Application Note

Protecting Distribution System Transformers against Overexcitation Caused by the Addition of Distributed Energy Resources

When most distribution systems were installed, they were much simpler than they are today. The structure was well defined. Generation was owned by the utility. Power flowed from the power plant or the transmission system across mostly radial-connected distribution to customer loads. This simplicity made it much easier to control system voltage, particularly at the load. Figure 1 shows a typical distribution feeder including a transformer with load tap changer (LTC) and customer load.

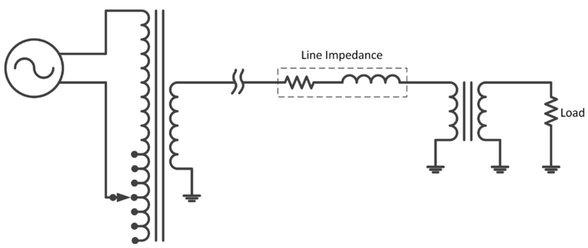

Figure 1. Typical Distribution Feeder

The LTC would be configured to maintain the voltage at the customer load within regulatory requirements. Typically, this would be ±5% of the nominal voltage. If the line impedance was large or there was a larger customer load, the line impedance needed to be considered. The voltage drop on the line could be sufficient to adversely affect the regulation of the voltage at the load.

Lately, distribution systems have become more complex. There has been a focus on renewable and low-impact energy sources. This is resulting in smaller distributed energy resources (DER) located throughout the distribution system. This makes the distribution system look more like Figure 2 instead of Figure 1.

Often, generation at the customer location may be solar, wind, or some other source that produces power on availability instead of on demand. As a result, customer voltages that were previously equal to or lower than the utility substation may be higher if the local generation exceeds the local load. LTCs that previously were able to maintain the voltage in the necessary range may no longer be able to do so. This could result in an increase

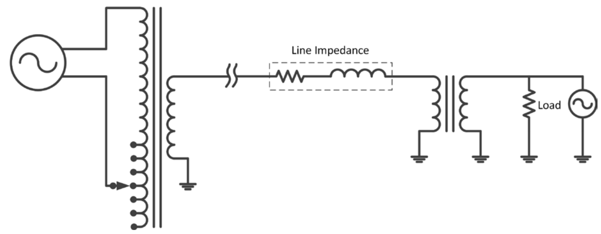

Figure 2. Complex Distribution Feeder

in voltage, causing overexcitation of the transformer located at the customer site. The Basler Electric BE1-FLEX, with the Intermediate protection option, includes overexcitation (IEEE device 24) protection. This provides an easy and cost-effective way to provide overexcitation protection for transformers located near the load. In this application, the concern is when the local generation is exporting power. For this reason, the 24 element is enabled only when a power element (IEEE device 32) indicates that power is being exported by the customer.To set up this protection in the BE1-FLEX, BESTCOMS*Plus*® is used.

The relay logic will be configured to provide a trip on output 1 from the 24 element. Additionally, the logic will enable the 24 element only when the relay is measuring reverse power. This assumes forward power has been defined as power supplied from the utility to the customer. This will be configured by using the BESTlogic™*Plus* feature contained within BESTCOMS*Plus*®. The completed logic is shown in Figure 3. The 32 element is used to enable the 24 element only when reverse power is detected. The fault trigger is used to generate fault reports and targets when the 24 operates..

The logic defines which elements of the relay will be used, how they will be connected, and the I/O that will be used.

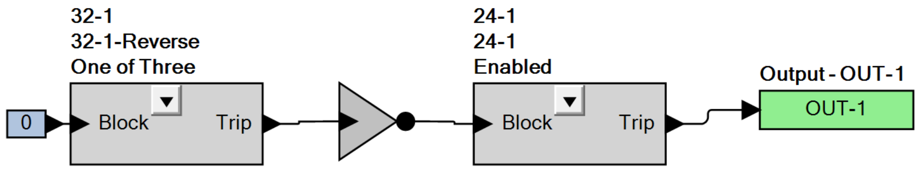

Figure 3. Completed Logic Diagram

To complete the application, the individual elements need a few settings to define the operating mode, pickup levels, and timing. Figure 4 shows the settings tabs for the 32 and 24 elements. The 32 element is set to pick up when any individual phase exports power. The pickup level is not critical because this element is used only to enable the 24 element. For this example, the pickup is set to minimum so that the 24 is enabled for the minimum measurable reverse power. Because the pickup is used as the enable, the time delay does not matter and remains at zero. The Fault Recorder for the 32 element is disabled in this example to avoid unnecessary data capture. The 24 settings are more critical than the 32 settings. The transformer data should be used to determine the correct pickup and timings to protect the transformer from overexcitation. The element has pickup and timing settings for one inverse timing and two definite timings. These timings can be combined to provide a simple two-step curve or an inverse time curve, depending on system requirements and utility company standards. The IEEE Guide for Protecting Power Transformers (IEEE-C37.91) identifies 5 to 10% overexcitation as a typical maximum continuous level. In this example, 2.1 is used to provide pickup at 5% overexcitation and a squared inverse curve is selected.

