Features and Advantages of B-PRO 4000 in Distribution Applications

Objectives

While briefing general features of B-PRO 4000 Bus Protection Relay, this technical note clarifies advantages of B-PRO protection functions in distribution applications at small or medium size utilities.

1. Key Features and Advantages

The B-PRO 4000 is a microprocessor-based numerical relay that provides bus and transformer differential protection (87B - 87T) as well as breaker failure (50BF), overcurrent (50LS, 50/51/67, 50N/51N/67, 46-50/46-51/67), over/under voltage (59/27), loss of potential (60), over/under frequency (81 O/U) protection functions, metering, fault and swing recording, event logging and SCADA control in a fully integrated protective relay solution. Features and advantages include:

- Simple use, installation and maintenance
- Simple selectable setting options and fully graphical environment for fast and easy setting and relay configuration
- Compact and cost effective protection in combined bus and transformer protection applications
- Multiple zones of protection: transformer, bus and dual bus zones
- Low-impedance bus differential protection with CT saturation security, delta phase and Rate of Change of Differential (ROCOD) algorithm that ensures reliable differential protection
- Re-configurable bus and transformer applications for up to 6 bays and 2 differential zones
- Transformer zone with internal magnitude and phase compensation as well as 2nd and selectable 5th harmonic restraint algorithm
- Full transformer protection, at no extra cost, for one bay (87T, 50BF, 50LS, 50/51/67, 50N/51N/67, 46-50/46-51/67)
- Complete back-up current, voltage and frequency protection for each bay including negative sequence and directional elements with VT supervision (50BF, 50LS, 50/51/67, 50N/51N/67, 46-50/46-51/67, 27, 59, 60, 81 O/U)
- Over-current functions with user-defined current curves in addition to IEEE/IEE standard curves
- 2 stage Over/Under Frequency protection functions (81) for load shedding
- IEC 61850-8-1 protocol included at no extra cost, fully implemented
- User-configurable logic with ProLogic: 15 statements, 5 inputs per statement (full Boolean graphics)
- Multi-functional recording, DFR-quality fault oscillography and event logging
- Power system troubleshooting after a power system event (high storage capacity of event system data)
- Small footprint and weight (3U chassis, 21 lbs)

2. Overview

The relay provides low impedance differential protection with CT saturation security and up to 6 three-phase current inputs for the following differential zones:

- Bus zone (87B)
- Transformer zone (87T)
- One bus and one transformer zone (87B – 87T)
- Two bus zone (87B-1, 87B-2)

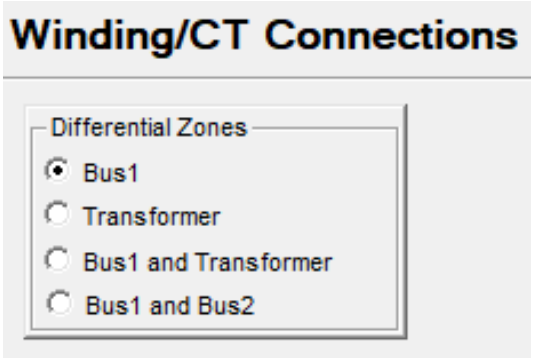

Figure 1 - Multiple differential zones

The transformer zone includes internal magnitude and phase compensation as well as 2nd and 5th harmonic restraint algorithm.

Back-up feeder protection is provided for all inputs, regardless of which zone is selected, even if an input is not used in a differential zone.

Overcurrent protection functions for each input cover low set overcurrent, breaker failure, selectable directional phase/neutral overcurrent with IEEE/IEC standard or user defined curves, as well as selectable directional negative sequence overcurrent with IEEE/IEC standard or user defined curves.

Each CT input can be automatically excluded from all relaying, metering and recording functions based on the status of an associated external input. This feature can be used to automatically adjust the CT inputs of a differential zone based on the changes in the bus configuration. The connections of the “Exclude When” setting accommodates the use of an “a” or “b” auxiliary contact as the Digital Control input.

