CHAPTER 4: CONTROL SYSTEM AND ELECTRONICS

Tip/Tilt Control Loop

The basic requirement of the control system is to make tip/tilt corrections as needed by measuring the position of the stellar image relative to the slit and compensating for errors by steering the beam with the tip/tilt mirror. The controller also regulates power to the PMT during safe operation, controls the gain level of the PMT current to voltage converters, and communicates with TELCO to keep the telescope pointed correctly. The closed loop feedback loop for basic tip/tilt operation is shown in Figure 23.

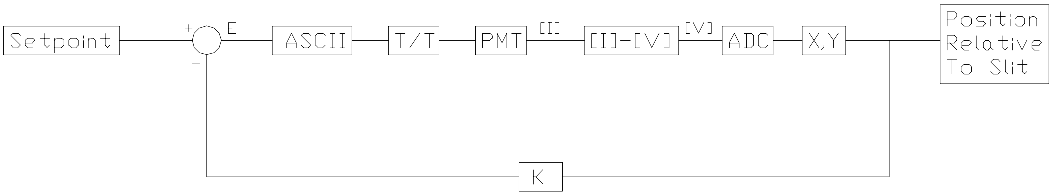

Figure 23. Tip/Tilt Feedback Loop.

This diagram is best explained beginning with the PMT block. The PMT outputs a 1x4 array of currents,I_n, one for each anode as discussed in Chapter 3. Each anode signal is converted to a voltage in preparation for the ADC (analog to digital converter). The ADC is one component of a data acquisition board attached to a PC running Visual Designer software. The PC scans 200 samples/channel at a sampling rate of 10kHz. The mean value of the 200 samples for each channel is calculated and plugged into equations similar to (24) and (25) for calculation of the position of the image in the X,Y block. These positions are multiplied by a gain coefficient in the feedback loop before being subtracted from the setpoint to define the error. The gain, K, is used to convert the position error to an angular error of the tip/tilt mirror. The driver for the tip/tilt mirror requires the correction angle in the form of an ASCII string, which is converted in the ASCII block. The tip/tilt mirror is then adjusted to steer the beam to its new focal point. Ideally this new position will be located at the center of the slit, corresponding to the center of the PMT. The PMT outputs the new signals and the process is repeated.

PMT Preamplifiers

The PMT preamplifiers, model PMT-5R from Advanced Research Instruments Corporation, perform the I-V conversions. The input and output ranges of these amplifiers are 10pA-10μA and ±10V, respectively. The I-V gain is adjustable using three remote logic lines, with a discreet range of 10^6-10^{12} V/A made in steps of one order of magnitude. The gain is controlled by the Visual Designer software via the digital output port on the data acquisition board. The program adjusts the gain such that the largest preamplifier output of the four preamplifiers is between 0.99 and 9.9 Volts. Should the signal be less than 0.99V, the program increases the gain incrementally by one step until the signal is greater then 0.99V. If the signal is greater than 9.9V, the program decreases the gain until the signal is less than 9.9V. Each preamplifier has a DC offset allowing the dark current from each anode to be subtracted from the signal. As each quadrant has a different dark current, the DC offset is necessary to even out the output signals.

Bandwidth and noise are both functions of preamplifier gain. Table I shows the relationship of gain versus bandwidth and noise.

Table I. Preamplifier Gain Vs. Bandwidth and Noise

Gain (V/A)	Bandwidth (Hz)	Noise (pA rms)
10^6	250000	500
10^7	90000	70
10^8	17000	10
10^9	2000	2
10^{10}	200	0.4
10^{11}	20	0.05

The PC is programmed to sample at a rate of 10kHz, limiting the available preamplifier gain range to 10^6-10^8. The noise is significant for each value of gain, resulting in an output noise of greater than 500mV rms. Taking the mean of 200 samples/correction and dynamically adjusting the gain to keep the output above 0.99V helps eliminate the adverse affect of this noise.

Data Acquisition Board

The data acquisition board, a PCI-20428W-1A from Intelligent Instrumentation, is configured for eight differential analog input channels, one digital output port and two analog output channels. All analog I/O channels have converters (ADC and DAC) with 12-bit resolution and throughput up to 100kHz. The jumper configurations are set such that all input and output channels have a 0-10V range, resulting in a voltage resolution of 2.44mV. Figure 24 shows the channel configurations and corresponding inputs and outputs. All I/O channels are connected through a PCI-20429T-1 termination panel.

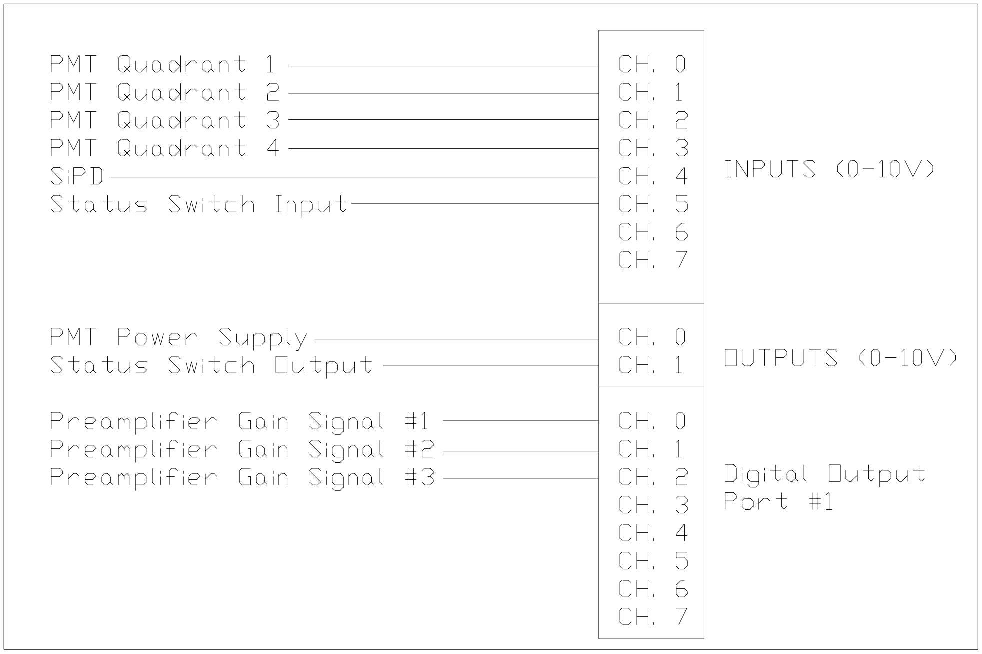

Figure 24. Data Acquisition Board Configuration. The I/O board has eight differential analog input channels, two analog output channels and one eight bit digital output port.

