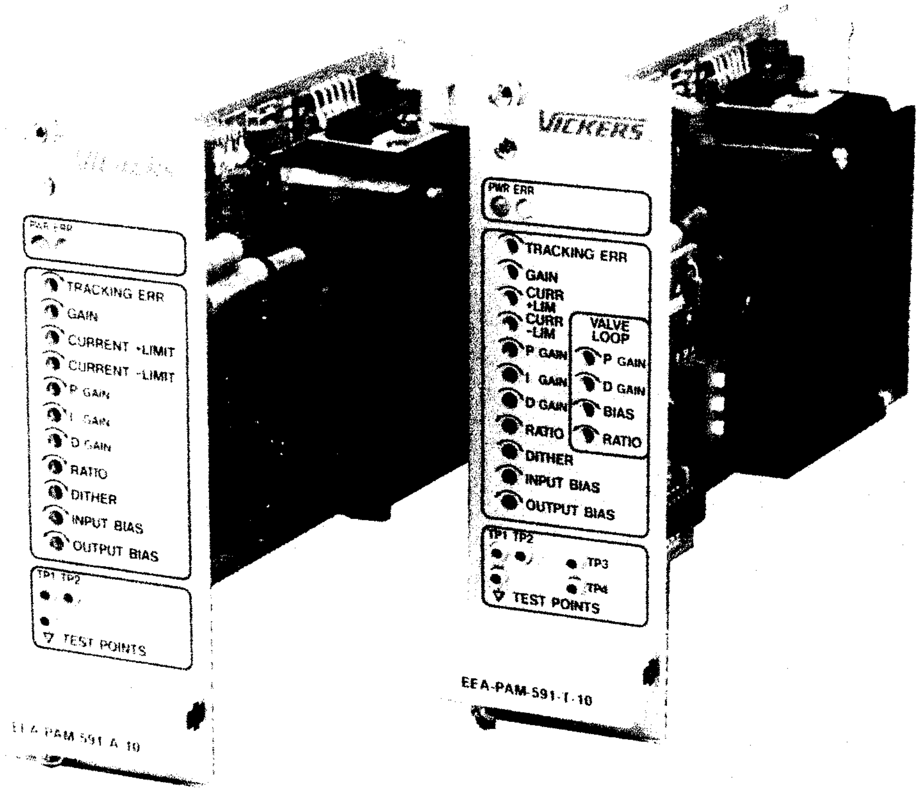
Commissioning Guide

VICKERS

Servo Amplifier

EEA-PAM-591-A-10



Released 6/93

General Installation Procedure

This comissioning guide is laid out in the sequence you should follow to install your servovalve amplifier. Read this guide first and take special note of the cautions. Then, prior to installation, visually inspect your new servovalve amplifier for defects or damage from shipping. If you notice any problems or need assistance, contact the factory at (313) 695-7000.

Follow this general procedure when installing the EEA-PAM-591-A Servovalve Amplifier:

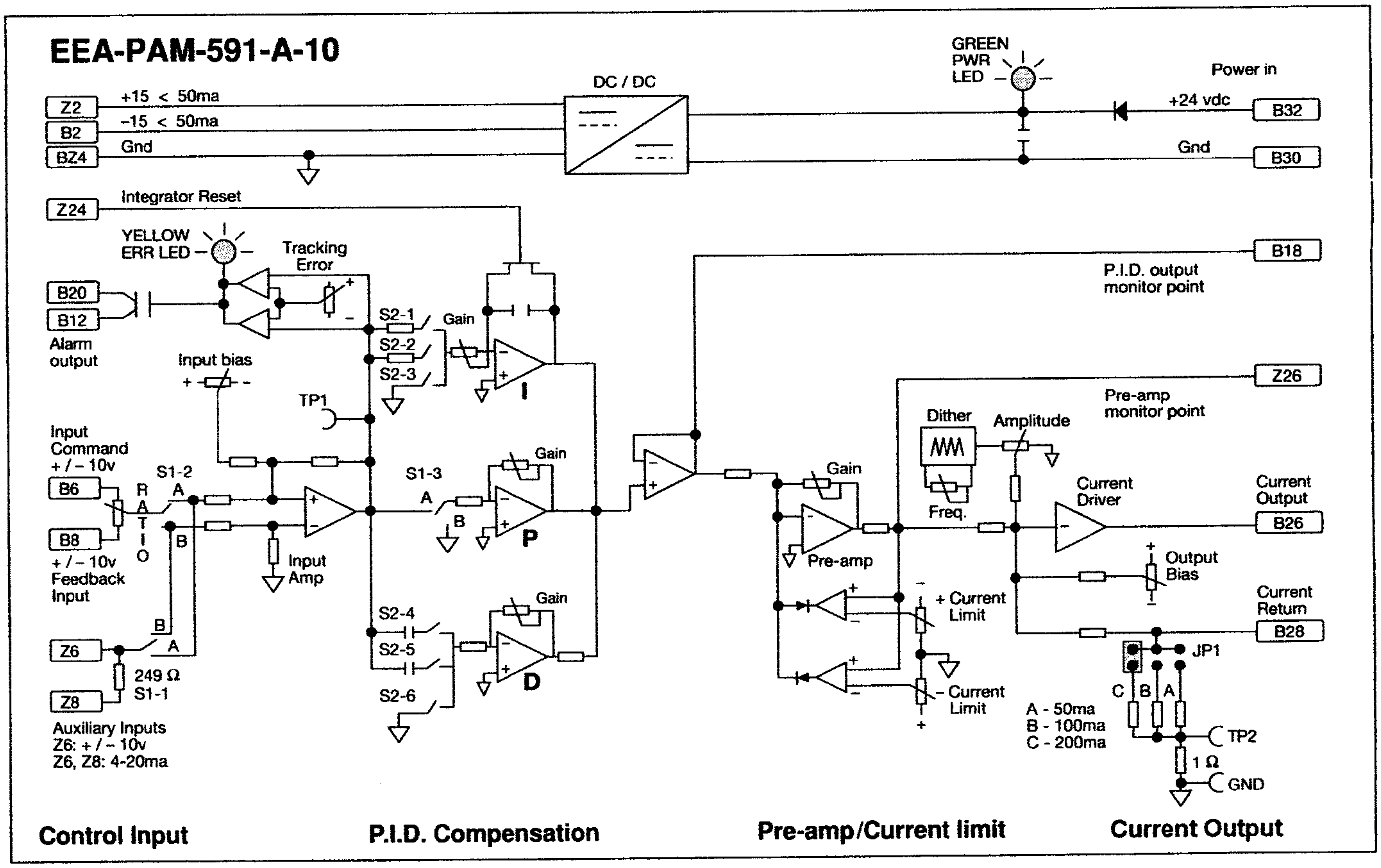
Step 1 Become familiar with the general operation of the amplifier card by referring to the "Servo Amplifier Discussed" and "Operating Data" sections.

