Lecture -6
# Sequential Circuit Design: Memory and Storage 3

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Read-Only Memory (ROM)

- A ROM contains permanently or semi permanently stored data.
- It can be read from the memory.
- Either it cannot be changed at all or cannot be changed without specialized equipment.
- ROMs retain stored data when the power is off and are therefore nonvolatile memories.

ROM Family
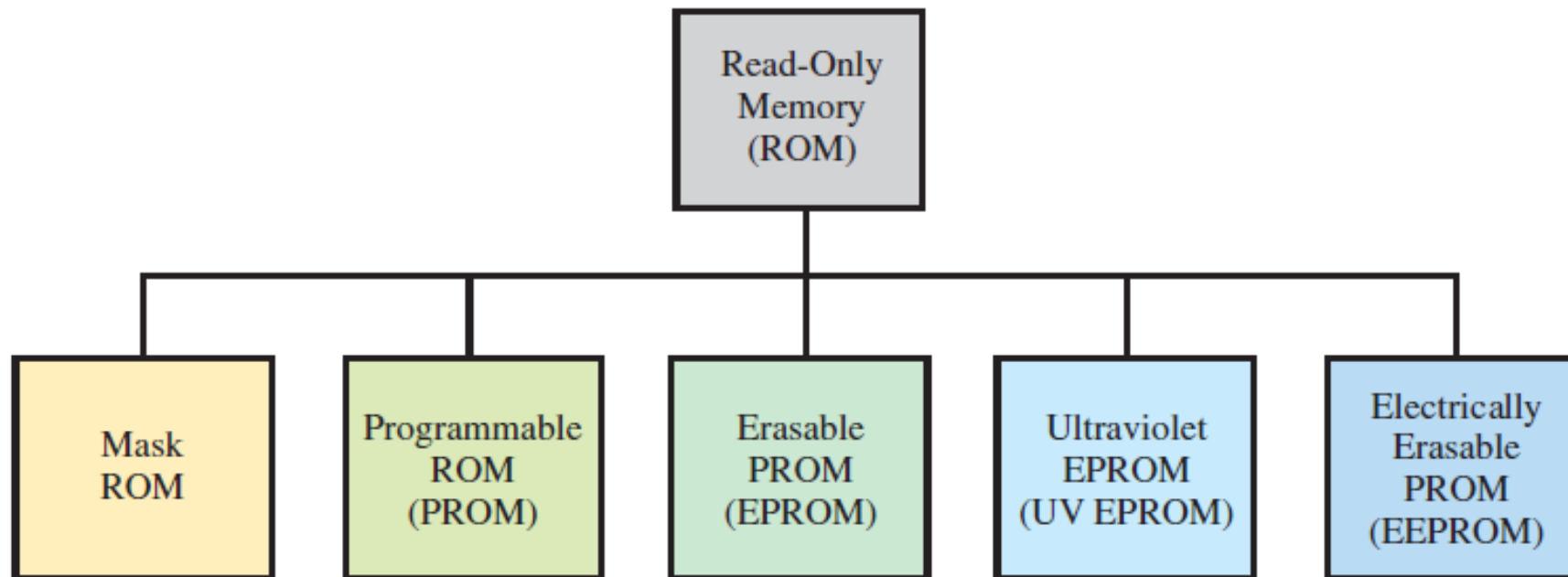
Mask ROM

- The mask ROM is usually referred to simply as a ROM.
- It is permanently programmed during the manufacturing process.
- It can provide widely used standard functions, such as popular conversions, or to provide user-specified functions.
- Once memory is programmed it cannot be changed.
- A connection with the Row line to the gate of the transistor represents a stored 1.
- A missing connection with Row line to gate of the transistor represents a stored 0.

