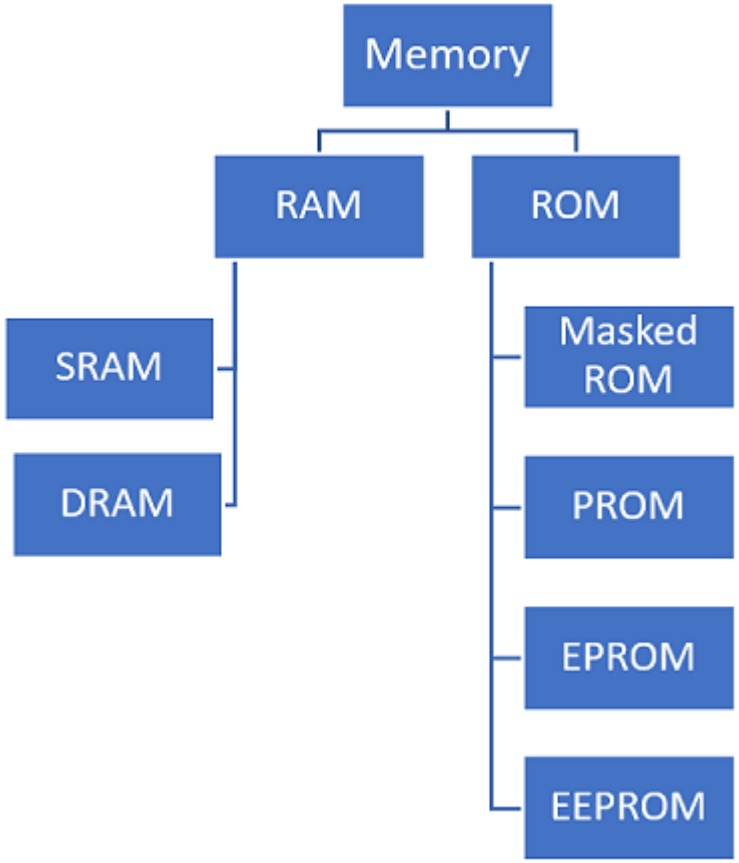
Memory

Memory is a set of registers that holds instructions and data for processing. Data inside these memory units are stored in the form of binary data. There are mainly two kinds of memory that are used in Digital Systems which are named **RAM (Random Access Memory)** and **ROM (Read Only Memory)**.

Classification of Memories

The memory inside Digital Systems can be classified as:



Random Access Memory (RAM)

RAM is called "Random Access Memory" because through it any storage location can be accessed directly. RAM belongs to the class of **volatile memory** which means if the power supplied to the system goes OFF, then data stored inside the RAM will get lost, that is why RAM is generally used to store only temporary data. Hence, RAM is also known as **data memory.**

- **Memory Write** operation can be defined as the process of storing new information into memory.
- **Memory Read** operation can be defined as the process of transferring the stored information out of memory.
- A RAM is capable of performing both Read and Write operations that is why it is also called **Read/Write**

The block diagram of a RAM can be drawn as:

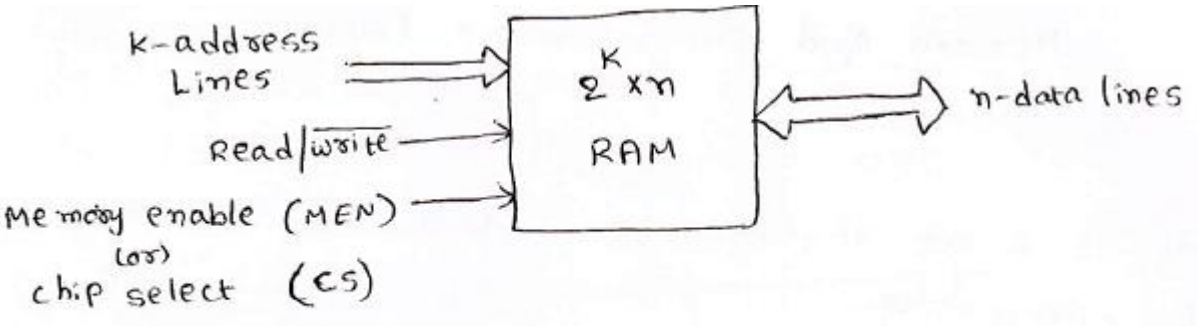


fig: B.D of 2^K x n RAM

In the above figure, the size of RAM is **2^K * N**, it means RAM consists of 2K memory locations and each memory location has a size of n-bits.
The communication between memory and other devices can be achieved through data lines. Each data line carries one bit of binary information. Data lines are bidirectional in nature, but at any time they act as either input or output lines. During memory write operation data lines act as input lines.
An address line carries the desired memory location address for memory read or writes operation.

