



Sep 20, 2022

BS191

Matter-Energy Lab

End-Semester Presentation

Dhruv Patel [20110129]

Kush Patel [20110131]

Vrajesh Patel [20110134]

Prithviraj Shaw [20110146]

R Yeeshu Dhurandhar [20110152]



Problem Statement

Design a centrifuge system that can go to a maximum speed of 10,000 rpm with digital control based on microprocessors.

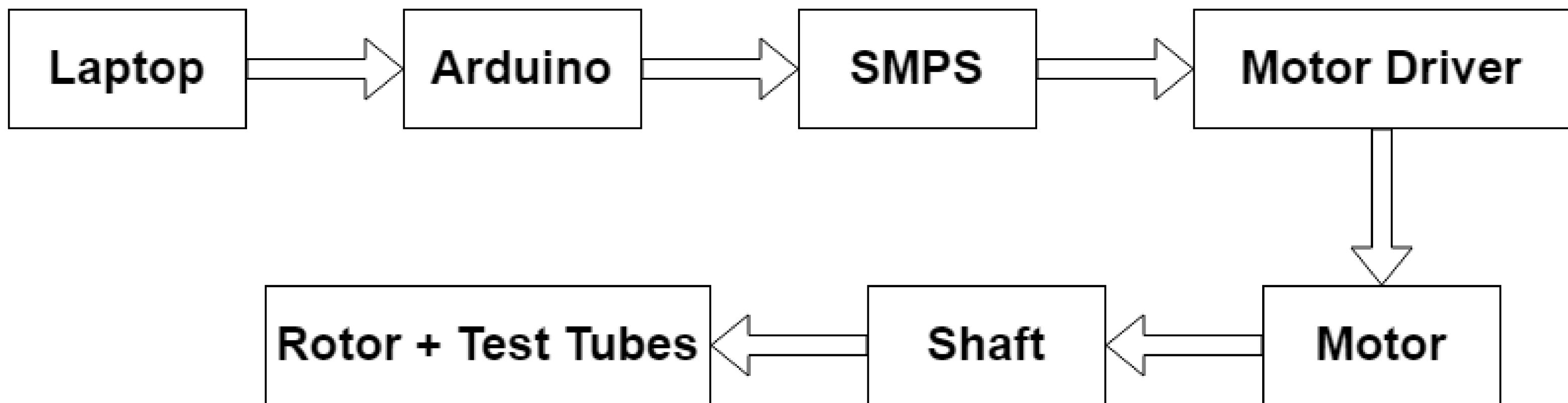
Motivation

- Common interest
- Each person can contribute
- Desirable functionality and control using microprocessors
- Fascination for difficult task (achieving 10K rpm)