Storing a 1

Storing a 0
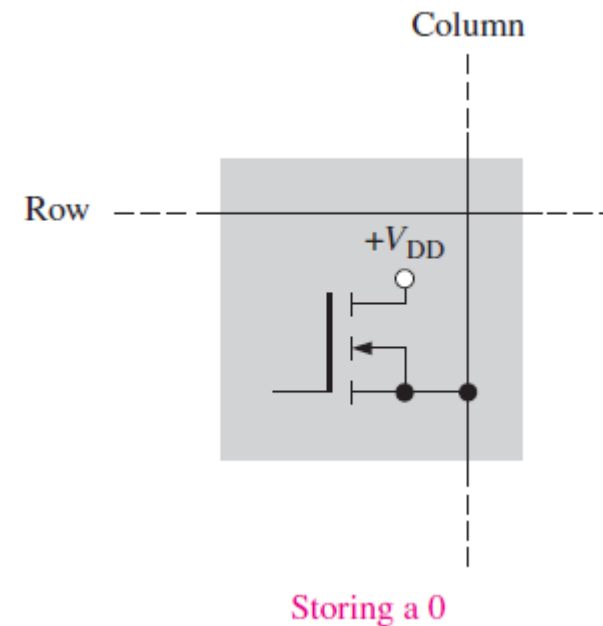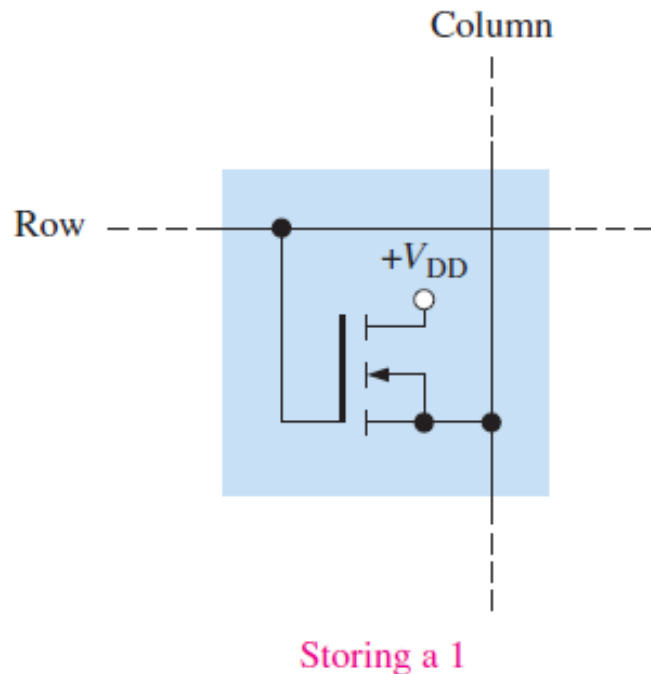
Read Operation:
- The blue squares represents stored 1.
- The gray squares represents stored 0.
- When binary address code is applied, corresponding row line becomes HIGH.
- Where there is 1 stored, the HIGH gets connected to the column line.
- Where there is 0 stored, the column line remains LOW.
- The column lines form the output line.
- The data stored in the row appears in the data line.
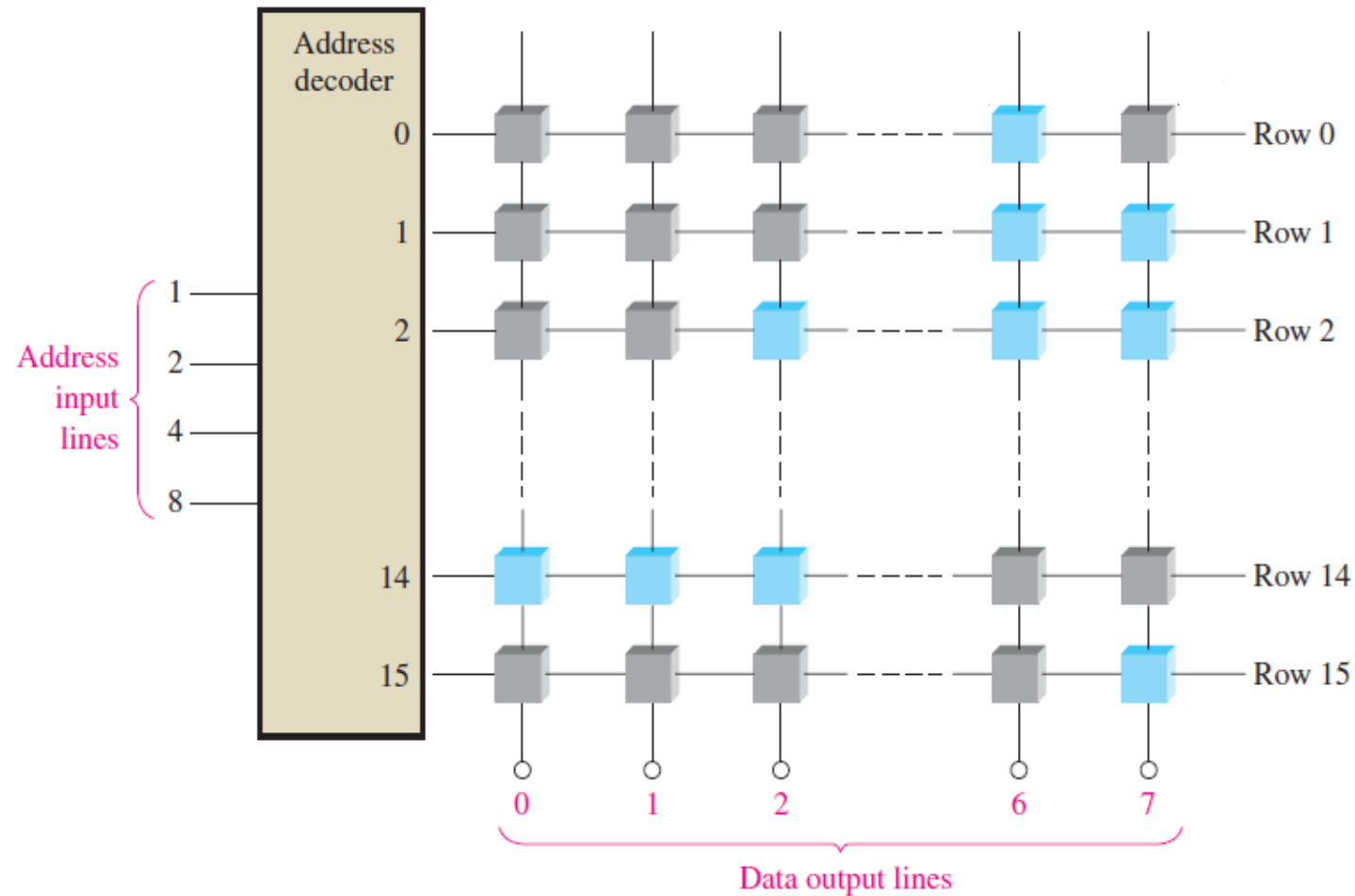
A 16 X 8-bit ROM array

