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Technical Report

The Control Scheme and the Software for the 75 cm Optical Telescope, VBO Kavalur

A.V. Ananth[1], P.Anbazagan[2], K.Ravi[2] ,

V.Arumugam[1], A.Ramachandiran[2] & S.VenkateswaraRao[2]

[1] **IIA Electronics Laboratory, Bangalore**

&

[2] **Electronics Laboratory, VBO, KAVALUR**

Abstract

This report describes the Salient features of the control scheme and the control software for the recently upgraded 75 Cm. Telescope at VBO, Kavalur.

The performance of the telescope in terms of controls is also highlighted.

Keywords: Optical Telescope controls, Turbo-PMAC II motion controller, Pcomm32 libraries, multi threading, MFC calls, GraphicalUserInterfaces ,WIN-NT.

Introduction

This report describes the Control scheme and the software for the 75cm. telescope at Kavalur. The 75cm, telescope was built in the early seventies when the technology availability and experience in building telescopes was limited in the country. So the telescope had serious performance limitations. The scheme is part of overall plan for up-gradation of the telescope to bring its Electro-mechanical performance on par with other telescopes in IIA. With recent advances in technology and availability of cost-effective tools, as well as the experience gained by Electronic and Mechanical groups from Designing, building and operating such facilities as Vainu Bappu Telescope (VBT) at Kavalur and the Himalaya Chandra Telescope(HCT) and Hanle Gamma Ray facility (HAGAR) at Hanle, it was felt worthwhile to improve the performance of the 75cm Telescope at a very modest cost. Since the tools available currently are quite sophisticated, the experience so gained would also enable us to implement the scheme and develop the control software for bigger facilities at IIA in the future.

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

The Telescope and associated sub-systems are to operate in two modes.

a. An autonomous mode where the telescope, dome and other sub- systems operate independently.

b. A networked mode where all sub-systems get connected through a common communication server.

The advantages with this two level approach are the following:

1. The controls are distributed and are sufficiently autonomous.
Each sub-system can be configured and tested independent of the other in the autonomous mode.

In the Networked mode where communication is between various sub-systems is through a concept of virtual instruments and uses Client/server technology and provides a mechanism for

1. Operation from a local/remote site and provide the possibility of controlling the facility over a WAN link from a remote site.
2. Telescope back-ends could also be clients and seek information from various sub-systems. (Additional information at the end of report)

At the present time, the First phase of Telescope control software is ready for use and provides the autonomous control of individual sub-systems like the Telescope and Dome and auto-guider which are operational at the site. The telescope can be operated from the computer to which the telescope Control hardware is directly connected. The Dome and shutter have also manual modes of operation.

Telescope Control Hardware Details

The Block schematic of the controls is as shown in figure -1.

The telescope control hardware basically comprises of the Turbo-PMAC Series of Motion Controllers from M/s. DeltaTau Controls .U.S.A.

These programmable motion controllers are extremely versatile and can handle from 2 axes to 32 axes (extendable up to 512) with fixed servo update rates of 2.2 KHz. For Each of the axis, there is a provision to read the incremental encoder, a homing feature to initialize the encoder and limit switch logic to read hardware limit switches if needed.

Provision also exists to choose and program parameters for Proportional, derivative and integral controllers to tune appropriately for the mechanical characteristics of the telescope.

The hardware can control motors of different types namely, A.C. Servo, D.C. Servo or Stepper motors.

In the present case, DC. Servomotors from BALDOR Germany, have been chosen for R.A. and DEC movements and stepper motor for focus movements. The Encoders are of incremental type, which can provide a resolution of 3.6 million counts per revolution.

The Telescope is of Equatorial Mount type and hence the telescope needs to be tracked only in one axis namely, RA axis and at a constant rate of 15 arc-sec/sec. The incremental encoders provide the feed-back for position loop for both RA and DEC axis and have a provision for homing electronically. The Tacho-generators built into the motor is fed back into the Power amplifier stage and provides the feedback for speed loops.

The D.C. Servo motor is connected through a large gearing of 1:5000 which provides necessary torque from slew speed to fine guide speed. The mechanical limit switches are placed such that the telescope can operate from +4 .5 hrs to –4.5 hours in east-west axis and –70 to +70 degrees in north-south axis.

The telescope has five speed settings viz:

1.Slew 2.Set 3.Track 4.Guide 5.Fine_guide

The Servo motor operates from approximately 800 R.P.M. at Slew speed to 3 R.P.M at track and 1 R.P.M and 1/5 R.P.M for guide/fine guide speeds. There is a handset control for set/guide/fine-guide speeds achieved through an accessory for Turbo-PMAC II boards. The accessory is the 8E extension Board.

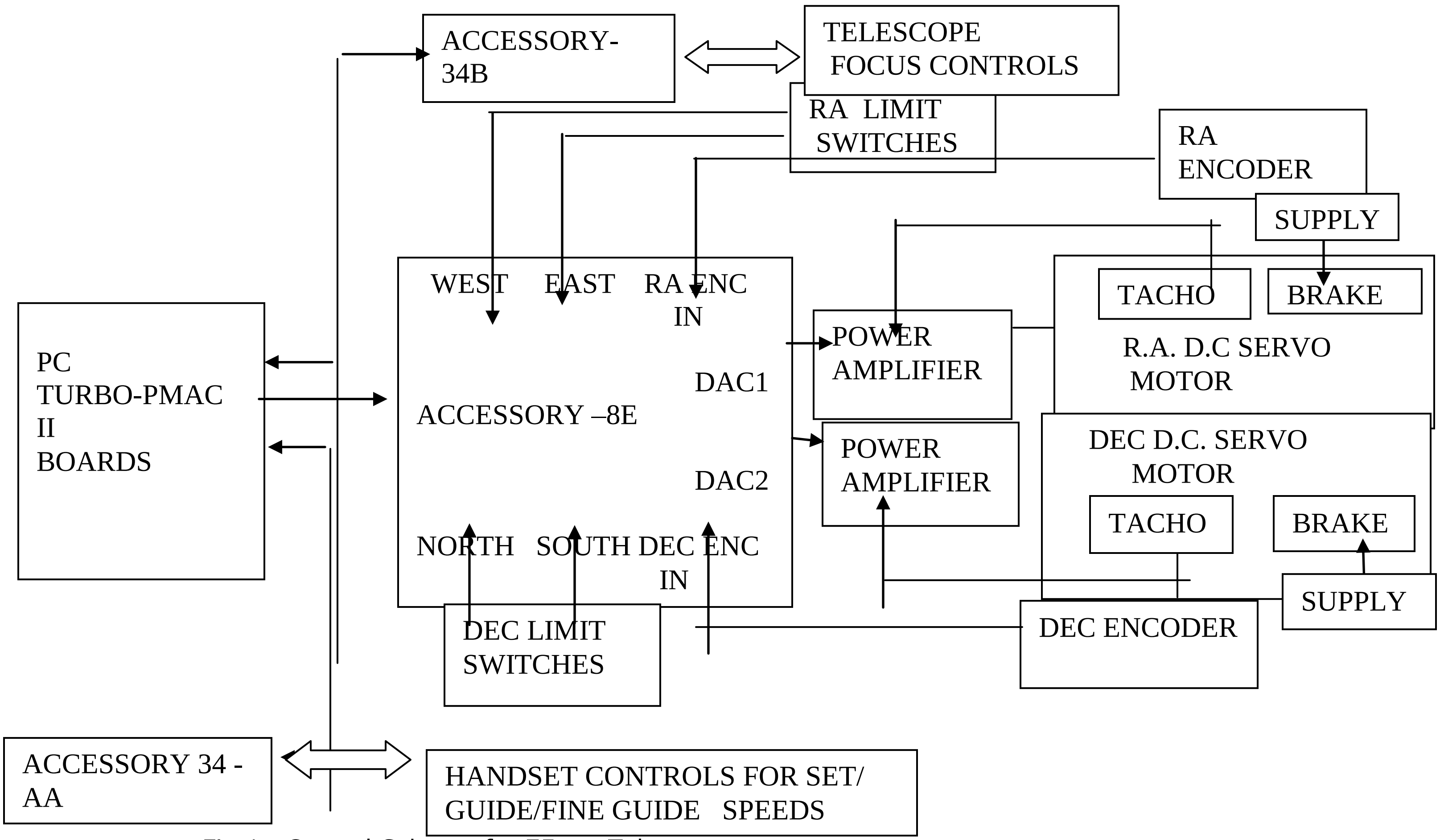


Fig 1 . Control Scheme for 75 cm Telescope

The Focus movements are achieved through a Micro-stepping motor and controller which can be controlled through another accessory for Turbo–PMAC II, called the 8E.

The focus motor is connected through a gearing arrangement so as to achieve a positioning resolution of a few microns which is programmable and is currently maintained at 5 microns/step for fine movement.

The focus display is through a digital dial-gauge which is read off through a serial port and has a resolution of 1 micron.

Control representation

The control scheme for both RA and DEC axis primarily consists of a position loop with a built-in velocity loop.

This is illustrated in fig.2.

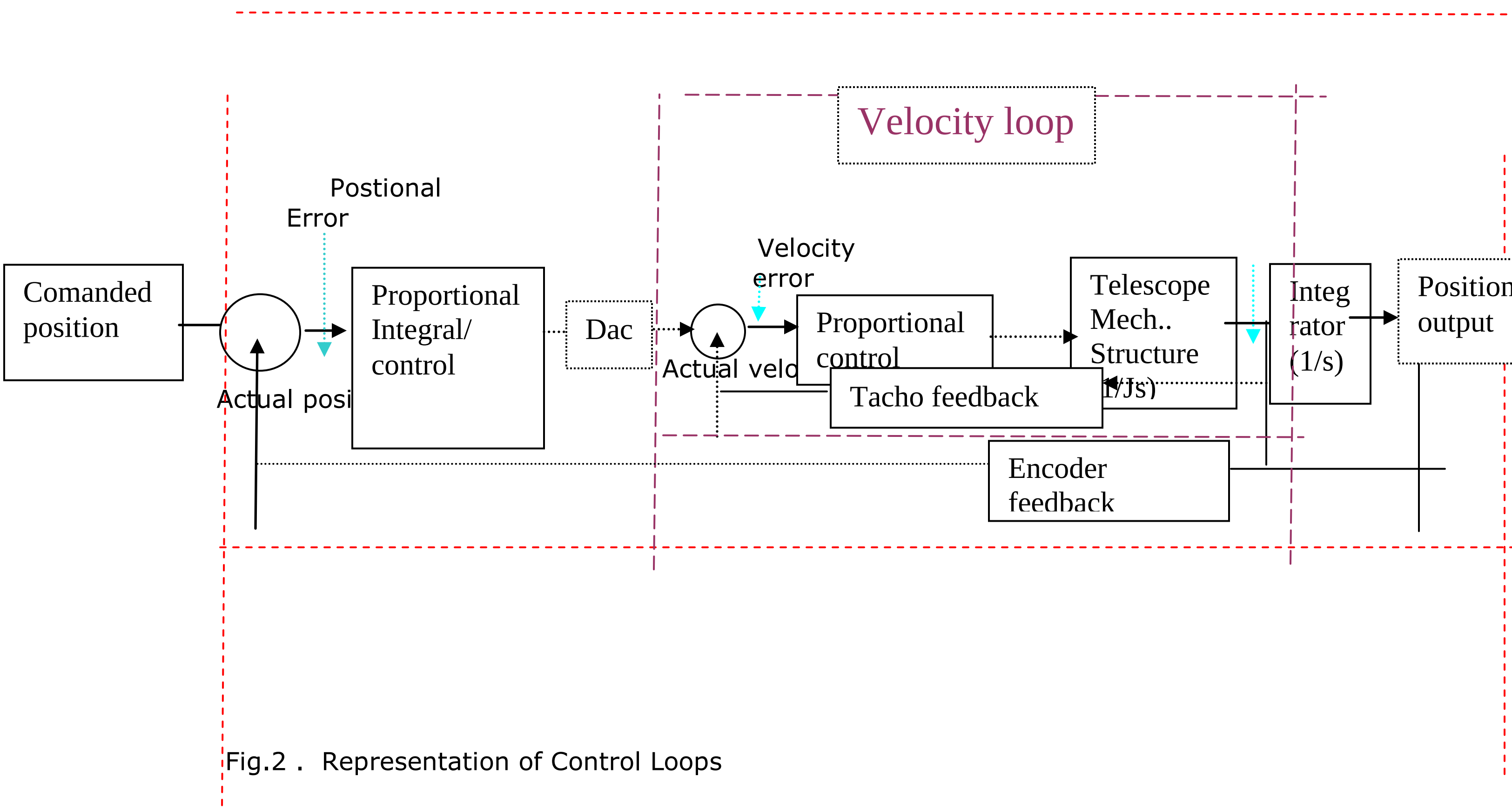


Fig.2 . Representation of Control Loops

Controller tuning:

The tuning of the controller involves tuning both the speed loop and the position loop so as to ensure proper responses for large /small step inputs for various speeds.

The parameters to be tuned are:

1. Settling time for step inputs.
2. Following error. (The difference between commanded and actual positions at various instances of time.)
3. Over shoot of the step inputs.
4. Final positional error.

Based on the above criteria, the PID parameters are tuned so that the telescope attains a performance as close to the original design goals as regards positioning, and tracking.

It may be noted that mechanical factors like backlash and friction, Telescope imbalance and wind gusts play a role in the final performance of pointing, tracking and guiding, although most of these factors have been considered, in the initial design of the mechanical and electrical controls of the system. However any errors arising out of defects in the manufacturing stage or site specific issues like balancing can give rise to errors and can be offset to some extent by appropriate tuning of parameters.

The response curves for various speeds in different orientation are as Enclosed in the appendix I.

The specifications of the electro-mechanical system are as follows:

Speeds:

1. Slew: 1 deg/sec

2. Set: 0.3 deg/sec

3. Track: 15 arcsec/sec

4. Coarse-guide: 5 arcsec/sec

5. Fine-guide: 1 arcsec/sec

Positioning accuracy : Better than 0.72 arcsec (electro-mechanical system)

Tracking accuracy : 1.5 arcsec/sec peak- peak (Electro-mechanical response)

Hardware limit switch position :

DEC: -70 (south) & 70 (north).

HA: -4.5 Hrs (East) & 4.5 Hrs.(West)

Telescope tracking performance : The image remains in the center of the cross-hair for about 3–4 minutes unguided.

