Sistemas Digitais I
LESI - 2º ano

Unit 9 – Advanced Topics

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9. Advanced Topics
- *Summary* -

- Memory
- ROMs
- RAMs
- CPLDs
- CAD Tools

9. Advanced Topics
- Memory -

- Any sequential circuit has memory of a sort, since flip-flops or latches store one bit of information.

- The word <u>memory</u> is used to refer to bits that are stored in a structured way, usually as a 2-dimensional array, in which one row of bits is accessed at a time.

- The applications of memory are many and varied.

- In a microprocessor's CPU, a ROM may be used to define the primitive steps that are performed to execute instructions.

- Memories are also used to construct caches.

- Microprocessor's main memory contains hundreds of millions of bits.

9. Advanced Topics
- ROMs (1) -

- A <u>Read-Only Memory (ROM)</u> is a combinational circuit with n inputs and b outputs.

- The inputs are called <u>address inputs</u> and the outputs are called <u>data outputs</u>.

- A ROM stores the truth table of an n-input, b-output combinational logic function.
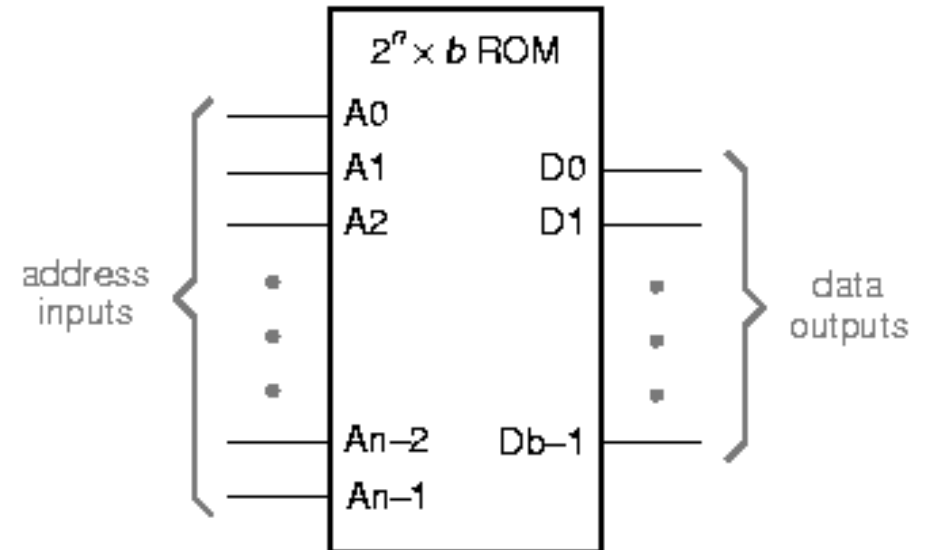
9. Advanced Topics
- ROMs (2) -

- Truth table of a 3 input, 4 output combinational logic function.

- It can be stored in a 2^3x4 (8x4) ROM.

- A ROM's data outputs equal the output bits in the truth table row selected by the address bits.

- Since a ROM is a combinational circuit, it is not really a memory.

- However, information is stored in the ROM when it is manufactured.

- ROM is a <u>non-volatile memory</u>. Its contents are preserved even if no power is applied.

Inputs			Outputs			
A2	A1	A0	D3	D2	D1	D0
0	0	0	1	1	1	0
0	0	1	1	1	0	1
0	1	0	1	0	1	1
0	1	1	0	1	1	1
1	0	0	0	0	0	1
1	0	1	0	0	1	0
1	1	0	0	1	0	0
1	1	1	1	0	0	0

9. Advanced Topics
- ROMs (3) -

- A modern ROM is fabricated as a single IC chip.

- A ROM that stores 4Mbit can be purchased for US$5.

- A <u>mask-programmable ROM</u> is programmed by the pattern of connections and no-connections.

- To program information into the ROM, the customer gives the manufacturer a listing of the desired ROM contents.

- The manufacturer uses this information to create customised masks to manufacture ROMs with the required pattern.

