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Measuring time-dependent variables

Because almost all physical systems vary with time, it's important to accurately determine elapsed time when taking a measurement. Early methods of determining time interval were based literally on clock watching. This led to the stop watch, followed by the electric timer. Each of these was an attempt to eliminate human error in reading instruments to improve repeatability.

As requirements became increasingly severe — and the necessity to compare time variant data increased — electronic time measurement methods were devised. Modern electronic timers can count in thousandths of a second. Frequency-comparing techniques have extended the capabilities into the nano-second (10^{-9}) range. However, using frequency as a timing or comparing function requires very accurate frequency generation to prevent inaccurate timer measurement. In many applications, accurate time measurement sets the upper limit on the results attainable.

Because velocity is the rate of change of position, much of the displacement instrumentation previously described can be used as velocity instrumentation by taking time into account. A simple displacement-measuring instrument described in September 1988 consists of a gear rack and magnetic pickup. The magnetic pickup generates an electrical pulse every time a gear-rack tooth passes. This instrument becomes a velocity transducer by counting the number of pulses per unit time, or frequency. Since the distance between each gear-rack tooth and the number of teeth passing the pick-up per unit time are known, linear velocity can be determined. Other pulse-generating linear-position hardware relies on the same principle — velocity measured by determining pulse frequency.

Another instrument widely used to measure velocity, the tachometer-generator, Figure 1, is an electrical device that produces a DC voltage proportional to a generator's rotational speed. A rack-and-pinion assembly converts linear motion to rotational motion.

Historically, rotational speed (rpm, °/sec, rad/sec) has been measured by analog devices that produce an output proportional to velocity. The most commonly used type of sensor for this has been the DC tachometer. Two basic types of DC tachometers are in use today — brush and brushless. Both produce accurate, linear output from zero through maximum speed.

Brushes in the brush-type tachometer wear out and must be replaced periodically. The instrument's output voltage contains greater ripple than other types of tachometers. These tachometers are best suited for relatively clean environments to avoid accelerating wear of brushes. Protective enclosures may improve their performance in dirty environments, but can reduce their accuracy if exposed to heat.

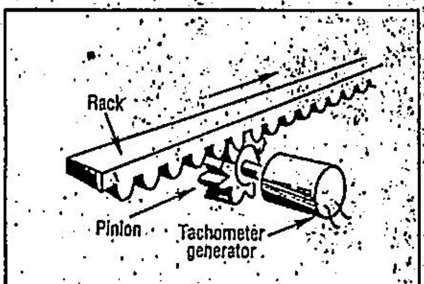

Fig. 1. Rack-and-pinion assembly allows measuring linear velocity by rotating a tachometer generator.

Brushless DC tachometers use no brushes because no electrical connection is needed for rotating members. External circuitry is needed, however, that can increase the cost of a brushless tachometer 25% to 50% over that of a brush type.

A user generally will find no difference in output signals between brush and brushless DC tachometers. The major advantage of a brushless version is its ability to operate in dirty environments. Because it has no brushes, which require periodic replacement, it can operate in more inaccessible locations.

AC tachometers and brushless DC tachometers share the advantage of virtually maintenance-free operation, but the AC and brush-type DC instruments share a cost advantage. AC tachometers, however, perform poorly at very low speed because output becomes nonlinear at low speed. This shortcoming occurs because a constant voltage drop consumes a greater and greater portion of output voltage as speed decreases.

Applications that do not require quick response or a wide range of speed control are best suited for AC tachometers. DC tachometers typically are used where speed ranges are several thousand to one, whereas AC tachometers are restricted to applications with speed ranges of less than 100 to one.

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