Step 2 Familiarize yourself with the amplifier card switch settings and front panel adjustments by referring the the "Amplifier Settings" section.

Step 3 Set up the amplifier card current limits and null adjustments by referring to the "Amplifier Set-Up" section.

Step 4 Decide on your application needs (position control, velocity control, force control, etc.) and the characteristic of your command feedback input signals (voltage or current). Then set the switches on the amplifier card, install the card in the holder, and make the appropriate connections according to the information in the "Application Notes" and "Control Input Options" sections.

Step 5 Adjust the proportional, integral and Derivative Gains (depending on which is appropriate for your appliction) according to the procedure outlined in the "PID Set-Up Procedure" section.



Servo Amplifier Discussed

This amplifier is designed to drive Vickers SM4 and SP4 servovalves and most other industry standard servovalves such as Moog, Atchley, Pegasus, Rexroth, etc. in open and closed loop servo systems. The package offers flexible circuitry in a standard rack mount format requiring a single +24 vdc supply.

Control Input Stage

The amplifier can accept control signals of either voltage or current. The command signal input at pin B6 and the feedback signal input at pin B8 are voltage type up to ±10. Control inputs at these pins can utilize the amplifier's "Ratio" potentiometer which provides for amplitude ratio balancing. The signals may be inverting or non-inverting via on board switch S1-2 (see switch descriptions). For current loop inputs, pin Z6 is used to accept the current and pin Z8 is used as a current return. Signal inputs on pin Z6 can be inverting or non-inverting via on board switch S1-1 (see switch descriptions). Input at pin Z6 can be either a command or a feedback signal of voltage type however, the Ratio potentiometer will have no influence. All above mentioned control signal inputs can be monitored at front panel test point TP1.

By adjusting the on board potentiometer "Input Bias" a ±10v signal can be added (summed) to the control signals, providing input offset when required. The signal present at TP1 is also monitored by the Tracking Error circuitry. The circuitry performs a comparison of the signal at TP1 to that of a user set reference point, set by on board potentiometer "Tracking Err." This comparison feature allows the user to establish a tracking error set point. If the signal at TP1 exceeds the "Tracking Err" set point the front panel yellow LED will illuminate and the on board "Alarm Output" will energize (opto-coupled transistor turns on).

P.I.D. Compensation Stage

Signals at test point TP1 are applied to the P.I.D. compensation section of the amplifier. The Proportional, Integral, and Derivative stages of this amplifier are independently adjustable and switch selectable. On board switch S1-3 is used to activate the Proportional Gain stage, switches S2-1, S2-2, and S2-3 are used to activate the Integral Gain stage and switches S2-4, S2-5 and S2-6 are used to activate the Derivative Gain stage (see switch descriptions for details).

The Proportional Gain can be used to influence system stiffness and possibly accuracy. This stiffness is typically described as system response.

The Derivative Gain provides a means for system damping. This damping is effective in reducing control signal overshoot. Damping may be required in systems that require high stiffness or accuracy. Integral Gain can be used to reduce static error. Static errors are typically those errors that exist but do not generate enough error signal for load correction. In positioning systems, the Integral Gain is typically not applied until the actuator approaches position. To facilitate this function a "Integrator Reset Input" is provided at pin Z24. This pin allows for external control of the Integral stage.

The summed result of the Proportional, Derivative and Integral stages are present at output pin B18. (maximum output is ±10v at 5 ma).

Power Pre-amplifier and Current Limiter Stage

The output of the P.I.D. compensation network (present at pin B18) is also applied to the Power Pre-amplifier stage. This Pre- amplifier provides yet more adjustable Proportional Gain if desired. This Pre-amplifier directly feeds the voltage to current driver and its output is ± 6v at 2 ma).

In parallel with this Pre-amplifier are two current limiting circuits. These circuits are used to establish the maximum positive and negative output currents. This feature allows the user to customize the amplifier for a particular valve in use, thus protect the valve from currents that exceed its rating. By adjusting on board potentiometers "+ Current Limit" and "– Current Limit" the amplifier output current can be limited from 0 to 100% of full scale output.

Current Output Stage

The output of the power pre-amplifier and current limiters is applied to the current output stage. This stage converts the voltage signal into an appropriate current output. Current is applied to the valve through pin B26. A current return path from the valve is supplied at pin B28 providing closed loop temperature compensation.

Additional signals such as "Output Bias" and "Dither" are also applied to the input of the current output stage. The output bias is typically understood as an electronic null adjust and is capable of biasing the output from ±12% of full scale output. Dither is an optional adjustment that can be used to reduce the effects of silting or stiction. This signal is basically a low amplitude fixed frequency AC signal that is superimposed onto the output signal. This allows the valve spool to remain active while at null. Front panel adjustment "Dither" will affect the amplitude of this signal while potentiometer P12 will adjust the frequency (factory set at 200 hz).

The amplifier is factory set for ± 200 ma output, however, if desired the maximum output capability can be reduced via on board jumper "JP1." The amplifier provides three jumper positions labeled (A), (B), and (C). When jumper JP1 is in the (C) position, the amplifier can output ± 200 ma, ±100 ma when in the (B) position, or ± 50 ma when in the (A) position. This feature may be beneficial where greater control of the input span is desired. Output current can be monitored at front panel test point TP2. The output is in volts where 1 mv equals 1 ma of output current.

