

# Circuit Breaker First Trip Testing

An Effective Circuit Breaker Asset Management Tool



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A circuit breaker is an important and critical component of the power delivery system. They are mechanical switching devices capable of making and carrying current in normal conditions, and breaking current when a fault occurs.

Ideally, in the closed position, a circuit breaker acts as a perfect conductor to ensure optimal current flow. In the open position, an ideal breaker acts as perfect insulator and can break the current instantaneously.

A circuit breaker may not be required to clear a fault for years, but when a fault occurs, it is expected to operate within its published specifications. Unfortunately, this is not always the case. Various factors such as environmental contaminants, hardened grease and mechanical issues can adversely affect a circuit breaker's operating time. Due to these factors it is possible that a breaker may not meet the manufacturer's specified operating time at its first opening, unless it has been properly maintained on a regular basis. Frequently, this problem is cleared after the first operation of the breaker, and thus the original cause can't be detected in subsequent testing. It is quite possible that a circuit breaker with a typical operating time of 3 to 4 cycles can take as long as 10 to 12 cycles due to a long period of inactivity. This can create problems with system stability and arc flash analysis, and may cause substantial damage to the circuit breaker as well as associated power apparatus such as transformers.

The ability to test high voltage circuit breakers without taking them out of service is becoming ever more important due to the shrinking operation and maintenance budgets. Off-line testing is usually performed as part of regular maintenance, but it can be costly and time consuming since it requires the breaker to be off-line. Before an off-line test can be performed, the breaker is first tripped and then isolated from the system. This first trip can provide great insight into the breaker mechanism's condition, but it is usually not timed due to the limitations of older circuit breaker analyzers. However, modern circuit breaker analyzers offer an on-line testing mode that can record the first on-line trip time. If an on-line test does not reveal any issues with the breaker, off-line testing may not be needed and the breaker can be kept in service, resulting in reduced maintenance costs and increased productivity.

On-line testing provides three key benefits:

- Saves time and resources
- Determines whether a circuit breaker needs off-line diagnostic testing
- Captures circuit breaker slow operation on first trip test

A typical On-Line timing test obtains the basic CB timing information such as contact time, coil current, DC voltage, and auxiliary contact times. This information is sufficient to determine if the CB is operating within the manufacturer's defined parameters.

The Vanguard CT-7000 S3 and CT-8000 S3's on-line timing option offers 3 timing channels for performing on-line tests. Three non-contact AC current probes, connected to the CB bushing CT secondary winding, are used to detect the circuit breaker main contact current. Since the timer can detect when the Trip or Close operation is initiated (using the external trigger input), the contact time can be determined based on the presence or absence of the bushing current.

Trip or Close coil current amplitude and signature are also recorded for current profile analysis. Additional information such as CB control DC voltage level and coil auxiliary contact time can also be recorded for further analysis.

