International Journal of Engineering and Information Systems (IJEAIS)
ISSN: 2643-640X
Vol. 7 Issue 11, November - 2023, Pages: 32-39

Design of Smart Power Supply for Home Security System

Wahyudi, Nur Husnina Hanani, Munawar Agus Riyadi

Electrical Engineering Department
Universitas Diponegoro
Semarang, Indonesia
wahyuditinom@elektro.undip.ac.id

Abstract—*The National Electricity Company (PLN), which distributes electricity to the Indonesian people, is still their primary source of electricity. However, PLN's electricity can occasionally go out owing to short circuits or recurring maintenance or repairs. When PLN power is lost, home security systems that depend on it may not function properly, making it difficult for the system to detect theft or other threats when they happen. To enable the home security system to function even when the PLN source is off, this study proposes a standalone power supply system using a 12 V/45 Ah accumulator. The accumulator in this paper has a relay voltage breaker that is used to disconnect the charger voltage by using the voltage parameter. When the voltage on the accumulator falls below 11.4 V, the relay will connect to the charger, and when the voltage rises to 12.3 V, it will disconnect the accumulator voltage. The 220 V AC PLN current used by the system to charge the accumulator is lowered to 14.04 V DC, which is the standard voltage. The DC-DC converter module lowers the output voltage from the accumulator to 5.01 V and 9.06 V, which is then used as the primary voltage source for the microcontroller of the home security system.*

Keywords—power supply; accumulator; charge; discharge; microcontroller; ESP8266

1. INTRODUCTION

Lead acid batteries or as known as accumulator are commonly used for energy storage, emergency power back up, engine ignition, vehicle lighting, and generator. Economic analysis Stand-alone PV using lead-acid batteries is more suitable than stand-alone PV systems using lithium-ion batteries, because the initial investment cost of lead-acid batteries is cheaper than lithium-ion batteries [1].

DC-DC buck converters are used for battery chargers in many applications including renewable energy sources, inverters, electric vehicles, and robots. The DC-DC buck converter works well when used to charge an accumulator circuit with a capacity of 45Ah with a constant current charging strategy [2]. A direct current converter or DC-DC converter is a device that functions to convert the DC voltage into a smaller DC voltage or a larger DC voltage by adjusting the on-off (duty cycle) switching of the DC-DC converter circuit through the PWM control circuit. Usually, electronic switches in the form of MOSFET, IGBT, and GTO are widely used to carry out the connecting function of the circuit [3].

Buck converter is the most basic switch mode power supply (SMPS) topology that is widely used throughout the industry to convert a higher input voltage to a lower output voltage. This topology is generally used to distribute power in complex systems. This converter consists of an IC controlled active switch, a rectifier, and a filter element. This converter has a filter inductor on the output side, which provides a smooth continuous output current waveform to the load [4].

The voltage level on the accumulator is used as a charge and discharge system, generally a low-rate discharge system per cell on the battery starts from 2.05 V and ends at 1.90 V [5]. While the 12 V accumulator has six cells, the low discharge rate on the 12 V accumulator starts at 12.3 V and finishes at 11.4 V. The voltage parameter in this paper is used as a relay breaker parameter in the charger system, the relay will disconnect the charger. to the accumulator when the voltage read by the sensor is 12.3 volts and will connect the charger to the accumulator when the voltage read by the voltage sensor is 11.4 V. To determine the impact of the charging process on the battery, the behavior of the different internal parameters of the battery is simulated. During charging mode, the rated current should decrease when the battery charge state is almost fully charged [6].

Hall Effect Sensor based sensor ACS712 has been the most widely used current sensor since 2018. The main advantage of this sensor is its low cost. The ACS712 sensor measures with an error below 1.5% (at 25℃), minimizing the current measurement cost by 7-20 times. Other works use shunt resistors to measure current but to a lesser extent [7].

This paper also discusses the use of a standalone power supply using an accumulator to supply a home security system, this system uses a DC-DC buck converter in the form of a circuit to lower the DC voltage to a DC voltage value for the Arduino and Raspberry Pi power supplies. The external power supply that can be supplied to the Arduino board is a DC voltage between 9-12V [8]. While the external power supply on the Raspberry Pi is a Micro USB connection that produces at least 700mA at 5 volts [9].

