# Automatic Space Noise Recorder

R. W. Livermore
Tidbinbilla Deep Space Communications Complex

*A method is described of adding hardware and software to the Antenna Pointing Subsystem (APS) for star tracking and to check pointing. The addition is also designed as an aid in using the antenna for radio astronomy. The antenna will automatically scan radio stars in hour angle and declination. Noise is sampled by an analog-to-digital (A-D) converter and recorded (along with other parameters) onto magnetic tape.*

## I. Introduction

Present methods of star tracking require careful operation and recording of levels, usually on a chart recorder. Operationally, this method is tedious and liable to errors. This article describes an automatic method which records all data on magnetic tape for future processing. It is proposed to deal with processing in a later article, however an initial program using a least squares curve fitting technique to a normal curve has proved very accurate in obtaining a measure of antenna accuracy. Recording errors should be eliminated, and a minimum of operator supervision is required to continuously star track. The program has been written with selectable modes of operation with a view to easily adding any extra scanning or data collection methods.

## II. Additional Hardware

An XDS TM4 magnetic tape recorder is connected to the W buffer of the APS. Records are written on magnetic tape in 480-word blocks using interlace. A 10-bit A-D converter is connected to a spare 24-bit parallel input of the APS which uses EOM 30020. The A-D converter is triggered 50 times per second in parallel with the normal 50 PPS supplied to the APS. Bits 0 to 9 of the 24-bit word input are used to allow use of the sign bit 0 when processing within the XDS 910 computer. The analog input to the A-D converter is obtained from the 2-volt output 0.1-second time constant of the broadband square law detector.

## III. Additional Software

The program was written as an overfill for program DOI-5047-OP, which is the antenna pointing program for the 64-meter antenna at DSS 43. The overfill uses about 2000 extra octal locations and was allocated locations 13000 and up. A new declination rate offset interrupt routine has been written to select the mode of operation and initialize counters and scan rates. A real-time auto-track facility has recently been added and has been tested

on a star of about 40 flux units. Briefly, the method is to keep a running mean of 10 seconds worth of data, and to optimize by automatic entry of offsets; hour angle and declination are adjusted alternately at one-minute intervals. Examination of the digi-switch input is made to determine the program selected. There are 20 remaining bits left, which will be useful for other information that may be required at a later stage.

## IV. Program Operation

A normal hour angle and declination star input is made at the APS control panel, and the antenna is pointed at the star. To commence an automatic scanning star track, magnetic tape unit No. 1 is made ready and the declination rate offset interrupt switch is operated with the declination rate offset value set to zero. The antenna then goes into continuous declination scans followed by hour angle scans. The drive off and on is at 5 times sidereal rate and the scan is at sidereal rate (sidereal rate = 0.004178 degrees per second). It is intended to be able to increase scanning rates up to 5 times sidereal rate with a later version of the program. The A-D converter samples 50 times per second and data are recorded only during the sidereal rate scans. The declination scan is over a local declination of one degree. The hour angle scan is over 1/cos declination degrees. Data are written on the magnetic tape in binary records of 480 words, once per minute.

## V. Magnetic Tape Data Formats

The 480-word record is divided up into 60 sections. Each section of 8 words is allocated the following values: DOY, GMT, sample, hour angle, declination, azimuth, elevation and sum of squares.

(1) DOY (day of year) is in 4-bit BCD (binary coded decimal).

(2) GMT is in 4-bit BCD.

(3) The value of the sample is the sum of the previous 50 samples per second.

(4) Hour angle, declination, azimuth, and elevation are all commanded angles in 1/1000 of a degree with binary point at bit 024 (octal).

(5) The sum of the squares of the sample is also available to allow calculations of the standard deviation.

To assist in processing to find accuracy of the antenna, the two most significant bits of the DOY word are used to indicate zero offsets in either hour angle or declination. This occurs when the antenna is being commanded to point at the source. Bit 0 is true for the center of the declination scan. Bits 0 and 1 are true for the center of the hour angle scan.

## VI. Printing and Graphing Results

A sample of the type of result obtained is shown in Table 1 for Virgo, Day 63. Other parameters can be listed, such as right ascension and declination, local hour angle and local declination, DOY and GMT, azimuth and elevation, and value of the least sum of squares.

## VII. Conclusions.

Initial processing of the magnetic tape recordings has been good. Filtering of the samples is necessary, and accurate estimations of antenna pointing accuracy can be made. Processing is not done in real time, therefore longer routines can be employed. Curve fitting equations can be used with greater accuracy than that of the pointing program itself which is ±0.001 degrees. It is feasable to record angle tracking data at the APS, together with sampling an analog input. This could be done at a rate of 50 times per second, without impairing normal pointing facilities while tracking a spacecraft.

## Acknowledgment

Thanks are due to D. L. Jauncey (Australian Commonwealth Scientific Industrial Research Organization) for valuable advice on desirable methods of star tracking.

**Table 1. Antenna offsets in 1/1000ths of degree**

| Hour angle | −20 | −10 | 0 | +10 | +20 |
|---|---|---|---|---|---|
| 344.197 | I | I | I | D[b] | I |
| 345.484 | I | H[a]I | I | I | I |
| 346.761 | I | I | I | D | I |
| 348.048 | I | HI | I | I | I |
| 349.320 | I | I | I | D | I |
| 350.612 | I | HI | I | I | I |
| 351.890 | I | I | I | DI | I |
| 353.177 | I | HI | I | I | I |
| 354.455 | I | I | I | DI | I |
| 355.741 | I | HI | I | I | I |
| 357.019 | I | I | I | DI | I |
| 358.306 | I | HI | I | I | I |

[a]D = declination.
[b]H = hour angle.