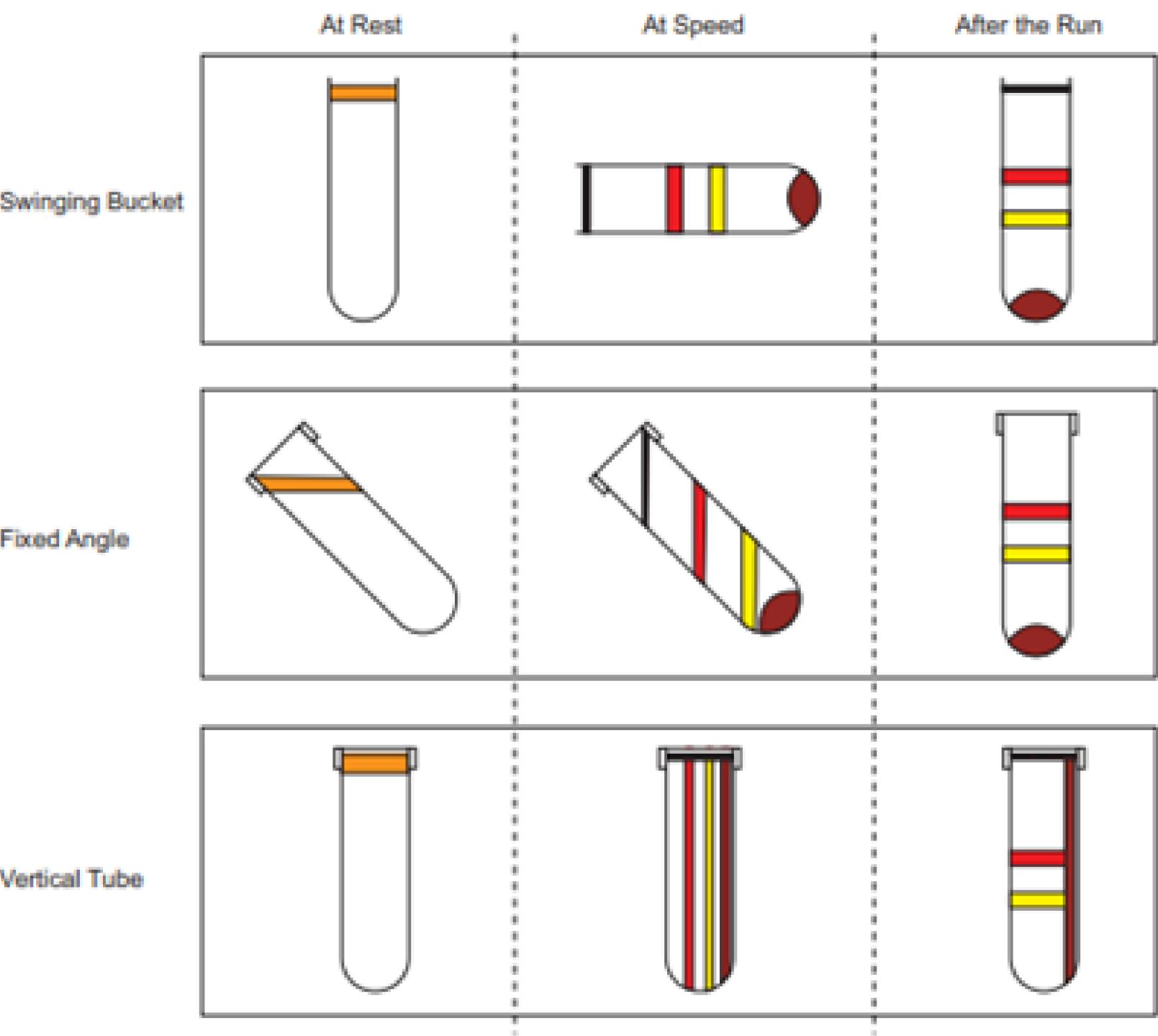
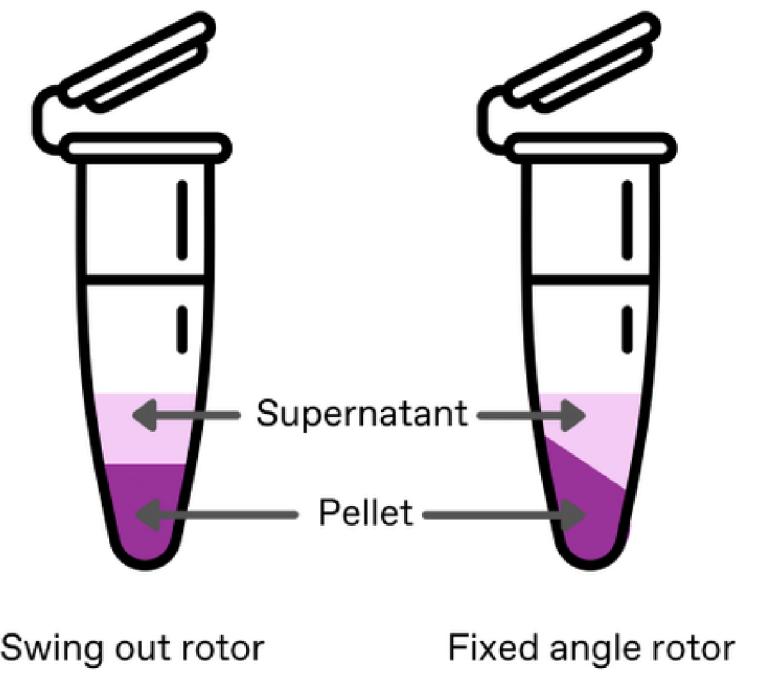
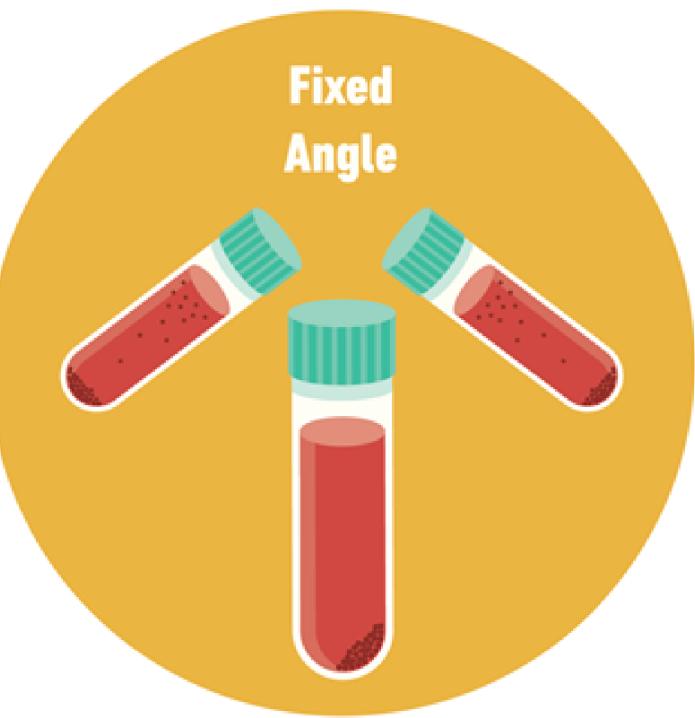
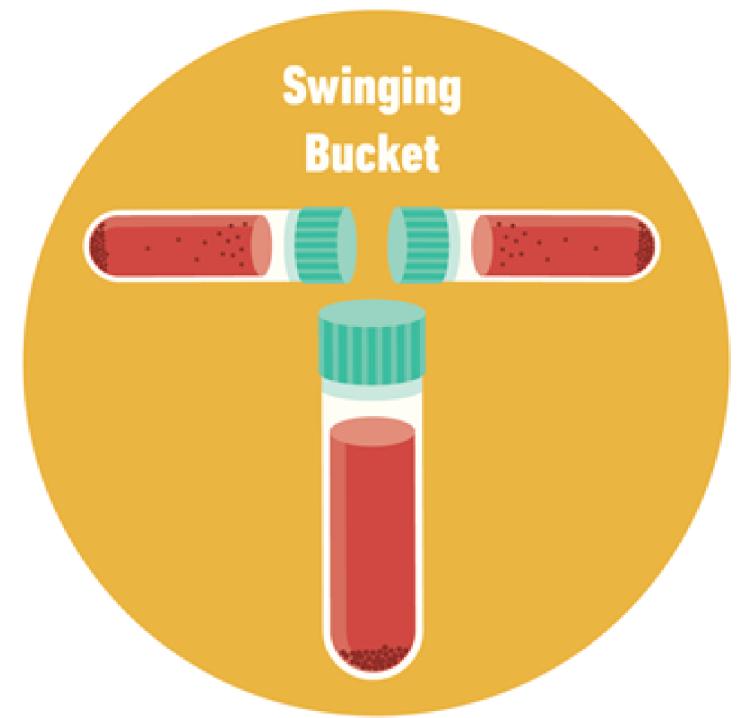
Journey...