Operating Data

Power requirements	Nominal +24vdc < 500 ma: (at 200 ma load) Range +20 to +32 vdc. Maximum ripple ± 5% pk: Reverse polarity protected. Amplifier shuts down below +20 vdc.
Output voltages At pins B2 and Z2	 ± 15vdc < 50 ma: Ripple < 50 mv pk/pk (– 15vdc not short circuit protected)
Command signal inputs Voltage input Current input	 At pins B6, B8 or Z6: Range ± 10 vdc. Impendance: 100k ohms. At pins Z6 and Z8: Range 0 to 20 ma. Impedance: 249 ohms.
Output current drive Jumper selectable (jumper "JP1")	 (A) position ± 50 ma (B) position ± 100 ma (C) position ± 200 ma
Front panel test points Tracking error monitor (TP1) Output current monitor	 ± 10v full scale: short circuit protected. 1 mv/ma: short circuit protected.
Edge connector monitor points P.I.D. output monitor Pre-amp output monitor	 At pin B18: ± 10 v at 5 ma At pin Z26: ± 6 v at 2 ma
Input bias	0 to ± 10 vdc
Output bias	0 to ± 12% of full scale output.
Current limiters	0 to ± full scale output current.
Dither Amplitude Frequency	 0 to 20% of full scale output current. 50 to 400 hz.
Proportional Gain	.1 v/v to 20 v/v
Integral Gain Low range High range	 0 to 40 v/v-sec 2 to 300 v/v-sec
Derivative Gain Low range High range	 .05 to .2 v-sec/v .3 to 2 v-sec/v
Pre-amp Gain	1 to 15 v/v
Drift over operating temperature range	< ± .03% of full scale output at maximum gain
Operating temperature range	0 to 50°C
Storage temperature range	–25 to 85°C

Amplifier Settings

Switches

S1-1 **Control Input Invert–** Affects control input on Pins Z6 and Z8. Set to the (A) position, the input signal will be inverted at test point (TP1). Set to the (B) position, the input signal will not be inverted at test point (TP1).

S1-2 **Control Input Invert–** Affects control input on Pins B6 and B8. Set to the (A) position, the input signal will be inverted at test point (TP1). Set to the (B) position, the input signal will not be inverted at test point (TP1).

S1-3 **P Gain Enable–** Used to control the Proportional Gain stage of the PID amplifier. Set to the (A) position, the proportional stage input will be enabled. Set to the (B) position, the proportional stage input will be disabled.

S2-1 **I Gain High Range–** Used to selected the high range of Integral Gain. Set closed, the gain range is 2 to 300 volts/ sec-volt. Switch S2-3 should never be closed at the same time as this switch.

S2-2 **I Gain Low Range–** Used to selected the low range of Integral Gain.Set closed, the gain range is 2 to 40 volts/sec-volt. Switch S2-3 should never be closed at the same time as this switch.

S2-3 **I Gain Enable–** Used to control the Integral Gain stage input. Set closed, the integrator is disabled. Set open, in conjunction with S2-1 or S2-2 closed, the integrator is enabled. Switch S2-1 and switch S2-2 should never be closed at the same time as this switch. Note: If the Integral Gain is not used, close S2-3 and ground the integrator reset pin (Z24). This will prevent the integrator output from drifting and influencing other control signals.

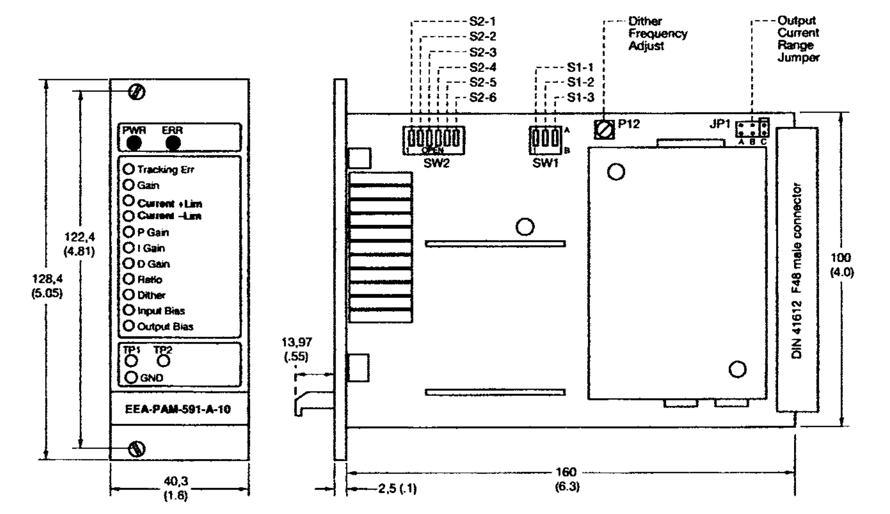
S2-4 **D Gain High Range–** Used to select the high range of Derivative Gain. Set closed, the gain range is .3 to 2 volt-sec/volt.

Switch S2-6 should never be closed at the same time as this switch.

S2-5 **D Gain Low Range**– Used to select the low range of Derivative Gain. Set closed, the gain range is .05 to .2 volt- sec/volt. Switch S2-6 should never be closed at the same time as this switch.

S2-6 **D Gain Enable**– Used to control the Derivative Gain stage input. Set closed, the stage is disabled. Switch S2-4 and switch S2-5 should never be closed at the same time as this switch.

Amplifier Overview



dimensions are in mm(in)

Front Panel Adjustment

Tracking Err Used to set a tracking error set point. The set point will be continuously compared to the signal at TP1. If the signal at TP1 exceeds the set point, the tracking error alarm output will energize and the "err" LED will illuminate.

Gain When adjusted fully CCW, the pre-amp gain is 1 volt/volt; when adjusted fully CW, the pre-amp gain is 15 volts/volt. This adjustment effects overall amplifier gain. Factory set fully CCW.

