SIGNAL CONDITIONERS

TTE TRAINING LIMITED

INSTRUMENT COURSE

SECTION 5

SIGNAL CONDITIONERS

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SIGNAL CONDITIONERS.

5.1 Need for signal conditioning.

So far we have discussed methods of generating pneumatic and also electrical transmission signals. We have also discussed methods of interpreting and displaying the signal information, either on a gauge or other electrical device.

There may be cases were the transmitter output signal is pneumatic but the receiving device is electronic as would be the case with some controllers. For this purpose there needs to be devices which are capable of converting signals from one form to another, the devices which do this are known as signal conditioners or transducers.

The commonly used signal conditioners are:-

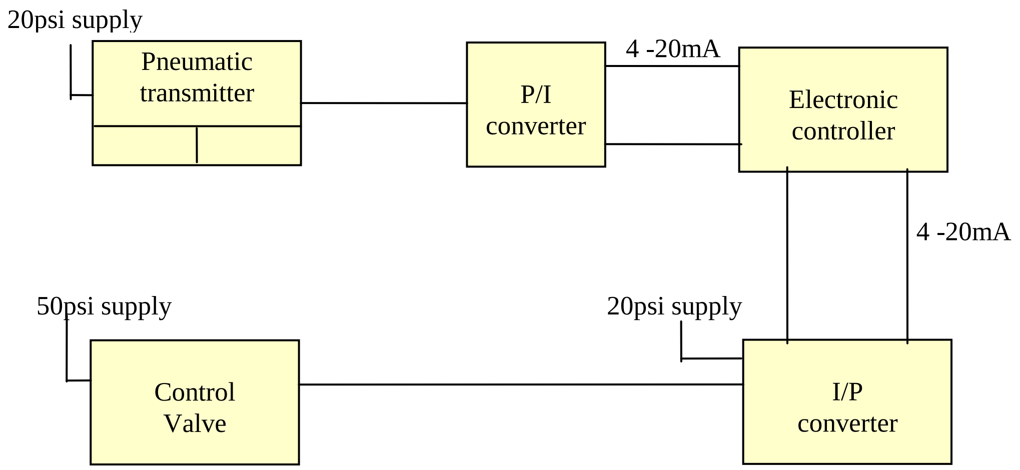
1. Electrical to Pneumatic - I/P - *4 to 20mA* to *3 to 15psi*
2. Pneumatic to Electrical - P/I - *3 to 15psi* to *4 to 20mA*

There are other signal conditioners available but these tend to be used in temperature measurement systems, these are:-

1. Resistance to current - Rt/I
2. Millivolt to current - Mv/I
3. Thermocouple to current - Tc/I

There are other specific transducers available, for example some electrical devices such as controllers require 1 to 5 volt input signals. Inputs for D.C.S computer control centres will require digital signals.

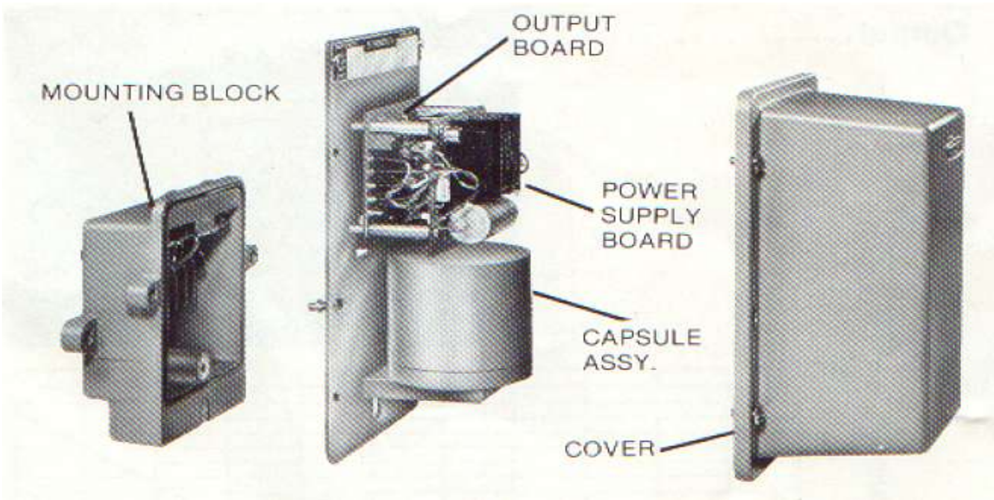
The reverse is also applicable; the output from electronic equipment such as controllers or D.C.S will need to be converted to a pneumatic signal in order to operate pneumatic control valves. The following diagram shows the signal conversion process from a pneumatic transmitter to a electronic controller re-feeding a control valve:-



