G122-202A1 Series
Servoamplifier

MOOG

SPECIFICATIONS

Power Supply:
±15 VDC stab. (25 mA each)
±24 VDC (valve + relay current)

Input Voltage Range:
pin 3, 7 . . . ±10 VDC
pin 9 . . . . . 0 to 120 VDC

Output Capability:
max current ±100 mA
max voltage ±10 V

Output Ranges:
10, 20, 50 and 100 mA
selectable with R34

Proportional Gain:
5 to 200 mA/V

Linearity:
±3% of full scale

Temp. Coefficient:
0.1 mV/°C from 10° to 50°C
(input resistance of 100 kOhm and gain of 50 mA/V)

Frequency Response:
-3 dB at f > 800 Hz with inductive load (1 Henry)

Dither:
Amplitude 0 to 40% valve drive
Frequency 25 to 300 Hz

External Controlled Relay:
consumption: 8 mA @ 24 VDC
contact rating: 1 A/125 VDC, 30 W max.

Dimensions:
3 U x 7 HP, 100 x 160 Euro card

Ramp Rate:
0.5 V/S to 20 V/S

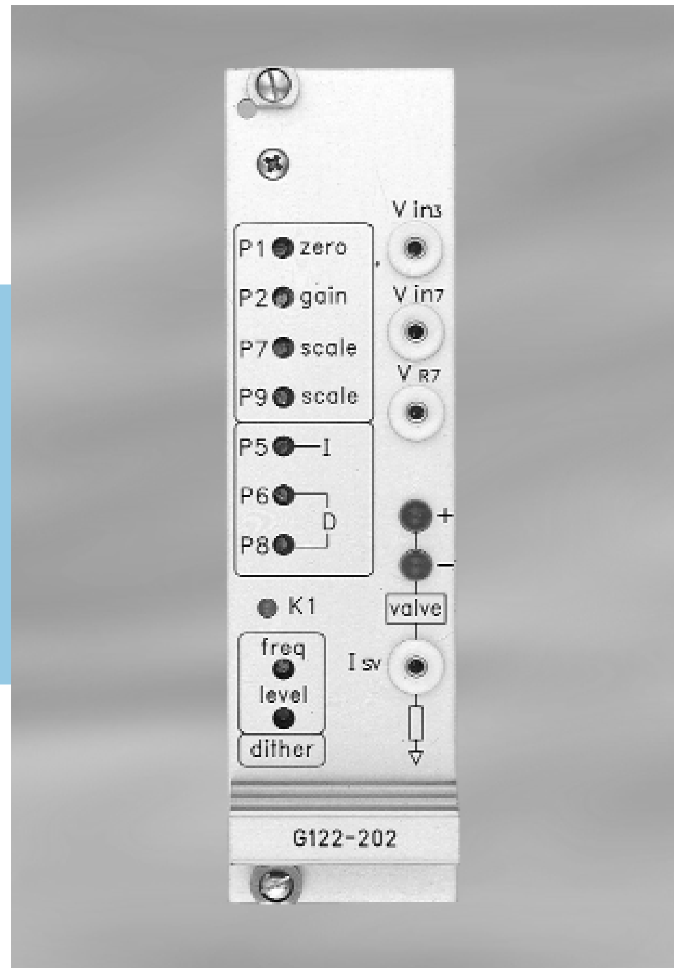
Inverter Accuracy:
± 1% of applied signal

4-20 mA Converter Accuracy:
± 1% of full scale

Connector:
DIN 41612 Type C, 64-pin

Form Factor:
Eurocard 100 x 160 mm,
7 HP, 3 U

Weight:
0.36 lb (0.16 kg)



The G122-202A1 Servoamplifier Card is a differential amplifier with a PID control section. It is primarily designed to drive electro-hydraulic servovalves in closed-loop control, although it can be used in any application which requires a current or voltage output, proportional to a command signal, or the difference of command and feedback signals.

The front panel has controls to adjust amplifier gain, Input sensitivity, zero offset and dither, as well as test points for I/O signals. LED indicators and a test point for valve current, are also located on the front panel. These allow fast and easy set-up of an electro-hydraulic control system.

