GMTROM

Building manual

GMTROMy

14th June 2023

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True Random Number Generator – GMTROMy

The developed product uses an Arduino microcontroller in conjunction with a ring oscillator to generate true random numbers. The ring oscillator serves as a source for physical fluctuations that are detected by the Arduino. The least significant bits of these fluctuations are used as resources.

The Arduino is connected to a Raspberry Pi computer, which is responsible for further processing of the generated random numbers. The Raspberry Pi provides a powerful platform for analyzing and using the numbers in various applications.

The product enables a reliable and efficient method for generating true random numbers. These random numbers find application areas in cryptography, simulations, lotteries and other scenarios where high quality and unpredictability of random numbers are crucial.

Materials and tools

Materials

- Arduino Due
- Ring Oscillator
- circuit board
- Raspberry PI
- 4x acrylic glass black
- 4x acrylic glass colorless transparent
- 1x acrylic glass black transparent
- Spacer bolt version¨supply external thread
    - m2.5x6+6 16pcs
    - m2.5x10+6 6pcs
    - m2.5x12+6 7pcs
    - m2.5x15+6 11pcs
- Spacer version internal thread
    - m2.5x6 3pcs
    - m2.5x10 2pcs
    - m2.5x12 3pcs
- Screws 14pcs
- single core conductive cables 7pcs
- Laser Cutter

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Tools

- Soldering
- C++:, Python, classes, memory allocation and basics should be known
- Arduino knowledge
- Basic technical knowledge
- Basic electrotechnical knowledge

Preparation

Materials needed

- 4x Acrylplatte schwarz
- Laser Cutter

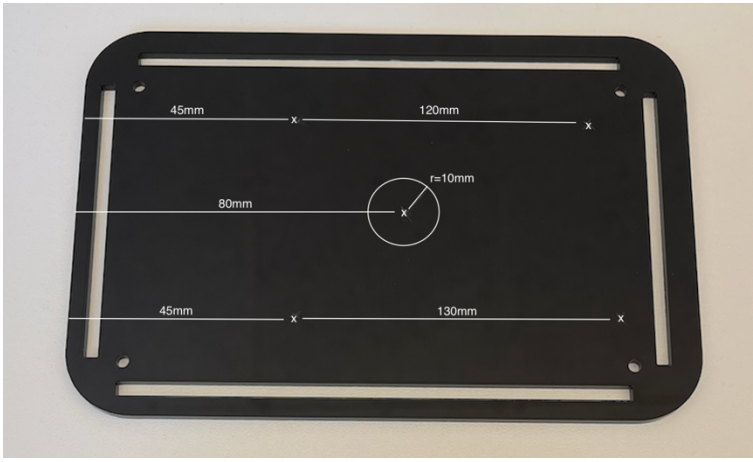
Laser cutting of acrylic plates black

Cutting the black acrylic glass: The black acrylic glass should be cut to the desired size with a laser cutter. The plates must conform to the exact dimensions of 150x100mm. A total of 4 sheets of black acrylic glass are required.

Drilling holes for the spacers: holes should be drilled on each black acrylic sheet at each corner. These holes will be used to attach the spacers and connect the various parts of the structure. It is important to ensure that the holes are the correct size for the spacers being used. These holes are 2.7mm in diameter and are each 14mm from the top edge and the edge next to it.

