2.2A EFFECTS OF PULSE WIDTH AND CODING ON RADAR RETURNS FROM CLEAR AIR

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In MST radar studies it is desired to obtain maximum information about the atmosphere and to use efficiently the radar transmitter and processing hardware. Large pulse widths are used to increase the signal-to-noise ratio since clear air returns are generally weak and maximum height coverage is desired. Yet since good height resolution is equally important, pulse compression techniques such as phase coding are employed to optimize the average power of the transmitter. Considerations in implementing a coding scheme and subsequent effects of an impinging pulse on the atmosphere are the subject of this paper.

As noted, a large pulse width is desirable to maximize S/N which varies as the square of the pulse width. In using phase codes one pays for good height resolution in terms of decreased S/N. As height resolution increases, noise increases since the receiver bandwidth must be widened to match the decreased pulse length. The net effect is for the S/N ratio to vary as pulse width squared for uncoded pulses but for coded pulses, S/N is proportional to the pulse width. In general, one selects an optimal set of system parameters (interpulse period (IPP), pulse width, coding scheme, gate delay) to avoid range aliasing, ionospheric interference (e.g., electrojet returns at Jicamarca), code sidelobes and ground clutter.

PULSE WIDTH EFFECTS

While a maximum duty cycle and high average power is preferred, a longer pulse causes ground clutter to be smeared over more heights. Hence strong clutter returns may overwhelm weak signals at higher altitudes.

As the scattering volume is proportional to pulse width, it is possible for one or more signal peaks to occur within a given range gate. The resolution of the structure of a particular phenomenon, e.g., wind shear, is dependent on height resolution available.

The spectral width of the signal is a measure of the distribution of velocities within the scattering volume. Velocities may be distributed due to some random process such as turbulent scattering. On the other hand, there may be some vertical structure such as velocity shear which organizes the velocity distribution. For a random distribution, one would expect no change in spectral width with pulse width, while in the case of a velocity shear the spectral width should vary with illuminated volume, i.e. pulse width.

PULSE CODING EFFECTS

While use of phase codes yields good height resolution and maximum average transmitter power, proper selection of IPP and codes helps to eliminate range aliasing and ambiguities. Certain codes such as Barker codes are undesirable due to range sidelobes. There exists a 2-3 dB/km dropoff in signal power in the neutral atmosphere. For a 13-baud Barker code, the range sidelobes are 22 dB down from the peak but are nevertheless sufficient at a 1-km baud length to cause clutter from signals 10 km below to interfere.

Correlation times of the medium in the stratosphere and mesosphere are on the order of .5 to 1 second, which is sufficiently long that complementary codes and coherent integration techniques can be used. The total coherent averaging time must be less than the coherence time of the atmosphere.

Ideally, perfect codes are generated, transmitted, scattered, received and decoded, but this does not happen in practice. SULZER and WOODMAN (unpublished manuscript, 1982) have considered some of the practical problems and have generated a set of quasi-complementary codes to overcome some of the deficiencies of complementary codes. Quasi-complementary codes are beneficial in eliminating ghosts from range sidelobes of complementary codes produced in the actual implementation of codes due to such effects as transmitter ringing and frequency domain asymmetry. Furthermore, quasi-complementary codes perform better than complementary codes when incomplete decoding due to truncated signals at lower altitudes occurs as a result of the loss of the first few bauds during receiver blanking. Finally quasi-complementary codes are good for suppressing interference from clutter since each individual code of the quasi-complementary code set is of higher quality (lower sidelobes) than an individual code of a complementary pair.