This section is going to deal only with 2 types of signal conditioner, these being the P/I and the I/P, the remainder which are temperature related will be dealt with in that section. The other transducers will not be discussed in any further detail at this stage, except to say that they do exist and should further information be required it is available in manufacturer's literature.

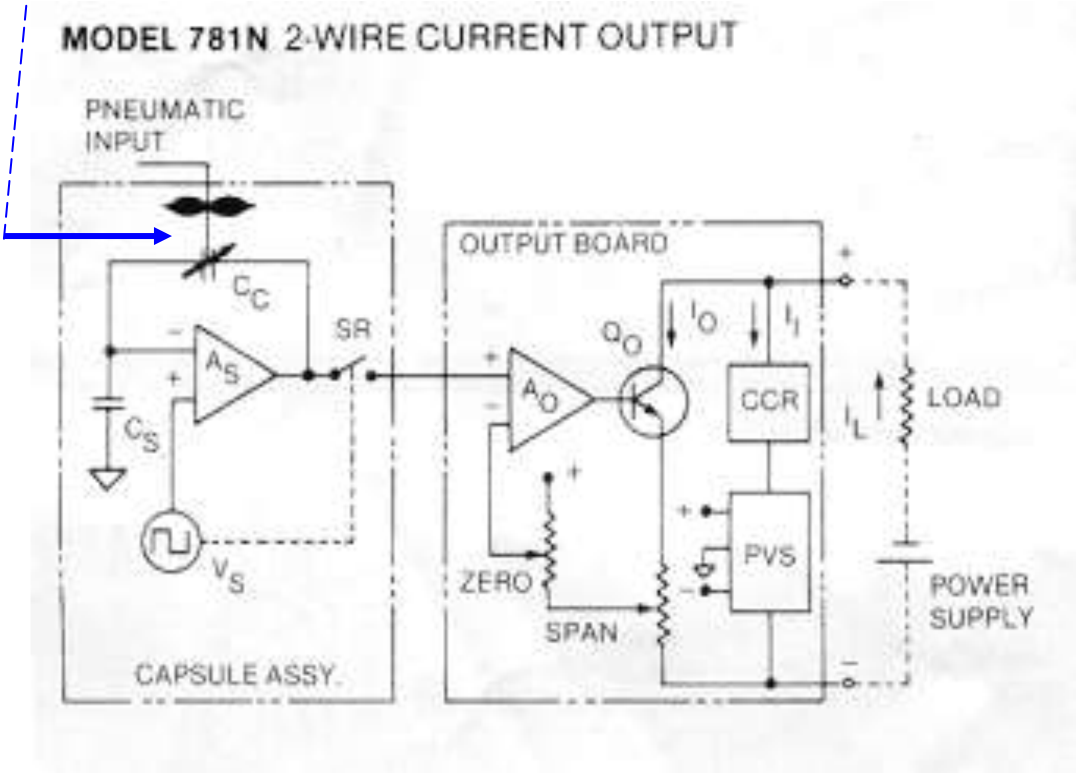
5.2 P to I converter.

There are probably 2 commonly used P/I converters, these being the Moore and the Foxboro type. Similar to the electronic transmitter both these converters work on the principle of variable capacitance. The next 2 diagrams show these 2 converters:-



The diagram above shows the Moore type P/I converter, and below the Foxboro P/I converter.

In each of the Transducers, the pressure is applied to the capacitance capsule between 3 to 15psi, as the distance between the capacitance measurement plates is decreased the capacitance is also changed, this information is sent to a P.C.B were it is converted into a 4 to 20mA output.

