

# Taking the guesswork out of pneumatic control

Here's a step-by-step approach to efficiently designing systems that work right the first time.

Designers have several options when constructing pneumatic-control systems. But modular air-logic systems are often a good bet when a compact, economical unit is a must. They typically consist of a series of valves mounted onto standard manifold subplates. Such systems speed assembly and piping, and all interconnections between valves and controls in the circuit are machined into the manifold subplate. This cuts design and installation time, reduces the number of fittings, and eliminates piping and the routing errors that often go with it.

For instance, compared with discrete air-valve control systems, a modular system features:

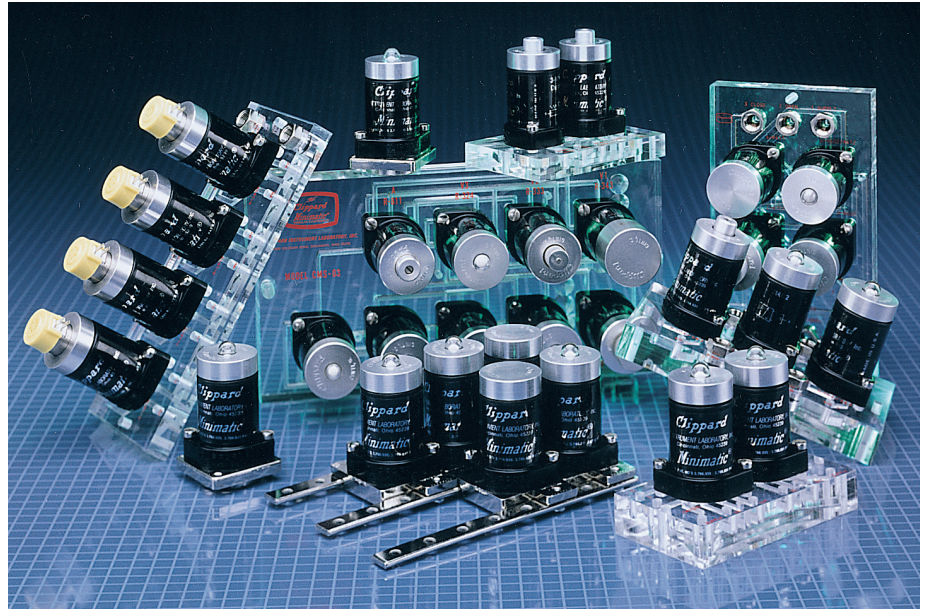
- Lower component costs.
- Simple plumbing and troubleshooting.
- Lower air consumption.
- No air locks.
- A smaller total package.

Compared with electrical-relay control, a modular system offers:

- An explosionproof system with no danger of burnouts.
- Lower power consumption.
- Lower costs by eliminating solenoids and relays.
- A single air supply.
- No heat buildup.

Only a few manufacturers offer modular, manifold-mounted pneumatic control systems. For instance, Clipard's Pneumatic Programmable Controller is a sequential controller that provides step-by-step system operation. It consists of a clear acrylic manifold for mounting sequence valves and other such components in a compact, efficient package.

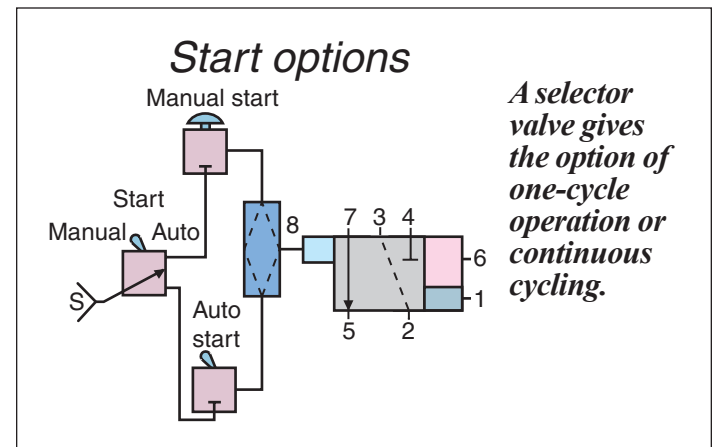
The system is designed so that when an operation finishes, feedback signals automatically initiate the next step. Many types of sensors can generate feedback signals, including limit valves, proximity sensors, pressure sensors,



***Pneumatic sequence controllers provide step-by-step system operation. Sequence valves and other components mount to the manifold subplates.***

Hall-effect switches, back-pressure cylinder sensors, and manual pushbuttons. Feedback signals provide positive, safe operation. If no signals are sent (due to a component failure, missing or jammed parts, and so on) the sequence stops and an indicator pinpoints where to troubleshoot. Internal interlocks prevent out-of-sequence feedback signals.