- ROM manufacturers impose a *mask charge* of several thousand dollars for the customised aspects of mask-ROM production.

9. Advanced Topics
- ROMs (4) -

- A <u>programmable ROM (PROM)</u> is similar to a mask ROM.

- However, the customer may store data values (i.e. <u>program</u> the PROM) in just a few minutes using a PROM programmer.

- A PROM chip is manufactured with all of its transistors connected.

- This corresponds to having all bits at a particular value, typically 1.

- The PROM programmer can be used to set desired bits to the opposite value.

- An <u>erasable programmable ROM (EPROM)</u> is programmable like a PROM, but it can also be erased to the all-1s state, by exposing it to ultraviolet light.
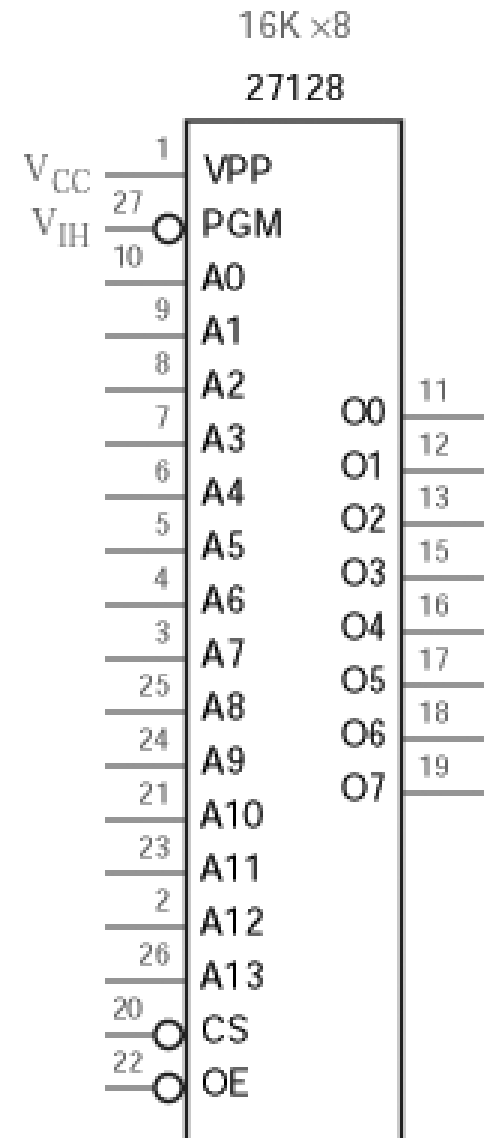
9. Advanced Topics
- ROMs (5) -

- Probably the most common application of EPROMs is to store programs in microprocessor systems for embedded applications.

- EPROMs are typically used during program development, where the program must be repeatedly changed during debugging.

- ROMs and PROMs usually cost less than similar EPROMS.

- Thus, once a program is finalised, a ROM or PROM is used in production to save money.

