Synchronous pulsing cuts three-phase motor's dissipation

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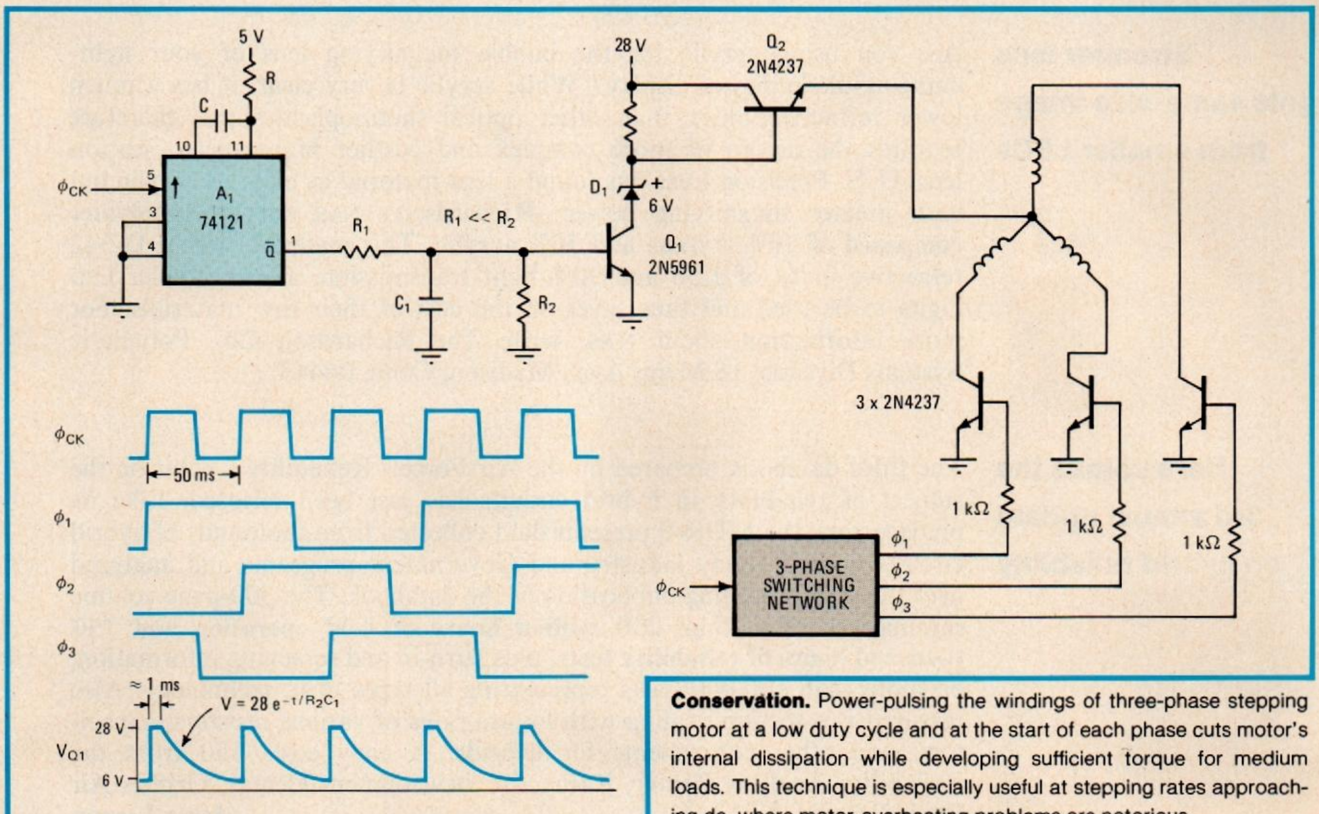
At very low clock rates, below 20 hertz, the windings of a three-phase motor dissipate excessive power. But this problem may be overcome if the motor is not heavily loaded—that is, the torque is less than 20 gram-centimeters. The circuit described here momentarily switches on the motor's supply line synchronously with the phase-generator clock pulse that activates each winding in sequence. Pulsing the windings at a low duty cycle and at the start of each phase increases circuit efficiency, yet enables the motor to develop sufficient torque.

Consider the savings in power. If each winding has a dc resistance of 15 ohms and is periodically energized from a 28-volt source, the power dissipated by each winding as the clock rate approaches zero is $P = (28)^2/15$, or 52.26, watts. Even when working at 20 hertz, or a 50-millisecond period, each winding would be energized for the same 50 ms or so and the power consumed per phase would be $P = (28^2/15)(50)(10^{-3}) = 2.61$ W. But if the energizing time can be reduced to 1 ms, say, the power consumed will be $P = (28^2/15)(1)(10^{-3}) = 52.26$ milliwatts.

The energizing time, T_e, is controlled by elements R and C of the 74121 monostable multivibrator, A_1, as shown in the figure. The one-shot is driven by the same phase generator clock, ϕ_{CK}, that also drives the three-phase switching circuit. (Since many well-known arrangements exist for deriving the required phase voltages for the windings, the actual schematic for the network is not shown here.)

A_1 fires on the positive edge of ϕ_{CK} and generates a 1-ms pulse that charges C_1, switches Q_1, and brings its collector to 28 V. Q_2 then turns on, driving the particular windings that happen to be activated at that instant by the switching network. The $\overline{Q}$ output of A_1 then moves back to 1 after the 1-ms interval and C_1 discharges through R_2 exponentially. C_1, R_1, and R_2 are selected once the frequency of ϕ_{CK}, R, and C are known.

It should be mentioned that at clock rates above 1 kilohertz, this circuit offers no power-saving advantage. This is because the period of 1-kHz waveform is 1 ms, comparable to the duty cycle required to reduce the dissipation for the 20-Hz clock previously discussed. □



Conservation. Power-pulsing the windings of three-phase stepping motor at a low duty cycle and at the start of each phase cuts motor's internal dissipation while developing sufficient torque for medium loads. This technique is especially useful at stepping rates approaching dc, where motor-overheating problems are notorious.