MAGNETIC FIELD MEASUREMENTS
BY PIONEER 7

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Elements from 17 August 1966
to 29 October 1967 (Bartels' Solar
Rotation 1820 to 1836)

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GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

(NASA-TM-X-65769) MAGNETIC FIELD
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N. F. Ness, et al 
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1. Introduction

The Pioneer 7 spacecraft is a spin stabilized interplanetary probe launched from the Eastern Test Range, Cape Kennedy, Florida on 17 August 1966. The geocentric orbit of the spacecraft has an aphelion of 1.125 AU, a perihelion 1.010 AU, inclination to the ecliptic of 0° and orbital period of 403 days. This spacecraft was the first of a series of four Pioneer spacecraft with identical structures but slightly different complements of experiments. A NASA-GSFC magnetic field experiment was proposed, accepted and flown on Pioneers 6 (in 1965) and 7. Subsequently, unique circumstances presented an opportunity for flight of a similar experiment by the GSFC group in collaboration with the University of Rome, Laboratory for Space Plasma Research group on Pioneer 8 (in 1967).

The magnetic field experiment detector is a monoaxial fluxgate magnetometer sensor mounted on the end of a boom at a distance of 2.1 meters from the spacecraft spin axis. The initial spin period was approximately one second and the field measurements were synchronized with the rotation of the spacecraft. The monoaxial sensor was oriented at an angle of 54° 45' to the spin axis so that during one spacecraft rotation three samples of the magnetic field at equal intervals yielded three independent measurements in mutually orthogonal directions. These basic measurements, obtained in a time interval of 2/3 of a second, define the total vector magnetic field in a spacecraft coordinate system.
The spin axis of the spacecraft was oriented orthogonal to the ecliptic plane with the high gain antenna of the spacecraft pointing to the south ecliptic pole.

Data transmission from the spacecraft experiment was synchronized with telemetry, which ranged from 8 to 512 bits/sec during the lifetime of the spacecraft. A complete three component measurement was not read out during each spin period and so individual data points are not equally spaced in time (see Scearce et al., 1968 for description of the experiment).

The Pioneer 7 instrument was a single range magnetometer ($\pm 32\gamma$) which with the 8 bit quantization of the analog to digital converter yielded a digital window size of $\pm 0.125\gamma$. The RMS noise level of the sensor was $0.12\gamma$ and the bandwidth 0 to 5 cps. The magnetic field of the spacecraft and associated solar array as measured at the sensor location was estimated to be less than $0.6\gamma$. Periodic sensitivity calibrations were made once each day as well as zero level checks approximately once every several months. The projection of the orbit described by Pioneer 7 on the ecliptic plane, relative to the earth-sun-line, is shown in Figure 1.
2. Data

The magnetic field elements have been computed in a spacecraft centered solar ecliptic system in which the $X$ axis points from the spacecraft to the sun, the $Z$ axis to the ecliptic north pole and the $Y$ axis being the third axis of the orthogonal right handed coordinate system.

The standard data analysis was performed to yield 30 second averages of the field components and the field magnitudes as

$$
\bar{X} = \frac{1}{n} \sum_{i=1}^{n} X_i \text{ etc.}, \quad \bar{F} = \frac{1}{n} \sum_{i=1}^{n} F_i, \quad \bar{F} = \sqrt{(\bar{X})^2 + (\bar{Y})^2 + (\bar{Z})^2}
$$

Also RMS deviations $(\delta_X, \delta_Y, \delta_Z)$ of the magnetic field were computed routinely for each component and for the field magnitude. The Pythagorean variance, which is an invariant of the coordinate system, is obtained from the component deviations as

$$
\delta = \sqrt{\frac{\delta_X^2}{2} + \frac{\delta_Y^2}{2} + \frac{\delta_Z^2}{2}}
$$

The choice of a 30 second time interval was based upon a desire to provide correlative data to each of the plasma probes on the Pioneer 6 and 7 spacecraft whose fastest cycle times were on the order of one minute.

Data shown in Figures 2 through 17 represent for each solar rotation the hourly averages of the field elements $\bar{F}, \bar{F}, \theta$ (latitude) and $\phi$ (longitude). The data are plotted in 27 day increments corresponding to Bartels' solar
rotation numbering system. The two variances $D_1$ and $D_2$ are obtained by different means. $D_1$ is a variance computed from equation 2 for each hourly interval using the hourly averaged components (and deviations from them). $D_2$ is the hourly average of the individual Pythagorean variance for each 30 time interval. The days of the year are indicated as calendar days and most of the missing data corresponds to gaps in tracking coverage of the spacecraft. Publications utilizing Pioneer 7 data which have already appeared are given in the reference list. This does not include those publications by other non-GSFC associated authors who have used Pioneer 7 data.
3. Summary

The orbit of Pioneer 7 was such that for much of its early lifetime (several months) it was located in the aftward portion of the disturbed solar plasma caused by interaction with the geomagnetic field. Observations of the geomagnetic tail at the greatest distance yet achieved (1000 R_E) were performed by this experiment. (Ness et al., 1967; Fairfield, 1968). Important simultaneous correlated measurements of the electron component of the plasma in the neutral sheet and the associated magnetic field were first performed by Pioneer 7 (Lazarus et al, 1968).

The 30 second average detail data and hourly average data are available from the National Space Science Data Center at NASA-GSFC (Mail Code 601), Greenbelt, Maryland 20771. This present document provides, in summary graphical form, a working data set which was used internally at the NASA-GSFC and parts of which have been made available to other groups.
4. References (in chronological order)


List of Figures

1. Projection of the orbit of Pioneer 7 on the ecliptic plane. Position of the spacecraft for the first day of each month is indicated by month/year.

2. Hourly averages of the magnetic field elements $\overline{F}$, $\overline{F}$, $\theta$, $\phi$, D1 and D2 for the Bartels' solar rotation number specified on the left hand side. The lack of two values for $\overline{F}$, $\overline{F}$, means that the spacecraft was in the DCS (Duty Cycle Storage) mode of operation with delayed transmission of data. The character A represents the "folding over" of the corresponding scale by the maximum value of the scale as shown on the left. Hence the correct value is to be read = A + Max Scale. Gaps in data are due to lack of telemetry recording by NASA-JPL DSN stations.
FIGURE 1
FIGURE 5

PIONEER HOURLTY AVERAGES

SOLAR ROTATION 1823

D2

D1

Φ

L

OCT. 1966

NOV. 1966

FIGURE 5
FIGURE 6

PIONEER HOURLY AVERAGES

SOLAR ROTATION 1824

D2

D1

φ

φ

TI

TI

NOV. 1966

DEC. 1966
Figure 10: Pioneer Hourly Averages

D2, D1

Solar Rotation 1828

MAR. 1967
SOLAR ROTATION 1829

MAR. 1967

APRIL 1967

FIGURE 11
FIGURE 12

SOLAR ROTATION 1830

D2

D1

F

F

APR. 1967 MAY 1967
FIGURE 15,

SOLAR ROTATION 1833

D2

D1

FOLDOUT FRAME

JULY 1967 AUG. 1967

PIONEER HOURLY AVERAGES
FIGURE 16

FOLDOUT FRAME 1

FOLDOUT FRAME 2
FIGURE 17