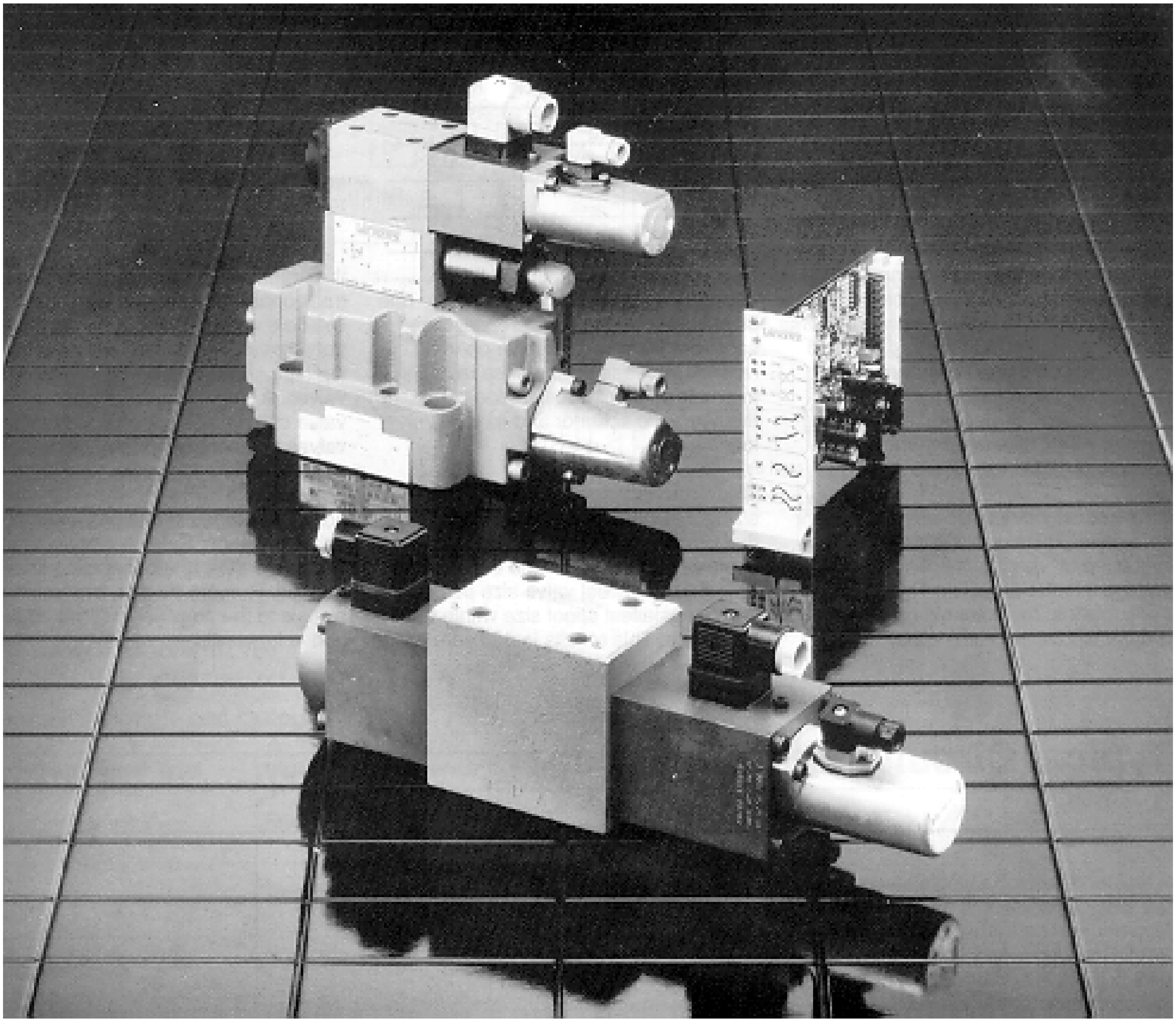
VICKERS®

Proportional Valves

Adjustment Procedure

30 Design Proportional Valve Amplifier



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General

This document describes how to set up the Vickers 30 design proportional valve power amplifiers.

The Eurocard type amplifiers covered in this procedure are listed below. More detailed information on the power amplifiers can be found in Vickers catalog GB-C-2007C.

AMPLIFIER	VALVE
EEA-PAM-523/525-A-30	K*G4V-3/5 Non-feedback valves
EEA-PAM-533/535-A-30	KFG4V-3/5
EEA-PAM-561-A-30	KFDG5V-5/7
EEA-PAM-568-A-30	KFDG5V-8
EEA-PAM-581-A-30	KHDG5V-5/7/8

This procedure may also be applied to the EEA-PAM-5**-C-30 and partially to the EEA-PAM-5**-B-30. Refer to Vickers catalog GB-C-2007C for more detailed information on these power amplifiers.

This is an easy-to-use procedure for anyone with a little understanding of how proportional valves work.

Proportional valve solenoids are current controlled. This current is usually regulated by varying the command voltage into the amplifier. The greater the current to the solenoid coil, the greater will be the valve spool displacement (travel) and oil flow through the valve. By controlling the rate of current increase or decrease, the spool displacement or valve opening rate will increase or decrease resulting in acceleration or deceleration control of the hydraulic actuator and its working load.

