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Research Article

Design of Electrical Power Meter for Alternating Current 1 Phase Source

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Abstract
Electricity utilization plays a significant role in shaping the power distribution system. Single-phase electricity is a common form of alternating current (AC) supply that is predominantly found in various applications within households and small industries. This type of power is essential for operating household appliances like refrigerators, washing machines, and air conditioners, as well as powering small businesses and workshops. Electrical load power measurements are carried out using a wattmeter or powermeter. This tool can help control lighting systems remotely and monitor household energy. Designed for measurement of electrical power consumed by electrical loads. Using voltage, current, phase sensors and an ATMega328 microcontroller to process data. The LCD screen will display data on electrical power consumption based on measurements of current and voltage. This innovative prototype is designed to offer users insights into their electricity usage habits, ultimately encouraging more efficient energy usage. The goal is to empower individuals to make informed decisions about their energy consumption and contribute to a sustainable future.

Keywords: Electric Power, Single-phase, Measurement

1. Introduction

Measurements are made to determine the value of the quantity to be measured. The goal is to get correct data and can be applied to various sciences. According to Stevens (1971), measurement is an activity to determine a value for the observed object. Electronic measurements can support technological advances, as well as a solution to remote measurements (Balestrieri et al., 2021; Hernandez-Jayo & Garcia-Zubia, 2016). However, development needs to be done to design tools to expand the existing library (Hernandez-Jayo & Garcia-Zubia, 2016; Iksal et al., 2018).

The increase in electrical load power is due to the increase in population, the increase in the number of electrical appliances, and the increase in the use of large power electrical appliances (Adityawarman et al., 2014). Thus, a measuring instrument is needed to measure electrical load power in order to reduce negative impacts (Butti, 2013). Among them are increased electricity costs, decreased voltage quality, damage to electrical equipment, and damage to the electricity network (Syahputra et al., 2020). With this tool, it is expected to be able to measure electrical power with more accurate accuracy than existing measuring equipment.

Development of an electrical power measurement system for single-phase alternating current sources becomes essential in responding quickly to growing energy monitoring demand. This research aims to devise a tool utilizing voltage and phase sensors alongside a microcontroller for real-time monitoring of electrical power usage accurately. Innovation here will not only boost precision of energy usage data somehow but also promote fairly efficient electricity utilization among various users. This paper quite thoroughly presents design process and evaluation of proposed system alongside its careful implementation apparently with meticulous attention.

2. Methods

Methods in designing this tool, including designing hardware and software. In the design of the electric load power measuring instrument in this home environment which is expected to help measure the power of the electric load to help the lights that are on with the control process automatically.accommodating the results of electric load power (Wibowo et al., 2023). Perform data reading. Able to calculate the electrical load power properly. The hardware design starts with making a circuit block diagram that describes the components and data flow. Next, circuit design is carried out for each component according to its function (Feucht, 1990).

2.1. Hardware Design

Presents the functional units needed to realise the design. The following diagram is shown:

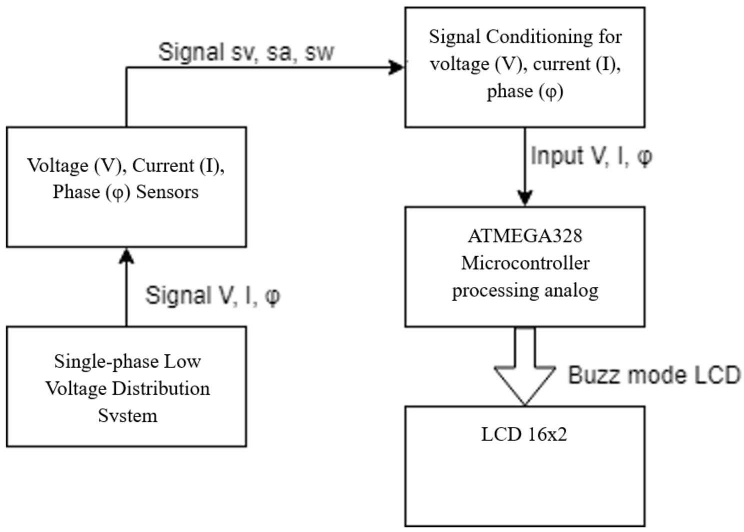

Figure 1. Hardware Block Diagram

The design of the voltage sensor aims to sense the 220 V grid voltage. PLN Electric voltage of 2000 with a tolerance of 10% of the nominal phase-neutral voltage.