A pneumatic output signal at each step actuates air-piloted devices, including power valves, hydraulic valves, pressure switches, and other components that may control



air cylinders. The last sequence valve resets the system to repeat the cycle of operations.

## DESIGN BASICS

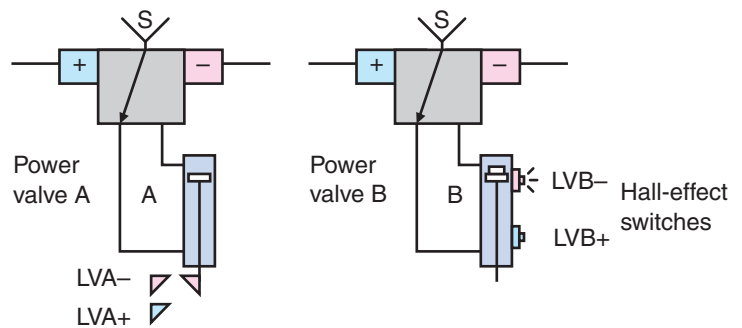
Modular systems can contain just a few valves or dozens, with many built-in functions, permitting a systematic approach to circuit design. As with any control system, it is essential to outline system requirements to save time and reduce the chances of missing a critical step.

The designer must also have a clear understanding of the sequence of operations. This should include a brief description of the machine's actions along with a sketch or drawing. Note pressure, temperature, filtration, and other operating conditions as well as control requirements, including manual, automatic, start, stop, and so on. Then list available input signals from limit valves, sensors, and other controls. Determine all mechanical and safety interlocks that are required. Finally, numerically list a step-by-step sequence of operations that indicates function and sensing method.

As a final check of circuit operation, consider proper actuation during all conceivable events. This includes startup, shut down, loss of air, panic stops in midcycle, re-starts in midcycle, and control during any other event likely to occur.

## Two-cylinder sequence

Actuating control	Step number	Function	Limit sensor
Start valve	1. Extend cylinder A	A+	LVA+ (limit valve)
LVA+	2. Retract cylinder A	A-	LVA- (limit valve)
LVA-	3. Extend cylinder B	B+	LVB+ (Hall-effect switch)
LVB+	4. Retract cylinder B	B-	LVB- (Hall-effect switch)
LVB-	5. Reset sequence	Reset	