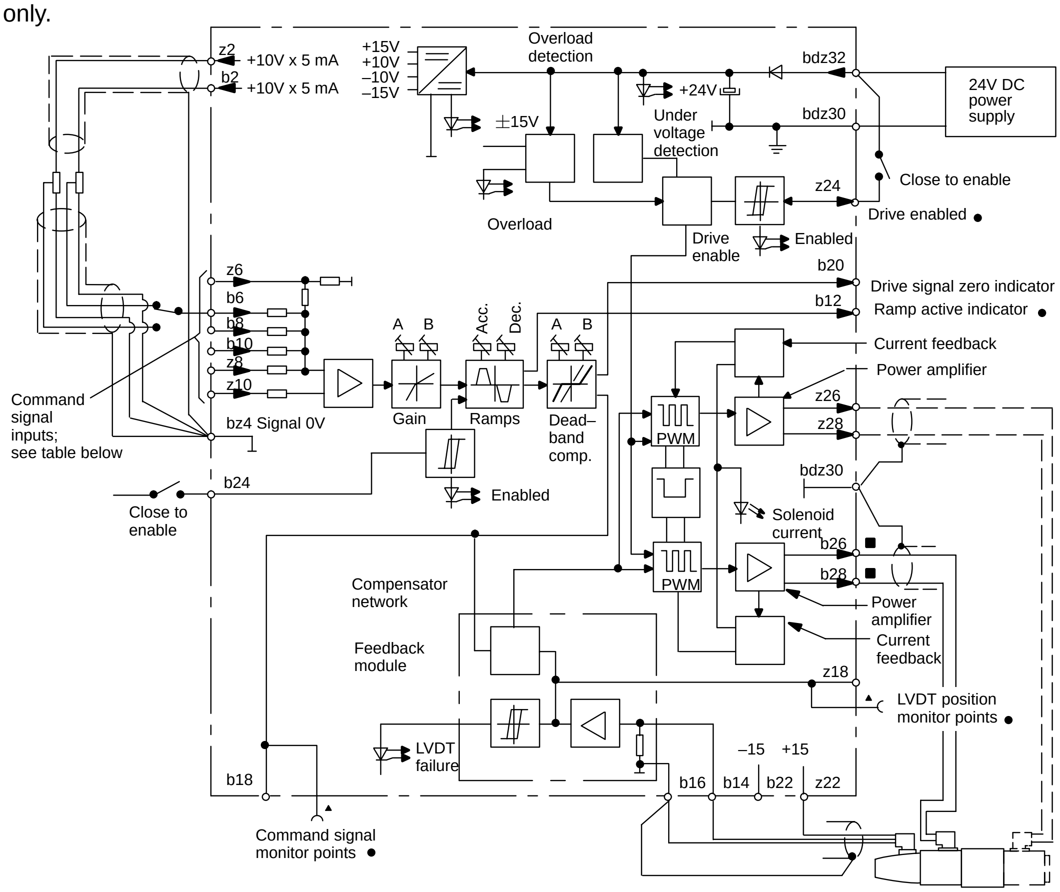
This document does not deal with valve sizing. However, it should be recognized that proper sizing will directly affect the control of acceleration and deceleration. Select the smallest valve size possible and the smallest spool size within that valve size. This results in pressure drop through the valve that exceeds levels traditionally experienced with on-off solenoid valves. Smooth speed change transitions are obtained as compared to the high shock with on-off solenoid valves. A single proportional solenoid valve can replace several conventional valves in a control system. Deceleration valve, acceleration valve, flow controls and solenoid switching valve functions are all packaged in one proportional valve envelope. Smaller manifolds and fewer hydraulic interconnecting lines are needed. Remote electric, programmable signals to the amplifier controls all of the above functions.

Typical Circuit and Connections

A typical circuit for a single stage feedback type valve in an open (outer) loop application is shown in Figure 1. A 24VDC power supply is connected to pins bdz32 (+) and bdz30 (–). An enable switch connected between bdz32 and pin z2a is required. The valve is connected according to the circuit diagram. A (+) or (–) 10V at 5mA reference is provided for command voltage control. When wired as shown in the diagram, the control pots should be 2000 ohms or greater. If the pot is to be connected across the (+) or (–) pins z2 and b2, the minimum pot size should be 4000 ohms.

Circuit and Connections

Note: Connect all shields
at card end only.



▲ On front panel
■ To solenoid adjacent to LVDT

Command Signals and Outputs

Command Signal Type	Input Pins Reference	Signal Polarity	Secondary Pins Reference	Valve Flow
Non-inverting voltages	b6/8/10 or z8	+	bz4	P–B
		–		P–A
Non-inverting current	z6	+		P–B
		–		P–A
Inverting voltage	z10	–	Link (connect) one of b6/8/10 or z8 to bz4	P–B
		+		P–A
Differential voltage		–	One of b6/8/10 or z8	P–B
		+		P–A
	One of b6/8/10 or z8	+	z10	P–B
		–		P–A

Figure 1

Setting Up The Amplifier

The basic procedure is a top-down approach. See Figure 2. The top section on the front face of the amplifier has several indicating lights (LED's). They indicate when the 24V power is on; if command control voltage is working; if the enable switch is closed; if there is an overload caused by improper wiring; a short condition internal or external of the amplifier that results in over current; or if there is current to a solenoid. In the latter case, the light brightens with increased current.

Though set-up is from the top, down, it is best to explain gain control first. Gain adjustments are the lower two pots in the second box from the top, on the front face of the amplifier.

