Assembling the Device

Developed by LIIS

A Trainers Toolkit To Foster STEM Skills Using Microcontroller Applications

Co-funded by the Erasmus+ Programme of the European Union

Project No. 2019-1-RO01-KA202-063965

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Assembling Devices with Microcontrollers

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- Summary

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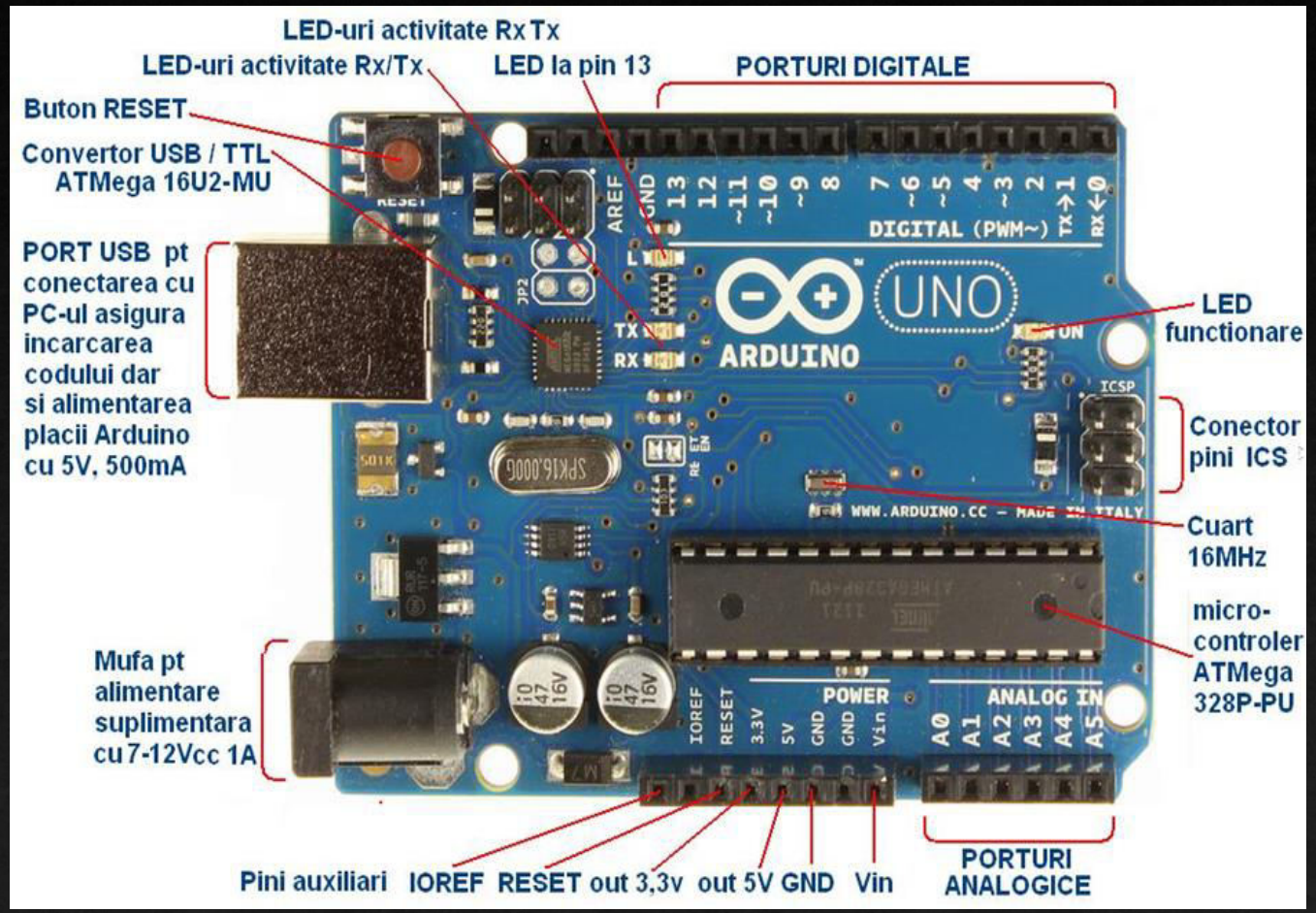
Arduino Boards

Arduino UNO

- open-source operating platform
- built on a ATMEGA 328P-PU microcontroller able to:

✓ collect data through sensors in the boards

✓ manage devices such as LEDs, motrors or mechanic devices through operating language inscribed in its memory (similar to C++).