2. Method

2.1 Hardware Design

The design of the power supply system in this paper aims to supply power to the home security system so that the home security system can still work when the PLN electricity is out. This system can also read the voltage and current from the power supply. The hardware block diagram designed in this paper is shown in Fig. 1.

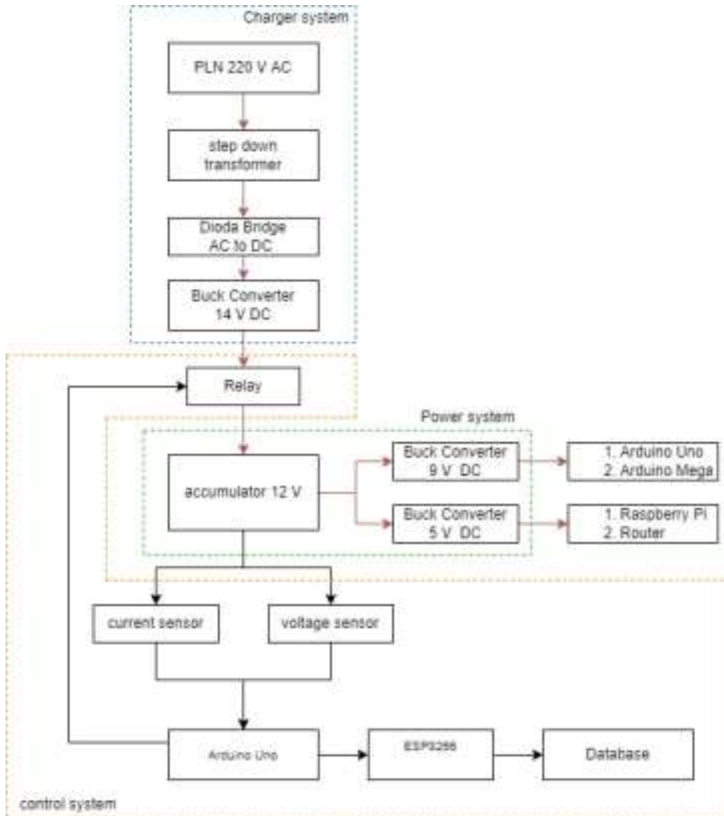


Fig. 1. *Hardware block diagram.*

Fig. 1 illustrates the design of a standalone power supply system in this paper consisting of three main blocks, namely the charging system, power system, and control system. The home security system consists of 2 Arduino microcontrollers, 1 Raspberry Pi, and 1 router. The amount of current needed for a home security system is for the microcontroller it needs 2 x 0.1 A, the Raspberry Pi needs 1 A, and the router needs 0.6 A, so the current requirement for the home security system is 1.8 A. If desired the power supply system can supply the home security system for 24 hours, a battery with a minimum capacity of 43.2 Ah is required, so a battery with a capacity of 45 Ah is selected.

2.2 Software Design

Arduino Ide v1.8.7 software is used to write and embed programs on Arduino Uno and ESP8266 microcontrollers. display of Arduino Ide v1.8.7 software. The software design on this system is used for the Arduino Uno voltage and current reading system which is used to control the accumulator charging so that there is no overcharge, then the data read by the Arduino Uno is sent to the database via the ESP8266 module. The battery charging algorithm is as follows.

1. Read the battery voltage
2. If the voltage is less than 11.4, relay on to charge the battery
3. If the voltage is more than 12.5, the relay is off
4. Go back to number 1

.

International Journal of Engineering and Information Systems (IJEAIS)
ISSN: 2643-640X
Vol. 7 Issue 11, November - 2023, Pages: 32-39

3. Result and Analysis

Results and analysis were done on the charger system, output voltage of power supply, voltage and current sensor output, relay network and software.

3.1 Testing of Charger System

Testing the accumulator charger circuit aims to determine the amount of current and voltage that goes into charging the accumulator, a good and normal charging system circuit on 12 V accumulator is in the range of 13.4 V - 14.8 V, in this paper a voltage of 14 V is used. This large voltage test is carried out by connecting a multimeter to the charger output without connecting to the accumulator as shown in Fig. 2.

