DEVELOPMENT OF A SIGNAL PROCESSING SUBSYSTEM FOR A SPACEBORNE ROTATING, FAN-BEAM SCATTEROMETER

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1. INTRODUCTION

A Ku-band rotating fan-beam scatterometer is proposed for an ocean satellite based on a small satellite platform in China. It's a dual-beam radar, i.e. VV and HH polarized fanbeams, operating in Ku frequency band (~13.256GHz) and flying on a polar-orbiting satellite at an altitude of 500 km. The two different polarized rotating, range-gated fanbeams observe sea surface in off-nadir viewing mode by tilting the radar beam about 28~51° to retrieve wind field. In this paper, a signal processing methodology is discussed for the proposed new system, which is different from either fixed fan-beam scatterometer or rotating pencil-beam scatterometer. A 1.3 ms linear chirped pulse is transmitted. In the receiver, the echo is deramped by mixing with a chirped reference signal after down conversion to intermediate frequency (IF). A Doppler compensation module is needed to control the frequency characteristic of the reference signal, so the center frequency of deramped signal will accord with the band-pass filter. In our primary design, the control module compensates the Doppler shift frequency in the direction of about 38° incidence angle. Then the signal is digitally sampled and filtered. To extract the range information, an FFT is performed on the filtered signal and a periodogram is implemented by applying a magnitude squared operation. Figure 1 presents the overall signal processing methodology.

2. SCATTEROMETER SIGNAL PROCESSING ANALYSIS

The radar echo can be treated as the summation of returns from many independent scattering patches, each with a different range delay r_i and Doppler shift $f_{d,i}$. As the detected energy is a random variable due to fading, the expected value is taken to find the mean detected energy $\mathrm{E}\left[E_s^{\,q}\right]$ under different wind conditions and the calibration factor X^q. Here, q indicates the slice number.

The antenna footprint determines that the receive gate length is about 2.57 ms (i.e. pulse is extended by 1.27 ms due to the large footprint) and the receive gate delay is 3.74 ms. The effective bandwidth of deramped signal is about 500 KHz. Considering the Doppler effects, the bandwidth of deramped signal is no more than 700 KHz.

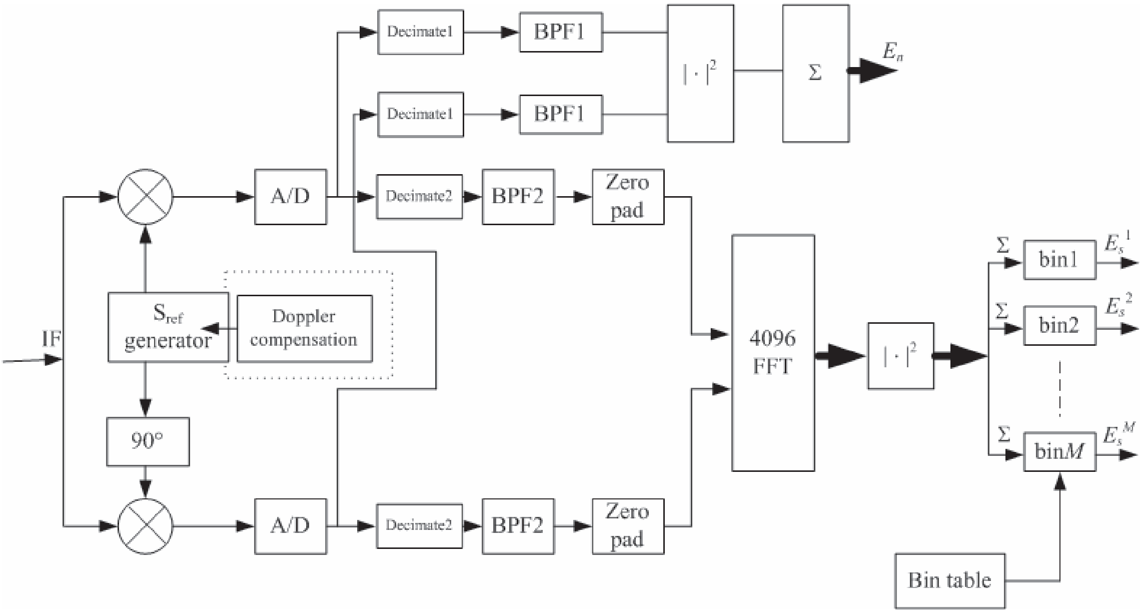

Figure 1. The overall signal processing methodology

If the sampling rate is less than 1.593MHz, a 4096-FFT will be adopted to extract the range information from the deramped signal, or else a larger scale of FFT is needed. The radar echo is contaminated by the near nadir returns which are illuminated by the antenna sidelobes. According to the previous analysis, a simulation process is adopted to analyze how the contamination affects the energy detection for the main measurement footprint.

3. DOPPLER EFFECTS ANALYSIS

Doppler shift is caused by the relative movement of the satellite with respect to the patch. It will compress or stretch the waveform after deramp and FFT. For instance, the bandwidth of deramped signal is about 490 KHz when the scanning beam points to the across-track direction. However, this value is about 314 KHz for forward looking case and 662 KHz for backward looking case respectively. As the total energy is invariable for certain weather condition, the waveform looks to be compressed or stretched. A bin table that is used to create slices of constant resolution in range gate is set up as a function of the Doppler shift.

4. MEASUREMENT VARIANCE OF DETECTED ENERGY

The detected energy E_s^q is noisy due to radar fading and thermal noise. It limits the measurement precision of normalized radar cross section. For the selected filter processing, the measurement precision is discussed. Usually, the measurement variance is quantified by the normalized RMS error, namely K_{pc}. An expression of K_{pc} for the rotating, fan-beam scatterometer is derived in this section, which is a bit different from the presentation of SeaWinds.

5. CONCLUSIONS

In this paper, a signal processing subsystem for a spaceborne rotating, fan-beam scatterometer is discussed. The analysis shows that the near nadir return contamination can be suppressed by the sidelobes of our primarily designed antenna. A bin table is set up to compensate the Doppler shift coarsely on board during summing periodogram bins for slices. Furthermore, the measurement variance of each slice is evaluated, and the variance of combined slices is presented.

6. REFERENCES

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