PC and Visual Designer Software

The PC is an IBM compatible with an Intel Pentium 166 MHz processor, 64 MB of RAM, 1.6GB hard drive and both PCI and ISA slots for the I/O boards. The only software installed is a Windows 95 operating system and the Visual Designer controls software described below. The PC is protected from power surges and blackouts, which are very common at the observatory, using a 300VA UPS.

The control software package consists of the "Visual Designer" data acquisition and control software by Intelligent Instrumentation. This is a user friendly package that allows the programmer to build a control system in the form of a block diagram, called a flowgram, that is interactive with the data acquisition boards. Preinstalled block functions can be used or specialized blocks can be created using quick basic. The software program, along with the data acquisition board, is capable of communicating and controlling all of the devices shown in Figure 25. This block diagram shows all devices connected to the tip/tilt system.

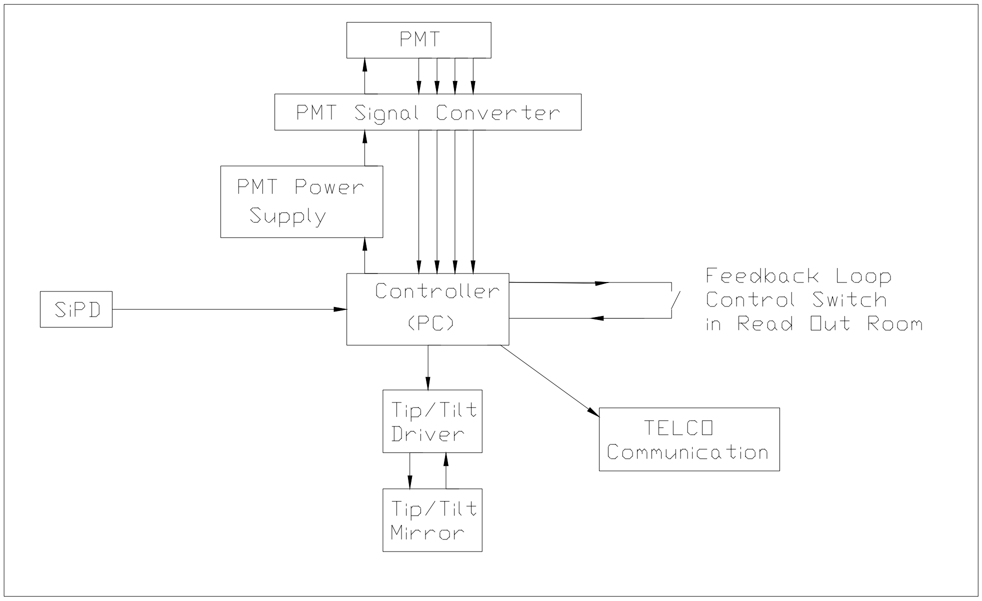

Figure 25. Controller Block Diagram.

PMT Power Supply and Signal Converter

All components of the PMT signal converter are enclosed in a rack mountable case located in a rack near the PMT. The proximity of the signal converter to the PMT allows negligible line loss in the PMT output lines. Figure 26 shows the components and electrical connections in the signal converter.

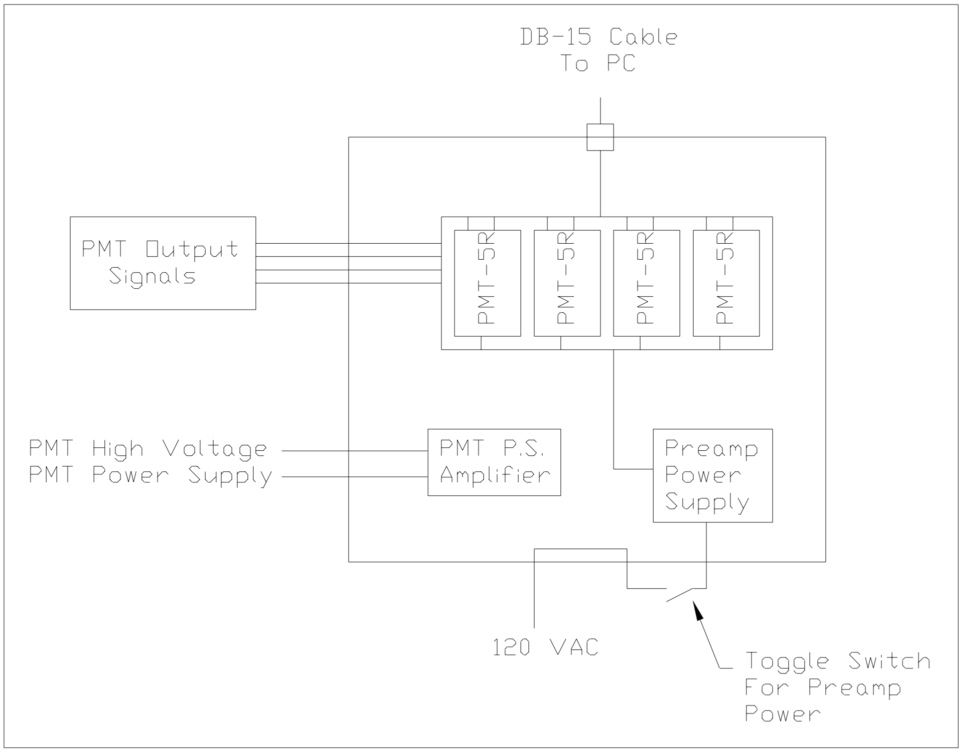

Figure 26. PMT Signal Converter. Converts PMT power supply to negative high voltage at PMT cathode and converts PMT output current to voltage.

