

## ABSTRACT

*This Final Project designs and implements a robotic arm system for waste collection based on a Field Programmable Gate Array (FPGA), controlled through Visible Light Communication (VLC). The system receives commands from the Ground Control Station (GCS) in the form of ASCII characters, which are then processed by the FPGA and forwarded to the ESP32 module to control the servo motors on the base, shoulder, elbow, and gripper. Each command has a specific function, such as 'O' to open the gripper at 90° and 'C' to close it at 0°, both achieving 100% success. The 'Y' (elbow forward 180°) and 'H' (elbow backward 90°) commands also achieved 100% success. However, the 'T' (shoulder down 90°) and 'G' (shoulder up 180°) commands only reached 20% success, as in certain conditions the FPGA did not receive VLC signals and thus failed to forward the commands to the ESP32. Similar issues occurred with the 'A' (base left 180°) and 'D' (base right 0°) commands, which also had a 20% success rate. Meanwhile, the 'X' command (base center 90°) achieved 100% success. The design process included hardware circuit development, control logic programming in Verilog on the FPGA, and field testing. The main devices used were the DE0-Nano FPGA, ESP32 module, and servo motors. The test results showed that the system could respond to commands in real-time. However, a looping phenomenon was found in certain commands when sent through the GCS, while serial monitor transmission worked normally. From the physical perspective, the gripper was only able to pick up small and lightweight waste due to limited gripping force. Overall, the system successfully performed its main function of waste collection based on GCS commands. Nevertheless, the robot is not yet capable of transporting waste to a final destination, limiting its functionality to the collection process only.*

*Keywords: FPGA, trash-collecting robot, VLC, ESP32, servo motor, robotic arm.*