4. Timing Tests

If the time delay uses a definite time curve, apply 90% of the pickup voltage and measure the time between test start and output contact operation. The time delay is compared to the setting and manufacturer's tolerances to make sure they match.

If the time delay is an inverse curve, perform the timing test by applying a multiple of pickup voltage and measure the time between the test start and output contact operation. Repeat the test for at least one other point to verify the correct curve has been applied.

Remember that prefault voltage higher than the pickup setting is required for successful 27-element testing!

A) Timing Test Procedure with Definite Time Delay and All Three Phases Required

- Determine which output the 27-element operates and connect the relay output to the test-set timing input.
- Determine if a breaker status contact is used to disable 27-element protection and ensure it is in the correct state.
- Determine if input current is required for 27-element operation and apply nominal 3Ø current as per the wiring diagrams in Figures 7-3, 7-4, and 7-5.
- Set the prefault voltage to nominal 3Ø voltage.
- Set the 3Ø fault voltage 10% lower than the pickup setting. The test for example would be performed at 59.23V (V_{Rated} * Pickup * 0.90= 69.28V *0.95 * 0.90). Set your test-set to stop when the timing input operates and to record the time delay from test start to stop.
- Apply prefault test voltage. Apply fault voltage and ensure timing input operates. Note the time on your test sheet. Compare the test time to the 27-element timing curve or formula to ensure timing is correct.
- Lower the test voltage to any value below the first test and above the minimum voltage setting, if one exists. Apply prefault for a few seconds, and then apply fault voltages. The time delay should be the same.
- Review relay targets to ensure the correct element operated.

B) Timing Test Procedure with Definite Time Delay and Two Phases Required

- Determine which output the 27-element operates and connect the relay output to the test-set timing input.
- Determine if a breaker status contact is used to disable 27-element protection and ensure it is in the correct state.
- Determine if input current is required for 27-element operation and apply nominal 3Ø current as per the wiring diagrams in Figures 7-3, 7-4, and 7-5.
- Set the AØ and BØ fault voltage 10% lower than the pickup setting. The test for our example would be performed at 59.23V (V_{Rated} * Pickup * 0.90= 69.28V *0.95 * 0.90). Set your test-set to stop when the timing input operates and to record the time delay from test start to stop.
- Apply prefault test voltage. Apply fault voltage and ensure timing input operates. Note the time on your test sheet. Compare the test time to the 27-element timing curve or formula to ensure timing is correct.
- Review relay targets to ensure the correct element operated.
- Lower the test voltage to any value below the first test and above the minimum voltage setting, if one exists. Apply prefault for a few seconds, and then apply fault voltages. The time delay should be the same.
- Repeat the steps above for BØ-CØ and CØ-AØ.

C) Timing Test Procedure with Definite Time Delay and Any Phase Required

- Determine which output the 27-element operates and connect the relay output to the test-set timing input.
- Determine if a breaker status contact is used to disable 27-element protection and ensure it is in the correct state.
- Determine if input current is required for 27-element operation and apply nominal 3Ø current as per the wiring diagrams in Figures 7-3, 7-4, and 7-5.
- Set the AØ fault voltage 10% lower than the pickup setting 59.23V (V_{Rated} * Pickup * 0.90= 69.28V *0.95 * 0.90). Set your test-set to stop when the timing input operates and to record the time delay from test start to stop.
- Apply prefault test voltage. Apply fault voltage and ensure timing input operates. Note the time on your test sheet. Compare the test time to the 27-element timing curve or formula to ensure timing is correct.
- Review relay targets to ensure the correct element operated.
- Lower the test voltage to any value below the first test and above the minimum voltage setting, if one exists. Apply prefault for a few seconds, and then apply fault voltages. The time delay should be the same.
- Repeat the steps above for BØ and CØ.

D) Timing Test Procedure with Inverse Time Delay and All Three Phases Required

- Determine which output the 27-element operates and connect the relay output to the test-set timing input.
- Determine if a breaker status contact is used to disable 27-element protection and ensure it is in the correct state.
- Determine if input current is required for 27-element operation and apply nominal 3Ø current as per the wiring diagrams in Figures 7-3, 7-4, and 7-5.
- Pick first test point from manufacturer's curve. (Typically in percent of pickup) Set the 3Ø fault voltage at the test point. The first test for our example at 90% pickup would be performed at 59.23V (V_{Rated} * Pickup * 0.90= 69.28V *0.95 * 0.90). Set your test-set to stop when the timing input operates and to record the time delay from test start to stop.
- Apply prefault test voltage. Apply fault voltage and ensure timing input operates. Note the time on your test sheet. Compare the test time to the 27-element timing curve or formula to ensure timing is correct.
- Review relay targets to ensure the correct element operated.
- Perform second test at another point on the manufacturer's timing curve. (E.g. 60%= 69.28V * 0.95 * 0.6 = 39.49V)
- Apply prefault test voltage. Apply test voltage, ensure timing input operates, and note the time on your test sheet. Compare the test time to the 27-element timing curve or formula to ensure timing is correct.
- Review relay targets to ensure the correct element operated.