Current + Limit Used to set the maximum allowable positive output current. Adjusted fully CCW, no positive current is available. Adjusted fully CW, maximum positive current is available. Factory set fully CCW.

Current – Limit Used to set the maximum allowable negative output current. Adjusted fully CCW, no negative current is available. Adjusted fully CW, maximum negative current is available. Factory set fully CCW.

P Gain Affects the amount of Proportional Gain applied to the control signal (providing P Gain stage is enabled — see switch descriptions). Adjusted fully CCW, the Proportional Gain is .1 volts/volt. Adjusted fully CW, the Proportional Gain is 20 volts/volt. Too much P Gain may cause instability. Factory set fully CCW.

I Gain Affects the amount of Integral Gain applied to the control signal (providing I Gain stage is enabled — see switch descriptions). Adjusted fully CCW, the Integral Gain is 2 volts/sec-volt. Adjusted fully CW, the Integral Gain is 40 volt/sec-volt in the low range and 300 volts/sec-volt in the high range. (See switch description for range settings). Too much Integral Gain may cause oscillations. Factory set fully CCW.

D Gain Affects the amount of Derivative Gain that is applied to the control signal. (Providing D Gain stage is enabled — see switch descriptions). Adjusted fully CCW, the Derivative Gain is .05 volt-sec/volt in the low range and .3 volt-sec/volt in the high range. Adjusted fully CW, the Derivative Gain is .2 volt-sec/volt in the high range. Too much D Gain may reduce system response. Factory set fully CCW.

Ratio Used to balance unequal amplitude command and feedback signals connected at inputs (B6) and (B8). Adjusted CW will increase the signal ratio of (B6) to (B8). Adjusted CCW will decrease the signal ratio of (B6) to (B8). Factory set centered.

Dither Used to control the dither amplitude. Adjusted fully CCW, no dither is applied. Adjusted fully CW, 20% of the full scale output is applied. Too much dither will cause actuator trembling. Factory set fully CCW.

Input Bias Used to control the amount of input bias applied to the input stage. Adjusted fully CW, the input will be biased +10 volts. Adjusted fully CCW, the input is biased –10 volts. Factory set for zero volt bias.

Output Bias 1 Used to control the amount of output bias applied to the output driver. Adjusted fully CW, the output driver will be biased, 12% of full scale in the positive direction. Adjusted fully CCW, the output driver will be biased 12% of full scale in the negative direction. Factory set for zero bias.

Amplifier Set-up

Preliminary Conditions

The following set-up procedure should be performed after hydraulic nulling of the servovalve has taken place. These steps are designed to aid the user in adjusting the amplifier for the particular valve in use. Refer to Figure 1 for calibration connections and monitor points.

Note: These procedures assume that the appropriate output range jumper "JP1" has already been selected. If this jumper is moved at a later date, these procedures should be repeated.

Before beginning, insure the following conditions exist:

- The hydraulic power is off.
- The servovalve is connected per Figure 1.
- No control signals are connected to the amplifier.
- The +24 VDC supply and ground are connected to the proper input pins.
- The front panel adjustments "current + limit," "current – limit," "dither" and "gain" are adjusted fully CCW.
- Pin BZ4 and pin Z24 are jumpered together. (This is done to insure no integrator interaction during calibration.)
- On board switches are set as follows: S1-1, S1-3 in (B) position, S1-2 in (A) position, S2-1, S2-2, S2-4, S2-5 in open position and S2-3, S2-6 in closed position.

Adjusting Output Null

While monitoring the signal at front panel test point TP2, adjust "output bias" for 0.000v (1mv = 1 ma output current).

Adjusting Current Limiters

The purpose for setting the current limiters is to establish a relationship between maximum control signal amplitude and maximum valve current. This procedure will utilize the input bias as an on board command source to set the current limits.

1. While monitoring front panel test point TP1, adjust input bias for +10v. To utilize this signal it must be allowed to pass through the Proportional Gain stage of the amplifier. To allow this set switch S1-3 to the (A) position. To insure the full signal is passing through this stage, monitor edge pin B18 and adjust "P Gain" for unity or –10v reading (the signal at B18 is inverted with respect to TP1).
2. While monitoring front panel test point TP2, adjust "current – limit" for maximum rated valve current. (Remember 1 mv = 1 ma output current. For example, a 200 ma valve would read at TP2 as 200 mv.)
3. While monitoring front panel test point TP1, adjust input bias for –10v.
4. While monitoring front panel test point TP2, adjust "current + limit" for maximum rated valve current.

Adjusting Input Null

While monitoring front panel test point TP1, adjust "input bias" for 0.00v reading.

