Hall-effect tachometer senses speed, direction of rotation

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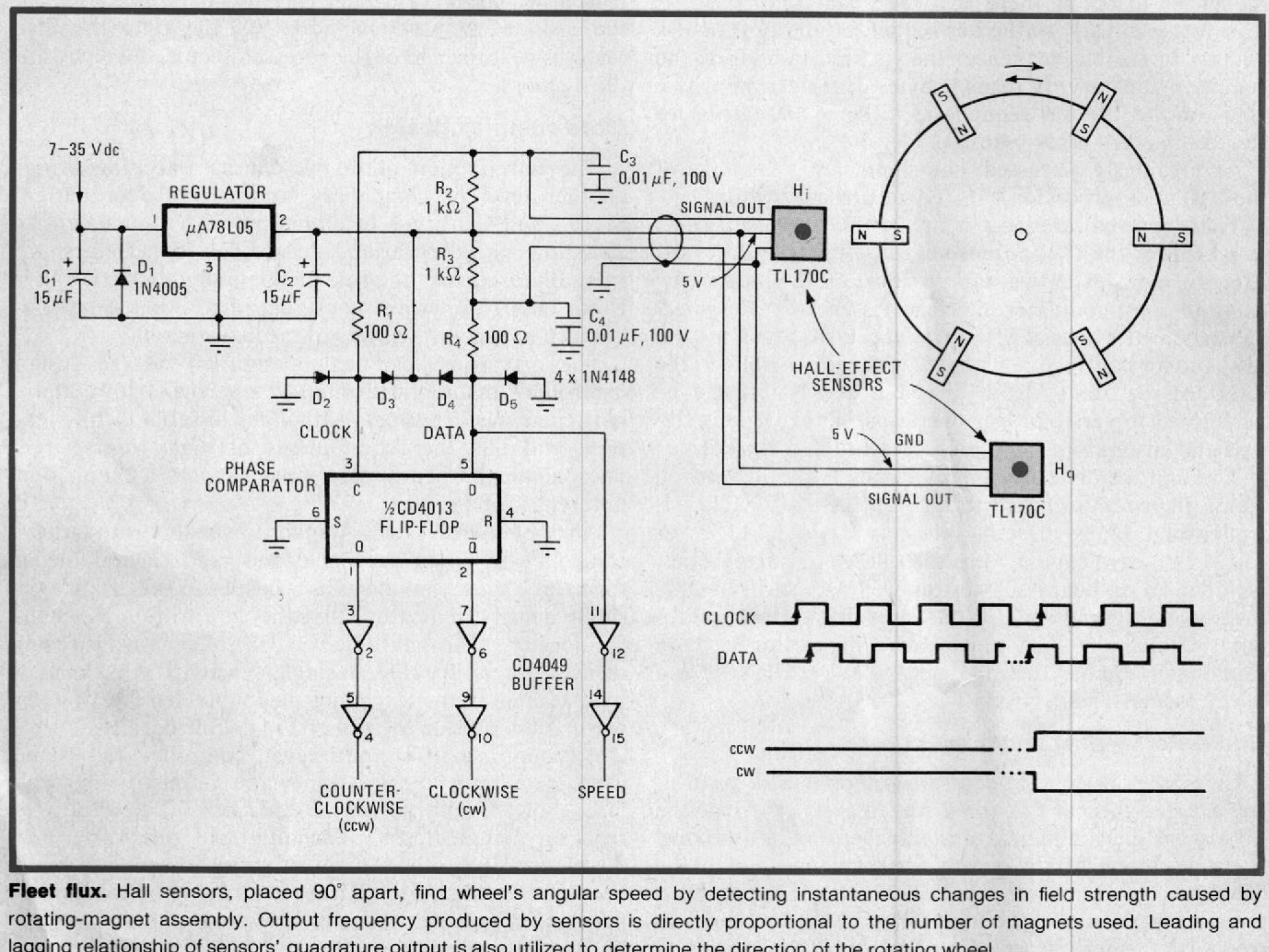
Two Hall-effect sensors placed 90° apart and at an equal distance from the center of a rotating magnet-wheel assembly form the basis for this simple but reliable tachometer. As an added bonus, owing to the circuit's physical configuration, the direction of the rotating wheel can be detected as well.

As shown in the figure, small magnets are radially arranged on the wheel in an alternating north-to-south, south-to-north fashion. When the wheel rotates, each magnet periodically turns Hall sensors H_i and H_q either on or off magnetically, depending on the magnet's instantaneous orientation, thus generating output signals from the sensors that are in quadrature. The leading or lagging relationship of the H_i signal to the H_q signal, as detected by the 4013 flip-flop (working as a phase comparator), will indicate the wheel's direction of rotation. The frequency of the H_q signal (or for that matter, the H_i output) is directly related to the angular speed of the wheel and may be used to drive counters or frequency-to-voltage converters for linear servoamplifiers.

As for the constructional details, this tachometer's rotating magnet assembly is built using small cylindrical Alnico magnets, 3/16 inch in diameter by 1 in. long, glued into a machined polyvinyl chloride wheel with epoxy. The spacing (air gap) between the assembly and the Hall sensors will vary with the magnets' residual induction, and some tweaking is necessary. For GE519-1 magnets, a gap of 1/16 to 1/8 in. is satisfactory for the Texas Instrument's TL170C sensors used, which require a minimum of 350 gauss to change state.

The output frequency that is generated will be directly proportional to the number of magnets used. To ensure optimum tracking, however, their placement should meet the criterion that when one magnet is directly opposite sensor H_i, H_q should be midway between two other magnets of alternate polarity. Under that condition, the output frequency will be $f = NT/120$ hertz, where N is



Fleet flux. Hall sensors, placed 90° apart, find wheel's angular speed by detecting instantaneous changes in field strength caused by rotating-magnet assembly. Output frequency produced by sensors is directly proportional to the number of magnets used. Leading and lagging relationship of sensors' quadrature output is also utilized to determine the direction of the rotating wheel.

the number of magnets used, and T is the wheel speed in revolutions per minute. Thus, N will equal 6, 10, 14, . . . for magnets symmetrically arranged at angles of 60°, 36°, 25.7°, . . . respectively.

The Hall sensors are biased from a regulated 5-volt source for optimum performance. Input diode D_1 protects the circuit from any input-polarity reversal. The 1-kilohm load resistors bias the open-collector output of the sensors; with C_3 and C_4, they form an rf filter. Diodes D_2 through D_5 protect the input of the D flip-flop from inductive spikes. Noise reduction is ensured by the use of a shielded three-conductor cable. □