2 Diodes and Transistors

Student Group

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Table of Contents

2. Diodes and transistors

Introductory example

Microcontrollers have many digital inputs that evaluate signals between $0...5V$ as a digital signal. However, the input signal can be disturbed during transmission by small coupled pulses. This interference can cause the signal to leave the permitted voltage range of approx. $-0.5...5.5V$ and thus destroy the logical unit.

To prevent such destruction, an overvoltage protection circuit consisting of diodes is installed (see e.g. ATmega 328). In case of an over-/undervoltage one of the diodes becomes conductive and lowers the input voltage by the resulting current. In the simulation it can be seen that the interference on the input side can be reduced to an acceptable, low level by the protection circuit.

This chapter explains why a diode becomes conductive at a certain voltage, what has to be considered when using diodes and which different types of diodes are available.

For the protection of digital interfaces that leave the device housing (e.g. USB), additional separate ICs are used that support this protection of the data processing chips. These protection diode ICs suppress the short-time voltages and are called Transient Voltage Suppressor or TVS diodes. Typical TVS ICs are NUP2301 or for USB NUP4201.

Further reading

- With a depth beyond this course can be found the topic Diodes in Tietze Schenk
- For a deeper look at the level of this course and in pleasant morsels, see Electrical Engineering in 5 Minutes - Diode Topic.
  Here, the considerations of interconnecting diodes with nonlinear components are beyond the subject matter of this course.
- A nice introduction on with less depth can be found in KIT Bridge Course - 4.3.6 Diodes and Transistors (*).
  Some of the following passages, videos and pictures are taken from this introduction.
- One with similar introductory character is available at LEIFIphysik.
- **as a podcast**: Several of the aspects of the silicon PN transition presented here are explained in Methodically Incorrect Episode 164 - "Small Grain of Sand Hope".

Objectives

After this lesson, you should:

1. Know how to distinguish electron mobility in metals, semiconductors, and insulators,
2. know what the intrinsic conductivity of a semiconductor is,
3. distinguish between electron and hole conduction and relate them to p- and n-doping,
4. know what doping is and what it is used for…
5. know the difference between real and ideal diode,
6. be able to show the course in forward and reverse direction,
7. be able to choose the correct diode from different diode types,
8. be able to explain physical quantities such as reverse/residual current, reverse/residual voltage, breakdown voltage.

2.1 Current conduction in semiconductors