Simone Candido’s
Arduino Nuts & Bolts

By Moreware
What is Arduino, and how does it work?
What is Arduino?

Arduino is a hardware-software platform composed by a series of electronic boards with a microcontroller on system.

The board permits the quick and simple prototyping of devices ready to complete the purpose they were designed for, like automated system for temperature/humidity checking.

It is possible for example to use sensors inside your mailbox and be alerted when something arrives.

Arduino is an open source platform.
Composition of the Arduino board
The hardware is accompanied by a multiplatform Integrated Development Environment (IDE) that is compatible with each Operating System.

The software Arduino IDE, like Code::Blocks or VisualStudio, allows to easily load and compile programs called “sketch” on the Arduino board.

The language used by Arduino derives from C and C++. This means that to use Arduino all you need to know are math and logic expressions, the if construct and the for, while and do-while loops.
What is a buzzer?
What is a buzzer?

The basic operating characteristics of the passive buzzer are the PWM modulation, where the pulse induces a vibration on the air over the internal membrane of the buzzer, thus generating the sound.

You can generate different sounds setting up the frequency of the waves. i.e. you can sound a C generating a frequency of 523 Hz, or an A at 440 Hz.

This way, it’s fairly easy putting the pieces together and compose a song through it.
What is a sound?

Sound is a longitudinal mechanical wave, which consists in the alternation of compressions and rarefactions of the medium in which it propagates.

When the wave reaches our ears, the membrane that makes up the eardrum vibrates. The membrane is pushed inwards by the compressed air and sucked outwards by the rarefied air.
Connections with Arduino
The sensor DHT11
What is the DHT11?

A temperature and humidity sensor is a device capable of detecting these two parameters, and simultaneously converting them into an analog or digital signal that indicates their value.

Temperature is a physical quantity that measures the kinetic energy of the particles that make up the different substances. The particles generate heat with the impacts due to their movement.

Humidity is defined as the amount of water value in the atmosphere, and can be divided into two forms: absolute humidity and relative humidity.
How does the DHT11 work?

These instruments work as transducers: they are composed of materials sensitive to a specific stimulus (humidity and temperature) which undergo structural variations consequent to the interaction with this stimulus, to then generate a corresponding electrical signal.

In particular:

- **Humidity** is measured through a hydrophilic polymer, which interacts with the water molecules.
- The **temperature** is detected thanks to metal elements sensitive to heat.
Connections with Arduino
How does the RC522 work?
RFID is the acronym for Radio Frequency Identification and represents a short distance data transfer system. The salient feature is being able to power only one of the terminals.

Through this feature, the passive terminal can be used in situations where it is impossible to supply energy, such as in the microchips used to identify dogs, or in contactless payment systems.
The active terminal is able to read and modify the data present inside the passive terminal.

Through the large area enclosed by a built-in antenna, it will be possible to pick up the passive terminal signal.
What is the RC522 module?

The RC522 module has several internal components: antenna, LEDs, resistors and capacitors, as well as a quartz oscillator and a chip.

The system is able to process the signals collected by the antenna and transform them into digital impulses, readable by the Arduino board through a specific library.
Connections with Arduino

The pins of the RC522 module must be connected to predefined Arduino ports (11, 12 and 13 for Arduino UNO) since their position is fixed within the libraries to be used.
What is a potentiometer?
A potentiometer is a resistor with variable resistance. A rotating bracket allows to manage the flow rate and the resistance value.

The potentiometer is widely used in electronics as an adjustable voltage divider, connected in series with a fixed resistor.
The potentiometer is an electrical device equivalent to a variable resistive voltage divider.

It corresponds to two resistors connected in series having the sum of the two resistance values as a constant, but of which the relative value may vary.

A section of such divider is used in parallel to the user load.
The potentiometer consists of an insulating cylinder on which a metal wire with suitable resistivity is tightly wound. The ends of the wire represent two of the poles of the resistor, while the third element, the central connector, is represented by a moving contact that moves along the coil of wire.

The potentiometer is often used as a tone or volume control in amplifiers.
Connections with Arduino
What is the module GY-521?
How does it work?