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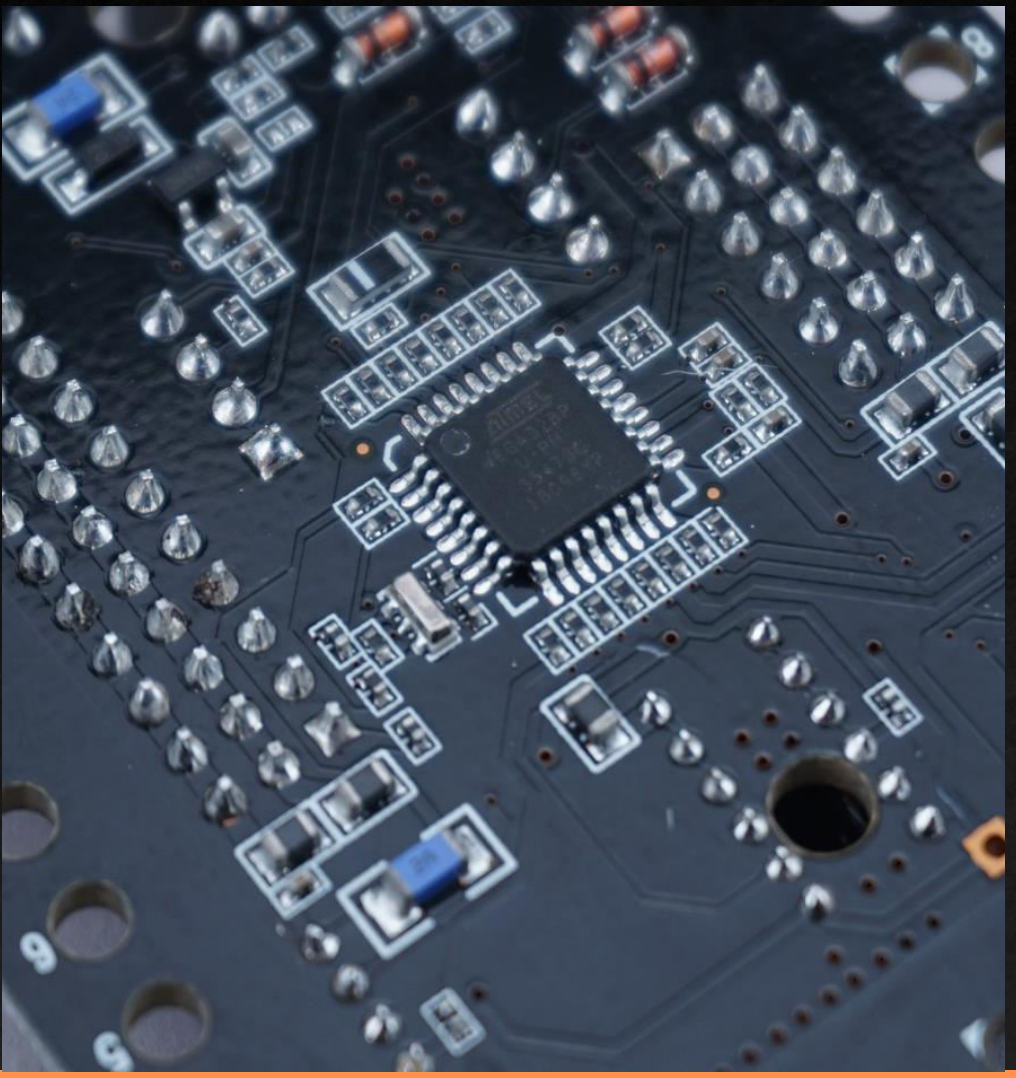
Power supply



- Automatic selection from the computer's USB port or other external source
- AC/DC adapter or batteries. The adaptor includes a 2.1 mm jack, with plus on the center. Battery wires can connect through the same port or to the header GND or Vin pins of POWER.
- The board work with voltage 6-20 (7 -12 recommended)

