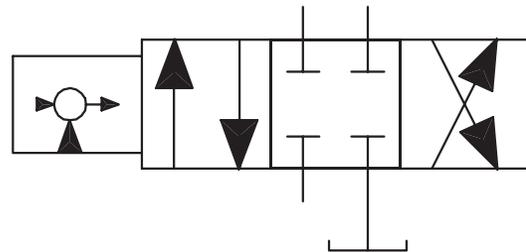


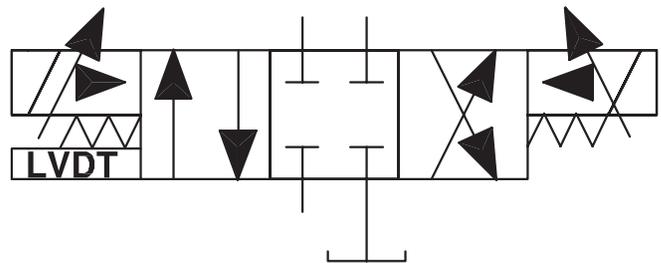
Servo and Proportional Valves

Servo and proportional valves are used to precisely control the position or speed of an actuator. The valves are different internally but perform the same function. A servo valve normally utilizes an internal mechanical feedback device. Proportional valves usually have an electrical feedback, commonly called an LVDT.



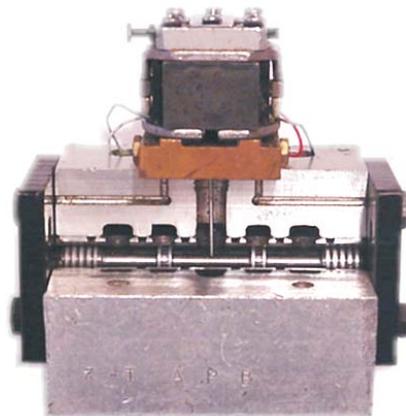
Servo Valve

Both valves operate from a variable D.C. Signal. The command voltage input into the valve amplifier is usually + or - 10 volts. The amplifier then converts the voltage into a current signal to drive the valve. Normally a positive voltage will shift the valve spool into the "A" position, a negative voltage will shift the valve spool into the "B" position. The valve spool shifts directly proportional to the strength of the command voltage.

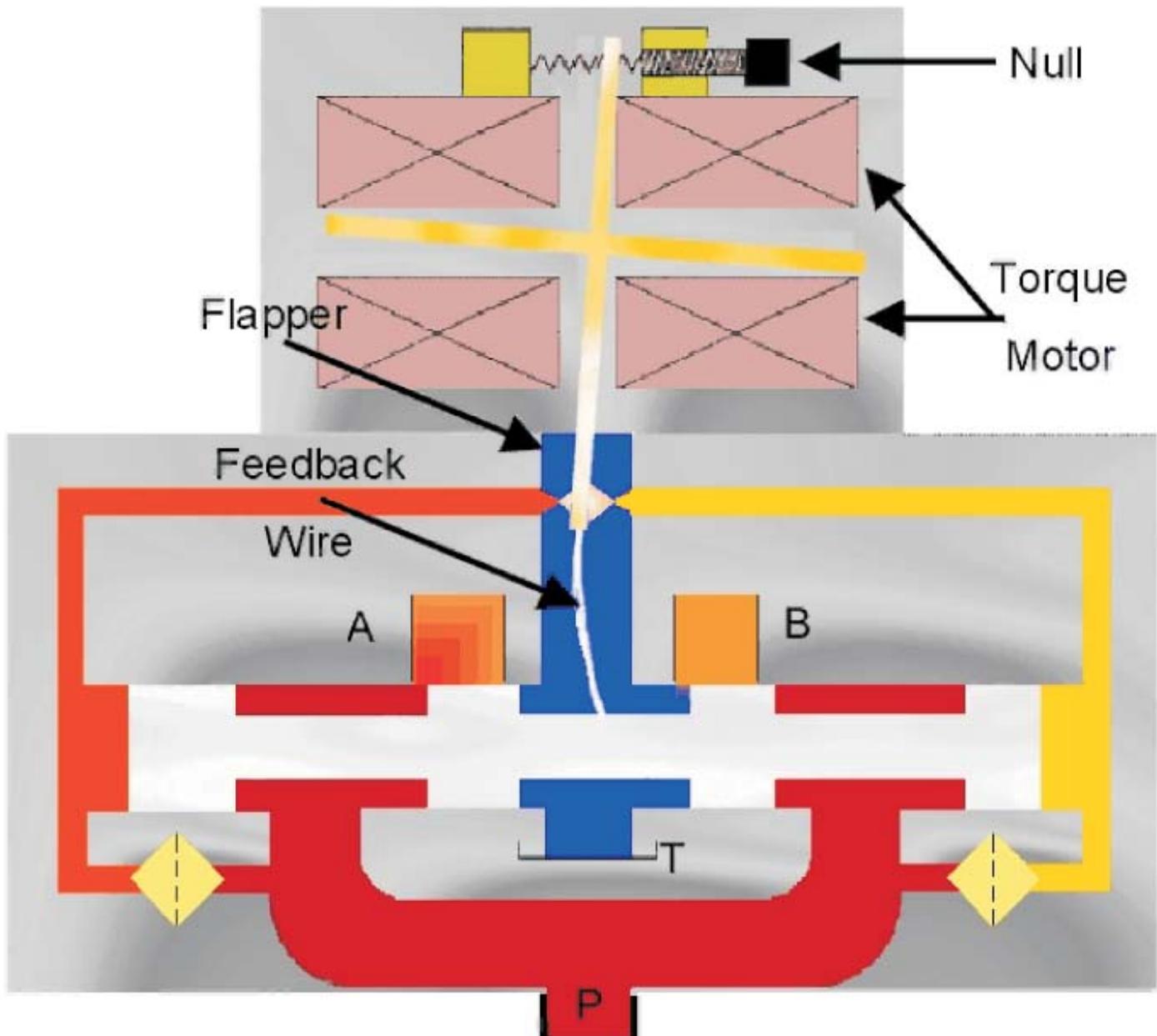


Proportional Valve

The higher the voltage the more oil can flow through the valve. The valve controls both the direction and speed of the actuator. Filtration to the servo valve is normally 3 micron. Most proportional valves only require 10 micron filtration. Although proportional valves have improved in recent years, servo valves are usually more accurate and can position a cylinder to within .001".



