Data Article

Direct current geared motor data: Voltage, current, and speed measured under different experimental conditions

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Abstract

This data article describes eleven datasets collected from laboratory individual tests with two DC motors of the same model. The motors are proposed to be used as the actuators of an Automated Guided Vehicle (AGV). Each dataset shares the same structure, with the measurement of twelve variables: instant of measurement, encoder pulse counts, calculated motor velocity, raw current, calculated current, raw voltage from output A1, raw voltage from output B1, calculated voltage from output A1, calculated voltage from output B1, potential difference applied to the motor terminals, motor status, and the Arduino analog output value in pulse width modulation (PWM). The data are helpful to model and identify the system considering its dynamics. Such consideration on control systems design, specifically on AGV position control, can improve the controller accuracy. It also can

Article history:
Received 18 October 2021
Revised 9 December 2021
Accepted 4 January 2022
Available online 6 January 2022

Keywords:
DC motor
Modeling
System Identification
Motor dynamics
Automated Guided Vehicle
Position control
Mobile robot

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https://doi.org/10.1016/j.dib.2022.107802
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Specifications Table

| Subject                      | Control and Systems Engineering |
|------------------------------|--------------------------------|
| Specific subject area        | Permanent magnetic direct current motors modeling and parameters identification. Identification of DC motor dynamic parameters to improve the accuracy of an AGV position controller. |
| Type of data                 | Table                          |
|                              | Graph                          |
|                              | Spreadsheet file               |
| How the data were acquired   | Data were acquired throughout laboratory individual tests with two motors of the same model. The primary data acquisition system is an Arduino Mega 2560. Using VNH2SP30 full-bridge motor drivers to control the input voltage using an Arduino PWM output, the system measures the motor’s voltage, current, and speed. The voltage sensor is a simple voltage divider with resistors to adapt the motor voltage range (0-12V) to a range allowed to an Arduino analog input (0-4V). The current sensor, model ACS712, is a Hall effect-based linear current sensor with an input range -30 A to 30 A and a proportional analog output compatible with the Arduino analog input. The speed sensor combines an OMRON rotary incremental encoder with 1800 pulses per revolution, model E6B2-CWZ6C, and a quadrature encoder buffer based on the integrated circuit (IC) LS7368R communicating to the Arduino board using SPI protocol. The data were saved to comma-separated values file via serial communication using the Arduino IDE software, the external tool ArduinoSpreadsheet, and the codes in [1] to generate input signals and acquired the data at 100Hz. |
| Data format                  | Raw                            |
|                              | Filtered                       |
| Parameters for data collection| The experiments were conducted in a controlled environment. The data collection process considers the following input signals under a no-load condition: sine and triangle waves (0.1 Hz, 1 Hz, and 10 Hz), a 0.25 Hz square wave, two Pseudorandom Binary Sequence signals (with 7 and 9 bits), and step functions. Only step functions were tested under a loaded condition with four load states: 1 kg, 2 kg, 3 kg, and 4 kg. |
| Description of data collection| A test platform was set up, allowing the experiments with and without a load attached to the motor shaft. The same sensors were used for both motors. Except for input voltages that do not start the DC motor, at least ten trials were conducted for each input signal and each motor. Besides the filtered values of voltage, current, and speed, the data also includes the time interval of each measurement, the raw values of the Arduino analog inputs, the number of encoder counts, and the reference values for motor control: the motor status (clockwise spin, counterclockwise spin, or brake), and the reference PWM output value that commands the motor driver. |
| Data source location         | Federal Institute of Education, Science, and Technology of Rio de Janeiro (IFRJ), Volta Redonda campus, Volta Redonda, Rio de Janeiro State, Brazil |
| Data accessibility           | With the article or Repository name: Mendeley Data |
| Data identification number   | 10.17632/2rkpss6fd2            |
| Direct URL to data           | https://data.mendeley.com/datasets/2rkpss6fd2 |
| Code accessibility          | Repository name: GitHub/Zenodo |
| Data identification number   | 10.5281/zenodo.5737539         |
| Direct URL to data           | https://zenodo.org/record/5737539#.YbKijprpv9hF |
Value of the Data

