8.4 ROM design

ROM using floating-gate transistors

Flip-flops, SRAMs, and DRAMs lose stored bits when electrical power is removed (*volatile* memory). In contrast, **ROM** (read-
retains stored bits when power is removed (*non-volatile* memory), by using technology that usually has slow writes, so writ
frequent than reads; hence the term "read-only" (a misnomer when writing is in fact possible). Writing to a ROM is called ***pr***
ROM.

Bit storage in a ROM commonly uses a ***floating-gate transistor*** having a special region where electrons can be trapped, sta
without power. Applying a large positive voltage traps the electrons (programming). A large negative voltage frees the elect
Applying such large voltages long enough to trap or free electrons is slow, which is why writing a ROM is slow.

PARTICIPATION ACTIVITY 8.4.1: ROM using floating-gate transistors.
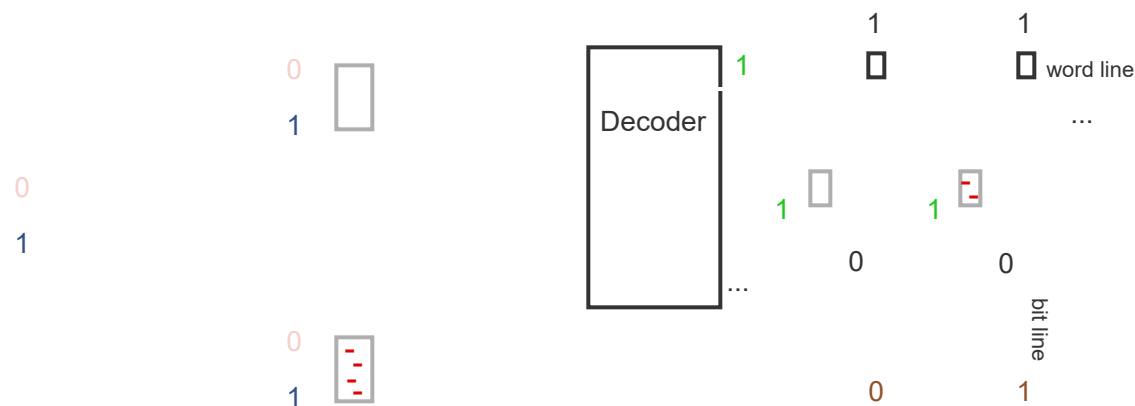
Note: The above is a "logical" view of a ROM, oversimplifying electrical features beyond this material's scope.

PARTICIPATION
ACTIVITY   8.4.2: ROM using floating-gate transistors.

1) An unprogrammed floating-gate
   transistor (no electrons trapped in the
   floating gate) _____.

   ○ acts as a normal transistor

   ○ acts opposite a normal transistor.

   ○ won't conduct

2) A programmed floating-gate transistor
   (electrons trapped in the floating gate)

   _____.

   ○ acts as a normal transistor

   ○ acts opposite a normal transistor.

   ○ won't conduct

3) Programming a floating-gate transistor
   is done via a large _____.

   ○ positive voltage

   ○ negative voltage

   ○ hammer

4) Erasing a floating-gate transistor is
   done via a large _____.

O   positive voltage

O   negative voltage

5)   A 256x16 ROM would have how many
     word lines?

     O   8

     O   16

     O   256

6)   A 256x16 ROM would have how many
     floating-gate transistors?

     O   16

     O   256

     O   4096

7)   A ROM has 8 bits per location. Location
     99 has only the first two transistors
     programmed (electrons trapped). What
     value is stored at location 99?

     O   11000000

     O   00111111

     O   11111111

8)   The ROM shown above would use
     _____ to achieve the 1's and 0's at the
     data output.