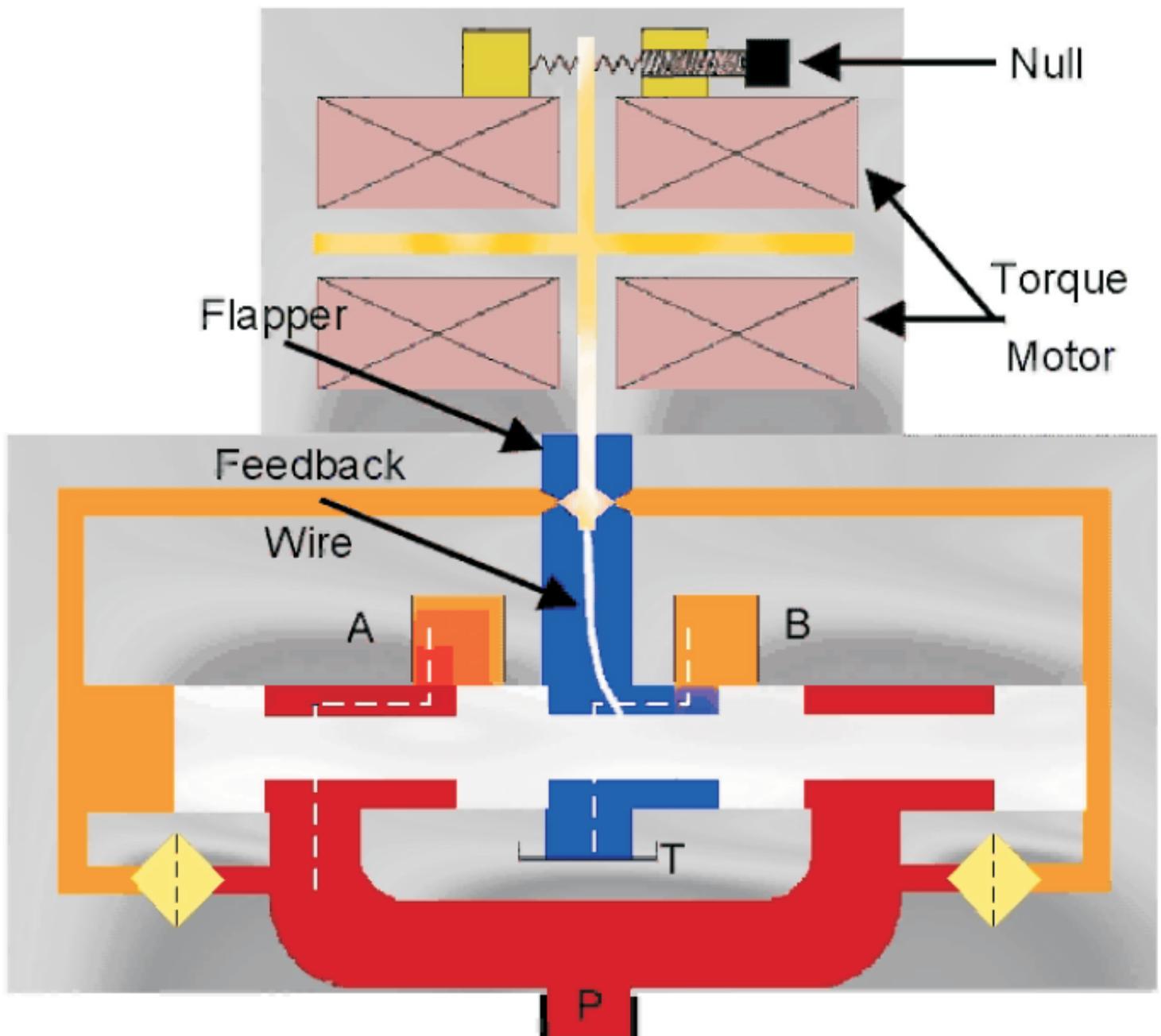
Servo Valve



When a current signal is applied to the valve coil, the torque motor rotates, moving the flapper closer to the left nozzle. Pilot pressure builds up on the left side of the main spool. The valve spool shifts, connecting the P to A ports and the B to T ports. As the spool shifts, the feedback wire bends.

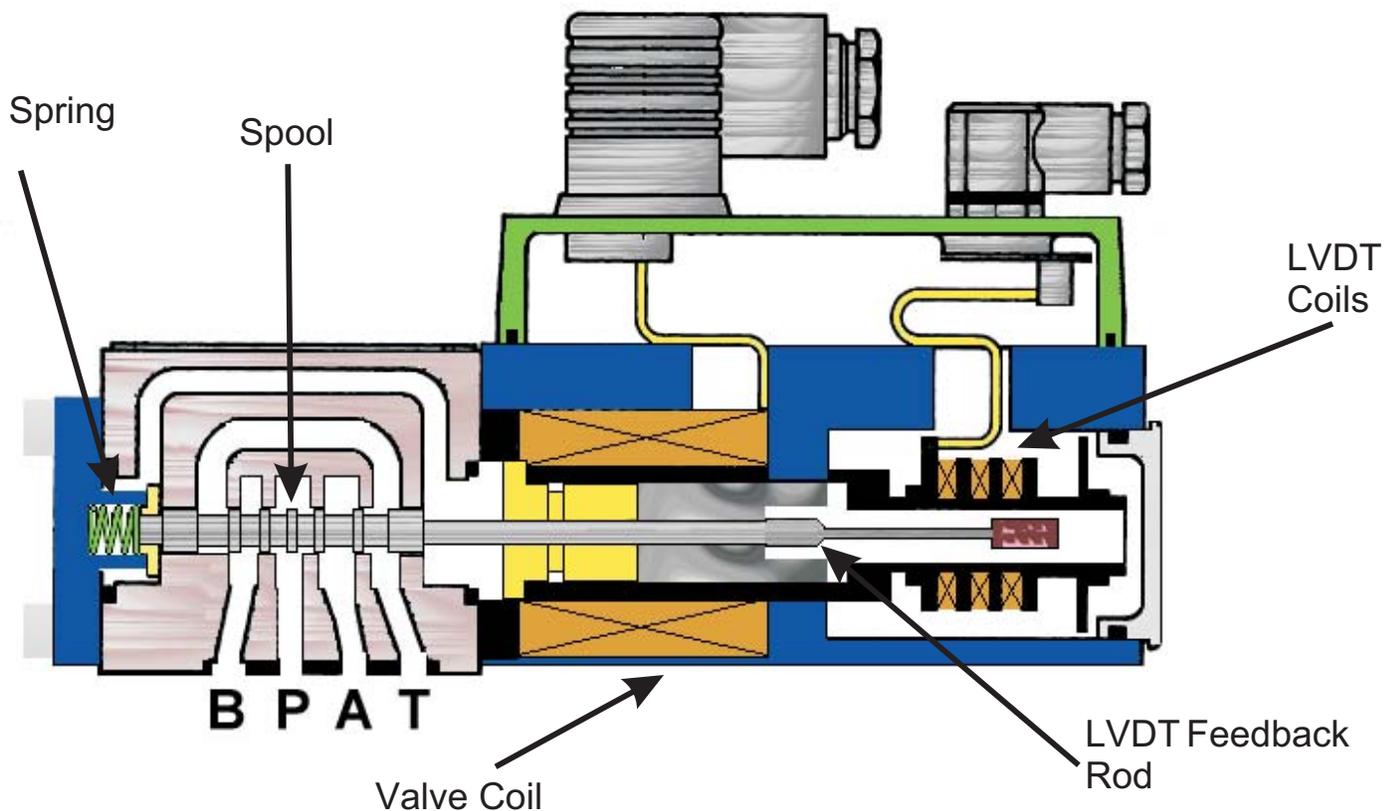
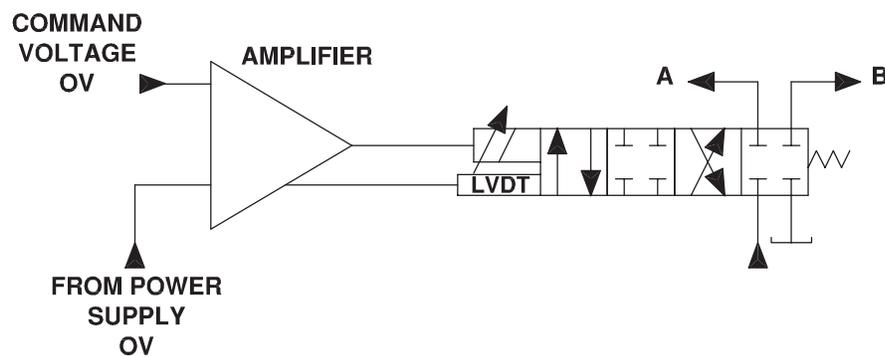
Servo and Proportional Valves

