Mannheim University of Applied Sciences

Construction manual

True Random Number Generator

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About this manual

This step by step guide will show you how to build a true random number generator that can pass the BSI AIS 31 statistical tests suite. Round paper snippets are used here as the noise source, which are made to fly by a normal PC fan. The generated numbers can be queried via a REST interface. In addition to this build guide, there is documentation for the software code used, as well as for using the REST interface. All relevant documents, as well as the software code can be found here: https://github.com/cep-sose2023/athena-security

Materials and tools needed

Materials

- NodeMCU v1 development board
- 2 x HTEM DN 75 x 1.9
- Micro-USB – USB-A Cable
- 3D-Printing PLA Filament ≥ 40 g
- 1m cable 30AWG with insulation
- Delta AFC0712DB 0.45A DC12V Fan
- LM2596S DC-DC 4,5-40V step-down power Supply module
- 4 x M4 47mm screws with nuts
- Power Supply DC24V
- Resistors (1 x 47 Ω | 1 x 4.7 kΩ | 2 x 10 kΩ)
- 5V solar cell 53 mm x 30 mm
- 5 mm LED white
- Velind Anti-Static spray
- Photo mounting board paper 270 g/m^2
- Mosquioto net 150 cm^2
- BC337 45V 800mA NPN Transistor
- BSS84 P-Channel Mosfet
- Soldering tin
- Sandpaper
- Cardboard with 1 mm thickness
- Hot glue sticks
- Breadboard 45 mm x 34.5 mm (optional)
- Cable ties (optional)
- Paint spray blue (optional)

Tools

- 3D-Printer
- Hot glue gun
- Drill Bits Ø 1/2/3/4 mm
- Countersink
- Cordless screwdriver
- Soldering Iron
- Wire stripping tool
- Flat nose pliers
- Side cutter
- Screwdriver
- Scissors
- Hole punch
- Angle grinder
- Multimeter
- Felt pen
- Ruler
- Electronic scale

Preperation

Previous knowledge required

- Basic craft skills
- Arduino knowledge
- Soldering
- 3D printing

3D-Printing the cover

Needed material for this step: 3D-Printer, ≥ 40 gram PLA filament

The cover for the wind tunnel consists of two parts, which can be 3D printed. The visible cover must be printed together with a closure. Both STL-files for 3D printing can be downloaded here: https://github.com/cep-sose2023/athena-security

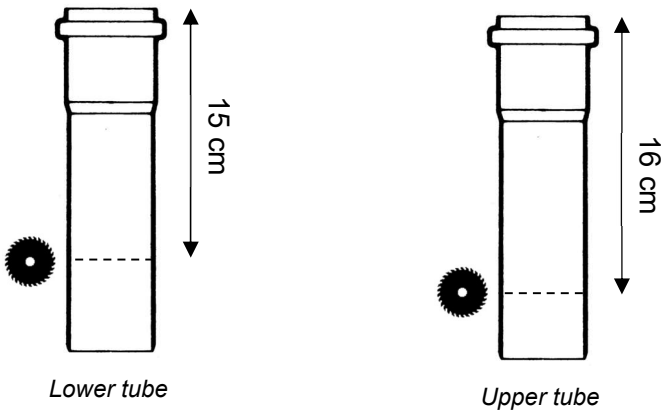
Cover

Closure

Cutting the two tubes

Needed material for this step: 2 x HTEM DN 75 x 1.9, angle grinder, felt pen, sandpaper

The two HT tubes must be cut to the correct length before assembly. An angle grinder, for example, can be used for the cut. It is recommended to mark the correct position for the cut with a felt pen beforehand. The cut must be made on the open side of both tubes. Tube 1 should be cut to a length of 15 cm and tube 2 to a length of 16 cm.



Lower tube *Upper tube*

After both tubes are cut to the correct length, it is recommended to sand the cut edges with sandpaper. As an optional step, the two tubes can also be sprayed with a paint here.

