ONLINE MONITORING SYSTEM FOR ELECTRICAL PARAMETERS

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ABSTRACT: *The paper presents a simple and easy to implement system for the online monitoring of electrical parameters. Current systems based on electricity meters or datalogger systems require the physical presence of a human operator at location of such equipment for data collection. The large-scale expansion of power generation systems as well as the need to know almost real-time electrical parameters to implement electricity management systems requires online monitoring systems.*

KEY WORDS: *Electrical parameters, electricity production and consumption, energy management, online monitoring*

1. INTRODUCTION

Current measurement systems require human person that go to the location of the equipment to collect data, to verify and record any error of functioning. The data thus obtained cannot be analyzed in a due time but only at large intervals of time (days, weeks). The increase in the number of alternative systems of electricity production (especially based on solar and wind energy) as well as the increase in the number of holiday homes and tourist pensions far away from cities makes it almost impossible to monitor certain parameters by collecting them by human operators. It is necessary the use of remote monitoring and control systems. The use of radio systems for long distance data transmission is a complicated and costly solution. The development of wireless communication systems or GPRS makes it possible to easily implement online monitoring systems such as the one presented in this paper. The only condition is access to a WiFi network in almost all homes, including holiday homes or the existence of a signal from a mobile telephone network in case of monitoring of electricity produced by wind installations or photovoltaic panels.

2. THE PROPOSED SYSTEM

The proposed system will measure the main electrical parameters such as the effective values of voltage and current but also the phase difference between them. The measured values will be recorded on a microSD card at predetermined time intervals. To know the time point at which the data was read, a real time clock is used. If there is no accessible WiFi network, a GPRS communication module is used.

The control system will read the desired parameters, save them on the microSd frame, transfer the data via a WiFi or GPRS connection online on request. The system is able to manage the data on the microSD card by deleting old but transmitted data online or by issuing warnings if the card is full and the data has not yet been read.

The structure of the proposed system is shown in Figure 1.

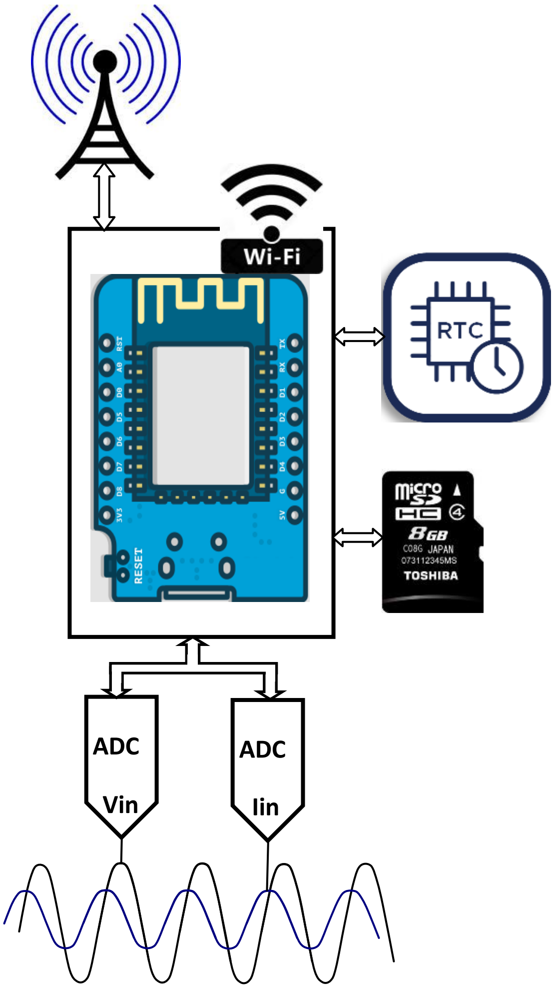


Fig.1 System structure

For easy implementation of the WiFi communication the control system was made with a WeMos D1 Mini module equipped with a WiFi system. This type of very compact module is shown in figure 2

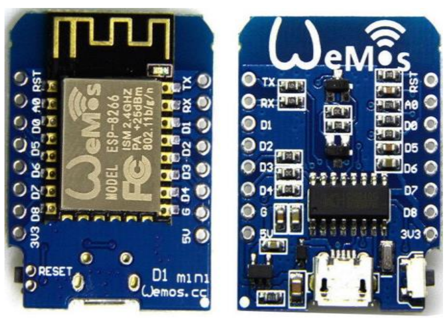


Fig.2 WeMos D1 Mini

The WeMos D1 Mini [1] is a miniature wireless 802.11 (WiFi) microcontroller development board. It turns the very popular ESP8266 wireless microcontroller module into a fully fledged development board. Programming the D1 mini pro is as simple as programming any other Arduino based microcontroller as the module includes a built in microUSB interface allowing the module to be programmed directly from the Arduino IDE (requires the ESP8266 support to be added via board manager) with no additional hardware.