ROM Access Time

- The access time, t_a, of a ROM is the time from the application of a valid address code on the input lines until the appearance of valid output data.
- Access time can also be measured from activation of the chip select ($\overline{CS}$) input to the occurrence of valid output data when a valid address is already on the input lines.
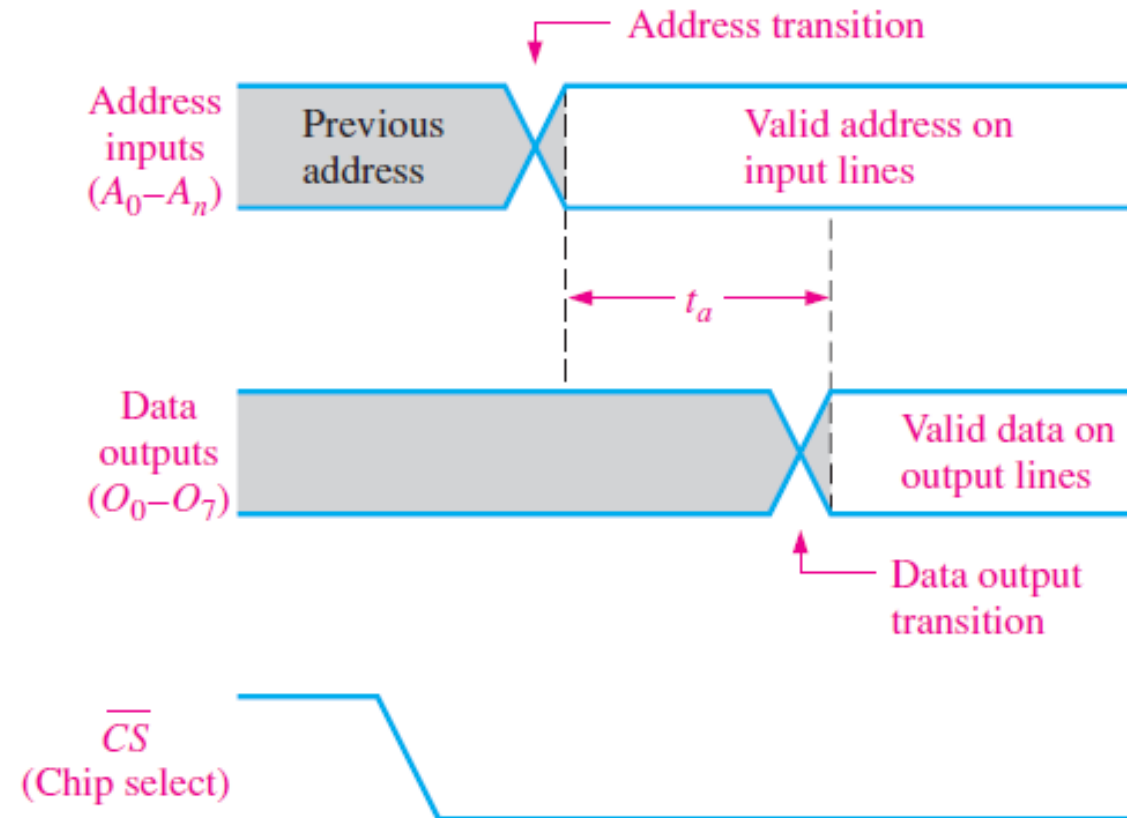
Programmable ROM (PROM)