- Blank 
- Initial thoughts: Easy project
- Lab visit:
 - Observe the actual centrifuge machine
 - Realized the depth of the project!
- Planning - parts + assembly
- Choosing the Motor
 - high load + high RPM => high torque/power
 - consulted Prof. S. Rajendran

Black Box diagram



Swing out vs fixed angle



Numerical/Analytical analysis

$$\text{Angular Acceleration}(\alpha) = \frac{\omega}{t} = \frac{10000\left(\frac{2\pi}{60}\right)}{t}$$

t = time required to achieve 10000 RPM from rest

$$\text{Torque}(\tau) = I\alpha$$

$$\tau = \left(\frac{mR^2}{2}\right)\left(\frac{10000\left(\frac{2\pi}{60}\right)}{t}\right)$$



Assume rotor as disk

Mass of rotor=m

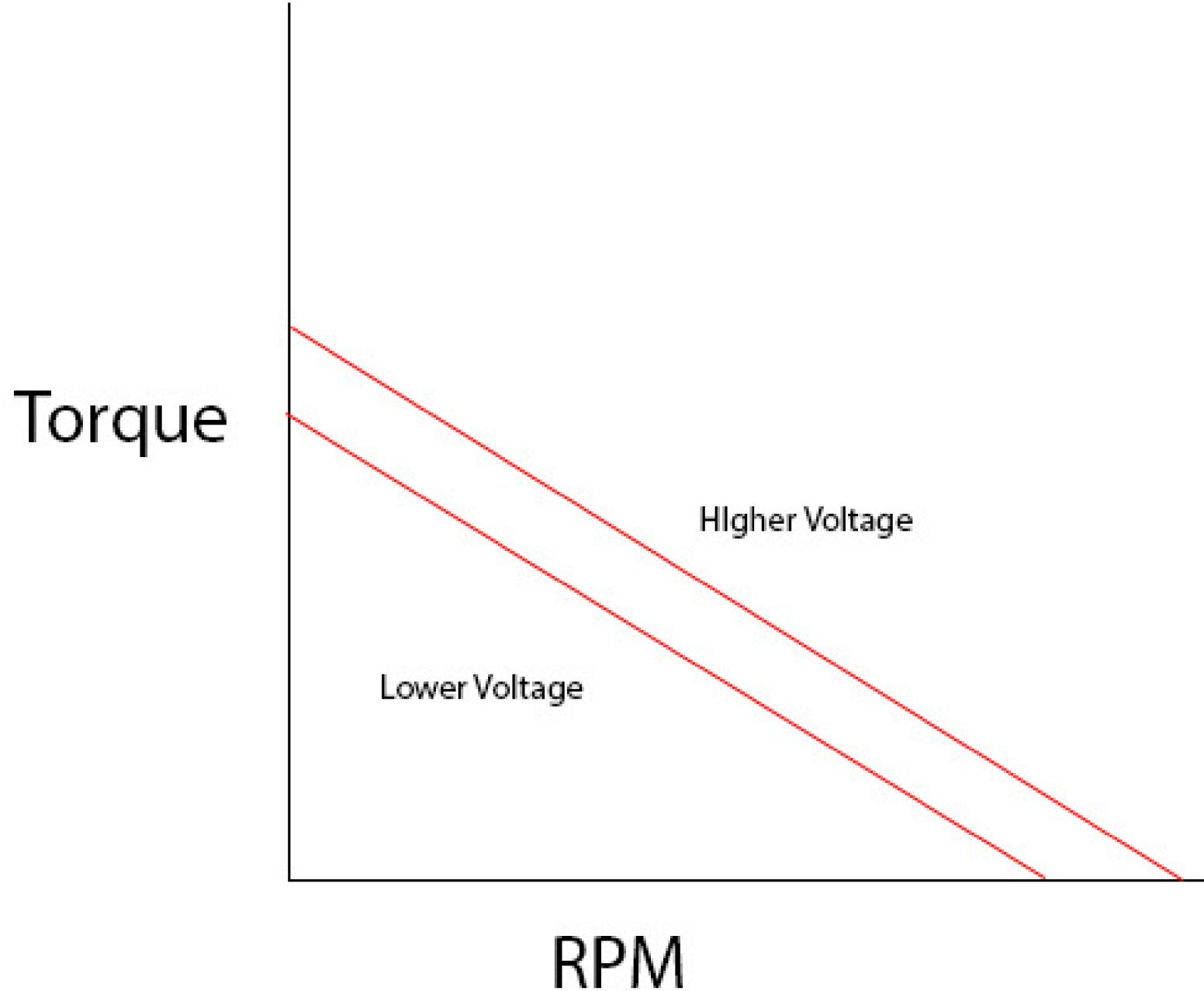
Radius of rotor = R

Inertia of rotor (I) = $\frac{mR^2}{2}$

Achieving stability

- Equal mass in radially opposite directions
- Strong connection between shaft and rotor balances additional normal forces