Read / Write is a control signal. It is used to select either Read or Write operation. If **Read / Write =0**, then RAM performs write operation. RAM enables or performs either read or write operation only when its **Chip Select (CS) or Memory Enable (MEN)** input is high. If CS=0, then RAM is disabled.

- **Static Random-Access Memory (SRAM):** SRAM consists of flip-flops to store binary information.
- **Dynamic Random-Access Memory (DRAM):** DRAM consists of CMOS transistors and capacitors. It stored the binary information in the form of electric charges on capacitors.

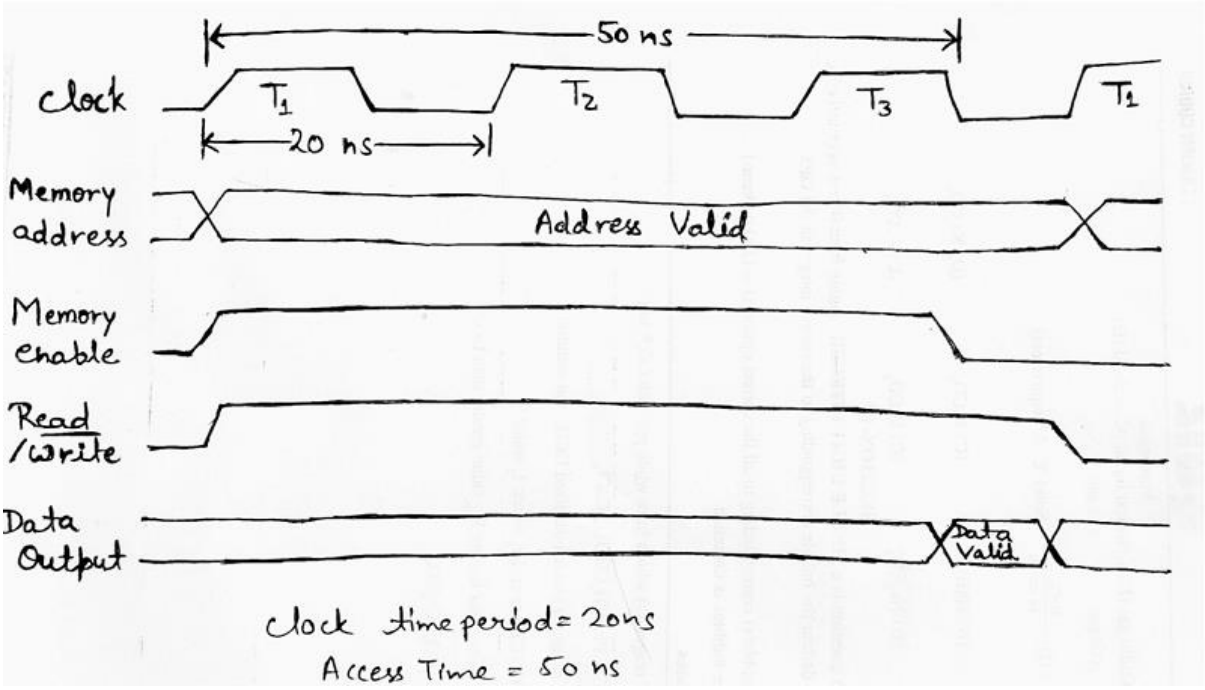
Memory Read operation steps:

Step 1: Apply the binary address of the desired word to the address lines.

Step 2: Activate the read input.

The memory unit then takes the bits from the word that already has been selected by the address and all of them are then applied to the output data lines. Hence, the content of the selected word doesn't change after the reading process is completed.

Memory Read Cycle timing diagram can be drawn as:



Access Time: It is the memory device operating speed. It is defined as the time required to perform the read (or) write operation.