- PROMs are basically the same as mask ROMs, once they have been programmed.
- The difference is that the PROM comes from the manufacturer unprogrammed.
- Thus they can be custom programmed in the field to meet the users' demand.
- A PROM uses some sort of fusing process to store bits, in which a memory link is burned open or left intact.
- The presence of fuse stores a 1 and the absence stores a 0.
- The fusing process is irreversible.
- In the programming process, a sufficient amount of current is injected though the fusible link to burn open a fuse link.
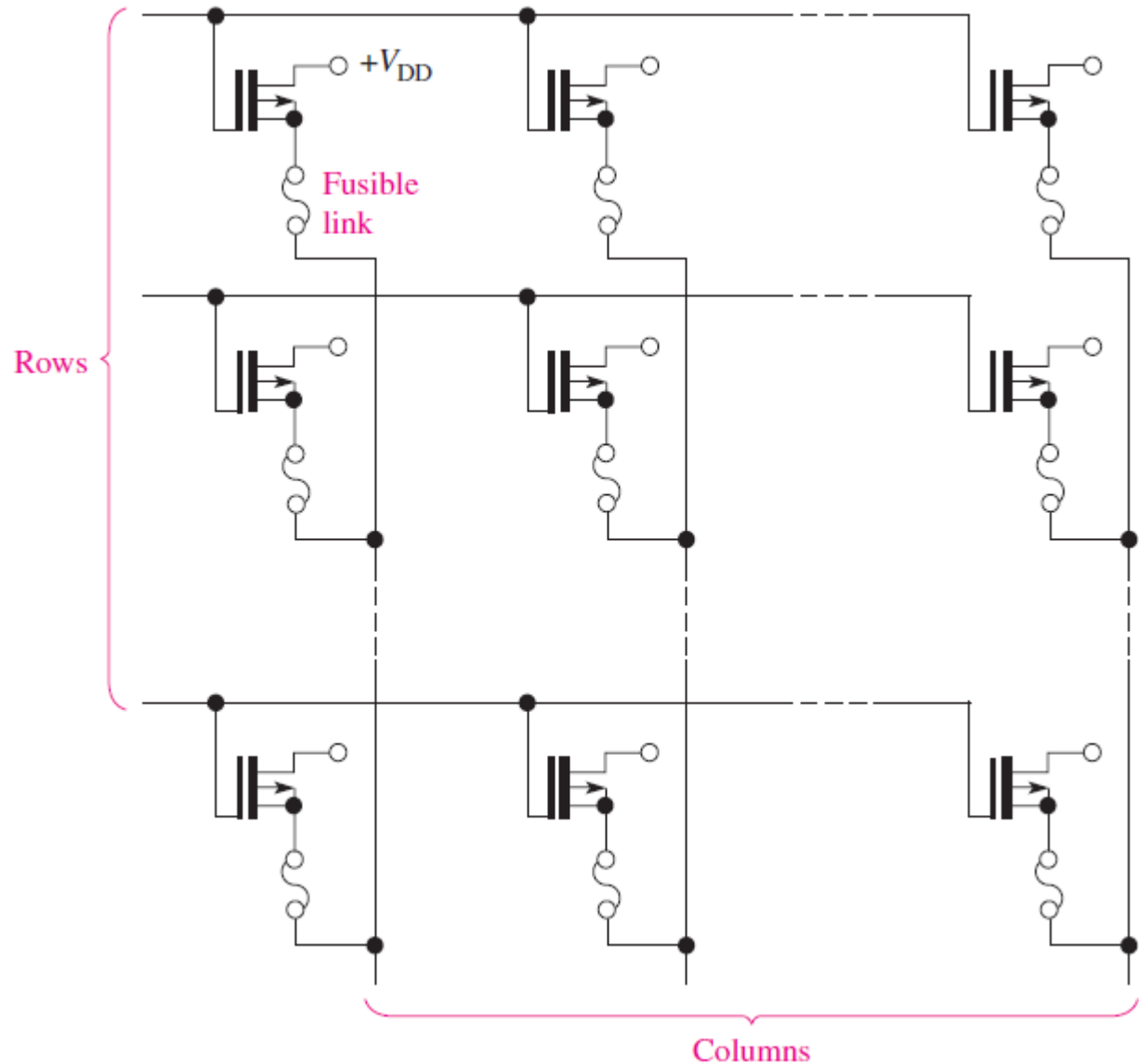