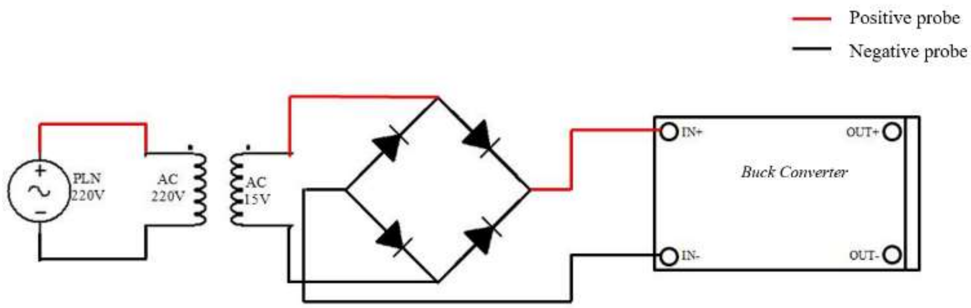


Fig. 2. *Charging system circuit.*

Based on the circuit in Fig. 2, it can be seen the results of testing using a digital multimeter as shown in Fig. 3.

Fig. 3. *The output voltage reading of the accumulator charger.*

Fig. 3 is the output of the test results of the accumulator charger circuit. It can be seen on the digital multimeter the visible output value is 14.04 V so that the voltage generated by the charger can charge the accumulator normally.

3.2 Testing of Power Supply Output Voltage

Testing the output voltage of the power supply serves to determine the output voltage of the accumulator that has been converted into the input voltage of the home security system. The output voltage of the power supply is 9V DC as the Arduino input voltage and 5V DC as the Raspberry Pi charging voltage. Testing the power supply output as the Raspberry Pi input voltage and the Arduino input voltage can be seen in Fig. 4. The output voltage of the power supply as the Raspberry Pi voltage is 5.01 V, the voltage is in accordance with the large voltage required by the Raspberry Pi, which is 5V DC and the result of measuring the output voltage of the power supply as an Arduino voltage of 9.06 V, the voltage is in accordance with the voltage required by the Arduino, which is 9V DC.

(a) the Raspberry Pi input voltage (b) the Arduino input voltage

Fig. 4. *The output voltage of the power supply*.

3.3 Testing of Voltage Sensor

Voltage sensor testing is done by connecting the voltage sensor with a voltage source, then the actual voltage value that passes through the sensor is compared with the voltage value read by the voltage sensor. The actual voltage value was measured using a ZOTEK ZT98 digital multimeter. This voltage sensor test aims to determine the level of accuracy of the readings. Fig. 5 is a series of voltage sensor testing.

Fig. 5. *Voltage sensor test circuit.*

The voltage sensor test was carried out in six variations with different voltage values, in determining the level of accuracy of the voltage sensor measurement against a ZOTEK ZT98 digital multi-meter, the mean absolute percentage error (MAPE) method was used [10]. The results of the voltage sensor test can be seen in Table 1.

Table 1. Voltage sensor test results.

Actual Voltage (V)	Voltage read by Microcontroller (V)	Absolute Error (V)	Percentage Absolute Error (%)
12.88	12.87	0.01	0.07
12.30	12.30	0	0
12.07	12.08	0.01	0.08
11.37	11.38	0.01	0.08
11.01	11.07	0.06	0.54
Mean Percentage Absolute Error			0.15

Based on Table 1, the Mean Percentage Absolute Error of the voltage sensor reading is 0.15%. The difference between the actual voltage value and the voltage read by the microcontroller is caused by the tolerance value of the resistor in the voltage divider circuit and the rounding of the constant value and the conversion value of analog to digital values at the time of calculation.

3.4 Testing of Current sensor

The current sensor used in this final project is the ACS712-05B current sensor which can measure both AC and DC currents up to 5 A. Current sensor testing is done by connecting the current sensor in series with the current source. The current source used is an accumulator which is connected to a household security system. The actual current value was measured using UNI-T UT210E digital ampere meter pliers. This current sensor test aims to determine the level of accuracy in its readings. Fig. 6 is a series of current sensor testing.

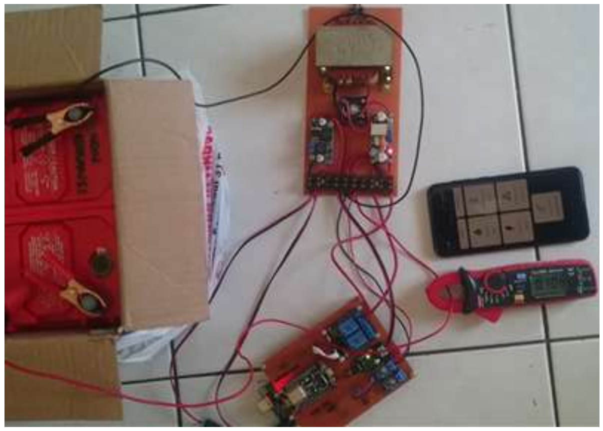


Fig. 6. *Current sensor test circuit.*

The voltage sensor test was carried out in six variations with different voltage values, in determining the level of accuracy of the voltage sensor measurement on digital ampere pliers. The results of the current sensor test can be seen in Table 2.