- An <u>electrically erasable programmable ROM (EEPROM)</u> is like an EPROM, except that individual stored bits may be erased electrically.
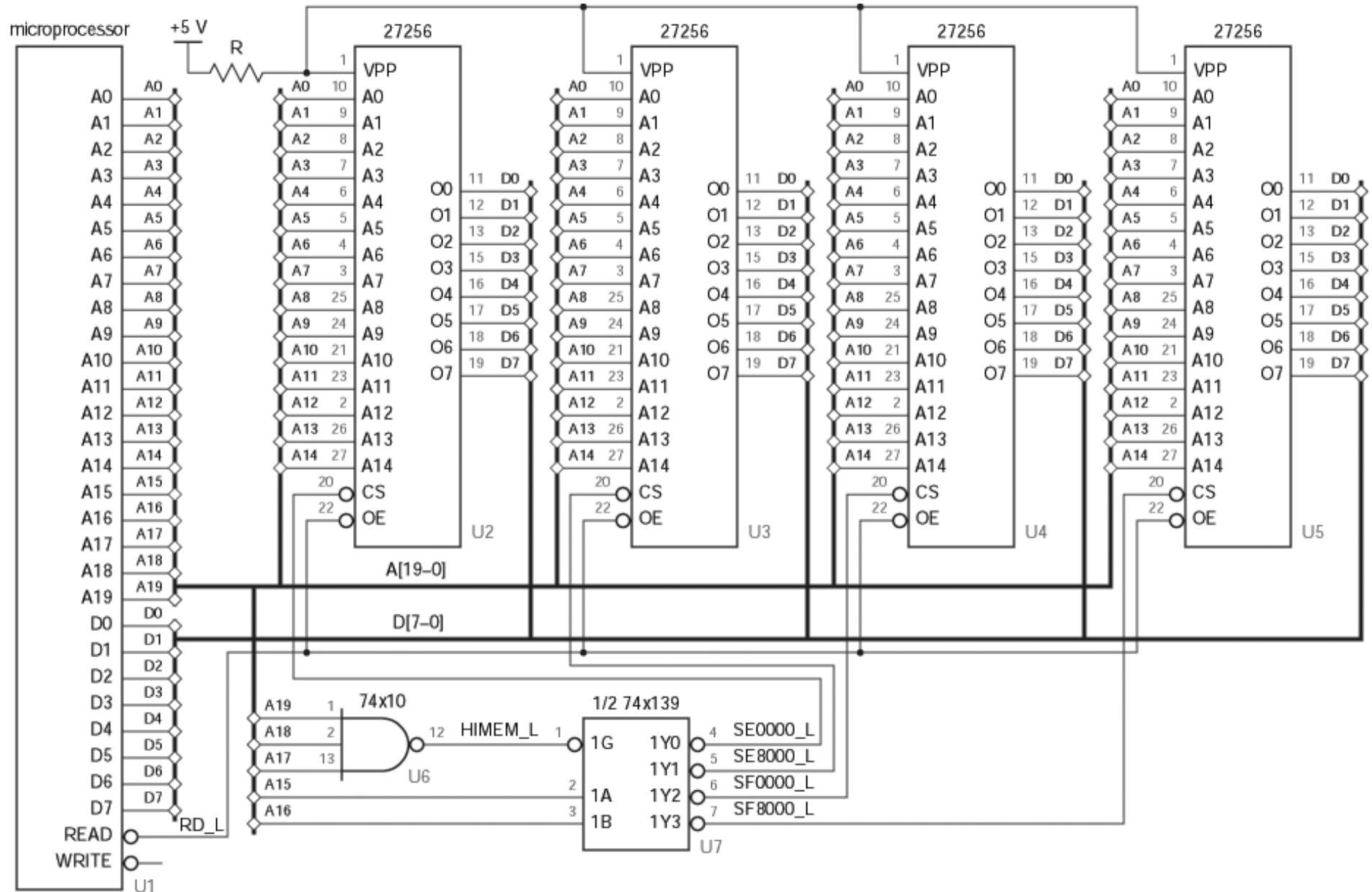
9. Advanced Topics
- ROMs (6) -

- The outputs of a ROM must often be connected to a 3-state bus, where different devices may drive the bus at different times.

- Thus, many chips have 3-state outputs and an OE (Output Enable) input that must be asserted to enable the outputs.

- Many circuits have multiple ROMs connected to a bus, where only one ROM drives the bus at a time.

- Most ROMs have a CS (Chip Select) input to simplify the design of those systems.

- In addition to OE, the CS input must be asserted to enable the 3-state outputs.

16K ×8

27128

9. Advanced Topics
- ROMs (8) -

- In addition to ease and speed of design, a ROM-based circuit has important advantages.

- A ROM-based circuit is usually faster than a circuit using multiple SSI/MSI devices and PLDs.

- The program that generates the ROM contents can easily be structured to handle unusual or undefined cases.

- A ROM function is easily modified just by changing the stored pattern, without changing any external connections.

- The ROMs prices are always dropping, which makes them attractive.

- The ROMs densities are always increasing, which expands the scope of problems that can be solved with a single chip.

