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Instruction Manual

Advanced Physics Lab
Electronics D

Modern Aspect of Data Taking and Processing with a Microcontroller

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Abstract

The experiment "Digital Electronic" provides an introduction into modern data taking by operating simple digital circuits utilising an Arduino board. This manual will inform you about the Arduino board, the installation of the required software and the electrical components you will have to use. Basic knowledge on electronics, how to use oscilloscopes, bread boards and power supplies is recommended.

During the experiment you will learn how to build a circuit that measures the temperature, how to operate it using the Arduino board and to modify and improve it using more components.

In case you should already have previous knowledge we will provide many more material and own ideas on implementation are very welcome and can be built consulting the assistants.

ETH Zürich, Switzerland, May 15, 2018

Contents

1 Introduction

Arduino is a computer company, project and user community based on easy-to-use hardware and software, that designs and manufactures single-board microcontrollers and microcontroller kits for building digital devices and interactive objects that can sense and control objects in the physical and digital world. All products are distributed as open-source hardware and software, and it's licences permit the manufacture of Arduino boards and software distribution by anyone. The boards are commercially available in preassembled form, or as do-it-yourself (DIY) kits.

The Arduino project started in 2003 as a program for students without a background in electronics and programming at the Interaction Design Institute in Ivrea (Italy). The aim was to provide a low-cost and easy way for novices and professionals to create devices that interact with their environment using sensors and actuators. The actual name Arduino comes from a bar in Ivrea, where some of the founders of the project used to meet. The bar was named after Arduin of Ivrea, who was the margrave of the March of Ivrea and King of Italy from 1002 to 1014 [4].

In order to work with the Arduino Boards the Arduino programming language, based on Wiring, and the Arduino Software (integrated development environment (IDE)), based on the Processing are used [1]. Both Wiring and Processing are programming languages using a simplified dialect of features from the programming languages C and C++.

1.1 Arduino Board

The original boards were produced by the Italian company Smart Projects but as of 2018, 22 versions of the Arduino hardware have been commercially produced. The information and specifications of these boards can be found on this website. During this Lab you will work the Arduino Uno shown in Figure 1.

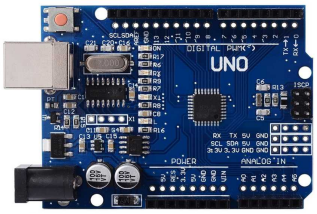


Figure 1: Arduino Uno.

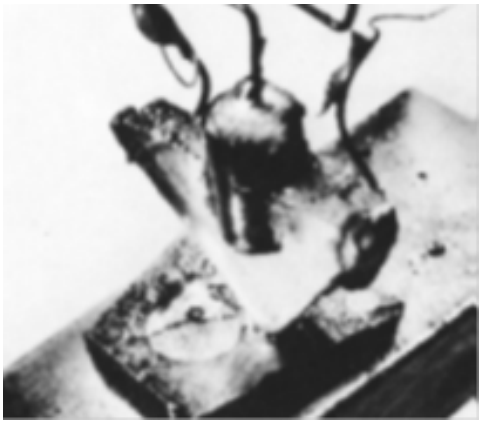
The Arduino Boards use a variety of microprocessors and controllers and are equipped with sets of digital and analogue input/output (I/O) pins that may be interfaced to various expansion boards or Breadboards (shields) and other circuits. The boards feature serial communications interfaces, Universal Serial Bus (USB) on some models, which are also used for loading programs from personal computers.

Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. You can tell the board what to do by sending a set of instructions to the microcontroller.

1.2 Transistor

The invention of the transistor was announced in 1948 by the American physicists, J. Bardeen and W. H. Brattain as a new type of amplifying device made fromsemiconducting crystals. At that time almost no one could have foreseen the revolutionary developments that were to follow, developments so important and far-reaching as to change the whole outlook of the science and technology of electronics. The physical principles of a transistor had been worked

out in conjunction with their colleague, W. Shockley. In recognition of their work the three physicists were awarded jointly the Nobel Prize for Physics in 1956.



