Bull. Astr. Soc. India (1992) 20, 353-361

Instrumentation

Automation of dome rotation at 2.34 m Vainu Bappu Telescope

V. Chinnappan and Faseehana
Indian Institute of Astrophysics, Bangalore 560 034

Received 1991 July 30; accepted 1992 August 10

Abstract. Even though the dome can be operated in manual mode by the observational assistant during the obsevations, it becomes inconvenient when the control is in a closed console room. Mointoring the dome shutters throughout the night becomes a vigilant task. Autommated dome reduces the strain on the observer. The 2.34 m VBT dome automation was implemented by using a Personal Computer (PC). The PC allows speedy program development and debug cycle. Printed circuit boards fabricated for this application is explained. Software details are given. Problems encountered during the execution of the project is highlighted. The software flow chart and the intricate points are explained in detail.

Key words : Automatic control—Personal computer—interface card-software

1. Introduction

This article gives details about using an IBM compatible personal computer (PC) and how the dome automation was implemented without much modification to the already existing wiring and control by the single board computer (SBC) based system. Problems encountered and the solutions found during execution of this project are highlighted.

The Vainu Bappu Telescope (VBT) control has two modes of operation. One is the manual mode and the other is automatic mode. In manual mode telescope is moved by pressing the switches in the console and stopping at the desired location by seeing the displays of right ascension and declination provided in the console. When the telescope has reached the desired position, the dome is positioned such that dome shutter opening matches with the telescope. In automatic mode, co-ordinates are entered into a microcomputer and positioning is controlled by the computer (Chinnappan 1988). The dome drive has independent manual or automode. When telescope is in manual mode, the dome can be operated in auto mode and vice versa. Here we deal only with dome automation.

2. Dome specifications

The VBT dome is 23 m in diameter fabricated in steel structure and weight about 265 tones. It moves on a circular rail with 40 wheels. Six wheels are driven by independent DC motors each of 2.2 KW capacity. The dome drove is Thyristor controlled variable speed DC drive, with speed feedback in a closed loop configuration. Power to the dome motor contol, shutter, wind screen and crane is carried through basbars. There are 32 busbars for various voltages and functions. Shutters are side way opening type with full open slit width of 4.8 m and is driven by two independent motors of 0.37 KW at the top and 0.74 KW at the bottom.

A schematic of automatic control of VBT is already explained (Chinnappan & Bhattacharyya 1985). In manual mode, a SBC 86/14 based system reads the hour angle and declination axes encoder values and computes right ascension, declination and hour angle. With the help of position information console switches like slew, set etc. are pressed to give different operational speeds to reach the required position. Being an EPROM based system and to conserve memory, entire program was written in assembly language. It would have been easier if the EPROM based system has built in higher level language such as BASIC provided in chips like INTEL 8052-AH-BASIC (Chinnappan 1991). Since computation of altitude, azimuth etc. involves transcendental functions and 8087 numeric co-processor present in the SBC does not directly provide sine and cosine functions, the dome automation was deferred to be taken up later. With the availability of PCs at moderate cost, the dome automation was implemented using the PC. Even though similar functions can be implemented using single chip computers like INTEL 8039 family (Chinnappan 1982) it is not versatile as a PC. The development time required is high. Software like QUICK BASIC allows integrated environment for entering, editing, running and debugging the program. The same PC is used for other functions like co-ordinate corrections and acts as a platform for image additions and enhancements for guide field intensified CCD camera, if required (Chinnappan *et al.* 1991)

There are two types of operations under PC control. One is to position the dome when the telescope is not yet reached the required position. This mode is called acquisition mode. In this mode, both telescope and dome are moving simultaneously to the demanded azimuth. In the second method, the telescope tracks an object (during observation) and the dome position is periodically corrected such that the telescope is always pointing through the shutter opening along with the telescope movement.

3. Dome encoder

To know the position of the dome a 16 bit 128 turn, absolute, binary, optical encoder is mounted outside the dome periphery. The wheel is pressed against the dome outer periphery by hanging weights. The encoder makes 128 rotations for one rotation of the dome. The friction wheel has diameter of 20.32 cm so that it can make 128 rotations for one rotation of the dome.

The encoder is supplied by M/s BEI Motion Systems and Controls, USA. It has two optical coded disks. This encoder has built-in differential line driver outputs. Fine disk has 9 bit resolution and course one has 7 bit resolution. Both disks are coupled through a

128 : 1 gear box. The design is such that the gear errors are not reflected in the position output data.

