

Applying Fault Indicators to Lightly Loaded Overhead Circuits

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INTRODUCTION

This application note explains the operation and benefits of applying Overhead AutoRANGER[®] faulted circuit indicators (FCIs) on lightly loaded circuits.

The Overhead AutoRANGER (AR-OH) and AutoRANGER 360 (AR360) FCIs, shown in Figure 1, are designed for normal operation on conductors with nominal load currents greater than or equal to 10 A. When load current drops below 10 A for 50 to 100 milliseconds, the FCIs enter current inrush restraint (CIR) lockout mode for a period of 3 minutes. During this period, the FCIs do not autorange to a lower trip threshold or respond to any fault events.

Immediately after this period, the FCIs look for continuous system voltage and current for 2 minutes. If system voltage (4.16 to 34.5 kV L-L for AR360 and 4.16 to 69 kV L-L for AR-OH) is present but the current is less than 10 A after the 2-minute duration, the FCIs enter voltage-only mode and continue monitoring system voltage for another 3 minutes. Once 5 minutes total of continuous system voltage have been monitored, the AR-OH and AR360 begin to autorange down every 30 seconds to the lowest trip threshold (50 A). In this mode, the units are armed and ready to respond to faults, but are not able to distinguish if the faults are momentary or permanent. Consequently, all fault types are displayed in the permanent fault mode with a permanent timeout period of 8 hours.

For example, if an AR360 is applied to a 13.8 kV L-L system with 225 A of load current, the unit selects a trip threshold of 600 A. If the load current suddenly decreases to 5 A for 50 to 100 milliseconds, the AR360 does not initially lower its trip threshold. Instead, the AR360 registers the drop in current as a loss-of-current (LOC) event and enters CIR lockout mode for 3 minutes. The AR360 then senses the continuous voltage field for 5 minutes, confirming that the system is energized. After sampling system voltage, the unit is armed and ready to respond to faults. The AR360 also begins to autorange down in 30-second intervals until it reaches the 50 A trip threshold.



Figure 1 AutoRANGER 360 and Overhead AutoRANGER

COMMON SCENARIOS

Three common scenarios in which the AR-OH or AR360 could be subjected to load currents less than 10 A are described in this section.

Scenario A

When installing the FCIs on a conductor with low load current, the following occurs, as shown in Figure 2:

- Out of the box, the FCIs are configured with a 600 A trip threshold. When installed on a conductor with nominal system voltage and 5 A load current, the FCIs enter system-detect mode and monitor continuous voltage and current for 2 minutes.
- Because 5 A in this scenario is below the minimum load current detection threshold, the FCIs begin to check for voltage-only mode and monitor continuous voltage for another 3 minutes.
- After 5 minutes of sampling voltage, the FCIs are armed and ready to autorange, detect faults, and respond to voltage inrush restraint. They are still configured with a 600 A trip threshold at this time.
- The FCIs autorange down to 50 A (one threshold every 30 seconds) in 2 minutes.
- The FCIs display all types of faults as permanent faults because they are not able to detect sufficient load current.
- The timed reset duration for faults is set to 8 hours to provide maintenance crews extra time to reach lightly loaded rural areas.

Similarly, when the FCIs are reset from a trip under these low current conditions, they also need to verify system voltage for 5 minutes in order to arm. However, they do not need to autorange down because they are already configured to trip at 50 A.

