PC-FLEX-HIGHSIDEFUSE • April, 2024
Published for the Basler Electric Power Systems Group

Application Note

Detection of High Side Fuse Operations on Delta-Wye Transformers with a BE1-FLEX

When a fuse blows on the high side of a delta wye transformer, unbalanced voltages are applied to the transformer bank and the connected loads.

The Application Note shows how it is possible to detect high side fuse operations on a delta-wye transformer with a multifunction digital relay, such as the BE1-FLEX Protection, Automation and Control System.

The BE1-FLEX is a multifunction digital relay that can provide three phase, ground, and negative sequence directional or non-directional overcurrent protection with four shot recloser, forward or reverse power protection, breaker failure, over/underfrequency, over/undervoltage and overexcitation protection, sync check, breaker monitoring and control, sequential events, fault reporting, and metering functions, and a wide variety of additional functions.

Using a combination of the 27P undervoltage element and 59P element allows the BE1-FLEX to operate for high side fuse operations while preventing false operations for a blown fuse on the secondary sensing voltage (VTP input) applied to the relay.

When a high side fuse blows the low side phase to phase voltage magnitudes decrease. One phase to phase voltage will go to zero and the remaining two voltages will decrease to approximately 0.87 per unit (pu) of nominal. Using phase to neutral voltage as the reference for "1pu," the good phase to phase voltage on the high side causes one good phase to neutral voltage on the low side, 1 pu, and two phases with approximately half voltage, 0.5 pu, both 180 degrees out of phase with the good voltage. If nominal phase to phase voltage is the reference for "1pu" then the good phase to neutral voltage is 1/1.73 or 0.578 pu while the two half voltages are 0.5/1.73 or 0.289 pu.

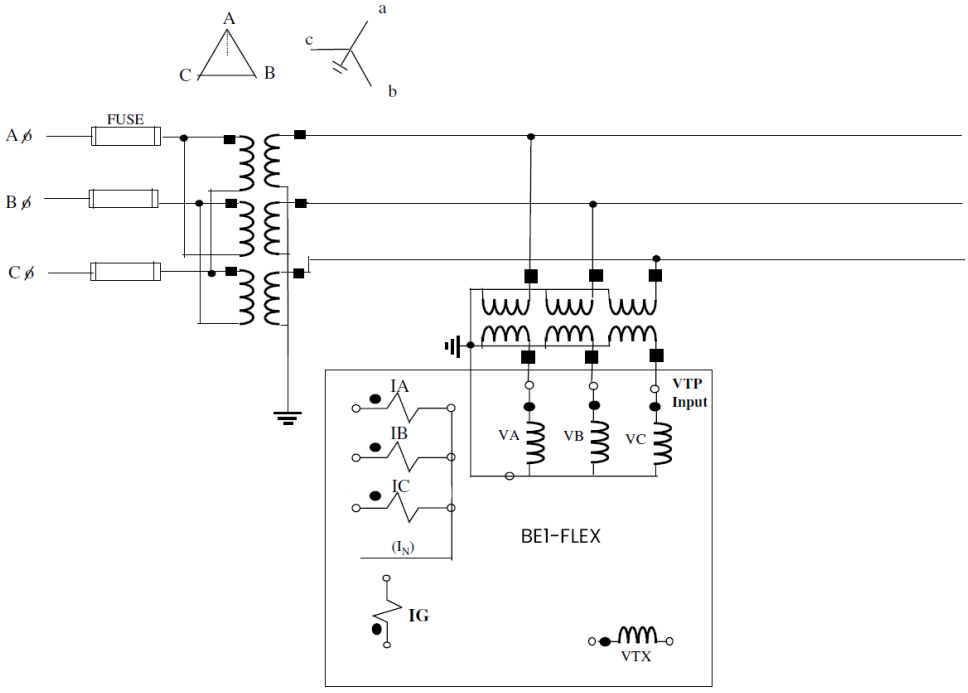

Figure 1 - One-Line Diagram of BE1-FLEX and Delta-Wye Transformer

Therefore for one blown high side fuse, one phase to phase voltage on the low side will be zero, and each the two remaining phase to phase voltages will be the sum of 0.289 and 0.578 or 0.87 pu of nominal phase to phase voltage. If two high side fuses blow, all low side voltages go to zero.

If a VTP secondary source fuse to the BE1-FLEX blows while the bank is under normal operation two of the phase to phase voltages connected to the relay will decrease to 0.58 pu of nominal phase to phase voltage. (On a phase to neutral basis, V2 will equal 0.333 pu)

For more information on how primary and secondary loads can affect phase loss detection, refer to technical paper "A Practical Guide for Detecting Single-Phasing on a Three-Phase Power System" also found at https://www.basler.com.

