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An Labview Based Experimental Setup For Electrical Machines

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Abstract: ***This study is about developing a PID (proportional- integration derivation) controller for controlling the speed of DC shunt motor. The software used for designing the controller is LABVIEW. The methodology is divided in two parts first one is software development and second one is interfacing with hardware. In software development calculation of DC motor transfer function and then simulation for finding out the parameter values of PID and developing the software controller. To obtain the value for Kp, Ki and Kd Ziegler-Nichols Closed- Loop Method is used. Finally to interface with the hardware (NIUSB6221) DAQ will be used. After interfacing experimental values of speed control of Dc shunt motor will be taken and transfer to Excel file and graph will be plotted. After that controlling closed loop system of speed control of .This motivation deals with Simulation of Electrical Machines Laboratory experiments which are part of Lab session at under- graduate Electrical Engineering level using Laboratory Virtual Instrument Engineering Workbench (LabVIEW) software.***

Keywords: ***DC motor, Lab VIEW, PID (proportional-integration derivation) controller.***

I. INTRODUCTION

Speed control of DC Motor is important in many applications. The speed control of separately excited DC motors by PID controller is widely used in industry. In this project, we will be designing transfer function for controlling the speed of the DC motor using LabVIEW. By the LabVIEW aided PID controller, the parameters are adjusted to control the motor speed. We will apply Ziegler-Nichols method in order to obtain best process response for tuning parameters of PID controller.

A. Introduction to Labview Software

LabVIEW 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 labelled 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.

II. DC MOTOR MATHEMATICAL MODEL

We will calculate transfer function of DC motor. We will use PID controller for getting optimum result. For calculating transfer function we need all the physical parameters and rating of motor.

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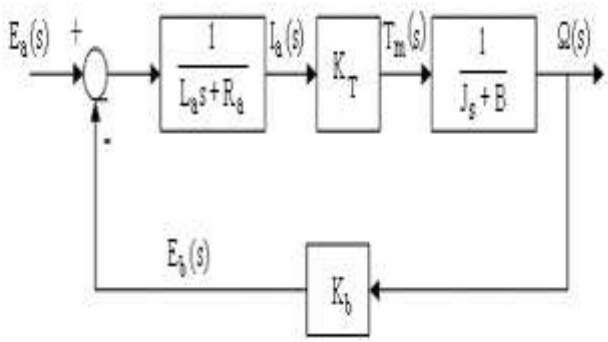


Figure 1 Mathematical model of DC motor

III. VARIOUS METHODS OF SPEED CONTROL OF DC SHUNT MOTOR

A. Field Current Control

In this method armature circuit is provided with a variable resistance. Field is directly connected across the supply so flux is not changed due to variation of series resistance. This is applied for DC shunt motor. This method is used in printing press, cranes, hoists where speeds lower than rated is used for a short period only.

B. Armature Voltage control

This method of speed control needs a variable source of voltage separated from the source supplying the field current. This method avoids disadvantages of poor speed regulation and low efficiency of armature-resistance control methods. The basic adjustable armature voltage control method of speed d control is accomplished by means of an adjustable voltage generator is called Ward Leonard system. This method involves using a motor-generator (M-G) set. This method is best suited for steel rolling mills, paper machines, elevators, mine hoists, etc. This method is known as Ward- Leonard System.

We know, back emf Eb of DC motor is the induced emf in the armature conductors due to the rotation of armature in magnetic field. Thus, magnitude of the E_b can be given by EMF equation of DC motor $E_b = {}^{PØNZ}/_{60A}$ (where, P = no. of poles, Ø = flux/pole, N = speed in rpm, Z = no. of armature conductors, A = parallel paths)

E_b can also be given as,E_b = V- I_aR_a thus, from the above equations N = ${}^{E}{}_{b}\,{}^{60A}/_{PØZ}$ but, for a DC motor A, P and Z are constants Therefore, N ∝ K ${}^{E}{}_{b}/_{Ø}$ (where, K=constant)
This shows the speed of a dc motor is directly proportional to the back emf and inversely proportional to the flux per pole.