The spool will continue shifting until the torque on the feedback wire overcomes the electrical force on the torque motor. At that time the torque motor is returned to the horizontal position. At the same time, the flapper re-centers between the two nozzles. This causes an equal pressure on both sides of the main spool once again. The main spool stops shifting and remains in that position until the voltage is changed. The higher the current to the coil, the more the valve spool will shift.



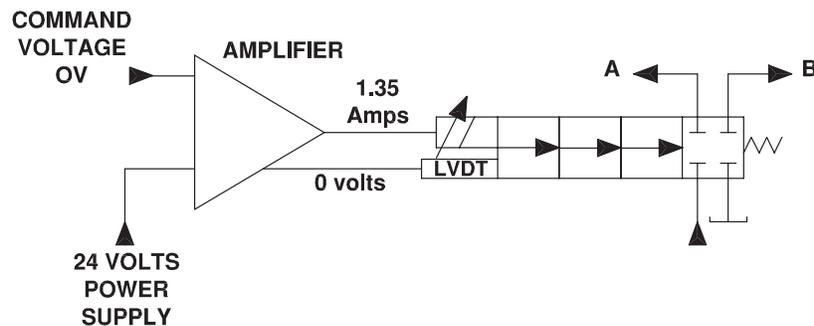
Direct Operated Valves

Direct operated valves are used to control the direction and speed of a motor or cylinder when the flow requirements are approximately 18 GPM or less. The valve shown below is called a four position valve. When there is no current applied to the valve coil, the spring will shift the spool into the position shown on the far right. This is known as the fail safe condition. All flow is blocked through the valve in this position. On some valves a “float” position is used as the fail safe position. An LVDT is used to electrically indicate the position of the spool.

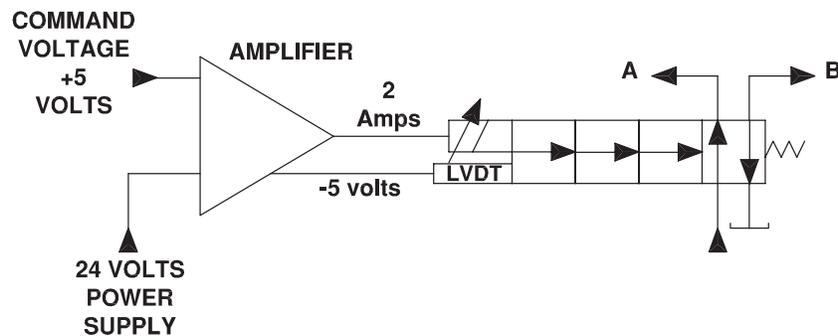


Servo and Proportional Valves

When the power supply is turned on, 24 volts is supplied to operate the amplifier. The LVDT will immediately send a voltage back to the amplifier of -12 volts. Notice that the command voltage is 0 volts. A current of approximately 1.35 amps will then be applied to the valve coil. This pulls a plunger in by magnetism which shifts the valve spool. As the spool shifts, the LVDT electrically indicates the spool position. The valve will continue to shift until the LVDT and command voltage both equal 0. The valve will then be in the “electrically closed” position.



To operate the actuator a positive or negative command voltage is input from the PLC. In the example, a +5 volts signal is used. The current is then increased to the coil which shifts the spool into the “A” position. The spool will shift until -5 volts is fed back by the LVDT. At that time, the command voltage(+5) and feedback voltage(-5) equal zero. The speed of the actuator is determined by the amount that the spool shifts. Increasing the command voltage will allow the spool to shift more into the “A” position. More oil will be directed through the spool to move the actuator at a faster speed.



Two Stage Valves

The two stage proportional valve is similar in operation to a standard solenoid controlled, hydraulic piloted directional valve. The main difference is that the positions of the main and pilot spools are many times electrically indicated by an LVDT (Linear Variable Differential Transformer). This allows the main spool to shift in direct proportion to the current applied to the pilot valve coil.

The pilot valve usually has four positions. When there is no signal from the amplifier the pilot valve spool will be in the “float” position. The pilot valve is only in this position in the power off mode or if the voltage signal from the amplifier is 0. This is sometimes known as the “fail safe” position because it directs any pressure on both sides of the main spool back to the tank.