Amplifier Calibration Diagram

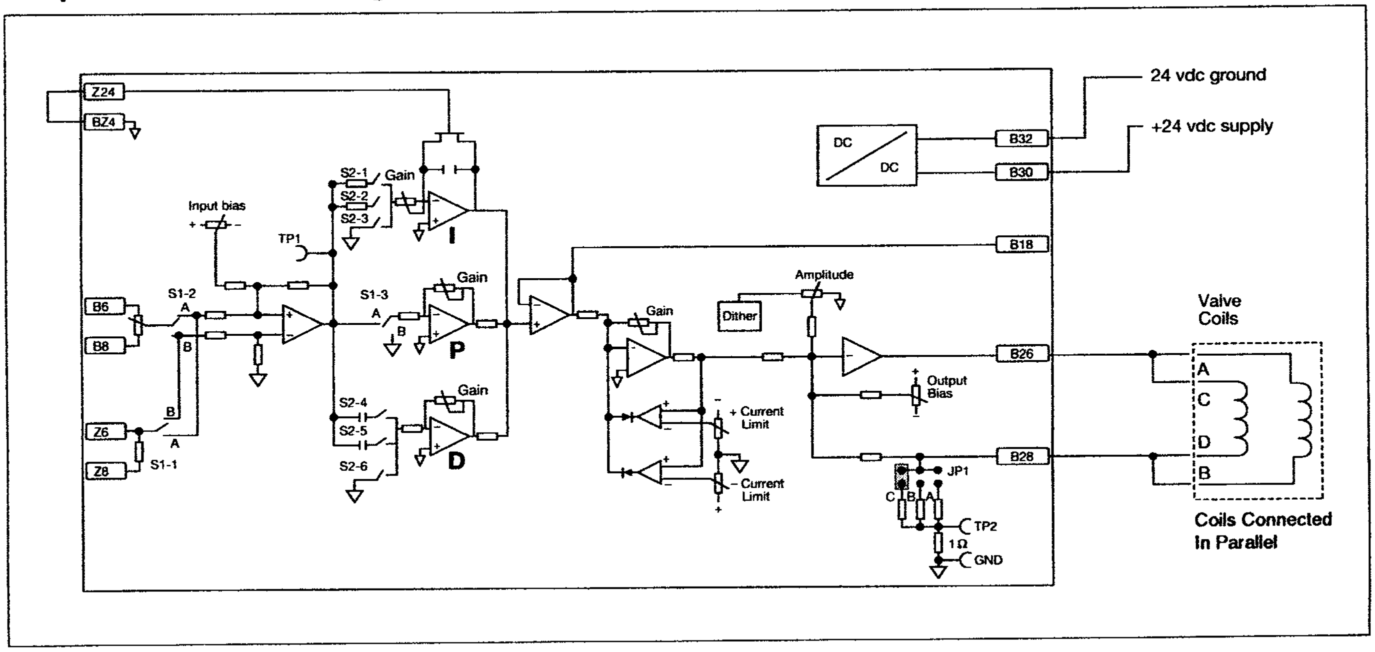


Figure 1. Servovalve amplifier set-up connections

Application Notes

Typical position control utilizing full P.I.D.

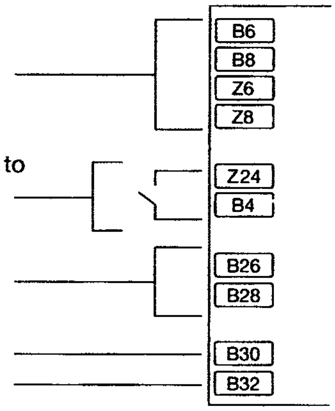
Connections | **Amplifier** | **Switches**

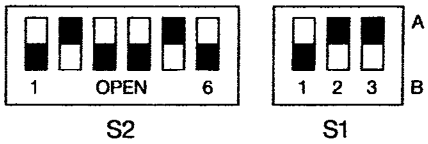
Control signal inputs. Refer to section on Control input options.

Integrator reset switch. Optional use to control operation time of the Integral gain stage.

Valve current outputs. Refer to calibration section for valve wiring.

24 vdc ground input
+24 vdc supply input





■ Side of switch depressed.

NOTE: Integral and Derivative gain ranges are application dependent.

These settings assume control inputs at B6 & B8.

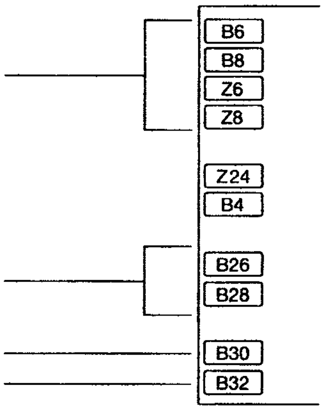
Typical velocity or pressure control.

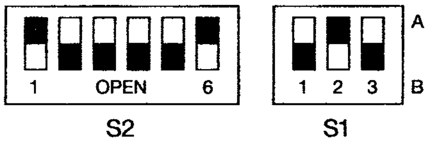
Connections | **Amplifier** | **Switches**

Control signal inputs. Refer to section on Control input options.

Valve current outputs. Refer to calibration section for valve wiring.

24 vdc ground input
+24 vdc supply input





■ Side of switch depressed.

NOTE: Integral gain range is application dependent.

These settings assume control inputs at B6 & B8.

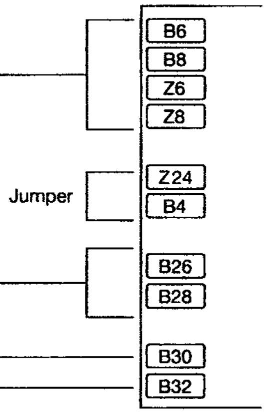
Typical force control utilizing P and D.

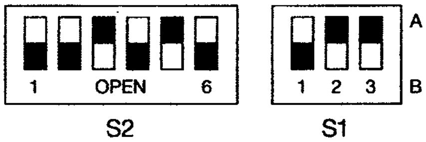
Connections | **Amplifier** | **Switches**

Control signal inputs. Refer to section on Control input options.

Valve current outputs. Refer to calibration section for valve wiring.

24 vdc ground input
+24 vdc supply input





■ Side of switch depressed.

NOTE: Derivative gain range is application dependent.

These settings assume control inputs at B6 & B8.

Control Input Options

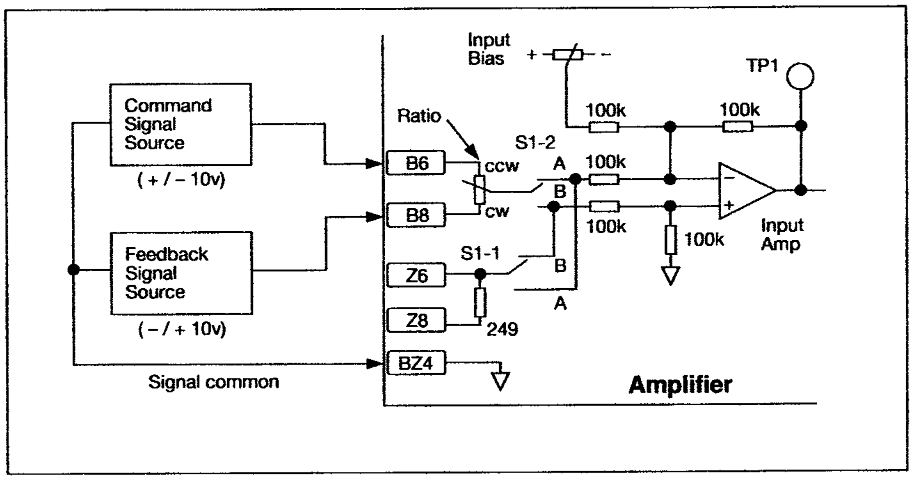
Option 1

In this configuration, command and feedback signals are voltages of opposite polarity and may require ratio balancing.

