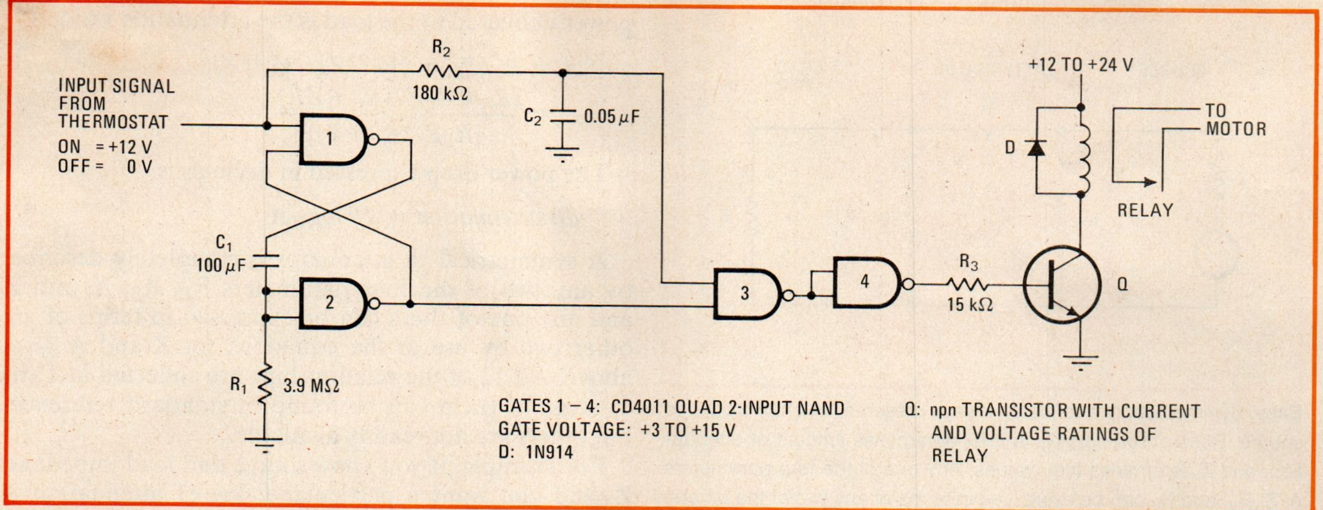
Adaptive motor starter delays when necessary

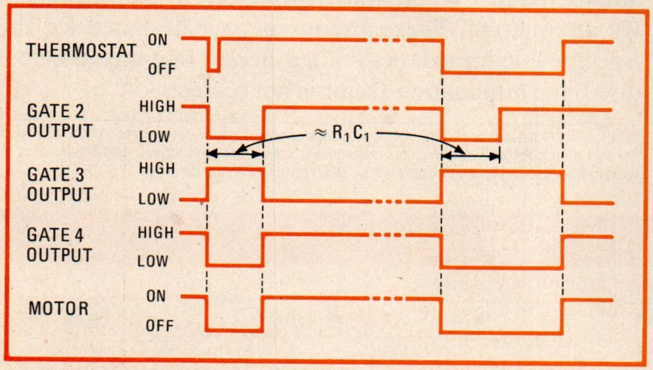
by Alan R. Miller
New Mexico Institute of Mining and Technology, Socorro, N.M.

The potential starting load on the compressor motor of an air conditioner or freezer is greatest immediately after the motor has been shut off. But after the motor has been off for a few minutes, the pressure in the system has equalized and the motor can safely be started again. Therefore a starting circuit need not provide delay if the motor has been off for several minutes, but it should if the motor has been off only momentarily (as might occur when lightning causes a brief loss of power, or when someone improperly turns the thermostat down and then right back up again).

An RC time-delay network coupled to a unijunction transistor and a silicon controlled rectifier will prevent



1. Restart delay. Motor is held off for a minimum time given by R_1C_1 in this circuit arrangement. NAND-gate one-shot multivibrator starts delay pulse when thermostat goes off, so delay is not added to thermostat off-time. Quad NAND gate keeps component count low, and npn transistor allows flexibility in gate voltages. The time constant of C_2 and R_2 smooths over any contact bounce in the actuating relay.



2. Timing. When thermostat goes off, gate 2 goes low and motor goes off. Motor then stays off until both thermostat and gate 2 are high again; gate 2 stays low for time of approximately R_1C_1, so motor is off for at least that long, and longer if thermostat is off longer.

the motor from starting too soon after turning off. Unfortunately such a circuit also delays starting even after a long time or under the usual automatic turn-on by the thermostat.

The starting circuit illustrated in Fig. 1 provides the necessary time delay by combining R_1 and C_1 with a pair of NAND gates to form a monostable (one-shot) multivibrator (gates 1 and 2). The output from the monostable (gate 2) is normally high; but when the signal from the thermostat goes to zero, the monostable goes to zero for a time of approximately R_1C_1 and then returns to its high level (as shown in Fig. 2). This output from the one-shot and the signal from the thermostat are both connected to a third NAND gate (gate 3) that allows the motor relay to close immediately if the thermostat has been off for more than the R_1C_1 delay time. If the input signal has not been off long enough, the one-shot keeps the output of gate 3 high until the delay time has elapsed.

The low output of gate 3 could turn on a pnp transistor to actuate the relay, but the gate voltage would have to be higher than the relay voltage to turn the transistor off. Use of gate 4 to invert the output from gate 3 allows the relay to operate with any positive voltage, either higher or lower than the gate voltage.

Resistor R_3 limits the base current drawn from gate 4 by the transistor. Any effect of point bounce from the actuating thermostat is eliminated with a delay provided by R_2 and C_2. With C-MOS NAND gates, a starting delay of 3 to 4 minutes can be obtained with $R_1 = 3.9$ megohms and $C_1 = 100$ microfarads.

If the thermostat sends an ac signal, the ac must be rectified and filtered. However, only a minimum of filtering and regulation is necessary because C-MOS gates can operate over a large voltage range (3–15 V) and the time delays are not critical. The IC and relay power could even be supplied by the thermostat signal. □