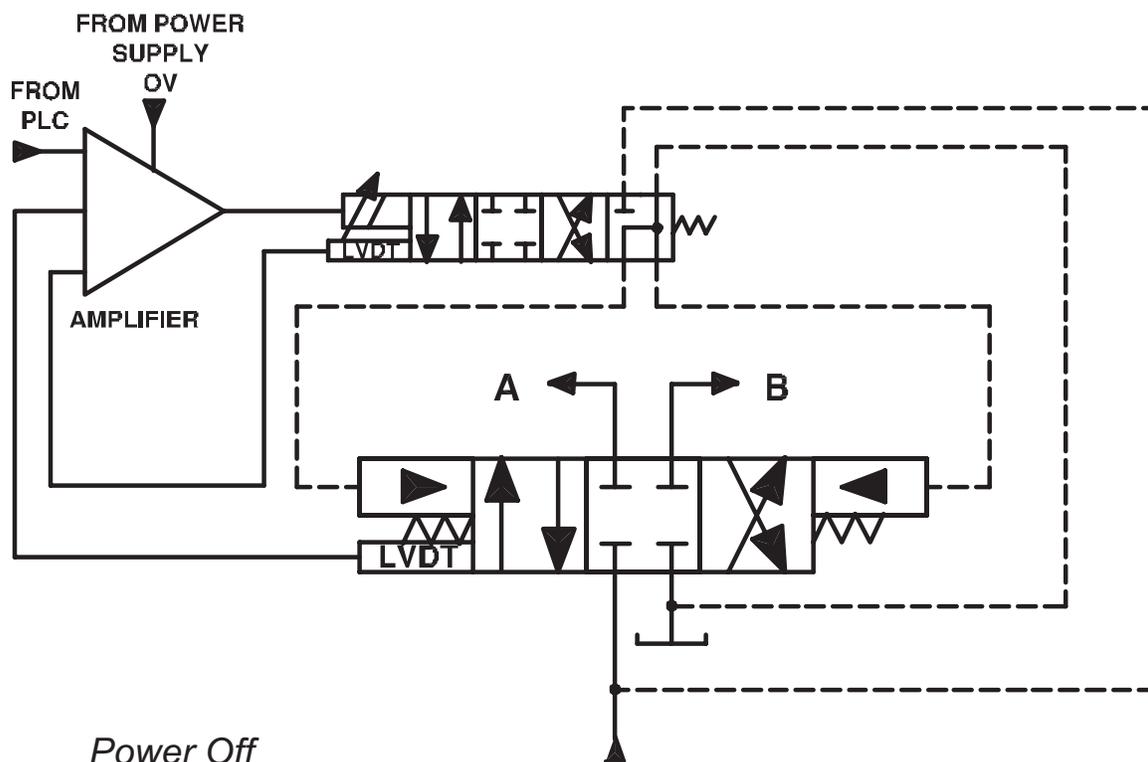
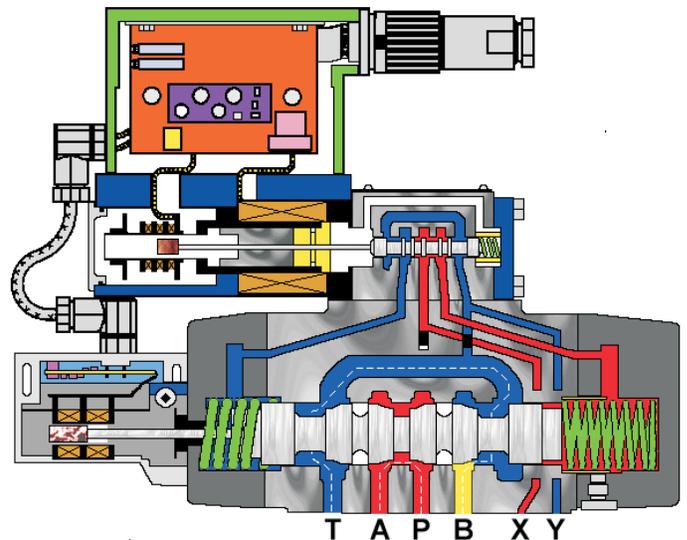
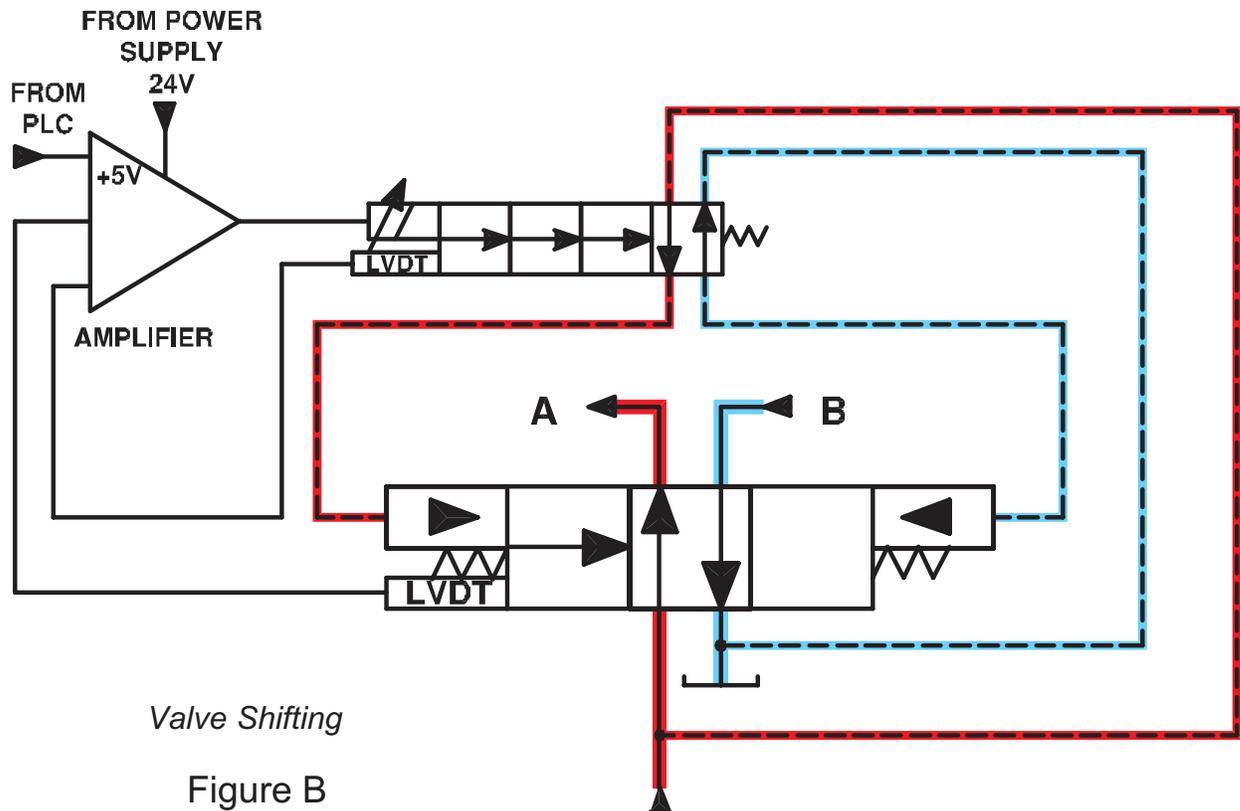


Figure A

In Figure A, the main spool is spring centered to the closed position because the pilot valve spool is in the fail safe position. Flow from the pump and accumulator is blocked to the cylinder or motor. Some systems will remove the current to the pilot valve if the main spool LVDT signal fails, a e-stop is activated or there is no “enable” signal from the PLC. If the linear positioner does not move to the proper position or the transducer fails, the current to the pilot valve may also be removed.



When a +5 volt signal is input into the amplifier (Figure B), current is applied to the pilot valve coil to shift the valve spool into the “A” position. Pilot pressure is then directed through the pilot spool to shift the main spool into the “A” position. As the pilot and main spools shift, the LVDT’s send voltage signals back to the valve amplifier proportional to the amount of movement. The main spool continues shifting until the D.C. signal from the LVDT (-5 volts) and the command voltage equal 0. At that time the pilot valve spool is electrically shifted closed, blocking flow to the main spool (Figure C). The LVDT on the pilot valve indicates when the pilot valve spool is in the closed position. With a command of +5 volts the main spool is shifted 50%. To move the main spool again the command voltage must be changed to vary the current the pilot valve coil.