Three additional function blocks are included. The first is an inverting amplifier that can be used to invert the polarity of the command or feedback, to give opposite polarity signals. The second is a 4 to 20mA converter that produces a proportional 0 to 10V output that is useful for interfacing to process instrumentation signals. The third is a ramp generator that allows control of the rate of change of a position command so actuator velocity can be controlled.

The G122-202 Servoamp is compatible with Moog standard card frame series including M127-102 (10-slot) and M127-105 (4-slot). Also forward compatible replacement for NFI22-202, FI22-202 and MI22-811.

FEATURES

- Proportional, Integral & Derivative (PID) control, jumper selectable
- User-Friendly Front Panel with LED indicators and Test Points
- Variable brightness LED's indicate valve current to enable loop tuning without an oscilloscope
- Five switch selectable output current ranges
- Two scaleable inputs including one fixed input
- Current feedback eliminates effect of load impedance
- Eurocard format compatible with Moog 127 Series card frames
- Dither is jumper selectable
- Inverting Amplifier designed-in for user interface
- 4-20mA to 0-10VDC Converter designed-in capability
- Ramp Generator designed-in capability
- CE-Mark & FCC part 15 compliant

ADJUSTMENTS

Input Sensitivity: signal V_{in7} → P7
signal V_{R7} → P9 (0. . .100%)

Zero Offset: P1 (± 750 mV)
Proportional Gain: P2
Derivative Gain: P6, P8
Integral Gain: P5
Dither: level, frequency
Ramp Rate - not on front panel

TEST POINTS

Input Voltages: signal on terminal 3 at V_{in3}
signal on terminal 7 at V_{in7}
signal on terminal 9 at V_{R7}
i.e. signal after potentiometer divider

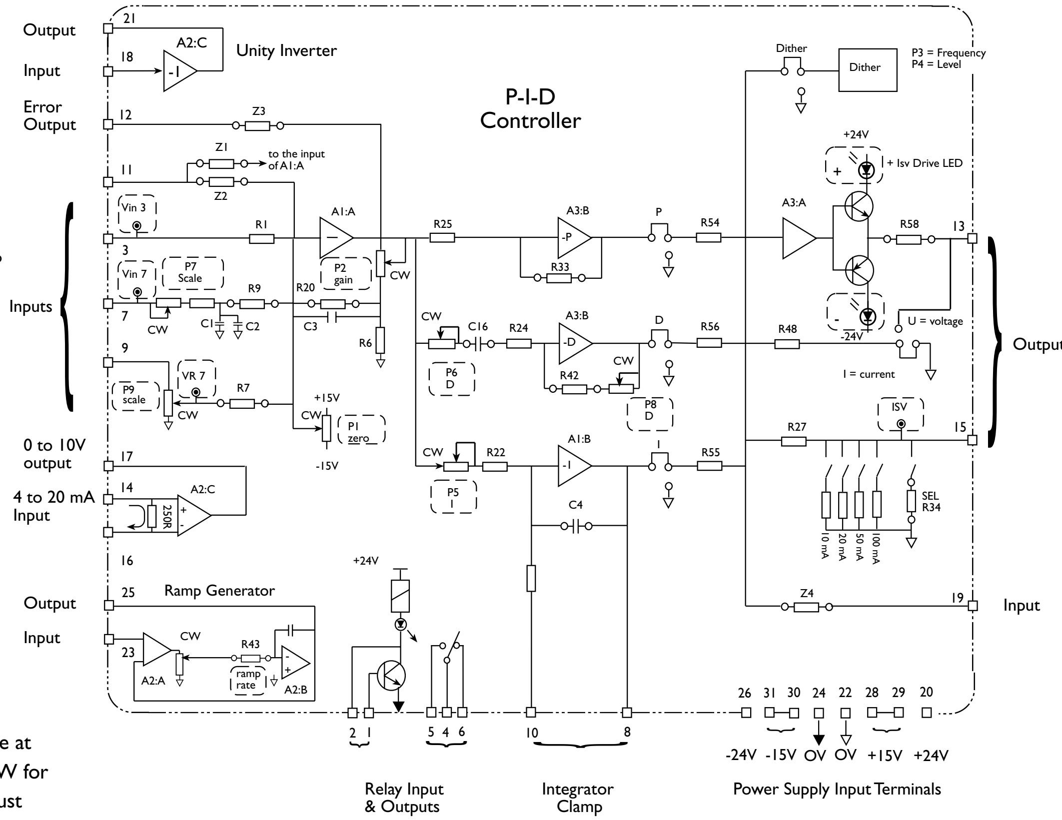
Voltage image of servovalve current: Isv Voltage drop across resistor proportional to servovalve current