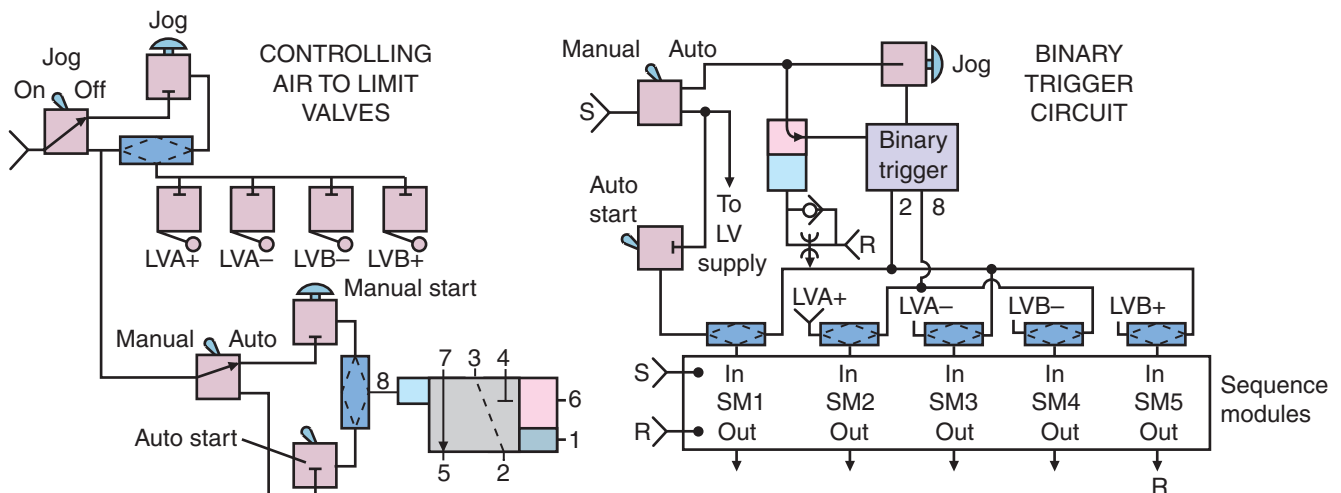


## PROGRAMMING GUIDELINES

After defining the overall functions and requirements of a system, engineers need to configure the system. Here are some basic guidelines:

Step one is to label all components in the pneumatic circuit. A practice Clippard recommends is to label each cylinder with a letter of the alphabet, starting with "A." The same holds for air motors and other controlled devices.

## Manual jog control



**Jog control lets users manually step through machine operations. This option can be added by controlling flow to limit valves or adding a binary trigger.**

# Sequence controller primer

Sequence controllers provide a straightforward, step-by-step approach to pneumatic system design and operation. For example, the pneumatic circuit shown here includes five sequence modules, two modular power valves, and two cylinders, both with dual limit valves. The circuit extends and returns Cylinder A, then extends and returns Cylinder B.

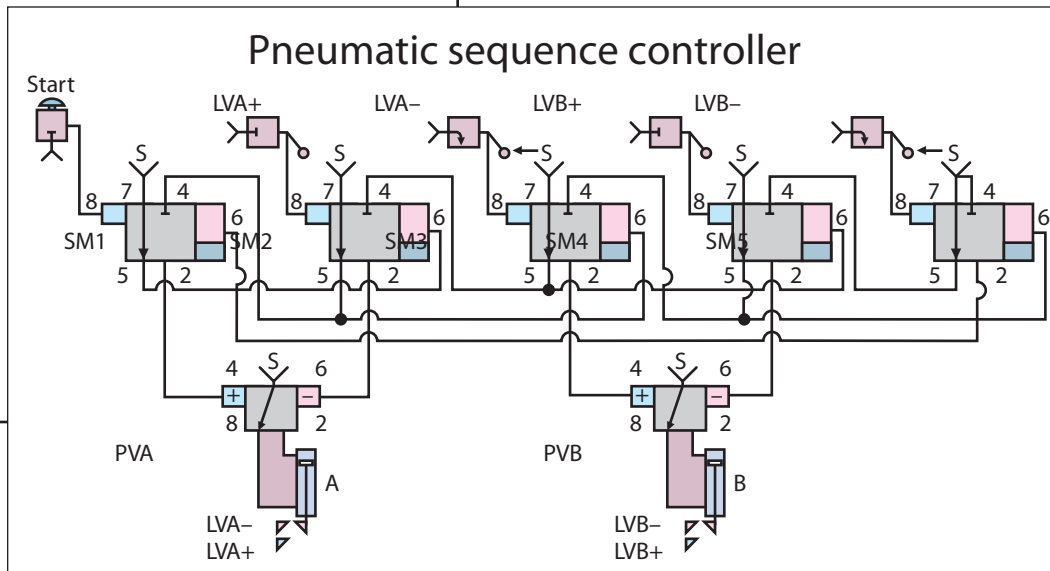
In the inactive mode, LVA- and LVB- are held passing, supplying pressure to Port 8 of sequence modules SM3 and SM5. The valves will not actuate because supply pressure to Port 6 connects to a larger pilot. Pushing the start button applies pilot pressure to SM1, shifting the valve and passing a pneumatic signal to power module PVA at Port 4. This shifts PVA and extends the cylinder. When SM1 shifts, it also removes pressure from SM2 at Port 6, preparing it for Step 2.

