IRRADIATION SYSTEM BUILD INSTRUCTIONS

This document describes in detail the steps to carry out the construction of the irradiation prototype. The prototype is mainly composed of the following elements:

1. RF Generator MAX2870
2. RF Amplifier
3. ZABDC Directional Coupler
4. Designed control circuit
5. Mini PC AWOW
6. 10.1-inch SunFounder touchscreen

In the same way, captures of the construction of the RF applicator will be presented, which are a complement to the instructions described in the scientific article.

1. Construction of the irradiation system:

The assembly of the irradiation system begins with the placement of the equipment with larger dimensions (Mini-PC, touchscreen, and power supply). A 3D structure was printed (for representative purposes), to demonstrate the placement of such equipment in the structure of the irradiation system.

Fig. 1. Initial view of the irradiation prototype assembly

The 12 volt supply has two outputs and a capacity of 10 A (max.). It is recommended to allocate an individual output of 12 V for the Mini-PC and the other output for both the display and the control circuit. To attach the Mini-PC to the screen, it is necessary to print the part **MiniPC_support.stl**. In the same way, the touch screen is connected to the Mini-PC by means of an HDMI connector.

Proceed to cut the acrylic sheets which correspond to the faces of the irradiation system, exporting the STL files present in the folder **Acrylics_laser_cutting**.

Fig. 2. Acrylic housing of the irradiation device

Once the faces are cut, the most important step is to properly fix the larger equipment in the system, so that they provide adequate support. To do this, the front face is used (**Case_front_side.svg**) y la cara inferior (**Case_bottom_side.svg**). Acrylic sheets are assembled using 3D designed parts printed with TPU filament (**Border_joint_1, Border_joint_2**).

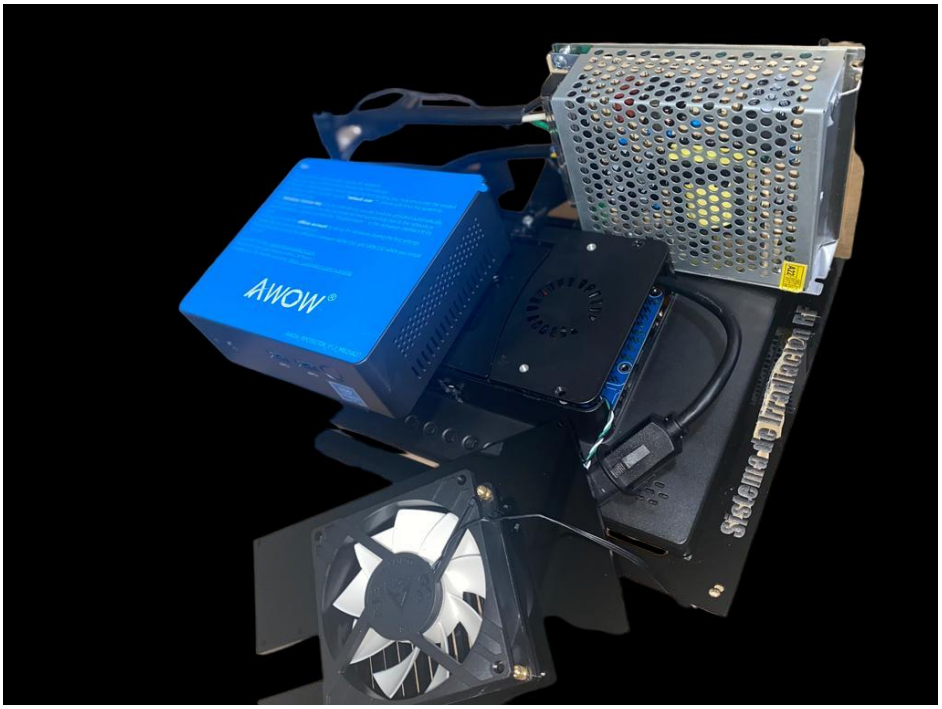

Fig. 3. Arrangement of touch screen, power supply and Mini-PC

Proceed to finish assembling the box with the rest of the faces except for the back face (**Case_back_side.svg**); this face corresponds to the last one that is assembled since it corresponds to the removable face of the device. The **Control_circuit_support_piece.stl** part is 3D printed and screwed to the acrylic part **Case_upper_side.svg**. In this part both the RF generator and the designed control circuit will be fixed. In the same way, the directional coupler is screwed to the **Coupler_support.stl** part and in turn, it is fixed in the acrylic box. The forced ventilation fans are screwed on the side faces and the emergency stop button is screwed on the left side face. Finally, two display mounts are printed using the **Screen_support.stl** file, to attach the touch screen to the acrylic box.

