



BACKGROUND

Dr. R Lee Kirby (MD, FRCPC) heads the Wheelchair Skills Program in Halifax, as well as Tartan Rehab Ltd. With 90% of wheelchair users removing their standard Fixed Rear Anti-Tippers, Dr. Kirby assigned us a project to create a proof of concept for an App-controlled, Battery-powered, Electromechanical Rear Anti-tipping Device for wheelchairs.

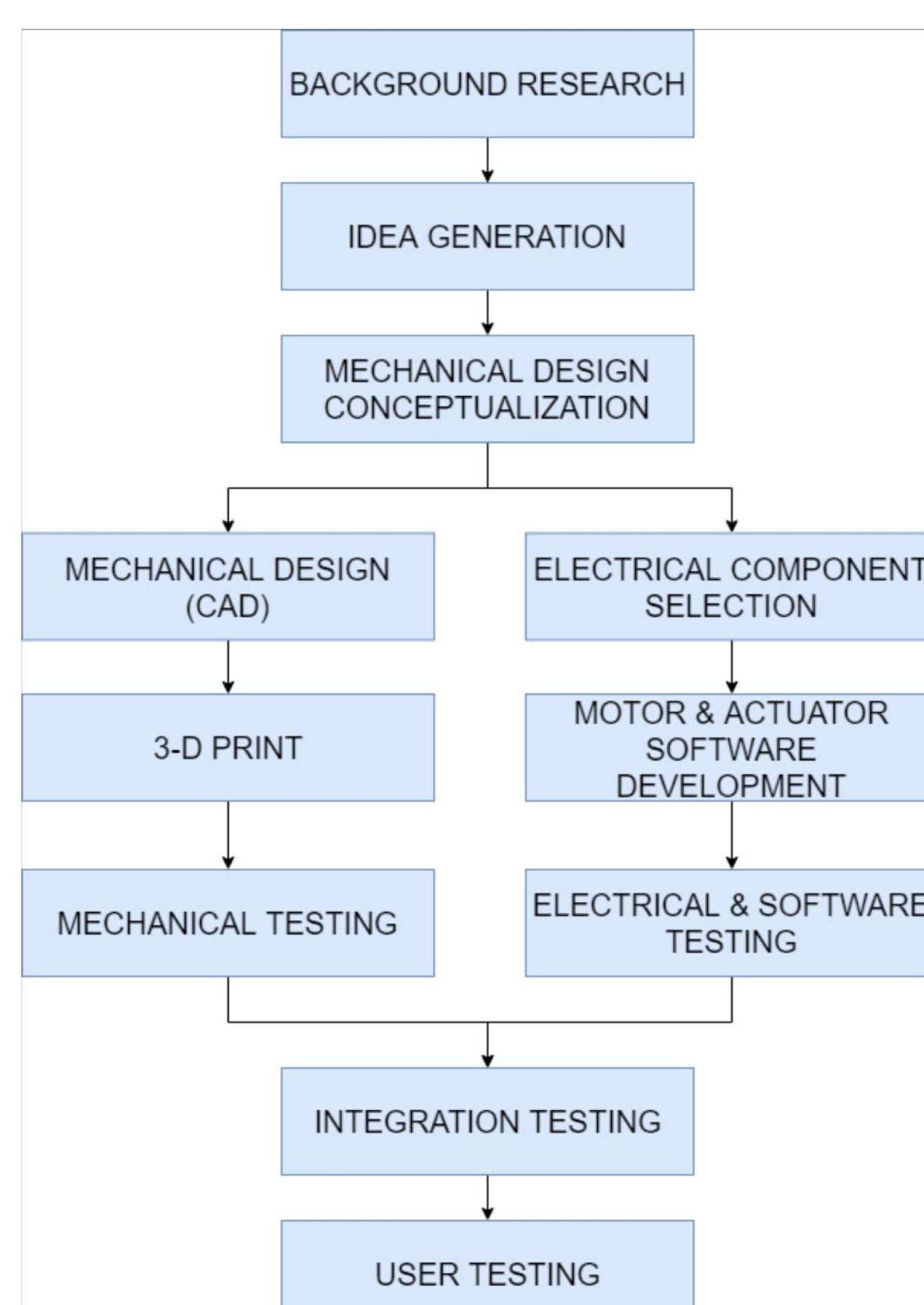
SCOPE

- Supplementing the existing RAD technology by making electromechanical additions to it.
- Design a retrofitable, rotating and locking mechanism to adjust the RAD arm's upper limit.