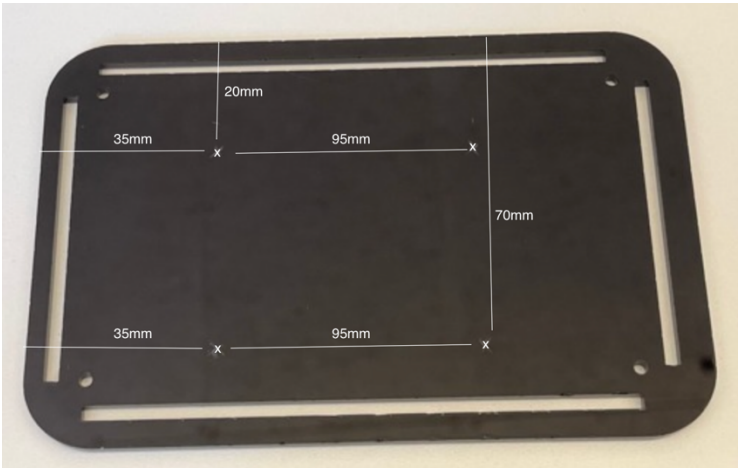
Creating Slots: Slots need to be cut on each side of three of the black acrylic panels. These slits will allow the colorless acrylic to be inserted later. The slots must be cut 120mm long on the wider side and 70mm long on the narrower side to ensure a snug fit of the colorless acrylic glass.

Arduino plate: To position the openings on the acrylic plate for mounting the Arduino, the following openings must be followed:



- Start with the two left openings. These are directly below each other and are 44 mm apart from the side.
- The upper right opening has a distance of 120mm to the left side of the plate.
- The lower right opening is located under the upper right opening and has a distance of 130mm to the left side of the plate.
- The openings have a diameter of 2.7mm.
- The hole in the middle has a distance of 80mm and a radius of 10mm
- Cut the holes with a laser cutter

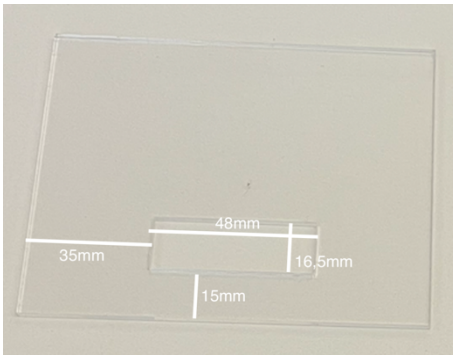
Raspberry PI plate: To prepare the mounting holes for the Raspberry Pi on the second plate, please follow these steps:



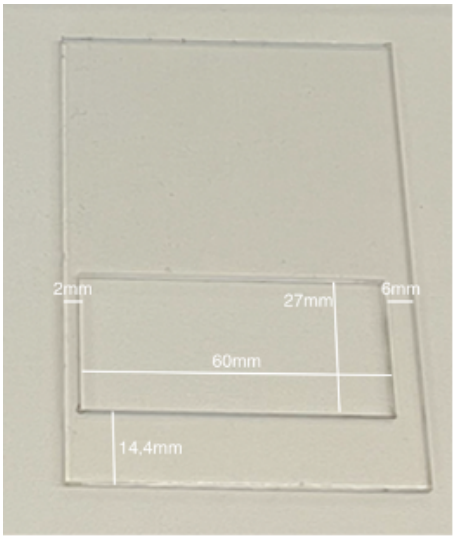
- Measure a distance of 35 mm along the wider side and mark a position for the mounting holes on the left.
- Measure a distance of 95mm along the wider side and mark a position for the mounting holes on the right.
- The two upper openings have a distance of 20mm to the upper side of the plate
- The two lower openings have a distance of 70mm to the upper side of the plate
- Use a suitable drill and the appropriate drill bit to drill the mounting holes at the marked positions.
- The holes have a diameter of 2.7mm

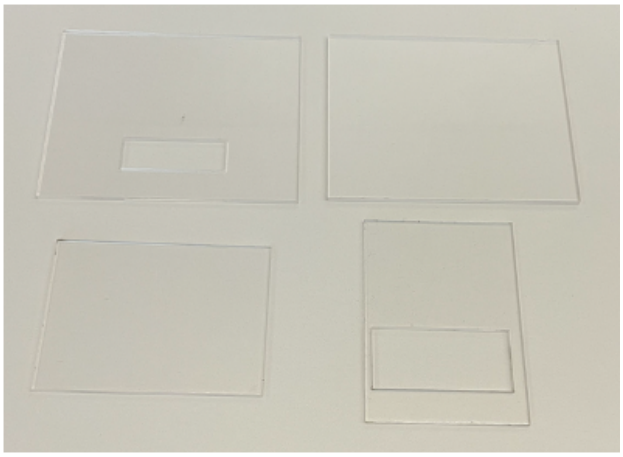
Laser cutting of acrylic sheets transparent and black translucent acrylic sheet