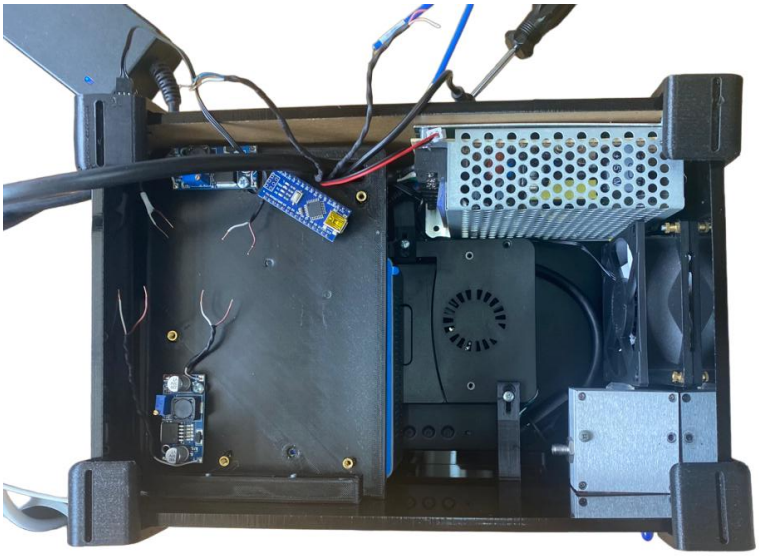

Fig. 4. Placement of the control circuit support part

Using a CNC engraver, the **Control_circuit_PCB_manufacturing.gbr** file is uploaded to carry out the manufacture of the PCB of the control circuit. Once the PCB of the control circuit is printed, a layer of solder mask is added to prevent corrosion and protect the copper tracks of the control circuit.

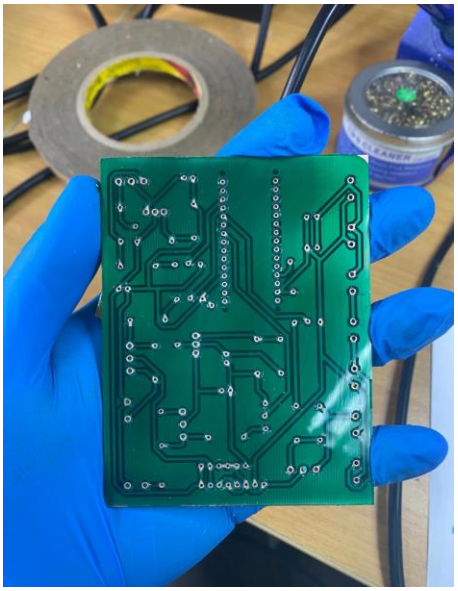

Fig. 5. Control circuit post – solder mask application

Once the solder mask layer is applied, the components are welded on the PCB of the control circuit. For this, the PCB design file present in the Zenodo repository is taken as a reference. **NOTE:** *By using only a single layer of the PCB, the design is greatly simplified, however, it is necessary to connect 4 ways in the control circuit by means of connectors.*

Once the control circuit components have been welded, the PCB is screwed to the **Control_circuit_support_piece.stl** part, as well as the supply voltage and BIAS step-down converters are fitted to the part. The Arduino Nano microcontroller is connected by means of a Mini-USB cable with the Mini-PC, to establish a serial communication between the electronics of the device and the graphical interface. The RF amplifier power pins are connected to the control circuit, and by means of SMA connectors the RF module connections are made between the RF generator, the RF amplifier, and the directional coupler.

Finally, we proceed to make the connections of the 12 V fans in the control circuit (following the PCB diagram). The power buck converter is set to an output voltage of 5 V and the BIAS buck converter can be set in a range of 5V to 5.25 V depending on the power output required (the higher the BIAS voltage, the higher the output power of the amplifier). Once all RF devices are interconnected, the final internal composition of the irradiation system is as follows:

