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Energy Management Solutions: an Efficient Digital Hardware-Software Complex for Metering Electricity

Bakhytzhan Suleimenov and Dilyara Nartova

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Energy management solutions: An efficient digital hardware-software complex for metering electricity.

Bakhytzhan Suleimenov[1], Dilyara Nartova[2]

[1] M.Sc. in IT, PhD candidate, Gumilev Eurasian University, Nur-Sultan, Republic of Kazakhstan

[2] PhD in Mathematics, IITU, Almaty, Republic of Kazakhstan

***Correspondence**:* nds2014@mail.ru

Abstract. Energy management is a widely extending practice among companies monitoring large buildings, enterprises, educational, health care campuses and other complex facilities.
Efficient energy management requires detailed information on how power is used. However, this valuable information is not available in facilities being actively monitored.
For effective energy management, facility engineers need to understand exactly how and where energy is being consumed on their properties. There are many problematic issues in the field of measuring household electricity consumption. Manual collection of readings still takes place despite the full-scale use of electronic meters. Consumers do not have a culture of electricity consumption; there is no basic knowledge about energy consumption and energy efficiency classes assigned to electrical devices. Knowledge and tools to forecast costs and manage energy consumption are lacking.
The purpose of this paper is to study issues related to the development of a prototype of a software and hardware complex for measuring the load (V) and volume (KWt / h) of consumed electrical energy.
Key words: Electricity, housing and the communal services, Energy efficiency, of M2M, of Internet of things, Automation's, Collect indications, Alternative energy.

1 Introduction

Automation tools penetrate into all areas of our live. Energy is the subject of research methods and techniques to
Energy management efficiency is main condition in achieving sustainability in construction and helps to control increasing their energy costs while reducing their environmental bad consequences. An energy management system can provide metering, sub metering and monitoring functions that allow facility managers to gather data that allows them to make more confident management decisions about energy use.
The benefits of digital hardware-software complex for metering electricity are the following:
Precise distribution of meter indicators among electrical devices.
Accurate energy monitoring, real-time energy consumption.
Detailed review of facility energy data.
Better informed to make decisions that can help optimize energy performance.
Ability to record actual energy usage.
Comparison of usage across similar facilities over time.
Ability to identify and eliminate wasted energy.
Early access to maintenance issues for repair before critical equipment fails.
On the territory of the Republic of Kazakhstan, electricity is available in all areas of residence, as well as cellular communications and the Internet. According to statistics, the level of penetration of cellular devices in Kazakhstan is more than 185 %, which indicates that the population is actively using mobile service communications, as well as smartphones and 4G Internet. Users have more than 1 GSM enabled devices. GSM network coverage is complete.
Today, the market uses two types of electronic meters, these are the Russian manufacturer Mercury and the Kazakh - Saiman . Regardless of the model, they are measure consumption of the electricity and display reading on the electronic display.
Taking readings requires human participation. At this level, local automation is necessary, focused on the interests of the consumer, but not Provider. Providing information on up-to-date and projected consumption.

Figure 1: Measuring devices used in the Republic of Kazakhstan.

Due to energy safety requirements, measuring devices are mounted in a separate electric power box installed on staircases and landings. The installation site is often poorly lit, hard to reach and locked, which makes it difficult

for consumers to keep track of electricity in a real-time mode.

Figure 2: Standard installation of meters in apartment buildings in the Republic of Kazakhstan.

The meter readings are taken with the participation of a person, namely, an electrical readings controller working for a billing company, or an electricity operator in a given area or city. Consumers, on the other hand, do not take readings at all, or only if there are deviations in payment for utility bills from the average monthly median.
However, the growing culture of electricity consumption encourages consumers to the following methods of control, accounting and savings:
- Verification of readings based on previously paid receipts;
- Control over the consumption of light in the room (apartment);
- Installation of energy saving lamps;
- Purchase of household uncertified wattmeter.

