A RISC-V Energy Harvesting in IoT System
Marmot System with PSU and Solar power supply

November 16, 2022
SH Consulting Group (SHC)

Overview

Continuing the series of firmware download demonstrations for MCU via OTA, this time we will introduce a rather important part of the Marmot system. This part helps to provide and manage power for the system, participates in system security activities such as malware detection and tampering. We call it is PSU (Power Supply Unit) module. It includes hardware and software that can help PSU communicate with other modules such as MCU board, Solar, battery.

PSU modules is shown inside gateway and endpoints in Marmot System:

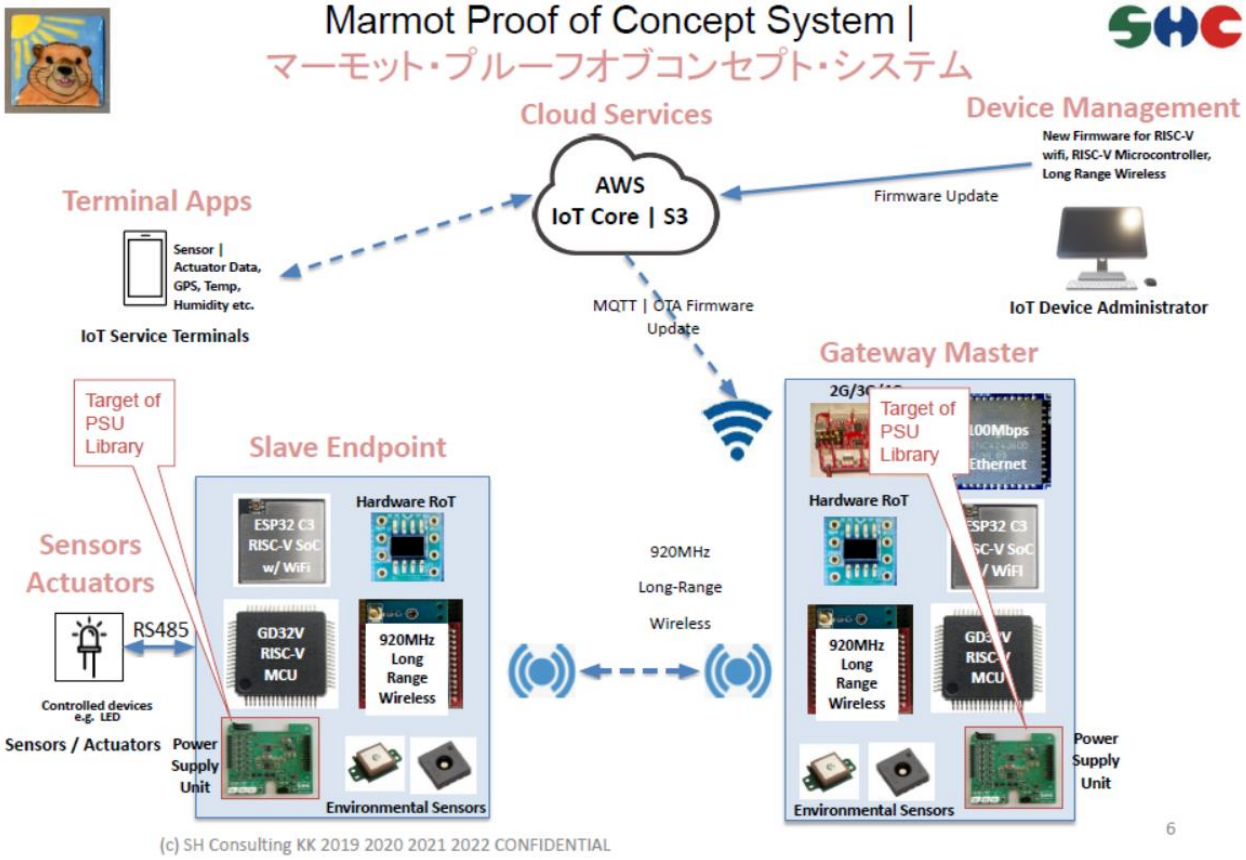

Figure 1: Full Diagram of a RISC-V AWS IoT Core Device Example

Gateway masters and sensor boxes are often installed in remote locations where traditional power lines are difficult to reach. So the solution of using solar panels and batteries is the best, to help the system be flexible installation and save energy.

