NASA TECH BRIEF
Manned Spacecraft Center

A Closed Loop Cryogenic Environment Pressure Regulating System

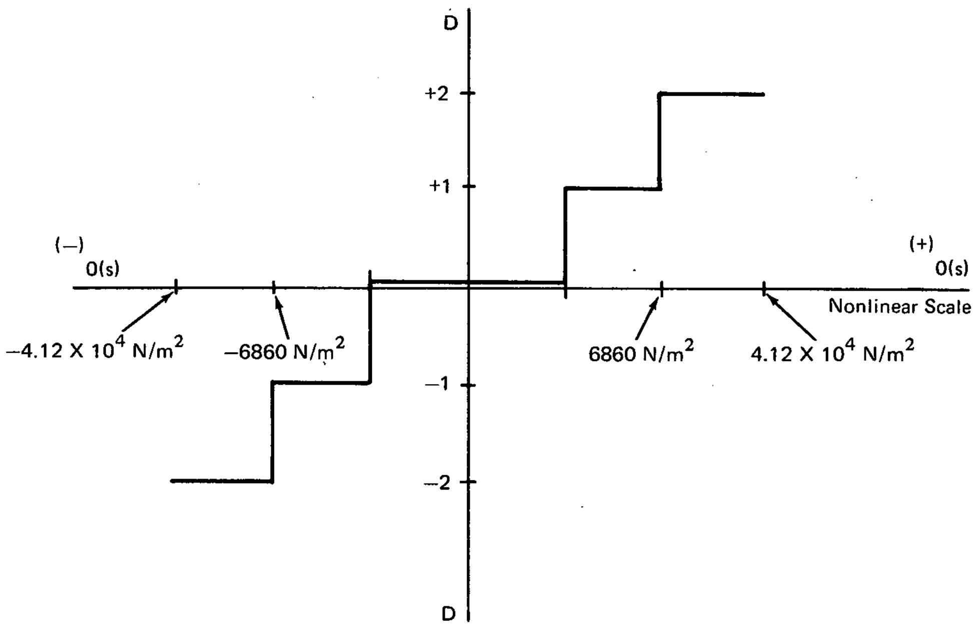


Figure 1. Element Transfer Function for 4-Position Nonlinear Contactor

The problem:

To control pressure automatically within ± 6860 N/m^2 of a 27.4×10^4 N/m^2 absolute pressure setpoint with minimum overshoot and quick damping, the system must have stable control at low flow rates and allow transition from low to high flow rates with no degradation in transient or steady state response. Supply pressures and temperatures range from 27.4×10^5 N/m^2 absolute to 68.6×10^5 N/m^2 absolute and from $-157°$C to $121°$C.

The solution:

A nonlinear closed loop control system utilizes an electronically controlled throttle valve to achieve the desired pressure regulation. The electronic control (controller) sets the throttle valve condition in relation to the pressure/flow characteristics and generates a discrete command signal to counteract disturbances.

How it's done:

The nonlinear closed loop control system uses a four-position contactor with two control bands, defined mathematically as follows:

$D = +2$, $I(s) - 0(s) \geq 4.12 \times 10^4$ N/m^2, full undamped signal from pneumatic transmitter;

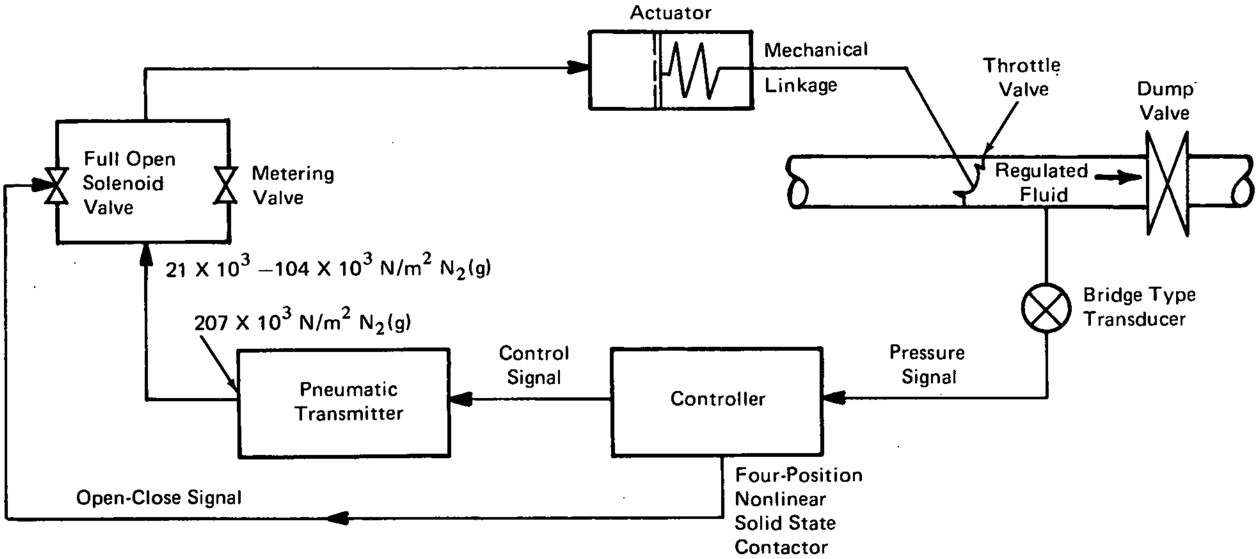
$D = +1$, $I(s) - 0(s) > 6860$ N/m^2, damped signal from pneumatic transmitter;

$D = -1$, $I(s) - 0(s) < -6860$ N/m^2, damped signal from pneumatic transmitter; and

$D = -2$, $I(s) - 0(s) \leq -4.12 \times 10^4$ N/m^2, full undamped signal from pneumatic transmitter

where D is the output signal generated by the nonlinear contactor; I(s) is the input signal to the controller, i.e., setpoint; 0(s) is the controller variable feedback signal; and s is the Laplace operator, for sinusodial case $s = j\omega$.

(continued overleaf)



When the output controlled variable, 0(s), is outside the ±4.12 X 10^4 N/m^2 band, as shown in Figure 1, a command signal of the form $1/(T_1s + 1)$ with small T_1 is desired, where T is the time constant of the transfer function. When 0(s) is within the ±4.12 X 10^4 N/m^2 band, a command signal of the form $1/(T_2s + 1)$ is desired with large T_2 to prevent overshoot. Within the design limits of ±6860 N/m^2, no correction signal is generated. Figure 2 shows the closed loop system.

Note:

Requests for additional documentation may be directed to:

Technology Utilization Officer
Manned Spacecraft Center
Code JM7
Houston, Texas 77058
Reference: TSP72-10390

Patent status:

No patent action is contemplated by NASA.

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