Telescope pointing: The telescope is to be modeled for obtaining Off-sets with respect to catalog positions. At the present time, the objects are off from catalog positions by about 1 degree 30 arc minutes in DEC and 3 min and 6 sec in R.A. which need to be offset by using offset command available in GUI. With this correction, the telescope is positioned to within a few arcsecs in DEC and RA. It should be possible to position more accurately with better modeling of the telescope. However it may be noted that in most positions of the telescope, the electro-mechanical system is positioned to better than 0.72 arcsec including while homing.

Software aspects of Telescope Controls:

The software for telescope control is being developed in two phases.

1. An autonomous mode where the telescope, dome and other sub-systems work independently .

2. A networked mode through a common communication server.

The first phase is nearly complete and the details are as follows:

The control software has been developed under WINDOWS-NT 4.1 Using Pcomm-32 library provided for Visual C++ by Delta Tau.

The program uses:

a. PLCs (programmable logic control feature) for Input/output interaction).
b. Motion programs for actual movement of axes.

The user currently needs to execute two executables.

1. A program for homing of R.A and DEC axis.

This is necessitated by the fact the encoders are of incremental type and the telescope needs to be brought to a reference position before the position control program can be run. This is needed to be done only once during an observation cycle during the night. This is a multi-threaded application with GUI buttons providing homing from various directions i.e. East/West for R.A. and North/South for DEC. It is possible to set the homing speed up to a maximum of 3000 counts/sec. (approximately 0.3 degrees/sec).

2. The Telescope control program which allows telescope to move from one object position to another and also track the object at sidereal rates.

This is also a multi-threaded application which uses Microsoft foundation Classes (MFC's) for graphical user Interface development.

The user interface allows to set the position (RA and DEC) through the GUI and allows the object so acquired to be tracked. There is also a provision for offset movement , so that telescope can be offset by small increments if required. There is also a provision for controlling the telescope through a handset interface which allows objects to be positioned, tracked and guided.

The GUI has a provision for displaying Universal Time (UT), Local Sidereal time (LST), Present R.A, DEC and H.A.

There is also a provision for enabling focus movements.

A graphical display in Real-time of the Telescope position is also part of GUI.

The Display update is performed every one second.

The user Interface details are illustrated in the appendix-II.

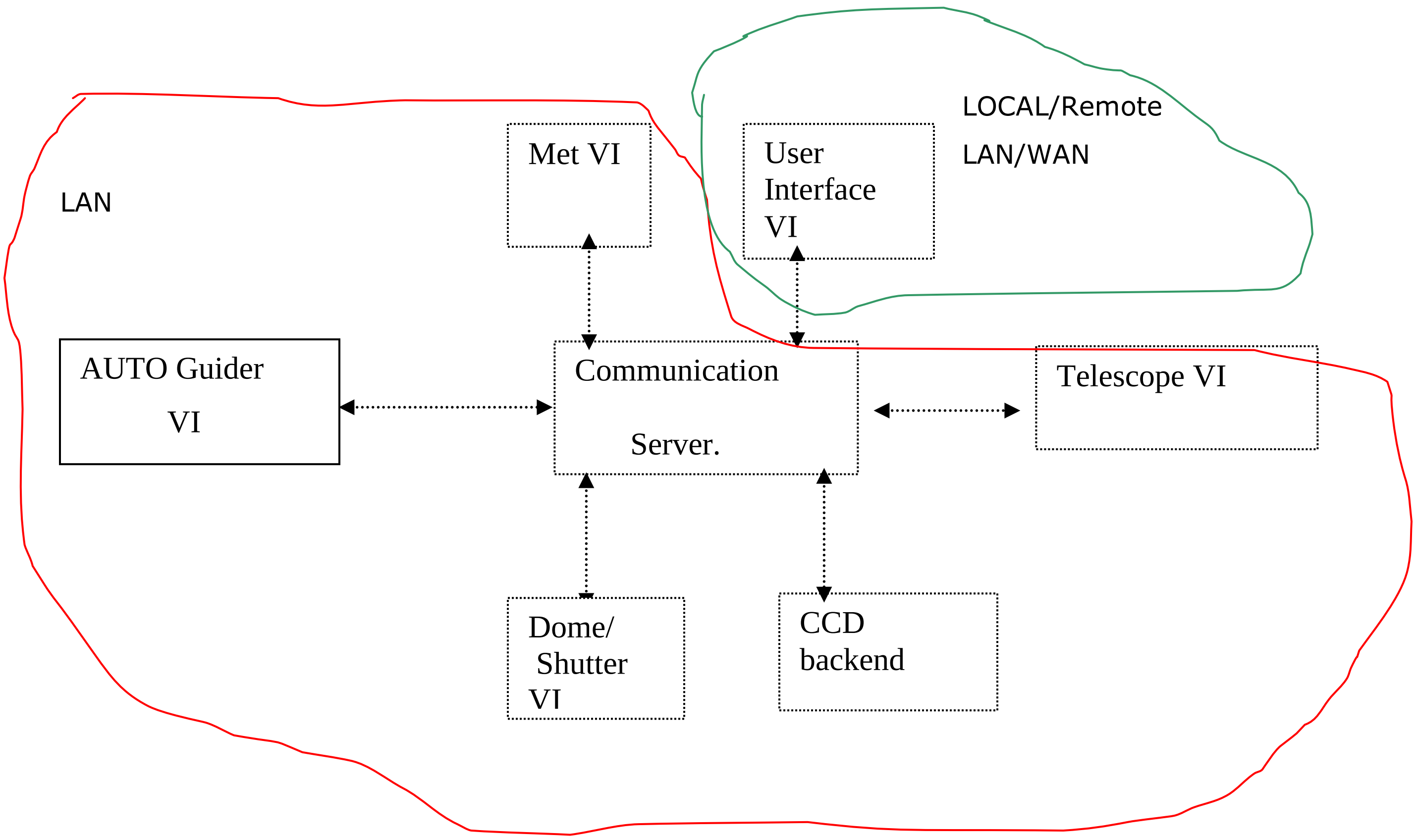
The proposed scheme to be implemented in phase-II is described in the section II

The Details of secondary focus drive systems is described are in next few sections II

SECTION II

A Scheme for networked mode of observatory-control

The proposed scheme for networked mode of observatory control comprising the 75cm telescope, dome, auto guider and possibly a meteorological unit are interconnected on a LAN and communicate through a common communication server. A Linux based user interface unit controls through a common GUI all the subsystems related to the telescope and dome/shutter. This is illustrated in the following figure.



The scheme is based Client/server Technology and uses TCP/IP based messages. The communication between server/client operates on the message passing paradigm.

The communication server is the repository of all information from various sub-systems which are updated periodically. The clients could also act as servers at times and provide various kinds of information if sought, However all messages get routed through the communication server .

Telescope back-ends such as a CCD camera can also act as a client and seek information from other Clients.

The user interface unit could be a local station or a remote unit connected over a WAN link.

This would permit that any remotely operable facility could utilize the software developed.

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Mr.D.Babu and Sriharsha & P.Janakiram from E-lab Bangalore .

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Appendix –I

1. A photographic view of Modified 30 " Telescope (West).

2. A photographic view of Modified 30" Telescope (East).

3. A photographic view of RA DEC dragchain.

4. A photographic view of RA dragchain.

5. An RA-DEC Position plot(commanded POS. &. Actual POS Vs. time)

6. A RA-DEC Response plot in NE zone at Slew Speed (commanded Vel & actual Vel vs. Time)

7. A RA-DEC Response plot in NW zone at Slew Speed (Commanded Vel. & actual Vel Vs. Time)

8. A RA-DEC Response plot in SE zone at Slew Speed (commanded Vel & actual Vel vs. Time)

9. A RA-DEC Response plot in SW zone at Slew Speed (commanded Vel & actual Vel vs. Time)

10. A RA-DEC Response plot in SE- PARK zone at Slew Speed (commanded Vel & actual Vel vs. Time)

11. DEC _SetButton response (Commanded Vel & Actual Vel Vs. Time)

12. DEC Guide_button Reponse (commanded Vel & Actual Vel Vs. Time)

13. DEC Fine_Guide_button Reponse (commanded Vel & Actual Vel Vs. Time)

14. RA Set_button Reponse (commanded Vel & Actual Vel Vs. Time)

15. RA Guide_button Reponse (commanded Vel & Actual Vel Vs. Time)

16. RA Fine_ Guide_button Reponse (Commanded Vel & Actual Vel Vs. Time)

17. Telescope _Tracking PLOT

Appendix-II

1. GUI for Homing program.

2. GUI for Telescope Control Program.

APPENDIX –III

1. An unguided Image acquired from a Cooled CCD camera (3 min On-chip Integration time).

2. A guided Image acquired from a Cooled CCD camera. (5 min On-chip Integration time)

3.A guided Image acquired from a Cooled CCD Camera. (20 min On-chip Integration time)

4.A guided Image acquired from a Cooled CCD Camera (40 min On-chip Integration time).

5. A Locus plot of the Guided Image.

6. A RA drift plot of the guided Image

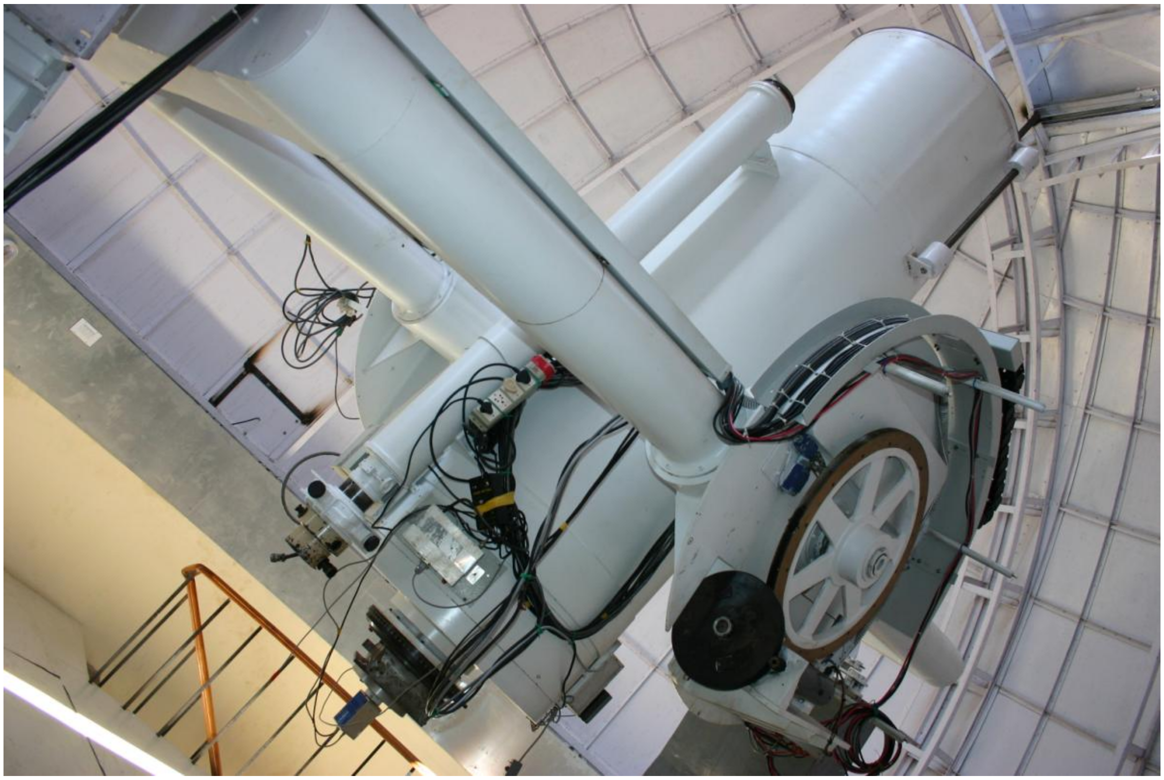
7. A DEC drift plot of the guided Image.

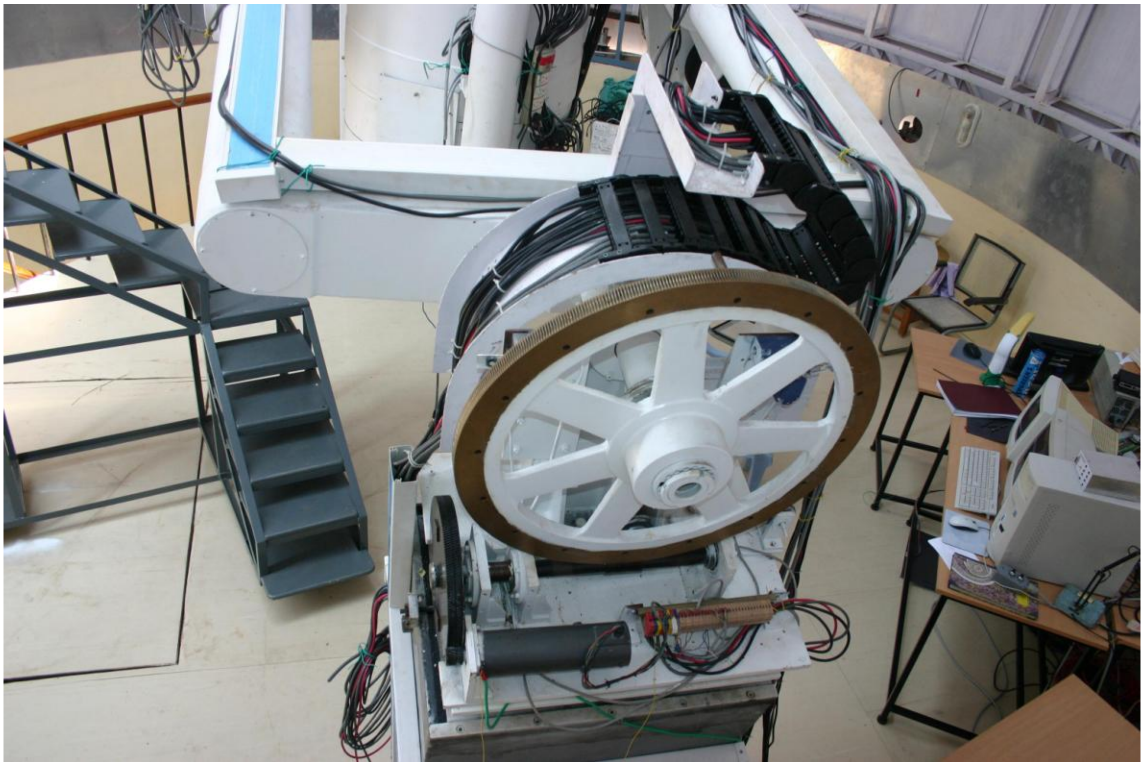
8. A surface plot of the star image.

