# Meteorological Monitoring Assembly

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*The DSN 64-meter antenna stations are being equipped with automated meteorological monitoring assemblies as a part of the Deep Space Station (DSS) Technical Facilities Subsystem. These assemblies provide data on atmospheric conditions necessary for calibrating metric data in support of flight project navigational requirements. Ground level temperature, barometric pressure, humidity and precipitation rate are sensed. Insolation is measured in support of solar energy monitoring. A polarization tracking receiver will be added to determine the Faraday rotation angle of a linearly polarized signal from a synchronous satellite. The paper describes the system components, organization, and output data.*

## I. Introduction

The DSN 64-meter antenna stations are being equipped with automated meteorological monitoring assemblies as a part of the DSS Technical Facilities Subsystem. These assemblies provide data on atmospheric conditions necessary for calibrating metric data in support of flight project navigational requirements. Ground level temperature, barometric pressure, humidity and precipitation rate are sensed. These data, together with antenna pointing direction and radio frequency (RF) parameters are processed digitally as a function of time, are recorded within the assembly, and are transmitted on a non-real-time basis through the High-Speed Data Subsystem (HSS) to the Network Operations Control Center (NOCC) and to Mission Operations Centers (MOCs). Insolation is measured and recorded in support of solar energy monitoring. A polarization tracking receiver will be added to determine Faraday rotation angle of a linearly polarized signal from a synchronous satellite. In the future (1977 era) data transmission to the NOCC and MOCs will be on a real-time basis through the metric data assembly. Provision is made for the future incorporation of wind velocity and direction measurement. A block diagram of the assembly is shown in Fig. 1.

## II. Description of the Meteorological Monitoring Assembly

### A. General Description

The meteorological monitor assembly consists of temperature, dewpoint, and static pressure sensors mounted on a tower near the control room building; a rain gage, solar sensor and ionospheric receiver antenna mounted conveniently at ground level; and a barometer, hygrometer, ionospheric receiver and data processing equipment mounted in a rack in the control room.

Data on antenna position, S-band polarization angle and mode status, and S- and X-band noise temperature are received from appropriate locations within the control room. Time signals are received from the Frequency and Timing Subsystem. There is a standard output interface to the High Speed Data Subsystem.

### B. Tower-Mounted Sensors

Temperature is sensed by a thermistor mounted in a motor-aspirated temperature shield. The analog output is conditioned in the translator assembly in the control room rack. This unit has a resolution of 0.1°C and an rss error of 0.14°C, combining a 0.1°C sensor error and a 0.1°C solar effect.

Dewpoint is measured by an aluminum oxide capacitor transducer which is mounted in a sample cell for high humidity application. Solid-state analog circuitry in the control room rack drives a local panel meter display which requires a calibration chart for dewpoint interpretation. The dewpoint accuracy is ±2°C from +30 to +60°C, ±1°C from −20 to +30°C and ±3°C from −50 to −20°C, where the ranges are the actual dewpoints. The dewpoint data are processed by the calculator to put out both dewpoint in °C and water vapor partial pressure.

A static pressure head which provides a pressure input for the barometer is mounted adjacent to the dewpoint transducer on the tower.

### C. Ground Level Sensors

Sensors are located at convenient points at ground level, in positions unaffected by adjacent structures:

Precipitation is measured by a tipping bucket rain gage, which tips to empty each time it is full. Measurement is by counting the number of times the bucket, which is heated to convert falling snow, is emptied. The count is kept in the translator assembly of the control room rack. This device has a resolution of 0.25 mm of water and accuracies of ±0.8 mm/hr at 75 mm/hr, ±13 mm/hr at 25 mm/hr and ±5% of total rainfall.

Incident solar radiation (insolation) is measured by an Eppley differential thermopile, with a total sun and sky response from 280 to 2800 nm. An analog data conditioning circuit card is installed in the translator assembly of the control room rack. Combining errors due to temperature effect (±2%), linearity (±1%), cosine response (±2% elevation 10 to 90 deg), the rss error of measurement is ±3%.

The polarization tracking receiver antenna will be mounted conveniently at ground level or on the control building roof. This antenna, compatible with the receiver installed in the control room, will be pointed permanently at a synchronous satellite, whose linearly polarized signal is used to measure the Faraday rotation angle.

### D. Control Room Equipment

Control room equipment is mounted in a single rack (Fig. 2).

