THE ISAAC NEWTON GROUP OF TELESCOPES

JACOBUS KAPTEYN TELESCOPE

R.A. & DECLINATION SERVO SYSTEM

REV 1.0

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J.K.T. R.A. & DEC. SERVO SYSTEMS

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These items can be found in the original document folder in the JKT control room

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WP/S2/15

1. SERVO SYSTEM DESCRIPTION

The system for both R.A and Dec. axes are similar and a schematic diagram is shown in Fig. 1. Each consists of an inner (hardware) velocity loop and an outer (software) position loop.

D.C. torque motors drive the telescope through 540:1 worm and worm-wheel gears. A DC tachometer is integral within each motor frame and an incremental encoder is mounted on the same shaft as the motor and worm-wheel. Flywheels are mounted on each drive shaft to make the system 'motor-heavy' to reduce the possibility of worm-wheel lock-up.

Printed circuit motors with integral 13.058:1 ratio gear boxes apply an anti-backlash torque via spur gearing having a 13:1 ratio.

Both drive and anti-backlash motors are powered by identical proprietary DC servo amplifiers; the drive amplifiers being connected in voltage amplifier mode and the anti-backlash amplifiers in current amplifier mode.

An error signal derived from the difference between a velocity demand voltage and the tachometer voltage is input to the drive servo amplifiers whilst a preset voltage is applied to the anti-backlash amplifiers to generate a constant torque. The latter are switched off when the tachometer voltage exceeds a pre-determined value to reduce wear on the gearing.

The bi-phase outputs from the incremental encoders are taken to CAMAC RGO 32 bit up-down counters which can be set to zero by datum pulses at the zenith, thus producing an absolute value of telescope position. This is used in the software position loop to compute velocity demands via a CAMAC DAC module (9085) to provide the input to the hardware velocity loop. The datum pulses are generated by opto-sensors which are ANDed with the 1 pulse / rev and bi-phase pulse trains from the encoders to give a final pulse with a repeatable accuracy of 0.05 arc seconds.

Provision is also made for manual control of the telescope, primarily for engineering purposes, via push-buttons and rate control potentiometers on the Control Desk Engineering Panel.

2. PRE-AMPLIFIER UNIT

2. 1 General Description

The pre-amplifier crate is a standard 3U Eurocard card frame containing the following:

- +/- 15V Power Supply Unit
- R.A. Drive Pre-amplifier card
- DEC. Drive Pre-amplifier card
- R.A. Torque Control card
- DEC. Torque Control card
- Manual Control Card

The analogue rate demands from a computer controlled CAMAC Multi-DAC module are connected to isolated Lemo sockets via co-axial cables.

The Manual Control card is connected to the rate potentiometers and control push-buttons on the Control Desk Engineering Control Panel via a multi-core cable. The voltage source for the rate potentiometers is derived from this card.

Output connections to the Main Drive, Torque Power Amplifiers and tacho and current feedback signals are connected via twisted pair cables to Lemo 2-pin sockets

Low drift operational amplifiers are used and all input signals are connected to differential amplifiers to eliminate the effects of varying common mode voltages. Internally, all analogue signals are connected via twisted pair wires to the card edge connectors.

2.2 Main Drive Pre-amplifier Cards

The following notes should be read in conjunction with drawing E-129.

The R.A. and DEC. Pre-amplifiers are identical except for a slight difference in the equalising networks, R18 and C4.

2.2.1 Computer Mode

Relays RLA and RLB will be energised via the Computer Manual Changeover relay contact RL10/2 on Alarm Board 2 in Card Frame 3 and the R.A. and Dec. 'Select Manual' push-buttons on the Control Desk System Control panel.

The output op-amp IC2 is used as a summing amplifier with the CAMAC DAC derived velocity demand connected to the -ve input and the drive motor tachometer feedback to the +ve input. The modified integrator connection (Cl, R32, R6) of this IC gives a high loop gain at DC and low frequencies.

