

THE TELESCOPE CONTROL SYSTEM

The telescope control system, better known as TCS, is the necessary complement of the telescope.

The observers forget easily about it when pointing and tracking go well. TCS is still under development at CFHT. This article is intended to make everyone more aware of what the TCS is doing.

SERVO-SYSTEM

The motions of the telescope about its α and δ axes are controlled by two similar but completely independent servo systems. Each system employs two DC torque motors driven by a power amplifier and controlled by velocity feedback from a tachometer and also, during tracking, by position feedback from an incremental encoder. For each axis, the absolute position of the telescope is obtained from dual absolute encoders, gear-driven and synchronized to give a 21-bit word. The resolutions are 1" for α and 1"3 for δ . The incremental encoders are friction-driven and have resolutions of 0"025 and 0"050 for α and δ respectively.

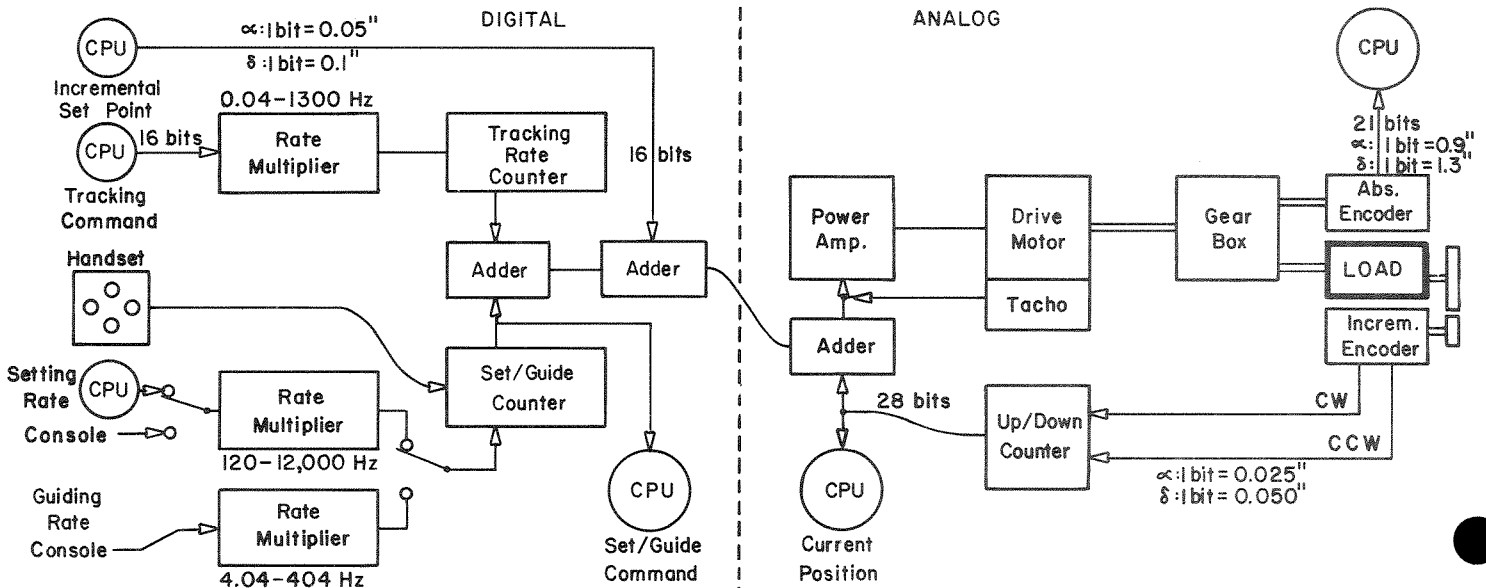
Two methods of moving the telescope are available to the TCS computer - slewing and tracking. The computer selects the mode desired by switching relays within the drive electronics.

Slewing: Slewing is obtained by making velocity demands via a digital-to-analog converter, the voltage produced being proportional to the desired speed. The system then responds by moving the telescope at a speed which produces a tachometer output equal to the command voltage. The required acceleration and deceleration are obtained by properly modulating the velocity. The computer monitors the slewing process by reading the absolute encoders every 50 ms. The incremental encoders are disabled and the position loop is open during slewing.

Tracking: Tracking is controlled by making precise rate demands by means of a hardware rate multiplier. This device sends out a regular stream of pulses, each of which represents a position offset demand of 0"025 in the case of the α axis or 0"050 in the case of the δ axis. The frequency of the rate multiplier is determined by the digital contents of the tracking rate buffer, and the resolution is 0.04 Hz. This leads to tracking rate resolutions of 0"001/sec and 0"002/sec for α and δ , respectively. The pulses from the rate multiplier are accumulated in an up/down counter (UDC) as are the pulses from the incremental encoder. The contents of these two UDC's are then subtracted in an "adder" and the difference converted to an analog voltage which is the error signal that drives the tracking motion of the telescope. This signal is amplified and applied to the torque motors.