A transducer senses barometric pressure by measuring the frequency difference between two oscillators timed by the atmospheric pressure. The output is directly in binary-coded decimal (BCD) form. Combining system linearity, hysteresis, repeatability and temperature errors, the rss accuracy at 38°C is 0.41 millibars.

An analog-to-digital (A-D) converter and scanner converts the analog signals received from the various sensors to BCD format for input to the programmed calculator. The scanner has a capacity as installed of 20 analog channels, with an ultimate capability of 50 channels. Channel selection is automatic, under control of the calculator. Ranges and accuracies are as follows:

| Range | Accuracy |
|---|---|
| 100 mV | 0.1% of reading +0.04 mV |
| 1.0 V | 0.01% of reading +0.1 mV |
| 10.0 V | 0.01% of reading +1 mV |

The translator provides data conditioning for analog transducers and an interface for various sources of digital data. Digital data interfaces are provided for the Frequency and Timing Subsystem, antenna angles, metric data assembly, incremental recorder, and rain gage storage register. A system malfunction alarm is also incorporated.

A Hewlett-Packard programmable calculator, Model 9821A, serves as the automation control and data processing center for the meteorological monitoring assembly. The calculator has 679 internal program and data registers, together with an additional 8000-word capacity in an auxiliary tape cassette. When used with the I/0 expander, there are 13 input/output ports, 9 general purpose and

4 dedicated to peripherals. Each digital input interface has a capacity of 9 decades of parallel 8, 4, 2, 1 BCD data, while the TTL input/output interface has 7 lines serial with data in binary or ASCII format.

Input and processed data records are kept on a Kennedy Model 1600 incremental tape recorder. This recorder stores 200 bits per inch on ½-in. magnetic tape, using 6 tracks plus parity. Up to 10 days of data can be recorded on one 8.5-in. tape reel.

The ionospheric receiver measures Faraday rotation angle of the signal received from a synchronous satellite. Total diurnal rotation angle is measured to an accuracy of less than 5 deg, with a resolution of 1 deg.

## E. Other Input Data

Other, nonmeteorological data are input into the computer for record purposes and for computational use as required. These data, received from other racks in the control room, are listed in Table 1.

## F. Data Handling Capability

Data are sampled and stored on 20-s intervals. Data output is by selected data types on intervals of 1, 2, 3, 4, 5, 6, 10, 15, 20, 30 or 60 min. In addition, a special calculator program, requiring the operator to set in an alternate program, will provide a 1-s sample rate for 10 min at a time, limited to two data types. In normal usage there are 10 output data types available (Table 2).

These data are output in binary form for transmission by the High Speed Data Subsystem to the Network Operations Control Center or to Mission Operation Centers.

## G. Local Data Readout

In addition to the basic output to remote locations, local readout is available in two forms. In the first, any parameter may be selected for local display when the operator inserts a binary number, selected from a register index, in binary switches on the translator control panel. The contents of that register are then displayed in decimal format on the calculator readout.

In the second form the tape printer output of the calculator is used to print out the day and time followed by the numerical content (in decimal format) of each data type in order listed in Table 2, followed by the internal power supply voltages. This printout occurs each 15 min under program control.

**Table 1. Other input data**

| Data | Source | Form |
| --- | --- | --- |
| Time | Frequency and Timing Subsystem | BCD |
| S-band ambient load temperature | Manual input | BCD |
| X-band ambient load temperature | Manual input | BCD |
| S-band system noise temperature | To be determined | Analog voltage |
| X-band system noise temperature | To be determined | Analog voltage |
| Polarization angle<br>S-band polarization diversity (SPD) cone linear polarization angle, SPD polarization mode | Microwave Subsystem polarizer control | BCD |
| 64-m antenna pointing<br>Azimuth 0–359.9 deg<br>Elevation 0–90 deg | Angle encoding system | BCD |

