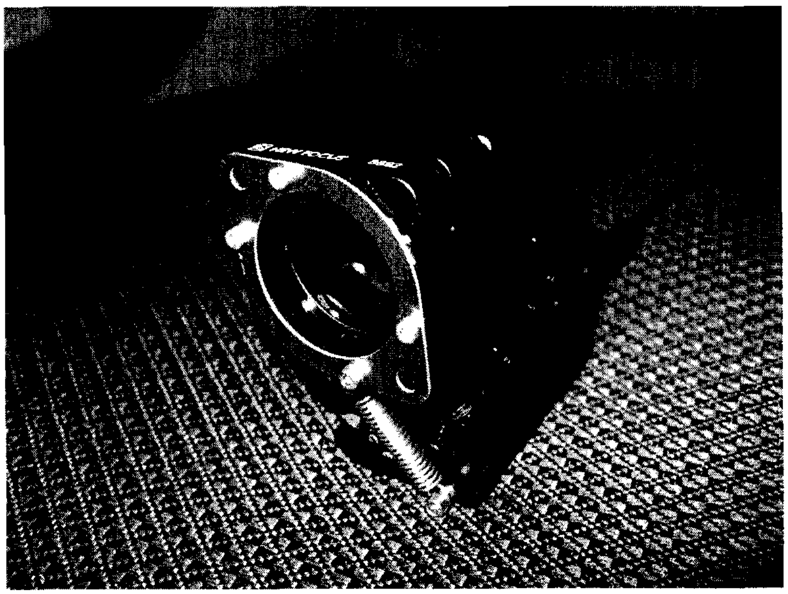
Operational Specifications for the Two-State Motor Controller

Jonathan Kyle

Operational Specifications
For the Two-State Motor Controller
Jonathan Kyle



University of Rochester
Laboratory for Laser Energetics

1.0 Goals of the Control System

Currently, on the OMEGA laser system, optical lenses as well as mirrors are flipped in and out the path of the laser beam by means of pneumatic devices. These apparatuses rely on an external supply of air as well as power. This hindrance makes the pneumatic devices cumbersome and quite large, not the ideal attributes when working in confined spaces. A more elegant solution to this problem would be to use electric motors that are smaller, cheaper, and more useful. Other advantages are as follows:

- low power (no external power)
- power comes directly from the Two State Control Module (TSCM)
- smaller size
- lower cost
- can be implemented in a vacuum
- more reliable
- added status features (jam, unplugged)

With these advantageous reasons, it was determined that using electric motors for "flip-ins" was the better method as opposed to pneumatic devices. This project accomplished developing a two-state motor controller to operate an electric motor as a "flip-in" by using "off-the-shelf" motorized "flip-in" motors from New Focus. It was also able to determine 5 state functions: 1) Is the motor plugged in? 2) Is the motor jammed? 3) Is the motor in the "in" position? 4) Is the motor in the "out" position? 5) "Run-away" detection.

2.0 Overview of the hardware design

For the electric motor to communicate with the TSCM, a black box was constructed which acted as an adaptor. As seen in fig. 1, the black box contains a micro controller, a motor driver, and a current sensor. The micro controller sends signals to the motor driver to control which direction the motor will turn. The current sensor monitors the current and sends signals back to the controller for analysis. When the current spikes after a certain period of time, it indicates that the motor has reached its desired position. If the current spikes too soon, the micro controller assumes that it is a jam. If the current doesn't spike initially, that's interpreted as no motor being plugged in. Finally, if the current never spikes but remains steady, that is a "run-away" scenario, which is the unlikely event of the optical assembly coming loose of the motor shaft.