IV. PID CONTROL THEORY AND TUNING ALGORITHM

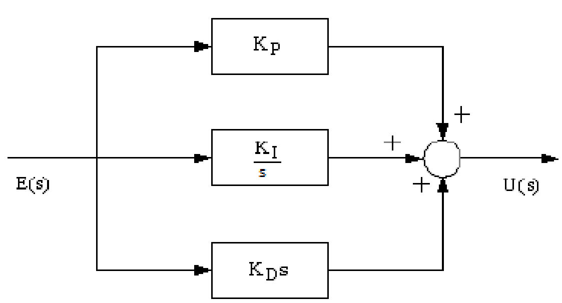


Figure 2. Block Diagram of PID controller

A PID controller is a feedback mechanism control loop (controller) mainly used for controlling industrial systems. A PID controller determines an error value as the difference between a measured process variable and a desired set point. The controller minimizes the error by adjusting the process through a manipulated variable.

Some applications use only one or two actions to provide the good system control. This is obtained by setting the other parameters to zero. A PID controller will be called a PD, PI, I or P controller in the absence of the respective control actions. PI controllers are common, since derivative controller is sensitive to measurement noise, whereas the absence of an integral controller may prevent the system from reaching its required value due to the control action.

V. PID CONTROLLER WITH DC MOTOR

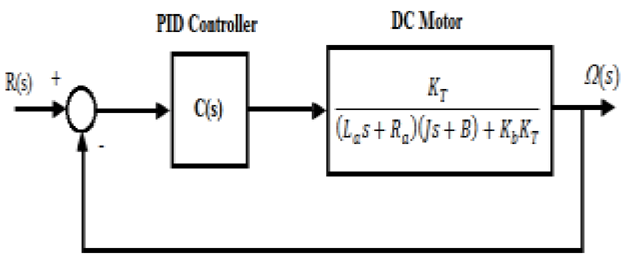


Figure 3 PID controller with DC motor

There are many methods available for tuning of PID controller. We will apply Ziegler-Nichols method in order to obtain best process response for tuning parameters of PID controller.

- Ziegler Nichols method

VI. IMPLEMENTATION OF PROJECT

1. Calculation of transfer function of DC motor theoretically
2. Plotting of Bode plot of transfer function and calculating Ziegler Nichols parameters
3. Model of the DC Motor represented in the Lab VIEW Math-Script Node.
4. Model of the DC Motor control using PID in Block diagram window.
5. Simulation results.

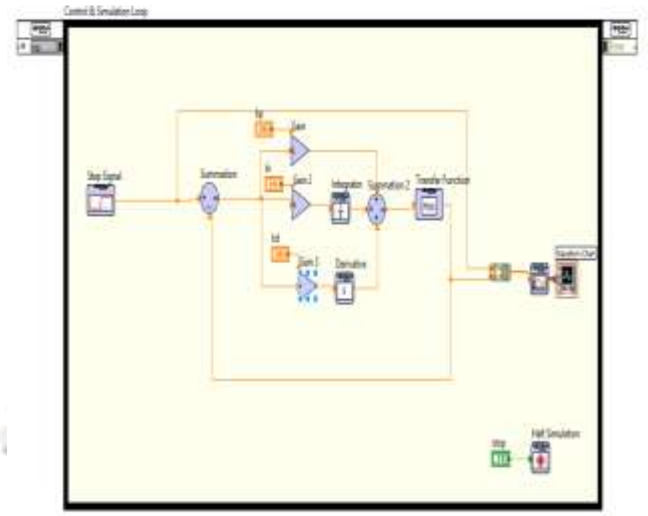
TABLE I Ziegler Nichols Parameters and finding values of Ku and Pu using Bode plot.

Controller	K_p	T_i	T_d
P	$0.5k_u$	∞	0
PI	$0.45k_u$	$P_u/1.2$	0
PID	$0.6k_u$	$P_u/2$	$P_u/8$