Indicators: + and - servovalve current LED's
relay K1 LED

EMC: EN 50081.1, AS/NZS 4251.1 emission
EN 50082.2 immunity
verified to be capable of compliance with FCC part 15, subpart B

G122-202A1 PID SERVOAMPLIFIER - DETAILED BLOCK DIAGRAM

NOTES:
1. Components on solder posts: o▭o
2. Refer to schematic for all detail



ADJUSTMENTS

PID Servoamplifier

P1 Zero: Changes bias voltage at input (summing) stage. Turn CW for Positive Input bias voltage. Adjust for desired offset between CMD and FBK. R4 (2Meg) can be decreased to increase range of bias adjustment.

P2 Gain: Varies amplification of the error signal at summer stage. Changes Proportional gain of input (summer) stage. Also changes Integral and/or Derivative Gains if jumpers I and D are on. Turn CW to increase gain. Adjust for system stability.

P3 Dither Frequency: Turn CW to increase frequency from 25 to 320Hz. Adjust for a frequency appropriate for system dynamics.

P4 Dither Amplitude: Turn CW to increase amplitude or signal level. Amplitude 0 to 40% valve drive. Dither signal is approx. 25Vp-p square wave. Measure amplitude at Test Point I_{SV} with an oscilloscope. Ensure peak-to-peak value $I_S \leq 20\%$ rated I.

On/Off Link: The Link 'DITHER On/Off' enables or disables the free-running multivibrator circuit configuration (A3D). Generally not needed for position control. Applies to velocity loop or pressure control. Provides the ultimate in pressure resolution.

P5 Integral Gain: Changes Integral Gain if Integral Jumper is ON. Turn CW to increase gain. Adjust for system stability.

P6 Derivative Filter Frequency: Turn CW to increase the 'break point' or corner frequency. At the same time, increases the gain beyond the 'break point' frequency. Adjust to reduce excessive noise.

P7 Trim Scale: Allows scaling of the CMD signal to match the FBK signal. Turn CW to decrease pot authority and reduce command signal. Adjust to provide scaling of input at Terminal 7.

P8 Derivative Gain: Changes Derivative Gain if Derivative Jumper is ON. Turn CW to decrease gain. Adjust to add Phase Lead.

P9 Scale: Allows scaling of the command signal to match the feedback signal. Turn CW to decrease pot authority of feedback signal on Terminal 9. Adjust to provide scaling of higher magnitude signal (CMD or FBK).

P-Mode Jumper: Select ON to add Proportional control.

I-Mode Jumper: Select ON to add Integral control.

D-Mode Jumper: Select ON to add Derivative control.

Integrator Clamp: Link Pin-8 to 4 and Pin-6 to 10 and arrange to energize/de-energize the Relay via Pin-1 or Pin-2.

Relay Logic Select - Control Input Pin-1: Changes activation state of relay. Connect Pin-1 HIGH (+5 to +24V) to energize relay and enable Integrator. Float or connect Pin-1 to GND to de-energize relay. This disables (resets) or shorts Integrator.

Relay Logic Select - Control Input Pin-2: Changes activation state of relay. GND Pin-2 (sink≈8mA) to directly energize the relay and enable the integrator. Float Pin-2 to de-energize the relay and disable (short) the Integrator.

C1 & C2: Capacitor C1 & C2 (factory supplied) provides low-pass filter on the set-point signal. Used to soften a step change in the set-point or remove electrical noise on CMD signal. Remove C1 & C2 to remove Time Constant.

SW1 Valve Current Select Switch: Allows selection of the current sense resistor and thus maximum output current. Positions SW1 thru SW4 select full scale current via selected resistor (10, 20, 50 & 100mA). SW5 selects R34 which can be modified via solder posts for field modification. Max current from amplifier is 100mA.

