RF Control of Pneumatic Actuators

In the world of Theater, it is becoming more and more common to see automated scenery – set pieces which move under 'magic' powers. One of the easiest ways to implement this theatrical magic is through the use of pneumatics. Pneumatic cylinders are devices which use air power to extend a pushrod or to rotate a lever. Pneumatics are especially easy to implement as they can be powered with a standard shop air compressor.

In the industrial world, there are manufacturers which make radio control systems for pneumatic machinery. However, these systems are prohibitively expensive for theater practitioners. This document will outline the technologies and techniques required to create a shop-brew remote-controlled pneumatic actuation system.

Valves

Pneumatic cylinders are controlled by ducting compressed air to ports on the body of the cylinder. This routing of air is accomplished with high-pressure hose, fitting, and valves.

It is the valves which control the motion of pneumatics. By opening a valve, air is routed to the input port on the cylinder. Valves can be manually or electrically actuated.

Solenoid Valves

The most common form of electrically actuated valve is the Solenoid valve. A solenoid is a combination of an electromagnet and a moveable piston. When electricity is applied to the electromagnetic coil, the movement of electrons creates a magnetic field which in turn moves the piston. In a solenoid valve, this movement is used to open the pathway through the valve.

Solenoid valves range in price from $30 and up, depending on valve type and pressure rating.

Solenoid Valve Types

Solenoid valves come in six main varieties, useful for different applications:

2-way Normally Closed valves have a single inlet and a singe outlet. When electricity is applied, the valve is opened, and fluid is allowed to pass. The valve closes when electricity is removed.

2-way Normally Opened valves have a single inlet and a single outlet. When electricity is applied, the valve is closed, and the passage of fluid is blocked. Flow is resumed when electricity is removed.

3-Way Normally Closed valves have inlet, outlet, and exhaust ports. When electricity is applied, the fluid is allowed to pass from the inlet to the outlet. When electricity is removed, the inlet port is blocked and the outlet is connected to the exhaust port.

3-Way Normally Opened valves connect the inlet to the outlet when there is no electricity applied. When energized, the inlet is closed off and the outlet is connected to the exhaust.

3-Way Multi-Purpose valves act as A-B switchers for fluid control. The inlet can be connected to either of two outlets, allowing the valve to be used as either normally opened or normally closed, as well as as a selector to choose different paths of flow.

4-Way valves are used to operate a double-acting cylinder. A 4-way valve will extend a cylinder when energized, and retract it when de-energized. This reduces the number of pneumatic and electrical connections and ensures synchronicity of valve operation.

Other Valve Considerations

When choosing a solenoid valve, the following parameters must be taken into account:

Pipe Size: The port size on the valve should be selected to accommodate the tubing and other connectors being used in a system. It also affects the flow rate of the valve.

Flow Rate: The amount of fluid which can pass through a valve at a given pressure. This is useful when selecting valves to accommodate a certain volume of air cylinder.

Operating Pressures: The Maximum pressure is the pressure at which the valve will no longer function, as the fluid pushes the solenoid opened or closed. Some valves – particularly 4-way valves -- have a minimum operating pressure. A certain pressure differential must be maintained in order for the valve to remain opened.

Electrical Ratings: Like any electrical equipment, solenoids operate at a given voltage and amperage. Valves are available in both AC and DC, with higher-pressure valves usually having higher electrical demands.

RF Control of Solenoid Valves

RF, or Radio Frequency remotes are common in applications where line-of-site transmission is not possible. The most common example of RF remote control is the garage door remote, which uses a weak radio signal to trigger the door motor.

The same technology can be used to control solenoids and pneumatic systems. RF Relay boards are common finds in electronic kit catalogs and online retailers such as electronickits.com. These kits use a small remote to transmit a radio signal which is received by a decoder board. This board has several relays (electromechanical switches) which are closed, allowing the flow of electricity. These kit remote systems have a range of approximately 100', more than enough for most theatrical applications.

RF Transmitter kits are available from 1 to 8 channels, and ranging in cost from $50.00 to $150.00 (respectively) for a remote transmitter and receiver/relay board. Multiple channels can be used to control different pneumatic elements. For example, a stage trap door may require one channel for actuation of locking pins, and another to prove the actual movement of the door.

Different transmission frequencies are available in order to minimize interference from other transmitting equipment such as wireless microphones or noisy electrical connections.

System Integration

A complete RF controlled pneumatic system would consist of:

- Source of Compressed Air
- Pneumatic Cylinders
- Solenoid Valves and appropriate power supply
- RF Transmitter
- RF Receiver

The compressed air is routed through hoses from the compressor to the valves, and from there to the cylinders. The valve will also have electrical connections in order to be actuated. Power from the power supply is run to the relay board, and then to the valve. Connected as such, the relay will be closed, and thus the valve actuated, when the proper remote signal is received.

It is essential that the rated current of the solenoid valve not exceed the rated current of the relay board. If more amperage is needed, a more powerful relay can be connected to the relay board. The current flowing through the relay board energizes the larger relay, which completes the valve circuit.

Sources:

www.valvestore.com -- huge selection of solenoid valves from various manufacturers, and lots of helpful information for selection.

www.electronickits.com -- one of many suppliers of RF transmitter and receiver kits.

System Hook-up Diagram