ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 8, Issue 2 , February 2021

Single-Phase Portable Meter Prototype

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ABSTRACT: The project presents the development of a portable meter for measuring consumption. For the development of the project, the Arduíno Uno device was used, based on hardware and software, which collects information from the current sensor of the ACS 712 current sensor. The results are sent for display, which can be viewed instantly or via page HTML. The use of electric energy is important due to environmental aspects, through rational and balanced consumption. The purpose of this work is to devise a prototype that instantly measures the electrical consumption of electrical equipment and provides the value spent in reais of the measured equipment.

KEY WORDS: Arduino. Meter. Chain. Consumption. Energy.

I RELATED WORKS

As basic works, the article "Design and implementation of smart energy meter" [1] is cited, which deals with electrical devices that measure and bill electricity and prevent theft of energy. In addition, the article "Intelligent Energy Meter Based on IoT" [2] that shows the implementation of arduino to the conventional energy meter with access to energy reading through the web page. Also noteworthy is the scientific work "Experimental study and design of smart energy meter for the smart grid" [3] that develops an energy meter that facilitates energy monitoring by the consumer, by sending measurements made to a cell phone.

II INTRODUCTION

In the case of electrical appliances, the increase in the number of electronics and appliances, leveraged by the technological revolution, has also led to a rapid increase in the consumption of residential electricity, requiring solutions aimed at measuring and controlling electricity consumption autonomously. One difficulty encountered is that conventionally adopted energy meters do not provide information on the devices' instantaneous consumption (ENERGÉTICA EMPRESA DE PESQUISA, 2019).

Thus, the present work aims to propose the assembly of a device that facilitates the monitoring of electricity consumption.

For that, it will be shown the development of this equipment is justified, the methods of calculating power and consumption of electric energy, the devices that make up this equipment and its operating principles, the method of assembly and operation of the equipment and the results of tests carried out certain electrical appliances, as well as the conclusions obtained from these tests.

It is proposed to implement a prototype that is capable of efficiently measuring the values of power and electricity consumption, in order to help consumers obtain information about the energy consumption of any electrical equipment.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
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The development of a tool that adequately monitors the energy consumed by an equipment is essential, and may assist in decision-making, either to reduce your monthly energy consumption or to make exchanges for more efficient appliances.

Another aspect to be considered is the waste of electrical energy, which is today one of the main issues regarding energy efficiency. New habits in energy consumption contribute positively to the environment and more quickly in decreasing the value of the electricity bill at the end of the month or even in the conservation of electrical equipment. Having energy efficiency as its main idea, the project presents the development of a portable meter for measuring electrical consumption. The information is shown in real time through a kWh display to demonstrate how much each device spends during use. Being easy to handle, the product can be used by anyone who is interested in better controlling their spending and residential consumption, making it easier to manage electricity consumption.

The project consists of joint programming of the display, sensors, for all voltage levels in the region and programming of the wi-fi connection module that receives the cataloged data and sends it to the global computer network, through a Determined IP.

III THEORICAL REFERENCE

The Energy research company (EPE) has been making available a study that shows the monthly history on national, regional and subsystem electricity consumption, in the residential, industrial, rural classes, etc.

As for residential consumers, EPE bases its calculation of the electric energy consumption in this sector considering the following electronic equipment: refrigerator, freezer, lighting, stereo, computer, electric shower, electric iron, blender, television and washing machine.

The study showed that the average consumption was 162 kWh / month, with great variations between regions. The region with the highest consumption levels was the central-west region, with 188 kWh / month and the region with the lowest consumption level was the northeast, with 124 kWh / month [4] .

The values obtained from measuring equipment are verified and evaluated by means of calculations that indicate that the measurements obtained from electricity consumption are correct.

To obtain the power and the time of use of each device, mathematical equations are used in order to obtain them.

According to ANEEL, (BRAZILIAN CHAMBER OF COMMERCIALIZATION OF ELECTRIC ENERGY, 2020), the power associated with the load flow results directly from the definition of voltage and current, as seen in the following equation:

$$P = V.\mathrm{I}.\mathrm{fp} \tag{1}$$

considering a unitary power factor, that is, equation (1) becomes:

$$P = V.\mathrm{I} \tag{2}$$

on what,

P = power in *watts,*
V = tension in *volts,*
I = current in *àmperes;*

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International Journal of Advanced Research in Science, Engineering and Technology
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fp = power factor.

Equation (2) shows that the power, when considered the power factor of the equipment being unitary, is simply the product of the current by the voltage [5] .

For the calculation of consumed energy, the equation to be used is:

$$E = P.\triangle t \quad (3)$$

where,

E = energy in*joules*,
P = power in *watts*,
Δt = time variation in hours.