Extending Cylinder A actuates LVA+. This shifts SM2 and provides pressure to Port 6 of PVA, which shifts and powers the retraction of Cylinder A. Shifting SM2 also removes supply pressure from Port 4 of valve PVA. This lets the cylinder retract and removes supply pressure from Port 6 of SM3, preparing it for Step 3.

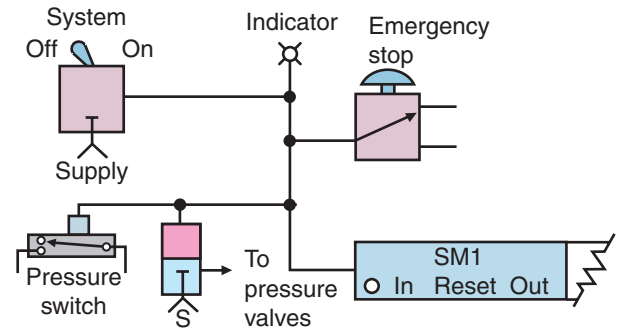
As a result, when LVA- is in the passing position, no pressure is on the larger pilot of SM3. SM3 shifts and supplies Port 4 of PVB. The power module shifts and the resultant flow extends Cylinder B. The sequence continues unless the start button remains actuated. Retraction of Cylinder B actuates LVB- causing a chain reaction that resets the sequence valves for the next cycle. Replacing the start button with a toggle or selector valve permits continuous cycling.

This is an example of a typical sequence circuit. Most applications require additional functions, such as delay-in and AND, that increase the number of sequence valves, but procedures for connections and adding steps remain the same.

Input signals can come from many devices, including limit valves and feedback devices such as proximity, pressure, Hall-effect, and liquid-level sensors. The sequence circuit can also be used with larger air-power valves or air-piloted hydraulic valves.



## System shutoff



**System shutoff prevents accidental machine operation.**

Next label the valve controlling the cylinder with the same letter. Label the pilot of the valve that extends the cylinder (or activates a device) with a “+” symbol, and the pilot of the valve that retracts the cylinder (or turns off a device) with a “-” symbol. Label the limit sensor the cylinder rod strikes with the letters LV (limit valve), the letter of the cylinder, and position of the sensor for extending or retracting. LVA+, for example, would mean the limit valve of an extended cylinder A.

The second step is to list in detail every sequence of operation. This includes the action or control that initiates a step, what function takes place during that step, and the limit sensor that ends the operation. An example of a simple two-cylinder sequence is shown in the accompanying table.

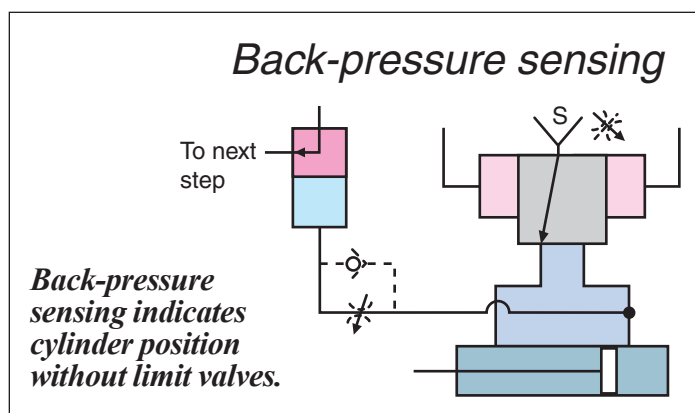
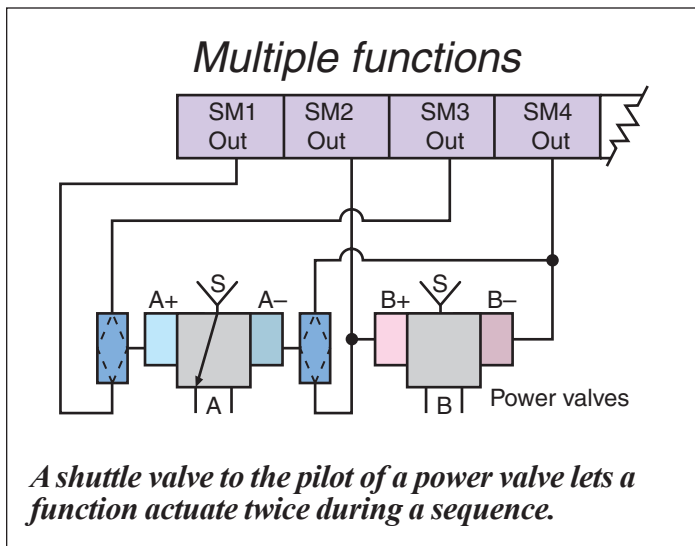
In step three, select components for the control system. Modular systems offer a lot of flexibility because users can choose from many options when selecting sequence valves.

