MODERN RADAR TECHNIQUES FOR GEOPHYSICAL APPLICATIONS: TWO EXAMPLES.
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Introduction: The last decade of the evolution of radar was heavily influenced by the rapid increase in the information processing capabilities. Advances in solid state radio HF devices, digital technology, computing architectures and software offered the designers to develop very efficient radars. In designing modern radars the emphasis goes towards the simplification of the system hardware, reduction of overall power, which is compensated by coding and real time signal processing techniques. Radars are commonly employed in geophysical radio soundings like probing the ionosphere, stratosphere-mesosphere measurement, weather forecast, GPR and radio-glaciology etc.

In the laboratorio di Geofisica Ambientale of the Istituto Nazionale di Geofisica e Vulcanologia (INGV), Rome, Italy, we developed two pulse compression radars. The first is a HF radar called AIS-INGV; Advanced Ionospheric Sounder designed both for the purpose of research and for routine service of the HF radio wave propagation forecast. The second is a VHF radar called GLACIORADAR, which will be substituting the high power envelope radar used by the Italian Glaciological group. This will be employed in studying the sub glacial structures of Antarctica, giving information about layering, the bed rock and sub glacial lakes if present. These are low power radars, which heavily rely on advanced hardware and powerful real time signal processing.

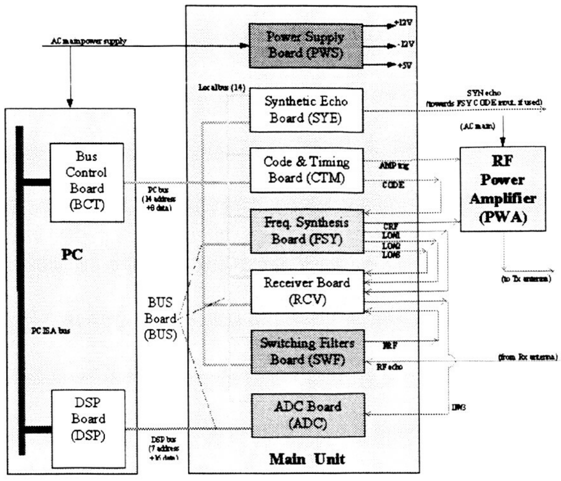
The AIS-INGV ionosonde is a Radar capable of measuring the virtual height of the ionospheric reflections in the frequency range 1-20MHz. It is based on a 16-bit complementary phase code that gives the system about 30 dB gain as a result of correlation process and coherent integration. The system is completely programmable and a directly interfaced PC supports the control, data acquisition, real time processing and storage of the acquired data. Two Italian Ionospheric stations have been equipped with AIS-INGV at Gibilmanna (Italy) and Terra Nova Bay (Antarctica). Both these stations are remotely programmable and giving real-time ionograms. This first generation system allows future expansions like polarization information, Doppler shifts etc. in the form of add on boards on the main radar unit.

The GLACIORADAR is airborne, working at 60 MHz with 13-bit Barker code encoding the carrier. Although this radar is a single frequency system the design constraints are very challenging; like wide bandwidth of 13.3 MHz, sensitivity of –110 dBm. These constraints are due to the range resolution of 10-15m and path loss of 165 dB. This phase coded system has a processing gain of about 21 dB, which literally allows a 500W transmitter replacing a 2kW.

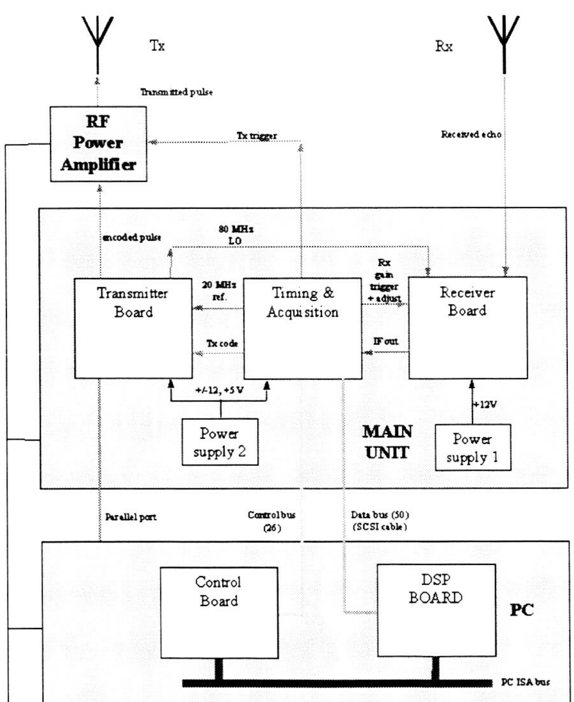
Majority of the functions of these radars are usually implemented digitally and demands high-speed hardware. The carrier, code, control and clock signal generation are implemented digitally. The analog front end of the receiver also plays a major role in improving the signal to noise ratio of the received signal. A special processing care is needed for noise that is inside the information bandwidth of the Radar. The received signal after quadrature sampling would be ready for digital processing. Real time digital processing includes amplitude and frequency filter or limiter, correlation that is a linear detector and coherent integration. The processed data is stored to extract relevant information like position, velocity, reflected energy etc. and displayed.

Concerning the real time signal processing, working in time domain as well as frequency domain is possible. Working in time domain is easier and faster; giving acceptable results in good signal to noise ratio condition. On the contrary changing to frequency domain introduces two more tasks, the Fourier transform and its inverse, but it comes handy when the number of samples increases and above all in poor SNR condition. A good evaluation of the type of coding, kind of noise due to the operating frequency and type of application led to the use of frequency domain processing in these two radars. A trade off between cost, speed and system requirements was done before choosing the type of computing machine. In these two radars the real time signal processing is done by Texas fixed point DSP and PC. This is a cost and computing effective hybrid of fixed and floating-point parallel processing. This hybrid exploits the integration time to run parallel processes. Another highlight of this hybrid is that the calculation/round off noise matches floating point processing.

This poster gives an overview of the two radars and their field results.



AIS-INGV functional diagram



GLACIORADAR functional diagram

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