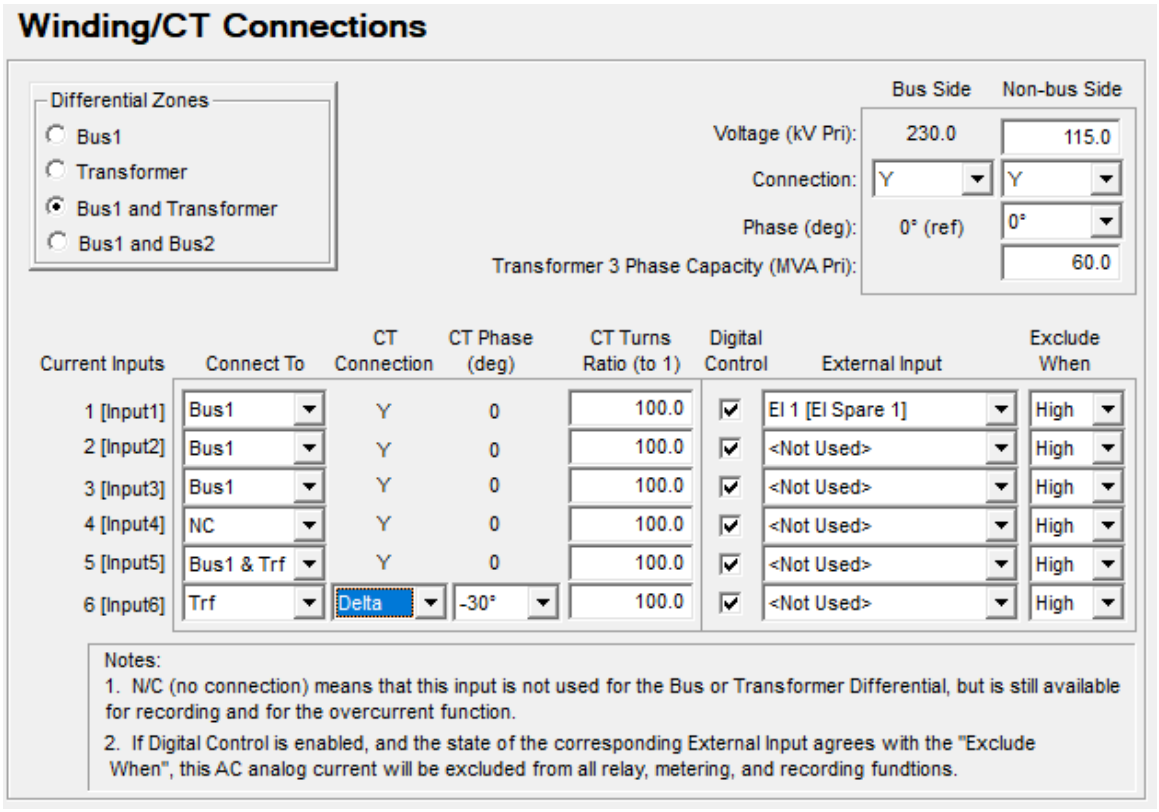

Figure 2 – Digital Control inputs

For specific protection and control needs, the relay provides 15 ProLogic statements (5 inputs per statement) for creation of user-configurable logic.

The relay also integrates a powerful recorder with 96 samples per cycle fault recording, 1 sample per cycle dynamic swing recording and 1ms resolution event logging. Triggering of fault records will be possible by graphical programming of the output matrix and by allowing any internal relay function or any external input to initiate recordings. The user has the option to compress the sequence of events every 230 events. Storage capacity can accommodate up to 75 x 2 second fault records, 150 x 2 minutes swing records and up to 150 compressed sequence of event records, or a combination with maximum of 150 fault, swing and event records.

Relay Control Panel (RCP) is a Windows-based graphical user interface software tool provided with all ERLPhase 4000 series relays to communicate, retrieve and manage records, display event logs, manage settings and graphical configuration, display real time metering values, and to view, analyze and export records in COMTRADE format.

3. Applications

3.1 Functional Overview – Single-Bus Single-Breaker Arrangement

Figure 3 shows a B-PRO 4000 functional overview in a single-bus single-breaker station arrangement. This simple and economical arrangement requires only one bus differential zone (Bus 1). A single B-PRO 4000 protects up to 6 feeders in this configuration.
In addition to bus differential protection, B-PRO can protect each feeder against breaker failure, overcurrent, two-stage over/under voltage and over/under frequency (load shedding) by monitoring bus voltage. B-PRO 4000 records any fault, dynamic swing, disturbance and event in the station to be used for further analysis of power system.