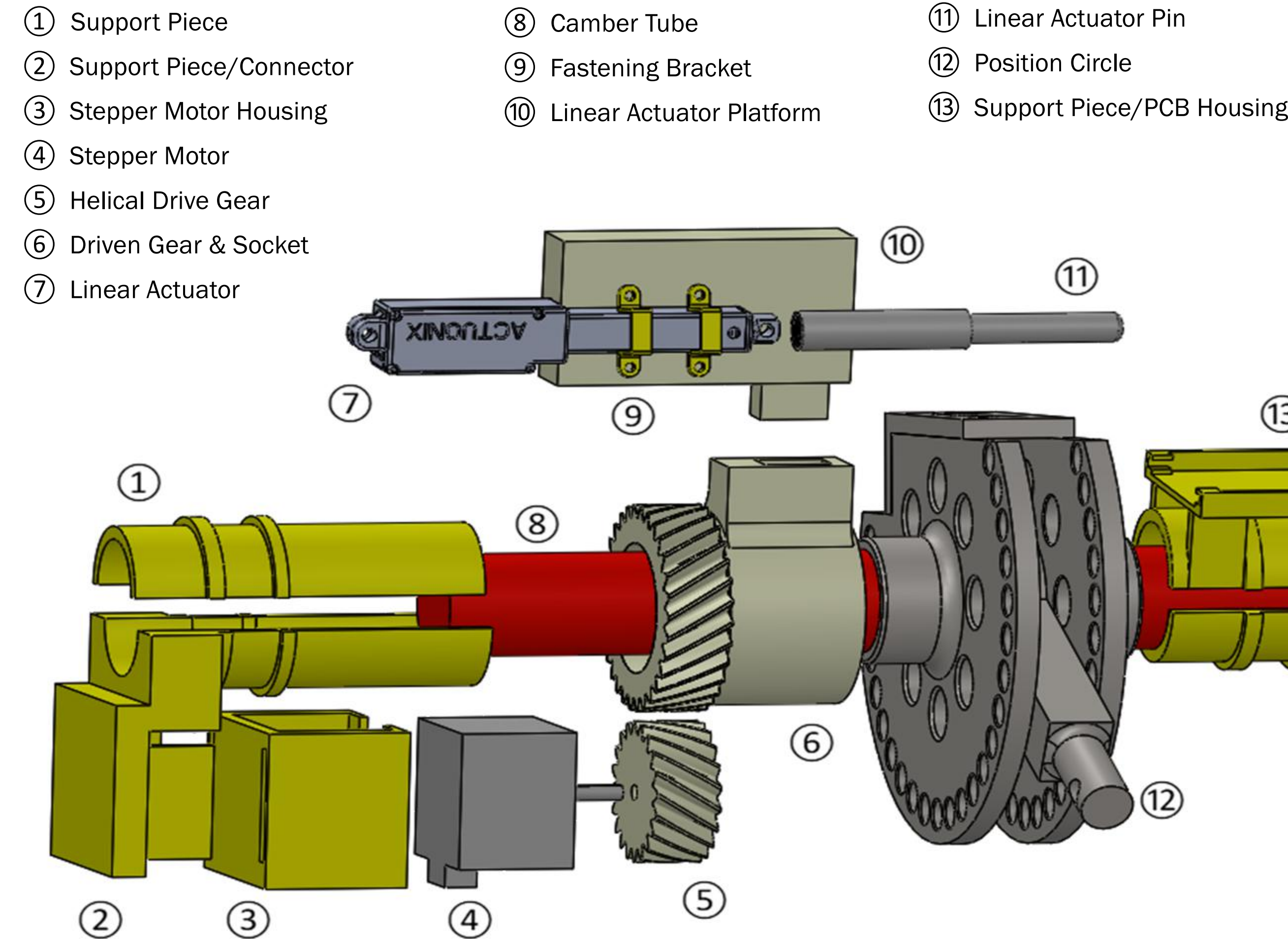
OBJECTIVES

- Complete a proof of concept for ROBO-RAD.
- Develop a circuit and software for precise stepper motor & linear actuator motion.
- Design a 3D support structure, housing & gearing apparatus to achieve linear & rotational movement around the wheelchair camber tube.
- Implement Bluetooth communication module for wireless control of the RAD arm position.
- Develop a Battery Regulation circuit to provide portability to the ROBO-RAD.

