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LabVIEW based Continuous Monitoring of Separately Excited DC Motor

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ABSTRACT

In this day and age the applications of electrical machines are diverse and overall quite advantageous to our current way of life. For this purpose, we have to make sure that the machines themselves are operating properly and are well maintained. In this paper two LabVIEW models have been presented which carry out continuous monitoring of both the single-phase induction motor and the separately excited dc motor. Also, their real time performance characteristics are analyzed to detect faults. Using Data Acquisition System (DAQ) this is achieved and LabVIEW version 2017 has been used.

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1. INTRODUCTION *(GİRİŞ)*

A simple electric motor makes electric energy. They work due to electromagnetic interactions. An electric motor is an electric machine that converts electrical energy into mechanical energy. In normal motoring mode, most electric motors operate through the interaction between an electric motor's magnetic field and winding currents to generate force within the motor. In certain applications, such as in the transportation industry with traction motors, electric motors can operate in both motoring and generating or breaking modes to also produce electrical energy from mechanical energy. The first thing you need to know is that magnets are the reason things move, and that's because magnets have poles such as north and south. Opposites attract and likes repel is true with any magnet. When electricity is running through the loop or coil you have made the electricity passes through the magnetic field. The magnet having both a north and a south pole attracts and repels the current through the rotor causing it to spin. This repetitive attracting and repelling can thus go on continuously as long as a stable current goes through it.

The aim of this project is to use LabVIEW to design a continuous monitoring and system for Separately Excited DC Motor. Also, the real time performance characteristics of the Separately Excited DC Motor will be analyzed using LabVIEW and DAQ system (to interface the motor with LabVIEW model).

In [1], LM35 and CNY70 have been used to collect data about temperature and rotor speed from the motor. This has been given to the LabView model using NI 6008 DAQ (Data Acquisition System) for monitoring and control of the motor.

In [2], A wireless sensor system has been implemented in accordance with IEEE 802.15.4 standard. This has resulted in a low cost, highly reliable and compact design.

Direct Current Motor

The DC or Direct Current motor works on the principle that when a current carrying conductor is placed inside a magnetic field it experiences torque and has a tendency to move. This is also known as motoring action and is caused by the interaction of electric field and magnetic field on the charges present in the conductor that produces mechanical movement [4]. The direction of which is given by Fleming's left-hand rule, which states that if the index finger, middle finger and thumb of your left hand are extended mutually perpendicular to each other and if the index finger represents the direction of magnetic field, middle finger indicates the direction of current, then the thumb represents the direction in which force is experienced by the shaft of the DC motor [4]. Structurally and construction wise a direct current motor is exactly similar to a DC generator, but electrically it is just the opposite. Here we unlike a generator we supply electrical energy to the input port and derive mechanical energy from the output port [4]. We can represent it by the block diagram shown in figure (1).

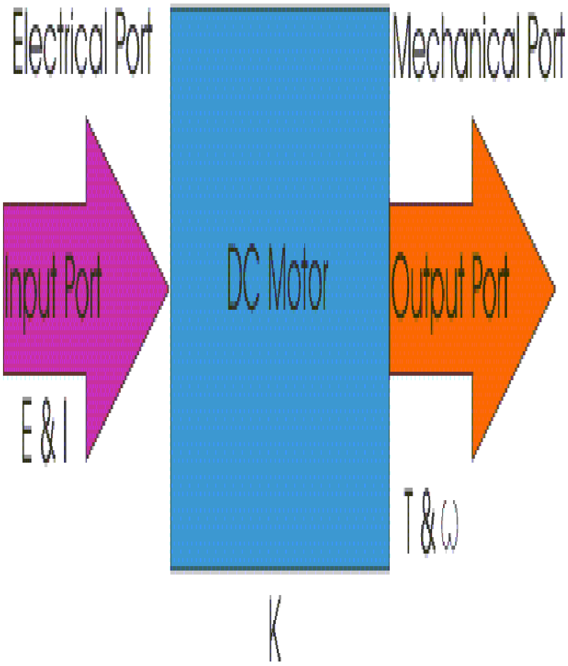

Figure 1. Block Diagram of DC Motor

Here in a DC motor, the supply voltage E and current I is given to the electrical port or the input port and we derive the mechanical output i.e. torque T and speed ω from the mechanical port or output port.