Memory Write operation steps:

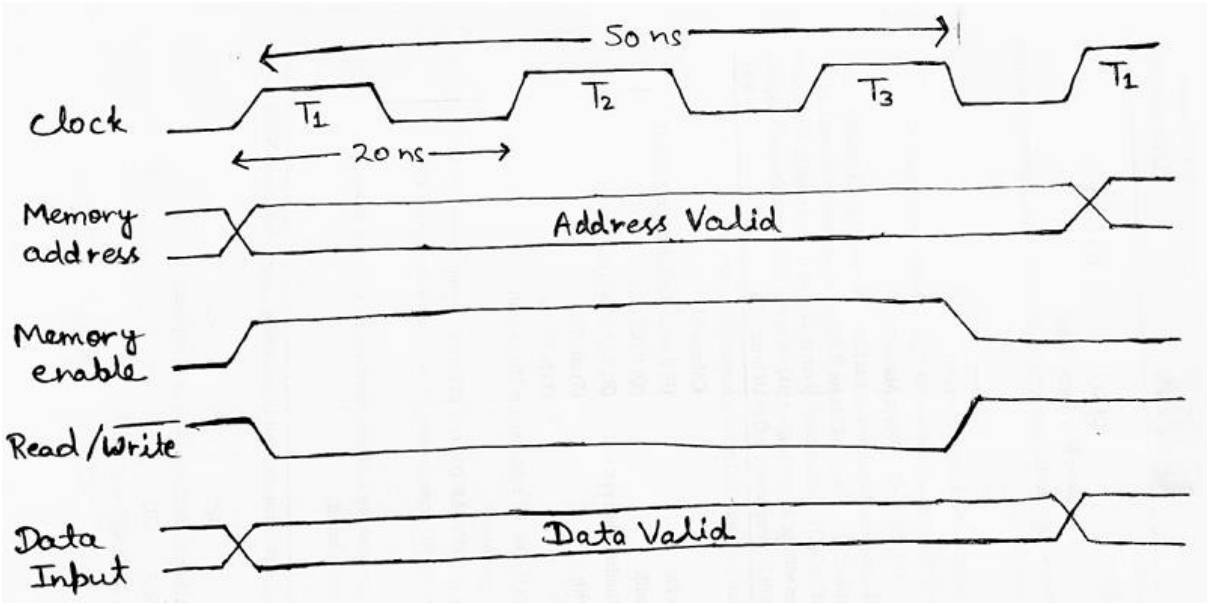
Step 1: Apply the binary address of the desired word to the address lines.

Step 2: Apply the data bits that must be stored in memory to the data input lines.

Step 3: Activate the write input.

The memory unit then takes the bits from the input data lines and stores them in the words which are specified by the address lines.

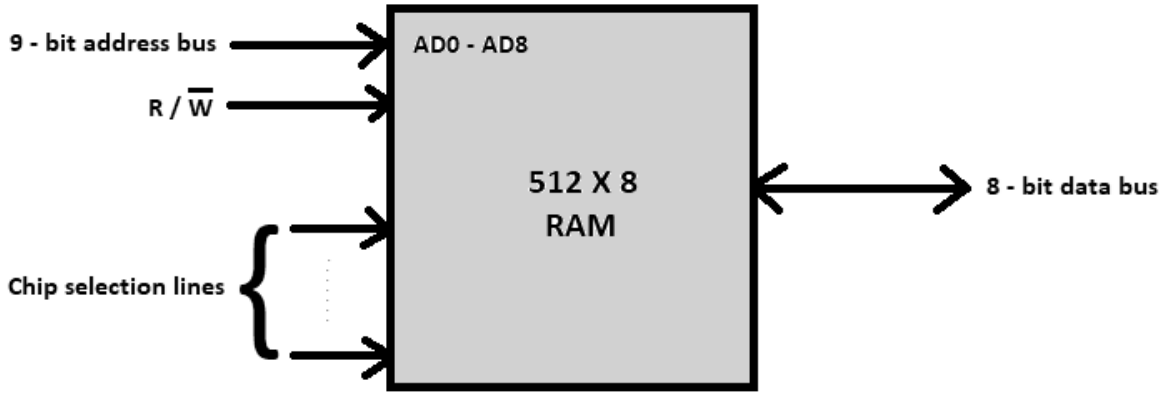
Memory Write Cycle timing diagram can be drawn as:



Integrated RAM chips are available in two form:

1. SRAM(Static RAM)
2. DRAM(Dynamic RAM)

The block diagram of RAM chip is given below.

