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Application Note

BESTCOMS*Plus*® Series – BE1-11 Step-By-Step Guide to Using BESTCOMS*Plus*®, BESTspace™, and Preprogrammed Logic Schemes: *Basic Low Impedance Generator Protection*

Setting up a numeric relay has never been easier than with BESTCOMS*Plus* BESTspace tool. A recent national study on electrical reliability has shown that the majority of numeric relay misoperations are caused by incorrect settings/design error. BESTspace combats the issue by clearly identifying relevant settings and adapting to your specific application - minimizing errors and time spent creating settings files. Although BESTspace files can be created and customized, the purpose of this guide is to assist you in using Basler Electric *preconfigured* BESTspace and preprogrammed logic files.

Basic Low Impedance Generator Protection

This guide is a walkthrough of the *Basic Low Impedance Generator Protection* BESTspace and logic scheme. The logic scheme provides protection for the system represented by the one line diagram shown in Figure 1. The logic scheme provides for basic protection of generators grounded through a low to moderate neutral impedance. The tripping scheme provides for three tripping outputs with the same logic being used for all three outputs. Tripping functions include 24, 27 Phase, two 32 Reverse Power, 40Q, 40Z, 46, 47, 50P/50N Inadvertent Energizing, 51 Phase with voltage control, 51 Neutral(calculated 3I0), 51 Ground, 59 Phase, two 81 under, two 81 over It does not provide for sequential trip logic or synchronism check while unneeded elements can be disabled without changing the logic.

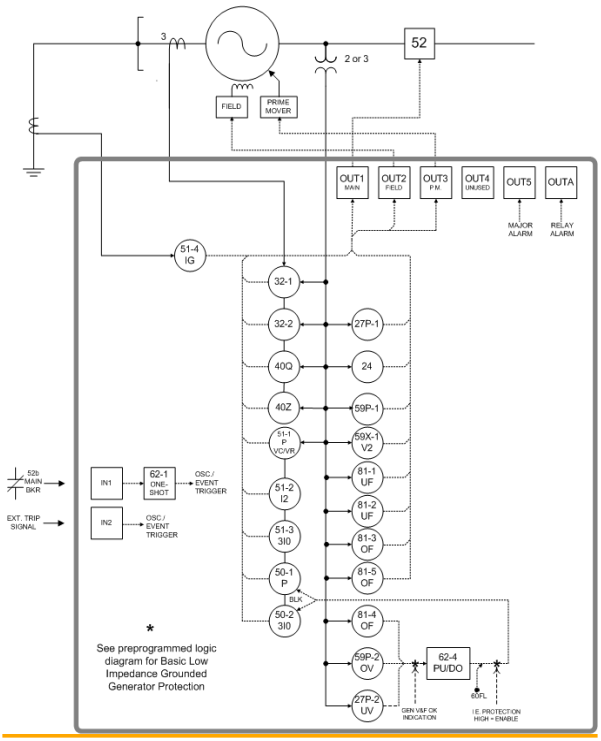

Figure 1 - One-Line Diagram of *Basic Low Impedance Generator Protection*

Recently, the BESTspace feature was added to BESTCOMS*Plus*. Opening a BESTspace file automatically formats the BESTCOMS*Plus* environment to support specific activities. BESTspace files do not add or alter actual settings. The BESTspace discussed in this document is specially designed to work with the *Basic Low Impedance Generator Protection* logic scheme developed by Basler.

Opening the BESTspace

BESTCOMS*Plus* refers to the software suite used to program BE1-11 relays. The BESTspace tool is only compatible with BESTCOMS*Plus* v 2.11.01 or greater.

If not already installed on your computer, it is easy to download the latest version at www.basler.com. BESTCOMS*Plus* requires an activation key for use without an active BE1-11 connection. Please email request for activation to info@basler.com.

The BESTspace file can be downloaded from www.basler.com/Product/BE1-11-Logic-Schemes.

To begin, launch BESTCOMS*Plus* and click on the 'File' dropdown menu at the top left-hand corner of the window. Select to open a new BE1-11 file as shown in Figure 2.

BESTCOMS*Plus* will then open a default settings file. To open the BESTspace, click on 'View' directly below 'File' and select to open a new BESTspace file as shown in Figure 3.