- The presented data allows the modeling and system identification of a DC motor from different approaches due to the number of recorded variables. The number of input signals tested and the experiments under load adjustment conditions differentiate the dataset from others.
- Mobile robot and Automated Guided Vehicle (AGV) simulation research, robot design, and control systems design can benefit from the data. The actuator dynamics are usually neglected in such cases. However, the regular operation of an AGV includes transportation of different payloads, which impacts the motor torque and dynamic behavior, besides other variables. Therefore, the experiments stress the tested motors with concentrated loads to measure the dynamic behavior under diverse conditions.
- Besides the DC modeling for simulation and control of dynamic systems use, the data also allows comparisons between system identification algorithms and attends as a training dataset to intelligent control approaches.
- The data can be used to compare AGV position controllers’ performance regarding position accuracy when considering the actuator dynamics.
- It is also useful to study the impact of the actuator dynamics modeling on the position control simulation of AGVs and its comparison to the actual vehicle.

1. Data Description

Data reported in this article describe the voltage, current, and velocity measurements of two DC motors of the same model. The motors are the actuators of an AGV in the development phase. As regular vehicle operation involves load transportation, it impacts the motor dynamics, mainly its torque. So, the experimental platform comprises the sensors to measure the variables mentioned above and the adjustment of a concentrated load in the motor shaft to emulate a load transportation condition. Similar experiments can be performed on the mounted vehicle.

Besides the processed measurements data of the DC motor, the data set also comprises the acquisition instant, the raw sensors readings, and the motor commands. Each dataset in the spreadsheet file consists of twelve variables recordings, divided into twelve columns as Table 1 shows, respectively described next. The recorded variables are common to every experiment and for both motors that were tested. The first column is the instant of measurements, the measurement time recorded in microseconds. The measurement with the Arduino board uses the timer interruption to generate a measurement rate of 100 Hz.

The following two columns register the encoder pulse counts and the calculated motor speed in RPM. The quadrature encoder buffer circuit was configured to count each pulse rising. So, the encoderCount column shows the pulse count without clearing the value. The pulse count signal indicates the motor’s rotation direction, being a positive signal related to a counterclockwise rotation and a negative signal related to a clockwise rotation. The motor velocity, showed in Velocity column, is calculated from the pulse counts considering the measurement interval of 0.01 seconds, according to Eq. (1), where \( V \) is the motor velocity in rotations per minute (RPM), \( N = 1/17 \) is the reduction rate of the gear box, \( \text{encoderCount}(n) \) is the actual value of the encoder buffer, \( \text{encoderCount}(n - 1) \) is the last value of the encoder buffer used in the previous iteration, \( \text{PPR} \) is the number of pulses per revolution of the encoder model used, which is 1800 PPR, \( \Delta t \) is the sampling time of 0.01 s, and 60 s/1 min is a unit conversion constant. Positive velocity means a clockwise rotation direction to follow the voltage signal applied to the motor.

\[
V = N \times \frac{\text{encoderCount}(n) - \text{encoderCount}(n - 1)}{\text{PPR}} \times \frac{60 \text{ s}}{1 \text{ min}} \Delta t
\]  

(1)

The current measurement has two distinct columns. The first one, named rawCurrent, is a single raw measurement of the Arduino board analog input, with a 10 bits resolution. So, such values are in the range from 0-1023. The sensor range is from -30 A to 30 A, and its 0-5 V
Table 1
The motor data structure: few lines of a single trial to exemplify the data organization.

