



MULTIPLE MIRROR TELESCOPE OBSERVATORY

Smithsonian Astrophysical Observatory and Steward Observatory, University of Arizona

MMTO Tech memo 84-7

From: C. Janes, J. Montgomery

Subject: Correcting Periodic Error in Telescope Absolute Encoders

A. Summary:

The Inductosyn/NPL absolute encoder system used to encode the telescope azimuth and elevation positions exhibit periodic errors of several arc seconds in amplitude. These errors are corrected in the mount computer by adding sine wave components to the encoder input; the coefficients for this operation determine the amplitude and phase of the components. The coefficients are determined empirically and updated periodically by measuring the movement of a star on the Grinnell processor TV video. This memorandum describes the procedure for updating the encoder coefficients.

B. Description of the encoder system:

The encoder consists of two transducers, a "fine" encoder which repeats every $1/512$ of a circle, assuming the telescope could move a full 360° in either axis, and a "coarse" encoder which counts revolutions of the fine encoder. The amplitude and phase of the two sine wave outputs of the fine transducer are compared in the NPL electronics to provide the absolute positional information. Imperfections in the fine transducer cause the measured position to vary slightly from the true position in a periodic and nearly sinusoidal way as the transducer turns. The predominant errors have periods of $1/512$ circle, $1/1024$ circle, and $1/2048$ circle, especially $1/1024$.

The coefficients used by the mount computer software define amplitude and phase corrections to subtract out the periodic encoder errors in the fine transducer information. There are six coefficients for each axis, defined by the period of the component that the coefficient corrects:

amplitude	phase
a512	p512
a1024	p1024
a2048	p2048

The command "ppec" used on the mount computer will print out the current parameters.

C. Setup:

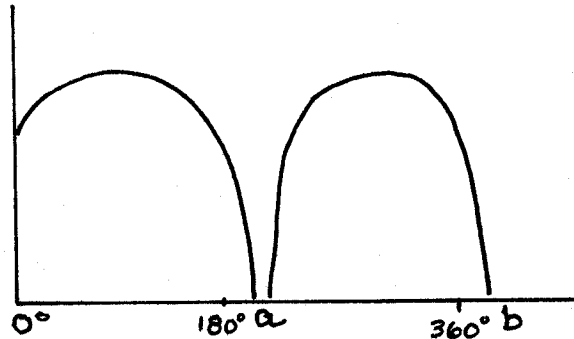
Install the top box with a mirror at the telescope focal plane, the AO lens, and an acquisition TV camera with the output connected to the TCS Grinnell. Enter the commands "sg", "0.0 pa-offset", and "vidicon-ao" on the TCS computer terminal to setup for a non-rotating top box with the AO lens and vidicon acquisition TV camera.

c. Enter Ael and Aaz as new "a" parameters for the frequency component measured.

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e1 Ael a1024 !
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2. To update a phase or "p" coefficient:

a. Try 1° , 2° , 3° , and 4° above and below the existing "p" parameter to shift the phase. Measure the error and select the value of "p" that minimizes the periodic error amplitude. The error takes the form shown below so that the error "null" is quite narrow:



a or b are ideal "p" parameters

b. Enter the "p" coefficient:

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e1      nnn.0000 d p1024 2!
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————— Forth double precision store
 ————— or p512 or p2048
 ————— converts angle given to 4 decimal places to 26 bit fractional part of circle
 ————— phase parameter in degrees
 ————— or az depending on axis

F. Permanent correction:

The new parameters must be edited on all the current mount computer system disks. Also enter the new parameters in the day log, for security and easy reference.

G. Quick fix:

Normally, the top box must be rotated to align the azimuth and elevation motions of the telescope with y and x on the Grinnell. This causes y measurements on the Grinnell to reflect periodic error in elevation only and x azimuth error only. But sometimes it may not be possible to rotate the top box. The measurements may still be made, but components of error in both telescope axes will appear in a single measurement. This section describes a procedure to sort out the components to make a quick fix on periodic error when the top box cannot be rotated.

1. To correct a periodic error in elevation, select a star in the east (or west) so that the azimuth velocity is near 0 and the elevation velocity is pronounced (15 arc seconds/sec or more). Set el a1024 = 0, perform the error measurement described in section D and plot. Any periodic error will be a function of elevation. Check by comparing the measured period with the calculated period.

$2531/\text{velocity} = \text{period for 1 cycle of fine transducer}$

Measure the 1/2 amplitude as described in section D and translate to the elevation axis by dividing by the cosine of the angle between the current top box position and 129°. Use this parameter to correct the coefficients as described in section E.

$$ep = A / \cos (tba - 129)$$

The diagram shows the equation $ep = A / \cos (tba - 129)$. A horizontal line extends from the letter 'A' to the right, with the label "1/2 amplitude of error" below it. A vertical line extends from the letters 'tba' down to the horizontal line, with the label "top box angle" to its right.

2. To find the periodic error in azimuth, find a star in the south with a minimum elevation motion component, and perform the same measurements for the azimuth periodic component, az a1024. Translate to the azimuth axis by dividing by the sine of the angle between the top box angle and 129°.

$$ep = A / \sin (tba - 129)$$

Use this measurement to correct periodic error as described in section E.

3. Other "a" components and all "p" components are typically too small and/or too difficult to measure to use this procedure. Enter what you have done in the log.