Dual-Frequency Amplitude and Phase Measurements by Blind Demodulation of MSK-Modulated VLF Signals

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A new method is demonstrated to improve the signal-to-noise ratio (SNR) of dual-frequency amplitude and phase measurements of MSK-modulated very low frequency (VLF, 3-30 kHz) signals propagating in the Earth-ionosphere waveguide. In real-time, a blind demodulation technique is employed to model the transmitted signal, evaluate the occurrence of a bit transition, and calculate the settling time necessary after a bit transition. Signal properties after the settling time elapses and before the occurrence of the subsequent bit transition are attributed to either of the two primary frequencies used to create the MSK modulation, depending on the slope of the detected signal phase. The technique results in an overall improvement in the SNR of the output amplitude and phase measurements when compared with the standard technique. On the other hand, this new method also experiences time periods during which the amplitude and phase cannot be evaluated due to the fact that the timing criteria are not met. In this paper, continuous ground-based observations from a VLF receiver located at the University of Florida are used to evaluate both techniques and critically compare the amplitude and phase measurements that result.