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Title: **The Monitoring System for the Australia Telescope.** JUL 1991


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**ABSTRACT**

Each of the seven antennas of the Australia Telescope has a range of complex electronic systems. Failure of just one component in any of the antennas will degrade the performance of the whole array. The monitor system in operation at the Australia Telescope enables engineers and astronomers to monitor the array's performance and to identify and repair failed components quickly.


*The Australia Telescope is operated in association with the Division of Radiophysics by CSIRO.

## 1. INTRODUCTION

Five of the six antennas of the Australia Telescope [1] at the Paul Wild Observatory can be moved along a 3 kilometre rail track and located at a number of fixed stations. The sixth antenna is located 4.5 kilometres from the control building. Remote monitoring of the antenna-based electronics provides the astronomer with information about the status of the antenna and receiver systems. A failure in any of the systems on an antenna would prevent that antenna from functioning satisfactorily.

The monitoring system on the Australia Telescope has been designed so that, in the event of a failure, the astronomer using the telescope is promptly alerted. The maintenance engineer can also use the monitoring system to localise the failure to module level. In addition to flagging system failures, the monitor system archives the values of many system parameters. Subsequent analysis of the archived data reveals long-term trends in receiver gain or cryogenic receiver operating temperature. This information can be used to identify gain instabilities or to schedule routine maintenance of cryogenic systems.

In this paper we will describe the range of parameters monitored in the antennas and the programs which collect and archive the monitor data. We will also describe how astronomers and engineers use the system to locate faults and monitor the performance of the antenna-based systems.

## 2. MONITOR POINTS

The Australia Telescope antennas have a number of complex systems as major sub-components. Each of these, from the cryogenically cooled low-noise receiver system to the fibre-optic communication system, has a number of monitor points. Fig. 1 shows the main antenna-based systems, and the distribution of monitor points among these. There are more than 500 monitor points in each antenna. The antenna parameters routinely monitored include:

(a) antenna azimuth and elevation,
(b) local oscillator lock,
(c) ambient temperatures in receiver and local oscillator modules, and
(d) the operating temperatures and bias voltages of the cryogenically cooled low-noise amplifiers.

The monitor points may be analog or digital. Fourteen-bit analog-to-digital converters digitise monitor-point voltages in the range -5 to +5 volts with a resolution of 2.5 millivolts. The normal voltage of many monitor points is within this range. Power supply voltages and other monitor points outside this range are scaled with resistive voltage divider networks before being digitised.

For some monitor points, such as the cryogenic temperature sensors and vacuum sensors, the output voltage of the sensor is an indirect measure of the physical quantity being monitored. For example, the operating temperature of the low-noise amplifiers in the receiver is sensed using a platinum resistor. This has a resistance of 0.36 $\Omega$ at 15 Kelvin, the normal operating temperature of the low-noise amplifiers, and the resistance increases almost exponentially with temperature to 200 $\Omega$ at room temperature. A constant current of 10 mA is passed through the resistor and the voltage across it is monitored. The monitor system converts the voltage measured across the platinum resistor to a temperature in Kelvin.

Some of the monitor data is used on line. For example, the correlator output is scaled by the estimated receiver sensitivity, or system temperature, $T_{SYS}$. This is based on two measurements: the total IF power, $P_{OUT}$, and the