If the two signals are of equal amplitude, adjust ratio pot to center position. (Approximately 9 turns from full CW)

If the two signals are of unequal amplitude, adjust ratio pot from center position CW to increase feedback ratio or CCW to increase command ratio.

Switch S1-2 can be set to either (A) or (B). Refer to switch description.

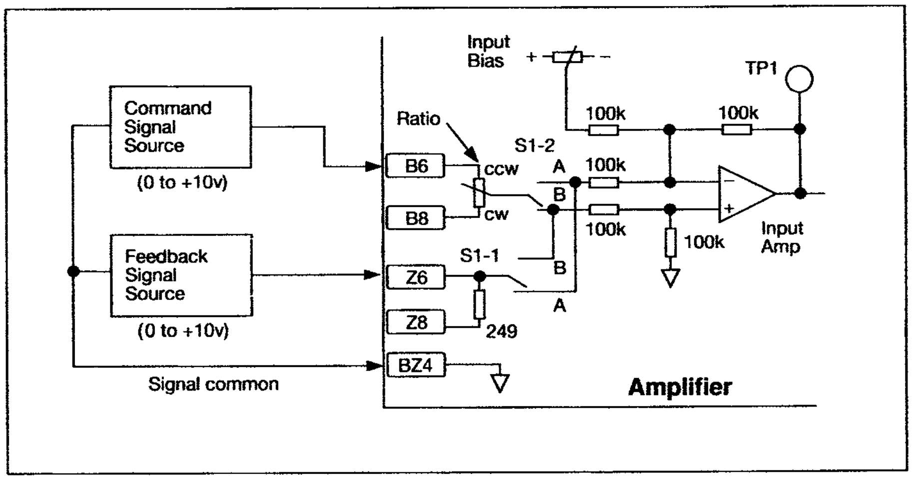


Option 2

In this configuration, command and feedback signals are voltages of the same polarity.

For this configuration the ratio pot should be adjusted fully CCW.

When using this configuration, care must be taken that switches S1-1 and S1-2 are not set to the same position. In this example, the command is not inverted, so switch S1-2 is set to (B). The feedback signal is inverted so switch S1-1 is set to (A).

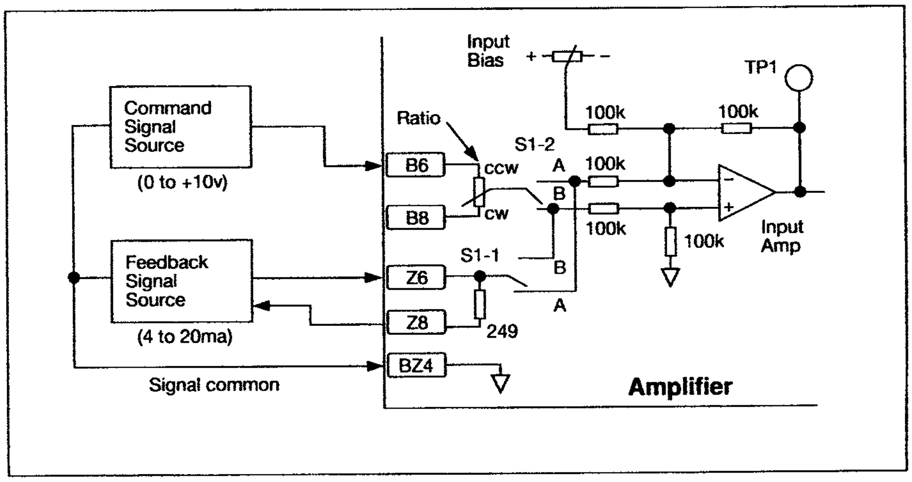


Option 3

In this configuration, one of the control signals is a voltage and the other is a 4-20 ma current loop.

For this configuration the ratio pot should be adjusted fully CW.

Before the voltage control signal is connected, the current loop signal must be calibrated. If the 4-20 ma signal is to be summed with a single ended control signal (Ex. 0 to 10v) apply 4 ma's and adjust the input bias so test point TP1 reads 0.00v. If the signal is to be summed with a double ended control signal (Ex. ± 10v), apply 12 ma's and adjust the input bias for 0.00v at test point TP1.



PID Set-Up Procedure

Preliminary Considerations

Before energizing the control system, review your application carefully. What would happen if your system overshoots — will damage result?

In an application where the load moves freely and cannot impact against anything or be crushed by the actuator, overshoot can be tolerated during the adjustment of the loop.

However, in a clamping application, for example, overshoot could damage the actuator or the load being clamped.

Stop and ask yourself — "Will my adjustments cause damage if not done properly?" If so, you may have to modify the equipment for safety reasons so that it can tolerate over-positioning, overspeed, or higher-than-planned forces during adjustments.

Caution: *A bad setting of the PID parameters may cause the drive to oscillate.*

An oscilloscope and a means of generating a square wave (signal generator or system controller) is required in order to tune a closed loop controller. To adjust the controller parameters, the command signal into the amplifier should continuously switch between 10-30% and 70-80%. Each signal level should have a dwell time of several seconds (Figure 2).