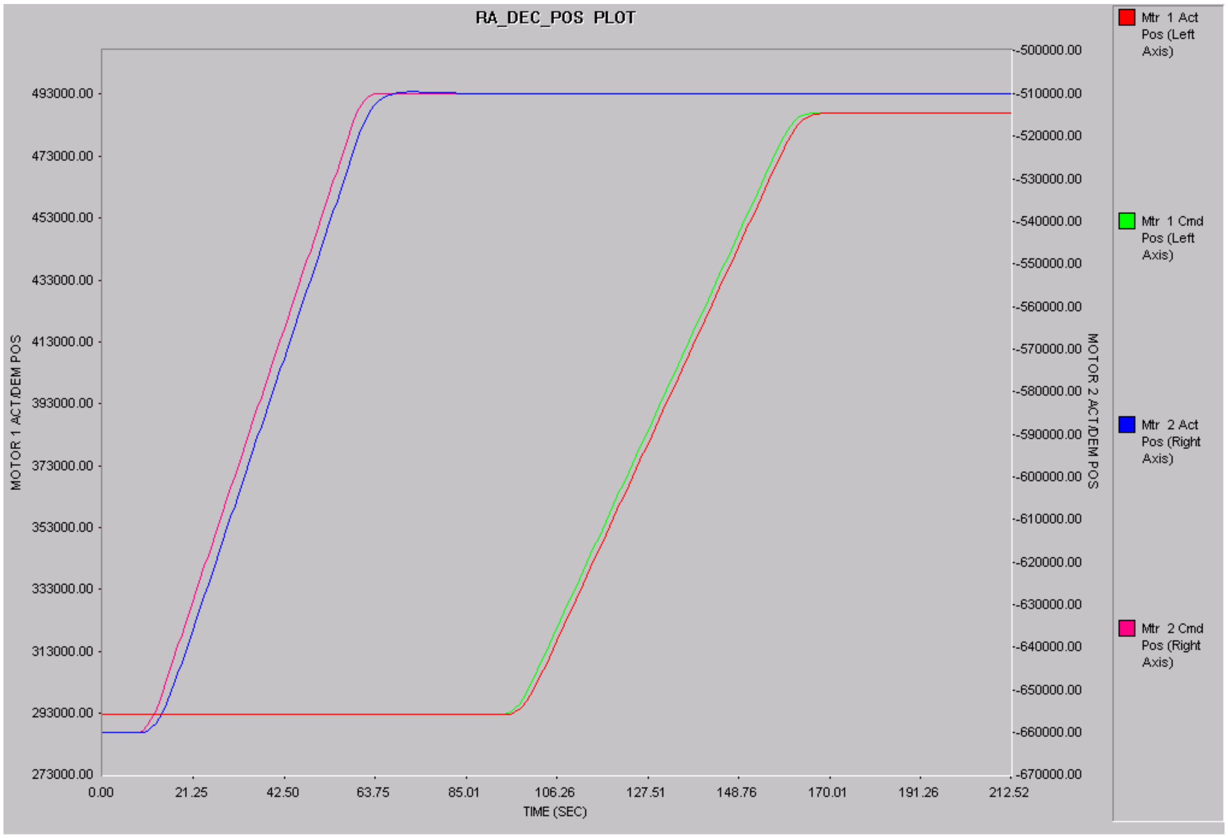
9. A contour plot of a star image.

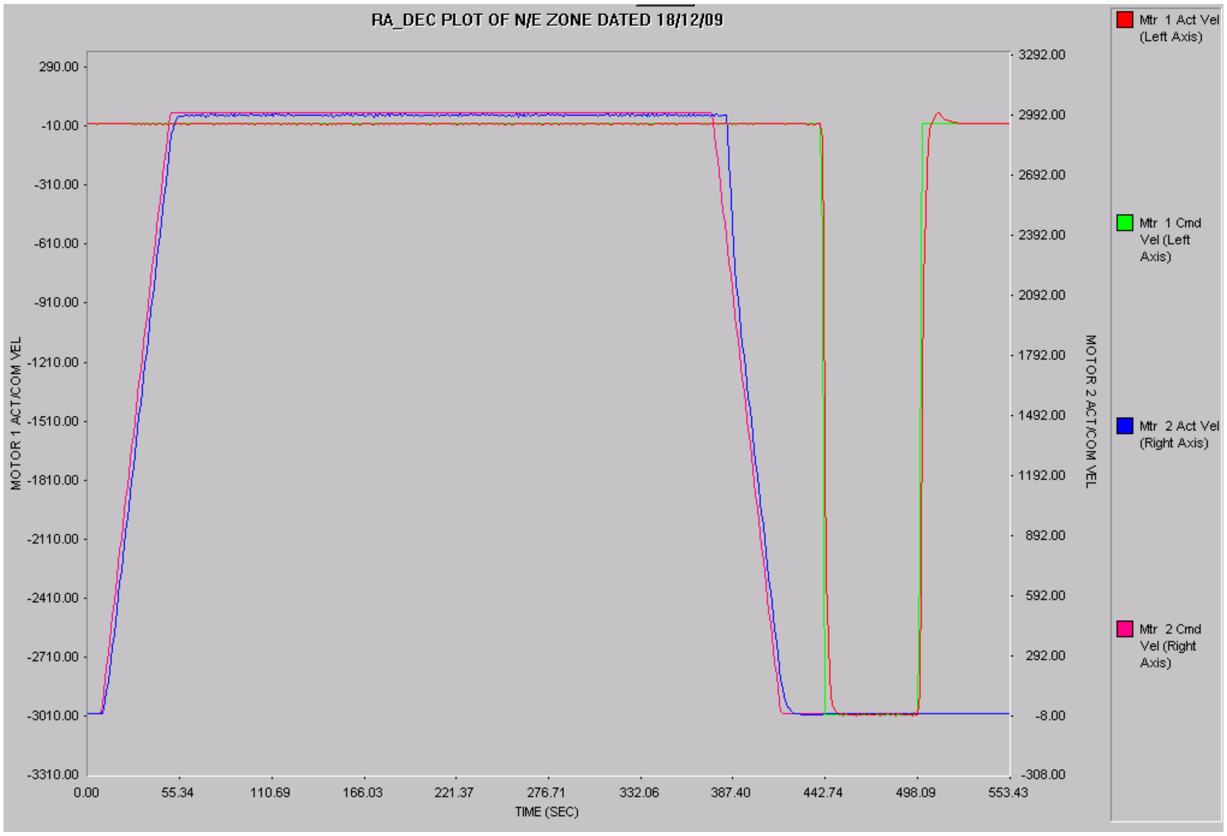
10. A radial plot of a star image.

