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BATTERY SUPERCHARGING SYSTEM IN ELECTRICAL VEHICLES USING PHOTOVOLTAIC PANELS

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A b s t r a c t

In this project, a system was designed there was designed a system for charging batteries in electric vehicles using photovoltaic panels. Low cost of operation, cheap reliable construction and simple user interface were among the main criterias taken into account.

Each energy source was carefully selected and, modules were used so that they could in the way to power the microcontroller and charge the energy storage source.

This article is a part of a project related to the design of digital control devices with electric drives carried out at the UWM.

Introduction

The solution was patented (SYROKA, JAKOCIUK 2020).

The core of this publication is to show elementary ideas of battery charging module with usage of PV panels in electric vehicles, patented by author. This kind of drive will become a primary type in nearest future.

Main goal in this work was to show block and idea scheme of module and to present its steering code. Symbols on electrical schemes were result of type of used design tools.

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The control system solutions developed at UWM have been published in the book (SYROKA 2019).

Presented bibliography is according to author, the core set of position treating about electric vehicles steering.

Block scheme specification of battery charging

The photovoltaic supercharging system is simple, easy to use and cheap cost effective. It is also very efficient. Figure 1 shows a block diagram of the system for supercharging batteries in electric vehicles using photovoltaic panels. The system is switched on or off with buttons in manual mode. The system can be only switched on and off manually. When vehicle is switched off, the system draws power from external battery and, thanks to the photovoltaic panels, it can operate when the vehicle is not moving. The device can be reset by pressing the button which returns the microcontroller to its factory stock condition. The system uses an ATMEGA 328 PU microcontroller.

There are five modules in the system responsible for correct energy storage and control:

– control module *2*;
– voltage measurement module (photovoltaic panels) *3*;
– energy storage module (photovoltaic panels) *4*;
– energy storage module (alternator) *5*;
– voltage measuring module (alternator) *6*.

The advantages includes:

– resistance to interference;
– small size of the control system which does not interfere with design of the vehicle;
– low cost and easy operation;
– support for two energy sources (battery and photovoltaic panels);
– clear interface.

In Figure 1, battery *1* of an in electric vehicle is connected to the control system *2* and voltage measurement module *3* of the photovoltaic panels. Control system *2* is connected to control module *4* collecting energy from photovoltaic panels, the control module *5* collecting energy from the alternator, control module *6* measuring alternator voltage, and control module *7* adjusting output signals from the microcontroller, which is connected on one side to LCD *8* screen, and on the other side is connected via microcontroller *9*, system *10* adjusting the input signals, the control system *11* with module *6* for measuring voltage from the alternator and module *3* measuring the voltage of the photovoltaic panel.

System *2* controls the system for supercharging batteries of an electric vehicle. System *2* analyses signals from module 4 collecting energy from photovoltaic

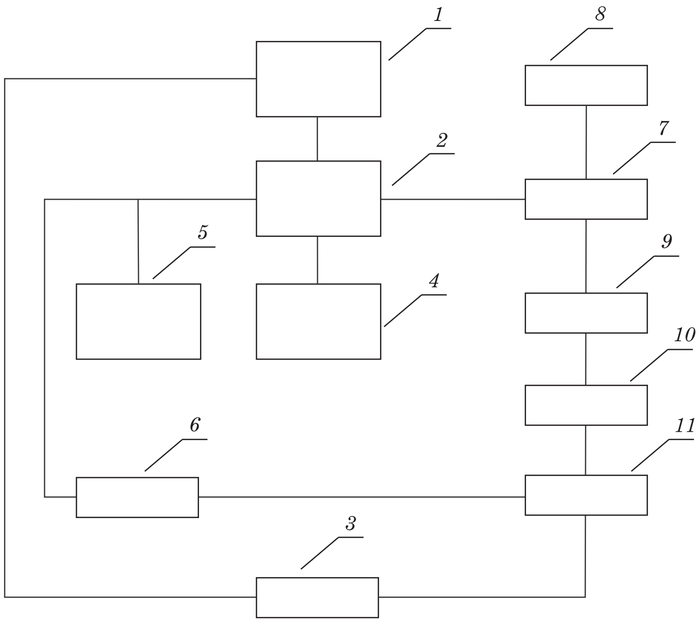

Fig. 1. Block diagram of system for charging batteries in electric vehicles using photovoltaic panels (description in the text)

panels, module *5* collecting energy from the alternator, module *6* measuring voltage from the alternator, and module *3* measuring voltage from photovoltaic panels. Through control system *11*, module *6* measuring voltage from the alternator and module *3* measuring voltage from the photovoltaic panel provide input signals for the microcontroller *9*. Output signals from microcontroller *9* control the control system *2*. Depending on the strength of the signals from the photovoltaic cells and the alternator, the battery is automatically supercharged. The modules collecting energy are independent, if one does not operate, the other can still supply energy to the battery and power it.