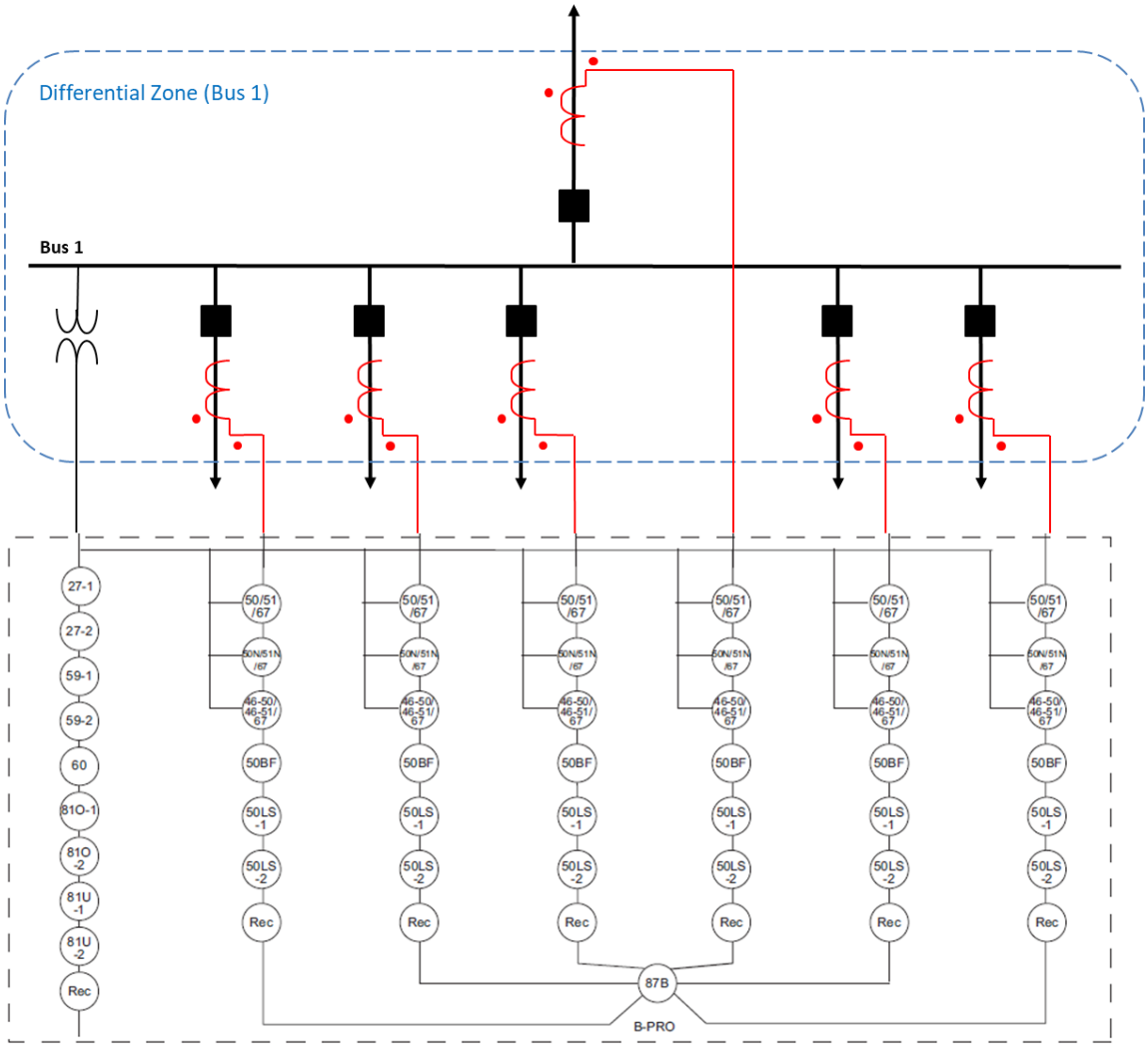

Figure 3 – B-PRO 4000 functional diagram in a single-bus single-breaker configuration

3.2 Functional Overview – Double-Bus with Tie Breaker

Figure 4 shows a B-PRO 4000 functional overview in a double-bus with tie breaker arrangement. Two differential elements in the B-PRO provide two bus differential zones with up to 6 feeders using a single B-PRO 4000 relay.

