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Automatic Speed Control of DC Series Motor by Using Arduino

Abstract. *The purpose of this project was to design and implement an aped control of a direct-current (DC) series motor. The Arduino UNO kit was used with four resistance armature control, and the approaches available with the Arduino kit enabled us to build this connection and measure the speed in a straightforward manner. This speed was measured using a speed meter (Autonics MP5w). Traditional armature resistance controls and also Arduino armature resistance controls were used. For each example, the speed readings were recorded. Finally, it was found that the Arduino control approach is less complicated than the old method.*

Streszczenier. *Celem tego projektu było zaprojektowanie i wykonanie sterowania silnika szeregowego prądu stałego (DC). Zestaw Arduino UNO został użyty z czterema opornikami sterującymi twornikiem, a podejścia dostępne w zestawie Arduino umożliwiły nam zbudowanie tego połączenia i zmierzenie prędkości w prosty sposób. Ta prędkość została zmierzona za pomocą prędkościomierza (Autonics MP5w). Zastosowano tradycyjne regulatory rezystancji twornika, a także regulatory rezystancji twornika Arduino. Dla każdego przykładu rejestrowano odczyty prędkości. Ostatecznie stwierdzono, że podejście do sterowania Arduino jest mniej skomplikowane niż stara metoda.* (***Automatyczna kontrola prędkości silnika serii DC za pomocą Arduino***)

Keywords: Resistance armature control, series DC motor, timer setting code, Arduino code, speed control, Arduino UNO.
Słowa mkluczowe: sterowanie prędkością, silnik DC, Arduinp

Introduction

Series DC motors are also savvied as series universal motors, have a single voltage source and a rotor winding that is in series with the field winding [1]. The motor has a very strong starting torque due to the series connection. When speed increments due to an increment in the electromotive force (EMF) or back, torque is decreases. When the load on the motor is increased, it slows down, lowering the back electromotive force (EMF) and increasing the torques to identically the load [2]. One downside of the These engines are that, for the bulk of their applications, The rotational sensation is fixed. The flow of current polarity must be adjusted to change the trend of torque and spin, control of a direct current series motor. This paper investigates the construction of a system of control. that makes use of the elevated torque capabilities of direct-current series motors [3].

These motors could be used in a broader span of applications. since they combine low current consumption and strong torque generation. Many schemas of control were attempted to increase the speed rendition of series DC motors [4]. These designs are primarily concerned with the power driver in the absence of reverse motion. Due to their simplicity and low cost, series DC motors play an important role in research and laboratory trials. The speed of the motor can be adjusted using one of There were three methods armature rheostat control and terminal voltage control and, or control of flux. The terminal voltage control approach is used in this project. For a long time, Variable speed drives have used direct current series DC motors [5].

The many characteristics of DC motors enable them to deliver elevate initiating torques, which are needed for move slowly drives. Control over a broad range of speeds, both lower and higher than the estimated speed, is straightforward. Control of speed methods are easier and slighter costly than those employed in AC motors. The speed of DC series motors can be controlled in a variety of ways [6]. DC motor speed control applications include washing machines, driers and other household appliances. In the automotive sector, DC motor speed control is utilized for applications like fuel pumps, engine controls and electronic steering. DC motor drives are less costly and simpler to operate than alternating current motor drives [7].

Furthermore, the utilies of embedded technologies for DC motor speed control lowers the cost significantly. The evolution of a low cost included speed control system could be used as an appropriate lab test for studying and learning control engineering [8].

Methodology of the DC series motor model

A series DC motor, such as compound wound or shunt wound DC motor, is self-excited. As seen in Fig.1, the armature winding is intramurally linked in series with the field winding. Also known as self-excited motors since they only require a single voltage source to power the field winding and the armature [9].

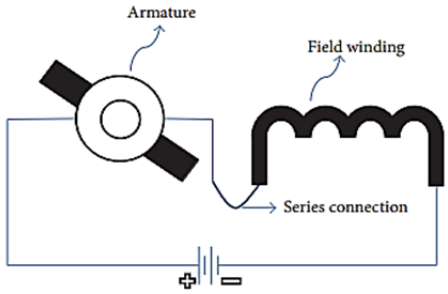


Fig.1. DC series motor connection

Fig. 2 depicts the electrical diagram of the a DC series wound motor.