Various Motor Options

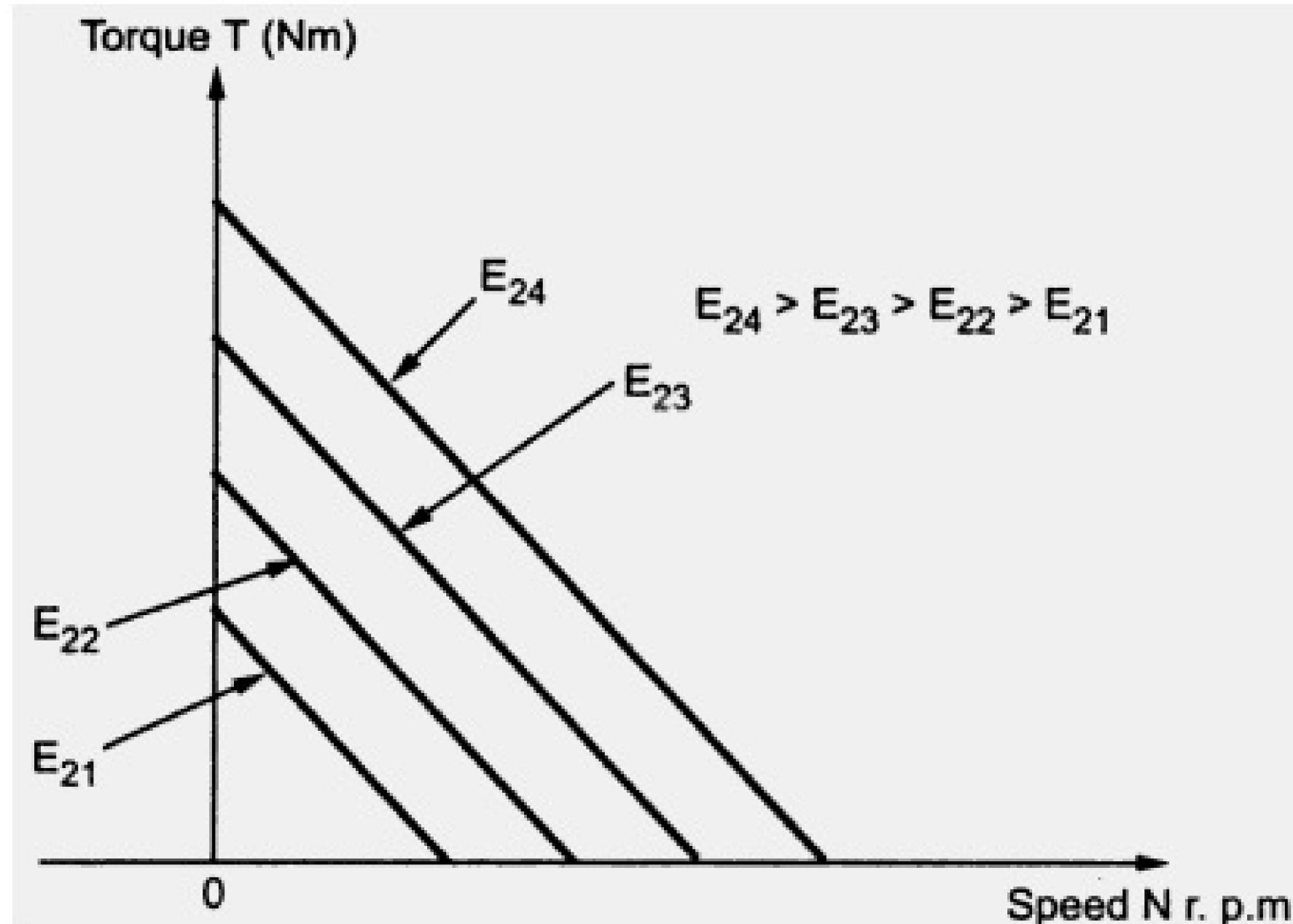


The Torque falls linearly with RPM

Our requirement is to have almost constant torque at higher RPM

Brushed DC Motor

Various Motor Options



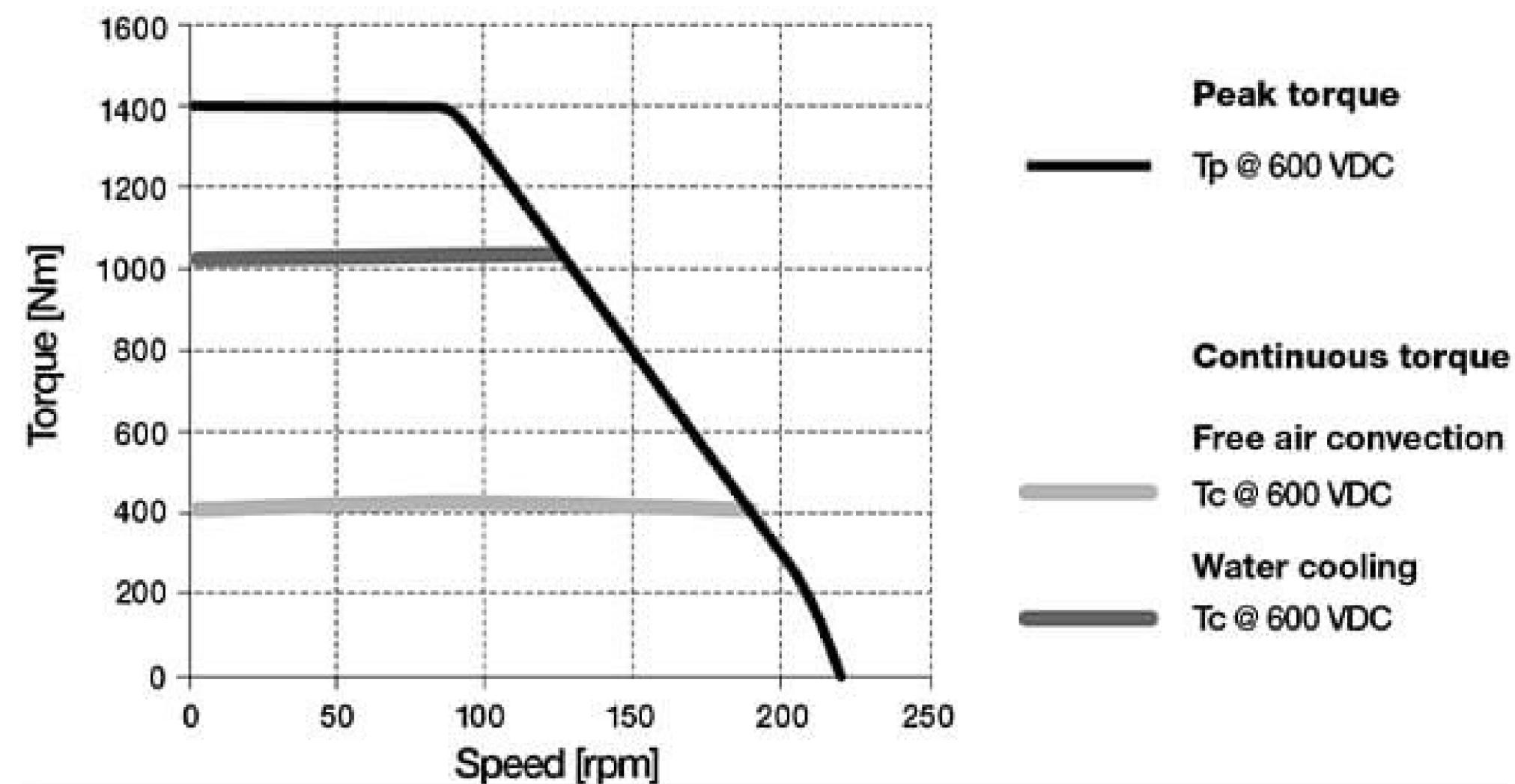
The Torque falls linearly with RPM similar to
Brushed DC motor