The four PMT-5R preamplifiers require a ±15V power supply. This power supply is connected to the supply voltage through a toggle switch to act as an on/off switch. The preamplifier inputs consist of the ±15V power supply, each PMT output signal, and a digital signal from the PC transmitted through the DB-15 cable. The only outputs are the I-V converted PMT signals. Because each PMT anode shares a common cathode, the low potential outputs of the preamplifiers are connected to a common ground.

The PMT power supply amplifier is a low noise, proportional high voltage module from EMCO High Voltage Corporation. This module provides a linear relationship between an input range of 0 to 12V DC and an output range of 0 to 1000V DC with a 0.025% ripple. This results in a theoretical relationship between V_o and V_{in} as

$$V_o = 83.3V_{in}. \tag{29}$$

The recommended PMT supply voltage of 800V results in a theoretical input voltage of 9.6V. The actual value was experimentally determined as V_{in}=9.9V. Datasheets for these amplifiers can be seen in the appendices.

The PMT power supply has an output range of 0-12VDC. A 0.5 amp fuse and a solid state relay have been installed in the power supply circuit as shown in Figure 27. The gating signal to the relay is supplied by the control system allowing the PMT power to be controlled by both the user and the control system programming. The power supply is activated whenever the tip/tilt feedback loop is closed. Opening the loop with the switch or too much light sensed by the SiPD (when installed), or the PMT itself, will result in power being cut from the PMT power supply.

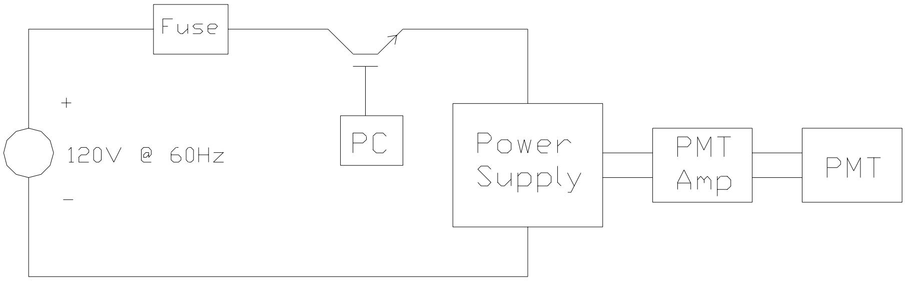

Figure 27. PMT Power Supply Circuit. Circuit is controlled by relay attached to the PC.

Silicon Photodiode

As stated earlier, a SiPD (Silicon PhotoDiode) is being designed to detect high levels of ambient light in the slitroom. The idea behind this design is that when the photodiode output reaches an upper threshold, the controller will sense this and immediately open the PMT power supply circuit. This will protect the PMT by adjusting its gain to zero. When the SiPD output is back below the limit, power will be restored to the PMT. The limiting voltage will be chosen by illuminating the SiPD with a safe amount of ambient light and recording the voltage. This system also gives the observer the ability to recognize the unlikely event that an observation was corrupted by external light in the slitroom. The SiPD circuit will be as shown in Figure 28. The Resistance, R, will be determined from testing and the output voltage, V_O, will be read across a differential channel at the data acquisition board.

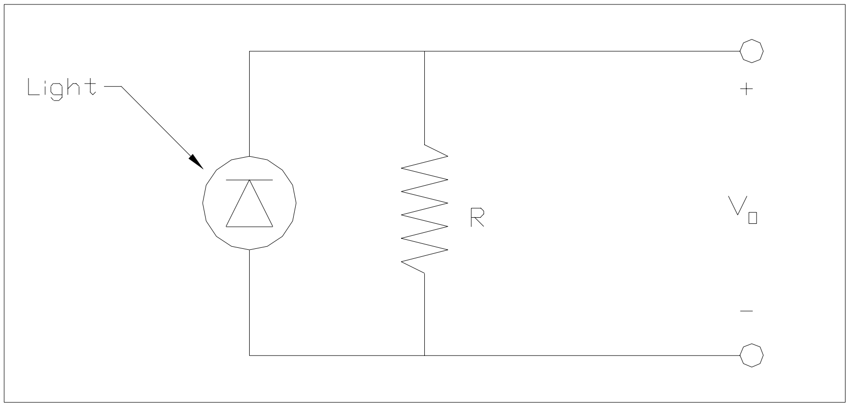

Figure 28. SiPD Safety Circuit

A photodiode has already been purchased for this application. The typical response of the SiPD is a rise time of <10ns. The actual speed issues to be considered are the response of the entire system including the SiPD, the ADC, the software execution cycle, the DAC, and the relay controlling the power to the PMT power supply. All of these devices have response times of the order of microseconds or less with the exception of the execution cycle of the Visual Designer software. Each execution cycle is on the order of 40ms, so the response time of the SiPD safety circuit will be approximately 40ms. Hard data on the intensity of light and its exposure time on the PMT surface that would result in damage to the PMT is unavailable from the manufacturer of the PMT. Upon consulting with Hamamatsu engineers, holding the SiPD threshold at lower than room light and stopping power to the PMT in less than 1 second will protect the PMT satisfactorily. Should the PMT be damaged with the SiPD in operation, an analog circuit must be built to achieve a faster response.

Feedback Loop Control Switch

The feedback loop control switch is used to activate the tip/tilt system. When the switch is opened, the feedback loop is opened causing PMT power to be shut down, and the tip/tilt mirror to reset to it's home position. The switch is located in the Shane control room, also known as the readout room, and placed in a convenient position for the telescope operator to easily close and open the loop when beginning and ending an observation, respectively. The loop signal is outputted from the PC, transmitted to the switch, and returned to the PC when the switch is closed. The PC recognizes the position of the switch by determining if the signal is returned or not.