Step by step guide

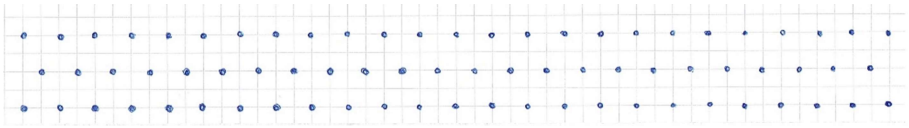
After the chapter "Preparation" has been completed, the main components consisting of the two tubes and the 3D-printed cover should be ready. The following steps show the rest of the assembly and should be followed in the correct order.

1. Drill holes for less wind resistance

Needed material for this step: drill bits Ø 1/2/3/4 mm, countersink, cordless screwdriver

Holes can be drilled in the top tube to give the air more opportunity to escape, and thus also to run the fan at a lower speed and with less noise.

A template for the holes can be found at the following link: https://github.com/athena-security/cep .This template should be printed and cut out. It can then be glued to the upper end of the tube with adhesive tape.

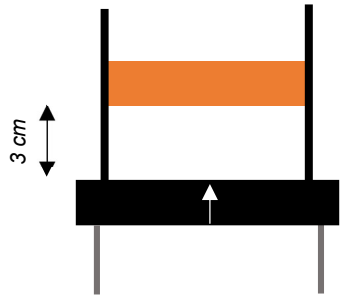


It is then recommended to pre-drill with 1 mm in order to reach the desired 4 mm holes with the further drills. After the 4 mm holes are finished, it is recommended to improve each hole with a countersink.

2. Decrease air rotation

Needed material for this step: hot glue gun, scissors, ruler, cardboard 1 mm thickness, prepared tube from ealier

The air that flows out of the fan has a rotary motion, which means that snippets can remain in the center and are not caught by the wind. To prevent this, a piece of cardboard is glued a few centimeters above the fan, which takes the rotation out of the air.



View from the side

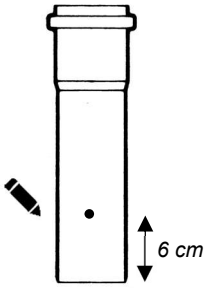
View from the top

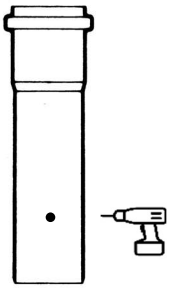
The cardboard used has a thickness of 1 mm. The piece of cardboard used was cut to a length of 80 mm and a height of 20 mm. After cutting, it should be glued about 3 cm above the end of the lower tube. A hot glue gun was used for gluing. The fan is attached to the tube at a later stage.

3. Install solar cell and LED

Needed material for this step: 5V solar cell 53 mm x 30 mm, 5 mm LED white, cable, cordless screwdriver, drill bits, hot glue gun, ruler, upper tube

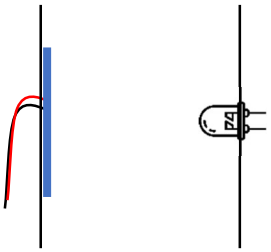
First, mark a point 6 cm above the end of the tube with a felt pen. There the hole for the cables of the solar cell should be drilled. The diameter to be drilled here should be 2 mm.

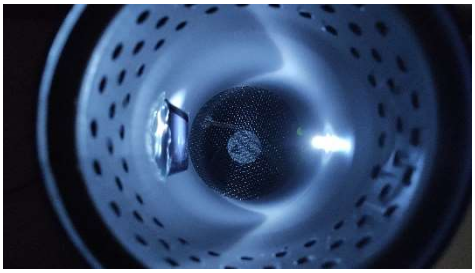




After the hole is drilled, it is time to glue the solar cell inside the tube, passing the cables through the hole that has just been drilled. A hot glue gun can be used for gluing.

The LED must now be installed on the opposite side of the solar cell. To do this, a hole is drilled on the opposite site and at the same height with a 5 mm drill. The LED is then inserted through the drilled hole and glued from the outside with hot glue.



