Application Note

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

Setting up a numeric relay has never been easier than with the 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 a settings file. 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.

Intertie Protection

This guide is a walkthrough of the *Intertie Protection* BESTspace and logic scheme. The logic scheme provides protection for the system represented by the one line diagram shown in Figure 1. It provides protection elements to cover all intertie needs defined by IEEE Standard 1547-2003, and reaffirmed in 2008. It is comprised of two phase, ground and negative sequence directional instantaneous overcurrent zones as well as two phase, ground, and negative sequence directional time overcurrent zones. Network and conditional reclosing (25 and 25VM), breaker failure protection, over/under voltage phase protection, directional power, and over/under/rate of change frequency protection are also included in this scheme. This scheme can be used in conjunction with other products to provide main-to-main protection. Unneeded elements can be disabled without changing the logic.

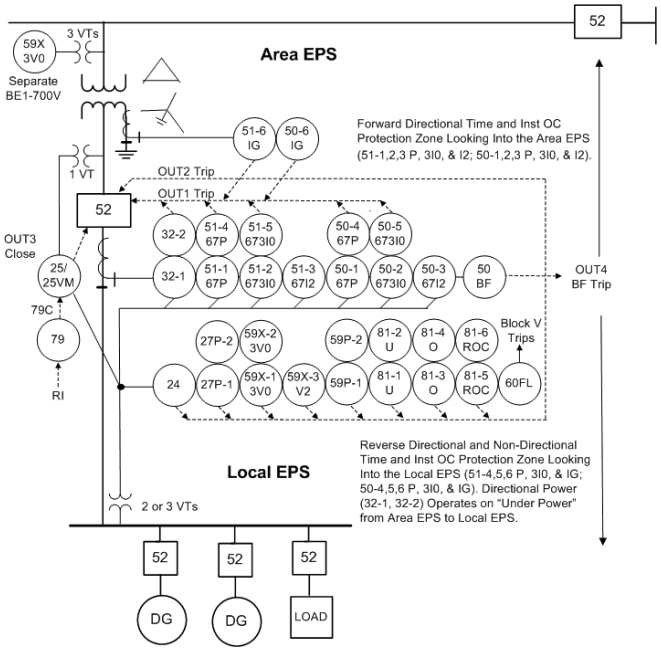

Figure 1 - One-Line Diagram of Intertie Protection

Opening the BESTspace

BESTCOMS*Plus* refers to the software suite used to program BE1-11 relays. The BESTspace feature 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 activation request 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 as shown in Figure 3.

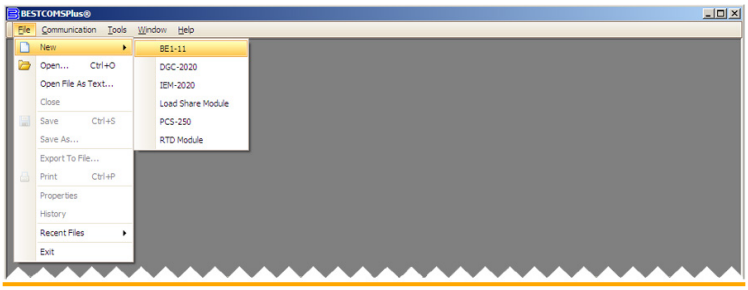

Figure 2 - Opening a File in BESTCOMS*Plus*

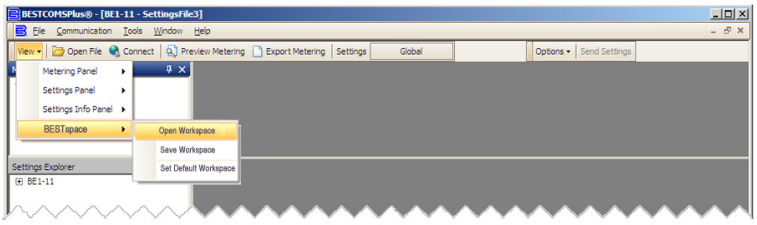

Figure 3 - Opening a New BESTspace in BESTCOMS*Plus*

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

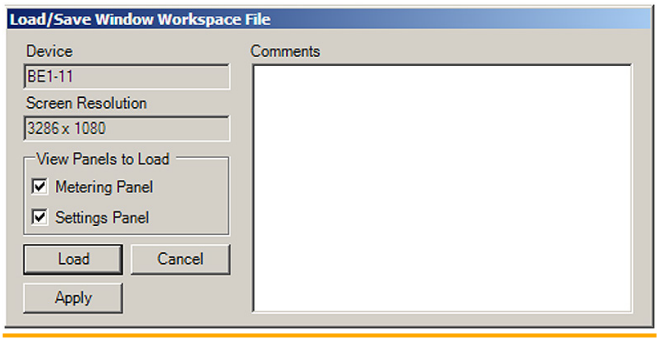

Figure 4 - Loading a BESTspace File

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 screens should be closed when finished except where noted.