Fig 1. **Block Diagram of the Two-Step Motor Controller**

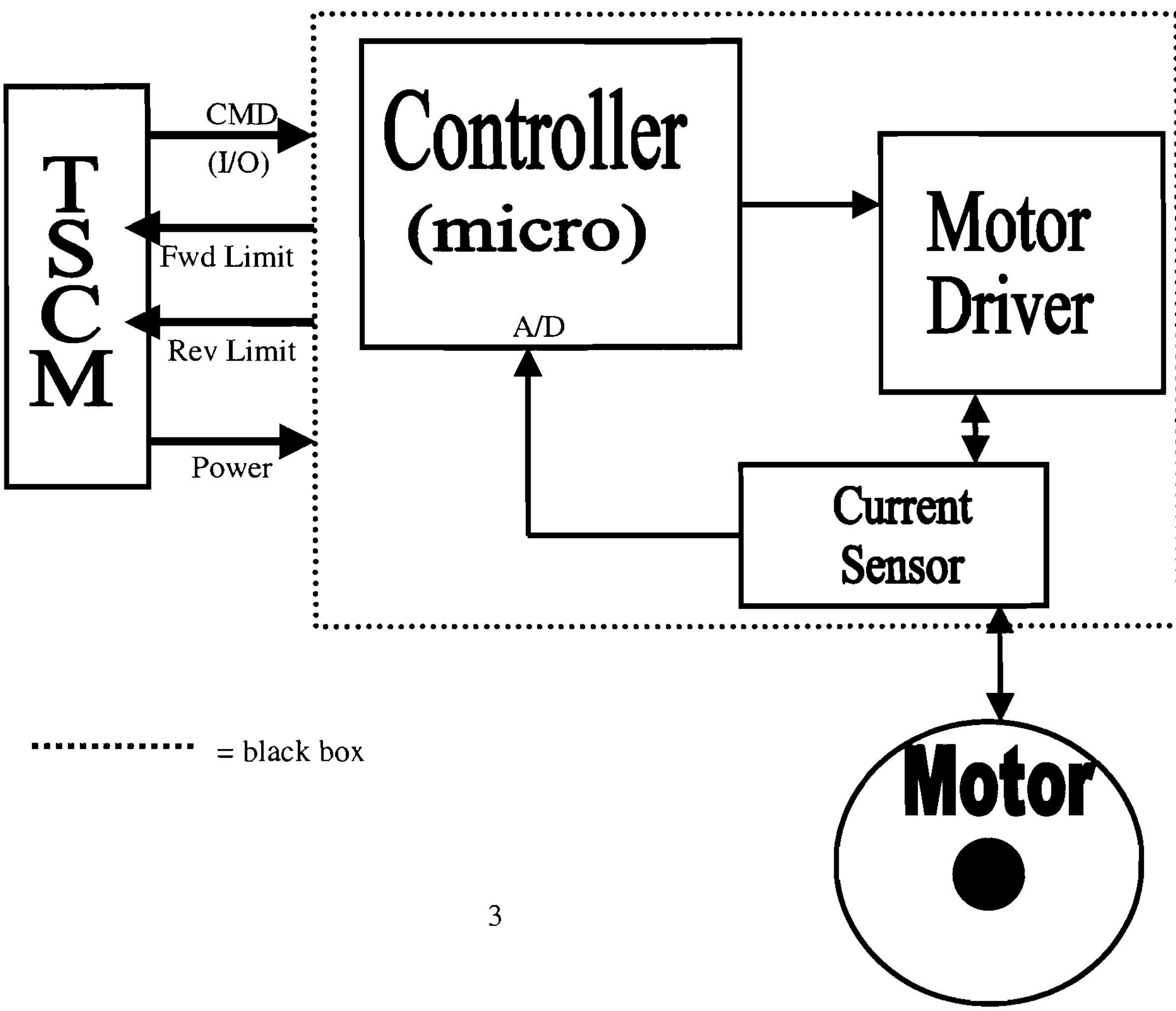


Fig 2. **Current Graph**

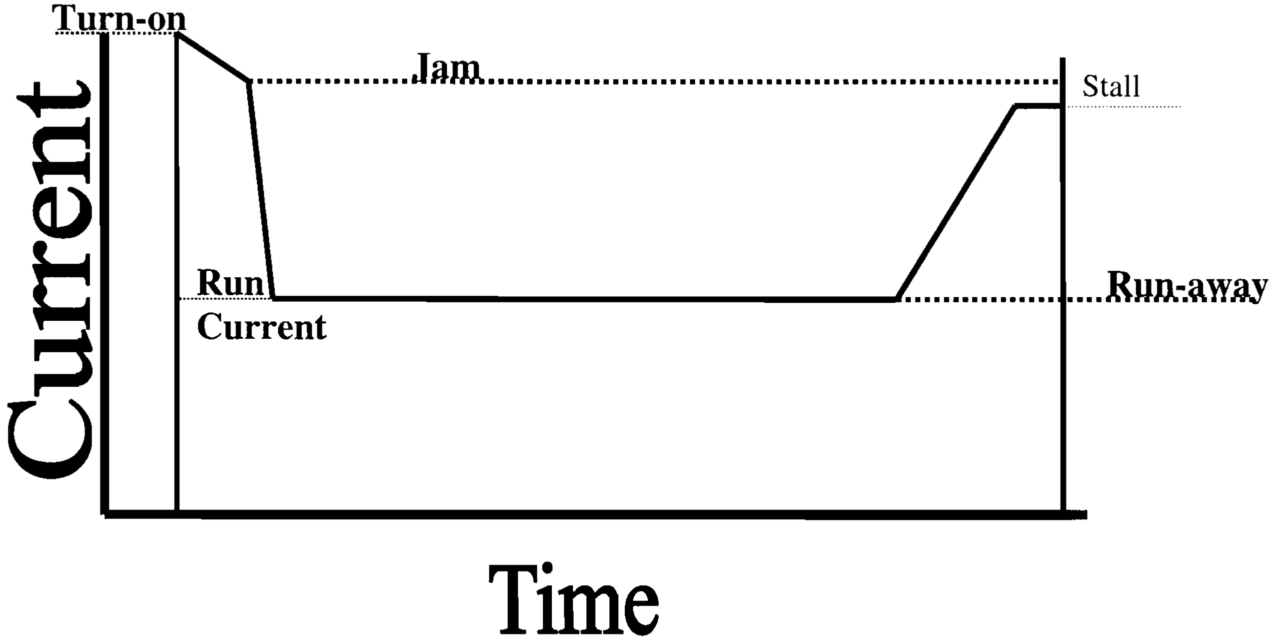


Fig 3. **Actual Current from Motor**

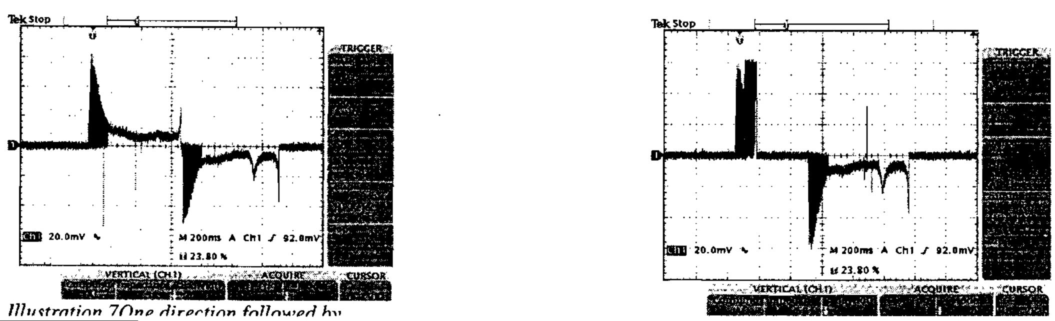


Illustration 7One direction followed by

As can be seen from Figures 2 and 3, there is an initial spike in the current when the motor is first turned on. This indicates the amount of work needed to get the motor started. Once its momentum builds up, the current goes down for a certain period of time until the motor assembly hits the other side. At this moment, the motor has stalled and the current spikes again, although not as much as it did when it was first turned on. By constantly monitoring these signals, the software is able to determine what state the motor is in and react accordingly.