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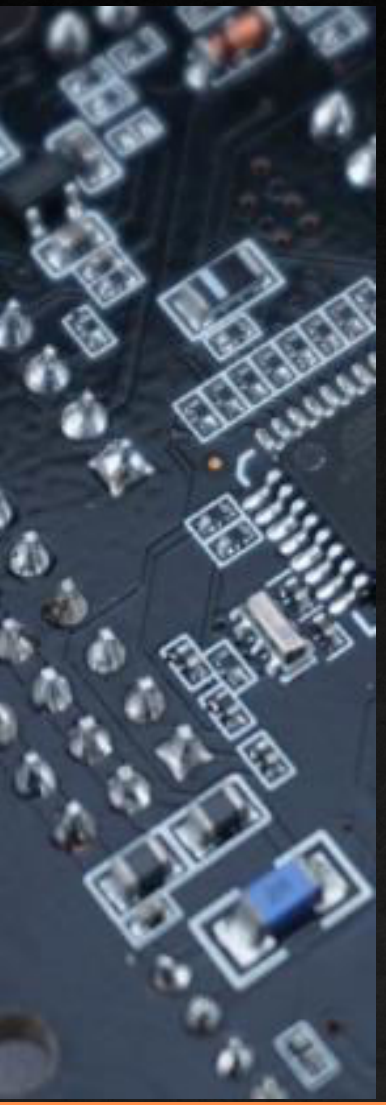

Power Supply pins:

- VIN. Input for external voltage supply (5 volts)

  The connection to the USB port of the computer is not used
- 5V. Internal stabilizer of the plate offers stabilized voltage of 5V.

  WARNING Power supply with external voltage through 5V or 3.3V pins can destroy the plate.
- 3V3. Internal stabilizer generates voltage of 3.3V at a maximum current of 50 mA, used for applications that require 3.3 volt power.
- GND. Table pins
- IOREF. Generates a reference voltage with which the microcontroller can operate.

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Memory

ATmega328 microcontroller

- 32 KB memory of which 0.5 KB are used for bootloader.
- It contains 2 KB SRAM and 1 KB EEPROM memory

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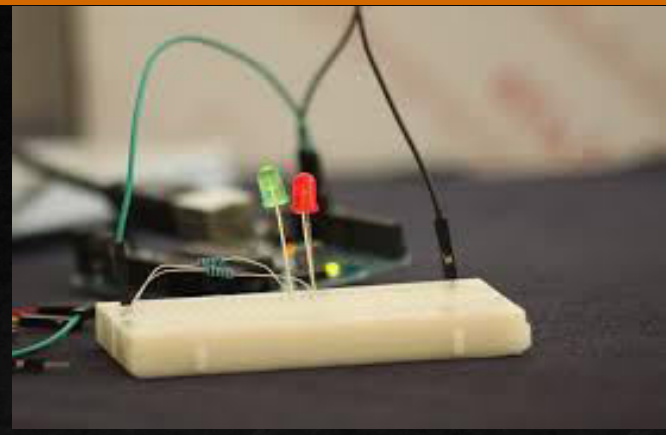
Making the Frame

- The frame of the device will depend on its intended function. The frame should be light and robust, made of 3D Printed or ready made materials.
- The project may use existing standard materials like cardboards, plastic, wood or metal plates, glass. They can easily be cut, glues, bent or layered. The colours may be changed accordingly. Holes for connecting the electronics and actuators will be drilled. Metal sheets can be bent or custom cut to fit the demanded size. The solution with 3D printing is an option for irregular, uncommon shapes. The weight of the device, if that is a requirement, will be considerably reduced.



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Gathering the right tools

- Select the material for the frame.
- Get the required parts for the microcontroller device both electrical and mechanical and measure them.
- Make a sketch of the device and a devise a plan for its assembly.
- Make sure the frame fits all the elements, the structure is sound and the design is balanced.
- Test fit each component before assembling the frame in case modifications are required.
- Aassemble your frame using hot glue, screws, nails, duck tape and any other required tools.
- Fit the elements onto the frame and connect the wires.