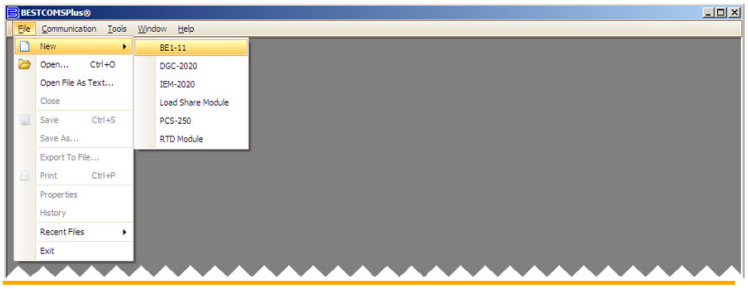

Figure 2 - Opening a File in BESTCOMS*Plus*

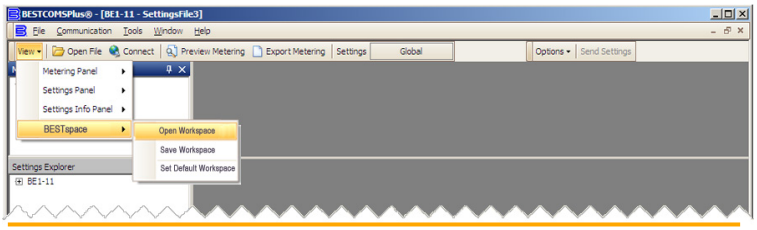

Figure 3 - Opening a New BESTspace in BESTCOMS*Plus*

Based on Figure 4, click 'Load' on the Load/Save Window BESTspace File window and browse for BESTspace file 'BasicLowImpedance GeneratorProtection.bswx'. Click 'Apply' to open the BESTspace.

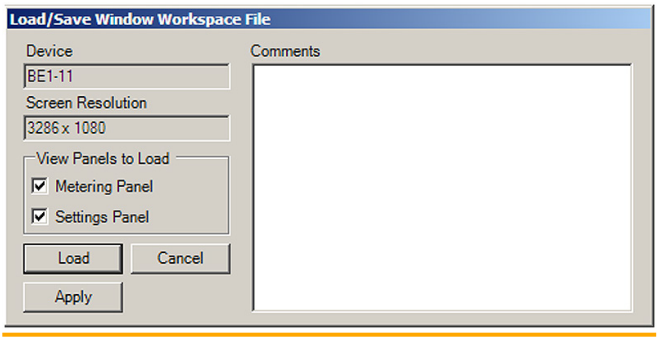

Figure 4 - Loading a BESTspace File

Establishing the Style Number

Figure 5 demonstrates how the BESTspace formats the working environment with the Style Number screen on top. The environment is tab-based, with tabs aligned across the top of the screen. Check the relay front faceplate for the style number and enter it on the style number screen using the dropdown selection boxes. The right-hand bottom portion of the viewable area contains settings information such as settings ranges and units. It can be closed at any time to increase viewing area. Tabs can be closed by clicking on the 'x' to the right of the right-most tab. Doing this will close the active tab. Close the style number screen when finished. Successive tabs should be closed once you are finished, except where noted.

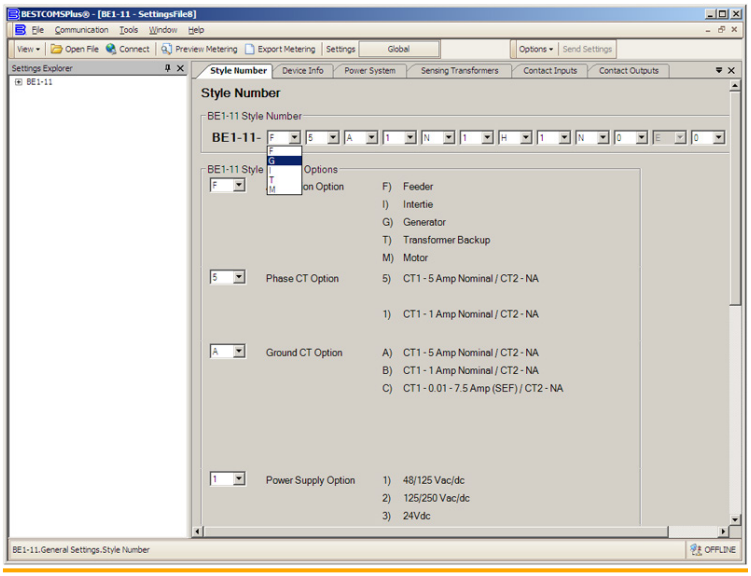

Figure 5 - The Style Number screen is on top when starting a BESTspace

Accessing Device Info

Closing the style number screen causes the next tab to the right, "Device Info", to activate. The Device Info screen contains information about the embedded software in the connected BE1-11 relay. If you are not connected to a relay, this should be mostly blank. It will populate information automatically when settings are downloaded from a relay. Device, station and user IDs also can be specified here.

