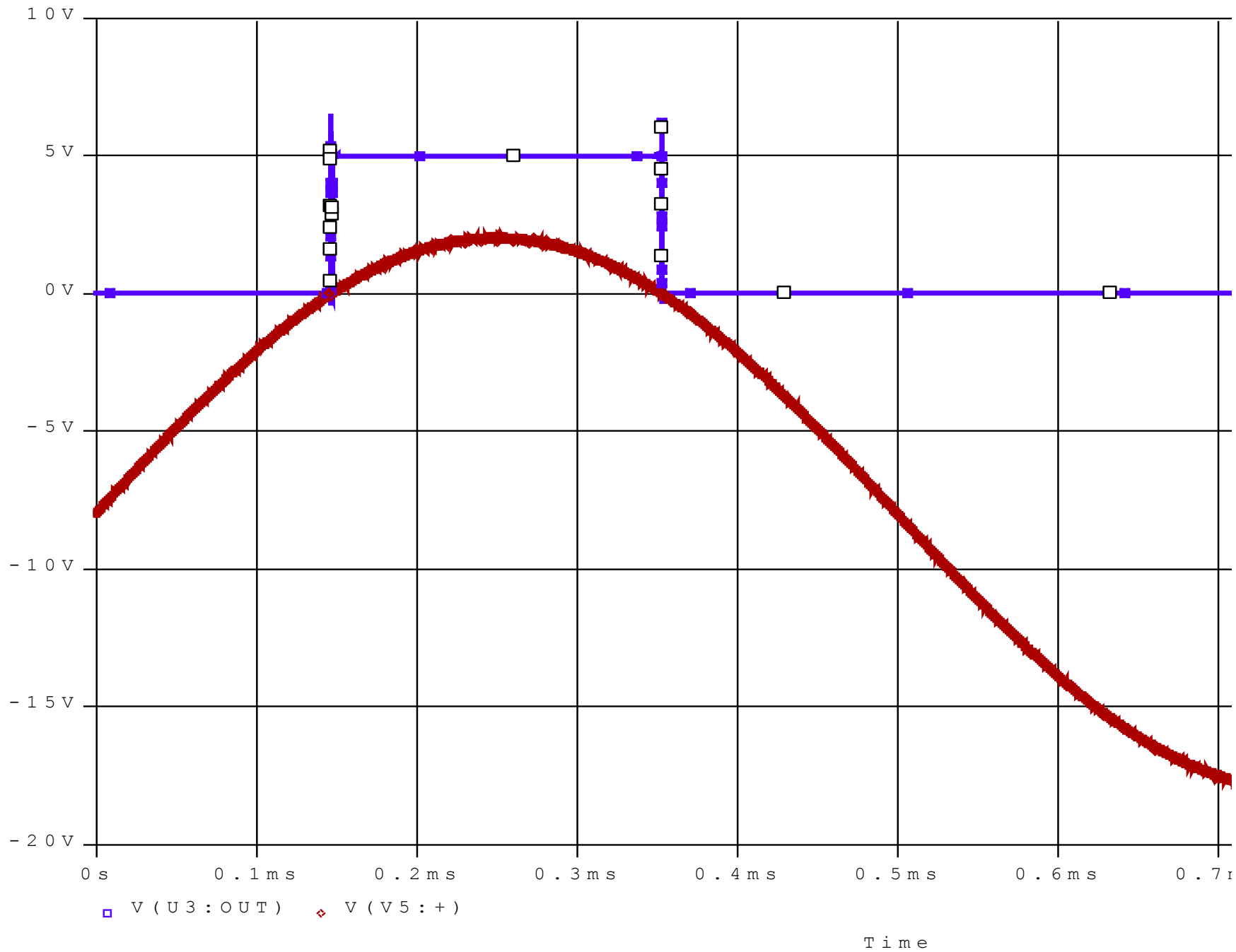
Ne radi dobro funkciju pojačavača