Drive (solenoid) enabled, yellow LED

Drive enabled (power available to solenoid)	Apply >9,8V to <40V at z24 (22 kΩ)
Drive disabled (no power to solenoid)	Apply open circuit or up to 4,5V at z24

±15V control supply output, green LED

Output voltages, for control:
At pins z22 and b22

At pins z2 and b2

±15V × 50mA
Ripple <50 mV pk.-to-pk.
±10V (±1%) × 5 mA.
Ripple <20 mV pk.-to-pk.
Temperature drift <1 mV/°C
(<0,5 mV/°F) thru 0-60°C
(32-104°F) range
All outputs short-circuit protected

24V power supply input, green LED

Power requirements

24V DC nominal × 40W
Maximum voltage range:
20-40V (including ripple)
Maximum ripple: ±10% pk.-to-pk.
Amplifier shuts down below 18V DC
Reverse-polarity protected

Overload protection, red LED

Factory set
Automatic reset when fault removed

Overload, red LED

Overload detection, factory-set
Automatic reset when fault removed

Drive to solenoid, yellow LED

Deadband compensation pots

Gain pots

Ramp pots

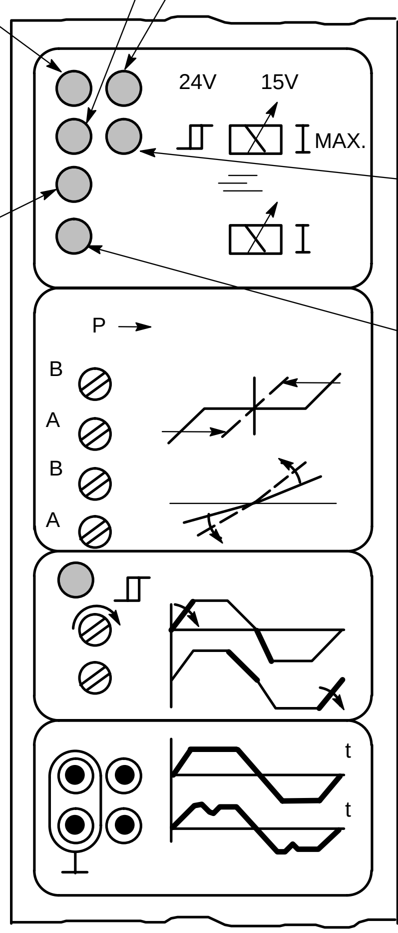
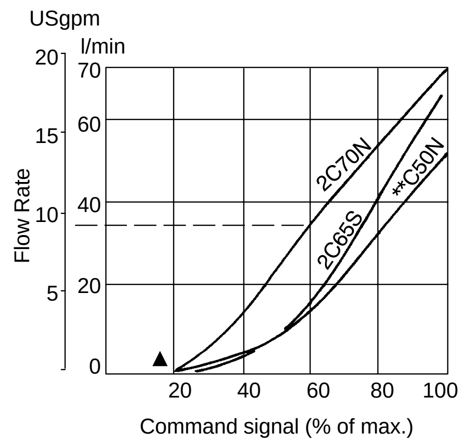


Figure 2. Proportional Valve Amplifier

Gain Adjustment

Figure 3 is a typical flow-gain curve. Flow is plotted on the vertical axis and percent of maximum command signal on the horizontal axis. With 10 volts applied to pin b6 (Figure 1) and no adjustments made to the deadband compensation, gain or ramp pots, the valve spool will move to the full open position allowing maximum oil flow through the valve. If a lesser command voltage were applied, for example, 60% (6 volts) flow would be about 9.0 USgpm. Valve opening is directly proportional to the input command voltage to the amplifier.
Note, that it takes about 20% of command voltage to overcome the valve spool overlap to start opening the flow path. This percentage varies with valve type and spool type. It can range from 20% to a little over 30% of spool travel or on a command voltage basis the variation is from about 2 volts to a little over 3 volts.

KFDG4V-5, spool types as noted



● Flow gain
At ΔP = 5 bar (72 psi) per metering path (e.g. P-A) ■, with flow thru P-A-B-T or P-B-A-T.
See footnote (▲) relative to point at which flow starts.

▲ Curves shown are for spool types “2”. These points will vary from valve to valve, but can be adjusted using the deadband-compensation feature of the drive amplifier. For spool types “33” the curves are similar but flow starts at slightly higher command signals.

■ At other ΔP values and within the power capacity envelopes, flow rates approximate to:

$$Q_x = Q_D \sqrt{\frac{\Delta P_x}{\Delta P_D}}$$

where Qp = Datum flow rate
ΔP_D = Pressure drop at datum flow rate
ΔP_x = Required ΔP

Figure 3. Flow-Gain Curve

Figure 4 shows the affect of pressure drop. Non-feedback single-stage curves are shown. Each level of pressure drop has its own flow-gain curve for a given valve type and spool type. At 145 PSI total loop pressure drop, between the “P” and “T” ports, with the “A” port connected (jumpered) to the “B” port, 6 USgpm flow occurs when the voltage command is about 68% (6.8 volts).
At a 725 PSI loop drop the valve is opened only 60% (6.0 volts) and at a 4570 PSI loop drop it is opened at about 48% (4.8 volts). This means that with 6.0 USgpm flow the valve will create a greater pressure drop as it closes further and further or as less and less command voltage is applied.
Again, the valve solenoid is controlled by current and regulated by command voltage into the amplifier. A lower input voltage level results in lower current to the solenoid and lesser opening of the valve spool.