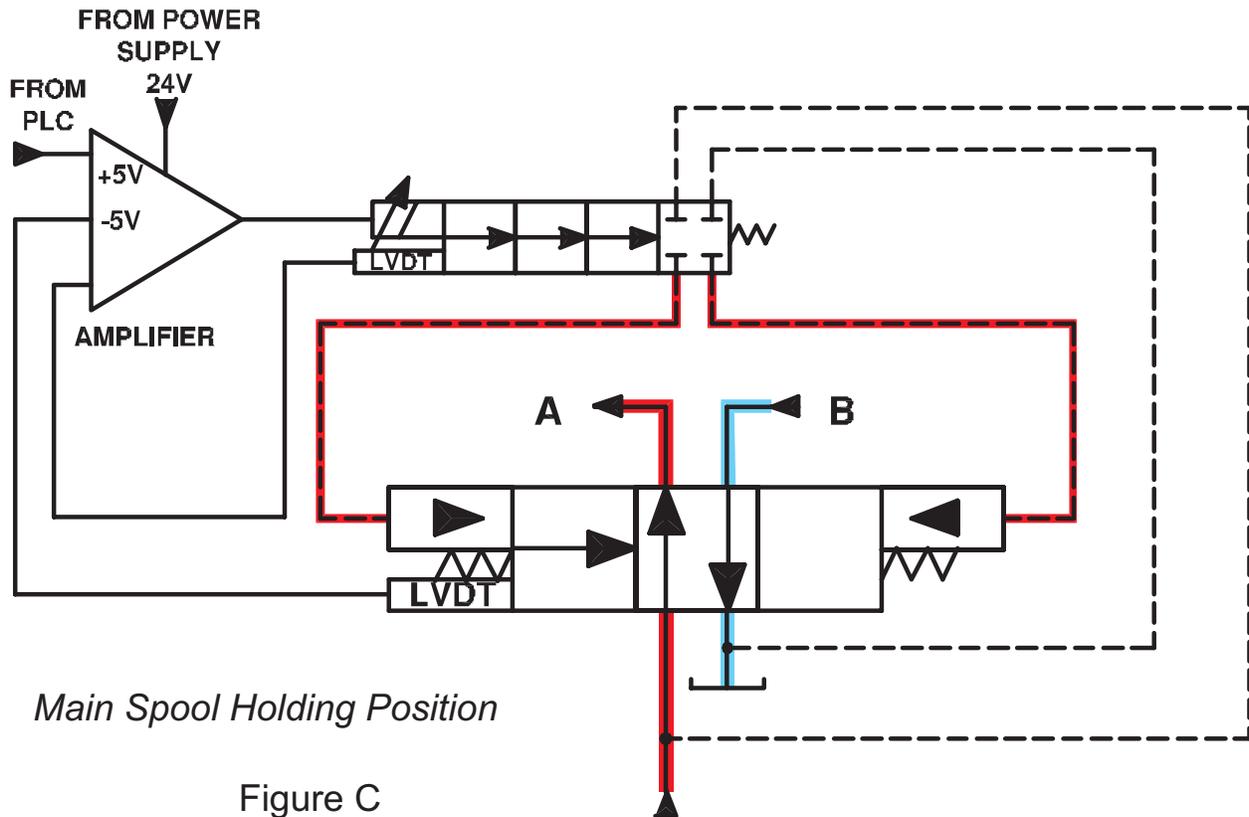


Figure C

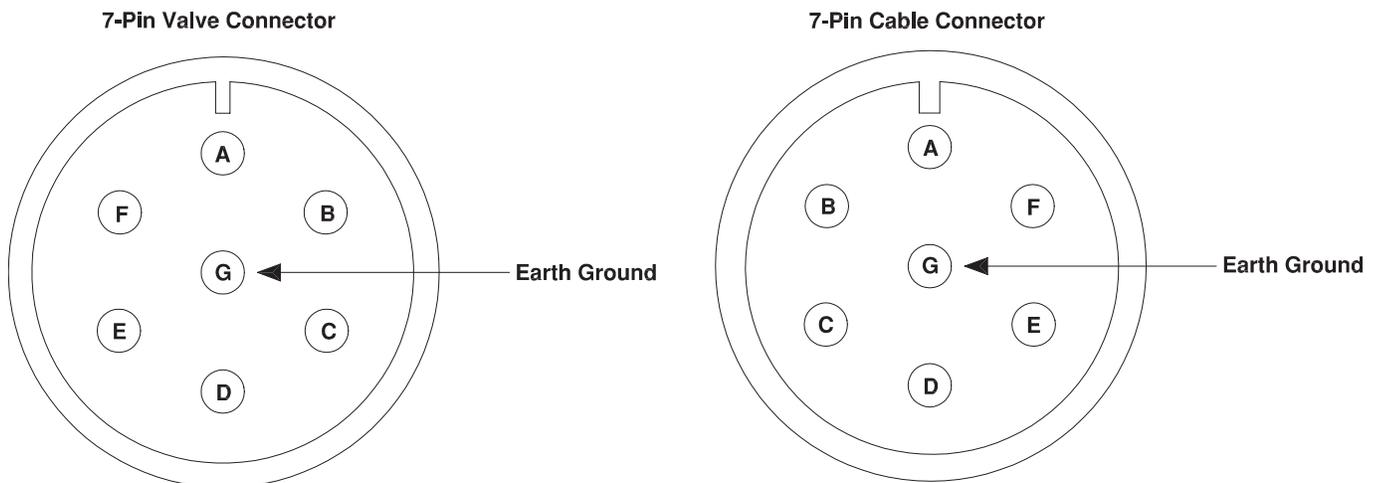
Many external amplifiers have a “Broken Wire” light that will come on if there is no signal from the main spool LVDT. If the light flickers, this means there is a loose connection. To check the proportional valve, there are two electrical tests that can be made. The hydraulic supply should be off and any pressurized fluid in the accumulator should be dumped to tank. Specific instructions and terminals for your exact amplifier should be referenced.

1. Check the command voltage to the valve amplifier that drives the pilot valve coil. If no voltage is present, then there may be a broken or loose wire or no signal from the machine controller. The coil can be checked with an OHM meter. A reading of approximately 2.4 ohms indicates that the coil is good.
2. Check the pilot valve and main spool LVDT's. This is done by checking the feedback signal from each LVDT with a voltmeter at the amplifier. As the command voltage to drive the pilot valve coil increases, so should the feedback signal.

On Board Amplifiers

In many cases, the amplifier is mounted on the valve. The amplifier is usually powered by a 24 volt power supply. Two checks can be made when troubleshooting valves with on board amplifiers.

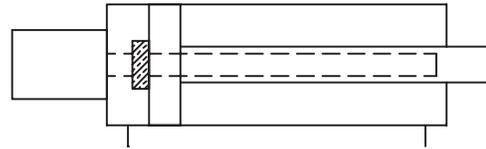
- Remove the cable and check the power supply voltage on the cable connector. Insert the red lead of the multi-tester into the “A” socket and the black lead into the “B” socket. 24 volts should be indicated.
- Check the command voltage to the valve amplifier. This is done by inserting the red lead into the “D” socket and the black lead into the “E” socket. A positive or negative 0-10 volt signal should be indicated when a command is given to drive the valve.