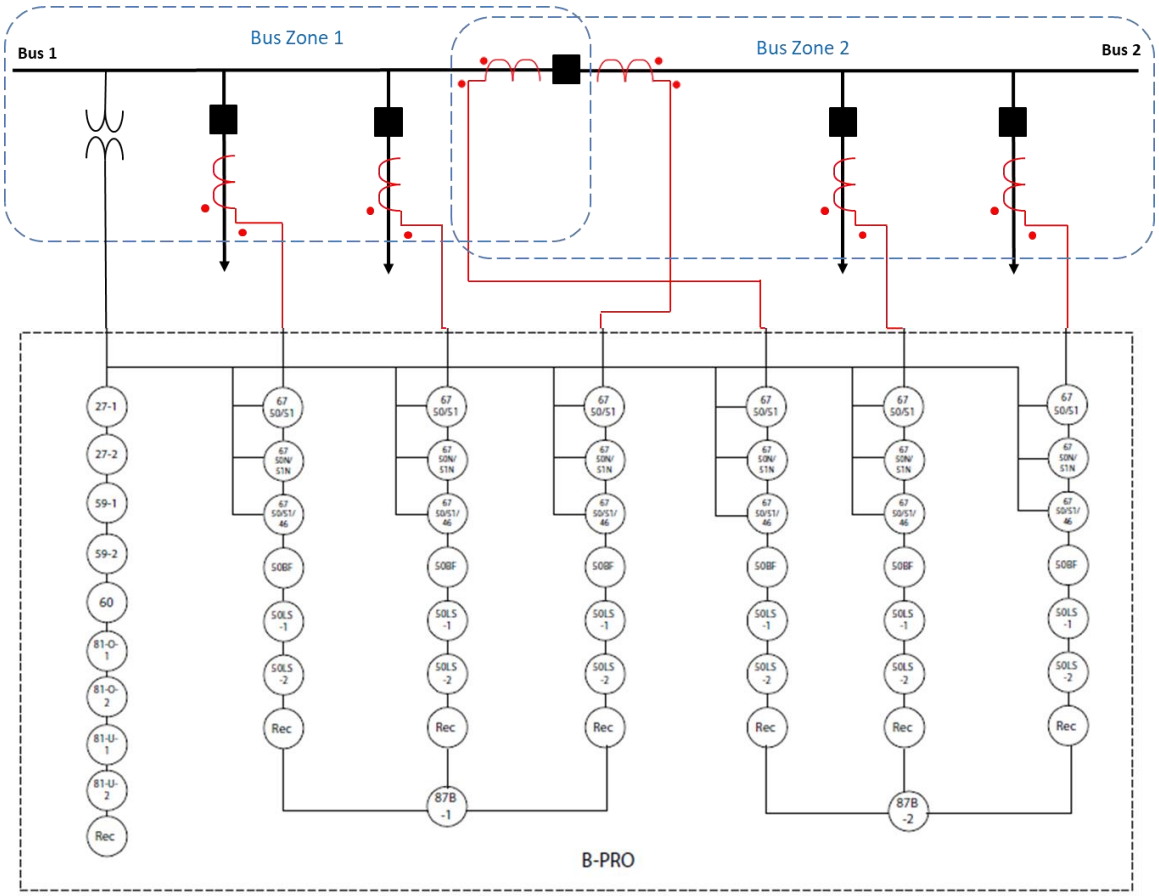

Figure 4 – B-PRO 4000 functional diagram in a double-bus with tie breaker configuration

Use two B-PRO 4000s for this application with up to 10 feeders (see Figure 5).

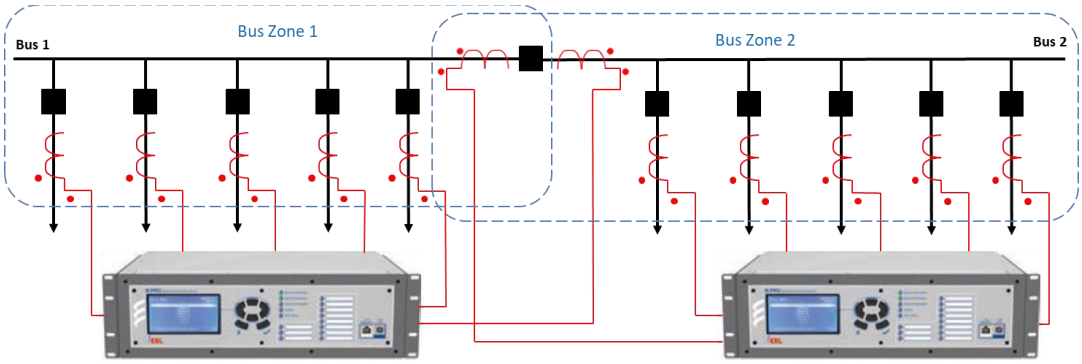

Figure 5 - Two B-PRO 4000s protecting a double-bus with tie breaker and up to 10 feeders

3.3 Combined Bus and Transformer Protection

B-PRO 4000 has a unique capability to provide combined bus and transformer protection in applications where a power transformer is directly connected to the bus. This configuration saves the breaker between the bus and the transformer. Figure 6 shows a typical example in a station where two lines supply a step-down transformer. Use a single B-PRO to protect combined bus and transformer arrangements; there is no need for separate bus and transformer relays. Although this application requires one protection zone, the B-PRO internally provides selectivity between bus and transformer protection zones. B-PRO also protects the lines with back-up protection functions as well as digital fault and event recording.