E) Timing Test Procedure with Inverse Time Delay and Two Phases Required

- Determine which output the 27-element operates and connect the relay output to the test-set timing input.
- Determine if a breaker status contact is used to disable 27-element protection and ensure it is in the correct state.
- Determine if input current is required for 27-element operation and apply nominal 3Ø current as per the wiring diagrams in Figures 7-3, 7-4, and 7-5.
- Pick first test point from manufacturer's curve. (Typically in percent of pickup) Set the AØ and BØ fault voltage at the test point. The first test for our example at 90% pickup would be performed at 59.23V (V_{Rated} * Pickup * 0.90= 69.28V *0.95 * 0.90) Set your test-set to stop when the timing input operates and to record the time delay from test start to stop.
- Apply prefault test voltage. Apply test voltage, ensure timing input operates, and note the time on your test sheet. Compare the test time to the 27-element timing curve or formula to ensure timing is correct.
- Review relay targets to ensure the correct element operated.
- Perform second test at another point on the manufacturer's timing curve. (E.g. 60%= 69.28V * 0.95 * 0.6 = 39.49V)
- Apply prefault test voltage. Apply test voltage, ensure timing input operates, and note the time on your test sheet. Compare the test time to the 27-element timing curve or formula to ensure timing is correct.
- Review relay targets to ensure the correct element operated.
- Repeat the steps above for BØ-CØ and CØ-AØ.

F) Timing Test Procedure with Inverse Time Delay and Any Phase Required

- Determine which output the 27-element operates and connect the relay output to the test-set timing input.
- Determine if a breaker status contact is used to disable 27-element protection and ensure it is in the correct state.
- Determine if input current is required for 27-element operation and apply nominal 3Ø current as per the wiring diagrams in Figures 7-3, 7-4, and 7-5.
- Pick first test point from manufacturer's curve. (Typically in percent of pickup) Set the AØ fault voltage at the test point. The first test for our example at 90% pickup would be performed at 59.23V (V_{Rated} * Pickup * 0.90= 69.28V *0.95 * 0.90). Set your test-set to stop when the timing input operates and to record the time delay from test start to stop.
- Apply prefault test voltage. Apply test voltage, ensure timing input operates, and note the time on your test sheet. Compare the test time to the 27-element timing curve or formula to ensure timing is correct.
- Review relay targets to ensure the correct element operated.

- Perform second test at another point on the manufacturer's timing curve. (E.g. 60%= 69.28V * 0.95 * 0.6 = 39.49V)
- Apply prefault test voltage. Apply test voltage, ensure timing input operates, and note the time on your test sheet. Compare the test time to the 27-element timing curve or formula to ensure timing is correct.
- Review relay targets to ensure the correct element operated.
- Repeat the steps above for BØ and CØ.

G) Evaluate Test Results with Definite Time Settings

Before we can evaluate the test results, we must determine manufacturer's expectations and tolerances. Use the following specifications from a GE D-60 relay to determine expected values.

UNDERVOLTAGE	
Voltage:	Phasor only
Level Accuracy:	+/- 0.5% of reading from 10 to 208 V
Timing Accuracy:	Operate @ <0.90 x Pickup +/- 3.5% of operate time or +/- 4 ms

Figure 7-7: GE D-60 Undervoltage Relay Specifications

The test time should equal the time delay setting within 3.5% error or within 4ms of the specified time. For example, if the time setting was 20.0s and the measured time delay was 20.2 seconds, we could use the percent error calculation below to determine a 1% error which is within the manufacturer's tolerances. You would use the 4ms criteria for time delay settings less than 1.14 seconds because the measured time difference could be greater than 3.5% error but less than 4ms.

$$\frac{\text{Actual Value - Expected Value}}{\text{Expected Value}} \text{ X 100 = percent error}$$

$$\frac{\text{20.2s - 20.00s}}{\text{20.00s}} \text{ X 100 = percent error}$$

$$\frac{\text{0.20s}}{\text{20.00s}} \text{ X 100 = percent error}$$

1.0% Error