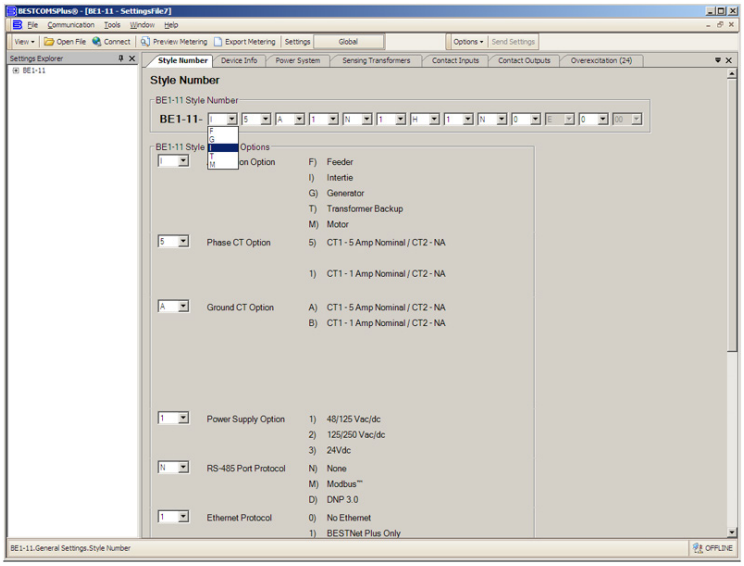

Figure 5 - The Style Number screen is on top when starting a BESTspace

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 about 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 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 used in the BE1-11 for calculating the distance to faults, they are not necessary. MTA is necessary only if you plan to specify a directional overcurrent element (reverse direction). Additional details on the power line parameter and MTA settings can be found in the BE1-11 manual.

Sensing Transformers

The Sensing Transformers screen contains settings used to calculate primary voltage and current from the sensed secondary values. Enter the turns ratio for the phase and ground CTs. For example, if your CT is 1200:5, the setting would be 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 *Intertie Protection* scheme utilizes three contact inputs, it may be helpful to label them here.

- Input #1 is designated as a 52b breaker status input.
- Input #2 is a 43 on/off switch enable or disable automatic reclosing.
- Input #3 is used for external reclosing initiate.

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 trip 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 may be damaged.

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.

- Output #1 is a tripping output for overcurrent and power elements.
- Output #2 is a tripping output for voltage and frequency elements.
- Output #3 is the reclose output supervised by the sync-check and voltage monitor element.
- Output #4 is a breaker failure trip.
- Output #5 is a breaker failure re-trip.

Overexcitation (24)

The BE1-11*i* detects overexcitation conditions in transformers with a volts/hertz element that consists of one alarm setting, one integrating time characteristic with selectable exponents (three 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 which timing schemes to use or how to set the element, refer to the *Overexcitation (24) Protection* chapter in the BE1-11*i* instruction manual. You also can download Basler's *Transformer Protection Application Guide* from www.basler.com. IEEE Standard C37.102-2006 has excellent example settings using the 24 element.

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

Sync-Check (25)

The sync-check element is required in the logic scheme to supervise reclosing. It can be enabled under the 'Mode' setting. Proceed to configure the acceptance window by setting the acceptable voltage difference in terms of voltage difference percent between the two sources. This is based on nominal setting under the sensing transformer setup screen, slip angle, and slip frequency. Checking the box next to 'Source Freq > Destination Freq' ensures that wattage will be exported from the source to the load when the breaker closes. For connections with inherent phase shift (i.e. Vpp on the phase input and Vpn on the auxiliary input) the angle compensation can be set accordingly. The range is 0° to 359.9°.

Setting up live and dead thresholds allows the sync-check feature to perform additional voltage monitoring. Set the thresholds according to your system and an appropriate drop out delay. The checkboxes allow for the ability to provide an output when a dead line and/or dead bus are sensed. This output is also used to supervise the 79 reclose.

Under/Overvoltage (27P-1, 27P-2, 59P-1, 59P-2, 59X-1, … 59X-3)

The order of the voltage elements included in the logic scheme tabs are:

- Phase Undervoltage
  - Level 1 (27P-1) / Level 2 (27P-2)
- Phase overvoltage
  - Level 1 (59P-1) / Level 2 (59P-2)
- Zero Sequence Overvoltage
  - Level 1 (59X-1) / Level 2 (59X-2)
- Negative sequence unbalance, overvoltage and phase rotation (59X-3)

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

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

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 has an inhibit threshold.