In this demonstration we will simulate the ability of PSU for handling the charge and discharge process by recording the system's current parameters when solar gets strong and weak sunlight.

Marmot System

Let introduce a bit with Marmot:

Marmot = Microcontroller **A**rchitecture to **R**esist **M**alware, **O**bstructions, and **T**ampering

Marmot Wireless IoT system is being developed. This is an RTOS IoT system which provides: (1) Fast Response Time, (2) Low Maintenance, (3) High Reliability, (4) High Security. Figure 4 shows a Marmot Emblem. Marmots are relatively large ground squirrels in the genus Marmota, with 15 species living in Asia, Europe, and North America. The handmade emblem was created to mark the boxes. Figure 5 shows Marmot systems.

Figure 2: Marmot Emblem. Marmots are relatively large ground squirrels in the genus Marmota, with 15 species living in Asia, Europe, and North America. A handmade emblem was created to mark the boxes but this emblem idea was discarded because a solar panel covers Marmot enclosure and there is no proper visible place for an emblem.

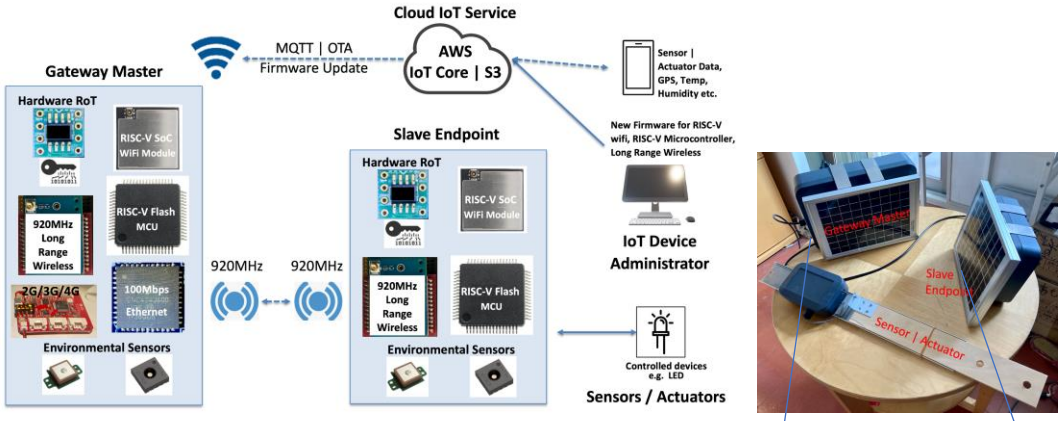

Figure 3: Marmot Wireless IoT System Example

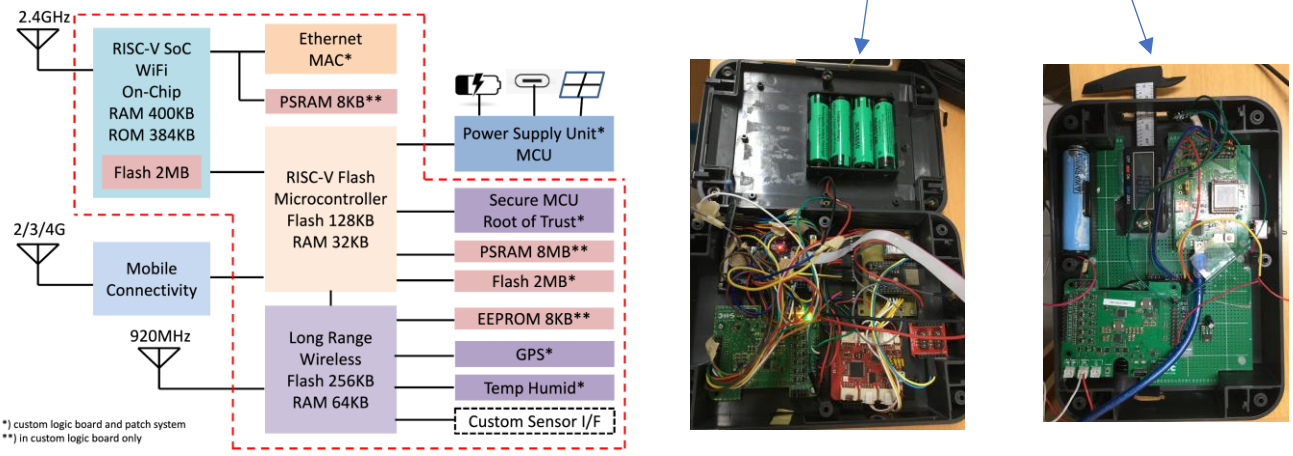

Figure 4: Marmot System Diagram and Patch Boards used for Software Development

Power Supply Unit (PSU) Board

Power Supply Unit Board is designed by SHC. This board is in cooperate with MCU board, solar, battery to management power supply for Marmot System and further for security.

The board can help system to collect: (1) battery voltage (2) battery charge/discharge current (3) SYS voltage (4) USB input voltage (5) solar input voltage. Those information will be stored in PSRAM for analyze the system later or help MCU board can change the system operation method includes adjusting the frequency of radio transmission of data measured by sensor according to climate, temperature, season, sunshine, and so on.

