Sistemas Digitais I

LESI - 2º ano

Unit 9 – Advanced Topics

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9. Advanced Topics

- Summary -

- Memory
- ROMs
- RAMs
- CPLDs
- CAD Tools

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- Memory -

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

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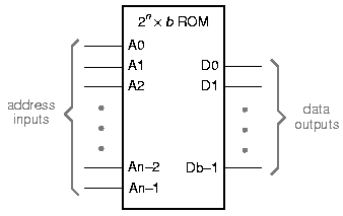
- ROMs (1) -

- A Read-Only Memory (ROM) is a combinational circuit with n inputs and b outputs.
- The inputs are called address inputs and the outputs are called data outputs.
- A ROM stores the truth table of an n-input, b-output combinational logic function.



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- 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.

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

- 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 non-volatile memory. Its contents are preserved even if no power is applied.

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- ROMs (3) -

- A modern ROM is fabricated as a single IC chip.
- A ROM that stores 4Mbit can be purchased for US$5.
- A mask-programmable ROM 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.

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- ROMs (4) -

- A programmable ROM (PROM) is similar to a mask ROM.
- However, the customer may store data values (i.e. program 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 erasable programmable ROM (EPROM) is programmable like a PROM, but it can also be erased to the all-1s state, by exposing it to ultraviolet light.

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- 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 electrically erasable programmable ROM (EEPROM) is like an EPROM, except that individual stored bits may be erased electrically.

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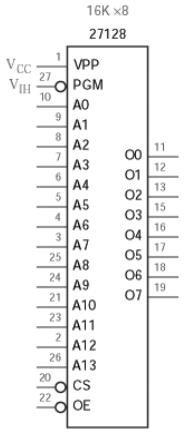
- ROMs (6) -

- 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.



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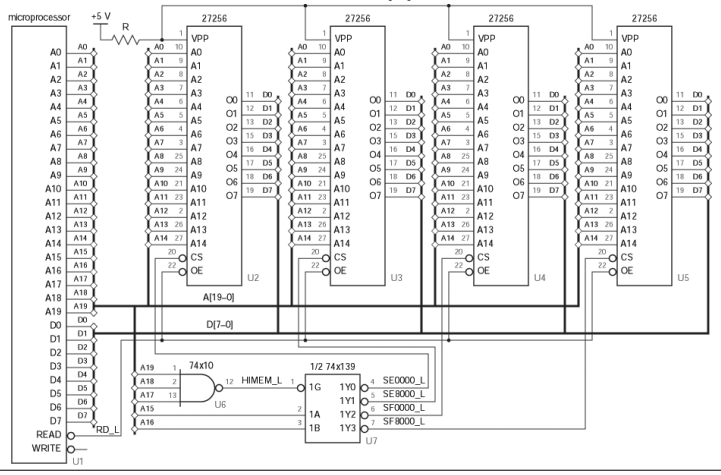
- ROMs (7) -



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- 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.

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- 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.

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- RAMs (1) -

- The term Read/Write Memory (RWM) 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 Random-Access Memory (RAM), 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 static RAM (SRAM), 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.

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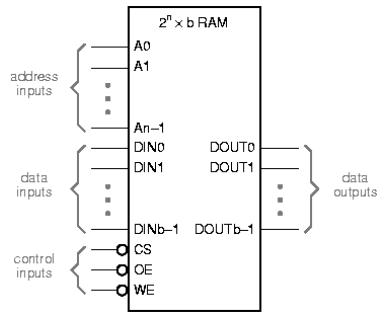
- RAMs (2) -

- Most RAMs are volatile memories. They lose their memory when power is removed.
- Some RAMs retain their memory even when power is removed. They are called non-volatile memory.
- A RAM has address, data and control inputs and data outputs.



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- 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.

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- RAMs (4) -

- Static RAMs normally has just 2 defined access operations: Read and Write.
- During a read, 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 write, 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.

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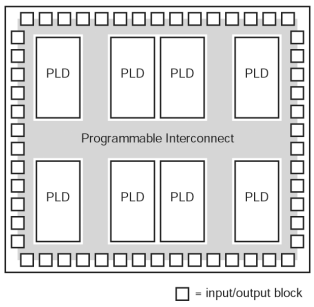
- CPLDs (1) -

- 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.



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- CAD Tools (1) -

- Digital design is being, more and more, carried out using software.
- The terms computer-aided design (CAD) and computer-aided 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.

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- CAD Tools (2) -

- HDLs.

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- CAD Tools (3) -

- Schematic Capture.

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- CAD Tools (4) -

- Timing Drawings.

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- CAD Tools (5) -

- Circuit Analysis and Manipulation.

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- CAD Tools (6) -

- PCB Layout.