# RFToy 3.1 User Manual

(Oct 29, 2021)

Specifications

- A WiFi-enabled gadget for interfacing with RF wireless power sockets and RF remote sensors.
- Version 3.1 is completely redesigned with a compact circuit and dedicated 3D printed enclosure.
- On-board ESP8266 WiFi chip (4MB flash) with CH340 USB-serial converter, Arduino-compatible (with ESP8266 core).
- One 128×64 OLED display (SSD1306), three tactile buttons.
- Includes one pair of 433MHz RF transmitter/receiver and one pair of 315MHz RF transmitter/receiver.
- Supports WiFi and web-based control; supports Over-the-Air (OTA) firmware update, and raw RF signal sampling.
- On-board microUSB connector for providing power (which also supports firmware update through USB).
- Includes a 3D printed enclosure
- *For future use (not yet supported by firmware)*: built-in IR transmitter and IR receiver pin headers for interfacing with IR remotes; pinout for AM2320 temperature/humidity sensor.
- RFToy is a completely open-source product.

Hardware Interface
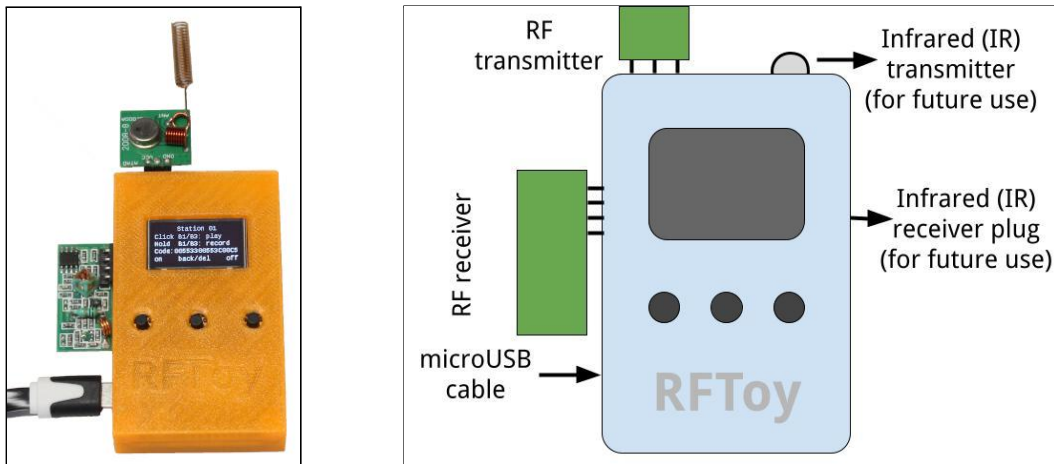
Note that both the RF transmitter and receiver should be plugged in <u>facing up</u>, as shown in the left image above. One pair of 433MHz RF transmitter/receiver and one pair of 315MHz RF transmitter/receiver are included in the package.

Antenna and Transmission Range

- The **transmitter** module does NOT have a built-in antenna. It's **recommended** that you solder a wire to the antenna pin (marked **ANT**) to extend the transmission range. The recommended wire length is 17cm (6.7 inch) for 433MHz transmitter, and 24cm (9.4inch) for 315MHz transmitter. The wire length is calculated based on 1/4 of the wave length. As the antenna is quite long, if it's not possible to keep the antenna straight, you can fold it down in half or curl it. See pictures on the right for example.

- The **receiver** module also does NOT have a built-in antenna. Generally you do not need to solder a wire antenna since the receiver is only used for decoding RF signals so the receiving range does not matter. You can place it next to your RF remote such that even without an antenna it receives the signal well. However, if you plan to use the receiver for long-distance reception, such as sniffing signals from RF wireless temperature and weather sensors, adding an antenna (same length as transmitter) is recommended.
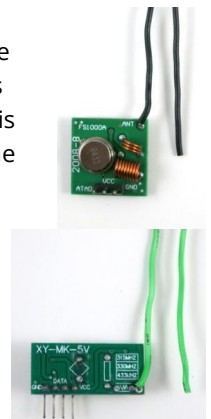
Power Up and Manual Mode

To power RFToy 3.1, insert a microUSB cable into the microUSB connector on RFToy 3.1, and the other end to a USB power source, such as your computer's USB port, a USB power adapter, or a USB power bank. Upon powering up, RFToy will prompt you to select whether you want to enter WiFi mode or Manual Mode. **Click B3 will enter Manual Mode**, where WiFi functions are disabled. If you don't click any button, it will time out in 15 seconds and enter WiFi mode automatically. The buttons, from left to right, are referred to as B1, B2 and B3 in the following.

Next, you will see a page of brief instructions about how to use buttons. Basically:

- Click B1 or B3 to navigate up/down the station list. Click B2 to enter the selected station.
- Long press B1 to reset everything to factory default.
- Long press B2 to reset WiFi settings.
- Long press B3 to display device IP address and MAC (IP address will be 0 in manual mode).