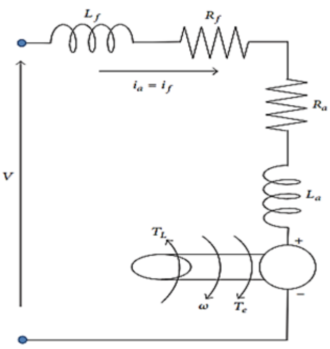


Fig.2. A DC motor in series electrical diagram.

Mathematical modeling of series DC motor

The equations of differential that govern a DC series motor's electrical and mechanical subsystems based on the electric circuit shown in Fig. 2 are as follows [10].

(1) $V(t) = (R_a + R_f)\, i(t) + (L_a + L_f)\, d/dt\, i(t) + E_a$

(2) $Te\,(t) = T_L\,(t) + b_\omega\,(t) + J\, d/\, dt_\omega\,(t)$

where $\omega(t)$: rotor's speed, Ea: is the counterelectromotive force, $TL(t)$: Load torque, $i(t) = ia(t) = if(t)$: is the current, b: coefficient of friction, J: inertia of the rotor, and $Te(t)$: torque of electromagnetic generated by motor [11,12].
$Te(t)$ and Ea together adopted on the air-gap flux Φ, that is

$E_a(t) = \omega\,(t)\,\Phi\,(i)$

(3) $T_e(t) = i(t)\,\Phi\,(i)$

Because the flux (I) is a function of the current i(t), equalizers, 1 to 3 are not linear. Furthermore, when the magnetic saturation is ignored, it is usual exercise to nearly the flux I by a linear relationship; that is,

(4) $\Phi\,(i) = k_0 i(t)$

where k_0 is inductance of the mutual of the field coils and armature.
As a result, the DC series motor differential equations without magnetic saturation yield

(5) $V(t) = R_i(t) + L\, d\,/dt\, i(t) + k_0\omega\,(t) i(t)$

(6) $k_0 i_{\,2}\,(t) = T_L(t) + b_\omega\,(t) + J\, d/dt\omega\,(t)$

where R=$R_a + R_f$ and L=$L_a + L_f$.

Flowchart of control procedures

The control of speed methods for a DC series motor with variable resistances (armature series control) The method utilized to control a DC series motor's speed is depicted in Fig.3 [13].

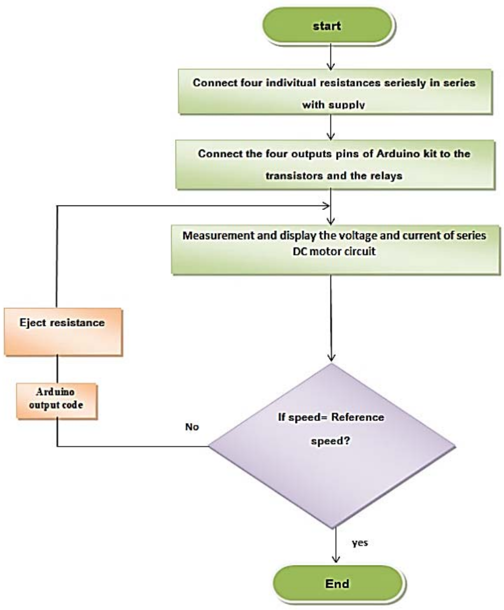


Fig.3. Flowchart of series DC motor based Arduino.

Fig.4. Arduino kit.

Materials and methods

Arduino type UNO kit

Arduino is a software and hardware open-source electrical platform. An Arduino can read the input signal from a sensor. It has an Atmega 328 microcontroller with 14 digital inp/out, a USB connection, a reset pin, a power connector through an ICSP header, and a 16MHz ceramic resonator [14,15].

Transistors

A transistor of type (2N2222) is used in this work. It is a popular NPN bipolar junction transistor (BJT) has been for general-purpose switching applications [16].