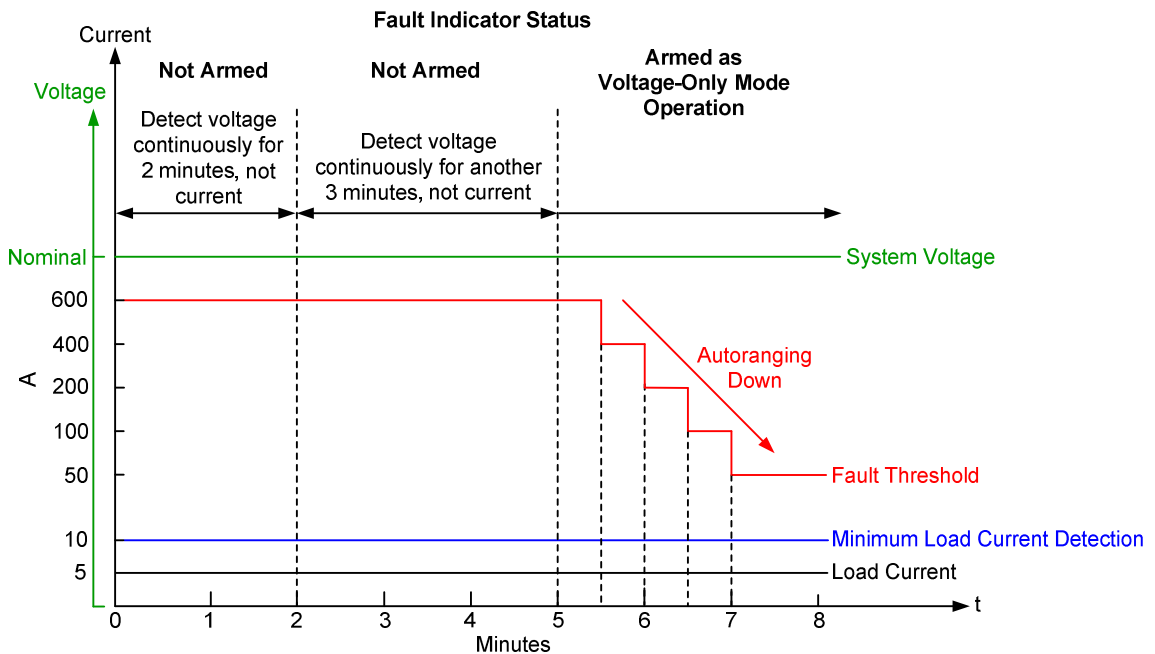


Figure 2 New Installation—Load Current Always Less Than 10 A

Scenario B

In this scenario, the following occurs, as shown in Figure 3:

- At $t = t_1$, the FCIs are armed on a system with nominal voltage and 60 A load current. The trip threshold is configured to 200 A based on this load current.
- At $t = t_2$, the FCIs experience a sustained drop in load current from 60 A to 8 A. After detecting this LOC event for 50 to 100 milliseconds, the CIR lockout period begins at $t = 0$.
- At $t = 3$ minutes, the FCIs enter the 2-minute sampling mode and begin to monitor for system voltage and current. Because 8 A is below the minimum load current detection threshold, the FCIs only recognize the system voltage field.
- At $t = 5$ minutes, the FCIs confirm the presence of voltage for another 3 minutes.
- At $t = 8$ minutes, the FCIs meet the voltage detection requirement to enter voltage-only mode operation. The FCIs are now armed with a 200 A trip threshold and begin to autorange down to 50 A (one threshold every 30 seconds) in 1 minute.
- The FCIs display all types of faults as permanent faults because they are not able to detect sufficient load current.
- The timed reset duration for faults is set to 8 hours.

