Application Note

Close-Open (Short-Circuit) Time Results Interpretation

Close-Open (C-O, trip-free) cycles simulate closing on a short circuit. In the actual event, the breaker closes first, then the protection relay system detects the short circuit and trips the breaker.

In the test event the timing device can be programmed to start a trip command as soon as the contacts close. This gives the fastest short-circuit time (C-O time) operation the breaker is capable of doing.

Most HV circuit breaker mechanisms are characterized as being trip-free. Performing trip-free operation simply requires the circuit breaker to be able to open without any delay once the auxiliary switch (contact), that controls the application of the electric signal to the operating coils, closes. Under these conditions the main contacts of the circuit breaker are allowed to touch instantly. This means the trip-free characteristic requires the circuit breaker to open at any instant that a trip command is issued to the unit, even if the circuit breaker is in the process of closing. To achieve this, the mechanism, interrupters and drive system must be able to withstand the forces of the sudden change of direction.

In other cases a circuit breaker must close before it opens.

For example, suppose a breaker is being closed manually by operating the contact closing mechanism or remotely. While the contacts are in the process of closing suppose a fault occurs in the system with the relay closing the trip circuit of the breaker. The trip-free mechanism allows the circuit breaker to be tripped by the relay even if the contacts are in the process of closing.

The major international standards for circuit breakers are IEC® and ANSI®/IEEE®. One section of IEC 62271-100 “High-voltage alternating current circuit-breakers” standard describes the circuit-breaker-related time definitions.

C-O (Close-open) time definition according to IEC is:

“Interval of time between the instant when the contacts touch in the first pole during a closing operation and the instant when the arcing contacts have separated in all poles during the subsequent opening operation.”

This standard also states:

“*Unless otherwise stated, it is assumed the opening release incorporated in the circuit breaker is energized at the instant when the contacts touch in the first pole during closing. This represents the minimum close-open time.”*

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Close-open (measured during test) should be distinguished from the make-break time (measured when a CB is under load), as illustrated in the Figure 1. According to the IEC standard make-break time is:

"Interval of time between the initiation of current flow in the first pole during a closing operation and the end of the arcing time during the subsequent opening operation (Figure 1).

NOTE: The make-break time may vary due to the variation of the pre-arcing time."

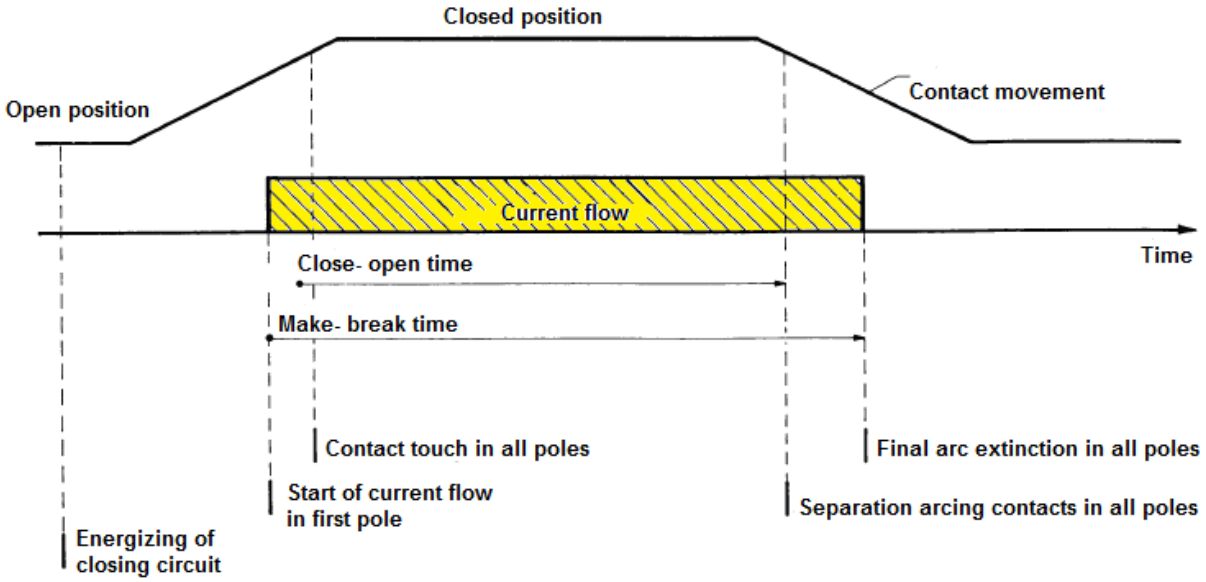

Figure 1. C-O (*Trip free) operation*

C-O time (also called dwell time) is the amount of time the breaker is in the closed position during a close-open operation. C-O time value is compared to the manufacturer's specifications. For the puffer SF6 circuit breakers, too short CO time (during trip-free operation) compared to specification can cause longer arcing time or in the worst case a failure to break a short-circuit during subsequent opening. It is because too short C-O time could mean CB didn't get time to close enough (during closing in the trip-free operation) to provide compression volume large enough to produce the blast of SF6 gas to extinguish the arc.