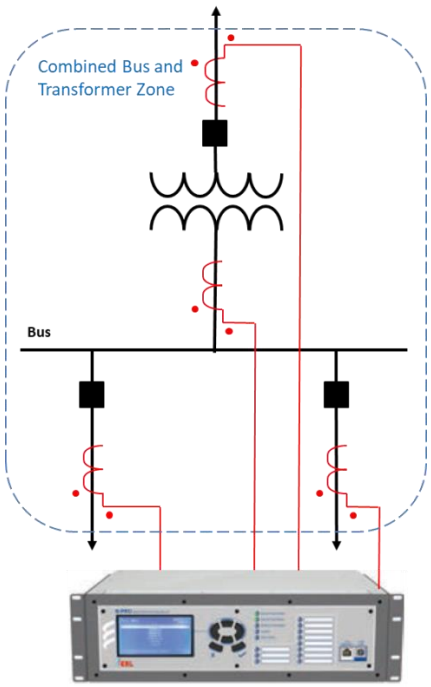

Figure 6 - B-PRO 4000 protecting combined bus and transformer configuration

3.4 Functional Overview - Bus and Transformer Protection

B-PRO 4000 is not only a bus protection relay but can also act as a transformer protection relay (separately or together with bus protection). The transformer differential element in the B-PRO 4000 includes 2nd and selectable 5th harmonic restraint algorithms to ensure a reliable and selective transformer protection (Protection A, Protection B or back-up protection in any bus protection applications). This feature provides cost-effective solutions in station configurations requiring transformer protection in bus applications. Figure 7 shows the B-PRO 4000 functional overview in a typical bus and transformer differential zone.

