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Pneumatic Analog-to-Pulse Frequency Converter

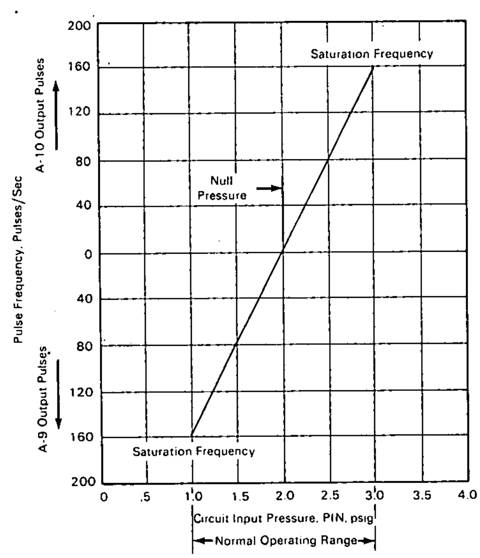

Figure 1

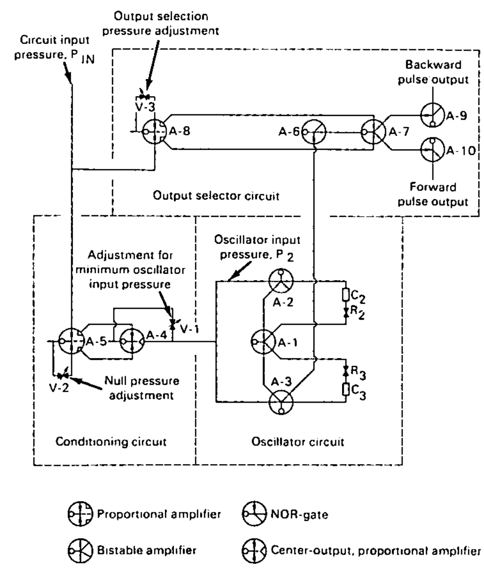

Figure 2

A pneumatic analog-to-pulse frequency converter circuit was designed in which the circuit output pulse frequency is proportional to the pressure level of the input signal. The circuit incorporates three unique features not used in other pneumatic circuits.

1) A pneumatic oscillator whose output is a function of its input pressure and operates uniformly to zero pulses per second.

2) The output frequency of the circuit is proportional to the deviation of the input pressure from a null pressure (Figure 1). The null pressure is the pressure at which the output frequency is zero and is set midway in the normal operating range of the input pressure signal. When the input pressure is increased above this value, the output pulse frequency increases and appears at one of the two output ports. As the input pressure decreases from the null pressure, the output frequency also increases but appears at the other output port.

3) The circuit saturates at a maximum frequency in either port and remains at this frequency for input pressures greater or less than their normal range.

This converter circuit was developed for driving a pneumatic stepping motor in either a forward or backward direction depending on the magnitude of an analog pressure signal, and was a part of a pneumatic control system for nuclear powered spacecraft. In locations close to a nuclear rocket engine, the nuclear radiation level is higher than the tolerance level of most electronic circuit elements. Hence systems using flueric devices, which appear to be inherently insensitive to radiation, are being investigated. The flueric

(continued overleaf)

converter may be of interest for other pneumatic control systems requiring a fluid oscillator which converts an analog pressure signal to pulse frequency and has a frequency range down to zero pulses per second. This converter may also be used in other situations where it is desirable to sense or use an analog pressure signal to actuate pneumatic devices.

The oscillator circuit shown in Figure 2 is composed of three bistable amplifiers with R-C time lags in the feedback paths. Amplifier A-1 outputs are connected through resistances and volumes to the control ports of two other amplifiers, A-2 and A-3. One output of each amplifier A-2 and A-3 is then connected to the control ports of amplifier A-1. The input pressure P_2 to the oscillator circuit is connected to both the remaining control ports of amplifiers A-2 and A-3.

To follow the sequence of operation of the oscillator circuit, assume the output of amplifier A-1 is switched to resistance R_2. The pressure in volume C_2 rises in a manner approximating a first order time constant system. When the pressure in volume C_2 is slightly higher than the oscillator input pressure P_2, amplifier A-2 will switch to the control port of amplifier A-1. This will switch amplifier A-1 to resistance R_3. As the pressure in volume C_2 drops below the oscillator input pressure P_2, the amplifier A-2 will switch from the control port of amplifier A-1. However, since amplifier A-1 is bistable, its output will remain switched to R_3. Similarly the pressure in volume C_3 rises until it is slightly higher than the oscillator input pressure P_2 at which time amplifier A-3 switches to the control port of amplifier A-1. Amplifier A-1 then switches to R_2. When the pressure in C_3 drops below the oscillator input pressure P_2, amplifier A-3 switches from the control port of amplifier A-1. This completes one cycle.

As the input pressure P_2 increases, more time is required for the volume pressures to exceed P_2. This decreases the pulse frequency. The frequency becomes zero when the input pressure P_2 equals the maximum obtainable volume pressure.

The conditioning circuit is shown schematically in Figure 2. The circuit is required to provide an input to the oscillator circuit that is a maximum when P_{IN} is at the null value and decreases when the input pressure P_{IN} to the converter either increases or decreases from the null value. The maximum conditioning circuit output pressure corresponds to that oscillator circuit input pressure P_2 which causes the pulse frequency to be zero. The minimum output pressure from the conditioning circuit corresponds to the oscillator circuit input pressure which causes the oscillator circuits pulse frequency to be the desired maximum value. To provide flat saturation characteristics, the minimum conditioning circuit output pressure must not fall below this value.

The conditioning circuit consists of two proportional amplifiers. Amplifier A-4 in the diagram is a center output amplifier whose output is maximum when the control port pressures are equal. The output pressure decreases when the control port differential increases in either direction. Amplifier A-5 is a proportional amplifier whose differential output is proportional to its differential input signal. An additional flow source is provided through valve V-1. This source maintains the output pressure of amplifier A-4 at the desired minimum pressure. Valve V-2 is used to set the null pressure at the desired value.

The output selector circuit directs the oscillator output pulses to the correct output port. If, as shown in Figure 2, the converter input pressure P_{IN} is greater than the null pressure, the pulses appear at the forward pulse output port. If the input pressure P_{IN} is less than the null pressure, the pulses appear at the backward pulse output port.

Amplifier A-6 in Figure 2 is an NOR gate that serves to amplify the pulses produced by the oscillator circuit. The output of amplifier A-6 is applied to the supply port of bistable amplifier A-7. The pulses are directed toward either the forward pulse output port or the backward pulse output port depending upon which control port pressure of amplifier A-7 is greater. Proportional amplifier A-8, which provides the control input pressures to amplifier A-7, serves to increase the switching sensitivity of the selector circuit. Valve V-3 is set so that amplifier A-7 switches when P_{IN} equals the null pressure. NOR gates A-9 and A-10 amplify the output pulse pressures.

Notes:

1. Documentation is available from:
   Clearinghouse for Federal Scientific
   and Technical Information
   Springfield, Virginia 22151
   Price $3.00
   Reference: TSP69-10276
2. Technical questions may be directed to:
   Technology Utilization Officer
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Patent status:

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