Separately Excited Direct Current Motor

As the name suggests, in case of a separately excited DC motor the supply is given separately to the field and armature windings. The main distinguishing fact in these types of DC motor is that, the armature current does not flow through the field windings, as the field winding is energized from a separate external source of DC current as shown in the figure beside [5].

From the torque equation of DC motor, we know that

$$T_g = K\emptyset I_a - (1)$$

So, the torque (T_a) in this case can be varied by varying field flux ($\emptyset$), independent of the armature current (I_a)[6]. The circuit diagram is shown in figure (2).

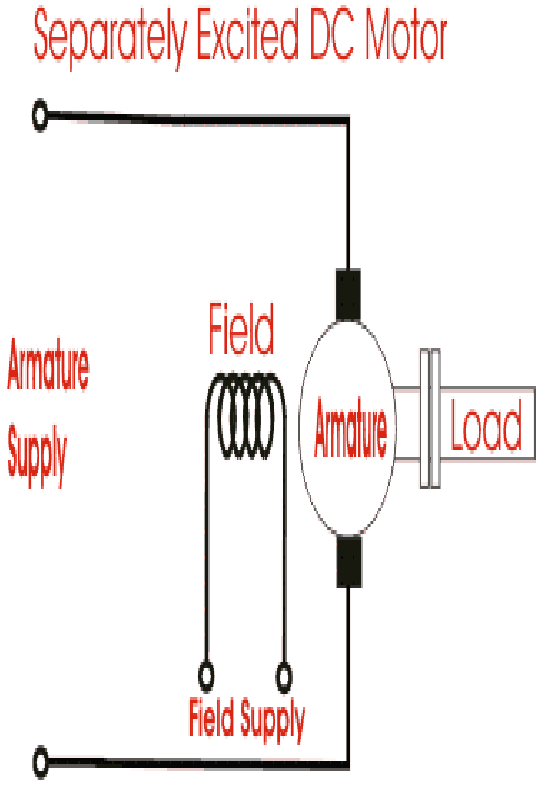

Figure 2. Separately Excited DC Motor

Laboratory Virtual Instrument Engineering Workbench

LabVIEW software which stands for Laboratory Virtual Instrument Engineering Workbench which is a graphical programming language, based upon icons/buttons instead of lines/programming codes for application purpose. This software has the ability to build user-defined interface with set of objects and graphical tools. These programs are labeled as Virtual Instruments, or VIs, owing to their operational replica of physical instruments, like oscilloscopes, multi-meters etc. A Virtual Instrument is the combination of following three components: a. Front panel b. Block diagram c. Icon and connector pane Using above mentioned functions of LabVIEW, the complete course of Electric Machines at under-graduate level has been simulated [3].

Data Acquisition System

The Data Acquisition System (or DAQ for short) is an information collecting system which collects, stores and distributes information. It has applications in commercial and industrial electronics and in environmental and scientific equipment to capture signals and transfer them to a computer [7]. Its general block diagram is given in figure (3).

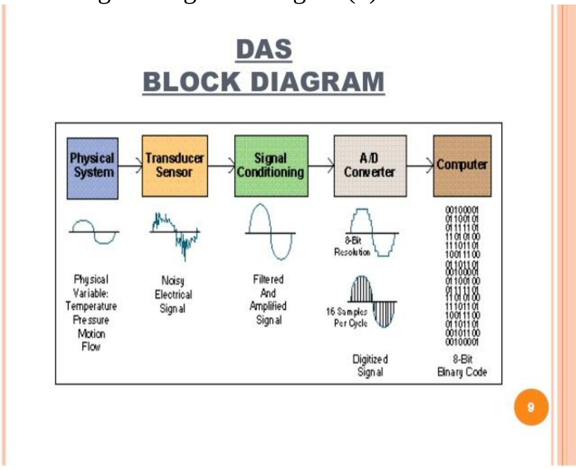

Figure (3)- General Block Diagram of DAQ System

As seen from the above figure the DAQ system can be classified into the following parts [8]:

