HOME AUTOMATION SYSTEM BASED ON ESP8266

Dimitar Minchev, Atanas Dimitrov

Burgas Free University

Faculty of Computer Science and Engineering

INTRODUCTION

Internet of Things (IoT) is becoming more and more a part of our lives on a daily basis. IoT devices are primarily used to control, monitor, and manage the technology that we use every day. This means that the devices are typically designed to be easily installed and managed by the consumer. Industry analysts estimate the number of connected devices to be 50 billion by 2020. This paper describes the implementation of Internet of Things Home Automation System with energy measurement capabilities.

ARCHITECTURE

The proposed system architecture model is modular and consists of multiple end devices, called Hosts, capable of incorporating a variety of household electrical appliances. Each of these end devices has a wireless network interface that allows the device to connect to the wireless home network using one of the popular 802.11 b/g/n wireless networking standards. A single control device called Gateway controls the operation of all Hosts. This control device provides a command connection to the terminal devices, thus providing their remote control.

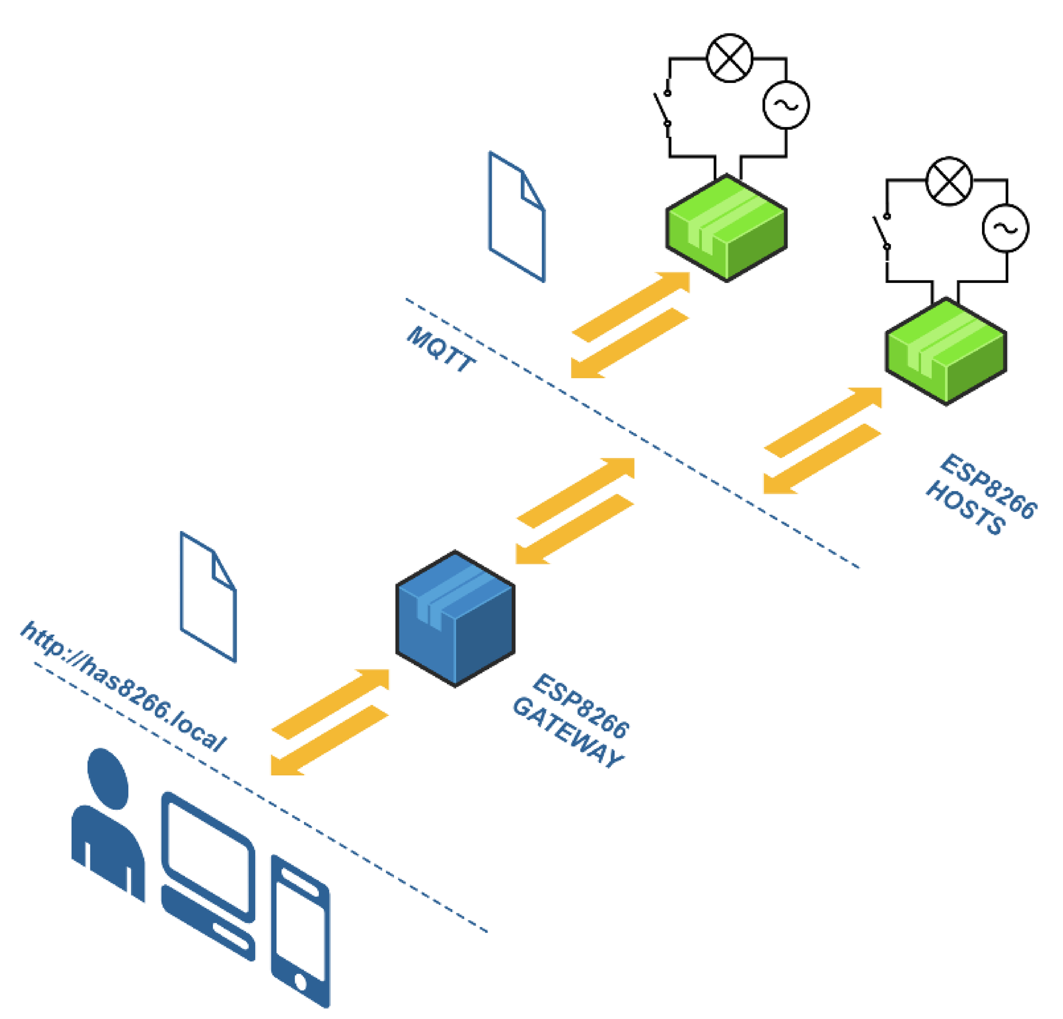


Fig. 1. A simplified architecture of the proposed HAS.

HARDWARE

HAS uses Espressif micro-controller - ESP8266 [4], integrated in ESP-12 Wi-Fi module developed by the Ai-Thinker team. The measurement of the consumed energy of the managed devices is accomplished with a single-phase energy monitor chip HLW8012 [5]. The ESP8266 chip integrates an ultra-low power 32-bit MCU architecture. The core of the processor can work with clock speed of 80MHz or 160MHz. The module supports RTOS, IEEE802.11 b/g/n standard and complete TCP/IP stack, which is making it ideal for adding to an existing network device or building a separate network controller.