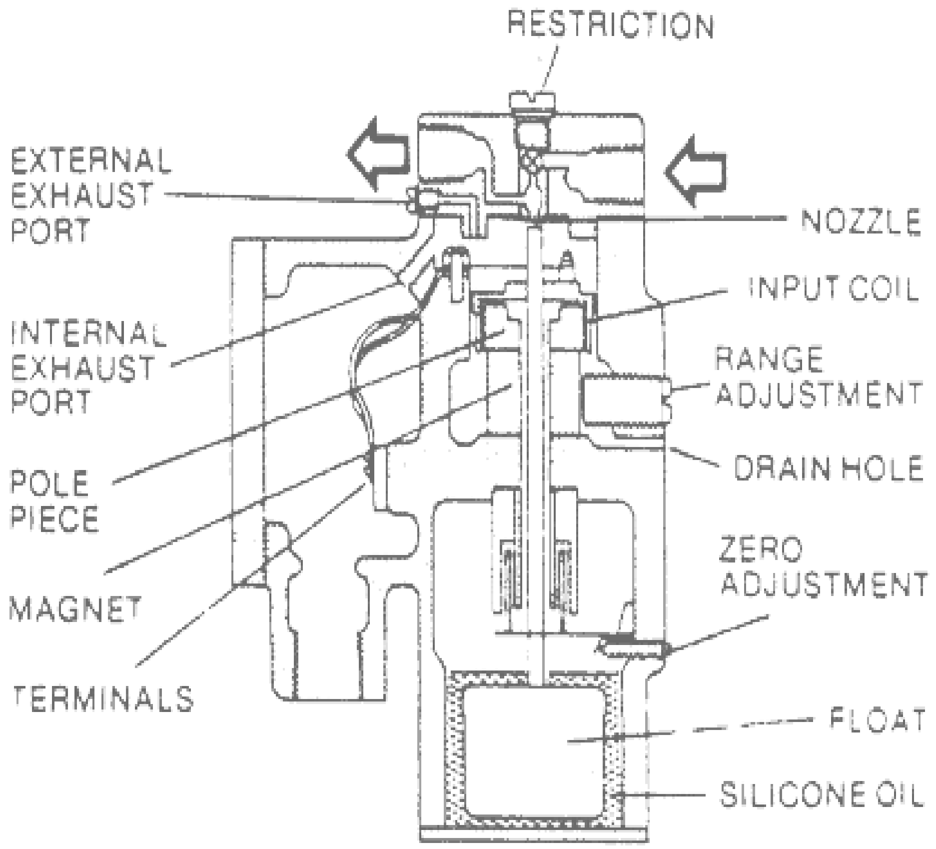


These devices require a 24volt supply for their operation. In both cases these converters have the standard zero and range adjustments, and an additional linearity adjustment.

5.3 I to P converter.

Probably the main function of the I/P converter is the conversion of electrical signals from controlling equipment that feeds pneumatically operated control valves. Probably the most common and probably the simplest is the Moore model 77. There are others such as the Braun/ Hartmann and the Fisher types, for this section we will deal with the Moore variety. As with all aspects of instrumentation technology has played a part, with one form of I/P converter being revamped as a digital valve controller - this product is available from the recently formed Fisher/ Rosemount Company and uses the HART (smart) communications system.