1. Prepare the 3 transparent acrylic plates and the black translucent acrylic plate.
2. Start with the two transparent acrylic plates. Mark them with the following dimensions: 96x120mm.
3. Place one of the clear acrylic sheets in the laser cutter and cut it out along the mark with the specified dimensions. Repeat this step with the second transparent acrylic plate.
4. Take the black translucent acrylic plate and the other transparent acrylic plate and mark both with the dimensions 96x70mm.
5. Place the plates in the laser cutter and cut them out along the marking with the indicated dimensions.



6. Select one of the two wider acrylic sheets (96x120mm) that you cut earlier. Mark the center of the plate with the measurments from the picture.
7. Use the laser cutter to cut a hole in the center of the wider acrylic sheet. The hole should be large enough to allow access to connectors.
8. Take the black translucent acrylic sheet and mark the center as well and mark the center of the plate with the measurments from the picture.
9. use the laser cutter to cut a hole in the center of the black translucent acrylic sheet. The hole should also be large enough to allow access to connectors.





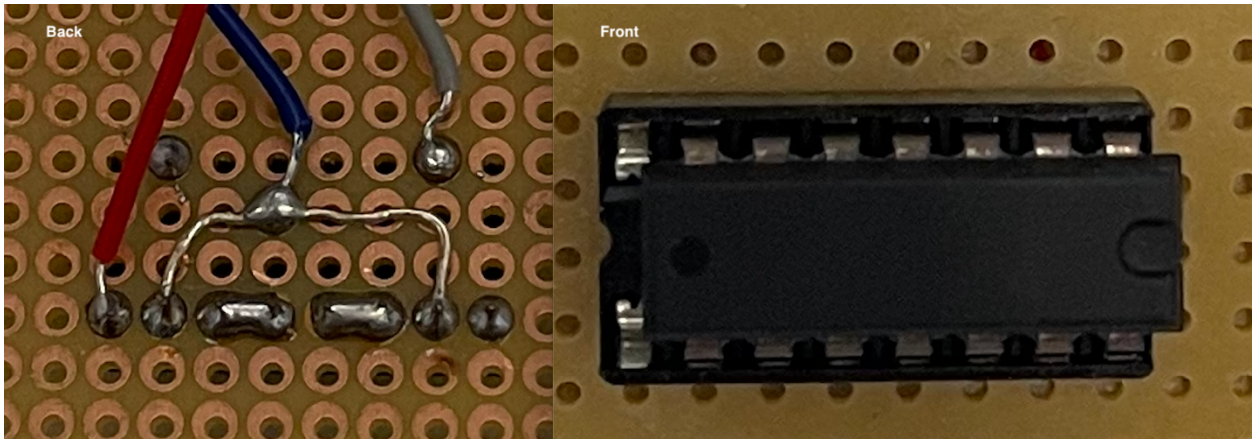
Build and solder ring oscillator

Materials needed:

- a circuit board
- a device for soldering
- an IC socket (at least 14-pin, we use a 16-pin socket)
- a SN74HC04N inverter
- single-core conductive cables 3x.

1. To drill the holes for the spacers on the yellow circuit board, please proceed as follows:
    a. Measure 1.2 cm up from the bottom edge of the board and mark this position as the bottom point of the first hole.
    b. Measure 2 mm to the left from the right edge of the board and mark this position as the right point of the first opening.
    c. Position the drill at the marked points and drill the first opening.
    d. Measure 3 mm from both edges of the board and mark these positions as the positions of the second opening.
    e. Position the drill at the marked points and drill the second hole.
    f. Measure 3.2 cm up from the bottom edge of the board and 7 mm to the right from the left edge. Mark this position as the point of the third opening.
    g. Position the drill at the marked position and drill the third opening.

