Servo Theory

Servo amplifiers are part of a closed loop control system having characteristics that are desirable for controlling an assembly positioning system. An ideal servo amp possesses the following features:

Constant Velocity
Ability to maintain a speed dictated by the velocity command input. A tachometer input is used to generate a proportional error signal equal to the difference between the velocity command and the actual motor speed. This signal is proportional (scaled) to the motor speed and will approximate the motor speed. Providing opposition to the servo motor shaft will generate an error signal in the tachometer circuit by subtracting the velocity command from the tachometer signal, this error is added to the original velocity command and forces the servo motor to maintain the original speed. This can be demonstrated by loading the shaft of the servo motor when it is being driven at a moderate speed, the motor will maintain its speed while the HVDC supply current increases.

Infinite Acceleration
The theoretical servo amplifier must be able to provide infinite acceleration, this can be seen by abruptly starting and stopping the servo motor. The actual servo system has a critically damped response, infinite acceleration is traded off for damping necessary to prevent oscillation.

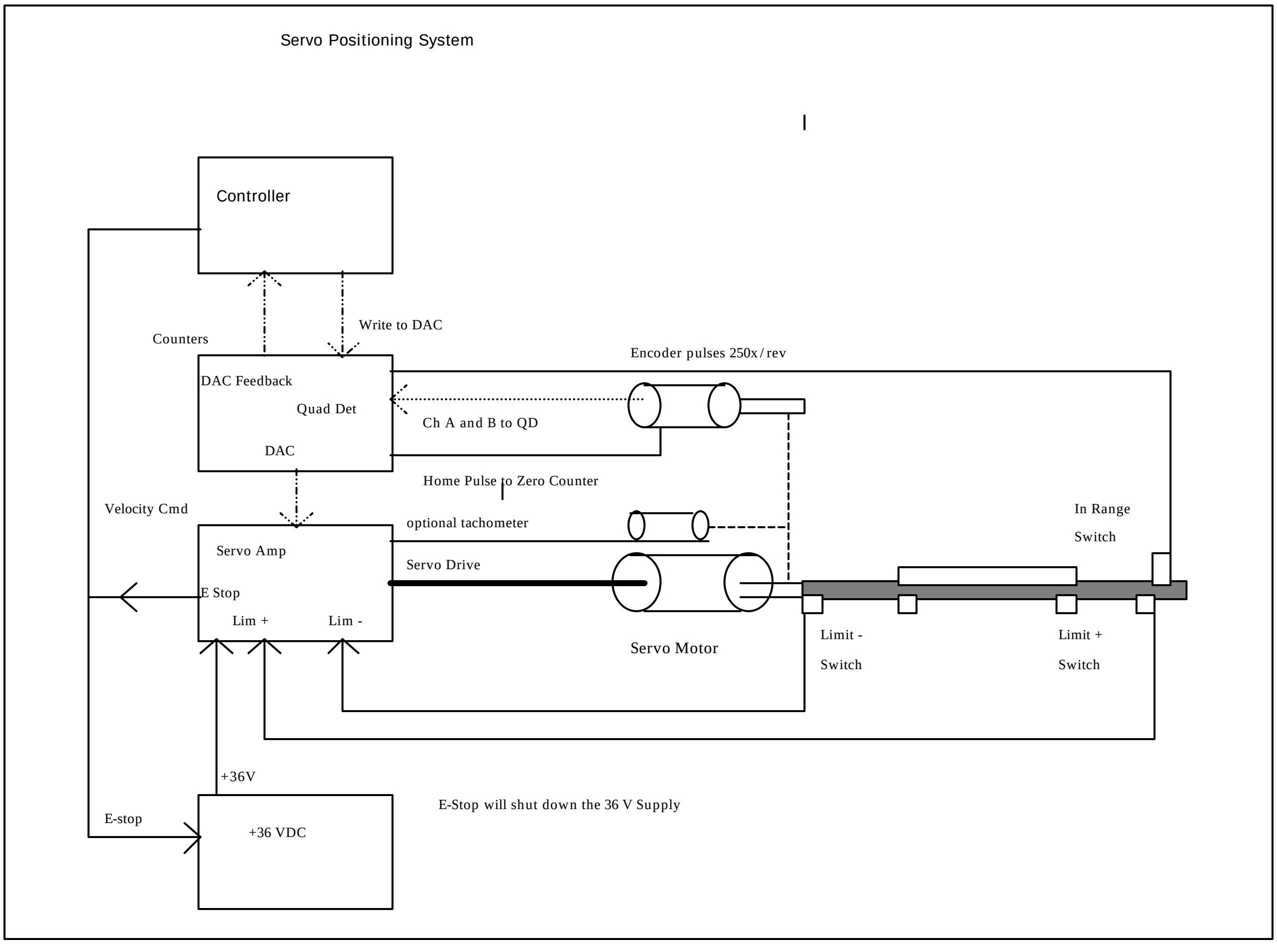
Linear response
The servo amplifier will respond proportionally to changes in the velocity-input command (a -10V to +10V signal). The servo amplifier uses the analog velocity command to drive the amplifier at any speed from reverse to forward. The amplifier controls the motor speed by varying the duty cycle (PWM) of the drive transistors (transistors operate as switches).

