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Technical Report

The Dome Automation for the 75 cm Optical Telescope VBO, Kavalur

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Abstract:

This report describes the Interface hardware and the automation control program implemented for the 75cm telescope dome at VBO, Kavalur.

1. Introduction:

The primary task of a dome in an optical telescope is to seek an object and automatically track the position of the telescope such that its field of view is not obscured during observation. The dome of this telescope uses, viz.

(1) Low cost ac motors available in electronics lab with inverter speed control, operating through a serial port of a PC working as dome computer.
(2) Multi turn absolute encoder.

The scheme is similar to that of 2m telescope dome at Hanle.

The dome weights about 2.5 tons and is rotated in azimuth by a 1Hp, ac motor whose speed is controlled by a variable frequency inverter drive. The dome has a diameter of 8m and a shutter width of 2.1m, the dome shutters are operated by solar power.

Two types of dome operations are required. In 'acquisition mode', both the telescope and dome are moving together to the demanded azimuth.

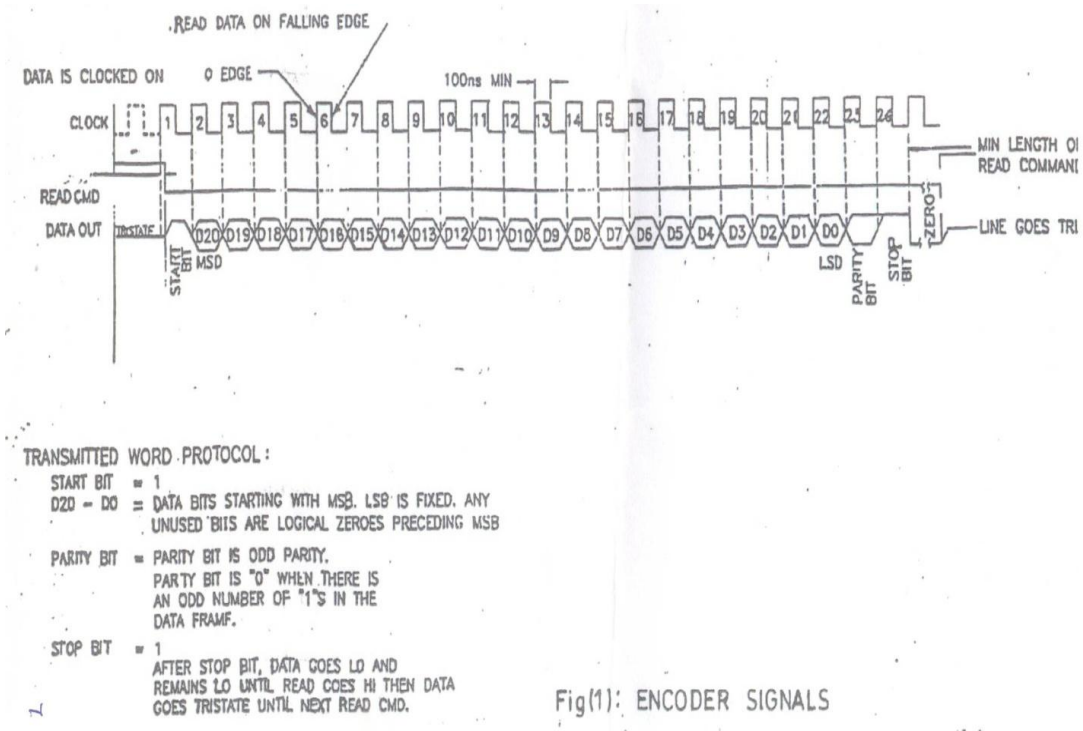
In 'track mode', as the telescope tracks an object during observation, the dome position is moved such that the telescope is always pointing through the shutter opening to the sky.

2. Inverter Drive and Absolute Encoder:

The MICROMASTER inverter drive supplied by M/s Siemens, rated for 2.2Kw, 3HP is used for controlling the speed of 3 phase ac dome motor. It is modular in design, reliable and versatile, uses microprocessor controlled state-of the art IGBT technology. The drive can be used in both 'stand-alone' application as well as being integrated into 'Automation System'. Initially we have to set the various parameters in the inverter drive to optimize to the specific operation using the Basic Operator Panel (BOP) supplied by the manufacturer. The acceleration and deceleration characteristics of the drive are suitably programmed for a smooth operation of the dome.