In the acquision phase, right ascension and declination of the object are entered into PC. PC then computes the demanded azimuth and altitude. If the demanded altitude is less than 5 degrees, then it gives a warning message that the telescope may hit the limit switches. It reads the dome encoder and computes the dome azimuth. Depending on the shortest distance, it rotates the dome either in clock-wise or anticlock-wise direction. A band of 2 degrees is given between computed azimuth and the dome azimuth to avoid hunting near the required point.

When the acquisition phase is over, the PC alerts the observer by a sound, indicating the end of that mode. In the tracking phase, telescope azimuth is compared with the dome azimuth, instead of the demanded azimuth. When the error between telescope azimuth and the dome azimuth is greater than 7 degrees, the dome drive is switched "ON" in the correct direction and it is adjusted within 2 degrees. As some of the observers may not like to rotate the dome without prior information during observation, the dome tracking the telescope will start only if he types to do so.

4. PC interface card

A 20 bit each of binary information from hour angle and declination encoder, the 16 bit information of dome encoder and sidereal clock is read into PC through the input lines provided in the card. Output lines drive dome rotation direction signals and dome stop signal. A schematic of the card is shown in figure. 1

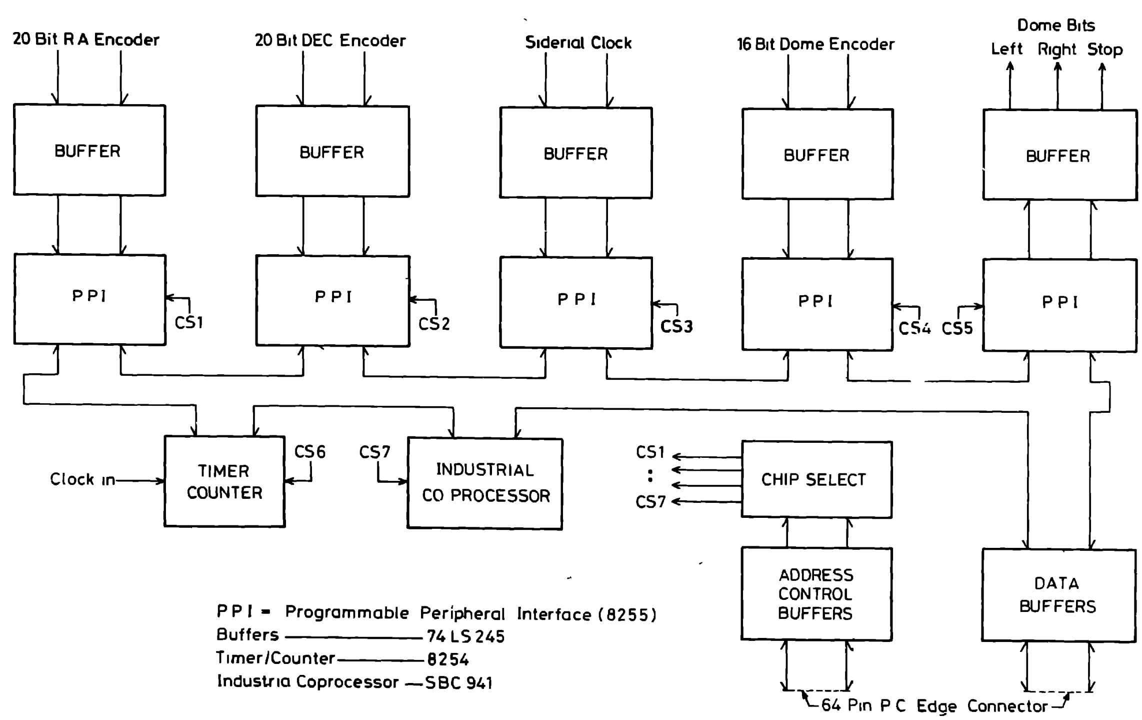

Figure 1. The PC interface I/O card.

