Pre-Internship Assignments for the Brushless DC Motor Controller

The objective of the internship project is to design, build, and test a compact controller for a brushless DC (BLDC) motor suitable for driving the joint of a cobot. Two circuits must be developed: one for the motor controller (MC) and the other for the external power supply (PS).

MC: As a pre-internship assignment for the controller, the applicant will assess the suitability of a motor controller from one of the following suppliers (each of which will be assigned to an applicant): MJBots, EPC, Texas Instruments, Infineon, Navitas, and Renesas. The preference is to use controllers that use GaN HEMTs (rather than Si MOSFETs) to increase switching frequency, enhance electrical efficiency, avoid heat sinks, and shrink the footprint. These assessments will be used to determine how to mix and match controllers for a compact and low-cost controller that will be designed, built, and tested during the internship phase of the project.

Starting with the documentation in the appropriate folder within Resources:

- Review the specifications and operating conditions for a BLDC motor (Turnigy Aerodrive SK3 - 4240-740kv) that are relevant for selecting the controller. This motor will be operated at 0 – 3000 rpm and will be connected to the joint of the cobot through a 100:1 reduction gearbox to achieve 30 Nm of torque at the joint. An input voltage of 48V – 60V (with a minimum of 40V) is desirable for each joint to minimize the size and weight of the power cables internal to the cobot.
- Survey and select an appropriate evaluation board or recommended circuit for driving the selected BLDC motor. For evaluation boards that can be configured with either GaN HEMTs or Si MOSFETs, determine how the board should be configured for GaN HEMTs.
- Select a rotary encoder (e.g. AS5147 from AMS or a variant such as AS5047) for providing motor position feedback to the controller and select the type of rotational feedback signal that is compatible with the controller.
- Select a microcontroller to interface with the evaluation board. Preferably select a microcontroller recommended for the evaluation board, or alternatively from Microchip, Texas Instruments, or ST Microelectronics. An Arduino or Raspberry Pi may be used for testing.
- Prepare a block diagram schematic showing the overall system that includes the BLDC motor, feedback sensor, evaluation board, microcontroller (if needed), external power supplies, and any additional components.
- Identify off-the-shelf or open-source code that is available or can be adapted to program the microcontroller, Arduino, or Raspberry Pi.
- Summarize the operation of the controller including its key circuit blocks and the description of signals (e.g. function, waveform (analog) or protocol (digital), voltage levels) between circuit blocks.
- Prepare a Bill-of-Material (BOM) for the test setup including estimated costs of components.
- Prepare and present the pre-internship assignment. A PowerPoint presentation is adequate.

PS: As a pre-internship assignment for the power supply, the applicant will assess the suitability of GaN HEMTs from one of the following suppliers (each of which will be assigned to an applicant): Texas Instruments, Infineon, Navitas, Power Integrations, and Transphorm. GaN HEMTs (rather than Si

MOSFETs) increase switching frequency, enhance electrical efficiency, avoid heat sinks, and shrink the footprint. These assessments will be used to determine how to mix and match components for a compact and low-cost power supply that will be designed, built, and tested during the internship phase of the project.

The power supply will use an input voltage of 110 VAC - 220 VAC and will output up to 20A at 48 VDC for ~1 kW of power which is sufficient to power all six joints and associated peripherals of the cobot. 48 VDC is a safe DC voltage for humans. It is a standard output voltage for telecom power supplies and is also being adopted as the new standard for AI servers and automotive electronics. Reference designs and evaluation boards are available from several suppliers.

Starting with the documentation in the appropriate sub-folder within Resources:

- Survey and select an appropriate evaluation board or recommended circuit for the power supply.
- If necessary, select a microcontroller to interface with the evaluation board or the circuit. Preferably select a microcontroller recommended for the evaluation board, or alternatively from Microchip, Texas Instruments, or ST Microelectronics. An Arduino or Raspberry Pi may be used for testing.
- Prepare a block diagram schematic showing the overall system that includes the evaluation board, microcontroller (if needed), feedback sensors (if needed), and any additional components.
- Identify off-the-shelf or open-source code that is available or can be adapted to program the microcontroller, Arduino, or Raspberry Pi.
- Summarize the operation of the power supply including its key circuit blocks and the description of signals (e.g. function, waveform (analog) or protocol (digital), voltage levels) between circuit blocks.
- Prepare a Bill-of-Material (BOM) for the test setup including estimated costs of components.
- Prepare and present the pre-internship assignment. A PowerPoint presentation is adequate.

Complete as much of the assignment as possible within the 4 week and 40-hour time limit. The documents should provide a starting point but use additional online resources as necessary.

It is possible that the assigned supplier does not have an evaluation board or reference circuit. If so, reference circuits provided by one of the other suppliers can be adapted for the GaN HEMTs from the assigned supplier. If suitable GaN HEMTs cannot be found, the assignment should be terminated with an explanation of the conclusions.