The drive can also be programmed for frequency, acceleration, deceleration and several other parameters from a PC. The appropriate software has to be installed (e.g. STARTER) through an isolated RS232/485 port adopter module for point to point connection to a PC using a standard RS232 cable.

The encoder used to read the dome position in the dome control software is MT40-X_HSS1024N-64T-GD10-CR-E-C14-T-5 from M/s BEI Motion Systems and Controls, USA. Encoder data forms the position feedback. This 64 turn, 16 bit absolute encoder is coupled to the dome motor shaft through a flexible coupling and record the dome position. The 16 bit serial data is read by sending 'clock' and 'read' signals as shown in timing diagram Fig-1.



Fig(1): Encoder Signals

3. Encoder Interface Unit:

The serial data from the encoder is converted to 16bit parallel data using a microcontroller based Encoder Interface Unit (EIU) developed in the lab. If a PC is used to generate the required timing signal to read the data from the encoder, a significant amount of PC time is spent on the same and hence affecting the other functions to be carried out by the PC. The EIU is designed to provide the necessary interface between the PC and the encoder without affecting the PC functionality. EIU contains all the required circuitry complete with power supplies in a standard 19" rack mountable 2U size cabinet. The heart of the circuit is the ATMEL 89C51 8-bit microcontroller. The encoder ground is isolated with that of main electronic circuit by using the high speed opto couplers HP2602. The firmware inside the microcontroller generates the required timing signals to read the encoder. The generated clock and read signals are converted to differential signals by the line driver 26LS31 as all the signals to and from the encoder are of differential type. The differential serial data is received by the line receiver 26LS32 which provides the single ended data to the microcontroller. The received serial data is stored in two bytes, forms the 16 bit parallel data which is terminated on a 50 pin FRC connector. This connector on the rear panel of EIU is connected by an external cable to the I/O card of the PC. The EIU also converts data into deg, arc min and arc sec for display on the front panel. The parallel data is read by the dome computer through digital I/O interface card.

4. Control Algorithm:

In order to move the dome to a demanded position, the difference (error) between the demanded position and the present position of the dome is computed. The shortest path for positioning of the dome is determined by the sign and magnitude of the error as shown in Table-1.