TABLE II For K_u=0.445,P_u=0.02

Controller	K_p	K_i	K_d
P	0.22	0	0
PI	0.20	12.63	0
PID	0.26	28.07	0.006

VII. BLOCK DIAGRAM OF DC MOTOR IN LABVIEW



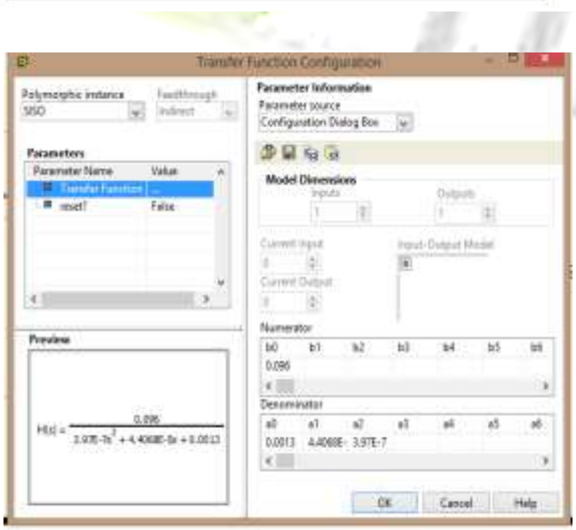


Figure 5.Transfer function of DC motor

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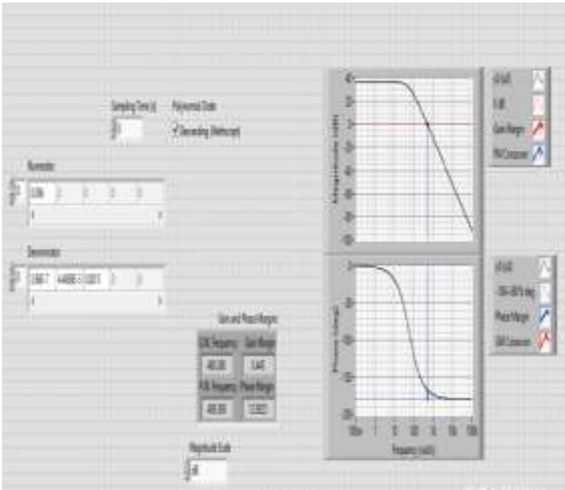

Figure 6 Bode plot of transfer function

VIII. SIMULATION RESULTS

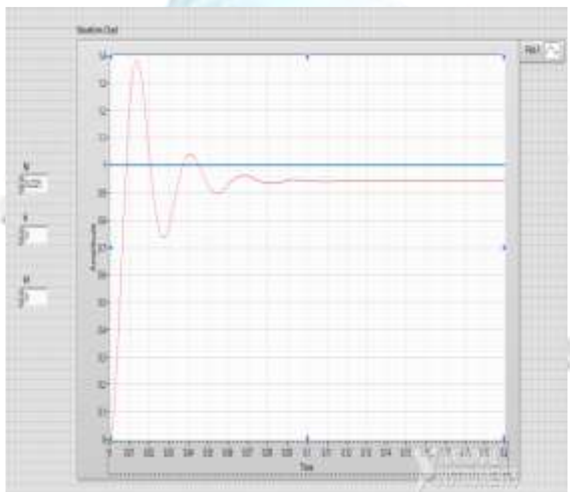

Figure 7.For Kp = 0.22, Ki=0, Kd = 0

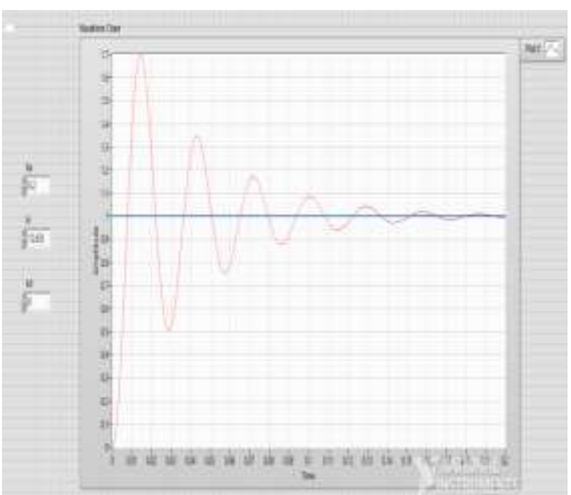

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Figure 8.For Kp=0.20, Ki=12.63, Kd=0

