ABSTRAK

PENGEMBANGAN PERANGKAT BUOY U-TEWS PADA LAUT DANGKAL UNTUK SISTEM PERINGATAN DINI TSUNAMI (*PILOT PROJECT* DI KAWASAN LAUT KRAKATAU)

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Perangkat pemantauan muka air berbasis PUMMA/IDSL yang menggunakan sensor ultrasonik memang murah dan mudah dipasang, tetapi kinerjanya sangat dipengaruhi kondisi lingkungan. Sinyal ultrasonik sangat rentan mengalami perubahan akibat suhu/kelembapan udara, percikan ombak, buih, hujan deras, kabut/embun garam, serta benda terapung yang kerap menimbulkan noise, *dropout*, dan bias pengukuran. Selain itu, pemasangan di struktur pantai membuatnya rentan rusak saat kejadian ekstrem dan membatasi jangkauan deteksi di sekitar garis pantai sehingga *lead time* peringatan berkurang. Untuk mengatasi keterbatasan tersebut, diperlukan platform lepas pantai yang tetap andal saat permukaan laut ekstrem dan tidak bergantung pada garis pandang ke permukaan, yakni buoy pengukuran berbasis sensor tekanan air. Penelitian ini mengembangkan perangkat buoy U-TEWS (*Unila-Tsunami Early Warning System*) yang dirancang untuk beroperasi di perairan laut dangkal dengan rentang 25 sampai 50 meter, sebagai sistem peringatan dini tsunami. Buoy dilengkapi sensor *submersible gauge* untuk mengukur ketinggian kolom air secara langsung, serta sensor kecepatan dan arah angin, serta tekanan barometrik untuk memvalidasi potensi anomali data. Selain itu, perangkat ini juga dilengkapi *gyroscope* dan *global positioning system* (GPS) untuk kebutuhan navigasi dan pemantauan posisi buoy. Hasil pengujian menunjukkan bahwa sensor *submersible gauge* pada buoy U-TEWS memiliki tingkat akurasi yang baik dengan nilai *root mean square error* (RMSE) sebesar 0,0273. Perangkat dapat beroperasi secara stabil dan mengirimkan data pemantauan dengan kerapatan 1 Hz secara kontinu selama pengujian. Uji ketahanan baterai dengan kapasitas 12 V 80 Ah menunjukkan bahwa perangkat mampu beroperasi hingga 96 jam tanpa pengisian ulang. Selain itu, panel surya memberikan daya pengisian hingga 148,13 W selama sekitar 10 jam penyinaran harian.

Kata Kunci: Gunung Anak Krakatau, Sistem Peringatan Dini Tsunami, Buoy, Tekanan Air, Raspberry Pi.

ABSTRACT

DEVELOPMENT OF U-TEWS BUOY DEVICES IN SHALLOW WATERS FOR TSUNAMI EARLY WARNING SYSTEMS (PILOT PROJECT IN THE KRAKATAU SEA AREA)

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Ultrasonic sea-level monitors such as PUMMA/IDSL are low cost and easy to deploy, but their performance is highly susceptible to environmental conditions. Variations in the speed of ultrasonic signals occurred due to the influence of air temperature and humidity, wave splash and foam, heavy rain, sea-salt mist, and floating debris often introduce noise, dropouts, and measurement bias. Shoreline installation also makes them vulnerable during extreme events and confines detection to the immediate coastal zone, reducing warning lead time. To overcome these limitations, an offshore platform that remains reliable under energetic sea surfaces and does not depend on line-of-sight to the water surface is required, namely, a buoy instrumented with a pressure sensor. This study develops the U-TEWS (Unila-Tsunami Early Warning System) buoy device, designed to operate in shallow coastal waters with a range of 25 to 50 meters depth, as a tsunami early warning system. This buoy is equipped with a submersible gauge sensor to directly measure water column height, as well as wind speed, wind direction, and barometric pressure sensors to validate potential data anomalies. The buoy is also equipped with a gyroscope and global positioning system (GPS) for navigation and buoy position monitoring. Testing shows that the submersible gauge sensor on the U-TEWS buoy has a good accuracy level with a root mean square error (RMSE) of 0.0273. The system operated stably and streamed monitoring data continuously in 1 Hz intervals. The 12V 80 Ah battery endurance tests show that the device can operate for up to 96 hours without recharging. Additionally, The solar array delivered an average charging power of 148.13 W across approximately 10 hours of sunlight. These results indicate that a pressure-sensor-based buoy can address the limitations of PUMMA/IDSL and strengthen coastal hazard early-warning capabilities.

Keywords: Gunung Anak Krakatau, Tsunami Early Warning System, Buoy, Water Pressure, Raspberry Pi.