The 'Fast' and 'Slow' DAC inputs are buffered by differential amplifiers IC1 and IC3 which each have a gain of 0.8. The 'Slow' input is attenuated by a factor of 11.1 relative to the 'Fast' input by R11 and R12 and the two signals are added in network R5 and R13. This arrangement allows a slewing velocity demand from the 'Fast' DAC to be ramped down until a preset position error is reached at which point the software transfers the velocity demand to the 'Slow' DAC.

The Tacho input, via the unit gain buffer IC4, is 10.03V at the maximum permissible velocity of 120^{o}/sec corresponding, after attenuation by R19, R20 and R25, to 1.75V at IC2 +ve input. The maximum permissible demand voltage for the sum of the 'Fast' output and 0.1 of the 'Slow' DAC output is 4.23V.

Derivative feedback from the tacho is obtained by network R18, C4, R19 and R20. This equalising network provides loop stability and also assists the drive motor fly-wheel in preventing lock-up of the worm/wormwheel gearing which may occur under certain conditions of telescope out-of-balance or rapid deceleration.

The current required to start the motors from zero velocity may be high compared to the current required to maintain constant motion. When zero velocity is demanded and the telescope is stationary and hence the tacho feedback is zero, drift in the output of IC2 may cause the motor current to rise to a level where it produces a sudden 'kick' to the drive motor. A small amount of current feedback via IC5 limits such drifts to levels which prevent this occurrence.

The output of IC1 is also taken to the Manual Control Card and the output from IC4 to the Torque Drive card (see Sections 2.4 and 2.3 respectively).

2.2.2 Manual Mode

When manual control is selected either by the Engineering/Computer switch on the Telescope Power panel or the R.A. or DEC. Select Manual push buttons on the System Control panel of the Control Desk, relays RLA and RLB are de-energised and the circuit configuration is changed as detailed below.

(1) Contact A2 shorts the integrating capacitor C1 thus preventing the possibility of telescope drift.

(2) Contact Bl disconnects the DAC Slow output from buffer IC3 and grounds the DAC Slow input to the summing network at R11.

(3) Contact Al disconnects the DAC Fast output from buffer ICl and connects the summing network resistor R5 to the Manual Control card output via buffer IC6.

(4) The signal to the Torque Control card (via terminal 26a) is transferred from the Tacho buffer IC4 to a fixed DC voltage derived from potential divider R26 and R27 by contact B2.

2.3 Torque Control Cards

The R.A. and Dec. cards are identical.

The following notes should be read in conjunction with drawing E-130

2.3.1 Computer Mode

The buffered tacho output from the Drive Pre-Amplifier cards are fed to voltage comparator IC2 via amplifier IC1a when positive and to comparator IC3 via IC1a and inverter IC1b when negative. Clamp diodes D1 and D2 prevent negative potentials from being applied to the comparator inputs. The outputs of the two comparators are wire ORed and connected to either the positive or negative input of amplifiers IC4 via link LK1 or LK2. This link enables the direction of current in the anti-backlash motors to be changed to give the required direction of torque. Capacitors C1 and C2 reduce the bandwidth of IC1a to about 7Hz preventing the comparators from switching by transient changes in tacho voltage.

At input voltages below 0.22V (which corresponds to a telescope rate of approximately 160 arc seconds/sec.) IC2 and IC3 are in the off state and a DC voltage of 3.6 volts is applied to the input of IC4. The output of IC4 is taken via R18 and the 'Set Current' potentiometer RV1 to IC5, the output of which goes to the Inland Motor torque drive power amplifiers which are wired in current amplifier mode and have a nominal sensitivity of 5A/V. RV1 will give a range of anti-backlash motor current of 0 to 5.6A.

When the input rises above 0.22 volts, IC2 or IC3 is switched on taking the input to IC5 low thus removing the current demand output and hence the anti-backlash torque. Since the low output of IC2 and IC3 is slightly above zero, 'Set Zero' potentiometer RV2 is connected to the positive input of IC5 and this may also be used to remove any zero offset current from the drive amplifiers.