1. Physical System/ Conditions
   The conditions of the external environment which can be fed to the DAQ system as inputs. A few examples of such conditions are machine speed, temperature, applied voltage, current, pressure, light, applied force, displacement etc.
2. Transducer Sensor
   A transducer is used to convert external inputs such as pressure, temperature, light etc. into readable electric signals of a preset amplitude. They allow any computational system to collect data from the external environment as they convert physical conditions to electric waveforms. Thus, allowing for easier signal processing.
3. Signal Conditioning System
   The signal conditioning circuits are used to change the signals received from the transducers into a better-quality signal thereby making it more suitable for the PC's data acquisition system to convert it in to digital signals. The most common forms of conversion employed by these systems are amplification, linearization, cold-junction compensation, altering, attenuation, excitation etc.
4. Analog to Digital (A/D) Converter
   As the name suggests this system is used to convert analog voltage or current in to digital values. This conversion is necessary as computers will only accept digital signals for processing.

2. METHODOLOGY

The LabVIEW model of the Separately Excited DC Motor is first simulated for reference values to check if the model is working correctly or not. Next the motor is integrated with the LabVIEW model via the Data Acquisition System for continuous monitoring. The experiment performed to check the validity of the LabVIEW model and for real time continuous monitoring is the speed control of the Separately Excited DC Motor.

Experiment Description

Armature Control

1) The connections are made as shown in circuit diagram given in the figure 4.
2) A variable resistance is connected in series with the shunt field and armature.
3) At the time of starting the motor the field rheostat should be kept minimum position and armature rheostat in maximum position.
4) For two different values of field current, the corresponding values of speed are taken, keep the armature voltage constant. Don't increase the speed more than the rated value mentioned on the nameplate of the machine.
5) The graph between armature voltage and speed is plotted.

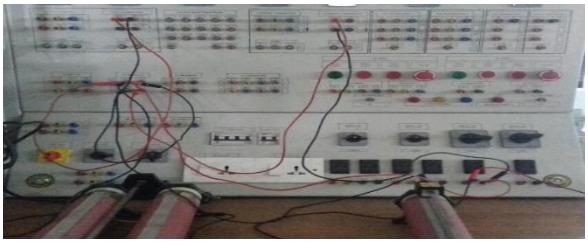

Figure 4 - Hardware connections for Speed Control of Separately Excited DC Motor

Field Control

1) The connections are made as shown in circuit diagram given in the figure 4.
2) A variable resistance is connected in series with the shunt field and armature.

3) At the time of starting the motor the field rheostat should be kept minimum position and armature rheostat in maximum position.
4) For two different values of armature voltage, the corresponding values of speed are taken, keeping the field current constant.
5) The graph between field current and speed is plotted.

Precautions

1. Avoid parallax errors and loose connection.
2. Take care while using the starter.
3. Keep the armature and field rheostats at proper positions.
4. The speed should be adjusted to rated speed.
5. There should be no loose connections.

Motor Modelling

The modelling of the motor in LabVIEW is done basis the equivalent circuit of the motor and the formulas used for this are:

$$K = \frac{ZP}{60A} - (2)$$

$$\emptyset = I_f L_f - (3)$$

$$E_b = V_a - I_a R_a - (4)$$

$$N = \frac{E_b}{K\emptyset} - (5)$$

$$P_{in} = V_a I_a - (6)$$

$$P_{out} = E_b I_a - (7)$$

$$\%n = \frac{P_{out}}{P_{in}} - (8)$$

$$T = \frac{9.55 P_{out}}{N} - (9)$$

Based on these formulas the LabVIEW model given in figure (5) has been designed and simulated first for reference values in order to check the feasibility of the model.

