Designer's casebook

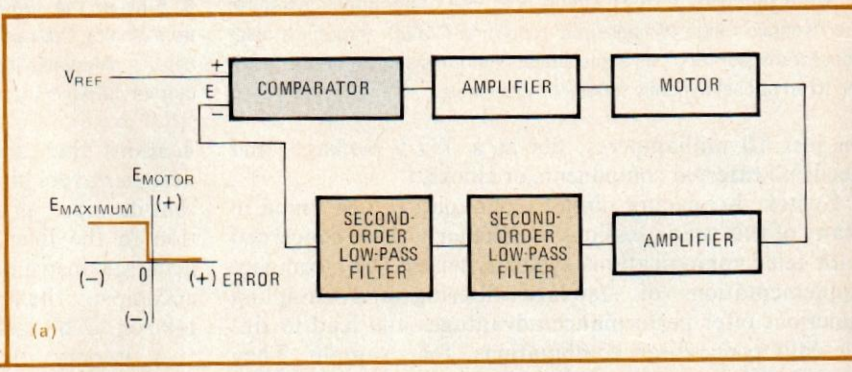
Resistor-based servo replaces mechanical governors in motors

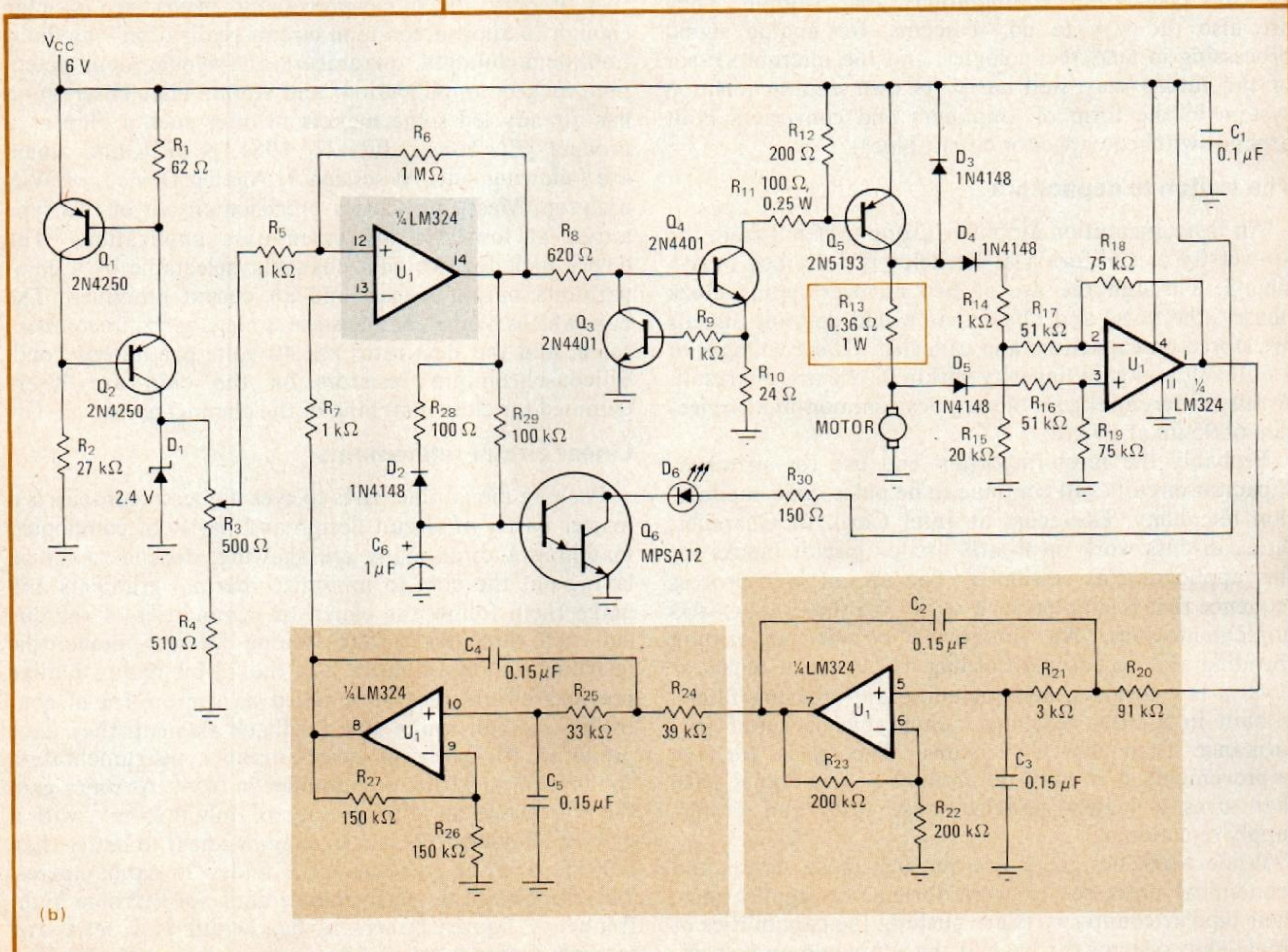
by John Gaewsky and Herbert Hardy
Polaroid Corp., Cambridge, Mass.