The GY-521 sensor is developed by InvenSense, and contains MEMS accelerometers and gyroscopes, as well as a 16-bit analog-digital converter for each channel. It can simultaneously detect inertia on the x, y and z axes.

To interface, the sensor uses an I2C-bus connection. IMU sensors are composed of multiple components such as accelerometer, gyroscope, magnetometer and altimeter.

The GY-521 sensor is able to provide 6 values as output: three of these obtained from the accelerometer, and 3 from the gyroscope, both contained in a single chip.
How does an accelerometer work?

An accelerometer works by exploiting the principle of the piezoelectric effect. Imagine a cubic-shaped box with a small sphere inside, as in the image below.

The walls of this box are made of piezoelectric crystalline material. By rotating the box, the ball is forced to move, according to the force of gravity, in the direction in which the box is tilted.

A sudden acceleration causes a shock and compression of the piezoelectric crystal structure, which reacts by generating a very precise electrical signal.

By detecting this electrical signal and processing it adequately, the accelerometer is therefore able to determine from which direction the accelerating thrust comes, and what its force is.
How does a gyroscope work?

The gyroscope is a physical device capable of moving on its axis, so as to seem capable of defying gravity. The principle on which the gyroscopic is based is that of the conservation law of the angular momentum, according to which the angular momentum of a system remains constant unless an external force acts on it. When this happens, the body tends to maintain a fixed orientation, with the axis pointing in the direction of rotation.
Connections with Arduino
The RTC module
What is a RTC module?

This module allows you to view the current year, month, day, hour, minute, second and day of the week.

The module is powered by a small battery, and works even in the absence of connection with the Arduino board.

Time is counted thanks to the use of an oscillator.

The module adopts serial communication (I2C) with Arduino, and can read / write data.
Advantages using a RTC module

The systems based on a RTC show peculiar advantages:

- Low power consumption
- Time calculation done inside the module
- High precision
Connections with Arduino
Using analog pins as digital ones
To use analog pins as digital ones, it is necessary to number them in a different way:

- The A0 pin corresponds to the digital pin #14
- The A1 pin corresponds to the digital pin #15
- The A2 pin corresponds to the digital pin #16
- The A3 pin corresponds to the digital pin #17
- The A4 pin corresponds to the digital pin #18
- The A5 pin corresponds to the digital pin #19
Connecting pins in the IDE

If you need to configure the analog pi A0 as digital, You should code the following inside the setup function of the Arduino IDE:

```
pinMode(14, OUTPUT);
```

Or

```
pinMode(14, INPUT);
```
Some examples

Such technique becomes quite useful whenever you need more digital pins for your project to use them with LEDs, sensors, buzzers and so on.

Here is an example to turn a LED using an analog pin as a digital one.
Blink code

```c
void setup()
{
    pinMode(14, OUTPUT); // viene utilizzato il pin analogico A0 come pin digitale
}

void loop()
{
    digitalWrite(14, HIGH); // il led viene acceso
    delay(1000); // pausa di 1 secondo
    digitalWrite(14, LOW); // il led viene spento
    delay(1000); // pausa di un secondo
}
```
How does a rain sensor work?
What is a rain sensor?

The sensor is composed by two parts: a base, exposed to the rain, and a module which gives access to a potentiometer.

The readings of the sensor will show whether it is raining or not.
How does a rain sensor work?

The detection pad is composed of a copper coil that acts as a variable resistor. The resistance varies with the quantity of rain present on the surface of the coil.

The value of the resistance is inversely proportional to the quantity of the water: The greater the quantity of water, the lower the value of the resistance.

The sensor will produce a value for the output tension based on the value of the resistance (Ohm’s law).

Reading such value will tell whether it is raining or not.
The pad detects the amount of rainwater resting on the surface.

Through this quantity it will be possible to get the resistance value.

From the resistance value it will be possible to deduce the analog value of the output voltage.

The module checks and compares the threshold value set by the user through the potentiometer.
A water level sensor
What is a water level sensor?

This sensor is capable of measuring water depth.

The core of this component is a transistor amplifier circuit.