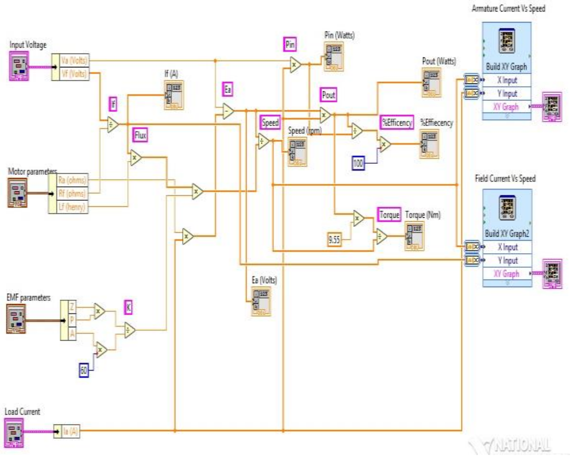

Figure (5) – LabVIEW model for Separately Excited DC Motor.

From the block diagram we are able to get continuous values for the different motor parameters which are then exported to an excel sheet and the graph between different parameters such armature current vs speed and field current vs speed can be plotted.

3. RESULTS

Simulation Results

Armature Control- The LabVIEW block diagram is tested for two different values of field current while performing armature based speed control.

The first one is performed for a field current of 0.5 A. The readings can be seen in Table 1, while the graph can be seen in figure (6)

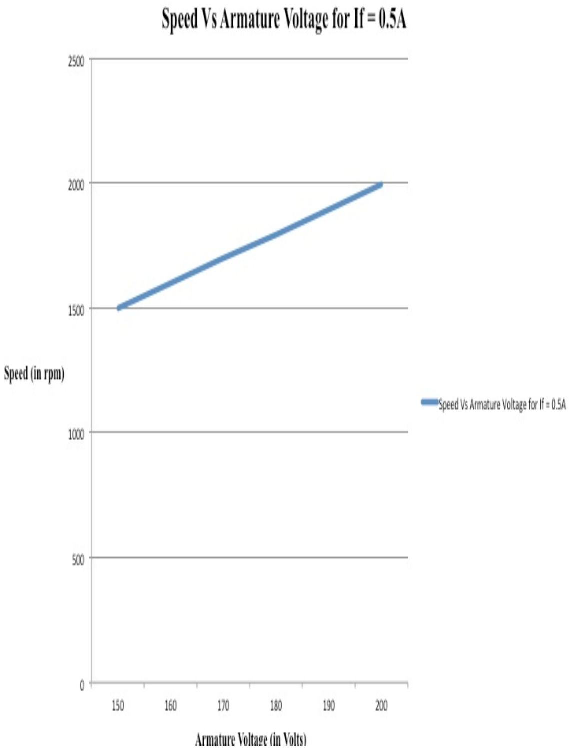

Figure (6)- Armature based speed control for I_f = 0.5A

Table 1- Armature based speed control for I_f = 0.5A

Armature Voltage (in V)	Speed (in rpm)
150	1499.2
160	1598.4
170	1697.6
180	1796.8
190	1896
200	1995.2

The second one is performed for a field current of 0.6 A. The readings can be seen in Table 2, while the graph can be seen in figure (7)

Table 2- Armature based speed control for I_f = 0.6 A

Armature Voltage (in V)	Speed (in rpm)
150	1249.33
160	1332
170	1414.67
180	1497.33
190	1580
200	1662.67

