Simulating an npn/pnp pair for high-voltage switching

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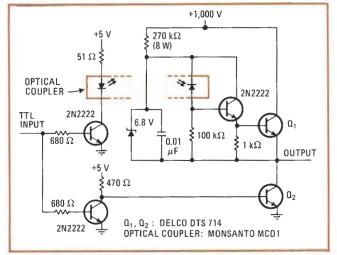
High-voltage transistors—those that have ratings on the order of 1,000 volts—are available only as npn devices. Pnp transistors generally have ratings of 400 v or less. This means that the fast switching performance obtainable with a complementary pair of transistors cannot easily be achieved at very high voltage levels. However, it is possible to simulate the performance of a high-voltage complementary pair with two npn devices by using an optical coupler in the drive circuit of one of the transistors.

The circuit in the figure is a high-voltage switch that is controlled by TTL signals at its input and switches 1,000-v signals at its output. Although both of the high-voltage transistors, Q₁ and Q₂, are npn devices, they operate as a complementary pair.

Transistor Q_1 is optoelectronically coupled to its drive voltage to simulate the operation of a pnp device. The optical coupler acts as a simple single-device voltage-level translator that also provides a voltage-polarity inversion. The base voltage of transistor Q_1 can then follow its emitter voltage during switching. The coupler avoids the low-frequency switching problems associated with capacitive circuitry.

When transistor Q_1 is off, transistor Q_2 is on, and vice versa. During the off time of transistor Q_1 , the capacitor charges to the zener voltage, creating a voltage reservoir that allows Q_1 to turn on hard and quickly through its optical coupler. Transistor Q_2 operates normally as an npn switching transistor.

Rise and fall times of 2 microseconds can be achieved with the components shown.



Optical helping hand. Complementary high-voltage switching transistors can be simulated with two npn devices by placing an optical coupler in the drive circuit of one of the transistors. The coupler translates and inverts the TTL-level input voltage so that transistors Q_1 and Q_2 conduct alternately. When Q_1 is off, a voltage reservoir is created across the capacitor for turning Q_1 on fast and hard.