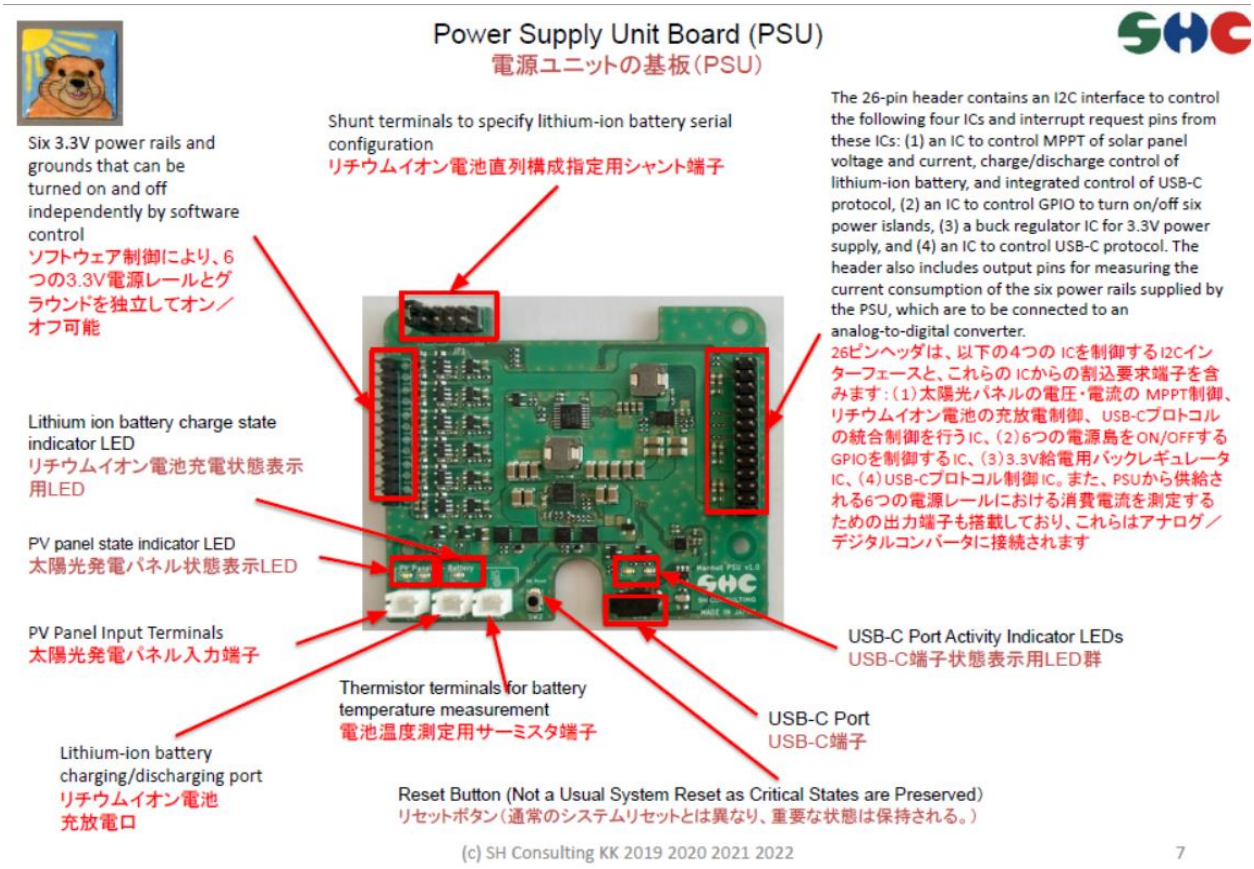

Figure 5: Power Supply Unit detailed explanation

PSU functionalities

PSU can support below functions:

(1) Manage 3 powers are integrated system to system to supply constant power
(2) Software control for Power Channels for Power Island and Chips
(3) USB-C Power Delivery Handshake Function

But in this demo we only show ability of manage powers (solar and battery) are integrated to system to supply constant power.