At equilibrium, the incremental encoder pulse rate equals that from the rate multiplier and the axis is moving at the demanded rate. The computer is responsible for properly setting the tracking rate buffer. The available tracking rates range from +32"/sec to -32"/sec.

Setting and guiding: Rate buffers similar to the tracking rate buffer have been used to implement the setting and guiding motions controlled by the handpaddle. The desired rates for setting and guiding are stored in buffers connected to rate multipliers which in turn are connected to the set/guide UDC. When the handpaddle is depressed, the UDC is enabled and the counting sense is determined by a signal generated by the handset controller card; the logical value of this signal depends on which pushbutton is depressed and also this signal can be reversed by a computer



Simplified block diagram of the computer controlled servo-system of the CFH Telescope.

Only the tracking part is shown; all that is related to the slewing mode is omitted.

command. The selection of the input to the set/guide counter is controlled by the S/G button on the active handset, which selects either the setting rate multiplier or the guiding rate multiplier.

The output of the set/guide counter is added to the output tracking rate counter modifying the position set point. The depressing and releasing of the handset generates an interrupt to the computer, the amount of the correction done by the observer can be examined by the computer, reading the set/guide counter.

The ranges of set and guide correction are from 5 to 295 arc sec/sec in increments of 5 arc sec/sec and from 0.1 to 9.9 in increments of 0.1 arc sec/sec respectively.

Incremental set point buffer: The third contribution to the position set point is the incremental set point buffer. This register permits the control computer to alter the characteristics of the position loop. One of the most frequent uses of this register is to produce precise offset with respect to the base tracking rate, then nodding operations can be implemented quite easily. The ranges are limited to ± 1600 arc sec for the α axis and ± 3200 arc sec for the δ axis. The setting time is rather long, from approximately 2 sec for offsets of 30 arc sec to 5 sec for offsets of 1500 arc sec.

SOFTWARE

Computer: The control processor is an HP 21 MX/M with 128 K words of 16 bit word memory, extensive set of instructions, including floating point arithmetics, dynamic mapping system for accessing up to 2 megabytes of memory, two DMA channels, a memory protect feature permitting several program partitions, and a vectored I/O interrupt structure. Several peripherals are permanently connected to the CPU, terminals, line printer, disc, TCS remote bus and a link to the instrumentation computer.

Software control: At present the software control in use operates under a stand alone customized operating system and is divided into several independent tasks. The communication between tasks is done through a common data table located on special area in memory and accessed by

each task. The execution of each task is managed by the operating system under an appropriate priority structure. The different tasks can be divided essentially in 2 categories, synchronous and asynchronous tasks. The synchronous modules are scheduled by the operating system at regular rates and are the ones responsible for driving the telescope in the various modes (slewing, tracking, nodding, etc.) and since they have to be precisely timed, their priority assignment is high. The asynchronous modules run at various frequencies and are not time dependent, in consequence their priority is low and can be interrupted several times by the synchronous ones.

Operating system: The system does not have any facilities to allow modifications of the program, or change priority assignment on line, or for editing, compiling, loading and linking the different modules. The process to maintain the programs requires the use of another computer system with a disc resident operating system. This disadvantage makes the process of upgrading very cumbersome and time consuming, specially in the debugging stage since no debugging facilities are supported by the operating system of the TCS computer. In order to simplify and make more efficient the process of software maintenance, a disc was added to the TCS computer and all the programs were rewritten under a disc based operating system (RTE-IVB). The telescope remote Bus driver was also completely redesigned in order to render it more efficient and to speed up the transactions between the telescope interface cards and the computer. This new software control will also take into account the errors produced by mechanical flexure of the telescope, gear errors, atmospheric errors etc, giving a better pointing accuracy. Furthermore it will permit a great flexibility of the movements of the telescope with respect to the sky, planetary motion, offsetting, scanning, trailing, etc.

A great flexibility for the maintenance of the programs has been achieved with the addition of a MODEM permitting to edit, compile, load and debug most of the programs from the Waimea office. This facility also opens the possibility of future remote observing.

B. Grundseth

NEWS FOR VISITORS: United Airlines has announced that on Sept. 7, it will begin daily direct service

to Kona Airport from Chicago via Los Angeles, and from Kona to Los Angeles via Hilo.

OBSERVING TIME ON THE CFH TELESCOPE IS ALLOCATED TWICE A YEAR BY THE TIME ALLOCATION COMMITTEE.

REQUESTS FOR OBSERVING TIME FOR THE FIRST SEMESTER OF 1984 SHOULD BE SUBMITTED BEFORE SEPT. 1, 1983 TO THE AGENCIES.

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