Tip/Tilt Driver

The tip/tilt driver, a Nanomover^{TM} Control System II from Melles Griot, communicates with the PC through a PCI-GPIB interface installed in one of the PC's empty PCI expansion slots. The PCI-GPIB interface is capable of transmitting up 1.5 Mbytes/s as configured. All specifications for this board can be seen in the datasheet included in the attachments. The tip/tilt driver consists of a power supply, a two channel Nanomover control card, and an IEEE 488 interface for communication with the PCI-GPIB interface of the PC. The driver inputs consist of the IEEE 488 interface and feedback from each Nanomover encoder for closed loop operation of the Nanomover stepper motors as shown in

Figure 29. The driver has two outputs, the Nanomover signals and the ability to return status information to the PC through the IEEE 488 interface.

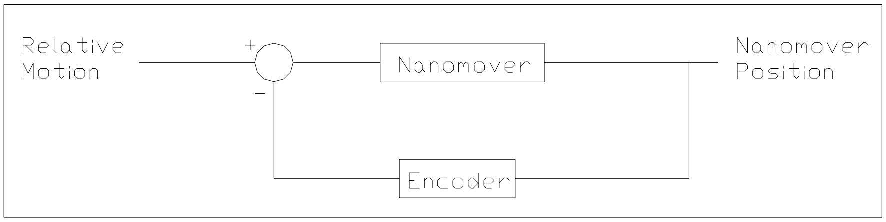

Figure 29. Stepper Motor Feedback Loop. The Nanomovers determine the required motion based on feedback from their encoders.

The Nanomover control card has its own CPU and memory on board and will determine the required Nanomover motion for each axis given the command sent and the previous position. Commands sent can consist of absolute movement, relative movement, velocity and acceleration ramp values, stopping limits and much more. The driver offers a wide velocity range and excellent positioning accuracy. The wide velocity range is achieved through the drivers ability to microstep the Nanomovers. Microstepping is done automatically with the driver choosing the required size of the microstep given the required velocity. The driver has an upper limit for the amount of pulses/s it can send to the stepper motors resulting in faster motion for large steps, and slower motion for microstepping. Accuracy is increased with microstepping, so as the velocity ramps down to zero when approaching the desired Nanomover position, the microsteps become smaller resulting in more accurate positioning and overshoot is taken care of by the encoder feedback loop. The velocity and acceleration ramps format is shown in Figure 30.

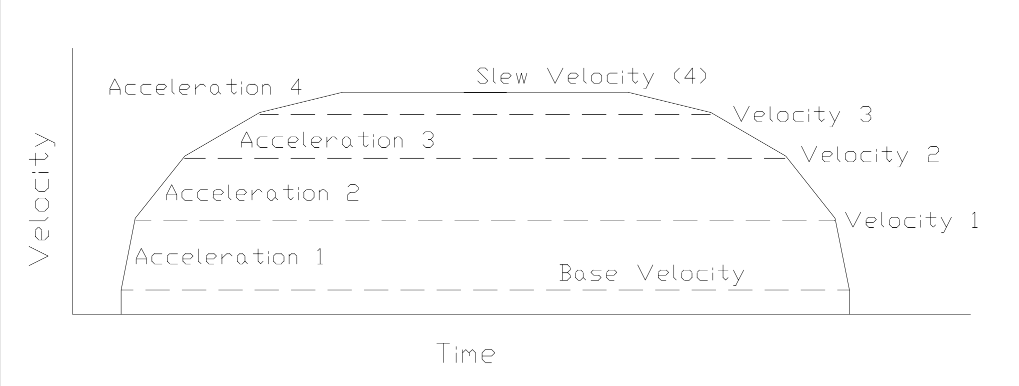

Figure 30. Velocity/Acceleration Ramps. Velocity and acceleration values for these ramps can be programmed by sending ASCII commands from the PC.

TELCO Communication

The current autoguider for the Shane telescope (TELCO) has two functions. It measures the position of the star on the aperture plate and corrects for errors by moving the telescope. This system is very similar to tip/tilt with the exception of a very slow position sensor and moving the entire telescope takes much longer than moving the tip/tilt mirror. The position sensor is a CCD camera, which only reads out at around 2Hz depending on the brightness of the star. With tip/tilt running, the tip/tilt mirror compensates for errors long before TELCO realizes that they are there, eliminating this function of TELCO. The second function that TELCO performs is to adjust the tracking rates of the telescope. These tracking rates must be updated to compensate for the motion of the Earth depending on the position of the Earth and the pointing of the telescope. The tracking rates are updated by measuring the errors that TELCO sees while performing it's first function.

With tip/tilt in operation, TELCO sees no errors and makes no adjustments to the tracking rates. This will result in the tip/tilt mirror compensating for larger angles than necessary. As the error increases, the angle of entry to the slit also increases resulting in the beam being offset from the collimator of the Hamilton Spectrograph as shown in Figure 31. For this reason, tip/tilt must communicate the errors to TELCO to maintain the ideal telescope position for the object being observed.

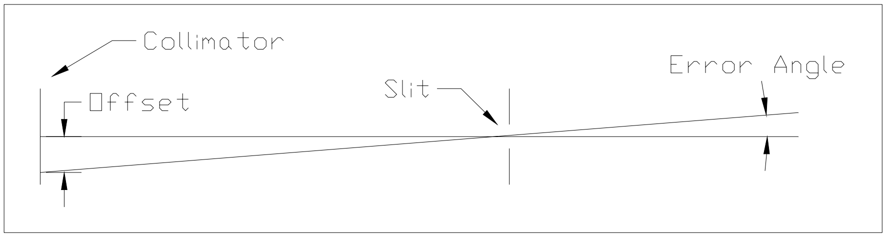

Figure 31. Error Angle Vs. Collimator Offset. The error angle must be kept small to keep the centroid of the beam near the center of the collimator.

The tip/tilt mirror must be kept near its origin to keep the error angle to a minimum. It is desirable to keep the beam within ±0.5", or ±12.7 mm, of the center of collimator. The amount of tip and tilt should not exceed the value required for a correction angle to result in an offset larger than this limit. The PC will output TELCO signals whenever these values of tip and/or tilt are nearly reached. Rearranging the relationship derived in (23) to solve for tip/tilt angle τ in terms of desired maximum offset,

$$\tau \leq 0.5 * \tan^{-1}(12.7/7000) = 0.91\text{mrad}, \qquad (30)$$

corresponding to an error correction of 5.1 arcseconds of incoming starlight angle.