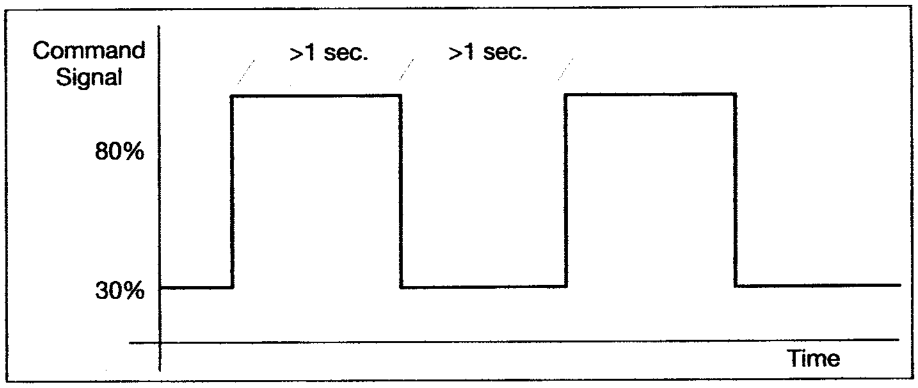


Figure 2. Set-up command signal

Before installing the card, the potentiometers P, I and D should be at the fully counter clockwise position and the switches on the card should be set based on the application described in the "Application Notes" section.

Finally, install the card and connect the command and feedback signals based on the appropriate option described in the "Control Input Option" section.

Caution: *If the feedback signal is not of the proper polarity, your load will promptly "run away" when the command signal is applied. This is because the feedback is being added to, not subtracted from, the command signal at the summing junction, producing a constantly increasing error signal.*

Tuning Procedure

1. Connect a monitoring device, such as an oscilloscope or an XY recorder to the COMMAND INPUT, and the FEEDBACK signals (see "Control Input Options").

   Caution: *Care should be taken when taking measurements using TP2. If this test point should become grounded, the feedback command will change in turn causing unintended operation.*

   Do not attempt to visually "eyeball" the results of the adjustment. Visual observation of the actuator is not accurate enough. If you do not know how to operate the monitoring device, seek the assistance of someone who DOES know how to use it.

2. Energize the system and be sure the servo valve has been mechanically nulled.

3. Apply the step input repeatedly, and slowly increase the Proportional Gain of the amplifier a little at a time while observing the system response (via the feedback signal).

   A position control system, for example, will respond as shown in Figure 3.

   As Proportional Gain is increased, the step input will give increasingly faster response. Eventually the gain will reach a value where the input step will cause the actuator to just barely reach the desired position.

(continued next page)

Tuning Procedure *(continued)*

Continue increasing the Proportional Gain until the system achieves the position that the step input should produce, as shown in Figure 4.

4. When the Proportional Gain is set high enough so that the step input causes the desired position to be achieved, measure the response time using the time base of monitoring instrument.
5. Now, continue to raise the Proportional Gain until a moderate overshoot occurs, as shown in Figure 5.
6. Begin increasing the DERIVATIVE Gain now, a little at a time, while observing the response carefully. The overshoot should begin to reduce as Derivative Gain is increased.

   Continue increasing the Derivative Gain, and applying the step input, until the overshoot is eliminated (Figure 6).

   If you find that you have turned the Derivative Gain to maximum, and overshoot is still occurring, then you have set the Proportional Gain too high. If this occurs, turn the Derivative Gain BACK TO MINIMUM, then decrease the Proportional Gain a bit and try Step 6 again.
7. When overshoot has been eliminated, measure the response time once again. You should see a marked improvement, as shown in Figure 7.
8. When the overshoot is corrected, try to increase the Proportional Gain some more, until a slight overshoot occurs. Then see if additional Derivative Gain will correct it. You should soon reach a point where response time cannot be improved any further.
9. Cycle the system several times, using the step input, to see whether the adjustments are stable. If occasional overshoot is noted, decrease the Proportional Gain SLIGHTLY, until this stops occurring.

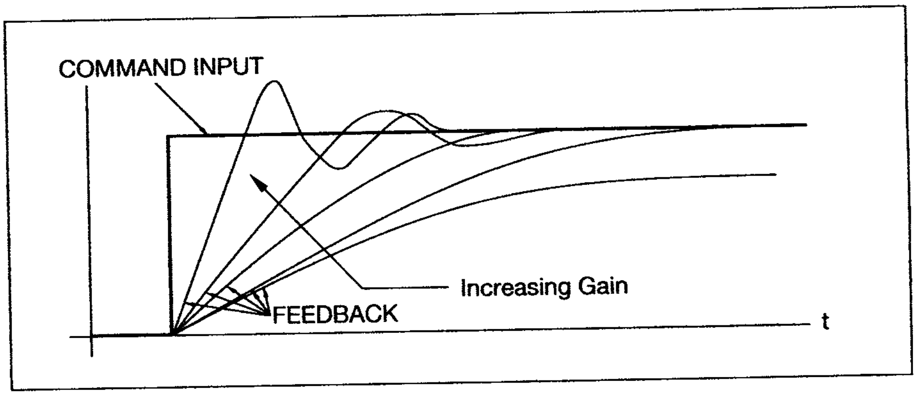


Figure 3. Increasing Proportional Gain.

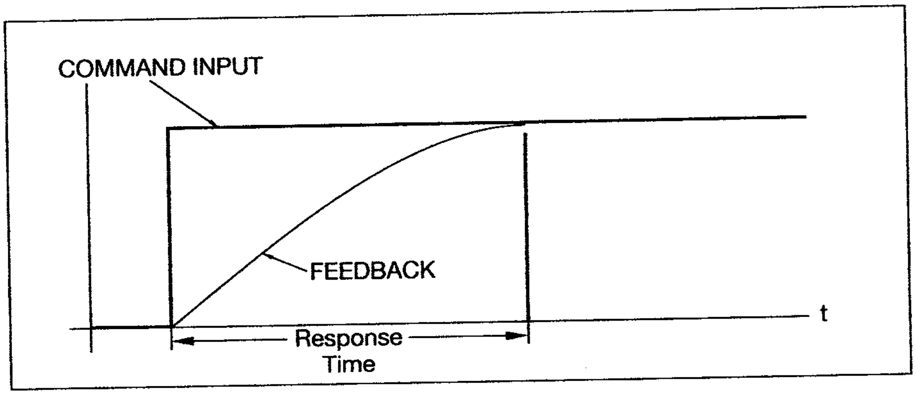


Figure 4. Reaching desired command level.