KDG4V-5, spool types 2C65S

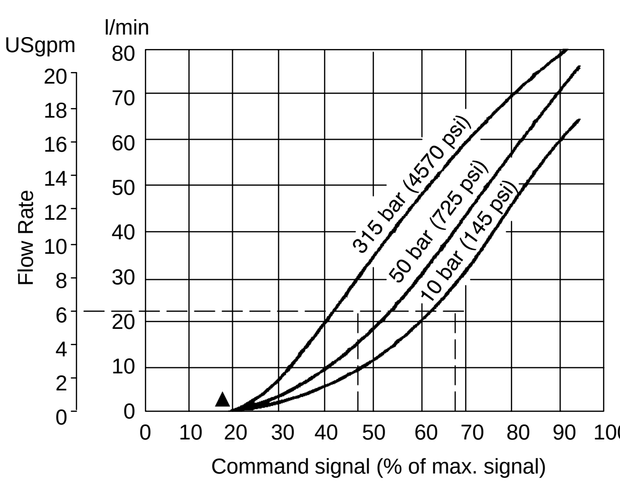
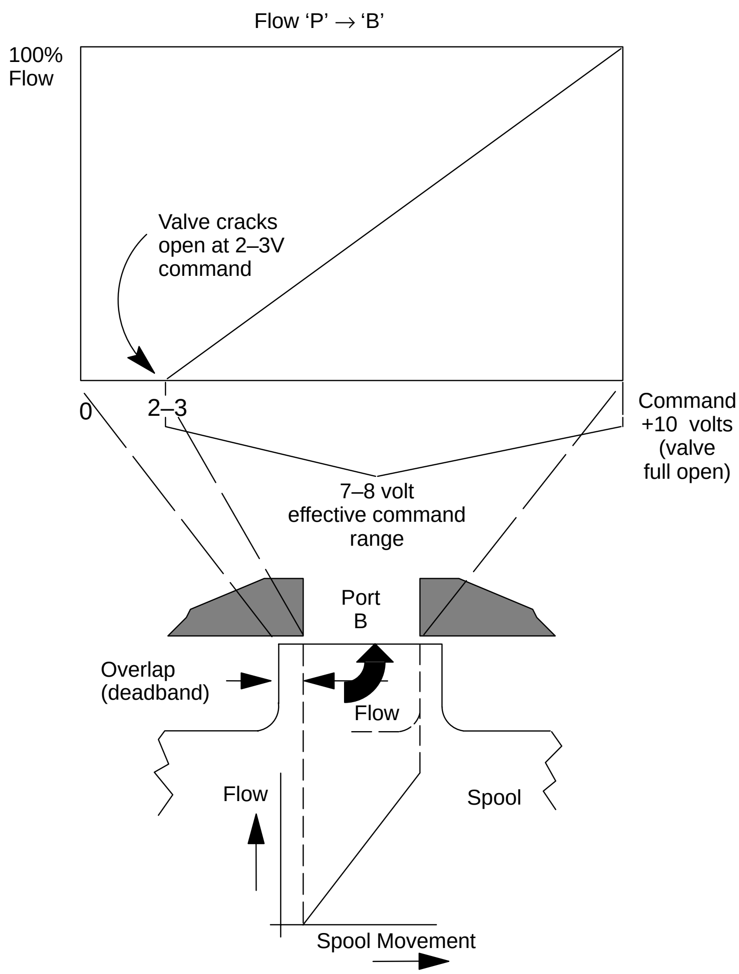


Figure 4. Pressure Drop

Command Voltage vs. Spool Opening

Figure 5 shows the spool position relationship to the flow gain curve. The flow gain curve is a straight line in this case, which makes it easier to understand. Note, again the spool must travel 20% or more of its full travel just to clear the overlap. Therefore, approximately 20% of spool travel occurs with approximately 2 volts of command input to the amplifier. With 10 volts command input, the valve is fully open.

That is, when a 10 volt command is applied at ‘b6’, ‘b8’, ‘b10’ or ‘Z8’, (as shown below) the valve spool moves to the full open position.



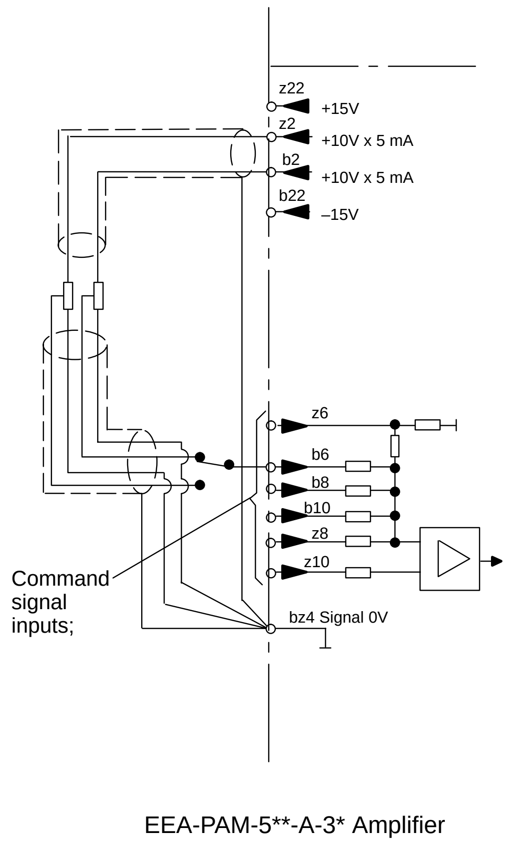


Figure 5. Spool Position

Gain Control

Figure 6 shows what happens when the gain pot is adjusted. If the “B” gain pot is turned clockwise, the gain is increased. Turned counterclockwise the slope of the gain curve is decreased. Adjustment is from 100% (valve full open) to 25% (valve 25% open). To get to 25%, the gain pot is turned counterclockwise as far as it will go. The pots are a 20 turn type so it will take about 20 turns to get to a reduction of 25%. This means that with 10 volts command input applied to pin b6, b8, b10 or z8, the valve will only be opened 25%.

