Adaptive Analog Nonlinear Algorithms and Circuits for Improving Signal Quality in the Presence of Technogenic Interference

Nikitin, A.V. / Avatekh Inc, Lawrence, KS 66044, USA
Davidchack, R.L. / Dept. of Mathematics, U. of Leicester, Leicester, LE1 7RH, UK
Sobering, T.J. / Electronics Design Lab., Kansas State U., Manhattan, KS 66505, USA

Abstract - We introduce algorithms and conceptual circuits for Nonlinear Differential Limiters (NDLs), and outline a methodology for their use to mitigate in-band noise and interference, especially that of technogenic (man-made) origin, affecting various real, complex, and/or vector signals of interest, and limiting the performance of the affected devices and services. At any given frequency, a linear filter affects both the noise and the signal of interest proportionally, and when a linear filter is used to suppress the interference outside of the passband of interest, the resulting signal quality is invariant to the type of the amplitude distribution of the interfering signal, as long as the total power and the spectral composition of the interference remain unchanged. Such a linear filter can be converted into an NDL by introducing an appropriately chosen feedback-based nonlinearity into the response of the filter, and the NDL may reduce the spectral density of particular types of interferences in the signal passband without significantly affecting the signal of interest. As a result, the signal quality can be improved in excess of that achievable by the respective linear filter. The behavior of an NDL filter and its degree of nonlinearity is controlled by a single parameter in a manner that enables significantly better overall suppression of the noise compared to the respective linear filter, especially when the noise contains components of technogenic origin. Adaptive configurations of NDLs are similarly controlled by a single parameter, and are suitable for improving quality of non-stationary signals under time-varying noise conditions. NDLs are designed to be fully compatible with existing linear devices and systems, and to be used as an enhancement, or as a low-cost alternative, to the state-of-art interference mitigation methods.

Keywords - analog signal processing; electromagnetic interference; in-band noise; man-made interference; non-Gaussian noise; nonlinear differential limiters; nonlinear filtering; signal quality; technogenic interference.