The tip/tilt driver reads the position signals in units of linear motion of each stepper motor. Converting τ to linear motion of the nanomovers,

$$\Delta \leq \tau d = 40(0.00091) = 0.0364\text{mm}. \qquad (31)$$

This is the value of stepper motor motion that should not be exceeded to keep the beam within the desired parameters on the collimator for one axis only. This condition should be met for a round collimator surface when looked at in two dimensions. Assigning Δ_1 and Δ_2 as the motion for each of the two nanomovers,

$$\Delta_1^2 + \Delta_2^2 \leq \Delta^2 = 0.00132 mm^2 . \qquad (32)$$

The control program will recognize when this constraint is met and immediately update TELCO with the proper correction signal. TELCO will point the telescope to the new coordinates and update its tracking velocities based on these corrections and the time from the last correction.

Visual Designer Tip/Tilt Control Programs

Three programs have been written for the tip/tilt system using the Visual Designer software package. The tiptiltrun.dgm program is used for operating the system during data taking observations, the tiptilttest.dgm is purely for trouble shooting and testing new changes, and the tiptiltalign.dgm program is used for initial alignment of the tip/tilt optics prior to each use of tip/tilt.

TIPTILTRUN.DGM

The tiptiltrun.dgm program was written to incorporate all of the above requirements into a single package. The flowgram begins with the blocks shown in Figure 32.

The "loop signal" block generates the signal to the feedback loop control switch. The output is a constant 1V to the "AnalogOutput 1" block, which is set up to output this value to the data acquisition board.

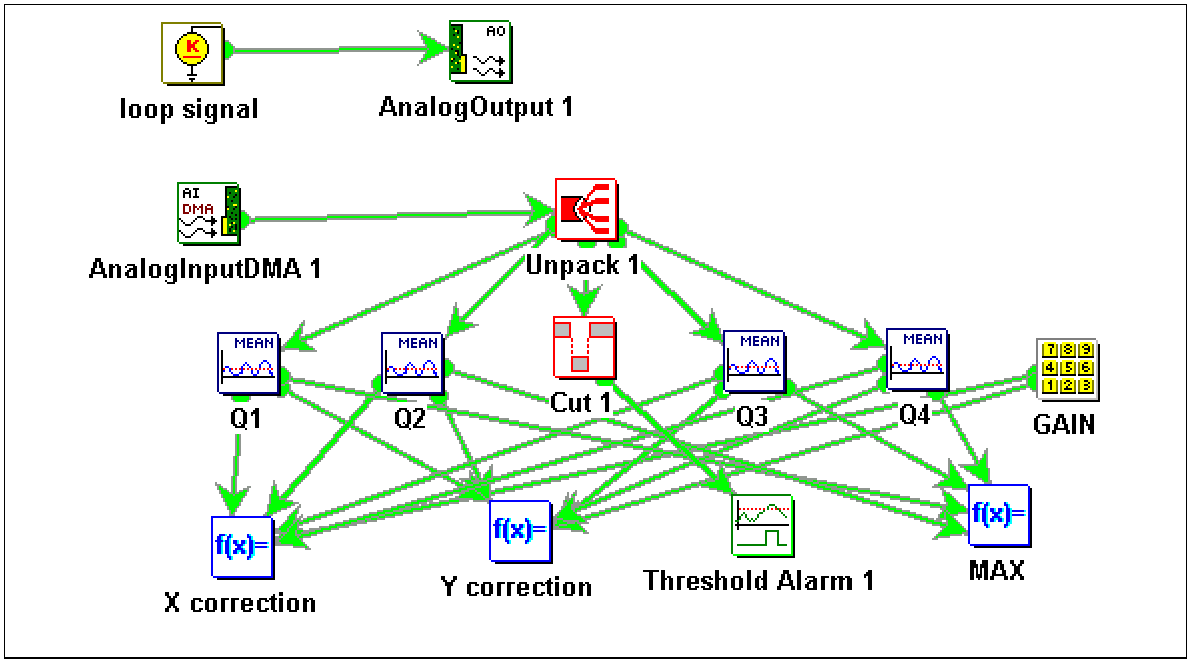

Figure 32. First Section of Flowgram Code. The input data is read using the “AnalogInputDMA 1” block and the data is analyzed using the function blocks.

All inputs to the data acquisition board are converted to digital and collected by the software at the "AnalogInputDMA 1" block. This block is configured to scan 200 samples from five channels at a rate of 10kHz. Each time the program begins a new execution cycle this block grabs the most recent buffers of 200 samples each for the five activated input channels. The output of the "AnalogInputDMA 1" block is a multidimensional buffer containing one buffer for each channel. The multidimensional buffer is converted to five individual buffers in the "Unpack 1" block.

The feedback loop control data is outputted to a "Cut" block which just removes all data in the buffer with the exception of the first value present in the buffer. This value is of float format and is either 0.00 or 1.00 depending on the feedback switch status. If the switch is closed the output from the "AnalogOutput 1" block is returned, while opening the switch cuts off this signal resulting in 0V returning to the I/O board. The remainder of the program will analyze this signal in a boolean format, true or false, so the value is converted to boolean in the "Threshold Alarm 1" block. This block outputs "true" if the input is >0.5, or false if this condition is not met.

The output buffers from the "Unpack 1" block containing PMT data are outputted to blocks "Q1", "Q2", "Q3" and "Q4" corresponding to quadrants 1-4 of the PMT. These blocks calculate the mean value of the 200 samples in each buffer to help smooth out the noise introduced by the PMT preamplifiers.