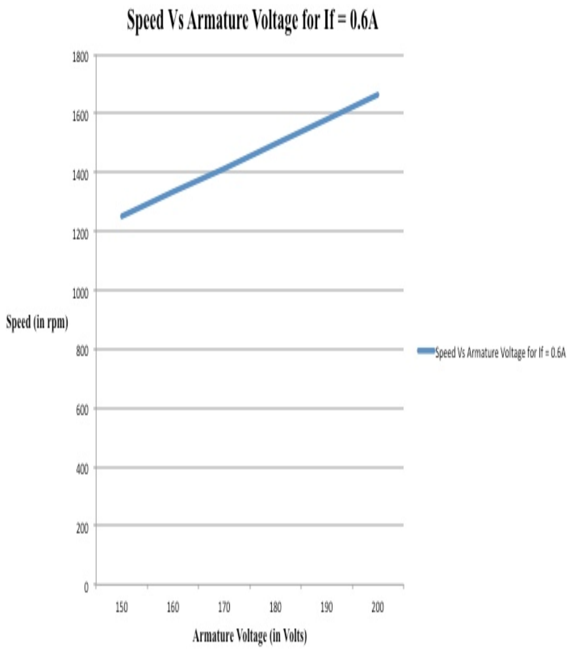

Figure (7) - Armature based speed control for I_f = 0.6 A

Field Control- The LabVIEW block diagram is tested for two different values of armature voltage while performing field based speed control.

The first one is performed for an armature voltage of 190V. The readings can be seen in Table 3, while the graph can be seen in figure (8).

Table 3- Field based speed control for V_a = 190V

Field Current (in A)	Speed (in rpm)
0.9	1055.11
0.8	1186.5
0.7	1355.43
0.6	1580.67
0.5	1896

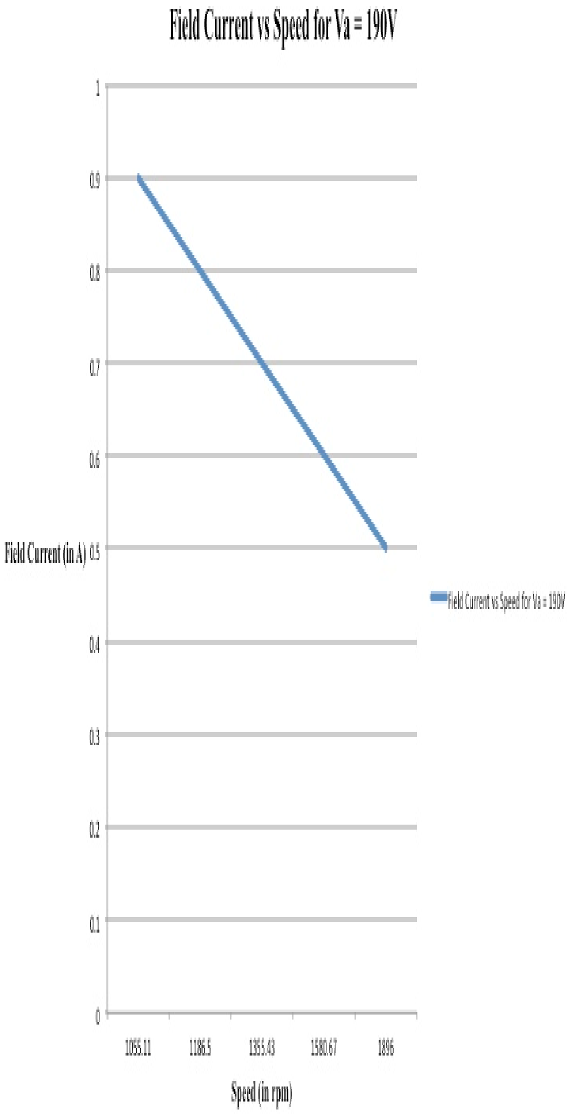

Figure (8) - Field based speed control for V_a = 190V

The second one is performed for an armature voltage of 200V. The readings can be seen in Table 4, while the graph can be seen in figure (9)

Table 4- Field based speed control for V_a = 200V

Field Current (in A)	Speed (in rpm)
0.9	1110.67
0.8	1249
0.7	1426.86
0.6	1664
0.5	1996