    Drilling these holes will allow the spacers to be securely attached to the yellow board. Make sure that the drill holes meet the requirements of the spacers to ensure stable mounting.



2. Start soldering the IC socket to the board. Place the socket at the desired position on the board and make sure that the pins of the socket are aligned correctly.
3. Use the soldering iron and solder to connect the pins of the IC socket to the corresponding solder pads on the board.
4. Once the IC socket is firmly seated on the board, you can insert the SN74HC04N inverter into the socket. Make sure the inverter is oriented correctly according to the markings on the component and the socket.
5. To solder the single-wire conductive cables, orientate yourself to the following positions on the lower side of the PCB:
    a. Solder the first cable at the bottom at the first position (see picture, red cable for reference).
    b. The second cable is soldered at the bottom at the second position (see picture, blue cable for reference).
    c. The identical cable is soldered at the bottom at the seventh position (see picture, blue cable as reference).
    d. Solder the fourth cable on the top at the seventh position (see picture, gray cable for reference).
6. Cut the single-core conductive cables to the required length so that they reach the desired positions on the board.
7. If necessary, remove some insulation from the ends of the cables to make a good solder connection.
8. Use the soldering iron and solder to connect the free ends of the cables to the corresponding solder pads on the board.

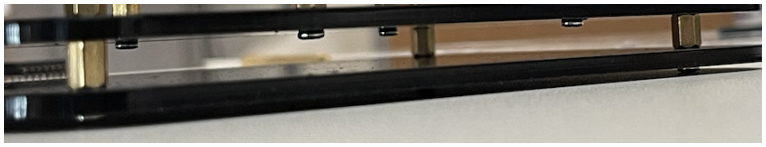
Step by Step Guide

Part 1 – Ground with Raspberry PI

Materials needed:

- Raspberry PI
- One black acrylic plate without slot
- One black acrylic plate with slot
- 8x spacers m2.5x6+6
- 8x spacers m2.5x15+6
- 4x spacers m2.5x12+6
- 8x screws

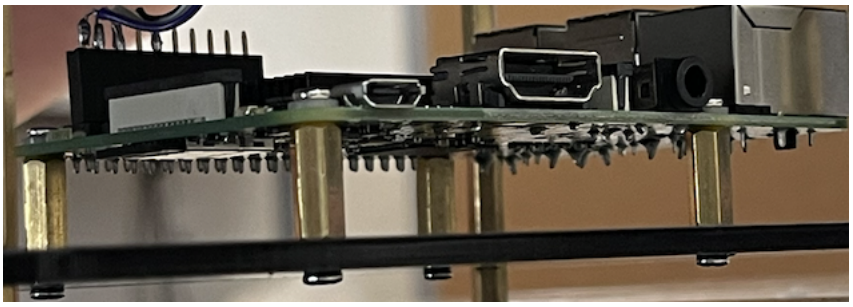
1. Start with the black acrylic plate without slot. Place this plate on the floor. The plate should have 4 holes on the corners to place the spacers.
2. Take a m2.5x6+6 spacer and place it in one of the corners of the black acrylic plate. Fasten the spacer with a screw from below. Repeat this step for the remaining three corners of the plate.
3. On the first following picture on the left you can see an example of how it should look approximately from the side and on the picture on the right is a picture of the plate from the back.



4. Before we attach the next plate, we need to attach the Raspberry PI. Take the black acrylic plate with a slot. This plate has holes to attach the Raspberry PI in addition to the holes for the spacers.
5. Place four m2.5x12+6 spacers on the upper side of the black acrylic plate with a slot. Attach each spacer with a screw, with the screw sitting on the bottom side of the plate. This way the screws are not visible from the top.

6. Position the Raspberry PI over the standoffs and secure it to the brackets with screws. Make sure the Raspberry PI is secure and tight.

7. In the following picture you can see an example of how the Raspberry PI should look like from the side after these steps.