The mean values of the four PMT signals are sent to three equation blocks: "MAX", "X correction", and "Y correction". The "MAX" block outputs the maximum value of the four quadrant signals for the program to determine later what gain range should be used for the PMT preamplifiers and if dangerous light levels are present. The "X correction" and "Y correction" blocks are used to calculate the required correction using equations similar to (24) and (25). The governing equations for these blocks are

$$X = K\frac{Q1 + Q4 - Q2 - Q3}{Q1 + Q2 + Q3 + Q4 + 0.0001} \tag{33}$$

and,

$$Y = K \frac{Q1 + Q2 - Q3 - Q4}{Q1 + Q2 + Q3 + Q4 + 0.0001}, \qquad (34)$$

where K is a gain coefficient and Q1 through Q4 represent the mean value of the voltage samples taken for each PMT quadrant. The best value of K was found to be -0.002 by testing for a wide range of stars at a wide range of seeing conditions. Too large a value of this gain results in too large a correction causing the image to oscillate around the slit while small gains cause the corrections to be too small, resulting in the system not correcting quickly enough. The best gain was found by slowly decreasing the value until oscillations ceased. The minus sign is necessary because the error is negative. By setting the DC offsets to zero on the PMT preamplifiers, with no external light illuminating the PMT, the output signals will be zero. The program will crash if the denominator of these equations is zero, resulting in the need for the addition of 0.0001 in the denominator. The output of these blocks are the actual correction signals sent to tip/tilt driver. The corrections are proportional to the error.

A control system representation of the control algorithm behind equations (33) and (34) can be seen in Figure 33. These are second order systems with gain, K, inversely proportional to the damping coefficients of the systems. As discussed earlier, when the gain is too large the image will oscillate. This is an underdamped system because the damping coefficient is too small. A root locus would show the poles nearing the imaginary axis as K is increased resulting in less system stability. Similarly, reducing the gain too much will overdamp the system and slow down the system response causing the correction times to be too slow. In this case the damping coefficient is too large and the poles on a root locus would be located far from the imaginary axis on the negative side. An optimal value of K would result in a quick system response with little overshoot and oscillations.

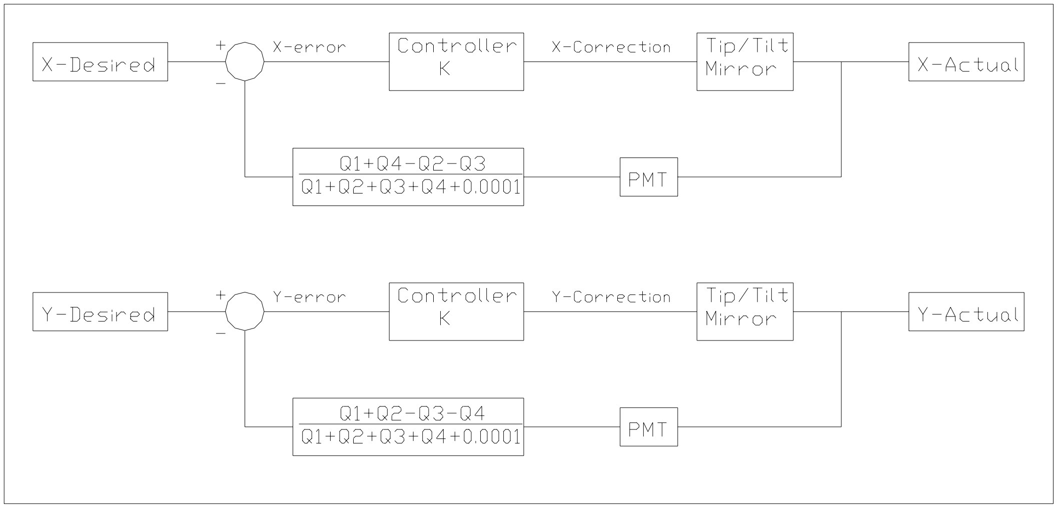

Figure 33. Control System Representation of Position Feedback Loops.

The remainder of the program is shown in Figure 34.   This section of the program utilizes a subgram block and four select case blocks to determine what signals should be sent to the tip/tilt driver, the PMT and TELCO.

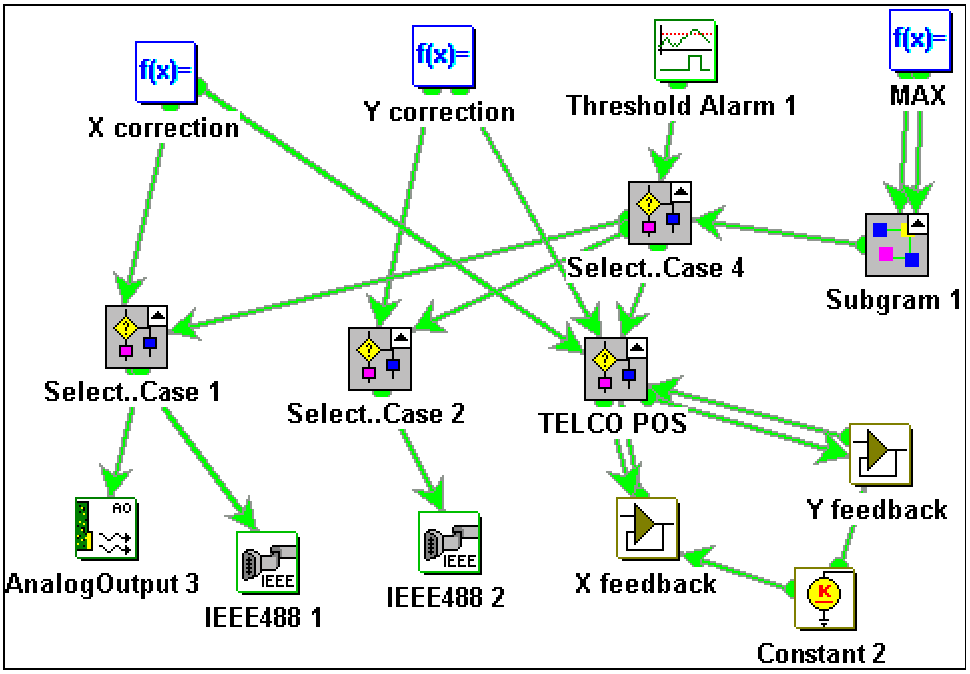

Figure 34. Remainder of the tiptiltrun.dgm Program. This section of the program determines what signals should be sent to the tip/tilt driver, the PMT, and TELCO, based on the input data.

