The Four Star Motor Controller

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1. Overview

This document gives a brief description of the Four Star Motor Controller (Hereafter FSMC). While the FSMC is fully specified by its schematics, this document will be useful to those seeking to understand the circuit details and motivations. The reading audience will include persons building or repairing the FSMC, persons tasked with repairing or trouble shooting the FSMC, and also those writing, debugging, or modifying computer code to communicate with and program the FSMC. The reading audience will also include persons seeking a better understanding of the associated Four Star limit switches, motors, and potentiometer encoders.

2. Description of the Four Star Motion Control Hardware

The Four Star Infrared Camera has six mechanisms controlled by stepper motors. There are two filter wheels, a wheel holding field flattener lenses, a passive detent arm for each filter wheels, a motorized focus mechanism for the imaging arrays, and a motorized mechanism to adjust the telescope pupil mask. The filter/flattener wheel and detent system is illustrated in Figure 1.

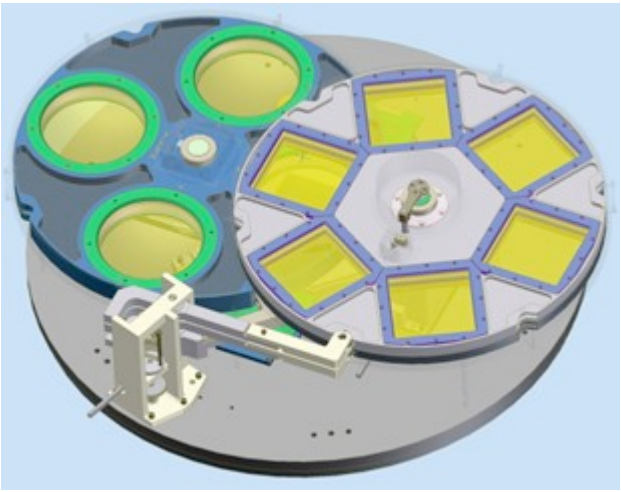

Figure 1. FWt and FWb are on the right hand side of the figure and FFW is the four-position wheel to the left. The view is that looking from the direction of the telescope.

The two filter wheels are referred to as “Filter Wheel Top” (hereafter FWt) and “Filter Wheel Bottom” (FWb). FWt and FWb are adjacent in the converging telescope beam forward of the imaging arrays with FWt being closest to the telescope. FWt and FWb have six detented positions and one home position each. The Field Flattener Field (FFW) resides under the two filter wheels and has four detented positions plus a home position.

Each wheel is driven by its own stepper motor located outside the cryogenic vacuum dewar. Motion from the outside is transmitted into the dewar via vacuum feedthroughs through a set of gears and shafts. A simple digital encoder, external to the dewar, encodes each detented wheel position. This works by utilizing a wheels outside the dewar geared 1:1 with the filter wheels inside the dewar. These external wheels actuate magnetic reed switches with a magnet that rotates to each switch when an internal detent position of the wheel is reached internally. This device is essentially a multi pole switch.

The detent arms are driven in unison by a stepper motor that drives a periodic mechanism (so as one runs the stepper forward continuously all three detent arms compress and relax against the wheel edges). Each detent arm is encoded with a micro switch to indicate a detent-in position.

The focus mechanism for the arrays is driven by an external stepper motor. The focus position is encoded with a linear potentiometer. Similarly, the pupil masking aperture mechanism is driven by an external stepper which has limit switches and a linear potentiometer to encode position.

3. Overview of the FSMC

The FSMC is a full-width 3U rack mounted instrument. The principle active elements are two Nyden MAC-300 stepper motor controllers, six Mycom IMS500-021 stepper motor drivers, an Acromag 962EN six channel Ethernet-based 12 bit ADC, a custom designed Logic Interface Board.

The MAC-300's are smart, programmable, stepper motor controllers. The Mycom units are basic stepper drivers. The function of the Acromag ADC is to measure a voltage drop across potentiometers used for positional encoding. This encoding voltage is in the +/- 5V range (approximately) and may require averaging in software to reduce noise. The Logic Interface Board serves several interfacing and logic decoding functions as discussed below.

Each MAC-300 is capable of controlling up to four stepper motors. The first MAC-300 in the FSMC designated MAC-300 #1 controls steppers for FWt, FWb, FFW, and the detent arm, on its internally labeled axes A, B, C, and D, respectively. The second MAC-300, #2 controls the pupil and focus motors on its axes A and B, respectively. Communication with each MAC-300 occurs through their RS-232 ports.

