ECE 3251 – Electromechanical Energy Conversion

Lab #9: DC Machine

Purpose:

In this lab we will explore the operating characteristics of a typical small DC machine. You will configure the machine to perform no-load and locked rotor tests, and measure the torque vs. speed at several different loads. You will also investigate the possibility of using the induction machine as a variable torque load for the DC machine.

Safety first! You should not wear loose clothing to this lab, dangling jewelry or drawstrings, and if you have long hair, it should be tied up. There are rotating parts!

Lab Procedures:

The setup for the lab bench is shown in Figure 1 below. Note that the induction machine is on the left and there is a DC machine on the right.

1) In the first step, we are going to measure the machine constant K_m for the DC machine, by measuring the open circuit output of the machine, used as a generator and powered by the induction machine.

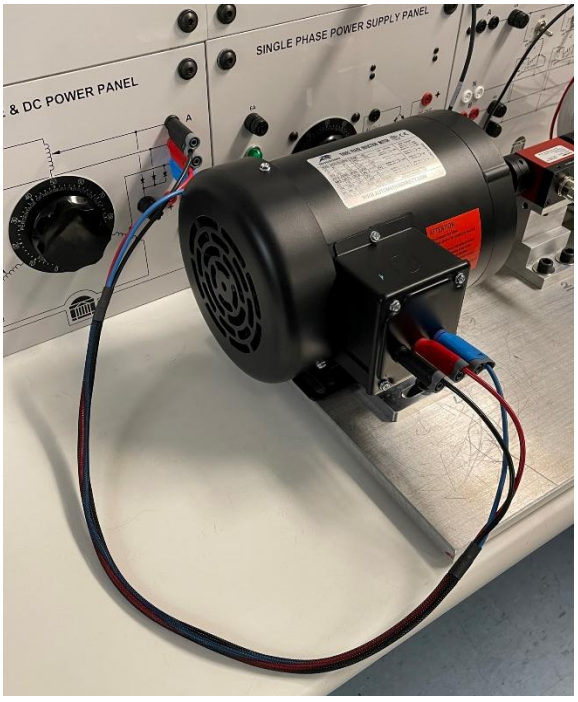

Figure 1

Connect the AC machine as shown in Figure 1. It will be used to spin the DC machine. We will not be measuring power on the AC machine, so just a direct connection to the Power Panel is all that is required.

Connect the DC Machine to the Fluke meter as shown in Figure 2 below. Set the meter to read DC volts. Turn on the Variac, and gradually increase the voltage to full output. Record the rotational speed in Radians/Second and the DC output voltage of the generator, and calculate K_m.