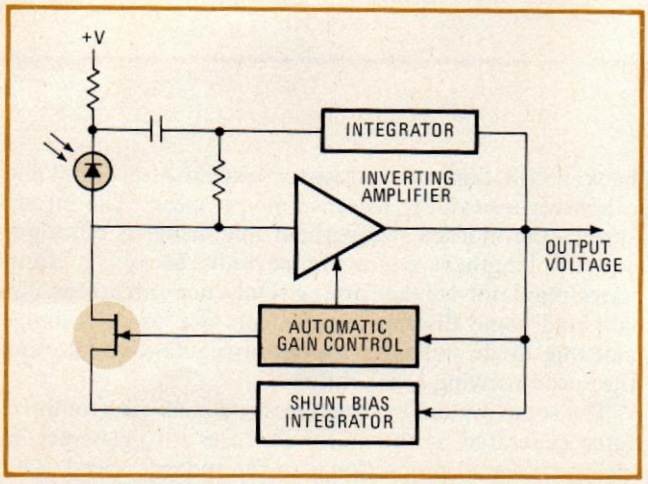
Mechanical governors in motors having two speed settings may now be replaced by an equally efficient feedback circuit that uses a resistor instead of a bulky and expensive transducer to sense motor speed. The circuit shrinks the motor's size without impairing its efficiency and also lengthens motor life, partially because it eliminates regulator-contact arcing. Only one integrated circuit and some discrete components are used. A light-emitting diode indicates an out-of-regulation state and the accompanying acceleration.

The servo system (a) measures the back electromotive force generated by the motor and uses it to generate an electrical signal proportional to the motor's speed. This

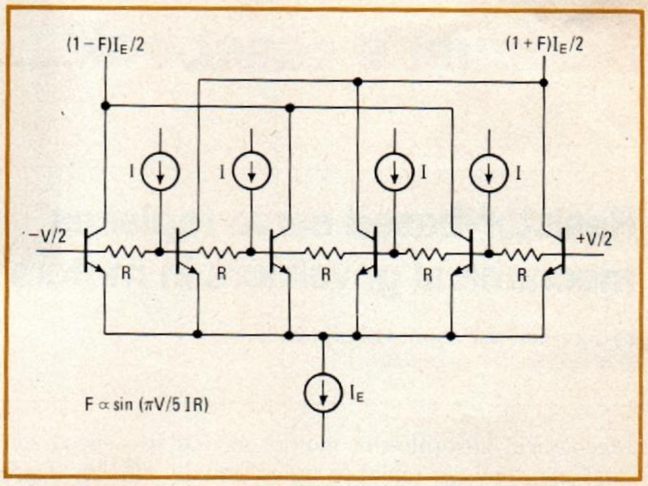
Servo control. The servo system in (a) allows a continuous speed adjustment of a electrically governed motor while retaining the efficiency of a mechanical governor. The circuitry in (b) uses only one IC (LM324) and few discrete components to emulate the mechanical governor. The circuit measures the back emf generated by the motor and uses it to generate an electrical signal proproportional to the motor's speed. It also indicates out-of-regulation and acceleration.