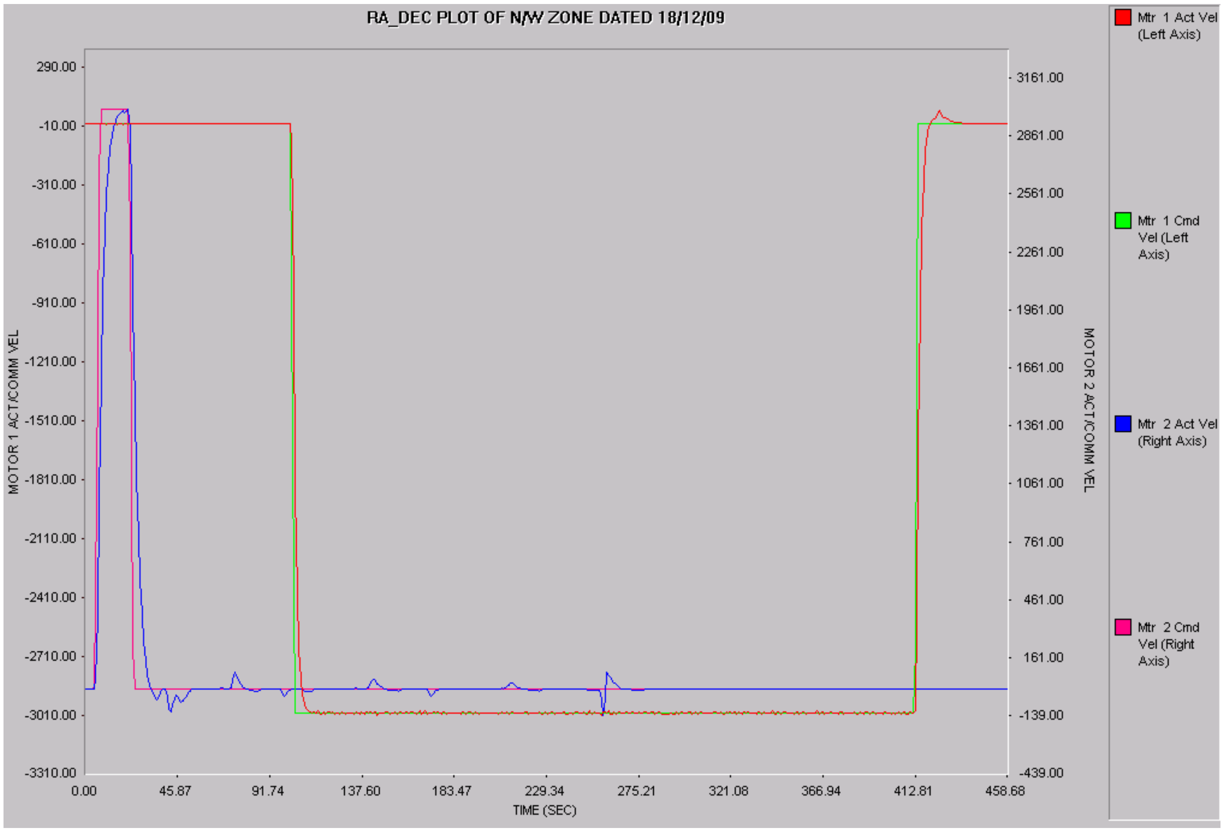
APPENDIX I

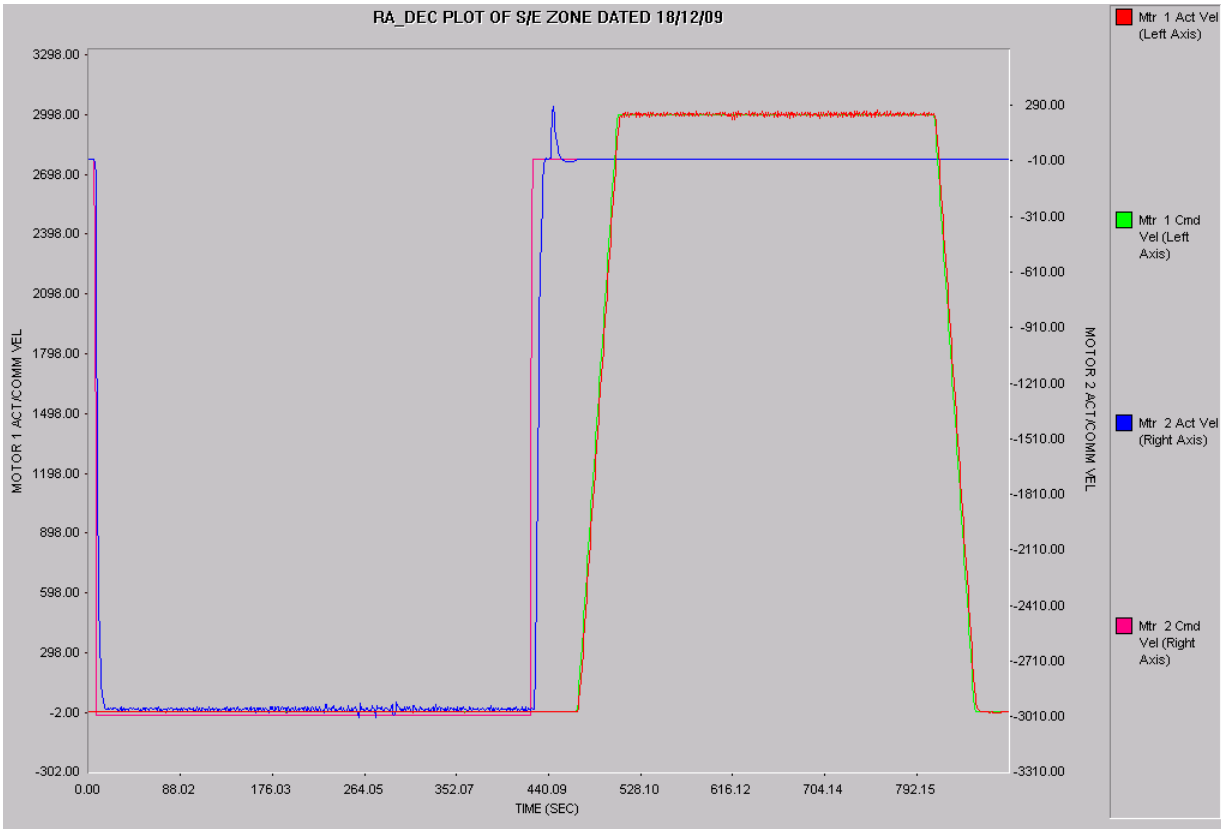


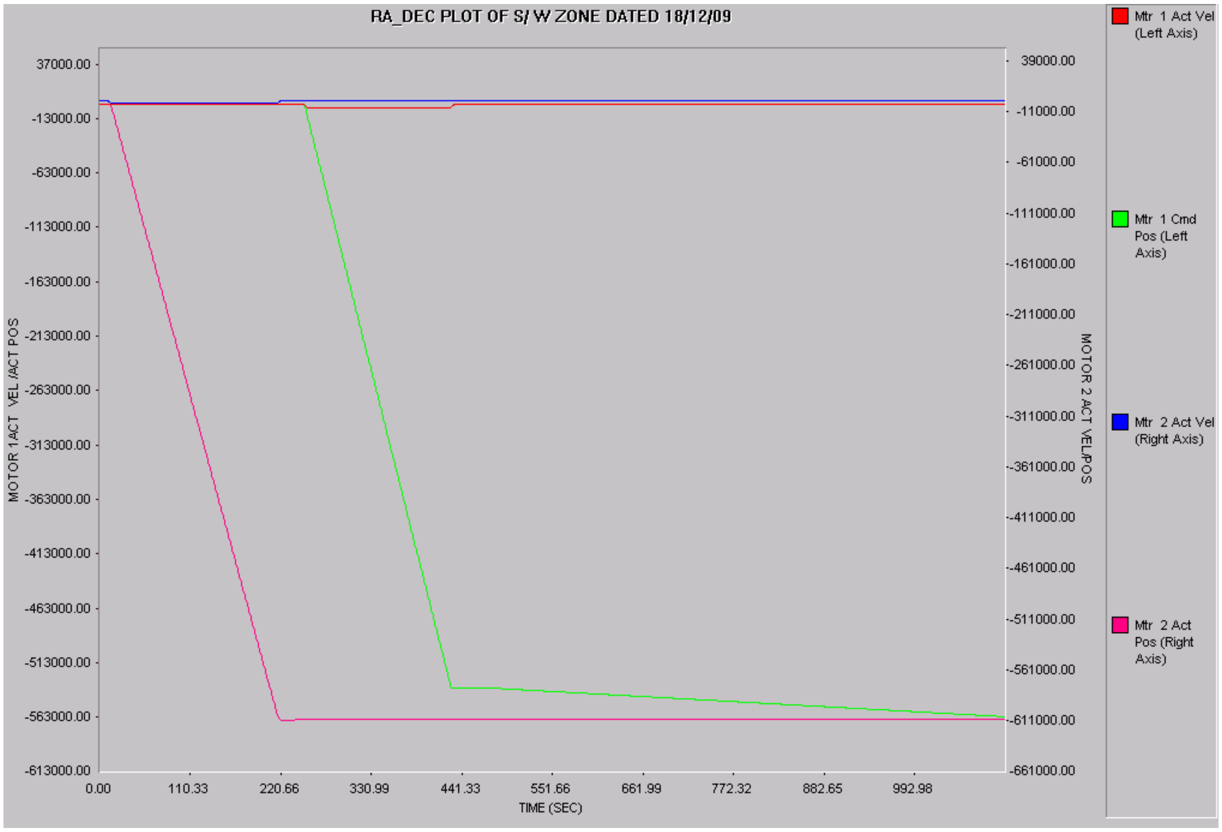



RA_DEC_POS PLOT
MOTOR 1 ACT/DEM POS
493000.00
473000.00
453000.00
433000.00
413000.00
393000.00
373000.00
353000.00
333000.00
313000.00
293000.00
273000.00
MOTOR 2 ACT/DEM POS
-500000.00
-510000.00
-520000.00
-530000.00
-540000.00
-550000.00
-560000.00
-570000.00
-580000.00
-590000.00
-600000.00
-610000.00
-620000.00
-630000.00
-640000.00
-650000.00
-660000.00
-670000.00
0.00
21.25
42.50
63.75
85.01
106.26
127.51
148.76
170.01
191.26
212.52
TIME (SEC)
Mtr 1 Act Pos (Left Axis)
Mtr 1 Cmd Pos (Left Axis)
Mtr 2 Act Pos (Right Axis)
Mtr 2 Cmd Pos (Right Axis)


RA_DEC PLOT OF N/E ZONE DATED 18/12/09
MOTOR 1 ACT/COM VEL
290.00
-10.00
-310.00
-610.00
-910.00
-1210.00
-1510.00
-1810.00
-2110.00
-2410.00
-2710.00
-3010.00
-3310.00
MOTOR 2 ACT/COM VEL
3292.00
2992.00
2692.00
2392.00
2092.00
1792.00
1492.00
1192.00
892.00
592.00
292.00
-8.00
-308.00
0.00
55.34
110.69
166.03
221.37
276.71
332.06
387.40
442.74
498.09
553.43
TIME (SEC)
Mtr 1 Act Vel (Left Axis)
Mtr 1 Cmd Vel (Left Axis)
Mtr 2 Act Vel (Right Axis)
Mtr 2 Cmd Vel (Right Axis)


RA_DEC PLOT OF N/W ZONE DATED 18/12/09
MOTOR 1 ACT/COMM VEL
290.00
-10.00
-310.00
-610.00
-910.00
-1210.00
-1510.00
-1810.00
-2110.00
-2410.00
-2710.00
-3010.00
-3310.00
MOTOR 2 ACT/COMM VEL
3161.00
2861.00
2561.00
2261.00
1961.00
1661.00
1361.00
1061.00
761.00
461.00
161.00
-139.00
-439.00
0.00
45.87
91.74
137.60
183.47
229.34
275.21
321.08
366.94
412.81
458.68
TIME (SEC)
Mtr 1 Act Vel (Left Axis)
Mtr 1 Cmd Vel (Left Axis)
Mtr 2 Act Vel (Right Axis)
Mtr 2 Cmd Vel (Right Axis)


RA_DEC PLOT OF S/E ZONE DATED 18/12/09
3298.00
2998.00
2698.00
2398.00
2098.00
1798.00
1498.00
1198.00
898.00
598.00
298.00
-2.00
-302.00
MOTOR 1 ACT/COMM VEL
290.00
-10.00
-310.00
-610.00
-910.00
-1210.00
-1510.00
-1810.00
-2110.00
-2410.00
-2710.00
-3010.00
-3310.00
MOTOR 2 ACT/COMM VEL
0.00
88.02
176.03
264.05
352.07
440.09
528.10
616.12
704.14
792.15
TIME (SEC)
Mtr 1 Act Vel (Left Axis)
Mtr 1 Cmd Vel (Left Axis)
Mtr 2 Act Vel (Right Axis)
Mtr 2 Cmd Vel (Right Axis)


RA_DEC PLOT OF S/ W ZONE DATED 18/12/09
37000.00
-13000.00
-63000.00
-113000.00
-163000.00
-213000.00
-263000.00
-313000.00
-363000.00
-413000.00
-463000.00
-513000.00
-563000.00
-613000.00
MOTOR 1ACT VEL /ACT POS
39000.00
-11000.00
-61000.00
-111000.00
-161000.00
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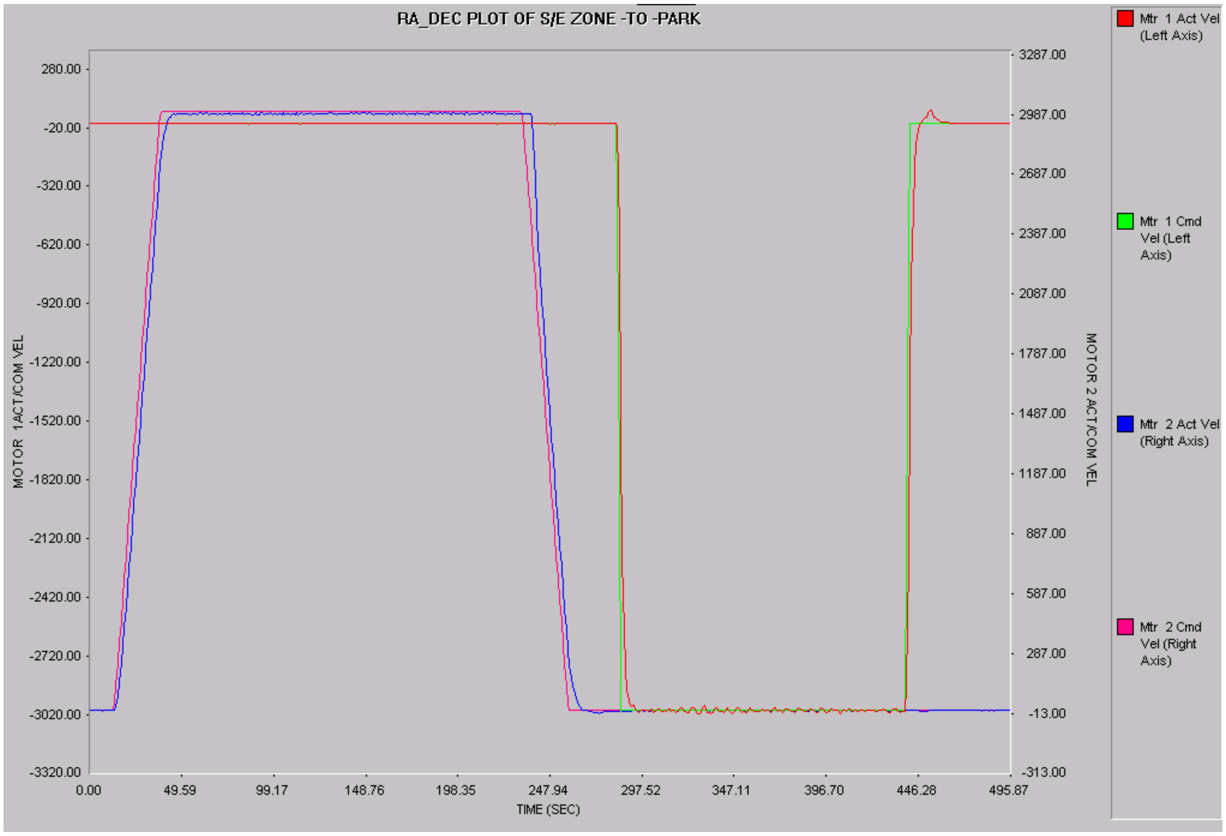
-261000.00
-311000.00
-361000.00
-411000.00
-461000.00
-511000.00
-561000.00
-611000.00
-661000.00
MOTOR 2 ACT VEL/POS
0.00
110.33
220.66
330.99
441.33
551.66
661.99
772.32
882.65
992.98
TIME (SEC)
Mtr 1 Act Vel (Left Axis)
Mtr 1 Cmd Pos (Left Axis)
Mtr 2 Act Vel (Right Axis)
Mtr 2 Act Pos (Right Axis)


RA_DEC PLOT OF S/E ZONE -TO -PARK
MOTOR 1ACT/COM VEL
280.00
-20.00
-320.00
-620.00
-920.00
-1220.00
-1520.00
-1820.00
-2120.00
-2420.00
-2720.00
-3020.00
-3320.00
0.00
49.59
99.17
148.76
198.35
247.94
297.52
347.11
396.70
446.28
495.87
TIME (SEC)
MOTOR 2 ACT/COM VEL
3287.00
2987.00
2687.00
2387.00
2087.00
1787.00
1487.00
1187.00
887.00
587.00
287.00
-13.00
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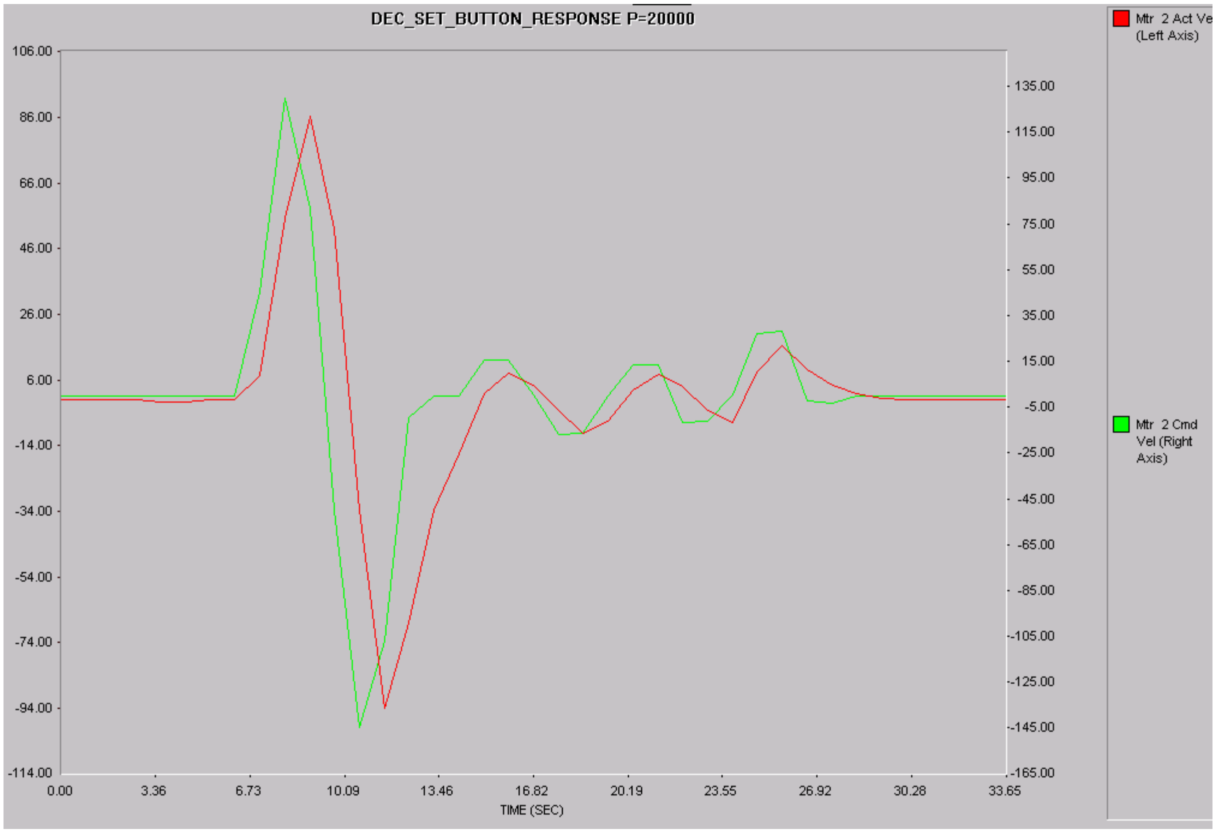
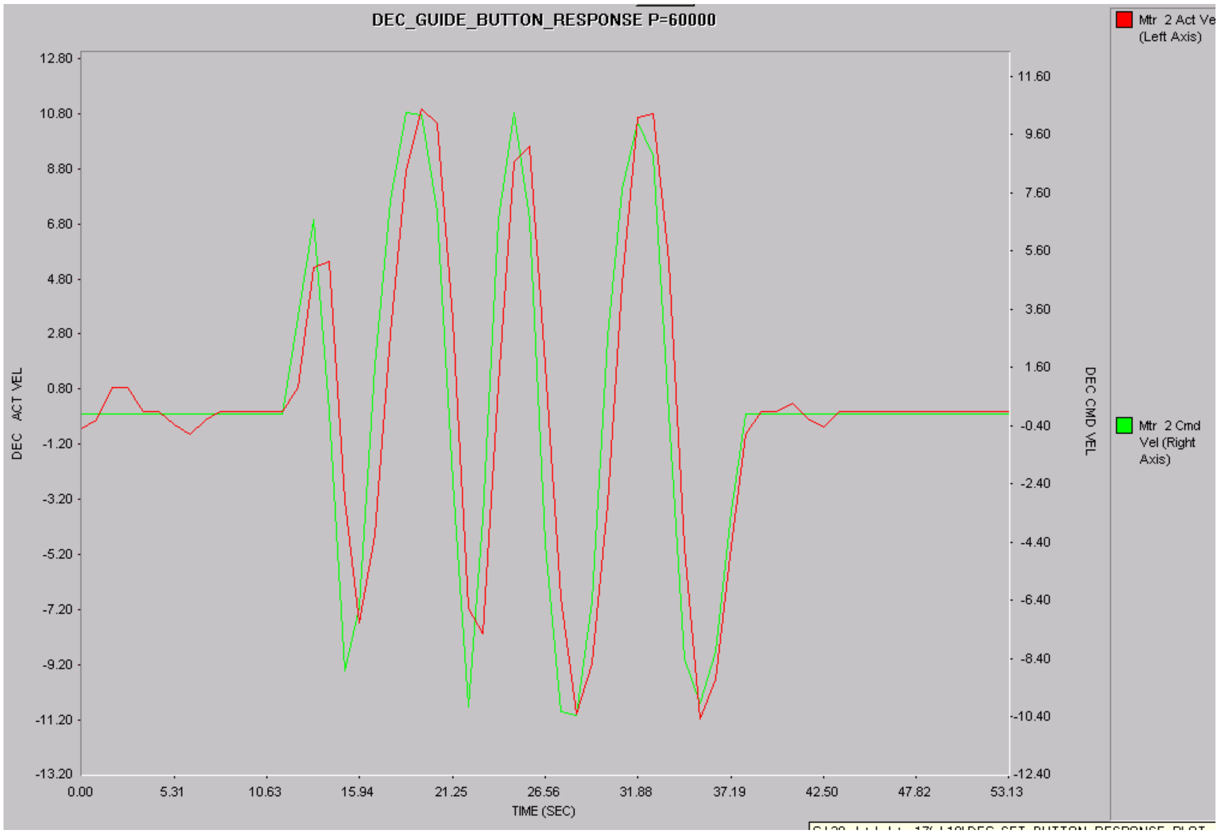
Mtr 1 Act Vel (Left Axis)
Mtr 1 Cmd Vel (Left Axis)
Mtr 2 Act Vel (Right Axis)
Mtr 2 Cmd Vel (Right Axis)