As noted, the energy consumed is nothing more than the product of the voltage due to the time variation in which the equipment was used [5] .
As for the consumption of billed energy, to be charged by the distributors to customers, it is done through meters, which measure the power consumed by the consumer unit.

The meter, in general digital, measures electricity consumption values, which can also be obtained manually, through calculations, which should lead to equal measured and calculated values.

In order to measure this consumption, the calculation method is as follows:

$$E = C.\text{tariff} \quad (4)$$

where,

C = consumption in reais;
E = energy in kWh;
tariff = tariff flag of the region in reais in effect at the time the prototype was used.

From the calculation described above, the amount spent in reais on the consumption of electricity is arrived at [5]

IV METHODOLOGY

In order to carry out the measurements of the reading of electric energy consumption, an embedded system was designed to perform the measurements and have access to these values remotely. This system consists of 3 blocks: acquisition, processing and transmission. In addition to the devices that make up these blocks, the displayit is another important element for verifying the results of measurements on the spot.

The acquisition block consists of a current sensor ACS712, whose function is to measure the current that is drained by the measured equipment. The processing block consists of a microcontroller, Arduíno Uno, which is responsible for processing the received data and processing it according to the programmed source code.

The transmission block is formed by the ESP8266 wi-fi module, which transmits the data processed by Arduíno Uno to an html page for monitoring the measurements remotely, via remote access. Figure 1 shows the blocks that make up the system.

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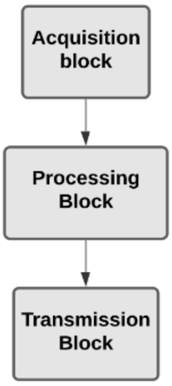

Fig. 1 - Blocks that make up the system.

V MATERIALS

- **Arduíno Uno**

Arduíno Uno is a microcontroller board based on the ATmega328P. It has 14 digital input / output pins (6 of which can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power connector, an ICSP connector and a reset button.

The language used by the processor to perform the required functions is C ++. [6] . The choice of Arduíno Uno was due to its open library and ease of development of microcontrolled projects.

- **ESP8266**

The ESP8266 module, in Figure 3, is a microcontroller that has Wi-Fi communication capability. This module can be applied to any microcontroller project, as an adapter, through its integrated interfaces.

The module has a Tensilica L106 RISC 32-bit processor, with low consumption and processing speed of 160 MHz. It has an operating current of 80 mA and an operating voltage of 3 V to 3.6 V [7] .

The use of this module is justified due to its wide applicability in projects that can be connected to the wireless network and because it has a value that does not make the prototype economically unfeasible.

- **ACS712**

The ACS712 current sensor offers an economical and precise solution for applications in direct current (DC) or alternating current (AC), as shown in Figure 4. The device consists of a circuit with a functioning footwear in the hall effect.

The applied current flowing through the copper conduction path generates a magnetic field that the device converts to proportional voltage.

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The accuracy of the device is optimized by the proximity of the magnetic signal to the hall transducer. As features, it has a bandwidth of 80 kHz, with an output sensitivity of 66 to 185 mV / A. It has low noise and an output current of 30 A. The choice of this current sensor is justified due to its good current operation range.

- **DISPLAY LCD 5110**

O display LDC Nokia 5110 in Figure 5 has 84x48 individual pixels, with digital inputs and outputs and with low power consumption characteristics.

Your video driver is made with a PCD8544 chip and works at 3.3 V, with a level displacement chip, for operation in 5 V as well. The use of the display was mainly due to the 1.5 inch screen size, which facilitates reading, as well as the demonstration of data obtained in the tests carried out.

VI OPERATION PRINCIPLE

The operation of the portable meter consists of measuring the current consumed by the equipment to be measured. Figure 13 illustrates the principle of operation of the meter.

In the wiring diagram, the ACS712 current sensor was connected in series with the circuit of the internal socket. V_{cc} The ACS712 is powered by Arduino, at a voltage of 5 V through its terminal , the GND connected to the Arduino ground terminal and the OUT terminal is responsible for the output voltage and is connected to an Arduino analog port, as shown in Figure 13. As mentioned earlier, the Arduino has the function of processing the data related to the script. The language is responsible for reading the data obtained by ACS712, calculating the equations, projecting the information to the display, and modifying the html created by ESP8266.

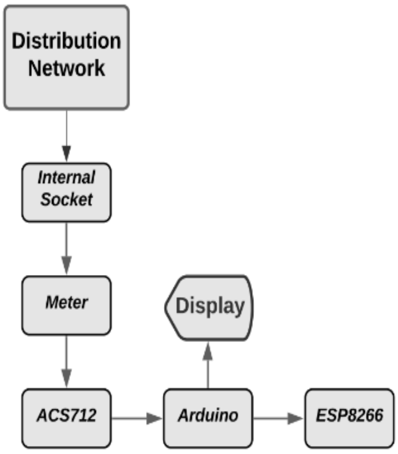

Fig. 13 - Flowchart of operation.