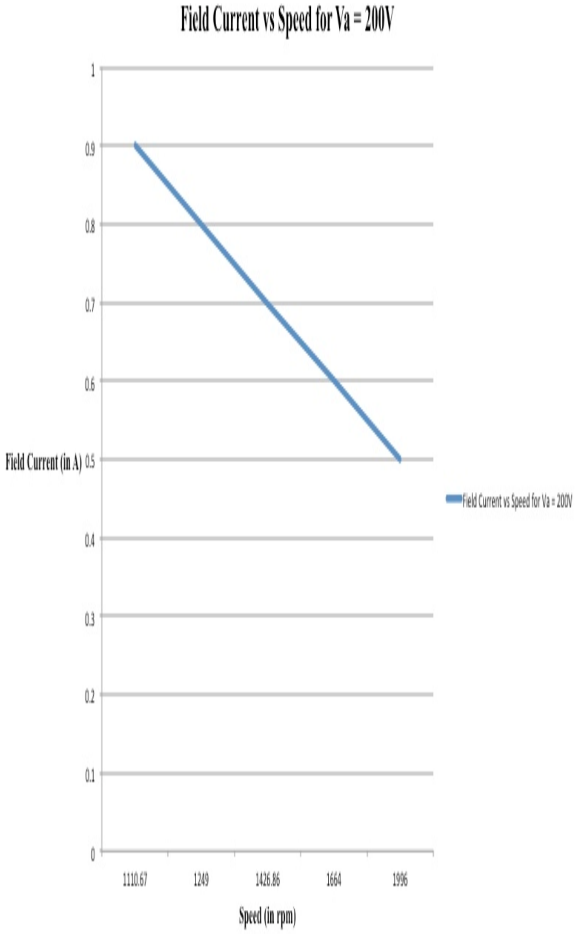

Figure (9) - Field based speed control for V_a = 200V

Hardware Results

Armature Control- The LabVIEW block diagram is now interfaced with the Separately Excited DC Motor using the Data Acquisition System and is tested for two different values of field current while performing armature based speed control.

The first one is performed for a field current of 0.5 A. The readings can be seen in Table 5, while the graph can be seen in figure (10).

Table 5- Armature control readings for I_f = 0.5A

Armature Voltage (in V)	Speed (in rpm)
180	1353
182	1362
184	1375
186	1395
188	1407
190	1423
192	1430

194	1458
196	1463
198	1488
200	1503

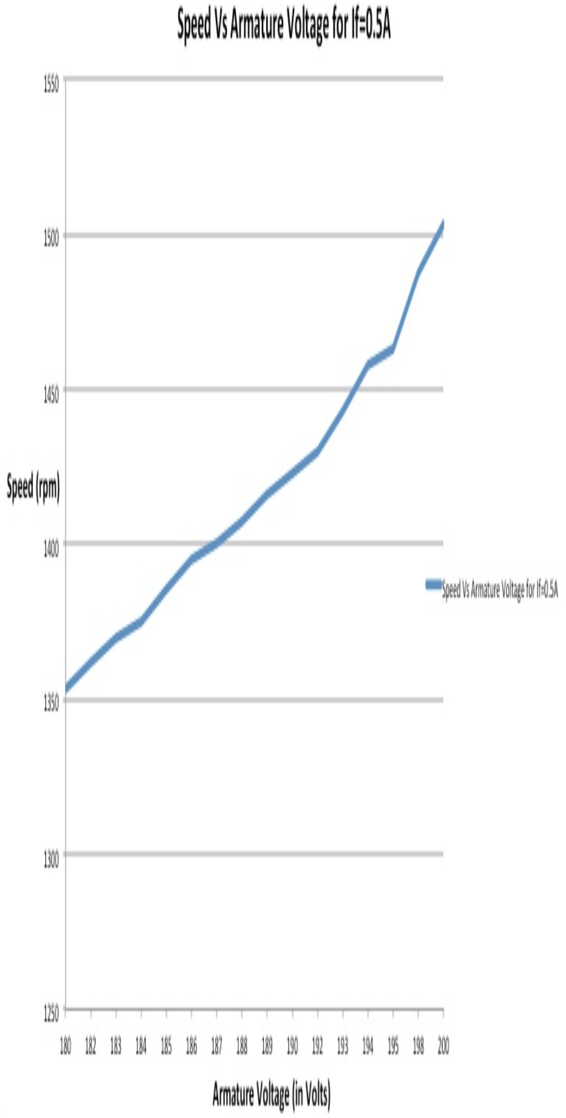

Figure (10) - Armature control readings for I_f = 0.5A

The second one is performed for a field current of 0.3 A. The readings can be seen in Table 6, while the graph can be seen in figure (11).