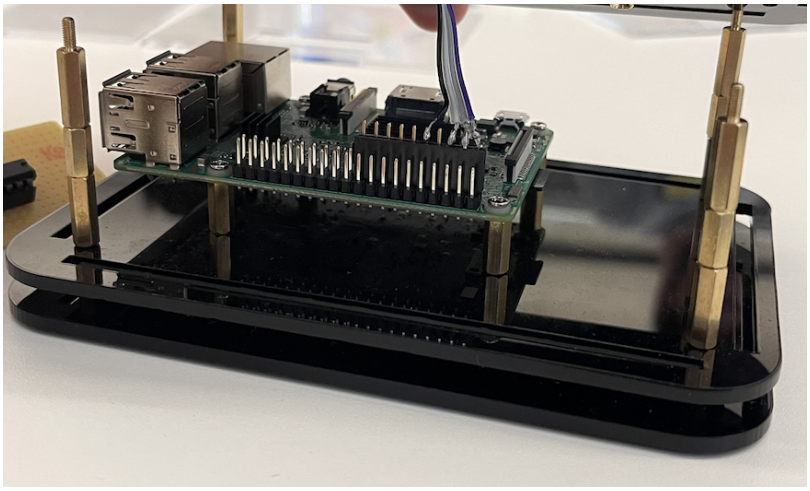


8. Now we can connect both plates together. Place the black acrylic plate with the Raspberry PI on the other plate so that the corners are on top of each other. The spacers on the lower plate have an external thread.

9. Place the upper plate so that the external thread of the spacers comes through the holes of the black acrylic plate with a slot. 3.

10. Mount three spacers m2.5x15+6, m2.5x6+6 and m2.5x12+6 on each other on the external thread of the spacers. Screw the screws onto the spacers to fix them. 4.Check if the spacers are tightly connected and hold the two panels securely.

At the end of this part it should look like this:



The cables that are connected to the Raspberry PI in the picture we leave out for the time being and describe it in the next step.

Part 2 - Arduino assembly of the Ring Oscillator

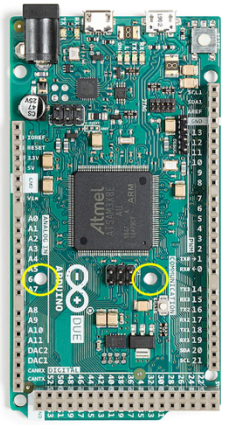
Materials needed:

- Arduino Due
- Ring oscillator with yellow board
- 4x spacers m2.5x6+6
- 6x spacers m2.5x10+6
- 2x spacers m2.5x10
- 3x spacers m2.5x15+6
- 3x spacers m2.5x6
- 3x spacers m2.5x12+6
- 3x spacers m2.5x+12
- Black acrylic plate with slot and hole
- 2x screws
- 4x Single core conductive cable
-

In this part, we first connect the Arduino to the board we created in the preparation.

1. Start by mounting the Arduino to a black acrylic plate with a slot and a hole in the middle. The plate should have a total of 8 holes for the spacers - four at the corners to connect the plates together, and four more to attach the Arduino to the plate.

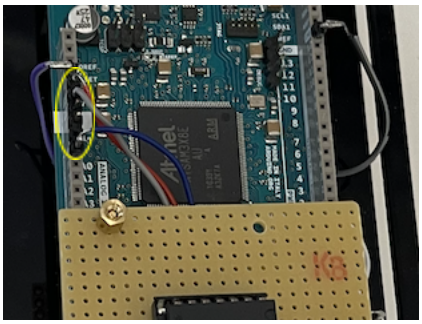
2. For mounting the acrylic plate, please follow the picture shown on the right:
    a. Insert m2.5x6+6 spacers from the bottom at all marked openings.
    b. At the openings marked with a 1, attach spacers of size m2.5x10+6 from the top.
    c. In the openings marked with a 2, attach m2.5x10 spacers from the top.



3. First attach the spacers for the board to the corresponding holes of the Arduino. On our prototype, we did this at one point. Place a spacer of size m2.5x10+6 from the bottom and another spacer of size m2.5x15+6 from the top. We used the left opening in our prototype (see picture on the right).