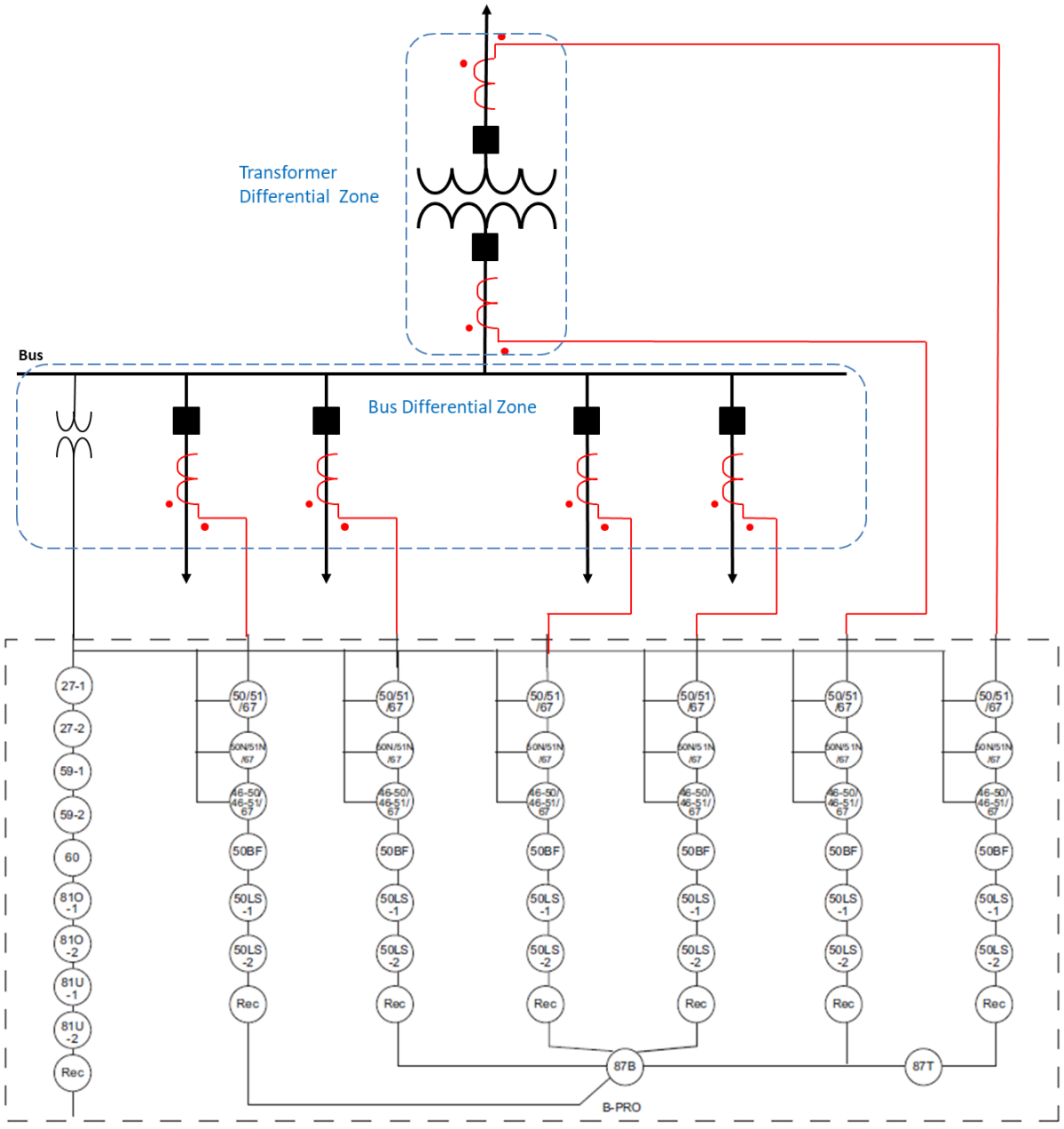

Figure 7 – B-PRO 4000 functional diagram in a typical bus and transformer configuration

3.5 Main and Transfer Bus Arrangement

A main and transfer bus arrangement needs one differential zone. Figure 8 shows the B-PRO 4000 in this configuration.

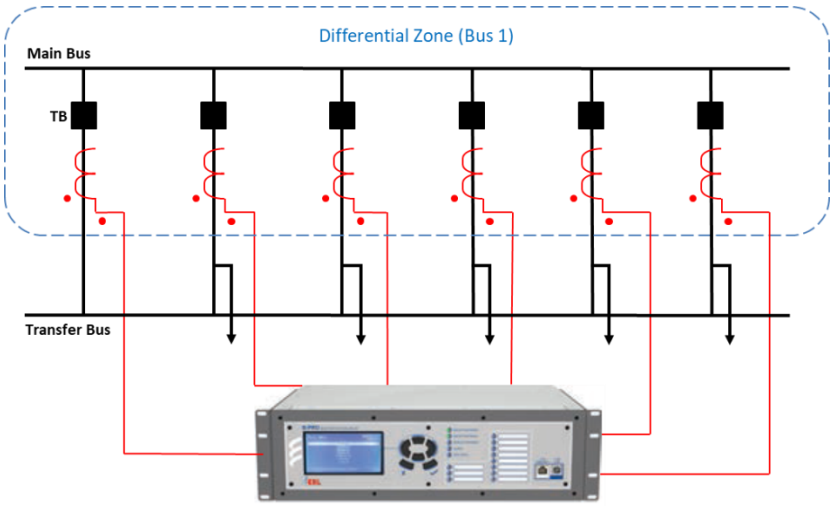

Figure 8 - B-PRO 4000 protecting main and transfer bus configuration

3.6 Double-Bus Single-Breaker arrangement

Use a single B-PRO 4000 for this application with up to 4 feeders or two B-PRO 4000 for more feeders up to 10. Figure 9 shows B-PRO 4000 for this configuration.

