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Drive control system for the TACTIC γ-ray telescope

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Abstract. We present here some salient features of the hardware and software aspects of the 2-axes drive system developed for the TACTIC γ-ray telescope array. A test-report of its performance is also presented

1. Introduction

The large-reflector size (~ 4m aperture) and heavy load (~ 6.5 tons) are the principal considerations which have governed the choice of an altitude-azimuth mounting for the TACTIC γ-ray telescope (Bhat, 1997) as against the comparatively simpler-to-operate equatorial mounting. For source tracking in the former case, the rotational speed of both, the altitude and the azimuth axes, have to be continuously altered as per a set of equations (Roy & Clarke, 1988). Moreover, close to the local zenith, the azimuthal speed is required to be sharply increased. The physical constraint in attaining such a high speed gives rise to a 'blind spot' within which the celestial source cannot be tracked. The TACTIC drive system has been designed with a comparatively small blind-spot size of ~ 1° and it can successfully track a significant majority of γ-ray candidate-sources at their upper transit.

2. System hardware

The dual-axes drive system of the TACTIC telescope (Koul et al., 1997) has been designed as a close-loop control system (Fig. 1). The two axes are driven through reduction gear-trains by 1N-m hybrid stepper motors which are operated in a full-step mode under a Personal Computer (PC) control. The motors are driven by constant current, chopper, drive circuits and their speed and direction of rotation are controlled by the PC through a Sequence Generator Module (SGM). Resolver-based, 16-bit absolute shaft encoders, mounted on either telescope axis, monitor the azimuth and zenith angle of the telescope at a rate of 10 Hz. An novel software-based procedure has been successfully developed which uses a look-up table for on--line compensation for the systematic error-component of these encoders (Kaul et al., 1997). The instantaneous angle information read from these encoders is used by the drive-system software to compute the updated values of speed and direction of the drive motors. These values are then loaded unto the CAMAC-based programmable stepper-motor controllers (SMC)

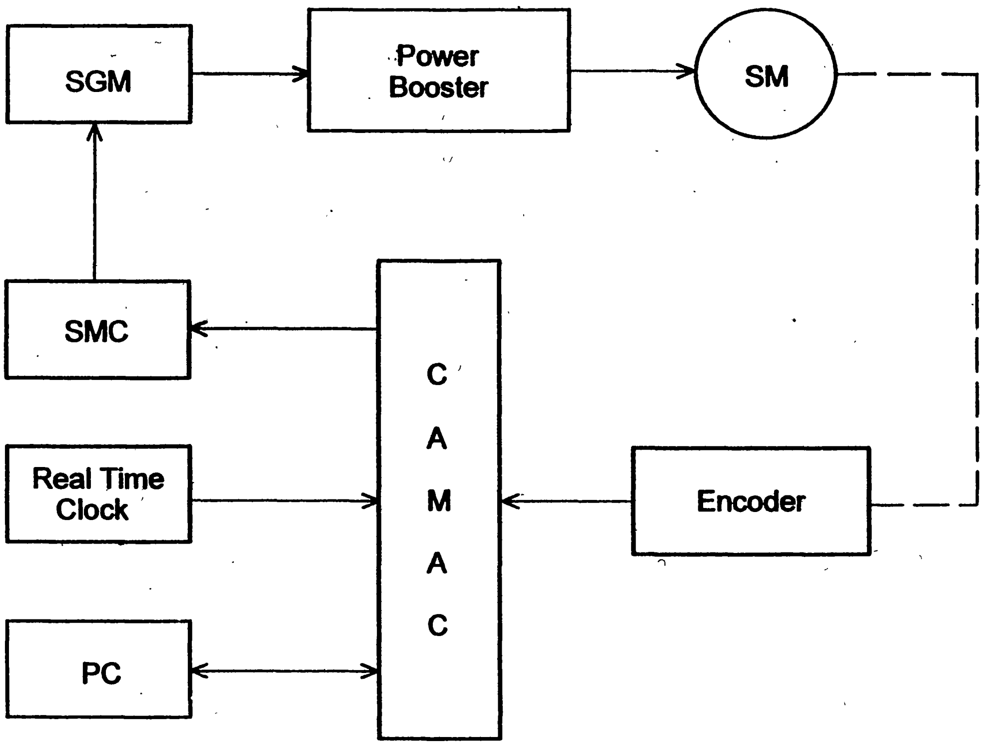

Figure 1. Schematic representation of the drive-control system for the alt-azimuth-mounted TACTIC γ-ray telescope elements.