Longer C-O time means longer short-circuit time during the potential fault. Due to high electric current, there may be high thermal stress in the insulation and conducting parts of CB. As the thermal stress in the circuit breaker is proportional to the period of short circuit, the breaking capacity of a circuit breaker depends upon the operating time that is C-O time.

When checking the C-O time of the breaker during timing tests, the auxiliary switch (contact) adjustment should be checked. The auxiliary switches are adjustable for most HV circuit breaker operating mechanisms. These switches are adjusted at the factory to set

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close-open time and close open travel during a trip-free or C-O operation of the breaker according to manufacturer's specifications. In case C-O time value is out of range, the auxiliary switches can be adjusted to bring the C-O time within tolerance.

C-O timing results in the DV-Win software

The contacts close-open times for a circuit breaker with one break per phase are displayed in the Figure 2.In the graphic display C-O times are marked for each pole and for breaker separately. Also, as shown in the Figure 2. C-O time is calculated and displayed in the tab ***Numerical results*** for each phase and breaker separately.

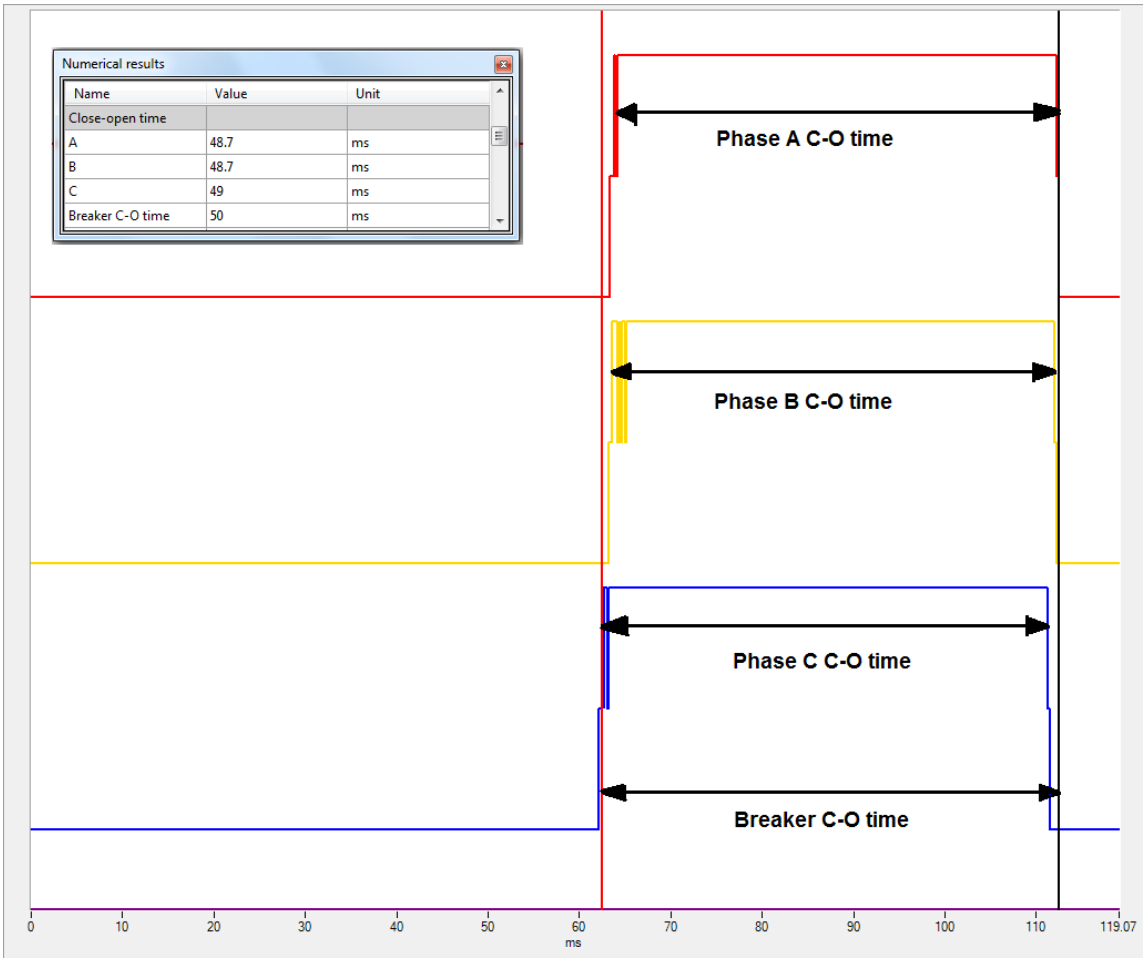

Figure 2. *C-O operation graphical and numerical results (one break per phase)*

For a circuit breaker with two breaks per phase, graphical results for C-O operation are displayed in the Figure 3. In the graphic display C-O times are marked for each contact separately. Also, C-O time is calculated and displayed in the tab ***Numerical results*** for each contact, phase and breaker separately.