Applying the Logic

BESTlogic™*Plus* programmable logic provided with the BE1-FLEX provides the user with high flexibility in configuring a protection and control system.

Each of the protection and control functions in the BE1-FLEX is implemented as an independent function block that is equivalent to its single function, discrete device counterpart. Each independent function block has all the inputs and outputs that the discrete component counterpart might have.

To apply this logic scheme (Figure 2), enable the 27 element for 1 of 3 and the 59 element for 2 of 3. Connect to an AND gate with 27 Pickup and 59 Pickup as the two inputs. Connect a 62 timer between the output and the input of Output 2, which will be used as the trip output. User programmable alarms can be added if annunciation is desired.

Operational Settings

In this example, operational settings (Figures 3 and 4) are based on 208 p-p nominal, VTP is set to 4-wire and 27/59 set P-P. Phase rotation is ABC, 60 cycles, PT ratio is 60. The transformer low side P-P primary voltage is 12,480.

Set the 27 pickup for 0.4 pu of p-p nominal and 59 pickup for 0.7 pu of p-p nominal. As previously described, if a high side transformer fuse opens, one low side phase-to-phase voltage will go to zero allowing the 27 Pickup input to drive the AND gate output high. Assuming the VTP fuses are good, at least two of the phase-to-phase voltages will be above 0.7 pu of p-p nominal causing the 59 Pickup input to be true. The AND gate output stays high. If both remain high for the duration of the 62 timer pickup setting (5 to 10 seconds), the timer output goes high and Output 2 Trip contact closes. If the transformer is normal and one fuse has blown in the VPT sensing circuit, one phase to phase voltage will remain at 1 pu, but two of the phase to phase voltages will drop to 0.58 pu causing the 59 Pickup input to the AND gate to go low. The 27 Pickup will also be low as all three phase-to-phase voltages are above the 0.4 pu 27 pickup threshold. Set Block with 60FL to disabled for both 27 and 59.