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Gathering the Right Tools

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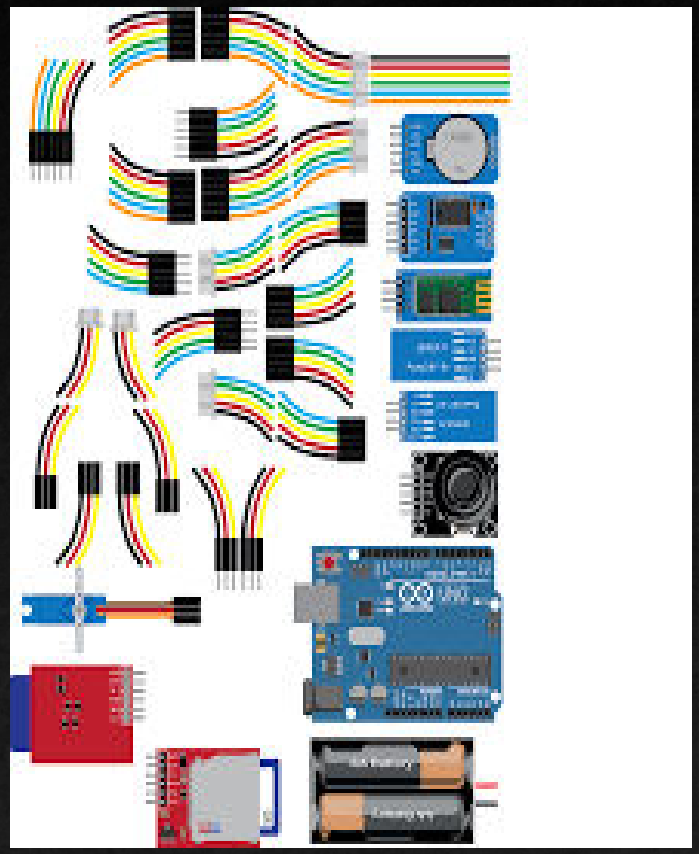
Connecting Motors to Motor Controllers

- A DC (gear) motor, or DC linear actuator will likely have two wires: red and black. Connect the red wire to the M+ terminal on the DC motor controller, and the black to M-. Reversing the wires will only cause the motor to spin in the opposite direction. A servo motor, there are are three wires: one black (GND), red (4.8 to 6V) and, yellow (position signal). A servo motor controller has pins matching these wires so the servo can be plugged directly to it.



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Connecting Batteries

- Most motor controllers have two screw terminals for the battery leads labelled B+ and B-. Match the battery with connectors and the controller using screw terminals, either through a matching connector with pigtails (wires) connected to the screw terminal or connect the battery to the motor controller while still being able to unplug the battery and connect it to a charger. Choose electromechanical products that can operate at the same voltage and do not require several batteries or voltage regulation circuits.

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Specifications

- DC gear motors - 3V to 24V
- Standard Servo motors - 4.8V to 6V
- Specialty Servo motors - 7.4V to 12V
- Stepper motors - 6V to 12V
- Microcontrollers that include voltage regulators - 3V to 12V
- Sensors - 3.3V, 5V and 12V
- DC motor controllers - 3V to 48V
- Standard batteries are 3.7V, 4.8V, 6V, 7.4V, 9V, 11.1V and 12V

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Connecting Motor controllers

- Serial: The controller has two pins labelled Rx (receive) and Tx (transmit). Connect the Rx pin of the motor controller to the microcontroller's Tx pin and vice versa.
- I2C: The motor controller will have four pins: SDA, SCL, V, GND. The microcontroller will have the same four pins to be connected.
- PWM: The motor controller will have both a PWM input and a digital input for each motor. Connect the PWM input pin of the motor controller to a PWM output pin on the microcontroller, and connect each digital input pin of the motor controller to a digital output pin on the microcontroller.
- R/C: To connect a microcontroller to an R/C motor controller, connect the signal pin to a digital pin on the microcontroller.

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Communication

- Regardless of the communication method, the motor controller's logic and the microcontroller need to share the same ground reference (this is achieved by connecting the GND pins together) and the same logic high level (this can be achieved by using the same V+ pin to power both devices). A logic level shifter is required if the devices don't share the same logic levels (3.3V and 5V for instance)
- communication devices (e.g. XBee, Bluetooth) use serial communication, so the same RX,TX, GND and V+ connections are required and use a single serial port for each one of them.