2.3.2 Manual Mode

No anti-backlash torque is required when driving the telescope manually.

The tacho input to IC1a is replaced by a constant DC voltage from the drive cards of approximately 0.6V which holds comparator IC2 on removing the current demand.

2.4 Manual Control Card

The following notes should be read in conjunction with drawing E-129.

2.4.1 Manual Mode

Relays RLD, RLE, RLF and RLG are operated by the R.A. and Dec. + and - push buttons on the Control Desk Engineering Panel and when actuated, provide a 3.6V DC supply of appropriate polarity to the Rate Control potentiometers on the Engineering Panel. The potentiometer wipers are connected through contacts H1 and A1 to two ramp generators IC1, IC2 and IC3, IC4.

If a positive or negative step input greater than 0.025V is applied to the ramp generator input, the first op-amp will saturate and the output of the second op-amp, which is connected as an integrator will ramp up or down until it approaches 0.025V relative to the input voltage. At this point the first stage will come out of saturation and the feed-back loop will pull the output to the level of the input. The ramp generator will now act as a voltage follower provided step changes in input do not exceed 0.025V or the rate of change of input is not greater than 2.5V/sec.

2.4.2 Computer Mode

In computer mode, relays RLH and RLA are energised connecting the outputs of the Drive Pre-amplifier Fast DAC buffer stages to the ramp generator inputs. Consequently, the outputs of the ramp generators will be at this potential and if the system is switched to Manual or Engineering mode with a DAC velocity demand present this will ramp down to zero avoiding excessive deceleration of the telescope.

2.4.3 R.A. Limits

Relays RLB and RLC are energised by the R.A. + and - limits and contact B1 or C1 disables the + or - R.A. push buttons (the Alarm and Interlock circuit will have switched the system into Engineering Mode) so that the telescope can only be driven in the correct direction out of limits.

Note : It is not possible to use a similar system for Dec. since the direction of drive to come out of the horizon limit depends upon whether the tube is East or West of the pier.

3. SETTING UP PROCEDURES

3.1 Test Equipment

Datron D.V.M.; **AVO** D.M.M.; Eurocard extender; Trimpot adjuster; assorted test leads.

3.2 Warming Up Period

Allow a 30 min. period with the Pre-amplifier, CAMAC and the Datron D.V.M. switched on before carrying out any adjustments. Always zero the Datron on the range to be used before taking measurements.

3.3 CAMAC Multidac (9085)

This should be periodically calibrated in accordance with the manufacturer's handbook, but the following checks should be made, using the Datron D.V.M. before proceeding with the setting up of the Pre-amplifier cards.

(a) In the initialised state (all channels OFF) check that outputs of channels 0 to 3 are zero.

(b) Overwrite channels 0 to 3 with 2048 (Bit 12 set) and set bi-polar offset potentiometer to give zero reading on any channel.

3.4 Torque Control Card

1. Connect AVO D.M.M. on 200mV range across the torque drive power amplifier current shunt (terminals 13 and 14 on tray). This shunt is calibrated at 51mV/A.

2. Switch Telescope Power ON. Switch Amplifier Power circuit breaker ON and select Engineering mode.

3. Adjust RV2 on Torque Control Card for zero output current at the power amplifier.

4. Select Computer mode.

5. Adjust RVI on Torque Control Card to give:

   3.5A (178mV) for R.A. torque.
   3.24A (166mV) for Dec. torque.

