Memory Types

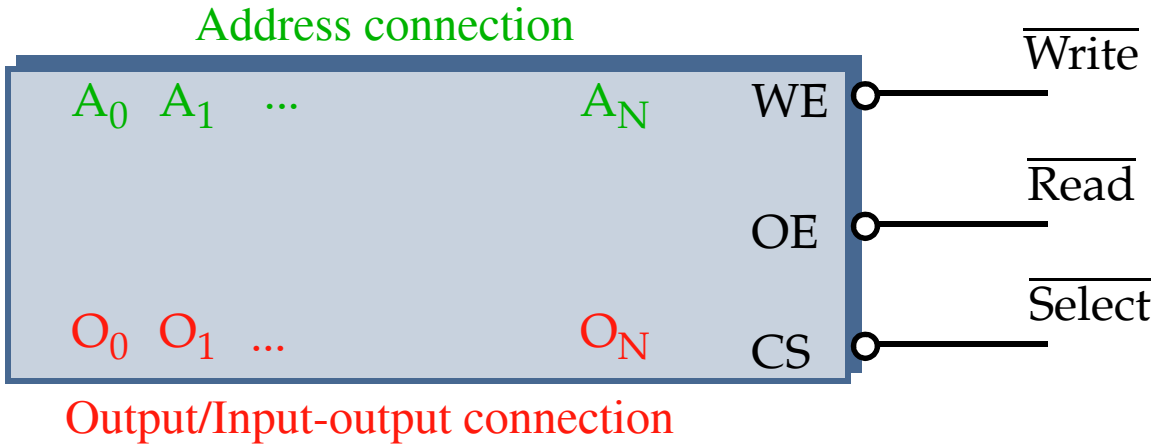
Two basic types:

- ***ROM:*** Read-only memory
- ***RAM:*** Read-Write memory

Four commonly used memories:

- ROM
- Flash, EEPROM
- Static RAM (SRAM)
- Dynamic RAM (DRAM), SDRAM, RAMBUS, DDR RAM

Generic pin configuration:



Memory Chips

The number of address pins is related to the number of ***memory locations***.

Common sizes today are **1K** to **256M** locations.

Therefore, between 10 and 28 address pins are present.

The data pins are typically ***bi-directional*** in read-write memories.

The number of data pins is related to the ***size of the memory location***.

For example, an 8-bit wide (byte-wide) memory device has ***8*** data pins.

Catalog listing of ***1K X 8*** indicate a byte addressable 8K bit memory with 10 address pins.

Each memory device has at least one ***chip select*** ($\overline{\text{CS}}$) or ***chip enable*** ($\overline{\text{CE}}$) or ***select*** ($\overline{\text{S}}$) pin that enables the memory device.

This enables read and/or write operations.

If more than one are present, then all must be 0 in order to perform a read or write.

Memory Chips

Each memory device has at least one control pin.

For ROMs, an ***output enable*** ($\overline{\text{OE}}$) or ***gate*** ($\overline{\text{G}}$) is present.

The $\overline{\text{OE}}$ pin enables and disables a set of tristate buffers.

For RAMs, a ***read-write*** (R/$\overline{\text{W}}$) or ***write enable*** ($\overline{\text{WE}}$) and ***read enable*** ($\overline{\text{OE}}$) are present.

For dual control pin devices, it must be hold true that both are not 0 at the same time.

ROM:

Non-volatile memory: Maintains its state when powered down.

There are several forms:

- **ROM**: Factory programmed, cannot be changed. Older style.
- **PROM**: Programmable Read-Only Memory.

  Field programmable but only once. Older style.
- **EPROM**: Erasable Programmable Read-Only Memory.

  Reprogramming requires up to 20 minutes of high-intensity UV light exposure.

Memory Chips

ROMs (cont):

- **Flash, EEPROM**: Electrically Erasable Programmable ROM.

  Also called **EAROM** (Electrically Alterable ROM) and **NOVRAM** (NOn-Volatile RAM).