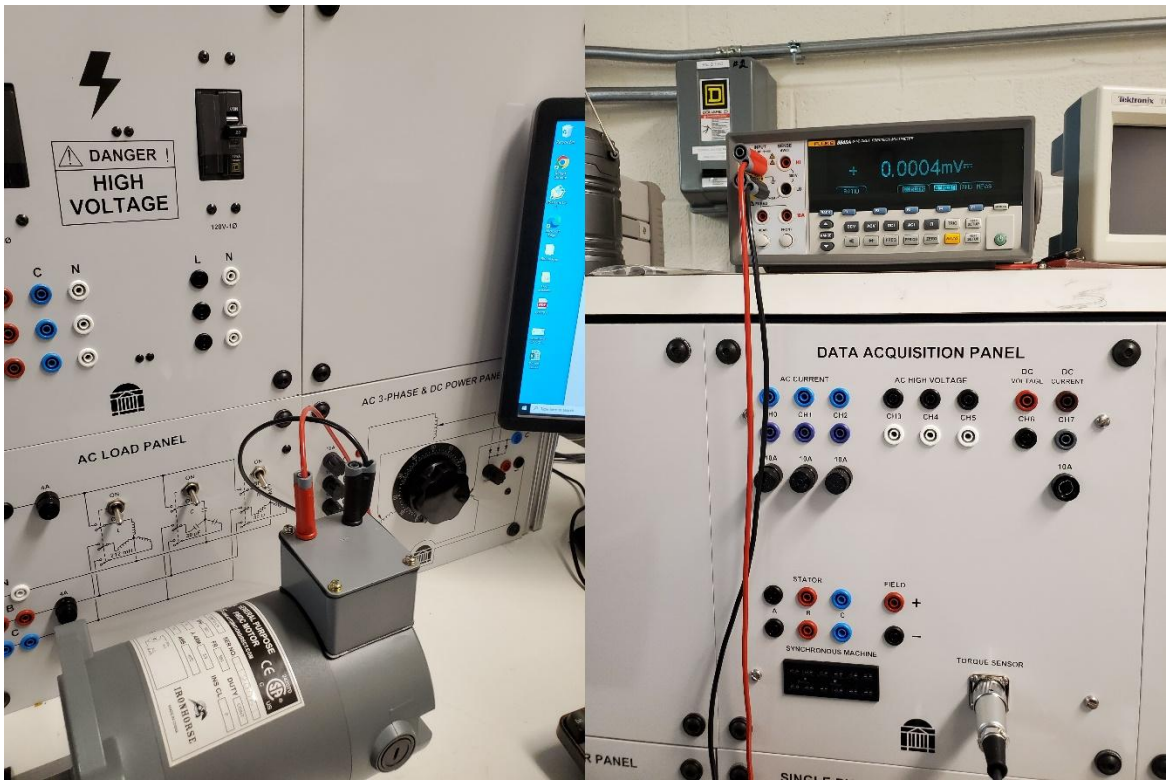

Figure 2

2) Now turn down the voltage on the AC machine and disconnect the leads. Connect the DC Machine to the DC power on the right 3-Phase power panel and Fluke meter as shown in Figure 3. We will use this to set the terminal voltage for the armature. Note that we are recording voltage and current simultaneously via the dual measurement mode.
    a. To set up dual measurement mode, first select DCI for the DC current measurement
    b. Press the Select 2nd Measurement button twice (the F5 button)
    c. The DMM should now have the armature current being monitored in a large font, and the terminal voltage in the small font in the upper right of the display.
    d. Press the F2 button to set the DMM to measure through the 10A fuse instead of the 400mA fuse.