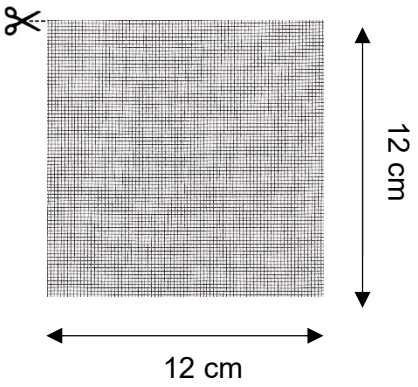


The wiring of the two components will be covered at a later time.

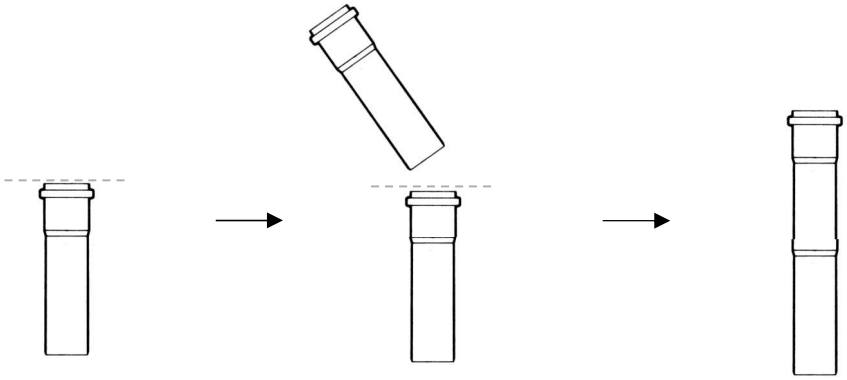
4. Connect the two tubes

Needed material for this step: mosquioto net 144 cm^2, scissors, prepared tubes from ealier

Before both tubes are connected, the mesh between the two tubes must be prepared. Cut a square from the mosquito net with a side length of 12 cm.



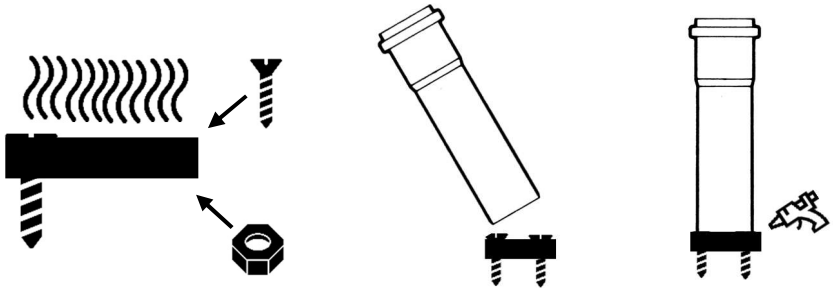
After this step, the lower tube is taken and on the joint is placed the cut net. Now the upper tube can be put on the lower. The net must be stretched between the two tubes.



5. Installing the fan

Needed material for this step: hot glue gun, fan DC12V, 4 x screws M4 47 mm with nuts

Find out the wind direction of the fan, making sure that the wind direction is upwards. Then insert the four screws together with the matching nuts through the holes on the fan. The fan should stand firmly on the base and not wobble. Then you can put the wind tunnel on the fan and glue it with a hot glue gun from the outside. Make sure that there are no more openings between the fan and the tube.



6. Mounting the microcontroller

Needed material for this step: NodeMCU development board, small breadboard 45 mm x 34.5 mm (optional), cable ties (optional)

In the first step, plug the microcontroller onto the breadboard. You can then fix the breadboard with cable ties around the wind tunnel. It is recommended to have the USB connector of the microcontroller pointing to the right to make this instruction easier to follow.

If you don't have a breadboard or cable ties available, you can also attach the NodeMCU board to the wind tunnel with hot glue. Make sure that the pins of the microcontroller are not covered with hot glue from above.