MOS PROM array with fusible links

Erasable PROM (EPROM)

- An EPROM is an erasable PROM.

- Unlike an ordinary PROM, an EPROM can be reprogrammed if an existing program in the memory array is erased first.

- Two basic types of EPROM are the ultraviolet erasable PROM (UV EPROM) and the electrically erasable PROM (EEPROM)

- UP EPROM: Erasure is done by exposure of the memory array chip to high-intensity ultraviolet radiation through the quarts window on top of the package.

- EEPROM: An electrically erasable PROM can be both erased and programmed with electrical pulses. Since it can be both electrically written into and electrically erased, the EEPROM can be rapidly programmed and erased in-circuit for reprogramming.

Flash Memory

- The ideal memory has high storage capacity, nonvolatility, in-system read and write capability, comparatively fast operations and cost effectiveness.
- The traditional memory technologies such as ROM, PROM, EPROM, EEPROM, SRAM and DRAM individually exhibits one or more characteristics.
- However, none of them have all these characteristics except for Flash Memory.
- The stacked gate MOS transistor consists of a control gate and floating gate in addition to the drain and source.
- The floating gate stores electron as a result of a sufficient voltage applied to the control gate.
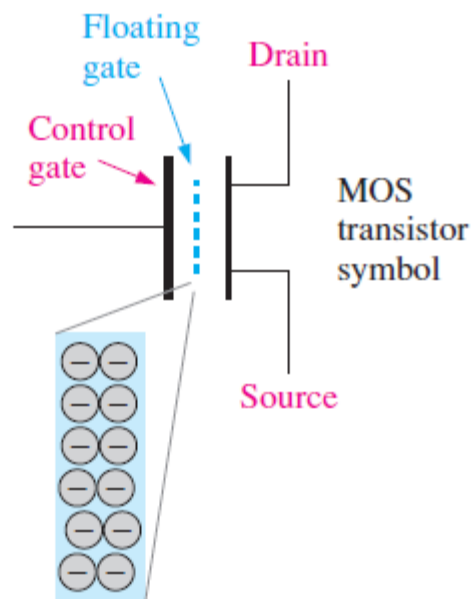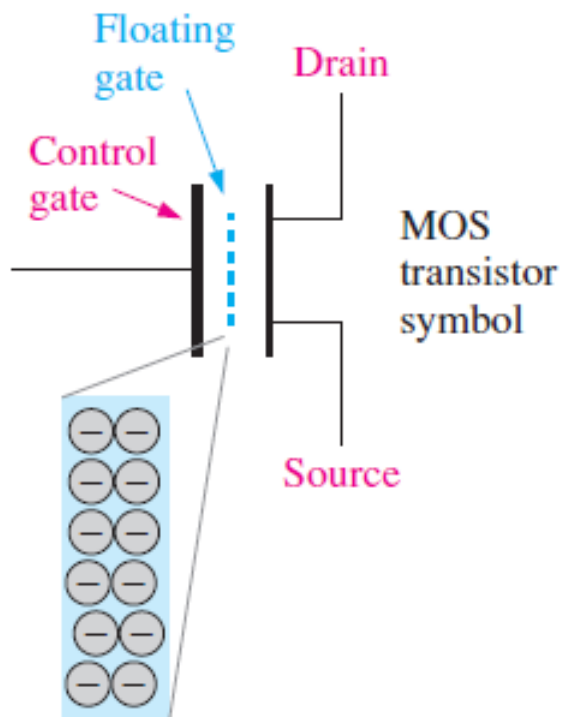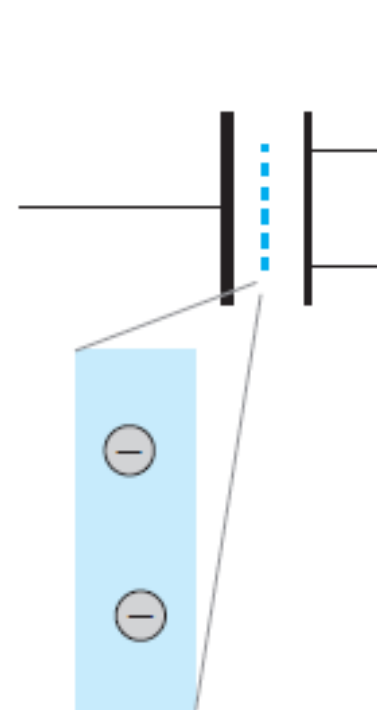

Many electrons = more charge = stored 0.
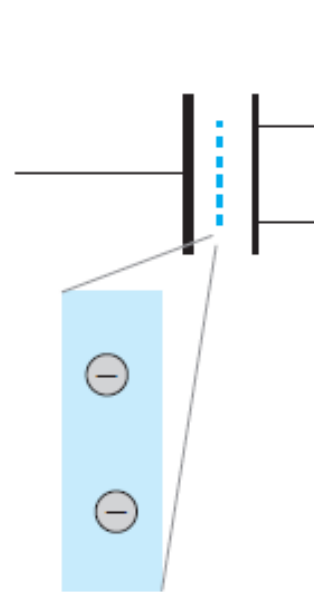
Few electrons = less charge = stored 1.

Flash Memory

- A 0 is stored when there is more charge and a 1 is stored when there is less charge.

- The amount of charge in the floating gate determines if the transistor will turn on and conduct current from the drain to source when a control voltage is applied during a read operation.
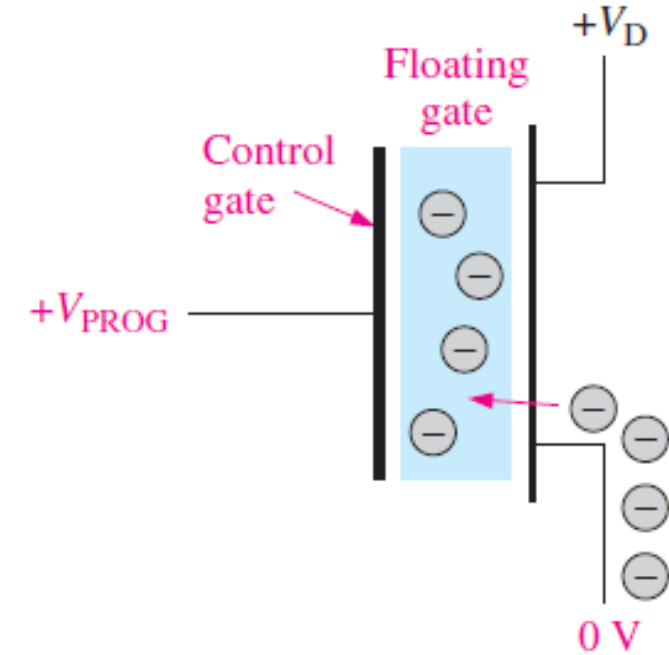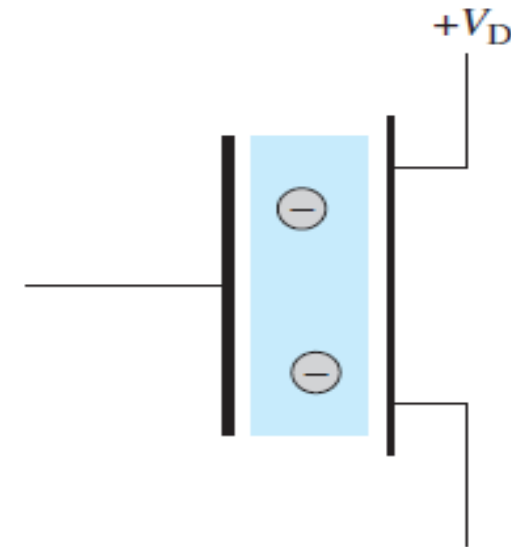