Minimum phase-neutral voltage, V_{Lmin} = 220 - 10%.220 = 198 V
Maximum phase-neutral voltage, V_{Lmax} = 220 + 10%.220 = 242 V

This current sensor design, the load current that measures comes from household loads. Assuming the maximum power of the resistive load is 350 W, the maximum current flowing is:
I_{Lmax} = 350/220 = 1.59 A

The maximum voltage produced by the CT, V_{Imax}, is
V_{Imax} = 0.333 . 1,59 = 0,053 V

In peak value, $VI_{maxpeak} = V_{Imax} . \sqrt{2}$ = 0.07495 V

This peak value is used to determine the gain of the V_I conditioning circuit.

Phase sensor design To determine the phase of voltage and current, a phase sensor is required. The sine voltage produced by the voltage sensor, V_v, and the current sensor, VI, is converted into a square wave to define the zero cross. Both are compared digitally by an EXOR gate to define the phase. The resulting pulse width will indicate the phase of the voltage and current.

2.2. Software Design

Presenting reasoning or algorithms, here is the diagram shown:

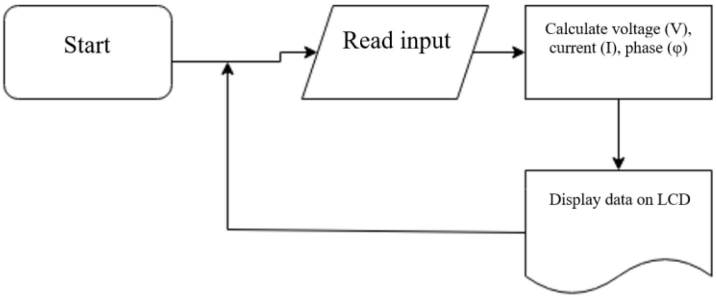

Figure 2. Software System Block Diagram

In the software design using the Arduino IDE as a programme to display power, namely:

In the overall test, what is displayed is the voltage and current values from the programme as follows:

```
#include <LiquidCrystal.h>

// Pins for current sensor
const int pinArus = A4;

// Pins for voltage sensor

const int pinTegangan = A5;

// Pin for LCD
const int pinLCD_RS = A2;
const int pinLCD_EN = A0;
const int pinLCD_D4 = 12;
const int pinLCD_D5 = 11;
const int pinLCD_D6 = 10;
const int pinLCD_D7 = 9;

LiquidCrystal lcd(pinLCD_RS, pinLCD_EN, pinLCD_D4, pinLCD_D5, pinLCD_D6, pinLCD_D7);

// Pin untuk LCD
float Vin;
float VS;
float IL;
const int Vref;
const int R2;
const int R3;
```

```
const int RL;
const int RS;
int DataADC;
void setup() {
  // put your setup code here, to run once:
  //Inisialisasi LCD
  Serial.begin (9600);
  lcd.begin(16, 2);
}

void loop() {
  // put your main code here, to run repeatedly:
  //lcd.setCursor(12, 0);
  //lcd.print(millis() / 1000);
  analogReference (DEFAULT);
  //lcd.print(0.00489*analogRead(A5)/1);
  //lcd.print = (analogRead(A5));
  DataADC = analogRead(A5);
  //Vin = (float)DataADC*(float)5/1023;
  VS = (float)DataADC*0.09775;
  IL = (float)DataADC*4.88;
  //lcd.print ("DataADC");
 // lcd.print ("Vin") ;
 delay(1000);

  lcd.setCursor (0,0);
  lcd.print("VS = ");
  lcd.print(VS);
  lcd.setCursor (0,1);
  lcd.print("IL = ");
  lcd.print(IL);
  //Serial.print ("VS = ");
  //Serial.println (VS);
  //Serial.print ("IL= ");
  //Serial.println (IL);
}
```

3. Results and Discussion

The following are the results and discussion of several simulation tests that have been carried out from several circuits:

3.1. Voltage circuit

The voltage sensor used is a voltage transformer. The test aims to determine the comparison of the primary voltage and secondary voltage of the voltage transformer. It is expected that the voltage transformer can provide a secondary voltage of 3.53 V when the primary voltage is maximum (240 V).