Power supply

The main control system is supplied by the system for voltage lowering and stabilization shown in Figure 2 (DENTON 2016, LUECKE 2005, SIKORA, ZIELONKA 2011).

The voltage stabiliser is based on the LM 7805CT system, which reduces the voltage from 12 V to 5 V. Two 100 nF ceramic capacitors were used to avoid oscillation. Finally, the stabiliser includes two diodes to inform about the operation and charging the stabiliser system and two resistors to prevent burning of the two diodes.

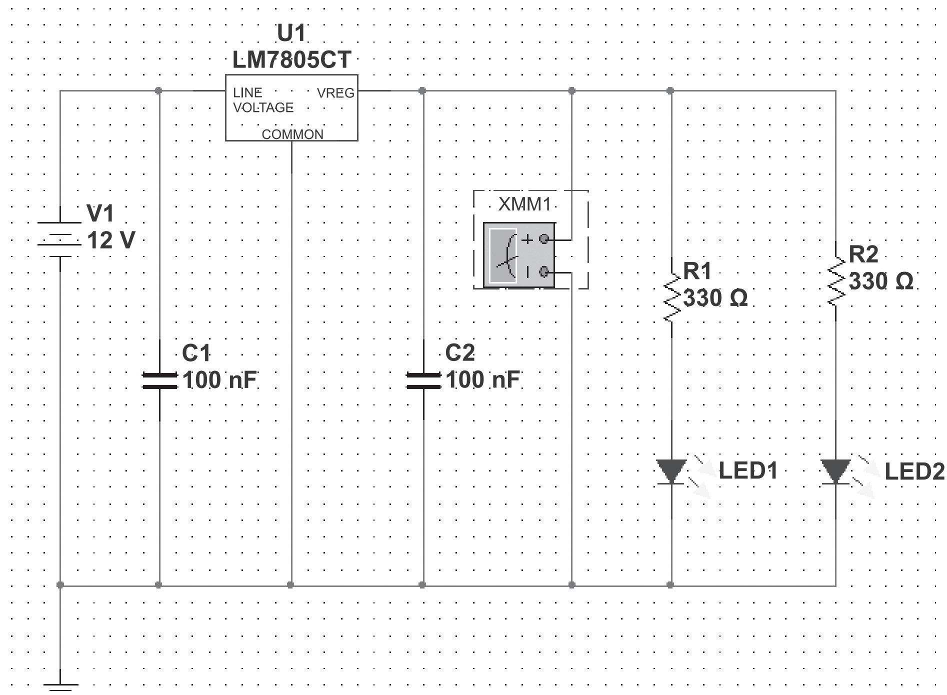

Fig. 2. System lowering and stabilizing voltage

Control system

A block diagram of the system for charging batteries in electric vehicles using photovoltaic panels is presented in Figure 3 (Buso, Mattavelli 2006, Gregory 2006, Moudgalya 2007).

The control system consists of:

– a power supply system;

– 5 V relays with coil;

– SW buttons;

– LCD with I2 C converter;

– signalling LEDs with 330 Ω resistors;

– bypasses consisting of four 100 kΩ resistors;

– 16 MHz quartz oscillator;

– ATMEGA328P-PU system.

The system starts after the first voltage application. The system is then in the zero (neutral) state and a message is displayed (S1-enable supercharging, S2-disable supercharging).