2.1 Microchip (PIC16F684)

The 14-Pin FLASH-Based 8-Bit CMOS Microcontroller was the best candidate for this design. It was powerful (200 nanosecond instruction execution) yet easy to program. The microcontroller contains Microchip's PIC MCU architecture in a 14-pin package and features an analog to digital converter and 128 bytes of EEPROM data memory.

Features

- 128 bytes of EEPROM data memory
- Programmable pull-up resistors
- MPLab ICD-2 programming support or debugging support with optional adapter
- 8 oscillator selections including 4 MHz RC oscillator with programmable calibration and Power-On Reset
- 8 Bit A/D
- Low cost

2.2 Motor Controller

By using two half bridges from International Rectifier, an "H" bridge was constructed. The IRF7507 HEXFET Power MOSFET is an extremely efficient and reliable device. The new Micro8 package provided the smallest footprint available in a Small-Outline Integrated Circuit, making it excellent for saving space. By utilizing advanced processing techniques, the fifth generation HEXFETs achieve a low on-resistance per silicon area.

Features

- Generation V Technology
- Ultra Low On-Resistance
- Dual N and P Channel MOSFET
- Very Small SOIC Package
- Low Profile (<1.1 mm)
- Available in Tape & Reel
- Fast Switching
- Low cost

3.0 Overview of the Software Design

As depicted in the flowchart in Fig. 4, the command signal from the TSCM can begin as either a 1 or a 0. If it is a 1 or high signal, the motor will move in a clockwise direction. If it's a 0 or low signal, the motor will move in a counterclockwise direction.

Counterclockwise

After the motor moves in a counterclockwise direction, the current sensor has to determine if the current is greater than the start current, which is the least amount of current needed to start the motor. This will determine if the motor is indeed connected. If it isn't, the current will not be greater than the start current and both limit switches will be set to 0 indicating that no motor was detected. If everything is normal, the current then has to be less than 70% after 1/2 of a second indicating that the motor is free from any obstructions. If the current spikes above that, that's indicative of a motor jam and both limit switches will be set to 1. Then, proceeding as normal, the current should spike above 75% after 1 second, meaning the motor has reached its desired position. In this case the motor turns off and the forward limit switch is set to 0 and the reverse limit switch to 1, indicating that the motor moved in a counterclockwise direction. Finally, all the outputs of the jam scenario, as well as the no-motor-detected scenario, would feed into the interrogative asking if the command signal is still 0. If it is, the system simply loops on itself but if it's not, the system is routed back up to the beginning to go through the whole process again.

Clockwise

Moving the motor clockwise is basically the same procedure except that the command signal has to be high or 1. Also, when the motor has reached its end, the forward limit is set to 1 while the reverse limit is set to 0. Finally, the last question is asking whether the command signal is 1 and if it is, it loops on itself and if it isn't, it starts back at the beginning.

4.0 Conclusion

The two state motor controller performed its job well. It allowed the Two State Control Module to communicate with the two state motor and move the motor clockwise as well as counterclockwise. Also, the limit switches performed well and ran back signals to a bi-color LED so we could monitor its status. We were able to send signals from the TSCM to the two state motor controller. Once the motor reached a certain position, it successfully sent the correct signals back to the TSCM. In order for this to be implemented into OMEGA EP, more tests need to be conducted to ensure that every scenario works perfectly. Figures 4 through 7 are the software flowcharts and the schematic of the two state motor controller.