Power System

The Power System screen contains information on your system that the relay uses to perform internal calculations. Starting under Nominal Settings, enter in the system frequency, nominal secondary voltage in terms of PN quantities, and nominal secondary current (this is the secondary rating of your CT). The auxiliary voltage input should be set up similarly as it is used for detection of zero and negative-sequence overvoltage. The phase rotation of the system is crucial. A reverse setting will cause the relay to calculate erroneous negative-sequence current and possibly misoperate.

Although the power line parameters are useful, they are not necessary if the information is not available. MTA is necessary only if you plan to specify a directional overcurrent element. Additional details on the power line parameter and MTA settings can be found in the BE1-11 instruction manual.

Sensing Transformers

The Sensing Transformers screen contains settings used to calculate primary voltage and current from the sensed secondary values. These settings are important for accurate primary metering and pickup values set in terms of primary quantities. Enter the turns ratio for the phase and ground CTs. For example, if your CT is 1200:5, the setting would be 1200/5=240. If there is no ground CT in your system, this setting can be left unchanged.

Follow the same process for the phase VT setup making sure to specify the type of transformer connection (4W-Y, 3W, PN, or PP). The auxiliary VT ratio and connection type settings should be specified similarly. When using a 4W-Y connection, the relay can operate on PN or PP sensed voltage for the 27 and 59 element. Select the units you wish to use under the 27/59 and 27R Mode settings.

Contact Inputs and Outputs

Closing the previous screen will pull up two successive Contact Inputs and Outputs screens. These screens allow you to customize the physical alarms and contact I/O with labels and energized state labels, which will appear on the BE1-11 LCD screen.

Each input has a contact recognition and debounce setting. The default contact recognition and debounce settings enable their use on ac signals as well as dc signals. Since the *Basic Low Impedance Generator Protection* scheme utilizes two contact inputs, it is helpful to label them.

- Input #1 is designated as a 52b breaker status input.
- Input #2 is an external fault trigger input for initiating oscillography.

The hold attribute serves several purposes for contact outputs. The main use for the BE1-11 is to prevent the relay contact from dropping out until the current has been interrupted by the 52a contacts in series with the trip coil. If the tripping contact opens before the dc current is interrupted, the contact might be damaged. Now label the contact outputs:

- Output #1 is tied to the tripping element
- Output #2 is tied to the tripping element
- Output #3 is tied to the tripping element
- Output #5 is a major alarm output.
- Output A is for relay failure.

Labeling of the output contacts is not required but it is useful for categorizing outputs as the settings file is created and for later analyzing relay operations.

Overexcitation (24)

The BE1-11*g* detects overexcitation conditions in generators with a volts/hertz element that consists of one alarm setting, one integrating time characteristic with selectable exponents (3 sets of time curves), and two definite-time characteristics. This allows the user to individually select an inverse-time characteristic, a composite characteristic with inverse time, and one or two definite-time elements, or a dual-level, definite-time element. If you are unsure of which timing schemes to use or how to set the element, there is more information on generator overexcitation in the BE1-11*g* instruction manual, *Overexcitation (24) Protection* chapter. You also can download Basler's *Generator Protection Application Guide* at www.basler.com.

By default, all protection elements are disabled. Choosing a mode of operation enables them. If used, enable it under the 'Mode' setting and then enter in your pickups, time dial, reset dial, and so on.

Under/Overvoltage (27P-1, 27P-2, 59P-1, 59P-2, 59X-1)

Use the 'Mode' setting to enable the elements you need. There are several modes of operation for the phase 27/59 elements:

- One of Three operates when the voltage on one phase rises above (59) or drops below (27) the pickup and times out.
- Two of Three operates when the voltage on two phases rises above or drops below the pickup and times out.
- Three of Three operates when all three phase voltages rise above or drop below the pickup and times out.

