International Journal of Current Engineering and Technology
E-ISSN 2277 – 4106, P-ISSN 2347 – 5161

Available at http://inpressco.com/category/ijcet

Research Article

Delineation and Advancement of Electric Power Measuring System using PIC Microcontroller and Processing

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Accepted 31 May 2015, Available online 02 June 2015, **Vol.5, No.3 (June 2015)**

Abstract

In this study, analysis has been conducted to make an efficient measuring device that precisely calibrates the electrical power which is further interfaced with a computer via microcontroller ATmega328P-PU and a Processing program. This focused study majorly explains conditioning of analog signals, conversion of analog to digital signal (ADC) and digital data processing. The microcontroller delivers high resolution and better sampling rate capabilities. It is capable of measuring the energy used by the DC Voltage power source device of 20 Volt, and has power of 2 to 400 W.

Keywords: *ATmega328P-PU, Measurement, ATmega328P-PU, Processing, hardware, ADC*

1. Introduction

Power meter devised in this inquisition is an instrument capable of clearly measuring parameters like voltage, current, power, and energy consumption of the electrical device. It is noticed that even the modern Power meters still use the perplexing analog system. Therefore, there is a pressing need to duly conduct further research on power meters that use elementary circuit.

Basing the implications on the conducted belletristic analysis, experiments are carried out to devise digital power meter with stipulation similar to input circuit (voltage sensor, current sensor), processing circuit (ATmega328P-PU Microcontroller), output circuit (text LCD 16x2), coupled with a DC power supply (Malmstadt,1981). Here, a power meter with a simple and yet an efficient sensing circuit is devised. Input circuit primarily consists only of voltage and current sensors, the processing circuit uses ATmega328P-PU (Atmel.Retrieved, 2014) which has been unified with a power supply (Malmstadt, 1981). The output is displayed on to a computer monitor. Here the microcontroller consumes power through the USB port which also feeds the power meter circuit. Measuring the obtained simulations of voltage, current, power consumption, and also energy used is done by processing software (allegromicro.com). These results are noted in the graphical form. Therefore, the devised power meter using the ATmega328P-PU Microcontroller and the Processing program displays an effective and efficient usage of materials.

2. Basic Theory

- *Microcontroller*

The microcontroller primarily consists of all the required components that in turn help in its standalone operation. It has been particularly placed to aid in monitoring and/or controlling of tasks. As a result, in addition to the processor it also includes memory and various other interface controllers, an additional timer, an interrupt controller, and lastly a general purpose I/O pins that aid in direct interface to its environment. Microcontroller gives one the possibility of bit operations to make changes to one bit within a byte without interfering in the operation of other neighbouring bits-microcontrollers. This mainly makes it economical to digitally control more number of devices and processes. Mixed signal type of microcontrollers are quite common; the integrating analog components are to be controlled by non-digital electronic systems.

The microcontroller that has been used in this analysis is a Peripheral Interface Controller whose power supply produces a stable output voltage of 5 V. This power supply is further utilized to shift the sensor output voltage to a value so that the output can be clearly read by ATmega328P-PU. The picture illustrates the ATmega328P-PU that is being used (Diunduh, 2013, Atmel.Retrieved, 2014)

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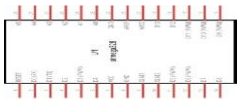

Fig.1 a Pin configuration of ATmega328P-PU

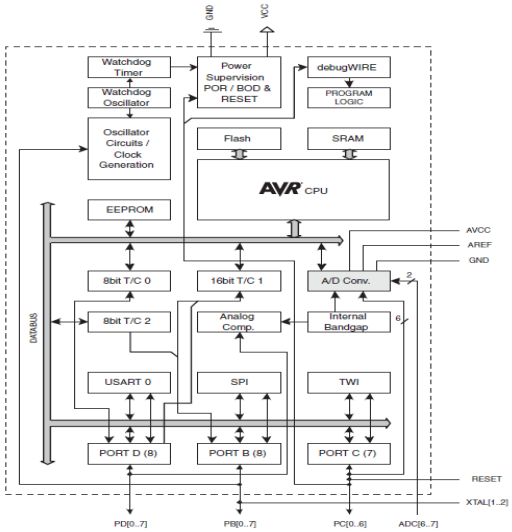

Fig.2 b Block Diagram ATmega328P-PU

- *Potential divider*

Power meters are built on the fundamental principles of potential divider in case of voltage sensor and Ohm's law in case of current sensor (wikipedia). Ohm's law helps in the conversion of the current to a value that is proportional to its voltage value. The signals acquired in the measurement of both the systems are formatted, to be read by the ATmega328P-PU. Digitization of analog signals obtained is carried out by the ATmega328P-PU. Then, the converted digital signal is further processed by the computer to receive the desired information, which is a graph of voltage, current, and power consumed.