The diagram below shows the Moore model 77 I/P converter:-

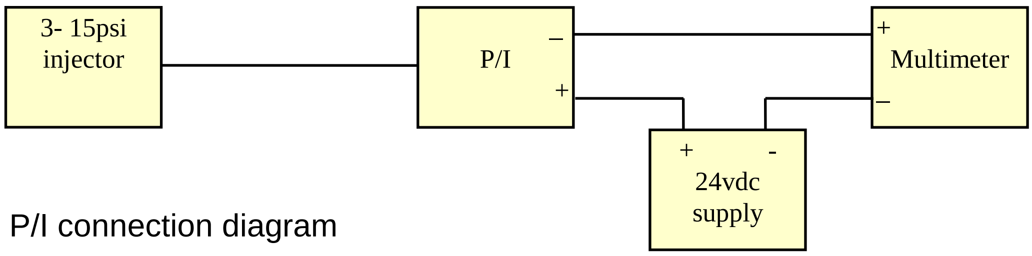


The input coil and float are attached to a common centre shaft, which is free to move vertically, with the float being submersed in oil to absorb any shock/ vibration and to make the float appear weightless. A permanent magnet surrounds the input coil, and when the 4 - 20mA input signal is increased the 2 magnetic fields react causes the free coil to move nearer the nozzle. A 20psi supply is fed to the nozzle and the further away the float shaft is from the nozzle the more air is allowed to escape, equally when the shaft gets nearer the nozzle with increased pressure, the gap reduces thus restricting the air exit and thus causing the output pressure to increase proportionally, so that 4mA = 3psi, and 20mA = 15psi. As with all instruments this device has a zero and range adjustment, however for linearity refer to manufacturers instructions.

5.4 Calibration of signal conditioners.

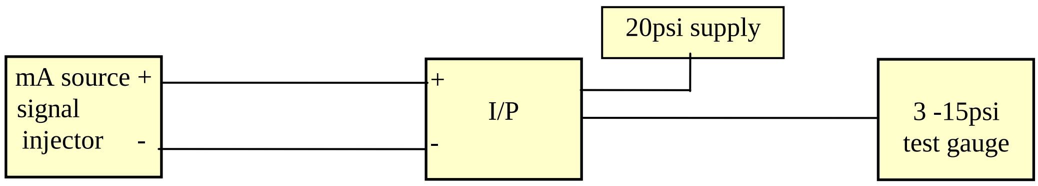
It is of utmost importance that signal conditioning equipment is calibrated well, as these devices if allowed to retain their error margin can/ will act as error amplifiers. In other words if the transmitter or device feeding it has a calibration error the output will not only possess the original amount of error also the combined effect of the transducer, the result could be errors in excess of 10%, which is totally unacceptable.

The next 2 diagrams show how a P/I and I/P may be setup for calibration:-



P/I connection diagram

P/I calibration:- the calibration signal is supplied from either a portable pressure calibrator or test panel equipment, the output signal needs a 24volt dc power supply and a multimeter (set on mA). Setup as the diagram shows by raising the input signal the output should raise by a proportional amount so that 3psi input produces a 4mA output signal (zero) and 15psi produces a 20mA output signal. The linearity can be checked by reducing the input to 9psi and the output should reduce to 12mA, any irregularities should be rectified through calibration. Detailed calibration information is available in each product specification catalogue.



I/P connection diagram

I/P calibration:- the calibration signal is this time supplied from a milli-amp source or signal injector. The output from the I/P is connected to a test gauge capable of measuring the output signal (3 - 15psi). With 4mA input applied the output should read 3 psi (zero), then increase the signal to 20mA and the output should read 15psi, again to check linearity reduce the input to 12mA and the output should read 9psi. Again any deviation from this should be rectified via calibration, with detailed information being available in manufacturer’s literature.

Having connected the transducer up for calibration, and applied the appropriate signals to zero and range, it may be required to check the output against any given input within its range. This is a useful way of checking the linearity. The following examples show how the output may be predetermined, and also how it is possible to work out the input, by measuring the output.

1. Measuring the output from a given input and range, for a transducer, or transmitter:-

For a transducer (the input here includes zero compensation)

$$\frac{\text{Output range}}{\text{Input range}} \times \text{input} = \text{output}$$

$$\frac{(20 - 4)}{(15 - 3)} \quad \frac{16\text{mA}}{12\text{psi}} \times 9\text{psi} = 12\text{mA}$$

For a transmitter, the value at zero needs to be added

$$\frac{\text{Output range}}{\text{Input range}} \times \text{input} = \text{output} \ (+ \text{ zero value}) = \text{true output}$$

$$\frac{(20 - 4)}{(0 - 100\text{"wg})} \quad \frac{16}{100} \times 50 = 8 \ (+4) = 12\text{mA}$$

2. Calculating the input from a measured output, and knowing the calibrated range:-

For example, a temperature transducer has a fixed range of 0 – 500 degrees C, the measured output for example is 16mA. The input temperature is therefore:-

$$\frac{\text{Input range}}{\text{Output range}} \times (\text{measured output - zero value}) = \text{actual input}$$

$$\frac{500}{20 - 4} \times (16 - 4) = 375 \text{ degrees C}$$