The D1 mini Pro is also designed to allow Wemos compatible shields to be plugged into the board in a similar way to the Arduino development board platform which greatly expands its capabilities. There is already a large range of compatible shields available and can also be purchased via our website. Included with the module is a set of headers (requires soldering) that allow thses shield to be easily added or removed from the D1 mini PRO.

Other features of the D1 Mini Pro include 11 digital input/output pins, 1 analogue input pin (3.2V Max), 16MB (128M bit) Flash, an external antenna connector, built in ceramic antenna and houses the new CP2104 US to UART IC.

The possibility to program WEMOS modules and the same software as the Arduino modules has led to their use in a large number of applications but also to the emergence of compact and easy-to-connect extension modules. For the wemos d1 module there is an shield module equipped with a socket for a microSd type memory card as well as a real time clock with battery in case the power supply is disconnected. Such a module is shown in figure 3.

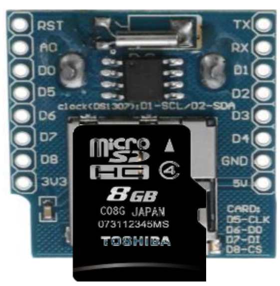


Fig.3 Card and RTC shield

SD card module

The card used to store data is a 8G micro SD. This Micro SD Card [2] is used for transfering data to and from a standard sd card. The pin out is directly compatible with Arduino and also can be used with other microcontrollers. It allow us to add mass storage and data logging to our project. The SD card module we have used is for the micro SD cards and it uses the FET's for level shifting and also a 3.3V regulator which converts the 5V from Arduino into the 3.3V for micro SD card. This uses the standard SPI interface for communication, which involve SPI buses, MISO, MOSI, SCK, and a CS signal pin. through programming, the data can easily be read and wrote into SD Card by using the Arduino microcontrollers. It is recommended to format the memory card before usage.

Real Time Clock

In order to be able to record the time at which the data was retrieved, a Real Time Clock (RTC) module was used. This is done with the DS1307 integrated circuit. The DS1307 serial real-time clock (RTC) [3] is a low-power, full binary-coded decimal (BCD) clock/calendar plus 56 bytes of NV SRAM. Address and data are transferred serially through an I2C, bidirectional bus. The clock/calendar provides seconds, minutes, hours, day, date, month, and year information. The end of the month date is automatically adjusted for months with fewer than 31 days, including corrections for leap year. The clock operates in either the 24-hour or 12-hour format with AM/PM indicator. The DS1307 operates as a slave device on the I2C bus. Access is obtained by implementing a START condition and providing a device identification code followed by a register address. Subsequent registers can be accessed sequentially until a STOP condition is executed. The DS1307 has a built-in power-sense circuit that detects power failures and automatically switches to the backup supply. Timekeeping operation continues while the part operates from the backup supply. When VCC falls below VBAT, the device switches into a low-current battery-backup mode. Upon power-up, the device switches from battery to VCC when VCC is greater than VBAT +0.2V and recognizes inputs when VCC is greater than 1.25 x VBAT.

GPRS module

For transmitting and receiving data when a Wi-Fi network is not available, the GPRS mode shown in figure 4 can be used.

Fig.4 GPRS Module

SIM900A Modem [4] is built with Dual Band GSM/GPRS based SIM900A modem from SIMCOM. It works on frequencies 900/ 1800 MHz. SIM900A can search these two bands automatically. The frequency bands can also be set by AT Commands. The baud rate is configurable from 1200-115200 through AT command. The GSM/GPRS Modem is having internal TCP/IP stack to enable you to connect with internet via GPRS. SIM900A is an ultra compact and reliable wireless module. This is a complete GSM/GPRS module in a SMT type and designed with a very powerful single-chip processor integrating AMR926EJ-S core, allowing you to benefit from small dimensions and cost-effective solutions.

It connects to the simple central module through the serial communication Rx and TX pins

ADC module

The WeMos D1 Mini module has only one input for reading analog signals. In order to be able to monitor the electrical parameters without using a multiplexing circuit of the only existing analog input A0, the solution of using additional analog analog converters of type MCP3021 was chosen. The structure of such a converter is shown in figure 5.