7. Wiring of the solar cell and the LED

Needed material for this step: wire, side cutter, soldering iron, 47Ω resistor

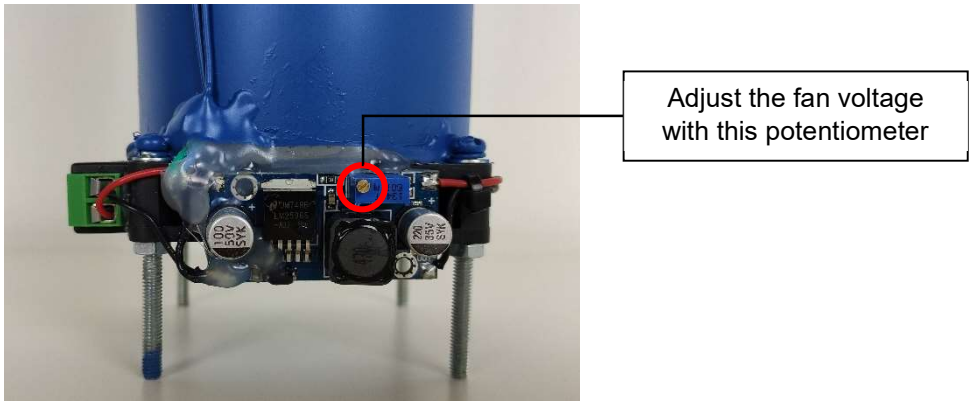
The positive pole of the solar cell is soldered to pin A0 of the NodeMCU. A circuit diagram can be found in the chapter "Logical circuit diagram and structure". The ground pin is then soldered to the lower GND pin on the NodeMCU.

The anode side of the LED can be determined with a multimeter. It should be soldered in series with a 47Ω resistor to pin D2 on the NodeMCU. The cathode side should be soldered to a GND pin on the NodeMCU.

8. Attaching the step-down power supply

Needed material for this step: LM2596 DC-DC module, power supply DC24V, multimeter, hot glue gun

The correct fan speed is crucial for the correct function of the random number generator. Optimum air flow can be set by varying the supply voltage of the 12 V fan. A prefabricated LM2596 DC-DC converter module converts the 24 V DC input voltage into the required fan voltage. The fan voltage, the fan speed and the air flow are adjusted with a potentiometer on the DC-DC converter module.



The DC-DC converter module can be glued to any side of the fan with hot glue. Before the DC-DC converter is wired and put into operation, you should make sure that the set output voltage is not too high for the fan. An output voltage of 12V is recommended for a first test. To set the potentiometer correctly, connect the DC-DC module to a power supply and measure the output voltage with a multimeter.

In order to be able to switch the fan on and off via the software, the 24 V supply voltage is fed via a transistor / mosfet circuit into the DC-DC converter module. The wiring of this circuit will be discussed in more detail in the next chapter.

8.1 Soldering the transistor / mosfet circuit

Needed material for this step: multimeter, hot glue gun, soldering iron, wire, BC337 45V 800mA NPN Transistor, BSS84 P-Channel Mosfet, resistors (2 x 10 kΩ | 1 x 4.7 kΩ), side cutter

To follow the steps it is recommended to have a look at the section "Logical circuit diagram and structure". The following part is for simple on/off switching of the DC-DC module using the microcontroller. This works by the micocontroller switching the base voltage of the mosfet Q3 with the help of the transistor Q2. Mosfet Q3 can then switch through the 24V supply voltage to the DC-DC converter module. To achieve this you can follow the steps below

Connect Controller Pin D1 to Q2's Base Pin: Connect the controller pin D1 to the base pin of the transistor Q2 through resistor R4. This will allow the microcontroller to control the transistor Q2.

Connect 24V Supply to Q3's Source Pin: Connect the 24V power supply input to the source pin of the PNP MOSFET Q3.

Connect Q3's Drain Pin to the DC-DC Converter Module: Connect the drain pin of Q3 to the Vin input of the DC-DC converter module. This allows the MOSFET to direct power to the converter module when it switches on.

Connect 24V Supply to Q2's Collector Pin: Connect the 24V power supply input to the collector pin of transistor Q2 via resistors R5 and R6. This allows the power to flow through Q2 when the transistor is in the ON state.

Connect the Line between R5 and R6 to Q3's gate: The line between resistors R5 and R6 should be connected to the gate of MOSFET Q3. This will control the switching of the MOSFET and sets Q3 to be able to switch the DC-DC converter module.