This serves two purposes:

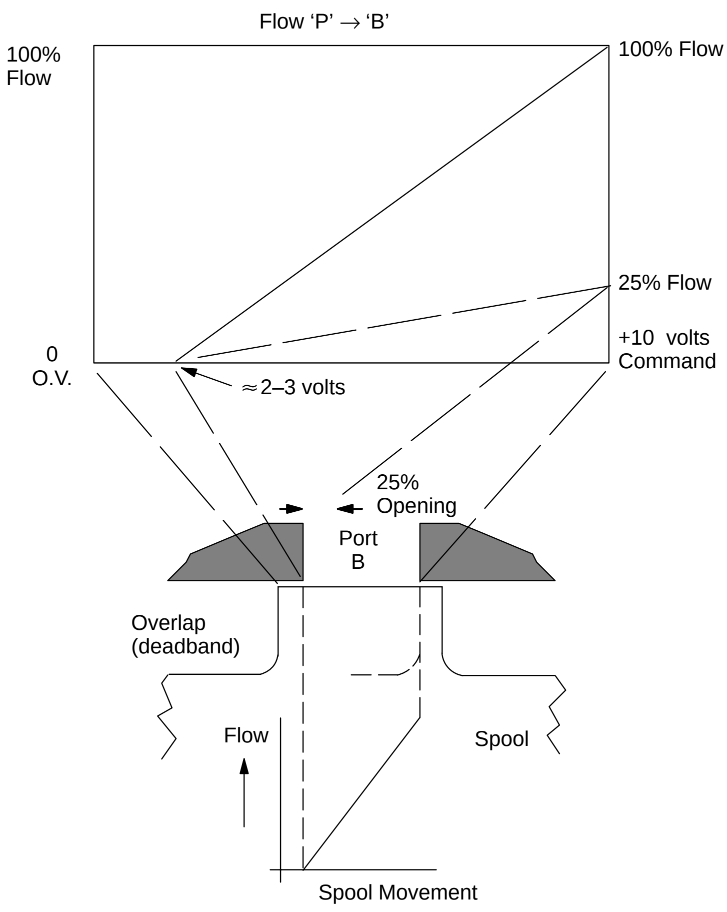
1. It enables the user to size the valve to the actual flow rate involved. That is, if a 10 USgpm rated valve is to be used on 10 USgpm flow, full gain or full clockwise adjustment of the pot is likely. If only 5 USgpm flow is involved, the user would want to reduce the gain to 50% by turning the gain pot about 10 turns clockwise from the full counterclockwise position.

   Also, as very often a single rod cylinder is involved, the flow to and from the blind end will be different from that to and from the rod end. Therefore, reduction in slope of the rod-end curve will be greater than that of the blind end.

2. By using the gain adjustments, the full range of the command voltage can be used, thereby providing more sensitive command control. If there were no gain adjustment and a 10 USgpm rated valve was operating at 5 USgpm, command control would be from zero volts to 5 volts. Any command adjustment beyond this point would have no affect on control. With gain control, sensitivity is improved by being able to control command inputs from zero to the full 10 volts.

$$\text{Gain} = \frac{\text{Output (Flow)}}{\text{Input (Comm.)}}$$

Gain = USgpm/Volt



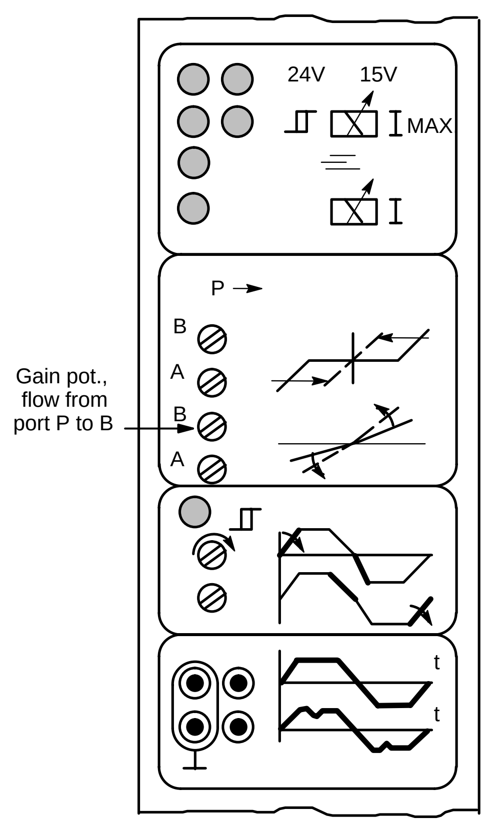


Figure 6. Gain Control

Deadband Compensation

Proportional valves are derivatives of standard solenoid valves. They are modified to provide spool displacement in proportion to the current level going to the solenoid. As solenoid valves are designed with spool land overlap in relation to the valve body land (see Figure 6), proportional valves have the same overlap, reduced to some extent by the notches in the spool. Therefore, flow doesn't start until this overlap is cleared. It would be desirable in the case of very accurate position control to have a zero lap condition between the spool and body lands, characteristic of more costly servo valves. This is shown by the dashed line flow gain curve in Figure 7.