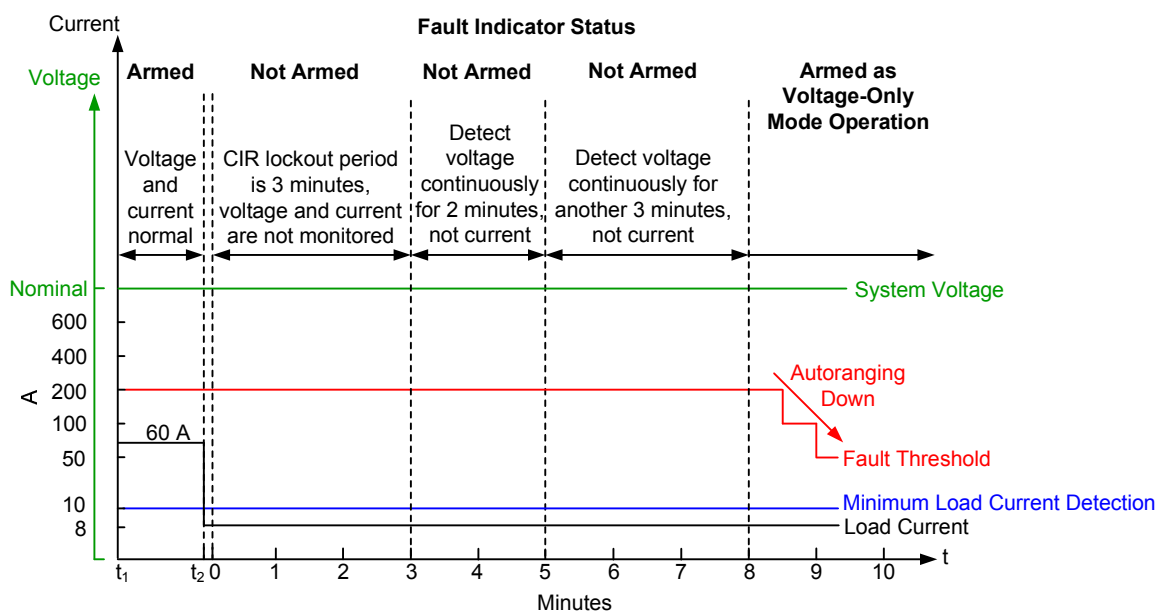


Figure 3 Current Normally Above 10 A Drops Below for a Sustained Duration

Scenario C

In this scenario, the following occurs, as shown in Figure 4:

- The FCIs are armed at $t = t_1$ in voltage-only mode with nominal system voltage and 5 A of load current. The FCIs are configured with a 50 A trip threshold.
- An overcurrent event occurs at $t = t_2$. The FCIs have a delayed trip (DT) response time of 24 milliseconds.
- The FCIs register the overcurrent event at $t = 0$ and enter the intermediate state for 2 minutes while displaying a permanent fault.
- At $t = 2$ minutes, the FCIs check for system voltage and load current. Because the load current is below 10 A, the FCIs fail to detect it and display the permanent fault sequence. (Note that the system voltage may be nominal or 0.)
- In the permanent fault state, the FCIs stop monitoring voltage and current and continue to display the permanent fault pattern for a timed reset duration of 8 hours.

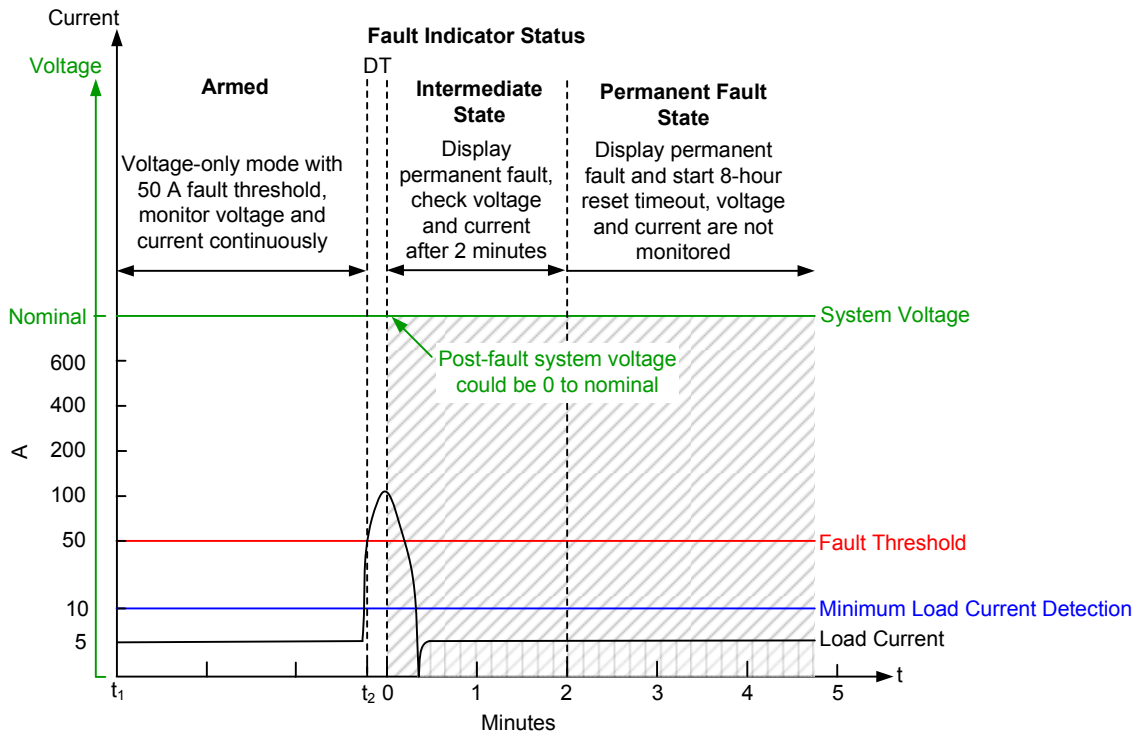


Figure 4 Voltage-Only Mode (Current < 10 A)—Trip and Lockout