Rechnerarchitektur Serie 2

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Theorie Aufgaben

1 Integrated Circuit

- Increased processing power.
  Miniaturization enables more components to be integrated into a single wafer, which increases the number of connections between the integrated circuit and printed circuit board. This increases the ability to route signals and therefore increases the processing power of the system it is being assembled into
- Reduced power consumption.
  Miniaturization reduces the distance between components on a chip, which reduces the amount of power required to move data between them.

2 Influence on the conductivity of semiconductors during production

The conductivity of a semiconductor can be influenced by doping during production. Doping is the process of adding impurities to a pure semiconductor material to change its electrical properties. Very small amounts of dopants (in the parts-per-million range) dramatically affect the conductivity of semiconductors. The electrical conductivity of a material depends on the number of free electrons and holes per unit volume and on the rate at which these carriers move under the influence of an electric field. In an intrinsic semiconductor there exists an equal number of free electrons and holes. If the temperature of the semiconductor increases, the concentration of charge carriers (electrons and holes) is also increased. Hence, the conductivity of a semiconductor is increased accordingly.

N-doping and P-doping are two types of doping used in semiconductors. N-type doping is the process of adding impurities such as phosphorus or arsenic to a pure semiconductor material to increase the number of free electrons in the material. P-type doping is the process of adding impurities such as boron or

aluminum to a pure semiconductor material to increase the number of holes in the material. Doped semiconductors are electrically neutral. The terms n- and p-type doped do only refer to the majority charge carriers. Each positive or negative charge carrier belongs to a fixed negative or positive charged dopant. N- and p-doped semiconductors behave approximately equal in relation to the current flow.

3 Changing the conductivity of a MOSFET

The conductivity of an NMOS MOSFET between drain and source changes based on the voltage applied to the gate terminal. The gate terminal is separated from the channel by a thin layer of oxide which acts as a dielectric material. When a voltage is applied to the gate terminal, an electric field is created across the oxide layer which induces a channel between the source and drain terminals. The conductivity of this channel depends on the voltage applied to the gate terminal and can be used for amplifying or switching.

4 MOSFET characteristics

When the gate voltage of an NMOS MOSFET is above the threshold voltage, it enters into saturation region where the current between drain and source becomes almost constant with increasing drain-source voltage.

5 Performance calculations

- How much faster/sloqer is a machine that needs 6 clock cycles for the LOAD instructions
  Assuming all operations are performed around the same amount:
  $LOAD\ with\ 4\ cycles \rightarrow execution\ of\ all\ operations\ takes\ 15\ cycles.$
  $LOAD\ with\ 6\ cycles \rightarrow execution\ of\ all\ operations\ takes\ 17\ cycles.$
  $cycles_{old} = \frac{15}{15} = 100\%, cycles_{new} = \frac{17}{15} = 113.3\%$
  that means on average you need 13.3% more time to complete a programme.

- How much faster is a CPU when its STORE works twice as fast?
  Assuming all operations are performed around the same amount:
  $STORE\ with\ 12\ cycles \rightarrow execution\ of\ all\ operations\ takes\ 15\ cycles.$
  $STORE\ with\ 6\ cycles \rightarrow execution\ of\ all\ operations\ takes\ 12\ cycles.$
  $cycles_{old} = \frac{15}{15} = 100\%, cycles_{new} = \frac{12}{15} = 80\%$
  that means on average you need 20% less time to complete a programme.

6 Using a stack in subroutines

There are several reasons why one needs the stack for assembler subroutines. One reason is that it allows for nested subroutines. Another reason is that it allows for passing parameters to subroutines. The processor stack is used to store the return address of the subroutine.

7 ALU SLT

- The slt command in the ALU (Arithmetic Logic Unit) stands for "Set Less Than". It is a command that compares two values and sets a register to 1 if the first value is less than the second value, and 0 otherwise.
- The ALU calculates that using second value minus first value and if the result is < 0, the msb (most significant bit) will be 1 and the first value must be smaller than the second value. This will then be fed back to the ALU and will be the output.