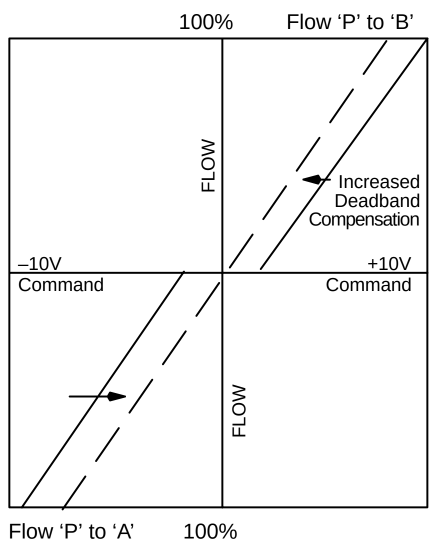


Figure 7. Valve Flow Gain

Though the physical overlap condition found in proportional valves exists, it can be essentially eliminated, on a time basis, by deadband compensation control. With maximum compensation, a very small input signal will cause the valve spool to jump through the deadband. Therefore, flow will start at a very low input signal level. This has the affect of increasing the control sensitivity around null (center) region of the spool. A very low command voltage input will trigger a relatively high level of current to the solenoid to move the spool a distance equal to clearing the overlap. As shown in Figure 7, increased compensation has the affect of shafting the flow gain curve towards center such that there appears to be no overlap. In reality, the flow gain curve doesn't go through center. A small step overlap remains.

Before going any further in the explanation, it is necessary to look at the gain curve for the amplifier. Figure 8 describes the amplifier current gain curve. Note, it doesn't go thru center. There is a small step of about 80mV on either side of center. This was designed in, to assure the valve will be centered when the command is zero or near zero. The dash line shows the affect of compensation. A minimum command input voltage causes a large jump in current to move the valve spool to near opening. Increasing the command further will then increase flow through the valve.

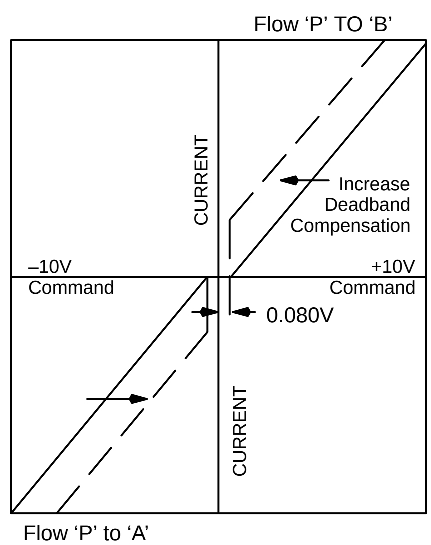


Figure 8. Amplifier Current Gain

Figure 9 combines the amplifier gain curve with the flow through the "B" port of the valve. Without any deadband compensation it will take 2-3 volts of command input to crack the valve open to flow. Therefore, to set-up the deadband compensation, start by inputting less than 2-3 volts and start turning the "B" pot clockwise until the actuator (cylinder or motor) starts to move. This can be done by starting with one volt of command and then reducing it in steps until a small command input of 80mV or more causes actuator motion.

Do not just turn the deadband compensation pot all the way clockwise.

As there are differences in overlap from valve-to-valve, it is possible that turning the deadband compensation the full amount would result in the valve spool moving to an open condition. Then there would be a jump in the actuator motion with the smallest of command input signal; that is with 80mV or little over this level applied.

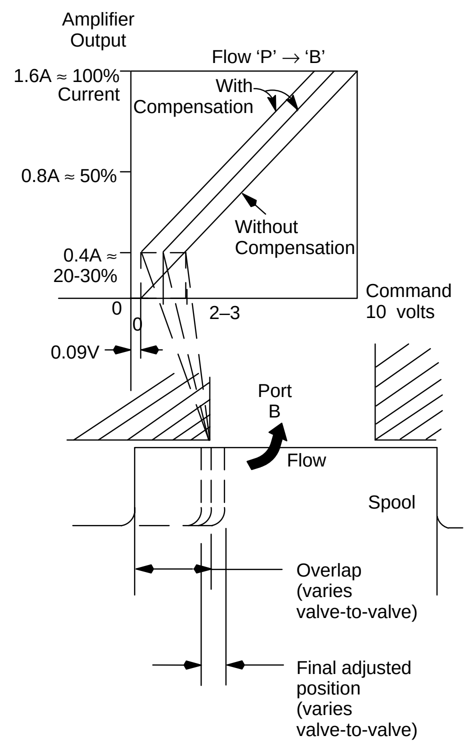


Figure 9. Deadband Compensation

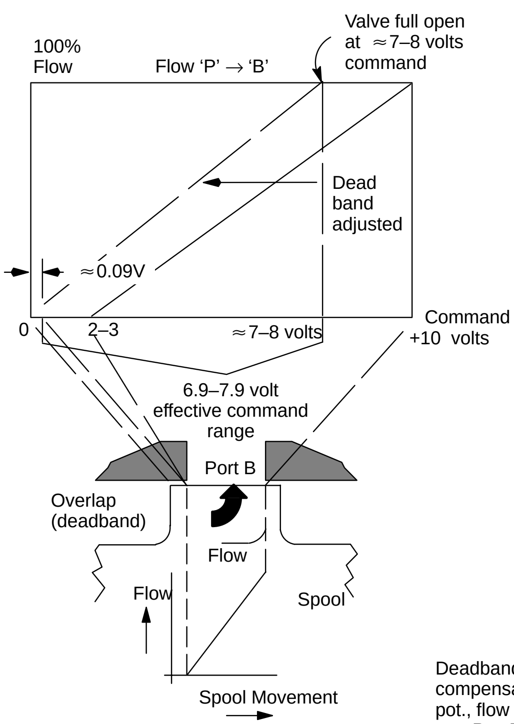
Deadband Elimination/Gain Adj. after Deadband Adj.