A linear Potential divider circuit basically divides the input voltage into its corresponding output voltage alongside a specific ratio. The connection of two impedances in a circuit results in a potential divider circuit. The impedances used could be a combination of resistors, inductors, and capacitors. In this study, potential divider is formed by combining resistor (J.L.Kirtley, 2007).

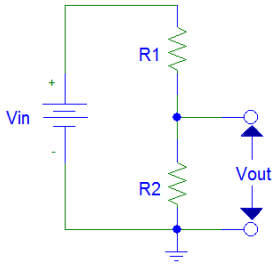

Fig.2 Potential divider

$$V_{out} = \frac{R_2}{R_1 + R_2} * V_{in} \quad (1)$$

- *Processing(programming language)*

Processing being an open source programming language and Integrated Development Environment (IDE) is being widely used to cater to the various electronic arts, new media art, and visual design groups with the intent being, to teach the basics of computer programming in a visual format, and also to importantly serve it as the underlying layer for electronic sketchbooks. The project had been proposed in 2001 at the MIT Media Lab. Processing tool majorly focuses on getting more non-programmers to get started with programming, playing up with the visual gratification as we continue to work with visual feedback and display. The language is built on Java, though it uses an extremely simple syntax and graphic programming model (Faludi, 2011). Voltage and current parameters are precisely measured using the formula of voltage and current resolution.

- *Current sensor (ACS712)*

The output obtained from ACS712 (ti.tuwien.ac.at) is an analog signal, V_{out} linearly diverges the uni- or bi-directional AC or DC primary sampled current, I_p, very much within the specified range of output. C_f is utilised for efficient noise management, the values correlate with its very application. In low-frequency sensing applications, it is wise to include an elementary RC filter to the obtained output of the device. As a low pass filter is noted to have significantly improve the signal-to-noise ratio, which also implies resolution, of the device output signal. However, the inclusion of an additional RC filter connected to the output of a sensor ACS712, results in undesirable attenuation at the device output even for the DC signals.

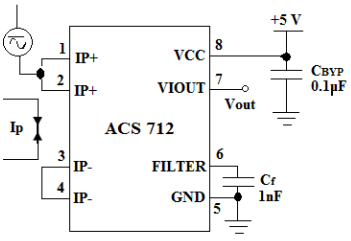

Fig.3 Current sensor circuit

- *Calibration*

The calibration is calculated using the formula stated below, the resolution ADC of the microcontroller (n) is used primarily to calculate the accuracy in current and voltage measurements. The formula is stated below for calculating the current and voltage.

$$f_{resolution} = \frac{2 \cdot f_{max}}{2^n - 1} \quad (2)$$

RMS value of voltage and current is calculated by Processing using a mathematical method.

The power resolution value is determined by the product of the voltage and current resolution, while the product of power resolution and the duration of ADC results in energy resolution. Power is a measure of how fast the energy is capable of being transferred, used, or transformed. Power that is being used to perform the real energy is known as real power of persuasive power.

3. Experiment

This inquisition was carried out in three stages, namely

a) Signal conditioning,
b) Conversion of analog to digital signals,
c) Digital data processing.

- Signal conditioning was carried out by circuits as shown in Figure 3 and Figure 4.
- The Power meter with two sensors, that is voltage and current sensors are primarily used in the conversion of analog to digital signals.
- The digital data is processed by resistors that have been connected to the power supply through the microcontroller to obtain the final output signal that has a value from 0 to 5V. Voltage value of 0V indicates zero value of current and voltage sensors, while 5V and 0V indicates the maximum and minimum values of the related sensors. These values are utilised from the second step in order to process the digital data by the microcontroller.