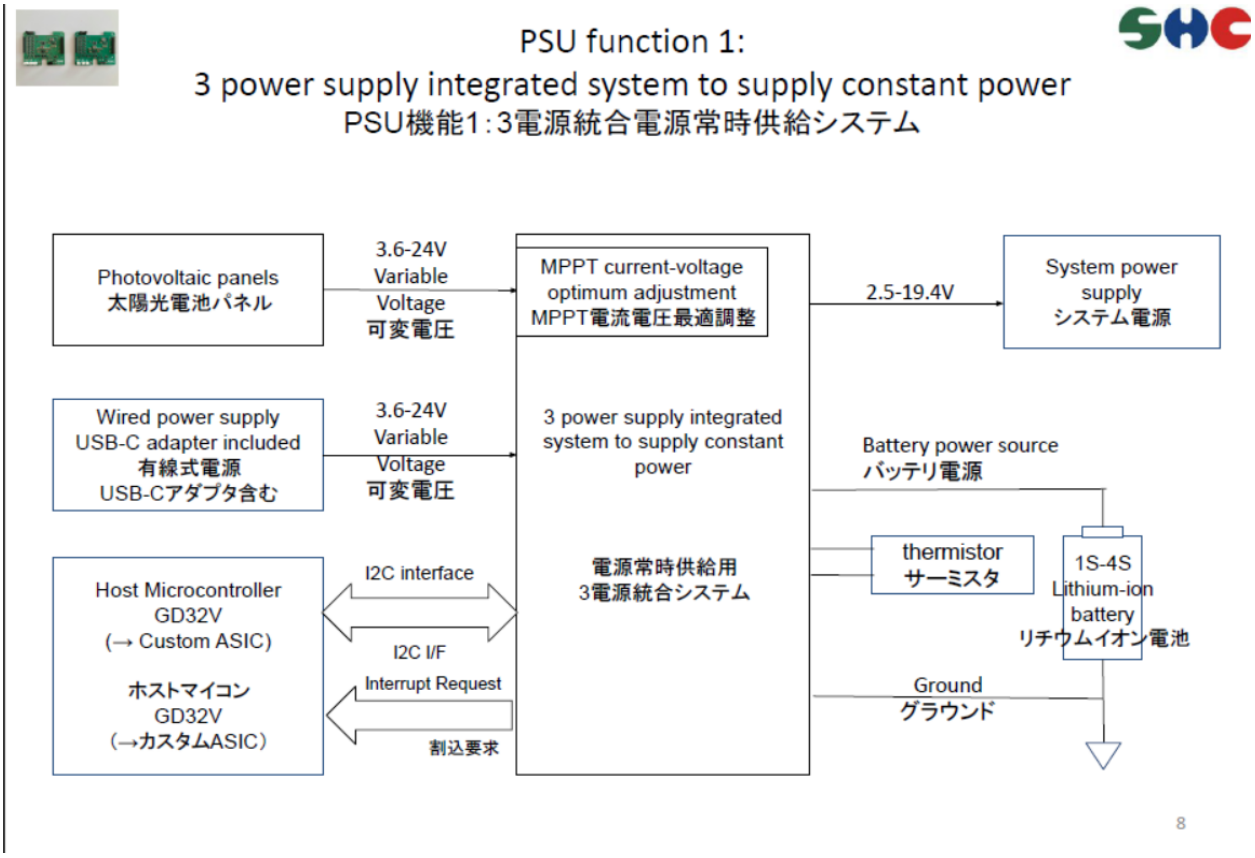

Figure 6: Power Supply Unit power management functionality

PSU library

Along with PSU board we have PSU library with includes several APIs that help MCU board communicate with PSU hardware for :

- Monitor (1) Battery voltage (2) Battery charging/discharging current (3) SYS voltage (4) USB input voltage (5) Solar input voltage.
- Turn on/off each of six channels of 3.3V supply rails.
- Capture single-short value for each channel, Capture waveform of each channel and store in PSRAM

Avoid the situation where system discharge to much power and leak to stops by monitor the battery voltage to determine the appreciate operation method such as adjusting the frequency of radio transmission of data…

PSU demo with Marmot Gateway

In this demo we can show how PSU works for handling charge/discharge process. Power supply for Marmot can get from Solar or battery depend on sunshine, PSU can monitor Voltage of Solar and Battery and decide resource of power can be used for system, in the good sunlight PSU use power from Solar to (1) Keep the system work as normal (2) Can charge for battery. Power from battery can be used when solar with weak sunshine such as raining or at the night.

Our system also need to optimize to use power as lower as possible by using sleep mode, wake up only when need to get or sending data. This will help our system can work longer.