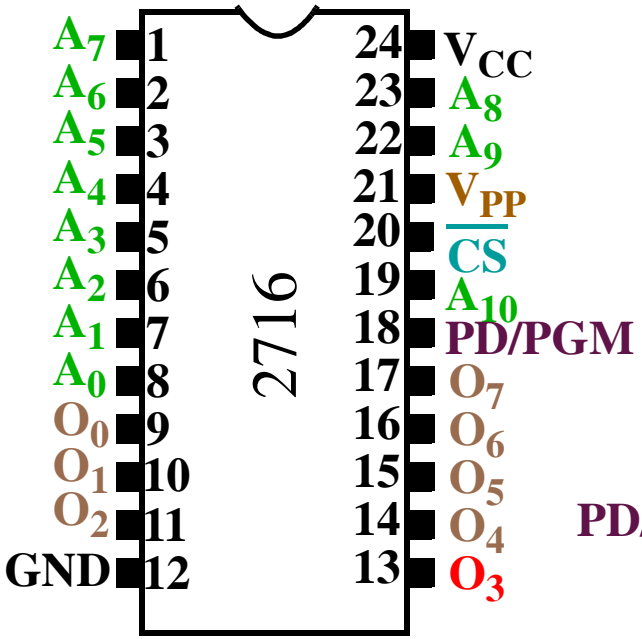
  Writing is much slower than a normal RAM.

  Used to store setup information, e.g. video card, on computer systems.

  Can be used to replace EPROM for BIOS memory.

EPROMs

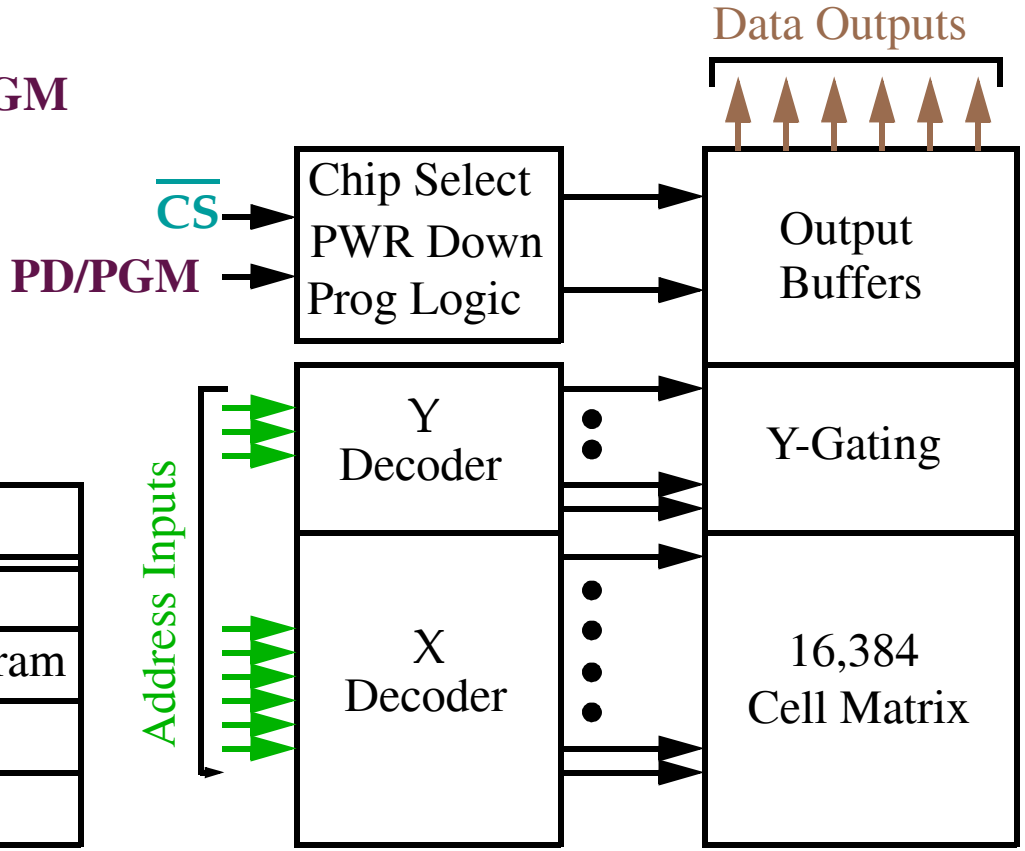
Intel 2716 EPROM (2K X 8):