| time  | Encoder Count | Velocity | raw Current | Current | raw VoltageA1 | VoltageA1 | VoltageB1 | Motor Voltage | Motor Status | PWM |
|-------|---------------|----------|-------------|---------|---------------|-----------|-----------|---------------|-------------|-----|
| 131540 | -1119         | 190      | 618         | 9       | 23            | 798       | 0.33      | 11.49         | 11.17       | 237 |
| 141520 | -2688         | 307      | 511         | 2.36    | 12            | 813       | 0.17      | 11.71         | 11.54       | 179 |
| 151536 | -4532         | 361      | 510         | 0.34    | 9             | 820       | 0.13      | 11.81         | 11.68       | 100 |
| 161532 | -6454         | 376      | 511         | -0.01   | 256           | 831       | 3.66      | 11.97         | 8.31        | 33  |
| 171544 | -8367         | 375      | 510         | -0.03   | 276           | 836       | 3.94      | 12.04         | 8.1         | 1   |
| 181536 | -10228        | 364      | 511         | 0.03    | 241           | 835       | 3.44      | 12.03         | 8.59        | 1   |
| 191560 | -12045        | 356      | 538         | 0.39    | 266           | 835       | 3.8       | 12.03         | 8.23        | 1   |
| 201540 | -13818        | 347      | 545         | 2.35    | 272           | 839       | 3.88      | 12.09         | 8.2         | 1   |
| 211576 | -15637        | 356      | 545         | 3.64    | 900           | 834       | 12.85     | 12.01         | -0.84       | 1   |
| 221548 | -17561        | 377      | 554         | 3.57    | 9             | 822       | 0.13      | 11.84         | 11.71       | 222 |
| 231584 | -19675        | 414      | 548         | 3.01    | 9             | 824       | 0.13      | 11.87         | 11.74       | 1   |
| 241568 | -21939        | 443      | 512         | 0.93    | 6             | 824       | 0.09      | 11.87         | 11.78       | 1   |
| 251584 | -24271        | 457      | 510         | 0.27    | 2             | 826       | 0.03      | 11.9          | 11.87       | 1   |
| 261584 | -26600        | 456      | 511         | 0.01    | 0             | 830       | 0         | 11.96         | 11.96       | 1   |
| 271596 | -28894        | 449      | 511         | -0.01   | 176           | 832       | 2.51      | 11.98         | 9.47        | 1   |
| 281588 | -31132        | 438      | 510         | -0.03   | 170           | 832       | 2.43      | 11.98         | 9.56        | 1   |
| 291576 | -33313        | 427      | 511         | 0.17    | 188           | 836       | 2.69      | 12.04         | 9.36        | 1   |
| 301588 | -35456        | 420      | 540         | 1.33    | 191           | 833       | 2.73      | 12            | 9.27        | 1   |
| 311588 | -37593        | 419      | 544         | 2.32    | 896           | 836       | 12.8      | 12.04         | -0.75       | 1   |

...
output is proportional to the motor current, then the value 512 is the zero current value. The other column, Current is the calculated current based on the sensor model using a software library [2], which calculates the measured current according to Eq. (2), where \(i\) is the measured current, \(acc\) is the variable that accumulates ten readings of the Arduino analog input pin in a row, \(ADC_{scale} = 1023\) is the analog to digital converter scale, \(v_{ref} = 5\) V is the reference voltage, and \(S_{sensor} = 0.066\) mV/A is the sensor sensibility, related to its current input range. Then, the current reading from the sensor is an average of ten readings.

\[
i = \frac{\text{acc}/10}{ADC_{scale} \cdot v_{ref} / S_{sensor}}
\]  

Likewise, the voltage measures also display the raw measurements from both motor driver outputs, A1 and B1, since they have the same polarity. So, the data is divided into columns rawVoltageA1 and rawVoltageB1. For each driver output, a voltage divider circuit with resistors converts the motor voltage from a 0-12 V scale to a 0-4 V scale, suitable for the Arduino analog input pins. As analog input readings, both columns register values in the range 0-1023.

The following two columns, named VoltageA1 and VoltageB1, display the calculated voltage from each drive output, i.e., converted from the readings to the 0-12 V scale. The values are calculated by Eq. (3), where \(x = \{A1, B1\}\), \(r_x\) is the reading of the respective Arduino analog input pin, 5/1024 is the constant voltage resolution of the analog to digital converter, and \(R1_x\) and \(R2_x\) are the measured resistance values of the resistors in the voltage divider circuit.

\[
v_x = \frac{\frac{5}{1024} \cdot R2_x}{R2_x + R1_x}
\]  

The potential difference applied to the motor terminals is determined based on the measurements of each driver output. It is registered on column MotorVoltage and calculated by Eq. (4), where \(v_{motor}\) is the potential difference applied to the DC motor, \(v_{A1}\) is the measured voltage of driver output A1, and \(v_{B1}\) is the measured voltage of driver output B1.

\[
v_{motor} = v_{B1} - v_{A1}
\]  

The last two columns of the data files register the motor status and the Arduino analog output value in pulse width modulation (PWM) used to command the motor driver. The column MotorStatus has three possible values: 0 for brake condition, 1 for the clockwise rotation direction, and 2 for the counterclockwise rotation direction. Lastly, the column PWM registers the values from Arduino analog output with a 0-255 range. It is the reference of the motor command.