In order to find the telescope's hour angle and declination, 20 bit absolute binary encoders mounted in the telescope axes are read and the above two parameters are computed. Right ascension is computed by first reading the sidereal time from the sidereal clock into PC through ports and then subtracting the computed hour angle from the sidereal time. From the telescope's parameter and altitude, telescope's equivalent azimuth value is computed. This is compared with the dome azimuth as given by the dome encoder. The dome operating relays are switched ON in the correct direction, taking into account the least distance to go to the desired point. As we can see, a number of digital data is to be read inside the PC and dome direction relays are to be operated. For this purpose a PC compatible digital Input/Output (I/O) card was designed and fabricated in the Electronics laboratory of the Institute.

The interface board has 74LS245 type buffers to drive the PC bus inside the card. This eliminates the PC bus loading by the card. This card is designed for the 8 bit slot of PC XT's and AT's. The 10 bit I/O address of PC bus is decoded by the chip select logic and individual chips are selected by 3 to 8 line decoder (74LS138). The card has provision to set the I/O base address by jumper selection, so that any clash of I/O address with the existing cards can be avoided. The ports are through Intel 8255 programmable peripheral interface chips. Five 8255s gives a total of 120 I/O lines. The I/O from 8255s are given to 74LS245 buffers. Since these buffers can be programmed as input or output by controlling a pin and 8255 can be controlled in the input or output mode through program, it is possible to have programmable option either as input or output for the I/O lines. Two numbers of 8254 chips provide 6 numbers of 16 bit Binary/BCD counters. There is also SBC 941 industrial co-processor. The last two chips are not used for the dome control work.

The dome encoder is mounted outside the dome periphery in the south side. A 75 m cable carries data from dome encoder to the console room. The encoder has differential line drivers (using 26LS31 ICs) and a differential line receiver card (using 75115 ICs) mounted in the console, converts the differential data to single ended form.

It is found that the differential driver, receiver combination transmits data from the encoder to the PC without data corruption due to dome motor operations, switching ON and OFF of relays etc.

5. The single board computer and PC link

The telescope display system and control were earlier implemented using a SBC 86/14 and three interface boards of multibus 1 design. The dome, windscreen and telescope operating relays are wired and controlled by SBC 86/14. Program written in assembly is fused in EPROMs and reside in the SBC board. It is found that EPROM based design is very difficult to modify. Since the control relays are wired to SBC system, the PC only sets the required direction bits as input to SBC. The SBC reads the bit values corresponding to dome left, right or dome stop signals. This necessitates that SBC should be ON before PC can set the bits. The telescope parameters are displayed by the SBC in the console using LED displays and the PC independently computes and displays the parameters in the PC monitor. The schematic of SBC to PC link is shown in figure 2.

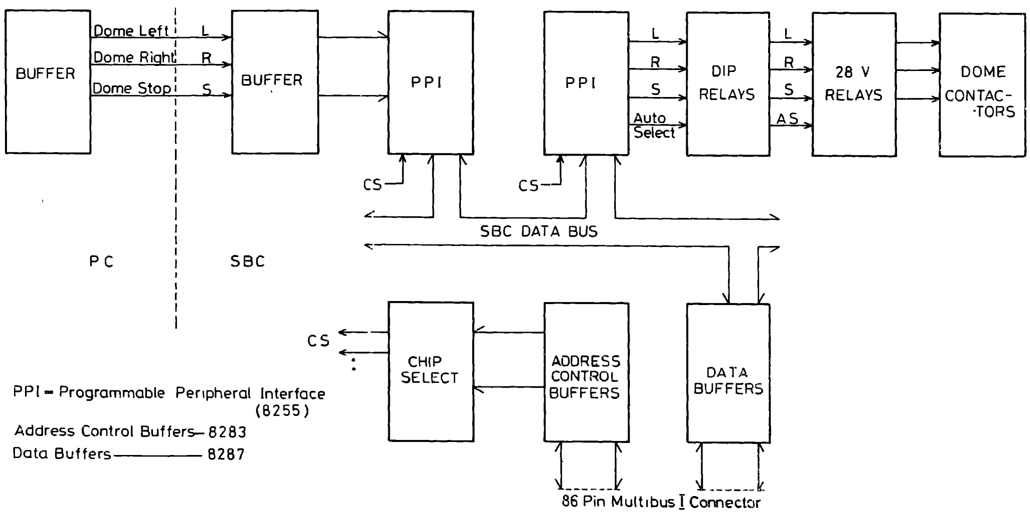

Figure 2. The PC and SBC link.