Many electrons = more charge = stored 0.

Few electrons = less charge = stored 1.

To store a 0, sufficient positive voltage is applied to the control gate with respect to the source to add charge to the floating gate during programming.
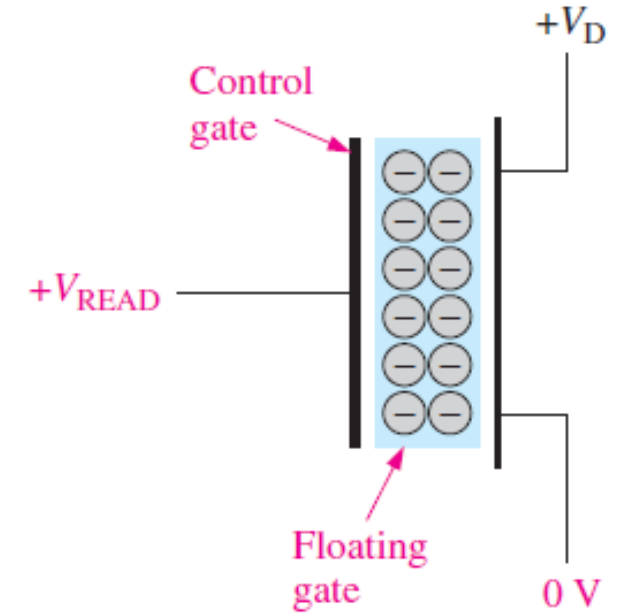
To store a 1, no charge is added, and the cell is left in the erased condition.
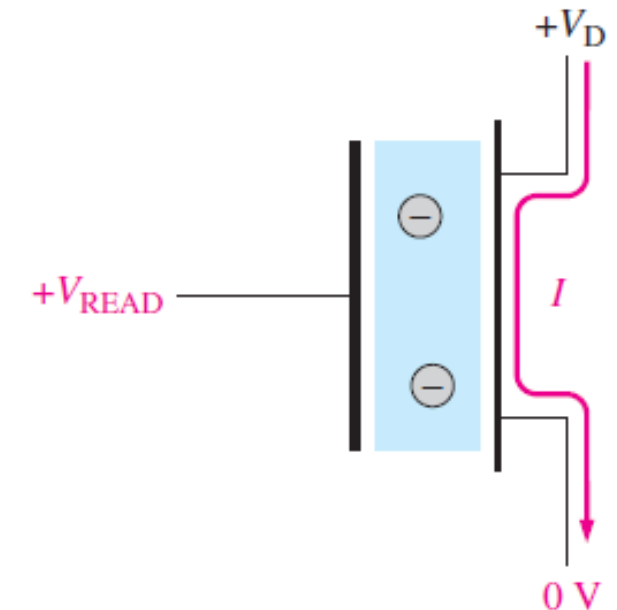
Flash Memory Read Operation

When a 0 is read, the transistor remains off because the charge on the floating gate prevents the read voltage from exceeding the turn on threshold

When a 1 is read, the transistor turns on because the absence of charge on the floating gate allows the read voltage to exceed the turn-on threshold.

References

1. Thomas L. Floyd, "Digital Fundamentals" 11th edition, Prentice Hall – Pearson Education.

Thank You