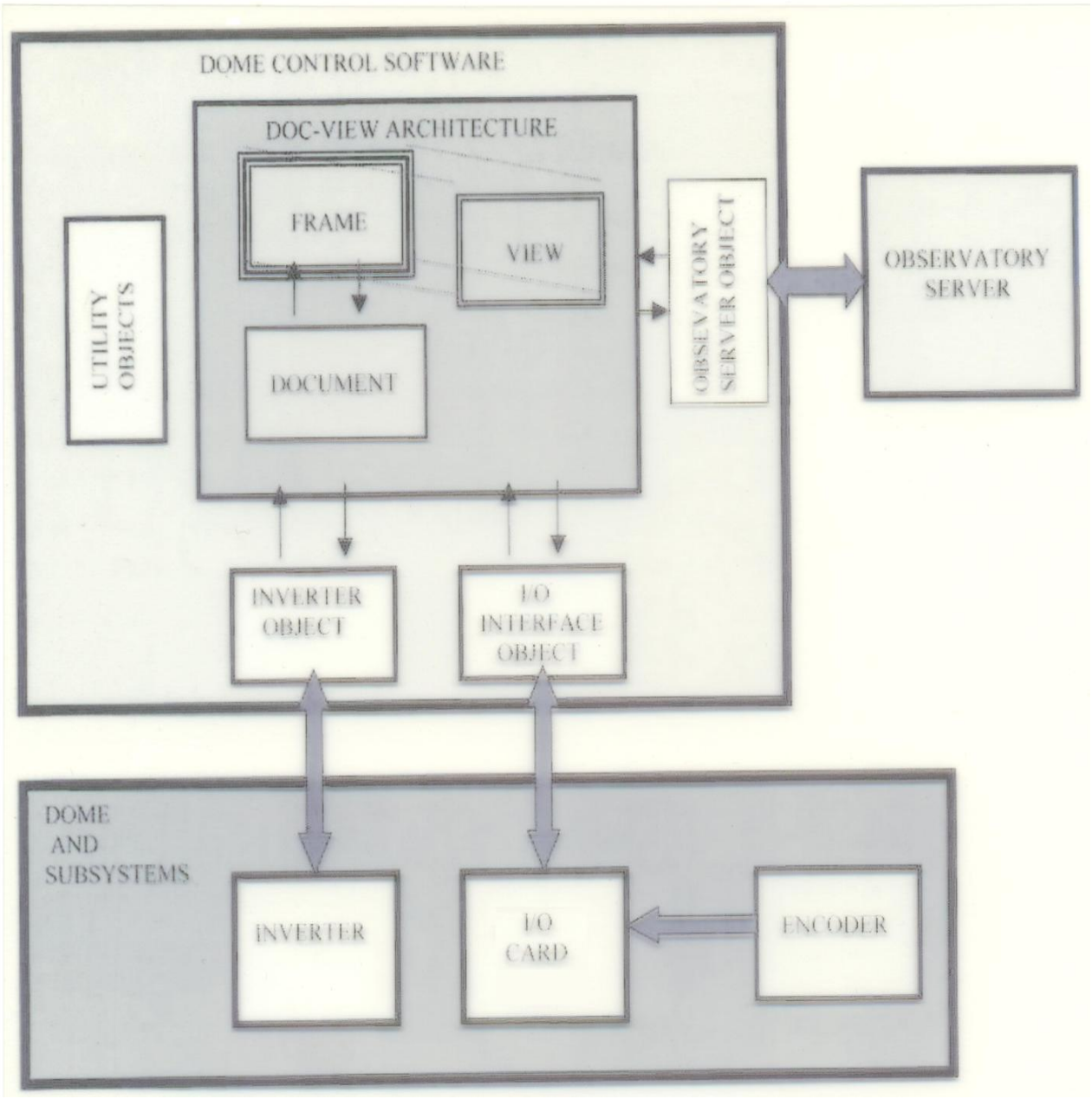
The speed of the motor are set by varying the frequency output of the inverter drive. A proportional control algorithm has been chosen. When the error is greater than 10°, full speed of the dome rotation is selected. Between 1 to 10° proportional control is applied to the speed. Below 1°, the speed is set constant to one tenth of the full speed. When absolute error reaches $\leq 0.2°$, the dome is considered as positioned and a 'stop' command is sent to the dome and enters the track loop correcting after every 1° of error accumulation.

Sign of Error	Magnitude of rotation	Direction of rotation	Corrected Magnitude
+	<180°	CW	-
+	>180°	CCW	(360-mag of error)
-	<180°	CCW	-
-	>180°	CW	(360-mag of error) -

Table-1

5. Software Description:

The integrated software scheme is shown in Fig -2. The dome control software developed in Visual C++ using MFC function calls runs under Microsoft Windows NT operating system making the best possible use of the non-real time environment for a real time application. This multithreaded software is capable of exchanging messages with an 'Observatory Server'. One of the threads handles the functions of I/O card interface to read the encoder and the variable frequency inverter drive. Another thread regularly updates the Graphical User Interface (GUI). Microsoft Foundation Class (MFC) architecture makes it easy to support multiple views, multiple document types, splitter windows, and other valuable user interface features.



Fig(2): Software Control Scheme

This multithreaded software has four concurrent threads of execution to fulfill its functional requirements. The main application thread spawns three other threads of execution. One of them is dealing with the main function involving the I/O card and Inverter drive. The second thread regularly updates the GUI. The third thread polls continuously for messages from the ‘Observatory server’ software.