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Note: ***For a circuit breaker with more than one break per phase, phase C-O time is calculated as interval of time between the instant when the last contact touched in the pole during closing and the instant when the first contact separated in the pole during subsequent O operation. Breaker C-O time is interval of time between the instant when the metallic continuity is established in the first pole during a closing operation and the instant when all poles have separated during the subsequent opening operation.***

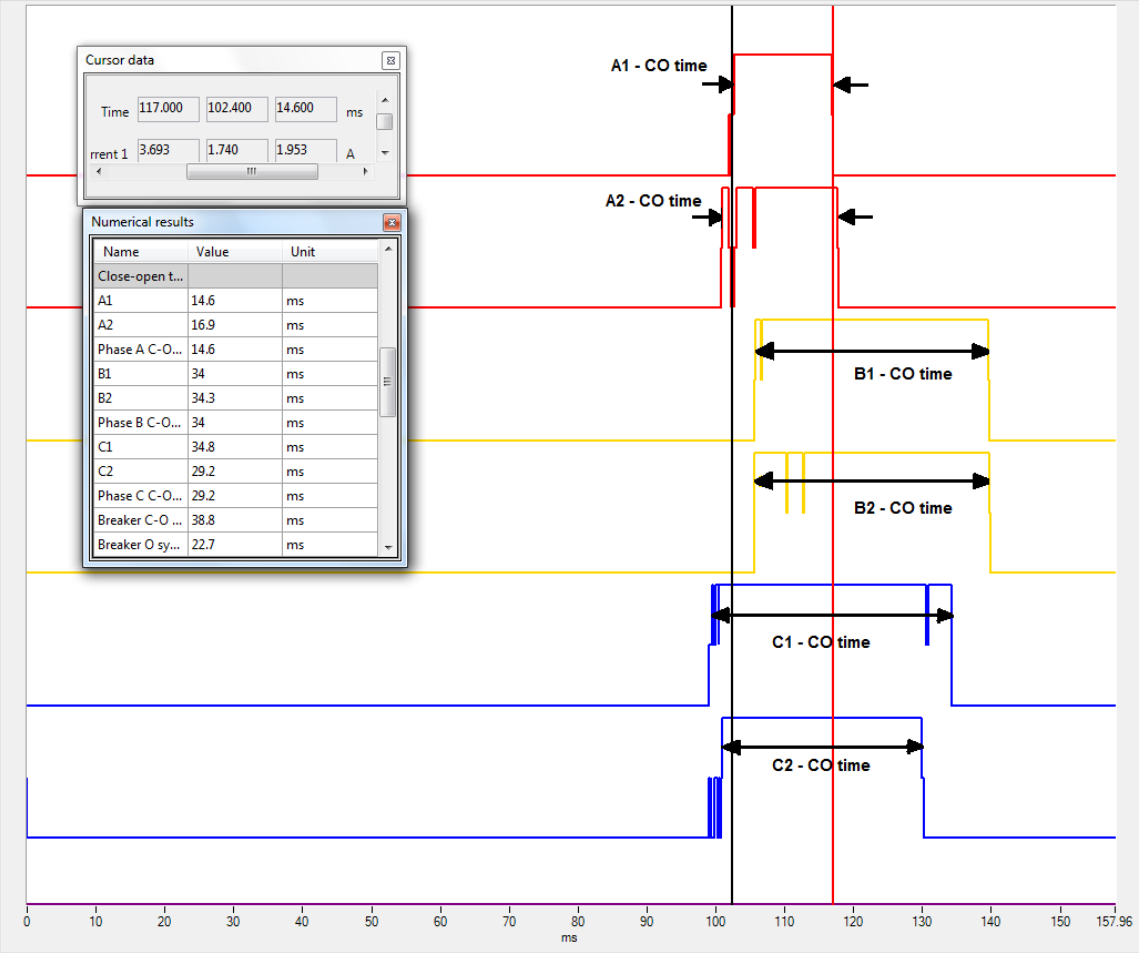

Figure 3. *C-O operation graphical and numerical results (two breaks per phase)*

As can be seen from the Figure 3, the C-O time in the phase A (14.6 ms) is much shorter than the C-O time of the other two phases (34 ms and 29.2 ms). Also, it is much shorter than minimum opening time (25 ms) for this CB. Since closing time of phase A is within tolerance (i.e. phase A is not slower at closing that could cause shorter C-O time) it indicates there is no problem with operating mechanism of the phase A but with auxiliary contact of type “a” adjustment. It tells the auxiliary contact “a” closes earlier than it should, causing the phase A to open faster at the next subsequent opening.

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