I/U Link: Links enable either a current or voltage output to be selected. Select 'I' for Current or 'U' for Voltage Mode.

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CIRCUITRY - OVERVIEW

The Servoamplifier consists of several main control stages including an Input Summer stage (A1A), Independent PID control stages - Proportional Gain (A3B), Integral Gain (A1B) & Derivative stage (A3B) - Dither control stage (A3D) and a Current Driver Output stage (A3A and Q2/Q3). Additional circuit configurations and functions are provided by the designed-in Relay Circuit, Unity Gain Inverter stage (A2C), Ramp Generator stage (A2A & A2B) and an I-V Converter stage (A2C).

The Input Stage (A1A) is available for Summing signals applied to Terminals 3, 7 & 9. Servo feedback is normally connected to Terminal 3. An additional command or feedback may be connected to Terminal 9. Pot P7 allows scaling of the command signal to match the feedback signal. Capacitors C1 and C2 provide a low-pass filter on the set-point signal. This is used to 'soften' a step change in the set-point or when a ramped set-point or command is not available. Similarly, it can be used to remove electrical noise on the command signal. This 'Time Constant' can be disabled by removing C1 and C2. Resistor R9 (located on standoffs) may be 'increased' if feedback signal is too large with P7 full CW or 'decreased' if feedback is too small with P7 full CCW.

Null or Zero Bias of the Servoamp is accomplished by adjusting Zero Pot (P1). Potentiometer P1 supplies a + or - input to compensate for small zero errors in the system. Pot 'wiper' resistance can be decreased in value from 2Meg to increase range of adjustment. Jumper select PID control is provided for servovalve control set-up and 'tuning'. An Integrator 'reset' function may be activated by external signals. The SPDT Relay provided may be used for Integrator reset, signal switching or other function. One application of the Relay Contacts is to clamp the Integrator to prevent Integrator wind-up and run-away during open loop modes.

The Output of Summing Stage (AIA) is amplified by Proportional Gain Stage (A3B). Input at Terminal 11 can be used as an additional feedback input using component Z1 and Z2. Component Z1 provides an input path to the non-inverting input of AIA. Z2 provides another input path to the inverting input of A1A. Terminal 12 can be used for Error Output Monitoring using component Z3. Input at Terminal 19 can be used as an Inner Loop Input when Z4 is properly loaded. Terminal 19 can also be used as a 'disturbance' input to tune the loop. Resistor Z4 location should be sized to produce 25-50% of rated I_{sv}. Z4 is factory installed at 1Meg.

The Input at Terminal 19 (Inner Loop Input) is typically used to provide 'Dither' on the output current as required. The dither signal is approximately a 25Vp-p Square Wave signal with a frequency range of 25 to 320Hz produced by stage A3D. Dither stage is configured as a free-running multivibrator circuit. Dither is an oscillating signal used to keep an object continually moving. This is to avoid or minimize stick-slip phenomena in this component. A typical use is to lower threshold of the spool in a control valve. Dither is generally not needed for position control using standard Moog Proportional Valves. For pressure control, Dither can enhance pressure resolution and the peak-to-peak value is usually ≤ 20% of rated current.

The Current Driver Output Stage (A3A) controls the voltage across the selected current sense or sampling resistor (R34) when a load (servo valve coil) is connected across Terminal 13 & 15. Since R34 << R27, the current through the 'load' (I_{sv}) Is approximately equal to the voltage across the sampling resistor divided by its resistance (R34 selected) in ohms. The current stage uses the voltage generated by the current flowing through the selected current sense resistor, as feedback to minimize the Inductive time constant of the servovalve coils and make the current independent of the temperature dependent coil resistance. LED "+" and "-" indicate polarity and amplitude of the current or voltage drive to the control valve.

CIRCUITRY - FUNCTIONAL DESCRIPTION

Unity GaIn Inverter

➢ The G122-202 Servoamp requires command and feedback signals which have opposite polarities. The Unity Gain inverter enables either the feedback or command signal to be inverted, if the two signals are of the same polarity. Input Impedance on Pin-18 is 100K and the output can drive ±l2V into a minimum load of 1K.

