FRI-ONLINE-1-EEEA-06

ELECTRONIC LOAD BASED ON ARDUINO NANO [6]

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Abstract: *The paper presents an electronic load with smooth current regulation, based on Arduino Nano microcontroller. Such an electronic load is used for recording of the operating characteristics of DC power supplies, batteries and DC generators. Taking these characteristics is essential when assessing the energy efficiency and performance of a DC source. The use of transistors as a load significantly reduces the size of the module as well as the test time compared to conventional load resistors.*

Key word: *microcontroller, electronic load*

INTRODUCTION

Energy efficiency is related to the reduction of electricity consumption which leads to a reduction of carbon monoxide emissions. This topic affects both everyday life and all industry. Energy efficiency is a key assessment of the operation of any designed system, which is stated in Directive 2005/32 / EC of the European Parliament and of the Council of the European Union of 06.07.2005.

The modern world is increasingly dependent on electronic devices, from everyday electronics to electric cars and photovoltaic panels. Most modern devices are dependent on DC power sources, such as DC power supplies and rechargeable batteries.

Their continuous improvement in terms of productivity is implemented through reducing their energy expenses. This way, in addition to their electronic components, their power supply is also becoming very important. More and more electronic devices work with different types of rechargeable batteries. This raises the need to take the performance characteristics in order to find the optimal mode of operation.

EXPOSITION

A. Object of research.

The development of electronics, in addition to the technology of production of the individual components, is also necessary to improve the power supply. The way to do this is through improving the power sources, such as DC power supplies and batteries. This can be achieved by studying the performance characteristics and finding their optimal modes of operation.

In the case of DC sources, there is a need to study the relationship between the input and output parameters at different loads. In other words, how the parameters change: current, voltage and power depending on the load at the power output, as well as the need to study the continuous operation at maximum load (Deblecker, 2013).

Rechargeable batteries require constant monitoring in order to preserve their life under normal operating conditions. For this reason, periodic checks of the ratio of the current capacity to the maximum of the batteries are necessary (Quintero, 2020). Giving us information on how the efficiency of the battery is affected depending on the current condition of the battery and its performance.

In the case of DC generators, in order to study their operating characteristics, it is necessary to take into account their efficiency at different loads (Yang, 2019).

In the case of photovoltaic panels, the temperature curve I-V is studied, as well as the dependence of idling and short circuit in order to determine the performance of the panel (Kuai, 2006).

[6] Докладът е представен на заседание на секция 3.1 на 29 октомври 2021 с оригинално заглавие на български език: ЕЛЕКТРИЧЕСКИ ТОВАР БАЗИРАН НА АРДУИНО НАНО

The tests listed so far are usually carried out using load resistors, which have a number of disadvantages (Quintero, 2020):

- dimensions;
- inability to control their parameters;
- using more than one to achieve a wider range of regulation;
- need for switching when changing the resistance.

Nowadays, all these problems are solved with the use of electronic load (Quintero, 2020) and the existing electronic load makes it possible to simulate a numerous modes of operation, such as (Ramirez, 2007):

- constant current;
- constant voltage;
- constant power;
- constant resistance.

B. Electronic circuit and working algorithm

Fig. 2 and Fig. 3 shows the block diagram of an electronic load based on MOSFET transistors.

The circuit consists of 2 MOSFET IRL3103PbF transistors connected in parallel, which implement the load. They have following parameters:

- Drain-to-Source Breakdown Voltage - $U_{DSS} = 30V$;
- Gate Threshold Voltage - $U_{GS(th)} = 1V$;
- Continuous Drain Current ($U_{GS} = 10V$) - $T_C = 25℃/100℃ - I_D = 64A\ /45A$;
- Gate-to-Source Voltage: $U_{GS} = \pm 16V$.

From the datasheet of IRL3103PBF can be seen that the maximum load voltage is limited by $U_{DSS} = 30V$ of the transistor.