**Table 2. Output data types**

| Data type | Parameter | Bits/parameter | Least significant bit | Range | Comments |
|---|---|---|---|---|---|
| 1 | Data type | 6 | – | – | |
| | Time, seconds past $0^h$ GMT | 24 | s × $10^{-2}$ | 0 – 8,640,000 | |
| | Dewpoint, °C | 12 | deg × $10^{-1}$ | 0 – 1100 | |
| | Temperature, °C | 12 | deg × $10^{-1}$ | 0 – 1000 | Offset + 500 |
| | Barometric pressure, mbar | 18 | mbar × $10^{-1}$ | 8900 – 10,600 | |
| | Partial pressure, mbar | 12 | mbar × $10^{-1}$ | 2 – 2000 | |
| | Total bits for data type = 1 | 84 bits | | | |
| 2 | Data type | 6 | – | – | |
| | Time, seconds past $0^h$ GMT | 24 | s × $10^{-2}$ | 0 – 8,640,000 | |
| | Precipitation rate, mm/hr | 18 | mm × $10^{-1}$ | 0 – 3000 | |
| | Total precipitation, mm | 18 | mm × $10^{-1}$ | 0 – 9999 | |
| | Total bits for data type = 2 | 66 bits | | | |
| 3 | Data type | 6 | – | – | High rate ionosphere data, 3 samples/min |
| 3 | Time, seconds past $0^h$ GMT | 24 | s × $10^{-2}$ | 0 – 8,640,000 | |
| | Diurnal Faraday rotation angle, deg | 18 | deg × $10^{-1}$ | 0 – 60,000 | Offset 30,000 3 samples per DT |
| | Faraday rotation angle 0, deg | 18 | deg × $10^{-1}$ | 0 – 1800 | |
| 3 | Faraday rotation angle 0 + 180, deg | 18 | deg × $10^{-1}$ | 1800 – 3600 | 3 samples per DT |
| | Signal strength, V | 12 | V × $10^{-2}$ | 0 – 500 | |
| | Total bits for data type = 3 | 228 bits | | | |
| 4 | Data type | 6 | – | – | |
| | Time, seconds past $0^h$ GMT | 24 | s × $10^{-2}$ | 0 – 8,640,000 | |
| | Diurnal Faraday rotation angle, deg | 18 | deg × $10^{-1}$ | 0 – 60,000 | Offset 30,000 |
| | Faraday rotation angle 0, deg | 18 | deg × $10^{-1}$ | 0 – 1800 | |
| | Faraday rotation angle 0 + 180, deg | 18 | deg × $10^{-1}$ | 1800 – 3600 | |
| | Signal strength, V | 12 | V × $10^{-2}$ | 0 – 500 | |
| | Total bits for data type = 4 | 96 bits | | | |
| 5 | Data type | 6 | – | – | |
| | Time, seconds past $0^h$ GMT | 24 | s × $10^{-2}$ | 0 – 8,640,000 | |
| | Satellite azimuth, deg | 12 | deg | 0 – 360 | |
| | Satellite elevation, deg | 12 | deg | 0 – 90 | |
| | Total bits for data type = 5 | 54 bits | | | |
| 6 | Data type | 6 | – | – | |
| | Time, seconds past $0^h$ GMT | 24 | s × $10^{-2}$ | 0 – 8,640,000 | |
| | Undefined | 18 | | | |
| | Undefined | 18 | | | |
| | Undefined | 18 | | | |
| | Undefined | 18 | | | |
| | Total bits for data type = 6 | 102 bits | | | |
| 7 | Data type | 6 | – | – | |
| | Time, seconds past $0^h$ GMT | 24 | s × $10^{-2}$ | 0 – 8,640,000 | |
| | Solar insolation, g-cal/min/$cm^2$ | 12 | gm-cal/min/ $cm^2$ × $10^{-2}$ | 0 – 200 | |
| | Solar energy per 24 hours | 12 | W-hr/ $cm^2$ × $10^{-2}$ | 0 – 200 | |
| | Total bits for data type = 7 | 54 bits | | | |

Table 2 (contd)