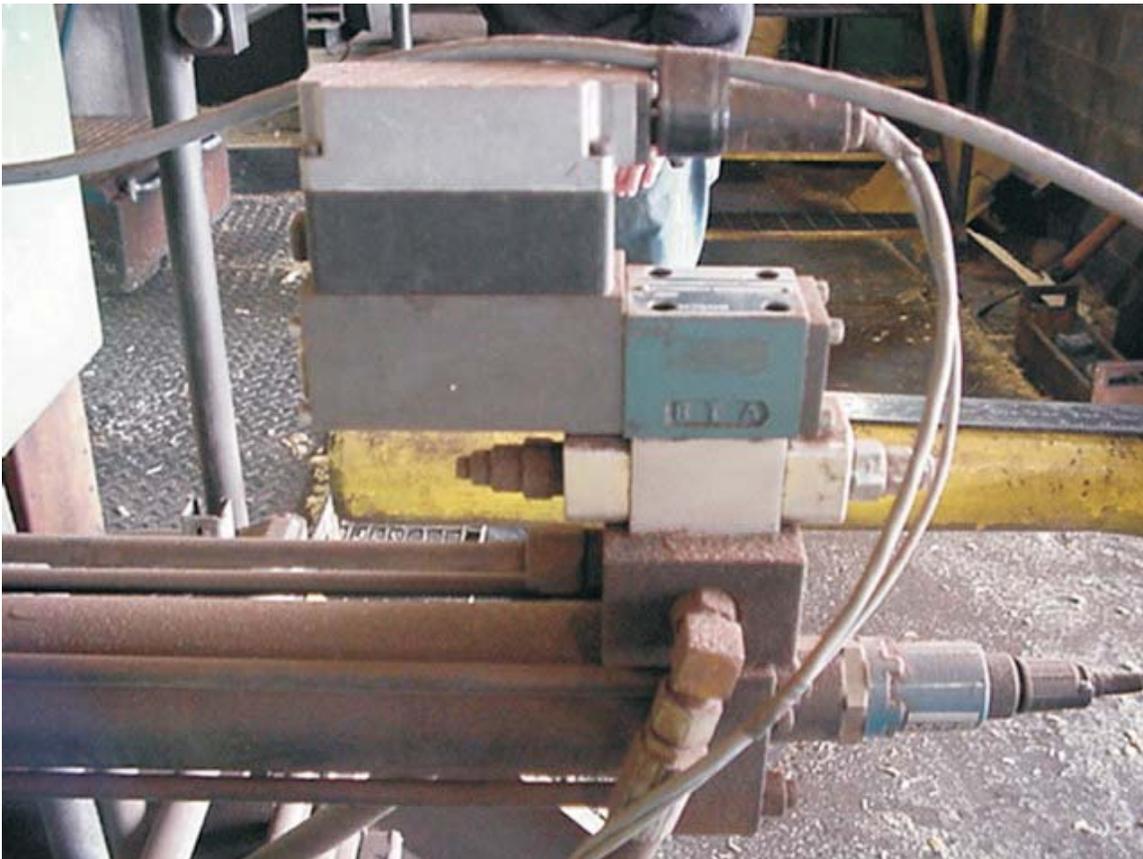
A - Power Supply + 24 Volt
B - Power Supply 0 Volt
C - LVDT Feedback 0 Volt
D - Command Signal 0 to + or - 10V
E - Command Signal 0 to + or - 10V
F - LVDT Feedback 0 to + or - 10V
G - Earth Ground

Linear Positioner

Cylinders used with servo and proportional valves usually have a feedback device such as a Temposonic transducer to indicate cylinder position. The transducer tube fits down inside the hollow rod of the cylinder. A magnet is bolted onto the cylinder piston. Electrical current pulses are sent through the transducer tube. As the cylinder piston moves, the magnet interacts with the current pulses. This magnetic “strain” electrically indicates to the transducer the position of the piston.



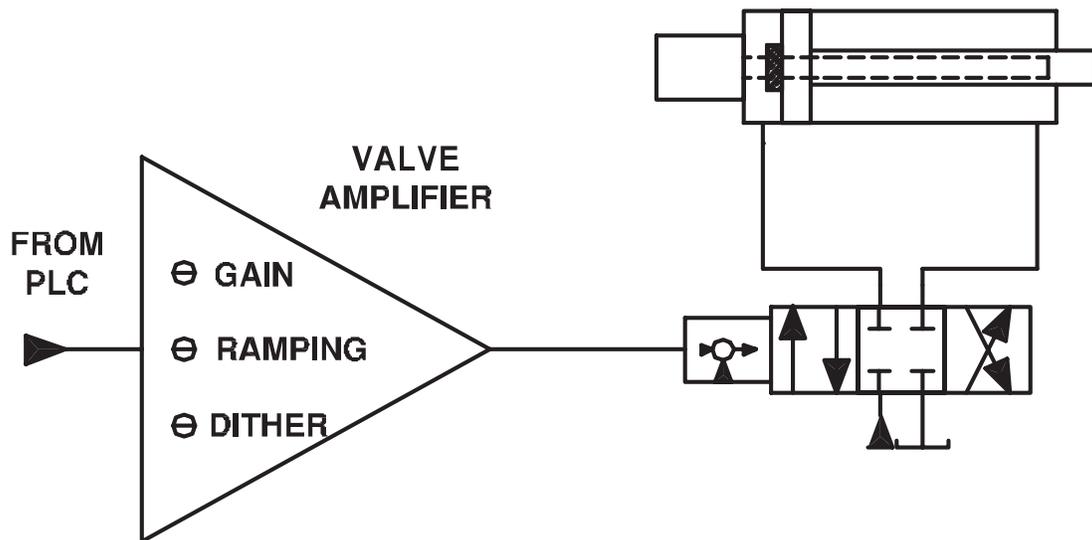
The transducer then sends digital pulses back to the machine controller indicating the precise position of the cylinder.



Hydraulic Cylinder with a Temposonic Transducer

Valve Amplifier

Most servo and proportional valves require valve amplifiers. The primary purpose of the amplifier is to boost the signal from the computer to drive the valve. The amplifier will also convert the input voltage into a current signal to drive the valve. Many times there are adjustments in the amplifier that affect the D.C. voltage to the servo or proportional valve.

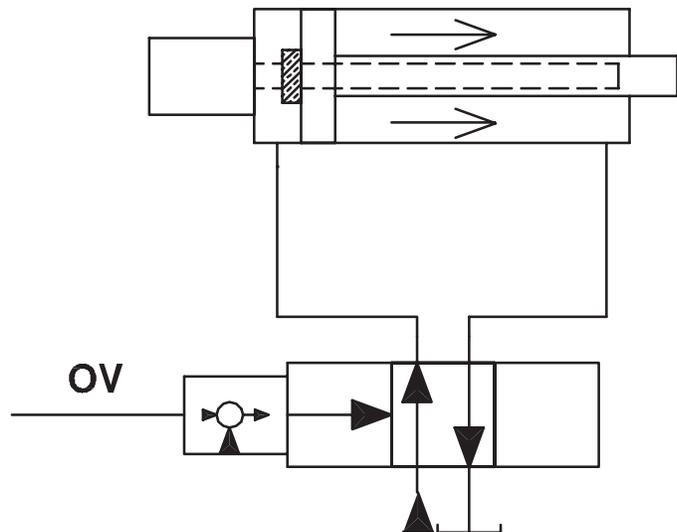


- Gain is the amount that the voltage increases from the computer to the servo or proportional valve. The gain should be adjusted so that the cylinder moves at the desired speed. If the gain is too low, the operation will be sluggish. Setting the gain too high will cause the valve to be unstable and cause poor positioning of the cylinder.
- The ramping adjustment controls the amount of time that the valve spool shifts. For example, if the gain is set to 10V and the ramp is set for $\frac{1}{2}$ second then the signal to the valve will gradually build to 10 volts in $\frac{1}{2}$ of a second. On amplifiers with a single ramp adjustment, the voltage will ramp down in the same amount of time. Some amplifiers have separate adjustments for ramping up and down. The ramps should be adjusted so that the cylinder starts and stops smoothly.