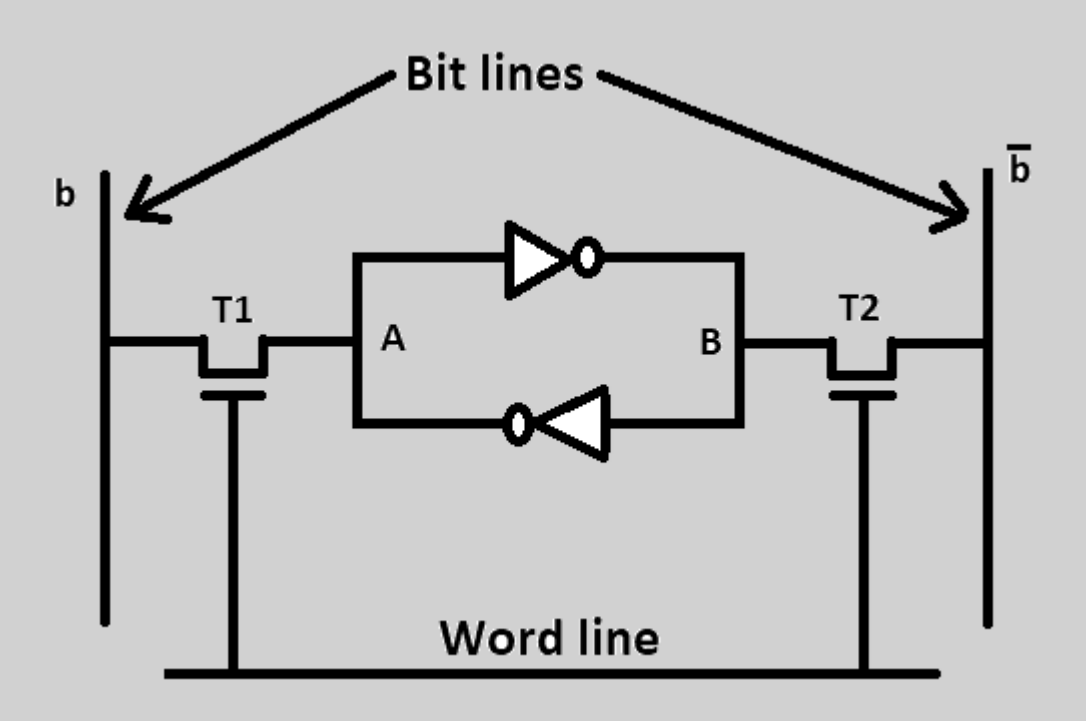


1. SRAM :

The SRAM memories consist of circuits capable of retaining the stored information as long as the power is applied. That means this type of memory requires constant power. SRAM memories are used to build Cache Memory.

SRAM Memory Cell: Static memories(SRAM) are memories that consist of circuits capable of retaining their state as long as power is on. Thus this type of memory is called volatile memory. The below figure shows a cell diagram of SRAM. A latch is formed by two inverters connected as shown in the figure. Two transistors T1 and T2 are used for connecting the latch with two-bit lines. The purpose of these transistors is to act as switches that can be

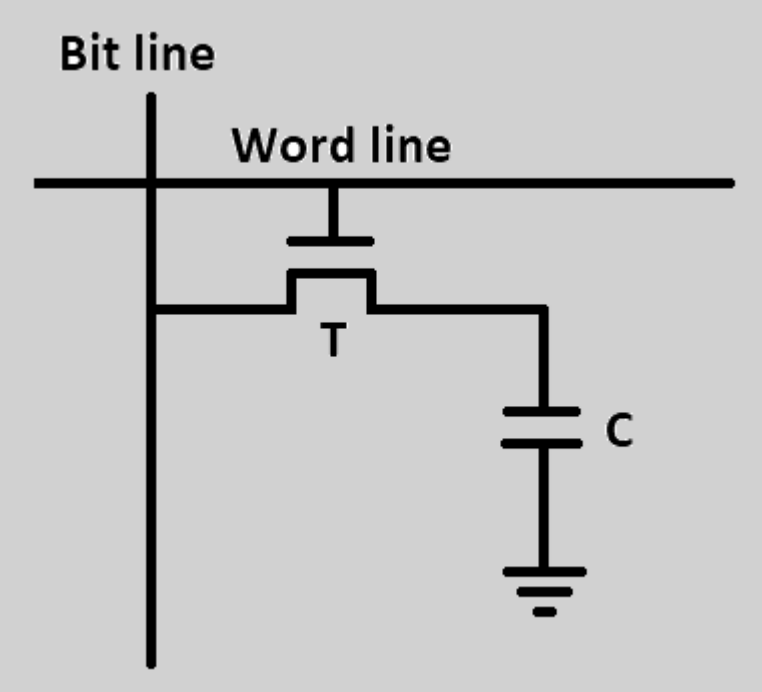
opened or closed under the control of the word line, which is controlled by the address decoder. When the word line is at 0-level, the transistors are turned off and the latch remains its information. For example, the cell is at state 1 if the logic value at point A is 1 and at point, B is 0. This state is retained as long as the word line is not activated.