Ramp Generator

➢ Ramp circuit is useful in controlling velocity of an actuator in a position loop. It is normally used to control the command signal. The circuit produces an output equal to the input. If the input is changed, the output changes at a rate set by Pl0, until the output is again equal to the input. This ramp, set by Pl0, has a minimum rate of 0.6 V/Sec and a maximum rate of 13.3 V/Sec. This rate can be adjusted by changing R43. Increasing R43 from 470K (factory installed) will 'slow' the ramp rate. R43 should not be increased beyond 4.7Meg. A 'faster' ramp rate can be achieved by decreasing R43. A typical minimum value is 10K.

4-20mA Converter

➢ This circuit converts a 4 to 20mA signal to either 0 to +10V or 0 to -10V, depending on the input wiring polarity. Basically, a 4mA results in 0V and 20mA results in 10V; currents between 4 and 20mA results in proportional voltage between 0 and 10V.

➢ For 0 to +10V: The input current is applied to Pin-14 and flows out of Pin-16. For this range, Pin-16 must be tied to the return line of the device generating the current

➢ For 0 to -10V: The input current is applied to Pin-16 and flows out of Pin-14. For this range, Pin-14 must be tied to the return line of the device generating the current.

➢ The Load between Pin-14 and Pin-16 is 250Ω. Care must be taken to ensure the common mode voltage on Pins 14 and 16 does not exceed +12V with respect to Pin-22 (0V ref). This is best achieved by connecting Pin-22 to 0V ref line of the device generating the current signal. The Output on Pin-17, can drive a minimum of a 1K Ohm Load with 10V Output.

GENERAL SET-UP INSTRUCTIONS - OVERVIEW

1. The Set-Up voltage is applied to Pin-7 of the Servoamplifier. Capacitors C1 & C2 provide an input ramp. This voltage can be taken from a potentiometer supplied by ±15V or by any type of voltage generator such as a PLC or set-point card FI24-202.

2. The feedback voltage is then applied to Pin-3 or Pin-9. This voltage is generally derived from a type of transducer (ex. position, force) and must be opposite polarity to the set-point voltage. Potentiometer P9 is used to adjust the input sensitivity of the signal on Pin-9.

3. The Input on Pin-9 can accommodate the higher voltages encountered when using a tachometer for measuring speed.

4. Adjust the Loop Gain using P2 to the largest possible value to achieve best system accuracy and speed. Increasing Loop Gain is limited by the system becoming unstable.

5. If Integral control action is required, close jumper 'I' to select the integrator and adjust Gain using P5 on Front Panel.

6. Integral control reduces static errors In Control Loops. To clamp the selected integrator, connect Terminals 8 to 5, 10 to 4 and energize relay K1. De-energizing relay K1 enables the Integrator.

7. To achieve Derivative control, close jumper 'D' and adjust gain using P6 and P8. Derivative control can improve system response and damping and can have a stabilizing effect on the control system.

8. To activate the dither, close jumper 'DITHER'. Use P4 to adjust dither level and P3 for dither frequency. Dither is rarely needed with Moog Servovalves.

9. To use voltage output, close jumper 'U'. To use current output, close jumper 'I'.

SPECIAL SET-UP INSTRUCTIONS

Valve Current Selection

➢ ***Standard Valves and Currents***
Valve current in excess of 125 to 150% of rated current can damage MFB valves. Select the full-scale valve current with SW1 to ensure that excessive current does not flow through the valve.

➢ From the valve data sheet, determine the rated current and select current range required with the Valve Current Select Switch. If the exact rated current is not available, select the next larger current range but check that 150% limit is not exceeded.

➢ ***Configuring for Non-standard Valves & Currents***
Where the valve has a rated current that does not fall within the standard range, it is possible the modify the output stage as required within certain limitations.