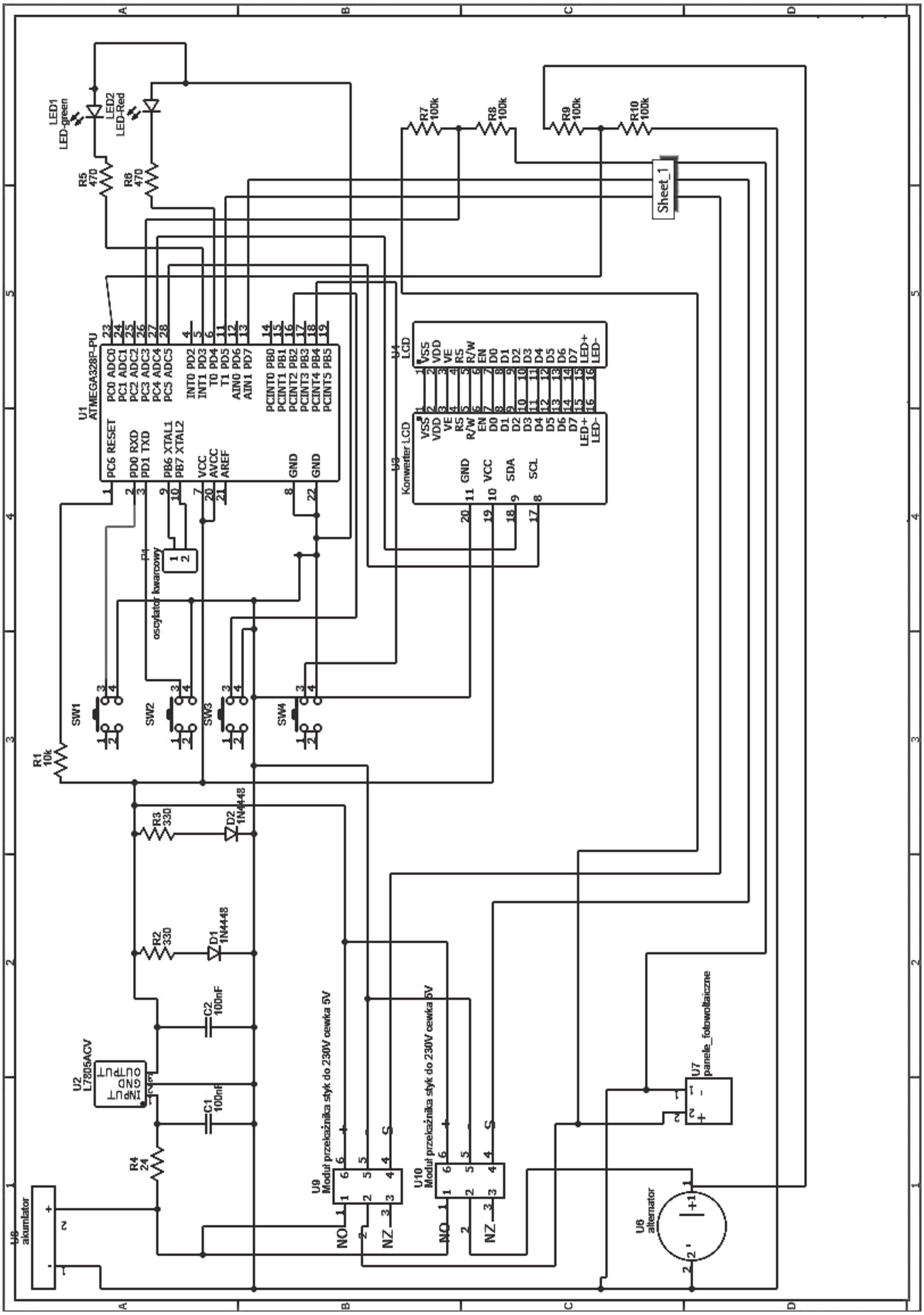

Fig. 3. Diagram of the control system for charging batteries in electric vehicles using photovoltaic panels

At this point, the user can perform four operations:

1. When the SW1 button is pressed, charging is activated (relay U9 and U10 are in high state), a message on the LCD is displayed (Charging on) and the green LED lights up.

2. When the SW2 button is pressed, charging is switched off (relay U9 and U10 are in the low state), a message on the LCD is displayed (Charging off), and the red LED lights up.

3. When the SW3 button is pressed, the voltage generated by the generators is measured, the information about the voltage is displayed on the LCD (Voltage= [measured voltage] V).

4. When the SW4 button is pressed, the voltage generated by the photovoltaic panels is measured, the information about the voltage is displayed on the LCD (Voltage= [measured voltage] V).

All of these operations can be performed at any time.

Control programme

The programme is constantly being improved. One of the control program versions is shown in Figures 4-7.

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x27, 16, 2);
void setup() {
  pinMode(3, OUTPUT);
  pinMode(4, OUTPUT);
  pinMode(5, OUTPUT);
  pinMode(7 , OUTPUT);
  pinMode(10, OUTPUT);
  digitalWrite(10, HIGH);

  digitalWrite(7, LOW); //przekaźnik prądnica
  digitalWrite(0, HIGH); //przycisk włączenie
  digitalWrite(1, HIGH); //przycisk wyłączenie
  digitalWrite(12, HIGH); // przycisk woltomierz na panelach
  digitalWrite(3, LOW);  //lampka zielona
  digitalWrite(4, LOW);  //lampka czerwona
  digitalWrite(5, LOW);  //przekaźnik panele fotowoltaiczne
  lcd.begin(16, 2);
  lcd.backlight();
  lcd.init();
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("S1=wlacz doladowania");
  lcd.setCursor(0, 1);
  lcd.print("S2=wylacz doladowania");

  for (int positionCounter = 0; positionCounter < 60; positionCounter++) {
    // scroll one position right:
    lcd.scrollDisplayRight();
    if (digitalRead(0) == LOW) {
      break;
    }
    if (digitalRead(1) == LOW) {
      break;
    }
    delay(150);

    for (int positionCounter = 0; positionCounter < 13; positionCounter++) {
      // scroll one position left:
      lcd.scrollDisplayLeft();
      if (digitalRead(0) == LOW) {
        break;
      }
      if (digitalRead(1) == LOW) {
        break;
      }
```

Fig. 4. Control programme code, part 1