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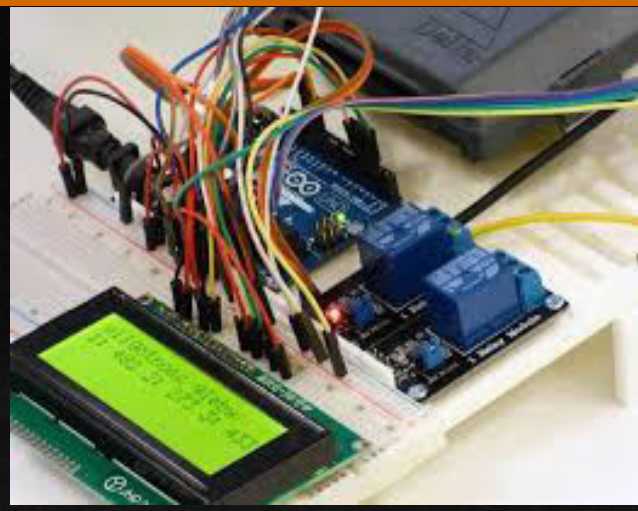
Connecting Sensors

- Sensors can be interfaced with microcontrollers in a similar way than motor controllers. Sensors can use the following types of communication:
- Digital: The sensor has a digital signal pin that connects directly to a digital microcontroller pin, eg. a switch.
- Analogue: Analogue sensors produce an analogue voltage signal that needs to be read by an analogue pin. If the microcontroller does not have analog pins a separate analog to digital circuit (ADC) is needed. Some sensors some with the required power supply circuit and usually have three pins: V+, GND and Signal. A simple variable resistor will require a voltage divider to read the resulting variable voltage.
- Serial or I2C: the same communication principles explained for motor controllers.



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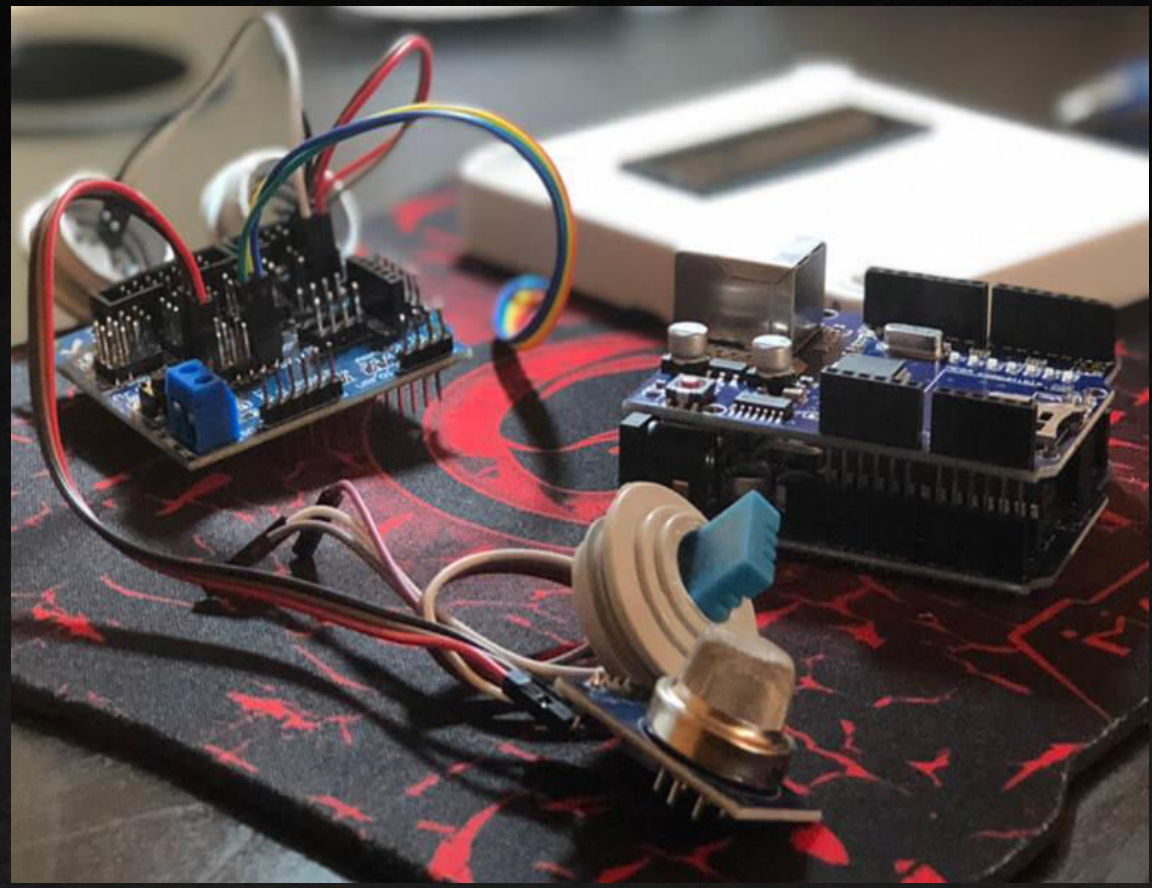
Connected Boards

