Multiple Backup Distance Zones in the D60 using Settings Group Control

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APPLICATION

The GE Multilin D60 Line Distance Relay provides four (4) independent zones for phase-to-phase protection and four (4) independent zones for phase-to-ground protection. These zones are independently programmable and always operative.

For some applications, it is desirable to have an additional zone for backup distance protection, resulting in up to five zones for a Stepped Distance backup protection scheme.

IMPLEMENTATION

With the D60 Line Distance Relay, the user can design and implement custom FlexLogic™ circuitry to control any element of the D60 system. Utilizing this capability along with the multiple settings groups feature, it is possible to implement a fifth (or sixth, seventh, etc.) zone of distance protection.

This implementation described in this paper progressively modifies the reach setting of one of the zones. The process is controlled by the largest distance zone, which used as a “Starting Element”. This scheme has been used successfully for many years by US and European manufacturers in “switched relays.”

There are two main types of switched relays. The first includes only one measuring element and switches the AC inputs to this element depending the fault type. The other type of switched relays include several measuring elements, but not enough to implement all the distance zones independently. In this case, relays switch the reach setting of one of the zones (changing to a longer reach) after the time delay set for that zone; that is, after waiting a sufficient time to assure the fault was not inside the zone.

Switched relays use one internal element to “start” the switching process after the detection of a power system fault. The starting element is generally an overcurrent detector or an underimpedance starter.

This Application Note explains how to implement a switching scheme in the D60 relay using an *underimpedance starter*.

APPLICATION SETTINGS

Assume that the following five zone settings are desired: Z_1, Z_2, Z_3, Z_4, and Z_5, each with their respective time delay requirements T_1, T_2, T_3, T_4, and T_5. The application requires Z_5 to be a backward looking zone. Assume also that:

$$Z_1 < Z_2 < Z_3 < Z_4 \quad \text{and} \quad T_1 < T_2 < T_3 < T_4 \qquad \text{(EQ 1)}$$

In this Application Note, capital letters represent the application requirements for zone reach and zone timers, and lowercase letters represent the available settings in the relay: z_1, z_2, z_3, and z_4, with the respective t_1, t_2, t_3 and t_4 timers.

Graphically, the situation and the proposed solution can be depicted as follows:

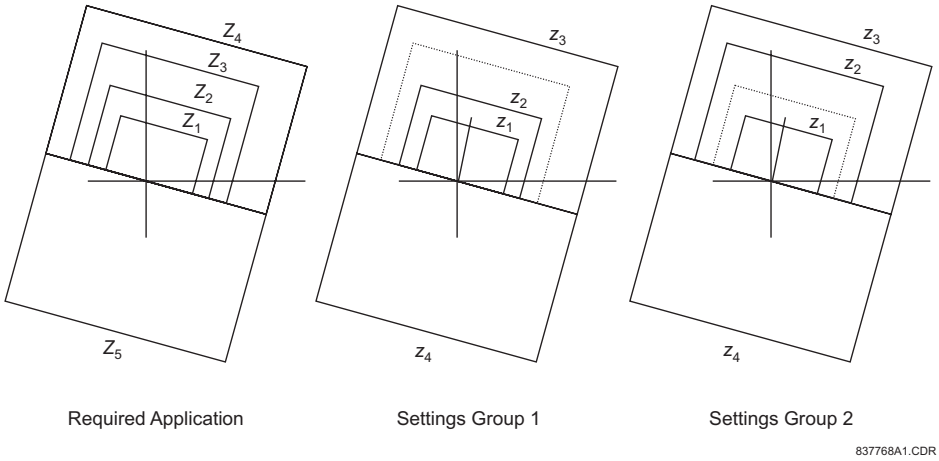


FIGURE 1. Multiple Distance Zone Illustration

CONTROL OF REACHES

The process of controlling reaches requires using the largest forward looking zone as the starting element to control the active settings group.

The reaches and time delays for each distance element are as follows:

Element	Group 1	Group 2
z_1	Z_1	Z_1
z_2	Z_2	Z_3
z_3	Z_4	Z_4
z_4	Z_5	Z_5
t_1	T_1	0
t_2	T_2	0
t_3	T_4	$T_4 - T_3$
t_5	T_5	$T_5 - T_3$

When a fault occurs inside any of the forward looking zones, the z_3 element picks up as the starting element, and starts counting down the Z_3 timer (T_3).

OPERATION

The application operates as follows:

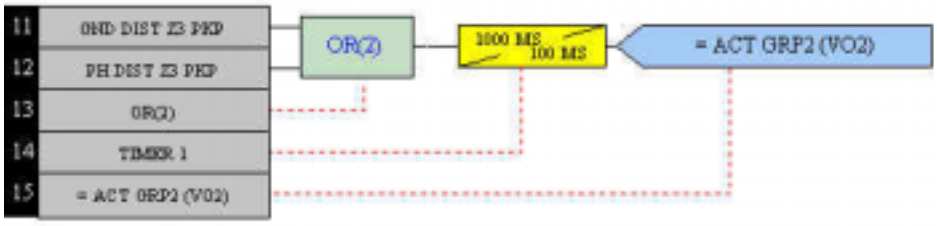
- If the impedance moves from outside the zones into Z_1 (line fault), z_3 picks up and the relay trips very fast, in T_1 seconds, without switching groups (z_2 and z_3 also pick up).
- If the impedance moves from outside the zones into Z_2, z_2 picks up and the relay trips in T_2 seconds, without switching groups (z_3 also picks up, but the relay trips before switching groups, since $T_2 < T_3$).
- If the impedance moves from outside the zones into Z_3, z_3 picks up and after the T_3 time delay, the relay switches to Settings Group 2 and trips immediately after Group 2 is placed in service, since the fault is inside the new z_2 reach and t_2 is set to zero. The relay tripping time is T_3 seconds, as required.
- If the impedance moves from outside the zones into Z_4, z_3 picks up and after the Z_3 time delay (T_3 seconds), the relay switches to Settings Group 2. When the new group is in service, the distance elements are re-initiated and timers begin counting again. For this reason, t_3 is set as $T_4 - T_3$, as T_3 seconds have already passed and only $T_4 - T_3$ seconds should be counted before tripping. The relay finally trips in $T_3 + (T_4 - T_3) = T_4$ seconds, as required.
- If the impedance moves from outside the zones into Z_5 (reversed zone), z_4 picks up and trips in T_5 seconds, as required, without switching groups.

Settings group changes only take place for faults in Z_3 or Z_4, which usually have tripping times greater than 1000 ms. The time involved in switching between settings groups is 4 ms – this can be considered instantaneous compared to the T_3 and T_4 time delays.

Only distance elements are re-initiated when settings groups are changed. All other protection elements (Overcurrent, Out-of-Step tripping, etc.) are not re-initiated, so pickup settings, reaches, and timers must be kept identical in Groups 1 and 2.

FLEXLOGIC™ CONFIGURATION

The FlexLogic™ involved in this Settings Groups control scheme is shown below:



The logic activates Settings Group 2 T_3 seconds after the z_3 element picking up. In this example, T_3 is set to 1000 ms.

Settings Group 1 returns to service 100 ms after the z_3 element drops out. This occurs when the fault is cleared from the power system, either by the D60 or some other relay in the system.