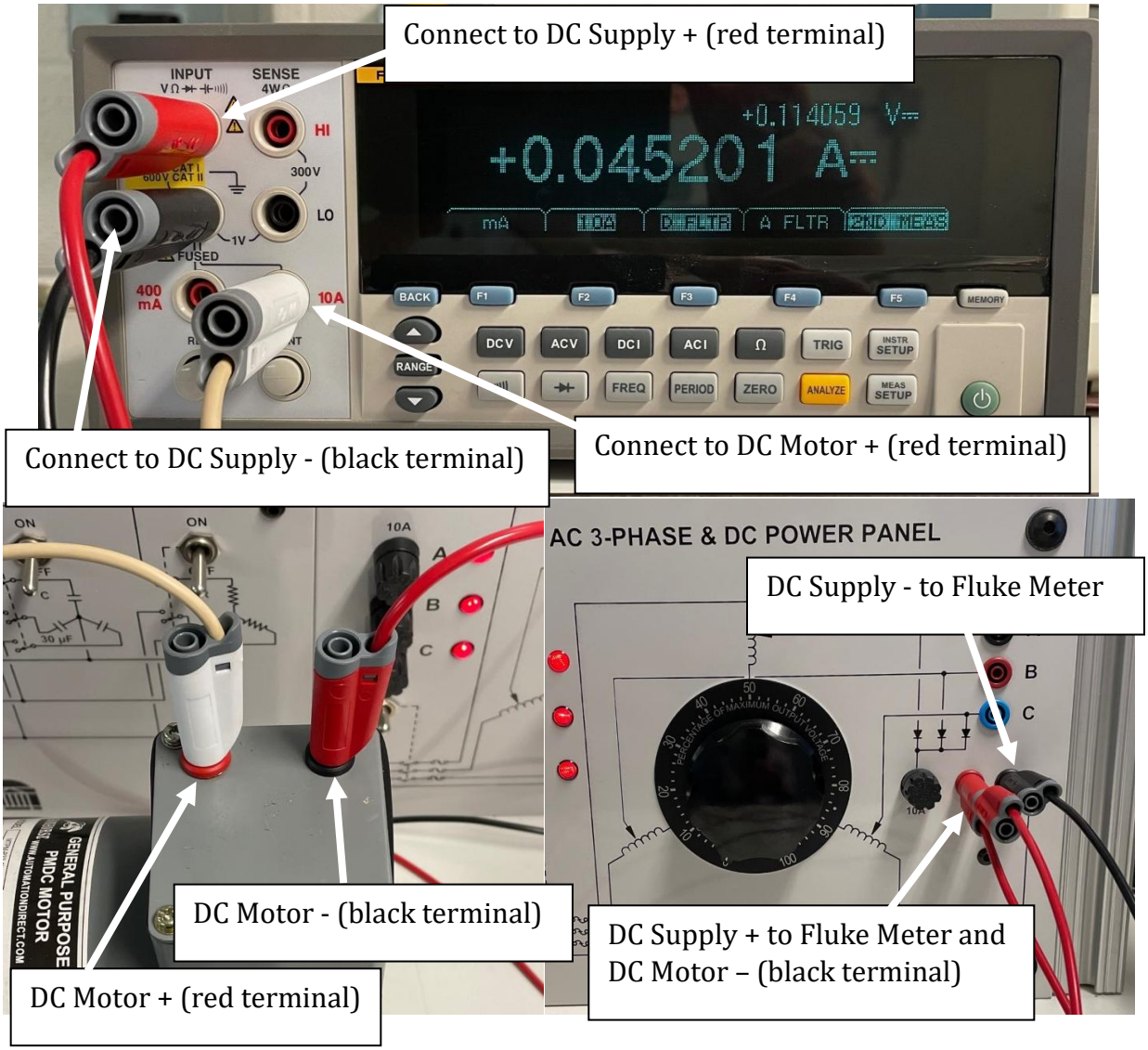

Figure 3

3) On the LabVIEW panel, go to the "Torque and Power" tab, and zero the torque.
4) Connect the AC machine to the DC outputs on the left 3-Phase panel as shown in Figure 4 below.

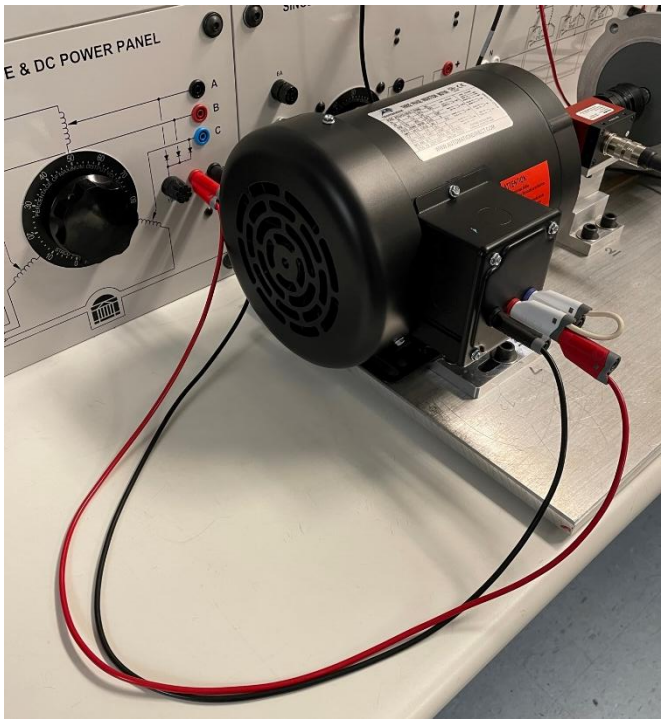

Figure 4

5) Have your TA connect the shaft lock on the AC machine side of the torque/speed transducer. Carefully bring up the voltage on the DC machine until the rated current is reached (your voltage should be less than 10V). **Do not exceed the rated current!** Measure the terminal voltage and armature current on the DC machine using the Fluke meter, and record the torque. Use this information to calculate K_m using the locked rotor info. It should be very close to the value calculated from the open circuit rotational value. Also, use the voltage and current to calculate R_a. Reduce the DC machine voltage back to 0, and have the TA remove the shaft lock.
6) Using the nameplate data on the motor for rated power and speed, calculate the rated torque in N-m. Create a table of 5 equally spaced values of torque from full load to 20% load. For each value, adjust the DC motor voltage to rated conditions, and increase the DC voltage on the AC machine until the torque is reached. (Note that this voltage will be fairly low.) Record voltage, current, torque, shaft speed, power out, and efficiency. **Note:** You may need to readjust the DC voltage to maintain rated voltage conditions on the DC machine, and DC voltage on the AC machine to maintain torque.
7) In your lab write-up, you should explain your calculations for both approaches to finding K_m, and how you obtained R_a. Also, create plots that compare a theoretical torque (using your measure values of K_m and R_a) to shaft speed, armature current, output power, and efficiency. Include on the same plots actual data obtained via

the measurements in step 6). Also, explain how the AC machine may be used as a load with DC applied to the stator.

Grading

- Formal report: Organization, neatness, clear writing, proper formatting of graphs, figures, tables, etc. (15 points)
- Lab Participation: Contributions from each lab partner are fairly distributed and documented (10 points)
- Introduction: What is the purpose of this lab? (5 points)
- Procedures: Brief account of the steps to obtain results (10 points)
- Results: Measurements and calculations for each lab step (45 points)
    - Calculation of machine constant K_m from open circuit test (5 points)
    - Calculation of machine constant K_m and resistance R_a from locked rotor test (10 points)
    - Calculation of rated torque (5 points)
    - Plot of theoretical torque vs. shaft speed, current, output power, and efficiency, including experimental values on the plots (25 points)
- Conclusions: Analysis and explanation of data (15 points)