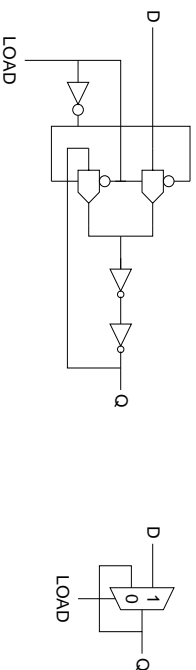


Latches and Flip-Flops

- CMOS transmission gate latch



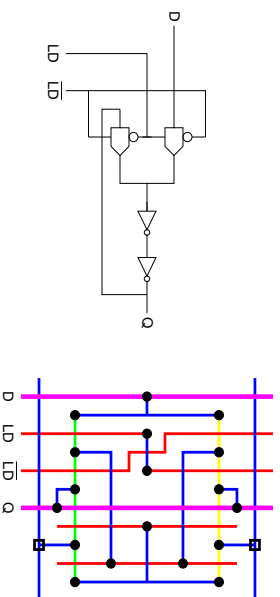
A simple transparent latch can be build around a transmission gate multiplexor

- transparent when load is high
- latched when load is low
- two inverters are required since the transmission gate cannot drive itself

8001

Latches and Flip-Flops

- Transmission gate latch layout

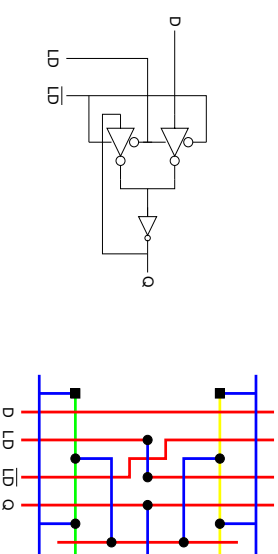


- a compact layout is possible using 2 layer metal

8002

Latches and Flip-Flops

- A simpler layout may be achieved using tristate inverters.

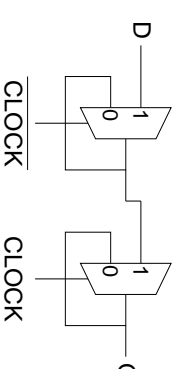


- this design requires two additional transistors but may well be more compact.

8003

Latches and Flip-Flops

- For use in simple synchronous circuits we use a pair of latches in a master slave configuration.

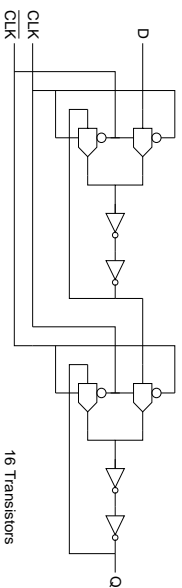


- this avoids the race condition in which a transparent latch drives a second transparent latch operating on the same clock phase.
- the circuit behaves as a rising edge triggered D type flip-flop.

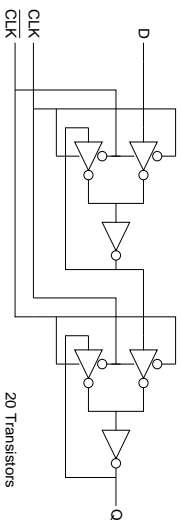
8004

Latches and Flip-Flops

- Transmission gate implementation



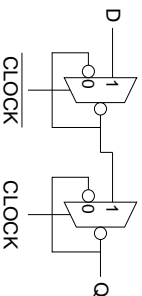
- Tristate inverter implementation



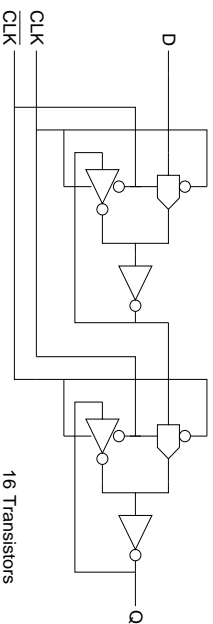
8005

Latches and Flip-Flops

- Alternative configuration



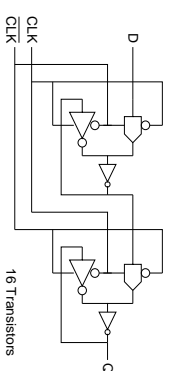
- Implementation



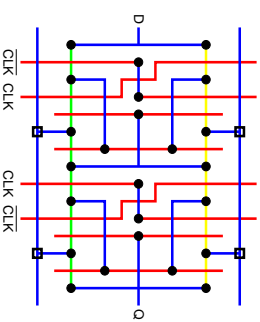
8006

Latches and Flip-Flops

- Layout of master slave D type.



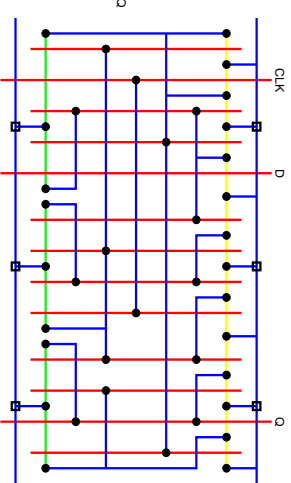
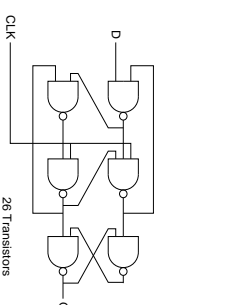
- very compact using alternative configuration.



8007

Latches and Flip-Flops

- For the same functionality we could use an edge triggered D type:

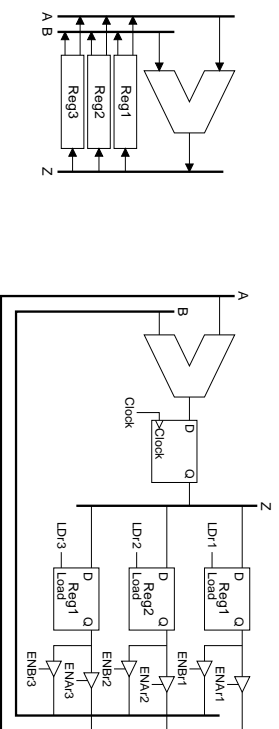


- a few more transistors
- more complex wiring
- simpler clock distribution

8008

Register File

Where we have large amounts of storage the use of individual latches can lead to space saving.



- Load signals must be glitch free with tightly controlled timing.
- Edge Triggered D-type prevents a race condition ($Reg1 \leftarrow Reg1 + Reg2$).