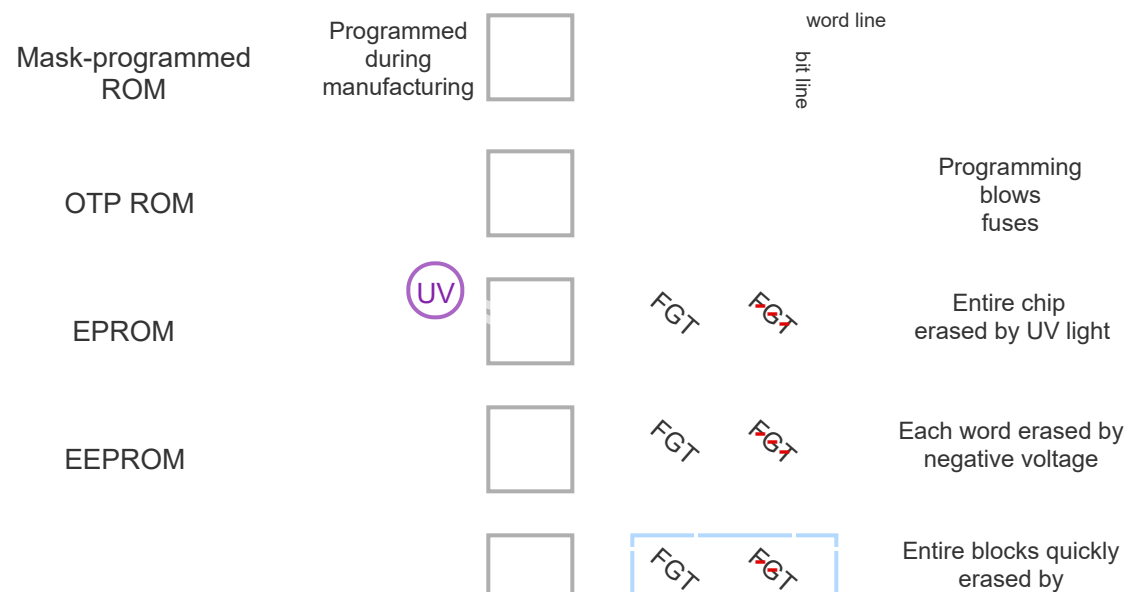   O   normal logic

     O   special circuitry

ROM types

Numerous ROM types exist.

- **Mask-programmed ROM**: The word line to bit line connections are hardwired during chip manufacturing, and can nev
- **OTP ROM** (one-time programmable ROM): The word line to bit line connections have a fuse that can be "blown" to bre connection. A user can program the device only once.
- **EPROM** (erasable programmable ROM): Programming uses large positive voltage to trap electrons in a floating-gate t erasing is done by placing the chip under ultraviolet light to provide the energy to free the trapped electrons. This ROM the more convenient EEPROM.
- **EEPROM** (electrically-erasable programmable ROM): Programming uses large positive voltage to trap electrons in a fl transistor, and erasing uses a large negative voltage.
- **Flash**: Programming uses large positive voltage to trap electrons in a floating-gate transistor, and erasing uses a large voltage to quickly erase entire blocks of locations at one time, like a "flash".

PARTICIPATION
ACTIVITY   8.4.3: ROM types.

Start   ☐ 2x speed

Mask-programmed   Programmed   word line
ROM   during   ☐
                   manufacturing   bit line

OTP ROM   ☐   Programming
                                                          blows
                                                          fuses

         UV   ☐   FGT   FGT   Entire chip
EPROM   erased by UV light

EEPROM   ☐   FGT   FGT   Each word erased by
                                                   negative voltage

                     ☐   FGT   FGT   Entire blocks quickly
                                                   erased by

Flash   negative voltage

PARTICIPATION ACTIVITY   8.4.4: ROM types.

Match the ROM type with the most likely usage scenario.

| EPROM | Mask-programmed ROM | Flash | OTP ROM | EEPROM |

Storing program instructions in a calculator that will be produced in the hundreds of millions.

Storing a unique ID number for a secure card key, which should never be changed.

Storing a program in a microprocessor chip being used for prototyping in an engineering lab, with the chip being reprogrammed a few times a day, in the 1980s.

Storing 256 phone numbers in a portable keychain device, each number reprogrammable by some button clicks.

A digital photo frame to which 8 photos can be uploaded, with the frame showing a different photo every minute.

Reset

Exploring further:

- ROM (Wikipedia)
- Flash (Wikipedia)

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