Sonoff S31 Relay with ESP Now firmware

Re-purposing a Sonoff S31 Smart Plug using Espressif ESP Now communications protocol to establish a connectionless WiFi link with a companion PB switch sender device.

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1   Overview

The popular Sonoff S31 Lite Smart Plug re-purposed to work as a smart relay that is controlled by a PB (push button) switch sender device over a connectionless WiFi link using the Espressif ESP NOW communications protocol.

The S31 Smart Plug device works as a smart relay receiver with a companion PB switch sender device. The WiFi link between the S31 smart relay receiver and the PB switch sender is direct and does not require an AP connection to a LAN network.

The PB switch sender is paired to work with the S31 smart relay receiver by embedding the relay's MAC address into the switch sender's program code.

To use the modified S31 as a smart relay, plug the device into a 120 V(ac) receptacle and plug in the load you want to control, for example a desk lamp. Connect the PB switch sender to a cell phone charger using a USB cable to provide power. The desk lamp can be remotely toggled on and off from the switch sender each time the PB is pressed.

2   Hardware

There are two hardware devices for this project, first is the Sonoff S31 smart plug device, and second is the PB switch device. The S31 device is an inexpensive off-the-shelf item and is readily available from many e-commerce stores. The second PB switch has to be made and is built using an ESP32 S2 mini controller board, a NO PB switch, all mounted in a small plastic case.

2.1   Sonoff S31 smart plug device

The Sonoff S31 device does not require any hardware modifications, only a replacement of the original factory firmware with the new 8266-recv program based on the ESP NOW communications protocol. To perform the flashing, the S31's PCB circuit board is removed from the case. A small daughter board with the microcontroller on it has six solder pads on one edge of the board that allows connecting an external USB to serial adapter to the devices serial port Tx and Rx pins, 3V3 power and GND connections.

The picture below shows the six solder pads on the daughter board.
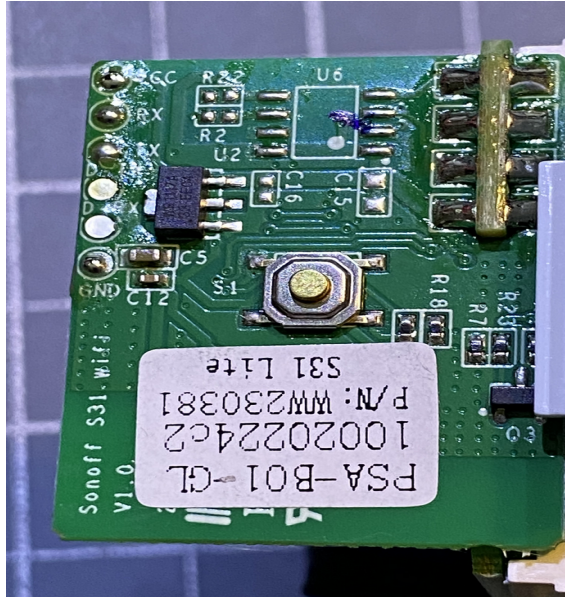
Solder 4 temporary wire connections to small solder pads on the daughter board. There are 6 solder pads on the edge of the board, labelled as follows:

Pad no.	Label	USB serial adapter pins
1	Vcc	3V3 (Set programmer voltage to 3V3)
2	Rx	Tx
3	Tx	Rx
4	Tx	---
5	Rx	---
6	GND	GND

The 4 wires are then connected to the USB serial adapter pins as shown above. The solder pads are small and delicate and can be easily stripped from the board is too much heat is applied during soldering.

Ensure that the USB adapter voltage selector is set for 3V3, otherwise the MCU device can be destroyed if 5V power is accidentally applied. The new 8266-recv module firmware can now be flashed to the MCU via the USB to serial adapter.

While the USB to serial adapter is connected to the MCU the MAC address may be retrieved from the device's ROM by running the bash script provided *mac_addr* from a serial terminal running on the programming PC. The bash script invokes the Espressif esptool.py tool to read the 's MAC address stored in the EFUSE block and displays it on the terminal.

The USB serial adapter and its temporary wire connections are removed from the S31 device's PCB after flashing of the new 8266-recv firmware is completed.

The internal circuit boards of the Sonoff S31 smart plug device are not isolated from the 120 V(ac) mains power connections. If the device is plugged into a 120 V(ac) receptacle, the circuit boards are exposed to potentially lethal voltages. Therefore, do not plug in the S31 device at any time while the circuit boards are exposed and connected to any external devices, such as a USB to serial adapter.

2.2   PB Switch sender device

The PB switch sender device is built on an ESP32 S2 mini controller board. A NO push button switch is wired between port pin GPIO17 and GND of the controller board completes and everything is packaged in a small plastic case. The switch sender device is powered via a USB type C cable connected to a 5 V cell phone charger.

The pictures below shows the assembled sender case and the internal arrangement of the ESP32 S2 mini board and the PB switch.

3   Software

The software source code for the 8266-recv module, the S2mini-send module and this documentation is available on github in the following repository:

4   Programming tools

An IDE consisting of the following tools are recommended if you plan to edit, compile and flash the firmware modules to the S31 smart plug and the PB switch devices.

- Visual Studio Code.

- PlatformIO Extension for VS Code.

- Esptool. Included in PlatformIO toolchain. You can install esptool independently and invoke it from a serial terminal window, outside of PlatformIO.

The programming tools allow you to edit, build and upload the firmware module code to the target microcontrollers. The serial ports of the ESP32-S2 mini and ESP8266 microcontrollers use different communication settings that are specified in the platformio.ini configuration file for each device. For example, the serial port for the ESP32S2 is /dev/ttyACM0 and runs at 115200 baud, while for the ESP8266 the serial port is /dev/ttyUSB0 and runs at 9600 baud. You should not need to change any of these configuration setting, only be aware of their values if you are trying to fix a communications error.

If you run into a problem establishing serial connections to the microcontroller you can check the following:

1. For ESP32S2 board, connect the USB to serial adapter to the host PC and check if the device is recognized on the /dev/ttyACM0 port. Another device may already be attached to this port, in which case it should be removed before connecting the ESP32S2 board. For the ESP8266 board, the correct port is /dev/ttyUSB0.

2. Both the ESP32S2 and ESP8266 boards need to be booted up in the bootloader mode before they can be flashed. This is done by pressing the reset pushbutton on the boards while applying power by plugging in the USB cable into the host PC. Release the pushbutton after powering up.

3. Check the temporary wire connections from the ESP8266 board to the USB to serial adapter pins to ensure the RX and TX lines are wired correctly. The ESP8266 Rx pad connects to the Tx pin on the serial adapter while the TX pad connects to the Rx pin.

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