The "Subgram 1" block uses the output value of equation block "MAX" to determine the gain level of the PMT preamplifiers and if the program should be stopped due to too much light present at the PMT active surface. The code of "Subgram 1" is shown in Figure 35.

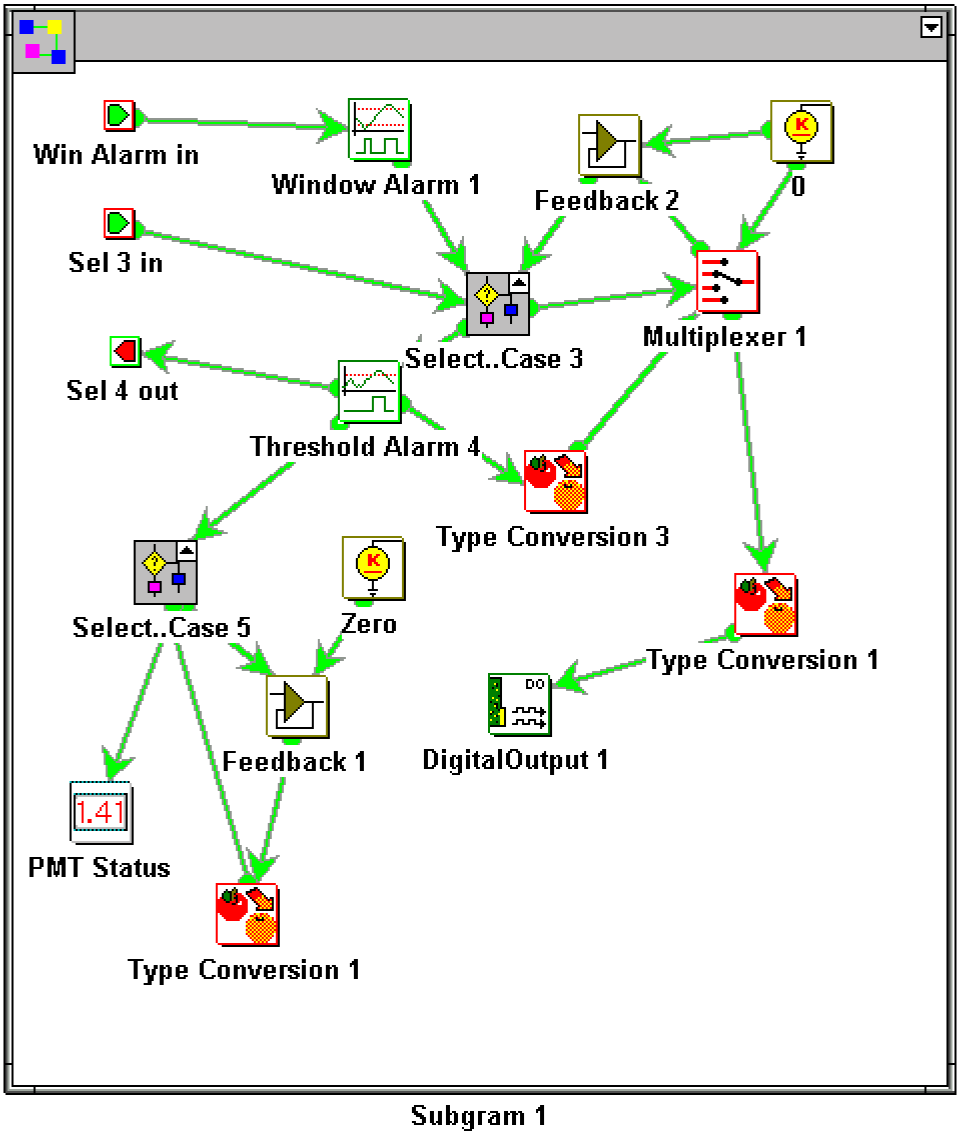

Figure 35. "Subgram 1" Code. Determines PMT preamplifier gain level and if dangerous amounts of light may be present.

The inputs from this subgram, "Win Alarm in" and "Sel 3 in", each input the output signal from the "MAX" block. "Win Alarm in" outputs its signal to the "Window Alarm 1" block, which determines if the data lies within a specified window within the output range of the PMT preamplifiers. If the input data is within a range of 0.99 to 9.9 Volts, the window block outputs "true", otherwise the output is "false". If the output is "true", the "Select..Case 3" block will retain the current value of preamplifier gain. If the output is "false", the "Select Case 3" block will adjust the gain appropriately. This is required to ensure that the PMT preamplifiers output signals below their output thresholds and above their noise levels. The code of the "Select..Case 3" block is shown in Figure 36.

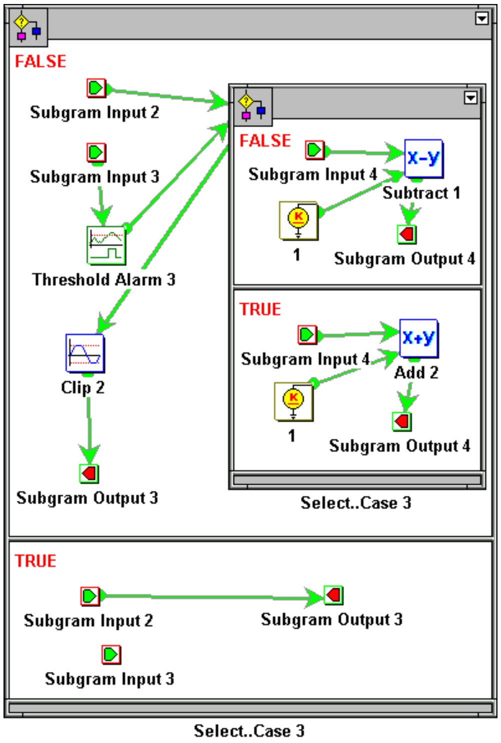

Figure 36. "Select..Case 3" Code. Adjusts the value of the PMT preamplifier gain if necessary.