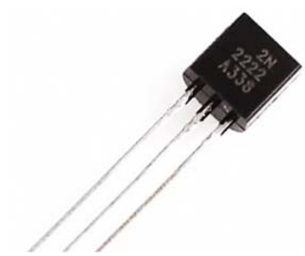


Fig.5. NPN bipolar transistor.

Relays

Relays are electrically powered switches. To turn their internal mechanical switches, they often use an electromagnet (coil) (contacts). When the relay contacts are open, the switch power for a circuit at the coil is turned on [17,18].

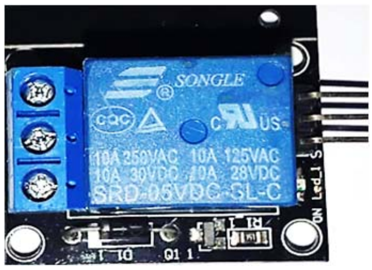


Fig.6.DC relay.

DC supply

Figure 7 depicts the power source utilized to directly drive the series DC motor without using the drive [19].

Fig.7. DC supply.

Series resistances

They were used to regulate the speed of a series of direct current motors. that was coupled in series with a DC supply. There are four 1k resistances. been used. Figure 8 depicts the single resistance [20].

Fig.8. Series armature control resistances.

Series DC motor

The series DC motor depicted in Fig.9 is known as a series universal motor because the field windings are linked in series with the rotor winding and are powered by a single DC source [21].

Fig.9. Series DC motor.

Software description

The Arduino open-source software makes it simple to write code and upload it onto the board. This code is suitable with any Arduino board. The program written by the Arduino software is described as a sketch. This outline is written in a text editor and saved with a file extension.

Software Implementation

The software was written using the Arduino Integrated Development Environment (IDE). This project involves programming for controlling the motor's speed and also motor direction control. The computational language C is used to build a program that utilizes attention commands, which are needed for GSM execution in any system. This can be observed in the serial port of the Arduino. This module sends this signal to the Arduino, which analyzes it according to the written program in the IDE and runs it on the serial port. It is then scooped up by the motor driver and utilized to control the speed of a series DC motor.

System construction

The control system consists of series DC motor, DC supply, series resistances, relay and Arduino software shown in Fig.10.

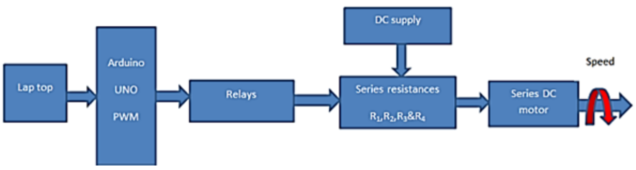


Fig.10. system hardware

Proteus

Series DC motor has just two leads, one of them is positive and the other is negative, the positive lead was connected to Vcc across four series resistors (500 ohm) and the other one linked to the four transistors (2N2222) through four resistors (100 ohm).

Each series resistor was connected parellely with realy (SRD-0.5VDC-SL-C) and the simulation has been ran on proteus programas shown in Fig. 11.

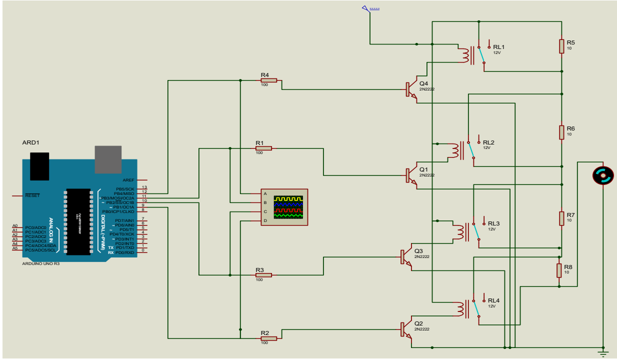


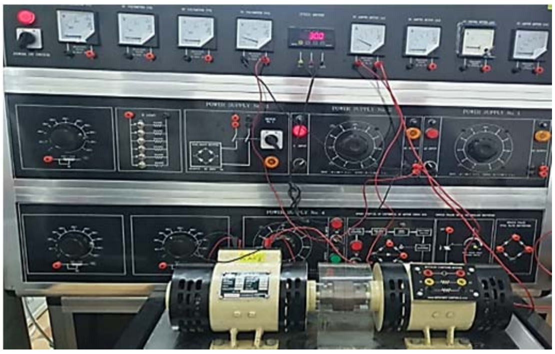
Fig.11. Proteus simulation for speed control of series DC motor.