6. The software

Software was written in BASIC language. The flow of the program is as follows :

Initially the program starts with a welcome message. Then it asks for the selection of auto mode or manual mode. In the manual mode, dome rotation like left or right is entered through the key board. Control bits for the particular direction is generated by the PC and sent to the console computer. The console computer energizes the relays for dome operation.

When automatic mode is selected, then it expects the required coordinates of right ascension (RA) and declination (DEC). RA and DEC values can be input through the key board or it can be read from the file created by the telescope modeling program. This program computes the current coordinates if the epoch is different and corrects for nutation, precession, refraction, telescope flexture and other errors. Otherwise corrected RA and DEC values are entered through the key board. The sidereal time (ST) from the free running sidereal clock is read into PC through I/O ports. Demanded hour angle is computed by subtracting the RA value from ST. Demanded altitude is computed. If it is less than 5 degrees, a warning message with beep is output and new position is requested. Demanded azimuth is computed next. The south point is taken as azimuth zero, increasing up to 359 degrees passing through west and east points. The rest of the progrm is run in interrupt mode at every second. The telescope's present RA value is computed from the hour angle (HA) and ST. The HA encoder is read through the I/O ports and the hour angle value is computed in +/ – 6 hour format, +6 being towards west. The declination encoder is read and declination of the telescope is computed in +/ – 90 degree format, +90 being towards north. Dome encoder is read and dome azimuth is computed. Using the telescope's hour angle, declination and latitude, altitude and azimuth of the telescope is computed. A correction factor is applied to dome azimuth value to correct for the error created by the shift in the centres of the telescope and dome. The demanded azimuth of telescope is further corrected such that the telescope is made to point towards the right edge of the shutter opening in the north side and