The voltage elements provided are as follows:

- 27P-1 phase undervoltage. Set pickup under nominal voltage. Picks up for low voltage on any one phase (Mode = One of Three). It is blocked when the breaker is open.
- 27P-2 phase undervoltage. Used for supervisory logic. Picks up for normal voltage on all three phases (typically set PU for V<110% rated). Target should not be enabled for this function. (Mode = Three of Three).
- 59P-1 phase overvoltage. Set pickup above nominal voltage. Picks up for high voltage on any one phase (Mode = One of Three).
- 59P-2 phase overvoltage. Used for supervisory logic. Picks up for normal voltage on all three phases (typically set PU for V>85% rated). The target should not be enabled for this function. (Mode = Three of Three).
- 59X-1 negative sequence overvoltage. (Mode = V_2).

Each phase voltage element can be set to your choice of inverse timing or definite timing. For an instantaneous response, set it for definite timing with a time delay of zero. In addition to these settings, the 27 also has an inhibit threshold.

Following the 59X-1 tab is the Voltage Protection Summary tab. Review the enabled elements and modes of operation on this screen. If elements are disabled when you believe they should be enabled, it will appear on this screen. Each element will have a status color to the left and the mode of operation to the right. Green status indicates that the element is enabled, yellow indicates the setting is disabled by a setting other than the mode (i.e. the element has an invalid setting such as a pickup of 0.000 volts), blue indicates the setting is disabled by only the mode setting, and gray indicates the element has both an invalid setting and disabled mode.

You will see similar summary screens throughout the walkthrough. It is a good idea to leave these screens open and double check the protection elements you have set up once you are finished.

Frequency (81-1, 81-2, … 81-5)

There are five total frequency elements. Set:

- 81-1 as level 1 underfrequency
- 81-2 as level 2 underfrequency
- 81-3 as level 1 overfrequency
- 81-5 as level 2 overfrequency

The 81-4 element is used for supervisory logic and picks up for normal frequency (typically set PU for F>85+% rated). The target should not be enabled for this function. Both underfrequency elements are blocked when the breaker is open.

Select the Phase VT source for each element and set the pickups as needed. The under and overfrequency elements employ an inhibit setting when voltage is too low. Set appropriately, if desired.

Review the Frequency Protection Summary screen on the tab following 81-6.

Instantaneous Overcurrent (50-1, 50-2)

The next two tabs contain settings for the Instantaneous Overcurrent elements 50-1 and 50-2. There are several modes of operation for overcurrent elements on the BE1-11:

1. I_A, IB, I_C operates only on the selected phase of current.
2. 3 Phase will monitor all three phases and operate on any one of them.
3. $3I_0$ operates on the calculated zero sequence current (calculated 50G).
4. I_2 operates on the calculated negative sequence current (46).
5. I_G operates on the ground CT input only (50G).
6. I_1 operates on the calculated positive sequence current.
7. Unbalance operates on calculated unbalanced current.

The *Basic Low Impedance Generator Protection* logic scheme utilizes two instantaneous overcurrent elements. The 50-1 is a phase overcurrent used to protect against inadvertent energization while the 50-2 is a neutral overcurrent used for the same purpose. Both elements are enabled only when abnormal system conditions are present and no fuses have been blown (60FL). Set the 50-1 element for Mode=3 Phase and the 50-2 element for Mode=$3I_0$.

Enter the secondary current pickup and intentional time delay (if no intentional time delay is desired, leave at 0). Choose the directionality of the element (Non-Directional).

Inverse Overcurrent (51-1, 51-2, 51-3, 51-4)

The inverse overcurrent elements have the same mode selections as the instantaneous elements.

- 51-1 phase overcurrent, voltage controlled/restrained. (Mode = 3 Phase)
- 51-2 negative-sequence overcurrent. (Mode = I_2)
- 51-3 neutral overcurrent. (Mode = $3I_0$ or I_G)
- 51-4 neutral overcurrent. (Mode = $3I_0$ or I_G)

The element screen contains a setting for pickup, time dial, curve, direction, voltage restraint, and reset timing. If you wish to implement voltage control or restraint on the phase overcurrent element, choose 'Control' or 'Restraint' under 'Mode' along with an appropriate threshold.

There are many curves to choose from. However, if the curves do not fit your needs, you can program your own custom curve using the IEEE C37.112 equation or construct one of up to 40 custom points using a table curve.