2K x 8 EPROM

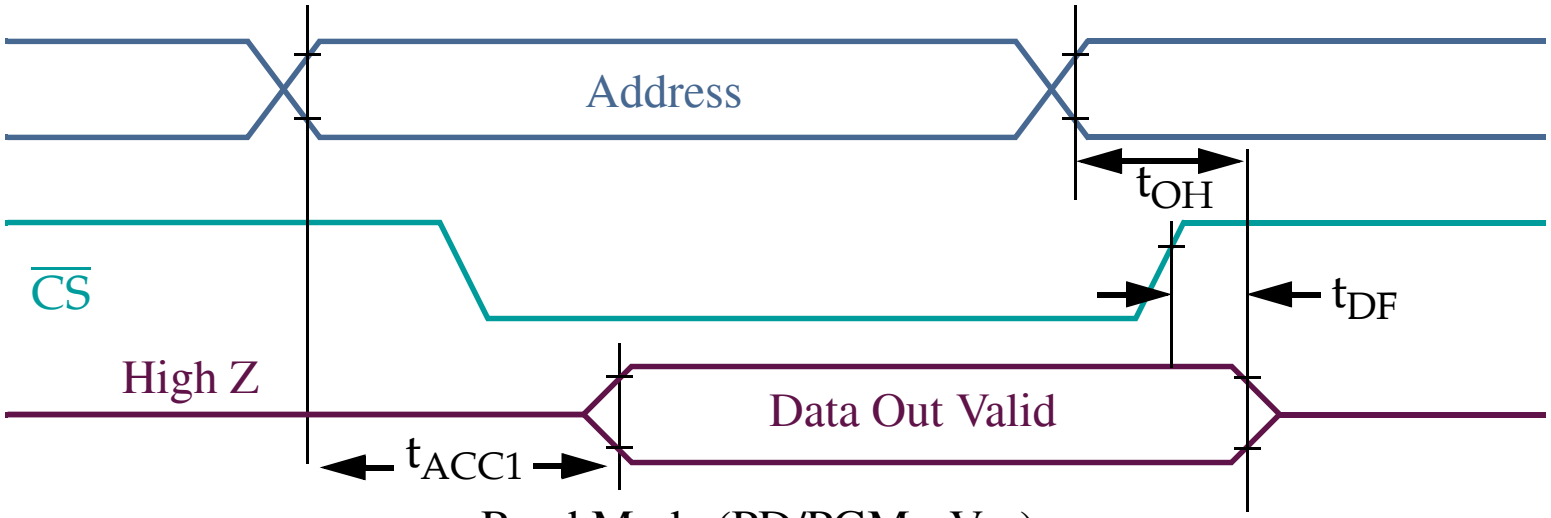
V_{PP} is used to program the device by applying 25V and pulsing PGM while holding $\overline{CS}$ high.

Pin(s)	Function
A_0-A_{10}	Address
PD/PGM	Power down/Program
$\overline{CS}$	Chip Select
O_0-O_7	Outputs



EPROMs

2716 Timing diagram:



Read Mode (PD/PGM =V_{IL})

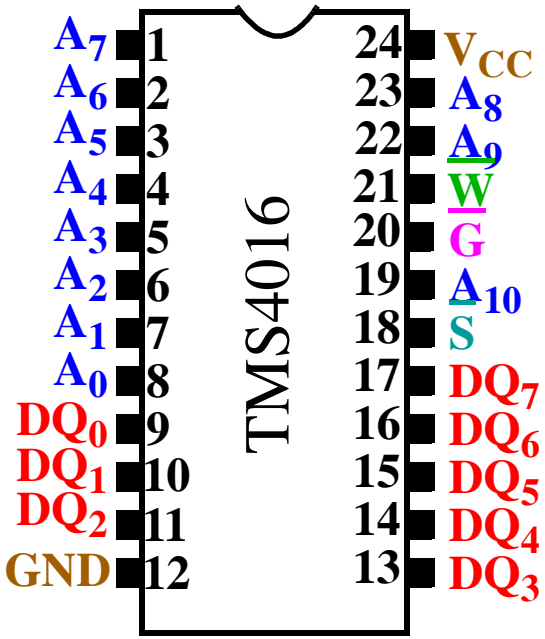
Sample of the data sheet for the 2716 A.C. Characteristics.