Fig. 4

Two State Motor Controller Software Flowchart

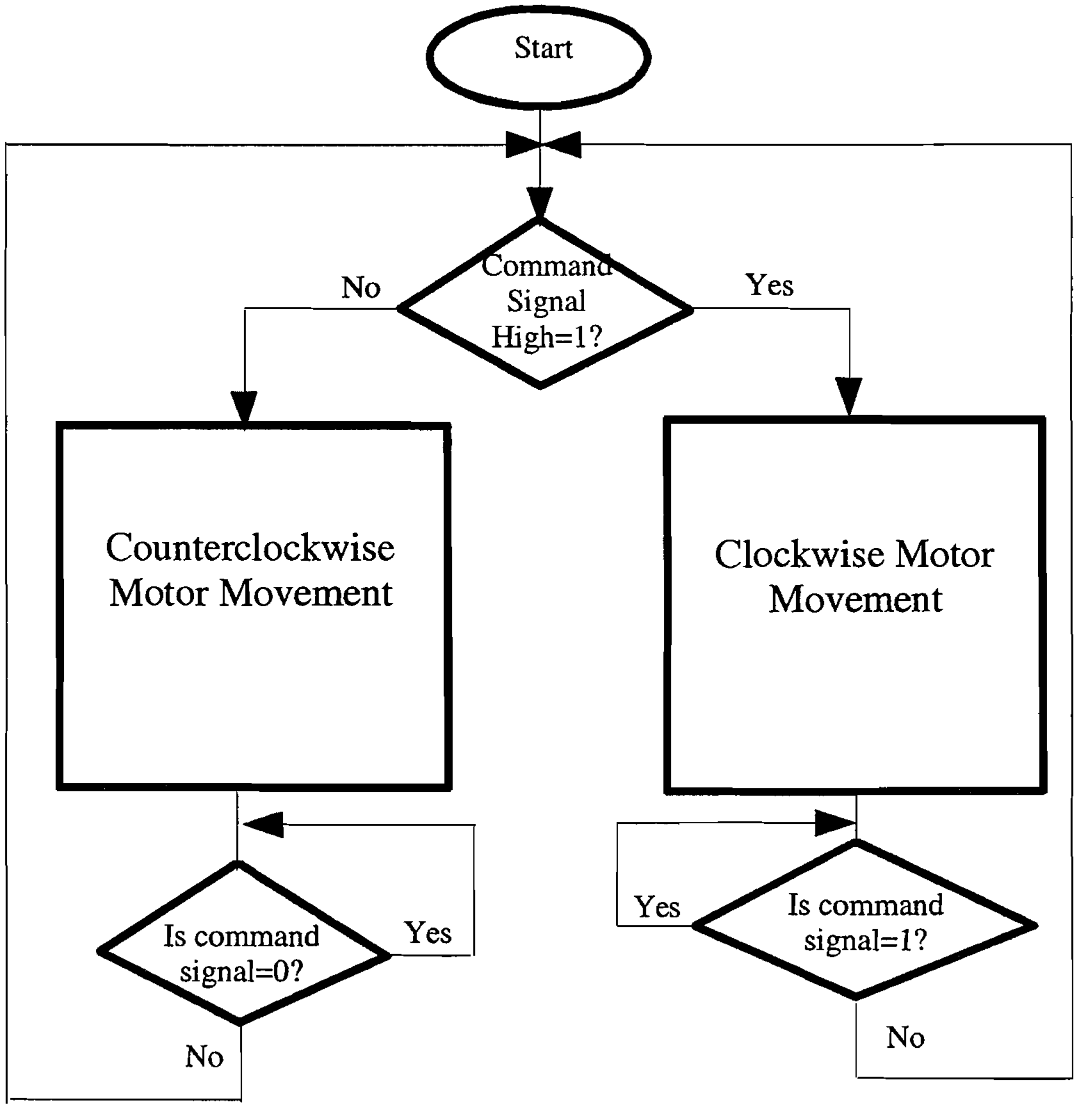


Fig. 5

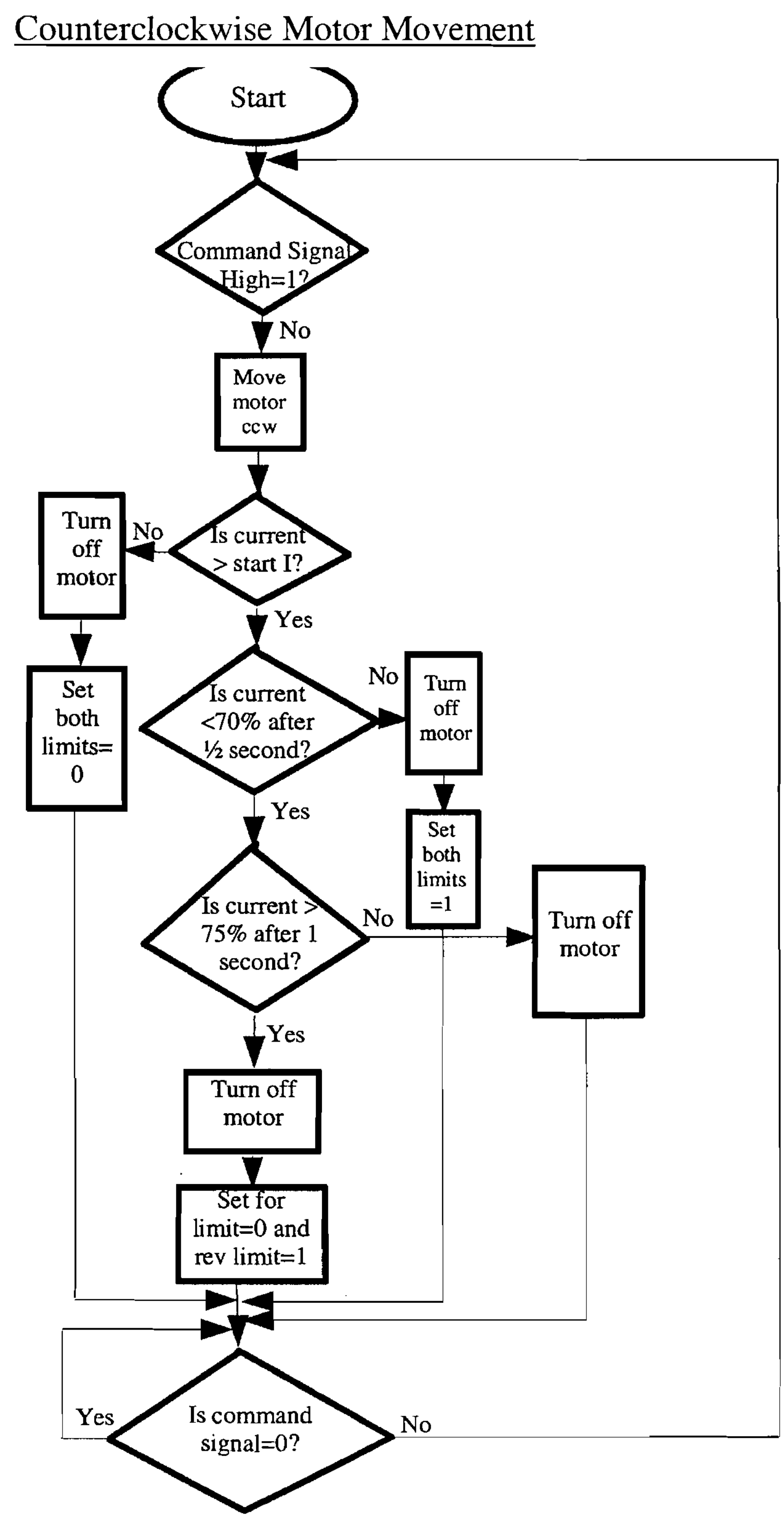

Counterclockwise Motor Movement
Start
Command Signal High=1?
No
Move motor ccw
Is current > start I?
No
Turn off motor
Set both limits= 0
Yes
Is current <70% after ½ second?
No
Turn off motor
Set both limits =1
Yes
Is current > 75% after 1 second?
No
Turn off motor
Yes
Turn off motor
Set for limit=0 and rev limit=1
Is command signal=0?
Yes
No

Fig 6.