DEC_SET_BUTTON_RESPONSE P=20000
106.00
86.00
66.00
46.00
26.00
6.00
-14.00
-34.00
-54.00
-74.00
-94.00
-114.00
135.00
115.00
95.00
75.00
55.00
35.00
15.00
-5.00
-25.00
-45.00
-65.00
-85.00
-105.00
-125.00
-145.00
-165.00
0.00
3.36
6.73
10.09
13.46
16.82
20.19
23.55
26.92
30.28
33.65
TIME (SEC)
Mtr 2 Act Ve (Left Axis)
Mtr 2 Cmd Vel (Right Axis)



DEC_GUIDE_BUTTON_RESPONSE P=60000
Mtr 2 Act Ve
(Left Axis)
Mtr 2 Cmd
Vel (Right
Axis)
DEC ACT VEL
DEC CMD VEL
TIME (SEC)
12.80
10.80
8.80
6.80
4.80
2.80
0.80
-1.20
-3.20
-5.20
-7.20
-9.20
-11.20
-13.20
11.60
9.60
7.60
5.60
3.60
1.60
-0.40
-2.40
-4.40
-6.40
-8.40
-10.40
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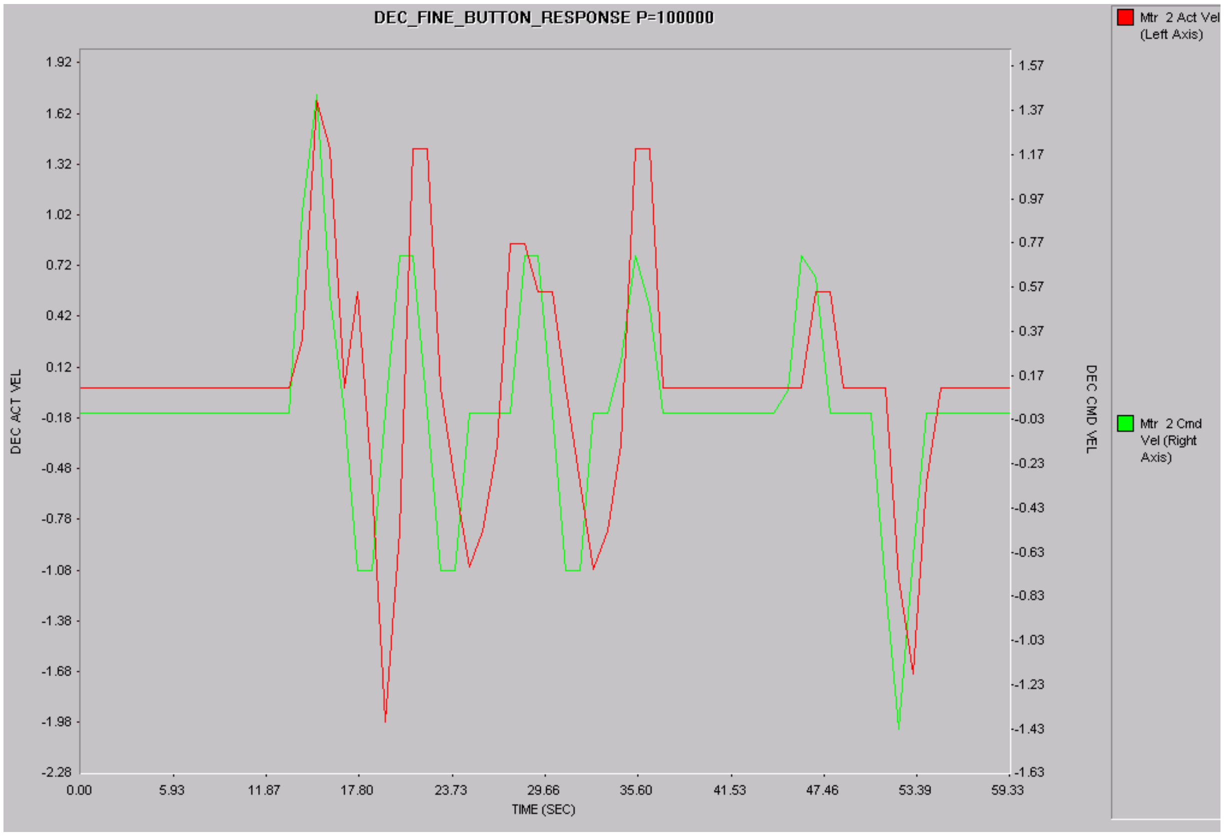
42.50
47.82
53.13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DEC CMD VEL
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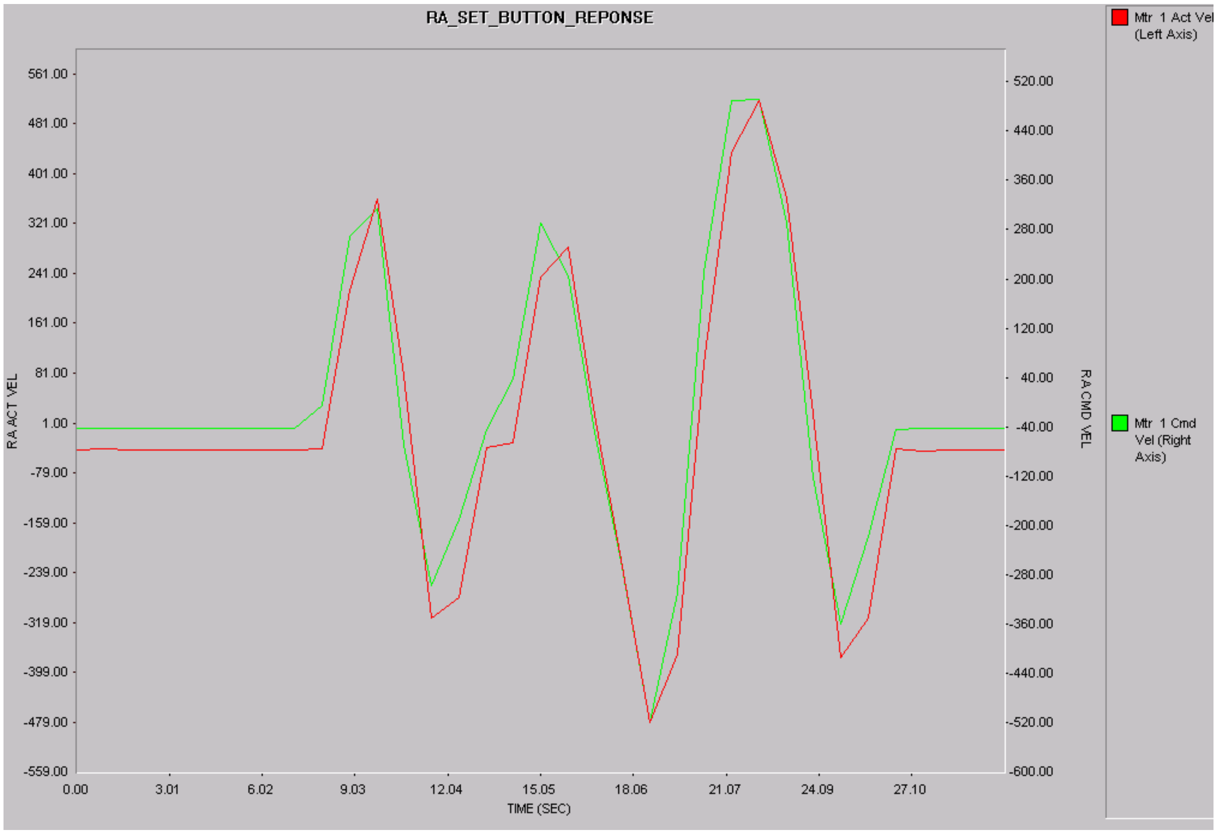
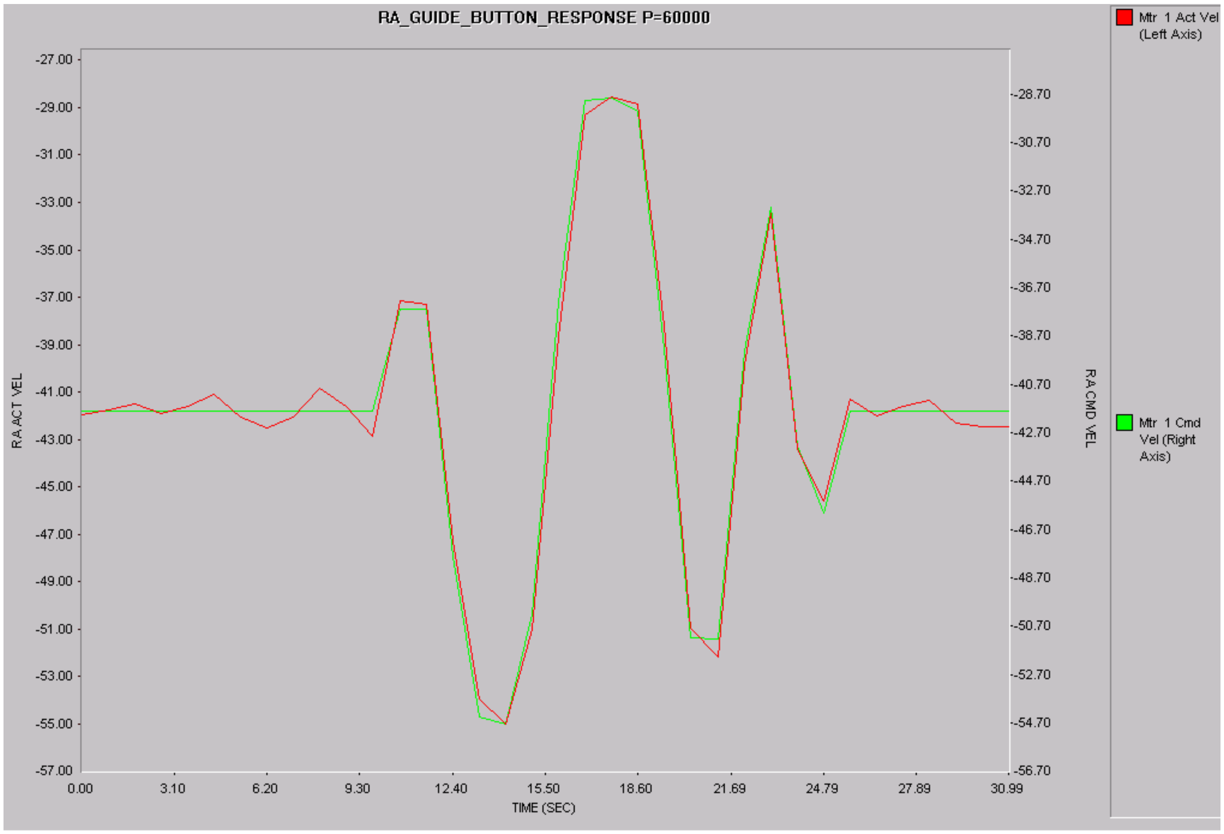
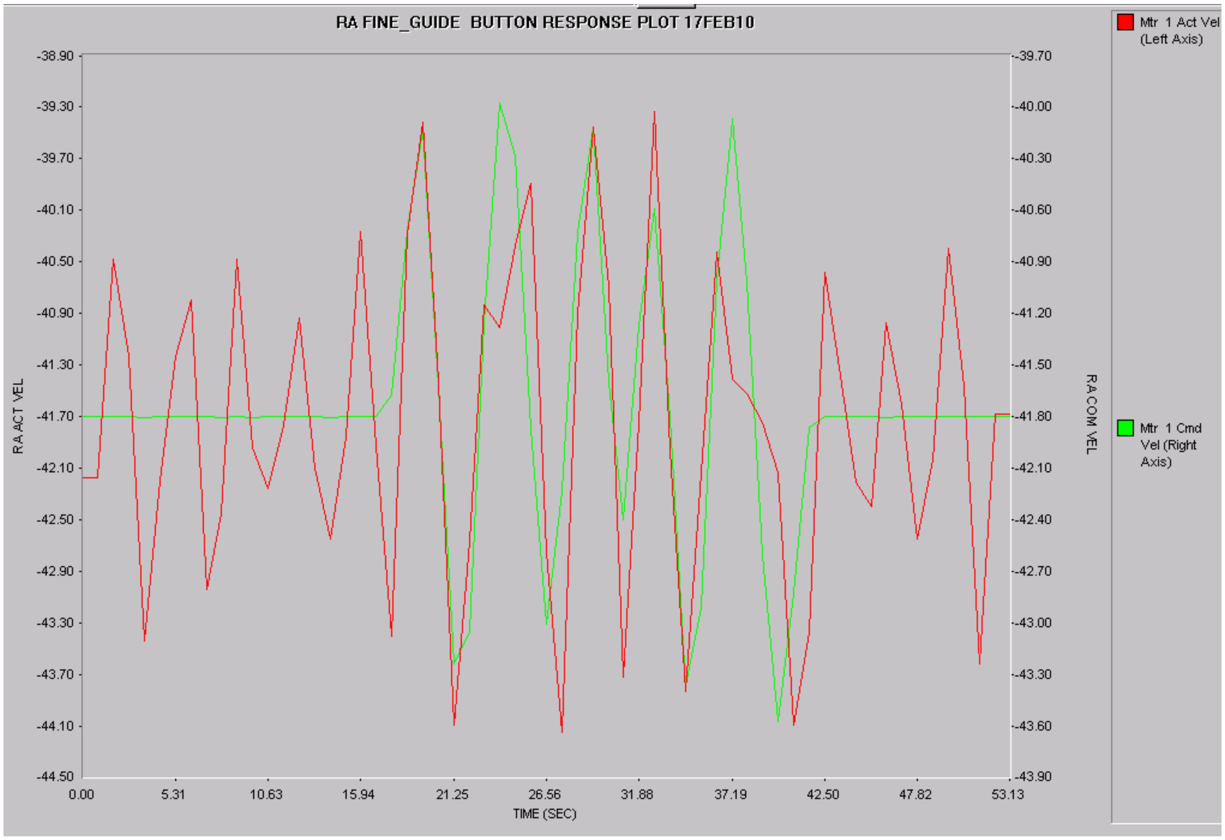
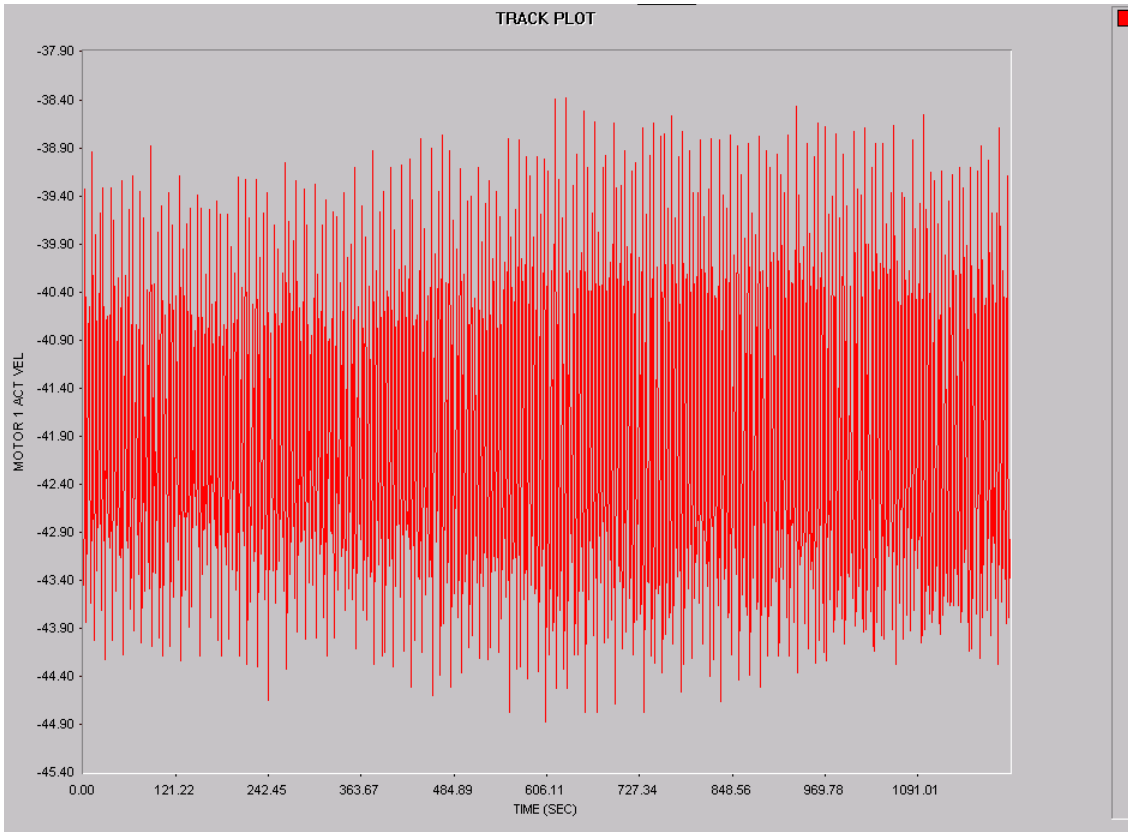
Mtr 2 Cmd Vel (Right Axis)

