Lab 2: Energy, power, force and efficiency

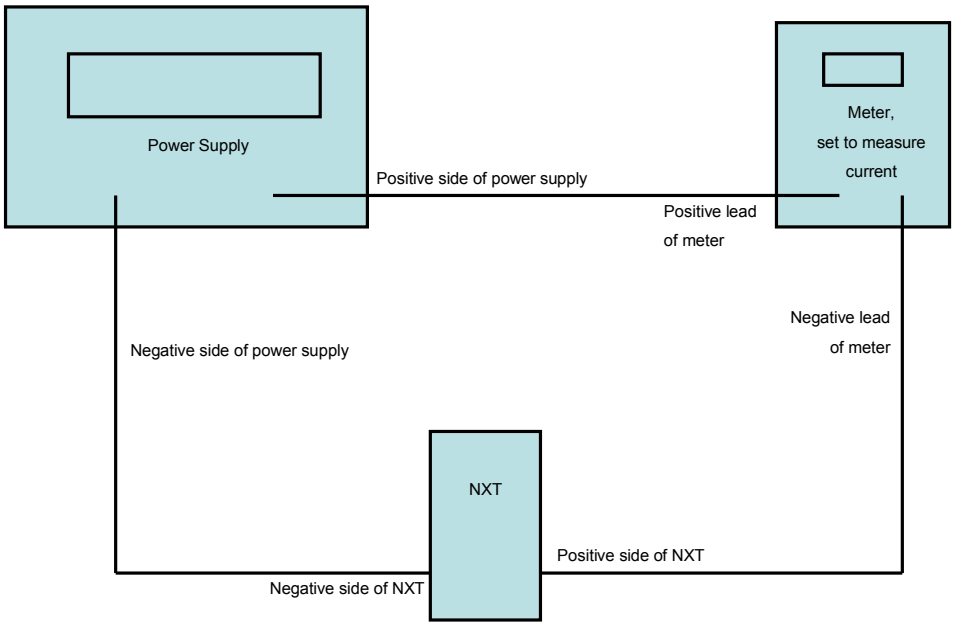
Lab objectives

In this lab you will quantify the power usage, output and efficiency of one motor in the NXT kit. You should try to develop an intuition about how electrical quantities such as power and voltage relate to force and mechanical work in the real world.

In this lab, you will construct a winching system, and use it to lift and lower a weight. The real work performed by this system is the weight x distance. However, we will find that the system uses much more energy than that.

Measuring the current used by the NXT

We want to measure the current that the NXT uses, to get an idea of how much power is going into the system. We can measure the useful work being done by the system, and then determine the systems efficiency. To measure the current used by the system, we will run it off a bench power supply, using a multimeter to measure the current. The circuit should be configured as shown in the following diagram. (Your TA will help you with the setup)



Step by step

1. Modify the Tribot constructed in the last lab in the following way.
    a. Unplug the sensors
    b. Take off the front gripper/sensor apparatus and construct the winching setup as shown in winch.ppt
2. In this experiment, you will use the winch to lift different weights at various motor speed levels. A lot of data is required to characterize a motor, but you will share data between groups to obtain it. Design an experimental procedure and program that will allow you to compute the following quantities when winching up the weight. Design your program to make these experiments easier to do.
    a. Mechanical Work output
    b. Torque output
    c. Electrical power input
    d. Efficiency of the system

    Adjust the bench power supply so that it is capable of providing enough current and then you may assume the voltage remains constant. Use the OUT_REGMODE_SPEED motor mode. The current will fluctuate a bit, try to observe the average current.
3. To characterize the motor, we wish to gather observations at all combinations of the following motor speed levels and weights.
    a) Motor Speeds: 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
    b) Weights: 100g, 200g, 300g, 400g, 500g

    Each group is responsible for carrying out only 10 of the 50 possible combinations. Each observation must be measured at least 5 times. With 15 groups, this means that each observation should be made by 3 groups. That is there will be a total of

15 measurements at each of 50 combinations. You are responsible for coordinating with other groups to be sure this is the case. Now carry out the experiment, and present the data collected in an Excel table.

4. Gather the other data from your colleagues and combine it all in a table. Use simple statistical methods as presented in class to reject outliers from each observation. Generate graphs showing the power used and the efficiency of the system as a function of the load and the motor speed.

To Hand in

1. The experimental procedure you have designed. 5 marks
2. Your winching program 5 marks
3. Experimental results from step 3 10 marks
4. Analysis in 4 25 marks

References

This lab was inspired from the motor tests by Phillippe Hurbain http://www.philohome.com/nxtmotor/nxtmotor.htm