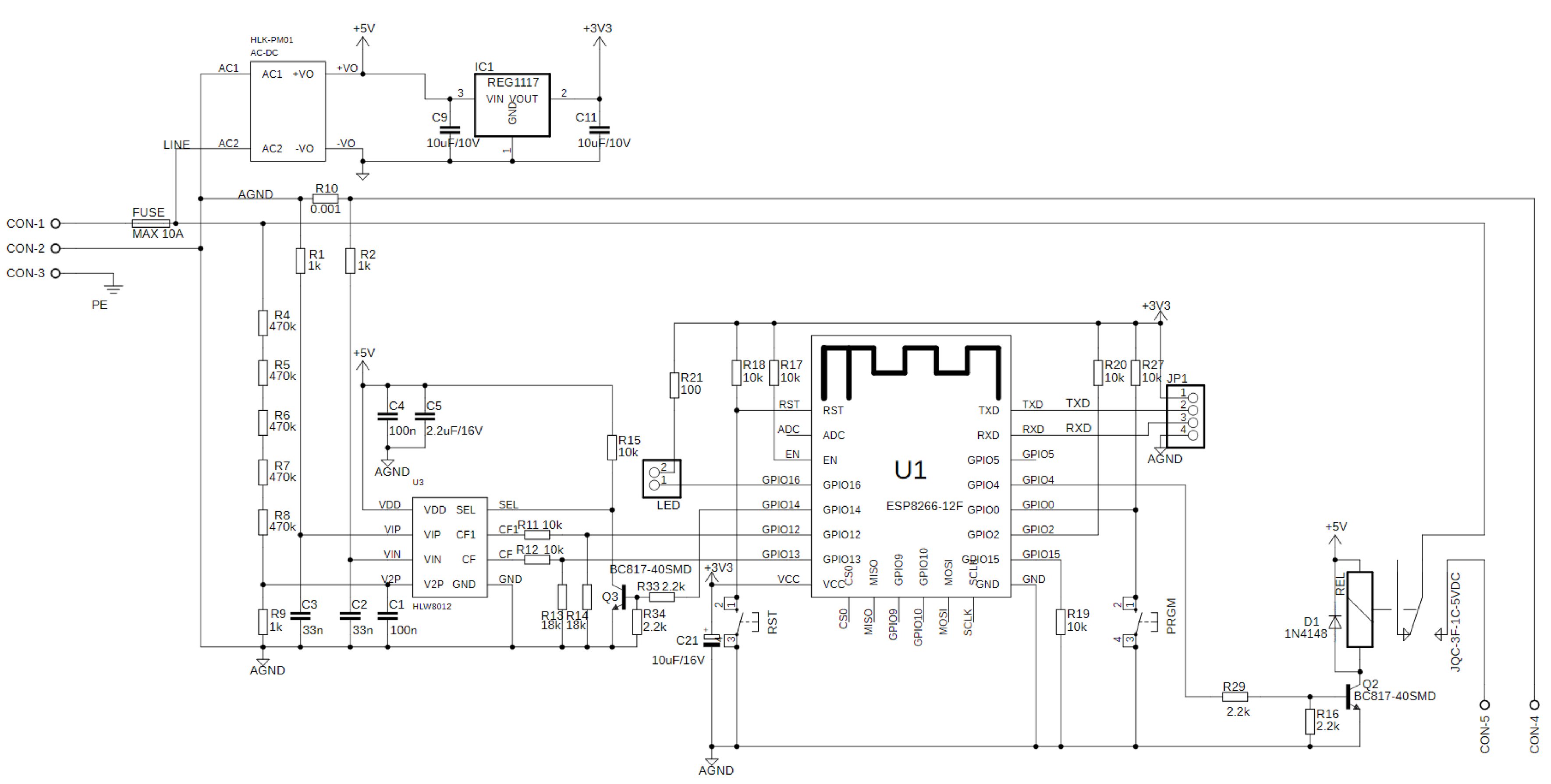


Fig. 2. Electrical scheme of the proposed Home Automation System.

HLW8012 can measure RMS values of current, voltage, and active power with an internal clock and a PWM interface. To operate, HLW80112 chip needs 5V DC voltage. It generates 50% duty square waves with frequency that depends on the magnitude of the measured parameter (power, current, or voltage).

The measurement of the consumed current is done by a differential potential measure across a milliohm copper-manganese or similar resistor, connected in series with a load (see Fig. 2) The differential potential is fed into pins V1P and V1N, where the potential of the V1P must always be more positive than V1N. The value of the shunt resistor must be selected with respect to the maximum peaks that the current will create on these pins (43.75mV). A 1milliohm resistor is well suited to measure currents up to 30A with a dissipation of less than 1W.

Voltage is measured on V2P pin, which supports peaks up to ±700mV. This imposes to scale down the potential of the measured voltage with a simple voltage divider.

HARDWARE (CONTINUE)

The HLW8012 datasheet recommends using a voltage divider of five 470kOhm resistors in the upper and a 1kOhm resistor in the lower lines. In this configuration, the scale factor is about 2821, which will