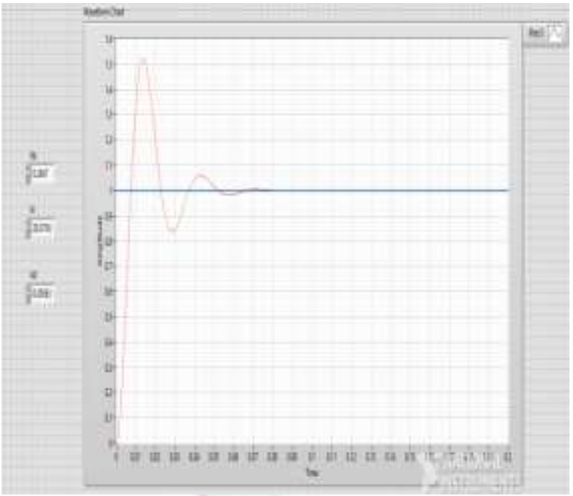

Figure 9 For Kp = 0.26,Ki = 28.07,Kd = 0.006

IX. INTERFACING WITH HARDWARE MACHINE SETUP

Current and voltage sensor unit is mounted on setup. The range of hall voltage sensor is from 0-800V.Each sensor will convert 0-800v input voltage to 0-10V output with same waveform as input. The range of hall current sensor is from 0-25amp.We can measure AC or DC current using this hall current sensor. Each sensor will convert 0-25 input current to 0-10V.IN interfacing we will first perform speed control of Dc shunt motor experiment. We will perform both methods of speed control of Dc shunt motor. First method is armature voltage control method and second is field control method and

we will interface hardware with NIDAQ USB (6221), for getting values in LabVIEW and respective graphs will be plotted. While interfacing with the hardware equipment we
will perform both the methods of speed control of DC shunt motor .The methods are armature control as well as field control. In armature control we will keep field current control and in field control we will keep armature voltage constant.

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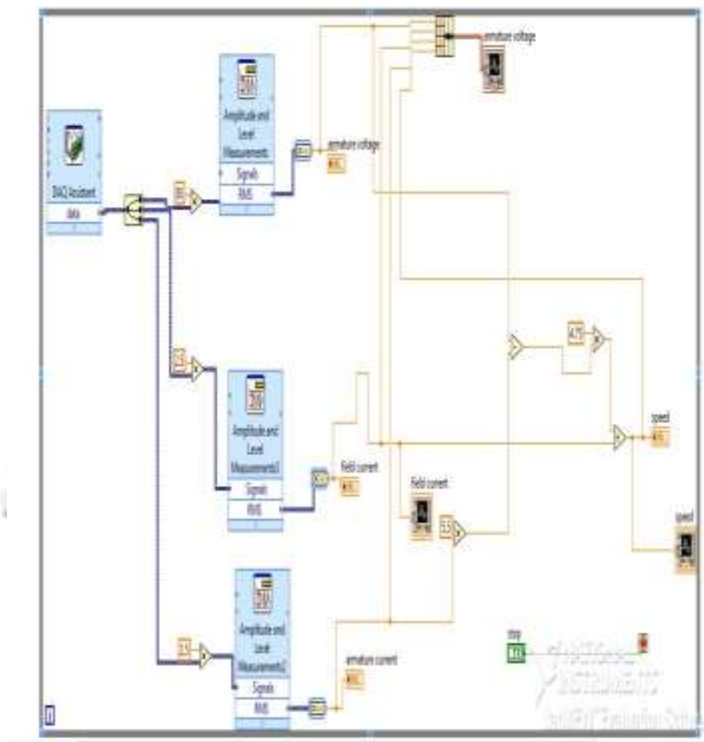