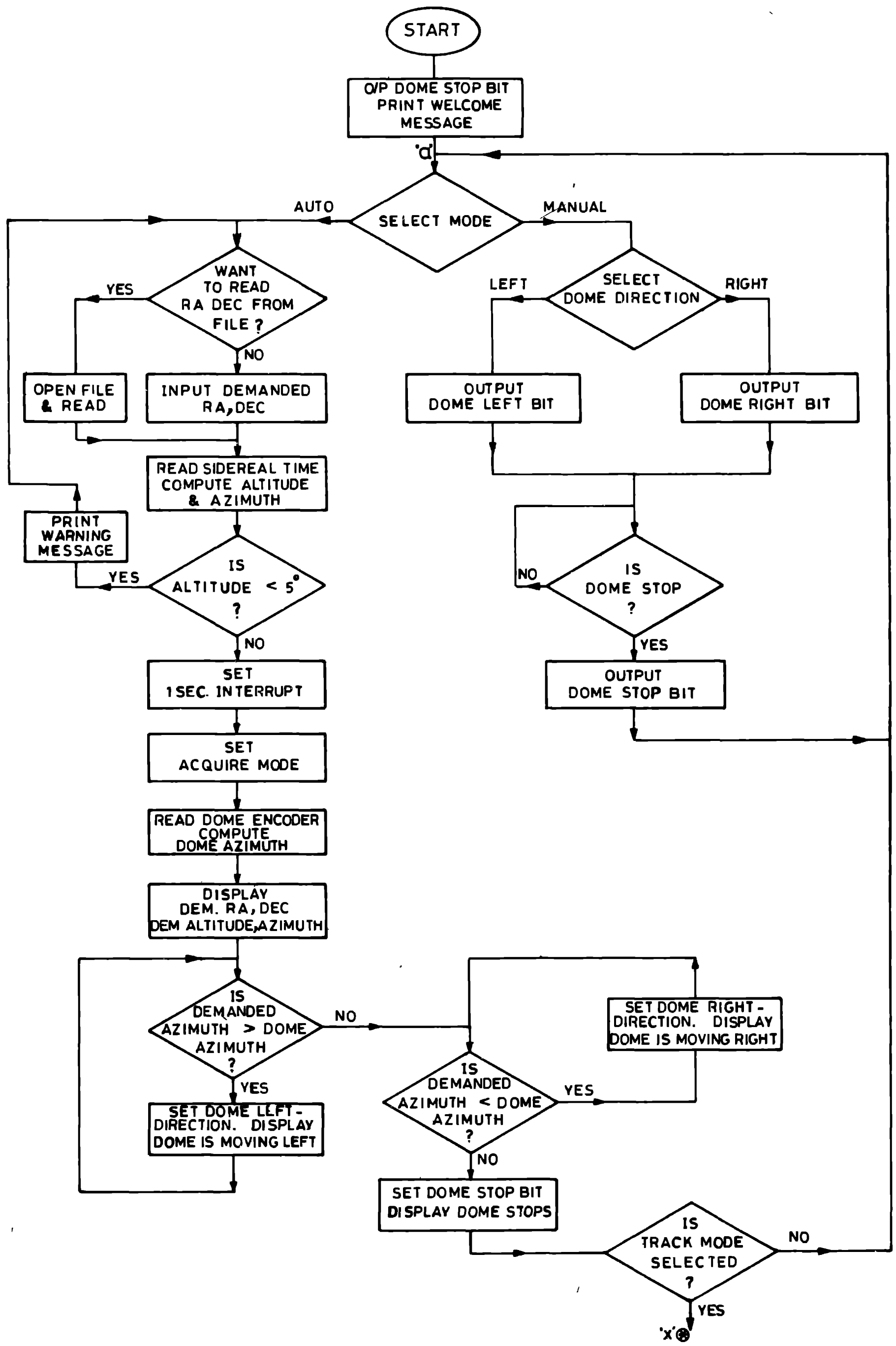

Figure 3. Flow chart of automatic dome control program.

(Continued on p. 359)

(Continued from p. 358)