(a) Point-contact transistor

(b) Bardeen, Brattain and Shockley

The term "transistor" is a combination from the words *trans*former and res*istor*, since the device is made from resistor material and transformer action is involved in the operation. In the beginning only point-contact transistors existed, but due to their vulnerability to mechanical shock they were soon replaced by junction transistors which are firmly established now [3].

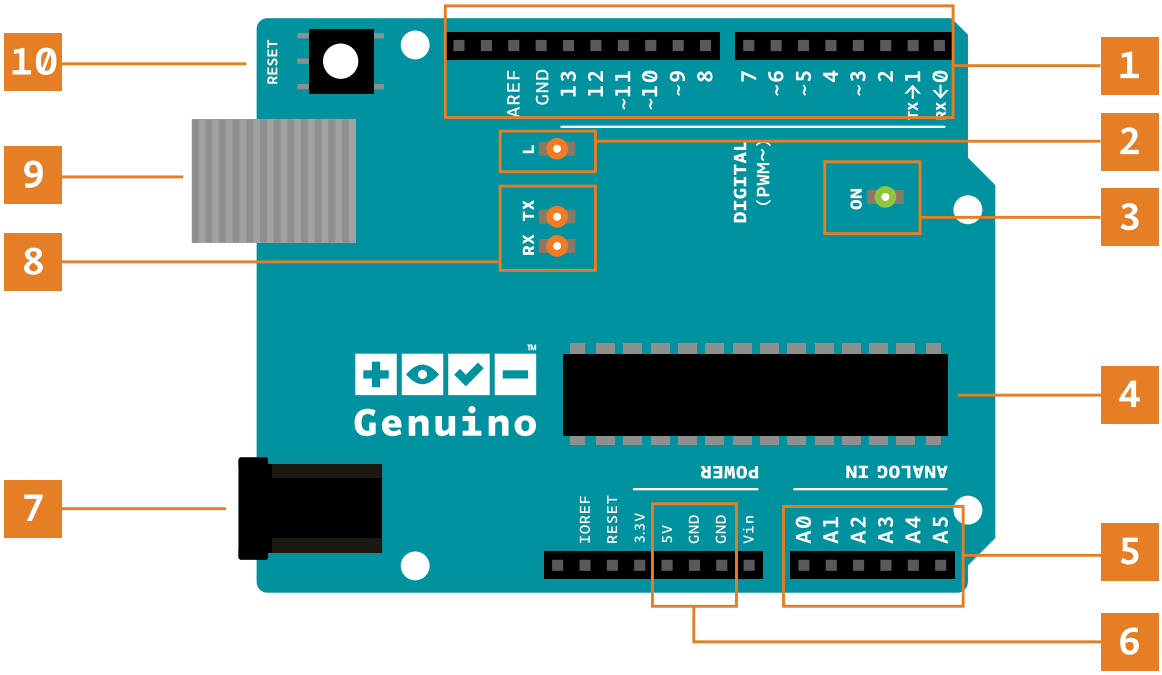
The transistor is the key active component in practically all modern electronics. It is considered as one of the greatest inventions of the 20th century. Its importance in today's society rests on its ability to be mass-produced using a highly automated process that achieves astonishingly low per-transistor costs (10 femto$/transistor) [2].

Although billions of individually packaged (discrete) transistors are produced every year the vast majority of transistors are now produced in integrated circuits (ICs). A logic gate consists of up to about twenty transistors whereas an advanced microprocessor, as of 2009, can use as many as 3 billion transistors. In 2014, about 10 billion transistors were built for each single person on Earth [2].

2 Basics

This section will give you the basic information about the components we are using in this lab.