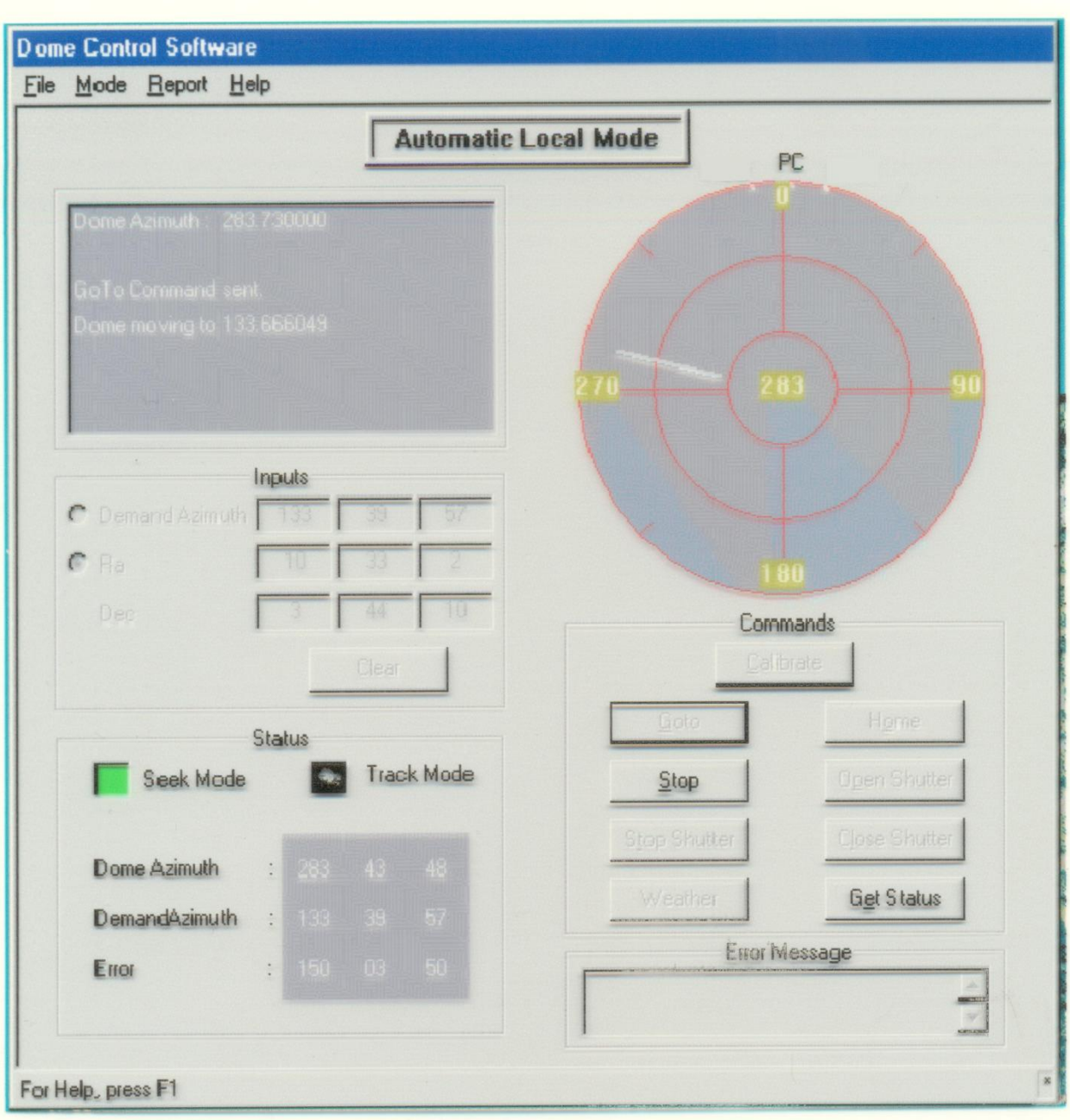
6. Modes of Operation for the dome:

Two modes have been configured, for the dome operation viz.

(1) Automatic Local Mode
(2) Automatic Remote Mode

Automatic Local Mode:

The user interface screen for this mode of operation in the Acquisition mode is shown in Fig-3 and in the Track mode in Fig-4. All functions of dome and shutter are incorporated in this mode. The dome can be moved to any position by giving the demanded azimuth or by providing RA and DEC values. A True time interface card is installed in the PC reads the sidereal time for computation of hour angle, demanded azimuth etc.



