Performance Analysis of Digital Compression Filters for Radar Application

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ABSTRACT

The paper presents accuracy analysis of digital compression line which consists of digital quadrature detector, simple decimator and matched filter. Up to now analogue quadrature detectors are commonly used for many applications. These detectors suffer from bias and channel balance problems. However, the problem disappears while using digital solution. The main goal was to decrease the computation complexity needed for the processing without loosing the detection accuracy. It was achieved by using the class of digital quadrature detector with sampling frequency four times of IF frequency and simple phase correction filters.

Keywords: quadrature detector, digital signal processing, detector error, chirp, digital compressing line, matched filtering, compression filters

1. INTRODUCTION

High range resolution is much-desired among radar users. This aims at short radar impulses. On the other hand when we are shortening radar impulses and want to maintain radar detection range we have to increase its peak power. This causes some technological problems in transmitting units and make radars easier to detect. Of course there is a solution for this problem: it is the impulse compressing technique (matched filtering).

2. MATCHED FILTER THEORY BACKGROUND

We use special coded impulses in radar signal compressing applications. There are many types of impulse coding [6]. Here we use a Linear Frequency Modulated (LFM) radar impulse.
Assume real deterministic signal $x(t)$ of limited time duration $x \in \langle 0, T \rangle$ received in pre-sence of additive white noise $w(t)$ of zero mean value and variance s_w^2. Under these assumptions we have a filter matched to the signal x(t) which impulse response must satisfy the condition

$$h(t) = x(t - T) \tag{1}$$

where t is any number not less than T satisfying causality of processing application.
The transmittance of the matched filter can be described as:

$$H(f) = X^*(f)e^{-j2pft} \tag{2}$$

From (1) we obtain that the compressed signal has form:

$$y(t) = x(t) * h(t) = x(t) * x(t - T) \tag{3}$$

In frequency domain the compressed signal is equal to [3]:

$$F\{y(t)\} = Y(f) = X(f)H(f) = X(f)X(f)^* e^{-j2pft} \tag{4}$$

Equation (4) is directly used for performing the operation of matched filtering in our application.