8.5B SIGNAL PROCESSING AT THE POKER FLAT MST RADAR

D. A. Carter

Aeronomy Laboratory
National Oceanic and Atmospheric Administration
Boulder, CO 80303

Signal processing at the Poker Flat MST radar is carried out by a combination of hardware in high-speed special-purpose devices and software in a general-purpose minicomputer/array processor. Figure 1 is a block diagram of the signal processing system.

The received signals from three antennas (one directed vertically and two directed obliquely) are detected by three receivers. The six receiver quadrature outputs are sampled simultaneously by six 8-bit analog-to-digital converters. With the current ADCs, the minimum sampling period is 2 μsec. Each conversion is triggered by a pulse from the Radar Pulse Box which also contains the system clock and creates the transmitter and TR switch pulses.

Because of the low atmospheric Doppler shifts (less than 10 Hz) and the high radar pulse rate (about 1 kHz), coherent integration of the received signals can greatly simplify the signal processing. Currently the digitized data points from the ADC box are transferred directly to the minicomputer. On the computer/ADC interface board is a simple circuit to add the incoming values one by one to the corresponding coherent integration sum in computer memory. This simple coherent integrator is much faster than software algorithms used previously.

Even greater coherent integration speed will be attained in the near future when the digitized ADC samples will be passed to a high-speed preprocessor, called the Radar Signal Compender (RSC), which can process the six channels in parallel. This box, designed by Wesley Swartz (Cornell) and Paul Johnston (NOAA), is currently being assembled and will be capable of performing coherent integration and decoding. The RSC consists of six function modules (FMs), each of which can process a pair of quadrature channels, and a master control module. Each function module contains four 2 k by 16-bit double-buffered input memories, four 2 k by 32-bit double-buffered output memories, and two high-speed 32-bit wide adders. Each function module can be individually programmed by the host computer via the master control module. In the anticipated operating mode at Poker Flat, each pair of quadrature channels will feed two function modules so that a different number of coherent integrations can be performed on two height ranges from each receiver. Pulse coding/decoding will be implemented in the system at a later date.

After coherent integration, the data (one 32-bit floating point value per range gate per channel) will be transferred from the RSC to the host computer. The computer is a Data General AP/130 which contains a 128 k by 16-bit main memory and an integral floating-point array processor with its own high-speed 2 k by 32-bit local memory. After all coherently integrated points (typically 64 for each range gate) are stored in the computer, the following operations are performed by the array processor on the data from each range gate:

(1) The values are normalized by dividing by the number of coherent integrations,

(2) The mean value of each quadrature component is computed and subtracted from the data.

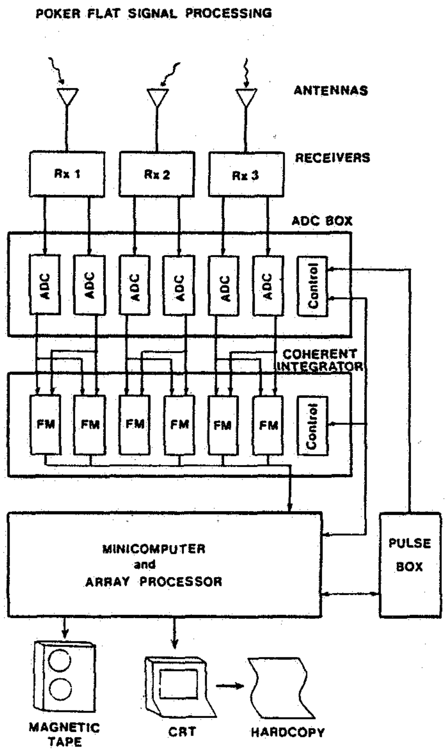

Figure 1.

(3) A Hanning window is applied,

(4) The fast Fourier transform is computed,

(5) The power spectrum is computed from the squared magnitude of the transform, and

(6) The spectrum is added to the spectral sum for that range gate.

The array processor performs the above operations much faster than possible using the standard minicomputer. A 1024-point complex floating-point FFT takes about 9 msec and a 64-point FFT about 0.3 msec in the AP, which is at least 50 times faster than an integer FFT algorithm used previously on a standard minicomputer. The entire analysis time for 45 heights on each of 3 receivers using 64-point spectra takes about 0.2 sec, which is much shorter than the 3-30 sec required to acquire the coherently integrated data set. Thus, many more heights can be sampled before data are lost due to processing overhead.

After about a minute of spectral averaging, the moments of the Doppler power spectra are calculated and the signal power, mean Doppler shift, spectral width, and noise power for each range gate are written to magnetic tape (see Riddle, p. 863, this volume). Long-term averages of the Doppler power spectra are accumulated for a longer period (typically about 10 min) and also written to tape when complete. By not writing the complete spectra to tape for every short-term average, a standard 2400 ft 1600 BPI tape of 1-minute averages for about 135 total range gates will last for at least 50 hours. The availability of the Doppler spectra on tape allows additional off-line processing of the spectra, a good quality control check of the system, and possible further averaging to detect signals at ranges where no echoes were apparent in the 1-minute data.

The Doppler spectra can also be displayed on a graphics CRT terminal. Hardcopies of the spectra are routinely printed out every hour, providing a good, quick overview of the data taken during the normal unattended operation of the radar.