Phase-sequence detector trips circuit breaker

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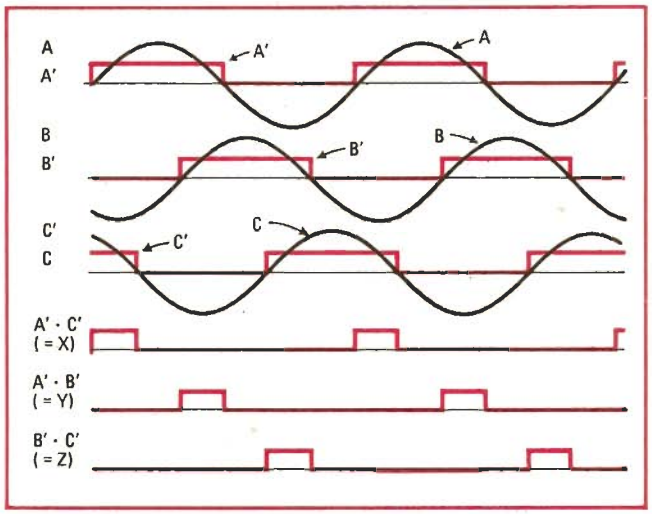
Some three-phase line-powered equipment is sensitive to the direction of rotation of the three phases. For example, if two of the connections to a three-phase motor are inadvertently reversed, the motor will reverse direction—a disaster if the motor is used to drive a pump or the compressor of an air conditioner. To guard against this failure, a low-power circuit can be built from standard complementary-MOS components that will detect the phase inversion and trigger a circuit breaker. Moreover, the circuit, which interfaces directly with C-MOS logic, can be appended easily to a line-undervoltage or line-unbalanced detector.

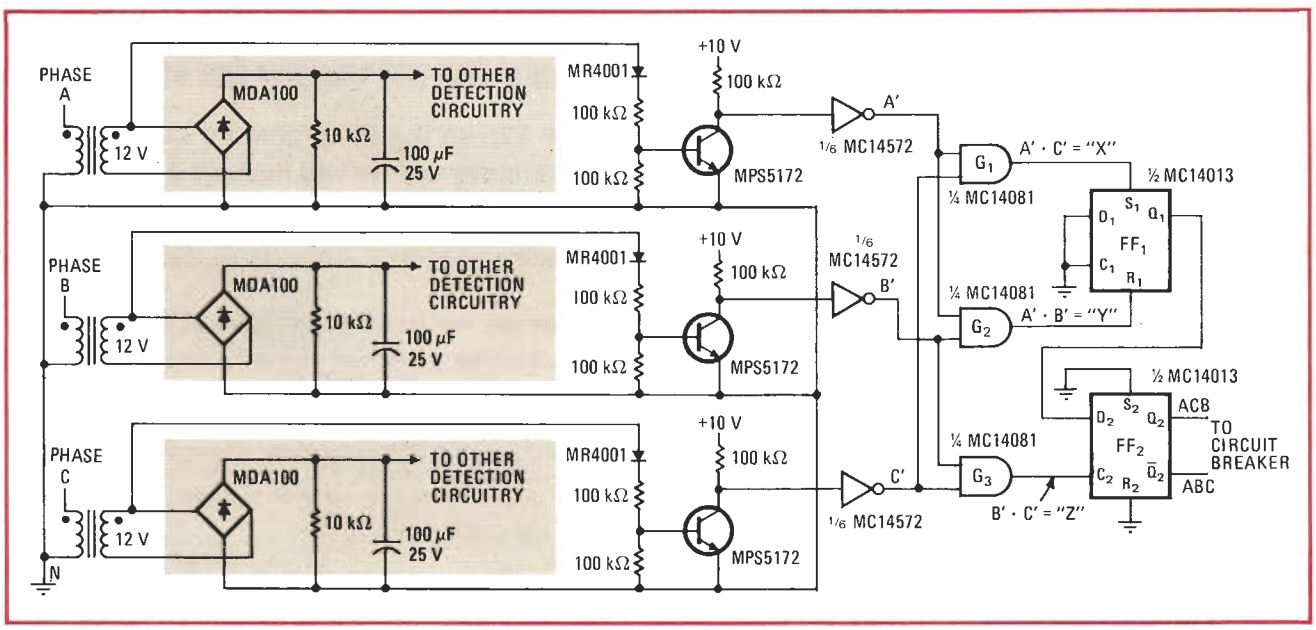
In the circuit (Fig. 1), the line voltages are stepped down and isolated by control transformers. The sine waves for phases A, B, and C are half-wave-rectified and shaped by the MR4001 diode and MPS5172 transistor, and shaped again by a C-MOS inverter. The resulting rectangular waveforms are shown as A′, B′, and C′ in Fig. 2.

The shaped outputs A′, B′, and C′ are now combined with one another in the AND gates G_1, G_2, and G_3, to produce the waveforms A′·C′, A′·B′, and B′·C′ (or X, Y, and Z in Fig. 2). The pulses X, Y, Z appear sequentially; this sequence will change to YXZ if, for instance, the B and C phases are interchanged.

The X, Y, and Z pulse trains are applied to D-type flip-flops FF_1 and FF_2 in such a way that the $\overline{Q}_2$ output of FF_2 is high if the sequence is XYZ (i.e., if the line phase sequence is ABC), and $\overline{Q}_2$ is low if the sequence is YXZ. For the XYZ sequence, an X pulse sets Q_1 and D_2 high, but then the Y pulse resets Q_1 and D_2 low. The Z pulse then clocks the low from D_2 to Q_2, making $\overline{Q}_2$ high.



2. Operation. Line phases A, B, and C are rectified and shaped to produce waveforms A′, B′, and C′. Overlaps of these rectangular waves produce AND-gate outputs A′·C′, A′·B′, and B′·C′; for convenience these outputs are referred to as X, Y, and Z. Line-phase sequence ABC generates XYZ; sequence ACB generates YXZ. These pulse trains cause flip-flop outputs to signal any phasing error.



1. Phase insurance. Incorrect sequence of line phases is detected by flip-flops, which trigger circuit breaker to prevent three-phase motor from running in reverse. Phase sequence ABC makes $\overline{Q}_2$ high, but sequence ACB makes Q_2 high; either output can be used to control protection devices. This phase-reversal detector can be a simple addition to other control circuitry, as shown here.