The operational amplifiers LM224M provides constant current mode, the potentiometer allows to regulating the current from the load. The Arduino Nano module is used to convert current values and display them on the LCD display. ADS1115 is used to extend the range of measurements on the resistor $R_M = 1\ Ohm$ voltage drop.

In fig. 1 is presented ADS1115 16-bit ADC which has the following limitations:

- Power supply (VDD to GND) – min to max (2V - 5.5V);
- FSR – GRD $\pm 0.256V$, VDD $\pm 6.144V$.

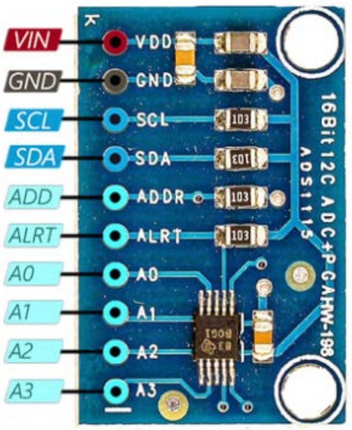

Fig. 1 The ADS1115 16-bit analog-to-digital converter

Using equation (1) and the FSR parameter of ADS1115 we can calculate the maximum current I_{DS} that can be measured by the circuit.

$$I_{DS} = \frac{U_{res}}{R_M} \quad (1)$$

$$max\, I_{DS} = \frac{6.144}{1} = 6.144\ A \quad (2)$$

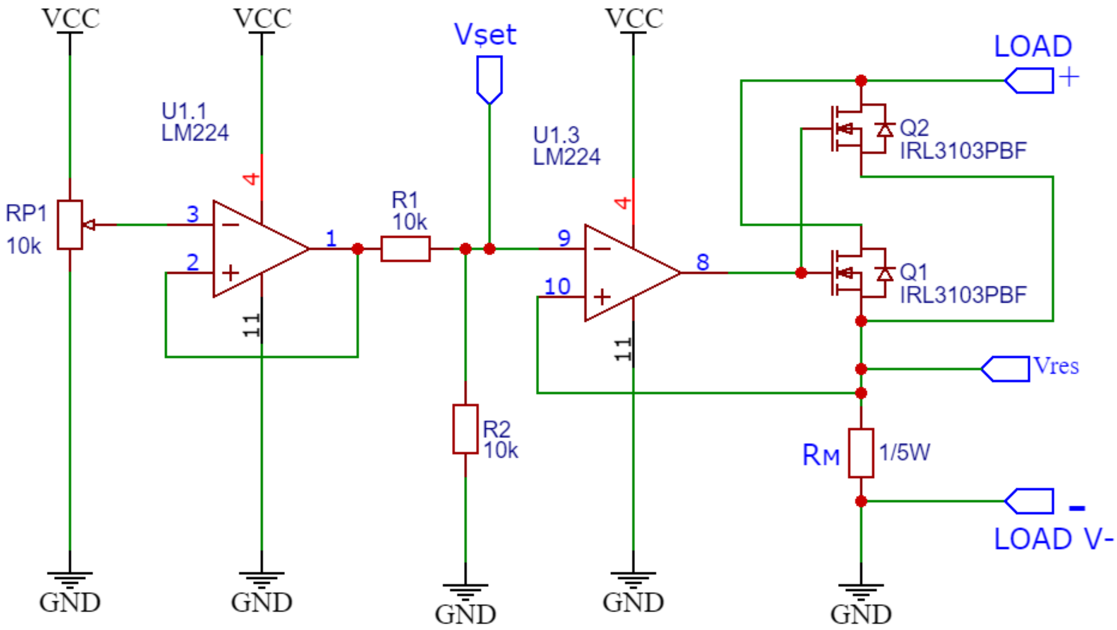

Fig. 2. Circuit of the electronic load

When switching on the module, the 12V power supply is fed to the Arduino module, the MOSFET transistors and the potentiometer. The voltage drop on the potentiometer is fed to the terminal of the operational amplifier LM224M, and depending on the value of the terminal, changes the value of U_{GS}. At the initial moment when the voltage drops on the potentiometer $U_{set} = 0V$, then the operational amplifier LM224M sets the voltage $U_{GS} = 0V$ and no current flows through the MOSFET transistors, i.e. they are in standby mode. When a voltage $U_{GS} > U_{TH}$ is supplied, the transistor turns on and I_{DS} current begins to flow between their drain and source terminals.