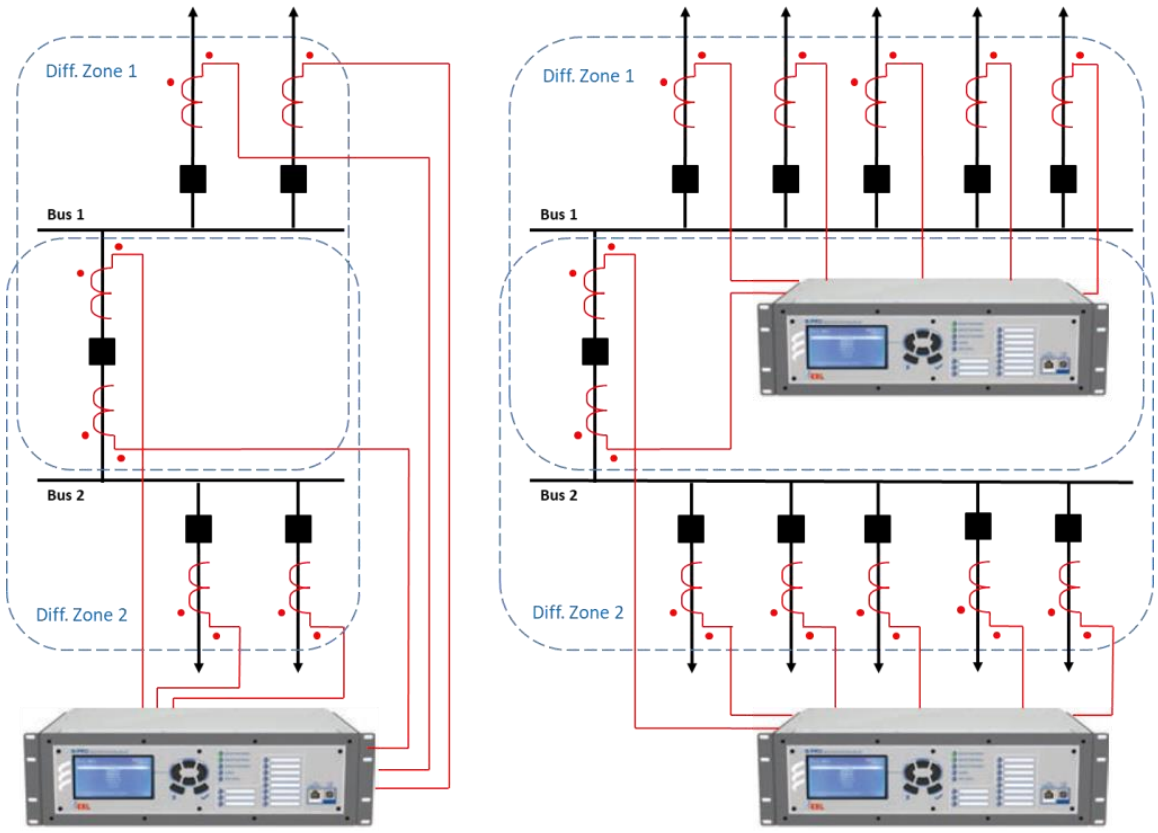

Figure 9 - B-PRO 4000 protecting a double-bus single-breaker configuration

3.7 Breaker and a Half Arrangement

This arrangement provides more operating flexibility and saves one breaker compared to the double-bus double-breaker configuration. Two bus differential zones are required. Figure 12 shows one B-PRO 4000 protecting up to 6 feeders and Figure 13 shows two B-PRO 4000s protecting up to 12 feeders for this application.

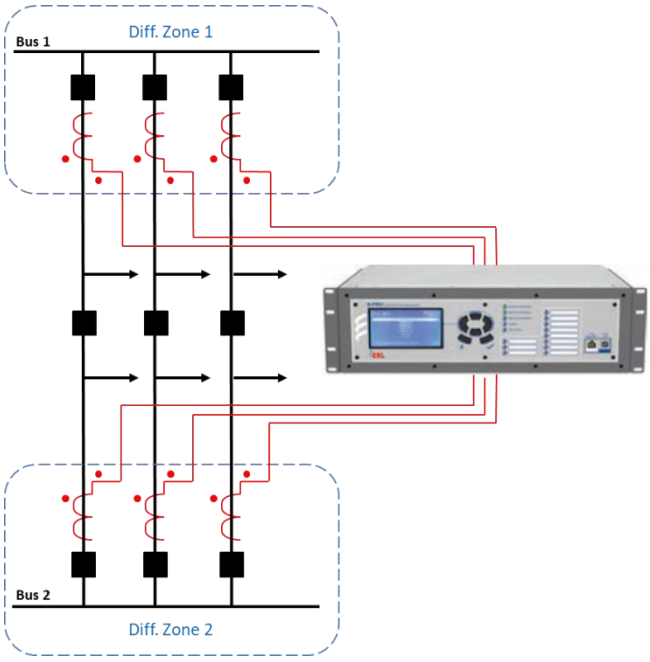

Figure 10 - B-PRO 4000 protecting a breaker and a half condiguration (up to 6 feeders)

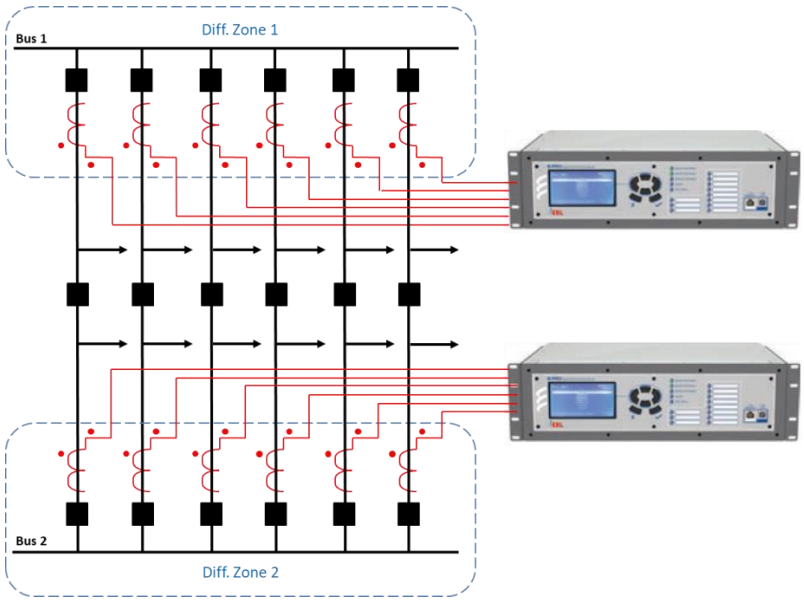

Figure 11 - B-PRO 4000 protecting a breaker and a half configuration (up to 12 feeders)

3.8 Double-Bus Double-Breaker Arrangement

This arrangement provides high flexibility and requires two bus differential zones. A bus fault does not interrupt service.