2. Wide receiver. A novel circuit from Bell Laboratories increases the dynamic range of fiber-optic receivers. Control through a field-effect transistor removes some limitations of resistor feedback, leading to an optical dynamic range of 52 decibels.



3. Sine of the times. A versatile trigonometric-function generator from Analog Devices uses two of the sine-synthesizer circuits shown here. A differential input voltage represents angles, and a differential current output is proportional to their sines.

on just 10 milliamperes, fits in a TO-5 package, and needs no external components or clocks.

Switched-capacitor circuit techniques can be found in many of this year's sessions, particularly those concerned with telecommunications systems, where their compact implementations of standard filtering and sampling functions offer performance advantages and lead to single-chip codec-filter combinations, for example. They are also the way to go, it seems, for analog signal processing in MOS technologies, and the microprocessor of the future may well carry its own data-acquisition system in the form of amplifiers and converters built around switched-capacitor circuit blocks.

The switch to capacitors

An instrumentation amplifier fitting that bill from the University of California at Berkeley is described in session 8. Through the use of two nonoverlapping clock phases, the noise and offset that would degrade signals are stored on capacitors and canceled. Offset voltages of 1 millivolt and gain linearity within 0.02% are the result. A fully differential gain block gives common-mode rejection of 95 dB at 10 kHz.

Probably the most important end use for switched-capacitor circuits will continue to be pulse-code–modulation telephony. Designers at Intel Corp. in Chandler, Ariz., discuss work on n-MOS analog circuit blocks for this application at session 3. The appeal is a process sequence that is simpler for n-MOS than the usual C-MOS implementations. An integrated circuit performing encoding and decoding according to European A-law or U. S. μ-law formats, and including anti-aliasing filters, is built in n-MOS, reaching comparable or better performance than C-MOS versions. The basis for the improvements is a fully differential analog-signal path that gives a higher signal-to-noise ratio and power-supply rejection.

While MOS designers are putting these dense and economical processes to work for analog applications, their bipolar counterparts are pushing the capabilities of single-chip systems far beyond the simple op amp specifications that are the backbone of the analog-system designer's tool kit. One perceived need is for analog chips that do more, bringing the benefits of increased integration to the linear realm. Another is to reduce highly accurate instrumentation amplifiers to single chips, to accompany the proliferating low-cost a-d converters that take on 12-bit tasks with ease.

A variety of signal-processing needs are similar enough to allow a common circuit realization—modulation, demodulation, quadrature and synchronous detection, lock-in amplification, and so on. That observation has already led some makers to offer such a chip as a product [*Electronics*, July 14, 1981, p. 172], and others are following suit. At session 3, Analog Devices of Wilmington, Mass., presents a precision circuit of this type aimed at low-level instrumentation applications. The device includes two gain channels, selectable by a comparator's output signal, and an output amplifier. The bandwidths of the channels are 6 megahertz, uncompensated, and the slew rates are 40 volts per microsecond. Silicon-chromium resistors on the chip are laser-trimmed for close matching of the channel gains.

Linear circuit refinements

Pushing monolithic parts to ever higher accuracies is a matter partly of circuit design and partly of component matching and, as many are showing, depends a lot on laying out the chip to minimize thermal gradients and make them follow the electrical symmetries of the circuit. All these tacks take Analog Devices' monolithic instrumentation amplifier into the 12-bit realm. Unlike previous efforts that have relied on some form of controlled current source as a feedback element, they have produced the classical three-amplifier instrumentation configuration, with a preamplifier in front. At unity gain the chip shows an offset voltage of only 0.25 mV, with a drift of 10 microvolts per °C. Gain is linear to better than 0.005%, and the bias current is under 25 nanoamperes. This impressive dc performance does not sacrifice high-frequency figures either, as bandwidth is 1 MHz and settling time to 0.01% is 15 μs.