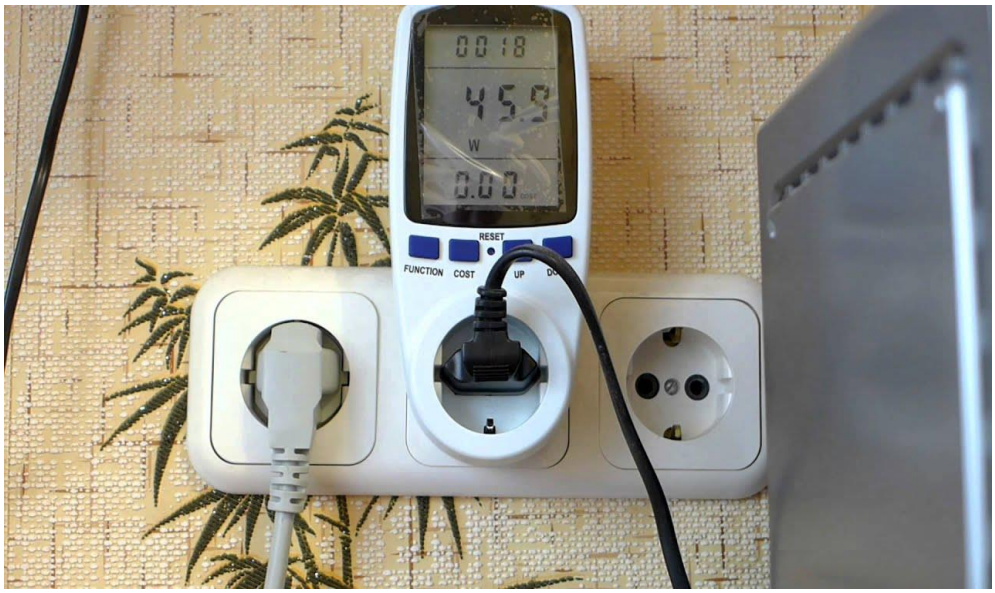

Figure 3: Household wattmeter. Manufactured in China.

However, measurement problems are the following:
The device takes only a one-time reading at the time of connection;
The device is not verified and may contain measurement errors;
The device measures the readings of one connected device;
The device does not transfer measured values to the PC.
Record logging must be kept and stored manually.

To solve these problems and achieve the desired functionality, focused on the needs of the consumer, requires the development of hardware and software complex (HSC). The article highlights the process of creating hardware at the Arduino Nano platform and other controllers connected to Wi-Fi using the open IoT platform ESP 8266.
This solution corresponds to the «Smart " concept and allows to automate the process of taking readings by both the consumer and the electricity supplier, and the data obtained is enriched with a mathematical model that allows deep analysis consumption of each device supplying the electricity power.
The resulting data will be available to the consumer through a web page or mobile application. This system will also allow you to turn off the power supply remotely, at the request of the consumer.

2 Methods and materials

2.1 Measuring electricity

As a platform, we use Arduino Nano, which, due to its compact size, can be placed in a standard case, also has a sufficient number of analog digital outputs for connecting analog and digital sensors and controllers.

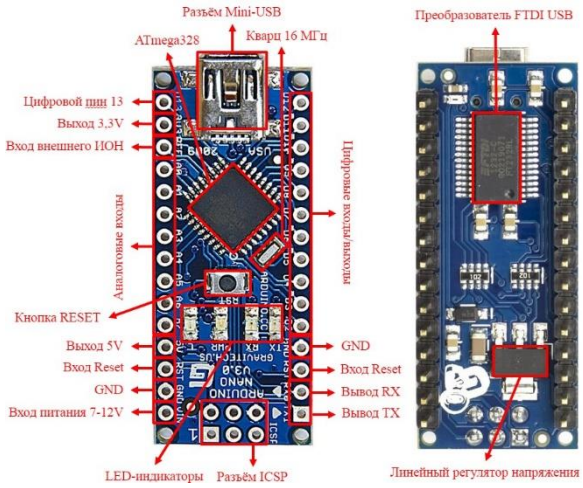

Figure 4: Arduino Nano circuit

2.2 NODE _ MCU (ESP 8266)

Node MCU is an open platform widely used in Internet of Things (IoT). It contains the firmware that runs on the ESP 8266 Wi- Fi SOC module and controls the ESP -12 hardware module installed on this platform. The firmware is written in the LUA scripting language, the code of which is open and allows us adapt it agile to the needs of the ESP 8266 platform.

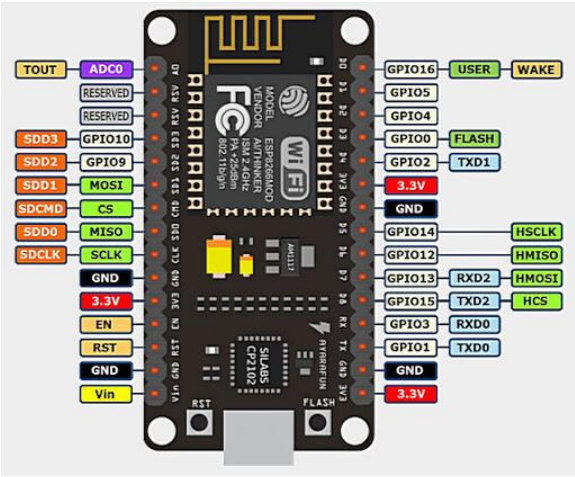

Figure 5 Scheme platform ESP 8266.