Rotor may not be able to handle high initial RPM

Servo Motor

Various Motor Options

Torque = f(speed) for 3UCN



Peak torque

$T_p @ 600 \text{ VDC}$

Continuous torque

$T_c @ 600 \text{ VDC}$ Free air convection

$T_c @ 600 \text{ VDC}$

Water cooling

$T_c @ 600 \text{ VDC}$

Torque maintained initially but not long enough. It decreases with even higher slope

Rotor may not be able to handle high initial RPM

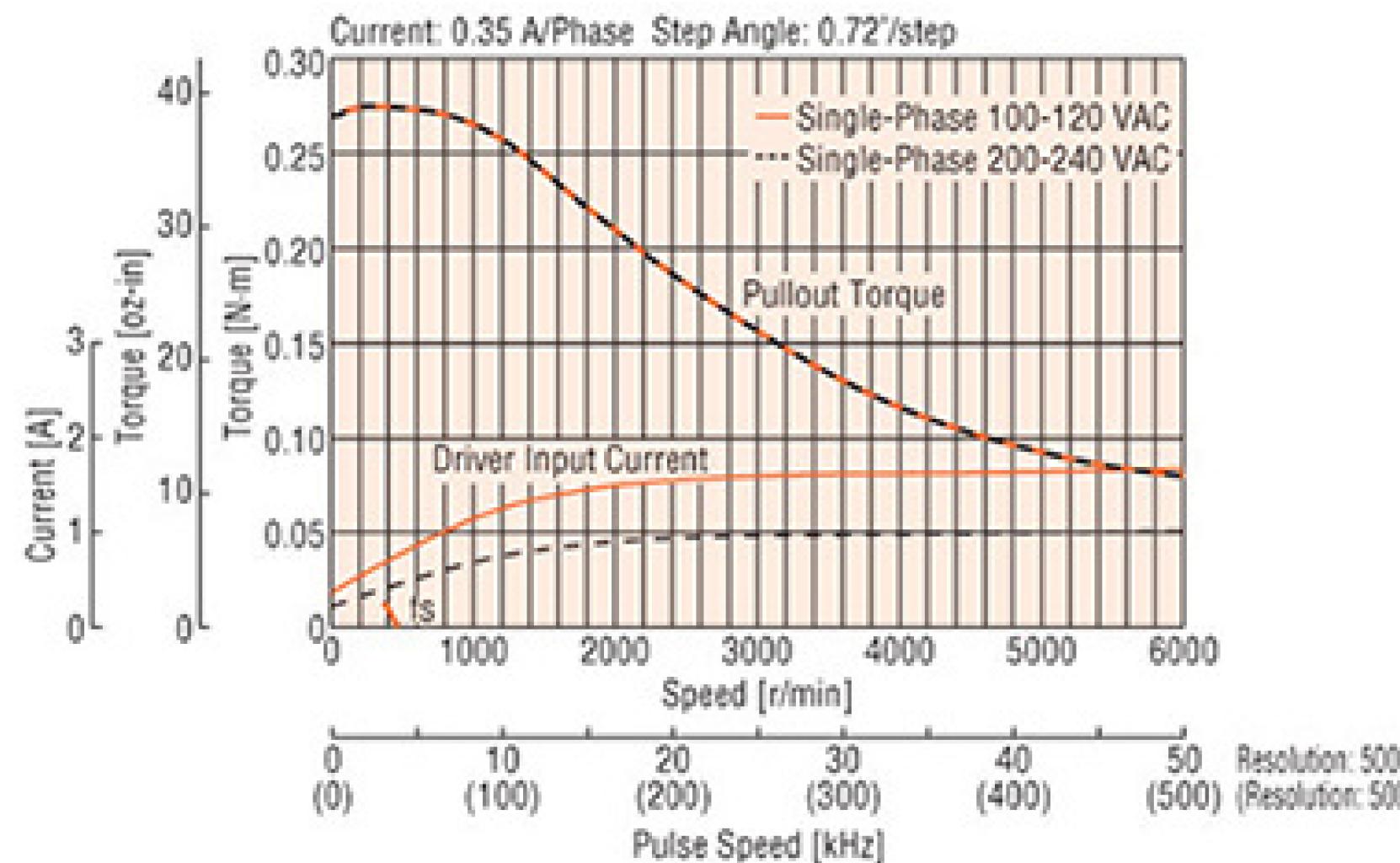
Direct Drive Motor

Various Motor Options