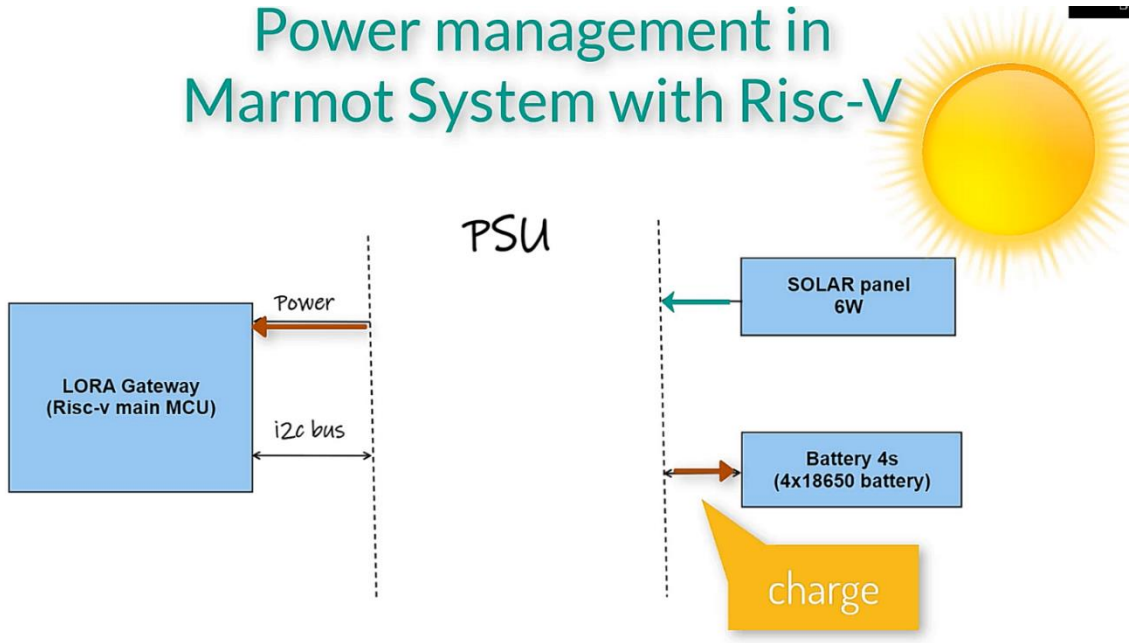

Figure 7: Route of Chage flow

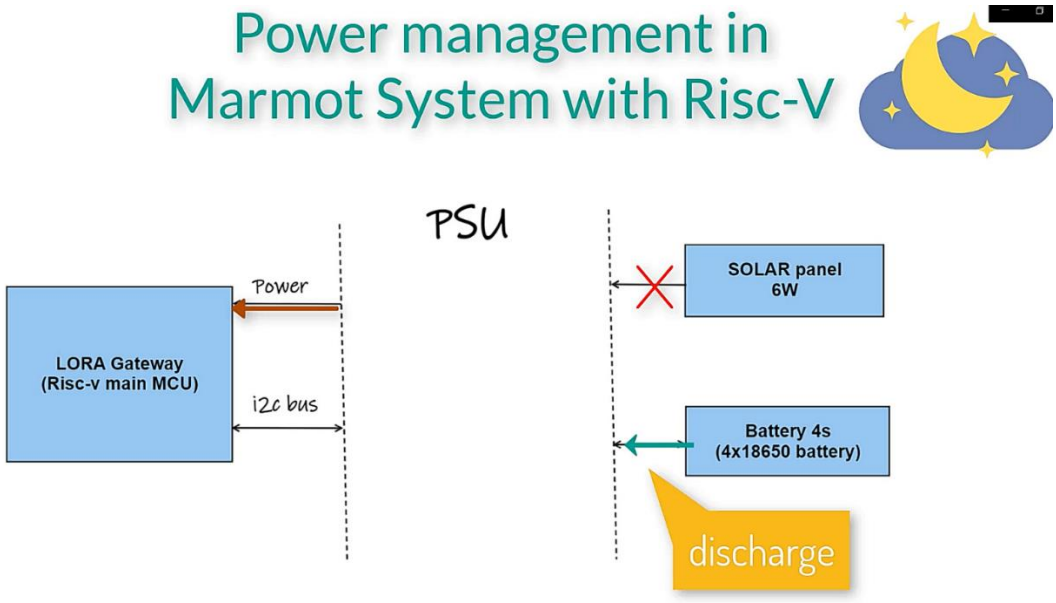

Figure 8: Route of Discharge flow

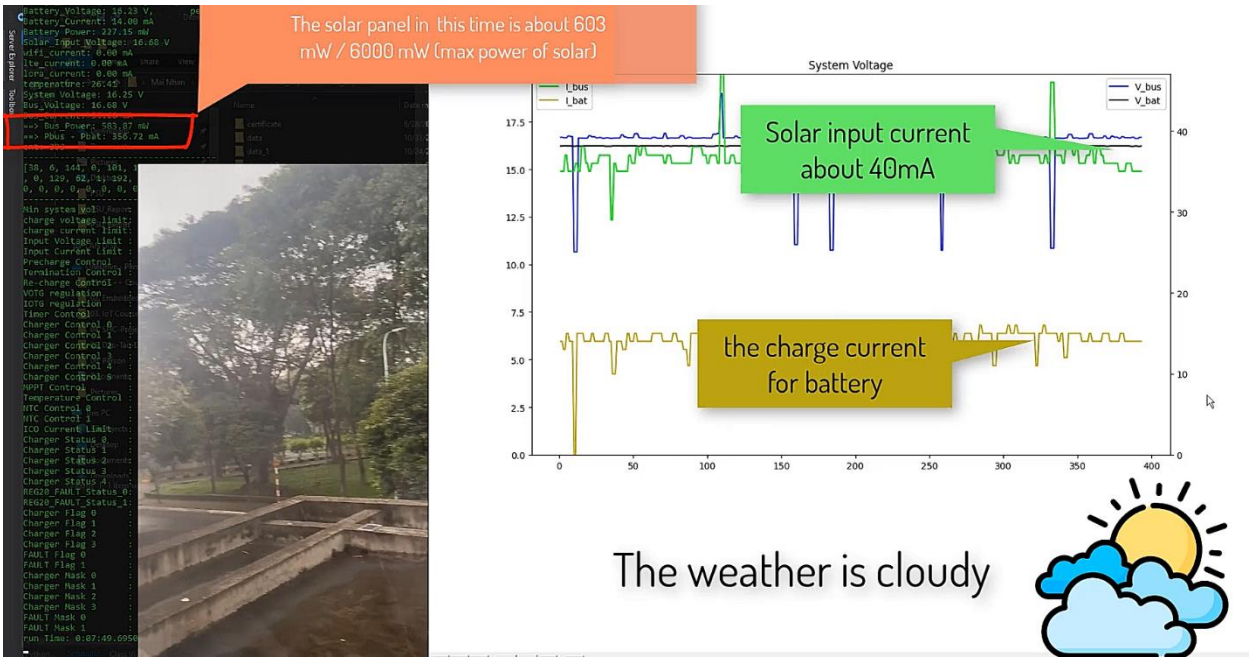

Figure 9: Weather is cloudy but system can charge a bit