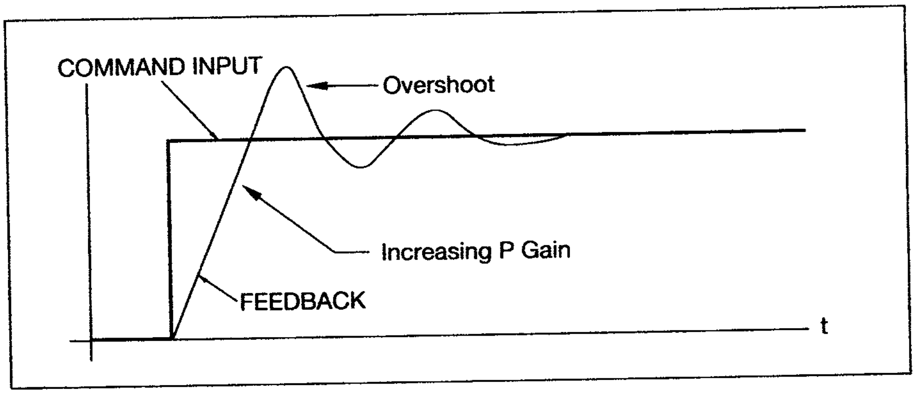


Figure 5. Moderate overshoot.

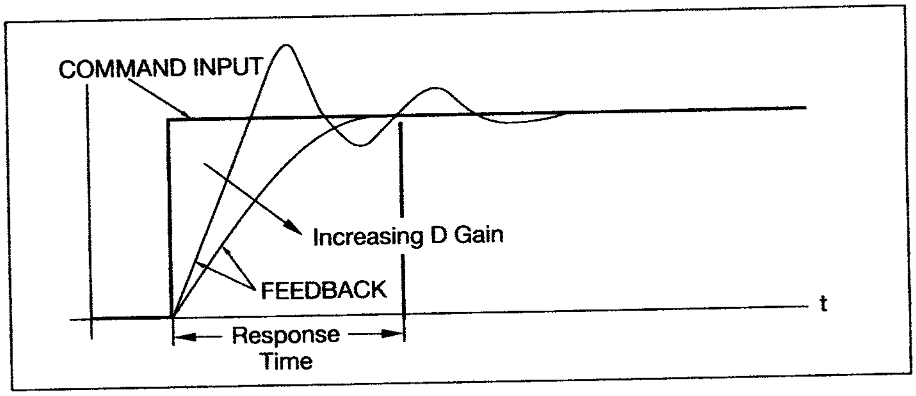


Figure 6. Eliminated overshoot by adding Derivative Gain.

10. When the Derivative Gain is set satisfactorily, you can then attempt to set the Integral Gain to eliminate any steady state error.

    Remember that you want the Integral Gain to be disabled (RESET) during the dynamic part of the motion cycle.

    If Integral Gain is improperly timed, the overshoots will return. This is usually caused by interaction between the Derivative and Integral terms, as they "fight" each other for control.

    If Integral Gain is set too high, you may even lose control of the system as it oscillates out of control. If this occurs, shut down the amplifier, turn the Integral Gain back to minimum, and start again.

    When in doubt, set the Integral Gain on the LOW side, since it tends to LESSEN THE STABILITY of a closed loop system.

11. Watch the system carefully through the first few days of operation, to ensure that you have not set the gains too high. Some performance "drift" can be expected as the hydraulic fluid changes temperature or as new mechanical components "wear-in," producing the need for some "fine tuning" later on.

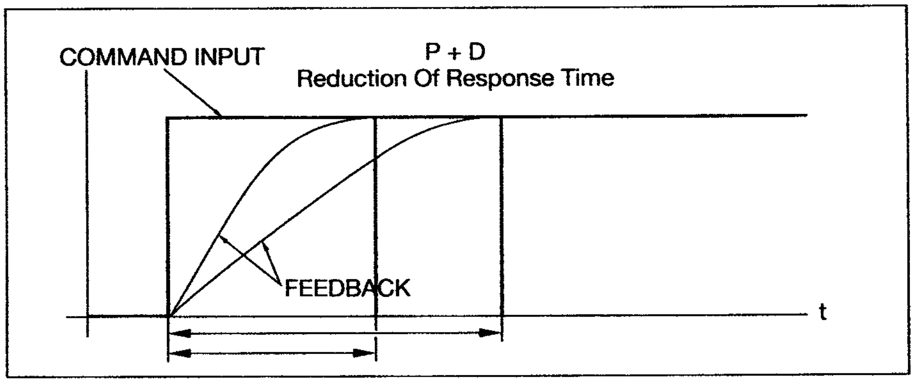


Figure 7. Better response using additional P and D Gain.

Accessory Products

Power supplies

- EHA-PSU-704-A-10

Input power: 110/130/220/240 vac
Output: +24 vdc @ 4 amps
Dimensions: 9.84 in x 4.53 in x 2.76 in
Style: Open frame, panel mount
Assembly (order) number: 732166

- EHA-PSU-704-B-10

Input power: 110/130/220/240 vac
Output +24 vdc @ 4 amps
± 15 vdc @ 250 ma
± 10 vdc @ 50 ma
Dimensions: 9.84 in x 4.53 in x 2.76 in
Style: Open frame, panel mount
Assembly (order) number: 732167

Universal card holder

Style: Accepts Eurocard format of 3U height
Connector: Din 41612 F48 female
Connections: Screw terminals
Dimensions: 5.1 in x 5.7 in x 2.2 in
Assembly (order) number: 732683

Female edge connector for 19' rack

Style: Adaptable into rack housing
Connector: Din 41612 F48 female
Connections: Solder terminals
Dimensions: 3.74 in x 1.15 in x .69 in
Assembly (order) number: 508178

Command and ramp generator

EEA-DSG-453-A-10

Supply voltage: +24 vdc @ 4 w max.
Command selects: 5 (± 10 v range)
Ramp selects: 5 (.1 to 10 s range)
Style: Eurocard format, 3U height
Assembly (order) number: 02104128

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