convert a 230V RMS into 82mV. In our case, to minimize number of the components on the printed circuit board (pcb) plate, in the upper line of the divider are connected five resistors in series. The changed scale factor is 2351 and it will produce voltage of about 98mV on V2P that falls way below the limit.

The HLW8012 has two output pins, assigned as CF and CF1, where PWM frequencies with 50% duty square waves is generated. CF pin is for the measured active power and CF1 is for the current (0) or voltage (1) depends on the logic state of pin SEL (see Fig. 2). According to the datasheet of the chip, the frequency generated on the CF pin for the measured power is equal to (1). For the current and the voltage these frequencies are related to equation (2) and (3) accordingly.

$$f_P = \frac{V_{1P}.V_{2P}.48}{V_{ref}^2}.\frac{f_{osc}}{128} \qquad (1)$$

$$f_I = \frac{V_{1P}.24}{V_{ref}}.\frac{f_{osc}}{512} \qquad (2)$$

$$f_V = \frac{V_{2P}.2}{V_{ref}}.\frac{f_{osc}}{512} \qquad (3)$$

where, f_P, f_I and f_V are the frequencies of the generated square waves for the measured active power, current and voltage, V_{1P} and V_{2P} are the measured potentials respectively on pins V1P and V2P on the chip, V_{ref}=2.43V is the internal reference voltage and f_{osc}= 3.579MHz is the frequency of the build on the chip clock generator.