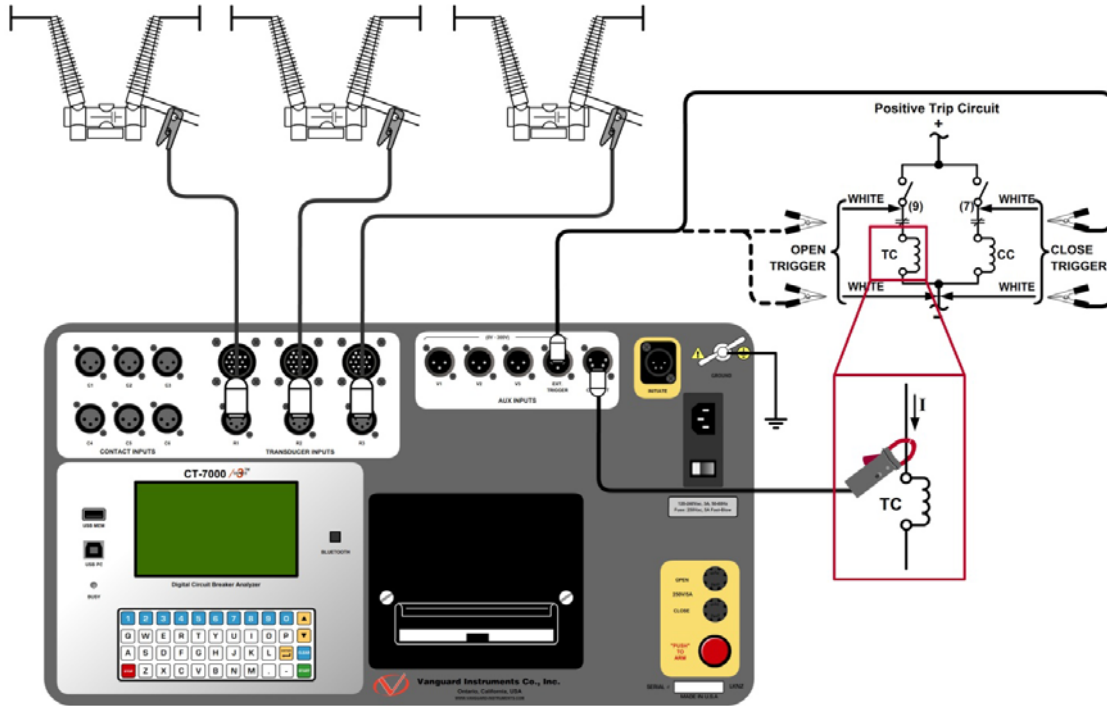


Figure 1. Typical Connection Diagram for an On-line Test

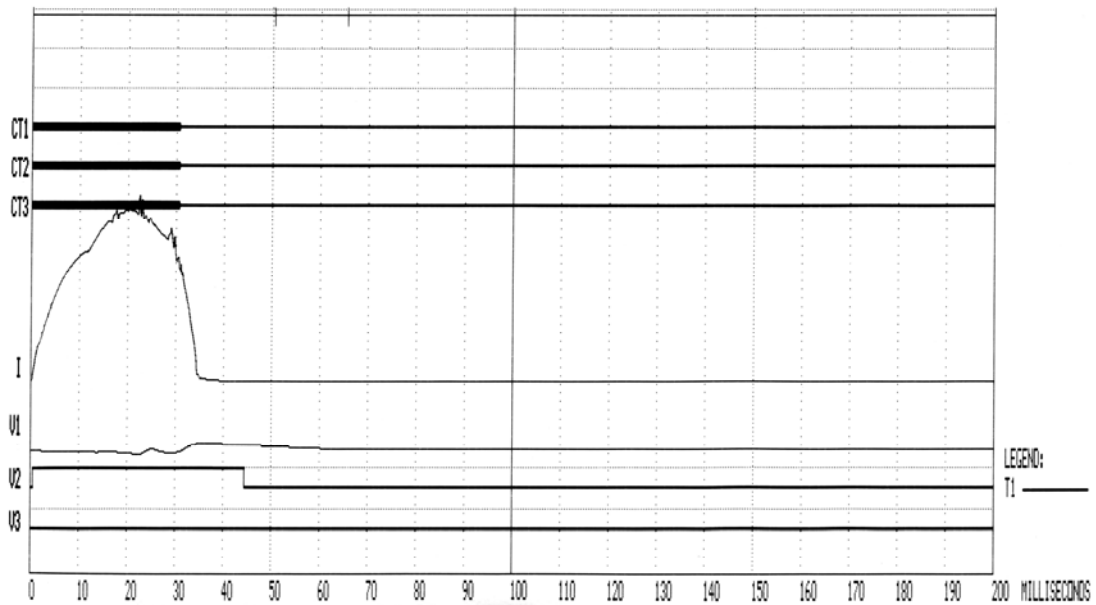


Figure 2. Typical On-line Timing Chart

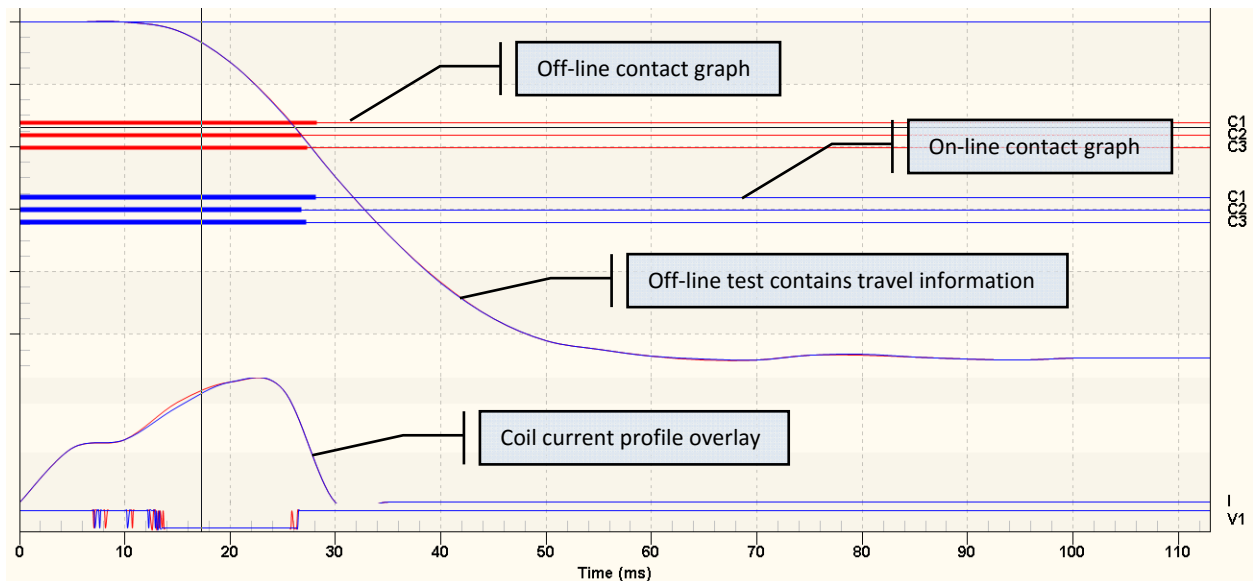
BREAKER TIMING RESULTS - 60 Hz		
SHOT NUMBER: 4		
DATE: 04/05/16 TIME: 14:09:08		
COMPANY: UIC		
STATION: LAB		
CIRCUIT:		
MFR:		
MODEL: CT 7000 S3		
S/N:		
OPERATOR: LU		
TEST: LIVE OPEN		
CT CHANNEL ANALYSIS		
CH	TIME	CYCLES
<ms>		
1	30.50	1.83
2	30.55	1.83
3	30.60	1.84
U1 NOMINAL VOLTAGE = 124 VOLTS		
U1 MINIMUM VOLTAGE = 116 VOLTS		
U2/U3 TRANSITION TIMES		
	U2	U3
T1:	0.40 ms	N/A
T2:	44.25 ms	N/A
T3:	N/A	N/A
INITIATOR CURRENT = 10.7 AMPS		

**Figure 3. Typical On-line Timing Test Report**

Figures 2 and 3 show a typical test record of a first trip test.

- Contact time phase A, B, and C is shown under CT Channels Analysis (30.50, 30.55, and 30.60 ms, respectively).
- DC nominal control voltage is shown as 124Vdc. The voltage dips to 116 Vdc during breaker trip operation.
- The Auxiliary switch contact 52a recorded activities at 0.4 ms and 44.25 ms
- Open coil current is reported as 10.7A

Using the Vanguard Circuit Breaker Analysis Software (VCBA-S2), we can compare the first trip timing test against an off-line timing test (Figure 4).



**Figure 4. Comparison of First Trip Time with Off-line Timing**

Following are some of the problems that can be revealed by first trip analysis:

Trip coil current graph comparison with the previous test results can reveal sticky trip latch components in the mechanism or a loose connection in the control circuit. The delay in the trip initiation can reveal the problem with the auxiliary contact timing. The coil voltage graph provides valuable insight into problems with the battery, battery chargers or associated cabling.

The benefit of performing a first trip test is to check the performance of the circuit breaker under “real world” operating conditions on the power system. What is the next step, if the values deviate from the last test value and the operation of the breaker seems suspect during the first-trip analysis? If the first trip indicates slow tripping time, then further analysis of the circuit breaker needs to be done by performing off-line testing. Tests such as dynamic resistance measurement, along with timing, motion, and coil current graph tests, should be performed. These tests will pinpoint the trouble before any maintenance activity is initiated.



**Figure 5. Vanguard CT-7000 S3 (left) and CT-8000 S3 (right) Circuit Breaker Analyzers**

The Vanguard CT-7000 S3 and CT-8000 S3 both offer an on-line timing option that can easily perform first trip testing. Both units are housed in a field-rugged enclosure and feature a QWERTY-style membrane user interface keypad with a built-in thermal printer. Each instrument can store up to 100 test plans as well as 200 test records internally. They can also be computer-controlled via the USB PC interface or an optional Bluetooth wireless PC interface. For further information on Vanguard Instruments' offerings for circuit breaker testing, please contact our local channel partner or visit our web site at [www.vanguard-instruments.com](http://www.vanguard-instruments.com).



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