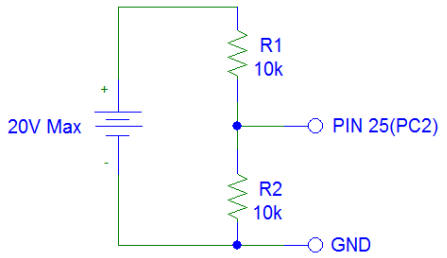

Fig.4 Voltage divider circuit

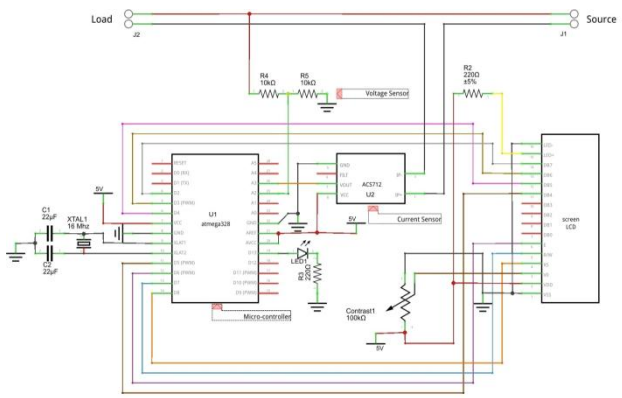

Fig. 5 Power meter circuit

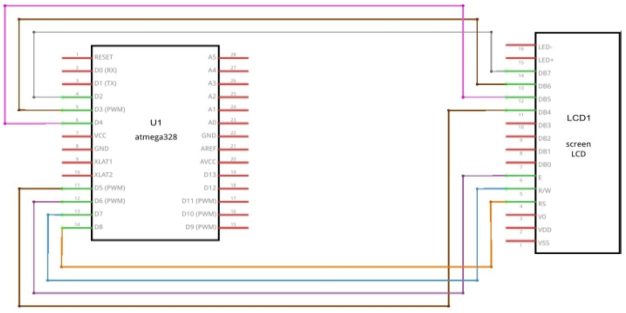

Fig.6 Load display circuit

4. Result

As noted in this inquisition, experimental analysis has been carried out further to measure of parameters such as the power and energy consumed by an LED. The results of the measured parameters are represented in a graphical format.

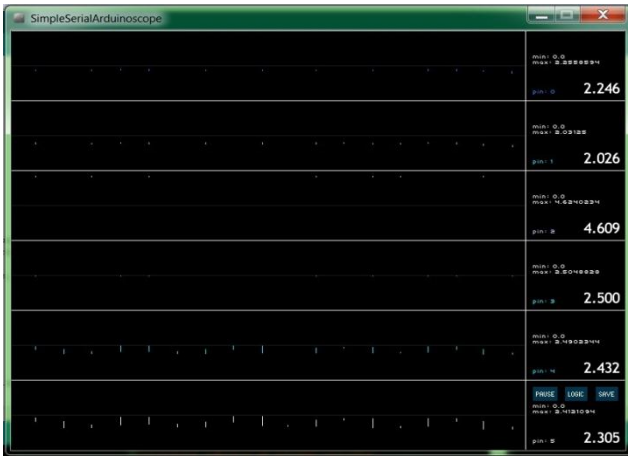

Fig.7 LED measurement data on Processing

Fig. 8 LED current measurement graph on Processing

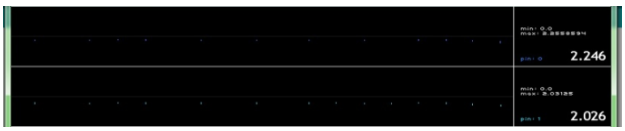

Fig. 9 LED energy cumulative measurement graph on Processing

It is observed that the power meter does not yield out the expected and satisfactory results for electronic devices that consume extremely low power. This is one of the limitations of voltage measurement precision and current measurement precision. The minimum power that can be accurately measured is 6.5mW DC. Maximum power that can be noted is limited by the maximum measurable voltage and current, since it is the result of the limitation of scaling arrangements of

the resistors and the microcontroller used. Therefore, the power meter can be used to measure electronic power of up to 400 W DC.

In this particular study, the current and voltage signals are processed by a microcontroller. Signal transmission regulation is being controlled by the Processing program through the ATmega328P-PU digital pin out. Signal transmission is accomplished by the alternate turns between the voltage and current signal.

For every turn of transmitting the signal, about 150 samples are taken (en.wikipedia.org). These transmissions in arrangement will produce a fake difference. To overcome this problem, a delay time insertion is carried out between the current signal transmission and the voltage signal transmission. Delay time is set up to a value so that the delta difference in the time between the current signal transmission and the voltage signal transmission takes multiple period of time of the voltage and current signals. In addition, the delay time efficiently monitors the signals acquired from voltage and current measurements which project that they are being performed simultaneously. However, this delay time inserted by arrangements has its own limitation and that being the signal condition variation is fast. If the condition of the measured signal changes when the delay time is currently occurring or when one cycle signals transmission is not yet completed, the voltage signal that has been detected will not successfully describe the similar voltage signal when the current signal sampling is still progressing. However, this can be overlooked as an error as it only occurs once in 270 milliseconds cycle transmission. To get necessary results, the condition of measured signal is expected to be stable enough until the sampling of voltage and current signal is being done.

This power meter is used to perform a test of measuring LED. The results of the measured parameters can be observed in Fig 7, 8, 9. The results are further compared to measurement results of other proven power meter and satisfactory results are observed.

Conclusions

This elementary power meter is quite capable of measuring the cumulative energy, voltage and current which are noted in the form of graphs. The power meter can persuasively measure the power consumption of electronic devices with specific stipulations.

Recommendations

For further improvement, the following technical considerations are recommended:

- Advancement can be done to log the data's obtained by the power meter into a data logger.
- The data stored in the data logger can be retrieved from a remote station using Ethernet.

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