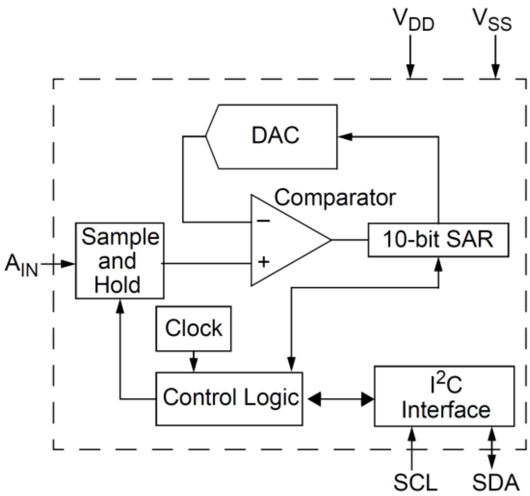


Fig.5 MCP3021 A/D Converter

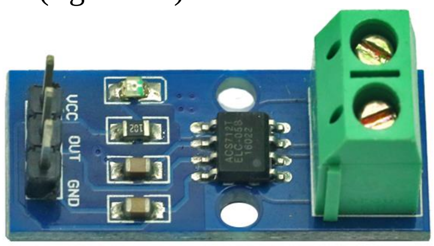
The converter has a communication of type I2c and there are 8 variants with different addresses so that on the same 2 wires (SDA and SCL) can be connected both the real time clock and up to 8 convertors of type MCP3021.

Microchip's MCP3021 is a successive approximation A/D converter (ADC) with a 10-bit resolution [5]. Available in the SOT-23 package, this device provides one single-ended input with very low-power consumption. Low-current consumption, combined with the small SOT-23 package, make this device ideal for battery-powered and remote data acquisition applications. Communication to the MCP3021 is performed using a 2-wire I2C compatible interface. Standard (100 kHz) and Fast (400 kHz) I2C modes are available with the device. An on-chip conversion clock enables independent timing for the I2C and conversion clocks. The device is also addressable, allowing up to eight devices on a single 2-wire bus.

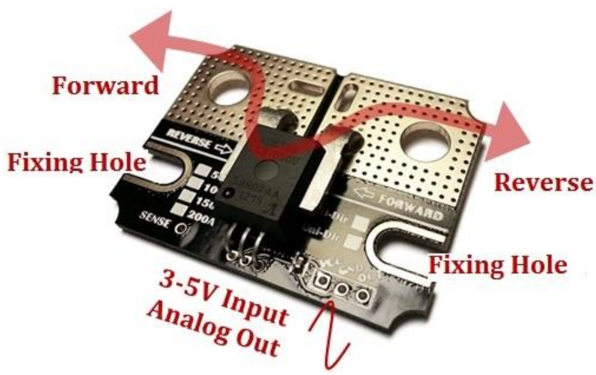
Measurement of voltage, current and phase shift.

For voltage measurement a voltage transformer was used to reduce the voltage from the value of the mains supply (240V) to a value of 2V.

The current measurement is implemented with a hall effect current sensor ACS 712 with a maximum current of 30A (figure 6 a). There are Hall effect sensors and much larger currents. (figure 6 b).



a) 30A-ACS712 current sensor



b) 200A-ACS758 current sensor

Fig. 6 Current module

Both modules have a simple way of connecting, to connect to the control system it is necessary to connect only 3 pins (+ 5V, Gnd, Vout). What is different is the physical size of the module and the measurement range.

Typical applications for ACS712 [6] include motor control, load detection and management, switch-mode power supplies, and overcurrent fault protection. The device consists of a precise, low-offset, linear Hall circuit with a copper conduction path located near the surface of the die. Applied current flowing through this copper conduction path generates a magnetic field which the Hall IC converts into a proportional voltage. Device accuracy is optimized through the close proximity of the magnetic signal to the Hall transducer. A precise, proportional voltage is provided by the low-offset, chopper-stabilized BiCMOS Hall IC, which is programmed for accuracy after packaging. The internal resistance of this conductive path is 1.2 mΩ typical, providing low power loss. The terminals of the conductive path are electrically isolated from the signal leads. This allows the ACS712 to be used in applications requiring electrical isolation without the use of opto-isolators or other costly isolation techniques. Typical application for ACS712 is presented in fig. 7 .