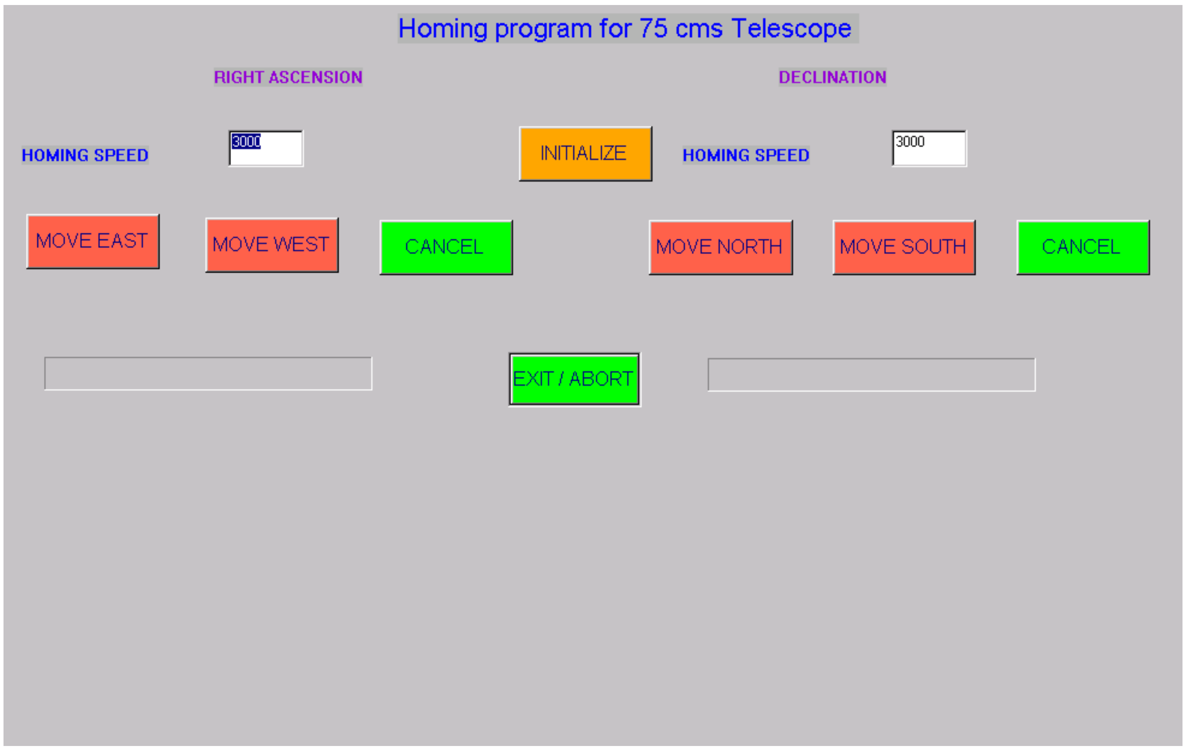

RA_SET_BUTTON_REPONSE
Mtr 1 Act Vel (Left Axis)
Mtr 1 Cmd Vel (Right Axis)
RA ACT VEL
RA CMD VEL
TIME (SEC)
561.00
481.00
401.00
321.00
241.00
161.00
81.00
1.00
-79.00
-159.00
-239.00
-319.00
-399.00
-479.00
-559.00
520.00
440.00
360.00
280.00
200.00
120.00
40.00
-40.00
-120.00
-200.00
-280.00
-360.00
-440.00
-520.00
-600.00
0.00
3.01
6.02
9.03
12.04
15.05
18.06
21.07
24.09
27.10

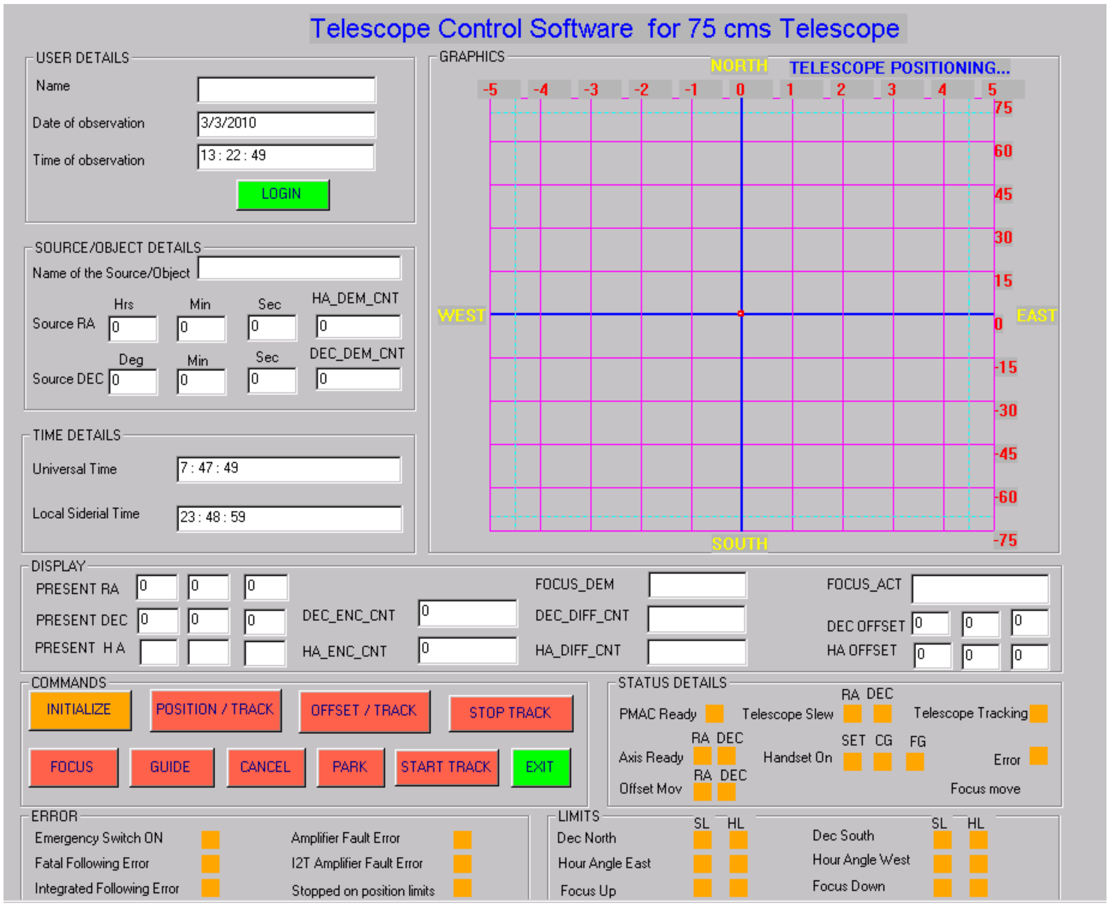

RA_GUIDE_BUTTON_RESPONSE P=60000
Mtr 1 Act Vel (Left Axis)
Mtr 1 Cmd Vel (Right Axis)
RA ACT VEL
RA CMD VEL
TIME (SEC)
-27.00
-29.00
-31.00
-33.00
-35.00
-37.00
-39.00
-41.00
-43.00
-45.00
-47.00
-49.00
-51.00
-53.00
-55.00
-57.00
-28.70
-30.70
-32.70
-34.70
-36.70
-38.70
-40.70
-42.70
-44.70
-46.70
-48.70
-50.70
-52.70
-54.70
-56.70
0.00
3.10
6.20
9.30
12.40
15.50
18.60
21.69
24.79
27.89
30.99


RA FINE_GUIDE BUTTON RESPONSE PLOT 17FEB10
Mtr 1 Act Vel (Left Axis)
Mtr 1 Cmd Vel (Right Axis)
RA ACT VEL
RA COM VEL
TIME (SEC)
-38.90
-39.30
-39.70
-40.10
-40.50
-40.90
-41.30
-41.70
-42.10
-42.50
-42.90
-43.30
-43.70
-44.10
-44.50
-39.70
-40.00
-40.30
-40.60
-40.90
-41.20
-41.50
-41.80
-42.10
-42.40
-42.70
-43.00
-43.30
-43.60
-43.90
0.00
5.31
10.63
15.94
21.25
26.56
31.88
37.19
42.50
47.82
53.13

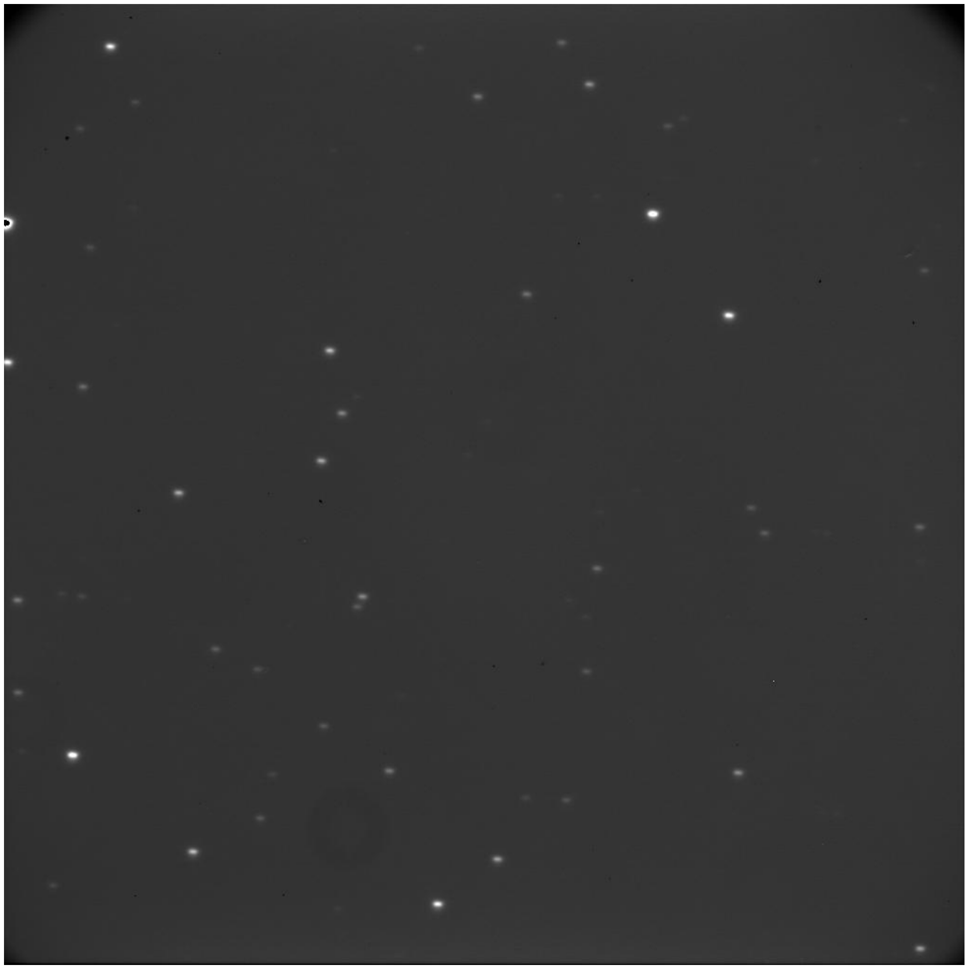

TRACK PLOT
MOTOR 1 ACT VEL
TIME (SEC)
-37.90
-38.40
-38.90
-39.40
-39.90
-40.40
-40.90
-41.40
-41.90
-42.40
-42.90
-43.40
-43.90
-44.40
-44.90
-45.40
0.00
121.22
242.45
363.67
484.89
606.11
727.34
848.56
969.78
1091.01