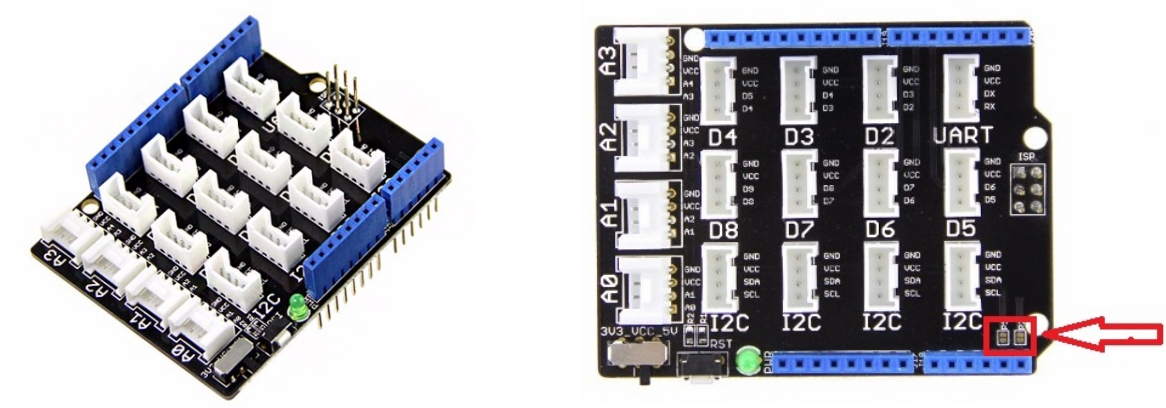
2.1 Arduino Uno



1. **Digital pins:** used with digitalRead(), digitalWrite(), and analogWrite() methods, analogWrite() only works on pins with the PWM symbol
2. **Pin 13 LED:** only built-in actuator
3. **Power LED**
4. **ATmega microcontroller**
5. **Analogue in:** used with analogWrite() method
6. **GND and 5V pins:** provide 5 V power and ground (GND) to the circuits
7. **Power connector:** additional power supply, accepted voltages: 7 V to 12 V
8. **TX and RX LEDs:** indicate communication between Arduino and computer
9. **USB port:** used for powering and communication with computer
10. **Reset button:** resets the ATmega microcontroller

2.2 Grove Base Shield

The so called shields are printed circuit expansion boards, which plug into the normally supplied Arduino pin headers. The Grove Base Shield is one example that simplifies projects that require a lot of sensors or LEDs. With the Grove connectors on the base board, one can add all the Grove modules to the Arduino Uno very conveniently.



(a) side view (b) top view

Figure 3: Grove shield.

There are 16 Grove connectors on the Base Shield which are shown in Table 1. Apart from the connectors the board also consists of a reset (RST) button, a green LED to indicating power status, a toggle switch and four rows of pinouts, which is equivalent to the pinout of the Arduino.

Specification	Name	Quantity
Analog	A0/A1/A2/A3	4
Digital	D2/D3/D4/D5/D6/D7/D8	7
UART	UART	1
I2C	I2C	4

Table 1: Base Shield connectors.

Every Grove connector has four wires, one of which is the voltage common collector (VCC). Since some micro-controller main boards need need different supply voltages the power toggle switch allows you to select the suitable voltage. In the case of the Arduino Uno a voltage of 5 V is required.

List of Acronyms

IDE integrated development environment

DIY do-it-yourself

USB Universal Serial Bus

I/O input/output

GND ground

RST reset

IC integrated circuit

VCC voltage common collector

References

[1] Arduino. Introduction to Arduino. https://www.arduino.cc/en/Guide/Introduction, 2018. [Online; accessed 15-May-2018].

[2] Dan Hutcheson. A look at Moore's Law. https://spectrum.ieee.org/computing/hardware/transistor-production-has-reached-astronomical-scales, 2018. [Online; accessed 15-May-2018].

[3] G.H. Olsen. *Electronics: A General Introduction for the Non-Specialist*. Springer US, 2013.

[4] Wikipedia contributors. Arduino — Wikipedia, the free encyclopedia. https://en.wikipedia.org/w/index.php?title=Arduino&oldid=839287116, 2018. [Online; accessed 15-May-2018].