The remaining tabs 59X-1 through 59X-3 refer to elements sensing on the auxiliary voltage input. Voltages monitored on the auxiliary input are reserved for a separate set of mode operations. To properly operate in the *Intertie Protectio*n logic scheme, the elements 59X-1 and 59X-2 should be set for $3V_0$. The 59X-3 element should be set for V_2. Be sure to set the pickup and timing settings. Any of the voltage elements trip OUT2.

Following the 59X-3 set up 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 these screens. Each element will have a status color to the right and the mode of operation to the right. Green status indicates 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 different 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, … 81-6)

There are six total frequency elements. Any of the six frequency elements will trip OUT2. Set:

- 81-1 as level 1 underfrequency
- 81-2 as level 2 underfrequency
- 81-3 as level 1 overfrequency
- 81-4 as level 2 overfrequency
- 81-5 as level 1 rate of change
- 81-6 as level 2 rate of change

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. Rate of change elements can be inhibited when voltage is too low or high or if negative sequence voltage is too high. Set appropriately, if desired.

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

Instantaneous Overcurrent (50-1, 50-2, … 50-6)

The next six tabs contain settings for the Instantaneous Overcurrent elements (50-1), (50-2),… (50-6). There are several modes of operation for overcurrent elements on the BE1-11:

1. I_A, I_B, 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 *Intertie Protection* logic scheme utilizes any od the six 50 elements to trip OUT1. Phase, neutral, and negative-sequence overcurrent elements are activated to provide a forward-looking (area EPS) directional time (51-1 phase, 51-2 neutral, 51-3 negative sequence) and instantaneous (50-1 phase, 50-2 neutral, 50-3 negative sequence) protection. The reverse looking directional time (51-4 phase, 51-5 neutral 3I0, 51-6 neutral IG) and instantaneous (50-4 phase, 50-5 3I0, 50-6 IG) overcurrent zone of protection looks into the distributed resource bus.

Set the 50 element modes as follows:

- 50-1 Mode, 3 phase.
- 50-2 Mode, $3I_0$.
- 50-3 Mode, I_2.
- 50-4 Mode, 3 phase.
- 50-5 Mode, $3I_0$
- 50-6 Mode, I_G

All 50 elements except 50-5 are directional. The direction setting is dependent on the CT and PT polarity connections to the relay. Enter the secondary current pickup and intentional time delay (if no intentional time delay is desired, leave at 0). If six instantaneous overcurrent elements are not needed, they can be left disabled as you continue to the next tabs.

Breaker Fail (50BF)

The breaker failure screen shows the logical operation of the element as well as all of the associated settings. If your application implements a breaker failure element, enable it under the 'Mode' setting. This logic scheme only uses the 50BFI input to initiate the element.

Upon sensing, the 50 initiate (50BFI) transitions from 0 to 1 state, a Control Timer seals in the 50BFI signal for the duration of the Control Timer setting. If the Control Timer expires and the 50BFI signal is still present, an alarm signal will occur. The Control Timer improves security by presenting a window of opportunity for the breaker failure element to operate. It improves dependability by sealing in the initiate to prevent the stopping of breaker failure timing if the tripping relay drops out prematurely. A Control Timer setting of zero will disable the control timer seal-in function allowing the Control Timer to follow the 50BFI input.

Phase and neutral fault detectors monitor current in the three phases and the optional ground current input. At least one of these four fault detectors must be picked up to start the breaker failure Delay Timer. The current detector logic is True if the current has been interrupted and is used to stop the BF timer.

The I=0 algorithm looks at the sample data directly and does not rely upon the one cycle phasor estimation calculation. It rejects dc tail-off by looking for the characteristic exponential decay. Current will be declared to be interrupted when the current in all three phases is below 5% nominal or if the current is decaying exponentially. Only the three phase currents are monitored by this function.

When the 50BFI is asserted, the Control Timer has timed out and current is sensed on the phase or neutral inputs based on the pickup settings. The I=0 algorithm drops out, and the block input is '0' so the Delay Timer will start. When the Delay Timer has timed out, a breaker failure trip output will occur. The 50BFI is driven by any of the protective elements.

Inverse Overcurrent (51-1, 51-2, … 51-6)

Based on the previous discussion in the instantaneous section, set the 51 elements as follows:

- 51-1 Mode, 3 Phase
- 51-2 Mode, $3I_0$
- 51-3 Mode, I_2
- 51-4 Mode, 3 Phase
- 51-5 Mode, $3I_0$
- 51-6 Mode, $3I_0$

The inverse overcurrent elements have the same mode selections as the instantaneous elements. The element screen contains a setting for pickup, time dial, curve, direction, and reset timing. 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.