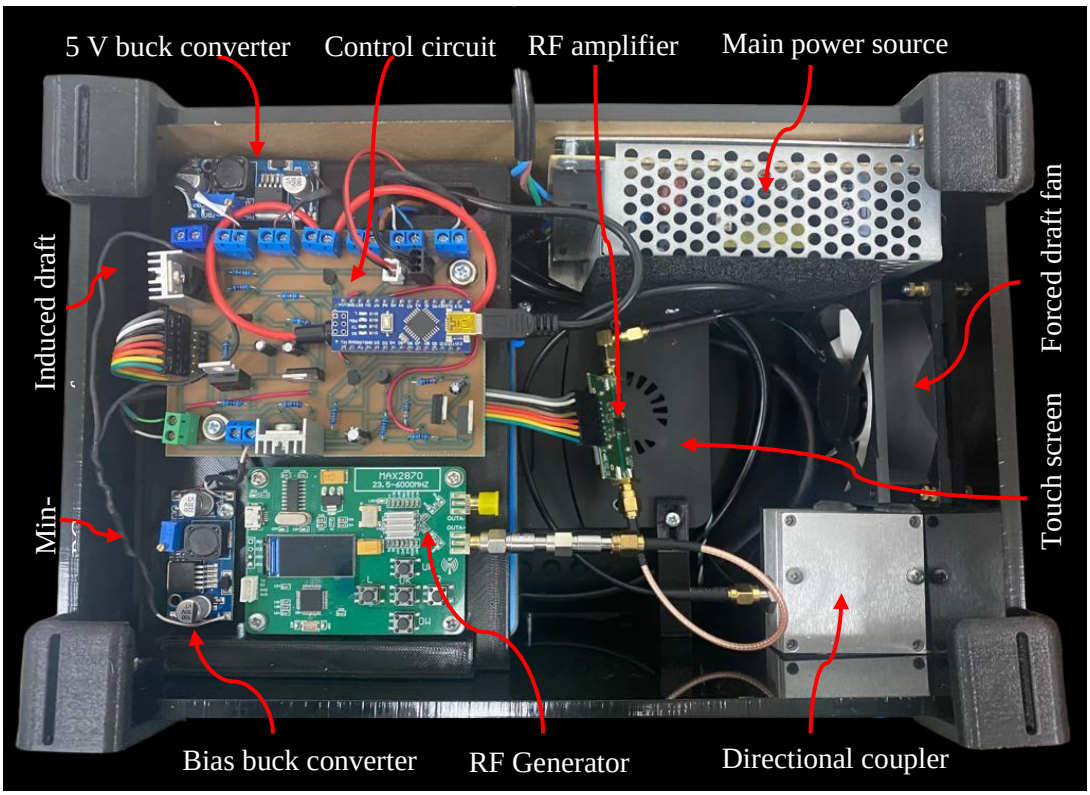

Fig. 6. Internal composition of the irradiation prototype

Once all the connections have been made, the irradiation equipment is closed, then connected to the AC power supply and the initial configuration is made. Once the prototype's embedded computer is initialized, it is necessary to copy and paste an executable file from the **ExposureSystemGUI.vi** file, in order to use the graphical interface in the designed prototype. If you want, it is possible to program the automatic start of the GUI each time the computer starts.

The final result of the irradiation prototype is as follows:

Fig. 7. Final result of the irradiation prototype

2. Construction of the RF applicator:

Below are attached some captures referring to the construction of the RF applicator, so that they complement the existing information in the scientific article.