<u>As Fig. 5 but for clockwise motions</u>

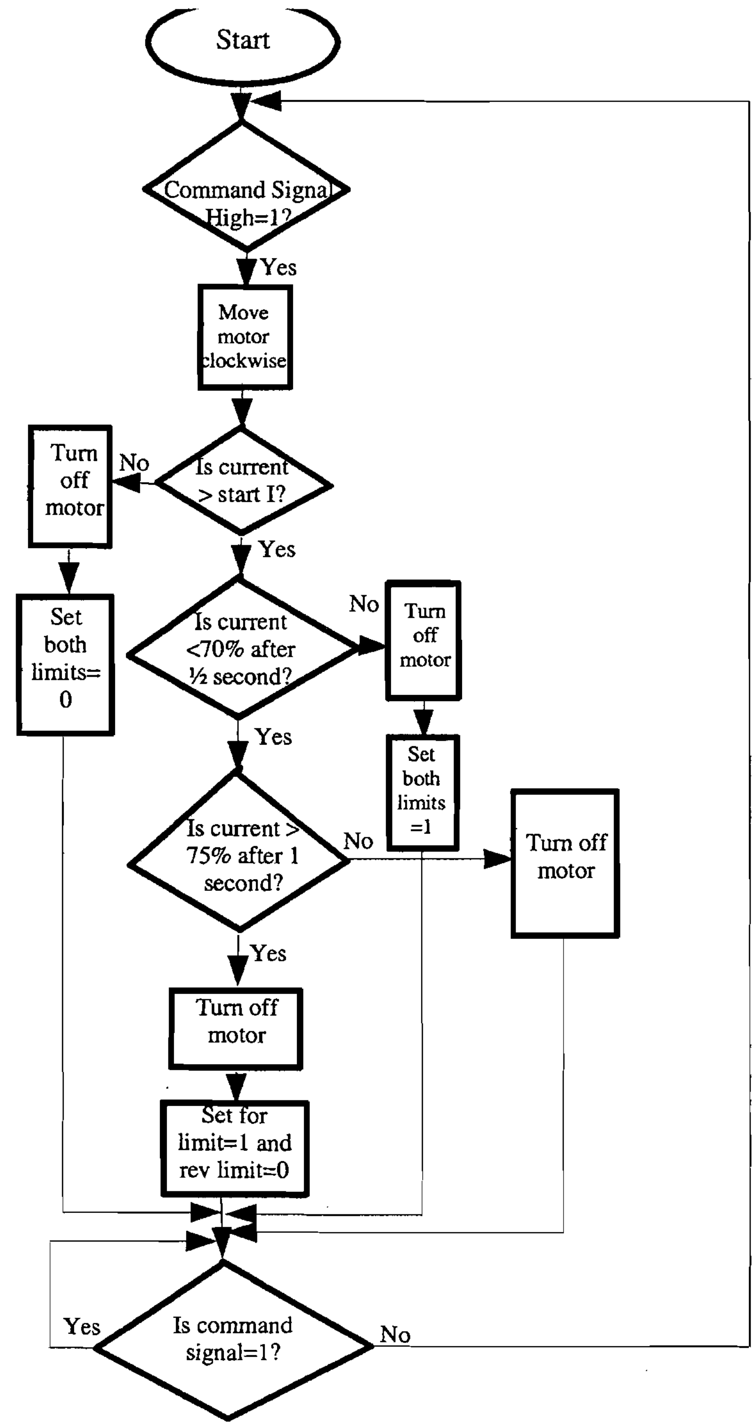


Fig. 7