4. Before you mount the Arduino, you have to connect the following cables:
    a. Connect a single wire conductive cable to the GND (Ground) port on the right side of the Arduino.
    b. Connect two single-wire conductive cables to the SDA (Serial Data) and SCL (Serial Clock) ports on the lower right side of the Arduino.
    c. Connect a single-wire conductive cable to the 3.3V power supply port located on the left side of the Arduino.
    Then feed all cables down through the largest opening of the acrylic plate.

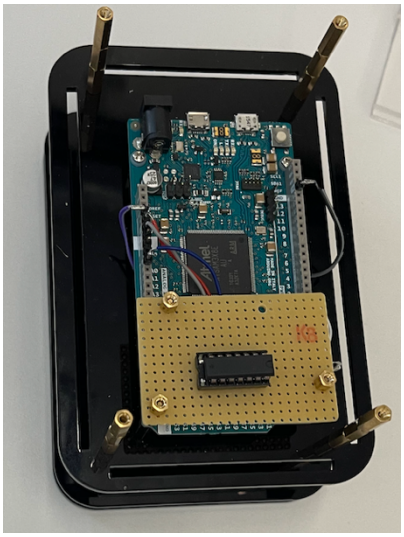
5. Now guide the openings of the Arduino through the threads on the acrylic plate and attach spacers of size m2.5x15+6 to the three bottom threads at the bottom of the Arduino. Also mount a screw to each of the two upper openings.



6. The board can now be attached to the Arduino.
7. Connect all cables of the ring oscillator to the Arduino. The three cables we have will be connected to the left ports of the Arduino. Cable 1 will be connected to pin 5V, cable 2 to pin GND and cable 3 to pin A0.
8. Mount the ring oscillator to the three threads at the bottom of the Arduino with a spacer of size m2.5x6.

9. Feed the 4 holes at the corners of the black acrylic plate through the threads at the corners of the previous acrylic plate and attach spacers of size m2.5x+12+6, m2.5x10+6 and m2.5x+12 to the corners of the acrylic plate in that order.

This should be the current state so far:



10. Now need to connect the cables that we have passed in step 4 through the hole to the Raspberry PI
    a. Connect the cable from pin 3.3V to pin 3.3V
    b. Connect the wire from the pin Ground to the pin Ground
    c. Connect the cable from pin SDA to pin SDA
    d. Connect the cable from pin SCL to pin SCL