After you have entered a selected station, you will see further instructions:

- Long press B1 or B3 to record ON/OFF signals (this requires the RF receiver to be plugged in, and you should click a button on your RF remote within 10 seconds, otherwise it will time out and go back to the station screen).
- Long press B2 to confirm and delete the station data.
- Click B1 or B3 to play back the ON/OFF signals (this requires the RF transmitter to be plugged in).
- Click B2 to go back to the station list

The default firmware has a capacity of 50 stations, which can be extended by modifying the firmware.

WiFi Mode

When powering up RFToy, if you **click B1** or wait till the initial screen times out, it will enter WiFi mode. The WiFi mode provides additional functionality, including web-based control, the ability to change station names, and Over-the-Air Firmware Update (i.e. update firmware through WiFi). If this is the first time it's placed in WiFi mode:

- The device will start in AP mode, presenting a WiFi AP with SSID (ESP_xxxxxx) printed on the LCD screen.
- Use your phone or computer to connect to this SSID (it's an open WiFi so no password). Then follow the sign-in instructions (or if you don't see any sign-in instructions, open a browser and manually type 192.168.4.1, then you will see instructions to further input your home router's SSID and password, in order to allow RFToy to log on to your home WiFi). Once this is completed, the **IP address** assigned to RFToy will be briefly displayed on the LCD. RFToy will then record the settings in non-volatile memory and reboot to connect to your home WiFi.

Following the WiFi setup, every time RFToy is booted into WiFi mode, it will log on to your home WiFi, and obtain an IP address. To find out the IP address, in the station list screen, long press B3.

Using a smartphone or computer that's connected to the same home WiFi, open a browser and type in RFToy's IP address. You will see a web UI with a station list and a menu icon on the top-right. Click a station, you can change its name, and also trigger record or playback of the station signal (these are the same as using buttons to record and playback signals).

In WiFi mode, all buttons still function exactly the same way as in manual mode.

Raw Sampling

In WiFi mode, RFToy 3.1 supports raw signal sampling. This is implemented by capturing the raw RF signal into its internal memory, then displaying the signal onto the web UI. You can also trigger RFToy to playback the most recently captured raw signal. The sampling frequency is **100KHz** (i.e. one sample per 10 microseconds), and the duration is **1 second** by default. Raw sampling is useful for visualizing RF signals or analyzing ad-hoc signals that are not well documented.

To start, at the homepage click the upper-right corner menu icon, then choose 'Raw Sampling'. Once you click 'Record' the device will listen to the RF signal for 1 second. Since this is very short, it's recommended that you start sending the RF signal shortly before the recording starts, in order to make sure it captures the signal.

Once the signal is captured, it will be displayed in the web UI. You can zoom in to check the signal in detail. You can also download the signal as raw byte data for further analysis.

To change the sampling frequency and duration, you can modify the RFToy source code. Note that the total memory required by raw sampling is `(duration*frequency/8) bytes`. In the default setting, it's 1*100,000/8 = 12.5KB. This is a considerable amount of RAM for ESP8266 (which only has a few tens of KB free RAM at run-time). So to increase duration, you should suitably reduce frequency to make sure the RAM usage doesn't increase dramatically.

Update Firmware

OTA Firmware Update

RFToy 3.1 supports Over-the-Air (OTA) firmware update. In WiFi mode, click the upper-right corner menu icon, and select Firmware. You can then choose a firmware file (`.bin`) and upload it over the web.

USB Firmware Update

If for any reason the OTA update doesn't work, you can optionally update firmware using a microUSB cable. RFToy has built-in CH340 USB-serial chip. To begin, you may need to install CH340 driver as explained below:

- **Windows 7/8 and Linux:**   a driver is usually not needed
- **Windows 10 or XP:**   download and install driver http://raysfiles.com/drivers/ch341ser.exe
- **Mac OS:**   download and install driver http://raysfiles.com/drivers/ch341ser_mac.zip

On Windows, the Serial Port name is **COM?** where ? is a number assigned to the USB-serial chip. On Linux, the Serial Port name is **/dev/ttyUSB?** where ? is a number. On Mac, the Serial Port name is **tty.wch ch341g xxx.**

After the driver is installed, you can use the open-source esptool to upload a new firmware to RFToy. Instructions are the same as any standard ESP8266 development board. RFToy 3.1 has built-in reset circuitry, so functionally it's compatible with Nodemcu or Wemos D1 Mini / R2.

RFToy 3.1 Hardware and Software

RFToy 3.1 is a completely open-source product. You can download its circuit design (including schematic and PCB design) and source code from:

- **https://github.com/openthingsio/rftoy**

The schematic and PCB design can be viewed and edited in EagleCAD

The source code can be compiled using Arduino installed with ESP8266 core. Please follow the instructions in Github.

Links and Resourcs

- RFToy Homepage: https://opensprinkler.com/product/rftoy
- RFToy Github: https://github.com/openthingsio/rftoy