Table 6- Armature Control for I_f = 0.3A

Armature Voltage (in V)	**Speed (in rpm)**
180	1558
182	1565
184	1578
186	1596
188	1610
190	1624
192	1637
194	1658
196	1667
198	1692
200	1714

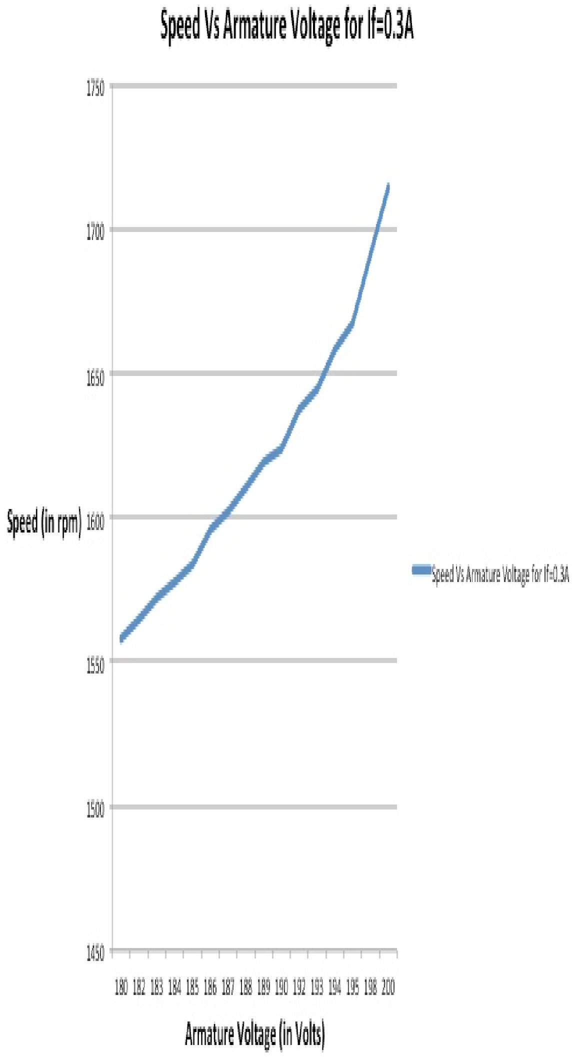

Figure (11) - Armature Control for I_f = 0.3A

Field Control- The LabVIEW block diagram is now interfaced with the Separately Excited DC Motor using the Data Acquisition System and is tested for two different values of armature voltage while performing field based speed control.

The first one is performed for an armature voltage of 200V. The readings can be seen in Table 7, while the graph can be seen in figure (12)

Table 7- Field Control for V_a = 200V

Field Current (in A)	Speed (in rpm)
0.3	1523
0.35	1489
0.4	1456
0.45	1412
0.5	1376
0.55	1347
0.6	1319
0.65	1298
0.7	1276