The Table Curve feature adds points to the curve and uses a point and click interface to move points around once they are inserted. A separate screen under Protection > Current allows you to configure a table curve.

Be sure to set the directionality (Non-Directional) and reset type. An integrating reset mimics the behavior of an electromechanical reset. When used to provide high-speed overcurrent protection for the substation bus, it is recommended that all 51 function timing curves be set for instantaneous reset. Both the inverse timing curve and the reset time can be viewed by changing the selection below the graph. Review the Current Protection Summary screen.

Power (32-1, 32-2)

The logic scheme incorporates two levels of reverse overpower protection in the 32-1 and 32-2 elements. Set the modes to Total Power and the pickups such that the 32-1 picks up on less severe reverse power conditions while the 32-2 picks up on more severe reverse power conditions and times out quickly.

Loss of Excitation (40Q, 40Z)

The BE1-11*g* offers loss of excitation protection via a reverse Var (40Q) or impendance based (40Z) element. The 40Q operates on Vars coming into the machine. Available settings are pickup and time delay and may be determined by analyzing the capability curve of the generator.

The 40Z is most often used for loss of excitation. It operates on mho characteristics identifying the minimum allowable impedance as seen from the terminals of the generator. Mho characteristic 1 defines the size and behavior of the inner circle most often used for more critical loss of sensing conditions. The diameter of this circle is typically set for 1.0 pu on the generator base impedance (the setting is in terms of ohms). Mho characteristic 2 defines the size and behavior of the outer circle, which is most often given a less sensitive setting to accommodate for power swings. The diameter of this circle is typically set for the direct axis reactance, X_d , while the offsets for both circles should be set in terms of the direct axis transient reactance, $X'_d/2$.

Although not used for some applications, the directional supervision angle (blinder angle) provides the ability to desensitize the 40Z for power swings by allowing it to neglect impedances above the line. Set the directional supervision angle appropriate to your application. It can be disabled by setting it to zero.

The voltage control feature allows the user to provide a faster trip when impedance measurements are supervised by a depressed level of voltage. It is not necessary and can be enabled or disabled based on the mode of operation you choose. Review the Power Protection Summary screen.

Protection/Control Summary

The control and the more comprehensive protection summary screens allow you to view all elements that are enabled and the modes of operation.

It is a good idea to leave these screens open and double check the protection elements you have set up once you are finished.

Logic Timers (62)

Two logic timers are used in the *Basic High Impedance Generator Protection* logic scheme.

The one-shot, non-retriggerable 62-1 is initiated when the breaker is closed to trigger an oscillography record. The output of a one-shot, non-retriggerable timer transitions to logic TRUE after the duration of Time Delay 1 for the duration of Time Delay 2.

The pickup/dropout 62-4 timer is used for inadvertent energization logic. Upon receiving an initiate, the pickup/dropout timer will transition its output to logic TRUE for the duration of Time Delay 1. Once the initiate input transitions to logic FALSE, it must stay FALSE for the duration of Time Delay 2 for the output to transition back to logic FALSE. It delays unblocking/blocking 50 elements when sensed V and F become abnormal/normal.

Enter in desirable time delays based on the behavior of the timers.

BESTlogic™*Plus*

BESTlogic*Plus* is a powerful logic editor used to customize relay operation and internally route trip signals and other virtual I/O into physical I/O. Notable features in the logic editor include being able to conditionally enable or disable protective elements and trigger oscillographic records.

Preprogrammed logic schemes make it easy to import a file for common applications. To download logic files, please visit www.basler.com/Product/BE1-11-Logic-Schemes and download the logic scheme 'Basic Low Gen Logic'.

Importing a file is easy; click on the 'Logic Library' dropdown menu as shown in Figure 6 and open 'BasicLowImpedanceGeneratorProtection.bslx' to import file.

The BESTlogic*Plus* working environment is nested within BESTCOMS*Plus* and follows the same tabbed interface. Each tab is a new page to organize and build logic. To the left of the logic pages is a toolbox containing all status, physical I/O, logic gates, and elements. Items in the toolbox can be dragged and dropped onto any logic page. Logical I/O are conveyed between pages using custom labeled off-page inputs and outputs.

Preprogrammed logic is complete as downloaded. No changes are necessary to use it. Reviewing it is recommended as it provides useful detail on the operation and purpose of the logic. Below are the tabs present.