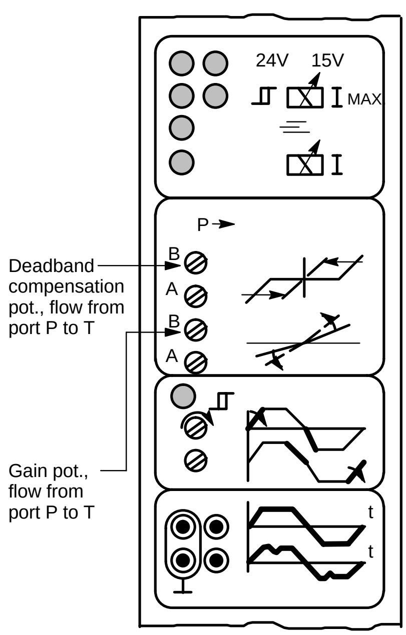
Note, in going thru this process, the gain curve is shifted to the left (for port “B”) as shown in Figure 10. Now a very low voltage input signal causes flow to start, but the valve will be full open with only, for example, 7-8 volts command applied. This can be offset by adjusting the gain. Turn the “B” gain pot counterclockwise until the valve is full open at 10 volts command. the actuator speed will stop increasing. The same procedure should be followed to eliminate the deadband on the “A” port. See Figure 11.

The deadband elimination serves two purposes:

1. It will enable the system to accomplish finer positioning in a closed (outer) loop system.
2. It provides a greater range of command input control, possibly from 80 mV to 10 volts.

Having completed this part of the set-up process, it is easier to understand why it is called a top-down procedure. That is, adjust the deadband before adjusting the gain.





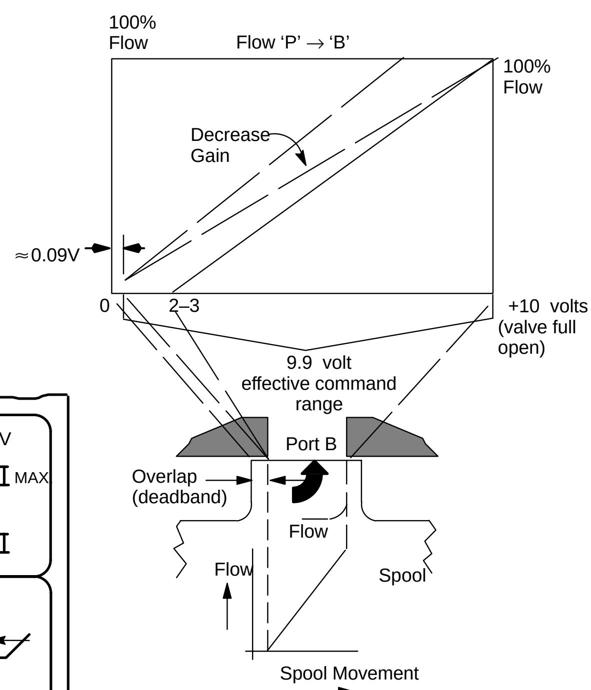


Figure 10. Deadband Elimination

Figure 11. Gain Adjustment after Deadband Adjustment

Load Acceleration/Deceleration (Ramp Control)

The final adjustments are to the acceleration and deceleration control. The upper pot in the third box on the front face of the amplifier controls the acceleration ramp. The standard Vickers "A" amplifiers have two ramp controls. Therefore, the ramp setting for acceleration in one direction of the actuator will be the same in the reverse direction. The same is true for the deceleration control or the lower of the two pots. Vickers has a "C" amplifier that has four ramp pots so acceleration and deceleration in either direction can be adjusted independent of each other.

The range of adjustment is from .050 seconds to 5 seconds as shown in Figure 12. These ramp adjustments determine how long it will take for the valve spool to shift open (acceleration) or shift closed (deceleration). That is, they set the rate of current buildup into the solenoid coil. With the ramp set for 5 seconds (ramp pot set full clockwise, 20 turns), 50% of maximum current will be going into the solenoid coil after 2.5 seconds.

If a command signal of 4 volts is applied to the amplifier, the valve will open or close (about 40%, with full deadband compensation) in about 2 seconds, if the ramp has been set for a full 5 seconds. Changing command voltage from 4 volts to 6 volts will see the valve open or close at the same rate or in this case take one second to go from 40% open to 60% open.