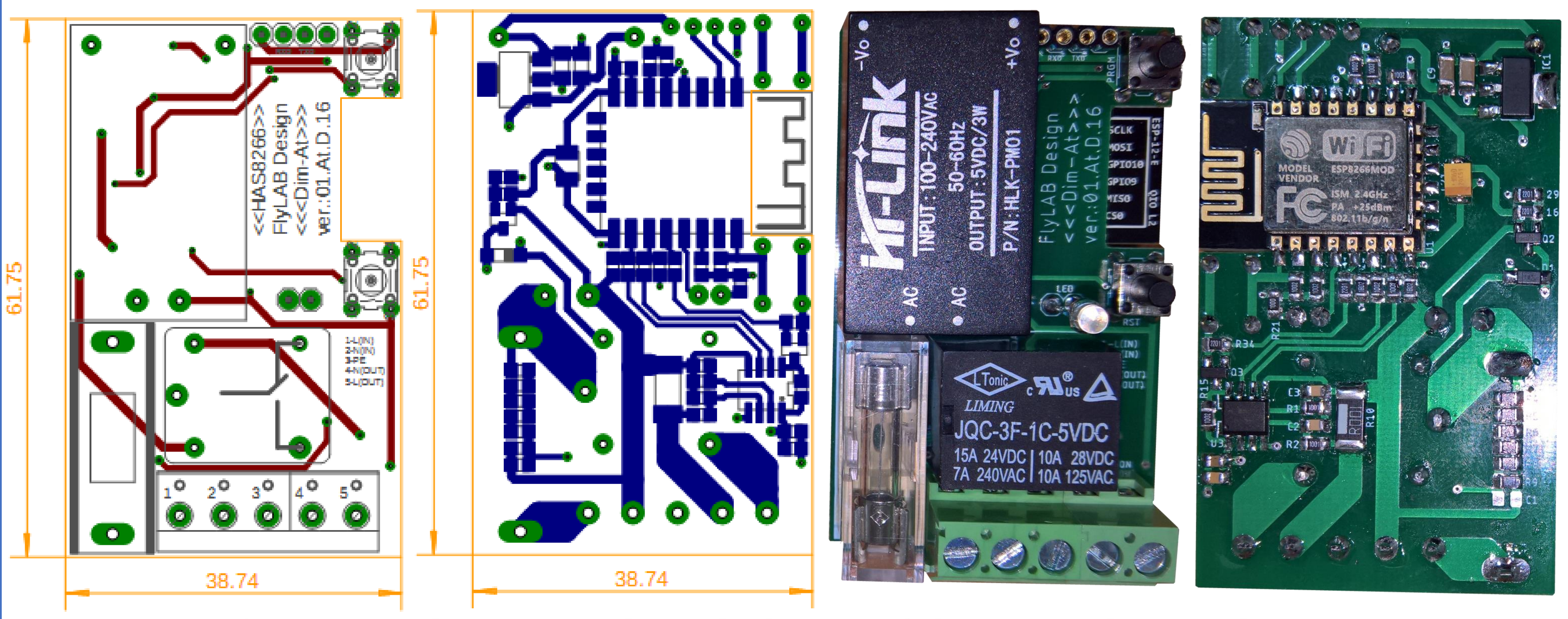
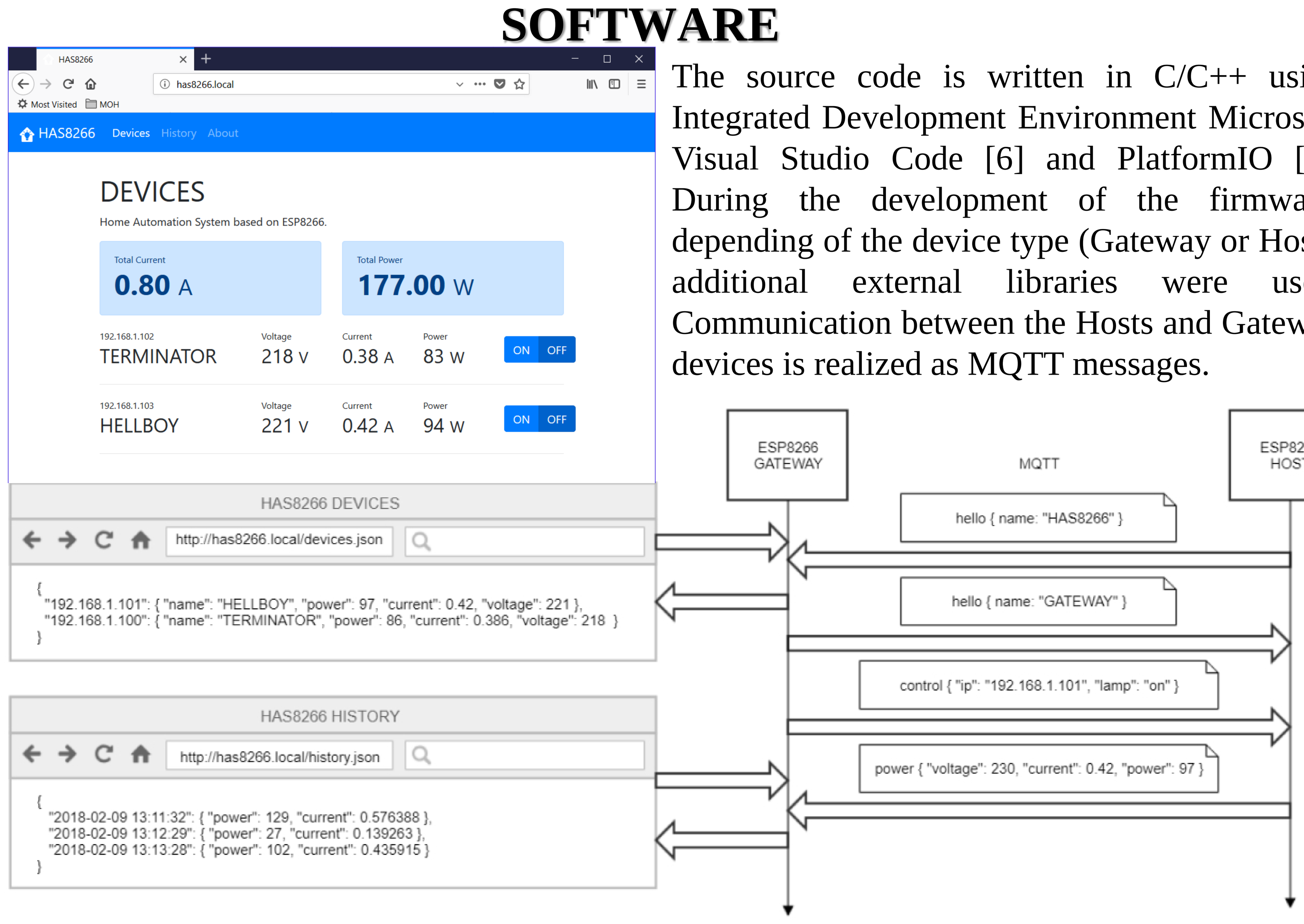


Fig. 3. Graphic originals and Photos of the created HAS device.

SOFTWARE



The source code is written in C/C++ using Integrated Development Environment Microsoft Visual Studio Code [6] and PlatformIO [7]. During the development of the firmware, depending of the device type (Gateway or Host), additional external libraries were used. Communication between the Hosts and Gateway devices is realized as MQTT messages.

Fig. 4. The view of the control web interface and HAS8266 Communication protocol

CONCLUSION

This paper describes the implementation of an Internet of Things Home Automation System with energy measurement capabilities. The basic hardware components are the ESP8266 micro-controller by Espressif and energy meter chip HLW8012 by HLW Technology. The Software works over the TCP/IP stack and uses the MQTT protocol to communicate between the devices. The minimum configuration of the HAS includes one control device called Gateway and two or more manageable Host devices. The user friendly, simplified interface is web based. The platform has open software and hardware.

REFERENCES

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