From this, the ACS712 sensor was introduced in the phase that powers the device, where it performs the reading of the alternating current, through the hall effect, which detects the magnetic field that is generated by the passage of electric current, and through of the OUT pin that communicates with the Arduino analog input, sending a signal.

The signal that is received by the Arduino analog port, is processed in the source code, which starts to provide the power and consumption values, from the current values measured using the ACS712 current sensor. The supplied power result is given by the product of the current by the voltage, which voltage is defined in the Arduino code, as 127 V phase-to-ground.

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Right after that, the Arduino projects the information received by the ACS712 on the display that is responsible for external communication, through real-time display of the consumption of the electrical device. On the Nokia 5110 display, the measurement data, such as current in amps (A), power in watts (W) and consumption in kilo-watt hours (kWh), are displayed by the external agent.

ESP8266 is responsible for the communication interface, between the processed data and the html page that receives it. This communication is done through Arduino UART commands (Universal Asynchronous Receiver / Transmitter), which communicates with the wi-fi network and transmits the data obtained on a web page.

VII SEARCH RESULTS

The sending of data to the network connected to generates an html page, to be provided by the internet protocol (IP) of the network connected to ESP8266. The supplied IP, as well as the measured current and power value is shown in Figure 14.

Fig. 14 – Página html geradopelo ESP8266.

Mounted the portable meter, tests were carried out on certain household appliances. Table 1 below provides the values measured by the meter and the values provided by the manufacturers.

Brand and Equipament	Plate Date (W)	Measured Values		
		Current (A)	Power (W)	Mistake (%)
Fan 1	300	2,13	269	10,33
Fan 2	50	0,39	50,53	0,01
Fan 3	135	0,51	64,12	52,5
Cooler	195	1,69	214	9,74
Blender	550	1,98	251,15	54,33
Juicer	250	1,84	233,24	6,74
Sandwich Maker	700	5,35	685,86	2,06
Food Mixer	400	1,1	143	64,25
Electric Iron	1200	8,98	1223,92	1,99
Notebook Power Supply	50	0,52	66,22	32,44
Flat Iron	40	0,91	107	167,5
Hair dryer	1000	7,52	947,77	5,22
Printer	1000	7,46	905,36	9,46
Television	80	0,62	80,14	0,17
Washer	400	3,5	327	18,25

Tab. 1 - Equipment and measurement results.

As a demonstration, the test for fan 2 will be shown. The manufacturer's plate data indicated the values in Figure 15.

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Fig. 15 - Fan plate data 2.

If the current reading was 0.39 A and the product of the current measured by the set voltage, which is 127 V, is realized, the power of 50.53 VA is obtained.

Note the proximity of the measured values and those reported by the company assembling the electrical equipment, as shown in Figure 16.

Fig. 16 - Equipment reading display screen.

VIII CONCLUSIONS

Therefore, the simultaneous configuration of the Arduíno Uno, the ACS712 current sensor, the ESP 8266 wi-fi module and the Nokia 5110 monitor together with a schedule containing conversion formulas, generate an electrical consumption measurement prototype, remotely accessible via internet, through measurement of the load current per phase, insertion of power equation and consumption in programming code.

It was noticed that the reading of the current sensor presented a margin of error within the limit predicted by the component's datasheet, with minimal changes, so that this difference between the measured and the expected was reflected in the power and, therefore, in the consumption.

It is worth noting that, it is expected that different values are verified between the values obtained between the measurements made and the values provided by the manufacturers of the electrical appliances through the plate data.

These divergences are in the current and power values. Such differences are noted due to several factors, such as fluctuations in the voltage values of the network delivered by the distribution utility, possible errors in the values of the plate data, variations in the power of the equipment to be measured according to the power selector, tests in empty of certain equipment, such as the blender, in addition to the permissible error of the sensors, which added together, produce the differences verified in Table 1.

However, the prototype in question proved to be considerably useful for the purpose of checking the consumption of certain equipment and monitoring it through online access to the internet.

The monitoring of the measured power of the equipment assists in verifying the veracity of the informed power of the equipment. In addition, observing the electrical consumption of the equipment helps in making decisions, such as changing the equipment and changing consumption habits.

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ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

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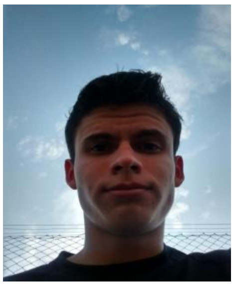

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