For **Read operation**, the word line is activated by the address input to the address decoder. The activated word line closes both the transistors (switches) T1 and T2. Then the bit values at points A and B can transmit to their respective bit lines. The sense/write circuit at the end of the bit lines sends the output to the processor.
For **Write operation**, the address provided to the decoder activates the word line to close both the switches. Then the bit value that is to be written into the cell is provided through the sense/write circuit and the signals in bit lines are then stored in the cell.

2. DRAM :
DRAM stores the binary information in the form of electric charges applied to capacitors. The stored information on the capacitors tends to lose over a period of time and thus the capacitors must be periodically recharged to retain their usage. The main memory is generally made up of DRAM chips.
DRAM Memory Cell: Though SRAM is very fast, but it is expensive because of its every cell requires several transistors. Relatively less expensive RAM is DRAM, due to the use of one transistor and one capacitor in each cell, as shown in the below figure., where C is the capacitor and T is the transistor. Information is stored in a DRAM cell in the form of a charge on a capacitor and this charge needs to be periodically recharged.

For storing information in this cell, transistor T is turned on and an appropriate voltage is applied to the bit line. This causes a known amount of charge to be stored in the capacitor. After the transistor is turned off, due to the property of the capacitor, it starts to discharge. Hence, the information stored in the cell can be read correctly only if it is read before the charge on the capacitors drops below some threshold value.



Difference between SRAM and DRAM :
Below table lists some of the differences between SRAM and DRAM:

SRAM	DRAM
1. SRAM has lower access time, so it is faster compared to DRAM.	1. DRAM has higher access time, so it is slower than SRAM.
2. SRAM is costlier than DRAM.	2. DRAM costs less compared to SRAM.
3. SRAM requires constant power supply, which means this type of memory consumes more power.	3. DRAM offers reduced power consumption, due to the fact that the information is stored in the capacitor.
4. Due to complex internal circuitry, less storage capacity is available compared to the same physical size of DRAM memory chip.	4. Due to the small internal circuitry in the one-bit memory cell of DRAM, the large storage capacity is available.
5. SRAM has low packaging density.	5. DRAM has high packaging density.

ROM

Memory is required in almost every computational device for making it operable and functional. ROM is the kind of memory, data stored in which persists, i.e. it does not disappear after a user logs out of the system or if the system restarts. This is possible because of non-volatile nature of ROM.

PROM

PROM stands for "**Programmable Read Only Memory**". On this PROM, data can be written only one time, and it remains there forever. PROM is capable to retain their needed data when Computer is getting turn off. User purchases a empty PROM, and inserts the needed data with help of PROM program.

To need the well trained PROM programmer for writing data on this chip. When programmer writes programs on the PROM, then this process is known as "Burning PROM". After burning data, you can't make any modification in the burnt content.

Applications of Programmable Read Only Memory

- Radio-Frequency Identification
- Video game consoles
- Mobile Phones
- **High definition Multimedia Interfaces**

EPROM

EPROM stands for "**Erasable and Programmable Read Only Memory**", and in which stored data can be deleted by using of ultra-violet light for some time frame up to 40 minutes. The ultraviolet light clears its data, and now you can to reprogram the memory. To write to and erase an EPROM, you require a special device called a PROM programmer or PROM burner.

Applications of Erasable Programmable Read Only Memory

- Well programmed chip in the micro controller, modem, video card and other electronic gadgets.
- Debugging
- For writing program
- BIOS chip in the computer

EEPROM

EEPROM stands for "**Electrically Erasable and Programmable Read Only Memory**", and In EEPROM, all activities such as programming and erasing are performed by electrically. This EEPROM is able to reprogrammed and erased in more than ten thousand time. Entire chip cannot be erased one time, only erase one byte at once.

Applications of Electrically Erasable Programmable Read Only Memory

- BIOS chip in Computer
- As storage for re-programmable calibration information in test-equipment
- As storage for in-built self learning functionality in remote operated transmitters