```
      delay(400);

    }

  }
}


void loop() {

  if (digitalRead(0) == LOW) {      // Włączenie układu doładowania
    digitalWrite(3, HIGH);
    digitalWrite(4, LOW);
    digitalWrite(5, HIGH);
    digitalWrite(7, HIGH);
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Ladowanie wlaczone") ;

    for (int positionCounter = 0; positionCounter < 60; positionCounter++) {
      // scroll one position right:
      lcd.scrollDisplayRight();
      if (digitalRead(1) == LOW) {
        break;
      }
    if (digitalRead(12) == LOW) {
        break;
      }
      if (digitalRead(10) == LOW) {
        break;
      }
    // wait a bit:
    delay(150);

    for (int positionCounter = 0; positionCounter < 13; positionCounter++) {
      // scroll one position left:
      lcd.scrollDisplayLeft();
      if (digitalRead(1) == LOW) {
        break;
      }
      if (digitalRead(12) == LOW) {
        break;
      }
      if (digitalRead(10) == LOW) {
        break;
      }
```

Fig. 5. Control programme code, part 2

```
    delay(400);
    }
    }


  }

 if (digitalRead(1) == LOW) {      //Wyłączenie układu doładowania
    digitalWrite(4, HIGH);
    digitalWrite(3, LOW);
    digitalWrite(5, LOW);
    digitalWrite(7, LOW);
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Ladowanie wylaczone");


    for (int positionCounter = 0; positionCounter < 60; positionCounter++) {
      // scroll one position right:
      lcd.scrollDisplayRight();
      // wait a bit:
      if (digitalRead(12) == LOW) {
        break;
      }
      if (digitalRead(0) == LOW) {
        break;
      }
      if (digitalRead(10) == LOW) {
          break;
        }
      delay(150);

      for (int positionCounter = 0; positionCounter < 13; positionCounter++) {
        // scroll one position left:
        lcd.scrollDisplayLeft();
        if (digitalRead(12) == LOW) {
          break;
        }
        if (digitalRead(0) == LOW) {
          break;
        }
        if (digitalRead(10) == LOW) {
          break;
        }
        delay(400);
      }
```

Fig. 6. Control programme code, part 3

```
    }

  }

        if (digitalRead(12) == LOW) {
          digitalWrite(3, LOW);
          digitalWrite(4, LOW);
          digitalWrite(5, LOW);
          lcd.clear();
          lcd.setCursor(0, 0);
          lcd.print("Napiecie:");
          lcd.setCursor(0, 1);
          lcd.print("U=    V");
            int sensorValue = analogRead(A0);
            float voltage = sensorValue / (90);
            lcd.setCursor(2, 1);
            lcd.print(voltage);
            delay(10) ;

        }

    if (digitalRead(10) == LOW) {
      digitalWrite(3, LOW);
      digitalWrite(4, LOW);
      digitalWrite(7, HIGH);
      lcd.clear();
      lcd.setCursor(0, 0);
      lcd.print("Napiecie:");
      lcd.setCursor(0, 1);
      lcd.print("U=    V");
        int sensorValue = analogRead(A3);
        float voltage = sensorValue / (86.5);
        lcd.setCursor(2, 1);
        lcd.print(voltage);
        delay(10) ;

    }
        }
```

Fig. 7. Control programme code, part 4

Summary

Under ideal weather conditions, it was concluded that the alternator is more efficient and generates more energy. Moreover, it can continue generating power when the photovoltaic panels are unable to do so, for example, at night.

It should still be noted that the alternator generates power when a vehicle is moving, whereas photovoltaic panels can draw energy when the car is immobile. Therefore, two energy sources were chosen to complement each other.

An industrial prototype was constructed to enable testing and improve the structure from both an electronic and mechanical perspective. The mechanical structure of the device posed quite a challenge due to the climate conditions in the car.

The software is being continuously improved, one version of which was presented in chapter Control system. Work results were patented SYROKA, JAKOCIUK (2020).

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