As soon as the water comes into contact with the sensor tracks, the printed circuit lines will act as a resistance, the value of which changes according to the depth of the water.
The sensor for checking the water level is composed of a base for printed circuits, on which parallel copper strips are applied.

On the base there are also resistors, a J3Y transistor and a LED.

On the strips of odd places a current is circulated which, due to the moderate electrical conductivity of water, is partially transferred to the strips of even places.
Connections with Arduino
How sensors for automatic doors work
Automatic door sensors are sensors based on the physical principle of the Doppler effect.

The Doppler effect is that physical phenomenon whereby there is a variation in frequency when an individual (or receiver) approaches or moves away from the sound source.

The consequences consist in the variation of the frequency, that is in a reflected sound with a higher or lower pitch than the original one.
What is the Doppler Effect?

The Doppler effect has to do with movement. To describe it, it is necessary to establish a reference system. We choose a system where the air is at rest. To see what happens when the source and the receiver are in relative motion, we distinguish two cases:

- The source is still with respect to the air, and the receiver is moving.
- The source is moving relative to the air, and the receiver is at rest.

In the first case, there is an increase in the frequency detected when the receiver approaches the source. If, on the other hand, the source approaches the receiver, it observes a shorter distance between the wave fronts, therefore a shorter wavelength, which corresponds to a higher frequency and therefore a more acute sound. The opposite happens when source and receiver step away.
Doppler Effect

Low Frequency

High Frequency
How does a distance sensor work?
What is a distance sensor?

An ultrasonic distance sensor HC-SR04 is able to measure distances ranging from 2 cm to 4 meters, even if in the latter case the opposition of the air could distort the measurements.
How does it work?

The principle with which HC-SR04 works is very simple: One of the two cylinders emits sound waves, at ultrasonic frequency. These frequencies bounce off the object in front of the emitter and go back.

The second cylinder detects these reflected frequencies.
Which pins are used?

HC-SR04 uses four connectors:
- **Vcc** – Connected to the supply voltage at 5Vcc
- **Trig** – This pin is “triggered” to send the ultrasonic signal
- **Echo** – This pin produces a pulse that stops when the reflected signal is received
- **GND** – Ground connection
How do we measure distance?

The speed of sound is a known physical quantity, equal to 331.5 m / s at 0 °C, and 343.4 m / s at 20 °C, and directly proportional to the temperature.

This speed varies according to the relationship:

\[ v = 331.4 + 0.62T \]

Speed is the relationship between space traveled and time taken to travel it. In our case, the sound wave we are measuring travels the space twice (on the outward and after the reflection), therefore the value of the space obtained will be divided by two.

For greater precision, the temperature must also be controlled.
Connections with Arduino
What is a ePaper display?

- E-Paper
- 2,4..3,3V
- 4 Grey Levels
- SPI Interface
Unlike conventional displays, an ePaper display is able to manage the reflected light as on ordinary paper, and imitates the ink trend on a sheet of paper.
Advantages:

The advantage of this technology lies in the fact that images and texts can remain permanently printed, even in the absence of electricity.

We also observe:

- Compatibility with passive NFC technology
- Battery not needed for power
- Image visible on the display for weeks
- Easy to set up
What is it used for?

Its features make it ideal for use as data-logging, to create price tags, labels, or use in outdoor environments, and in configurations that require low energy use.
What is a LCD display?

The LCD display used with Arduino has an LED backlight, Abd can visualize up to 2 lines of 16 characters.

Each character position is displayed using a dot matrix (pixels).

These LED displays are mostly monochromatic, and visualize essentially text or special characters.
Which pins are used?

The most common 1602 LCD displays use the following PINS:

- VSS - GND
- VDD - 5Vcc
- VO - to define the contrast of the display
- RS - defines the area where the new character is written
- R/W - Select the Read - Write mode
- E - Enable pin
- D0-D7 - Read and write data
- A - K - Control the backlight
Connections with Arduino

The LCD display needs 6 output digital pins from Arduino. Also a 5Vcc and GND connections should be provided. The potentiometer is used to determine the contrast.
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