ABSTRACT

This research develops a 6S 24 V lithium polymer (Li-Po) battery charging system for the Picobot Ankle-Foot Orthosis (AFO) robot using the Constant Current–Constant Voltage (CC–CV) method equipped with a PID current controller, temperature-based current limitation, and passive cell balancing features. The system was designed through buck converter simulation in MATLAB/Simulink, then implemented in hardware using Arduino Mega, ACS712 current sensor, per-cell voltage divider, MLX90614 non-contact temperature sensor, and buck converter and balancing circuits using MOSFETs. Testing included sensor calibration, PID response testing for current set points of 1–5 A, PWM signal verification with an oscilloscope, temperature-based current limiting testing, battery charging time testing, and evaluation of balancing performance and per-cell voltage accuracy.

Test results show that the PID controller is capable of maintaining the current at a set point of 1–5 A with a rise time and settling time of several seconds, an average steady-state error of <1.5%, and overshoot of <5%, making the current loop quite fast and stable. Current regulation based on temperature using the MLX90614 sensor works effectively, with a current of 5 A supplied when the temperature is <40 °C, reduced when the temperature approaches the limit, and stopped when the temperature exceeds 45 °C, thereby minimizing the risk of overheating. The developed charger system is capable of charging a battery pack from around 18 V to nearly 24 V with an average charging time of 741 s (±12.35 minutes) at a current of 5 A, which is much faster than the system in the previous study that took 1 hour and 9 minutes, and shorter than the commercial ToolkitRC M7 charger that takes about 2 hours and 32 minutes for similar conditions. The passive balancing feature successfully equalized the voltage of the six cells to around 4.0 V at the end of charging, with a reading difference from the ToolkitRC M7 in the range of ±1.01–3.59% per cell after calibration, without any cells lagging far behind or overcharging. Thus, the proposed system has proven capable of achieving faster

charging, remaining safe within temperature and voltage limits, while maintaining voltage balance between the cells of the 6S Li-Po battery in the AFO Picobot robot.

Keywords: *AFO robot, battery balancing, battery charging, battery temperature, CC-CV, lithium polymer.*