

ABSTRACT

Water quality degradation threatens ecosystems and human health, but traditional monitoring methods are inefficient and prone to inaccuracies. This study addresses this challenge by designing and implementing a PID-controlled Autonomous Underwater Vehicle (AUV) with a buoyancy engine for precise depth-specific water quality measurements in shallow reservoirs (1–4 m depth). The system replaces manual sampling with automated, real-time monitoring of key parameters (temperature, dissolved oxygen, pH, turbidity), overcoming limitations like transport delays and infrequent data collection. The AUV integrates a pressure sensor for depth feedback and a motorized syringe mechanism for buoyancy adjustment. A cascaded PID control architecture enables precise depth regulation: an inner loop controls motor position via magnetic encoder feedback, while an outer loop adjusts depth using pressure sensor data. Critical hardware refinements, including neutral buoyancy calibration with 49.7g counterweights and a tuned proportional gain ($K_p=450$), achieved stable vertical positioning despite hydrodynamic disturbances. Testing in a pool environment validated the system's performance, with depth accuracy exceeding 97% across all setpoints (1–3 m). The pressure sensor demonstrated high reliability (>97% agreement with theoretical hydrostatic calculations), while the buoyancy engine enabled smooth depth transitions. Although near-surface turbulence slightly reduced stability, the system consistently settled within ± 0.2 m of targets, confirming its efficacy for autonomous monitoring in calm/deeper waters. This work provides a foundation for energy-efficient AUVs in environmental sensing, though future studies should address deeper waters and integral gain tuning to eliminate residual steady-state error.

Keywords: control systems, PID, buoyancy engine, water quality.