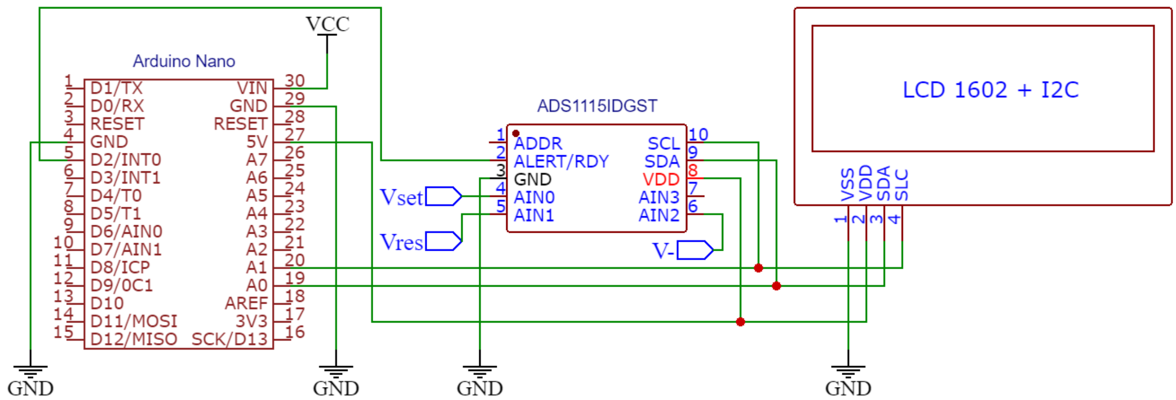

Fig. 3 Schematic of the measuring system

Due to the lack of connection between the I_{DS} current and the voltage between the gate terminal and the load (U_{GS}), a load resistance of 1 Ohm is included. The measured voltage between resistor R_M

is applied to the output of the operational amplifier (-). In this way he controls the value of the current in order to reach $U_{res} = U_{set}$.

C. Arduino code

The source code of the developed module is presented in Table 1.

Table 1. Source code of the developed module.

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include <Adafruit_ADS1015.h>
Adafruit_ADS1115 ads(0x48);
LiquidCrystal_I2C lcd(0x27, 16, 2);
const float multiplier = 0.0001875;
float offset = 0.004;
void setup() {
 Serial.begin(9600);
 ads.begin();
 delay(10);
  lcd.init();
 lcd.backlight();
 lcd.clear();
 lcd.setCursor(0,0);
 lcd.print(" ELECTRONIC LOAD  ");
  delay(500);
 lcd.setCursor(0,1);
 lcd.print(" CONSTANT  LOAD ");
 delay(1000);
}
void loop() {
 float set_value, real_value;
 real_value = ads.readADC_Differential_1_2();
 set_value  = ads.readADC_SingleEnded(0);
 set_value = (set_value * multiplier) - offset;
 real_value = real_value * multiplier - offset;
 if(real_value < 0)
 { real_value = 0;   }
 if(set_value < 0)
 { set_value  = 0;   }
 lcd.setCursor(0,0);
 lcd.print("Set:     ");
 lcd.print(set_value,2);
 lcd.print(" A");
 lcd.setCursor(0,1);
 lcd.print("Current: ");
 lcd.print(real_value,2);
 lcd.print(" A");
 delay(200);
}
```

CONCLUSION

In the present study an electronic load circuit based on MOSFET IRL3103PbF transistors has been designed, which can be used as constant current load. The block diagram and programming code of the Arduino controller are presented.

The implemented scheme could be applied in the study of the characteristics of low-power DC motors and laboratory power supplies.

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