Questions:

Task 6B:

*1) Based on your observations in Task 4 B and C, explain what determines the maximum torque that you can get out a PM Synchronous Motor? Provide an equation to support your answer?*

There are a few factors determining the maximum torque from a motor. In general, power is correlated to torque and speed, and current and voltage as:

P = Tw = IV

Equation X: General Power Formula

In synchronous motors, speed doesn’t change, so the best way to determine maximum torque is to look at power. In our experimental set up, two main factors are efficiency and input voltage. The higher the efficiency, the more torque can be gotten from motor. From Task 4B, Table 3:

T = P(in)\*n/w = 67.3W\*.657/(899rpm\*(2pi/60)) = .47Nm [Maximum torque given highest load]

T = P(in)\*n(perfect)/w = 67.3W\*1/(899rpm\*(2pi/60)) = .71Nm [Maximum torque with ideal efficiency]

Equation X: Comparison of Real and Ideal Motor Efficiency, Showing Efficiency as a Limiting Factor of Maximum Torque

Another way is input voltage. In Task 4C, we reduced input voltage until it stalls. It stalls at around 5.5V input voltage, with 0.48Nm of torque. This means that the amount of input voltage limits the amount of maximum load the motor can take, hence limiting the maximum torque.

*2) How does the efficiency of this BLDC motor compares to that of the Brushed DC Motor in your previous lab? Can you roughly assign the percent of losses to the Inverter, PM Syn. Machine, etc.*

In the previous lab the maximum efficiency of the Brushed DC Motor was observed to be approximately 55%, where our measurement for the BLDC efficiency is 39.4%. Of the BLDC losses 43.5% of the power lost was from the inverter, the remaining 56.5% was from the PM Synchronous Machine. If we compare only the motors, then the Brushed DC Motor and the BLDC motor had similar efficiencies. However, the motors were not necessarily tested under the respective loads and power supplies in which we would observe their maximum efficiencies, so the comparison is only approximate.

*3) Which method in Task 5 B is more practical for controlling the motor speed and why?*

|  |  |  |
| --- | --- | --- |
| V(V) | n(rpm) | Step(V/rpm) |
| 15 | 850 |  |
| 30 | 1686 | 55.73333333 |
| 45 | 2480 | 52.93333333 |

Table X: DC Voltage(Vl) vs n(rpm) at 300ohms

|  |  |  |
| --- | --- | --- |
| D(ul) | n(rpm) | Step(1/rpm) |
| 0.25 | 250 |  |
| 0.5 | 888 | 2552 |
| 1 | 1953 | 2130 |

Table X: Duty Cycle(ul) vs n(rpm) at 35V, 300ohms

While both methods approximately gives a linear control over speed, most likely controlling the duty cycle is more practical. The DC source might be coming from a power outlet, a DC adapter, or a source that we don’t have control over, while duty cycle can be control by a control box readily available to us.

Conclusion/Summary:

BLDC motors are an excellent choice if the appropriate three phase power supply is available. Otherwise the BLDC motor has the drawback of additional power losses in the necessary converter. Other major drawbacks of PM Synchronous machines is the starting routine. Only under specific conditions (most likely consistent, industrial conditions) would the following compromises be acceptable:

* Rotor must be brought up to speed by an alternate prime mover before BM Sync. Machine is engaged. This requires to motors where preferably only one is needed.
* Rotor will only spin at one speed if the AC electrical source is steady.
* If the load becomes to large or the system is subjected to shock, the motor will immediately stall out and require the start up routine to be rerun, unlike a DC machine which would only slow down temporarily.
* Power losses to the inverter and control circuitry.

However, let it be noted that in applications where steady rotor speed is required, the BLDC machine is the clear choice as is seen in the lack of speed variation under varying loads and supplied power in tasks 3 and 4.