6. Select Engineering mode.

7. Check torque current falls to zero. <u>If not repeat steps 3 to 7.</u>

3.5 Drive Pre-amplifier Card

1. Switch Telescope Power OFF, Amplifier Power C.B. ON and Engineering mode selected.

2. Put Drive Pre-amplifier Card on extender board.

3. Check CAMAC Multi-DAC is connected and overwrite channels 0 to 3 with 2048.

4. Set Datron DVM to DC; Filter On; Range 100V and zeroed.

5. Connect DVM ‘Lo’ input to TP9 for ALL measurements.

6. Turn RV6 to zero (fully anti-clockwise).

7. With DVM ‘Hi’ input to TP1, adjust RV1 for zero ± 0.lmV.

8. With DVM on TP3, adjust RV4 for zero ± 0.1mV.

9. With DVM on TP4, adjust RV5 for zero ± 0.lmV.

10. With DVM on TP6, adjust RV7 for zero ± 0.lmV.

11. With DVM on TP5, adjust RV2 for zero ± 0.2mV.

12. Switch Telescope Power ON.

13. With DVM on TP4, re-adjust RV5 for zero ± 0.lmV.

14. Switch Amplifier Power C.B. OFF and select Computer mode.

15. With DVM on TP5, adjust RV2 to give a drift rate of less than 0.lmV/sec at an output voltage approximating to zero. Note, output can be reset to zero at any time by temporarily switching to Engineering mode.

16. Switch Telescope Power OFF.

17. Switch Power Amplifier C.B. ON. (Both Drive and Torque amplifiers should be ON).

18. Switch Telescope Power ON. Select Engineering mode.

19. With DVM on TP3, check voltage is less than lmV and that Position Encoder Module (RGO 32bit counters in CLIP centre CAMAC crate) indicates the telescope is stationary.

    Note: For convenience, the Position Encoder L.S. 16 bits can be read using the Manual Test Controller and written to the Dataway Test Module in the Control Desk CAMAC crate. If not then recheck the zeroing stages, 1 to 14.

20. Switch to Computer mode.

21. With DVM on TP3, check voltage is less than 1mV and that Position Encoder Module indicates the telescope is stationary.

22. If telescope is not stationary, slowly increase RV6 (clockwise rotation) until the telescope stops moving.

    Check the telescope returns to zero motion when given a nudge in both directions using the Engineering push-buttons with rate potentiometer set as low as possible to give discernible motion then switching back to Computer mode with push-button still depressed.

    Note: If previous stages are correctly carried out not more than 1 or 2 turns of RV6 should be required.