- Choose wheels or sprockets designed to fit the shaft of the motor or fit a hub between the two. If this is not the case one can find another hub which connects to the wheel but has a smaller bore, you would then drill out the hub's bore to the same diameter as the shaft.
- Mount the electronics onto the frame using means that do not conduct electricity, eg. hex spacers, screws, nuts, double-sided tape, Velcro, glue, cable ties, etc.



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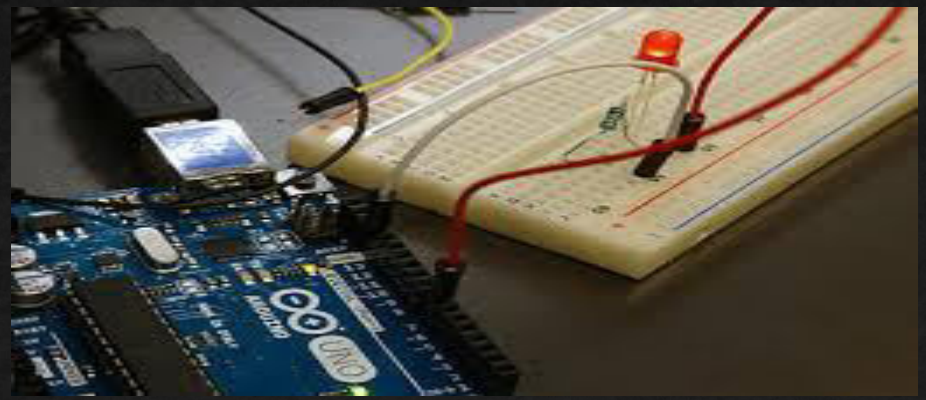
Assemblying a model project

- The Ethernet shield is mounted on the Arduino Uno board, and the expansion board for sensors is mounted on the Ethernet shield.
- The device will detect the environmental parameters in a servers room.
- Rationale: in case of air conditioner malfunction the temperature will rise (same with humidity and smoke levels) which can damage the servers.
- Aim: the device will signal through mail the malfunction.



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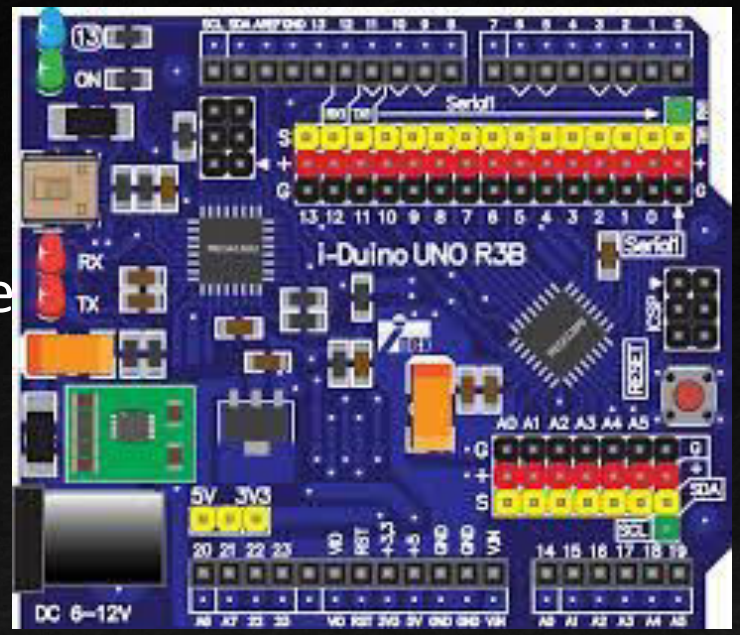
Required elements for Arduino Uno