DESIGN PROCESS



MECHANICAL SYSTEM



Helical Drive Gear

With a helix angle of 30°, it provides the 1.5x the torque, to assist the motor in rotating the socket piece.

Position Circle

Manual locking mechanism designed by a Capstone Team in 2017.

Camber Tube

designed to resist movement of the motor, thereby ensuring a firm fit.

Driven Gear & Socket

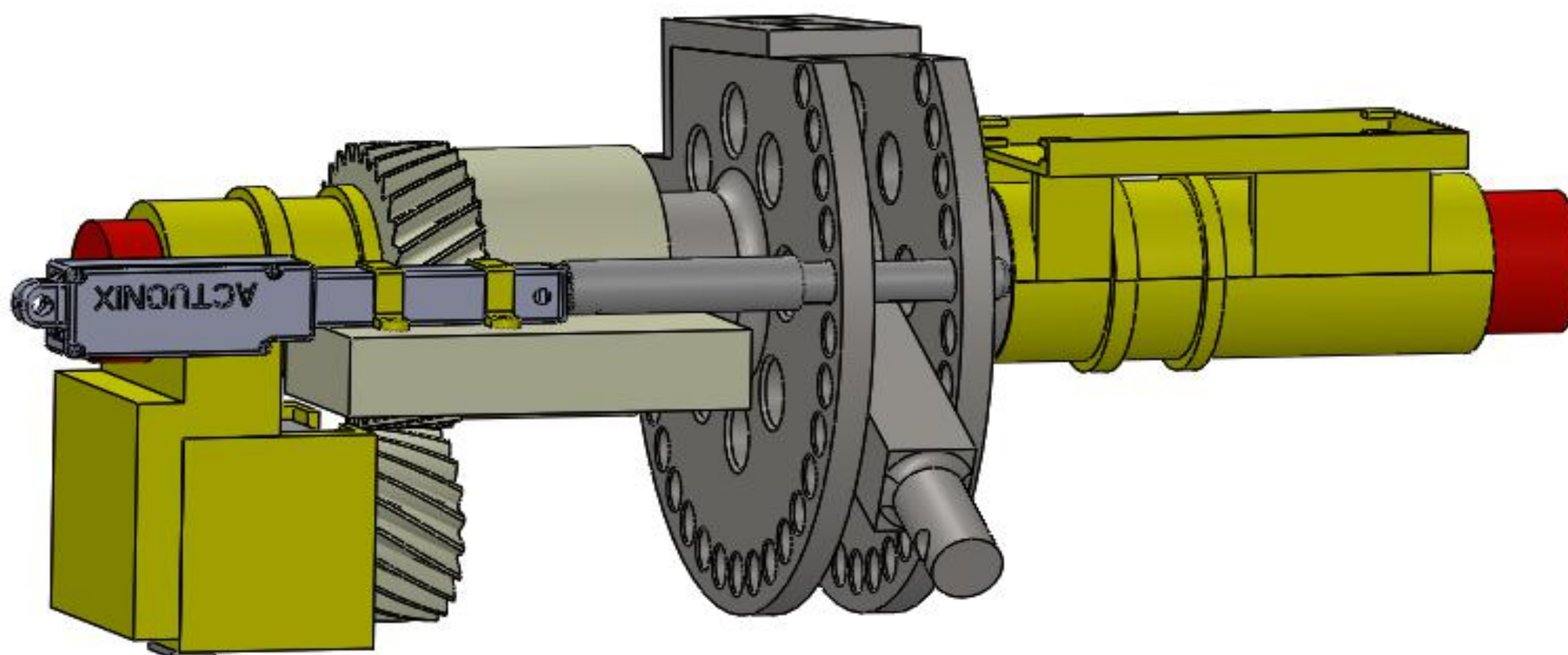
Designed as a singular part with the socket part to create a rotational movement about the camber tube.

Support Piece

Prevents horizontal movement of the device.

Linear Actuator Pin

Machined with a stronger material to allow for a greater force and torque.