Figure 10.Block Diagram Of Interfacing Niusb (6221) With Hardware In Labview

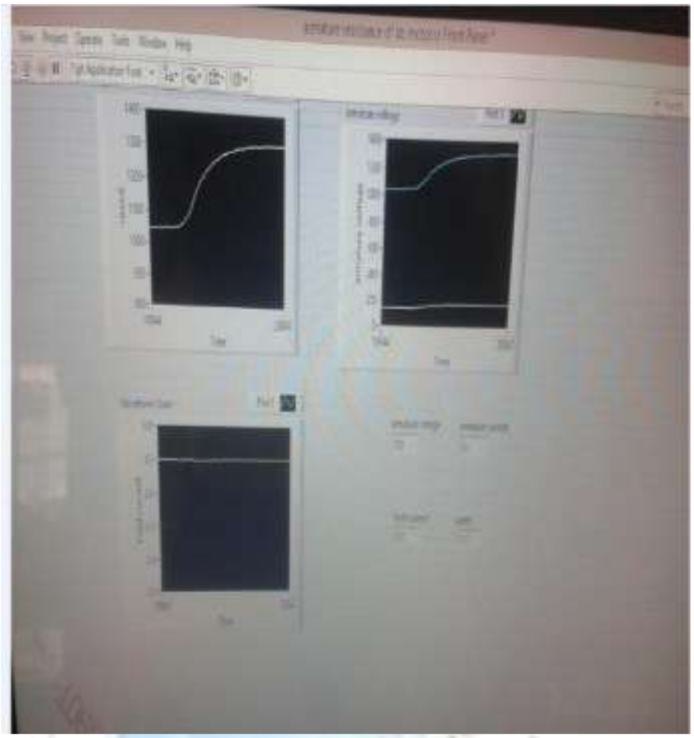

Figure 11 Output in LabVIEW

	A	B	C	D	E	F	G	H
1	Time - armature v	armature voltage - armatu	Time - Pl	armature current -	Time - Pl	field current - Plot	Time - Pl	speed - Plot 3
2	31043	155.522	31043	0.664839	31043	0.635071	31043	1086.1
3	31044	155.621	31044	0.665588	31044	0.637914	31044	1085.5
4	31045	155.834	31045	0.664644	31045	0.660235	31045	1087.7
5	31046	156.07	31046	0.664691	31046	0.689625	31046	1088.
6	31047	156.389	31047	0.664644	31047	0.715361	31047	1089.5
7	31048	156.702	31048	0.66368	31048	0.723161	31048	1093.0
8	31049	156.972	31049	0.664142	31049	0.721445	31049	1094.
9	31050	157.277	31050	0.663943	31050	0.72552	31050	1096.6
10	31051	157.581	31051	0.663476	31051	0.730119	31051	1099.4
11	31052	157.889	31052	0.664305	31052	0.734616	31052	1100.0
12	31053	158.248	31053	0.66394	31053	0.747161	31053	1102.7
13	31054	158.681	31054	0.663247	31054	0.763066	31054	1106.3
14	31055	159.217	31055	0.66381	31055	0.780713	31055	1108.5
15	31056	159.706	31056	0.663424	31056	0.794918	31056	1112.1
16	31057	160.235	31057	0.662784	31057	0.806143	31057	1116.5
17	31058	160.734	31058	0.663094	31058	0.814783	31058	1119.
18	31059	161.302	31059	0.663343	31059	0.824735	31059	1122.5
19	31060	161.875	31060	0.662948	31060	0.831591	31060	1127.0
20	31061	162.458	31061	0.66257	31061	0.837056	31061	1131.6
21	31062	163.07	31062	0.66295	31062	0.845075	31062	1135.0
22	31063	163.689	31063	0.663235	31063	0.850188	31063	1138.8

Figure 12.Values of Armature control of Dc motor

	A	B	C	D	E	F	G	H
1	Time - Plot 0	armature voltage - Plot 0	Time - Plot 1	armature current - Plot 1	Time - Plot 2	field current - Plot 2	Time - Plot 3	speed - Plot 3
2	2928	160.476	2928	0.70451	2928	0.359096	2928	1439.13
3	2929	160.555	2929	0.705238	2929	0.358779	2929	1441.09
4	2930	160.697	2930	0.702608	2930	0.35915	2930	1441.04
5	2931	160.741	2931	0.703524	2931	0.359084	2931	1441.64
6	2932	160.76	2932	0.7088	2932	0.358691	2932	1443.55
7	2933	160.9	2933	0.701138	2933	0.359134	2933	1443.04
8	2934	160.903	2934	0.699036	2934	0.359255	2934	1442.68
9	2935	160.97	2935	0.699767	2935	0.358851	2935	1444.48
10	2936	161.063	2936	0.696556	2936	0.359013	2936	1445.25
11	2937	161.12	2937	0.698653	2937	0.359619	2937	1443.24
12	2938	161.169	2938	0.696342	2938	0.359129	2938	1445.77
13	2939	161.236	2939	0.696733	2939	0.358718	2939	1448.02
14	2940	161.282	2940	0.695453	2940	0.359379	2940	1445.86
15	2941	161.356	2941	0.695246	2941	0.359057	2941	1447.84
16	2942	161.363	2942	0.693347	2942	0.358898	2942	1449.45
17	2943	161.393	2943	0.694385	2943	0.358851	2943	1448.65
18	2944	161.487	2944	0.691201	2944	0.358895	2944	1449.5
19	2945	161.496	2945	0.693112	2945	0.358982	2945	1449.53
20	2946	161.537	2946	0.691624	2946	0.359041	2946	1449.74
21	2947	161.652	2947	0.692196	2947	0.358845	2947	1451.16
22	2948	161.628	2948	0.690066	2948	0.359077	2948	1450.51