The Acromag unit is interfaced to the computer with Ethernet. Channel 0 reads the Pupil encoder voltage and channel 1 reads the focus position. Refer to the Acromag manual for programming details.

MAC-300 digital inputs are active low (i.e. logical condition asserted when grounded) and are opto isolated. When these inputs are floated they pull high to within a diode-drop of the FSMC 24V supply, so they must not be simultaneously wired to TTL or CMOS

inputs. They are designed to be connected directly to switches which ground their inputs to indicate the relevant condition.

Positional switches are wired to each MAC-300. The home switches from FWt, FWb, and FFW are wired to the NEAR HOME inputs of axes A, B, and C, on MAC-300 #1, respectively. On MAC-300 #2 the forward and reverse limits from the pupil mechanism are wired to the FOR.LIMIT and REV.LIMIT bits of axes A.

In addition to home and limit inputs, each MAC-300 has eight general purpose digital inputs. Thus a system total of 16 digital inputs are available. The MAC-300 input definitions are as follows:

MAC-300 #1 Input Bit Assignments

Bit 0 FWt Position Encoding Bit 0 (LSB)
Bit 1 FWt Position Encoding Bit 1
Bit 2 FWt Position Encoding Bit 2 (MSB)
Bit 3 FWb Position Encoding Bit 0 (LSB)
Bit 4 FWb Position Encoding Bit 1
Bit 5 FWb Position Encoding Bit 2 (MSB)
Bit 6 FFW Position Encoding Bit 0 (LSB)
Bit 7 FFW Position Encoding Bit 1 (MSB)

MAC-300 #2 Input Bit Assignments

Bit 0 Pupil Limit L- (0 => in Limit)
Bit 1 Pupil Limit L+ (0 => in Limit)
Bit 2 FWt Home (0 => at Home Pos.)
Bit 3 FWb Home (0 => at Home Pos.)
Bit 4 FWt Detent In (0 => Denent In)
Bit 5 FWb Detent In (0 => Detent In)
Bit 6 FFW Detent In (1 => Detent In)
Bit 7 FFW Home (0 => Detent In)

4. FSMC Front and Rear Panel Description

The only user controller functions on the FSMC are a power switch and a momentary contact reset button to initialize the MAC-300's. The reset button should never have to be used at the telescope and is basically for software debugging. Each limit switch is duplicated inside the dewar for redundancy. The selection of which switch to use is made by small locking toggle switches on the front panel. *These toggle switches must be not manipulated except by trained and properly informed personnel.*

There are a number of useful status LED's on the front panel:

5V POWER	- Pilot light for 5V power supply
24V POWER	- Pilot light for 24V power supply
ERROR 1	- Indicates Software Error on MAC-300 #1
ERROR 2	- Indicates Software Error on MAC-300 #2
BUSY 1	- Indicates Software Executing on MAC-300 #1
BUSY 2	- Indicates Software Executing on MAC-300 #2
FWt HOME	- Indicates FWt at the home position
FWb HOME	- Indicates FWb at the home position
FFW HOME	- Indicates FFW at the home position
FWt DETENT IN	- Indicates the FWt detent is in
FWb DETENT IN	- Indicates the FWb detent is
FFW DETENT IN	- Indicates the FFW detent is in
DETENT OUT ALL	- Indicates all detent arms are out (not implemented)
PUPIL L-	- Indicates the Pupil Negative Limit is reached
PUPIL L+	- Indicates the Pupil Positive Limit is reached
FOCUS L-	- Indicates the Focus Negative Limit is reached (not implemented)
FOCUS L+	- Indicates the Focus Positive Limit is reached (not implemented)

There are also three LED digits to indicate the numerical position of the wheels. These positions range from 0-5 for FWt and FWb, and 0-3 for FFW. When a wheel is not in a detent position, the digit is blanked and the decimal point flashes at 7 Hz. This signifies a state of motion.

5. FSMC Rear Panel Description

There are nine connectors on the rear panel of the FSMC. The connector part numbers and detailed pin-outs are given on the FSMC schematic.

P1	- AC power entry module
P2	- Pupil limits and encoding inputs
P6	- FWt reed switch encoding inputs
P8	- FWb reed switch encoding inputs
P10	- FFW reed switch encoding inputs
P12	- Wheel home/detent positions, focus limits, and focus encoding inputs
RJ-45	- 100BaseT connector to communicate with Acromag ADC
J1	- RS-232 interface for MAC-300 #1
J2	- RS-232 interface for MAC-300 #2