Gray-code counter steps torque motor

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The positional accuracy of a simple stepping-motor system is limited by the response of its mechanical drive. This drawback can be eliminated electronically by using a position sensor and a counter working in Gray code to control the motor. The mechanical-drive circuit can be simplified with digital logic to reduce system errors and nonlinearities. A four-state Gray-code counter enables the system to move smoothly from its starting point to the desired position.

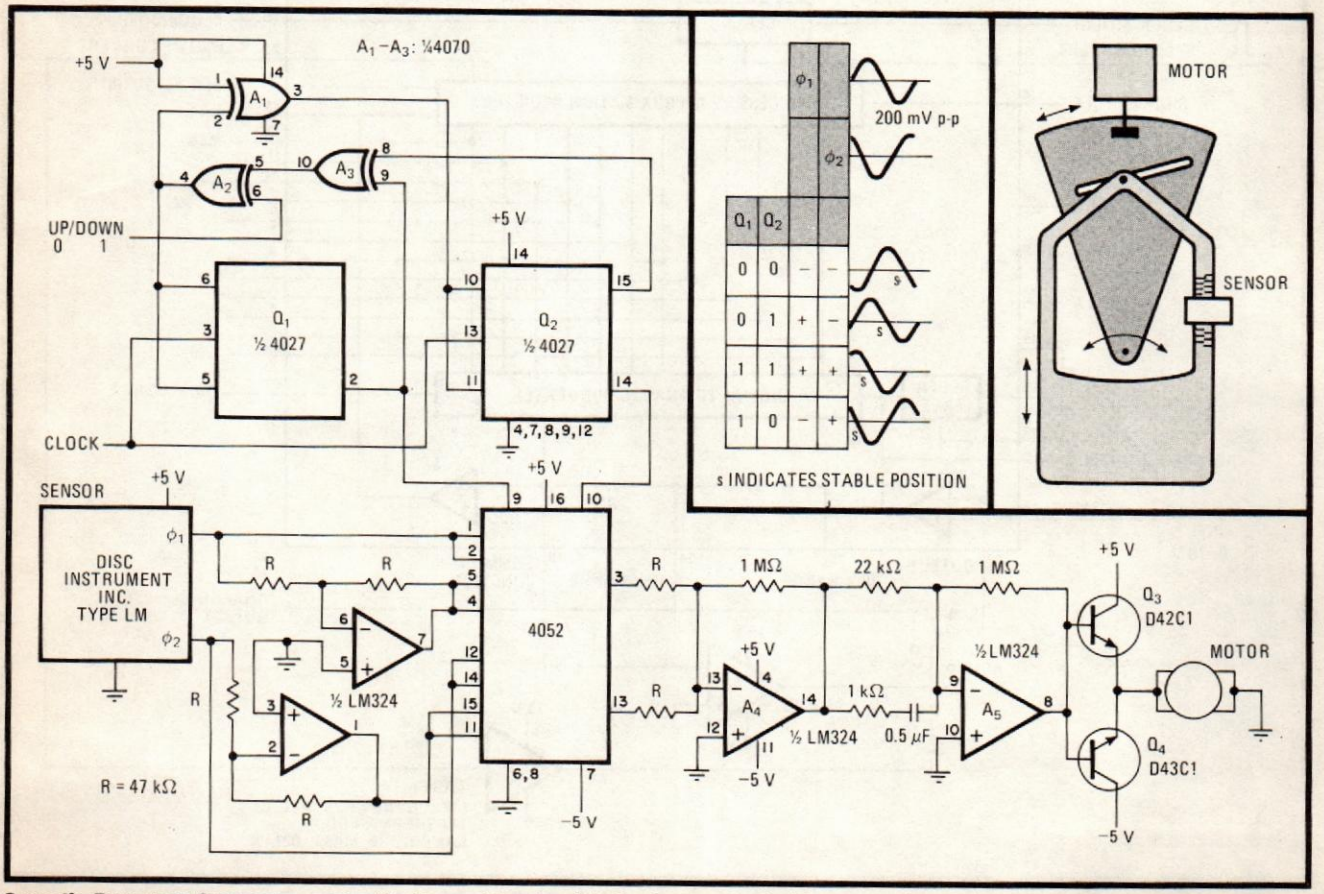
In this circuit, the summed quadrature outputs of a photoelectric sensor and the counter (see inset) set the position of the system. With suitable clock signals, the counter is advanced one location, causing the motor's position to change and the output from the sensor to vary accordingly. Thus the system is rotated 90° for each clock signal.

This circuit is intended for visual setting of a desired position through manual control of the clock and up/down inputs. For automatic tracking, the sensor's output must be compared to the desired position with additional circuitry in order to generate those signals.

Flip-flops Q_1 and Q_2 and exclusive-OR gates A_1–A_3 comprise the up-down Gray-code counter. The direction of the counting is determined by the logic state at the up/down input.

The output of the counter changes on the positive transition of each clock pulse. Depending upon the state of the counter, either the normal or inverted sine-wave outputs of the sensor are summed at the output of the 4052 four-input multiplexer. As a consequence, the output from A_4 forces the system to a new position, which is reflected at the sensor as its output steps a quarter cycle. The motor is driven through Q_3 and Q_4 by a positional signal that progressively advances or recedes (depending upon the state of the up/down counter) by a quarter cycle.

A minimum settling time of a few milliseconds is set for the system by the lead-compensation components between stages A_4 and A_5. Lead compensation is required in this situation because the system response is that of a double integration network that acts to saturate Q_3 and Q_4. The open loop would tend to be sluggish without the lead compensation, which reduces the effective system gain at low frequencies. □



Smooth. Four-state Gray-code counter Q_1–Q_2 provides signal that, when summed with output of optical sensor by 4052 multiplexer and op amp A_4, generates quadrature output for smooth stepping of motor in quarter-cycle increments. Compensation network between A_4 and A_5 prevents saturation of Q_3 and Q_4, eliminating sluggish system response by reducing effective gain at low frequencies.