For instance, in the “Two-cylinder sequence” example, five steps — extending and retracting the two cylinders plus the reset — require five sequence valves. A basic valve could be used for each step, or designers could choose valves with special features. For example, the first two steps could use a valve that provides a sequence reset lock if the start button is held down or if the limit valve

LVA+ is locked down. Reset lock means the sequence will not reset and bypass the valve being actuated.

After choosing components, it





is just a matter of assembling fittings and modular valves into the subplate. Connect the air supply and lines from the limit valves and electrical connections from the Hall-effect sensors to the inlet connections. And connect air lines from the outlet to the air pilots of the power valves.

## CHANGING OPERATIONS

Modular systems can be quickly tailored to meet specific requirements. Sequence conditions can be altered or adapted to the application by using different control modules. Here's a look at some common options.

**Start options.** If the application demands an input for each cycle of operations, use a pushbutton input signal and a sequence valve that provides a reset lock if the button is held actuated. If continuous cycling is required, use a selector or toggle valve at the input of the first step along with a valve that permits continuous cycle sequences. For applications that require the choice of selecting one cycle or continuous cycling, add a selector valve that determines the type of operation.

**Manual jog.** Another consideration is manual jog. This control option lets users jog (step-by-step) through the machine sequences. One way to do this is to control air-flow to the limit valves, with the jog control a pushbutton or spring-return selector. If held actuated, the sequence continues until released.

Another method for manual-jog control is to use a bi-

nary-trigger circuit that controls the input to the sequence circuit. This approach requires actuating the jog signal for each step. A delay-out valve resets the binary trigger when there are an odd number of sequence steps.

**Reset.** This control, when actuated, returns the sequence to the start position. Reset can also place power valves in a home position. A reset circuit should only be used when the control is in manual mode.

**Emergency stop.** E-stop controls can halt system operations in several ways:

1. Stop the sequence only.
2. Stop the sequence and relieve pressure from the power valves.
3. Stop the sequence and activate reset controls.

A latching mushroom-head button is commonly used for the emergency-stop because it gives users a positive response when activated.

**System shutoff.** These controls turn off the main air supply. This prevents harm to personnel or product from accidentally operating the machine. If the system has large power valves, a piloted three-way main supply valve can control a specific machine section. When electrical circuits are part of the system, an air-piloted pressure switch ensures the system has electric power only if the air is on.

**Multiple outputs.** When two (or more) functions start with the same step, connect the output from that sequence step to both power valves.

**Multiple functions.** Functions that actuate twice during the sequence call for the system to connect a shuttle valve (OR function) to the pilot of the power valve.

**Multiple inputs.** When two functions actuate at the same time, a piloted three-way valve (AND function) ensures both functions are complete before the next step begins.

**Delays.** Applications that require a delay before a step can use a delay-in module between the limit valve and the input to the step being delayed.

**Back-pressure sensing.** Many air-cylinder applications cannot use mechanical limit valves for sensing because of physical interference, temperature extremes, or other conditions. A method called back-pressure sensing indicates cylinder position without limit valves. For example, as a cylinder retracts, it creates a back pressure behind the piston. Restricting exhaust air at the control valve further increases pressure and slows return of the cylinder rod. This back pressure holds the pilot down on a three-way valve. When the cylinder fully returns, back pressure diminishes at the pilot port of the three-way valve, letting a spring shift the valve and send a pneumatic signal to the next step. If the system requires a delay, substitute a delay-out module for the three-way valve.