- R3 development board with Atmega328P chip.
- Ethernet Expansion Board W5100 for connecting the system to the network and sending emails.
- Expansion plate V5.0 for sensors, to attach the components to the development board
- 1602 IIC / I2C LCD screen with pins and serial mode attached.
- MQ 135 air quality sensor module (can detect smoke/ammonia/benzene etc.)
- DHT11 temperature and humidity sensor.
- Dupont wire of 10 or 20 cm, type mother-mother.
- 2 LEDs and a 5V and 3A power supply.
- Box



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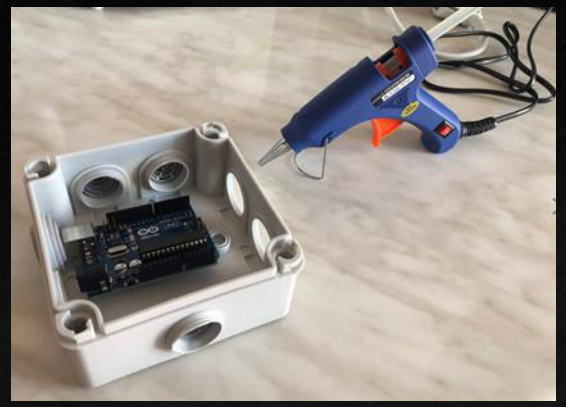
Connecting the Elements



- Ethernet shield is mounted on the Arduino Uno board.
- Expansion board for sensors is mounted on the Ethernet shield.
- If the box in which the project is mounted has a lower height (if we use a bypass dose for example) it should be slightly cut with a patent from the ends of the Ethernet shied . WARNING! The metal part of the LAN socket should not be touched by the glues of the expansion board.

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Derivative Dose

- The white LED connects to GND and V on digital pin 1 → system is ON.
- The red LED connects to GND and S on digital pin 2 and lights up when one of the parameters (temperature, humidity, smoke) exceeds the set maximum limit.
- Mails are sent through an SMTP server, and the user and password must be encrypted as in BASE64.

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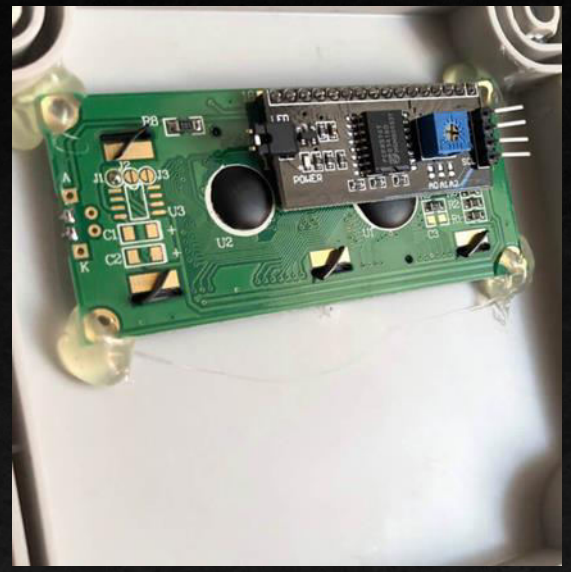
LCD Screen



The LCD screen connects as follows:

- GND (orange cable) to G in the A5 analog pin area
- VCC (yellow cable) to V from analog pin area A5
- SDA (green cable) to S from analog pin A4 area
- SCL (blue cable) to S from analog pin A5 area

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Assembled Device

- The maximum temperature (eg 25 ° C), humidity (eg 80%) and air quality (eg maximum 150) are set.
- Exceeding any parameter set triggers the alarm and if for 1 minute the system does not detect the return to normal, it means that the contact person must be alarmed and is set to send mail with the recorded values.
- Send mail every minute until the situation returns to normal or it is reset by turning off the power.

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Assembling the Device

Topic Summary

Here is what we learned

- **First skill:**

  To identify the components and their roles on Arduino Uno Board

  Second skill:
  To assembly a model project using a Starter Kit Arduino Uno

- **Third skill:**
  To connect the parts of the model and test the result

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