FUTURE RECOMMENDATIONS

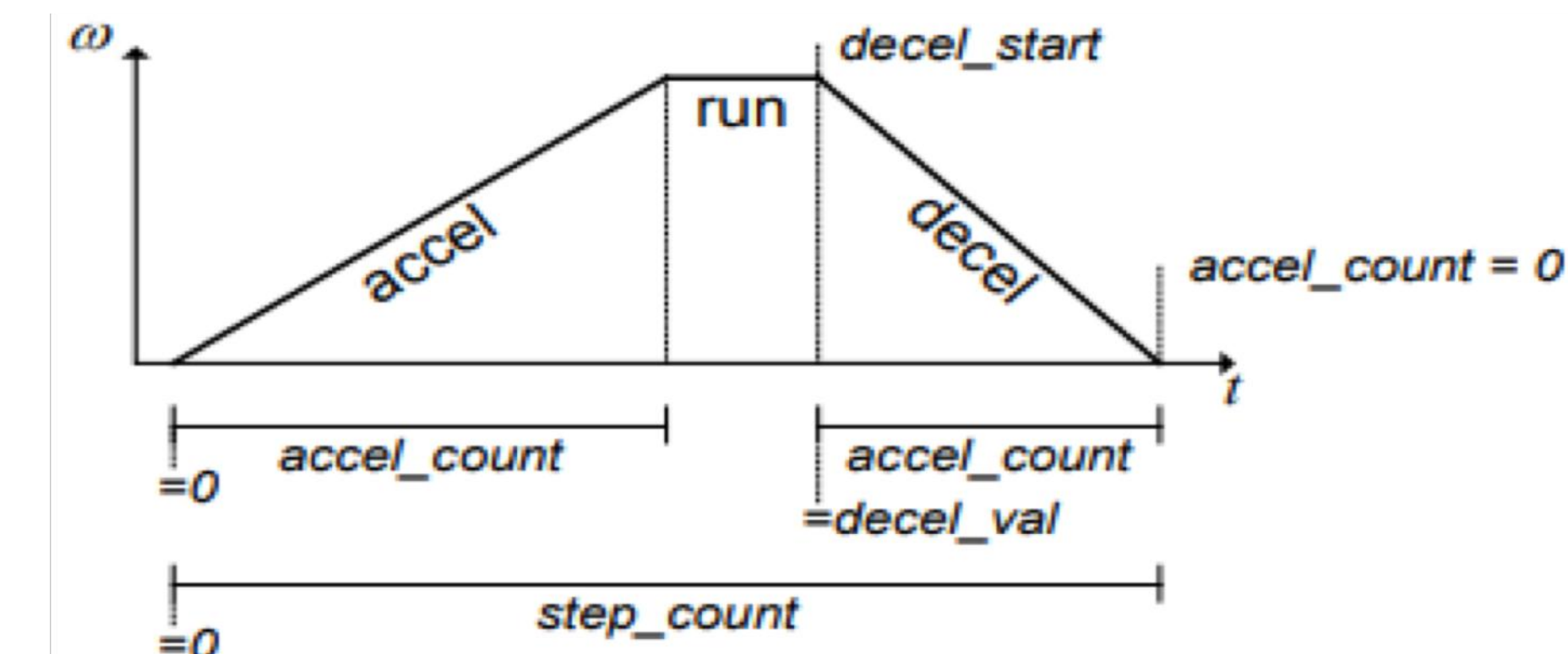
- Faster & more compact linear actuation component, can be low torque.
- Bearing system for reduced friction between gearing and camber tube.
- Dedicated, user-friendly angle control phone application.
- Negative feedback circuit for improved stepper motor position tracking.
- Steel Gears for improved durability

ELECTRICAL SYSTEM

Stepper Motor (NEMA 17)

Bi-polar stepper motor that consumes a total of 0.8 Amps (0.4 A/φ) utilizes a linear speed control algorithm outlined in (AVR446).

- Step Angle of 1.8°
- The algorithm calculates, custom speed profiles on-board and deploys to the A4988 stepper motor controller.