The dataset is presented in a spreadsheet file, which tabs are divided into the carried experiment and the DC motor used, motor A or motor B. It includes experimental data from two DC motors submitted to ten different input voltage signals in a no-load condition and voltage steps with different amplitudes with a load attached to the motor shaft. Each experiment is equivalent to a different voltage input stimulus applied to the DC motor. With only four exceptions, stimuli were repeated at least ten times for each motor. Table 2 summarizes the dataset file, indicating the tested voltage input signal and the respective tab within the spreadsheet file.

Two Pseudorandom Binary Sequences (PRBS) were tested as the input voltage signal considering that the higher level is the maximum value of the PWM duty cycle, equivalent to 12 V, and the lower level is zero. A PRBS signal is a binary sequence generated with a deterministic algorithm to allow the reproduction of the sequence. Fig. 1 exemplifies the applied voltage to the DC motors from the PRBS7 signal and Fig. 2 from the PRBS9 signal considering a single experimental data.

The number of shift registers used indicates the sequence maximum number of bits. In the case of the PRBS7, it indicates that the sequence has \(2^7 - 1 = 127\) bits before repeating the sequence. Analogously, the PRBS9 signal has \(2^9 - 1 = 511\) bits before repeating the sequence.

In the experiments, each bit of the sequence spans approximately 240 milliseconds before transitioning to the next value. The recorded data do not cover the entire sequence, registering the first ten seconds of the PRBS7 signal and the first 20 seconds of the PRBS9 signal.
| Input Voltage Signal | Description | Tab Name | N° of Trials | Tab Name | N° of Trials |
|----------------------|-------------|----------|--------------|----------|--------------|
| Pseudorandom Binary Sequence 7 | A binary sequence with ten seconds long generated with a deterministic algorithm. Each bit has approximately 240 milliseconds of span. There is no load attached to the motor shaft. | PRBS7-MotorA | 10 | PRBS9-MotorB | 11 |
| Pseudorandom Binary Sequence 9 | A binary sequence with twenty seconds long generated with a deterministic algorithm. Each bit has approximately 240 milliseconds of span. There is no load attached to the motor shaft. | PRBS9-MotorA | 11 | PRBS9-MotorB | 11 |
| Sine Wave 10 Hz | Sine wave generated throughout the Arduino PWM output. The algorithm updates the PWM output every 3.88 microseconds to generate an approximated 10 Hz wave. There is no load attached to the motor shaft. | Sine10Hz-MotorA | 10 | Sine10Hz-MotorB | 10 |
| Sine Wave 1 Hz | Sine wave generated throughout the Arduino PWM output. The algorithm updates the PWM output every 3.88 milliseconds to generate an approximated 10 Hz wave. There is no load attached to the motor shaft. | Sine1Hz-MotorA | 10 | Sine1Hz-MotorB | 10 |
| Sine Wave 0.1 Hz | Sine wave generated throughout the Arduino PWM output. The algorithm updates the PWM output every 38.8 milliseconds to generate an approximated 10 Hz wave. There is no load attached to the motor shaft. | Sine0.1Hz-MotorA | 10 | Sine0.1Hz-MotorB | 10 |
| Triangle Wave 10 Hz | Triangle wave generated throughout the Arduino PWM output. The algorithm updates the PWM output every 388 microseconds to generate an approximated 10 Hz wave. There is no load attached to the motor shaft. | Triangle10Hz-MotorA | 10 | Triangle10Hz-MotorB | 10 |
| Triangle Wave 1 Hz | Triangle wave generated throughout the Arduino PWM output. The algorithm updates the PWM output every 3.88 milliseconds to generate an approximated 10 Hz wave. There is no load attached to the motor shaft. | Triangle1Hz-MotorA | 10 | Triangle1Hz-MotorB | 13 |
| Triangle Wave 0.1 Hz | Triangle wave generated throughout the Arduino PWM output. The algorithm updates the PWM output every 38.8 milliseconds to generate an approximated 10 Hz wave. There is no load attached to the motor shaft. | Triangle0.1Hz-MotorA | 10 | Triangle0.1Hz-MotorB | 10 |
| Square Wave | Square Wave with alternate spin direction and 1/4 Hz. There is no load attached to the motor shaft. | SquareWave-MotorA | 10 | SquareWave-MotorB | 10 |