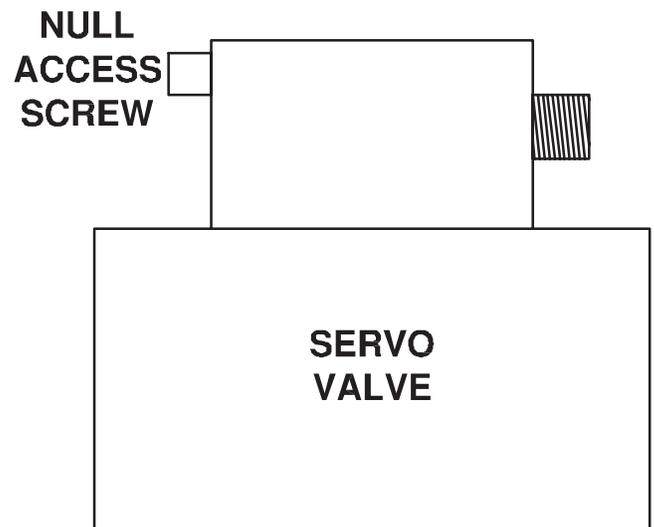
Troubleshooting and Adjusting the System

Nulling the Servo Valve

A valve that is out of null will allow the cylinder to drift when there is no voltage to the valve coil. The main spool will be either in the “A” or “B” position. This occurs because there is a higher pilot pressure on one end of the valve spool.



The system should be at normal temperature when nulling the valve. To null the valve, the electrics should first be disconnected. Remove the null access screw to get to the allen head null adjustment. On some servos the null adjustment is located on the main spool.



The null is usually a 1/8" or 3/16" allen head. If possible use a brass wrench as it won't interfere with the magnetism in the coils. Observe the cylinder drift while nulling. The adjustment should not be turned more than 1 or 2 turns maximum. When the cylinder stops drifting, the valve is nulled.

The null should not have to be continually adjusted once set. The valve can get out of null if the temperature or pressure changes are more than approximately 5%. Coolers and heaters on the reservoir should be set to turn on and off to maintain a constant temperature.

Nulling the Proportional Valve

Depending on the type of valve that is used, the null or "bias" adjustment may be in the amplifier or on the valve itself. On many valves made by Moog, the null is located on the end of the LVDT housing. A threaded pan screw has to be removed to access the allen head adjustment. The electrical cable should remain connected when nulling the valve. Whether on the valve or in the amplifier, the adjustment should be made in small increments until the drifting of the cylinder or motor stops.

Servo and Proportional Valve Troubleshooting

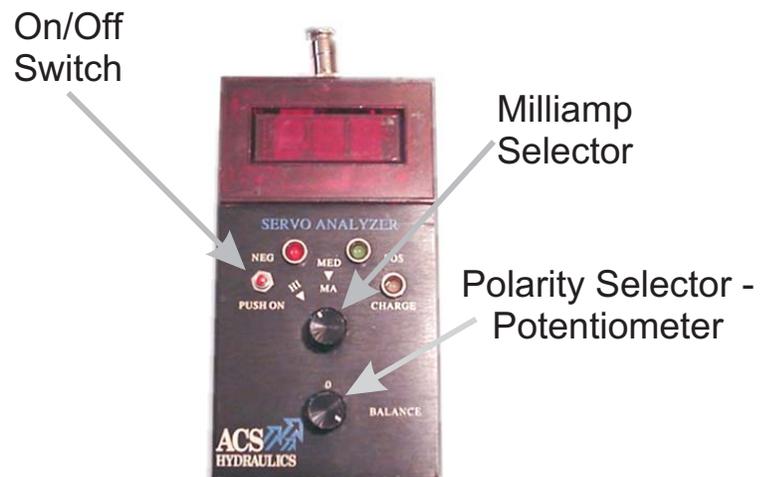
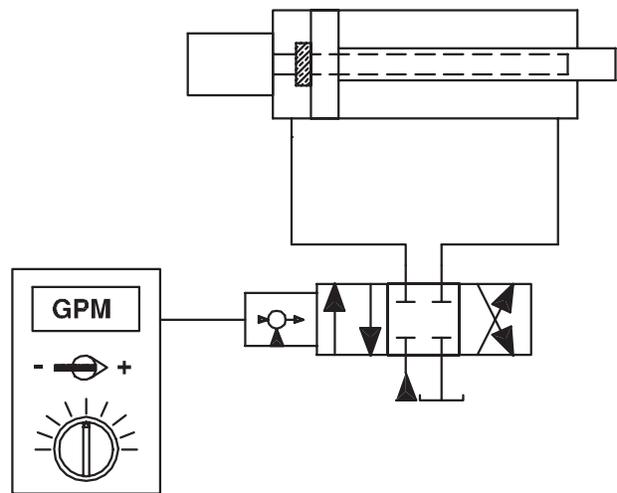
When a problem occurs in a system, the first thought many times is to change the servo or proportional valve. There are two problems with indiscriminately changing these valves:

1. Servo and proportional valves are expensive! Of valves used in plants today, the starting price is \$1500.00 and it goes up from there.
2. When a servo or proportional valve is removed, the hydraulic lines are immediately opened to airborne contaminants.

Servo and Proportional Valves

One of the first things that should be done when a problem occurs is to determine if it is electrical or hydraulic. The best way to test this is to unplug the electrical connector to the valve and plug a battery box in. If a battery box is not available to drive the valve, a 1.5 volt battery can be connected to the wires.

A battery box will normally have an on/off switch, a method for selecting a positive or negative voltage and an adjustment for increasing and decreasing the signal. The box shown is used for driving a servo valve. The position of the knob marked "Balance" determines the polarity and strength of the signal supplied to the valve coil. The box also contains a milliamp selector switch. Most servo valves operate on a 10 - 80 milliamp current signal. The switch should be set to the "Lo" setting initially to prevent overdriving the valve.

