

Simulasi dan Analisis Sistem Reduksi Dispersi Berbasis Hybrid LMS-Kalman pada Subsea Optical Network = Simulation and Analysis of LMS-Kalman Based Hybrid Dispersion Reduction System for Subsea Optical Network

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Abstrak

Penelitian ini berfokus pada simulasi dan analisis sistem reduksi dispersi berbasis algoritma hybrid Least Mean Squares (LMS) dan Kalman Filter untuk jaringan kabel serat optik bawah laut. Dispersi, khususnya dispersi kromatik dan polarisasi, merupakan faktor utama yang menyebabkan degradasi sinyal dalam transmisi data jarak jauh, sehingga meningkatkan Bit Error Rate (BER) dan menurunkan Signal-to-Noise Ratio (SNR). Sistem hybrid LMS-Kalman dirancang secara seri, dengan LMS sebagai filter awal, diikuti oleh Kalman Filter untuk menyempurnakan estimasi sinyal dengan. Simulasi dilakukan menggunakan MATLAB R2021a dengan sinyal input bermodulasi On-Off Keying (OOK) sebanyak 10^6 bit dan panjang kabel 70 km. Hasil simulasi menunjukkan bahwa sistem komunikasi optik End-to-End (E2E) berhasil menurunkan BER seiring peningkatan E_b/N_0 . Namun, algoritma LMS dan hybrid LMS-Kalman tidak menunjukkan penurunan BER yang signifikan dibandingkan sinyal raw, akibat perbedaan linearitas antara sistem optik non-linear dan algoritma linear. Meskipun demikian, sistem hybrid LMS-Kalman menunjukkan performa lebih baik dibandingkan LMS saja karena kemampuan Kalman dalam menstabilkan sinyal. Penelitian ini memberikan wawasan tentang tantangan penerapan algoritma linear pada sistem non-linear dan menyarankan pengembangan lebih lanjut dengan penyesuaian algoritma atau parameter untuk meningkatkan efektivitas reduksi dispersi.

.....This study focuses on the simulation and analysis of a dispersion reduction system based on a hybrid Least Mean Squares (LMS) and Kalman Filter algorithm for subsea optical networks. Dispersion, particularly chromatic and polarization mode dispersion, is a primary factor causing signal degradation in long-haul data transmission, leading to an increased Bit Error Rate (BER) and reduced Signal-to-Noise Ratio (SNR). The hybrid LMS-Kalman system is designed in a serial configuration, with LMS serving as the initial filter to mitigate chromatic dispersion-induced distortions, followed by the Kalman Filter to refine signal estimation by minimizing dynamic noise. Simulations were conducted using MATLAB R2021a with an On-Off Keying (OOK) input signal of 10^6 bits and a 70 km cable length. Results demonstrate that the End-to-End (E2E) optical communication system successfully reduces BER with increasing E_b/N_0 . However, the LMS and hybrid LMS-Kalman algorithms do not significantly reduce BER compared to the raw signal, due to the linearity mismatch between the non-linear optical system and the linear algorithms. Nevertheless, the hybrid LMS-Kalman system outperforms LMS alone, owing to Kalman's ability to stabilize the signal. This study provides insights into the challenges of applying linear algorithms to non-linear systems and suggests further development through algorithm or parameter adjustments to enhance dispersion reduction effectiveness.