Table 2. Current sensor test result.

Actual Current (A)	Current read by Microcontroller (A)	Absolute Error	Percentage Absolute Error (%)
0.15	0.15	0	0
0.25	0.25	0	0
0.67	0.65	0.02	2.98
0.84	0.83	0.01	1.90
Mean Percentage Absolute Error			1.22

From Table 2, the Mean Percentage Absolute Error reading of the current sensor is 1.22%. The difference between the actual current value read by the ampere pliers and the current read by the microcontroller is due to the rounding of the constant value and the ACS712-05B current sensor reading is influenced by the magnetic field around the sensor.

3.5 Testing of Accumulator Relay Circuit

Testing The circuit connects the charger circuit to the accumulator and connects the accumulator to the load, this test is carried out to determine the condition of the relay when the voltage is greater than 12.5 V and when the voltage is less than 11.4 V. Fig. 7 is the result of relay testing, and the overall data relay testing can be seen in Table 3.

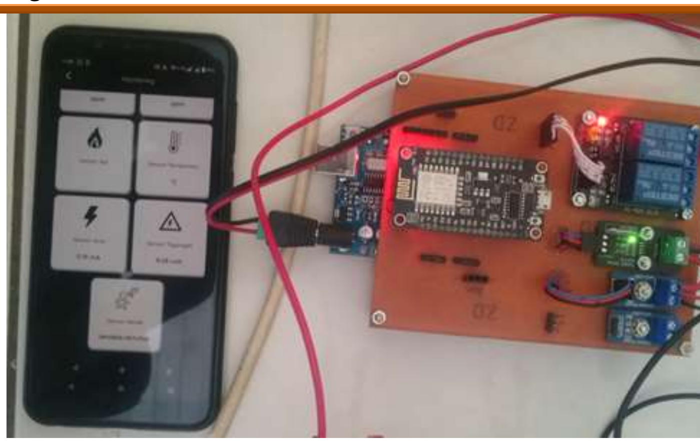


Fig.7. *Relay test results.*

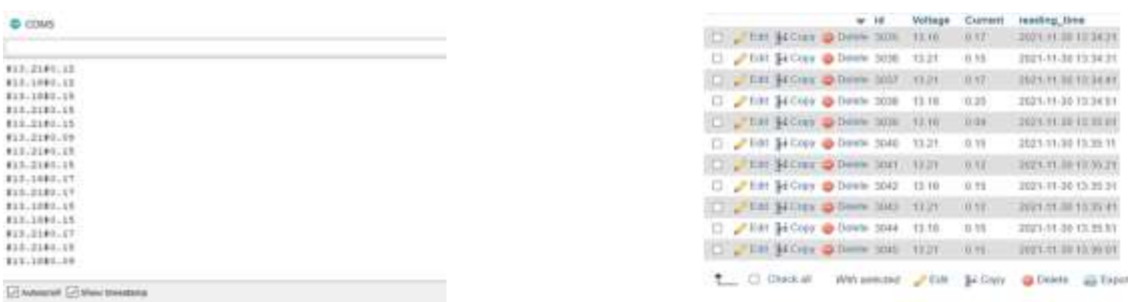
Table 3. Accumulator relay test.

Number of Data	Volage Sensor Reading (V)	*relay* Condition (On/Off)
1	12.52	Off
2	11.36	On

From the data in Table 3 above, it can be seen when the initial voltage read by the voltage sensor is 12.52 V, the relay condition is Off or the power supply is not connected to the accumulator or the accumulator is in discharging condition, and when the second condition is the voltage read by the sensor. The voltage is 11.36, the relay condition is On, or the power supply is connected to the accumulator, or the accumulator is in charging condition. In this system, the user does not need to monitor the voltage periodically and the relay automatically disconnects the charger circuit if it reaches the maximum limit of the accumulator voltage, in contrast to the accumulator charging system which is not equipped with a relay that must be monitored for voltage magnitude to disconnect and connect the accumulator to the charger circuit.