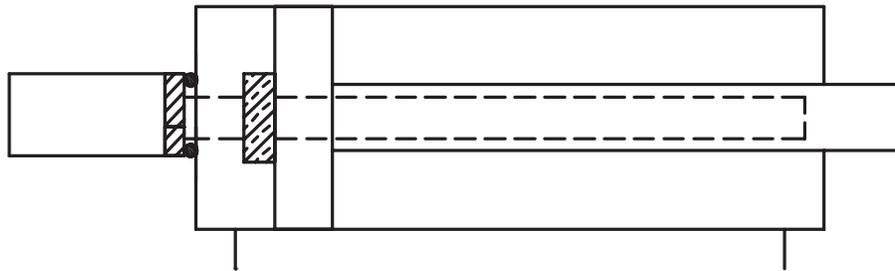


With the On/Off switch depressed and the "Balance" knob at 0, gradually rotate the adjustment in one direction until the cylinder or motor starts to move. As the signal is increased, the actuator should speed up. Once the On/Off switch is released, the actuator should stop. Repeat the test by rotating the Balance pot in the opposite direction. The actuator should move in the opposite direction and speed up as the signal is increased. Test boxes are also available specifically for proportional valves. A box can be purchased from the manufacturer of the valve. Proportional valve testers have the added feature of reading the feedback signals from the valve LVDT's.

If the cylinder operates correctly when driving the valve with the battery box but moved erratically or not at all when it was operated normally, then the problem is probably electronic. Keep in mind that you have broken the closed electrical loop, so the cylinder will not move to a specific position. If the cylinder operates OK when driving with the battery box, the linear positioner should then be checked.

Checking The Linear Positioner

The feedback signal can be checked with an oscilloscope. Some machine electrical controllers have built in diagnostics, which indicate the feedback signal. If the transducer is bad, the cylinder will usually fully extend or retract. One method of verifying that the transducer is operating is to remove the probe from the cylinder, then run a magnetic device along the tube. If the signal changes on the scope or computer screen, then the transducer is operating.

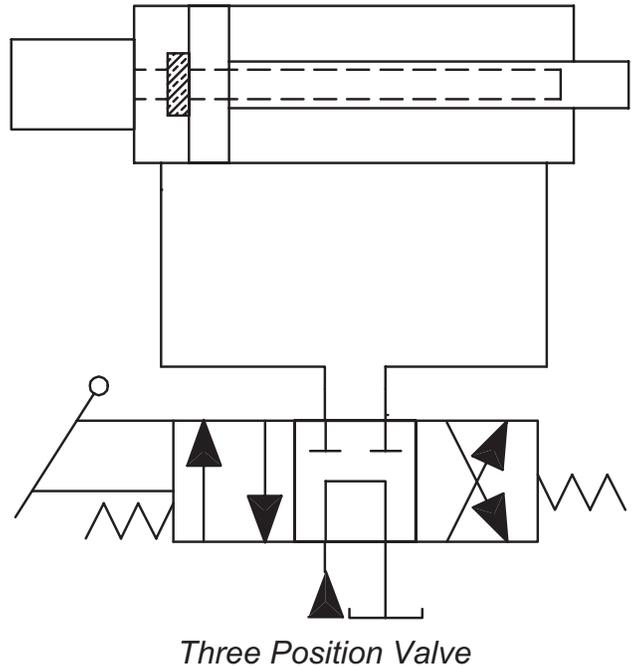


The oil temperature in the hydraulic system should not exceed 140°F (60°C). Oil starts breaking down above this temperature. Varnish or oil silting on the transducer tube will cause erratic positioning.

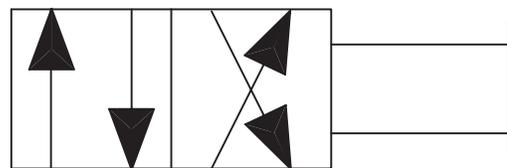
Check the electrical plug where the transducer plugs into the electrical box. Oil on this plug can cause transducer feedback problems. If the magnet is loose or cracked on the piston, then erratic positioning can also occur. If the cylinder is taken apart, the servo valve should be replaced with a flushing valve prior to operating. If the transducer is sending the proper signal back to the PLC then the problem would have to be in the PLC or valve amplifier.

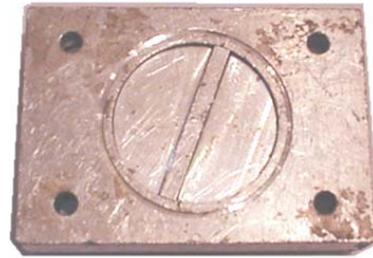
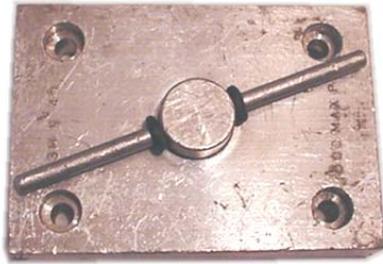
If the problem still exists when driving with the battery box, then the problem is in the servo or proportional valve, the hydraulic system or the mechanical linkage. To isolate the problem, remove the valve and place it in a clean, plastic bag. Do not put a new valve on at this time.

The next step is to install a manually operated valve. Ideally a three position, tandem center valve will make it easier to test and flush the system. An adapter block may need to be used to mount the manual valve. If a three position valve is not available, use a two position flushing valve made specifically for this purpose.



Operate the cylinder in both directions by shifting the manual valve. If the cylinder still moves erratically or not at all, then the problem is elsewhere in the hydraulic system or mechanical linkage. The hydraulic power supply should be checked as outlined in the hydraulic pump section of this manual. The mechanical linkage should be checked for jamming or binding.





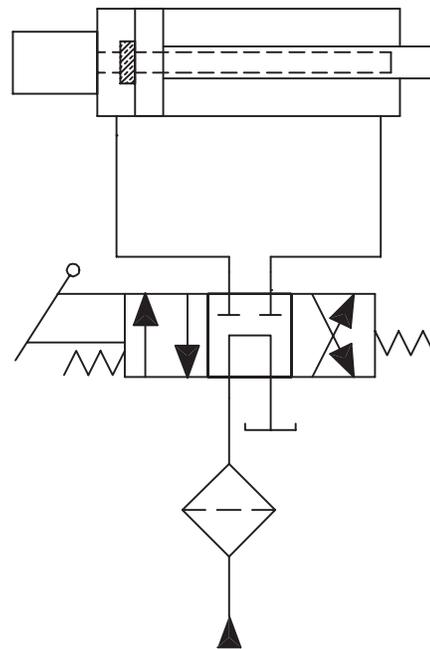
Flushing Valve

If operating the positioner with the manual valve solves the problem, then the servo or proportional valve is bad. The inclination now is to install a new valve, but most valves fail because of contamination. Installing a new valve at this time could result in immediate failure.

The system should be flushed prior to putting a new valve on. Some manufacturers recommend installing a low pressure flushing filter. The system pressure should be turned down when using this filter. If a flushing filter is not available then the existing pressure filter element should be replaced.

Operate the manual valve several times once the filter element is replaced. This flushes the contaminants in the linear positioner back to the tank. If a three position valve is used, return the spool back to the center position. If a two position valve was used, replace it with a flushing block.

The oil needs to be re-circulated for an hour or more if possible, although this is not always the real world. After flushing replace the filter element with a new one.



Flush System and Replace Filter