Speed – Torque Characteristics

fs: Maximum Starting Frequency

RKS545

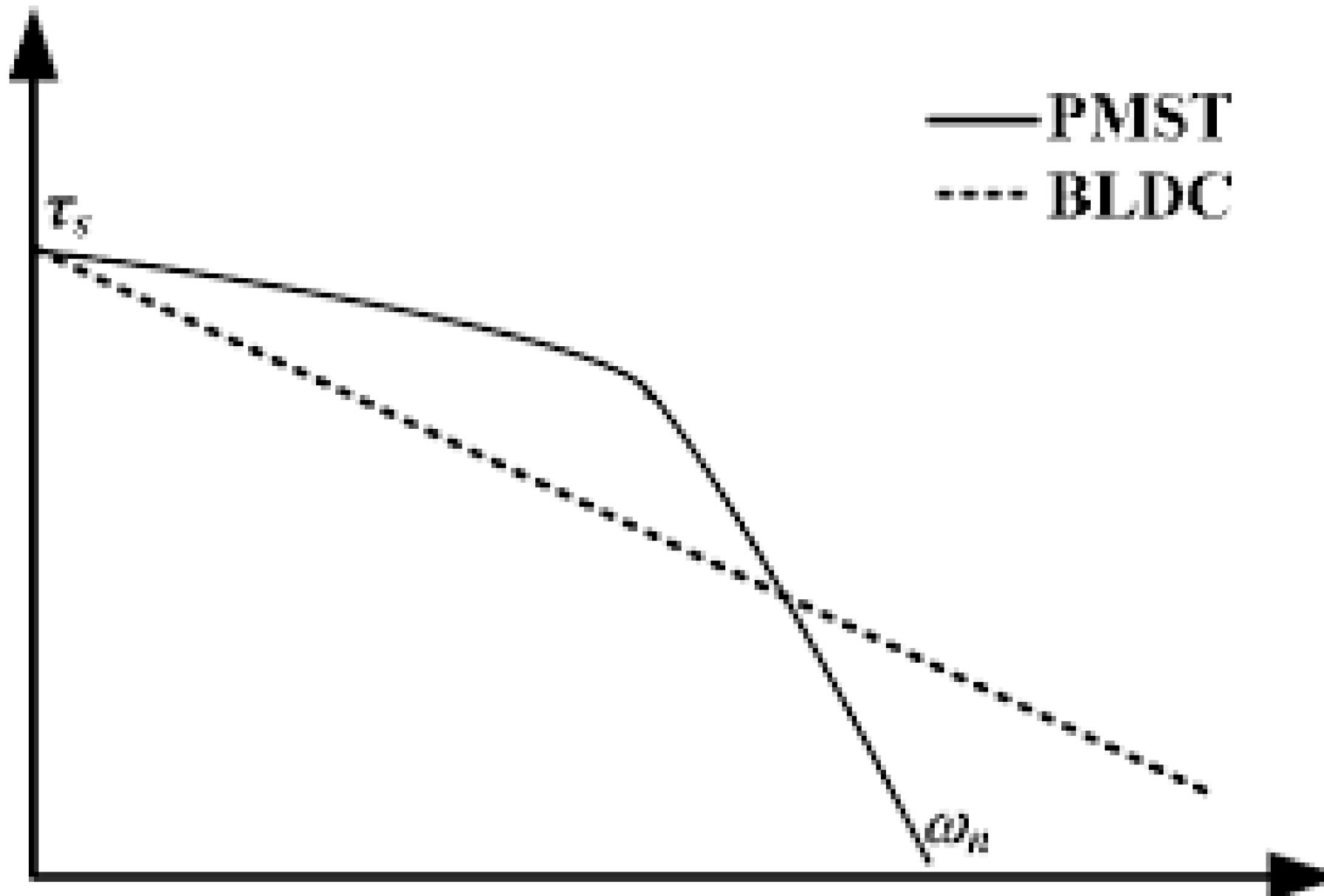


Able to hold the torque for small values of RPM

However, it decreases exponentially after a certain point

Stepper Motor

Various Motor Options



Able to hold the torque for higher values of RPM

High rating BLDC motor can be used

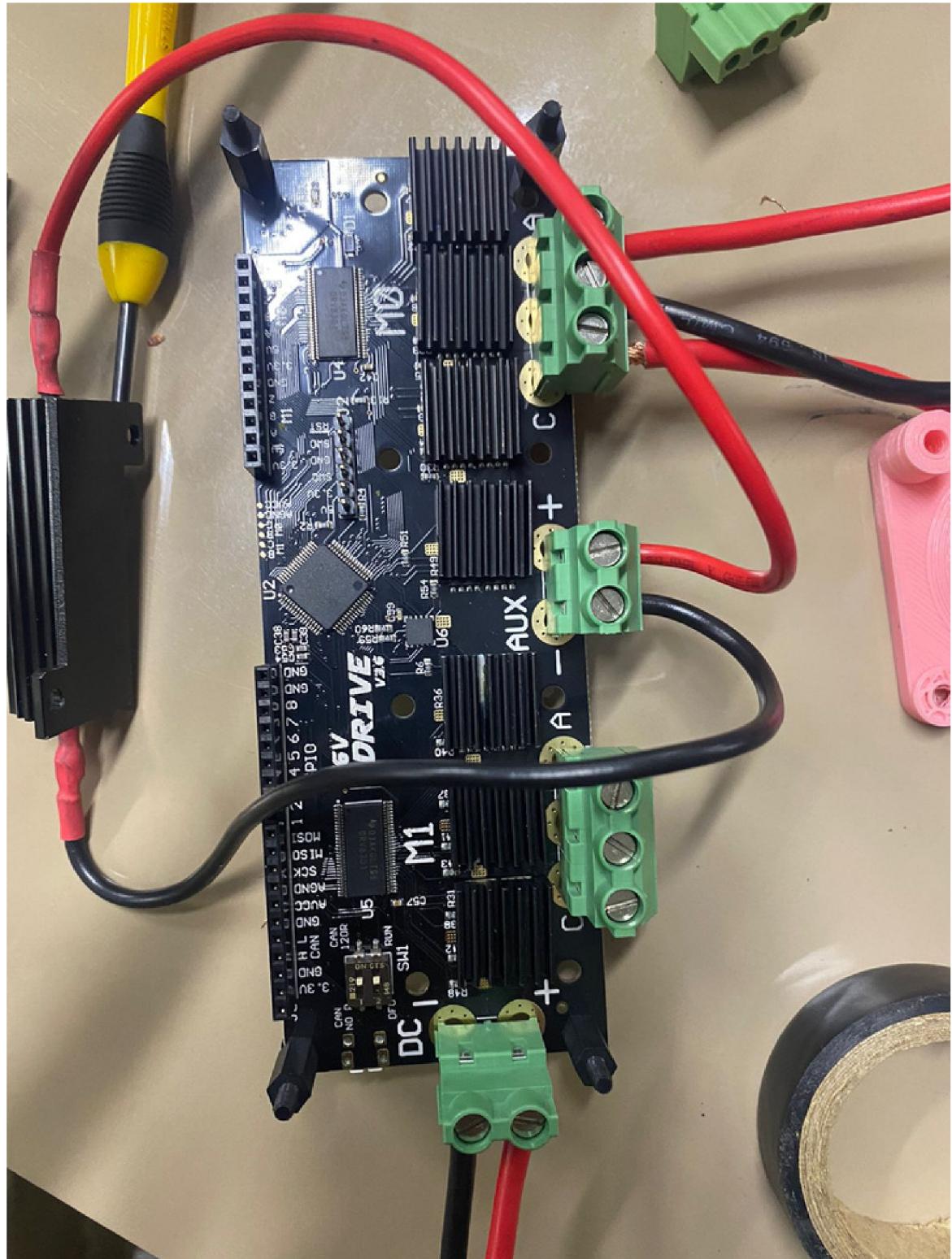
BLDC Motor

Components: SMPS



SMPS converts 220V AC voltage to 48V DC voltage which can be directly fed to motor driver.