Figure 13.Values of Field control of Dc motor

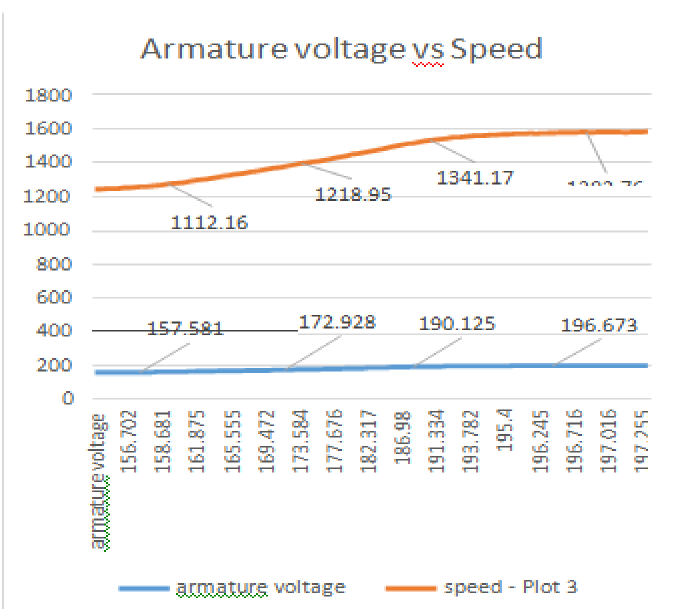

Figure 14. Graph of armature voltage vs speed

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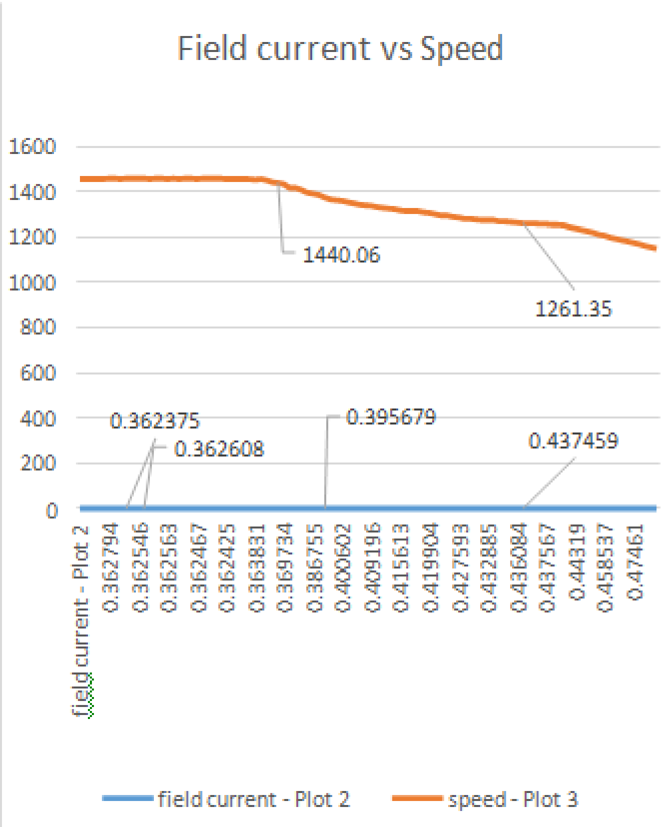

Figure 15.Graph of field current vs. speed

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