# Stator Differential Protection during Transformer Inrush Conditions in the 489

## GE Publication No. GET-8403



**DESCRIPTION OF PROBLEM**

A common configuration for small generation is as follows:

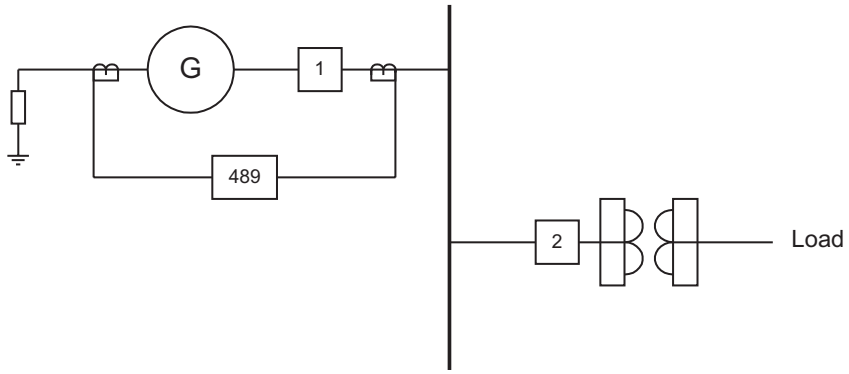



**FIGURE 1. Typical small generation connection**

In this configuration the generator can be subjected to a significant inrush current when the transformer is energized on closing of Breaker 2. Each of the generator CTs will see the same current. However, the current can be as large as 10 pu If the CTs have different characteristics; or, if there is a significant difference in the CT burdens, the CTs may saturate unequally.

The following example shows a typical waveform as seen by the 489 during transformer inrush conditions.

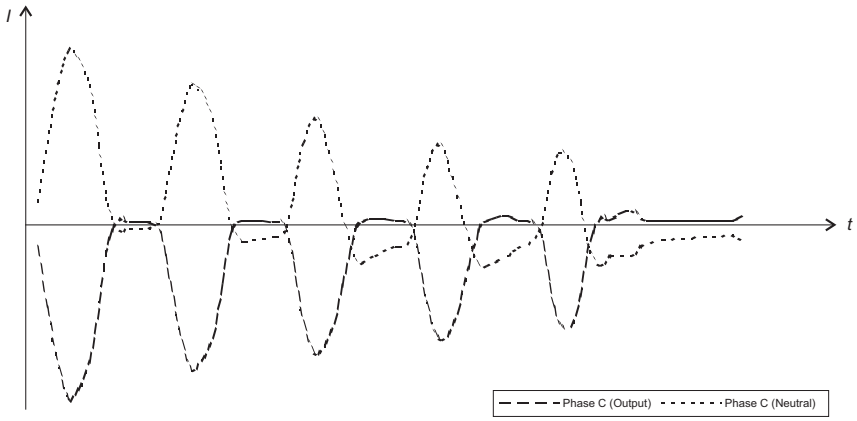



**FIGURE 2. Example generator CT currents in presence of transformer inrush**

Ideally, the currents in the output and neutral CTs would be mirror images of one another. Unequal saturation creates a false differential current. Increasing the slope in these cases may not solve the problem since there are intervals when the currents are summating. This would require a slope setting greater than 100%.

**SOLUTION 1**

The 489 differential element has an associated time delay setting. This can be used to delay the operation of the differential element long enough to ride through the inrush event. The drawback of this solution is an increased clearing time for in-zone faults. This can be avoided by taking advantage of the dual settings feature available in the 489. A digital input (ideally, the transformer breaker close command) is required to predict the onset of the saturation event. This input forces the 489 to change to an alternate setting group with an extended delay time (20 cycles is usually sufficient). A dropout timer is necessary to maintain the signal for the duration of the inrush. The associated relay settings and wiring are shown below.