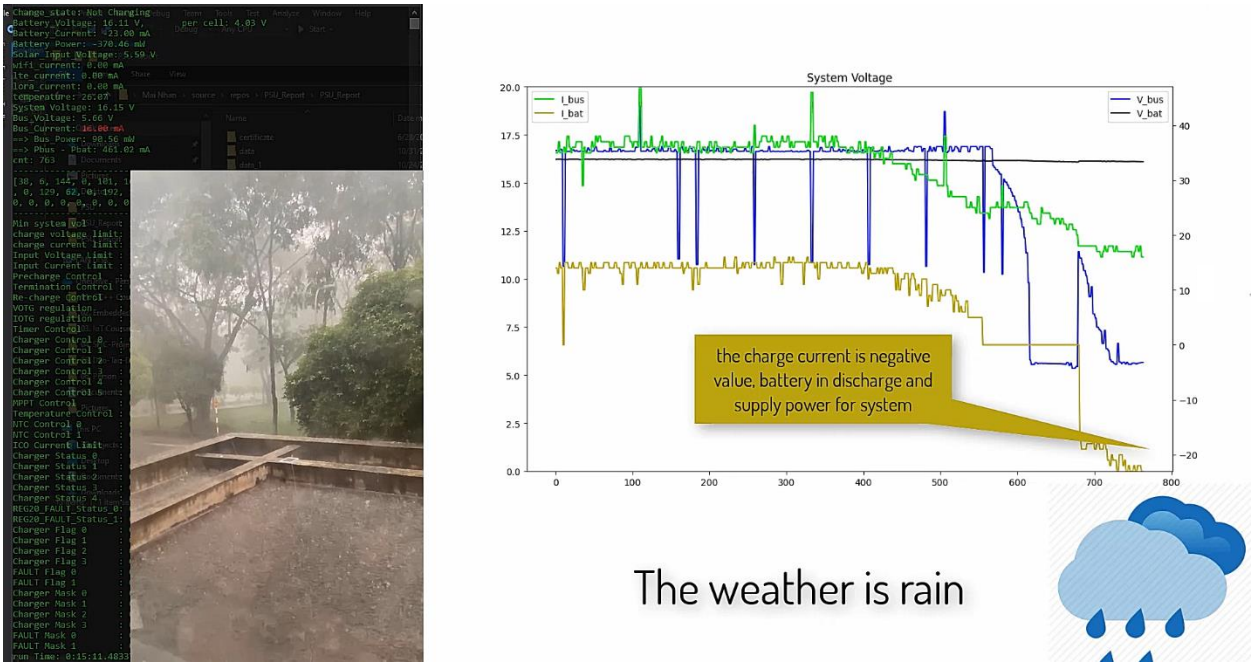

Figure 10: Weather is raining so system discharge

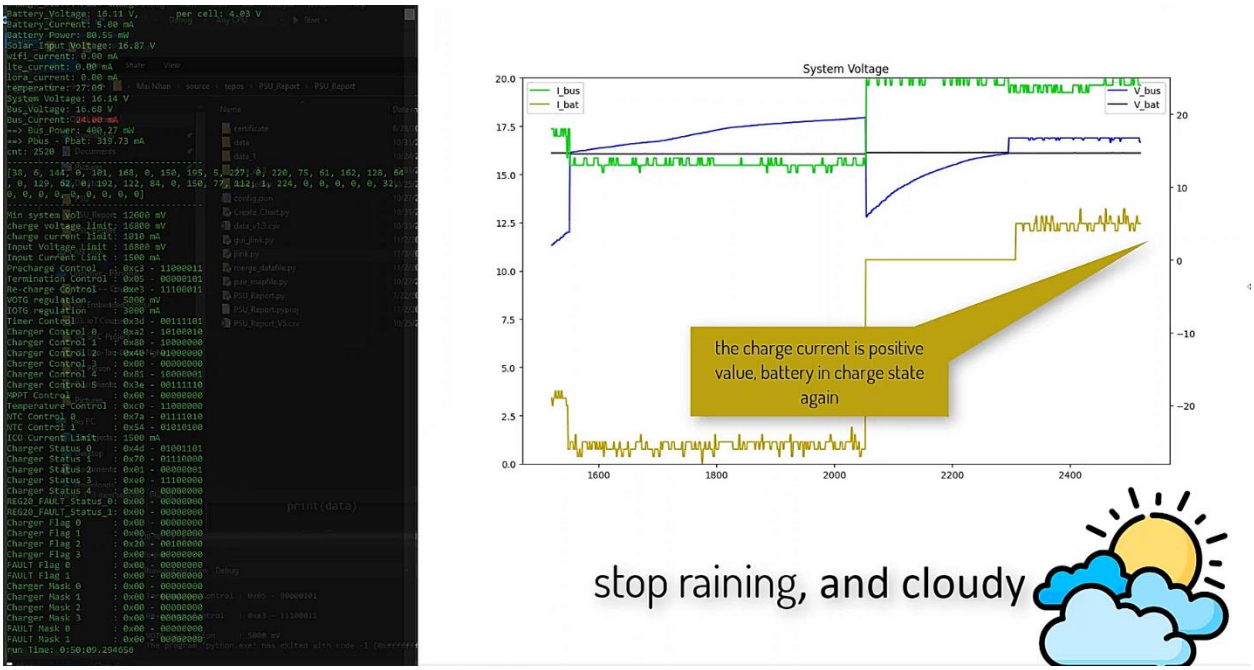

Figure 11: Weather stops raining so system can charge again

About SH Consulting Group

SH Consulting Group (SHC) has engineers in Vietnam and in Japan specialized in providing stability to RTOS, device drivers, and wireless connectivity for MCUs such as H8s, SHs, ARMs and RISC-Vs. It has been integrating OSes such as QNX, .NETMF, Linux, and Windows for MCUs and wireless solutions such as Lora, WiFi and Bluetooth for many years. They worked on Windows, Android and iOS platforms. In recent years SHC engineers enabled FreeRTOS for large semiconductor companies on ARM and RISC-V.

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