Modifying an HA/Dec Coordinate Antenna Pointing System to Process Data From an X/Y-Mounted Antenna

W. Davis
DSN Data Systems Development Section

About mid-1972, JPL assumed responsibility for the operation of NASA's STDN station at Canberra. This action was prompted by the decommissioning of DSS 41 at Woomera and increased tracking commitments for the DSN. Although DSS 44 (previously STDN's Honeysuckle Apollo) is a unified S-band 26-m antenna, its coordinate system is X/Y. This article addresses the differences between the X/Y system and that of the DSN's HA/dec, and describes how a functional system was created using subsystem assemblies from both stations.

I. DSN/STDN Configuration

The antenna pointing assembly (APA) and the tracking data handling (TDH) subsystem within a DSN 26-m Deep Space Station (DSS) operate in conjunction with an antenna whose orthogonal axes are oriented in hour angle (HA) and declination (dec). Servo position information is processed by a transmitter-repeater-encoder servo system and routed directly to storage registers within the TDH. This is the distribution point for all angle information such as visual displays, angle information to the APA computer, and angle information to the digital instrumentation subsystem (DIS) for high-speed data line transmission to the Network Operations Control Center (NOCC) and Flight Project.

Such a system (see Fig. 1) was available from DSS 51 for installation at Honeysuckle. It would seem that substituting a complete system would be the most logical approach from the standpoint of conversion requirements. However, mechanical problems involved with the mounting and coupling of the DSN transmitter-repeaters on the axis shafts of the STDN antenna precluded this approach. An approach using parts from both systems was finally employed. The interface was selected at a point following the STDN translator. This then included the STDN transmitters and the servo repeaters on the antenna structure, thus maintaining the integrity of the precision calibrations that are necessary with that portion of a servo system, as well as eliminating the mechanical problems mentioned previously.

II. Problem Areas and Software

Combining portions of both systems created two basic incompatibilities:

1. The data code generated by the STDN translator is in binary rather than binary-coded decimal (BCD) as it is in the DSN.
2. Data processing must operate with an X/Y coordinate system rather than an HA/dec system.

The APA computer provided a ready solution to the coordinate conversion problem, and because this approach involved writing a new operational software program, the additional task of converting the coding format was also placed within the software. This second consideration eliminated the need for extensive circuit redesign of the TDH storage registers. These registers accept six packed-decimal digits (4 bits each except for the most significant digit, which has 2 bits) in BCD. Output from the STDN translators is 16 bits of straight binary plus sign.

In its new role, the APA computer will process 16 bits of straight binary data from the translator and deliver them as 21 bits of BCD to the TDH storage buffer. Because there is no sign capability within the buffer, negative angles will be represented by angles within the fourth quadrant. (The STDN antenna delivers + and -90 deg readings in both axes.) The conversion between the coordinate systems is done within the software using trigonometric routines. The unmodified DSN software utilized the HA/dec and azimuth/elevation (az/el) coordinate systems, converting from one to the other as needed. The az/el system is used for refraction corrections, visibility/rise time considerations, angle "stop" tests, position offsets, and rate offsets. The HA/dec system is used for antenna positioning, error display, and position and rate offsets.

In the modified version, the X/Y system takes the place of the HA/dec. However, the HA/dec system is still utilized internally for some purposes. For example, right ascension and declination are converted to hour angle and declination, and then a conversion is used to obtain the X/Y equivalents.

III. Problem Areas and the Hardware

Logic level requirements and system timing problems were solved using hardware. The APA uses positive logic, as opposed to negative, for both the TDH registers and the STDN translator. Fortunately, the input circuits of the APA were already equipped with negative-to-positive logic conversion circuits; so no modifications were required to handle the input angle data. Output circuits, however, were not buffered for conversion from positive to negative. Two existing spare parallel output channels were cabled to an existing auxiliary chassis within the APA computer. The appropriate buffering was done in this chassis using standard circuit board cards, and the necessary backplane wiring was added. Output cabling to the TDH registers was also added. The new interface as assembled at DSS 44 is shown in Fig. 2.

Another important consideration was that of timing relative to the transfer of data between the interfaces. Communication between the APA and the translator was accomplished by using a system clock pulse from the computer in conjunction with a software mechanized delay in the data sample routine. Both the "read" pulse, required by the translator for sampling its data, and the pulse furnished by the translator, which alerts the reading device (in this case the APA) to take data, required characteristics not inherent in the pulses furnished by the APA.

The read pulse was modified by taking a 50-pps clock pulse from the computer and modifying its width and polarity using existing circuitry within the TDH buffer before sending it to the translator. The translator's "sample ready" to the APA was simulated by a corresponding "built-in" delay within the software routine.

There was also a timing consideration associated with the output data to the TDH storage buffer. As mechanized within the DSN, the APA and TDH either singularly or in unison can command data storage from the DSN translator. The flow of data in this case was from the translator directly to the APA or to the TDH via the storage registers. Essentially, they received data in parallel, the TDH path being buffered by the storage registers. This allowed the TDH longer sample periods for such things as visual displays, but did not hinder the higher rate required by the APA for angle error updates to the servo drive system.