| Data type | Parameter | Bits/parameter | Least significant bit | Range | Comments |
|---|---|---|---|---|---|
| 8 | Data type | 6 | – | – | |
| | Time, seconds past $0^h$ GMT | 24 | $s \times 10^{-2}$ | 0 – 8,640,000 | |
| | System noise temperature, S-Band | 12 | $K \times 10^{-1}$ | 100 – 3000 | |
| | System noise temperature, X-Band | 12 | $K \times 10^{-1}$ | 100 – 3000 | |
| | Azimuth angle, deg | 12 | $deg \times 10^{-1}$ | 0 – 3600 | |
| | Elevation angle, deg | 12 | $deg \times 10^{-1}$ | 0 – 900 | |
| | Ambient load, S-band | 12 | $°C \times 10^{-1}$ | 0 – 1000 | |
| | Ambient load, X-band | 12 | $°C \times 10^{-1}$ | 0 – 1000 | |
| | Total bits for data type = 8 | 102 bits | | | |
| 9 | Data type | 6 | – | – | |
| | Time, seconds past $0^h$ GMT | 24 | $s \times 10^{-2}$ | 0 – 8,640,000 | |
| | Microwave polarization angle, deg | 18 | $deg \times 10^{-2}$ | 0 – 36,000 | |
| | Microwave mode | 6 | – | – | 1 = linear auto<br>2 = linear manual<br>3 = RCP<br>4 = LCP |
| | Total bits for data type = 9 | 54 bits | | | |
| 10 | Data type | 6 | – | – | |
| | Time, seconds past $0^h$ GMT | 24 | $s \times 10^{-2}$ | 0 – 8,640,000 | |
| | Microwave polarization angle 1 | 18 | $deg \times 10^{-2}$ | 0 – 36,000 | 1 sample per 20 sec |
| | Microwave polarization angle 2 | 18 | $deg \times 10^{-2}$ | 0 – 36,000 | |
| | Microwave polarization angle 3 | 18 | $deg \times 10^{-2}$ | 0 – 36,000 | |
| | Microwave mode 1 | 6 | – | – | 1 = linear auto<br>2 = linear manual<br>3 = RCP<br>4 = LCP |
| | Microwave mode 2 | 6 | – | – | |
| | Microwave mode 3 | 6 | – | – | |
| | Total bits for data type = 10 | 102 bits | | | |
| 11 | Data type | 6 | – | – | Once per block |
| | Time, seconds past $0^h$ GMT | 24 | $s \times 10^{-2}$ | 0 – 8,640,000 | Once per block |
| | Microwave polarization angle,[a] deg | 18 | $deg \times 10^{-2}$ | 0 – 36,000 | |
| | Diurnal Faraday rotation angle,[a] deg | 18 | $deg \times 10^{-1}$ | 0 – 60,000 | Offset 30,000 |
| | Faraday rotation angle 0, deg[a] | 18 | $deg \times 10^{-1}$ | 0 – 1800 | |
| | Faraday rotation angle +180,[a] deg | 18 | $deg \times 10^{-1}$ | 1800 – 3600 | |
| | Microwave mode[a] | 6 | – | – | 1 = linear auto<br>2 = linear manual<br>3 = RCP<br>4 = LCP |
| | Signal strength (ionosphere receiver) | 12 | $V \times 10^{-2}$ | 0 – 500 | Once per block |
| | Total bits per block | 978 bits | | | |

[a]12 1-s samples per high-speed data block.

