

TechTopics No. 55

Capacitor trip devices

Capacitor trip devices (CTDs) have been used with medium-voltage circuit breakers for decades. Even though CTDs are workhorse components in the switchgear, Siemens still receives questions about the basic function and need for them.

A CTD is an energy storage device for “impulse” type loads, for situations in which the normal source of control power may not be present when action is required. The classic application for a CTD is for tripping of a medium-voltage circuit breaker in installations that derive the control power from the ac primary system through a control power transformer (CPT). If a bolted fault occurs on the ac primary system (or any major fault on a weak power system), the voltage on the primary bus will be depressed and the secondary voltage from the CPT will be at a low value. An energy storage device is needed so that the power to trip the medium-voltage circuit breaker will be available even under fault conditions.

The most common use of CTDs is to trip medium-voltage circuit breakers. A secondary application is for actuation of lockout (device 86) relays powered from the ac supply of a CPT. A separate CTD is required for each circuit breaker or lockout relay. A CTD must never be connected to parallel (multiple) loads.

The principle of a basic capacitor trip device is very simple. A capacitor is connected to a half-wave rectifier or a bridge rectifier, and charged from the normal ac control power supply. The charging time of the capacitor is typically in the vicinity of 10 cycles or so. The charging current is limited by a series resistor, both to protect the capacitor from excess current, and to protect the bridge rectifier. The capacitor is isolated, with no continuous load connected to the capacitor output circuit. When a protective relay or any other trip contact closes, the capacitor output is connected to the circuit breaker trip coil circuit (or to the solenoid circuit of a lockout relay), and the stored capacitive energy is released to trip the circuit breaker or lockout relay.

When the ac supply is at rated voltage (240 Vac, for example), the capacitor will charge to the peak of the ac voltage, or 339 Vdc. The capacitor stays at this voltage as long as the incoming supply voltage is maintained. When the ac voltage is lost, the capacitor begins to discharge slowly. If a trip command is received, the charge on the capacitor is released to trip the circuit breaker.

The capacitor size is selected so that it has sufficient energy to operate the trip coil of the circuit breaker. Ideally, the capacitor size and charge current magnitude are tuned to the inductance and resistance of the tripping solenoid (an RLC series circuit). The objective is to produce a discharge current through the tripping solenoid that emulates the magnitude of current and current duration that the solenoid would experience if operated from a dc tripping supply voltage.

For convenience, most applications of CTDs are designed for use with conventional dc trip coils on the circuit breaker, in line with the objective of matching the coil characteristics to the decaying dc output of the capacitor. CTDs are nearly always furnished with a capacitor size that provides more energy than the ideal minimum.

An important consideration in the design of the capacitor trip circuit is that it must have sufficient energy to trip the circuit breaker even when the ac control power supply is at the minimum voltage of the allowable range in ANSI/IEEE C37.06. For a 240 Vac supply, the standard stipulates that the circuit breaker shall operate properly with a minimum control voltage of 208 Vac. Siemens' practice during production tests is to charge the capacitor from a source adjusted to 208 Vac, and then disconnect the source. The CTD must be able to trip the circuit breaker if the tripping command is issued 10 seconds after the ac supply is removed. This assures that the CTD has enough energy to perform its design function even when conditions are not optimal. For perspective, the rated (maximum) permissible tripping delay specified for a medium-voltage circuit breaker in ANSI/IEEE C37.04 and C37.06 is two seconds, so the 10-second value used in Siemens' production testing provides a large margin compared to the requirements of the standards.

So far, the basic concept of a capacitor trip device, as typically installed directly on a circuit breaker, has been discussed. There are also more complex devices, which include an electronic circuit to maintain capacitor charge after the ac supply is lost. The electronic circuit is powered by rechargeable batteries, typically of size AA. The Siemens Enerpak model A-1 is an example of this type of unit. This device will maintain a voltage on the capacitor sufficient to trip the circuit breaker for 140 hours after the ac supply voltage is disconnected. While the charging system makes these devices more complex, the underlying principle of the device is identical to the basic device described.

The CTD uses a charged capacitor, so care must be exercised when performing inspection or maintenance activities. The capacitor self-discharges after removal of the ac source, but the discharge time is relatively long. The capacitor must always be discharged before any work is done in the area of the capacitor, or of wiring to which the capacitor is connected (such as, the trip circuit of the relays or the tripping contact of a control switch).

The preferred method of discharging the capacitor is to disconnect the ac control power, and then use the circuit breaker control switch to issue a trip command that discharges most of the stored energy through the circuit breaker trip coil. Finally, short-circuit the terminals of the capacitor to remove any remaining residual charge.

Alternatively, the capacitor can be discharged directly. This must not be done with a short-circuiting conductor, but must be done with a circuit having a resistor to limit the current magnitude. A five-watt, 500-ohm resistor works well for this purpose.

Advantages

- Economic for small installations with only a few circuit breakers, compared to use of a battery
- Particularly suited to installations in isolated locations, or unattended substations, where the user wishes to avoid the initial cost and ongoing maintenance of a station battery
- Suitable for use in outdoor installations where battery capacity is reduced at low temperatures.

Disadvantages

- Capacitor trip devices cannot be used for continuous loads – thus, they cannot be used with a red light in the trip circuit to monitor trip coil integrity, nor with a trip coil supervision circuit of microprocessor relays
- Use of ac control power precludes the use of communications devices (protective relays, power meters) that require dc control power for communications when the ac power is off (such as, immediately after a fault)
- Uneconomic for large installations, compared to use of a battery
- An electrolytic capacitor is used, which has limited life, particularly in high temperatures. The periodic maintenance program must include functional testing (annually) of the capacitor trip device.

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