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Adaptive Clutter Rejection

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Abstract—Principles of designing adaptive rejector filters with auto-compensation of Doppler phase clutter are considered. Analysis of auto-compensation accuracy as a function of clutter properties and parameters of auto-compensator's nodes is conducted. A method of analyzing adaptive rejector filters depending on their order, parameters of auto-compensator's nodes, volume of the training sample set and clutter characteristics is suggested.

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INTRODUCTION

Extraction of radar signals on the clutter background becomes essentially difficult in conditions of prior ambiguity of spectral and correlation characteristics of noise as well as its heterogeneity in the observation region and non-stationarity in time. Approaches to overcoming prior ambiguity are based on adaptation, though different strategies provide quite different results.

Correlation auto-compensators are known [1] that possess long transient process, which leads to extended edge of uncompensated clutter remnants [2]. When extracting signals with high duty cycle the main operation consists in rejecting clutter with prior compensation of its Doppler frequency (phase) by the corresponding tuning of heterodyne reference signal [3]. Adaptation to the argument of clutter correlation function (Doppler phase) is a necessary condition o fits rejection, but is not sufficient for achieving extreme efficiency.

Complete adaptation to the correlation properties of clutter in accordance with the methodology of adaptive Bayesian approach based on direct estimation of unknown parameters leads to adaptive rejector filters (ARF) with feed-forward connections [4, 5], which, in contrast to the correlation auto-compensators, adapt within the duration of transient process in ARF itself. However due to complex nature of weight coefficients these ARF possess a rather difficult design and require improved speed of executing arithmetic operations for real-time processing.

A way to escape the mentioned difficulties expects prior compensation of clutter Doppler phase shift caused by relative movement of interfering reflection source and radar carrier. In [6] the authors synthesized algorithms and designs of optimal discriminator and auto-compensator of clutter Doppler phase with feedback channel. Rejection of clutter without Doppler phase shifts may be accomplished by a filter with real weight coefficients that adapt to the clutter correlation properties at auto-compensator's output.

Design principles of ARF based on auto-compensator with feedback channel and analysis of ARF efficiency depending on its order, volume of teaching sample set and clutter properties are of essential scientific interest.

PRINCIPLES OF DESIGNING ARF WITH AUTO-COMPENSATOR

Clutter caused by interfering reflection from long objects is a random narrowband Gaussian-type process, which is observed as a mixture with receiver's intrinsic noise. The mixture at jth period in lth range resolution element is described by complex envelope samples $U_{jl} = x_{jl} + \mathrm{i}y_{jl}$ that follow with a period T.

In two adjacent periods within one time strobe that corresponds to n adjacent range resolution elements clutter samples form a teaching set denoted by $\{U_{j-1,l}, U_{jl}\}$, $l = \overline{1,n}$. Under assumption of clutter homogeneity within the considered time strobe clutter in each resolution element is described by the corresponding correlation moments