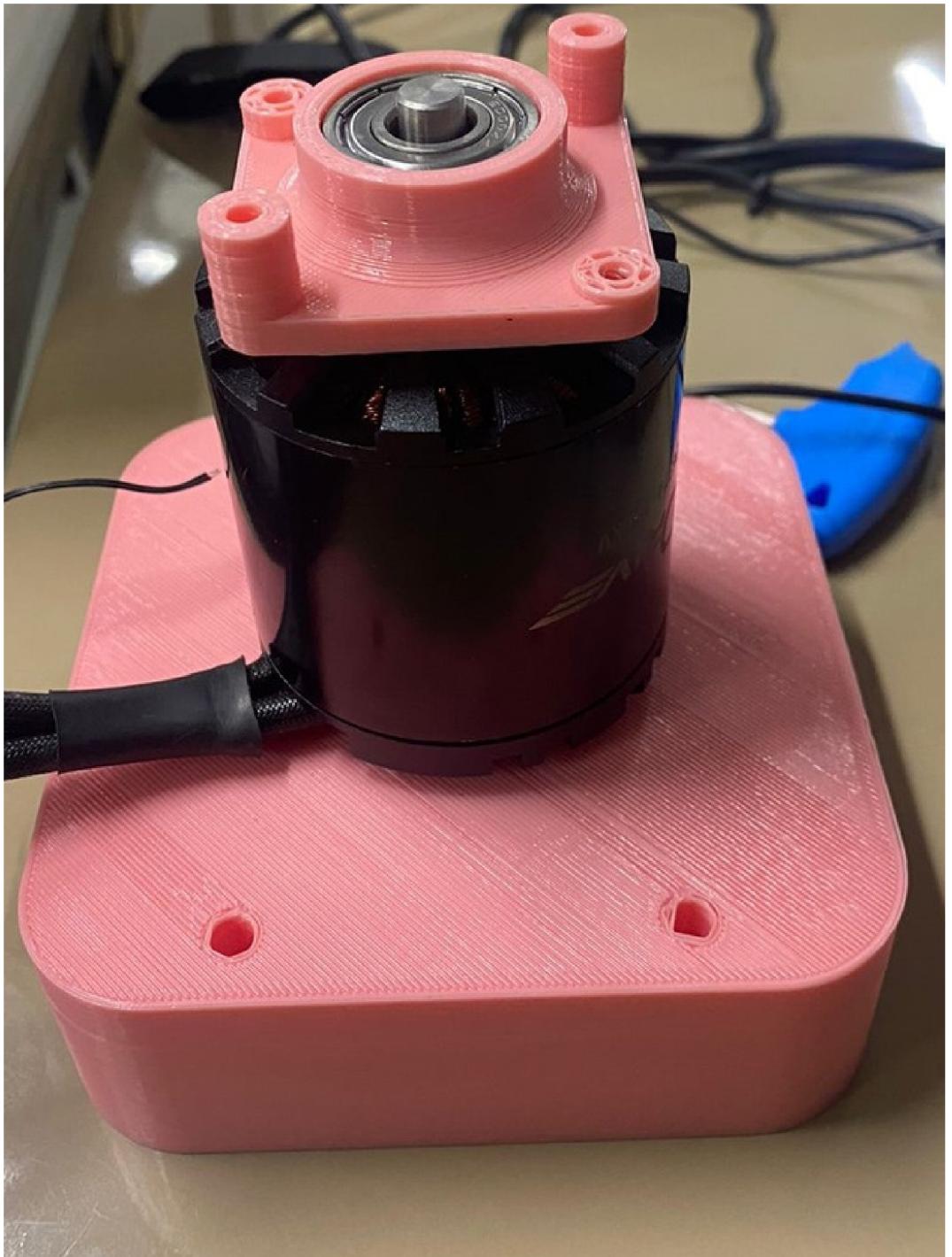
Components: Driver



To give high power to the motor using small voltages.

Connected with arduino for controlling purpose.