- *Input/Output* - You will find a brief description of the logic scheme on this page. Additionally you will find the physical output assignments with a description of their intended purpose.
- *Voltage/Power* - This tab shows all protection elements related to voltage and power. Logic elements can be blocked by asserting Logic 1 at the 'Block' input. or example, the 27P-1 element is blocked by the 52b off-page input. Logic elements such as the 27P-1 generate 'Pickup' and 'Trip' signals that are used elsewhere in the logic scheme via off page outputs to generate physical trips and oscillography.
- *Current* - All elements related to time and instantaneous overcurrent are located on this tab.
- *Misc. Logic* - The Misc. Logic tab shows the consolidation of the element off-page outputs using OR gates and four more off-page outputs, 'Trip Bus' and 'Pickup Bus'. It is useful to have a consolidated bit for performing other functions elsewhere in the logic scheme. Also on this tab are the protective elements used for supervisory purposes and the fault trigger element. For full descriptions on the inputs and outputs of a logic element, consult the BE1-11*g* manual.

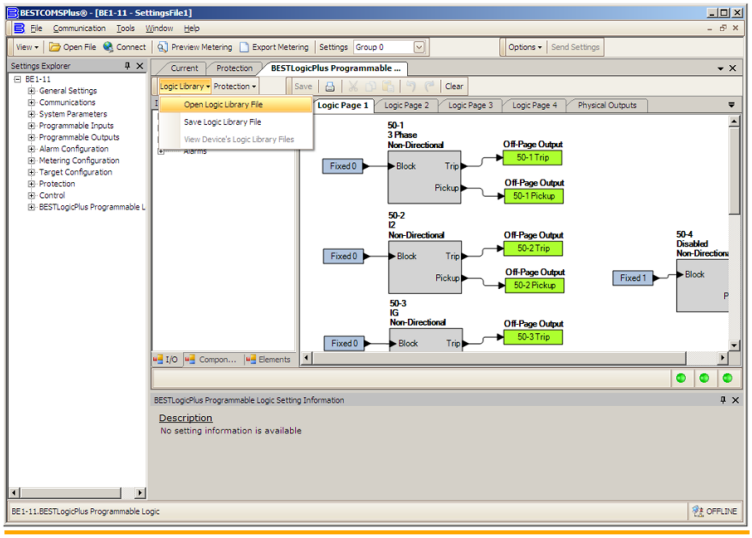

Figure 6 - Working with the Logic Library

To use the logic scheme, click on the 'Save' button shown in Figure 7 so that it is saved to the settings file. Before saving, a healthy logic scheme will have three indicators at the bottom right-hand corner of the window. A yellow and two greens indicate that there are no errors in the scheme and it can be saved. Saving the logic will result in three green indicators.

To finish, save the entire settings file by clicking on 'File' at the top left-hand corner of the BESTCOMS*Plus* and select 'Save' or 'Save As…' from the dropdown menu.

For More Information

To get more information on BESTCOMS*Plus* and the BE1-11 product line, including additional application notes, product bulletins, and instruction manuals, go to www.basler.com or contact Technical Support at 618-654-2341.