Hold Position
The servo amplifier must be drive the servo motor in such a way so that the motor can hold a position regardless of inertia from a previous movement or any external force that may push on the table in its axis. The servo amplifier will actually oscillate (critically damped) whenever the velocity command is zero volts (assuming the amplifier is offset-nulled). The oscillation is actually the fwd and rev bridge drivers alternating to hold a position. The servo amplifier may have a gain selector (switch) and must be set according to the servo motor used. Mismatching the gain will create an under-damped response and cause excessive oscillation when the velocity input is zero. Actual tachometer signal from a tachometer on the motor assembly or the actual motor terminal voltage can be the source of tachometer feedback.

Overload protection
Drive current is sensed using a low resistance (0.1 ohm resistor) current to voltage circuit on each side of the drive bridge, when excessive current is sensed (high voltage drop) the amplifier will trip the solenoid breaker by energizing it.

Travel Protection
Limit switches on the table positioning system are depressed whenever the table is driven to

extremes, these limit switches are located on the machine at opposite ends of each axis travel. The limit switches are wired to their respective servo amplifiers, when activated (low), the servo amplifier will be disabled. The servo amplifier will also activate the e-stop output to signal the machine controller of trouble, the e-stop signal is also used to interrupt the 36 VDC power to the servo amplifiers.



Closed Loops Servo Systems

Analog Positioning

The machine controller issues a digital velocity command to the DAC Feedback card based on programmed coordinates. The DAC outputs a corresponding analog velocity signal to the servo amplifier velocity input. The amplifier compares this velocity command to the tachometer feedback from the motor. The error (difference) signal causes the servo drive to deliver DC pulses (via PWM) to the servo motor. The servo motor begins moving and a resulting tachometer voltage is again summed with the velocity command to generate a new error signal. The motor will continue accelerating until the motor speed and the resulting tachometer feedback signal equals the original analog velocity signal. The motor velocity stabilizes when the signals match.

Digital Positioning

At the same time the encoder is providing pulses back to the DAC Feedback quadrature decoder and up/down counter. The controller software now compares the programmed position to the actual position of the axis by reading the up/down counter registers on the DAC Feedback card. The controller will generate the appropriate digital velocity command to ramp up and ramp down the velocity when repositioning an axis. Once the position is reached, the controller outputs a zero velocity and the closed loop servo system will attempt to hold that position with a minimum overshoot and damped oscillation.

Zeroing

The machine zeroing function will drive all axis to a home position to zero the up/down counters of the respective DAC Feedback cards. Each axis will first trigger an in range switch as the axis position approaches the home position. Once the in-range switch is made, the DAC Feedback then awaits the home pulse from the encoder to precisely zero the counters at a specific physical location. Since the encoder only has one home pulse per revolution it is possible for a position displacement from the encoder rotating nearly 360 degrees from the onset of the in range switch before the counters zero. If a limit switch is made in this space, the axis will fault before completing the zeroing. Once the axis reaches the home position, the controller will generally drive all the axis to a "park position" that is located in a desirable location to allow board transfers or manual loading.

Trouble Shooting Advice

- Tripped servo amp electrical circuit breakers will usually indicate a shorted servo amplifier.
- If the servo amplifier is faulty, there is a possibility the servo motor has internal carbon shorts between the positive or negative terminal and the case. Since either of these leads can have a positive or ground potential, the motor can create a short circuit of the drive signal. Measuring the motor terminals with the servo wiring removed should measure near infinite electrical resistance between each terminal and the motor case. Low resistance indicates an excessive carbon buildup from the motor brushes. Attempting to clean this carbon dust with compressed air or solvents is not recommended, motor replacement is.
- Axis oscillation can be caused by mechanical adjustments such as a anti backlash coupler.
- Consistent axis position error post zeroing can occur when the encoder and in-range switches need adjustment.
- On zeroing, if gross errors randomly occur suspect a faulty encoder (missing home pulse) or faulty DAC Feedback card.
- If random positioning errors occur suspect a faulty encoder (channel A and B pulses) or a faulty DAC Feedback card (quadrature decoder or up/down counters).