9. Advanced Topics
- ROMs (9) -

- There are a few disadvantages for a ROM-based circuit.

- For simple to moderately complex circuits, a ROM-based circuit may cost more, consume more power, or run slower than a circuit using multiple SSI/MSI devices and PLDs or a small FPGA.

- For functions with more than 20 inputs, a ROM-based circuit is impractical because of the limit on ROM sizes that are available.
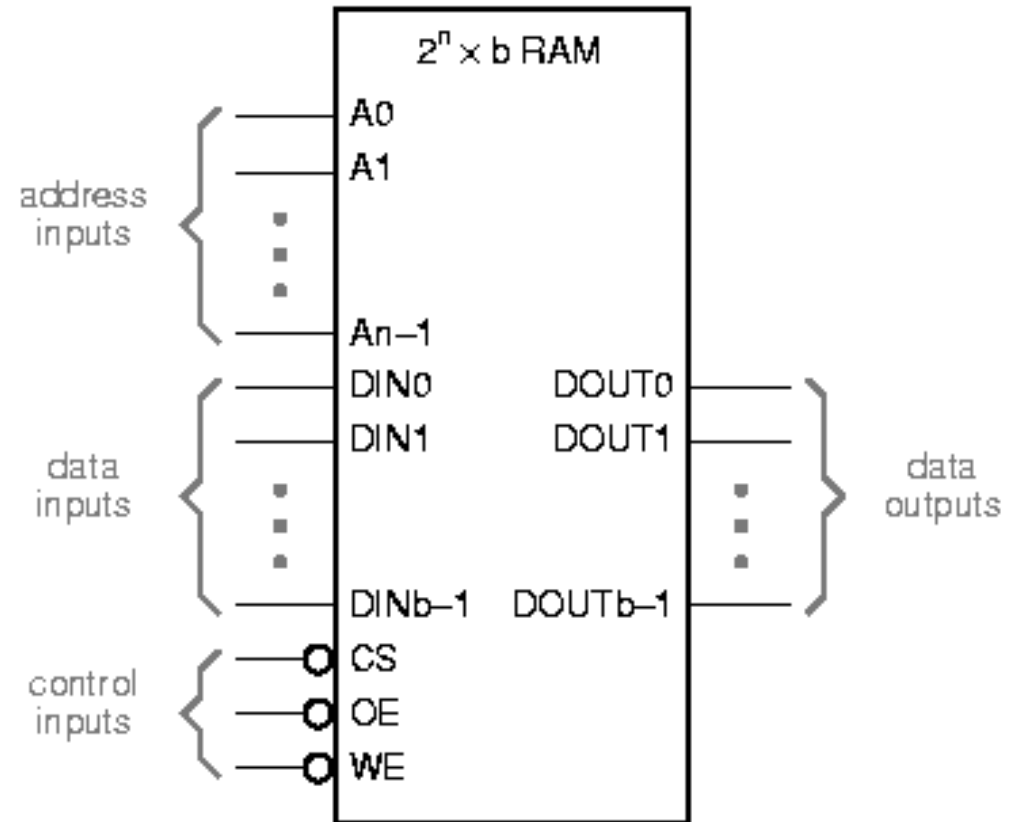
9. Advanced Topics
- RAMs (1) -

- The term <u>Read/Write Memory (RWM)</u> is given to memory arrays in which information can be stored and retrieved at any time.

- Nowadays, most of the RWMs used in digital systems are RAMs.

- In a <u>Random-Access Memory (RAM)</u>, the time it takes to read or write a bit of memory is independent of the bit's location.

- ROMs are also random-access memories, but the name "RAM" is generally used only for read/write random-access memories.

- In a <u>static RAM (SRAM)</u>, once a word is written at a location, it remains stored as long as power is applied to the chip, unless the same location is written again.

9. Advanced Topics
- RAMs (2) -

- Most RAMs are <u>volatile</u> memories. They lose their memory when power is removed.

- Some RAMs retain their memory even when power is removed. They are called <u>non-volatile</u> memory.