(continued on next page)
Table 2 (continued)

| Input Voltage Signal | Description                                                                                                                                                                                                                     | Tab Name                  | N° of Trials | Tab Name                  | N° of Trials |
|----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|--------------|---------------------------|--------------|
|                      | Voltage step applied to the motor without attached load and a duration of 2.4 seconds. Trials were divided into step percentages regarding the PWM duty cycle. Steps amplitude: 3%, 4%, 5%, 7%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, and 100%. | StepNoLoad-MotorA         | 122          | StepNoLoad-MotorB         | 152          |
| Step without load    | Voltage step applied to the motor with adjusted load attached to the motor shaft. Trials were divided into step percentages regarding the PWM duty cycle and load range (1 kg to 4 kg). The steps duration was modified due to the load, and it was adjusted to maximize the observation time. Steps amplitude: 40%, 50%, 60%, 70%, 80%, 90%, and 100%. Loads: 1 kg, 2 kg, 3 kg, and 4 kg. | StepLoaded-MotorA         | 283          | StepLoaded-MotorB         | 315          |

Fig. 1. PRSB7 signal applied to the DC motor A and B and the respective measured voltages.

The sine and triangular waves were tested with three frequencies, 0.1 Hz, 1 Hz, and 10 Hz. The Arduino algorithm uses lookup tables with 256 values to generate the reference signal in output PWM values. To generate the reference signals in each frequency, the algorithm updates the PWM output as described in Table 2, but referring to the same lookup table.

Fig. 3 shows the sine waves reference signal and the motor voltages measured for motor A, while Fig. 4 shows the data for motor B.

Likewise, Fig. 5 shows the triangle waves reference signal and respective measured voltages for motor A and Fig. 6 for motor B.
Fig. 2. PRBS9 signal applied to the DC motor A and B and the respective measured voltages.

Fig. 3. Sine waves of 0.1 Hz, 1 Hz and 10 Hz, respectively, applied to the DC motor A and the respective measured voltages.

The square wave signal tests the DC motors in both rotation directions. It applies a maximum voltage pulse to the motor during 1 s, alternating the rotation direction, generating a 0.25 Hz wave from the DC motor perspective. Two and a half cycles of the signal were recorded in the experiments.

Fig. 7 shows the reference signals, the motor status values at each instant, and the measured motor voltage for both tested DC motors.

The last type of tested signal is the voltage step. It was applied to the DC motors without and with a load attached to the motor shaft. As described in Table 2, the signal amplitudes cover the output scale from the minimum value that starts the motor to the maximum voltage value under no-load conditions.
To exemplify the recorded data, Fig. 8 shows six reference steps and their respective measured motor voltages. The bottom plots detail the measured voltage in a shorter time scale as the motor driver outputs a PWM signal.

Concerning the loaded condition, steps with an amplitude from 40% to 100% were tested with four load stages, as described in Table 1. The recorded data has different time spans according to the tested load. Fig. 9 shows the input steps and the measured velocities to motor A with the load adjustment. The input is the same for each load value. Likewise, Fig. 10 shows the data from motor B trials.
Fig. 6. Triangle waves of 0.1 Hz, 1 Hz and 10 Hz, respectively, applied to the DC motor B and the respective measured voltages.

Fig. 7. Square wave signal with rotation direction inversion applied to the DC motor A and B and the respective measured voltages. The Motor Status graph shows the rotation direction at each period, generating a 0.25 Hz wave.
Fig. 8. Voltage steps applied to the DC motor A and B under no-load condition, and the respective measured voltages.

Fig. 9. Step signals applied to the DC motor A under loaded condition, and the respective measured velocities.
2. Experimental Design, Material and Methods

Table 3 shows the description and essential specifications of the sensors used in the experiments to measure the DC motor current, voltage, and speed, and the other devices as the Arduino Mega board, the encoder count board, the DC motors, the objects of the experiments, and the motor driver circuit used for motor actuation.