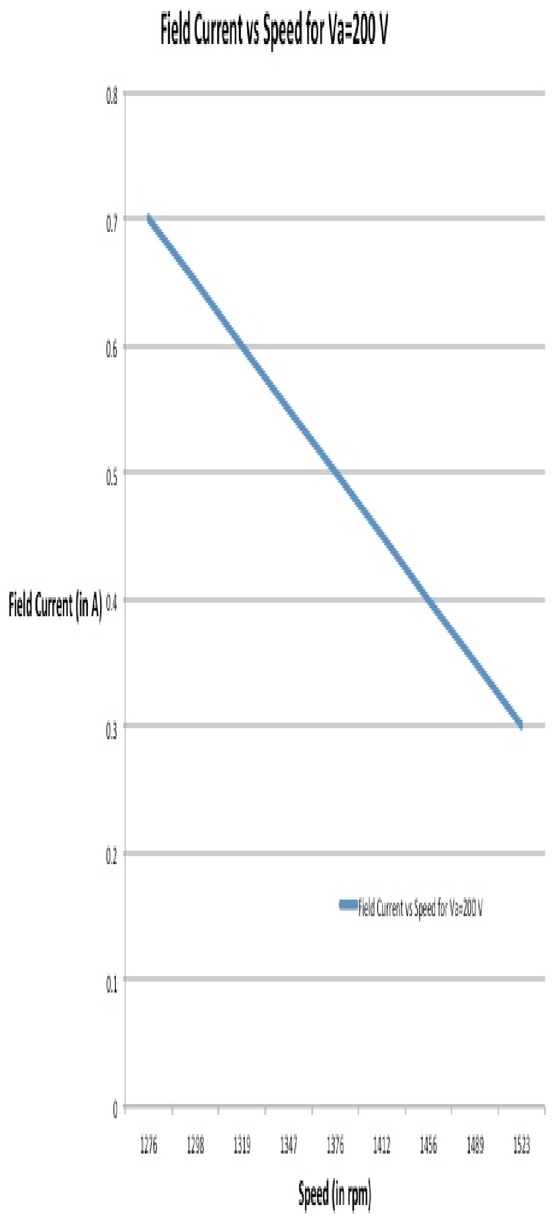

Figure (12) - Field Control for V_a = 200V

The second one is performed for an armature voltage of 190V. The readings can be seen in Table 8, while the graph can be seen in figure (13)

Table 8- Field Control for V_a = 190V

Field Current (in A)	Speed (in rpm)
0.3	1660
0.35	1637
0.4	1560
0.45	1498
0.5	1438
0.55	1410
0.6	1367
0.65	1348
0.7	1315

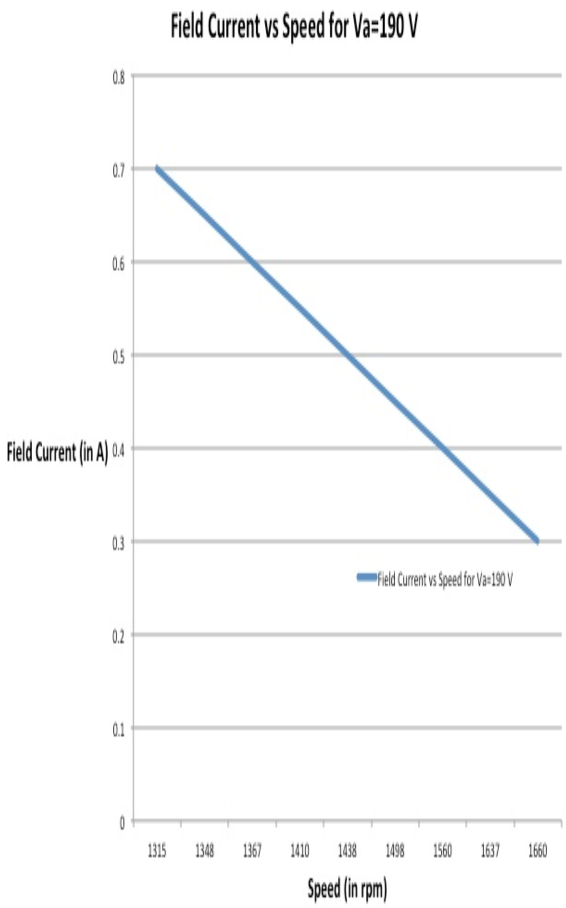

Figure (13) - Field Control for V_a = 190V

CONCLUSION & FUTURE SCOPE

The continuous monitoring system for the Separately Excited DC Moto has been tested and implemented successfully for both reference values and real time values. By analysis of the results it has been found that the motor is in perfect running condition as no faults have been detected.

The future scope of this work is to create an extensive LabVIEW model, which can work for multiple motors at once, thereby making it easier to implement in industries. Also, the bandwidth and the scaling down factors of the Data Acquisition System are constraints, which can limit the working of the monitoring system. A suitable alternative should be found to counter this problem.

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