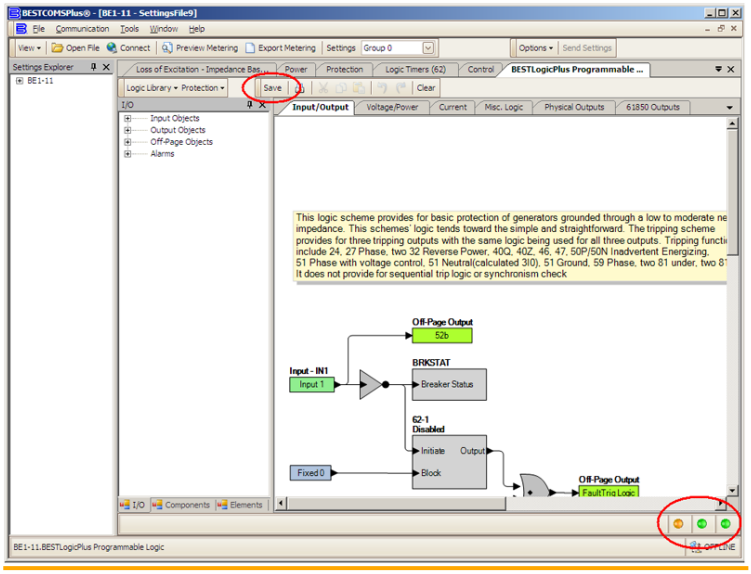

Figure 7 - Saving a Settings File with a Functional Logic Scheme

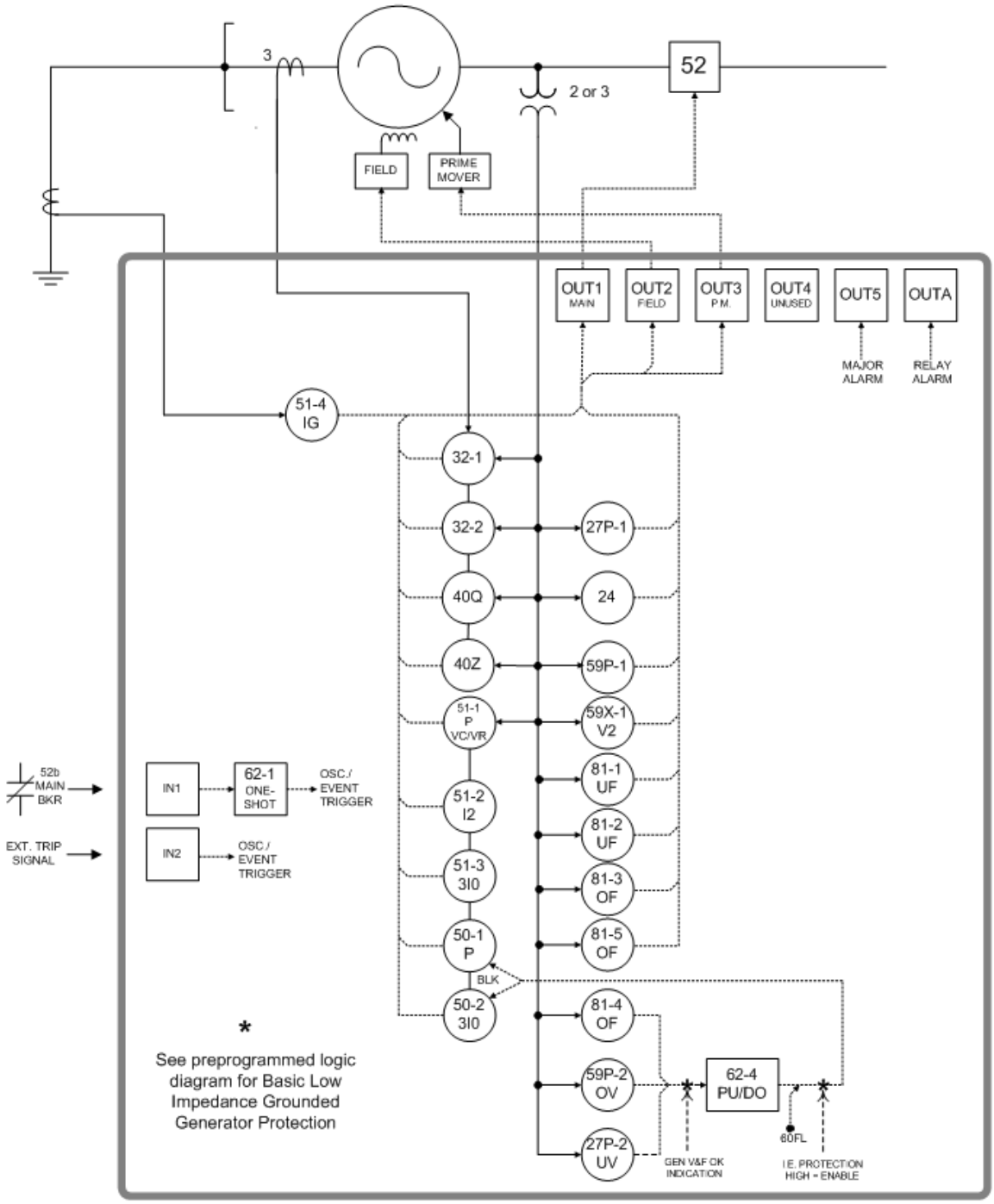

Figure 8 - Expanded version of *Figure 1: One-Line Diagram of Basic Low Impedance Generator Protection*

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