NASA TECH BRIEF

Combination Ranging System and Mapping Radar

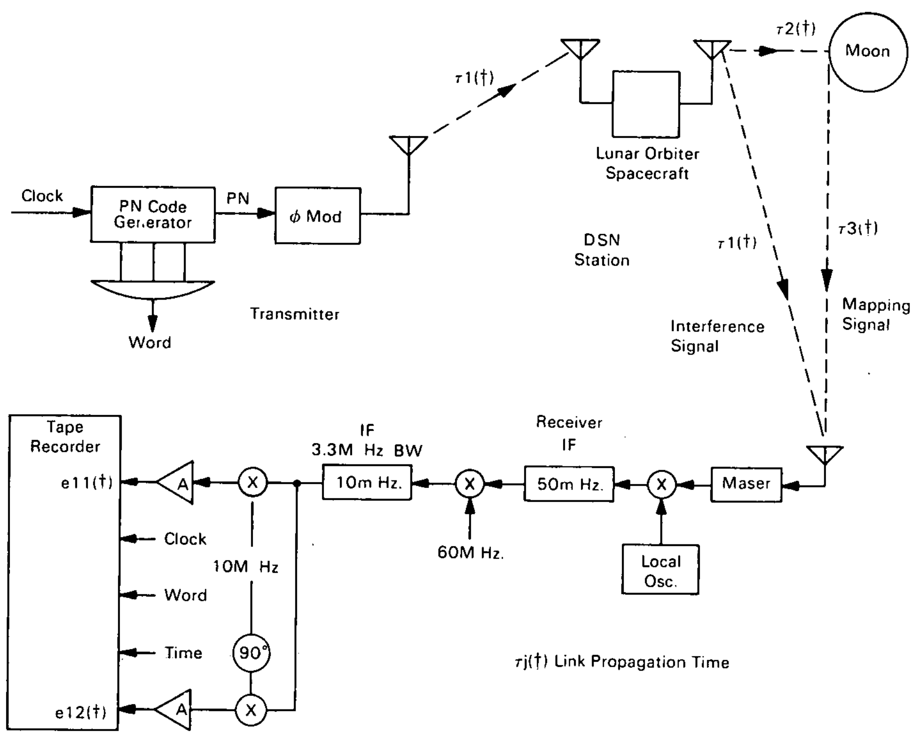

Fig. 1. Combination Ranging System and Mapping Radar

The problem:

To develop accurate radar maps of lunar and/or planetary surfaces using currently available communications elements. Present earth based techniques illuminate a planetary surface with a time coded waveform, which allows resolution of constant time delay contours. These are circles concentric to the point nearest earth. Planetary rotation produces constant doppler contours parallel to the planet axis of rotation. Thus, spatial coordinates are represented by the signal properties time delay and doppler frequency. An image is formed by converting the signal properties back into spatial coordinates. Since the doppler-time delay contours may intersect at more than one point, several surface features may correspond to a given doppler-time delay coordinate. These surface features can be separated only by comparing data from several observation periods.

The solution:

Use of a transmitter radiating at a right angle to the spacecraft trajectory and intersecting the surface at a shallow angle. An earth based station receives

(continued overleaf)

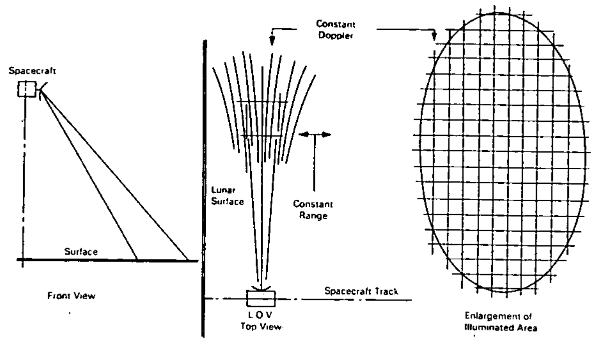

Fig. 2. Combination Ranging System and Mapping Radar

the signal reflected from the planetary surface. The principal features of the technique are the mapping coordinates and signal strength which can be produced by an earth based transmitter. The time delay contours are segments of concentric circular arcs, while the doppler contours are segments of hyperbolic sections. These contours intersect one point only and are nearly orthogonal. Thus the signal properties and spatial coordinates are identical, and mapping results may be obtained from a single observation.

How it's done:

Preliminary investigation has shown that the S-band ranging transponder with a high gain antenna could serve as a side looking radar with the Deep Space Stations (DSS) a part of the system. A bistatic side-looking radar experiment was performed, and as shown in the figures, the actual radar signal is transmitted from the spacecraft, reflected from the lunar surface, and received at the Deep Space Station (in this case, Goldstone, California, 210 cassegrainian antenna). In order to keep time and frequency references, the ranging modulation was actually transmitted from the DSS to the spacecraft, routed through the transponder, and retransmitted to the lunar surface on a different carrier frequency. The experimental communication link contained three time-varying propagation times: station-to-spacecraft; spacecraft-to-surface; and surface-to-station. Proper tracking of the round-trip delay and doppler is the crux of the data processing problem.

The received signal is recorded in phase quadrature, as shown in Figure 1, along with end of code word pulse, clock, and time reference. Range resolution of point scatterers on the lunar surface is achieved by using a pseudo noise (PN) code biphase modulated on the carrier. The received signal is multiplied by an identical locally generated PN sequence. The portion of the received signal whose modulation is synchronized to the local code can be separated from the rest by a low pass filter. This signal corresponds to a narrow strip at constant range from the spacecraft, as shown in Figure 2. Each point within that strip passes through the lines of constant doppler caused by the motion of the spacecraft. A filter which matches that motion-induced phase behavior can resolve individual point scatterers. This is the basic principle of the side-looking radar.

The surface resolution is determined by the radar beam incidence angle, the PN code bit length, and the bandwidth of the spacecraft transponder, the DSN Receiver IF Amplifier, and the tape recorder. The bit rate chosen for the experiment was a one third MHz clock rate, allowing a 3 μsecond bit time. This is 1.0 km in slant range, corresponding to about 1.4 km on the surface.

The code length was long enough to keep the spacecraft's direct signal and the surface reflected signal unambiguous. Also, the longer the code, the better the suppression of the direct signal. However, searching for the surface reflected signal becomes more difficult as the code is lengthened. The code length chosen was 1023 bits.

Signal strength calculations were based on resolving a one-kilometer square on the surface. Predictions showed a 3 db signal-to-noise ratio. Such a noisy picture should reveal a recognizable shape, such as a large crater.

Notes:

1. An analysis of the data is not yet complete.
2. Documentation is available from:
   Clearinghouse for Federal Scientific
   and Technical Information
   Springfield, Virginia 22151
   Price $3.00
   Reference: TSP69-10325

Patent status:

This invention is owned by NASA, and a patent application has been filed. Royalty-free, non-exclusive licenses for its commercial use will be granted by NASA. Inquiries concerning license rights should be made to NASA, Code GP, Washington, D.C. 20546.

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