

ABSTRAK

SISTEM *ADAPTIVE* PENGUKURAN LEVEL AIR MENGGUNAKAN METODE PID

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NABILA RAHMADANI

062330320602

JURUSAN TEKNIK ELEKTRO

PROGRAM STUDI DIII TEKNIK ELEKTRONIKA

POLITEKNIK NEGERI SRIWIJAYA

Sistem pengendalian level air yang akurat dan adaptif merupakan aspek penting dalam menjaga kestabilan proses pada sistem penyimpanan cairan. Penelitian ini bertujuan merancang dan mengimplementasikan sistem pengukuran level air adaptif berbasis ESP32 pada sistem dua tangki menggunakan sensor ultrasonik HC-SR04, pengendali PID *Adaptive* untuk proses pengisian, serta kendali *on/off* untuk proses pengosongan. Kajian pustaka meliputi teori sistem kendali, sensor ultrasonik, mikrokontroler ESP32, algoritma PID *Adaptive*, dan metode kendali *on/off* sebagai dasar perancangan perangkat keras dan perangkat lunak. Hasil pengujian menunjukkan bahwa sensor ultrasonik memiliki rata-rata pengukuran sebesar 2,41% pada Tangki 1 dan 0,85% pada Tangki 2. Pengendali PID *Adaptive* mampu menyesuaikan parameter K_p , K_i , dan K_d secara otomatis sesuai perubahan error sehingga menghasilkan *rise time* 78 detik, *settling time* 122 detik, dan *maximum overshoot* 5,25% pada pengujian awal. Dibandingkan PID *Fixed*, PID *Adaptive* memberikan respons awal yang lebih cepat meskipun menghasilkan *overshoot* yang lebih besar, sedangkan PID *Fixed* memberikan respons yang lebih stabil. Selain itu, kendali *on/off* pada proses pengosongan mampu menurunkan level air secara konsisten hingga *setpoint* minimum. Berdasarkan hasil pengujian, sistem yang dirancang mampu mengendalikan proses pengisian dan pengosongan level air secara adaptif dan efektif.

Kata kunci: ESP32; PID *Adaptive*; sensor ultrasonik; pengendalian level air; sistem dua tangki.

ABSTRACT

ADAPTIVE WATER LEVEL MEASUREMENT SYSTEM USING THE ADAPTIVE PID METHOD

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NABILA RAHMADANI

062330320602

DEPARTMENT OF ELECTRICAL ENGINEERING

DIII ELECTRONICS ENGINEERING STUDY PROGRAM

SRIWIJAYA STATE POLYTECHNIC

Accurate and adaptive water level control is an essential aspect of maintaining process stability in liquid storage systems. This study aims to design and implement an ESP32-based adaptive water level measurement system for a dual-tank system using the HC-SR04 ultrasonic sensor, an Adaptive PID controller for the filling process, and an on/off controller for the draining process. The theoretical framework includes control system theory, ultrasonic sensors, the ESP32 microcontroller, the Adaptive PID algorithm, and the on/off control method as the basis for the hardware and software design. The experimental results show that the ultrasonic sensor achieved average measurement errors of 2.41% for Tank 1 and 0.85% for Tank 2. The Adaptive PID controller automatically adjusted the K_p , K_i , and K_d parameters according to changes in the control error, resulting in a rise time of 78 seconds, a settling time of 122 seconds, and a maximum overshoot of 5.25% during the initial test. Compared with the Fixed PID controller, the Adaptive PID provided a faster initial response despite producing a higher overshoot, whereas the Fixed PID exhibited a more stable response. In addition, the on/off controller consistently reduced the water level to the minimum setpoint during the draining process. Based on the experimental results, the proposed system was able to control both the filling and draining processes adaptively and effectively.

Keywords: *ESP32; Adaptive PID; ultrasonic sensor; water level control; dual-tank system.*