Connect 0V Line of Power Supply to Various Components: Connect the 0V line of the 24V power supply to the controller GND, the emitter of transistor Q2, and the negative input pin of the DC-DC converter module. This completes the return paths for the currents in the circuit and establishes a common ground.

The whole circuit can be fixed and protected with hot glue afterwards. Loose cable pairs can be brought together with cable ties.

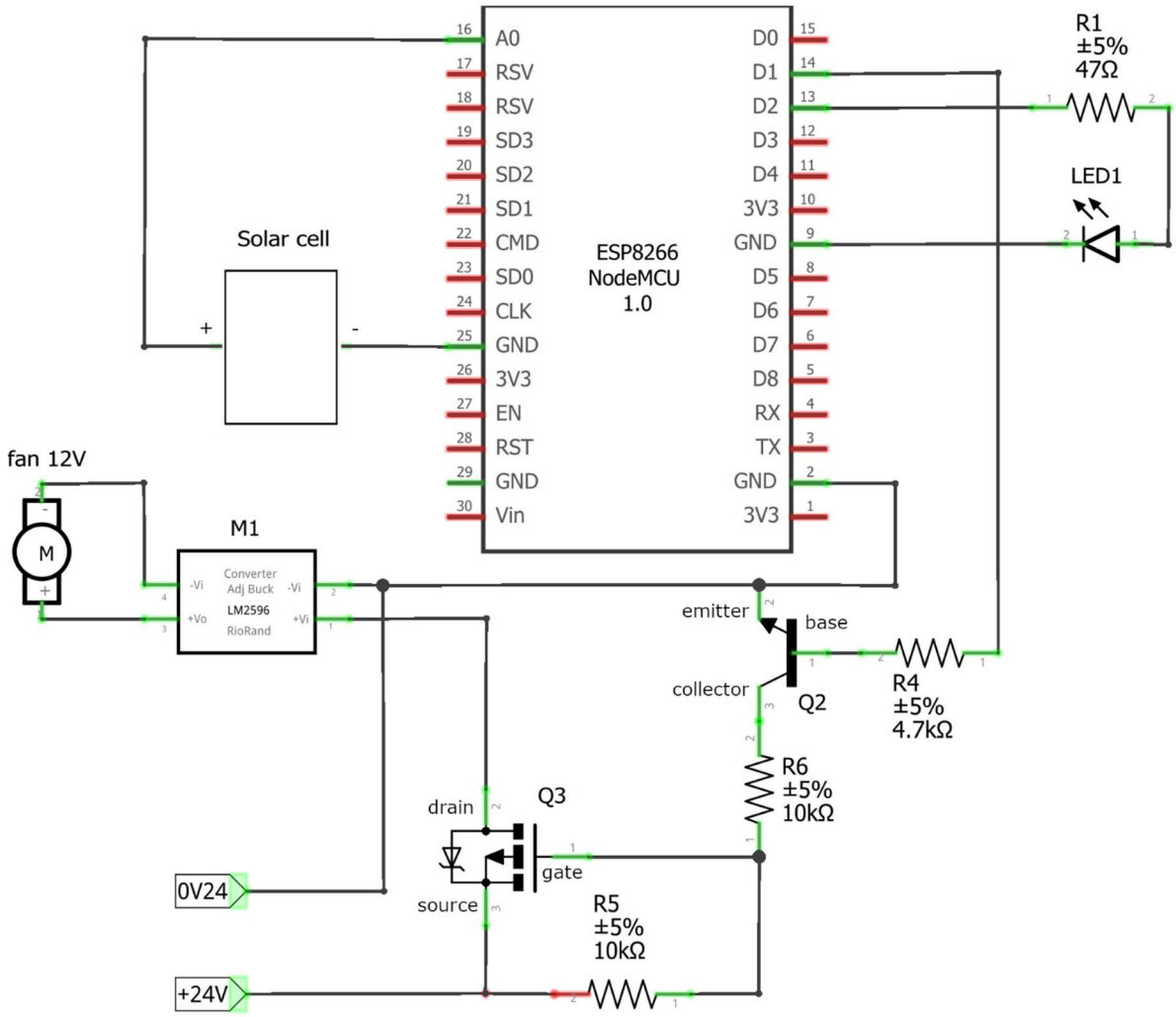
9. Punching the round paper snippets

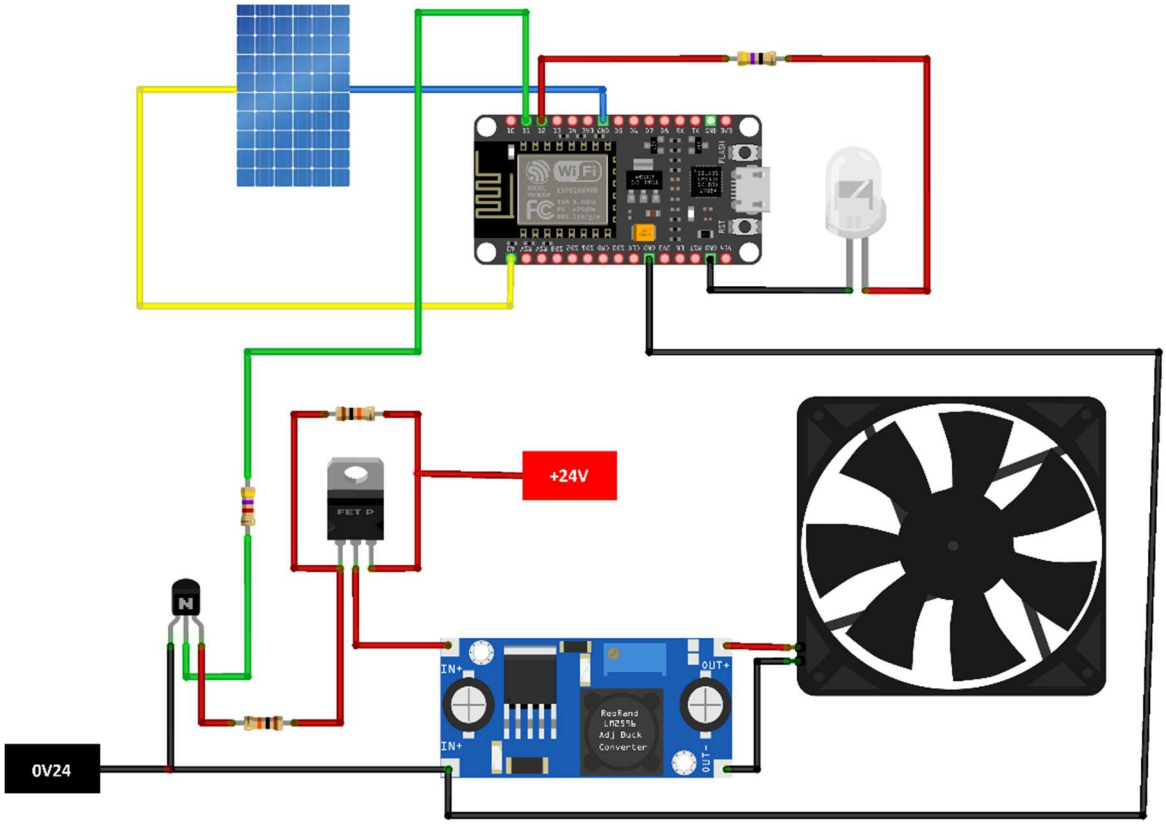
Needed material for this step: Photo mounting board paper 270 g/m^2, hole punch, electronic scale, anti-static spray

For this section, it is important that the paper thickness is chosen correctly. Paper that is too thin can cause snippets to stick due to electrostatic charge. Paper that is too thick will make the snippets too heavy for the intended use. Photo mounting board paper with a weight of 270 g/m^2 has proven to be suitable. Punch out 0.56 g of round paper snippets with a hole punch and fill the wind tunnel with them.

If the snippets stick to the inside during operation due to electrostatic charge, it is recommended to use an anti-static spray. Apply the spray on a microfiber cloth and apply it on the inside.

10. Logical circuit diagram and structure




+24V
FET P
N
0V24
IN+
IN+
OUT+
OUT-
RoaRand
LM2596
Adj Buck
Converter