➢ ***Design Steps***

There are 3 resistive components In series which limit the maximum current that the full-scale output of the ±10V can produce including:

- R58 - Factory Installed fixed resistor value of 68Ω mounted on PCB solder posts: applies to all current MFB valves: ease of field changes
- Valve Coil Resistance - Typically 2 Coils are used which can be connected in series or parallel depending on desired valve-coil response
- Current Sense Resistor - SW1 switch allows selection of various current sense resistor values for limiting maximum Output current. SW1 position 5 is a user selectable sense resistor (R34) used for non-standard currents; mounted on PCB solder posts for ease of field modification; Note Max current from amplifier is 100mA.
- From the valve data sheets, determine the rated valve current and the coil resistance. Note that rated current is the current at which the valve is 'fully' open.
- Determine coil configuration. In critical applications, coils are connected in parallel to reduce the inductive Time Constant and provide back-up should one coil fail open. High Impedance Coils will run into voltage limits if connected in series. Low Impedance Coils are typically high current coils and may result in current limitations of the amplifier. If the current exceeds the max 100mA rating, use either one coil only or two connected in series.
- Select R34 via SW1 (4 selectable values & 1 fixed value easily modified as required)
- R34 should be sized so that the rated valve current produces a Iv drop across it.
- Select R58 (Driver Output) so that maximum valve current of 125 to 150% of rated current flows when the amplifier output is 10V. Use the I-V relationship as follows:

$I_{MAX} = 10V/(R34 + \text{Coil Resistance} + R58)$

I/U Links

➢ The Links enable either a current output (I-select) or voltage output (U-select). Select mode as required.

➢ Typically MFB valves have floating coils and requires Current Mode (I) drive to (1) maintain constant current independent of the temperature dependent coil resistance and (2) to reduce the inductive time-lag.

➢ Control valves with on-board electronics are called Electrical Feedback (EFB) valves. Select the Voltage Mode (U) for current or voltage inputs.

➢ Values of R48 may need to be adjusted to limit the voltage drive for different Moog MFB valves with different current inputs. R48 is factory set at I00K.

➢ Note that the I_{SV} LED's still 'illuminate' proportionally to the voltage drive signal.

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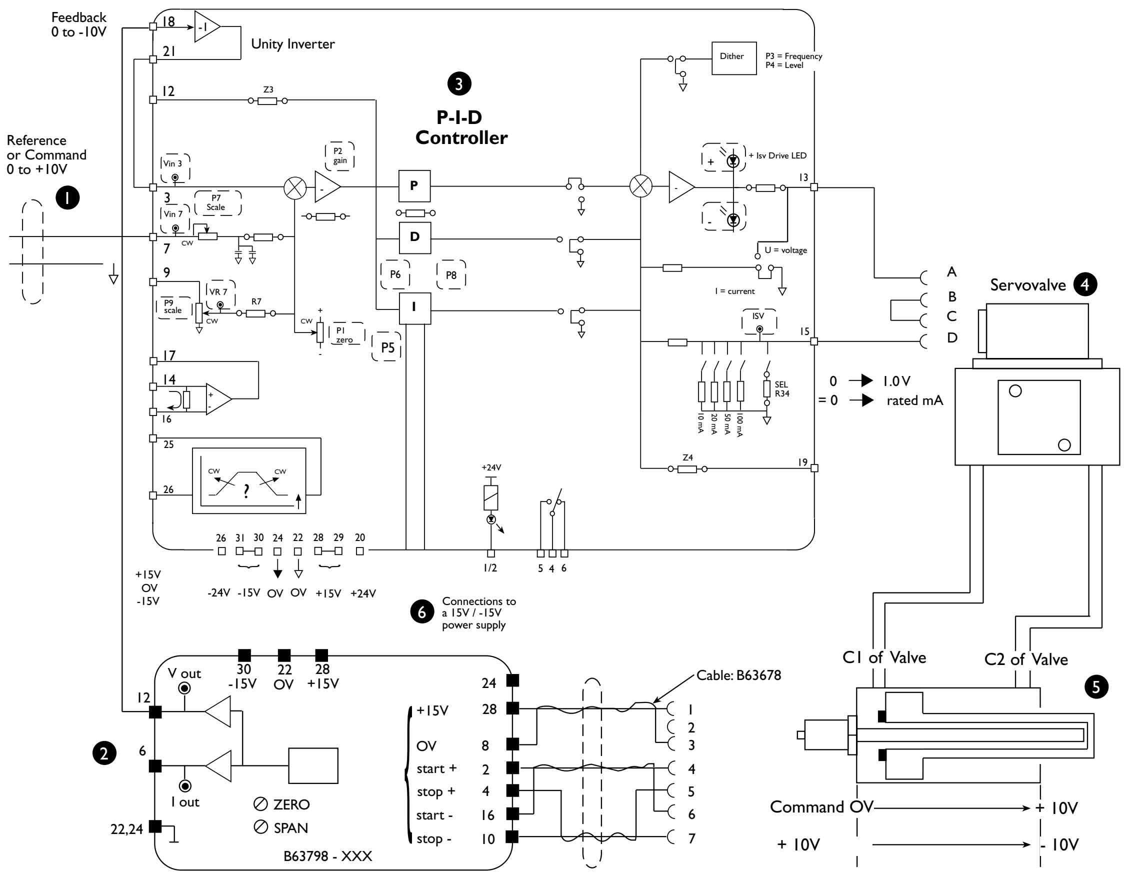
TYPICAL INTERCONNECT DIAGRAM