SGM : Sequence Generator Module, SMC : Stepper-Motor Controller, PC : Personal Computer

which generate the required stepping frequency and direction information to be used subsequently by the SGM. Having a basic oscillator of 10 MHz frequency, the 22-bit resolution SMC can generate drive speeds in the range of 0.1 arcsec/sec to 0.416 deg/sec.

3. Drive system software

The control software for the drive-system, comprising 2000 lines of source code and input data - files has been developed under the DOS. It has several user-friendly options to ensure a reliable operation of the telescope. Once the source to be observed has been selected, the system controls the movement of the telescope automatically for, both, the source-pointing and the source-tracking operations. The software calculates on-line the angular position of the selected source as a function of time. The source seek-time is dynamically minimized by the software within the above-referred physical bounds on the maximum possible drive speed and acceleration. A quasi-continuous mode of speed variation has been adapted for the source-tracking operation. The software compares the angular position of the telescope as read from the encoders with the computed value. Whenever, the position error goes beyond a pre-selected value, a correction cycle is applied to compensate for it and the drive speed is changed to minimise further error build-up. All the important system parameters, including the tracking error, are logged by the software. A built-in alarm annunciation routine keeps track of various anticipated error conditions of the drive.

4. Drive system performance

The drive system of the Imaging Element of the TACTIC telescope has been operating satisfactorily for more than 2 years. Pointing and tracking-accuracy of better than ± 2 arcminutes has been achieved at this stage to be compared with 18 arcminutes diameter for the central pixel of the 349-pixel imaging camera of this element. Fig. 2 gives the representative error-profiles in pointing, azimuth and zenith angles logged during an actual on-source tracking session of the Crab Nebula lasting for a duration of ~ 4.5 hours on February 26, 1998. An important, new software effort, presently, in progress, will allow for concurrent on-source and off-source tracking by the telescope.

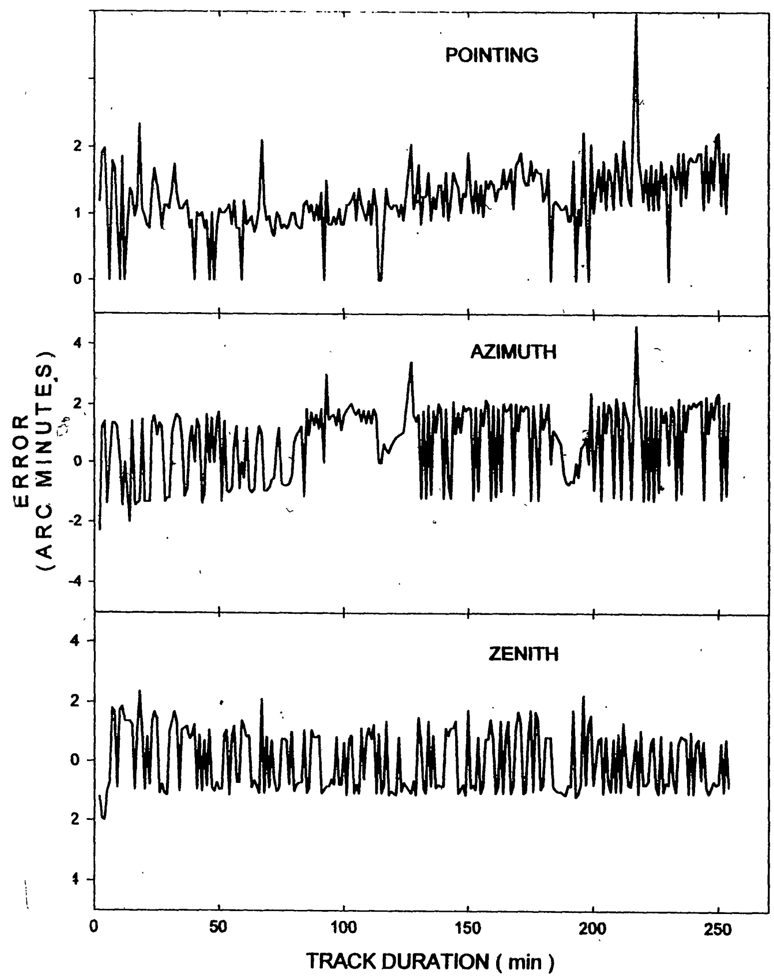

Figure 2. A representative pointing direction error-plot logged for the TACTIC imaging element while tracking the Crab Nebula for ~ 4.5 hours on 1998 February 26.

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