APPENDIX II


Homing program for 75 cms Telescope
RIGHT ASCENSION
DECLINATION
HOMING SPEED
3000
INITIALIZE
HOMING SPEED
3000
MOVE EAST
MOVE WEST
CANCEL
MOVE NORTH
MOVE SOUTH
CANCEL
EXIT / ABORT


Telescope Control Software for 75 cms Telescope
USER DETAILS
Name
Date of observation
3/3/2010
Time of observation
13 : 22 : 49
LOGIN
SOURCE/OBJECT DETAILS
Name of the Source/Object
Hrs
Min
Sec
HA_DEM_CNT
Source RA
Deg
Min
Sec
DEC_DEM_CNT
Source DEC
TIME DETAILS
Universal Time
7 : 47 : 49
Local Siderial Time
23 : 48 : 59
GRAPHICS
NORTH
TELESCOPE POSITIONING...
WEST
EAST
SOUTH
-5 -4 -3 -2 -1 0 1 2 3 4 5
75 60 45 30 15 0 -15 -30 -45 -60 -75
DISPLAY
PRESENT RA
PRESENT DEC
PRESENT H A
DEC_ENC_CNT
HA_ENC_CNT
FOCUS_DEM
DEC_DIFF_CNT
HA_DIFF_CNT
FOCUS_ACT
DEC OFFSET
HA OFFSET
COMMANDS
INITIALIZE
POSITION / TRACK
OFFSET / TRACK
STOP TRACK
FOCUS
GUIDE
CANCEL
PARK
START TRACK
EXIT
STATUS DETAILS
PMAC Ready
Telescope Slew
RA DEC
Telescope Tracking
Axis Ready
Handset On
SET CG FG
Error
Offset Mov
Focus move
ERROR
Emergency Switch ON
Fatal Following Error
Integrated Following Error
Amplifier Fault Error
I2T Amplifier Fault Error
Stopped on position limits
LIMITS
SL HL
Dec North
Hour Angle East
Focus Up
Dec South
Hour Angle West
Focus Down

APPENDIX III



A 3 min unguided image of M67 taken from 30 inch on 18-2-10

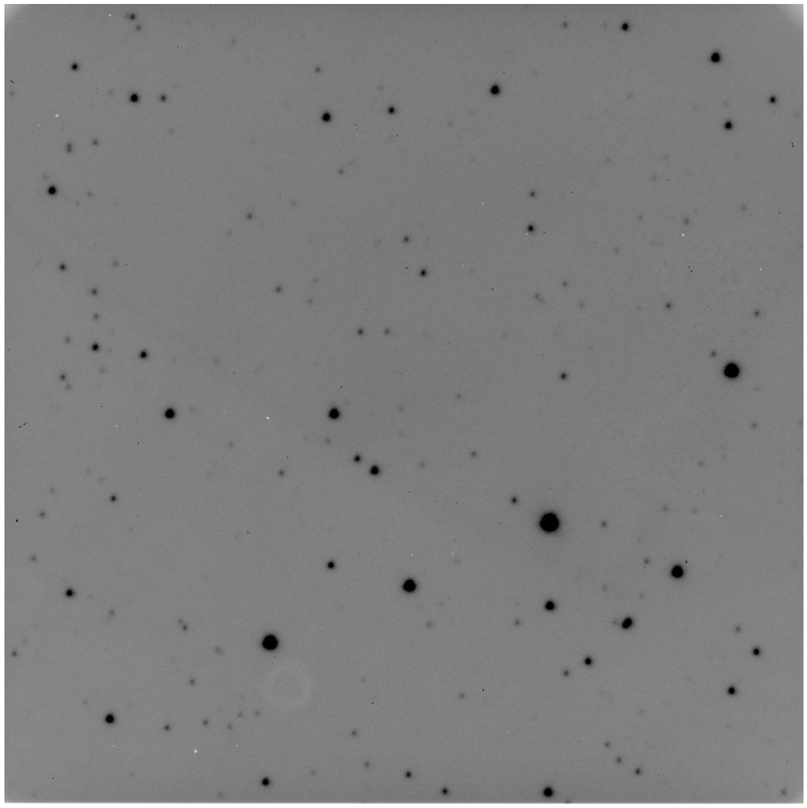
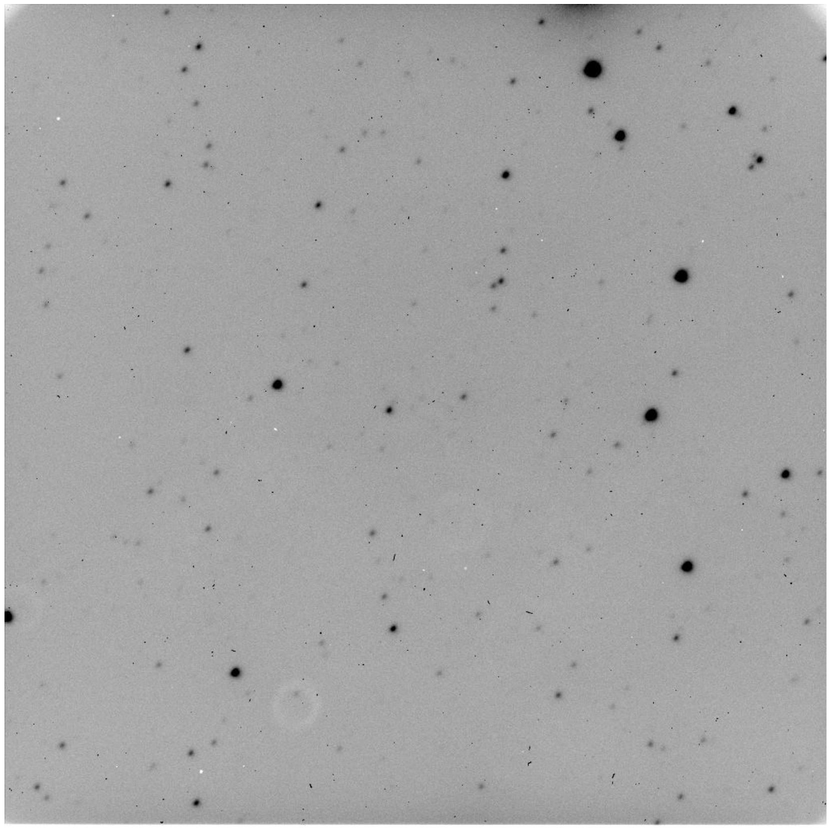
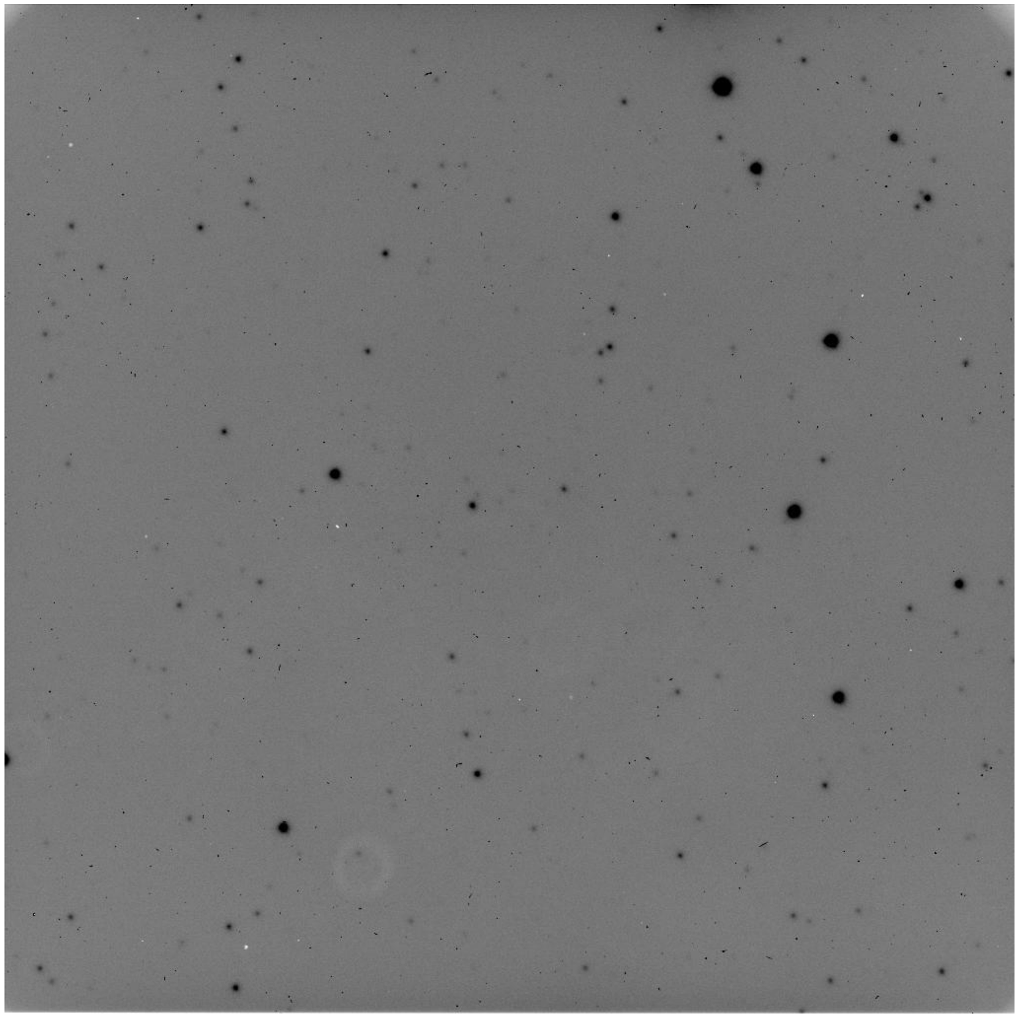


Image taken from 30"Telescope on 3rd March 2010
at cassegrain focus with 1kx1k photometrics CCD Auto Guider