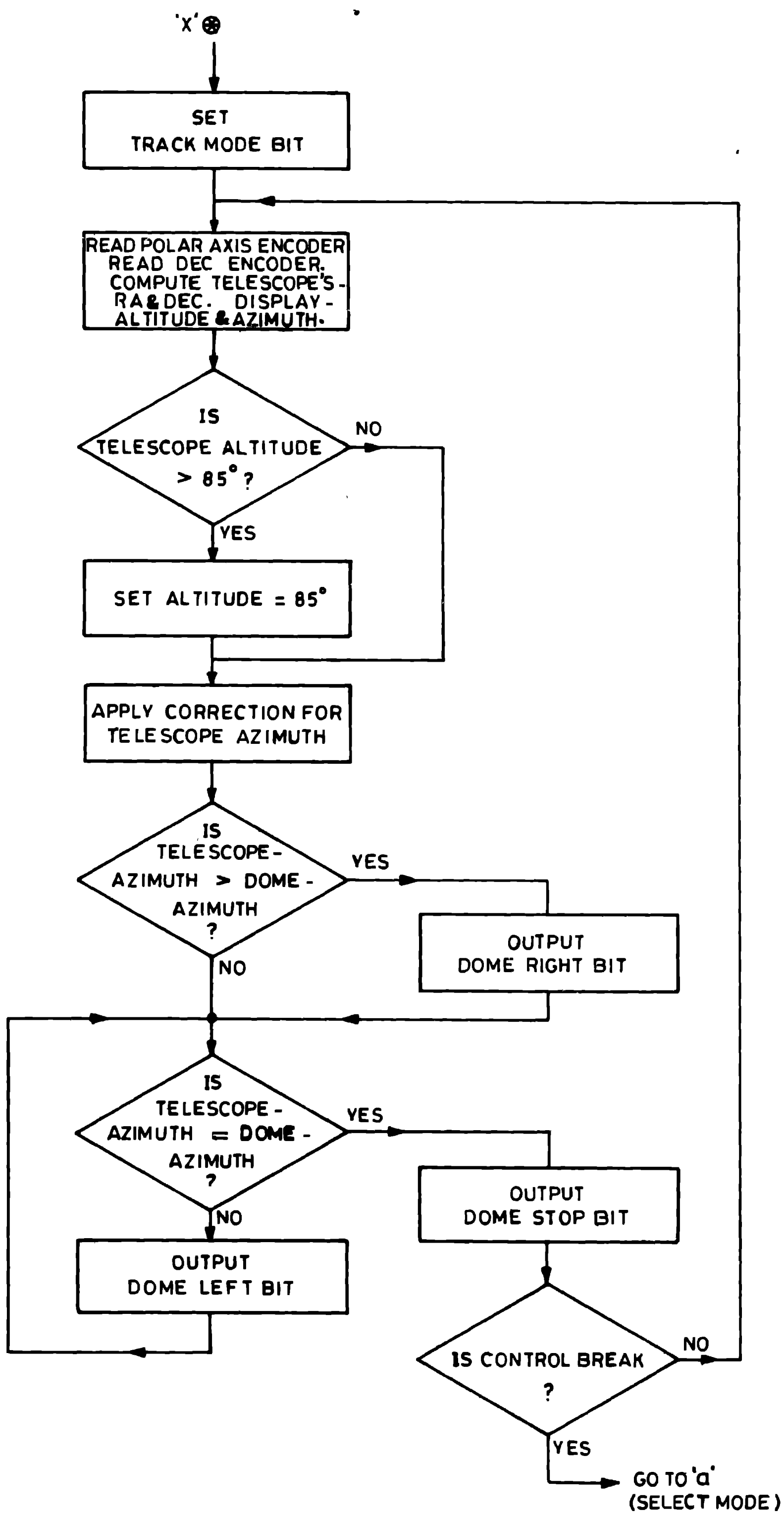

Figure 3. Flow chart of automatic dome control program.

towards left edge of the shutter in the south side. This will allow maximum time for the telescope to track within the shutter opening during observation. Initially, the program is in the acquisition mode. In this mode, dome is positioned to a given RA and DEC values irrespective of telescope position. This is useful because when the telescope is being positioned, the dome also can be positioned at the same time, thus saving time. The demanded azimuth of the telescope is compared with the present azimuth of the dome and the dome left or right direction bits are generated taking into account the least possible distance to reach the demanded position. The direction bits are read by the console microcomputer and it operates the relays (Chinnappan & Bhattacharyya 1985)

When the dome stops in the acquire mode, it flashes a message whether the dome is to follow the telescope during observation. If yes, then the present azimuth of the telescope is compared with the present dome azimuth and dome direction bits are generated accordingly. Dome position is corrected within two degree error band, reducing this to a lower value will lead to unnecessary correction back and forth near the end position. When the error exceeds 7 degrees, dome position is corrected again. The dome correction at present is not in a fixed time interval but on fixed error margin. This way the frequency of dome correction depends on the position of the telescope. It is less often in east and west and tend to be more often in north and south. No correction is made when the altitude is greater than 85 degrees as the telescope will be always within the shutter opening. The flow chart for the program is given in figure 3. Complete listing of the program written in QBASIC, which runs on an IBM compatible PC, can be obtained from the authors on request.

7. Problems encountered and solved

1. Initially dome position encoder data was received without differential line receiver. The data was not reliable. Hence differential line recivers were used at console end.

2. A local 5V regulator near the encoder was put and the encoder was powered using the local regulator, instead of sending 5V remote control supply from the console end.

3. Dome periphery was not smooth due to welding of dome plates. the surface was ground to avoid sudden jumps.

4. The dome encoder is mounted outside the dome, in open space, with a cover. Moisture has entered in the encoder and the coded disk had water marks. This encoder was changed with a new one. Mounting of the encoder was modified to avoid ingrress of moisture inside.

5. Encoder bulb has fused inside. Replaced with a suitable bulb such as the one available in the console.

6. Dome tends to move often when the telescope altitude is greater than 85 degrees. The dome rotation is stopped at 85 degree altitude. It is always within the shutter opening for values greater than 85 degrees altitude.

7. Occasional noise pick up changes the dome direction. The program is run in interrupt mode with one second sampling time. Previous loop directions are compared with the present one. If it is different, that cycle is not executed.

Acknowledgements

M. R. Somasekar made the art work for PCB and mounted the components. A. S. Babu, K. Ravi, S. Ramachandran and A. Venkateswara Rao did the wiring at VBT during system installation. F. Gabriel, A. Mani and the mechanical workshop people at Kavalur smoothened the dome surface by grinding; they also machined the friction wheel to the correct size. We thank Prof. N. Kameswara Rao for his suggestions and helpful discussion.

Refrences

Chinnappan V., 1982, J. Instrument. Soc. India, 12, 364.

Chinnappan V., Bhattacharyya J. C., 1985, BASI, 13, 153.

Chinnappan V., 1988, Proceedings of National Symp. on Tracking Technology, published by Aeronautical sevelop. Establishment, Banglore, p. A-1.

Chinnappan V., Saha S. K., Faseehana, 1991, Kodaikanal Obs. Bull., 11, 87.

Chinnappan V., 1991, Kodaikanal Obs. Bull., (in press).