Symbol	Parameter	Limits			Unit	Test Condition
		Min	Typ.	Max		
t_{ACC1}	Addr. to Output Delay		250	450	ns	PD/PGM= $\overline{CS}$ =V_{IL}
t_{OH}	Addr. to Output Hold	0			ns	PD/PGM= $\overline{CS}$ =V_{IL}
t_{DF}	Chip Deselect to Output Float	0		100	ns	PD/PGM=V_{IL}
...	...	...	...	...	...	...

This EPROM requires a wait state for use with the 8086 (*460ns* constraint).

SRAMs

TI TMS 4016 SRAM (2K X 8):



2K x 8 SRAM

Pin(s)	Function
A_0-A_{10}	Address
DQ_0-DQ_7	Data In/Data Out
$\overline{S}$ ($\overline{CS}$)	Chip Select
$\overline{G}$ ($\overline{OE}$)	Read Enable
$\overline{W}$ ($\overline{WE}$)	Write Enable

Virtually identical to the EPROM with respect to the pinout.

However, access time is faster (250ns).

See the timing diagrams and data sheets in text.

SRAMs used for *caches* have access times as low as *10ns*.

DRAMs

DRAM:

SRAMs are limited in size (up to about 128K X 8).
DRAMs are available in much larger sizes, e.g., 64M X 1.

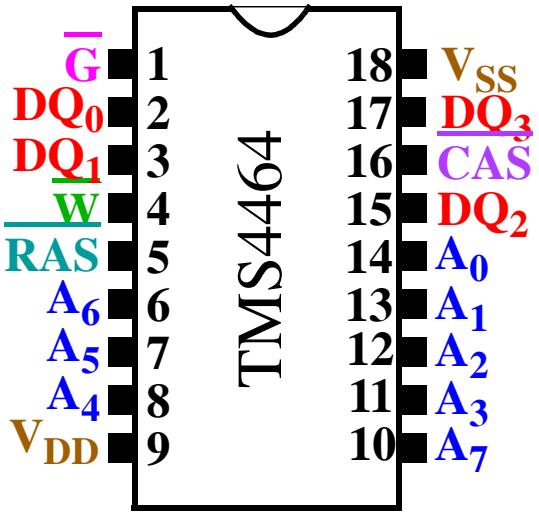
DRAMs MUST be refreshed (rewritten) every **2** to **4** ms
Since they store their value on an integrated capacitor that loses charge over time.

This refresh is performed by a special circuit in the DRAM which refreshes the entire memory.
Refresh also occurs on a normal read or write.
More on this later.

The large storage capacity of DRAMs make it impractical to add the required number of address pins.
Instead, the address pins are *multiplexed*.

DRAMs

TI TMS4464 DRAM (64K X 4):



64K x 4 DRAM

Pin(s)	Function
A_0-A_7	Address
DQ_0-DQ_3	Data In/Data Out
$\overline{RAS}$	Row Address Strobe
$\overline{CAS}$	Column Address Strobe
$\overline{G}$	Output Enable
$\overline{W}$	Write Enable

The TMS4464 can store a total of 256K bits of data.