The imbedded Select case block either adds or subtracts one to current PMT gain level, or returns the current value if the maximum PMT output is within the desired range. This value is outputted to the "Clip 2" block, which limits the output to -1,0,1, or 2, corresponding to too much light present, 10^6 V/A, 10^7 V/A, or 10^8 V/A, respectively. If the output is between 0 and 2, this value is simply returned to the "Select..Case 3" block via the "Feedback 2" block of Figure 35. If the gain value is chosen to be -1, there is too much light entering the PMT, saturating the preamplifiers. When this situation occurs "Threshold Alarm 4" is activated "true". The multiplexer of Figure 35 will be switched such that a value of zero is used for preamplifier gain, -1 is not an option, and the "Select..Case 5" block is activated "true" to stop the program before the PMT can be damaged. This select case block lets the program run one more cycle, using its feedback block, so the tip/tilt mirror can be sent to the home position and the power to the PMT can be switched off before the program kills. A PMT Status display is switched from "PMT O.K." to "PMT OVEREXPOSED, Check for external light in slit room" as well. Vega, one of the brightest stars in the sky, was found to not trigger this function, so roomlights or a flashlight are the only possible causes for this type of error. Should this error occur, the "Sel 4 out" block outputs a signal to the "Select..Case 4" block of Figure 34 to override the feedback loop control switch and cut off PMT power and send the tip/tilt mirror to its home position.

The output of "Select..Case 4" will be true if the feedback loop switch is in the "closed loop" position and the PMT is not overexposed. A value "true" results in the "Select..Case 1" and "Select..Case 2" blocks sending correction signals to the tip/tilt driver and the activation of the "TELCO POS" block. The "TELCO POS" block, along with the "X Feedback" and "Y Feedback" blocks, keeps track of the position of the tip/tilt mirror. When the X and Y positions of the tip/tilt mirror meet the constraint given in (32), an ASCII string is outputted to TELCO of the form

$$\mathrm{POS},X_{error},Y_{error} \tag{35}$$

where X_{error} and Y_{error} are the corresponding angular errors, in arcseconds, of the telescope. This information is transmitted to the TELCO controller through the serial port.

The "Select..Case 1" and "Select..Case 2" blocks output 0V to the PMT, "AnalogOutput 3" block, and send the mirror to its home position, "IEEE488 1" and "IEEE488 2" blocks, when activated "false". The commands for sending mirror to its home position is two ASCII strings of the form

MA,1,<*x-axis home*> (36)

and,

MA,2,<*y-axis home*>. (37)

The command MA,n,p means Move Absolute motor number n to position p. This command tells the tip/tilt driver to move Nanomovers 1 (x-axis) and 2 (y-axis) to their respective home positions.

When the "Select..Case 1" and "Select..Case 2" blocks are activated "true", a value of 10V is outputted to the PMT power supply relay and the results of (33) and (34) are transmitted to the tip/tilt driver in the form

$$\text{MR,n,d.} \tag{38}$$

In this command, MR means Move Relative from the current position, motor number n, distance d.

The IEEE488 blocks are formatted to communicate with the tip/tilt driver. These blocks transmit three types of data, initialize, run, and deinitialize. The run data are simply the results of (36), (37), and (38). The initialize data sets the run time parameters for the tip/tilt driver that are not met by its default parameters. The commands have the form

$$\textit{<command>,<motor \#>,<value>} \tag{39}$$

similar to (36), (37) and (38). The commands used in the initialize stage are summarized in Table II. These commands override the default values for motor velocities, accelerations, and range limitations.

Table II. Initialization Commands

Commands	Description
WB,1,0.2 WB,2,0.2	Writes the base velocities of motors 1 and 2 to 0.2mm/s.
WV1,1,0.75 WV1,2,0.75	Writes the peak velocity ramp values for ramp #1 of each motor 0.75mm/s.
WV2,1,1.25 WV2,2,1.25	Writes the peak velocity ramp values for ramp #2 of each motor 1.25mm/s.
WV3,1,2.0 WV3,2,2.0	Writes the peak velocity ramp values for ramp #3 of each motor 2.0mm/s.
WV4,1,2.5 WV4,2,2.5	Writes the peak velocity ramp values for ramp #4 of each motor 2.5mm/s.
WA1,1,1250 WA1,2,1250	Writes the acceleration for ramp #1 of each motor to 1250mm/s^2.
WA2,1,800 WA2,2,800	Writes the acceleration for ramp #2 of each motor to 800mm/s^2.
WA3,1,400 WA3,2,400	Writes the acceleration for ramp #3 of each motor to 400mm/s^2.
WA4,1,100 WA4,2,100	Writes the acceleration for ramp #4 of each motor to 100mm/s^2.
WAL,1,0.0 WAL,2,0.0	Writes the absolute left for the range of motion for each motor to 0.0mm.
WAR,1,24.5 WAR,2,24.5	Writes the absolute right for the range of motion for each motor to 24.5mm. (The default for this option is 25.0mm. Moving the motor this far exceeds the range of motion of the gimbal mount and can result in damage to either component.)
MA,1,<*x-home*> MA,2,<*y-home*>	These commands move the tip/tilt mirror to its home position for alignment and telescope pointing purposes.

In the deinitialization stage, the only commands sent are move absolute commands to reposition the motors to zero. This allows the motors to begin at zero the next time the driver is initialized. If the driver is turned off while the motors are not at zero, the driver will label the next start positions incorrectly to be zero. This could result in the motors attempting to exceed their range.

TIPTILTTEST.DGM

The tiptilttest.dgm code is exactly the same as the tiptiltrun.dgm code but with added displays on the run time screen. As displays are added, the execution cycle time is dramatically reduced. For this reason, the only displays for the run program are the "PMT Status" display and the run time adjustable gain for the correction blocks. The test program has additional displays of every component of interest for the purpose of trouble shooting and testing new modifications to the system code.

TIPTILTALIGN.DGM

The tipttiltalign.dgm program is used to install and align the system during nightly set-up. It is identical to the test program, but with no TELCO communication, and leads the user through a step by step setup procedure. A list of procedures is displayed on the run-time screen. Once the user performs these tasks he must click a button on the run time screen to see the next steps required. This process leads the user through all procedures until the system is set-up and aligned properly.