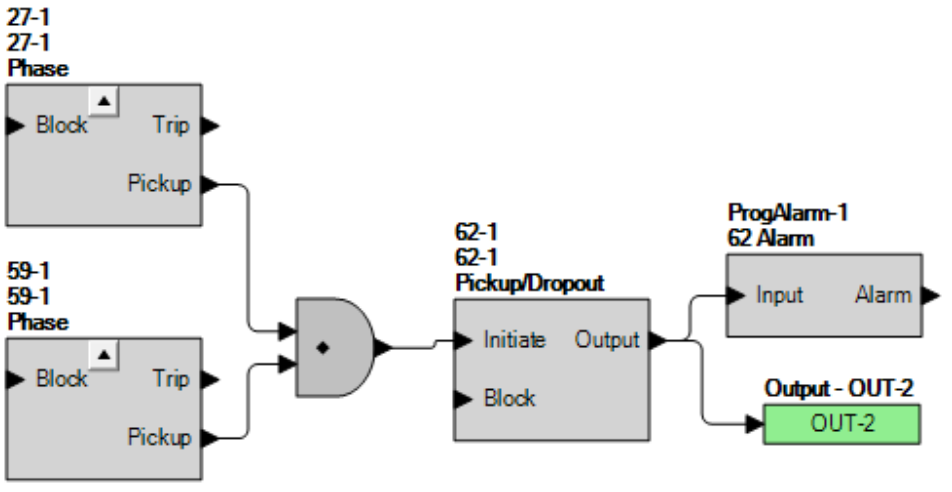

Figure 2 - Logic Diagram

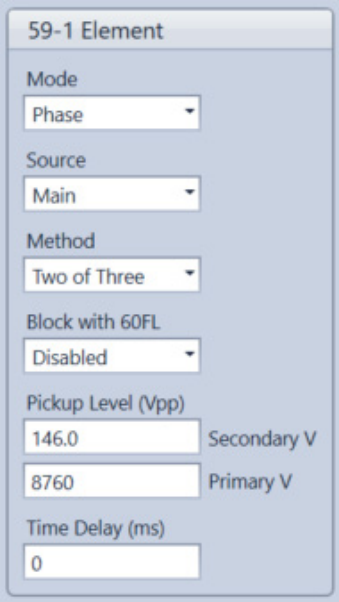

Figure 3 - 59 Element Settings

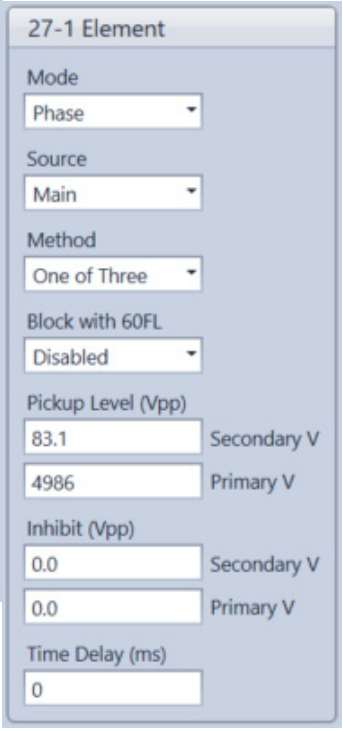

Figure 4 - 27 Element Settings

Using BESTCOMS*Plus*®

The BE1-FLEX can utilize Basler's BESTCOMS*Plus* for setting the relay. BESTCOMS*Plus* is a Windows® based program that provides a user friendly, graphical user interface (GUI) for use with Basler Electric communicating products.

BESTCOMS*Plus* provides the user with a point and click means for setting and monitoring the in-service relay or relays under test. The point and click method provides an efficient, fast setup for configuring one or several relays.

> Note: You must have the BESTCOMS*Plus* software to utilize this file. To obtain a copy of the software, please visit https://www.basler.com or contact Customer Service at 618-654-2341.

Testing

The scheme was tested by applying 3-phase to neutral voltage, ABCN to relay terminals VA, VB, and VC (neutral on VN) at 0, 120, and 240 degrees respectively. Phase to neutral test voltage magnitudes were set at 120 volts.

By monitoring the BESTCOMS*Plus* Metering screens, phase-to-phase voltages read 12,480 volts on each p-p combination (120xsq rt 3x60). Viewing BESTlogic™*Plus* Live Metering showed the 59 was picked up as expected.

The exact phase to phase pickup point of the 59 and 27 elements was determined by lowering and raising all three phases simultaneously and monitoring the Live Logic in Metering. Pickup for 59 was verified to be 84 volts p-n x sq rt3= 146 p-p (0.7 pu x 208 nominal). Pickup for 27 was verified the same way and found to be 48 volts p-n x sq rt3= 83.1 volts p-p (0.4 x 208 nominal).

To test the logic, 1 pu p-n voltage was set on channel A (120) at 0 degrees. Channel B and C were set at 0.5 pu p-n voltage (60), both at an angle of 180 degrees. When the voltages were applied to the relay, the logic metering was viewed and indicated that the AND gate was picked up and the 62 timer was timing. 5 seconds later (62 timer setting) Output 2 trip contact closed and the 62 Alarm was displayed (see Figure 5). When the conditions causing the trip were removed, the Logic Metering transitioned. The 62 Alarm remained on until the Alarm was reset.

Three-phase voltage was returned to 120 volts p-n with 120 degrees between each phase. To simulate a blown secondary sensing fuse, A phase was suddenly dropped to 0 V. The 62 Alarm remained off and the Live Logic Metering showed the 59 not picked up, indicating that p-p voltage applied to the relay had dropped below 0.7 pu on at least 2 phases. This was verified on the Voltage metering screen of the HMI. As expected, one p-p voltage combo stayed at 1 pu (12480) while the other two dropped to 0.58 pu (7238). With neither voltage element picked up, the AND gate was correctly not picking up.

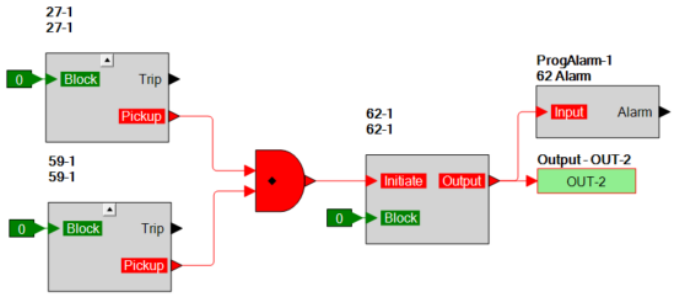

Figure 5 - BESTlogic*Plus* Live Metering

For More Information

Visit the Basler web site at www.basler.com or call 618-654-2341.

Basler Electric®

Highland, Illinois USA
Tel +1 618.654.2341
Fax +1 618.654.2351
email: info@basler.com

Suzhou, P.R. China
Tel +86 512.8227.2888
Fax +86 512.8227.2887
email: chinainfo@basler.com

Quality System Certification
Basler
ISO 9001:2015