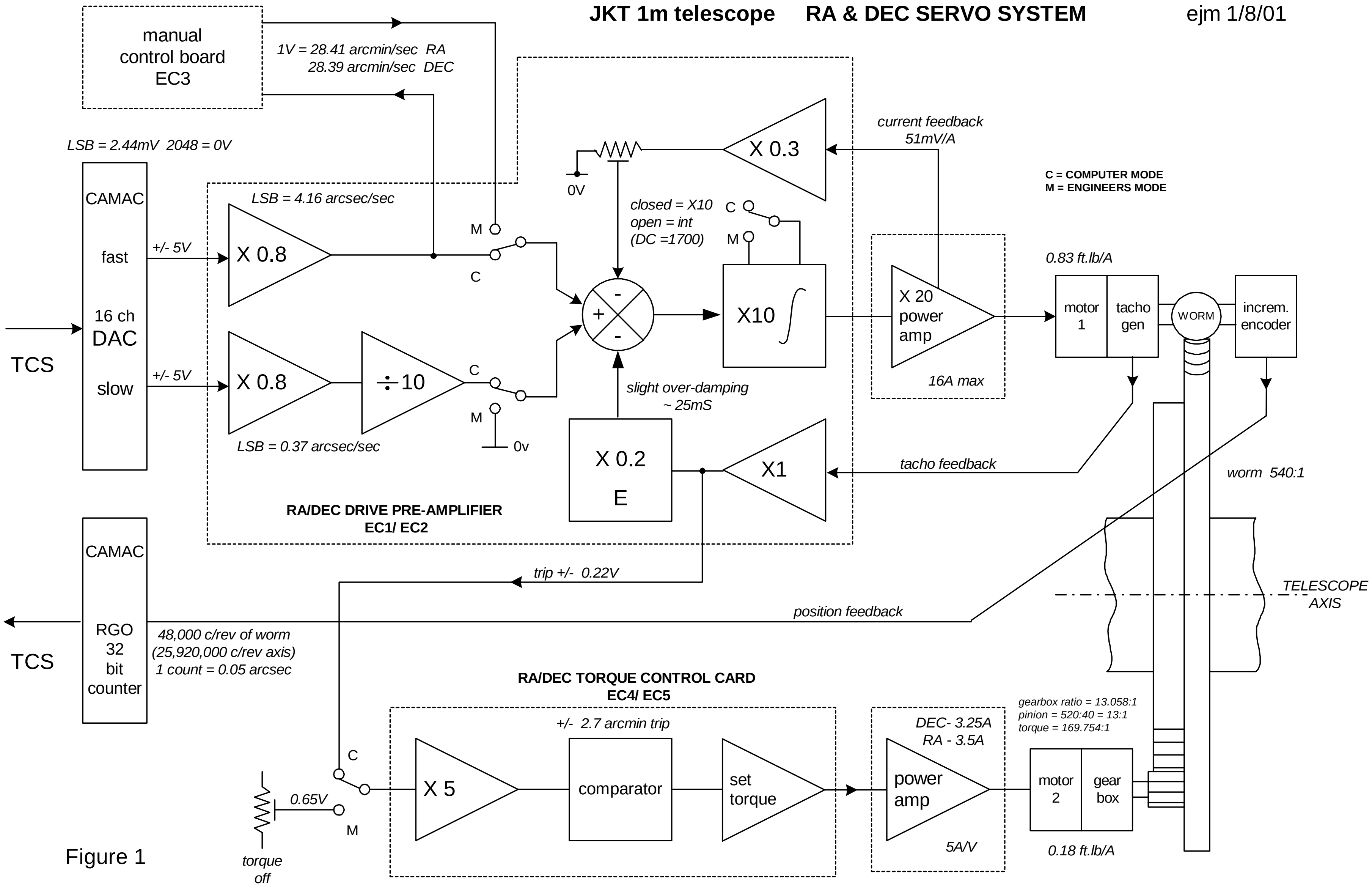
JKT 1m telescope RA & DEC SERVO SYSTEM
ejm 1/8/01
manual
control board
EC3
1V = 28.41 arcmin/sec RA
28.39 arcmin/sec DEC
LSB = 2.44mV 2048 = 0V
CAMAC
fast
16 ch
DAC
slow
TCS
+/- 5V
+/- 5V
LSB = 4.16 arcsec/sec
X 0.8
X 0.8
÷10
LSB = 0.37 arcsec/sec
M
C
C
M
0v
0V
X 0.3
current feedback
51mV/A
closed = X10
open = int
(DC =1700)
C
M
X10
X 20
power
amp
16A max
C = COMPUTER MODE
M = ENGINEERS MODE
0.83 ft.lb/A
motor
1
tacho
gen
WORM
increm.
encoder
slight over-damping
~ 25mS
X 0.2
E
X1
tacho feedback
worm 540:1
RA/DEC DRIVE PRE-AMPLIFIER
EC1/ EC2
CAMAC
RGO
32
bit
counter
TCS
trip +/- 0.22V
position feedback
TELESCOPE
AXIS
48,000 c/rev of worm
(25,920,000 c/rev axis)
1 count = 0.05 arcsec
RA/DEC TORQUE CONTROL CARD
EC4/ EC5
+/- 2.7 arcmin trip
X 5
comparator
set
torque
DEC- 3.25A
RA - 3.5A
power
amp
5A/V
gearbox ratio = 13.058:1
pinion = 520:40 = 13:1
torque = 169.754:1
motor
2
gear
box
0.18 ft.lb/A
C
M
0.65V
torque
off

Figure 1