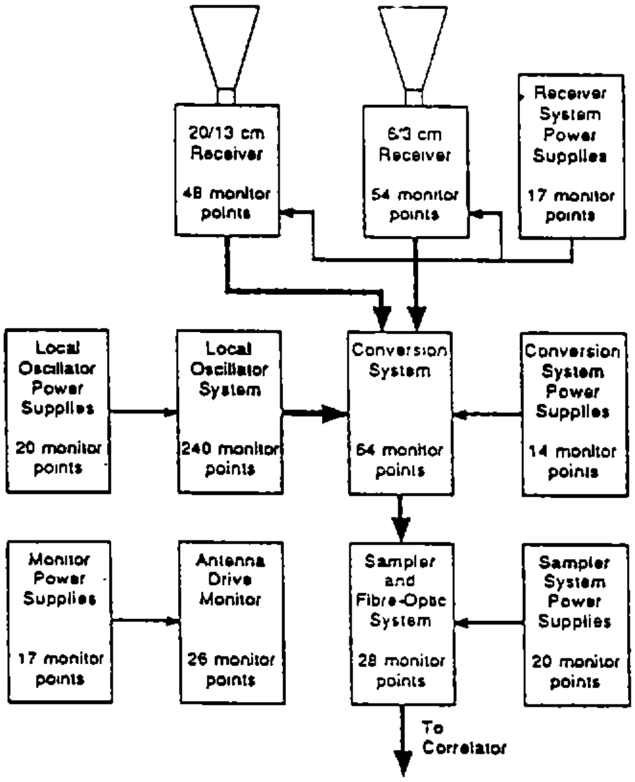


**Figure 1.** The distribution of monitor points in the antenna-based systems

gated IF power contributed by a switched noise source, $\Delta P$,

$$T_{SYS} = T_{CAL}\frac{P_{OUT}}{\Delta P} \quad (1)$$

where $T_{CAL}$ is a scaling factor [2]. The system temperature is calculated for each 10 second cycle.

## 3. COLLECTION OF MONITOR DATA

A block diagram of the monitoring system is shown in Fig. 2. The antenna control computer (ACC) cycles through a list of monitor-point addresses while it is controlling the antenna. The ACC requests the appropriate dataset to read the states of digital monitor points and the voltages of analog monitor points. At present the ACC takes about 30 seconds to cycle through the list. Some critical monitor points, like those associated with the measurement of receiver system temperature, are measured in each 10 second integration cycle. The ACC time stamps the monitor data and sends it to the VAX in the control building.

In the VAX a process, CHECKER, collects monitor data from all the antennas, scales each datum, and checks that it is within normal operating limits. Most analog monitor points are scaled with a gain factor and offset only. Some analog monitor points, for example the vacuum sensors and the cryogenic temperature sensors, have a more complex scaling applied. Logical states are translated to functional meanings. For example, the monitor points that indicate whether or not a local oscillator is locked are read by the dataset as 0 or 1, but are stored as "LOCKED" or "UNLOCKED".

For each analog monitor point, maximum and minimum values have been set, and for each digital monitor point there is a "correct" and a "fail" state. An error condition exists when the value of an analog monitor point is outside the limits set or when a digital monitor point indicates a "fail" state. Each monitor point in the common area has a flag to indicate whether or not the monitor point value is within limits. CHECKER also archives the monitor data on disk. Two archive files are written: the first is the scaled monitor data, written as it comes back from the antennas, and the second is a complete "snapshot" of the array, written every 30 minutes. CHECKER also writes a file logging the time when any monitor point goes "out of range" and the time the fault is cleared.

Monitor-point limits are entered and changed using the utility program CHKINI. The limits are set array wide and have been set as wide as possible, consistent with satisfactory operation, to ensure that only monitor points with unacceptable values are flagged as being out of range. Warning is given of some important error conditions so that prompt corrective action may be taken. CHKINI can also be used to disable error checking when, for example, a receiver is removed from an antenna for maintenance.