2.3 CURRENT SENSOR ACS 712

Figure 6: ACS712 current sensor, Hall Effect.
The current sensor is a Hall Effect device that detects the voltage in the network and generates a signal proportional to the voltage.

The generated signal can be analog or digital. The generated signal can then be displayed on an ammeter or saved for further calculations or analysis in the system. In addition, the data can be used to create a control algorithm of action, e.g, supply voltage to the network, or switching devices such an air conditioner or heater. Thus, this sensor is also the basis for creating a local infrastructure for controlled electrical appliances according to the "Smart house" concept.

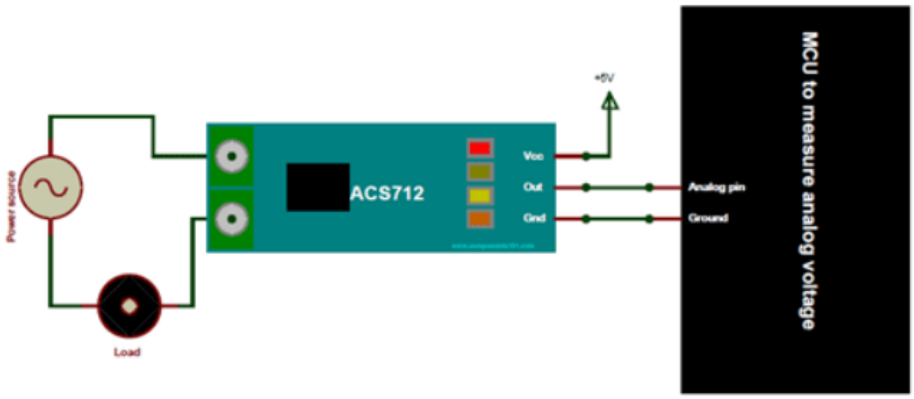

Figure 7: ACS712 current sensor, wiring scheme.

3 Principle of operation

The HSC is connected in a gap to the 220V alternating current phase into the network after an electromechanical electrical measuring device. The connection is made to the ACS 712 current sensor. The current sensor transmits the captured data via VCC and connects to the analog input of the Arduino Nano? (AO). ADC Arduino processes the data in accordance with the mathematical model embedded in the compiler program code and transmits the data to the Wi - Fi access 802.11 b\g\n on protocol to a google cloud is an IOT the CORE platform, which creates the file c data in the cloud, the Google. Subsequently, our web and mobile applications will refer to this file, updated every 10 milliseconds (Frequency 100Hz), to collect the necessary information and graphical display.

4 Result and discussion

In 2014, the enterprises of the republic supplied 85.3 billion kWh of electricity. Out of the total electricity supplied for lighting apartments and other housing needs of the population, 11.4 billion kWh (13.4%) of electricity was supplied. Losses in power grids amounted to 7.0 billion kWh. (8.2%). Which can also be attributed to the consumption of the housing sector.
The challenge of reducing energy consumption for housing is both a strategic and tactical challenge.
The relevance of research and development in this direction is based on the fact of a rapid increase in consumption in apartments, for the following reasons:

- The rapid development of consumer electronics;
- Dynamic construction of new apartment buildings;
- Global population growth;
- Increasing the level of urbanization;
- Use of electric vehicles;
- The spread of the cult of consumerism and neglect of resources.

5 Problem statement

The developed HSC, which can be connected to an existing measuring device, provides a simple and convenient interface in the form of an application for a mobile device.

6 Issues for discussion

1. The choice of a case for the assembly and installation of HSC, subject to the standards of the Republic of Kazakhstan and anti-vandal measures.
2. Determination of the required functionality for the operating modes of the HSC.
3. Ensuring the autonomy of the HSC in case of power outages.
4. What additional plug-in sensors and modules can be used to enrich the received data for consumption analysis?

7 Data availability

The data set is available upon request by contacting the corresponding author.

Author contributions

BS contributed to conceptualization, data curation, methodology, tool assembling, the visualization, and writing of the original draft, contributed to supervision, validation, and writing. DN contributed to supervision, formal analysis, review and editing.

Competing interests

The authors declare they have no conflict of interest.

Special issue statement

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