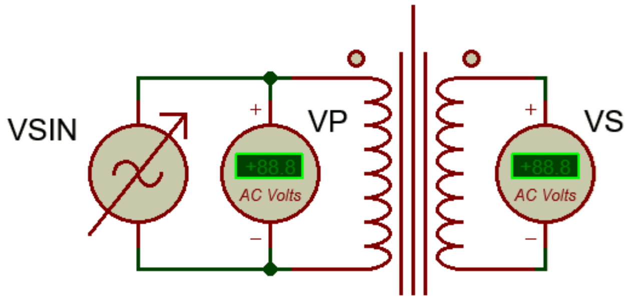

Figure 3. Voltage Sensor Experiment

From the above circuit, the simulation test results are obtained in the following table:

Table 1. Measurement of Voltage Sensor using YX-329TR multimter

No	Primary Voltage	Secondary Voltage
1.	160 V	2,2 V
2.	190 V	2,6 V
3.	220 V	2,9 V
4.	230 V	3,1 V
5.	240 V	3,2 V

Source: Author's

3.2. Current Circuit

Current sensor testing aims to determine the comparison of the primary voltage and secondary voltage of the current transformer (Wahyu Suryawan et al., 2012). Testing is done by giving variations in current and measuring the voltage output. Measurements are made by utilising an AC ampermeter and AC voltmeter.

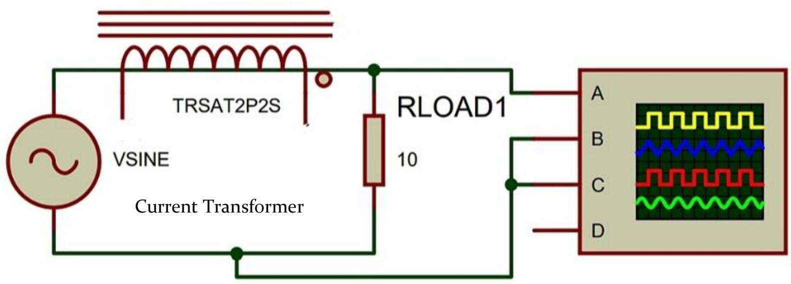

Figure 4. Current Sensor Test Results

From the above circuit, the simulation test results are obtained in the following table:

Table 2. Current Sensor Measurement Table using resistive load

No	Input		Output
	Voltage	Current	
1.	33 V	0,5 A	75,8 mV
2.	132 V	2 A	147 mV
3.	165 V	2,5 A	168 mV
4.	198 V	3 A	187 mV

Source: Author's

3.3. Phase Circuit

The phase sensor test aims to determine the relationship of pulse width, tPW, and phase between two input signals, VV and VI. The input signal source uses a sine signal generator connected to a series RC circuit as a phase shifter. The amplitude of the generator is set as high as 5 Vpp and the frequency is 50 Hz.

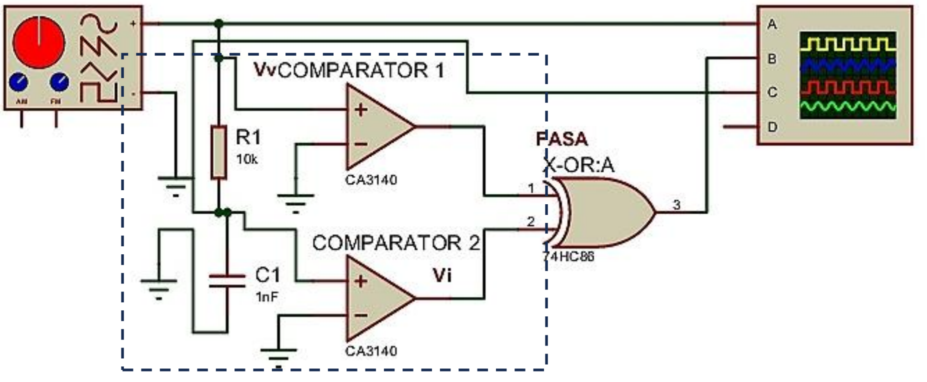

Figure 5. Phase Sensor Test Results

From the above circuit, the simulation test results are obtained in the following table:

Table 3. Phase measurement

No.	Resistor	Capasitor	Phase Difference	Pulse Width tw
1.	10 kΩ	100 nf	17,2 °	993 µS
2.	22 kΩ // 27 kΩ	100 nf	21,06 °	1,17 mS
3.	22 kΩ	100 nf	33,48 °	1,95 mS
4.	27 kΩ	100 nf	39,06 °	2,31 mS
5.	32 kΩ	100 nf	44,1 °	2,53 Ms
6.	37 kΩ	100 nf	46,44 °	2,74 Ms

Source: Author's

4. Conclusion

The electrical power measurement system designed in accordance with the planned needs produces several important conclusions. The voltage, current, and phase measurements taken will display the power measurement results, the data obtained will be stored on the microcontroller and displayed in the form of numbers on the LCD. In addition, the greater the load given, the higher the error results obtained.

As a suggestion for further research, it is recommended to use stronger components to reduce the risk of fire, choose resistive loads to get more accurate measurement results, and use sturdier materials so that the tool is not easily burned or damaged.

5. References

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