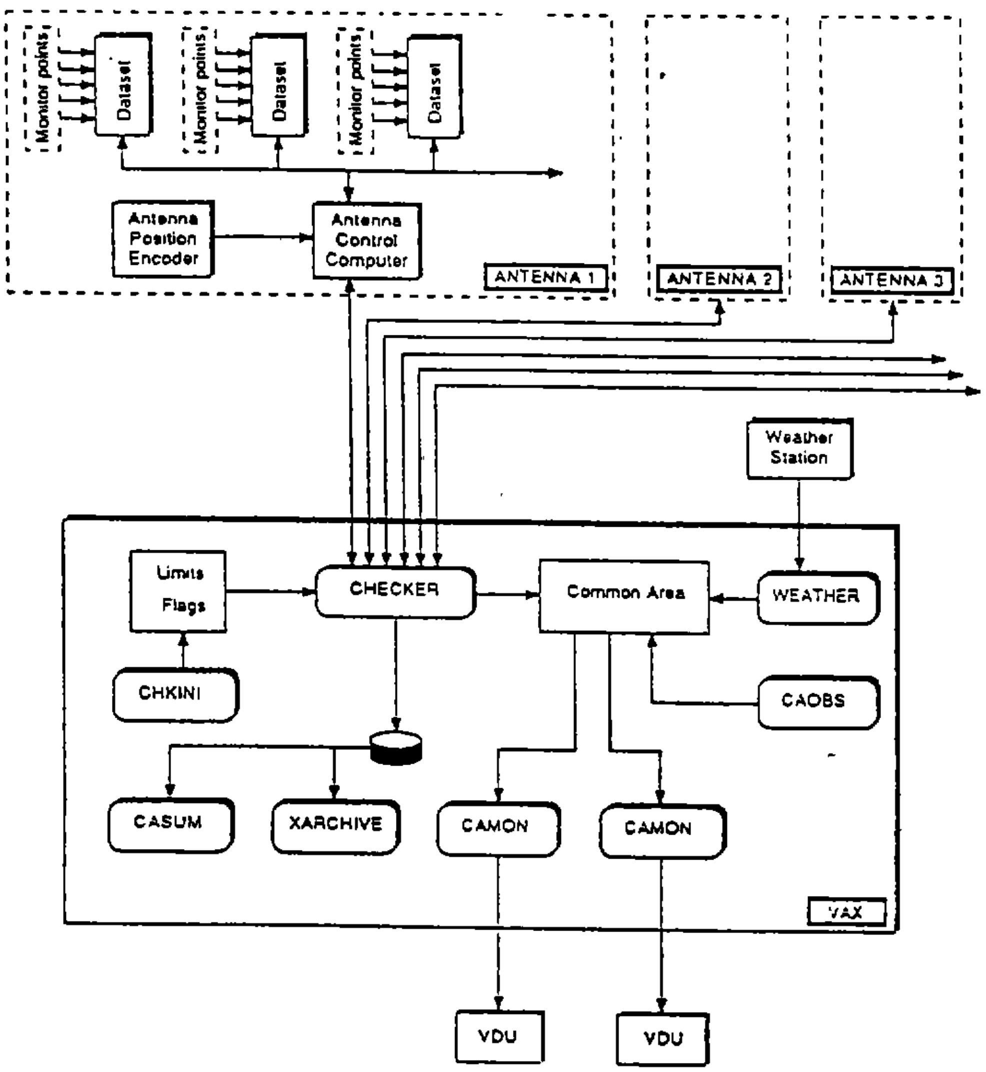


Figure 2. Block diagram of the monitoring system

The program which collects data from the weather station and the observing task, CAOBS, also deposit information in the common area. Users logged in at terminals outside the control room have access to weather information and the observational parameters set by the astronomer.

## 4. DISPLAY OF MONITOR DATA

The monitor data held in the common area is read and displayed using the program CAMON. Because scaling and limit checking is done by CHECKER, the job of CAMON is merely to retrieve the required monitor data from the common area and display it. The convenience and ease of use of display formats have received particular attention.

There are, at present, more than 80 different page definitions, which fall into three categories:

(a) a small number of pages with critical system monitor points, designed to give the astronomer an overview of the system,

(b) a complete set of module orientated pages in which each monitor point is displayed on at least one of the pages, and

(c) customised pages which may contain a diverse set of monitor points from across the array. The monitor points are chosen to suit a particular astronomer, or to investigate a particular problem on the array.

The definition of the display pages is flexible, allowing any combination of monitor points on a single page. Two different formats are available: up to 13 monitor points can be displayed in six columns, one column per antenna; or up to 78 monitor points can be displayed for just one antenna. The location of the monitor points on each display page is defined by a simple text file. Error conditions are indicated by displaying each out-of-range monitor point in reverse video. CAMON also has an "error" page on which it displays all the monitor points in the array which are out of range or in error.

The display program is routinely run from terminals remote from the observatory by astronomers and engineers interested in monitoring the status of the various systems on the antennas. When necessary, engineers diagnose problems on the array from home.

Monitor data archived by CHECKER can be extracted and plotted for time intervals of up to 24 hours using the utility program XARCHIVE. The plots can reveal correlations between monitor points, temperature dependence of monitor points, and receiver gain stability. XARCHIVE can also be used to extract data from the 30 minute "snapshot" archive so that trends in system parameters over time intervals of up to 3 months can been seen. This is particularly useful when assessing the performance of the cryogenic systems and determining when they will need servicing.

## 5. CONCLUSION

The monitoring system is an invaluable aid in the quick identification and repair of component failures, and in gathering information about the long-term performance of antenna and receiver systems.

## 6. ACKNOWLEDGEMENTS

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## 7. REFERENCES

1. Frater, R.H., "The Australia Telescope – the Radio Astronomer's Highway to the Future". *Proc. Astron Soc Aust.*, 5 (4), 1984, pp. 440-445.
2. Sinclair, M.W. and Gough, R.G., "The System Temperature Calibration of the Australia Telescope Receiver Systems", these proceedings.