RA : 08 52 00 DEC : 09 33 22 UT : 14 05 00 5 min R filter 3mar10

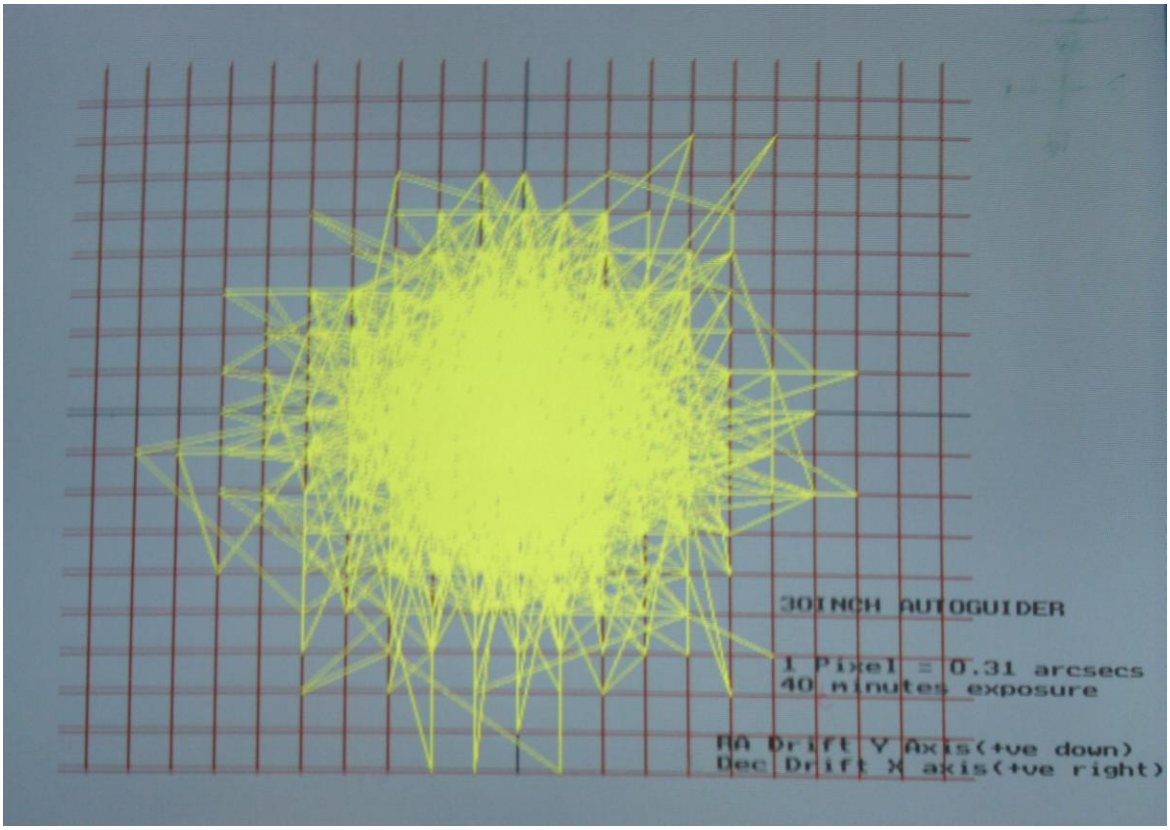


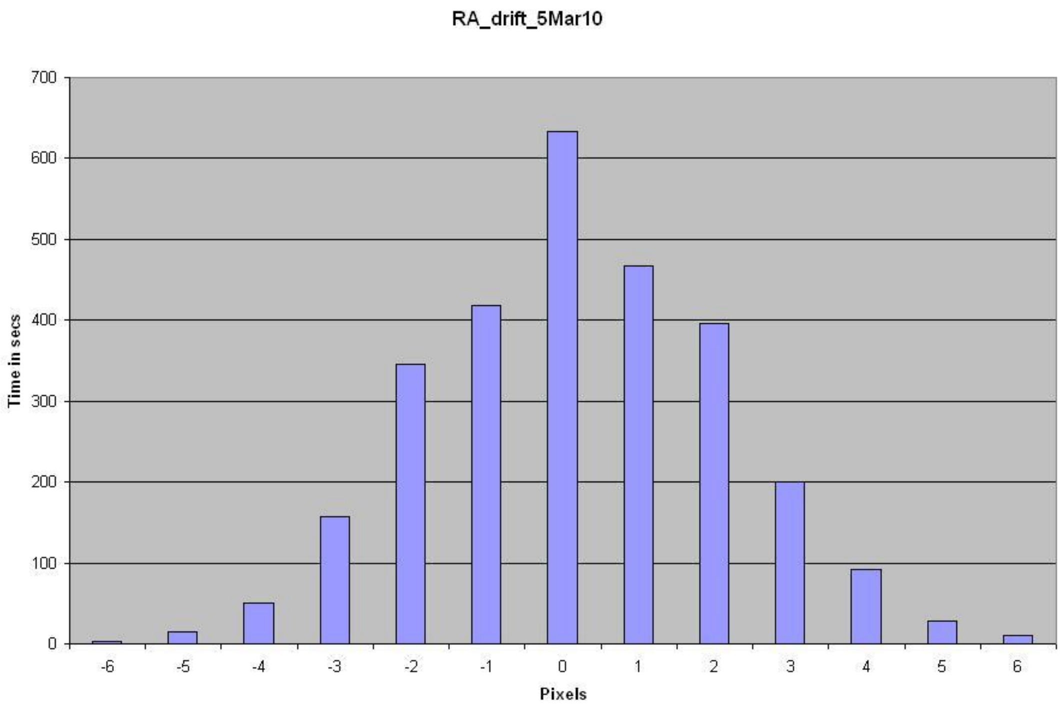
NGC 2169 R filter 20min HAe 02 41 Dec 12 22 5mar10
Image taken from 30" Telescope at cassegrain focus with
1kx1k Photometrics CCD using Auto Guider

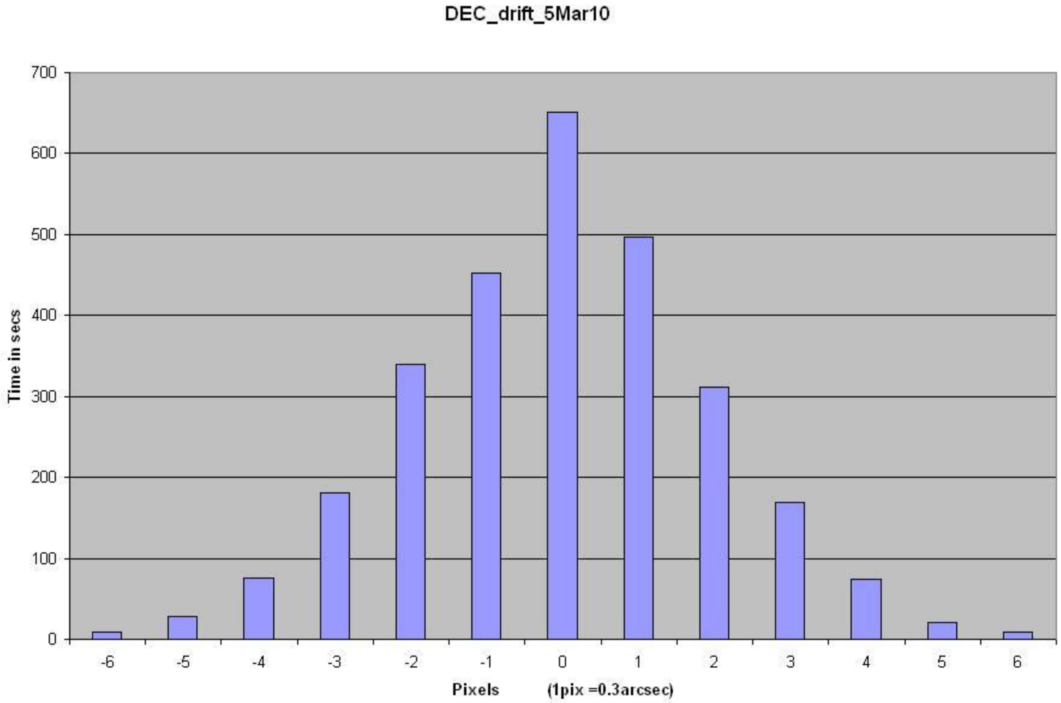


NGC 2169 R filter 2400S Hae 03 10 Dec 12 22 5mar10

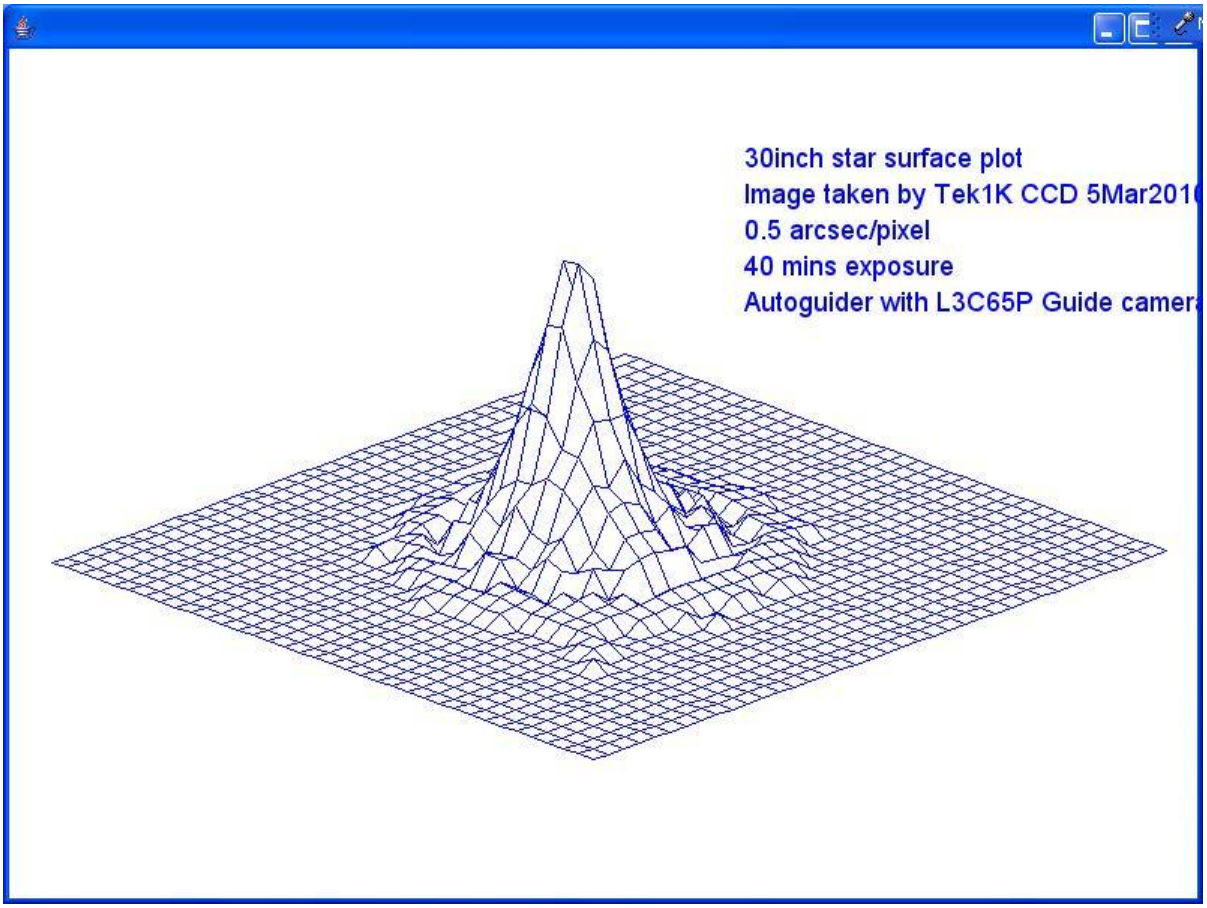
Image taken from 30"telecope cassegrain with 1kx1k Photometrics CCD using Auto Guider

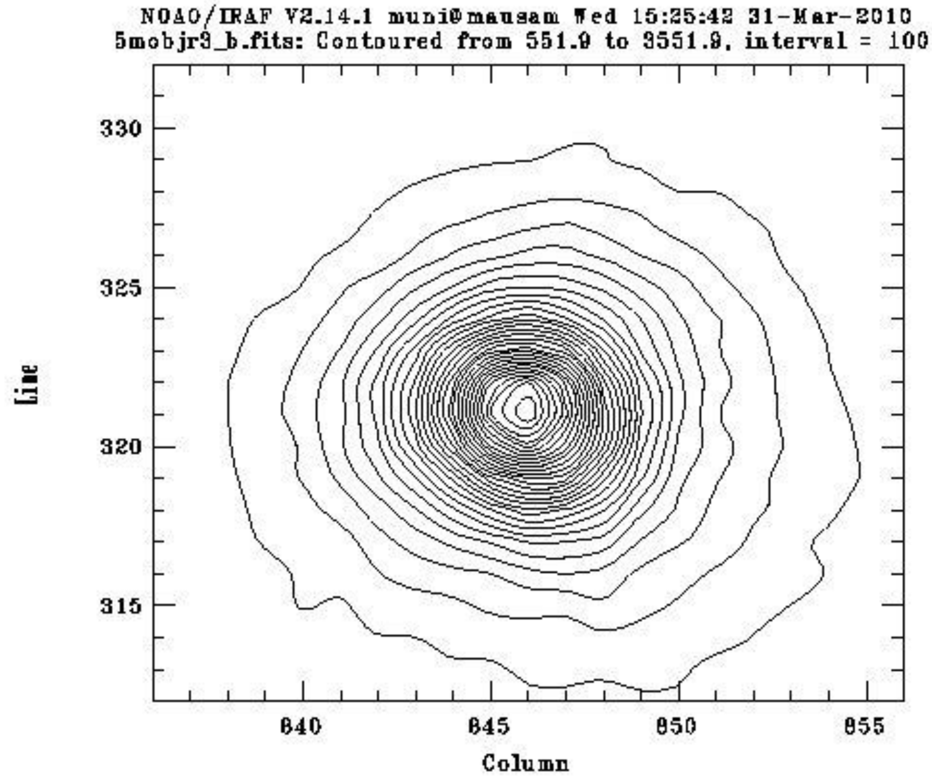

30INCH AUTOGUIDER
1 Pixel = 0.31 arcsecs
40 minutes exposure
RA Drift Y Axis(+ve down)
Dec Drift X axis(+ve right)

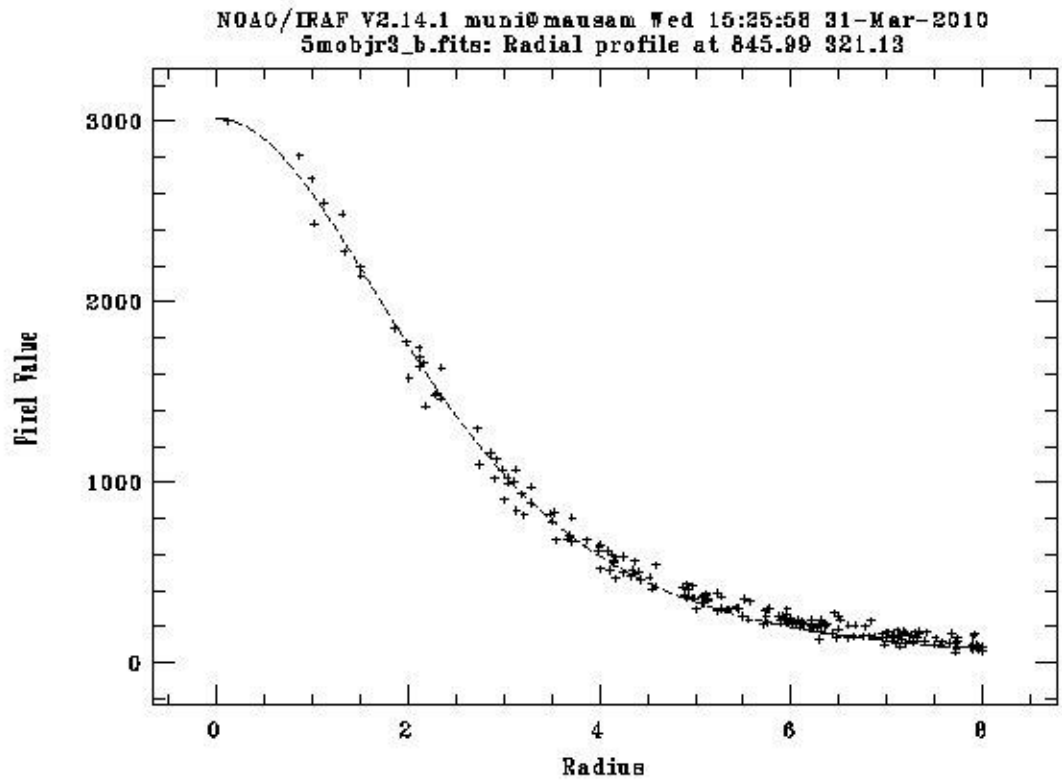

RA_drift_5Mar10
Time in secs
700
600
500
400
300
200
100
0
-6
-5
-4
-3
-2
-1
0
1
2
3
4
5
6
Pixels



DEC_drift_5Mar10
Time in secs
700
600
500
400
300
200
100
0
-6
-5
-4
-3
-2
-1
0
1
2
3
4
5
6
Pixels
(1pix =0.3arcsec)


30inch star surface plot
Image taken by Tek1K CCD 5Mar201
0.5 arcsec/pixel
40 mins exposure
Autoguider with L3C65P Guide camer


NOAO/IRAF V2.14.1 muni@mausam Wed 15:25:42 31-Mar-2010
5mobjr3_b.fits: Contoured from 551.9 to 3551.9, interval = 100.
330
325
320
315
Line
640
645
650
655
Column


NOAO/IRAF V2.14.1 muni@mausam Wed 15:25:58 31-Mar-2010
5mobjr3_b.fits: Radial profile at 845.99 321.13
Pixel Value
3000
2000
1000
0
0
2
4
6
8
Radius