All 51 elements except 51-5 are directional. The direction setting is dependent on the CT and PT polarity connections to the relay. Be sure to set the 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 your overcurrent settings on the Current Protection Summary screen.

Power (32-1, 32-2)

Two directional power elements are used for level 1 and 2 overpower protection. These should be set for the Total Power mode. The normal direction of power flow is dependent on the CT and PT polarity connections to the relay. Set the pickup and time delay.

Protection Setting Summary Review

Review your power settings o nthe Power Protection Summary screen. The Protection summary screen allows you to view all elements that are enabled and the modes of operation.

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

Recloser (79)

Provision for one sync check or conditional voltage reclose is provided in this logic scheme. Enter in a valid time for Reclose Time 1.

The reset time is the amount of elapsed time required after a successful reclose for the 79 to reset. A maximum cycle timer keeps track of the entire reclose sequence, locking out the 79 when it is exceeded. The reclose fail time is the amount of acceptable time between a reclose output and the breaker state input.

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 'Intertie'.

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

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. On this tab, the 79 reclose OUT3 is supervised by either the 25 or the 25 voltage monitor.

- *Current/Power* - This tab contains all elements having to do with current or overpower protection. The typical element will have two outputs 'Trip' and 'Pickup', except in the case of the breaker failure (50BF) element. These outputs are routed to off-page outputs where they will be consolidated into a single signal.
- *Voltage/Frequency* - This tab contains all elements having to do with voltage or frequency protection (including 24 overexcitation). Trip and pickup outputs are routed in the same manner as the current/power elements.
- *Misc. Logic* - The Misc. Logic tab contains all trip and pickup signals consolidated into single signals. This tab also contains the 79 and 25 elements, as well as the fault trigger block used for triggering oscillography recordings. For full descriptions on the inputs and outputs of a logic element, consult the BE1-11*i* instruction manual.

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 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* window 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.

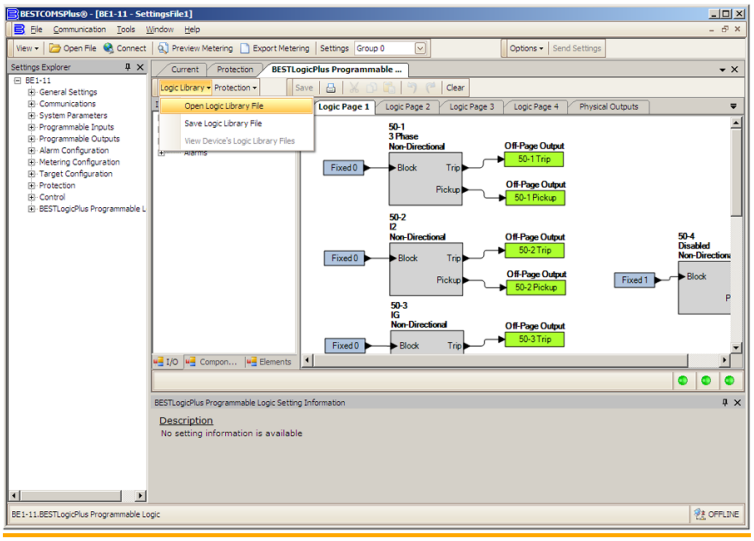

Figure 6 - Working with the Logic Library

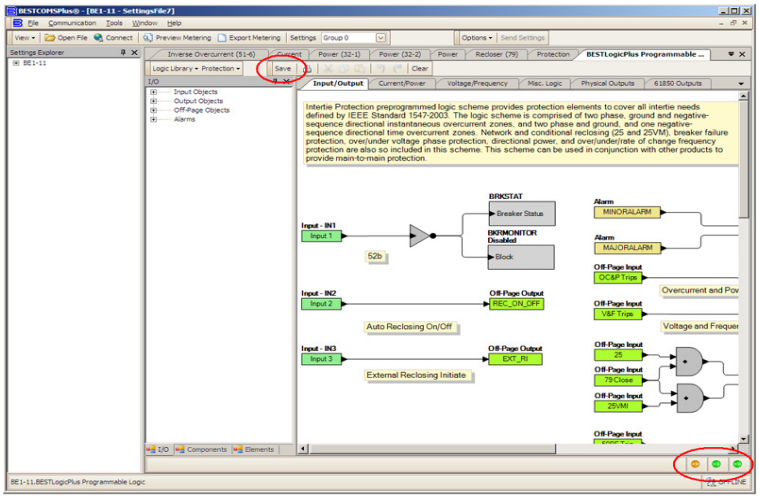

Figure 7 - Saving a Settings File with a Functional Logic Scheme

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