Fig. 11 shows the experimental platform layout, highlighting each component. To simplify, the devices’ interconnections are not displayed. The proposed platform was designed as a portable experimental apparatus that can be used on different workbench heights. A traction pulley is attached to the DC motor shaft to test the motor with a concentrated load to resemble the AGV operation under a loaded condition. It also allows the exchange of the motor-encoder set, keeping the other measuring devices.
Table 3
Description and specifications of the sensors and other electronic devices used in the experiments.

| Device       | Description                                      | Specifications                                                                 |
|--------------|--------------------------------------------------|-------------------------------------------------------------------------------|
| Current Sensor | Hall effect-based current sensor ACS712 [3]      | Supply voltage: 5.0 V; Output sensitivity: 66 mV/A;                           |
|              |                                                  | Input current range: ±30 A;                                                  |
|              |                                                  | Bandwidth: 80 kHz; Output rise time in response to step input current 5 μs; |
|              |                                                  | Output voltage proportional to AC or DC currents                             |
| Voltage Sensor | Voltage divider circuit with three 100 kΩ resistors | Maximum input voltage: 12.0 V; Output range, approx.: 0 – 4 V;              |
| Rotary Incremental Encoder | Omron E6B2-CWZ6C [4] | Supply voltage: 5.0 V; Resolution (pulses/rotation): 1800;                   |
|              |                                                  | Current consumption: 80 mA max.; Output phases: A, B, Z;                    |
|              |                                                  | Phase difference between outputs: 90° ± 45° between A and B;                |
|              |                                                  | Output configuration: NPN open-collector output;                            |
|              |                                                  | Maximum response frequency: 100 kHz                                         |
| Arduino Board | Arduino Mega 2560 Rev3                            | Microcontroller: ATmega2560; Clock Speed: 16 MHz;                           |
| Encoder Counter | Quadrate Counter with Serial Interface based on the LS7366R IC [5] | Operating Voltage: 3 V to 5.5 V; 5 V count frequency: 40 MHz;               |
| DC Motor     | Worm Geared DC Motor                              | Nominal input voltage: 12.0 V; Rotating Speed (No-load): 470 RPM;           |
| Driver       | SparkFun Monster Moto Shield based-on VNH2SP30-E full-bridge IC [6] | Supply Voltage, max.: 16 V; Maximum current rating: 30 A;                   |
|              |                                                  | Practical Continuous Current: 14 A;                                          |
|              |                                                  | MOSFET on-resistance: 19 mΩ (per leg);                                     |
|              |                                                  | Maximum PWM frequency: 20 kHz; Thermal Shutdown;                            |
|              |                                                  | Undervoltage and Overvoltage shutdown                                        |

Fig. 12 presents the electronics schematics of the experimental platform, detailing the connections between the device and Arduino pins used. Arduino’s analog input pins read the current and voltage sensors, and the encoder pulses are primarily counted in a quadrate encoder buffer and then transmitted to the Arduino via serial communication using the Serial Peripheral Interface (SPI) protocol.

Fig. 13 shows the typical flowchart of the data acquisition Arduino code [1] used in the experiments. The first lane, called Initial Declarations, encompasses the inclusion of libraries, pins definitions, and the declaration of variables used throughout the code.

Next, in the void setup() lane, the necessary configurations are carried out to execute data acquisition, such as the configuration of the Arduino pins mode, sensor initialization, and the timer used to count the interruption period. Thus, the overflow of the timer, i.e., when it reaches the 10 ms count, is the interruption trigger, which is the routine responsible for reading the sensors and updating the command to the motor driver.

Still in Fig. 13, the lane named void loop() represents the main execution loop of data acquisition. At each interruption occurrence, the sensors are read, the necessary calculations are carried out, the variables of interest are transmitted via serial communication, and the command output of the full-bridge motor driver is updated.

The motor driver command signal is only sent when the motor start criterion is satisfied. For this work, the criterion was a time interval of 10 ms, i.e., the motor only starts after 10 ms have passed since the Arduino was started. Before that, the motor only receives a zero speed value, meaning the duty cycle is minimal, and the output of the motor drive is not enabled. Finally, if
Fig. 12. Electronics schematics of the experimental platform. The resistors measured values are: $R_1 + R_2 = 192.5 \, \text{k}\Omega$, $R_3 = 100 \, \text{k}\Omega$, $R_4 + R_5 = 195 \, \text{k}\Omega$, and $R_6 = 100 \, \text{k}\Omega$.