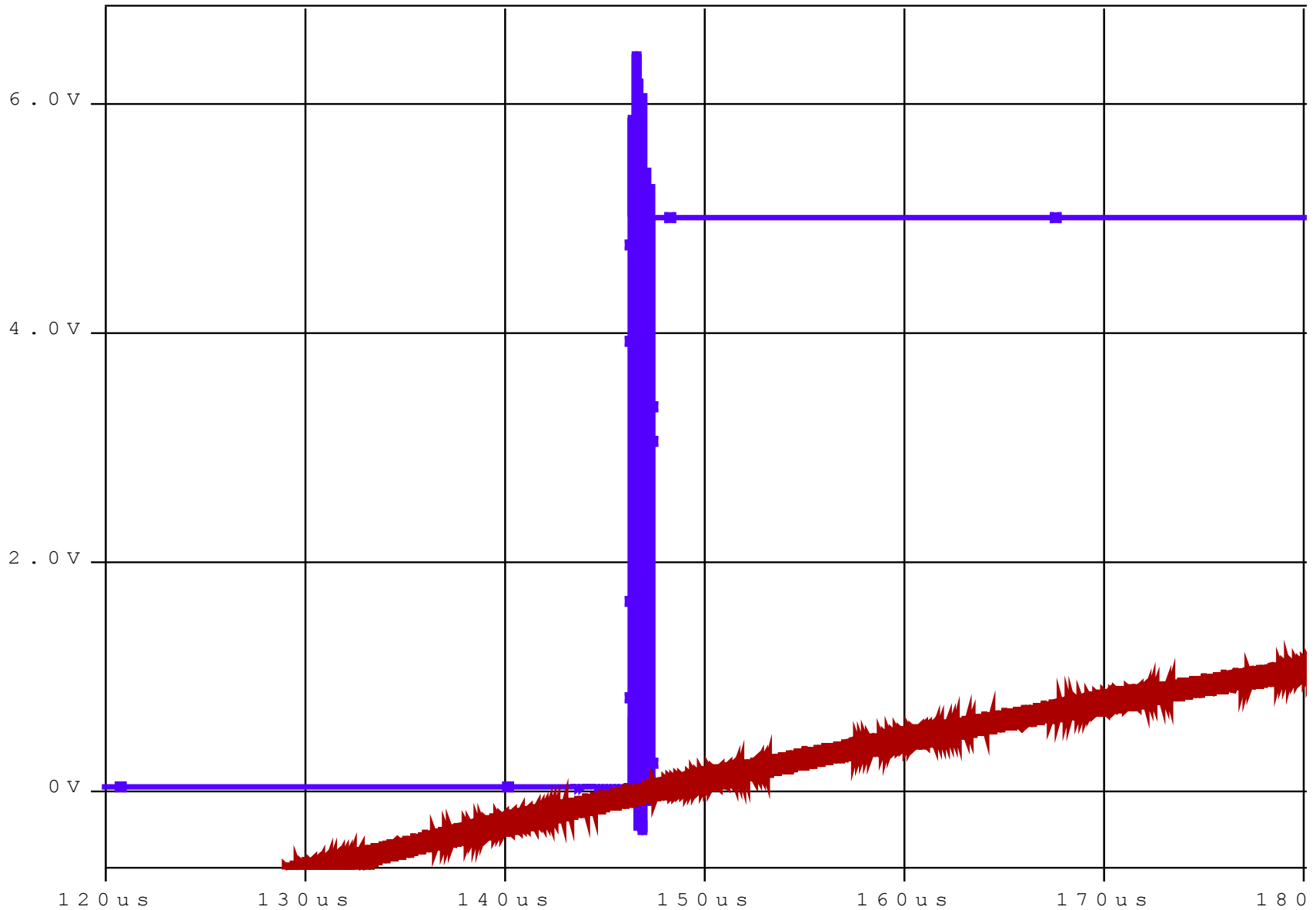
Ne radi dobro sa negativnom povratnom spregom