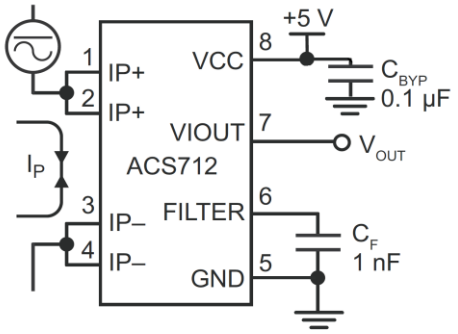


Fig.7. Typical application for ACS712

For a unipolar supply voltage, when the primary current is zero, the output of the sensor it nominally remains at $V_{CC}/2$. Thus, V_{CC} = 5 V translates into V_{Iout} = 2.5 V. To convert to amperes, divide output voltage to the device sensitivity. Output Voltage versus Sensed Current is presented in figure 8.

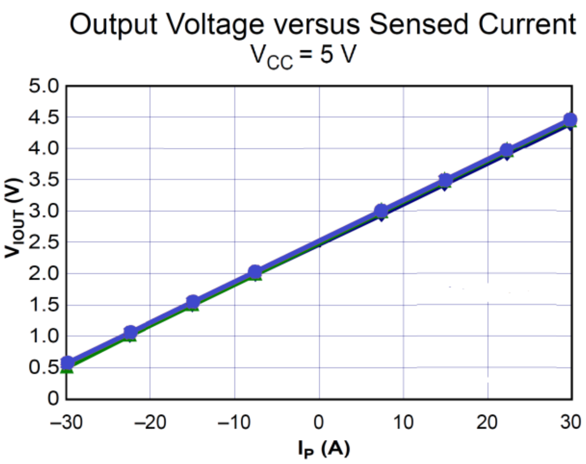


Fig.8. Output Voltage versus Sensed Current for ACS712-30A

Because at the output of the voltage transformer there is an alternate bipolar signal, while the described system uses only unipolar supply voltage, a voltage translation circuit will be used. Thus for V_{Vout} = 0 at the output mode V_{Vout} = $V_{CC}/2$ will result. The circuit is a simple one and is shown in figure 9 where the signals from the output of the transformer and the one from the module output are observed.

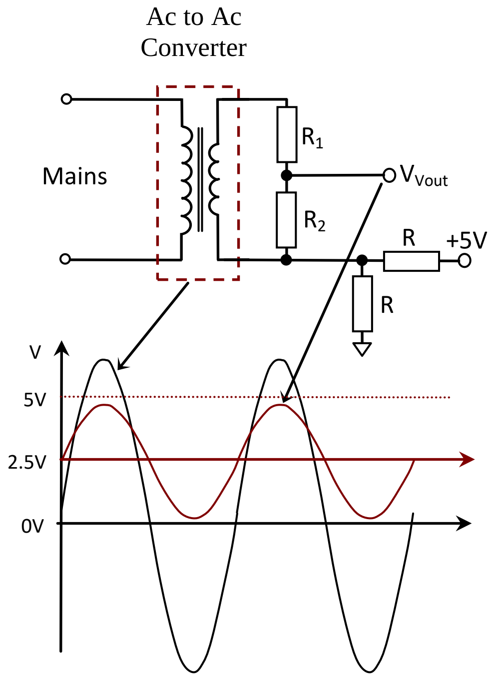


Fig.9. Circuit and signals for V_{Vout}

To determine the values for voltage, current and phase, the following procedures are used: it calculates the actual value of voltage and current for a period of the signals as well as the time difference between the change from positive to negative values for the voltage and current signals. Calculate the phase shift and record the data on the microSD card. Each recording will contain the time at which it was made, the effective value of the voltage, the effective value of the current as well as the phase difference between current and voltage. For each day at 00:00 a new file with the name year_ month_Day.txt will be generated. This will create a local database that will be easy to manage and transmit online, with smaller data files.

3. CONCLUSIONS

The measurement of the parameters of a single-phase electric circuit has very important implications both in the energy domain and in the environment. Modern systems with multiple functions of energy management, who are not just monitoring, play a defining role in order to reduce greenhouse gas emissions, as well as the cost of producing and delivering electricity.

With the help of the implemented device, can be implement both real-time visualization of the values achieved through a graph displayed through a browser, as well as their storage via a microSD card for further data analysis.

In conclusion, it can be stated that in the current context, of continuous development of the devices and technical means used, of the increasingly use of the concept of IoT (Internet of Things), this work constitutes a topical theme, being a starting point in order to achieve more efficient devices, with diversified functions, systems that can eventually analyze the newly emerged situations and make easy decisions in order to solve them.

4. REFERENCES

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