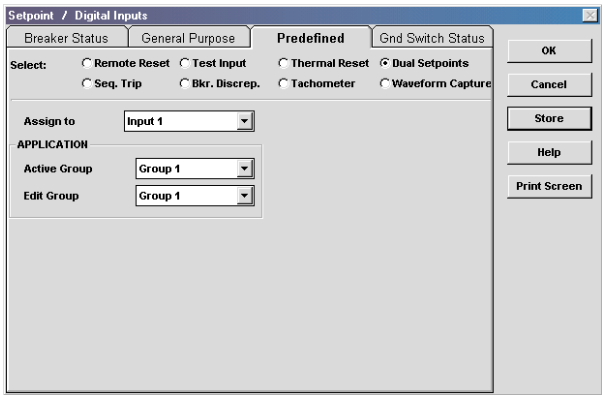



**FIGURE 3. Settings for Solution 1**

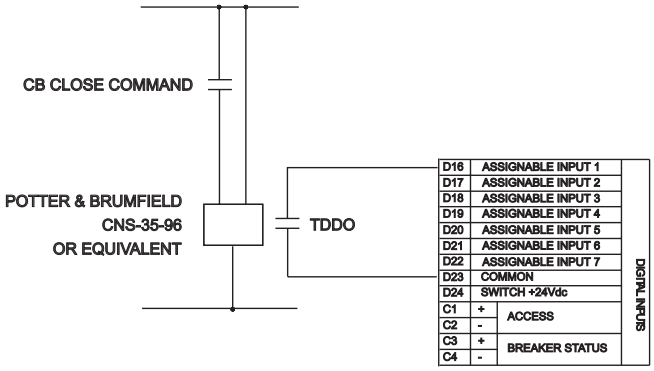
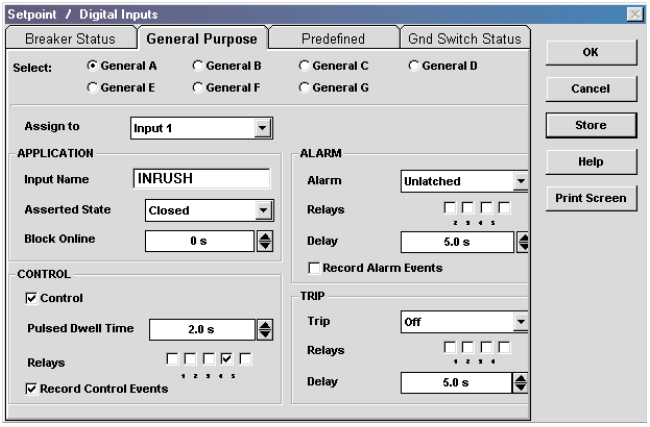



**FIGURE 4. Connections for Solution 1**

## SOLUTION 2

If an additional digital input and contact output are available, then the dropout time delay can be incorporated into the 489. A general purpose input can be programmed as a control element. The desired dropout time would be entered as the dwell time setting.



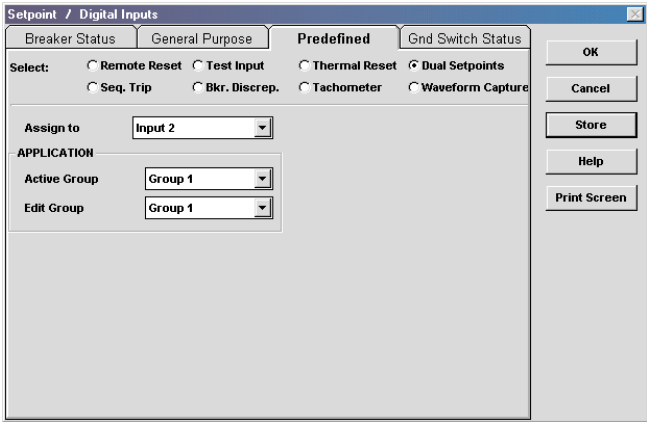




**FIGURE 5. Settings for Solution 2**

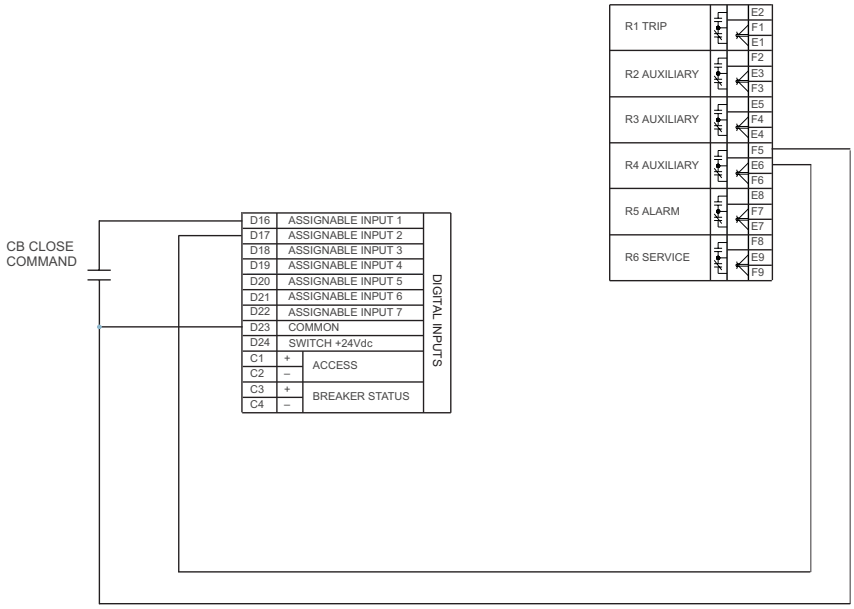



**FIGURE 6. Connections for Solution 2**

Either solution requires that the settings for **all** elements be entered in both setting groups. The Group 2 Phase Differential element would be programmed with an extended time delay.