

**RANCANG BANGUN SISTEM TRANSMISI DATA ULTRASONIK
DENGAN PENGATURAN *GAIN* OTOMATIS BERBASIS *MACHINE*
LEARNING PADA MODULASI *ON-OFF KEYING***

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INTISARI

Meningkatnya kebutuhan akan sistem komunikasi jarak pendek yang efisien, aman, dan bebas interferensi elektromagnetik mendorong pengembangan teknologi alternatif. Sistem komunikasi berbasis gelombang elektromagnetik seperti NFC dan Bluetooth rentan terhadap interferensi elektromagnetik yang menimbulkan *noise*. Namun, teknologi tersebut masih mendominasi pasar karena kemudahan penggunaan dan luasnya ketersediaan. Untuk mengatasi hal tersebut, penelitian ini mengembangkan sistem transmisi data ultrasonik jarak pendek (hingga 5 meter) menggunakan modulasi *On-Off Keying (OOK)*, pengaturan *gain* otomatis berbasis *machine learning*, dan konfigurasi *array* transduser guna meningkatkan jangkauan.

Penelitian dilakukan melalui tahapan perancangan, pembangunan, dan pengujian sistem komunikasi data ultrasonik. Untuk meningkatkan keandalan deteksi, sistem dilengkapi *Automatic Gain Control (AGC)* menggunakan potensiometer digital X9C103S yang dikendalikan mikrokontroler berdasarkan pola kesalahan *decoding*.

Hasil pengujian menunjukkan sistem dapat mentransmisikan data dengan *Bit Error Rate (BER)* = 0 hingga jarak 1 meter, dan tetap berfungsi hingga 5 meter dengan peningkatan BER secara bertahap. Namun, saat diberi penghalang kertas atau plastik, sistem gagal mendeteksi *bit* secara konsisten. Latensi rata-rata tercatat 164,7 ms dengan *jitter* <1 ms, menunjukkan performa *real-time* stabil. Meskipun *signal-to-noise ratio (SNR)* hanya 10–14 dB, keandalan lebih dipengaruhi oleh kestabilan bentuk pulsa. Meskipun akurasi *Decision Tree* hanya 52%, sistem tetap efektif karena prediksi resistansi masih menghasilkan sinyal yang valid.

Kata kunci: komunikasi ultrasonik, *On-Off Keying*, *automatic gain control*, *array* transduser, *machine learning*

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DESIGN AND DEVELOPMENT OF AN ULTRASONIC DATA TRANSMISSION SYSTEM WITH AUTOMATIC GAIN CONTROL BASED ON MACHINE LEARNING USING ON-OFF KEYING MODULATION

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ABSTRACT

The growing demand for efficient, secure, and interference-free short-range communication systems has driven the development of alternative technologies. Electromagnetic-based communication systems such as Wi-Fi and Bluetooth are vulnerable to interference and eavesdropping, especially in enclosed or industrial environments. To address this issue, this study developed a short-range ultrasonic data transmission system (up to 5 meters) using On-Off Keying (OOK) modulation, automatic gain control based on machine learning, and a transducer array configuration to improve transmission range.

The research involved the design, implementation, and testing of the ultrasonic communication system. To enhance detection reliability, the system was equipped with Automatic Gain Control (AGC) using a digital potentiometer X9C103S, controlled by a microcontroller based on decoding error patterns.

Experimental results showed that the system can transmit data with BER of 0 up to a distance of 1 meter and remains functional up to 5 meters with gradually increasing BER. However, when obstructed by paper or plastic, the system consistently failed to detect bits. The average latency was recorded at 164.7 ms with jitter below 1 ms, indicating stable real-time performance. Although the signal-to-noise ratio (SNR) was only 10–14 dB, reliability was more influenced by pulse shape stability than amplitude. The Decision Tree model achieved a classification accuracy of 52%, yet system effectiveness remained high, as several resistance values still produced valid signals.

Keywords: ultrasonic communication, On-Off Keying, automatic gain control, transducer array, machine learning

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