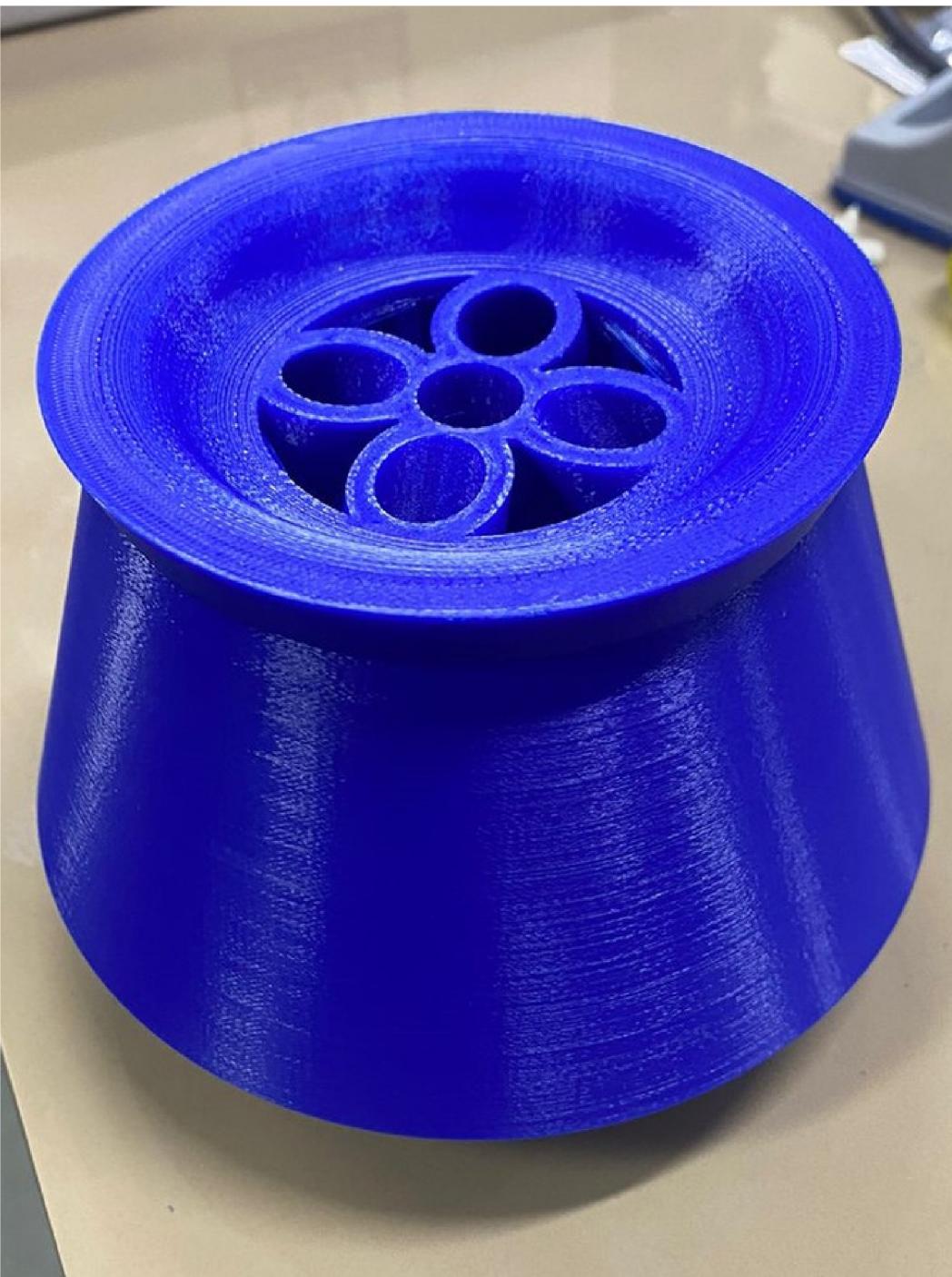
Components: Motor



Motor of 270KV and 90A max current rating.

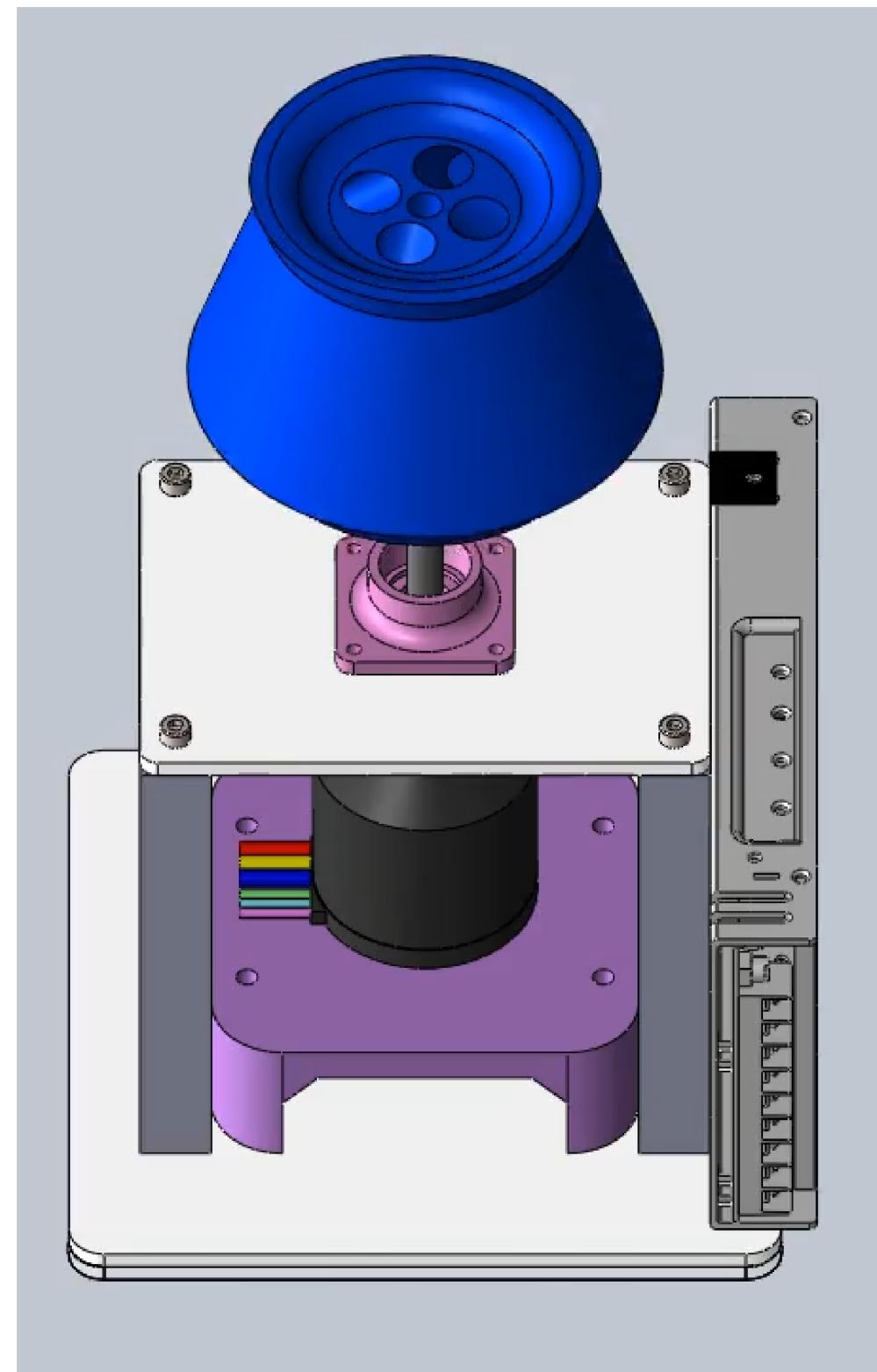
The shaft of the motor will be connected to the rotor

Components: Rotor



The shaft from the motor is connected to rotor base.

CAD Model



CAD Model



Prototype





Thank you!