Fig(3): Automatic local mode - Acquisition

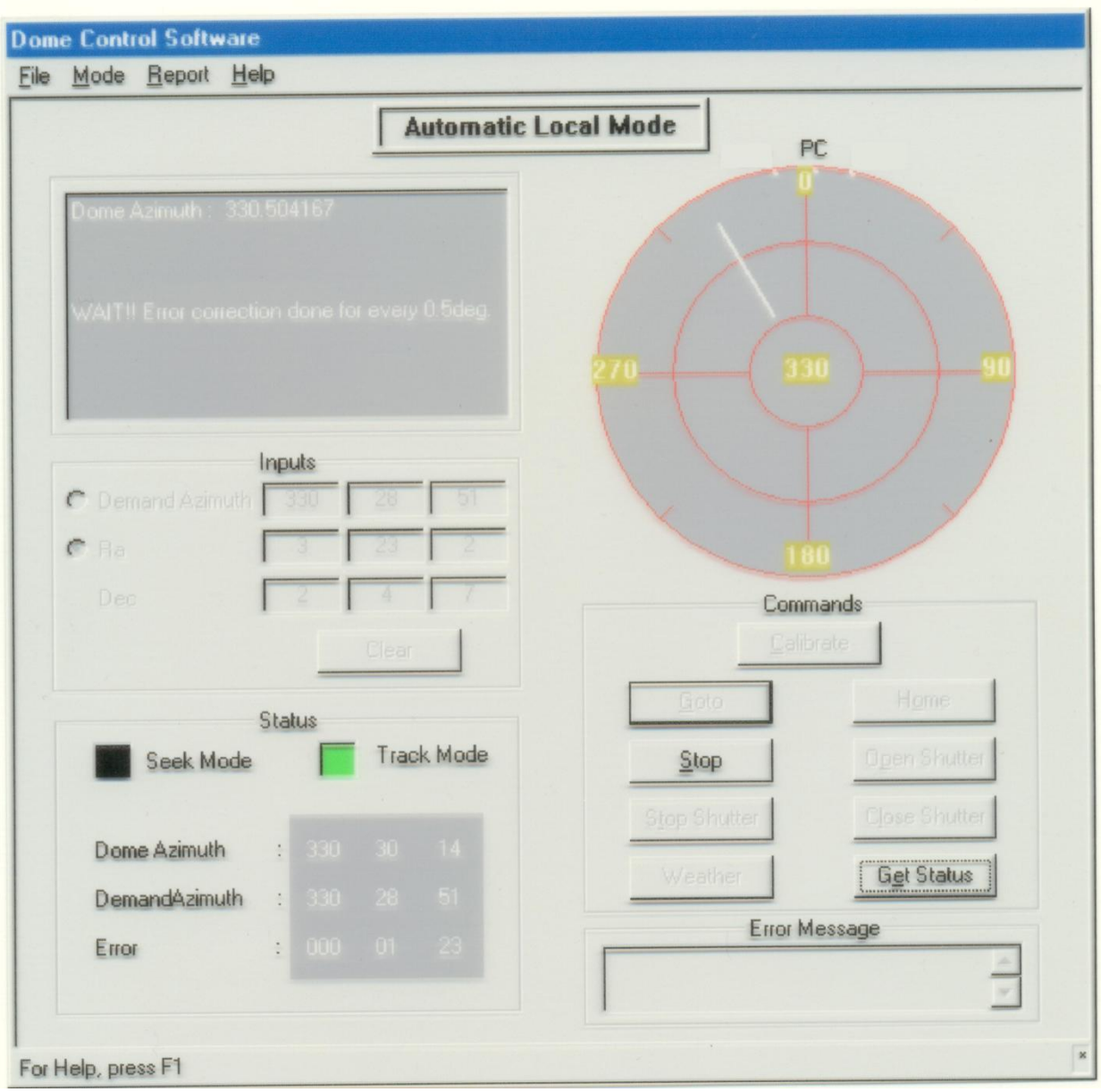
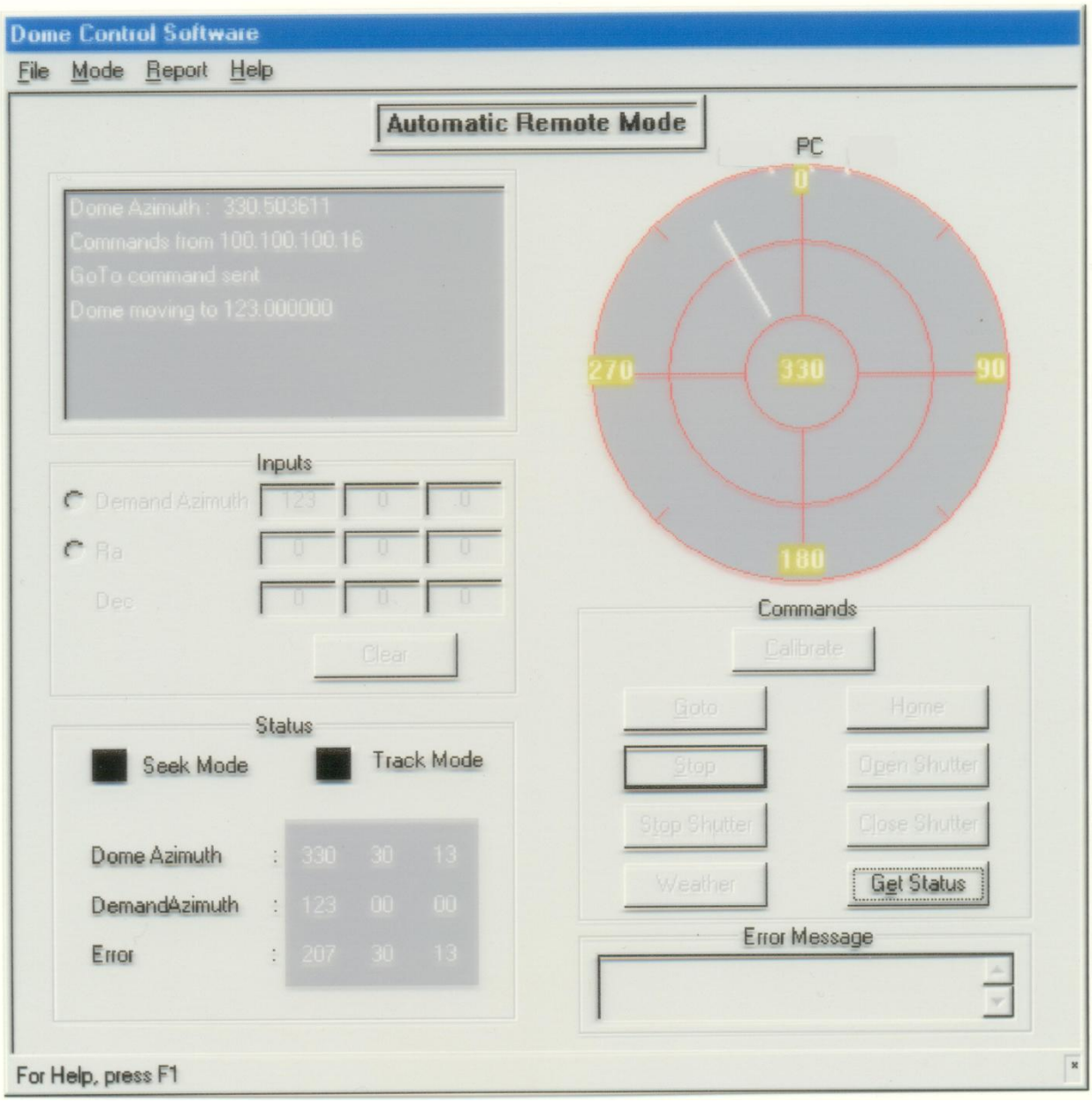


Fig (4): Automatic Local Mode - Tracking

Automatic Remote Mode:

The user interface screen for this mode of operation is shown in Fig-4. The dome and the shutter are controlled by the observatory server, using sockets in the LAN environment. The dome server accepts commands from the observatory server and reports the status to the observatory server. This mode is not implemented at present.



Fig(5): Automatic Remote mode

7. Performance Status:

Since the dome is nearly 30 years old a few mechanical modifications were carried out. At present the dome is operated in Automatic Local Mode. The control algorithm has been extensively tested and the position accuracy is ±0.5° and the tracking performance is centers to telescope within 0.5° and tracks within 1°.

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References:

1. New approach to dome Automation for optical telescopes

R.Srinivasan, R.Cowsik, Faseehana & A.Krishnan