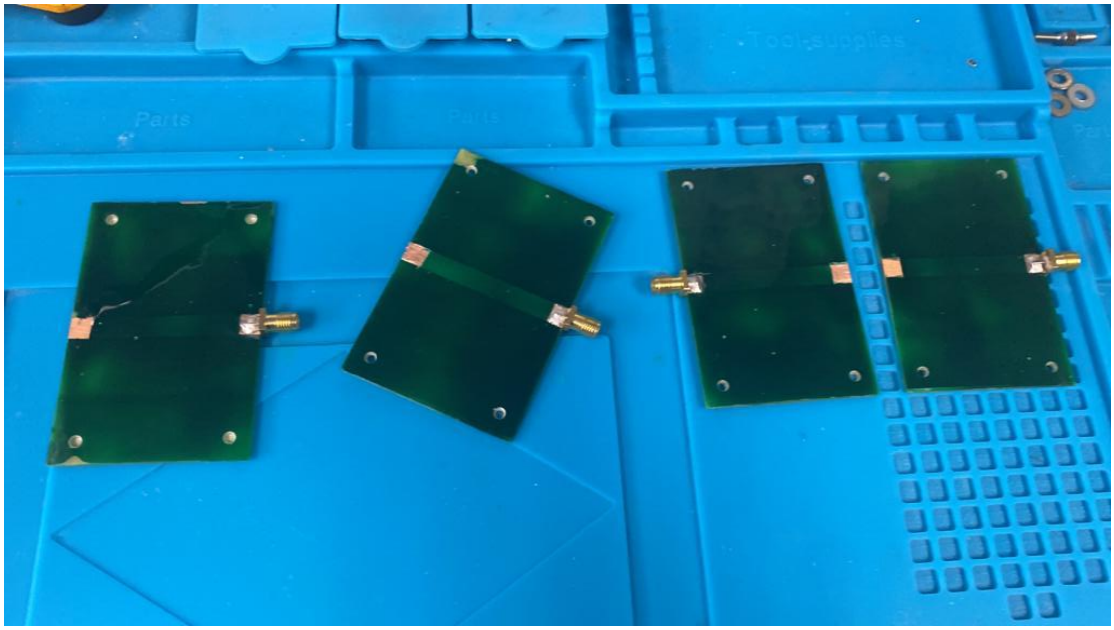

Fig. 8. RF applicators superior sections

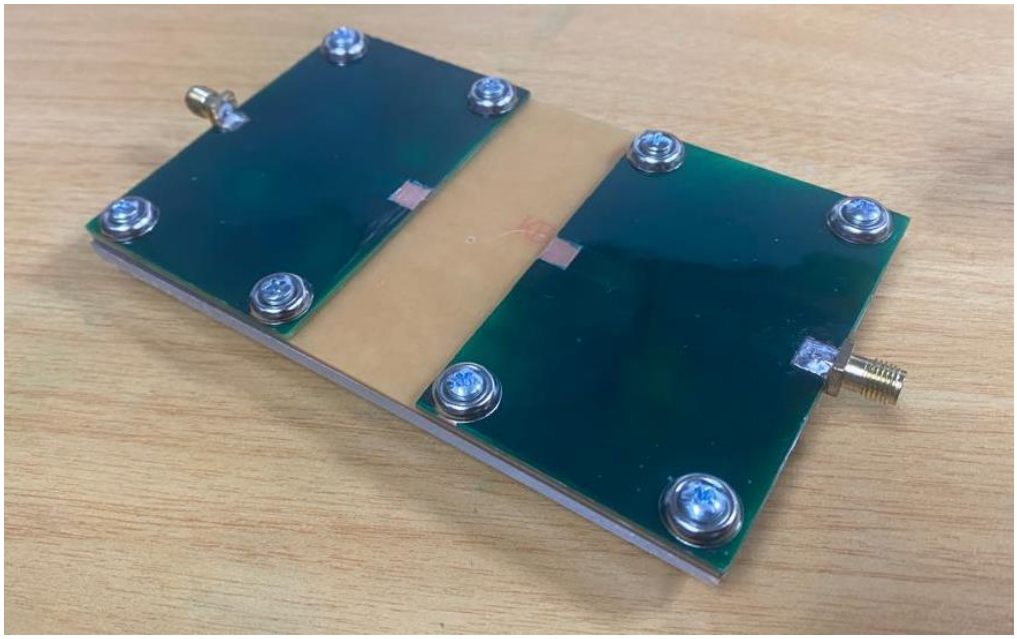

Fig. 9. RF applicator post-assembly

The RF applicator parts are screwed in the order indicated by the paper, and fixed to the bottom of the applicator with M3 nuts, as shown in **Fig. 9.**

