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CW-Doppler Guidance Technology

6.1 Introduction

An outline of the principles of the CW-Doppler seeker has been given already in section 2.3, and derivations of the Doppler frequency spectra appear in chapter 5. The purpose of the present chapter is to present a detailed account of the signal processing in the receiver, of the properties of the illuminator and of the effects of external factors on the guidance system.

The functions of the guidance receiver are to amplify signals received by the antenna, to extract the Doppler frequency of every signal, and to select the wanted target echo on the basis of its Doppler frequency, excluding all others; steering signals are then derived from the angle tracking information conveyed by the selected target echo. Outline block diagrams of active and semi-active seekers appear in figures 2.3b and 2.4b respectively; however, several different receiver configurations have evolved during the 30 years or so of the existence of the technology\(^1,\!^{2}\), and the next four sections of the chapter describe these configurations in a comparative manner. Various terms are employed and it will be helpful to explain these at the outset.

Late narrow-banding

The wanted target echo is segregated in Doppler frequency from all other signals by a narrow band-pass filter at a late stage in the receiver chain incorporated within the main IF amplifier (IFA).

Early narrow-banding

(also known as an 'inverse receiver')

The segregation takes place as early as possible in the receiver chain, before the main IF amplifier.

Doppler Frequency Extraction

Explicit  The Doppler frequencies are translated to baseband and hence each Doppler frequency is explicitly represented by an AC frequency.

Implicit  The Doppler frequencies remain always as shifts on a carrier and their presence is implied by the change of frequency.

Doppler Tracking

Frequency lock loop  The Doppler frequency of the wanted target echo is changed to a second intermediate frequency which is compared with that set by a fixed frequency discriminator. Any maladjustment in frequency is sensed and used to retune the associated local oscillator.

Phase lock loop  As for the frequency lock loop, but a phase discriminator is used which senses phase difference. This difference retunes the local oscillator via an integrator.

The treatment of the subject is to give first of all a description of Doppler frequency extraction by the late narrow-banding explicit receiver, as this is the earliest type and the techniques are well established. Then follows an account of Doppler frequency selection and tracking; although this is given in connection with the first type of receiver, it relates to all types of receiver configuration. This is followed by the late narrow-banding implicit receiver and then the early narrow-banding receiver, which is implicit by nature. These sections conclude with a block diagram of a complete seeker using early narrow-banding.

6.2 Late narrow-banding receivers — explicit Doppler extraction

The most common arrangement of this is as shown in figure 6.1. The target signals picked up in the front antenna are amplified at intermediate frequency (IF) by the superheterodyne principle in the channel marked 'Signal IFA'. The reference signal for extraction of the Doppler frequency is derived from the original transmitted signal, either directly by means of a low-power transmission line coupler, as in an active system, or indirectly via the rear reference transmission in semi-active homing. The reference signal is converted to the same IF as that of the target signals by a common microwave local oscillator, and it is then amplified in a separate reference IF channel, the 'Ref IFA'.

Doppler extraction is by heterodyning the reference signal at the output of the 'Ref IFA' with the target signals at the output of the 'Signal IFA' in the Doppler balanced mixer; the target signal Doppler frequencies appear at the output of this mixer at baseband. The signal IFA carries out a large part of this amplification of the target signals, with a maximum gain of about 100 dB. AGC