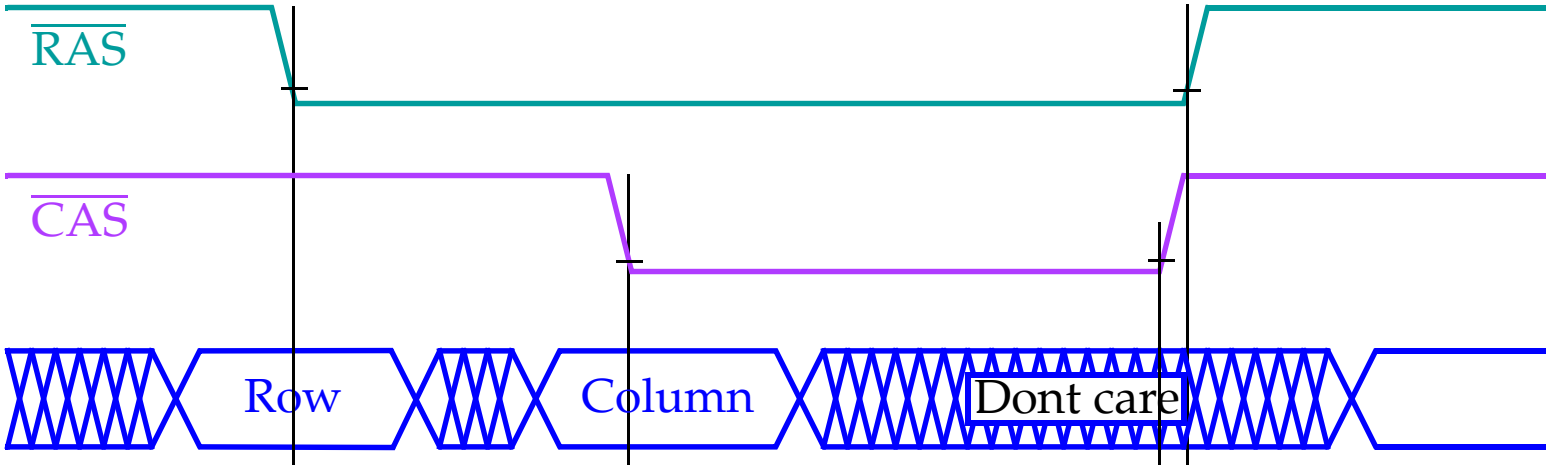
It has **64K** addressable locations which means it needs **16** address inputs, but it has only **8**.

The row address (A_0 through A_7) are placed on the address pins and strobed into a set of internal latches.

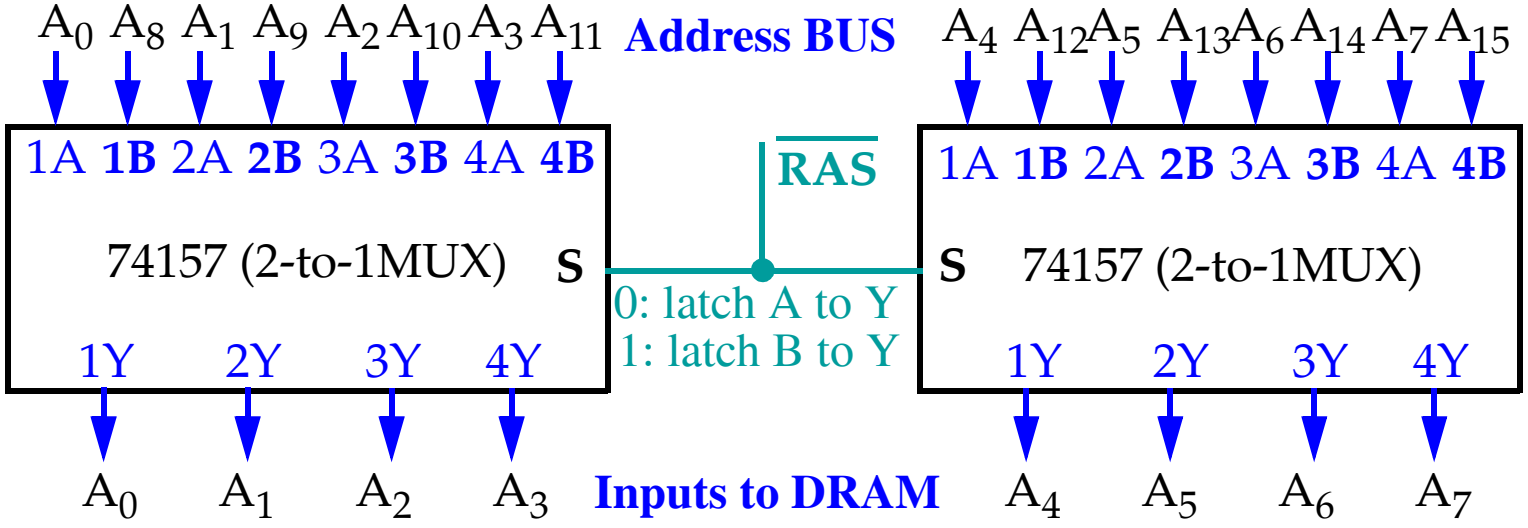
The column address (A_8 through A_{15}) is then strobed in using CAS.