TYPICAL POSITION LOOP INTERCONNECTION DIAGRAM

Loop Description:

1. Command Path. The 0 to +10V command or reference signal is applied to Pin-7.
Scaling is possible with P7 and low-pass filtering is effected by C1 and C2.

2. Feedback Path. The 0 to +10V transducer signal is applied to Pin-18 of the 'Unity Inverter'. The signal is then 'Inverted' and the 0 to -10V output (from Pin-21) goes to Pin-3 Input of Summer Stage.

3. PID Servoamplifier
Summing Amplifier. The command signal and transducer signal are compared and the resulting error signal is amplified. The amplification is set by P2, 'GAIN' potentiometer and the amplified signal can be monitored at Pin-12. The amplified position error then continues through the PID Stage, configured as a 'simple' P-controller. Note also that NO Dither is used.
Output Stage. The output current stage drives the valve while the LED's in the Front Panel (Isv Box), indicate the polarity and magnitude of the drive signal.

4. Servovalve and **5. Actuator**
The control valve ports oil to the cylinder and drives it into the commanded direction.

6. Transducer & Controller. The Position Transducer feeds back a proportional signal to the Controller which converts it to the 0 to +10V feedback signal.

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RAMP GENERATOR SECTION APPLICATION EXAMPLE

➢ A PLC outputs a 0 to +10V position command that corresponds to a 0 to 800 mm cylinder stroke. It is required to set the cylinder velocity to 100 mm/Sec. What is the ramp rate required? What ramp time is required for a +1V Step at the new ramp rate? What adjustments must be made to achieve the new ramp rate?

➢ Calculate Ramp Rate;
100 mm/Sec (100 mm/800mm)
10 V/Sec = 1.25 V/Sec

➢ Calculate Ramp Time @ +1.0V Step input;
V_{IN} = Rate x Time = (1.25V/Sec) (X Sec) =
1.0 V Step ➔ Ramp Time = 0.8 Sec

➢ The ramp rate falls between 0.6 to 13.3 V/Sec range provided by R43 set at 470K
All that is needed is to set P10 to produce the desired rate. This can be achieved in two ways:
- Input a known voltage step and measure the output voltage ramp time. A +1.0V step will ramp in 0.8 Sec when the ramp rate is 1.25 V/Sec.
- With the closed-loop operating, input a known step and measure the time the cylinder takes to move to the new position.

A WORD OF CAUTION

➢ Stability of a Closed-Loop Control System, together with adequate performance, is sometimes difficult to achieve. Each individual component may perform perfectly, yet connection of the components into a Closed-Loop may result in such undesirable effects as:

- Hunting
- Oscillation
- Wild 'Overshoot'
- Chatter
- Sluggishness
- Poor Resolution
- Hard-over condition
- Drift

➢ The type of load, length of hydraulic lines, sizing of valve & actuator, loop-gains, presence of backlash, friction, load limiters, compliance, location of feedback transducers, or other individual 'idiosyncrasies' can contribute to unacceptable closed-loop behavior.

➢ For most general system control questions, Moog's Application Engineering group can usually provide the answers.

➢ For more in-depth system questions or problems, Moog does provide Engineering Support trained in the theory and practice of servo-systems that can carry-out detailed studies (often computer program assisted) to predict performance of Closed-Loop systems.

WARNING

➢ Polarities MUST be observed or serious damage or personal injury may occur.

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