A4988 Stepper Motor Driver

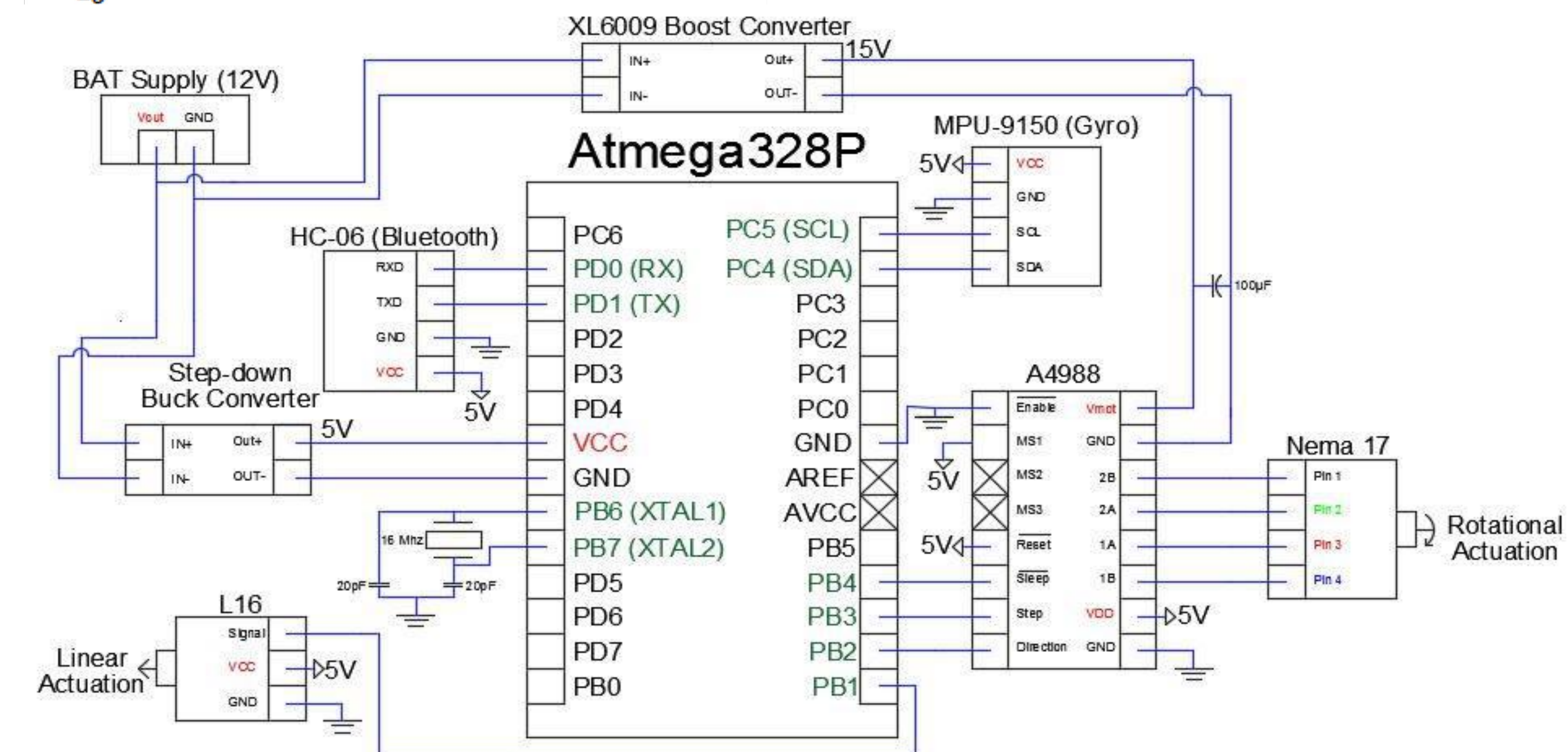
- Operated in half-step mode.
- Utilized micro-stepping to reduce output noise.
- Sleep mode provides optimal power consumption.

Linear Actuator (L16 50mm)

- Controlled by 20msec pulse signal.
- Variation of duty cycle from 5% to 10%.

MPU-9150

- Accelerometer, gyro and temperature data.
- Two Wire Interface with max. transmission rate of 400 kHz.



BATTERY

- Minimum Requirements
- Voltage - 12V
 - Current - 3A
- 12V, 10A, 18 Ah Li-ion Battery was chosen.

To regulate voltage through all the modules of the ROBO-RAD, Step-Up Boost Converters and Step-Down Buck Converters were utilized.



MOBILE APP

- Open-source App; Serial Bluetooth Terminal.
- User-friendly Interface, Button Modifications.
- Bluetooth Module, HC06 used for communication between App & 328P.



CONCLUSION

ROBO-RAD is unique product that aims to dethrone the current standard of RAD's along with improving accessibility for wheelchair users. ROBO-RAD empowers wheelchair users to remotely adjust the RAD arm angle, therefore, unlocking a new level of functionality and comfort in modern, fixed-frame wheelchairs.

REFERENCES

- Atmel (2006). AVR446: Linear speed control of stepper motor (Application Note 8017A-AVR-06/06).
- Graham, M., Saxon, B., Wang, Ke, Zandieh, Parsa. (2018) "Design & Refinement of an Anti-Tip Device for Manual Wheelchair". Dalhousie University, Canada.
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