DRAMs

TI TMS4464 DRAM (64K X 4) Timing Diagram:



$\overline{CAS}$ also performs the function of the chip select input.



DRAMs

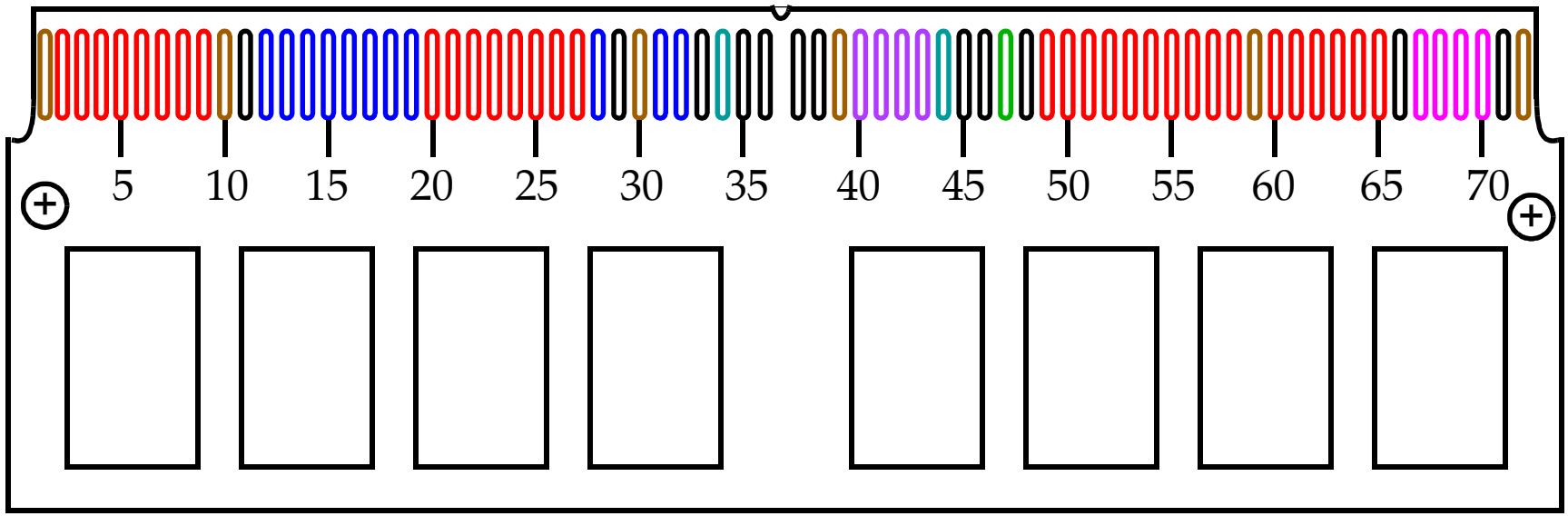
Larger DRAMs are available which are organized as *1M X 1*, *4M X 1*, *16M X 1*, *64M X 1*, *256M X 1*.

DRAMs are typically placed on SIMM (Single In-line Memory Modules) boards.

30-pin SIMMs come in *1M X 8*, *1M X 9* (parity), *4M X 8*, *4M X 9*.

72-pin SIMMs come in *1/2/3/8/16M X 32* or *1M X 36* (parity).

V_{SS}	$Addr_{0-11}$	$\overline{RAS}$	$\overline{W}$	NC
V_{CC}	DQ_{0-31}	$\overline{CAS}$	$\overline{PD}_{1-4}$	



DRAMs

Pentiums have a 64-bit wide data bus.

The **30-pin** and **72-pin** SIMMs are not used on these systems.

Rather, **64-bit DIMMs** (*Dual In-line Memory Modules)* are the standard.

These organize the memory 64-bits wide.

The board has DRAMs mounted on both sides and is **168** pins.

Sizes include *2M X 64* (**16M**), *4M X 64* (**32M**), *8M X 64* (**64M**) and *16M X 64* (**128M**).

The DIMM module is available in **DRAM**, **EDO** and **SDRAM** (and **NVRAM**) with and without an EPROM.

The EPROM provides information about the size and speed of the memory device for PNP applications.