3.6 Testing of Software

Software testing in the form of testing the transmission of voltage and current sensor data sent via ESP8266 to the database. Measurements are made to see whether the data on the voltage and current sensor readings have been successfully entered into the database, the parameters of this test are that the data sent to the database changes the voltage and current table. Fig. 8 is the result of sending sensor data to the database.



(a) *Data sent from ESP8266 to database* (b) *Data sent to the database.*

Fig. 8. *The results of sending voltage and current data to the database.*

The data from the voltage and current sensor readings read by Arduino Uno in Fig. 8.a was successfully sent to the database via ESP8266. The data sent are in the form of a voltage column and a current column as shown in Fig. 8.b. Sending data from the voltage and current sensor readings allows users to monitor remotely, while the monitoring system for reading voltage and current data displayed on the 16x4 LCD cannot be monitored remotely [7].

4. Conclusion

In the accumulator charging system, the accumulator charger has succeeded in producing a DC voltage of 12.04 V and can charge the accumulator. The voltage released by the accumulator has been successfully converted into the voltage required by the system, which is 5.01V for the Raspberry Pi and 9.06V for the two Arduinos. In the output system, the power supply has succeeded in converting the 12V accumulator voltage into 5.01V and 9.06V. The ACS 712-05B Current Sensor has succeeded in reading the current read by the sensor with an average error of 1.22% of the current sensor reading. The voltage sensor managed to read the voltage that passed through the sensor with an average error of 0.15% of the voltage sensor reading. The relay has successfully worked using voltage parameters, the initial voltage read by the sensor is 12.52, the relay condition is off, and when the voltage condition read by the sensor is below 11.36, the relay condition is on.

5. Acknowledgment

This research was financially supported by The Faculty of Engineering, Diponegoro University, Indonesia through Strategic Research Grand 2021.

6. References

[1]. S. Anuphappharadorn, S. Sukchai, C. Sirisamphanwong, and N. Ketjoy, "Comparison the Economic Analysis of the Battery between Lithium-ion and Lead-acid in PV Stand-alone Application," Energy Procedia, vol. 56, no. C, pp. 352–358, 2014.

[2]. Nugroho. Asep, Rijanto. Estiko, Rozaqi. Latif, "Buck Converter Control for Lead Acid Battery Charger using Peak Current Mode" International Journal of Power Electronics and Drive System (IJPEDS), Vol. 8, No. 2, June 2017, pp. 686-694.

[3]. M. H. Rashid, Power Electronics Handbook: Devices, Circuits, and Applications, United State, 2007.

[4]. J. Ejury, Buck Converter Design, North America: Infineon Technologies North America (IFNA) Corp, 2013.

[5]. H. A. Keihne, Battery Technology Handbook, 2nd ed., Renningen-Malsheim: Expert Verlag, 2003.

[6]. V. Selmani, A. Ed-Dahhak, M. Outanoute, A. Lachhab, M. Guerbaoui, and B. Bouchikhi, "Performance Evaluation of Modelling and Simulation of Lead Acid Batteries for Photovoltaic Applications," Int. J. Power Electron. DriveSyst., vol. 7, no. 2, p. 472, Jun. 2016 argas.

[7]. Lopes, Fuentes. Manuel, Vivar. Marta, "Current challenges for the advanced mass scale monitoring of Solar Home Systems: A review," Science Direct, vol. 163, pp. 2098-2114, 2021.

[8]. Arduino Uno R3 datasheet [online]. Available: https://docs.arduino.cc/resources/datasheets/A000066-datasheet.pdf

[9]. Raspberry Pi. "Raspberry Pi 4 Model B" [Online]. available: https://datasheets.raspberrypi.com/rpi4/raspberry-pi-4-datasheet.pdf".

[10]. J. J. e. a. Montaño Moreno, "Using the R-MAPE index as a resistant measure of forecast accuracy," Psicothema, vol. 25, no. 4, pp. 500-506, 2003.

Authors

Wahyudi

Lecturer in Department of Electrical Engineering, UNDIP
Interest research in control and instrumentation.

Nur Husnina Hanani

Assistant of lecturer in Department of Electrical Engineering, UNDIP
Interest research in control and instrumentation.

Munawar Agus Riyadi.

Lecturer in Department of Electrical Engineering, UNDIP
Interest research in electronic circuits and telecommunication.