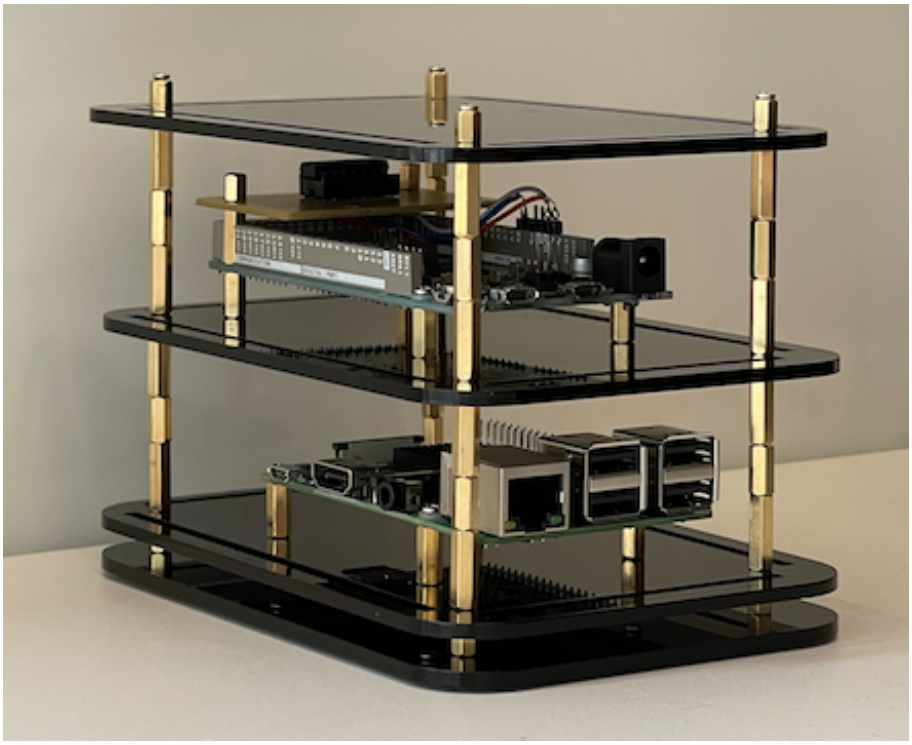
Part 3 - Finish

Needed Materials:

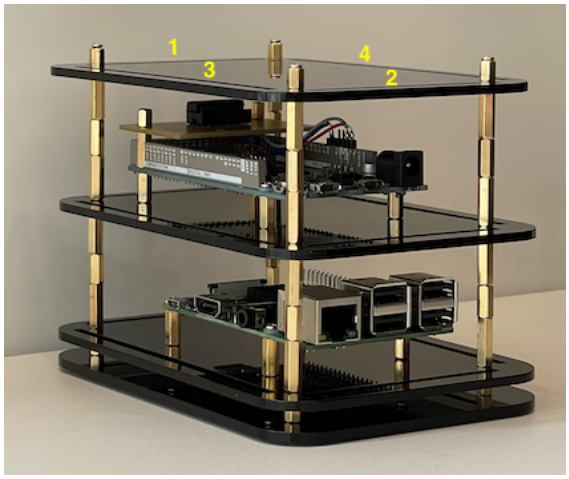
- Black acrylic plate with slot
- 4x spacer m2.5x6+6
- 4x screw
- 3x transparent colorless acrylic plates
- 1x transparent black acrylic plate

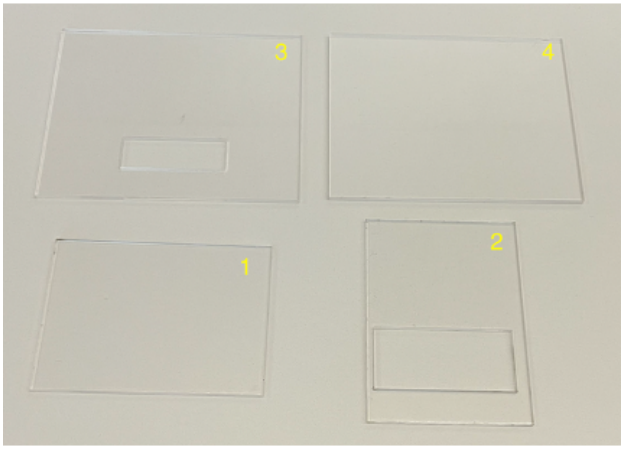
1. We put the last black acrylic plate over the spacers of step 9 part 2 and fix them with the spacers m2.5x6+6 and mount screws on each spacer.

2. **Now this is the current state:**

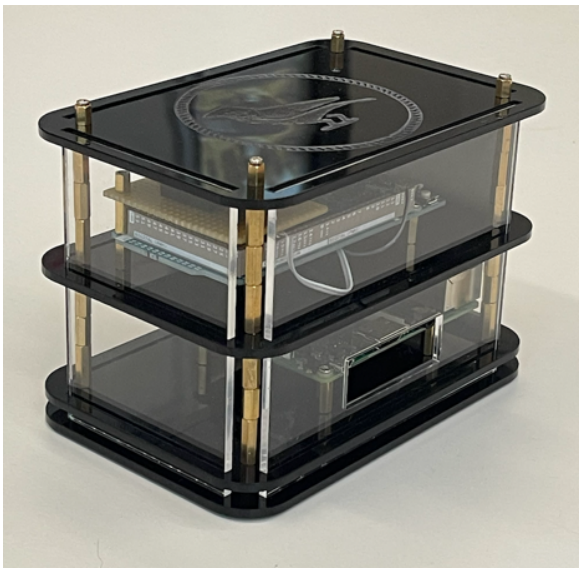


3. Now slide the following transparent colorless and black acrylic plates through the corresponding slots, following the specific numbering:

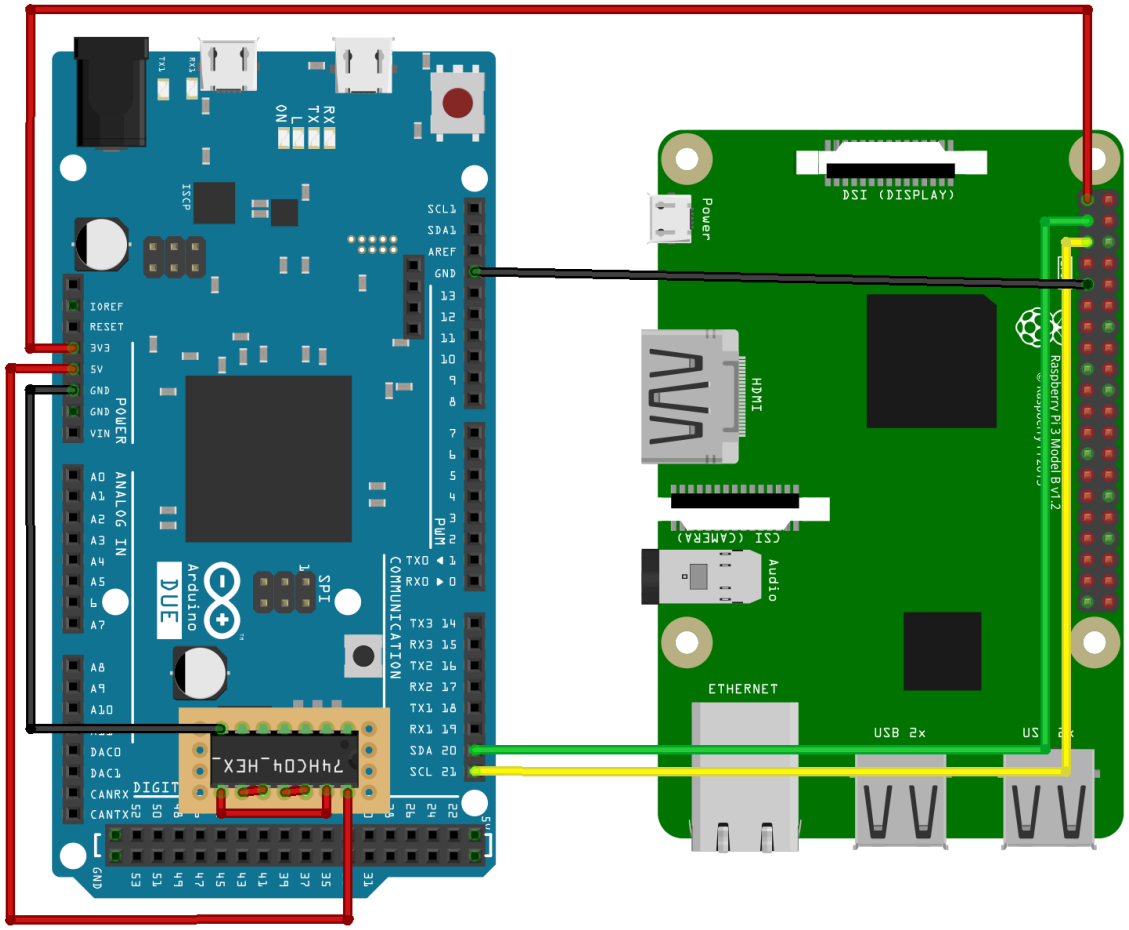




After completing all steps we now get the following prototype - the True Random Generator. (The logo is optional)



Circuit diagram



Software setup

To run the True Random Number Generator (TRNG) correctly, you need to load the required codes and scripts on the Arduino and Raspberry Pi. You can get the codes and scripts from the following GitHub project:

https://github.com/GMTROM/TRNG_GMTROM