SIGNAL PROCESSING TECHNIQUES FOR IONOSONDE AND HF-VHF RADARS

Baskaradas James Arokiasamy [2], Cesidio Bianchi [1], Umberto Sciacca [1], Achille Zirizzotti[1], Enrico Zuccheretti [1]

([1]) *Istituto Nazionale di Geofisica e Vulcanologia, Rome, Italy*
([2]) *TRIL fellow, International Center for Theoretical Physics Trieste, Italy*

Abstract

HF-VHF radar techniques are rather easy to employ and commonly used in geophysical applications. Among them are deep radio soundings, used for probing the ionosphere, stratosphere-mesosphere measurement and glaciological study. Fast algorithms and powerful processors facilitate the development of several kinds of low power radars. Nevertheless, the reduction of the transmitted power has to be compensated by on-line processing of an encoded signal in order to maintain a favorable signal-to-noise ratio suitable for detection. Moreover, radars have to reconstruct return echoes with different travel times due to various origins (multi-path). Such needs can be accomplished by means of phase coding the signal and one of the most attractive is the reversal phase code. The composite echo signal must be processed in order to extract the physical information useful for the measurement considered. In this paper some algorithms used for on-line processing of phase-coded signals will be described, both in time and frequency domain. These techniques exploit the resources both DSP and PC for computation.

The actual trend in HF-VHF radars goes toward the simplification of the system hardware, the reduction of transmitted power and the development of more powerful techniques of signal processing. The last is one of the challenging jobs of these radars (phase- coded included), because it consists in a series of tasks, each of them involving a heavy iterative procedure. With the advent of powerful digital signal processors and very fast PCs, the implementation of these algorithms, that gives HF-VHF radar systems the required performances, has become possible. Although these algorithms can be implemented both in time and in frequency domain, working in frequency domain has given more interesting results. These On-line processing techniques have been used in the ionosonde developed by the authors. The present work means to point out the concepts behind the signal processing techniques implemented in systems like those, though, a more general description and design reference can be found in radar manuals.

In this kind of radar the sequence of the process starts from the quadrature sampling and the analog-to-digital conversion; in this way the information is available in digital format, ready for the actual processing carried out in the second step. The quadrature sampling is preferred because it allows retrieving all the information (amplitude and phase) of a composite received signal. These two passages are essential for the following detection process, to extract relevant information from the received echo (i.e. position, velocity, reflected energy, etc.). The final step on the processed signal is data displaying and data storing for further analysis (off-line), worked out by a PC. Working in time domain is easier on some aspects, because the changing of domain introduces two more tasks, the Fourier transform and its inverse. Nonetheless, in frequency domain new processing techniques turn to be possible, so such an approach has become dominant at present. In the phase coded radar care should be taken to maintain the phase information till the phase coherent integration. This helps in increasing the sensitivity at the input of the receiver. The approach should be like employing optimal techniques in the initial raw signals that combine with a highly tolerable detection stage. The raw signal goes through a high gain processing and then in the successive steps, the classification criteria progressively sharpens the identification of the echo.