Poređenje ima smisla za isti red veličine cene

Komparatori sa histerezisom

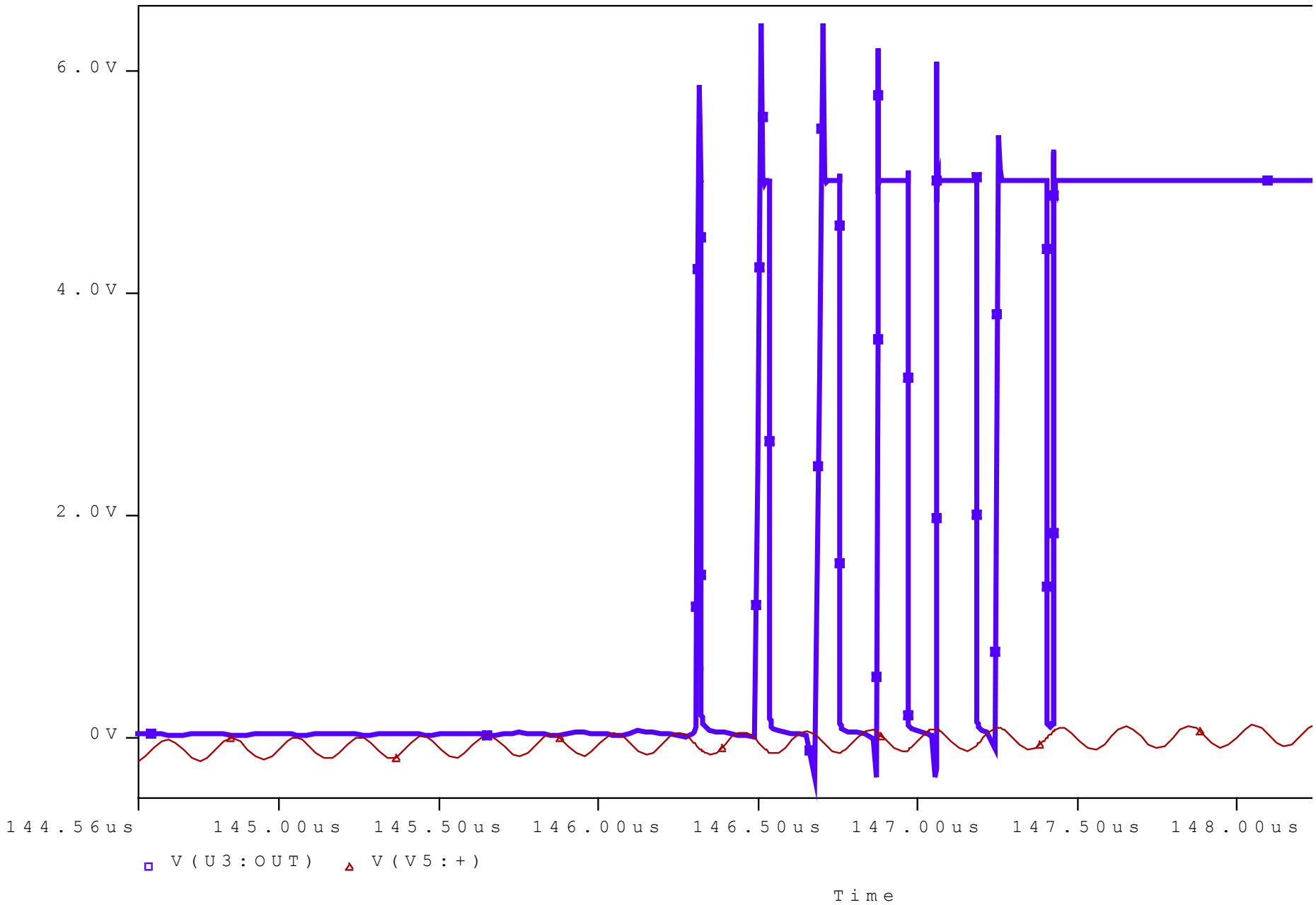
Šmitova kola





□ V(U3:OUT) ◆ V(V5:+)

Time



VOFF = 0
VAMPL = 0.1
FREQ = 5Meg

VOFF = -8
VAMPL = 10
FREQ = 1k

