the remote rack, where it is reconditioned to logic level specifications, de-serialized, and converted back to analog. In the rotating electronics are code generators to indicate the beginning of files for data synchronization.

An alternative method would be to use two symmetrical coils. Since the two coils are rotationally symmetrical, rotation does not influence the magnetic coupling from the primary to the secondary. Since the secondary coil is electrostatically shielded, environmental noise pickup is intrinsically low. Since the transformer is air-core, the uncompressed bandwidth can be high — 50 MHz, 200 MHz, or higher.

The rotating coil is the primary component of the transformer and is in the shape of a thin ring, containing a few turns of wire. The plane of the ring is perpendicular to the axis of rotation. Radially, just beyond the rotating primary coil, is the secondary coil in the shape of a ring, and lying close to the primary. The secondary coil is a single turn of coaxial cable with the center conductor connected to the shield of the cable where it leaves the coil. The binary data are fed into both ends of the primary coil through an impedance matching resistor, with one end receiving the data inverted. This double-ended (full-bridge) approach reduces propagation delay distortions and increases signal strength. The secondary coil has an impedance matching resistor at the end of the cable. Use of a coaxial cable reduces capacitive coupling, but freely allows magnetic coupling. To enhance the coupling, ferrite cloth can be laid into a groove and the primary coil wound on top of it. Similarly, ferrite cloth can be formed around the secondary coil. Copper rings can be placed on either side of the coil set to reduce outside influences.

This work was done by Elmer Griebeler, Nuha Nawash, and James Buckley of Glenn Research Center. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steven Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18575-1/7-1.

Telemetry-Based Ranging

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A telemetry-based ranging scheme was developed in which the downlink ranging signal is eliminated, and the range is computed directly from the downlink telemetry signal. This is the first Deep Space Network (DSN) ranging technology that does not require the spacecraft to transmit a separate ranging signal. By contrast, the evolutionary ranging techniques used over the years by NASA missions, including sequential ranging (transmission of a sequence of sinusoids) and PN-ranging (transmission of a pseudo-noise sequence) — whether regenerative (spacecraft acquires, then regenerates and retransmits a noise-free ranging signal) or transparent (spacecraft feeds the noisy demodulated uplink ranging signal into the downlink phase modulator) — relied on spacecraft power and bandwidth to transmit an explicit ranging signal.

The state of the art in ranging is described in an emerging CCSDS (Consultative Committee for Space Data Systems) standard, in which a pseudo-noise (PN) sequence is transmitted from the ground to the spacecraft, acquired onboard, and the PN sequence is coherently retransmitted back to the ground, where a delay measurement is made between the uplink and downlink signals. In this work, the telemetry signal is aligned with the uplink PN code epoch. The ground station computes the delay between the uplink signal transmission and the received downlink telemetry. Such a computation is feasible because symbol synchronizability is already an integral part of the telemetry design.

Under existing technology, the telemetry signal cannot be used for ranging because its arrival-time information is not coherent with any Earth reference signal. By introducing this coherence, and performing joint telemetry detection and arrival-time estimation on the ground, a high-rate telemetry signal can provide all the precision necessary for spacecraft ranging.

This work was done by Jon Hamkins, Victor A. Vilnrotter, Kenneth S. Andrews, and Shervin Shambayati of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-47170