At DSS 44, however, the APA furnishes the input to the storage register rather than the translator. With the TDH requesting data and the APA storing, it is obvious that a priority system had to be designed. This was done by using existing logic within the buffer register. The timing circuits originally used for the DSN requirements furnished all the needed logic, making it possible to accomplish the task by simply restructuring that logic. The new circuit design allows the buffer register to follow data inputs from the APA at a 50-pps rate whenever a

TDH sample pulse is not present. The sample pulse has priority and will hold the buffer register in the store mode, thus guaranteeing the validity of the data output to the TDH.

IV. Operating Personnel Considerations

Station operational requirements had to be considered when data output formats to the station were established. All visual readouts of angles are in values of X and Y, so that station personnel can readily relate them to the observed position of the antenna. This includes all displays serviced by the TDH buffer register, the typewriter printout, and the commanded angle information of the APA remote control panel. Manual inputs to this panel, such as position and rate offsets, are recognized by the APA program as X and Y angles, as are the predicted angles delivered to the station by the Flight Project/NOCC.

V. Conclusion

DSS 44 is unique to the Deep Space Network, and in all probability will remain so. Under the circumstances, lengthy new designs were not considered worthwhile. Adoption of this hybrid system was only the first of several approaches used to minimize the total effort. Relying heavily upon software and restructuring of existing circuit logic accomplished the job in a reasonable amount of time and at low cost.

Bibliography

1. Corliss, W. R., *Space Craft Tracking*, NASA EP-55, Oct. 1, 1968.
2. Davis, W., *MSFN Translator, DSN APS/TDH Interface*, Modification Procedure BP510007A, Sept. 6, 1974 (JPL internal document).
3. McCornock, D., *Modifications to APS Software for Operations at DSS-44*, D01-5069-OP, October 1974 (JPL internal document).
4. Perlman, M., *Description and Evaluation of Angular Encoding Systems Utilized by Goldstone Tracking Antennas*, Technical Memorandum No. 33-25, Nov. 30, 1960 (JPL internal document).

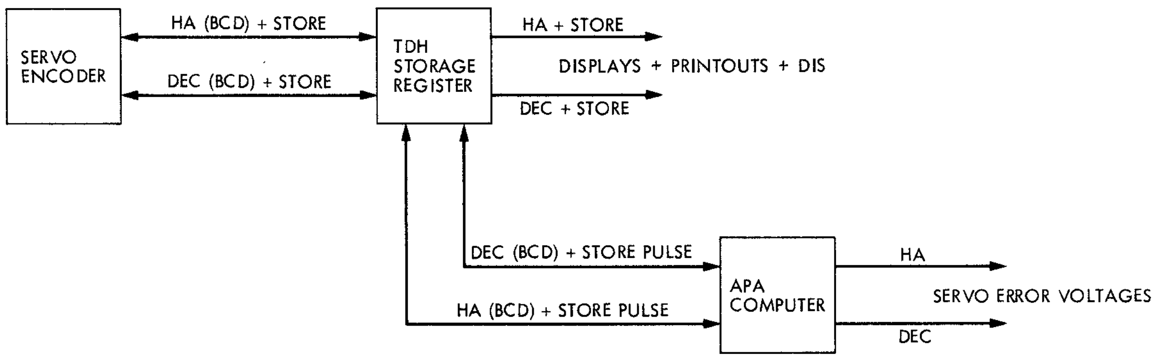

Fig. 1. DSN configuration

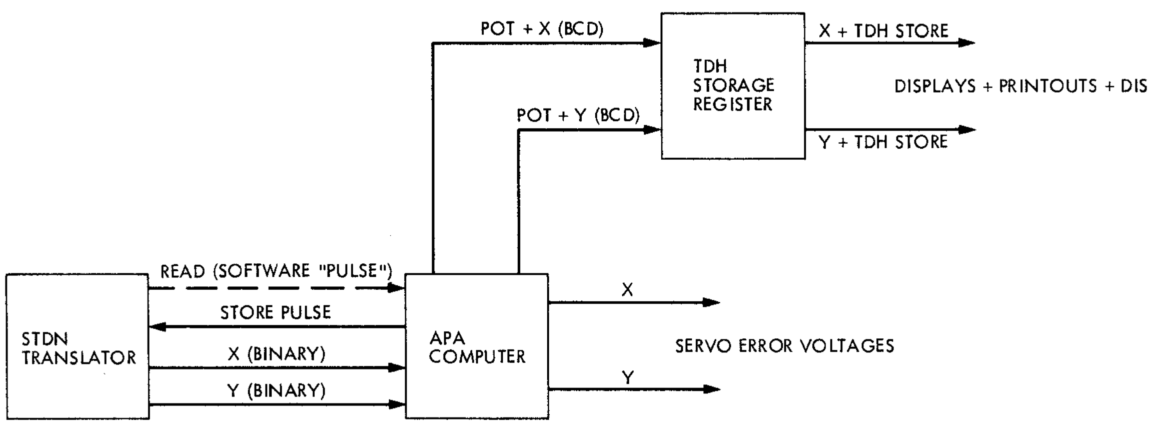

Fig. 2. DSS 44 configuration