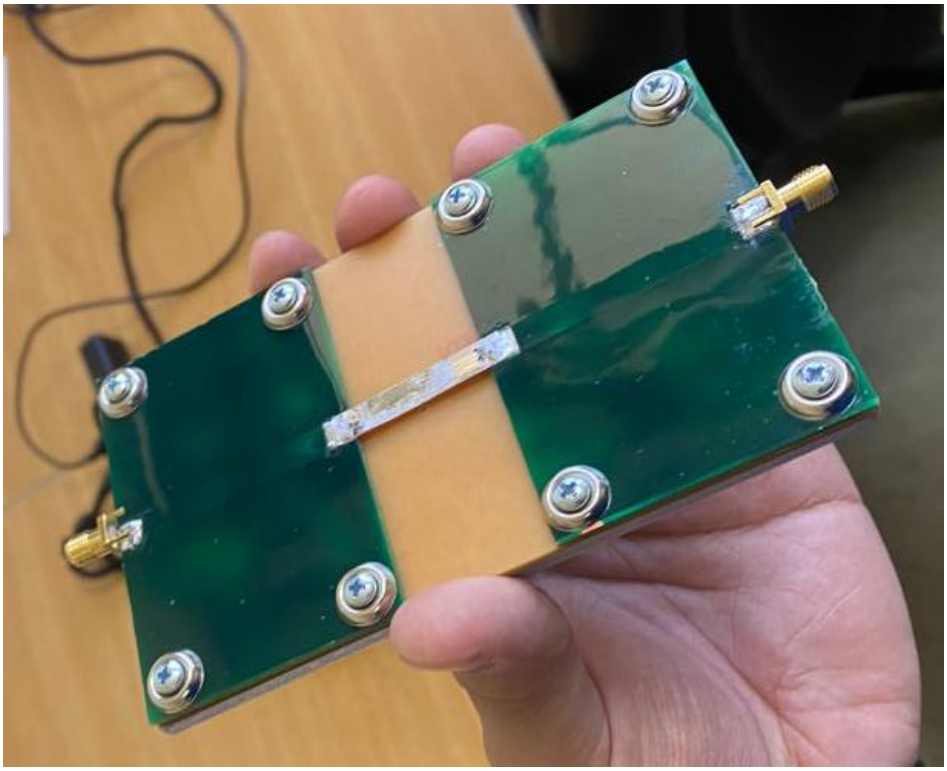

Fig. 10. RF applicator post-assembly

It is necessary to weld a strip of tinned copper 1 oz and 6 mm wide on the already assembled M3. This is necessary to provide continuity in the RF applicator. For this step, we have the following recommendations:

- The manufacturing of the copper strip should be as accurate as possible, so that the electromagnetic properties of the RF applicator are not impaired.
- To tin the copper strip, it is recommended to lightly sand the copper strip on both sides and use a flat tip for the soldering iron, so that the tin spreads evenly.
- When welding the strip in the RF applicator, it is necessary that it is as aligned as possible with respect to the applicator, so that return losses (S11) are avoided.
- We recommend not applying heat for very long periods to the RF applicator, as copper may peel off from FR4.

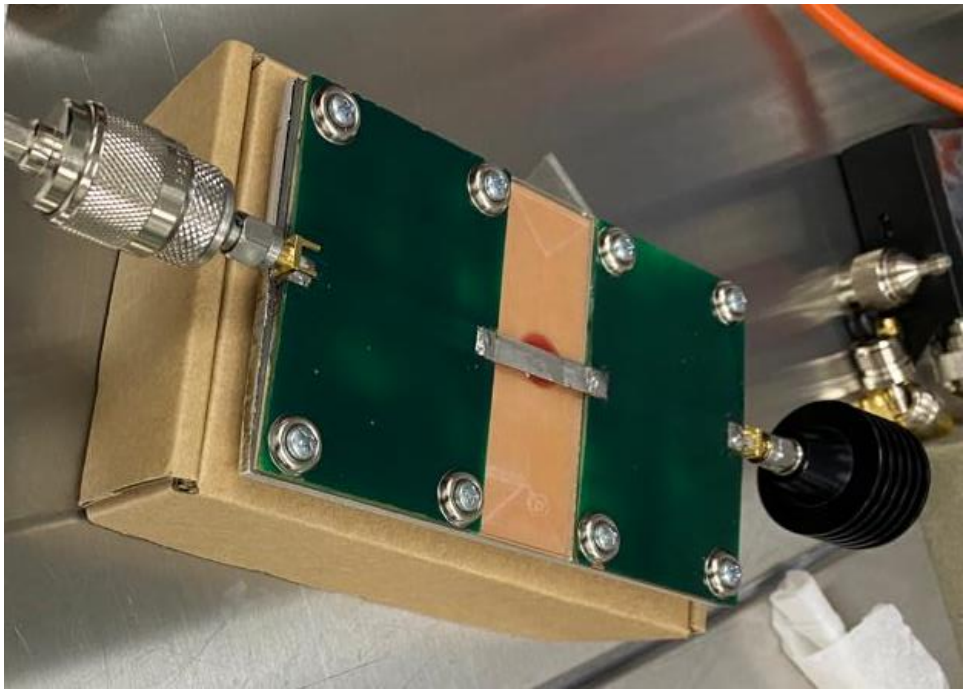

Fig. 11. Operating RF applicator

To be used in *in vitro* testing, the RF applicator is connected to the output of the RF generator. It is necessary to connect a termination load of 50 ohms to the other end of the applicator so that maximum power transfer is maintained. In the hollow cavity, a sample of contaminated blood is placed on a slide. The contaminated blood sample is around 90 microliters.

NOTE: *It is important to clean the slide very well before and after the test, so that the properties of the blood are not affected. In addition to this, it is necessary to spread the drop of blood well, because it cannot touch the strip of the RF applicator, since the return losses increase by approximately 300%.*