- A RAM has address, data and control inputs and data outputs.

9. Advanced Topics
- RAMs (3) -

- When WE is asserted, the data inputs are written into the selected memory location.

- The memory locations in a static RAM behave like D latches, rather than edge-triggered D flip-flops.

- Whenever WE is asserted, the latches for the selected memory are open and inputs flow into and through the latch.

- The value stored is whatever is present when the latch closes.
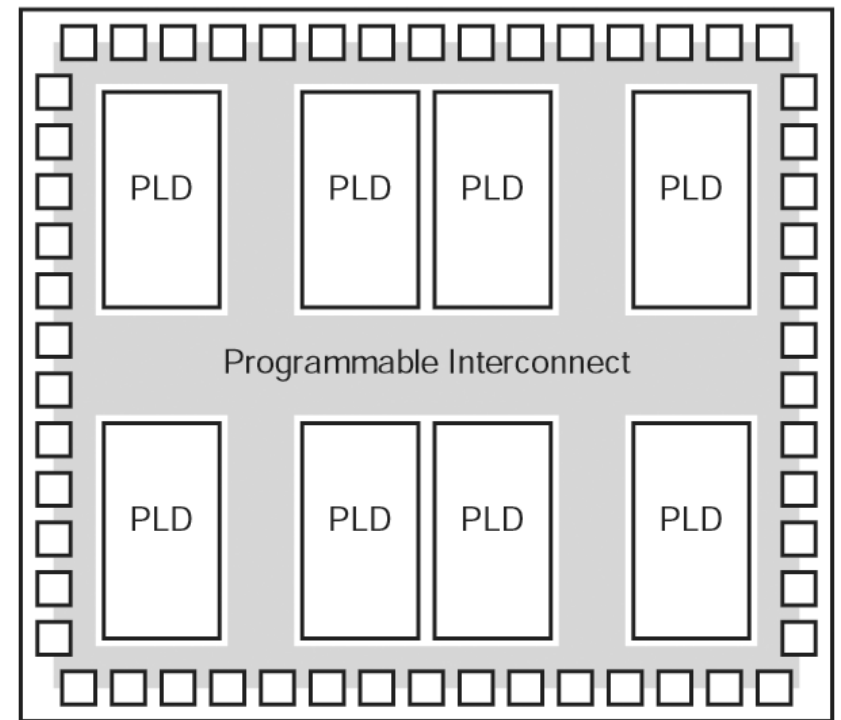
9. Advanced Topics
- RAMs (4) -

- Static RAMs normally has just 2 defined access operations: Read and Write.

- During a <u>read</u>, an address is placed on the address inputs while the CS and OE are asserted.

- The latch outputs for the selected memory location are delivered to the DOUT output.

- During a <u>write</u>, an address is placed on the address inputs and a data word is placed on DIN; then CS and WE are asserted.

- The latches in the selected memory location open, and the input word is stored.

9. Advanced Topics
- CPLDs (1) -

- As IC technology advances, there was a natural interest in creating larger PLDs to take advantage of increased chip density.

- A CPLD is just a collection of individual PLDs on a single chip, accompanied by a programmable interconnection structure.

- This structure allow the PLDs to be interconnected in the same way as can be done off-chip.

- The Xilinx 9500 series architecture is one example of a CPLD.

9. Advanced Topics
- CAD Tools (1) -

- Digital design is being, more and more, carried out using software.

- The terms <u>computer-aided design</u> (CAD) and <u>computer-aided</u> engineering (CAE) are used to refer to software tools that aid the development of circuits, systems and other things.

- CAD is the more general term and applies also to other engineering fields, such as architecture and mechanics.

9. Advanced Topics
- CAD Tools (2) -

- HDLs.

9. Advanced Topics
- CAD Tools (3) -

- Schematic Capture.

9. Advanced Topics
- CAD Tools (4) -

- Timing Drawings.

9. Advanced Topics
- CAD Tools (5) -

- Circuit Analysis and Manipulation.

9. Advanced Topics
- CAD Tools (6) -

- PCB Layout.