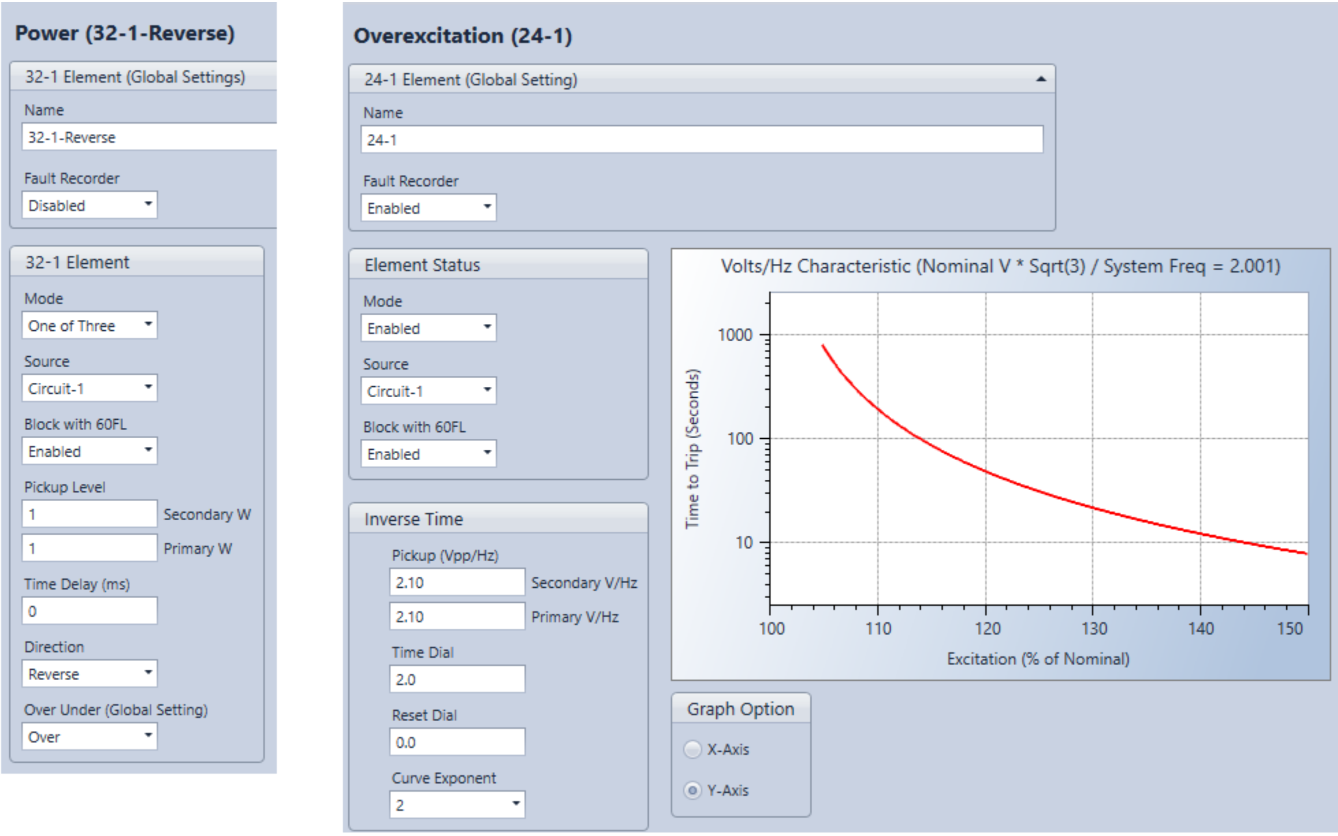

Figure 4. Power (32) and Overexcitation (24) Settings Screens

The 24 element is just one of many elements provided in the BE1-FLEX Protection, Automation and Control System. Figure 5 shows the protective functions included in each protection package.

For more information

For further assistance with product orders or questions, contact Basler Electric Technical Support at 618-654-2341.

For additional information about the BE1-FLEX Protection, Automation and Control System including more application notes, product bulletins, and instruction manuals, visit www.basler.com, contact your Application Engineer, or contact Technical Support at 618-654-2341.

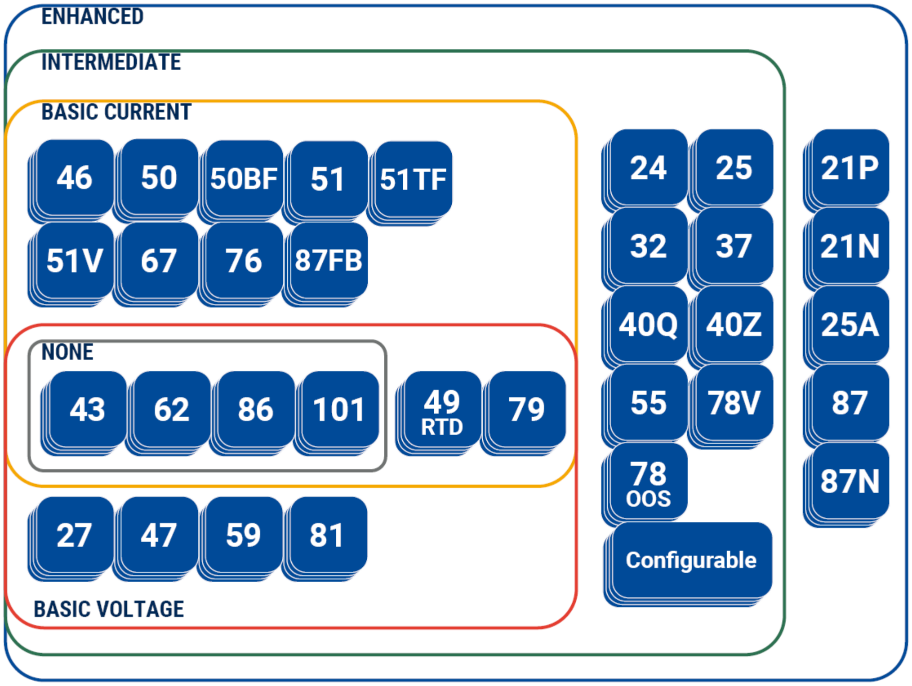

Figure 5. System Summary Screen

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