Electronic Design

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Gas-Filled Contactors Defeat High-Voltage, High-Current Switching Woes

Sponsored by Digi-Key and TDK: High-voltage switching can be a headache in applications ranging from automotive to energy, but high-reliability contactors offer a rescue plan.

When designing equipment with switching functions, most engineers find that switching high currents and high voltages is a major problem. A solid-state solution may be possible, but it's complex and expensive. One sure approach is to use a contactor. High-voltage, high-current contactors are available that can solve even the toughest of switching problems.

Contactor Basics

A contactor is just a heavy-duty mechanical relay for switching high voltages or high currents, or both. A common application is the contactor in every car and truck that starts the engine. When the ignition switch is turned or button is pressed, 12 V from the battery is applied to a contactor. It contacts then close, connecting the 12-V battery to a starter motor that spins the engine and starts the vehicle.

The starter motor requires very high current of 100 A or so to produce enough torque to turn the engine. The contactor is the switch that applies the battery voltage to the motor.

Like a relay, a contactor consists of an electromagnetic coil that mechanically moves the switching contacts. Commonly used switching arrangements are usually available:

- Form A: Normally open (NO)
- Form B: Normally closed (NC)
- Form C: SPDT (single pole, double throw)

Contactor Applications

The main use cases for contactors fall into three basic categories: automotive, energy or power, and general.

Automotive

The automotive sector may be the biggest user of contactors, thanks to the electric- and hybrid-vehicle movement. High-voltage battery switching in an EV is a major need. Most vehicles contain a battery and a disconnect contactor to take the battery off the bus.

Another use is a connect-disconnect contactor for use in vehicles and charging stations. Level 3 fast chargers use high-voltage dc to speed up the battery charging with heavy current flow. The contactor acts as a fuse or automatic safety current cutoff. Contactors are also employed in vehicles with on board chargers (OBCs).

Energy

In the energy sector, HV contactors are used in medium to large solar-panel arrays. These typically supply around 400 V at high current to a group of inverters that convert the dc into ac.

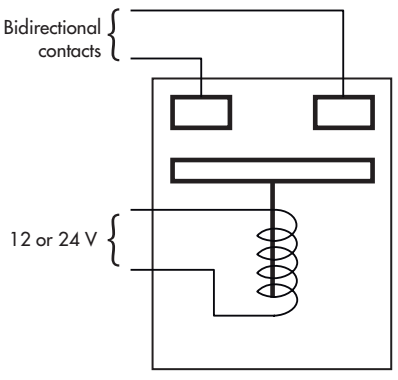
Wind-power systems also usually require battery storage with inverters feeding the power line or other load. One or more contactors take care of any switching uses and protective operations.

Other Apps

Any time you need to switch high voltage and/or high current, a contactor may be your solution. Any energy storage system, UPS, light rail, forklifts, wheelchairs, EV motorcycles, plus any heavy-duty aircraft or marine electrical systems, will have a contactor.

Contactor Features and Specifications

A good example of a top-of-the-line contactor is TDK's HVC200a high-voltage contactors. These units are hermetically sealed, gas-filled, and designed to exhibit excellent reliability in harsh environments. The HVC series can be used in a wide range of applications that require fast and reliable



This shows a simplified view of the real contact arrangement in TDK's HVC contactors.

high-voltage and/or high-current dc switching operations. For instance, factory automation systems may use contactors to turn heavy-duty equipment off and on.

The *figure* illustrates a simplified diagram of a typical contactor. Let's talk about the contacts first. Made of a copper alloy, they're good for over a million make-break cycles. The nominal current maximum is 200 A; however, other models are available to accommodate 300 to 500 A. The minimum make-break current is 1 A. Typical contact resistance is 0.4 mΩ. Furthermore, the contacts are bipolar, meaning they're not polarity or direction-of-current-flow sensitive like some other electrical and mechanical contactors.

The big issue with relay and contactor contacts revolves around arcing. When a contactor opens its contacts while carrying a high current, it causes arcing. Arcing subjects the contacts to high temperature, melting, and burning. Thus, the contacts can quickly be destroyed completely in a short time.

Arcing can be minimized by optimizing the physical size and arrangement of the contacts. The general arrangement shown in the *figure* works well. Then, to fully quench the arc, the chamber containing the contacts is filled with a hydrogen gas mixture. This is a key feature of the HVC series.

As for the coil specifications, contactors with 12- or 24-V operation are available. The 12-V coil operates over the 6- to 16-V range. The general pickup voltage is 9 V and the minimum holding voltage is 1 V. Typical coil current is 500 mA and the minimum holding current is 160 mA. Switching times are fast for a contactor. Common make time is 40 ms, while typical break time is 20 ms.