The necessary data acquisition has been performed, the execution is stopped. The Arduino codes used for each signal input tested are available in [1].

The experimental procedure consists in defining the DC motor input signal from Table 1 and repeating the stimuli at least ten times, recording the sensors data in a .csv file using Ardu Spreadsheet [7], an Arduino IDE tool. For each tested input, the motor conditions are kept the same. In the case of the motor under load conditions, the platform allows the installation of a pulley and a cable so that the DC motor can pull an experimental load.

The platform was attached to a workbench for the execution of the experiments, and its height has limited the load excursion. Therefore, the structure height has limited the DC motors input stimuli duration. Fig. 14 shows the accessory attached to the motor shaft to adjust the experimental load, and Fig. 15 exhibits the real platform used to record the data.

3. DC Motor Efficiency Estimation

Efficiency in a DC motor is generally defined as the ratio between the power output and power input. During the conversion of electrical energy into mechanical energy, several losses
DC motor data acquisition flowchart

Begin

Libraries Inclusion and pins definitions

Variables initialization

void setup()

Input and output pins setting

Set the serial communication

Initialization of the SPI protocol and communication to the encoder buffer board

Clear the encoder counter

Current sensor calibration

Set the Arduino timer peripheral

Clear the motor speed variable

Enable the motor driver output

void loop()

Timer register burst

Yes

Read encoder counter

Calculate the motor speed

Read motor current

No

Read voltages from motor terminals

Calculate the motor potential difference

Print the reading via serial communication

Save the last encoder count

End data acquisition

End of data acquisition

Motor start condition reached

Yes

Update the duty cycle value according to the motor input signal

Write the duty cycle value in the Arduino PWM output pin

End data acquisition

No

End

Fig. 13. Flowchart of the data acquisition code embedded in Arduino.
occur [8]. These losses are electrical, such as copper or magnet, and mechanical, such as friction losses. The experimental platform does not intend to measure them. However, from the data of loaded condition experiments, one can estimate the efficiency of the DC motor.

The loads applied to the motor shaft are known. Considering that the adjustable load inclicts a traction force $T$ to the center of the motor shaft at a 90 degrees angle, as Fig. 16 shows. Disregarding the steel cable mass, the load torque $\tau_{load} \ [N.m]$ is calculated according to Eq. (5), where $m[kg]$ is the mass of the load, $g \ [m/s^2]$ is the gravitational acceleration, and $d = 6.1 \ mm = 0.0061 \ m$ is the distance between the center of the motor shaft and the pulley.

$$\tau_{load} = mgd$$

(5)

With the estimated load torque value, the power output $P_{out}$ is calculated by Eq. (6), where the motor velocity $V$ from Eq. (1), in RPM, is converted to radians per second, so the final unit is Watts [W].

$$P_{out} = \tau_{load} \frac{2\pi V}{60}$$

(6)

Eq. (7) gives the input power $P_{in}$, in W, where $i$ is current given by Eq. (2), and $v_x$ is the voltage obtained by Eq. (3). Eq. (8) calculates the motor efficiency $\eta$, relating the power input and the estimated produced power output.

$$P_{in} = v_x i$$

(7)

$$\eta = \frac{P_{out}}{P_{in}} \times 100\%$$

(8)
Fig. 15. Experimental platform developed to DC motor experiments.

Fig. 16. Study of the torque output developed by the DC motors.
Appendix A. Supplementary data

Supplementary data to this article can be found online at Data in Brief paper’s website or at [9] https://data.mendeley.com/datasets/2rkpsss6fd/2

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships which have, or could be perceived to have, influenced the work reported in this article.

CRediT Author Statement

Wallace Pereira Neves dos Reis: Conceptualization, Methodology, Software, Investigation, Writing – original draft; Giselle Elias Couto: Investigation, Writing – review & editing; Orides Morandin Junior: Conceptualization, Supervision, Writing – review & editing.

Acknowledgments

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001. Wallace dos Reis was financed in part by the Federal Institute of Education, Science and Technology of Rio de Janeiro – IFRJ, campus Volta Redonda.

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.dib.2022.107802.

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