Results and discussion

The DC series motor practical circuit control of speed with Arduino armature resistance control is depicts in Fig.12, four (1000 ohm) resistors of added in serially with intramural armature resistor.

a)

b)



c)

d)

e)

Fig.12. Controlling the speed of a DC series motor with a practical circuit.
(a) Readings from all resistors in general experimental connections.
(b) After ejecting two resistors, the following parameters were measured.
(c) Readings of three resistors after ejection.
(d) Parameter readings following ejection of four resistors.
(e)

Figures (12-a to 12-e) depict the back e.m.f speed and current values for whole resistors connected in series with field resistor and the internal armature resistor after ejection of one resistor, two resistors, three resistors, and four resistors, respectively. Table 1 shows the readings.

Table 1. Readings of parameters

Connection of resistors	I (A)	E_b (V)	N (RPM)
Internal armature resistors are used in all resistors.	0.22	136	280
After ejection one resistor	0.2	138	300
After eviction two resistor	0.19	140	451
After ejection three resistor	0.18	142	675
After ejection four resistor	0.17	144	816

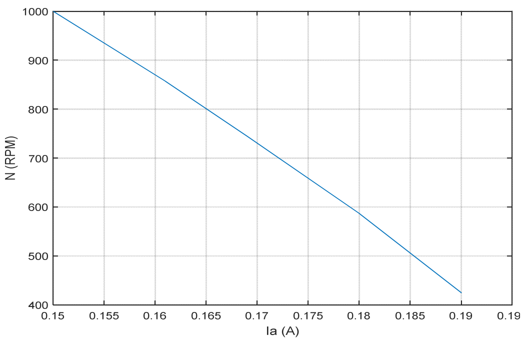


Fig.13. Back e.m.f Speed vs E_b

After ejecting the four resistors one by one, the speed of the DC series motor was gradually increased until all four resistors were ejected, as shown in table 1. This resulted in an increase in speed when the voltage was increased after the resistors were ejected.

Speed is exactly related to back e.m.f., and as seen in Fig.13, as the back e.m.f. grows, so does the speed. Because speed is inversely related to current, when the current reduces, the speed increases, as illustrated in Fig. 14.

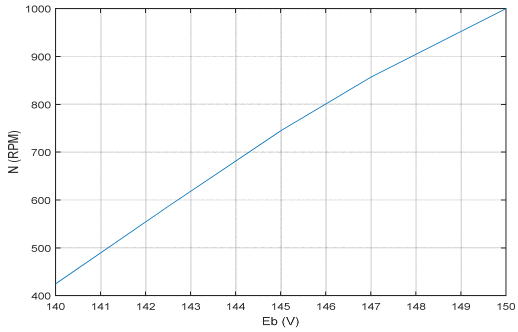


Fig.14. speed N_s current

Table 2 shows the specifications of DC series motors.

Table 2. DC motor parameters (MOTCO IS:7422)

Parameters	Value and units
Types	Motco 4722
Field voltage	240V
Armature voltage	240V
H.P./KW	0.75 W
Current	3 A
Speed	1750 RPM

Conclusions

The empirical curves of a DC series motor-based Arduino kit were obtained in this work, and all practical data for speed and current were collected within the Northern Technical University laboratory (NTU).

Table 1 shows the smallest percentage difference in speed between the periods of ejection three and four resistances equal to 17.4 percent.

As seen in Fig. 13, increasing the Eb increased the DC series motor's speed to 816 RPM.

As shown in Fig. 14, the speed of DC series motor has been reduced to 280 RPM as the current rises

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