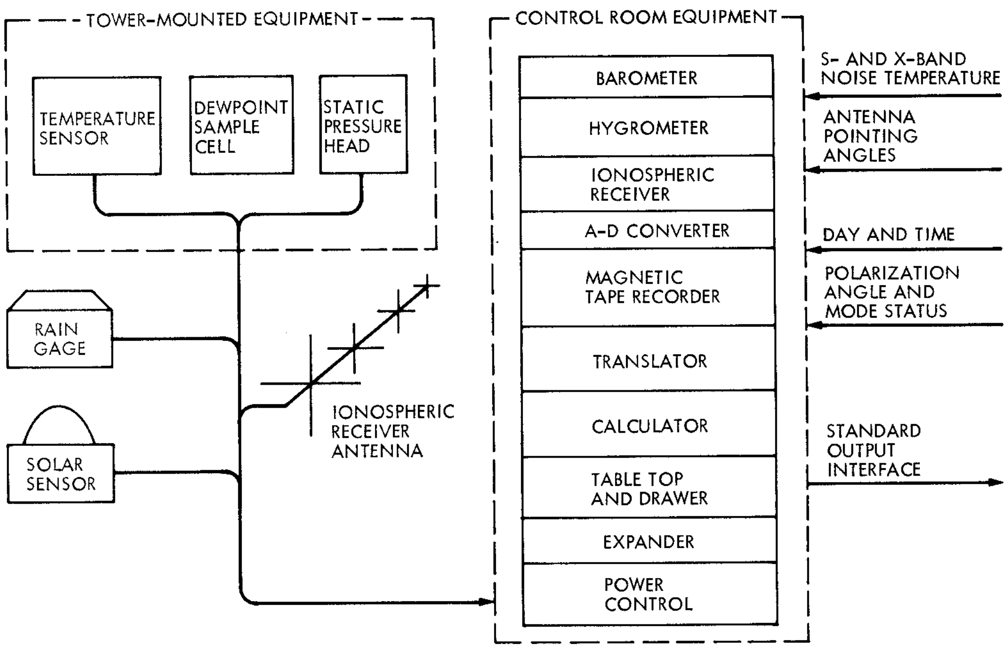


**Fig. 1. Meteorological monitoring assembly block diagram**

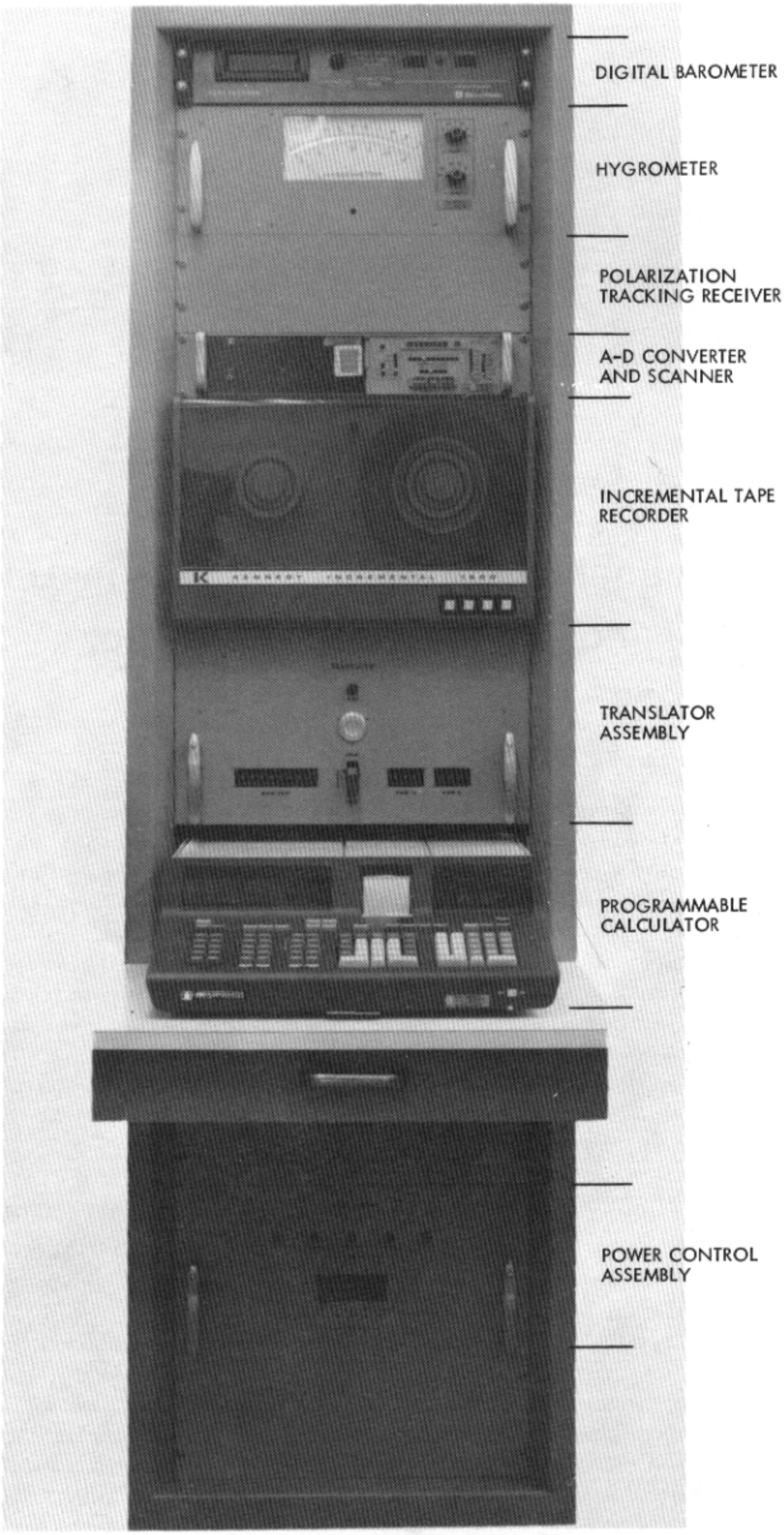


**Fig. 2. Meteorological monitoring assembly control rack**