Use a single B-PRO 4000 for this application with up to 3 feeders (Figure 10) or two B-PRO 4000 for more feeders up to 6 (Figure 11).

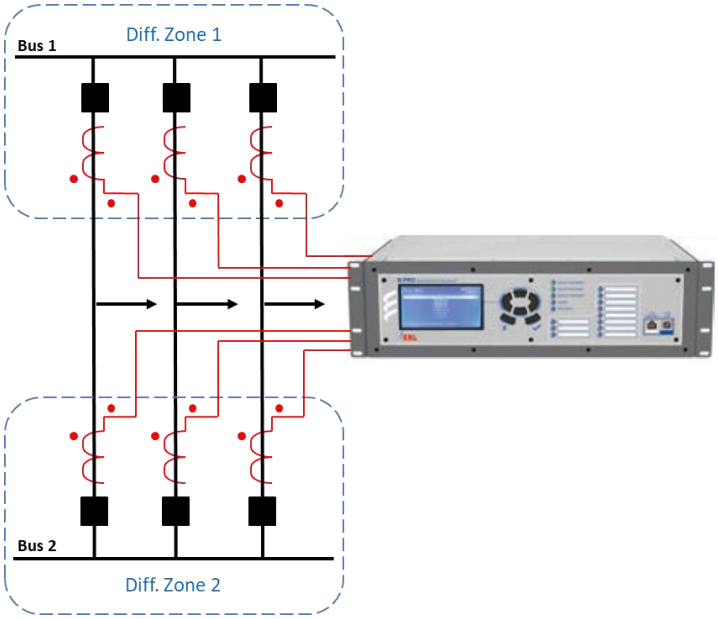

Figure 12 - B-PRO 4000 protecting a double-bus double-breaker configuration (up to 3 feeders)

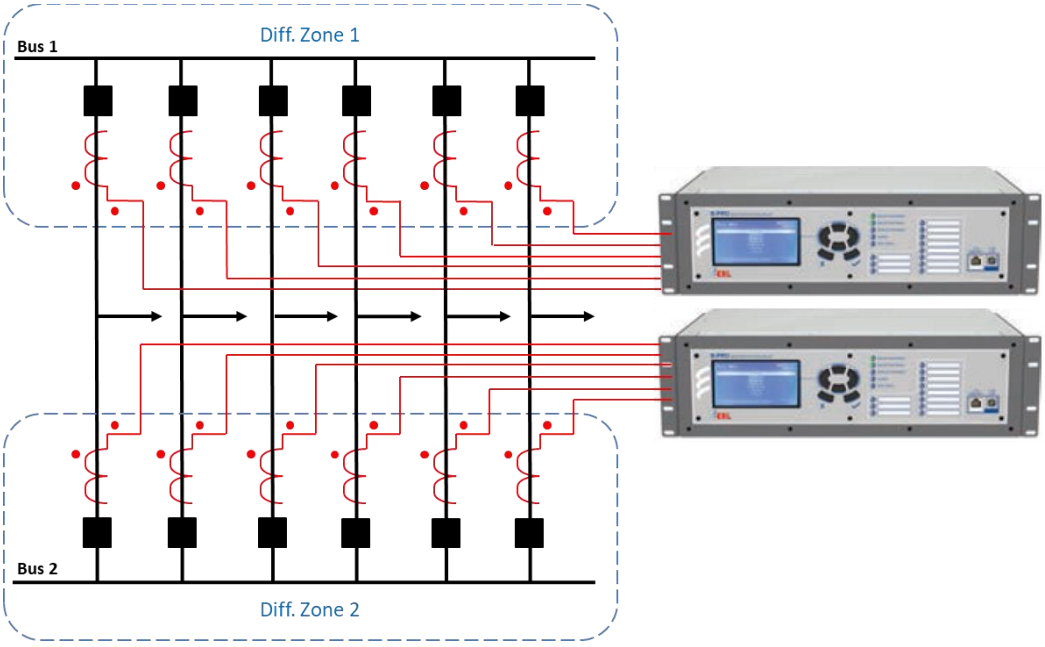

Figure 13 – B-PRO 4000 protecting a double-bus double-breaker configuration (up to 6 feeders)

If you need any further assistance,

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In case of inconsistencies between documents, the version at www.erlphase.com will be considered correct.
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