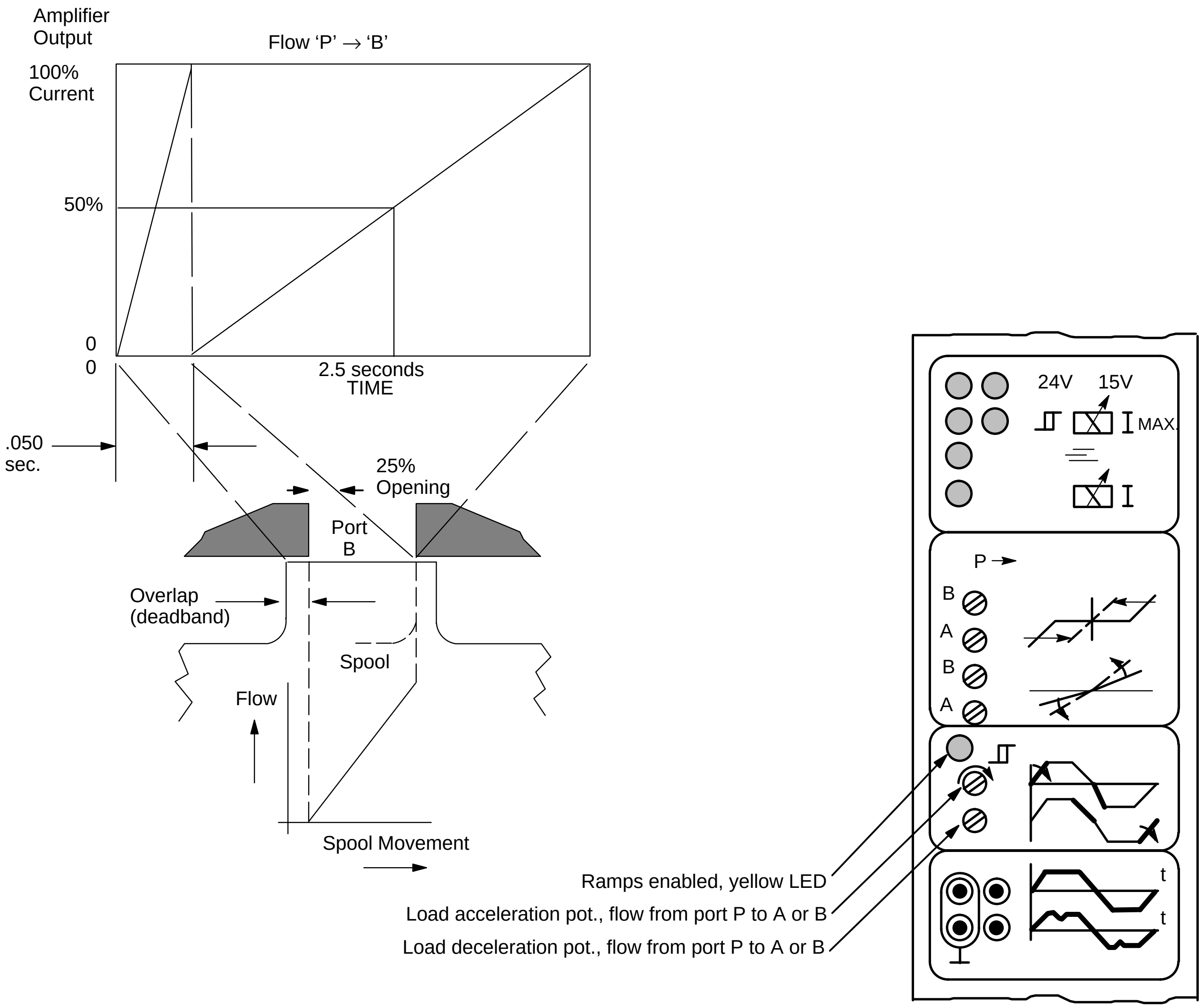


Figure 12. Ramp Function

Monitoring Points

The box at the bottom of the front face of the amplifier provides a means of monitoring the valve condition relative to the input commands and on-board adjustments. The two ports on the left side (Figure 13) are grounds. The upper port of the two, to the right of the grounds, is the monitor for the conditioned command or pin b18 (Figure 1). Note, if a +10 volts is applied at b6, b8, b10 or z8, the reading at b18 will be –10 volts. The polarity is reversed. If the gain had been decreased 50%, the reading at b18 would be –5 volts.

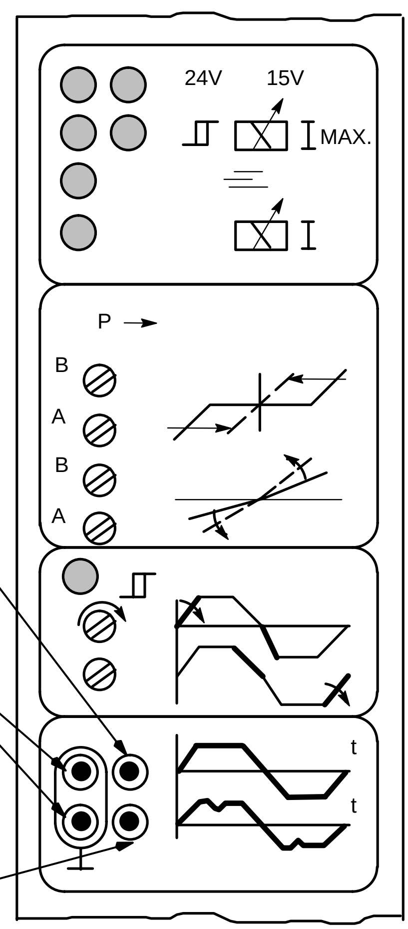
The lower monitoring port measures the output as seen by the LVDT feedback device. With 10 volts command and full gain, the output at z18 will be +10 volts (the same polarity as the command). Again, with a 50% decrease in gain, the reading would be about +5 volts.

In the case of single stage non-feedback valves, i.e., KDG4V-3, the readings at b18 follow the same rule as above for feedback valves (those with an integral LVDT). However, the output at z18 measures current going to the solenoid at a ratio of one volt per amp. If the solenoid pulls 1.6A max., the maximum voltage will read +1.6 volts with 10 volts command and full gain.

For two-stage valves the outputs at b18 and z18 follow those of the feedback type single-stage valves described above.

Conclusion

Set-up is easy if you follow this procedure and understand what is happening to the valve spool with each adjustment.



Monitor point, conditioned command signal

Command signal monitor points, front panel and b18	±10V full scale. Command signal conditioned by deadband compensation, gain and ramp functions (opposite polarity of command signal input).
Output impedance	10kΩ. Short-circuit protected

Common ground, 0V

Monitor point

Solenoid current (non-feedback)

KD/TG4V models

Front panel and z18	1 V/A solenoid current
Output impedance	10 KΩ. Short-circuit protected

LVDT (spool) position (feedback)

KFD/T4V, KFDG5V & KHDG5V models

Front panel and z18	±10V at full stroke (Same polarity as command signal input)
Output impedance	10 KΩ. Short-circuit protected

Figure 13. Proportional Valve Amplifier Set-Up Procedure